Suppression of Coherent Optical Transition Radiation in Electron Beam Diagnostics for FLASH.

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Joint School
Erice, 13.Apr.2011

HELMHOLTZ ASSOCIATION

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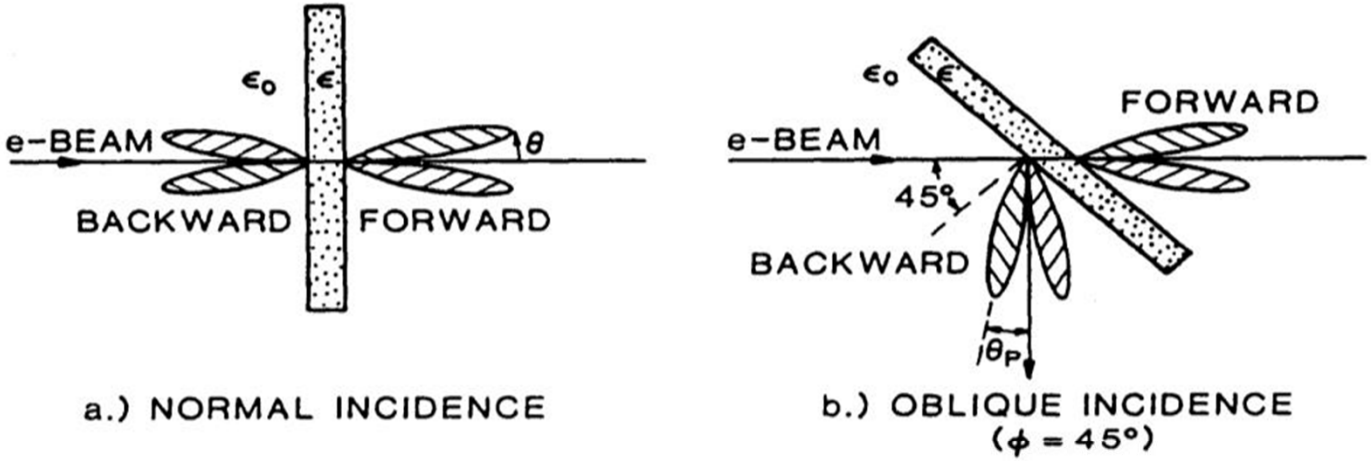
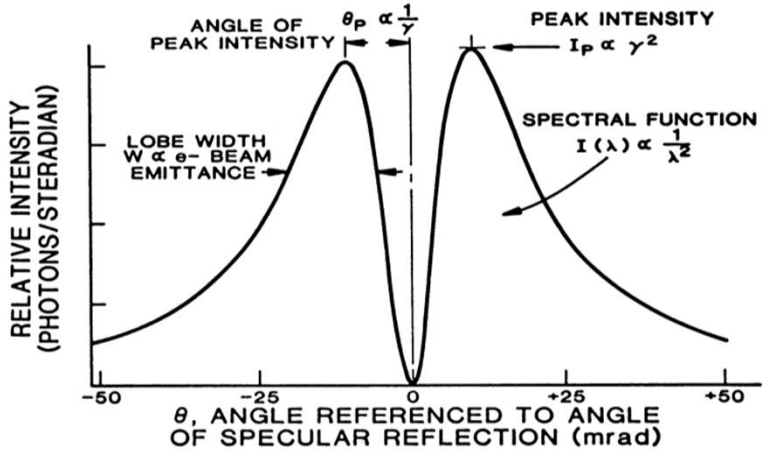
Outline

- Motivation
  - Problem of OTR-screens
  - Why is scintillation screen an alternative choice for beam diagnostics of high brightness electron beams
- Scintillation screen + fast gated camera
  - First experiments using this method as a proof-of-principle
- Investigation on the resolution of scintillation screens
- Summary and Outlook

Motivation

- Optical Transition Radiation(OTR) screen as standard for e-beam diagnostics: beam position, transverse beam profile, emittance, longitudinal beam profile measurement etc.

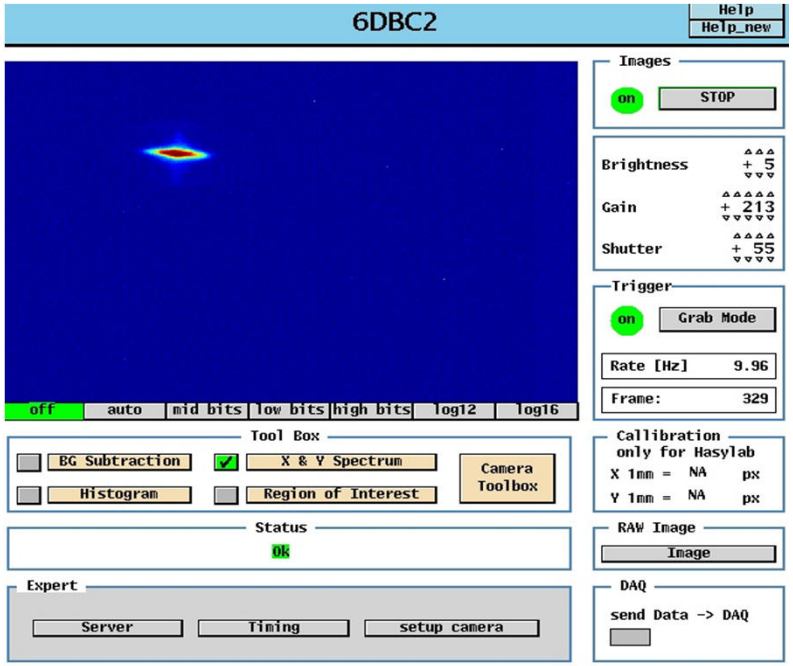




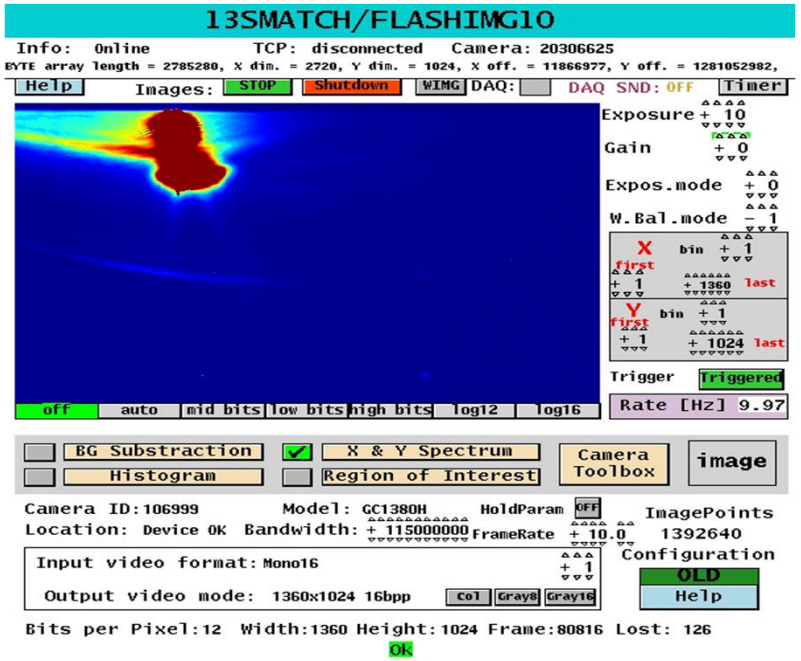
A.H. Lumpkin et al., Fermilab
NIM A296, 150 (1990)

Motivation

- Problem: micro-bunching instability in high-brightness e-beam leads to coherent TR in *visible* regime, which impedes beam diagnostics.
- Coherent TR observed at FLASH, LCLS etc..



Incoherent TR*



coherent TR*

(*Original camera image, taken from logbook of FLASH, DESY)

Motivation

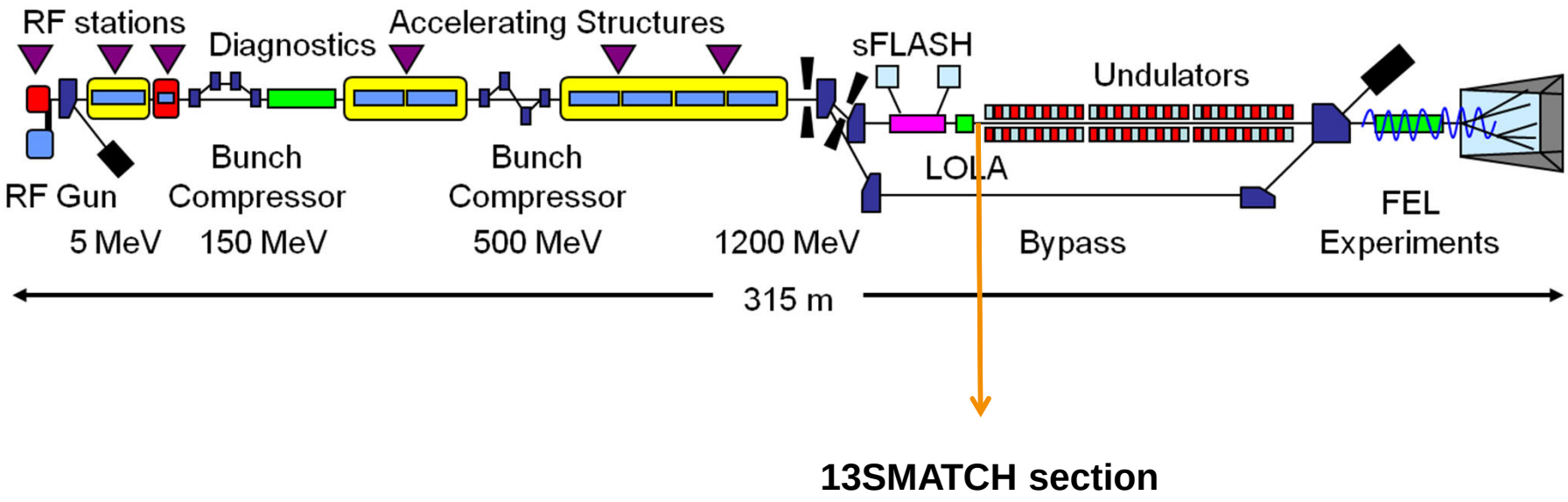
- Some beneficial characteristics of scintillator
  - Scintillating is a statistical ionization process, not sensitive on micro-structures in the particle bunch causing coherent radiation
  - Scintillation light is emitted isotropically, while OTR in narrows cones in forward and backward directions.
  - Scintillating process is a multi-stage process(delayed emission), while OTR emission is an instantaneous process.

- Remaining problem
  - OTR generation at boundary scintillator/vacuum

- 2 ways to circumvent the problem of coherent OTR:
  - Suitable observation geometry to avoid OTR light on the detector (spatial separation)
  - **Scintillation screen + fast gated camera (time separation)**

Scintillation screen + fast gated camera

- first experiments successfully performed at FLASH, DESY as a proof-of-principle.

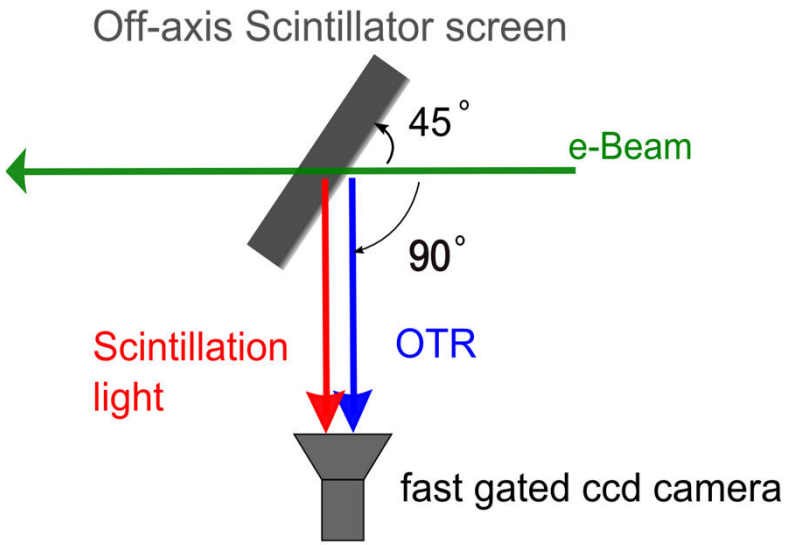


13SMATCH section

Scintillation screen + fast gated camera

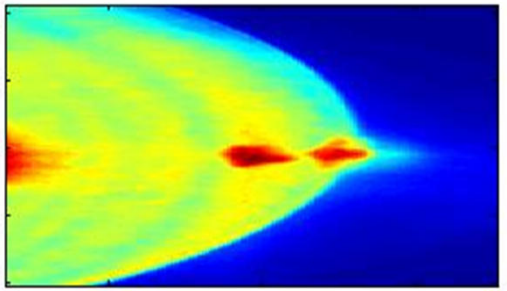
- first experiments successfully performed at FLASH, DESY as a proof-of-principle.

Top-view

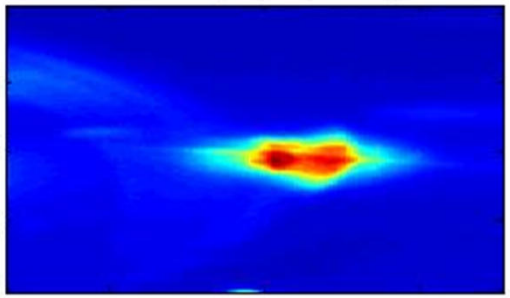


FLASH(13SMATCH section)

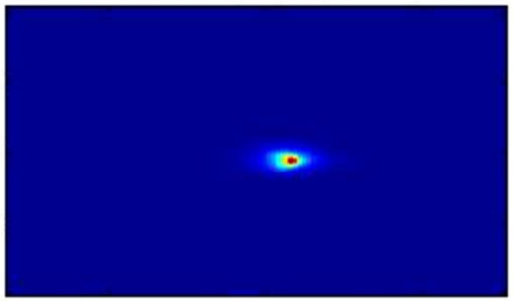
Camera image: FLASH, 13SMATCH section, 9.Jan.2011



Al coated Si OTR screen,
COTR light,
Coherent SR



LuAG screen,
COTR & scintillation light

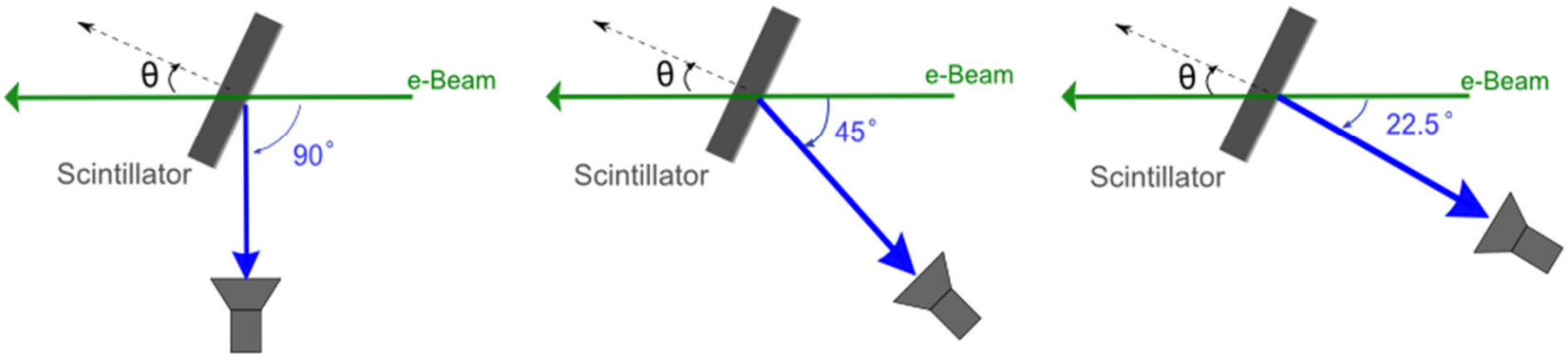


LuAG screen
+100ns delay
Only scintillation light

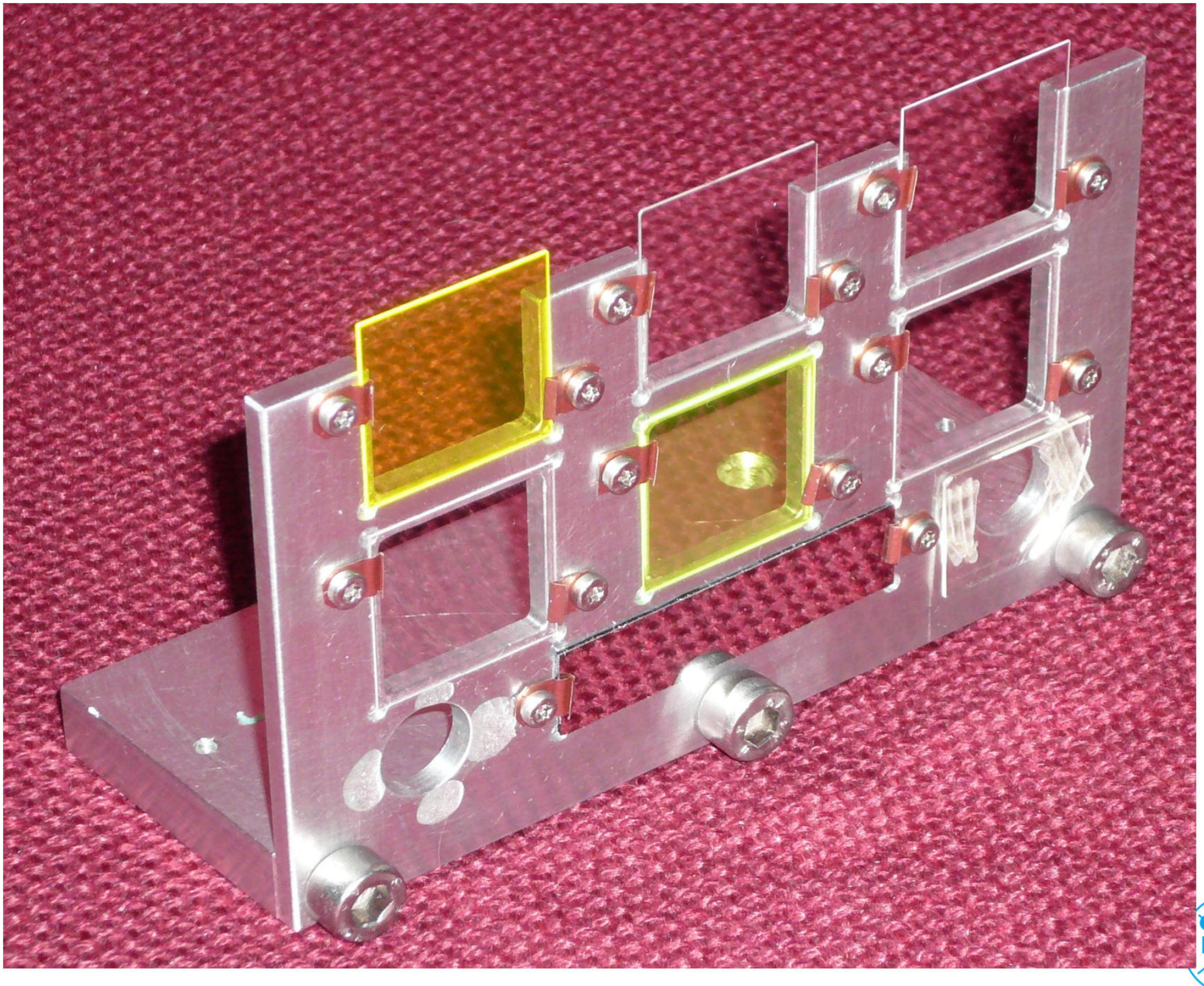
- Resolution of scintillation screens needs to be studied.

Investigation on the resolution of scintillation screens

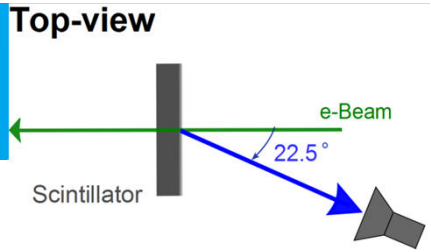
Top-view



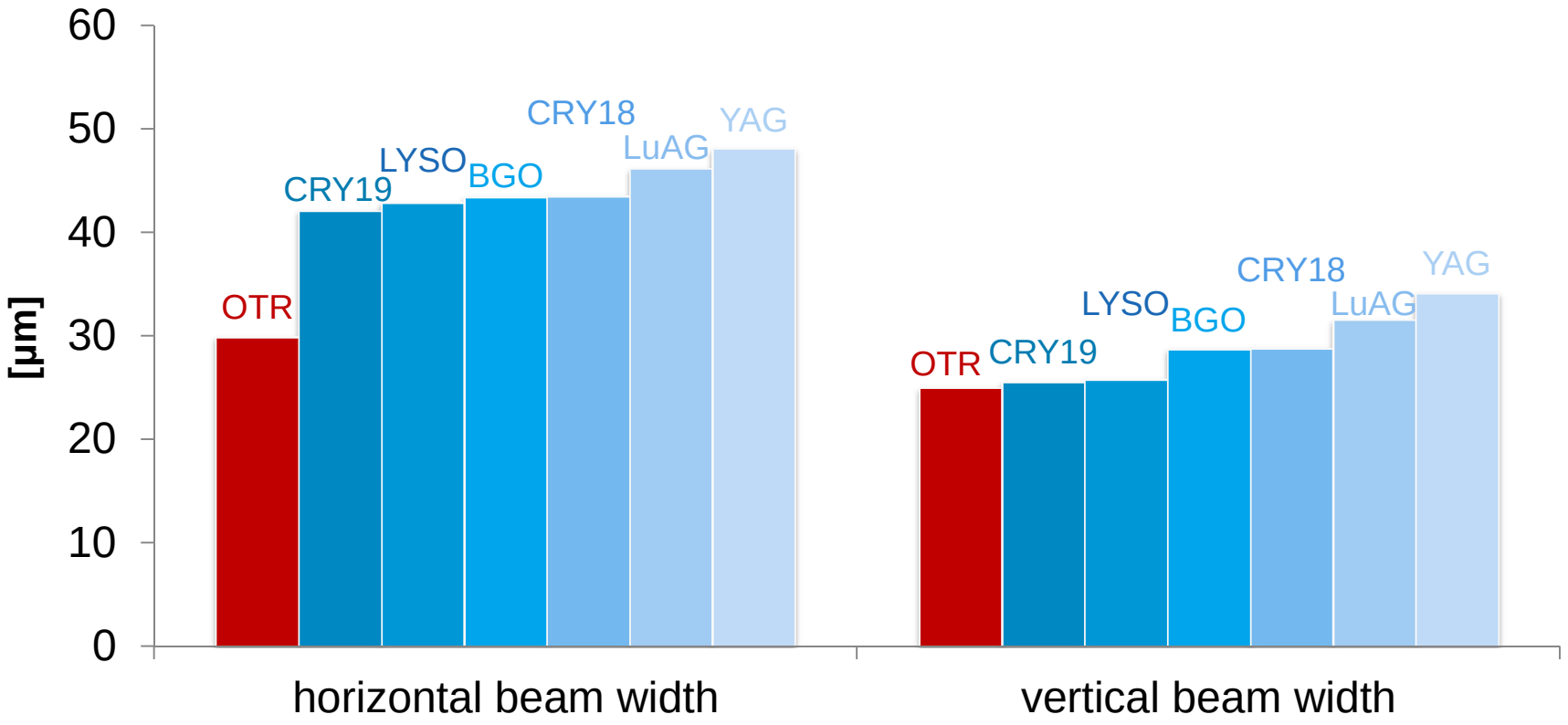
- Simulation with ZEMAX
- Preliminary results of the experiments performed at Mainzer Microtron (MAMI) in March
- Investigate the influence of 3 factors on the beam profile resolution:
  - Screen tilt
  - Scintillator material
  - Scintillation screen thickness



Influence of scintillation material



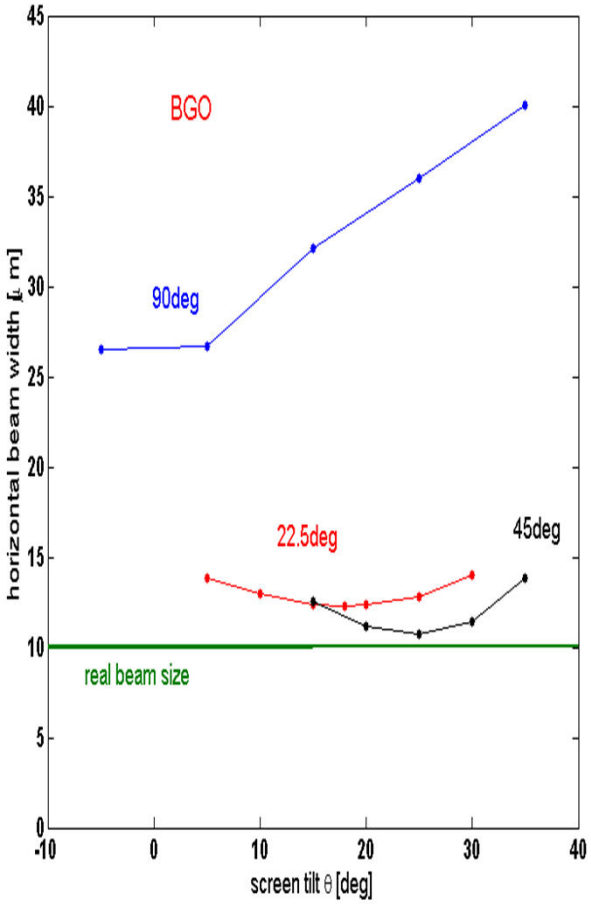
Resolution of different material



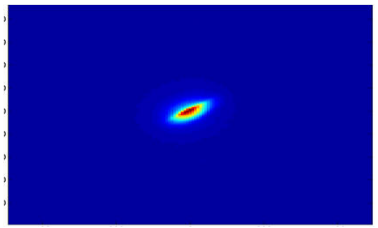
- CRY19(CRYTUR) offers the best resolution.

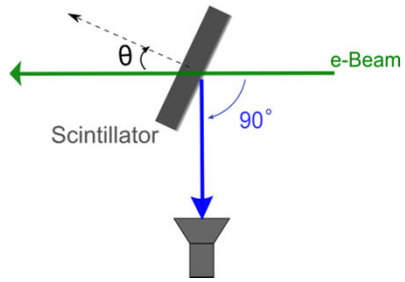
Influence of screen tilt

Influence of observation geometry

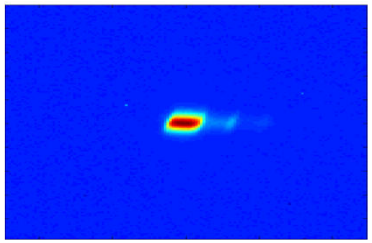


OTR screen

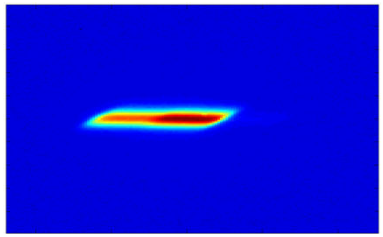




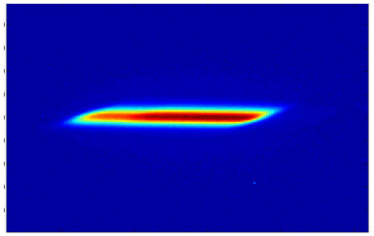
BGO screen, Θ=15°



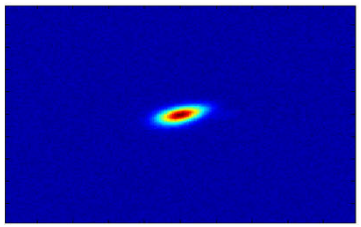
BGO screen, Θ =45°

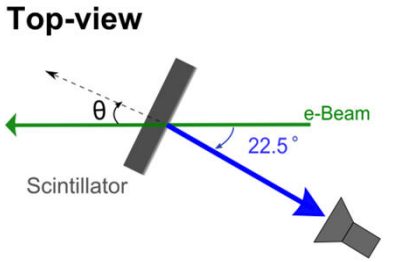


BGO screen, Θ =55°

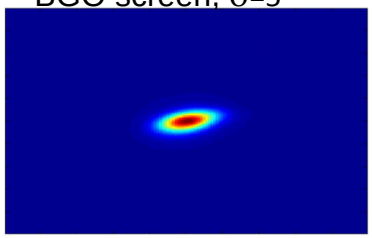


OTR screen

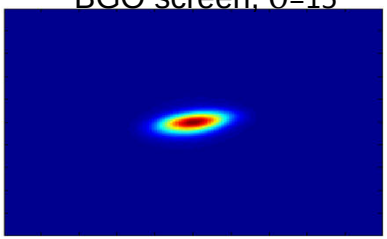




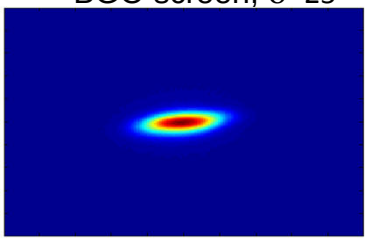
BGO screen, Θ=5°



BGO screen, Θ=15°

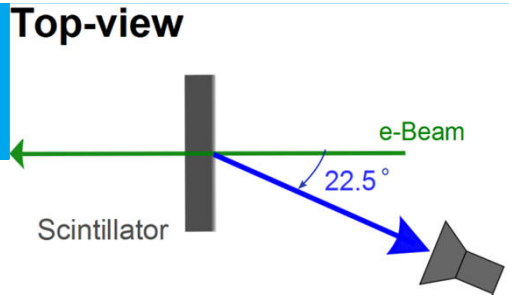


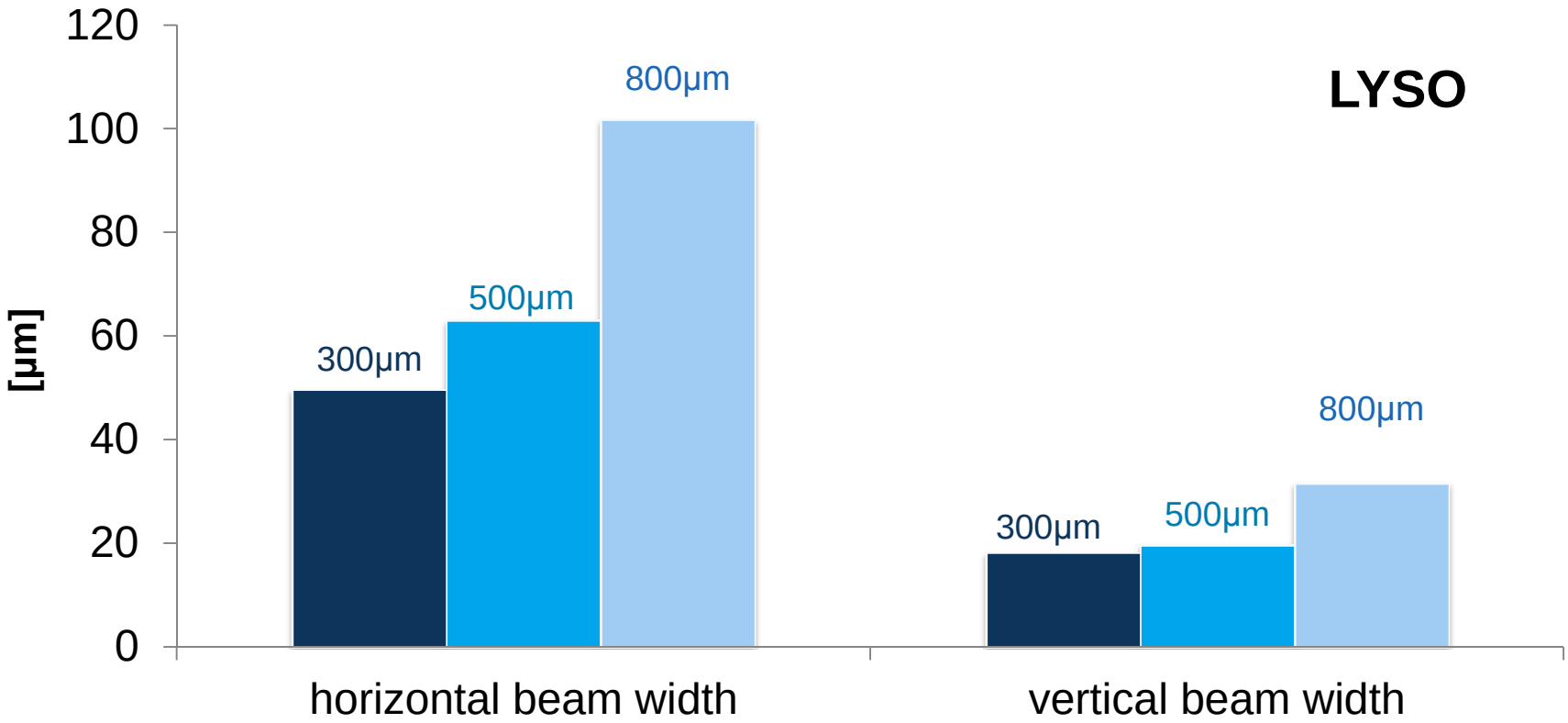
BGO screen, Θ=25°



- Observation geometry has considerable influence on resolution.

Influence of screen thickness





- Thicker scintillation screen shows worse resolution.

Summary and Outlook

- General behaviors in simulation are reproduced in the experiments:
  - Observation geometry has a considerable influence on the spatial resolution.
  - CRY19 is the best amongst all the tested materials, YAG the worst.
  - Thinner scintillation screen shows better resolution.
- Qualitative analysis of the experiment results will be done in the near future.
- Test experiments at FLASH,DESY in presence of coherence effect
- Continue search for optimum scintillator material
  - The same scintillator with different doping-material
  - The same scintillator with different doping-concentration
  - Powder scintillator
- This study will help design the imaging screen configuration for E-XFEL

Thank You