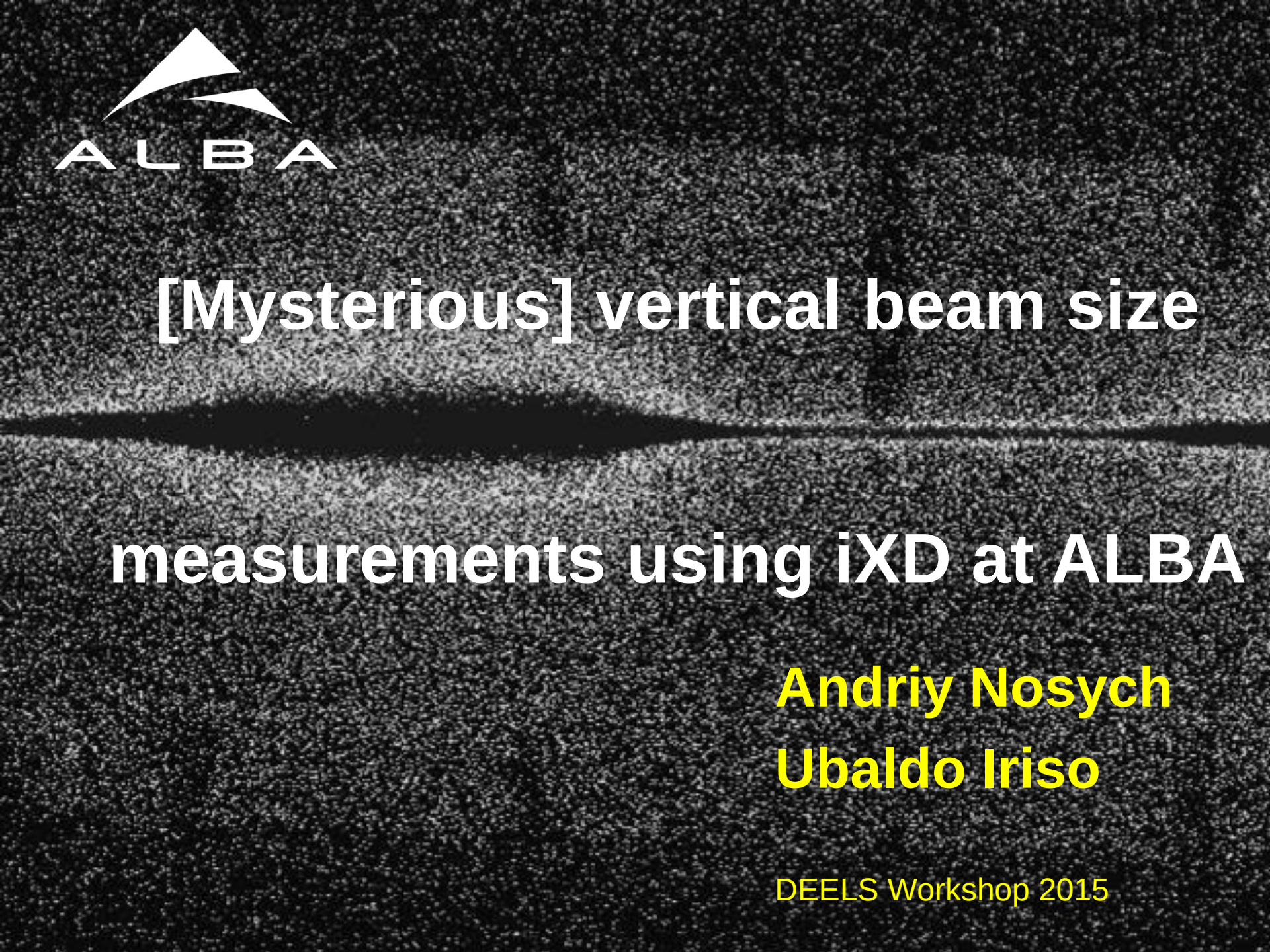
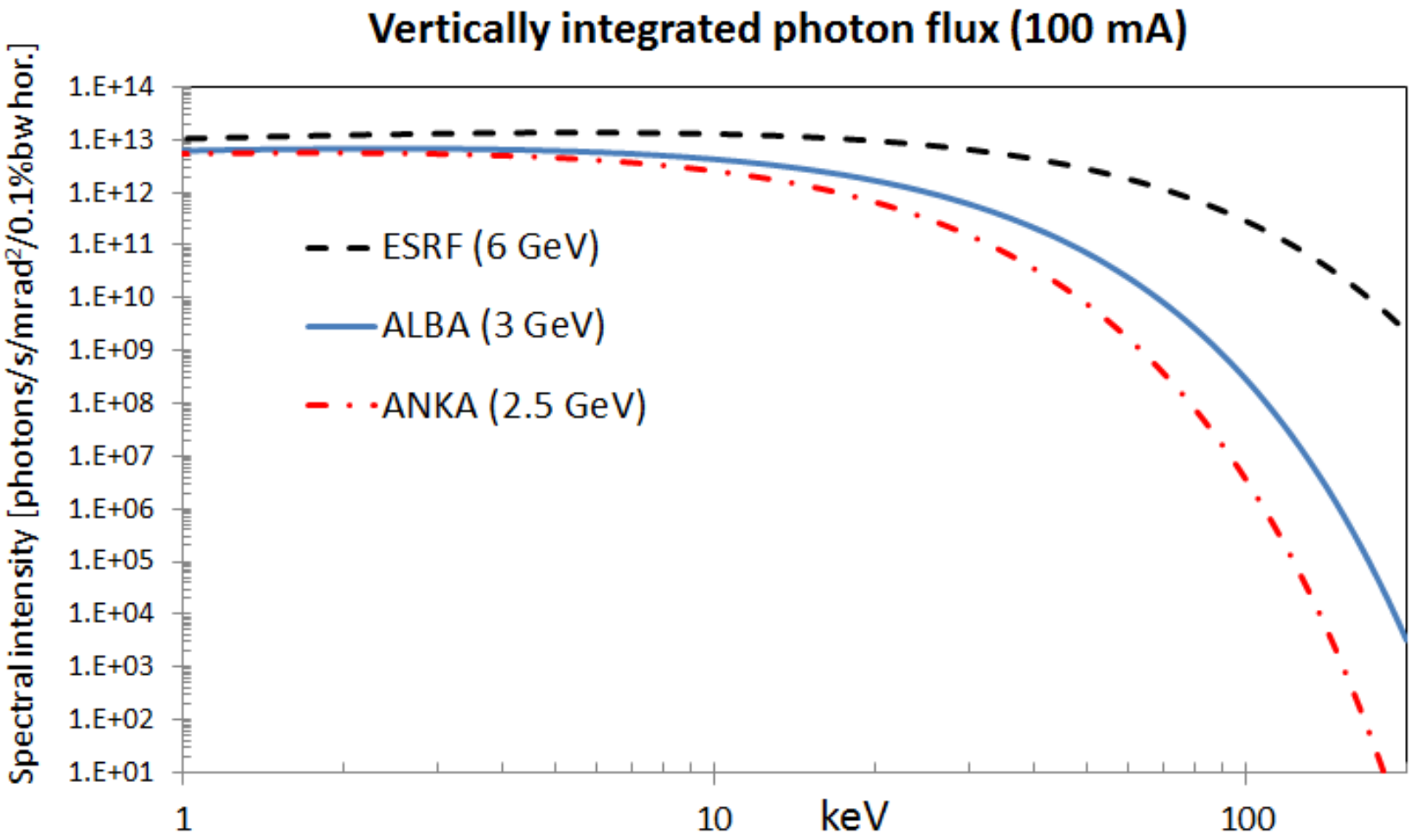


[Mysterious] vertical beam size measurements using iXD at ALBA

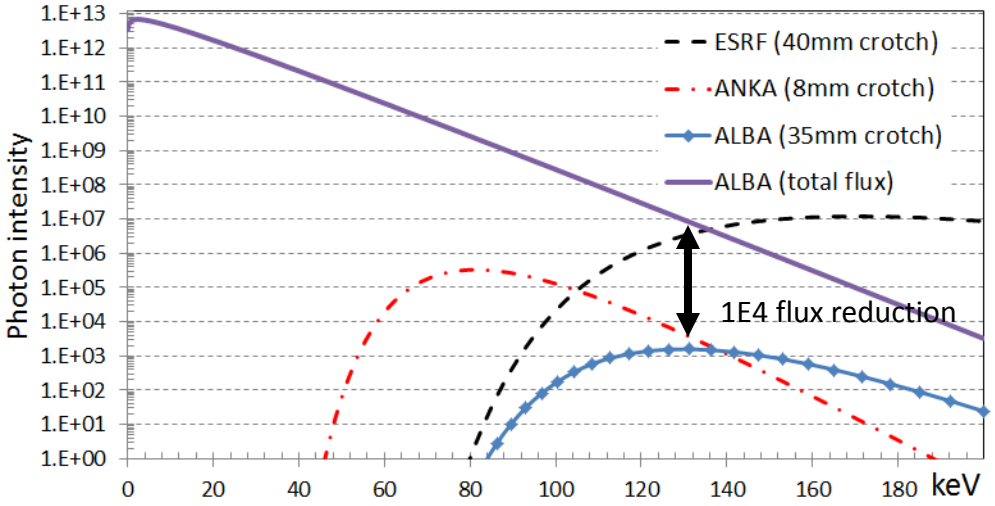
Andriy Nosych
Ubaldo Iriso

DEELS Workshop 2015

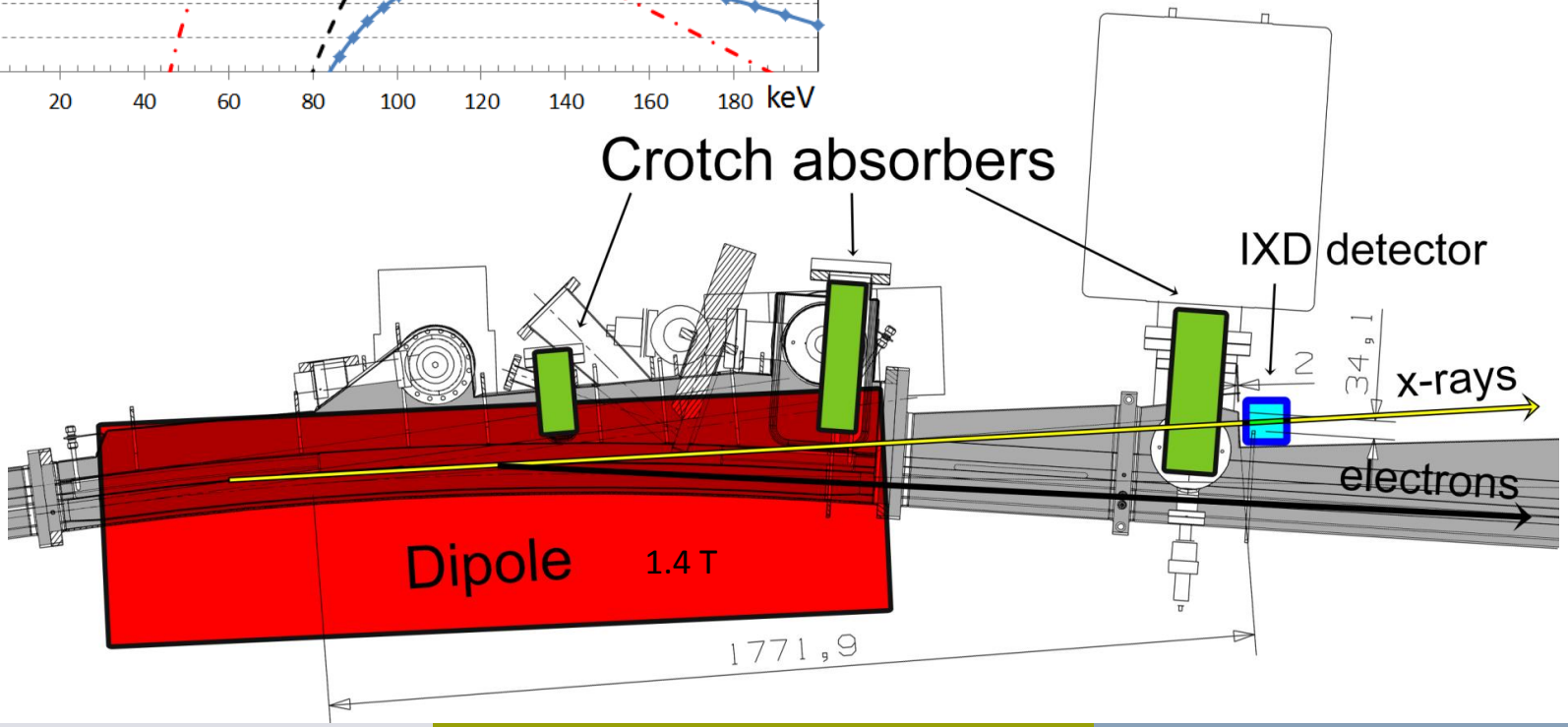
The ALBA machine provides:



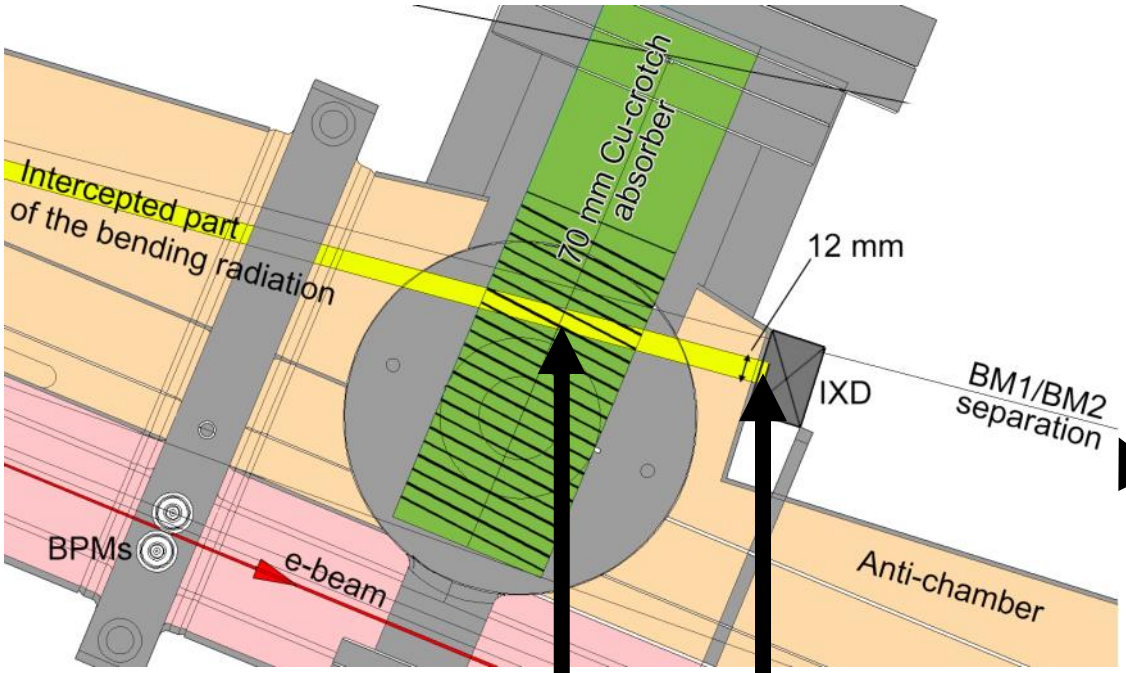
The idea behind IXD:



To provide an alternative-to-pinhole vertical beam size measurement, possibly in real time



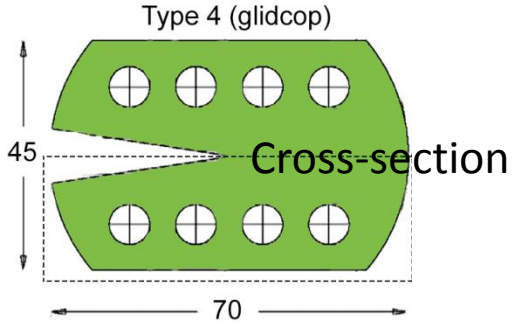
Crotch absorbers

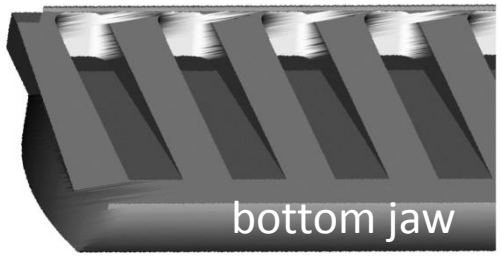


1700 mm
to source

35 mm of Cu

2 mm of steel

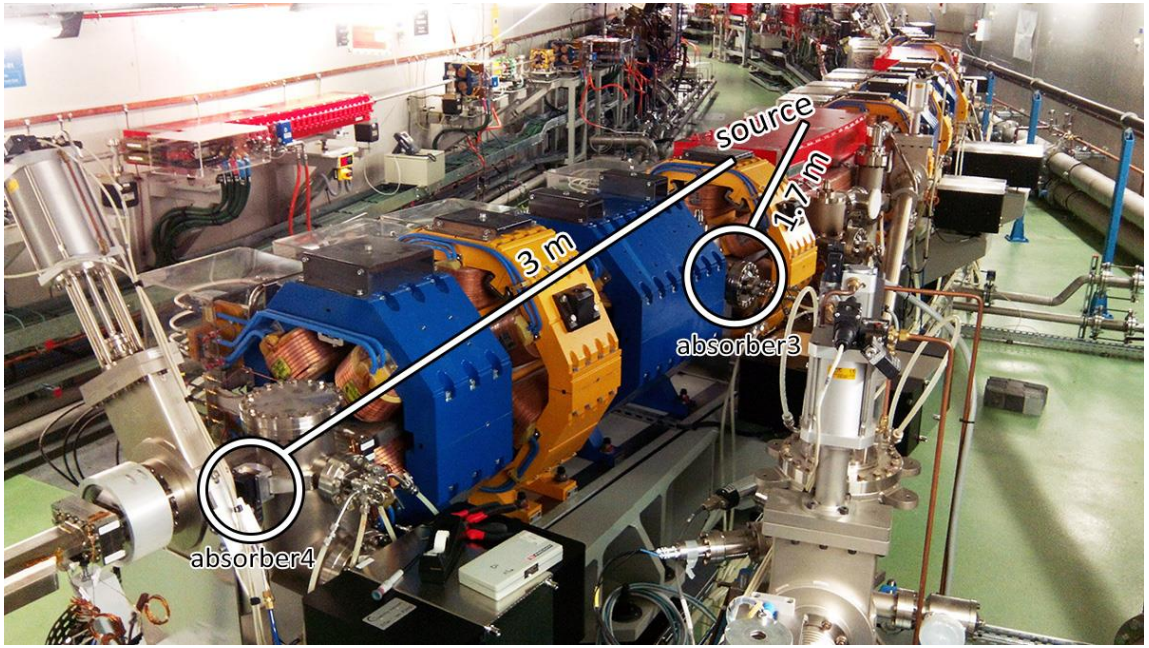


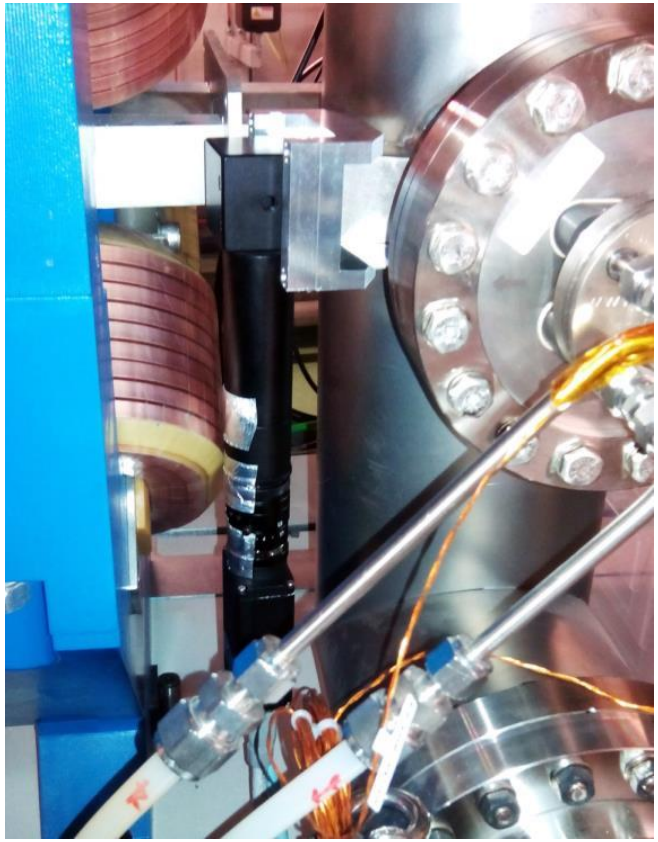


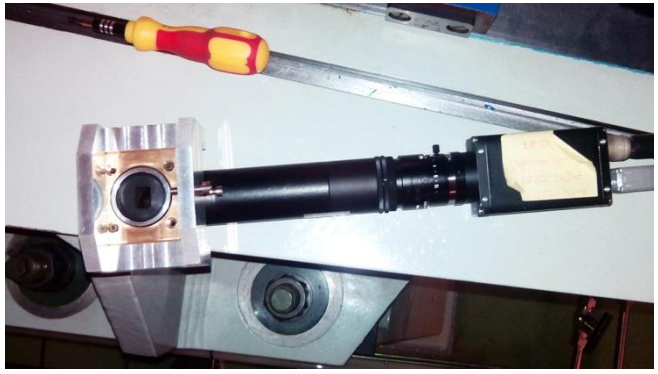
Tooth width: 6 mm
Teeth inclination angle: 8.8º

Ray tracing shows that radiation from previous dipole does NOT pass by the IXD, so we are looking at a single photon source

How it looks like







Storage ring sectors: 16
Dipoles per sector: 2
Absorbers per dipole: 4

Given the space constraints, there are 2 possible IXD locations at the end of each sector. We choose the one closer to the source (second dipole).

Green-paper study

Scintillators

SAINT-GOBAIN CRYSTALS

PreLude® 420

Chemical composition: $Lu_{1.8}Y0_{.2}SiO_5$:Ce
Light yield: 32 photons/keV
Decay time: 41 ns
Scintillation emission wavelength: 420 nm
Available size: 1” x 0.8 mm, 1 mm, 2 mm

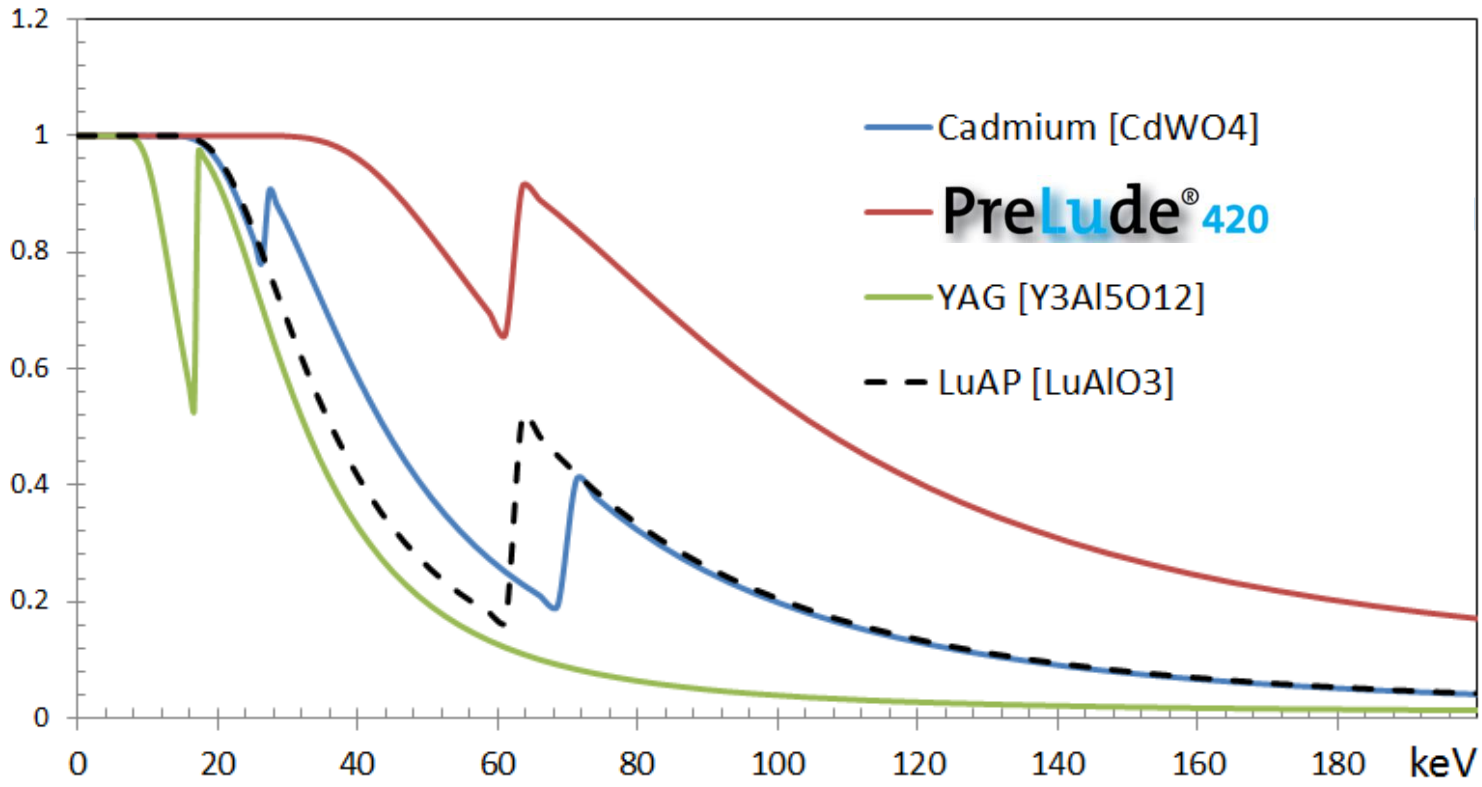
crytur

CRY19 a silicate single crystal for X-ray detectors.

Chemical composition: unknown
Light yield: 28 @300K [10^3Ph/MeV]
Decay time: 41 ns
Scintillation emission wavelength: 420 nm
Available size: 1” x 1 mm

Scintillators

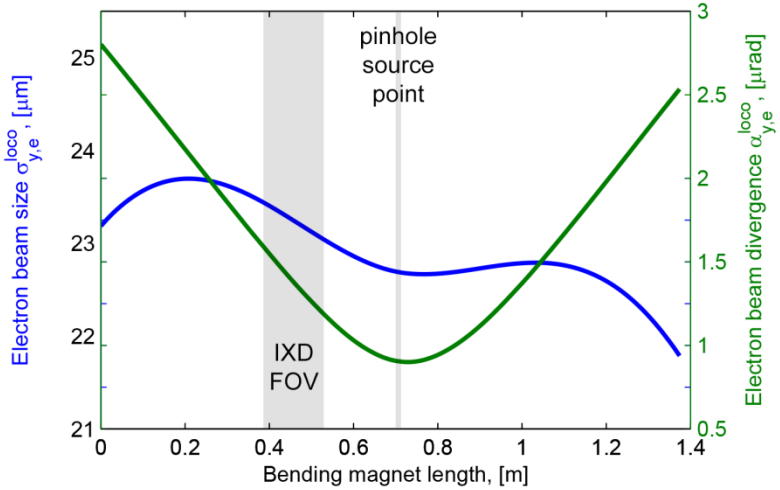
Photon absorption by common scintillators (0.8 mm thick)
Simulation by XOP

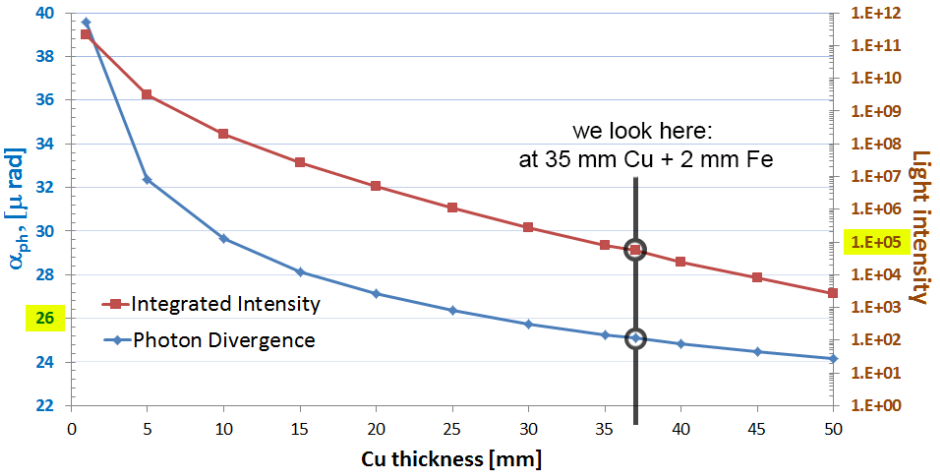


Theory & expectation

Vert e-beam size at source (inside dipole): 24 um (σ_e)
Vert e-beam size seen by pinhole: 23 um (σ_e)

Vert e-beam divergence at source (LOCO): 1.6 urad (α_e)
Photon divergence (XOP simulation) at IXD location: 26 urad (α_{ixd})

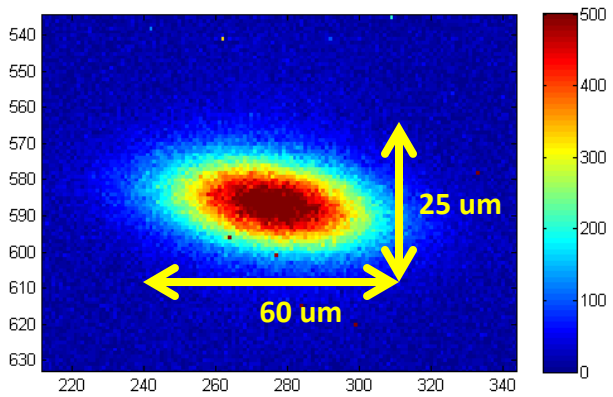




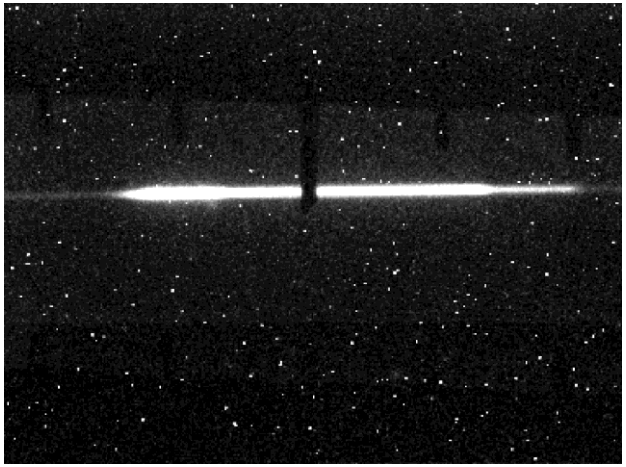
Expected vertical <u>photon</u> beam size at IXD:

$$\sigma_{photons,ixd} = \sqrt{(\sigma_e)^2 + R^2(\alpha_e{}^2 + \alpha_{ixd}{}^2)} = 48 \text{ um}$$

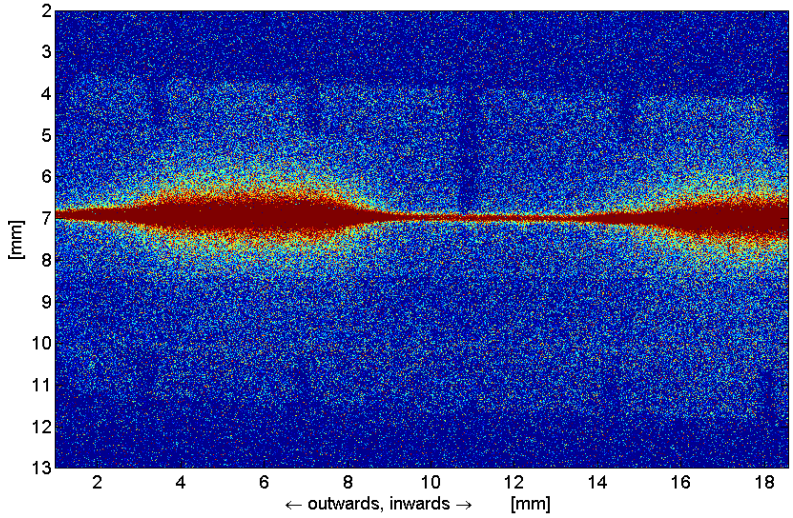
Best IXD shots (@10s)

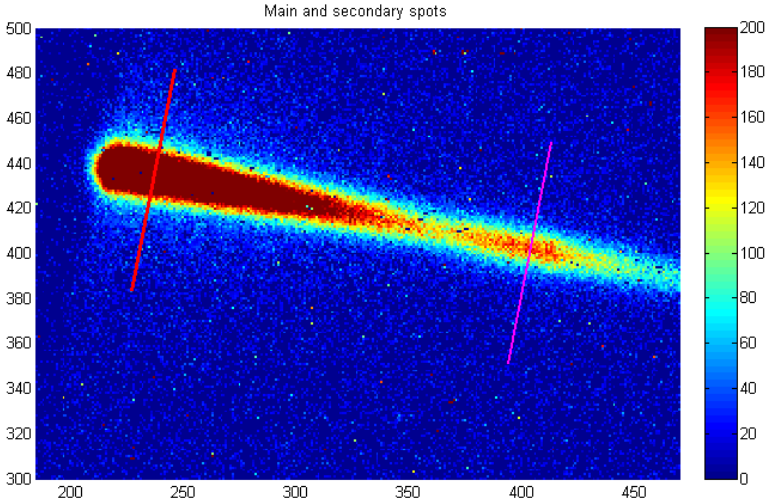


Typical pinhole image

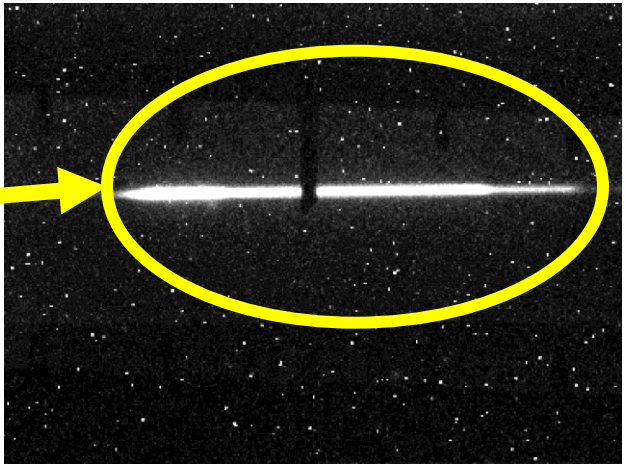


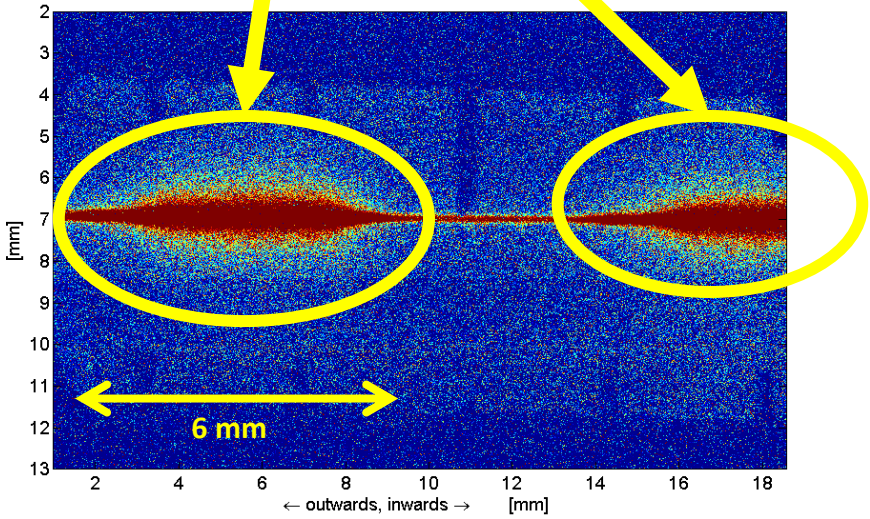
IXD images

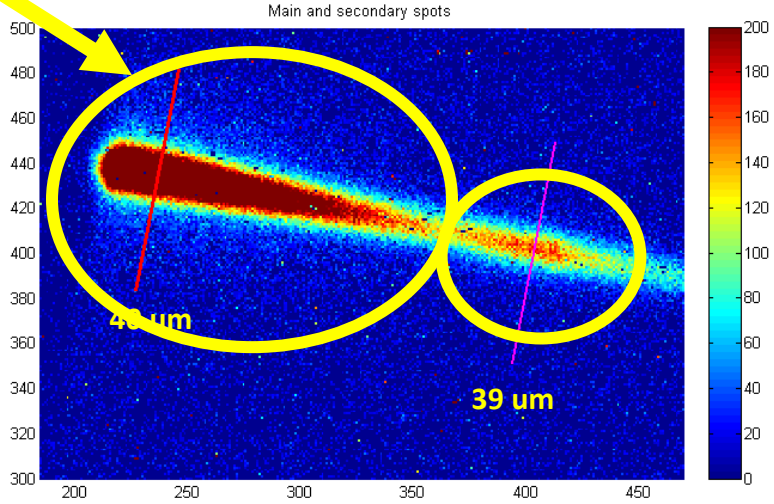




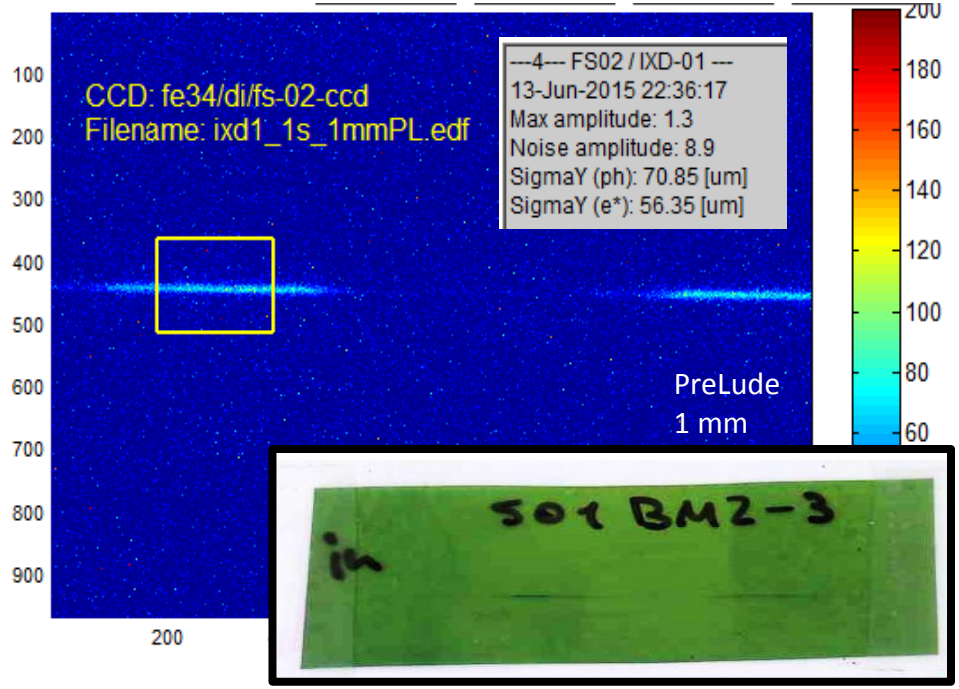
The teeth imprint

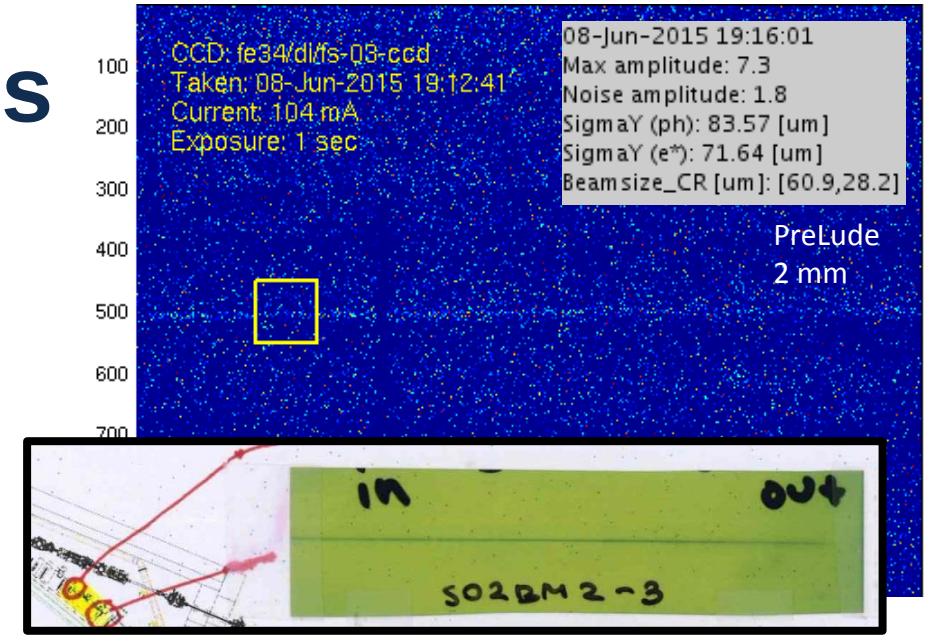


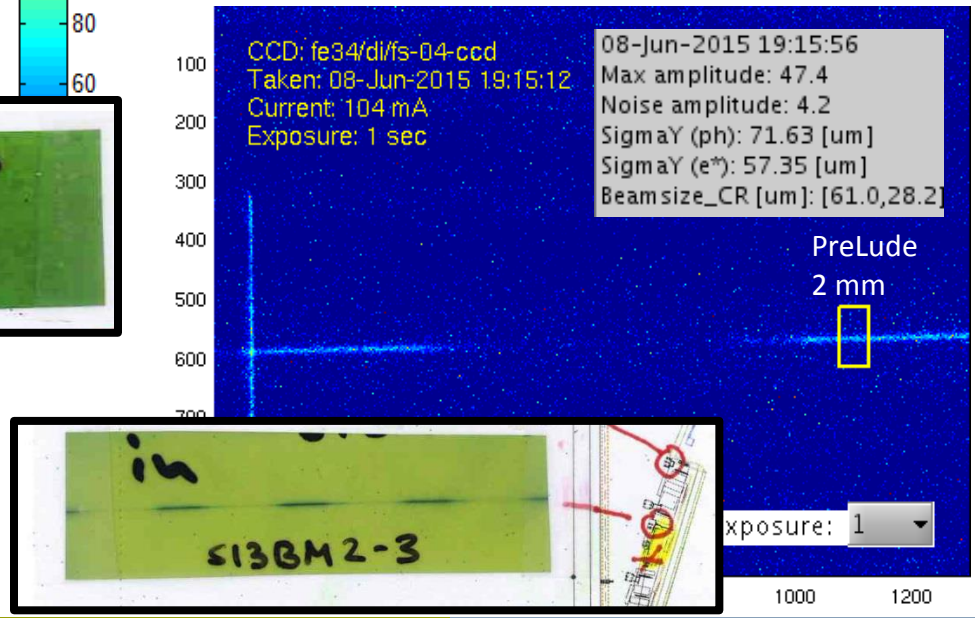




Current status (@1s)

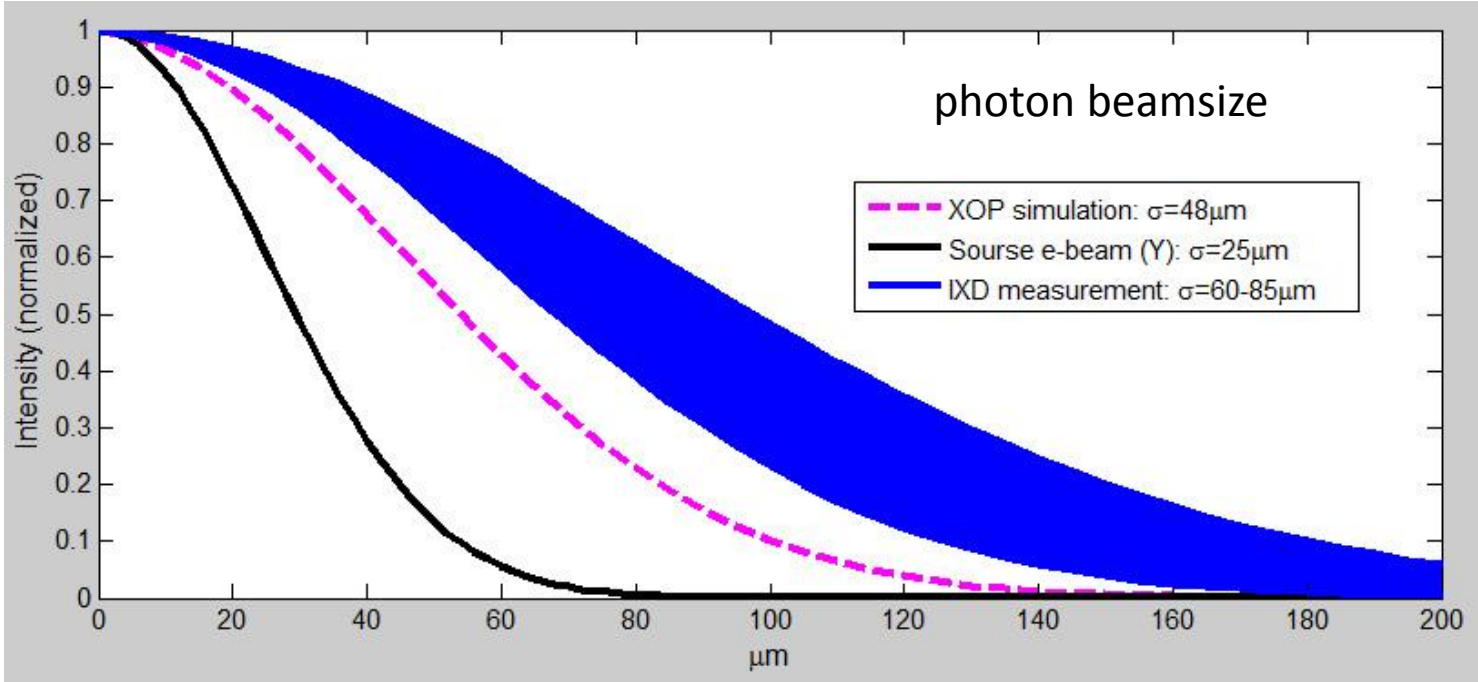






FOV: around 18 x 13 mm

Current status

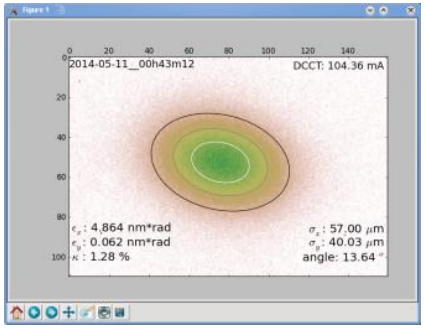


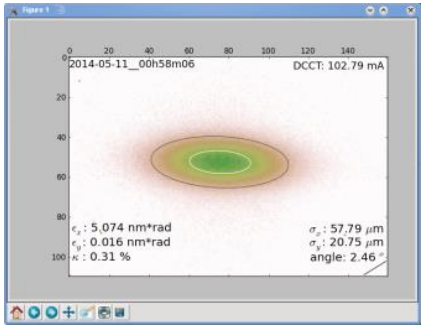
Measured photon beam size is quite far off the expected value.

Photon divergence corresponding to the measured values is: 32-47 urad
Copper thickness corresponding to this divergence: <5 mm !!!

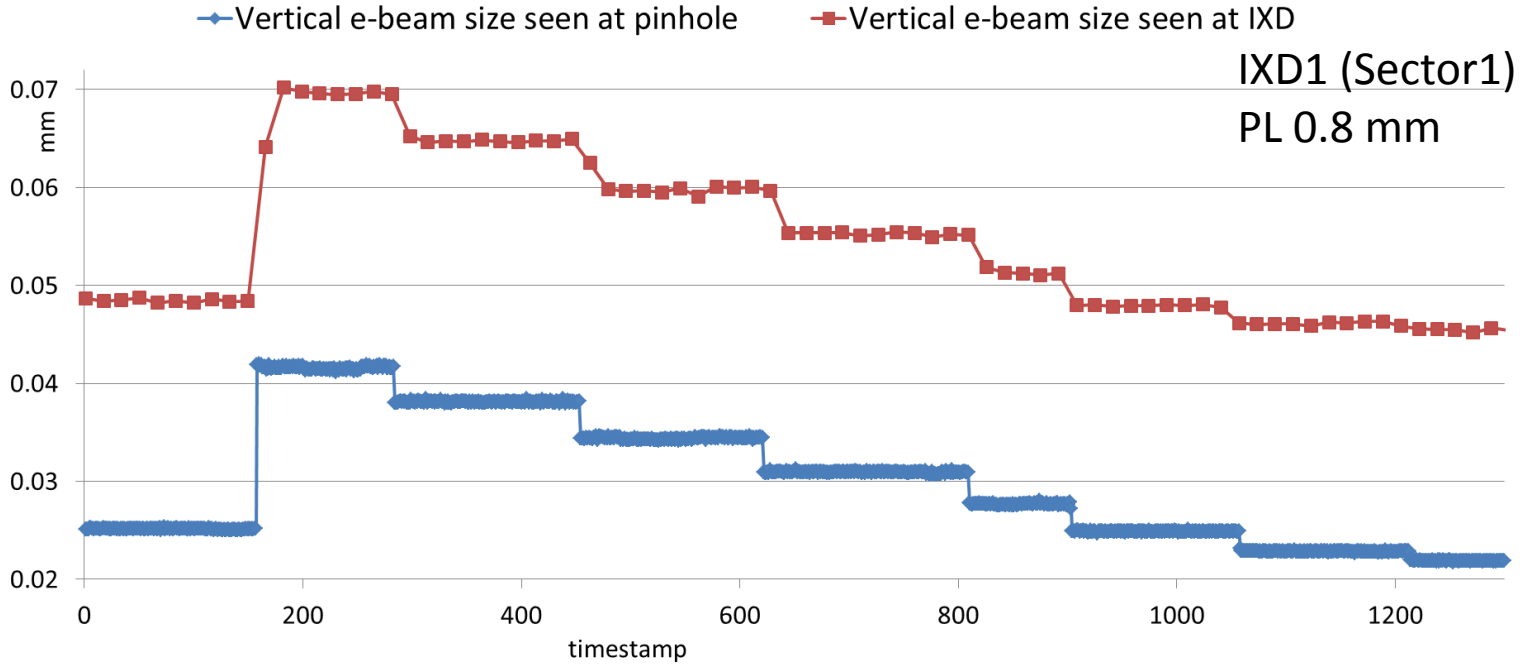
Coupling scans

1.3% coupling



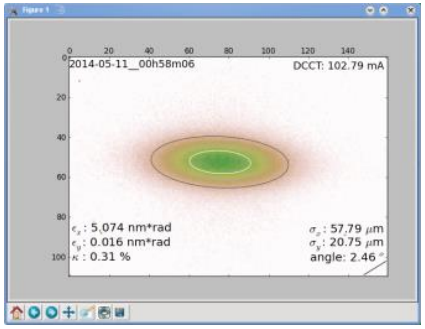


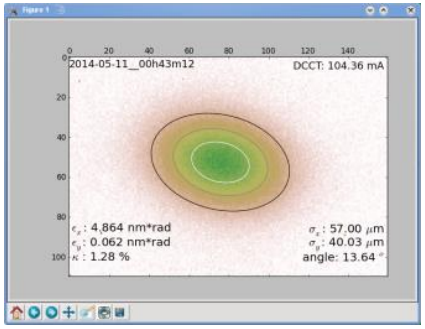
0.3% coupling



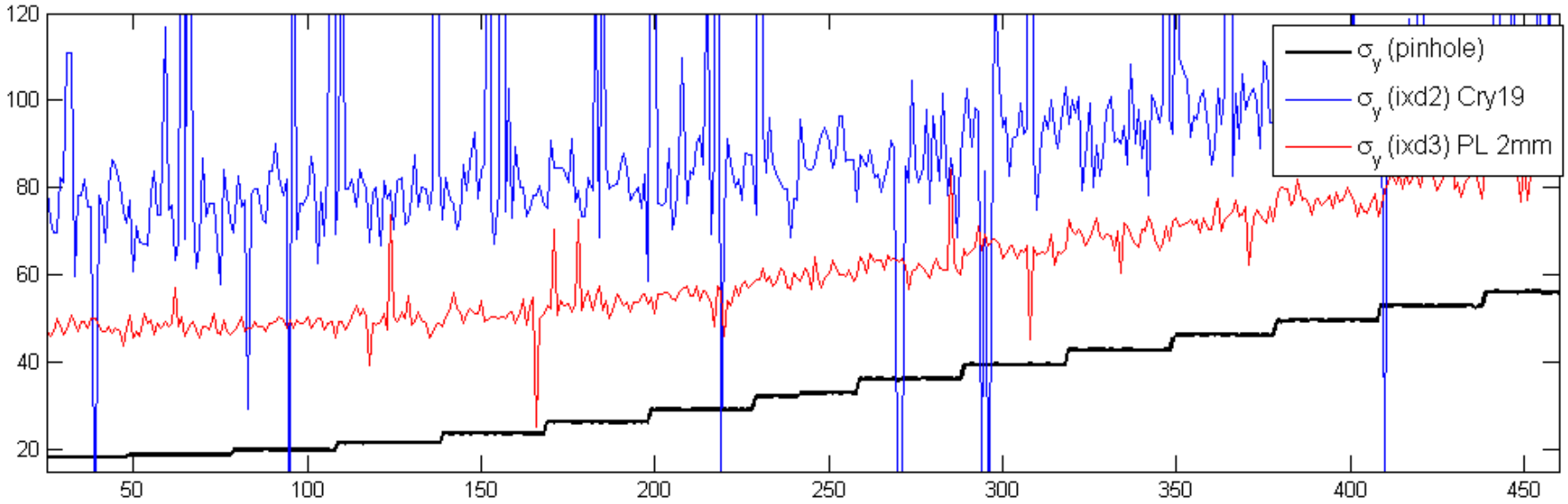
Coupling scans

0.3% coupling

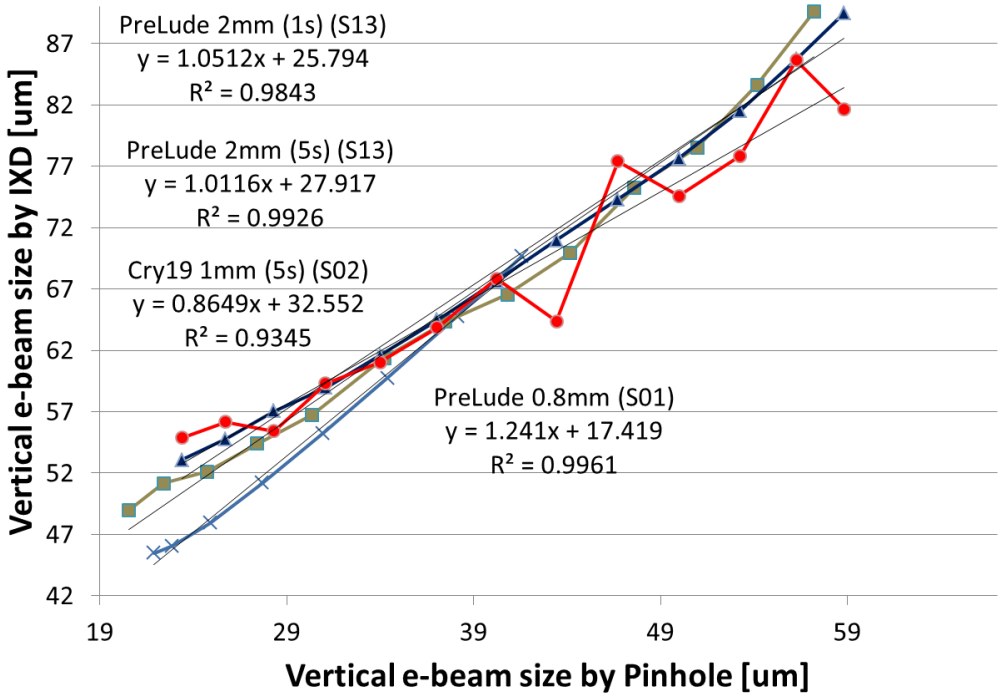




2.4% coupling



Screen materials test



	Lin	PSF*	R^2
PL 2mm (1s)	1	25	.984
PL 2mm (5s)	1	27	.992
CR 1mm (1s)	0.8	32	.934
PL .8mm (1s)	1.2	17	.996

Sensitivity to remaining flux > 130 keV (most to least):

PreLude (2 mm)

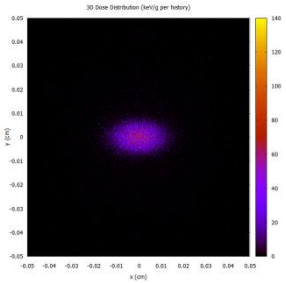
CRY19 (1mm)

PreLude (0.8 mm) ← cleanest measurements

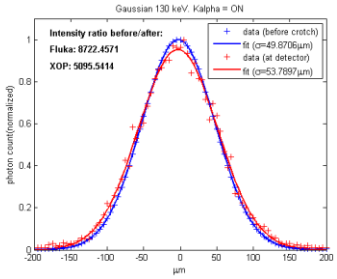
What is enlarging our beam?

Penelope & Fluka simulations

to evaluate the PSF enlargement by secondary emission

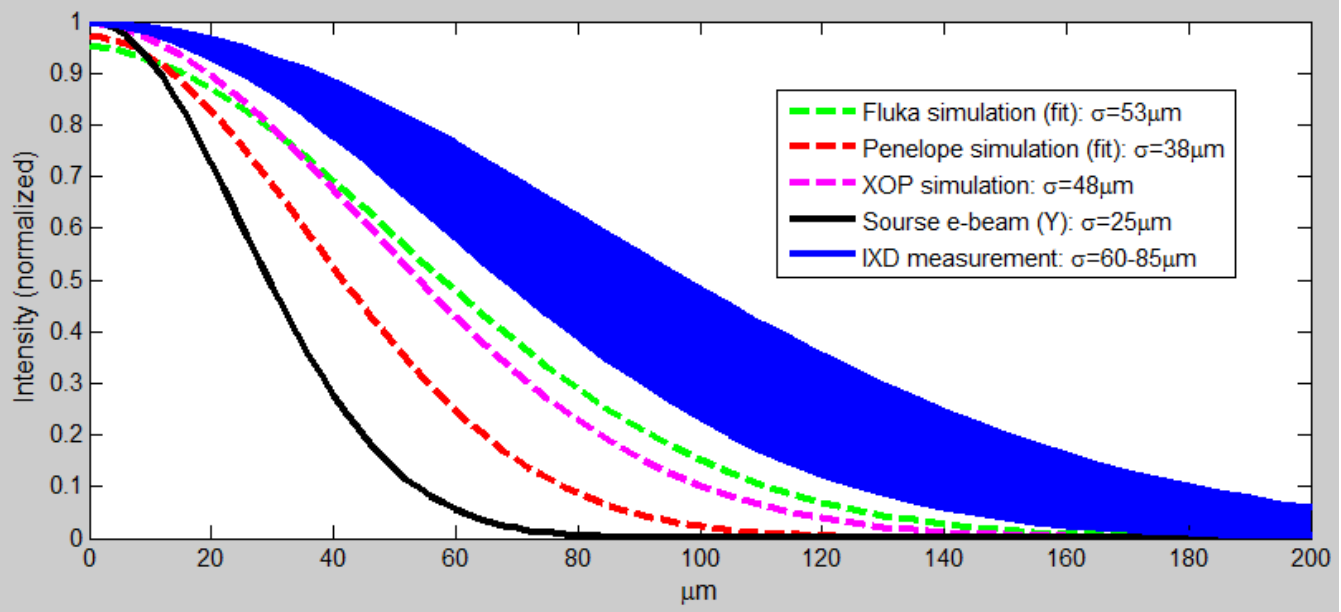


Penelope:
Secondary <u>electrons</u> tracking ON produced 0.1% more beamsize w.r.t to tracking OFF

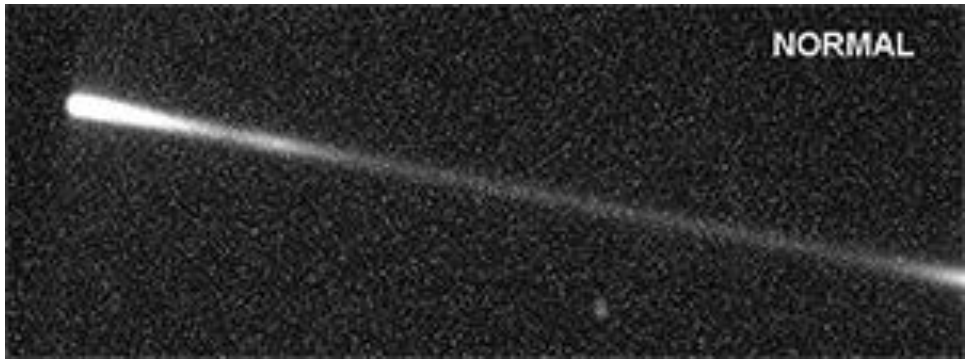


Fluka:
Secondary Cu <u>photons</u> (K_alpha) tracking ON produced 0.2% more beamsize w.r.t. to tracking OFF

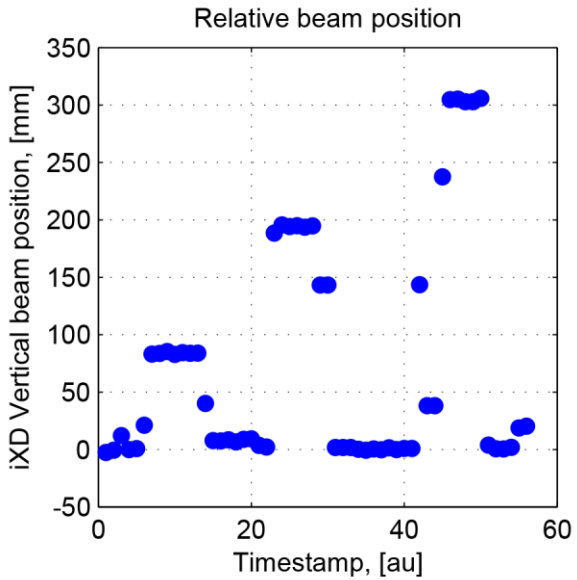
Neither are able to predict the PSF enlargement of IXD

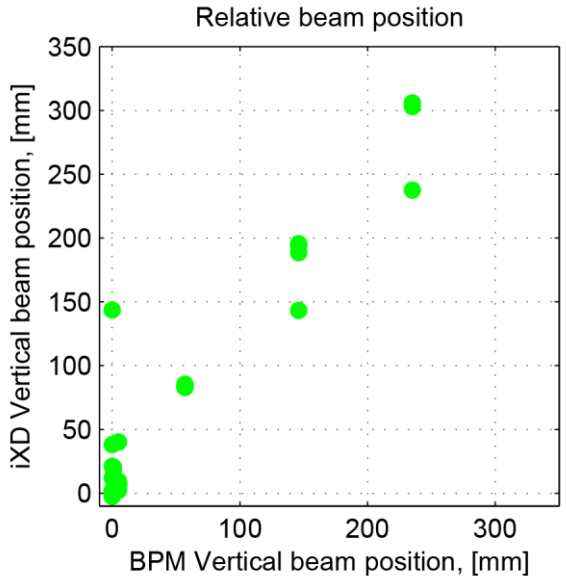


Vertical bumps



Bumps of 50-100-200-300 um are detected well by the IXD
(calculating the difference in Gaussian centroids)





Conclusions

- We see a linear correlation between beam size measured by IXD and Pinhole

- There is a linear offset which is not understood:
  - Optics effect? (DOF checked, pixel size calibrated)
  - Secondary emission? (checked by tracking simulations: Fluka, Penelope, which explain the negligible enlargement by secondary photons and electrons)
  - Other?

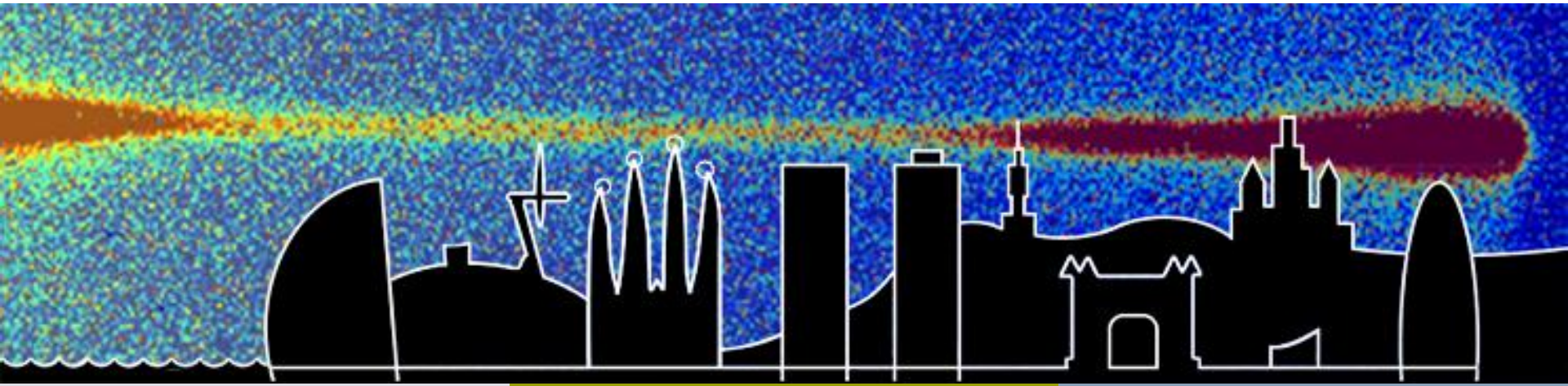
- IXD measurements with different screen materials: results are similar but measure different beam sizes, intensities, and have different sensitivity to high energy x-rays.

- IXD measurements in different but geometrically-identical machine sectors show difference in photon intensity and IXD image shape.

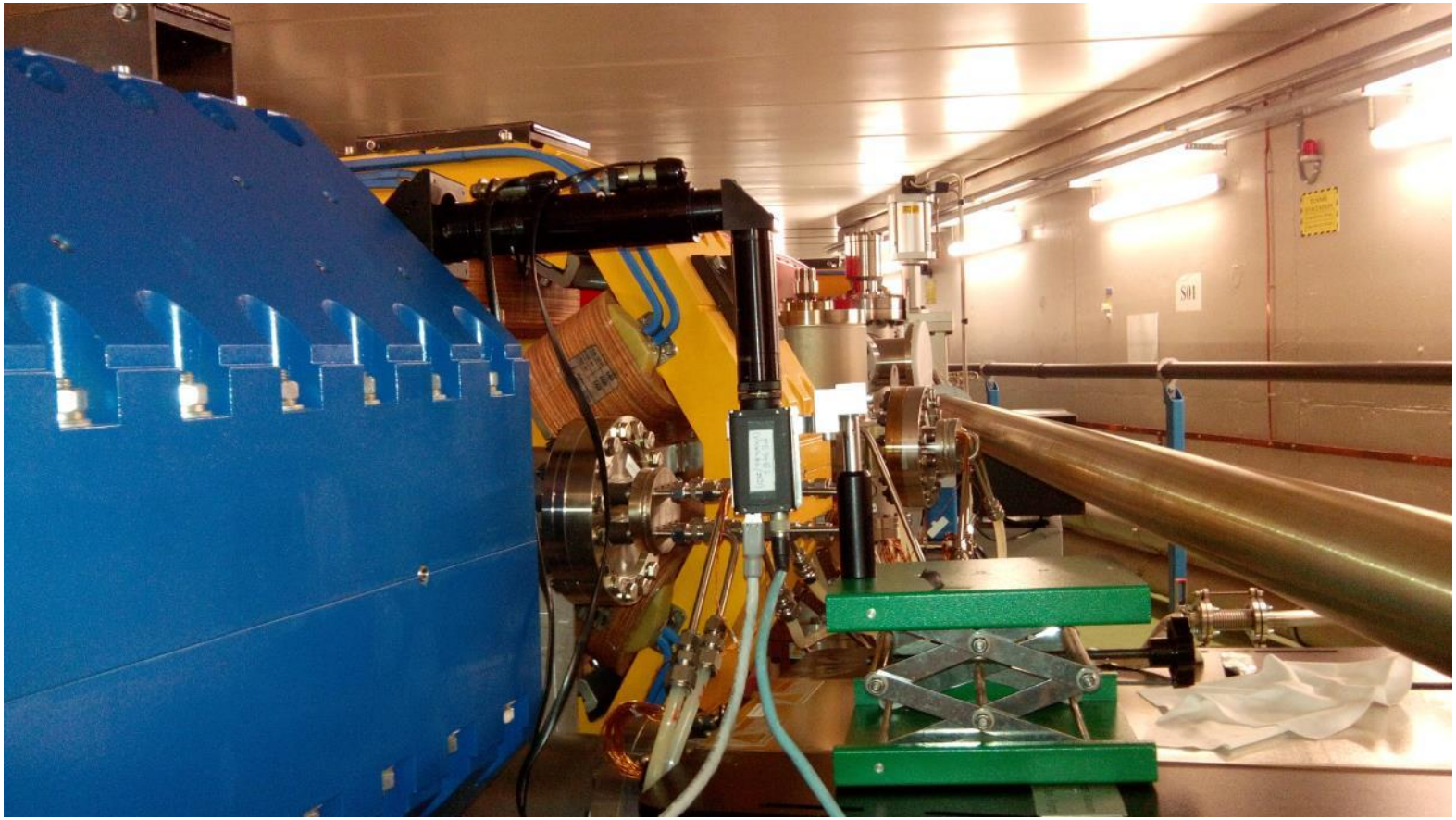
- Difficult to get to sub-second measurement due to overall low residual flux (absorbers are doing a good job).

- Difference in attenuation by identical absorber is not fully understood as well

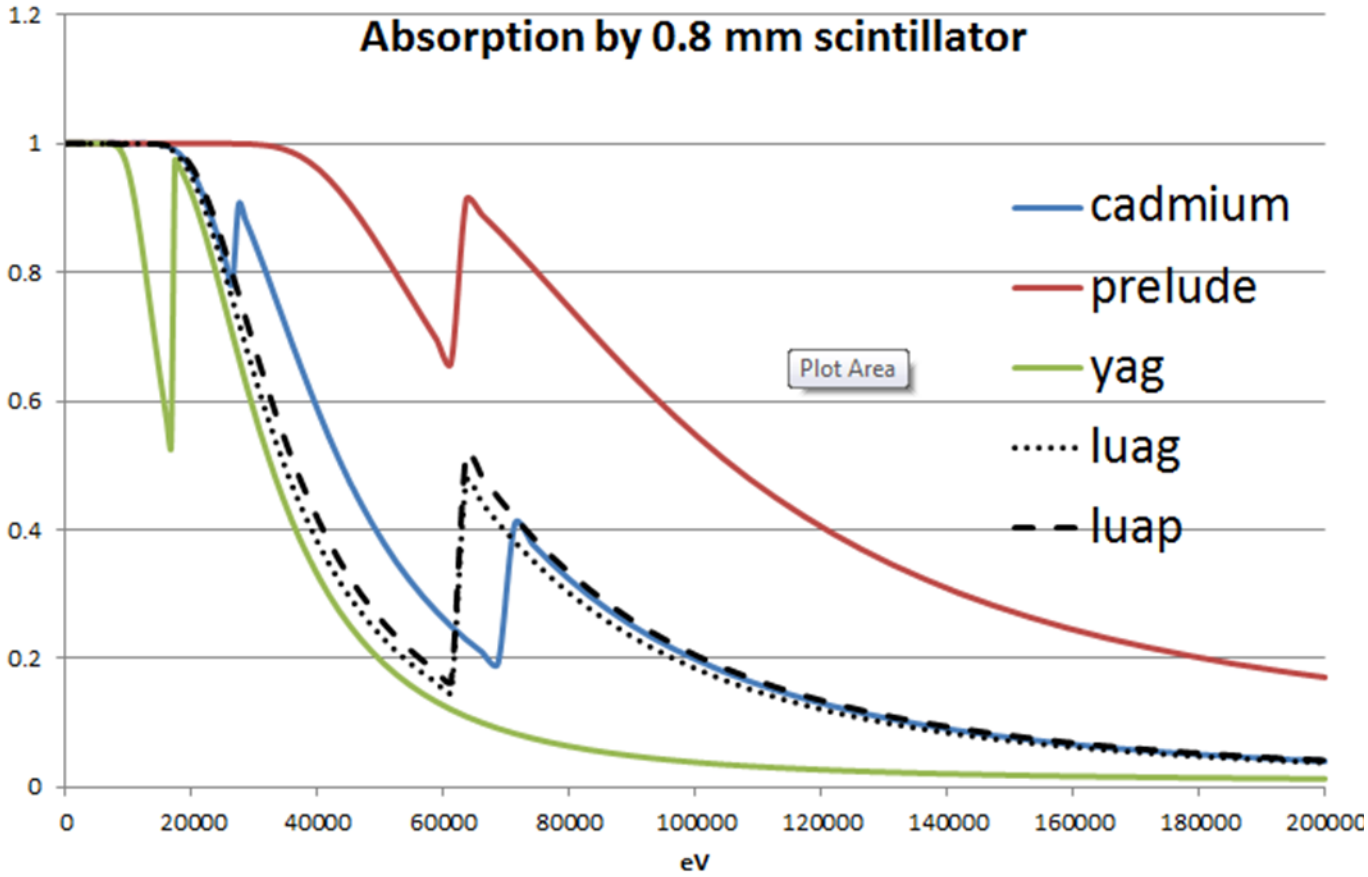
Thank you!



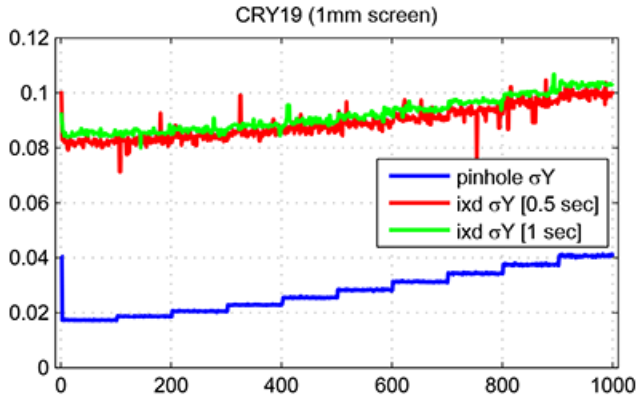
Motorized setup (fail)

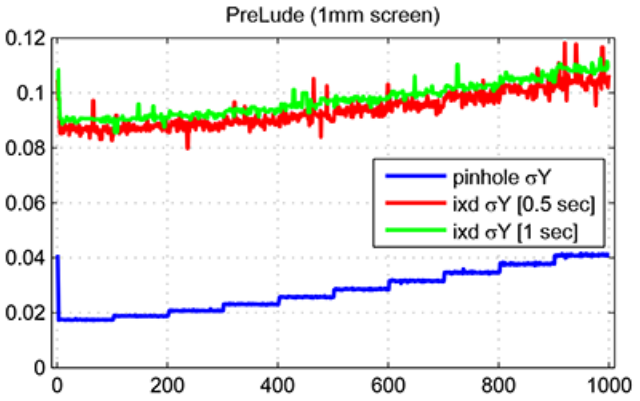


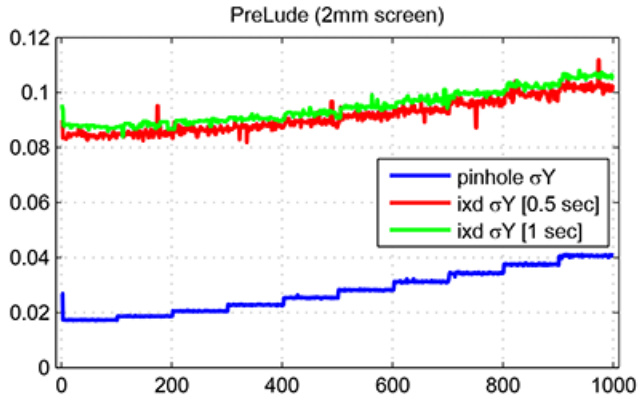
More absorption

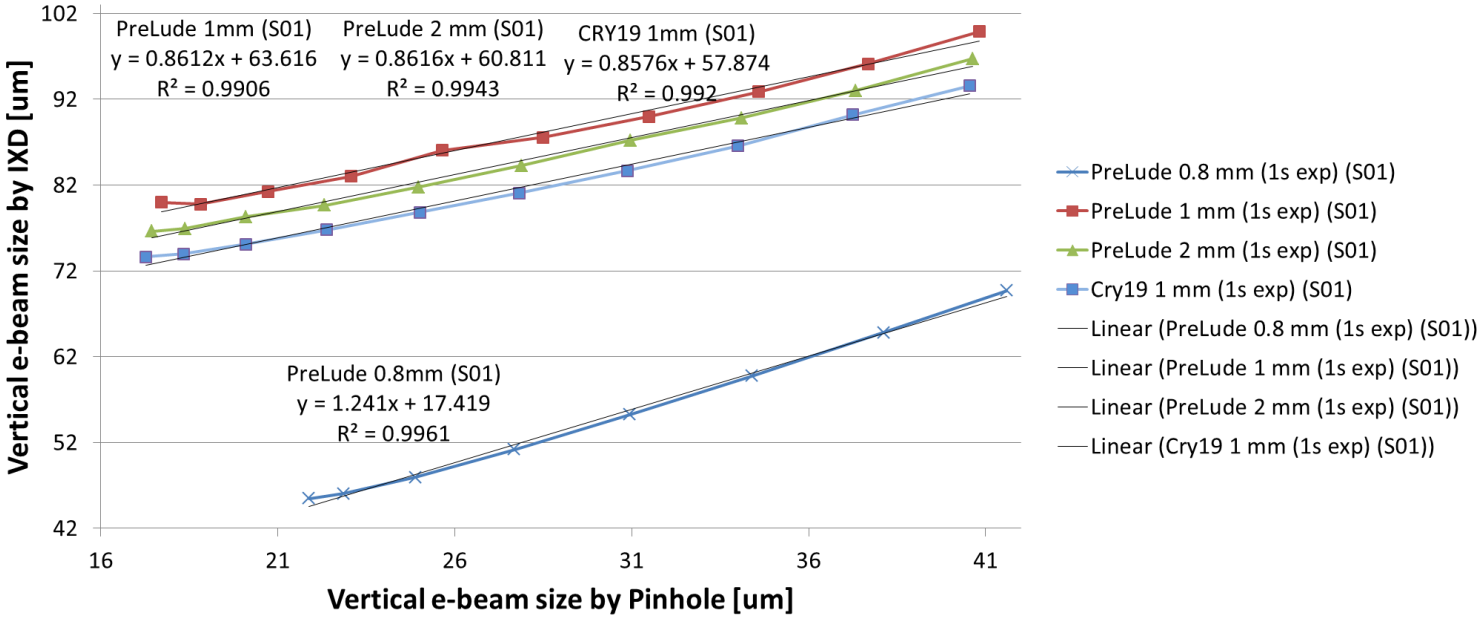


Coupling scans

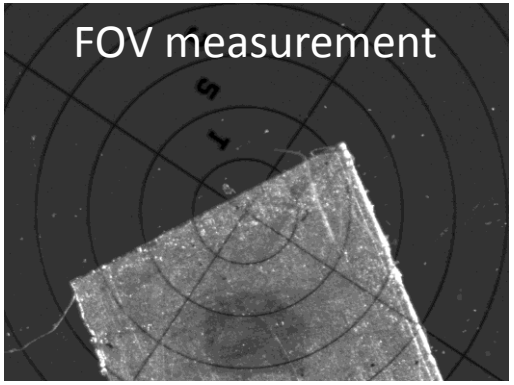




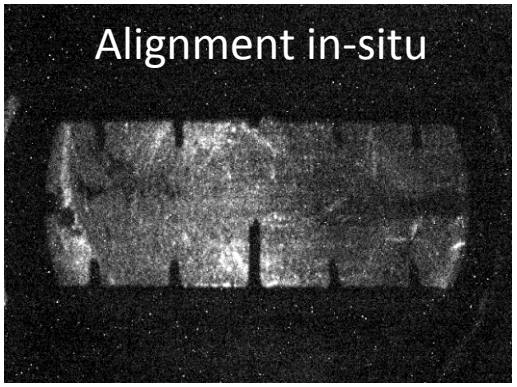




Backup: IXD calibration



Pixel size calibration
DOF test (typically 1 mm) so focusing on either side of the screen is OK



Calibration can be cross-checked online by looking at the shadow of marks (if visible, especially at high CCD exposures)