the H A L O Monitor

The vertical beam Halo monitor

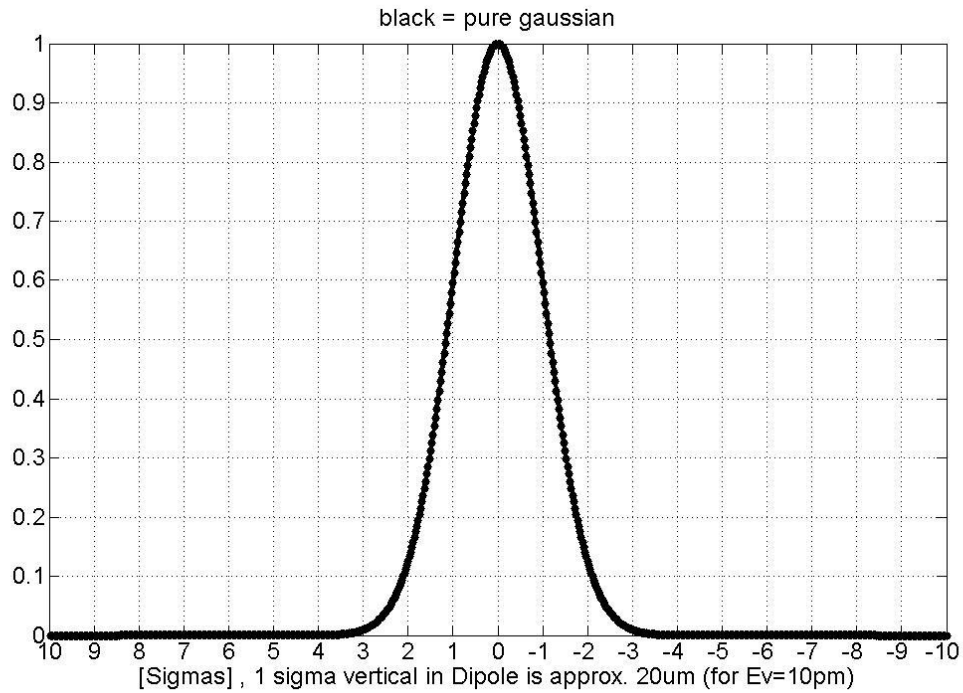
1) the Halo itself : what is it ?
what creates it ?
how does its vary with different conditions ?

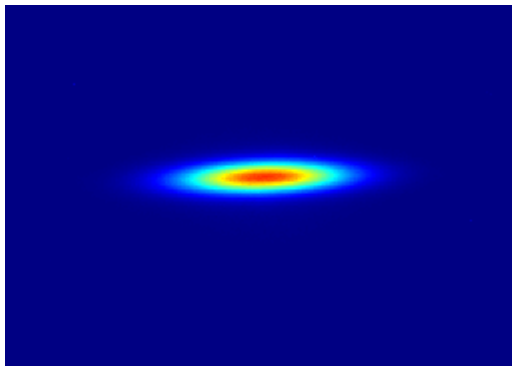
2) Principle of technique :

- using X-rays from a dipole
- on a beamport with adapted absorbers
- with a light-blocker to shadow against the intense beam-core
-and a sensitive detector further down-stream

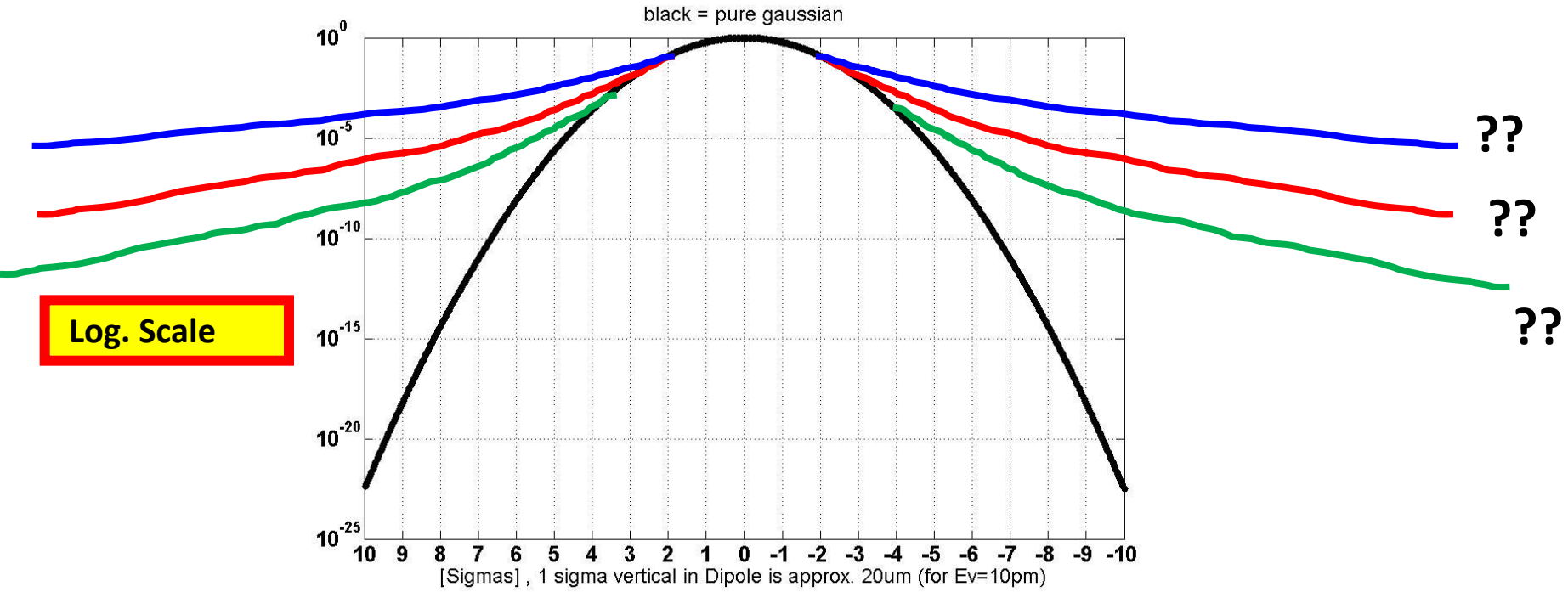
3) Results, Calibration, Initial Problems & Solutions, Conclusions

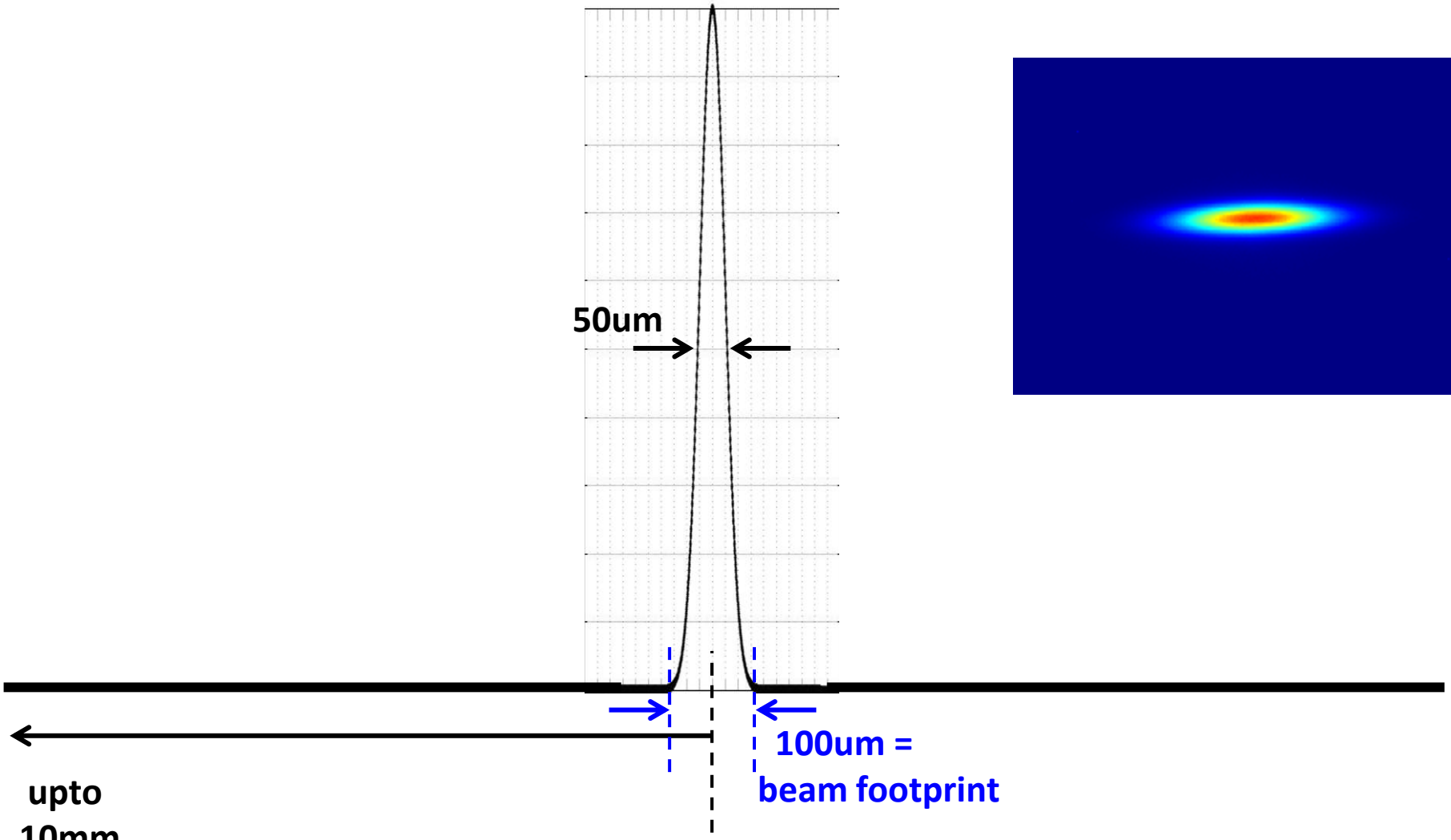
Linear Scale





Log. Scale

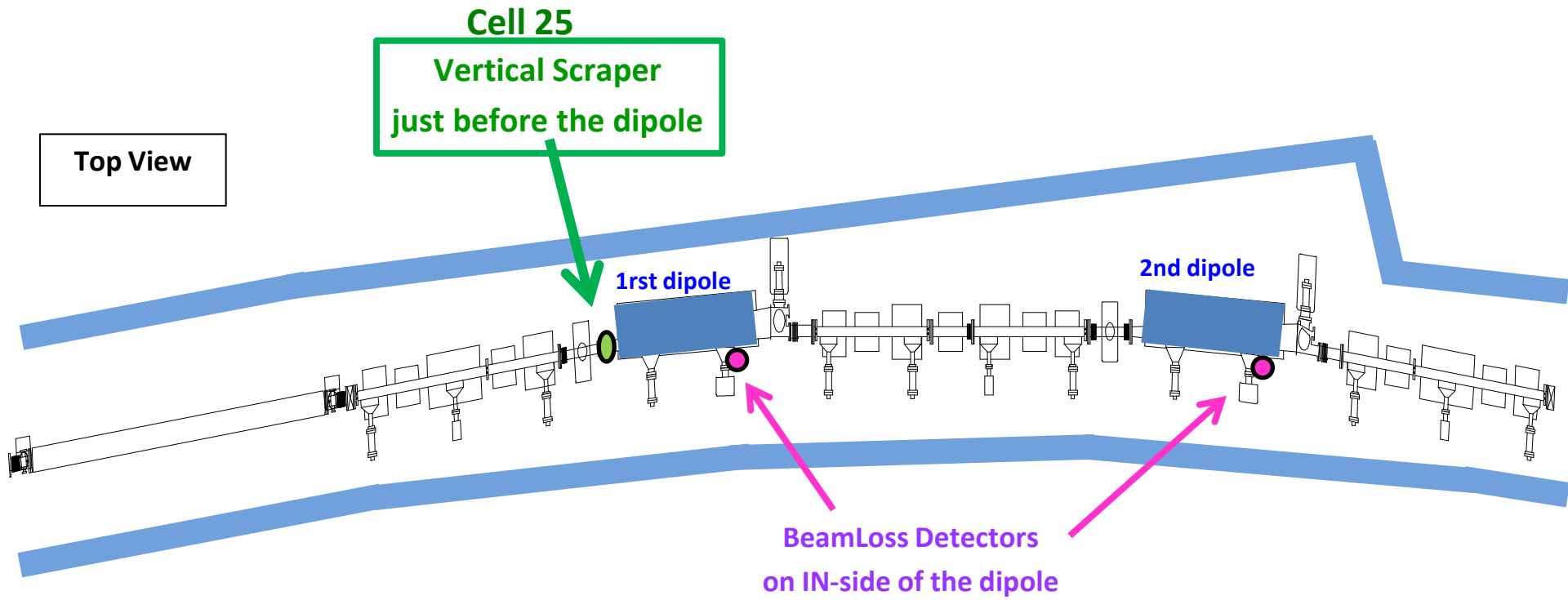




i.e. 100 x footprint

there are still electrons .....

Scraper Manipulations



In total in the Ring :

1 horizontal scraper (C4)

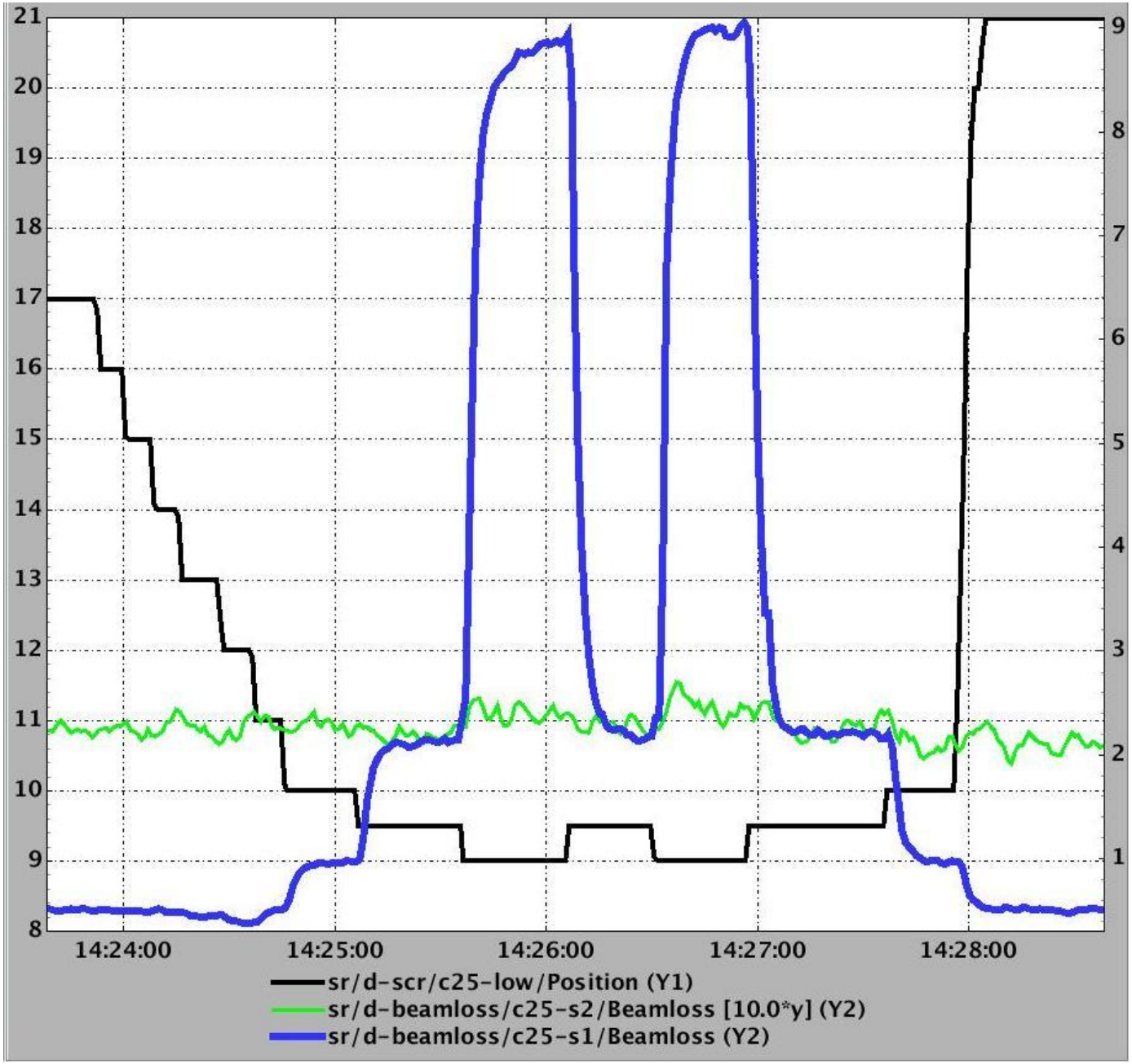
3 vertical scrapers (C5, C22, C25)

Scraper material & thickness very different :

Copper : 20mm, 30mm, 90mm

Tantalum : 90mm

Black : Scraper position [mm]



Blue : BLD-signal [a.u.]

The vertical beam Halo monitor

what is the Halo ? Electron density, at "large" distance from the central core

what creates it ? **Scattering** between :
- the electrons themselves (Touchek)
- electrons & residual gas particles

how does its vary with different beam conditions ?

- stronger beam density → stronger Halo
- poor vacuum → stronger Halo

The non-destructive vertical beam Halo monitor

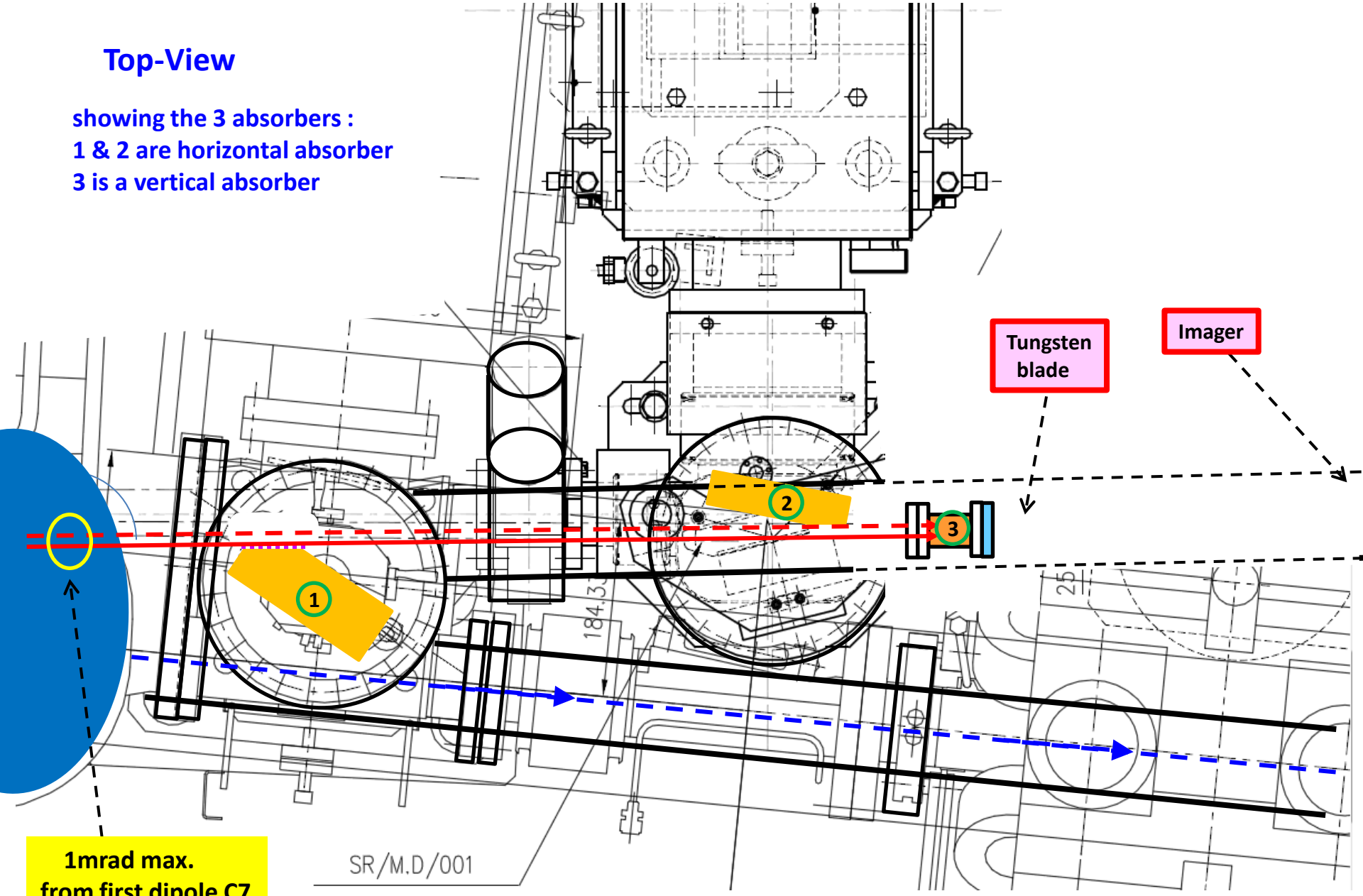
Principle of technique :

- using X-rays from a dipole
- on a beamport with an adapted absorber
- with a light-blocker to shadow against the intense beam-core
- and a sensitive detector further down-stream

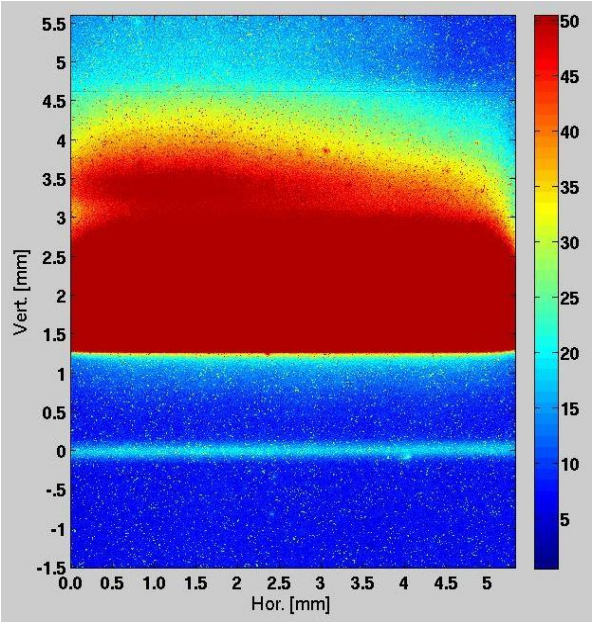
Goal : the permanent monitoring of the Halo intensity,
in a region of 2 – 10mm above the beam-core,
and with a calibrated value of this intensity

Top-View

showing the 3 absorbers :
1 & 2 are horizontal absorber
3 is a vertical absorber

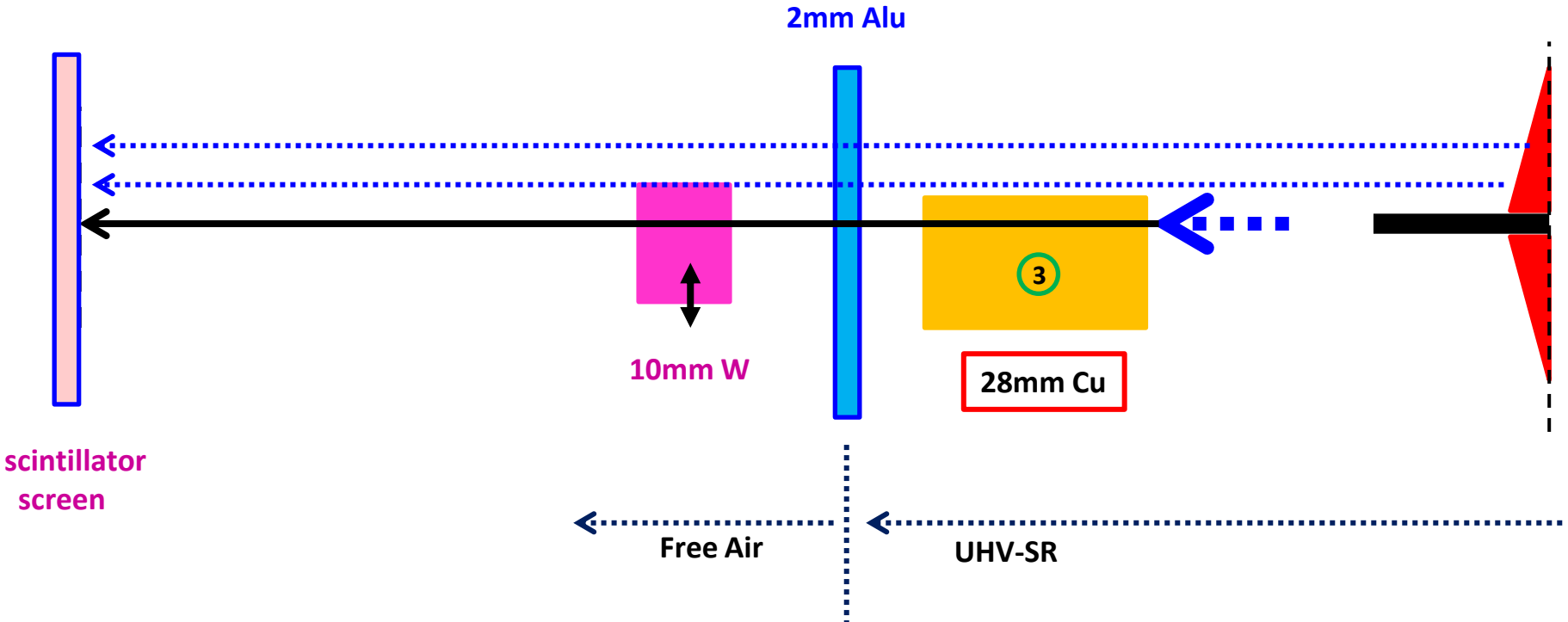


Side-View

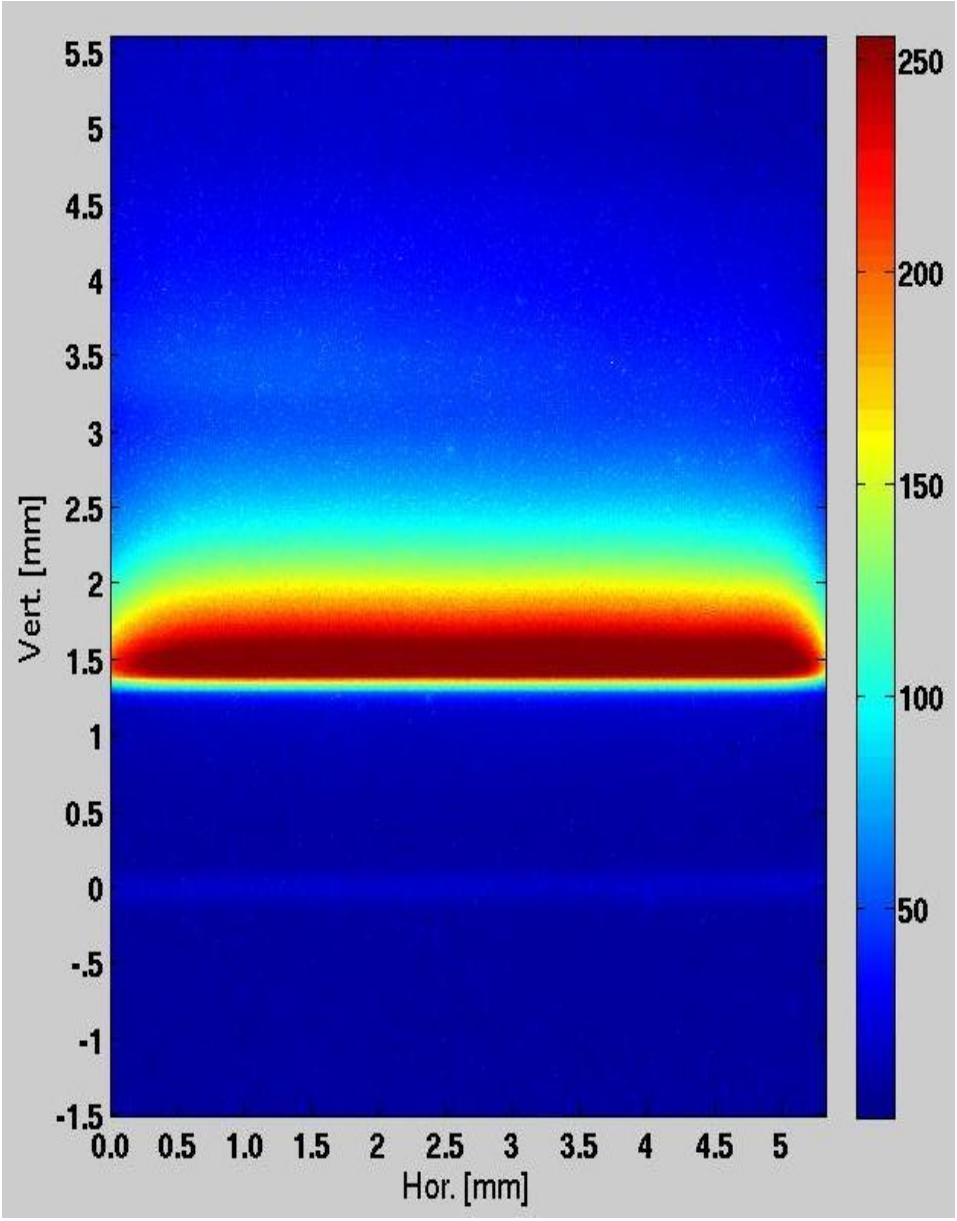


is this the Halo ? or is it an artefact (scattering, reflection) ??

from the beam-core (very strongly attenuated)

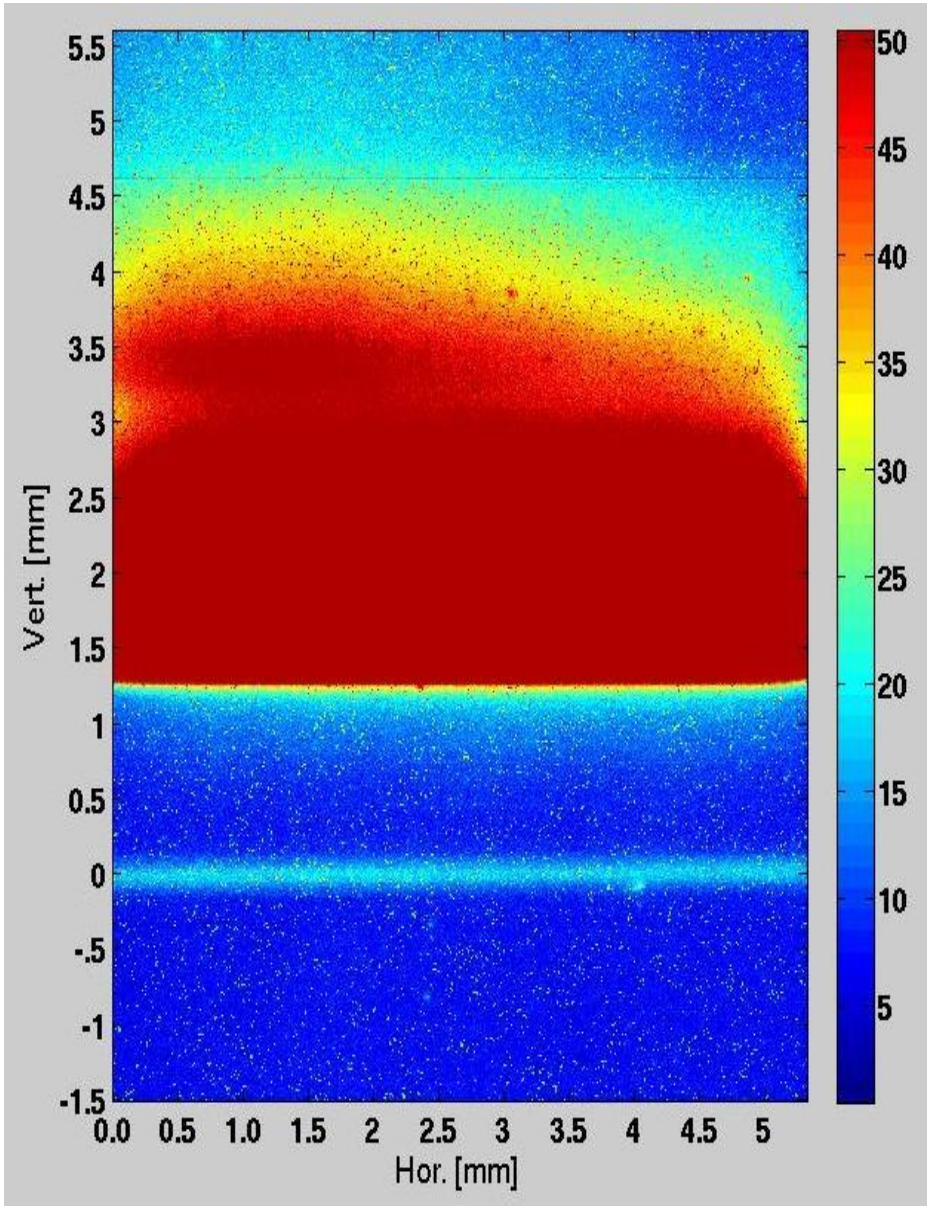


Colormap 250



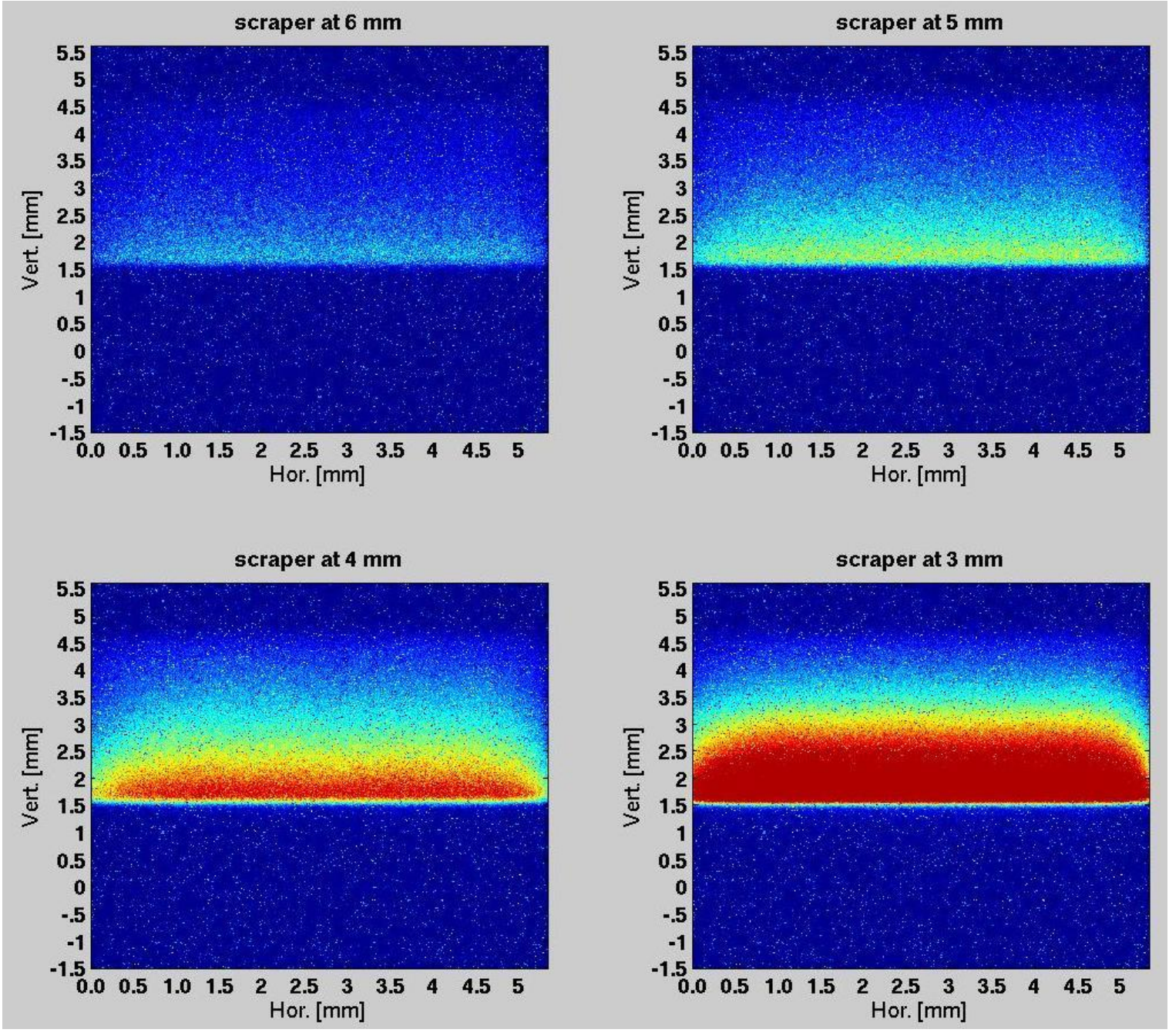
Hor. Accepted Dipole Radiation ~1mrad

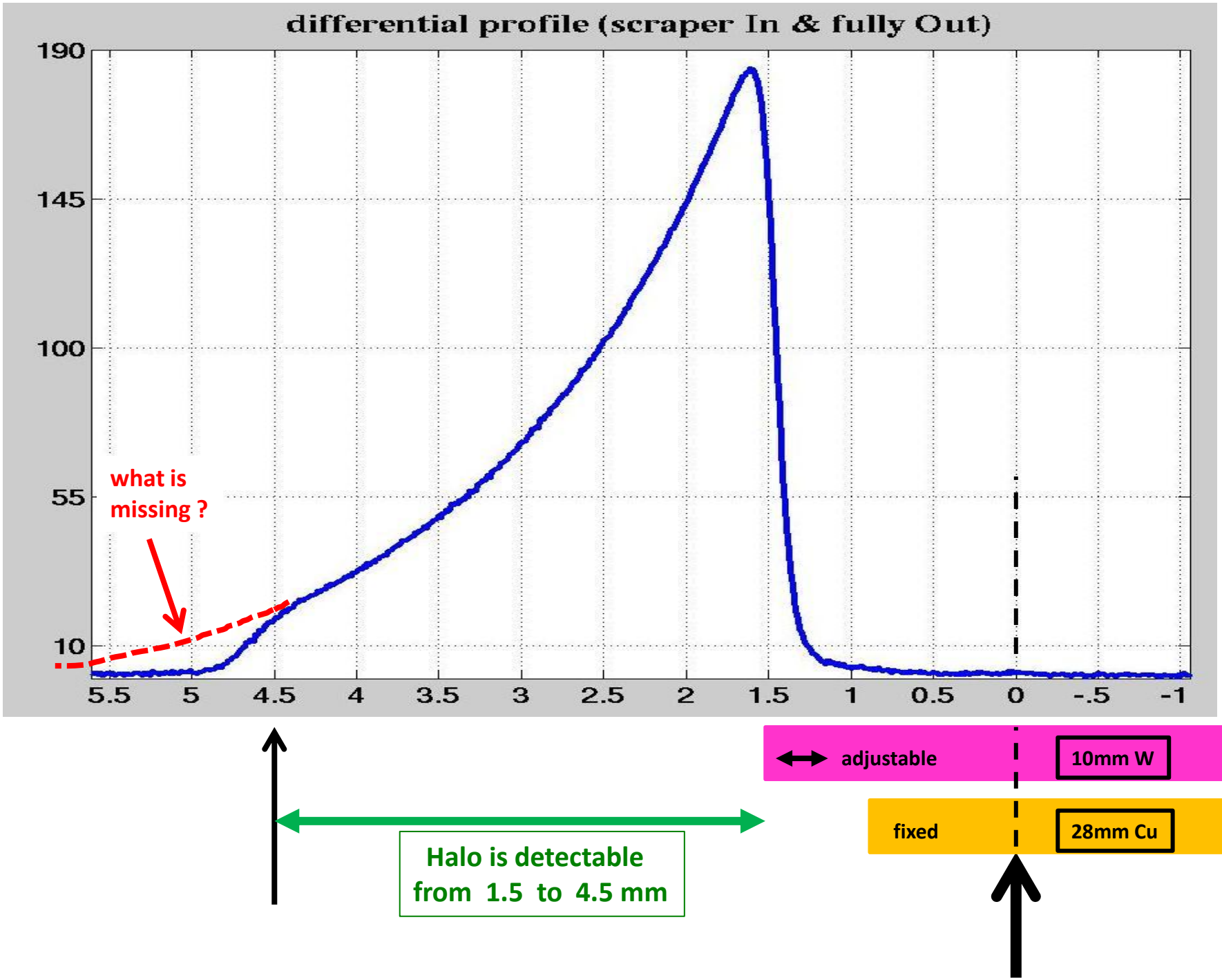
Colormap 50



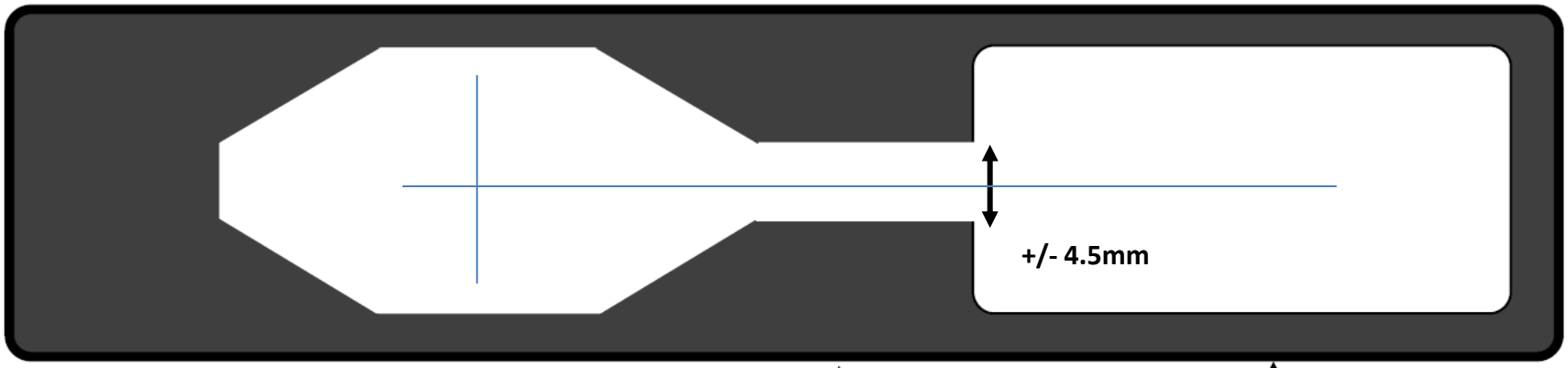
Hor. Accepted Dipole Radiation ~1mrad

Differential Images while scraping




differential profile (scraper In & fully Out)
190
145
100
55
10
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-.5
-1
what is
missing ?
adjustable
10mm W
fixed
28mm Cu
Halo is detectable
from 1.5 to 4.5 mm

Dipole chamber cross-section



Electron Beam Chamber

Photon Beam Chamber

RF shielding
Standard gap = 9 mm

Results with various Beam manipulations :

1) Closing the In-Vac undulators : to verify if (and how much) they “scrape” the beam

2) Detecting the fluctuations of the UHV quality (detecting ultra-small gas-outbursts)

3) Measuring the Halo strength while varying the Touchek scattering conditions

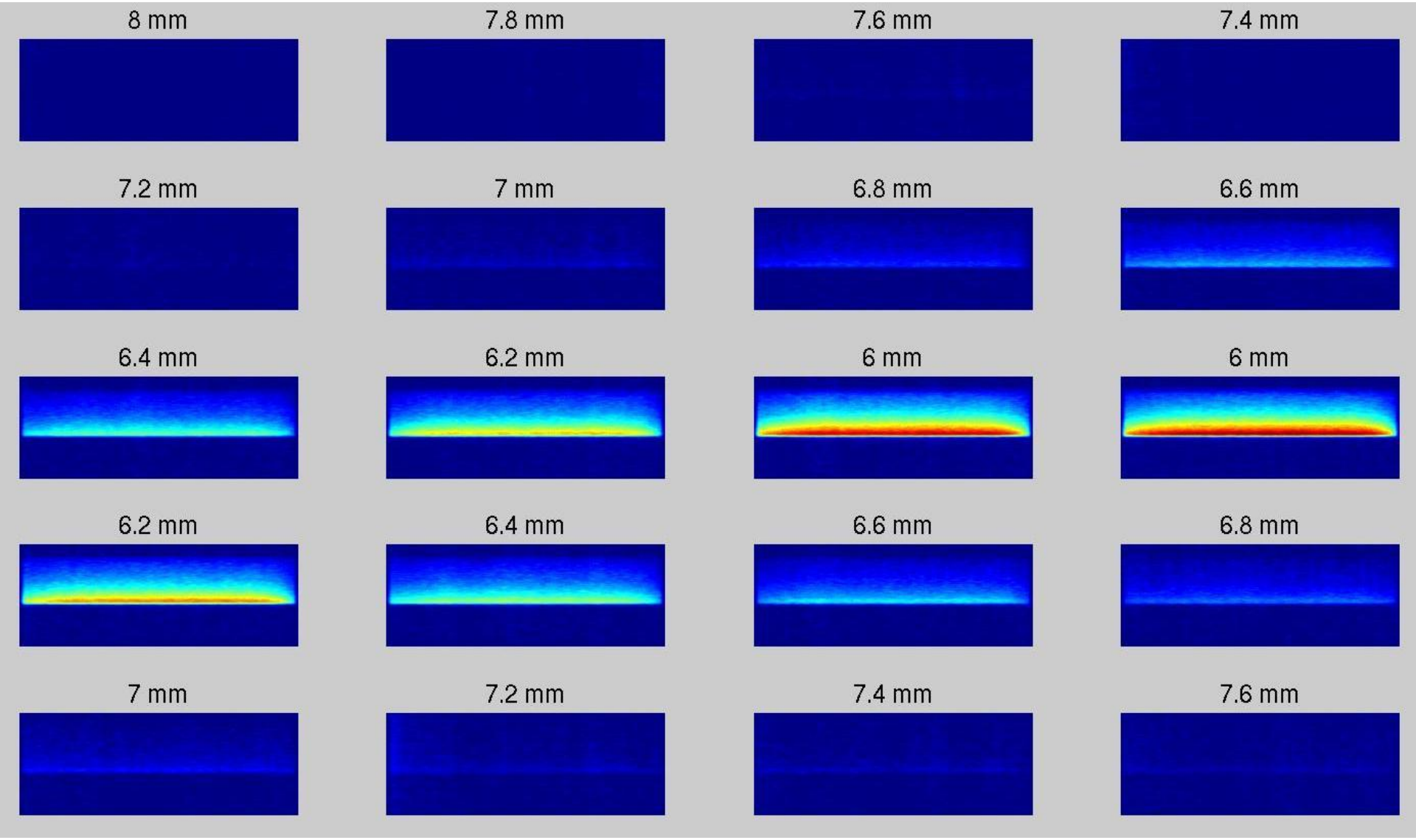
Can the Halo monitor now measure the effect of closing the Gap of the In-Vacuum undulators ??

We assessed this precisely by closing the gap of the In-Vacs of ID-11 and of ID-15 from 8 to 6mm (in 0.2mm step)

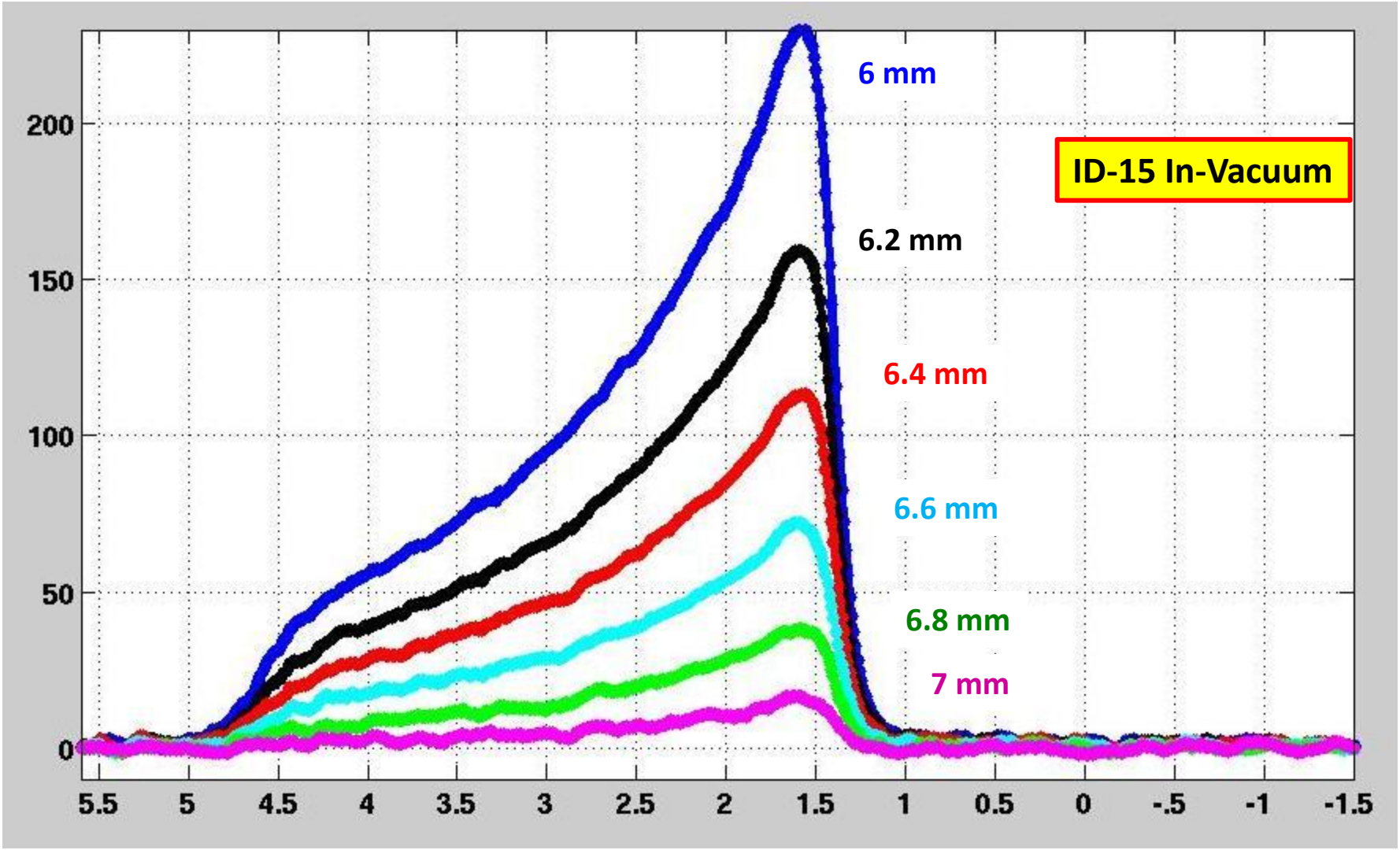
see results in next slides

ID-15 In-Vacuum

Differential images while closing & opening the Gap from 8 to 6 to 8 mm

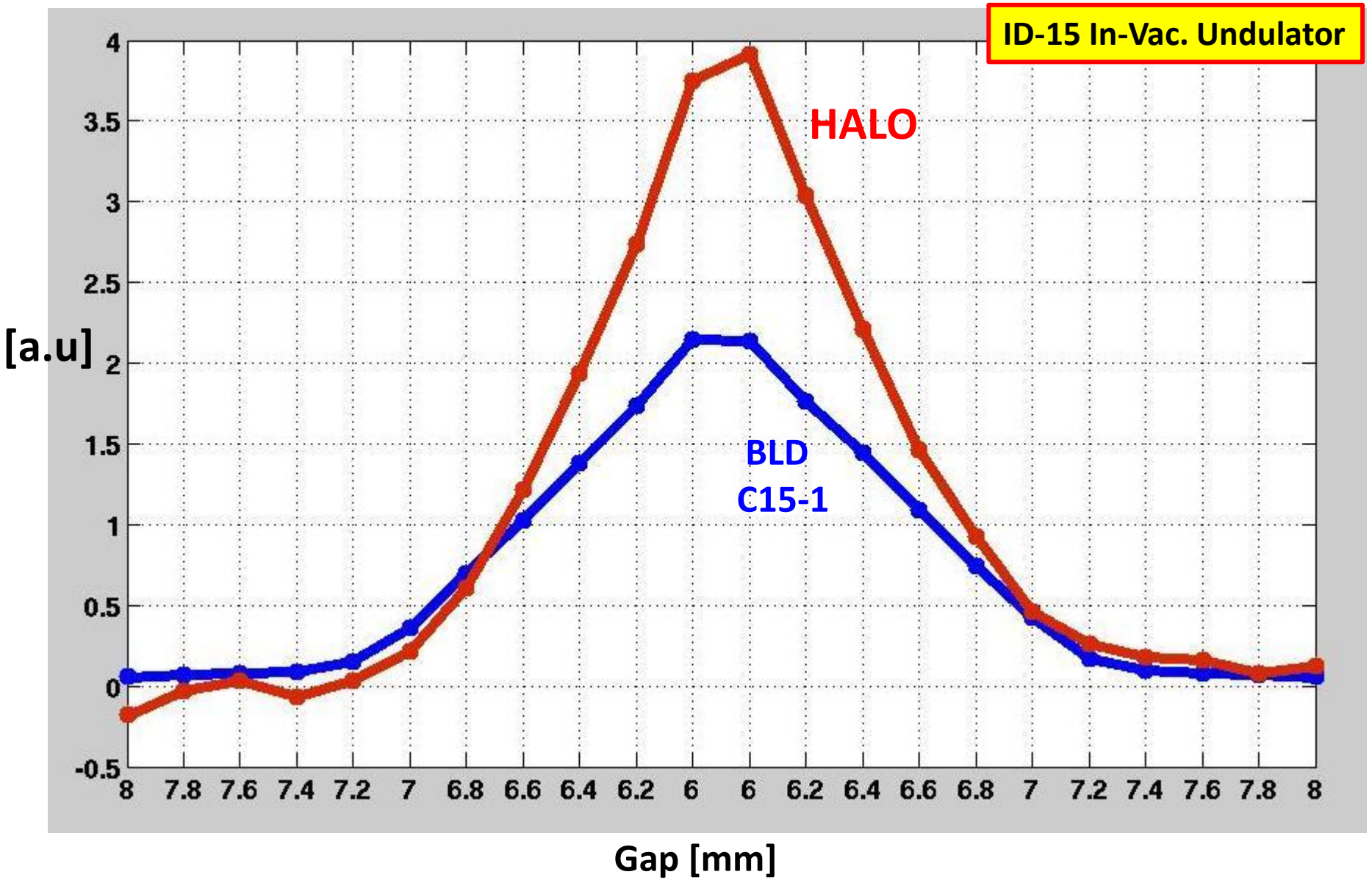


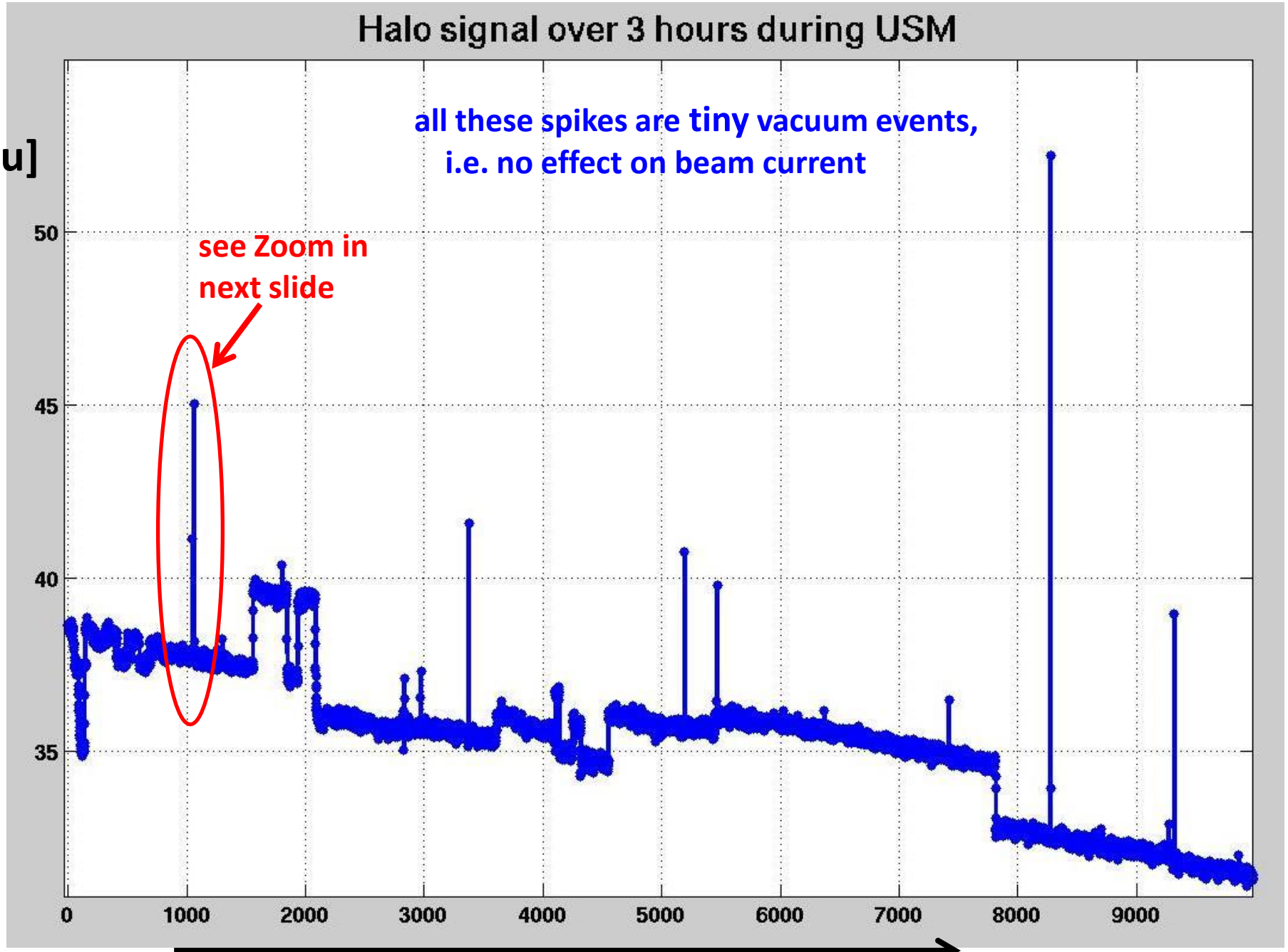
Gap from 7 to 6 mm



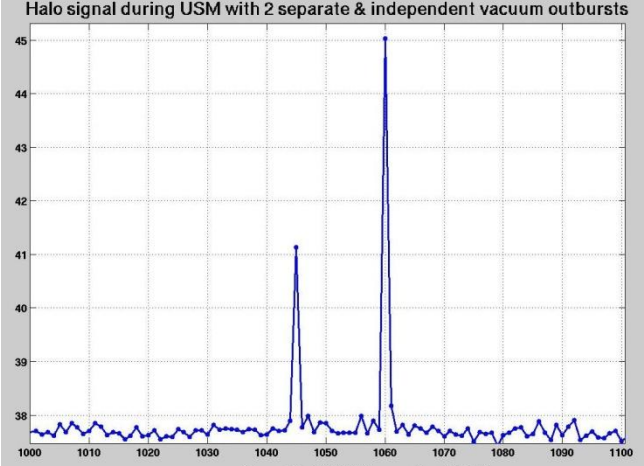
Distance from beam centre [mm]

how does the Halo monitor compare with the (local) BeamLoss Detector :

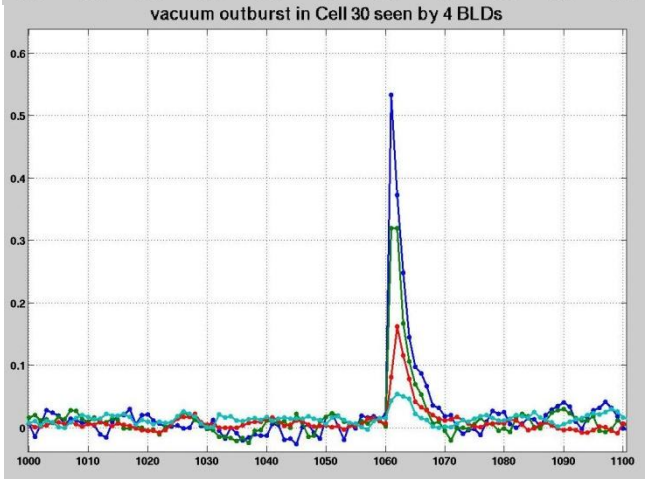



Halo signal over 3 hours during USM
[a.u]
all these spikes are tiny vacuum events,
i.e. no effect on beam current
see Zoom in
next slide
50
45
40
35
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Time [sec]

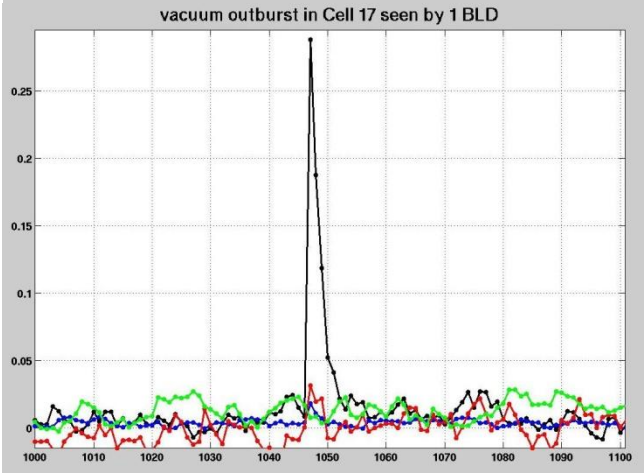
Halo



BLDs
C30-31



BLD
C17

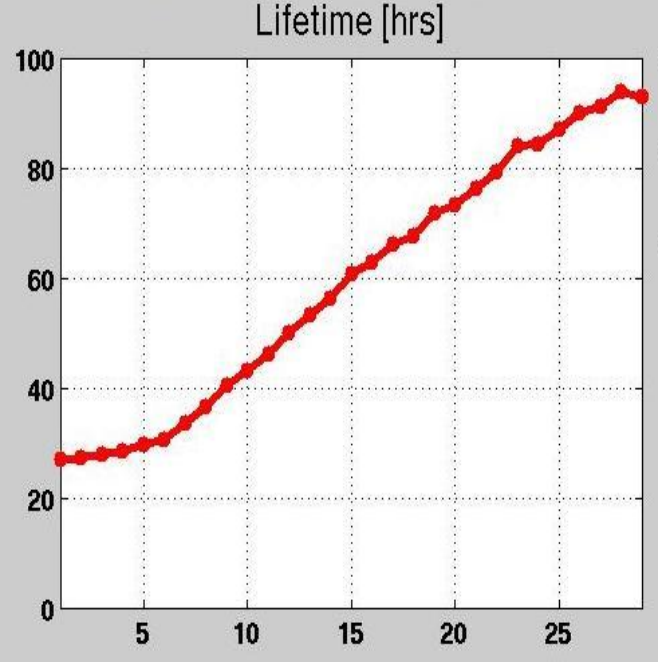


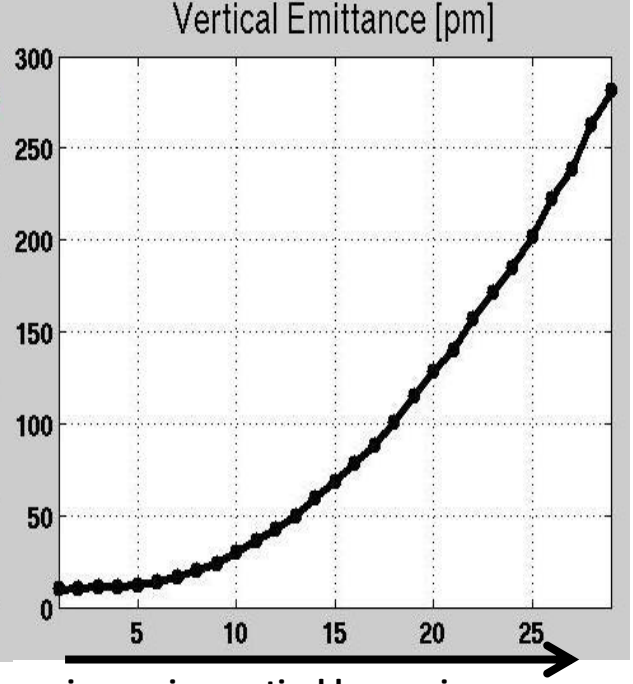
the Halo is very sensitive to vacuum quality :

in terms of sensitivity and signal/noise ratio the Halo is comparable to a BLD that is close to that Vacuum event

so the Halo is the best "Watch-Dog" of general SR vacuum quality

all data @1Hz, 1000sec



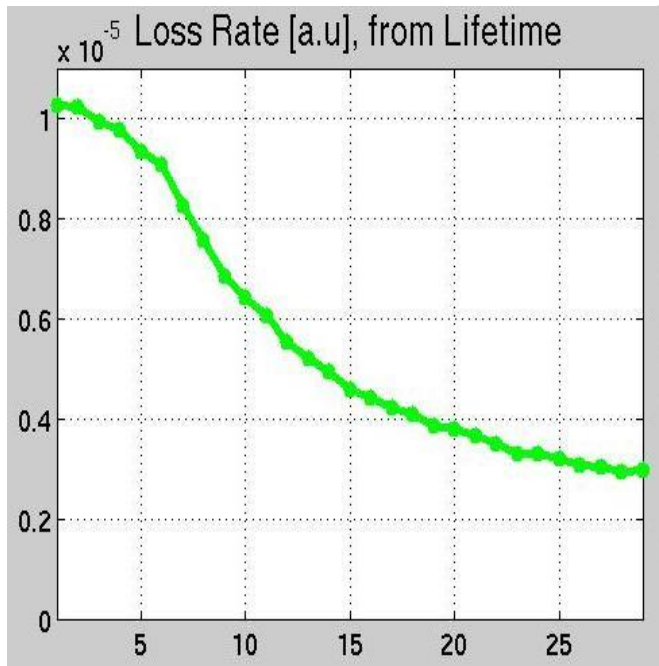


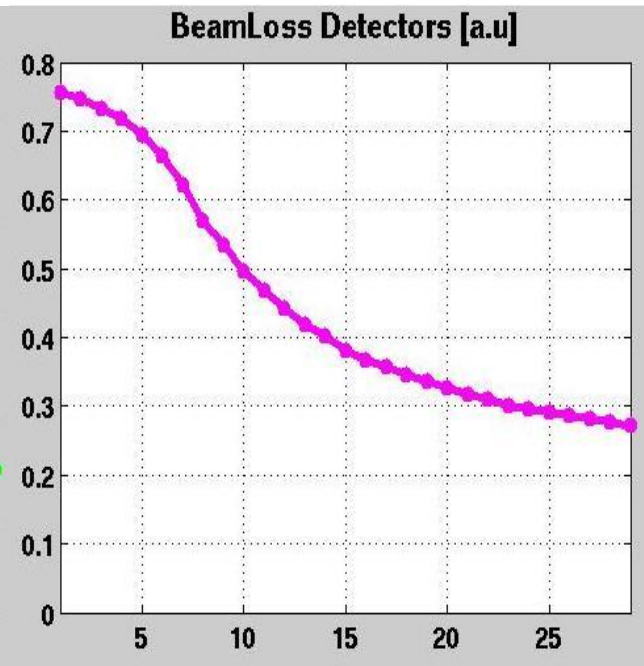
Comparative results when :

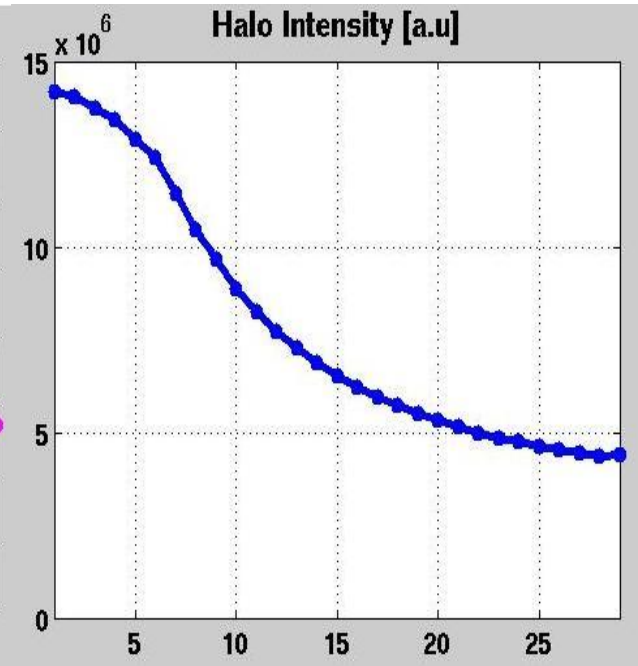
increasing the vertical beam size

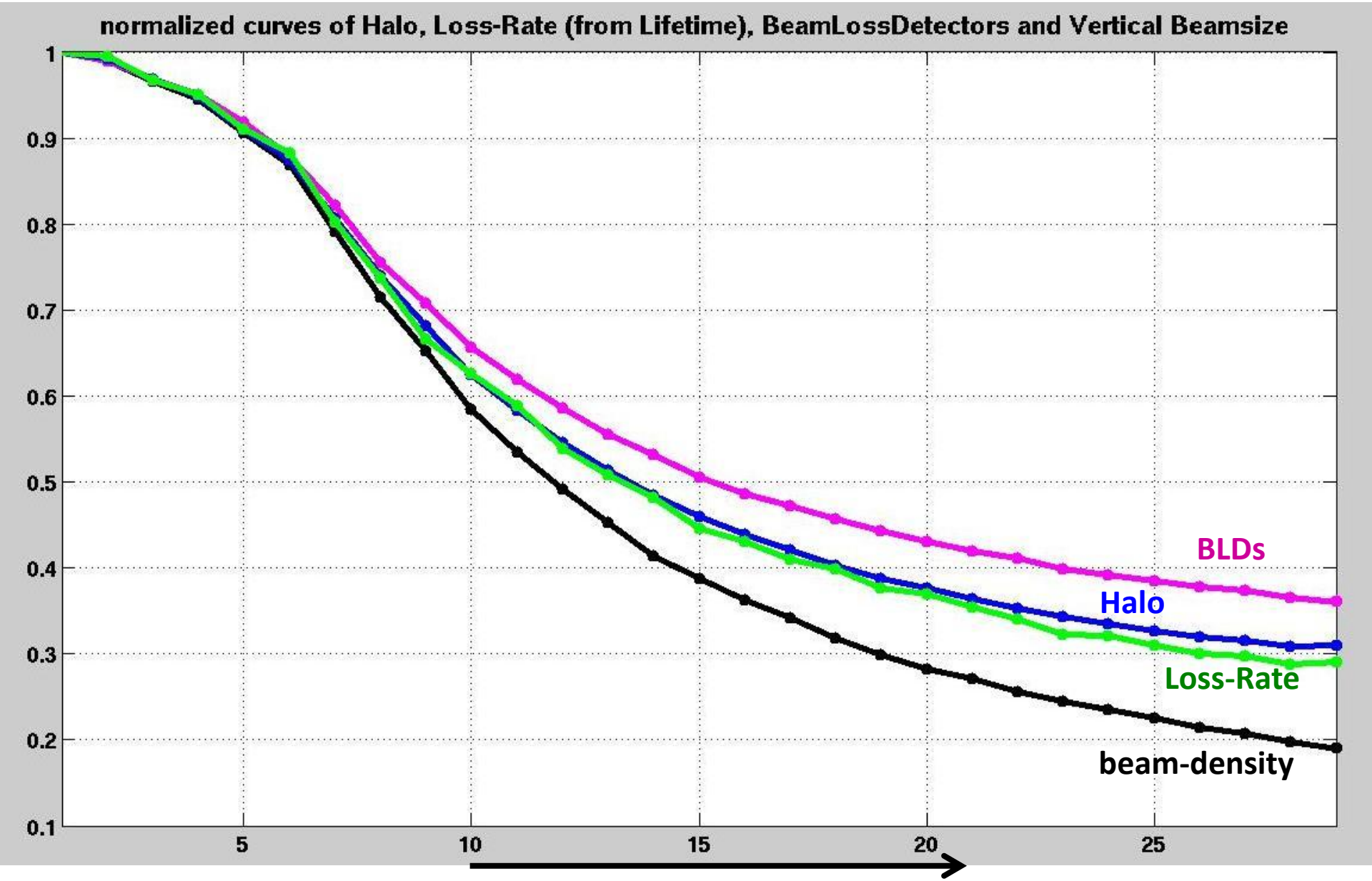
thus reducing the Touchek effect and going towards (mainly) UHV effect

increasing vertical beam-size, away from Touchek dominated scattering







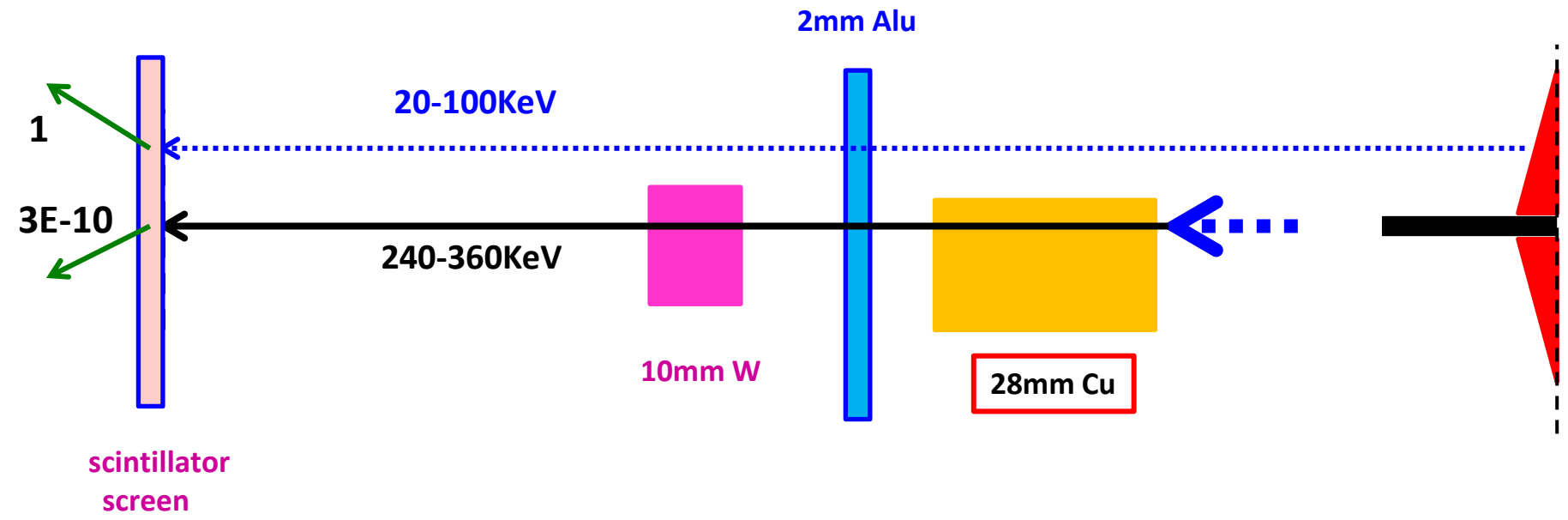


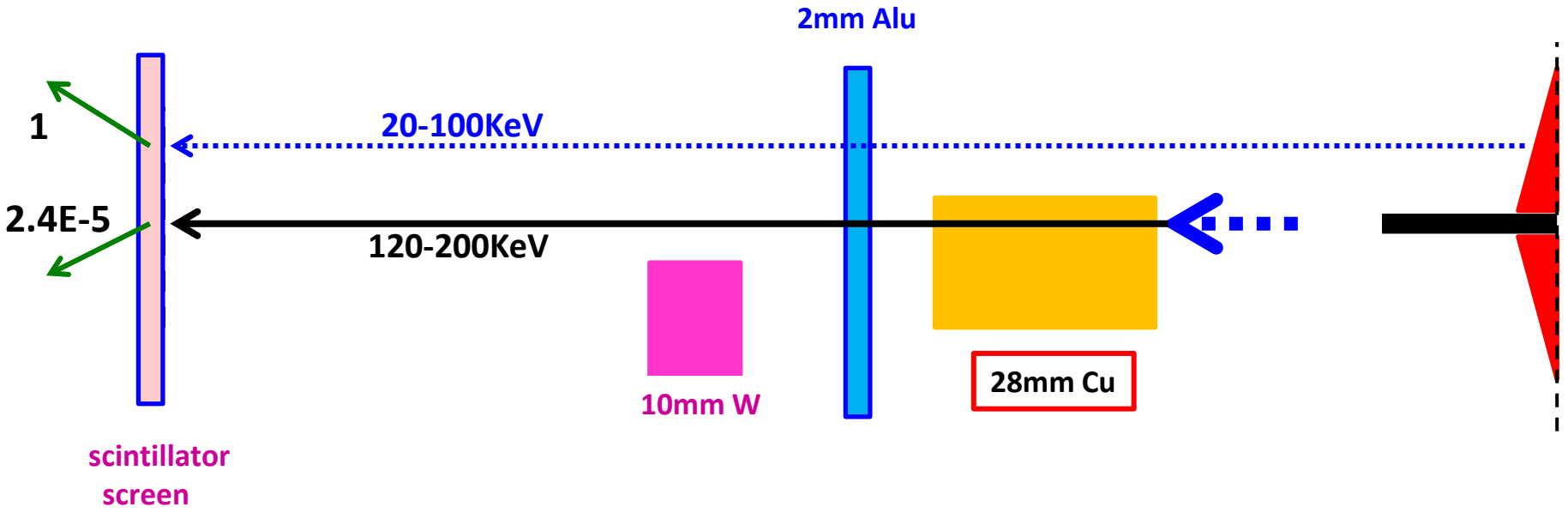
increasing beam-size, away from Touchek dominated scattering

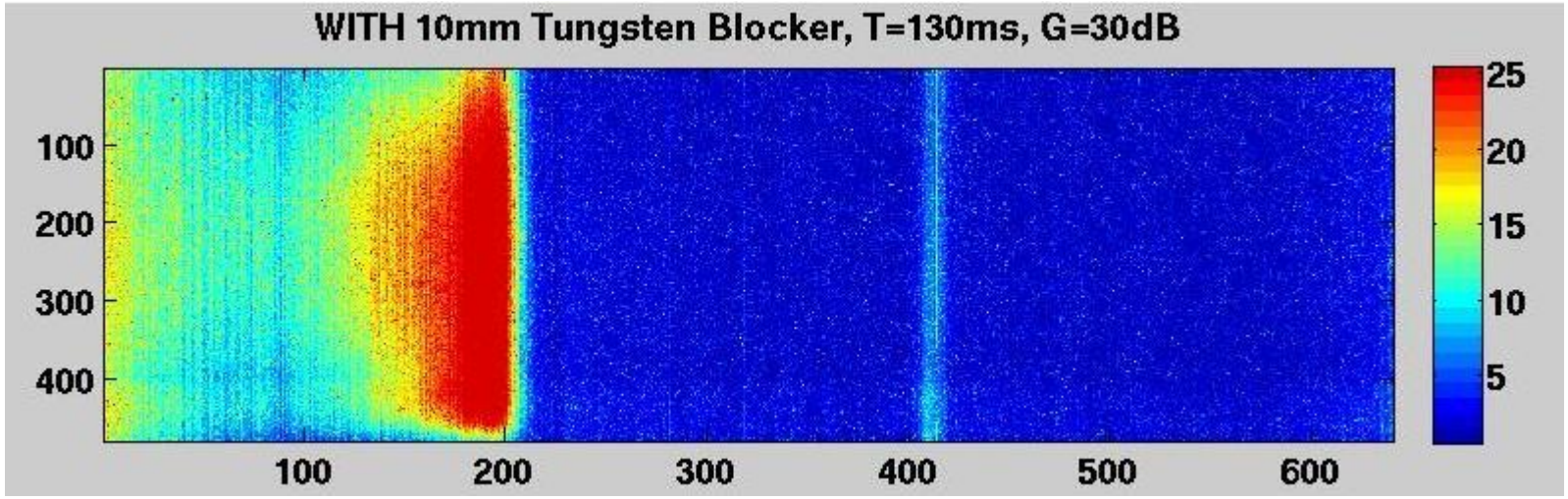
1) absolute calibration

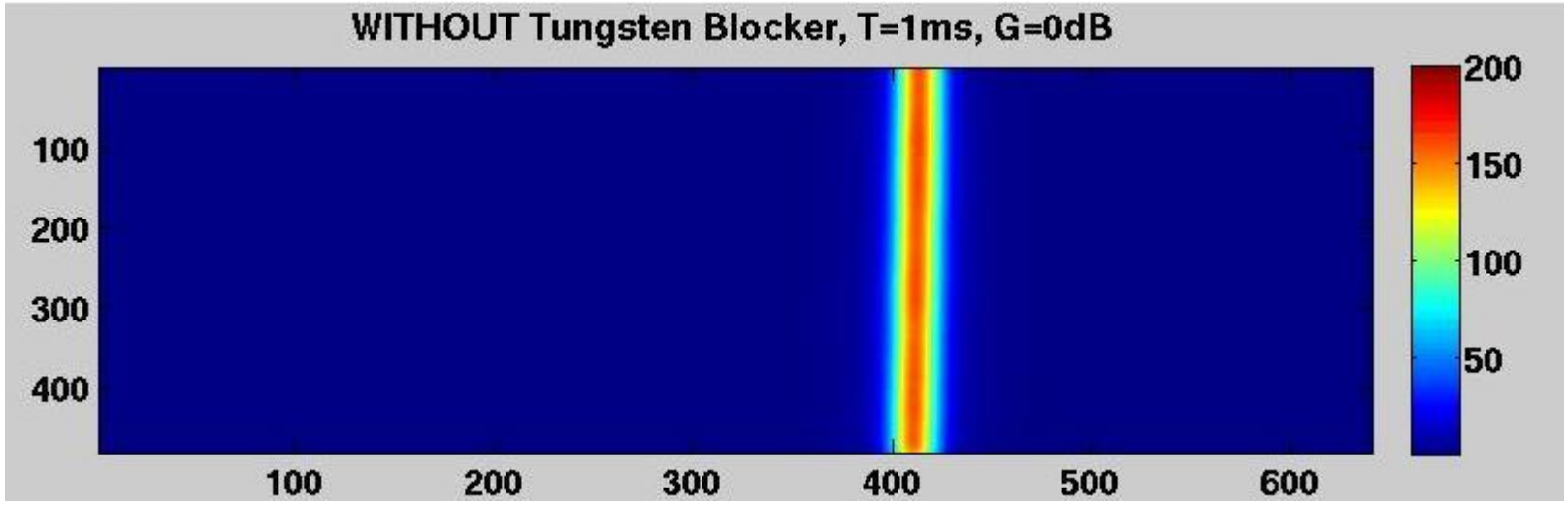
2) limitations of spatial resolution & range of detection

3) some initial problems resolved

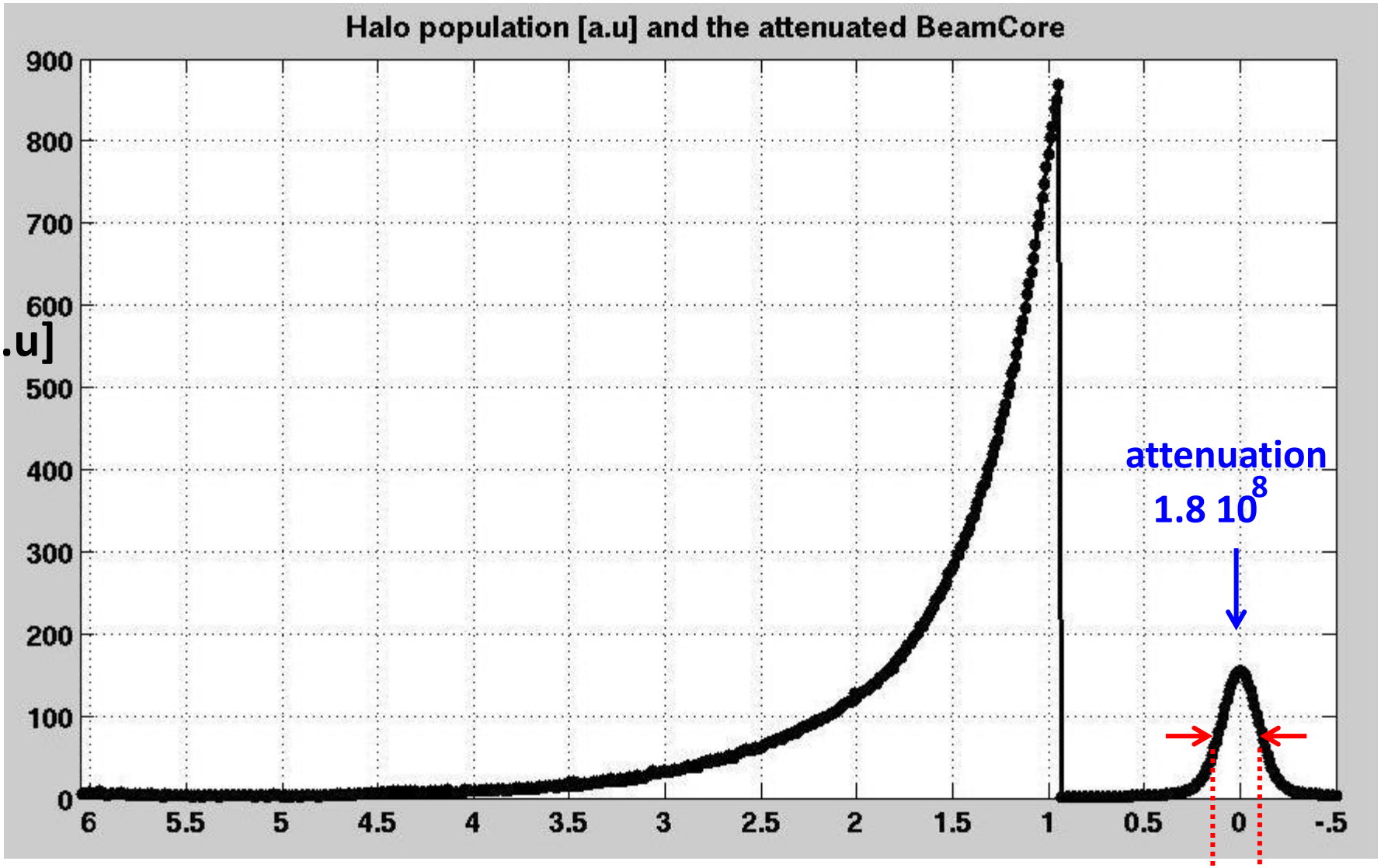

2mm Alu
1
20-100KeV
3E-10
240-360KeV
10mm W
28mm Cu
scintillator
screen


2mm Alu
1
20-100KeV
2.4E-5
120-200KeV
10mm W
28mm Cu
scintillator
screen

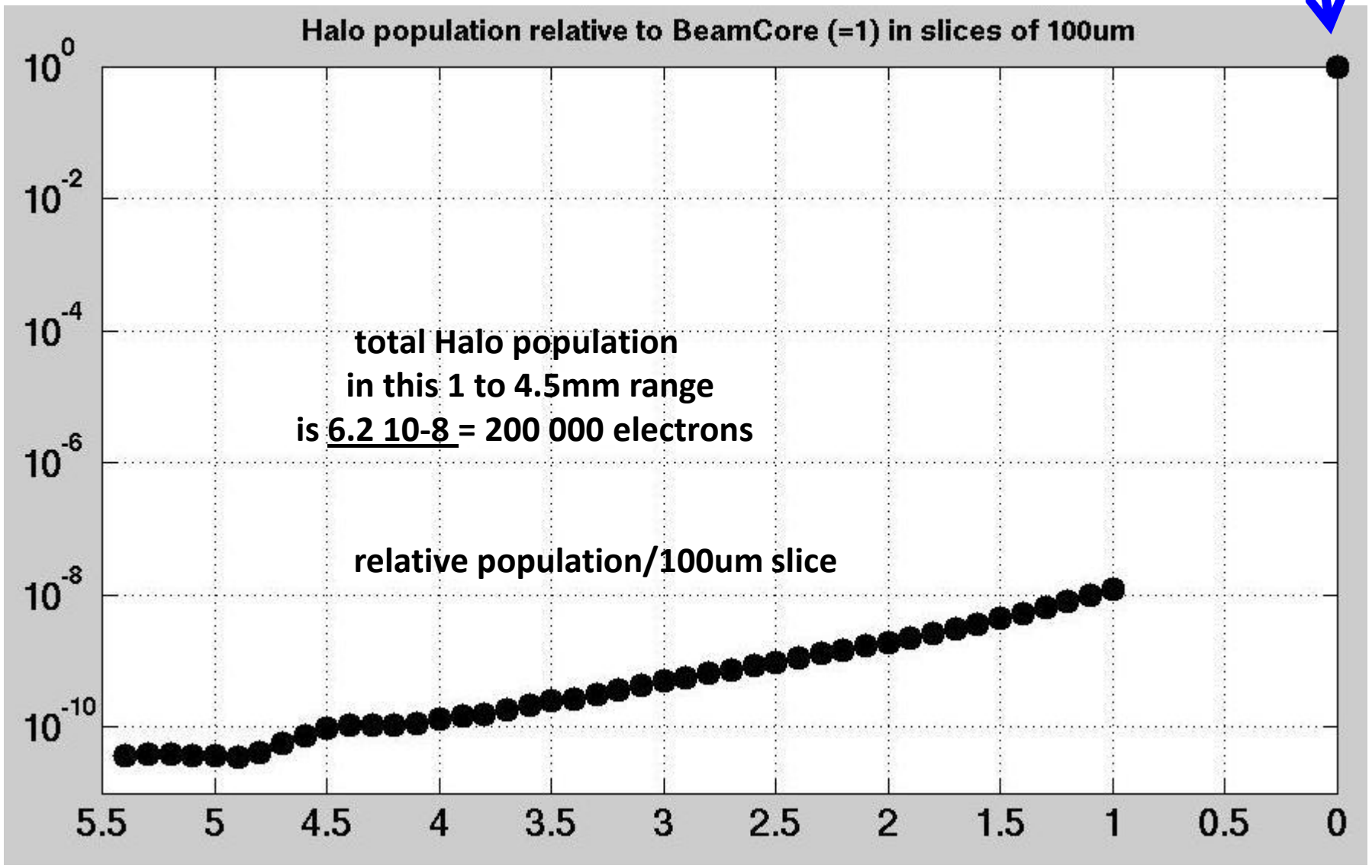

WITH 10mm Tungsten Blocker, T=130ms, G=30dB
100
200
300
400
100
200
300
400
500
600
25
20
15
10
5


WITHOUT Tungsten Blocker, T=1ms, G=0dB
100
200
300
400
100
200
300
400
500
600
200
150
100
50

Attenuation = 28mm Cu & 30dB camera gain & 130 exposure time



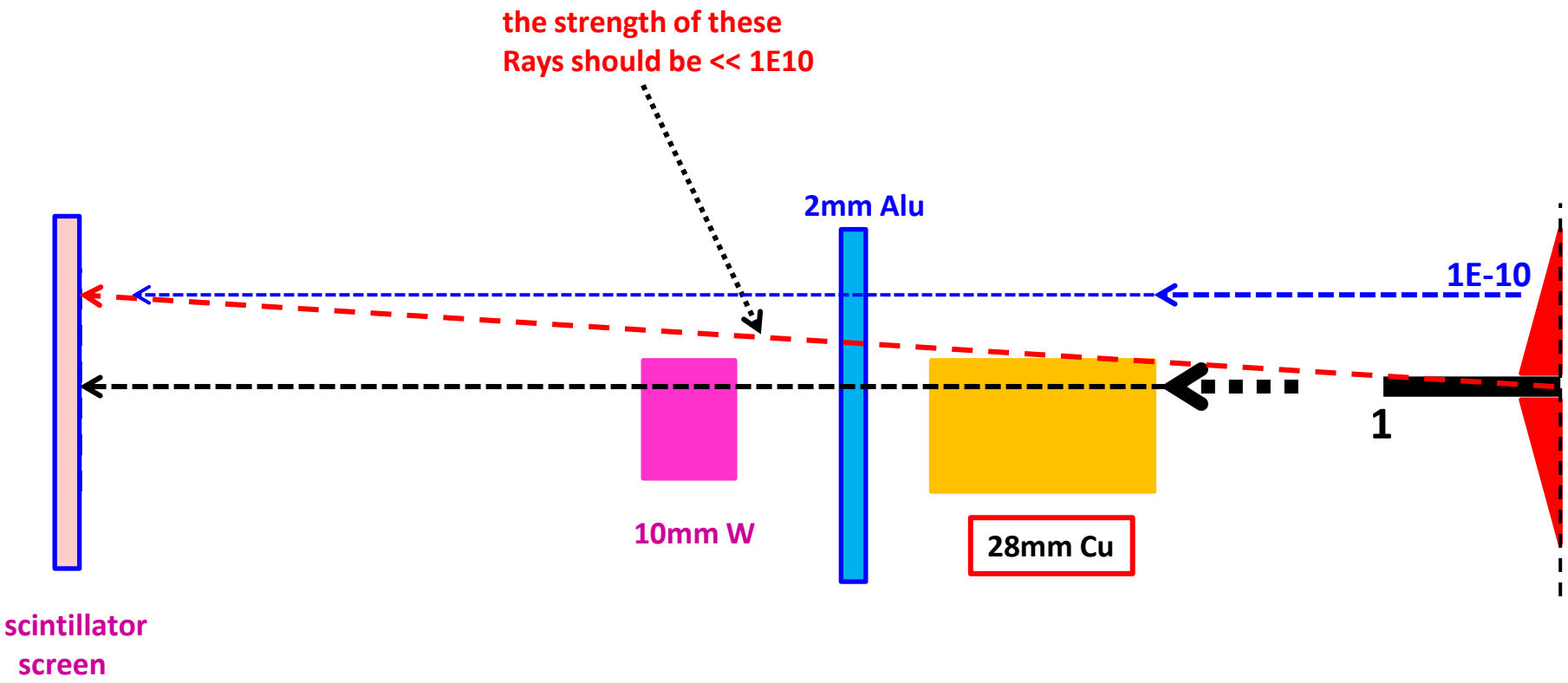
BeamCore = 1

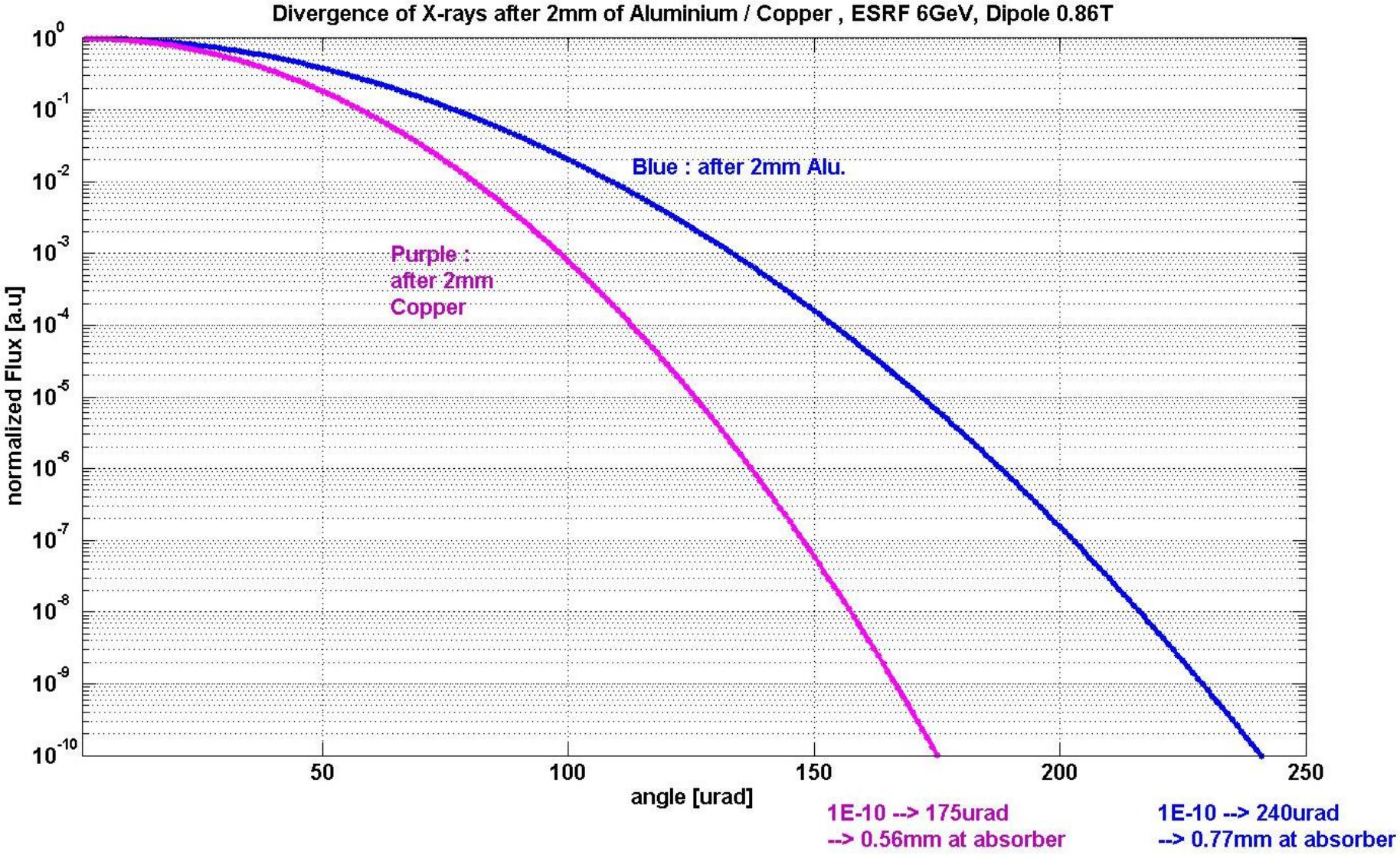

Halo population relative to BeamCore (=1) in slices of 100um
10^0
10^-2
10^-4
10^-6
10^-8
10^-10
total Halo population
in this 1 to 4.5mm range
is 6.2 10-8 = 200 000 electrons
relative population/100um slice
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Distance from beam centre [mm]

the "not-so-small" <u>divergence</u> of the "not-so-hard" X-rays

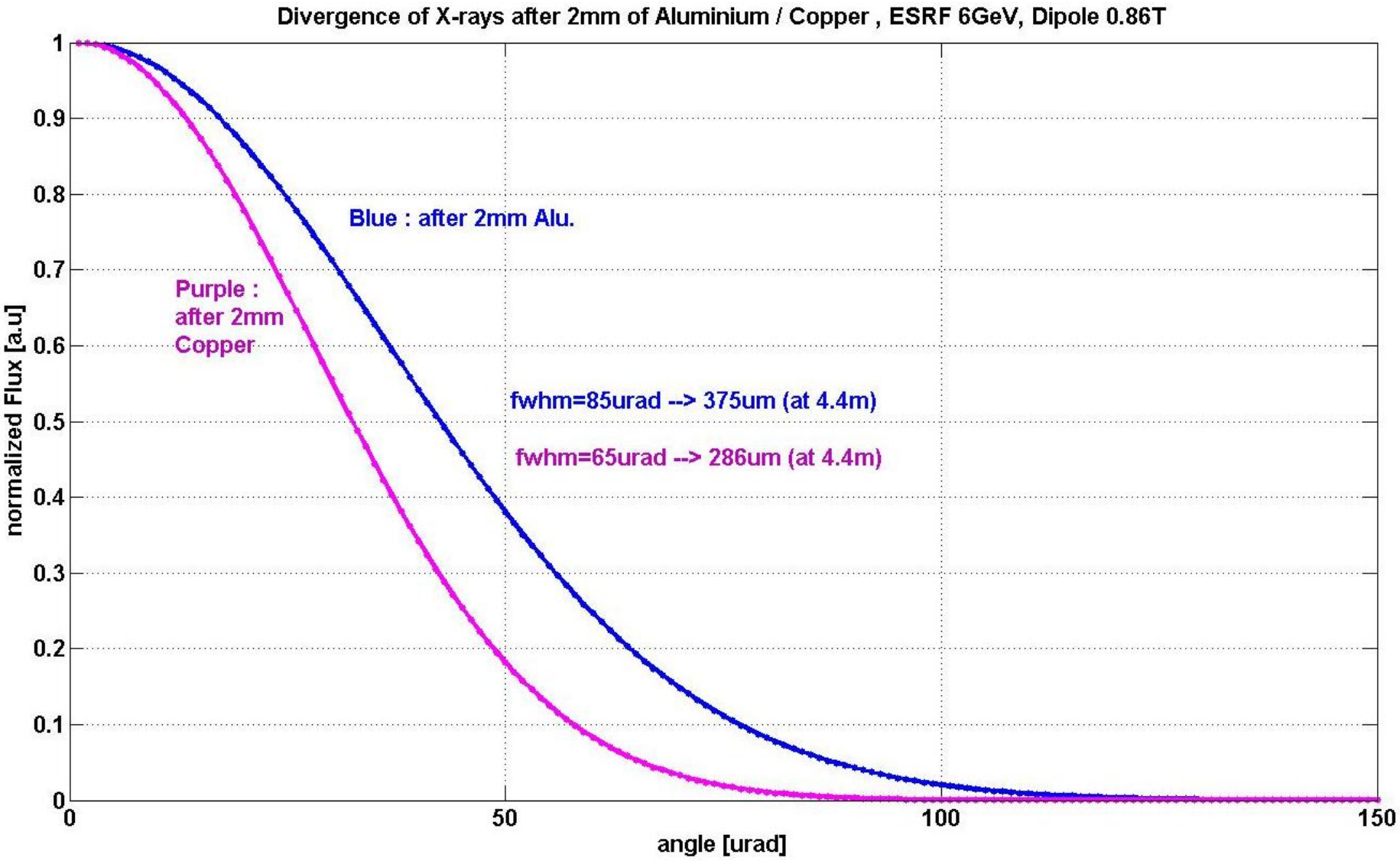
determining :

1) **the spatial resolution of the monitor**
2) **how close to the beam-core we can measure**





but nearly a factor 6 less flux with 2mm Copper



but nearly a <u>factor 6 less flux</u> with 2mm Copper

Some technical problems & challenges being solved :

phantom signals :

from scattering / reflections of the intense X-ray beamcore
from some of the (unavoidable) absorbers

solution (empirical) : move absorber & detector to a different part ...

in today's optimized set-up the phantoms have disappeared !!

fast degradation of the detector (CCD camera)

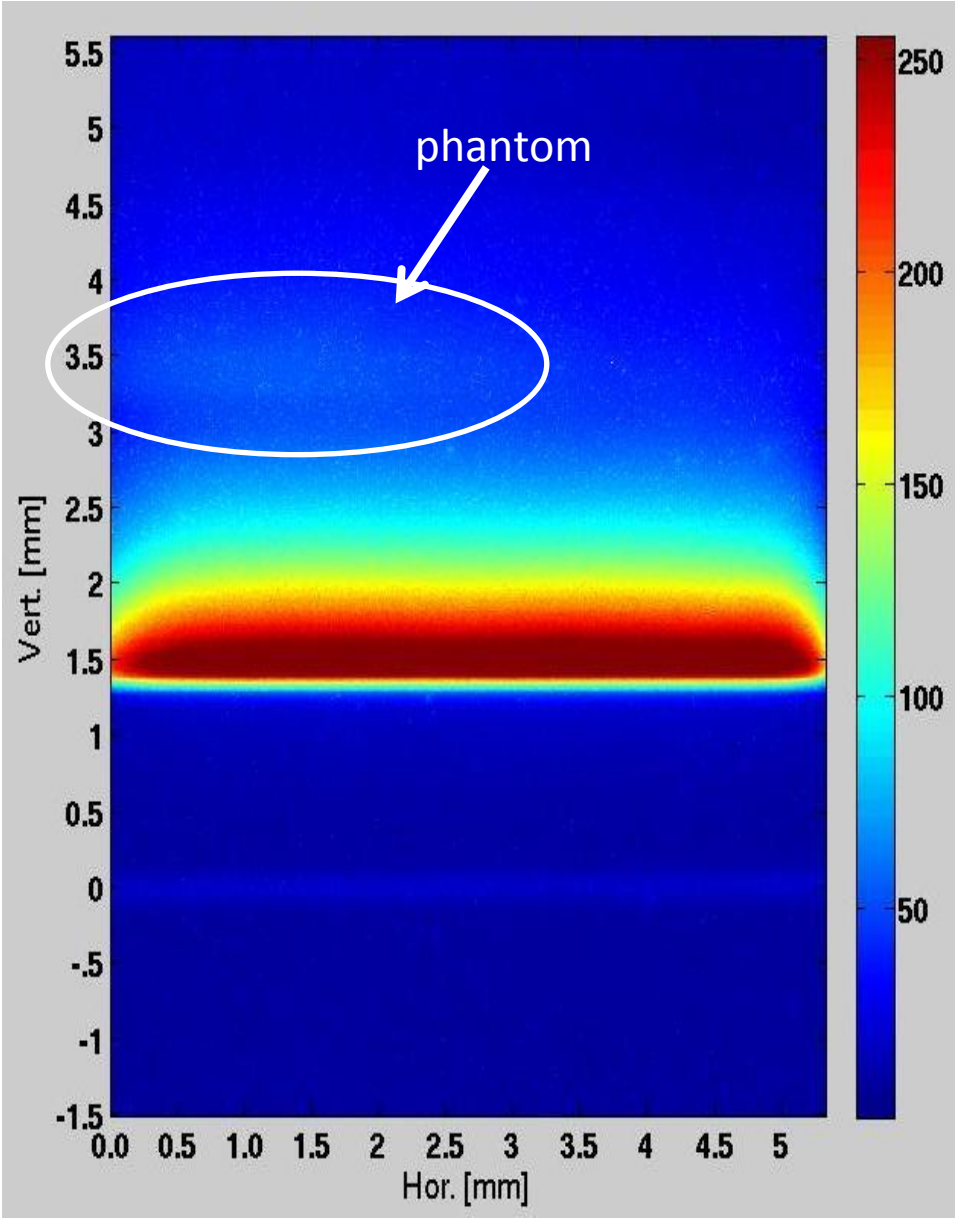
due to nasty radiation environment

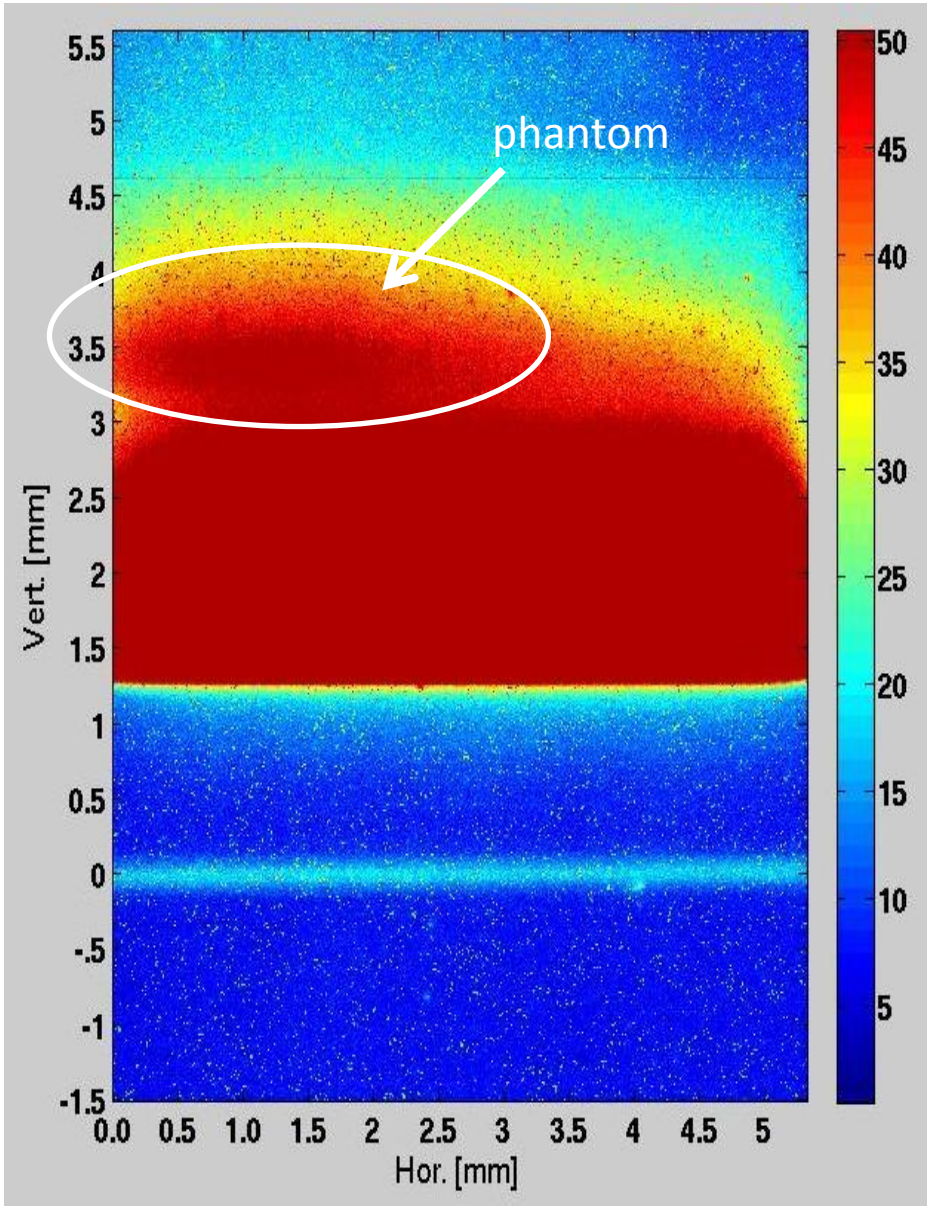
used till recently : Flea camera (fire-wire standard) , 430 Euros

now : BlackFLY camera (GigE standard, power_over_Ethernet) , 240 Euros
hardly any degradation noticeable after 2 weeks .... !!

Colormap 250

Colormap 50



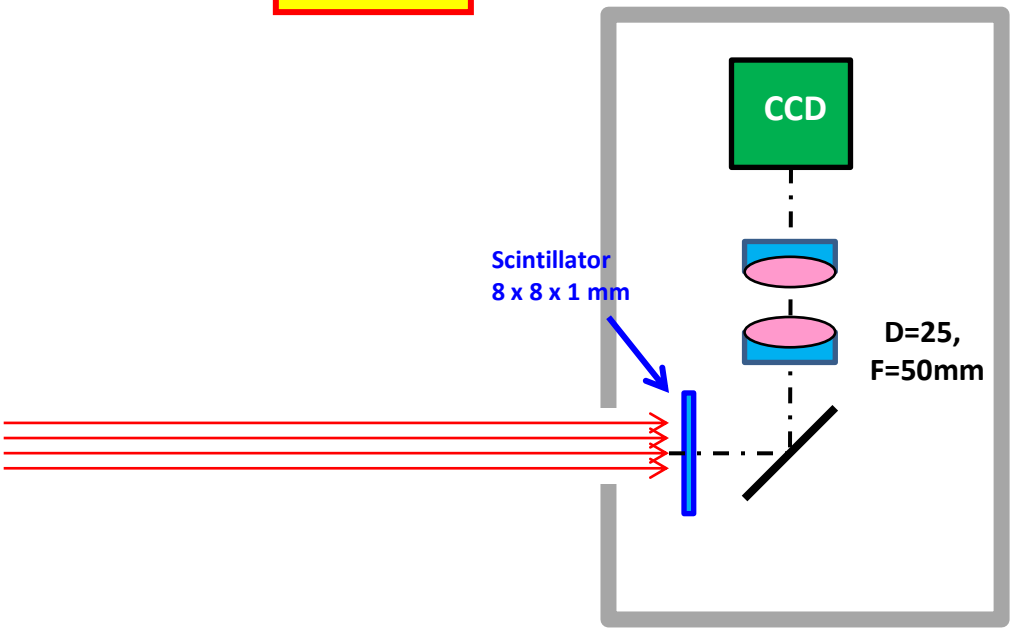


Hor. Accepted Dipole Radiation ~1mrad

Hor. Accepted Dipole Radiation ~1mrad

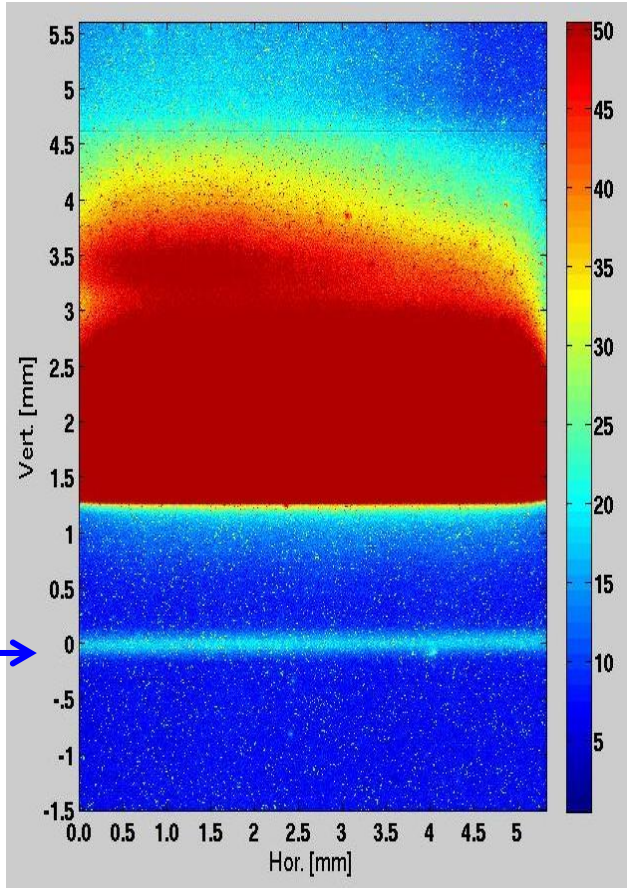
X-ray Imager

top view



No image intensifier, No cooled camera, <u>just a cheap camera</u>, at max gain (30dB) and exposure time (130millisec)

"degradation" means :
Loss of sensitivity & linearity
(mainly at high Gain)



Flea (430 Euros) 1/3" ICX424 Sony 7.4um
"degradation" within days

BlackFly (240 Euros) 1/3" ICX693 Sony 6um
much more resistant . . .

Halo lujah