Diagnostics, Control and Synchronization Working Group Summary

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Synchronization

Uesaka, Wang:

Laser-laser

10 fs -- 300 fs nominal

Laser-beam

500 fs (multiple pulse) -- 150 fs (single shot)

10^{-4} voltage regulation and control of long-term drifts needed to achieve < 50 fs

Diagnostics

Ross, Kim, Lumpkin

Beam position/size measurement

30 nm - laser wire; 200 nm – high q cavity BPM ***- ultimate target: 3 nm***

Protons: inchorenet OTR , electrons: COTRI : 1 micron- ***need 1nm***

Bunch length measurements

Clayton, Watanabe, Wang, Korbly, van Tilborg, Haimson, Kim, Schelkunov

CTTR interferometry and spectroscopy 50 fs (single shot) 170 fs (multiple shots)
from plasmas, gratings, foils, dielectric channels

Deflector cavities **< 30 fs maybe possible**

EO effect CTTR + EO ~300 fs **< 50 fs maybe possible**
possible with cross correlation in nonlinear crystal and short (10-50fs) lasers

Halo Measurements

Gilpatrick, Fiorito

10^5 dynamic range - wires+scrapers **probably OK , theoretical, simulations**

10^6 with coronagraph technique (Mitsuhashi) **needed to confirm (Kishek)**

Beam rms divergence /emittance

Chouffani

Laser Compton scattering (multi-shot) 5% at 1 mrad **needs improvement precision and accuracy**

Beam phase space

Shaftan, Loos

phase-advance tomography (E,t) **needs development**

Optical pepper pot (transverse) **needs development**

Single quad scan and multi position slice tomography **space charge may effect + large lattice alternate easier needed for wide applic.**

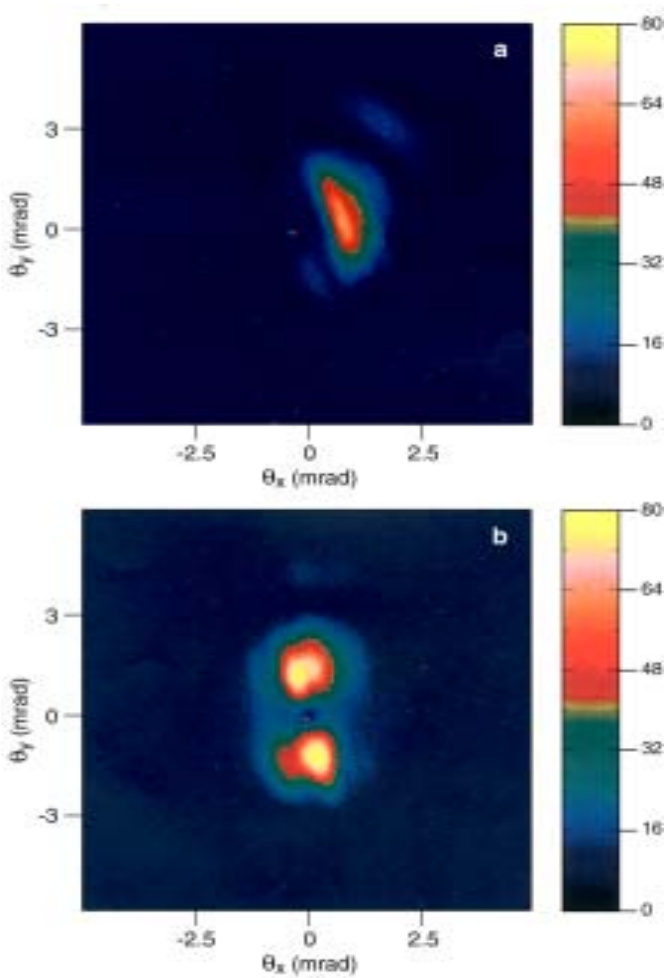
Control techniques
Travish, England

Permanent magnet quad focusing system: alternate to convention quads
Chicane sextupole corrections: phase space pulse tailoring for plasma/laser accelerator expermts.

Special Topics
Downer, Kim
Pump/probe techniques for temporal and
SSSI spatial index of refraction measurement
10 fs and 7 μ resolution **can these be applied to beam diagnostics?**

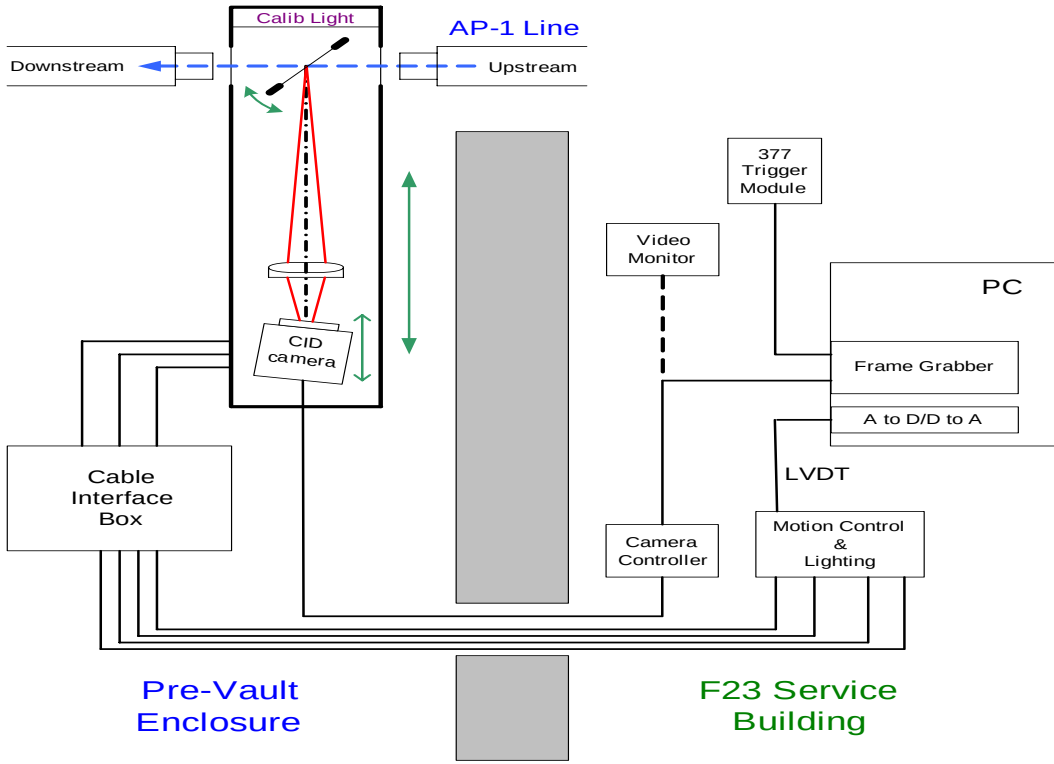
A. Lumpkin ANL

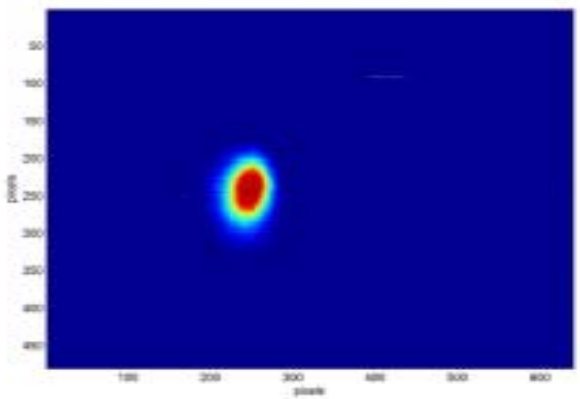
COTRI Far Field Imaging for diagnostics of microbunched e beam position angle and size



A. Lumpkin ANL

OTR Near field imaging of spatial distribution of 120-GeV protons





Chouffani, Idaho Accelerator Center

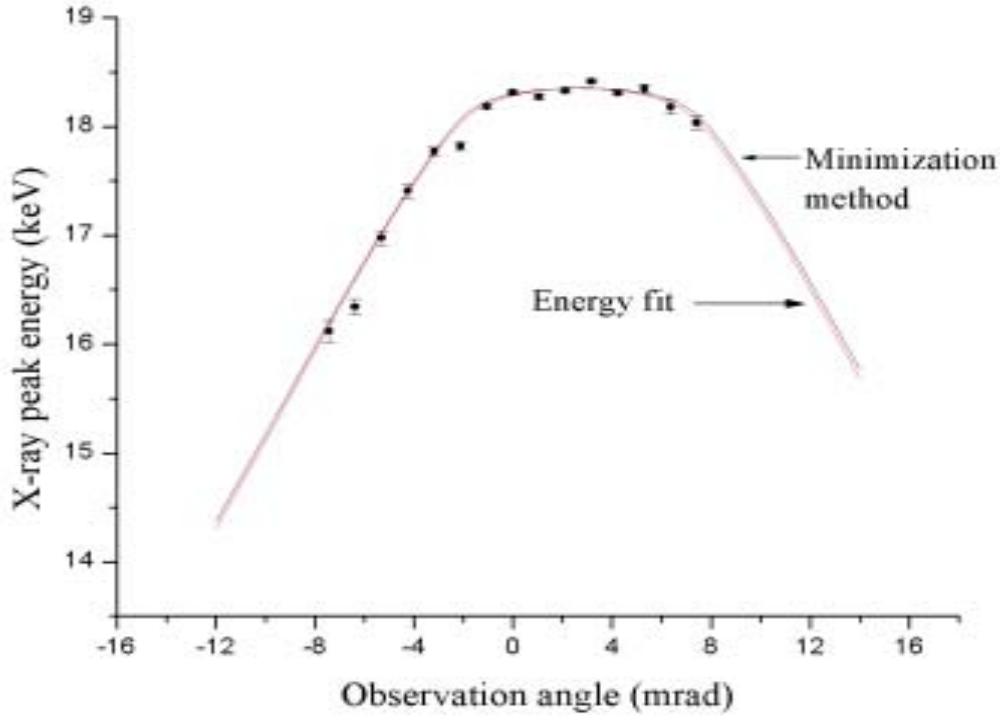
Laser Compton Scattering Beam Diagnostics

$$\sigma = 2.4 \pm 0.1\text{mrad}$$

$$\Delta E = 0.25 \pm 0.02\text{MeV}$$

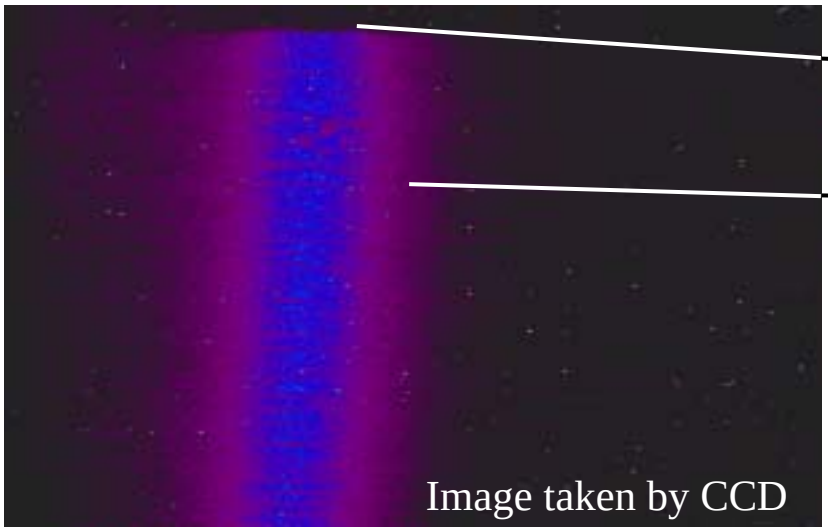
$$\theta_{traj} = 2.7 \pm 0.1\text{mrad}$$

$$E = 22.30 \pm 0.02\text{MeV}$$



Watanabe,BNL

Cherenkov Beam Trajectory Angle Diagnostic



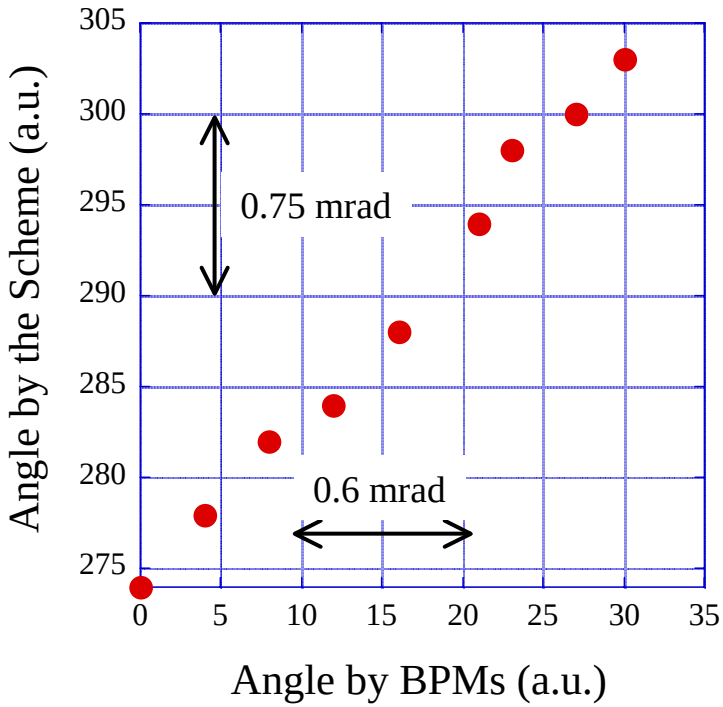
Field of view

Far-field Cherenkov radiation

Gaussian distribution

σ = 0.5 mm@CCD

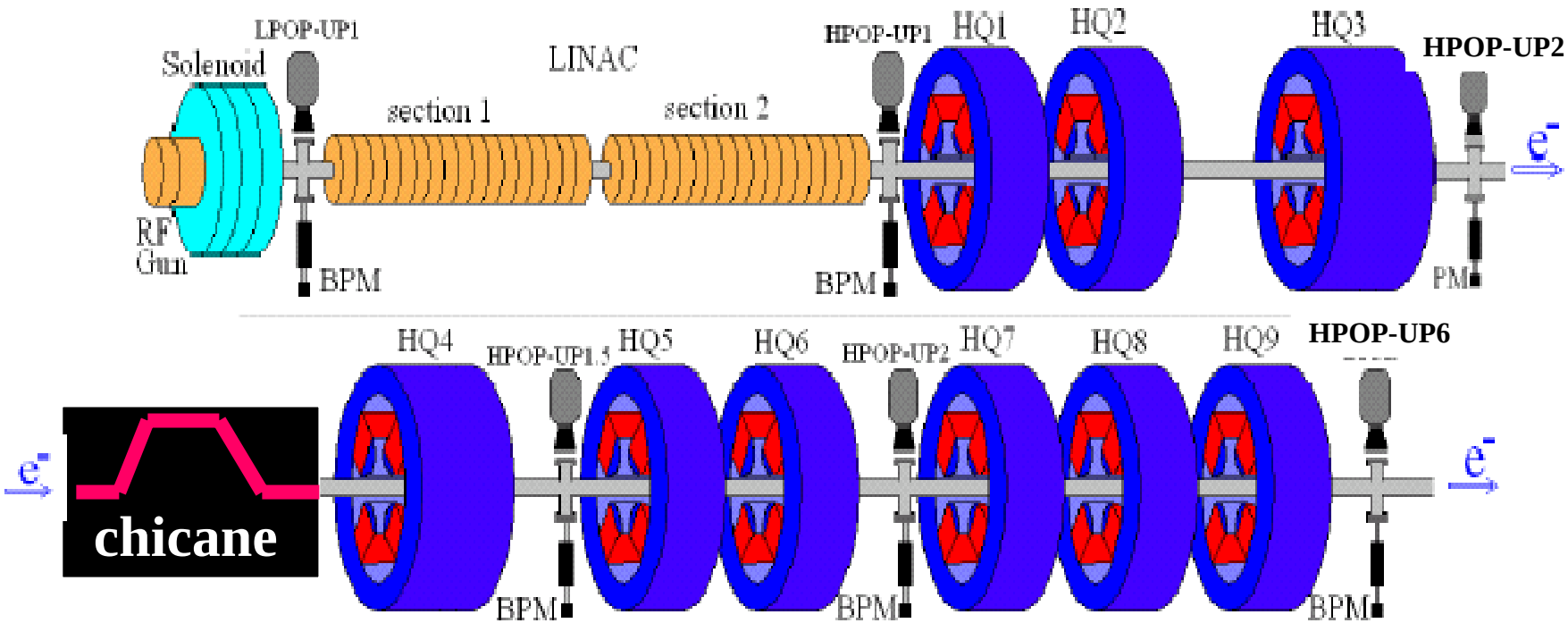
Position dependence



Zhou

Tomography technique

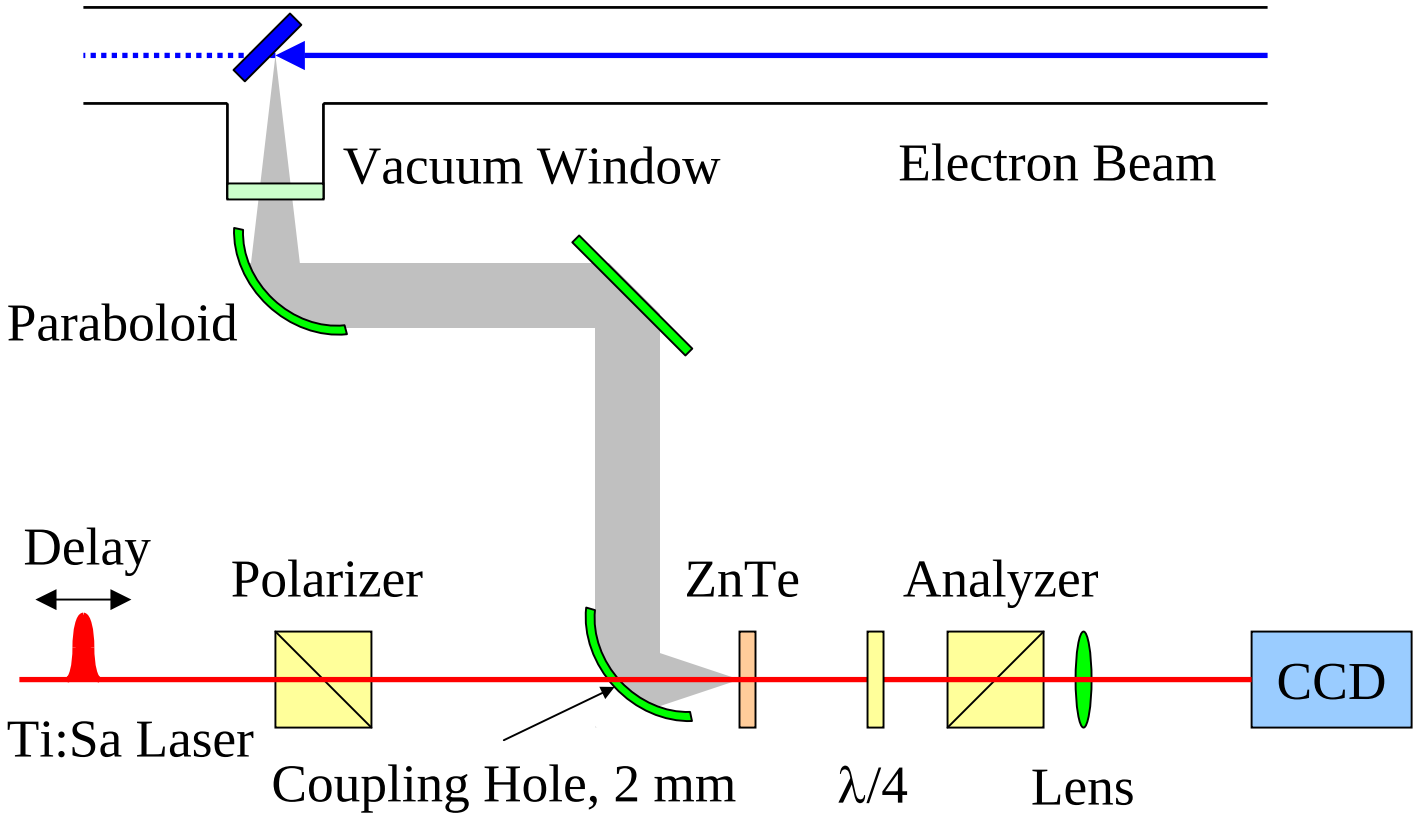
Yakimenko et al., PRST-AB, 2003



$$\mu(x,x') = \int_0^{\pi} \lambda_\phi^*(\xi)\, d\phi \,|_{\xi=\cos\phi + x'\sin\phi}$$

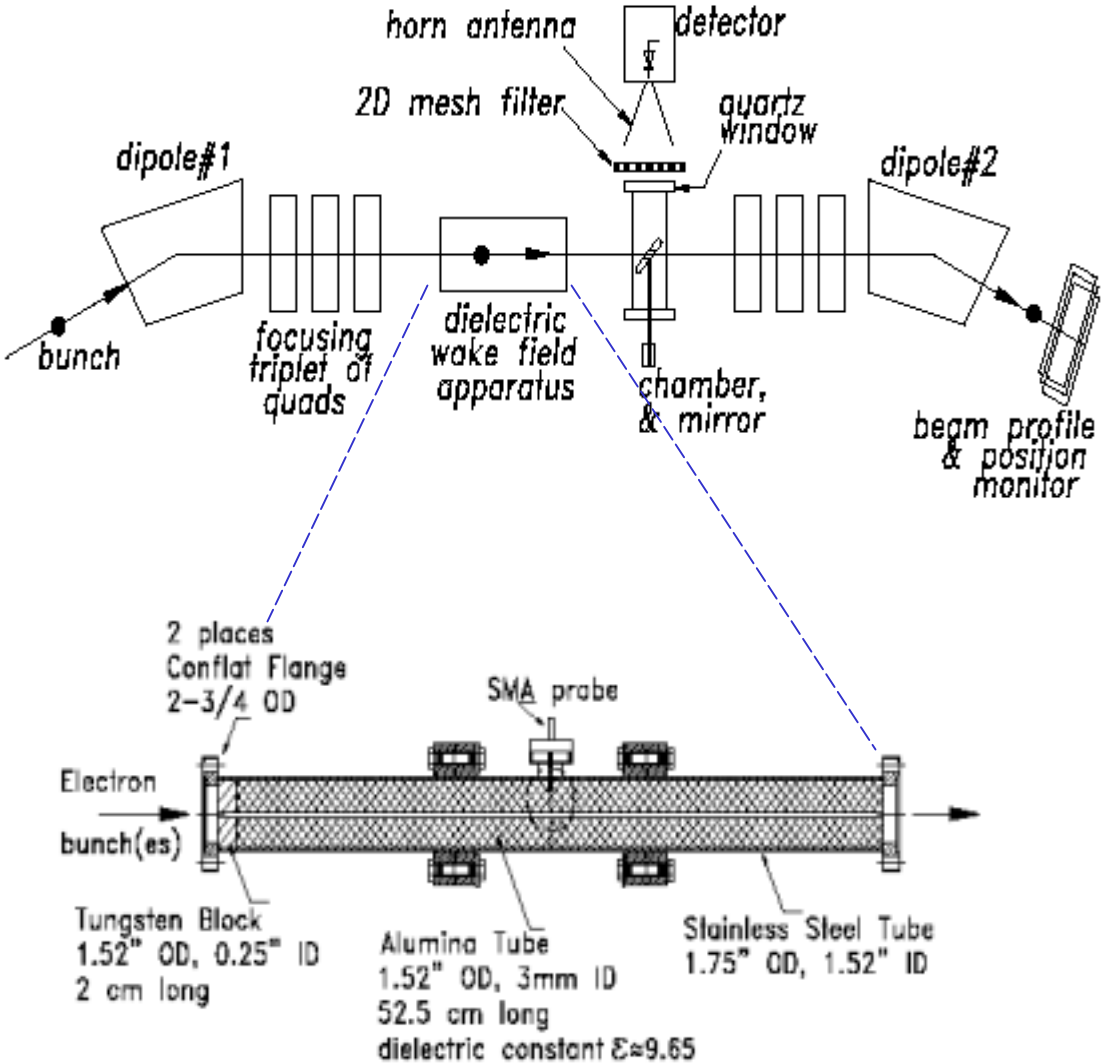
filtered projection $\lambda_\phi^*(ms) = \frac{1}{4s}\lambda_\phi(ms) - \frac{1}{\pi^2 s}\sum_{\substack{n \\ m-n=odd}} \frac{\lambda_\phi(ns)}{(m-n)^2}$

CTTR Electro-Optic Bunch Length Measurement



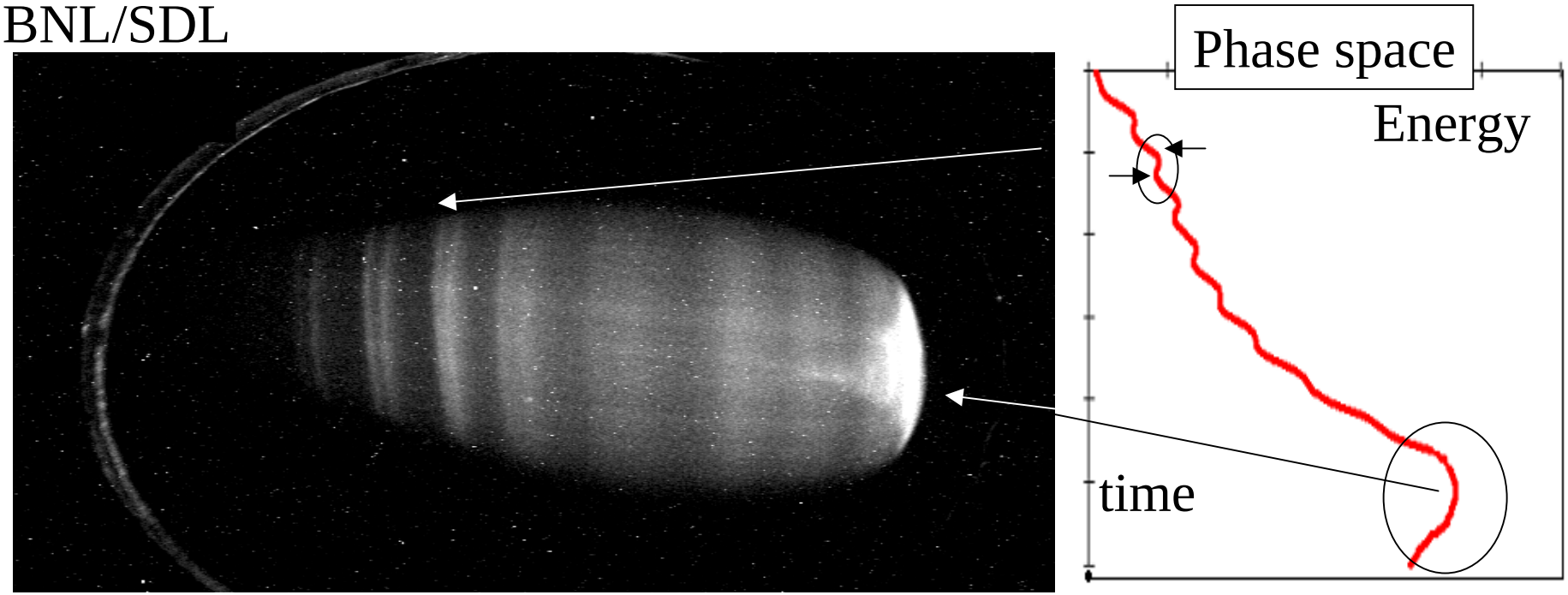
Schelkunov

APPARATUS, & EXPERIMENTAL SCHEMATICS



. Shaftan,
BNL/SDL

Zero Phase modulation analysis

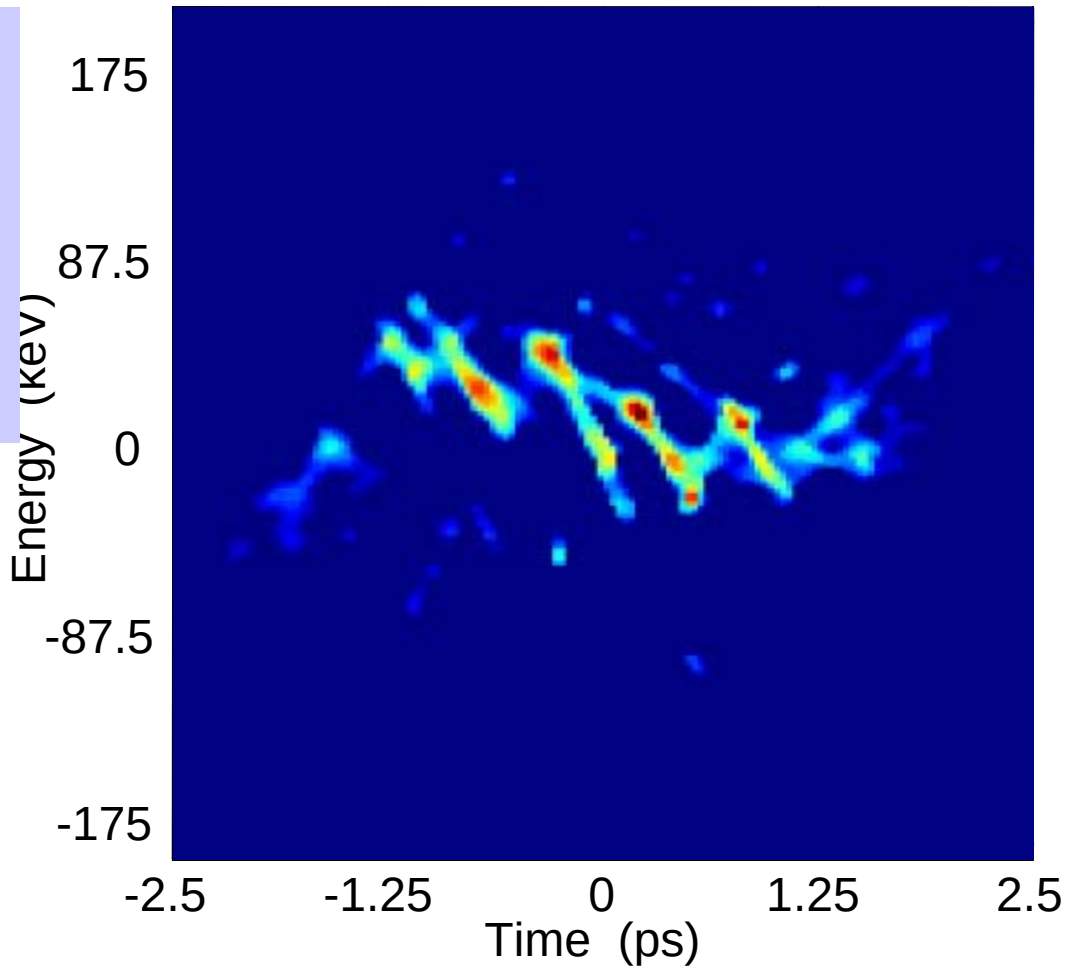


An example of the chirped beam image. One of the interesting features here is evolution of the modulation wavelength along the bunch, corresponding to nonlinear chirp. Interpretation of double peaks on the left: “overmodulated” periods. Every couple of double spikes in this region represents a single modulation period. Tail of the bunch is folded back over, introducing bright region on the right side of the image (space charge).

“Analysis of space charge driven modulation in electron bunch energy spectra”, T. Shaftan and L.H. Yu, BNL-71490-2003-JA .

Tomographic E,t Phase Space Reconstruction

- Used 19 different RF chirps
- Inconsistency in data from beam jitter causes artefacts
- Original intensity modulation in laser evolves into energy-time correlation



Courtesy of H. Loos