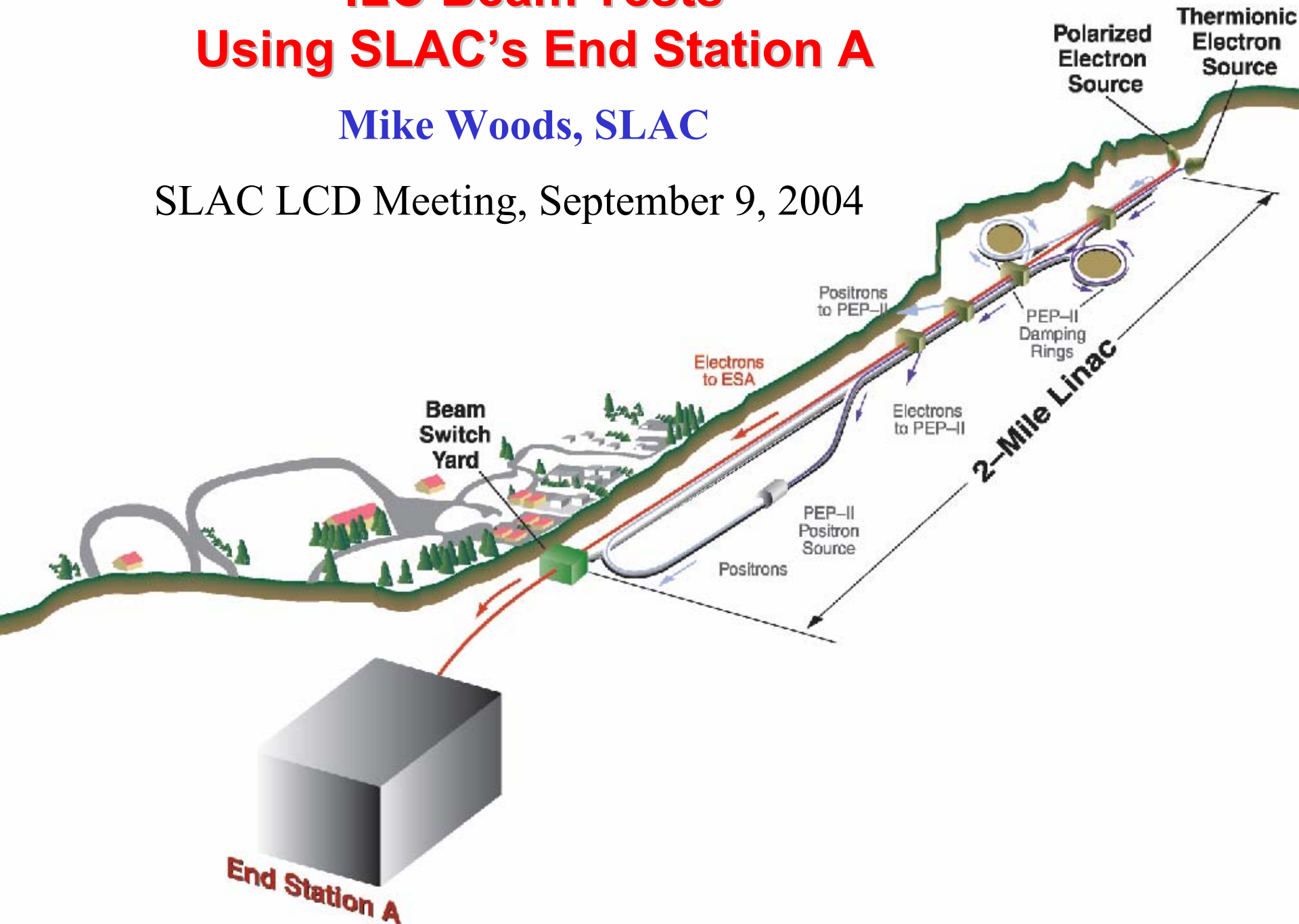
ILC Beam Tests Using SLAC's End Station A

Mike Woods, SLAC

SLAC LCD Meeting, September 9, 2004



Beam Instrumentation Tests for the Linear Collider using the SLAC A-Line and End Station A

SLAC-LOI-2003.2

Y. Kolomensky
University of California, Berkeley

J. Hauptman, O. Atramentov
Iowa State University

E. Gulmez,† E. Norbeck, Y. Onel, A. Penzo*
University of Iowa

D. J. Miller
University College London

R. Arnold, S. Hertzbach, S. Rock
University of Massachussets

M. Hildreth
University of Notre Dame

E. Torrence
University of Oregon

J. Clendenin, F.-J. Decker, R. Erickson, J. Frisch, L. Keller,
T. Markiewicz, T. Maruyama, K. Moffeit, M. Ross, J. Turner, M. Woods
SLAC

W. Oliver
Tufts University

G. Bonvicini, D. Cinabro
Wayne State University

27 physicists
10 institutions

†also Bogazici University, Istanbul, Turkey

http://www.slac.stanford.edu/grp/rd/epac/LOI/LOI-2003.2.pdf

LCRD and UCLC

FY04 R&D Proposals to DOE and NSF

Luminosity

Fast Gas Cherenkov Calorimeter (*Iowa St.*)
Parallel Plate Avalanche, Secondary Emission Detectors (*Iowa*)
Large Angle Beamsstrahlung Monitor (*Wayne St.*)
3d Si Detector for Pair Monitor (*Hawaii*)

Energy

Synchrotron Stripe Spectrometer (*Oregon, UMass*)
rf BPM Spectrometer (*Notre Dame*, *UC Berkeley*)

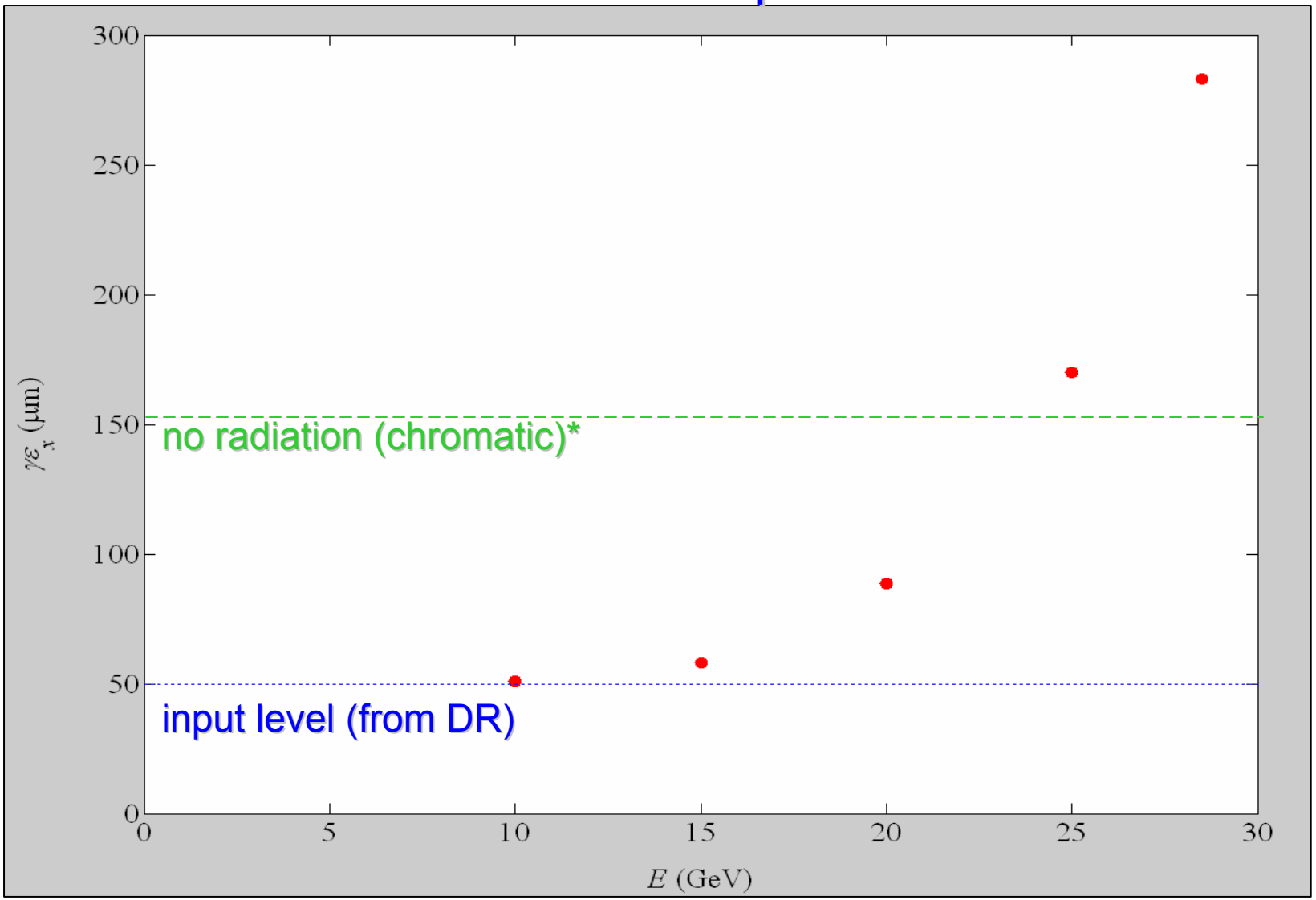
Polarization

Quartz Fiber Calorimeter; W-pair asymmetry (*Iowa*)
Background study (*Tufts*)
Quartz Fiber Detector; transverse polarization (*Tennessee*)

Beam Parameters at SLAC ESA and ILC

Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
e^- Polarization	85%	>80%
Train Length	up to 400 ns	1 ms
Microbunch spacing	20-400 ns	337 ns
Bunches per train	2	2820
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Energy Spread	0.15%	0.1%

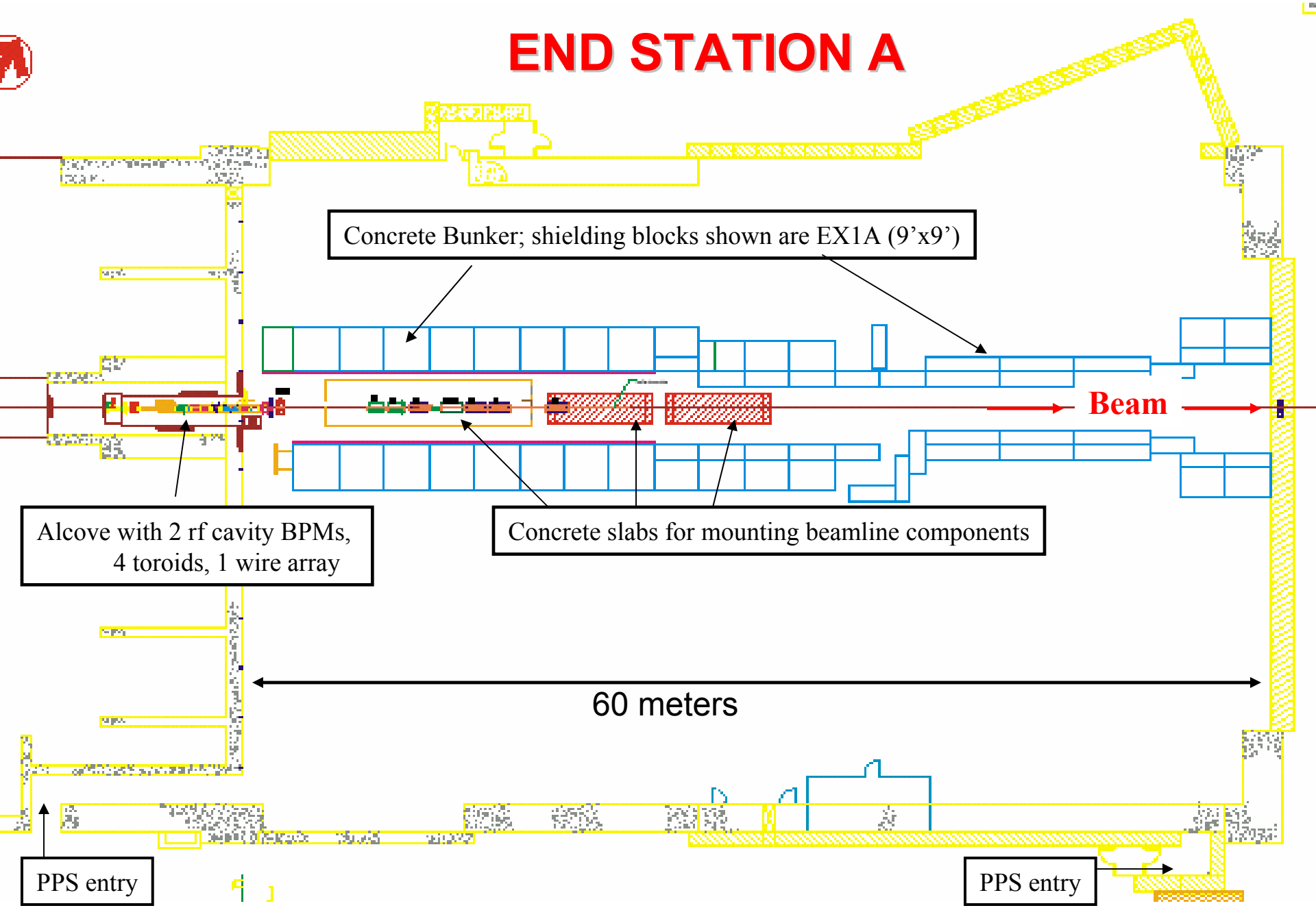
Nominal A-Line Synch. Rad. Emittance Growth in horizontal plane



*2nd –order dispersion effect (horizontal only); could be corrected with additional sextupole

From P. Emma

END STATION A



M. Woods, SLAC

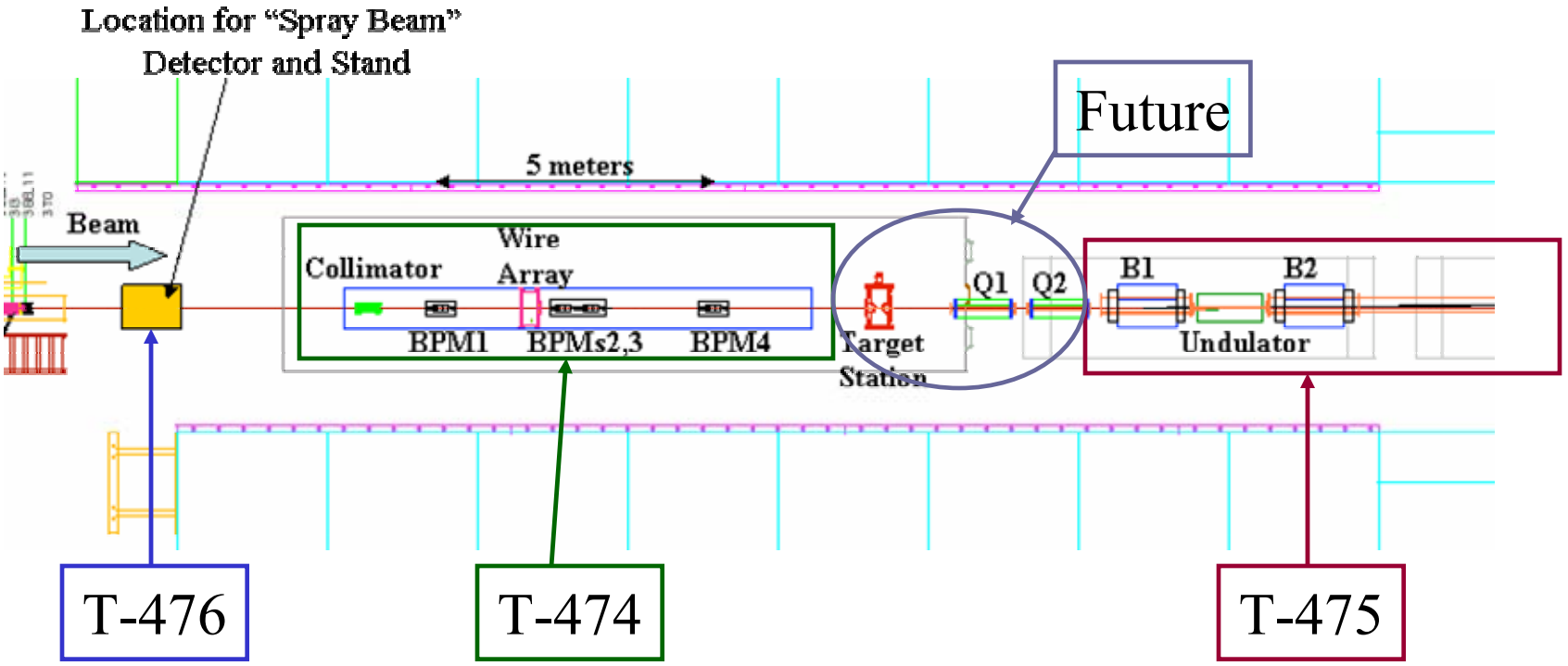
First Beam Tests Proposed

1. **Energy BPMs (T-474 submitted)**
   - Mechanical and electrical stability at 100-nm level
   - BPM triplet at z = 0, 2.5 and 5.0 meter spacing. BPMs 1 and 3 define straight line. Monitor BPM2 offset over time scales of minutes, hours
   - 2 adjacent BPMs to test electrical stability, separate from mechanical

2. **Synchrotron stripe diagnostics (T-475 submitted)**
   - test chicane scheme with wiggler magnet
   - characterize detector (quartz fiber / other) performance and capabilities

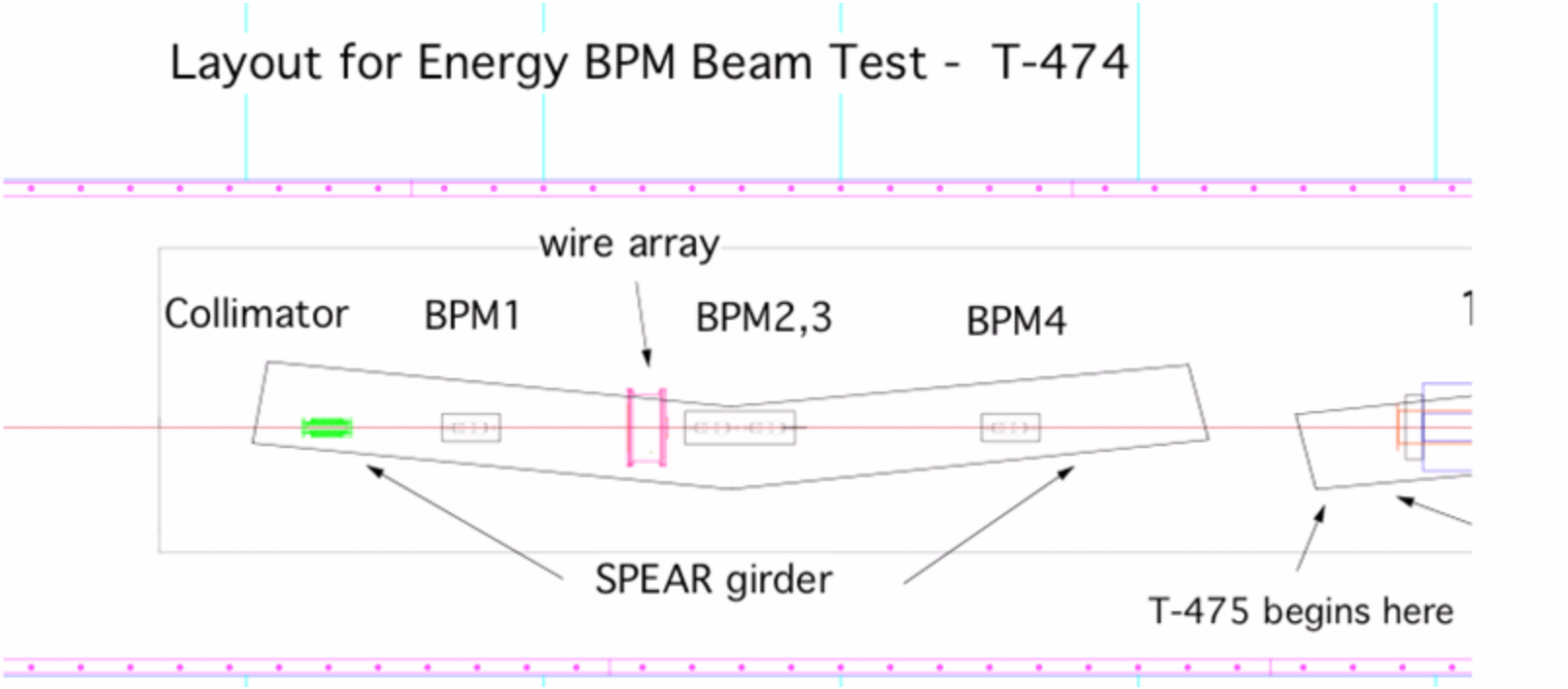
3. **Pair detectors (T-476 submitted)**
   - use "spray" beam of ~ 4-GeV electrons to mimic pair background
   - test speed (at nano-second level) of both 3-d and planar Si
   - characterize detector response to "pair background"; can vary spray beam energy and absorber thickness in front of detector plane
   - use MonteCarlo to superimpose 250 GeV electron to determine electron id efficiency

Overview of Proposed Layout for T-474, T-475, T-476



T-474 Proposal

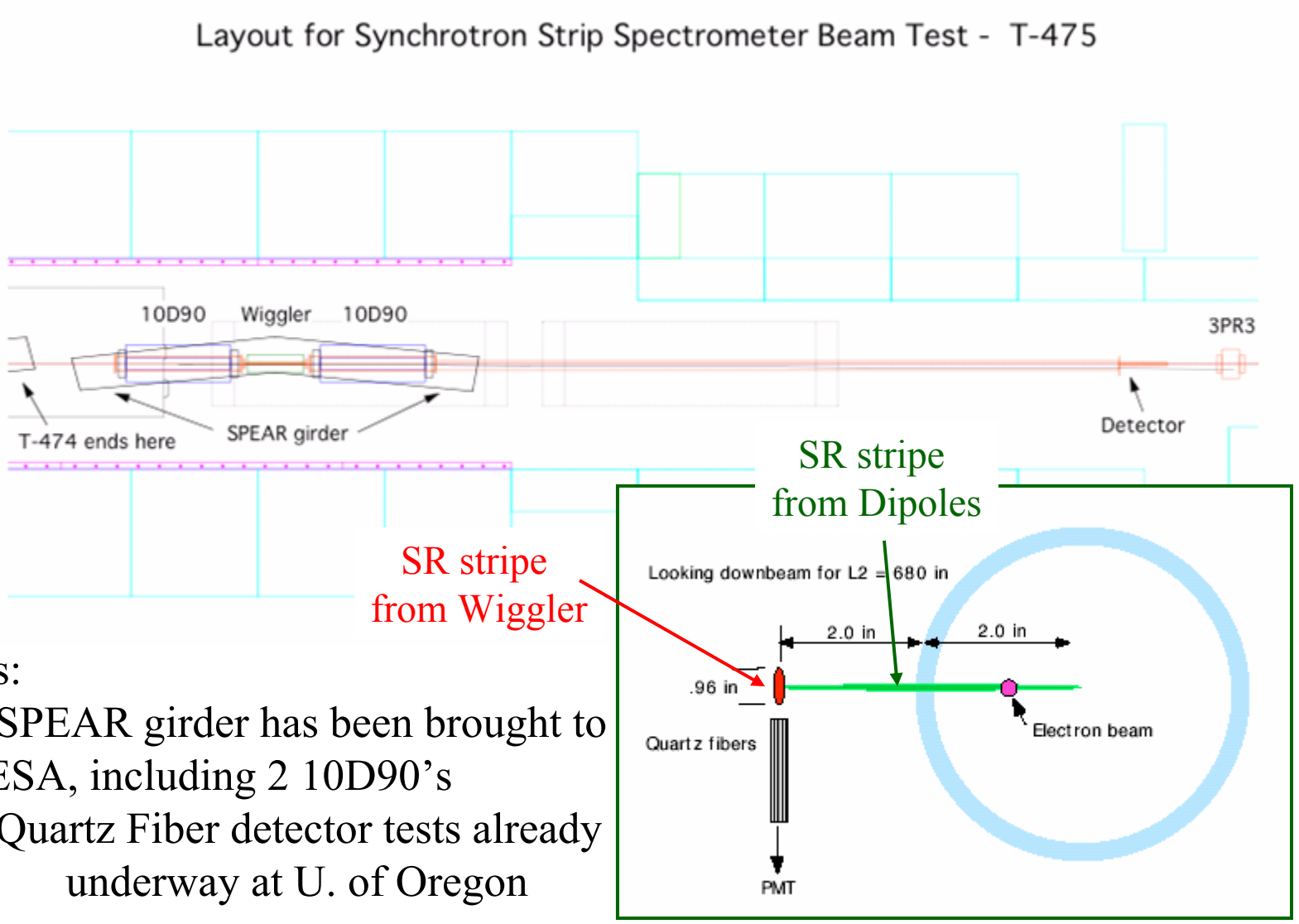
Spokesperson: Mike Hildreth, U. of Notre Dame
Collaborators: U. of Notre Dame, UC Berkeley, UC London, U. of Cambridge, SLAC



Notes:
1. 3 rf BPMs and associated electronics were removed from SLAC Linac and brought to ESA
2. SPEAR girder has been brought to ESA
3. BPM testing using alcove BPMs already underway by UC Berkeley group
4. UK resources: 2 postdoc positions + M&S money available

T-475 Proposal

Spokesperson: Eric Torrence, U. of Oregon
Collaborators: U. of Oregon, SLAC (+ ?)



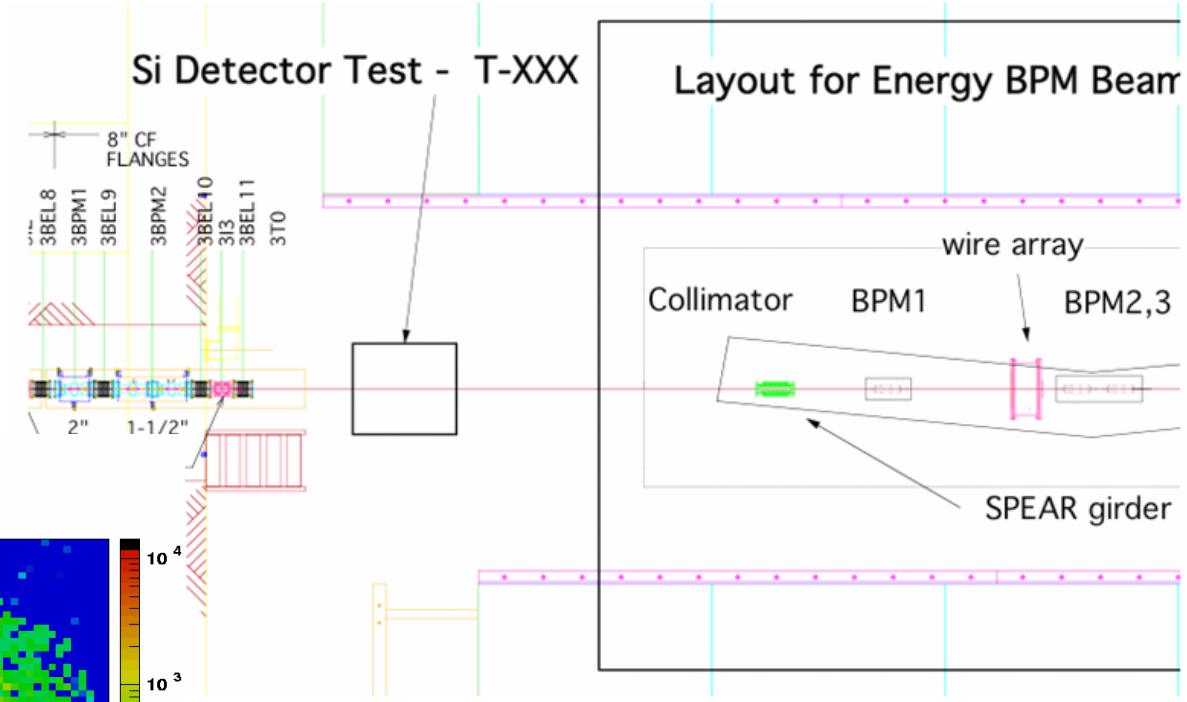
Notes:

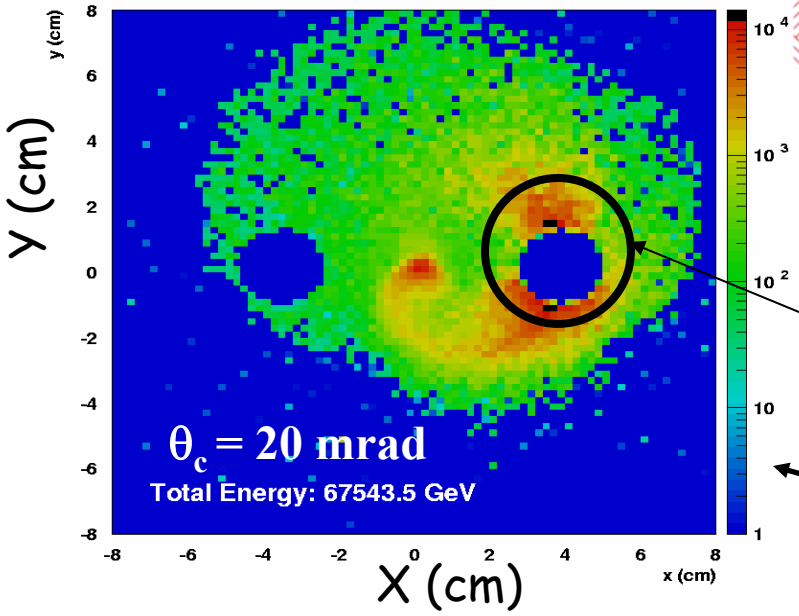
1. SPEAR girder has been brought to ESA, including 2 10D90's
2. Quartz Fiber detector tests already underway at U. of Oregon

T-476 Proposal

Spokesperson: Chris Kenney, Molecular Biology Consortium

Collaborators: Molecular Biology Consortium, U. of Hawaii, Tohoku U., Brunel U., CERN





Spray beam size In End Station A

Can span interesting range of energy density in ESA beam test

Pair energy distribution at BEAMCAL detector; From K. Busser presentation at LCWS 2004

Some Preparations in ESA are Underway

Other Beam Tests Possible in ESA

1. **IP BPMs (necessary for fast inter-train and intra-train feedbacks)**
   - Sensitivity to backgrounds, rf pickup
   - Mimic LC geometry, including fast signal processing (but no feedback)
   - Sample drive signal to kickers

2. **Tests with short bunches (~100-300 μm possible)**
   - EMI for beam instrumentation or Detector electronics
   - collimator wakefield tests

3. **Single Particles (electrons, photons, pions)**
   - 1-25 GeV particles with 1 or less particles/bunch at 10Hz for LC Detector test beams

4. **Fixed target to mimic beamsstrahlung and disrupted beam**
   - for synchrotron stripe energy spectrometer
   - for IP BPM tests

5. **IR Mockup**
   - Mimick beamline geometry at IP within ±5 meters in z and ±20 cm radially

Improving ESA Test Beam Facilities?

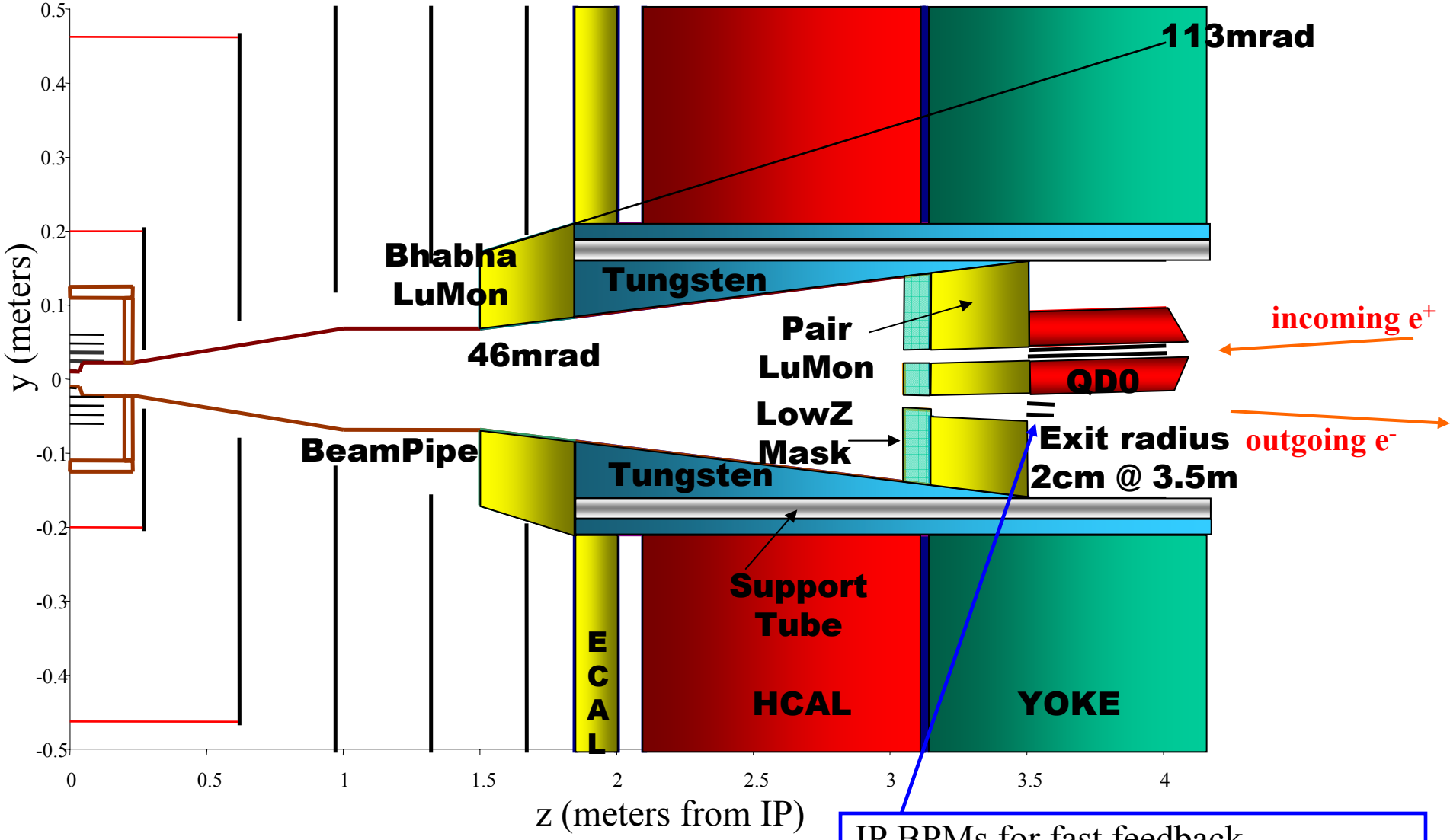
1. **Low emittance beams to ESA**
   - preserve DR emittance thru Linac/A-Line?
   - vertical ok? Could add sextupole to improve horizontal

2. **Diagnostics**
   - emittance measurements
   - bunch length measurements
   - particle ID (for single particle/bunch electrons, pions, …)
   - hodoscope for single particle (scintillating fiber array, …)

3. **Increase available run time and access**
   - quick (1-hour?) turnaround between FFTB and ESA possible?
   - 4 days/month?
   - share 4-7 days/month with FFTB? 12 hours each/day to ESA/FFTB

(4. **Targets and secondary beam lines?**)
   - …

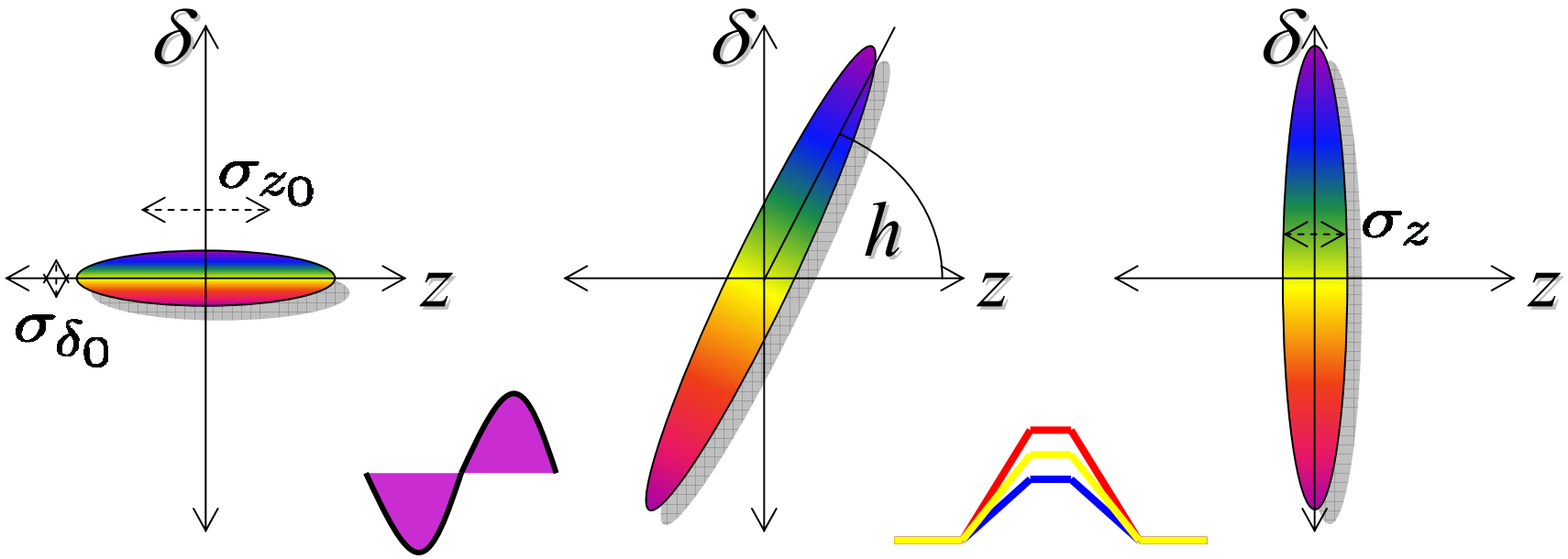
Mockup forward region within 5 meters of IP, for masking, apertures, IP BPMs (example Detector design shown)



IP BPMs for fast feedback
and feed forward @ ~z = 3.5 meters

Short Bunches using R_{56} in A-Line

P. Emma



$$V = V_0 \sin(\omega\tau)$$

$$\Delta z = R_{56}\delta$$

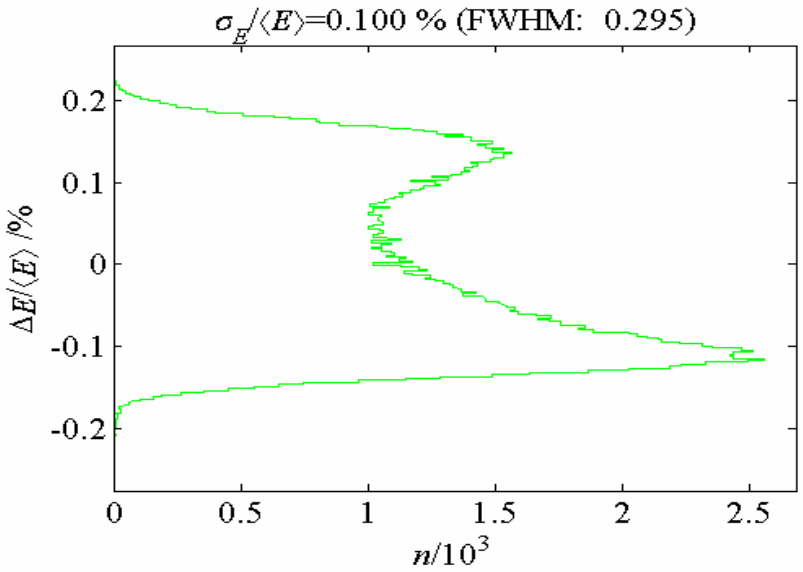
RF Accelerating Voltage (or Wake)

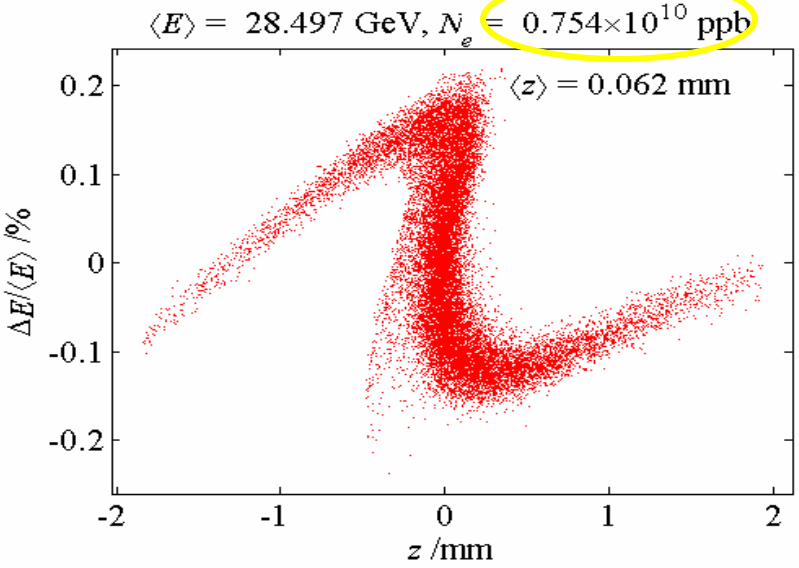
Path Length-Energy Dependent Beamline

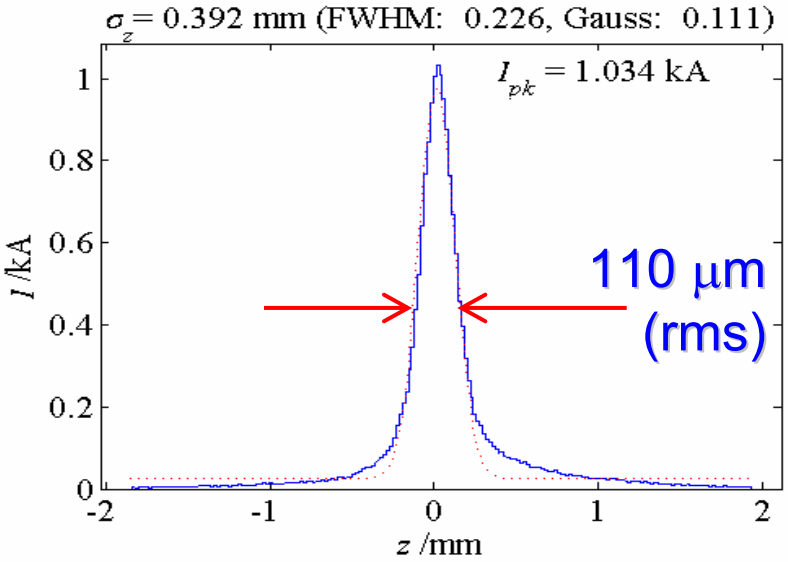
$$\sigma_z = \sqrt{(1 + hR_{56})^2\sigma_{z0}^2 + R_{56}^2\sigma_{\delta 0}^2}$$

P. Emma and M. Woods, IPBI TN-2004-8

Long. Phase Space after A-Line (28.5 GeV)





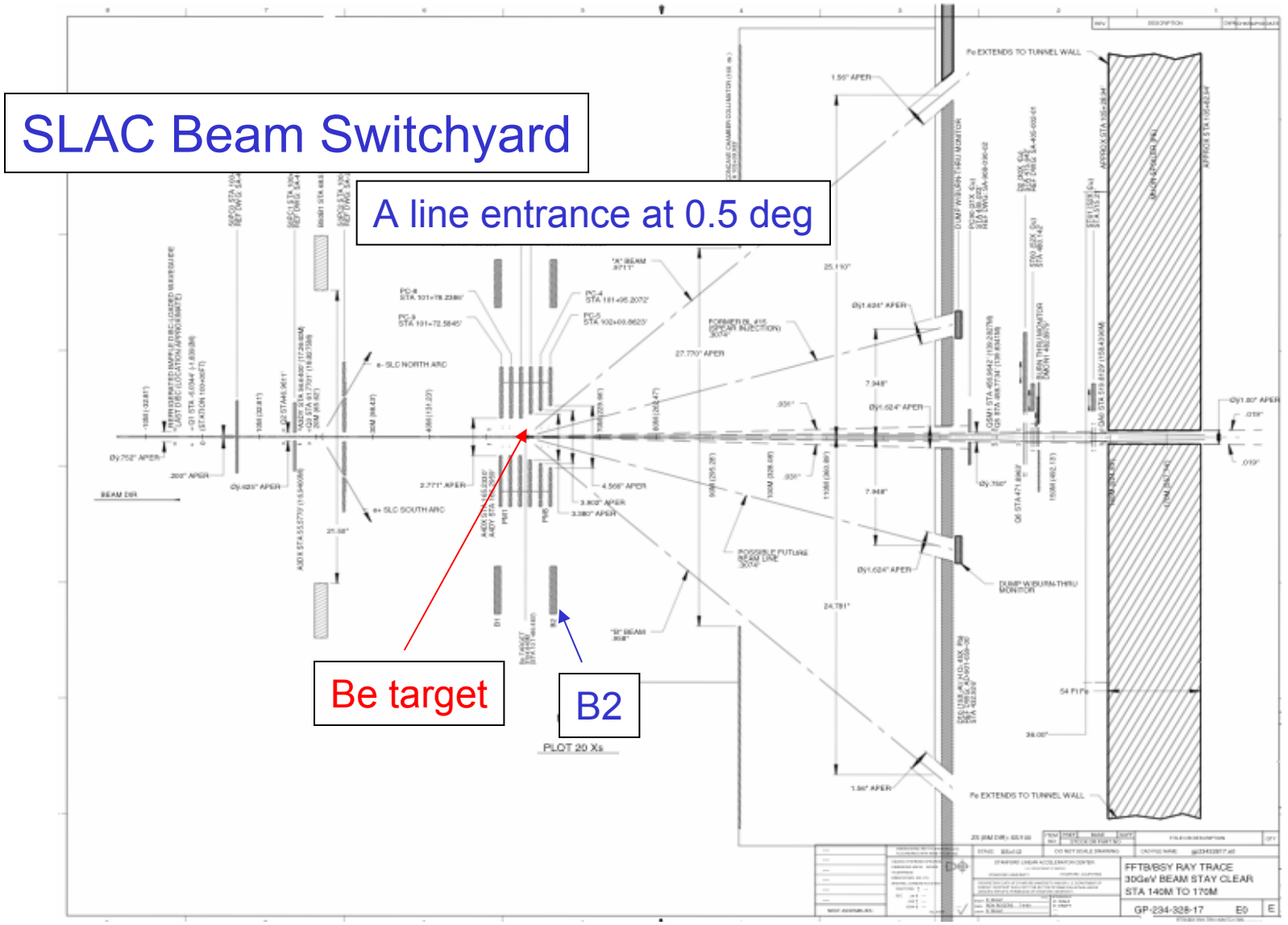


parameters

σ_z(DR)	= 5 mm
σ_δ(DR)	= 0.07%
V(RTL)	= 39 MV
R_{56}(RTL)	= 590 mm
φ(2-6)	= +10 deg (BNS)
sec-10 chicane **OFF**	
φ(10-20)	= –9 deg (BNS)

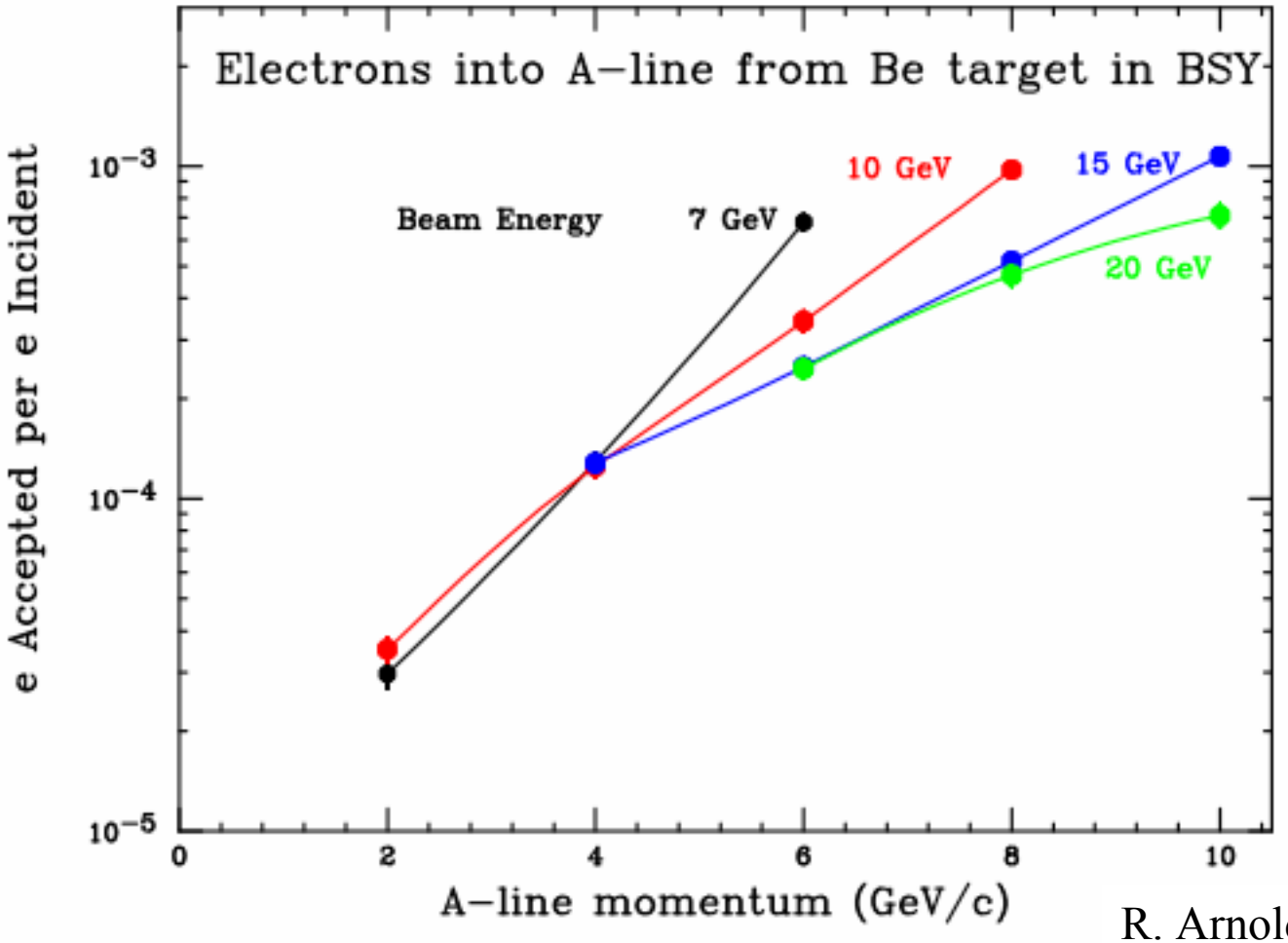
_woods_lit.m: A-Line Bunch Compressor (4-June-2004 - P. Emma)
JL-2004 15:18:37

Existing Be Target Station at End of Linac



Electrons in ESA per e on Be target

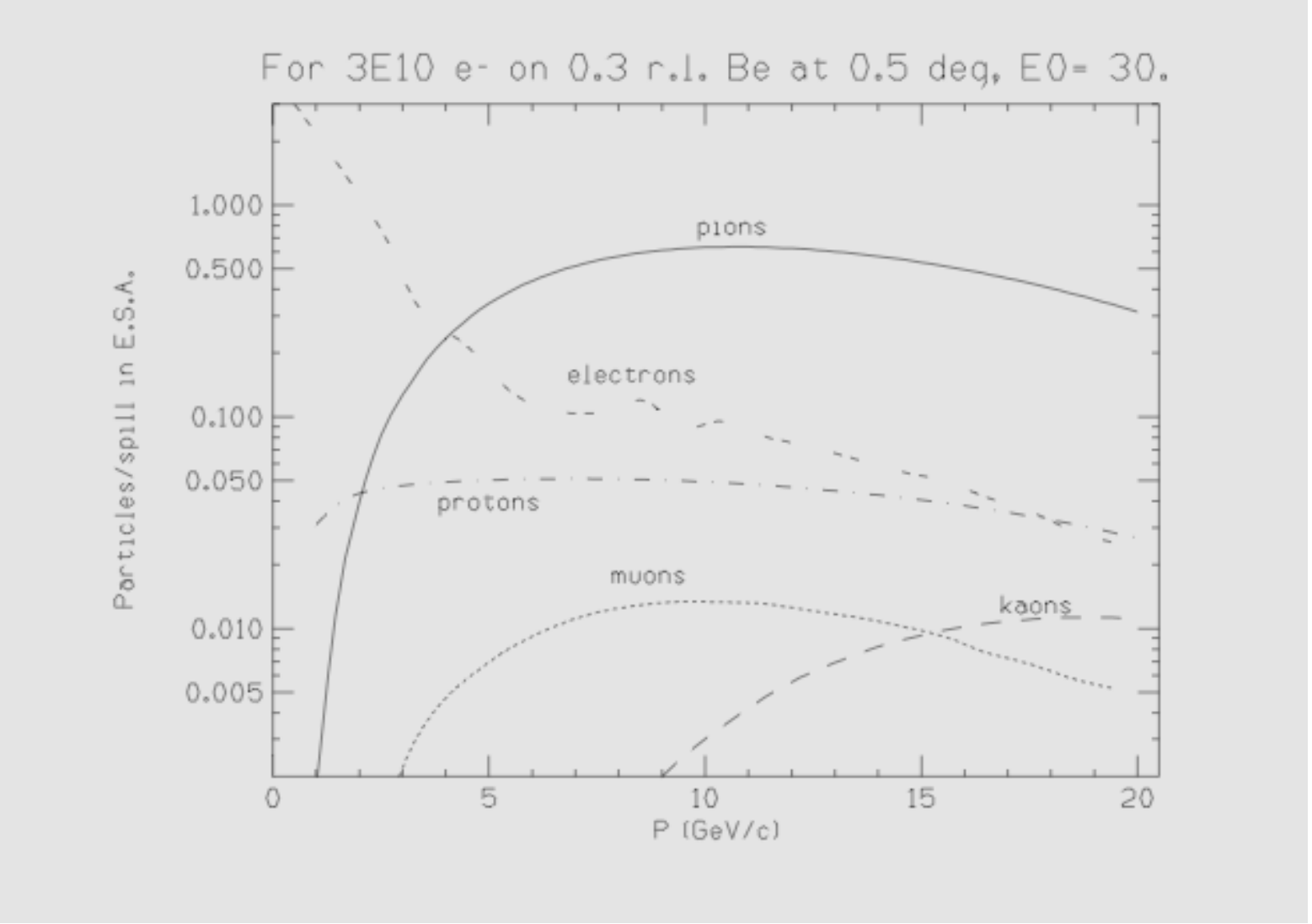
From GEANT3 model of spray from Be, D10 aperture, simplified A-line



R. Arnold and T. Fieguth, IPBI TN-2004-5

Particle fluxes to ESA using Be Target in Linac with 0.5 deg B2 bend off

LC Detector Tests with electrons, photons or pions



Outlook

A Letter-of-Intent for LC Beam Instrumentation Tests in ESA was submitted to SLAC in Fall 2003 and presented to the SLAC EPAC. Response from the EPAC and the SLAC Director was very positive.

First 3 Test Beam Requests have been submitted to SLAC and cost estimates have been made. Requesting a run in June 2005.
Currently waiting for SLAC response as we go thru evaluation of SLAC's efforts for ILC; I expect a positive response

Preparations are underway:

- research activities by University groups
- BPMs moved from Linac to ESA
- SPEAR girders moved to ESA

SLAC's End Station A can be highly valuable for ILC Beam Tests for IP Beam Instrumentation and ILC Detector Studies. Resources needed to improve facility and to make beam time available.