Working Group 2

Diagnostics & Beam Manipulation

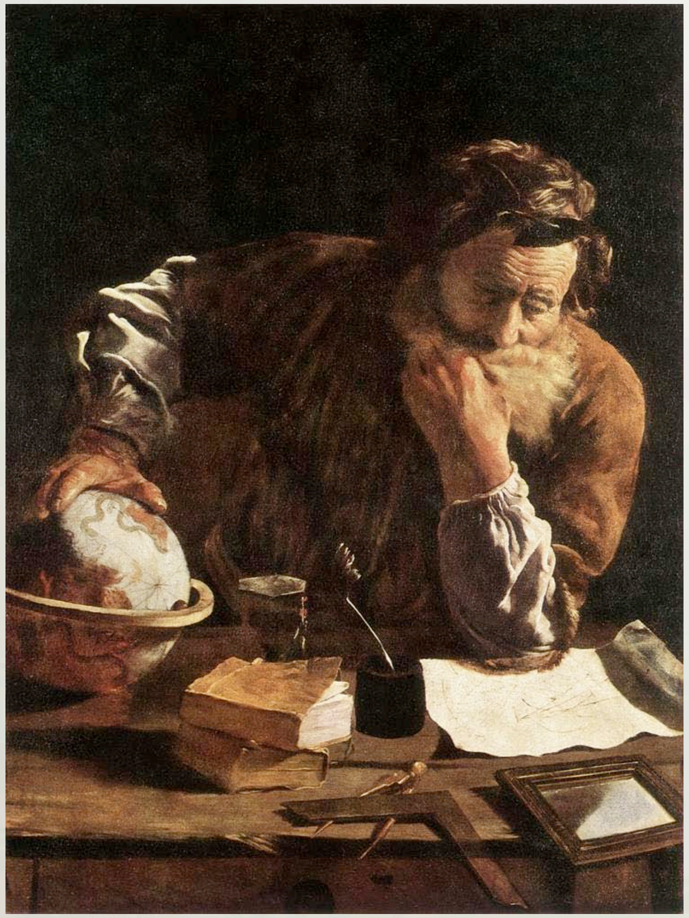
Leader: Gil Travish

Secretary: Daniele Filippetto

Guest Leader: Thorsten Kamps

Last Night

Gil



You Guys

Participants

25 +

Gerard Andonian UCLA
Manuela Boscolo LNF-INFN
Francesco Broggi INFN-LASA
Mario Ferianis SINCROTONE TRIESTE
Dario Giove INFN MILANO
Lazar Staykov DESY
Scott Anderson LLNL LIVERMORE
Les Dallin CANADIAN LIGHT SOURCE
Mike Dunning UCLA
R Joel England UCLA
Daniele Filippetto LNF-INFN
Mark Hogan SLAC
Katja Honkavaara UNI-HH
Thorsten Kamps BESSY BERLIN
Sergiy Khodyachykh DESY
Patrick Krejcik SLAC
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Anne Oppelt DESY
Lenny Rivkin PSI SWITZERLAND
Jorg Rossbach UNIVERSITY- HAMBURG/ DESY
Fernando Sannibale LBL BERKELEY
Siegfried Schreiber DESY
Todd Smith Stanford U.
Gil Travish UCLA
Rao Triveni BNL UPTON USA
Alexander Tron LEBEDEV PHYSICAL INSTITUTE (RUSSIA)
Max Zolotorev LBL BERKELEY
...

Presentations

12

Monday

G. Andonian
Compression Studies at the ATF with the BNŁUCLA Chicane
T. Kamps
Laserwire Based Beam Profile Monitor
A. Tron
New principles in photochronography of femtosecond resolution

Tuesday

K. Honkavaara
Measurements of the Transverse Emittance at the VUV-FEL at DESY
M. Boscolo
SPARC e-meter @PITZ: simulation studies compared to measurements
M. Dunning
Overview of the LCLS Single-Shot Relative Bunch Length Monitor System
R. J England
Beam Shaping and Permanent Magnet Quadrupole Focusing with Applications to the Plasma Wakefield Accelerator
D. Filippetto
The Sparc Movable Emittance Meter: Commissioning And First Operation At Pitz

Thursday

J. Rosenzweig
Optimum Beam Creation in Photoinjectors Using Space-charge Expansion II: Experiment
A. Sakumi
Synchronization between laser and electron beam at photocathode RF gun
T. Smith
Temporal Diagnostic with 10fs Resolution
L. Staykov
Emittance Measurements -- to the point

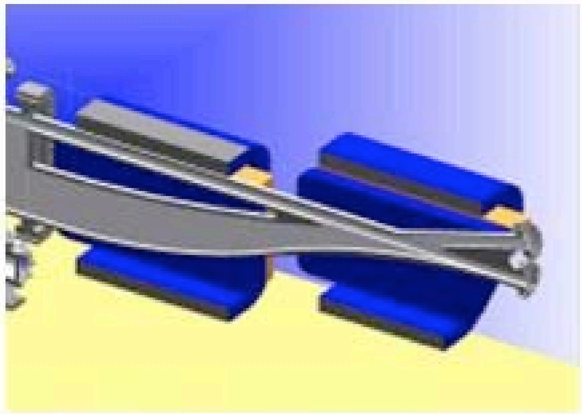
Monday

G. Andonian

Beam Manipulation

CER Experiment

- Radiation collected from boundary region of dipoles 3-4
  - 7 m transport
- New regime for Edge Radiation
  - <50 micron wavelength
- Cold Bolometer
  - 4.2 K Si bolometer (IR Labs)



G. Andonian

Conclusions

- Summary
  - Chicane compressor installed and commissioned
  - Compressor provides a rich data set
    - CTR, CER, momentum spread, tomography
  - Simulations need to catch up
    - Microscopic physics model
- Future Run Plans
  - CER filter measurements
  - Improved CER polarizer measurements
  - Compare to models (Field-Eye)

G. Andonian

LBBD
Laserwire

Laser-wire Beam Profile Monitor

T. Kamps (BESSY)
for the LBBD Collaboration
PAHB Workshop, Erice, October 2005

T. Kamps

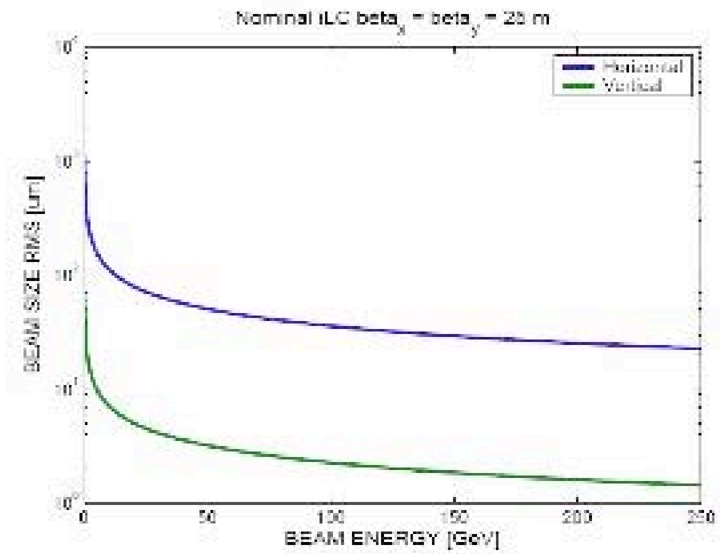
Beam Profile Monitor

LBBD Laserwire

Target of the LBBD Collaboration

- Provide a non-invasive, high-precision beam profile monitor for the linac and beam delivery system of a linear collider
  - Non-invasive: low background for surrounding accelerator environment, surviving high energy and bunch charge electron beam
  - High-precision: measure spot sizes in the several ten μm range

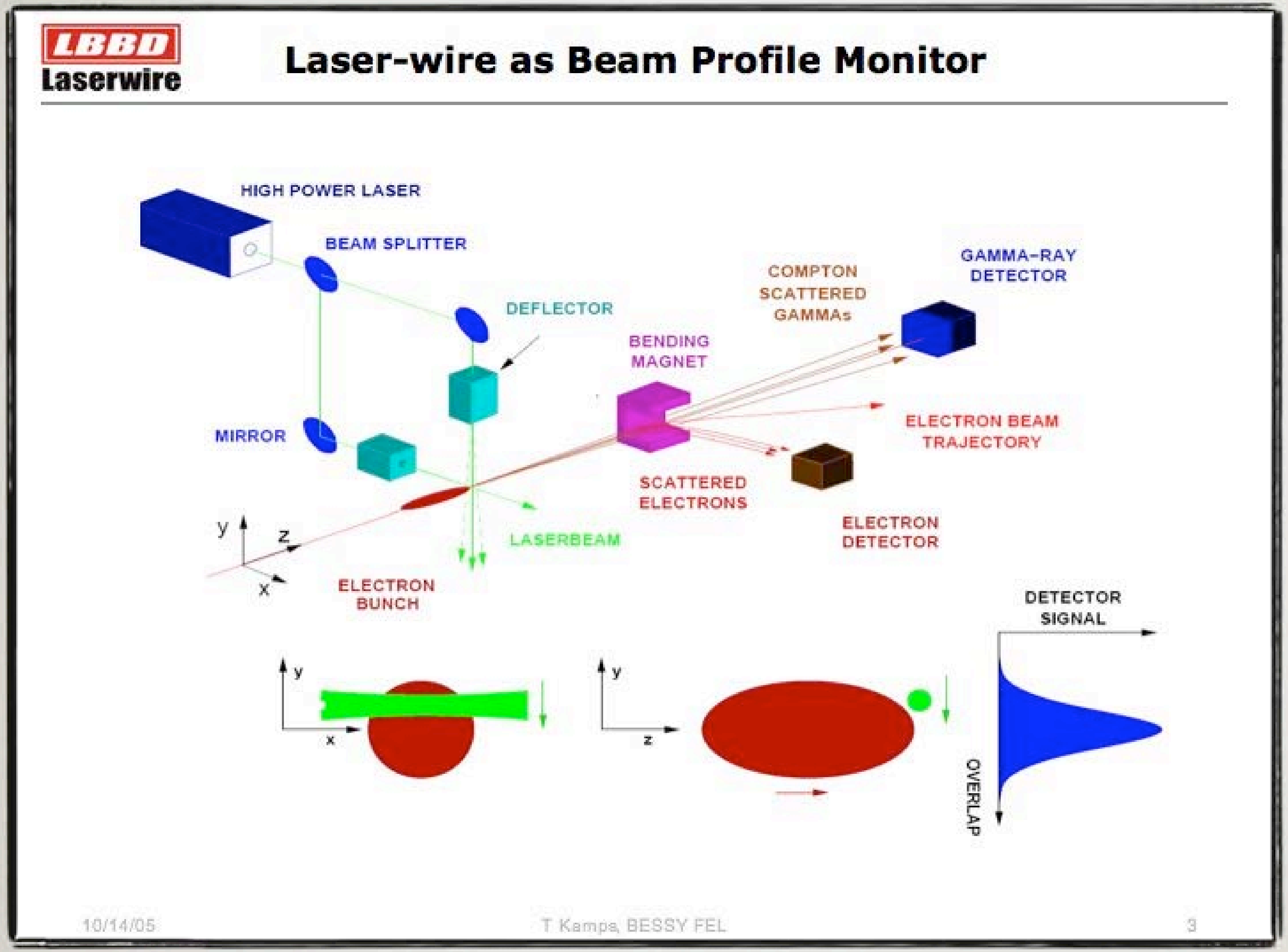
		TESLA	Nom	LowQ
E	GeV	[0 250]	[0 250]	[0 250]
N	10^{10}	2	2	1
N_b		2820	2820	5640
T_{sep}	ns	336.9	307.7	153.8
$\gamma\varepsilon_{x,y}$	μm/nm	10/30	10/40	10/30



- Groups of three (or four) monitors in FODO channel for emittance measurement, each monitor measures vertical, horizontal size and coupling
- Desirable to measure beam size within bunch train
- Standard beam size monitors as OTR screens or wirescanners are at their resolution and operational limit ▶ Compton Scattering based monitor

T. Kamps

Beam Profile Monitor



T. Kamps

Beam Profile Monitor

LBBD Laserwire

Conclusion and Outlook

- Laserwire at PETRA2 operational after 3 years of R&D
  - 2000 – 2002: Learning, design studies and lab measurements at RHUL, participation at CTF2 laserwire
  - 2002 – now: continouus setup of laserwire at PETRA2
  - Aug 2003: first Compton photons
  - Dec 2003: first slow scans (30 min/scan)
  - Feb 2005: fast scans (30 sec/scan), big breakthrough due to installation of dedicated exit chamber
  - Next steps installation of new laser and vertical breadboard with second scanning dimension
- Started collaborative effort with colleagues from CERN, DESY, KEK, SLAC and UK universities on laserwire diagnostics
- Training of UK students at PETRA2/DESY: 3 MSc students, 3 PhD students plus conversions of HEP PostDocs into AccPhys
- Efforts at PETRA2/3 complementary to ATF Laserwire (aiming at μm spotsizes and iLC bunch trains)

T. Kamps

Method of Bunch Radiation Photochronography with 10 Femtosecond and Less Resolution

ALEXANDER TRON[†]

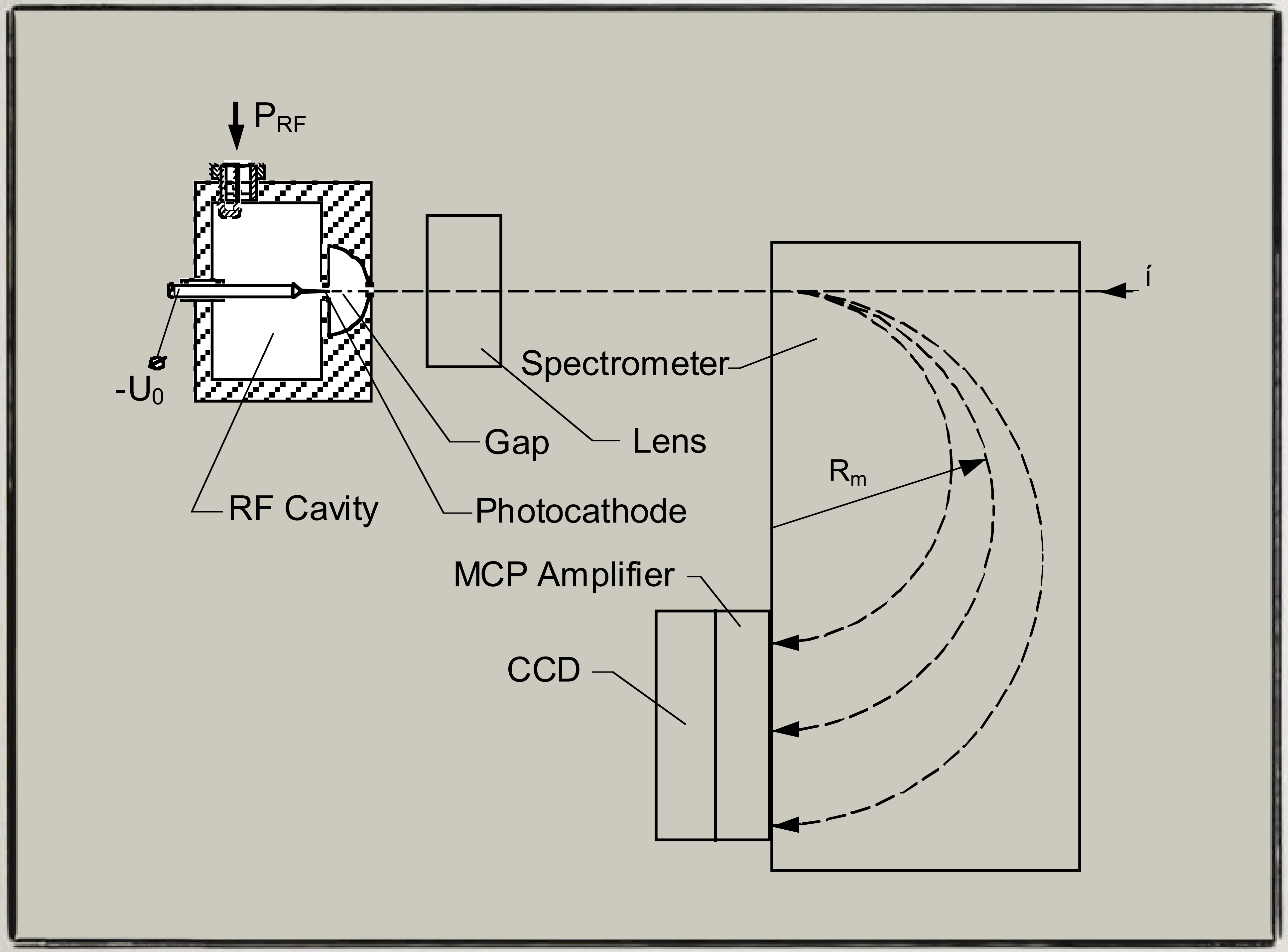
Lebedev Physical Institute, Leninsky prospect 53
Moscow, 119991, Russia

IGOR MERINOV

Moscow Engineering Physics Institute, Kashirskoe shosse 31
Moscow, 115409, Russia

The success in creation of the proposed facilities, where the required electron bunch duration can be of about 100 fs and less, will be depend directly on the ability to measure the bunch longitudinal profile with resolution of the order of 10 fs and less. The only method for the bunch monitoring with the mentioned temporal resolution is the method of photochronography of the bunch incoherent radiation, for example, in the frequency range of visible light and at realizing streak camera with new principles of its operation. Results of novel type streak camera design and its investigation with photoelectron dynamics simulation taking into account space-charge effect are presented.

A. Tron



P_{RF}
$-U_0$
Spectrometer
Gap
Lens
R_m
RF Cavity
Photocathode
MCP Amplifier
CCD

A. Tron

Considered method of electron bunch radiation photochronography, based on new principles of streak camera operation, allows to carry out measurement of the bunch shape with temporal resolution of 10 fs and much less.

Magnitude of this resolution is independent of frequency range of investigated radiation and it can be used for radiation registration in the rang from visible light to x-ray with the same high temporal resolution.

There was proposed a simple scheme of the device realizing these new principles in high-speed photochronograhpy. It was shown that the mentioned high temporal resolution can be reach at rather low voltages, small RF-power consumption and all device can be placed on the sheet of format A4.

A. Tron

Tuesday

PARMELA simulations on PITZ1.5: first machine studies and interpretation of measurements

M.Boscolo

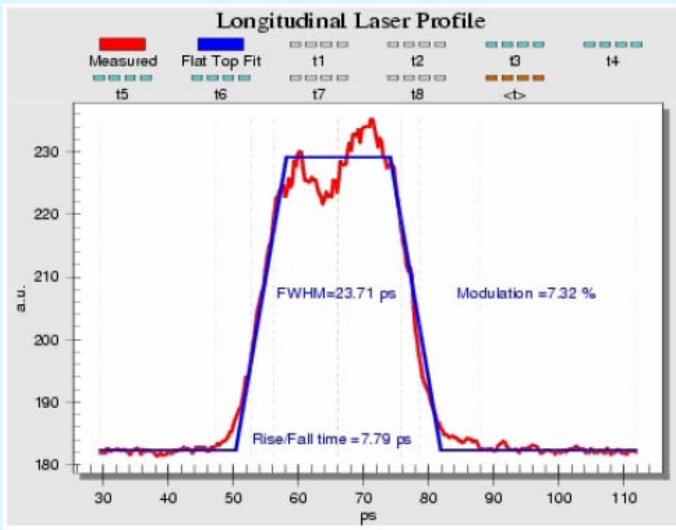
on behalf of the PITZ Team

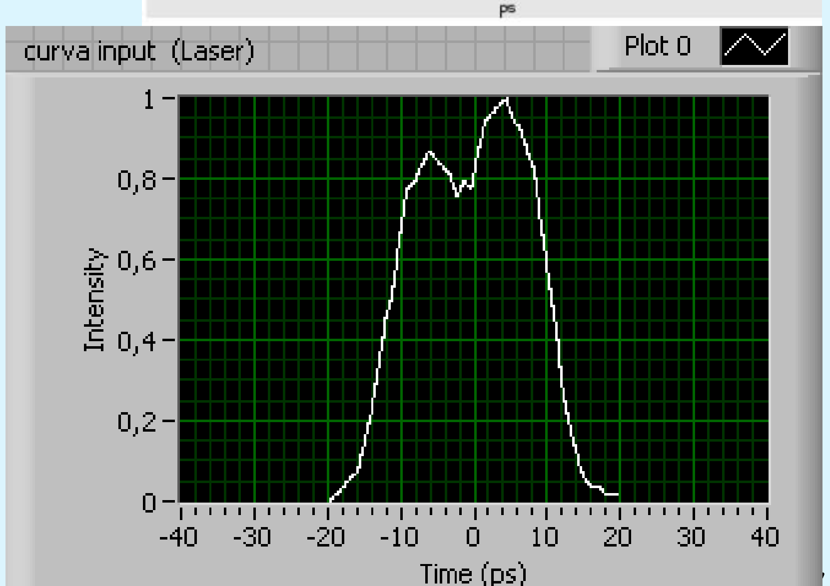
M. Boscolo, Erice, October 2005

M. Boscolo

Diagnostic Simulations (Emittance)

Simulation studies with real laser profile
(measurement 28-29 Sept.05)





Q = 1nC

I(B) = 295A

at optimum phase at booster
a solenoid scan and energy spread
measurements have been done

Realistic pulse used for
PARMELA simulations

ASSUMPTIONS for simulations:

- beam pulse shape=laser pulse shape
- laser/beam pulse radially uniform

Erice, October 2005

If we consider a 10% mismatch between the solenoid current and strength

Measurement and simulation

Measurements including a shift in B(I)

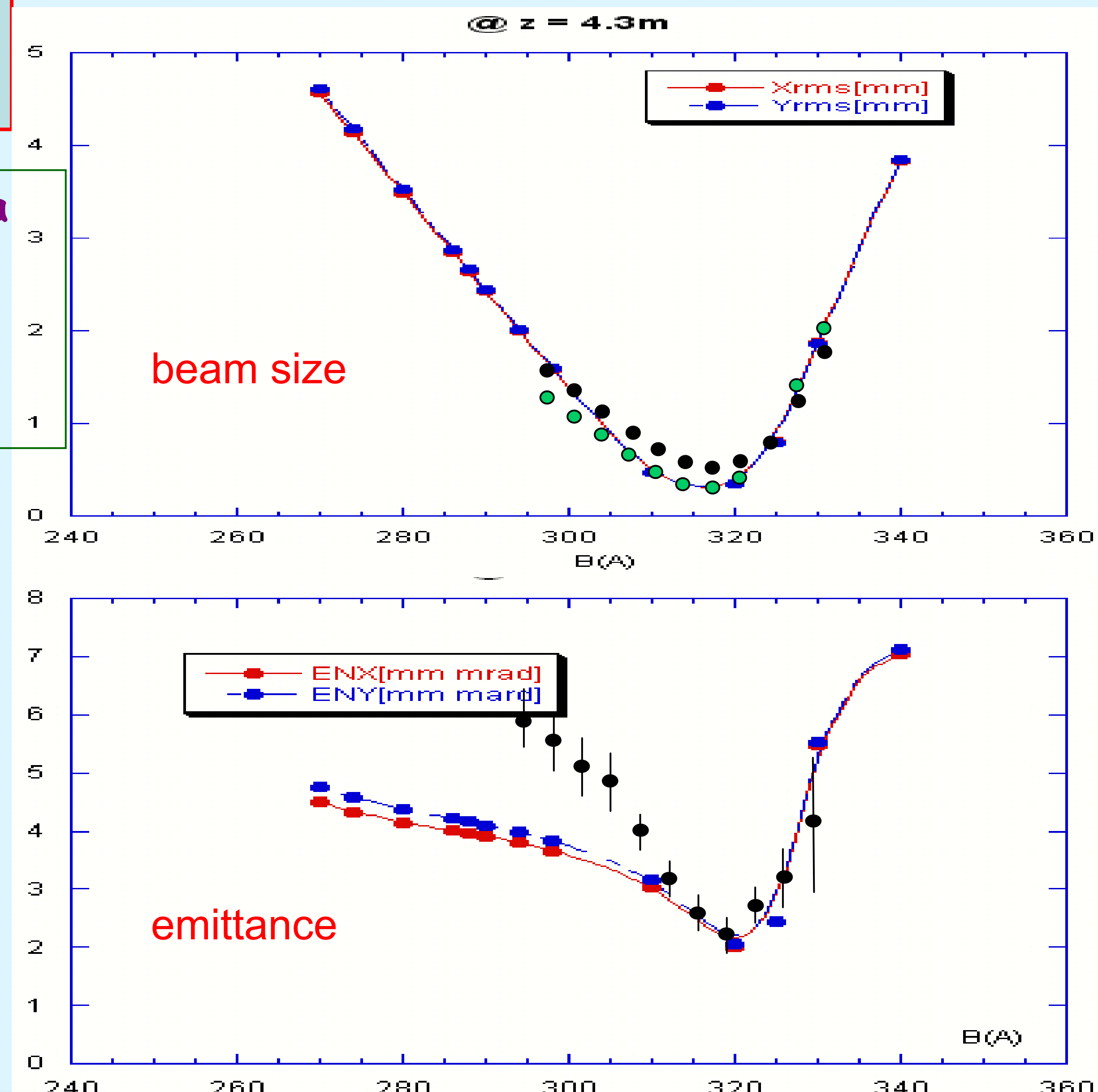
Black dots: horizontal

Green dots: vertical

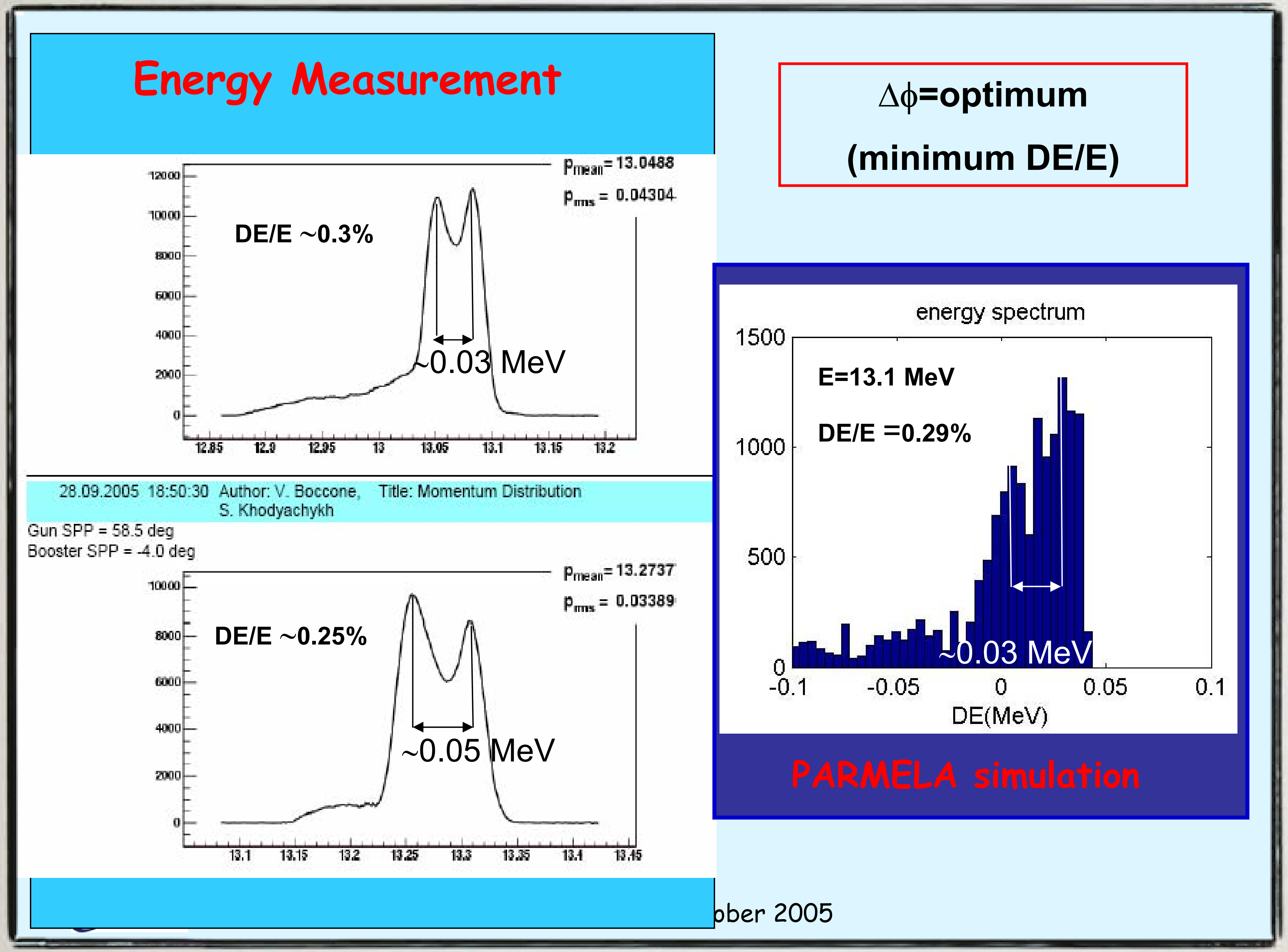
PARMELA simulations

red: horizontal

blue: vertical



M. Boscolo

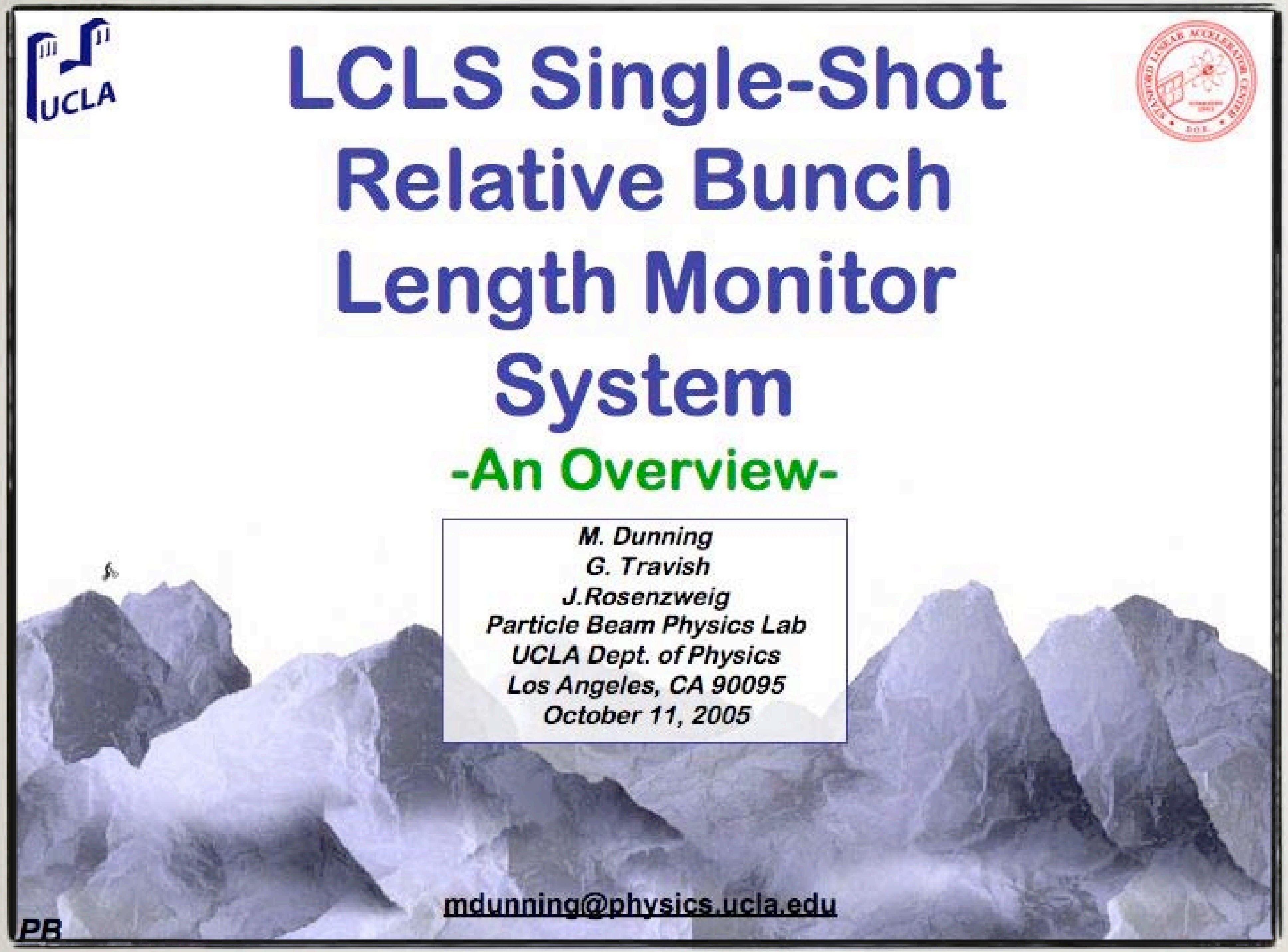


M. Boscolo

Diagnostic Simulations (Emittance)

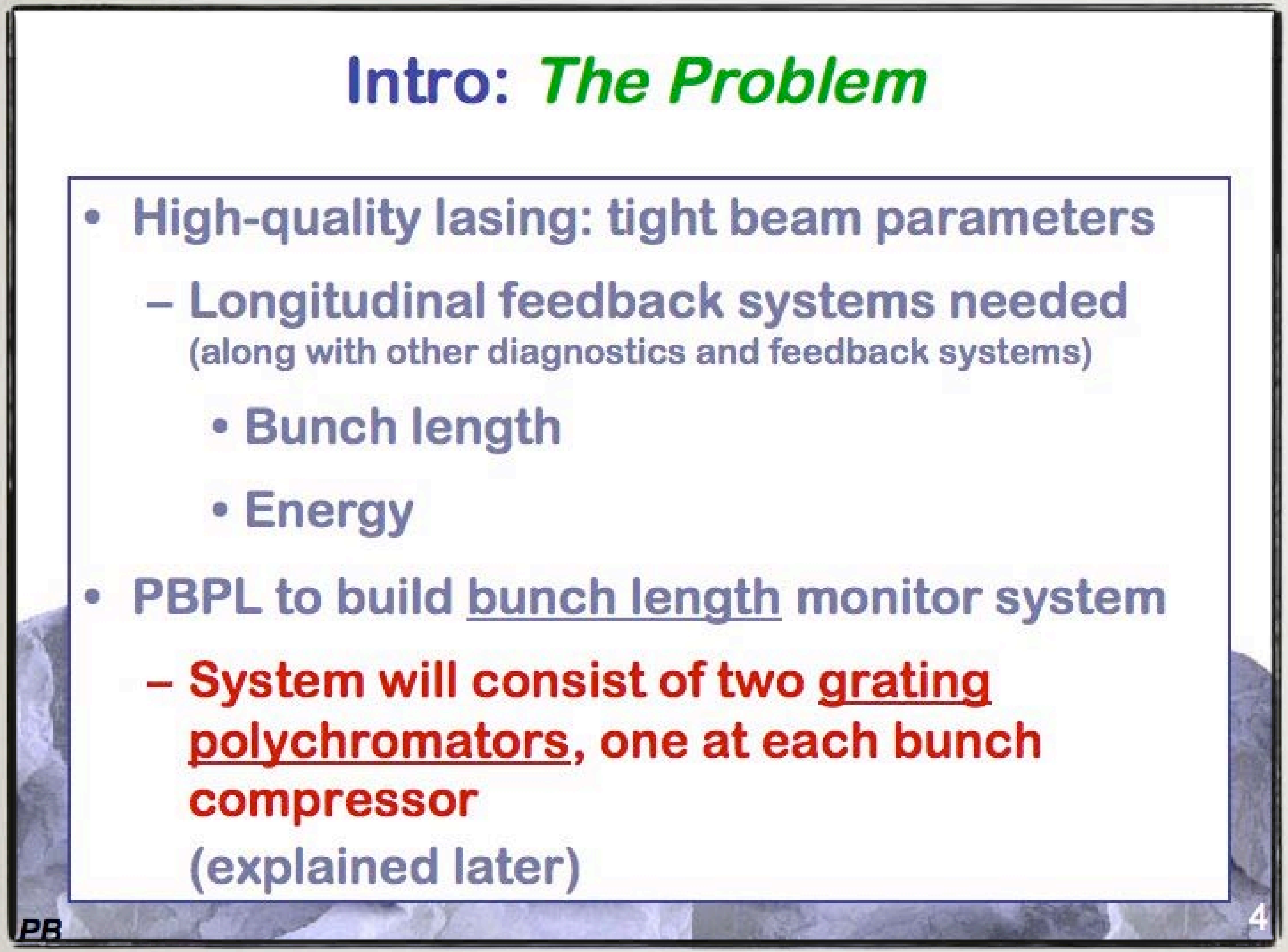
Conclusions

- First simulations have been performed for the PITZ1.5 facility
- There are still some problems due to the limited knowledge of machine parameters, but
- an overall good agreement has been found.



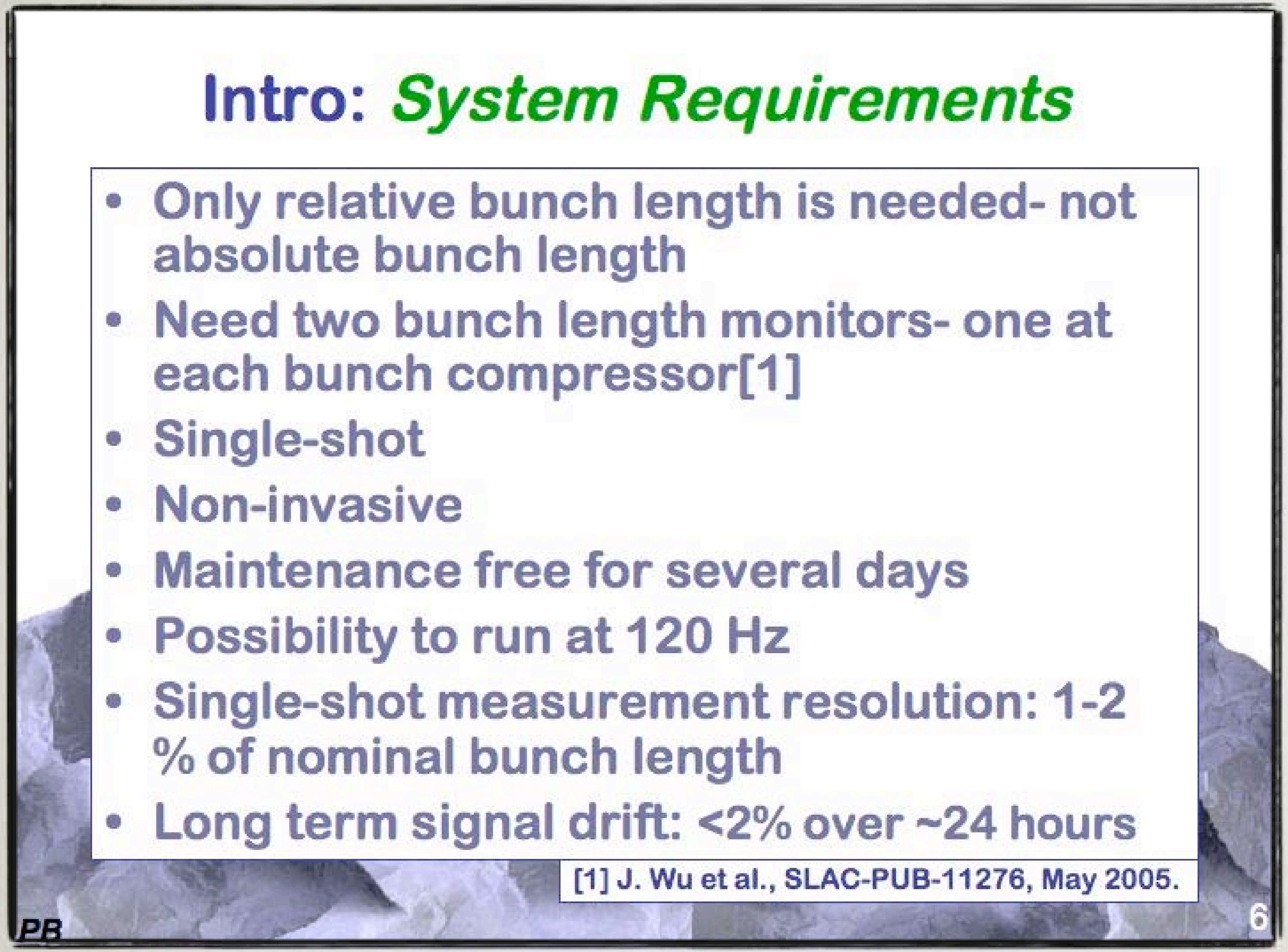
M. Dunning

Bunch Length Monitor



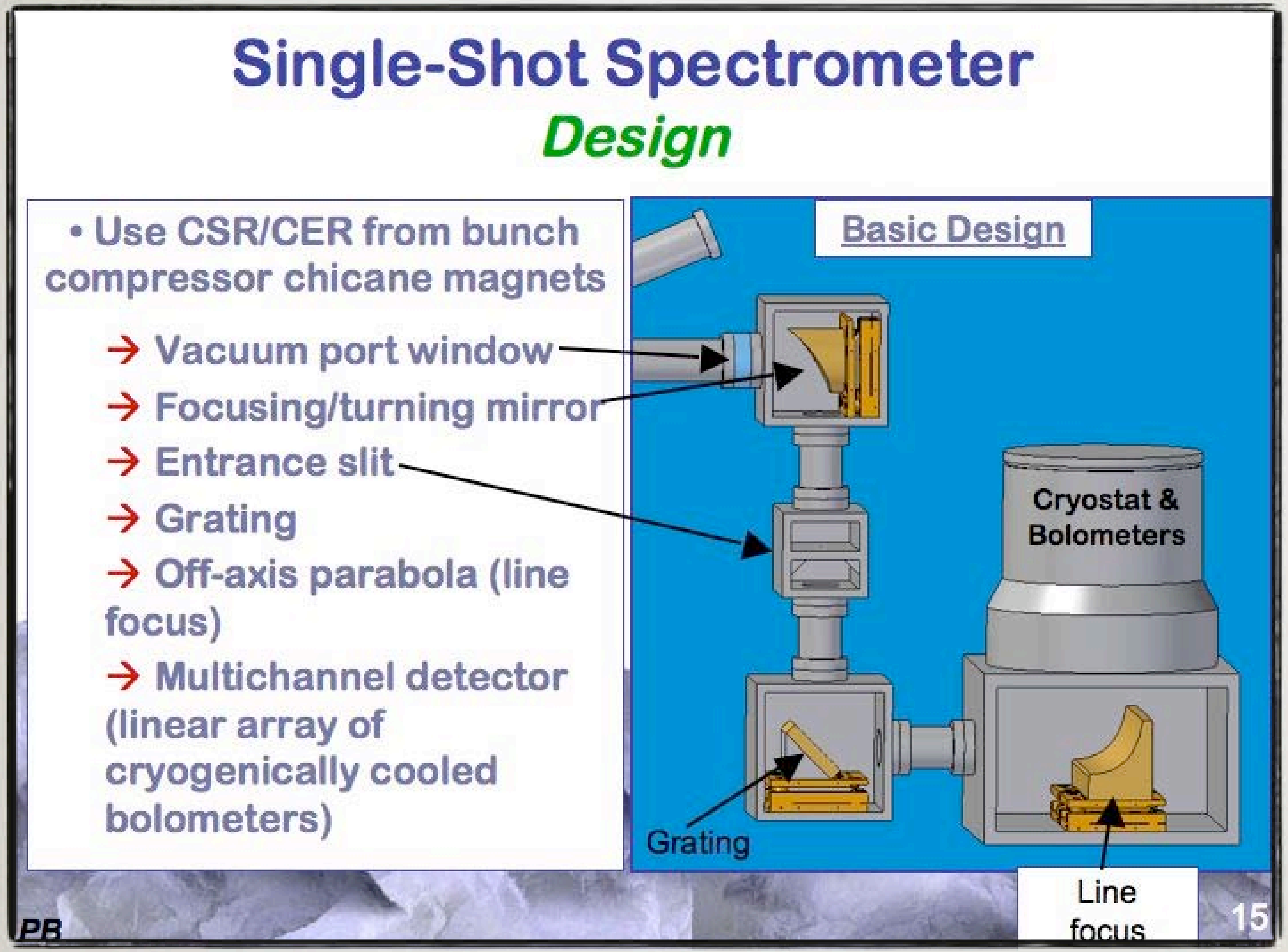
M. Dunning

Bunch Length Monitor



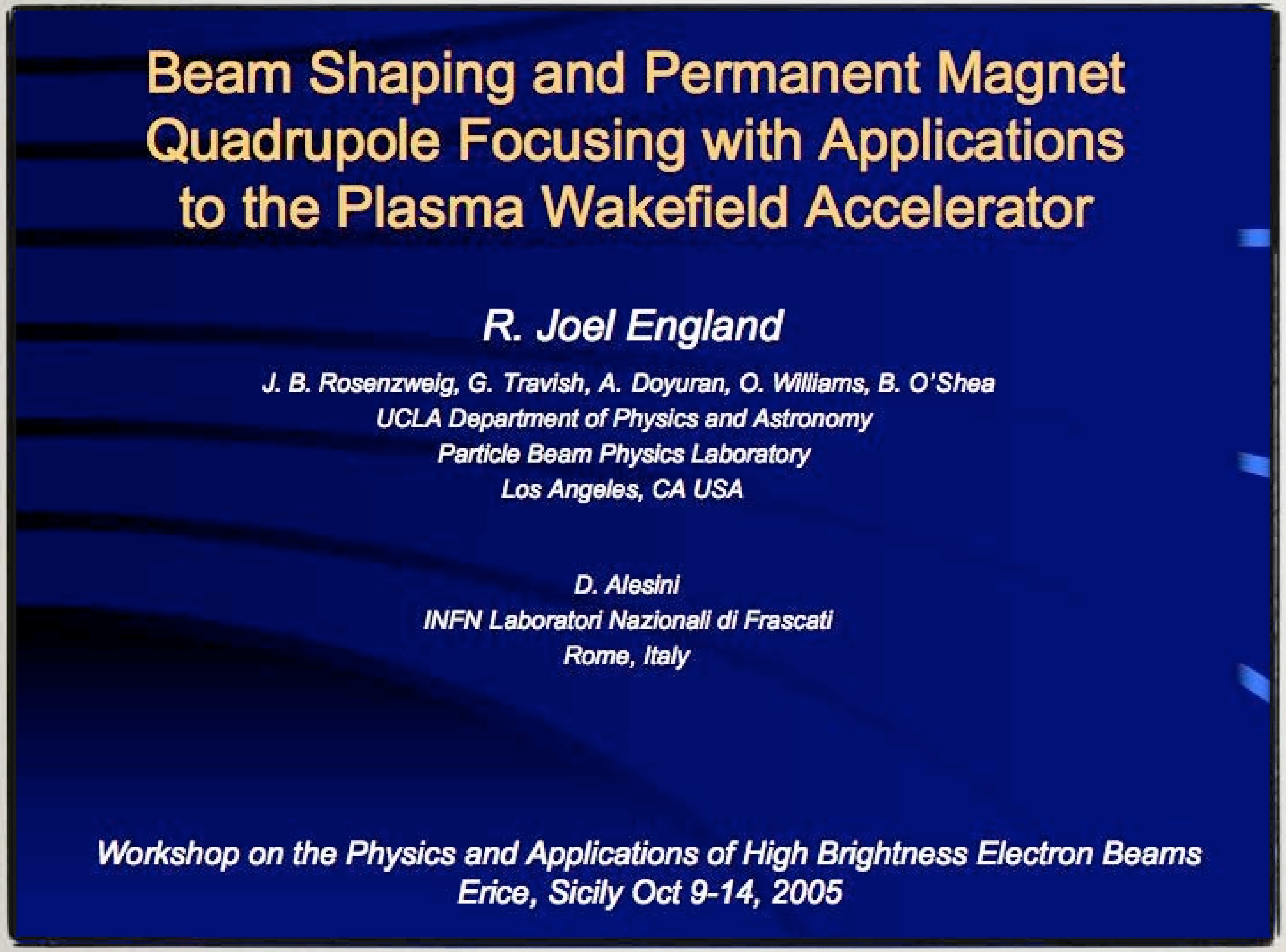
M. DUNNING

Bunch Length Monitor



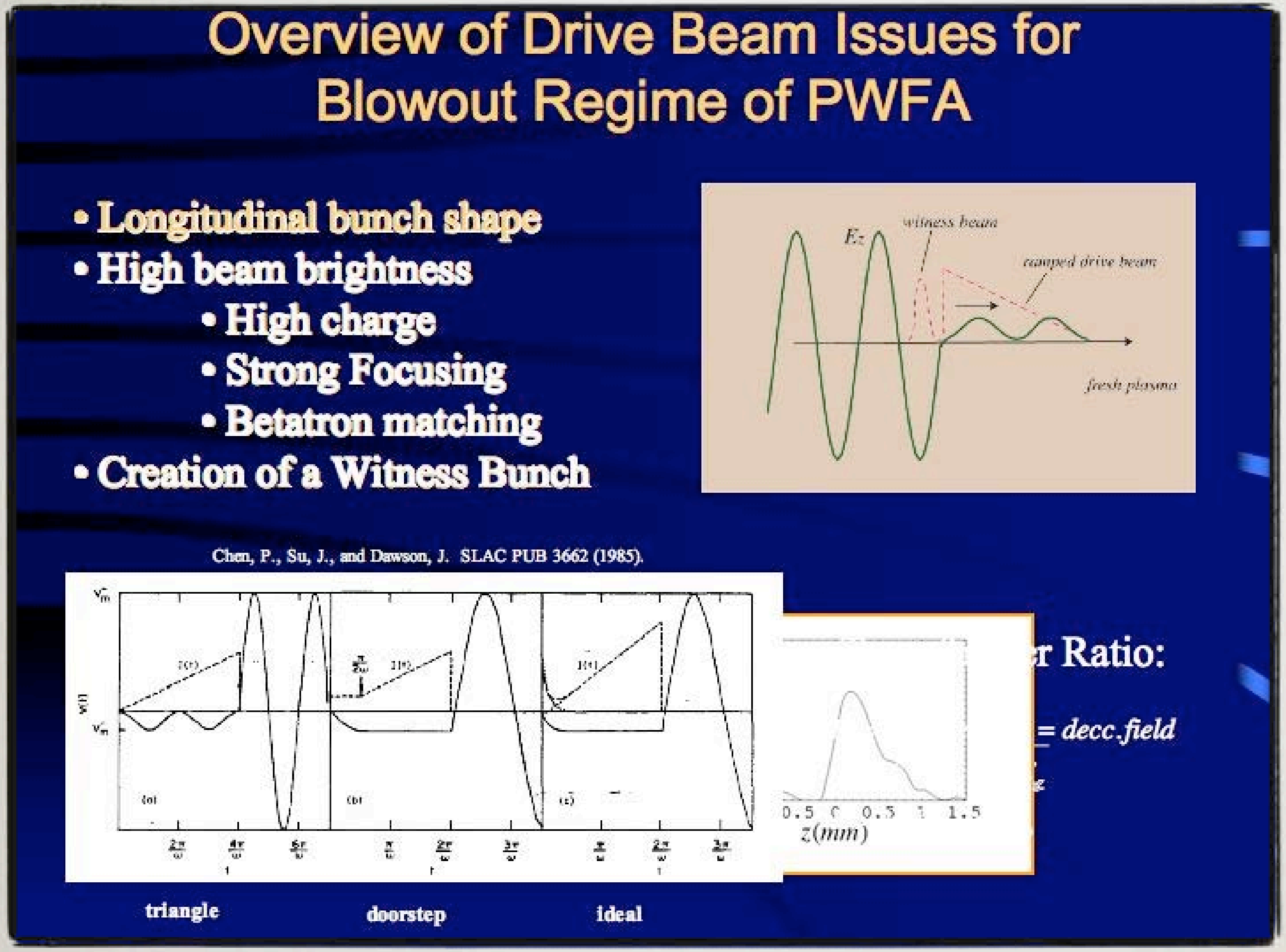
M. Dunning

Bunch Length Monitor

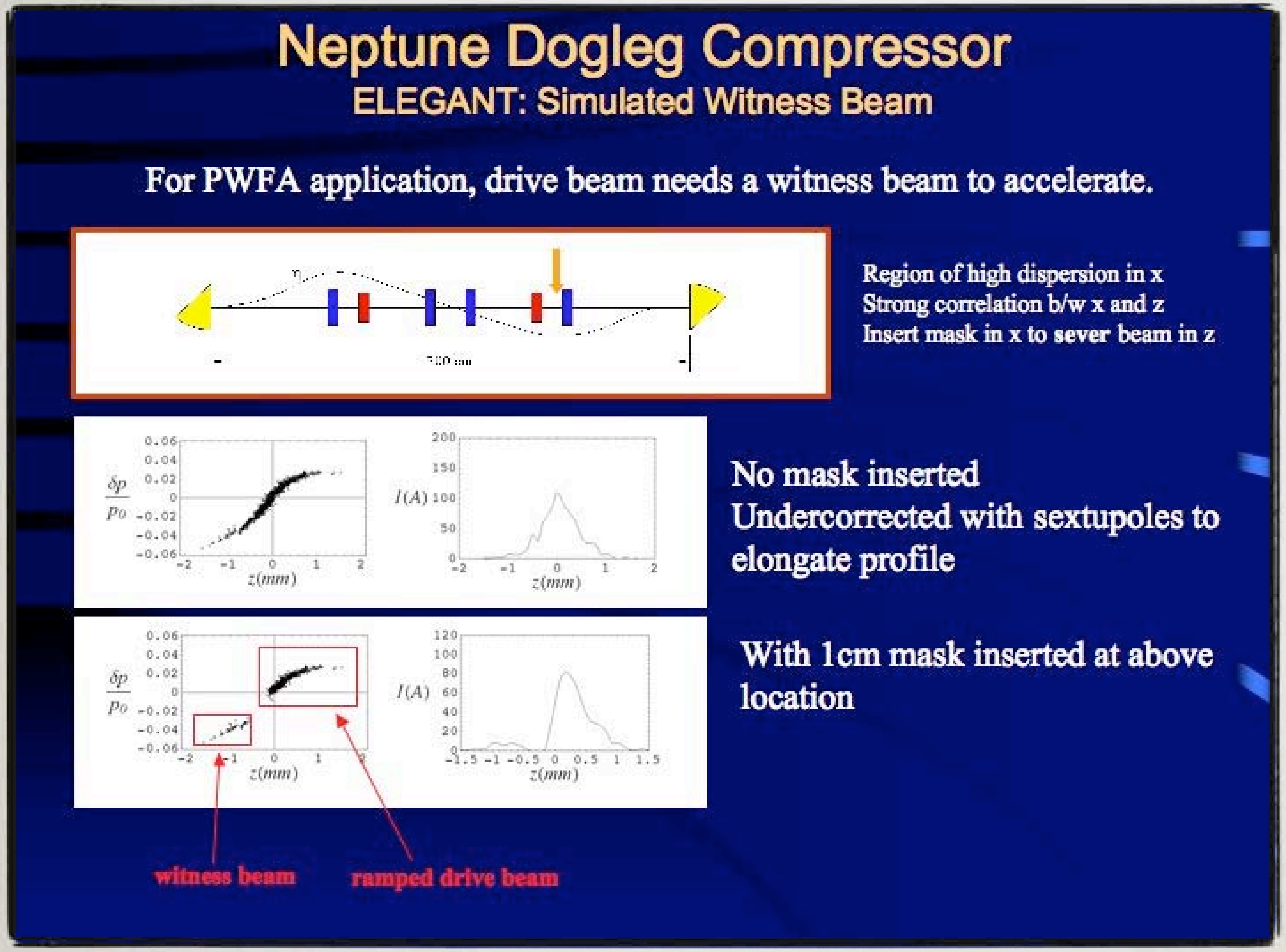


R. J. England

Beam Manipulation

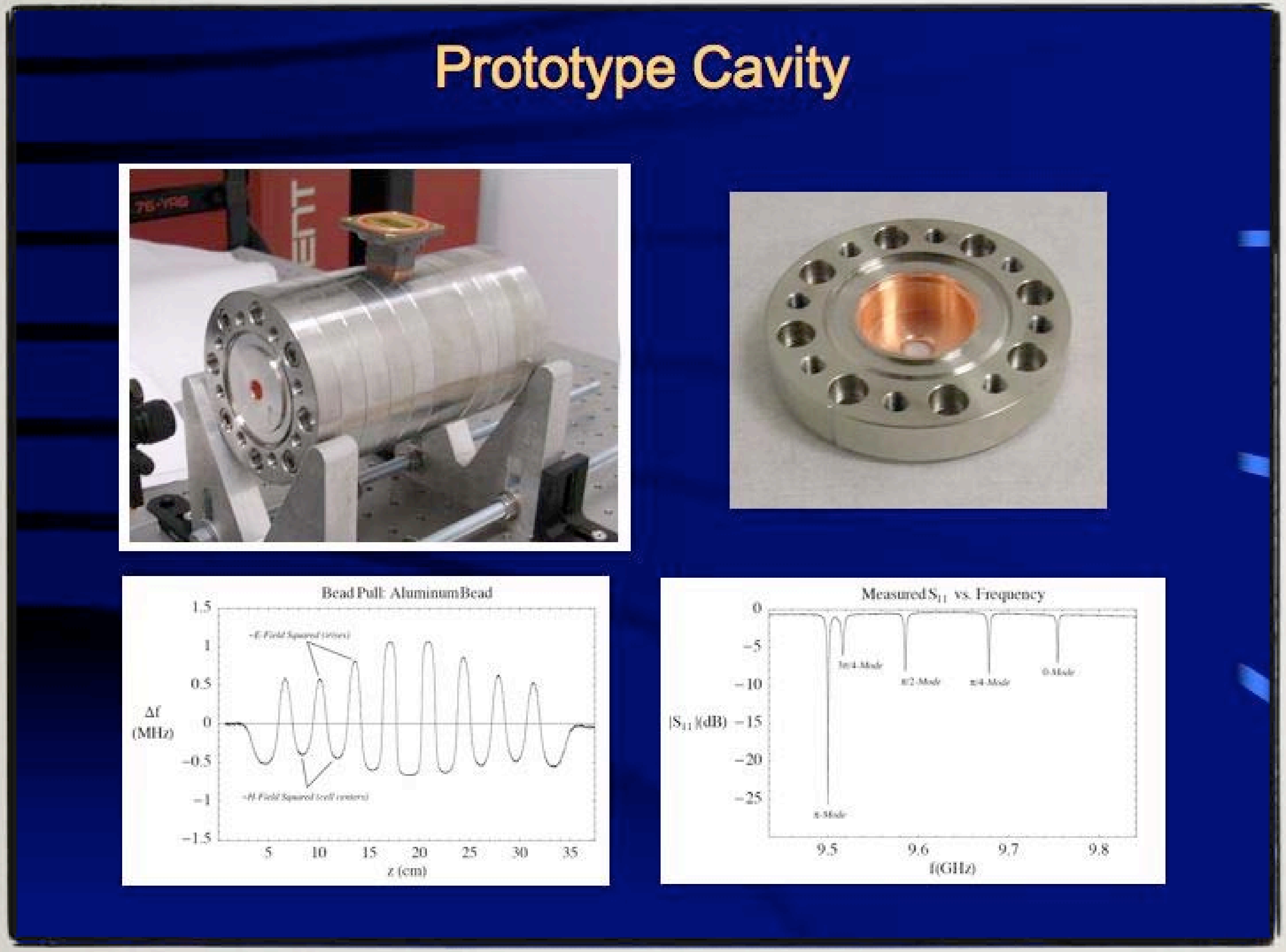

Overview of Drive Beam Issues for Blowout Regime of PWFA
• Longitudinal bunch shape
• High beam brightness
• High charge
• Strong Focusing
• Betatron matching
• Creation of a Witness Bunch
witness beam
Ez
ramped drive beam
fresh plasma
Chen, P., Su, J., and Dawson, J. SLAC PUB 3662 (1985).
r Ratio:
= decc.field
z(mm)
triangle
doorstep
ideal

R. J. England



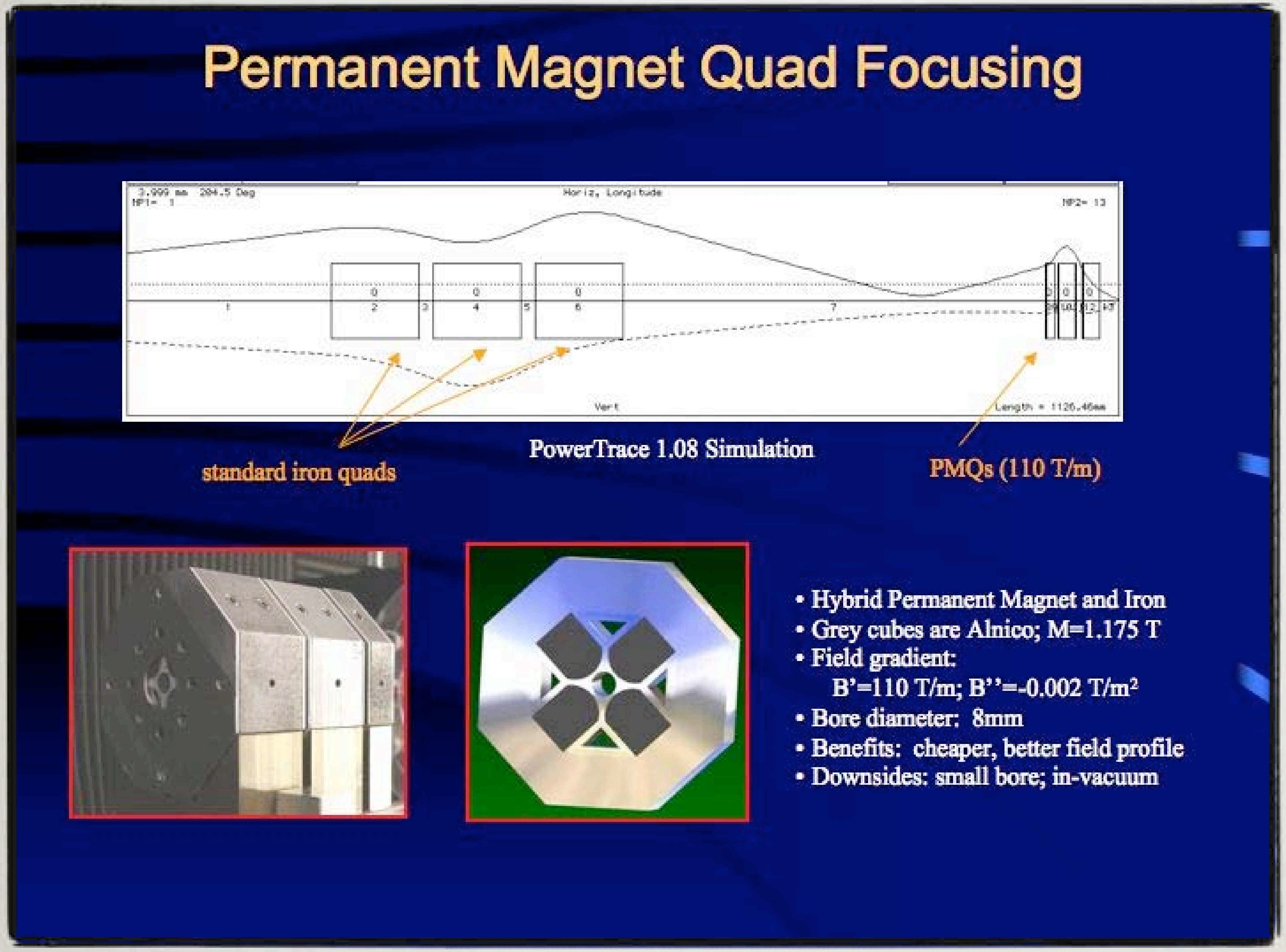
R. J. England

Beam Manipulation



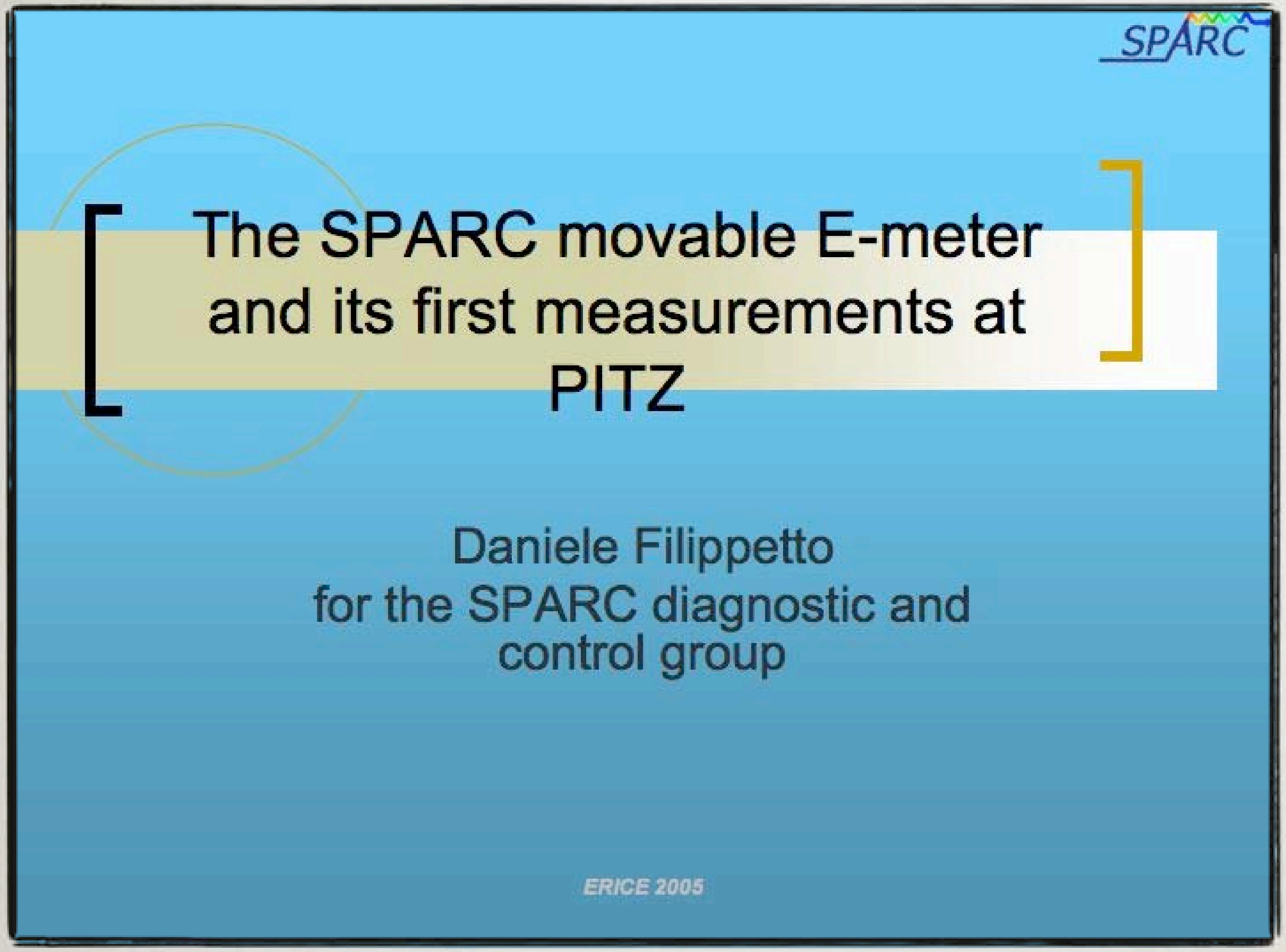
R. J. England

Beam Manipulation



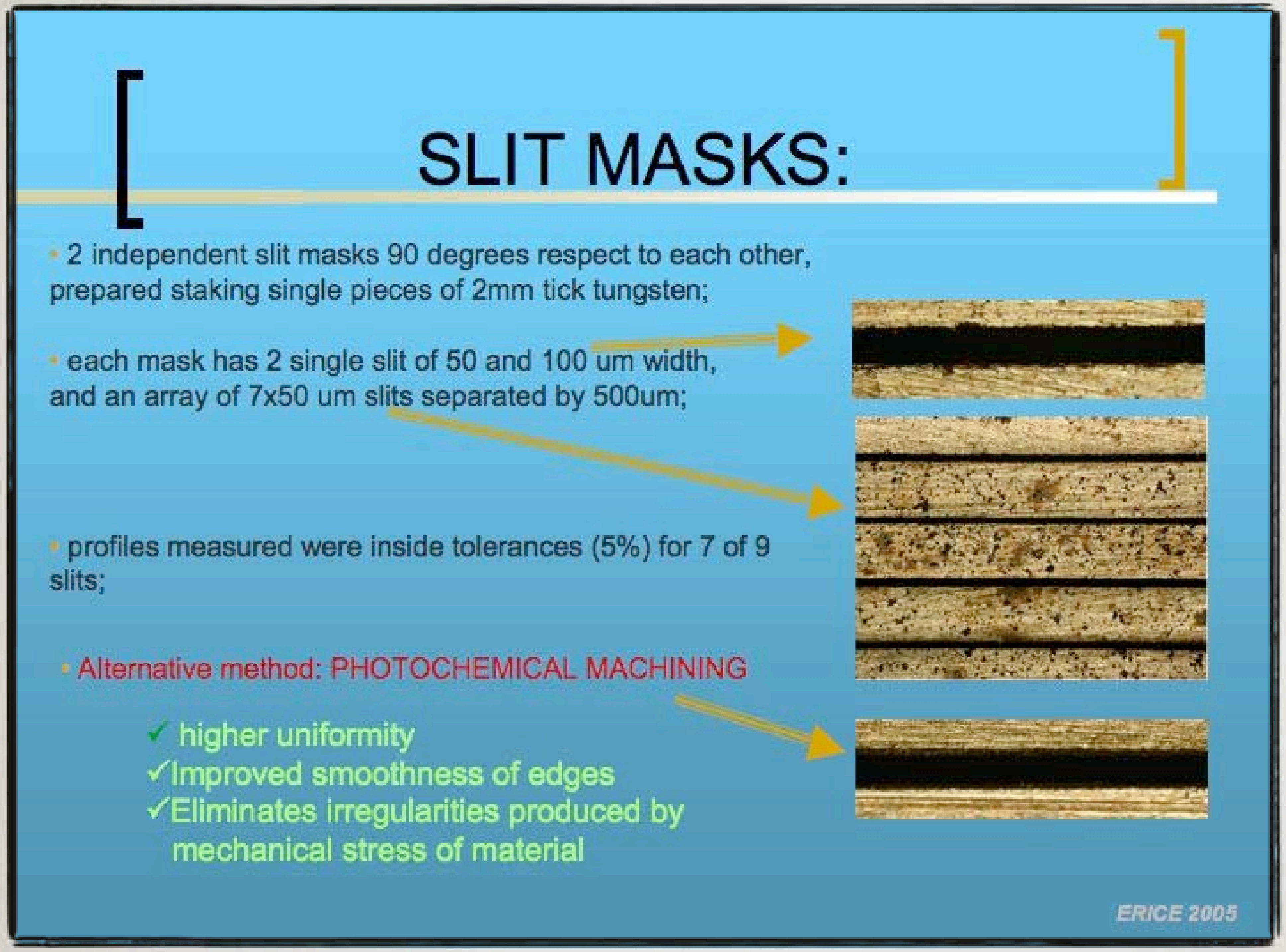
R. J. England

Beam Manipulation



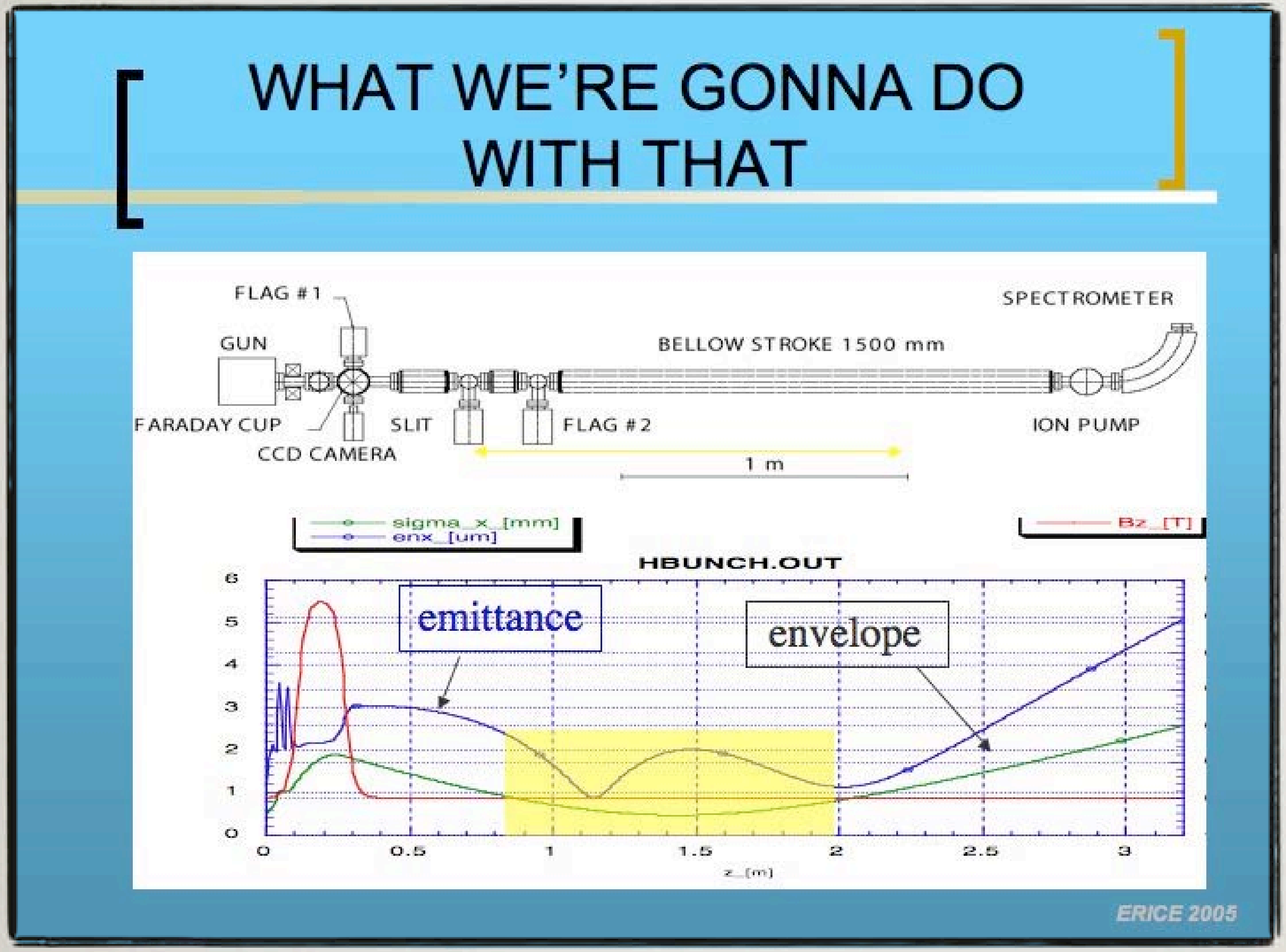
D. Filippetto

Emittance Diagnostic



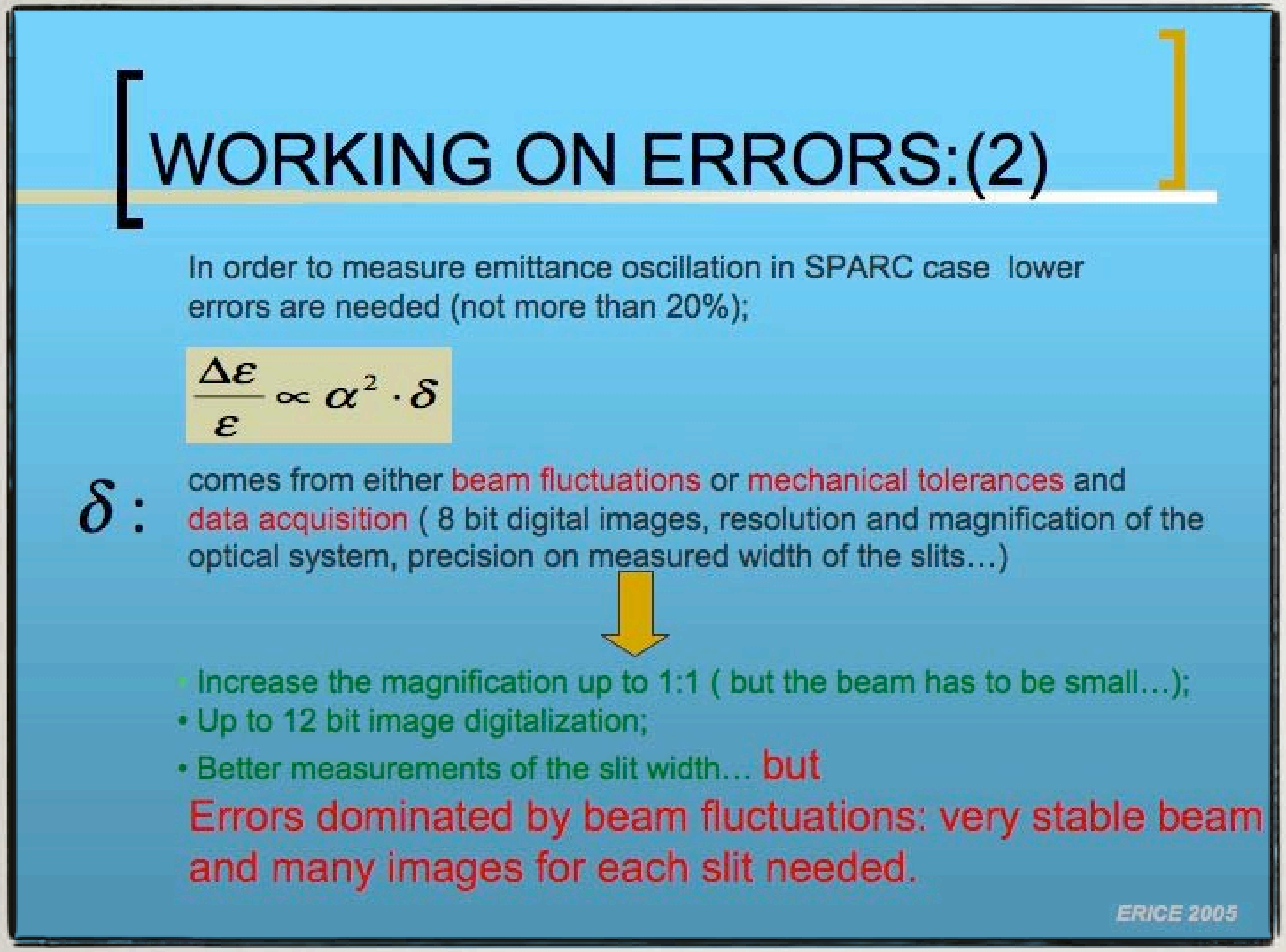
D. Filippetto

Emittance Diagnostic



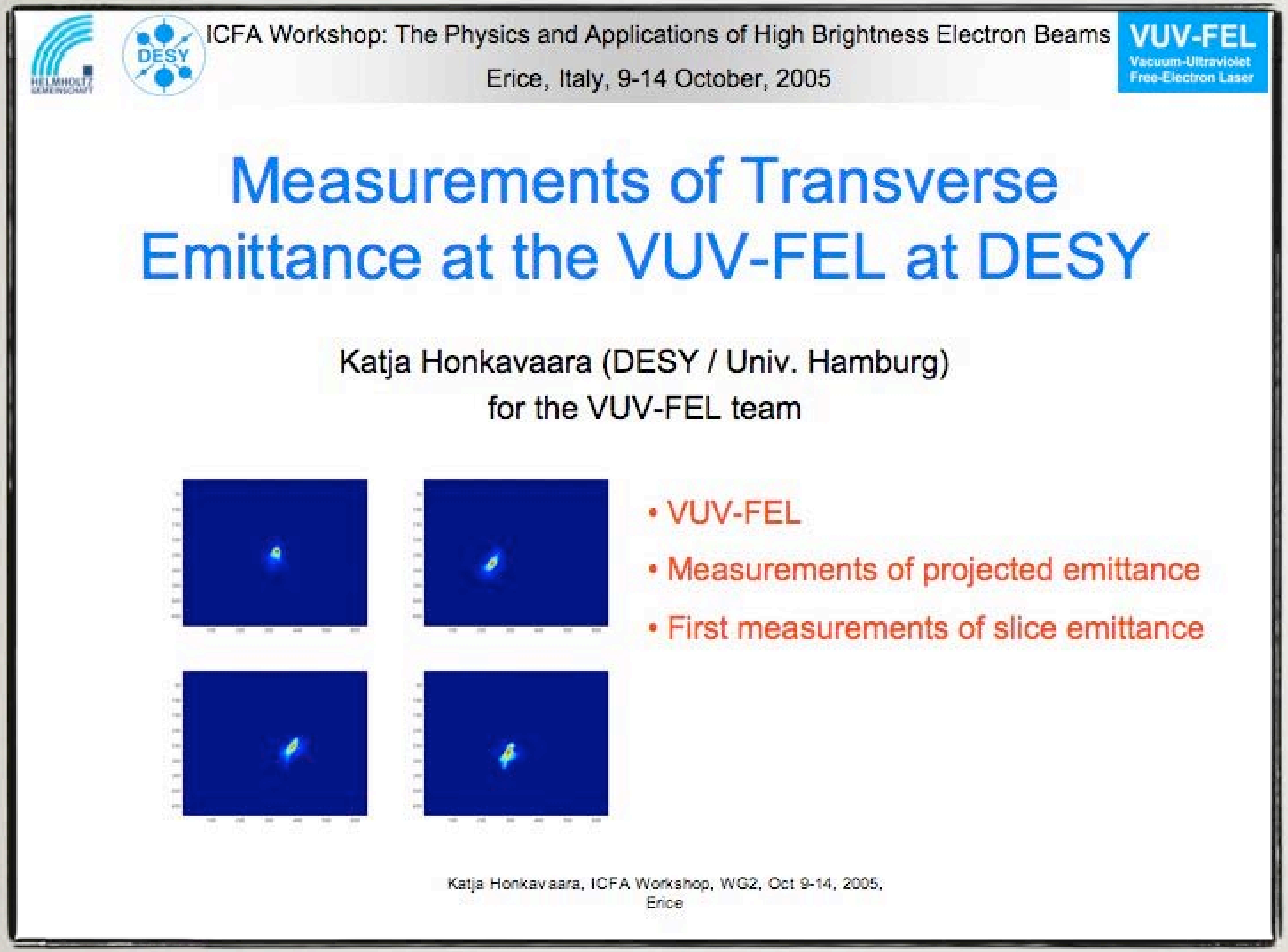
D. Filippetto

Emittance Diagnostic



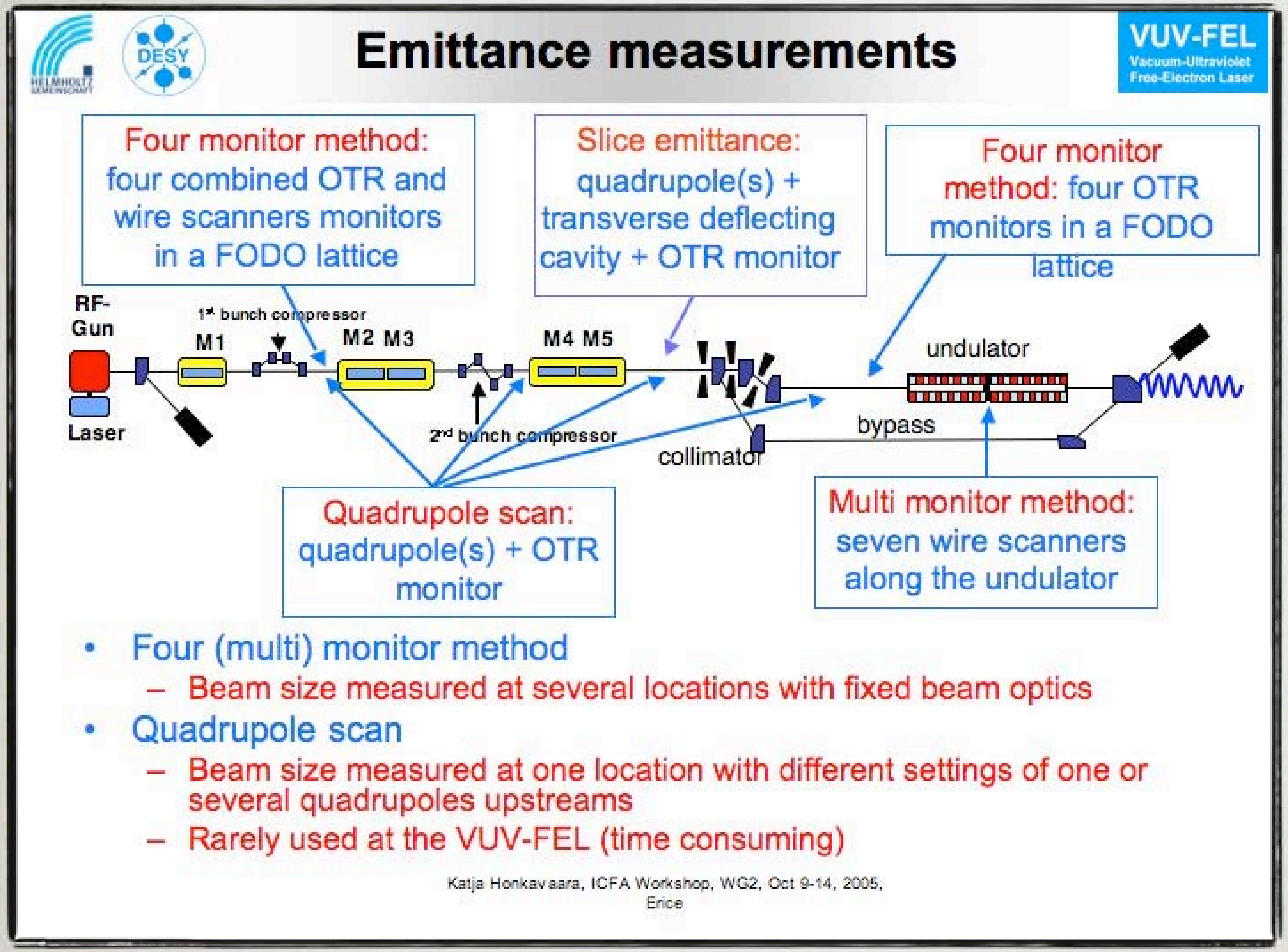
D. Filippetto

Emittance Diagnostic



K. Honkavaara

Emittance Measurements



K. Honkavaara

Emittance Measurements

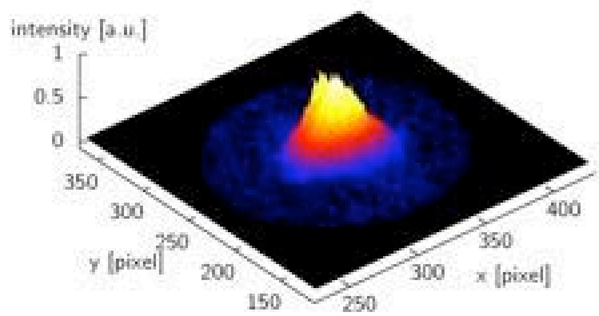
Data analysis (F.Löhl)

VUV-FEL
Vacuum-Ultraviolet Free-Electron Laser

Image analysis

Sophisticated analysis procedure applied to beam images

- Subtraction of background
- Determination of region of interest
- Off-set corrections, filtering
- Determination of beam core containing 90% (an arbitrary choice) of the beam intensity
- Calculation of rms beam sizes



Emittance calculations

rms emittance of the entire beam and the core rms emittance containing 90% of the beam intensity are determined using two methods:

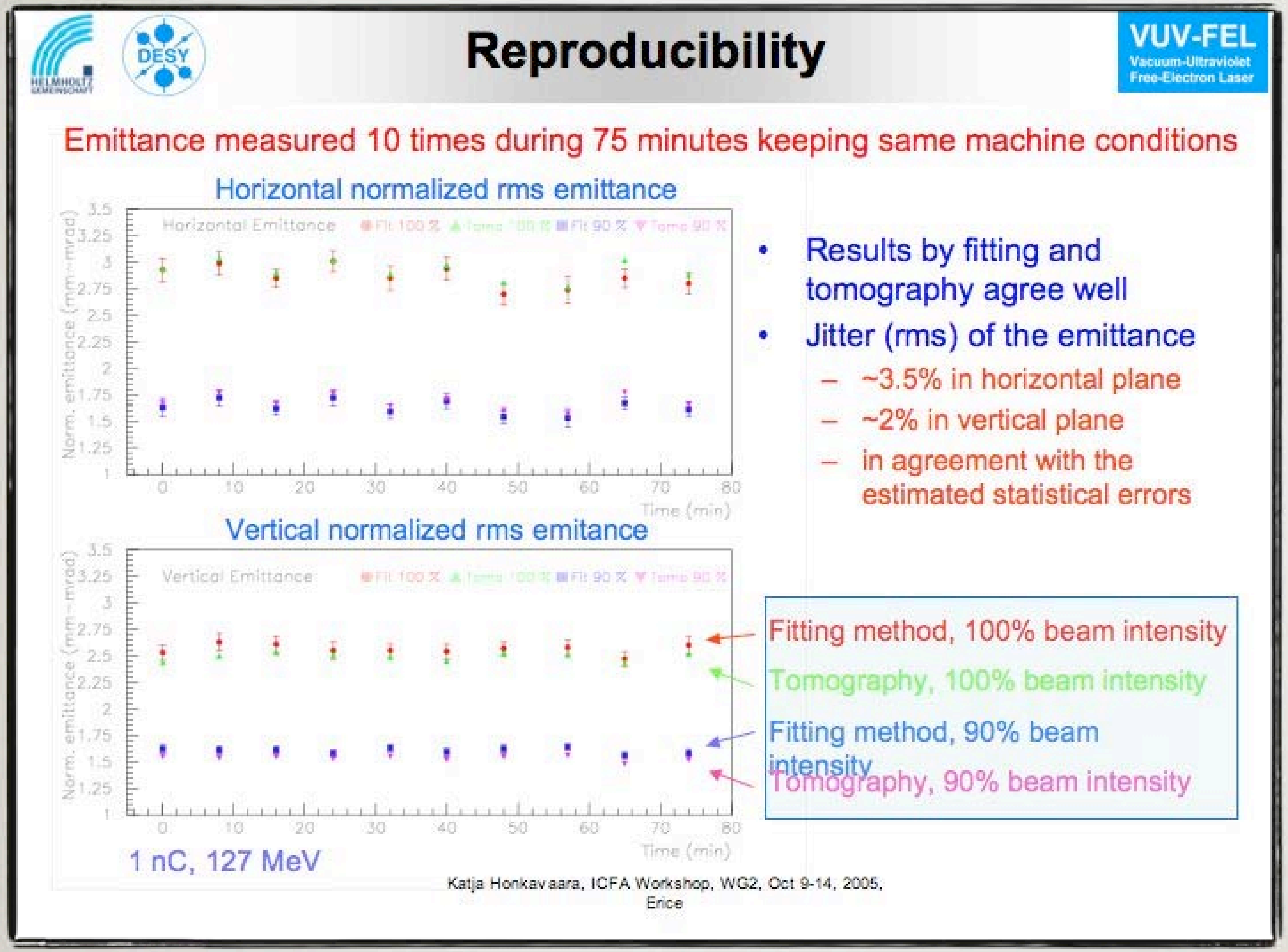
- Least square fitting
- Tomographic reconstruction of phase space

Error estimation

- Error estimation performed for the fitting method
- Statistical errors due to fluctuations of measured beam sizes: typically 2-4%
- Systematical errors taking into account errors in beam energy, quadupole gradients and calibration of OTR monitors estimated by Monte Carlo simulations: typically 5-6%
- Errors in following statistical errors only

Katja Honkavaara, ICFA Workshop, WG2, Oct 9-14, 2005, Erice

K. Honkavaara



K. Honkavaara

Emittance Measurements

Summary and Outlook

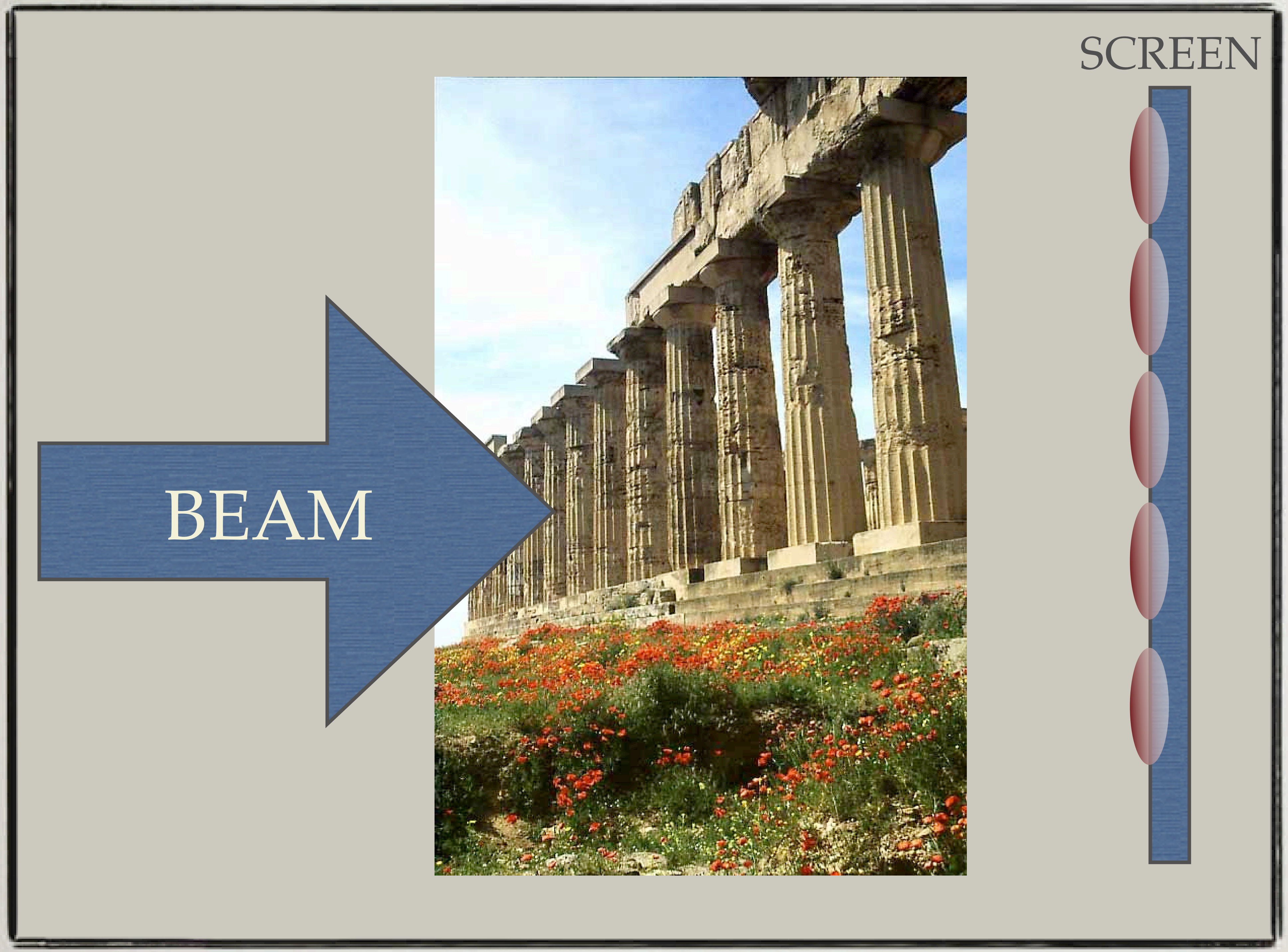
VUV-FEL
Vacuum-Ultraviolet
Free-Electron Laser

- Measurements of projected emittance at the VUV-FEL
  - routinely at the injector using four-monitor method with OTR monitors; wire scanners available soon
  - before undulator using multi-monitor method with OTR monitors
    - measurements conditions not yet optimized
  - in the undulator using multi-monitor method with wire scanners
  - along the linac at several locations using quadrupole scan
    - time consuming, rarely used
- First measurements and preliminary data-analysis of slice-emittance using transverse deflecting cavity and quadrupole scan done. Next steps:
  - measurements with an uncompressed bunch
  - better optimized beam optics
  - quadrupole scan using two or more quads (tomography)
  - improvements of data-analysis

Katja Honkavaara, ICFA Workshop, WG2, Oct 9-14, 2005, Erice

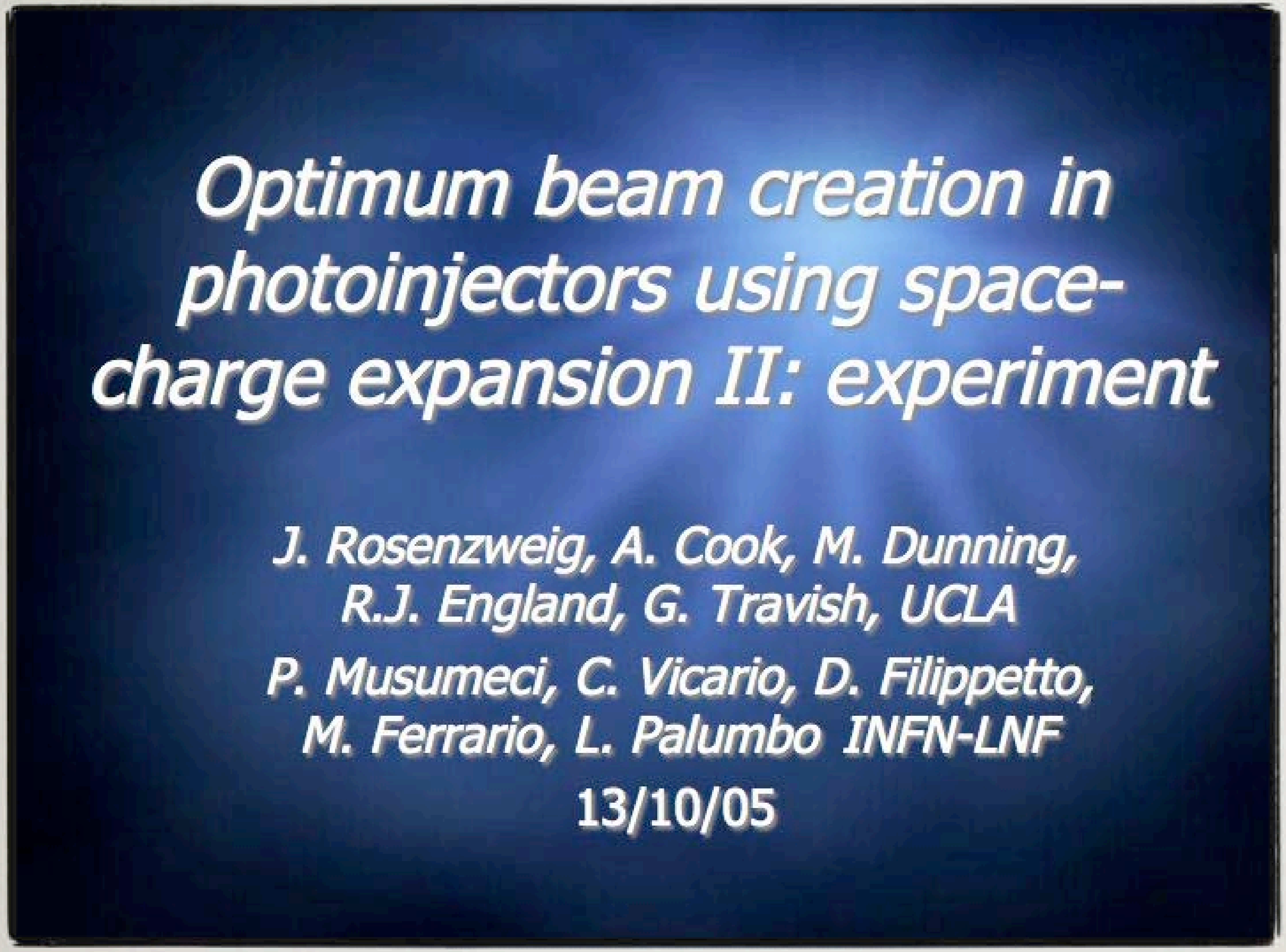
K. Honkavaara

Wednesday



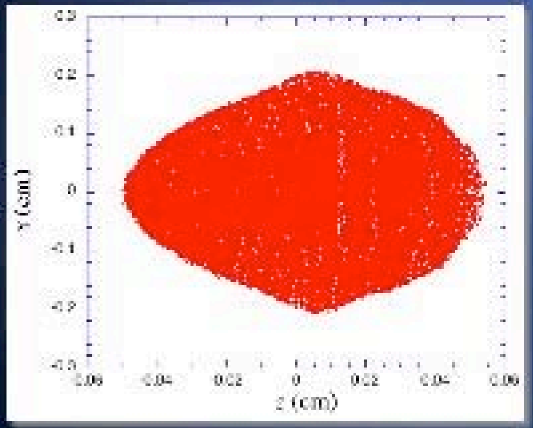
Proposal for New Emittance Measurement Device

Thursday

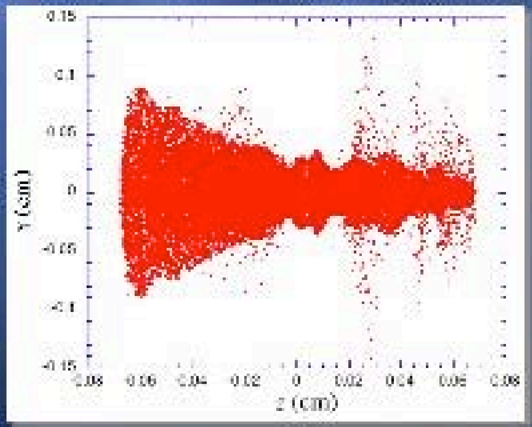

Optimum beam creation in photoinjectors using space-charge expansion II: experiment
J. Rosenzweig, A. Cook, M. Dunning, R.J. England, G. Travish, UCLA
P. Musumeci, C. Vicario, D. Filippetto, M. Ferrario, L. Palumbo INFN-LNF
13/10/05

Ellipsoidal beam at SPARC

- Launch 0.33 nC, 120 MV/m peak gun field, 2.7 kG solenoid
- Laser assumed 80 fs in initial study (Gaussian, to 3σ)
- Some longitudinal asymmetry due to image charge
- Small artifact from non-ideal radial profile (cut-Gaussian, 1.8σ)
- At low energy (only) ellipsoidal beam shape is visible



Beam distribution showing ellipsoidal boundary (12.5 MeV)

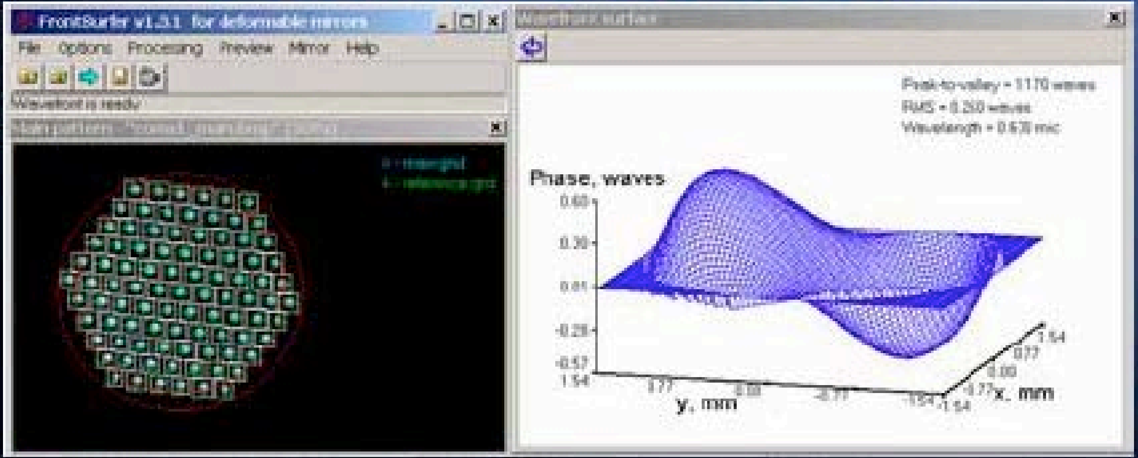


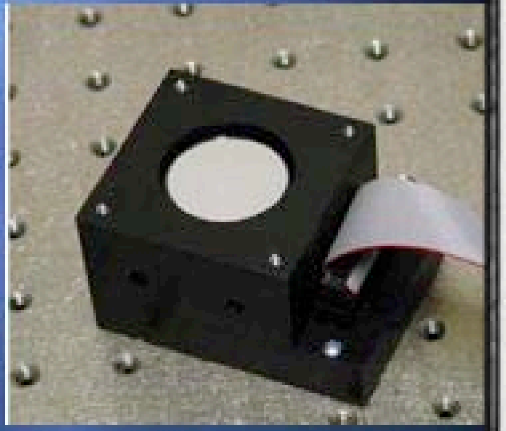
Beam distribution at high energy shows Boundary collapse (84.5 MeV)

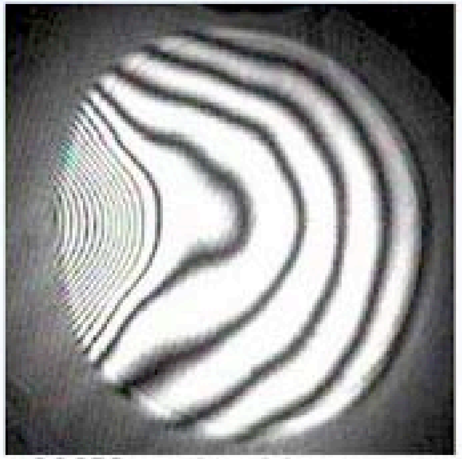
J. Rosenzweig

Experiment setup 1: laser shaping

- Pulse length (x-correlation) w/100 fs resol.
- Laser must be radially shaped
- "Cut-Gaussian" case easy
  - Collimation (soft aperture?)
  - Relay imaging
- Optimum shape hard (but better!)
  - Use deformable mirror to tailor

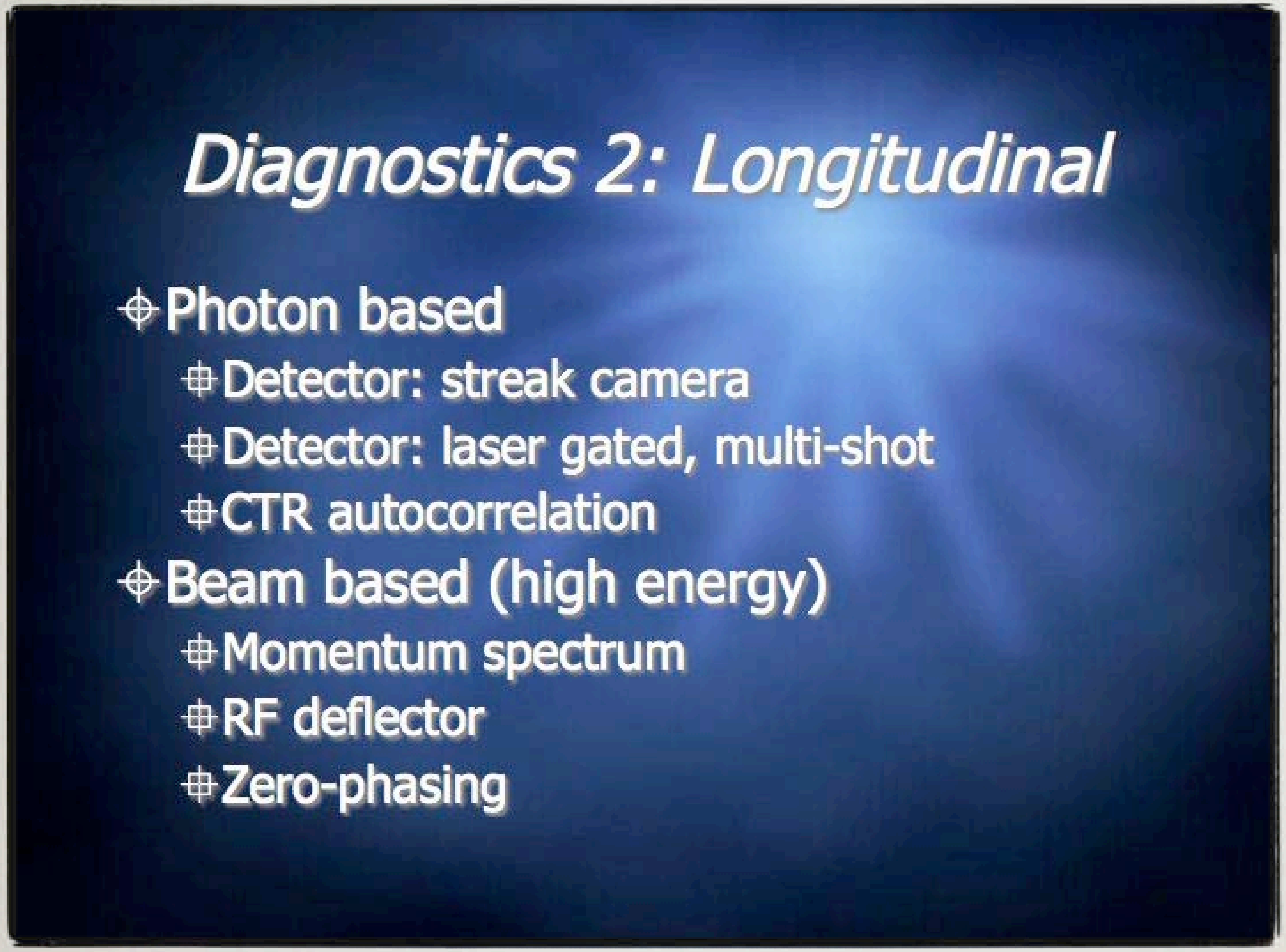






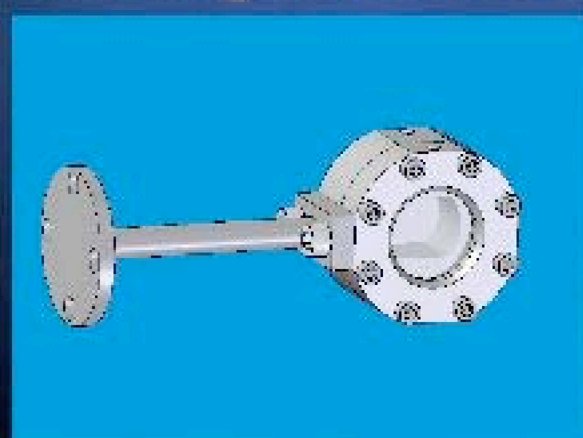
+300V on the side actuator

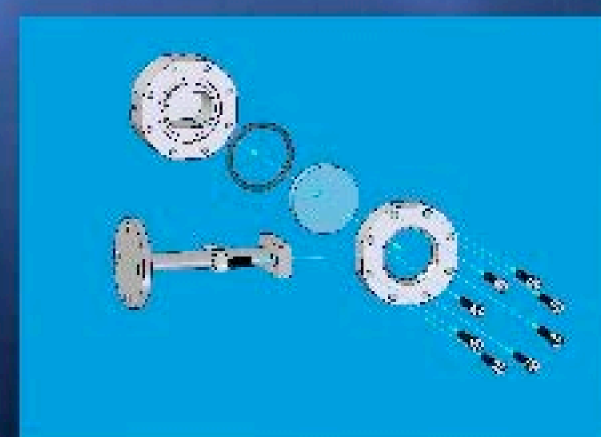
J. Rosenzweig


Diagnostics 2: Longitudinal
Photon based
Detector: streak camera
Detector: laser gated, multi-shot
CTR autocorrelation
Beam based (high energy)
Momentum spectrum
RF deflector
Zero-phasing

Diagnostics 3: Creating photons

- Aerogel-based Cerenkov cells
  - At 5 MeV threshold is n=1.005
  - Low index (n=1.007-1.02), "small" angle (3.5-9.5 deg)
- Holder protects aerogel from vacuum
  - Building for SLAC/SPARC at UCLA
- Multiple scattering upstream (150 μm Al)
  - 4.7 degrees at 5 Mev
  - Limits length of material for imaging? Depends on n



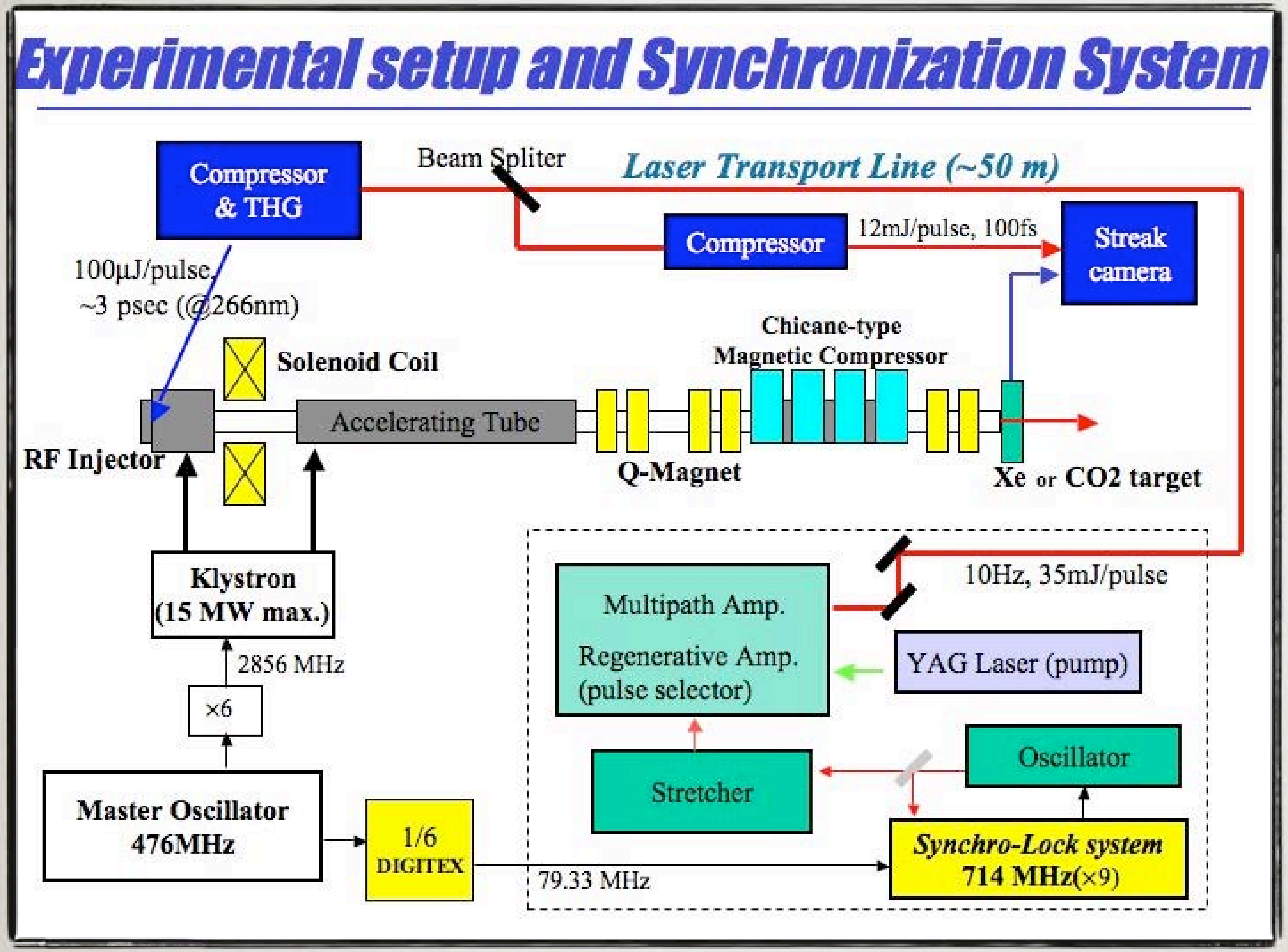


Suppression of Timing drift between laser and electron beam driven photo-cathode RF gun

A. Sakumi, M. Uesaka, Y. Muroya, T. Ueda
Nuclear Professional School, University of Tokyo
J. Urakawa, *KEK, Japan*

A. Sakumi

Timing



A. Sakumi

Timing

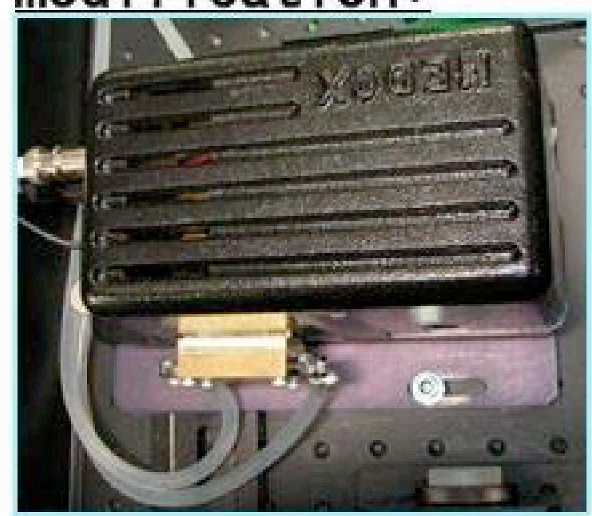
Operation for Long-term stability by water cooling

In laser room, there are a lot of local thermal source, especially pumping YAG laser and Pockels cell make bad influence to Oscillator and regenerative timing.

In order to suppress local thermal modification, we do water cooling to laser case and Pockels cell by Spring-8 method.

Base plate:Water cooling
:suppress distortions of case

Pockels cell
Suppress local thermal
modification:



A. SAKUMI

Timing

Summary

・We can reduce the fluctuation of room temperature within 0.1 degrees

We can observe a good synchronization of 600 fs between the pumping electron beam and the probe laser in an hour.

It has the potential to do the experience of the pulse radiolysis experiment in an hour.

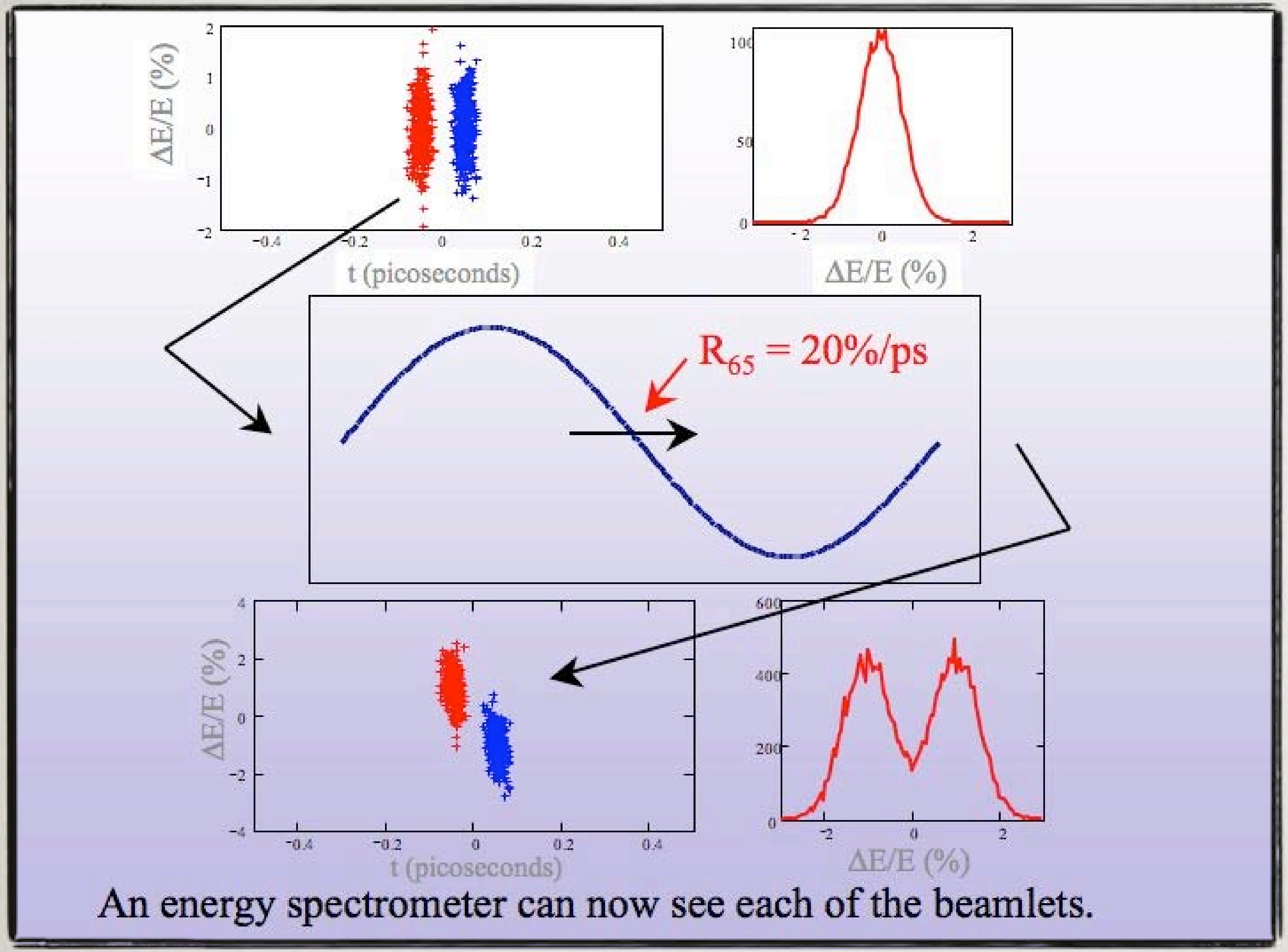
In order to synchronize in long period as one-day, we are developing to new feedback system of phase matching and point stabilizing.

A. Sakumi

Timing


A Temporal Diagnostic
with 10 fs Resolution
Todd I Smith
Stanford Picosecond FEL Center
W. W. Hansen Experimental Physics Laboratory
Stanford, California 94305-4085
Todd.Smith@Stanford.edu

T. Smith



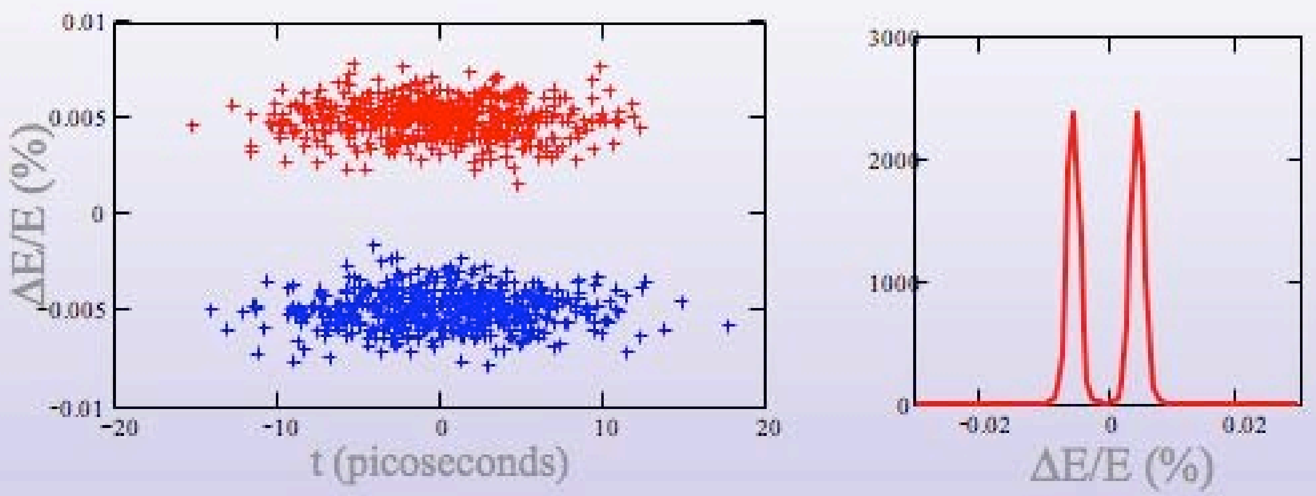
An energy spectrometer can now see each of the beamlets.

T. Smith

Longitudinal Diagnostics

Enhanced technique

- Pass the beam through a chicane with an R_{56} of 10 ps/% (typical of those used in FELs) and then through an accelerator cell with an R_{65} of only 0.1%/ps. The phase space distribution becomes:

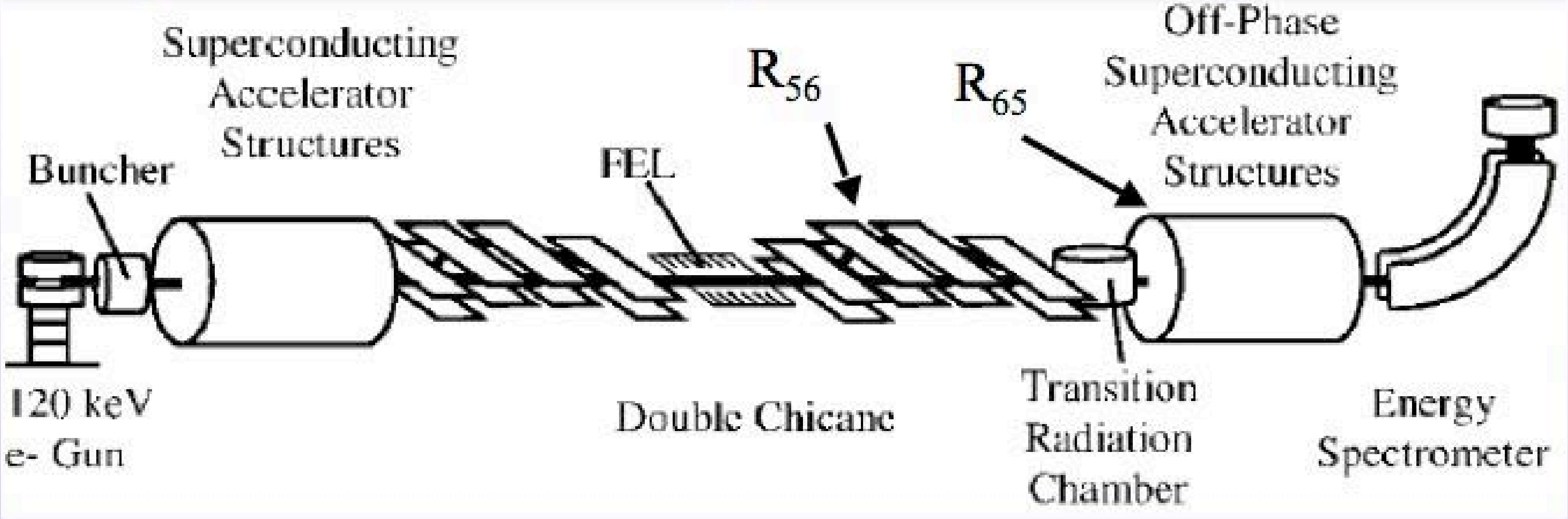


- The beamlets are now fully resolved. The production of this R_{65} requires only a 10 MeV, 1 GHz accelerator cell-a factor of 200 reduction from the previous example.

- The 1% by 100 fs beam is now a .01% by 10 ps beam.

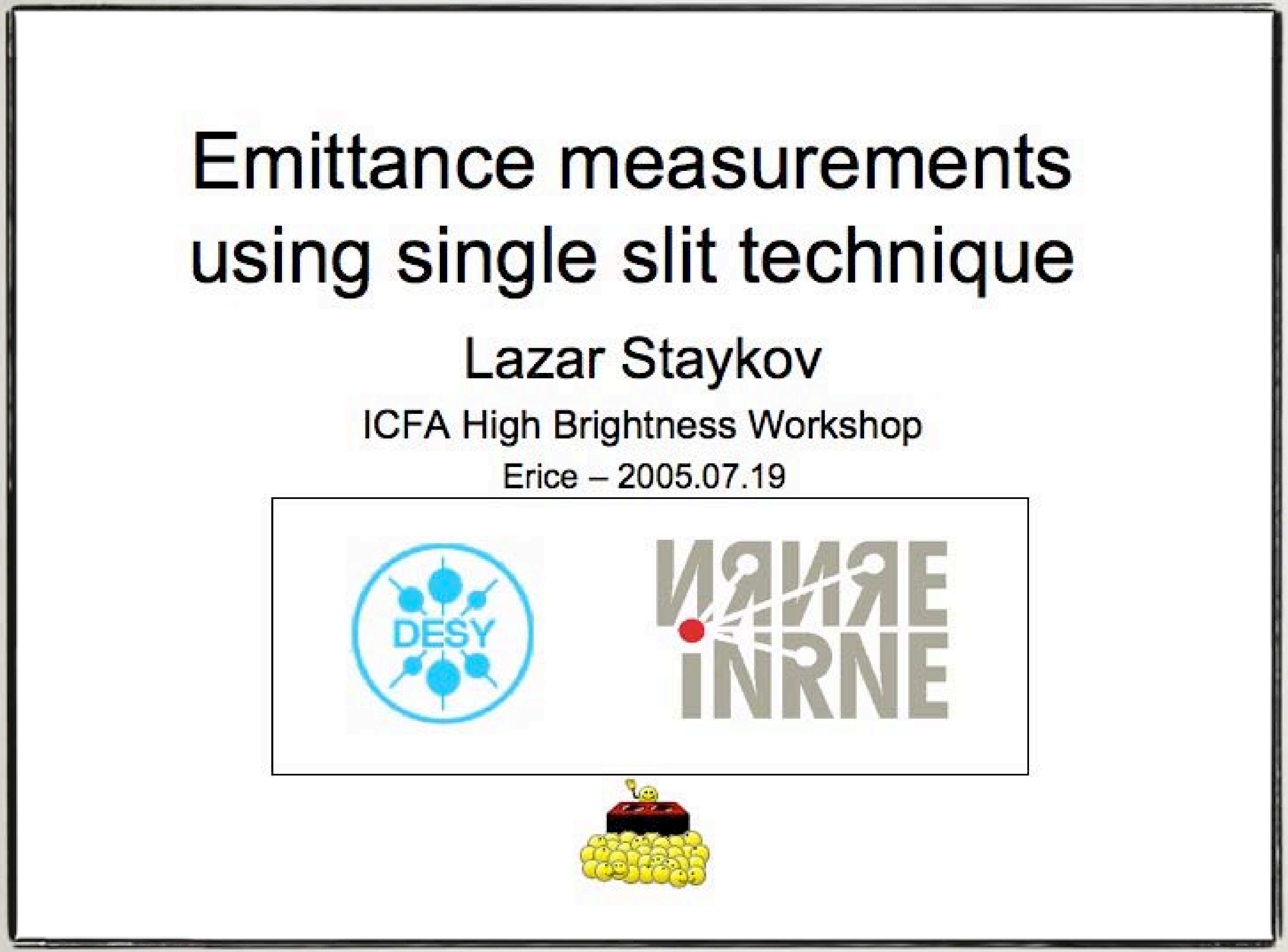
T. Smith

- Theory is good, but experiment is better. Our superconducting linac/FEL system just happens to be configured in just the right way to test the enhanced temporal resolution concept.



- The results of an experiment to observe the microbunching expected to be imposed by the beam-FEL interaction are shown on the next slide. A temporal resolution of better than 150 fs was demonstrated.

T. Smith

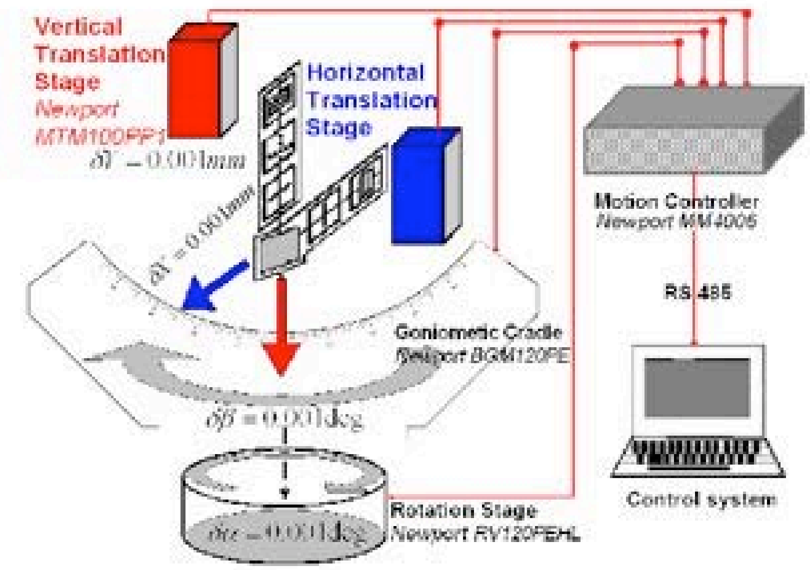


L. Staykov

Emittance

Slit base technique

- Slit technique is used
- The image of the slit is observed with CCD on a distance ***L*** downstream

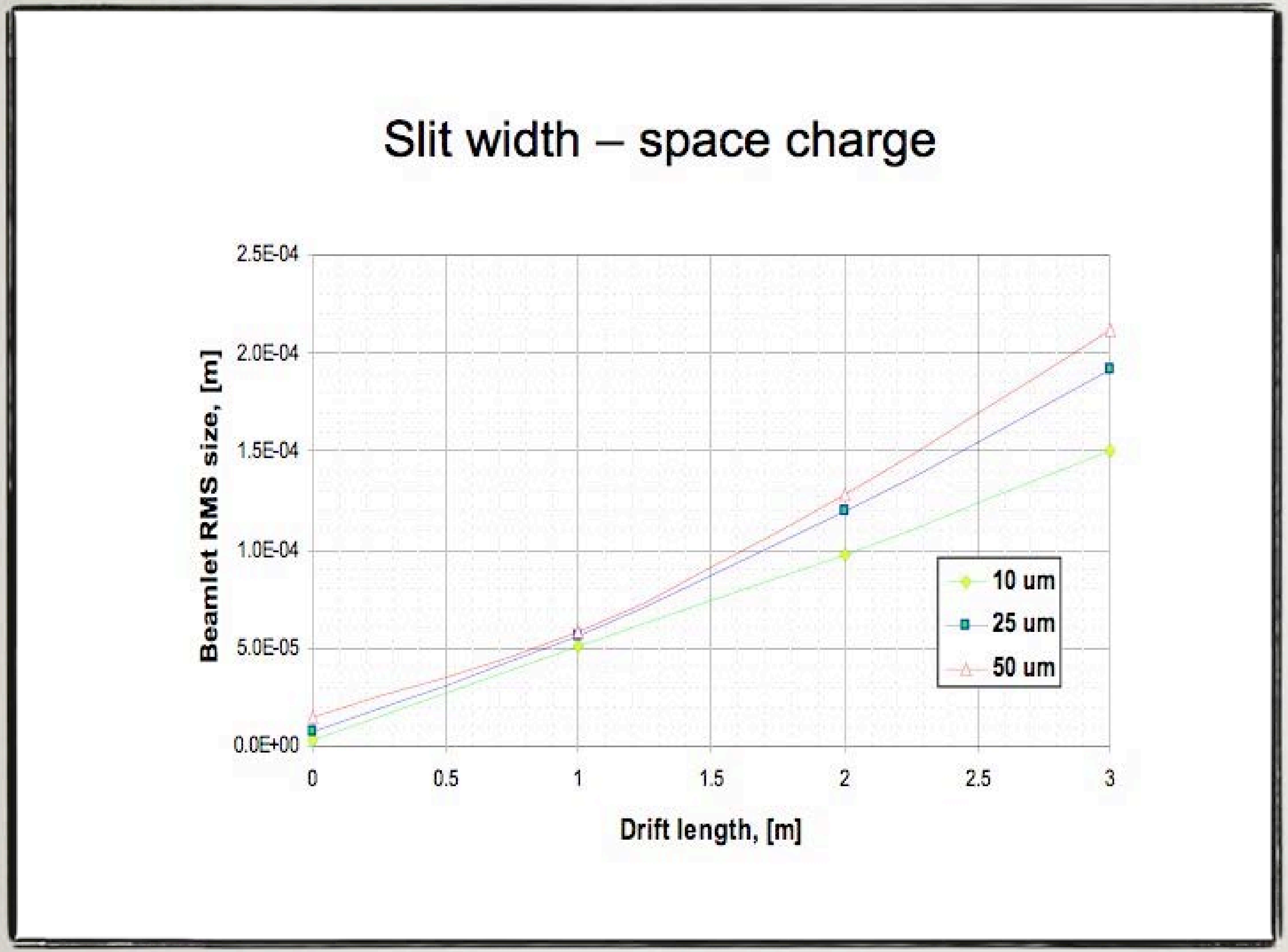


$$\langle x' \rangle = \frac{\langle p_x \rangle}{\langle p_z \rangle} = \sqrt{\frac{\sigma_b}{L^2}}$$

$$\varepsilon_n = \beta\gamma \cdot \sqrt{\langle x \rangle^2 \cdot \langle x' \rangle^2 - \langle x \cdot x' \rangle^2}$$

L. Staykov

Emittance



L. Staykov

Emittance

Summary - EMSY

- Optimal slit opening is estimated to be 10 μm
- The optimal drift length and mask thickness is > 1.5 m.
- The production of the EMSY2 stations has started at High Energy Physics – Hi – Tech Group (INRNE HEPHIT GROUP) immediately after the funds receival
- EMSY stations are under construction. All EMSY's mechanical components were done until 4-th of April
- Full assembling of EMSY including all NEWPORT stages and software has started from 4-th of October at PITZ Zeuthen

L. Staykov

Emittance

What not to do

WG2

Diagnostics Tabulation

Name	Measurement	Intercepting	Operator	Scientist	Single Shot	Mature	High Power	Absolute	Rep Rate	Dynnamic Range	Resolution	Applicability
OTR + CCD	Transverse	Y	Y	Y	Y	Y	N	Y	Detector Limited			
OTR + Streak	Longitudinal	Y	?	Y	Y	Y	N	Y			500 fs	
CSR + Streak	Longitudinal	N	?	Y	Y	Y	Y	Y			500 fs	
Slits / Pepper Pot	Emit / Tom	Y	Y	Y	Y	Y	N	Y		x10	10% @ 1µm	Low energy
Deflecting Cavity	Longitudinal	Y	?	Y	Y	Y	Y	Y		> x100		
C*R Power	Longitudinal	N	Y	N	Y	Y	Y	N		x10		
Wakefield Energy Lc	Longitudinal	Y	Y	Y	N	Y	Y	N		x10		High energy; long linac
Variable Lattice	Emit / Tom	Y	N	Y	N	?	Y	?		?		
Fixed Lattice	Emit / Tom	Y	Y	Y	N	?	Y	?		?		
Laser wire	Transverse	N	Y	Y	N	N	Y	Y	<< 1 KHz		< 3µm	> 100s MeV
Wire scanner	Transverse	?	Y	Y	N	Y	N	Y	beam rep limited		10 µm	
Laser Interferomete	Transverse	N	N	Y	N	N	Y	Y			~ nm	$$$
Zero Phase	Long / Tom	Y	Y	Y	N	Y	Y	Y	beam rep limited		10 fs (R56)	Long linac
EO	Longitudinal	?	N	Y	Y	N	Y	Y			>50 fs	Timing!
Cerenkov Cell	Energy	Y	N	Y	N	N	N	Y				very absolute
Smith Purcell	Long / Energy											
X-ray stripe												
C*R Interferometer												

Conclusions

Great Workshop
Lots of useful interactions
Diagnostics more critical than ever
Multiple approaches necessary
I have no idea what formation length means