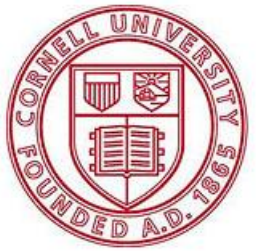
Pavel Karataev

John Adams Institute for Accelerator Science at Royal Holloway, University of London

CLIC-UK Collaboration

CERN, May 9 – 11, 2012



Cornell University

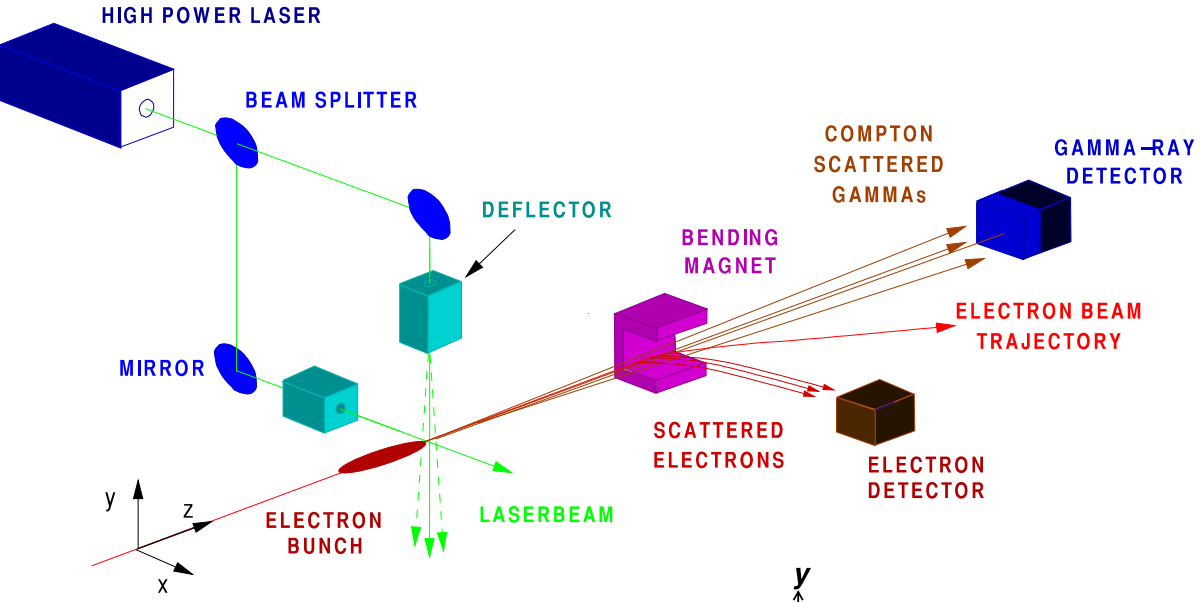
Introduction

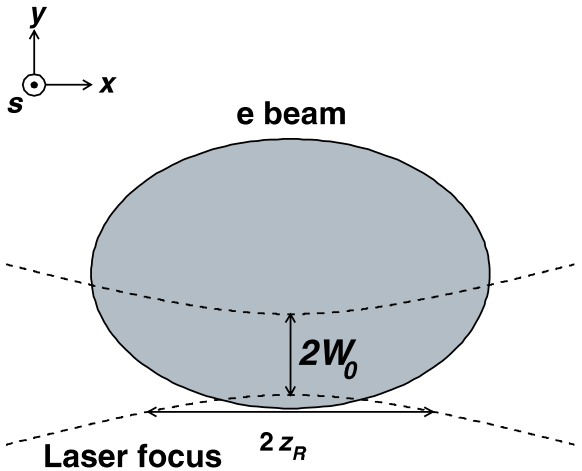
Royal Holloway University of London

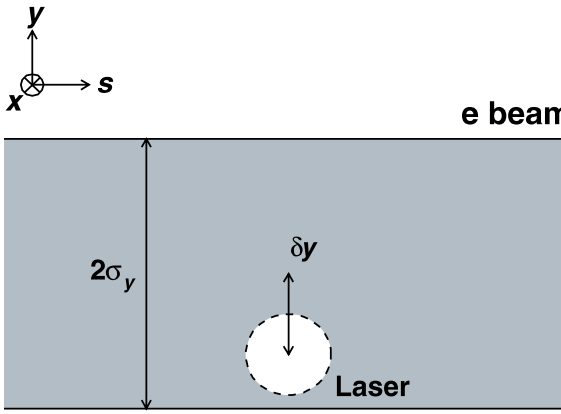
- **Laser-Wire beam size monitor**
  - **At ATF2**
- **UV/X-DR beam size monitor**
  - **CesrTA**
- **Cavity Beam Position Monitor**
  - **at ATF and for CLIC**

Laser Wire beam profile monitor

L. Nevay, L. Corner, S. Boogert, P. Karataev,
A. Aryshev, J. Urakawa, N. Terunuma

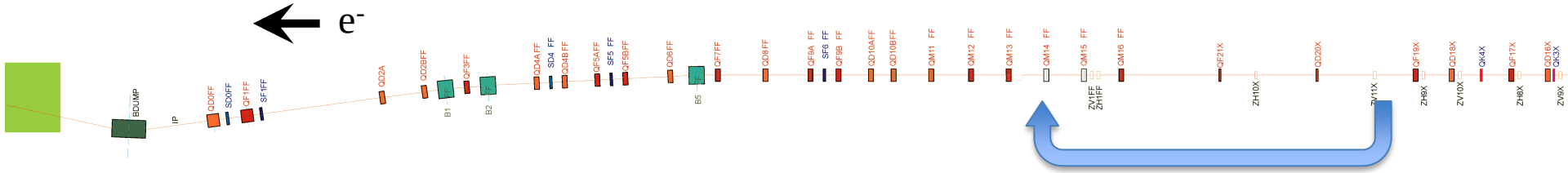


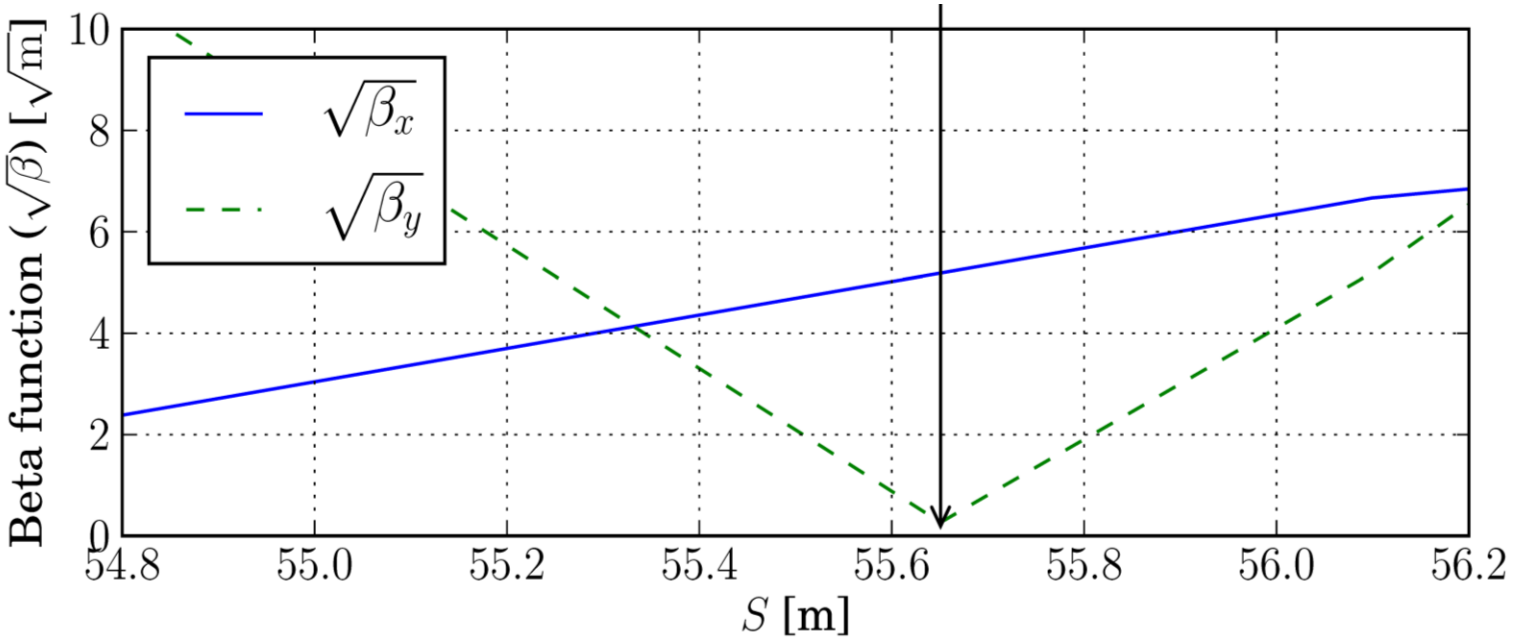




Laser Wire beam profile monitor

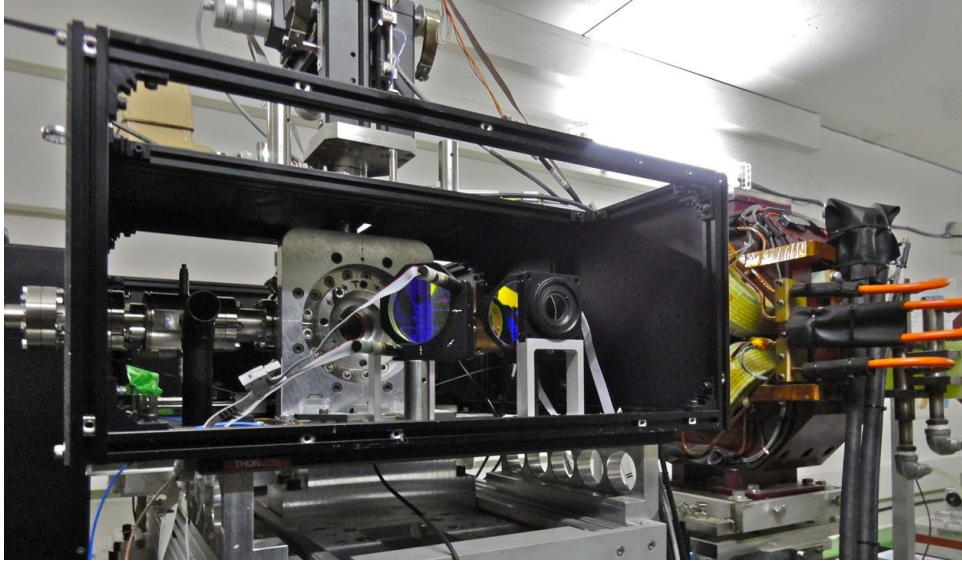
Laurie Nevay, L. Corner, S. Boogert, P. Karataev, A. Aryshev, J. Urakawa, N. Terunuma

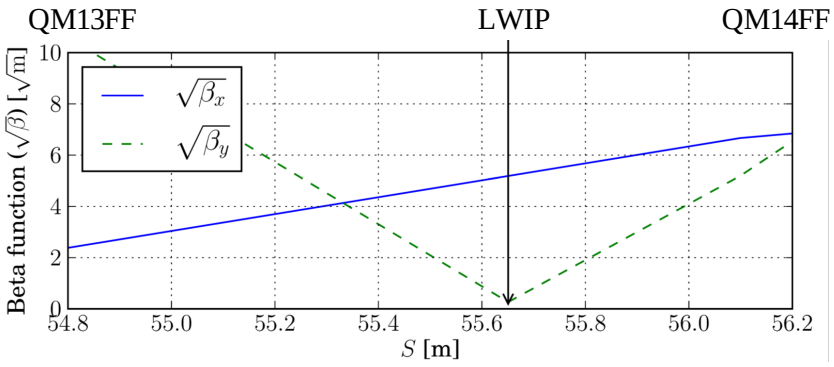


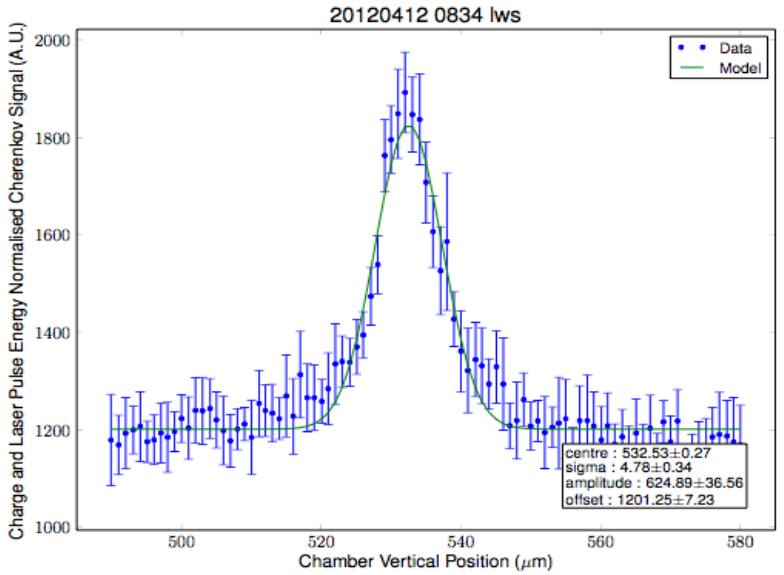


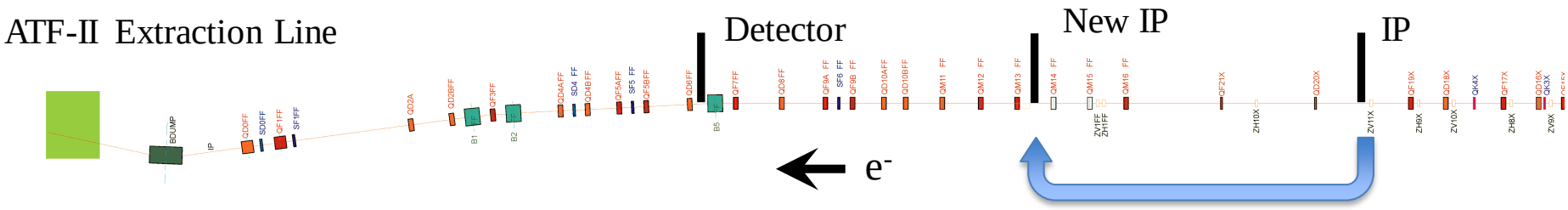
ATF2 Laser-wire

- LW moved post earthquake
- e^- optics V:1µm x H:200µm
- Initial collisions found
- 4µm vertical scan so far



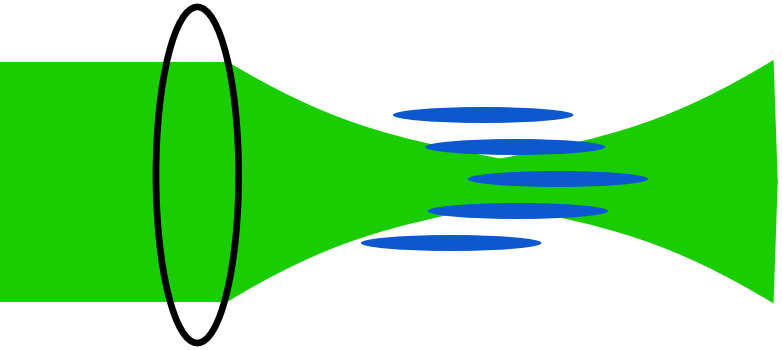


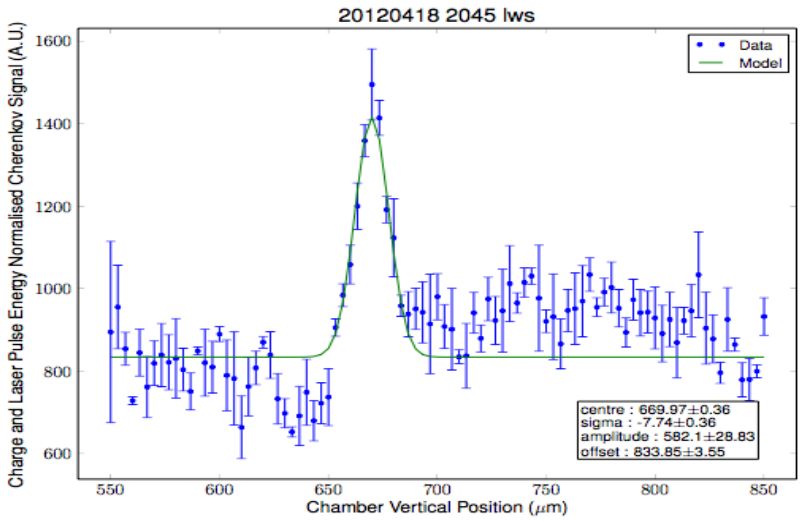


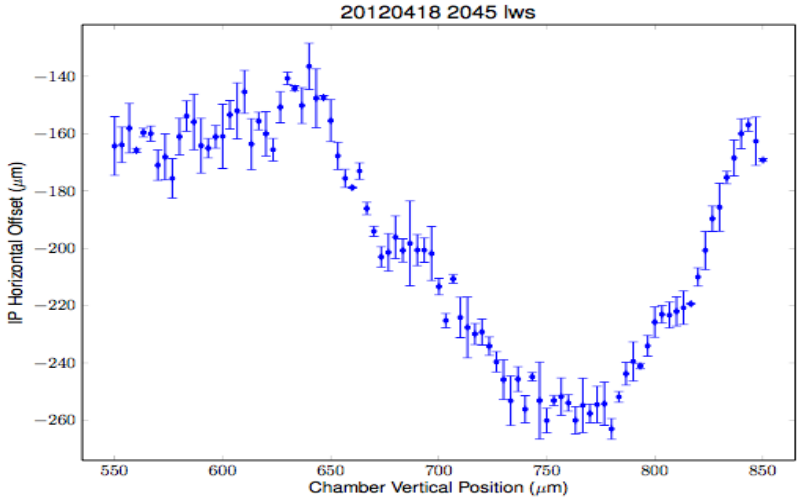


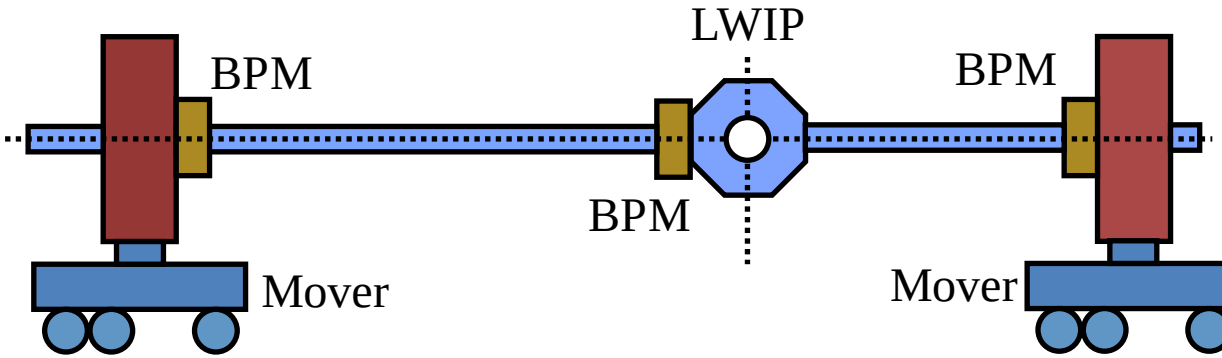
ATF2 Laser-wire with CBPMs

- Electron beam moves horizontally
- Modulates Signal
- Use CBPMs to measure position
- LW follows electron beam



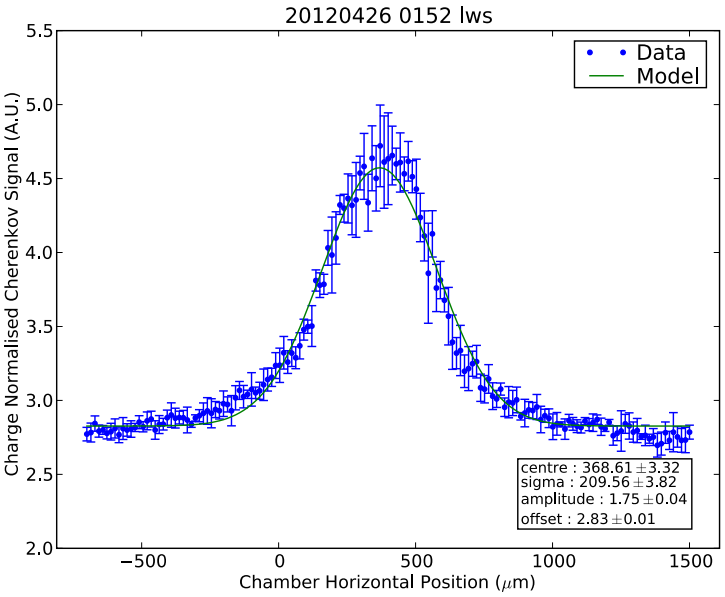


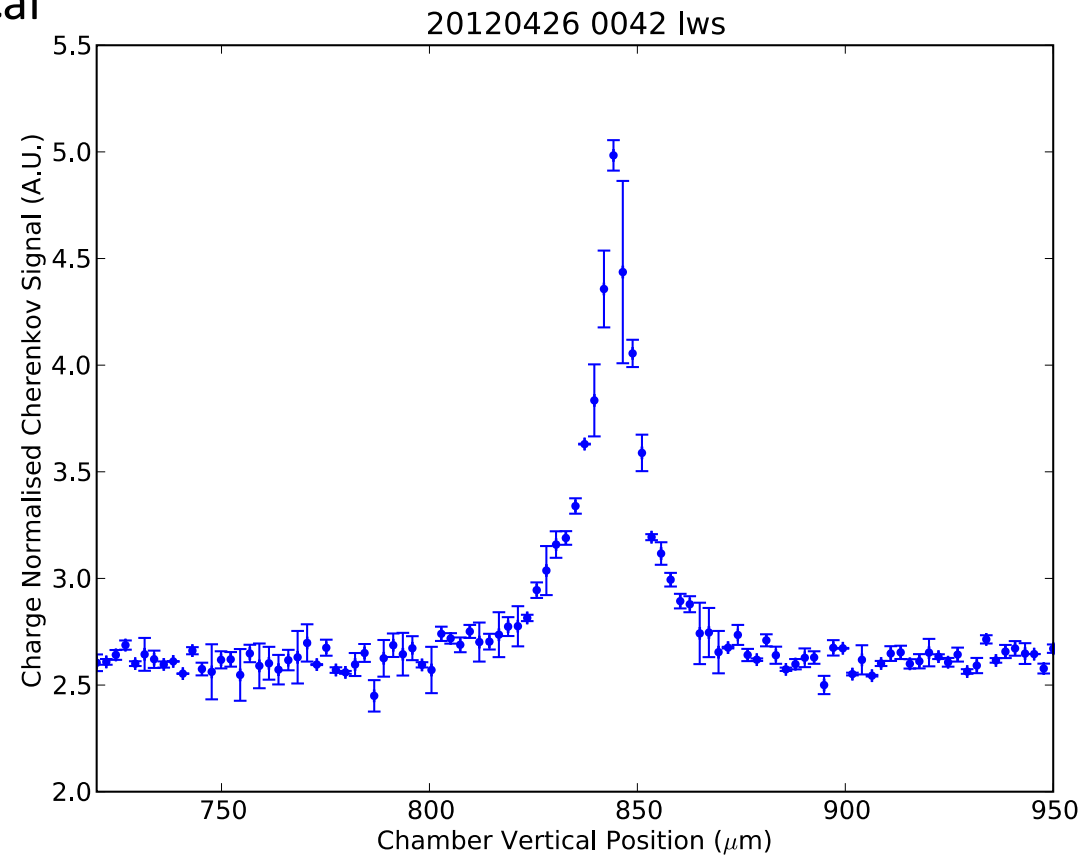




April 2012 Data

- Initial laser-wire scans
- Horizontal measured 210 ± 4µm
- Vertical not Gaussian -> Rayleigh range
- Basic analysis shows ≤ 4µm vertical
- Further data taking in May 2012
- Will use CBPMs to track e^- beam





Sub-micrometer resolution transverse electron beam size measurement system based on optical transition radiation. "ATF2 LW OTR"

A. Aryshev, N. Terunuma, J. Urakawa, ***KEK ATF***

S. Boogert, P. Karataev, ***JAI at RHUL***

L. Nevay, ***JAI at Oxford***

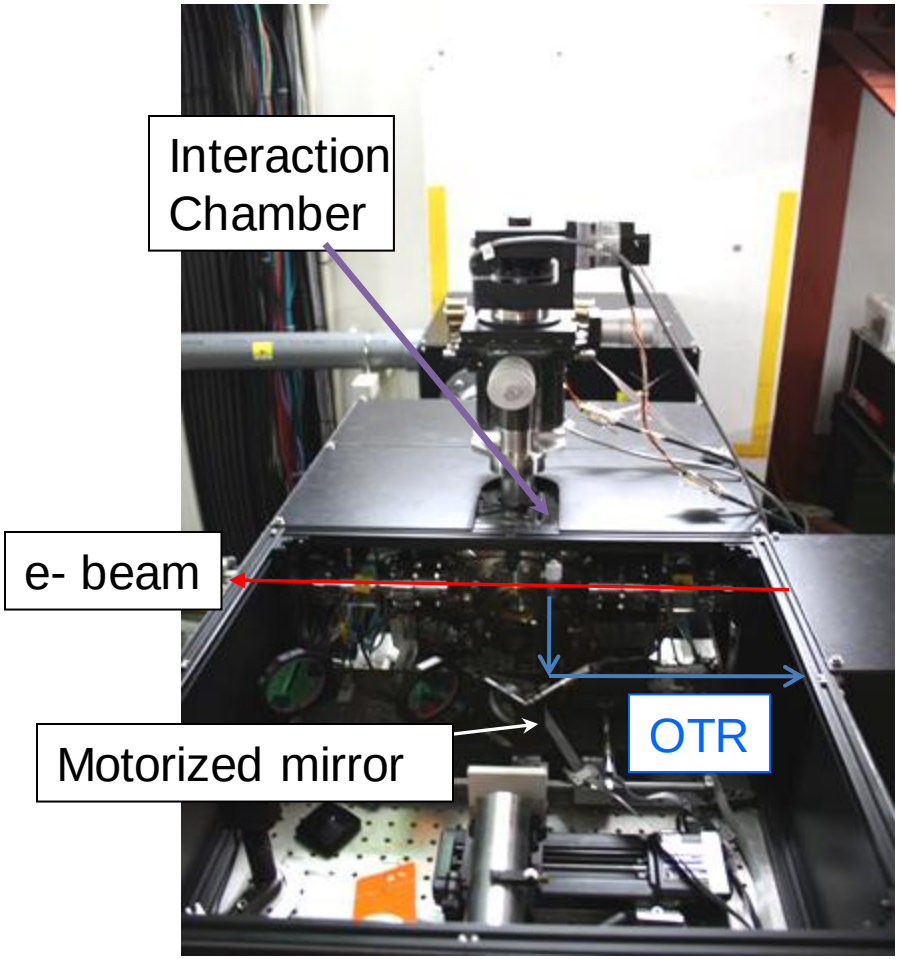
T. Lefevre, E. Bravin, B. Bolzon, ***CERN CTF3***

Milestones

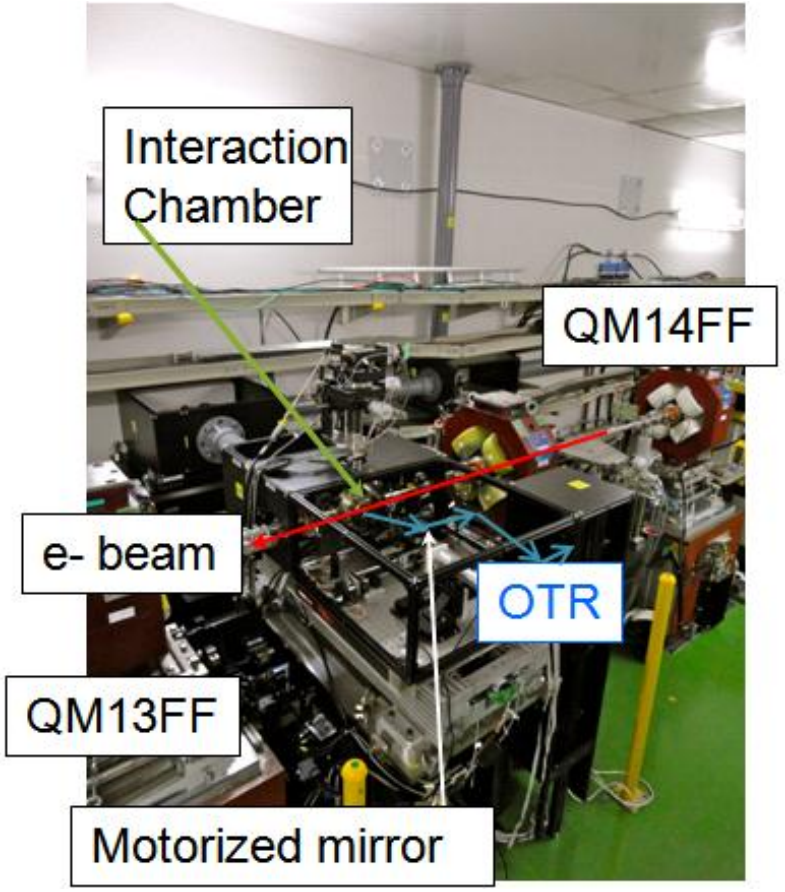
- **Initial setup spring 2009**
- **Observation of OTR PSF end of 2009:** *P. Karataev, et.al. "The First Observation of the Point Spread Function of Optical Transition Radiation", PRL* ***107****, 174801 (2011).*
- **EXT LW optics verification and cross-check 2009 – 2011:** *A. Aryshev, et.al. IPAC-11 WEOBB01, IPAC-10 MOPEA052, RREPS-09: Journal of Physics: Conference Series* ***236 (2010) 012008***
- **Relocation of EXT LW, OTR re-commissioning:** 2011 – present
- **Re-commissioning has completed in April 2012.**
- **Simulations and further optimization to be done by the end of 2012.**
- **Propose a plan to integrate the OTR monitor into the Laser Interferometer based Beam Size Monitor at ATF2 FF: end of 2012**

Setup overview

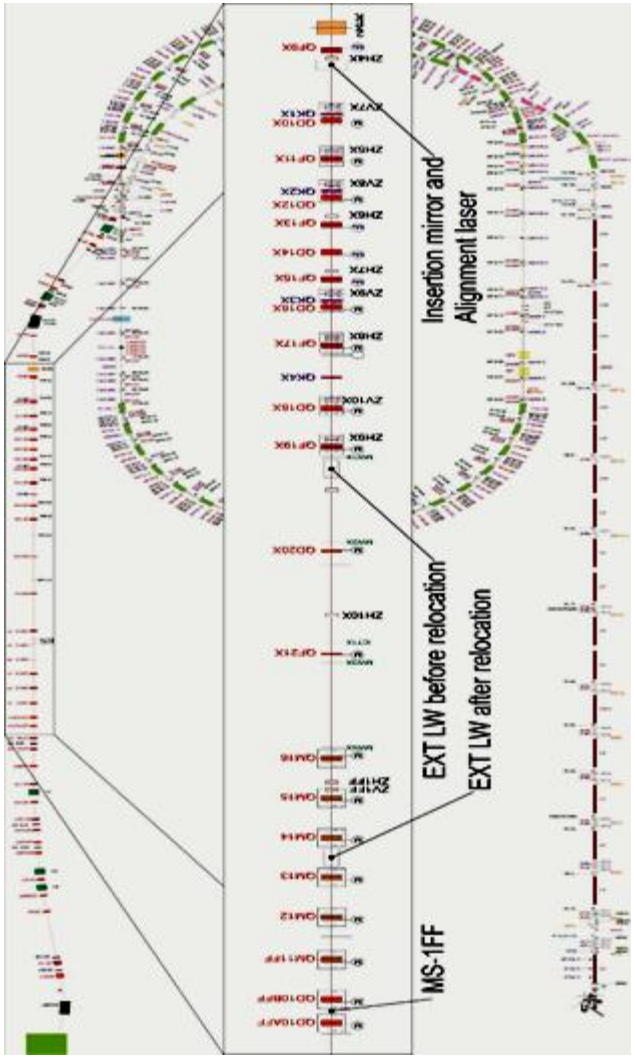
Before relocation

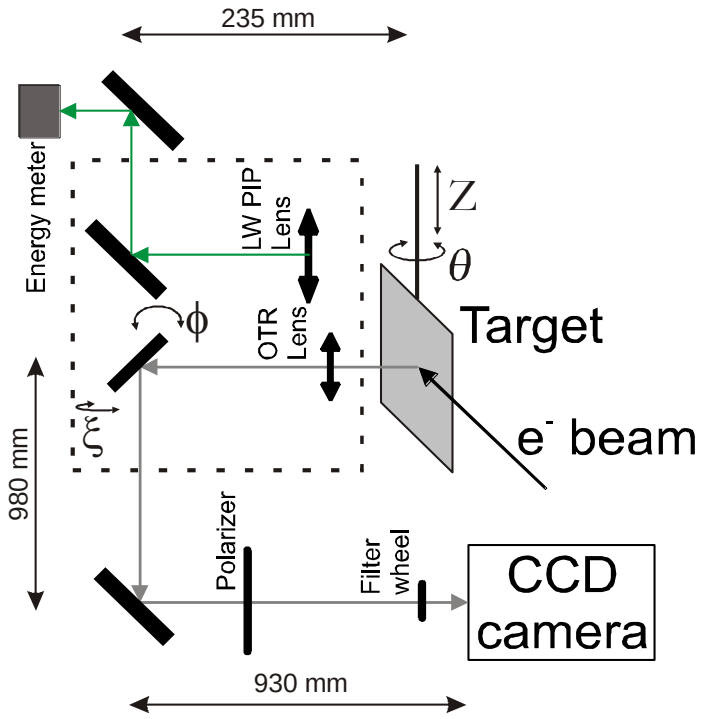


After relocation



Setup overview





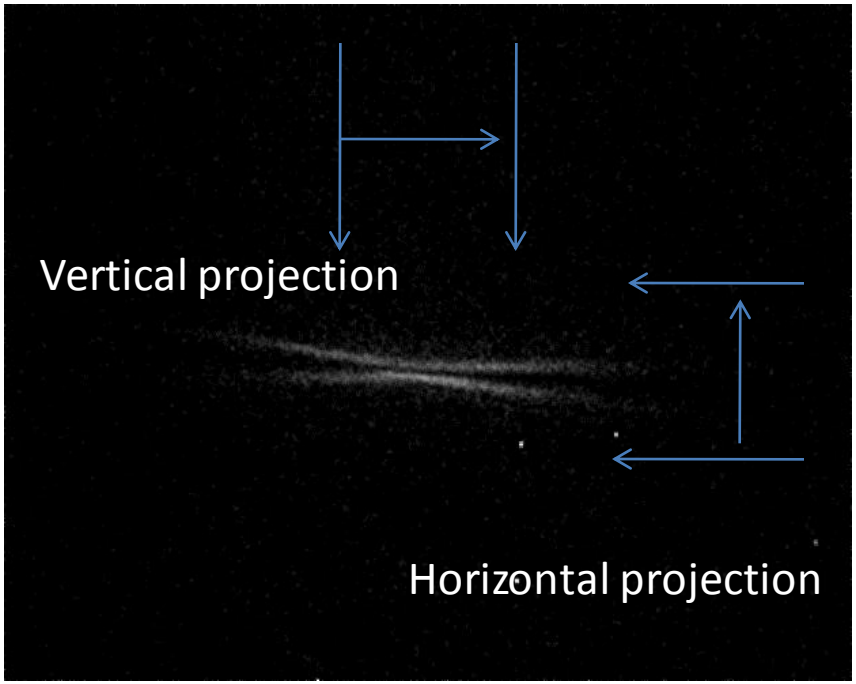
- CCD replacement:

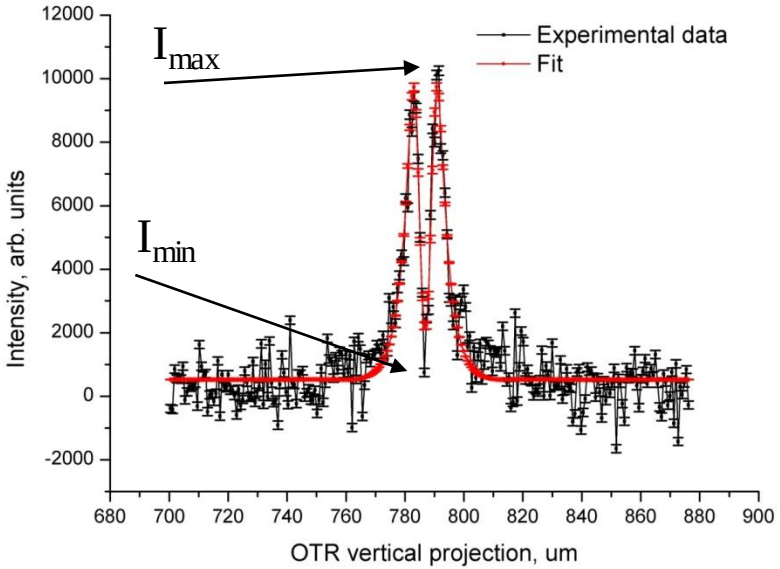
Alta E4000, ~ 55% Q.E., 7.4 um/pixel

SBIG ST 8300 MT, ~ 50% Q.E., 5.4 um/pixel

OTR image and OTR PSF-like Fit function

$$f(x) = a + \frac{b}{1+\left[c(x-\Delta x)\right]^4}\left[1 - e^{-2c^2\sigma^2}\cos\left[c(x-\Delta x)\right]\right]$$

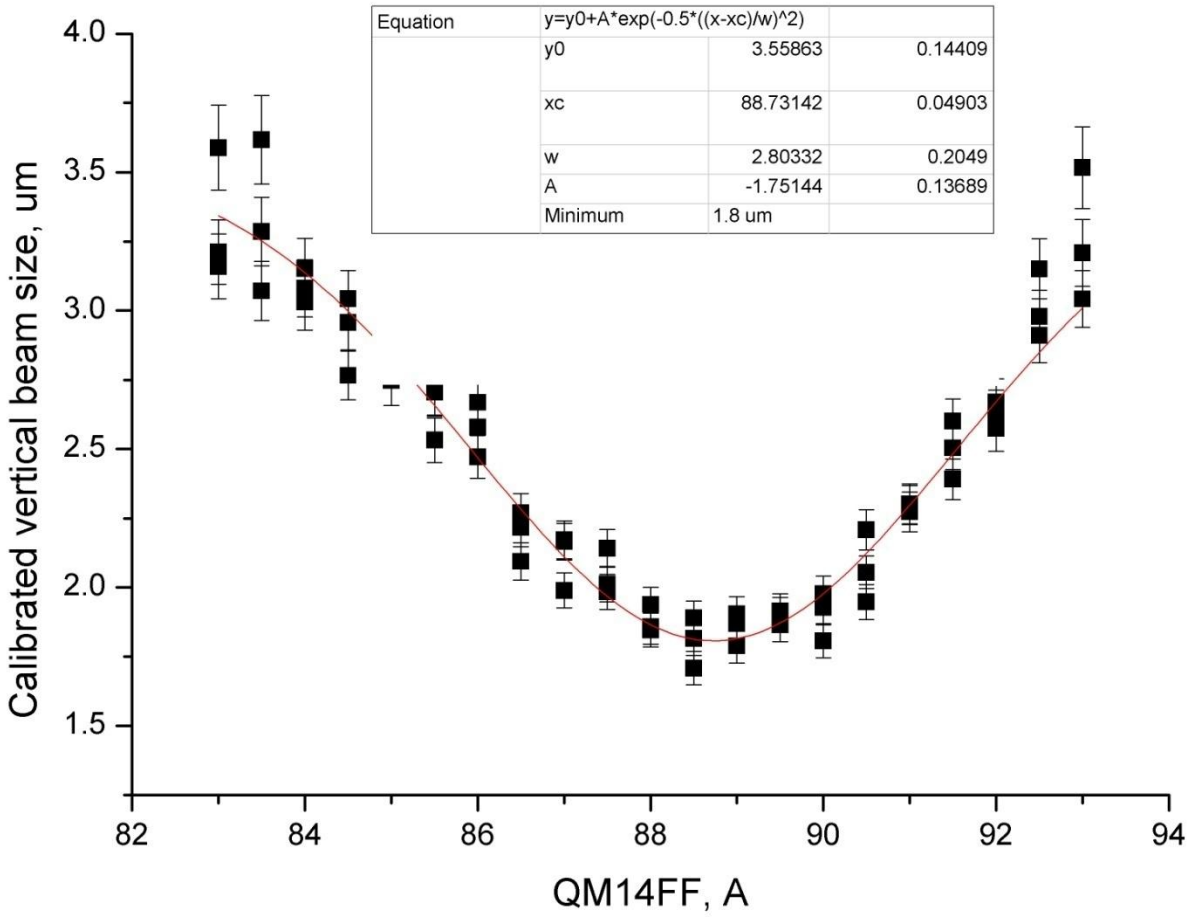




$$\Delta f(x) = \sqrt{\sum \left(f(x)'\right)_i^2 \cdot \Delta_i^2}$$

a	522.981 +/- 4.43887
b	37773.1 +/- 116.182
c	0.231221 +/- 0.00049
Δx	786.905 +/- 0.00679
σ calibrated	1.28202 +/- 0.0479

04.11 Quadrupole scan



Future Plans and Improvements

- Simulations of the Point Spread Function and further optimization together with CERN colleagues
- Project approved by ATF2 Technical Board. From the minutes:

"The TB is certainly very supportive of this initiative, which is in the spirit of the collaboration, could bring practical benefits to diagnose the ATF2 beam and moreover will foster our collaboration with CLIC-CTF3 physicists."

- Try thinner lens with smaller diameter: d=12.7mm and a concave mirror

UV/X-ray Diffraction Radiation for non-intercepting beam size measurement

L. Bobb[1, 2], T. Aumeyr[1], M. Billing[3], R. Jones[2], P. Karataev[1], T. Lefevre[2], M. Palmer[3], H. Schmickler[2]

1. John Adams Institute at Royal Holloway, Egham, Surrey, United Kingdom
2. CERN European Organisation for Nuclear Research, CERN, Geneva, Switzerland
3. Cornell University, Ithaca, New York, USA

Project aim:

To design and test an instrument to measure on the micron-scale the transverse (vertical) beam size for the Compact Linear Collider (CLIC) using incoherent Diffraction Radiation (DR).

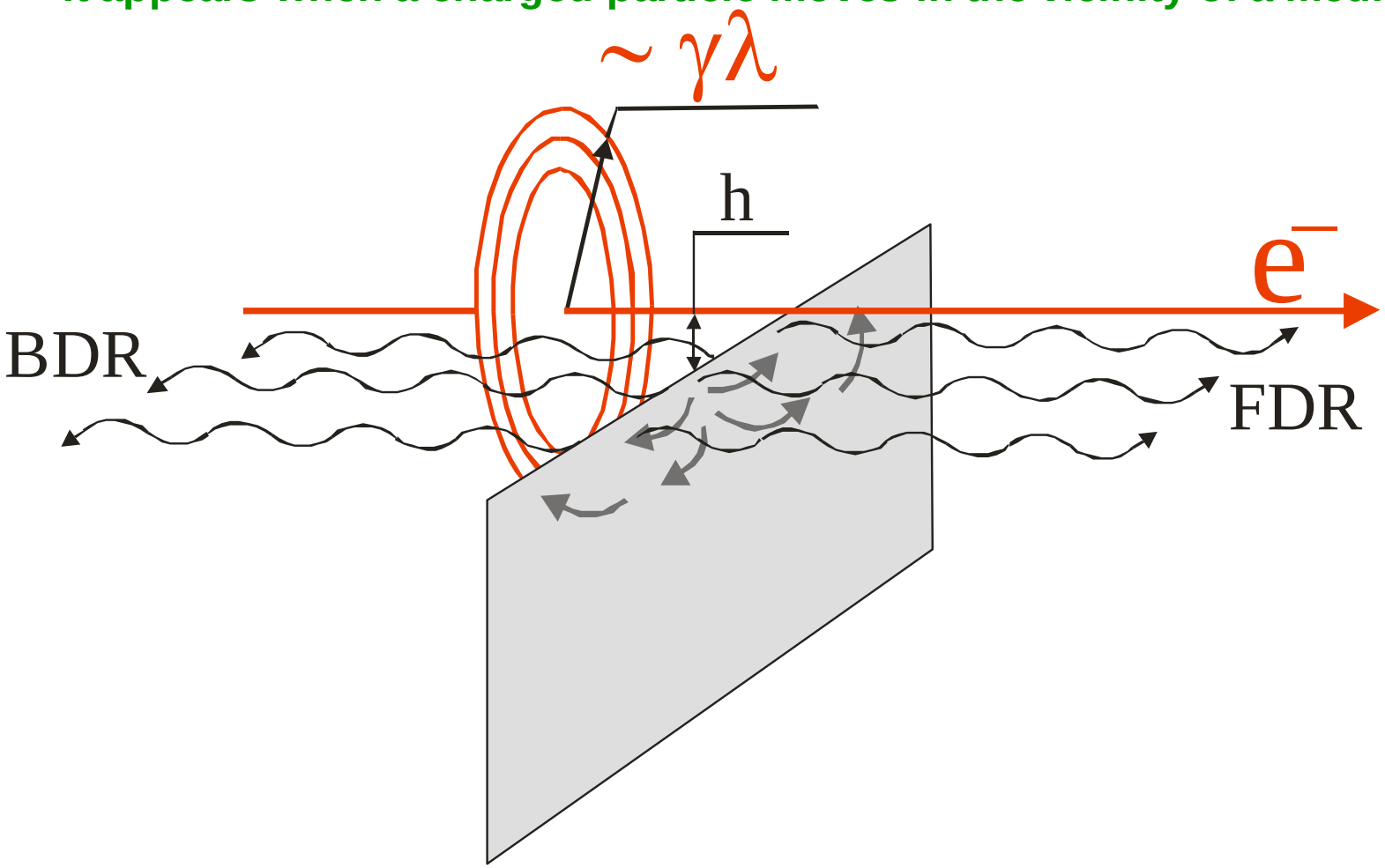
Schedule:

- Manufacturing of the setup (July 2012)
- Installation in L3 straight section CESRTA (~5th August 2012)
- Beam and operational test (~25th August 2012)
- Phase 1: DR experiment (25th Nov- 20th Dec 2012)
- Phase 2: DR experiment (Summer 2013)

E (GeV)	β_H (m)	σ_H (μm)	β_V (m)	σ_V (μm)	
2.1	38	320	8.7	~9.2	← 2012
5.3	23	2500	2.5	~65	

Diffraction Radiation

It appears when a charged particle moves in the vicinity of a medium



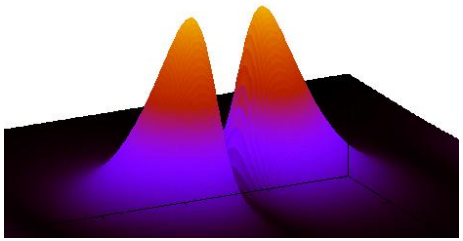
Impact parameter, h, – the shortest distance between the target and the particle trajectory

$$h \leq \gamma\lambda$$

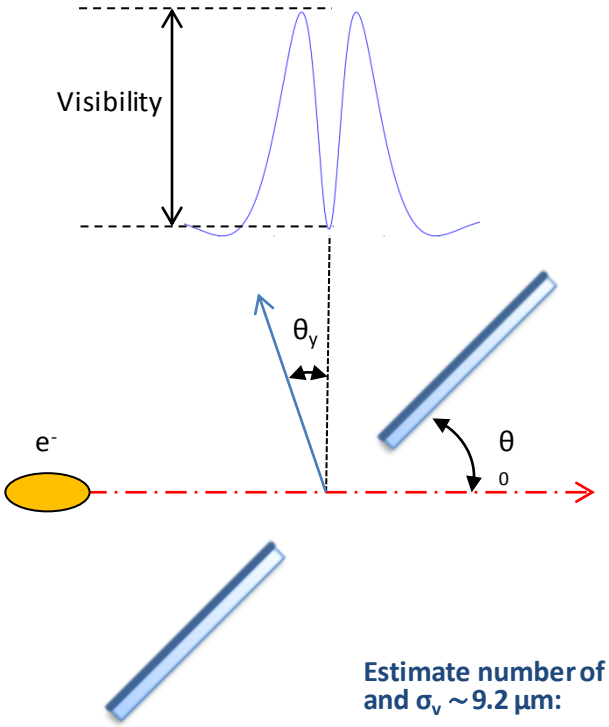
λ - observation wavelength

$\gamma = E/mc^2$ – Lorentz - factor

Basic concept of DR beam size measurement

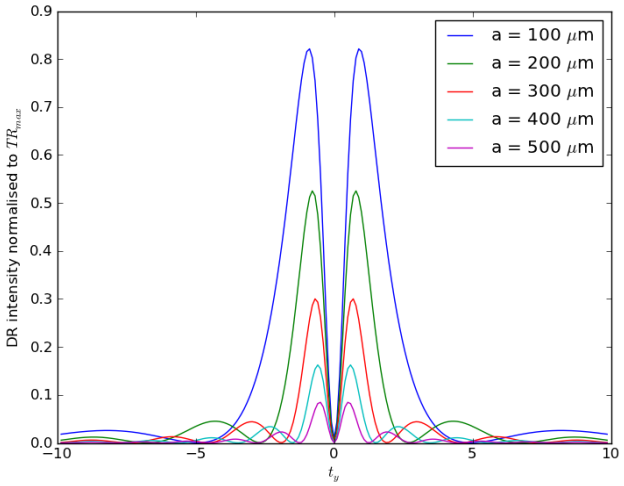


DR Angular distribution



Principle:

1. Electron beam moves through a high precision co-planar slit in a conducting screen (Si + Al coating).
2. Electric field of the electron beam polarizes the screen surface which emits radiation in the direction of specular reflection.
3. Visibility of the vertical polarization component of the DR angular distribution is sensitive to vertical beam size.

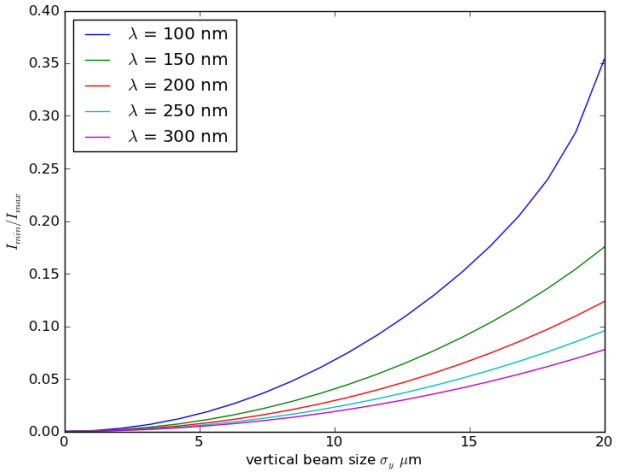


Max intensity is the Transition Radiation (TR_{max}) case when a = 0:

DR observation wavelength: λ = 200 nm
Slit size a = 100 μm
$t_y = \gamma\theta_y$

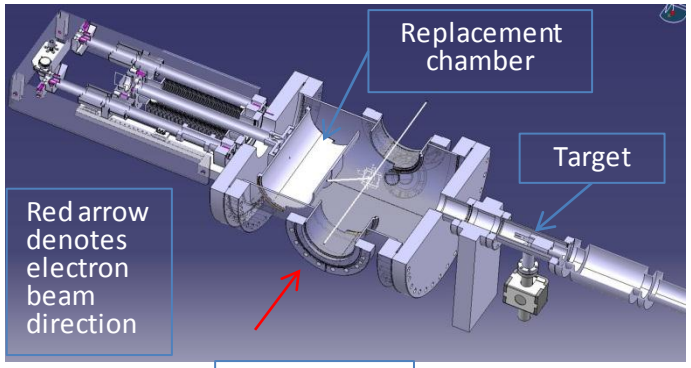
Synchrotron radiation (SR):

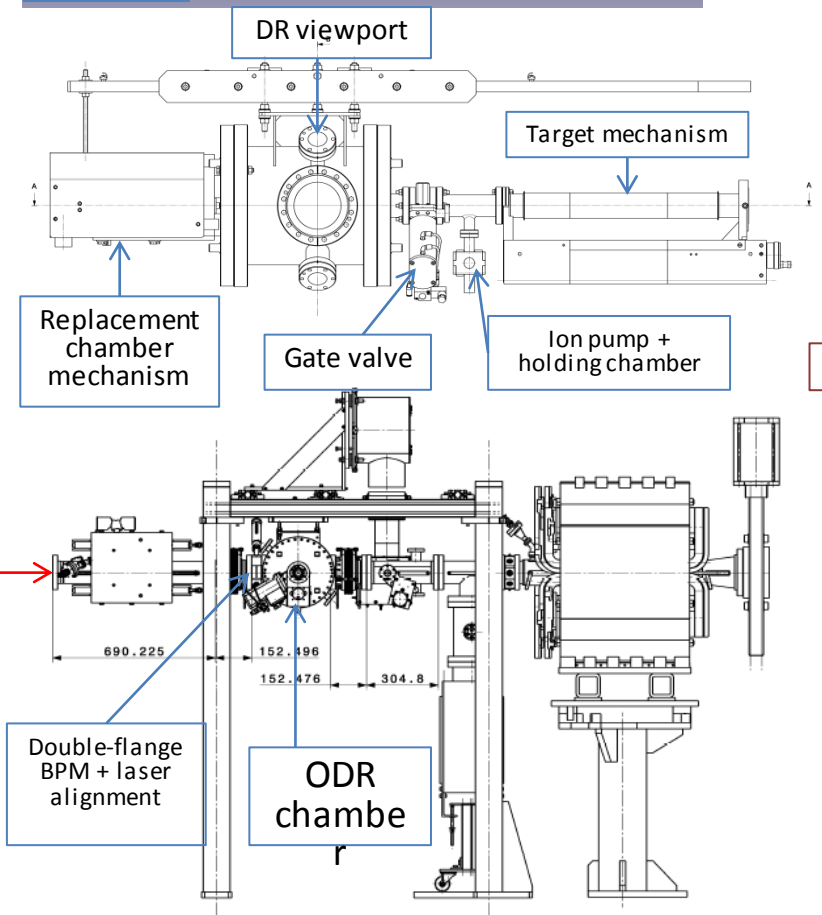
- Main contributor to background
- A mask will be used to reduce SR incident on the target. This will have a similar design to the target with a larger slit width.



Estimate number of DR photons per e⁻ for a = 100 μm, λ = 200 nm and $\sigma_y \sim 9.2$ μm:

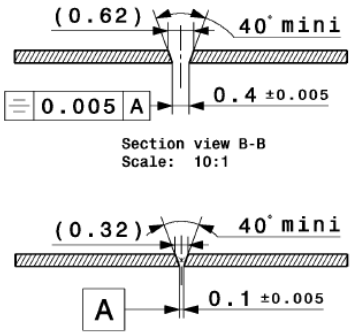
Current status

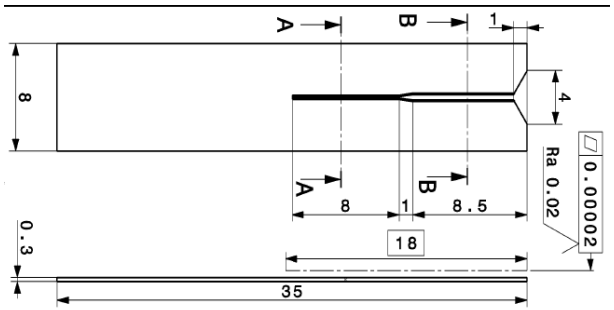




- Drawings are in final stage to launch manufacture at CERN (April 2012)

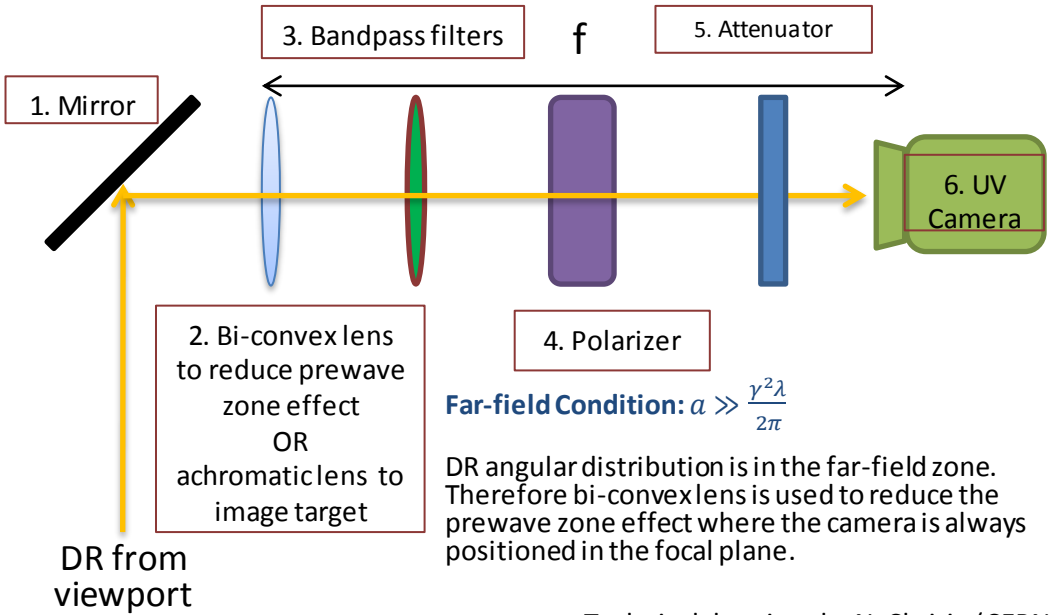
Target with slit to generate DR





Optical system schematic:

1. To image the target
2. To obtain DR angular distribution



Far-field Condition: $a \gg \frac{\gamma^2 \lambda}{2\pi}$

DR angular distribution is in the far-field zone. Therefore bi-convex lens is used to reduce the prewave zone effect where the camera is always positioned in the focal plane.

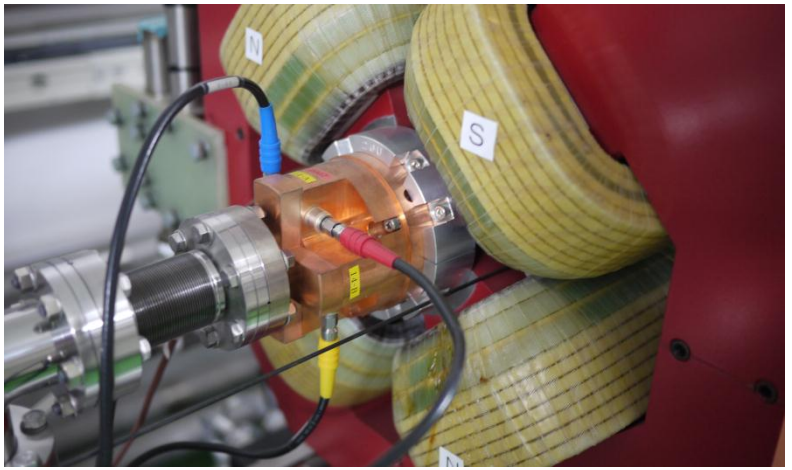
Technical drawings by N. Chritin (CERN)

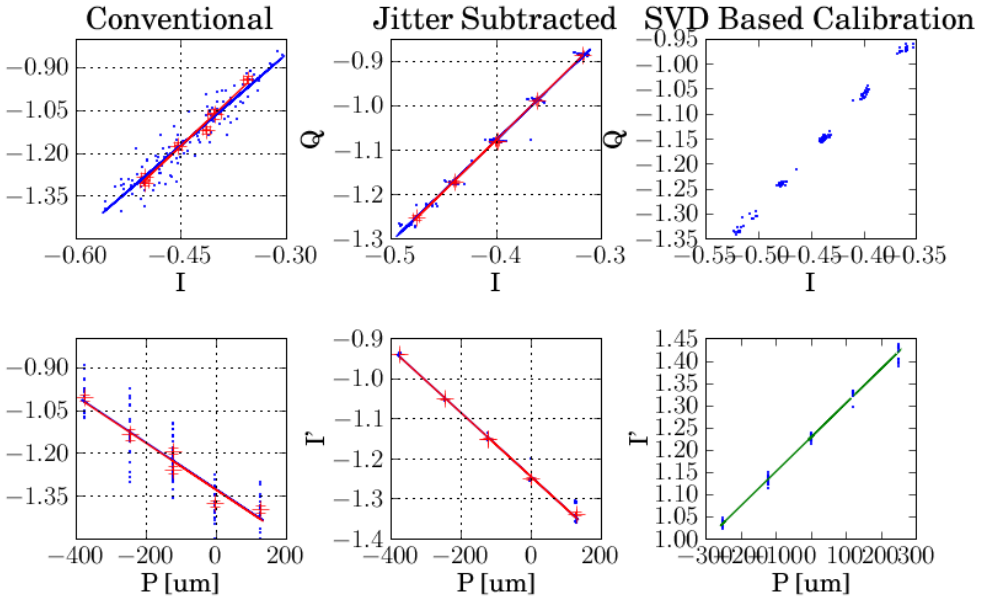
Cavity Beam Position Monitors

A. Lyapin, S. Boogert, G. Boorman, F. Cullinan, N. Joshi, J. Towler (JAI/RHUL, UK)
A. Morgan, G. Rehm (Diamond Light Source, UK)
M. Ross (Fermilab, USA)
A. Aryshev, Y. Honda, T. Tauchi, N. Terunuma, J. Urakawa (KEK, Japan)
A.-Y. Heo, E.-S. Kim, H.-S. Kim, Y. I. Kim (KNU, Korea)
J. Frisch, D. McCormick, J. Nelson, T. Smith, G. White (SLAC, USA)

ATF2 BPM system

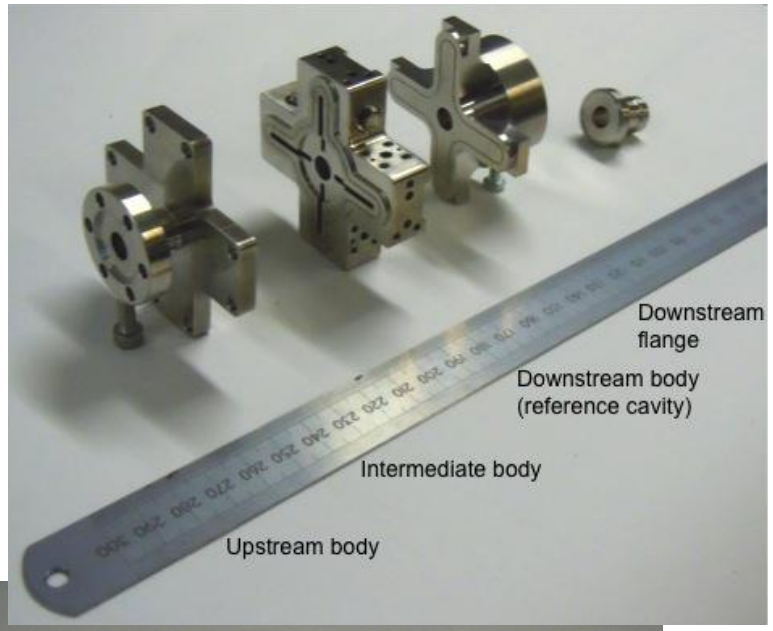
- 44 BPMs
  - 36 C-band, 4 S-band, 4 IP
- Resolution
  - 20 to 30 nm
- Calibration takes 8-12 hours
  - Complex lattice
  - Low repetition rate
- Beam jitter significant during calibration
  - Developed mitigation methods





CLIC Main beam BPM

- Requirement
  - 50 nm
  - 100 MHz
- Stainless steel prototype
  - f = 15 GHz
  - Q = 200 – 500
- Based on FNAL design
- Plans
  - Brazing now
  - Electronics and digitisation being developed
- Beam test at CERN, summer 2012



- CERN+RHUL+FNAL+SLAC collaboration
- Initial design made by FNAL
- Prototype fabricated by CERN

- Measurements at RHUL
- Electronics design for the test almost done
- F. Cullinan, a RHUL PhD student is now at CERN for a long-term attachment to work on the beam tests of the prototype

Summary

- LW system
  - Improve data analysis
  - Continue the measurements and beam physics studies
  - Optimize the optical system for sub-micrometer OTR system
- X/UV DR system
  - Manufacture the hardware and achieve the fist experimental results towards the end of the year
- Cavity BPM
  - Start the beam tests at CTF3 later this year