Americas Regional Program

ALCPG Meeting
Fermilab, October 22nd 2007

Tor Raubenheimer

ILC International Linear Collider – Americas

Americas Regional Team

- The Americas Regional Team (ART) is led by Mike Harrison with support from Jerry Blazey at DOE
- Focused on ILC R&D and development of the EDR
- Includes most national laboratories:
  - FNAL, SLAC, ANL, BNL, Jlab, LBNL, LLNL, LANL, Cornell, …
  - And a number of Universities
- Strong effort which has grown rapidly over last few years

Approximate US ILC Accelerator Budgets FY05-FY09

	Estimated FY05	Actual FY06	Appropriated FY07	Planned FY08	Requested FY09
TOTAL ILC line	$21,923	$29,700	$41,700	$60,000	$75,000
SRF Infrastructure and Industrialization	$8,725	$12,000	$19,000	$23,400	$35,000
Overall total: ILC+SRF	$30,648	$41,700	$60,700	$83,400	$110,000

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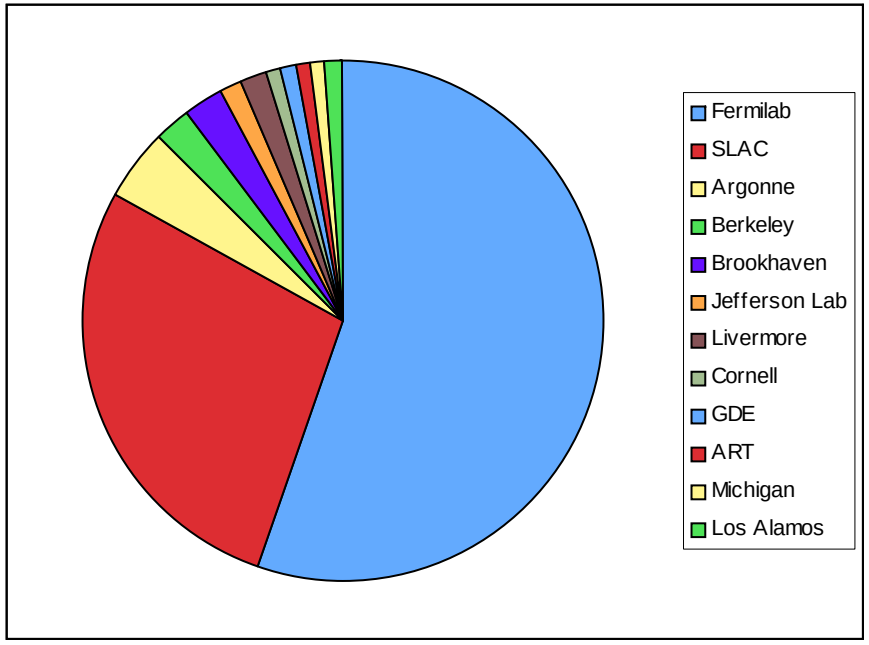
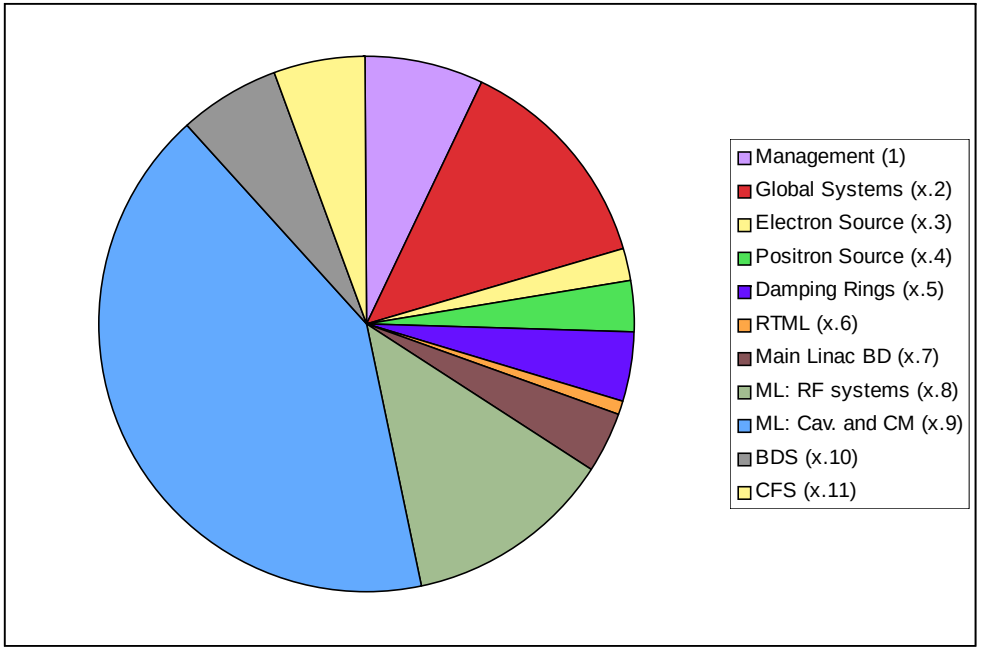
ART Budget and Foci

- FY08 program was developed with strong focus on SCRF
  - Roughly 2/3 is focused on the main linac SCRF and RF power
    - Large infrastructure development to support SCRF
  - Significant efforts on CFS and BDS with smaller efforts on DR, Sources, and ML Beam Dynamics

FY08 budget planning by lab



FY08 budget planning by topic



ART Level-2 Managers

- The ART program is constructed with the help of the Level-2 managers who develop the specific programs

Global Systems	J. Carwardine and R. Larsen
Electron Source	A. Brachmann and M. Poelker
Positron Source	J. Sheppard and J. Gronberg
Damping Rings	A. Jackson and M. Palmer
RTML and ML BD	P. Tenenbaum and N. Solyak
Main linac RF	C. Adolphsen and S. Nagaitsev
Main linac Cav. and CM	S. Mishra, H. Padamse, J. Mammoser, and M. Kelly
BDS	A. Seryi and B. Parker
CFS	V. Kuckler and F. Asiri
Regional Interest	B. Kephart and E. Paterson

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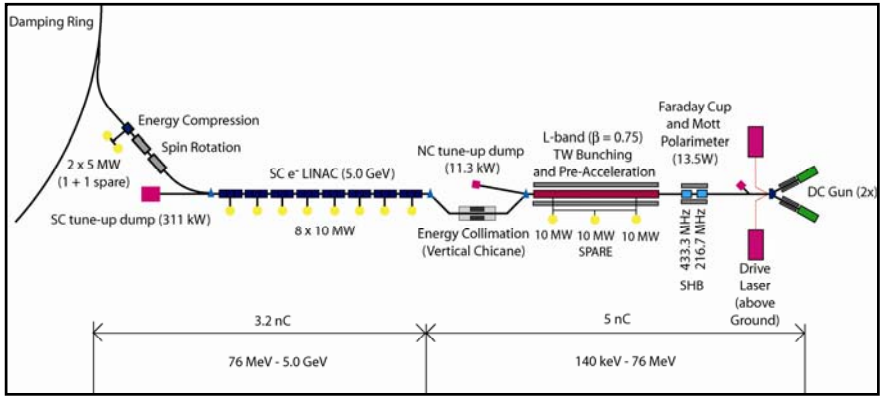
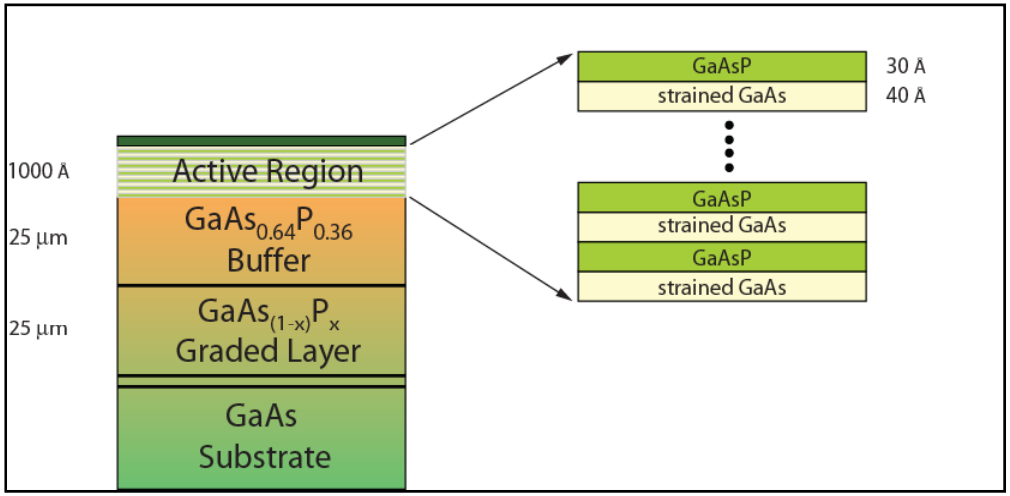
Polarized Electron Sources

- Constructed laser room for ILC laser and purchased most laser components
- Working on robust photocathodes for high polarization
  - Need laser system to verify charge and current limits with long pulses
- Start polarized gun design in FY08
  - Understand high voltage and vacuum performance

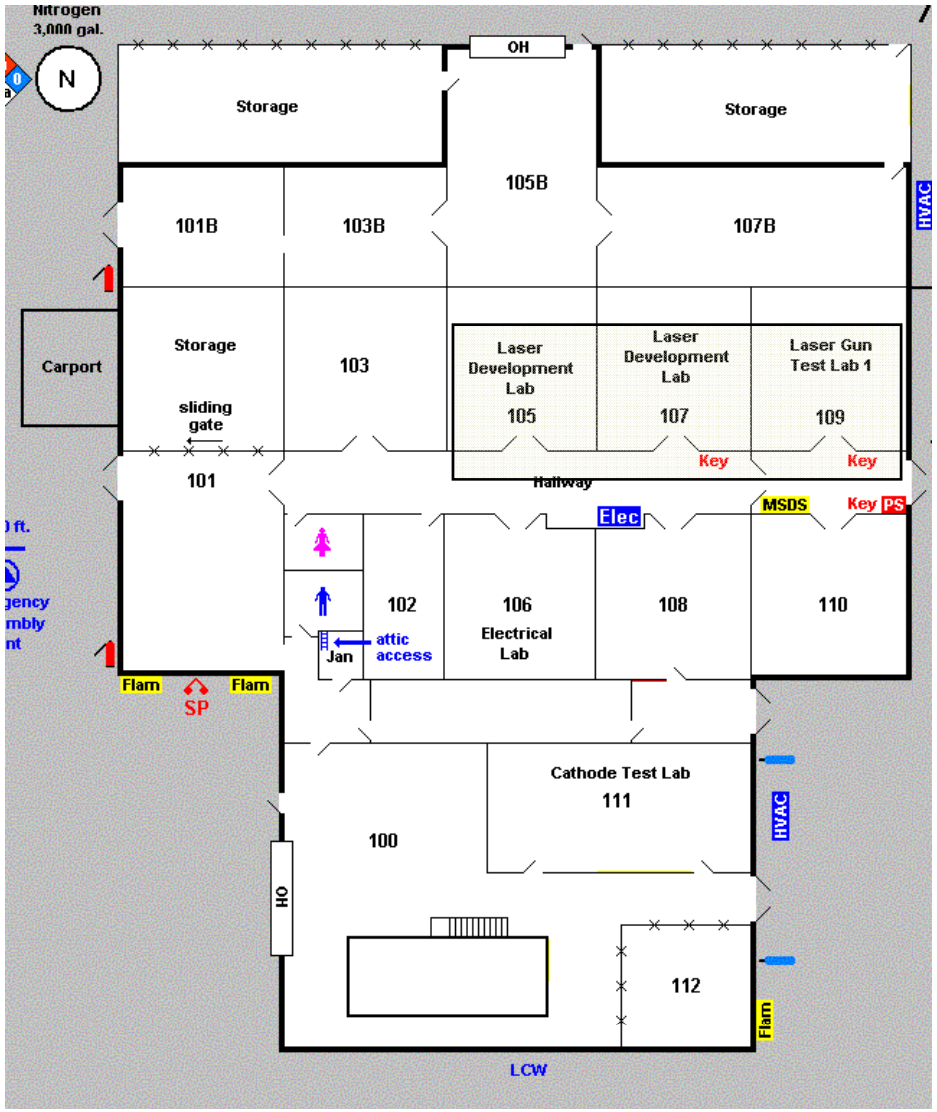
Electron source schematic



High polarization strain GaAs photocathodes



ILC Laser Development Lab



Investments FY05-07:

250 k$ HVAC system
175 k$ 40 W pump laser
120 k$ regenerative amplifier
(cryocooled, 3 MHz)

Current activities:

- Laser work
- Gun operation
- Photocathode development

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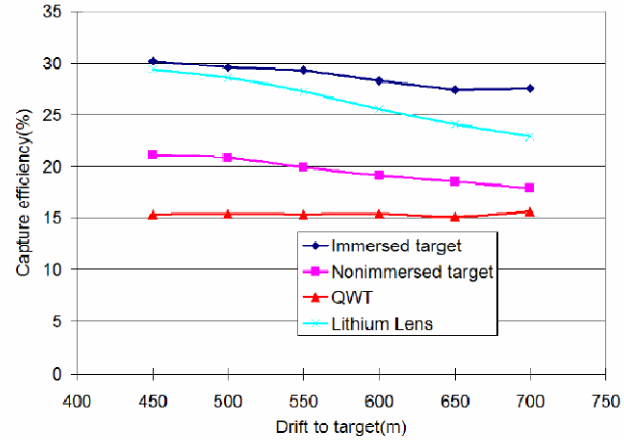
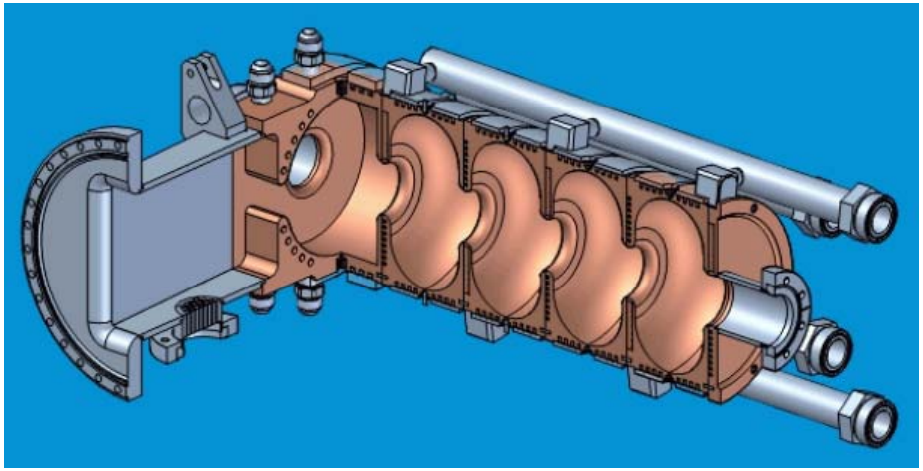
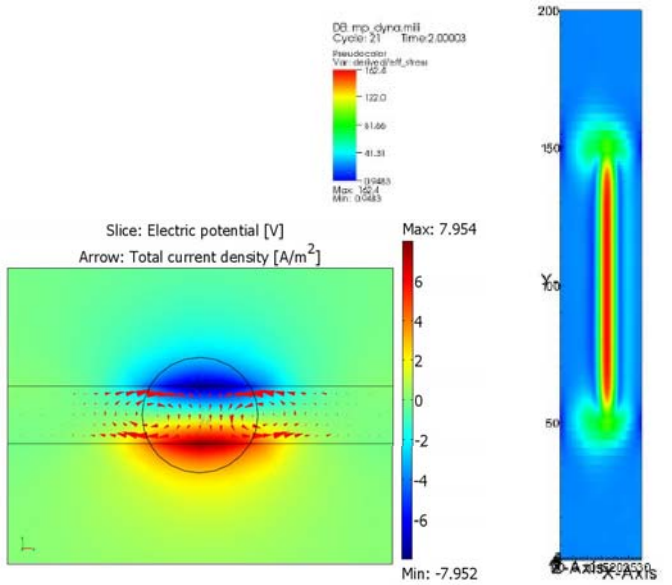
Positron Source: FY07

- Led the RDR effort
  - Systems design, optics, target, capture, transport
- Analysis of capture efficiency in magnetic optics
  - Minimize undulator cost by maximizing capture of produced positrons
    - Evaluation of options for OMD
    - Analysis of OMD / target interactions
- Target prototype effort with Daresbury
  - Eddy current calculations; stress-strain calculations; rotor-dynamic analysis
- Beam loss and collimation simulation
- NC capture structure design and demonstration

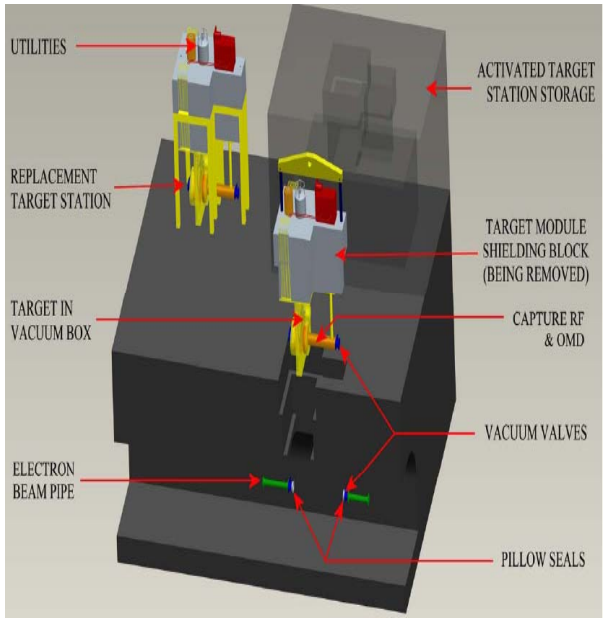


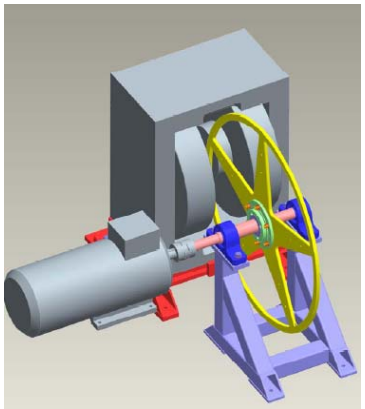


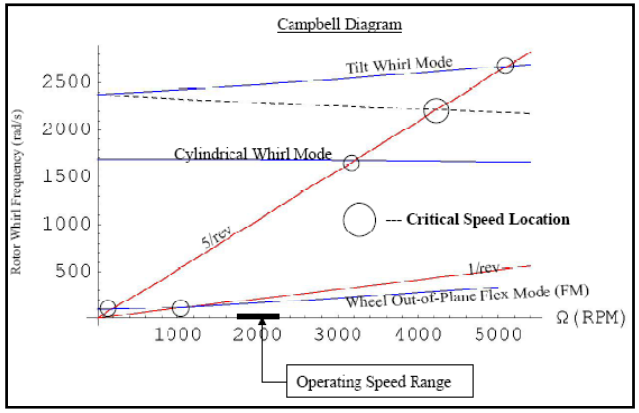


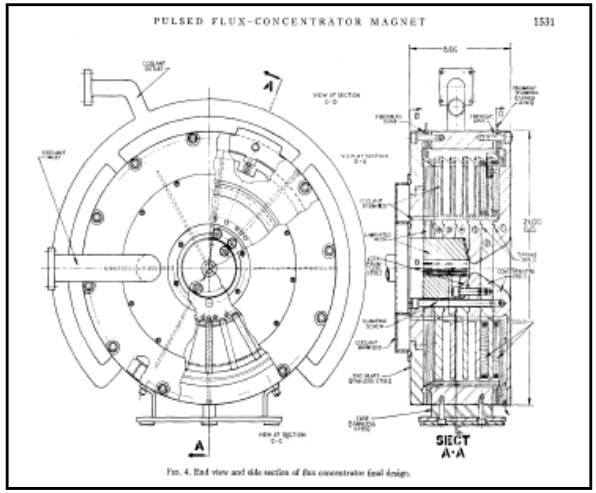
Positron Source: FY08 Narrowing scope in US

- UK will take over management of e+ design
  - Narrowing scope of US EDR effort
- Many outstanding issues still exist
  - Target prototype design
  - Capture optics and flux concentrator
  - Remote handling design and issues









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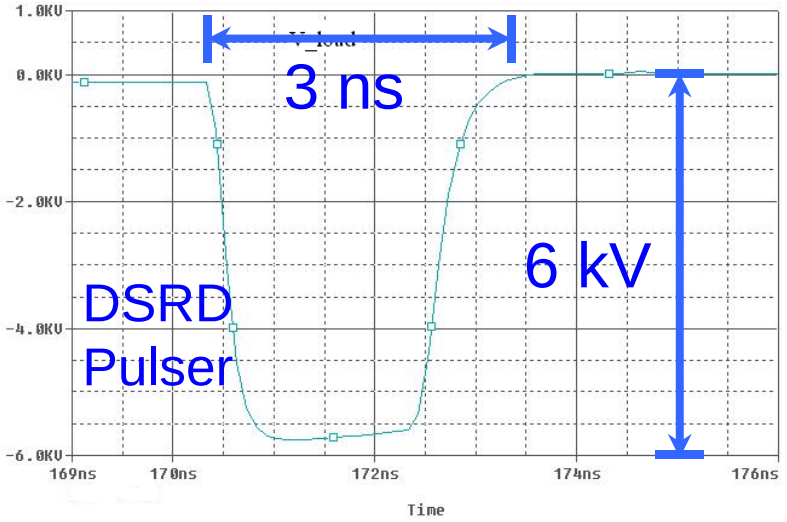
Damping Rings

- Contributing Institutions: Alfred U., ANL, U. of British Columbia, Cornell U., FNAL, U. of Illinois, LBNL, LLNL, SLAC
- Major Efforts
  - Accelerator Design
    - Baseline Lattice design and evaluation
    - Impedance and Instabilities
  - R&D
    - Electron Cloud experiments
    - Fast High Voltage Pulser and Kickers
  - Component and System Engineering
    - Vacuum and Magnet Systems design
    - Systems Integration
  - Test Facilities
    - KEK-ATF instrumentation support and experiments at CESR-TA

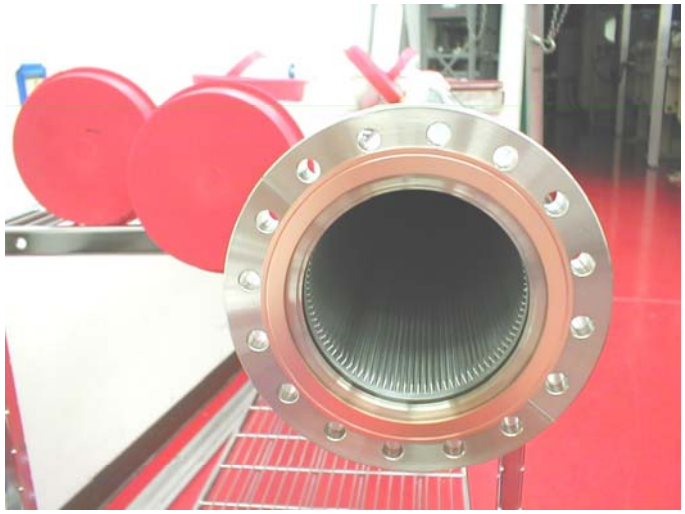


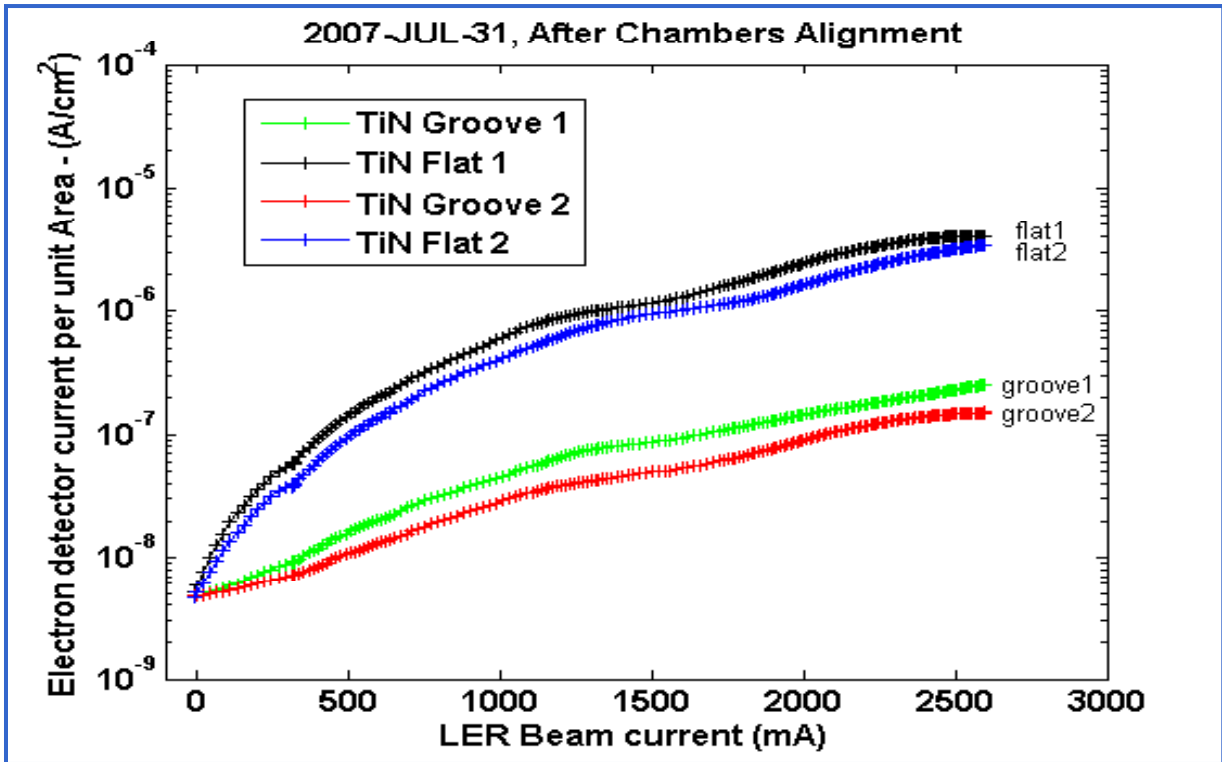
A. Krasnykh (SLAC, in collab. w/Ioffe PTI, St. Petersburg)

- Key R&D Results
  - Promising results on electron cloud mitigation with coatings and grooved surfaces
  - Demonstration of DSRD pulser meeting timing requirements for 3 ns bunch spacing

Electron Cloud Studies

- Experiments at PEP-II in FY07 and FY08 will clarify the utility of TiN coatings and longitudinal grooves
- Subsequent experiments at KEK and CESR-TA will study clearing electrodes as well as above techniques with parameters closer to ILC damping rings





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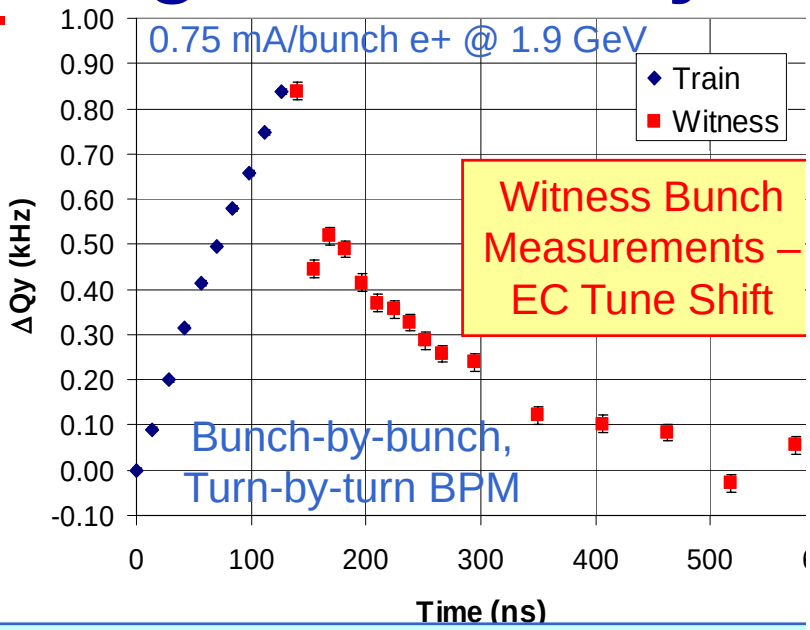
CESR-TA: Damping Ring Test Facility

Goal:

Provide a vehicle for ILC Damping Rings R&D on the timescale of the EDR. The primary focus is to study the impact of the electron cloud on ultra low emittance beams and mitigation methods in a wiggler-dominated storage ring.



Baseline Lattice

Parameter	Value
No. of Wigglers	12
Wiggler Field	2.1 T
Beam Energy	2.0 GeV*
$\Delta E/E$	8.6×10^{-4}
ε_v (geo) target	~5 – 10 pm
ε_h (geo)	2.3 nm
Damping Time	47 ms
Bunch Spacing	4 ns
Bunch Length	9 mm

*CESR operating range is 1.5-5.5 GeV

R&D Plans

- EC Growth and Mitigation Studies
  - Probe bunch configurations similar to ILC DR
  - Conduct unique studies in high field damping wigglers
- Ultra Low Emittance Operation & Beam Dynamics Studies
  - Validate correction algorithms
  - Measure and maintain ultra low emittance beams
  - Characterize sources of emittance growth in ultra low emittance beams
  - Probe species dependent effects
- Deliver design inputs to the ILC EDR

Main Linac High Level RF

- Development and evaluation of modulators, klystrons, rf distribution, and couplers
  - Baseline design is being developed for XFEL at DESY
    - Use much of what is done for XFEL although some requirements differ somewhat
  - Alternate paths for significant cost reduction and performance improvements being investigated in US
    - Marx modulator
    - Sheet beam klystron
    - Alternate RF distribution
    - Incremental improvements

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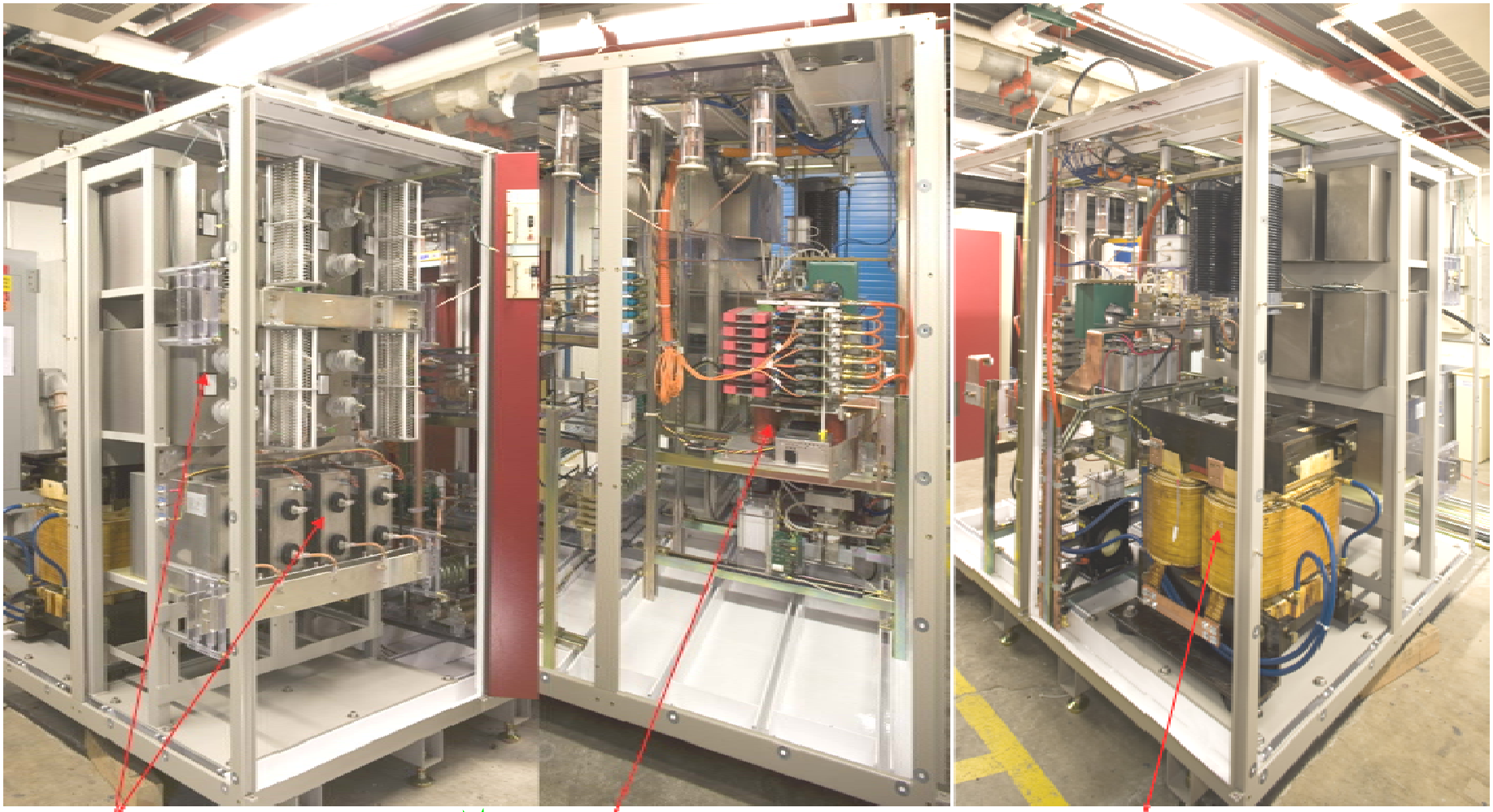
Bouncer (Baseline) Modulator



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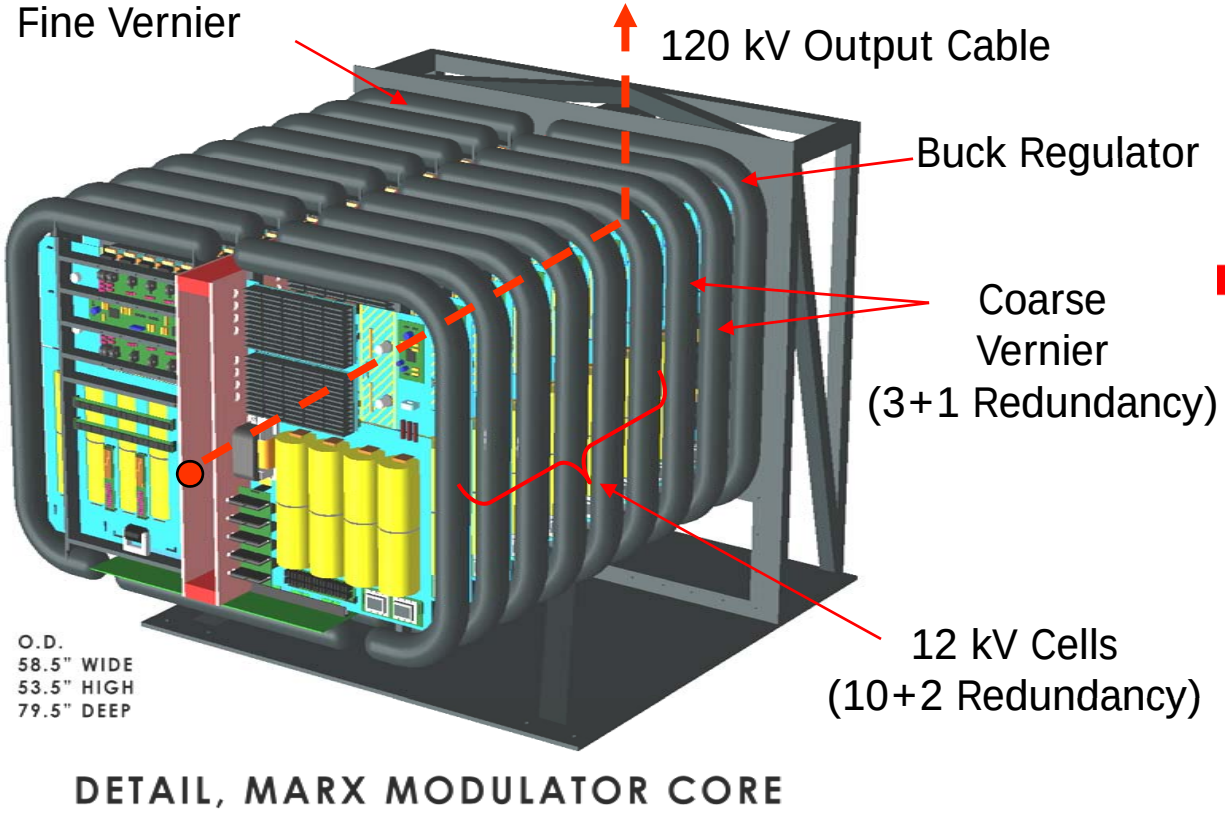
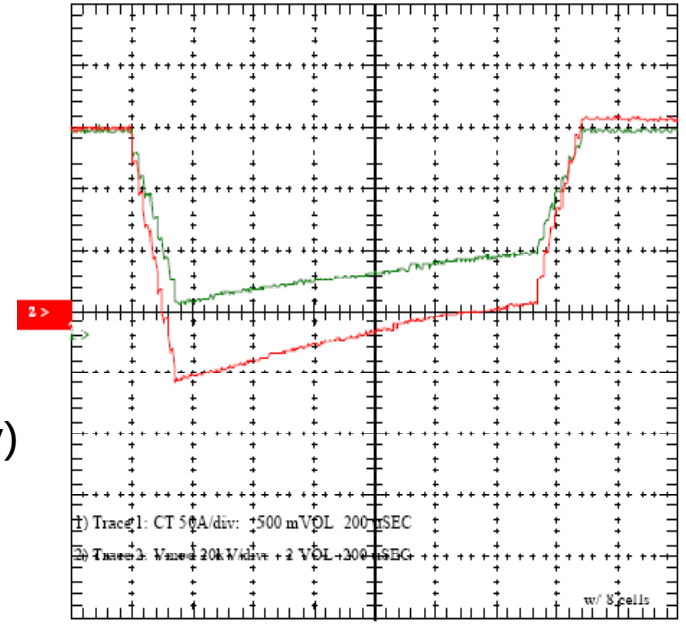
Marx Generator Modulator

- Prototype is operating well at 5Hz and ~100 kW



DETAIL, MARX MODULATOR CORE

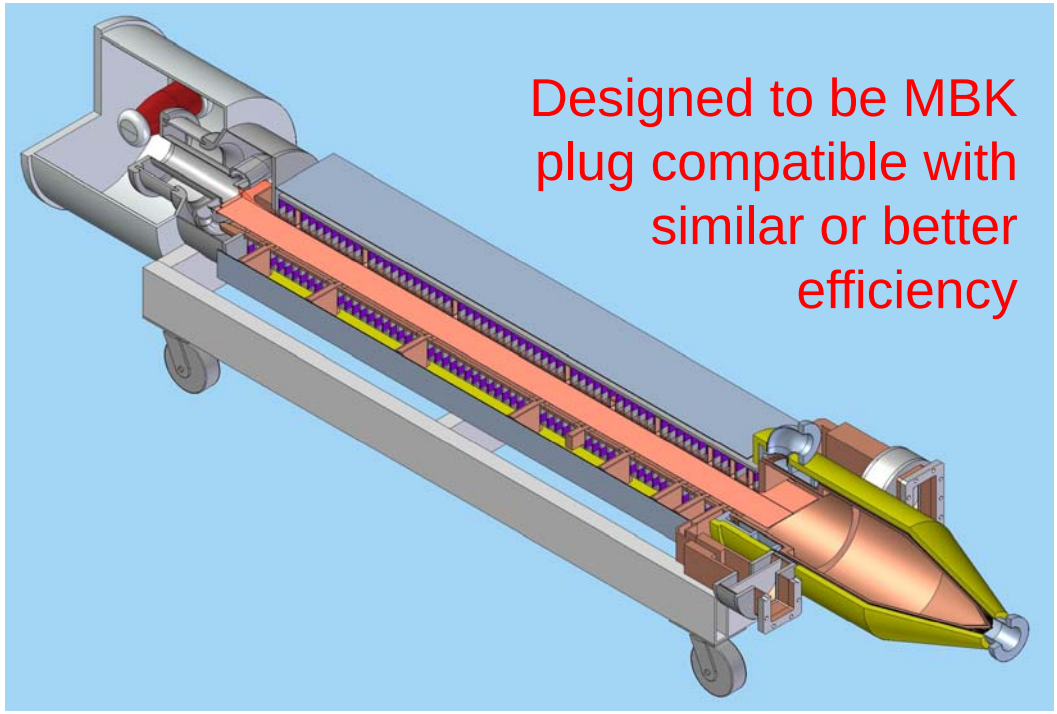
100kV; 150A; 5Hz; 100kW.



Vernier boards to flatten pulse will be tested next month

Klystron R&D

- Baseline is 10 MW multi-beam klystron
  - Toshiba, Thales, CPI manufacturing horizontal tubes for XFEL
  - US will be testing vertical Toshiba klystron
  - Concerns about industrializing tubes in US

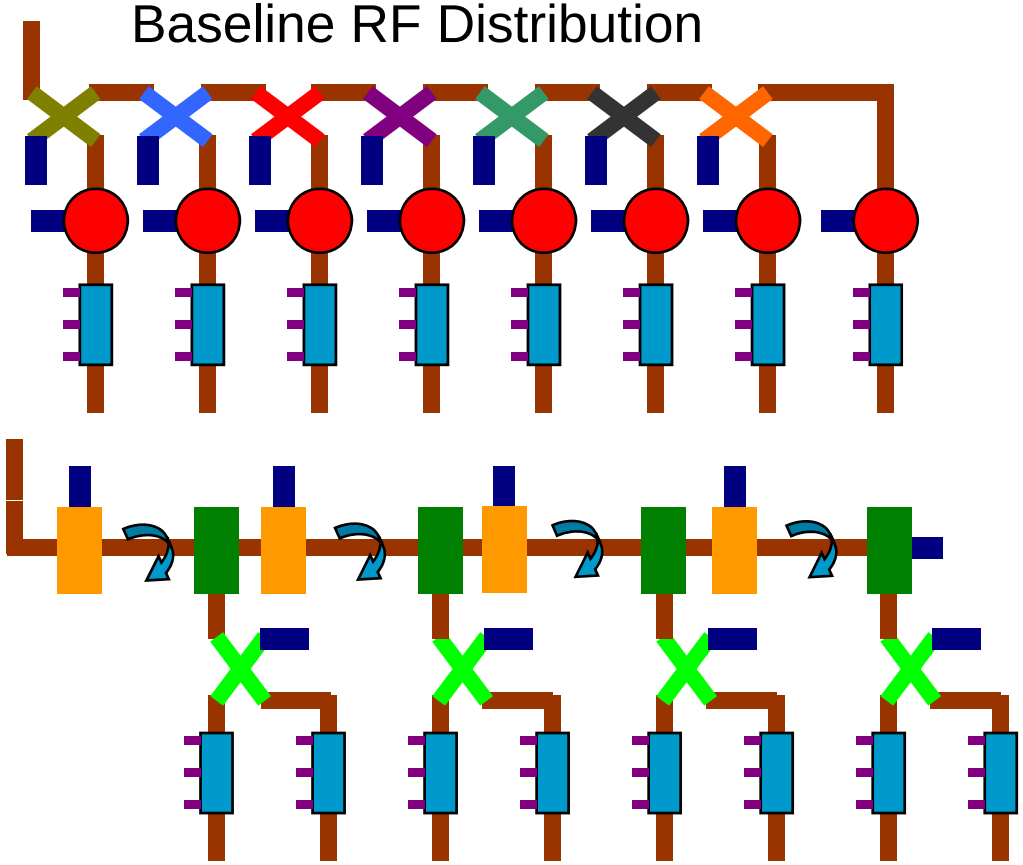


- Sheet Beam Klystrons
  - Allows higher beam current (at a given beam voltage) while still maintaining low current density for efficiency
  - Will be smaller and lighter than other options
  - PPM focusing eliminates power required for solenoid

RF Distribution

- Developing improved rf distribution designs to optimize distribution with cavity gradient variation and reduce cost
  - To be tested in ILCTA (Fermilab)

Baseline RF Distribution



Case	Sorted [%]
Individual P's and Q's (VTO and Circ)	0.0
P's in pairs, Q's in pairs (VTO but no Circ)	0.8+/-0.2
1 P, Q's in pairs (no VTO, no Circ)	3.3+/-0.5
Gi set to lowest Glim (no VTO, no Circ)	19.8+/-2.0

Variable Tap-offs (VTOs)

3 dB Hybrids

US Cavity Program

- **Number of cavity goal:** Fabricate 1/3 of the Cavity needed for the Global S0/S1 program, with focus on getting US Industry involved and qualified
  - FY05
    - 4 Cavities from ACCEL (Type-III+ length)
  - FY06
    - 4 Cavities from AES (Type-III+ length)
    - 4 Jlab (2 Fine, 2 Large)
    - 9 Cavities from ACCEL (To be delivered by 12/31/07)
    - 6 Cavities from AES (To be delivered by 12/31/07)
  - FY07
    - 12 Cavities (ACCEL) (Mid CY08)
    - 12 1-cell Cavities (AES & ACCEL) (AES 9/18/07, ACCEL 12/31)
  - FY08-09
    - 24 & 60 Cavities (Planned)

All of these cavities are fine grain Nb and ILC design

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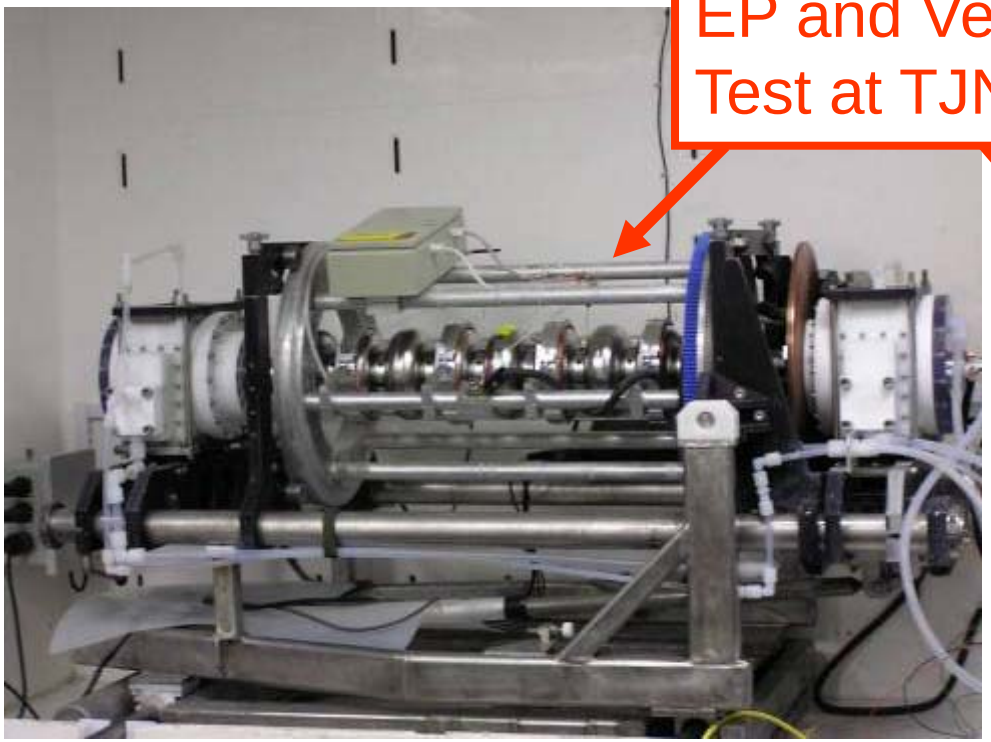
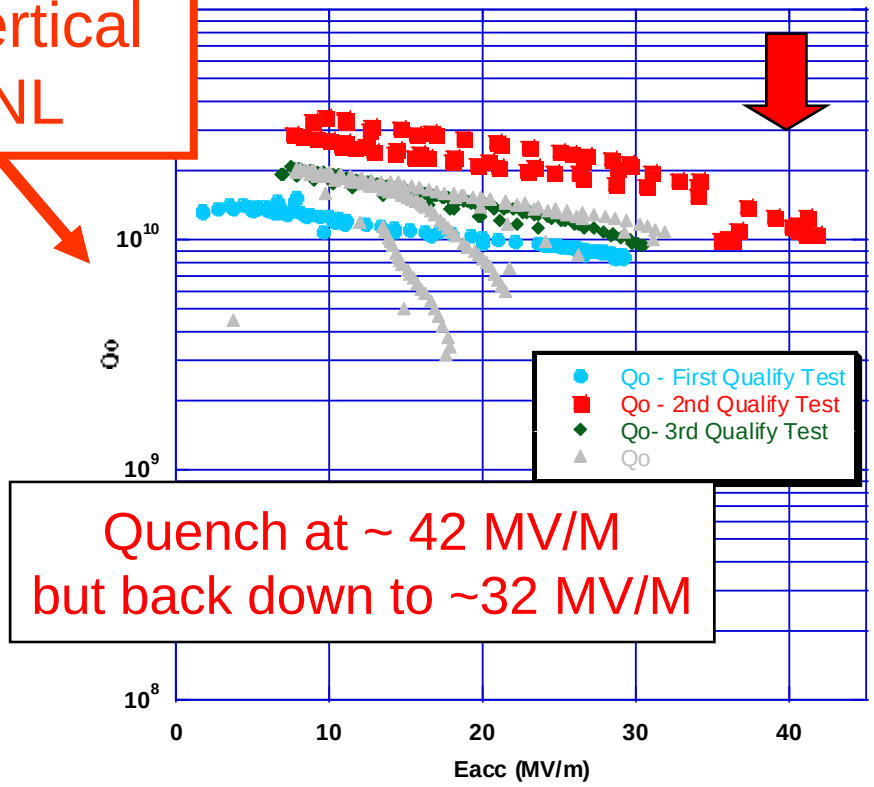
EP and Vertical Test at Jlab

- FNAL collaborates closely with Jlab on cavity processing
- Jlab modified existing infrastructure for Electropolish, High Pressure Rinse, and Vertical Test of ILC cavities
  - Capable of > 40 process and test cycles/yr
  - Completed 32 in FY07



EP and Vertical Test at TJNL



Quench at ~ 42 MV/M
but back down to ~32 MV/M

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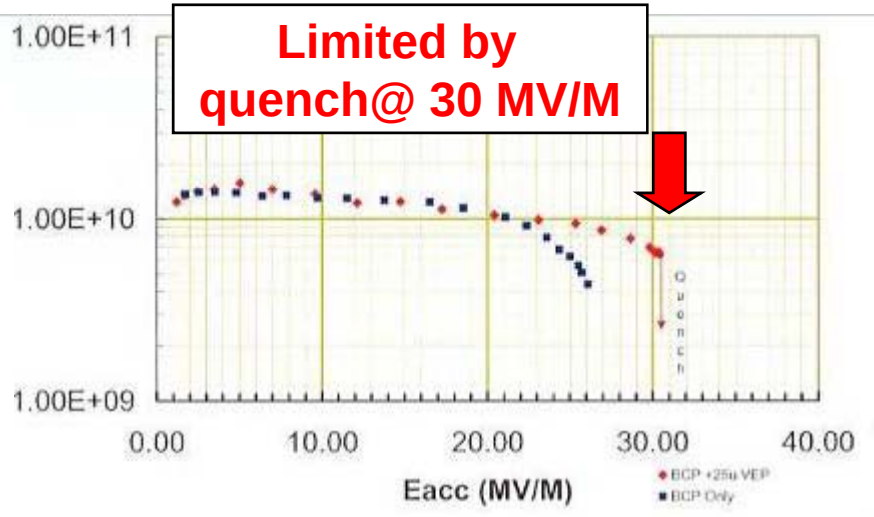
EP & Vertical Test at Cornell

Vertical EP Infrastructure

HPR (High Pressure Rinse)

Vertical test

ACCEL cavity EP Processed & tested at Cornell



- New vertical EP R&D infrastructure
- HPR & Vertical Test of ILC cavities
- 3 ACCEL cavities processed # 5, 8, 9
- 8 process and test cycles in FY07
- Gradients achieved 24-30 MV/M
- Limited by quench

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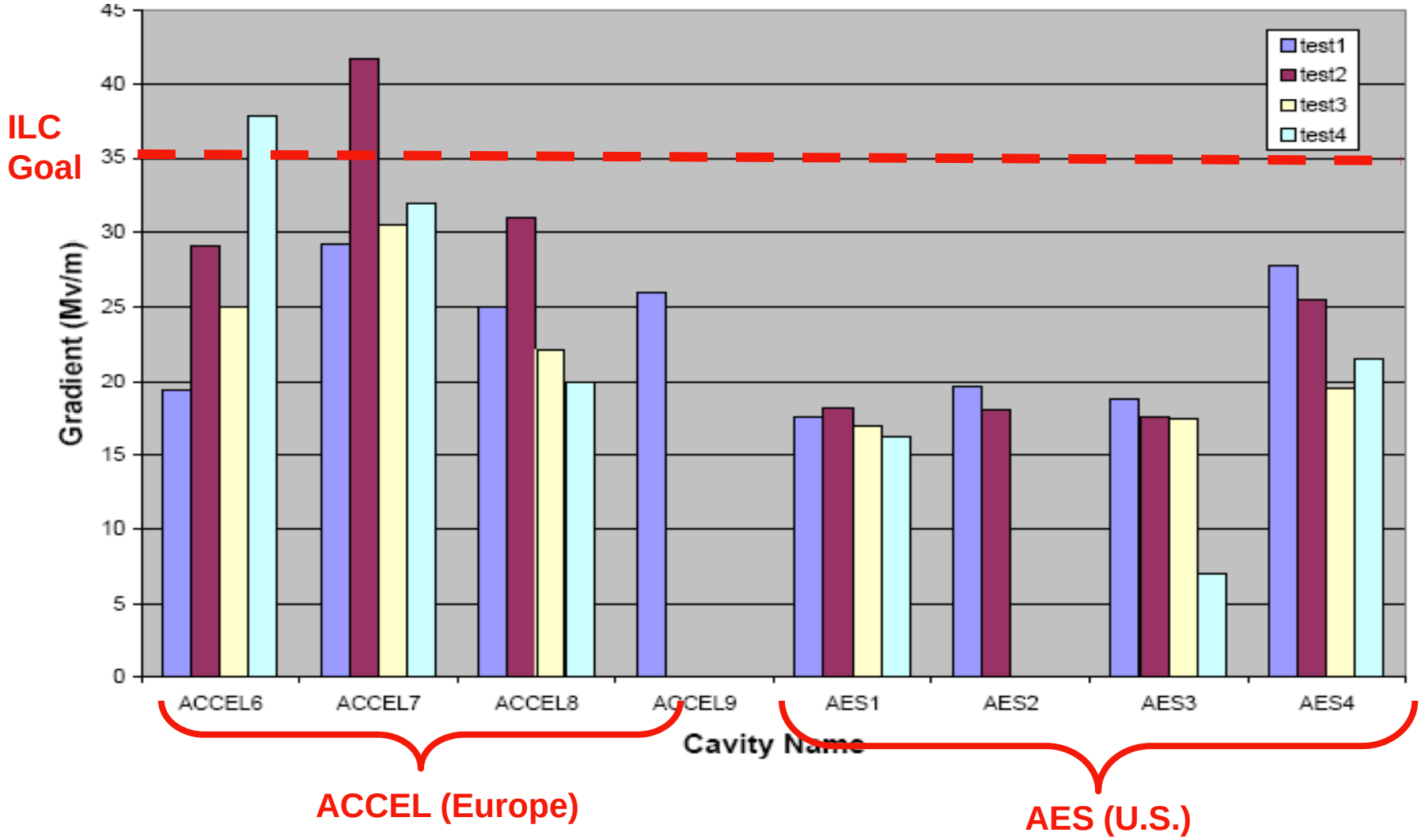
ART: Cavity Process & VTS Results



Most cavities, esp U.S. cavities are limited by Quench vs FE

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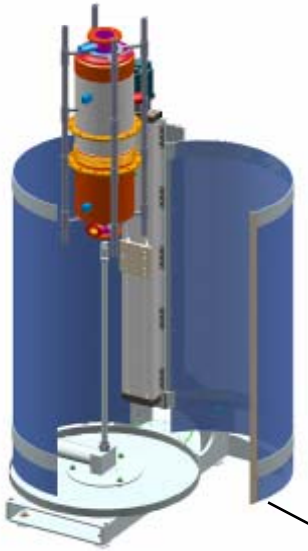
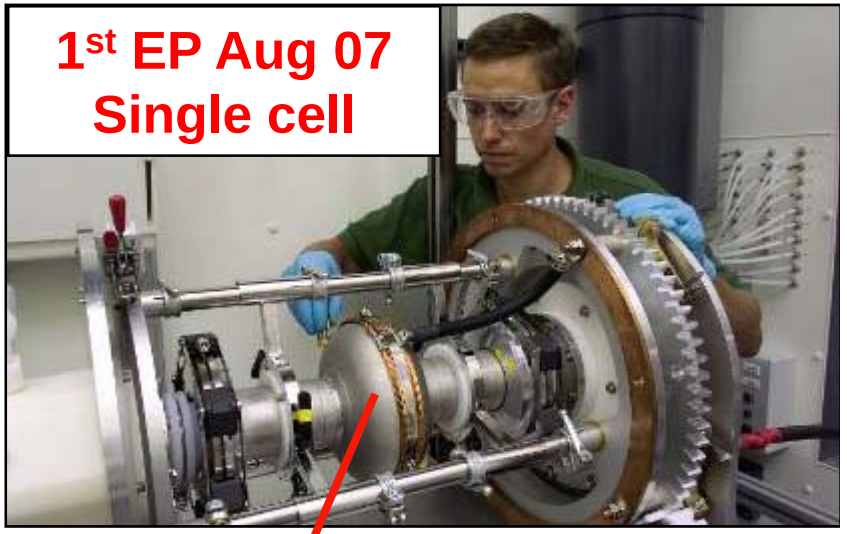
Processing Facility at ANL

Chemistry, Clean rooms, BCP, HPR & EP @ANL: ~ 50 cy/yr

New Clean Rooms

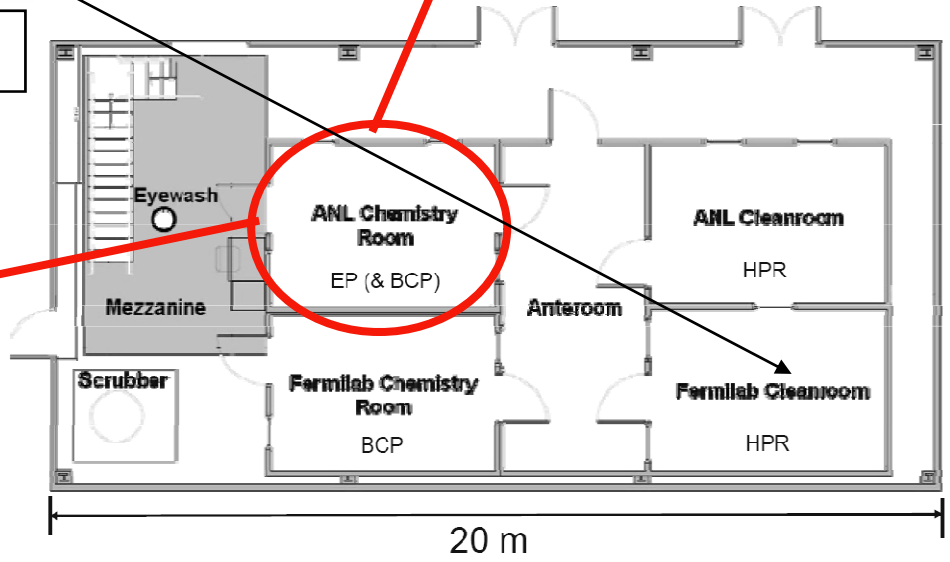


1st EP Aug 07 Single cell



New Chemistry Rooms & EP

HPR



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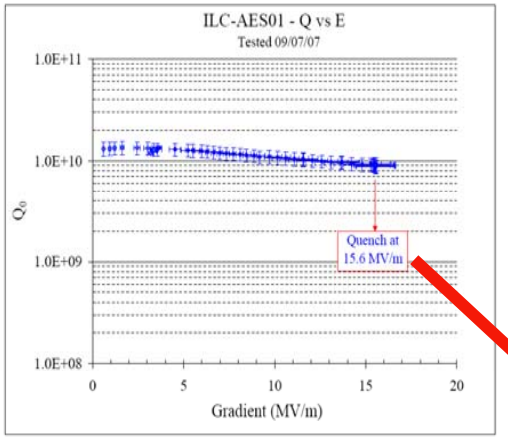
New Vertical Test at FNAL

- Recently commissioned (IB1)
  - Existing 125W@ 1.8 K Cryogenic plant
  - RF system in collaboration with Jlab
  - Capable of testing ~50 Cavities/yr
  - Evolutionary upgrades:
    - Thermometry for 9-cells, 2 cavities at a time, 2 top plates, Cryo upgrades
    - Plan for two additional VTS cryostats
  - Ultimate capacity ~ 264 cavity tests/yr

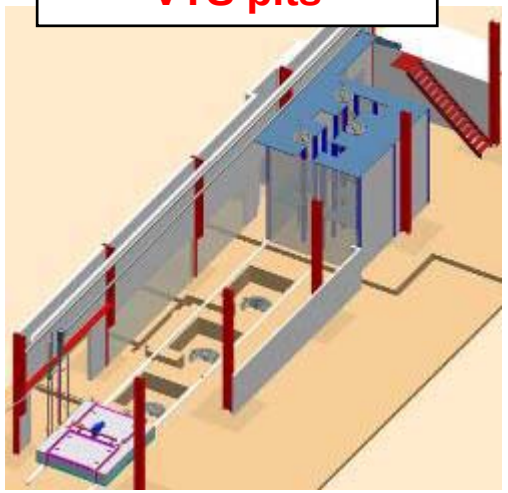
Nine-cell Tesla-style cavity



VTS Cryostat:IB1

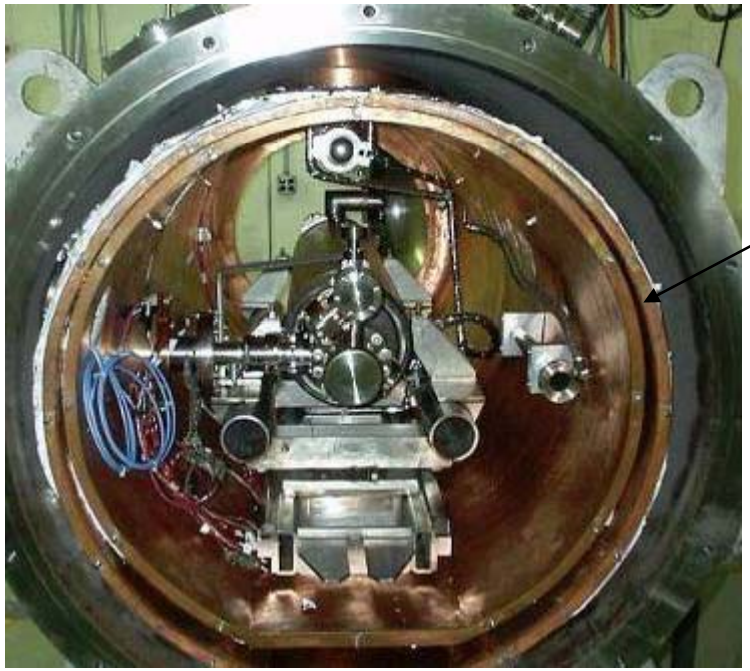
New RF & Control Room

Plan for 2 more VTS pits



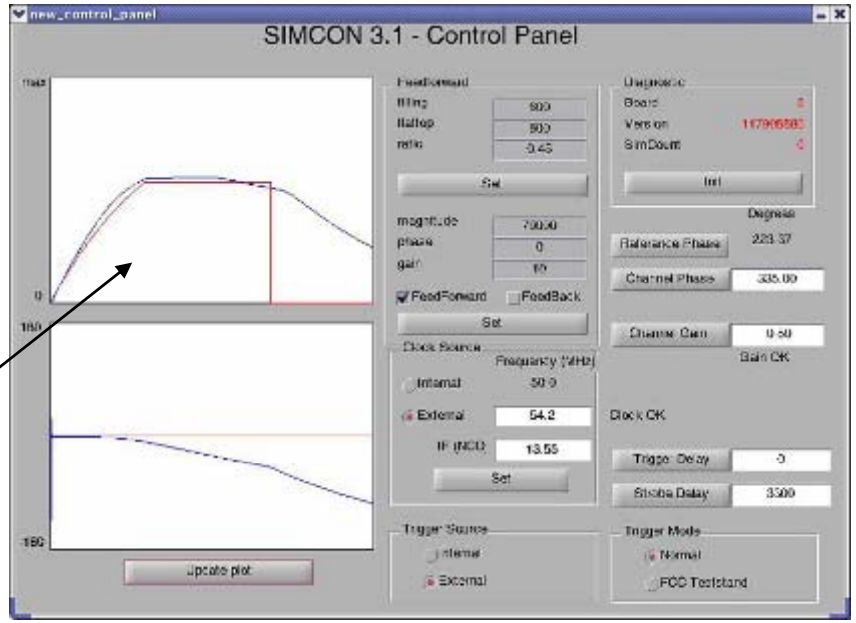
Horizontal Test System at FNAL

- Dressed cavities are tested with pulsed RF power
  - 300 KW klystron & modulator complete and tested
- Extensive MDB cryo modifications➔ 100 W @ 1.8 K
  - HTS currently cold & being commissioned with 1st cavity
- Serves as test bed for LLRF, tuner & coupler studies
- Unique capability in Americas: Goal 24 cavity tests/yr



1st 1.3 GHz Cavity in HTS

C22 Reached 17 MV/m



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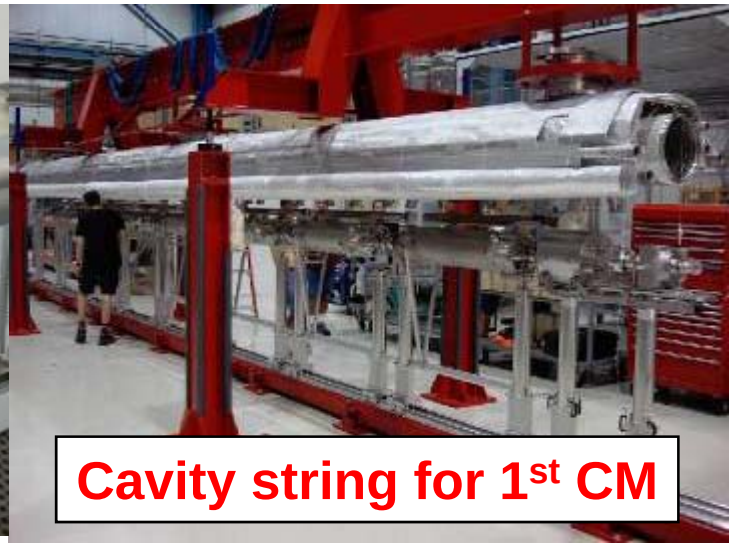
Cryomodule Assembly Facility

- Goal: Assemble R&D Cryomodules
- Where: MP9 and ICB buildings
  - MP9: 2500 ft^2 clean room, Class 10/100
  - Cavity dressing and string assembly
  - ICB: final cryomodule assembly
- Infrastructure:
  - Clean Rooms, Assembly Fixtures
  - Clean Vacuum, gas, water & Leak Check
- DESY Cryomodule “kit” being assembled now

ICB clean: Final Assembly fixtures installed

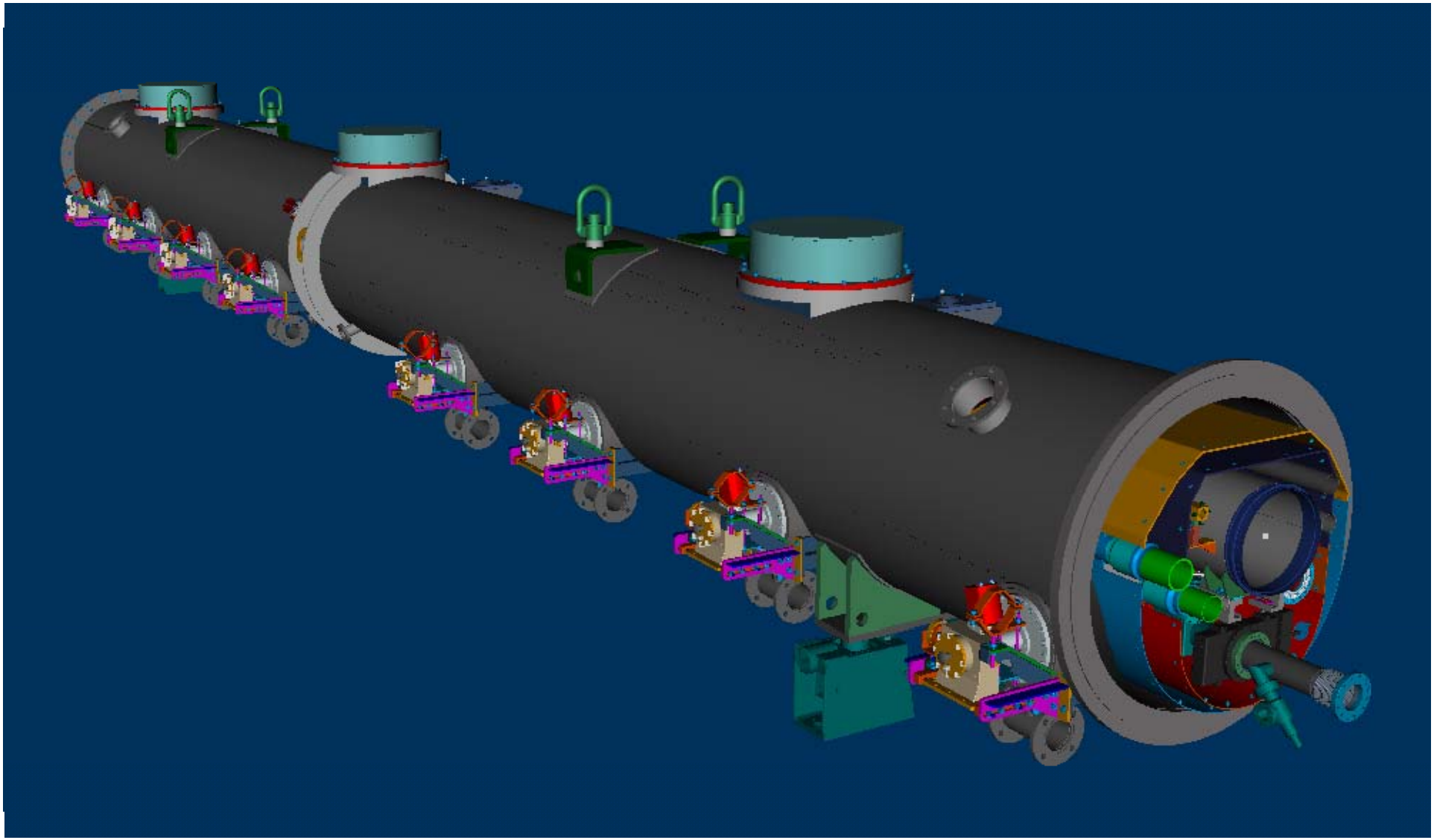
MP9 Clean Room

String Assembly



Cavity string for 1st CM

Type-4 Cryomodule



US Cryomodule Plan

- 1st Cryomodule (2007)
  - Assemble a TESLA TTF type III CM from DESY "kit"
  - Cavities built and fully tested by DESY
- 2nd Cryomodule (2008)
  - Also TTF type III cryomodule
  - Cavities are processed and tested in the US
  - Electropolished and tested at JLAB, Cornell, and ANL/FNAL
  - Cryostat and cold mass from Zannon in Europe
- 3rd Cryomodule (2009)
  - 1st type IV ILC cryomodule built anywhere
  - Parts built in U.S. industry
- 4th-6th Cryomodules (2010-11)
  - Build ILC RF unit in U.S.
  - Transfer knowledge gained to Industry

- Develop, build & test basic building blocks of the Main Linac to evaluate main linac cost and reliability issues

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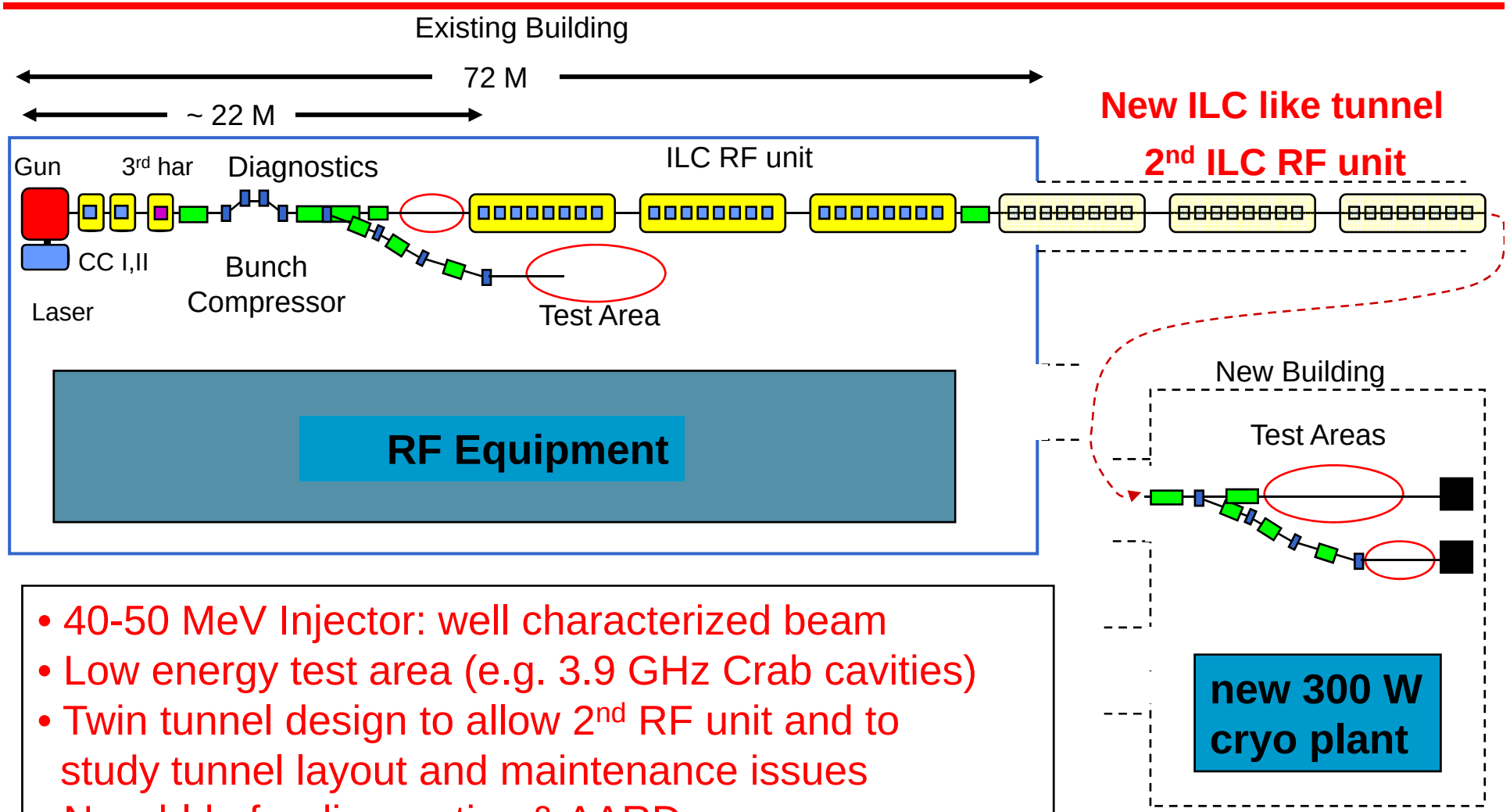
ILCTA at FNAL Layout



- 40-50 MeV Injector: well characterized beam
- Low energy test area (e.g. 3.9 GHz Crab cavities)
- Twin tunnel design to allow 2nd RF unit and to study tunnel layout and maintenance issues
- New bldg for diagnostics & AARD
- Also houses new cryo plant

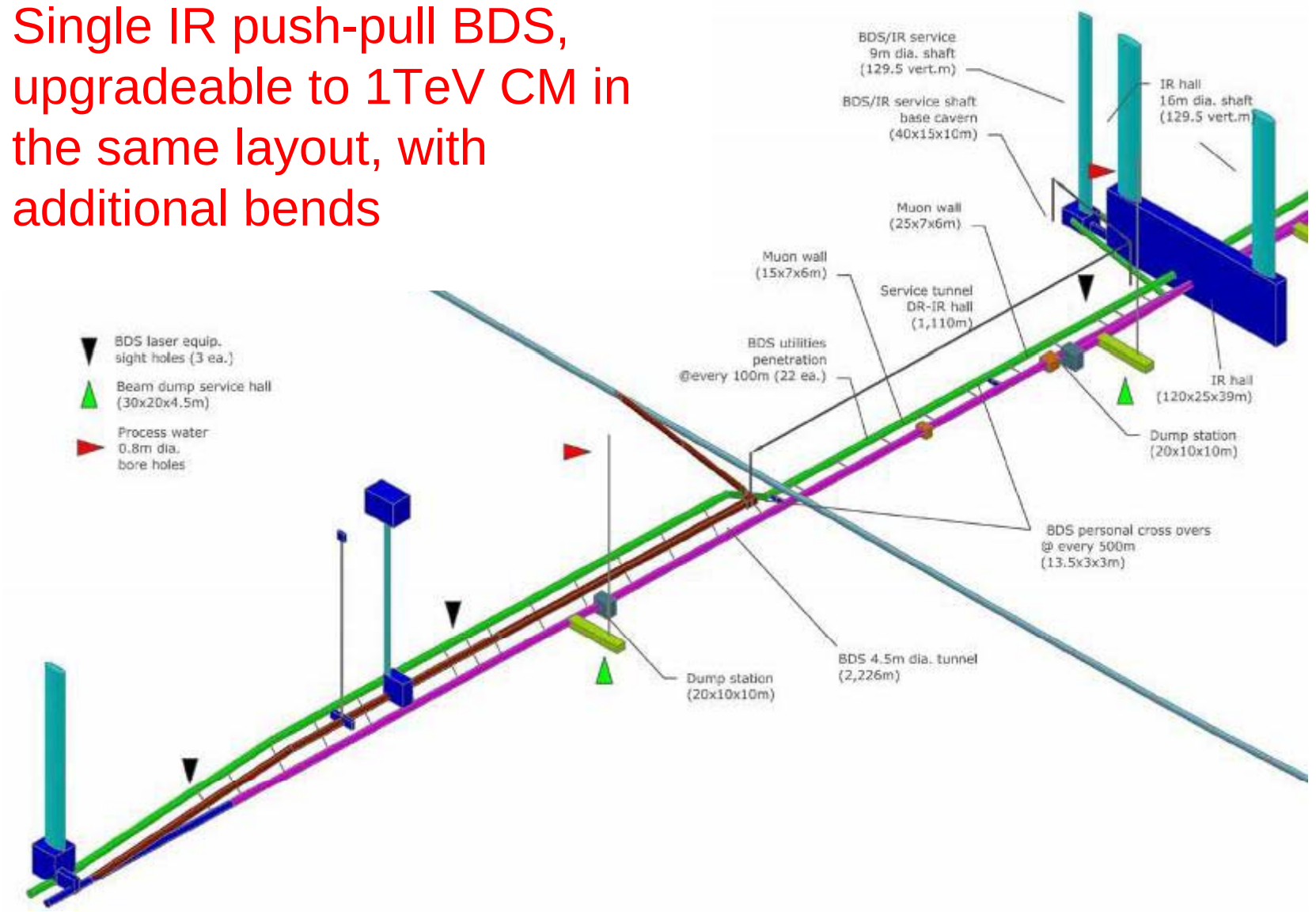
Beam Delivery System

- Design
  - Integrate worldwide BDS design efforts, develop EDR plans
  - Accelerator & detector physics design
  - Address GDE goals on design optimization & cost reduction
  - Develop revised IR designs compatible with push-pull

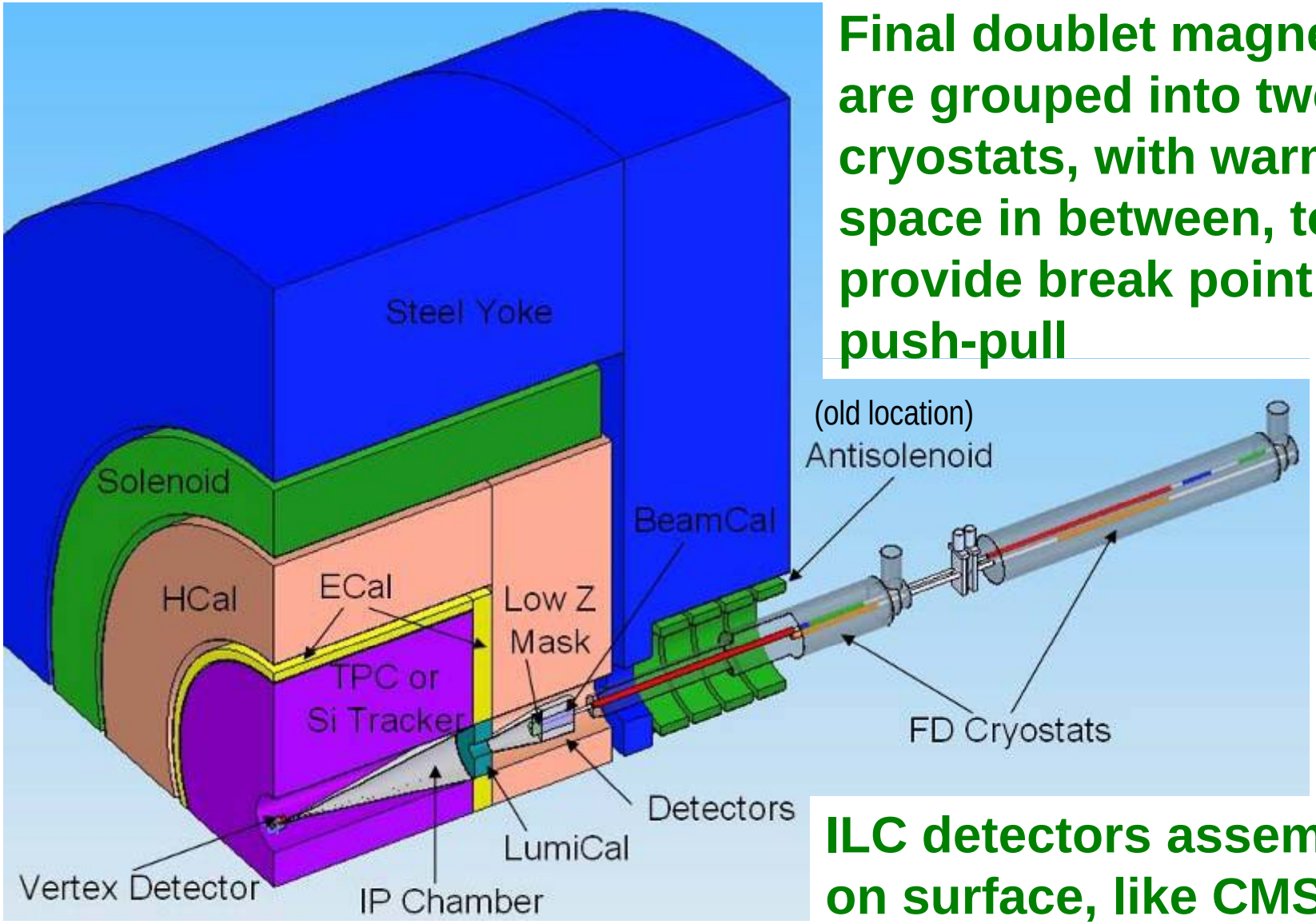
- R&D & Test Facilities (ATF2 and ESA)
  - Prototypes and performance enabling hardware
  - Long IR magnet prototype, study vibration issues in SC FD
  - Study nanometer BPM system at ATF
  - ESA experiments on energy spectrometers, collimator wakefields, bunch length diagnostics and IP feedback
  - ATF2 design and construction

BDS Layout

- Single IR push-pull BDS, upgradeable to 1TeV CM in the same layout, with additional bends



Interaction Region Integration

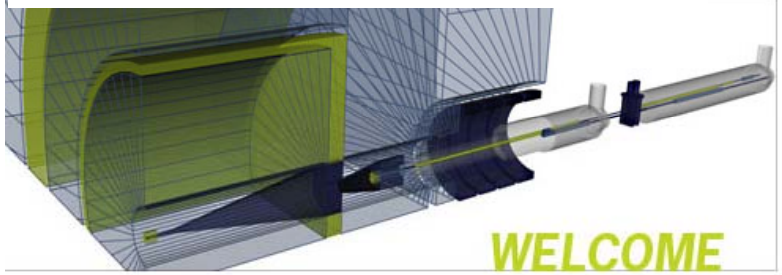


Final doublet magnets are grouped into two cryostats, with warm space in between, to provide break point for push-pull

ILC detectors assembled on surface, like CMS

Push-Pull Layout

http://www-conf.slac.stanford.edu/ireng07/



ILC Interaction Region Engineering Design Workshop

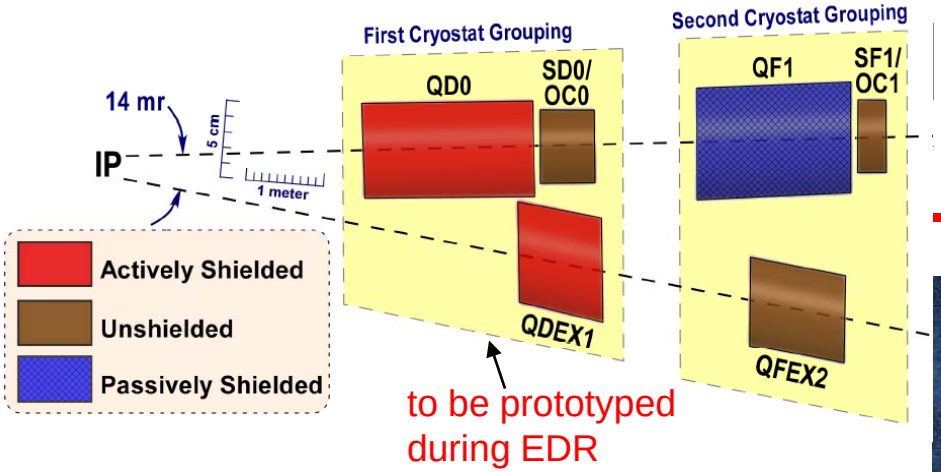
September 17-21, 2007

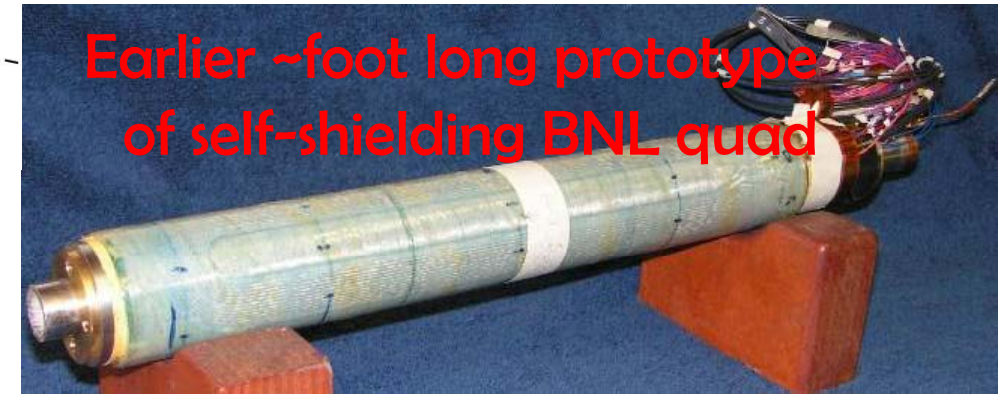
Stanford Linear Accelerator Center

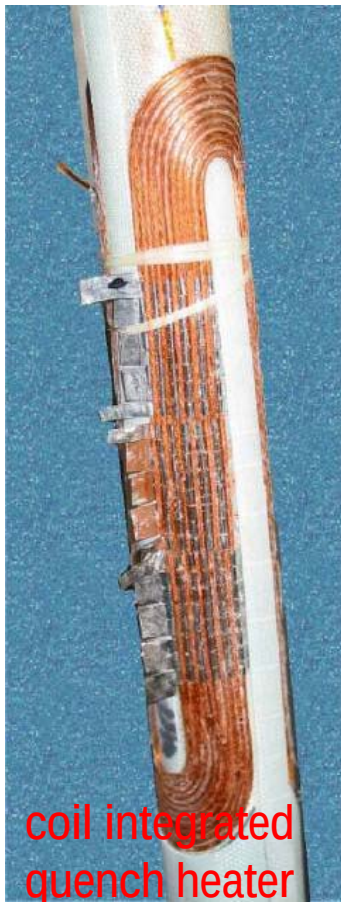
Menlo Park, California

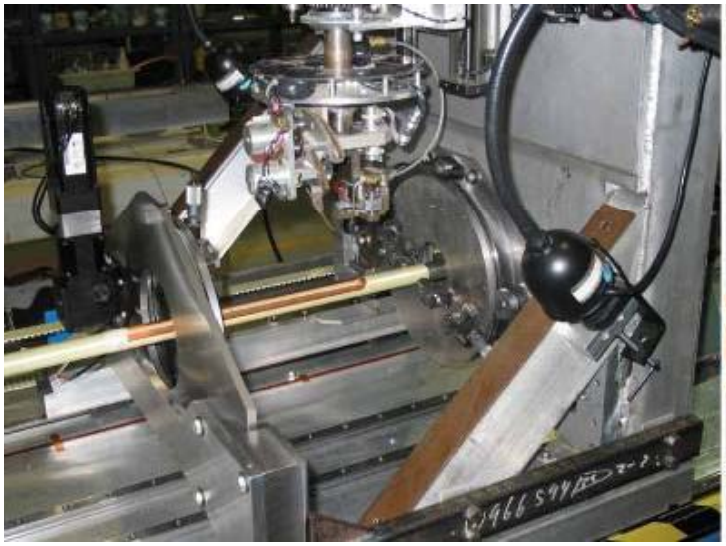
Result of IRENG07 workshop: a more detailed scheme of IR & push-pull scheme. Credits to many participants of IRENG07, conveners of WG-A, WG-B, and WG-C, the CF&S team and in particular CERN's Alain Herve and John Osborne

IR FD prototype @ BNL









Preparation for FD prototype: winding machine modifications to accommodate longer coils, integrated coil heater to test quench threshold, engineering integrated design

ATF2

ATF
Accelerator Test Facility

Scaled down model of ILC final focus

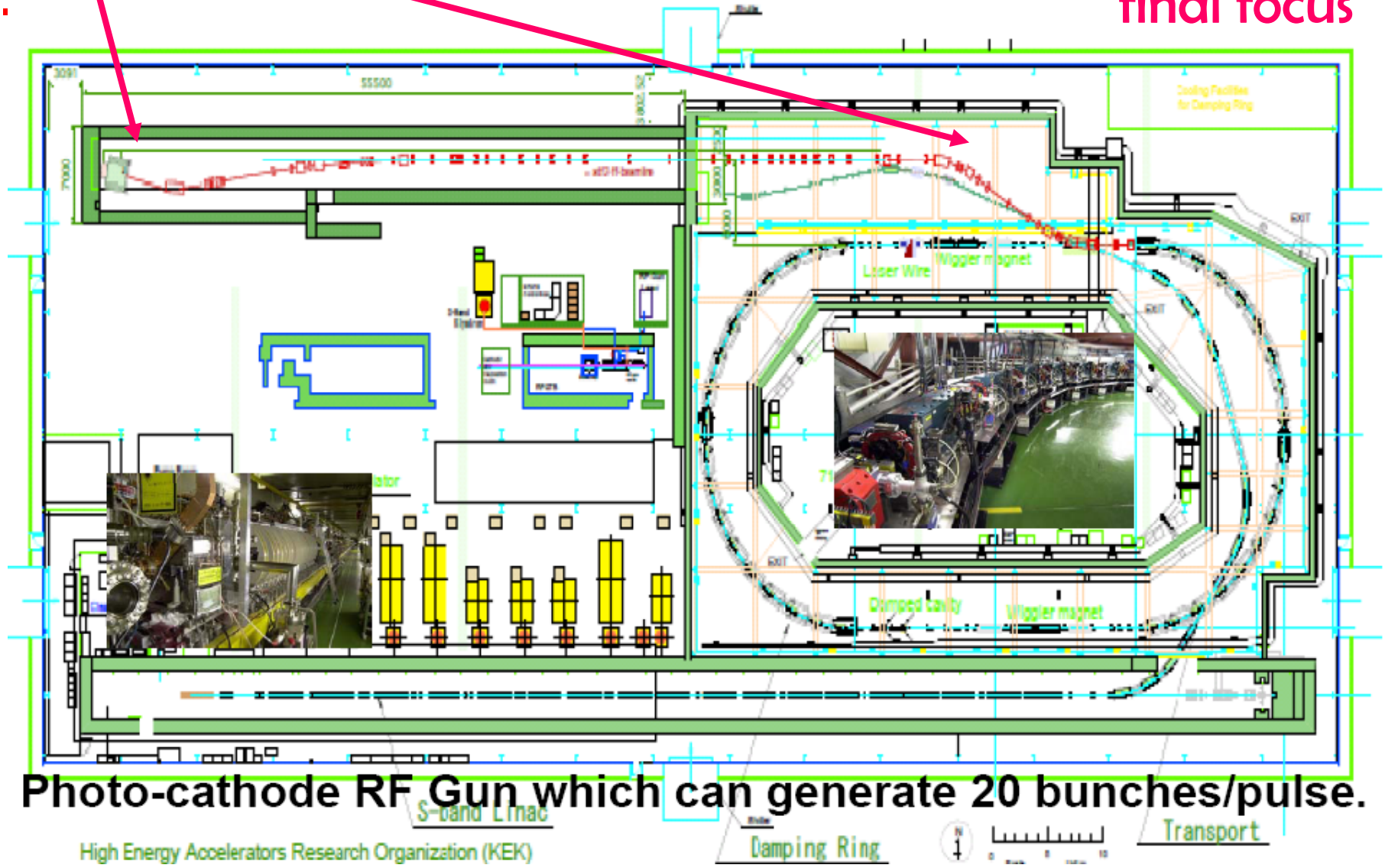
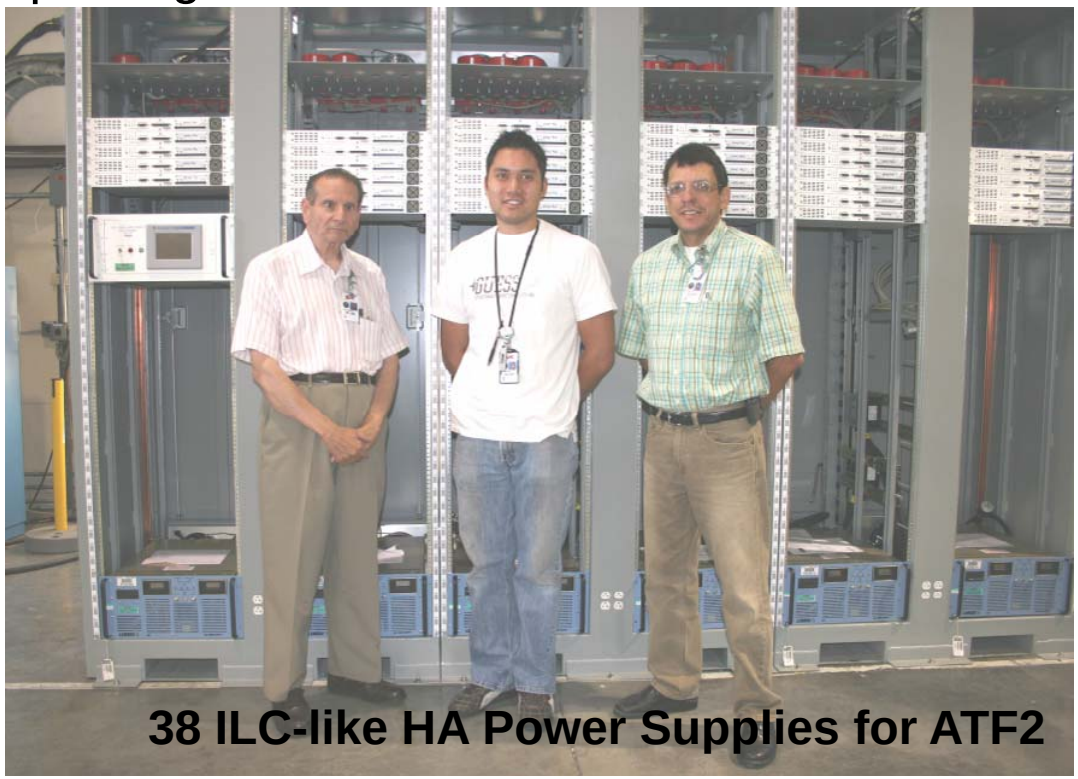


Photo-cathode RF Gun which can generate 20 bunches/pulse.

International Linear Collider – Americas

ATF-2 Final Focus Test

- Rapid progress being made on infrastructure at KEK
- US is contributing a large number of components and expertise:
  - Magnets: dipoles, final quadrupoles, and sextupoles
  - Beam line tuning software packages
  - High availability power supplies
  - ATF damping ring BPMs
  - Fast kicker pulsers
  - RF bpm electronics
  - Magnet movers
  - Optics design
  - Operational support

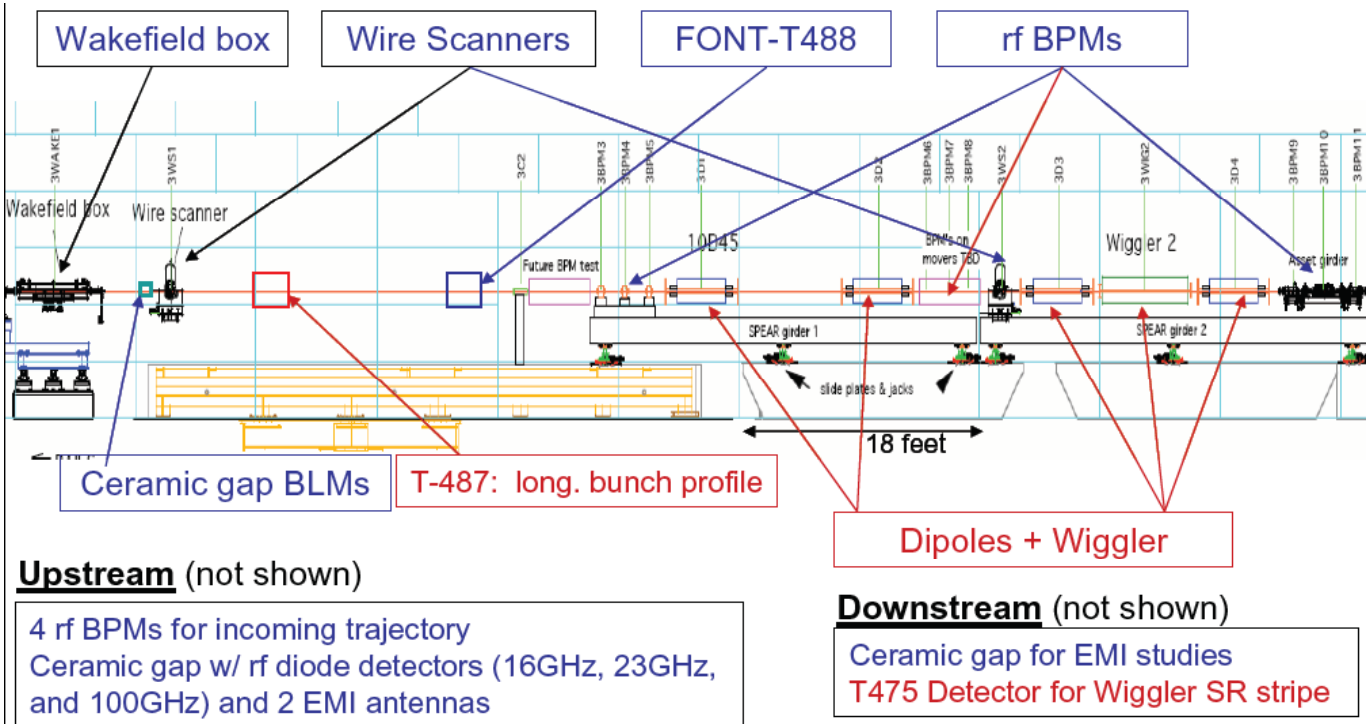


38 ILC-like HA Power Supplies for ATF2

BDS beam tests at ESA

BPM energy spectrometer (T-474/491)
Synch Stripe energy spectrometer (T-475)
Collimator design, wakefields (T-480)
IP BPMs/kickers—background studies (T-488)
EMI (electro-magnetic interference)
Bunch length diagnostics (T-487)

March 7-26, 2007
~ 40 participants



Upstream (not shown)

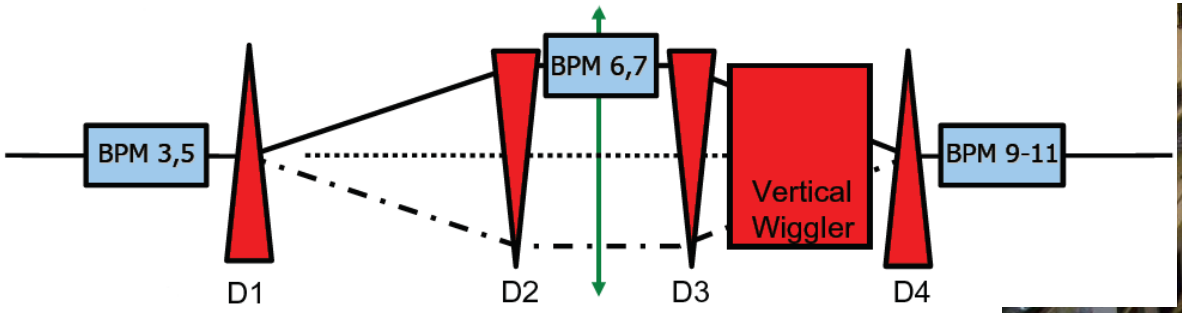
4 rf BPMs for incoming trajectory
Ceramic gap w/ rf diode detectors (16GHz, 23GHz, and 100GHz) and 2 EMI antennas

Downstream (not shown)

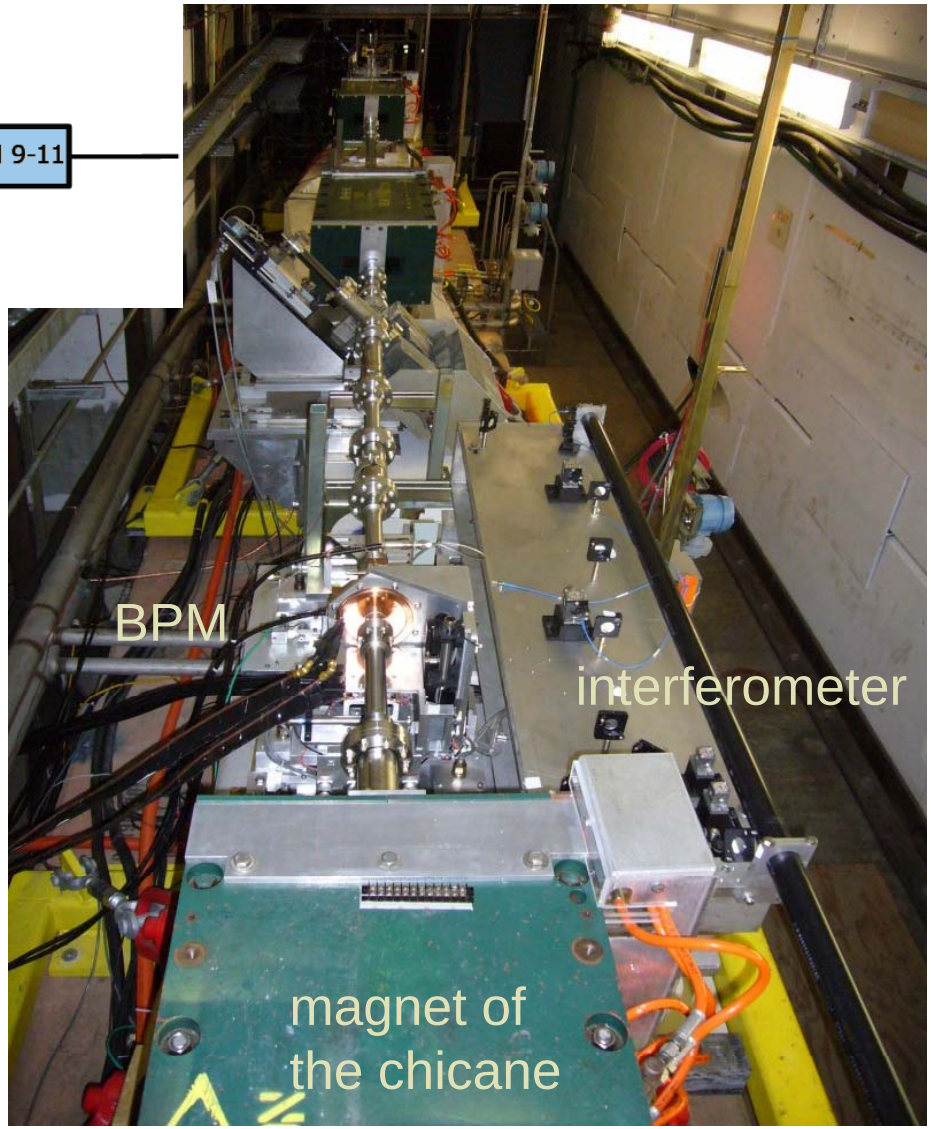
Ceramic gap for EMI studies
T475 Detector for Wiggler SR stripe

Runs: three 2-week runs in 2006 & 07; request two runs in 2008

Energy Spectrometer at ESA



- BPM & SR based
- Interferometer metrology grid for BPMs
- NMR probes in magnets
- 0.5um BPMs with η=5mm => 1e-4 energy resolution
- Study calibrations, systematics, stability
- SR version with quartz fiber detector will be used next run



International Linear Collider – Americas

TRIUMF SCRF Infrastructure

RF Controls Lab

Boot Area

RF Meas

HPWR Rinse Clean Area

Preparation Area

SCRF Test Clean Area

Clean Assembly Area

BCP Chemical Lab

Test Pit

TRIUMF 5-Year Plan

- TRIUMF now preparing 5-year plan for Canadian Government for 2010-2015
- Funds allocated in 5-year units
- ILC being discussed on how it might be included in plan
- TRIUMF has signed an umbrella MOU with Fermilab for ILC (draft MOU -- DESY detector)
- Addendum being prepared
  - Make three single-cell cavities 1.3 GHz using multi-grain niobium (electro-polish elsewhere)
  - Move towards single crystal large grain version which only needs BCP
- Produce a 9-cell cavity and qualify PAVAC as an ILC vendor for North America
- University researchers getting involved in SRF

Summary

- Very strong program across the US covering a broad spectrum of ILC topics
  - Led the RDR effort and coordinated many of the Area and Technical Systems
  - Strong R&D programs
  - Narrowing focus of design efforts during EDR phase as international partners assume larger role
  - Will need to re-align programs when actual EDR effort becomes clear
- Rapid buildup of SCRF infrastructure for ILC as well as other future projects using SCRF (ERL's, XFEL's, RIA, ProjectX, …)
  - Industrialization process for SCRF components is beginning