Latest laser-wire results

- How does a Laser-Wire work?
- Latest ATF results
- Focusing optics
- Latest PETRA results

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BESSY: Thorsten Kamps

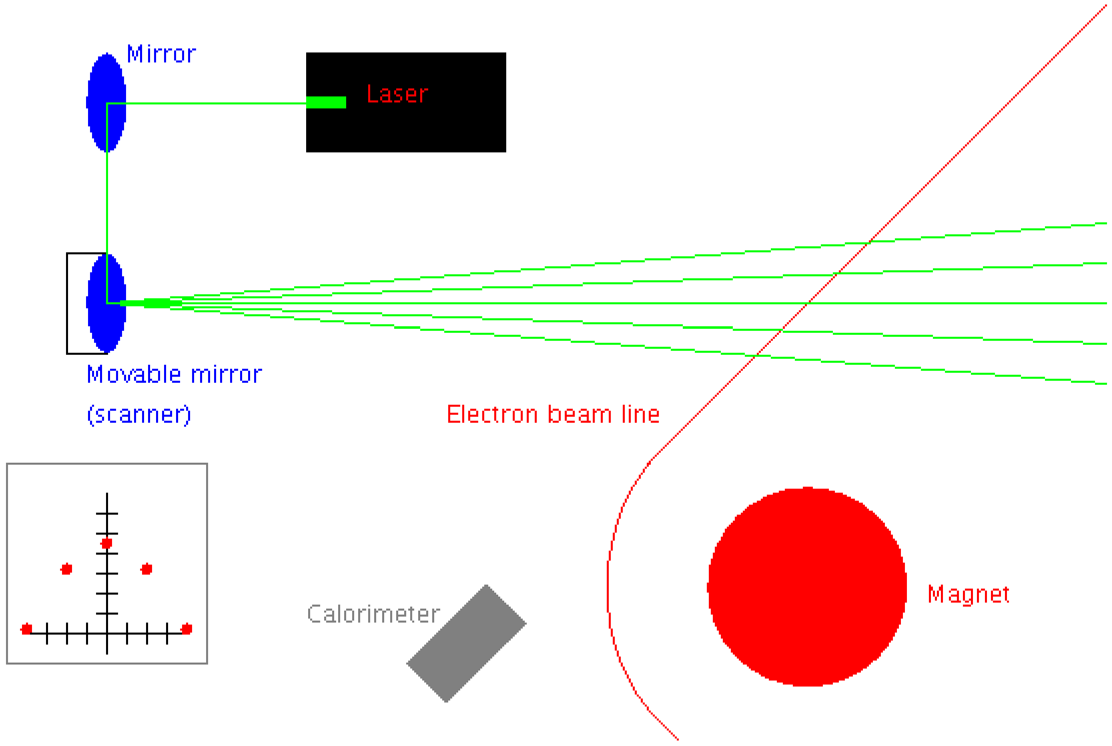
DESY: Klaus Balewski, Hans-Christoph Lewin, Freddy Poirier, Siegfried Schreiber, Kay Wittenburg

FNAL: Marc Ross

KEK: Alexander Aryshev, Nobuhiro Terunuma, Junji Urakawa

SLAC: Joe Frisch, Douglas McCormick

How does a laser-wire work?



- The resolution of a laser-wire depends on the size of the laser beam

- When the photons of a laser interact with electrons, Compton photons are produced.
- The number of Compton photons produced is proportional to the electrons' density at the position of the laser.
- By sweeping a laser across an electron beam one can produce a profile of the beam and hence measure its size.
- Knowing the size of a beam allow to measure its emittance.

Laser-wire R&D for the ILC

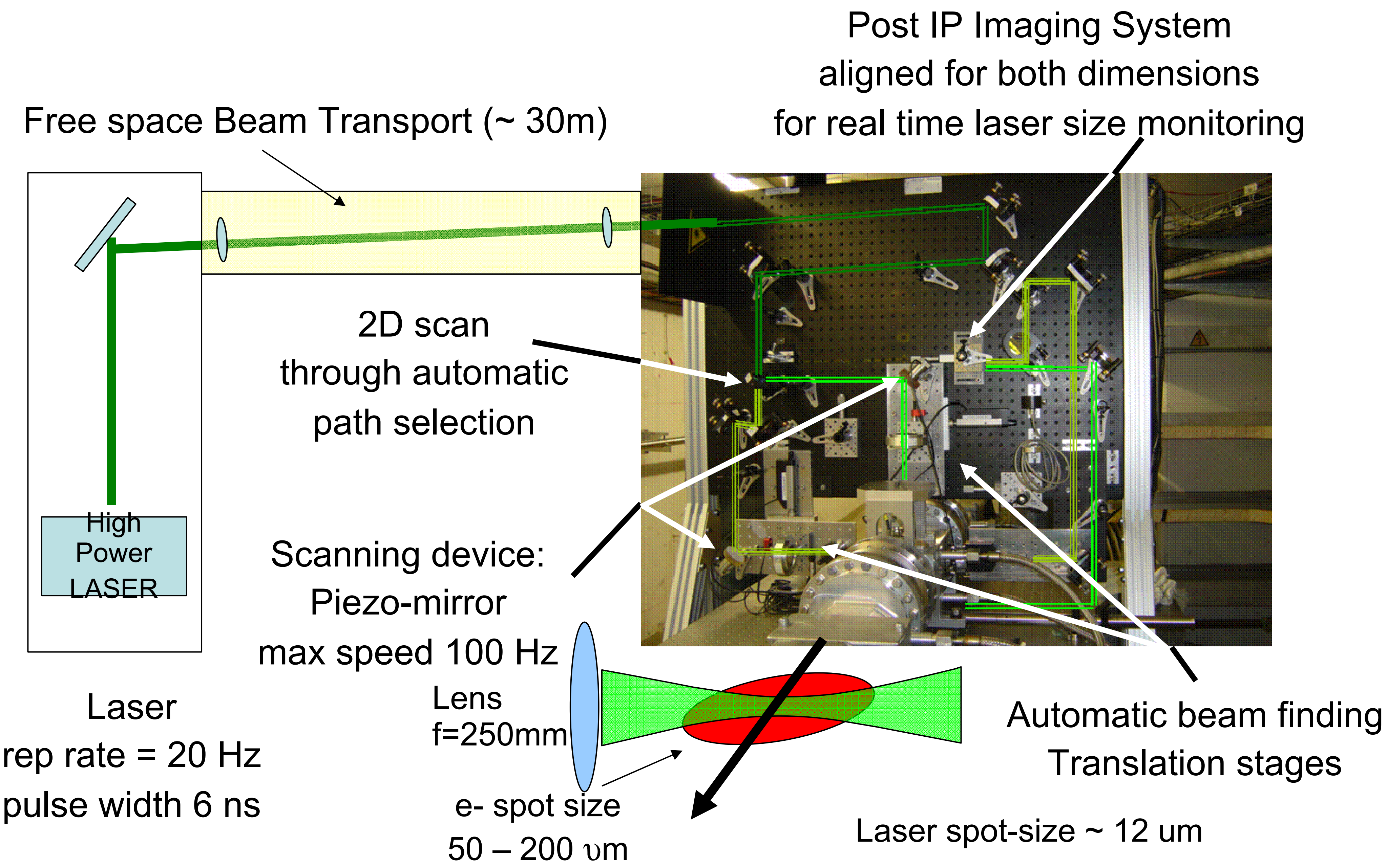
- Many (~70) laser-wires will be used along the ILC to control the emittance from the source to the Interaction Point.

- Important R&D is needed to demonstrate laser-wire operations in ILC-like conditions: ultra fast scanning, strong focusing, high power high rep. rate low M^2 laser

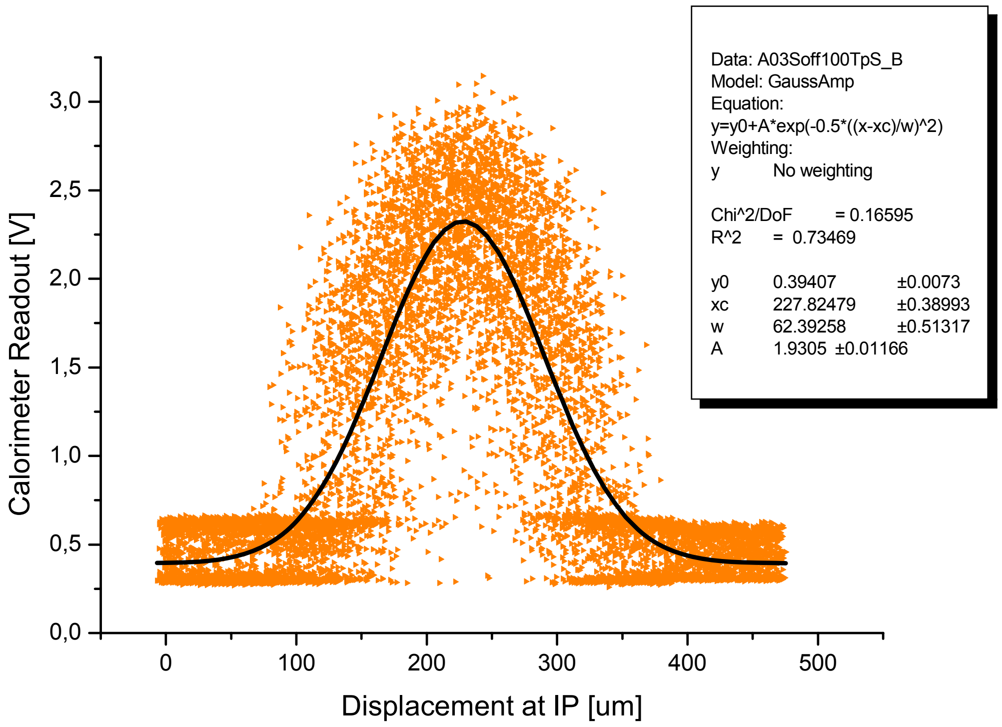
- 2 single-pass prototypes in operation:
  - One at PETRA (DESY): fast scanning, 2D...
  - One at the ATF (KEK): um-resolution

- Other LW applications are investigated by other groups (DR LW,...)

2D LW scanner at PETRA

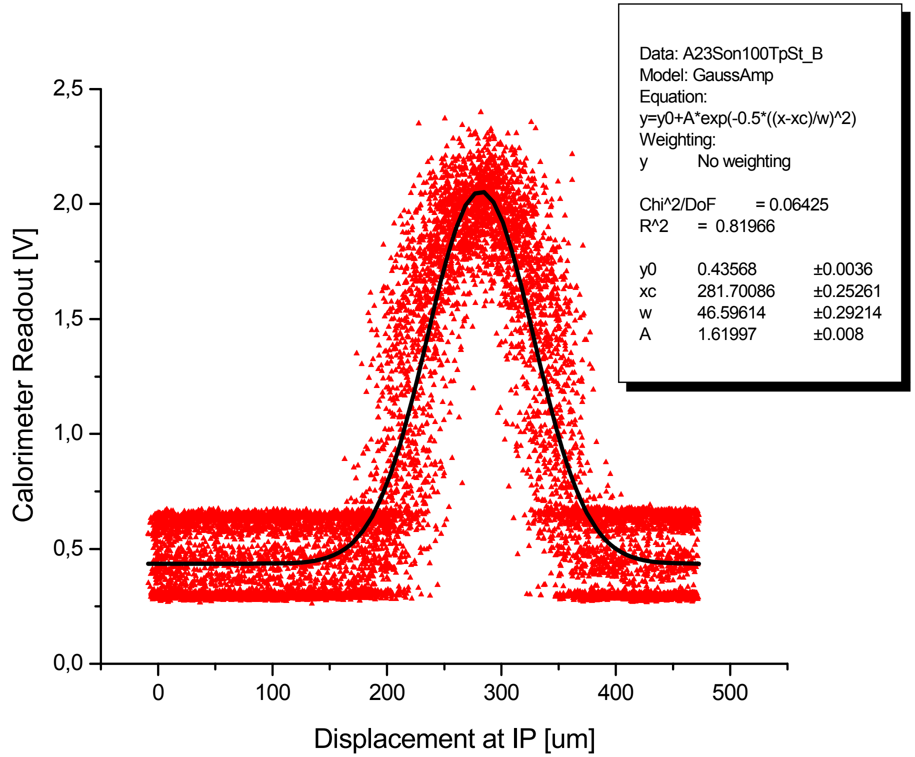


Unseeded (100 steps, 100 points per step) 10,000/20Hz = 500sec



Sigma ~ 62um

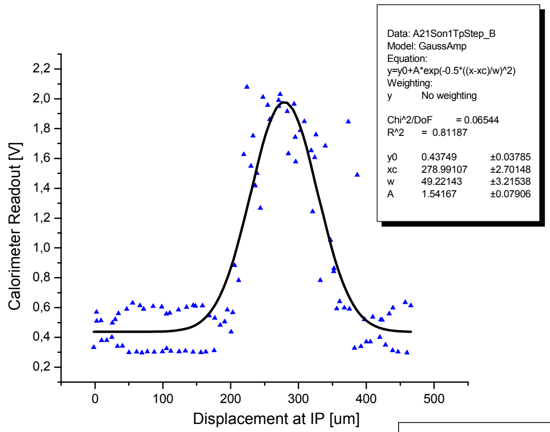
Seeded (100 steps, 100 points per step) 10,000/20Hz = 500sec



Sigma ~ 46um

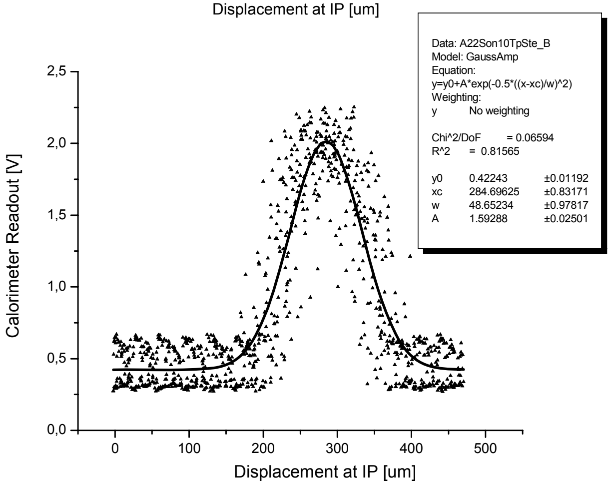
Scan give a better resolution when the laser is seeded.

Alessio Bosco & Michael Price



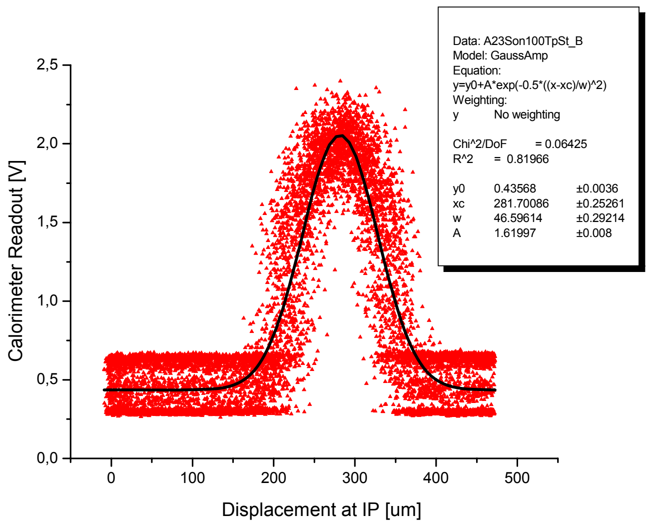
Seeded (100 steps, 1 point per step) 100/20Hz = 5 sec

Sigma ~ 49um



Seeded (100 steps, 10 points per step) 1,000/20Hz = 50sec

Sigma ~ 49um

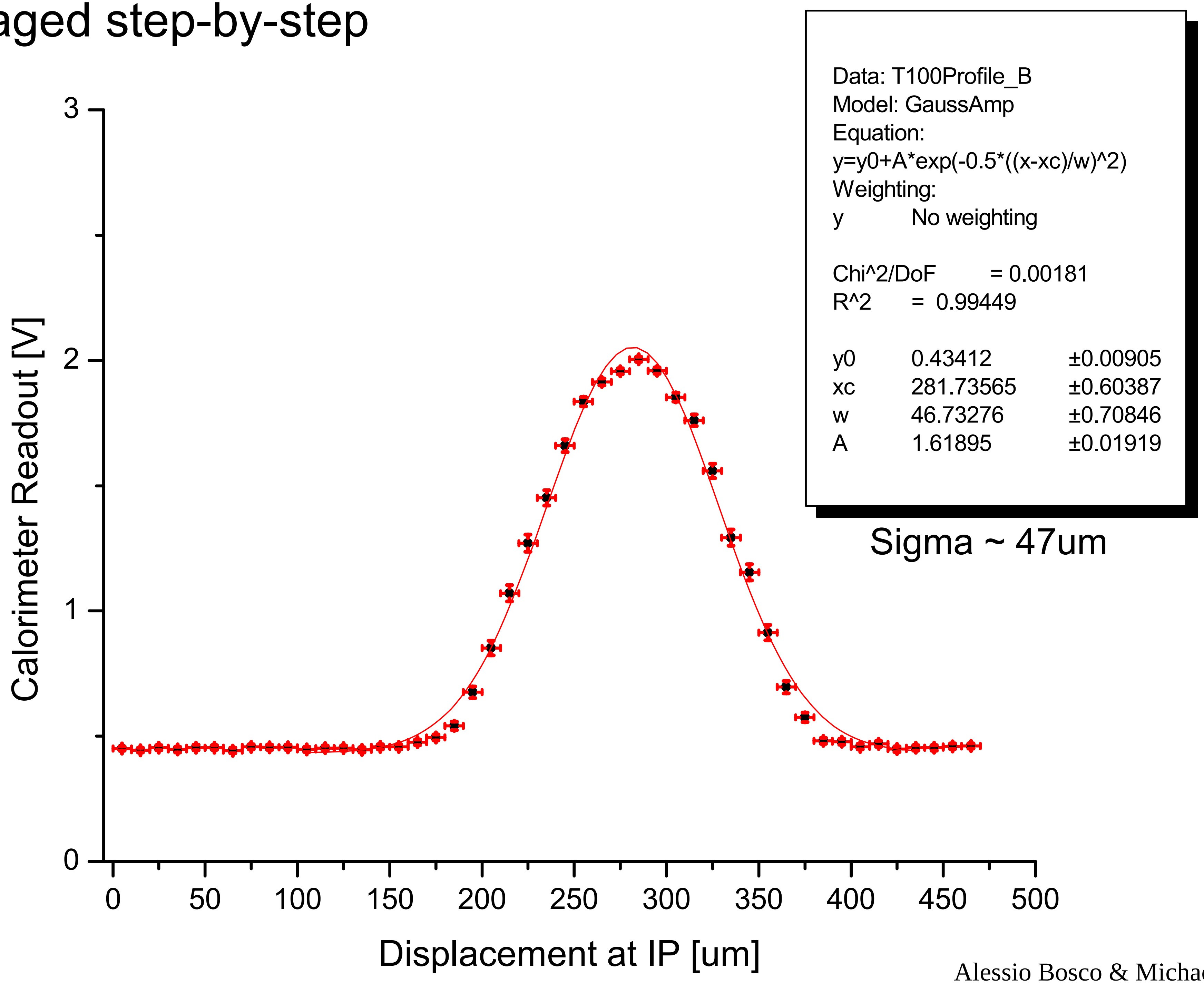


Seeded (100 steps, 100 points per step) 10,000/20Hz = 500sec

Sigma ~ 47um

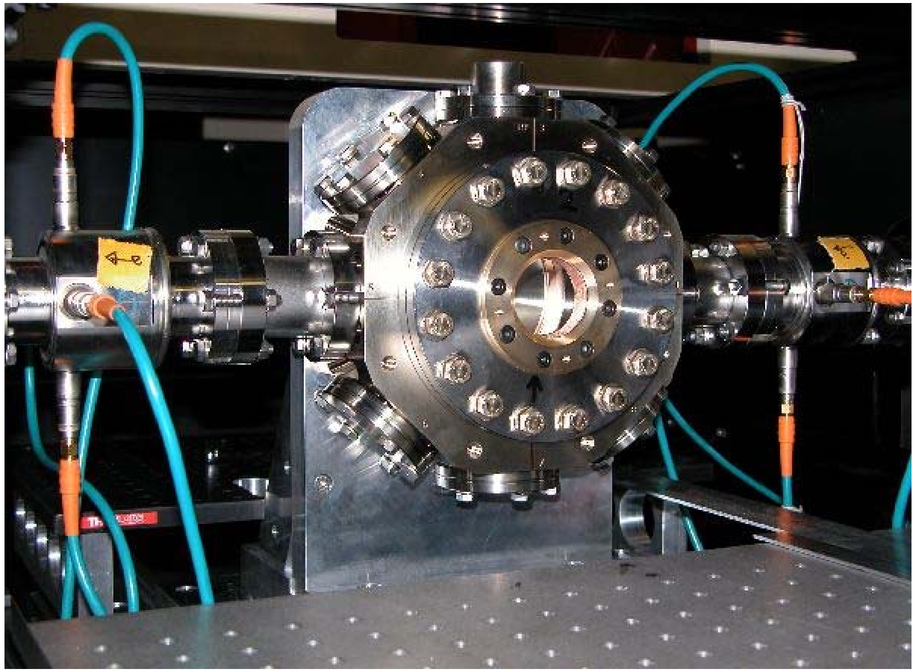
Fast scans give a resolution comparable to scans with more data points

Seeded (100 steps, 100 points per step) 10,000/20Hz = 500sec
Averaged step-by-step



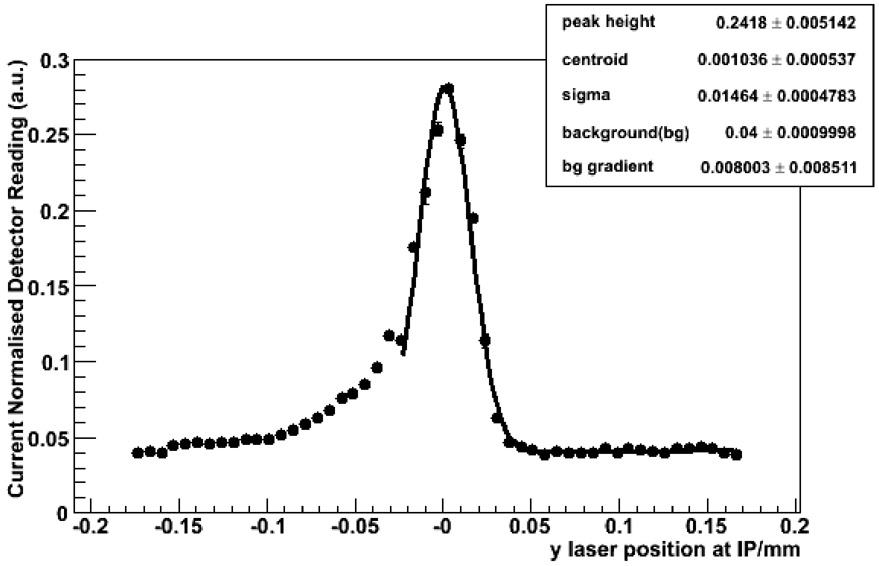
Alessio Bosco & Michael Price

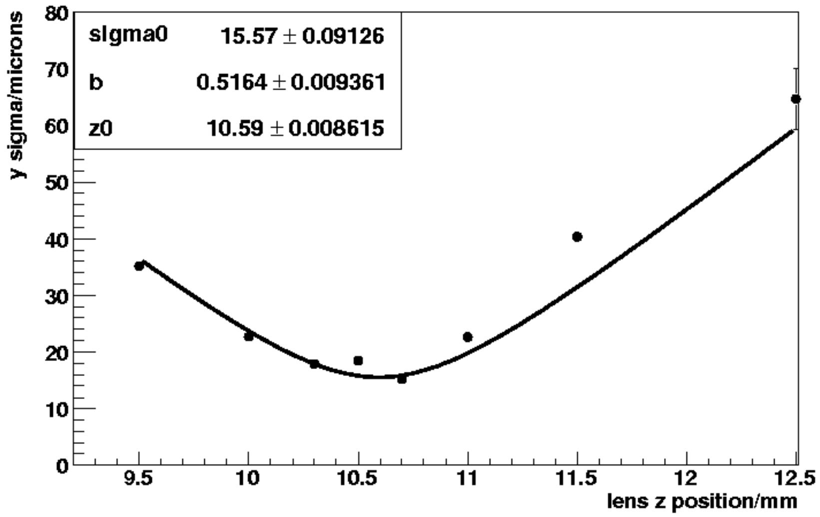
ATF Extraction line laser-wire



- Goal: demonstrate um-scale resolution in a single pass system
- System successfully installed and tested last year with a commercial lens
- Strong focusing lens will be installed this year

ATF LW data (spring 2006)



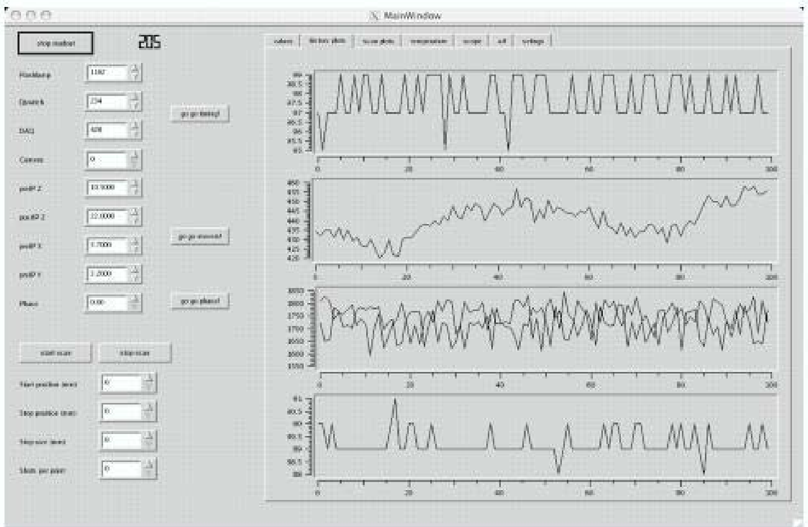


- Obtaining Compton photons at the LW IP is a 2D problem: photons and electrons must overlap in time (within 200ps) and space (vertically, within 20um)
- First collisions observed in April 2006.
- Measured beam size compatible with our expectations.
- Scan asymmetry due to lens aberrations
- Laser $M^2 \sim 2.9$

System improvements

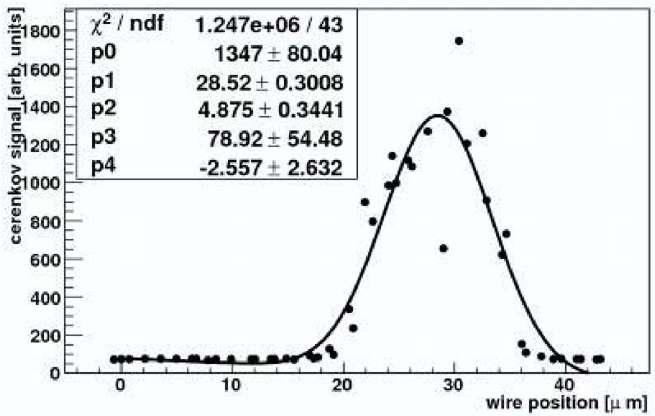
- Added Lead glass calorimeter detector
  - Calibrated with cosmic muons
  - Compare with Aerogel Cerenkov detector

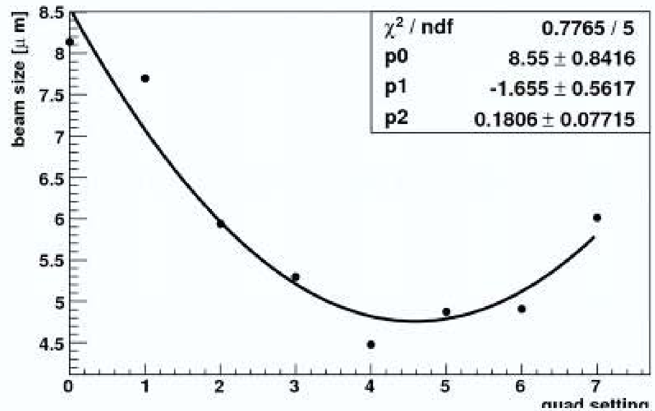
- Integrated DAQ
  - Camac ADCs/TD/TDC
  - Laser power meter
  - ATF-EXT stripline BPMs
  - Wire scanner (stage)
  - Labview control of optics (mirrors)
  - RF phase timing control



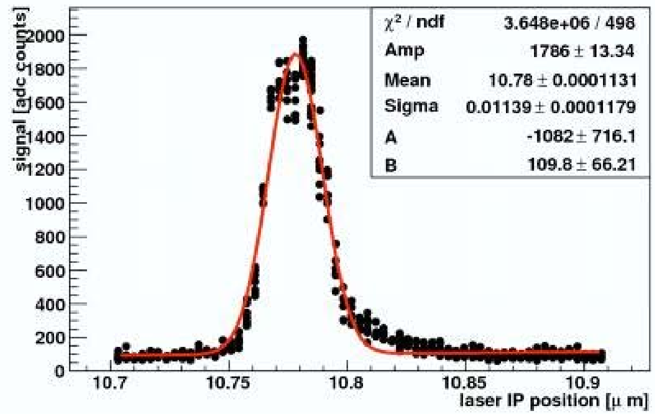
Stewart Boogert

Results (>Nov 2006)



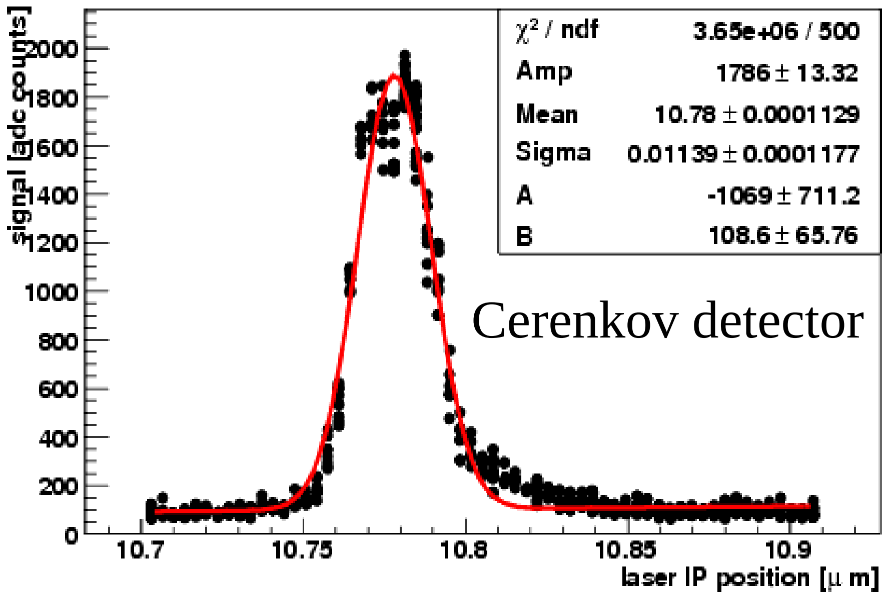


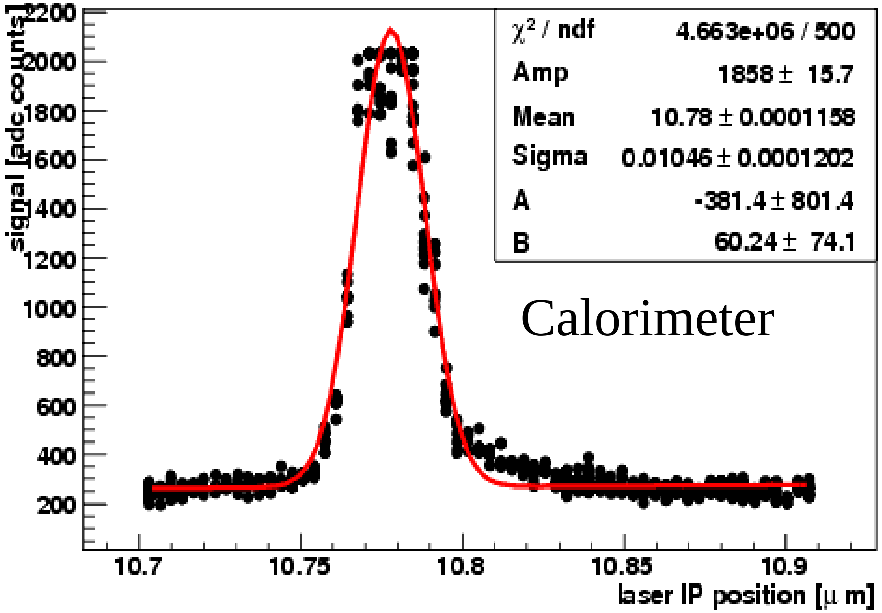
- Wire scanner measurements to confirm optics
  - Electron beam size ~4μm
- Laser scans
  - Laser-electron beam quadrature size ~11.4μm



Stewart Boogert

Photon detector comparison

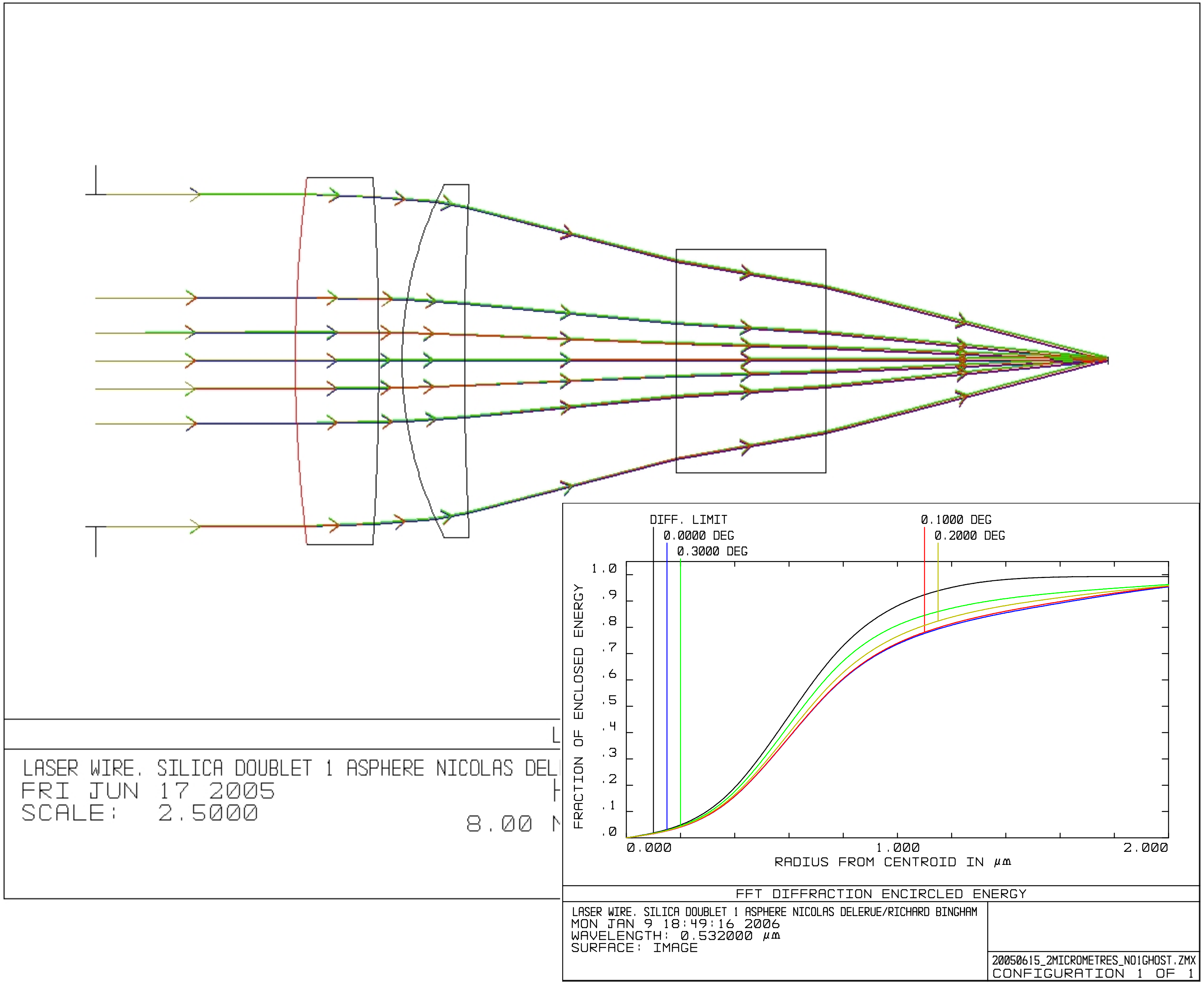




LW Scans 13th December 2006

f/2 lens design@532nm

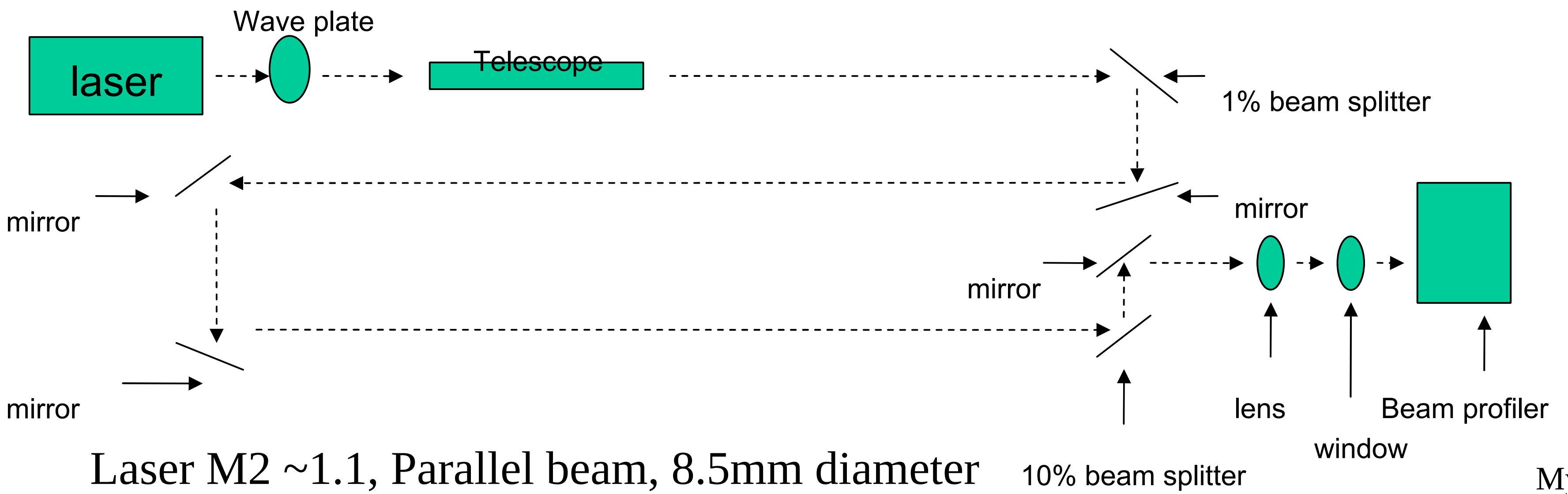
A low f# lens is needed to reach um-scale resolution.



- Focal length: 56mm
- One aspheric element, one flat element
- Back focal length: 24mm
- Aperture f/2
- All elements in fused silica
- No primary ghosts, one secondary ghost
- Expected spot radius ~2 micrometres

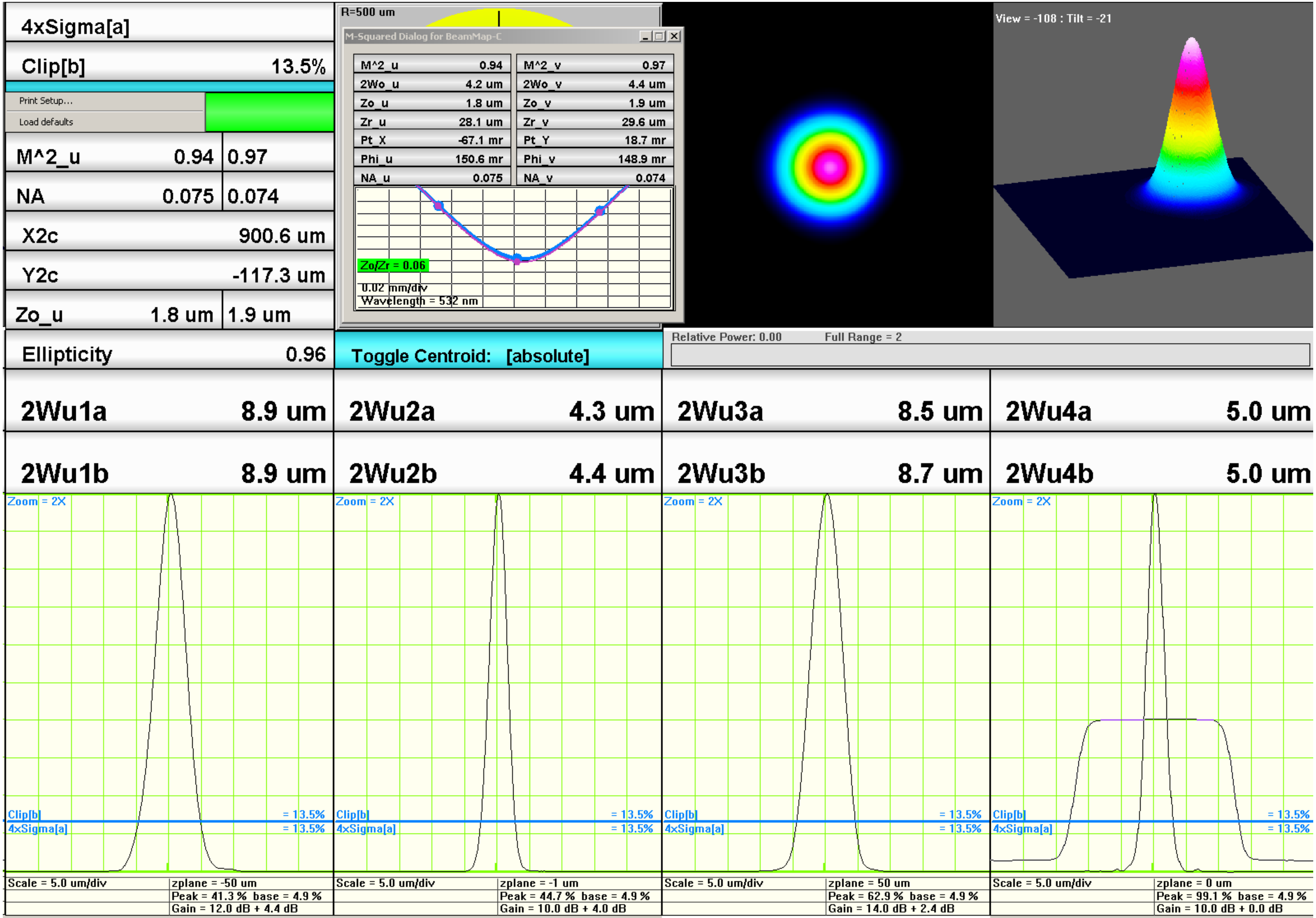
Lens profiling

- A precise measurement of the characteristic of the lens as produced is necessary.
- A commercial lens with known properties has been used as benchmark of the test setup.
- Profile measurements with a knife-edge scanner confirm the expected performances.



Laser M2 ~1.1, Parallel beam, 8.5mm diameter

Myriam Newman


4xSigma[a]
Clip[b] 13.5%
Print Setup...
Load defaults
M^2_u 0.94 0.97
NA 0.075 0.074
X2c 900.6 um
Y2c -117.3 um
Zo_u 1.8 um 1.9 um
Ellipticity 0.96
R=500 um
M-Squared Dialog for BeamMap-C
M^2_u 0.94
2Wo_u 4.2 um
Zo_u 1.8 um
Zr_u 28.1 um
Pt_X -67.1 mr
Phi_u 150.6 mr
NA_u 0.075
M^2_v 0.97
2Wo_v 4.4 um
Zo_v 1.9 um
Zr_v 29.6 um
Pt_Y 18.7 mr
Phi_v 148.9 mr
NA_v 0.074
Zo/Zr = 0.06
0.02 mm/div
Wavelength = 532 nm
View = -108 : Tilt = -21
Toggle Centroid: [absolute]
Relative Power: 0.00
Full Range = 2
2Wu1a 8.9 um
2Wu1b 8.9 um
2Wu2a 4.3 um
2Wu2b 4.4 um
2Wu3a 8.5 um
2Wu3b 8.7 um
2Wu4a 5.0 um
2Wu4b 5.0 um
Zoom = 2X
Clip[b] = 13.5%
4xSigma[a] = 13.5%
Scale = 5.0 um/div
zplane = -50 um
Peak = 41.3 % base = 4.9 %
Gain = 12.0 dB + 4.4 dB
zplane = -1 um
Peak = 44.7 % base = 4.9 %
Gain = 10.0 dB + 4.0 dB
zplane = 50 um
Peak = 62.9 % base = 4.9 %
Gain = 14.0 dB + 2.4 dB
zplane = 0 um
Peak = 99.1 % base = 4.9 %
Gain = 10.0 dB + 0.0 dB

Laser development

- Need a high power high repetition rate laser
- Mode quality is very important to achieve good resolution
- => Fibre laser technology with chirped pulse amplification (CPA) best suited for our needs.
- Currently discussing possible systems with several companies

Outlook

- Two laser-wire prototypes are now operational for ILC related R&D
- 2D scans will soon be attempted with the PETRA system
- Strong focusing lens (f/2) performances are being measured
- ATF LW mechanical hardware is being upgraded for the installation of the strong focusing lens
- Laser technology & design have been chosen