Scaled-Electron Experimental Facilities for Heavy Ion Driver Dynamics

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IREAP

Research sponsored by US DOE & DoD ONR

The Charged Particle Beam Group

Outline

1. The University of Maryland Electron Ring: Why and What?
2. Progress Update
3. New Diagnostics
4. Perturbations: a Powerful Tool
5. Conclusions

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Common Beam Dynamics Challenges

Transverse:

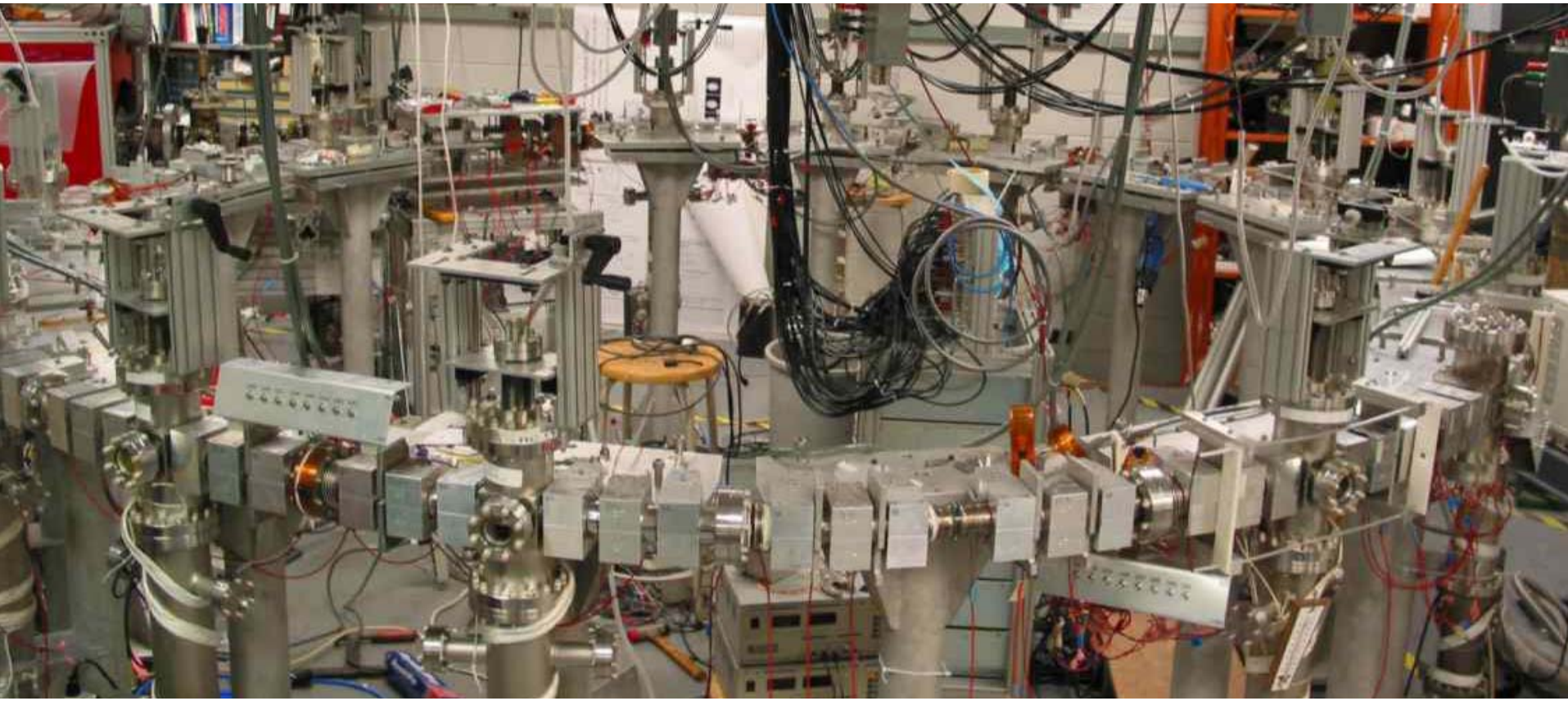
- Errors & Control
- Halo Formation & Beam Losses
- Emittance Growth
- Instabilities
- Resonances

Longitudinal:

- Energy Spread
- Transverse-Longitudinal Coupling
- Compression
- Instabilities

UMER Progress Update

The University of Maryland Electron Ring



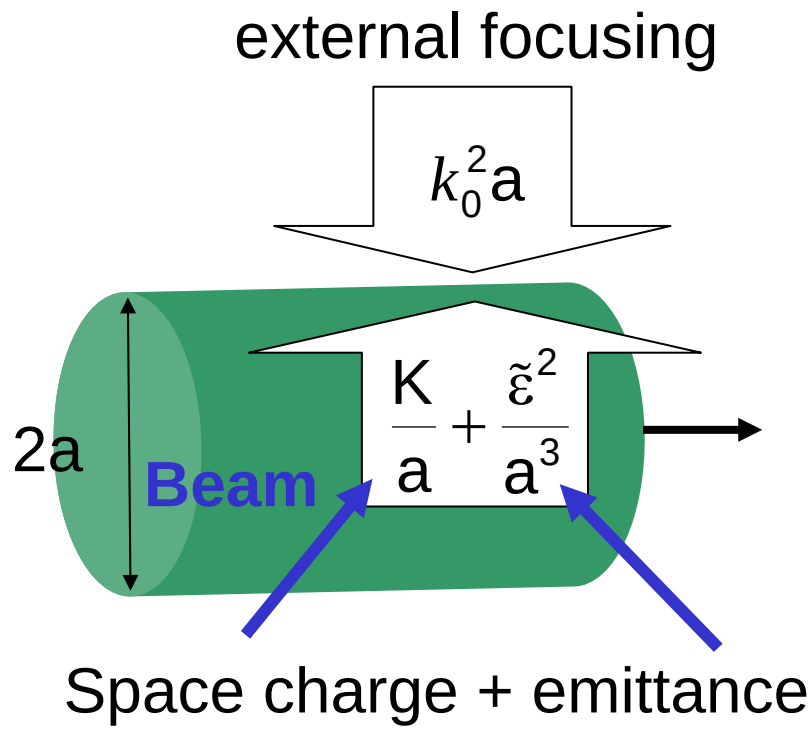
Energy	10 keV	Circulation time	200 ns
Energy Spread	20 eV	Pulse length	5-100 ns
Current Range	0.6-100 mA	Zero-Current Tune	7.6
rms Emittance	0.2-3 μm	Depressed Tune	1.5 – 6.5

Dimensionless Space Charge Intensity

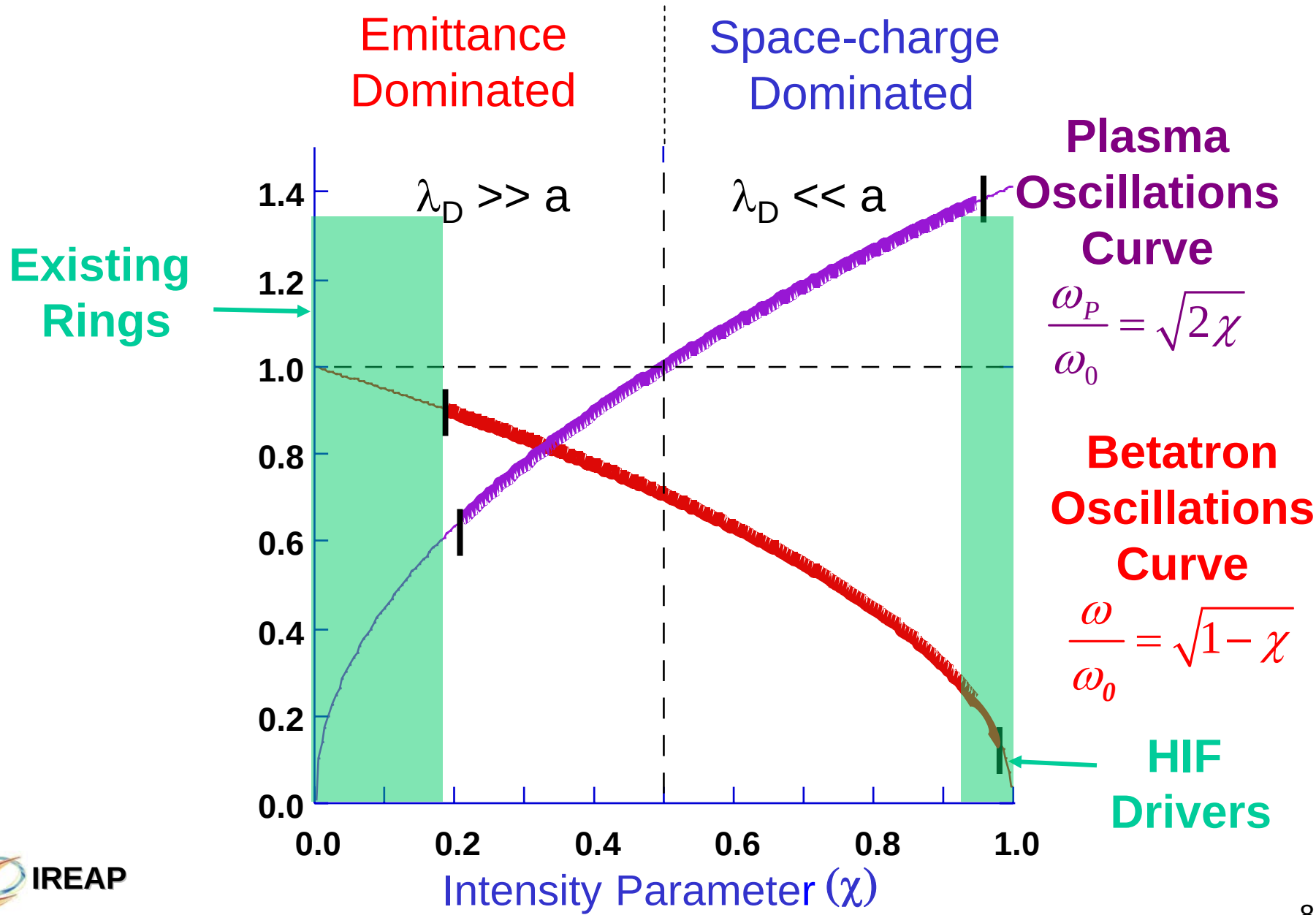
Intensity Parameter:

$$\chi \equiv \frac{K}{k_o^2 a^2} = \frac{\text{space charge force}}{\text{external focusing force}}$$

$$0 \le \chi \le 1$$



Intensity Scalings



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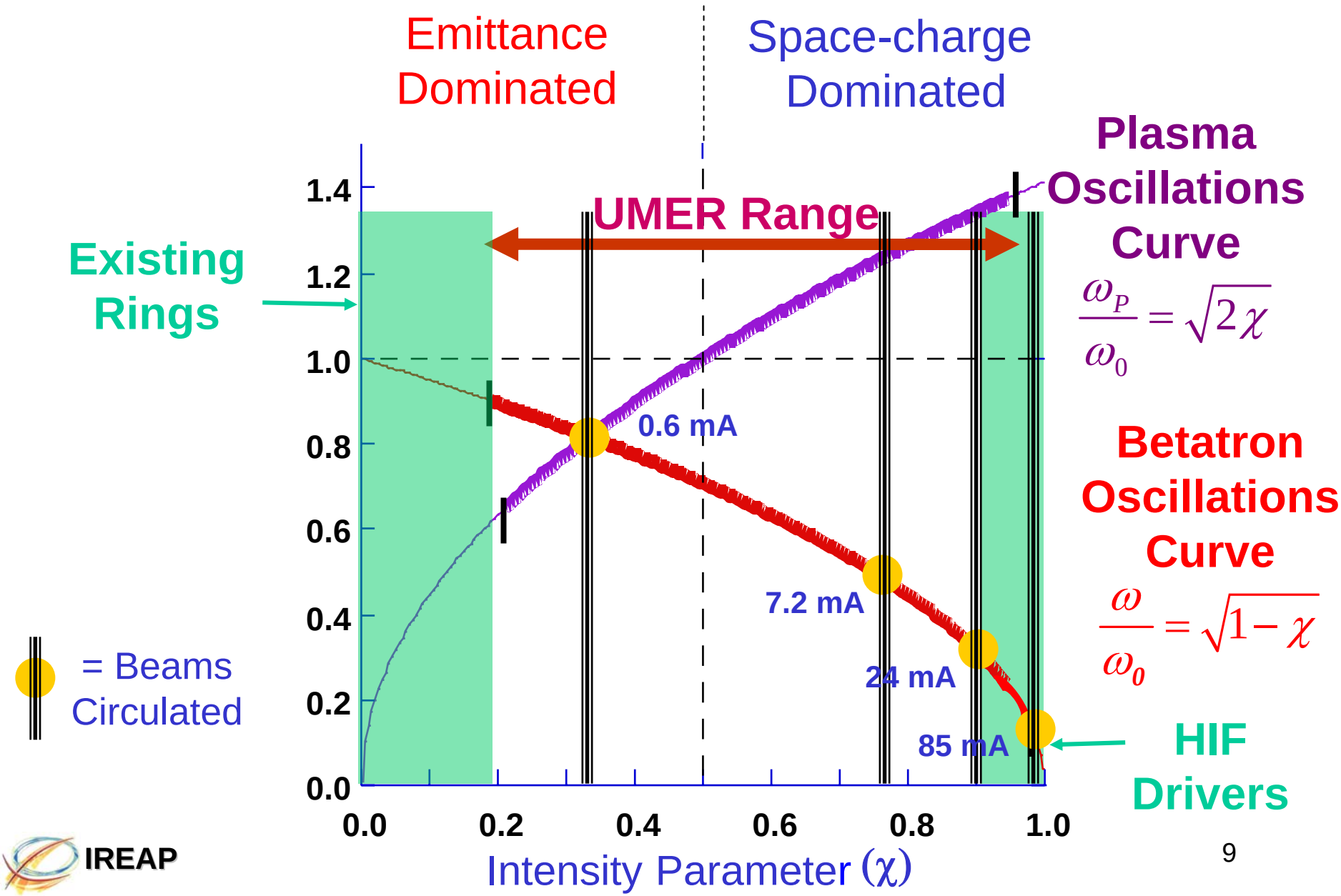
Present UMER Operating Points



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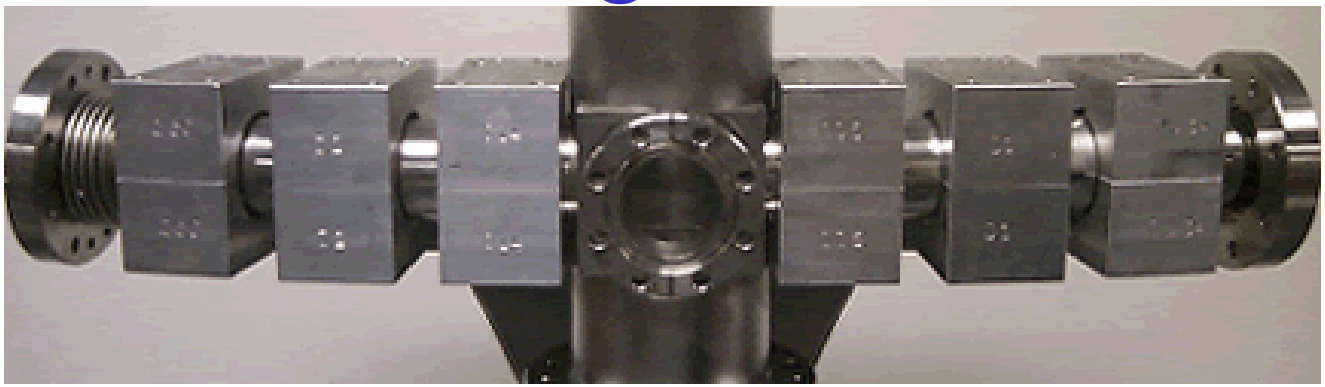
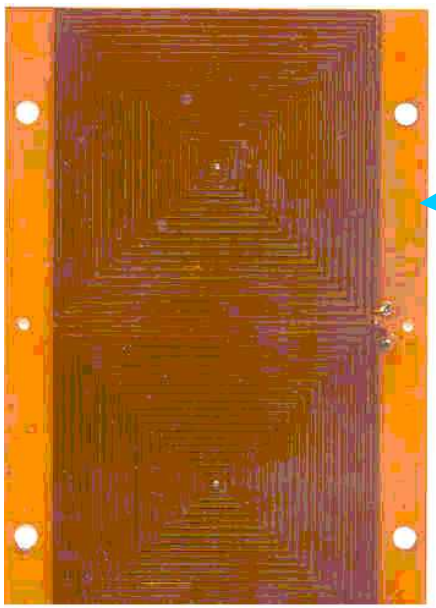
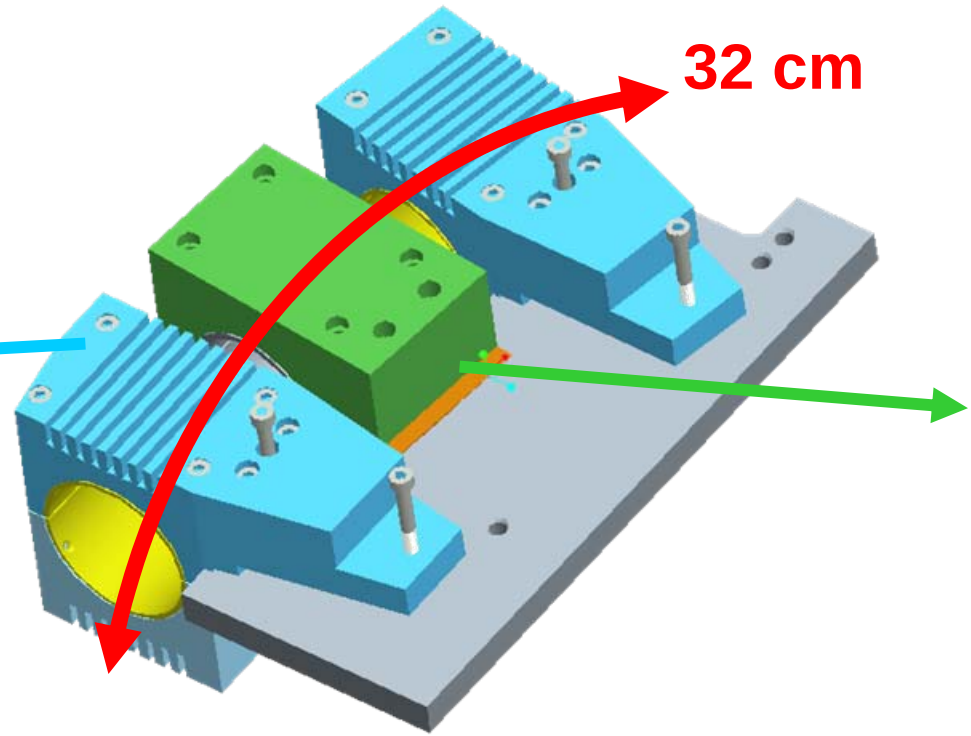
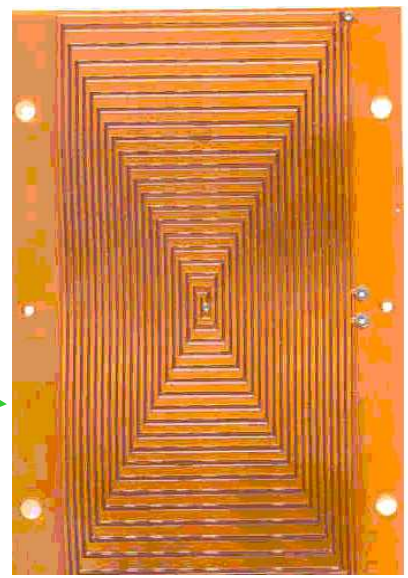
UMER Magnets & Lattice



72 Quads
(~ 7.8 G/cm)



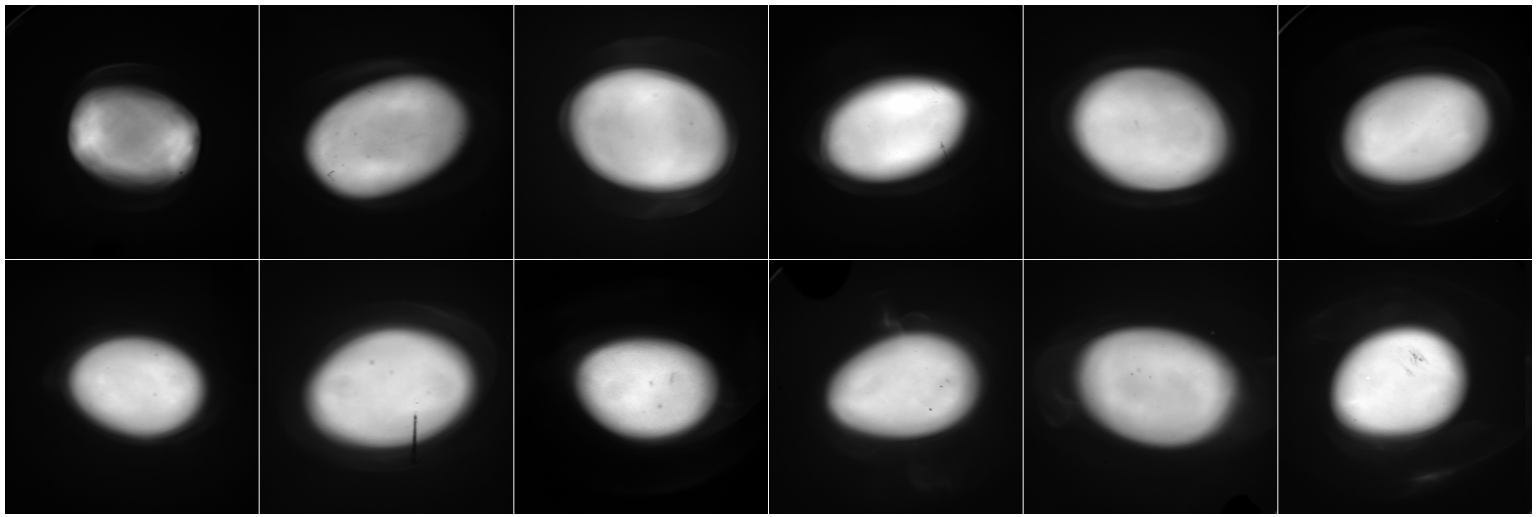




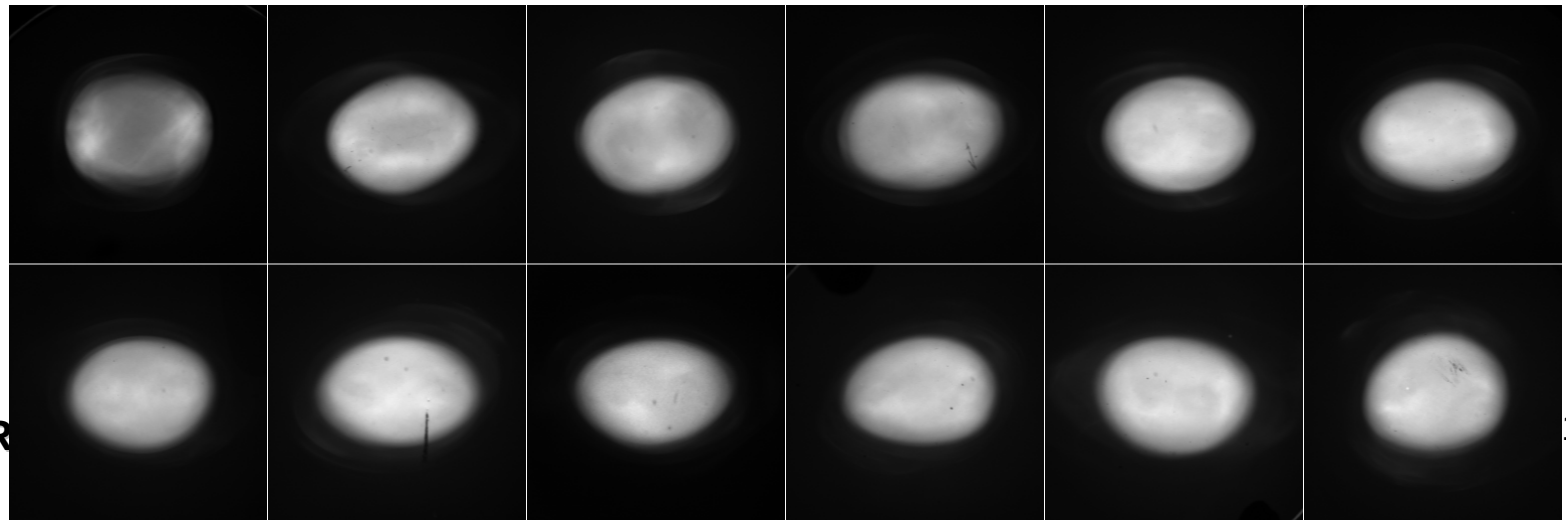
36 Dipoles
(~ 15 G)

Beam Rotation and Matching Corrections

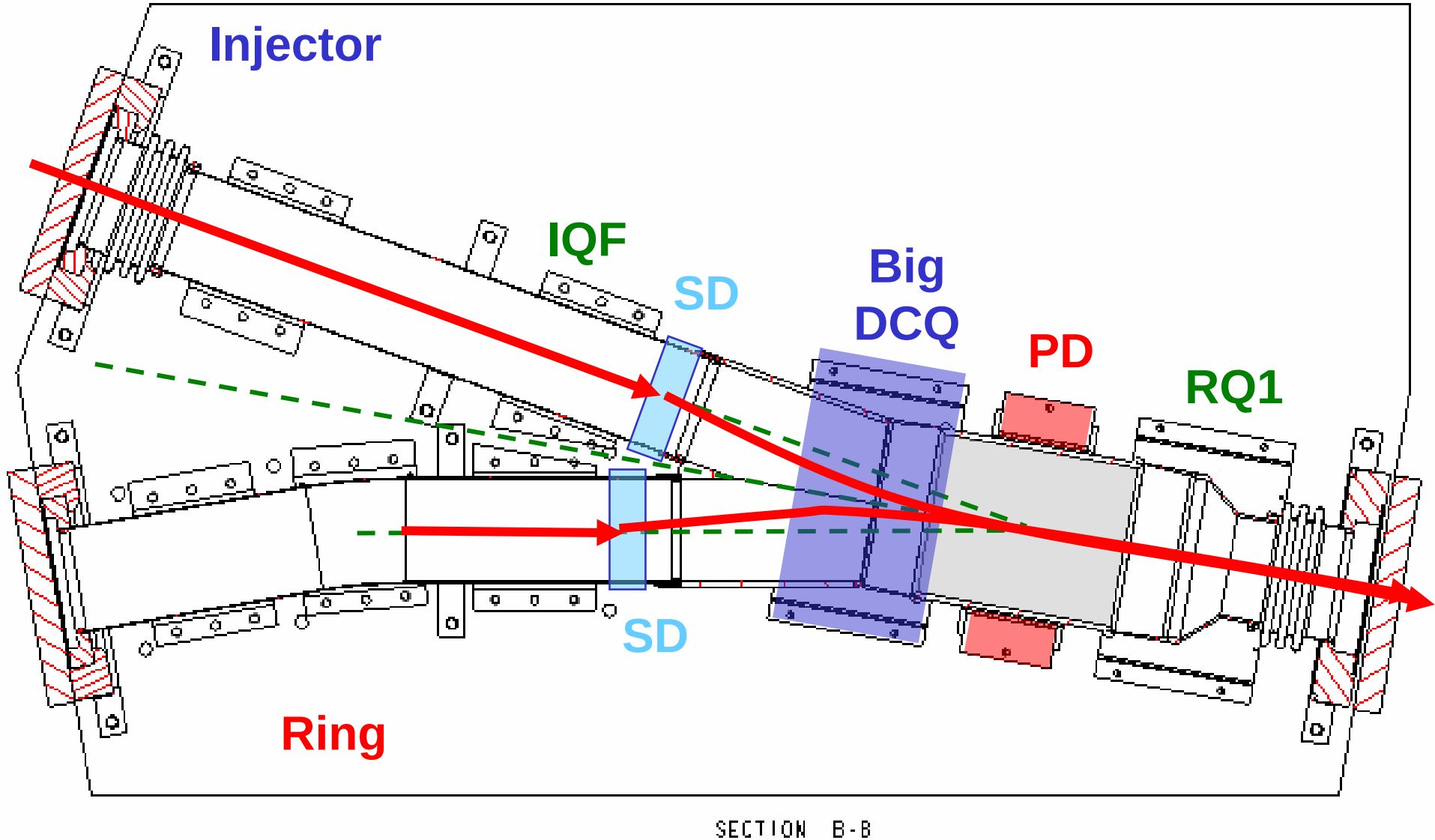
24mA Beam (RC1-12) Before Skew and Matching Corrections



24mA Beam (RC1-12) After Skew and Matching Corrections

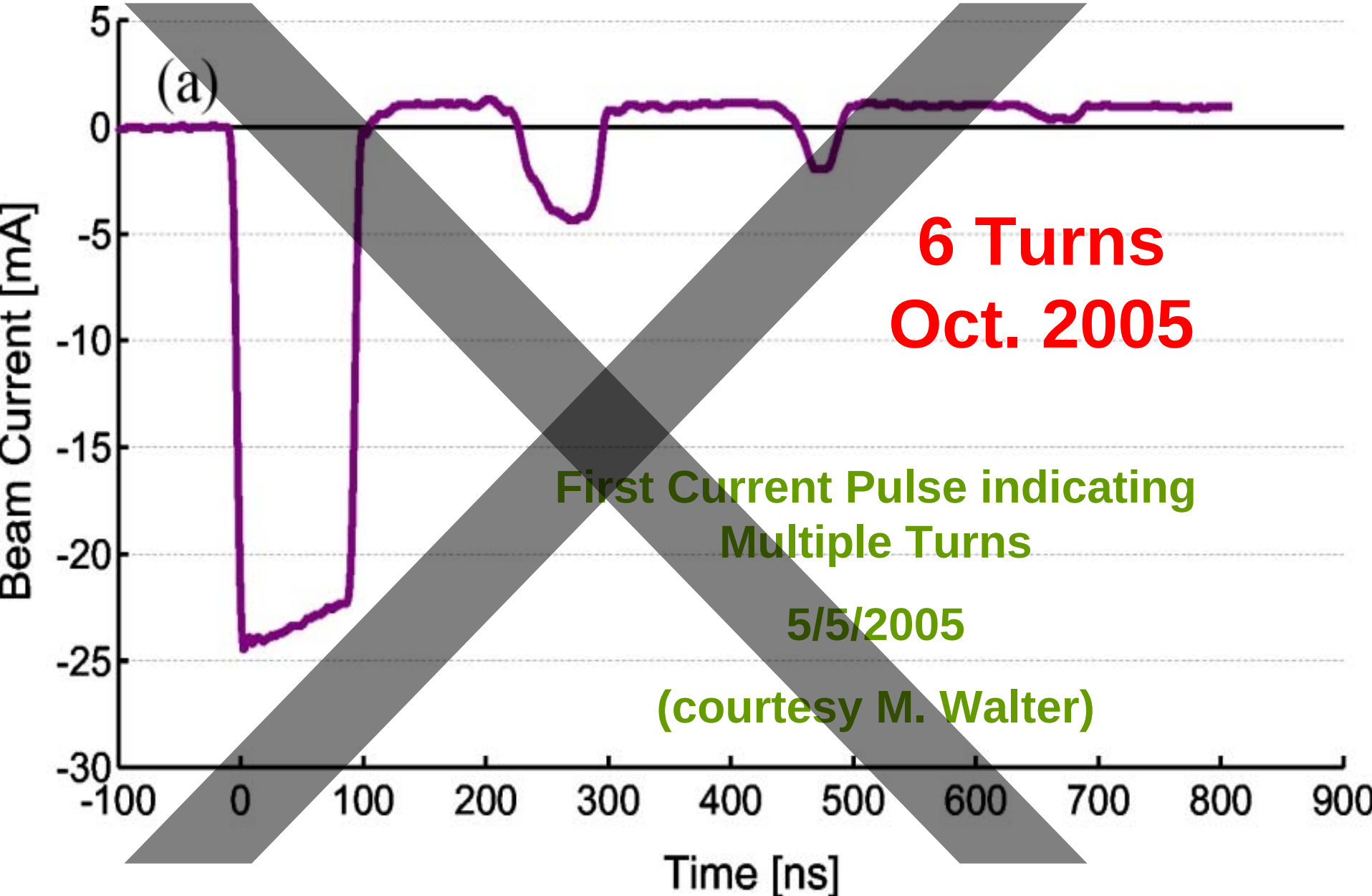


New Injection Y in place



Commencement of Multi-Turn Operation

(Work in Progress)



6 Turns
Oct. 2005

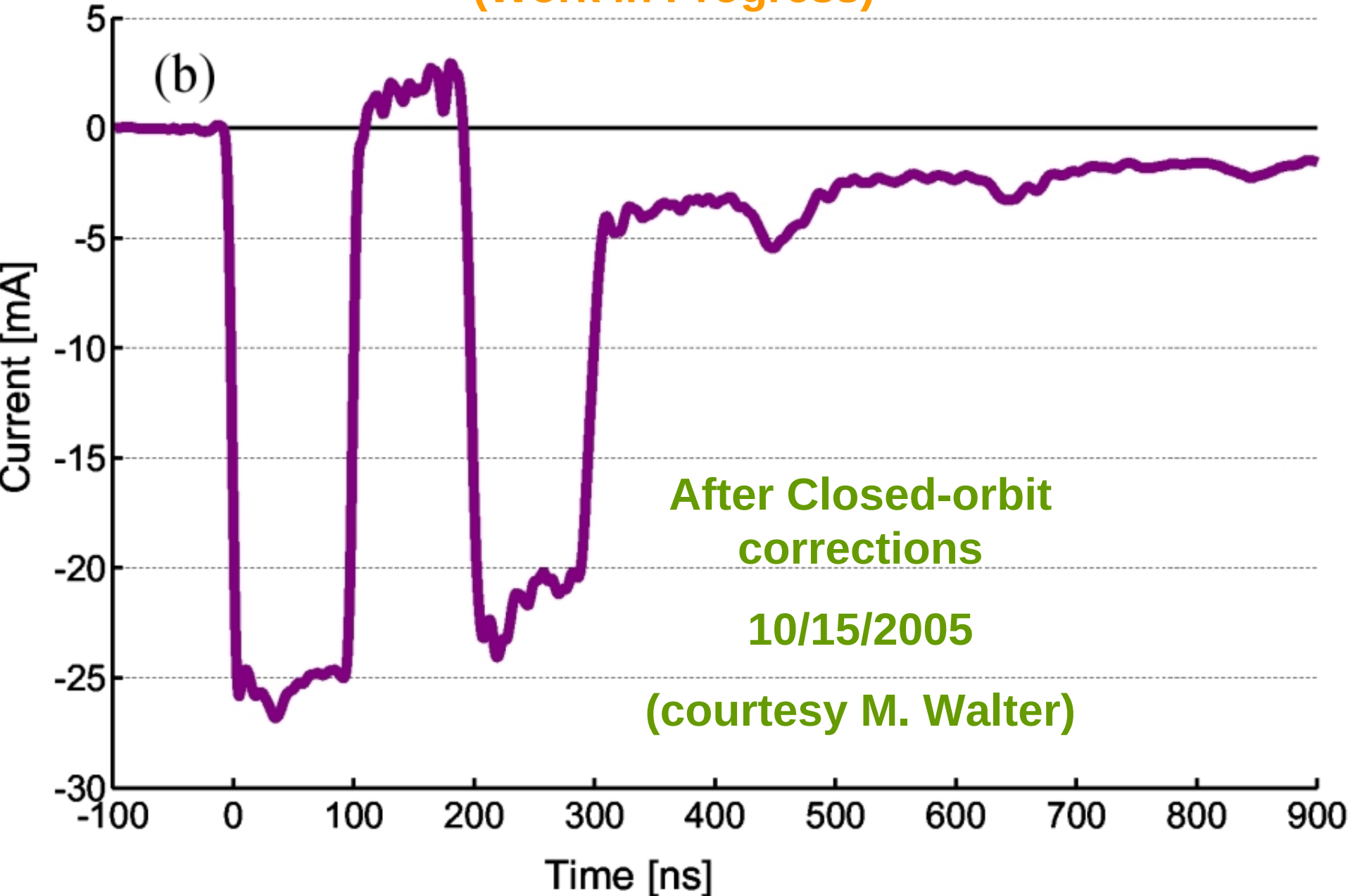
First Current Pulse indicating Multiple Turns

5/5/2005

(courtesy M. Walter)

Commencement of Multi-Turn Operation

(Work in Progress)



After Closed-orbit corrections

10/15/2005

(courtesy M. Walter)

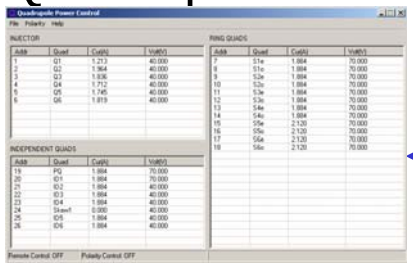
Powerful Diagnostics

Diagnostics Available to UMER

Diagnostics	Uses	Num	Time Resolution
Axially-translatable Phosphor-Screen	*Beam Imager: Beam Centroid, Rotation Angle, Size, & Shape*	*1*	*(integrated)*
Other Phosphor-screens	(same, but at fixed position in s) With tomography, becomes a 4-D Transverse Phase Space Mapper	15	(integrated)
OTR screen	Fast Beam Imaging	2	1 ns
Beam Position Monitor (BPM)	Beam Centroid, Current, Eccentricity	15	2 ns
Bergoz Coil	Beam Current	2	2 ns
Energy Analyzer	*Longitudinal Phase Space Mapper: Beam Energy, Energy Spread*	*3*	*5 ns*
Slit-Slit Meter	*Transverse 4-D Phase Space Mapper*	*1*	*5 ns*
Pepper-Pot	*Transverse 4-D Phase Space Mapper*	*1*	*(integrated)*
Faraday Cup	*Beam Current*	*1*	*5 ns*

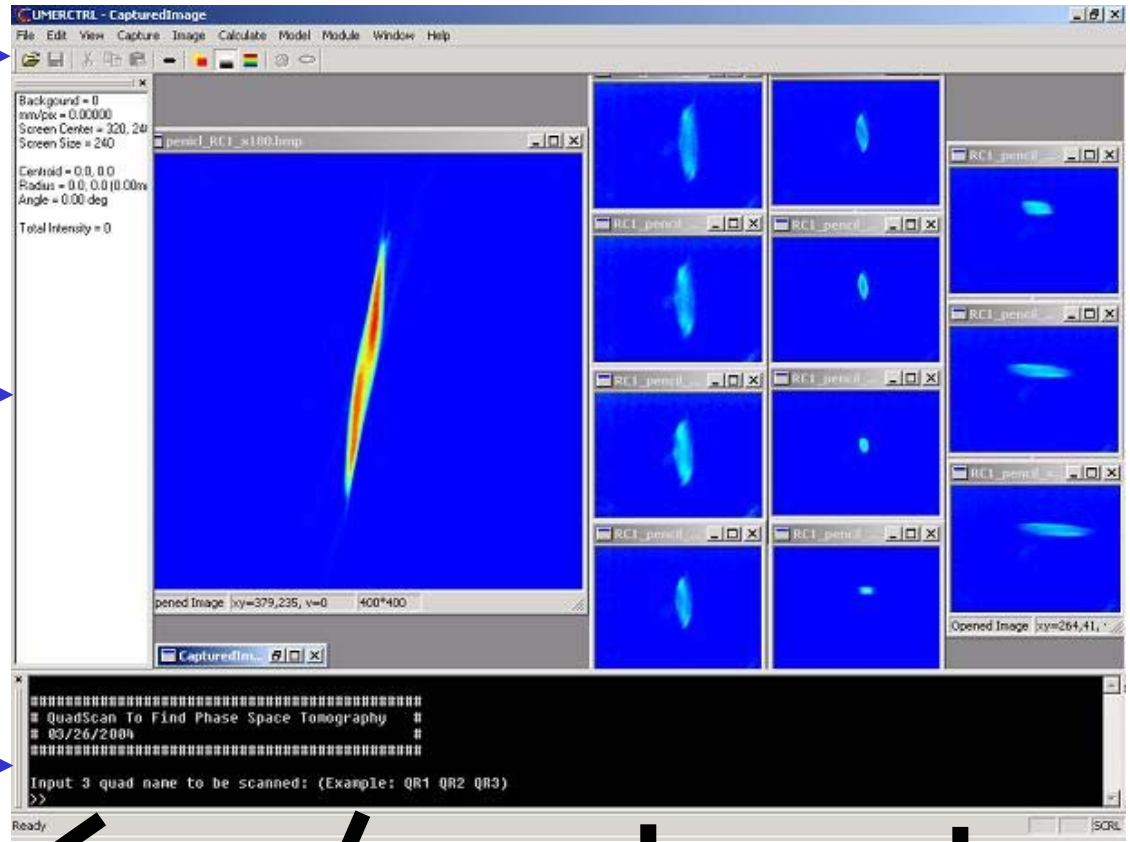
Tomography: Detailed Phase Space Mapping

Quadrupoles Control

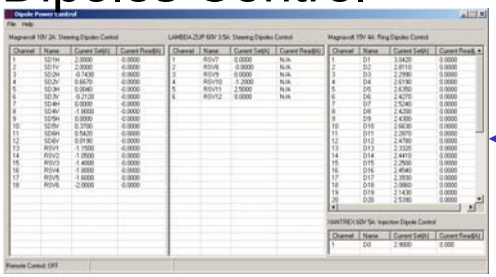


network

Central Control Platform

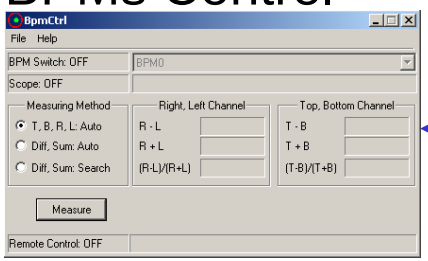


Dipoles Control



network

BPMs Control



network

Steering Module

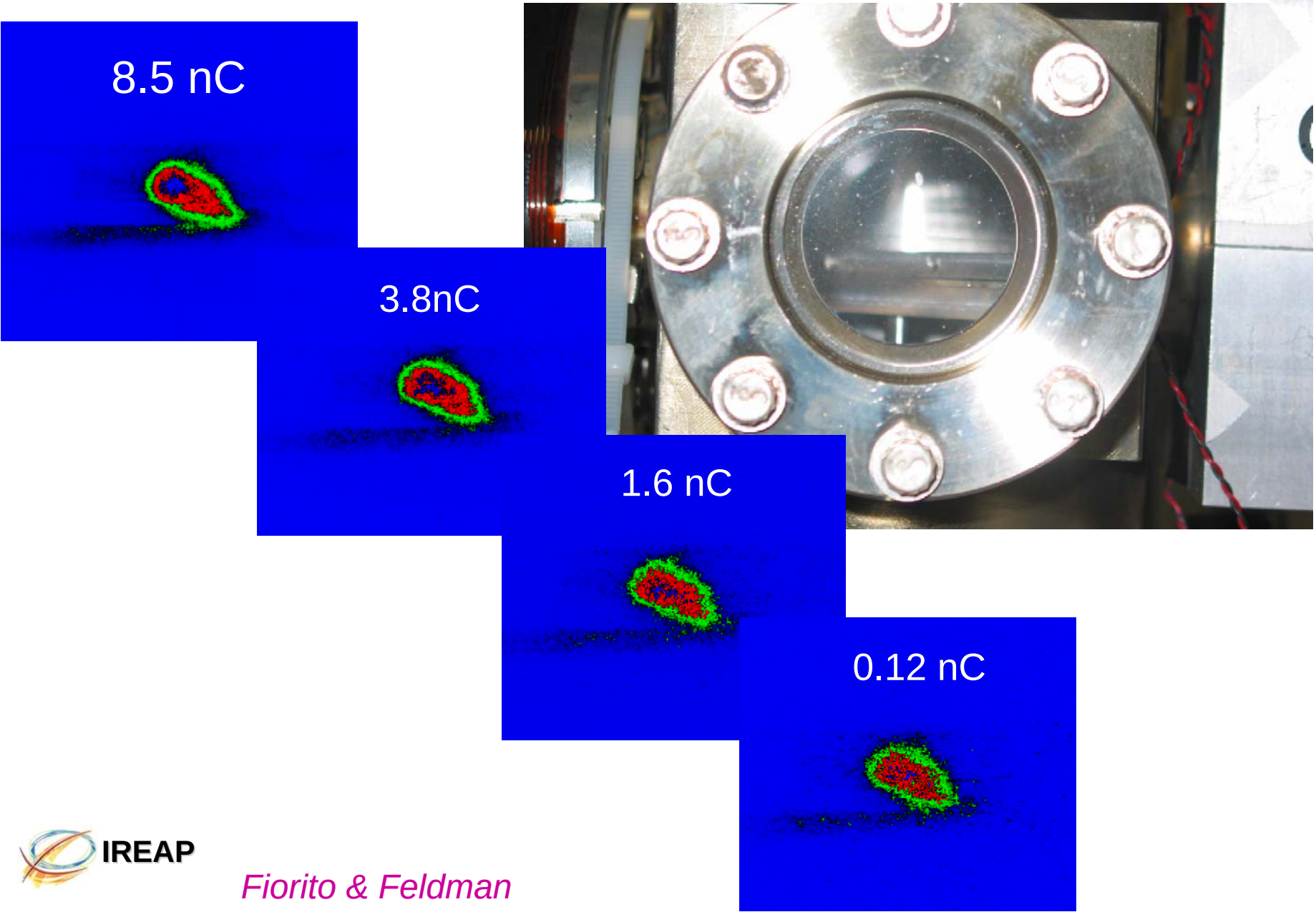
Skew Correction Module

Matching Module

Tomography Module

Low Energy (10 kV) Optical Transition Radiation

Ideal for exploring the fast time structure of low energy beams in injector



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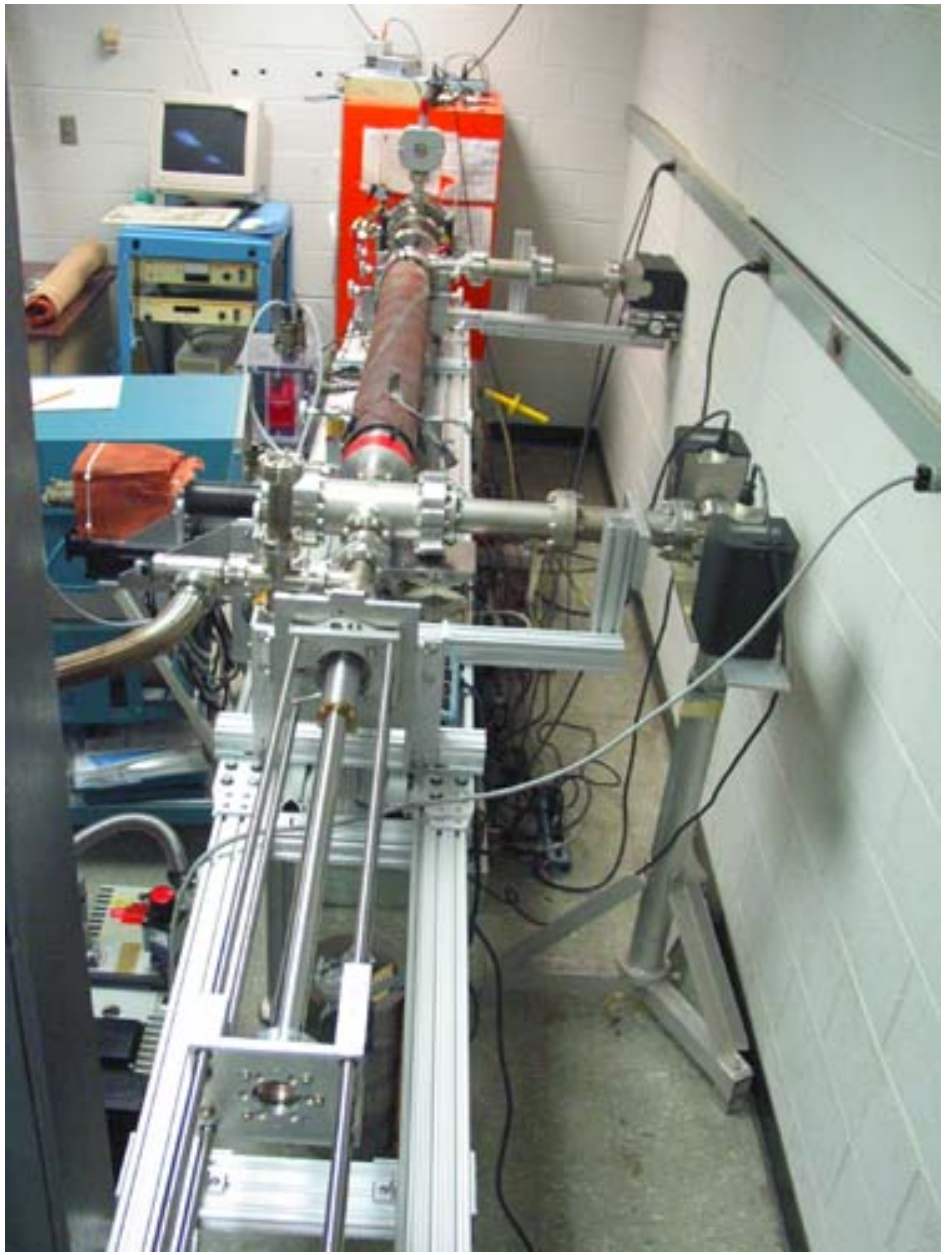
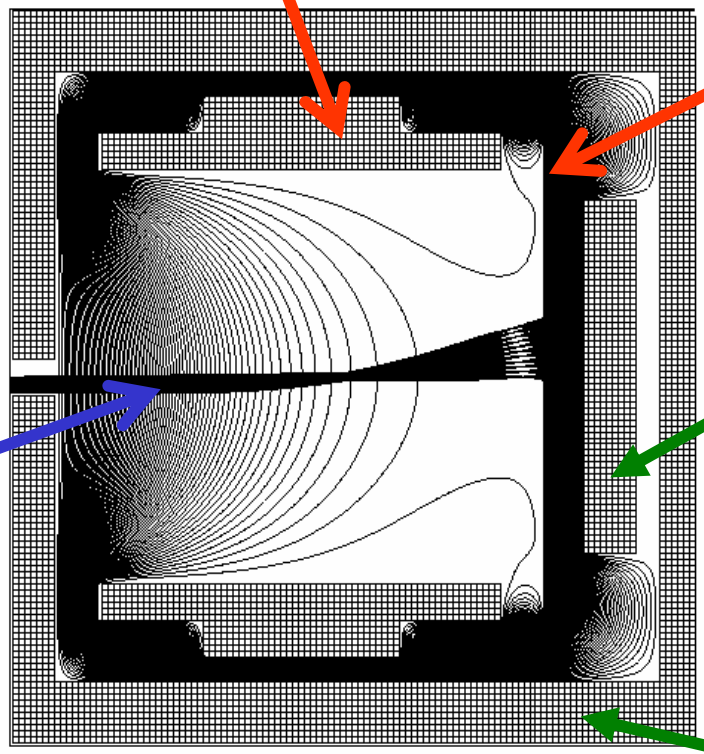
Fiorito & Feldman

Long Solenoid Experiment (LSE)



Experimental Study of Beam Energy Spread Energy Analyzer Design

Collimating Cylinder
-10.13kV



Retarding Mesh
-9999.5 V

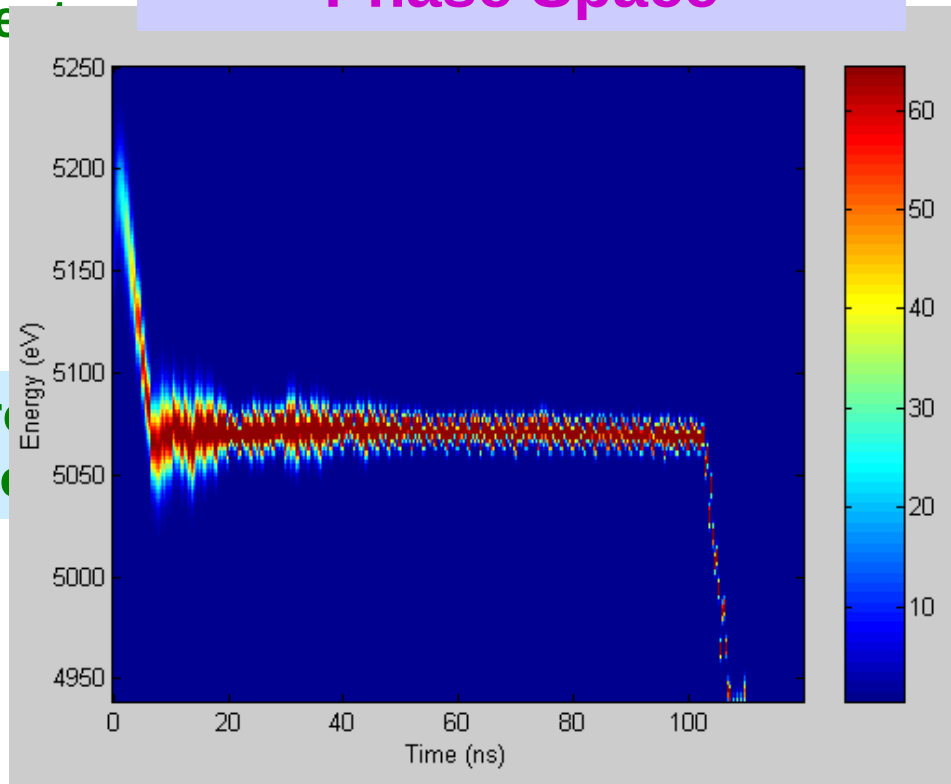
Colle

) keV
eam

Gr
H

3rd Generation: Res. < 1 eV

Measured Longitudinal Phase Space



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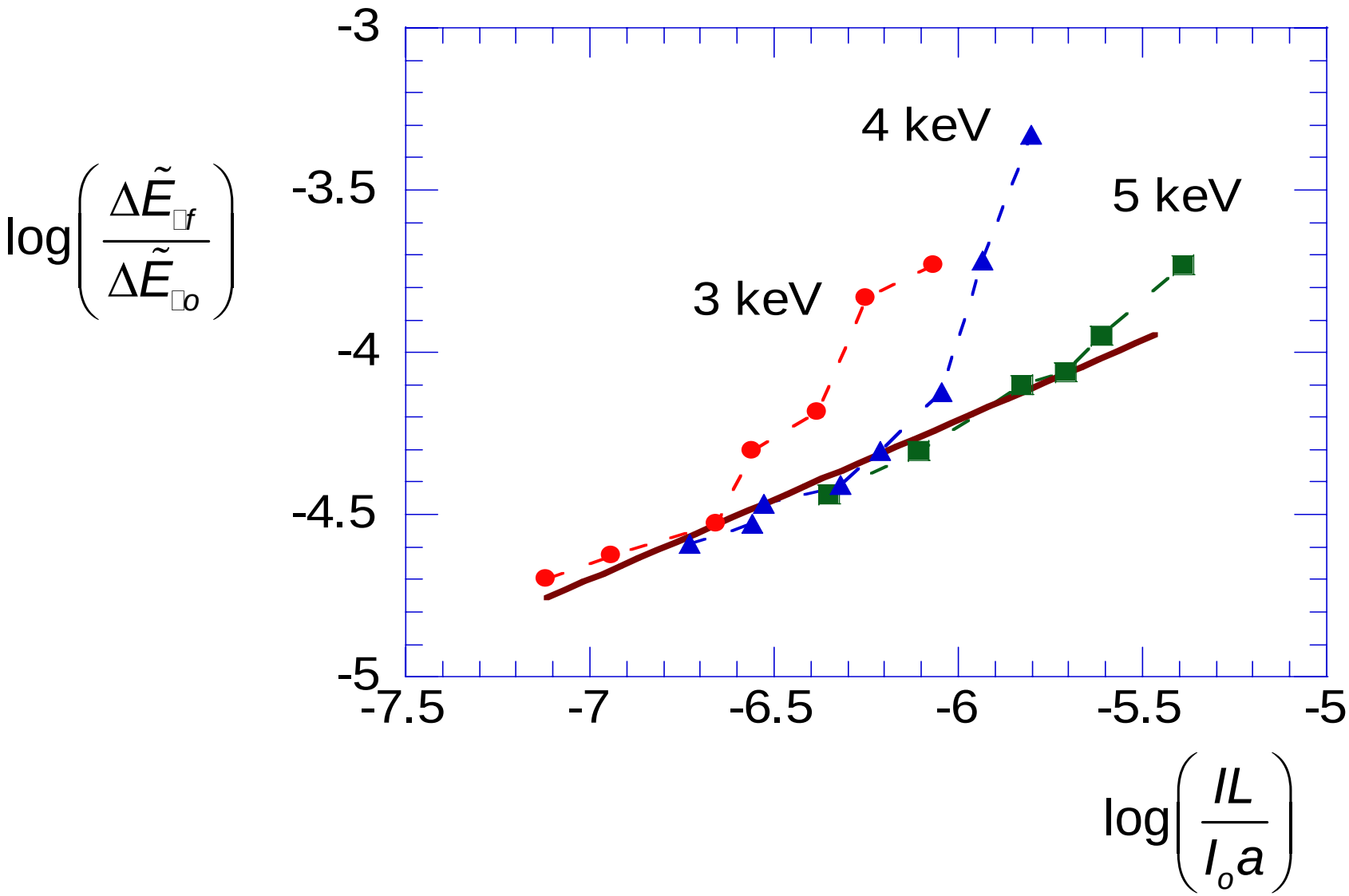
Y. Zou and Y . Cui

Aside: Anomalous Growth of Energy Spread



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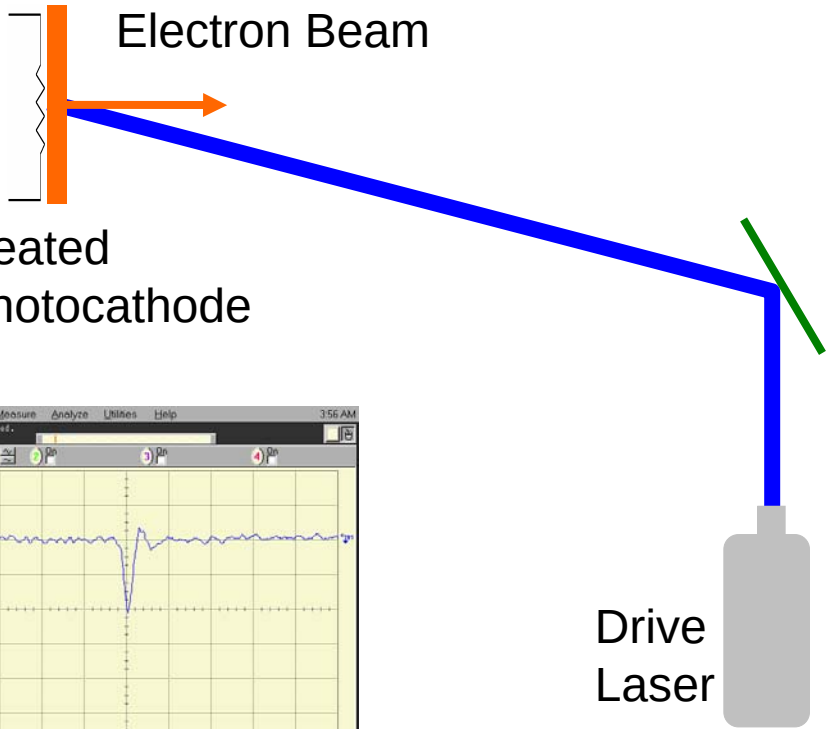
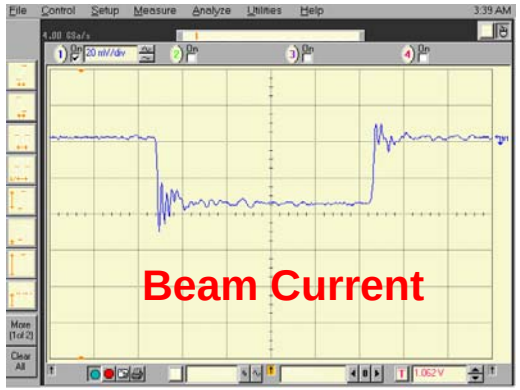
Perturbations-R-US

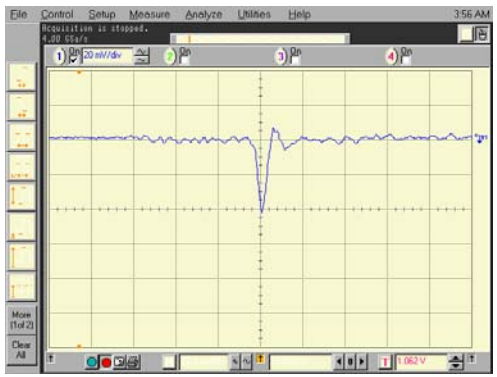
Generating Perturbations with Lasers





Thermionic only, 100ns pulse

Photoemission +
Thermionic 5ns pulse



Photoemission only
(Cool cathode)

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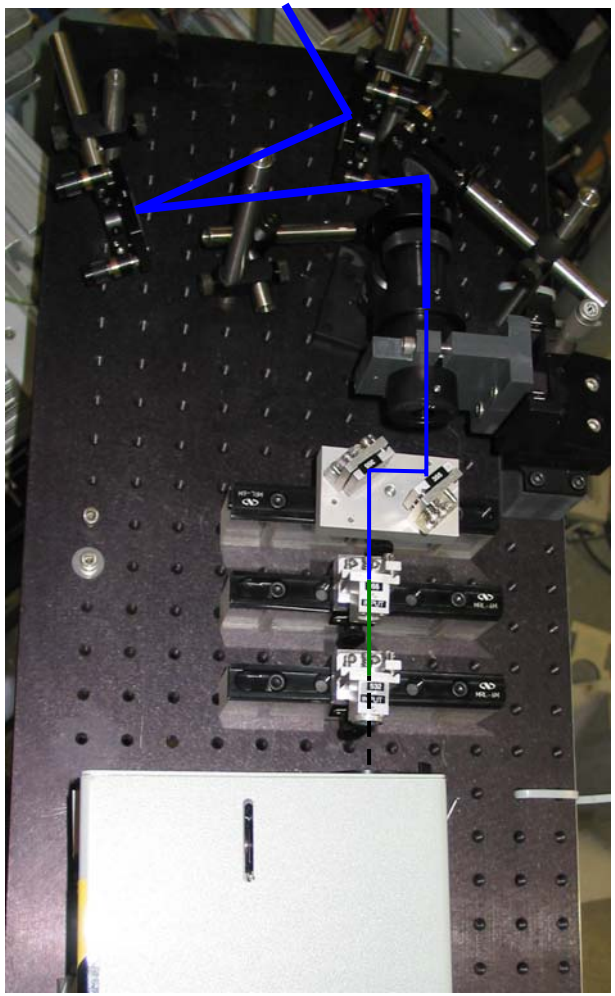
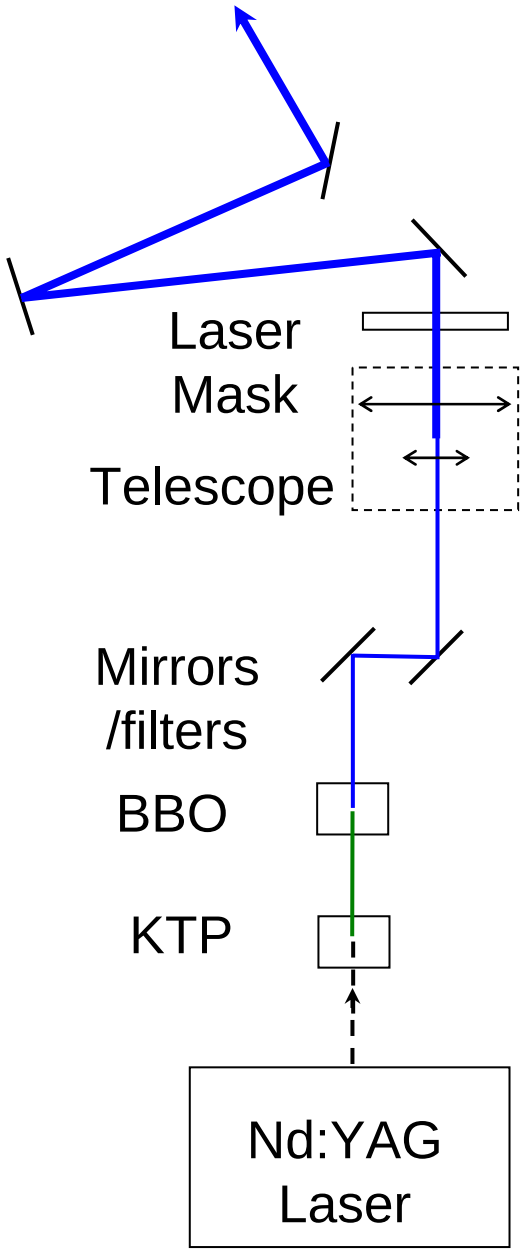
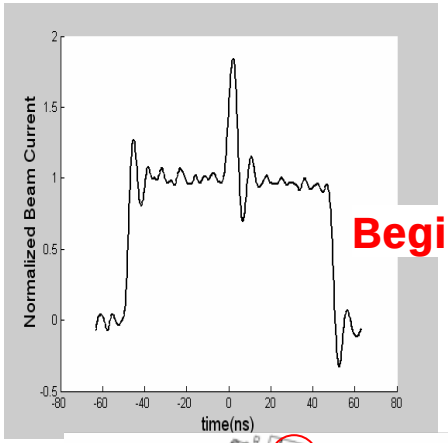
Drive Laser Setup



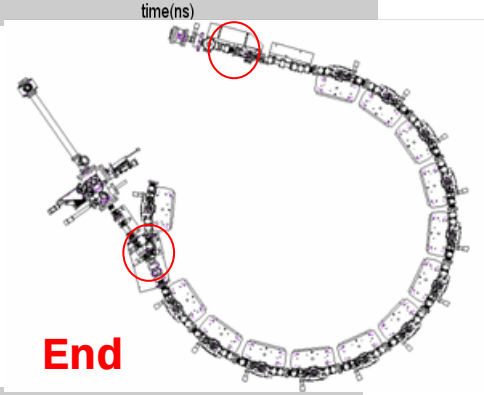


UV (355nm) Laser
Photon energy: 3.5 eV
Work function: 2.7 eV

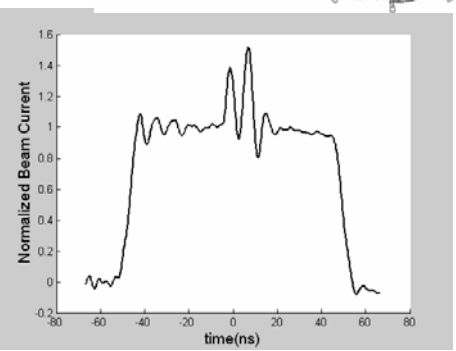
Experiment: Propagation of Perturbed Beam



Beginning

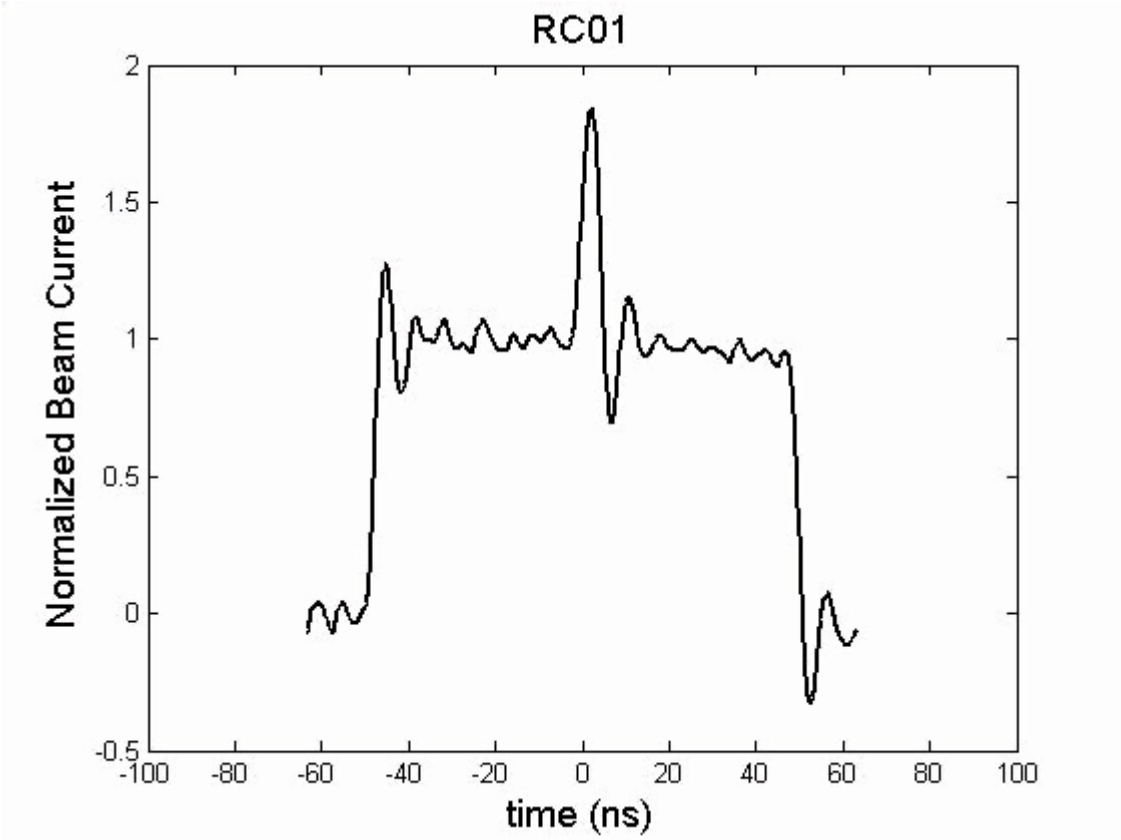


End



20 mA thermal-emission beam current

20 mA photo-emission beam current



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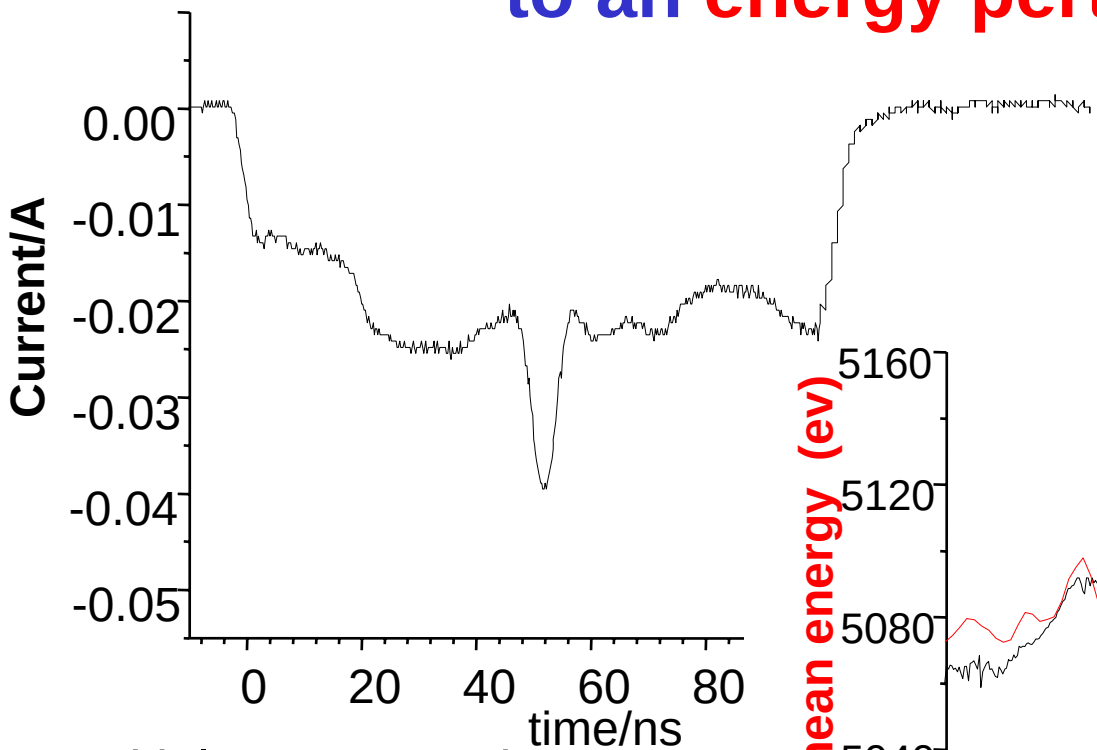
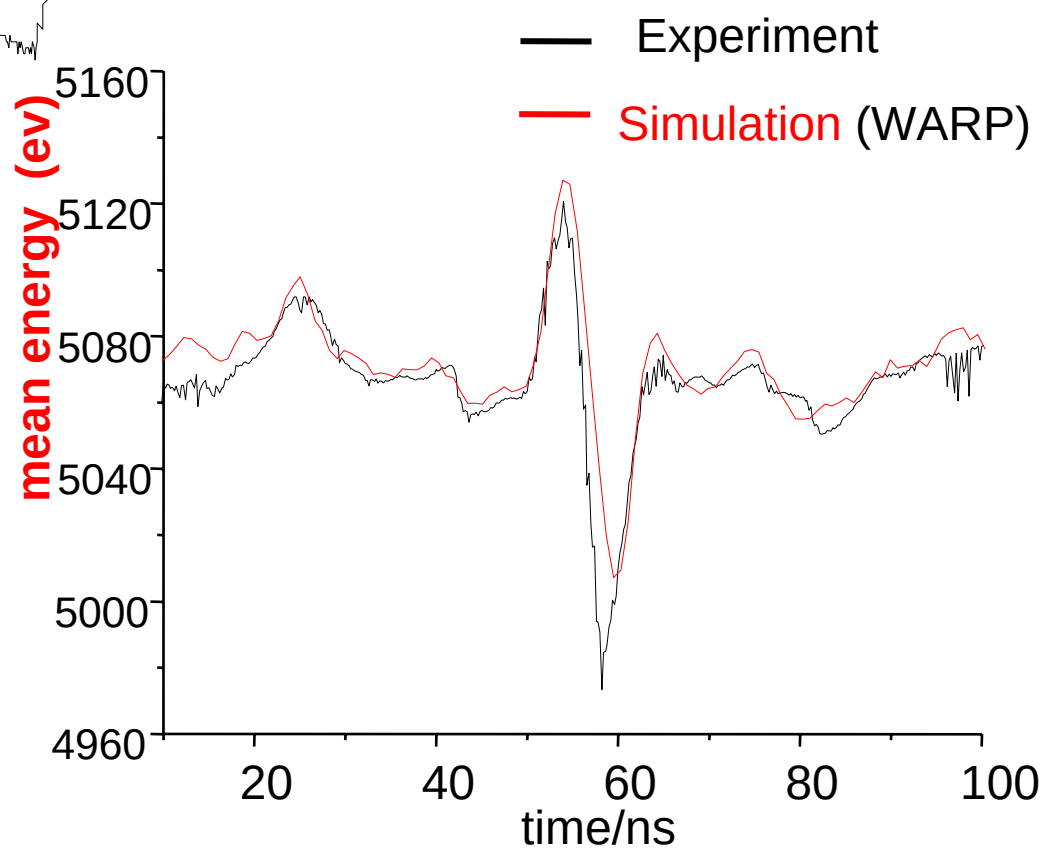
Y. Huo

Space charge converts density perturbation to an energy perturbation



Initial Current vs time



Energy vs time

2-m downstream

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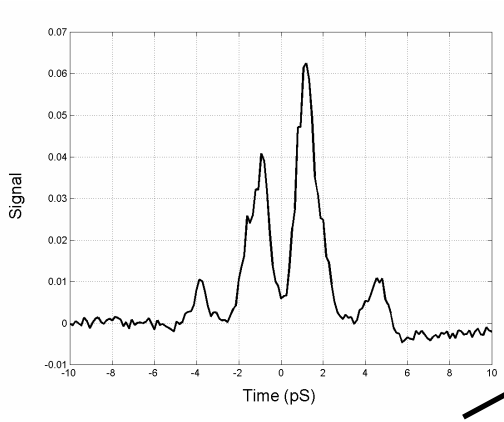
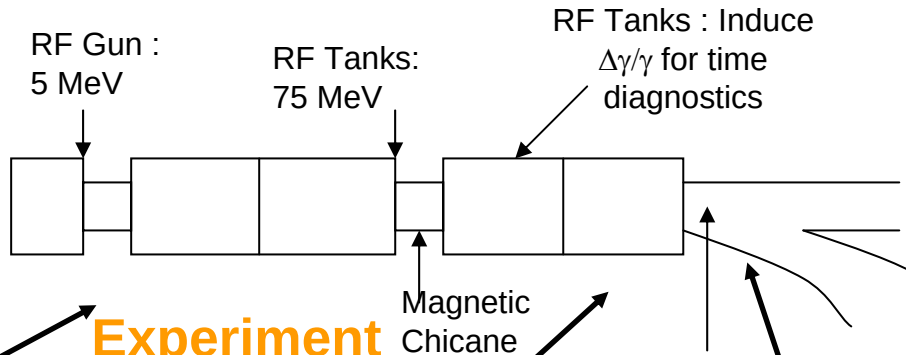
K. Tian

Direct Electron Beam Modulation at Cathode using a Ti:Sap driver laser

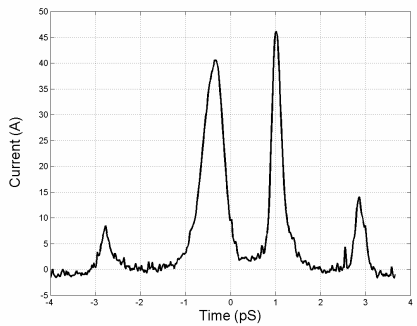




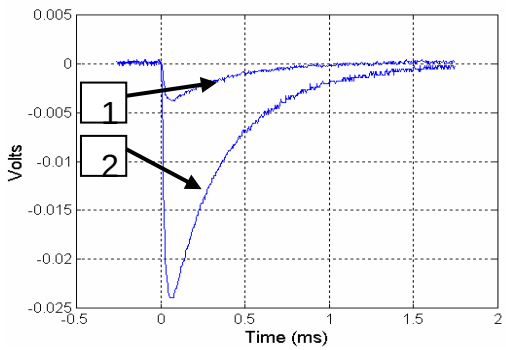
Experiment

J. Neumann

Laser Pulse Shaping on sub ps time scale



Electron Beam Dynamics
Laser structure preserved through linac



THz Radiation Measurements

Production of Photoemission-Modulated Beams in a Thermionic Electron Gun, .J.G. Neumann, J.R. Harris, B. Quinn, and P.G. O'Shea, Review of Scientific Instruments, **76**, 033303 (2005).

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Conclusion

- UMER Commenced Multi-Turn Operation
- Optimization and control underway
- Powerful Diagnostics: EA, Tomography, OTR
- Can produce perturbations with a variety of methods – good agreement with WARP simulations.
- Rich physics content promises exciting results

IREAP Website: http://www.umer.umd.edu/