the H A L O Monitor

where other diagnostics can not reach .....

the vertical Halo monitor
on the
ESRF's 6GeV electron beam

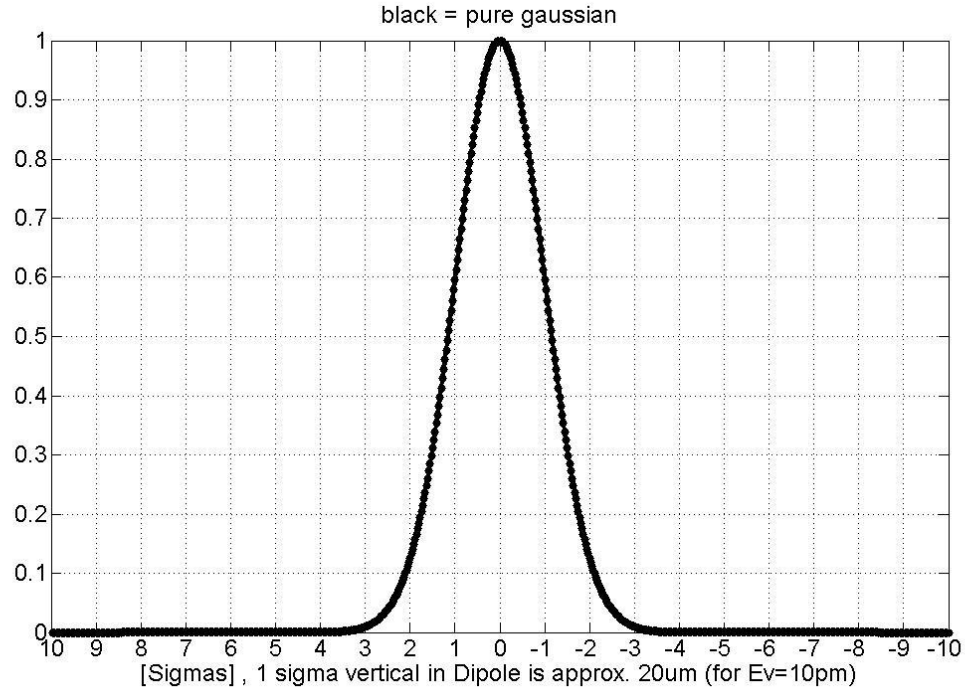
1) the Halo itself : what is it ? what creates it ?
how strong is it ? is it a problem ?

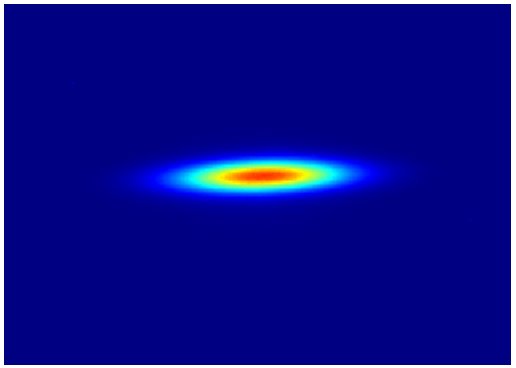
2) Principle of technique :

- Non-destructive to the electron beam, using X-rays from a dipole
- Calibrated (quantitative) levels (e.g. nA)

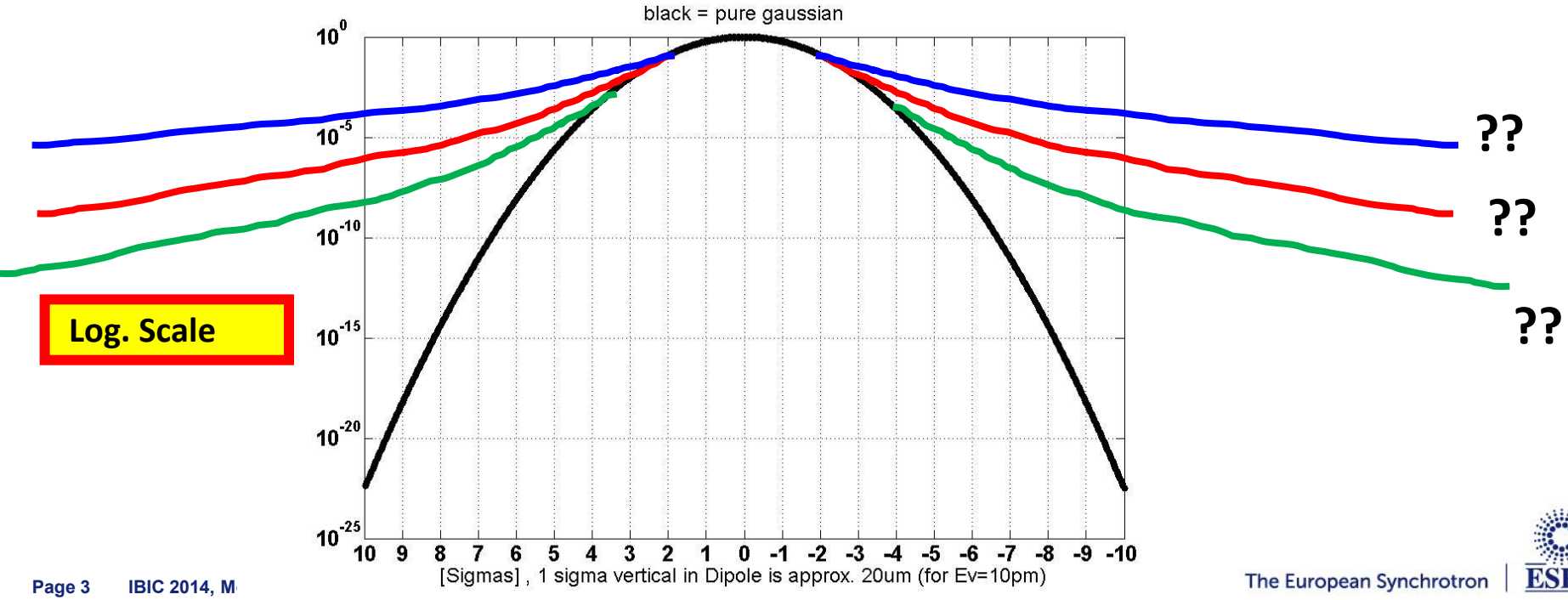
3) Results, Initial Problems & Solutions, Conclusions

Linear Scale

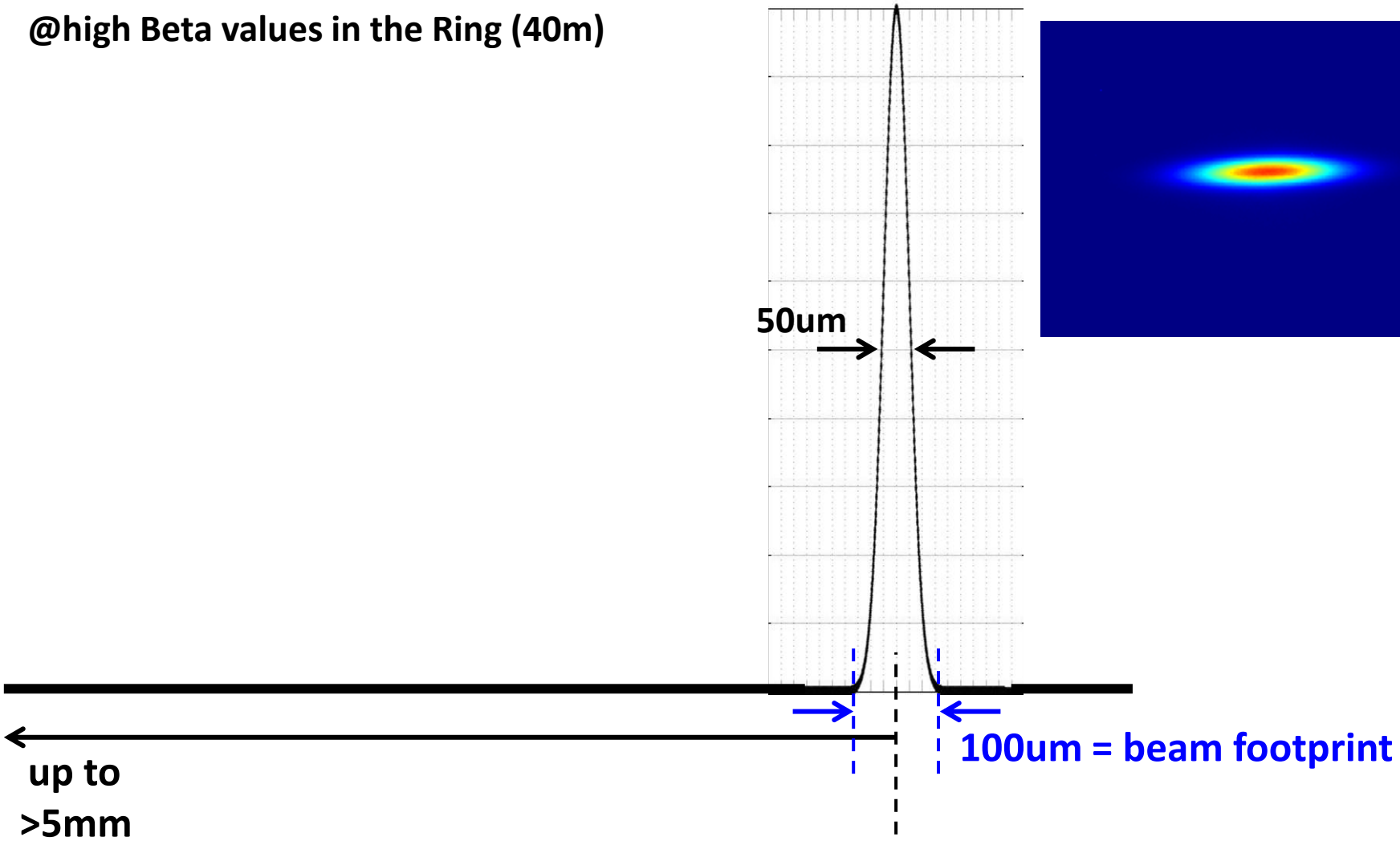




Log. Scale



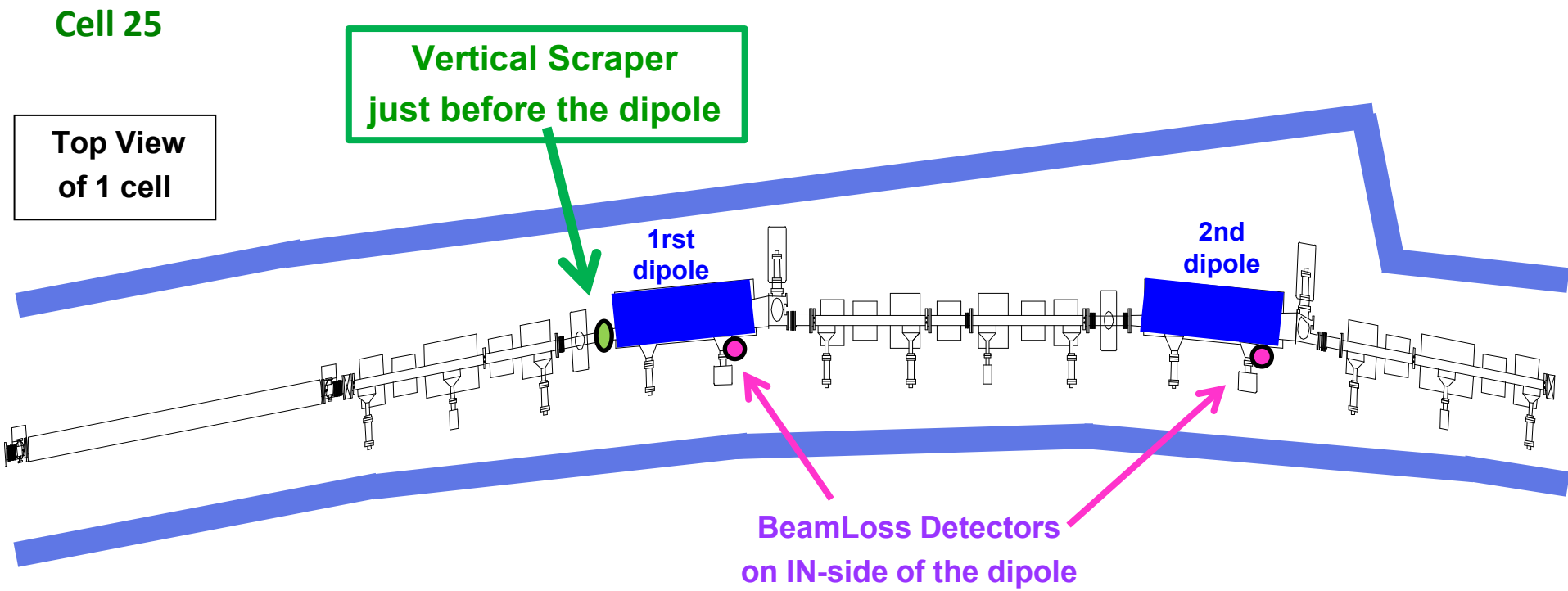
@high Beta values in the Ring (40m)



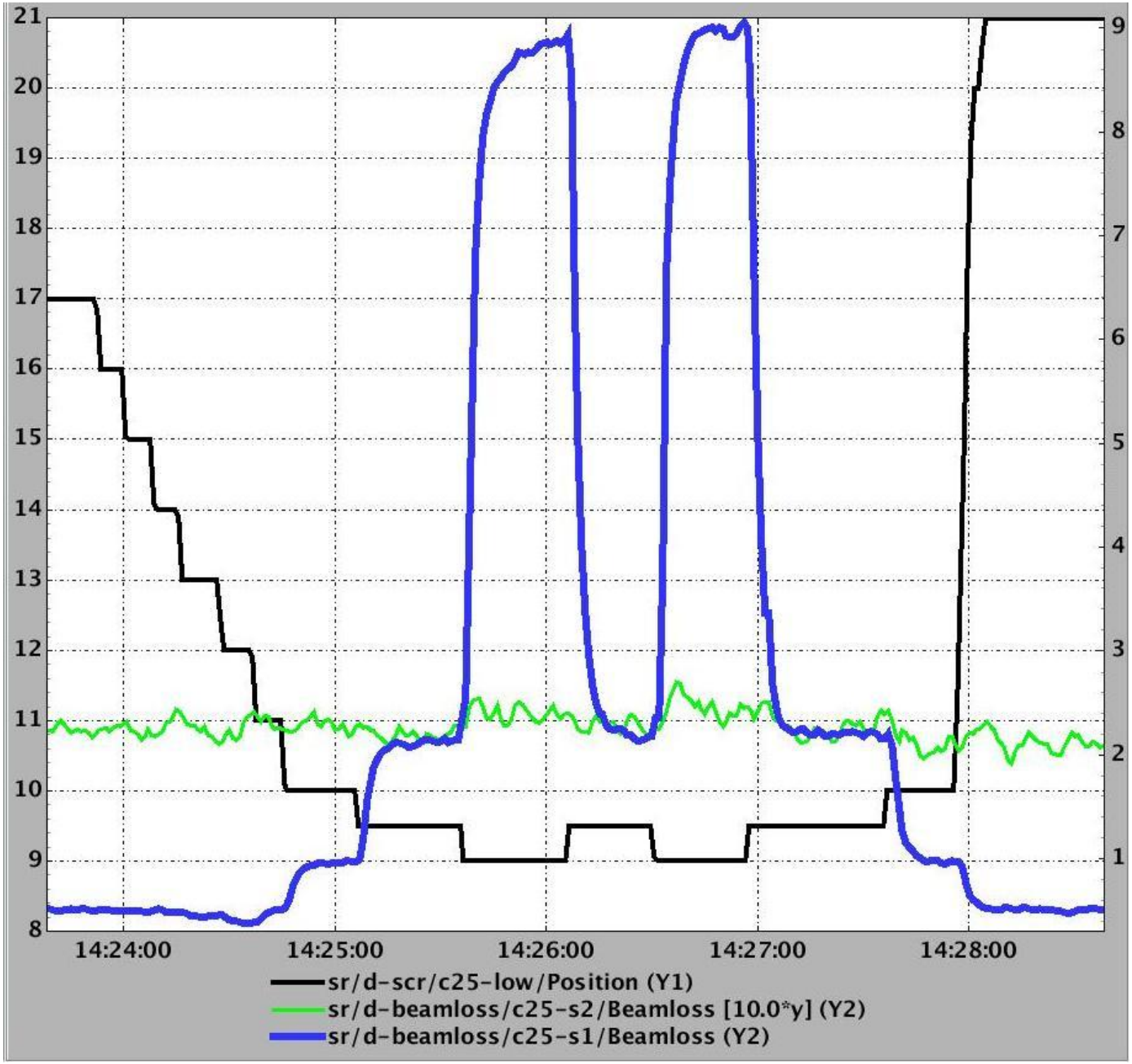
i.e. 50 x footprint

there are still (many) electrons .....

Scraper Manipulations & BeamLoss Detectors : destructive assessment of the Halo level



Black : Scraper position [mm]



Blue : BLD-signal [a.u.]

this vertical beam Halo in our 6GeV light source

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

is it a problem ? - yes, for small-gap In-Vacuum undulators

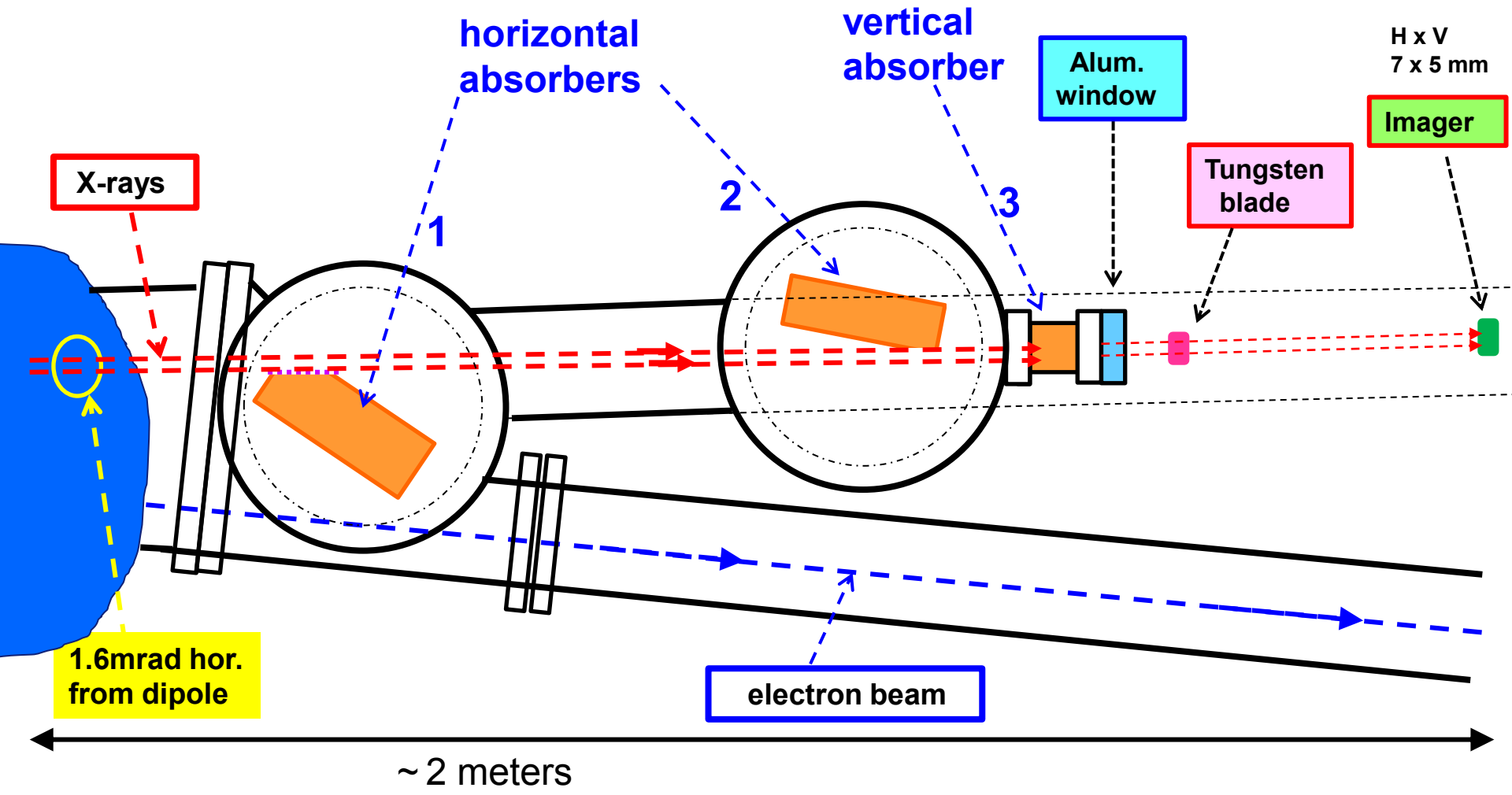
The non-destructive vertical beam Halo monitor

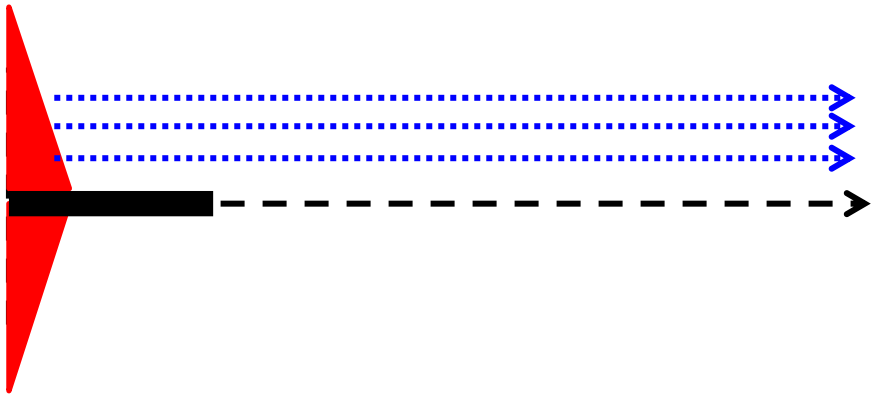
Principle of technique :

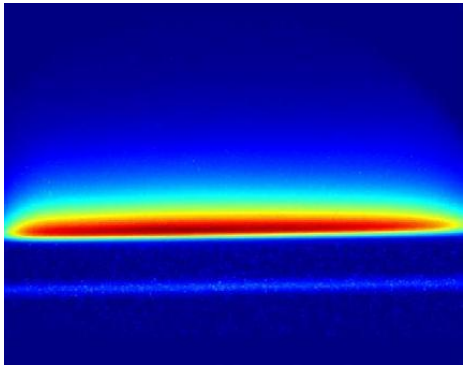
- using X-rays from a dipole
- on a beamport with a set of 3 adapted absorbers
- with a light-blocker to shadow the intense beam-core
- and a sensitive detector further down-stream

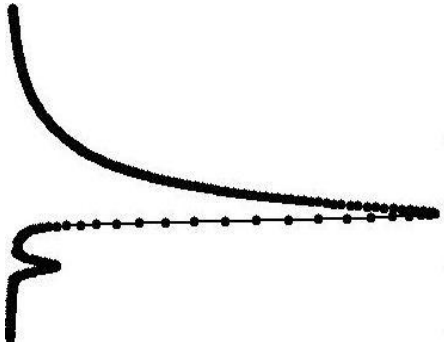
Goal : the permanent monitoring (at 1Hz) of the Halo intensity,
in a region of 1 – 5mm above the beam-core,
and with a calibrated value of this intensity

Top-View

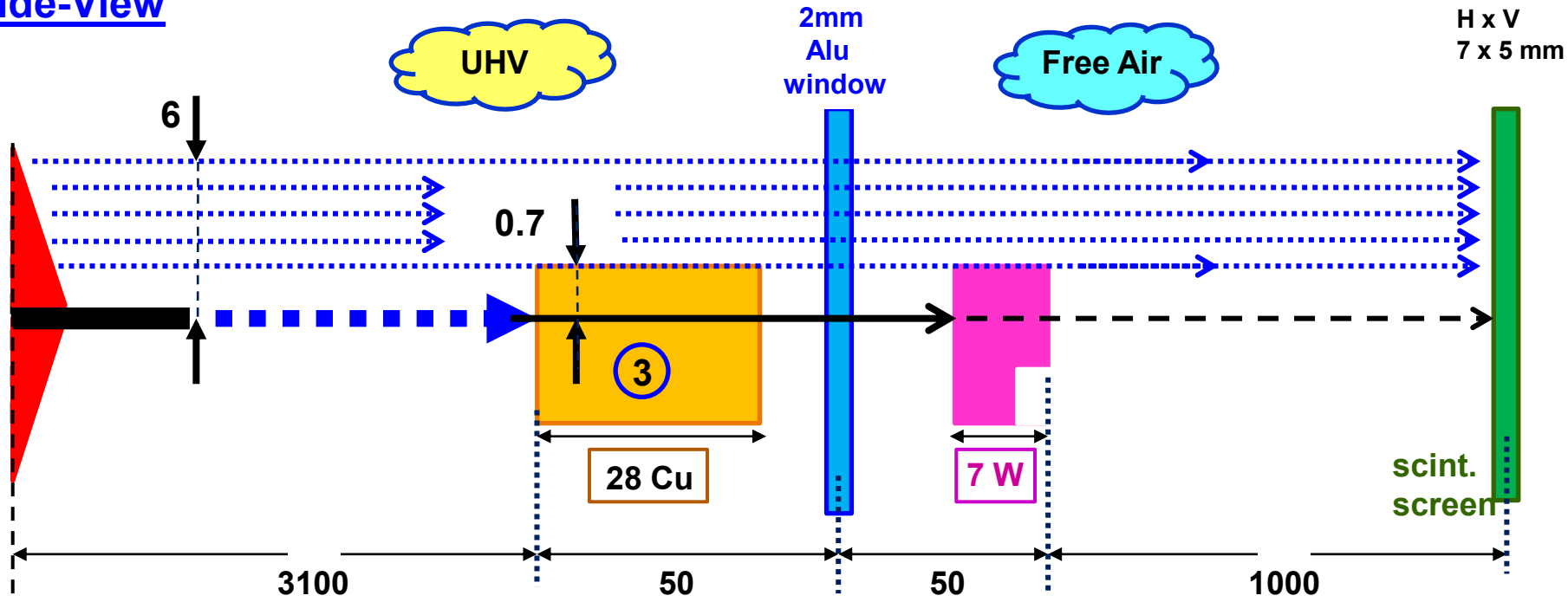

horizontal absorbers
vertical absorber
Alum. window
H x V
7 x 5 mm
Imager
Tungsten blade
X-rays
1
2
3
1.6mrad hor. from dipole
electron beam
~ 2 meters

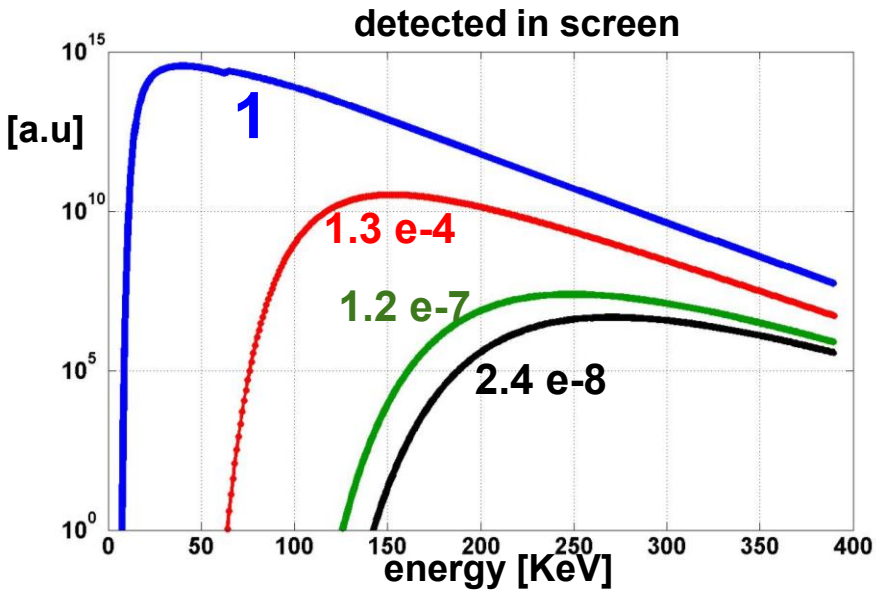


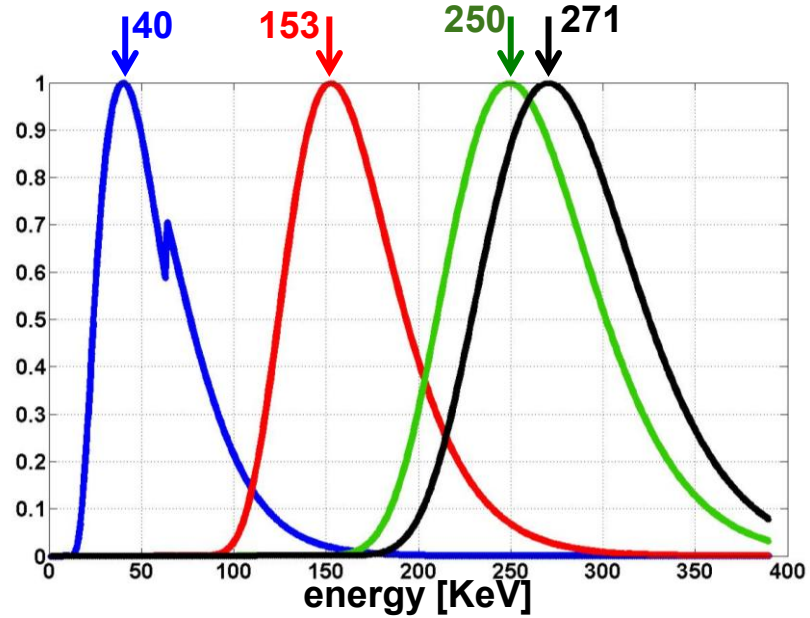


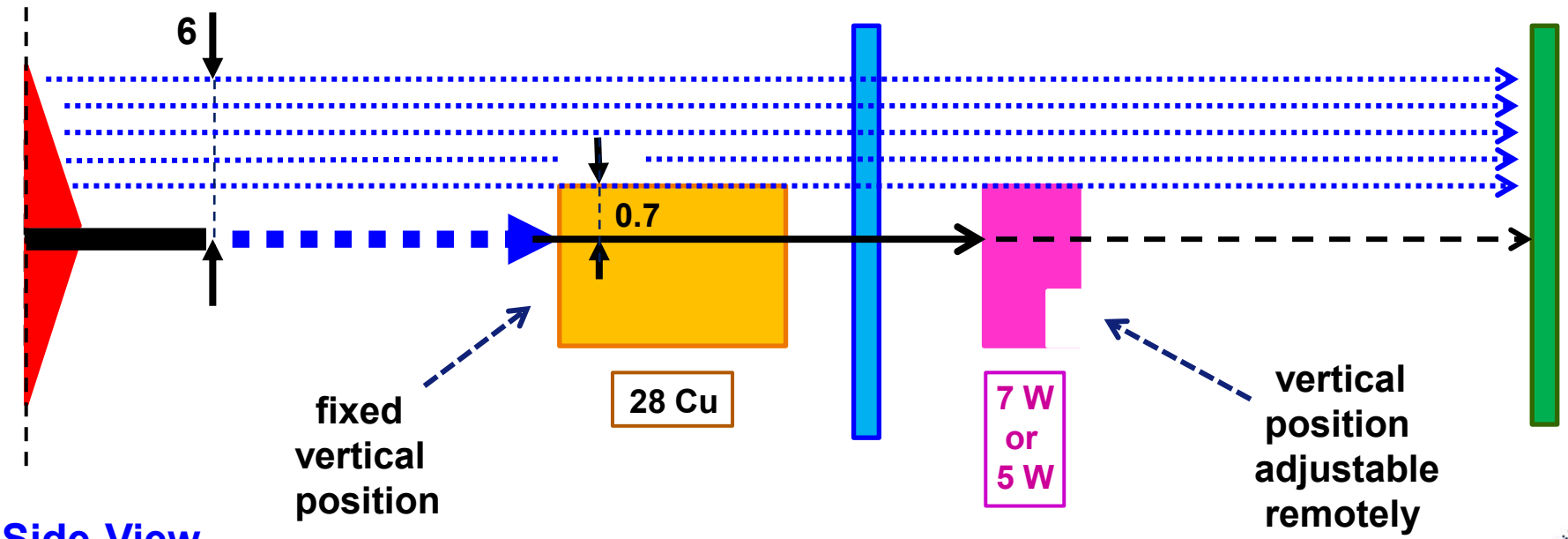


Side-View

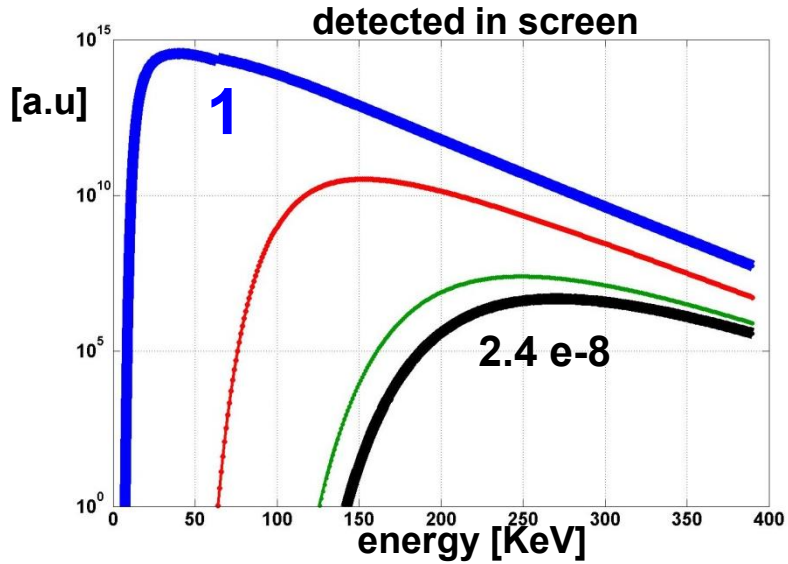

UHV
2mm
Alu
window
Free Air
H x V
7 x 5 mm
6
0.7
3
28 Cu
7 W
scint.
screen
3100
50
50
1000

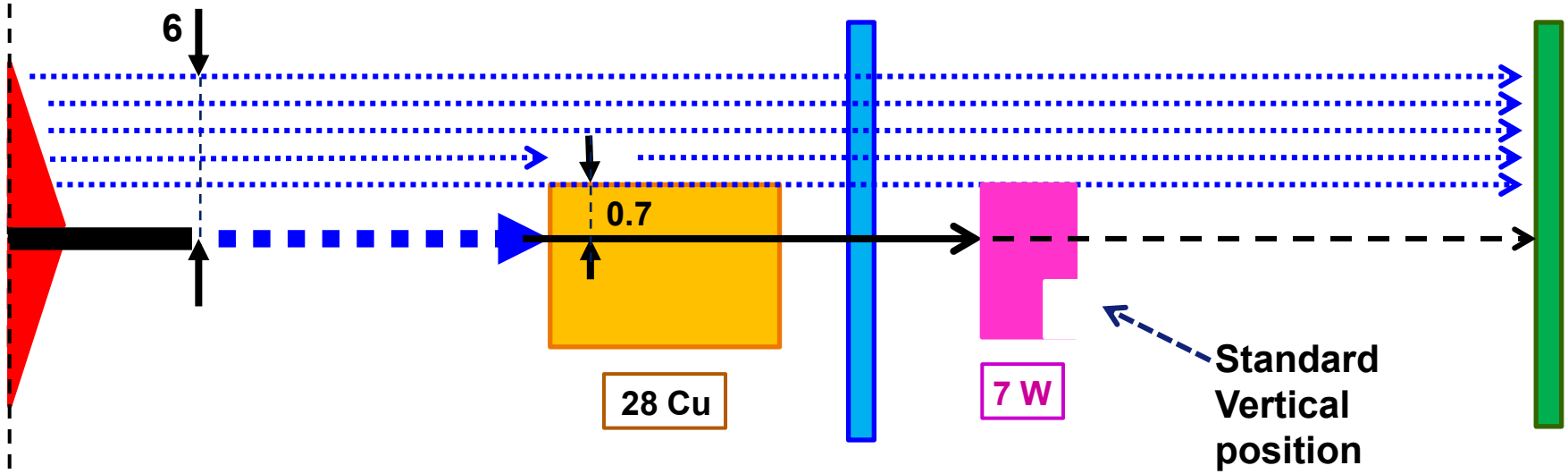

detected in screen
[a.u]
1
1.3 e-4
1.2 e-7
2.4 e-8
energy [KeV]


40
153
250
271
energy [KeV]

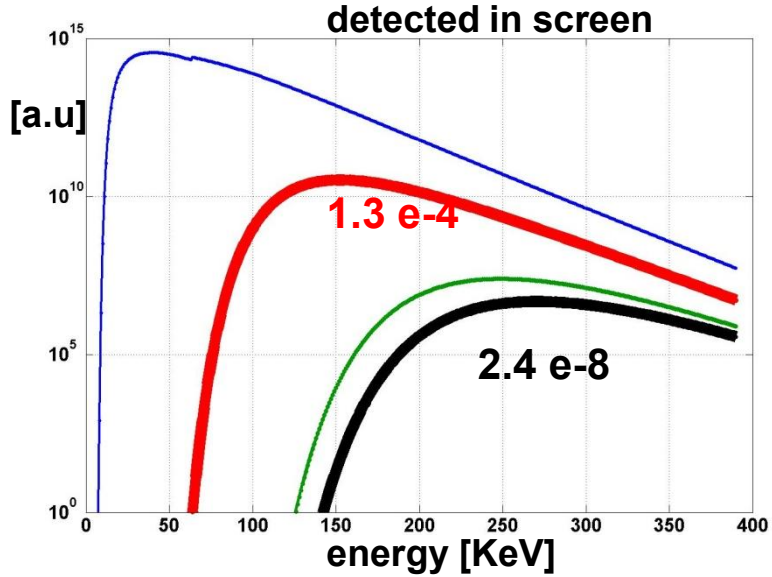

6
0.7
28 Cu
7 W
or
5 W
fixed
vertical
position
vertical
position
adjustable
remotely

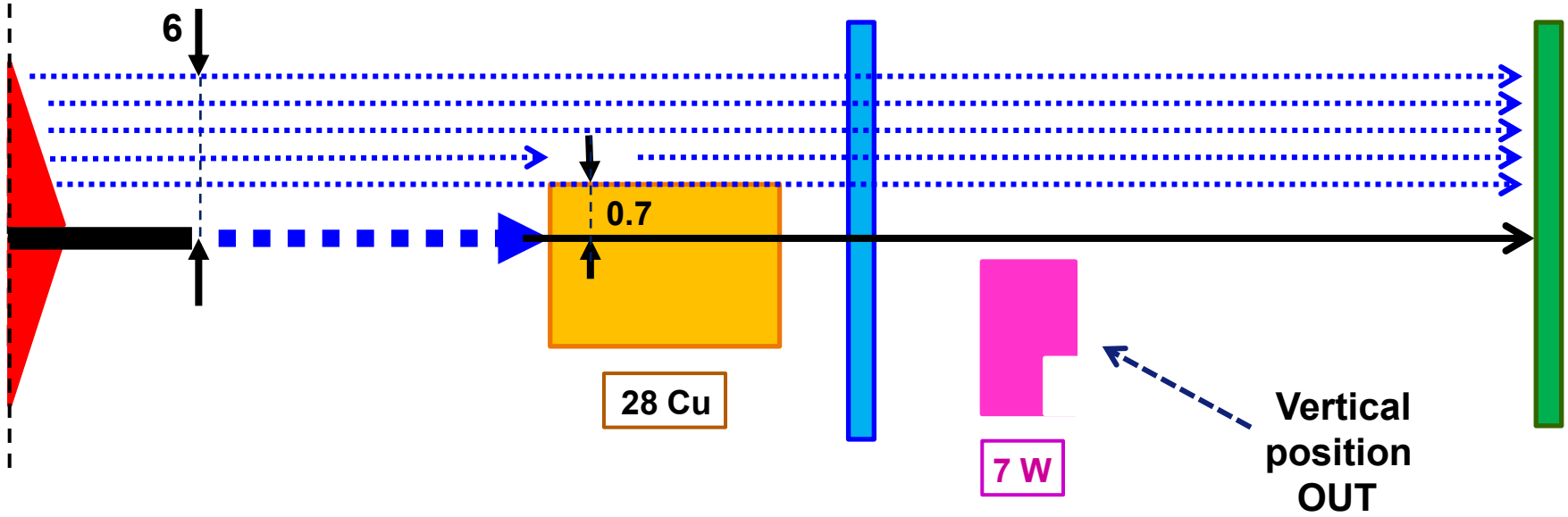
Side-View


detected in screen
[a.u]
1
2.4 e-8
energy [KeV]

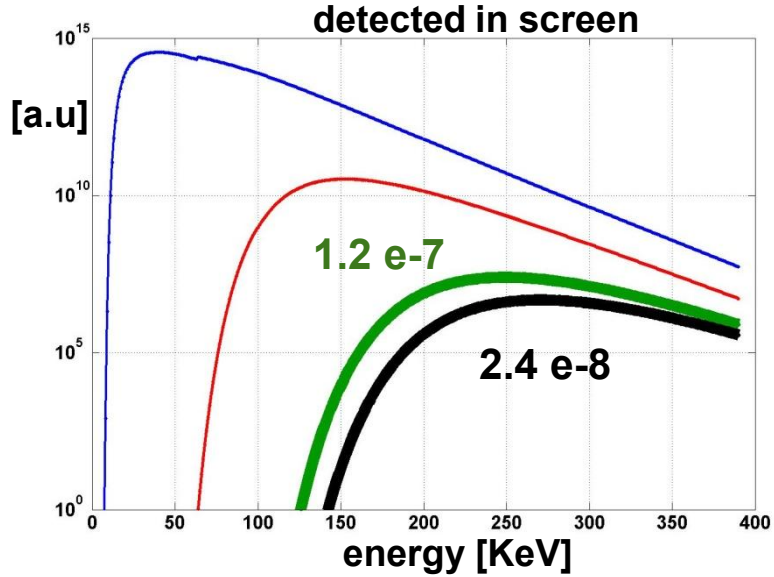

6
0.7
28 Cu
7 W
Standard
Vertical
position

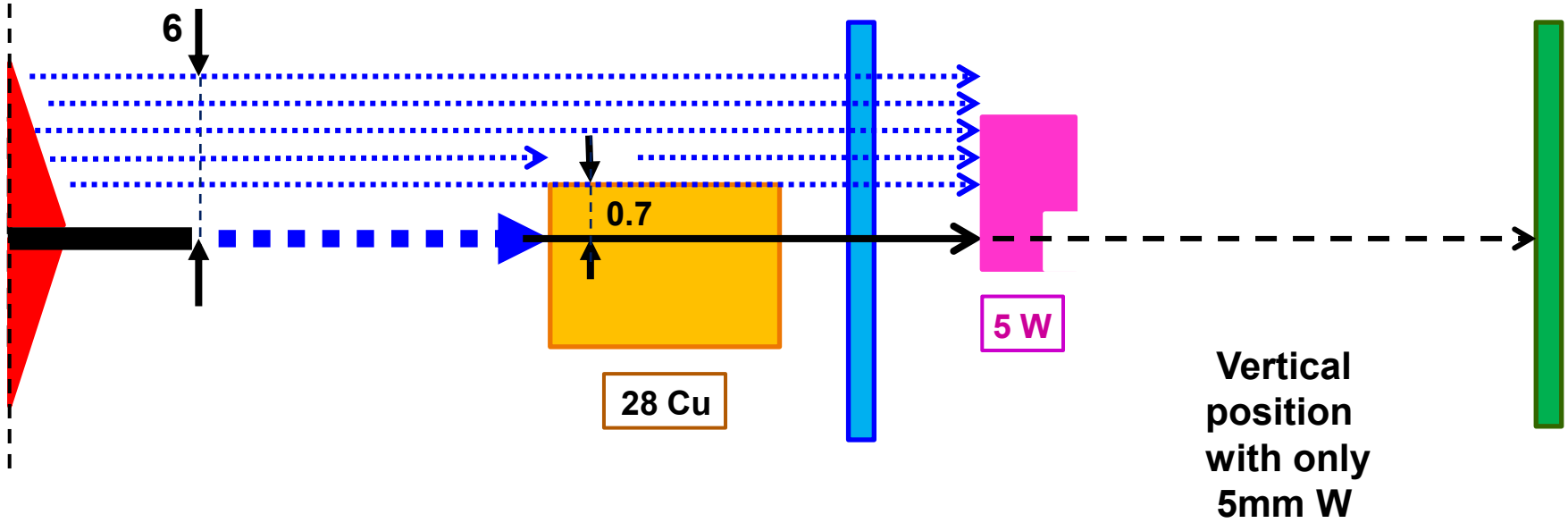
Side-View


detected in screen
[a.u]
10^{15}
10^{10}
10^{5}
10^{0}
1.3 e-4
2.4 e-8
0
50
100
150
200
250
300
350
400
energy [KeV]

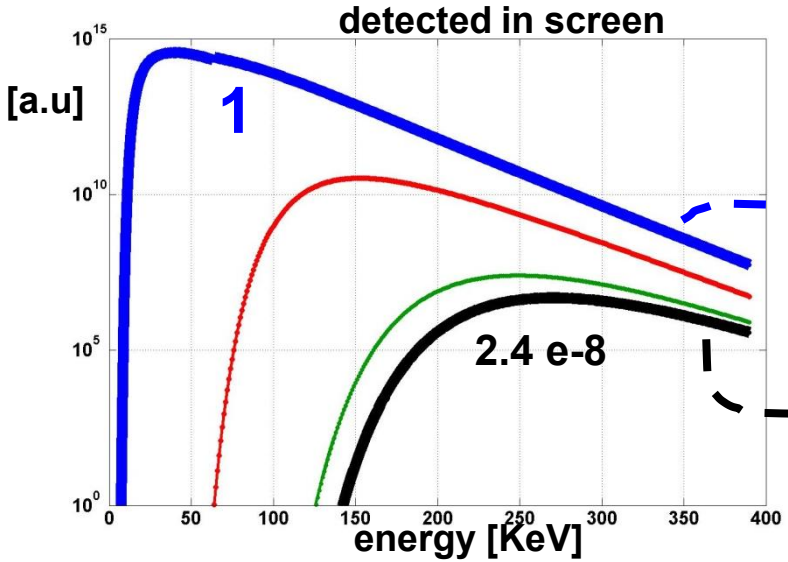

6
0.7
28 Cu
7 W
Vertical
position
OUT

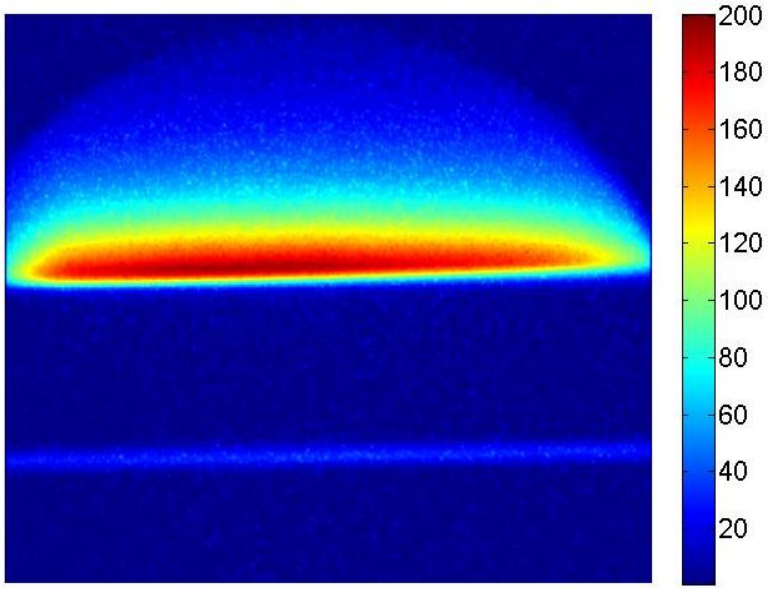
Side-View

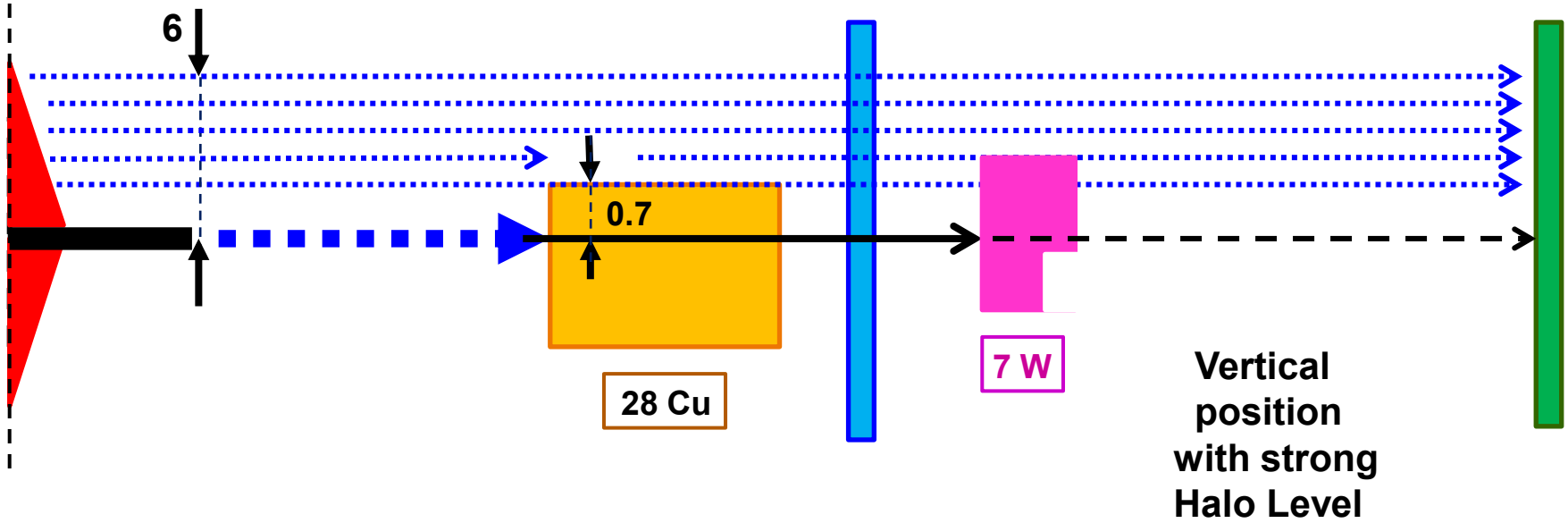

detected in screen
[a.u]
10^{15}
10^{10}
10^{5}
10^{0}
1.2 e-7
2.4 e-8
0
50
100
150
200
250
300
350
400
energy [KeV]


6
0.7
5 W
28 Cu
Vertical position with only 5mm W

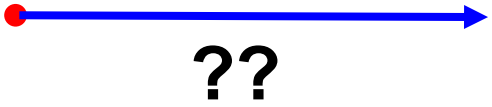
Side-View

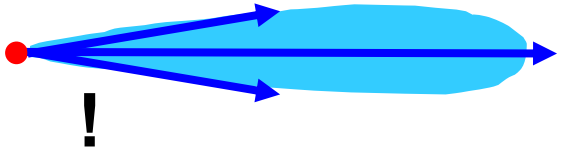

detected in screen
[a.u]
1
2.4 e-8
energy [KeV]




6
0.7
28 Cu
7 W
Vertical position with strong Halo Level

Side-View

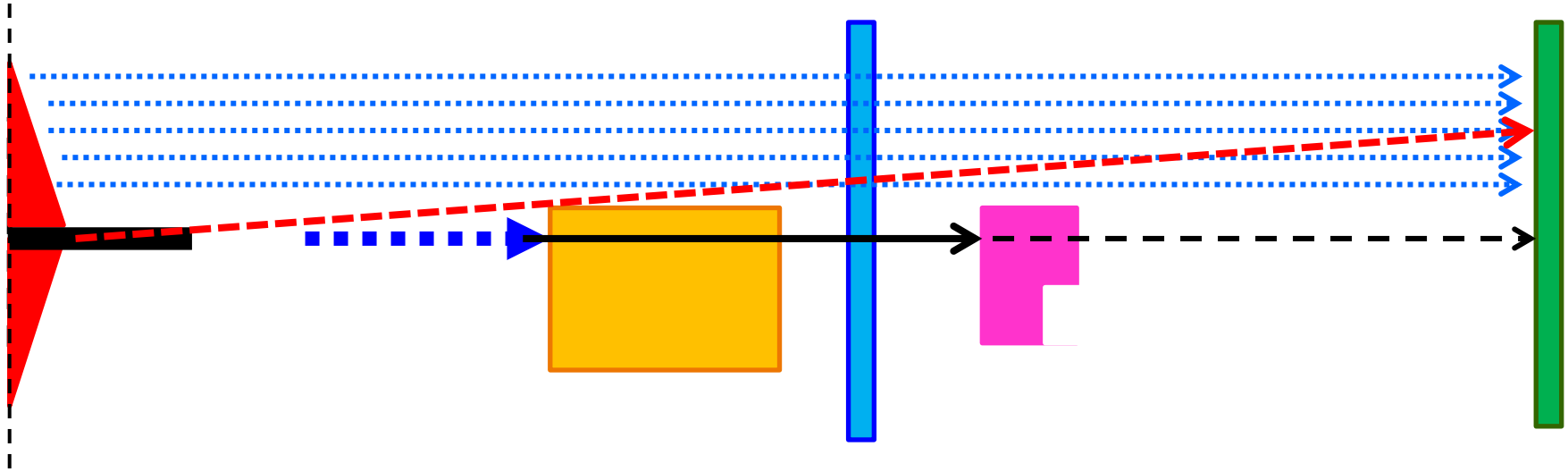




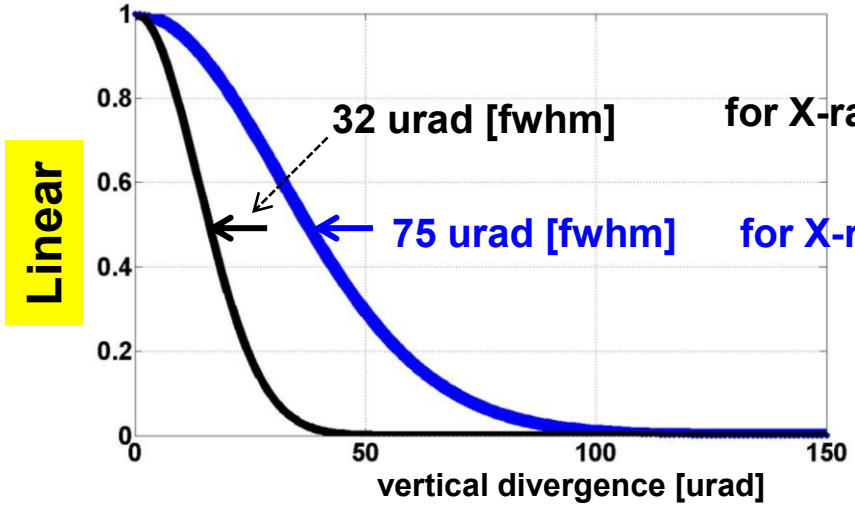
the emitted X-rays <u>do diverge vertically</u> , it causes two limitations :

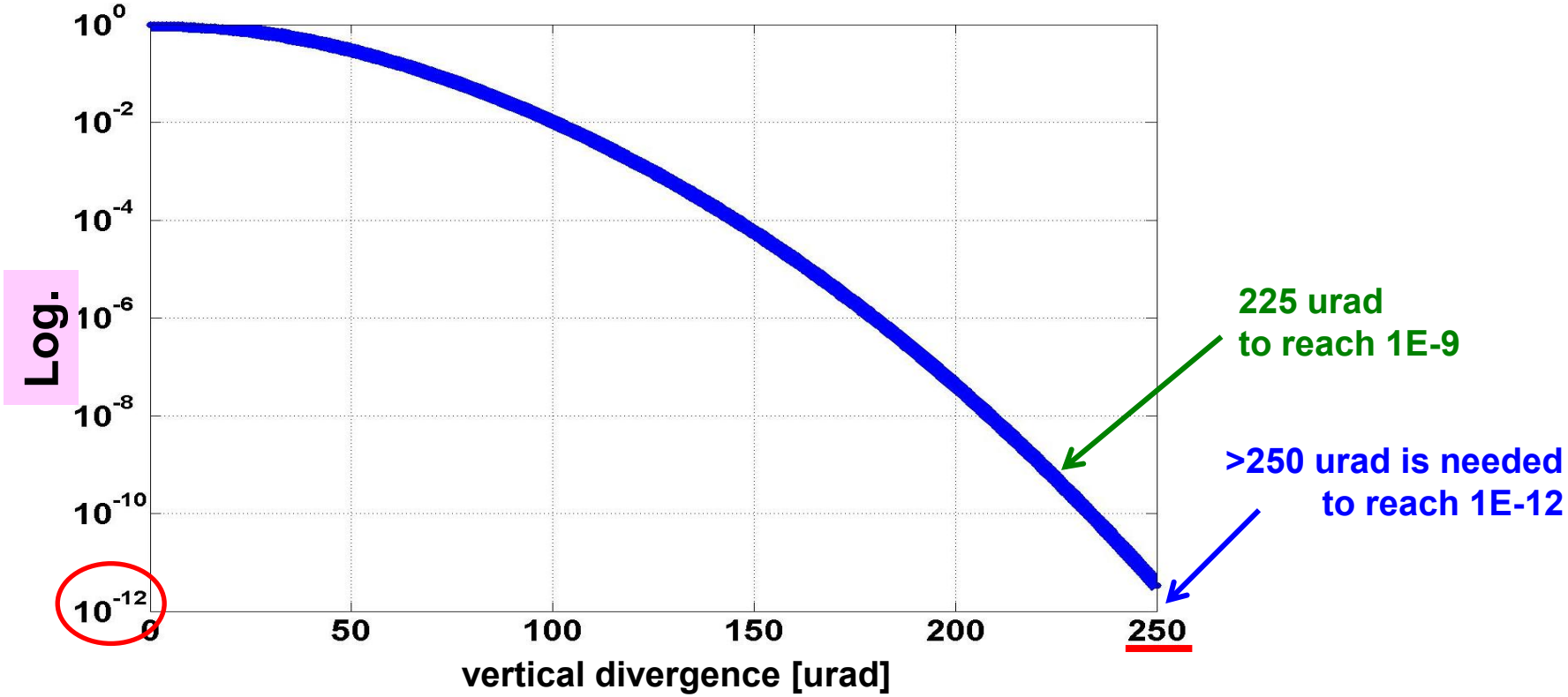
1) spatial resolution of the imaged Halo profile

2) how close to the beam-core can this system measure



Side-View

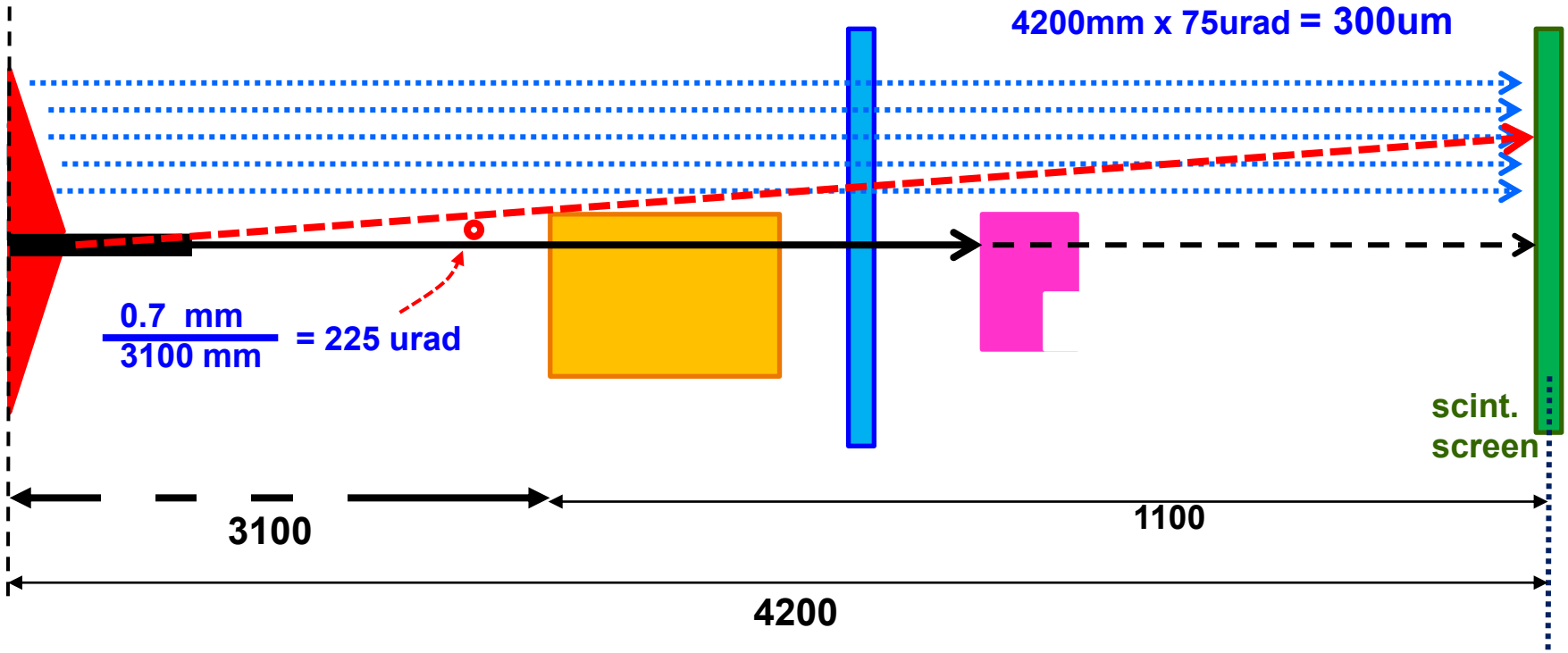

Linear
32 urad [fwhm]
for X-rays @271KeV after 28mm Cu & 7mm W
75 urad [fwhm]
for X-rays @40KeV after only 2mm Aluminium
1
0.8
0.6
0.4
0.2
0
0
50
100
150
vertical divergence [urad]

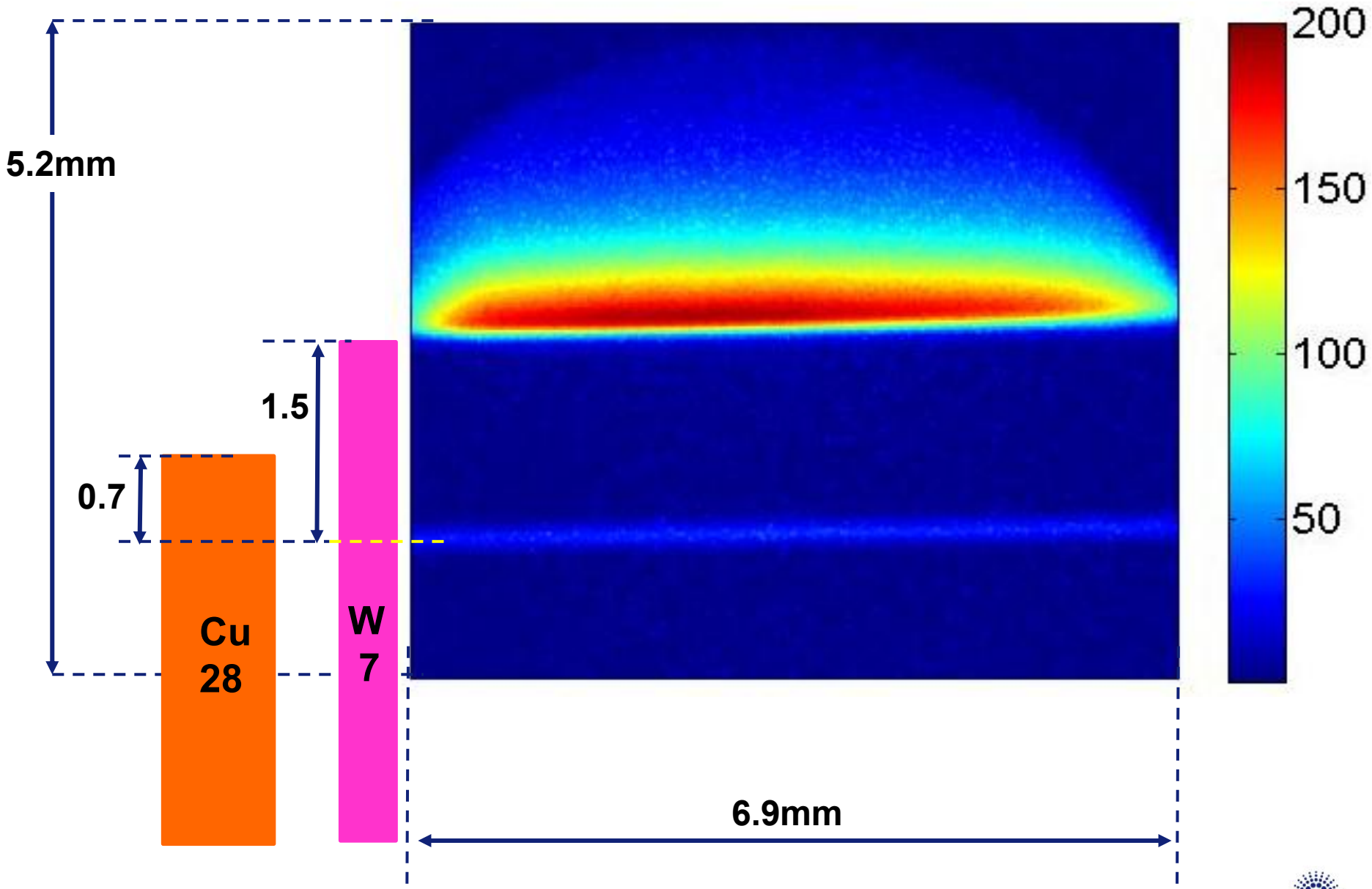

Log.
10^{0}
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
0
50
100
150
200
250
vertical divergence [urad]
225 urad
to reach 1E-9
>250 urad is needed
to reach 1E-12

limitations due to <u>vertical divergence</u> of the "soft" X-rays :

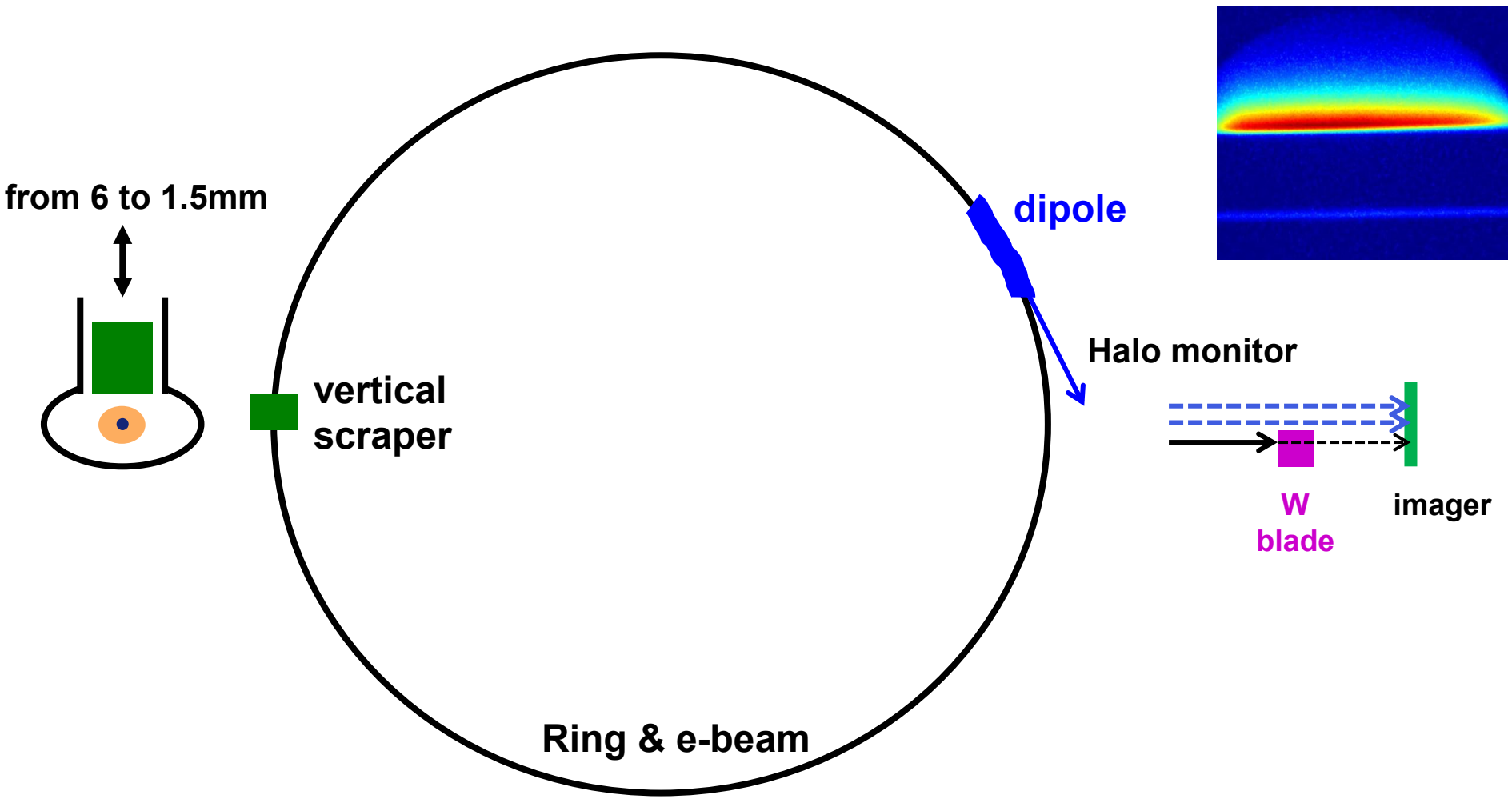
1) spatial resolution the Halo profile is 300um [fwhm]

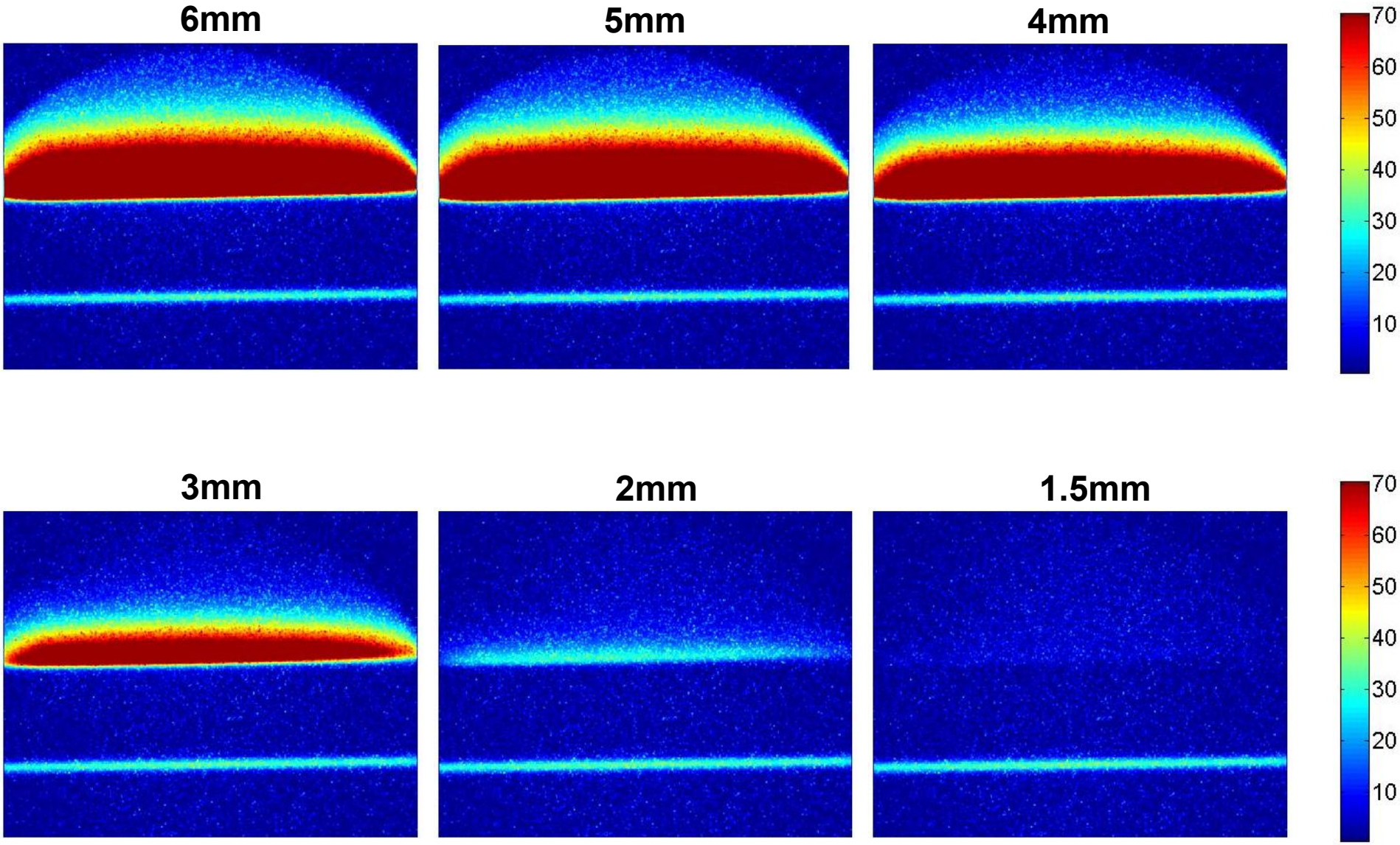
2) can not get closer than 700um from beam-core




5.2mm
1.5
0.7
Cu
28
W
7
6.9mm
200
150
100
50

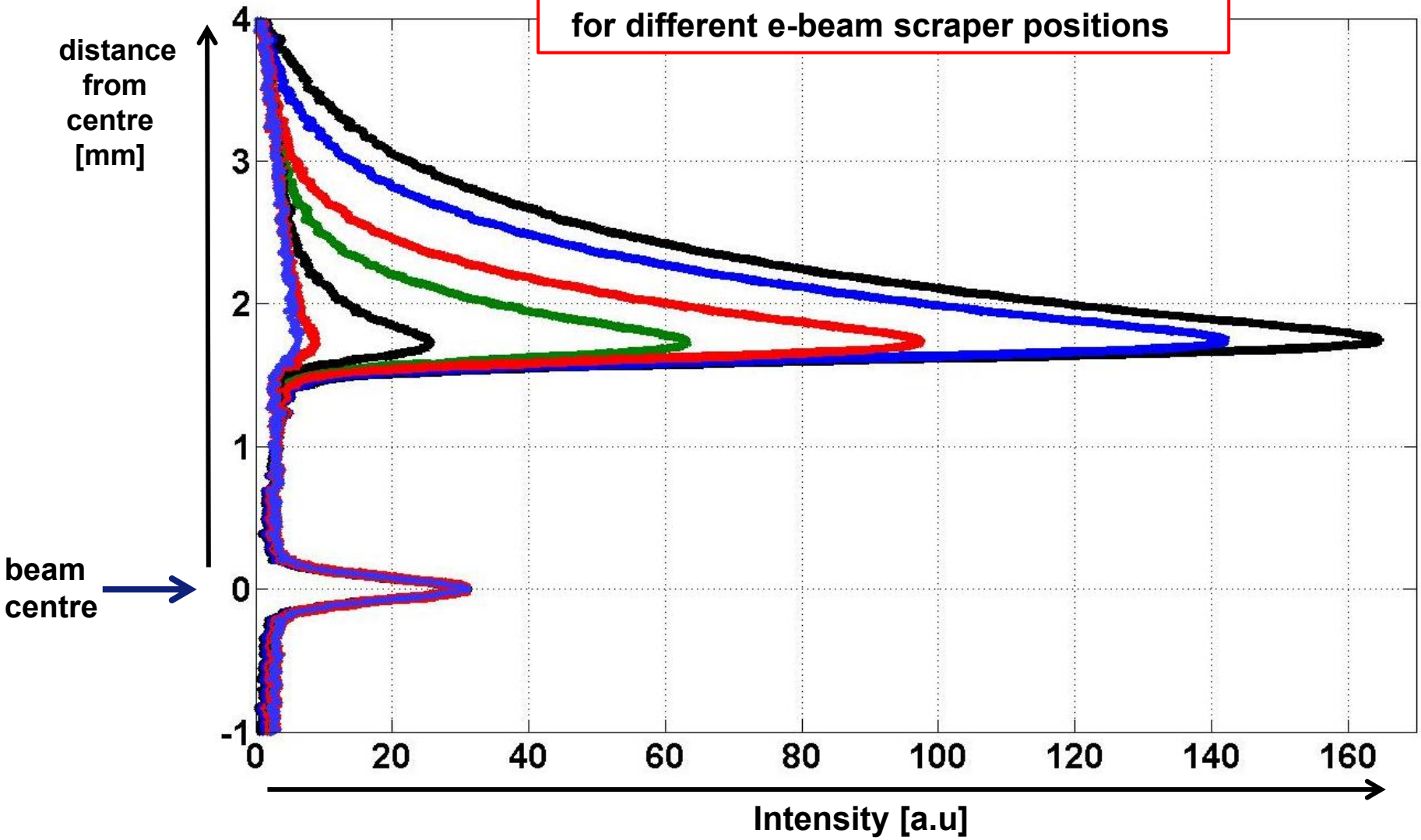
Scrape the electron beam and **Observe the Halo monitor**

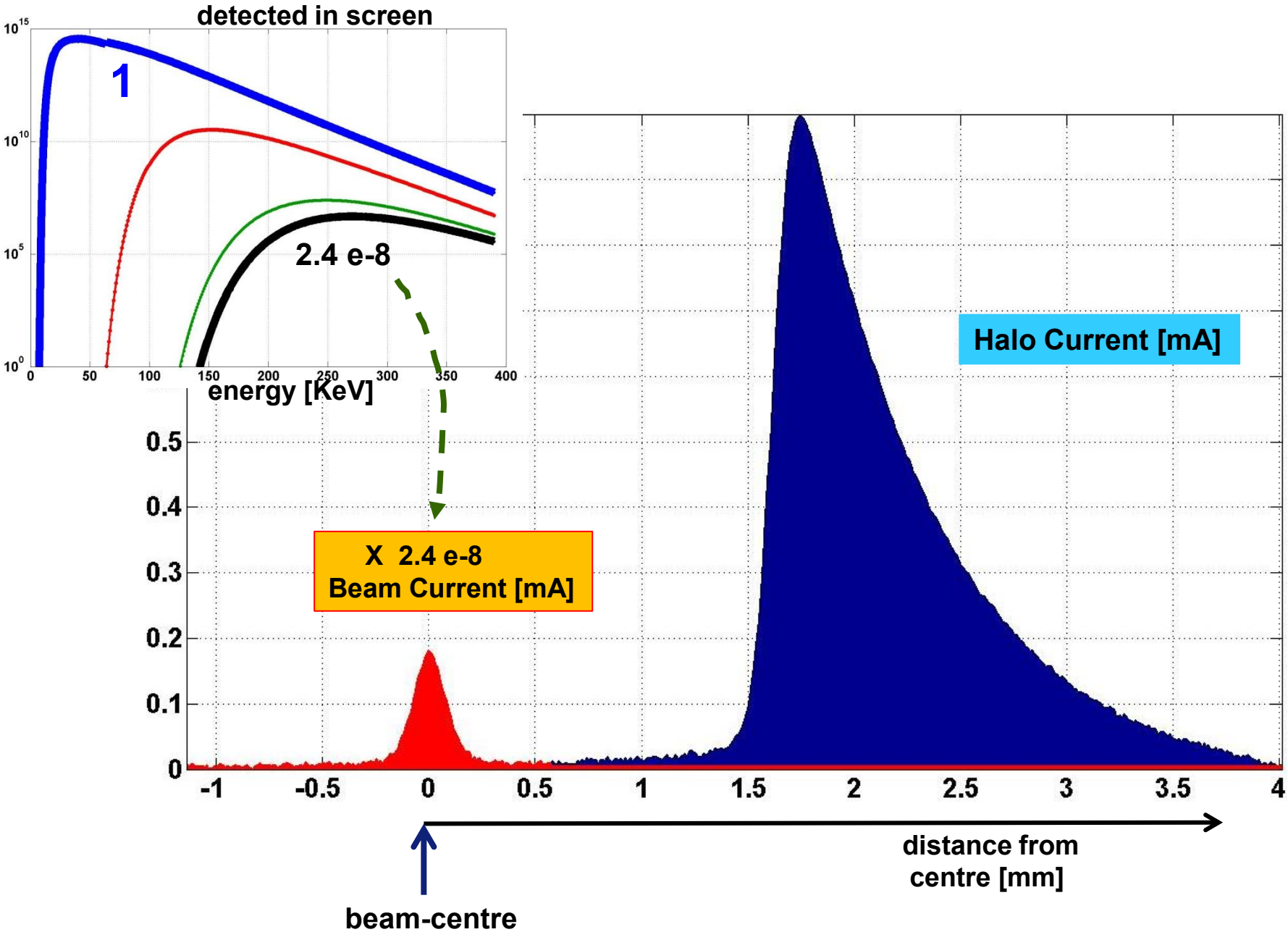



6mm
5mm
4mm
70
60
50
40
30
20
10
3mm
2mm
1.5mm
70
60
50
40
30
20
10

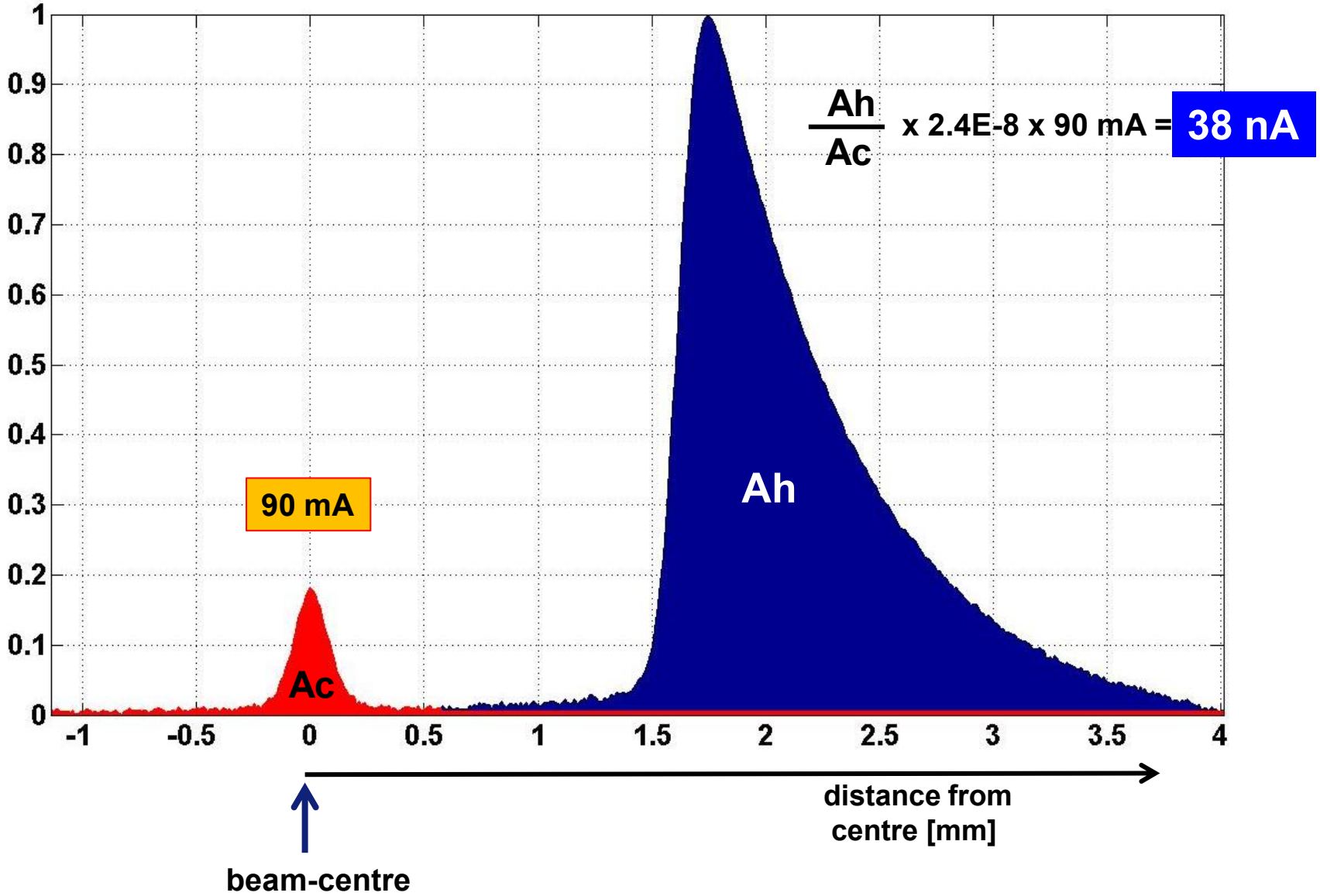
Vertical Profiles of the Halo monitor

for different e-beam scraper positions

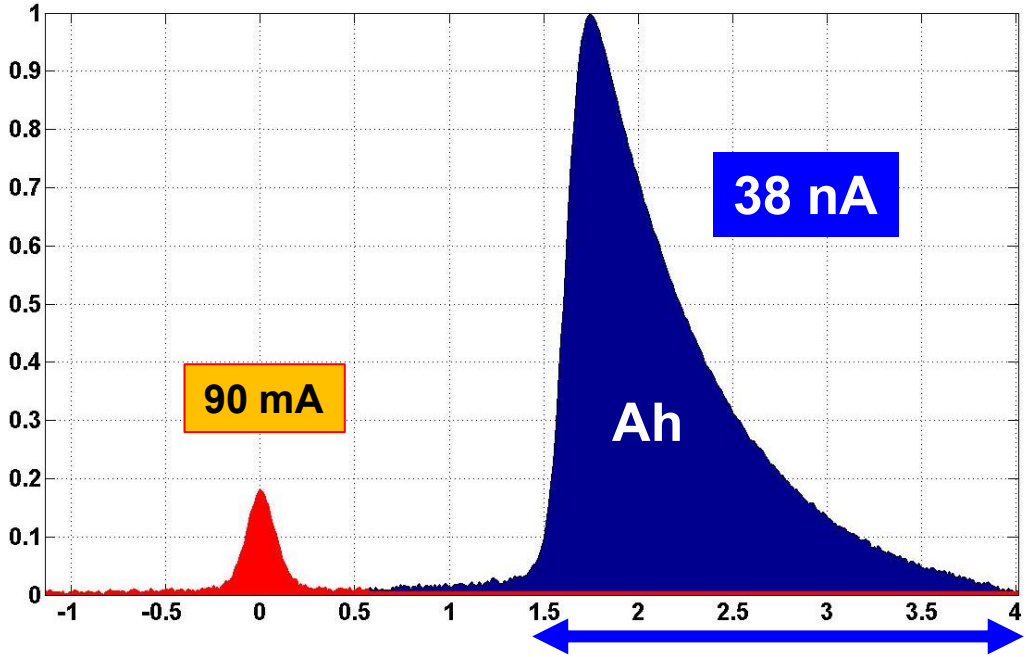



detected in screen
1
2.4 e-8
energy [KeV]
Halo Current [mA]
X 2.4 e-8
Beam Current [mA]
distance from
centre [mm]
beam-centre

Vertical Profile of the Halo monitor



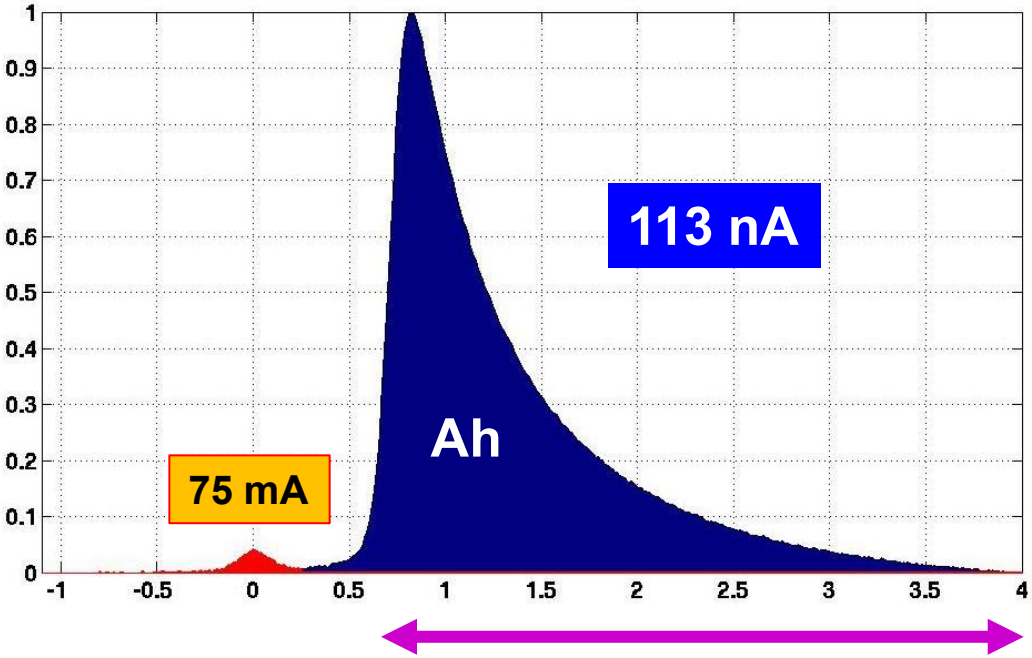
Vertical Profiles of the Halo monitor for different settings



in 1.5 to 4 mm
distance from centre

these images and profiles are generated at 1Hz rate,

the sum_of_profile is stored permanently in a data base



in 0.7 to 4 mm
distance from centre

different usages of the vertical Halo monitor

During User operation mode :

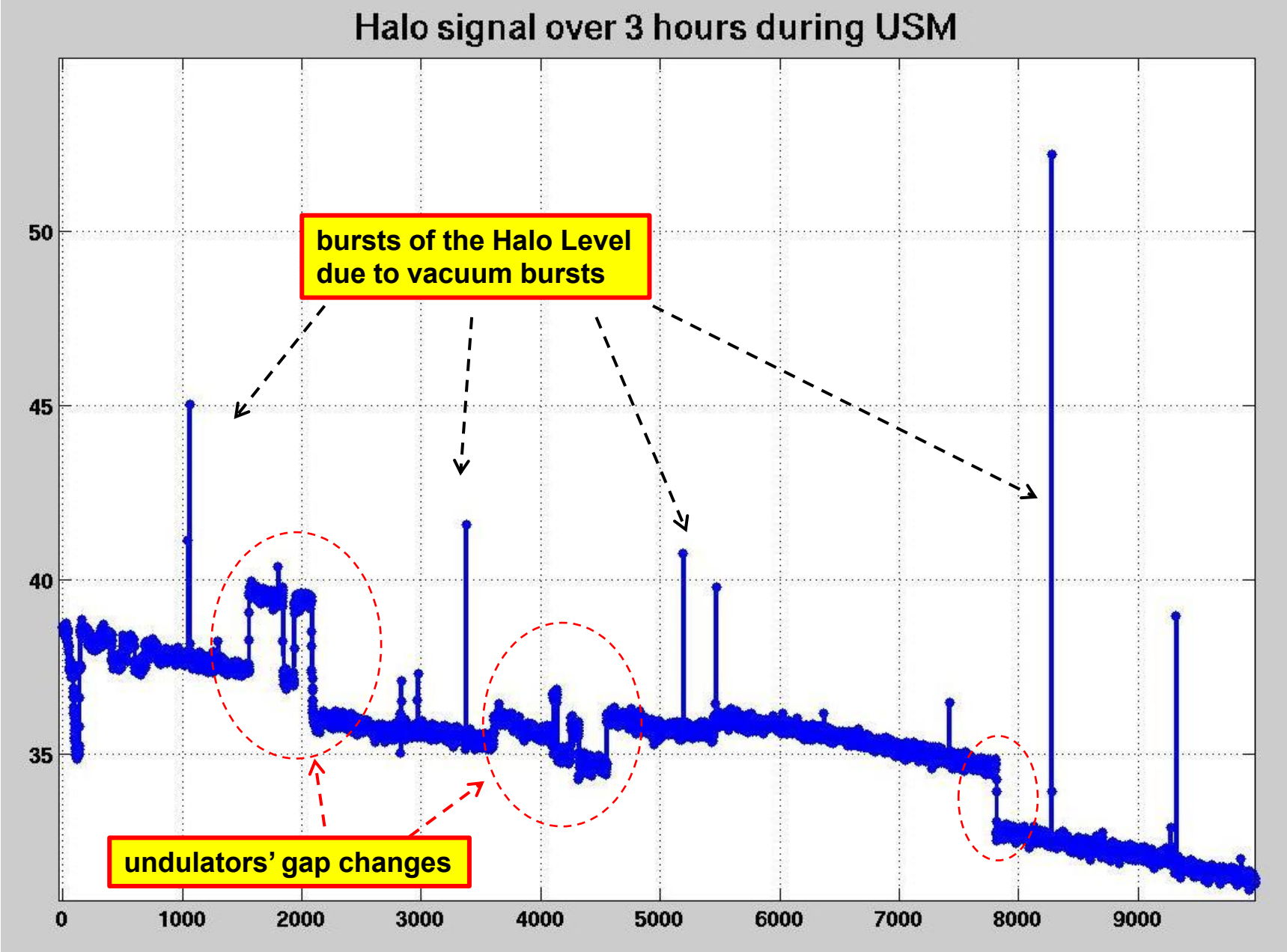
1) Drastic Halo level variation with Vacuum burst

2) Halo variation due to In-Vac. undulator Gap changes

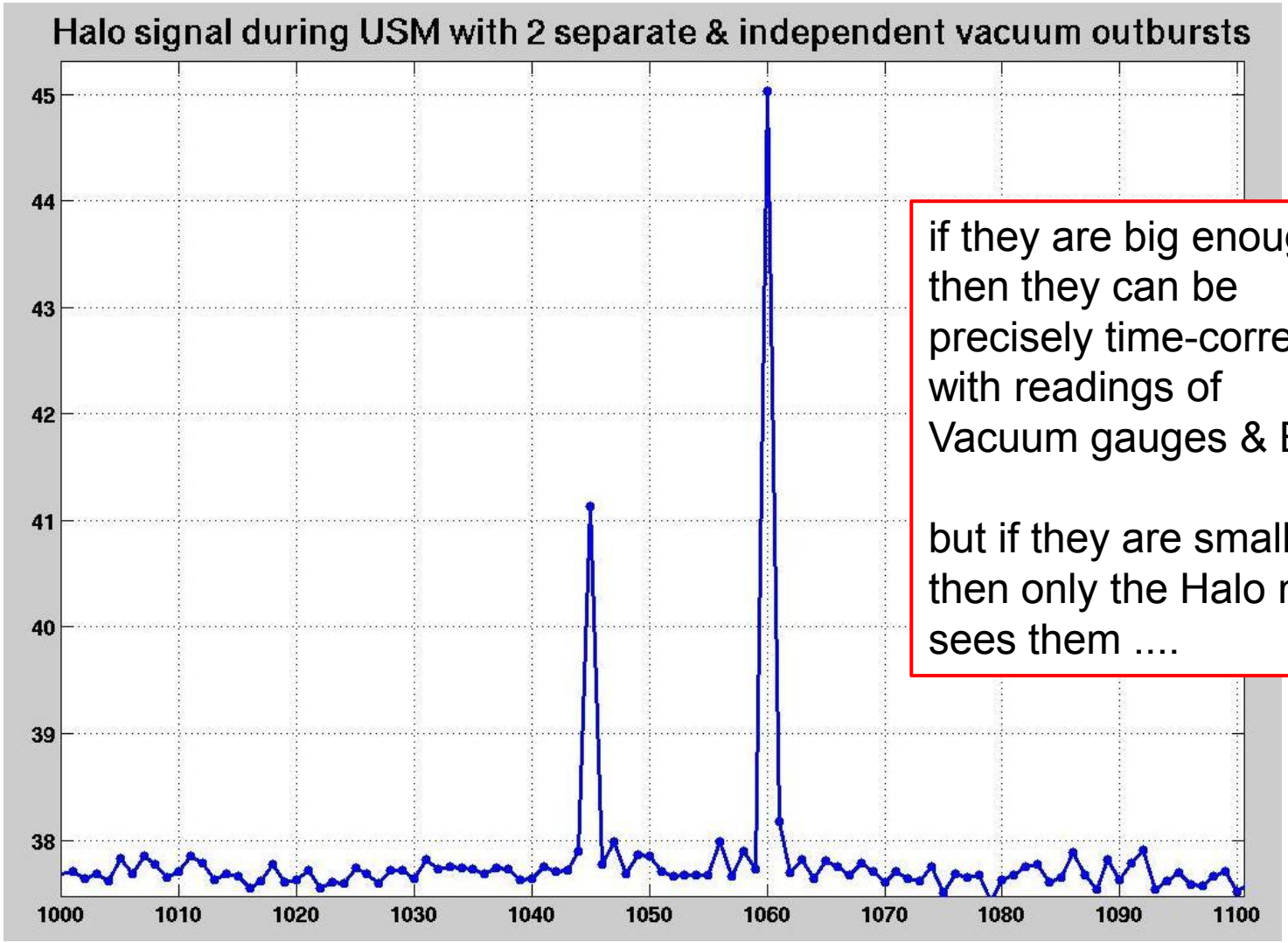
During Accelerator Studies :

1) Halo level - versus - beamsize (emittance) → Touchek
   and for different positions of the scrapers (both Hor. & Vert.)

2) Quantification of the interception of 6GeV electrons by any
   In-Vac. Undulators as function of their (small) Gaps


Halo signal over 3 hours during USM
bursts of the Halo Level due to vacuum bursts
undulators' gap changes
50
45
40
35
0
1000
2000
3000
4000
5000
6000
7000
8000
9000

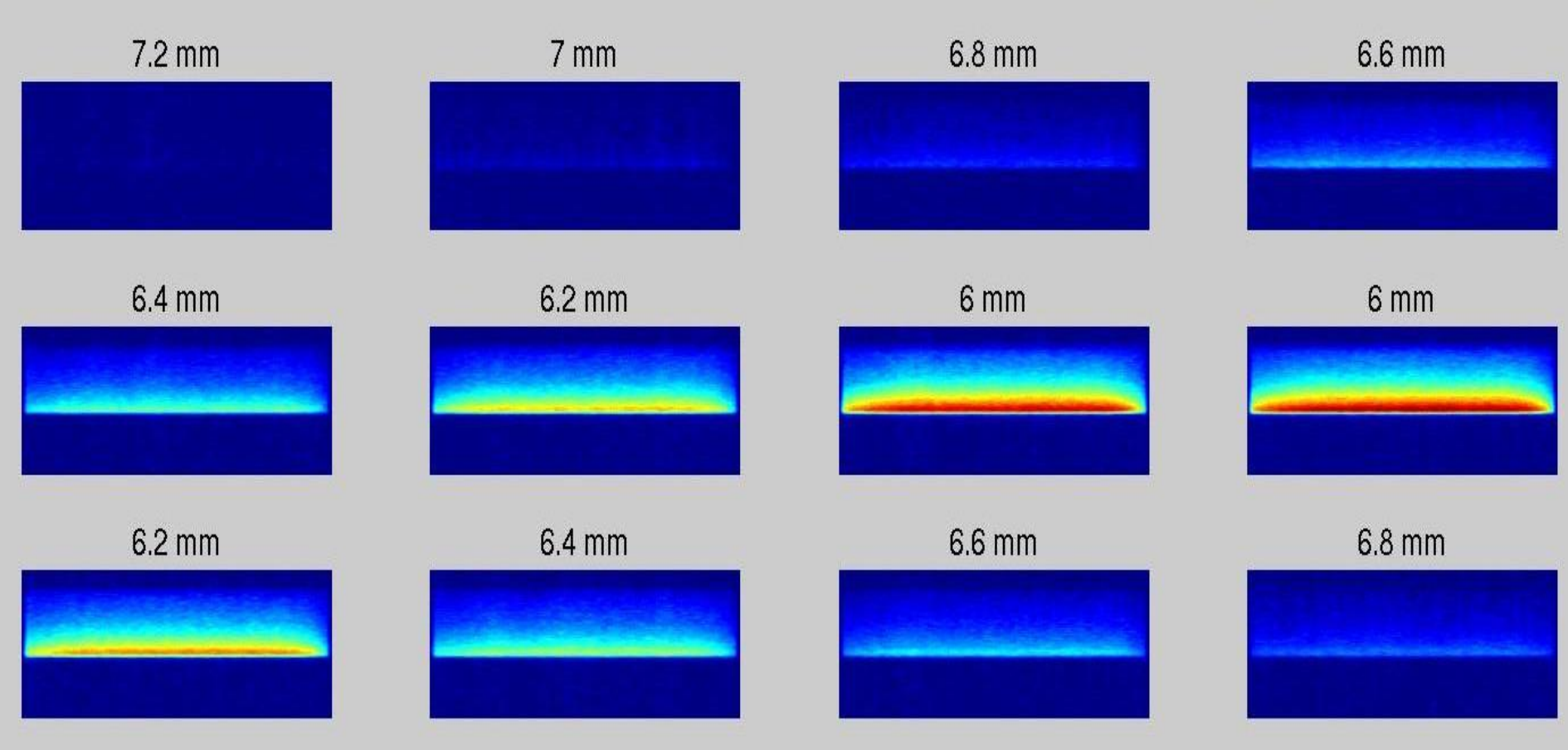
bursts of the Halo Level, due to vacuum bursts



if they are big enough then they can be precisely time-correlated with readings of Vacuum gauges & BLDs,

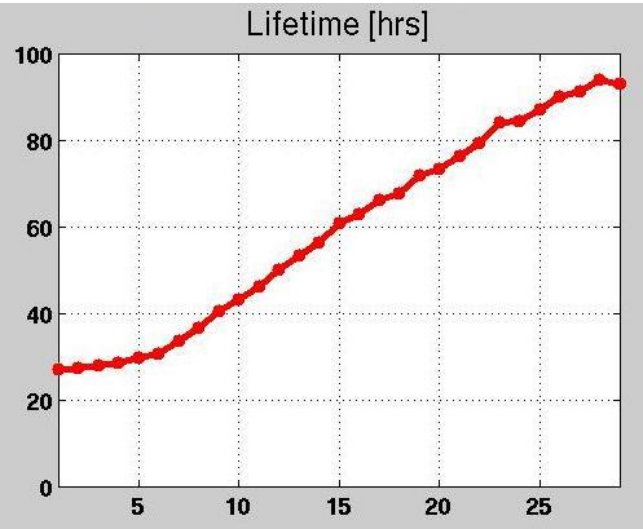
but if they are small then only the Halo monitor sees them ....

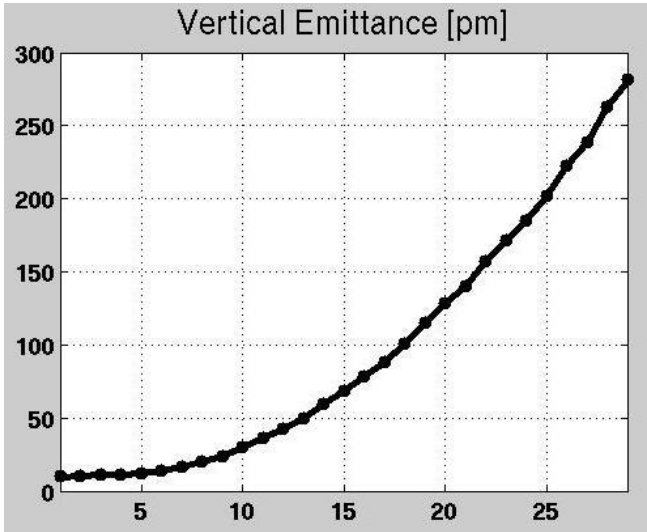
Differential Halo Images when closing an In-Vacuum Undulator gap

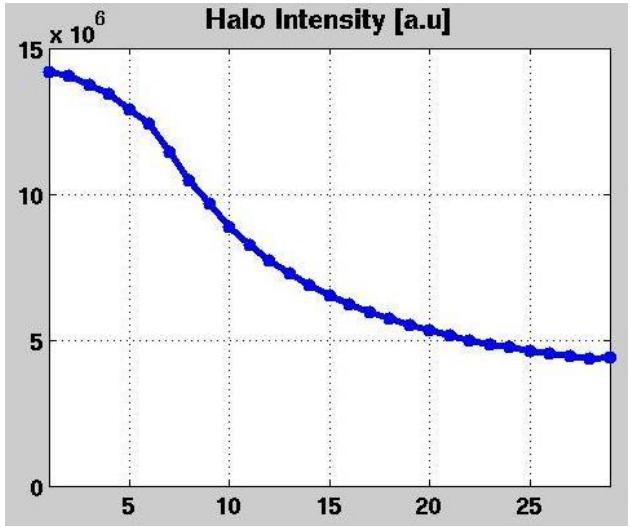


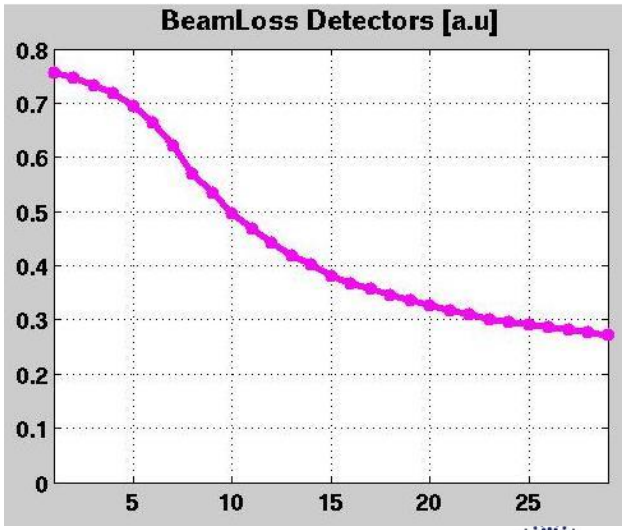
Differential image : image@fully_open_gap minus image@small-gap
i.e. 40mm i.e. 6mm

Accelerator studies : e.g. increasing beam-size (30 steps)

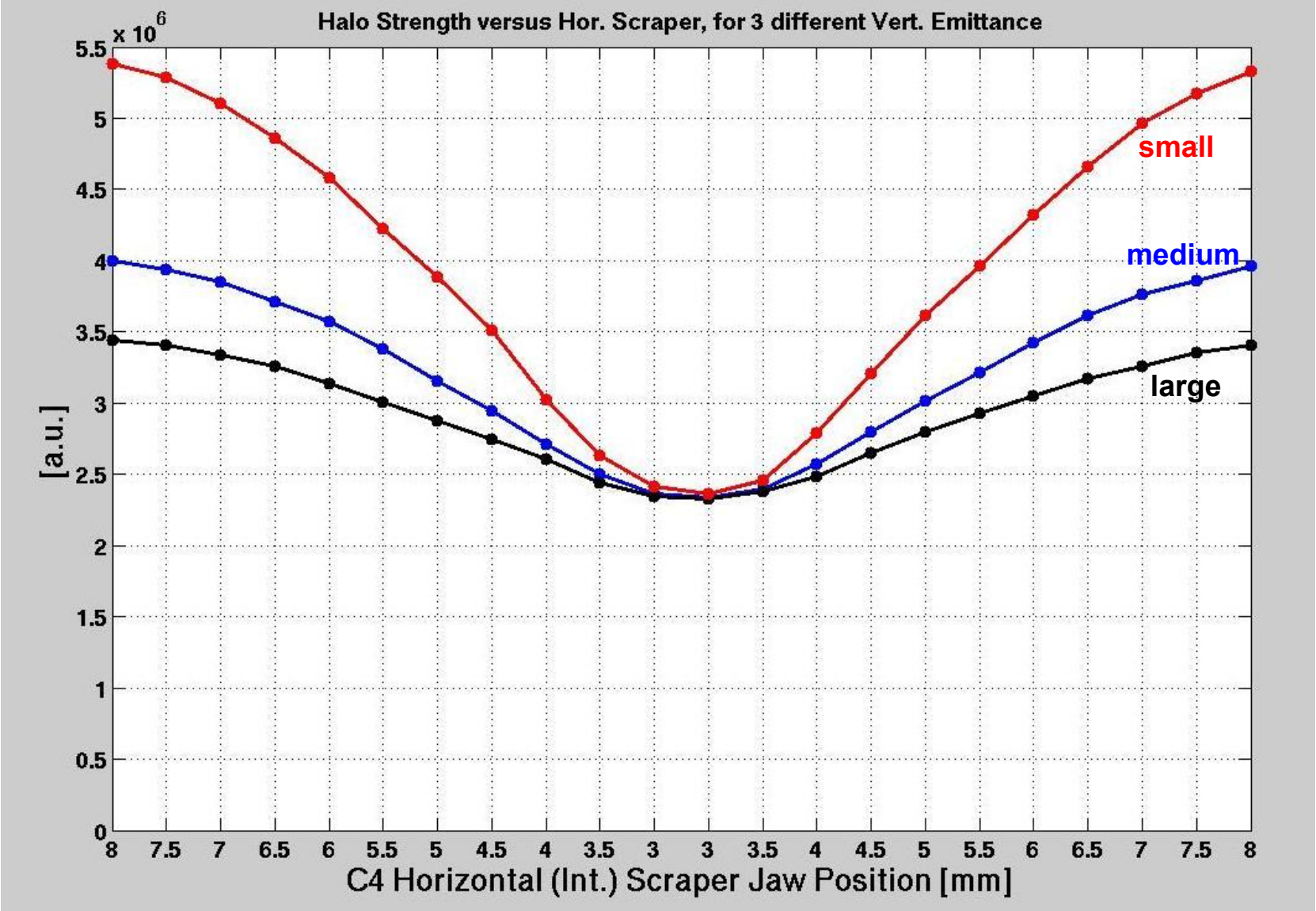








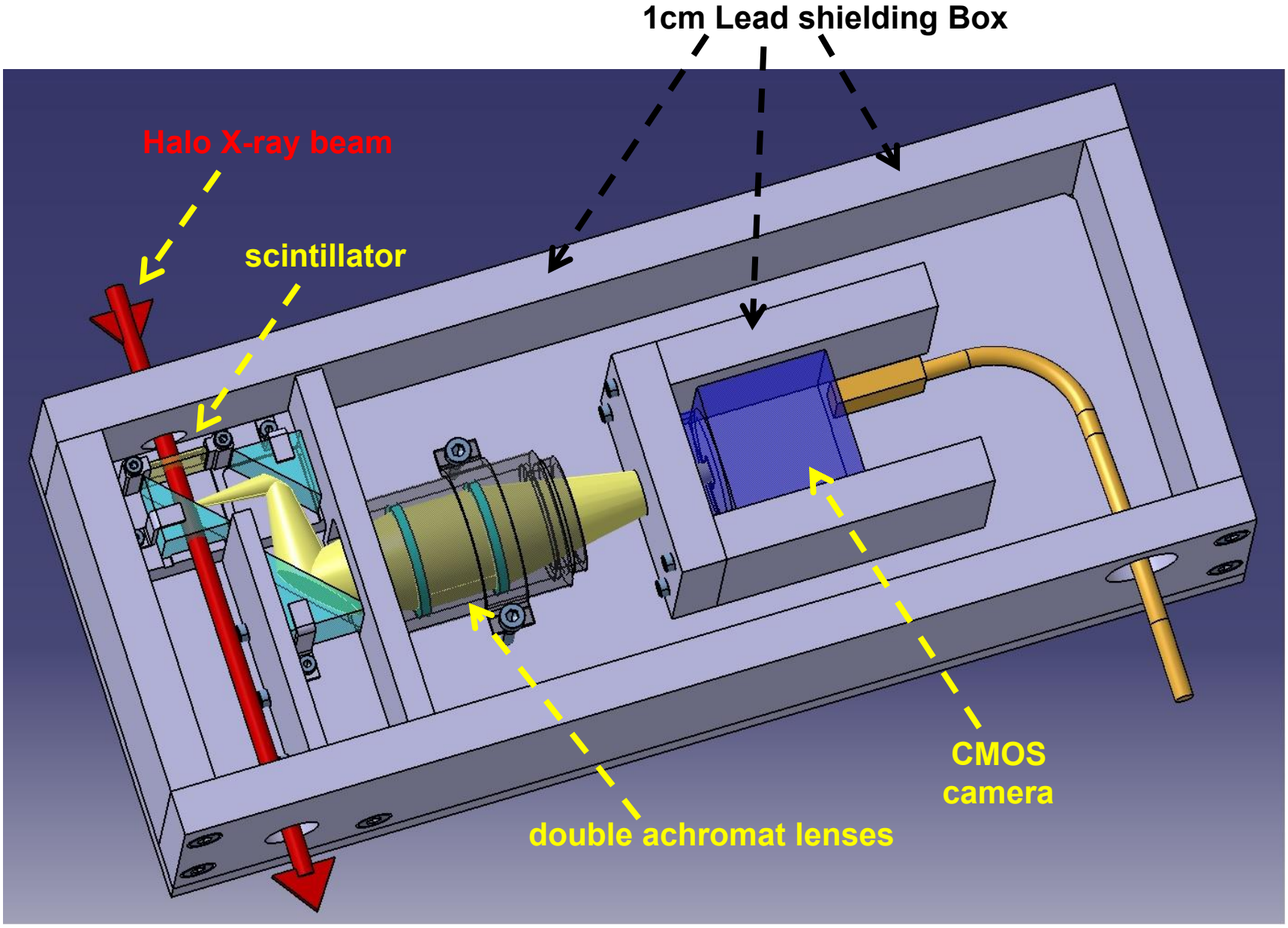
Accelerator studies : the effect of the Horizontal e-beam Scraper for 3 different values of Vertical Emittance



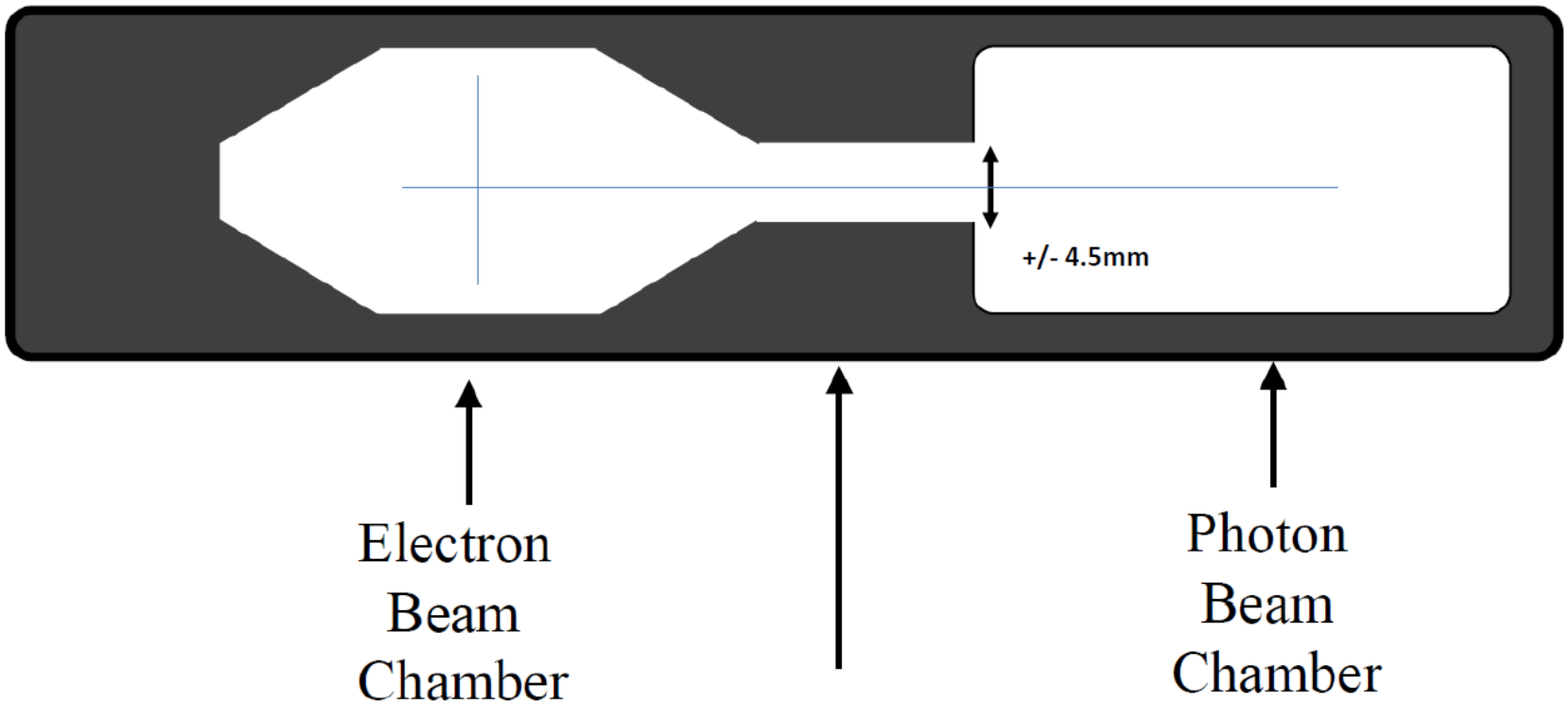
Halo lujah

the H A L O Monitor

where other diagnostics can not reach .....

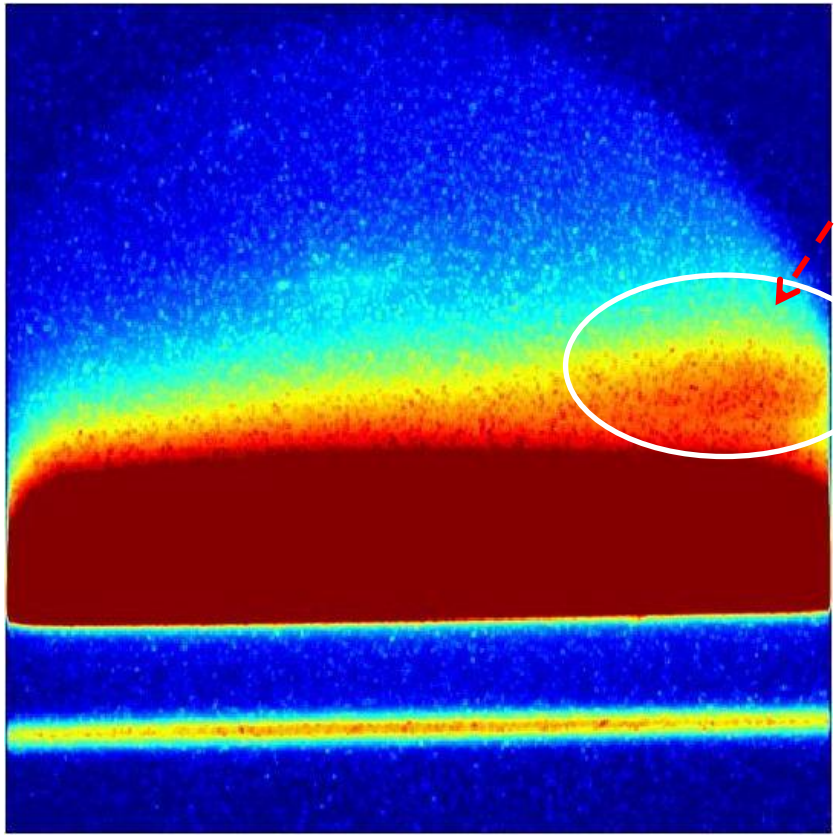

1cm Lead shielding Box
Halo X-ray beam
scintillator
double achromat lenses
CMOS
camera

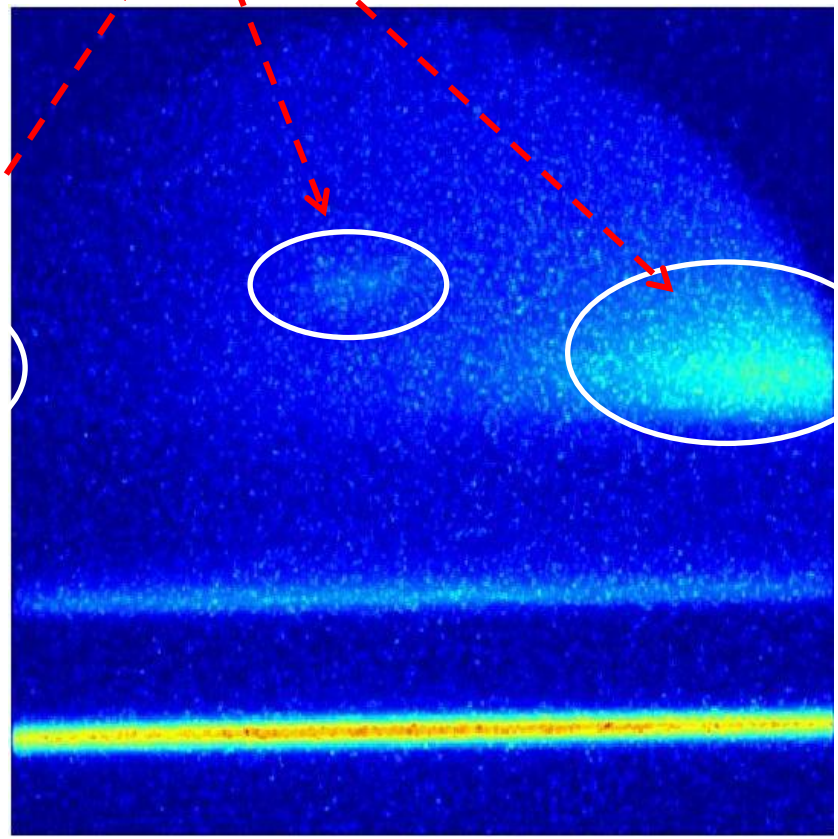
Dipole chamber cross-section



RF shielding
Standard gap = 9 mm

phantoms from X-ray scattering





scraper is fully open
phantoms difficult to see

scraper at 1mm
phantoms are obvious