PETRA laserwire update

BESSY

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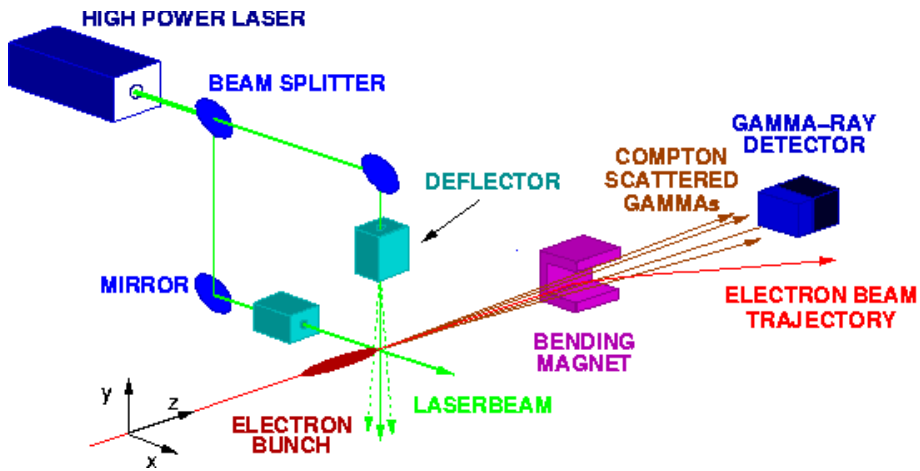
Introduction

- Non invasive Beam size measurement essential for linear collider
  - Determination of beam emittance
  - Wire-scanners will not withstand the beam intensity
- Laser-wire
  - Compton scattering of laser light from electron beam
  - Measure rate of either
    - Compton photons (colinear with particle beam)
    - Degraded electrons (does not require a beam bend)
  - Investigate technology for deployment at light sources and ILC
    - Test system at PETRA
    - Develop technologies required
      - Scanner
      - Laser



$$N_C = N_b \frac{P_L \sigma_C \lambda}{c^2 h} \frac{1}{\sqrt{2\pi}\sigma_s} \exp\left(\frac{-y^2}{2\sigma_s^2}\right)$$

P = 2 MW

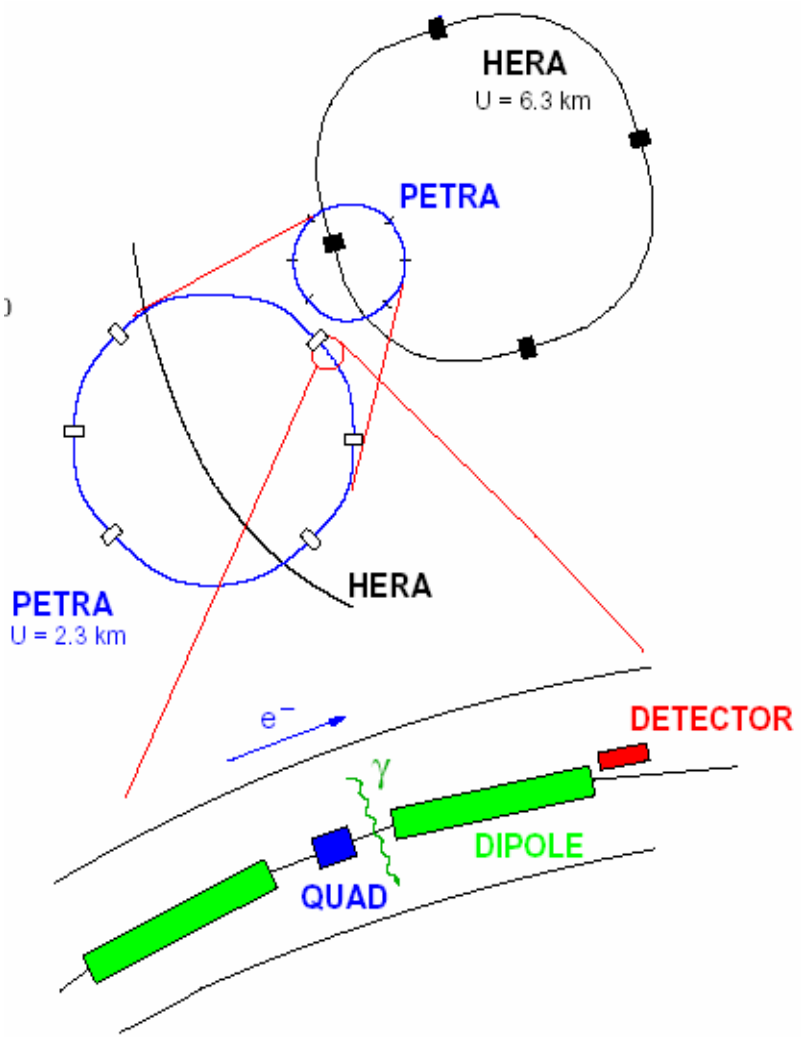
σ_x/σ_y [μm]	Beam Energy [GeV] 4.5	7	12
500/50	115/689	257/664	685/619
300/30	185/1111	416/1070	1056/998
100/10	415/2485	930/2393	2362/2231

E_{tot}[GeV]/N_γ

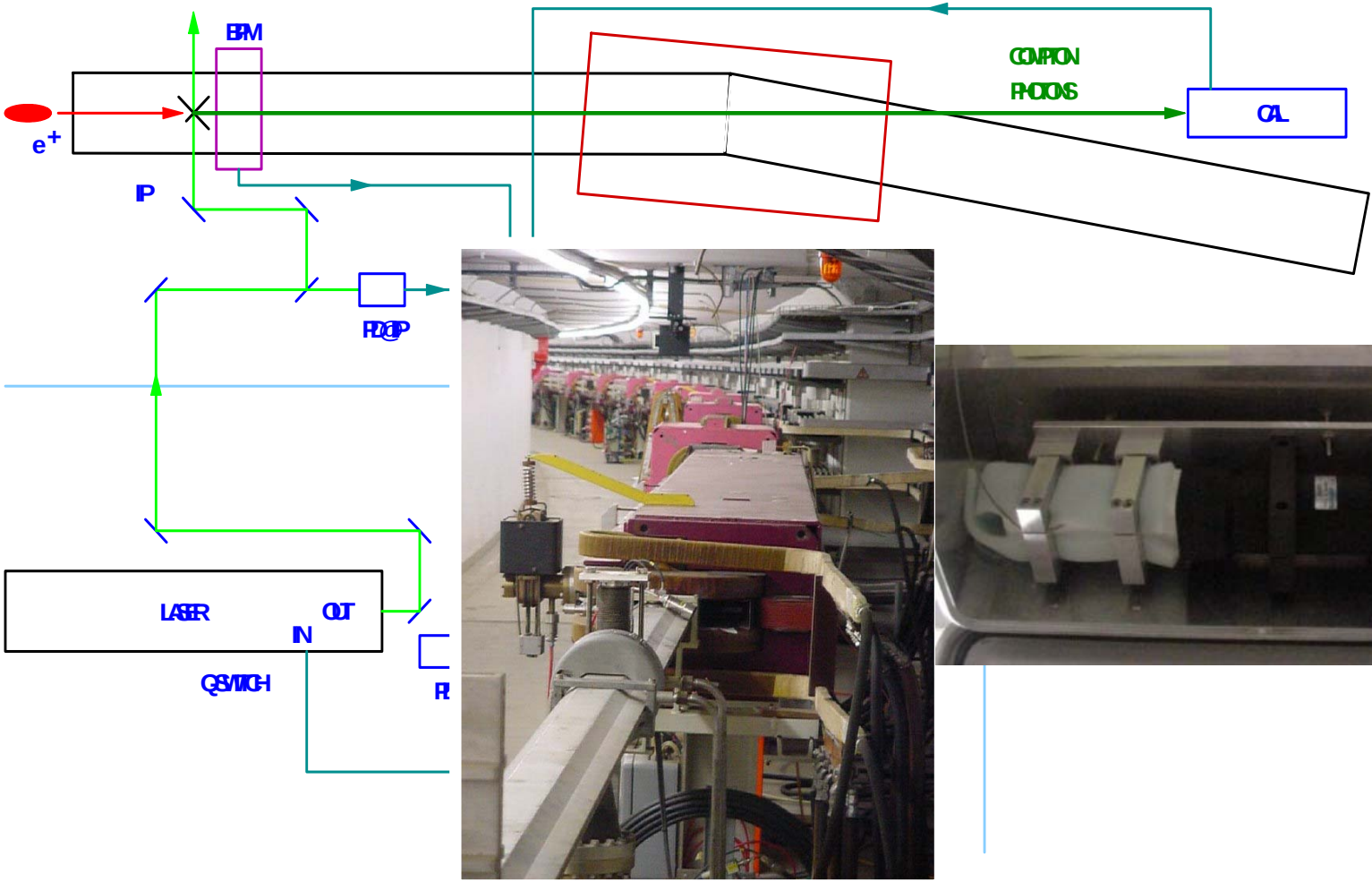
PETRA accelerator

- Positron Electron Tandem Ring Accelerator
- Long free straight section
- Easy installation of hardware due to existing access pipe and hut outside tunnel area
- New IP chamber with viewports and button BPM
- Dedicated beam time between HERA fills

Energy	E/GeV	4.5 to 12
Bunch Length	σ_z/ps	~100
Charge/bunch	nC	3 to 20
Hor. beam size	σ_x/μm	1000 to 100
Ver. beam size	σ_y/μm	100 to 10

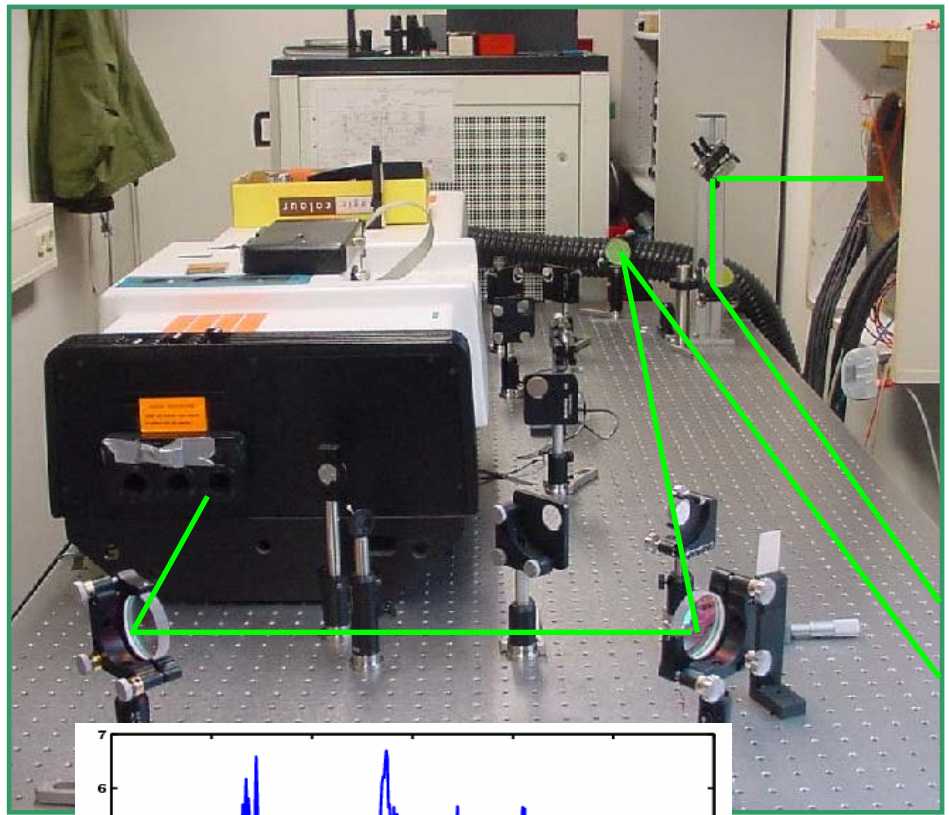


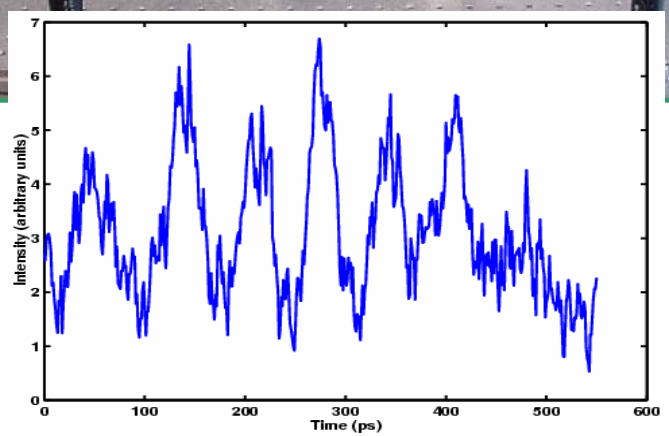
Overview of PETRA system



Laser

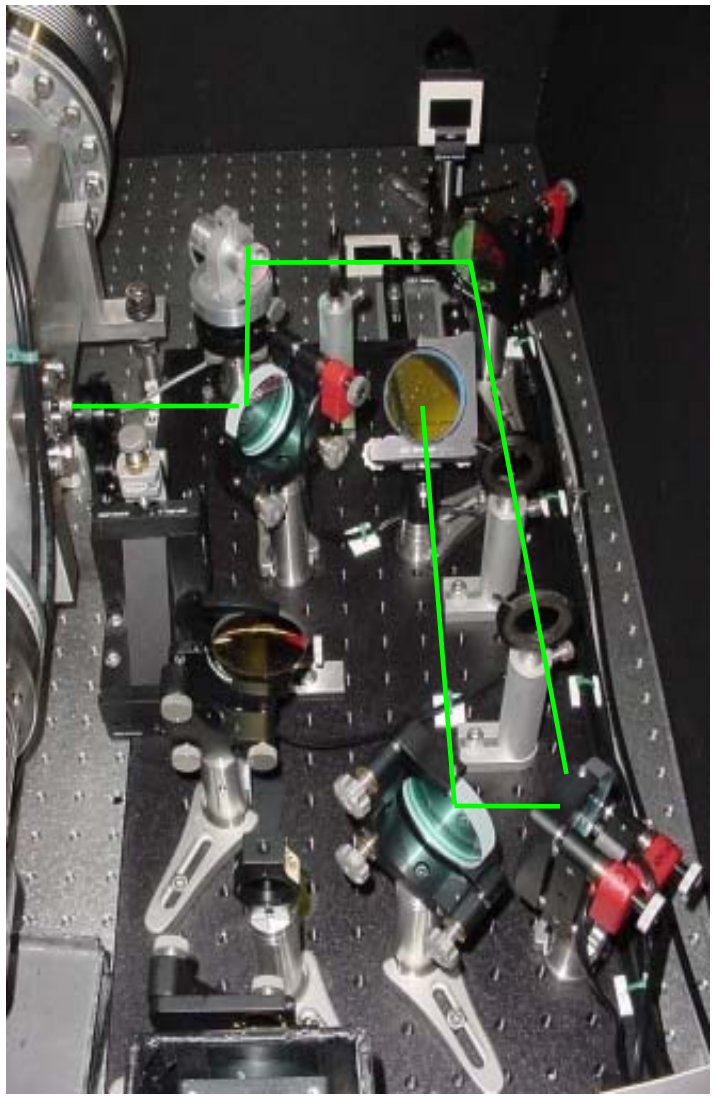
- Re-claimed from CERN, LEP polarimeter (B. Dehning)
- Q-switched Nd:YAG with SHG
- Complete refurbishment at Oriel workshop, new YAG crystal
- External trigger unit CERN/RHUL enabling synchronisation with PETRA timing
- Transverse mode quality poor with M^2 ~ 10 to 15
- Longitudinal mode quality ± 20%, mode beating with picosecond substructure
  - ~60 ps

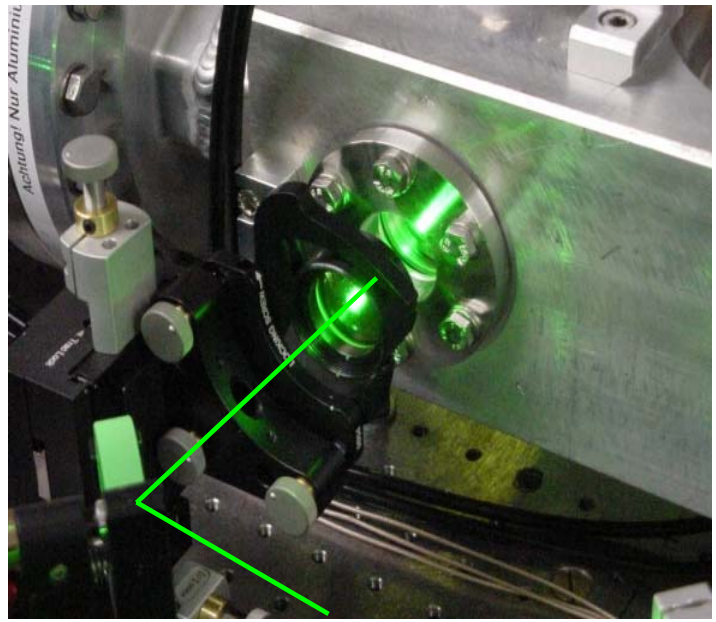




Wavelength	λ/nm	1064/532
Energy	E/mJ	250/90
Pulselength	dt/ns	10
Rep rate	f_{rep}/Hz	up to 30
Beam size	$\sigma_{x,y}$	≤ 1 mm

Focusing and scanning optics

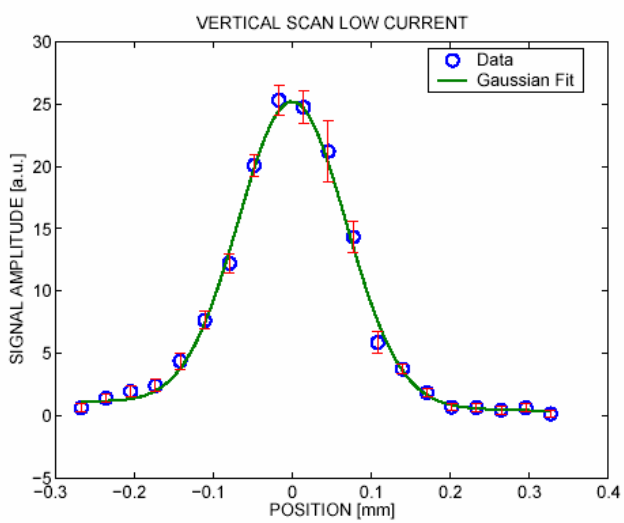


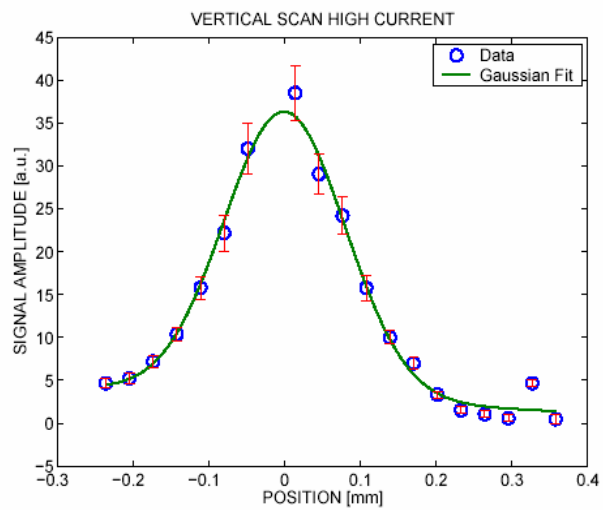


- Scanner
  - Piezoelectric tilt platform from PI
  - Angular tilt range
    - ±2.5 mrad
- LAP125 focusing lens from CVI
  - CCD measurements indicate laser beam size at IP
    - σ=36μm

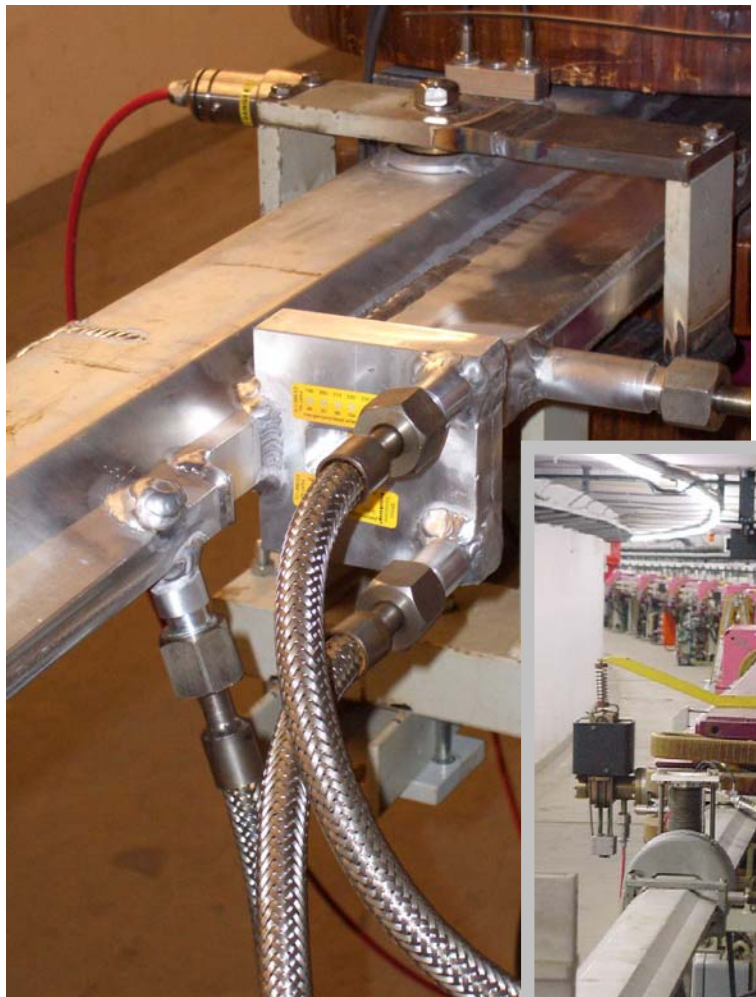
Previous measurements (Dec 2003)

- Two runs 7 GeV
  - Bunch pattern 14 x 1 bunch evenly filled
  - Low current
    - 7.1 mA, first bunch 0.458 mA
  - High current
    - 40.5 mA, first bunch 2.686 mA
- Sloped Background + Gaussian signal, approximation of beam shape
  - σ_m = (68 ± 3 ± 14) μ m at low current
  - σ_m = (80 ± 6 ± 16) μm at high current
- Manual control of scanner and DAQ systems
  - Single scan took ~30 minutes





New beam pipe window



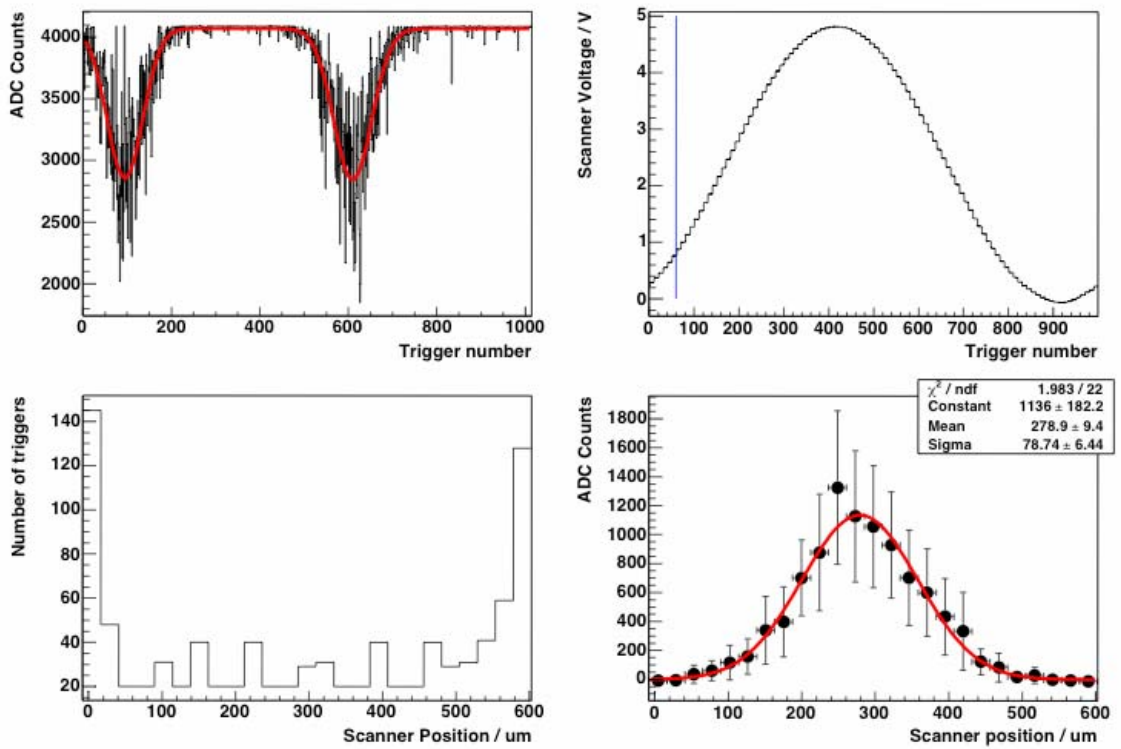
- Calorimeter energy spectrum indicated that the photos produced at the IP were not reaching the detector
  - Geant 4 simulation of the beam pipe, detector and Compton process,
- Need for a new vacuum pipe with window for Compton photons
  - Installed Janurary
  - Difficult job due to beam pipe curvature and SR heat load on the window
  - Solution found with impressive welding!
  - **Big thanks to DESY**

New data (Feb 2005)

- Improvements in the last year
  - Upgraded data acquisition system
  - Laser improvements and fixes
    - Temporary repair for cracked window
    - Resonator rear mirror tuned
- New data from the last few days
  - 11/02/05
    - First fast scans with piezo electric deflector
  - 16/02/05
    - More automated DAQ
    - Included BPMs into readout
    - Bump scan to cross check
  - 17/02/05
    - Included Photodiode in tunnel
    - CCD cameras monitoring a second IP-like laser focus
- Data taking procedure
  - Trigger
    - Laser trigger sequence derived from PETRA bunch clock and revolution clocks (131kHz)
    - Trigger piezo movement from laser trigger (30Hz)
  - Move piezo to new angle
  - Take data with
    - Compton calorimeter
    - Local BPM
    - CCD cameras
    - PETRA (bunch currents etc)
  - Drive scanning platform though full sinusoidal oscillation taking data
- Problems gating the digitisation on the calorimeter compared with scanner (see next slides)

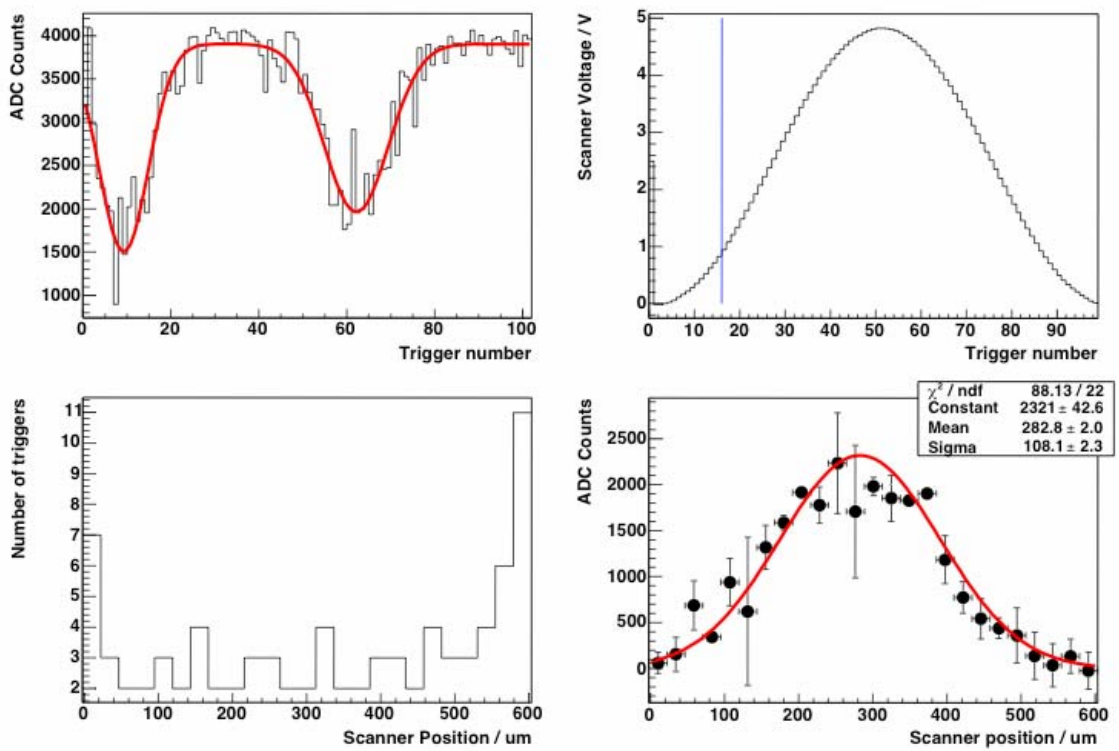
Fast scanning results (very preliminary)

- Data from 11/02/05
- PETRA conditions
  - 7 GeV, 1 bunch
- Scan
  - 100 scan points
  - 10 triggers/point
  - 33.3 second scan time
- Calorimeter DAQ started late
  - Fix in data by fitting the (two) peaks in Compton signal as a function of trigger number.
  - The mean of the two gives the anti-nodes of the scanner oscillation
  - Bin signal in laser beam position
- Result of preliminary analysis
  - **σ_m=78.8±6.4 μm**



Fast scanning! (very preliminary)

- Data from Wednesday 16/02/05
- PETRA conditions
  - 7 GeV, 1 bunch
- Scan
  - 100 scan points
  - 1 triggers/point
  - 3.33 seconds for whole scan
- Clear signal observed
  - Thanks to the new window
- Analysis as before
- Result
  - σ_m=108.1± 2.3 μm
  - Slightly larger beam size than slower scan



Summary and future plans

- First runs with fast scanning and new beam pipe window
  - Very promising first results
  - Not all the data has been analyzed
    - BPM measurements
    - Orbit bump scan
    - CCD measurements
  - More routine data analysis
- Results
  - Scan consistent with results of over one year ago
  - Faster scan indicates larger electron beam size (real effect or artifact of measurement?)
- More detailed analysis to come
  - Binning is rather inelegant method

- Future plans
  - Continue to automate the DAQ and analysis
    - Real diagnostic device opposed to developing experiment
  - Check travel range calibration
  - Upgrade laser
    - Q-switched or Mode locked
  - Vertical optical system
    - Measure both vertical and horizontal beam sizes
    - No need for beam bump
  - PETRA 3
    - Excellent diagnostic for light sources
    - Investigating sites within PETRA

Many thanks to BKR and PETRA shift crews and DESY mechanical engineers