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LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

Overview of ILC Plans

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ILC R&D Activities and Plans

1. Positron Source
2. Damping Ring
3. Low Emittance Transport - damping ring to final focus

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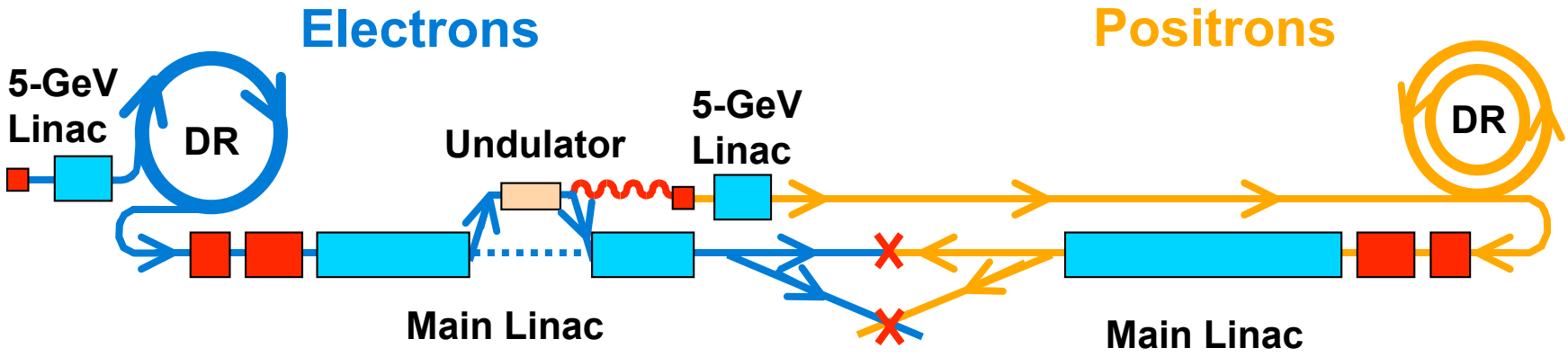
Positron Source

Design, construction and testing of prototype superconducting helical undulator

Evaluation of impact of undulator on electron beam (Emittance dilution, depolarization)

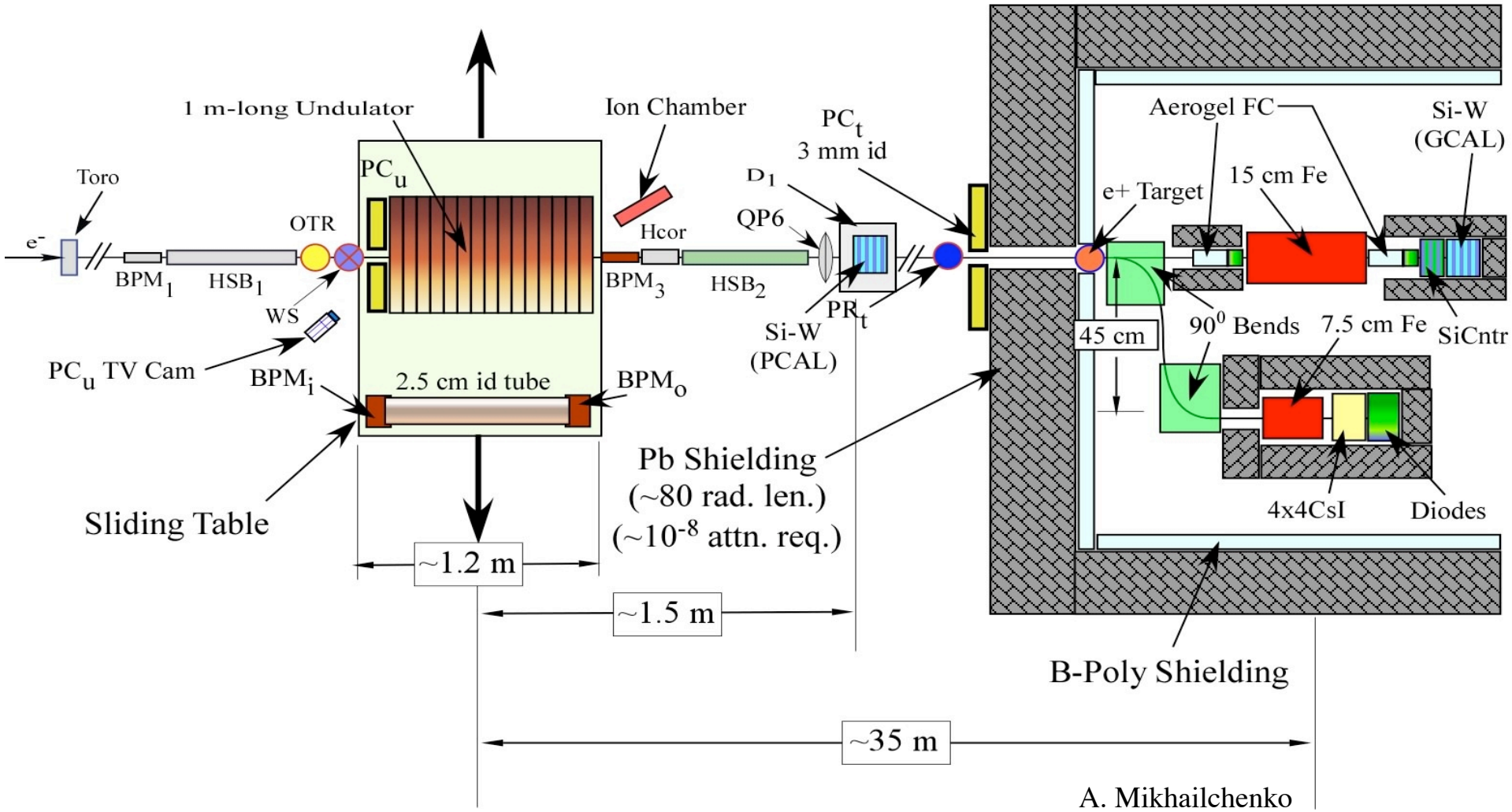
Undulator for Polarized Positron Source

- ILC polarized positron source
  - High energy electrons/positrons pass through a helical undulator
  - Circularly polarized photons converted in thin target polarized positrons



E166

E-166 : Plan View, r2
(50 GeV)

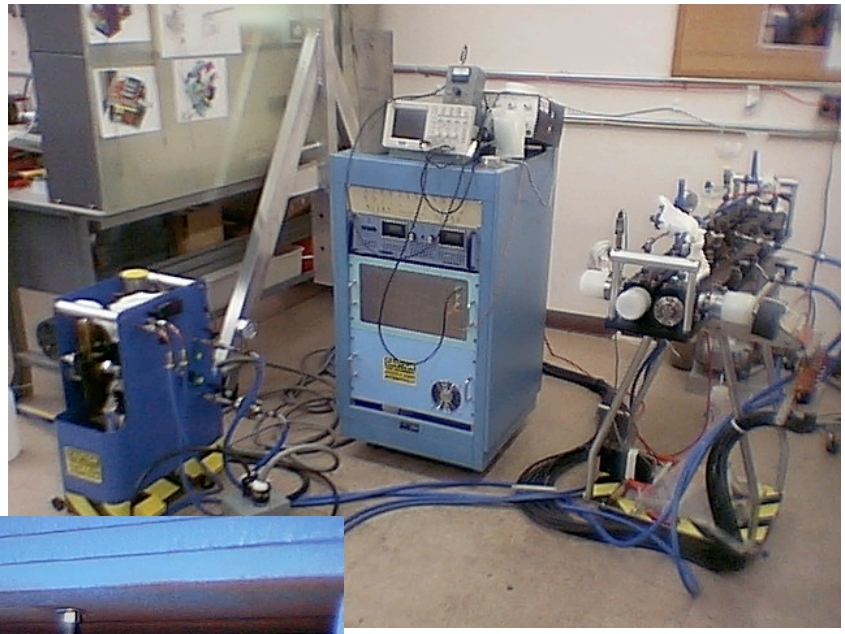


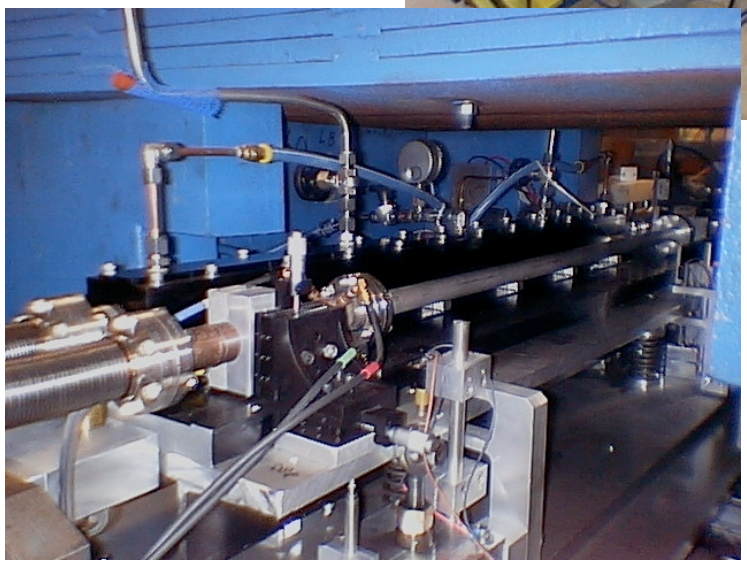
A. Mikhailchenko

E166 Helical Undulator

Undulator Parameters

- Length = 1m
- Undulator parameter, K= 0.17
- Period, □ = 0.25
- Inner diameter, 0.88mm
- Magnetic field, 0.76T
- Pulsed current 2300A
- Pulse width, 12□s





E166 Polarization (preliminary)

Positron asymmetry measured with maximal transmission through spectrometer

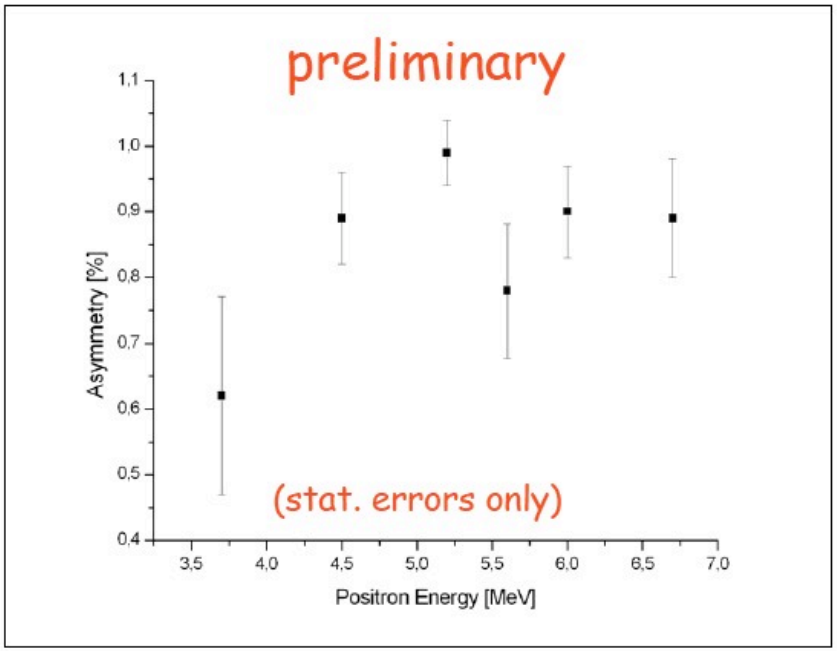
$$P_{e^+} = \frac{\square}{P_{e\square} A_{e^+}}$$

For analyzing power A~17%, P_e =7%

Asymmetry measured □~1%

□ P_+ = 85%±10%

(Simulated P_+ = 84%)



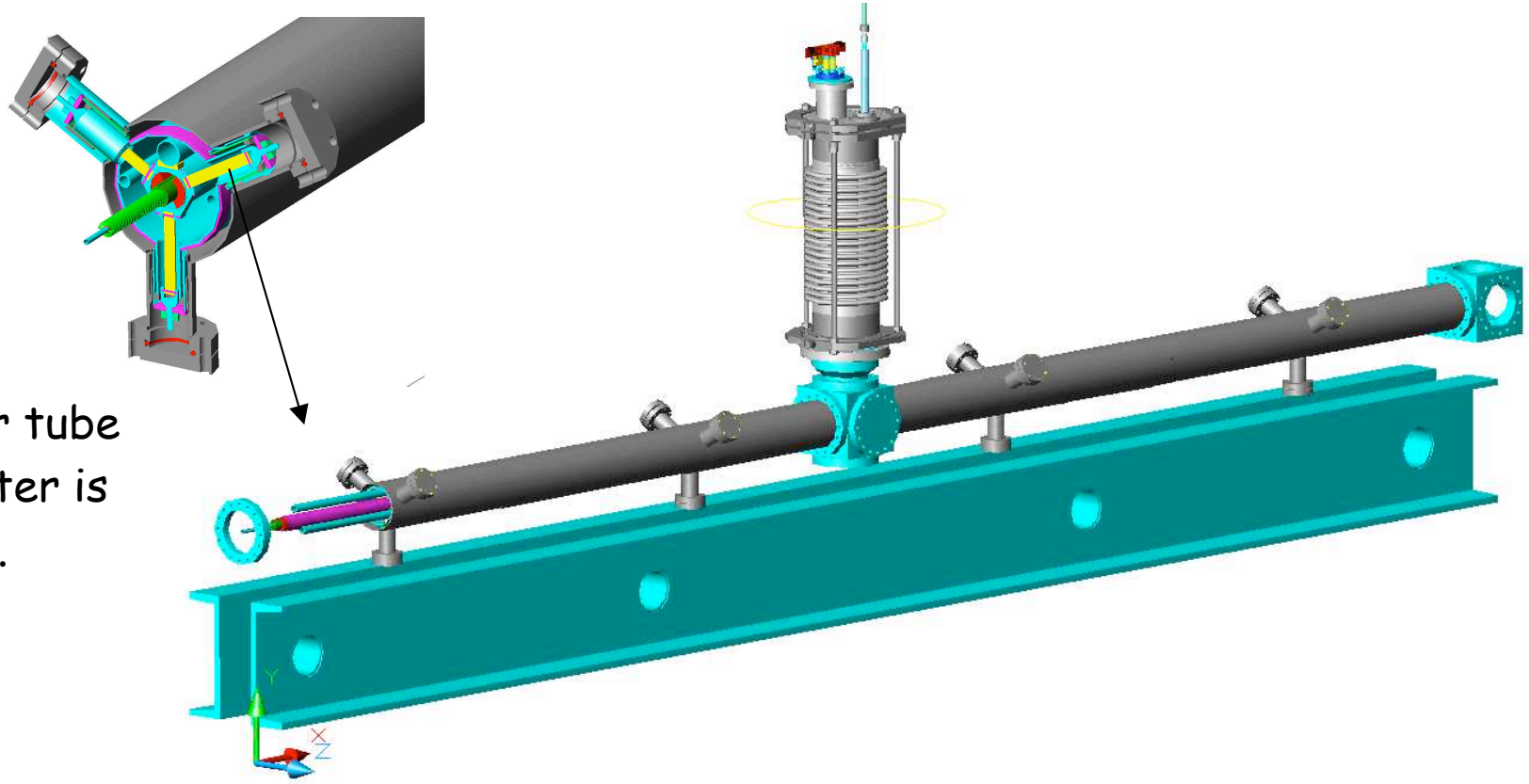
Plot by A. Mikhailichenko

Undulator for Polarized Positron Source

Parameters of superconducting helical undulator

- λ_u = 10mm
- Aperture = 8mm
- $K = eH_0\lambda_u/(2\pi mc^2) = 0.7$
- Length ~ 200m
- Assembled from 4-m long modules

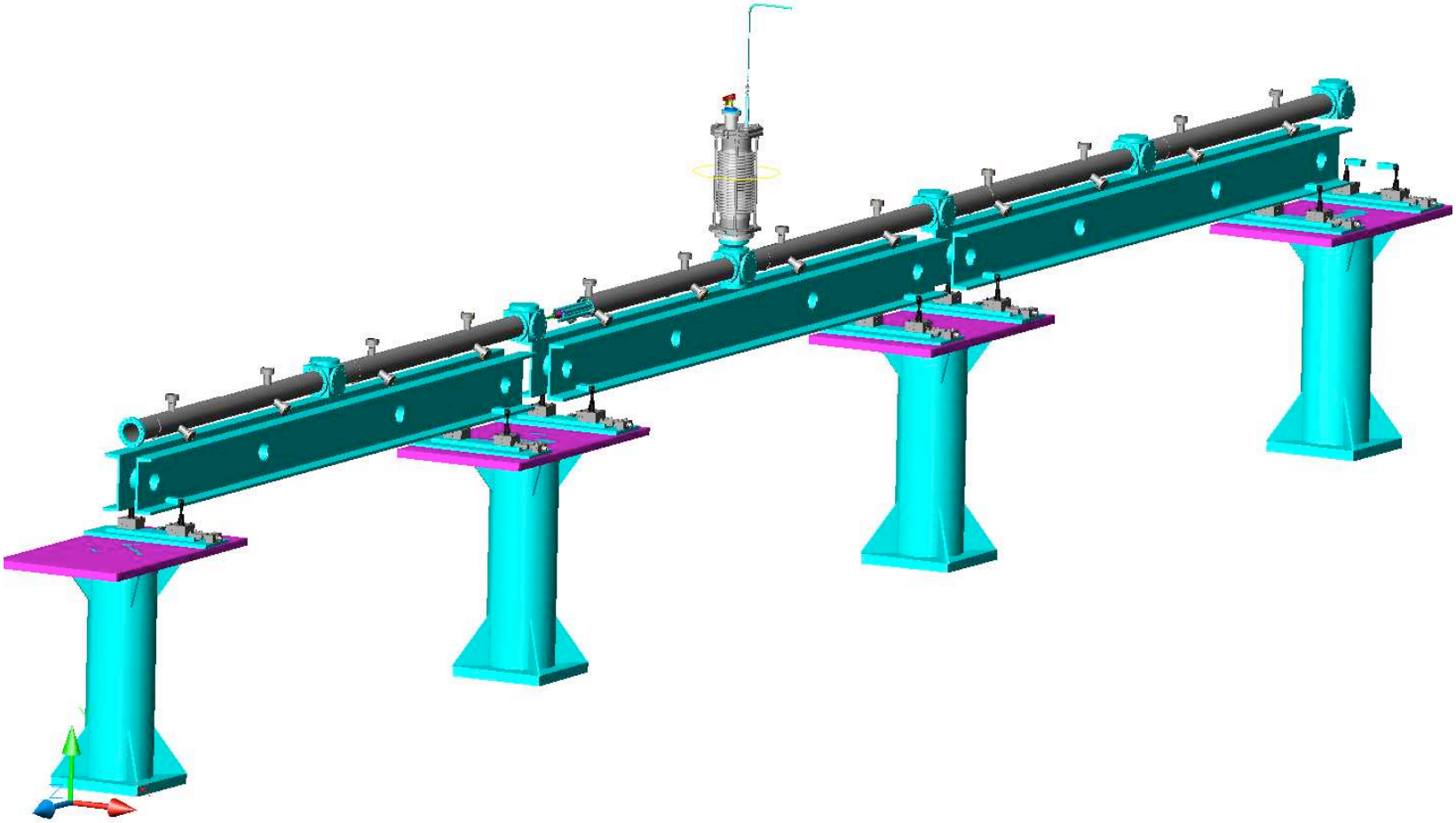
Superconducting Helical Undulator



Outer tube diameter is 5 inch.

Cryomodule, 4 m—long. Cryostat contains two 2 m-long identical sections having opposite polarity. This delivers zero first integral along this module

Superconducting Helical Undulator



Sections installed in series. BPMs, pumps, quads etc installed between sections.
Total length of installation ~200 m

Undulator for Polarized Positron Source

- 0.3m long undulator model
  - Optimize field quality
  - Evaluate effects on emittance and polarization of electron beam
  - Design, assemble and test
  - Field measurement in vacuum

(Collaboration with Daresbury)

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Damping Ring

- Design, construction and test of fast extraction/injection kicker
- Design, construction, test of superconducting damping wiggler
- Evaluation of design optics, including dynamic aperture
- Development of modeling code for investigation of phenomena that limit beam current, bunch charge, emittance, stability. And measurement in CesrTF of the same
- Development of beam based algorithms for alignment and low emittance tuning. And test in CesrTF
- Development of instrumentation for measuring bunch by bunch beam size. And test in CesrTF

R&D is coordinated with the ILC Damping Ring Working Group

Fast Kicker R&D

Baseline recommendation for ILC damping ring

- 6ns bunch spacing in damping ring
  - kicker rise and fall time and width
- Bunch structure, 2820 bunches/train spaced 330ns apart in main linac
  - pulser burst rate = 3.25MHz
- Stability of extraction kicker constrained by resulting jitter at IP
- 0.6mrad kick to 5GeV beam
  - Kicker length limited to 360mm by rise and fall time requirement
  - 10kV pulse > 15 kickers in series

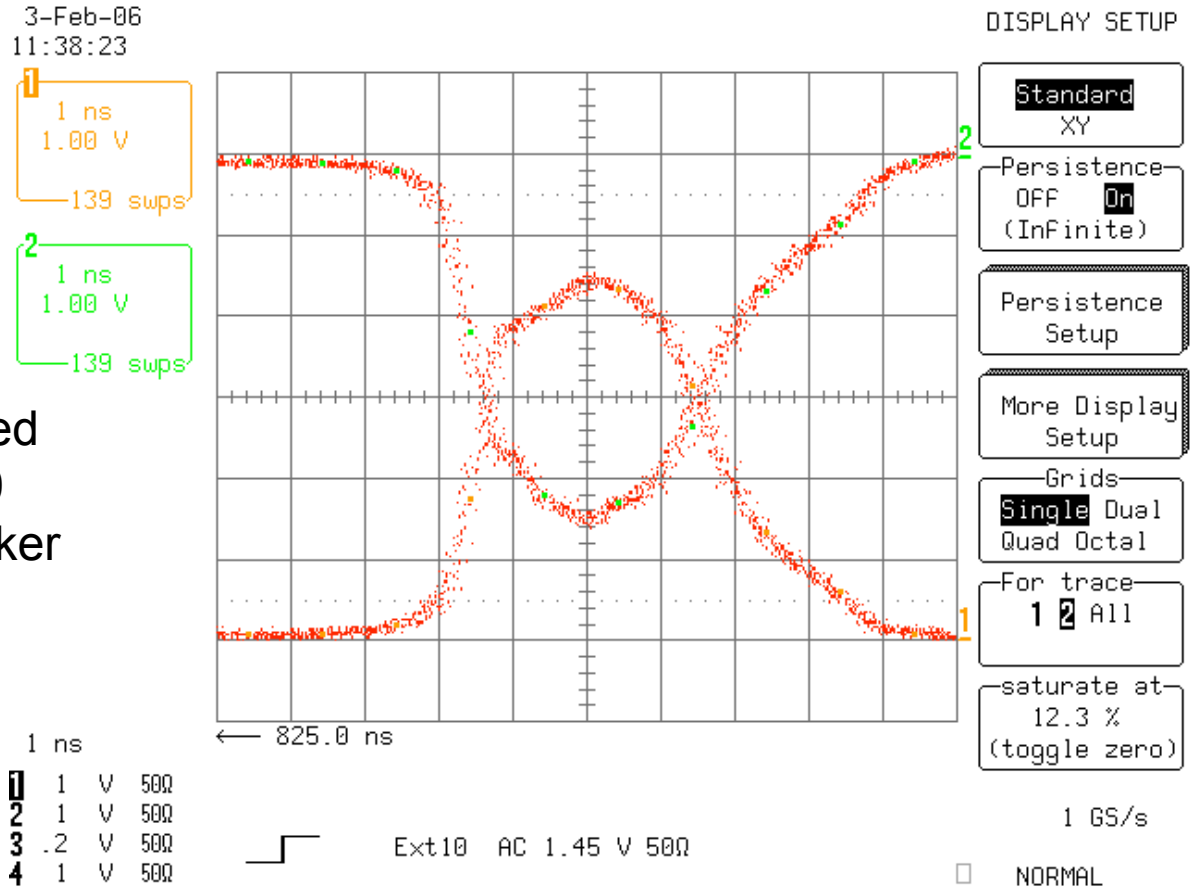
Testing a conventional stripline kicker, with FID pulser

±1 kV fast ionization dynistor (FID Technology, Ltd.)

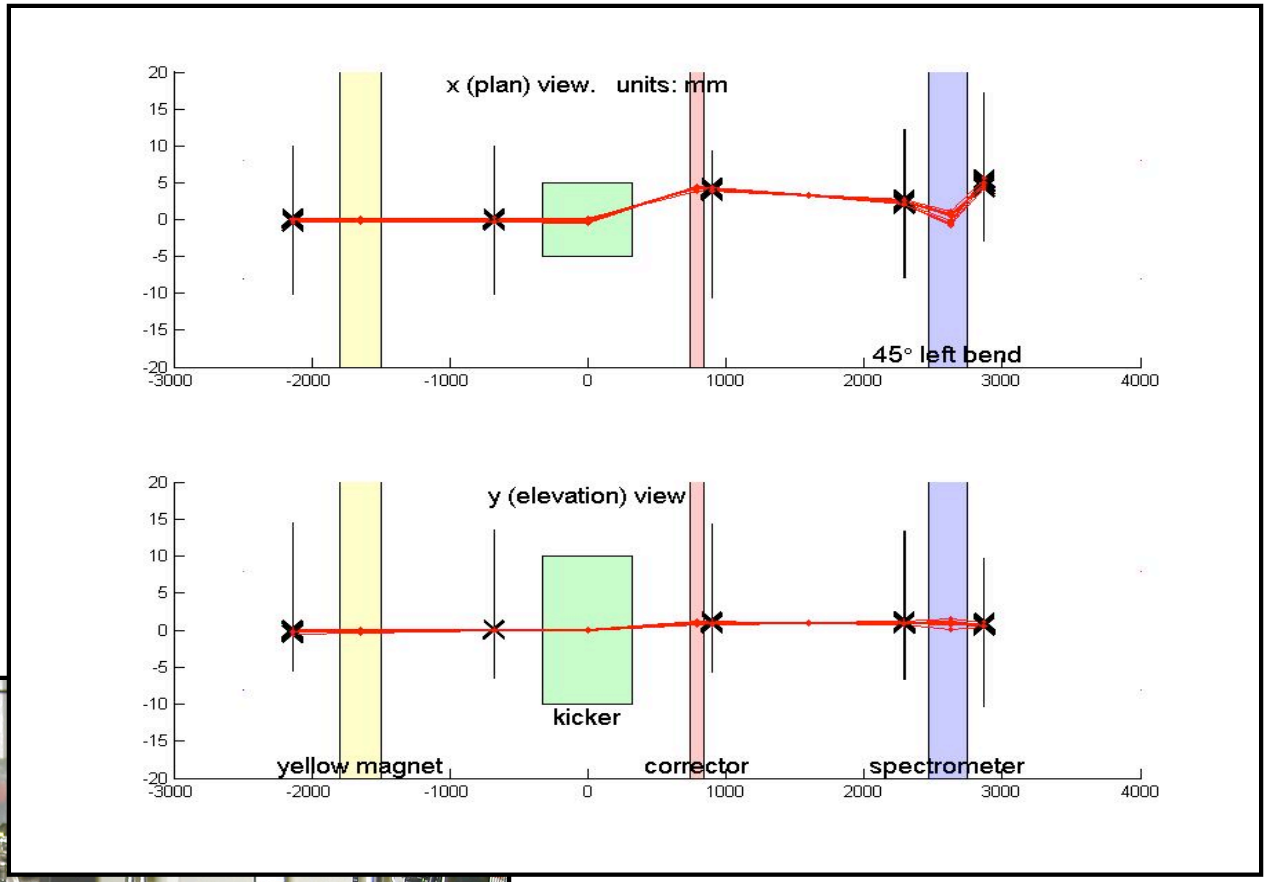
Collaboration with UIUC

Fast Kicker R&D

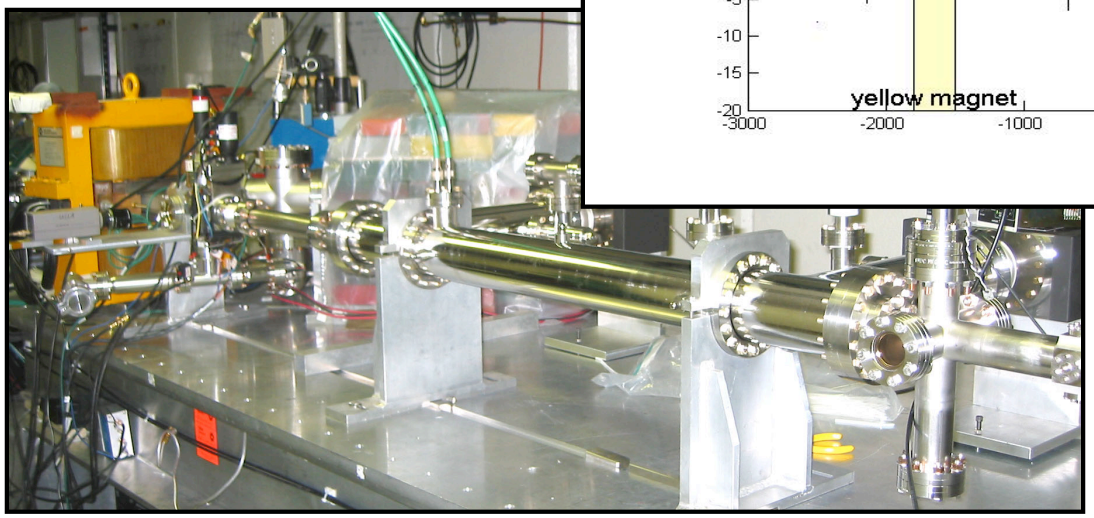
As measured *after* the A0 stripline kicker



Fast Kicker R&D



10 pulses



Kicker in A0 beam line

Fast Kicker R&D Plans

- Complete testing of 1kV pulser in FNAL A0 test beam
- Purchase higher voltage pulser from FID Technology Inc.
- Design and construct matched stripline kicker (with INFN?)
- Install kicker in linac (CESR injector)
  including beam position monitors
- Test kicker/pulser with 100 - 300MeV electron beam in linac

Superconducting Damping Wiggler

Recommendation for baseline configuration ->

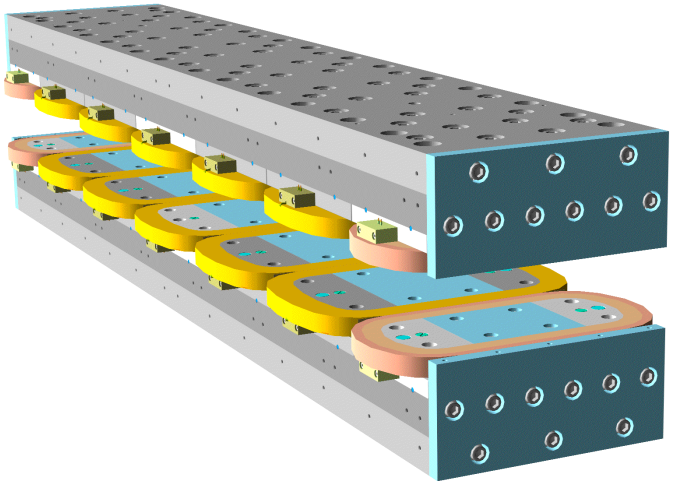
- > 200m of ~1.6T wiggler
- Superferric design (CESR-c wiggler)

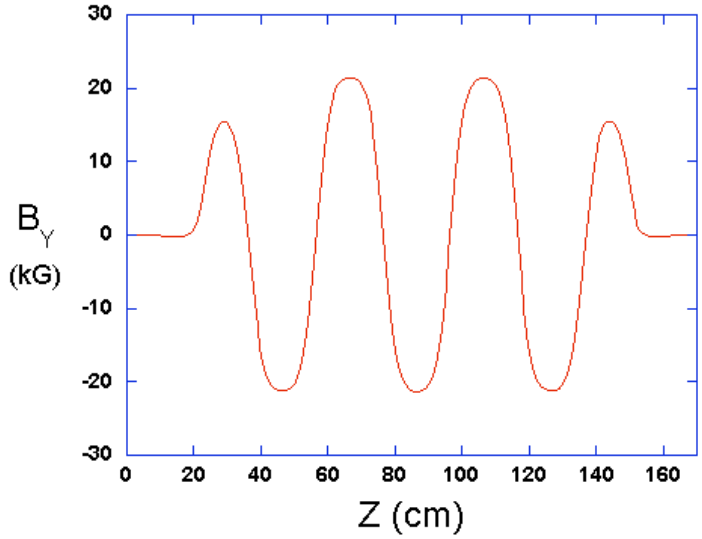
Design study ->

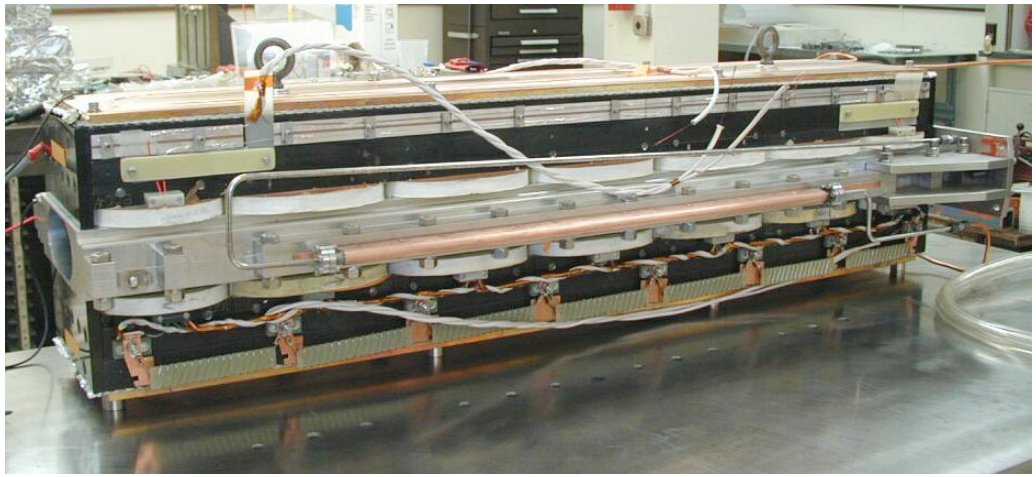
- CESR-c wiggler field quality and physical aperture are more than adequate

We propose to design, construct and test a damping wiggler based on CESR-c wiggler and optimized for cost

CESR-c Damping Wiggler







Modeling and numerical evaluation of damping ring properties

Development of simulation and modeling tools (BMAD library)

Modeling code has been extensively tested in CESR and used to

- Design and characterize CESR, CESR-c optics, including effects of wiggler nonlinearities
- Evaluate collective effects in CESR/CESR-c
- Diagnose and correct guide field errors

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- We have extended the code to include
  - Spin tracking
  - Touschek effect
- And work is underway to incorporate
  - Space charge, intrabeam scattering etc.

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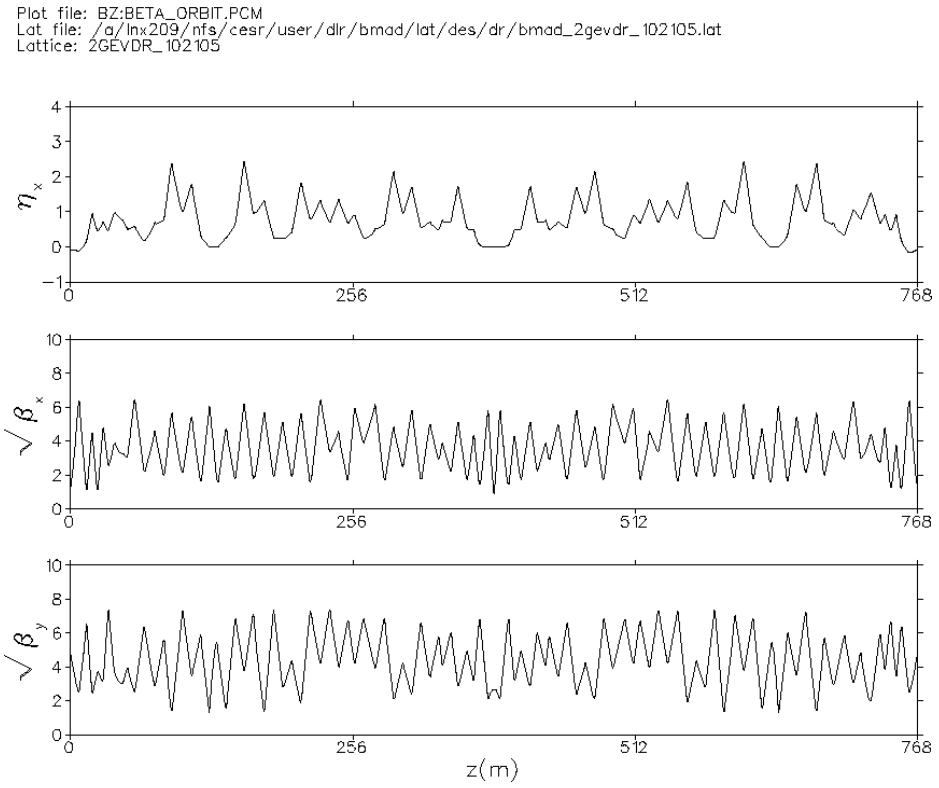
- We have extended the code to include
  - Spin tracking
  - Touschek effect
- And work is underway to incorporate
  - Space charge, intrabeam scattering etc.
- Used it to evaluate
  - Dependence of dynamic aperture on wiggler properties
  - Dynamic aperture of all viable ILC damping ring & wiggler designs

  for ILC damping ring configuration study (in collaboration with ILC damping ring working group)
  - Beam-based alignment and emittance correction algorithms for CesrTF

Damping Ring Beam diagnostics

- Integrated streak camera into CESR control system
- Turn by turn measurement of vertical beam size
  - radiation damping rate
- X-ray imaging beam profile monitor
  (collaboration with Cal Tech and CHESS)

CESR Damping Ring Test Facility



12 2.1 T wigglers, 2GeV/beam

ε_{min} ~ 2.25nm (ε_{norm} ~ 8.8πm)

τ_x = 47ms

σ_E/E = 0.086%

σ_l = 6.8mm @ 15MV accelerating field

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Low Emittance Transport Damping Ring to Final Focus

Development of model of transport of phase space and spin vector

- Through guide field elements from damping ring to final focus
- Including spin rotator, bunch compressor, main linac with charge dependent wakes, nonlinearities, misalignments, …

Investigate sources of emittance dilution and depolarization

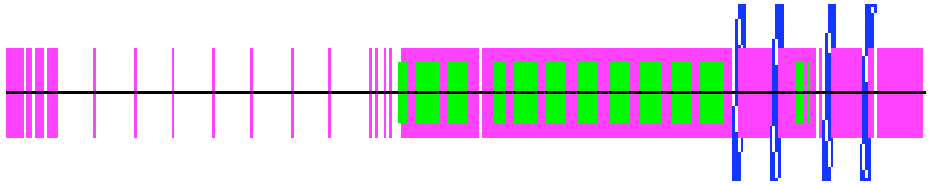
Evaluate beam based correction algorithms

Diagnose guide field errors during commissioning

- Interpretation of information from BPM, beam size monitors, cavity HOM probes
- To extract details of guide field errors and implement corrections

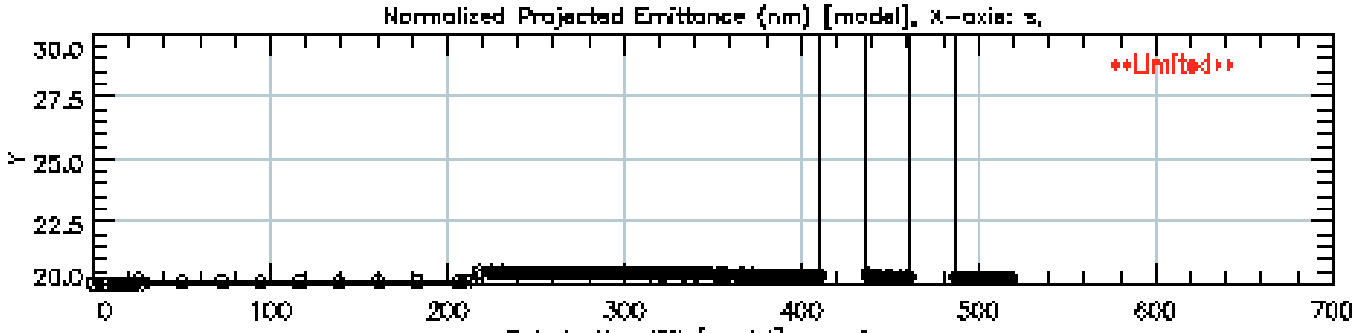
(In collaboration with LET working group [SLAC,FNAL,DESY,CERN])

Modeling of beam transport in main linac

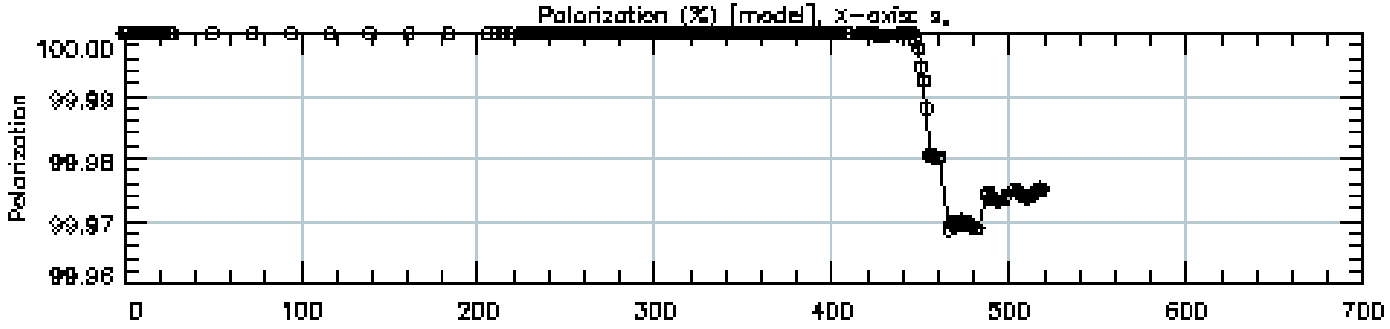


Spin rotator

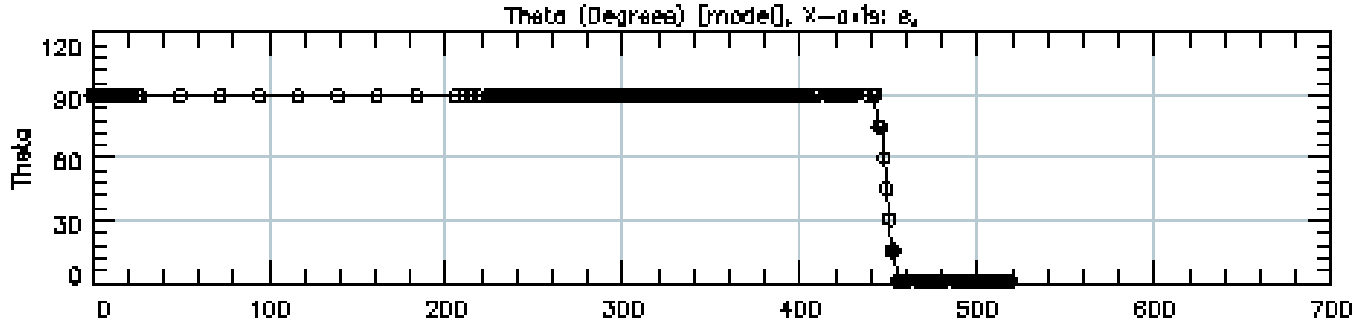
J.Smith



Vertical projected emittance

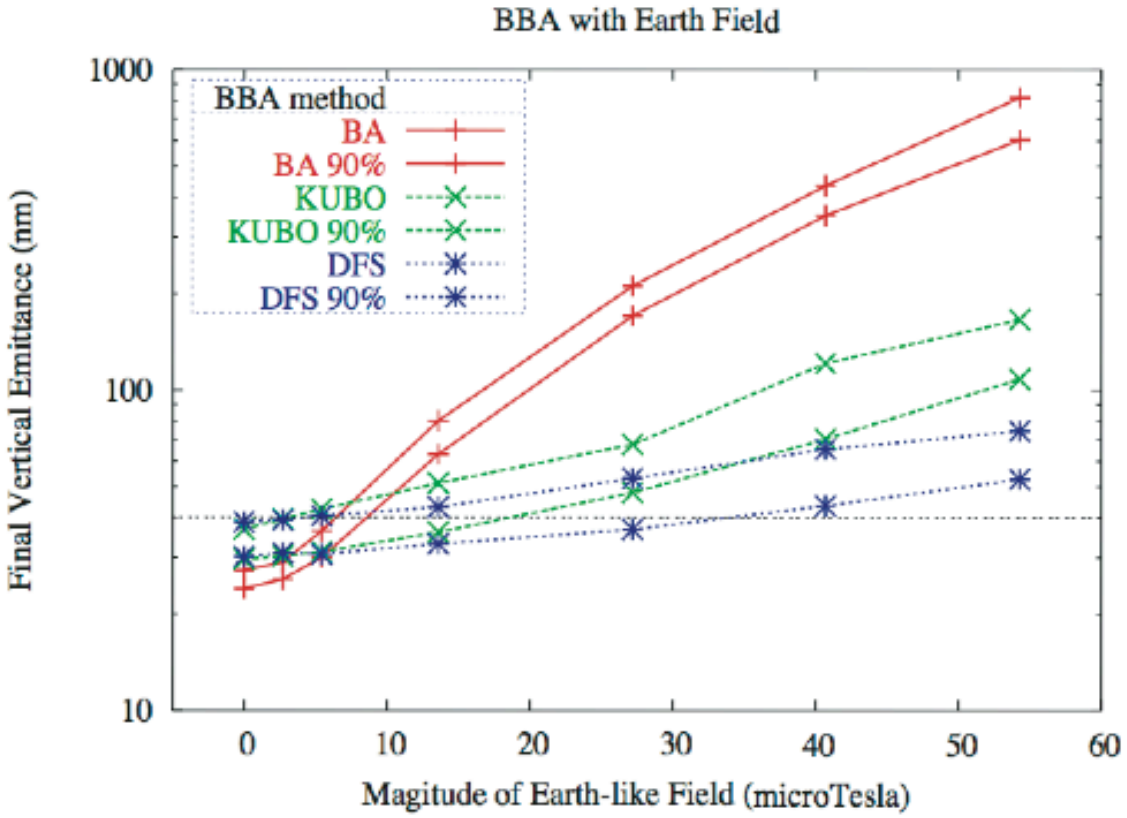


Polarization



Spin orientation

Modeling of beam transport in main linac



Effectiveness of beam-based alignment in the presence of earth-like magnetic field

J.Smith

Summary of ILC R&D Plans
(and LEPP qualifications)

1. Helical Undulator for Positron Source
   [Pulsed undulator for E166,
   Superconducting wigglers and anti-solenoids for CESR-c]

2. Damping Ring
   (pulser/kicker, wiggler, instrumentation, modeling, CesrTF)
   [Pulsed electronics, (gun pulser), CESR stripline feedback kicker,
   Superconducting magnets, wigglers, quadrupoles, solenoids,
   Modeling code, extensively tested in application in CESR,
   Bunch by bunch instrumentation in CESR,
   (beam size, position, luminosity,tune),
   Operational experience]

3. Low Emittance Transport - damping ring to final focus
   [Modeling code extended to include linac elements,
   Expertise implementing beam-based alignment in CESR]