

MASTER PhyMed

GMPH308 - Physique de l'imagerie médicale

TRAITEMENT des IMAGES MEDICALES



Numérisation

$$f(x, y): \mathbb{R}^2 \rightarrow \Omega (\mathbb{R}, \mathbb{R}^+, \mathbb{N})$$

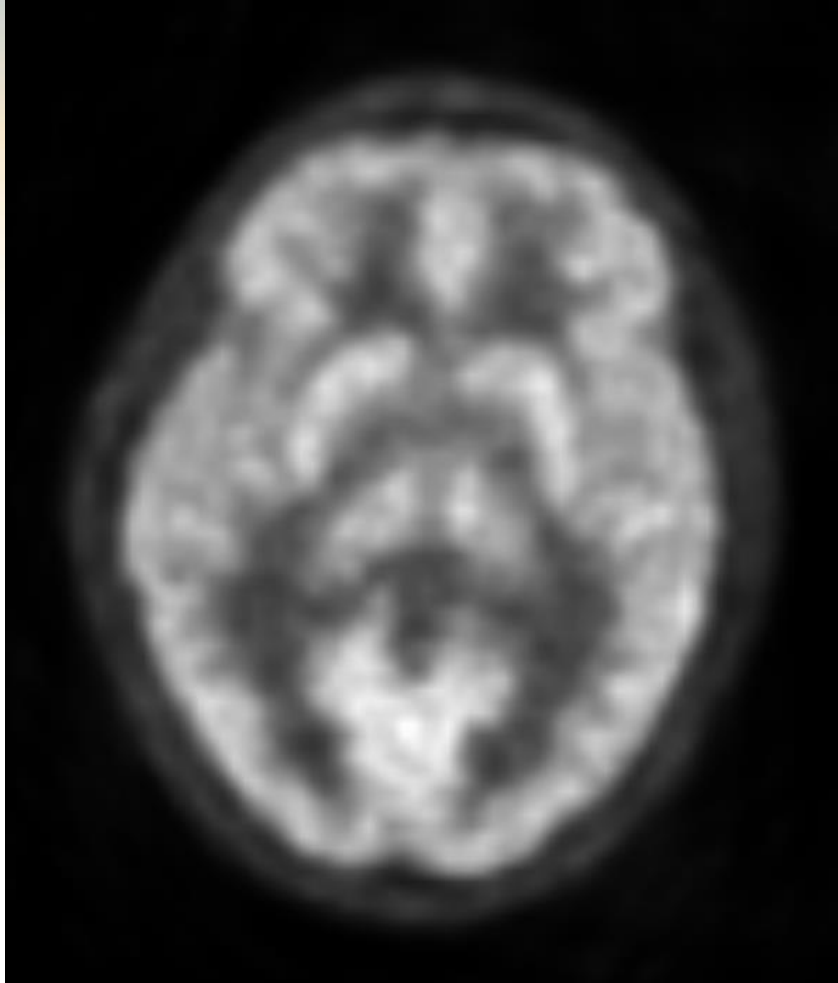


IMAGE ANALOGIQUE

$$\bar{f}(i, j): \dots \rightarrow \dots$$

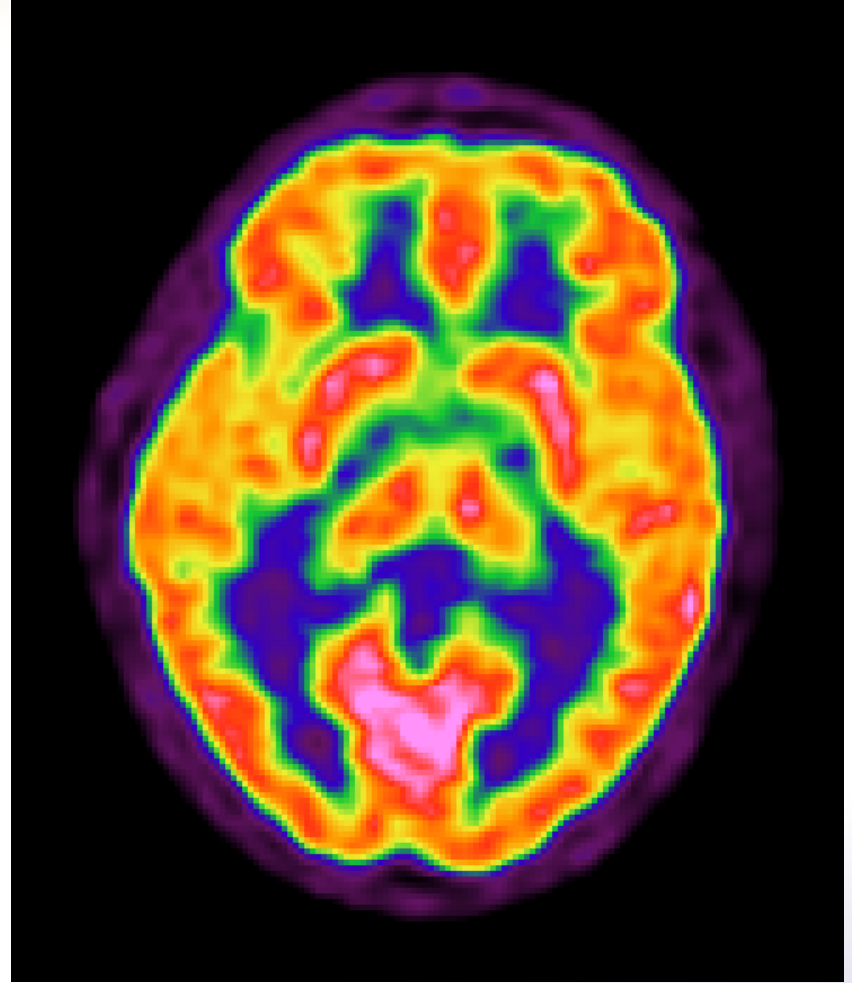
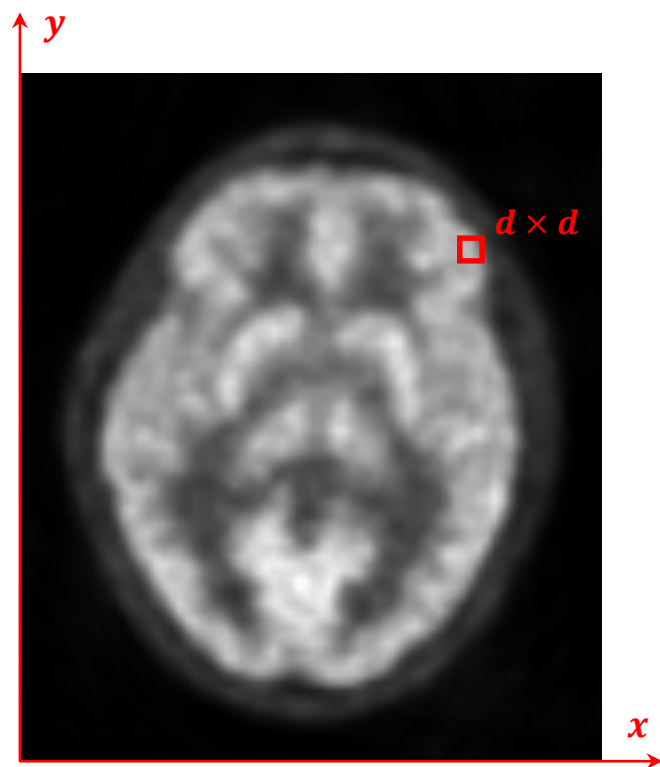


IMAGE NUMERIQUE

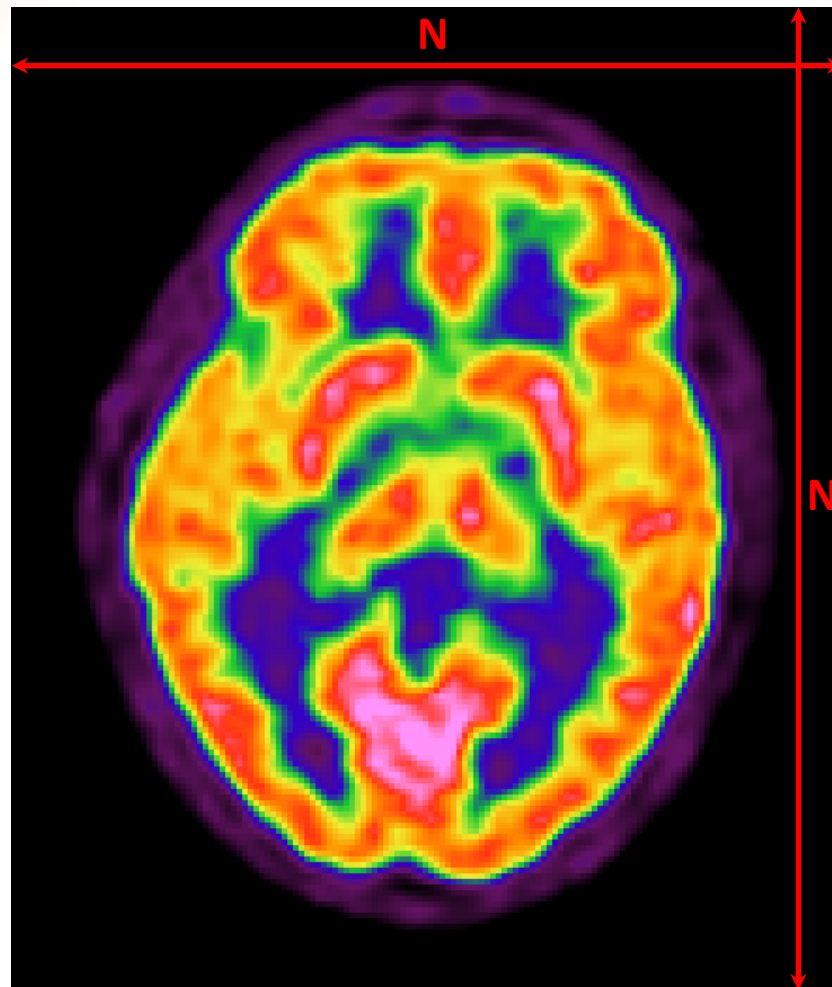
Numérisation

- Echantillonnage : 128×128
 $512 \times 512 \dots$

$$(x, y) \rightarrow (i, j) : \begin{cases} x_i = i d \\ y_j = j d \end{cases}$$



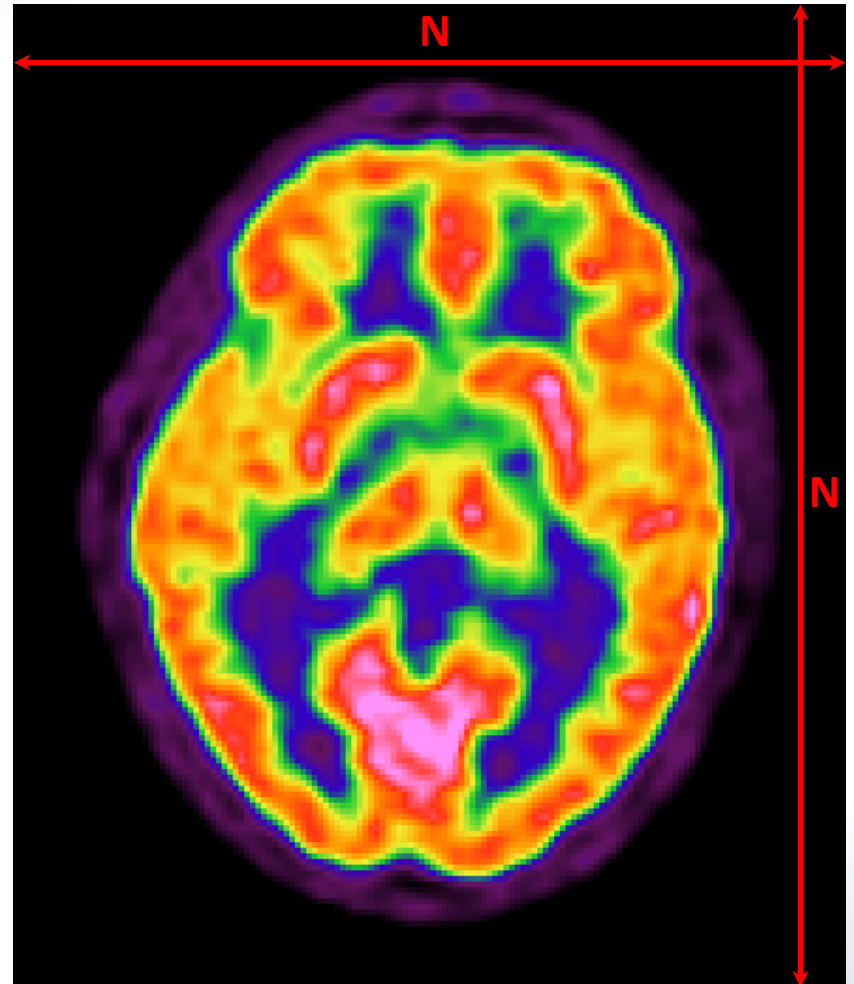
$$\bar{f}(i, j) : \{1:N\} \times \{1:N\} \rightarrow \dots$$



Numérisation

- Echantillonnage : 128 × 128
512 × 512 ...
- Quantification : 1, 2, 4 octets

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



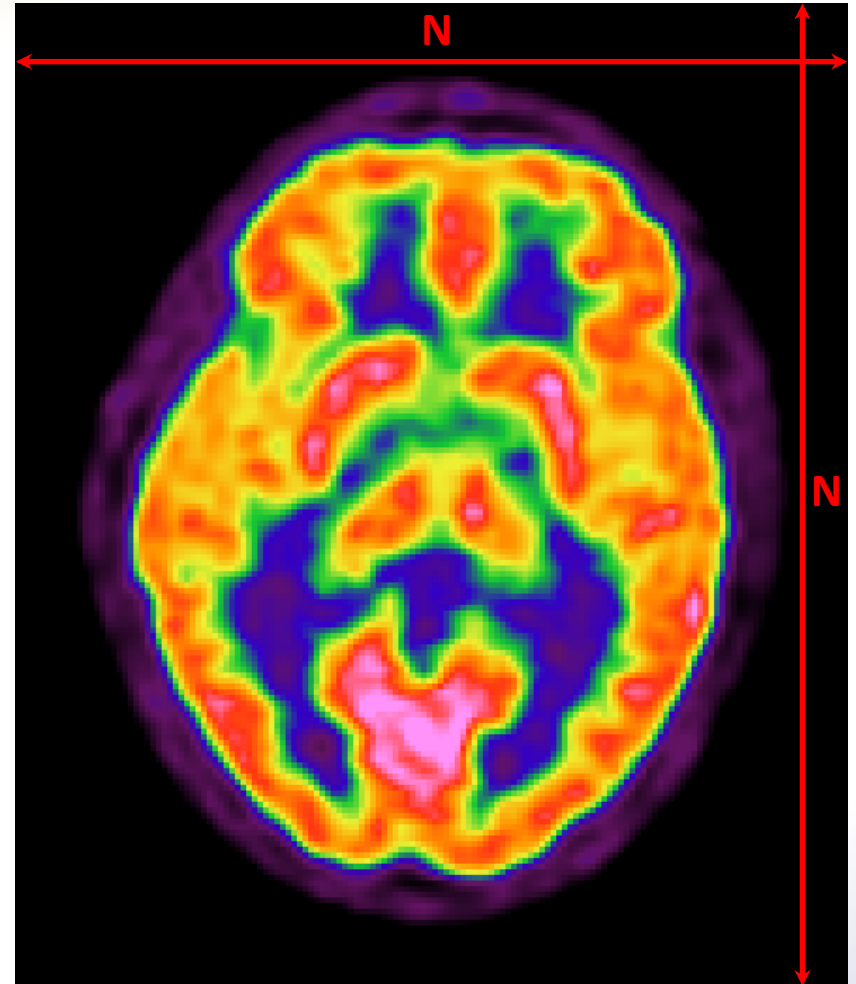
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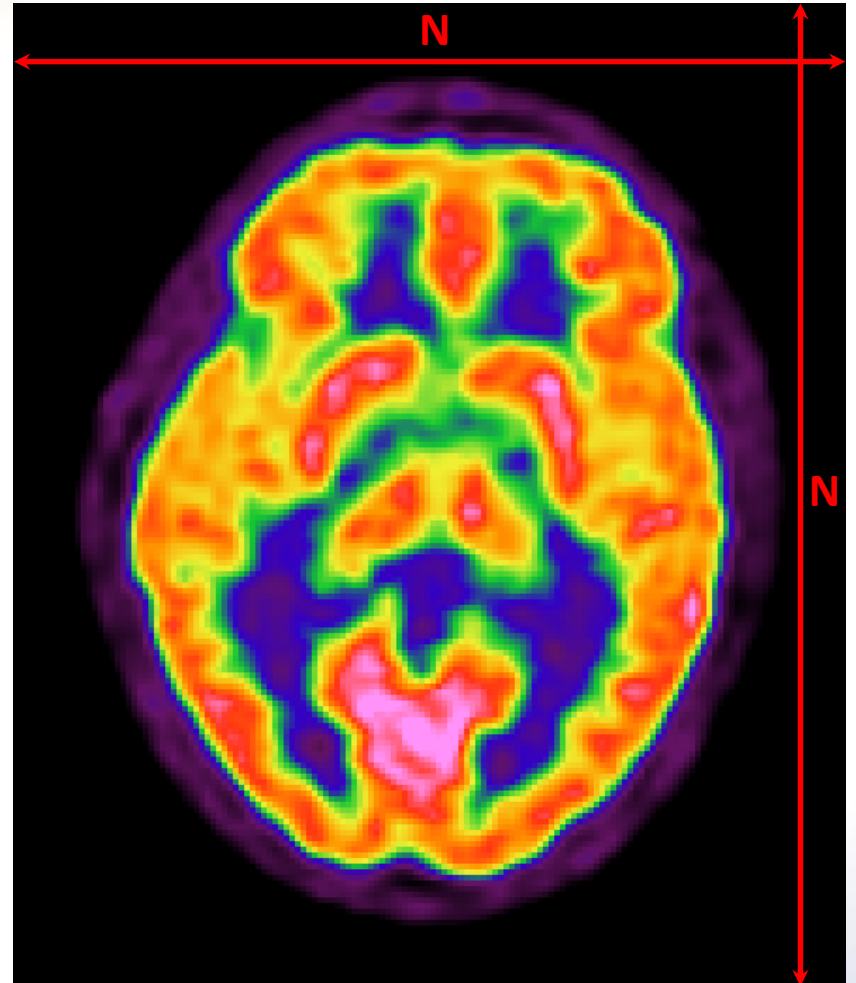
Numérisation

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- Quantification : 1, 2, 4 octets

byte / char (1 octet)
 $0 \rightarrow 255$

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



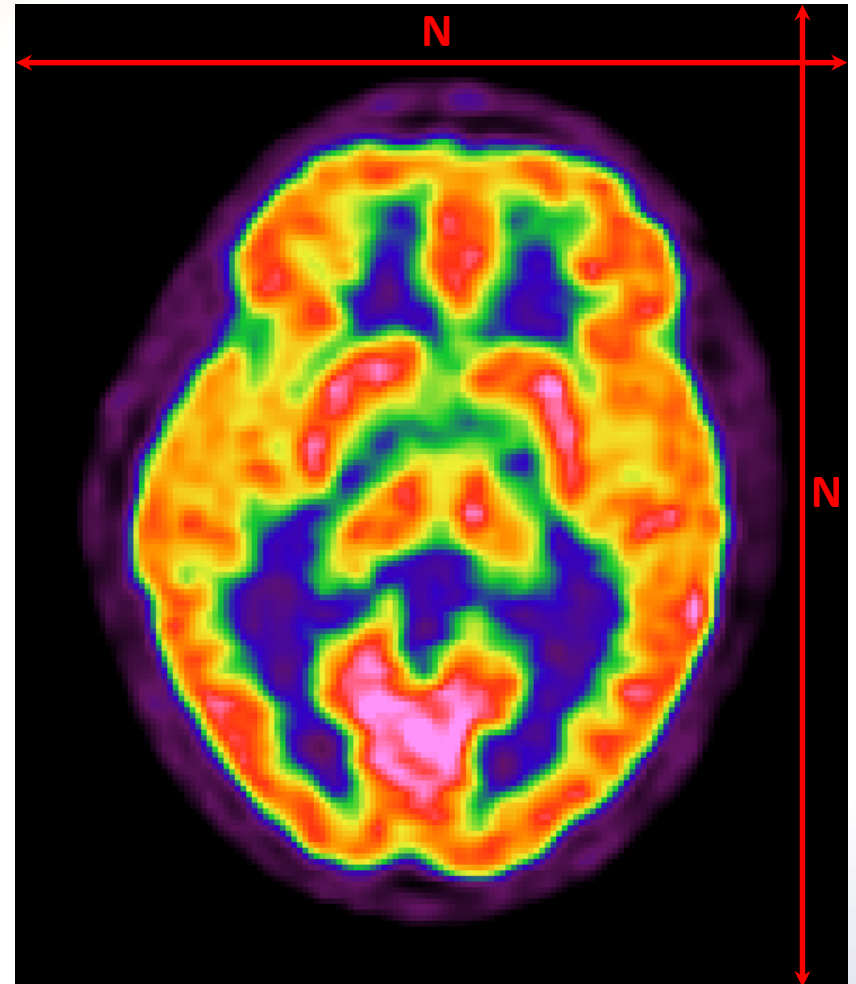
Numérisation

- Echantillonnage : 128 × 128
512 × 512 ...

- Quantification : 1, 2, 4 octets

unsigned short int (2 octets)
0 → 65535

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



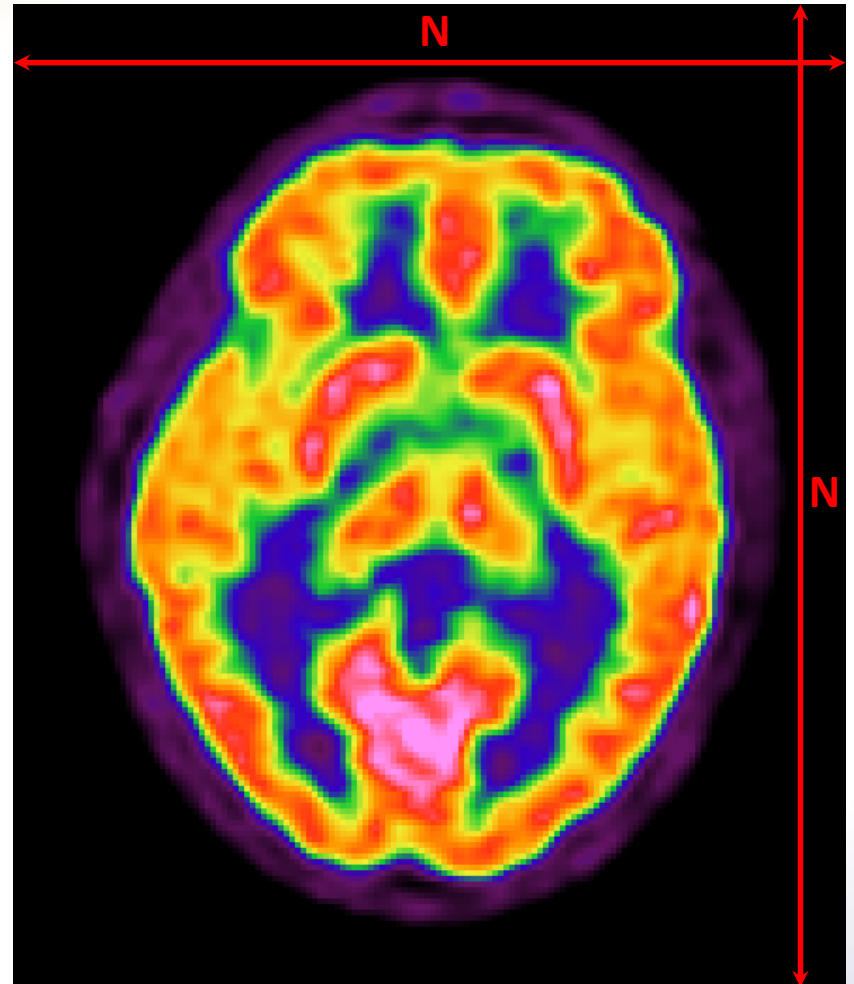
Numérisation

■ Echantillonnage : 128 x 128
512 x 512 ...

■ Quantification : 1, 2, 4 octets

signed short int (2 octets)
-32767 → 32768

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



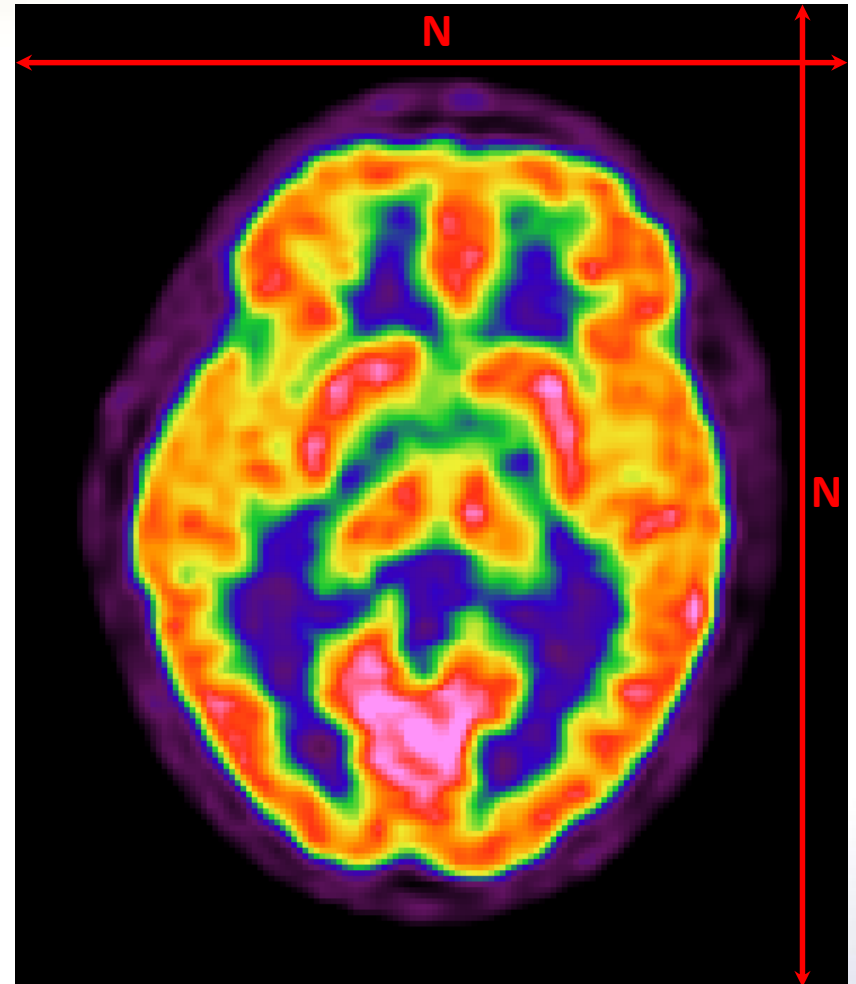
Numérisation

- Echantillonnage : 128×128
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- Quantification : 1, 2, 4 octets

long int (4 octets)
 $0 \rightarrow 4 \cdot 10^9$

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



Numérisation

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■ Quantification : 1, 2, 4 octets

floating point (4 / 8 octets)

$$f = (-1)^S \cdot M \cdot 2^{127-E}$$

$$S : \{0, 1\}$$

$$M : 0 \rightarrow 8 \cdot 10^6$$

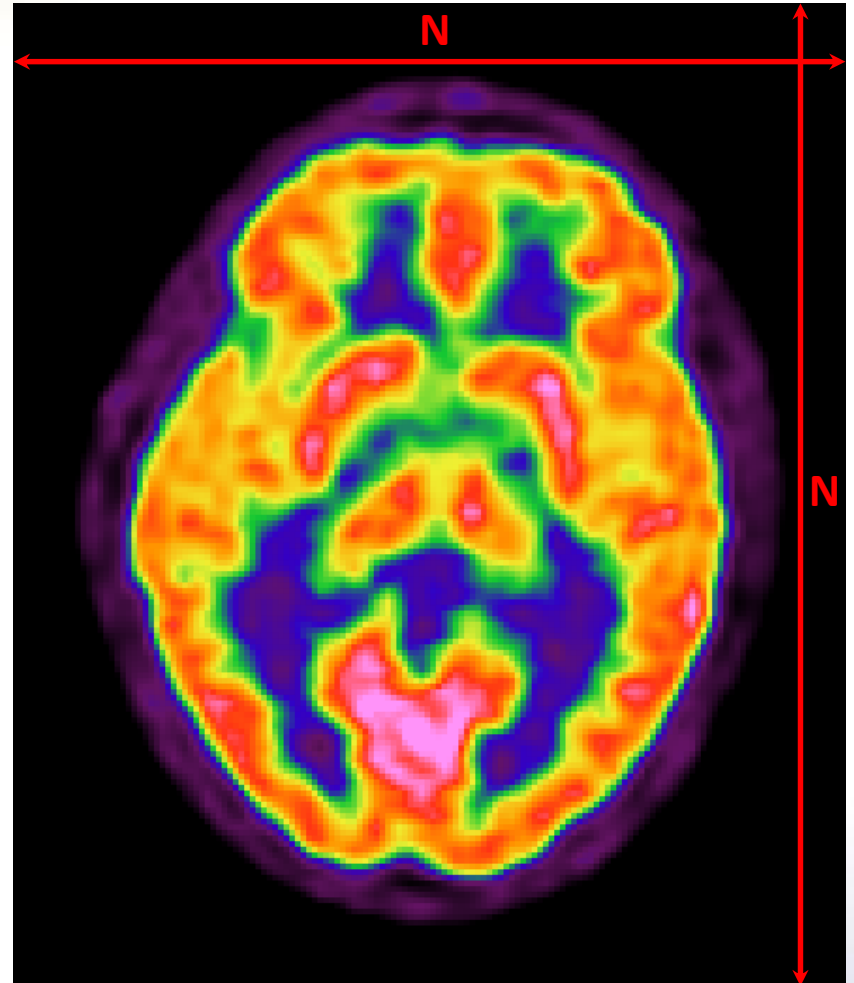
$$E : 0 \rightarrow 255$$

$$q_{\min} = -8 \cdot 10^6 \times 2^{127} \sim -10^{45}$$

$$q_{\max} = 8 \cdot 10^6 \times 2^{127} \sim 10^{45}$$

$$e = 2^{-128} \sim 10^{-40}$$

$$\bar{f}(i, j) : \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{\min} : e : q_{\max}\}$$



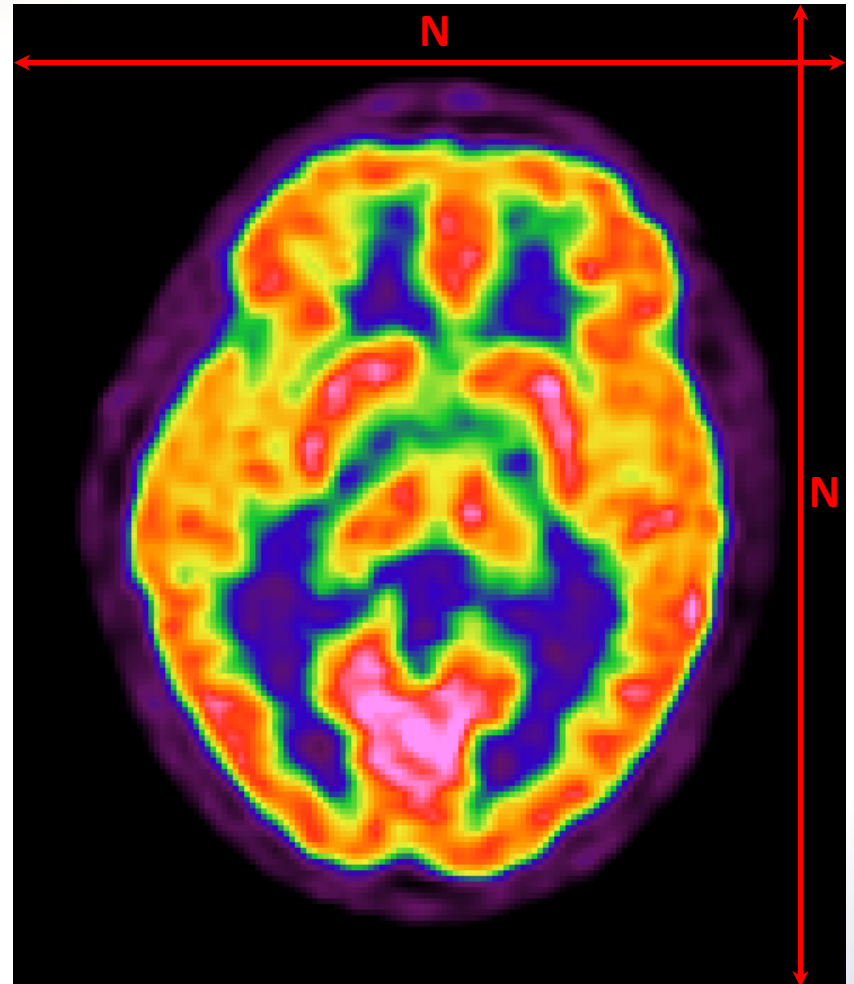
Numérisation

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512 × 512 ...

- Quantification : 1, 2, 4 octets

$$\bar{f}(i, j) = [f(x_i = di, y_j = dj)]_{\Lambda}$$

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



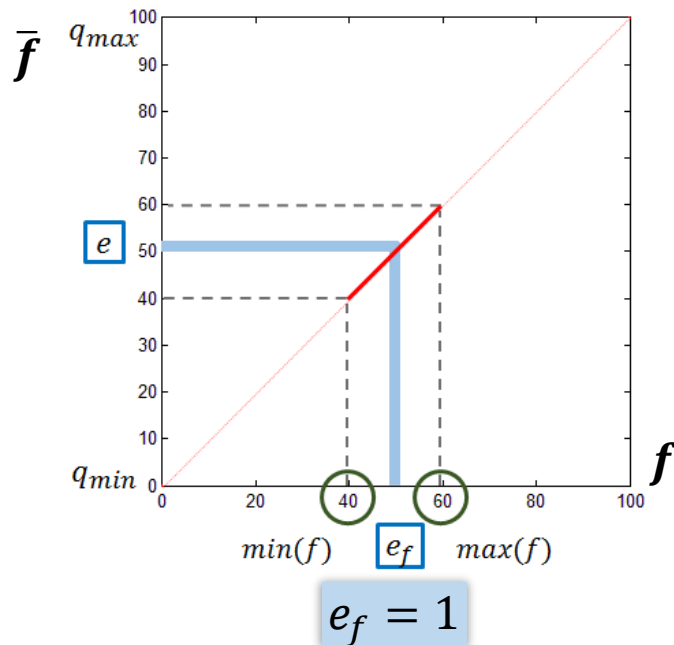
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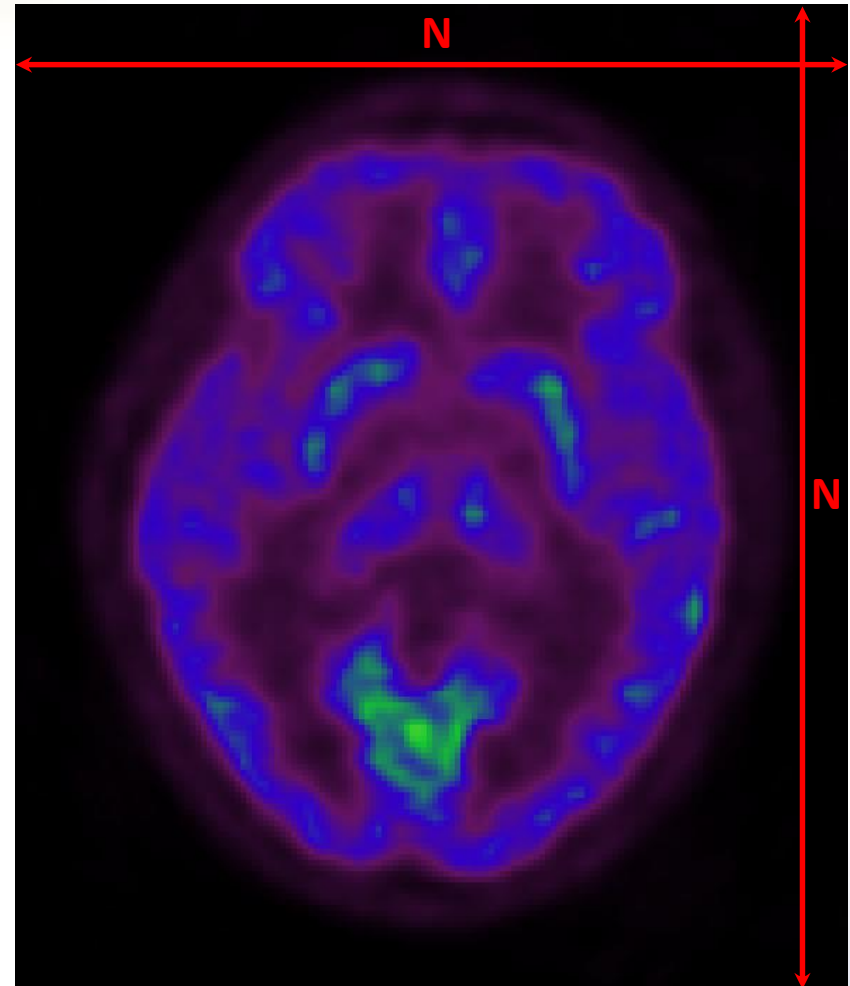
- Quantification : 1, 2, 4 octets

$$\bar{f}(i, j) = [f(x_i = di, y_j = dj)]_{\Lambda}$$

- Mise à l'échelle :



$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



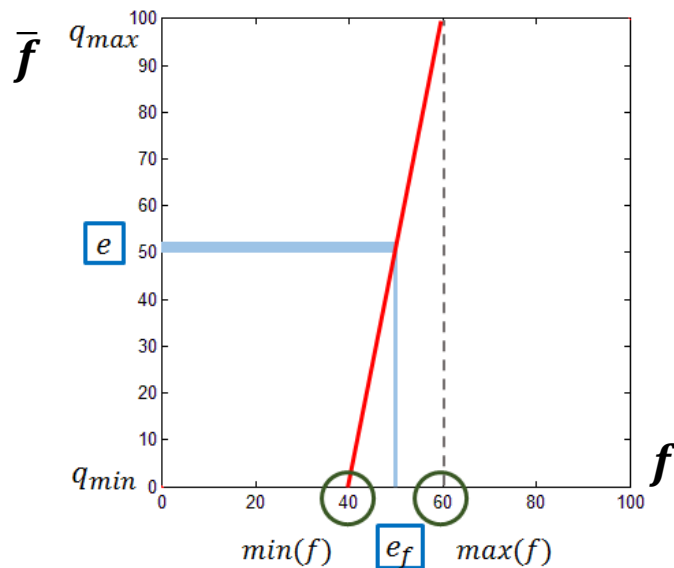
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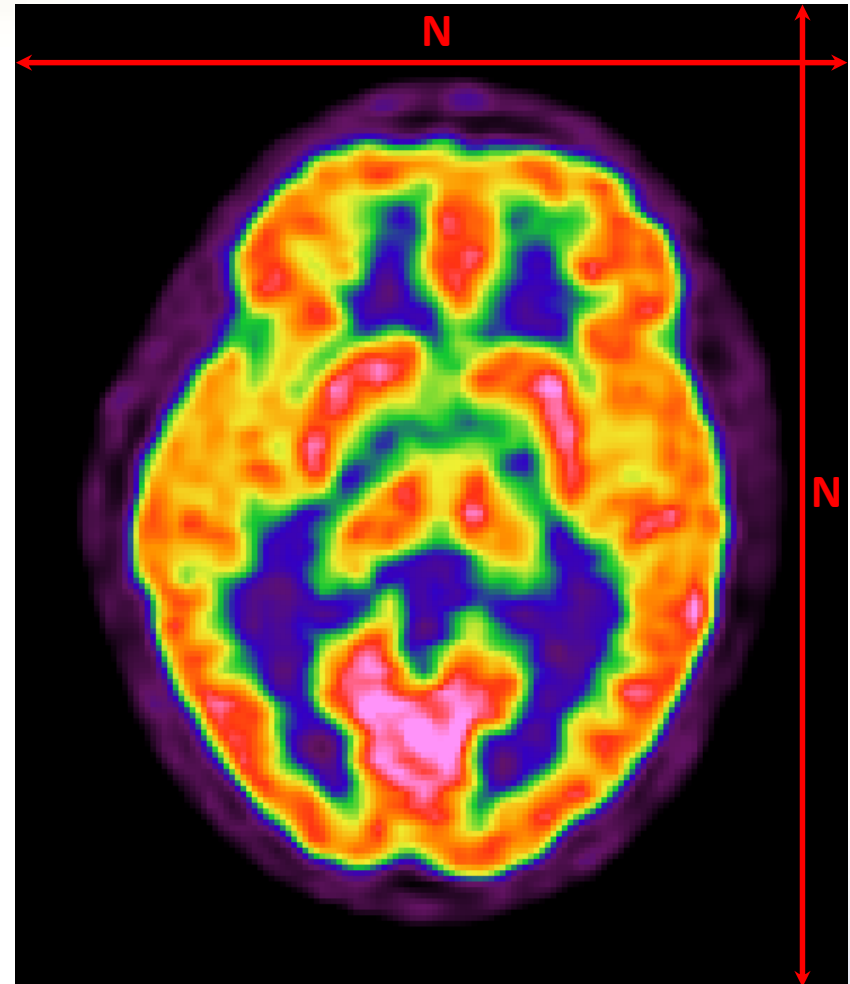
$$\bar{f}(i, j) = \alpha [f(x_i = di, y_j = dj)]_{\Lambda} + \beta$$

- Mise à l'échelle :



$$e_f = 0,2$$

$$\bar{f}(i, j): \{1:N\} \times \{1:N\} \rightarrow \Lambda = \{q_{min}:e:q_{max}\}$$



Numérisation

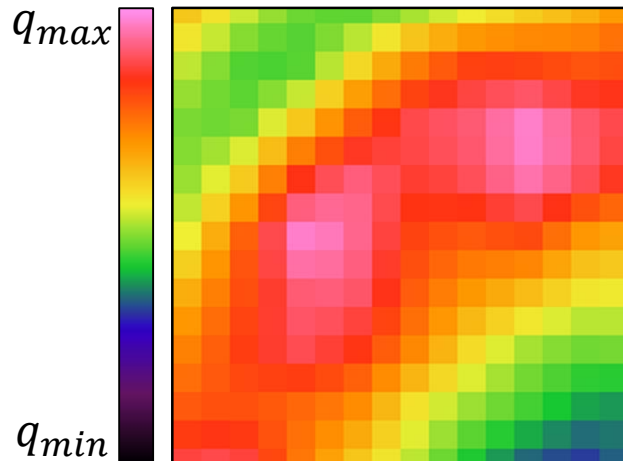
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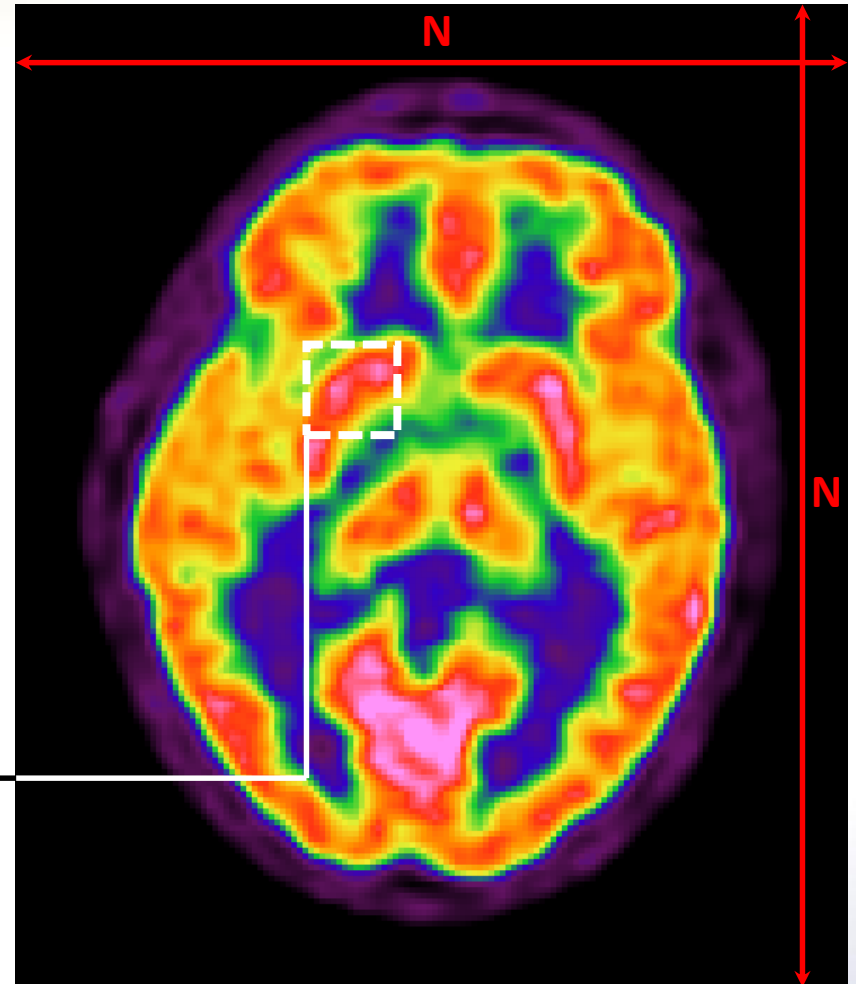
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- Mise à l'échelle

- Visualisation



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Numérisation

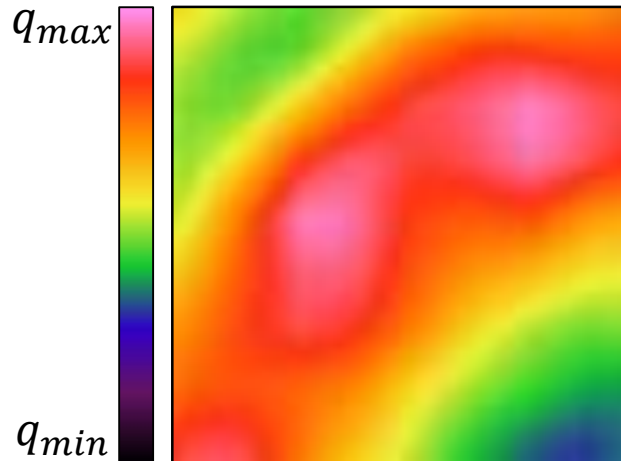
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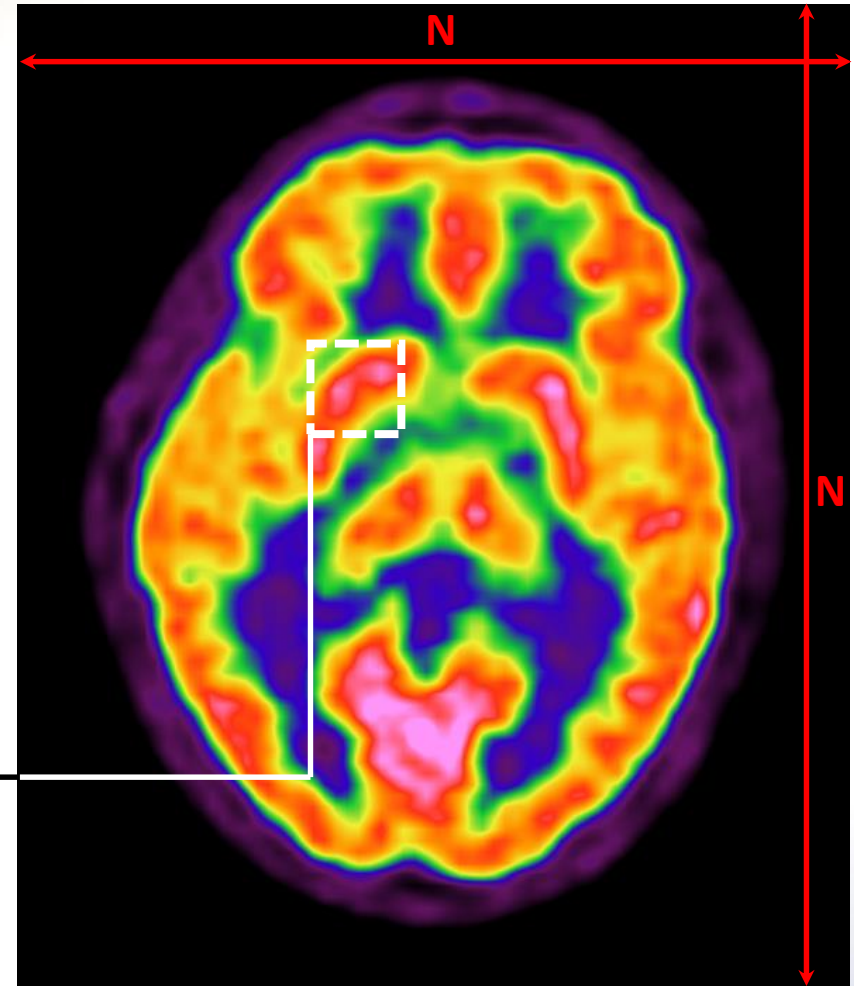
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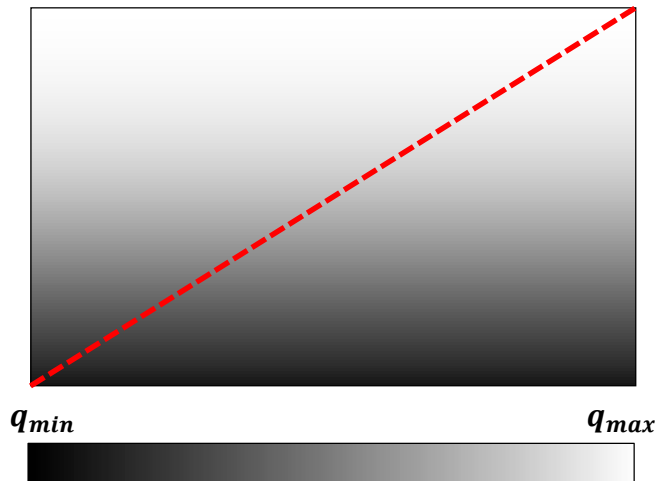
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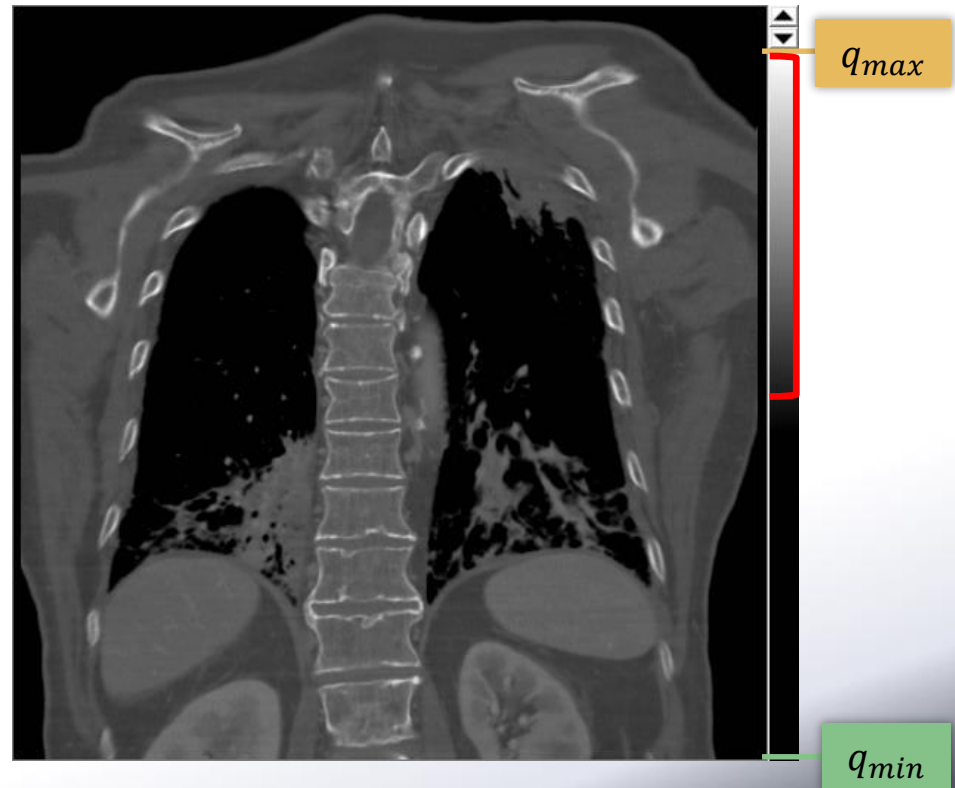
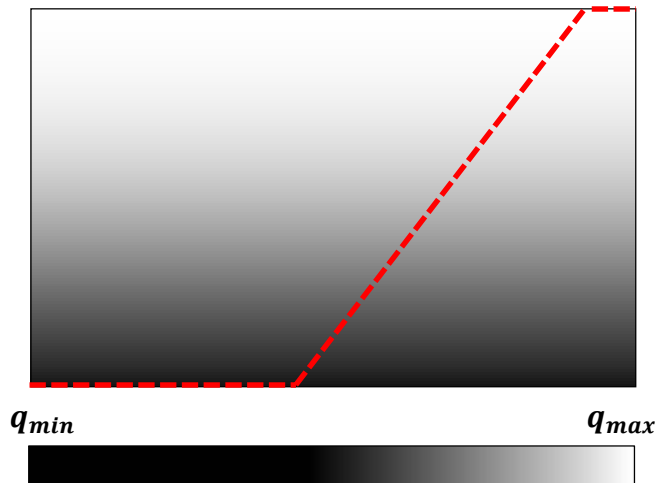
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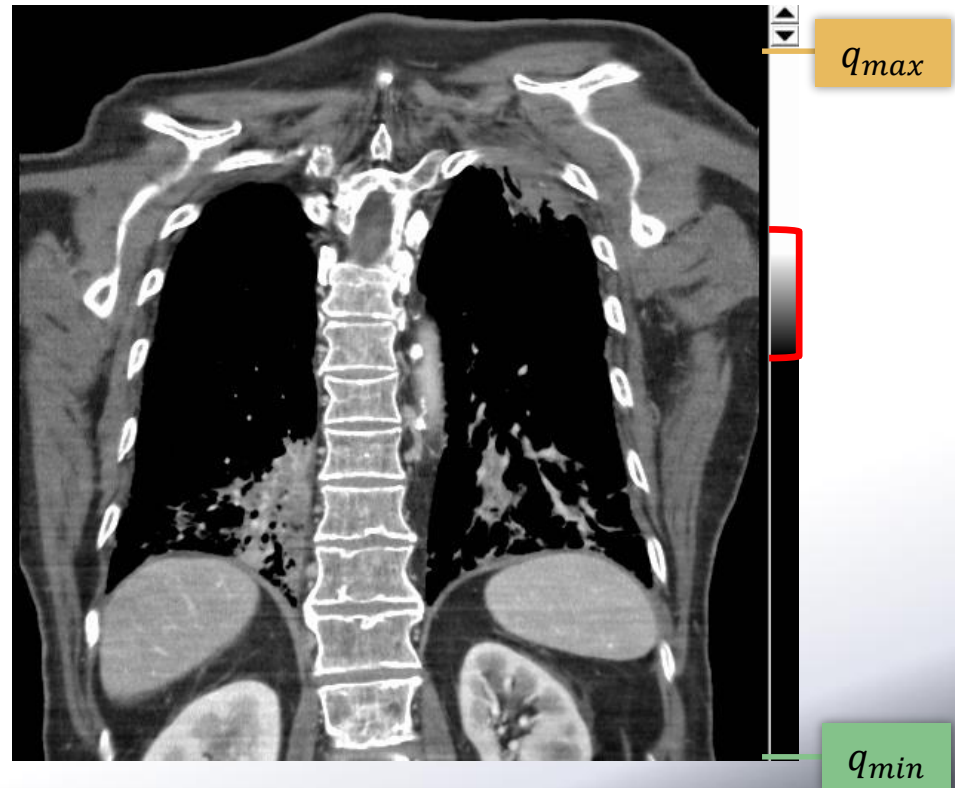
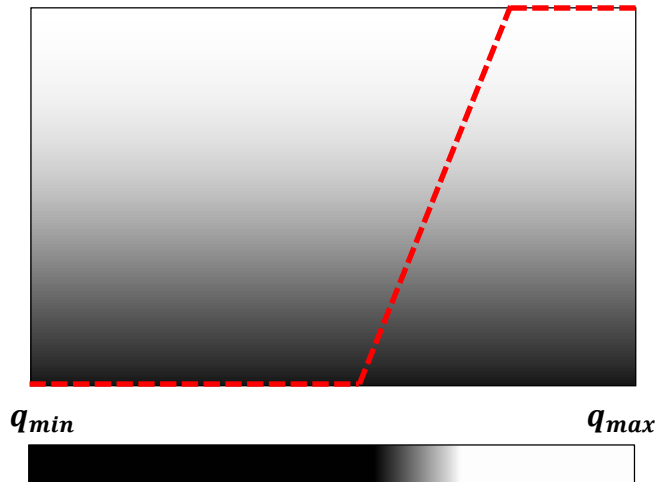
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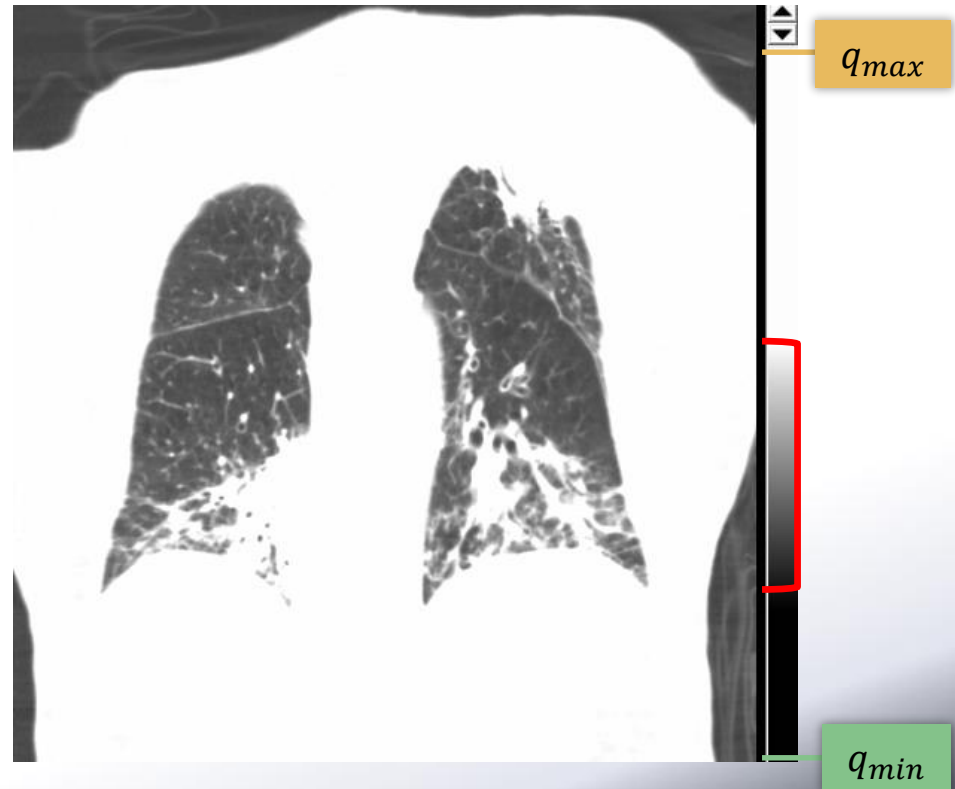
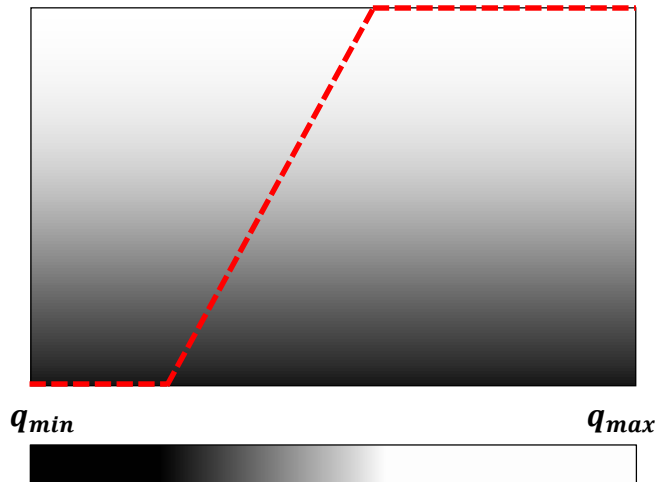
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- Stockage / échange (DICOM)

« *Digital imaging and communications in medicine* »

<http://dicom.nema.org/>

<http://medical.nema.org/standard.html>

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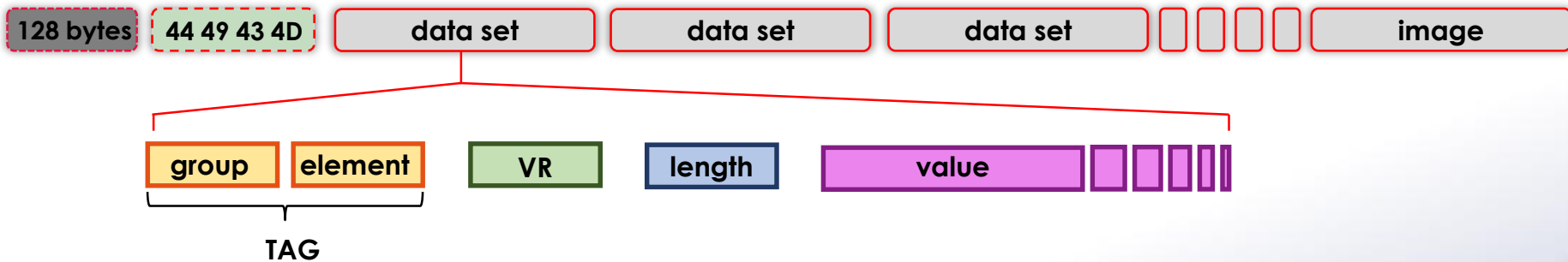
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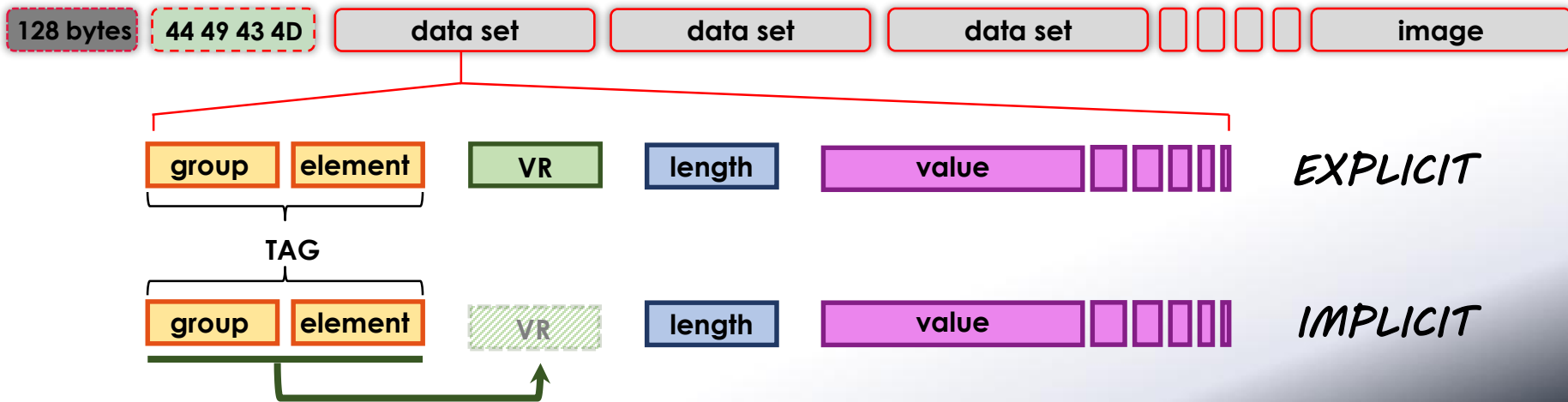
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- Stockage / échange (DICOM)



Numérisation

DICOM

Property	Value
0008,0012 : Instance Creation Date	
0008,0013 : Instance Creation Time	
0008,0014 : Instance Creator UID	
0008,0016 : SOP Class UID	
0008,0018 : SOP Instance UID	
0008,0020 : Study Date	
0008,0021 : Series Date	
0008,0022 : Acquisition Date	
0008,0023 : Content Date	
0008,0030 : Study Time	
0008,0031 : Series Time	
0008,0032 : Acquisition Time	
0008,0033 : Content Time	
0008,0050 : Accession Number	
0008,0060 : Modality	
0008,0070 : Manufacturer	
0008,0080 : Institution Name	
0008,0090 : Referring Physician's Name	
0008,1010 : Station Name	
0008,1030 : Study Description	
0008,103E : Series Description	
0008,1060 : Name of Physician(s) Reading Study	
0008,1070 : Operators' Name	
0008,1090 : Manufacturer's Model Name	
Attribute Tag	0008,0022
Description	Acquisition Date
Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312
00000240	08 00 32 30 31 34 30 33 31 32 08 00 22 00 44 41 ..20140312..".DA
00000250	08 00 32 30 31 34 30 33 31 32 08 00 23 00 44 41 ..20140312..#.DA
00000260	08 00 32 30 31 34 30 33 31 32 08 00 30 00 54 4D ..20140312..0.TM
00000270	0A 00 31 31 35 37 35 34 2E 30 30 20 08 00 31 00 ..115754.00 ..1.
00000280	54 4D 0A 00 31 31 35 37 35 34 2E 30 30 20 08 00 TM..115754.00 ..
00000290	32 00 54 4D 0A 00 31 31 35 37 35 34 2E 30 30 20 2.TM..115754.00
000002A0	08 00 33 00 54 4D 0A 00 31 31 35 37 35 34 2E 30 ..3.TM..115754.0
000002B0	30 20 08 00 50 00 53 48 0A 00 31 30 32 39 36 30 0 ..P.SH..102960
000002C0	35 33 39 20 08 00 60 00 43 53 02 00 4E 4D 08 00 539 ..`.CS..NM..
000002D0	70 00 4C 4F 12 00 47 45 20 4D 45 44 49 43 41 4C p.LO..GE MEDICAL
000002E0	20 53 59 53 54 45 4D 53 08 00 80 00 4C 4F 10 00 SYSTEMS....LO..
000002F0	43 48 55 20 4D 4F 4E 54 50 45 4C 4C 49 45 52 20 CHU MONTPELLIER
00000300	08 00 90 00 50 4E 00 00 08 00 10 10 53 48 0A 00 ....PN.....SH..
00000310	4C 41 50 49 4E 46 49 4E 49 41 08 00 30 10 4C 4F LAPINFINIA..0.LO

Numérisation

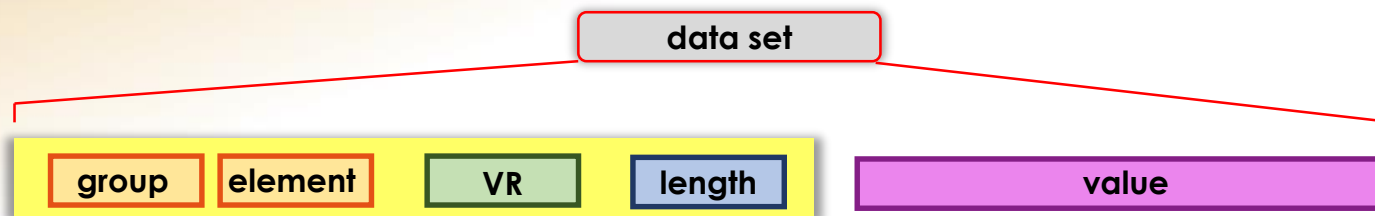
DICOM

Property	Value
Attribute Tag	0008,0022
Description	Acquisition Date
Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312

0008,0012 : Instance Creation Date	00000240	08 00 32 30 31 34 30 33 31 32	08 00 22 00 44 41	..20140312..".DA
0008,0013 : Instance Creation Time	00000250	08 00 32 30 31 34 30 33 31 32	08 00 23 00 44 41	..20140312..#.DA
0008,0014 : Instance Creator UID	00000260	08 00 32 30 31 34 30 33 31 32	08 00 30 00 54 4D	..20140312..0.TM
0008,0016 : SOP Class UID	00000270	0A 00 31 31 35 37 35 34 2E 30	30 20 08 00 31 00	..115754.00 ..1.
0008,0018 : SOP Instance UID	00000280	54 4D 0A 00 31 31 35 37 35 34	2E 30 30 20 08 00	TM..115754.00 ..
0008,0020 : Study Date	00000290	32 00 54 4D 0A 00 31 31 35 37	35 34 2E 30 30 20	2.TM..115754.00
0008,0021 : Series Date	000002A0	08 00 33 00 54 4D 0A 00 31 31	35 37 35 34 2E 30	..3.TM..115754.0
0008,0022 : Acquisition Date	000002B0	30 20 08 00 50 00 53 48 0A 00	31 30 32 39 36 30	0 ..P.SH..102960
0008,0023 : Content Date	000002C0	35 33 39 20 08 00 60 00 43 53	02 00 4E 4D 08 00	539 ..`.CS..NM..
0008,0030 : Study Time	000002D0	70 00 4C 4F 12 00 47 45 20 4D	45 44 49 43 41 4C	p.LO..GE MEDICAL
0008,0031 : Series Time	000002E0	20 53 59 53 54 45 4D 53 08 00	80 00 4C 4F 10 00	SYSTEMS....LO..
0008,0032 : Acquisition Time	000002F0	43 48 55 20 4D 4F 4E 54 50 45	4C 4C 49 45 52 20	CHU MONTPELLIER
0008,0033 : Content Time	00000300	08 00 90 00 50 4E 00 00 08 00	10 10 53 48 0A 00	....PN.....SH..
0008,0050 : Accession Number	00000310	4C 41 50 49 4E 46 49 4E 49 41	08 00 30 10 4C 4F	LAPINFINIA..0.LO

Numérisation

DICOM

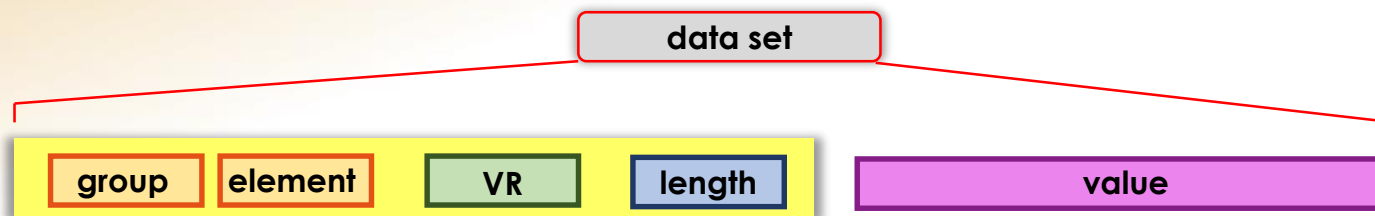


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Tag Offset	0000024A : (586)
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00000240	08 00 32 30 31 34 30 33 31 32	08 00 22 00 44 41	..20140312..".DA
00000250	08 00 32 30 31 34 30 33 31 32	08 00 23 00 44 41	..20140312..#.DA
00000260	08 00 32 30 31 34 30 33 31 32	08 00 30 00 54 4D	..20140312..0.TM
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00000290	32 00 54 4D 0A 00 31 31 35 37	35 34 2E 30 30 20	2.TM..115754.00
000002A0	08 00 33 00 54 4D 0A 00 31 31	35 37 35 34 2E 30	..3.TM..115754.0
000002B0	30 20 08 00 50 00 53 48 0A 00	31 30 32 39 36 30	0 ..P.SH..102960
000002C0	35 33 39 20 08 00 60 00 43 53	02 00 4E 4D 08 00	539 ..`.CS..NM..
000002D0	70 00 4C 4F 12 00 47 45 20 4D	45 44 49 43 41 4C	p.LO..GE MEDICAL
000002E0	20 53 59 53 54 45 4D 53 08 00	80 00 4C 4F 10 00	SYSTEMS....LO..
000002F0	43 48 55 20 4D 4F 4E 54 50 45	4C 4C 49 45 52 20	CHU MONTPELLIER
00000300	08 00 90 00 50 4E 00 00 08 00	10 10 53 48 0A 00	....PN.....SH..
00000310	4C 41 50 49 4E 46 49 4E 49 41	08 00 30 10 4C 4F	LAPINFINIA..O.LO

Numérisation

DICOM

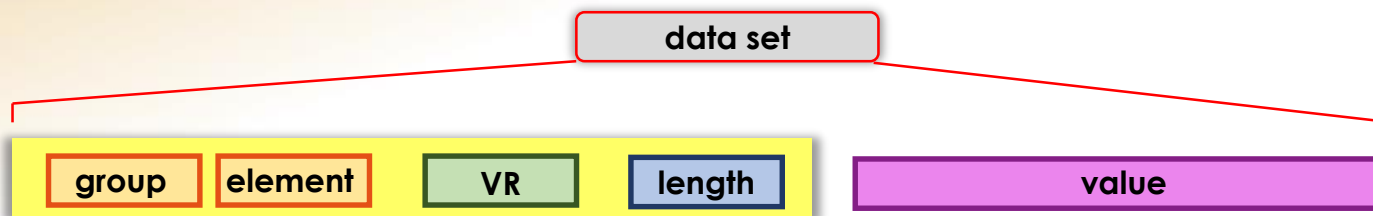


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Attribute Tag	0008,0022
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Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312

00000240	08	00	32	30	31	34	30	33	31	32	08	00	22	00	44	41	..20140312..".DA
00000250	08	00	32	30	31	34	30	33	31	32	08	00	23	00	44	41	..20140312..#.DA
00000260	08	00	32	30	31	34	30	33	31	32	08	00	30	00	54	4D	..20140312..0.TM
00000270	0A	00	31	31	35	37	35	34	2E	30	30	20	08	00	31	00	..115754.00 ..1.
00000280	54	4D	0A	00	31	31	35	37	35	34	2E	30	30	20	08	00	TM..115754.00 ..
00000290	32	00	54	4D	0A	00	31	31	35	37	35	34	2E	30	30	20	2.TM..115754.00
000002A0	08	00	33	00	54	4D	0A	00	31	31	35	37	35	34	2E	30	..3.TM..115754.0
000002B0	30	20	08	00	50	00	53	48	0A	00	31	30	32	39	36	30	0 ..P.SH..102960
000002C0	35	33	39	20	08	00	60	00	43	53	02	00	4E	4D	08	00	539 ..`.CS..NM..
000002D0	70	00	4C	4F	12	00	47	45	20	4D	45	44	49	43	41	4C	p.LO..GE MEDICAL
000002E0	20	53	59	53	54	45	4D	53	08	00	80	00	4C	4F	10	00	SYSTEMS....LO..
000002F0	43	48	55	20	4D	4F	4E	54	50	45	4C	4C	49	45	52	20	CHU MONTPELLIER
00000300	08	00	90	00	50	4E	00	00	08	00	10	10	53	48	0A	00PN.....SH..
00000310	4C	41	50	49	4E	46	49	4E	49	41	08	00	30	10	4C	4F	LAPINFINIA..O.LO

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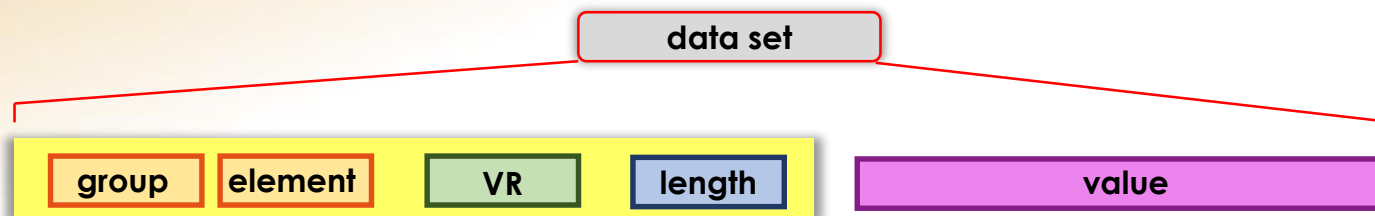


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00000240	08 00 32 30 31 34 30 33 31 32	08 00 22 00	44 41	..20140312..".DA
00000250	08 00 32 30 31 34 30 33 31 32	08 00 23 00	44 41	..20140312..#.DA
00000260	08 00 32 30 31 34 30 33 31 32	08 00 30 00	54 4D	..20140312..0.TM
00000270	0A 00 31 31 35 37 35 34 2E 30	30 20 08 00	31 00	..115754.00 ..1.
00000280	54 4D 0A 00 31 31 35 37 35 34 2E 30	30 20 08 00	31 00	TM..115754.00 ..
00000290	32 00 54 4D 0A 00 31 31 35 37 35 34 2E 30	30 20		2.TM..115754.00
000002A0	08 00 33 00 54 4D 0A 00 31 31 35 37 35 34 2E 30			..3.TM..115754.0
000002B0	30 20 08 00 50 00 53 48 0A 00 31 30 32 39 36 30	0 ..P.SH..102960		
000002C0	35 33 39 20 08 00 60 00 43 53 02 00 4E 4D 08 00	539 ..`.CS..NM..		
000002D0	70 00 4C 4F 12 00 47 45 20 4D 45 44 49 43 41 4C	p.LO..GE MEDICAL		
000002E0	20 53 59 53 54 45 4D 53 08 00 80 00 4C 4F 10 00	SYSTEMS....LO..		
000002F0	43 48 55 20 4D 4F 4E 54 50 45 4C 4C 49 45 52 20	CHU MONTPELLIER		
00000300	08 00 90 00 50 4E 00 00 08 00 10 10 53 48 0A 00	....PN.....SH..		
00000310	4C 41 50 49 4E 46 49 4E 49 41 08 00 30 10 4C 4F	LAPINFINIA..O.LO		

Numérisation

DICOM

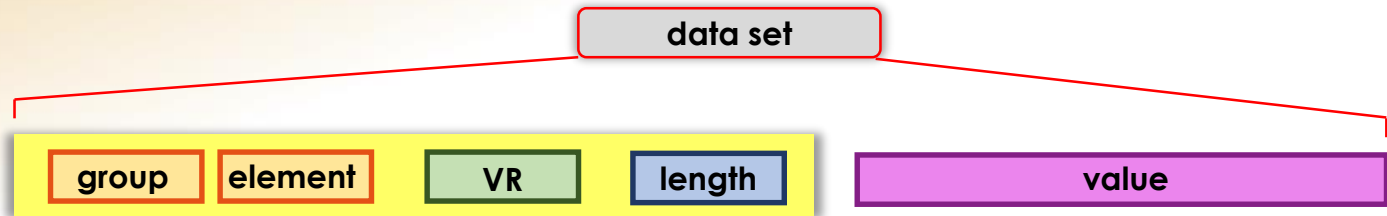


Property	Value
Attribute Tag	0008,0022
Description	Acquisition Date
Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312

00000240	08 00 32 30 31 34 30 33 31 32	08 00 22 00 44 41	..20140312..".DA
00000250	08 00 32 30 31 34 30 33 31 32	08 00 23 00 44 41	..20140312..#.DA
00000260	08 00 32 30 31 34 30 33 31 32	08 00 30 00 54 4D	..20140312..0.TM
00000270	0A 00 31 31 35 37 35 34 2E 30	30 20 08 00 31 00	..115754.00 ..1.
00000280	54 4D 0A 00 31 31 35 37 35 34	2E 30 30 20 08 00	TM..115754.00 ..
00000290	32 00 54 4D 0A 00 31 31 35 37	35 34 2E 30 30 20	2.TM..115754.00
000002A0	08 00 33 00 54 4D 0A 00 31 31	35 37 35 34 2E 30	..3.TM..115754.0
000002B0	30 20 08 00 50 00 53 48 0A 00	31 30 32 39 36 30	0 ..P.SH..102960
000002C0	35 33 39 20 08 00 60 00 43 53	02 00 4E 4D 08 00	539 ..`.CS..NM..
000002D0	70 00 4C 4F 12 00 47 45 20 4D	45 44 49 43 41 4C	p.LO..GE MEDICAL
000002E0	20 53 59 53 54 45 4D 53 08 00	80 00 4C 4F 10 00	SYSTEMS....LO..
000002F0	43 48 55 20 4D 4F 4E 54 50 45	4C 4C 49 45 52 20	CHU MONTPELLIER
00000300	08 00 90 00 50 4E 00 00 08 00	10 10 53 48 0A 00	....PN.....SH..
00000310	4C 41 50 49 4E 46 49 4E 49 41	08 00 30 10 4C 4F	LAPINFINIA..O.LO

Numérisation

DICOM



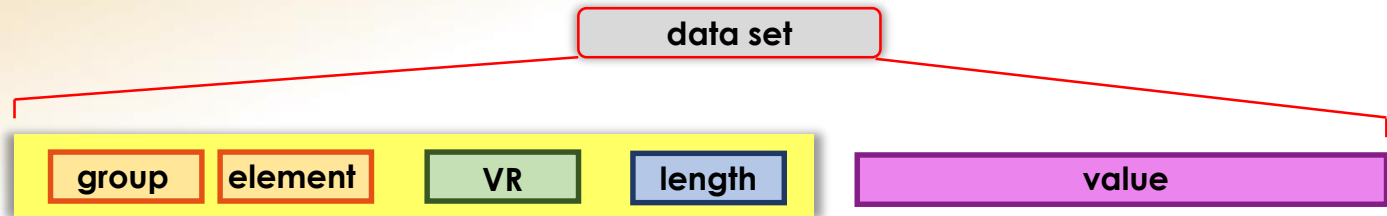
Property	Value
Attribute Tag	0008,0022
Description	Acquisition Date
Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312

Date : 12/03/2014

00000240	08	00	32	30	31	34	30	33	31	32	08	00	22	00	44	41	..20140312..".DA
00000250	08	00	32	30	31	34	30	33	31	32	08	00	23	00	44	41	..20140312..#.DA
00000260	08	00	32	30	31	34	30	33	31	32	08	00	30	00	54	4D	..20140312..0.TM
00000270	0A	00	31	31	35	37	35	34	2E	30	30	20	08	00	31	00	..115754.00 ..1.
00000280	54	4D	0A	00	31	31	35	37	35	34	2E	30	30	20	08	00	TM..115754.00 ..
00000290	32	00	54	4D	0A	00	31	31	35	37	35	34	2E	30	30	20	2.TM..115754.00
000002A0	08	00	33	00	54	4D	0A	00	31	31	35	37	35	34	2E	30	..3.TM..115754.0
000002B0	30	20	08	00	50	00	53	48	0A	00	31	30	32	39	36	30	0 ..P.SH..102960
000002C0	35	33	39	20	08	00	60	00	43	53	02	00	4E	4D	08	00	539 ..`.CS..NM..
000002D0	70	00	4C	4F	12	00	47	45	20	4D	45	44	49	43	41	4C	p.LO..GE MEDICAL
000002E0	20	53	59	53	54	45	4D	53	08	00	80	00	4C	4F	10	00	SYSTEMS....LO..
000002F0	43	48	55	20	4D	4F	4E	54	50	45	4C	4C	49	45	52	20	CHU MONTPELLIER
00000300	08	00	90	00	50	4E	00	00	08	00	10	10	53	48	0A	00	....PN.....SH..
00000310	4C	41	50	49	4E	46	49	4E	49	41	08	00	30	10	4C	4F	LAPINFINIA..O.LO

Numérisation

DICOM



Property	Value
Attribute Tag	0008,0022
Description	Acquisition Date
Value Representation (VR)	DA
Tag Offset	0000024A : (586)
Data Offset	00000252 : (594)
Data Length	00000008 : (8)
Undefined Length in File	False
Value	20140312

00000240	08 00 32 30 31 34 30 33 31 32	08 00 22 00 44 41	..20140312..".DA
00000250	08 00 32 30 31 34 30 33 31 32	08 00 23 00 44 41	..20140312..#.DA
00000260	08 00 32 30 31 34 30 33 31 32	08 00 30 00 54 4D	..20140312..0.TM
00000270	0A 00 31 31 35 37 35 34 2E 30	30 20 08 00 31 00	..115754.00 ..1.
00000280	54 4D 0A 00 31 31 35 37 35 34	2E 30 30 20 08 00	TM..115754.00 ..
00000290	32 00 54 4D 0A 00 31 31 35 37	35 34 2E 30 30 20	2.TM..115754.00
000002A0	08 00 33 00 54 4D 0A 00 31 31	35 37 35 34 2E 30	..3.TM..115754.0
000002B0	30 20 08 00 50 00 53 48 0A 00	31 30 32 39 36 30	0 ..P.SH..102960
000002C0	35 33 39 20 08 00 60 00 43 53	02 00 4E 4D 08 00	539 ..`.CS..NM..
000002D0	70 00 4C 4F 12 00 47 45 20 4D	45 44 49 43 41 4C	p.LO..GE MEDICAL
000002E0	20 53 59 53 54 45 4D 53 08 00	80 00 4C 4F 10 00	SYSTEMS....LO..
000002F0	43 48 55 20 4D 4F 4E 54 50 45	4C 4C 49 45 52 20	CHU MONTPELLIER
00000300	08 00 90 00 50 4E 00 00 08 00	10 10 53 48 0A 00	....PN.....SH..
00000310	4C 41 50 49 4E 46 49 4E 49 41	08 00 30 10 4C 4F	LAPINFINIA..O.LO

Numérisation

DICOM

0002,0000 : Group Length
0002,0001 : File Meta Information Version
0002,0002 : Media Storage SOP Class UID
0002,0003 : Media Storage SOP Instance UID
0002,0010 : Transfer Syntax UID
0002,0012 : Implementation Class UID
0002,0013 : Implementation Version Name
0002,0016 : Source Application Entity Title
0008,0000 : Group Length
0008,0008 : Image Type
0008,0012 : Instance Creation Date
0008,0013 : Instance Creation Time
0008,0014 : Instance Creator UID
0008,0016 : SOP Class UID
0008,0018 : SOP Instance UID
0008,0020 : Study Date
0008,0021 : Series Date
0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
0008,0060 : Modality
0008,0070 : Manufacturer
0008,0080 : Institution Name
0008,0090 : Referring Physician's Name
0008,1010 : Station Name
0008,1030 : Study Description
0008,103E : Series Description
0008,1060 : Name of Physician(s) Reading Study
0008,1070 : Operators' Name
0008,1090 : Manufacturer's Model Name

explicit / implicit
little / big endian

Numérisation

DICOM

0002,0000 : Group Length
0002,0001 : File Meta Information Version
0002,0002 : Media Storage SOP Class UID
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0008,0018 : SOP Instance UID
0008,0020 : Study Date
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0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
0008,0060 : Modality
0008,0070 : Manufacturer
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0008,103E : Series Description
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0008,0013 : Instance Creation Time
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0008,0016 : SOP Class UID
0008,0018 : SOP Instance UID
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0008,0021 : Series Date
0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
0008,0060 : Modality
0008,0070 : Manufacturer
0008,0080 : Institution Name
0008,0090 : Referring Physician's Name
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0008,103E : Series Description
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0008,0013 : Instance Creation Time
0008,0014 : Instance Creator UID
0008,0016 : SOP Class UID
0008,0018 : SOP Instance UID
0008,0020 : Study Date
0008,0021 : Series Date
0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
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0008,1030 : Study Description
0008,103E : Series Description
0008,1060 : Name of Physician(s) Reading Study
0008,1070 : Operators' Name
0008,1090 : Manufacturer's Model Name

0010,0000 : Group Length
0010,0010 : Patient's Name
0010,0020 : Patient ID
0010,0030 : Patient's Birth Date
0010,0040 : Patient's Sex
0010,1000 : Other Patient IDs
0010,1001 : Other Patient Names
0010,1020 : Patient's Size
0010,1030 : Patient's Weight
0010,2160 : Ethnic Group
0010,2180 : Occupation

Numérisation

DICOM

0002,0000 : Group Length
0002,0001 : File Meta Information Version
0002,0002 : Media Storage SOP Class UID
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0008,0018 : SOP Instance UID
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0008,0021 : Series Date
0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
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0008,0070 : Manufacturer
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0008,1030 : Study Description
0008,103E : Series Description
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0010,0000 : Group Length
0010,0010 : Patient's Name
0010,0020 : Patient ID
0010,0030 : Patient's Birth Date
0010,0040 : Patient's Sex
0010,1000 : Other Patient IDs
0010,1001 : Other Patient Names
0010,1020 : Patient's Size
0010,1030 : Patient's Weight
0010,2160 : Ethnic Group
0010,2180 : Occupation

0018,0000 : Group Length
0018,0015 : Body Part Examined
0018,0050 : Slice Thickness
0018,0070 : Counts Accumulated
0018,0071 : Acquisition Termination Condition
0018,0088 : Spacing Between Slices
0018,1000 : Device Serial Number
0018,1020 : Software Version(s)
0018,1030 : Protocol Name
0018,1061 : Trigger Source or Type
0018,1086 : Skip Beats
0018,1088 : Heart Rate
0018,1243 : Count Rate
0020,0000 : Group Length
0020,000D : Study Instance UID
0020,000E : Series Instance UID
0020,0010 : Study ID
0020,0011 : Series Number
0020,0013 : Instance Number
0020,0052 : Frame of Reference UID
0020,1040 : Position Reference Indicator
0028,0000 : Group Length
0028,0002 : Samples per Pixel
0028,0004 : Photometric Interpretation
0028,0008 : Number of Frames
0028,0009 : Frame Increment Pointer
0028,0010 : Rows
0028,0011 : Columns
0028,0030 : Pixel Spacing
0028,0051 : Corrected Image
0028,0100 : Bits Allocated
0028,0101 : Bits Stored
0028,0102 : High Bit
0028,0103 : Pixel Representation
0028,0106 : Smallest Image Pixel Value
0028,0107 : Largest Image Pixel Value
0028,1050 : Window Center
0028,1051 : Window Width

Echantillonnage :
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Numérisation

DICOM

0002,0000 : Group Length
0002,0001 : File Meta Information Version
0002,0002 : Media Storage SOP Class UID
0002,0003 : Media Storage SOP Instance UID
0002,0010 : Transfer Syntax UID
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0010,1020 : Patient's Size
0010,1030 : Patient's Weight
0010,2160 : Ethnic Group
0010,2180 : Occupation

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0018,0070 : Counts Accumulated
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0018,1243 : Count Rate
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0028,0102 : High Bit
0028,0103 : Pixel Representation
0028,0106 : Smallest Image Pixel Value
0028,0107 : Largest Image Pixel Value
0028,1050 : Window Center
0028,1051 : Window Width

Quantification

Numérisation

DICOM

0002,0000 : Group Length
0002,0001 : File Meta Information Version
0002,0002 : Media Storage SOP Class UID
0002,0003 : Media Storage SOP Instance UID
0002,0010 : Transfer Syntax UID
0002,0012 : Implementation Class UID
0002,0013 : Implementation Version Name
0002,0016 : Source Application Entity Title
0008,0000 : Group Length
0008,0008 : Image Type
0008,0012 : Instance Creation Date
0008,0013 : Instance Creation Time
0008,0014 : Instance Creator UID
0008,0016 : SOP Class UID
0008,0018 : SOP Instance UID
0008,0020 : Study Date
0008,0021 : Series Date
0008,0022 : Acquisition Date
0008,0023 : Content Date
0008,0030 : Study Time
0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
0008,0060 : Modality
0008,0070 : Manufacturer
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0018,0050 : Slice Thickness
0018,0070 : Counts Accumulated
0018,0071 : Acquisition Termination Condition
0018,0088 : Spacing Between Slices
0018,1000 : Device Serial Number
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0018,1086 : Skip Beats
0018,1088 : Heart Rate
0018,1243 : Count Rate
0020,0000 : Group Length
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0028,0102 : High Bit
0028,0103 : Pixel Representation
0028,0106 : Smallest Image Pixel Value
0028,0107 : Largest Image Pixel Value
0028,1050 : Window Center
0028,1051 : Window Width

Mise à l'échelle

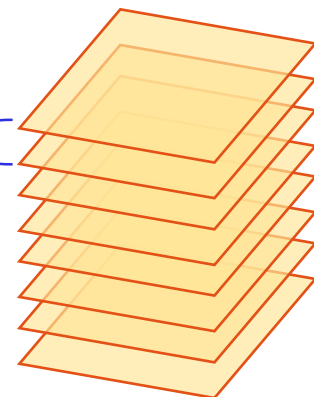
Numérisation

DICOM

0002,0000 : Group Length
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0008,0022 : Acquisition Date
0008,0023 : Content Date
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0008,0031 : Series Time
0008,0032 : Acquisition Time
0008,0033 : Content Time
0008,0050 : Accession Number
0008,0060 : Modality
0008,0070 : Manufacturer
0008,0080 : Institution Name
0008,0090 : Referring Physician's Name
0008,1010 : Station Name
0008,1030 : Study Description
0008,103E : Series Description
0008,1060 : Name of Physician(s) Reading Study
0008,1070 : Operators' Name
0008,1090 : Manufacturer's Model Name

0010,0000 : Group Length
0010,0010 : Patient's Name
0010,0020 : Patient ID
0010,0030 : Patient's Birth Date
0010,0040 : Patient's Sex
0010,1000 : Other Patient IDs
0010,1001 : Other Patient Names
0010,1020 : Patient's Size
0010,1030 : Patient's Weight
0010,2160 : Ethnic Group
0010,2180 : Occupation

0018,0000 : Group Length
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0018,0050 : Slice Thickness
0018,0070 : Counts Accumulated
0018,0071 : Acquisition Termination Condition
0018,0088 : Spacing Between Slices
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0028,0102 : High Bit
0028,0103 : Pixel Representation
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0028,0107 : Largest Image Pixel Value
0028,1050 : Window Center
0028,1051 : Window Width



Numérisation

DICOM

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0008,0022 : Acquisition Date
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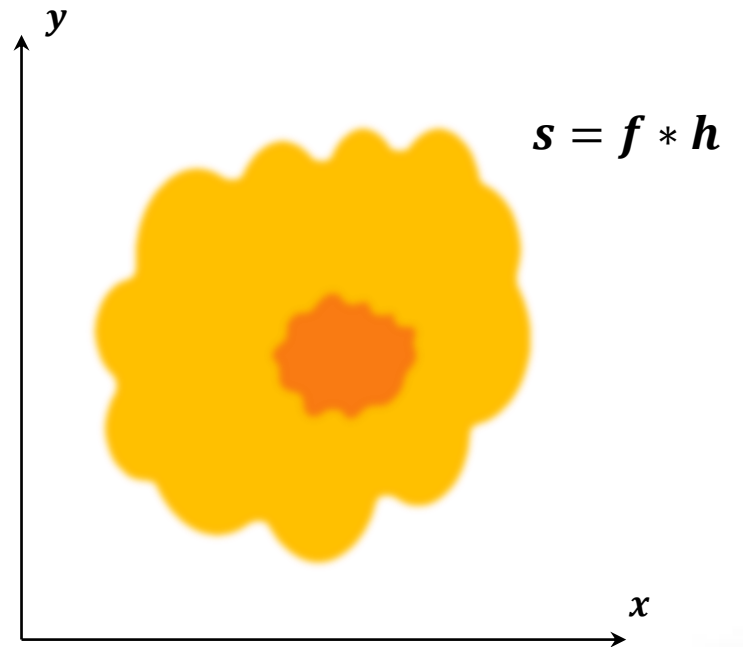
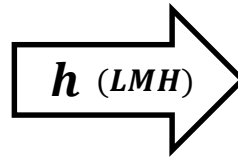
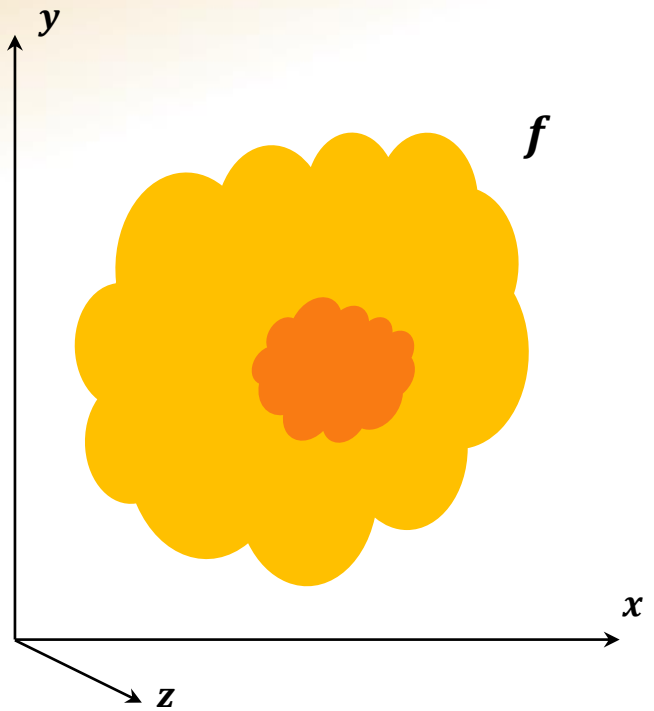
0018,0000 : Group Length
0018,0015 : Body Part Examined
0018,0050 : Slice Thickness
0018,0070 : Counts Accumulated
0018,0071 : Acquisition Termination Condition
0018,0088 : Spacing Between Slices
0018,1000 : Device Serial Number
0018,1020 : Software Version(s)
0018,1030 : Protocol Name
0018,1061 : Trigger Source or Type
0018,1086 : Skip Beats
0018,1088 : Heart Rate

0018,1243 : Count Rate
0020,0000 : Group Length
0020,000D : Study Instance
0020,000E : Series Instance
0020,0010 : Study ID
0020,0011 : Series Number
0020,0013 : Instance Number
0020,0052 : Frame of Reference
0020,1040 : Position Reference
0028,0000 : Group Length
0028,0002 : Samples per Pixel
0028,0004 : Photometric Interpretation
0028,0008 : Number of Frames
0028,0009 : Frame Incrementor
0028,0010 : Rows
0028,0011 : Columns
0028,0030 : Pixel Spacing
0028,0051 : Corrected Image Data
0028,0100 : Bits Allocated
0028,0101 : Bits Stored
0028,0102 : High Bit
0028,0103 : Pixel Representation
0028,0106 : Smallest Image Pixel
0028,0107 : Largest Image Pixel
0028,1050 : Window Center
0028,1051 : Window Width
0054,0011 : Number of Energy Windows
0054,0012 : Energy Window Information Sequence
FFFE,E000 : Item
0054,0013 : Energy Window Range Sequence
FFFE,E000 : Item
0054,0014 : Energy Window Lower Limit
0054,0015 : Energy Window Upper Limit
0054,0016 : Radiopharmaceutical Information Sequence
0054,0021 : Number of Detectors
0054,0022 : Detector Information Sequence
FFFE,E000 : Item
0018,1120 : Gantry/Detector Tilt
0018,1145 : Center of Rotation Offset
0018,1147 : Field of View Shape
0018,1149 : Field of View Dimension(s)
0018,1180 : Collimator/grid Name
0018,1181 : Collimator Type
0018,1182 : Focal Distance
0018,1183 : X Focus Center
0018,1184 : Y Focus Center
0020,0032 : Image Position (Patient)
0020,0037 : Image Orientation (Patient)
0028,0031 : Zoom Factor
0028,0032 : Zoom Center
0054,0220 : View Code Sequence

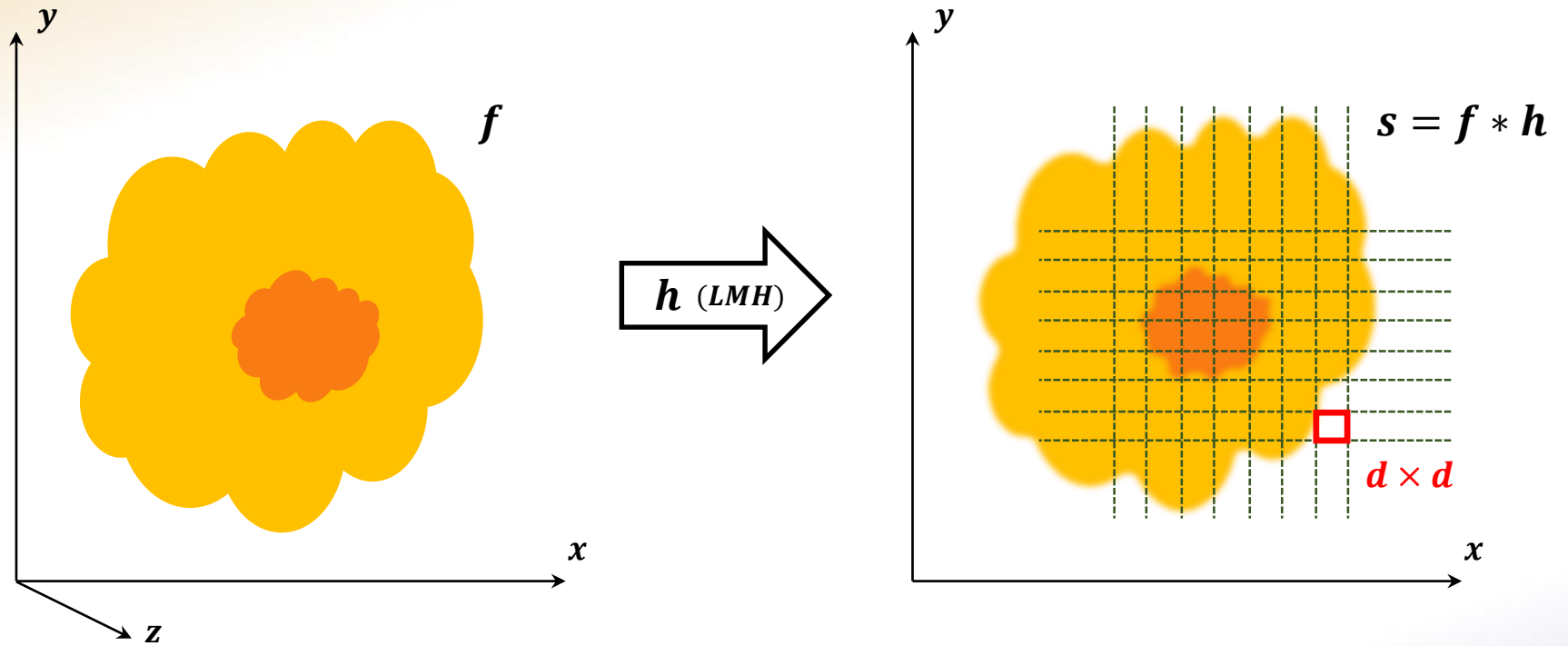
Numérisation

0054,0022 : Detector Information Sequence	0003C200	E0 7F 00 00 55 4C 04 00 0C 00 13 00	E0 7F 10 00	....UL.....
FFFE,E000 : Item	0003C210	4F 57 00 00 00 00 13 00	00 00 00 00 00 00 00 00	OW.....
0018,1120 : Gantry/Detector Tilt	0003C220	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1145 : Center of Rotation Offset	0003C230	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1147 : Field of View Shape	0003C240	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1149 : Field of View Dimension(s)	0003C250	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1180 : Collimator/grid Name	0003C260	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1181 : Collimator Type	0003C270	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1182 : Focal Distance	0003C280	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1183 : X Focus Center	0003C290	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0018,1184 : Y Focus Center	0003C2A0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0020,0032 : Image Position (Patient)	0003C2B0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0020,0037 : Image Orientation (Patient)	0003C2C0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0028,0031 : Zoom Factor	0003C2D0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0028,0032 : Zoom Center	0003C2E0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0220 : View Code Sequence	0003C2F0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0051 : Number of Rotations	0003C300	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0052 : Rotation Information Sequence	0003C310	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0060 : R-R Interval Vector	0003C320	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0061 : Number of R-R Intervals	0003C330	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0062 : Gated Information Sequence	0003C340	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0070 : Time Slot Vector	0003C350	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0071 : Number of Time Slots	0003C360	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0080 : Slice Vector	0003C370	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0081 : Number of Slices	0003C380	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0202 : Type of Detector Motion	0003C390	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0400 : Image ID	0003C3A0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0410 : Patient Orientation Code Sequence	0003C3B0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0054,0414 : Patient Gantry Relationship Code Sequence	0003C3C0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,0000 : <Private>	0003C3D0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,0010 : <Private>	0003C3E0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,1012 : <Private>	0003C3F0	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,1022 : <Private>	0003C400	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,1052 : <Private>	0003C410	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,1062 : <Private>	0003C420	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
0055,1065 : <Private>	0003C430	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
7FE0,0000 : Group Length	0003C440	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
7FE0,0010 : Pixel Data	0003C450	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
	0003C460	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
	0003C470	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00	.....
	0003C480	00 00 00 00 00 00 00 00	00 00 00 00 00 00 00 00

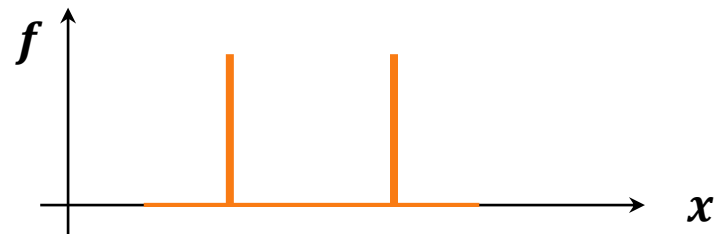
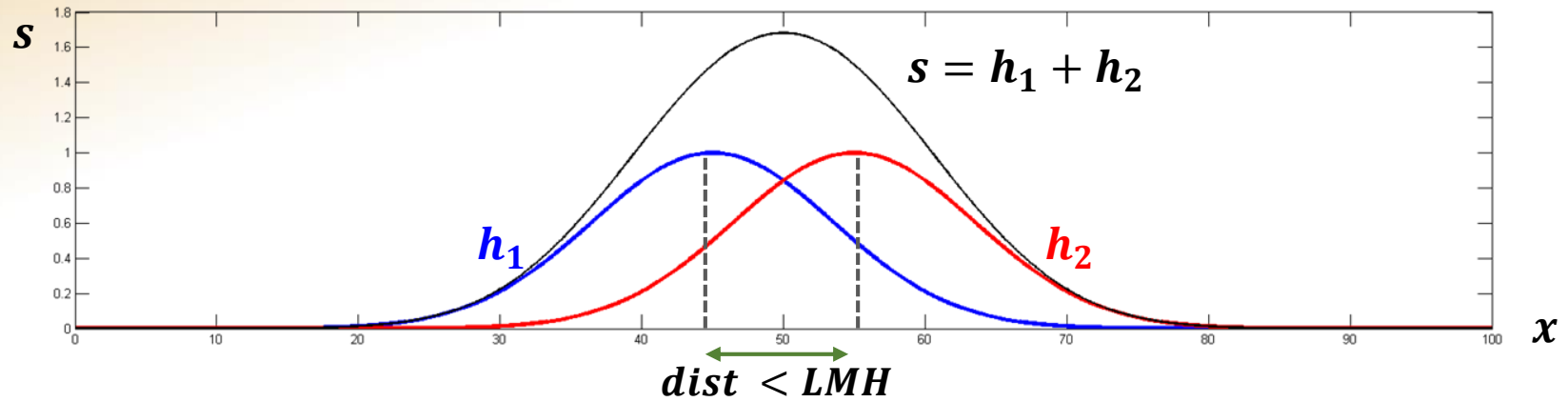
Echantillonnage



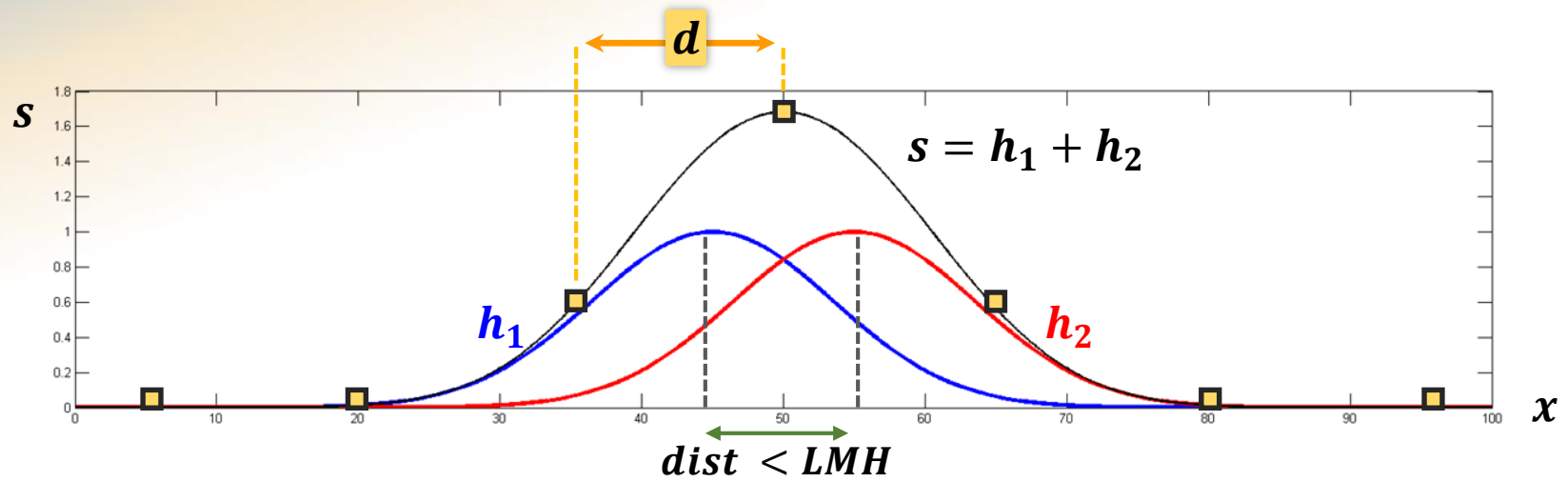
Echantillonnage



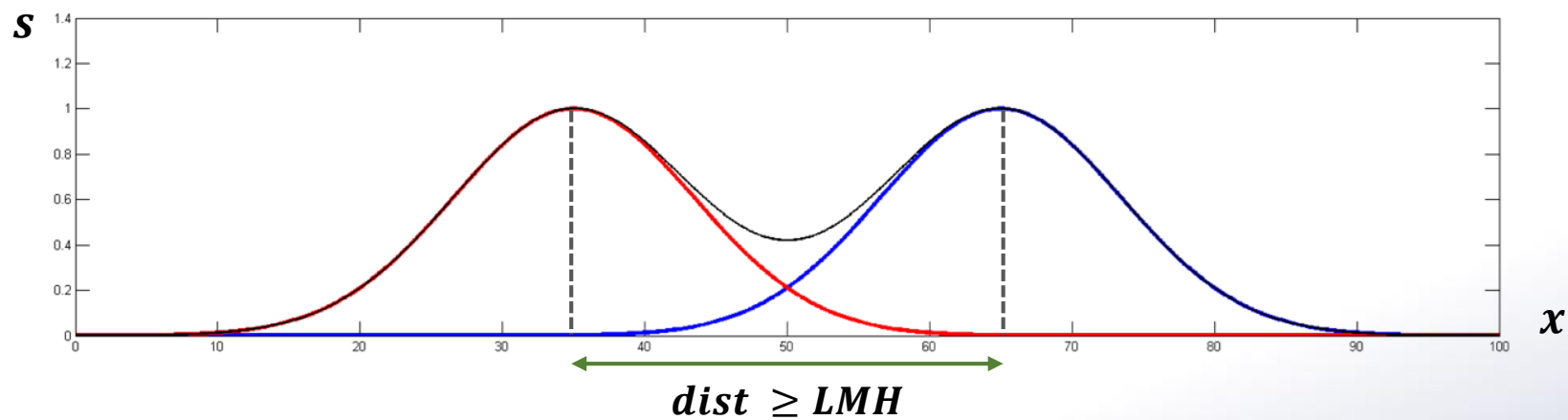
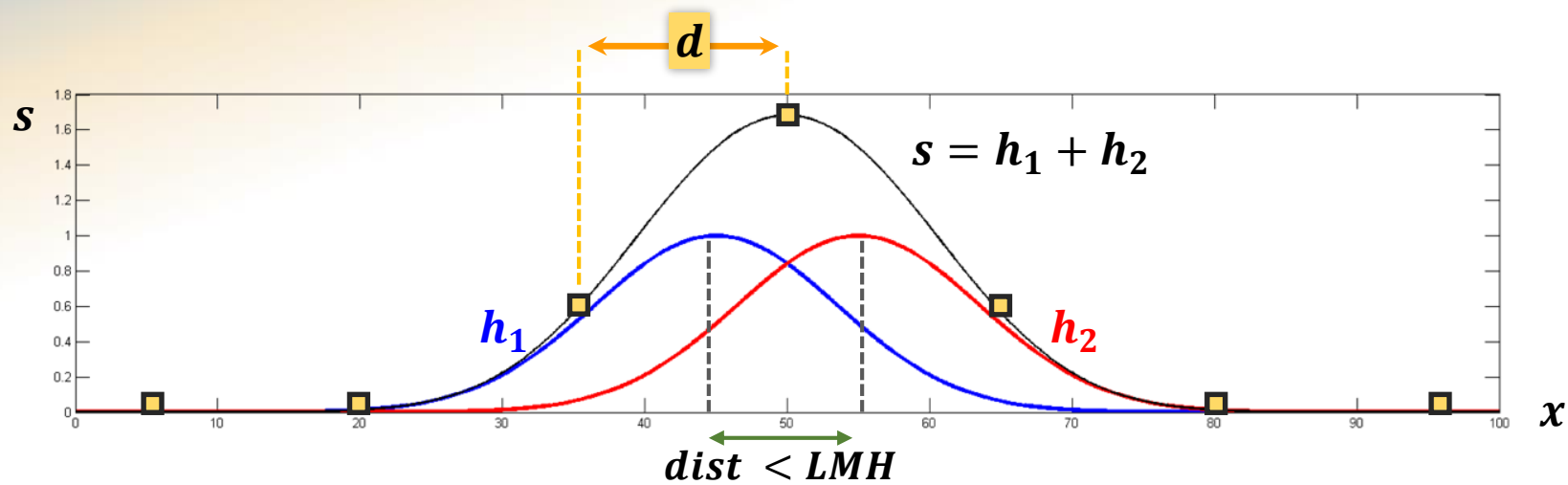
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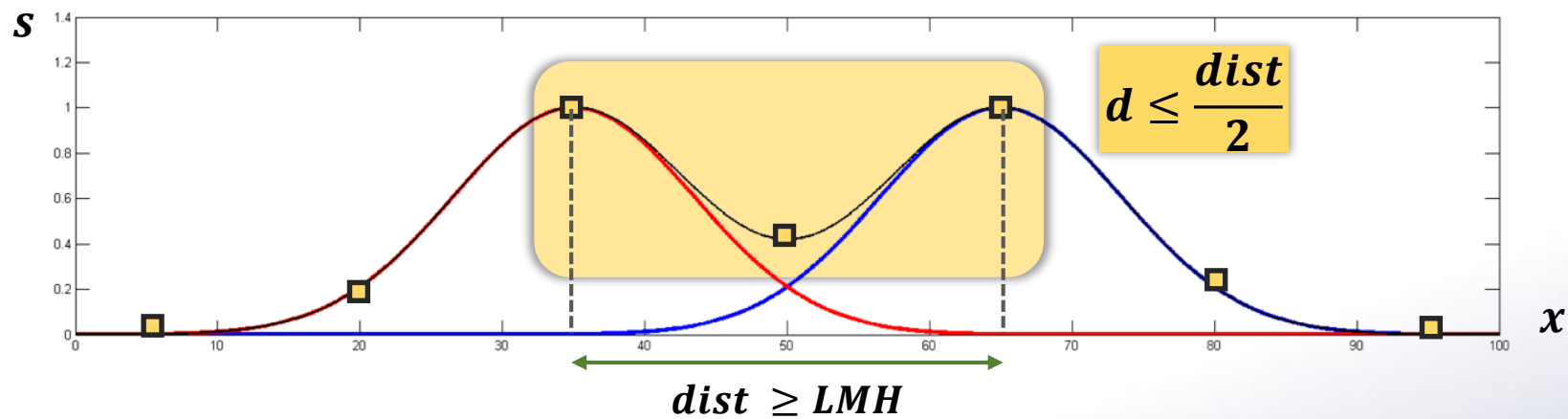
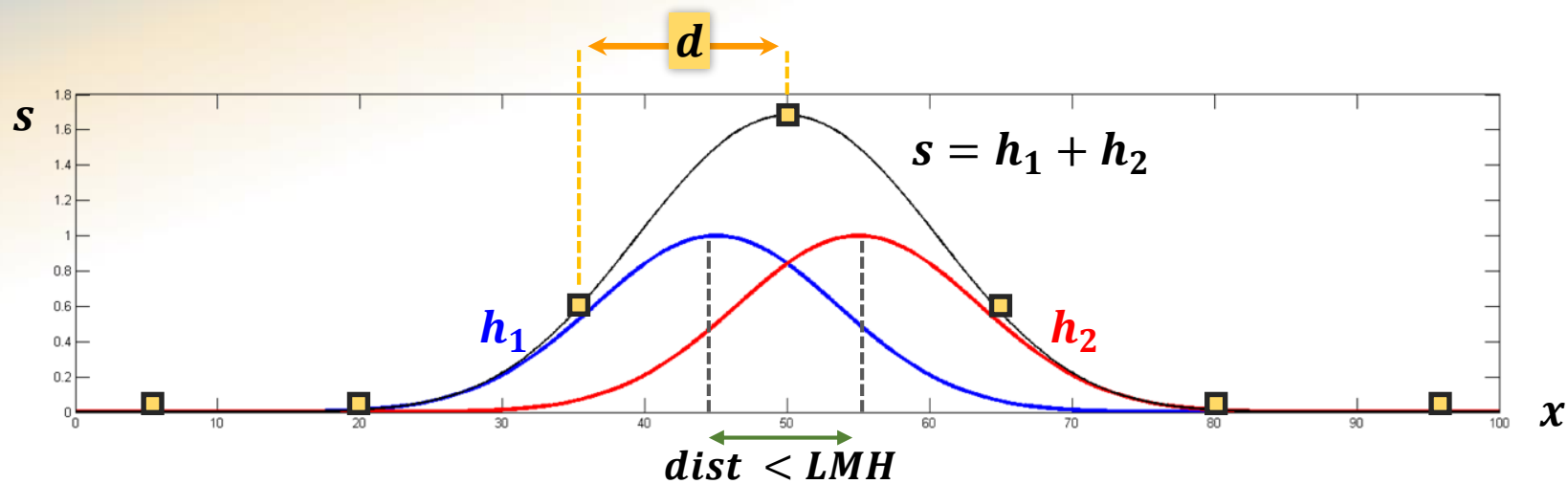
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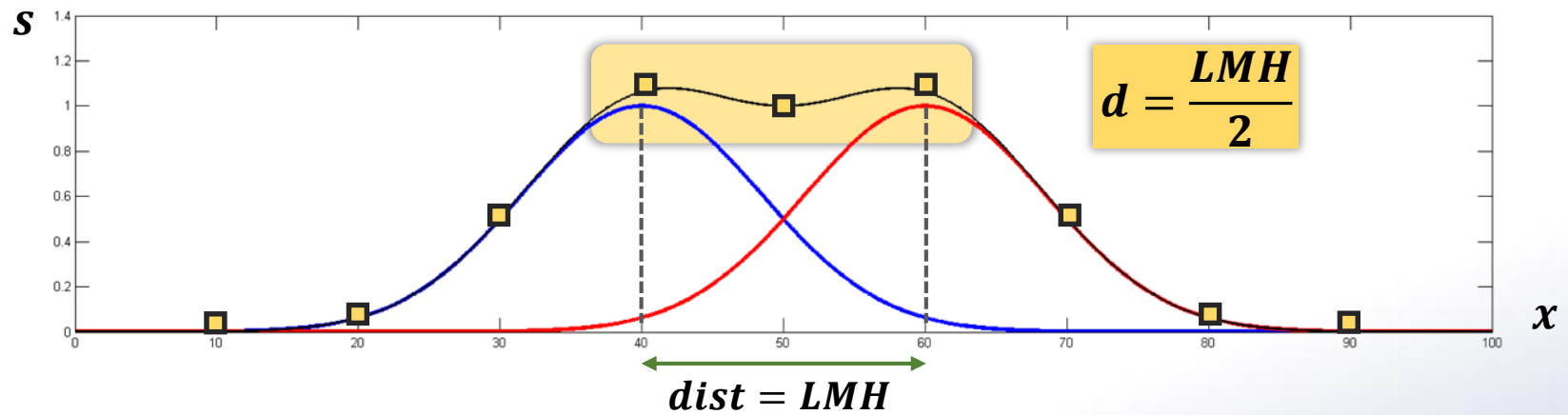
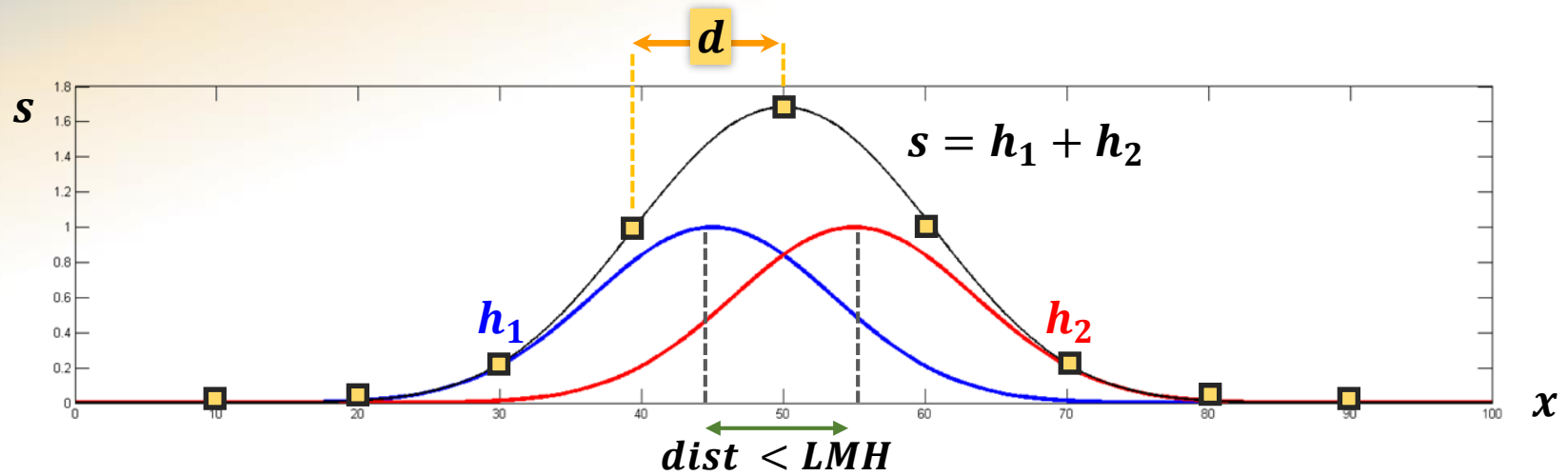
Echantillonnage



Echantillonnage



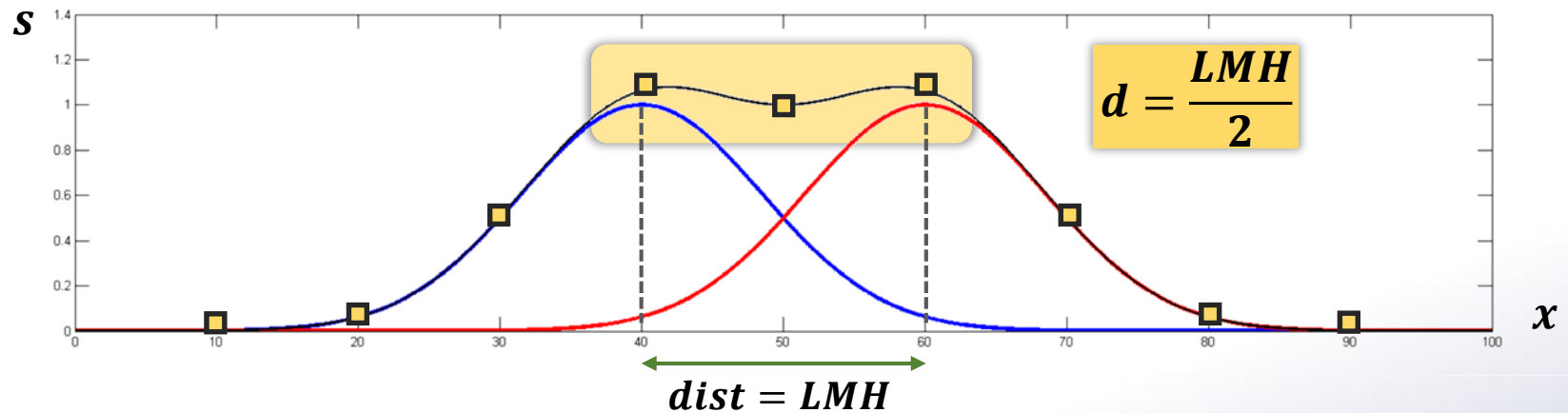
Echantillonnage



Echantillonnage

Théorème de Shannon-Nyquist :

La **fréquence d'échantillonnage** doit être supérieure ou égale à **deux fois** la **fréquence maximale** contenue dans le spectre du signal à échantillonner

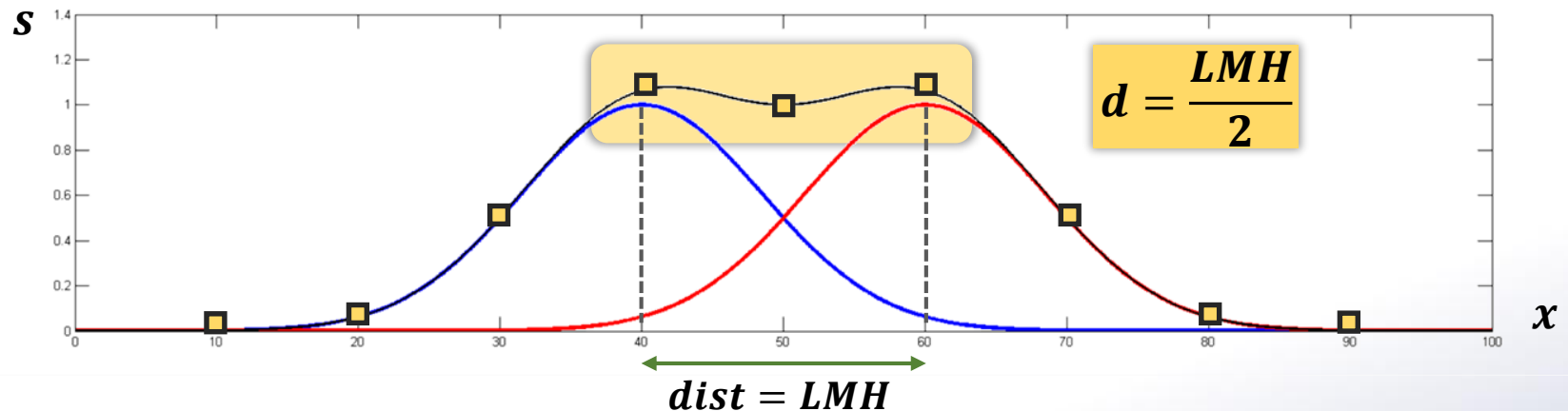


Echantillonnage

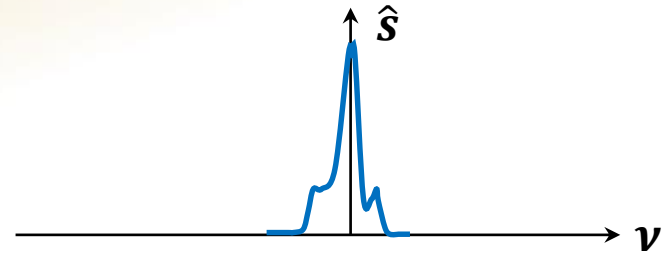
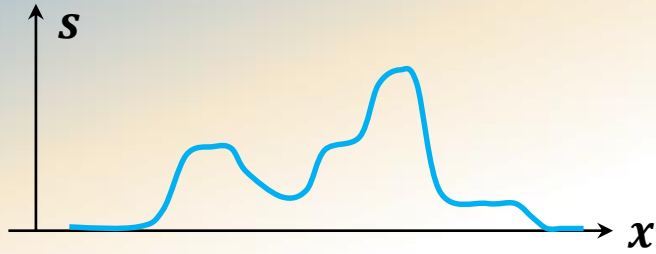
Théorème de Shannon-Nyquist :

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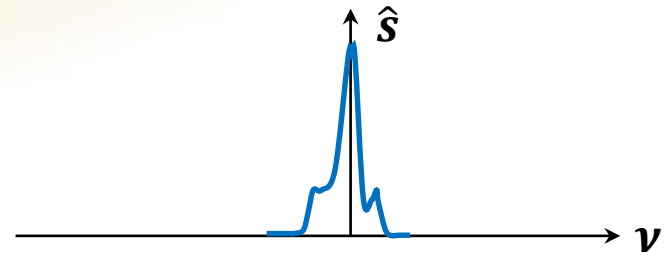
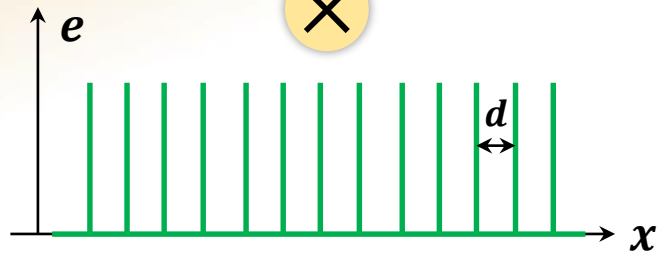
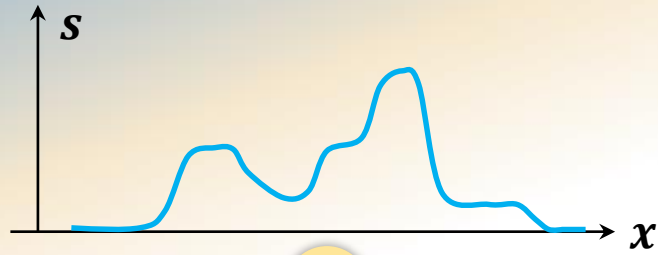
Alors l'échantillonnage se fait **sans perte d'information** et le signal original peut être **restitué intégralement** par interpolation



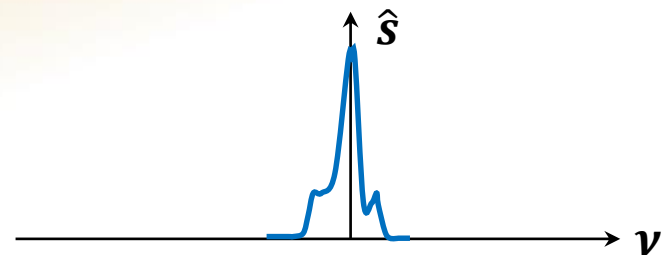
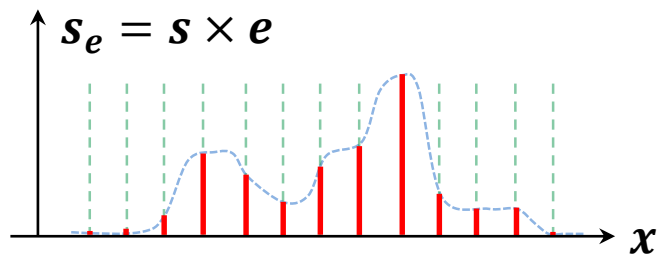
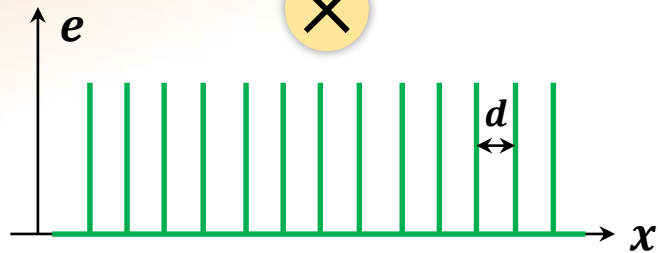
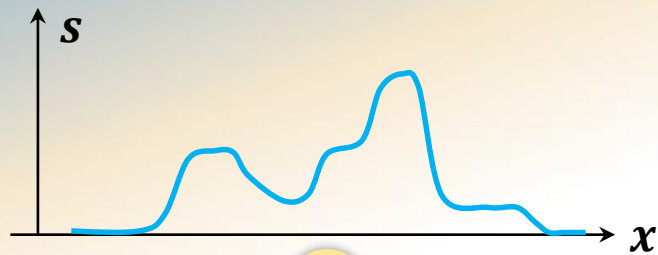
Echantillonnage



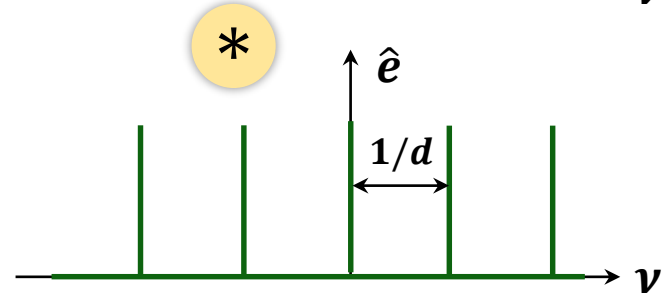
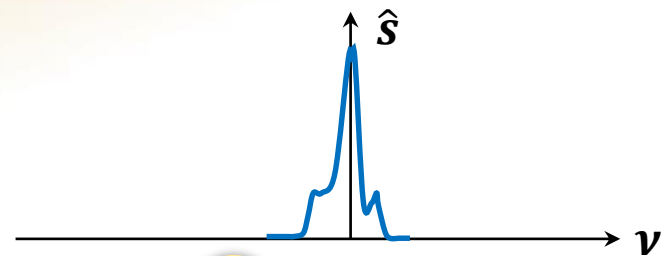
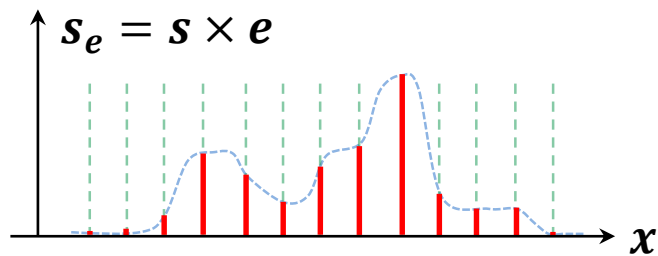
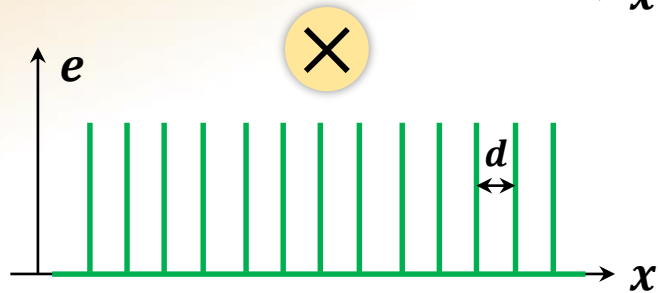
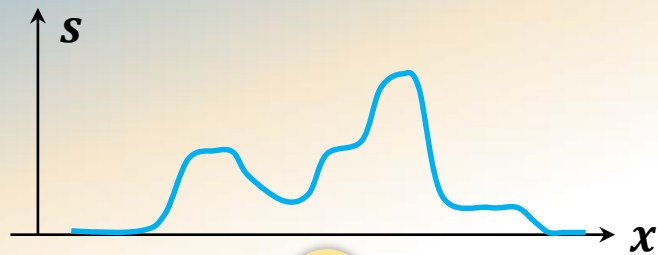
Echantillonnage



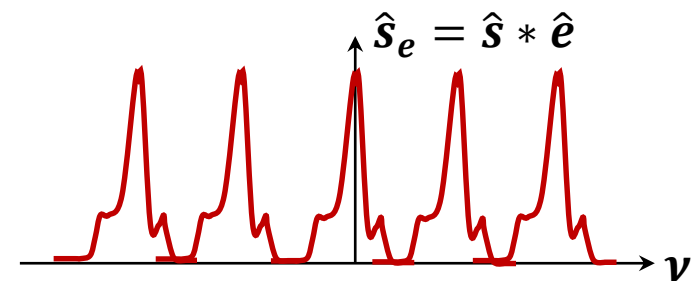
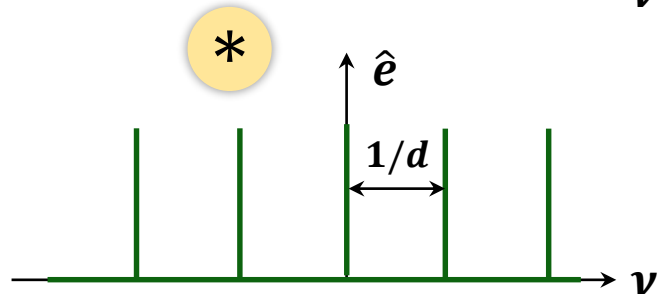
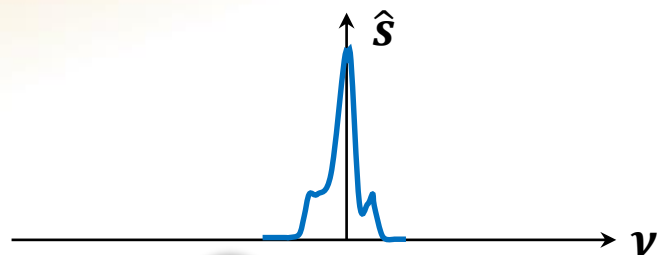
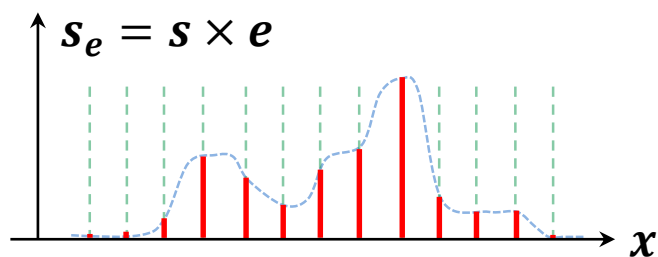
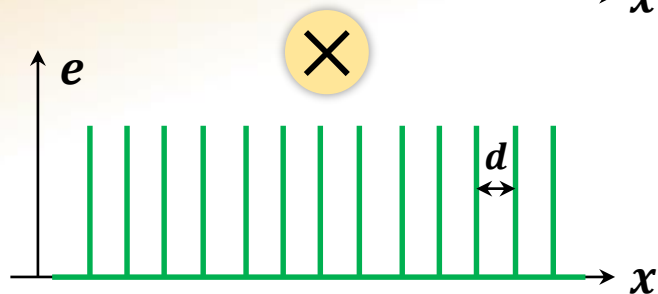
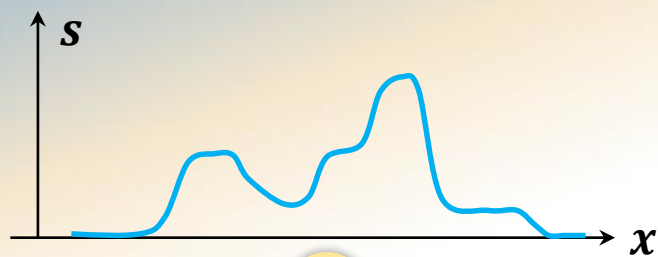
Echantillonnage



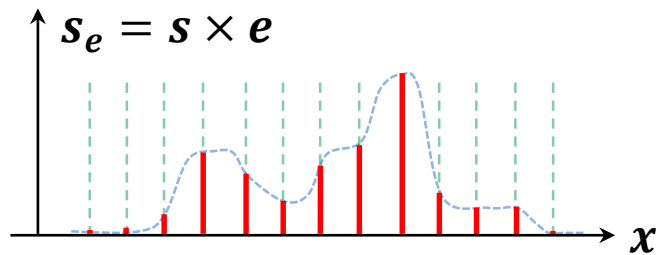
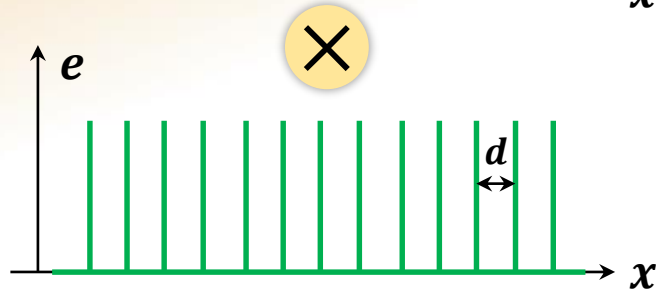
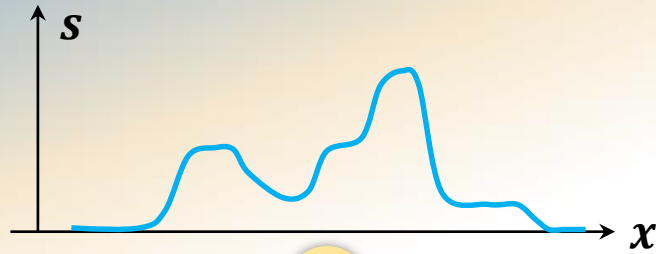
Echantillonnage



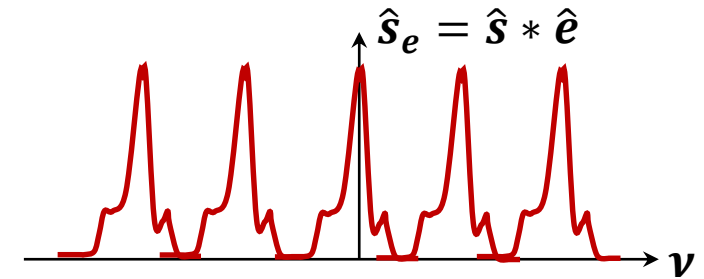
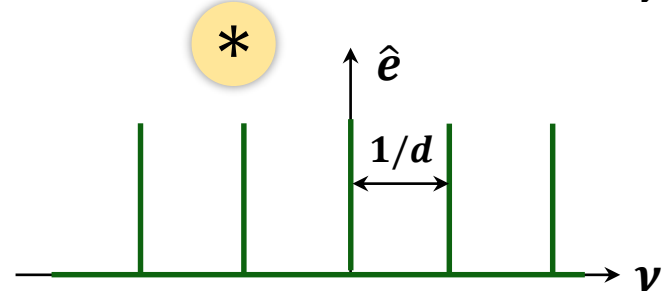
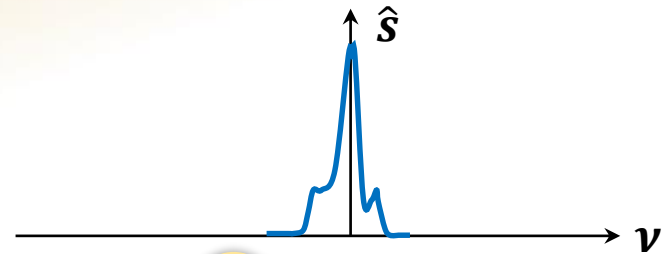
Echantillonnage



Echantillonnage



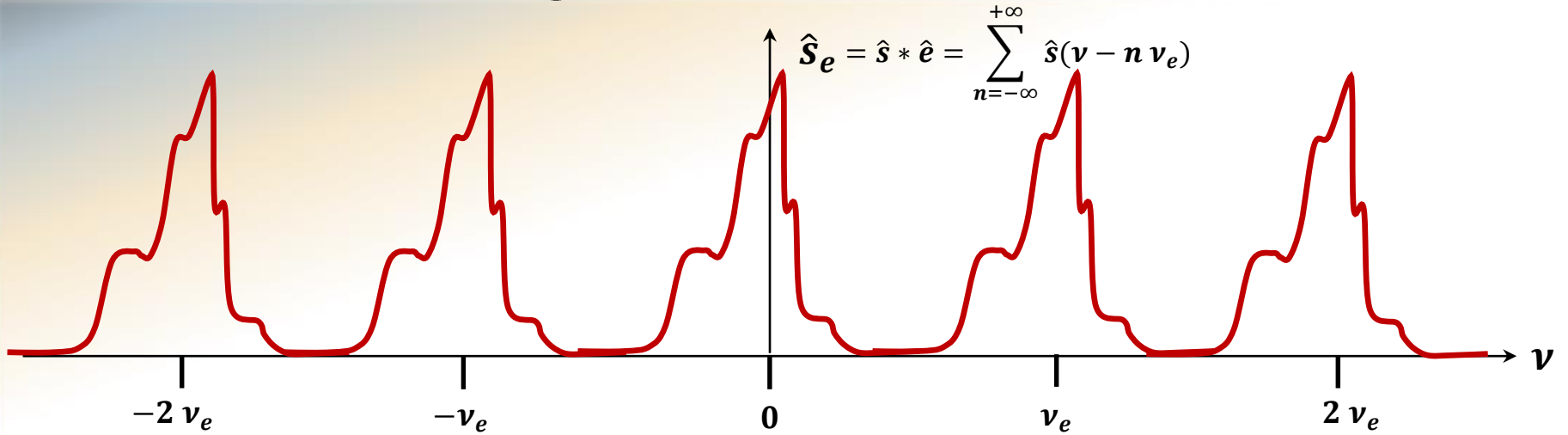
$$s_e(x) = s(x) \sum_{n=-\infty}^{+\infty} \delta(x - nd)$$



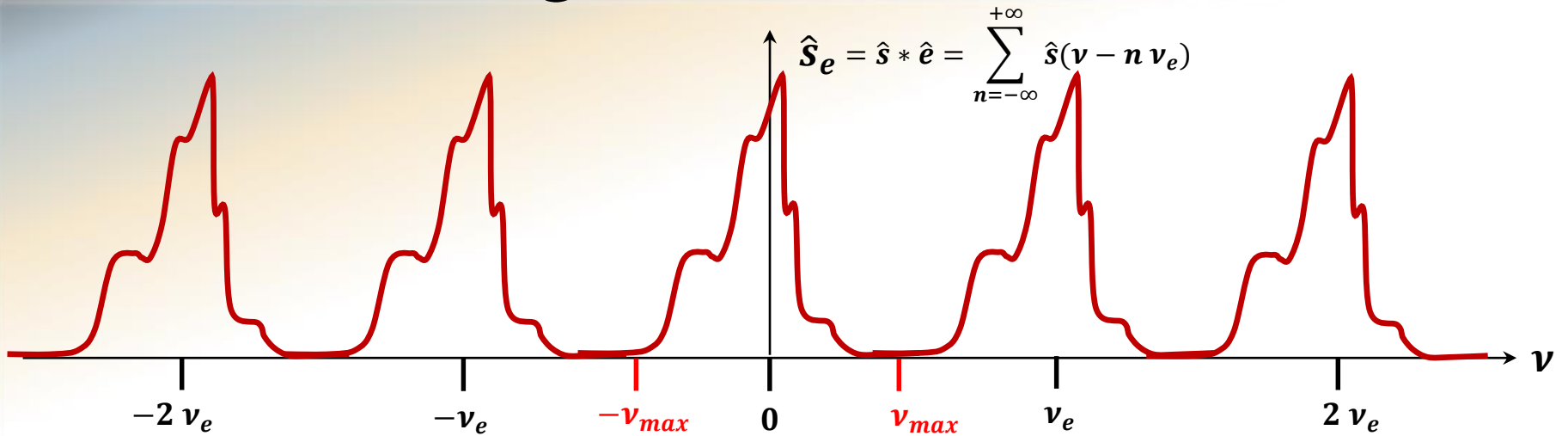
$$\hat{s}_e(v) = \sum_{n=-\infty}^{+\infty} \hat{s}(v - n v_e)$$

$$v_e = 1/d$$

Echantillonnage

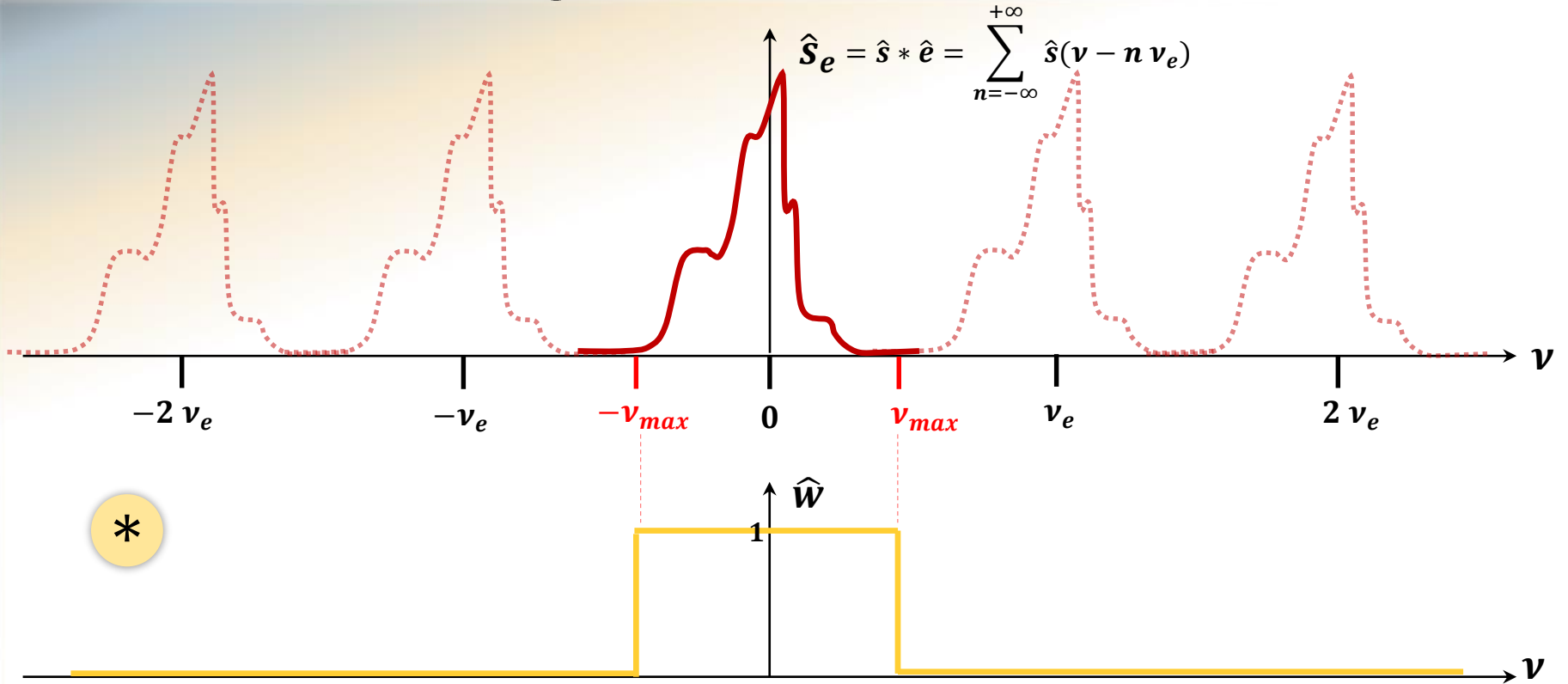


Echantillonnage

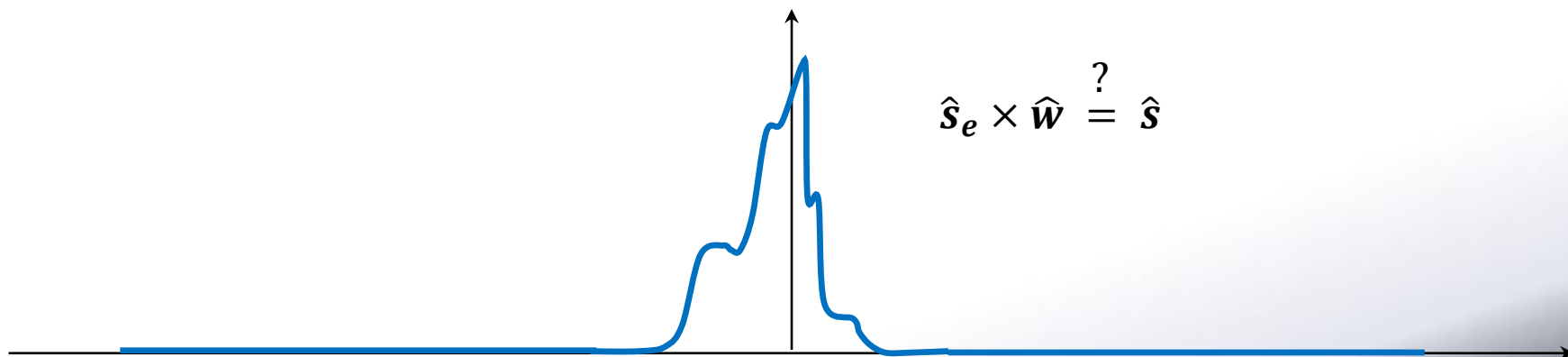
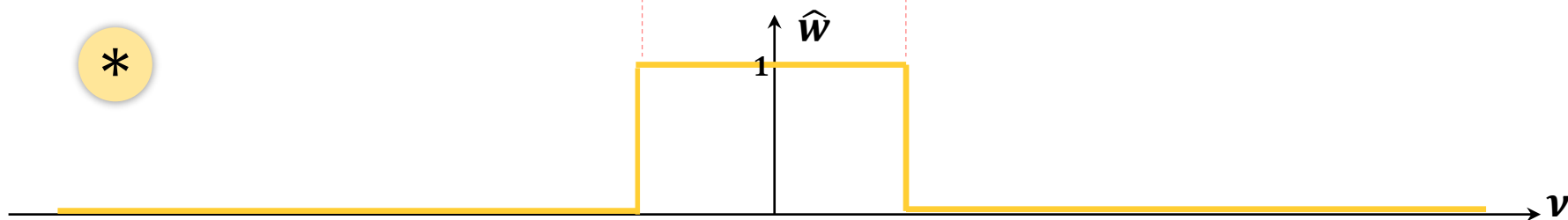
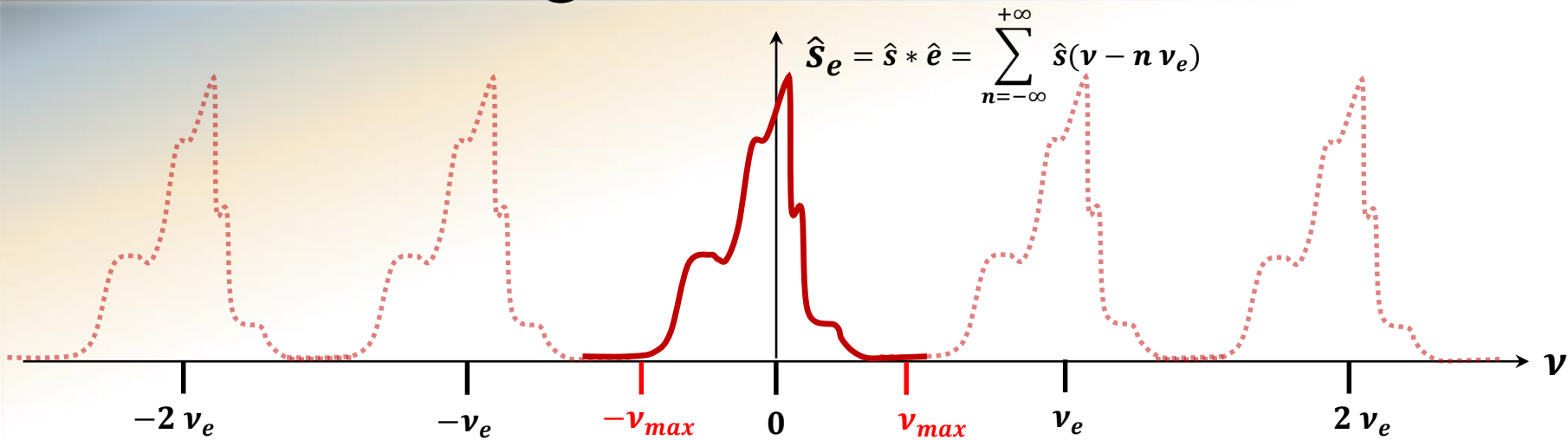


$$|\nu| > \nu_{max} : \hat{s}(\nu) = 0$$

Echantillonnage

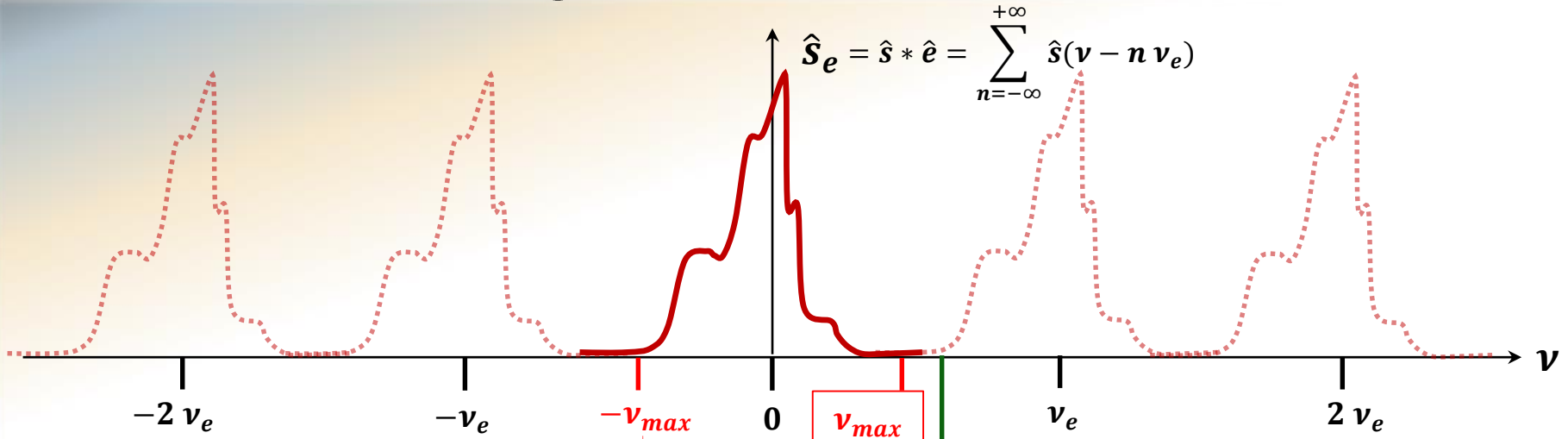


Echantillonnage

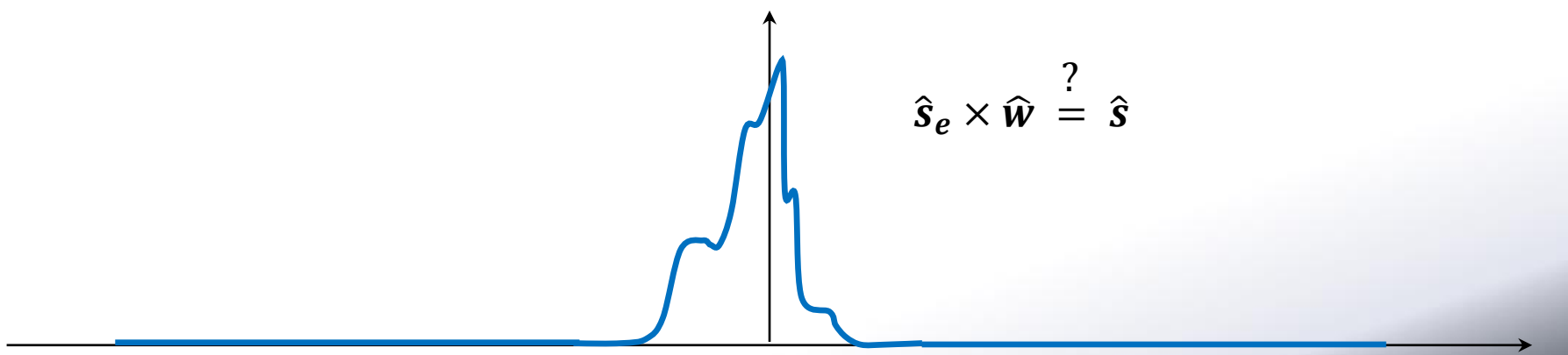
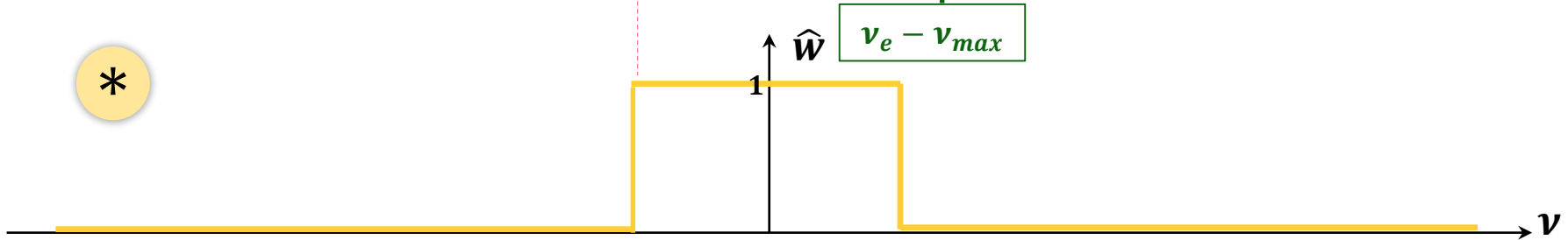


$$\hat{s}_e \times \hat{w} \stackrel{?}{=} \hat{s}$$

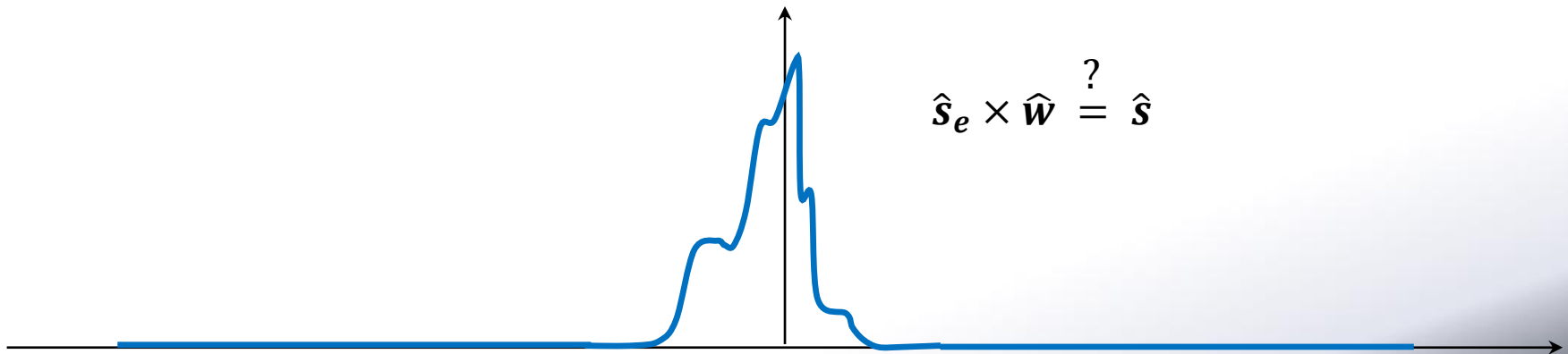
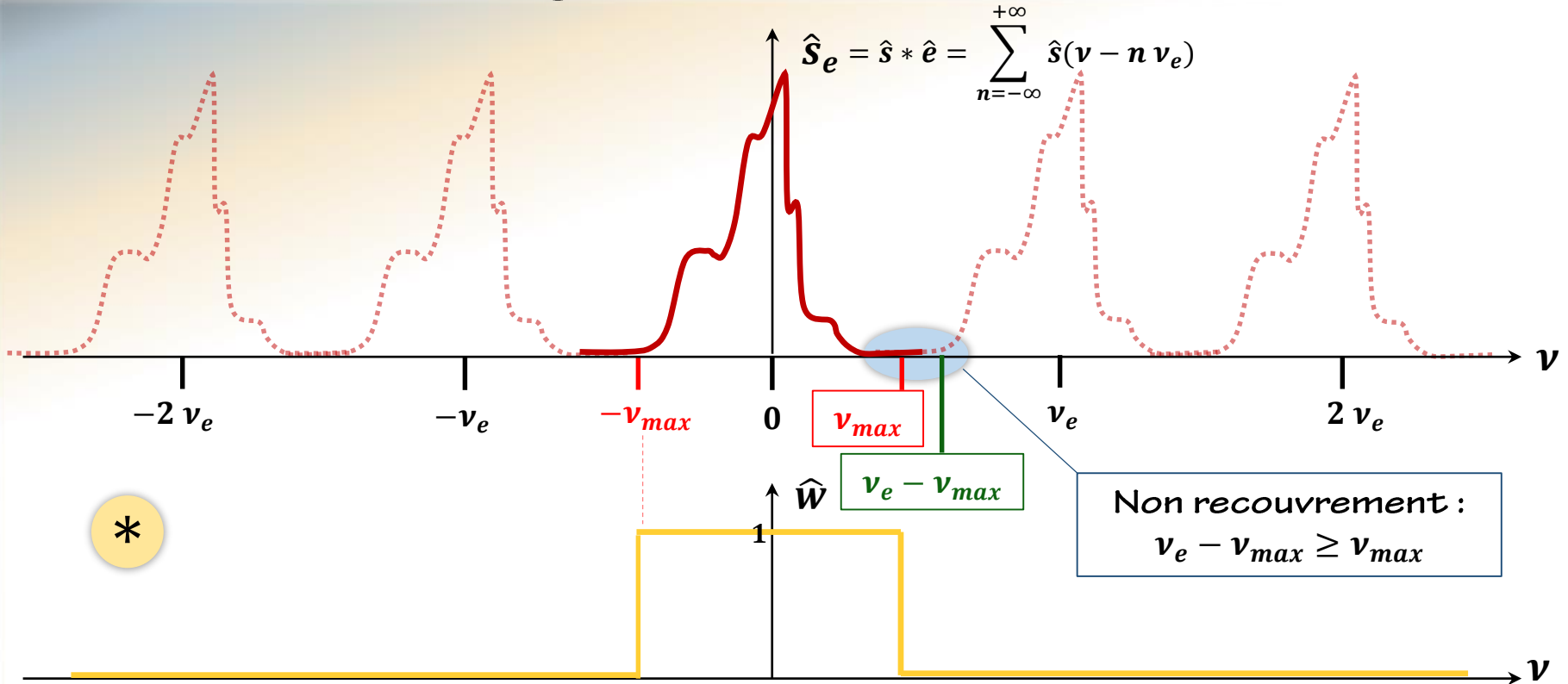
Echantillonnage



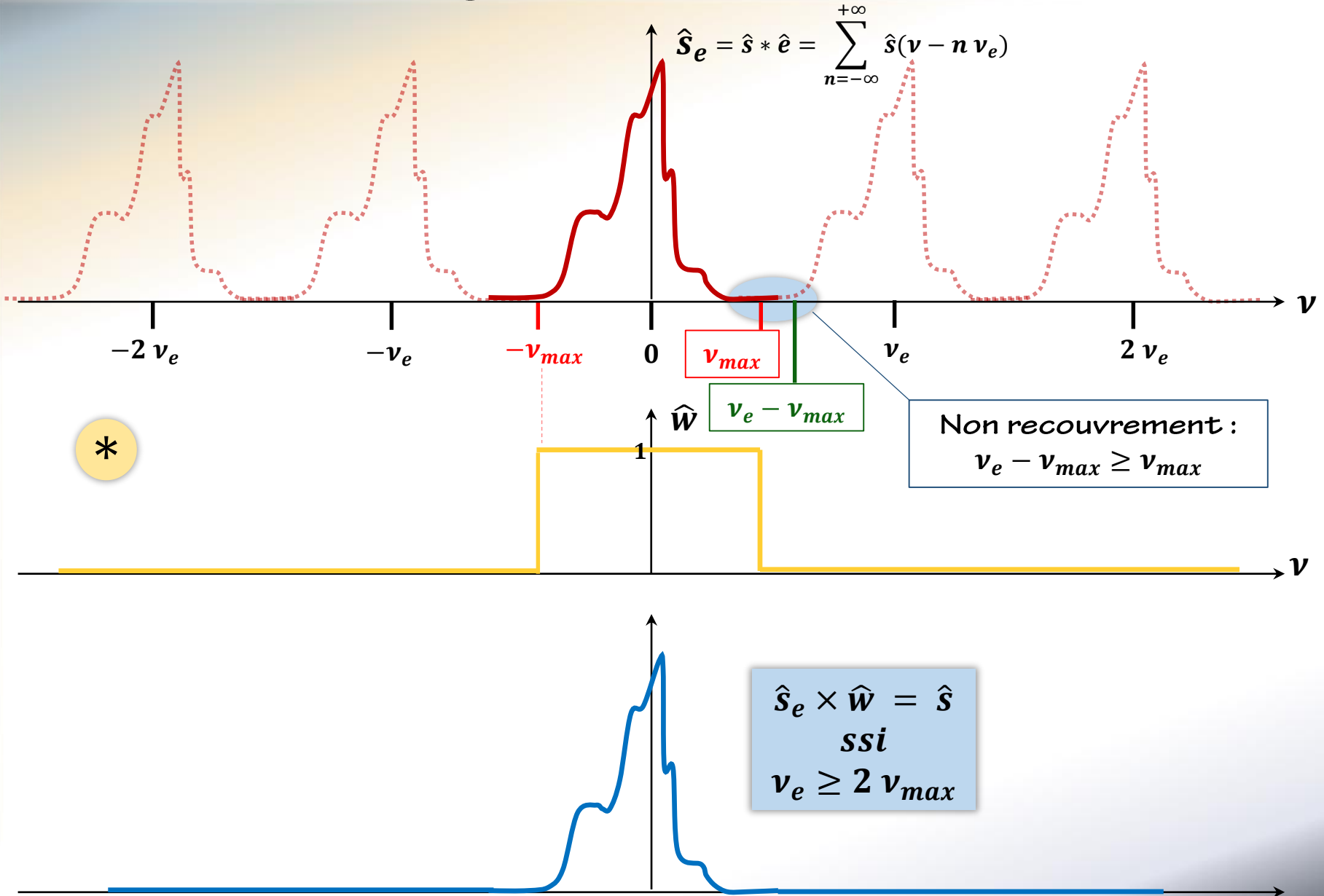
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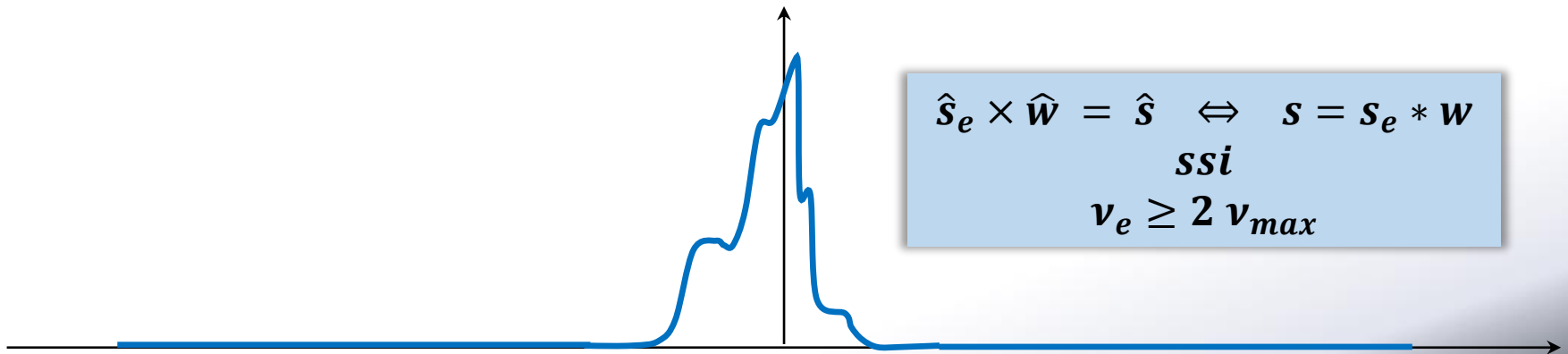
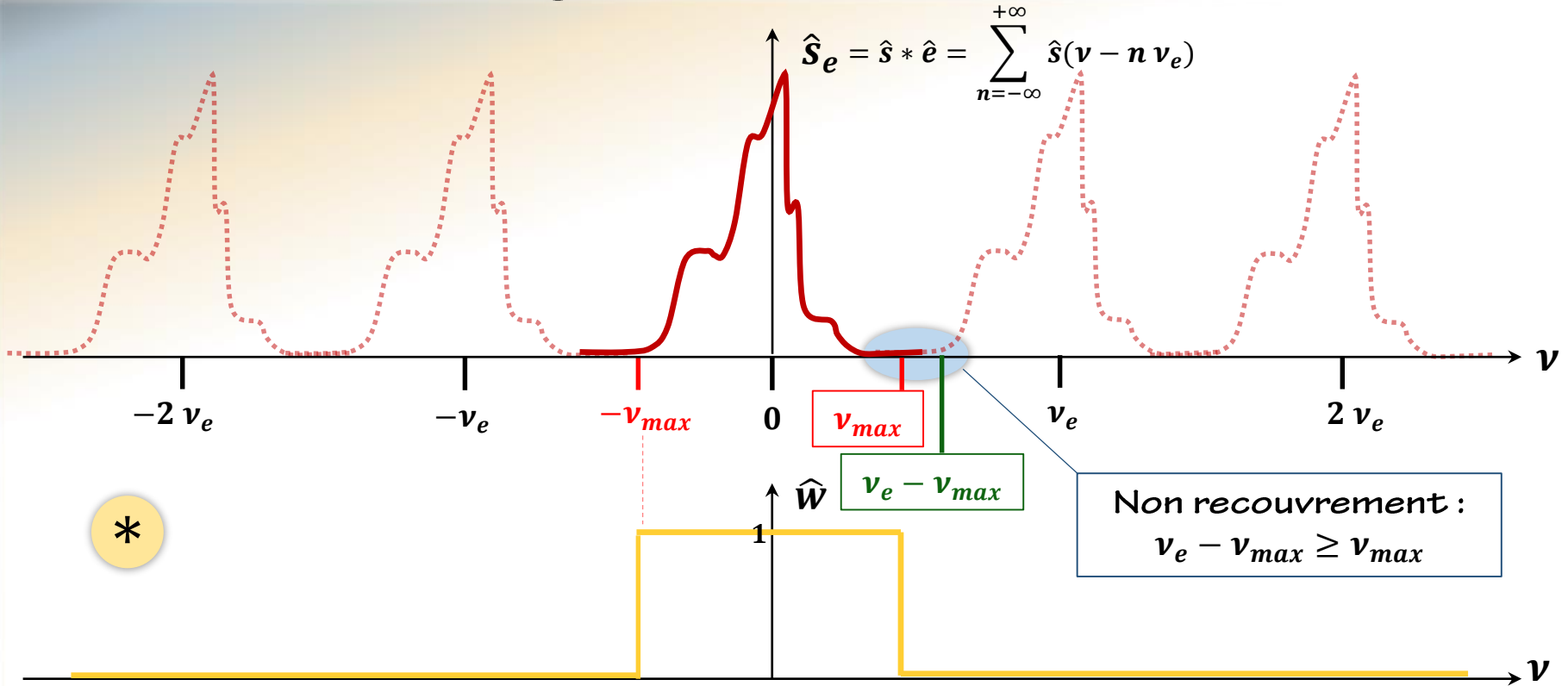
Echantillonnage



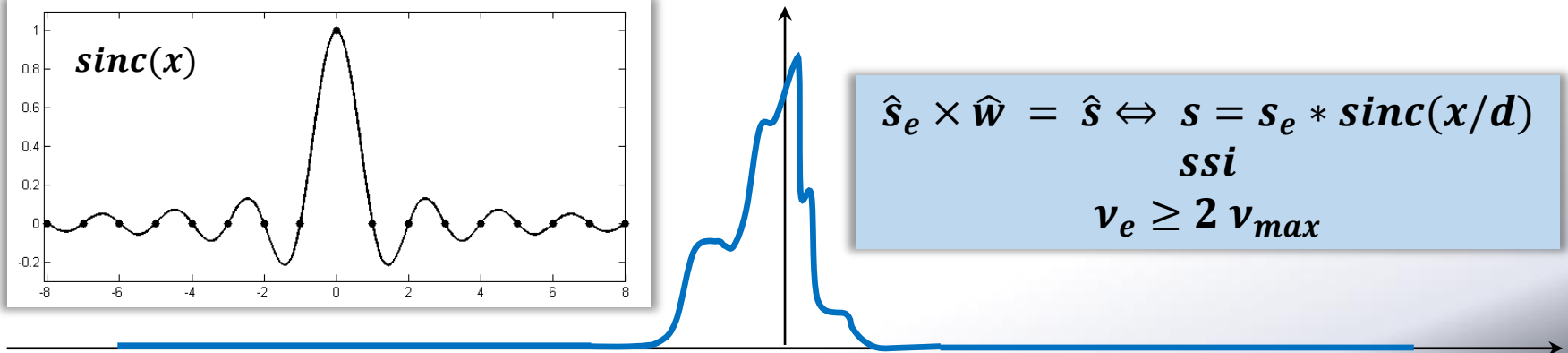
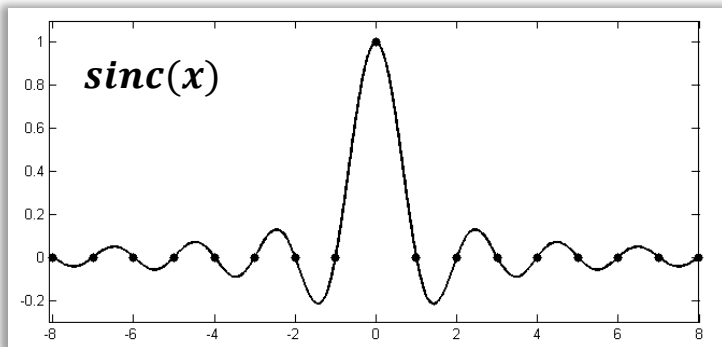
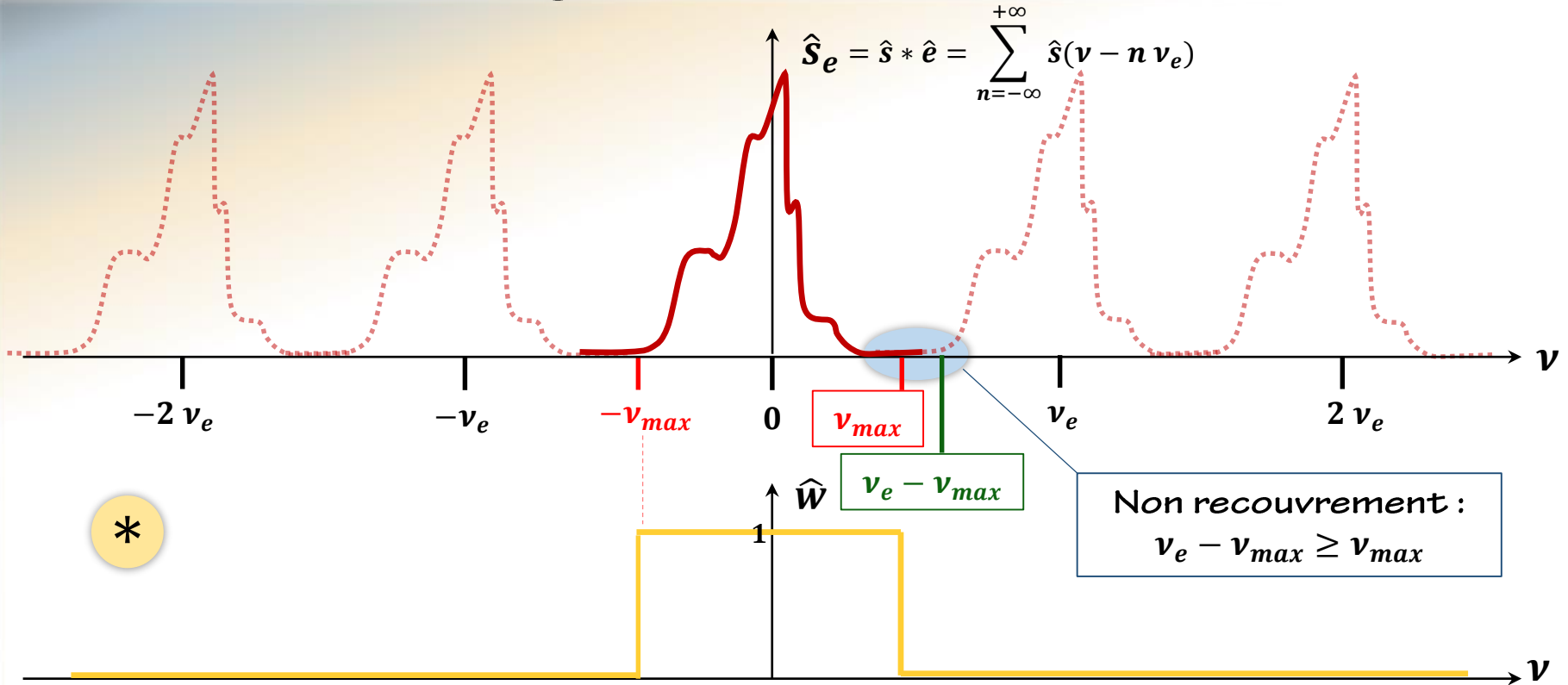
Echantillonnage



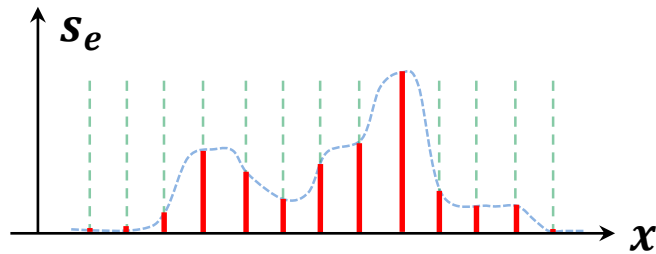
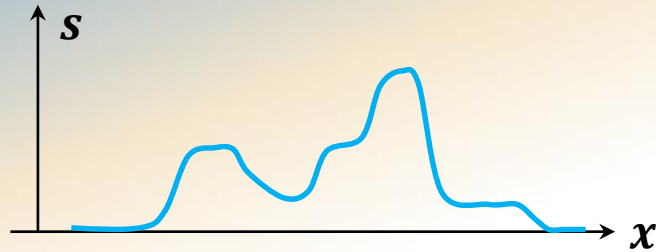
Echantillonnage



Echantillonnage



Echantillonnage

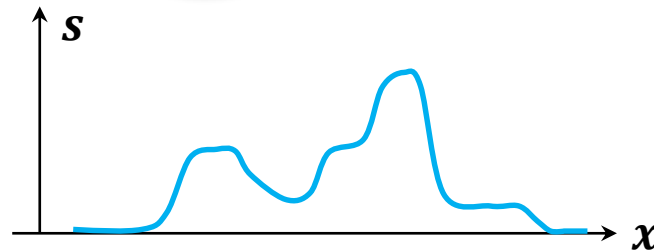
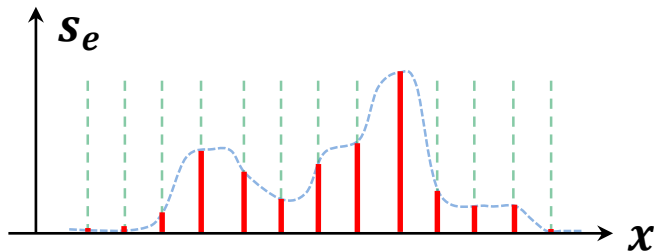
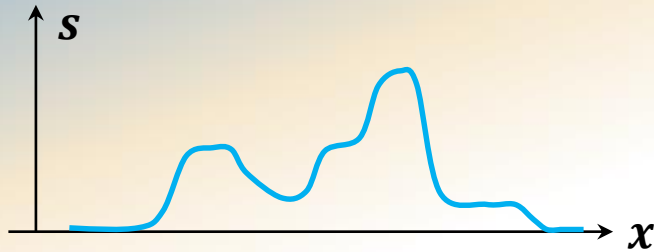


La **fréquence d'échantillonnage** doit être supérieure ou égale à **deux fois** la **fréquence maximale** contenue dans le spectre du signal à échantillonner

$$s_e(x) = s(x) \sum_{n=-\infty}^{+\infty} \delta(x - nd)$$

$$v_e \geq 2 v_{max} : d \leq \frac{1}{2 v_{max}}$$

Echantillonnage



La **fréquence d'échantillonnage** doit être supérieure ou égale à **deux fois** la **fréquence maximale** contenue dans le spectre du signal à échantillonner

$$s_e(x) = s(x) \sum_{n=-\infty}^{+\infty} \delta(x - nd)$$

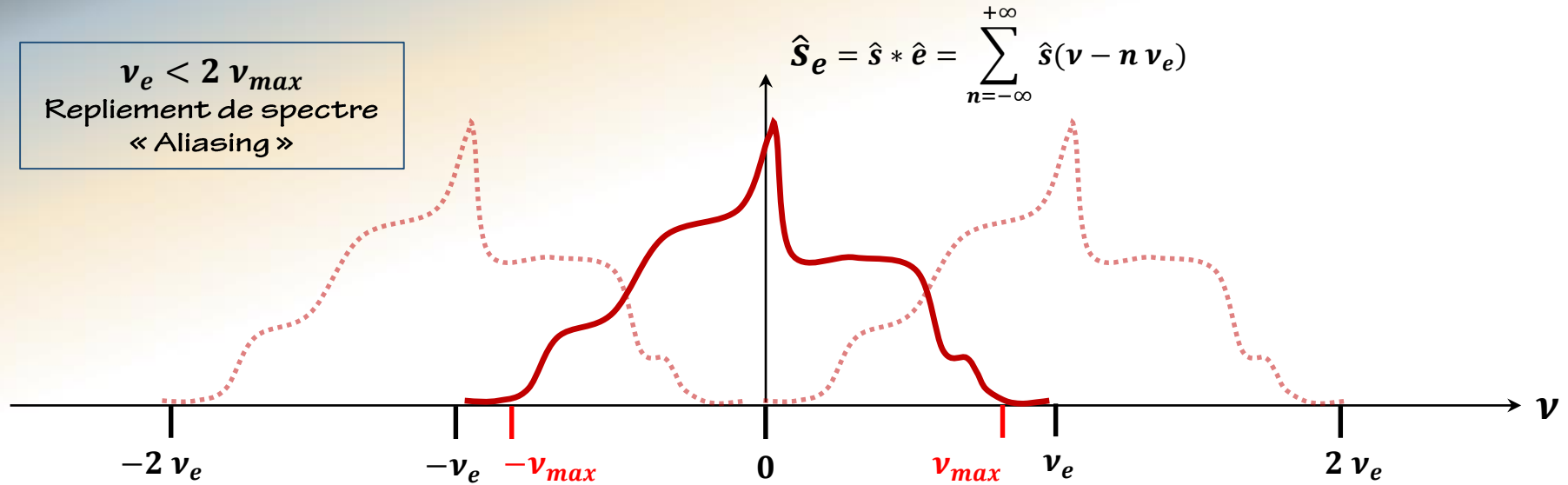
$$v_e \geq 2 v_{max} : d \leq \frac{1}{2 v_{max}}$$

Alors l'échantillonnage se fait **sans perte d'information** et le signal original peut être **restitué intégralement** par interpolation

$$s(x) = s_e(x) * sinc(x/d)$$

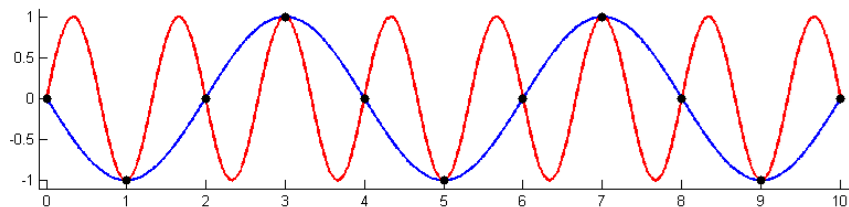
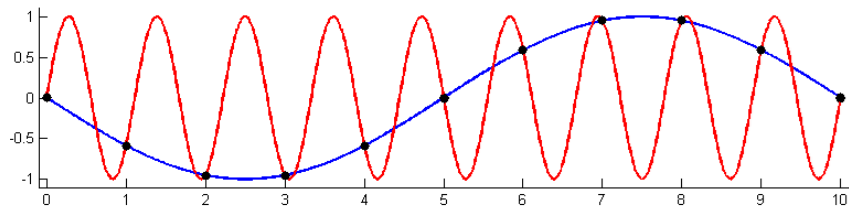
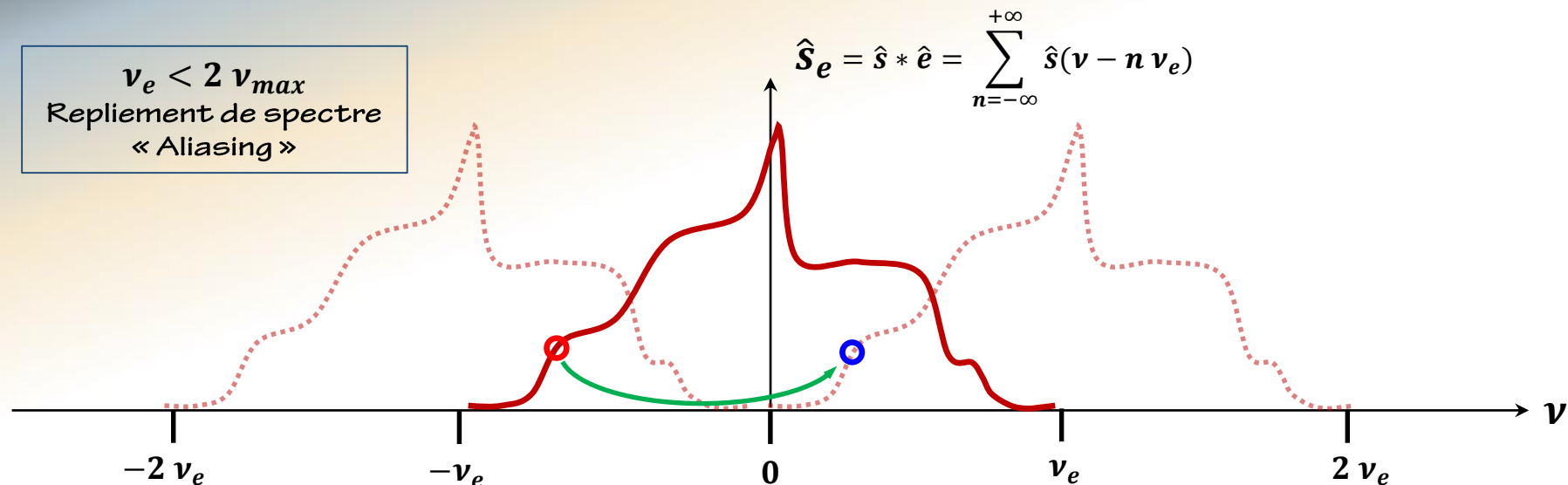
Echantillonnage

$\nu_e < 2 \nu_{max}$
Repliement de spectre
« Aliasing »



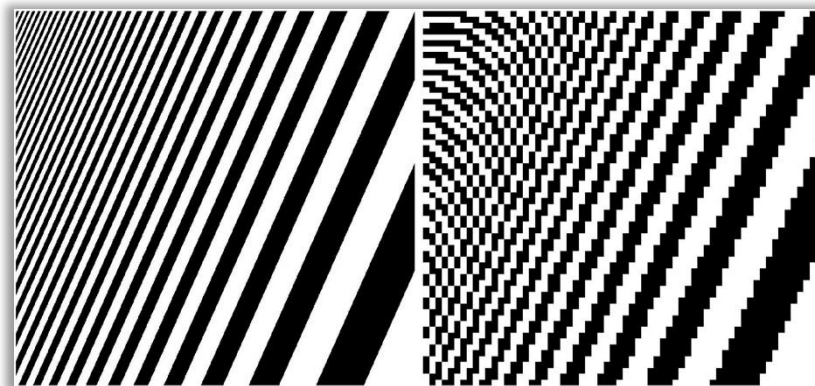
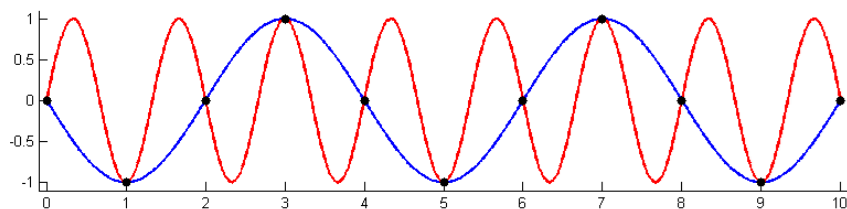
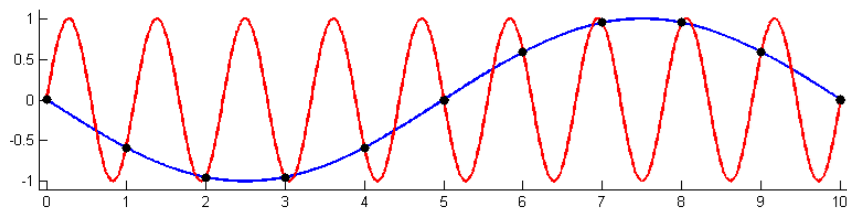
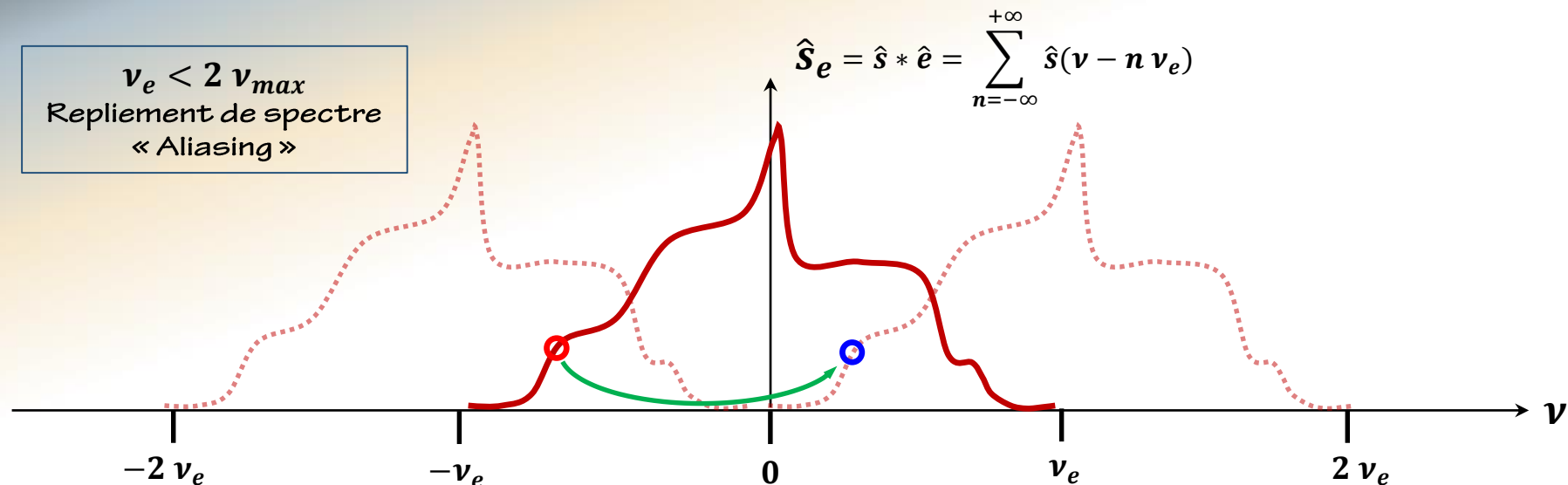
Echantillonnage

$\nu_e < 2 \nu_{max}$
Repliement de spectre
« Aliasing »



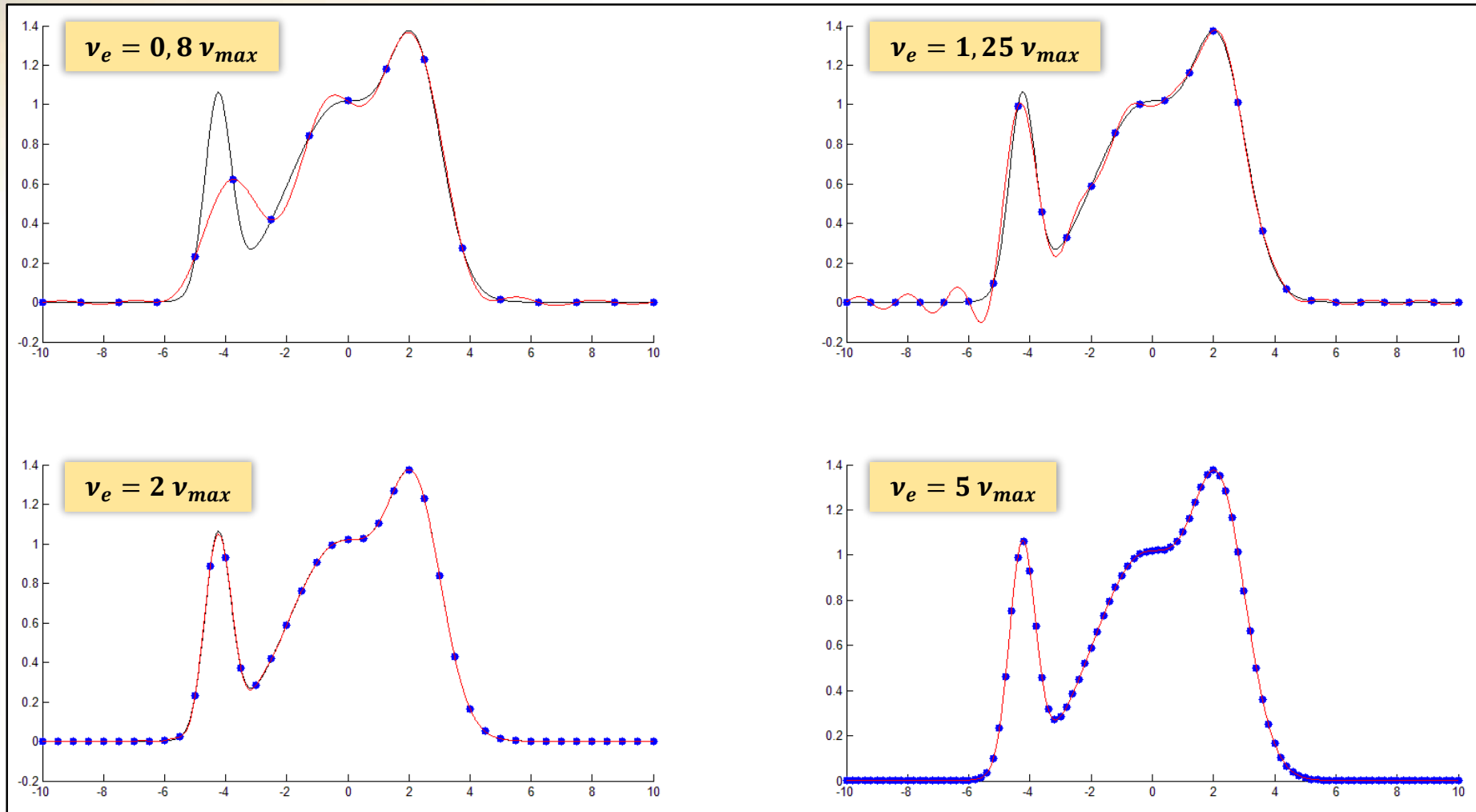
Echantillonnage

$\nu_e < 2 \nu_{max}$
Repliement de spectre
« Aliasing »

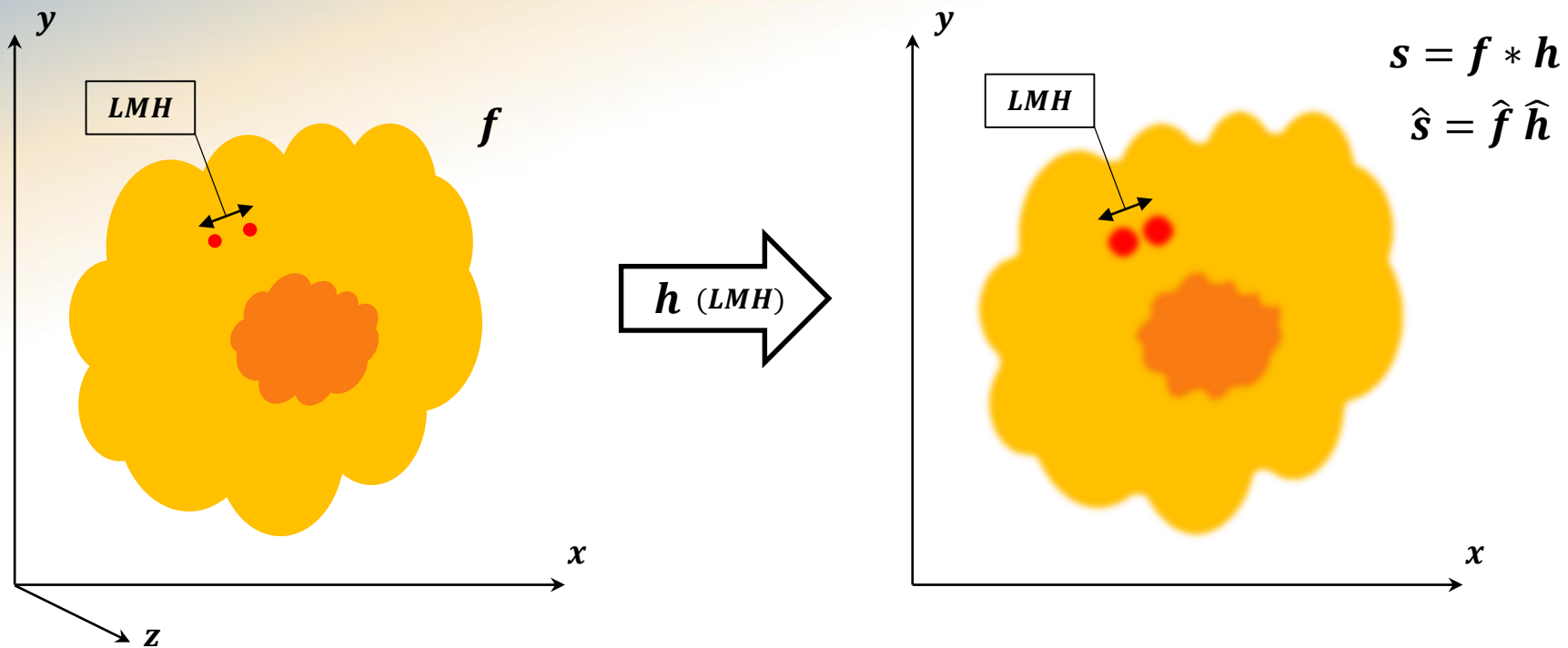


Echantillonnage

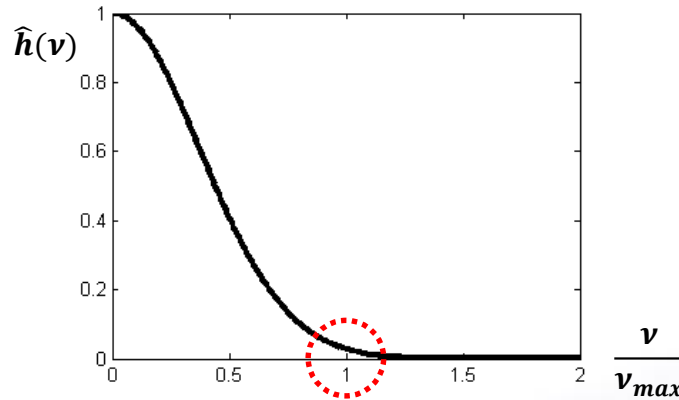
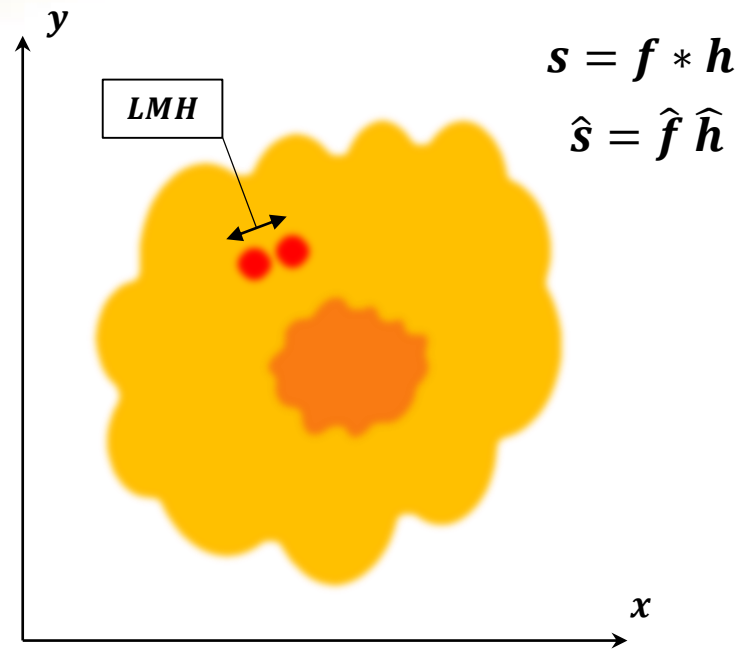
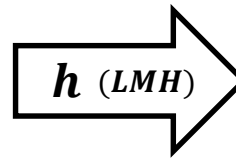
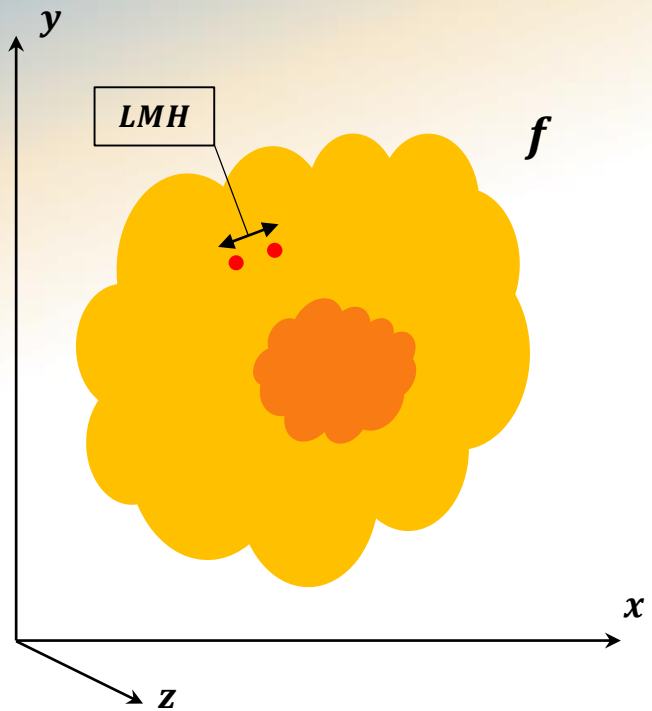
$$s(x) = s_e(x) * \text{sinc}(\pi v_e x)$$



Echantillonnage

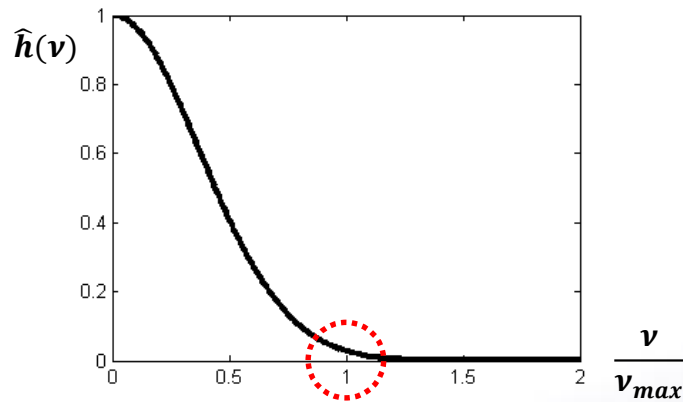
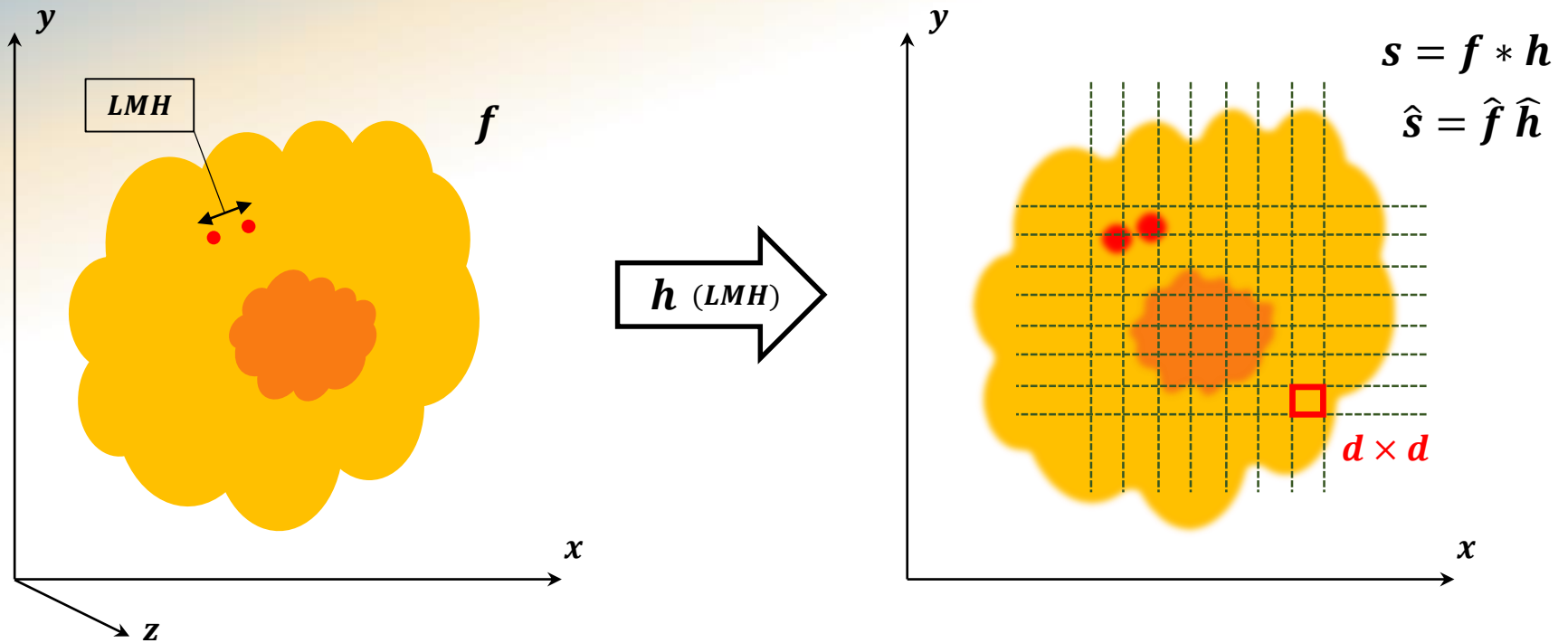


Echantillonnage



$$v_{max} \approx \frac{1}{LMH}$$

Echantillonnage

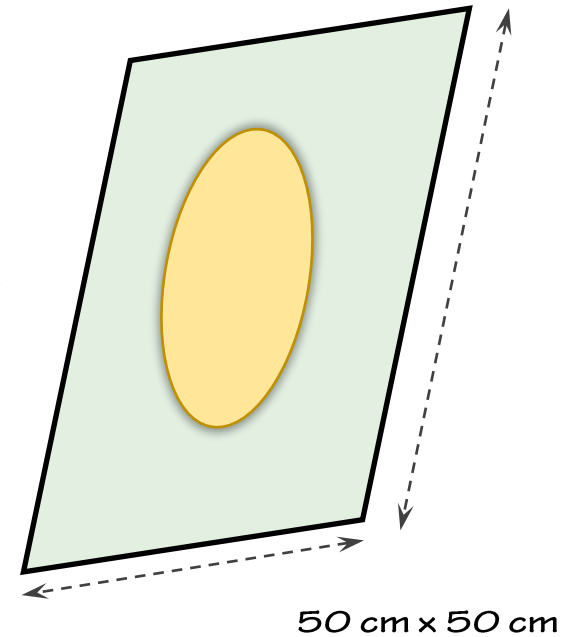
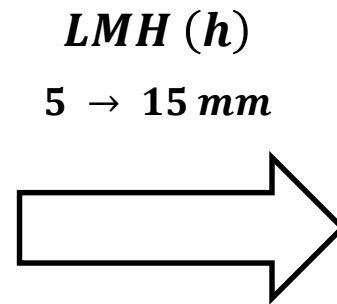
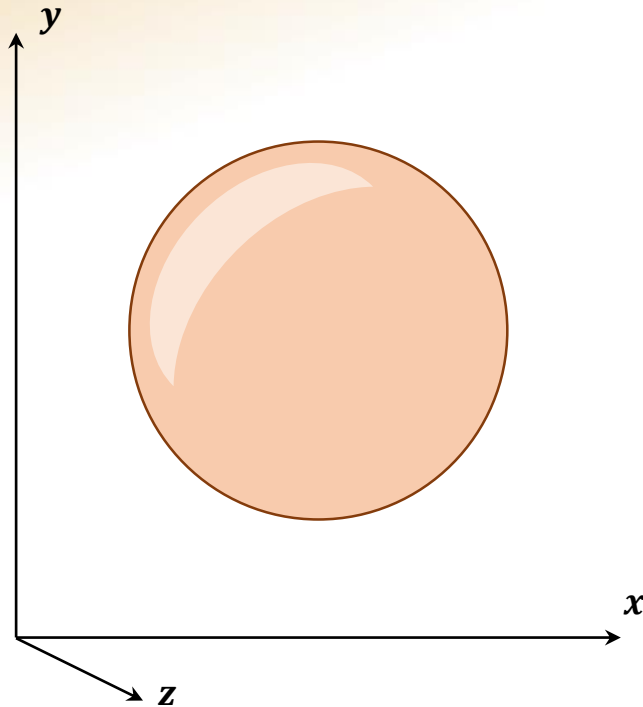


$$v_{max} \approx \frac{1}{LMH}$$

$$v_e = \frac{2}{LMH} ; d = \frac{LMH}{2}$$

Echantillonnage

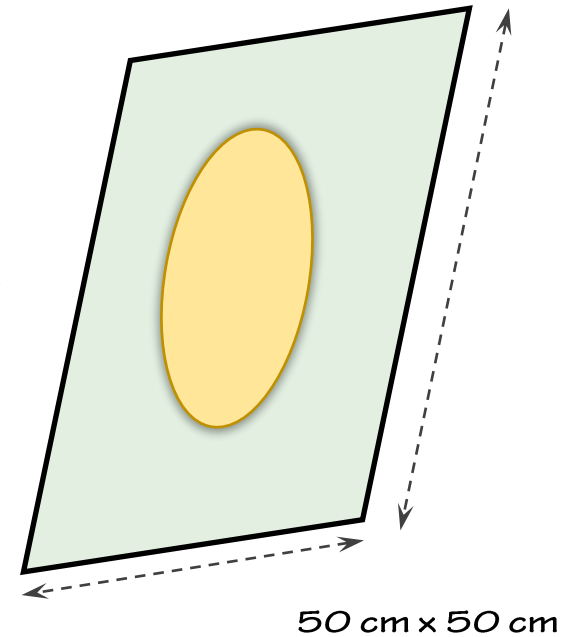
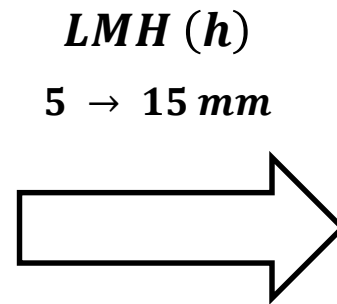
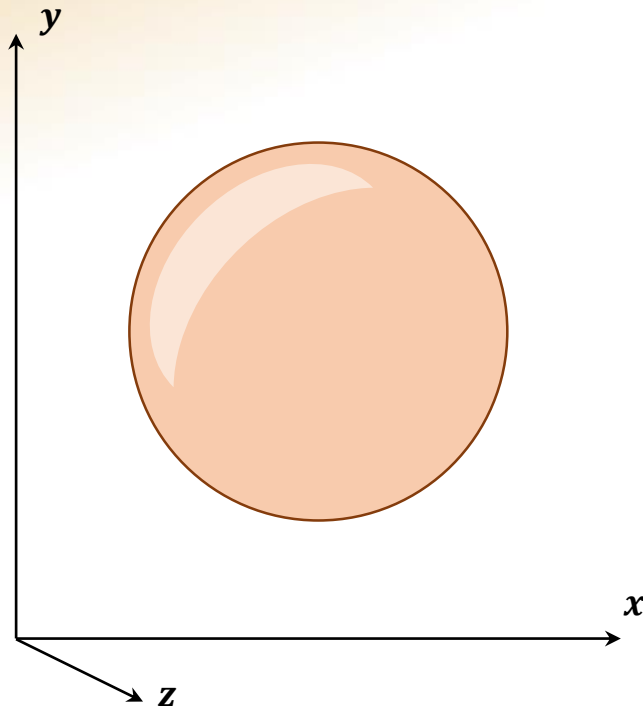
SPECT



$$N = 256 : d = \frac{500}{256} \approx 2 \text{ mm} \ll \frac{LMH}{2}$$

Echantillonnage

SPECT

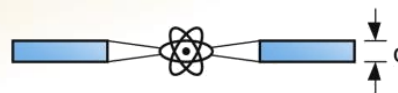


$$N = 128 : d = \frac{500}{128} \approx 4 \text{ mm} \approx \frac{LMH}{2}$$

Echantillonnage

TEP

Taille du détecteur



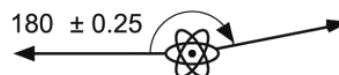
$d/2$

Démultiplexage



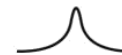
0 (individual coupling)
2.2 mm (Anger logic)*
*empirically determined
from published data

Non collinéarité

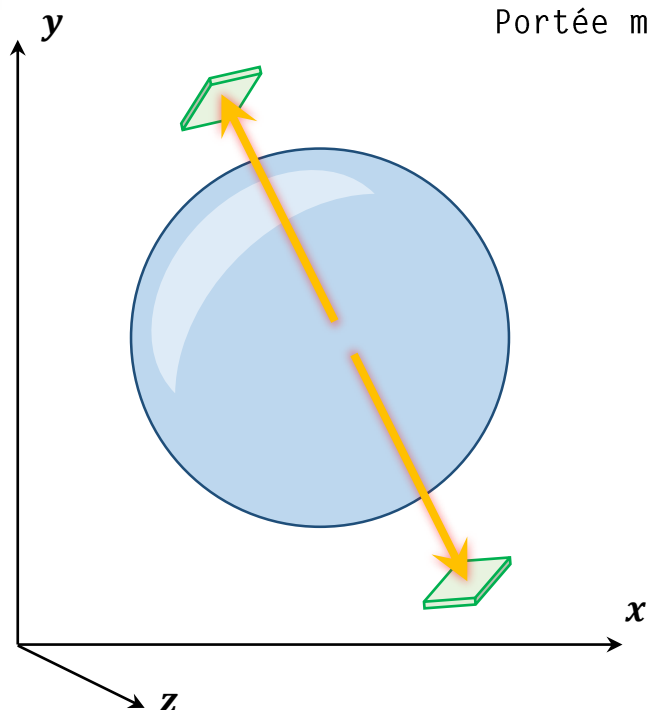


1.3 mm (head)
1.8 mm (heart)

Portée moyenne

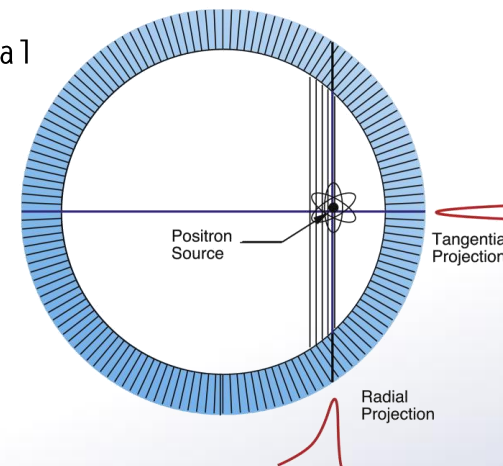


0.5 mm (^{18}F)
4.5 mm (^{82}Rb)



Astigmatisme radial

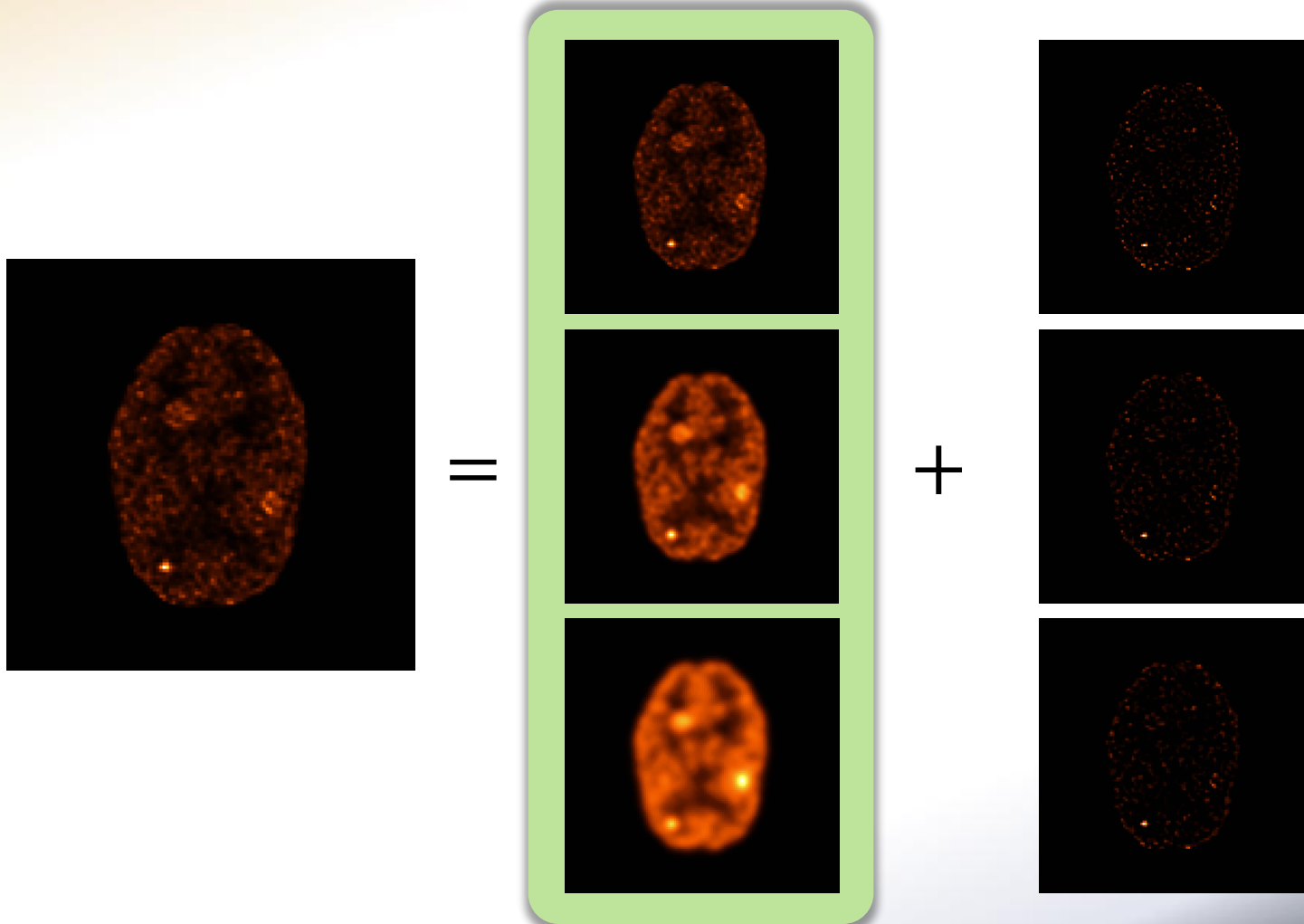
$LMH (h)$
 $4 \rightarrow 10 \text{ mm}$
 $d \approx 3 \text{ mm}$



Filtrage

Extraction d'un signal d'intérêt / utile

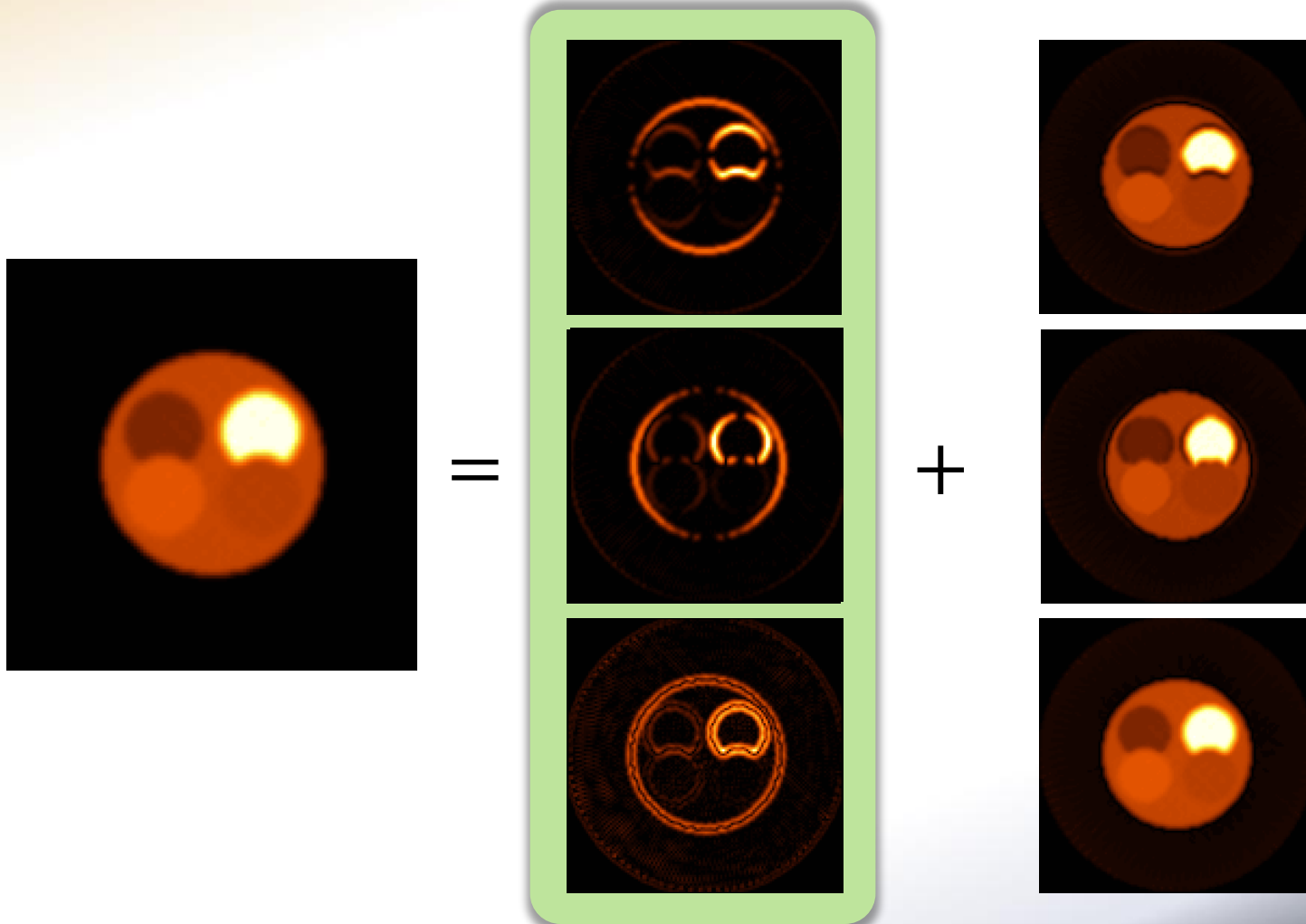
Élimination du signal inutile / bruit



Filtrage

Extraction d'un signal d'intérêt / utile

Elimination du signal inutile / bruit



Filtrage

Extraction d'un signal d'intérêt / utile

Elimination du signal inutile / bruit

FILTRAGE LINEAIRE :

$$\varphi = f * h$$
$$\hat{\varphi} = \hat{f} \hat{h}$$

Filtrage

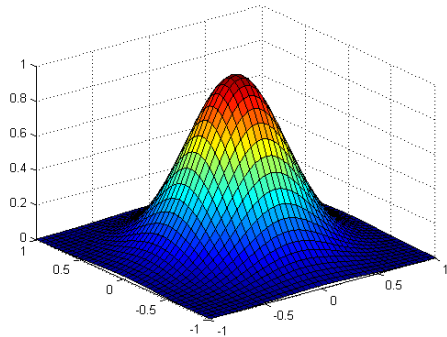
Extraction d'un signal d'intérêt / utile

Elimination du signal inutile / bruit

FILTRAGE LINEAIRE :

$$\varphi = f * h$$
$$\hat{\varphi} = \hat{f} \hat{h}$$

h = noyau de convolution
(moyenne pondérée)



$$\varphi_{i,j} = \sum_{m=-1}^1 \sum_{n=-1}^1 f_{i-m,j-n} h_{m,n}$$

$$h = \frac{1}{4} \begin{bmatrix} 0,25 & 0,5 & 0,25 \\ 0,5 & 1 & 0,5 \\ 0,25 & 0,5 & 0,25 \end{bmatrix}$$

Filtrage

Extraction d'un signal d'intérêt / utile

Élimination du signal inutile / bruit

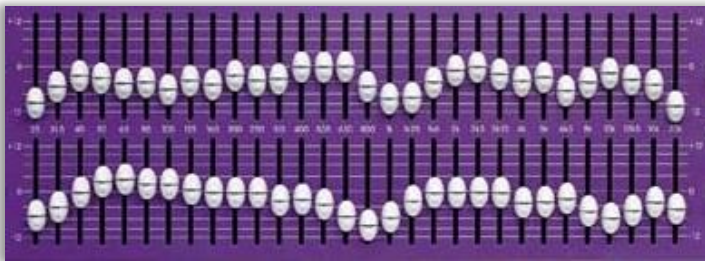
FILTRAGE LINEAIRE :

$$\varphi = f * h$$
$$\hat{\varphi} = \hat{f} \hat{h}$$

\hat{h} = fonction de transfert
(égaliseur)

modulation sélective

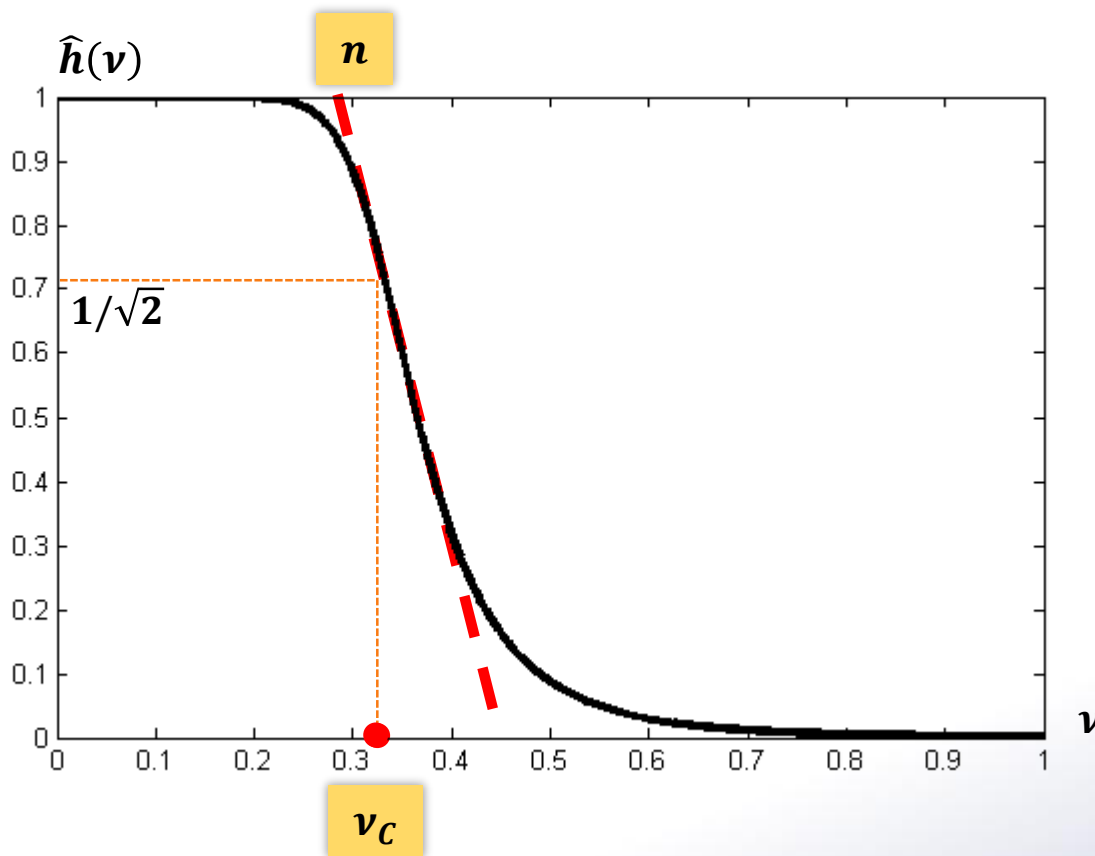
$$\hat{\varphi}(v_i, v_j) = \hat{f}(v_i, v_j) \hat{h}(v_i, v_j)$$



Filtrage

FILTRAGE PASSE-BAS :
Butterworth

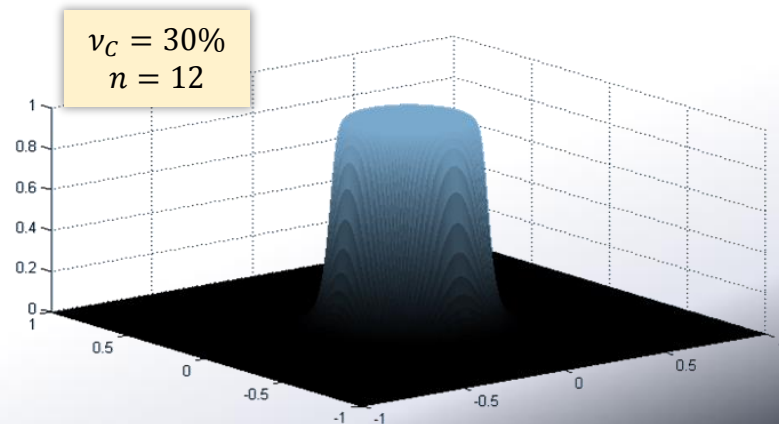
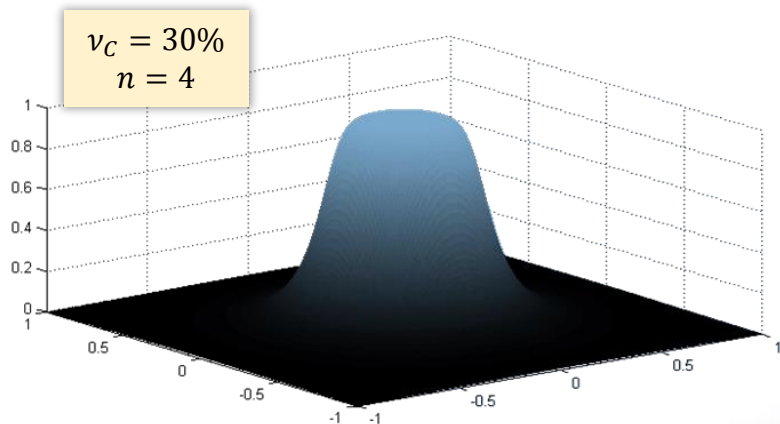
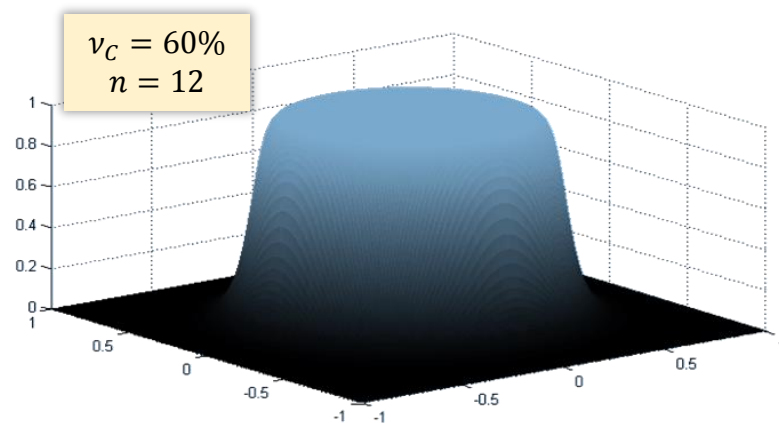
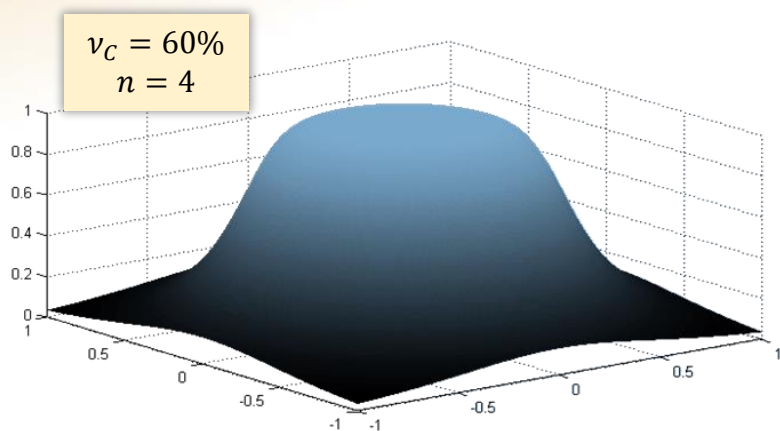
$$\hat{h}(v_i, v_j) = \frac{1}{\sqrt{1 + \left(\frac{\sqrt{v_i^2 + v_j^2}}{v_c}\right)^{2n}}}$$



Filtrage

FILTRAGE PASSE-BAS :
Butterworth

$$\hat{h}(v_i, v_j) = \frac{1}{\sqrt{1 + \left(\frac{\sqrt{v_i^2 + v_j^2}}{v_C} \right)^{2n}}}$$

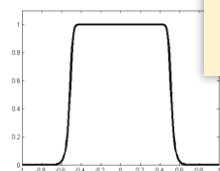
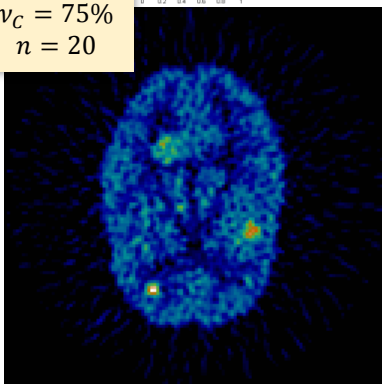


Filtrage

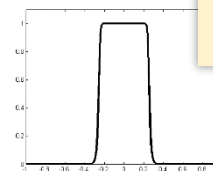
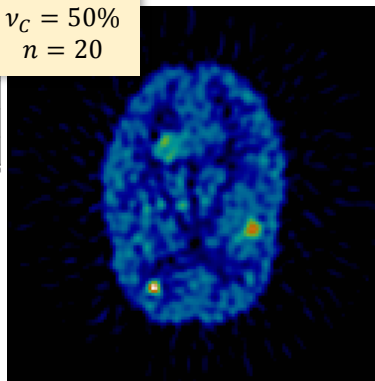
FILTRAGE PASSE-BAS :
Butterworth

$$\hat{h}(v_i, v_j) = \frac{1}{\sqrt{1 + \left(\frac{\sqrt{v_i^2 + v_j^2}}{v_c}\right)^{2n}}}$$

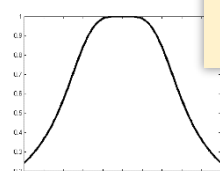
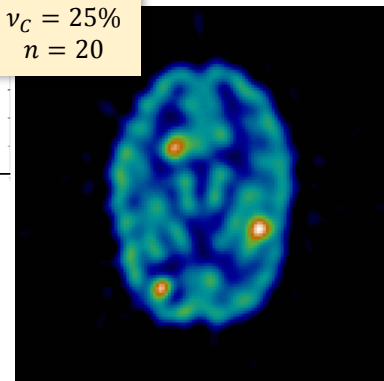
$v_c = 75\%$
 $n = 20$



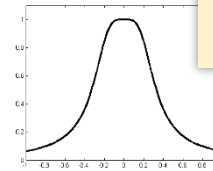
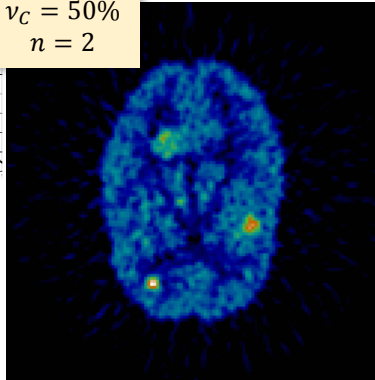
$v_c = 50\%$
 $n = 20$



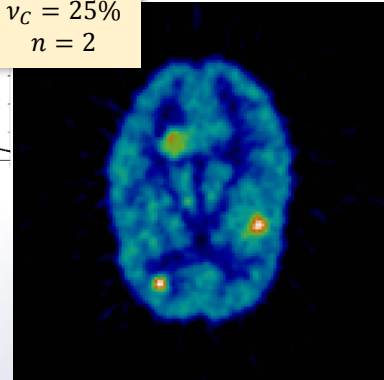
$v_c = 25\%$
 $n = 20$



$v_c = 50\%$
 $n = 2$

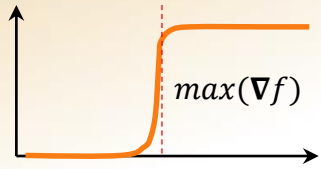


$v_c = 25\%$
 $n = 2$



Filtrage

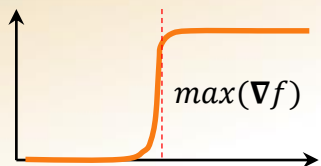
FILTRAGE PASSE-HAUT :
Sobel



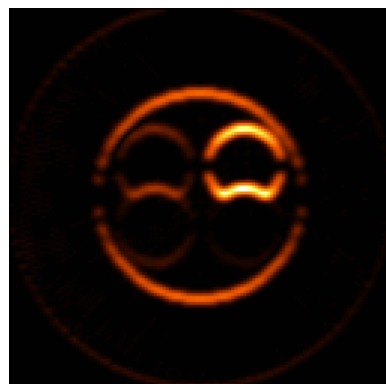
$$\nabla f(x) = \lim_{\varepsilon \rightarrow 0} \frac{f(x + \varepsilon) - f(x - \varepsilon)}{2\varepsilon}$$

Filtrage

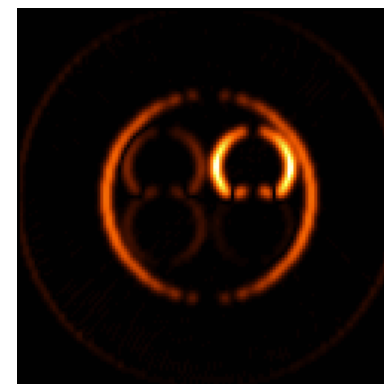
FILTRAGE PASSE-HAUT :
Sobel



$$\nabla f(x) = \lim_{\varepsilon \rightarrow 0} \frac{f(x + \varepsilon) - f(x - \varepsilon)}{2\varepsilon}$$



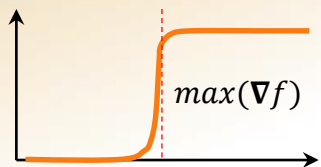
$$h = \nabla_x = \begin{bmatrix} -0,5 & 0 & 0,5 \\ -1 & 0 & 1 \\ -0,5 & 0 & 0,5 \end{bmatrix}$$



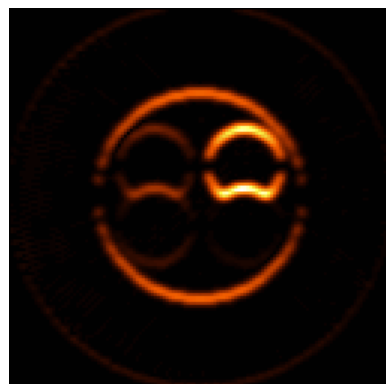
$$h = \nabla_y = \begin{bmatrix} -0,5 & -1 & -0,5 \\ 0 & 0 & 0 \\ 0,5 & 1 & 0,5 \end{bmatrix}$$

Filtrage

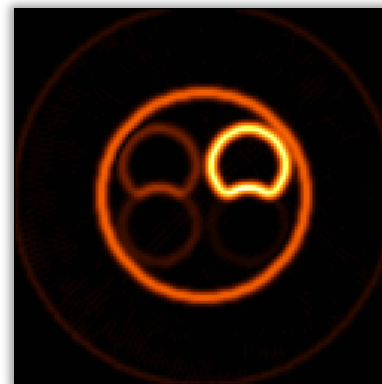
FILTRAGE PASSE-HAUT :
Sobel



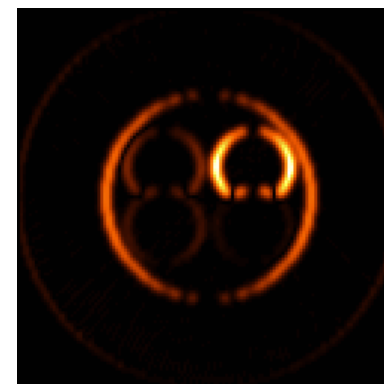
$$\nabla f(x) = \lim_{\varepsilon \rightarrow 0} \frac{f(x + \varepsilon) - f(x - \varepsilon)}{2\varepsilon}$$



$$h = \nabla_x = \begin{bmatrix} -0,5 & 0 & 0,5 \\ -1 & 0 & 1 \\ -0,5 & 0 & 0,5 \end{bmatrix}$$



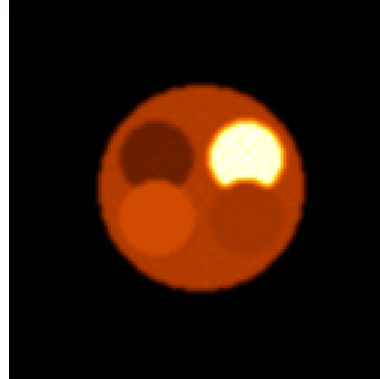
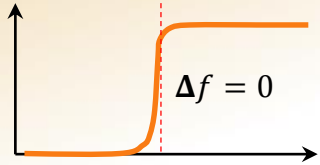
$$h = \sqrt{\nabla_x^2 + \nabla_y^2}$$



$$h = \nabla_y = \begin{bmatrix} -0,5 & -1 & -0,5 \\ 0 & 0 & 0 \\ 0,5 & 1 & 0,5 \end{bmatrix}$$

Filtrage

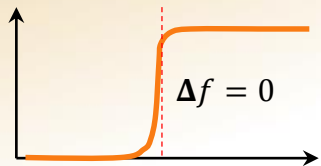
FILTRAGE PASSE-HAUT :
Laplacien



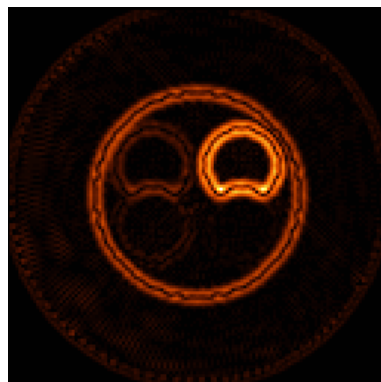
$$\Delta f(x) = \lim_{\varepsilon \rightarrow 0} \frac{f(x + \varepsilon) - 2f(x) + f(x - \varepsilon))}{\varepsilon^2}$$

Filtrage

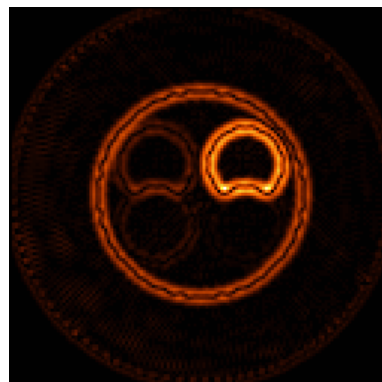
FILTRAGE PASSE-HAUT :
Laplacien



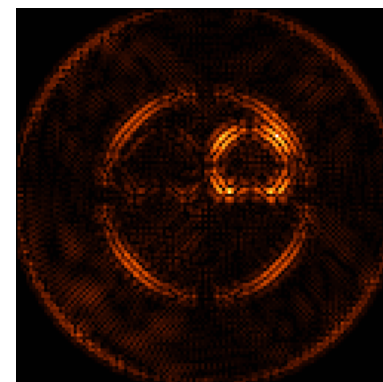
$$\Delta f(x) = \lim_{\varepsilon \rightarrow 0} \frac{f(x + \varepsilon) - 2f(x) + f(x - \varepsilon)}{\varepsilon^2}$$



$$\mathbf{h} = \begin{bmatrix} 0 & -0,25 & 0 \\ -0,25 & 1 & -0,25 \\ 0 & -0,25 & 0 \end{bmatrix}$$



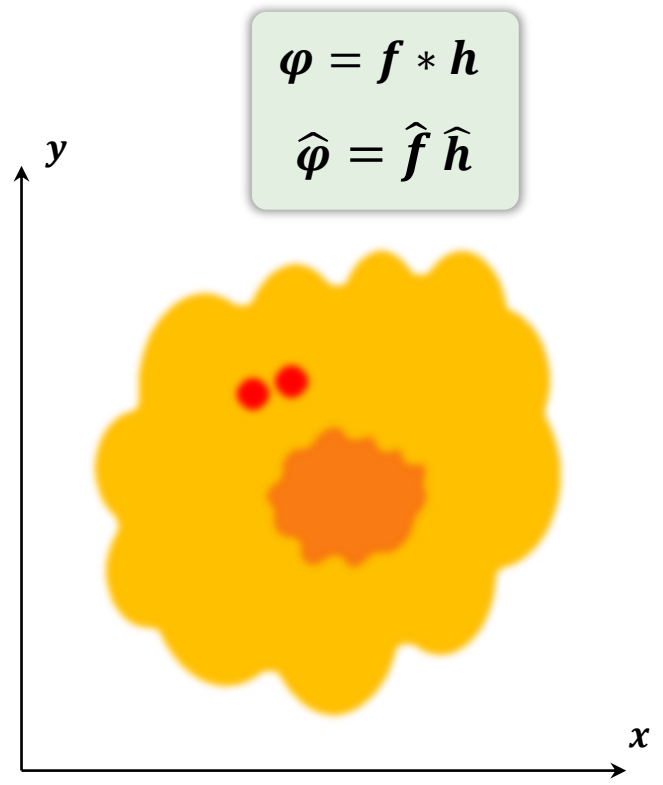
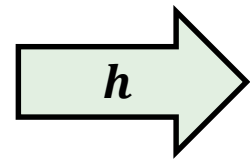
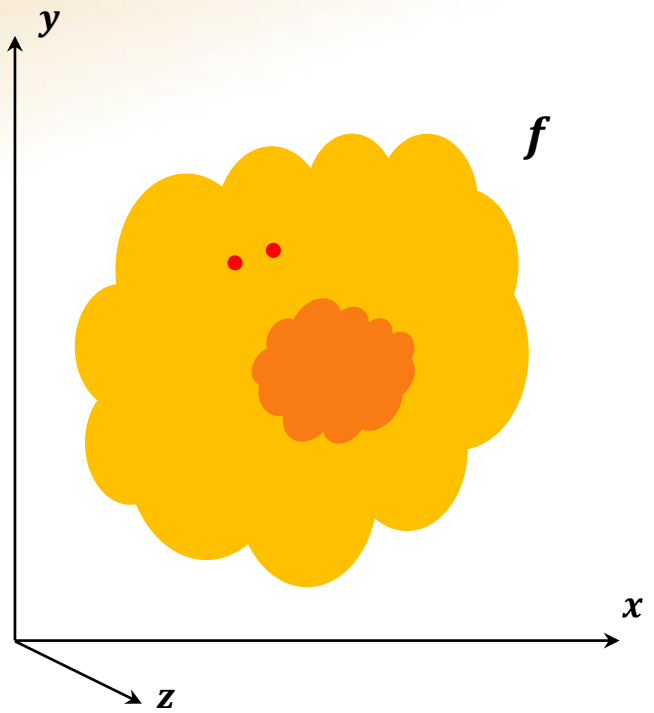
$$\mathbf{h} = \begin{bmatrix} -0,125 & -0,125 & -0,125 \\ -0,125 & 1 & -0,125 \\ -0,125 & -0,125 & -0,125 \end{bmatrix}$$



$$\mathbf{h} = \begin{bmatrix} 0,25 & -0,5 & 0,25 \\ -0,5 & 1 & -0,5 \\ 0,25 & -0,5 & 0,25 \end{bmatrix}$$

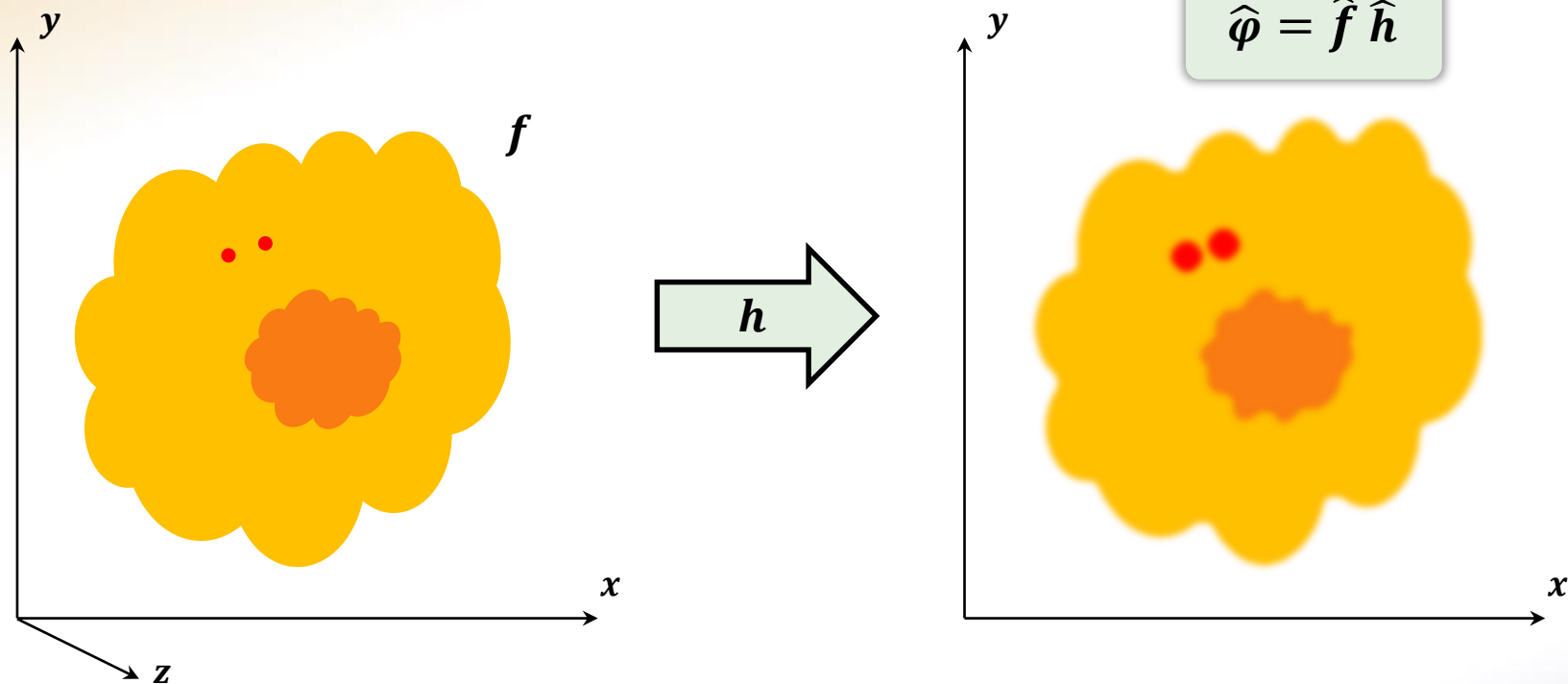
Filterage

DECONVOLUTION



Filterage

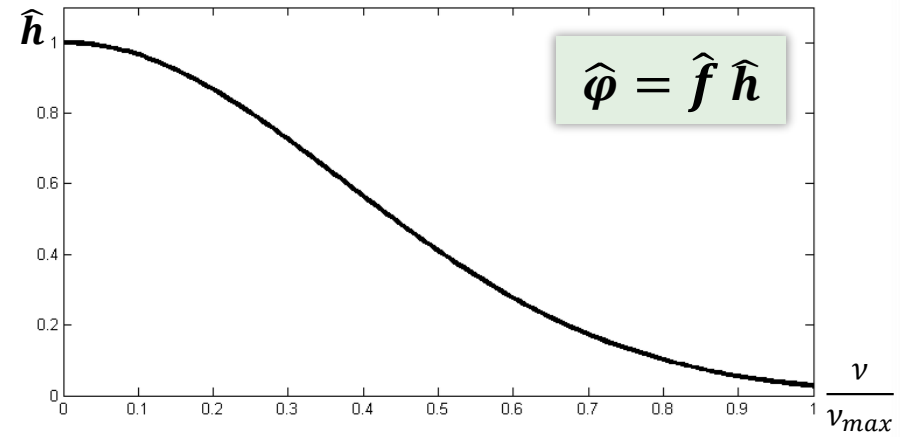
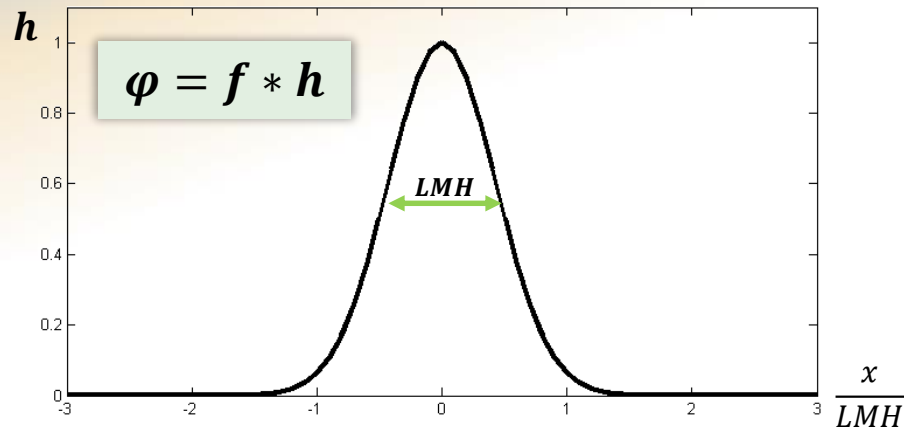
DECONVOLUTION



$$\hat{f} = \frac{\hat{\varphi}}{\hat{h}} \quad f = \varphi * \left(\overline{\frac{1}{\hat{h}}} \right)$$

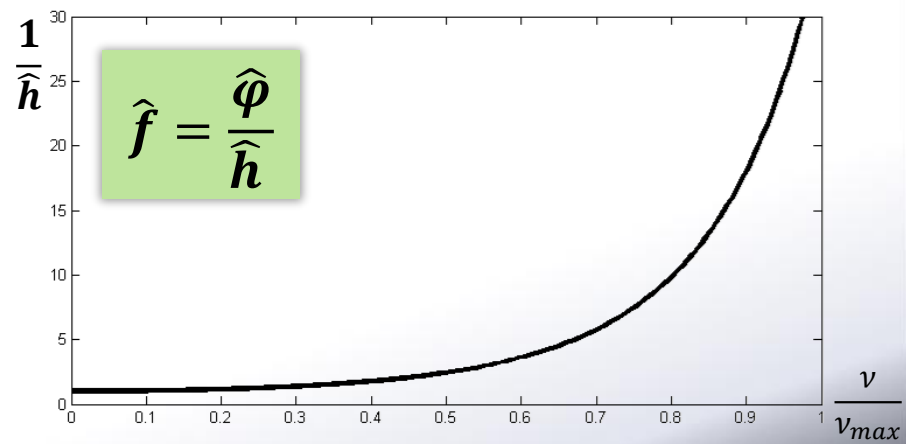
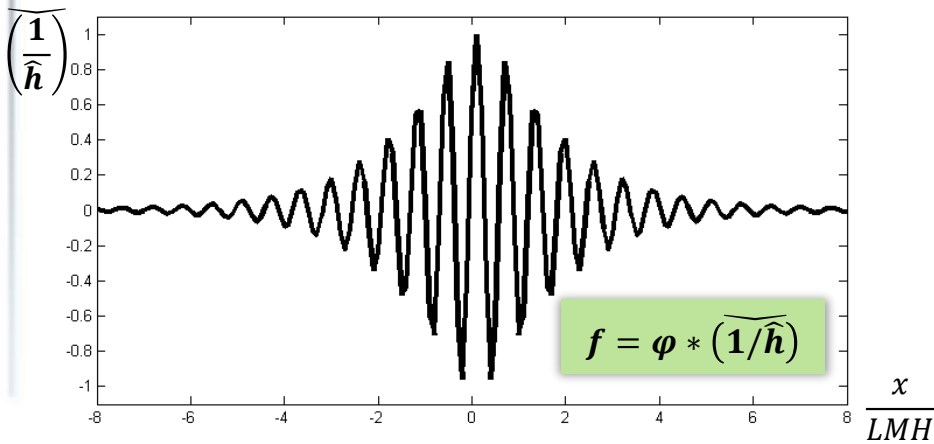
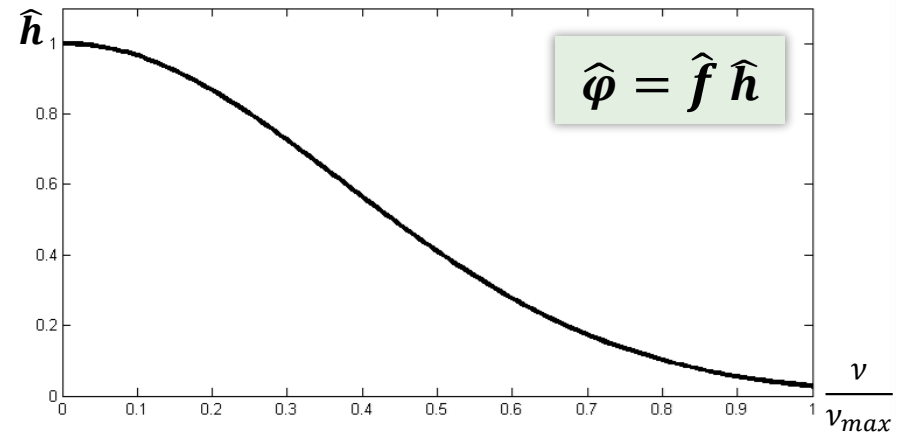
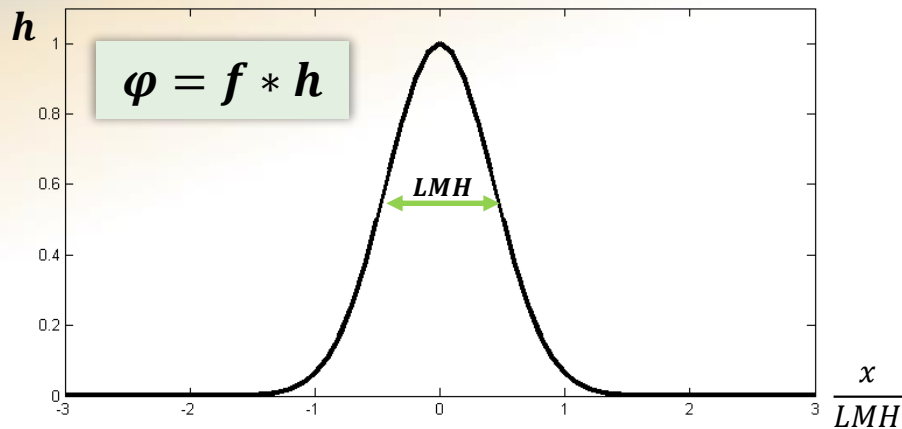
Filterage

DECONVOLUTION



Filtrage

DECONVOLUTION



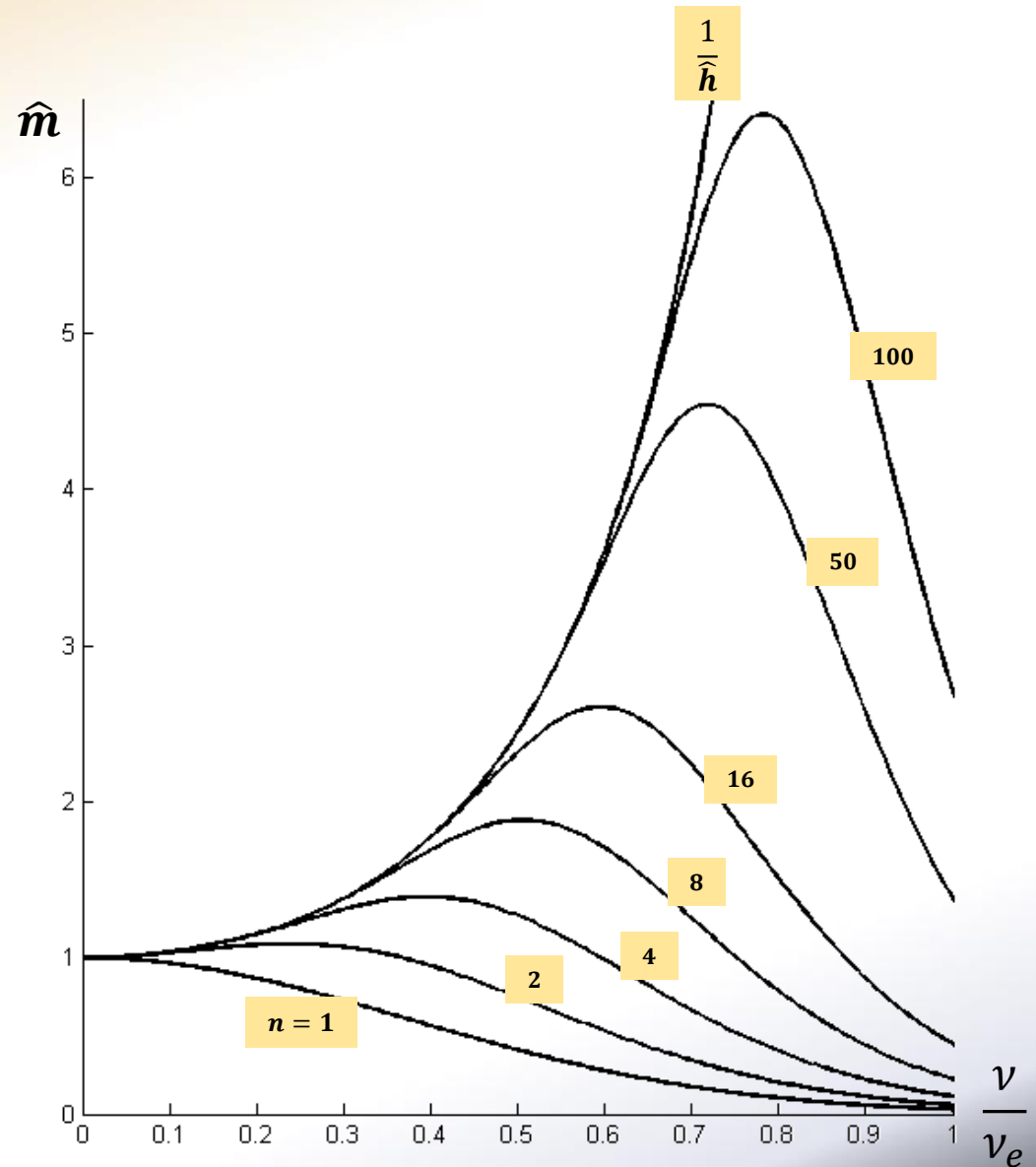
Filtrage

DECONVOLUTION
Filtre de Metz

$$\hat{f} = \frac{\hat{\varphi}}{\hat{h}}$$

$$\hat{f} = \hat{\varphi} \hat{m}$$

$$\hat{m}_n = \frac{1 - (1 - \hat{h}^2)^n}{\hat{h}}$$



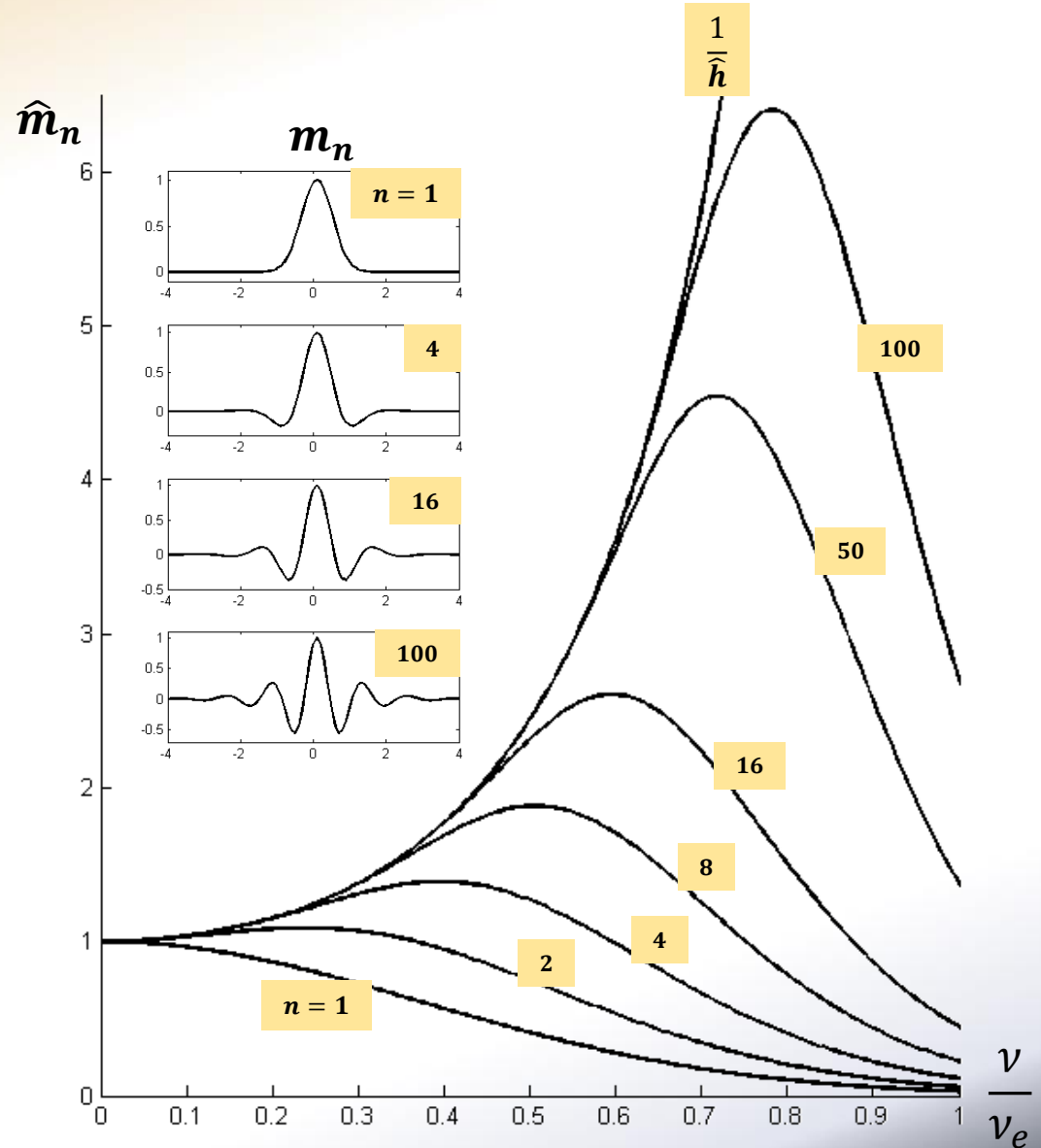
Filtrage

DECONVOLUTION Filtre de Metz

$$\hat{f} = \frac{\hat{\varphi}}{\hat{h}}$$

$$\hat{f} = \hat{\varphi} \hat{m}_n \quad f = \varphi * m_n$$

$$\hat{m}_n = \frac{1 - (1 - \hat{h}^2)^n}{\hat{h}}$$



Filtrage

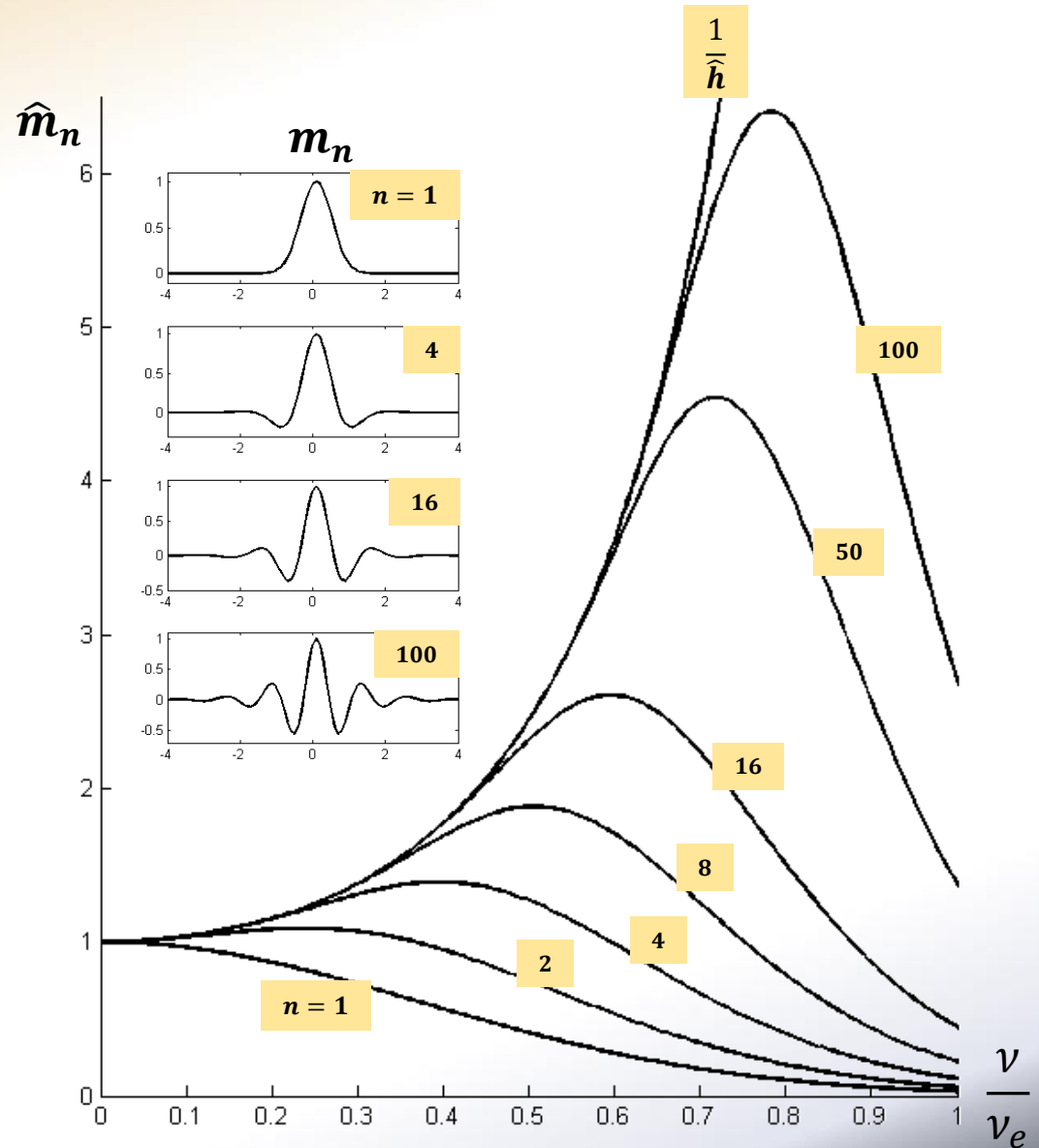
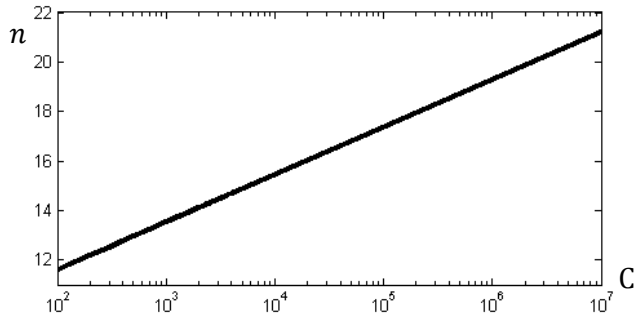
DECONVOLUTION Filtre de Metz

$$\hat{f} = \frac{\hat{\varphi}}{\hat{h}}$$

$$\hat{f} = \hat{\varphi} \hat{m}_n \quad f = \varphi * m_n$$

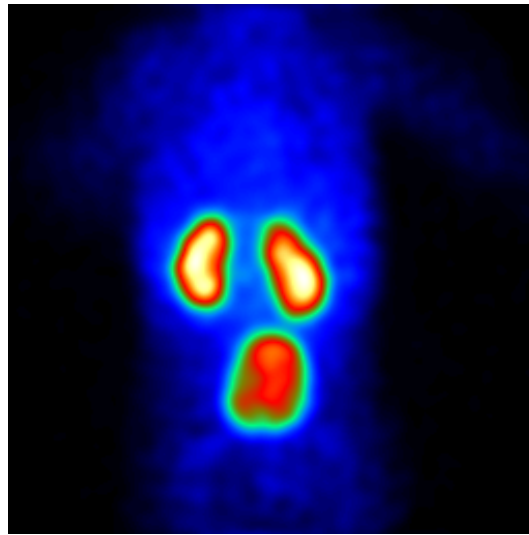
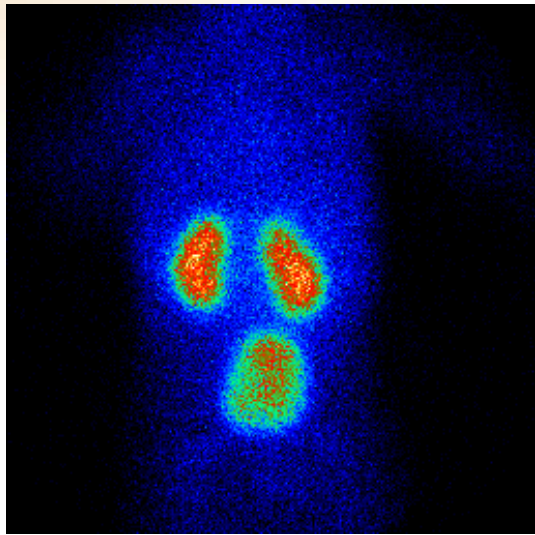
$$\hat{m}_n = \frac{1 - (1 - \hat{h}^2)^n}{\hat{h}}$$

$$n = 0,834 \ln(C) - 7,774$$

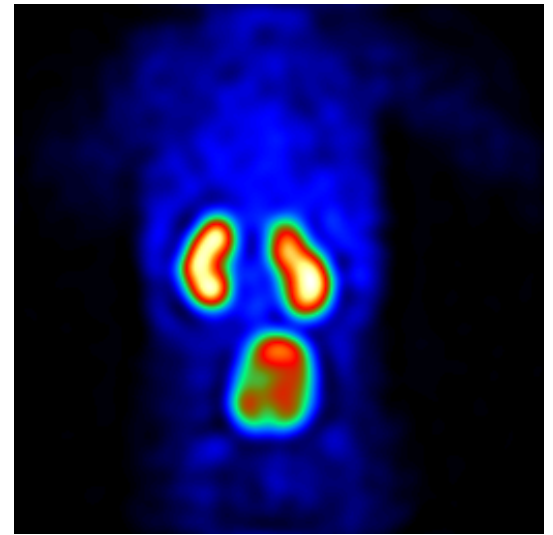


Filtrage

DECONVOLUTION
Filtre de Metz



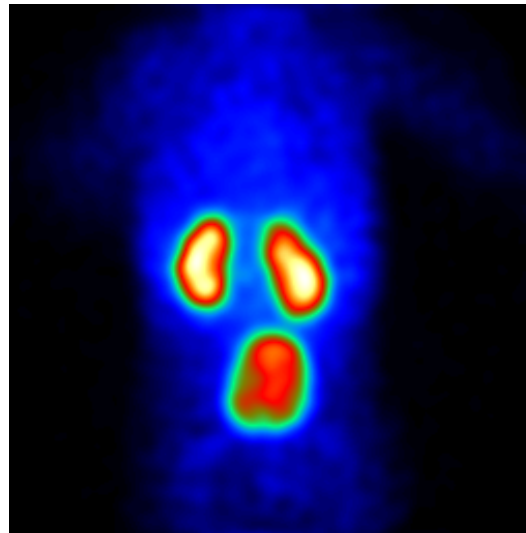
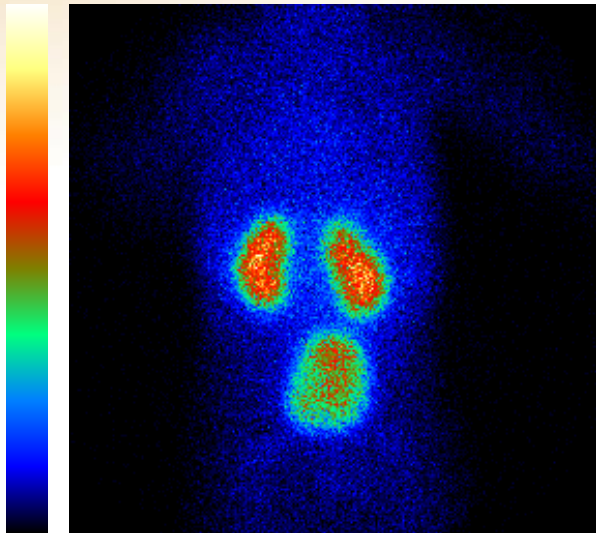
Butterworth



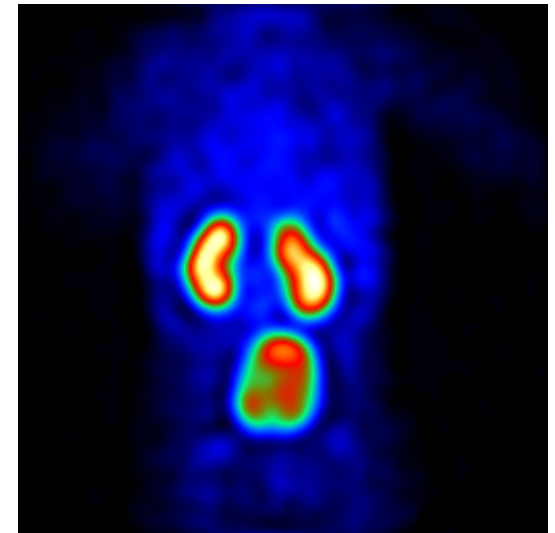
Metz

Filtrage

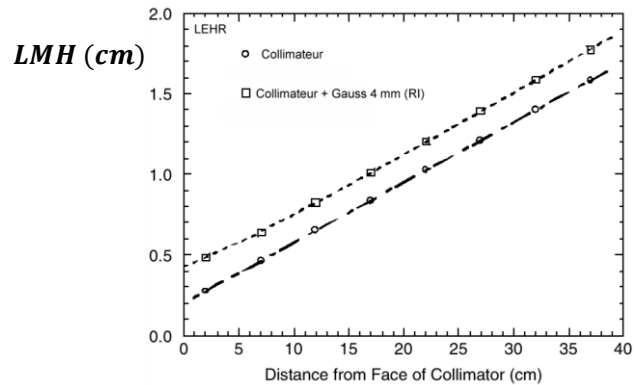
DECONVOLUTION Filtre de Metz



Butterworth



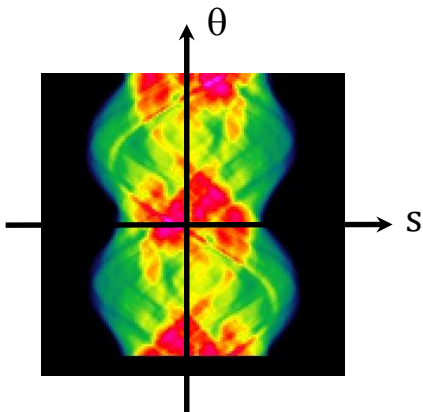
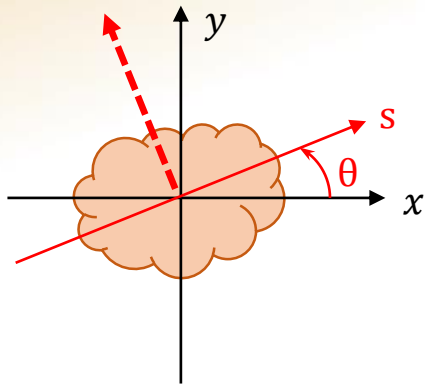
Metz



Filtrage

DECONVOLUTION

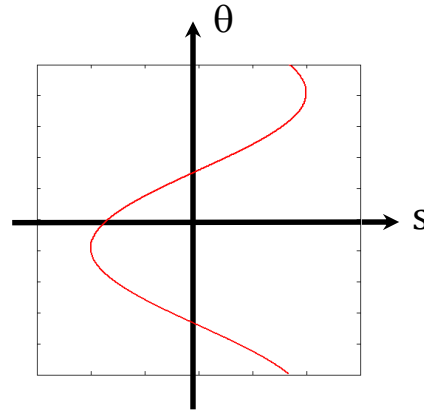
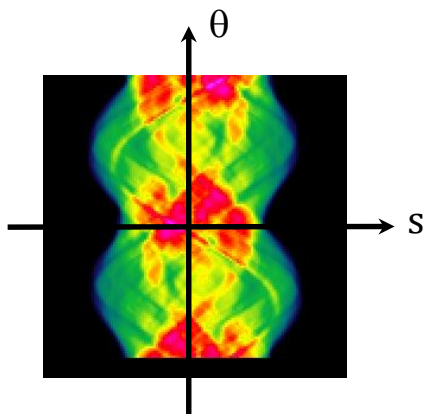
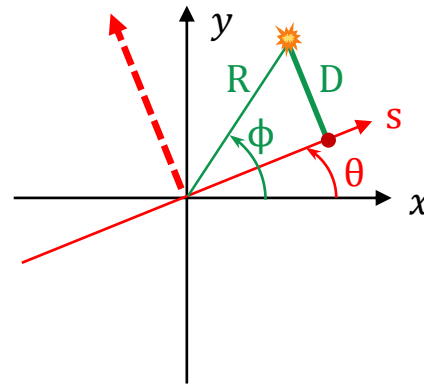
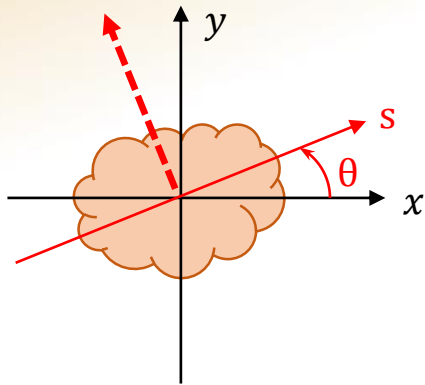
Principe fréquence-distance



Filtrage

DECONVOLUTION

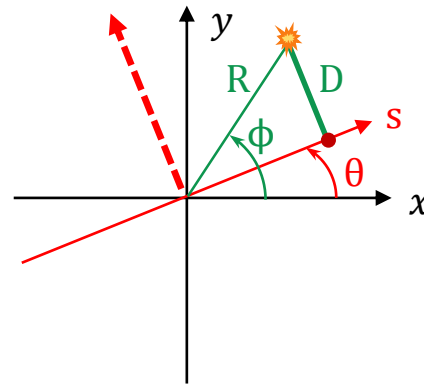
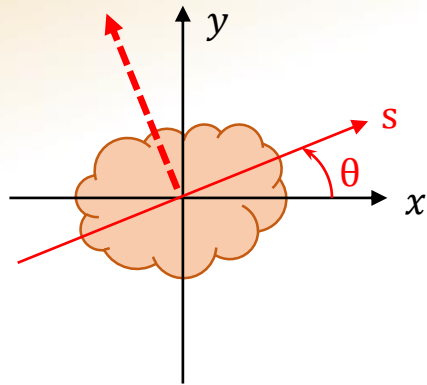
Principe fréquence-distance



Filtrage

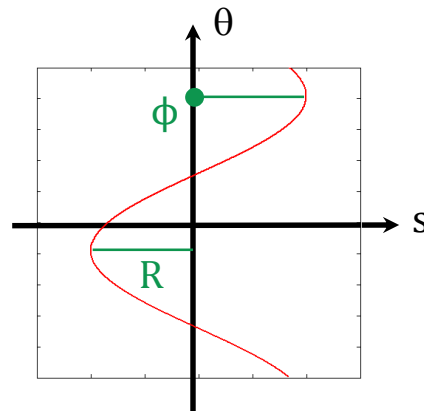
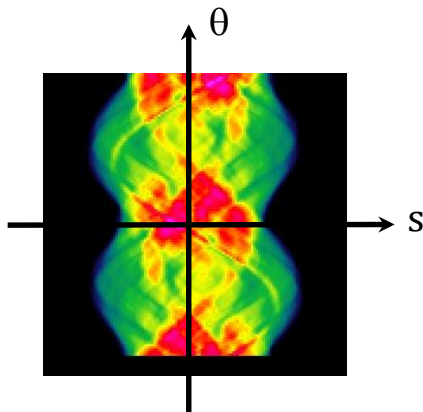
DECONVOLUTION

Principe fréquence-distance



$$s(\theta) = R \cos(\theta - \phi)$$

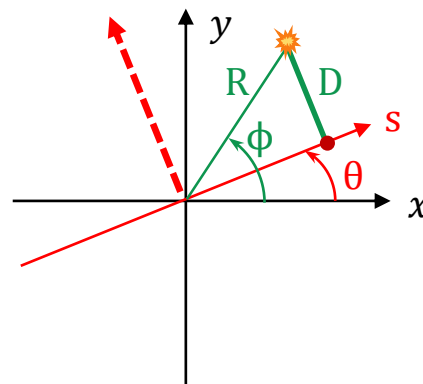
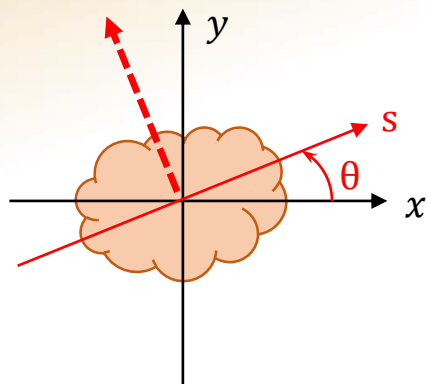
$$s'(\theta) = R \sin(\phi - \theta) = D$$



Filtrage

DECONVOLUTION

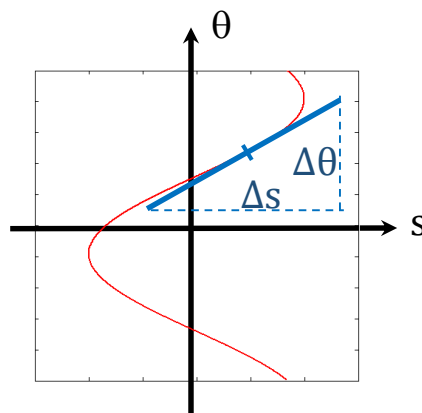
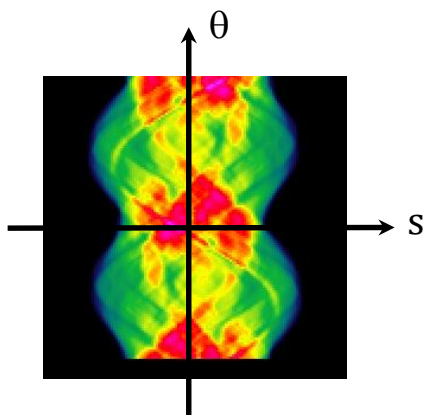
Principe fréquence-distance



$$s(\theta) = R \cos(\theta - \phi)$$

$$s'(\theta) = R \sin(\phi - \theta) = D$$

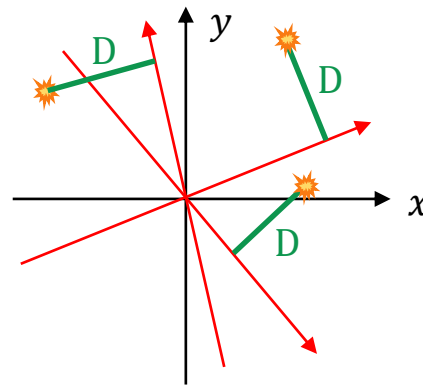
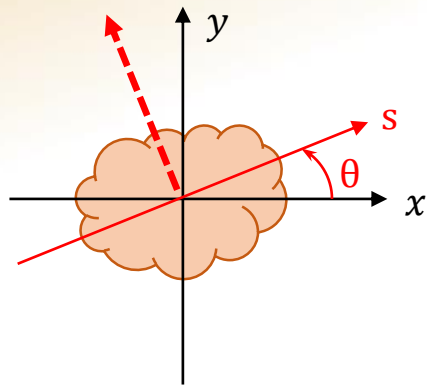
$$\frac{\Delta s}{\Delta \theta} = D$$



Filtrage

DECONVOLUTION

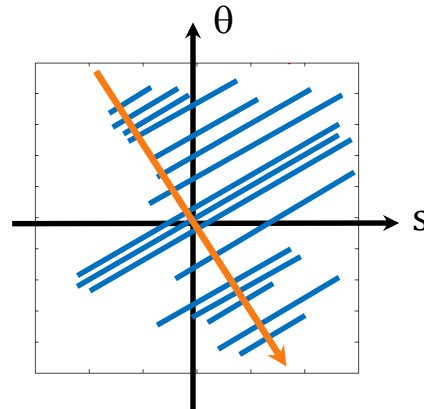
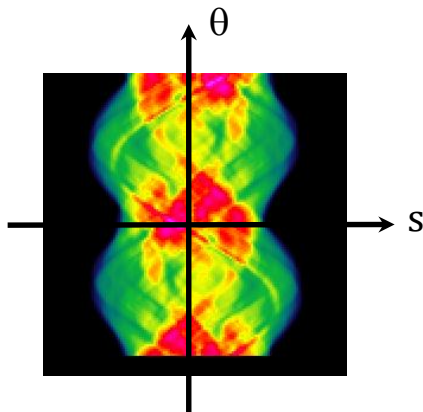
Principe fréquence-distance



$$s(\theta) = R \cos(\theta - \phi)$$

$$s'(\theta) = R \sin(\phi - \theta) = D$$

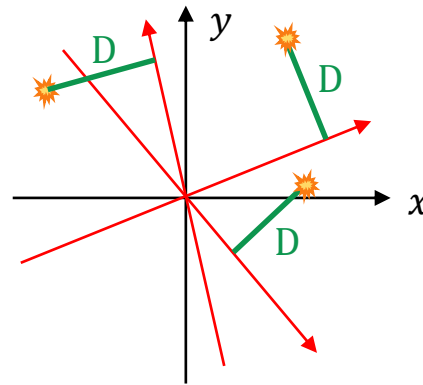
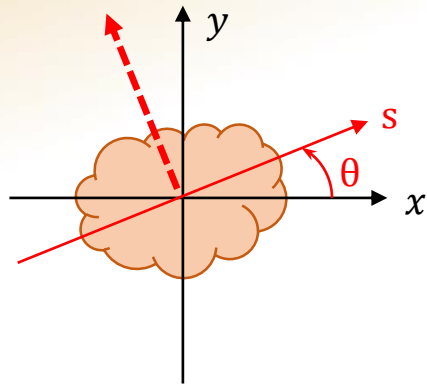
$$\frac{\Delta s}{\Delta \theta} = D$$



Filtrage

DECONVOLUTION

Principe fréquence-distance

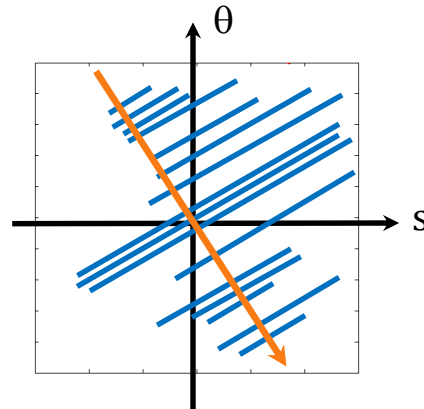
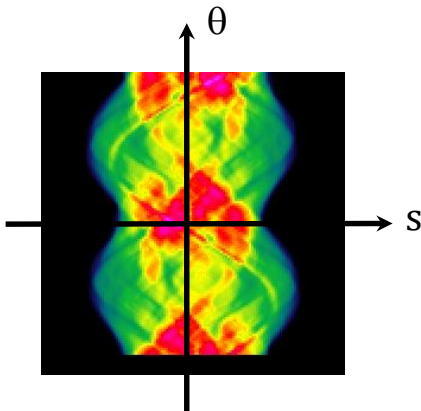


$$s(\theta) = R \cos(\theta - \phi)$$

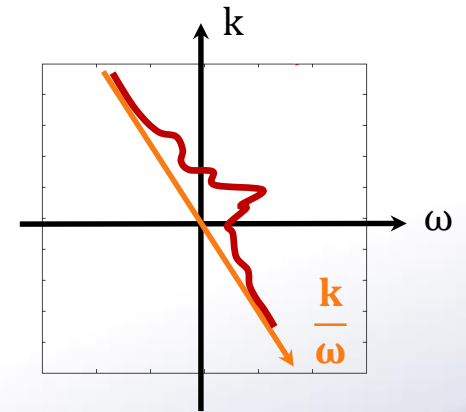
$$s'(\theta) = R \sin(\phi - \theta) = D$$

$$\frac{\Delta s}{\Delta \theta} = D$$

$$\frac{k}{\omega} = -D$$



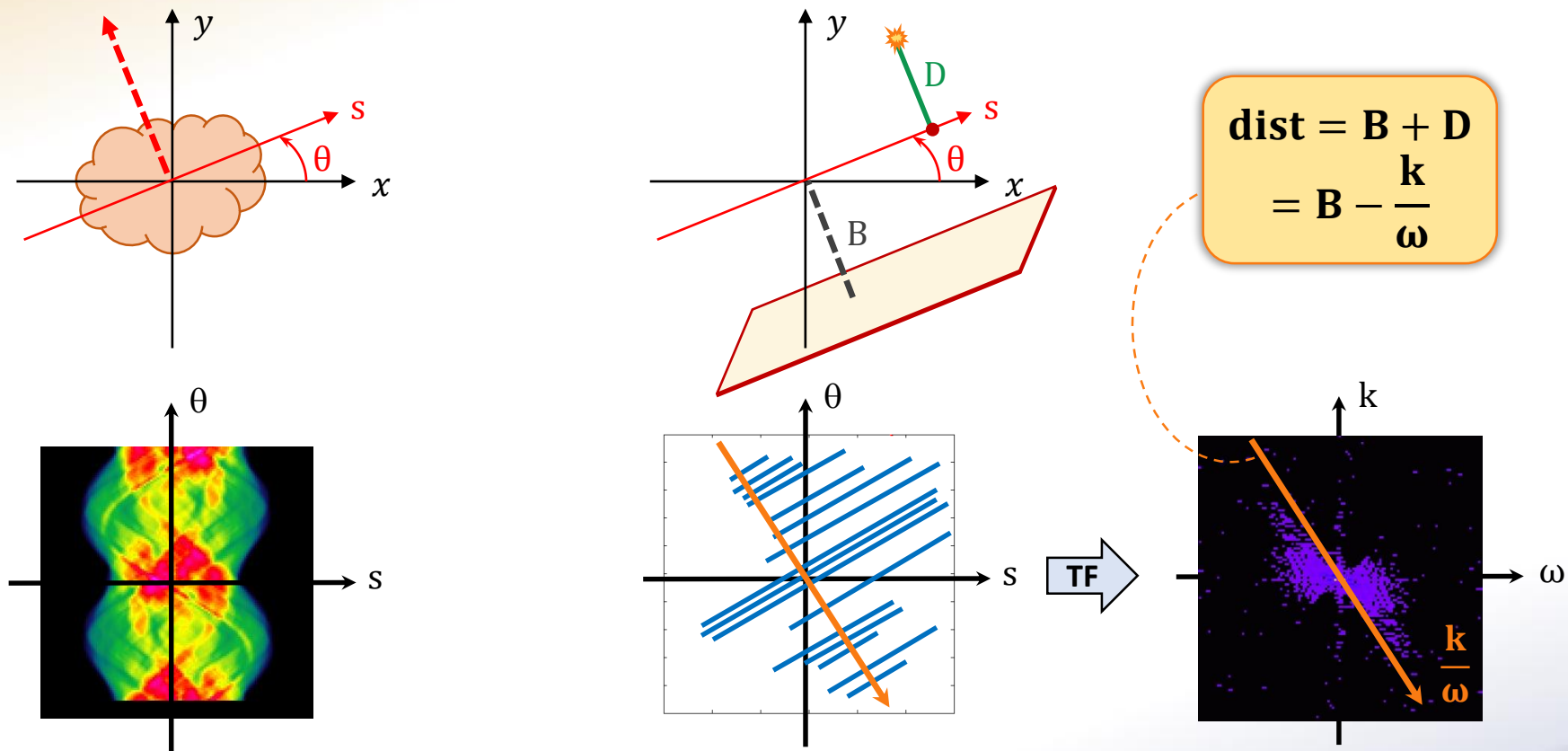
TF



Filtrage

DECONVOLUTION

Principe fréquence-distance



Filtrage

DECONVOLUTION

Principe fréquence-distance

$$\hat{f} = \hat{\varphi} \hat{m}$$



LMH



$$\begin{aligned} \text{dist} &= B + D \\ &= B - \frac{k}{\omega} \end{aligned}$$

