Laser-wire

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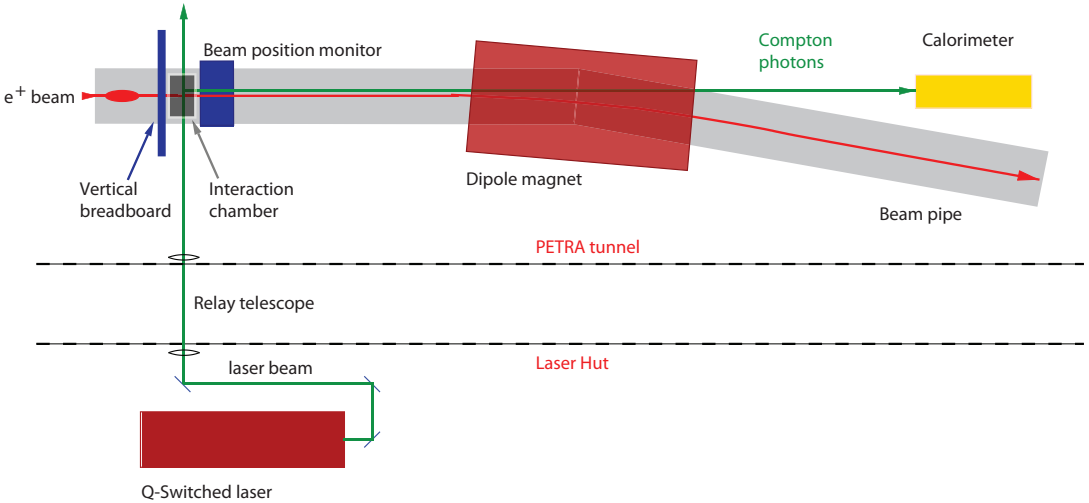
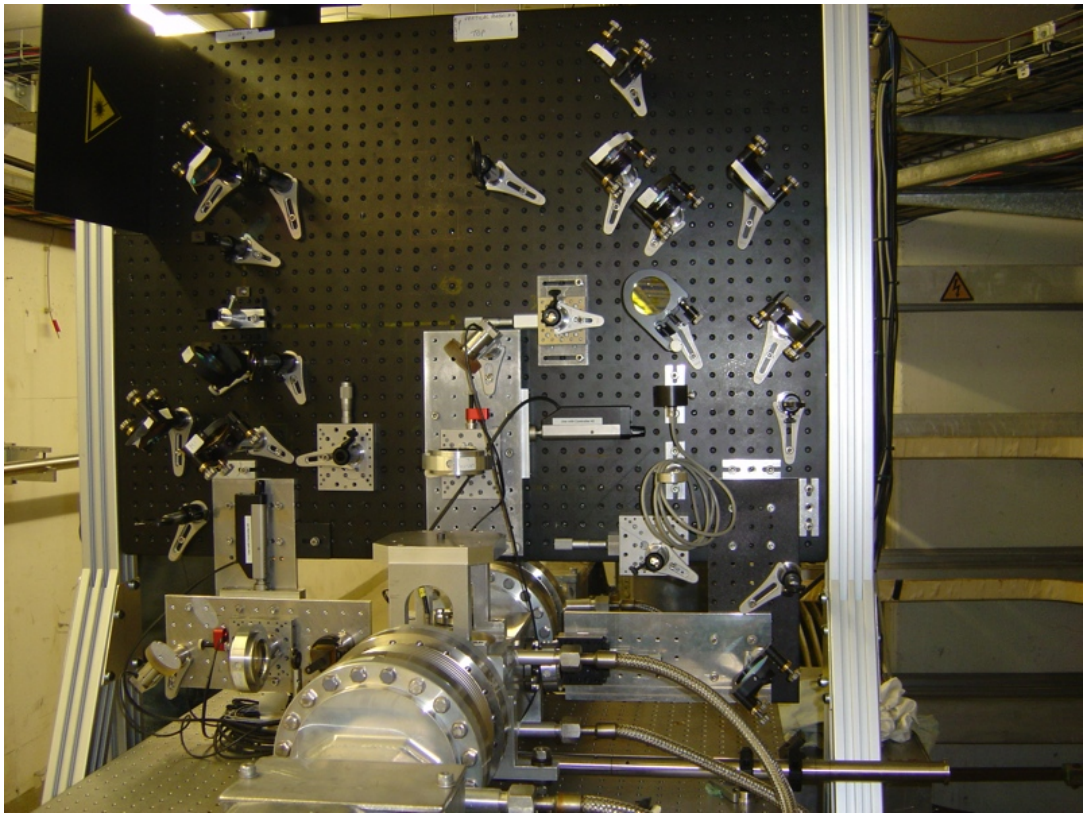
Overview

- Progress at both laser-wire installations
  - PETRA, test of two dimensional scanning system
  - ATF extraction line, smallest possible beam size
- Other activities at the JAI/DESY/KEK
  - Final results from the PETRA 2D system
  - Micron scale laser-wire at the ATF
  - Fast scanning developments (RHUL)
  - ILC diagnostics laser system (Oxford)
  - PETRAIII laserwire planning

PETRA system

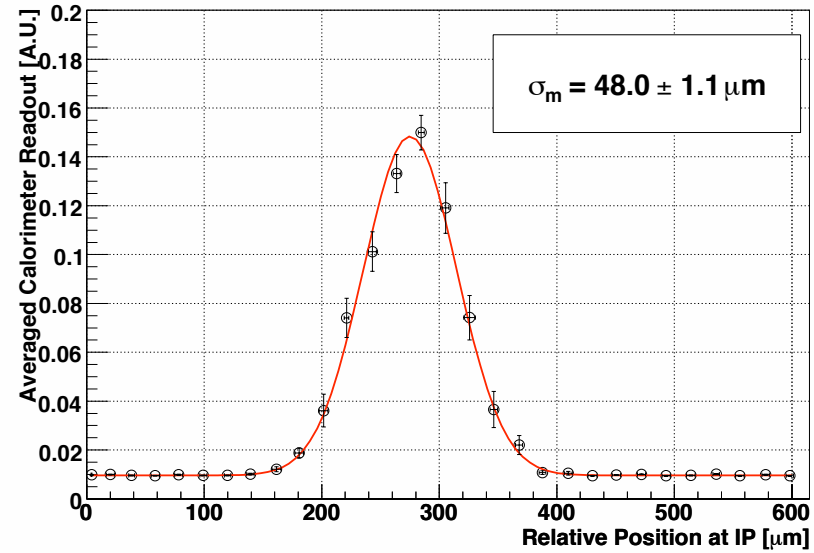
- PETRAII program complete
- Verified new design
  - Beam finding
  - Axis selection
- Improvements
  - Vacuum window
  - Injection seeded Q-switched laser
  - Readout and DAQ
- NIM publication in preparation

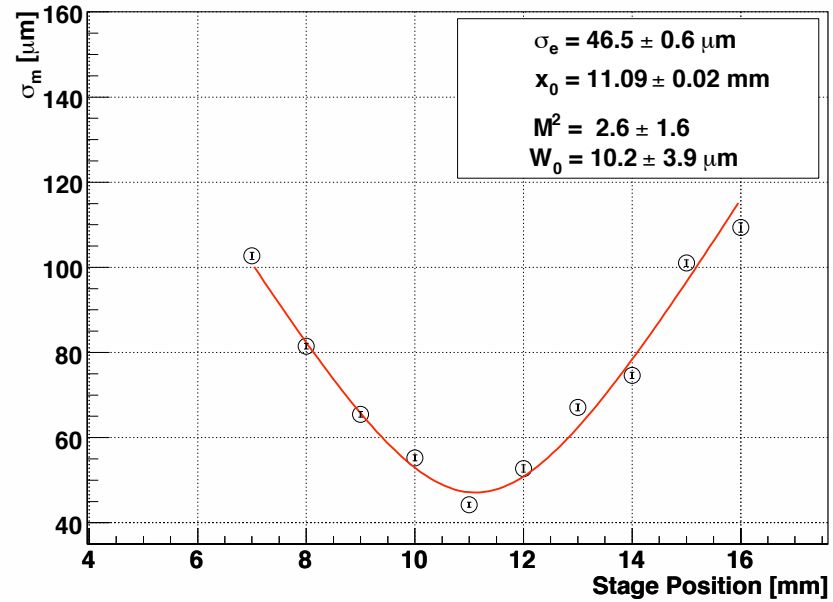




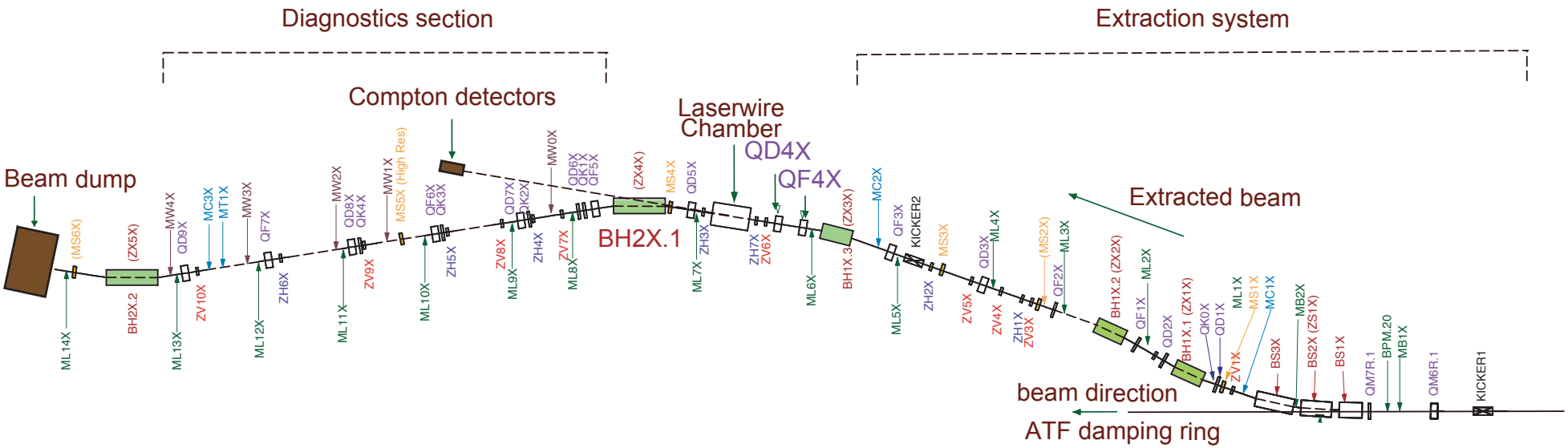
Summary of PETRA LW results

- Example scans from Vertical profiling system
  - Measurement error
  - Also considered
    - laser pointing jitter
    - beam motion
  - 1 minute scans (20 Hz laser)
  - Dynamic range of horizontal system a little small
    - Used beam finding translation to move IP





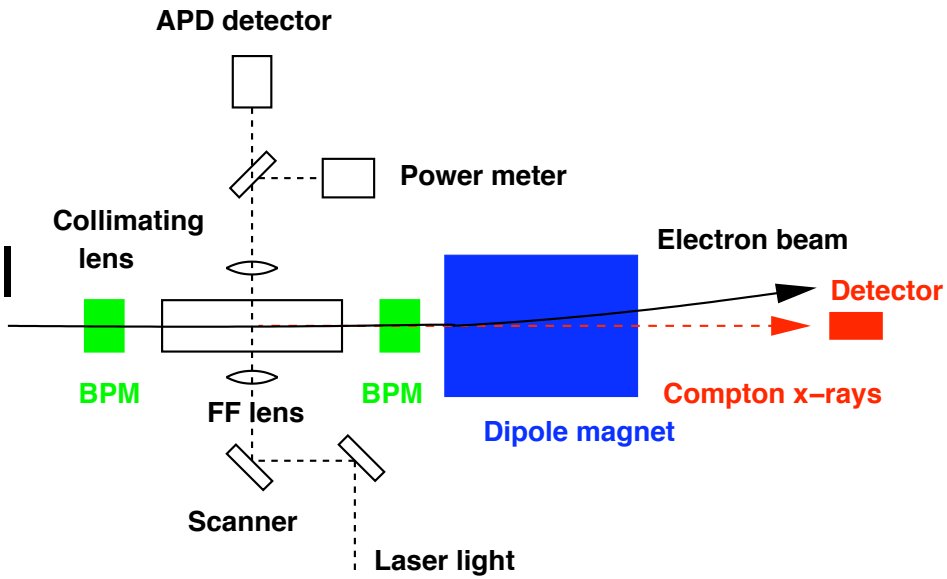
ATF extraction line

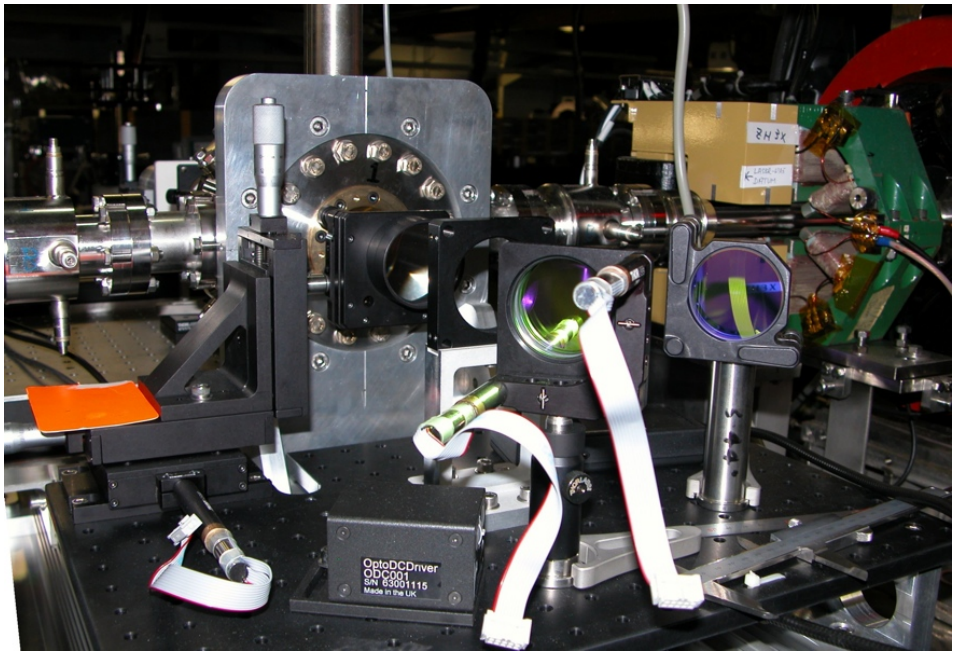


- ATF optics generate 20×1μm beam
  - Zero dispersion at between BH1X and BH2X
  - Backgrounds from kicker septum region difficult to control

ATF extraction line system

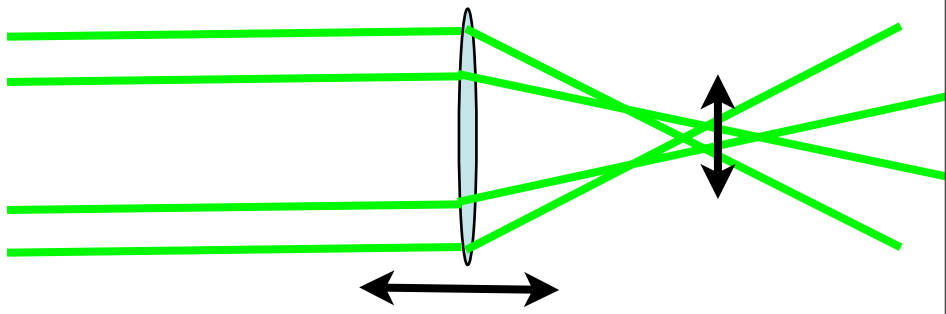
- Custom interaction chamber
  - Thin to allow short focal length optics
- Commercial plano-convex lens with 150mm focal length
- Motorised mirror control for laser scanning
- High power laser (maximum ~6GW)

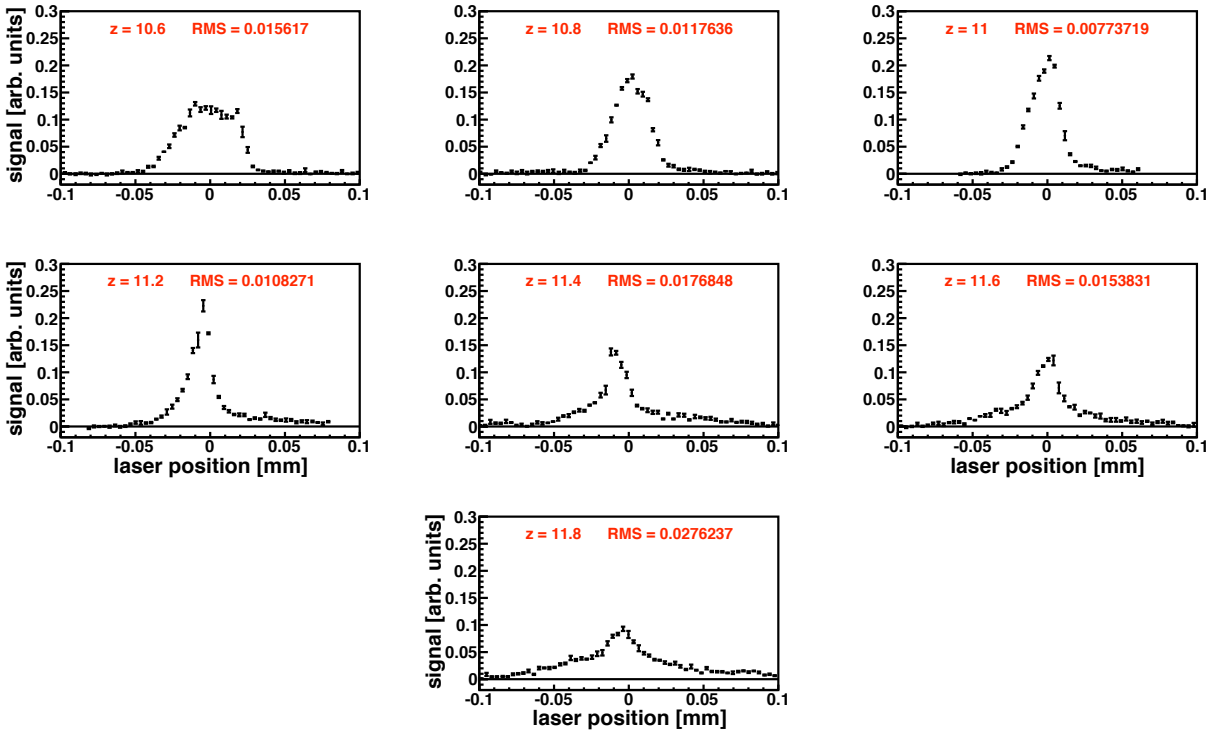




Early laser-wire results

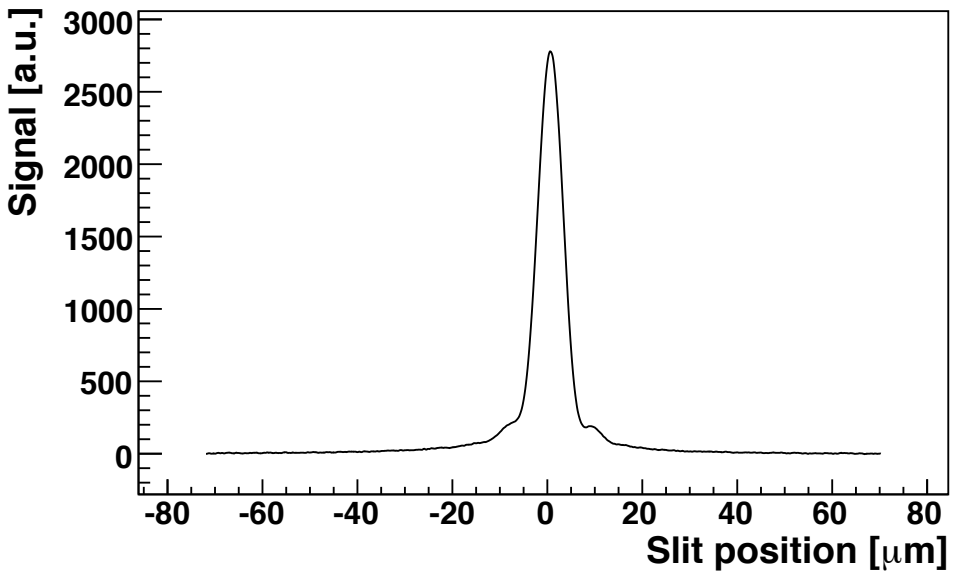
- Vertical scans for different lens longitudinal positions
  - Minimum beam size 7.7 micron
  - Scans clearly non-Gaussian
  - Components of aberrations and Coma



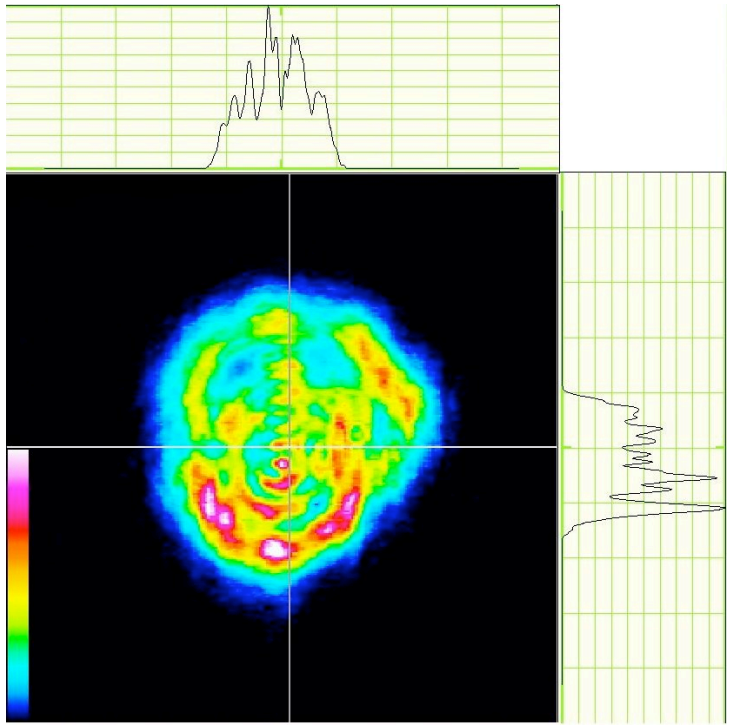


Spherical aberrations and laser

Focus profile with TEM_{00} laser



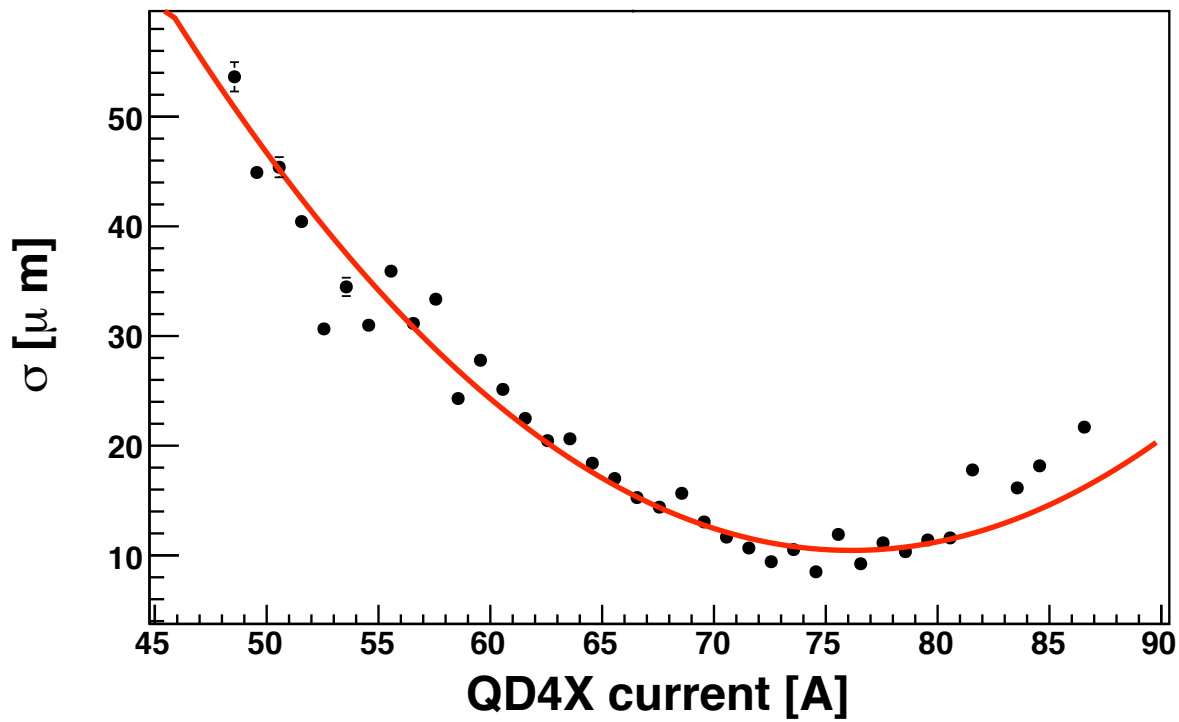
High power laser profile



- Large numerical aperture introduces profile distortions
- High power laser is more flat top than Gaussian

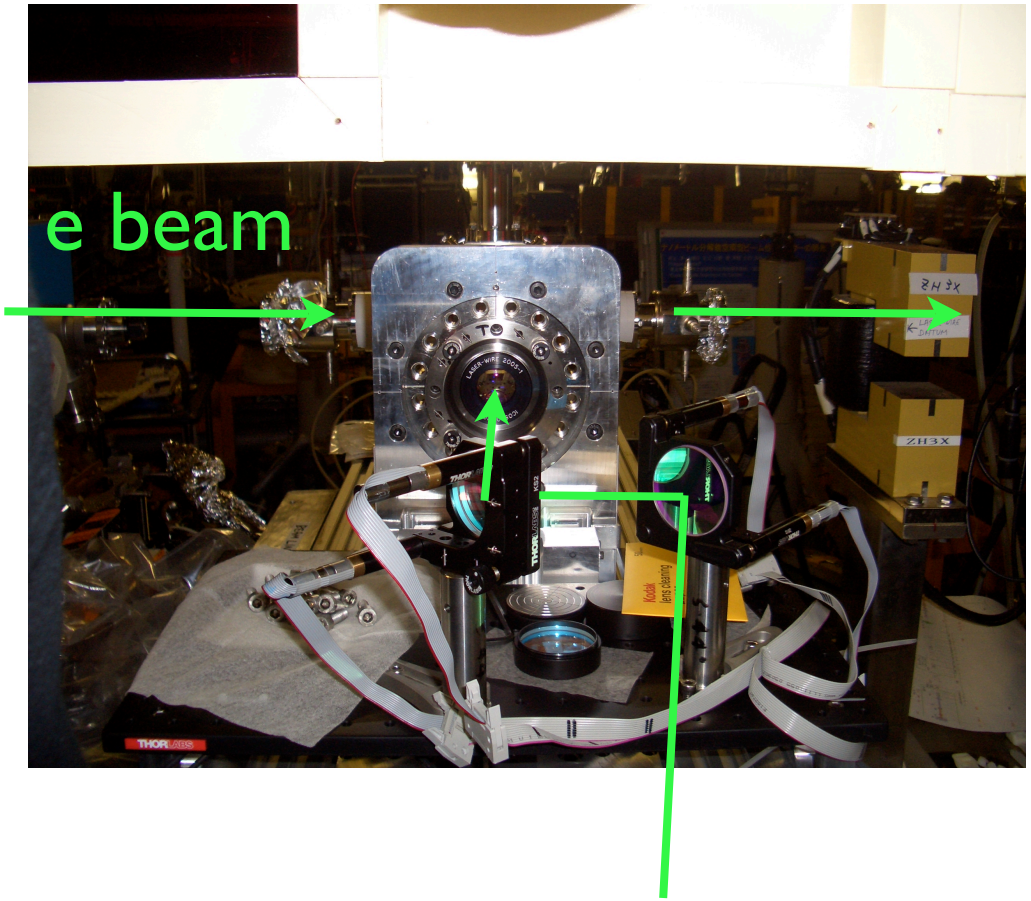
Quadrupole scan

- Vertical beam size quad scan
- Clear beam size variation between
  - 10μm limited by aberrations and laser
  - 50μm limited by S/N

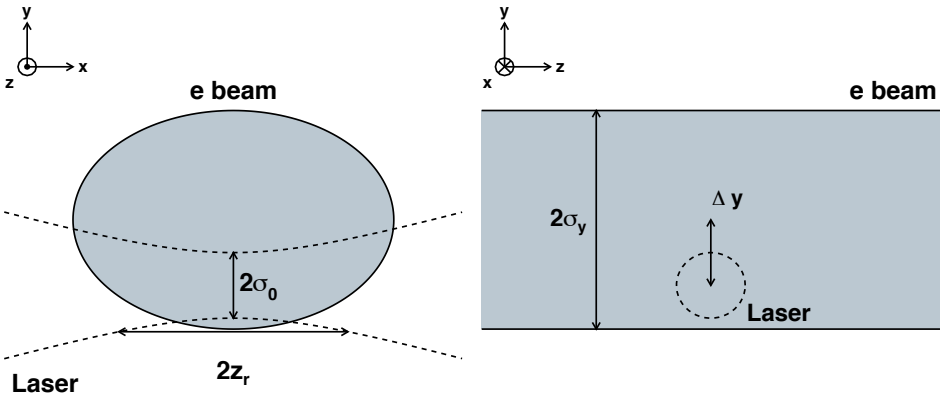


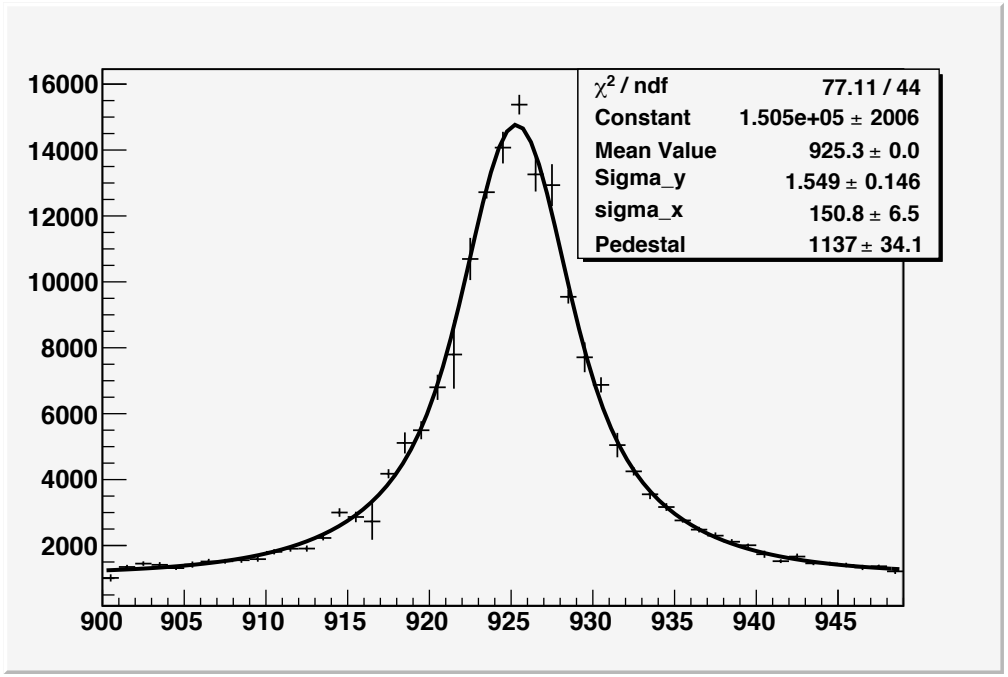
Upgraded ATF laser-wire system

- Major hardware upgrades
  - 2D chamber mover system
  - 4D vacuum manipulator system
  - Spherical aberration corrected lens connected to chamber
  - Reconfigured laser cleaning TEM_{00} mode



December 2007 ATF results

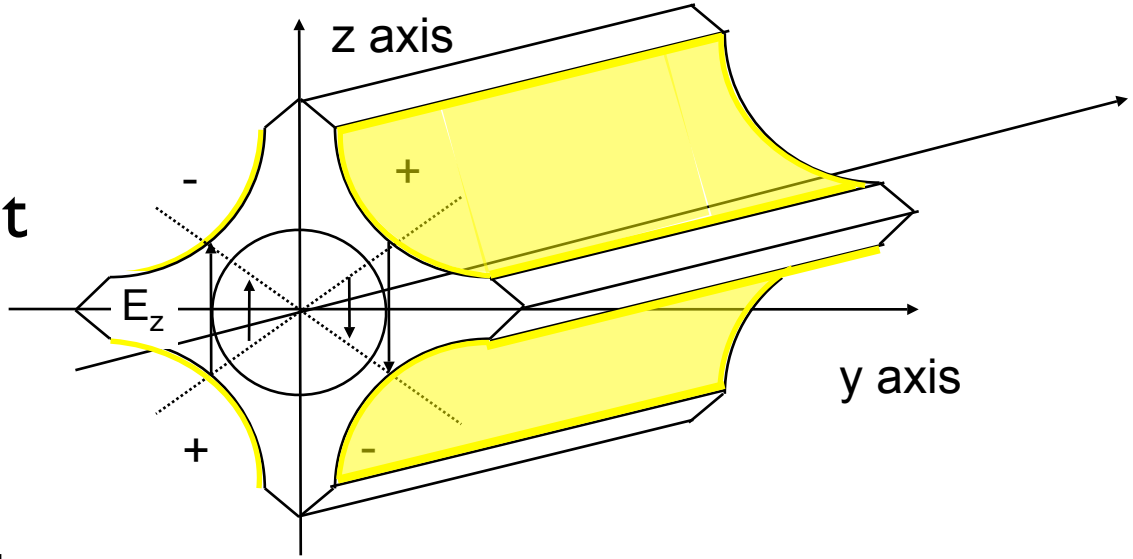




- Installed custom lens
  - Three surfaces, spherical, aspheric, flat (vacuum window)
  - Focal length 56 mm
  - Rayleigh range ~10μm
  - Focus radius ~1μm
- Observed signal
  - Definitely non-Gaussian
  - Full overlap integral fit
  - 10% measurement error

Electro-optic scanning system

- E_z generated by electrostatic quadrupole
  - Left and right sides of the beam have different speeds
    - Deflection of beam
  - Capacitance and maximum electric field important
  - Already commercially available for low laser power

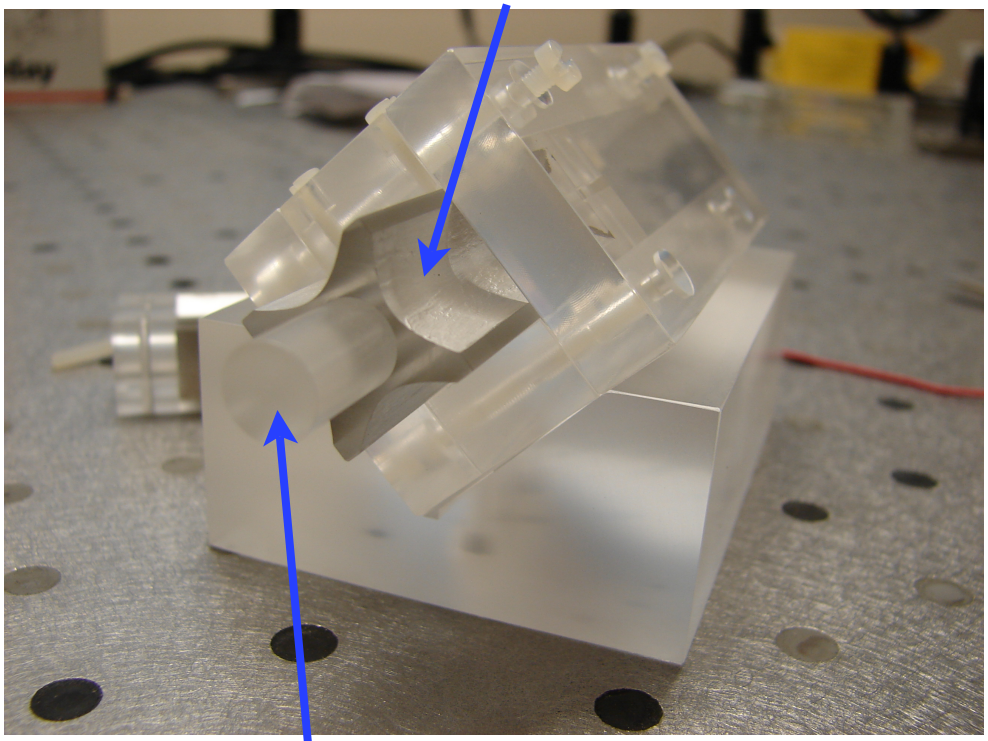


$$\Delta n = \frac{1}{2} n^3 \, r_{33} E_z$$

Prototype scanner

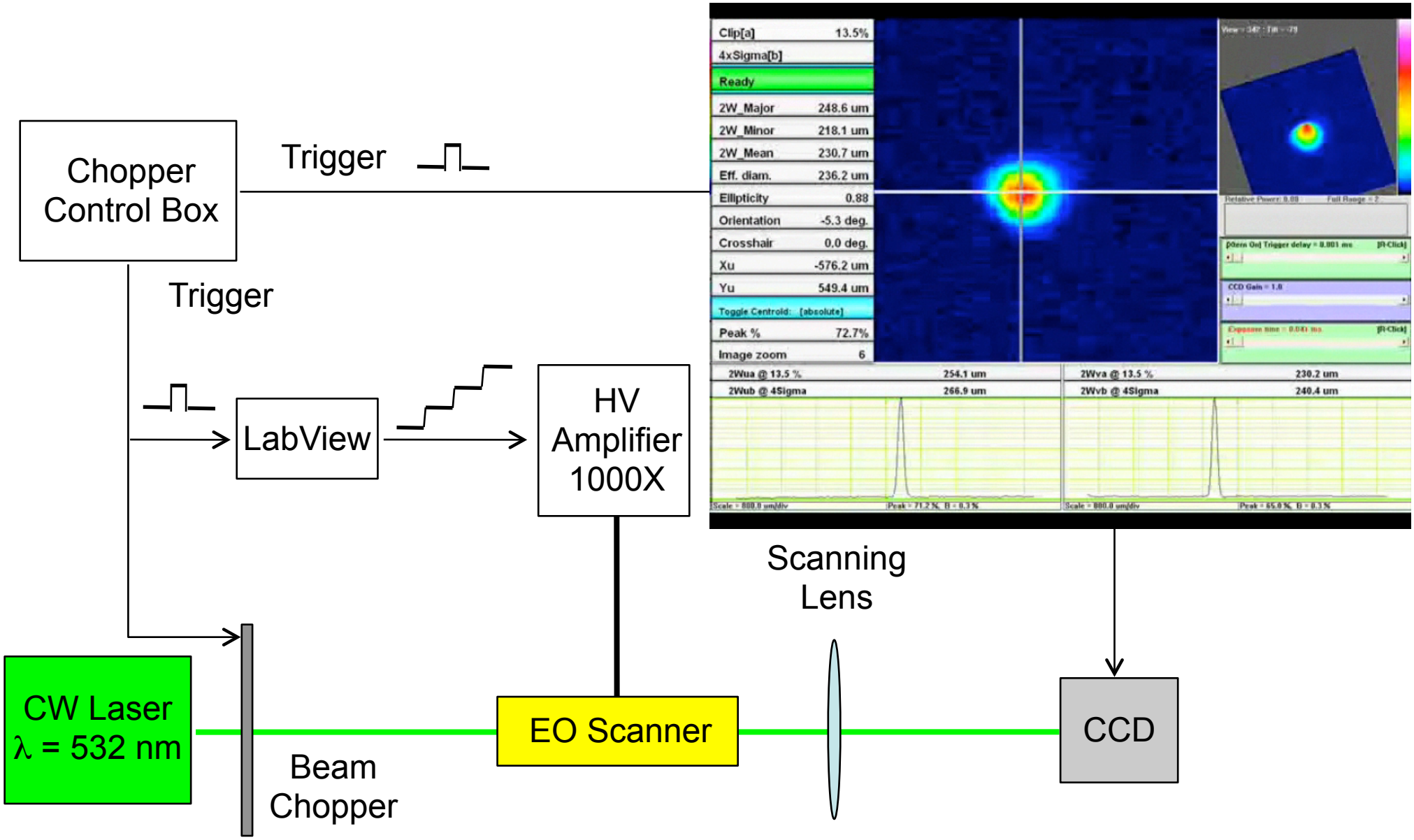
- First stage of high power scanner prototype
  - Simple EO crystal geometry
- Currently using
  - Lithium Niobate
  - Diameter 8.5 mm
  - Length 45 mm
- Different crystals
  - Damage thresholds
  - Electro-optic coefficient

Quadrupole electrodes on outer surface



Cylindrical crystal hole

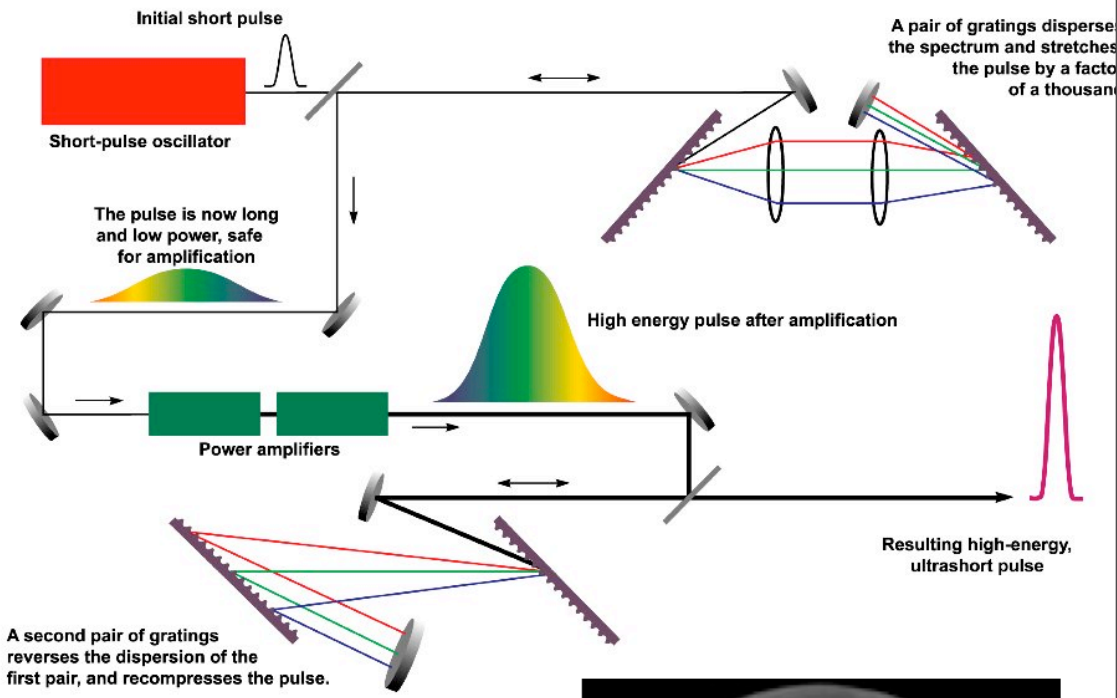
EO scanner tests



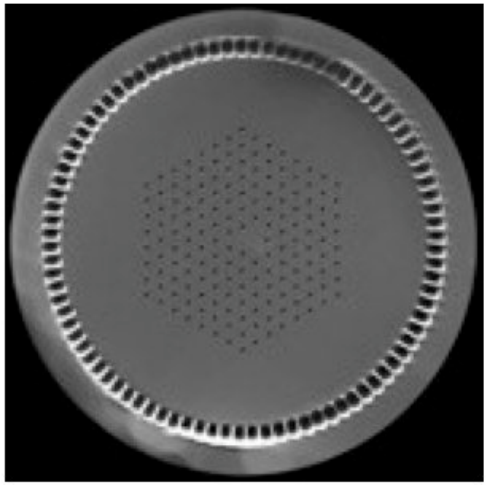
Fiber laser developments

- ILC diagnostics laser R&D
  - Fiber amplifier
  - Chirped amplification
- Photonic crystal fibre
  - Large core, but single mode
  - Samples difficult to obtain
- Started with bulk amplifier, passive mode locked. Amplitude Systemes

Chirped amplificaction



Example photonic crystal



Summary

- Good progress at both PETRA2 and ATF
  - NIM publications almost complete
  - Almost completed a prototype ILC specification laser-wire system
- ATF plans
  - Complete systematic studies to verify beam size measurement
  - Make emittance measurement with micron scale beams
  - Complete micron scale program before end of ATF operations in summer 2008
- Continue in short term with laser and scanning developments