Status of the Electron Beam Transverse Diagnostics with Optical Diffraction Radiation at FLASH

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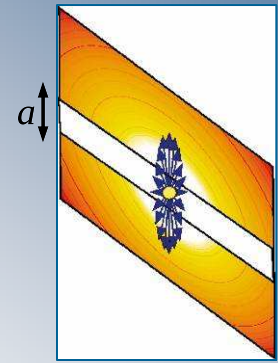
DESY FLASH Seminar
Hamburg, 05/06/2007

Work supported by the European Comunity Infra-structure Activity under the FP6 “Structuring the European Reaserch Area” program (CARE, contract number RII3-CT-2003-506395)

Diffraction Radiation Theory



- DR is produced by the interaction between the EM fields of the traveling charge and the conducting screen
- The radiation intensity is $I \propto e^{-\frac{2\pi a}{\gamma\lambda}}$
- DR impact parameter is $\frac{\gamma\lambda}{2\pi}$ ➔ if $a \begin{cases} >> \frac{\gamma\lambda}{2\pi} & \text{No radiation} \\ \cong \frac{\gamma\lambda}{2\pi} & \text{DR} \\ << \frac{\gamma\lambda}{2\pi} & \text{TR} \end{cases}$
- Excellent candidate to measure beam parameters **parasitically**

Diffraction Radiation Diagnostics

- Low γ, λ of the order of *mm* ➔ Coherent Diffraction Radiation

  ➔ Longitudinal diagnostics*

*** M. Castellano et al.**, Phys. Rev. E 63 (2001)
*** E. Chiadroni**, "*Bunch Length Characterization at the TTF VUV-FEL*", PhD Thesis, Univ. of Rome "Tor Vergata"

- Large γ of the order of 10^3 ➔ Optical Diffraction Radiation

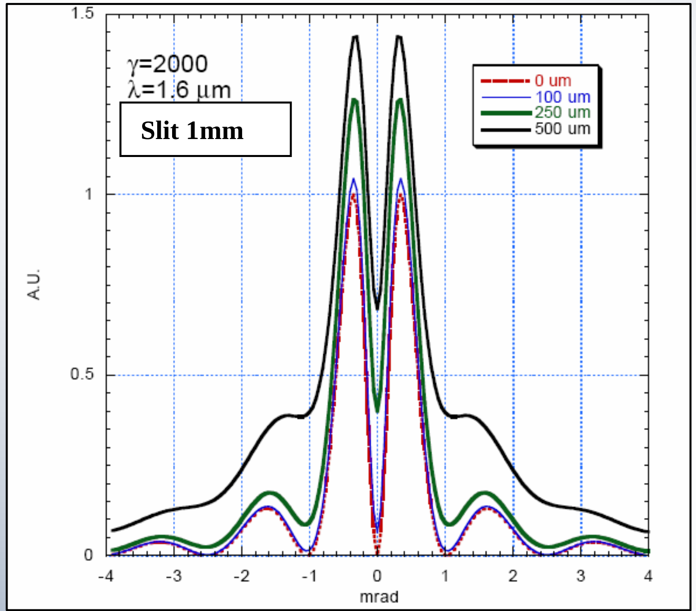
  ➔ Transverse diagnostics**

  - Position
  - Angular divergence
  - Transverse dimensions
  - Emittance

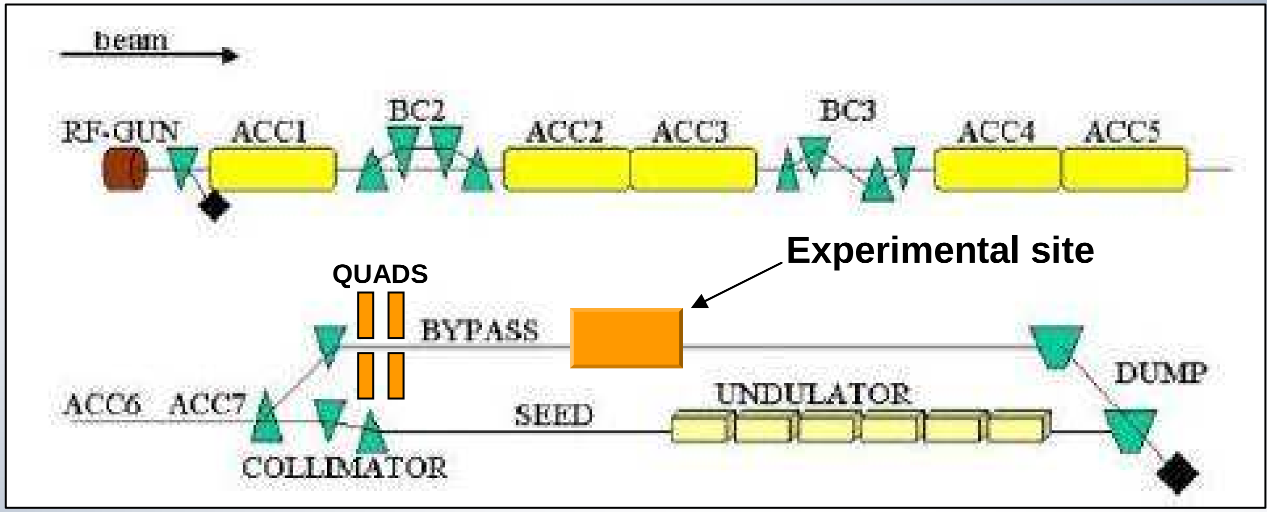
**** M. Castellano**, "*A New Non Intercepting Beam size Diagnostics Using Diffraction Radiation from a Slit*", Nucl. Instr. And Meth. in Phys. Res. A394, 275, (1997)
**** P. Karataev et al.**, "*Beam-Size Measurement with Optical Diffraction Radiation at KEK Accelerator Test Facility*", Phys. Rev. Lett. 93, 244802 (2004)

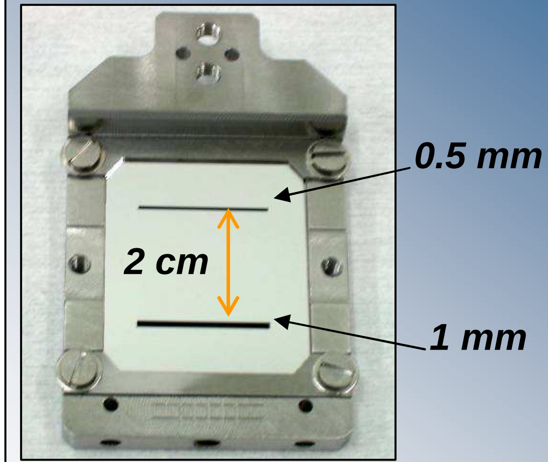
Beam Transverse Diagnostics with ODR

ODR angular distribution gives information on the transverse beam size: increasing σ_y both the peak intensity and the central minimum increase



The Experiment

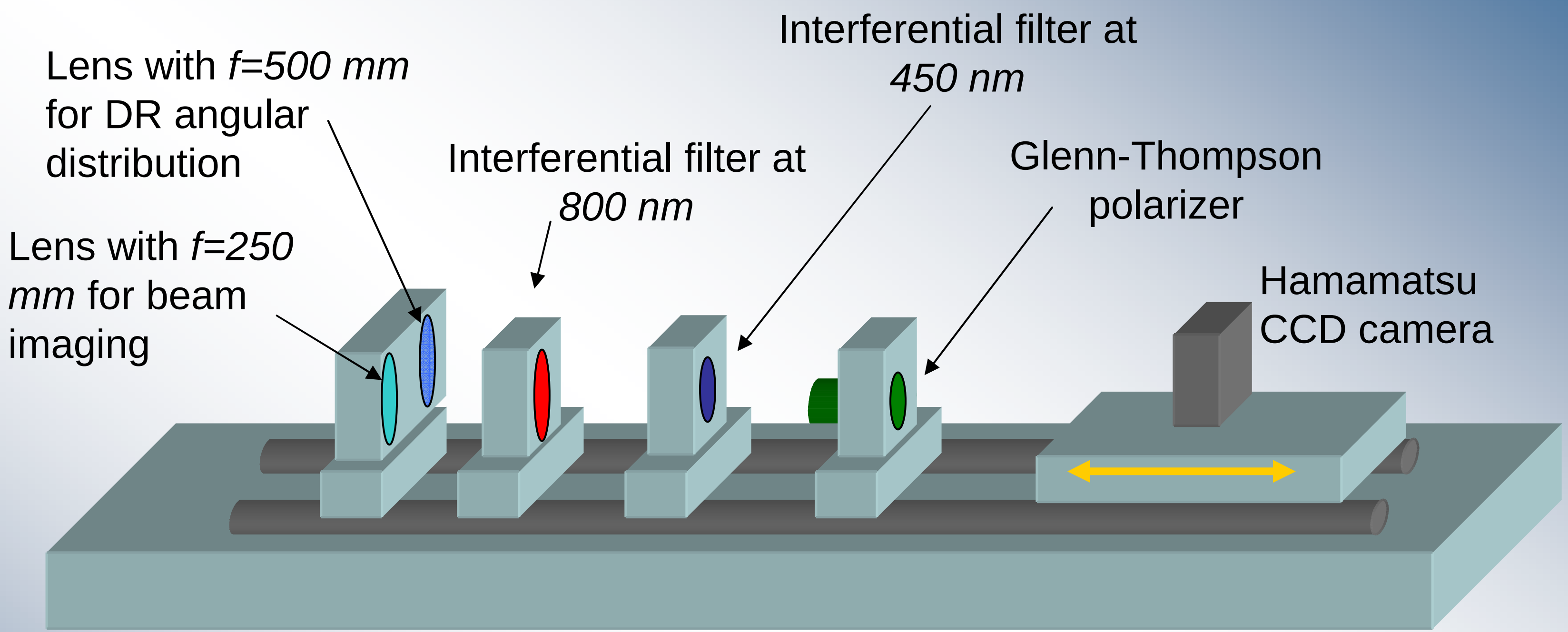




FLASH is a good test facility for several reasons:

- High energy, up to *1 GeV*
- Up to 30 bunches per macropulse
- Repetition rate 5 Hz

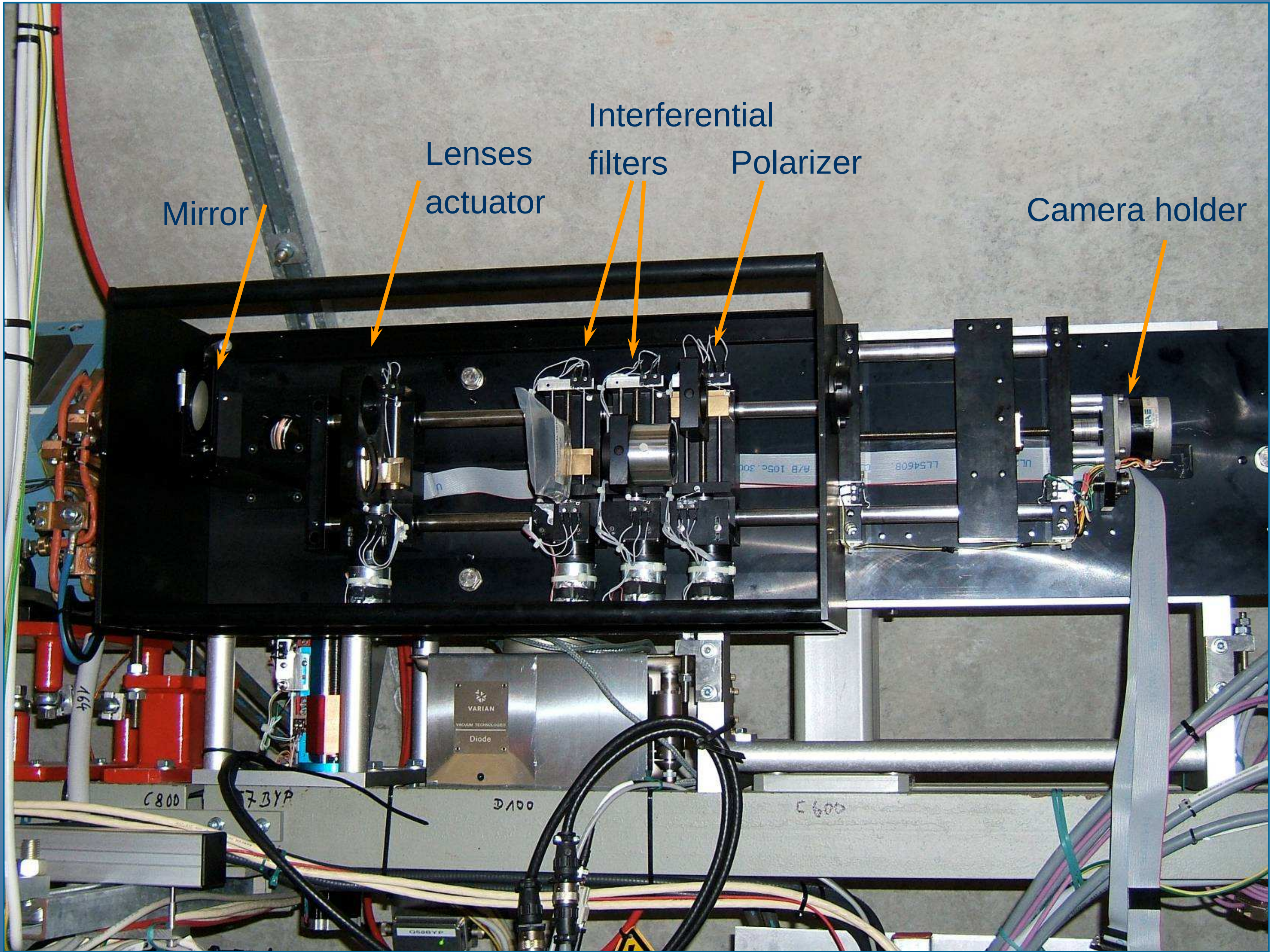
Optical System



High Sensitivity Hamamatsu Camera

- High quantum efficiency
- Air Cooling -55°C
- Long exposure time up to 2 hours

Experimental Setup



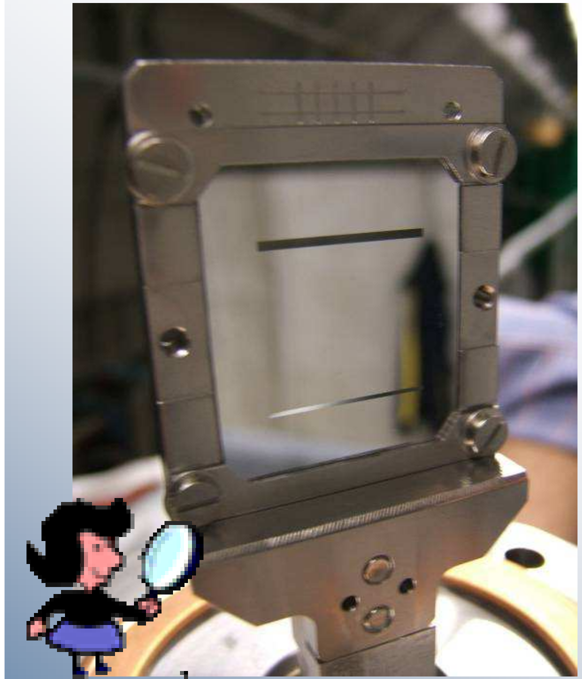
Acquisition System

- The optical system is controlled by electronic box placed in the tunnel

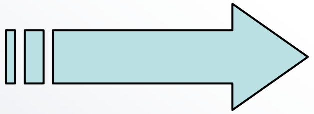
- This is a quasi-standard FLASH electronic box, using can-bus modules, partially integrated in linac control system

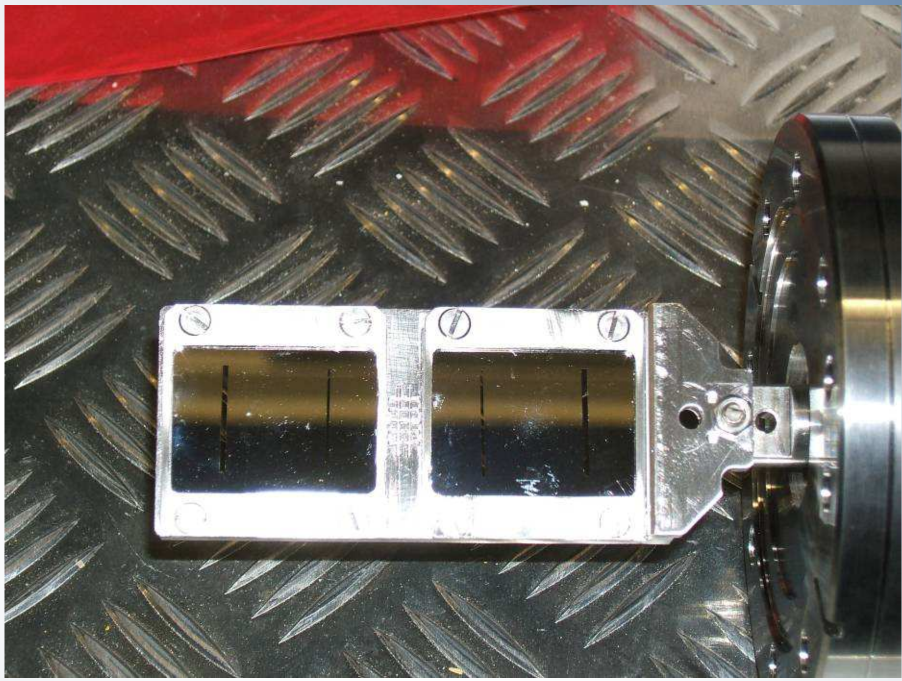
- The more accurate stepper motors for the target and the camera position, as well as the camera, are controlled via Firewire by industrial PC

October 2006
Improvements in the Setup: OTR57BYP



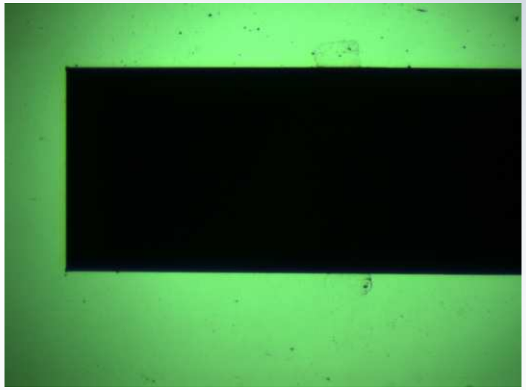
Old screen and holder

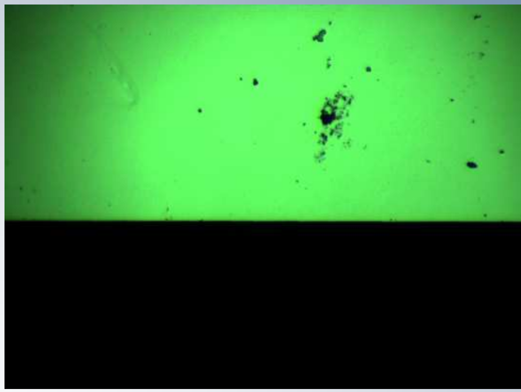


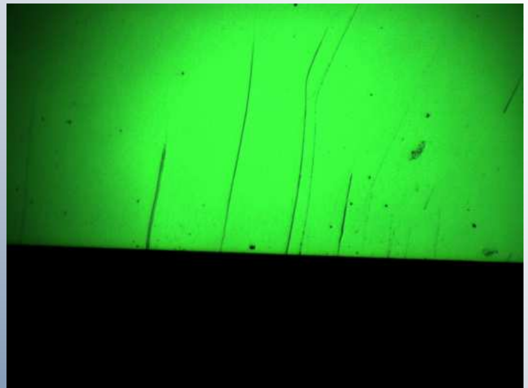


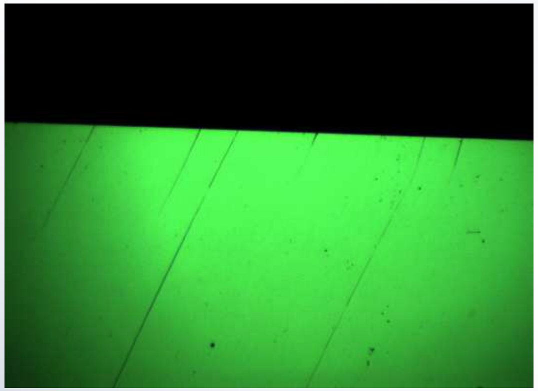
New holder housing two screens in order to have a target for tests

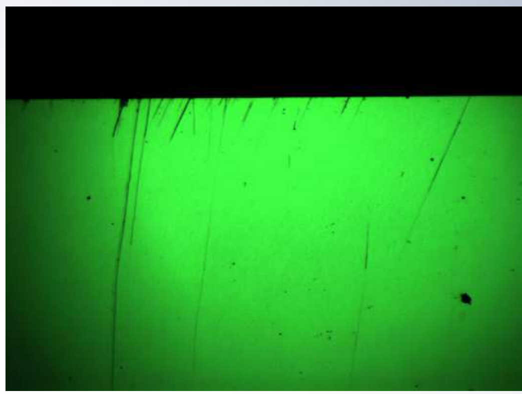
0.5 mm slit







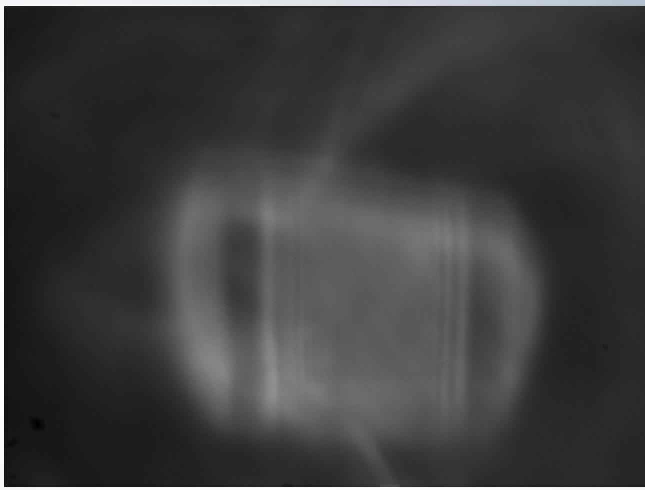


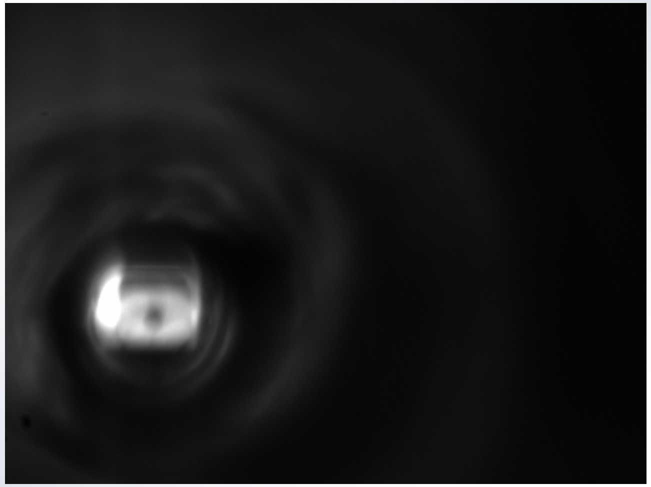


1 mm slit

October 2006
Improvements in the Setup: OTR35BYP

A screen with a hole has been installed at the OTR35BYP to be used both as alignment tool and as background stopper during measurements





January 2007
ODR Measurements

ENERGY: ≈*680 MeV*

- January 12^{th}, 2007
  - Alignment without beam
  - First OTR measurements
- January 14^{th}, 2007
  - Beam optimization up and through the bypass
  - Few measurements with 1 mm slit in
- January 15^{th}, 2007
  - First measurements with *0.5 mm* slit in
  - Several scans within the whole slit in order to see the transition between ODR and OTR
  - Few measurements with a smaller beam

Critical Issues

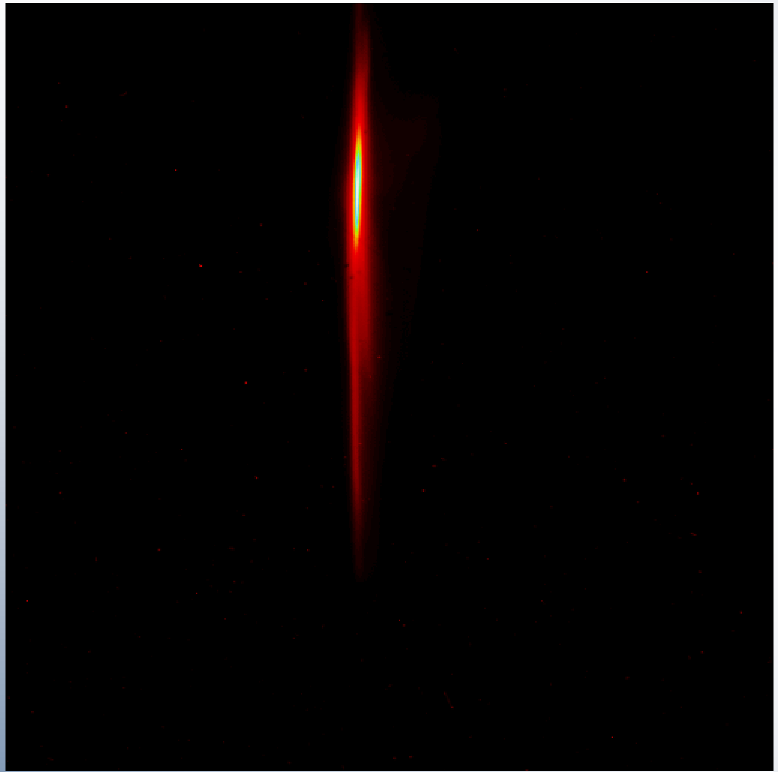
- Not optimized optics in the by-pass
  ➔ Optimization of the beam transport:
  Low charge, High # of bunches

- Synchrotron radiation background coming from the dipole and quads and multiple reflections in the vacuum pipe

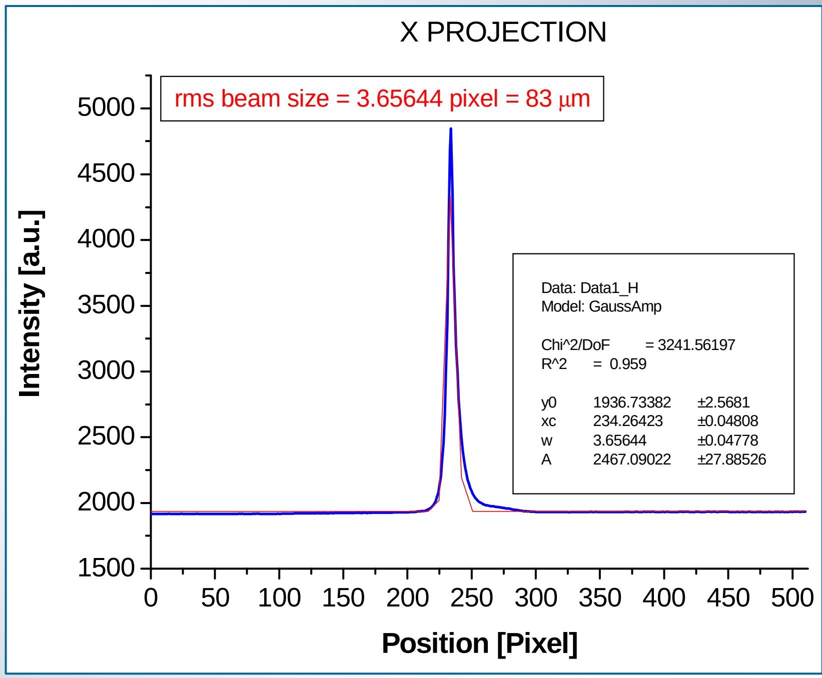
- Strange behavior of this background

- The background must then be subtracted playing with the steerers
  ➔ Severe X-rays background which does not allow to integrate over a long time

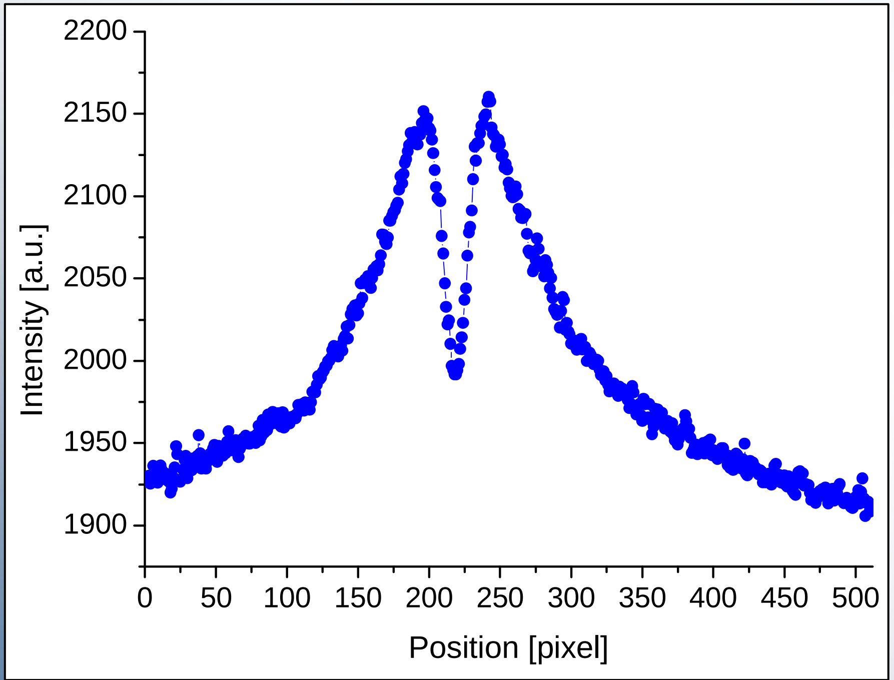
The Beam

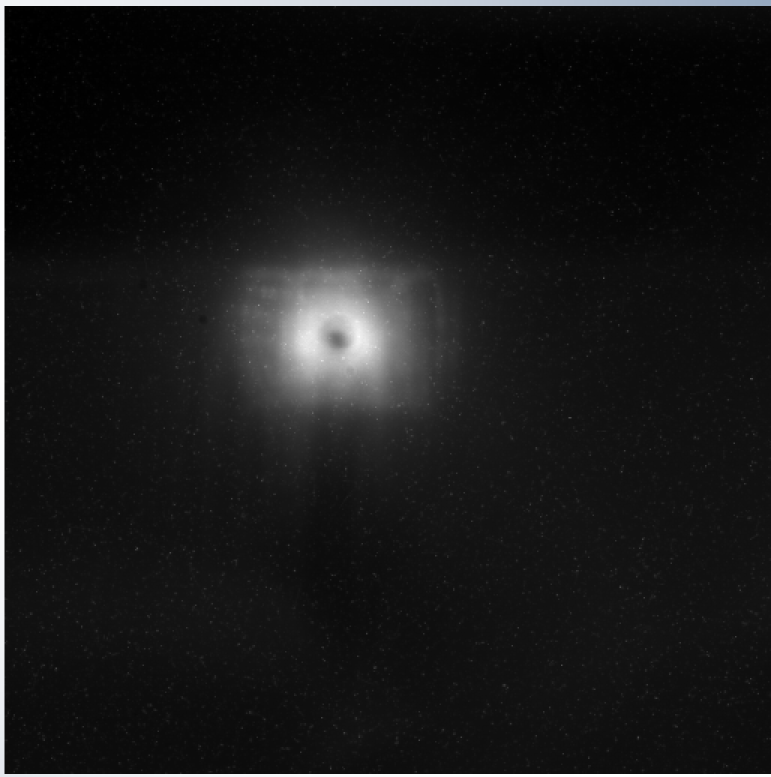


Charge: 0.7 nC
Exposure Time: 0.8 s
2 pulses



OTR Angular Distribution





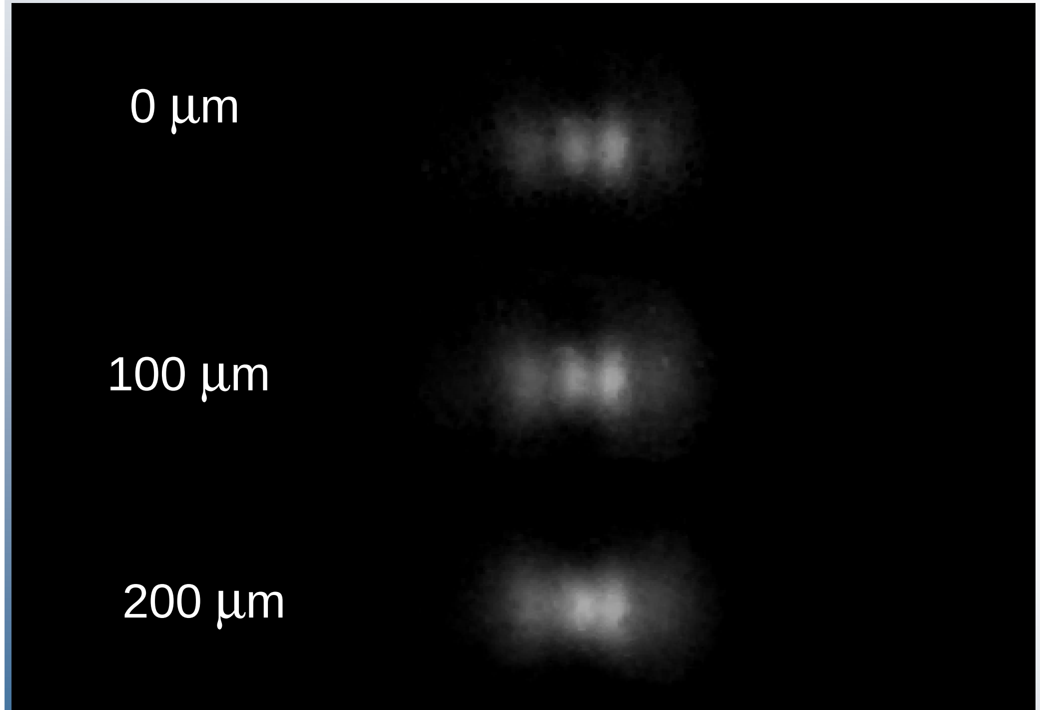
From OTR to ODR

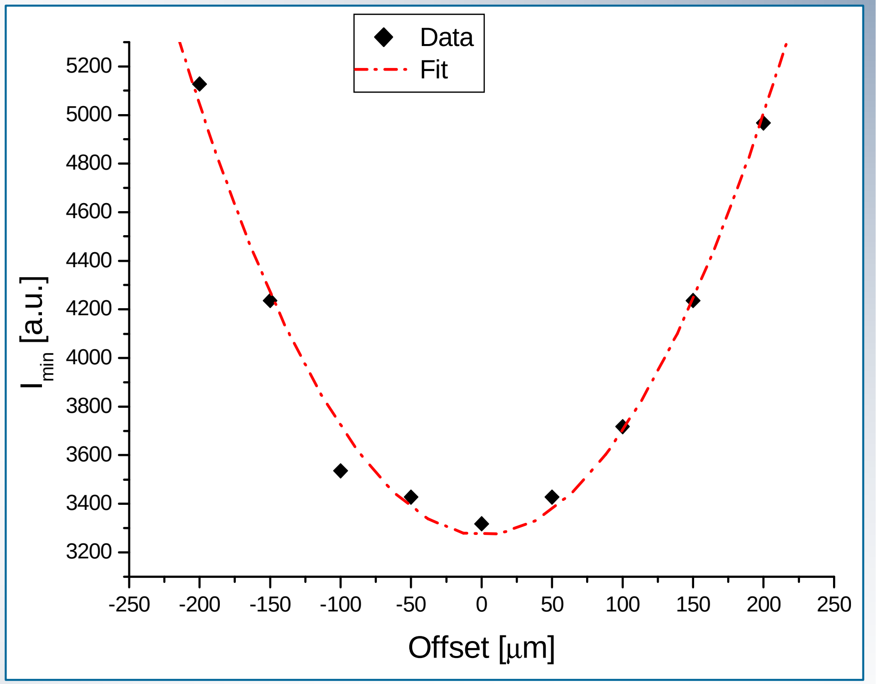
Beam transport optimization:

- *0.7 nC*
- 25 bunches
- *1 s* exposure time

Optics optimization:

- *800 nm* interferential filter in
- polarizer in

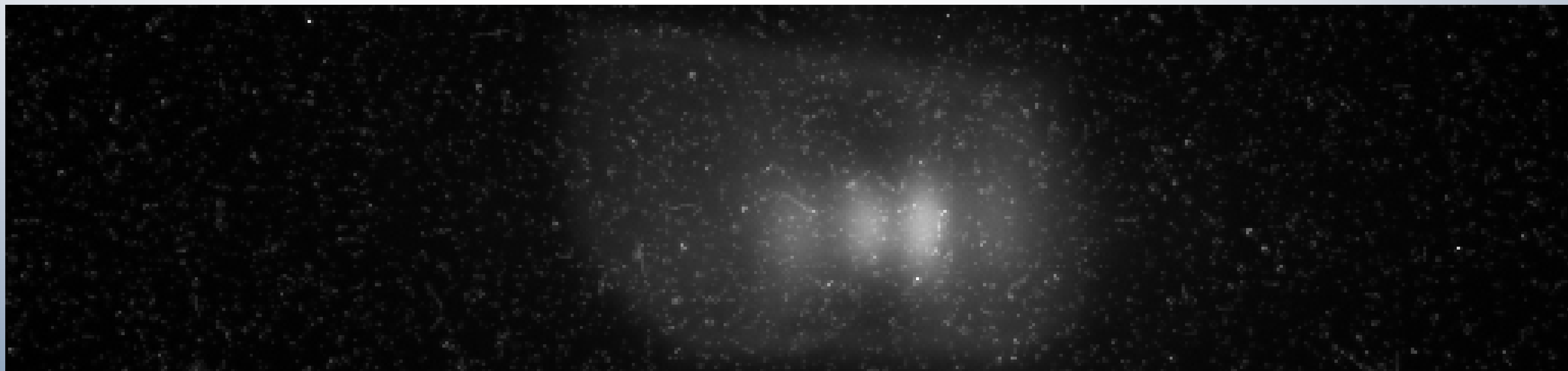


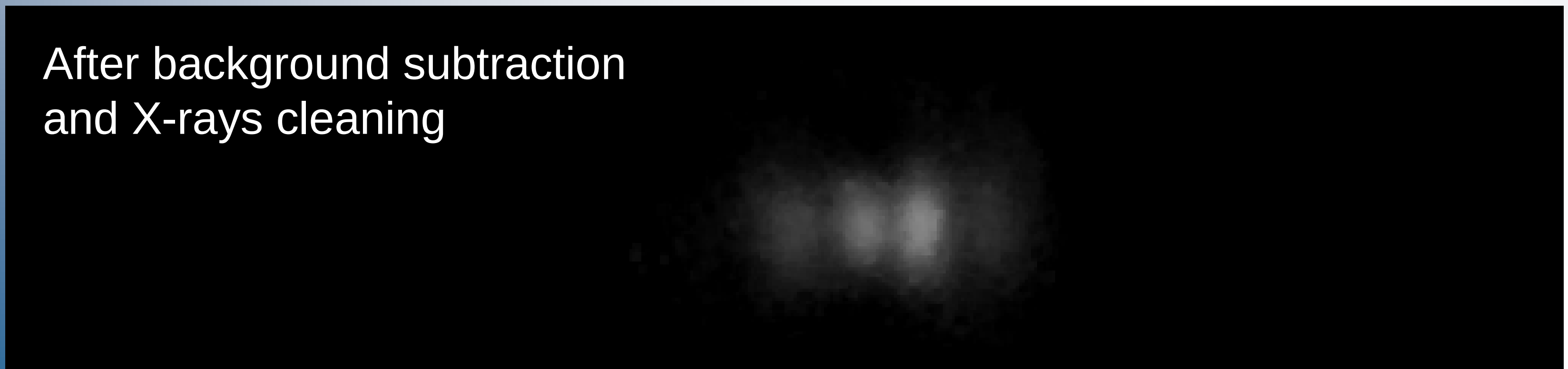


ODR Evidences (1)

Beam transport optimization

- *0.7 nC*
- 25 bunches
- *2 s* exposure time
- $E_{beam} = 680\ MeV$
- *800 nm* filter and polarizer in

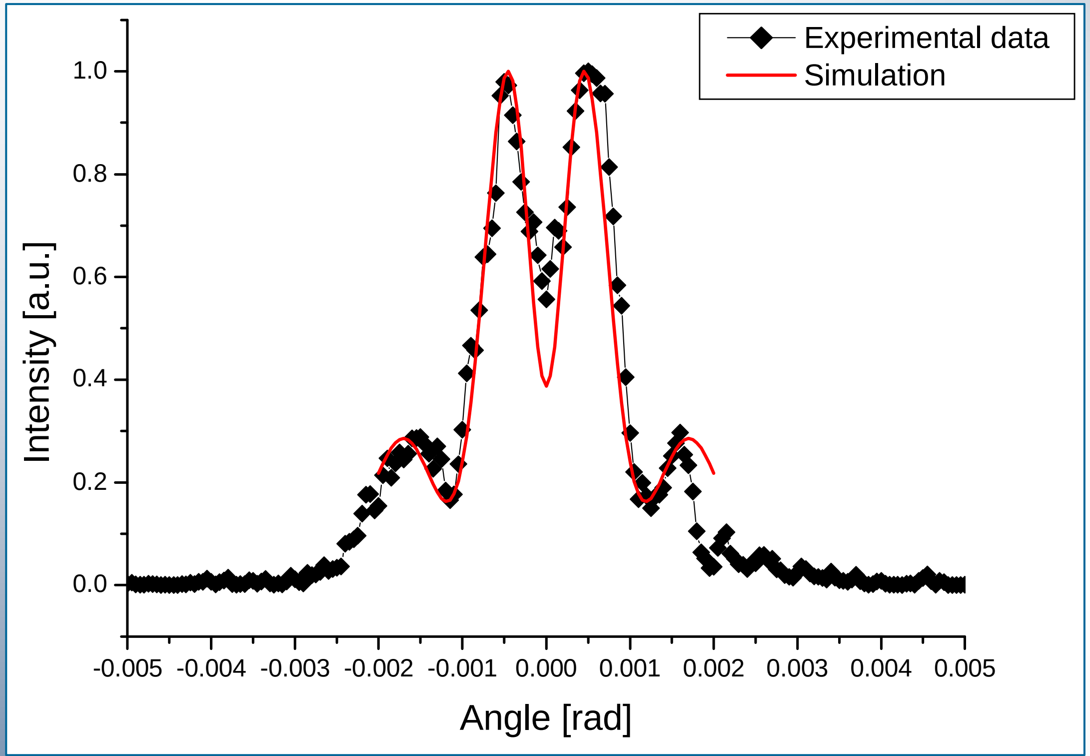




ODR Evidences (2)

Simulation parameters:

- a = 0.5 mm
- $\sigma_y = 73\ \mu m$
- $\sigma'_y = 30\ \mu rad$
- Both the angular divergence and the beam are assumed to be Gaussian distributed



Conclusions

- The ODR experiment at FLASH is in progress
- The background is a severe limitation for the detailed reconstruction of the beam parameters from the ODR angular distribution
- To reduce its influence we are mounting a new thin shield just in front of the target

BUT…

- The off-line software tool developed to filter x-ray and subtract the background has allowed an **interesting analysis**
- **A qualitative good agreement is evident between measurements and simulations**

Outlook

Beginning of 2008

Measurement shifts

- *1 GeV* electron beam energy

- reduction of the background thanks to a shield, mounted at 45° with respect to the screen, and to the new holder which is machined such that reflections are reduced

- better shielding of the CCD camera thanks to a custom design from Maike Siemens and Silke Vilnius.

THANKS TO ...

…FLASH shift crews

…Rossano Sorchetti and Luciano Cacciotti (LNF-INFN)

…Ben Polzin

… Federica Stella and Vittorio Merlo
(Univ. of “Tor Vergata”) for the construction of the target