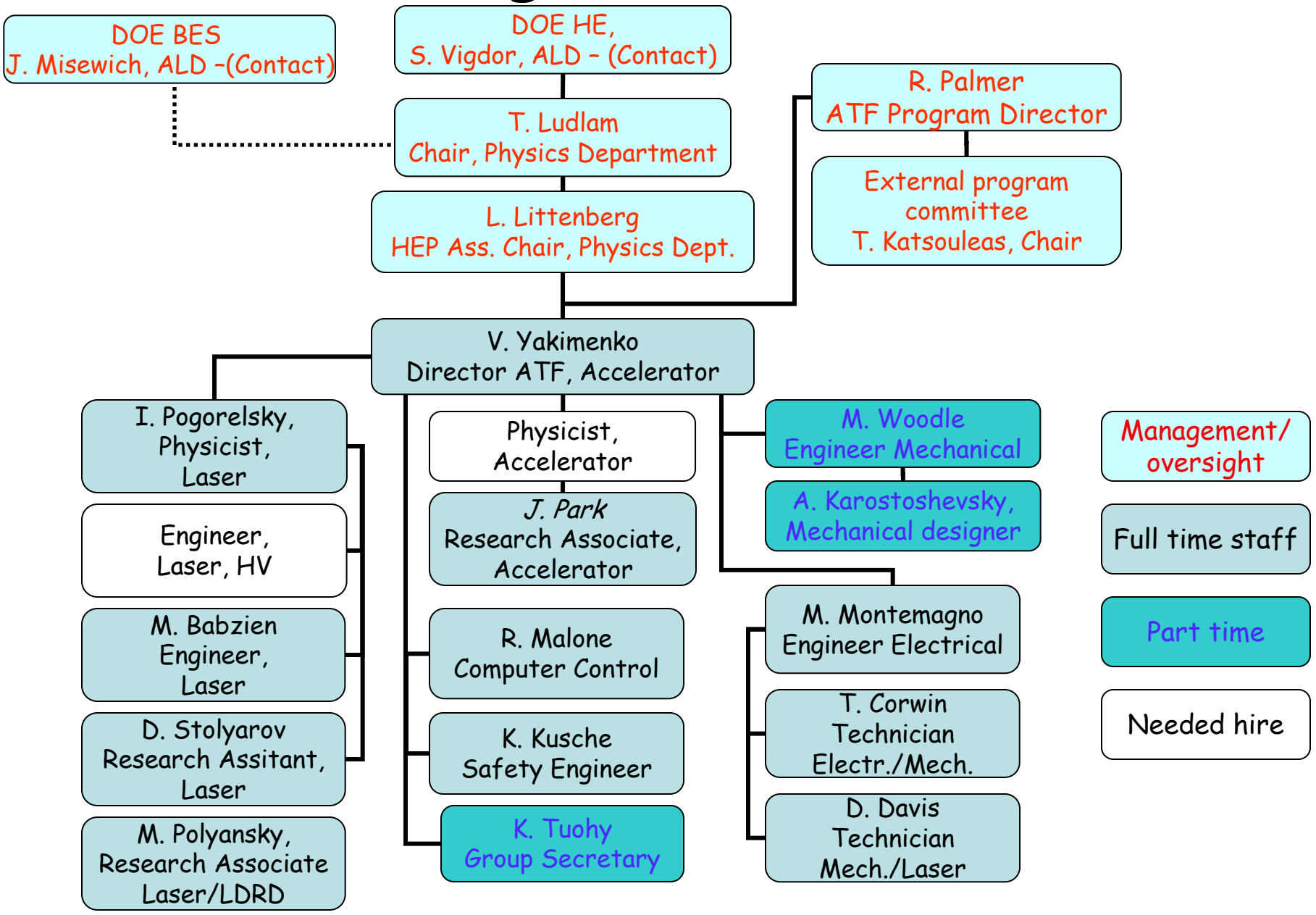
Accelerator test Facility

Vitaly Yakimenko

April 2, 2009

ATF Organization Chart



Infrastructure upgrades

- 1.5 micron emittance at 0.5nC routinely measured by users
- 85MeV beam energy tested for Compton experiment (12KeV X rays)
- 3.5ps RMS CO2 laser pulse duration measured
- 1:1000 CO2 laser contrast measured

- Low level X band power
- RF amplifiers/klystrons stability/lifetime monitoring
- Temperature monitoring and alarms
- Two channel Liquid Helium cooled bolometer
- Pair of new 4 channels frame grabbers
- High dynamic range GigE cameras
- Synchronized beam line cameras
- Input AC Power monitoring
- Vacuum interlocks
- New AC for the mezzanine installed

- Laser diagnostics development will be covered in later talks

Budget priorities

- Accelerator scientist
- X band capability
- Short pulse laser

- Stable, reliable and well characterized operations.

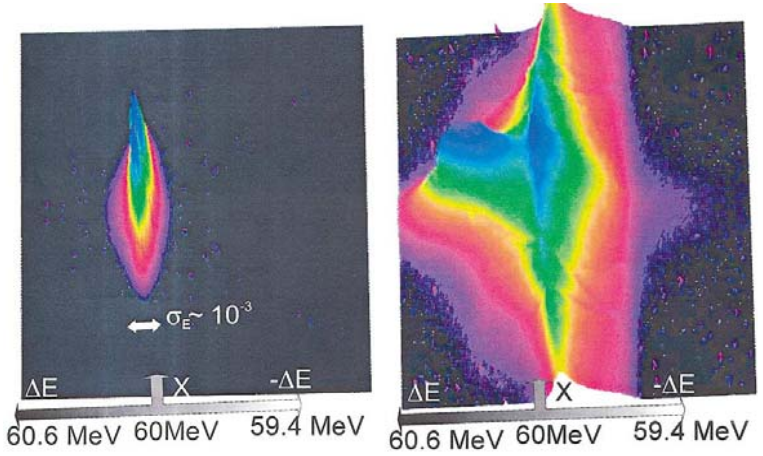
Recent fire at ATF

- Fire started due to failure of the high voltage capacitor in the pulse forming network of the Linac modulator.
- The modulator was completely destroyed
- Replacement modulator was built ~6 month before the fire (cost of parts ~$100K)
- Recertification, cleanup, upgrades (~$60K)
- Interlock systems disabled power to minimize chance of fire and made it safe for fire fighters.
- Operator on duty followed instructions prioritizing personal safety.
- Factors affecting the outcome were:
  - No high voltage trained person was not in the building at the time of the capacitor failure. (Both of the planned hires)
  - Replacement capacitors were ordered 2 days before the fire (at ~25% of the specified life time).
- Lasers were not affected and after recertification of interlocks restarted operations within days
- Waiting on the report of the fire investigation committee to restart operations

Challenges used as Opportunities

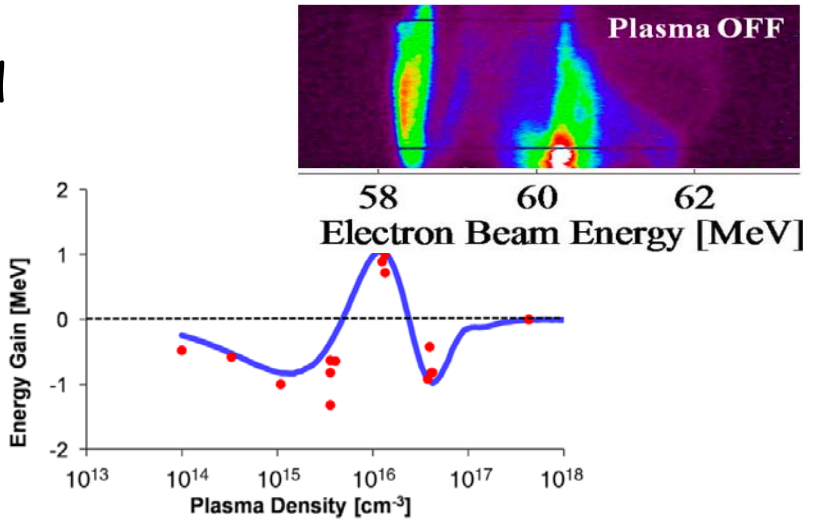
Phys. Rev. Lett. 91, 014802 (2003)

- Strong focusing of the e-beam in the laser guiding plasma capillary in the Compton experiment was used to precisely characterize focusing of the PWFA



Phys. Rev. Lett. **100**, 074802 (2008)

- Stable beam break up during compression in the chicane was used in two beam PWFA (T. Kallos, IEEE NPSS Particle Accelerator Science and Technology Doctoral Student Award in 2009)

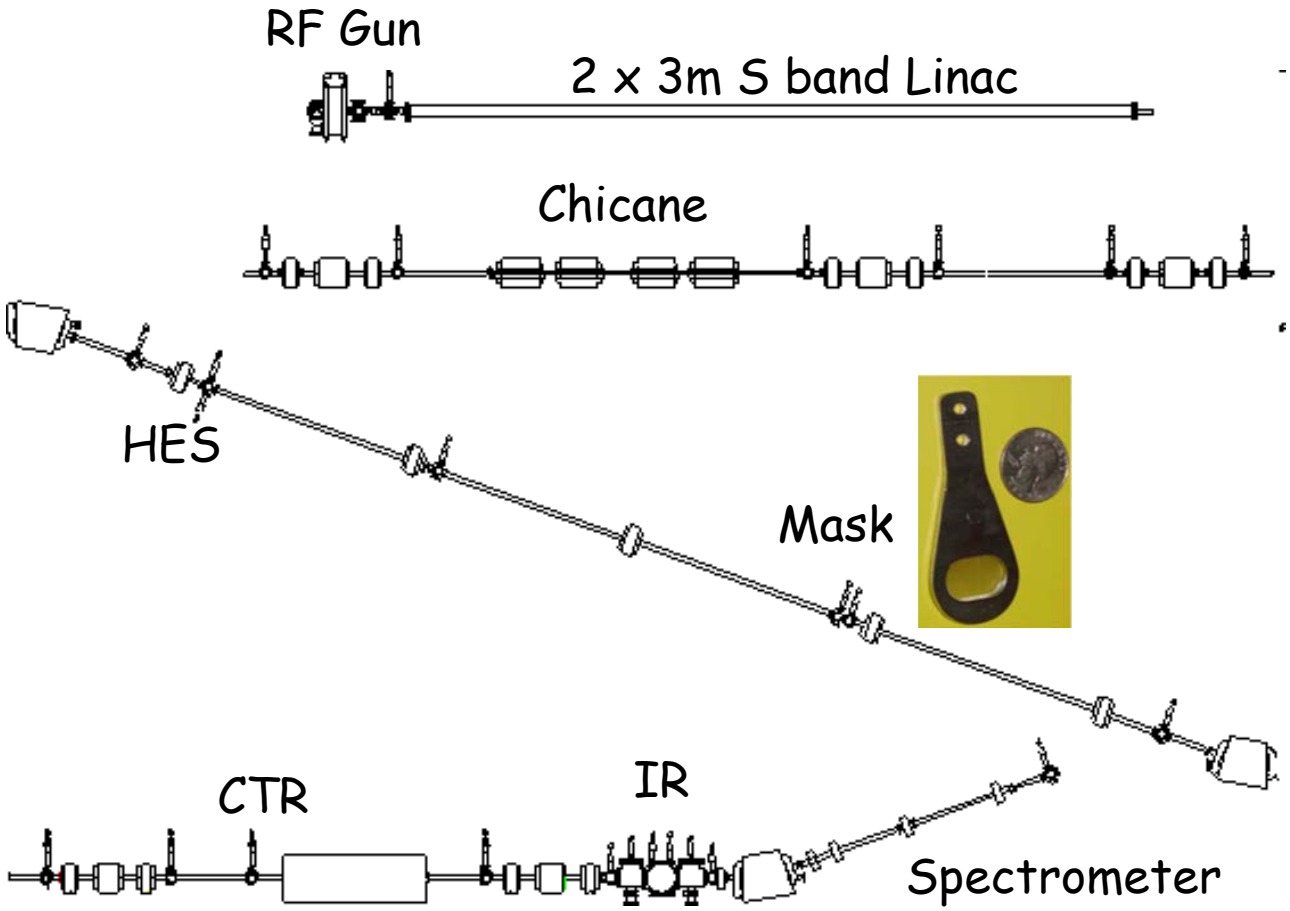


- ...

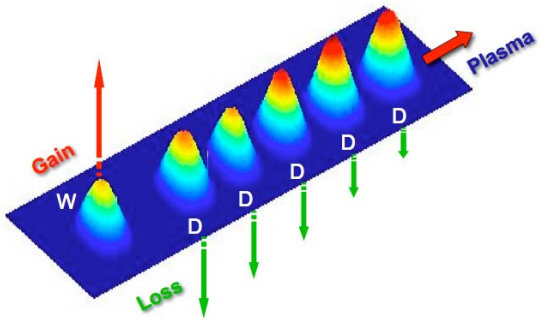
Collaboration with CAD, SB (CASE)

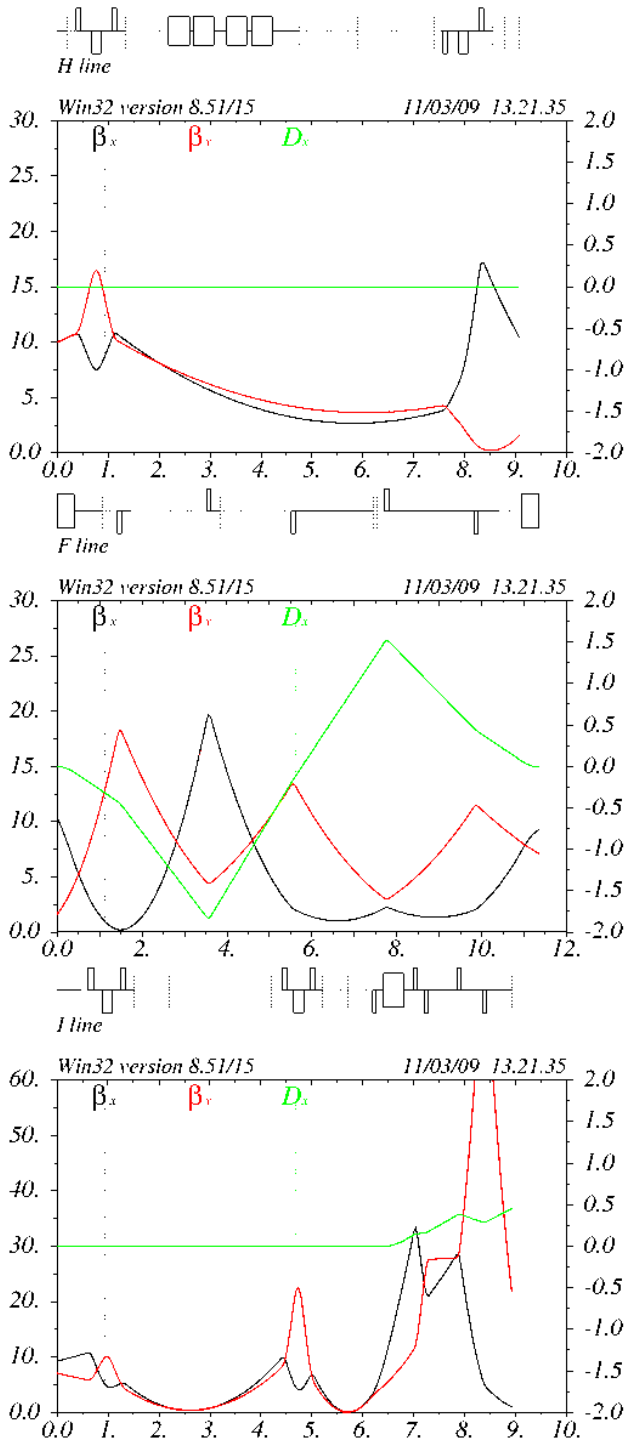
- It is nearly impossible to find broadly educated young accelerator scientist
- "In house" training is a practical option
- ATF is ideal place to obtain hands on experience on:
  - Magnets and transport design;
  - Diverse instrumentations
  - Injectors and RF accelerators
  - …
  - Collective effects (space charge and emittance, CSR and energy spread, ….)
- The training will be available to ATF users and will allow better understanding of the limitations of the experimental conditions.

Experimental Layout



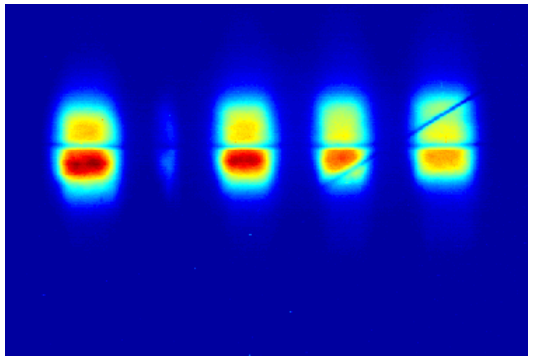
Measured microbunches



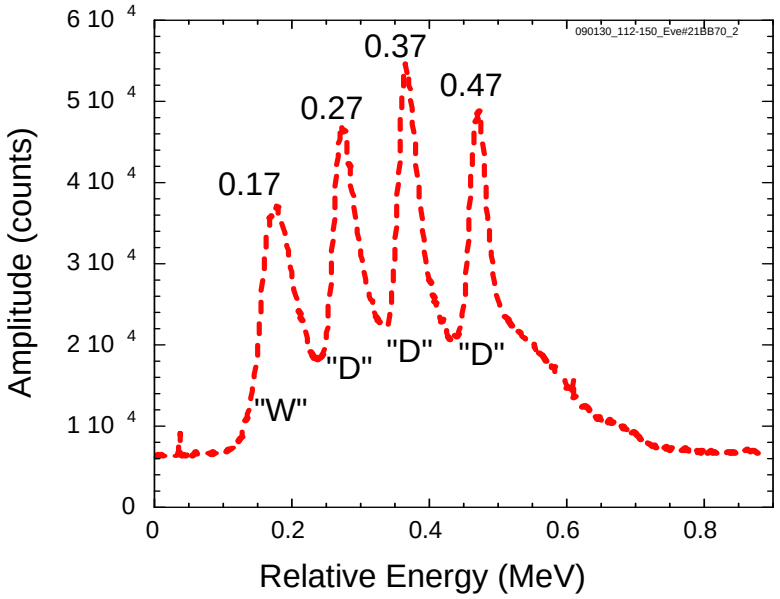


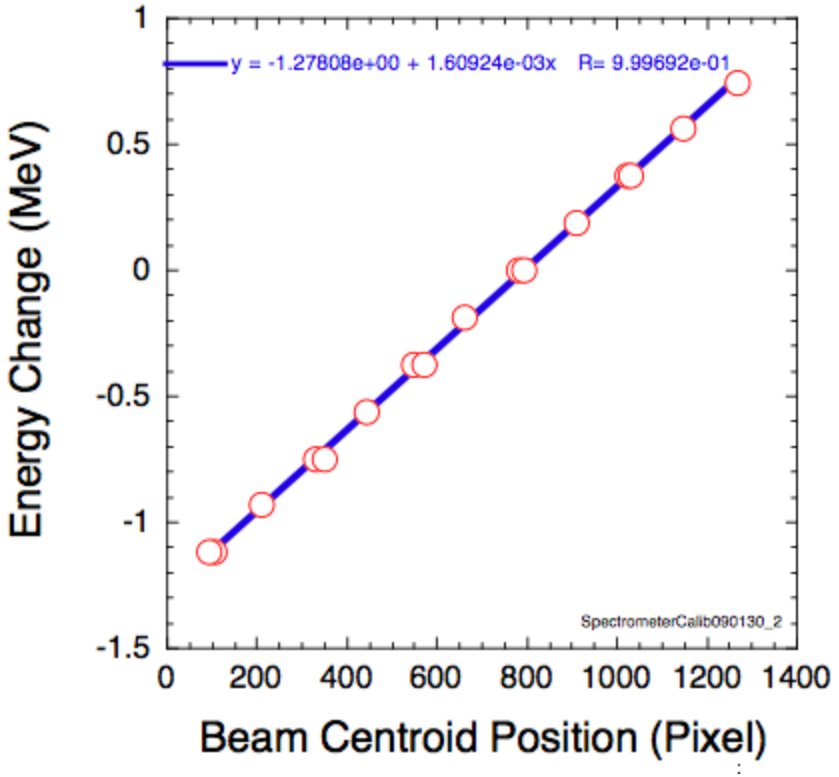
"CSR" challenge

Image after mask



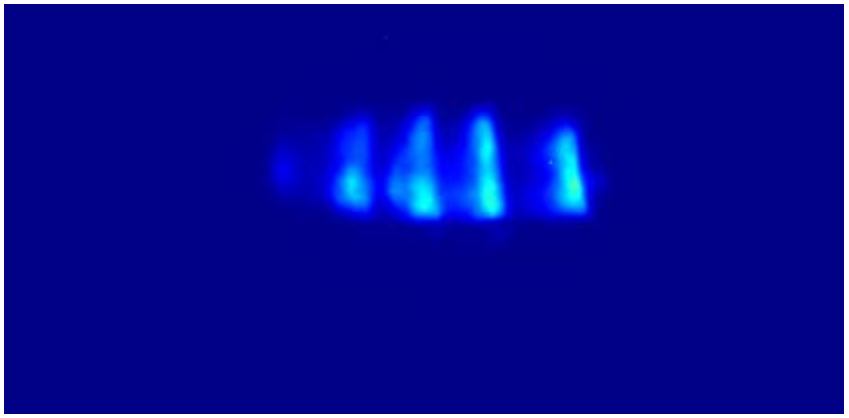
Projection at spectrometer





Energy is redistributed among bunches due to CSR

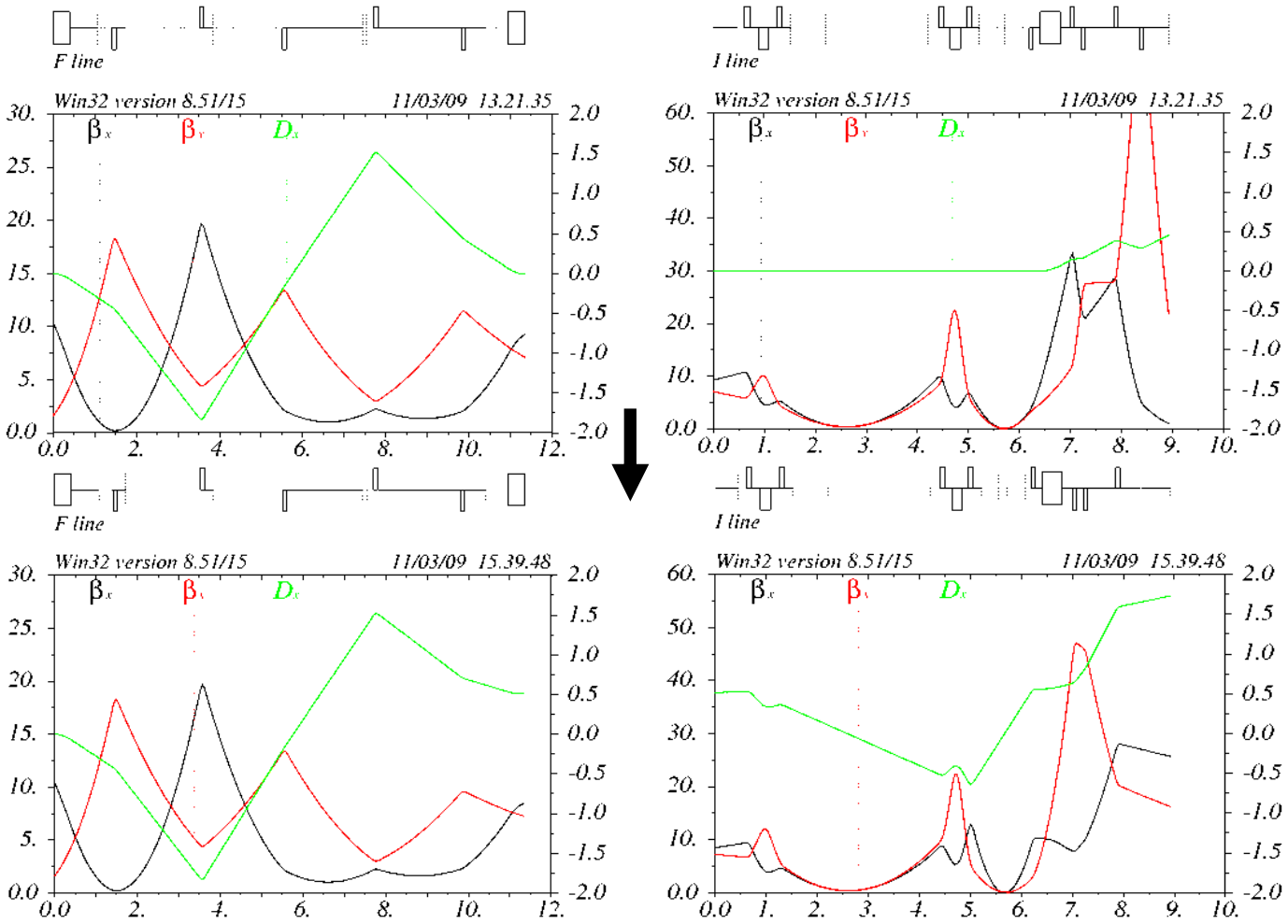
High contrast after mask leads to low contrast at spectrometer



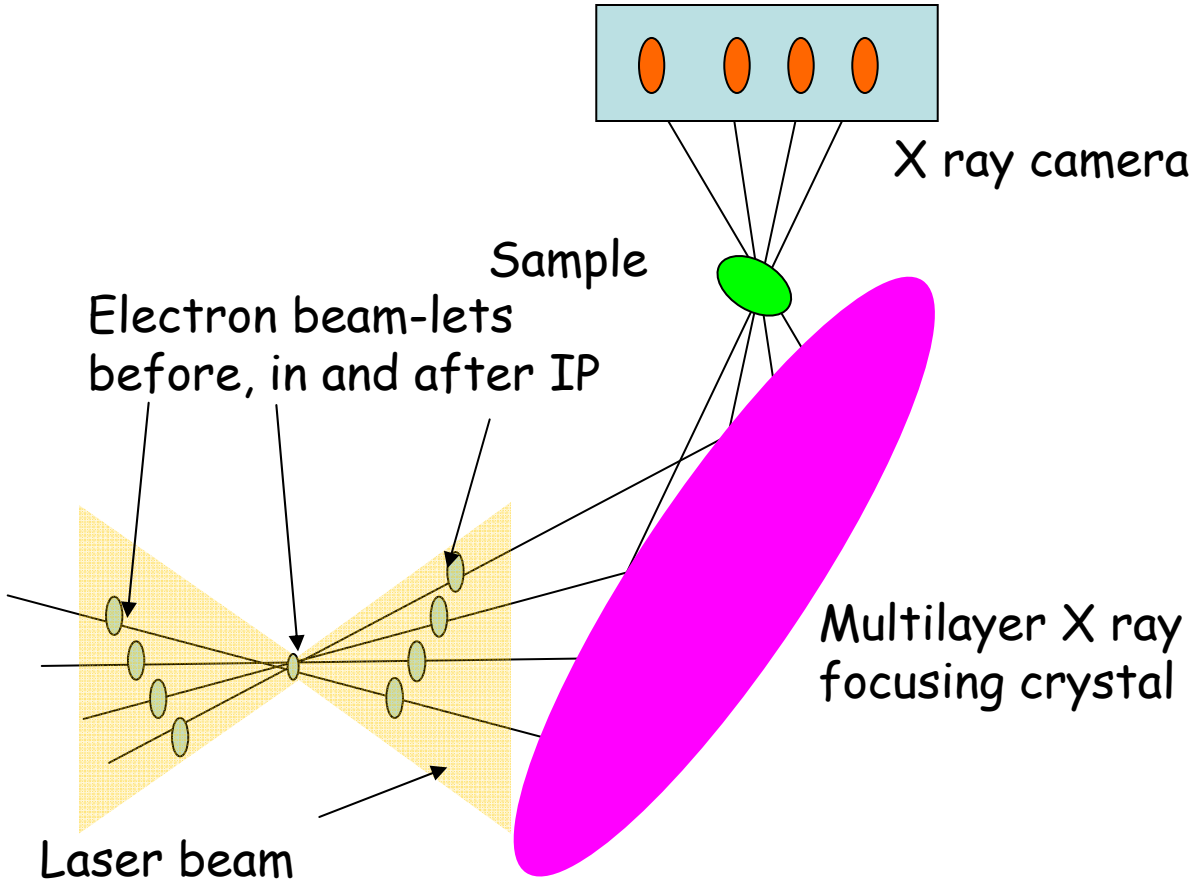
- Adjusting betatron size at the mask allows to generate Gaussian or "square" bunches.
- Energy spread from CSR changes ~3 times.
- A. Fedotov will present proposal to study CRS and its suppression using shielding.

Challenges: Beam line tuning

Quad currents are adjusted to have zero dispersion with large derivative at IR. Angular distribution at IR is dominated by the energy chirp.



100fs X ray movie



- 10^7 X rays per beamlet are expected with 1% energy spread and 0.3 mrad 35μm and 100fs or 10^{23} ph/sec/mm^2/mrad^2/0.1%
- Delay between frames can be adjusted with individual multilayer crystals per beamlet.

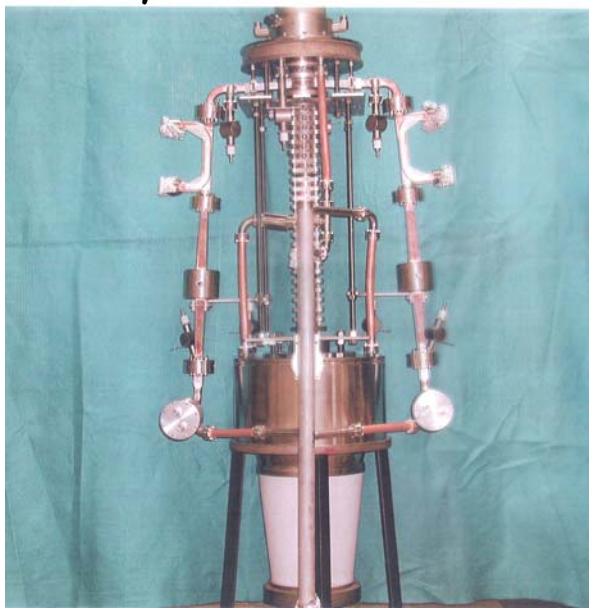
X-band klystrons

- We tested two SBIR klystrons: Patric Ferguson (MDS) and Lawrence Ives (CalCreek)
- MDS klystron did not have any cathode emission current
- We are working on getting beam transmitted through the second (SLAC loaned high power loads for testing)

- SLAC klystron is needed for reliable high power X-band program at ATF

- Why do we need it?
  - To test deflector cavity and measure beam with 3fs resolution
  - To silence energy chirp after compression and deliver controllable kilo-amp beam to user experiment (PWFA and FEL)
  - To study effect of accelerator break down on the beam with submicron emittance…

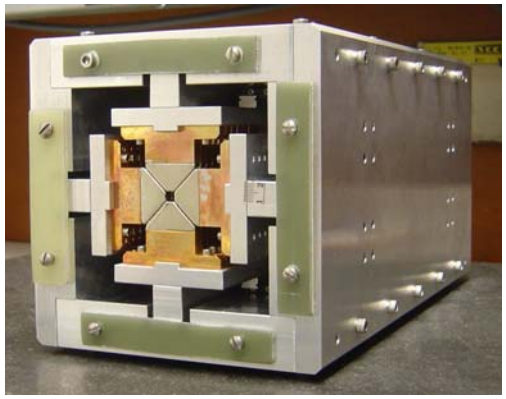
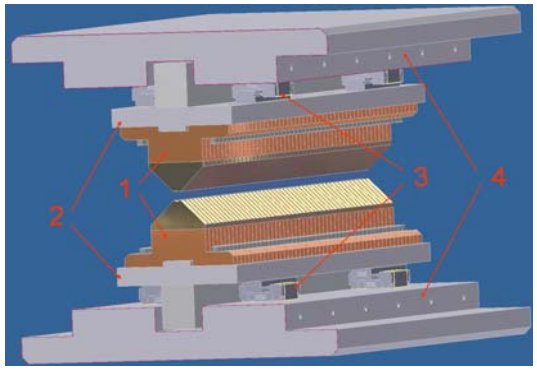
MDS klystron, 500kV 150MW

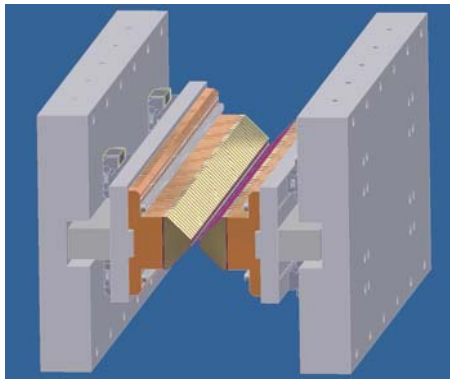


CalCreek klystron,
8 beams, 190kV 50MW

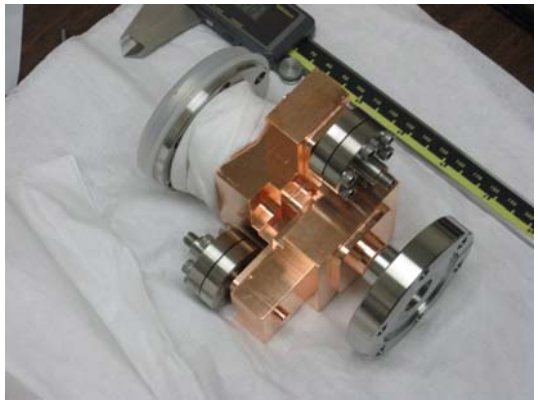
Very short tests

- Delta undulator from Cornell



- Second momentum cavities (Far-Tech)


- …

Quadrupole Cavity Measurements at the Brookhaven ATF*

Slides prepared by Nick Barov, FAR-TECH, Inc.
ATF User's meeting, April 2-3, 2009

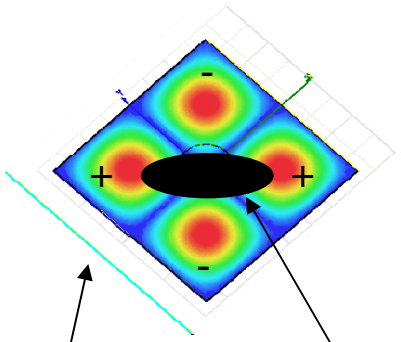
Jin-Soo Kim
Nick Barov

V. Yakimenko,
J. Park,
and the ATF team

C.D. Nantista
R.H. Miller

*Work suported by US DOE SBIR grant

Beam Second Order Measurement



Beam with unequal σ_x and σ_y

Quadrupole (TM_{220}) mode profile.

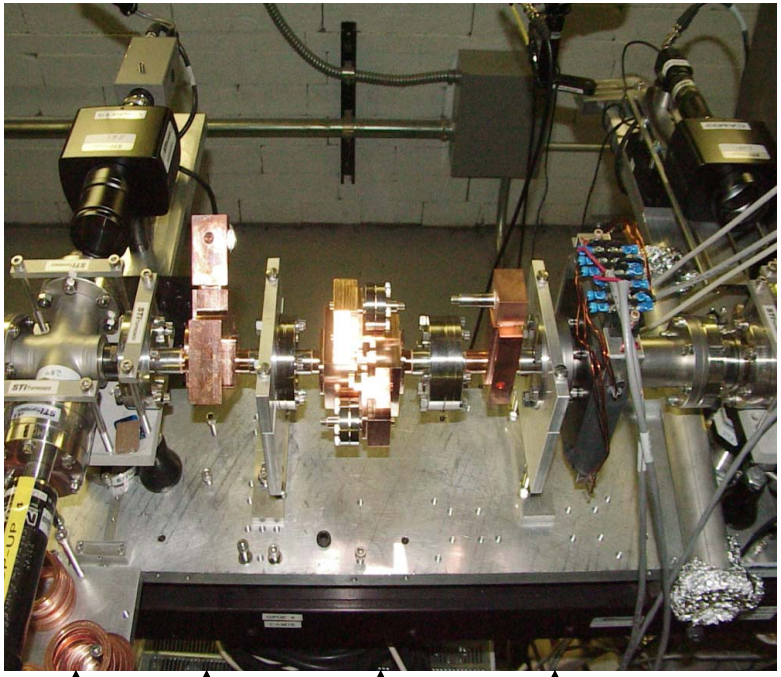
A quadrupole mode cavity can measure the "second order" moment of a beam, $\langle x^2 - y^2 \rangle$. Position measurements are needed to distinguish between a round, offset beam and an on-axis beam with unequal σ_x and σ_y.

Quadrupole cavity built by FAR-TECH, Inc: 2 cells, 11.384 GHz.

High shunt-impedance design, Patent granted to FAR-TECH

FAR-TECH

Experimental setup



Beam direction

(ATF Beamline 1)

The RF signals were fed to a 4-channel heterodyne system (110 MHz IF) and 500 MHz oscilloscope

Phase reference cavity

Dipole cavity

Quad cavity

YAG screen

YAG measures:

$\langle x \rangle$, $\langle y \rangle$ and $\langle x^2 \rangle - \langle y^2 \rangle$

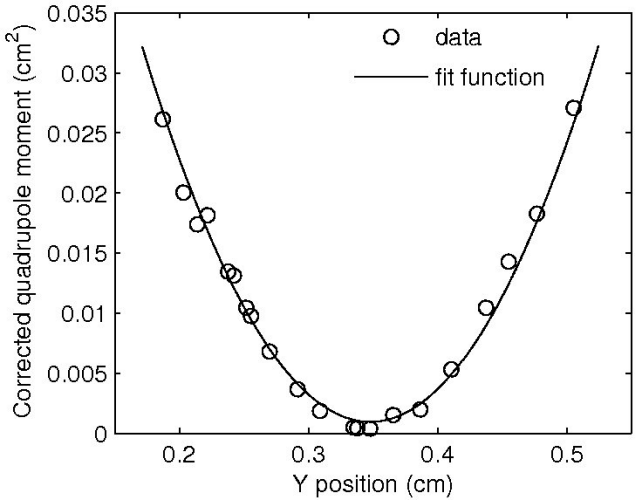
Quad cavity measures:

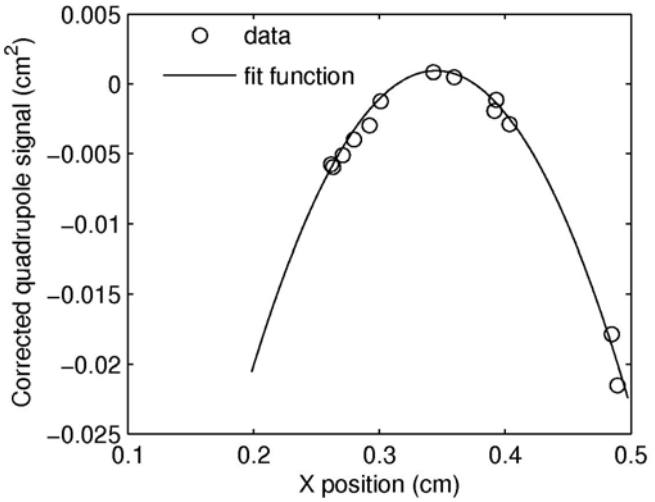
$\langle x \rangle^2 - \langle y \rangle^2 + \langle x^2 \rangle - \langle y^2 \rangle$

The two measurements can be directly compared.

FAR-TECH

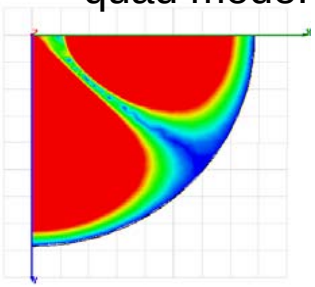
Experimental Results





Quad cavity and YAG screen data was fit to a hyperboloid.

Asymmetric quad mode:



Given a perfect quad cavity, the above data should go through zero. However, the cavity had a known asymmetry such that the signal was $x^2 - y^2 + K$, where,

sqrt(K) = 196 +/- 58 microns (e^- beam data shown above)
sqrt(K) = 146 microns (wire test measurements)

Conclusion: The beamline data and the wire test data are in agreement.

Schedule

- **9:00 - 10:10 ATF Status**
  - *40 min, V. Yakimenko, Facility Status and Plans*
  - *30 min, I. Pogorelsky, CO2 laser: present status and research highlights*
- **10:10-10:30 Coffee break**
- **10:30-12:10 Multibunch and plasma: Status and Proposals**
  - *20 min, P. Muggli, USC, Generation of multi-bunch trains with sub-picosecond separation for PWFA*
  - *20 min, P. Muggli, USC, Status of the multi-bunch PWFA experiment at ATF*
  - *30 min, B. Allen, USC, Proposal: Experimental investigation of the current filamentation instability*
  - *30 min, R. Zgadzag, U. Texas, Proposal: Direct measurement of plasma wave structure produced in multi-bunch driven PWFA*
- **12:10-13:30 Working Lunch/Executive Session**

Schedule

- **13:20-15:20 X ray beams: Status and Proposals**
  - *30 min, O. Williams, UCLA, Compton Results at ATF*
  - *30 min, M. Carpinelli, INF, Compton Proposal*
  - *30 min S. Boucher, RaiaBeam, High-flux Inverse Compton Scattering for Medical, Industrial and Security Applications*
  - *20 min M. Polyanskiy, BNL, Multi-pass CO2 laser cavity for high-repetition pulse trains*
- **15:20-15:50 Coffee break**
- **15:50-17:10 Ion generation and applications: Status and Proposals**
  - *20 min, P. Shkolnikov, Stony Brook U, Proton beams from laser-irradiated foils*
  - *30 min, I. Pogorelsky on behalf of Z. Najmudin, Imperial College, Ion acceleration in the interaction of ultra-short, high-intensity CO2 laser pulses with gas jets*
  - *30 min, E. Polyakova, Columbia U., Modification of graphene films by laser-generated high energy particles*
- **17:10-18:00 Executive Session (Room 2-160)**
- **18:30-20:30 Dinner**

- **8:30-10:20 ATF lasers Plans**
  - *30 min, M. Babzien, BNL, YAG Status, Experimental Support & Instrumentation*
  - *20 min, D. Stolyarov, BNL, A femtosecond CO2 front end based on frequency mixing with an Ytterbium laser*
  - *30 min, M. Polyanskiy, BNL, Simulation and diagnostic tools for better understanding and upgrade of the CO2 laser*
  - *30 min, I. Pogorelsky, BNL, CO2 laser: near-term plans*
- **10:20-10:50 Coffee Break**
- **10:50-12:20 New Proposals**
  - *30 min, A. Fedotov, BNL, CSR Shielding Studies*
  - *30 min, T. Shaftan on behalf of A. Gover, Israel, Proposal: Study of collective interaction control over e-beam current noise*
  - *30min Pietro Musumeci 220 MV/m - 130 MeV energy gain helical IFEL experiment @ BNL*
- **12:20-13:30 Working Lunch/Executive Session**
- **13:30-14:50 Current Experimental Status**
  - *20 min, L. Zhao, UCLA, Vacuum Acceleration*
  - *20 min S. Shchelkunov, Yale, First Results from LACARA and Interpretation*
  - *20 min J. Rosenzweig, UCLA, Coherent Edge Radiation*
  - *20 min J. Park, BNL, The Emittance Improvements by the Alignments in a Photoinjector*
- **14:50-15:20 Closing Executive Session**