Accelerator Research Department A

Groups:

- Lattice Dynamics
- Collective Effects
- Advanced Beam Concepts
- Advanced Electronics
- RF Structures
- High Power RF

Lattice Dynamics Group

April 12, 2003

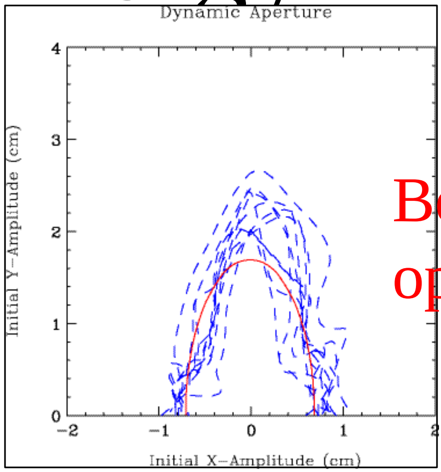
Yunhai Cai, Tom Knight, Martin Lee,
Yuri Nosochkov, Yiton Yan

Current Activities

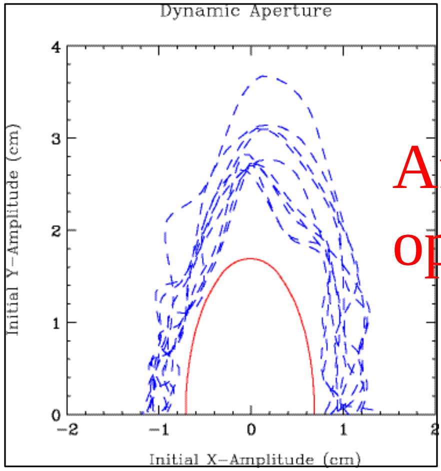
- Improve the performance of the PEP-II
  - Design lattice for the upgrades
  - Analyze and correct the machine optics
  - Simulate electron cloud instability and the beam-beam interaction
- Develop and maintain the object-oriented computer programs: LEGO and Zlib
- Study the long-range beam-beam effects in the Tevatron at Fermilab

Low-momentum-compaction Lattice (High Energy Ring)

- Makes 16% shorter bunch for a potential gain of the luminosity
- 90^0 phase advance
- Stronger lattice requires better optimization of chromaticity to enlarge the dynamic aperture



Before optimization

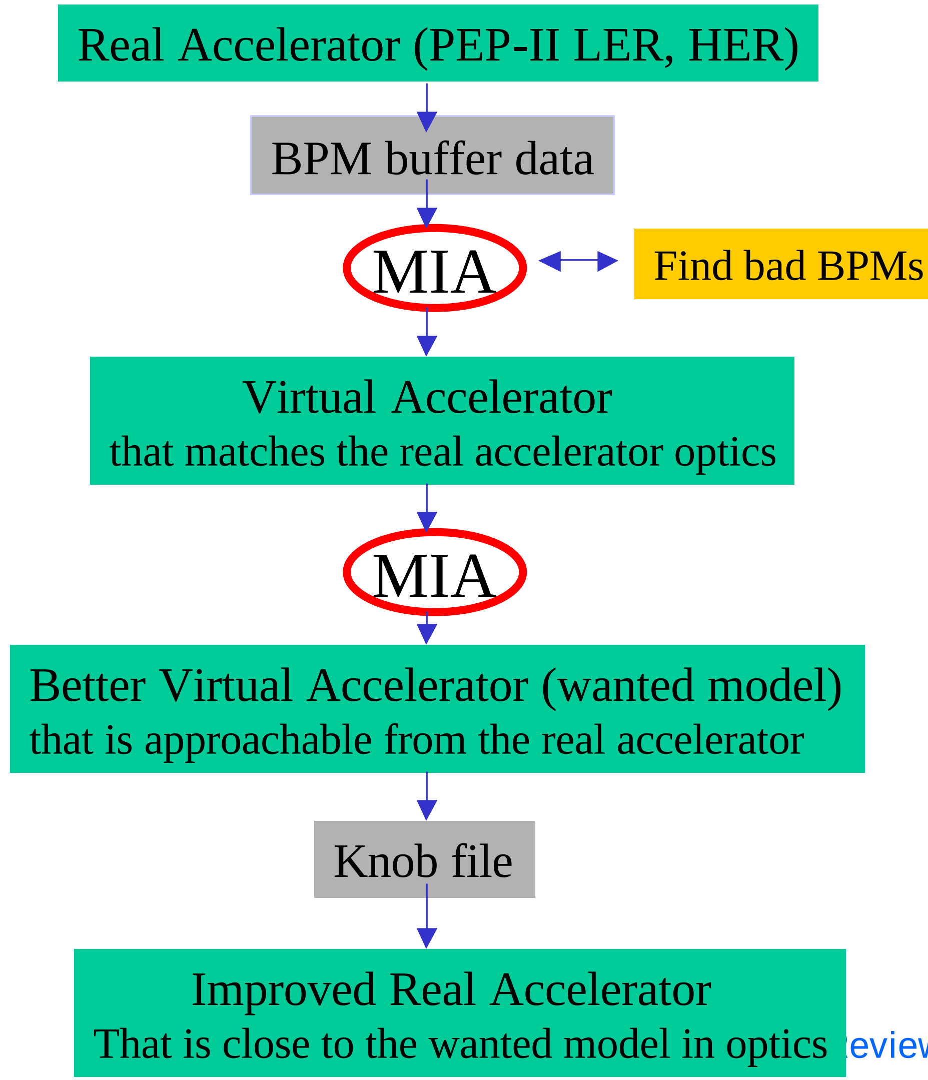


After optimization

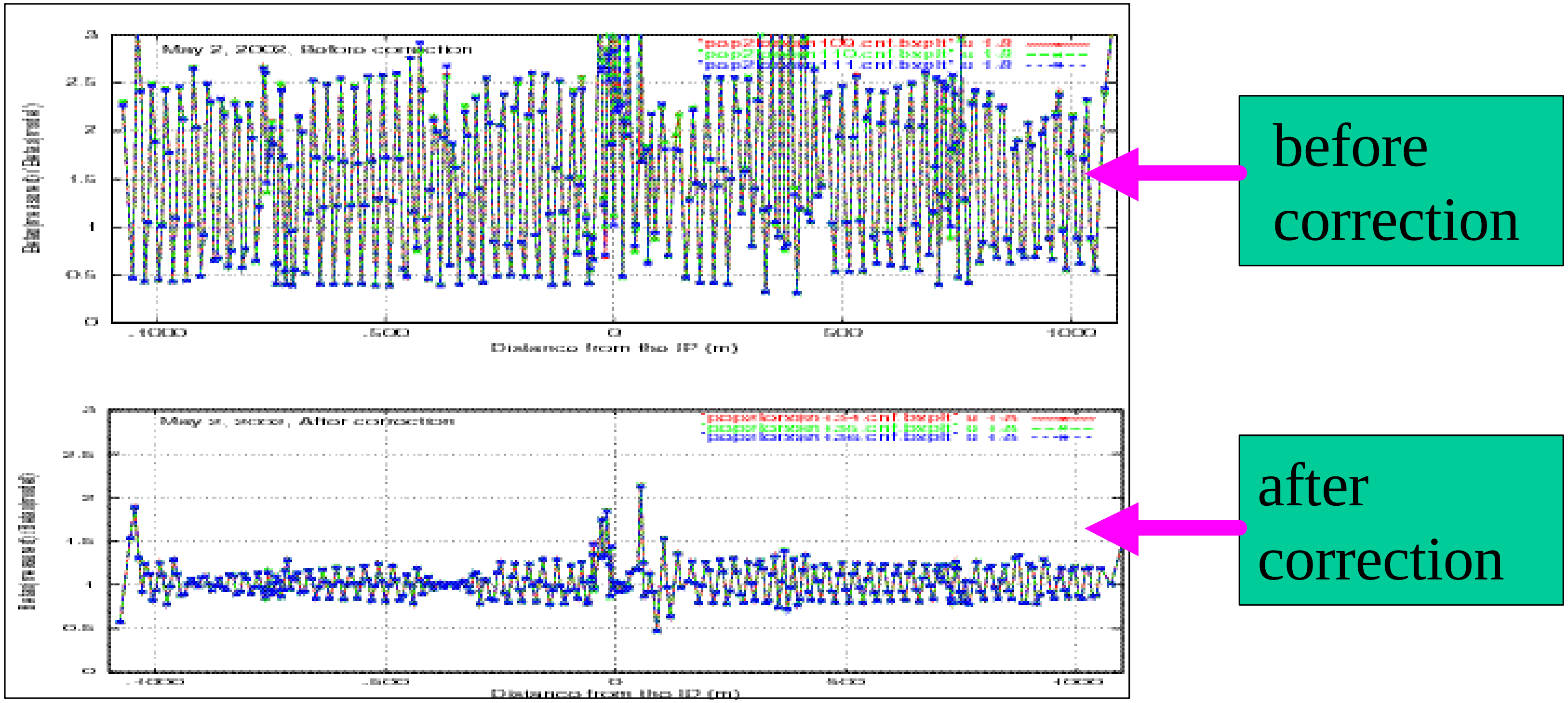
Model Independent Analysis

With a Model-Independent Analysis (MIA) of the massive BPM buffer data, we are able to obtain a computer virtual accelerator that matches the real accelerator optics.

An approachable better-Optics (wanted) model can then be obtained by adjusting (fitting) a limited amount of well selected magnets and tested in the real accelerator.



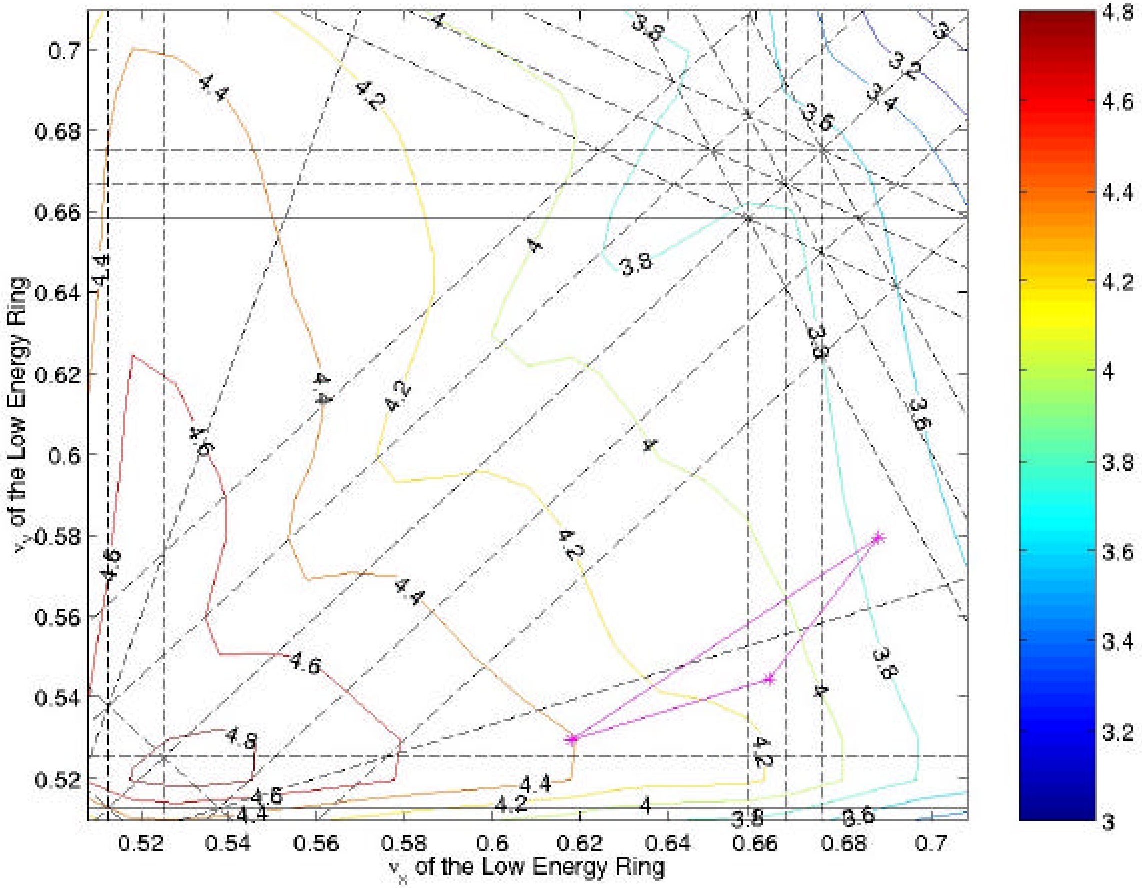
β Beating in the Low Energy Ring



The horizontal β beating was reduced from 250% to 30% near the half integer resonance in May, 2002.

Search of a Better Luminosity

Single bunch luminosity (10^{30} cm^{-2} s^{-1})



Electron Cloud Instability

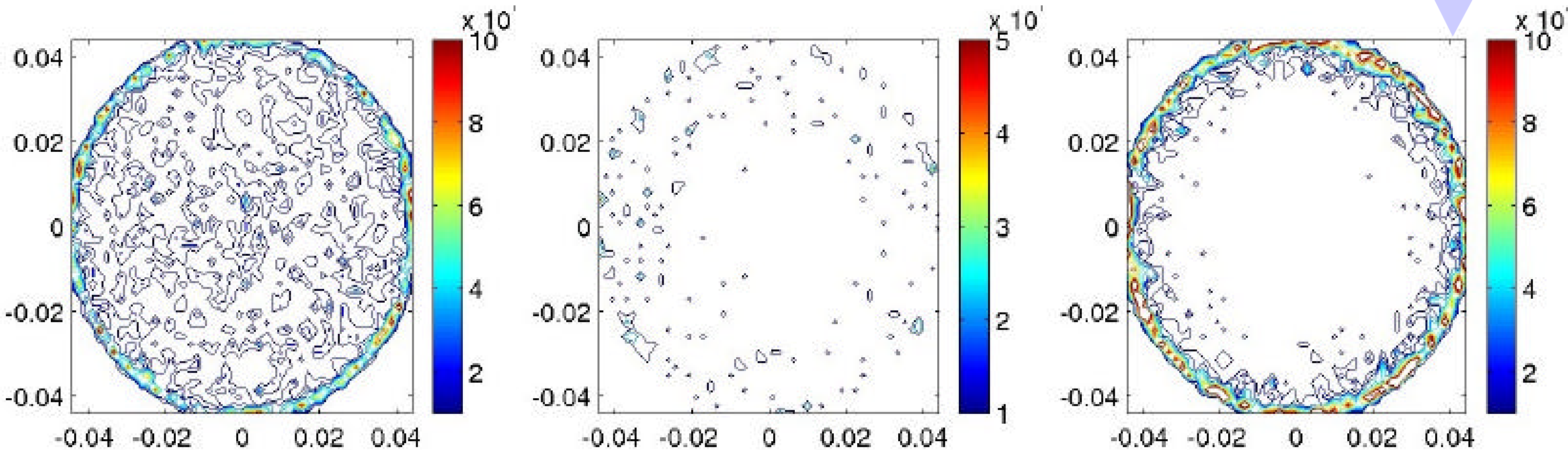
Simulation of generating electron cloud in the presence of solenoid field is carried out recently for the PEP-II.

Resonance condition:

$$T_c / 2 = b_s / c$$

$$T_c = 2p \frac{mc}{eB}$$

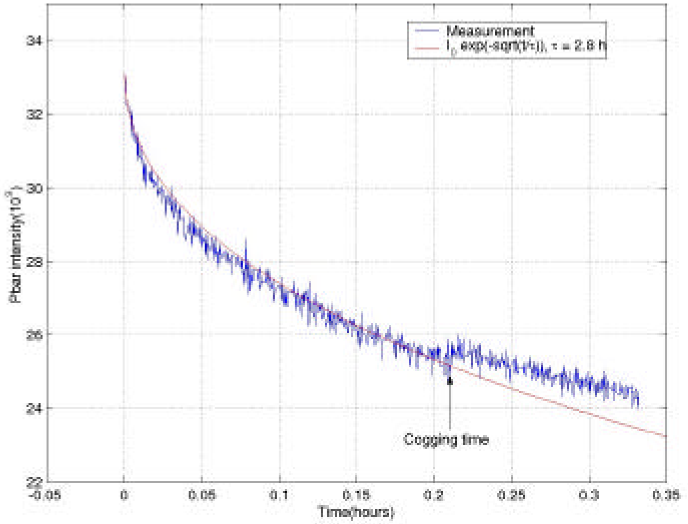
No solenoid　　　10 Gauss　　　20 Gauss



Antiproton Lifetime at Injection of Fermilab Tevatron

- Lifetime is about 1 hour
- Without the presence of the proton beam, the lifetime is about 20 hours
- 72 parasitic beam-beam crossings on the helical orbits
- 20% beam loss during half-hour injection

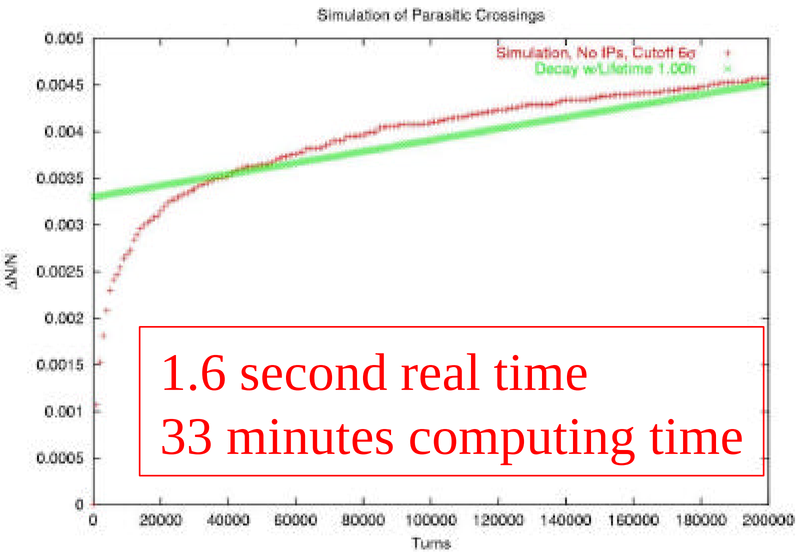
Antiproton loss after the injection of the first bunch



Tevatron Lifetime Simulation

- Parallel strong-weak
- 10^6 particles-turns/second speed
- Runs on about 100 processors at NERSC
- 6D linear maps extracted from the Tevaron lattice
- Includes synchrotron oscillation

Simulation when the beam emittances are three times larger than the measured values



Future Work(FY 2003, 2004)

- Create better lattices near half integer with lower β^* for the PEP-II
- Simplify the tuning procedure for higher luminosity of PEP-II
- Continue the MIA work to improve the machine optics for the PEP-II
- Simulate more realistically the beam lifetime in the Tevatron at Fermilab
- Simulate the combined effects of the electron cloud and beam-beam interaction

The **Collective Effects Group** focuses on studies of instabilities and impedances in circular and linear accelerators, as well as general accelerator research.

Karl Bane

Alex Chao

Paul Emma

Sam Heifets

Zhirong Huang

Gennady Stupakov

Bob Warnock*

*retired

Recent and current topics of research (2002)

- Electron cloud effects in PEPII and NLC damping rings.
- Code development (LIAR, shielded coherent synchrotron radiation [CSR])
- Intra-beam scattering and impedance effects in rings.
- Roughness impedance in the LCLS undulator.
- **Microbunching instability due to CSR in rings (NLC) and bunch compressors (LCLS)**
- Study of design issues for LCLS
- Experiment on SPPS
- Space charge effects in plasma sources

Microbunching instability due to CSR in rings (NLC) and bunch compressors (LCLS)

•Shorter electron bunches and higher peak current characteristic for modern accelerators make the beam prone to effects of the coherent synchrotron radiation (CSR).

•The CSR may lead to the microwave instability producing longitudinal modulation of the bunch with wavelengths small compared to the bunch length.

•A linear theory of microwave modulation has been developed that takes into account incoherent energy spread and finite emittance of the beam (Heifets, Stupakov. PRST-AB, 2001).

•The theory was confirmed experimentally at the ALS in LBL.

Experimental observation of CSR Instability at ALS (J. Byrd et al. PRL, 2002)

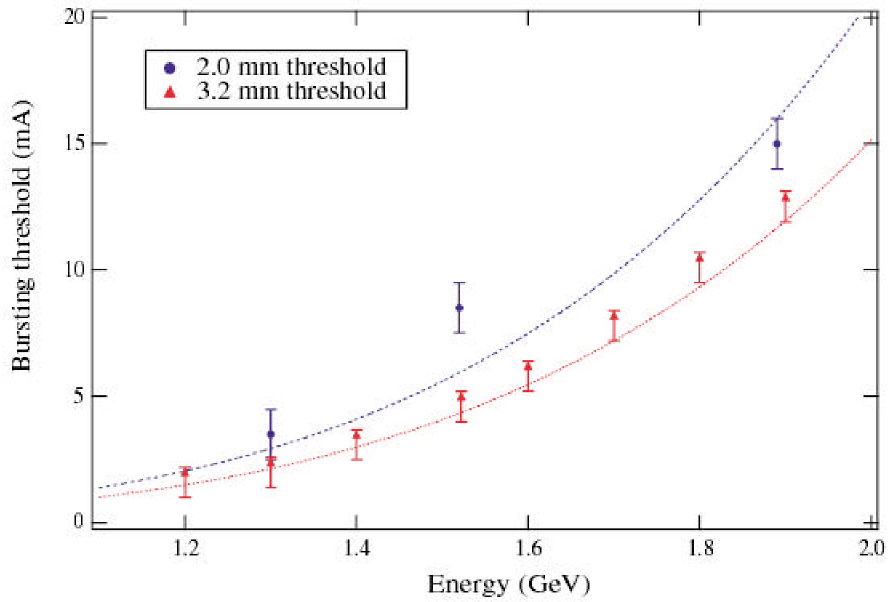
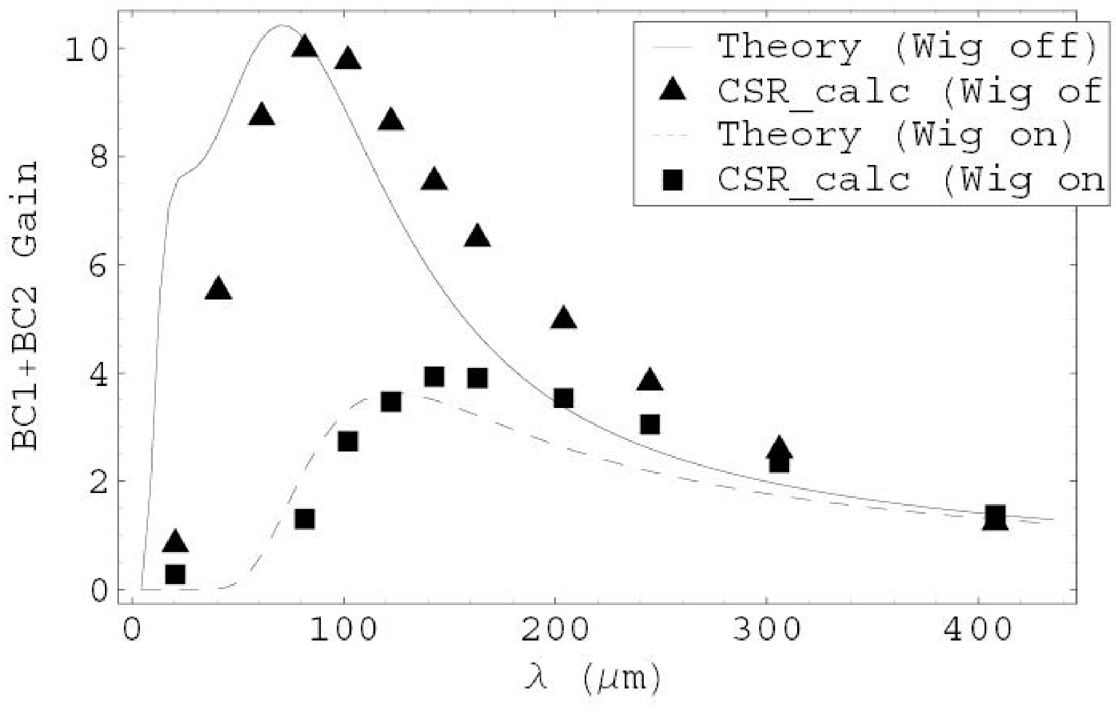


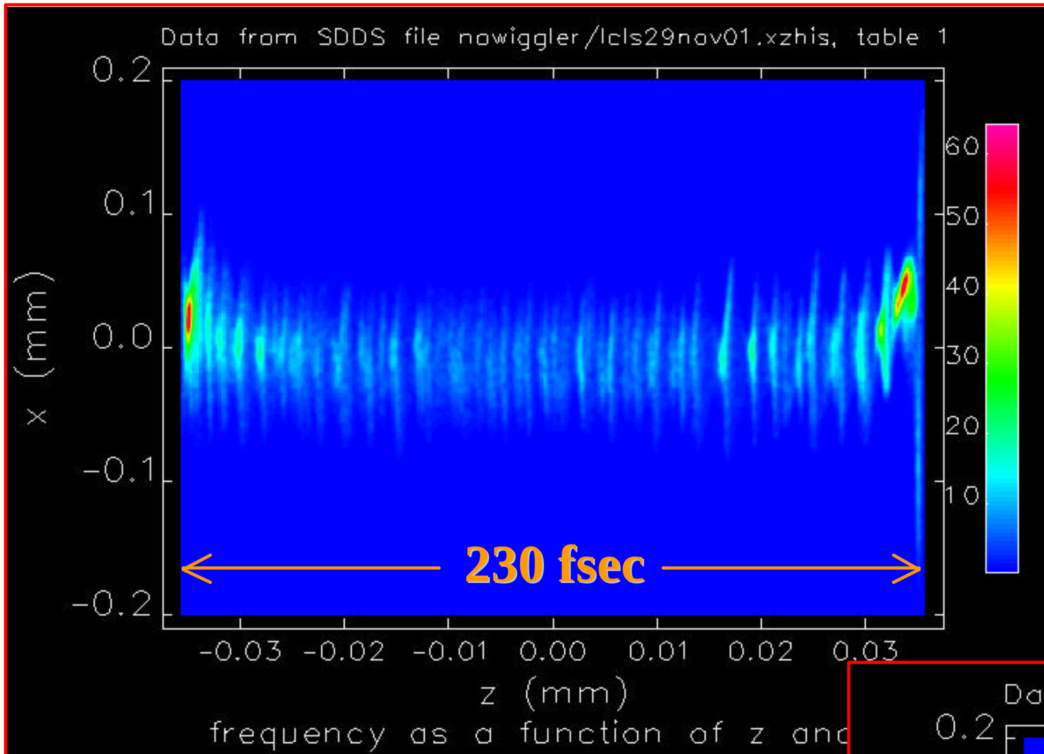
FIG. 4 (color online). Bursting threshold as a function of electron beam energy at 3.2 and 2 mm wavelengths. Data are shown as points. Calculated threshold using nominal ALS parameters at 3.2 and 2 mm wavelengths are shown as dashed lines.

The same instability may result in the microbunching of the LCLS beam in the bunch compressor (S. Heifets, S. Krinsky, G. Stupakov , PRST-AB, 2002; Z. Huang and K.-J. Kim, PRST-AB, 2002).



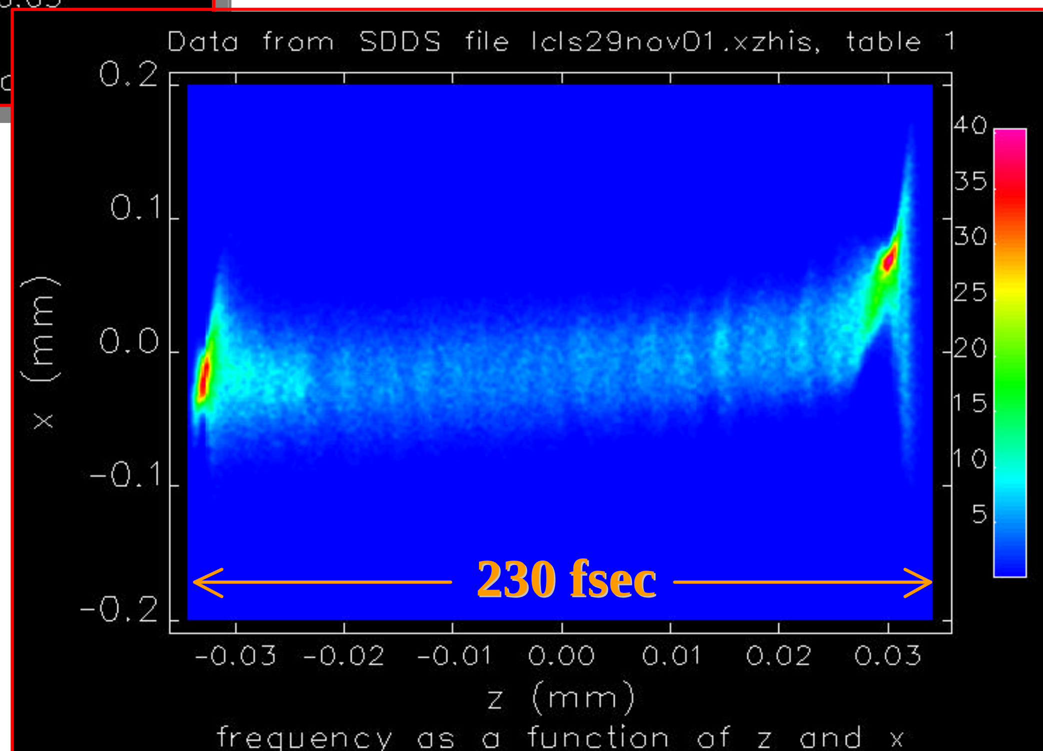
Gain factor G as a function of wavelength λ of the perturbation in the LCLS bunch compressor, $\sigma_\delta=3\cdot10^{-6}$, ε=1 μm. Solid line – theory, dots – simulations.

Micro-bunching induced by coherent synchrotron radiation (CSR) in *LCLS* bunch compressors



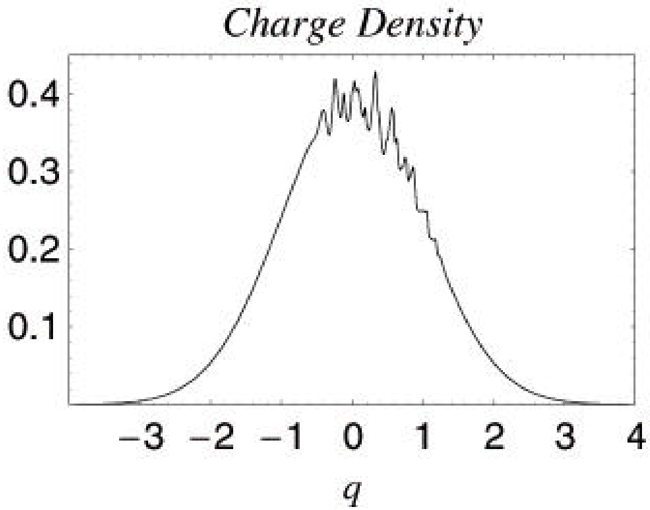
Electron bunch (*x* vs. *z*) with incoherent energy spread of 8×10^{-6} at 14.3 GeV

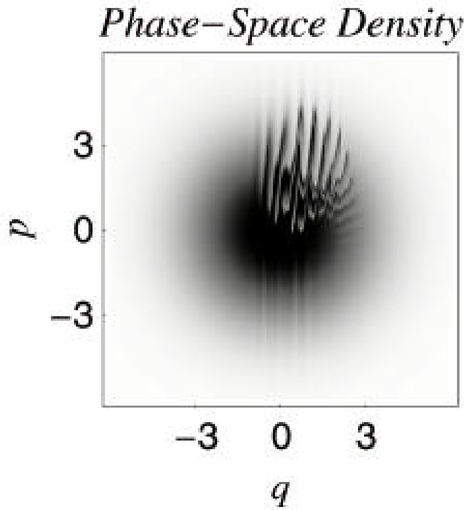
Same bunch, (*x* vs. *z*) with energy spread increased to 8×10^{-5} providing suppression of micro-bunching



Courtesy P. Emma

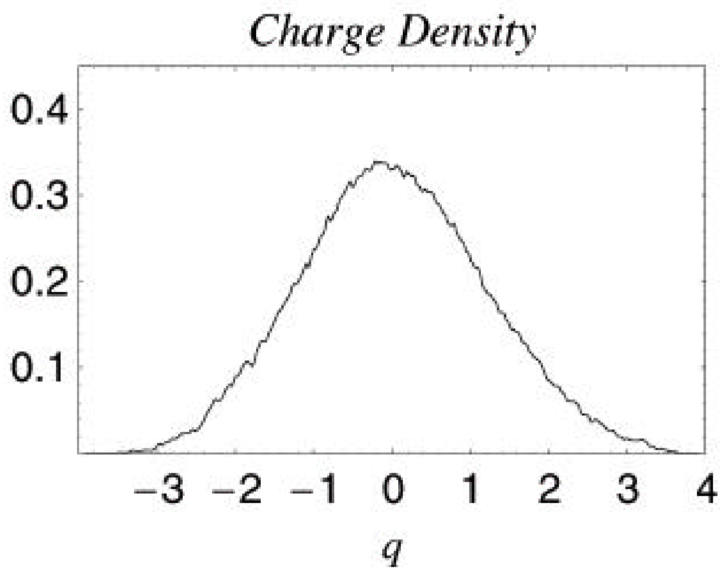
Nonlinear regime of the CSR instability is studied by time-domain simulations using a Vlasov equation solver (M. Venturini and R. Warnock, PRL, 2002)

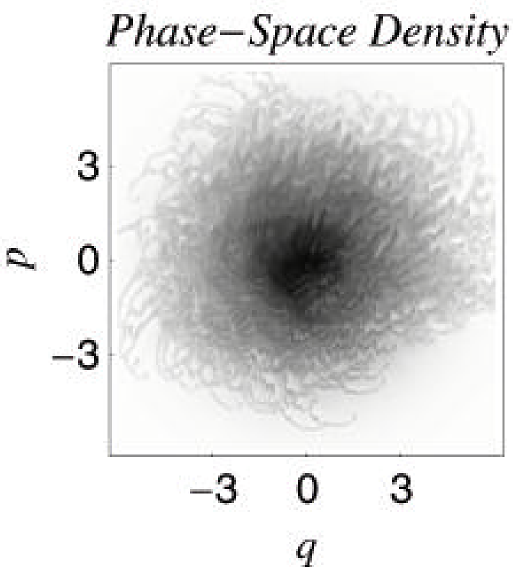




Onset of instability developing from initial noise after a fraction of synchrotron period.

Distribution after 1.5 synchrotron oscillation periods.

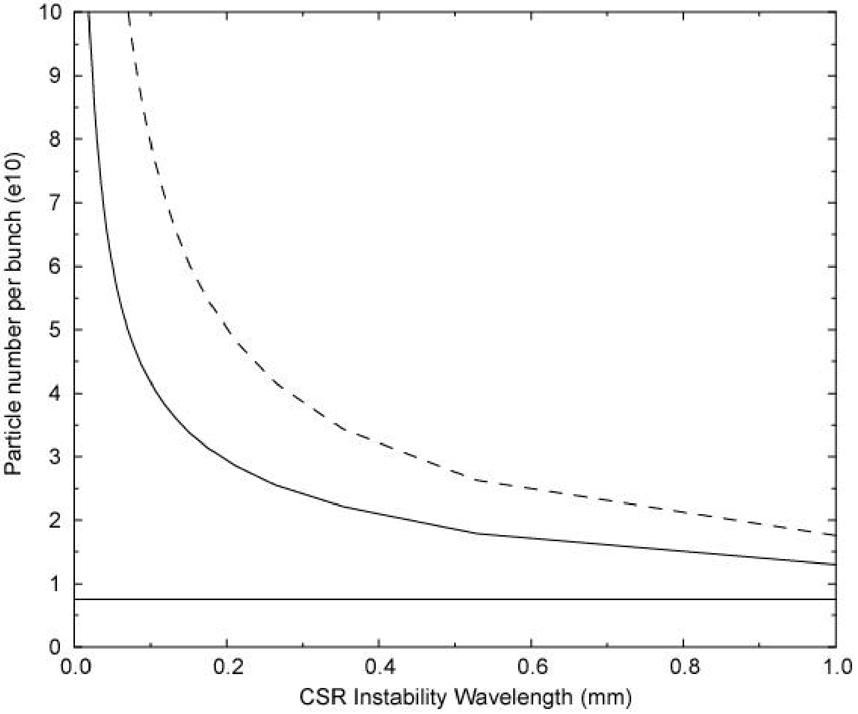




Saturation of instability causes smoothing of microbunching and enlargement of rms bunch-length.

Nonlinear analysis demonstrates bursting of the instability, in qualitative agreement with experiment.

The CSR instability is studied for the NLC damping rings, with strong wigglers (J. Wu, T. Raubenhemer and G. Stupakov, in preparation).



Instability threshold for the NLC damping ring as a function of wavelength.

Expected progress in FY 2003-04

- Shielding effects in CSR microbunching instability.
- Study of energy chirped beam for generation of femtosecond X-ray pulses in LCLS
- Study of design issues for LCLS
- Participation in experiments on SPPS
- Theoretical analysis of vacuum laser acceleration
- Collective effects in PEP-II upgrades

Astro Beam Studies Group

March 28, 2003

- Particle Astrophysics and Cosmology

Pisin Chen (Group Leader)

John Irwin, Johnny Ng, Kathy Thompson,

Kevin Reil, Marina Shmakova, Aleksandr Yashin

Particle Astrophysics and Cosmology

- Laboratory Astrophysics
  (Pisin Chen , Johnny Ng, Kevin Reil)
- FLASH (Fluorescence from Air in Showers)
  (Pisin Chen , Johnny Ng, Kevin Reil)
- Unruh Effect (Pisin Chen, Aleksandr Yashin)
- Gravitational Lenses (study of mass distribution in the galaxy clusters) (John Irwin, Marina Shmakova)
- Early Universe Simulation Code
  (Pisin Chen, John Irwin, Kathy Thompson, Marina Shmakova)
- Theoretical Studies of Black Holes, Early Universe Cosmology, Dark matter and Cosmic Rays (Pisin Chen , John Irwin, Kathy Thompson, Marina Shmakova)

Particle Astrophysics and Cosmology

- Ultra High Energy Cosmic Rays
- Nature of Dark Energy and Dark Matter in the Universe
- Fundamental issues related to Black Hole Physics and Unruh Radiation

Scientific Motivation for Laboratory Astrophysics Experiments

- Frontier astrophysical phenomena involve extremely complex physical conditions
- Progress requires joint efforts in observation and sophisticated computer simulations

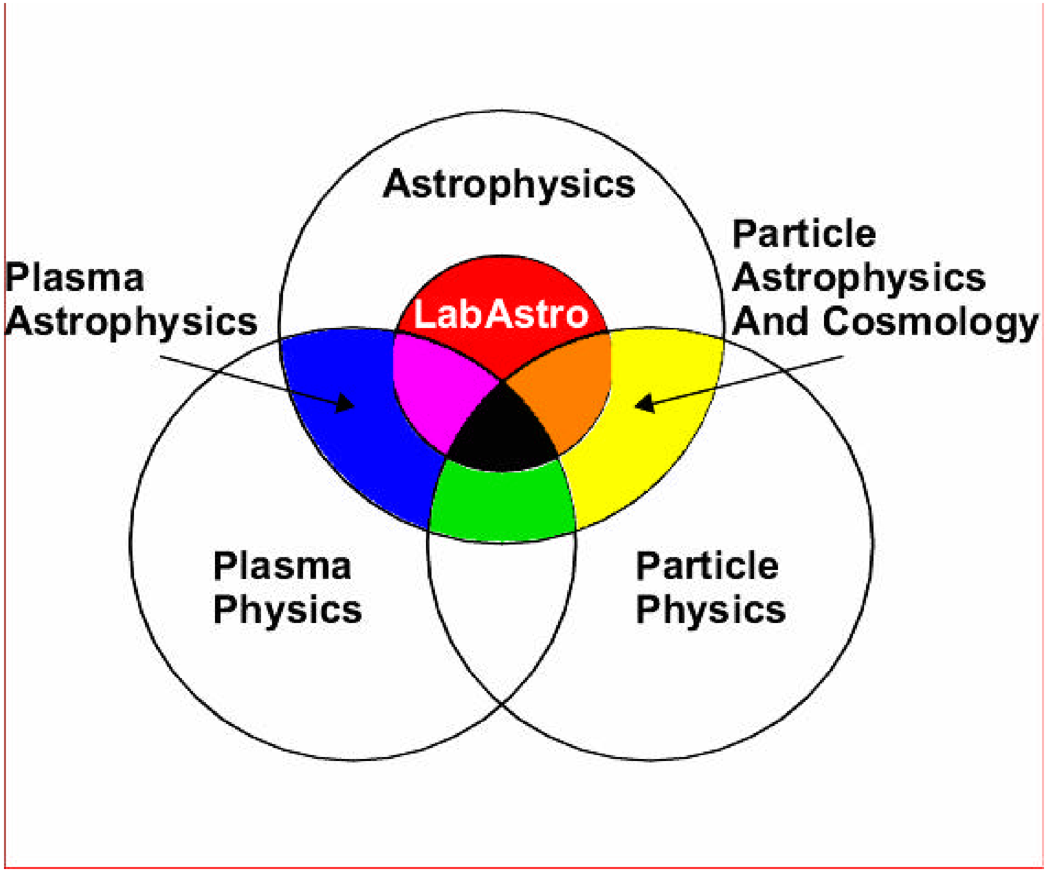
→ Gain insights into the underlying physics through controlled laboratory experiments

→ Investigate instrumentation effects.

→ Bench mark large-scale computer simulations.

Laboratory Astrophysics

- LabAstro is the overlapping of Astrophysics, Particle and Plasma Physics.
- The lab can be used to calibrate astrophysics instruments, test underlying dynamics and probe into fundemental physics.



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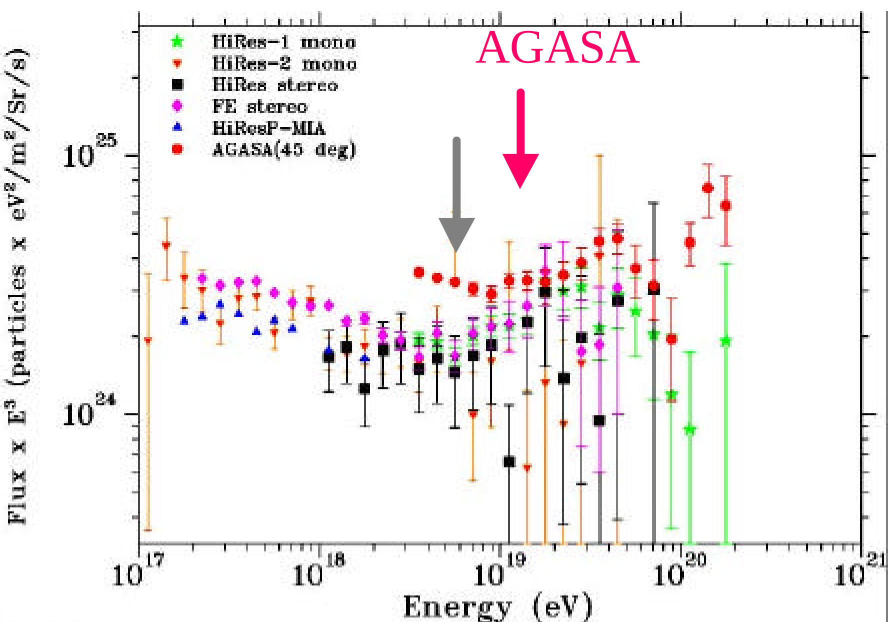
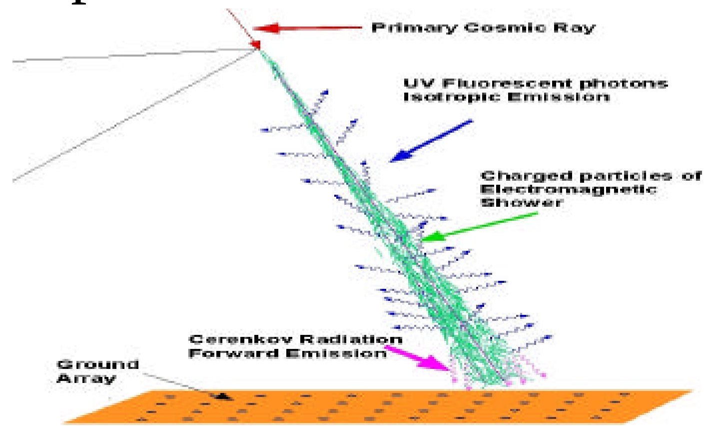
Astro-Beam Studies Group: ARDA

Discrepancy in the UHECR spectrum:



HiRes

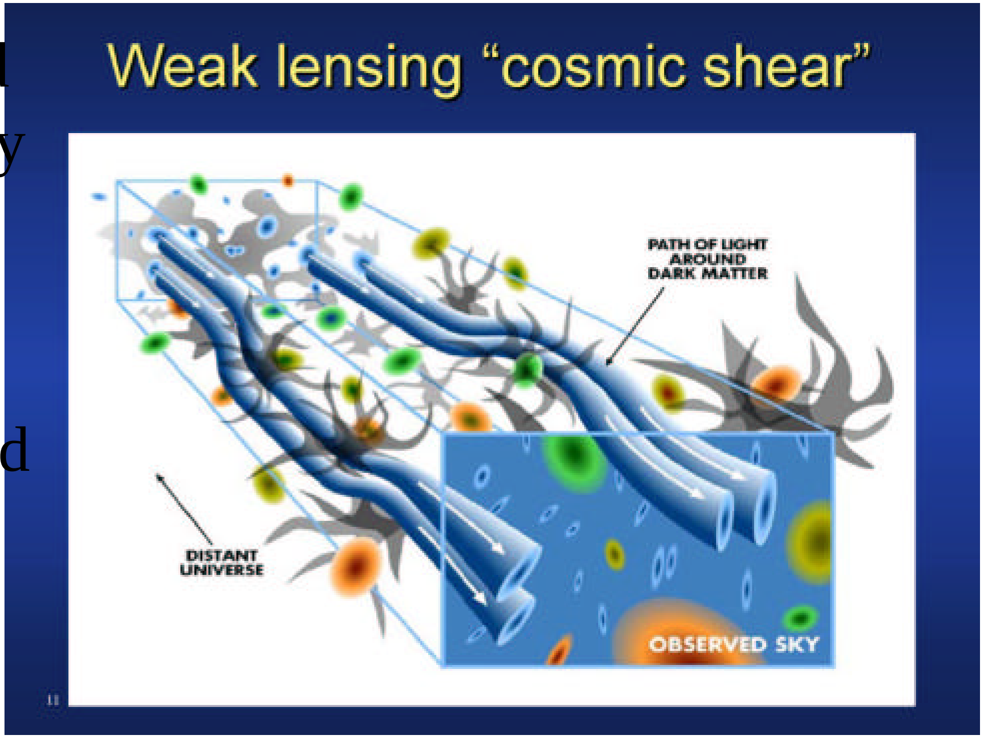


The SLAC beam can create an E/M shower analogous to a cosmic ray shower. A calibration on energy scale can then be performed.

Gravitational Lensing Or Cosmological "Final Focus" Systems

John Irwin & Marina Shmakova

- Mapping of the dark matter and dark energy may be achieved by applying math methods used in beam optics. By examining the higher moments of images arriving at earth the location and mass of small clusters of dark matter can be determined.



Early Universe Simulation Code

Pisin Chen, John Irwin, Kathy Thompson, Marina Shmakova

GOAL: Develop a master code to track the development of the universe.

- Reheating => particle production => start of “standard big bang”
- Imprinting of fluctuations of cosmic microwave background
- Development of large scale structure
- Formation and evolution of black hole distribution in universe
- Black hole remnants (posited as the end stage of black hole evaporation) as a dark matter candidate

to obtain predictions to compare with observations.

Methods: Development and Adaptation of N-body, Particle-mesh, Lattice codes and existing CMB codes

Theoretical Studies of Black Holes, Early Universe Cosmology, Dark matter and Cosmic Rays

Pisin Chen, John Irwin, Kathy Thompson, Marina Shmakova

- The Generalized Uncertainty Principle and Black Hole Remnants
- Cosmology of Black Hole Remnants and Dark Matter
- Fundamental Length Problem
- Cosmological Models based on supersymmetric and higher dimensional models

Pisin Chen, Toshiki Tajima, Yoshiyuki Takahashi, **Plasma Wakefield Acceleration for Ultrahigh Energy Cosmic Rays, Phys.Rev.Lett. 89 (2002) 161101**

Pisin Chen , R. J. Adler, **Is Dark Matter actually Black? (to be published)**

Pisin Chen , R. J. Adler, **Black Hole Remnants and Dark Matter, gr-qc/0205106**

R. Kallosh, A. Linde, S Prokushkin, M. Shmakova **, Supergravity, Dark Energy And The Fate Of The Universe, Phys.Rev.D66:123503,2002**

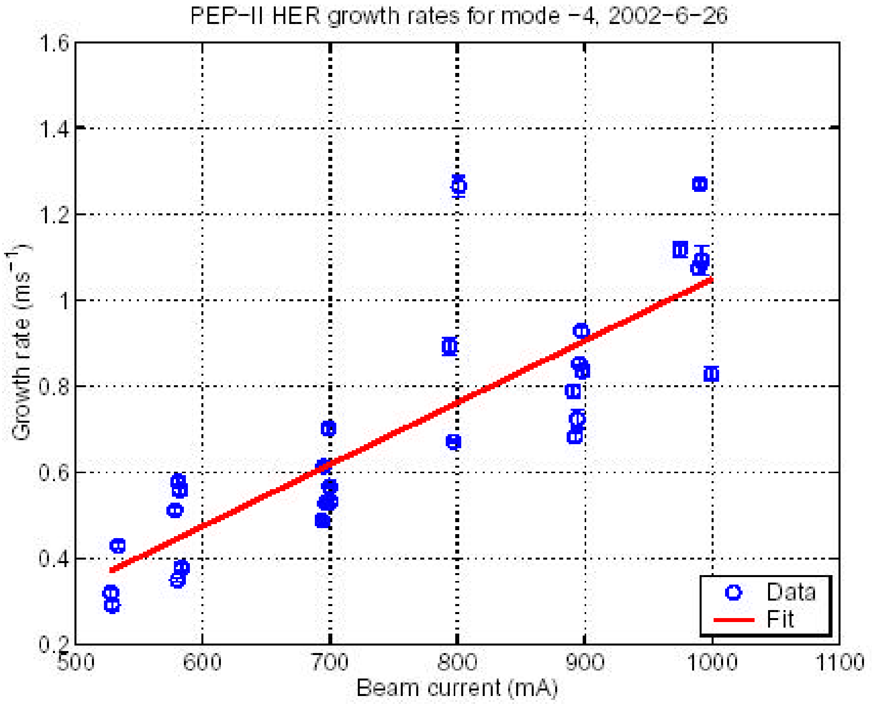
Electronics Research - ARDA -

DOE Review 4/03

L. Beckman, J. Fox, N. Hassanpour, M. Tobiyama, D.Teytelman

Electronics Research

- particle beam dynamics and instabilities
- technology development
- fast signal processing and feedback control systems.
- SLAC staff, Stanford Ph.D. students and collaborator/visitors



Ongoing Projects

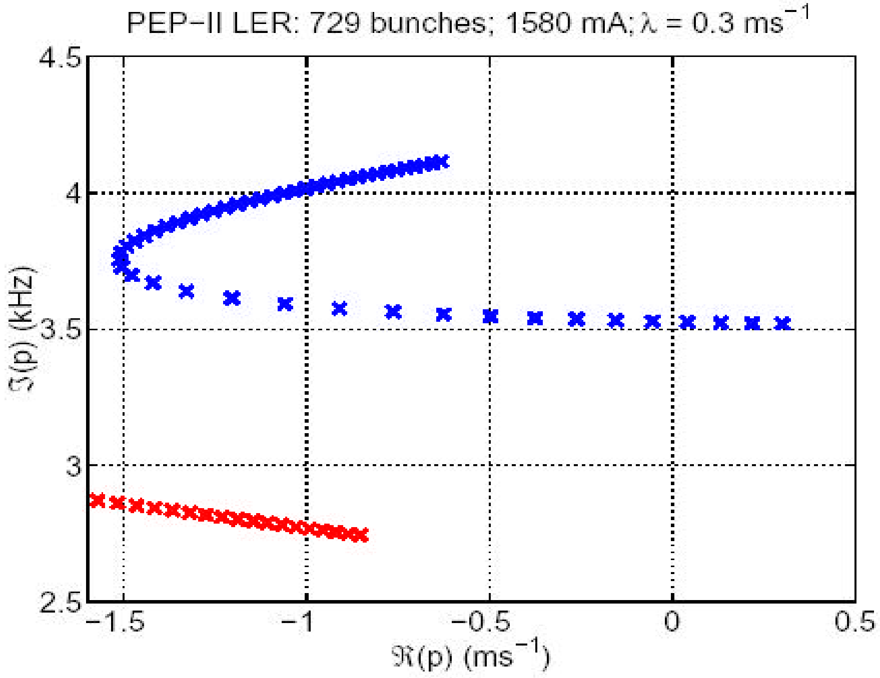
PEP-II RF systems and Longitudinal instabilities

- PEP-II machine studies, growth rate measurements
- studies show that the effective impedance from the RF cavities is 5 to 20X expected from LLRF design - Why?

Ongoing Projects, continued

High-current stability predictions -

- LER and HER measurements
- predict operating conditions for the LLRF and instability growth rates for higher-current upgrades and new operating configurations

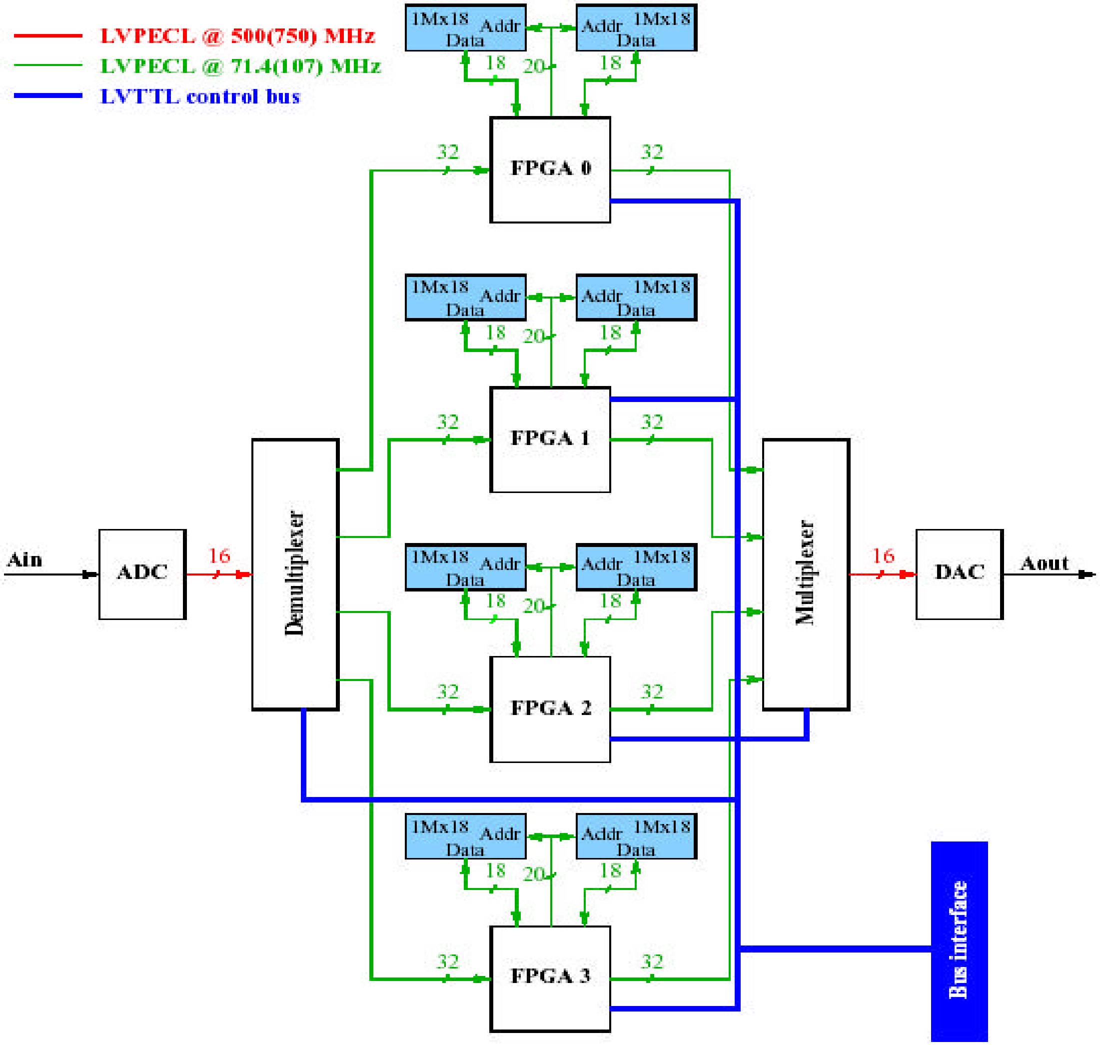


low-group delay Woofer channel model

- prototyping, measuring, and modeling
- low-mode "woofer" feedback path to control impedances in the RF system.
- programmable 12-tap FIR filter
- lower group delay than the existing design
- greater flexibility in gain and phase margins configuration
- existing implementation is not useful for significantly higher anticipated PEP-II operating currents.

GBoard 1.5 GS/sec. processing channel

- Next-generation instability control technology
- SLAC, KEK, LNF-INFN collaboration - useful at PEP-II, KEKB, DAFNE and several light sources.
- Transverse instability control
- Longitudinal instability control
- High-speed beam diagnostics (1.5 GS/sec. sampling/ throughput rate)
- Builds on existing program in instability control and beam diagnostics.
- Significant advance in the processing speed and density previously achieved.



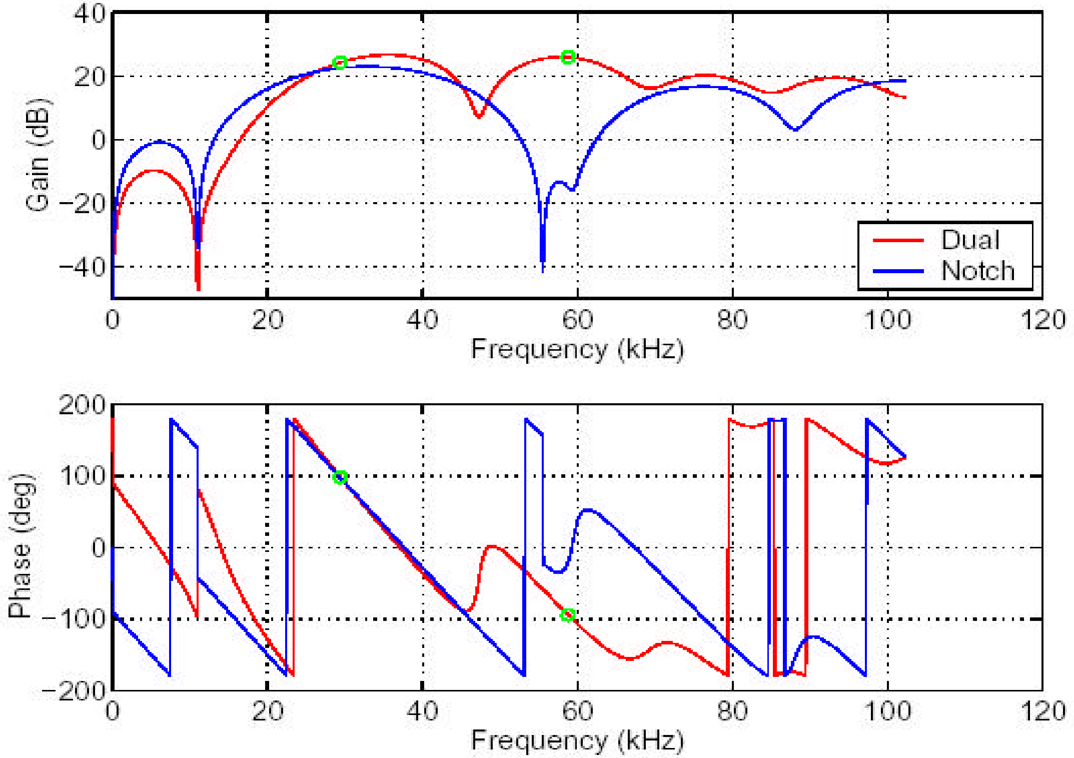
Quadrupole instability control

DAFNE e+/e-collider at LNF

- increased operating currents
- quadrupole mode longitudinal instabilities have appeared (the installed system suppresses the dipole modes).

We implemented a novel quadrupole control filter

- software programmability of the DSP farm
- two parallel control paths for dipole and quadrupole modes.
- quadrupole control has been successful, allowing a 20% increase in luminosity.



The flexibility of the software-configured control scheme allows this new function without any changes in the installed hardware.

Expected Progress in 2003/2004

PEP-II high-current commissioning -

- Measurement and control of bunch instabilities
- Analysis of the low-level RF systems and feedback stability.
- Test the low-group delay woofer channel, predict the performance limits of such control techniques.
- Commission and characterize the high-current damped-cavity kicker for PEP-II
- Design the low group delay woofer and control filter for production use in PEP-II, based on the experience from the lab evaluation model.

Quadrupole Mode Control Studies

- Follow-on DAFNE measurements of Quadrupole-mode instability control, expanding our initial results to include the electron ring. Publication on the general topic of dual-mode control feedback, with commissioning results.

GBoard Processing Channel

- Detailed design of the 1.5 gigasample (GBoard) processing channel (joint development project with KEK and LNF-INFN). Construct and evaluate critical high-speed functions of this architecture in FY2003, demonstrate key features at one of the labs in late 2003. For 2004 commissioning of a complete Gigasample/sec. feedback channel for routine use at a light source or collider.

Publications/Presentations at PAC-2003

D. Teytelman, “Survey of Digital Feedback Systems in High Current Storage Rings"(invited Talk)

L. Beckman, et al “Low-Mode Coupled-Bunch Feedback Channel for PEP-II”

F. Marcellini, et al “An Over-damped Cavity Longitudinal Kicker for the PEP-II LER”

Activity Report for RF Structures Group

Juwen Wang, Nicoleta Baboi, Gordon Bowden,
Roger Jones, Jim Lewandowski, Roger Miller
ARDA

In collaboration with High Power RF Group, NLC, ACD, Klystron, KEK

2003

Mission for RF Structures Group

Mission

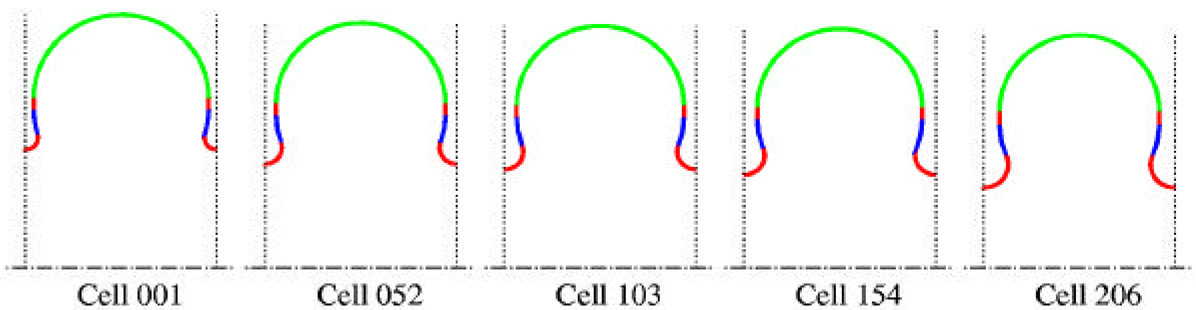
We design, engineer and test accelerator structures for future linear colliders operating under extremely high gradient conditions with superior properties in higher modes suppression.

The activities

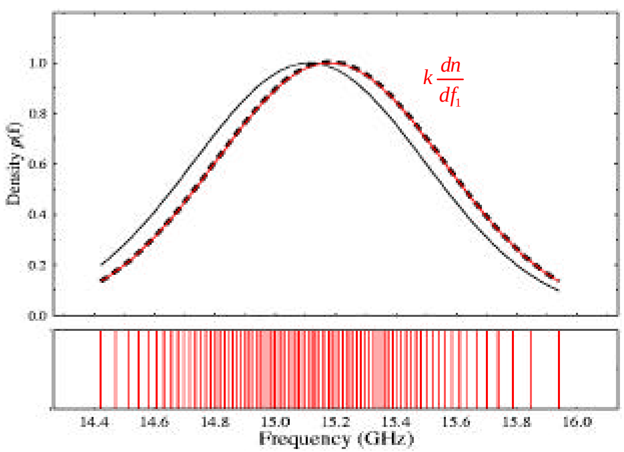
- Accelerator Theoretical Studies.
- Simulation and Computer Aided Accelerator Design.
- Mechanical Design.
- Fabrication Technologies Studies.
- Microwave Characterization.
- High Power Experiments.

Basic Structures for Dipole Mode Suppression

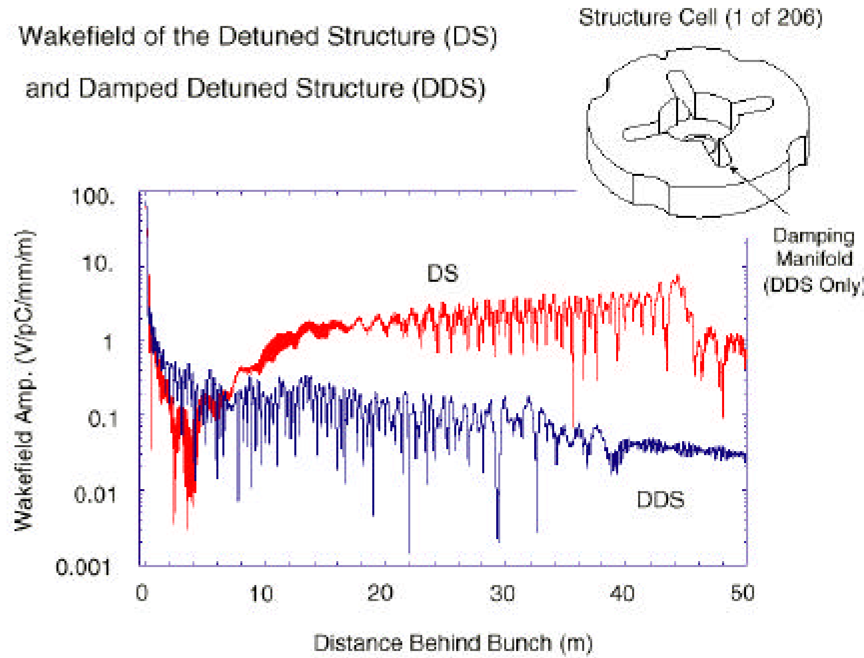
Cell profile for
Detuned Structure



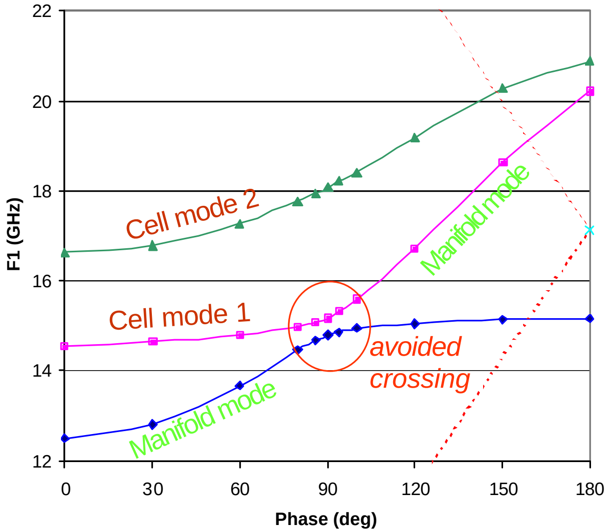
Dipole mode distribution
for Detuned Structure



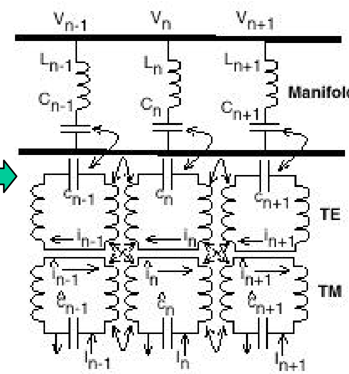
Dipole mode wakefields for
Detuned and Damped Detuned Structure



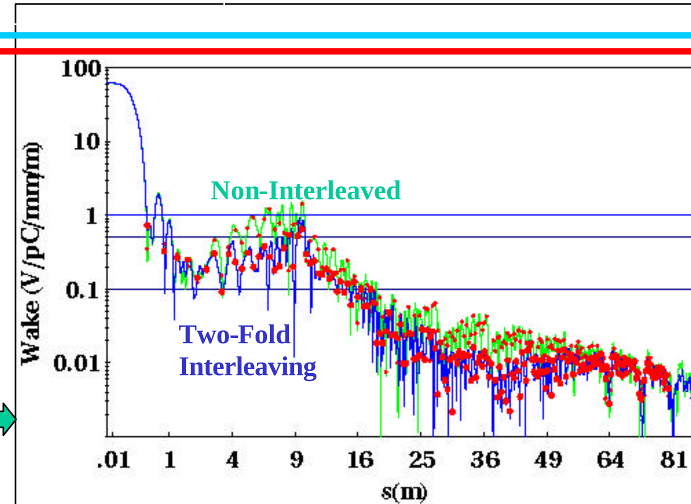
Long-Range Wakefield Simulation



- **Treat each cell as periodic**
- **Calculate 5 sample cells (MAFIA)**
  - ✓**Dispersion curves**
  - ✓**synchronous kick factor**
  - ✓**avoided crossing (coupling)**

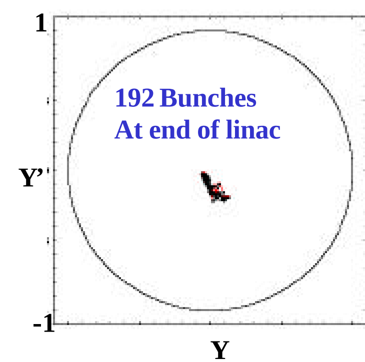


- **Fit dispersion curves of sample cells to obtain cell parameters**
- **Interpolate to obtain parameters of all cells**



H60VG3S17 wakefield simulation: Envelope of Two-fold interleaved and non-interleaved wakes (Bunch position indicated by dots)

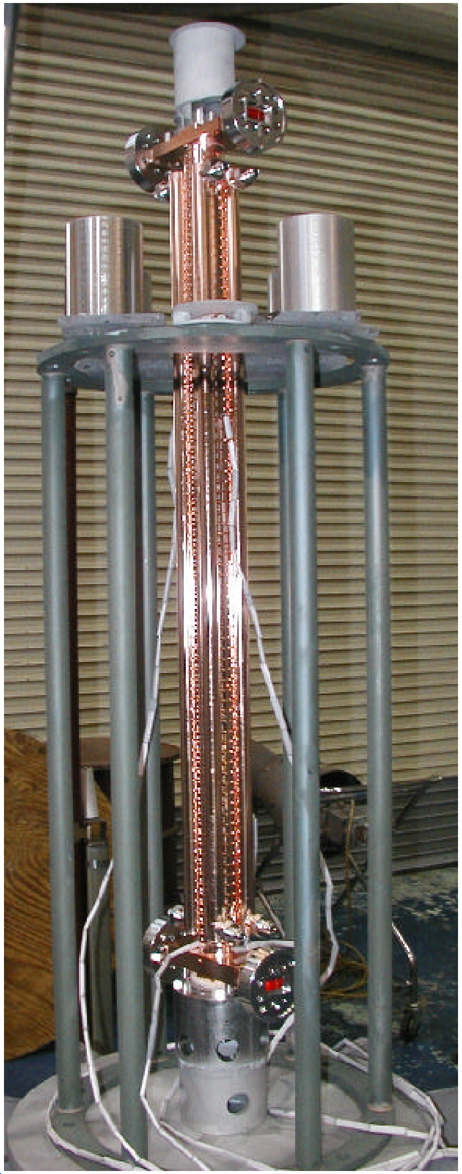
- Solve coupled circuit system
- Integrate spectrum for wake
  - ✓Optimize cell-manifold coupling
  - ✓Optimize "UN"-coupled spectrum

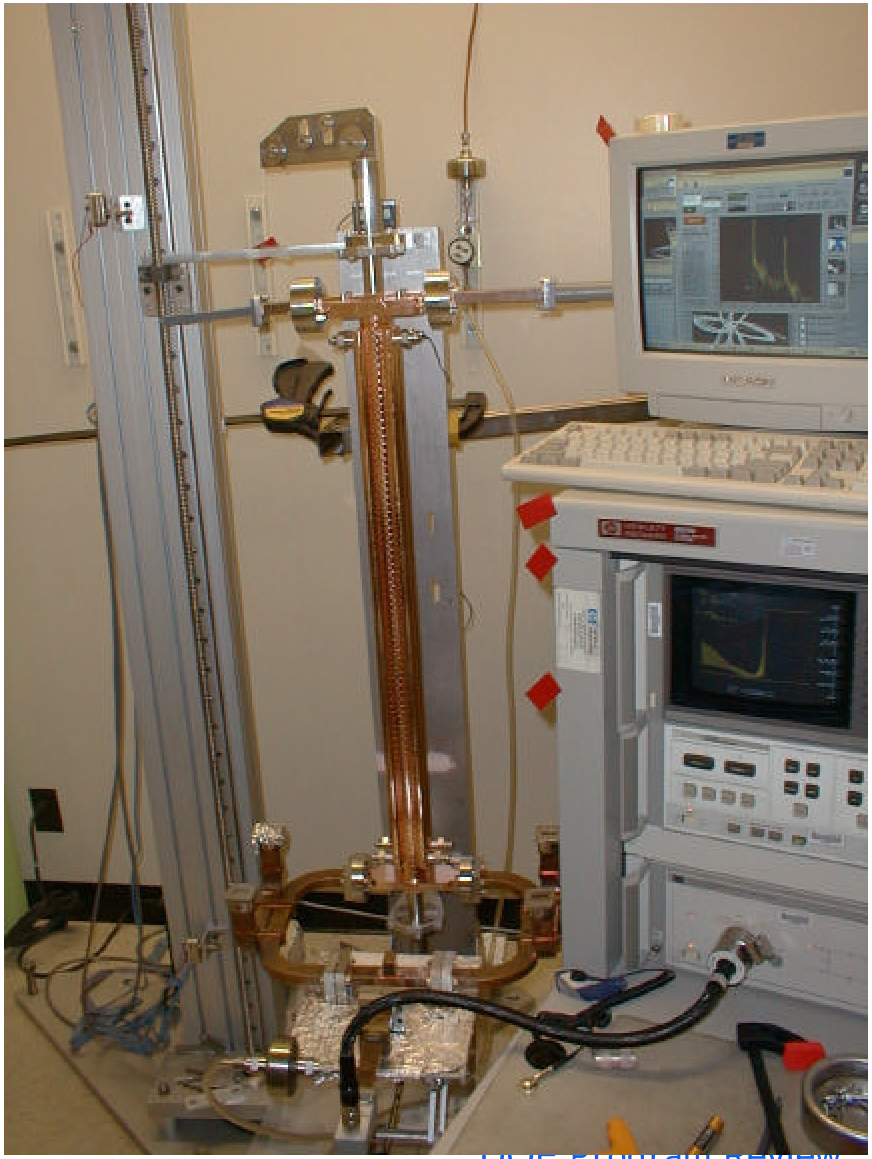


Phase space of particles at end of linac

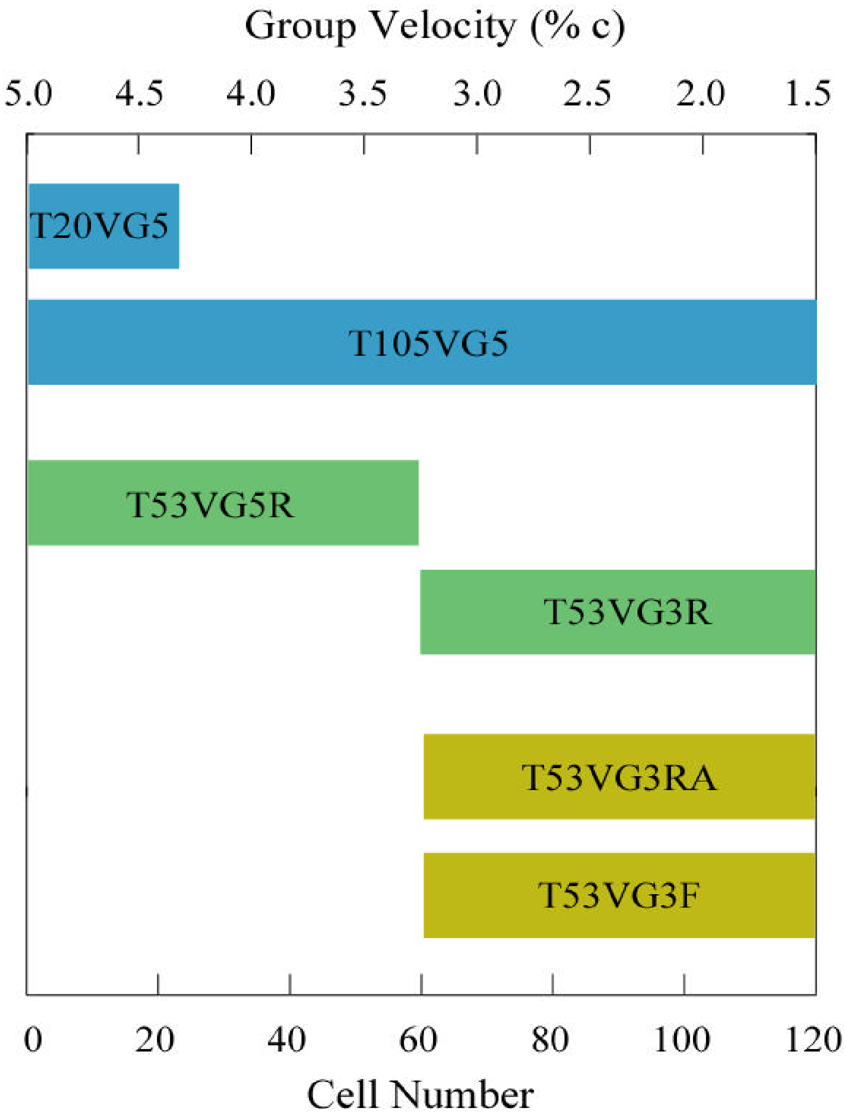
- Track bunches
- down linac
  - ✓**No BBU**
  - ✓**No emittance dilution**

Assembly Brazing and Microwave QC for H90VG3N





T-Series High Gradient Test Structures



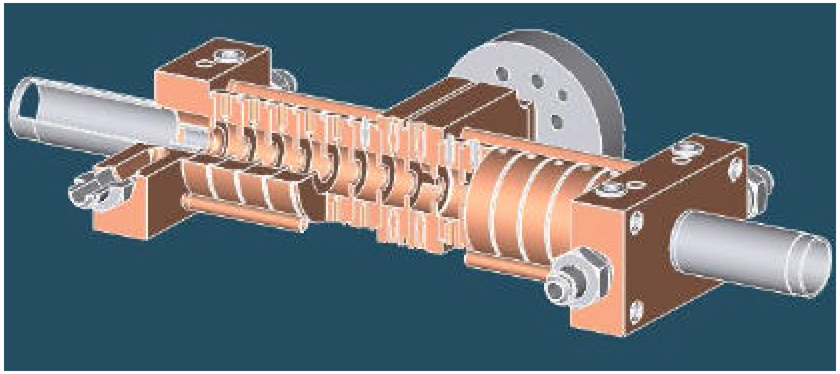
Number of Breakdowns to Process to ≈ 75 MV/m with 240 ns Pulses

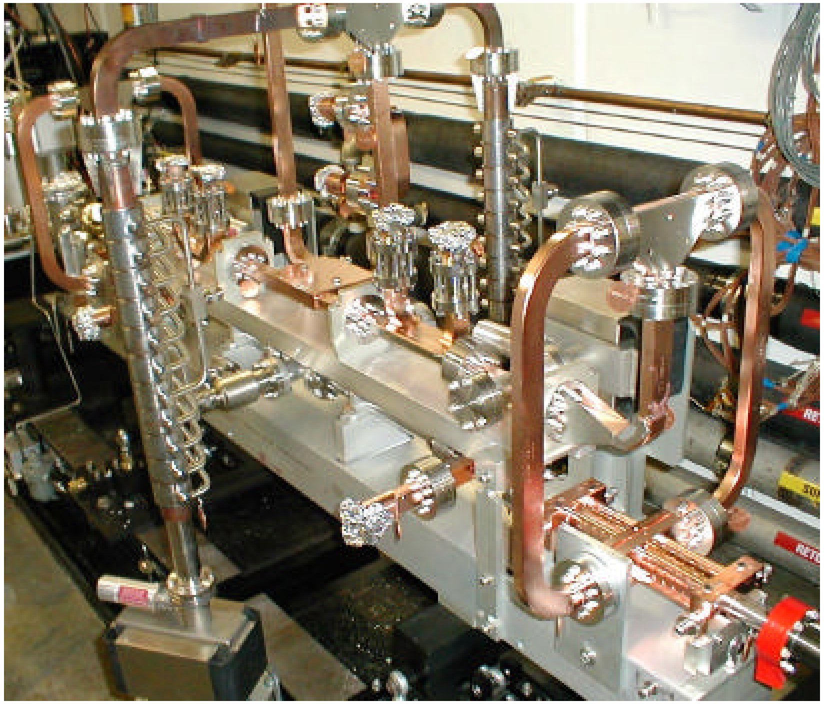
Structure	Number of Breakdowns	Cell Machining	Etch Depth for Cell Cleaning
T20VG5	4700	Diamond Turned	0.3 microns
T105VG5	3800		
T53VG5R	300	Conventionally Machined	3 microns
T53VG3R	350		
T53VG3RA	2500	Conventionally Machined	1.5 microns
T53VG3F	2400	Diamond Turned	No Etch

Standing Wave Structures

(15 Cells, 20 cm Long, 124 ns Field Rise Time)

- In NLC, standing-wave structures would operate at the loaded gradient of 55 MV/m.
- Of three pairs tested, one pair had breakdown rates of < 1 per 8 million pulses at this gradient and no discernable frequency change after 600 hrs of operation.
- Pulse heating in coupler likely limiting higher gradient operation – will be reduced for next test in May, 2003. .

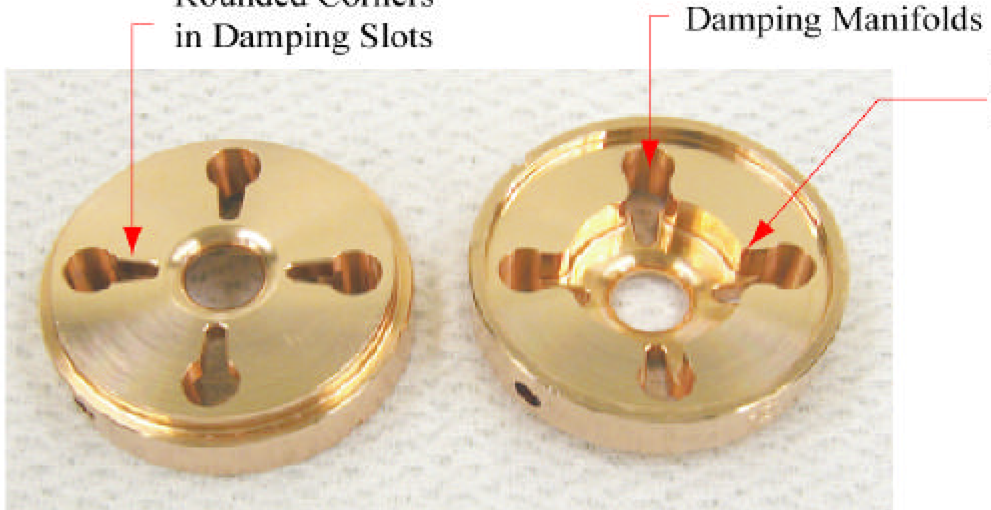


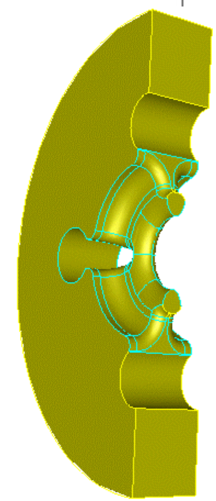


Rounding Damping Slots for Reduction of RF Pulse Heating

Prototype Cells to Damp the Long-Range Wakefield in H60VG3

- Redesigned from RDDS geometry to lower pulse heating.
- Expect 50 deg C temperature rise at 70 MV/m, 400 ns.



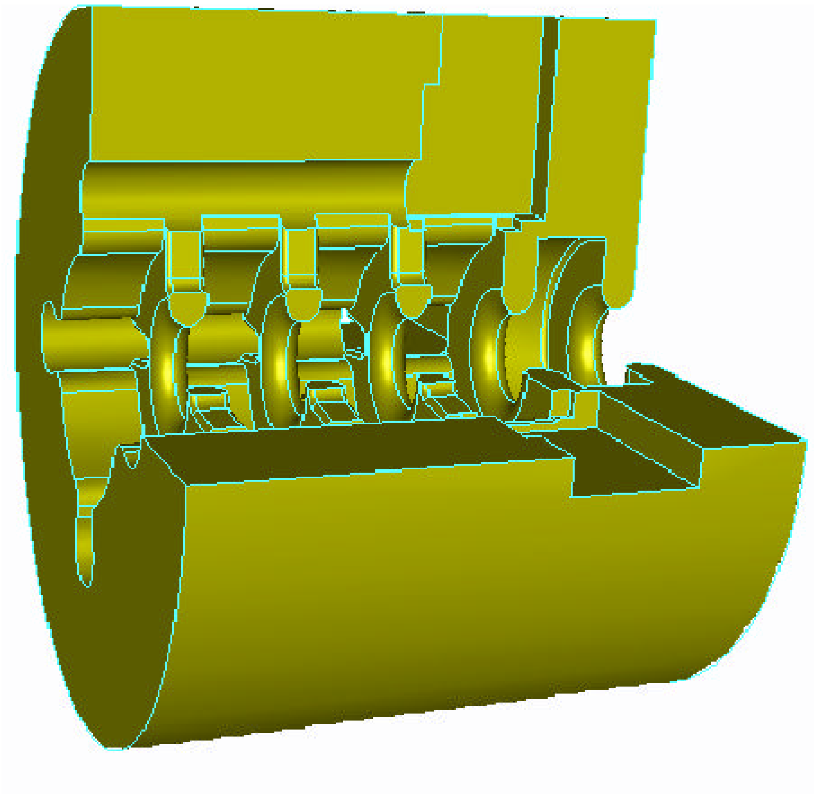


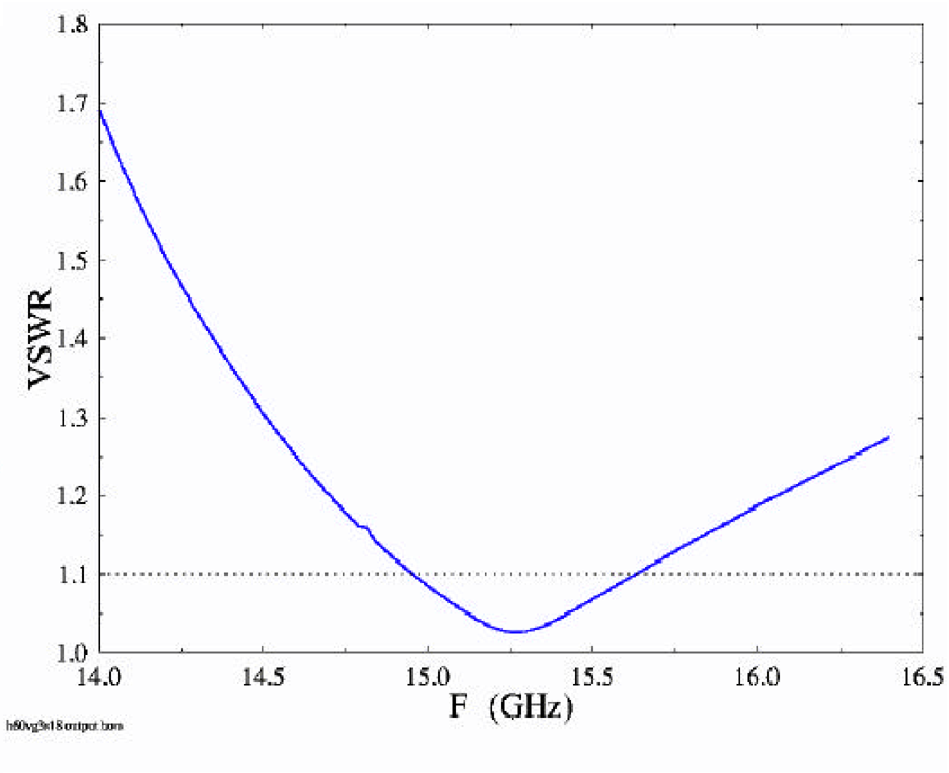
- High Gradient Tests of Damped Cells:

  January 2003: Process H60VG3 that includes 6 damped cells.

  March and June 2003: Test full scale versions (called HDDS) without manifold termination (HDDS1) and with termination (HDDS2), respectively.

High-Order Mode (HOM) Coupler Design For NLC Prototype Accelerator Structures





Structure Plan for Year 2003

Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.

Install H90VG3N (0.18, 150°, no slots) 92 MW — KEK/SLAC
Install FXB-002 (0.18, 150°, no slots) 73 MW — FNAL

Install H60VG3N (0.18, 150°, 6 slotted) 73 MW — KEK/SLAC

Install SW20a375 x 2 12 MW x 2 — KEK/SLAC

Install H60VG3S18 (0.18, 150°, slots, no HOM loads) 78 MW — KEK/SLAC
Install FXB-003 (0.18, 150°, no slots) 73 MW — FNAL

Fabricate cells for H75VG4S18. → Assemble H75VG4S18 → Install H75VG4S18 (0.18, 150°) slots, no HOM loads) 86 MW — KEK/SLAC

Install CERNW/Mo (W/Mo iris) 100 MW — CERN

Fabricate FXB 004-006 (H60VG3-18). → Install FXB 004 (0.18, 150°, no slots) 73 MW — FNAL

Complete design and place cell order. → Install H60VG3R17 (0.17, 150°, no slots) 66 MW — SLAC; FXB-5 (0.18, 150°, no slots) — FNAL

Complete H60VG3S17 design with slots and HOM loads. → Four H60VG3S17 (0.17, 150°, DDS) 68 MW — KEK/SLAC; Five FXC (H60VG3S17) (0.17, 150°, DDS) 68 MW — FNAL

Future Work for RF Structures Group

- Design and Build Prototype Structures for NLC Main Linac.
- Improve Simulation Technologies.
- Study Various Structure Building Materials.
- Design Compact HOM Damping Structures.
- Optimize and Finalize NLC Accelerator Structure.
- Set Criterion on Tolerances for Cost Reduction.
- Develop Automated RF QC and Tuning Systems.
- Complete Manufacturability Studies.

High Power RF Group Activities

Sami G. Tantawi (Leader), P. Wilson, C. Nantista, V. Dolgashev, A. D. Yeremian, J. Guo, D. Farkas

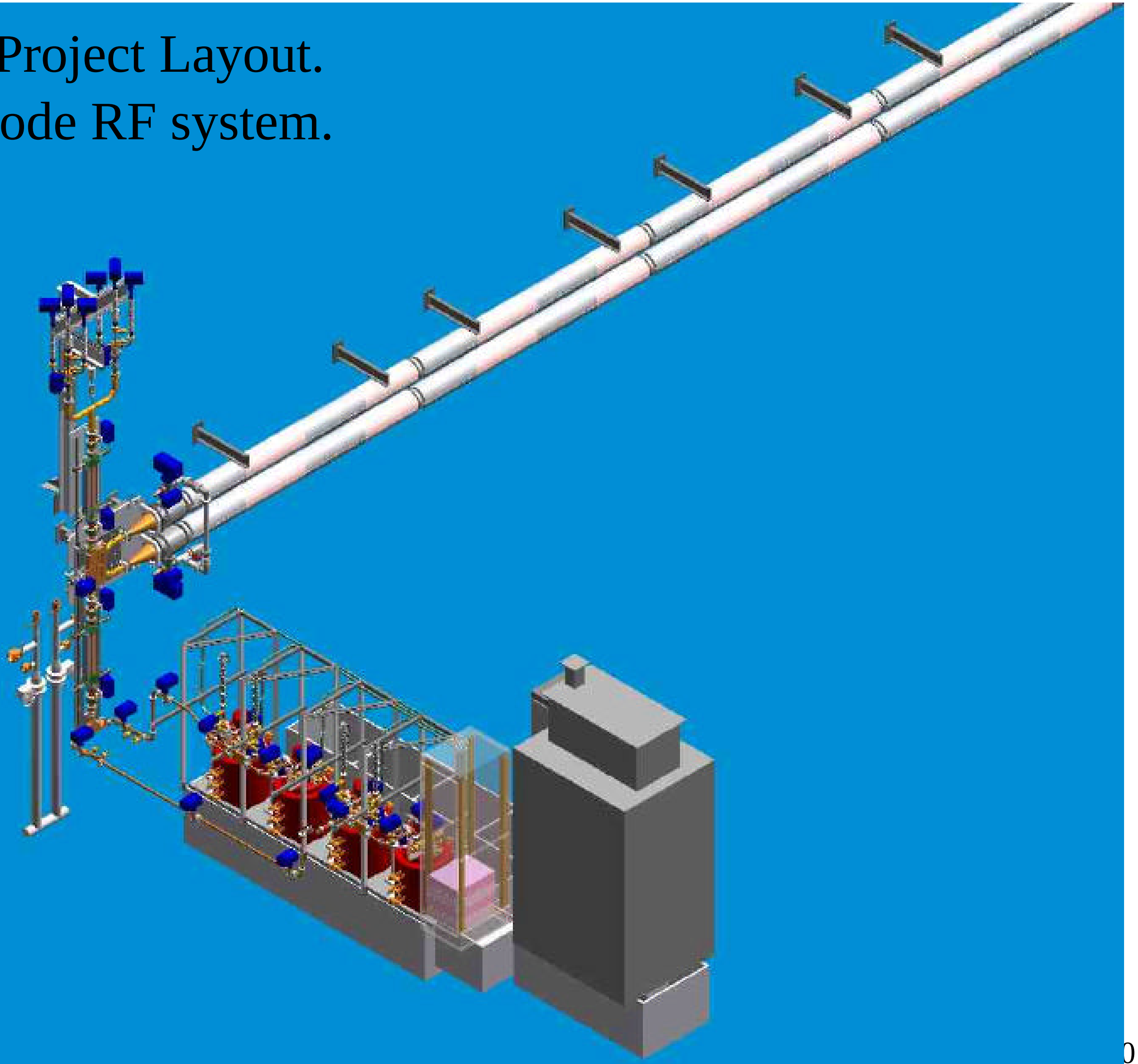
Group Activities

- RF Designs for the Pulse compression systems of the NLC and Accelerator Structure
  1. Overmoded and Multimode components
  2. Multimoded Delay Lines
  3. Accelerator structure couplers
  4. Novel RF accelerator Structures

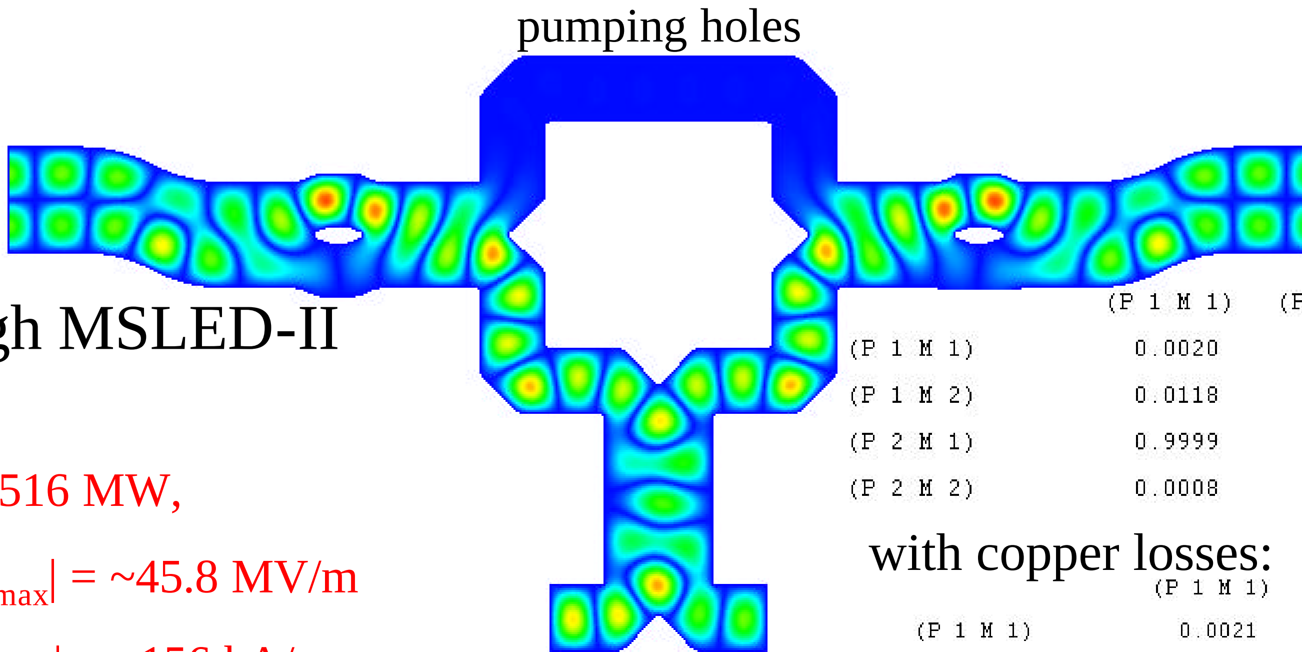
- Breakdown studies
  1. Experimental Studies
  2. Theoretical studies and simulations

- Advanced Solid state Components
  1. Overmoded nonreciprocal devices
  2. Overmoded Semiconductor devices

Phase-I 8-Pack Project Layout.
A Fully dual-mode RF system.



8-Pack Cross Potent Substitute



TE$_{20}$

through MSLED-II

@ 516 MW,

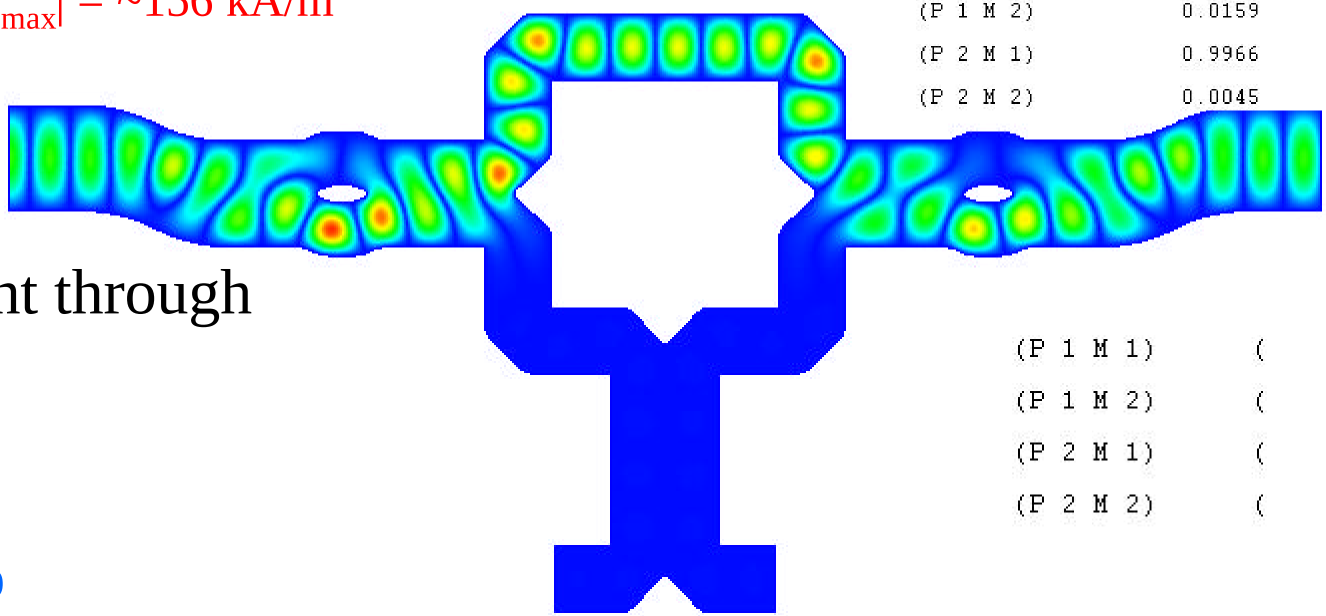
$|E^s_{max}|$ = ~45.8 MV/m

$|H^s_{max}|$ = ~156 kA/m

	(P 1 M 1)	(P 1 M 2)	(P 2 M 1)	(P 2 M 2)
(P 1 M 1)	0.0020	0.0118	0.9999	0.0008
(P 1 M 2)	0.0118	0.0077	0.0008	0.9999
(P 2 M 1)	0.9999	0.0008	0.0020	0.0118
(P 2 M 2)	0.0008	0.9999	0.0118	0.0077

with copper losses:

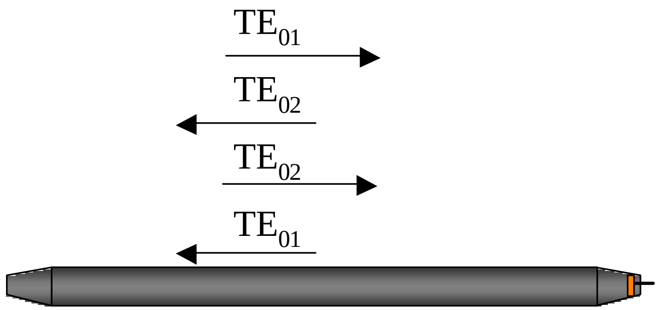
	(P 1 M 1)	(P 1 M 2)	(P 2 M 1)	(P 2 M 2)
(P 1 M 1)	0.0021	0.0159	0.9966	0.0045
(P 1 M 2)	0.0159	0.0010	0.0045	0.9942
(P 2 M 1)	0.9966	0.0045	0.0021	0.0159
(P 2 M 2)	0.0045	0.9942	0.0159	0.0010



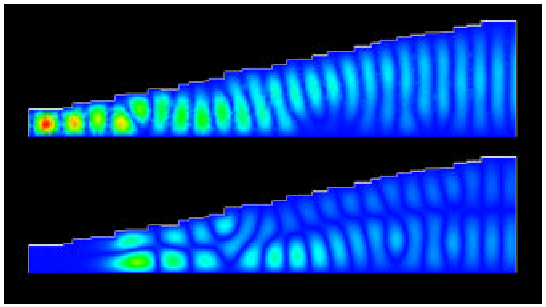
TE$_{10}$

straight through

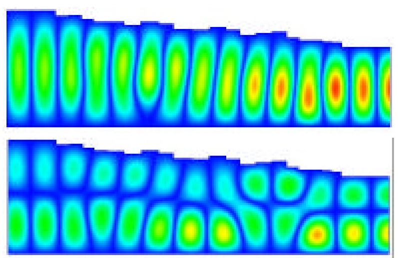
	Gamma	
(P 1 M 1)	(0.0031	223.5)
(P 1 M 2)	(0.0066	167)
(P 2 M 1)	(0.0031	223.5)
(P 2 M 2)	(0.0066	167)



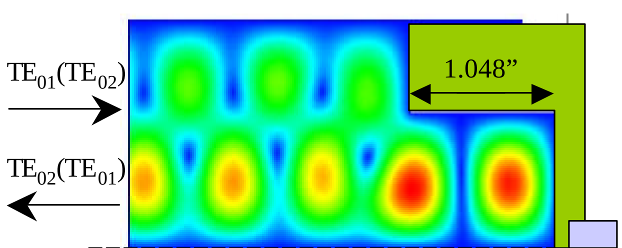
Input Taper

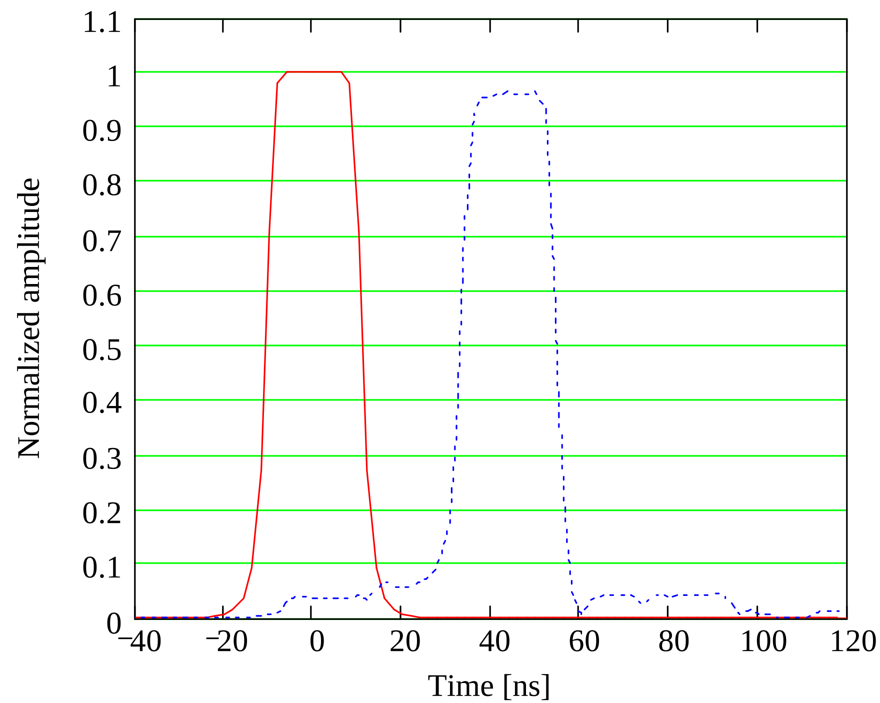


Output Taper



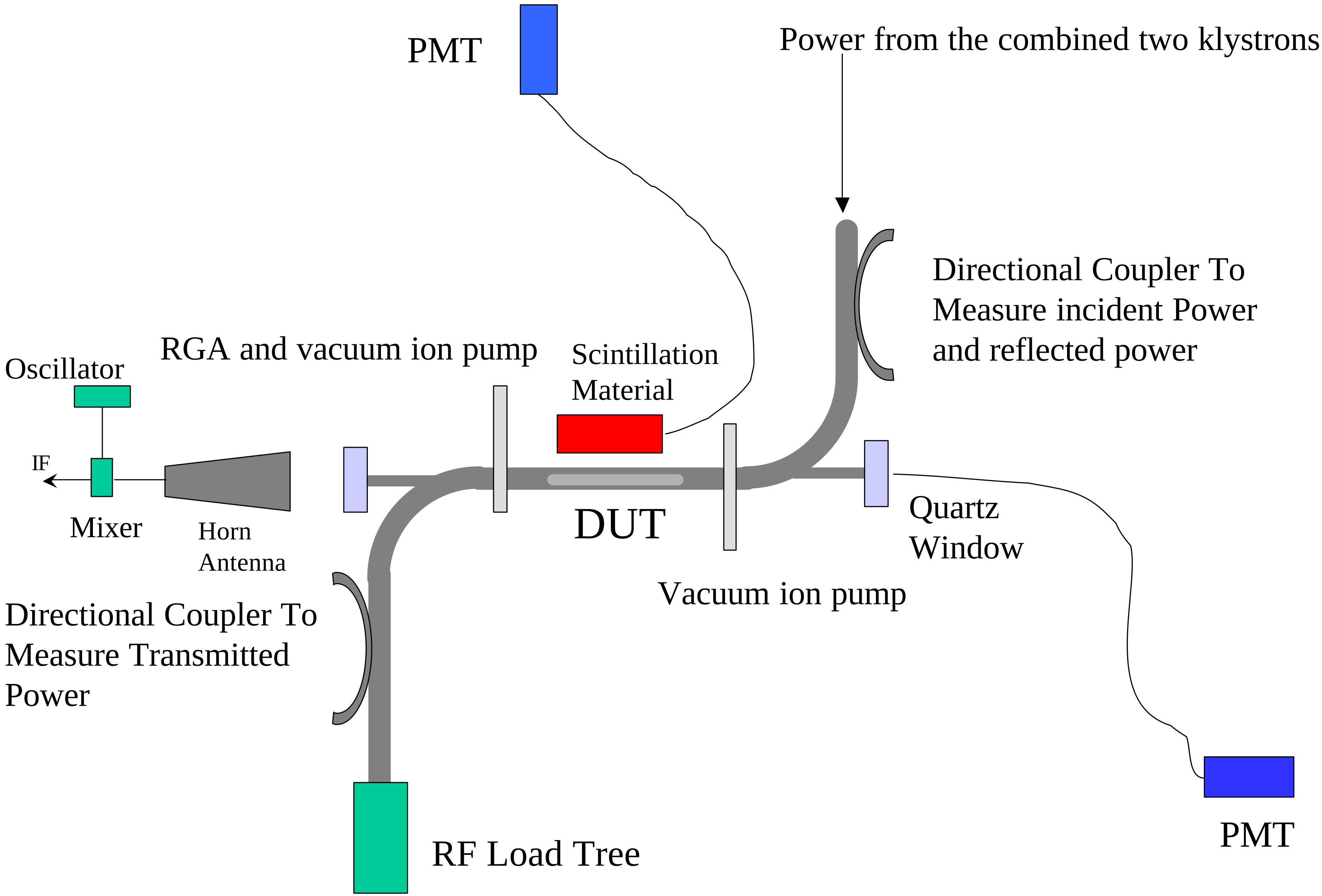
End Mode converter





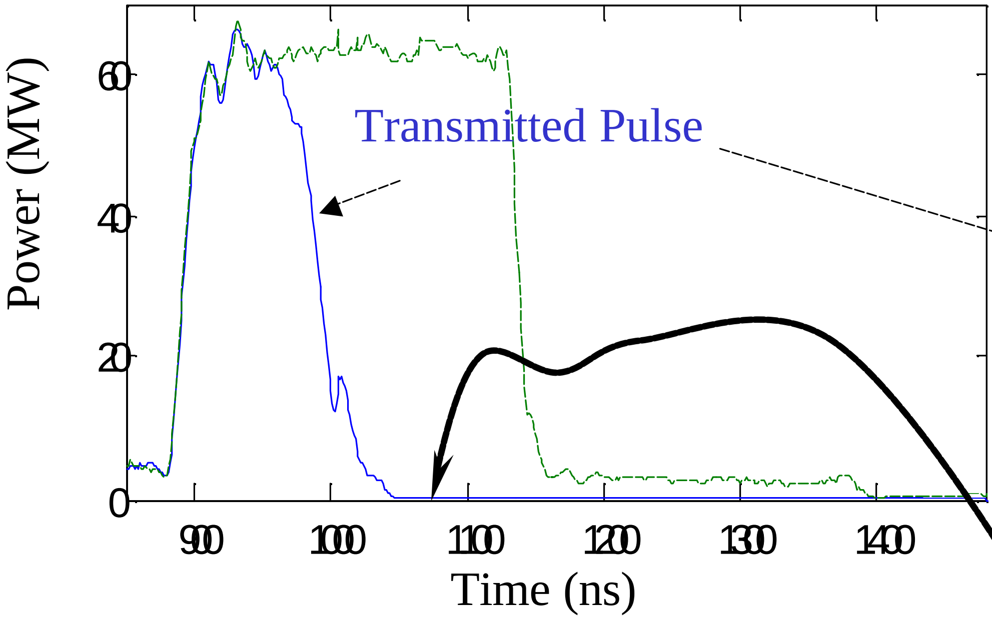
Experimntal result for a ~40 nanosecond delay from a transmission line which is only ~20 nanosecond long

Multimoded Delay line Development

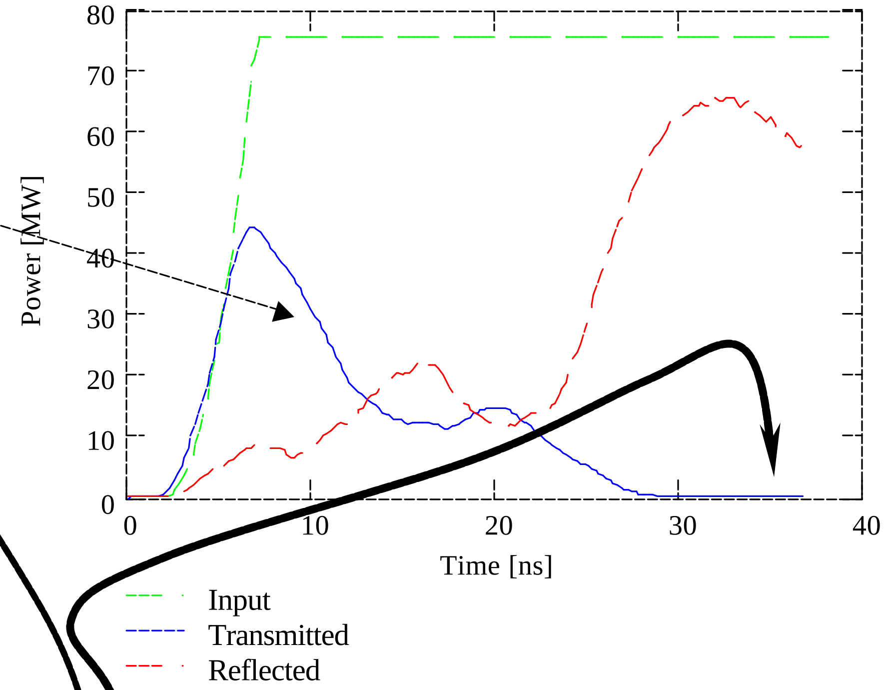


Experimental Setup

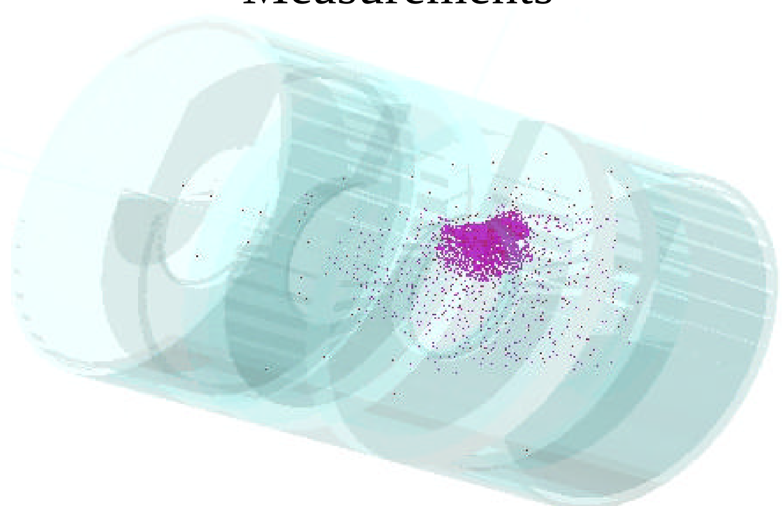
RF signals for a breakdown event in TW structure



Measurements



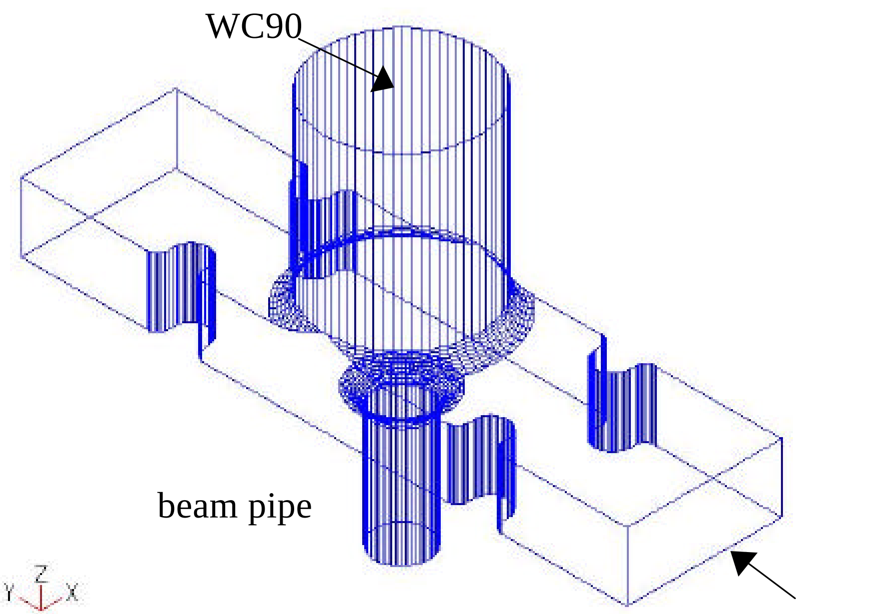
3D PIC simulations, coupler breakdown, T20VG5, ion current 20A, spot size ~1mm^2

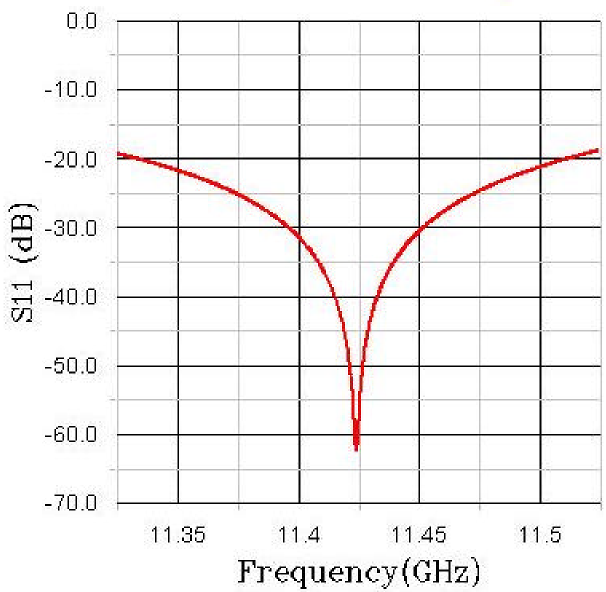


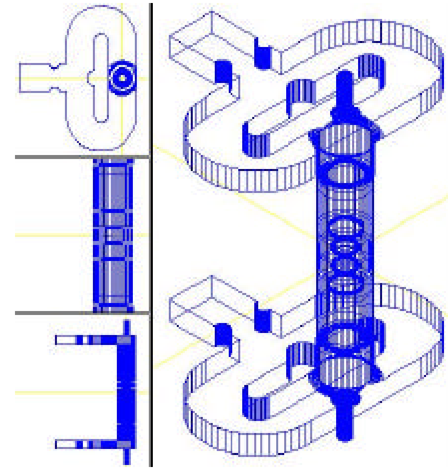
Shut off of transmitted rf power

3D PIC model

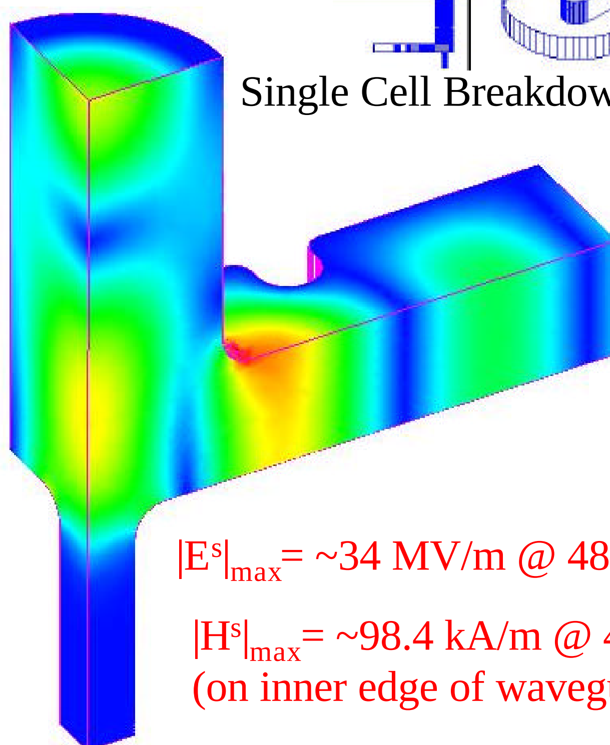
TM_{01} Mode Launcher for Accelerator Structure Coupler







Single Cell Breakdown experiment



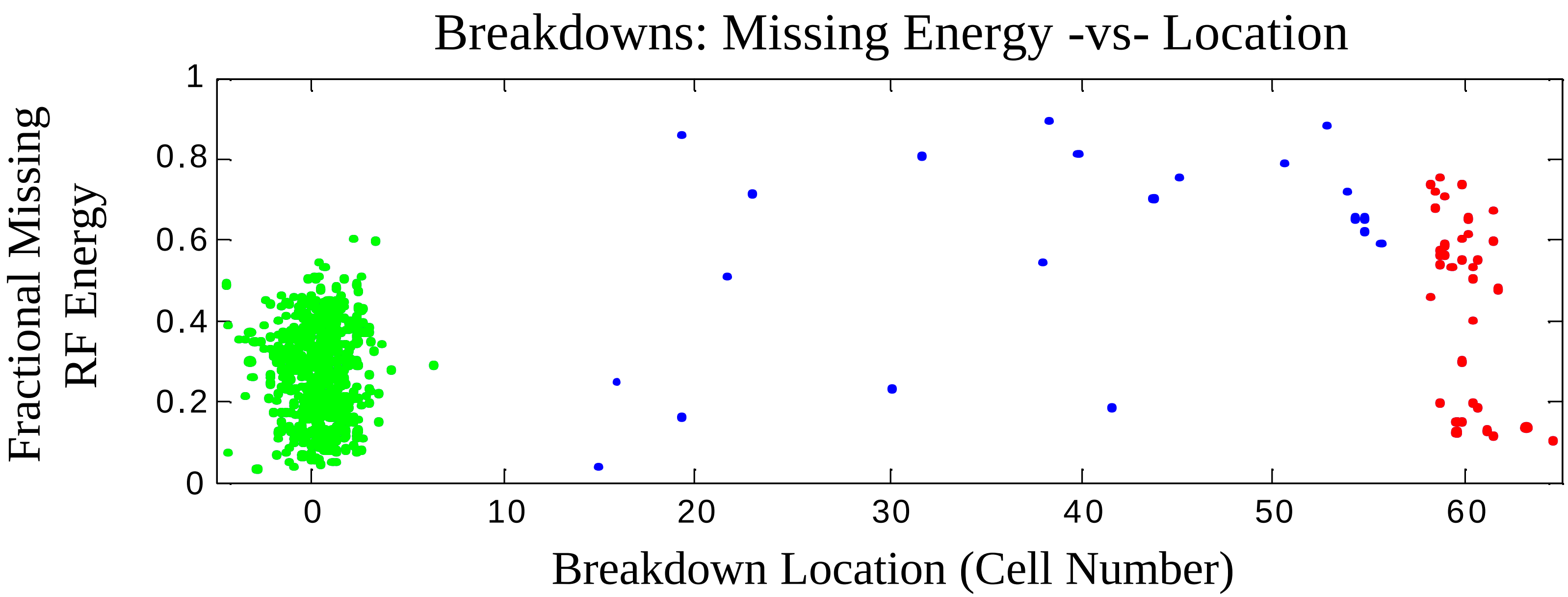
$|E^s|_{max}$= ~34 MV/m @ 48 MW

$|H^s|_{max}$= ~98.4 kA/m @ 48 MW
(on inner edge of waveguide iris)

⇒ pulsed heating ~3°

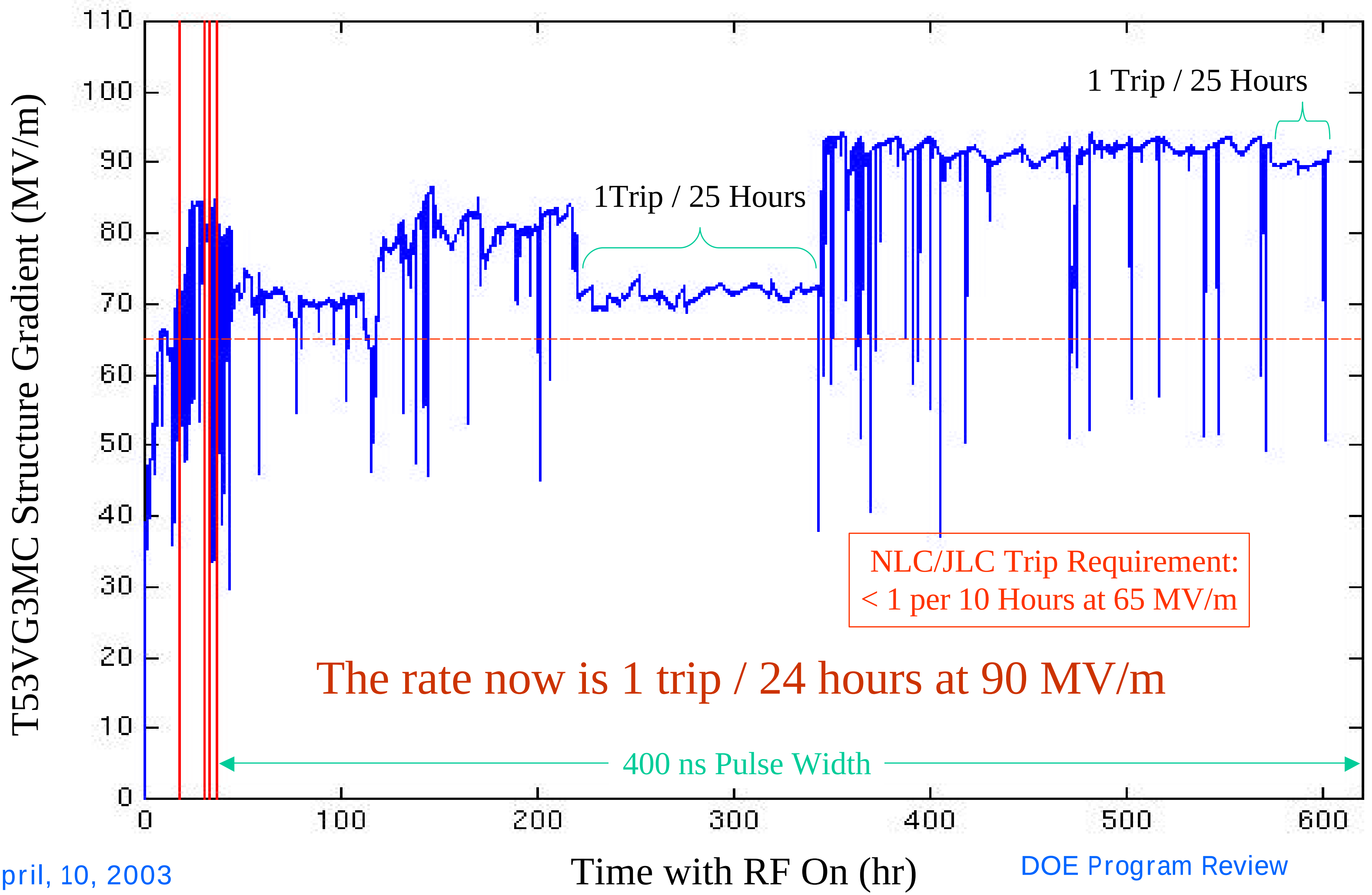
Example of Low Group Velocity Structure Performance at 70 MV/m

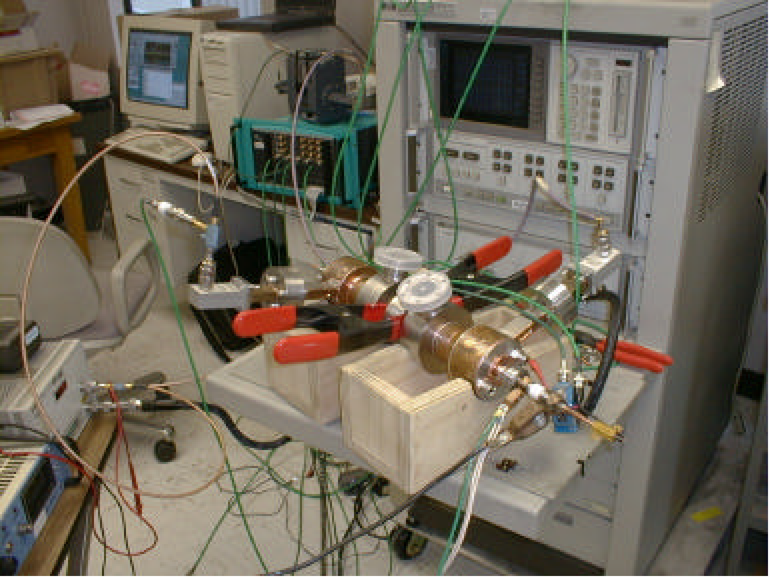
(120 Hours of Operation at 60 Hz with 400 ns Pulse Widths)

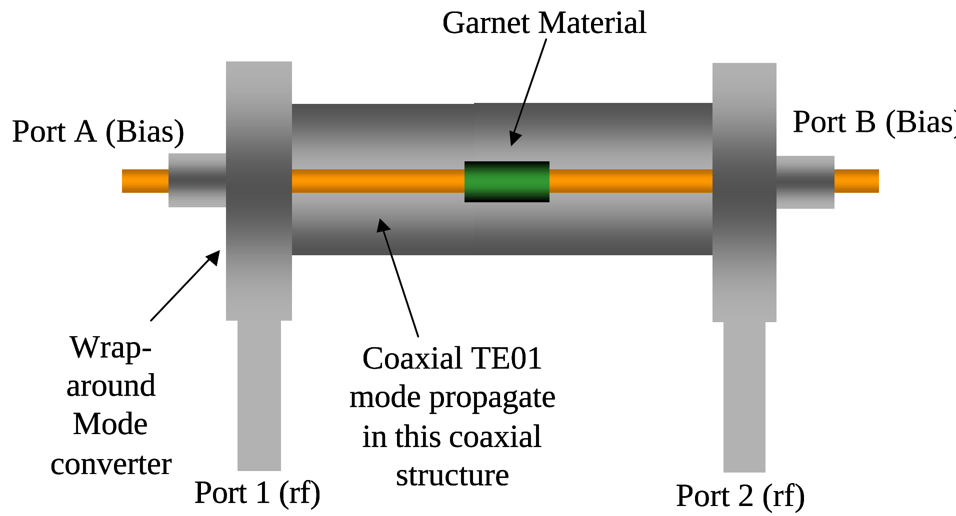


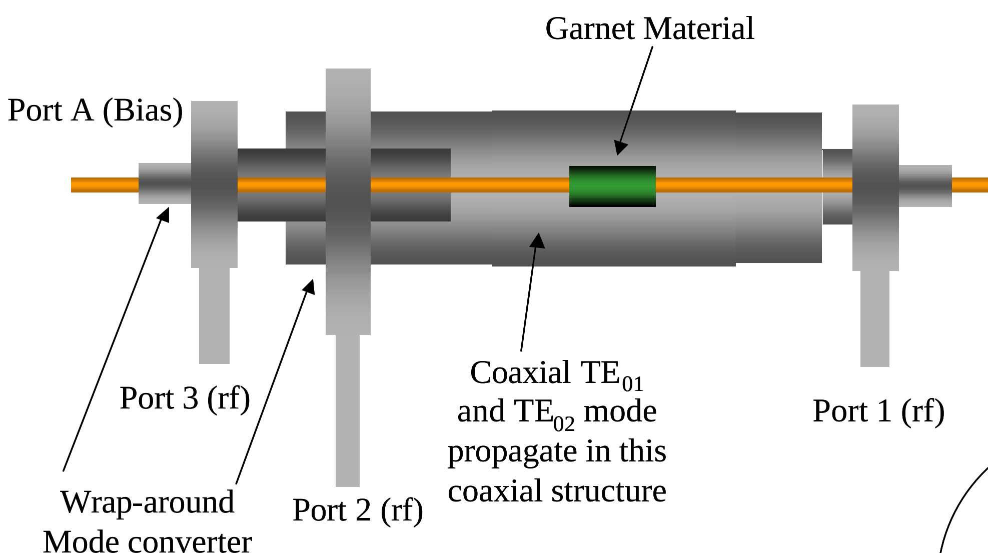
- Breakdown rate in structure body (blue events) = 0.2 per hour or about <u>one in a million pulses</u>.
  - NLC goal is < 0.1 per hour: measure from < 0.1 to 0.3 per hour in five structures.
- Breakdown rate in the two coupler cells (green and red events) = 5.5 per hour
  - Rates in other structure couplers vary from 0.1 to 5 per hour

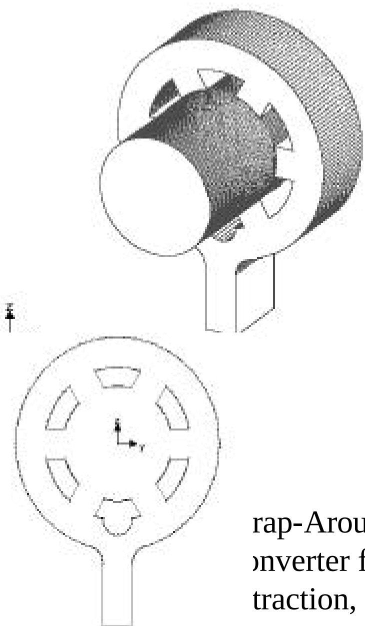
Processing History of Structure (T53VG3MC) with Upstream Mode Launcher Coupler and Downstream Fat-Lip Coupler



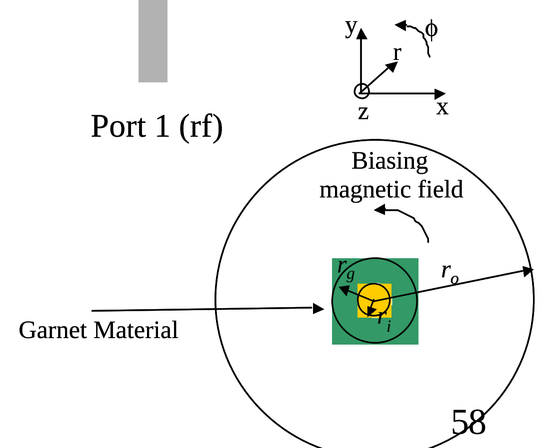








rap-Around Mode
›nverter for Tap-off, and
traction, tested to 470 MW



SLAC / CERN Collaboration on the CLIC Test Facility 3 (Two Beam Linear Colliders)

SLAC participates in the CTF 3 collaboration with CERN and a number other laboratories to build a model of the two-beam power source envisioned for CLIC and Multi-TeV linear colliders

- **SLAC proposed the current design for the power source for multi-TeV two-beam colliders.**
- **SLAC designed the Injector for CTF3**
- **SLAC spare thermionic gun was modified for CTF3, tested at SLAC and at CERN for performance.**
- **The gun meets all the design specifications 160 KV maximum voltage, 8 A at 140 KV operation**
- **SLAC will participate in the commissioning of the CTF3 injector.**

SLAC / SPRing8 Collaboration on the FEL Facility

- Fourth generation light source planned at SPRing8 in Japan

- SPRing8 prefers an injector based on thermionic high voltage gun with subharmonic bunching to avoid beam stability and reliability difficulties associated with photocathode RF guns.

- Design of a thermionic injector with the necessary beam qualities is in progress. The task is challenging as producing the stringent beam qualities with a subharmonic bunching system is very difficult.

- The beam qualities required at approximately 250 MEV are:
  Q = 0.5nc to 1nc, P.W. = 3ps ~sqare, $\varepsilon_{N,rms}$ = 1 to 3 mm-mrad

Anticipated Progress in FY 2003

•Results from the dual-moded high power test facility.
•Demonstrate a transmission line operating with four modes simultaneously.
•Demonstrate practical high power circulators.
•Test high power semiconductor switches.
•Si wafers on a copper substrate will be tested as internal loads; which are required for wakefield damping in accelerator structures.
•Some theoretical understanding of the RF breakdown phenomenon.

Anticipated Progress in FY 2004

•Build and demonstrate an active pulse compression system that utilizes either nonreciprocal devices or semiconductor switches.
•Reasonable understanding of rf breakdown physics.
•Theoretical and experimental work for delay lines that can support 10 modes or more