Recent Developments of Novel Beam Diagnostics at the ESRF

1) Non-destructive Halo measurements in the vertical plane

2) Energy fluctuation measurements

3) Turn-by-Turn imaging of the injected beam size

1) Non-destructive Halo measurements in the vertical plane

with Halo is meant : the electron population 'far-away' from the beam's central core (the 'far-away' tails)

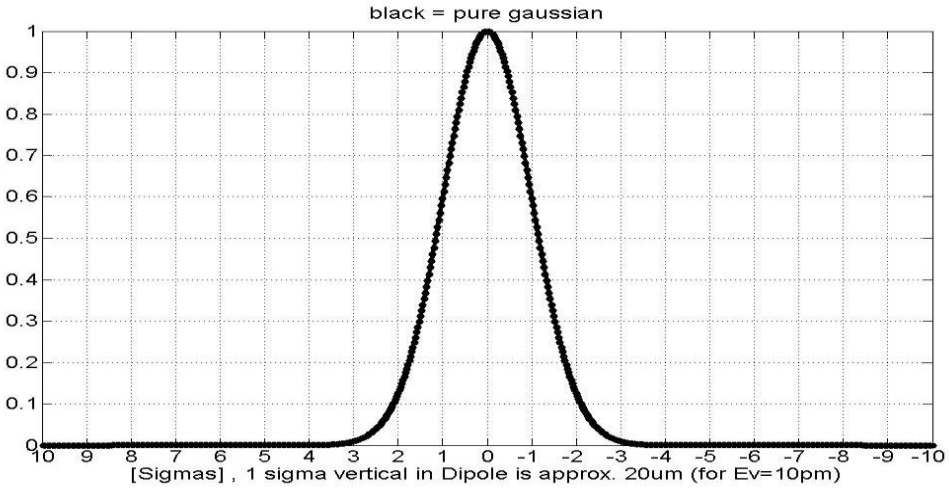
Halo is created by : scattering (Touchek, gas particles)

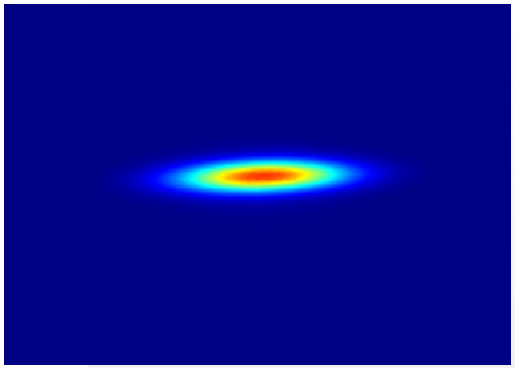
how can the Halo be measured ?

1. with scraper(s) & associated BLD(s) BUT : is destructive
2. with X-ray projection monitors BUT : only with BAD vacuum
3. Dipole magnet X-ray detection on a dedicated beamport

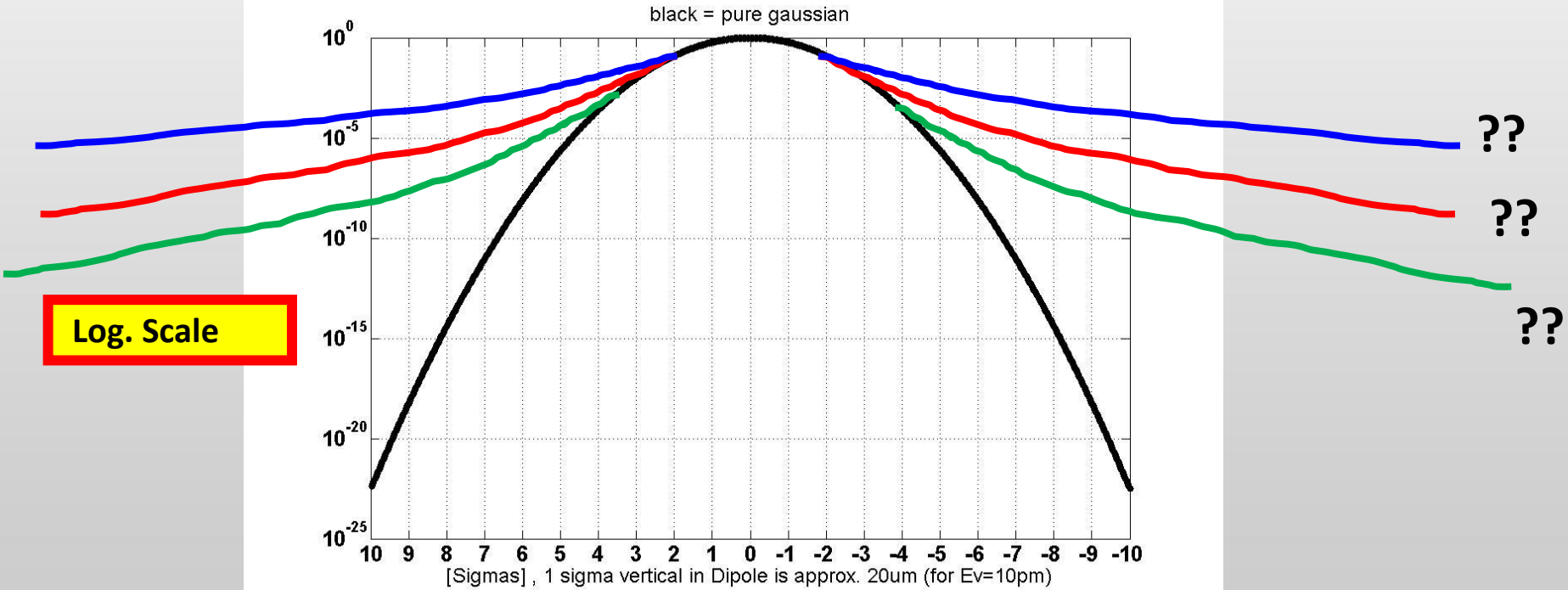
Non-destructive Halo measurements

Linear Scale



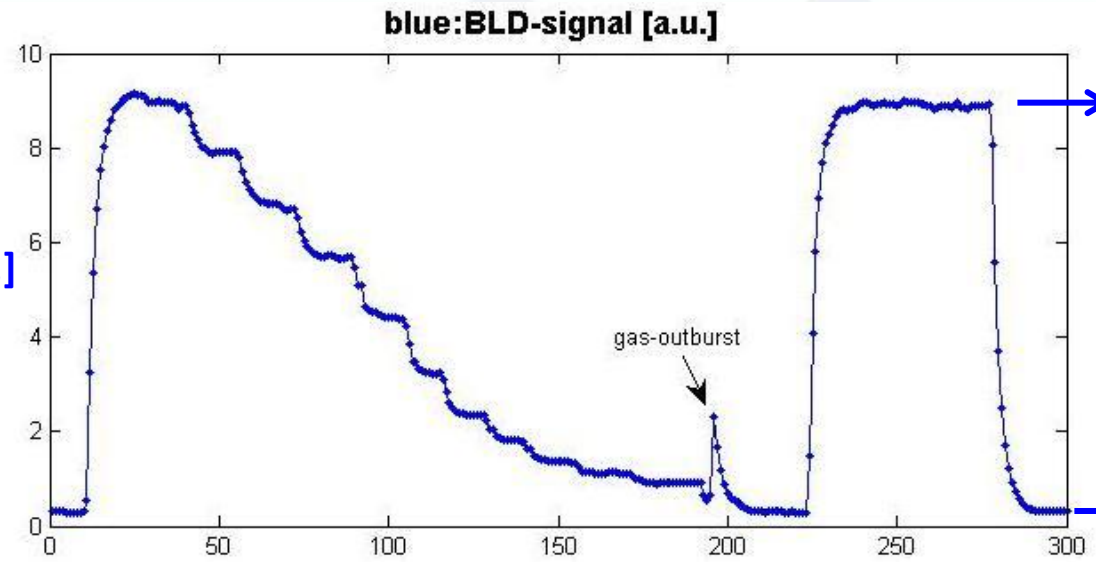


Log. Scale



Non-destructive Halo measurements

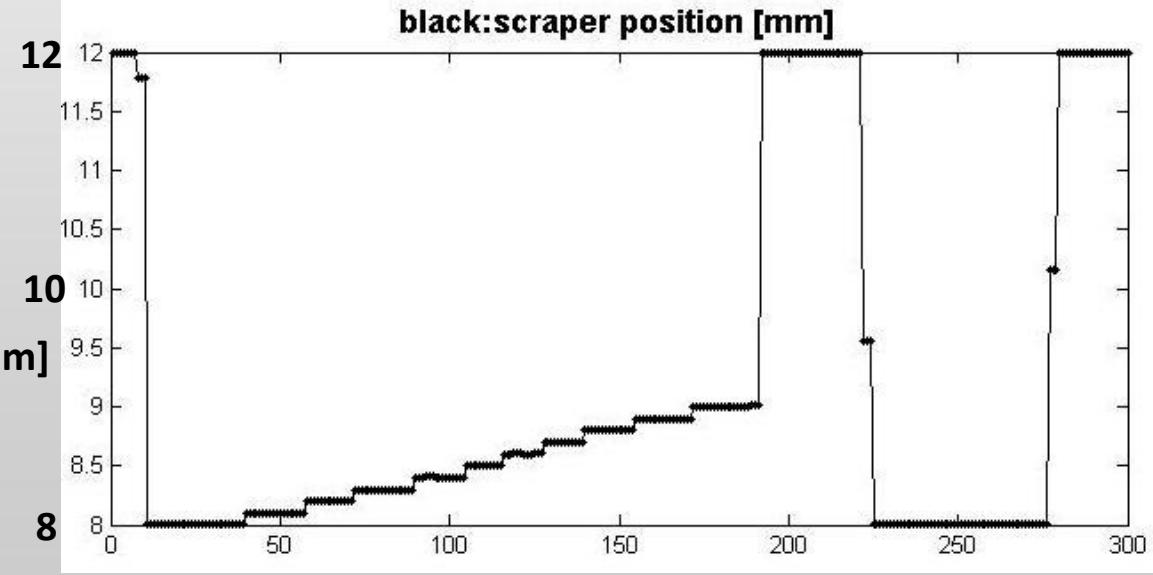
Beam Loss Detector [a.u.]



at 8mm (400 sigmas !!)

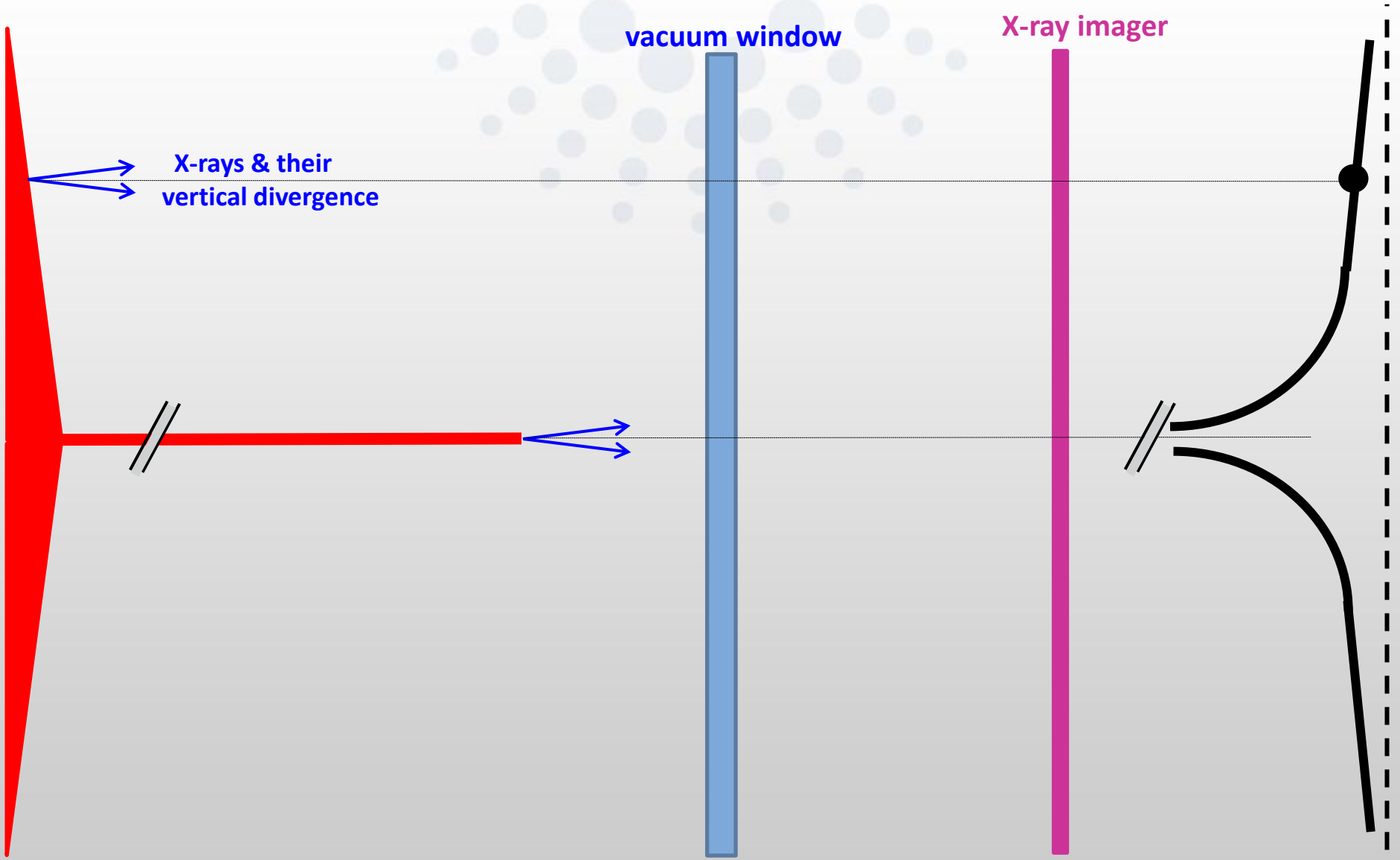
at 12mm (fully-out)

Scraper position [mm]



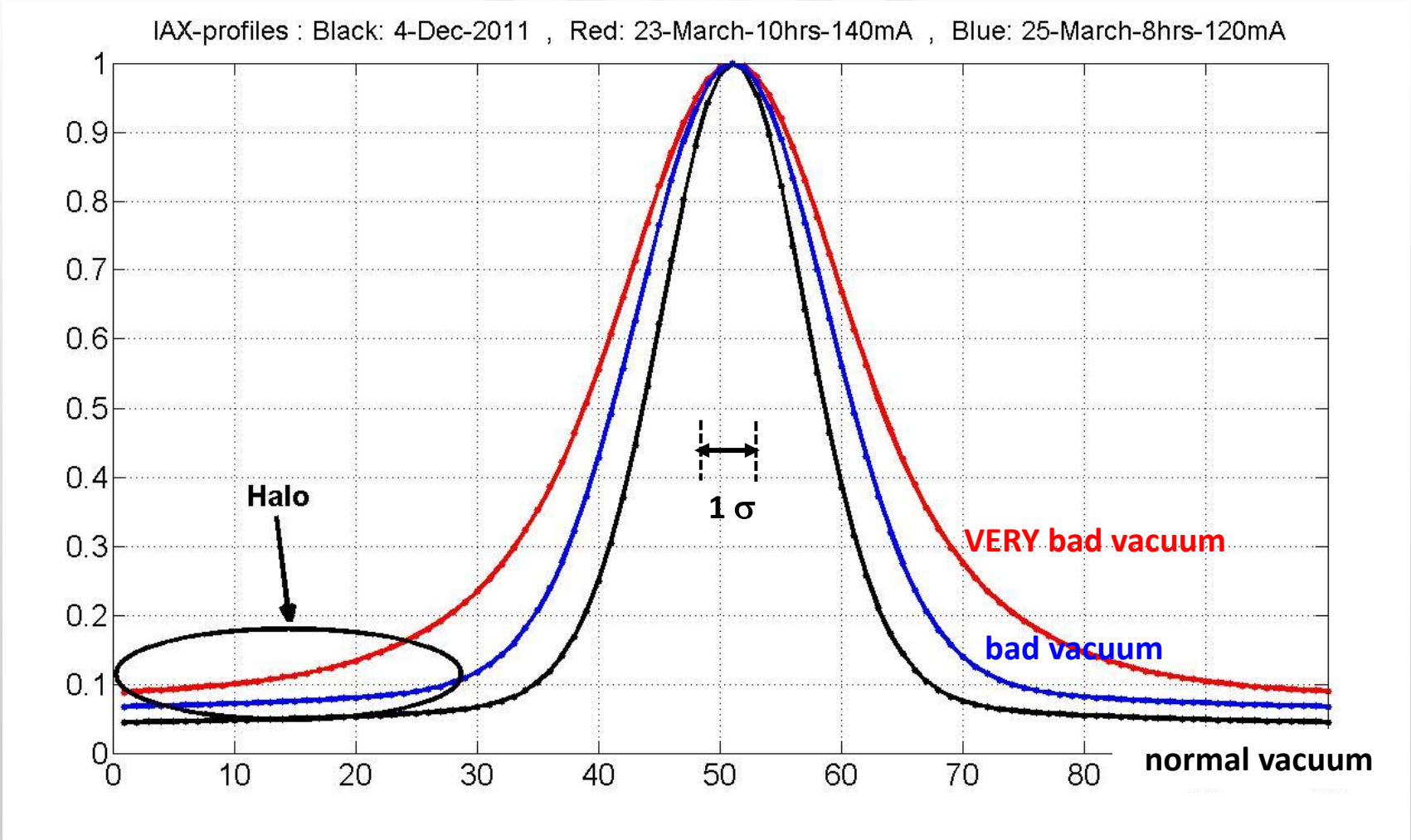
Non-destructive Halo measurements

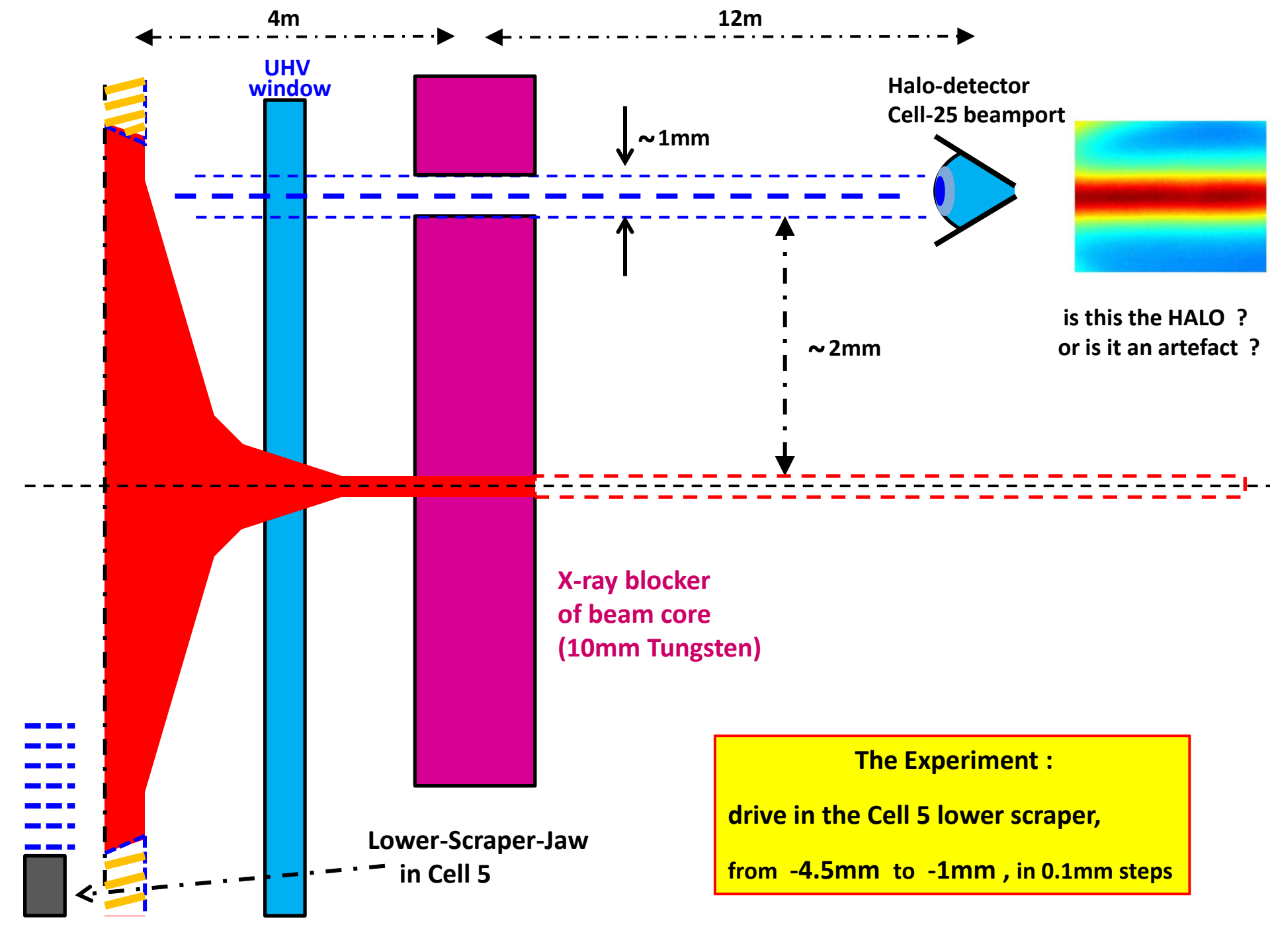
simplistic explanation of long-distance synchrotron radiation X-ray projection



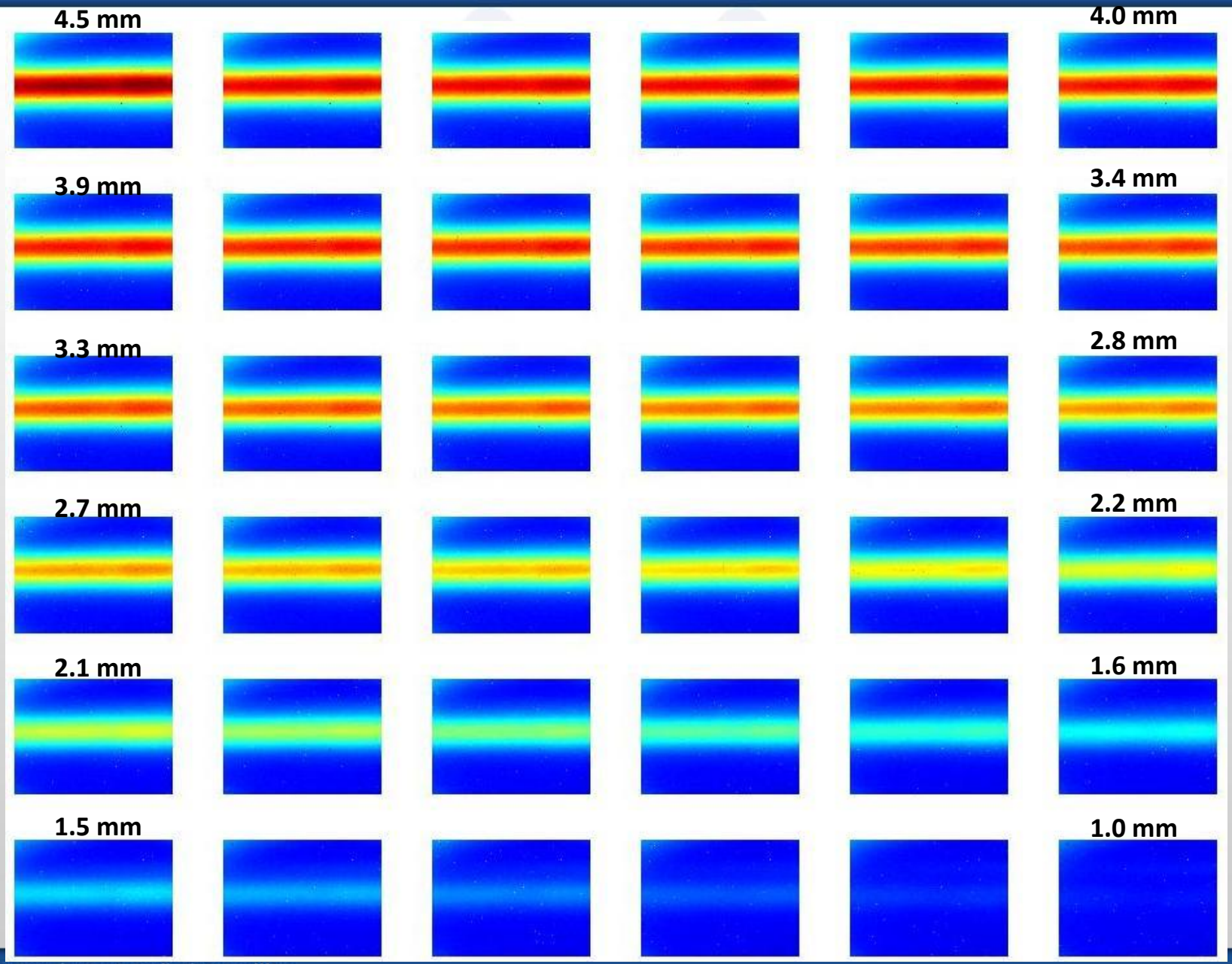
Non-destructive Halo measurements

long-distance synchrotron radiation X-ray projection under BAD vacuum conditions : strong Halo tails (several %) visible at a few sigmas from beam core

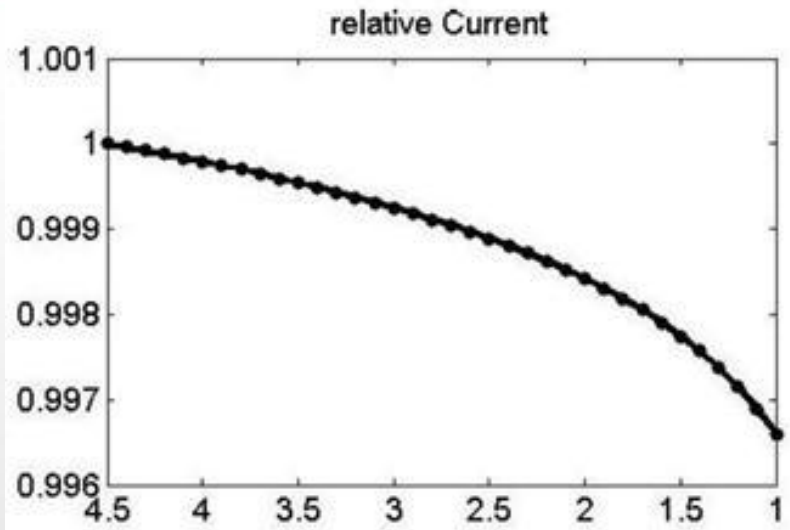


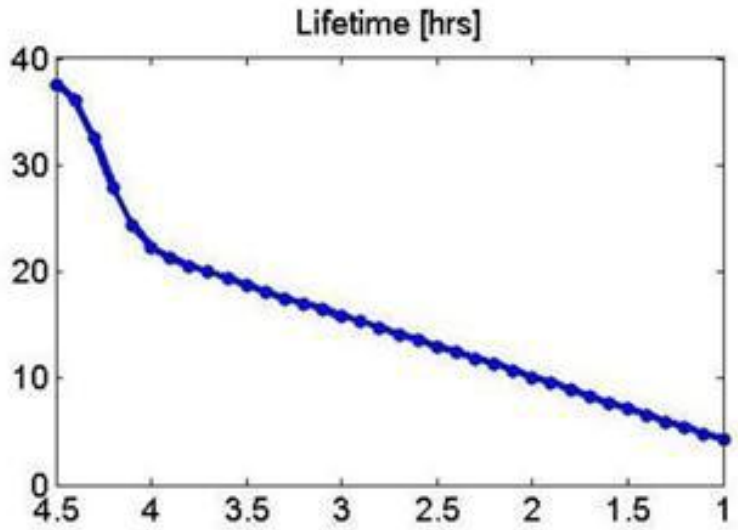

4m
12m
UHV window
~1mm
Halo-detector
Cell-25 beamport
~2mm
is this the HALO ?
or is it an artefact ?
X-ray blocker
of beam core
(10mm Tungsten)
Lower-Scraper-Jaw
in Cell 5
The Experiment :
drive in the Cell 5 lower scraper,
from -4.5mm to -1mm , in 0.1mm steps

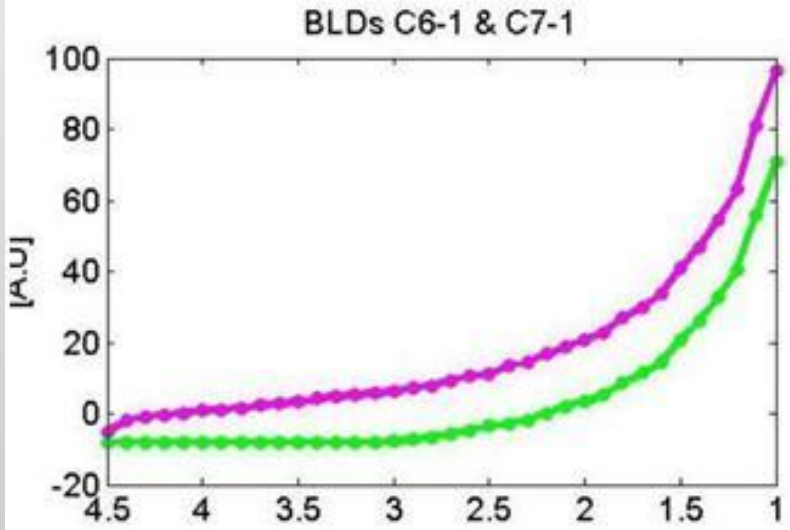
Non-destructive Halo measurements

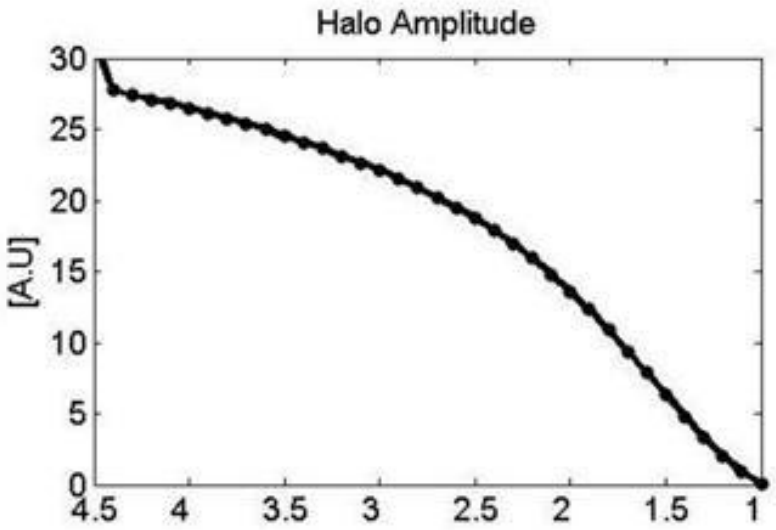


Non-destructive Halo measurements









with the Cell 5 lower scraper,
from -4.5mm to -1mm , in 0.1mm steps

Non-destructive Halo measurements

Conclusion :

It is possible to image, through X-rays of dipole synchrotron radiation, the vertical electron beam Halo, at several mm away from beam core.

this proof-of-principle prototype needs improvement to enhance the spatial resolution and a calibration method to measure quantitatively the relative strength of the Halo (with respect to beam core intensity)

2) Energy fluctuation measurements

the Energy-Fluctuation monitor

ESRF : 6 GeV
Dipole : 0.86 T, Ec=20 KeV

Principle :

- measure the Flux of 170 KeV X-rays from a Dipole

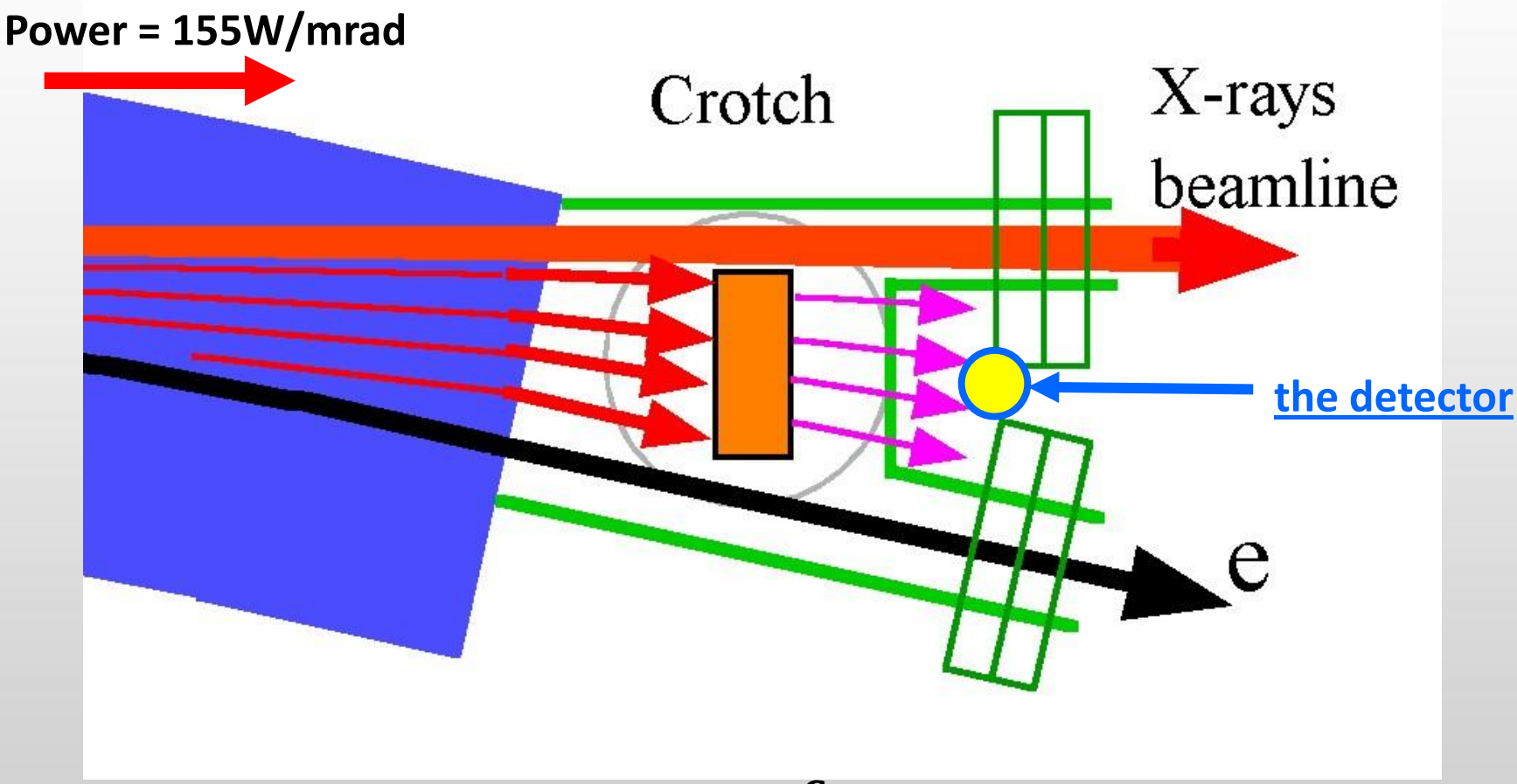
  note : this Flux is : proportional linear with Current
  factor 17.2 linear with Electron energy

- normalize the measured Flux against current in the Ring (using the Sum of 224 BPMs)

- The signal that remains is very sensitive to Energy fluctuations

Energy fluctuation measurements

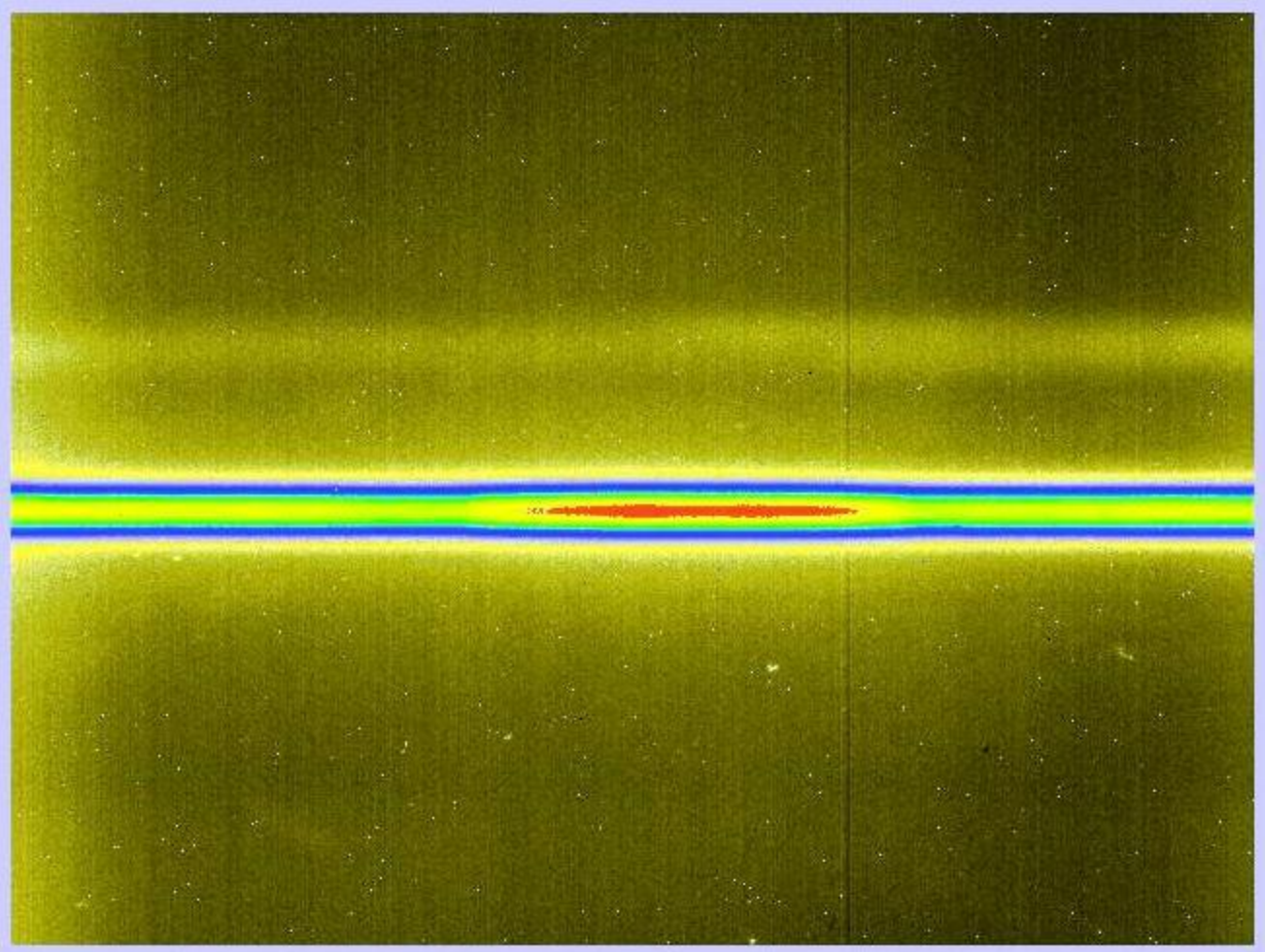
Top-view



a tiny fraction (~$2 \cdot 10^{-6}$ = 300uW/mrad)
traverses the crotch : Xrays >150KeV

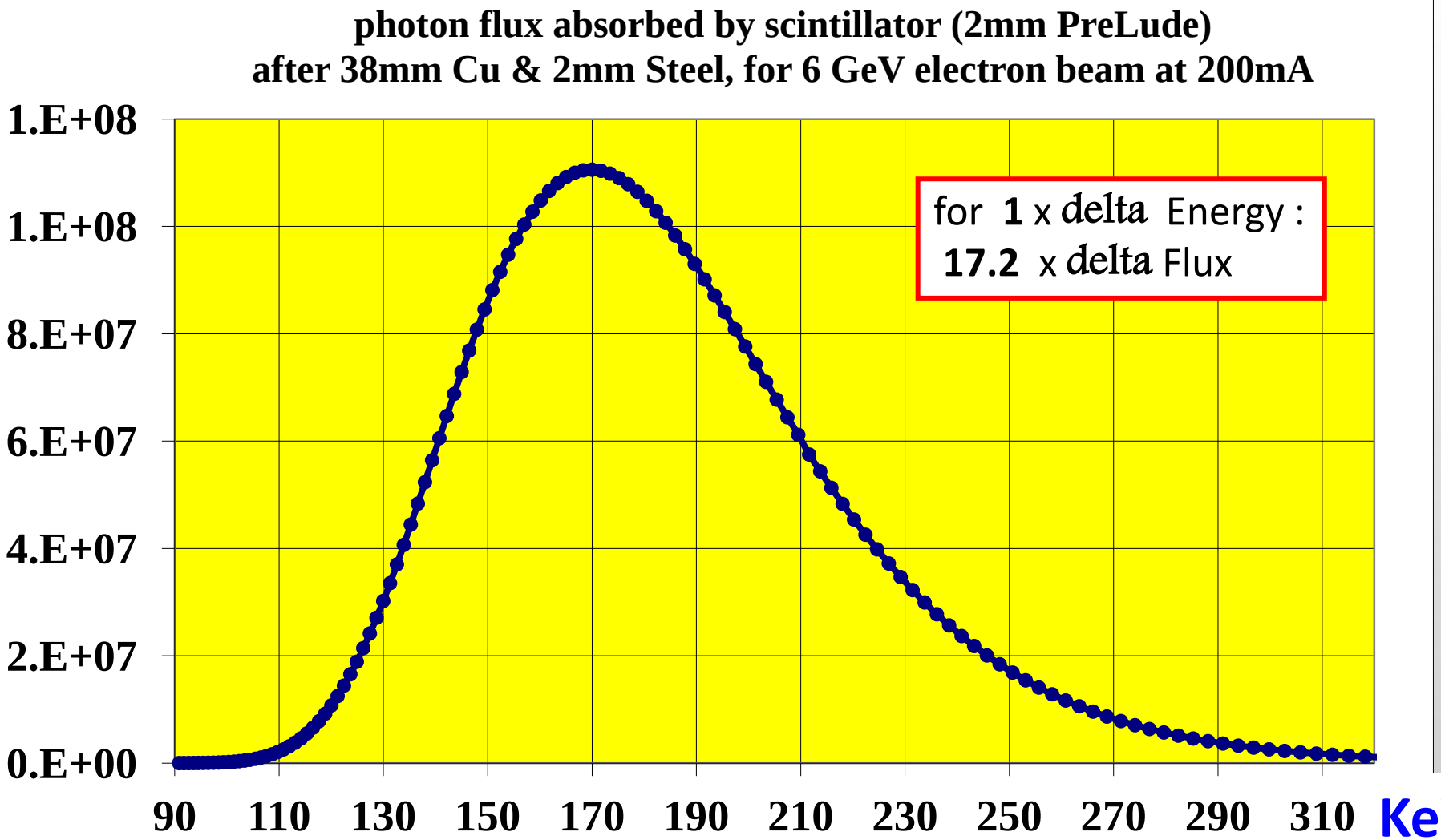
Energy fluctuation measurements

ordinary X-ray projection monitor, used to measure vertical beamsize (emittance)

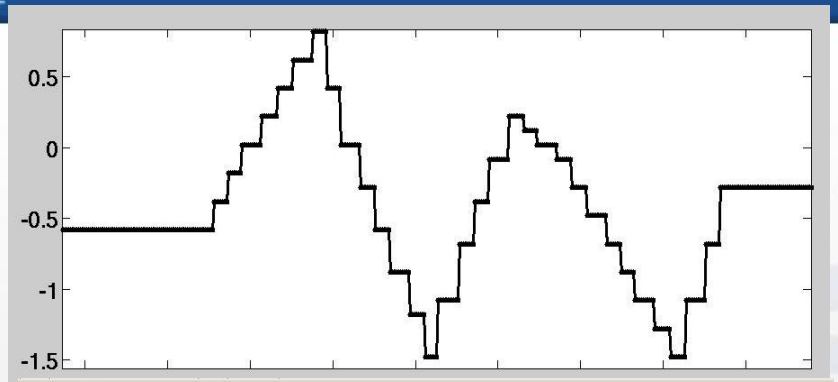


Energy fluctuation measurements

Spectrum of the X-rays



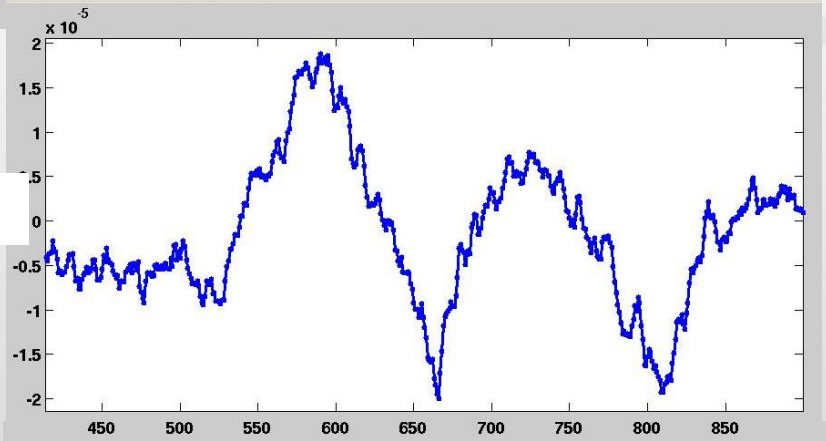
Energy fluctuation measurements



2 Hz

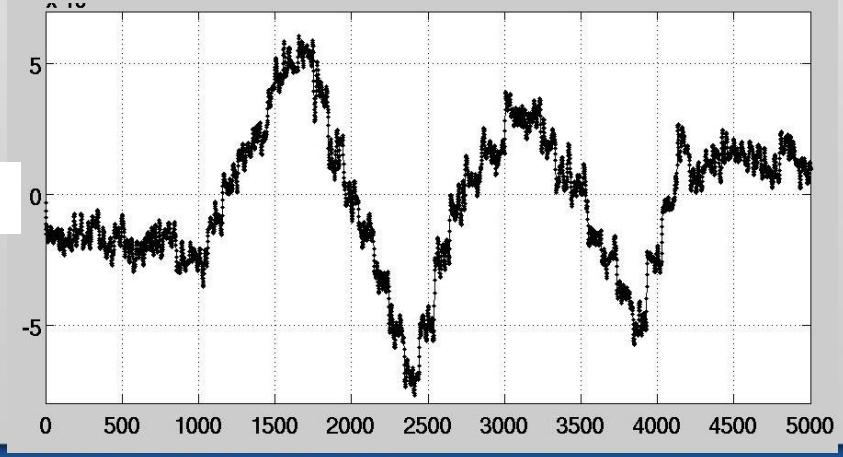
RF variation [Hz]

a bug in the RF freq. control by the Fast-Orbit-Correction system is creating these variations ...



4 E-5

Energy variation

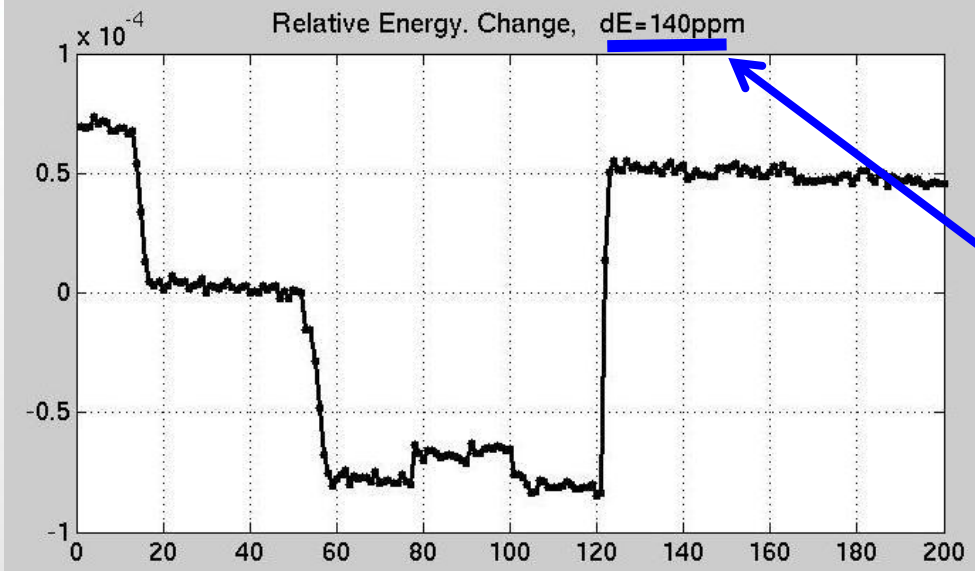


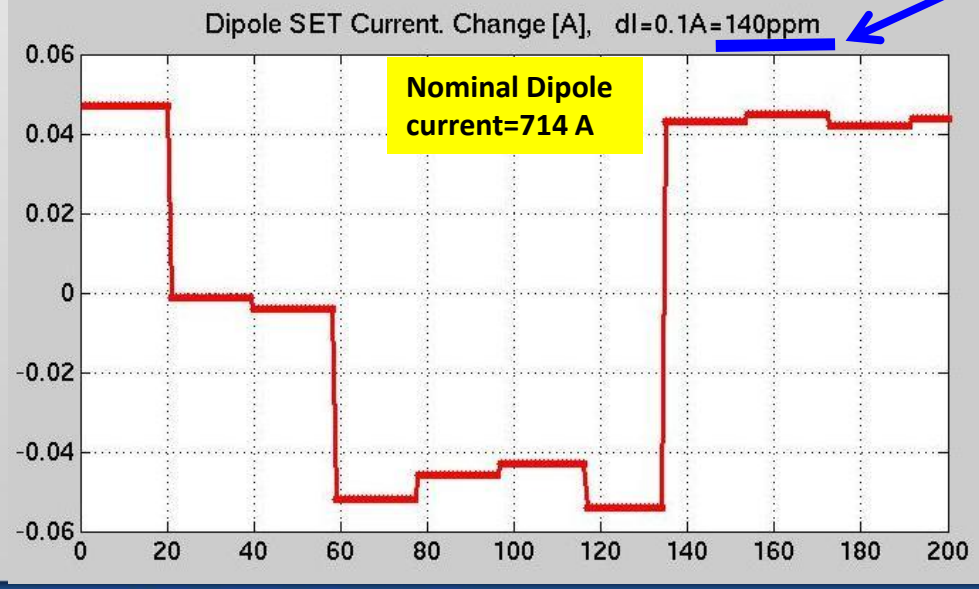
10um

Orbit deviation [um]
in dispersive sections

8 minutes recording

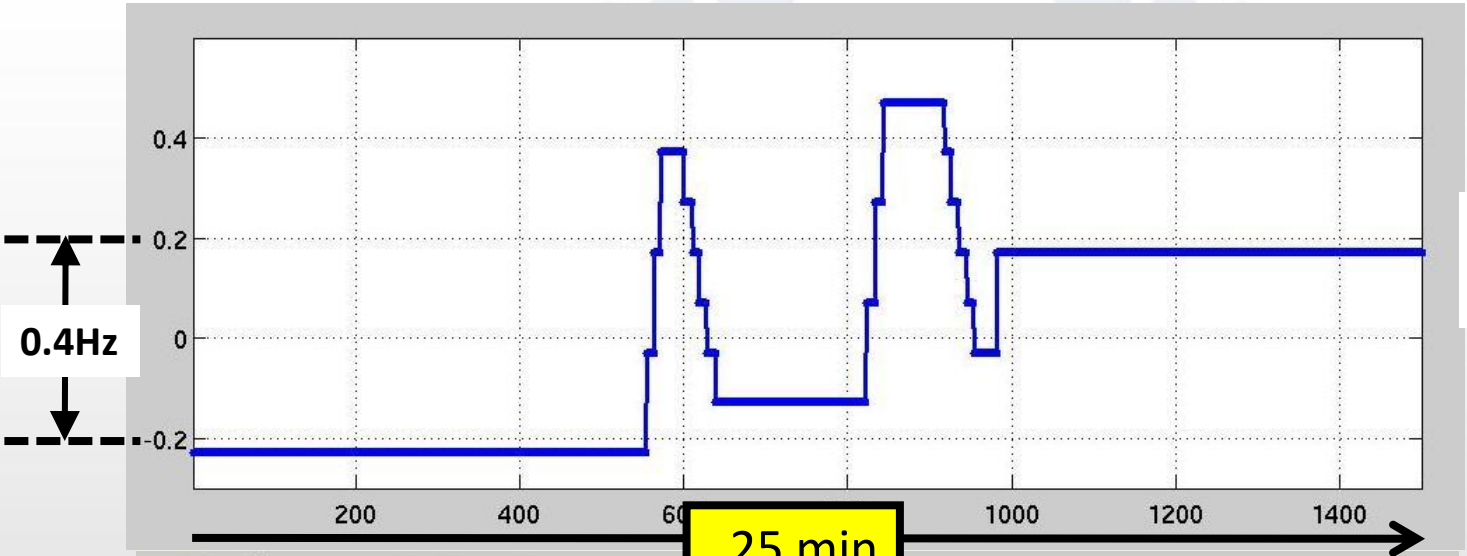
Energy fluctuation measurements



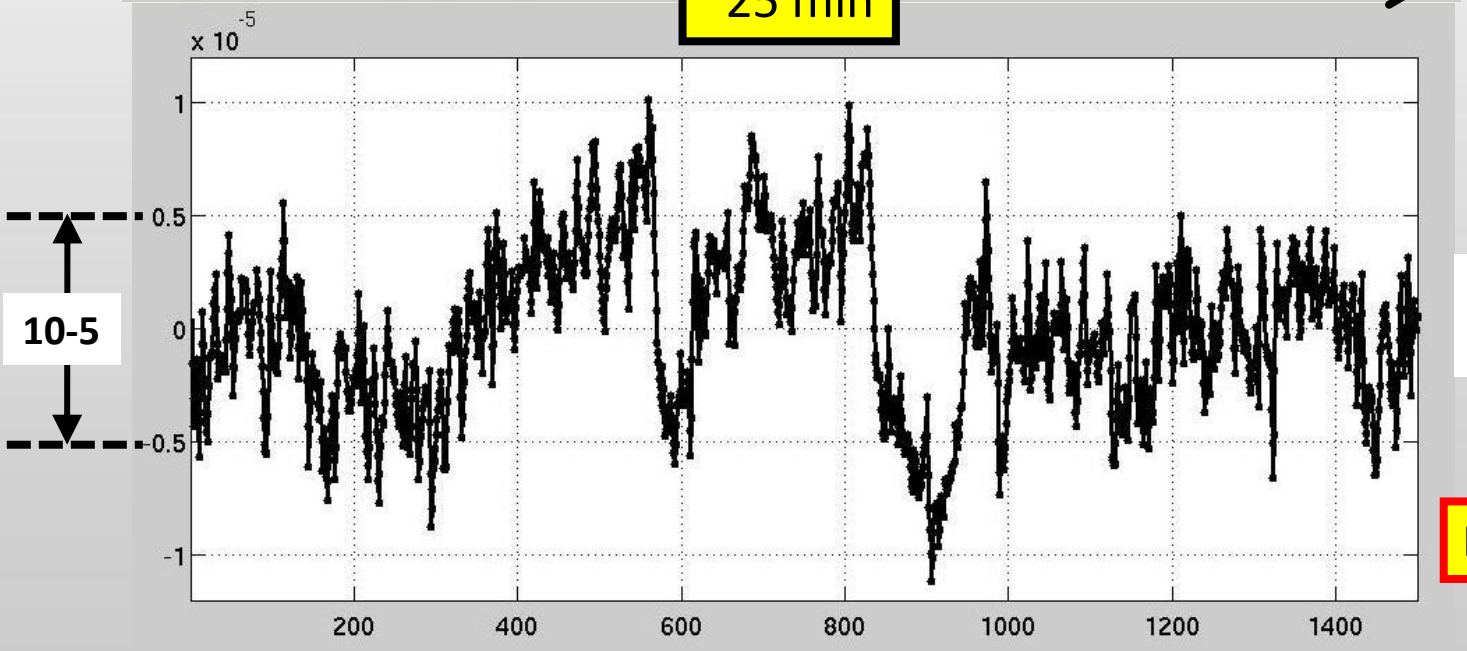


the intrinsic calibration of this Energy Fluctuation monitor is verified by varying the dipole field strength

Energy fluctuation measurements



RF frequency change [Hz]



Energy-Fluctuations Monitor

Resolution =10ppm

3) Turn-by-Turn imaging of the injected beam size

Technique & method :

visible synchrotron light from a Storage Ring dipole,

that light is directed into an accessible lab at 8m from dipole source point

the Visible Light Mirror (inside UHV) fully inserted,

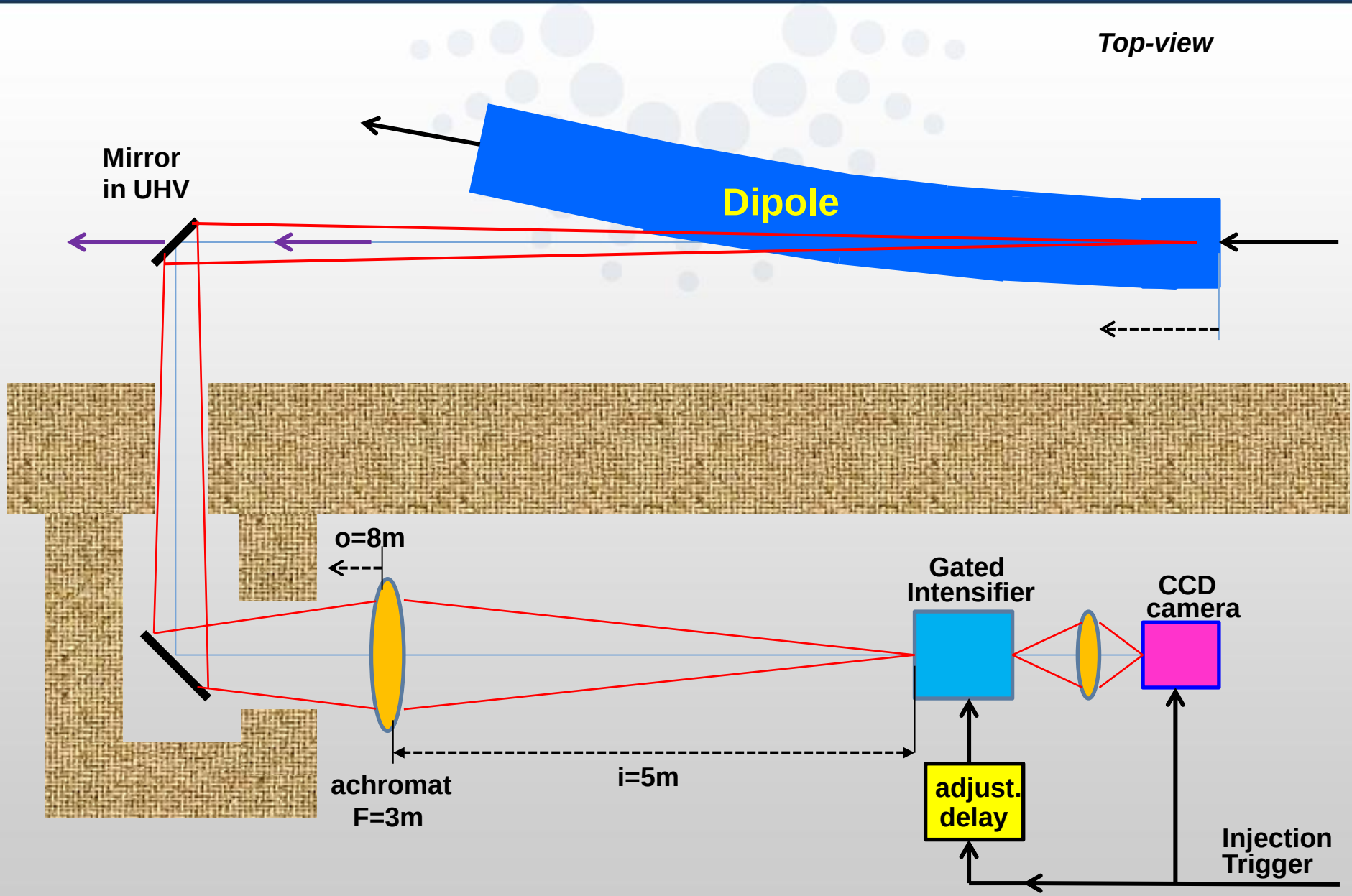
light collected & focussed by an achromat (f=3m) at 8m distance in optics Lab

onto a gate-able intensifier that is read-out by a camera

the exact timing of the gate pulse determines which Turn is selected

to avoid beam storage (not compatible with Mirror fully inserted) the RF is off, so beam is lost after about 70 Turns

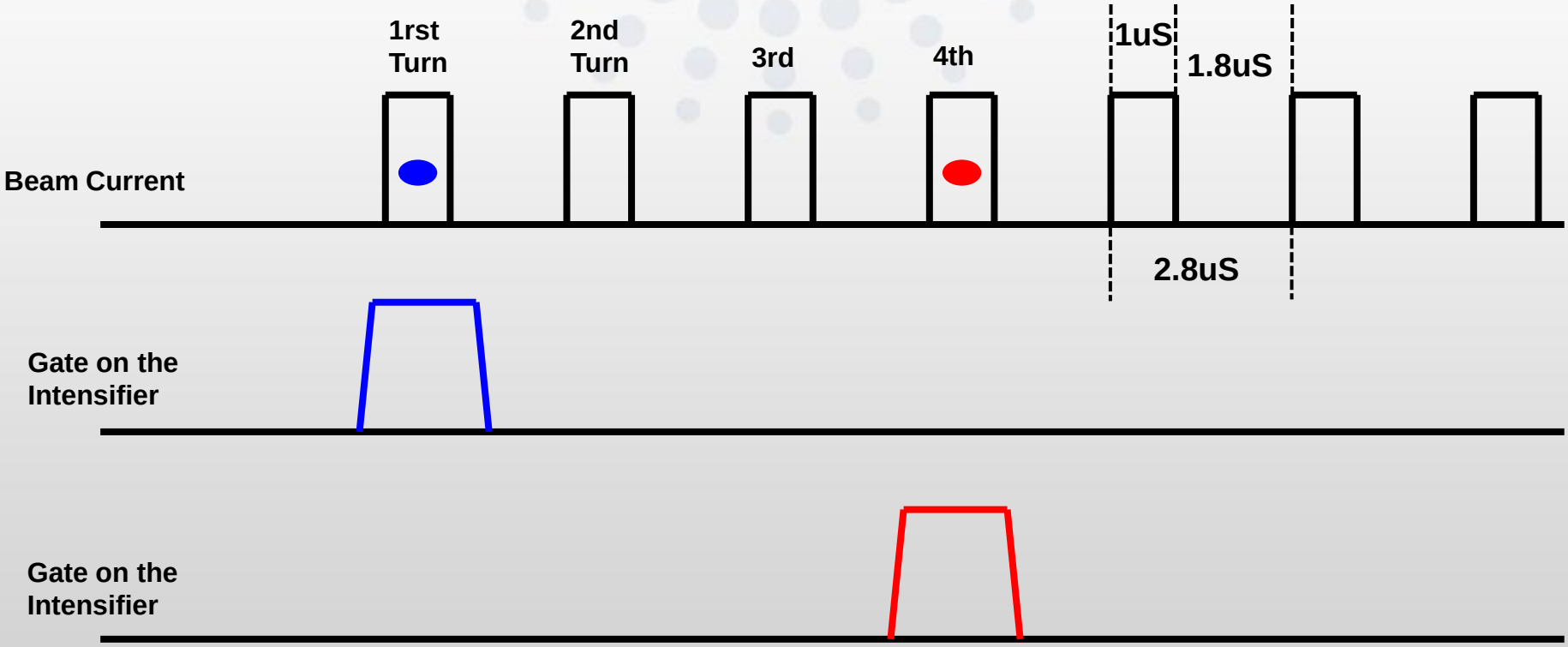
Turn-by-Turn imaging of the injected beam



Turn-by-Turn imaging of the injected beam

only 1 image can be taken at each injection,

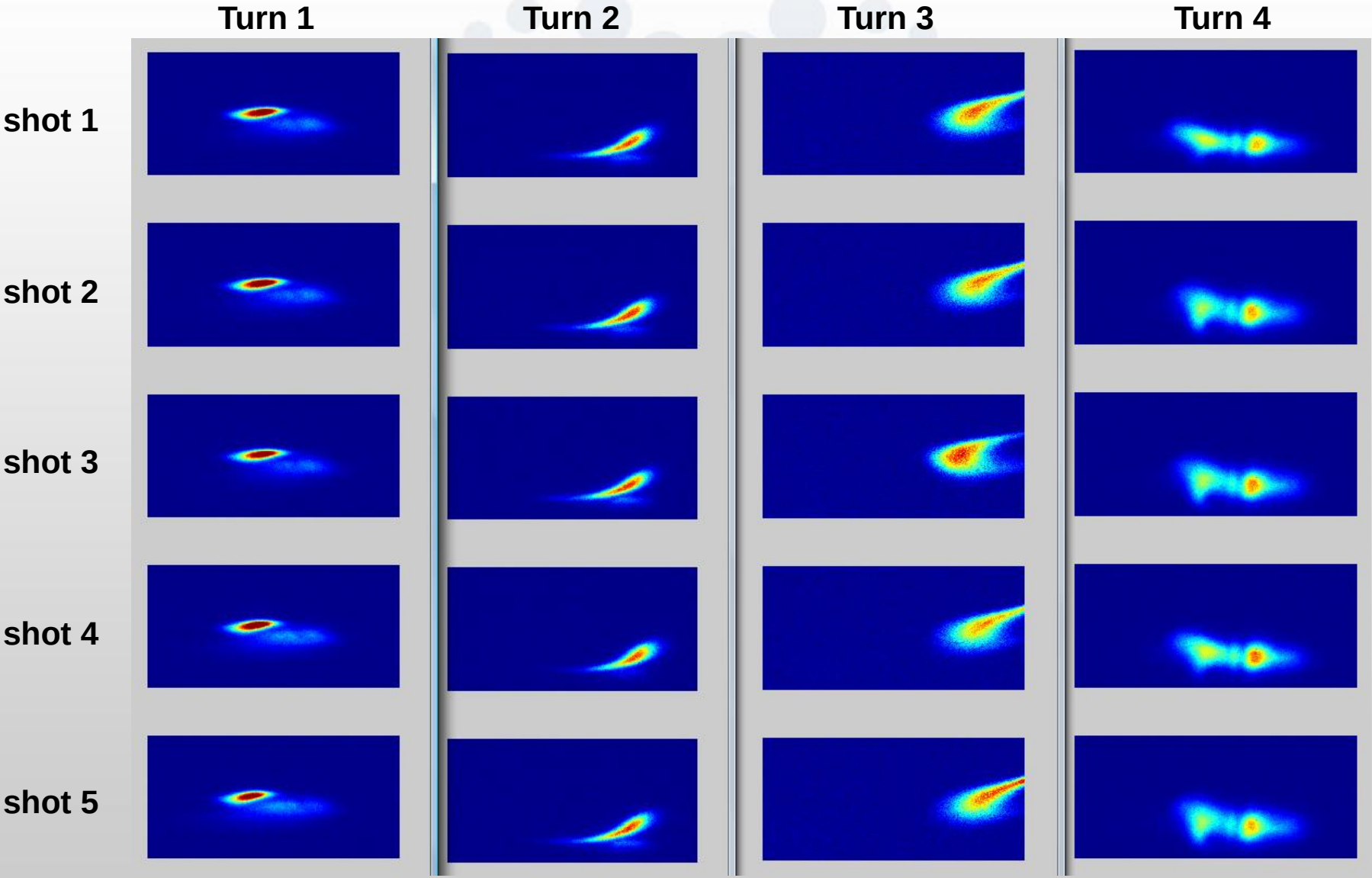
so taking images of e.g. 20 Turns means 20 different Injections are needed



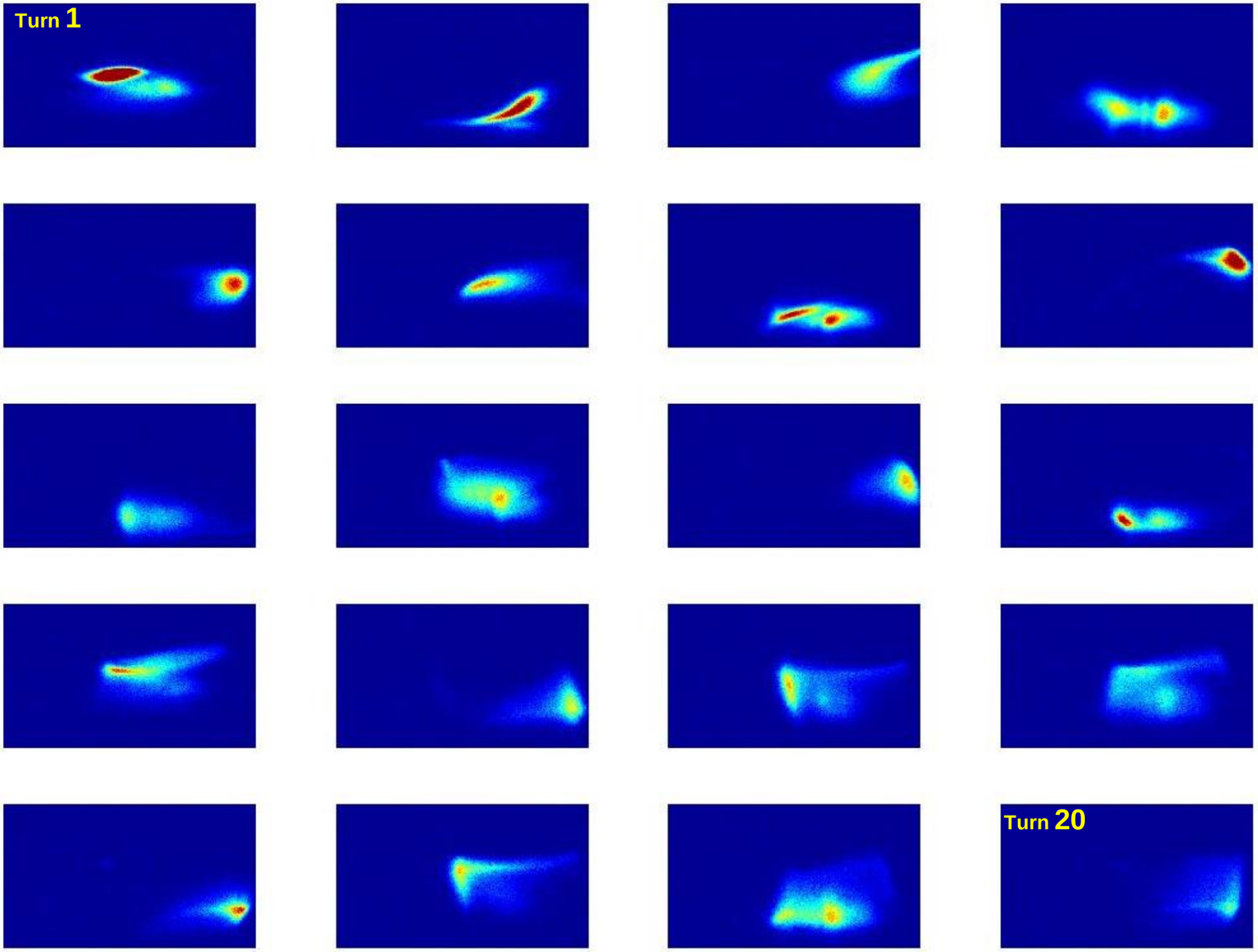
so first some verifications are done to see if these different Injections are reproducible (or not)

Turn-by-Turn imaging of the injected beam

First : Reproducibility checks over the first 4 turns, over 5 x 4 shots



Turn-by-Turn imaging of the injected beam



Turn-by-Turn imaging of the injected beam

Conclusion :

the measurement concept & components works well.

interpretation of this beam data needs more time.

BUT : presently the measurement sequence is manual & slow & cumbersome

AND : with the RF OFF the number of Turns is very limited

so future improvements :

1) **Kill beam automatically after a say 10 millisec ,**
   more tests to be done on this technique,
   needs a total reliability,
2) **Automatic Gate delay increments (2.8us) after each shot**
3) **Specific application of a sequenced camera read-out & storage**

@1Hz

once realised such measurement sequence (i.e. 1000 different Turns)
could be realised in 15 minutes