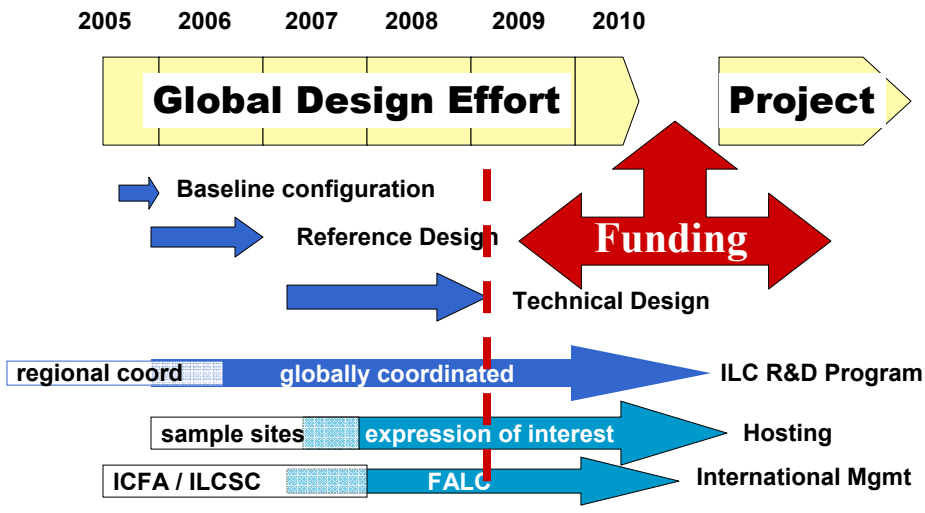
SLAC ILC Accelerator Efforts

SLAC HEP Program Review
June 6th, 2006

Tor Raubenheimer

ILC International Linear Collider – Americas

Global Design Effort Schedule



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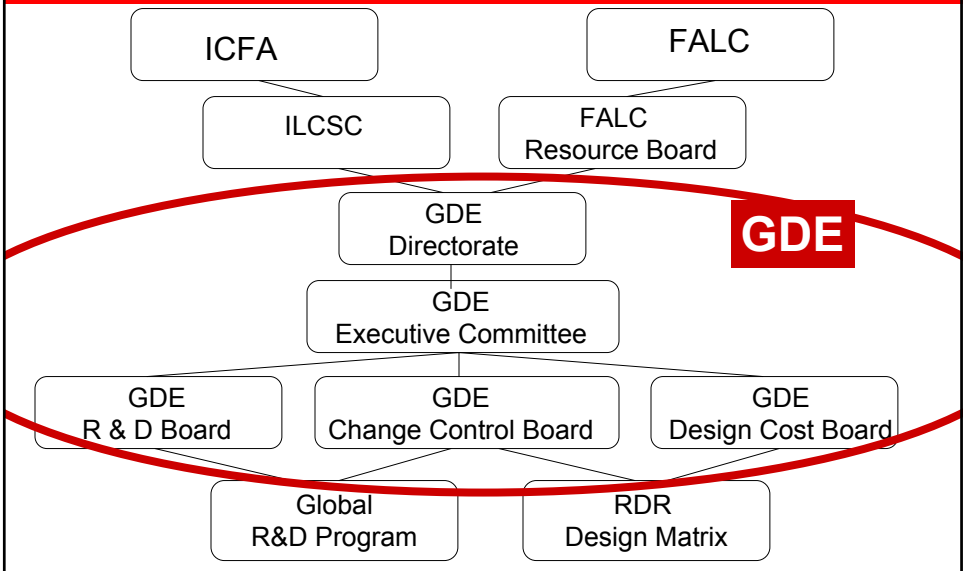
Global Design Effort



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ILC GDE Program

- The present GDE ILC program has two portions:
  - Reference Design Report (RDR)
    - A conceptual design based on sample sites with a cost estimate
    - Accelerator physics and engineering efforts are being developed
  - R&D Program
    - Presently administered through the different regions
    - ILC Global Design Effort will coordinate effort more globally
- ILC design timeline
  - RDR at end of CY2006
  - TDR based on supporting R&D in ~2009
- ILC Americas
  - Effort spread between RDR and R&D programs
  - Coordinated by Gerry Dugan – MOUs between GDE and labs
    http://www.lns.cornell.edu/~dugan/LC/Labs/

SLAC ILC and the GDE

- GDE has formed with 63 people from all three regions:
  - Nine people from SLAC representing a breath of experience: Chris Adolphsen, Tom Himel, Tom Markiewicz, Ewan Paterson, Nan Phinney, Tor Raubenheimer, Marc Ross, Andrei Seryi, John Sheppard
- Developing the Reference Design Report (RDR) in CY06
  - Supposed to be the 1st priority this year
  - Big effort from SLAC group – roughly 50% of SLAC ILC FTEs
- Strong design & R&D program to be coordinated by the GDE
  - RF sources and critical issues for Area Systems
- SLAC is playing a critical role in the ILC and the GDE
  - Bring both design and operational experience to the GDE
  - Leadership of RDR as well as members on all Boards
  - Strong R&D program aligned with ILC priorities

Reference Design Report

- What exactly is the RDR?
  - A 1st attempt at an international cost estimate for the ILC using 'reasonable' extrapolations from present technology
    - Baseline design mostly established at Snowmass, Aug. 2005
    - Not TESLA and not USTOS
  - Must document sufficiently to estimate cost
  - Cost estimate based on sample sites from different regions
  - Goal of completing the estimate in CY2006
    - Need to use existing information: TESLA TDR, USTOS, Japanese ITRP estimate
    - New information from US industrial estimates, DESY XFEL estimates, Japanese industrial estimates but most of these will be late → provide calibration but not a basis
    - Need to make laboratory estimates for cost drivers
- ***Highest priority for the GDE in 2006***

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RDR Working Groups

- Established working groups to complete RDR effort
  - Organized by Area around regional sections of LC
    - Sources; damping rings; main linac; beam delivery; …
  - Technical design provide by technical groups that reach across Areas
    - Coordinates technical resources but makes communication harder
    - Uniform technical standards applied across collider
    - Similar to style used for NLC Lehman design and TESLA TDR
  - Some groups provide technical support for Areas but also have system-wide responsibility → Global groups
    - Conventional Facilities and Siting (CF&S)
    - Control systems; Operations; Installation; …
  - Costs get rolled up to the Area groups so that they can study cost versus performance trades
  - Costs get output to Cost Engineers so they can study cost basis across systems

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RDR Matrix (Organization to complete Design)

- Matrix of Area Systems and Technical Systems to develop cost estimate
  - International representation in all working groups

	Area Systems					
	e- source	e+ source	Damping Rings	RTML	Main Linac	BDS
		Kiriki	Gao	ES Kim	Hayano	Yamamoto
			Guiducci		Lilje	Angal-Kalinin
	Brachmann	Sheppard	Wolski	Tenenbaum	Adolphsen	Seryi
	Logachev		Zisman		Solyak	
Technical Systems						
Vacuum systems	Suetsugu	Michelato	Noonan			
Magnet systems	Sugahara		Thomkins			
Cryomodule	Ohuchi	Pagani	Carter			
Cavity Package	Saito	Proch	Mammosser			
RF Power	Fukuda		Larsen			
Instrumentation	Urakawa	Burrows	Ross			
Dumps and Collimators	Ban		Markiewicz			
Accelerator Physics	Kubo	Schulte				
Global Systems						
Commissioning, Operations & Reliability	Teranuma	Elsen	Himel			
Control System	Michizono	Simrock	Carwardine			
Cryogenics	Hosoyama	Tavian	Peterson			
CF&S	Enomoto	Baldy	Kuchler			
Installation	Shidara	Bialwons	Asiri			

RDR Management group: Nick Walker, Tor Raubenheimer, Kaoru Yokoya, Ewan Paterson, Wilhelm Bialowons, Peter Garbincius, Tetsuo Shidara

SLAC contributions in red

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SLAC ILC Efforts

- SLAC has a broad program where we are leading four main elements of the ILC design:
  - RF Sources
  - Electron and Positron Sources
  - Beam Delivery System
  - Availability and Operations
  - Working closely with people at LLNL, FNAL, ANL, BNL, DESY, & UK
- In addition, there are smaller or supporting efforts in:
  - Damping ring design
  - Low emittance transport
  - Beam instrumentation
  - Test facility utilization
  - Conventional facilities and Installation

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ILC Technology Status

- Very High R&D priorities (categorized by Global Board):
  - Superconducting cavities and gradient
    - Gradient of 25 versus 35 MV/m
    - Cavity tuners
  - Rf sources → SLAC
    - Klystrons do not meet spec
    - New modulator designs, eg Marx Generator
  - High availability hardware → SLAC with DESY & ANL
    - Power supplies and magnets
  - Positron target → SLAC with LLNL
  - Instrumentation (BPMs, laser wires, and energy spectrometers)
  - Damping ring (collective effects, kickers and emittance)
  - Beam delivery system (crab cavity, feedback and tuning)

} SLAC

http://www.linearcollider.org/wiki/doku.php?id=rdb:rdb_external:rdb_external_home

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SLAC Strengths in GDE

- Built and operated the 1st and only Linear Collider (SLC)
  - Operational experience
    - Highly available hardware, Instrumentation, Beam collimation, Emittance preservation, Damping ring instabilities
- Two-decades of next-generation linear collider R&D
  - X-band design program was very broad (not just RF design)
  - >70% of superconducting LC is actually normal conducting
  - Most of normal conducting experience is transferable
    - Klystrons
    - Modulators
    - RF distribution
    - Particle sources, damping rings, beam delivery system
    - Civil design
- Very motivated and strong group

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Major Test Facilities

- End Station B
  - Support Advanced Acceleration experiments (including X-band work)
  - Create new L-band rf Test Facility
    - Develop klystron and modulators for ILC
    - Test normal conducting structures for e+/e- sources
    - Construct coupler test facility
- End Station A
  - Study Interaction Region issues and instrumentation
  - Mockup of full IR
  - Develop rf source test area to operate 24/7
- ATF/ATF-2 (Located at KEK but with big SLAC participation)
  - Test final focus system using very low emittance beam
- Work on the linac test facilities around the world: TTF @ DESY, ILCTA @ FNAL, and STF @ KEK

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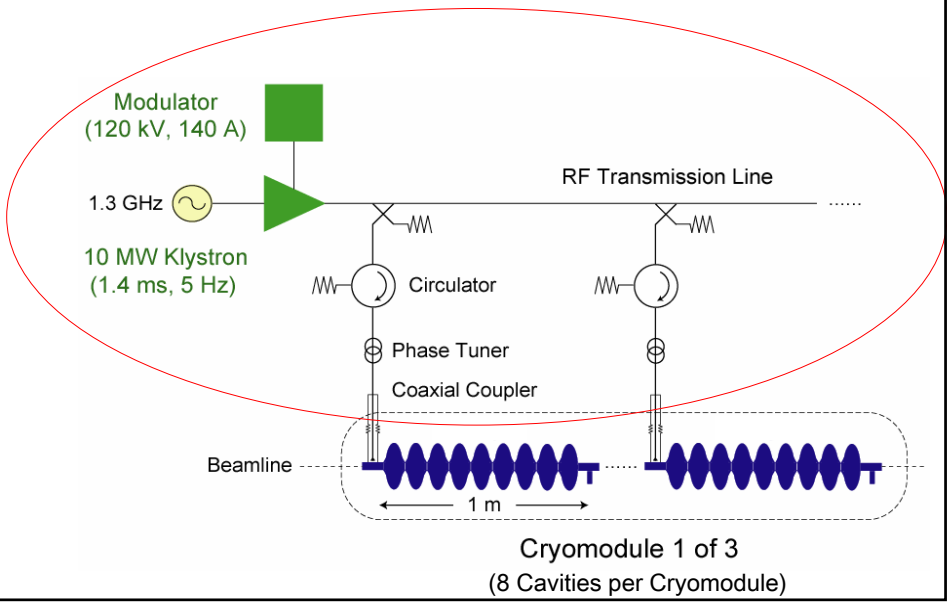
RF Sources
(Chris Adolphsen in breakout)



Cryomodule 1 of 3
(8 Cavities per Cryomodule)

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RF Test Stands

- Need to develop operating rf sources for ILC
- Developed an rf test stand in End Station B
  - Borrowed, begged, or stole most of the components
    - Borrowed a high power modulator from SNS
    - Purchased a 5 MW klystron for ~10% nominal cost
    - Converted NLCTA infrastructure from X-band to L-band
  - Rf system delivered 3.3 MW in March
    - Found some problems with waveguide system when operating at full pulse length
  - Presently upgrading the modulator to 15 MW capability
- Starting to develop 2 new test stands in End Station B
  - One for a 'direct-switched' modulator that will come from DTI and one for the 1st Marx generator prototype
- Ultimately would plan for 5 more stations in End Station A

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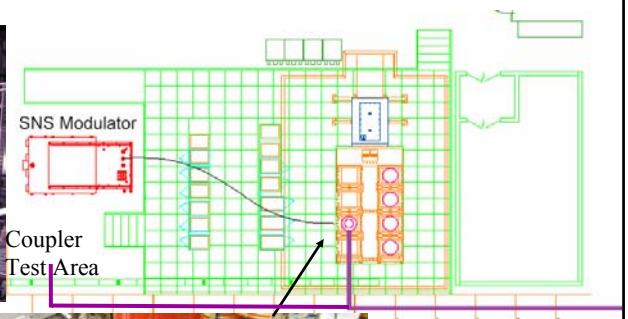
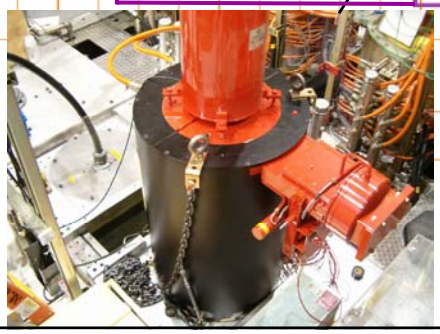
End Station B



SNS converter-modulator installed in ESB



TH2104U Klystron (red) with Solenoid (black) Installed in an Oil Tank at ESB

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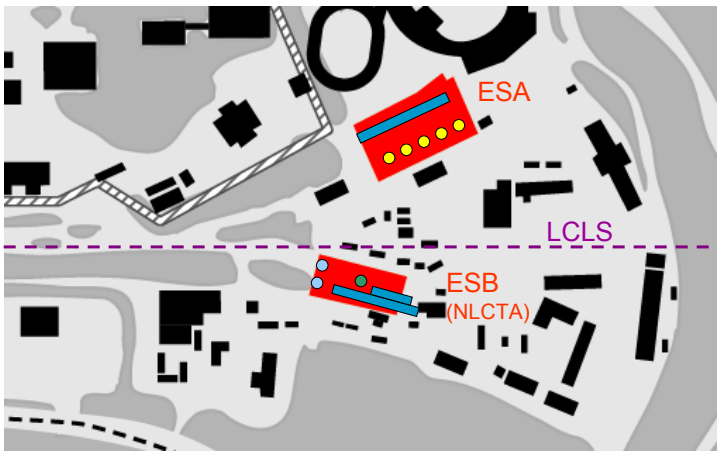
RF Test Stand Development

L-Band Test Stands: Existing (green), FY07 (blue), FY08-09 (yellow)



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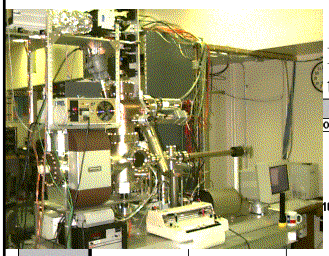
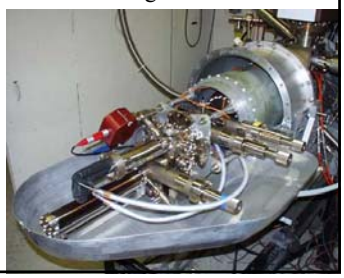
Electron Source
(Axel Brachmann in breakout)

- Polarized electron source
  - Baseline source similar to SLAC polarized electron source
  - Working on photocathode, laser, and systems design
    - Optimizing photocathode for lower current with >90% pol.
    - Designing laser system and NC bunching and capture structures
    - Designing e- system gun→damping ring for RDR



Polarized photocathode test facility

120KV DC gun with load lock



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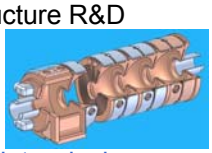
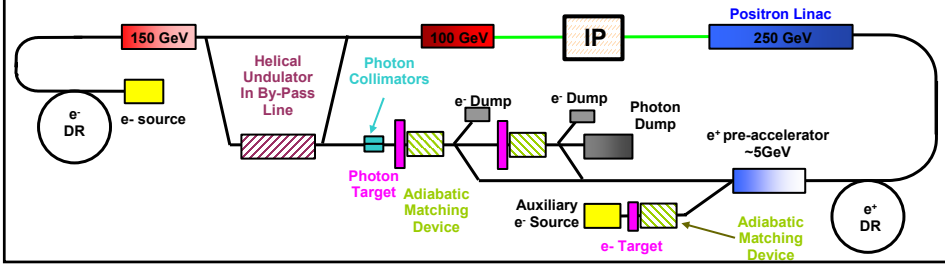
Positron Source
(John Sheppard in breakout)

- Positron source
  - SLAC is coordinating the positron source development
  - Undulator-based positron source is a large system
  - Focused on systems design and capture structure R&D
    - Working with LLNL on target design
    - Working with ANL on AMD and capture simulations
    - Working with UK and ANL/LBNL on undulator design





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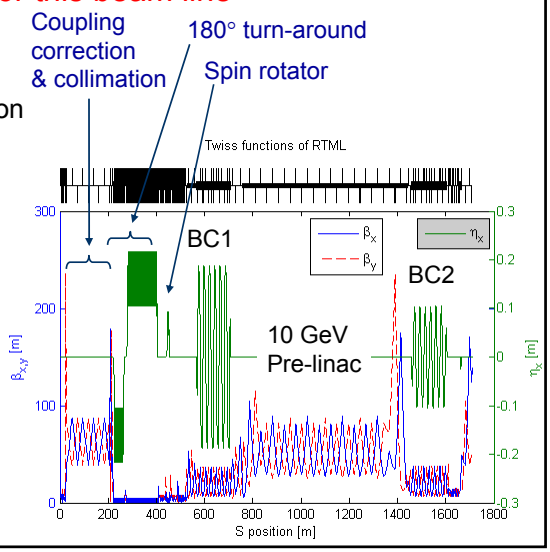
Ring to Main Linac
(Peter Tenenbaum in breakout)

- Ended up responsible for this beam line
  - Spin rotators
  - Coupling correction
  - Pre-linac beam collimation
  - 180° turn-around for feed-forward
  - Multi-stage bunch compression
  - Emittance diagnostics



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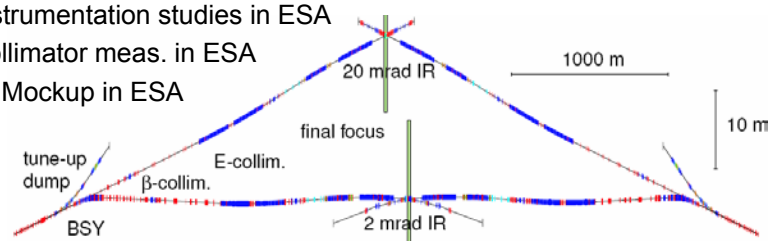
Beam Delivery System
(Andrei Seryi in breakout)

- SLAC is coordinating the BDS development
  - Working with UK on optics and R&D on technical components with:
    - BNL on compact FD quadrupoles for 20 mrad X-ing
    - FNAL on background simulations and crab cavity development
    - LBNL on possible FD quadrupoles for 2 mrad X-ing
    - Plans to develop IR mockup in End Station A (ESA)
- Additional R&D at End Station A and ATF2 test facilities
  - SLAC is planning large contributions to ATF2 at KEK
  - Instrumentation studies in ESA
  - Collimator meas. in ESA
  - IR Mockup in ESA

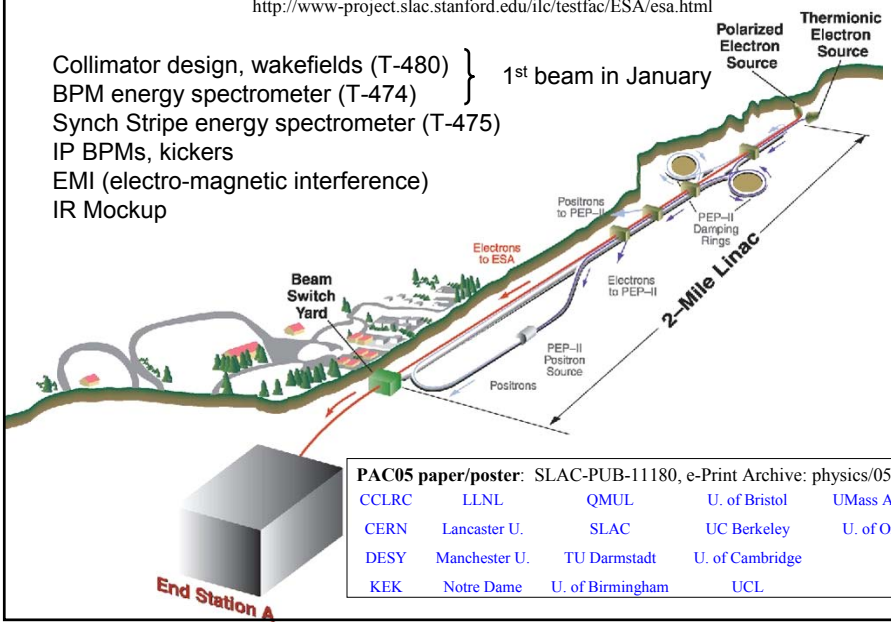


End Station A Test Facility

For Prototypes of Beam Delivery and IR Components

http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

Collimator design, wakefields (T-480)
BPM energy spectrometer (T-474)
} 1st beam in January
Synch Stripe energy spectrometer (T-475)
IP BPMs, kickers
EMI (electro-magnetic interference)
IR Mockup



PAC05 paper/poster: SLAC-PUB-11180, e-Print Archive: physics/0505171

CCLRC	LLNL	QMUL	U. of Bristol	UMass Amherst
CERN	Lancaster U.	SLAC	UC Berkeley	U. of Oregon
DESY	Manchester U.	TU Darmstadt	U. of Cambridge	
KEK	Notre Dame	U. of Birmingham	UCL	

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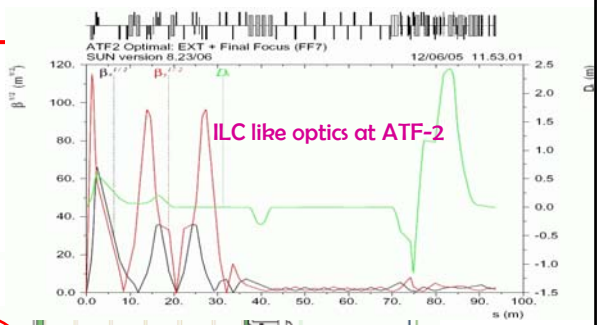
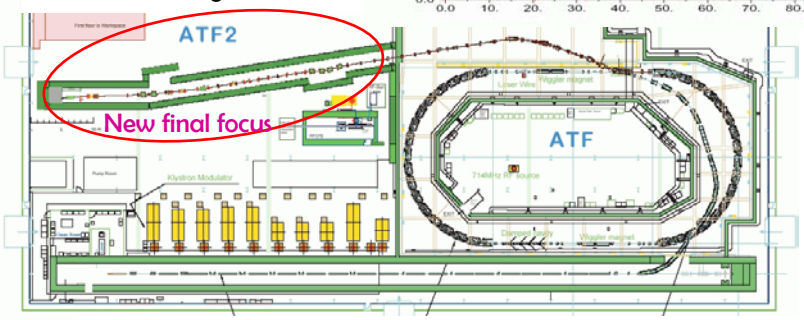
ATF-2 at KEK

- ATF-2 would be the BDS test facility
  - Follow-on to FFTB
  - New FFS optics
  - Operational issues
  - Train next generation





http://lcdev.kek.jp/ILC-AsiaWG/WG4notes/atf2/proposal/public/atf2-web.pdf

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Availability and Operations
(Ray Larsen in breakout)

- The ILC will be an order of magnitude more complex than any accelerator ever built
  - If it is built like present HEP accelerators, it will be down an order of magnitude more (essentially always down)
  - For reasonable uptime, component availability must be much better than ever before → requires serious R&D

Device	Required MTBF Improvement Factor	MTBF from Present Experience (khours)
magnets - water cooled	20	1,000
power supply controllers	**50**	100
flow switches	10	250
water instrumention near pump	10	30
power supplies	5	200
kicker pulser	5	100
coupler interlock sensors	5	1,000
collimators and beam stoppers	5	100
all electronics modules	**10**	100
AC breakers < 500 kW	**10**	360
vacuum valve controllers	**5**	190
regional MPS system	**5**	5
power supply - corrector	**3**	400
vacuum valves	**3**	1,000
water pumps	**3**	120
modulator		50
klystron - linac		40
coupler interlock electronics		1,000

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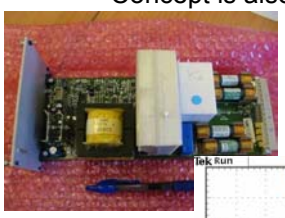
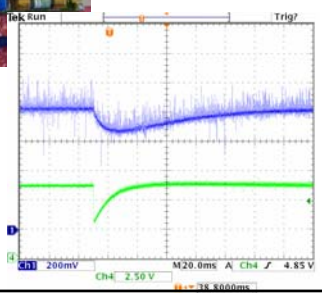
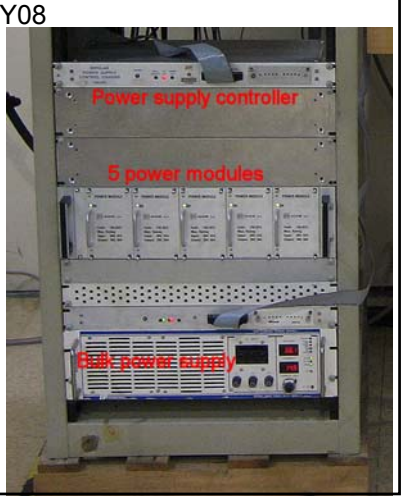
High Availability Power Supplies

- HA design to be demonstrated at ATF2 using n/M config
  - US-Japan funds allocated after initial demonstration
  - 40 supplies to be sent in FY07 and FY08
  - Concept is also useful for LCLS







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Supporting Roles

- Conventional facilities
  - Make connection between Area System and conventional group
  - Developing Installation model for RDR
- Damping ring
  - Collective effects, primarily ECI and SEY reduction
  - Demonstration of low SEY chambers using PEP-II positron ring
- Low Emittance Transport
  - Led this field for years -- Educating new participants
  - Tightly tied to understand operational issues
- Beam instrumentation
  - Group has led instrumentation development: ATF BPMs, rf BPMs, TTF HOM detectors, laser wires
- Test facility utilization
  - Test facilities are under utilized around the world

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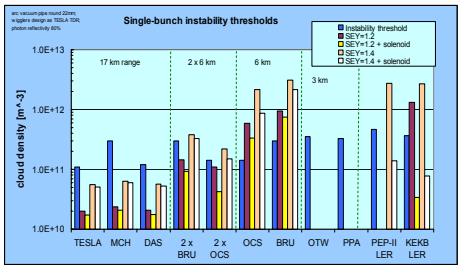
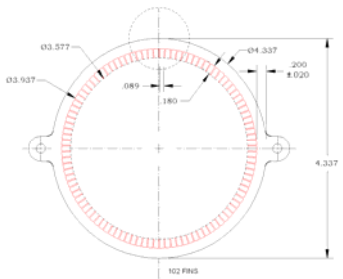
Damping Ring E-cloud
(Needed for ILC and High $\mathcal{L}$ Factories)

- Multi-pronged program
  - Simulations (SLAC, KEK, LBNL)
  - Secondary yield lab studies
  - Test sample chamber to be installed in PEP-II
  - Chambers with fins to trap e- and chamber w/ clearing electrodes to be tested in PEP-II





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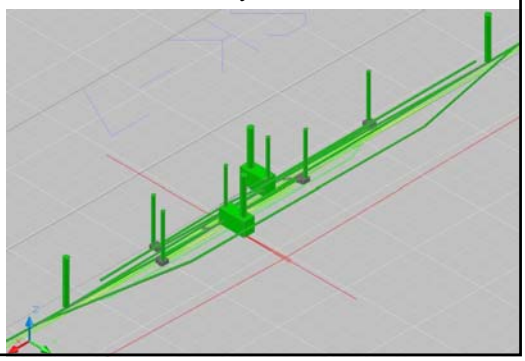
Civil Design Effort

- Conventional Facilities group has two goals:
  - Work with local Area System leaders (Electron Source, Positron Source, RTML, and BDS) to specify and optimize civil design
    - Space, power, cooling, layout
    - Access and safety
  - Develop installation plan
    - Both tunnel installation as well as receiving, testing, and warehousing
- Group works closely with FESS group at Fermilab on development of a US sample site

Beam Delivery Tunnels and IR Halls



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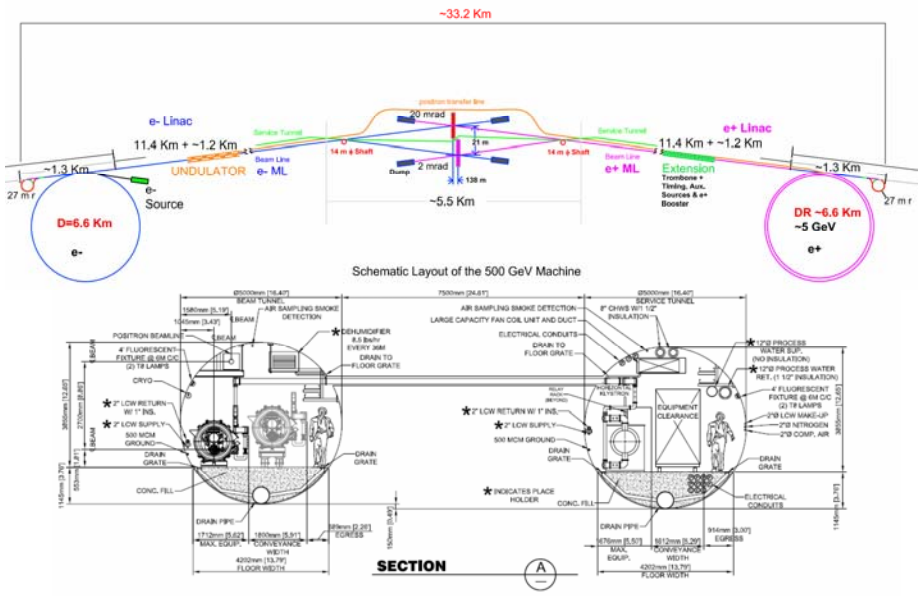
ILC Schematic and Tunnels



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International Test Facilities

- Linear Collider facilities at DESY and KEK are under-utilized
  - ILC experimental beam program is not developed
- SLAC has been leading an effort to bring greater effort to TTF at DESY and ATF at KEK
  - Helped create a large user group at ATF – working at ATF since 1997
    - New collaborators from Cornell, LBNL, UK, and DESY
    - Focused on beam instrumentation but also beam physics studies
    - Ship hardware to KEK as part of collaborative effort (US-Japan $)
  - Been working with DESY group on the TTF
    - Started working on diagnostic problems (HOM diagnostics)
    - Trying to engage in LLRF and beam operational issues
    - Proposed approach to operate rf system at ILC parameters
    - Brought collaborators from FNAL to TTF
  - Hans Weise stated “wished all collaborators worked like those from SLAC”

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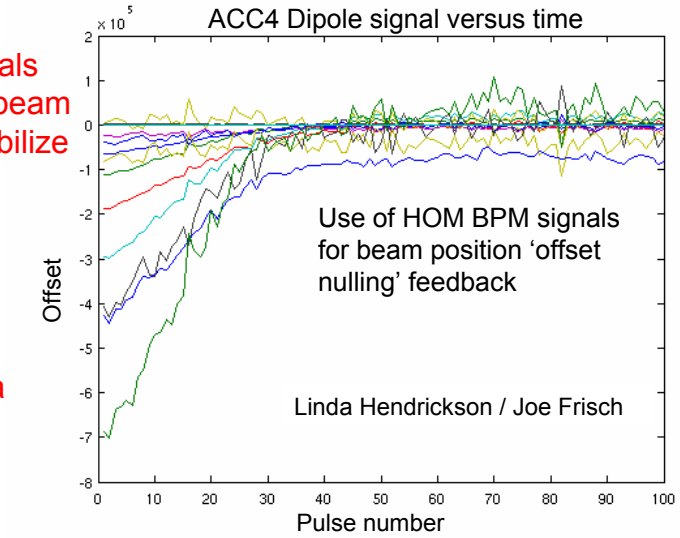
TTF Cavity HOM Project (Linac Diagnostics)

- Developed a new diagnostic working at the DESY TTF
- TTF HOM signals were used for beam feedback – stabilize FEL beam
- Installed 80 new systems in TTF-2 last November as a joint ILC and DESY XFEL project



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Planning for FY07

- Planning done in the context of delivering a TDR in 2009
- Major milestones of SLAC program:
  - Six operating rf sources (modulator, klystron, rf distribution)
  - Electron source photocathode and laser prototyped; engineering design mostly complete
  - Positron source (undulator section, target, AMD), and capture structure prototyped; engineering design mostly complete
  - Beam delivery system (specialty magnets), collimators, diagnostics prototyped; engineering design in progress
  - Critical beam instrumentation demonstrated
  - High availability hardware demonstrated
  - Installation plan developed; tunnel mockup constructed
  - ATF and ATF2 operating; IR mockup constructed in ESA
  - One or more full rf units operating with ILC parameters somewhere
- Hope to develop an integrated schedule in future

ILC International Linear Collider – Americas

FY06 & FY07 Budget Request

- Request has large increase in funding for rf sources
  - Evaluate and down-select between modulator options
  - Purchase klystrons for evaluation in FY08
  - Start construction of new klystron at SLAC
  - Develop the rf distribution system
  - Six operating rf sources by end of 2009
- Also a large increase in Availability R&D and Engineering
  - Engineering in support of the sources and the BDS

		FY06				FY07		
WBS	Name	FTEs	M&S K$	Total		FTEs	M&S K$	Total
1	Program management	4.2	$430	$1,150		4.5	$550	$1,465
2	Accelerator Design	24.8	$100	$4,176		25.5	$300	$5,052
3	R&D	21.9	$2,240	$5,993		35.7	$7,285	$14,980
4	Engineering & Costing	0.0	$0	$0		10.2	$200	$2,116
5	Test Facilities	10.0	$1,130	$2,851		13.7	$1,400	$4,144
7	Bid-to-Host	0.0	$0	$0		2.0	$200	$600
Sum		**60.9**	**$3,900**	**$14,169**		**91.6**	**$9,935**	**$28,357**

ILC International Linear Collider – Americas

Summary

- Broad program
  - SLAC ILC group is recognized as excellent throughout the world
    - ILC effort builds on core SLAC strengths
    - Strong design effort with beam dynamics studies, integrated R&D and engineering studies
  - Focused on rf sources, particle sources, BDS, and operation issues
  - Developing plans through the TDR in ~2009
- R&D program is well matched to ILC needs
  - RF source work is needed for ILC project – needs differ from XFEL
  - High availability hardware is essential for operations
  - Working with test facilities at KEK, DESY, and FNAL
  - Working well with other laboratories – LLNL, LBNL, ANL, BNL, UK
  - Program is not duplicated at other laboratories around the world