Status report WP-11
beam diagnostic

11.2 Emittance monitor

Non intercepting devices

- Emittance measurements are often performed imaging a beam on a metallic screen

BUT

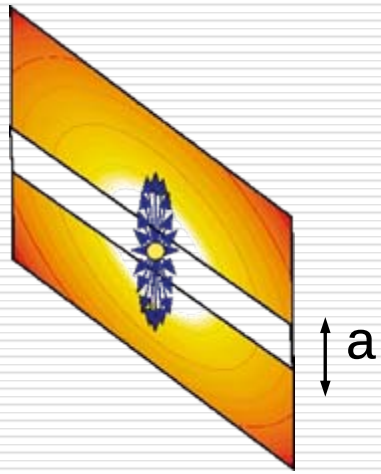
- Traditional diagnostic based on OTR cannot be used for high power beam
- All other intercepting devices are easily damaged or destroyed from these type of beams
- It is fundamental to develop non intercepting alternatives for emittance measurements

Diffraction Radiation Theory

- DR is produced by the interaction between the EM fields of the traveling charge and the conducting screen

$$I \propto e^{-\frac{2\pi a}{\gamma\lambda}}$$

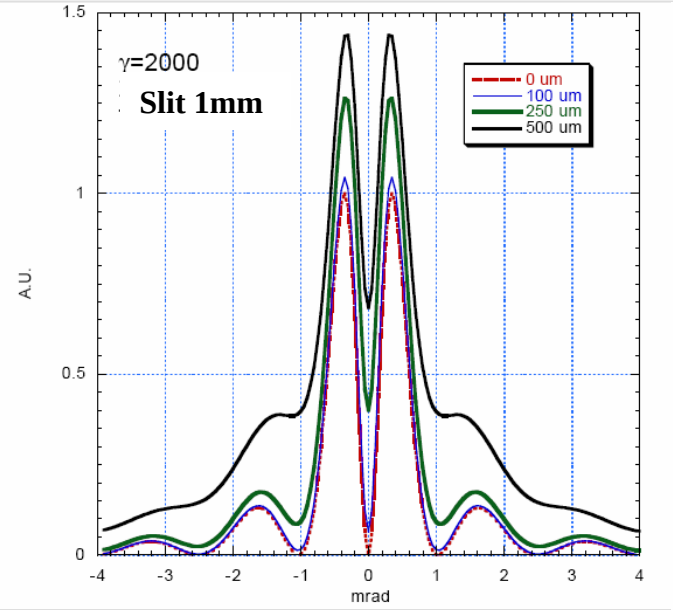
If a
$$\begin{cases} >> \dfrac{\gamma\lambda}{2\pi} & \text{No radiation} \\ \cong \dfrac{\gamma\lambda}{2\pi} & \text{DR} \\ << \dfrac{\gamma\lambda}{2\pi} & \text{TR} \end{cases}$$

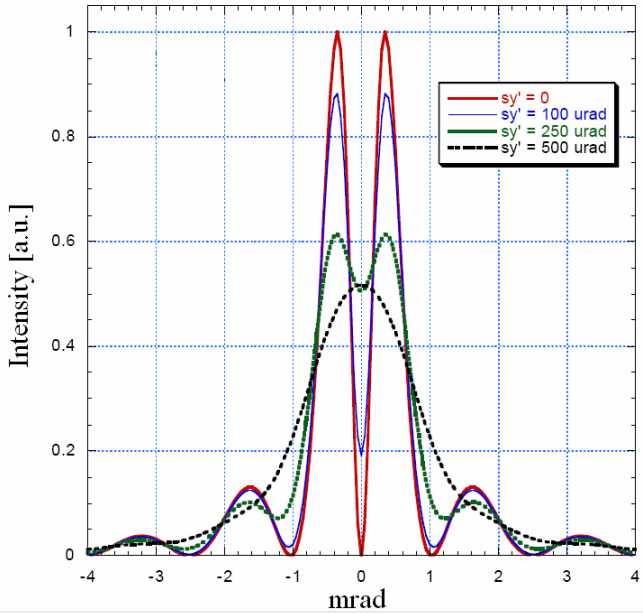


- Excellent candidate to measure the beam parameter parasitically

Beam Transverse Diagnostics with ODR

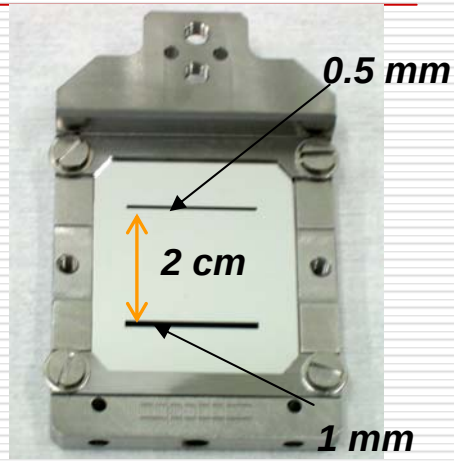
ODR angular distribution gives information on transverse beam size and beam divergence





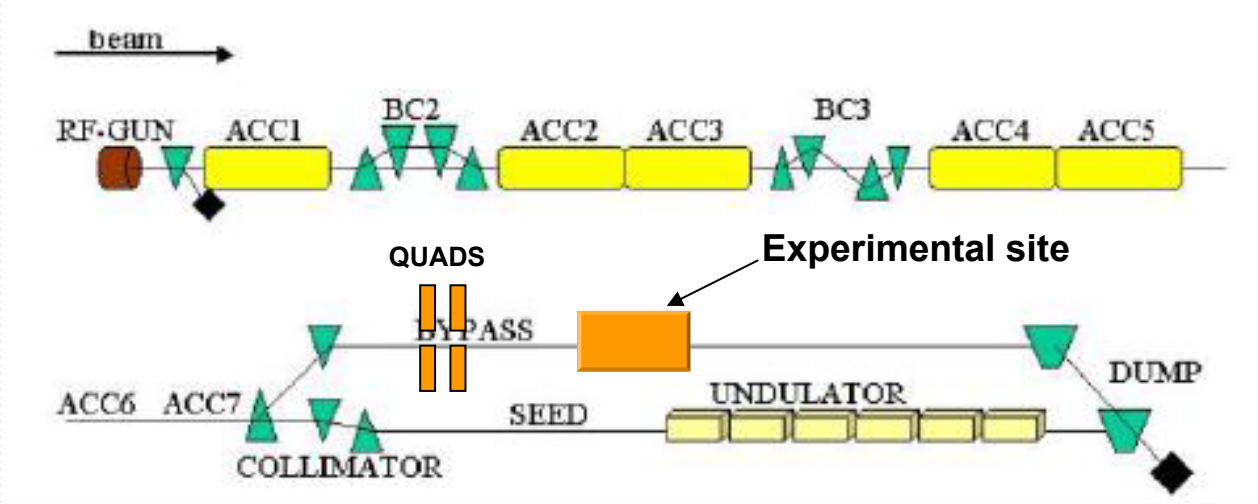
Diffraction Radiator

- The radiator was realized in the University of Rome “Tor Vergata” by F. Stella and V. Merlo with **lithographic technique**



- The surface roughness, the planarity of the target mounted in the holder and the sharpness of the apertures borders were careful monitored.

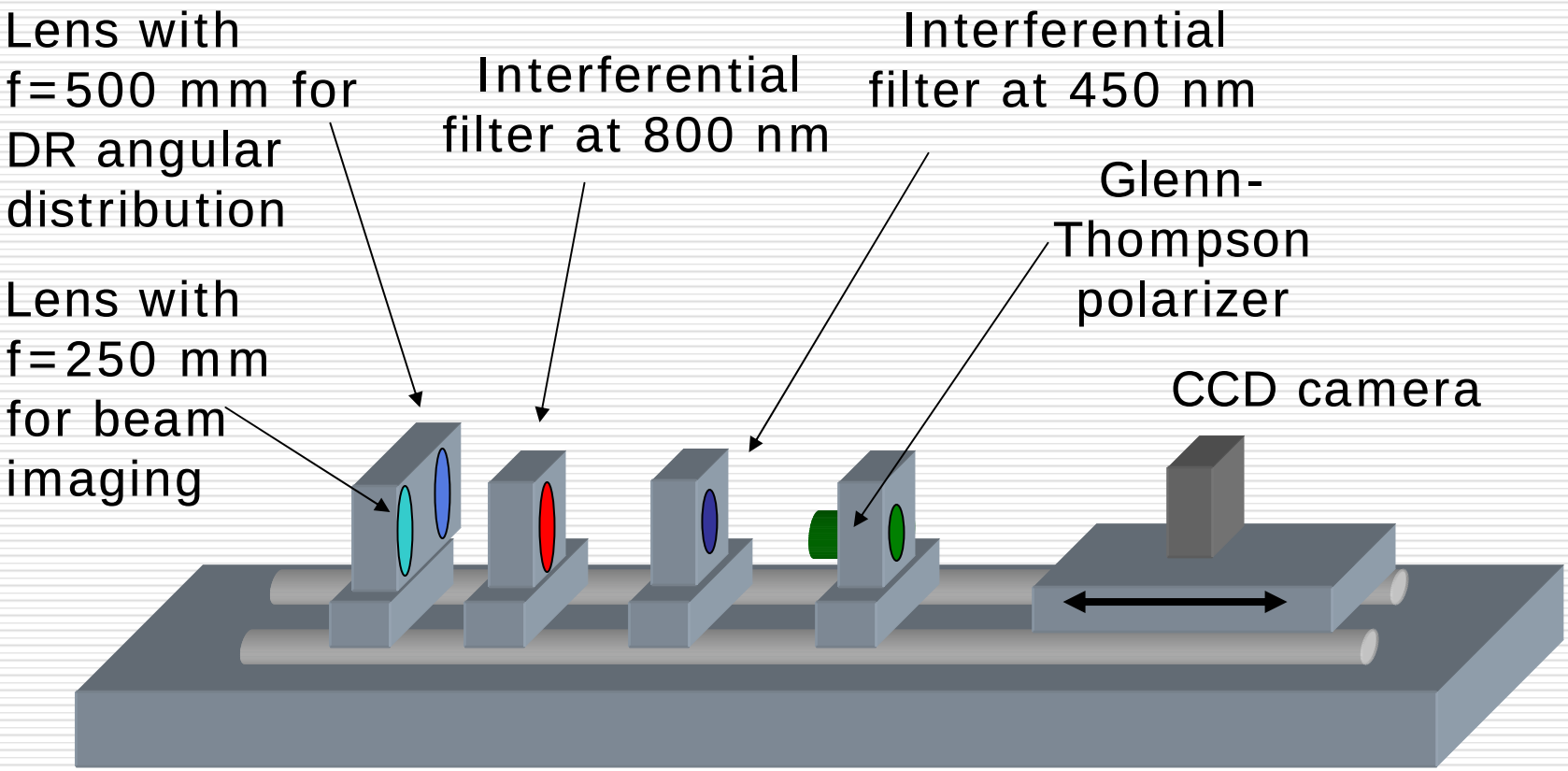
The Experiment @ FLASH



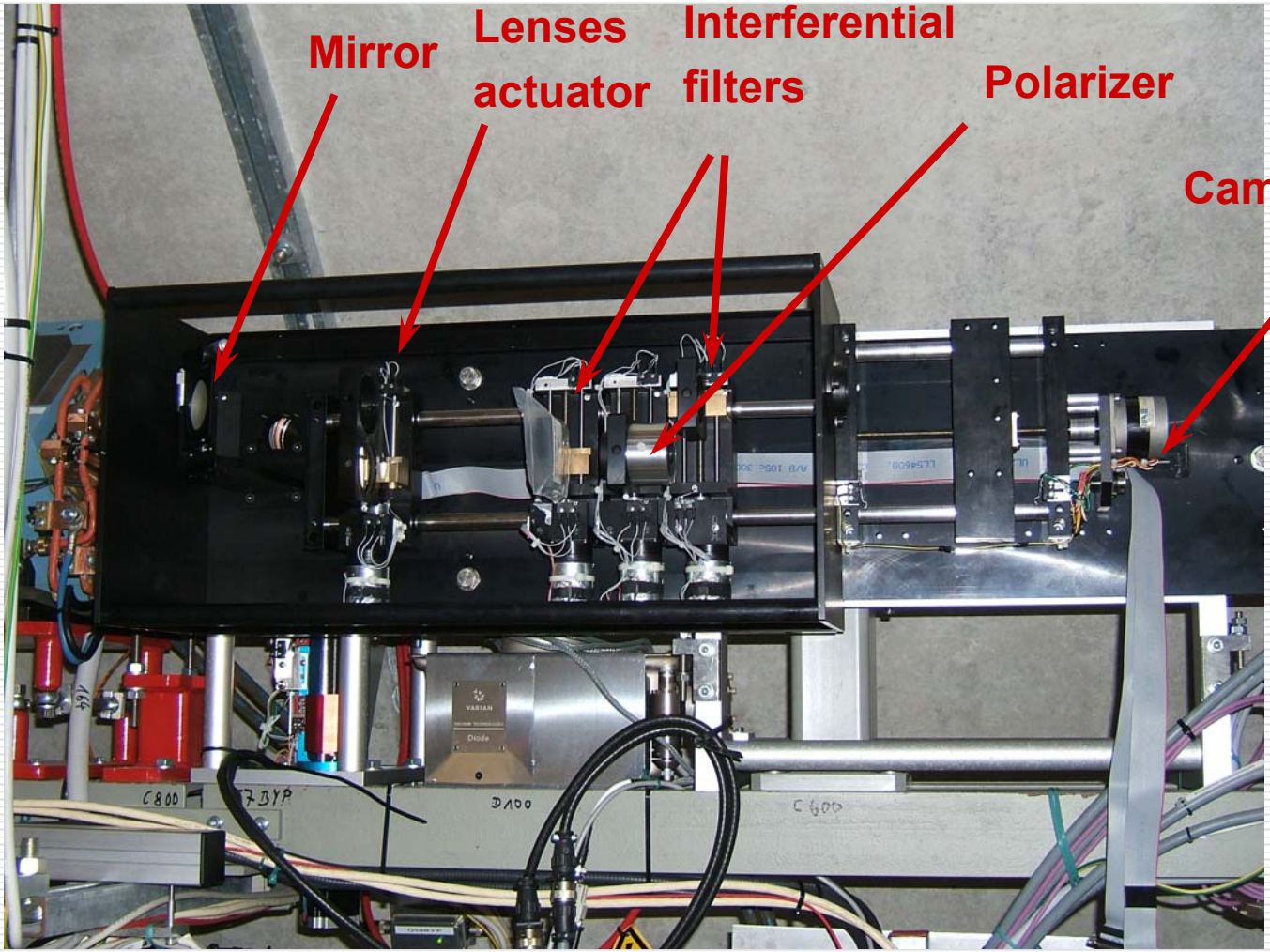
FLASH is a good test facility for several reasons

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

Optical system



Experimental Setup



Hamamatsu camera

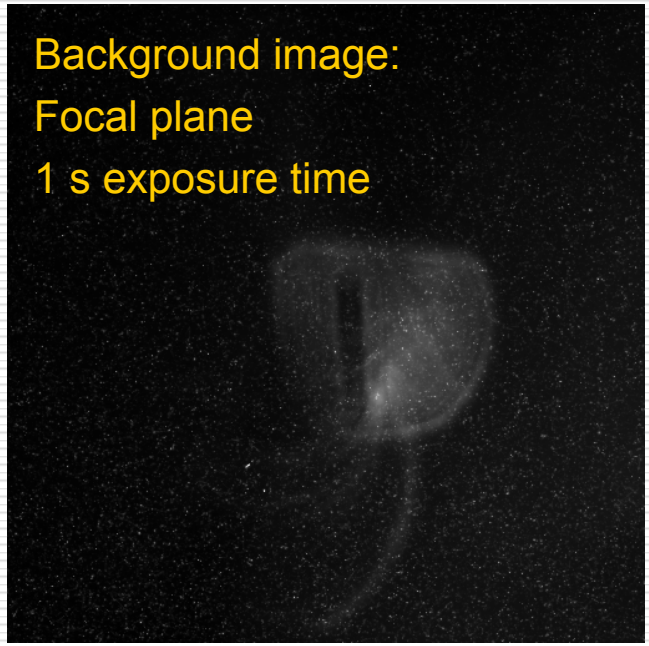
- Back illuminated, up to 90% of quantum efficiency
- Cooled @ -55 °C
- No dark noise signal
- Integration time up to hours
- 30 bunches of 1 nC @ 5 Hz integrated for 60 seconds = 150 nC !

2 Periods of Measurements

- **1st Period, Low Energy: *480 MeV***
  - First tests of the whole apparatus
  - First observation and understanding of the background
  - Rough energy measurement with OTR
- **2nd Period, High Energy: *620 MeV***
  - Background subtraction
  - Tuning of the bypass
  - First measurements with *1 mm* slit in

Critical Issues

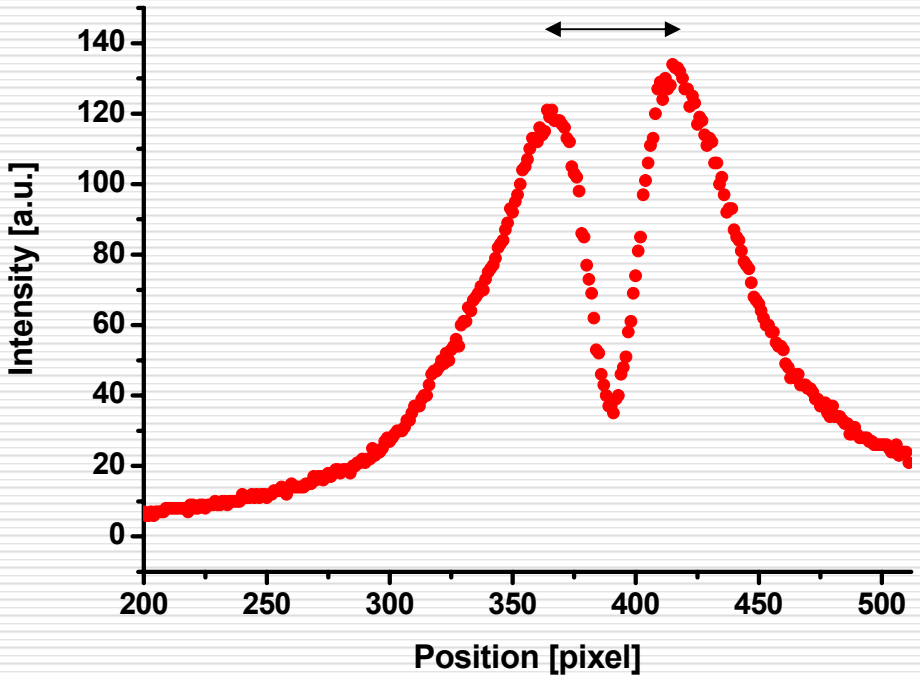
- Synchrotron radiation background coming from the dipole and quads
- Severe X-rays background which does not allow to integrate over a long time
- Low electron beam energy
- Large and unstable beam

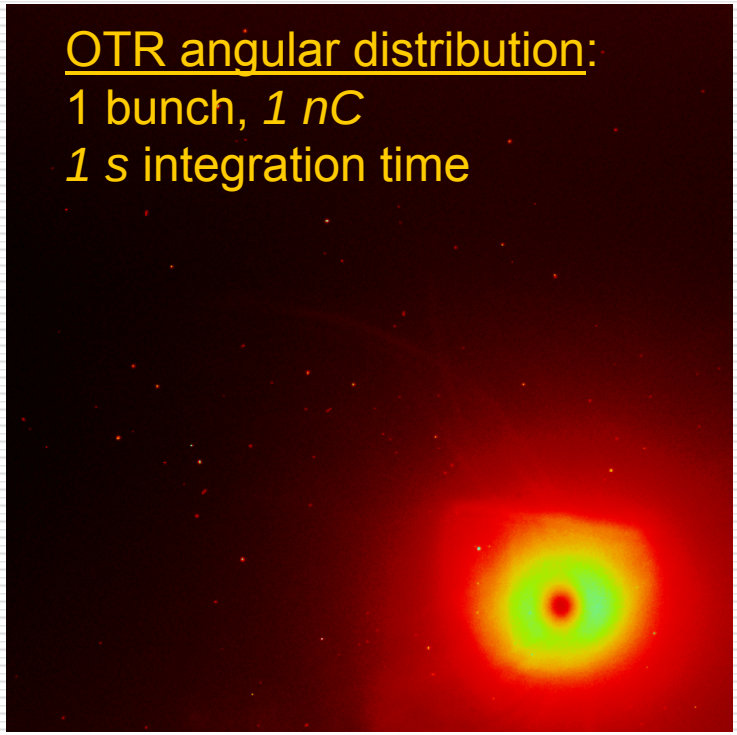


Beam Energy Measurement

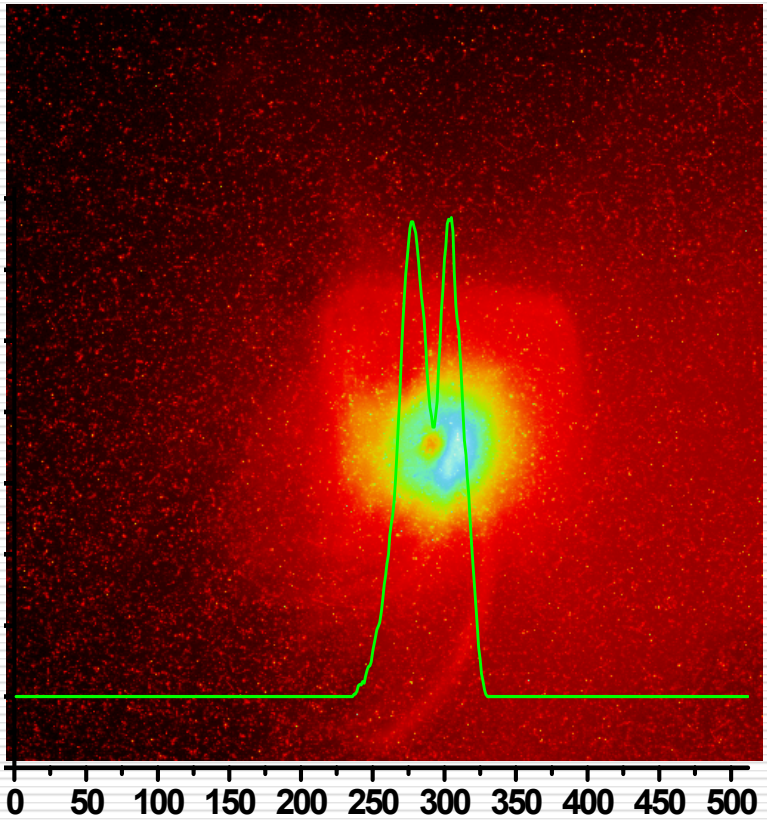
A rough energy measurement has been done by measuring the aperture of the OTR angular distribution cone.
The agreement with the energy measured by the FLASH team is within 20%.

51 pixel ≈ *408 MeV*



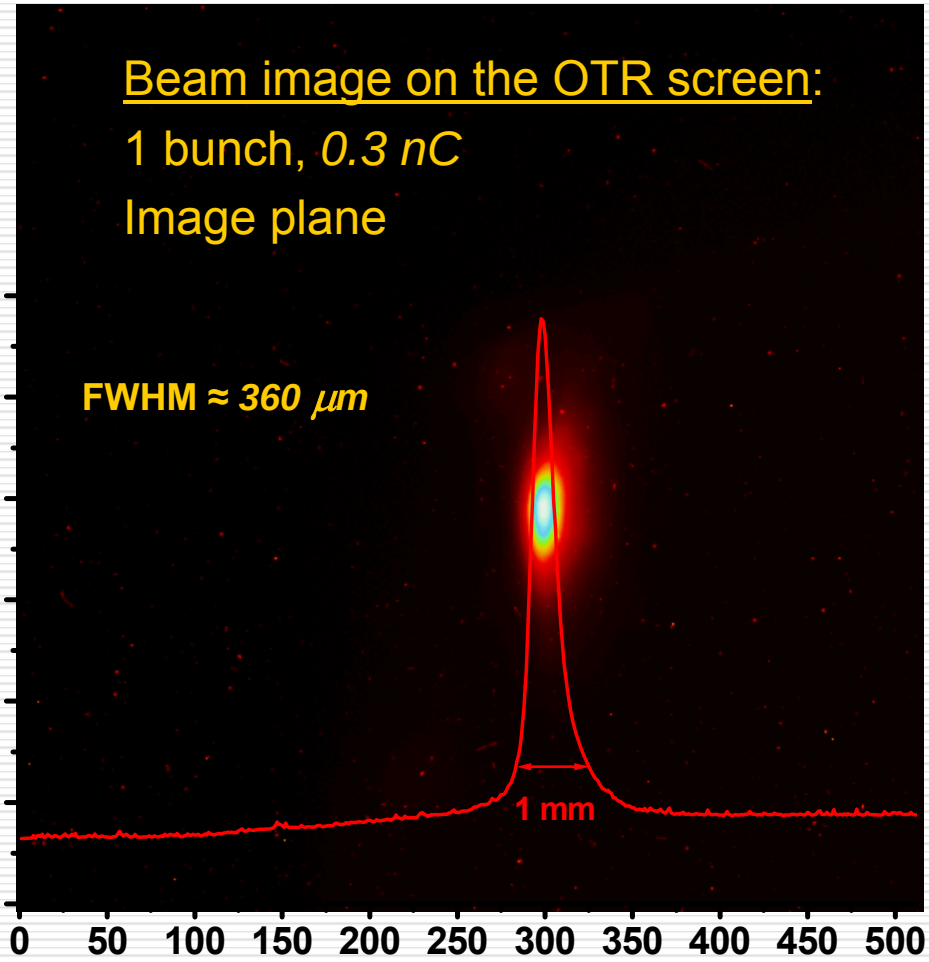


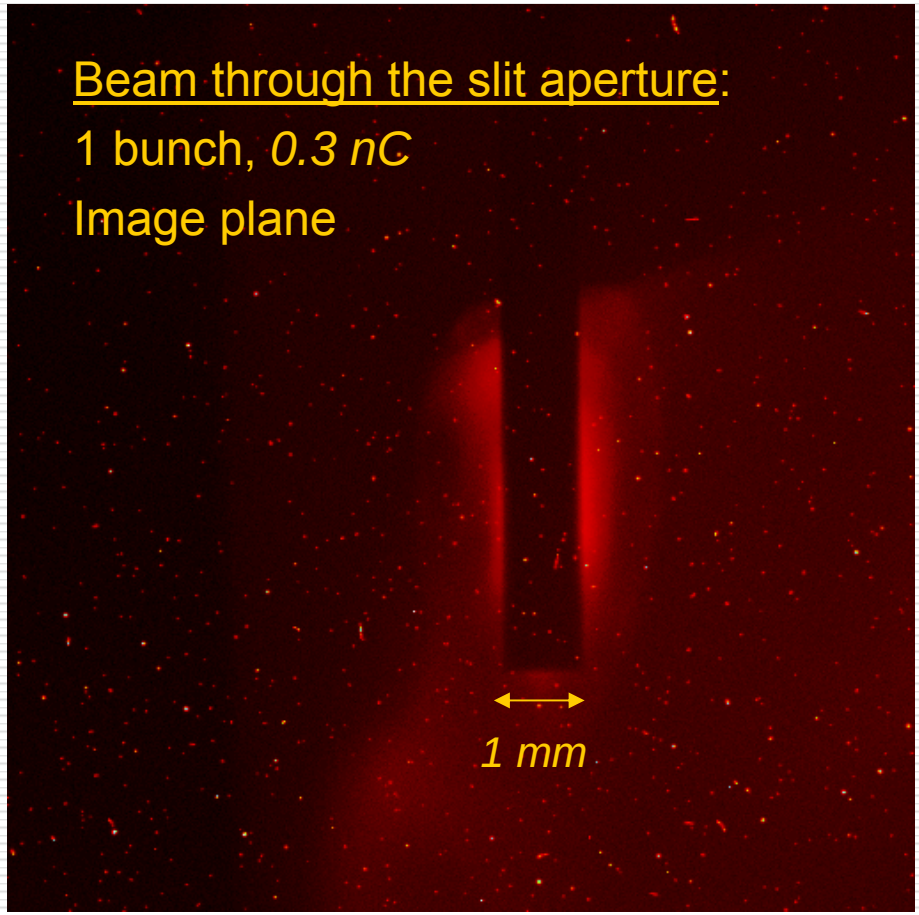
Background Subtraction



LabView tools to remove hot spots and subtract background

The Best Beam

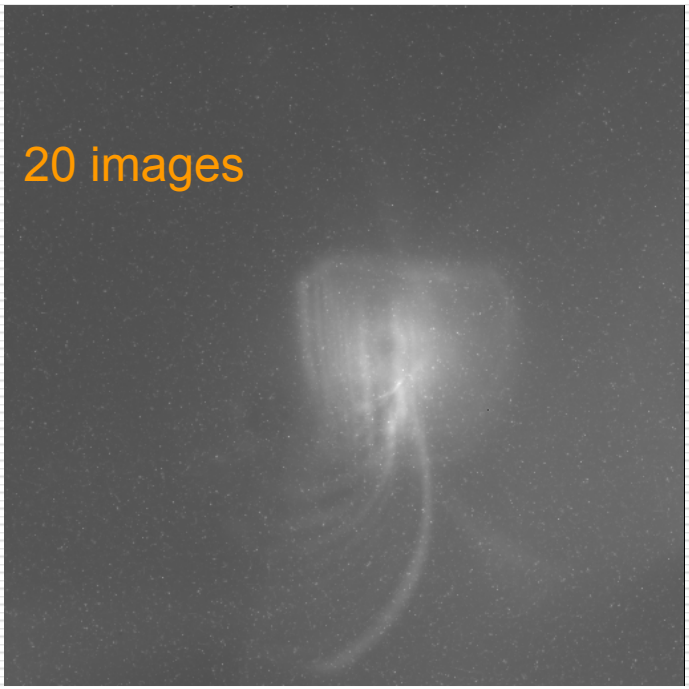




ODR Evidences

Beam transport optimization:

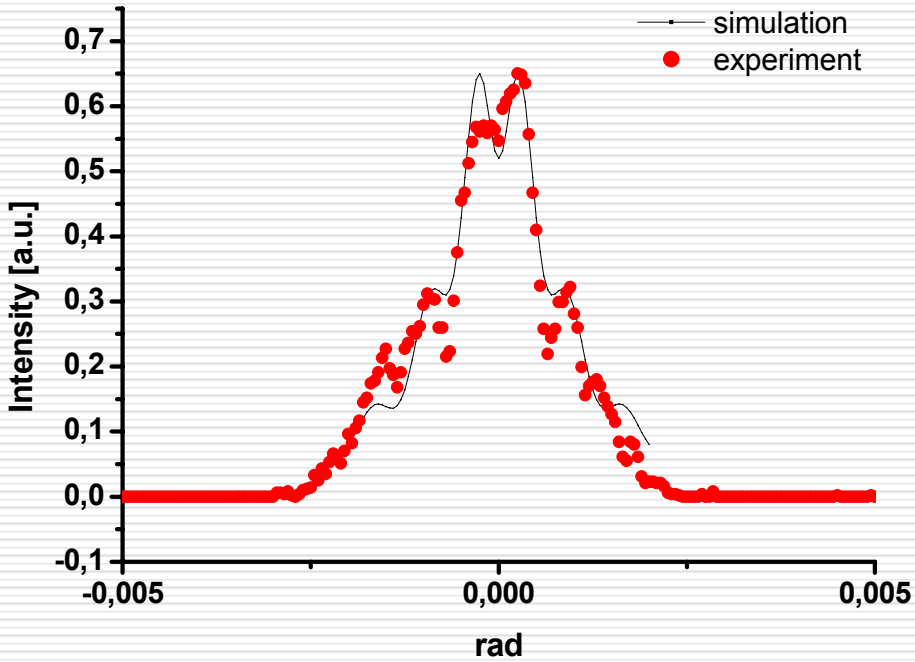
- *0.3 nC*
- 10 bunches
- *2 s* exposure time
- E_{beam} = *620 MeV*



Simulation parameters:

- a = *1mm*
- σ_y = *150* μm
- σ'_y = *0*
- E_{beam} = *620 MeV*

Projected ODR profile



Reduce Background and improve alignment

- New installation in BYP35 station (20 m before the DR radiator)
- Inserted a pinhole (8 mm diameter) in a movable actuator
- Placed a bright light in the windows to illuminate the back of the screen @ BYP35 and simulate a far away source

Status

Nr.	Task	Begin of task	End of task	finished end 05	finished April 06	finished August 06
11	WP 11 BEAM DIAGNOSTICS	1/1/04	28/5/08	19%	53%	60%
11.1	Beam Emittance Monitor	01/01/04	28/05/08	42%	53%	60%
11.1.1	Slit width simulations	01/01/04	02/04/04	100%	100%	100%
11.1.2	Slit design	05/04/04	02/07/04	100%	100%	100%
11.1.3	Optics simulations	05/04/04	02/07/04	100%	100%	100%
11.1.4	Optics appropriations	05/07/04	15/08/05	100%	100%	100%
11.1.5	System assembly and tests	25/10/04	30/09/05	50%	100%	100%
11.1.6	Mechanical assembly at TTF	03/10/05	02/11/05	100%	100%	100%
11.1.7	Optical assembly at TTF	03/11/05	01/12/05	0%	100%	100%
11.1.8	Integration of controls into TTF	02/12/05	31/12/05	25%	100%	100%
11.1.9	Ready for beam test in TTF	31/12/05	31/12/05	100%	100%	100%
11.1.10	Beam tests at TTF	02/01/06	02/06/06	0%	100%	100%
11.1.11	Evaluate first beam test result	02/06/06	02/06/06	0%	30%	100%
	Successive measurements	05/06/06	28/05/08	0%	0%	0%
11.2	Final evaluation	28/05/08	28/05/08	0%	0%	0%

Milestone

Conclusions

- Commissioning of the ODR experiment at FLASH started
- First measurements have shown a strong **background**
- An off-line software tool has been developed to filter x-ray and subtract background ➔ processed images give **interesting results**
- Qualitative agreement between measurements and simulations
- Improvements of optics alignment procedure and halo reduction: done
- Ready for new data acquisition in January 2007