Scintillator screens at Diamond

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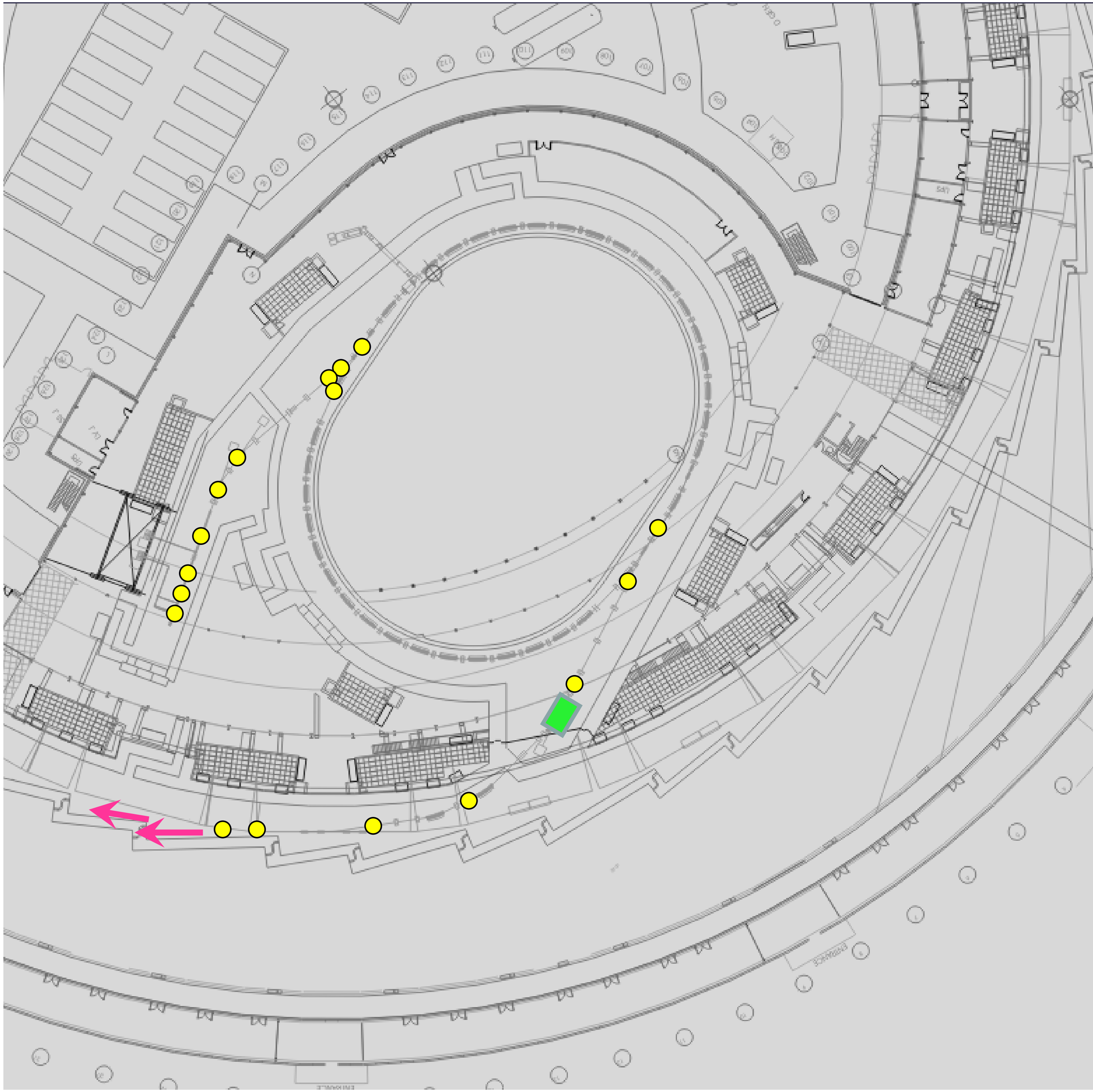
diamond

Contents

- Diamond screens layout
  - From LINAC to SR
- Electron beam transverse size in the BTS
  - Comparison YAG:Ce and OTR with 3 GeV electrons
- X-ray camera scintillators
  - X-ray screen resolution, speed, linearity, etc.

Diamond Screens Layout

- 17 screens in injector:
  - Linac: electrons: 90 keV to 100 MeV
    - 4 YAG
    - 1 OTR
  - LTB: electrons 100 MeV
    - 4 OTR
    - 4 YAG:Ce
  - Booster: electrons: 100 keV to 3 GeV
    - 2 OTRs
  - BTS: 3 GeV
    - 4 OTRs
    - 2 YAG
- Diagnostics test area
  - 4 OTR / YAG
- SR: 3 GeV
  - 2 X-Ray pinhole cameras



17 Screens ●

2 Pinholes ➔

BTS test ■

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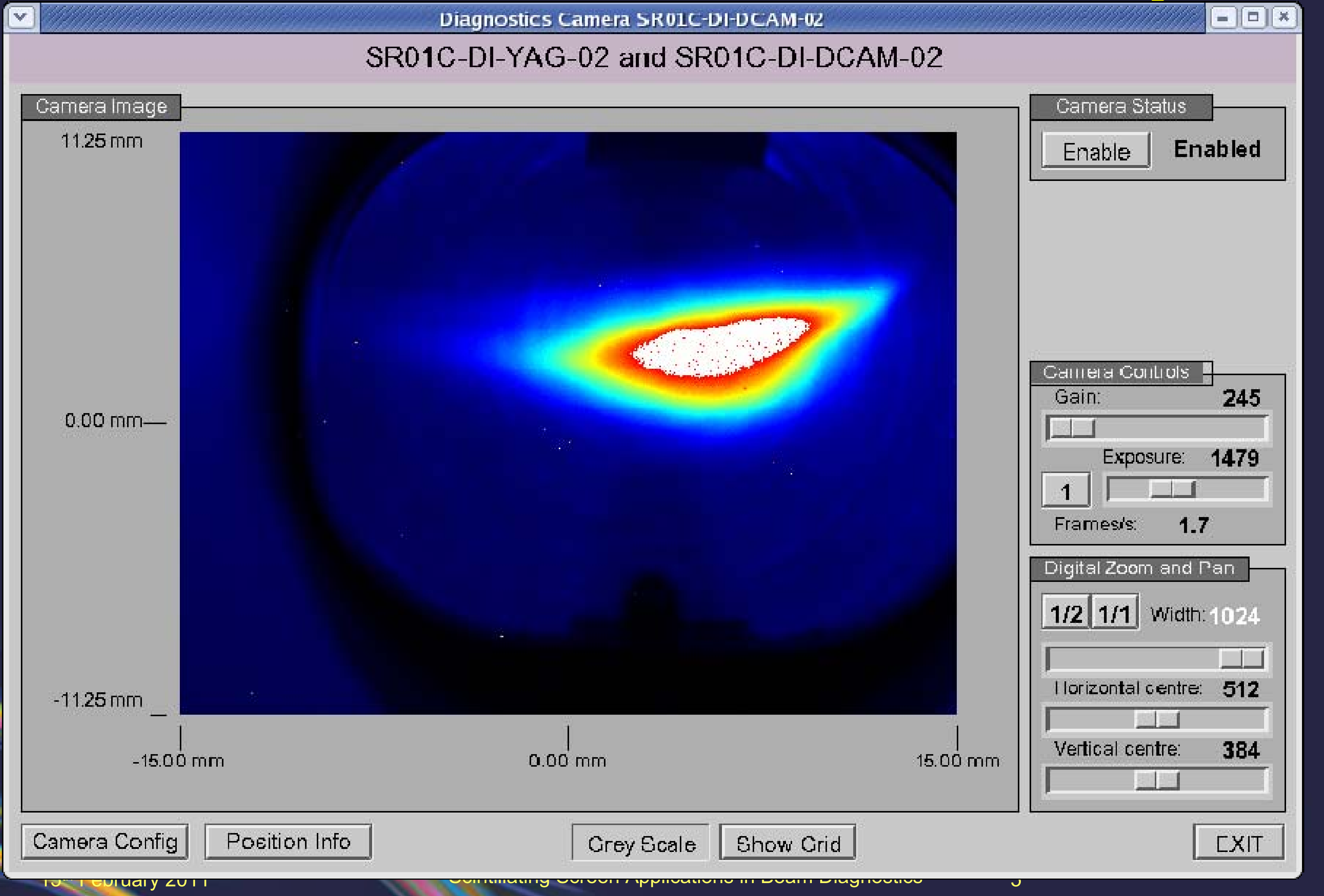
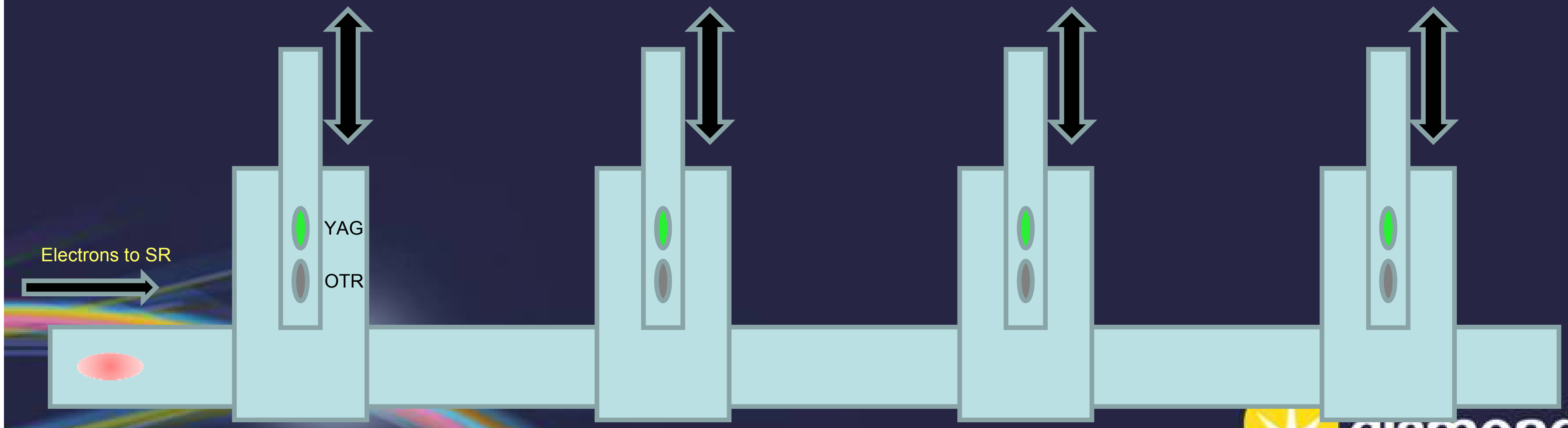
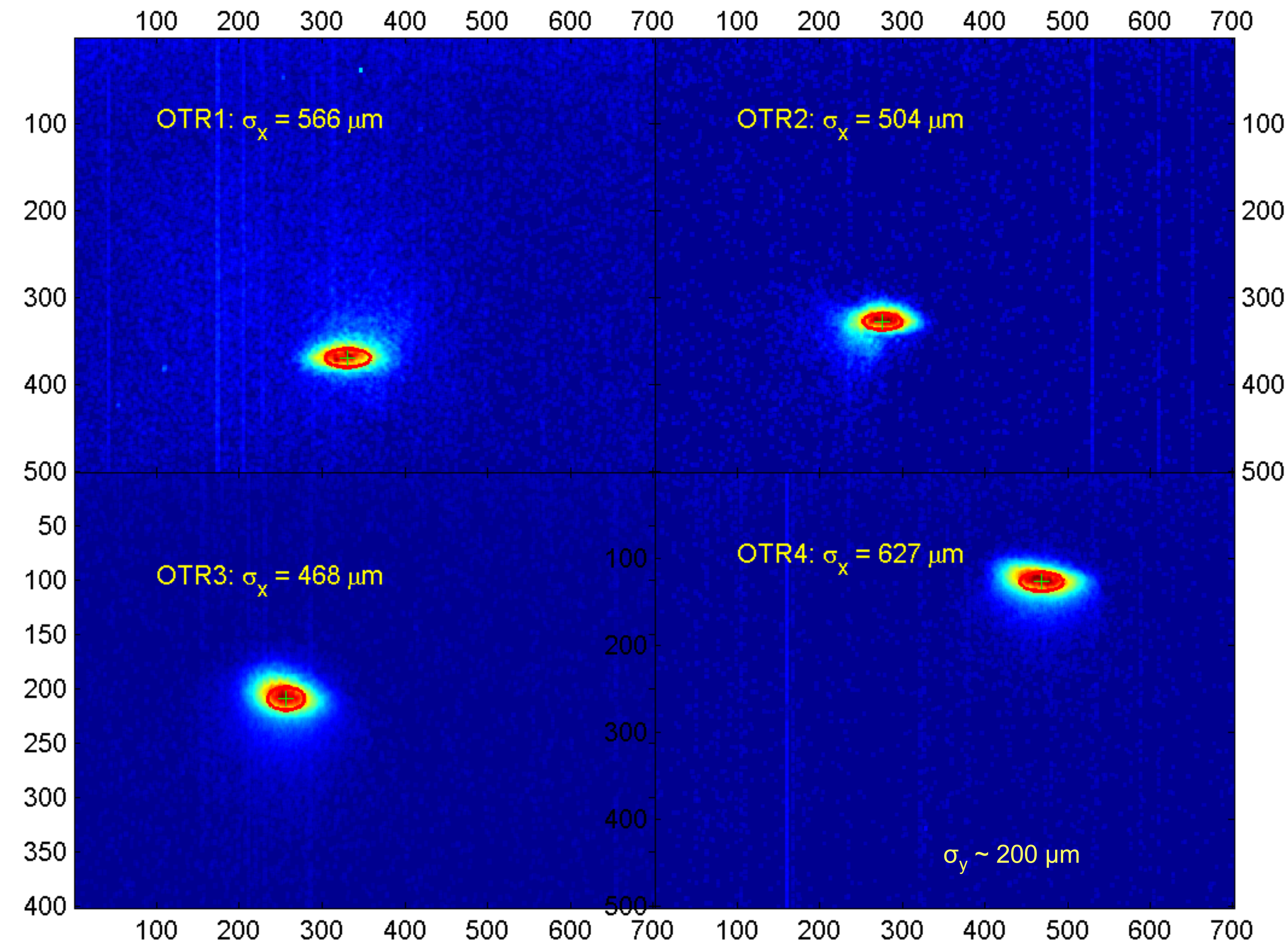
Beam Profiles in the Diamond Injector



Electron Beam Transverse Size in the BTS

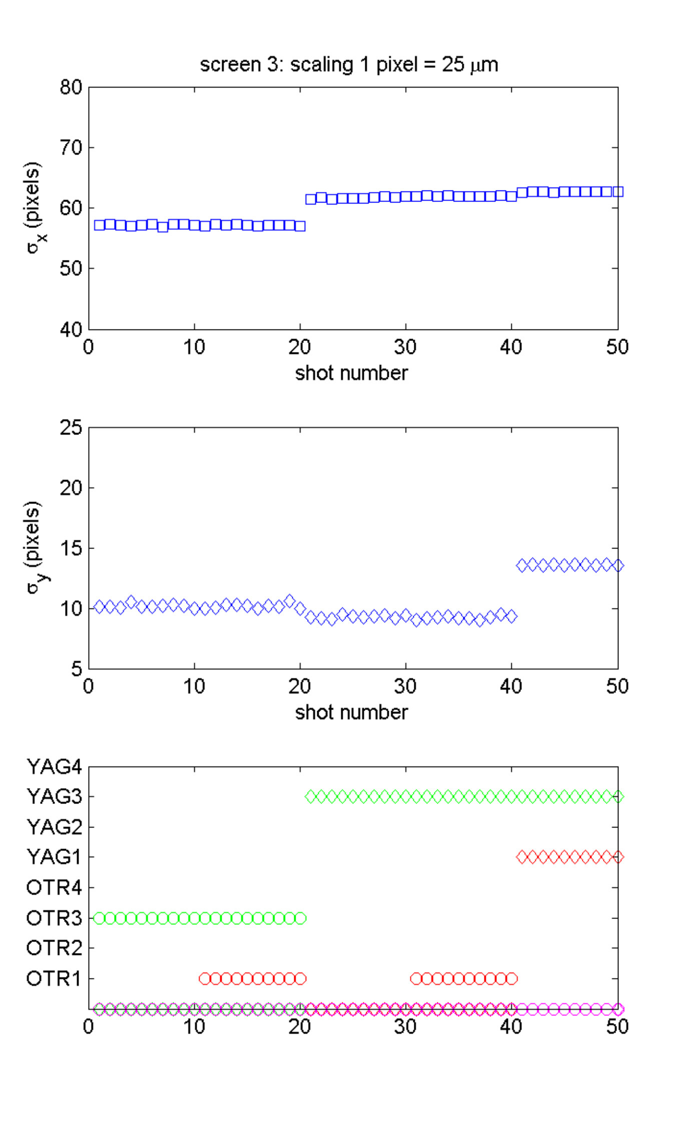
- 4 screens positions in drift space
  - Beam profile with YAG:Ce (100 μm thick)
  - Beam profile with OTRs (5 μm thick Mylar with Al coating)
    - Single shot emittance measurement

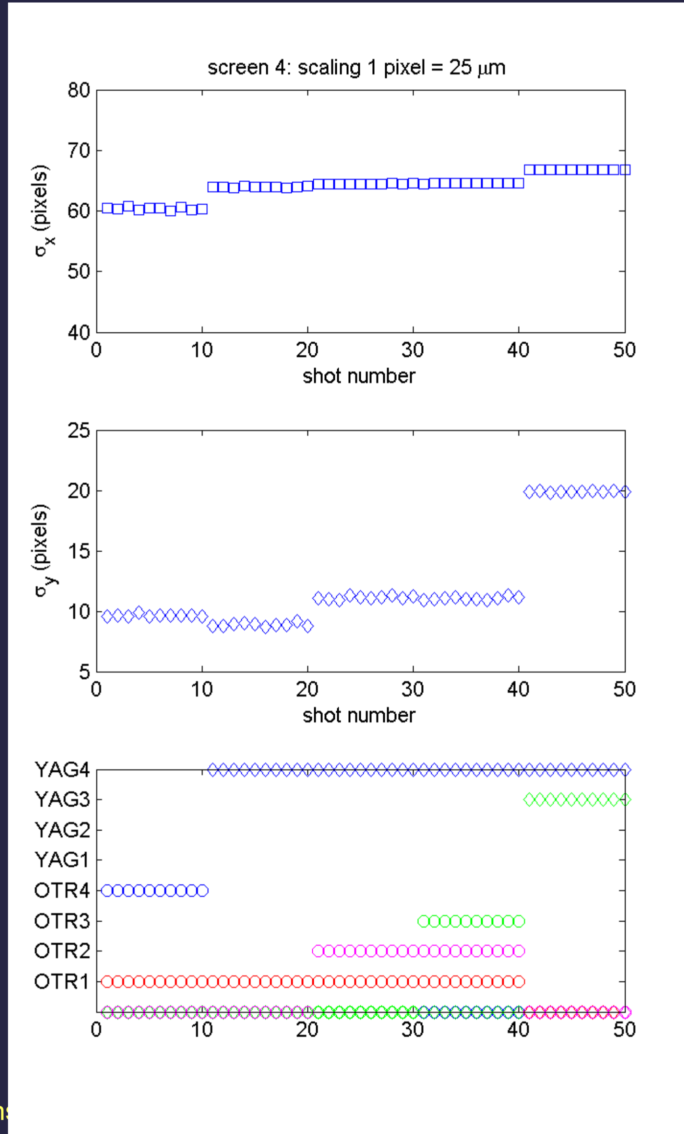




3 GeV electro

Screen Comparison and Scattering Effects





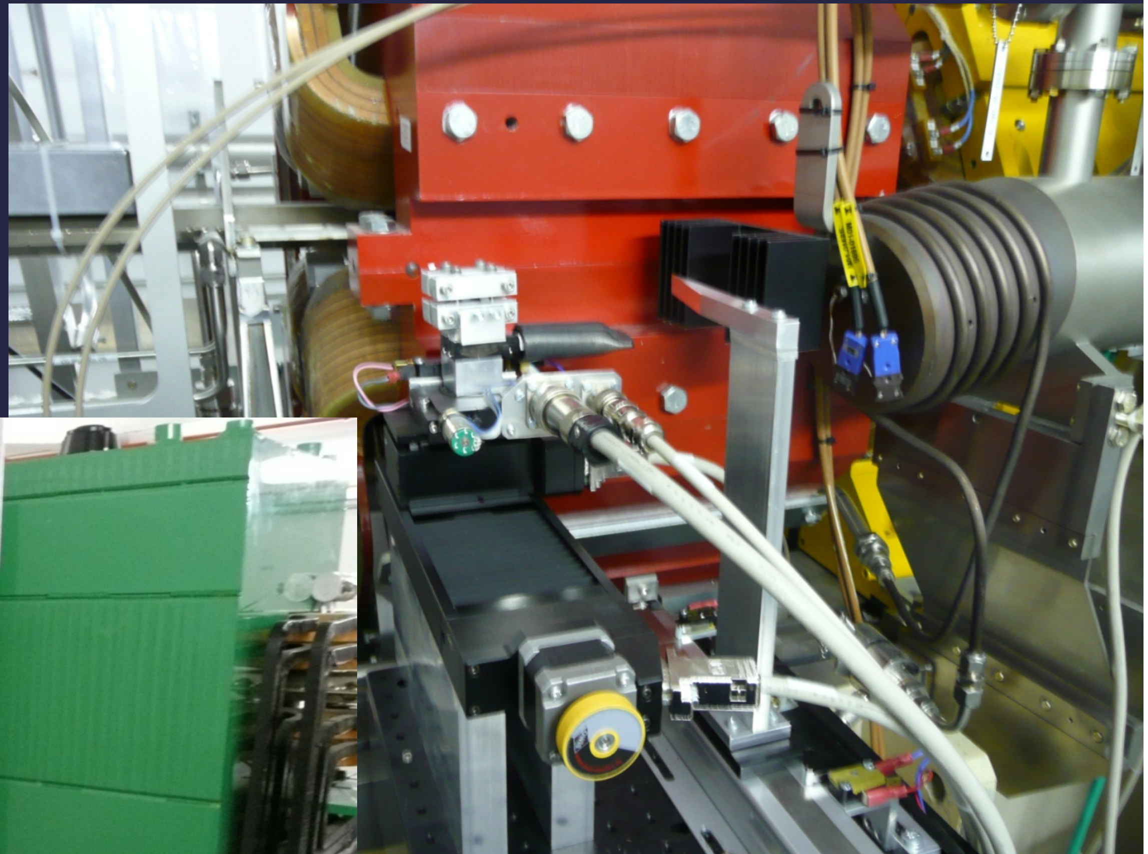
- YAG:Ce presents sensitivity so that small charge can be detected (<<1pC for 2x0.2 mm^2)
- OTR less sensitivity detection limit (70pC for 2x0.2 mm^2) <u>with flea2 CCD cameras</u>

- Resolution: appears to be sufficient to measure beam size down to 100 μm - better resolution need to be measured

- Linearity has been checked against measured charge

X-ray Camera Scintillators

- Screen resolution
  - LuAG, $CdWO_4$ and P43 Compared
- Linearity
  - Test against a diode
- Speed and photon yield
  - Measurement with fast camera



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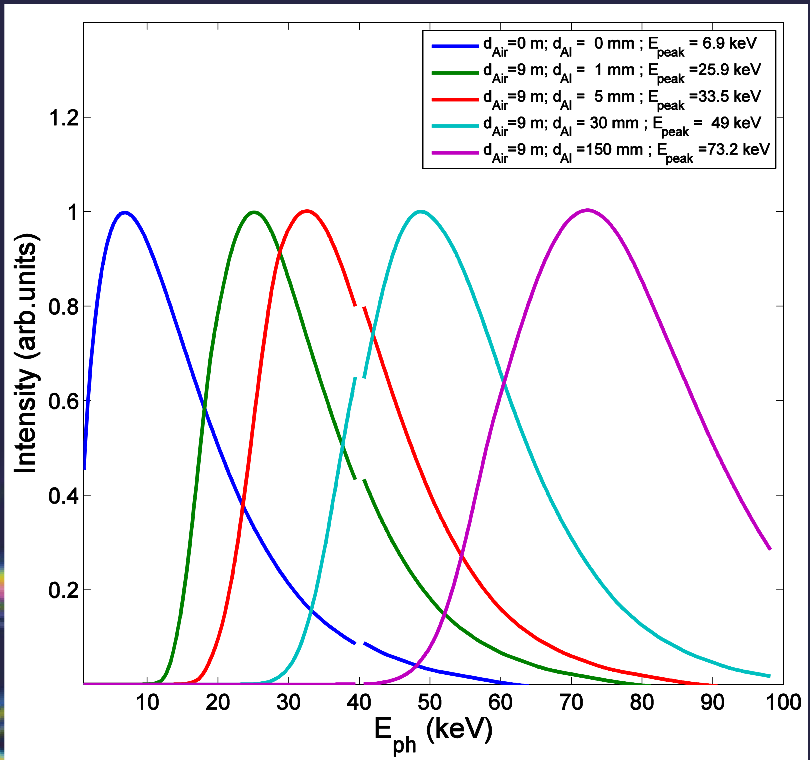
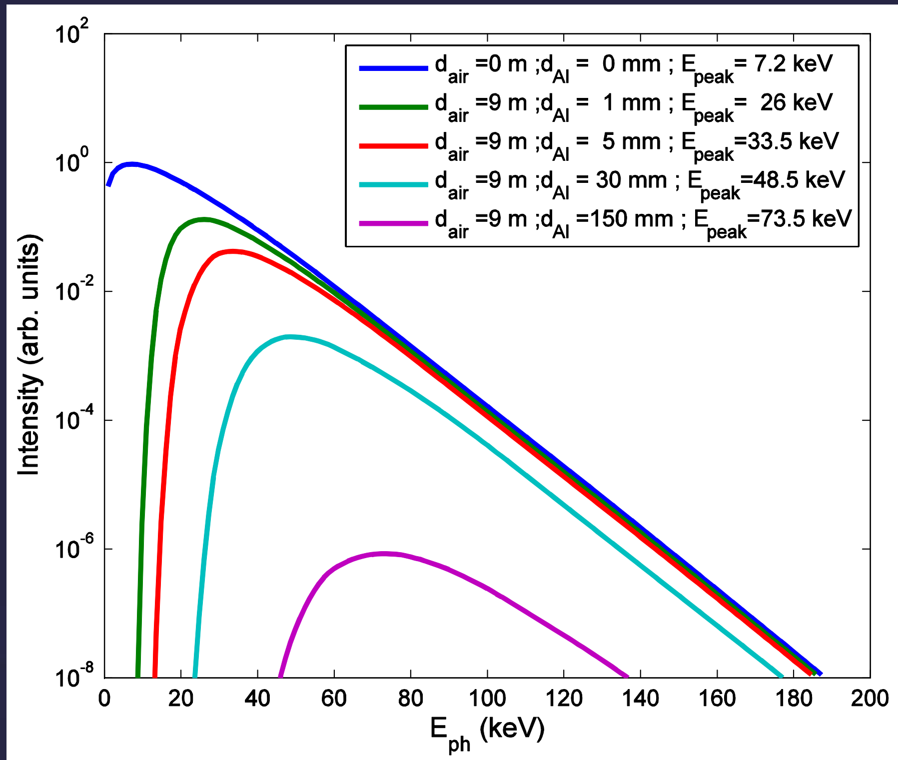
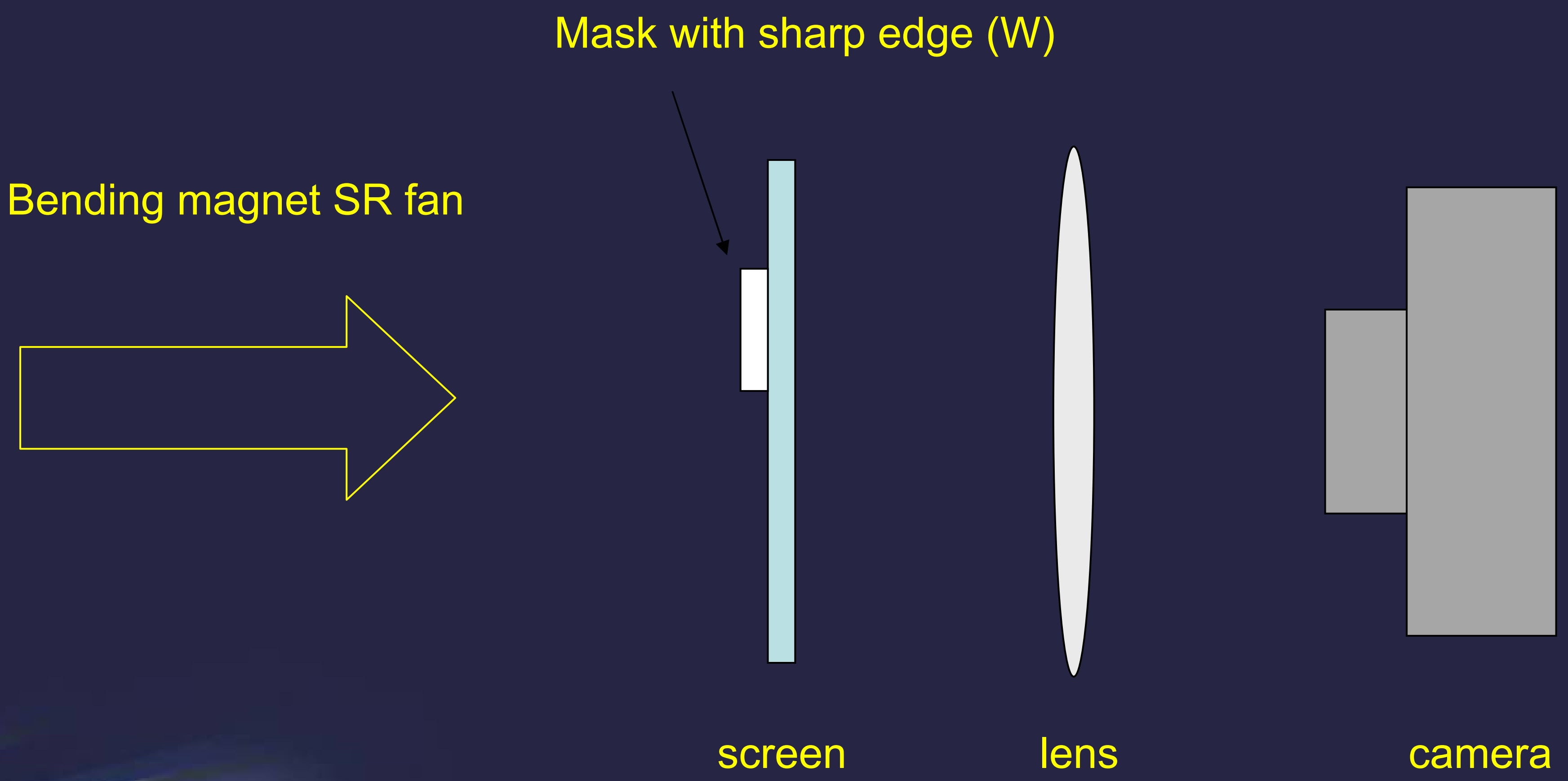
X-ray power spectrum from bending magnet

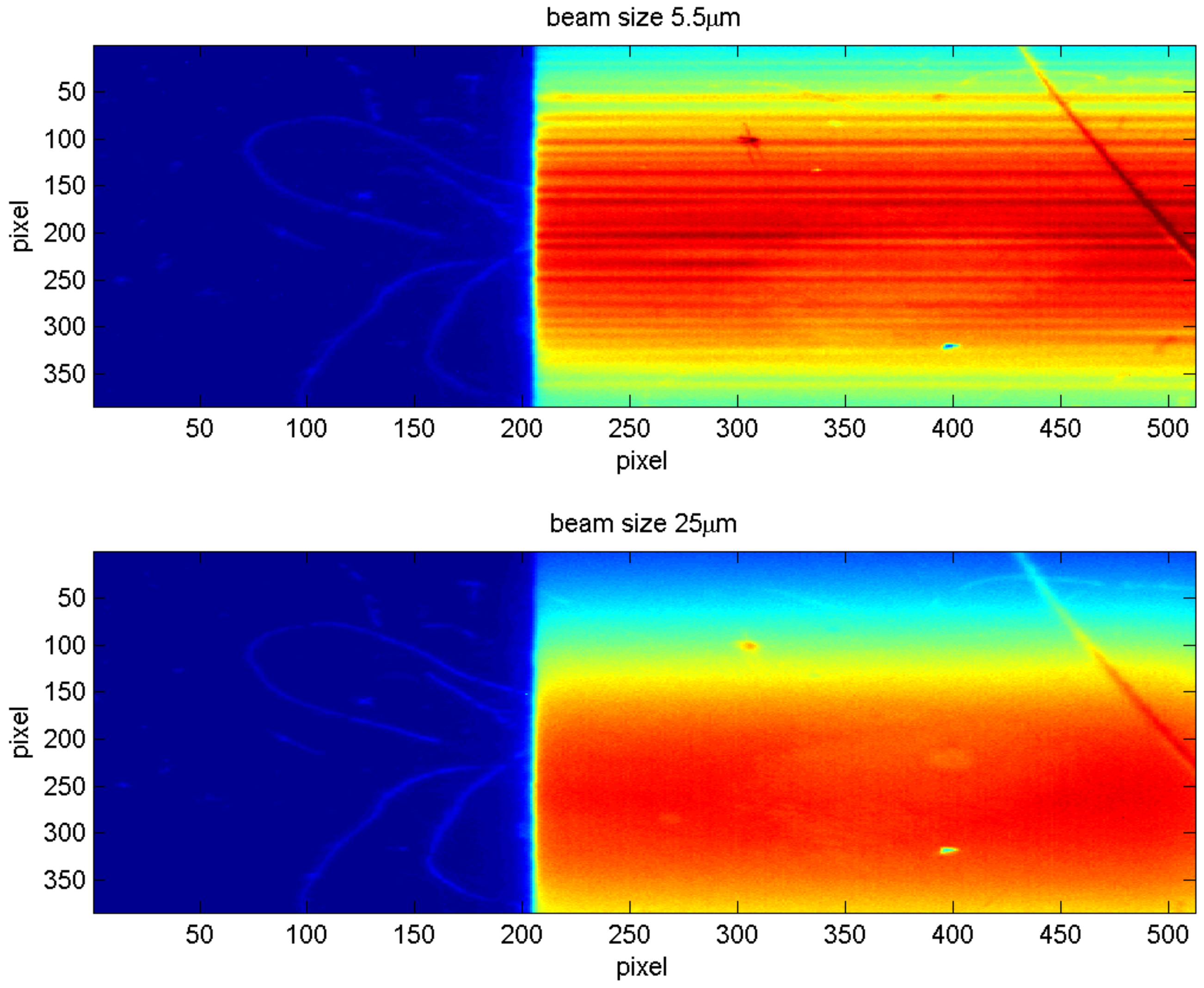




Screen Resolution Measurement

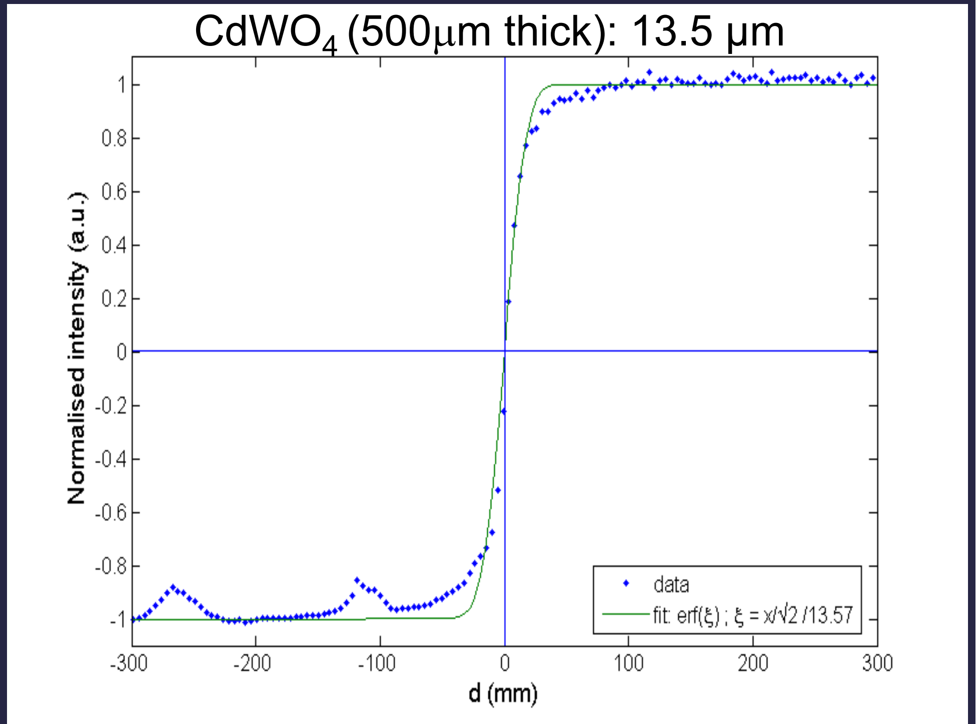


Resolution Measurement Example



Screen Resolution Results

- Nominal electron beam (K=1%)
- constant current
- camera mag = 1
- pixel size 4.65 μm



PSF width for several screens

	Thickness (μm)				
	500	**400**	**200**	**100**	**5**
CdWO4	13.5	10	8	7	-
LuAG	-	10	8	-	-
P43	-	-	-	-	6

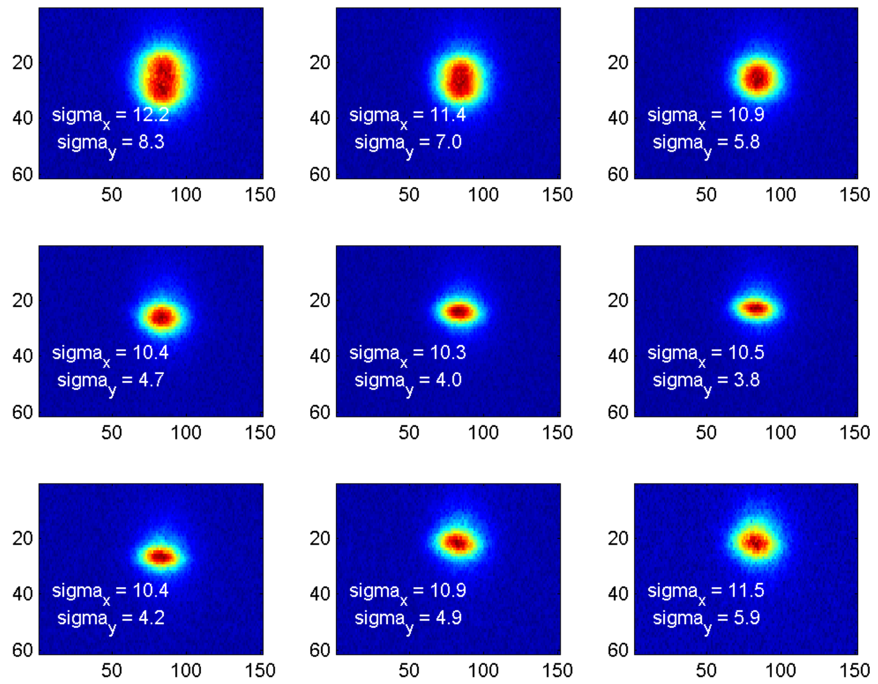
Improved System Resolution

- New camera design
  - magnification = 4
  - pixel size = 4.65 μm
  - CdWO4 (200 μm thick)

- Measurement varying photon energy

➢ PSF width: ~2.5 μm deduced from beam size and geometric optics predictions

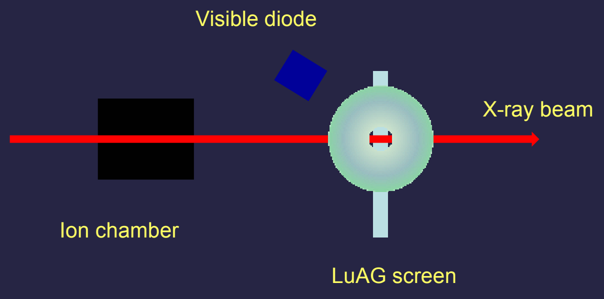
Beam profile through focussed point of CRL

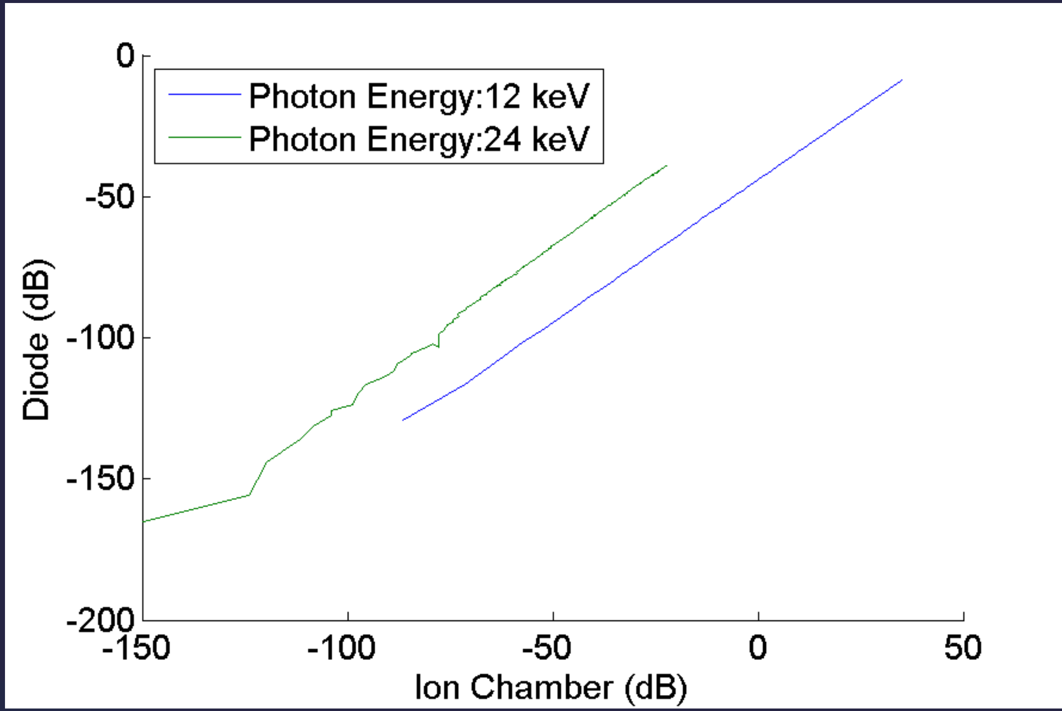


Screen Linearity

- Linearity measurement with diode against ion chamber signal

Set up:





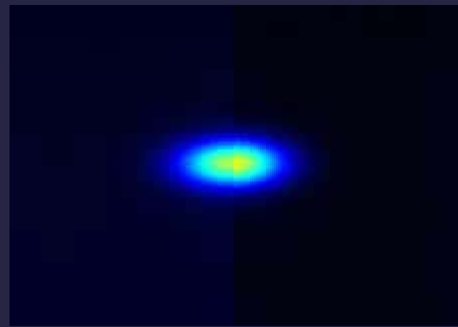
Speed and Photon Yield

- Photon yield: 30 ph / keV
- Short response: ex. CdWO4 has typically 20µs
  - ➢ Can be used with fast cameras to observe kHz beam motion
  - – Examples:
    - Electron beam motion from kickers
    - Photon beam: beamline stability

Kicker effect on the stored beam

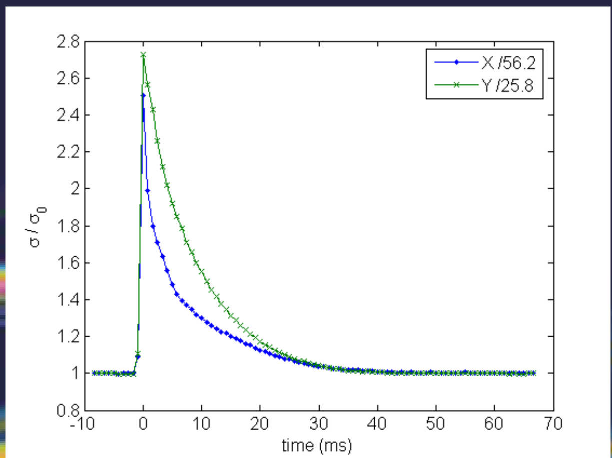
Camera: 1500 fps
pixels = 7.4 mm
magnification = 1
Screen LuAG (200 μm)

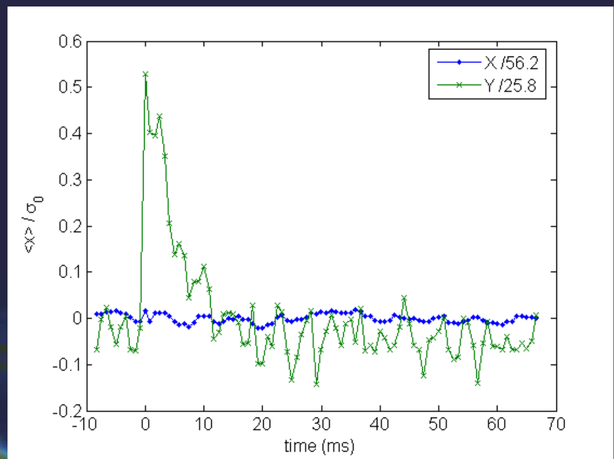
50 % of $\sigma_{vert.}$ vertical displacement

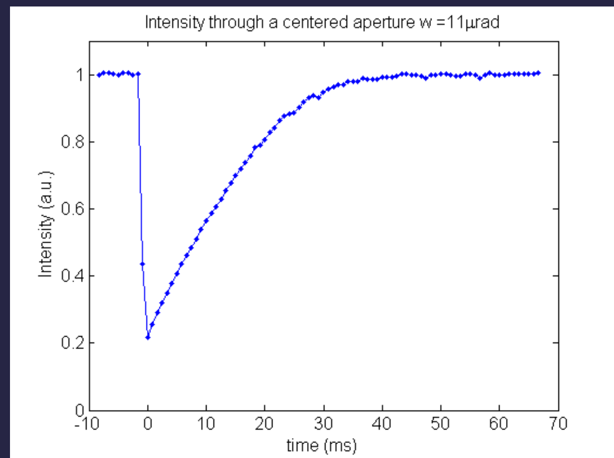


250 % rel. increase of beam size
⇨ $\sigma_{hor.}$.= 145 μm
⇨ $\sigma_{vert.}$= 67 μm

Large reduction of the intensity across an aperture

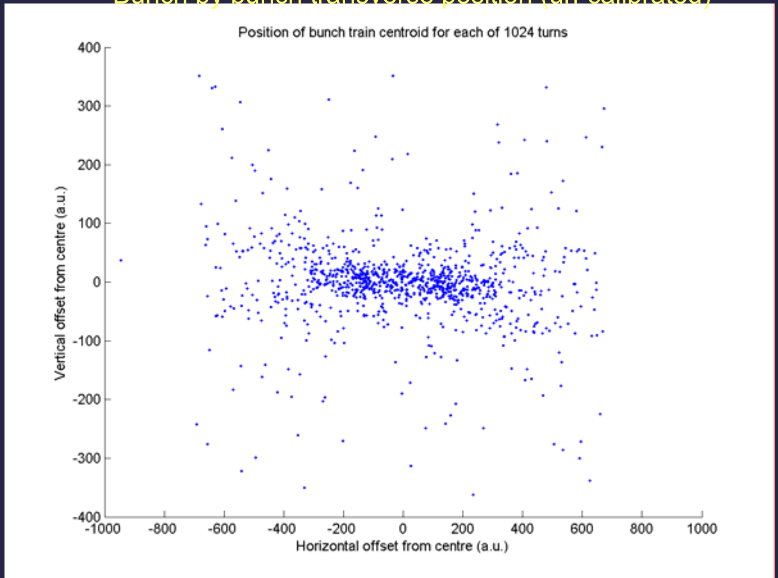


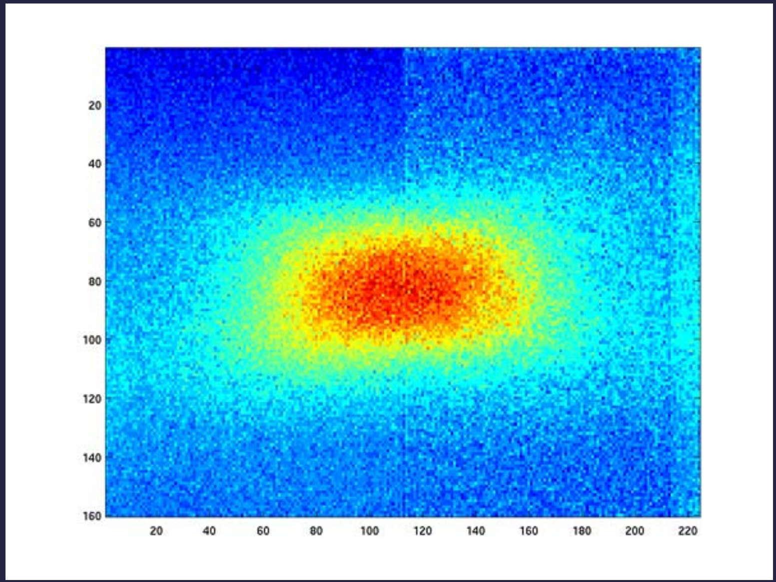




Beam motion seen by the bunch by bunch and fast camera (1500 fps)

Bunch by bunch transverse position (un-calibrated)





600 μs = 300 turns = 9000 betatron oscillations

Beamlines Stability

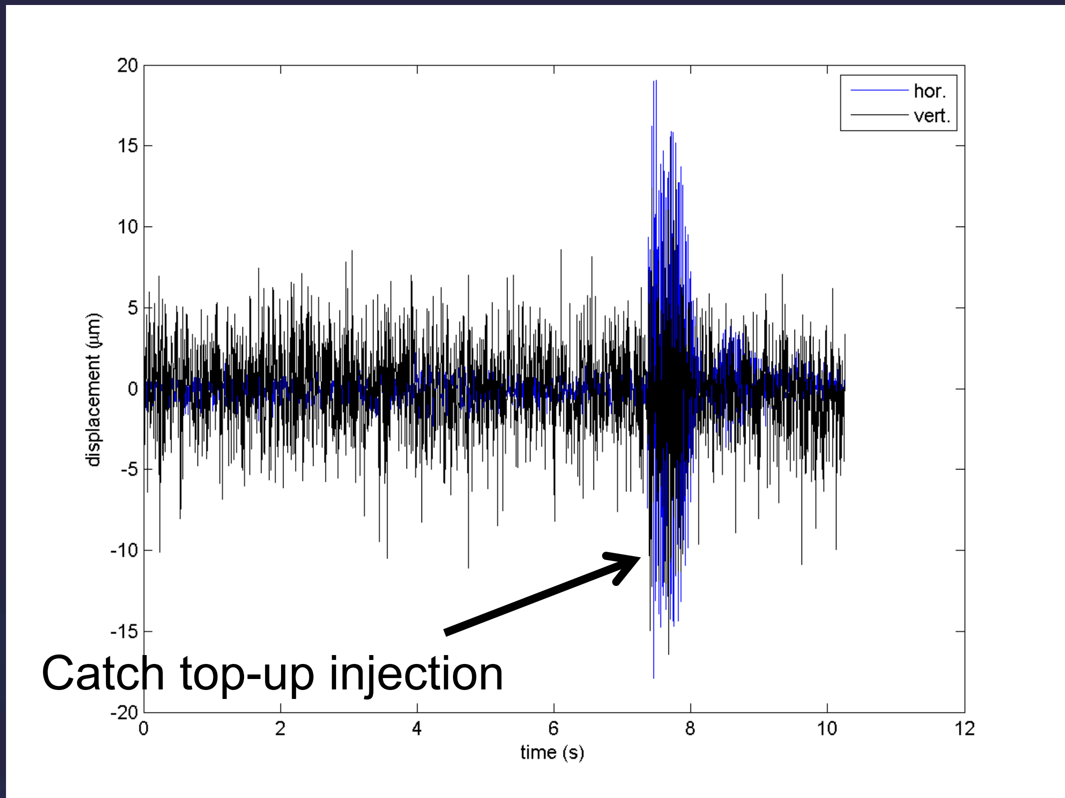
Camera: 200 fps
pixels = 7.4 mm
magnification = 1

Screen: $CdWO_4$ (200 µm)

Std: 0.3 x 1 µm
≡ 0.9 x 2.5 % of the beam size

Vertical motion
5 µm ≡ 0.2 µrad from DCM

Photon beam centroid motion at sample position



Conclusion

- OTR and YAG:Ce used at Diamond for injector diagnostics. YAG:Ce mainly for low energy electrons, OTR for > 100 MeV electrons.
- Comparison YAG:Ce vs OTR (extra thin):
  - OTR best resolution (from literature however never measured at Diamond)
  - YAG best sensitivity
  - OTR scattering negligible whereas 100um thick YAG gives significant scattering to 3GeV beam: thin OTR could be used as permanent diagnostics
- Crystals for hard X-rays:
  - Different sensitivity depending on mainly their absorption coefficient
  - Resolution depends mainly on screen thickness (normal incidence) and optical imaging system performance
  - Linearity permits true representation of the imaged photon beam
  - Speed and high photon yield allows short time exposure imaging thus it renders possible the use of fast camera

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