WG5 Summary

Philippe Piot (NIU)
John Lewellen (Argonne)

NORTHERN ILLINOIS UNIVERSITY

Argonne NATIONAL LABORATORY

First things first

- Thanks to all of our participants
  - Interesting talks on a wide range of ideas
  - Good questions!

- Thanks to our colleagues in other groups, in particular:
  - Computation
  - EM Structures

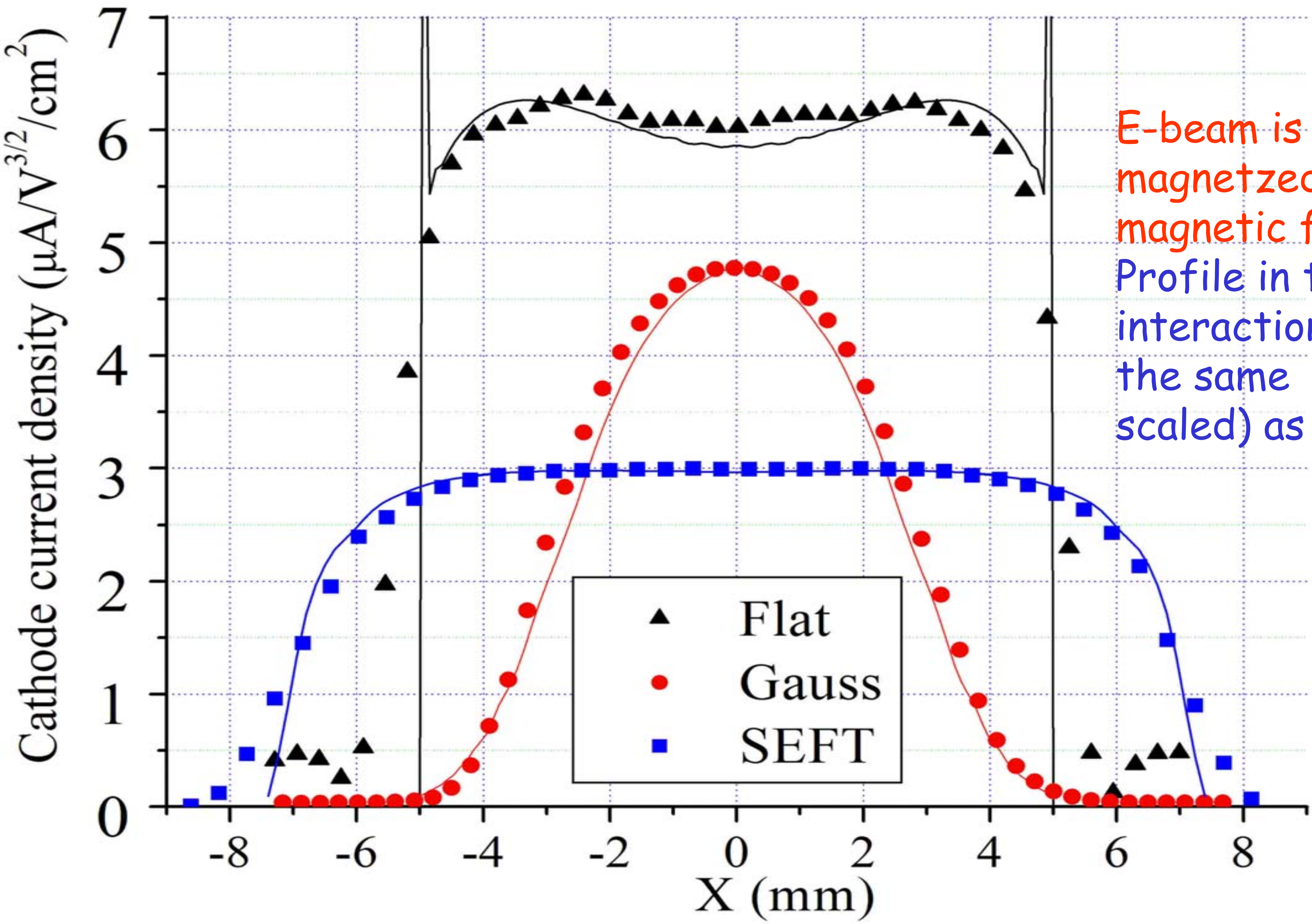
What we talked about

- Beam Sources
  - Some quite unusual
  - Some used for “non-typical” purposes
- Beam Monitoring
  - Evolving field
  - Tomography (trans. & long.) becoming more common
  - Improvements in non-intercepting techniques
- Beam Control & Manipulation
  - Advanced techniques that need to be tested
  - Advanced techniques that already are interesting
  - Starting to use improved beam monitoring techniques

Beam Sources

- "Directed" sources
  - Time-synchronized pulse radiolysis (U. Tokyo)
  - Compton backscatter (U. Tokyo)
- "Beam Phyiscs" sources
  - A0 photoinjector (Fermilab)
  - SPARC photoinjector (Frascati) (incl. ellipsoidal blowout)
  - TW/SW photoinjector (UCLA)
- "Enabling" sources
  - Tevatron e^- lenses
  - Polarized e^+ source
  - Diamond amplifier photocathode

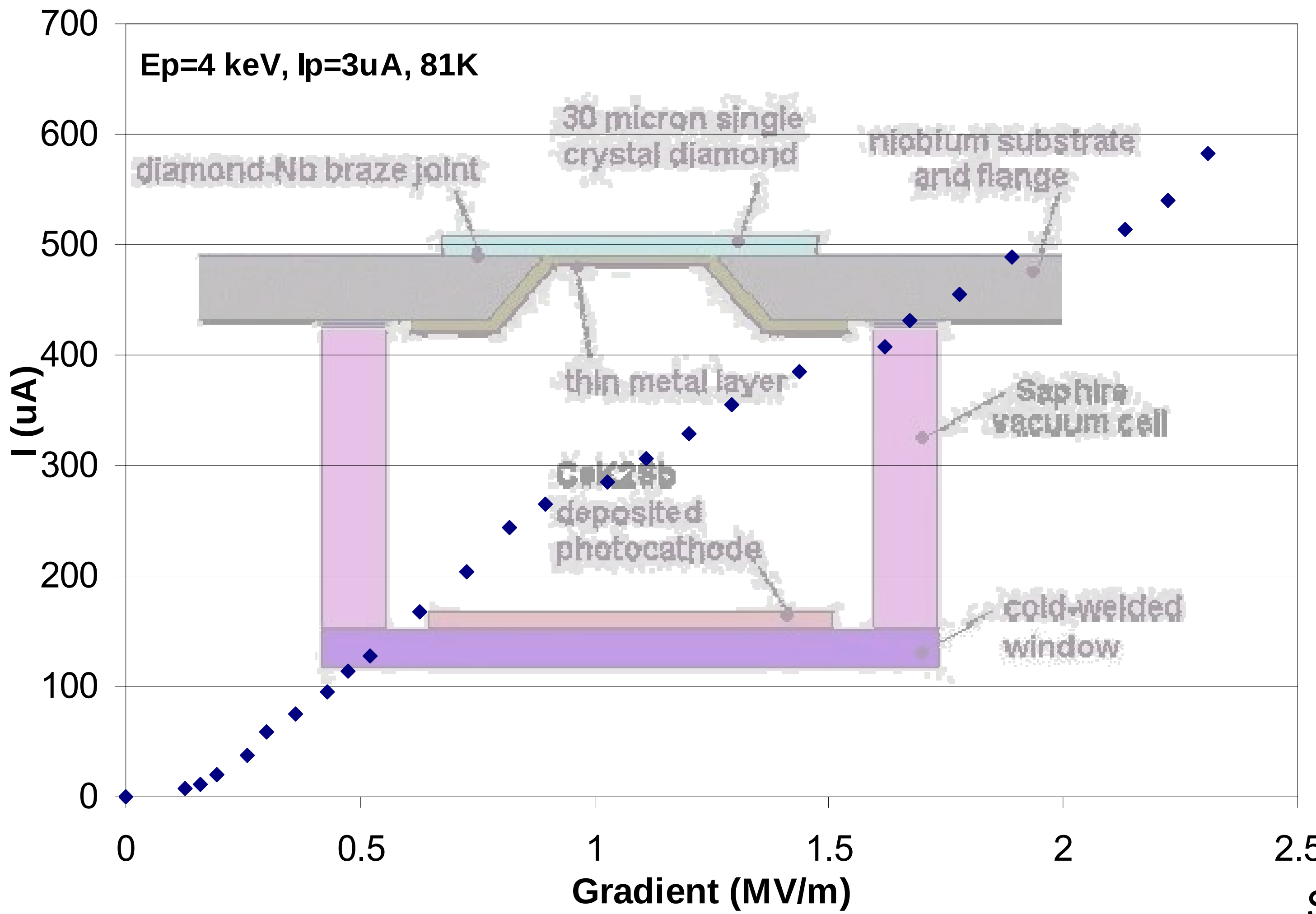
Three current profiles from TEL-1 e-guns



E-beam is strongly magnetzed in 2-40 kG magnetic field → Profile in the interaction region is the same (just scaled) as on cathode

Shiltsev

SEY Natural Diamond, Transmission Mode, 81K



Smedley

Beam Diagnostics

- Longitudinal measurements are maturing
  - CTR is almost “routine” for bunch length
  - Advanced methods for profile reconstruction with CTR, phase-space projection with deflector cavities + dipoles
  - Working towards “single-shot” CTR-based meas.

- Transverse measurements
  - Tomographic reconstruction is now widely used
  - New BPM designs for position and moment extraction
  - Ideas for full phase-space projections to a screen

Some Upcoming Non-Intercepting Techniques

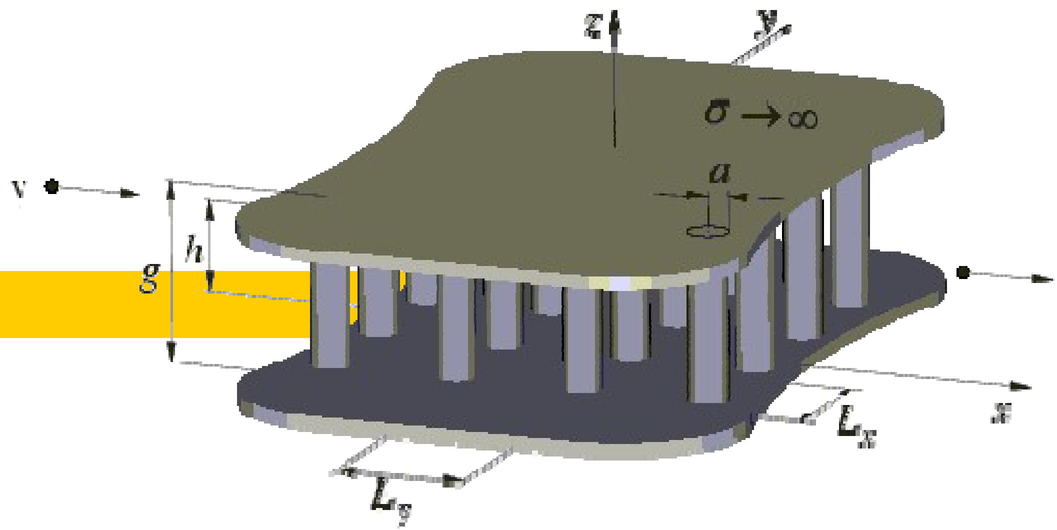
- Quad cavity BPMs to extract beam moments, measure rms emittance
- Optical diffraction radiation to monitor high-energy beam size
- Metallic post BPMs
- Photonic bandgap structures
- Coherent edge radiation

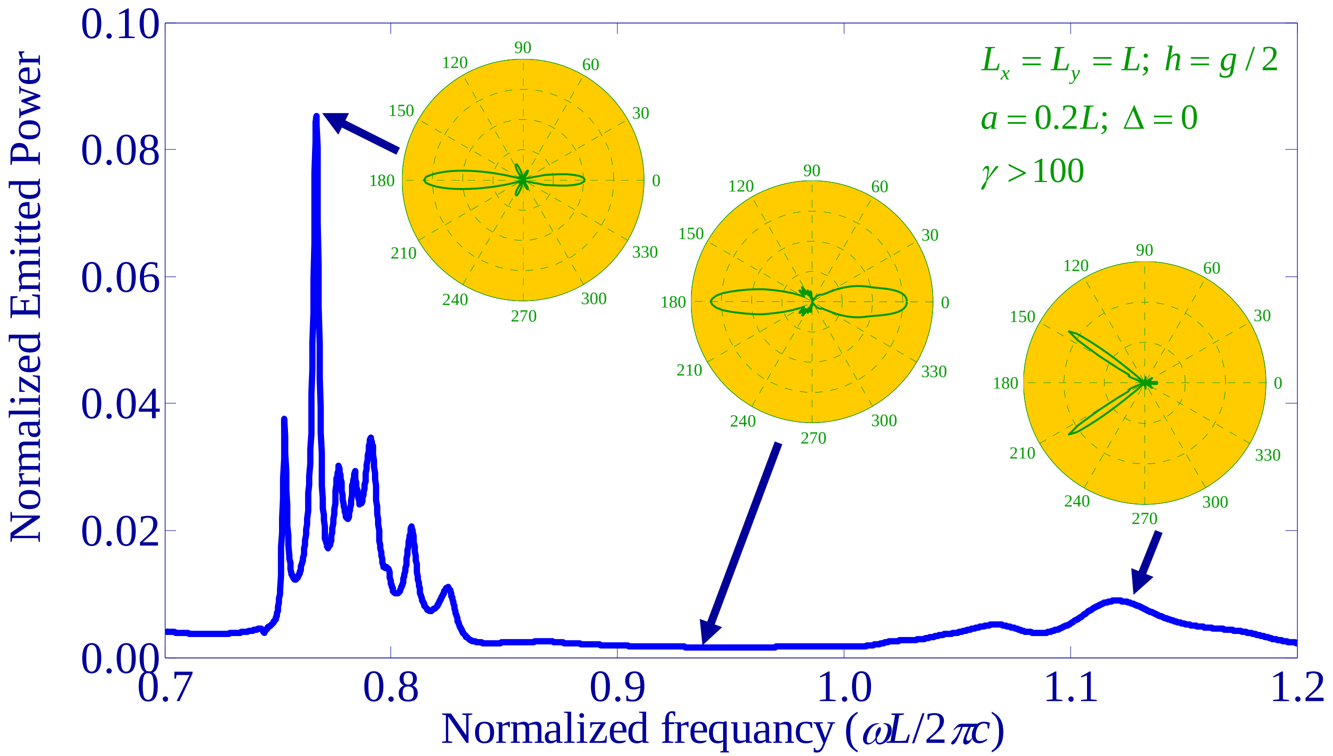
- Questions: wakefields, beam-to-structure clearance

- (Not discussed in our WG: laser wire, EO techniques)

Technion - Israel Institute of Technology
Department of Electrical Engineering

Metallic Post BPM

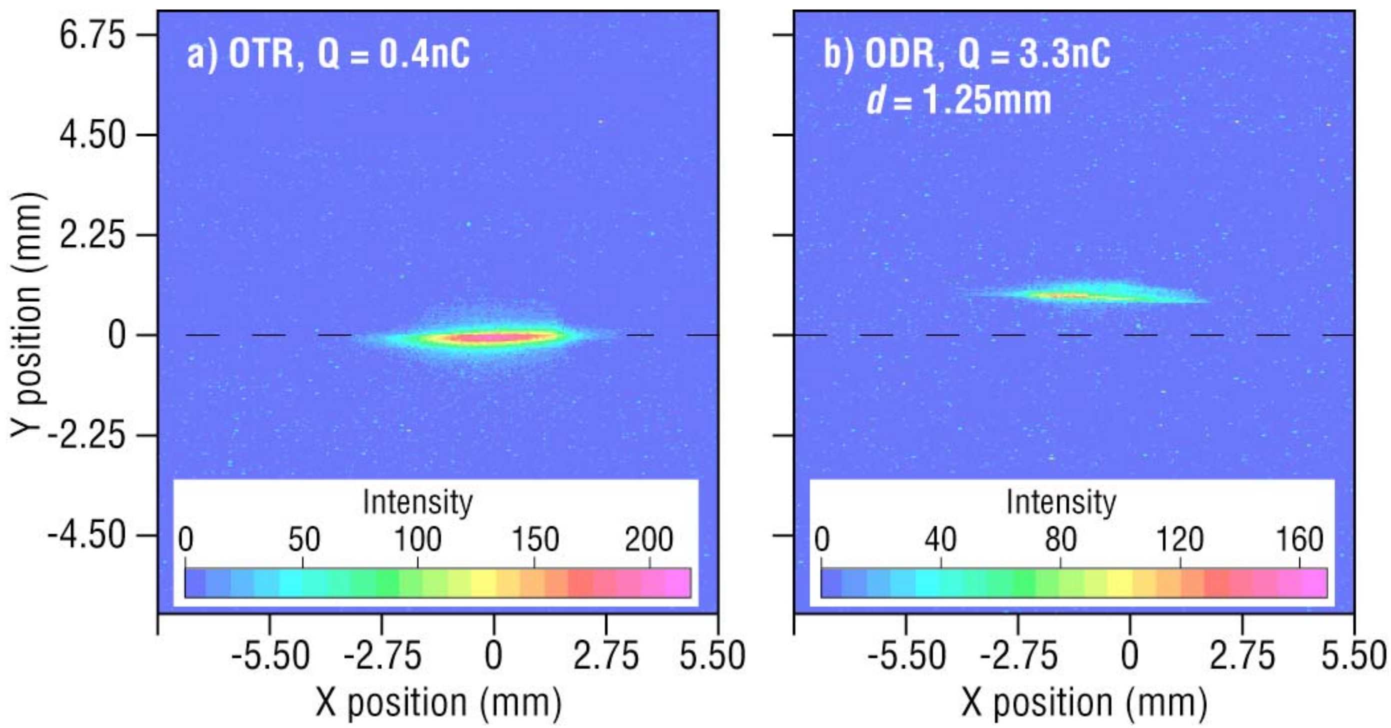




Banna

Investigations of Optical Diffraction Radiation on 7-GeV Beams at APS are Relevant to ILC Beams

- ODR offers the potential for nonintercepting, relative beam-size monitoring with near-field imaging. This is an alternate paradigm to far-field work at KEK.



Submitted to Phys. Rev.

Edge Radiation Frequency Spectrum

- Edge radiation is a variant synchrotron radiation while the beam crosses the boundary of a magnet.
- Intensity is much higher than SR for wavelengths $\lambda >> \lambda_c$
  - Spectral resolution will give most information (boost to long wavelength components)
  - Flat ER spectrum good for faithful response
- *Radial polarization* allows contrast with SR

Synchrotron radiation

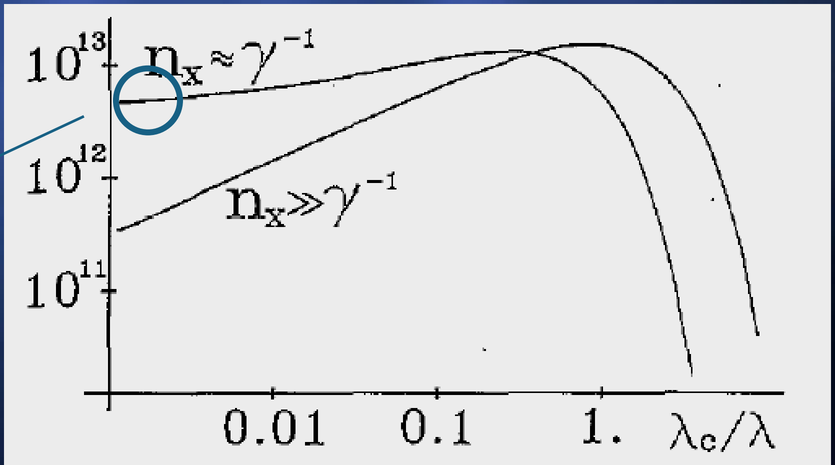
$$E_0(\omega) \sim \omega^{21/3} \qquad \left(\frac{c}{R} << \omega << \omega_c\right)$$

$\lambda_c \sim 50$ nm

Edge radiation

CER

$$E_c(\omega) \sim \left|I_b(\omega)\right|^2$$



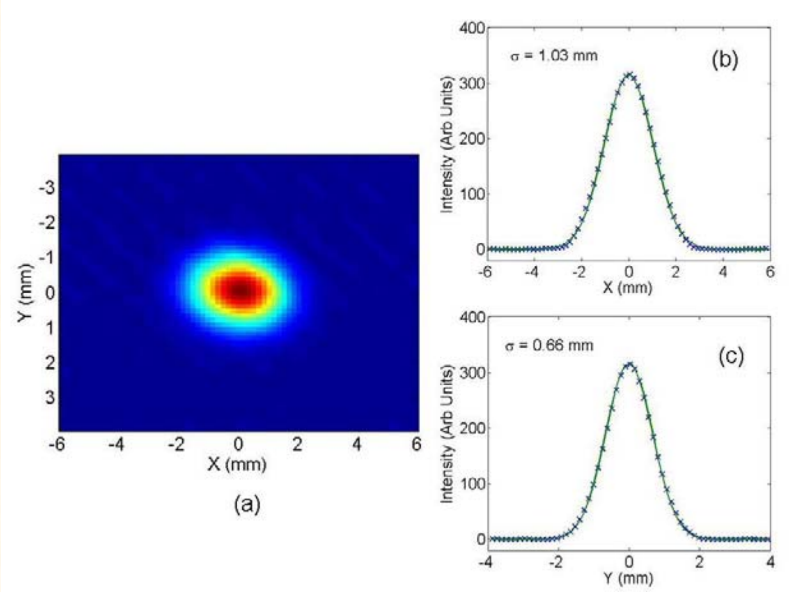
O.V. Chubar, N.V. Smolyakov, J.Optics, **24**(3), 117 (1993)

Rosenzweig

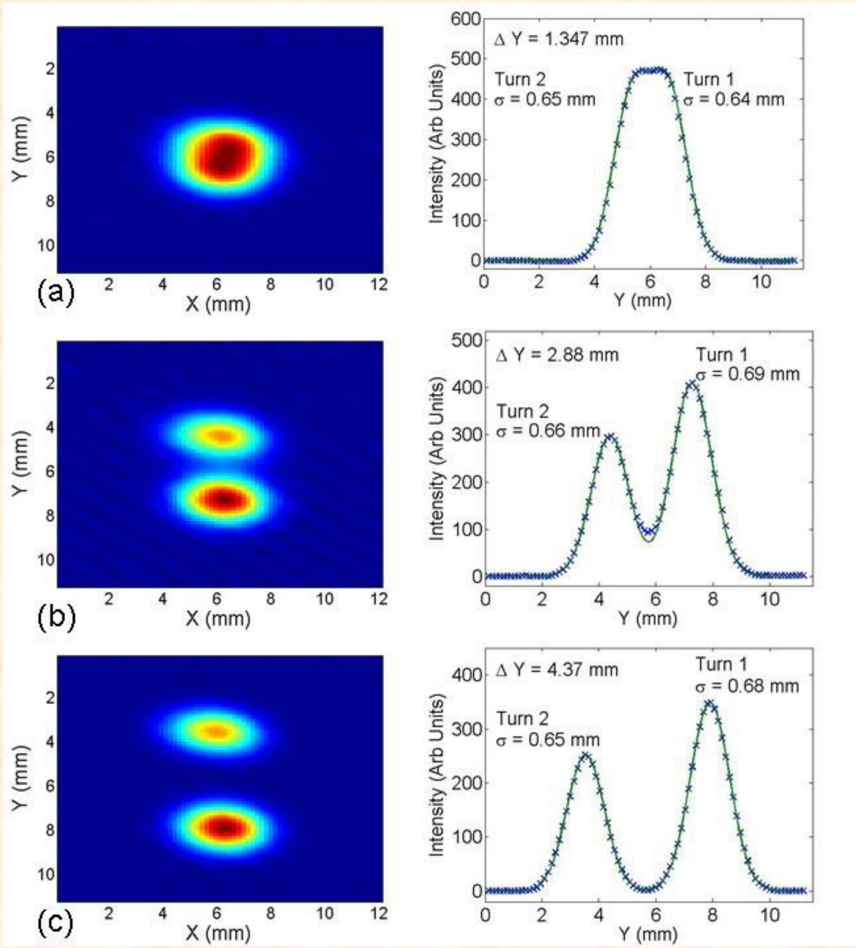
Intercepting Techniques

- OTR screen – commissioning at Fermilab for p & p-bar imaging @ 150 GeV
  - Formation length effects observed?
- Movable emittance meter at SPARC probes phase-space evolution
- Transverse deflectors for long. profile measurements
- Phase-space reconstruction of “extreme beams” in UMER

Preliminary Tevatron Uncoalesced Proton Beam Measurements



(a) Single-turn OTR image of 3e11 uncoalesced protons. (b) and (c) are X and Y beam profile data with fits, respectively.

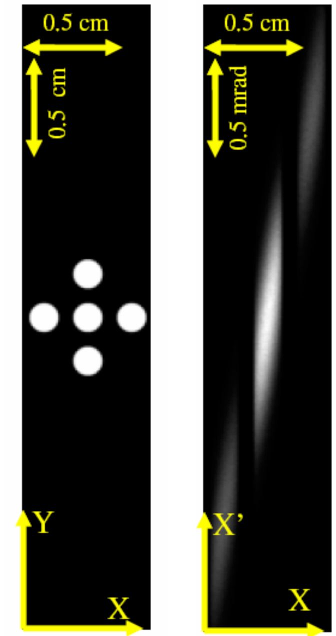


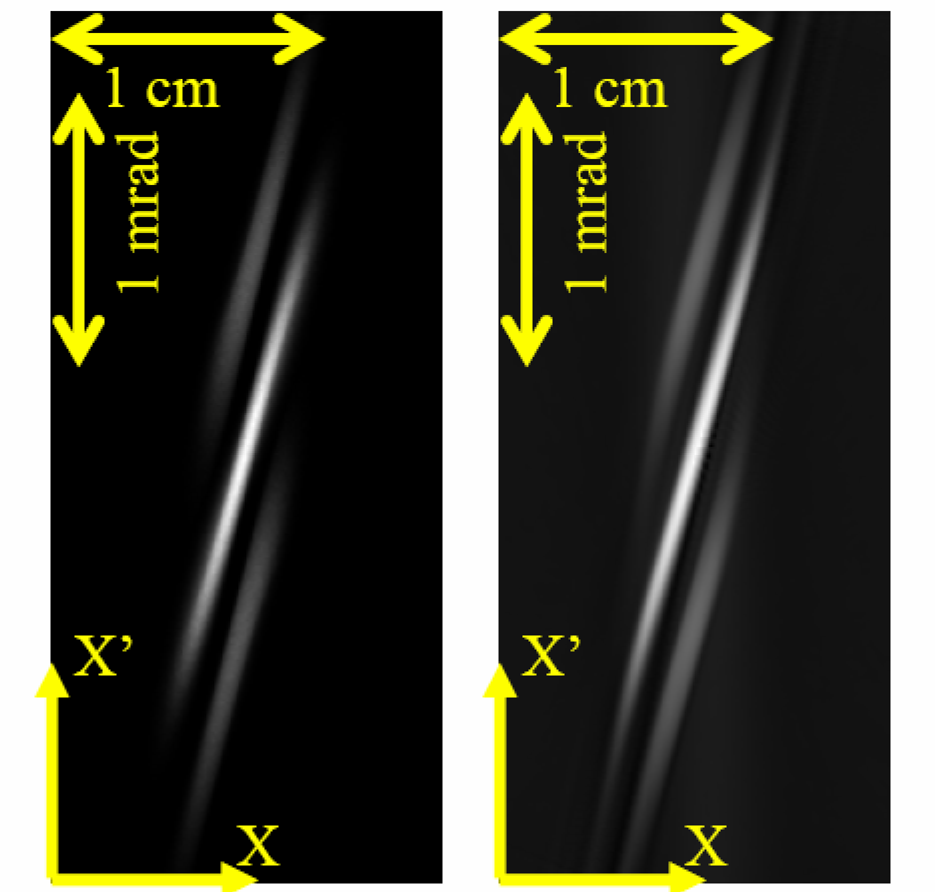
(a) Two-turn OTR image of 3e11 uncoalesced protons with double Gaussian fit of vertical profile. (b) and (c) Same as (a) but with increased vertical injection mismatch from the Main Injector into the Tevatron.

Scarpine

Phase Space Tomography - Different Distributions

- χ=0.72 , I=7mA (space charge)
- Initial Distribution: Five Beamlet
- Highly non-uniform distribution





WARP   Tomography

	Direct WARP	Tomo	Error (%)
$\varepsilon_x(4\times rms)\mu m$	19.0	17.6	7.5
$X(2\times rms)mm$	2.39	2.26	5.4

Tomography can be used to map the phase space of complex multi-beamlet distributions

Stratakis – U. Md.

Possibilities...

- Combine:
  - Transverse deflector
  - Quad cavity BPMs
- Extract
  - RMS profile information w/o blocking beam

Beam Control

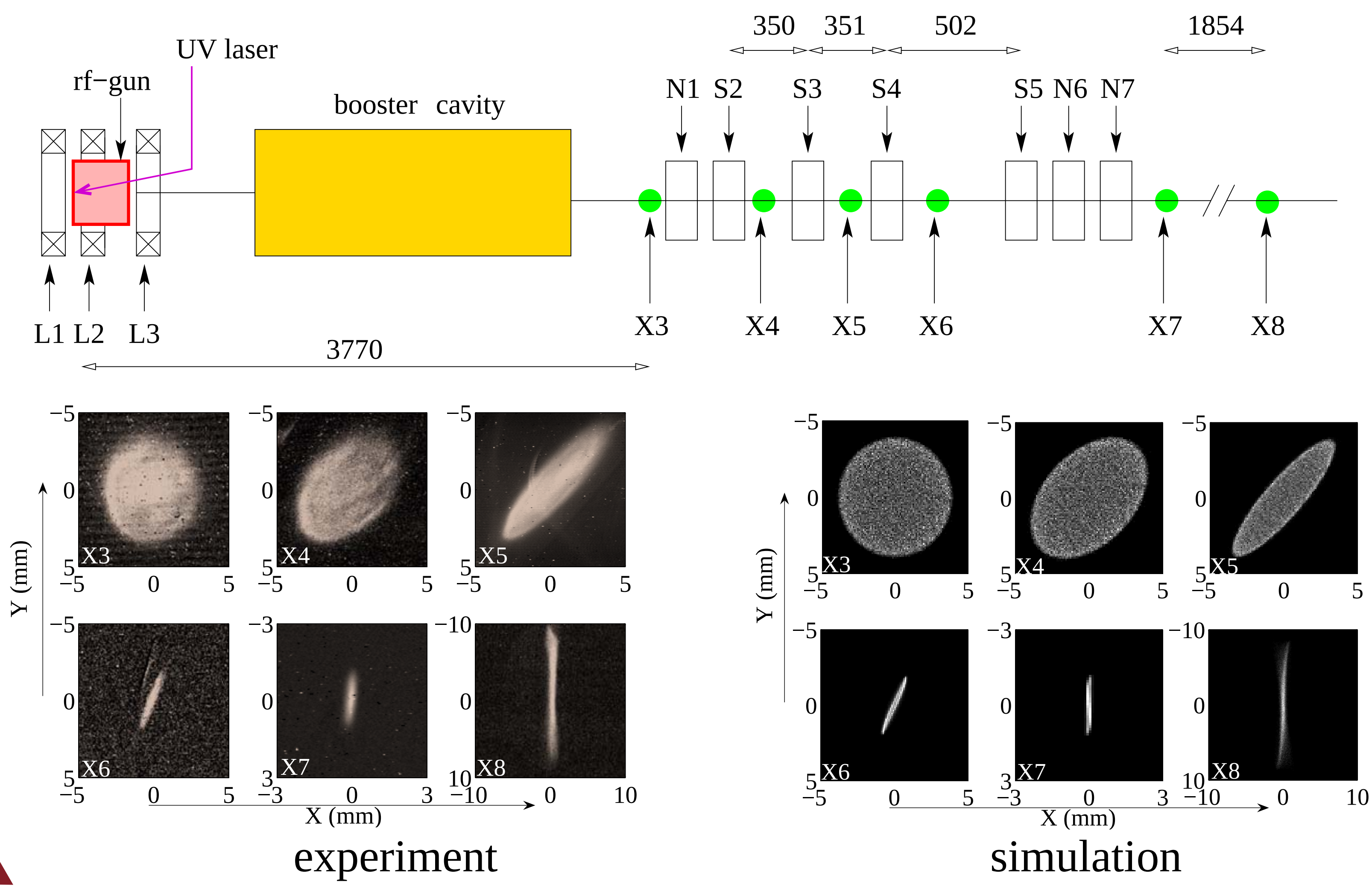
- "Beam Taffy" - Manipulate all dimensions of phase space
  – Emittance exchange: transverse/longitudinal
  – Flat-beam: Transverse aspect ratio
  – Velocity bunch compression

- Beam formation
  – Elliptical pulse generation
  – Photocathode drive laser pulse shaping

- Machine control
  – Response matrix formulation for steering & matching
  – Migrate SR techniques to ERLs and single-pass linacs

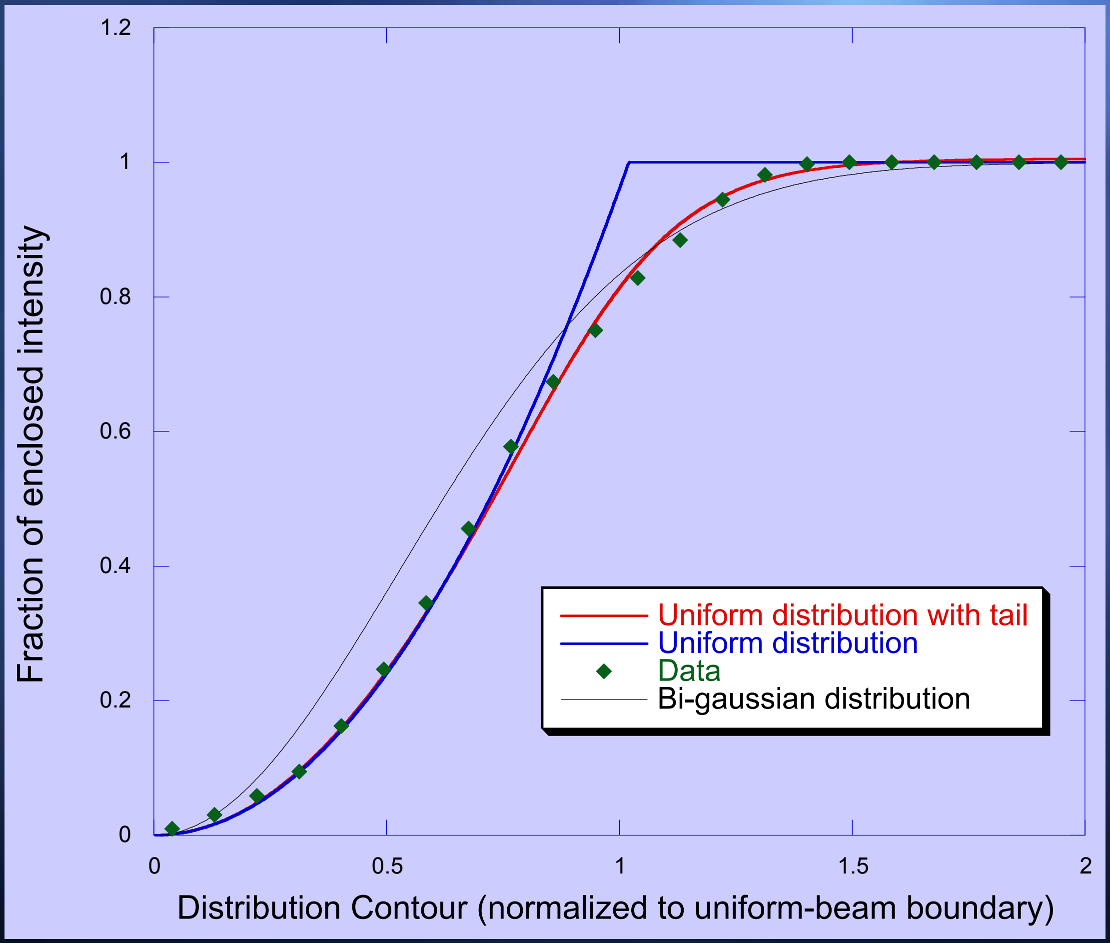
Generating a Flat Beam with Angular Mom. Dominated Beam

(D. Edwards, …), (Y.-e Sun)



Kim

Maximum likelihood: Fermi-Dirac distribution!

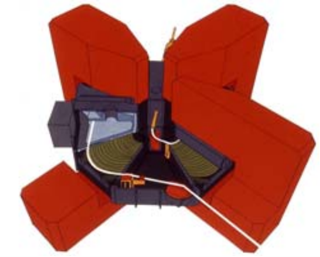


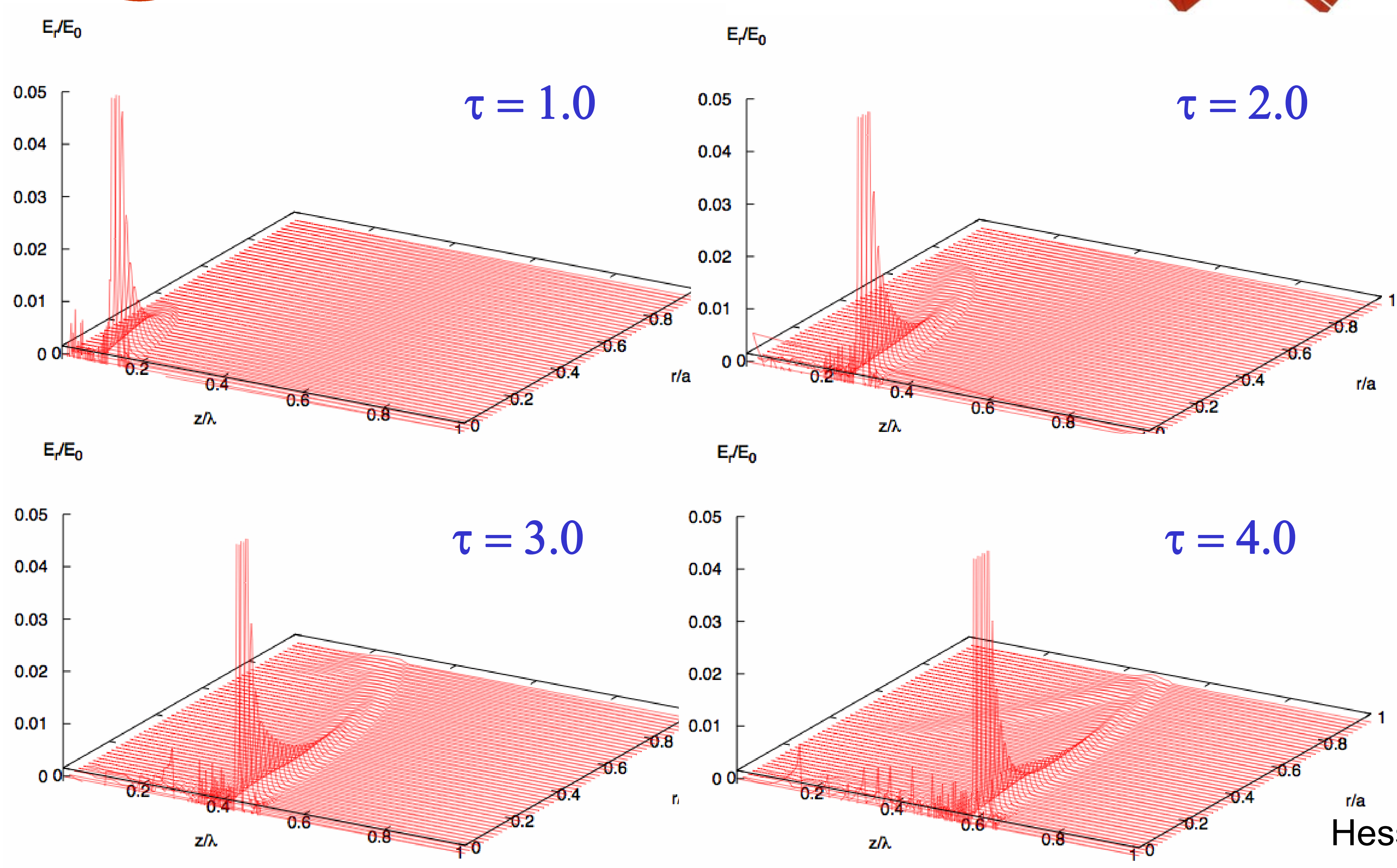
Rosenzweig

Simulation & Modeling

- Advanced codes are being applied to high-brightness sources
  - Analytic approaches (Green’s function solver)
  - wavelet-based space charge solvers
  - “binned” Poisson solvers for energy spreads
  - full-on 3D PIC codes with improved geometric modeling
- Realistic cathode modeling

Numerical Solution of E_r (C. S. Park)





Hess

Wanted!

- Realistic cathode *data* to go with the realistic cathode *models*
  - measurements of electron spectra from the cathode is needed for:
    - band structure
    - thermal emittance
  - quantum efficiency at multiple wavelengths
  - surface characterization for various prep. techniques (metal)
  - depth profile for material composition (semiconductor)

- See John Smedley (BNL) for details