ILC R&D in the Americas Region

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ILC/GDE and Cornell University

ILC GDE Meeting
Frascati, Dec. 8, 2006

ILC-Americas Regional Team

ANL	BNL	Cornell LEPP	Fermilab	LBNL
Jefferson Lab	LLNL	SLAC	TRIUMF	Universities

FY06 resources

	FTE	Labor	M&S	Indirect	Total
SLAC	59.9	7,182	3,700	2,909	13,791
FNAL	31.0	3,565	4,635	1,826	10,026
ANL	0.0	140	14	0	154
Jlab	1.0	170	651	79	900
LLNL	0.0	580	230	390	1,200
LBNL	2.3	330	0	170	500
BNL	0.0	0	0	0	500
Cornell	0.0	0	165	0	165
Universities	0.0	0	0	0	841
sum	**94.1**	**11,967**	**9,395**	**5,374**	**28,077**

University program:
Wisconsin, Northwestern, Old Dominion, Yale, MIT, Tennessee, Princeton, Illinois, NCA&T, UCLA, Berkeley, Vanderbilt, Colorado State, UC Davis

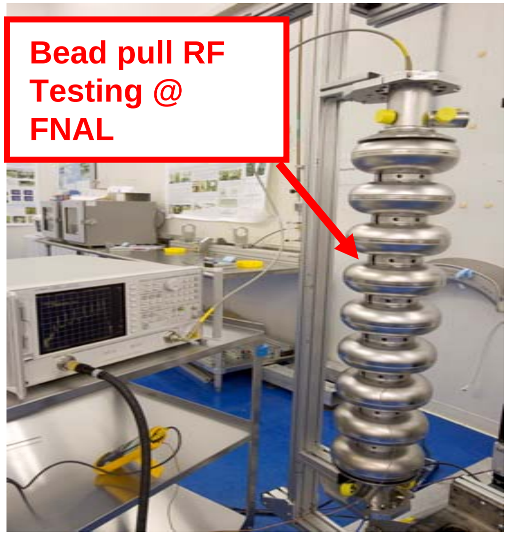
ILC R&D at Fermilab

- The ILC R&D effort at Fermilab is focused on key design & technical issues in support of the RDR, cost estimate and eventually the TDR for the ILC.
- Fermilab's efforts are focused on two main areas of the ILC
  - Main Linac Design
  - Civil and Site Development
- Main Linac R&D:
  - The goals are to demonstrate the feasibility of all Main Linac technical components, develop engineering designs, estimate costs, explore cost reduction, and engage industry in the Americas region
- Civil and Site Development
  - Fermilab is working with the GDE and international partners to develop a matrix for comparing possible ILC sites
  - Fermilab is also working to develop Americas region sites at or near Fermilab for the RDR.

Main Linac R&D at Fermilab

- The main thrust of the Fermilab ILC Accelerator R&D is to establish Americas region technical capabilities in the Superconducting RF Cavity and Cryomodule technology. The main goals are
  - 1) Cavity technology development in the Americas region to routinely achieve $\geq$ 35 MV/m and Q ~0.5-1X10^{10},
  - 2) ILC Cryomodule design, fabrication, and cost reduction
  - 3) Develop facilities (ILC Test Accelerator-ILCTA) to fully test the basic building blocks of the Main Linac (to evaluate performance and reliabilities issues)
  - 4) Explore Main Linac accelerator physics and design issues (e.g. simulation of emittance preservation, RF control, feedback systems, etc.)
  - 5) RF power system development (modulators)
  - 6) LLRF, Instrumentation and Controls development

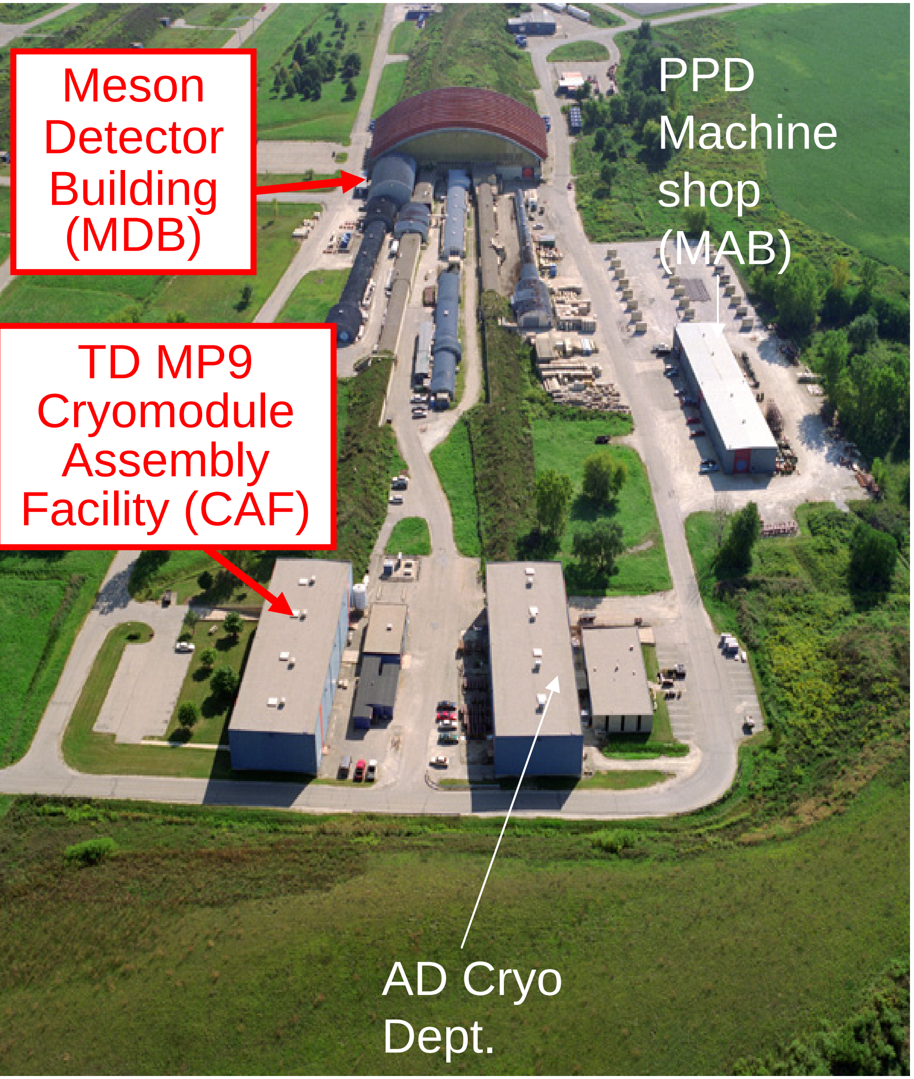
ILC 1.3 GHz Cavities at FNAL



Joint ANL/FNAL BCP/EP Facility

- Industrial fabrication of cavities.
- BCP and vertical testing in collaboration with Cornell (25 MV/m)
- EP and vertical testing in collaboration with JLab. (35 MV/m)
- Joint BCP/EP facility being developed at ANL (late 06)
- High Power Horizontal test facility @ FNAL (ILCTA-MDB)
- Vertical test facility under development @ FNAL (ILCTA-IB1)
- Single/large grain Crystal cavity development in collaboration with Jlab.

SCRF Infrastructure at FNAL



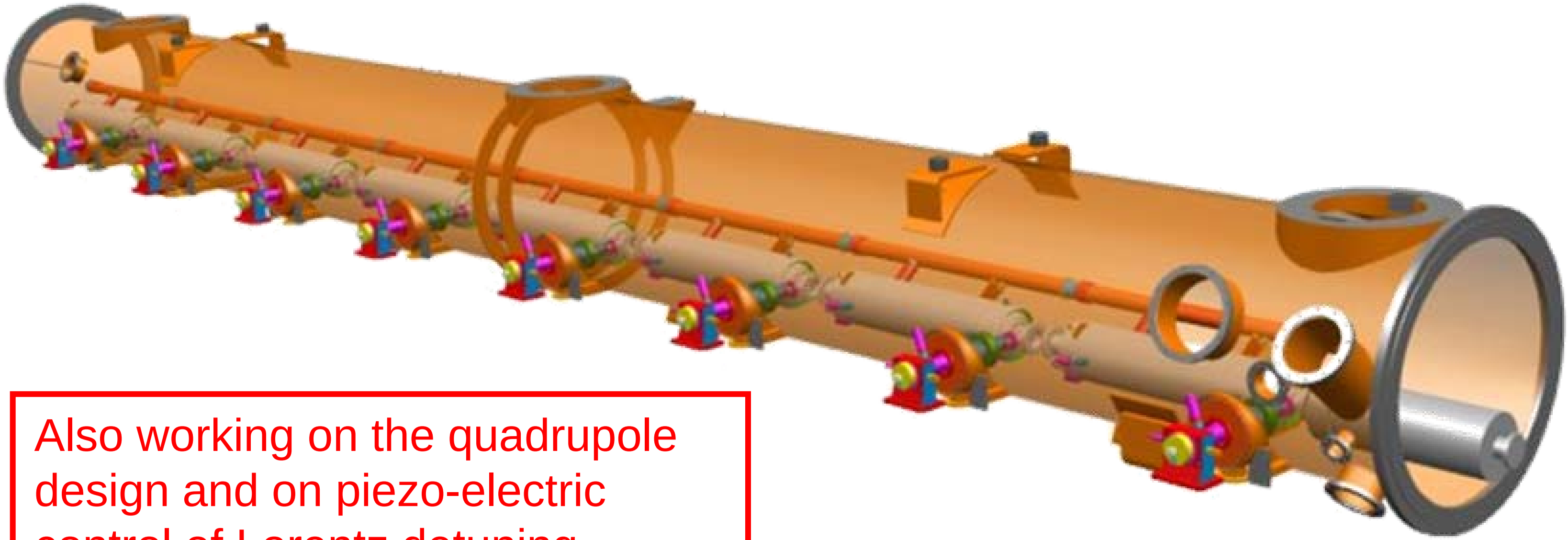
Cryomodule Assembly Facility (CAF) at FNAL

- Vertically tested cavities will be dressed (He vessel, coupler, etc) in CAF clean rooms prior to horizontal test at ILCTA-MDB.
- Horizontally tested cavities assembled into a string at CAF
- Final Cryo-module assembly takes place at CAF

- CAF design intended to improve on DESY facility
- Expect parts for a type III cryomodule from DESY; FNAL is building a 3.9 GHz (3rd harmonic) cryomodule for DESY
- CAF ready to start fabrication of cryomodules by summer of 06

Cryomodule Design at FNAL

- Industrial fabrication and cost reduction of the ILC cryomodule are both crucial issues for a realistic ILC cost estimate
- In FY05 Fermilab started on converting drawings of the DESY/INFN design of the ILC cryomodule (Type-III+) to US standards for U.S. vendor fabrication and for cost reduction.
- Next goal is to design an improved ILC cryomodule (Type-IV).

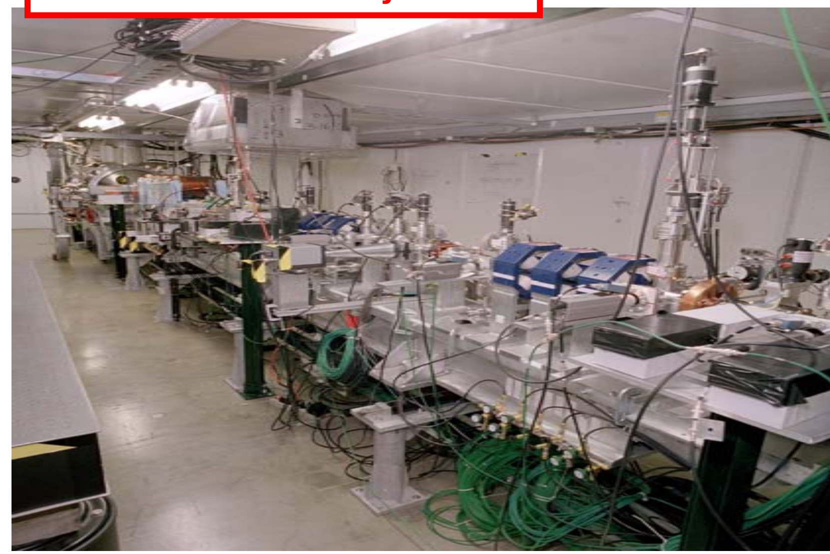


Also working on the quadrupole design and on piezo-electric control of Lorentz detuning

Cryomodule string test: ILCTA-NML at Fermilab

New Muon Lab (NML)

FNPL Photo-Injector



Building a dedicated ILC cryomodule string test facility in the New Muon Lab

- Building is cleaned out except for removal of CCM (in progress)
- Started to install cryogenic system
- Move FNPL Photo-injector to provide electron beam (Late FY06)
- Upgraded FNPL will provide beam tests of ILC cryomodules

Jefferson Lab : Develop electropolishing processes for 1.3 GHz cavities

- **FY06 Funding (MOU with FNAL) $600k**
- **Objectives:**
  - Commission the Jefferson Lab EP and HPR processing and Vertical Test systems for 1.3 GHz TESLA cavities.
  - Carry out processing of cavities from a variety of sources
  - Develop and refine processing parameters.
  - Carry out detailed test program planning for individual cavities and evaluation of results.
  - Develop more cost effective procedures with high yield.
  - Develop written procedures and proposals for future improvements and toward industrial transfer.
  - Provide or process samples as appropriate for the SCRF materials program at FNAL
  - Fabricate two TESLA 9-cell cavities from large grain material
- **Status:**
  - DESY cavities needed to begin infrastructure development -- received by FNAL

Jefferson Lab : Fabricate, process and test cavities from large-grain/single-crystal material

- **FY06 Funding (direct transfer) $300k**
- **Objectives:**
  - **Several single cell and at least one multi-cell cavity made from large grain/single crystal niobium**
  - **Improved buffered chemical polishing system for producing very smooth rf surfaces on large grain/single crystal material**
  - **Test cavity for superconducting rf joint investigations**
  - **Optimization studies of superstructure configuration based on superconducting joint**
  - **Two cavities suitable to be combined into a superstructure**
  - **Engineering package for the completion of a superstructure assembly ready for cold tests**

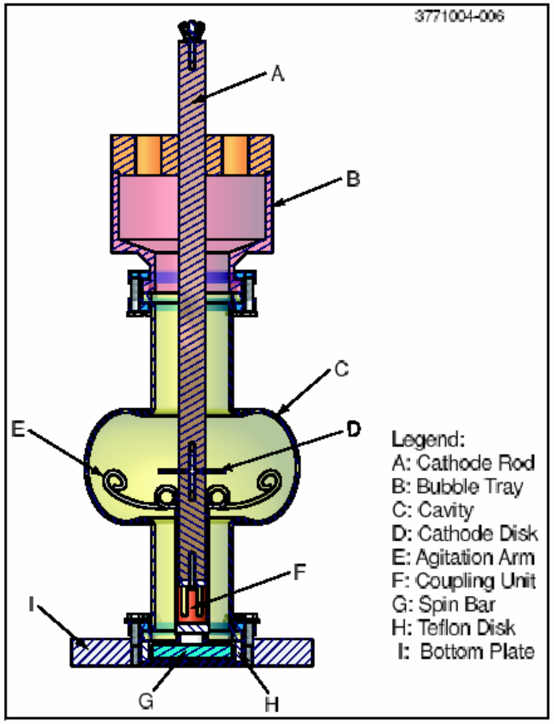
Status: **large-grain/single-crystal material cavity: fabrication and test**

- **Superconducting joint cavity**
  - **completed, tests pending**
- **single cell cavities from large grain material of different vendors (CBMM, Ningxia, Wah Chang and W.C.Heraeus)**
  - **fabricated, treated and tested**
- **A 7-cell Low Loss cavity from large grain material**
  - **completed, being tuned and will be tested in next 2 weeks**
- **fabrication of 9- cell aluminum model, 2 LL single-cells, 9-cell TESLA-shape Nb cavity, and dies and trim fixtures for the TESLA shape cavity**
  - **complete**
- **Issue: Determining correct modification of cell shape to yield LL geometry after stiffening ring welding**

Cornell LEPP ILC SCRF activities

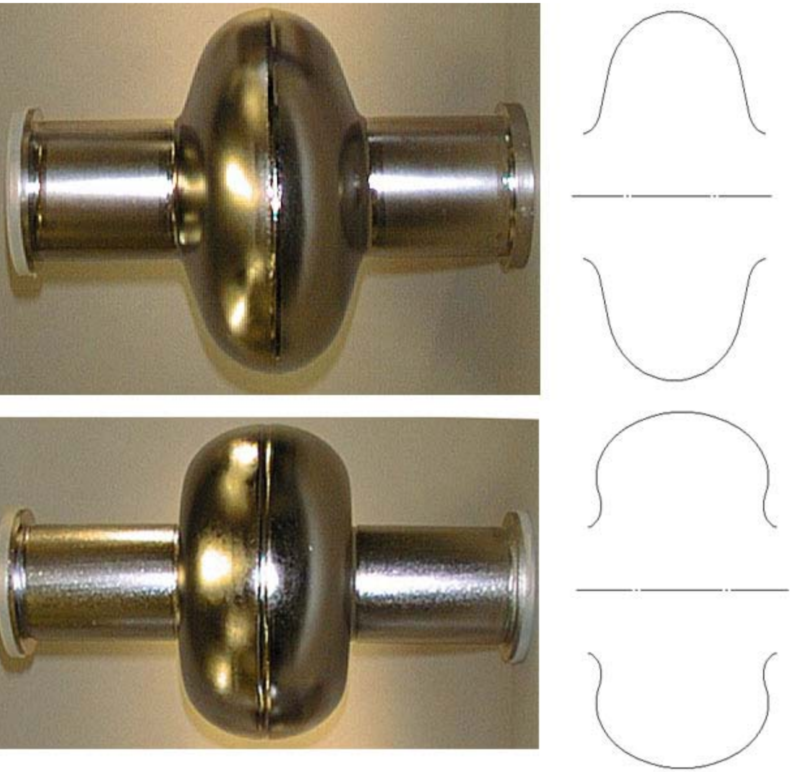
Preparations for BCP and HPR in Clean Room for 9-cell from Fermilab (ACCEL production)

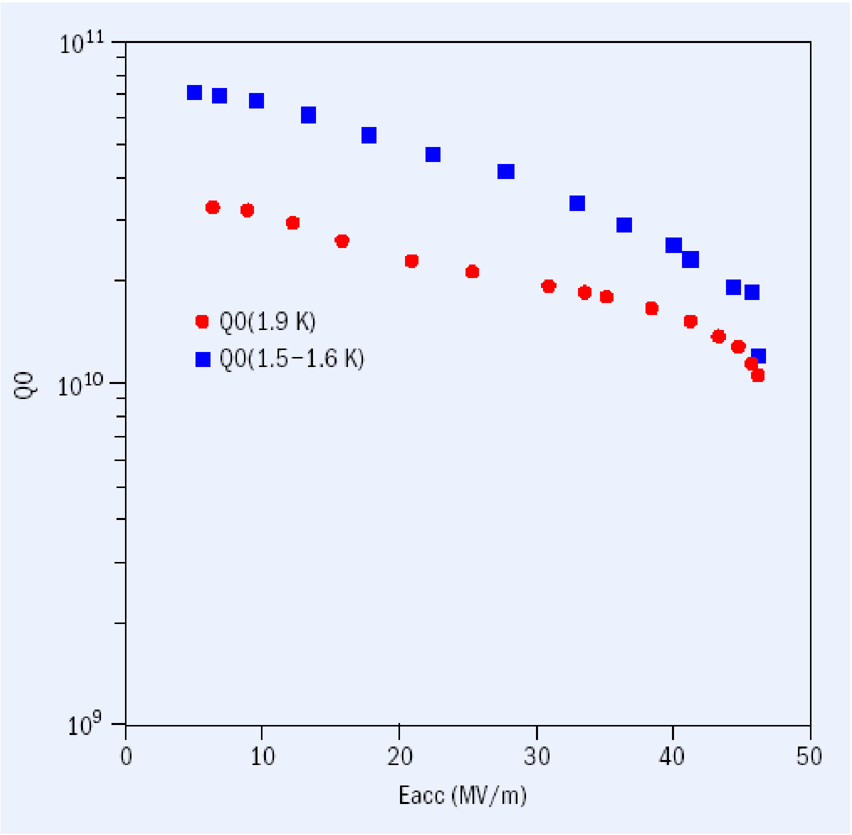
Vertical EP Development at Cornell



Cornell LEPP ILC SCRF activities

Re-entrant Cavity Shape
47 MV/m at Cornell…Later 52 MV/m at KEK
9-cell re-entrant cavity ordered from AES





Cornell LEPP ILC accelerator physics activities

- RTML design
- LET emittance preservation simulation studies
- Damping ring optimization:
    - studies of wigglers: electromagnetic design, impact on ring dynamic aperture
    - studies of fast kickers
- Positron source
    - undulator design:
    - E166 participation
- Study of the use of CESR as an ILC positron damping ring test facility (after 2007)
- Supported by NSF and DOE university grants and NSF LEPP co-operative agreement

ANL Plan for ILC-GDE/FY06

- **SCRF Cavity Electropolishing at the ANL-FNAL Joint Facility**
  - Leverage the new (~$2M) chemistry facility and Argonne expertise to build a complete EP apparatus for ILC-type 9-cell cavities
  - Close collaboration with FNAL
  - The EP to be operational in FY 06, processing in FY07

- **Positron Source Development (**1.95 FTE and $10K M&S; ANL will provide $90K)
  - A comprehensive start-to-end simulation of conventional, polarized, and keep-alive sources, in collaboration with SLAC
  - Optics for positron beam separation and selection
  - Conventional adiabatic matching device based on Bitter magnet

ANL Plan for ILC-GDE/FY06

- **Damping Ring Design and Optimization(**1.4 FTE and $10K M&S; ANL will provide $40K)
  - Lattice optimization including practical effects (errors, injection/extraction,...) using multi-objective evolutionary algorithms; Improve simulation tools and correction schemes for vertical emittance and coupling
  - Particle tracking for single-bunch instabilities with 3-D wakefield
  - Studies of ion instability in the APS ring
  - Design of a hybrid wiggler satisfying the field quality tolerance
- **ANL can contribute significantly in other areas, for example in the control system**

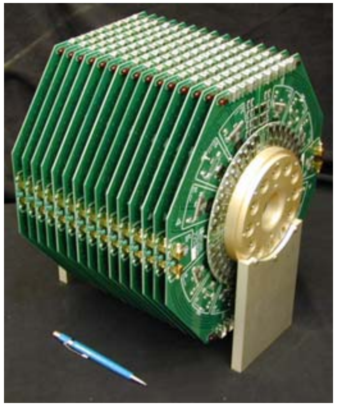
SLAC ILC Accelerator Design (RDR)

- Strong efforts throughout the machine design
  - Electron and positron sources
  - Contributions to the damping rings and RMTL
  - Main linac design and instrumentation
  - Rf sources
  - Beam Delivery System
  - Civil construction and conventional facilities
- Able to provide leadership for some RDR Area Sub-systems

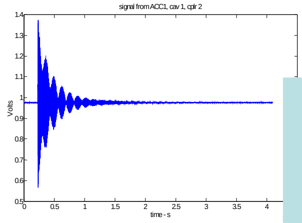
SLAC ILC R&D Program

- Broad R&D Program
  - Availability issues (~1.3 M$)
    - Kickers, Power supplies, and control system

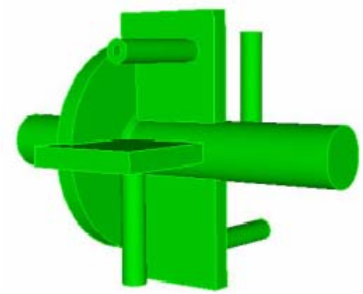
Fast (redundant) kicker for DR



  - Beam instrumentation (~1 M$)



TTF HOM Signal 800 monitors installed



RF BPM for linac

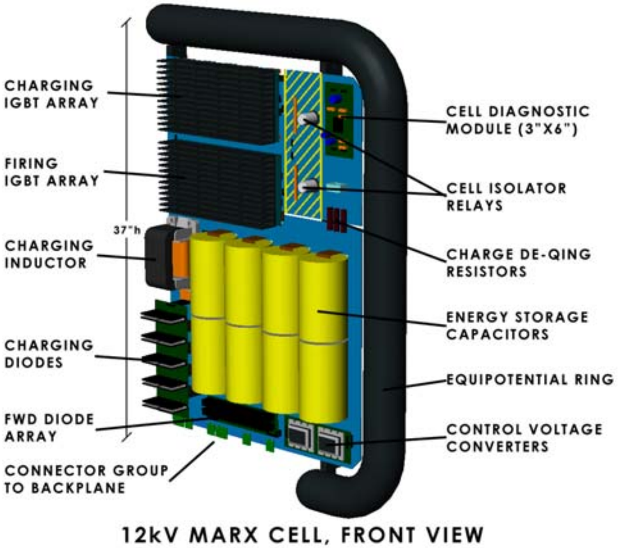
  - Linac beam dynamics (~0.5 M$)
    - SC quad and BPM

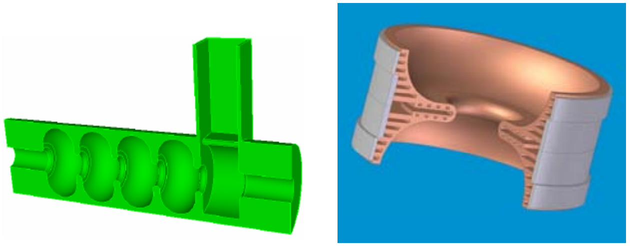
SC Quad for magnetic center tests

SLAC ILC R&D Program

- Broad R&D Program (cont.)
  - Linac rf sources (~1.5 M$)
    - Marx generator modulator
  - Electron and Positron sources (~1.2 M$)
    - NC structure, E-166, electron laser, and cathode
  - Damping rings (~ 0.3 M$)
    - SEY studies in PEP-II

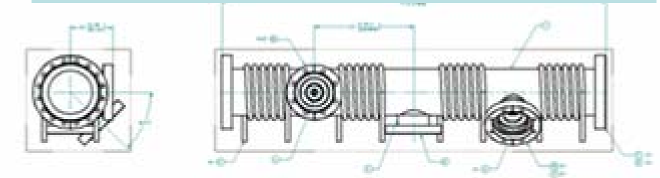
12 KV Marx Cell





Positron capture structures

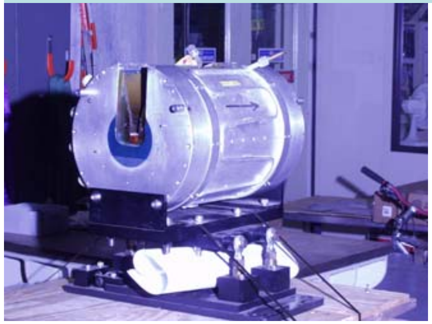
SEY Test Chamber for PEP-II

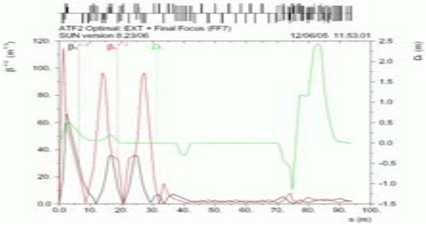


SLAC ILC Test Facilities

- Five efforts:
  - ATF damping ring (~0.7 M$) (includes R&D)
    - Over 1 FTE in residence at KEK
  - ATF-2 (~1 M$) (includes R&D efforts)
    - Construction of magnets, PS, and instrumentation
  - ILCTA at FNAL (~0.2 M$)
    - Cryo-system design and modulator switch
  - ESA MDI Test Facility (~0.5 M$)
  - ESB L-band klystron station (~1.4 M$)

ATF Extraction Kicker



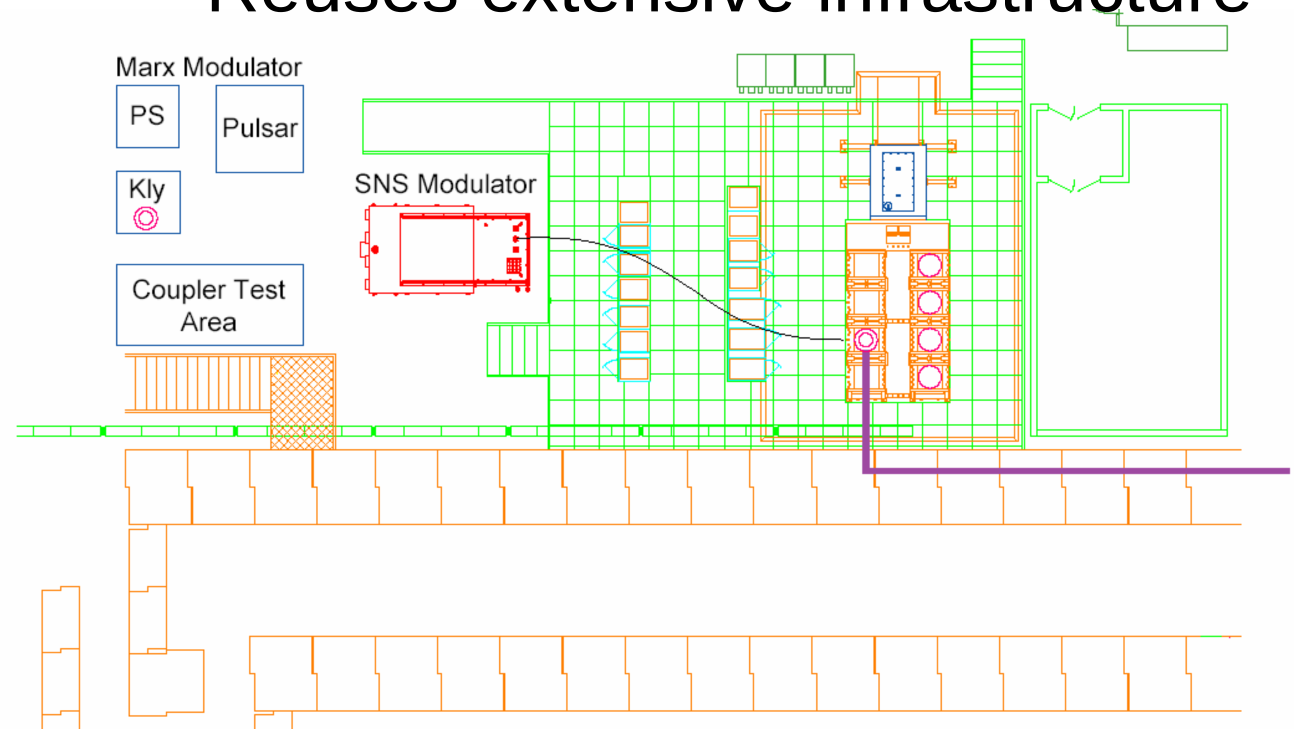


ATF2 Optics

ESA Energy Spectrometer

SLAC End Station B (RF Test Fac.)

- Develop 5 MW and 10 MW stations
  - Test rf system components
  - Reuses extensive infrastructure



LBNL: Accelerator Design

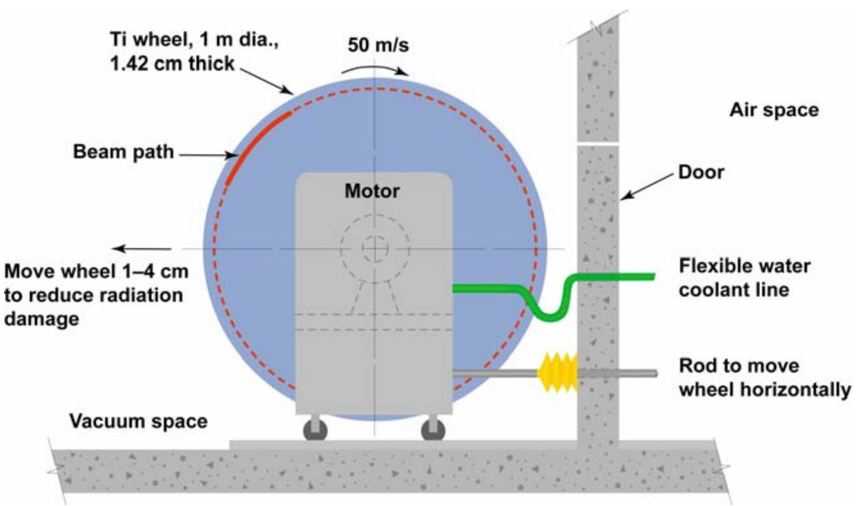
- Lattice designs for damping rings and injection/extraction lines (1.0 FTE)
- Characterization of some collective effects, including space-charge, IBS and microwave instability (0.7 FTE)
- Contribution to development and optimization of bunch compressor lattices (0.2 FTE)

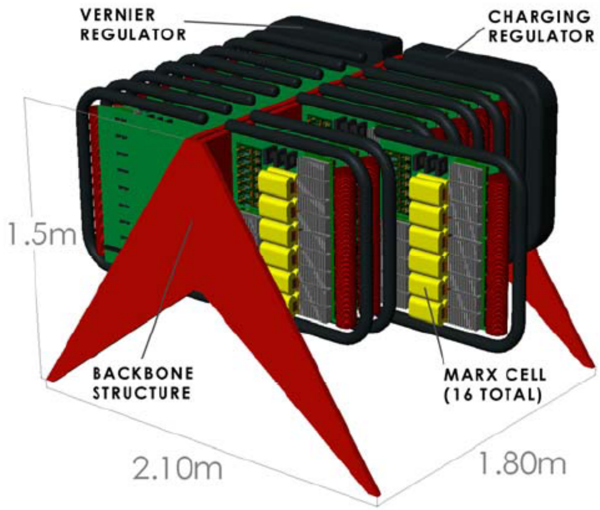
LBNL: Test Facilities

- Physics design of stripline kickers for single-bunch extraction at KEK-ATF (0.15 FTE)
- Contribution to beam-dynamics studies at KEK-ATF, including CSR studies, low-emittance tuning and nonlinear dynamics (0.2 FTE)

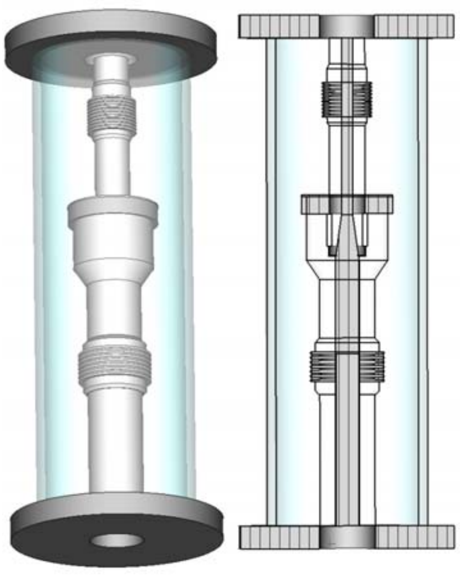
LLNL ILC Activities in FY06

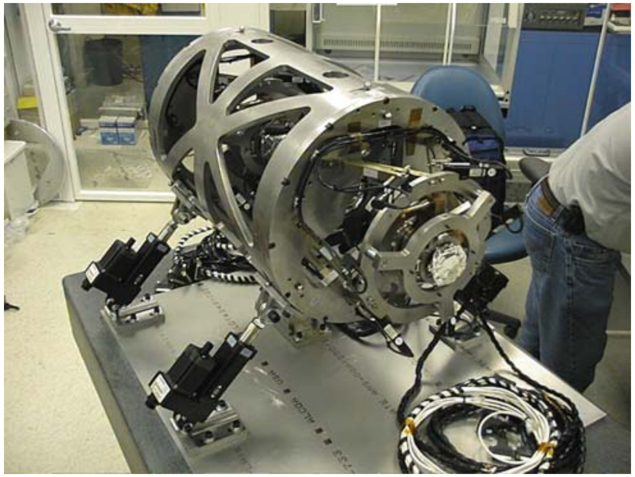
- Positron target design
  - $600K (1.5FTE)
  - Detailed engineering
  - Target simulations
    - Energy deposition, radiation damage, activation
- Marx modulator
  - $200K (.75 FTE)
  - Mechanical engineering of modulator and test equipment





- Coupler Test Stand
  - $100K (.25FTE)
  - Evaluation and analysis of RF coupler designs
- NanoBPM
  - $100K (.35 FTE)
  - Installation and data taking of nanometer resolution metrology frame





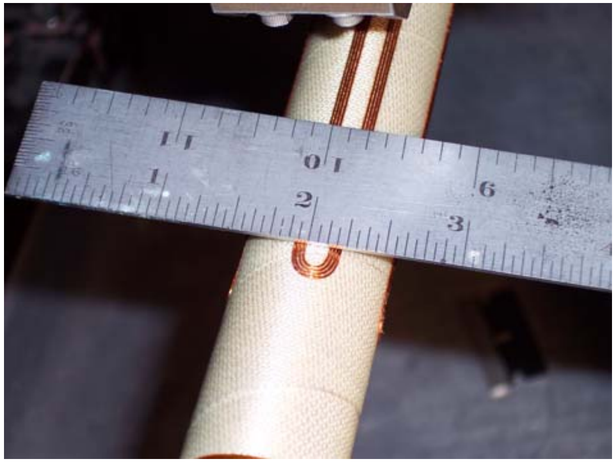
$1M (3 FTE) program using LLNL’s engineering resources to advance the ILC design

ILC Final Focus Magnet Development
Brookhaven National Lab

FY06 goals:

- Continue to support the baseline design efforts in WG4
- Support the development of the Conceptual Design/Cost Estimate for the Beam Delivery System
- Fabricate and test a short proof of principle shielded final-focus-like quadrupole coil
- Fabricate and test a short proof of principle sextupole/octopole corrector-like coil

Final Focus Magnet Development
Brookhaven National Lab



Winding tests octopole coil - how small can you go ?

Shielded quadrupole proof of principle coil fabrication

Beam delivery system Conceptual Design work	2 FTE's (1 Sci, 0.75 Eng, 0.25 Design)	$320K (labor)
Coil R&D	1 FTE (0.5 Eng, 0.5 Tech)	$130K (labor) $50K (materials)
Total	3 FTE's	$500K

Potential TRIUMF Accelerator R&D Resources for ILC

The specific nature of Canadian involvement is under development. Some potential collaboration areas have been identified, along with relevant LHC experience:

- The design of kicker magnets and the construction of associated pulse-forming networks and fast switches using power semiconductors

- Precision room temperature magnet systems
e.g. 52 twin-aperture quadrupoles built at Alstom Canada

- Beam instrumentation and readout systems
e.g. 2000 matched-pair 70MHz low pass filters
e.g. VME64x compliant Digital Aquisition Board (DAB)

- Contributions to beam dynamics & lattice calculations for damping rings.

Building on expertise developed for TRIUMF ISAC radioactive beams accelerator, additional possible areas are:

- Remote handling design/consulting of target stations possible applicability to conventional positron source

- Peripheral aspects of superconducting r.f. such as cryogenic coolant distribution system design/consulting small quantity e-beam welding of niobium for low-beta, low-frequency

UBC -Tom Mattison
Vibration control systems and alignment of components for final focus system; also interest in abort kickers

Summary/Conclusion

FY06 resources by functional area

WBS	Description	Laborate	FTE	Labor	M&S	Indirect	Total
1	Program direction and administration		9.4	1,097	780	453	2,330
2	Accelerator design, including RDR		32.4	4,050	764	1,553	6,367
3	Research and development		33.5	4,600	5,221	2,298	13,460
4	Engineering, including cost estimates		0	0	0	0	0
5	Infrastructure and test facilities		18.9	2,220	2,630	1,069	5,919
Total			**94.1**	**11,967**	**9,395**	**5,374**	**28,077**

FY06 resources by machine area

MACHINE AREA	**FTE**	**Labor**	**M&S**	**Indirect**	**Total**
Program direction and administration	9.4	1,097	780	453	2,330
Management	4.3	506	100	188	794
Global systems	5.5	744	460	330	1,707
Electron sources	3.3	390	100	151	676
Positron sources	7.5	1,310	202	574	2,086
Damping rings	7.9	1,061	567	446	2,298
Bunch compressor	1.6	198	0	77	312
Main Linacs: Optics, beam dynamics, instru	7.1	837	50	295	1,248
Main Linacs: RF systems	18.0	2,240	2,170	1,019	5,493
Main Linacs: Cavities and Cryomodules	16.5	1,958	3,896	1,115	7,143
Beam delivery system	10.2	1,267	520	514	2,867
Conventional facilities	3.0	360	550	212	1,122
TOTAL	**94.1**	**11,967**	**9,395**	**5,374**	**28,077**