LBBD Laserwire

PETRA Laserwire Experiment Status and Outlook

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TESLA Meeting, APDG Working Group

16 January 2004

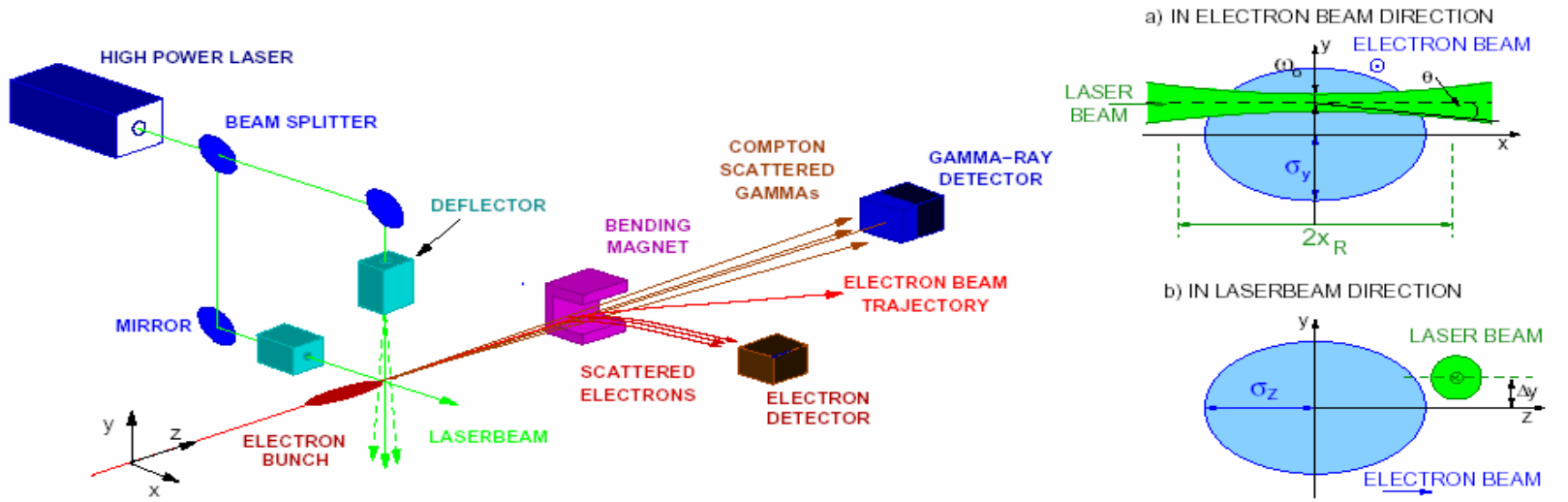
DESY Zeuthen

The next 20 minutes

LBBD Laserwire

- Motivation for the project
- Environment at PETRA
- Hardware Installation
- Laser parameter measurements
- First Compton signal
- First full profile measurements
  - with orbit bumps
  - using the fast scanner
- Plans for upgrade of PETRA Laserwire
- Conclusion and Outlook
- Discussion

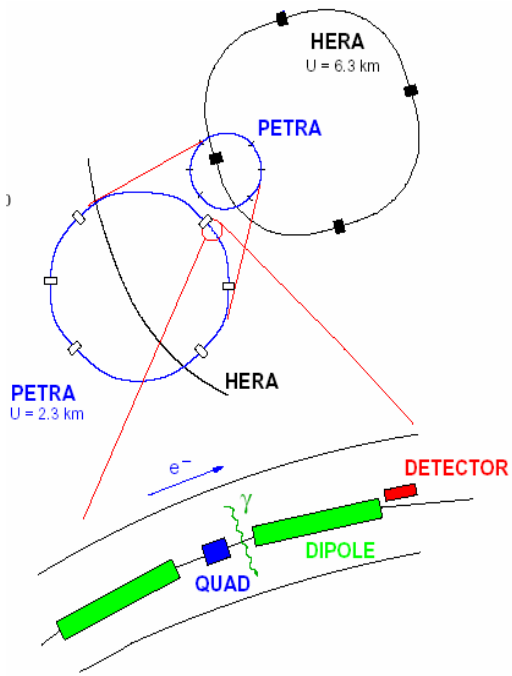
Laserwire Operation Principle



- Scanning of finely focused laser beam through electron beam
- Detection of Compton photons (or degraded electrons) as function of relative laser beam position yields electron beam profile
- Challenges
  - Produce scattering structure smaller than beam size in the µm range
  - Provide fast scanning mechanism for intra train scanning (TESLA 950 µs bunch train with 3000 bunches)
  - Achieve efficient signal extraction, detection and background suppression
  - Integration into beam delivery system of LC/FEL

Laserwire at PETRA

- Positron Electron Tandem Ring Accelerator
- Injector for HERA, upgrade to synchrotron light source
- Long free straight section in north-east sector
- Easy installation of hardware due to existing access pipe and hut outside tunnel area
- New IP chamber with viewports and BPM
- Dedicated run time between HERA fills
- Parasitic running during HASYLAB operation
- Training of people to run the machine, bumps



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

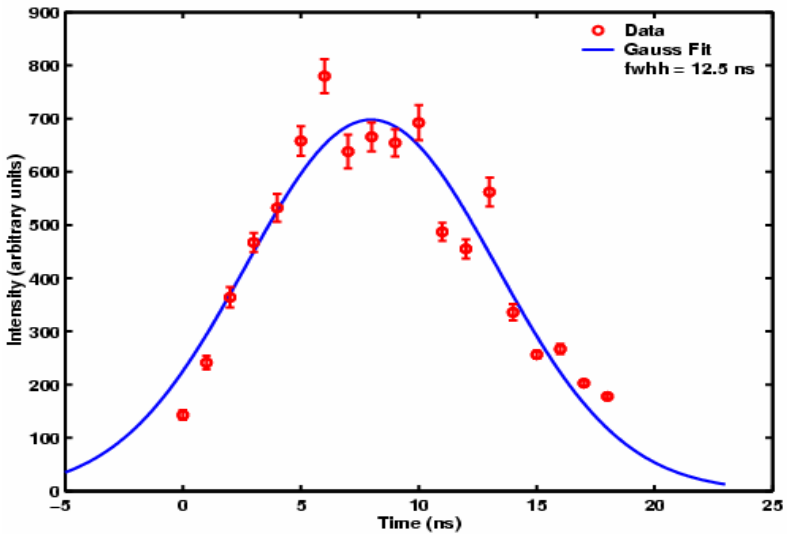
Laser

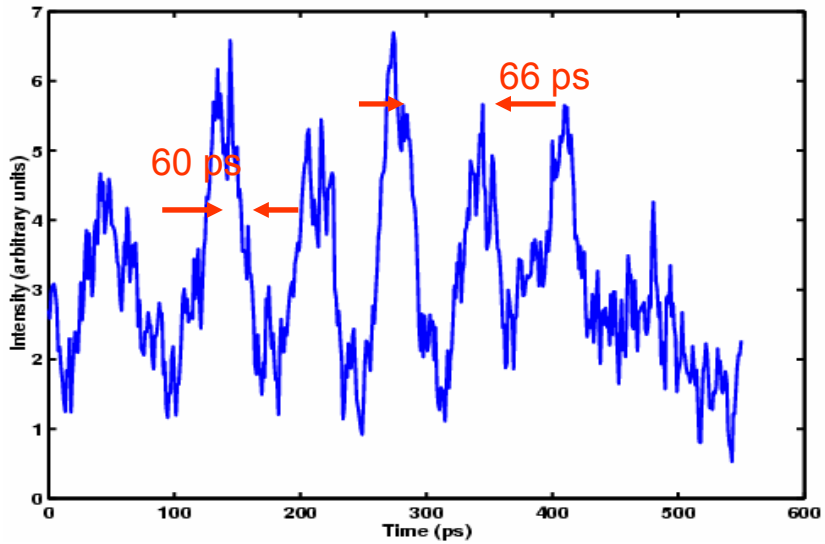
LBBD Laserwire

- Claimed from CERN, LEP polarimeter (B Dehning)
- Q-switched Nd:YAG with SHG
- Almost 20 years old
- Complete refurbishment at Oriel workshop, new YAG crystal
- External trigger unit CERN/RHUL enabling synchronisation with PETRA timing
- Transverse mode quality poor with $M^2 \sim 10$ to 15
- Longitudinal mode quality ± 20%, mode beating with ps substructure

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

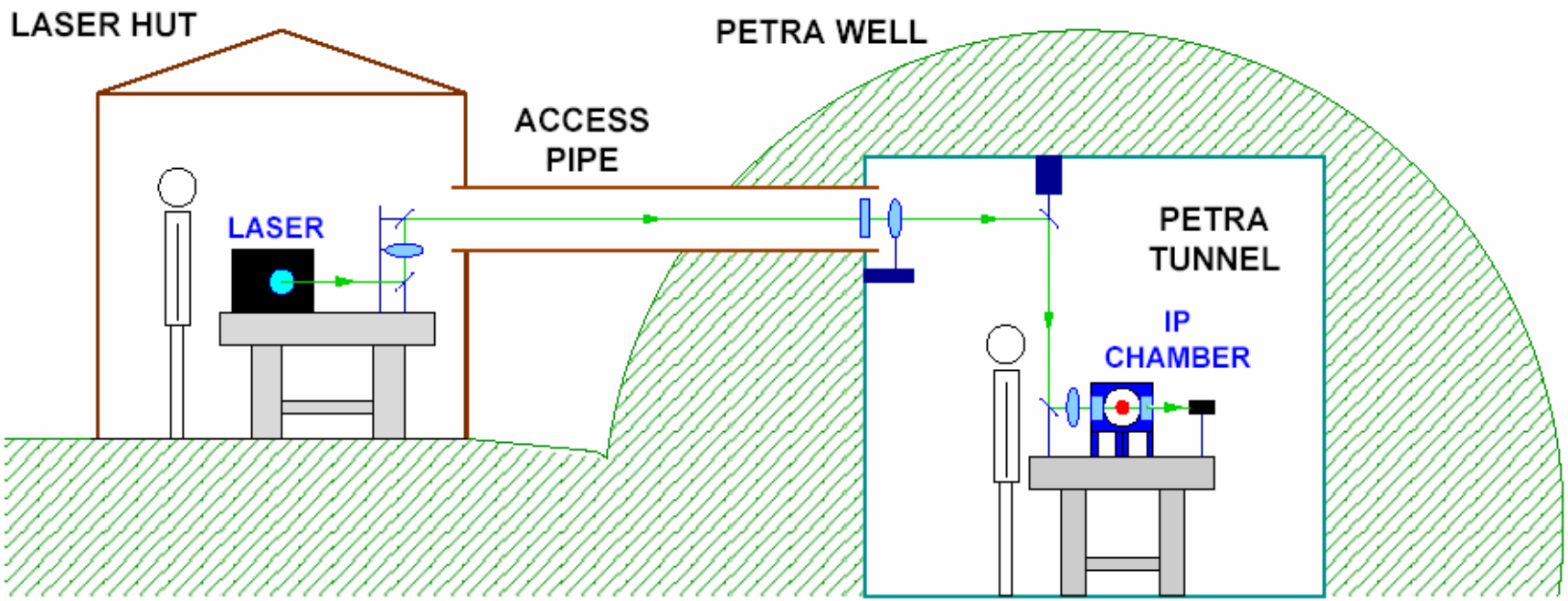
Laser Performance



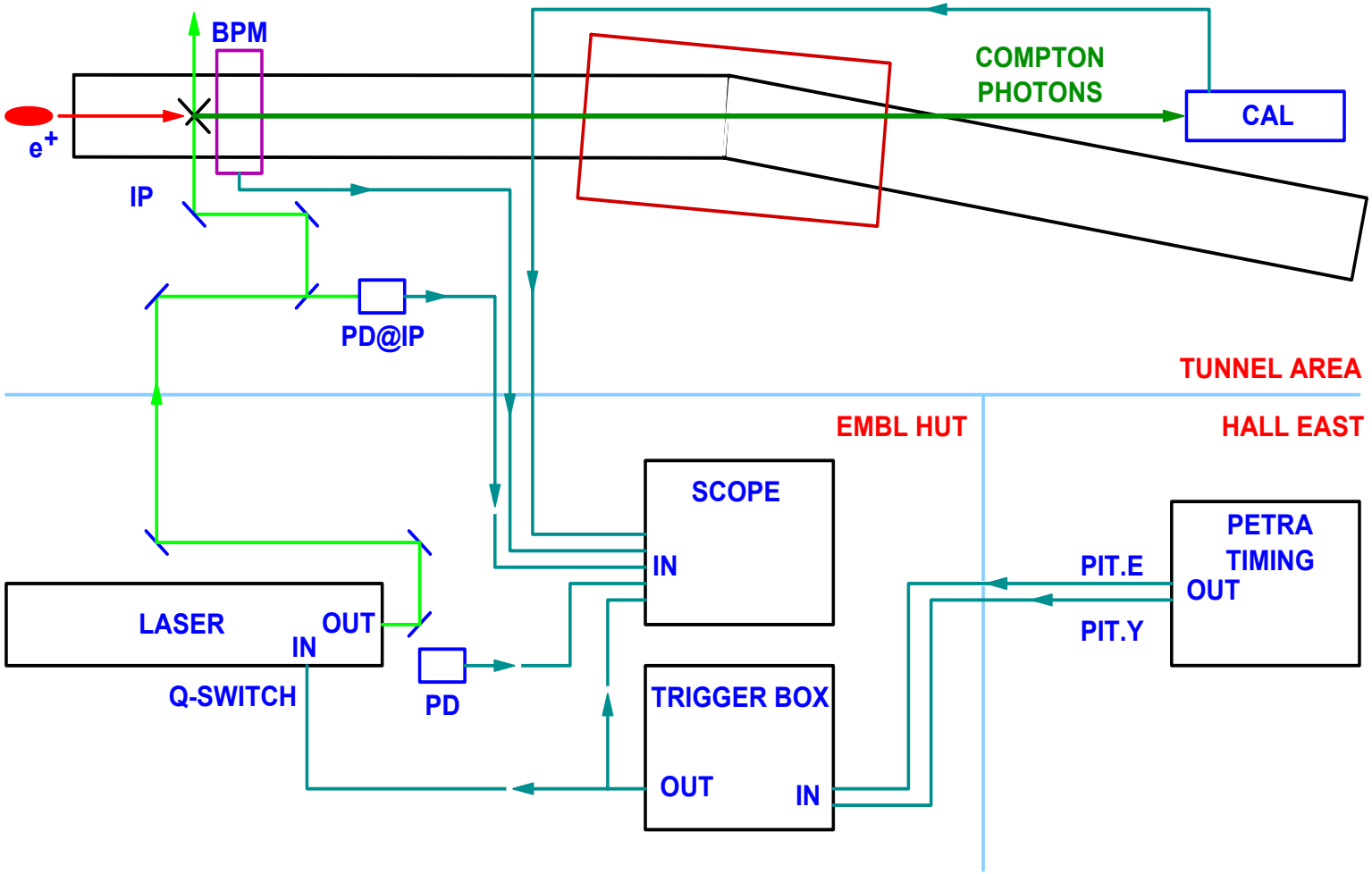


- Longitudinal profile measured with streak camera (Hamamatsu FESCA 200), triggered with laser pulse pickoff on photo diode
- Scan window of 200 ps width with 5 ps resolution moved over puls
- Envelope 12.5 ns pulse length (FWHH)
- Structure under envelope
  - almost full contrast, ~ 70 ps peak to peak, ~ 70 ps peak width
  - unstable, beating changes from shot to shot
- ➢ Need injection seed (mid to long term), or etalon (short term) to fix

Setup at PETRA

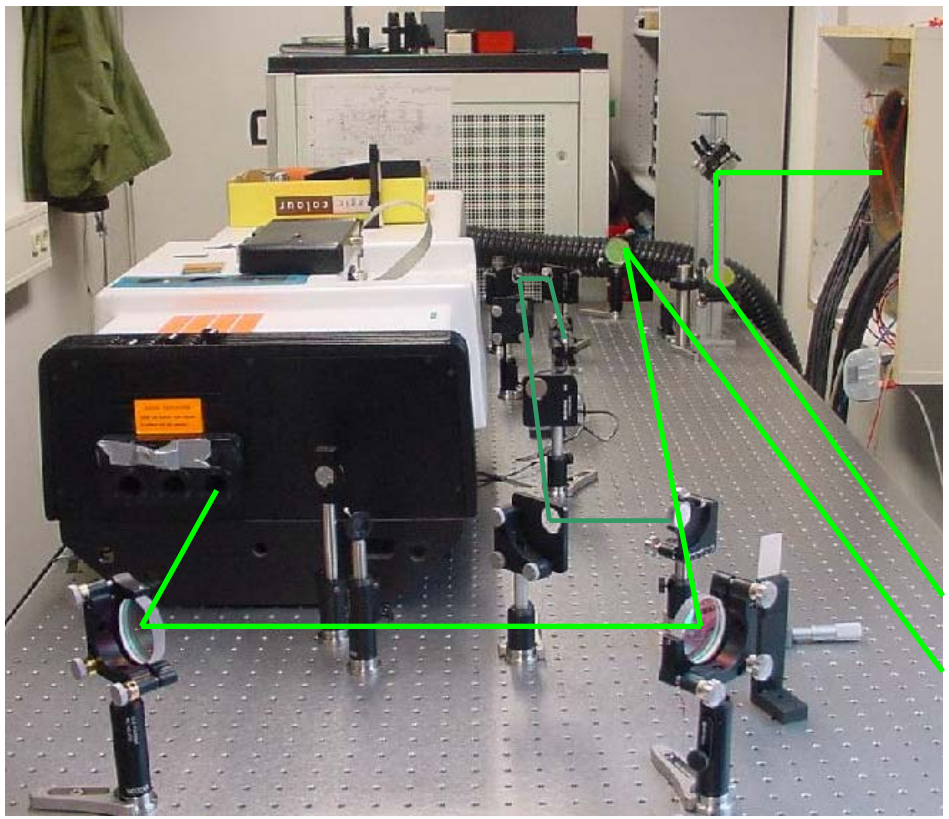


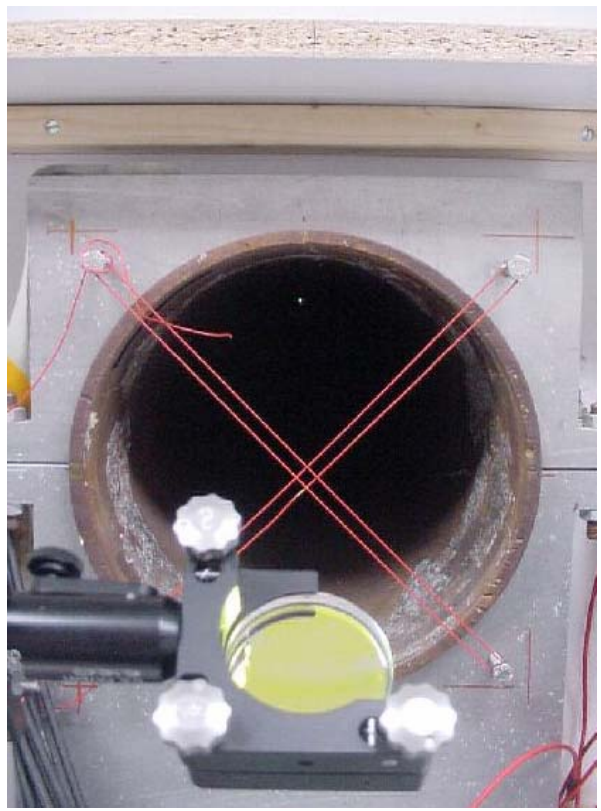
Setup at PETRA (cnt'd)



Installation at PETRA

LBBD Laserwire





Installation at PETRA

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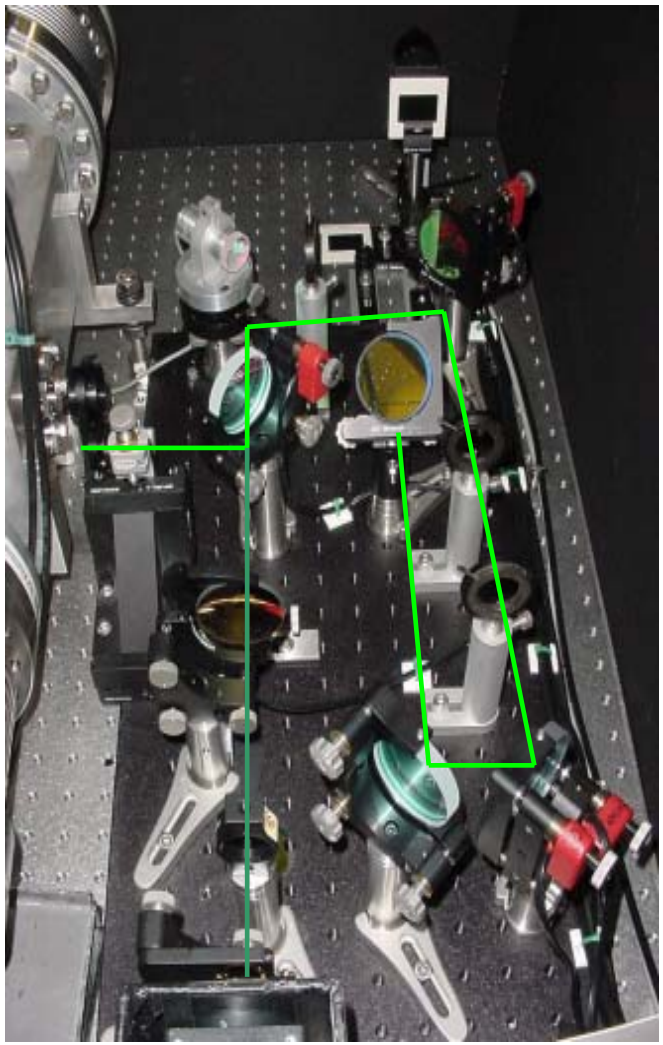
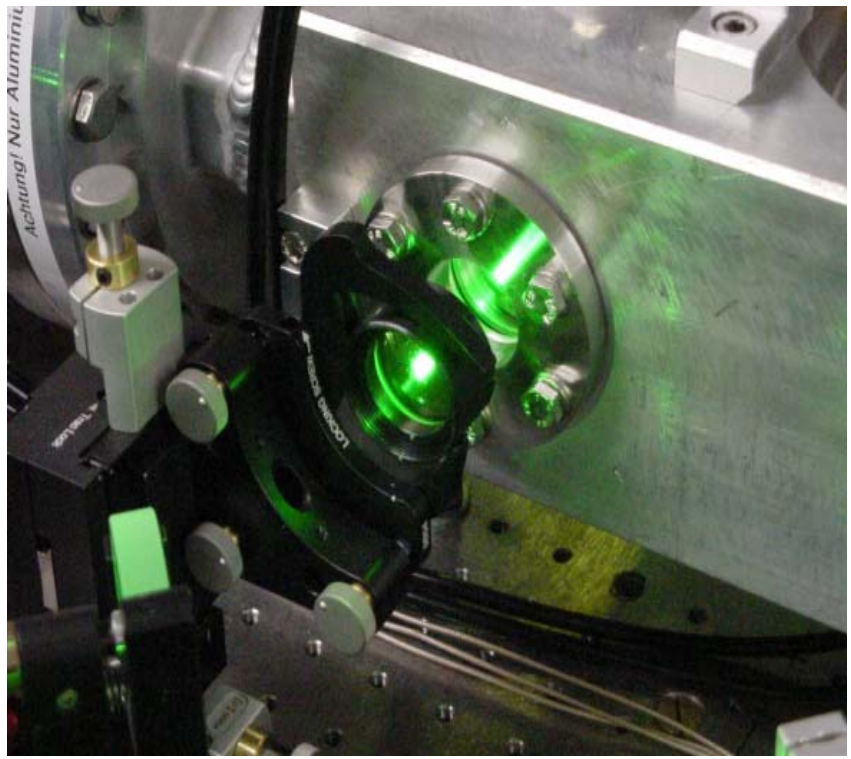
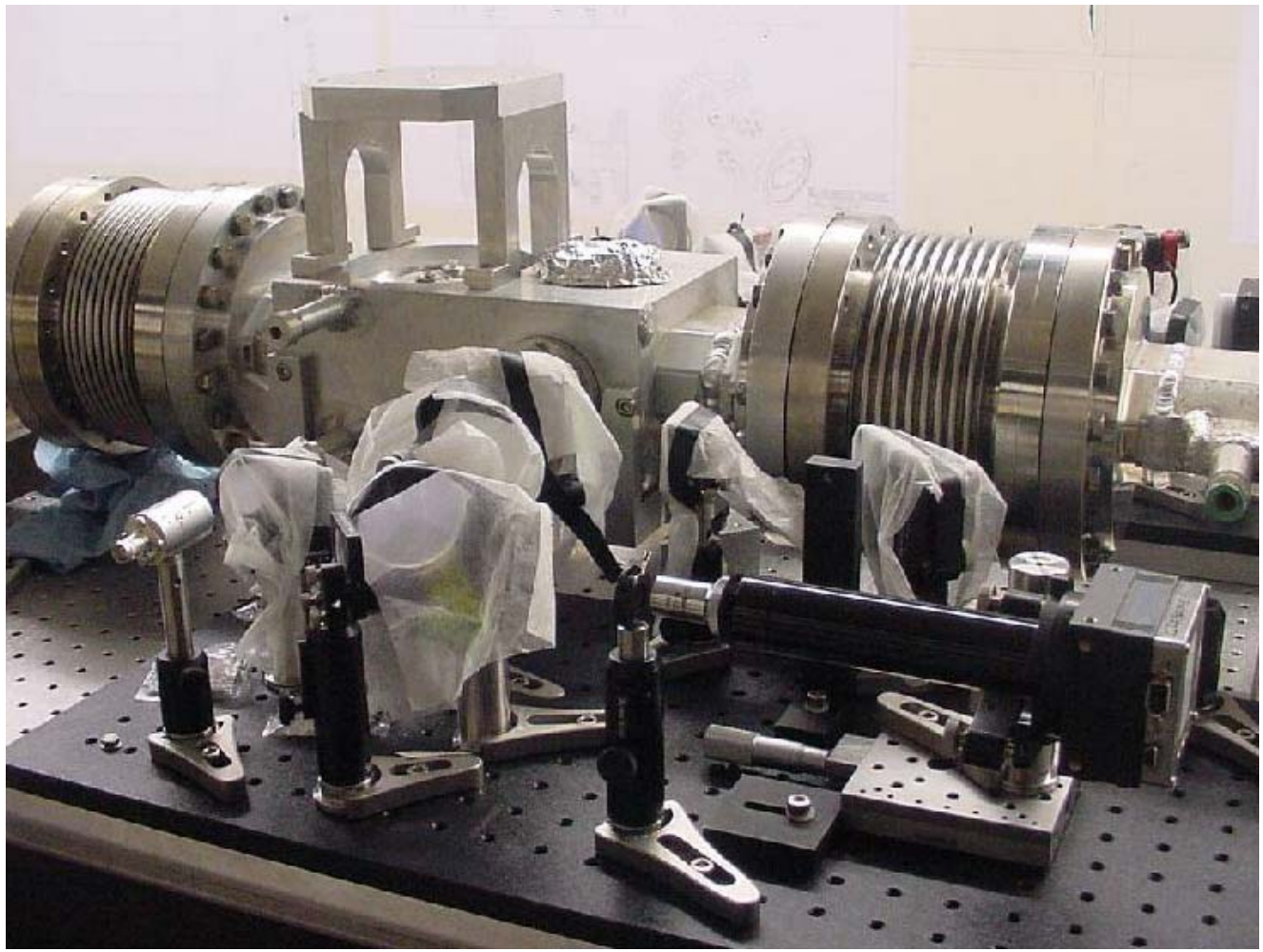


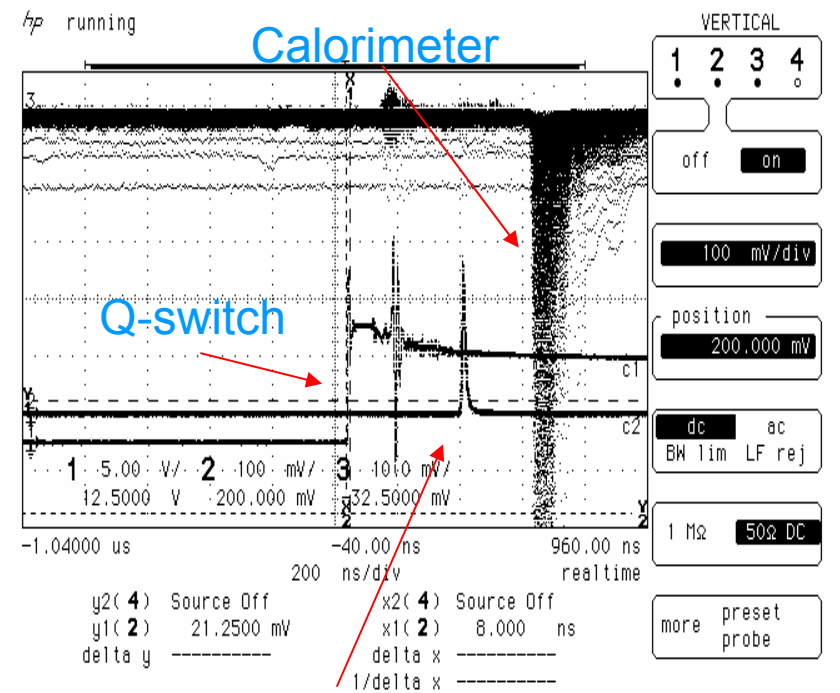


Installation at PETRA

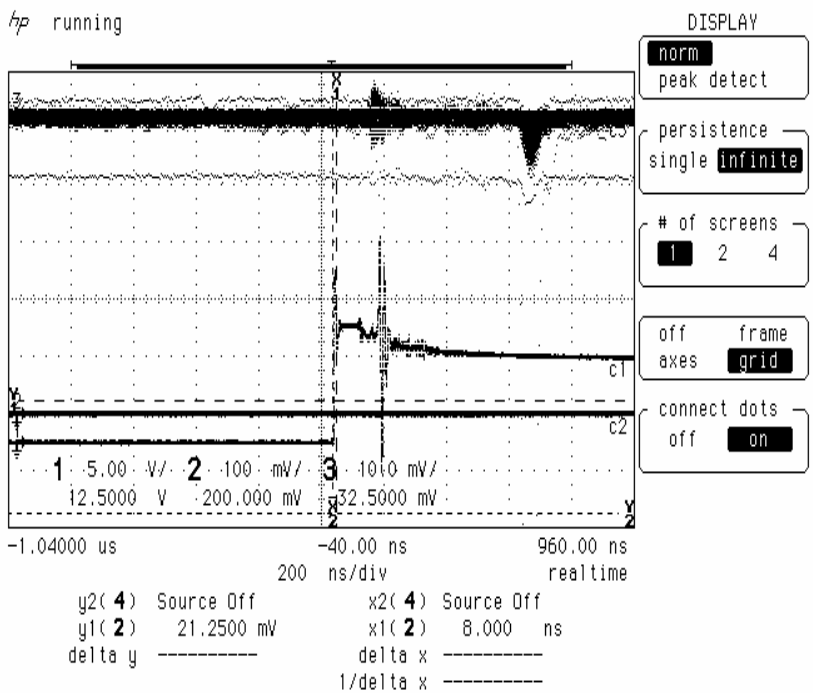


First Photons 31.07.03

Laser on



Laser off

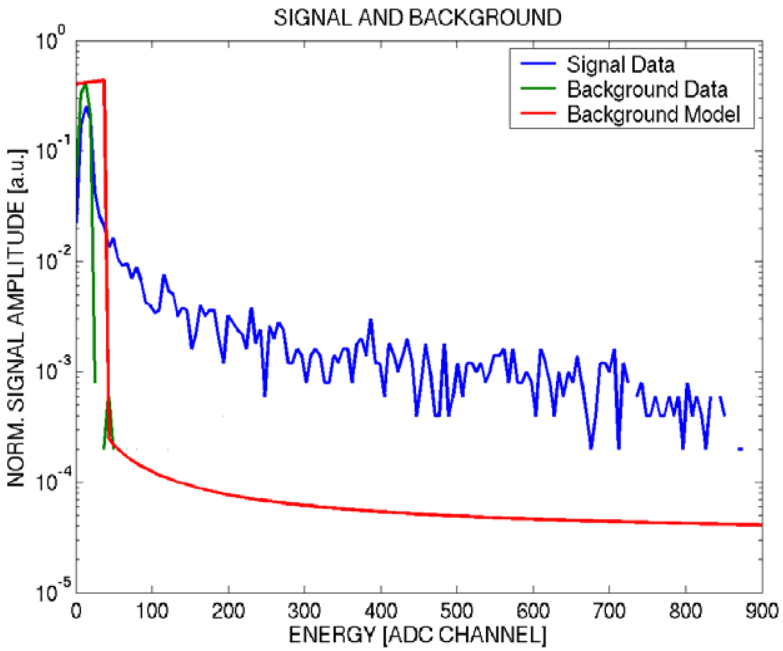


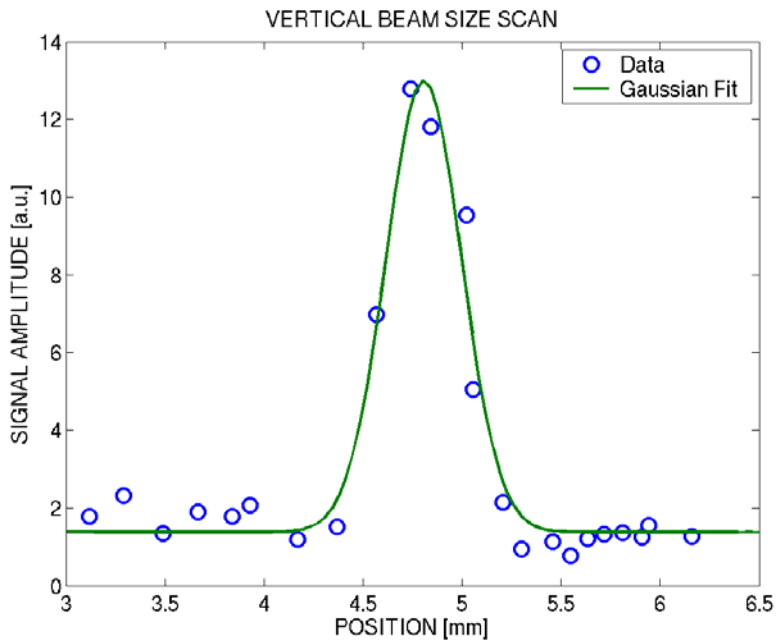
Beam Profile Measurements

LBBD Laserwire

- Positron beam in PETRA at 7 GeV
- Two runs so far (one week with few hours of beam per day)
  - October: Tests with orbit bumps and piezo scanner
  - December: Operation of piezo scanner
- Bunch pattern 14 x 1 bunch evenly filled
- Low current setup 7.1 mA, first bunch 0.458 mA (3.9 nC)
- High current 40.5 mA, first bunch 2.686 mA (22.3 nC)
- Vertical and horizontal orbit bumps to steer positron beam into laser beam, 50 m bump length with 10 mm max offset
- Optimization of laser trigger point
- Laser energy measured to 40 mJ (specs 90 mJ), P_L = 4 MW
- Scanning of laser beam with piezo
- Asymmetric orbit bumps to test detector alignment

Result Orbit Bump Scan (Oct run)

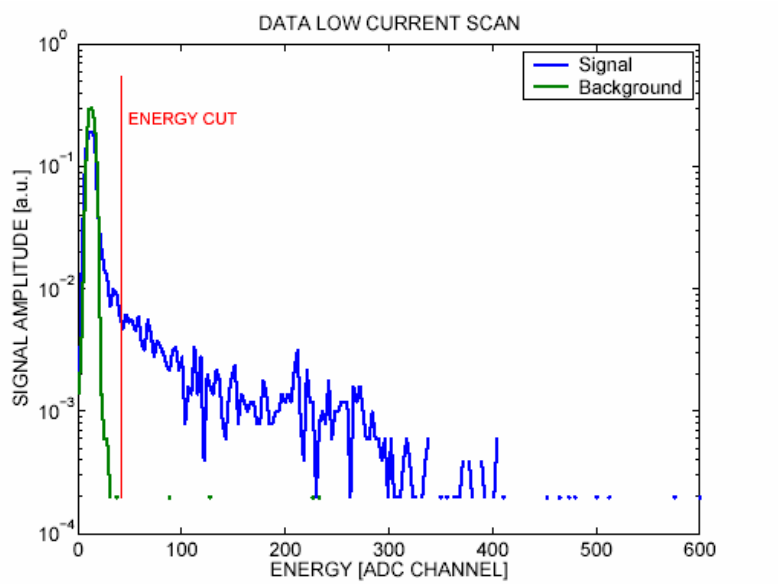


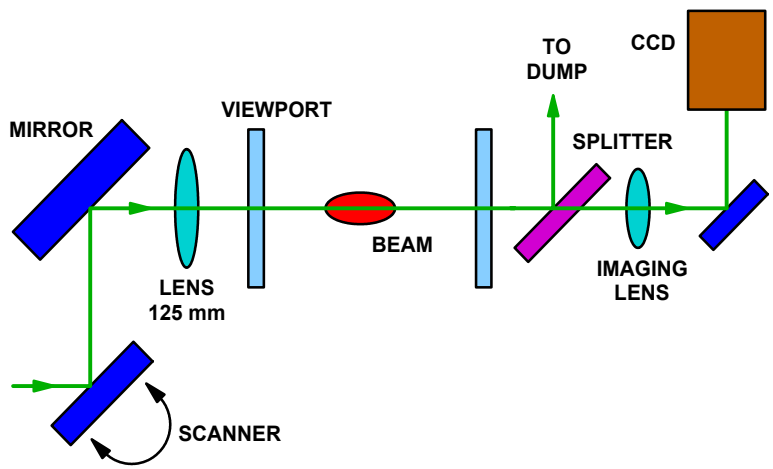


- Laser at rest and movement of orbit by 3.5 mm in ~ 0.1 mm steps
- Background substracted from signal at each point
- Gaussian fit of beam shape
  - $\sigma_m = (0.175 \pm 0.020_{stat} \pm 0.038_{sys})$ mm
- Large background variation during scan
  - Different local vacuum pressure in beam pipe

Fast Scanner Operation (Dec run)

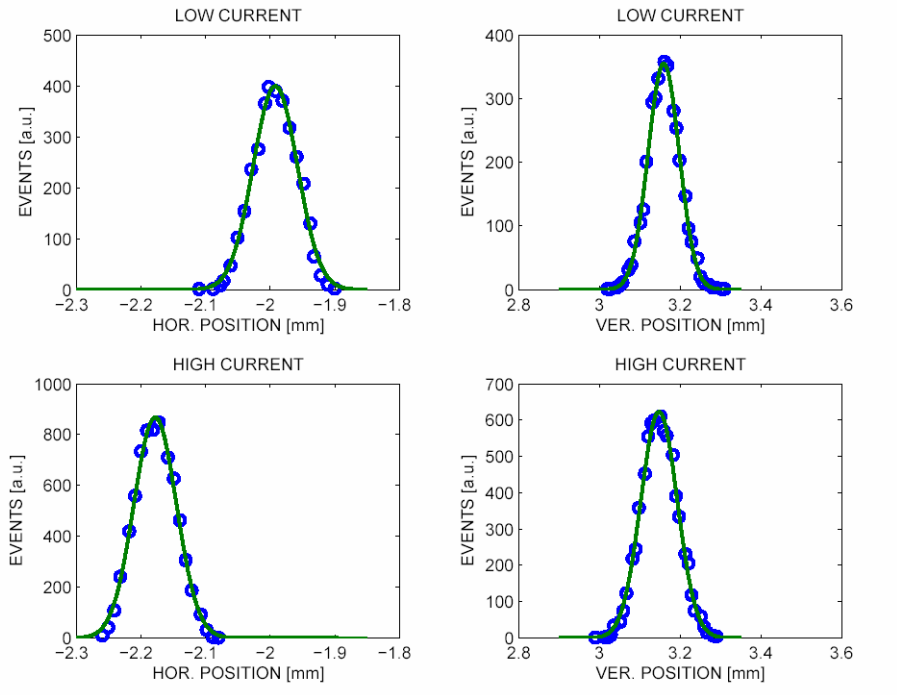
- First scan with signal on scope
- Then sampling of peak using ADC
- Changing piezo voltage from 0 to 9.5 V in 0.5 V steps (amp times 10)
  - ± 2.5 mrad scan range
- 5000 events at each position
- In total 20 position points
- Complete scan done in 40 min
- Background scan with 20k events
  - Mainly synchrotron radiation and bremsstrahlung
- Signal rate expected at peak
  - 100 gammas x 380 MeV avg energy
- Strong fluctuations because of laser mode beating
- Oscillating pedestal in ADC data





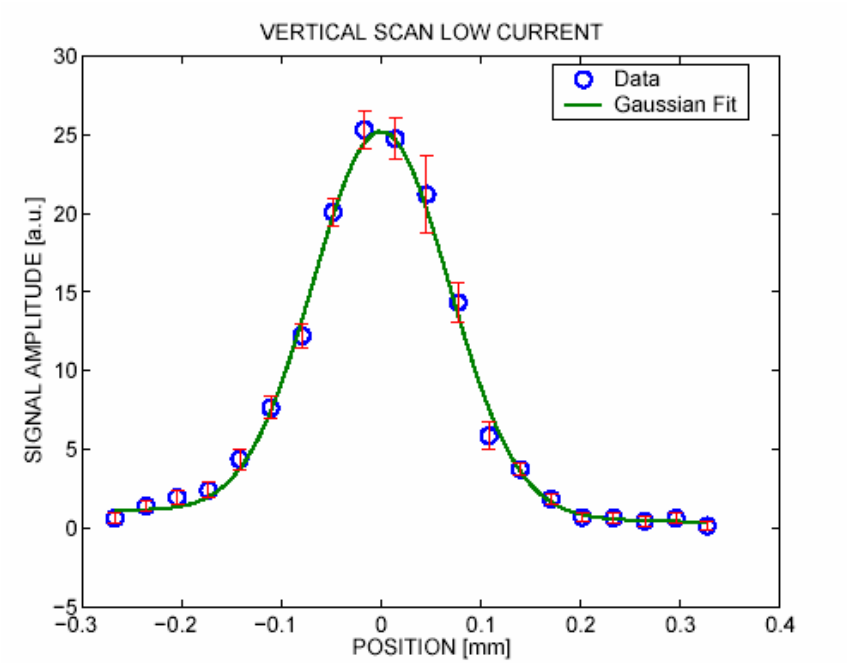
Positron Beam Orbit Stability

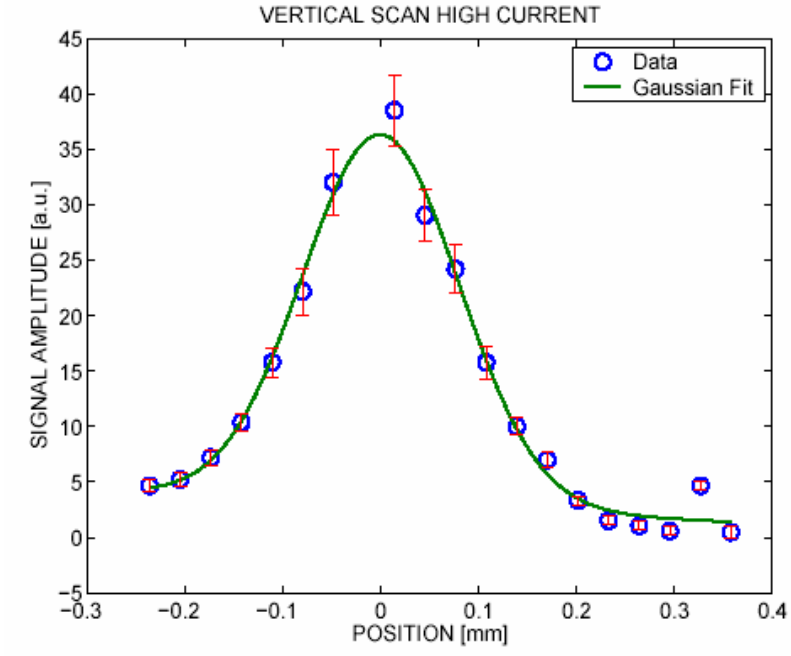
- BPM read out every second and data written to disk
  - talk by J Carter
- Low current:
  - x = -1.99 ± 0.04 mm
  - y = +3.16 ± 0.04 mm
- High current:
  - x = -2.18 ± 0.04 mm
  - y = +3.15 ± 0.04 mm



Results from Scanner Operation

- Slopy Background Gaussian approximation of beam shape
  - $\sigma_m = (68 \pm 3 \pm 14)$ µm at low current
  - $\sigma_m = (80 \pm 6 \pm 16)$ µm at high current





Conclusions and Outlook

- Laserwire at PETRA setup and in operation
- Measured vertical beam size
  - using orbit bumps
  - with fast piezo scanner
- Results agree with std error with expectation from PETRA operation

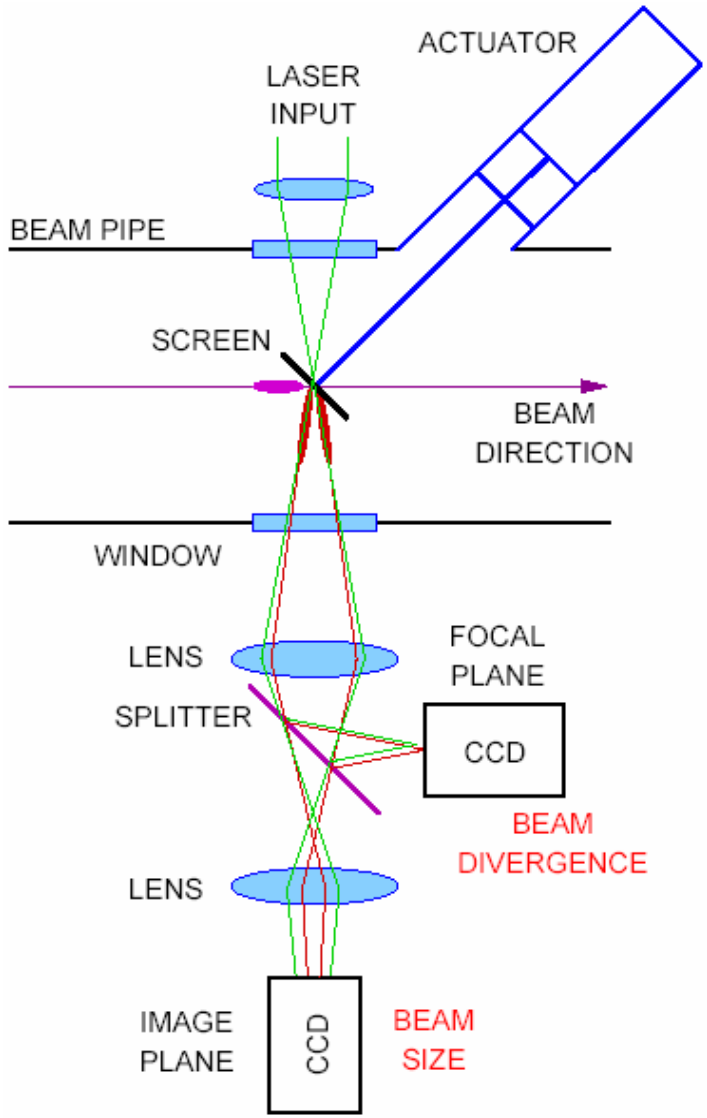
Next steps

- Understand low Compton rate
  - Laser characterisation (profile and power)
  - Study Compton path from IP to detector
  - Detector calibration
- Improve Compton rate
  - Background suppression with shielding
  - Improve trans. and long. laser profile
- Machine studies
  - Profile measurements at different energies and optics setups
- Second dimension
- Next run Feb04, analysis meeting end of Jan04

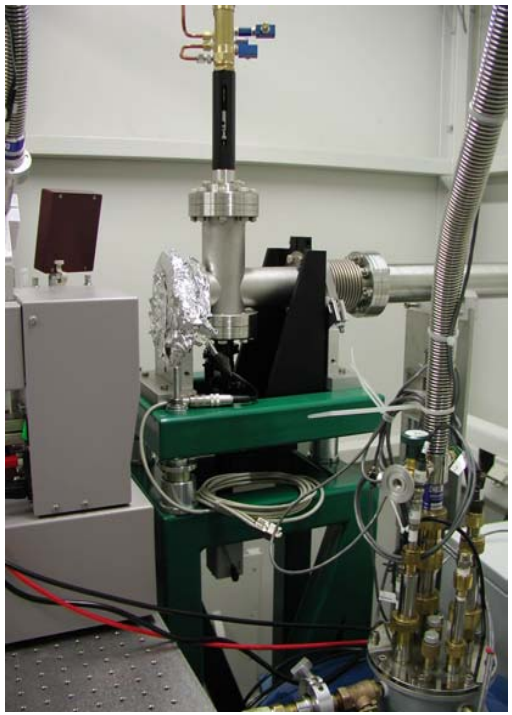
Combined Laserwire/OTR Station

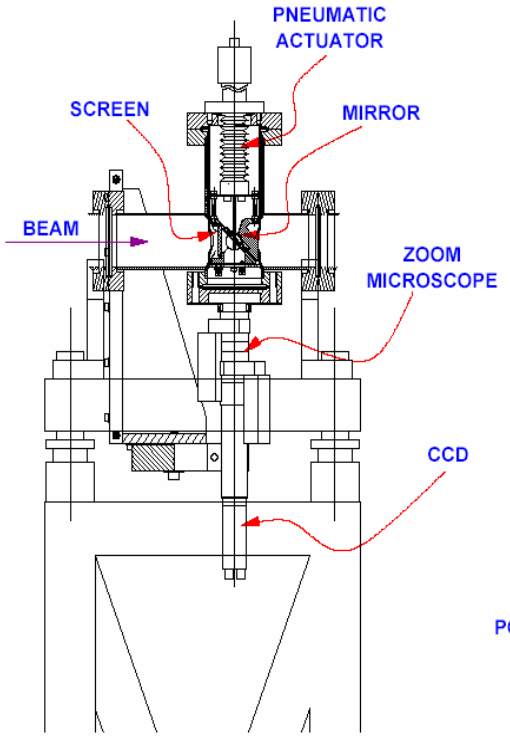
LBBD Laserwire

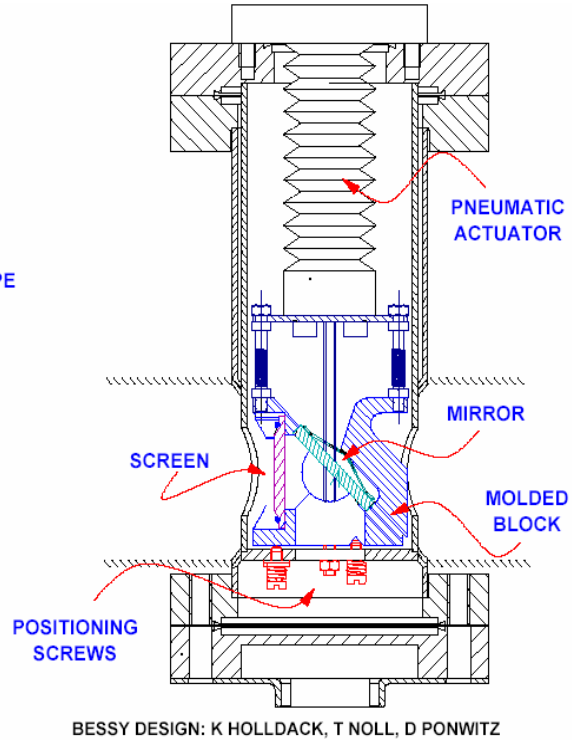
- Take laserwire IP chamber with four viewports and add one 45° port
- Special OTR: surface treated fused silica carrier
  - speckles of laser beam
  - OTR light of electron beam
- Actuator with foil holder inserts screen in optical beam path
- Common detection of laser beam image and OTR light with CCD cameras in focal and image plane
- In situ measurement of laser beam size and location
- Cross check of electron beam size
- For timing measurement guide both pulses on streak camera



Photon Beam Screen at BESSY II







- Photon beam screen station intalled at three Bessy II beamlines
- Simple, robust and cost-effective design
- Pneumatic actuator combined with three-point-fixture
  - Repeatibilty of screen position ± 2 µm
- Could be modified to fit in laserwire chamber IP design

People

K Balewski, G Blair, S Boogert, G Boorman,
J Carter, J Frisch, K Holldack, T Kamps,
P Kuske, T Lefevre, H C Lewin, F Poirier,
I N Ross, M Ross, S Schreiber, M Wendt,
K Wittenburg

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