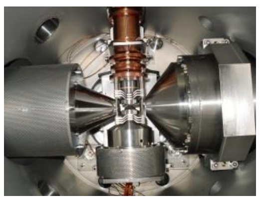
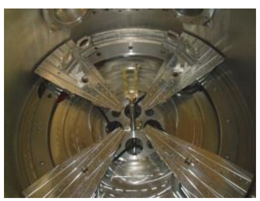
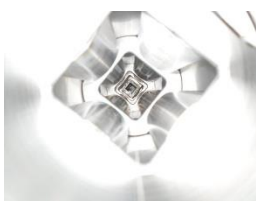



lpc caen
laboratoire de physique corpusculaire

« PTFI » , a Beam Profiler for low Intensity, low Energy, Radioactive Beams Measurements

cnrs IN2P3 Les deux infinis

UNICAEN université de Caen Basse-Normandie

ENSICAEN

Programm

- Context & issue
- The object we called PTFI
- Beam imaging
- Beam intensity measurement
- Conclusion

Context & issue of the PTFI

-1- to measure beam **position,**	σ x,y < $1mm_{RMS}$
-2- beam **intensity,**	dN/dt < 10^5 pps
-3- for **low energy**…	typ. 10→60 keV
-4- (highly) **exotic** (=radioactive)	eventually multiple decays
-5- **ions** beams	range : few 10nm
-6- at GANIL SPIRAL II facility	(no comment!)

Context & issue of the PTFI

-1- to measure beam **position,** σ x,y < 1mm$_{RMS}$

-2- beam **intensity,** dN/dt < 10^5 pps

-3- for **low energy…** typ. 10→60 keV

Counting mode

(part. by part. measurement)

-4- (highly) **exotic** (radioactive) eventually multiple decays

Charge measurement

(=integration over time)

-5- **ions** beams range : few 10nm

-6- at GANIL SPIRAL II facility (no comment!)

Context & issue of the PTFI

Beam implantation on microchannels plate (MCP)

-1- to measure beam **position**, σ x,y < $1mm_{RMS}$

-2- beam **intensity**, $dN/dt < 10^5$ pps

-3- for **low energy**… typ. 10→60 keV

-4- (highly) **exotic** (=radioactive) eventually multiple decays

-5- **ions** beams range : few 10nm

-6- at GANIL SPIRAL II facility (no comment!)

Context & issue of the PTFI

-1- to measure beam **position,** σ x,y < 1mm$_{RMS}$

-2- beam **intensity,** dN/dt < 10^5 pps

Localization anode behind the MCP

pixels

-4- (highly) **exotic** (=radioactive) eventually multiple decays

delay lines

-5- **ions** beams

resistive readout

wedge & stripes anode

Context & issue of the PTFI

-1- to measure beam **position,** σ x,y < 1mm$_{RMS}$

-2- beam **intensity,** dN/dt < 10^5 pps

-3- for **low energy**... typ. 10→60 keV

-4- (highly) **exotic** (=radioactive) eventually multiple decays

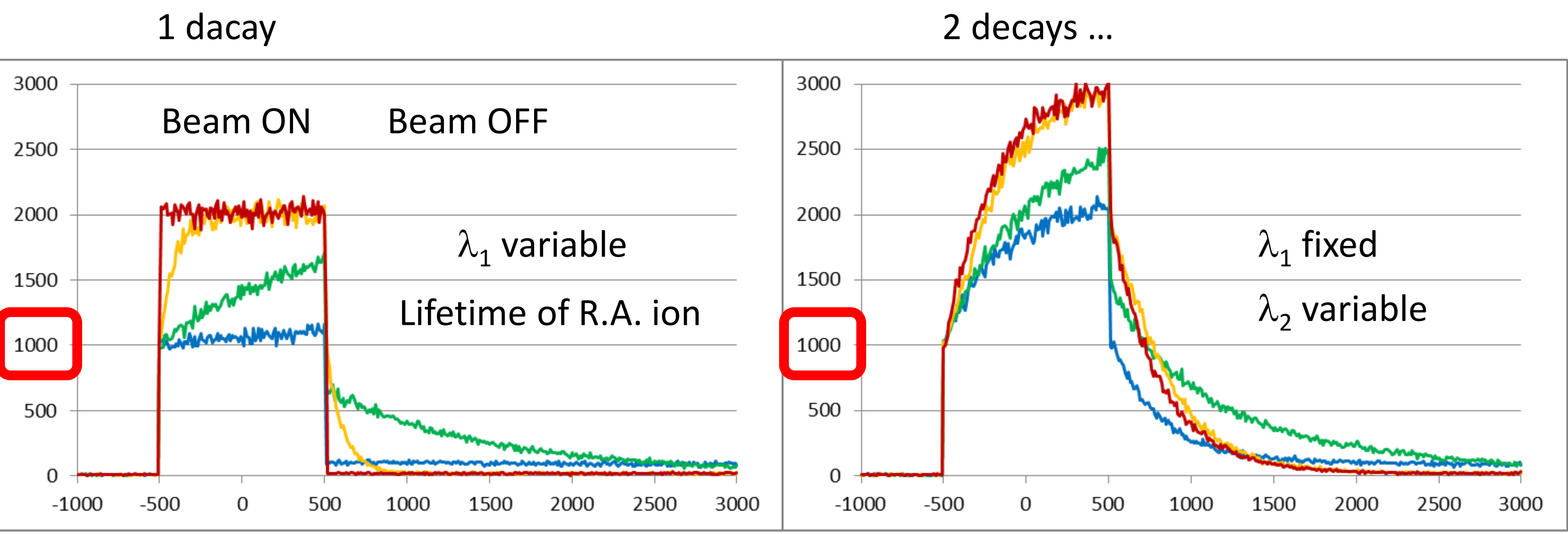
-5- **ions** beams range : few 10nm

-6- at GANIL SPIRAL II facility (no comment!)

THIS is the main chalenge of radioactive beams measurements…

Counting incident ions and ONLY incident ions, not β decays!!!

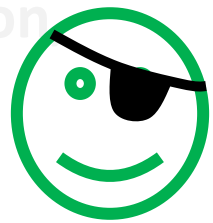
Exemple : 1000 ions/s



Context & issue of the PTFI

-1- to measure beam **position** σ x,y < $1mm_{RMS}$

Cheap !!!



-2- beam **intensity,** $dN/dt < 10^5$ pps

NO active electronics (preamps) near the beam line !!!

-5- **ions** beams

-6- at GANIL SPIRAL II facility (no comment!)

Programm

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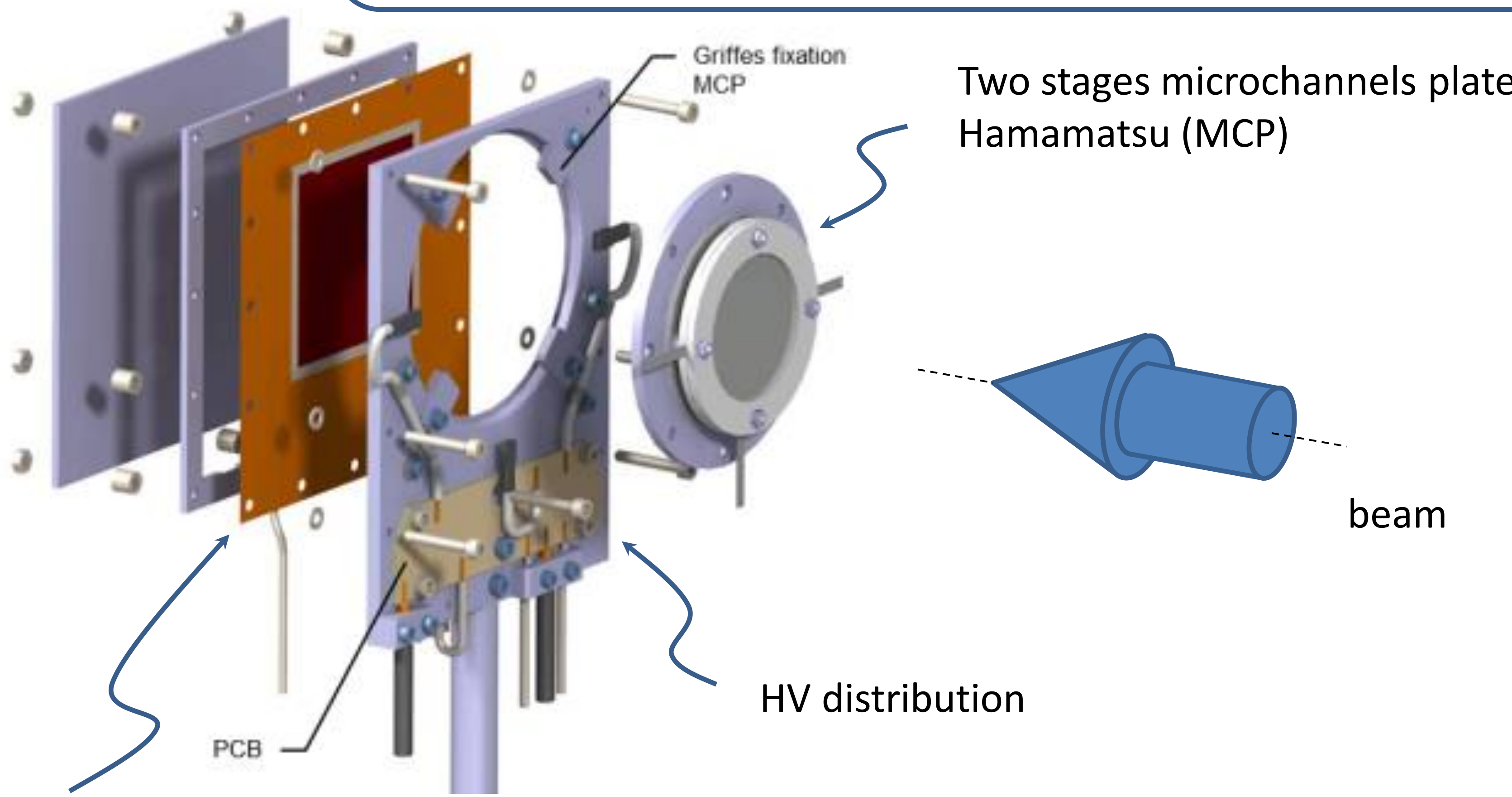
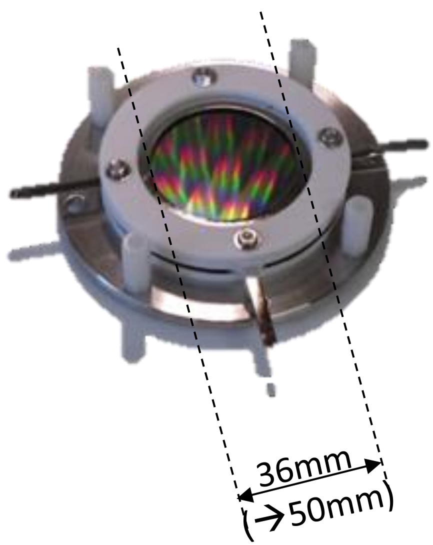
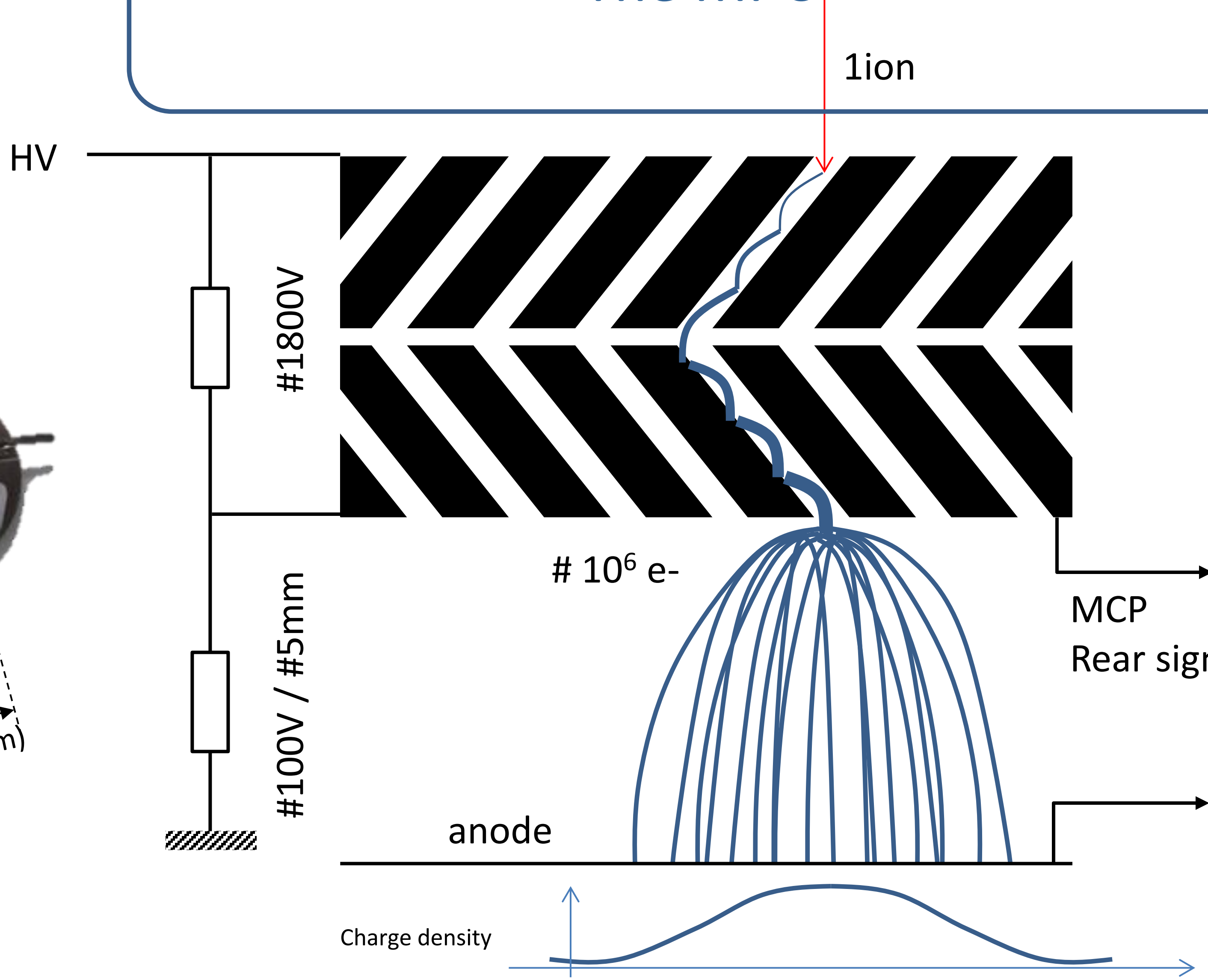
PTFI Drawings :



Localization : charge division resistive anode
(two sides kapton PCB)

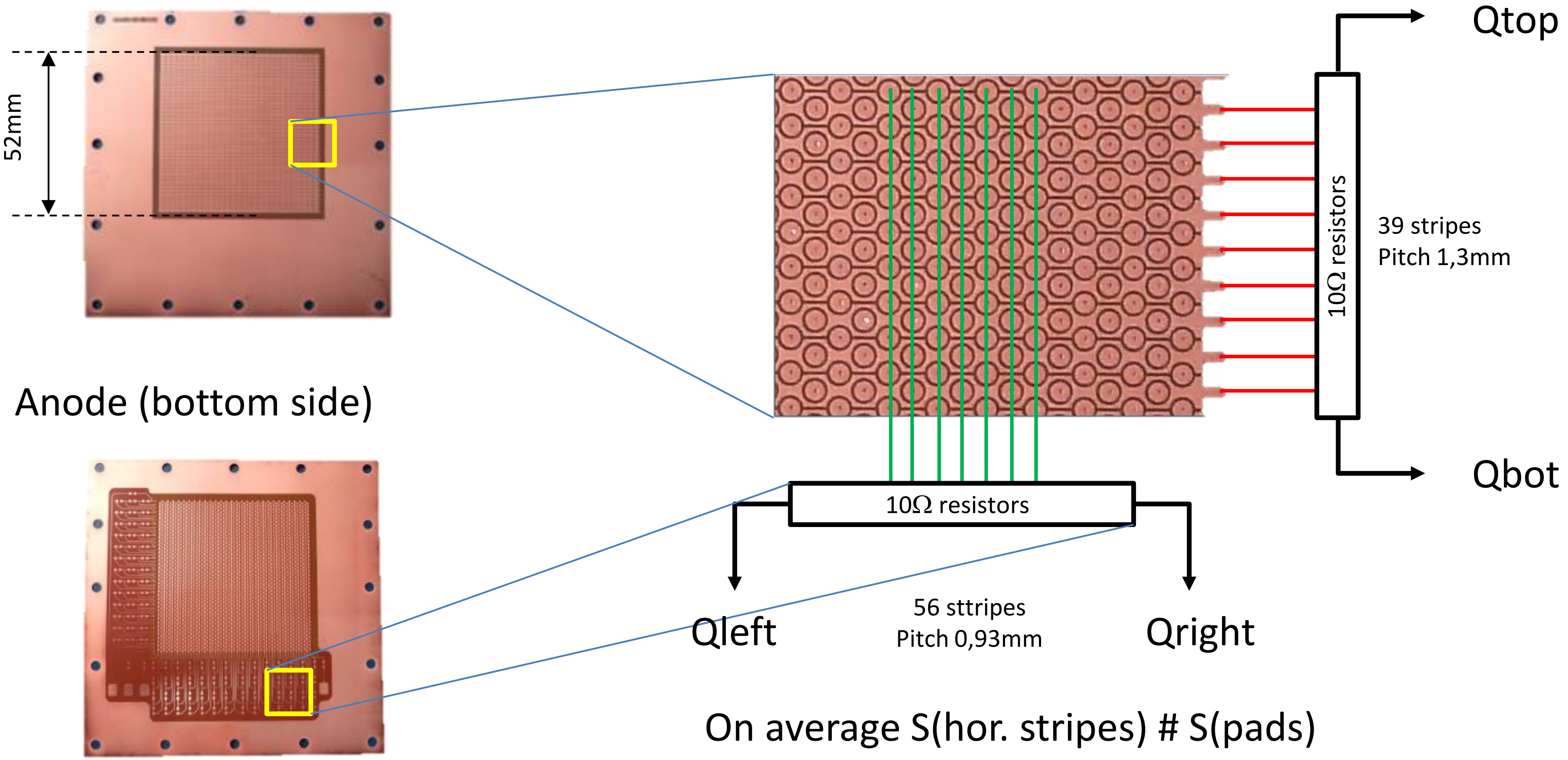
The MPC


36mm
(→50mm)


1ion
HV
#1800V
#100V / #5mm
10^6 e-
MCP
Rear signal
anode
Charge density

Two axis charge division resistive anode

Anode (top side = MCP)



On average S(hor. stripes) # S(pads)

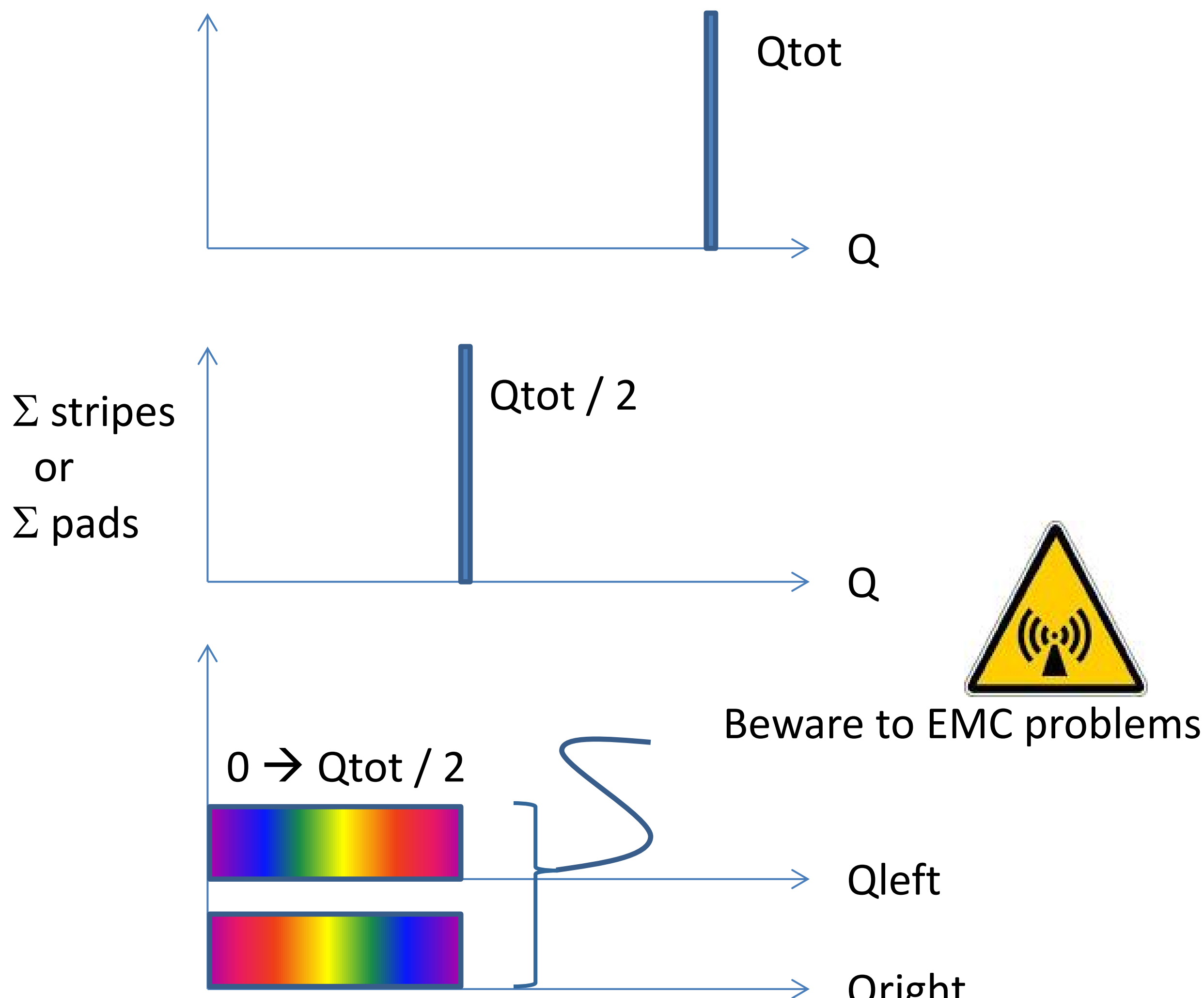
→ Qtot / 2 dans chacun

Charge spectra vs position

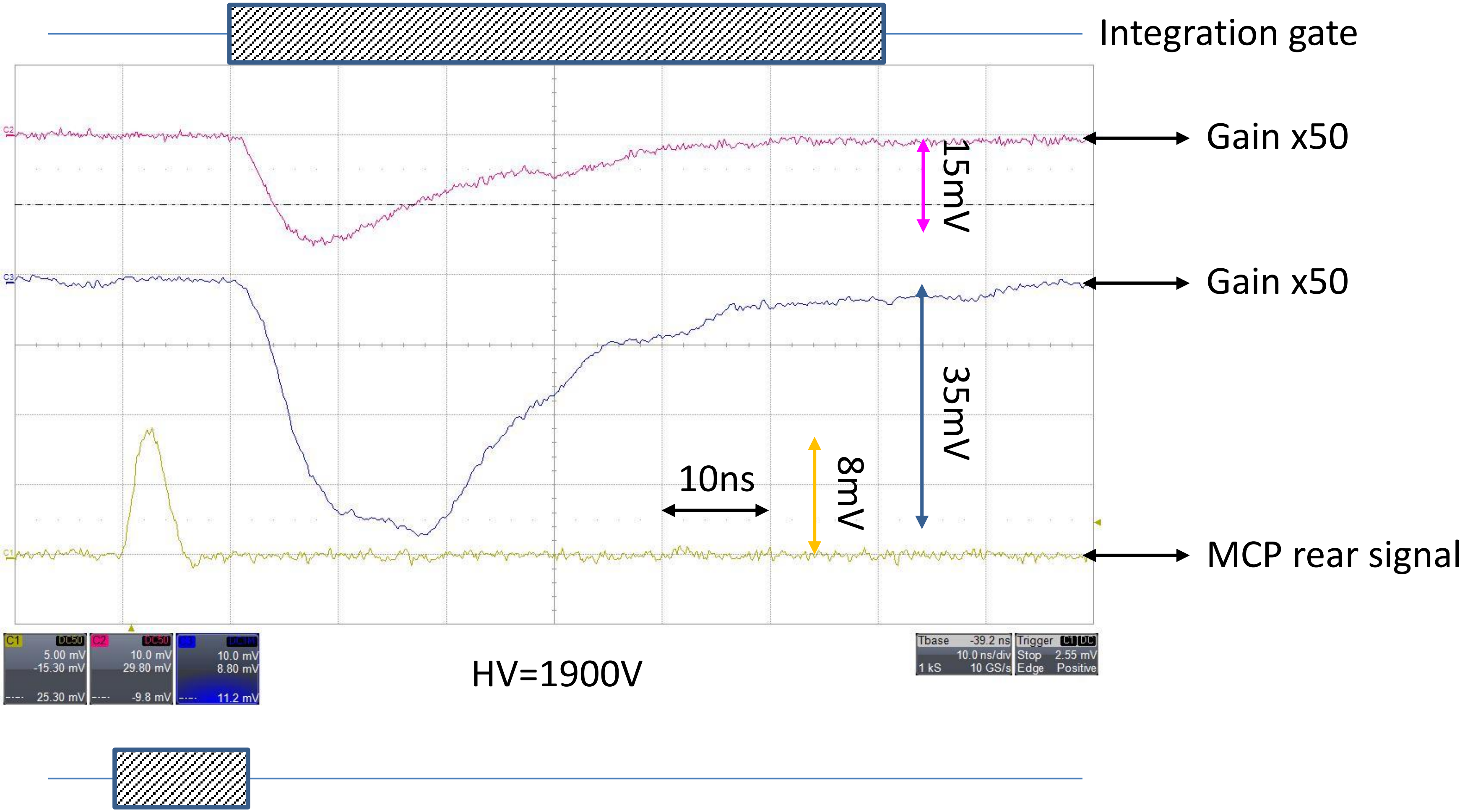
MCP rear charge:

On localization channels, at best :

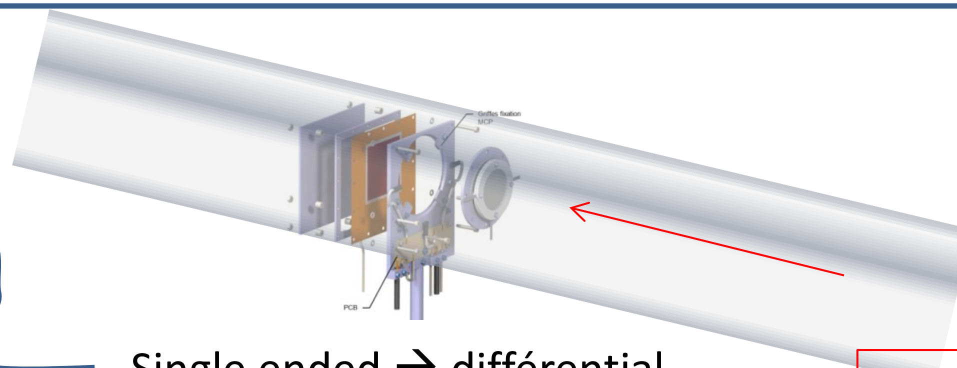
For individual signals, depending on position



Example of PTFI signals



Data acquisition



Single ended → différential

1 ion

faster.in2p3.fr

General purpose data acquisition system for time, charge, energy… measurements

FASTER :
3x syroco AMC
3x caras
1x HV ???
1x logic ???

RJ45 privé

Qtot
Qleft
Qright
Qtop
Qbot
date

Programm

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Spatial calibration

3 steps :

1) Gain matching
2) Distortion correction
3) Beam line reference transfer

$$[Qlef\,;Qright;Qtop;Qbot]$$

$$\Downarrow$$

$$[\tilde{x};\tilde{y}]$$

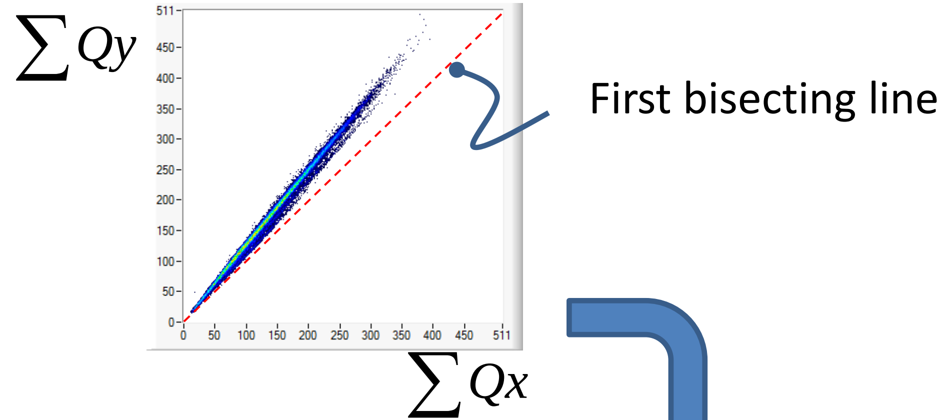
$$\Downarrow$$

$$[Xdest;Ydest]$$

... ready to use

Electronics gain matching

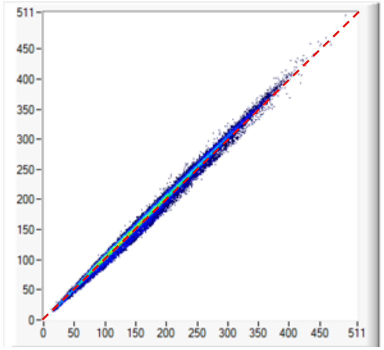
Based on charge conservation :



Just keep #1000 points
Uniformly selected on MCP front face
And solve by using a linear Least Squared fit

$$a \cdot Qleft + b \cdot Qright = c \cdot Qtop + 1 \cdot Qbot$$

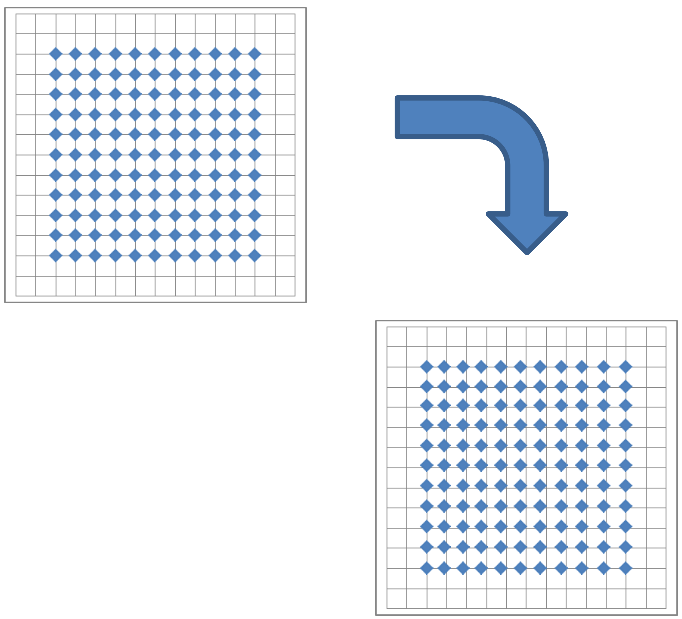
Typ. [a,b,c] # 1



Electronics gain matching

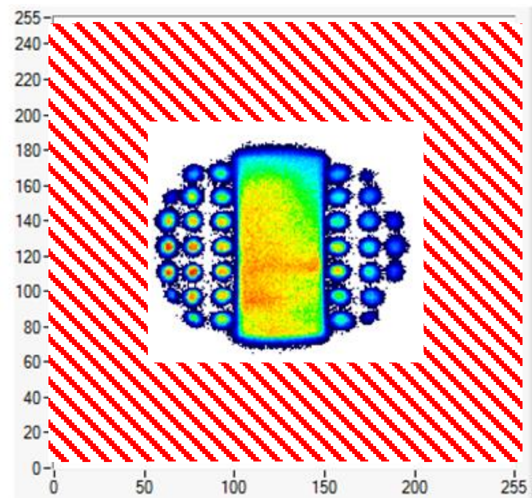
Position estimator

$$\begin{cases} \tilde{x} = \dfrac{a \cdot Qright - b \cdot Qleft}{a \cdot Qright + b \cdot Qleft} \\ \tilde{y} = \dfrac{c \cdot Qtop - 1 \cdot Qbot}{c \cdot Qtop + 1 \cdot Qbot} \end{cases}$$



+1

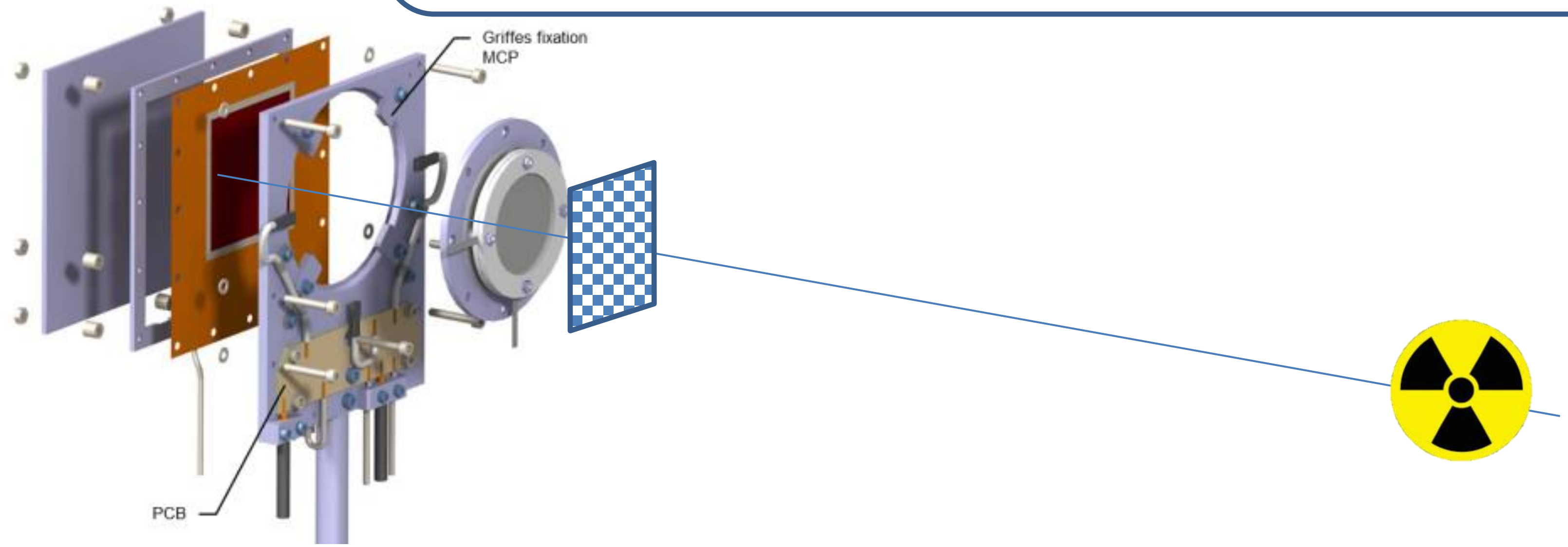
-1



-1 +1

Typ. [a,b,c] # 1

Distortion correction & Beam line reference transfer

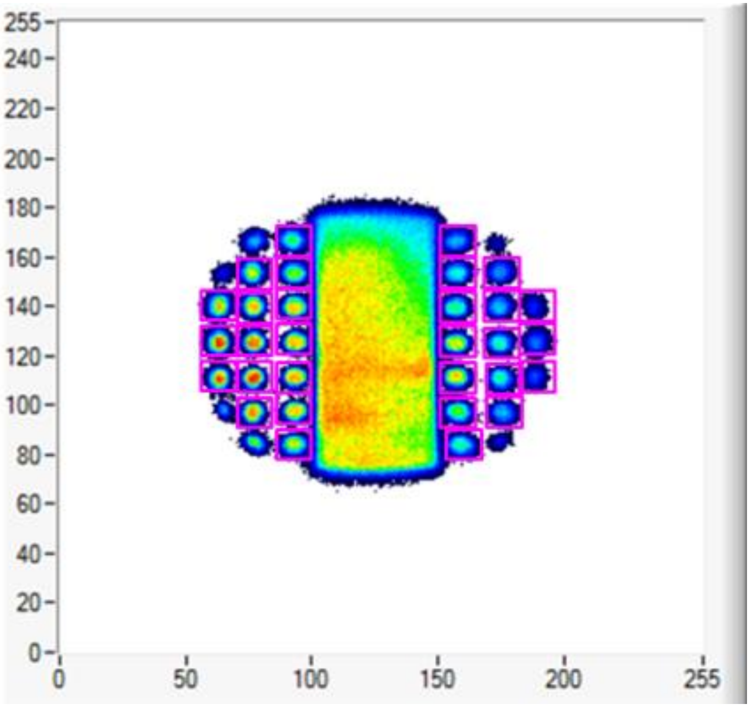


PTFI mounted on its propulsor

mask
holes referenced to
beam line coordinates,
placed near the MCP front face

Radioactive source
(α for inst.)
at beam axis

Distortion correction & Beam line reference transfer

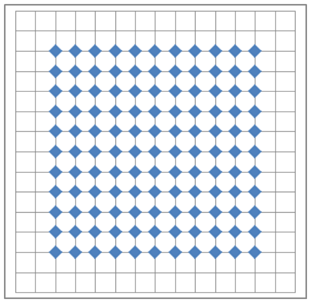


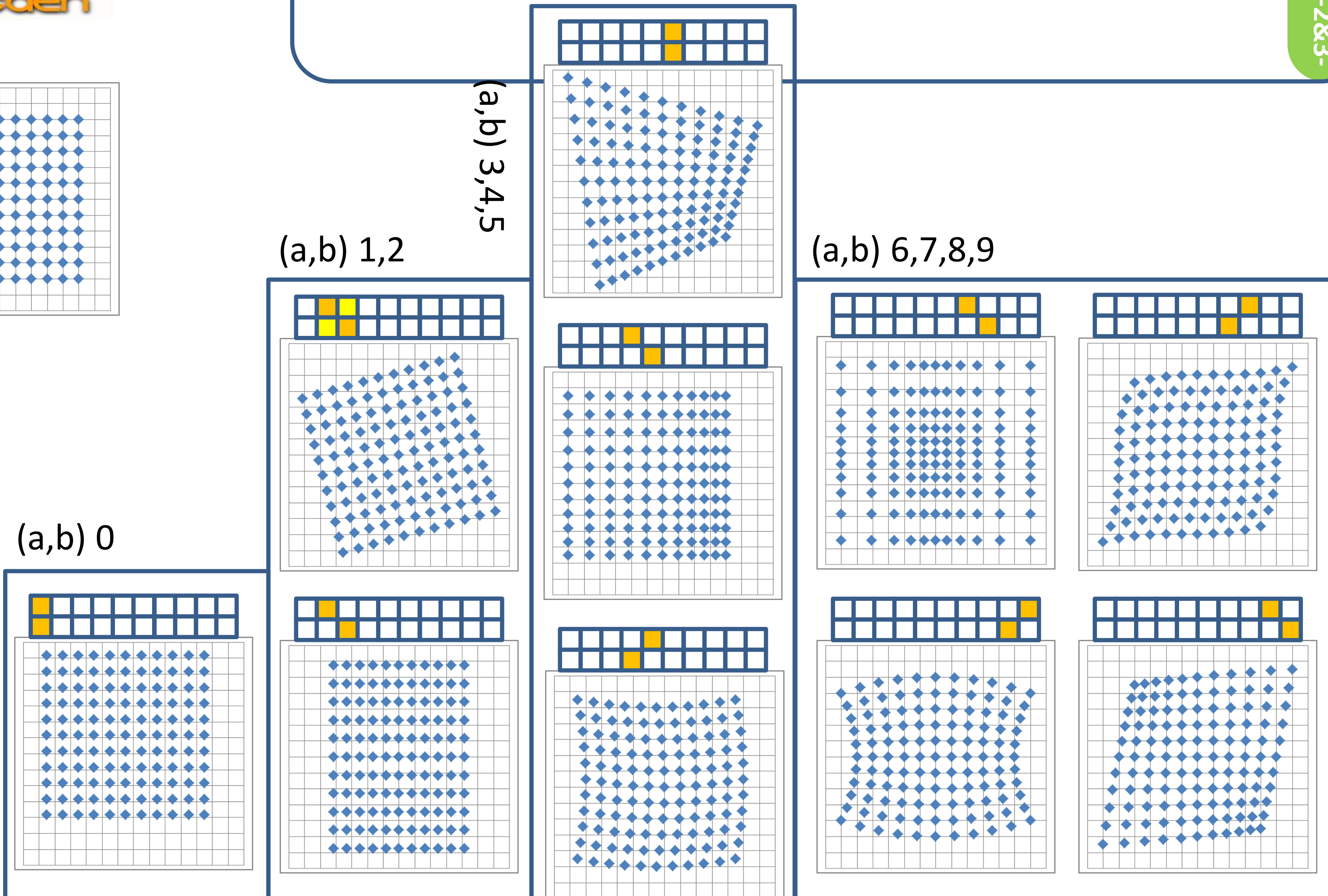
One just have to measure
([x,y] in arb. units)
centroïd position of every hole
([Xdest,Ydest] known in « beam line units » thank's to the mask)

$$Xdest = a_0 + a_1 \cdot x + a_2 \cdot y + a_3 \cdot x^2 + a_4 \cdot y^2 + a_5 \cdot x \cdot y + a_6 \cdot x^3 + a_7 \cdot y^3 + a_8 \cdot x^2 \cdot y + a_9 \cdot x \cdot y^2$$

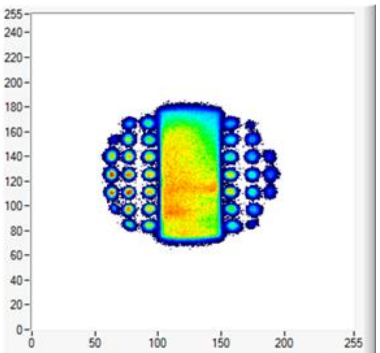
$$Ydest = b_0 + b_1 \cdot x + b_2 \cdot y + b_3 \cdot x^2 + b_4 \cdot y^2 + b_5 \cdot x \cdot y + b_6 \cdot x^3 + b_7 \cdot y^3 + b_8 \cdot x^2 \cdot y + b_9 \cdot x \cdot y^2$$

« general » transformation function

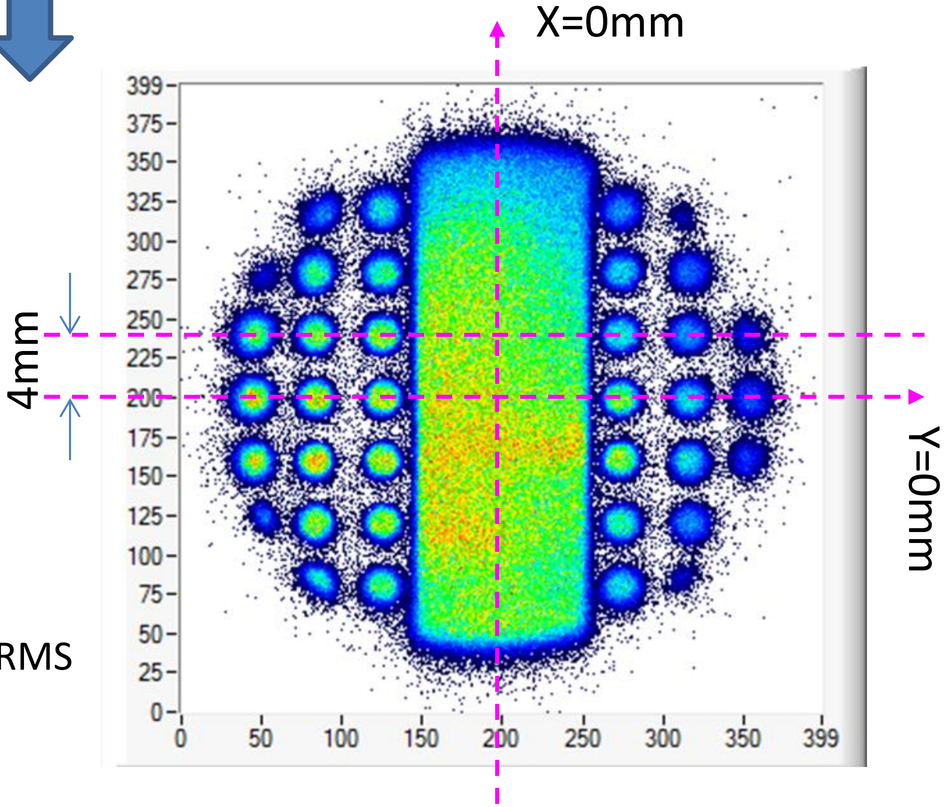




Beam image referenced to beam line coordinates



A.U.



Beam line coordinates (mm)

For each ion:

Position uncertainty ≈ 250µm$_{RMS}$

Programm

Context & issue

The object we called PTFI

Beam imaging

Beam intensity measurement

Conclusion

Ions intensity measurement

3 steps :

1) MCP spatial gain correction
2) Reference spectra (ions, β) learning
3) Ions/decays unfolding

$$[\text{rawspectra}(x,y)](Q)$$

$$\Downarrow$$

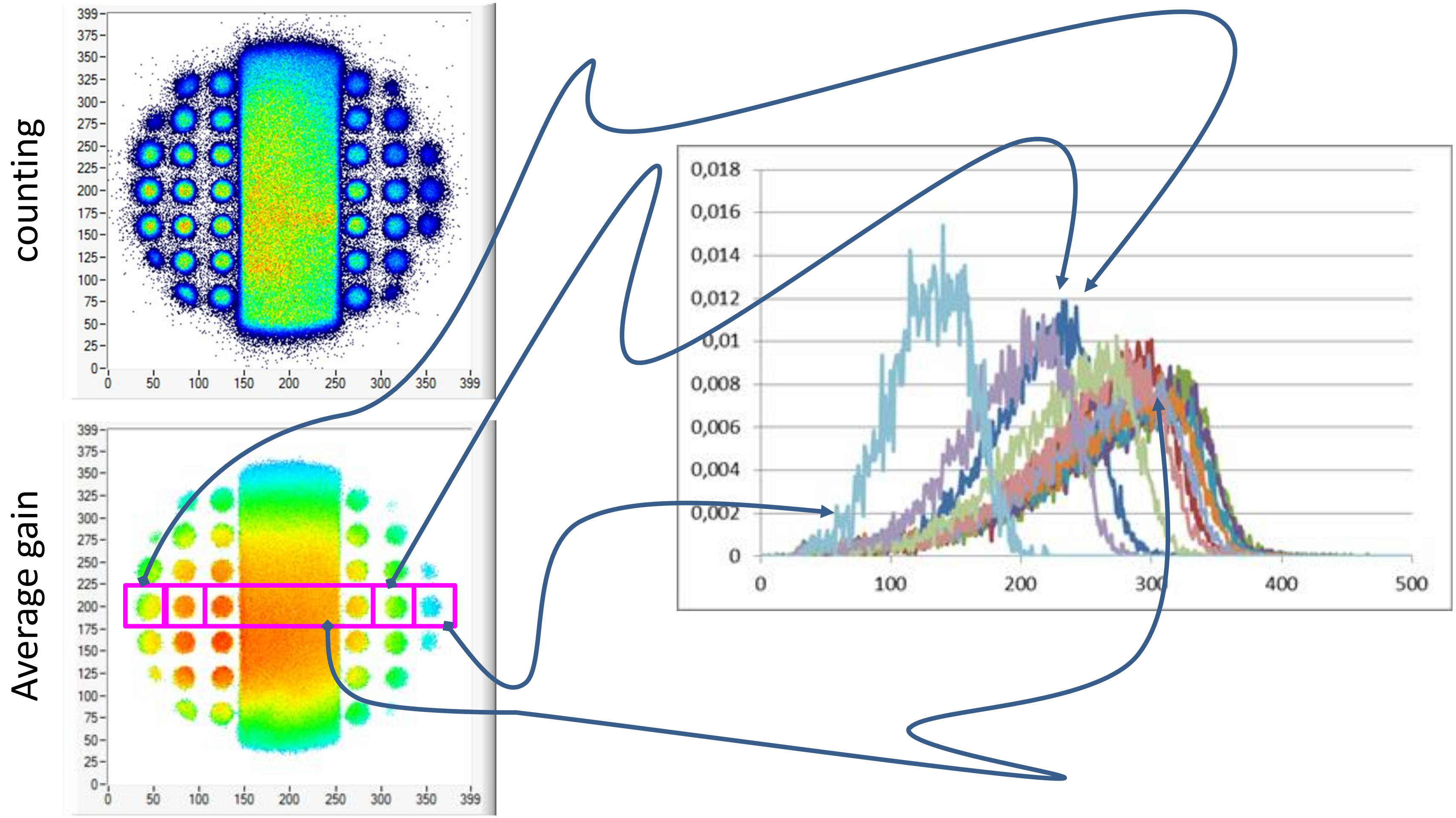
$$[\text{standardized spectra}(x,y)]$$

$$\Downarrow$$

$$[\beta\_\text{ref}(x,y)];[\text{ion\_ref}(x,y)]$$

… ready to use

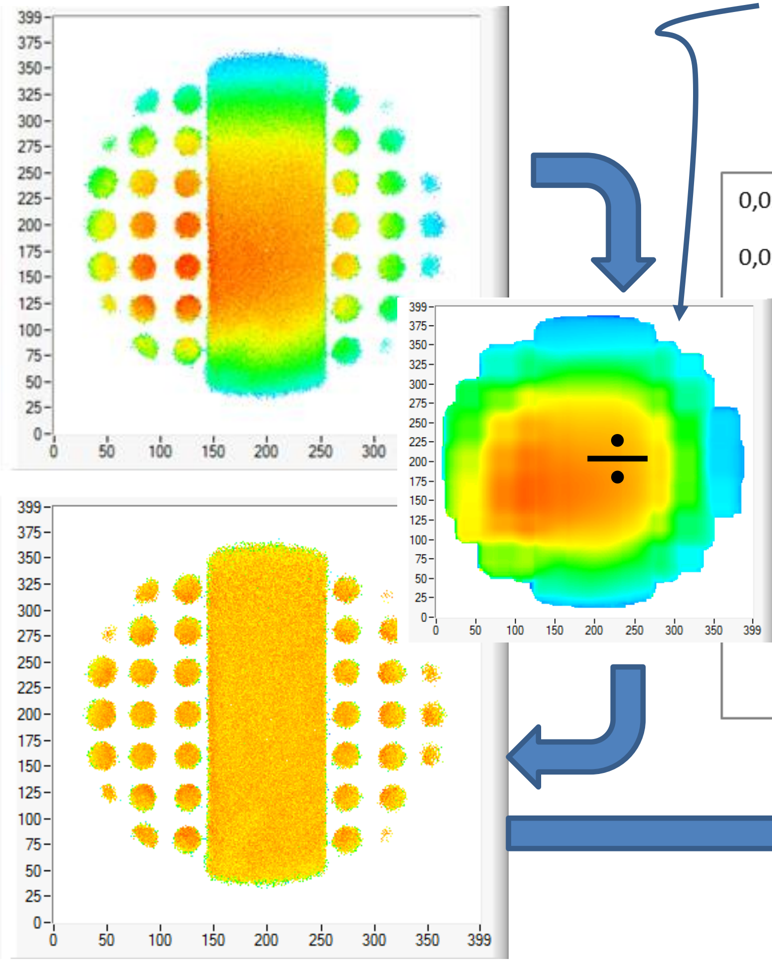
The MCP gain is NOT uniform



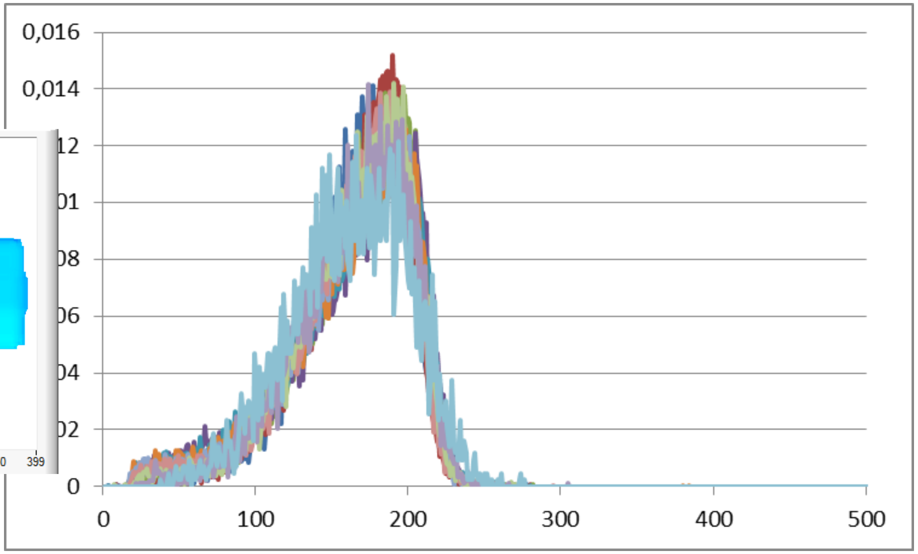
MCP gain standardization

Current map

Corrected map



Gain correction map
(measured by the mean
of a radioactive source (for inst.))



Must be performed once for all.

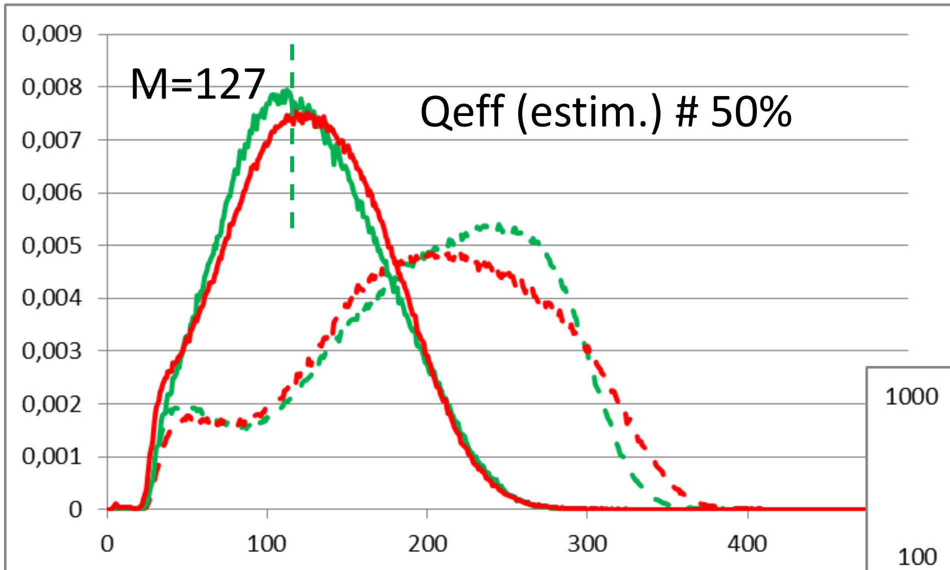
Let's have a look at measurements

Mixed beam

(35-40)**Ar**1+ @10keV

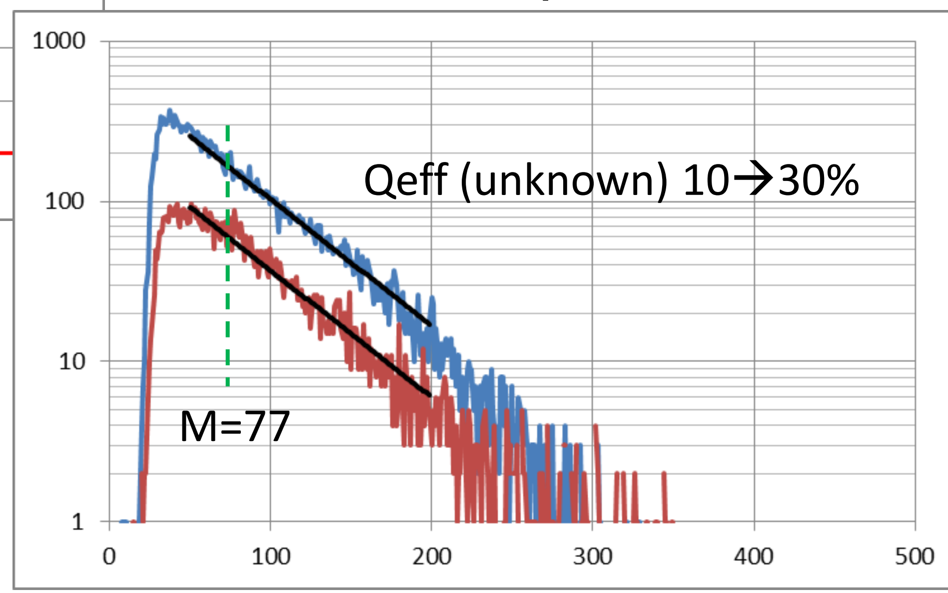
Stable beam

36**Ar**4+ @(25-30)keV



Problem -1-
Ions spectra (←) depend on …

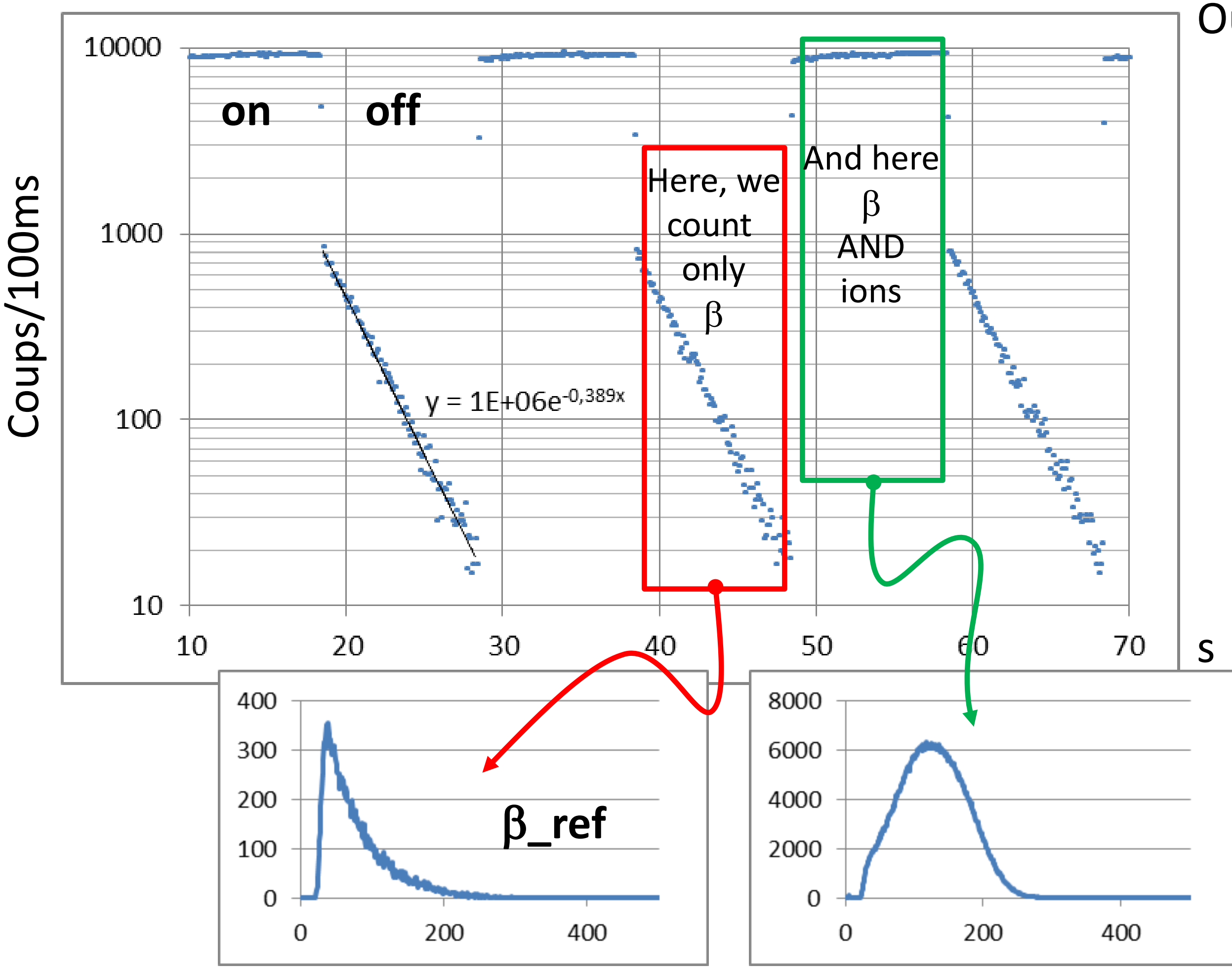
MCP background & β decays spectrum



Problem -2-
One can efficiently measure β spectra (→) but ions are always in presence of their β decays…

And now…
hang on to your seats & let's have fun!

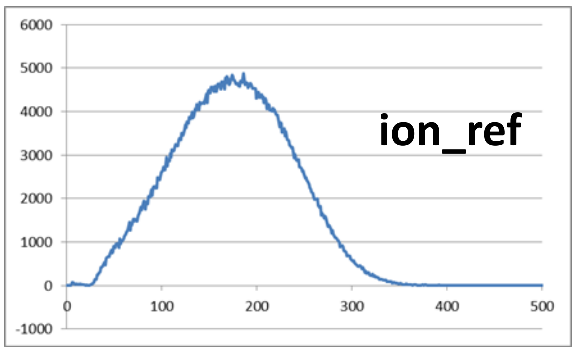
Chopped beam



Our objective :

Counting ONLY ions

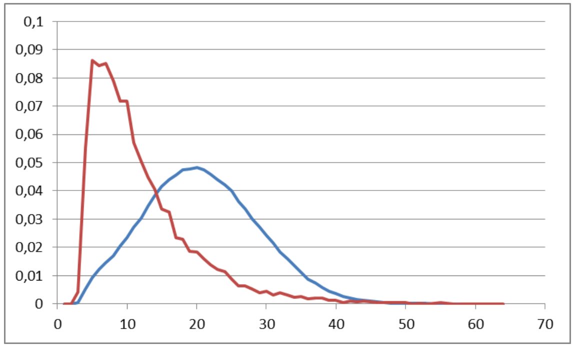
Spectre ions pur



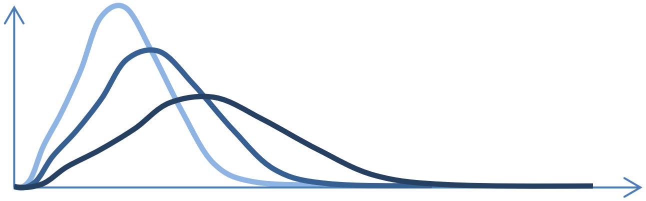
By measuring β decays shape vs time, one can decude how many decays were present during ions implantation

And now…
hang on to your seats & let's have fun!

We learned experimental spectra (β & ions) → basis spectra



We mount ions spectrum on a « rubber band » → scaling purpose

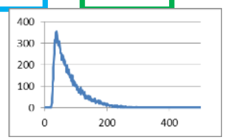


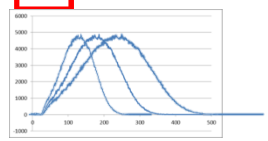
Step -3- : we fit experimental spectra with β and elastic ions basis spectra

And now…
hang on to your seats & let's have fun!

We adjust experimental spectrum by the mean of :

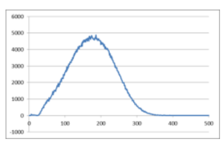
$$curr\_spectrum[i] = |n_\beta| \cdot \beta\_ref[i] + |n| \cdot ion\_scaled(\alpha \cdot i) \qquad n_{ions} = |n/\alpha|$$

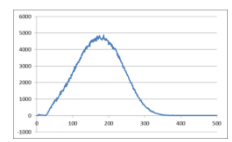


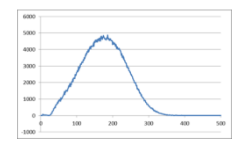


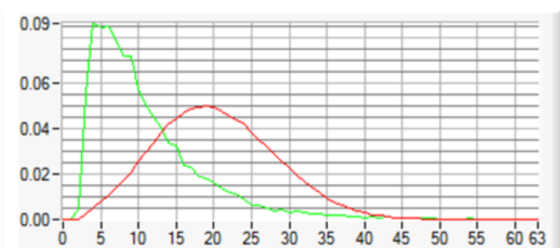
Spectrum interpolation used for scaling purposes:

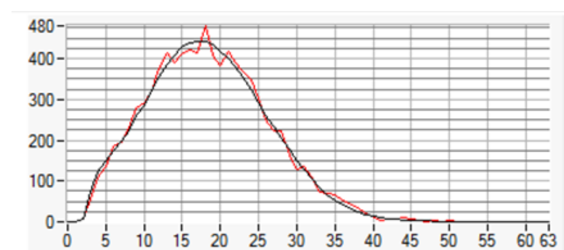
$$ion\_scaled(x) = ion\_ref[\mathrm{int}(x)] + (x - \mathrm{int}(x)) \cdot (ion\_ref[\mathrm{int}(x)+1] - ion\_ref[\mathrm{int}(x)])$$





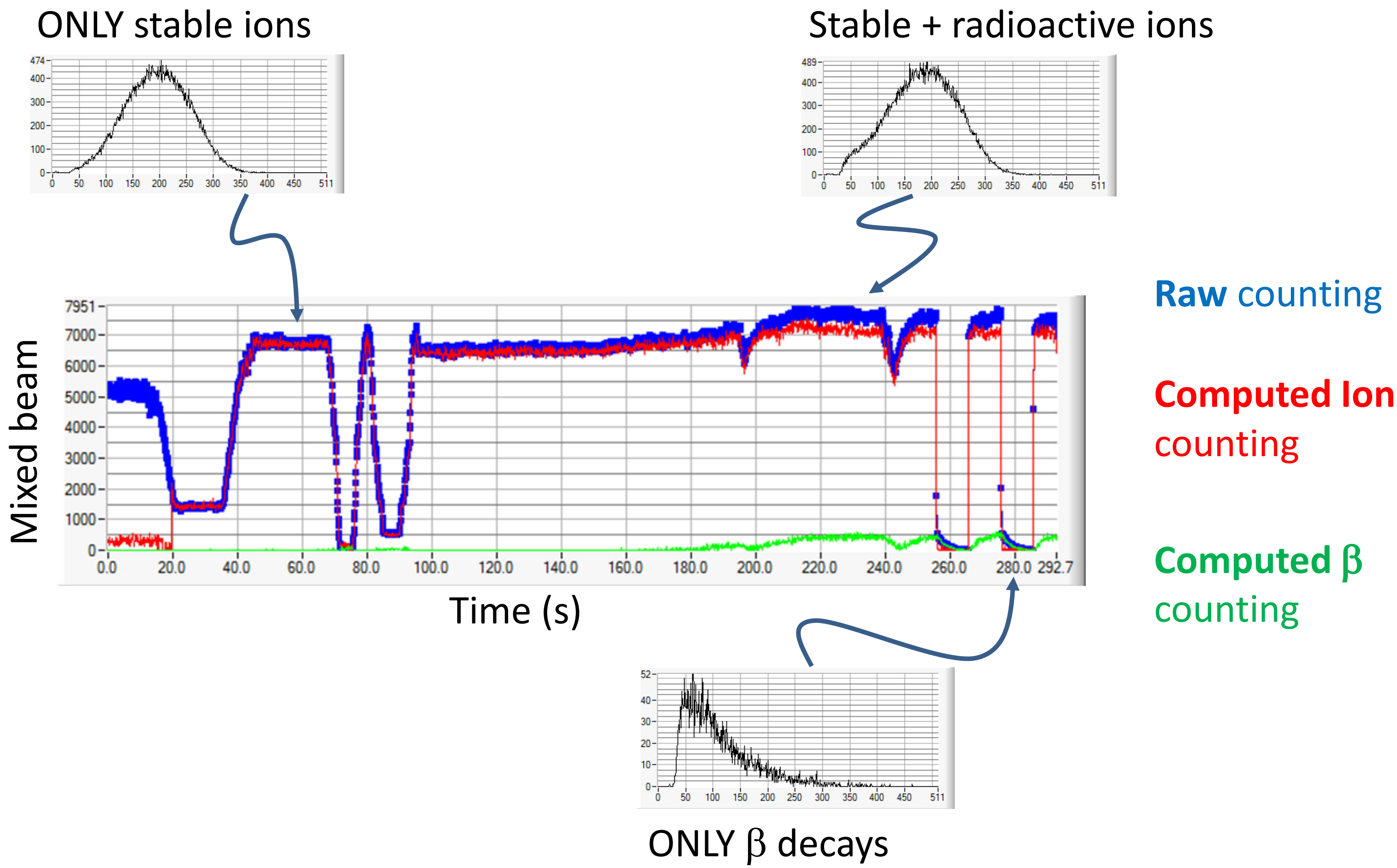




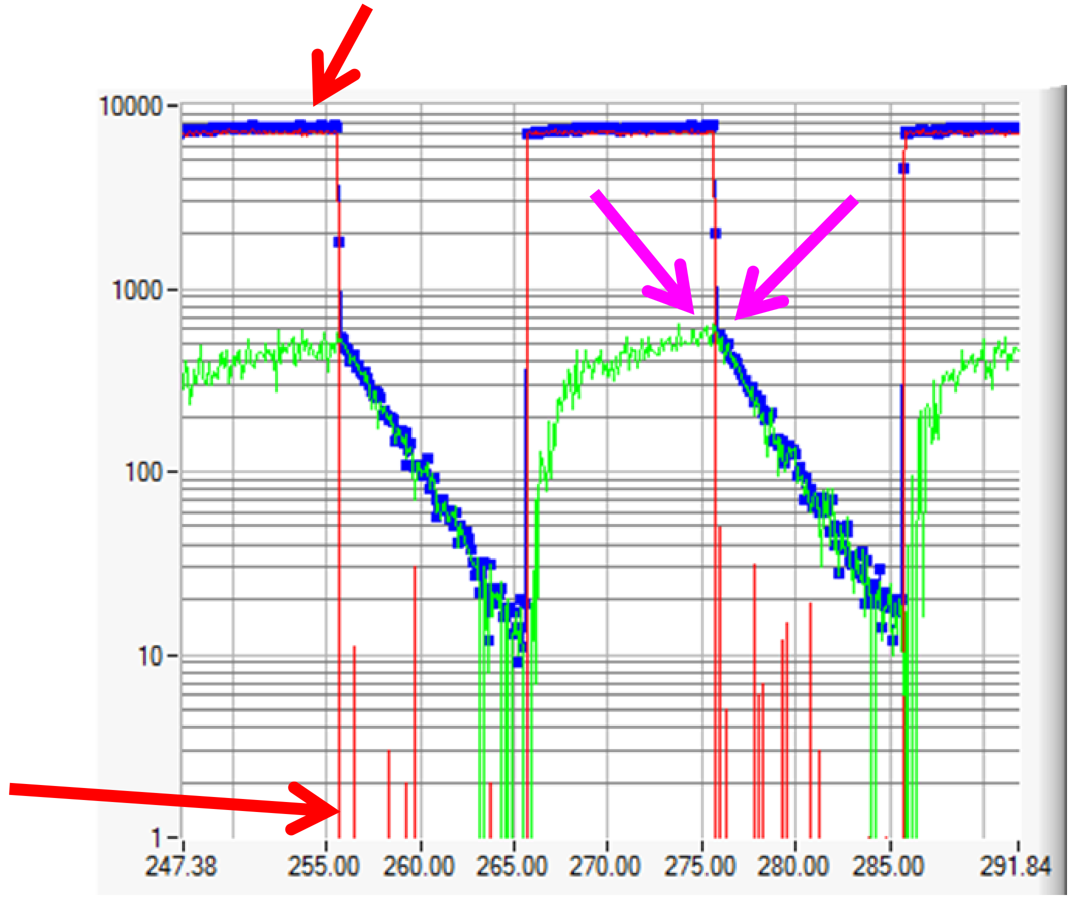


It works for dilatation/contraction up to 50%

At least, particles are correctly identified



At least, particles are correctly identified



Raw counting

Computed Ion counting

Computed β counting

Programm

Context & issue

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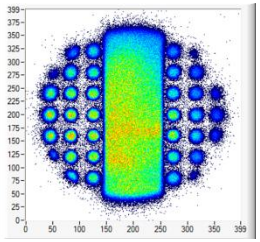
Conclusion

It works !!! (at least it seems to work)

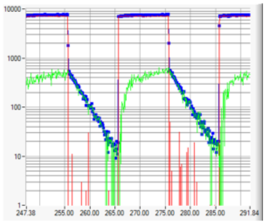
Position uncertainty << $1mm_{RMS}$

(for each ion ! → far better for the beam)



2D beam image !!! (not X and Y projections)

One can clearly identify β and ions contributions in the total counting

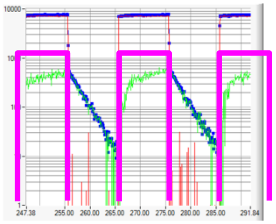


The unfolding procedure is ROBUST

→ tested for scaling parameters in the range [0.5 ; 1.5]

Next step

Test it with pure radioactive beams with multiple decays



If we knew (measured, estimated ?) Qeff(ions) & Qeff(β)…

→ we would be able to measure N'_{stable} AND $N'_{radioactive}$

Thank's

The team:

detector:	Jérôme perronnel
vacuum:	Christophe Vandamme
mechanics:	Damien Goupillère
electronics:	Laurent Leterrier, Sébastien Drouet
data acquisition:	Faster Team (faster.in2p3.fr)
calcul & interface :	Jérôme Poincheval

+ J-M Fontbonne & M. Parlog