Influence of observation geometry on resolution for beam profile measurements using scintillation screens.

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Outline

- Motivation

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

- Simulation results

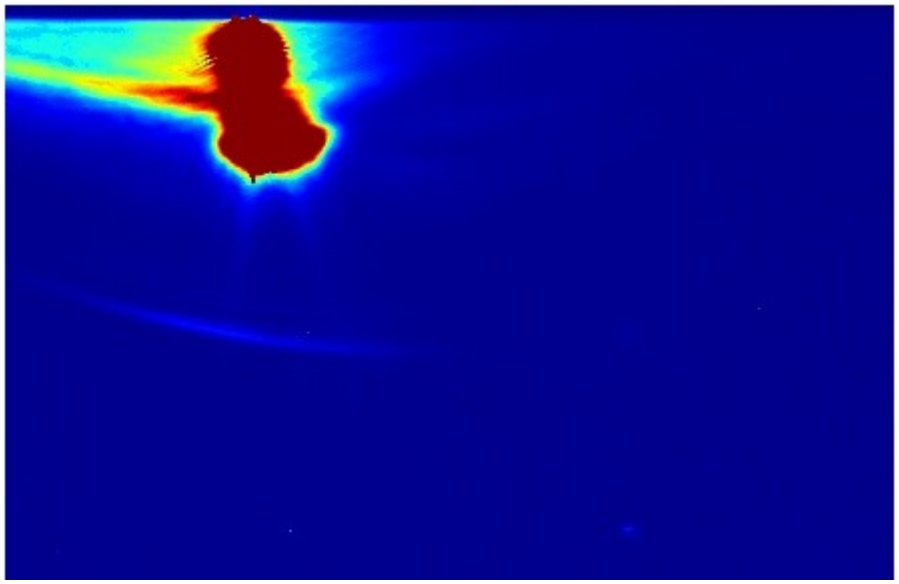
  Investigation on resolution influencing factors

- Future plans

Motivation

> Problems of OTR screens

- Optical transition radiation (OTR) diagnostics might fail because of coherence effects



Original camera image: observation of coherence effect at FLASH, DESY. No beam profile diagnostics are possible from this image.

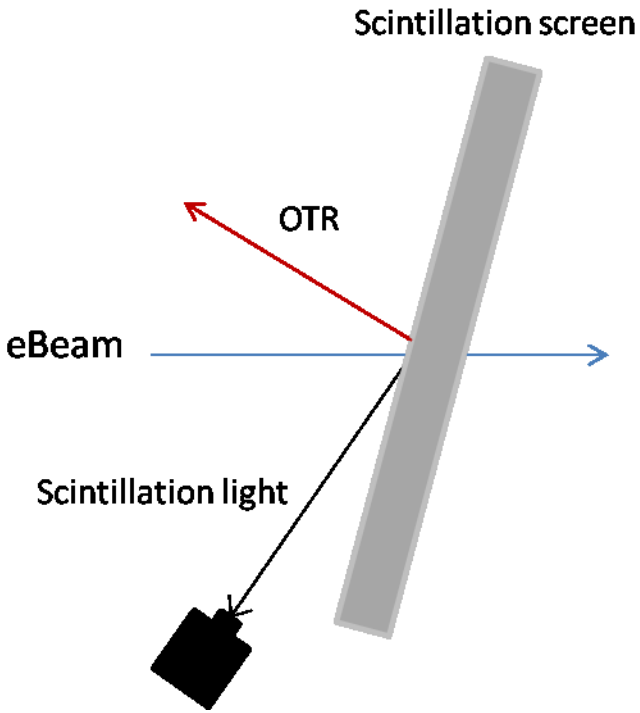
Motivation

- Idea
  - Scintillation process is not sensitive on micro-structures in the particle bunch, causing coherent radiation
  - Scintillation light is emitted isotropically
  - Scintillating process is a multi-stage process(delayed emission), while OTR emission is an instantaneous process.
- Problem

  OTR generation at boundary scintillator/vacuum
- 2 ways to circumvent the problem of coherence effect:
  - Suitable observation geometry to avoid OTR light on the detector (spatial separation)
  - Scintillation screen + gated camera (time separation)

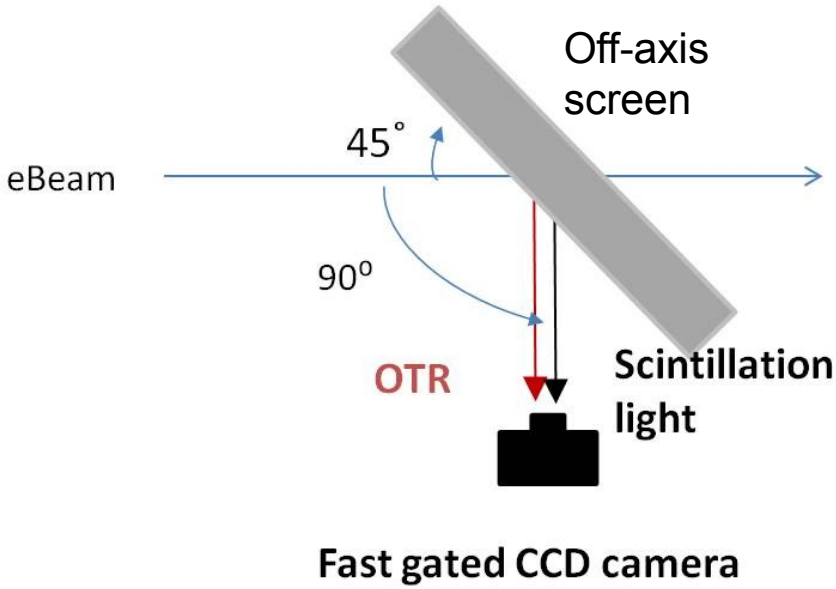
Motivation

- Suitable observation geometry to avoid OTR light on the detector

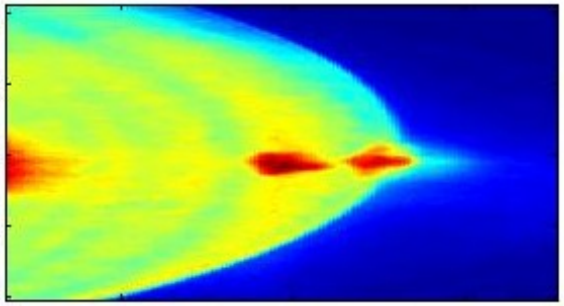


Motivation

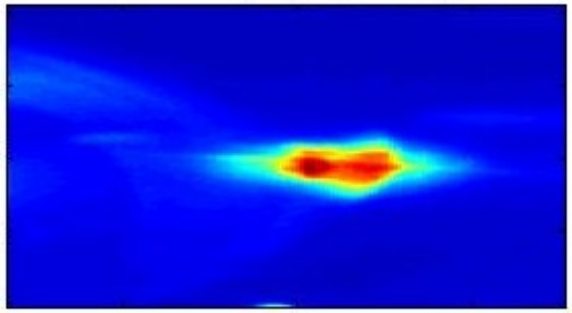
- Scintillation screen + gated camera



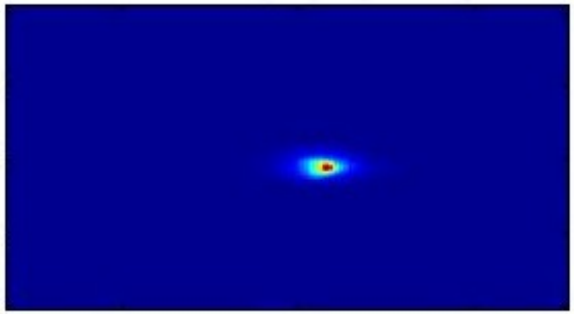
Camera image: FLASH, 13SMATCH section, 9.Jan.2011



Al coated Si OTR screen,
COTR light,
Coherent SR



LuAG screen,
COTR & scintillation light

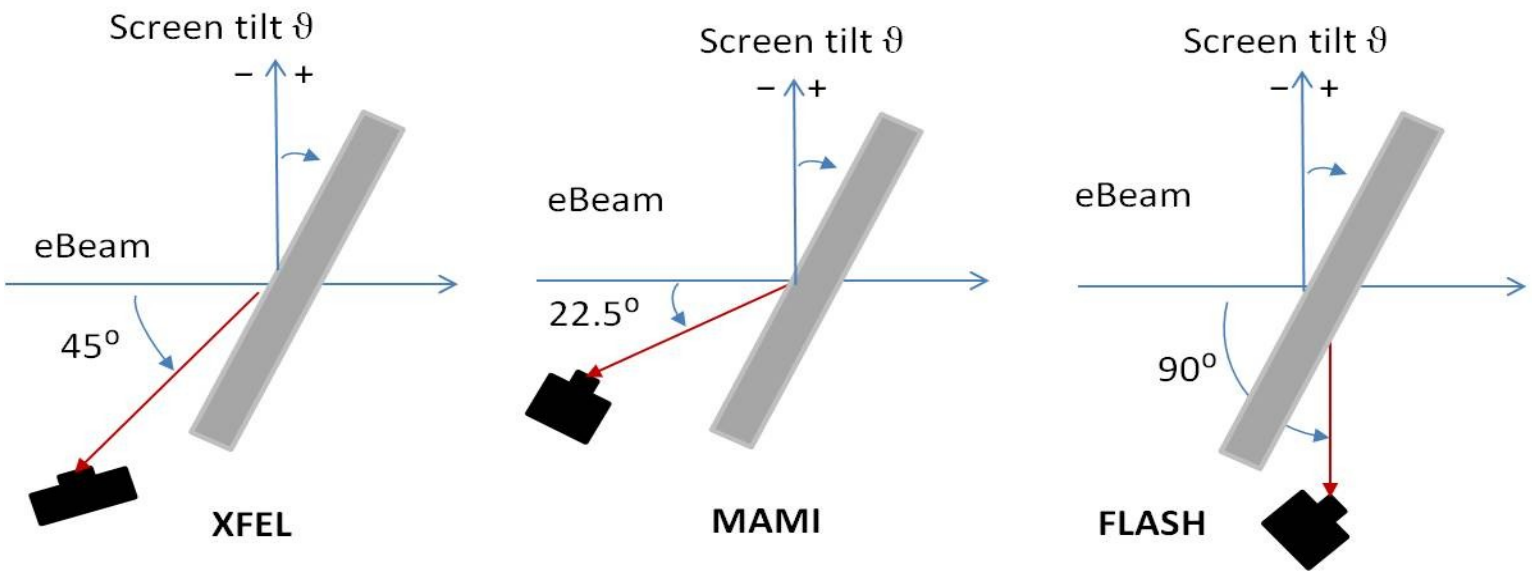


LuAG screen
+100ns delay
Only scintillation light

Applicability of scintillation screen in beam profile diagnostics for high-brightness electron beams should be studied.

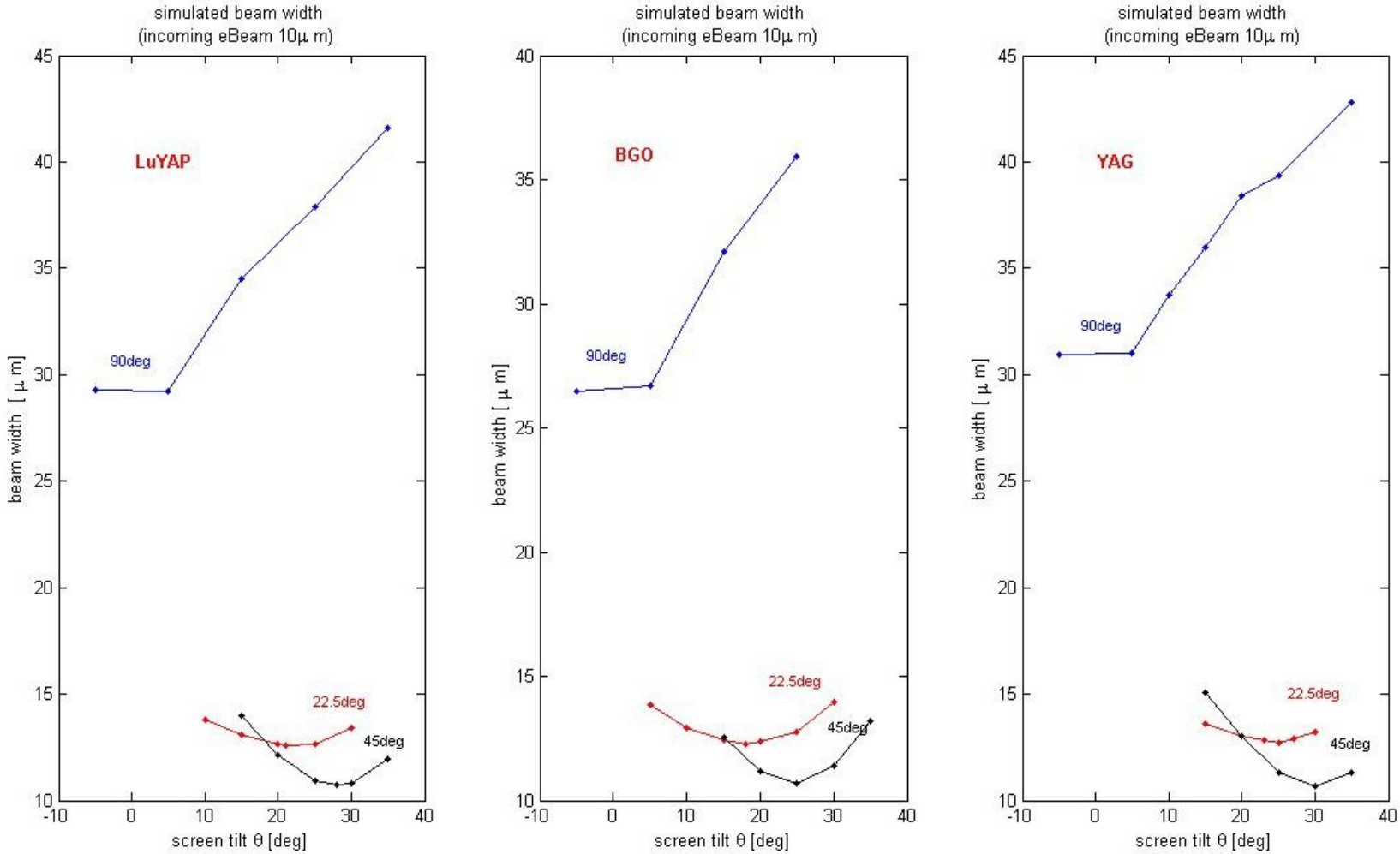
⟶ Simulation with ZEMAX to investigate the spatial resolution of scintillation screen

Simulation



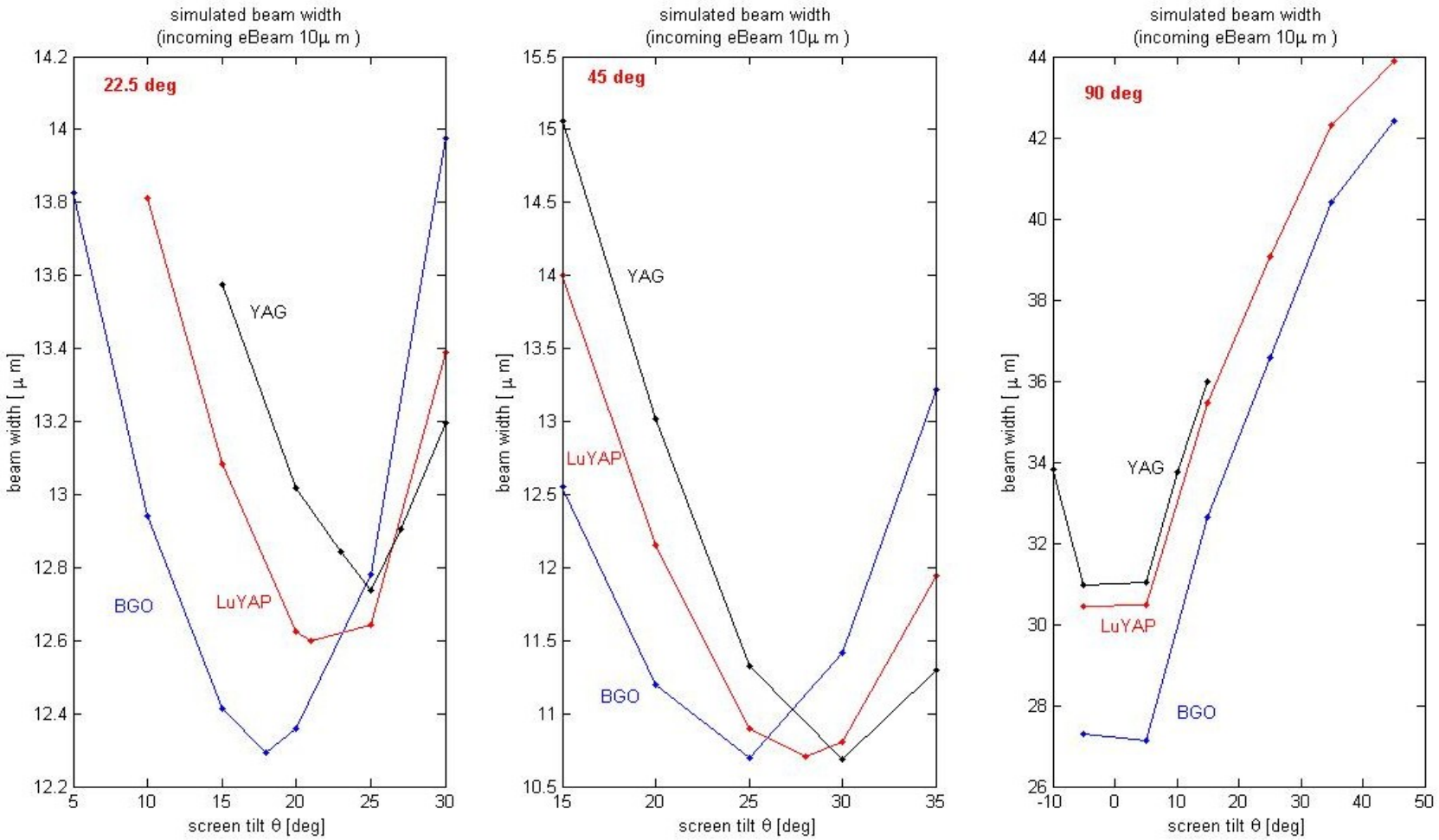
- ZEMAX Simulation for 3 observation geometries in consideration of *Scheimpflug principle*
- Investigate the influence of 4 factors on the beam profile resolution:
  - Screen tilt
  - Scintillator material
  - Scintillator screen thickness
  - Focal plane

Simulation Results. Influence of screen tilt



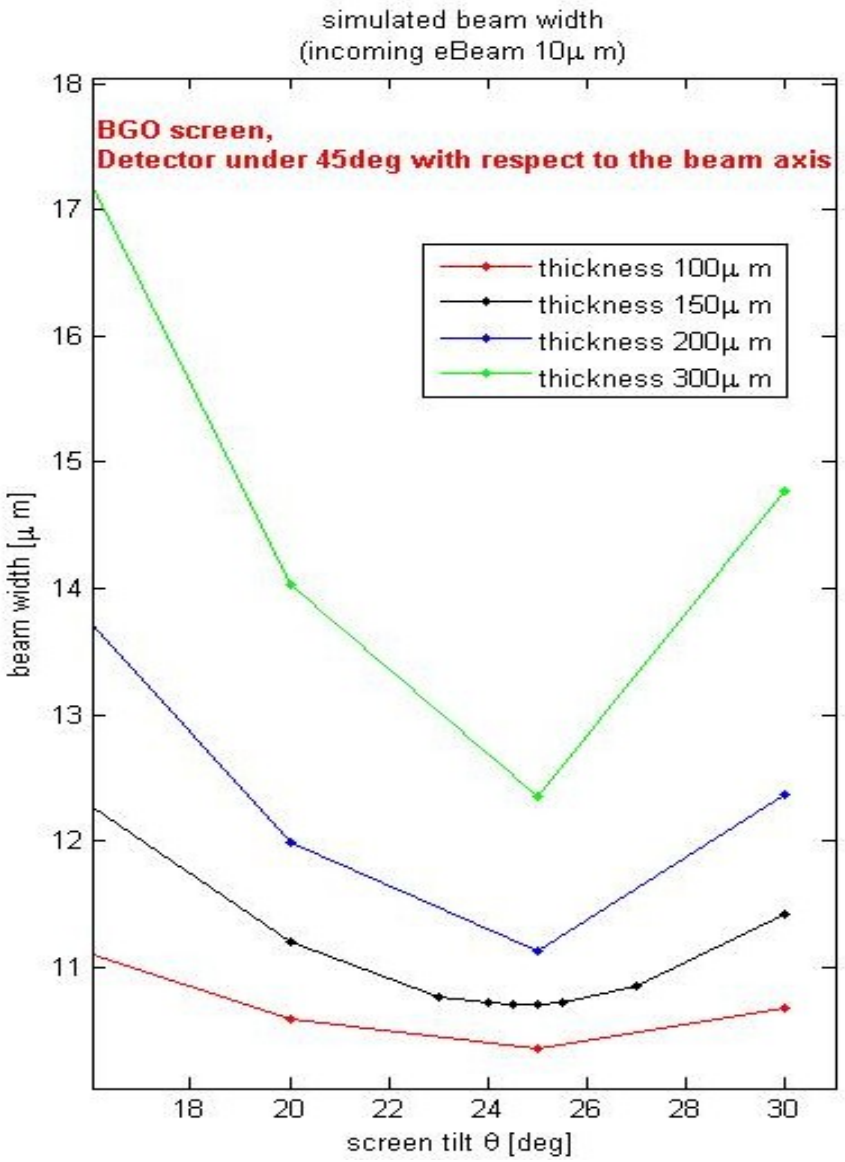
- There always exists an optimum screen tilt angle.
- Placing detector under 45˚ with respect to the beam axis seems to offer better resolution

Simulation Results. Influence of scintillator matierial



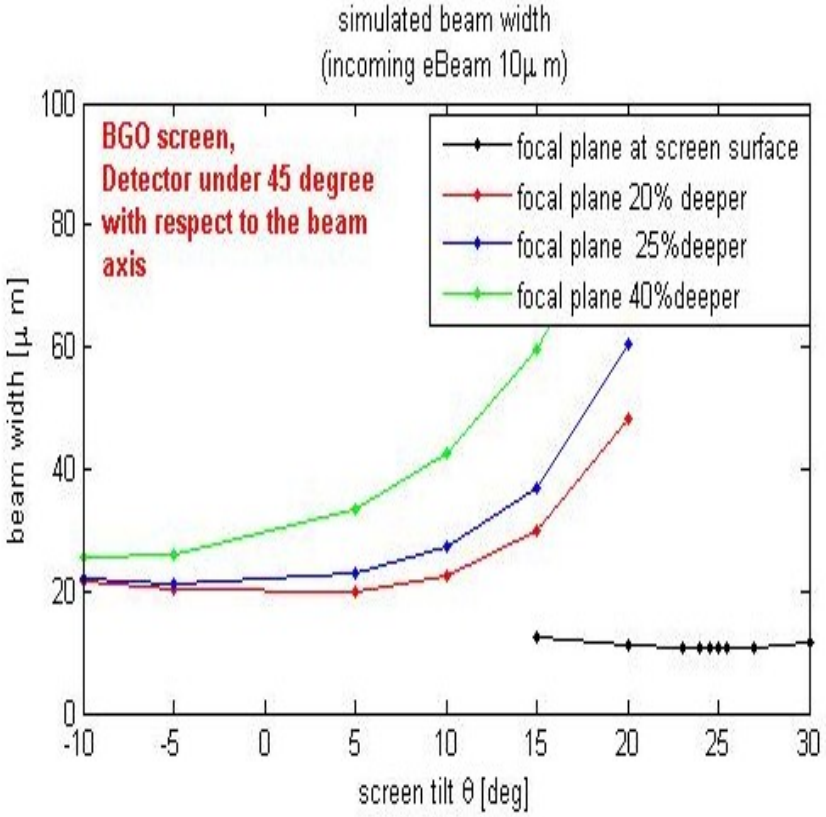
- The best resolution is achieved in BGO crystal with the biggest refractive index among the 3 materials.
- larger refractive index seems to have better resolution (but weak influence)

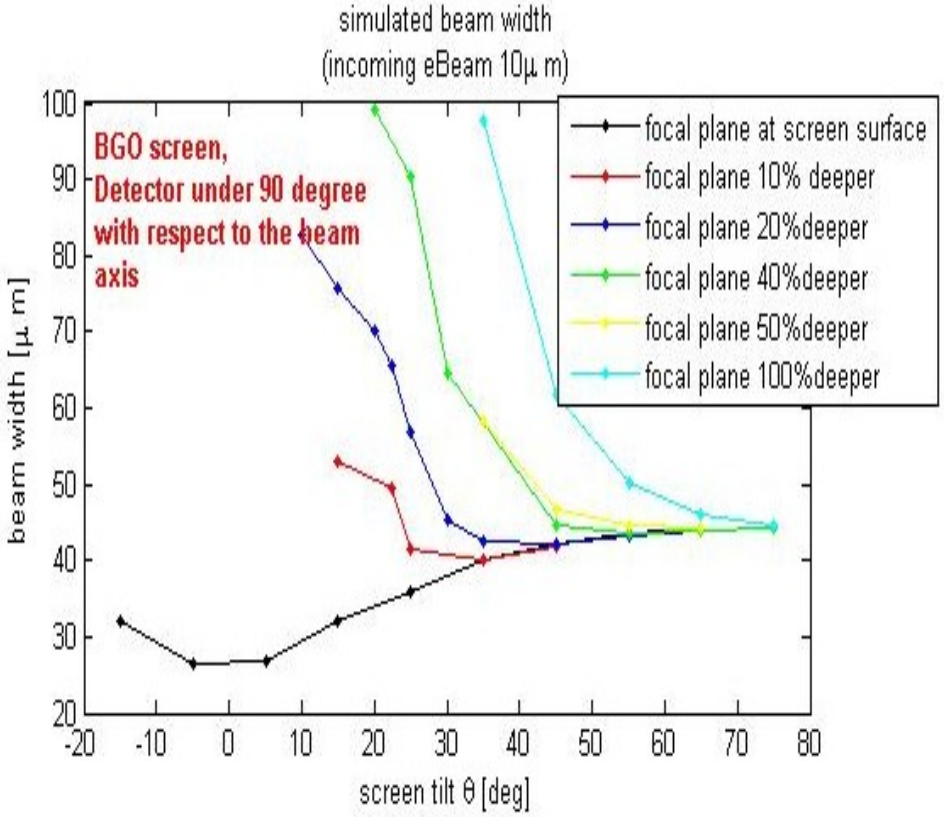
Simulation results. Influence of scintillation screen thickness



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

Simulation Results. Influence of focal plane





- The optimum screen tilt angle could be shifted by focusing deeper in the scintillation screen.
- Resolution is sensitive to the focal plane.
- Simulation with real optical lens-system is in process.

Simulation Results

Conclusion

- Observation geometry has a considerable influence on the spatial resolution.
- refractive index only shows weak influences on the resolution.
- Thinner scintillation screen shows better resolution.
- Resolution is sensitive to the focal plane.

- The method of using scintillator screen in combination with a fast gated camera seems to avoid COTR influence.

Future Plans

- New beam time in March 2011Mainz: new experiments to be compared with the simulation results
- Test experiment at FLASH 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

Thank You