

Investigation on resolution influencing effects in beam profile measurements using scintillator.

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Karlsruhe, 28.Mar.-01.Apr.2011

> Motivation

- Why is scintillation screen an alternative choice for beam diagnostics of high brightness electron beams

> Simulation results

- Investigation on resolution influencing factors:
observation geometry, scintillator material, scintillator thickness

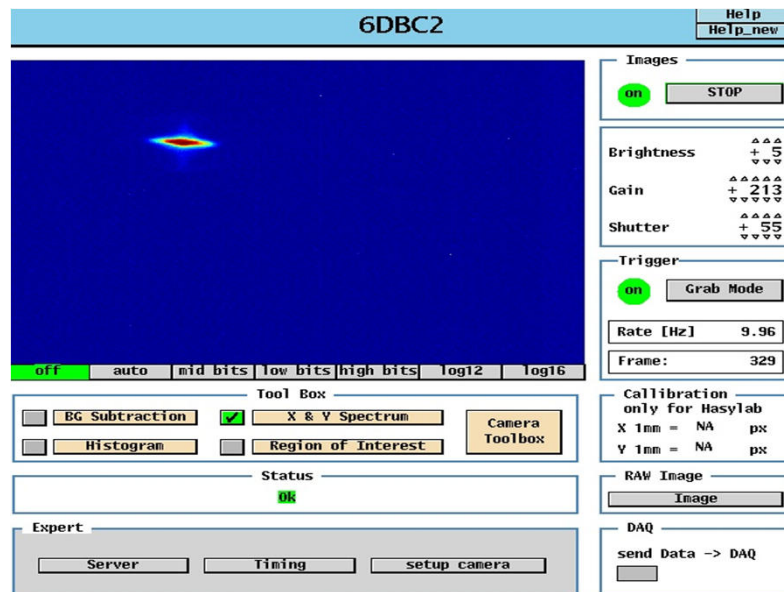
> Experimental results

- Preliminary results from the experiments at Mainzer Mikrotron(MAMI)

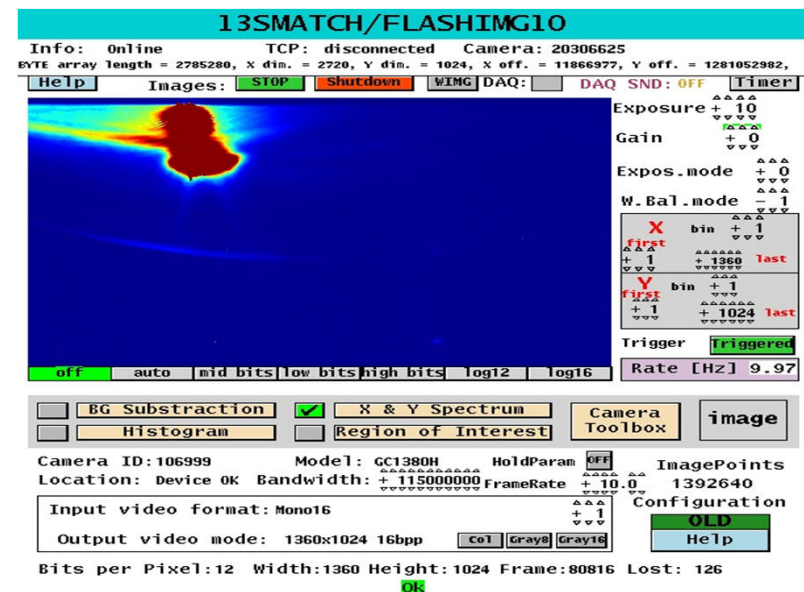
> Summary and Outlook

Motivation

- Optical Transition Radiation(OTR) screen as standard for e-beam diagnostics: emittance, transverse beam profile measurement etc.
- Problem: coherent TR in visible regime from high-brightness e-beam
- Coherent TR observed at FLASH, LSLC, which impedes beam diagnostics.



Incoherent TR*



coherent TR*

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



> 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

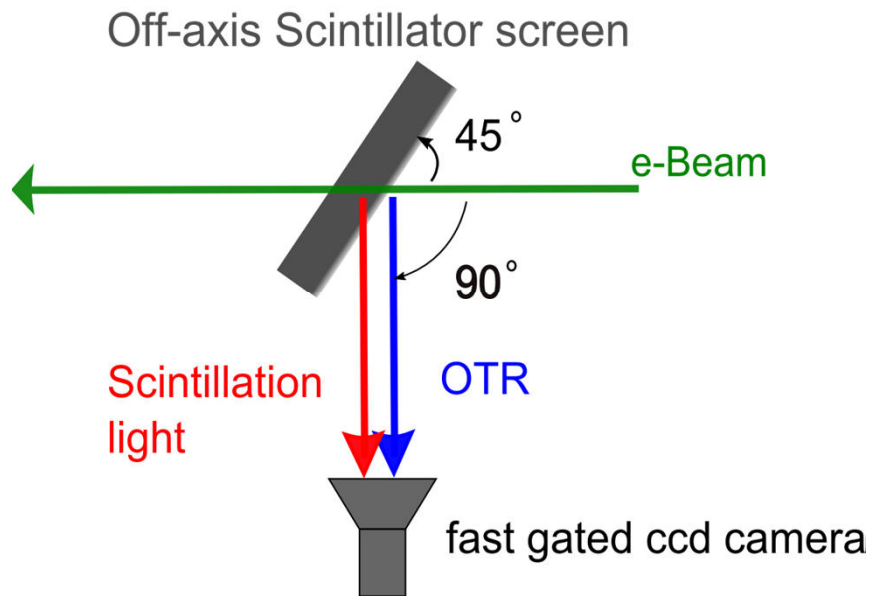
> 2 ways to circumvent the problem of coherent OTR:

- Suitable observation geometry to avoid OTR light on the detector (spatial separation)
- Scintillation screen + fast gated camera (time separation)

Motivation

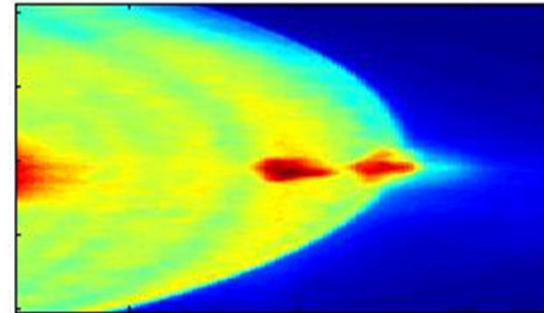
- > Scintillation screen + fast gated camera: first experiments successfully performed at FLASH, DESY as a proof-of-principle.
- > Resolution of scintillation screens needs to be studied.

Top-view

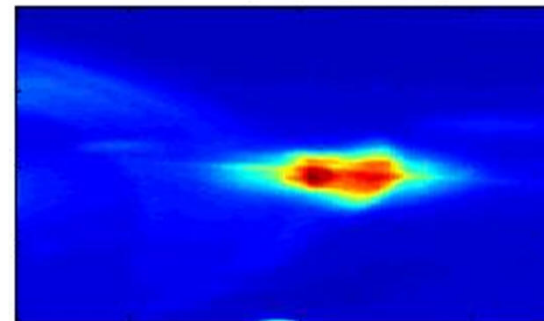


FLASH(13SMATCH section)

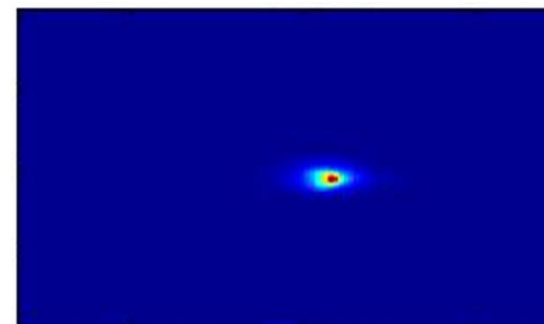
Camera image: FLASH, 13SMATCH section, 9.Jan.2011



Al coated Si OTR screen,
COTR light,
Coherent SR



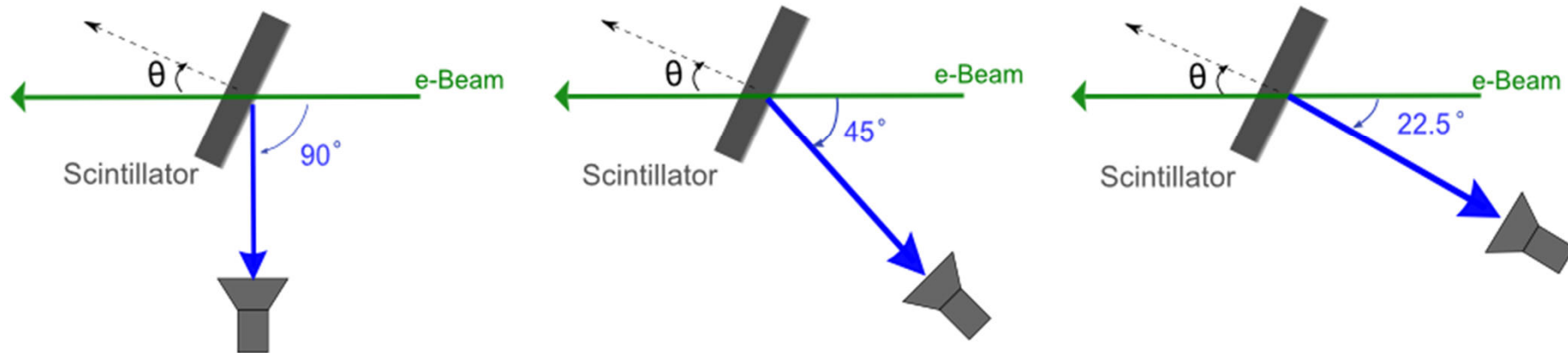
LuAG screen,
COTR & scintillation light



LuAG screen
+100ns delay
Only scintillation light

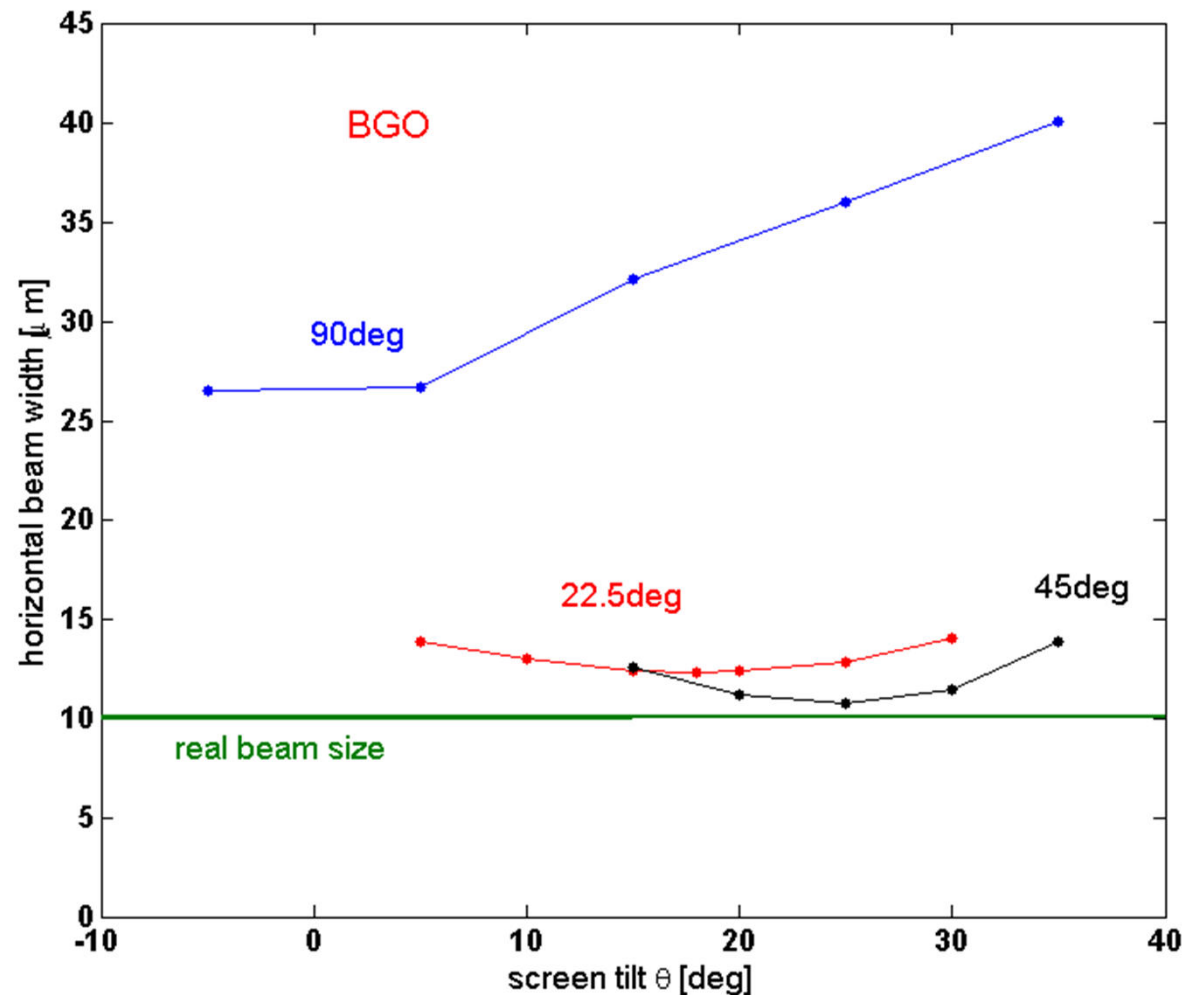
Resolution Simulation

Top-view



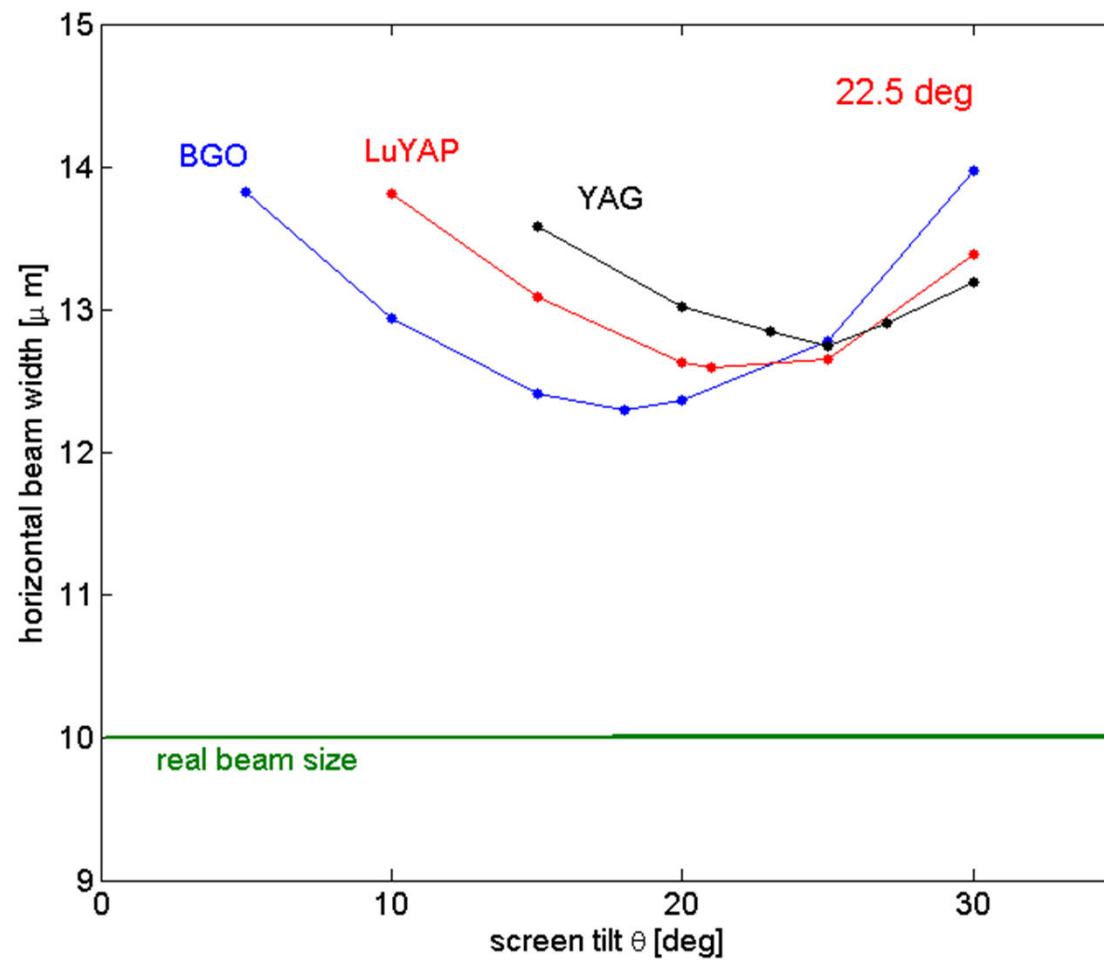
- ZEMAX Simulation for 3 observation geometries
- Investigate the influence of 3 factors on the beam profile resolution:
 - Screen tilt
 - Scintillator material
 - Scintillation screen thickness

Resolution Simulation. Influence of screen tilt



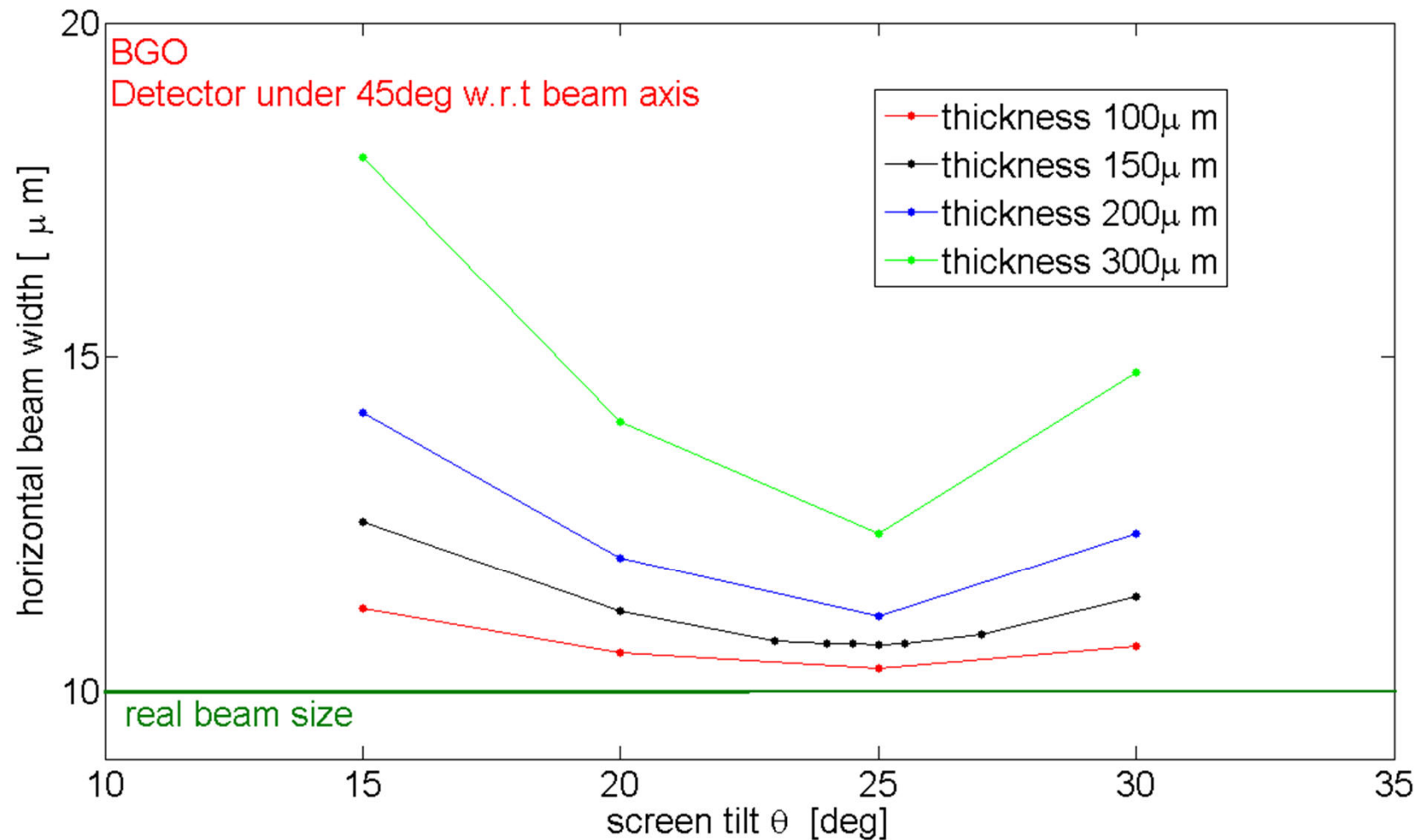
- There always exists an optimum screen tilt angle.
- Placing detector under 45° with respect to the beam axis seems to offer better resolution

Resolution Simulation. Influence of scintillator material



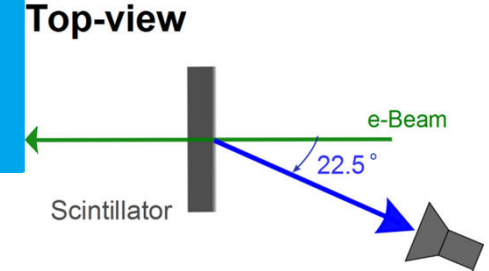
- The best resolution is achieved in BGO crystal

Resolution Simulation. Influence of scintillation screen thickness

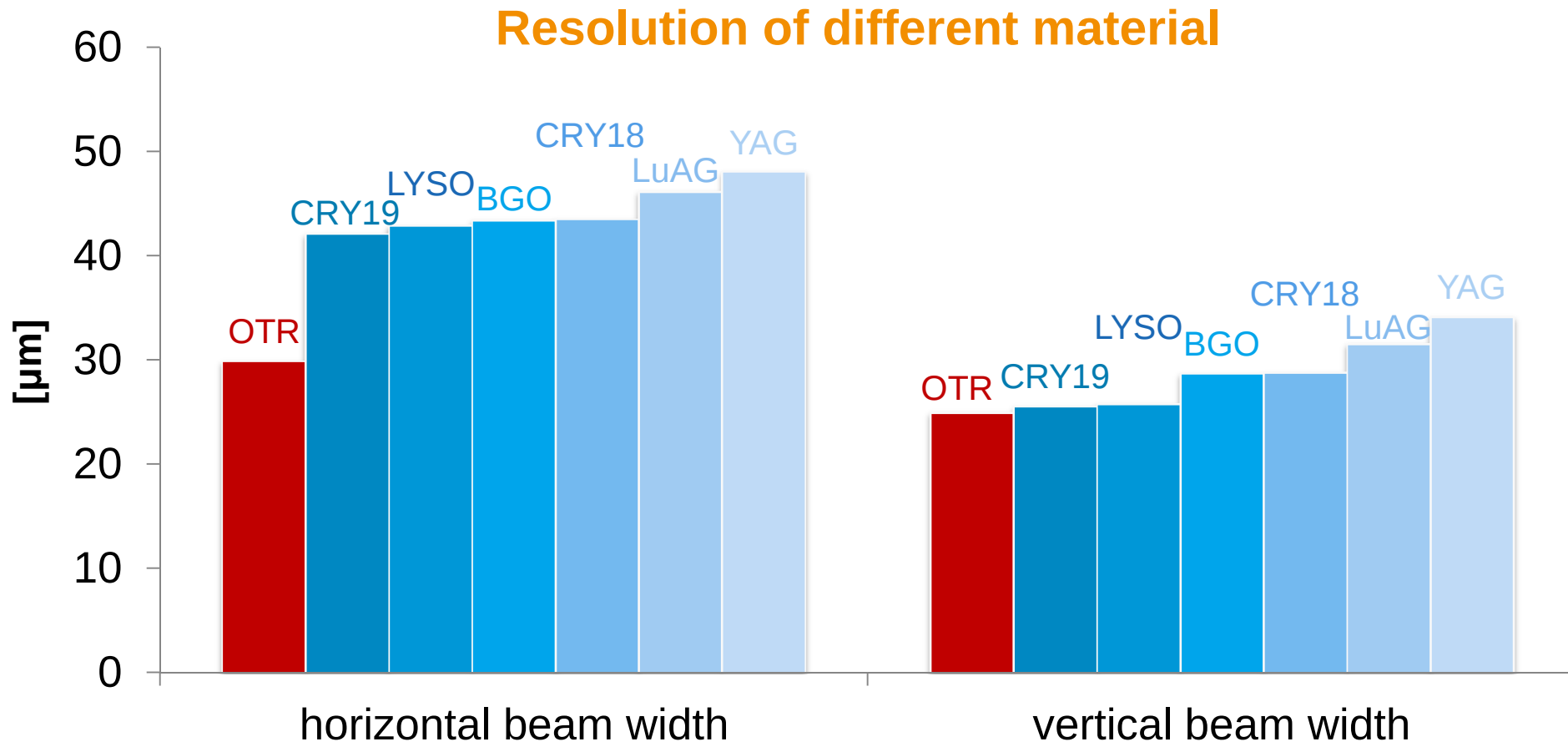


- Thicker scintillation screen shows worse resolution
- The optimum screen tilt angle is not affected by the thickness of the scintillation screen

Experimental results



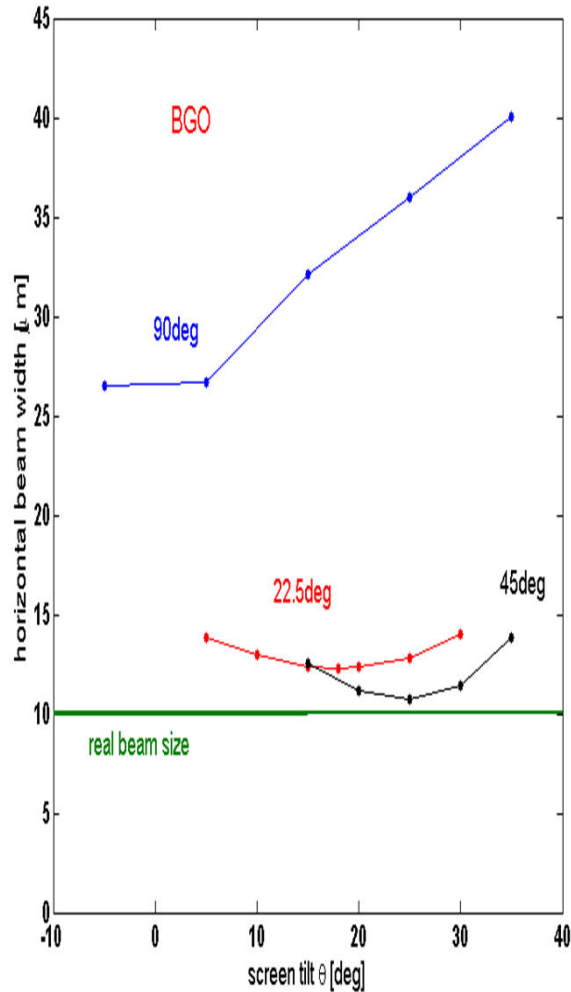
- Experiments at Mainzer Mikrotron (MAMI)



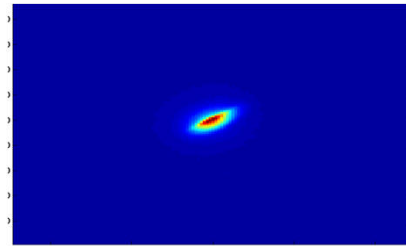
- CRY19(CRYTUR) offer the best resolution.

Experimental results

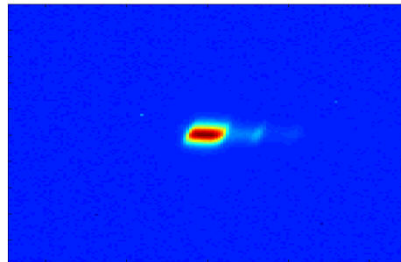
Influence of observation geometry



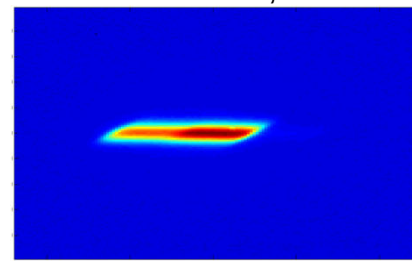
OTR screen



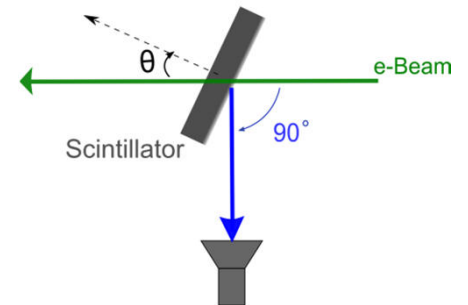
BGO screen, $\theta=15^\circ$



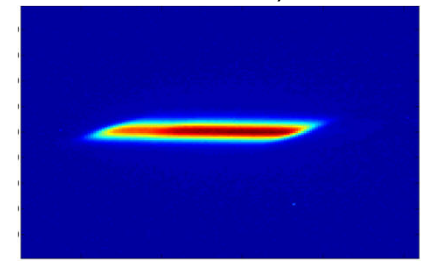
BGO screen, $\theta=45^\circ$



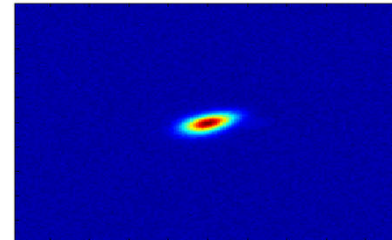
Top-view



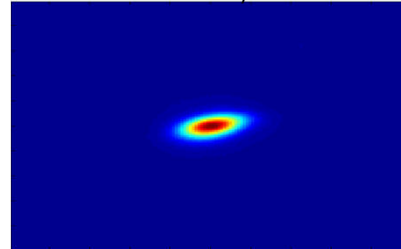
BGO screen, $\theta=55^\circ$



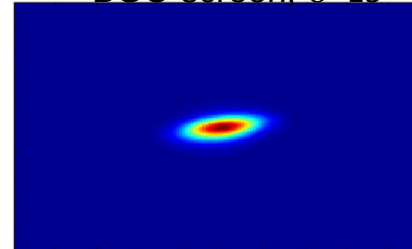
OTR screen



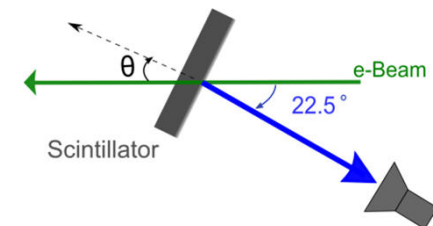
BGO screen, $\theta=5^\circ$



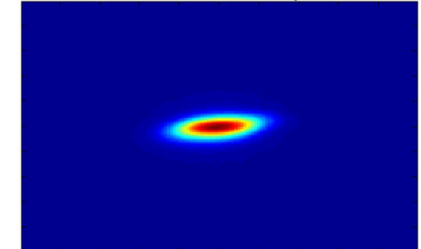
BGO screen, $\theta=15^\circ$



Top-view



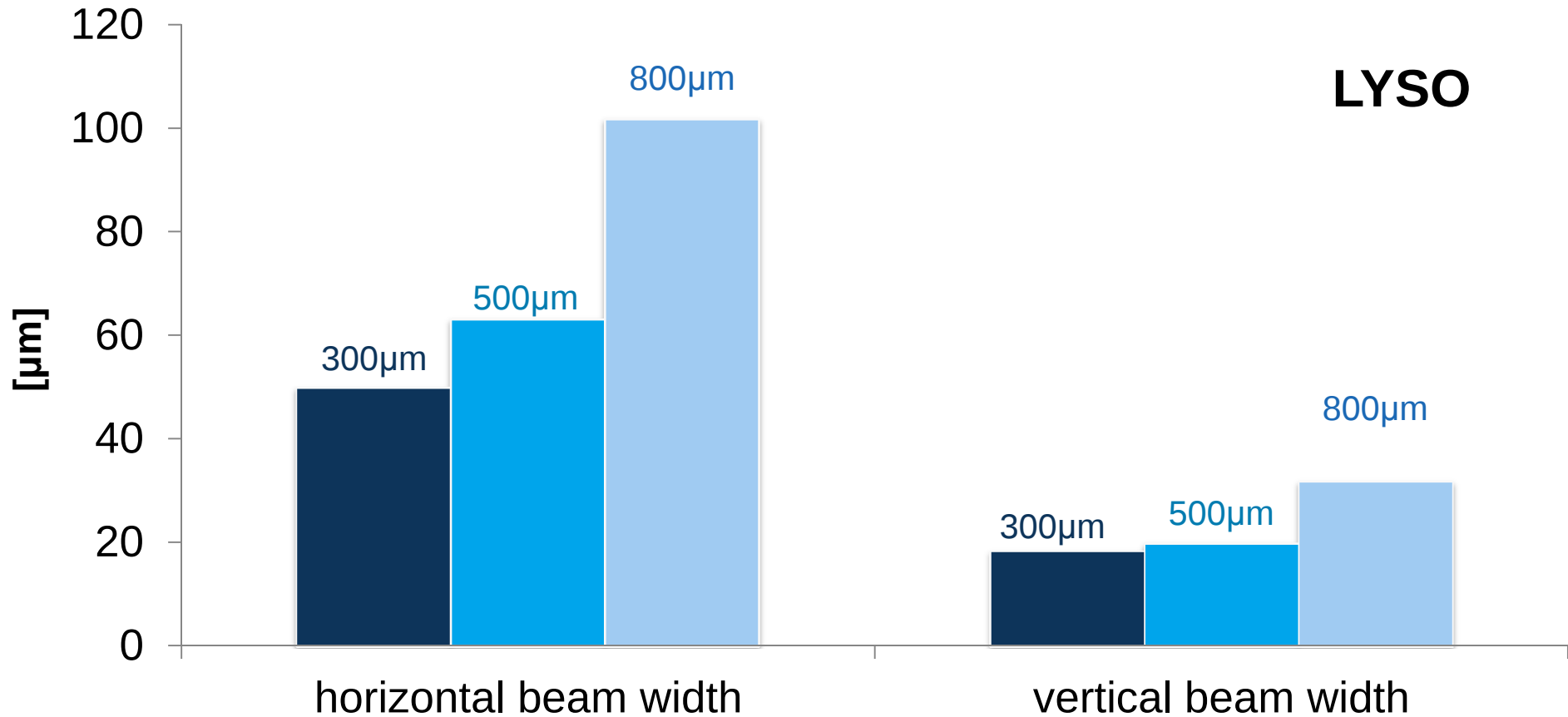
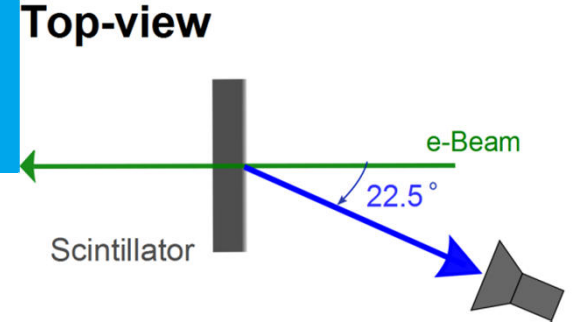
BGO screen, $\theta=25^\circ$



- Observation geometry has considerable influence on resolution.

Experimental results

Influence of scintillator 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



Thank You



Motivation

- Suitable observation geometry to avoid OTR light on the detector

