1. Physics of Space Charge Dominated Beams

2. Microwave Sources for High Frequency Colliders

Patrick G. O'Shea

Professor & Chair

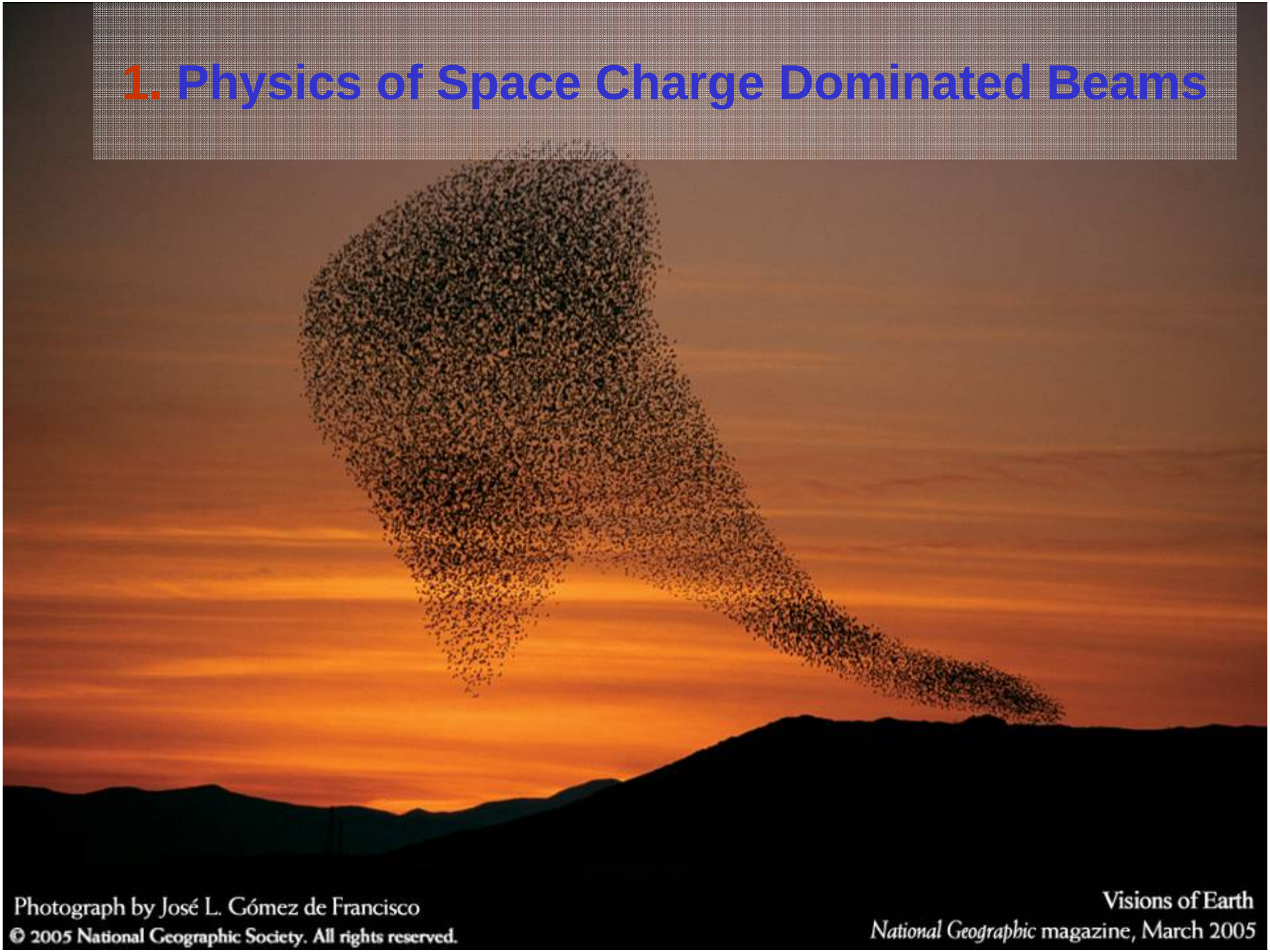
Department of Electrical & Computer Engineering

Institute for Research in

Electronics & Applied Physics

Funded by DOE High Energy Physics
Advanced Accelerator R&D

1. Physics of Space Charge Dominated Beams



Photograph by José L. Gómez de Francisco

Visions of Earth

National Geographic magazine, March 2005

1. Physics of Space Charge Dominated Beams
What we do :

- The physics of beams at high intensity at the intersection of beam and plasma physics.
- Close collaboration between experiment, theory and simulation.
- Medium to long term research

Relevant to several programs

- High Energy Physics
- Fusion energy (Heavy-ion driven inertial confinement)
- Basic energy Sciences: SNS, Light sources
- Office of Naval Research

1. Physics of Space Charge Dominated Beams 2005-6

Principal Investigators
Prof. P. O'Shea,
Prof. M. Reiser,
Prof. R. Kishek (Project Manager)*
I. Haber

Experiments
S. Bernal
D. Feldman
R. Fiorito

Mechanical Engineering
M. Walter
D. Cohen

Theory & Simulation
R. Kishek
I. Haber

Graduate Students
C. Tobin
K. Tian
G. Bai
D. Stratakis
C. Papadoulos
B. Beaudoin

Electronics & Magnetics
B. Quinn (Lab Manager)
T. Godlove

Undergraduate Students
J. Yeager
J. Francis
M. Stanley
O. Kuznetsova
A. Sharifzada*

External Collaborators
T. Wangler (LANL)
C. Bohn (Fermilab/NIU)
I. Hofmann (GSI)
H. Nishimura (LBNL)

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Space Charge Dominated Beams Group History

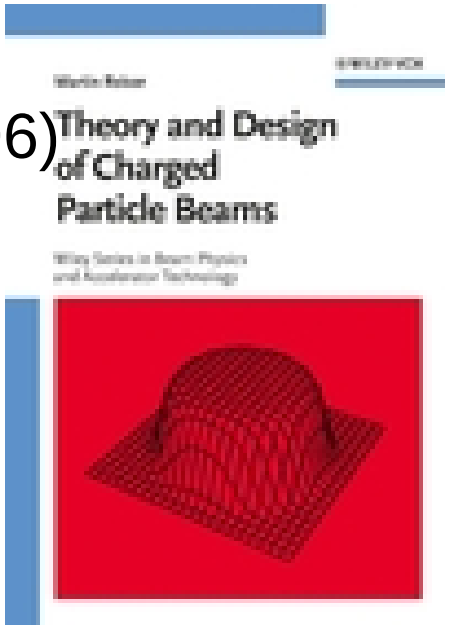
Founded by Prof. Martin Reiser

Three Phases:

Mid 1980s: Space charge waves to accelerate ions, GeV/m demonstrated

Late 1980-90s: Emittance growth from space – charge (weak focusing, linac)

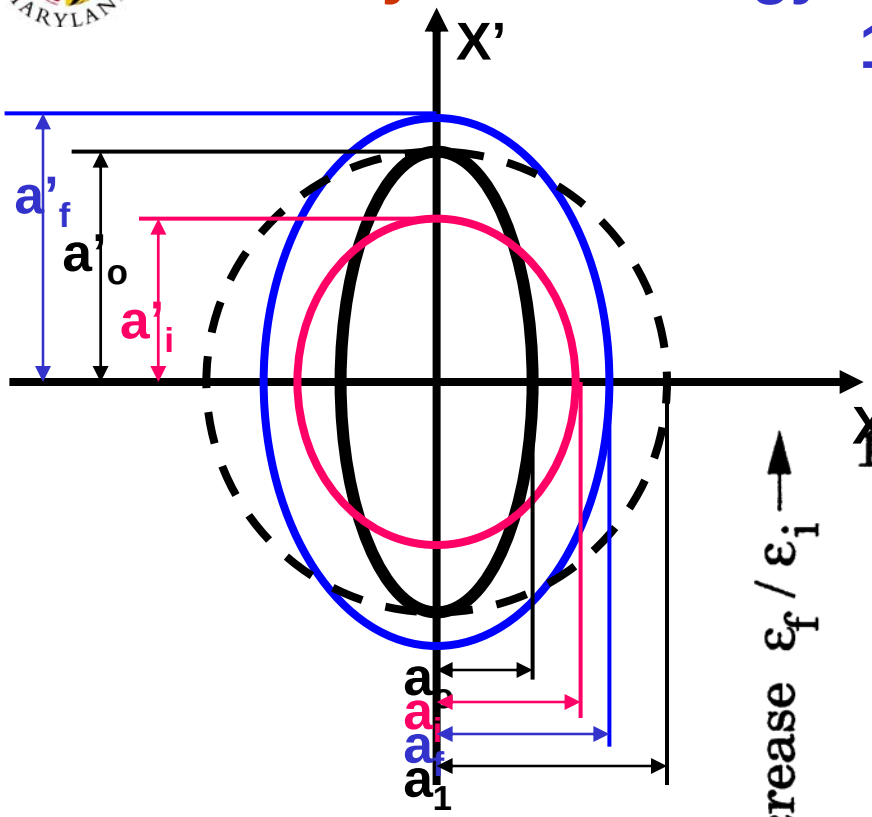
Today: Space-change in a stong focusing lattice - UMER

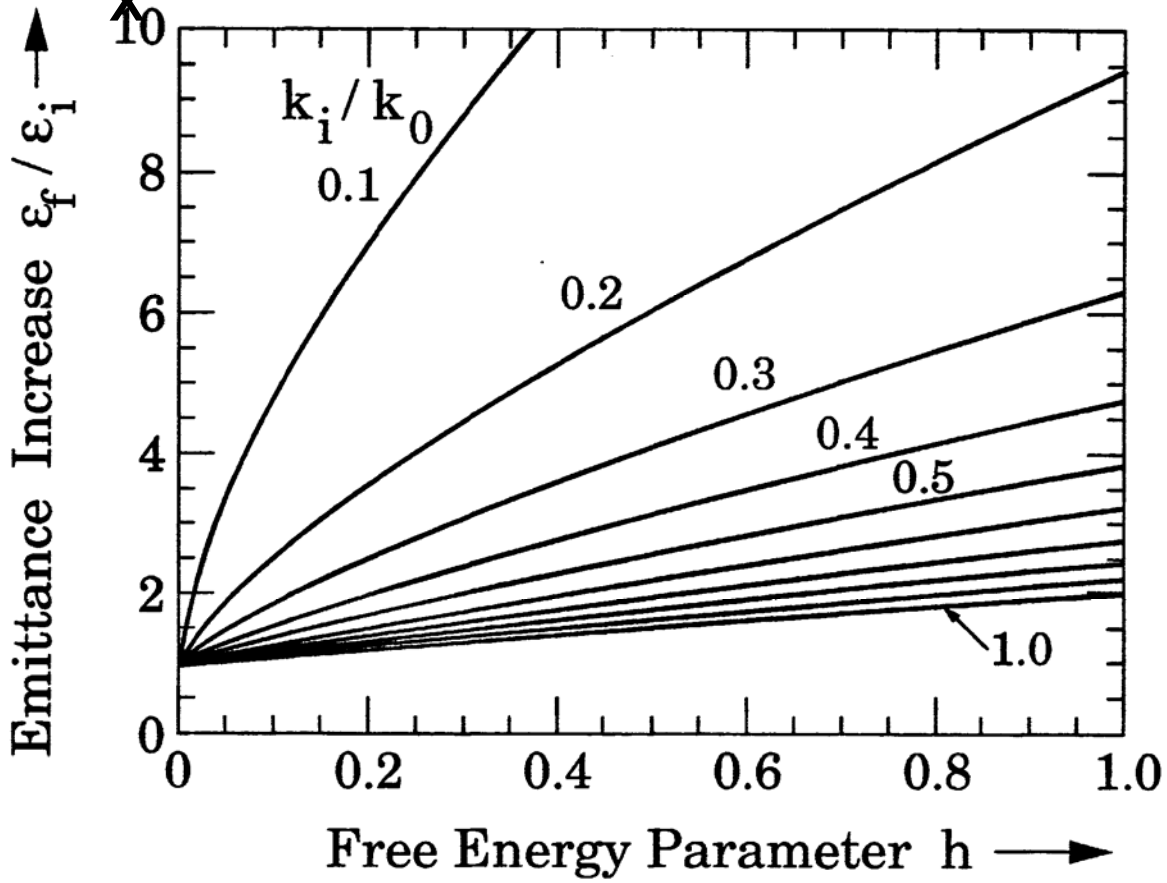


- > 20 PhDs produced since 1983 (7 since 1996)
- 6 PhD candidates currently
- Tens of undergraduates trained
- > 60 refereed publications since 1996
- > 80 conference papers since 1996
- 9 Physical Review Letters since 1996

IREAP Recent funding approx 750k$ per annum

History: Free Energy Theory of Emittance Growth 1980s





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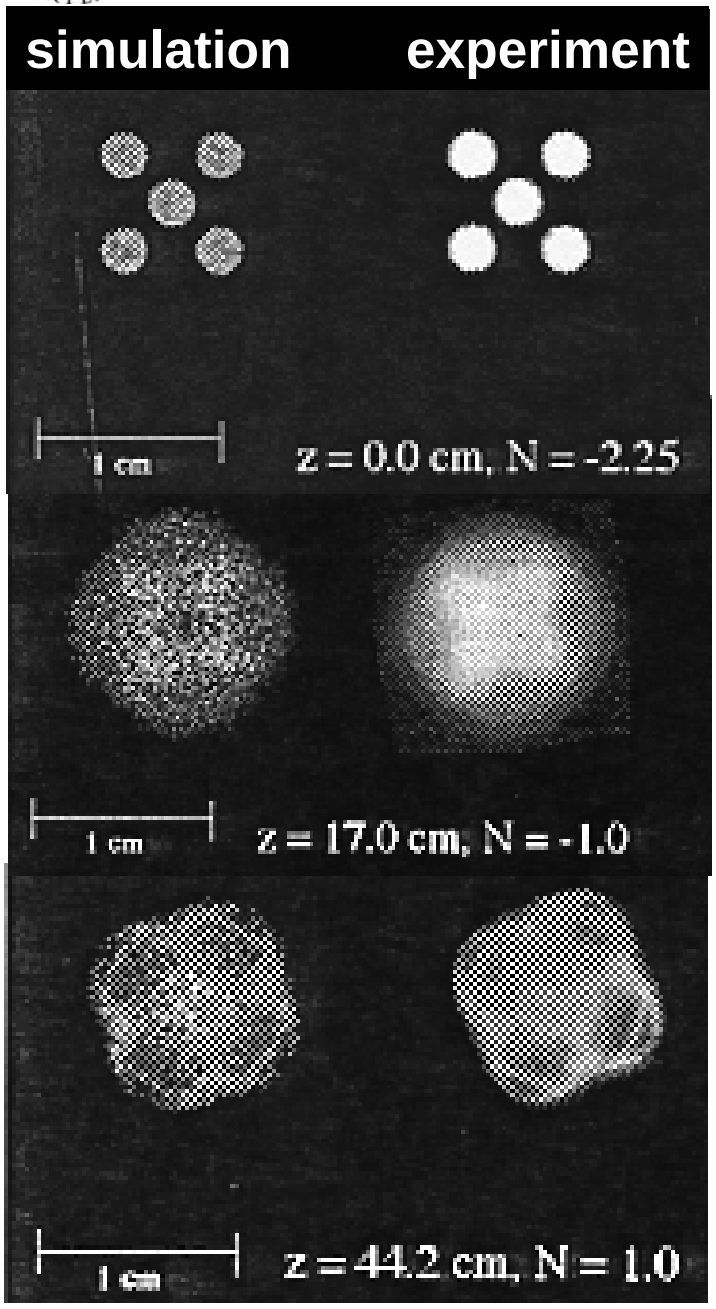
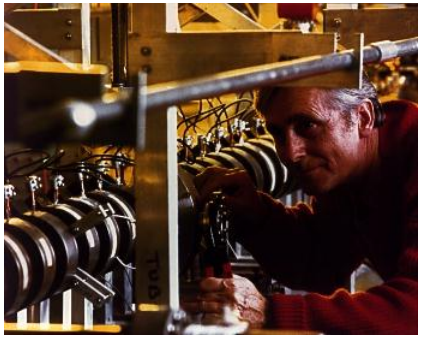
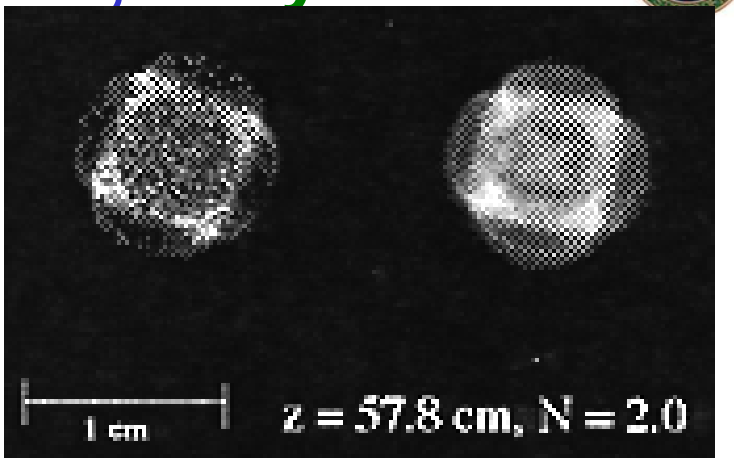
M. Reiser

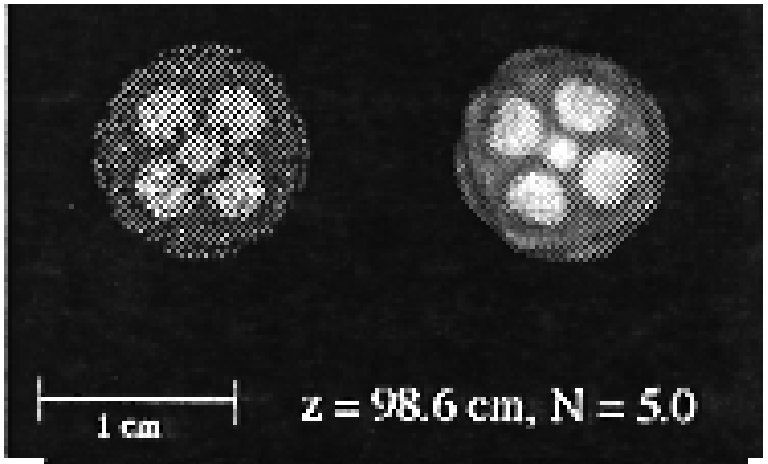
History: 5-Beamlet Experiment, early 1990s

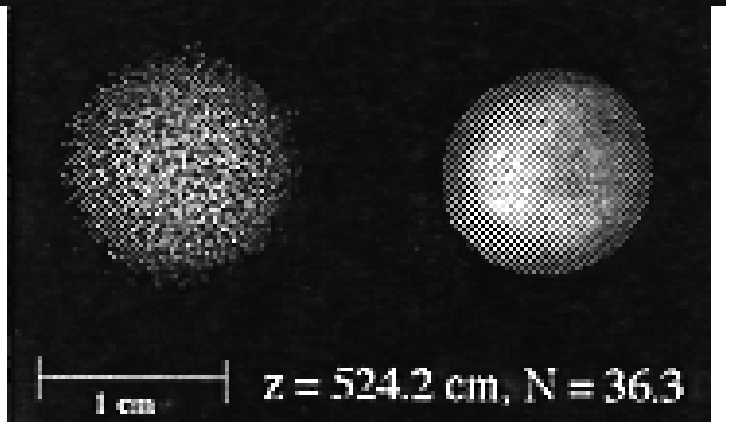
Matched





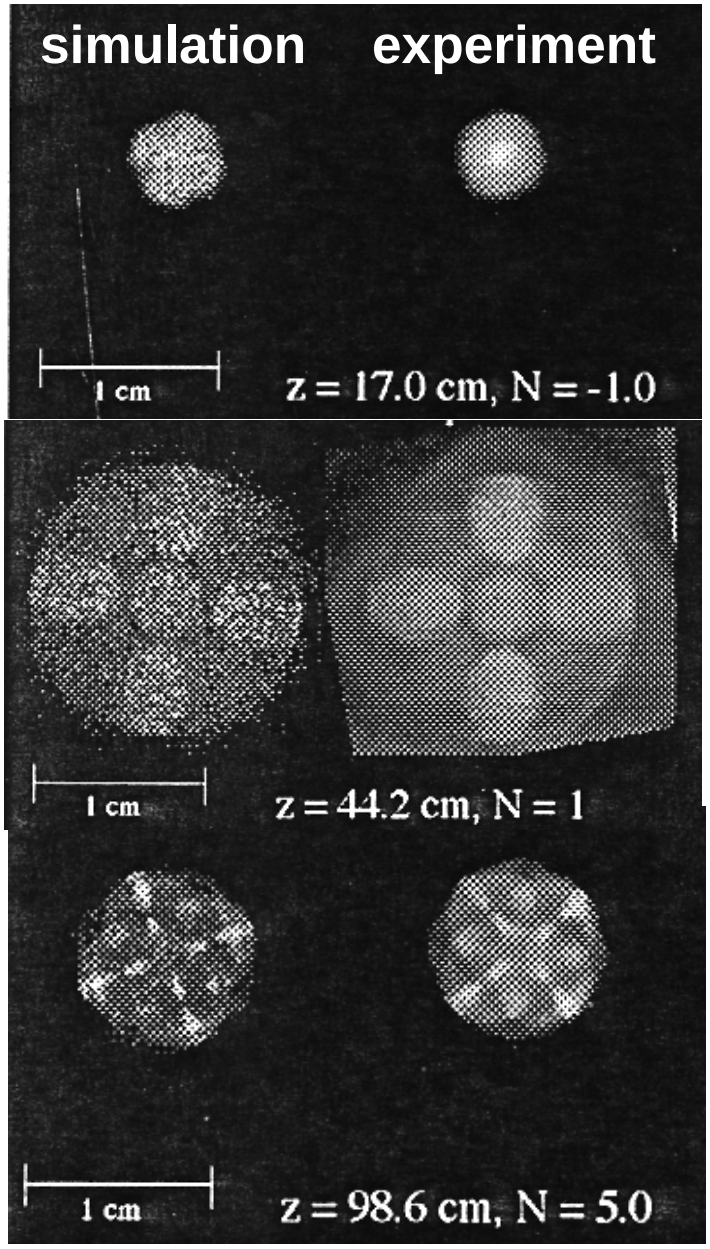


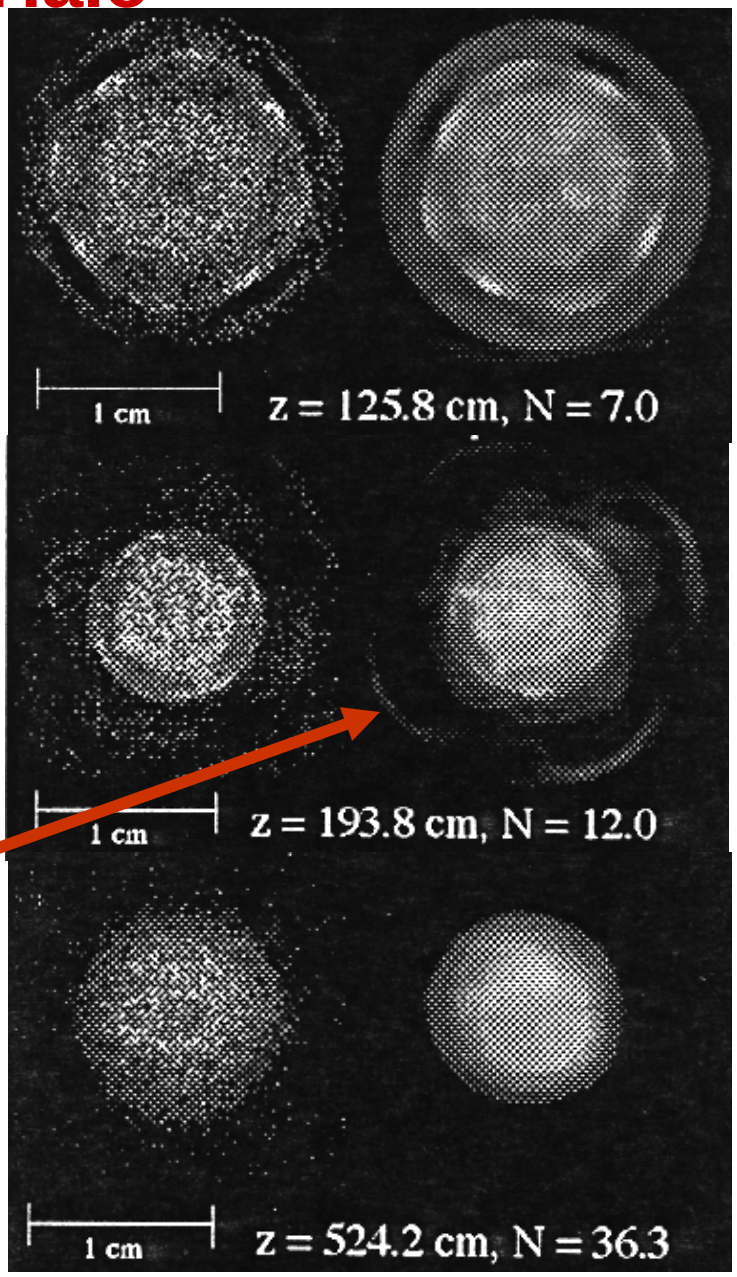




D. Kehne, I. Haber, and M. Reiser

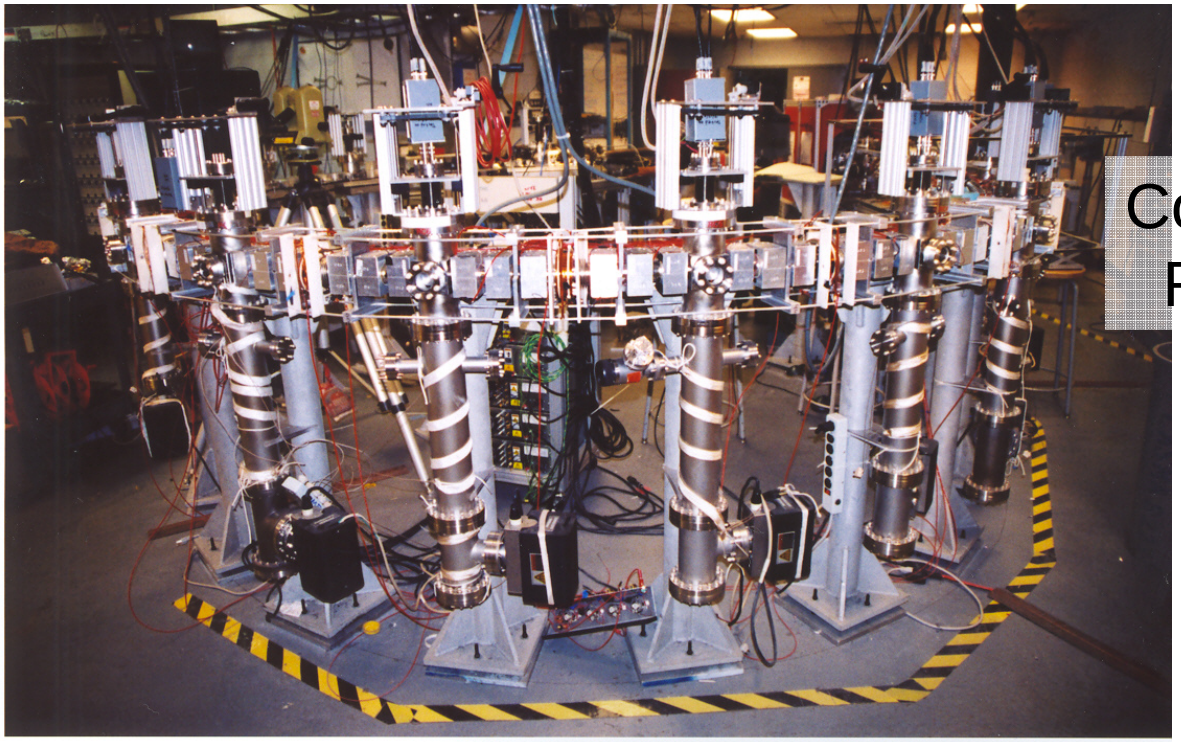
History: 5-Beamlet Experiment, RMS Mismatched and Halo





Halo

Today: The University of Maryland Electron Ring (UMER)



Construction period 2000-5
Reviews ≈ every 2 years

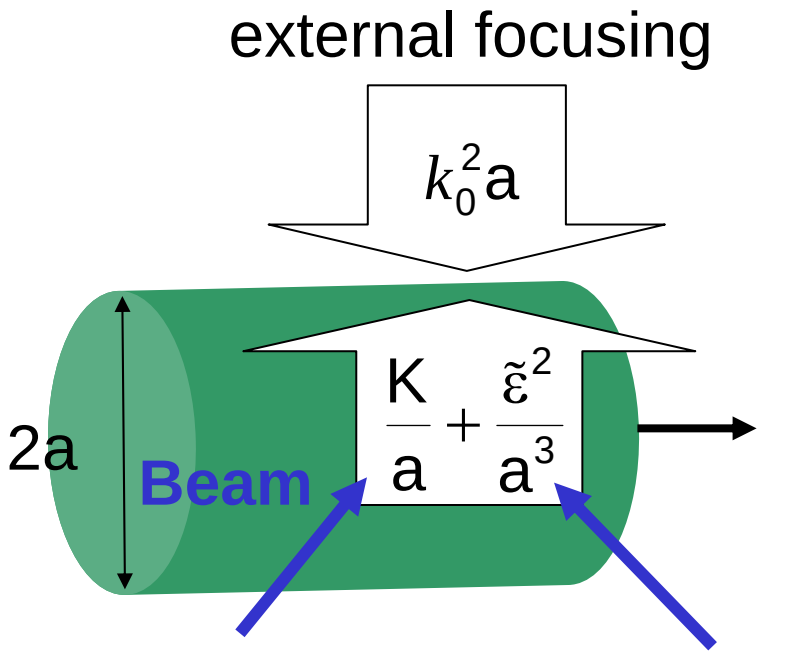
Energy	10 keV	Circulation time	200 ns
Energy Spread	<20 eV	Pulse length	5-100 ns
Current	0.6-100 mA	Zero-Current Tune	7.6
rms Emittance	0.2-3 μm	Depressed Tune	1.5 – 6.5

Dimensionless Space Charge Intensity (χ)

Intensity Parameter:

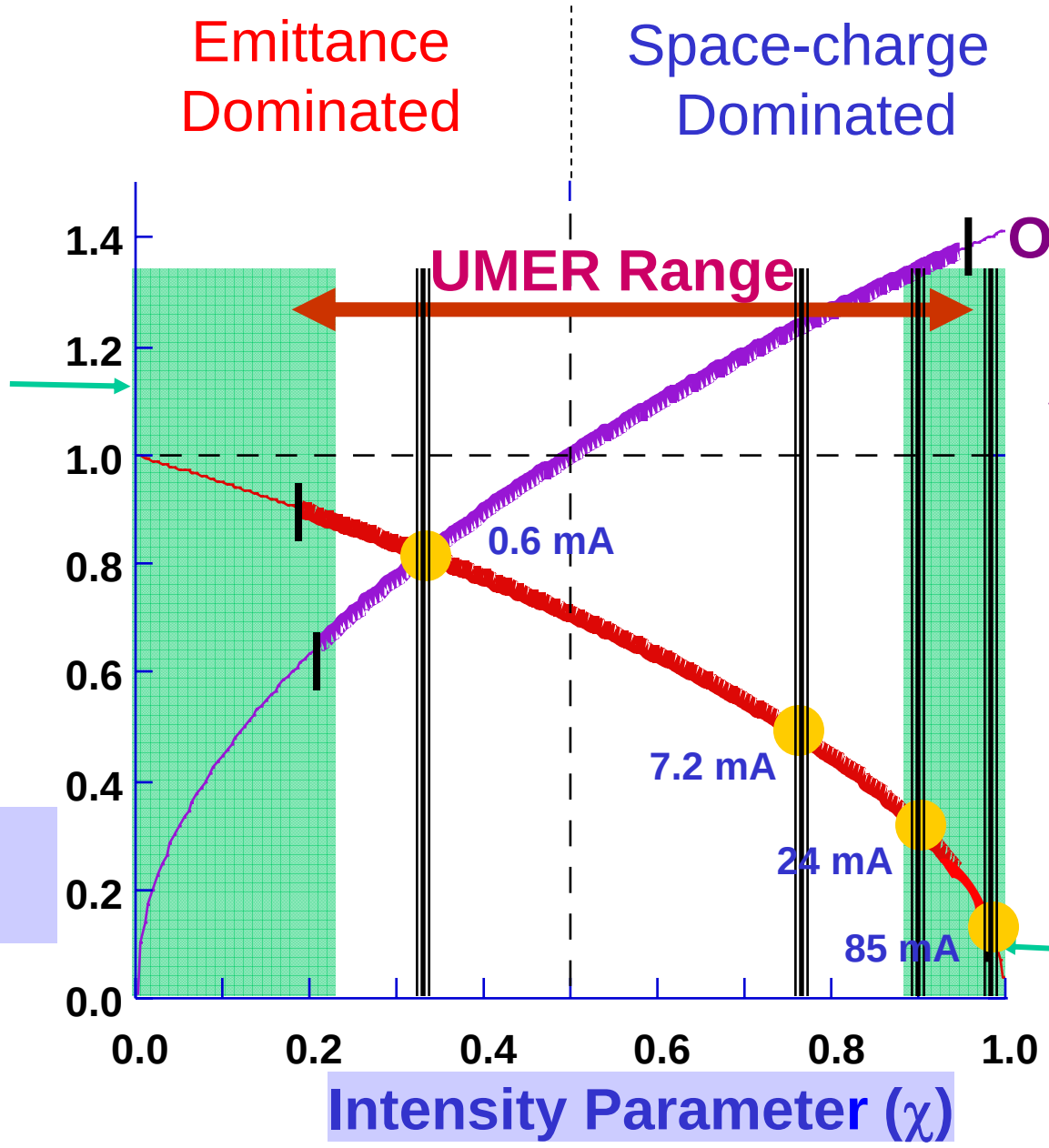
$$\chi \equiv \frac{K}{k_o^2 a^2} = \frac{\text{space charge force}}{\text{external focusing force}}$$

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



$$K = \frac{2I}{I_o (\gamma\beta)^3}$$

Present UMER Operating Points



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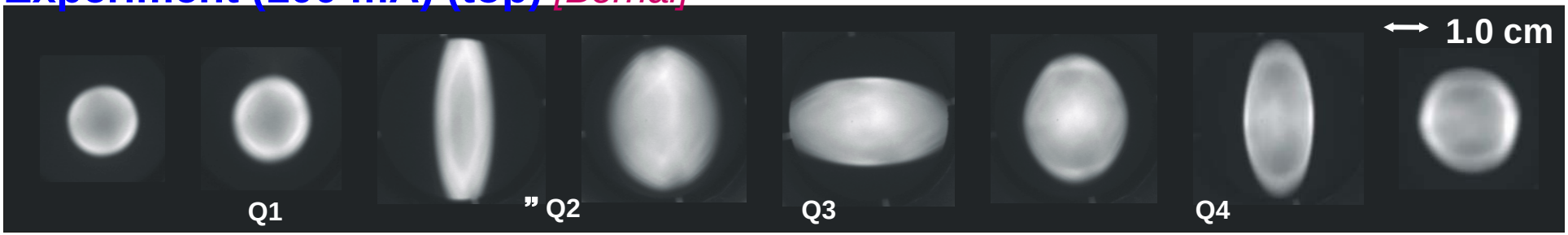
Transverse Space-Charge Waves on UMER

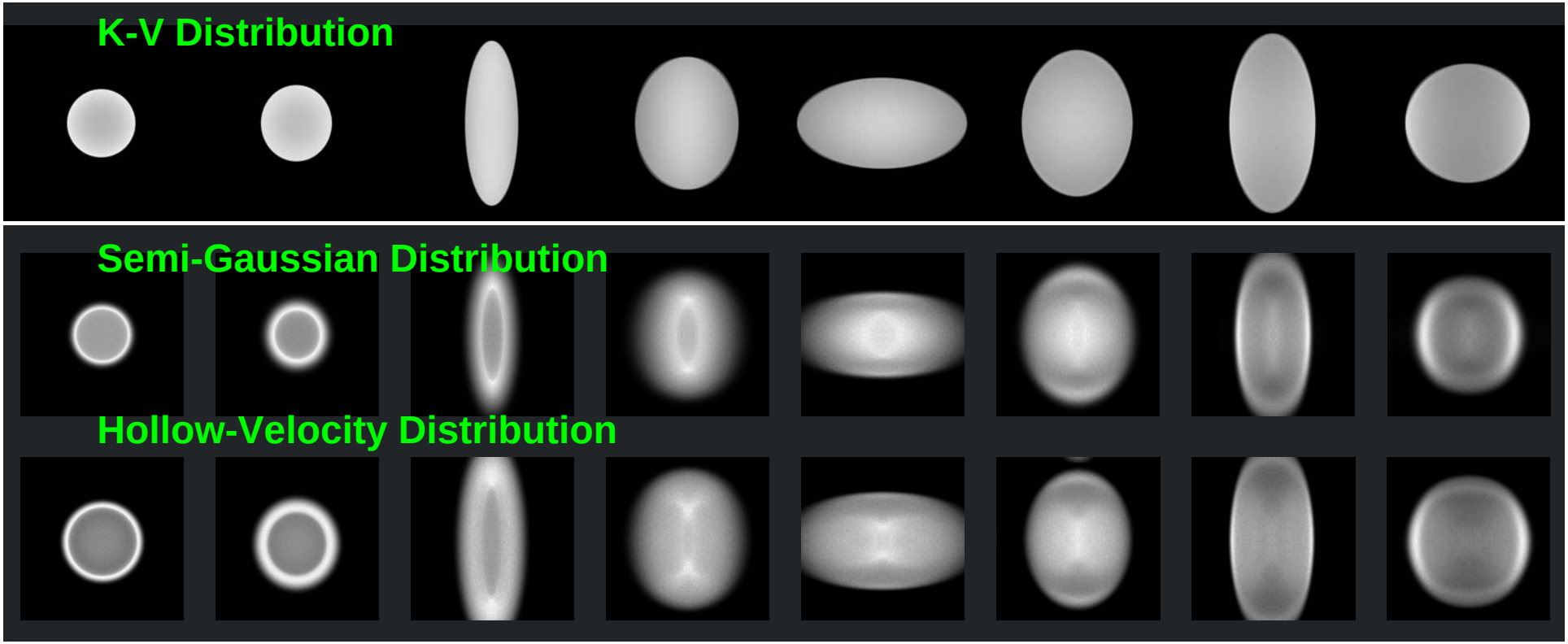
Beam patterns sensitive to initial velocity distribution!

Experiment (100 mA) (top) *[Bernal]*

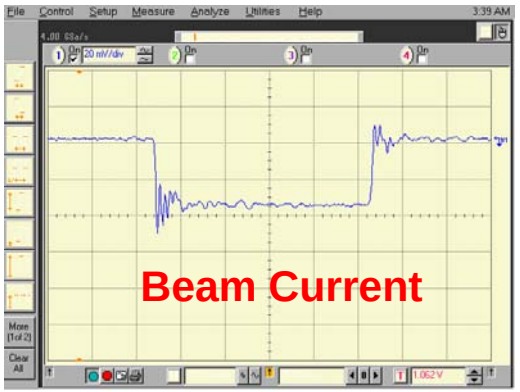


Moving down beam line

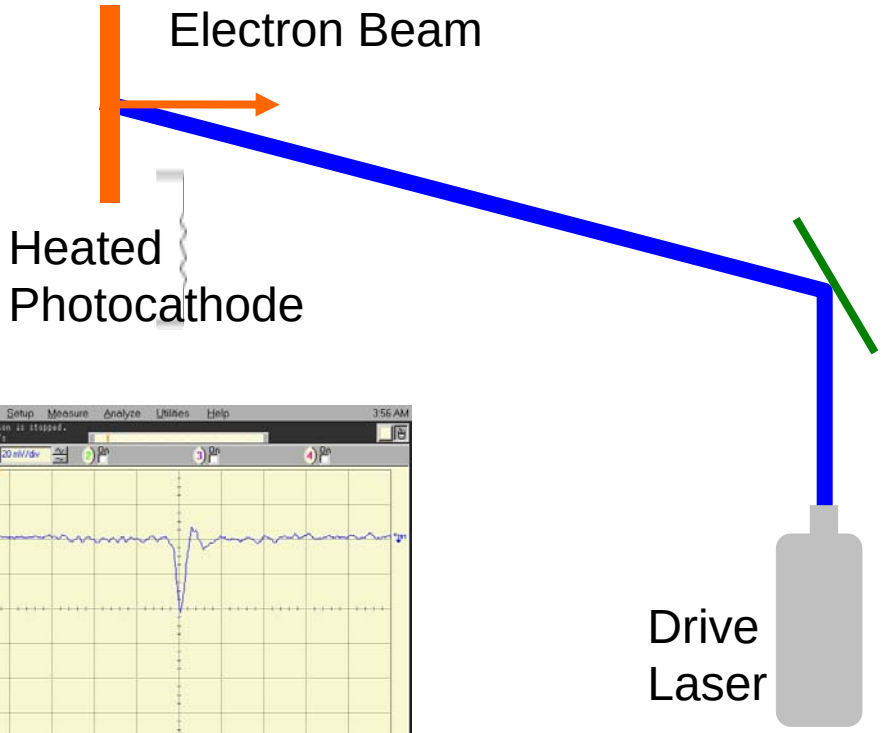
WARP Simulation (below) *[Kishek]*



Longitudinal Space Charge Waves von UMER Generating Perturbations with Lasers



Thermionic only, 100ns pulse



Photoemission only
(Cool cathode)

Photoemission +
Thermionic 5ns pulse

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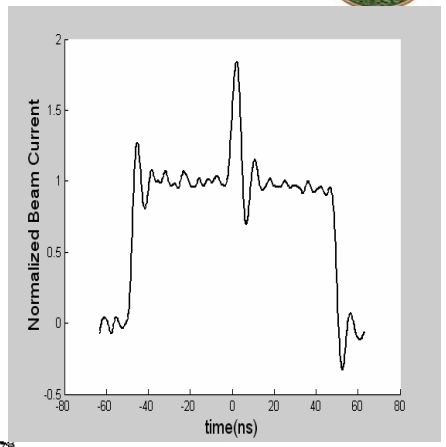
Experiment: Propagation of Perturbed Beam

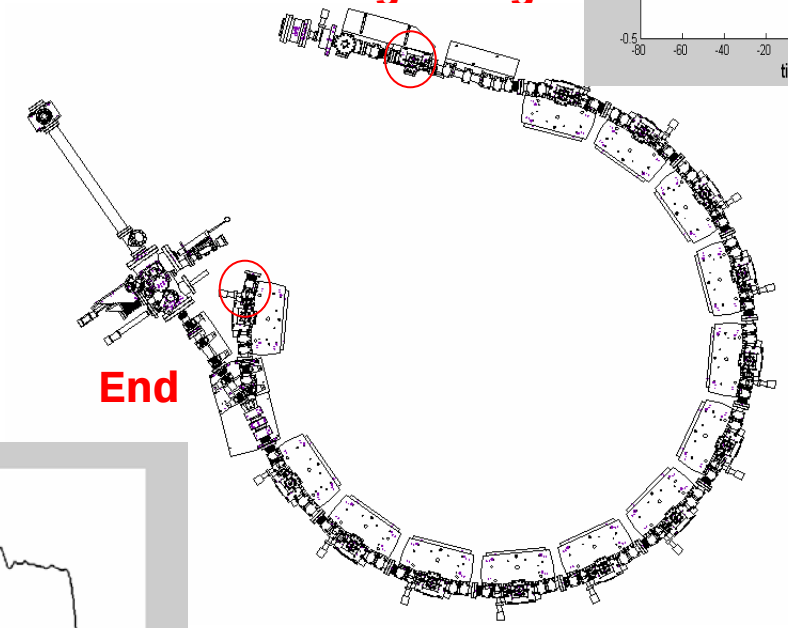
Conversion of density modulation to energy modulation

20 mA thermal-emission beam current

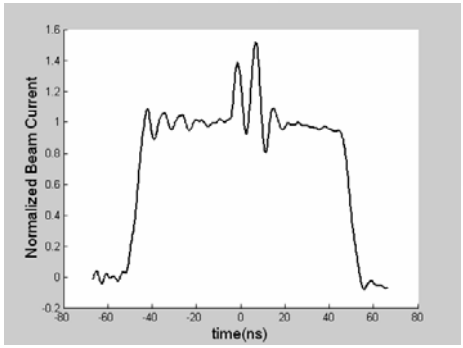
20 mA photo-emission beam current



Beginning

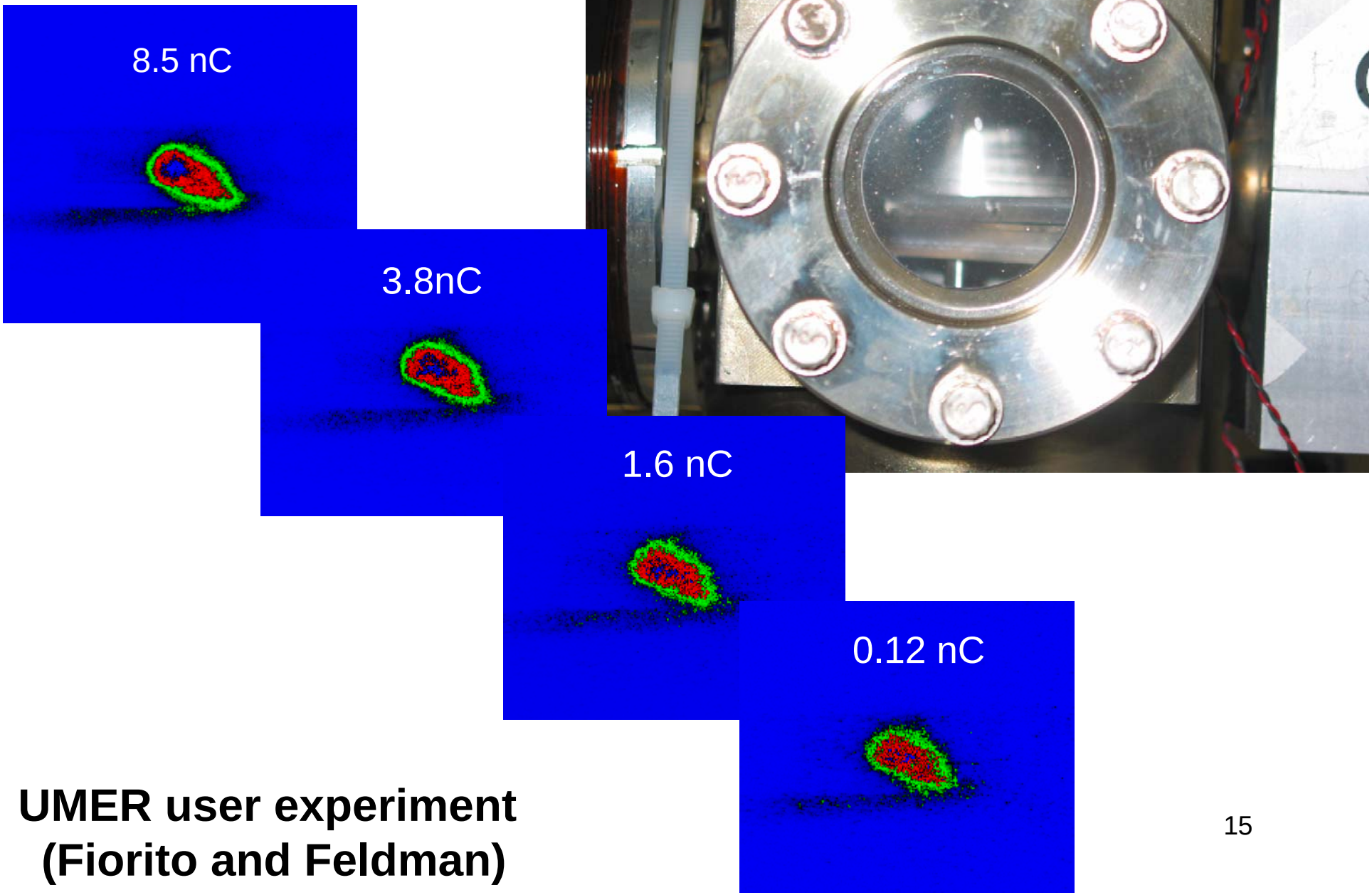


End

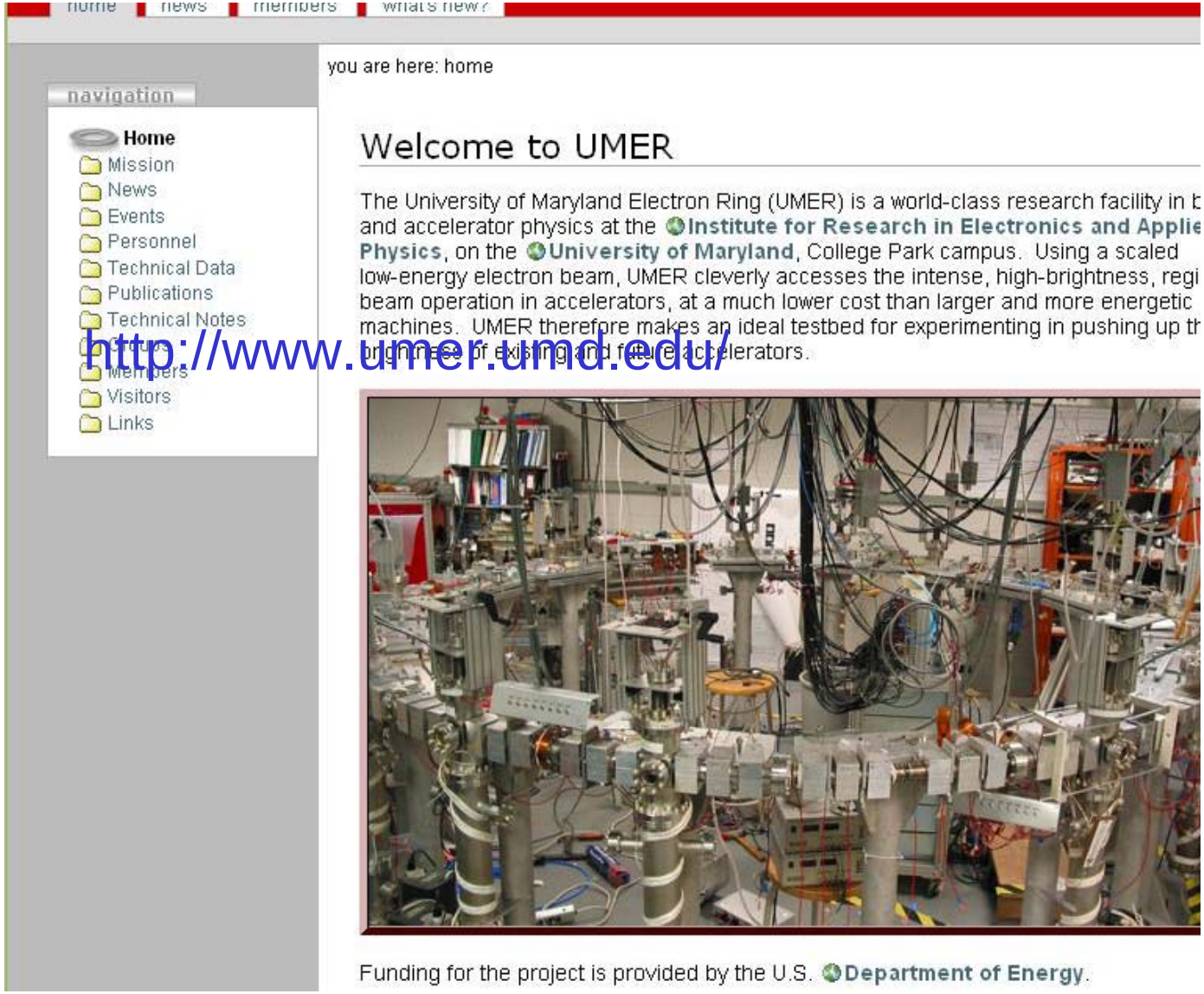


Low Energy (10 kV) Optical Transition Radiation Images

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



UMER user experiment (Fiorito and Feldman)


home
news
members
what's new?
navigation
Home
Mission
News
Events
Personnel
Technical Data
Publications
Technical Notes
Visitors
Links
you are here: home
Welcome to UMER
The University of Maryland Electron Ring (UMER) is a world-class research facility in b
and accelerator physics at the Institute for Research in Electronics and Applie
Physics, on the University of Maryland, College Park campus. Using a scaled
low-energy electron beam, UMER cleverly accesses the intense, high-brightness, regi
beam operation in accelerators, at a much lower cost than larger and more energetic
machines. UMER therefore makes an ideal testbed for experimenting in pushing up th
http://www.umer.umd.edu/
Funding for the project is provided by the U.S. Department of Energy.

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2. Microwave Sources for High Frequency Colliders (Maryland Gyroklystron Program)

Principal Investigators:

W. Lawson, V. L. Granatstein, P. O'Shea, and M. Reiser

Participating faculty:

G. Nusinovich, T. Antonsen. R. Kishek

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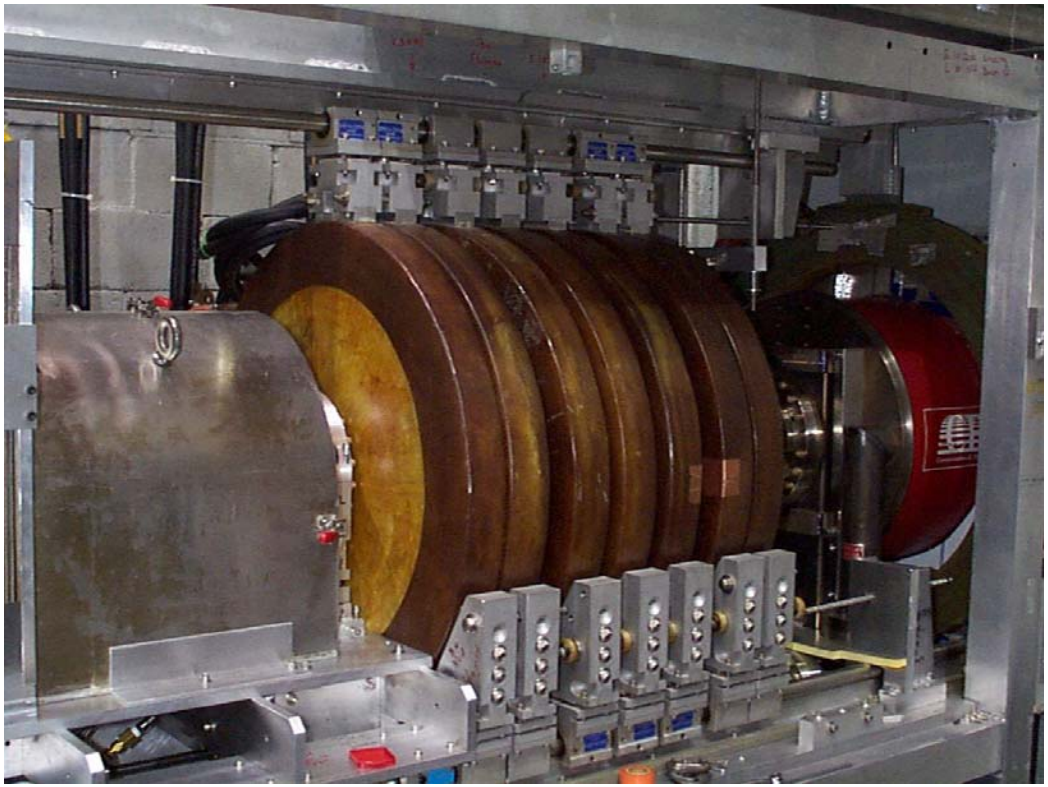
Test facility and gyroklystron circuit



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Project scope

Microwave program started in 1984

- The initial goal was to develop high power gyro-amplifiers (gyroklystrons and gyrotwystrons) and assess the suitability of these devices as drivers of advanced colliders (100% long range).
  - Complete success would result in a tube that could be used to drive electron-positron colliders up to the TeV level and beyond.
- New goal is to develop and use gyroklystrons to support the US collaboration on high gradients (HG) for a multi-TeV linear collider by providing a facility by 2008 to test and condition HG structures from 17 GHz to 30 GHz (Lawson) and explore breakdown issues (Nusinovich Kishek) (100% medium range).
  - Complete success would be the production of one or more test facilities in the US that could be used to test and develop HG structures for 5-10 years.

Major accomplishments

- We developed a suite of gyrotron amplifier design codes and related tools for the community.
- We have produced state-of-the-art levels of peak power density in ~1 μs amplifiers with our frequency-multiplying tube that produced 32 MW near 20 GHz.
- We have produced 75 MW in a coaxial gyroklystron in X-Band.
- We have pioneered the development of state-of-the-art Magnetron Injection Guns for gyro-devices with design laws, scaling equations, improved fabrication techniques, and space-charge limited guns.
- ≈ 50 refereed journal articles (one invited) resulting directly from our DOE-HEP program on microwave production, electron gun development, high-power, overmoded waveguide components. We have had over a dozen invited talks and over 100 contributed papers.
- A spin-off from the DOE-HEP work produced the first gyroklystron actually used in a product (the WARLOC radar) and resulted in the 1999 RL Woods Award for Excellence in Microwave Sources (with Prof. Lawson as one of many co-winners).

Summary
GKL Research Accomplishments and Impact

- Gyroklystron operation demonstrated with parameters relevant to driving high energy linacs
- Developed suite of gyroklystron design codes
- Other R&D groups have used Maryland codes to design GKLs for 30-100 GHz, high power amplifier requirements (NRL, CERN, CPI, CCR)
- Preparing 20 MW,17.14 GHz GKL driven by phase controllable TWT to drive high gradient Haimson accelerator to G~100 MV/m
- New plans for test stand for US collaboration on HF structures, and accelerator breakdown studies