Beam Delivery System R&D

S4 Task Force

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http://bilcw07.ihep.ac.cn/

S4 Charge (1)

- The S4 task force is formed to fulfill the following functions:
  - **To provide oversight for the overall coordination and progress of the BDS R&D program.**
  - **To advise the GDE via its Global R&D Board (RDB) on the research and development program for the ILC Beam Delivery System (BDS).**
- The environment, in which the Task Force is operating, is described by the following assumptions:
  - **Overall coordination and progress of international R&D and design work in BDS area is the responsibility of BDS area leaders.**
  - **Everyday responsibility for specific R&D work in BDS belongs to the leaders of particular work packages, which often involve two or more international partners.**

S4 Charge (2)

- In its advising and overviewing role, the Task Force is following the general charge of the RDB and of the BDS area, paying particular attention to the following:
  - **Perform prioritization of R&D**
  - **Determine optimal timeline for expected progress for various R&D and how they change as ILC moves from design to construction**
  - **Determine availability of test facilities and their suitability for specific R&D and for the integrated system tests**
  - **Identify the programs where the expertise is spread and which have to be performed by collaboration of several international partners**
  - **Identify duplications and determine if concentrated efforts or spreading the efforts may be beneficial**
  - **Identify missing R&D not addressed by any institute and suggest appropriate mitigation of R&D program**

R&D database for the BDS

- An R&D database is being set up to manage the organisation of BDS/MDI R&D
- The list of the "ideal" objectives is nearly complete and details of developing the actual activities is under way.
- The categories under discussions for the R&D "WBS":
  1. **Accelerator system and MDI design**
  2. **R&D in support of baseline and alternatives**
  3. **Component and subsystem engineering design**
  4. **Test facilities and experimental studies**

Overview of R&D plans by institutes

	Accelerator design	IR design	SC magnets	Warm/ pulsed magnets	Crab system	Collimation & backgrounds	Vacuum design	Instrumentation	Feedback	Beam dumps	Stabilisation
SLAC											
BNL											
FNAL											
UBC/TRIUMF											
US Universities											
LC-ABD, UK											
LAL											
CEA											
LAPP											
CERN											
DESY											
KEK											
Kyoyo University											
Tohoku University											
Tokyo University											
IHEP, China											
Dubna											
BINP											
Any other?											

(green)	Presently working - may continue depending upon funding in few cases
(orange)	May be/could do

At detailed level, there are over 30 institutes

R&D Database

Over 100 objectives have been defined. Priorities are being discussed within the task force.

R&DObjectiveTitle	Priority
Beam tests of beam dump window	High
Build BDS+detector integrated model with realistic field maps, tunnel	Very High
Characterize vacuum system performance	High
Demonstrate maintaining of low emittance	High
Design study of stability of IR magnets	Very High
Detector integration for push pull studies	Very High
Develop a fast high-power pulser for fast extraction kickers	Very High
Develop beam dump alternatives	Moderate
Develop beam dump design for full power	Very High
Develop beam sweepers in the extraction line	High
Develop bunch-by-bunch feedback systems	High
Develop collimator damage monitoring system	Very High
Develop compton polarimeter	Moderate
Develop design of anti-DID	Very High
Develop design of anti-solenoid	Very High
Develop design of beam dump window	Very High
Develop design of diagnostics wiggler	Moderate
Develop designs of extraction line magnets	Moderate
Develop detailed compton laser, IP and detector designs	Moderate
Develop engineering design for 3.9GHz crab cavities, cryomodules ar	Very High
Develop engineering design of high availability power supplies	High

R&D Objectives list (from database)

ILC Beam Delivery System Research and Development Objectives

Very High Priority

1.0.0.0 Build BDS+detector integrated model with realistic field maps, tunnel and experimental halls
2.1.4.3 Demonstrate maintaining of low emittance
3.1.1.3 Characterize vacuum system performance
3.2.0.2 Prototype complete 3.9 GHz RF unit and test at high power
3.2.1.1 Specify 3.9GHz Crab cavity RF system
3.2.1.2 Develop engineering design for 3.9GHz crab cavities, cryomodules and supporting
3.4.6.0 Develop design of anti-solenoid
3.5.1.1 Develop a fast high-power pulser for fast extraction kickers
3.6.1.1 Prototype final doublet
3.6.2.1 Detector integration for push pull studies
3.6.2.2 Develop engineering designs for push-pull IR
3.6.4.0 Develop design of anti-DID
3.7.3.2 Develop laser wire for better resolution
3.10.2.0 Design study of stability of IR magnets
3.11.2.0 Develop collimator damage monitoring system
3.12.1.0 Develop design of beam dump window
3.12.1.4 Develop beam dump design for full power
3.13.1.0 Integration of anti-DID into detector solenoid
3.13.1.0 Integration of final doublet into detector solenoid
4.1.1.0 Beam tests of beam dump window
4.1.1.1 Experimental studies at ATF2
4.1.1.3 Experimental studies at ESA
4.2.1.1 Development of ATF2
4.2.1.3 Development of ESA
4.2.1.4 Development of other test facility for beam damage

Very high priority R&D

- Includes items which have major impact on operational performance & need substantial amount of R&D.
  - **Development of IR superconducting magnets, their integration into the IR, and a design study to ensure their mechanical stability**
  - **Development of technical details of the push-pull design**
  - **Development of crab cavities, and related systems to provide phase stability**
  - **Measurements of collimator wakefield and their validation with codes**
  - **Study of collimator beam damage and damage detection**
  - **Accelerator physics design work which enable performance optimization**
  - **Design, construction, commissioning and operation of ATF2**
  - **Development of laser wires for beam diagnostics**
  - **Development of intratrain feedback**
  - **Development and tests of MDI type hardware such as energy spectrometers and polarimeters**
  - **Development of beam dump design and study of beam dump window survivability**

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High Priority R&D

- Includes items which enable performance optimization and development of engineering aspects of the design.
- become the highest priority as we come to the second half of EDR (08-09) and moving closer to the project start.
  - **design work for cost-performance optimization**
  - **engineering design of collimators**
  - **engineering design of beam dumps**
  - **engineering design of vacuum chamber**
  - **engineering integrated design and development of IR region including push-pull requirements**
  - **engineering design of magnets, septa and kickers**
  - **design of machine protection system**
  - **design work to ensure mechanical stability of components**

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Next level of priority

- The R&D of the next level of priority includes those items which enable development of alternative configurations which may be needed
  - **Small crossing angle/ head-on design**
  - **Gas beam dump**
  - γ–γ **collider**
- There are synergies with ongoing developments in some cases
  - **LARP programme for large bore SC magnets**
  - **Laser R&D for the e+ Compton source**

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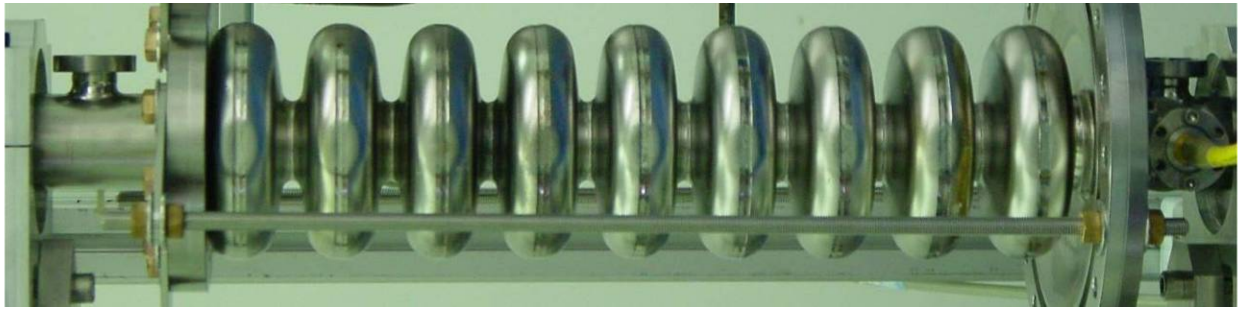
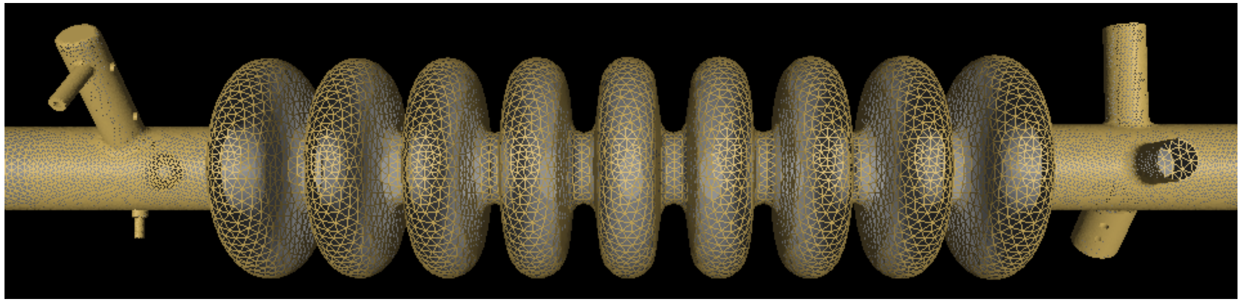
- Based on a Fermilab design for a 3.9GHz TM110 mode 13-cell cavity.
- The uncorrelated phase jitter between the positron and electron crab cavities must be controlled to 61 fsec to maintain optimized collisions.
- Other key issues to be addressed are LLRF control and higher-order mode damping.



Earlier prototype of 3.9GHz deflecting (crab) cavity designed and build by Fermilab



Cavity modeled in Omega3P, to optimize design of the LOM, HOM and input couplers.

Crab cavity collaboration

Design and Development of Very High priority Tasks – Crab system (2)

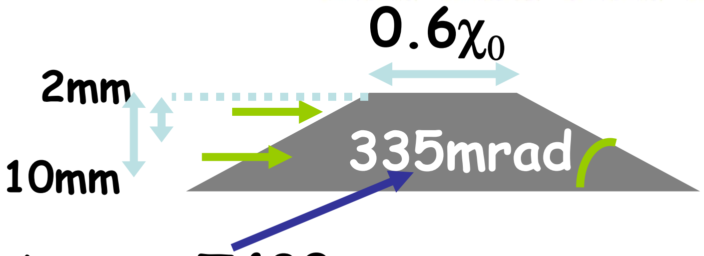
- Prototype cavity
- Development of input coupler, prototypes
- Final designs for LOM/SOM/HOM couplers and their prototypes
- Engineering design of cryomodule
- Design of the frequency tuner including feedback actuators and full integration with cavity into the cryomodule
- Phase control and cavity synchronisation systems
- High power testing of a fully dressed cavity with beam
- Testing of two cavities with beam
  - **Ultimate test of phase/amplitude control, synchronisation and timing stability.**
  - **Demonstrate precision for bunch rotation**
- Beam tests ILCTA (FNAL)

Design and Development of Very High priority Tasks – Collimator design (1)

Specify and find optimal solutions for BDS spoilers :

- Combine information on geometry, material, construction, to find acceptable baseline design for
  - **Wakefield optimisation**
  - **Collimation efficiency**
  - **Damage mitigation**
- Damage survival, 2 (1) bunches at 250 (500) GeV
  - **Jaw construction (coatings, inhomogeneous bonding, shockwave damage)**
- Study geometries which can reduce overall length of spoilers while maintaining performance
- Damage detection/inspection after incident

Spoilers considered include…

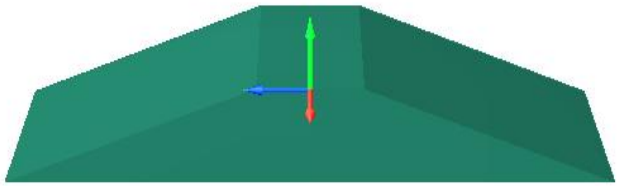


As per T480

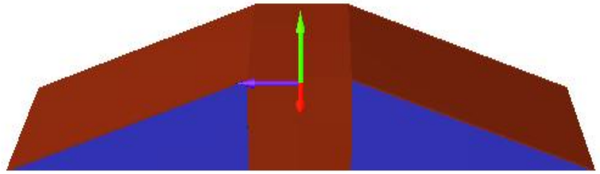
2.10^{10} e^-, E_{beam}=250 GeV, $\sigma_x \times \sigma_y$=111×9μm^2
also, E_{beam}=500 GeV

Ti, Cu, Al

Beam direction

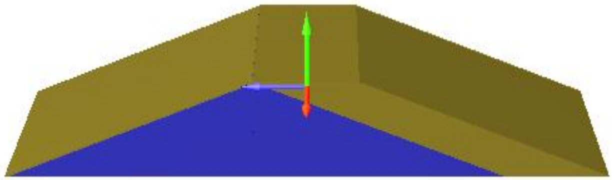


Option 1: Ti/C, Ti/Be



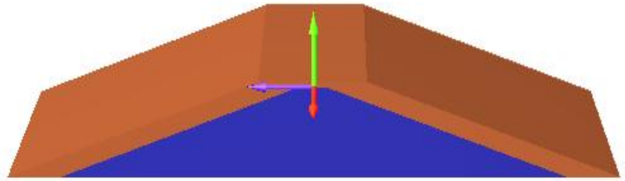
Graphite regions

Option 2: Ti/C, Cu/C, Al/C



0.6 Xo of metal taper (upstream),
1 mm thick layer of Ti alloy

Option 3: Ti/C



0.3 Xo of Ti alloy upstream and downstream tapers

[Details, see EuroTeV Reports 2006-015, 2006-021,2006-034]

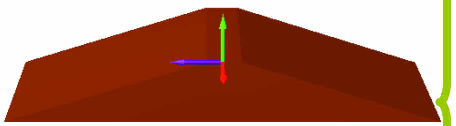
Summary of spoiler simulations

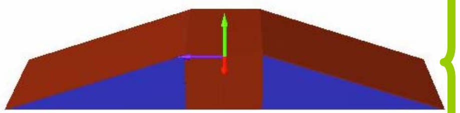
Exceeds fracture temp.

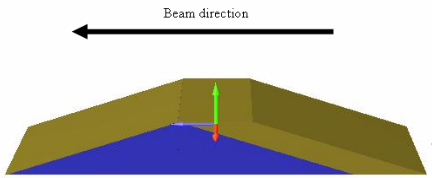
Exceeds melting temp.

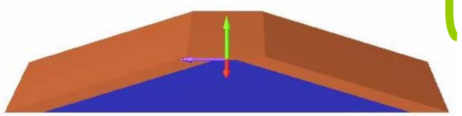
Temperature increase from 1 bunch impact

	2mm depth		10mm depth	
	250 GeV e⁻ 111×9 μm²	500 GeV e⁻ 79.5×6.4 μm²	250 GeV e⁻ 111×9 μm²	500 GeV e⁻ 79.5×6.4 μm²
Solid Ti alloy	420 K	870 K	850 K	2000 K
Solid Al	200 K	210 K	265 K	595 K
Solid Cu	1300 K	2700 K	2800 K	7000 K
Graphite+Ti option 1	325 K	640 K	380 K	760 K
Beryllium+Ti ≈ option 1	-	-	-	675 K
Graphite+Ti option 2	290 K	575 K	295 K	580 K
Graphite+Al option 2	170 K	350 K	175 K	370 K
Graphite+Cu option 2	465 K	860 K	440 K	870 K
Graphite+Ti option 3	300 K	580 K	370 K	760 K







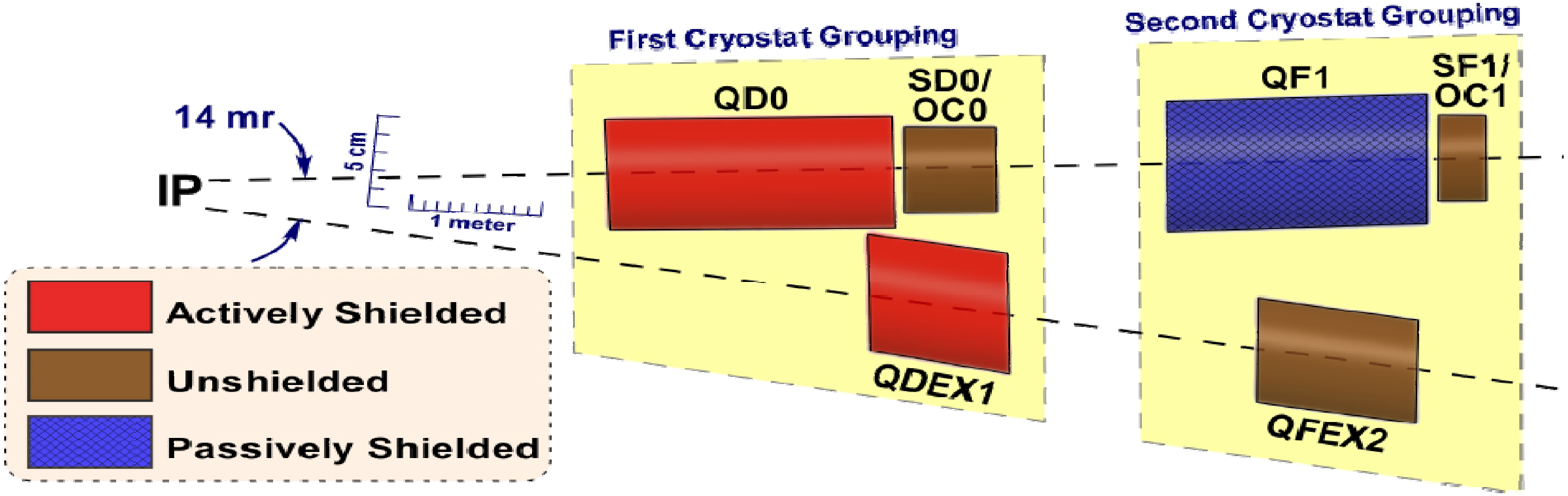


[Simulations L.Fernandez, ASTeC]

MDI Interface

- Machine Detector Interface issues which require careful balance of very different constraints from Detectors and Machine
  - **IR design, FD, support, connections, alignment**
  - **Detector design, opening, movements**
  - **Backgrounds, machine and beam related**
  - **Stability**
  - **Conventional facilities**
  - **Services**
  - **Radiation safety**
- MDI/IR design – A. Seryi's yesterday's talk

Modification of FD design and R&D plans for push-pull



- **BNL will prototype the QD0 part of FD with full length QD0 to test its magnetic performance.**

- **Need to address the stabilisation of magnetic centres to the required precision.**

- **Need to know about support tube and their utility connections (potential sources of vibration) to provide the required stabilisation.**

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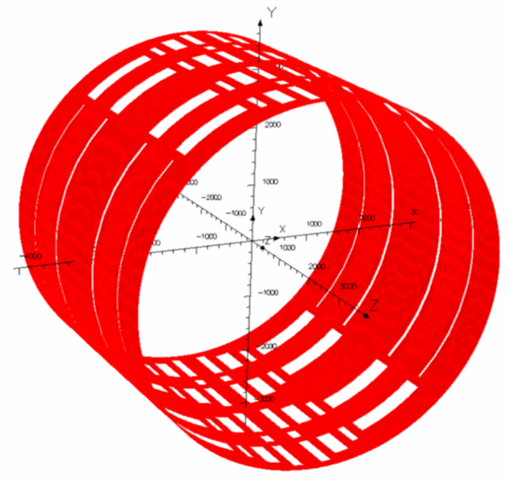
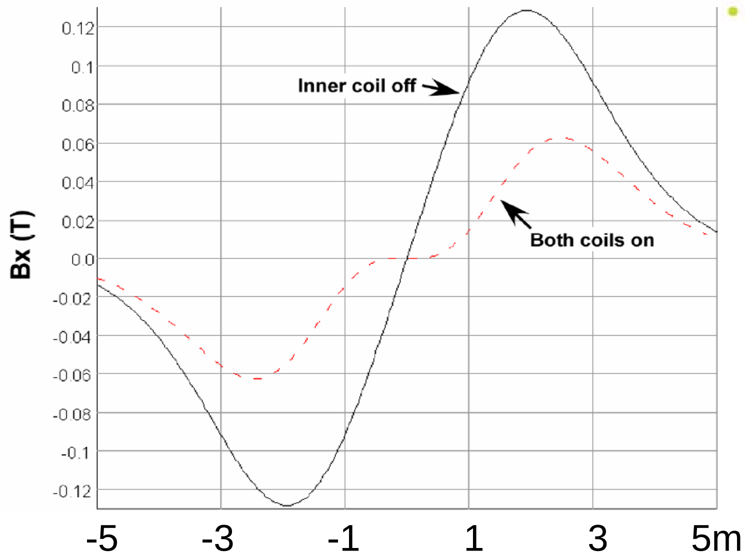
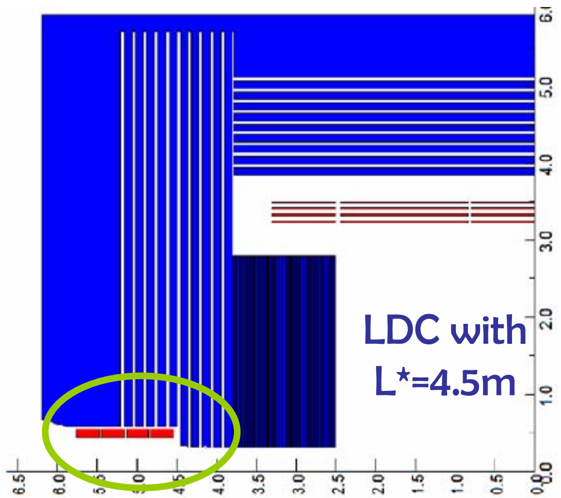
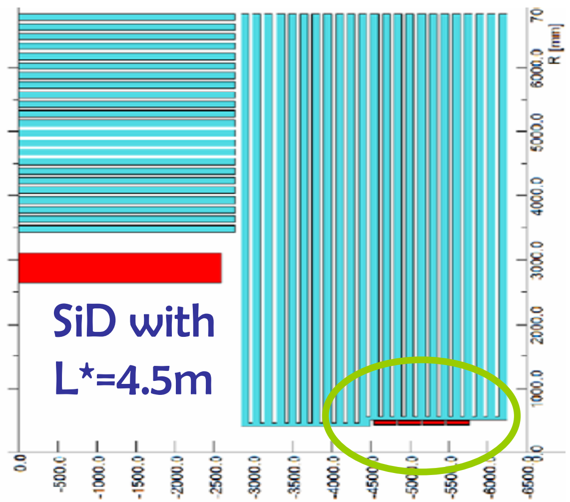
Anti-DID coils



- Anti-DID guides pairs to the exit hole
- Two overlapping Detector Integrated Dipole coils create field flattened in the IR region



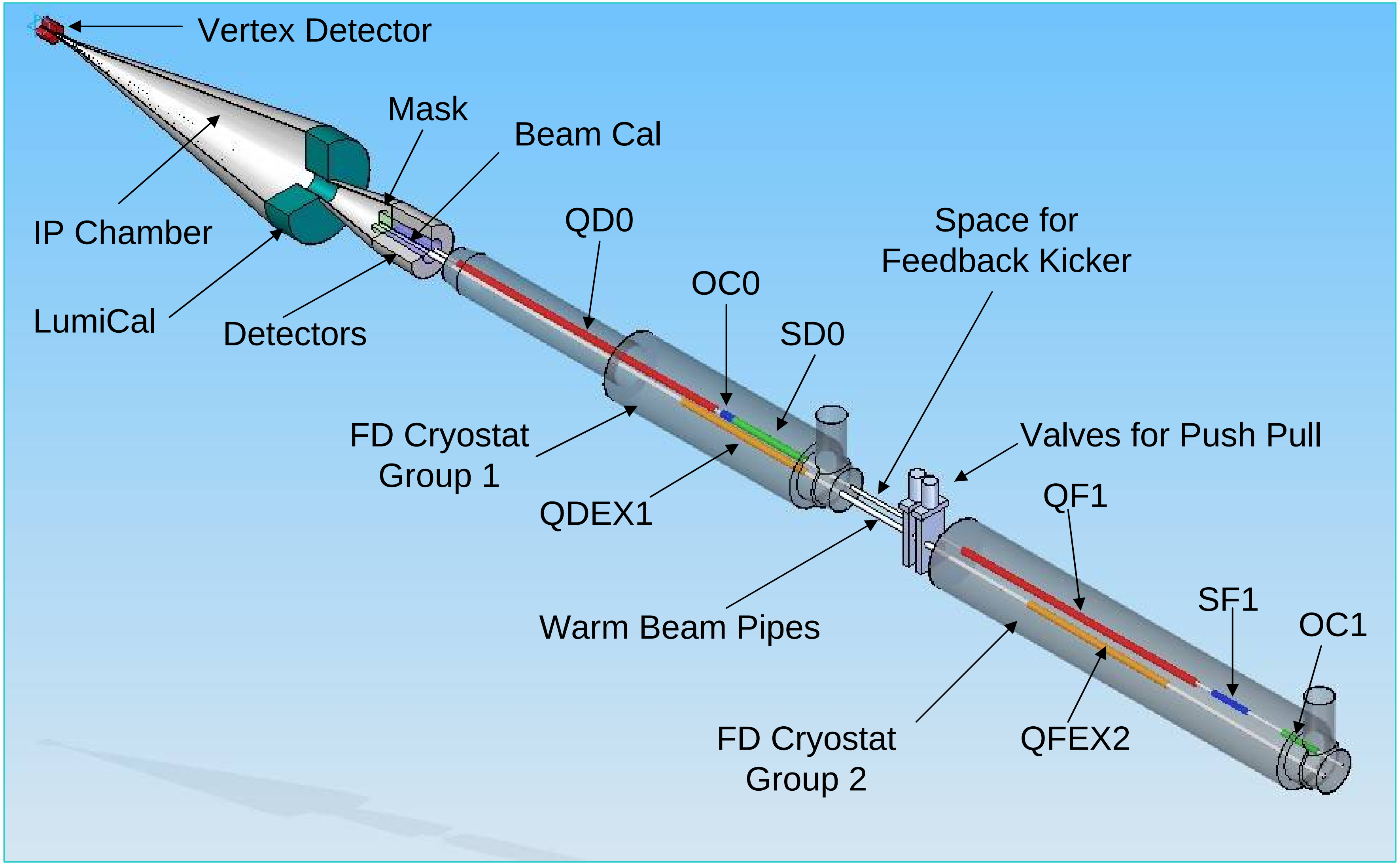




- Antisolenoids for local compensation of beam coupling
- Depend on all parameters (L*, field, sizes, etc) and is a delicate MDI issue

B.Parker, BNL

Generic IR layout



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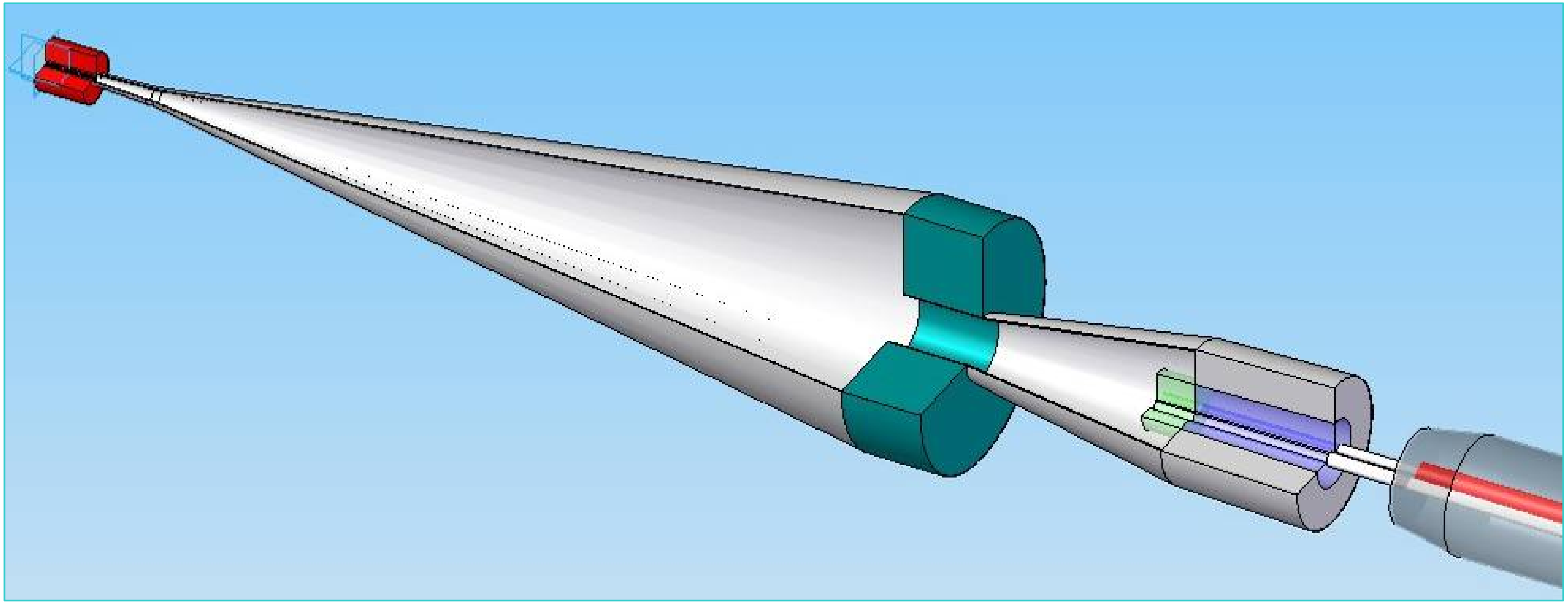
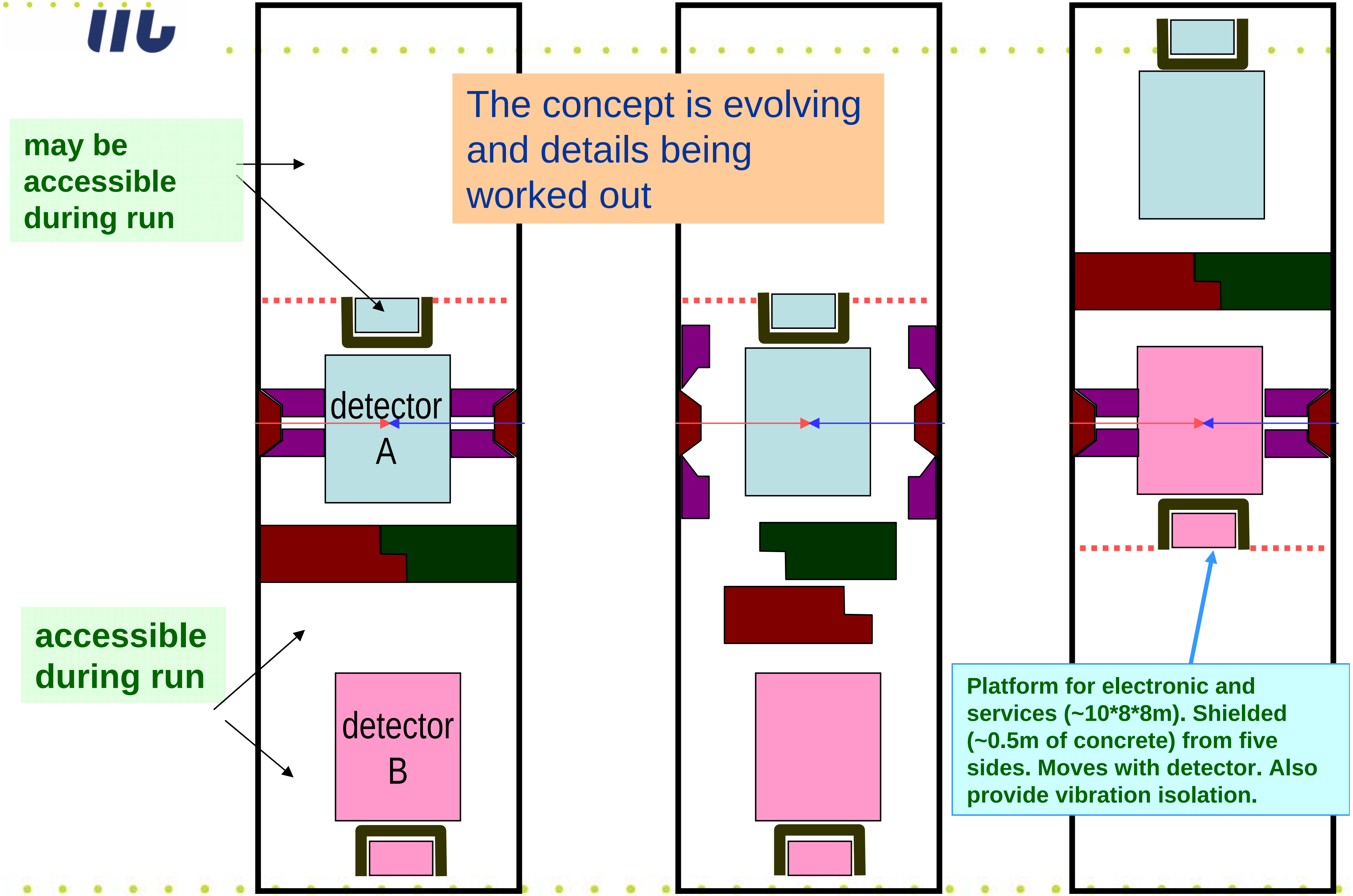
IR forward region and chambers



- Study & design:
  - **integration; support; assembly; wake-fields and EMI; location of BPMs; vacuum & pumping; cold-warm transitions; etc.**

Concept of IR hall with two detectors

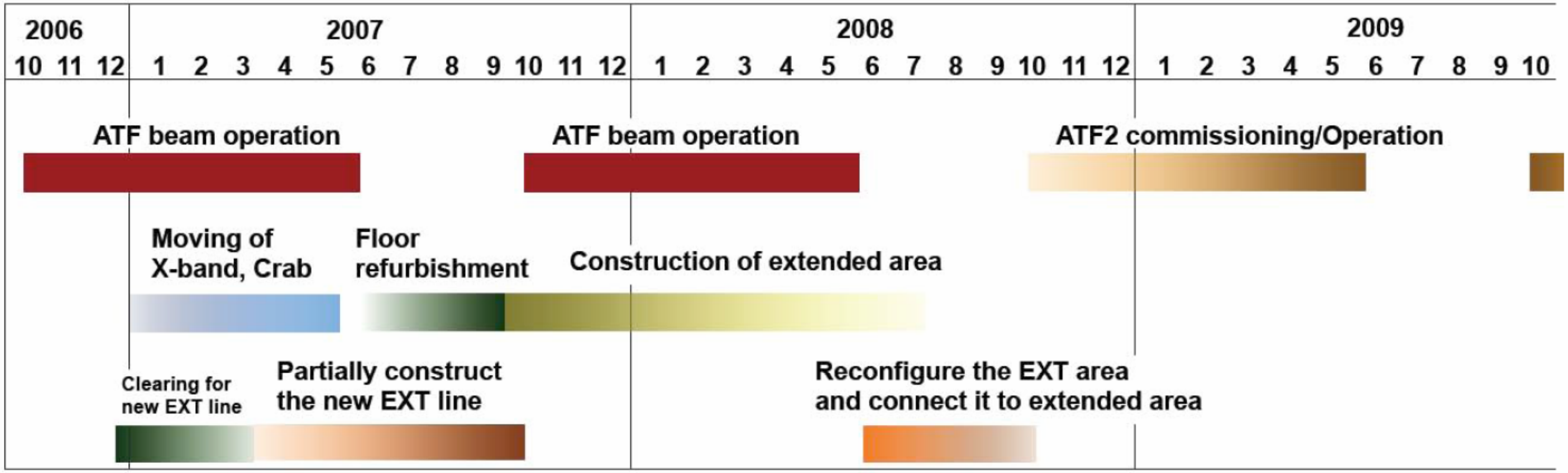


BDS Test facilities : ATF2 at KEK

- Unique facility for
  - **Beam delivery final focus demonstration**
  - **MDI instrumentation and Controls Development**
- Beam Delivery Optics, Tuning, Control and Instrumentation Demonstration (2008-2010)
  - **35 nm vertical beam size**
  - **2 nm stabilization**
- Well developing project, increasing participation
  - **E.g., FNAL actively joined recently**
- Space allocation appear to develop positively – the KEK-B crab cavity system is installed into the ring and space will be ready for Civil construction work this summer
- Schedule was adjusted (by about 7-8 months) to accommodate the recent decision to modify also the existing extraction line

As discussed at 3rd ATF2 Project Meeting, Dec 2006

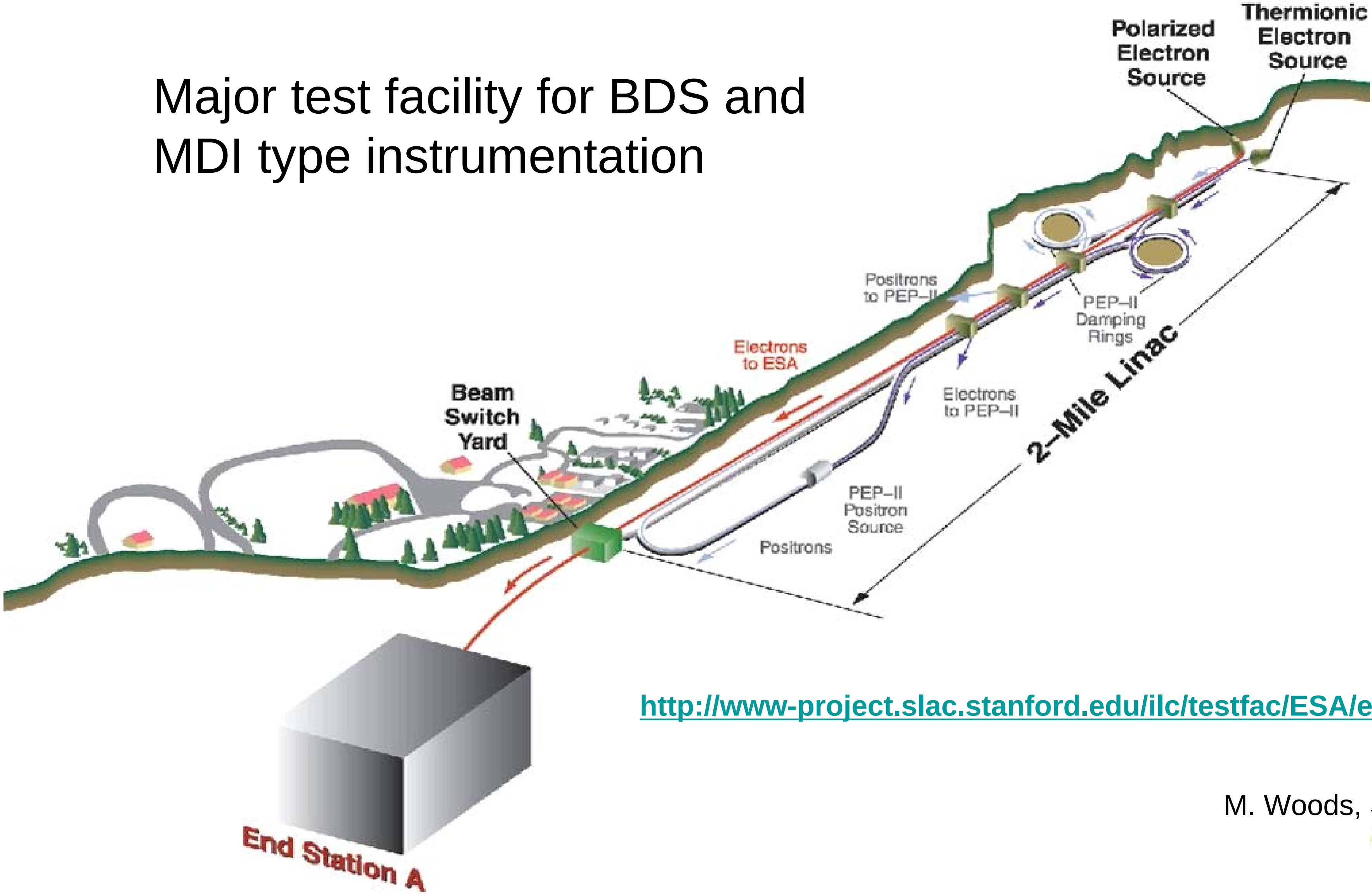
New schedule for construction



- **Construction of the extended shield area for final focus system can be done during the ATF beam operation.**
- Partial construction beside the current EXT line in shutdown week will release the work load for reconfiguration of the EXT line in summer of 2008.
- **ATF2 beam will come in October, 2008.**

ILC Beam Tests in End Station A

Major test facility for BDS and MDI type instrumentation



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

BDS Test Facilities : ESA

- Very successful program in 2006
  - **4 weeks of beam tests for 7 experimental programs**
  - **50 participants from 18 institutions**
- Collimator Wakefield Study
  - **Results essential for ILC collimator design**
  - **Minimize risk for emittance degradation to IR and for achieving design luminosity**
- Energy Spectrometer Prototypes
  - **Experimental results needed to demonstrate ability to meet design goals for precise energy measurements for the ILC physics program.**

- **FY07** : strong program, with 5 weeks of Beam Tests planned
- **FY08 :** continue program, requesting 4 weeks of Beam Tests
  - **beam scheduling more difficult: priority for LCLS commissioning, also for SABER**
- **FY09 and beyond** (LCLS era, parasitic operation with PEP-II ends at end of FY08)
  - **ESA PPS upgrade needed for continued ESA operation**
  - **ILC beam instrumentation tests in SABER possible**

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Summary : S4

- Many high priority goals need to be achieved in the EDR phase
- R&D development plan is evolving to develop the detailed work packages
- Strong collaborations for both design and R&D at test facilities ESA and ATF/ATF2
- Resources and schedule have to be properly addressed for the EDR
- Have to deal with the uncertainties in the funding situations in the best possible way