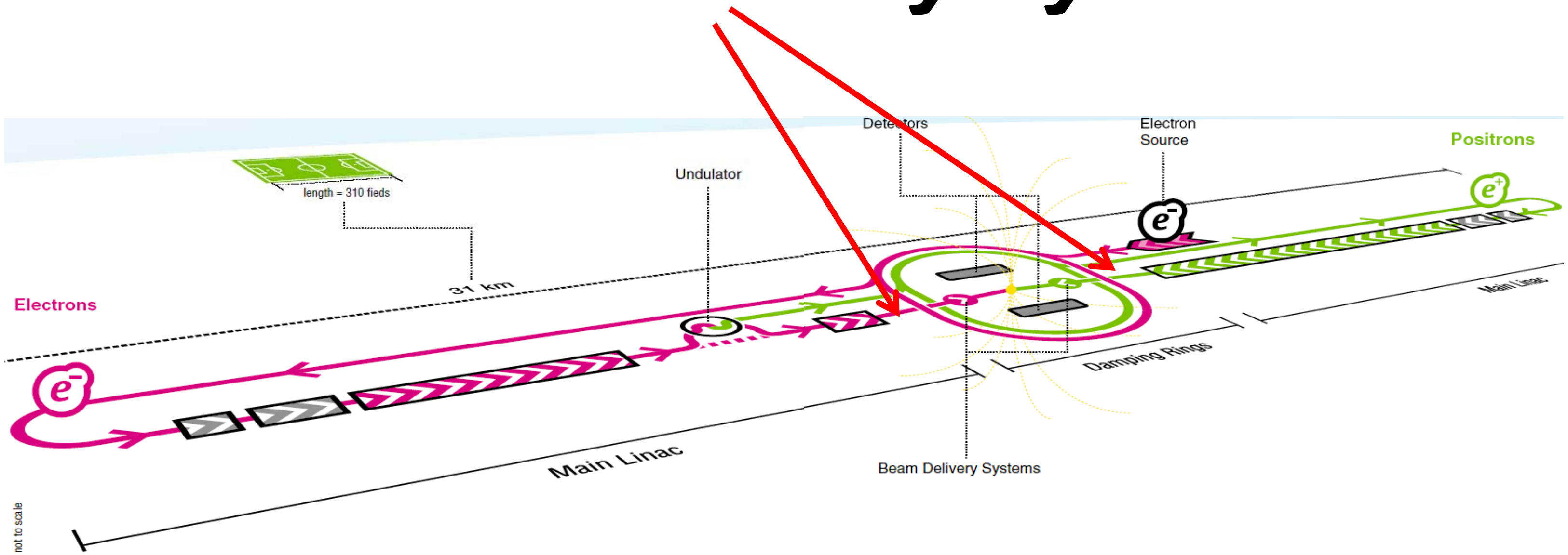
Beam Delivery System



Andrei Seryi
SLAC
for BDS design team

DOE/NSF FY08 Americas Regional Team Review

30 June 2008

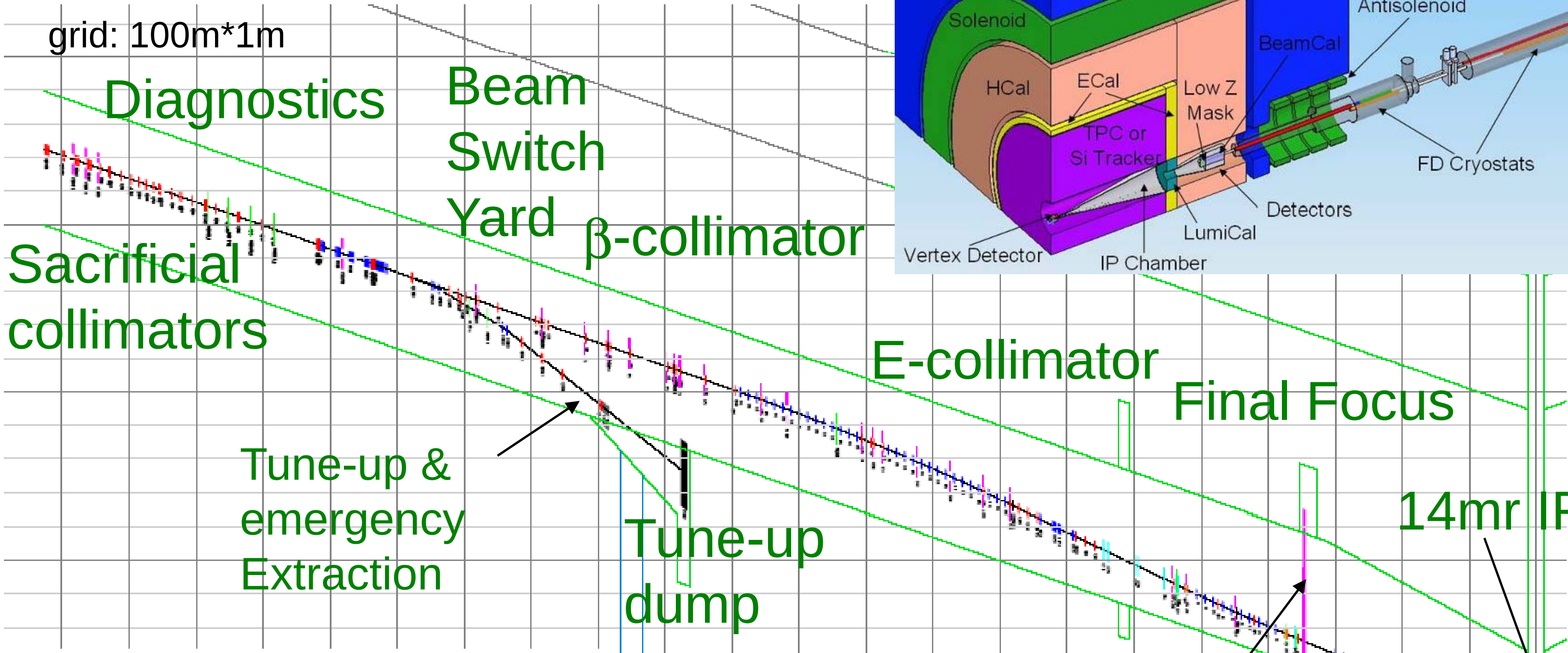
Plan of the presentation

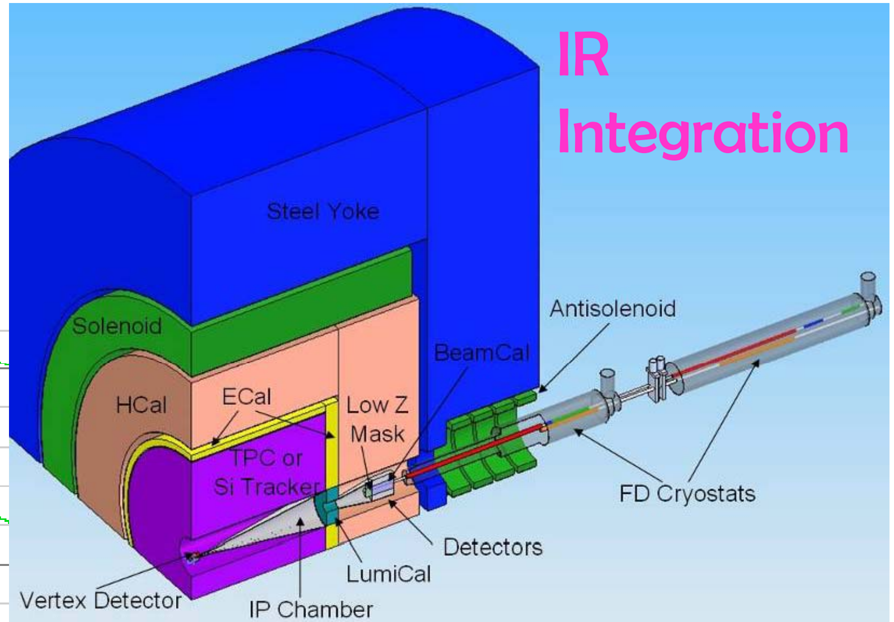
- FY2007 accomplishments
- New strategy, criteria & plan in TDP I & II
- FY2008 achievements
- FY2009 resources
- Five years plan

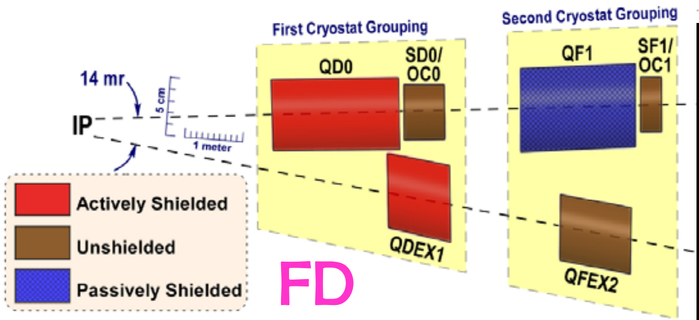
FY2007 accomplishments

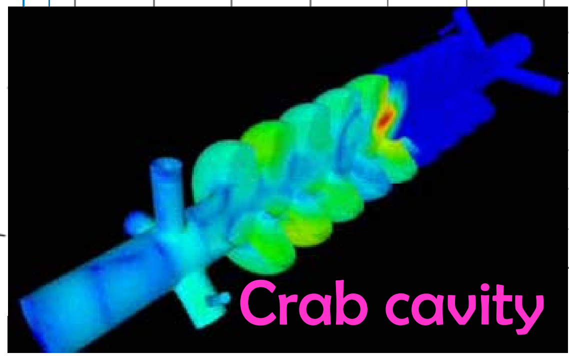
- BDS design work
- Progress in construction of ATF2 facility
- Design & prototype of crab cavity system
- MDI instrumentation studies at ESA facility
- Detailed design of SC Final Doublet and prototype development
- Progress with Interaction Region integration efforts by machine and detector groups
- Organization of BDS international team & resources for TDR phase design

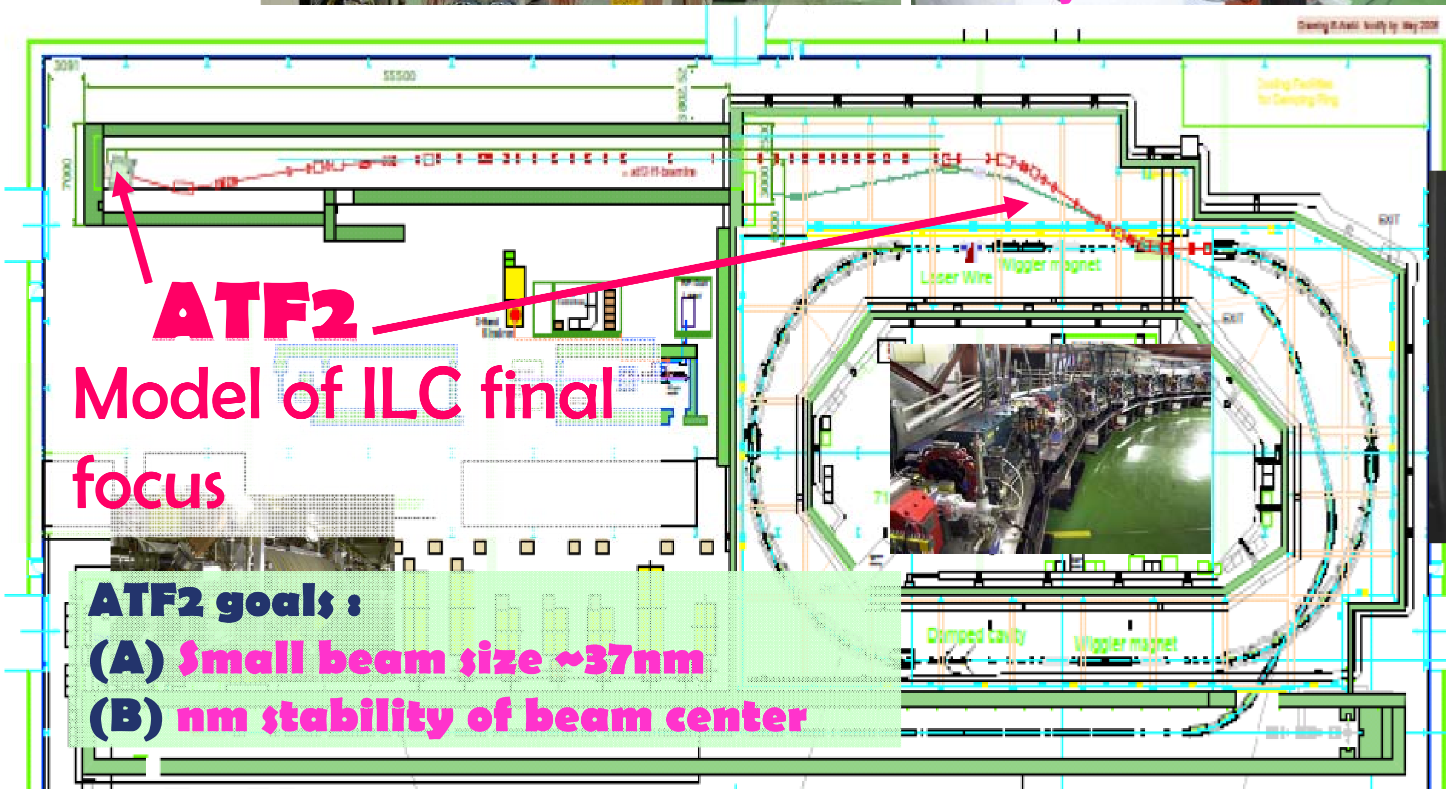
BDS RDR design











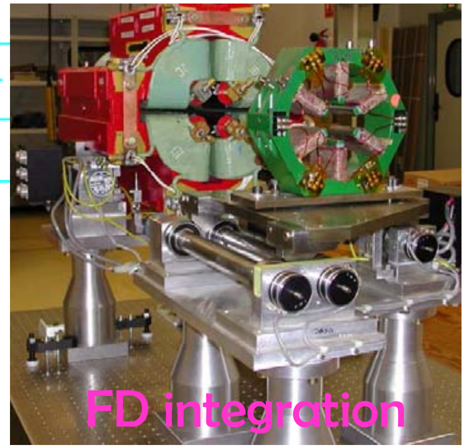
ATF2

Model of ILC final focus

ATF2 goals :

(A) Small beam size ~37nm

(B) nm stability of beam center

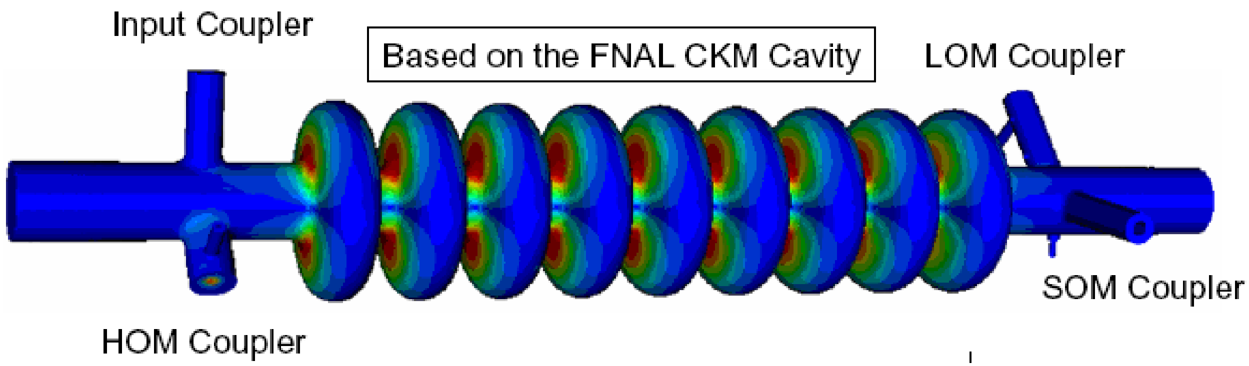


- ATF international collaboration: MOU signed by 20 institutions
- ATF2 constructed as ILC model, with in-kind contributions
- Start of beam commissioning: October 2008

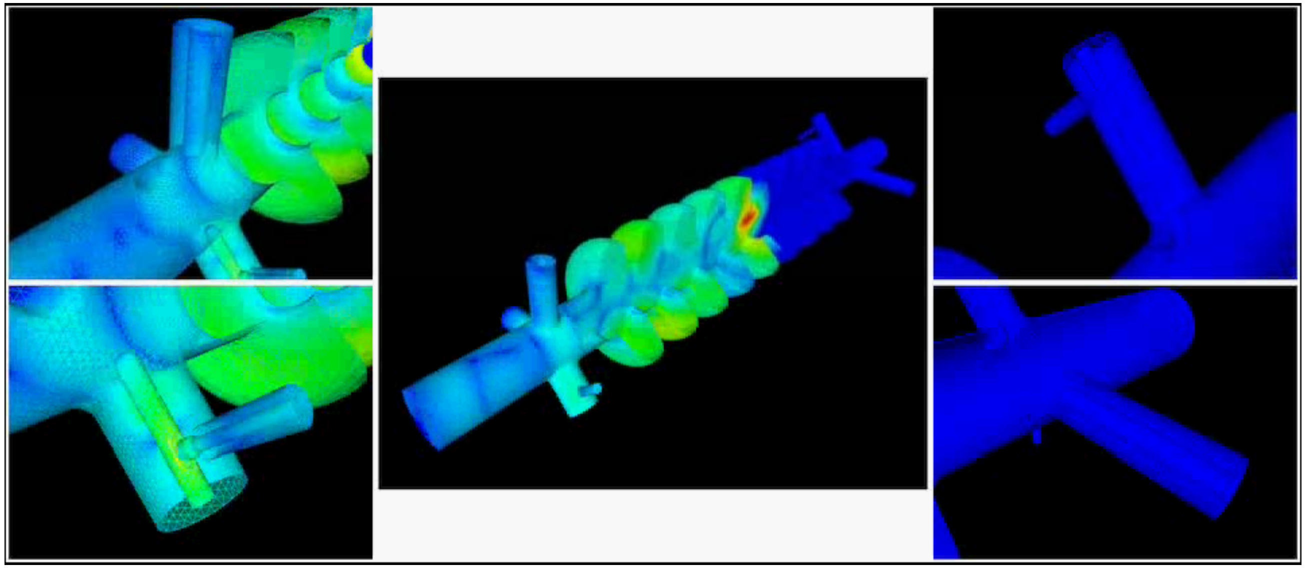
Crab Cavity

UK-FNAL-SLAC crab-cavity collaboration

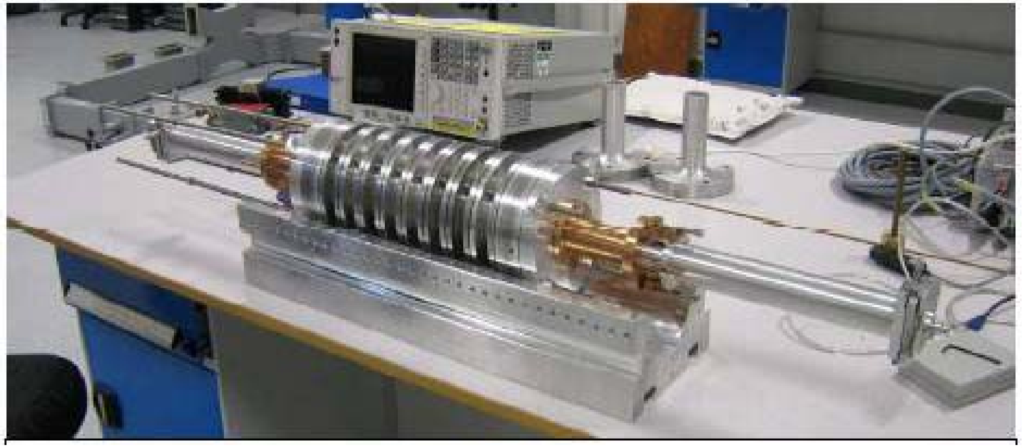
FNAL 3.9GHz transverse cavity achieved 7.5 MV/m

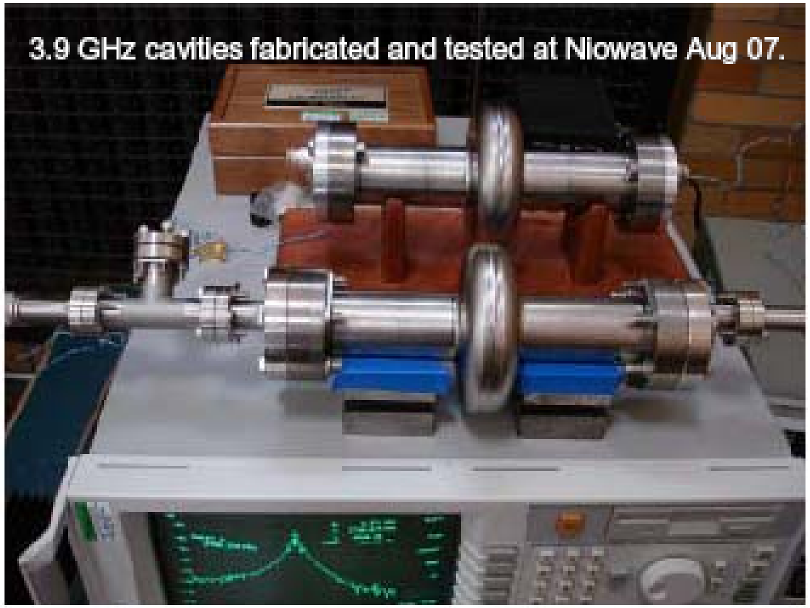


3d simulations by SLAC ACD



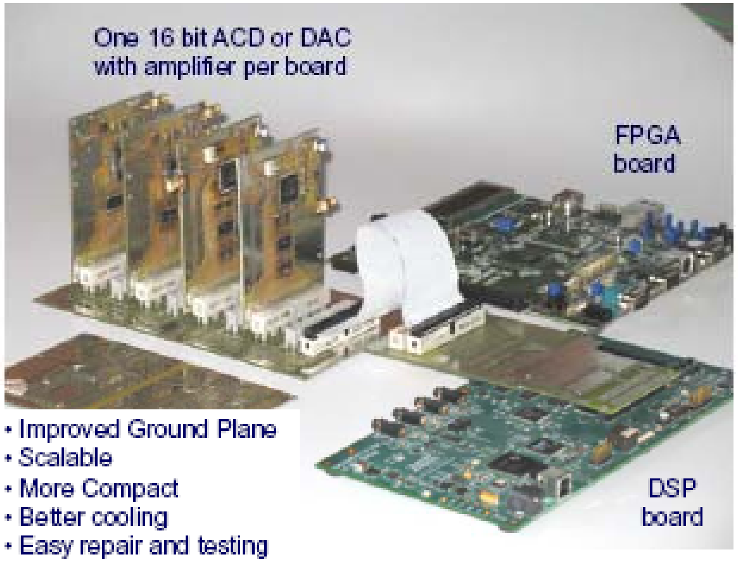
Challenges: damping of parasitic modes, tight phase stability, integration into IR



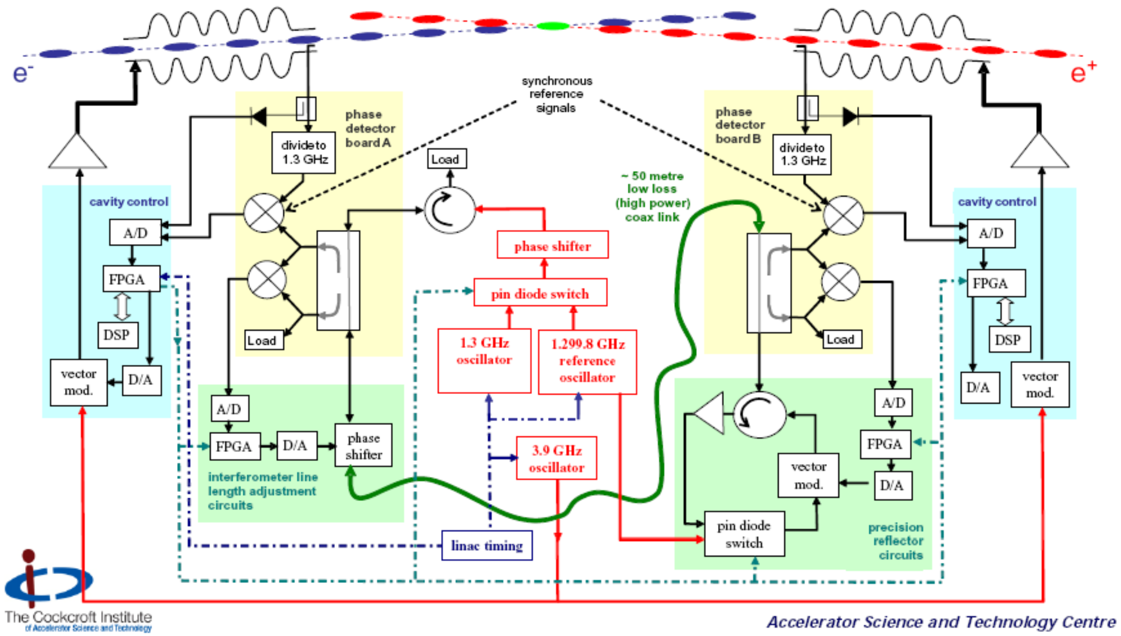


UK efforts

The Cockcroft Institute
of Accelerator Science and Technology

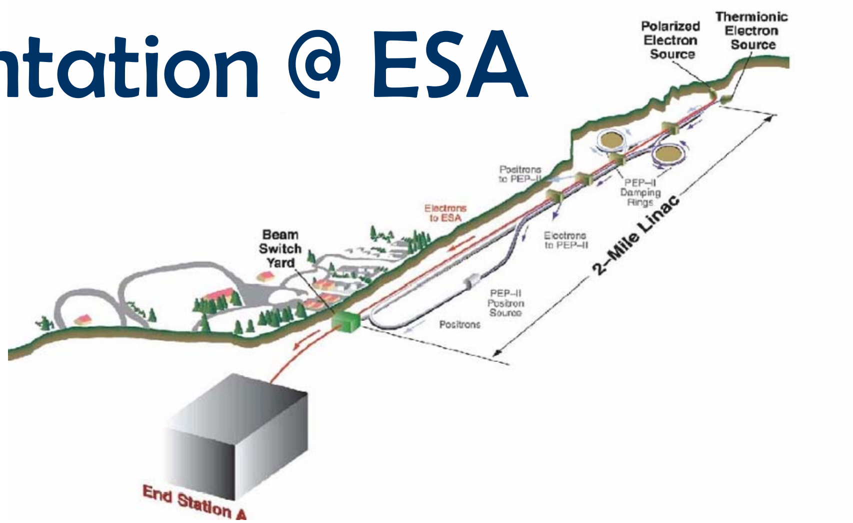


- Improved Ground Plane
- Scalable
- More Compact
- Better cooling
- Easy repair and testing



Peter McIntosh **et al**

MDI instrumentation @ ESA



Study:

BPM energy spectrometer

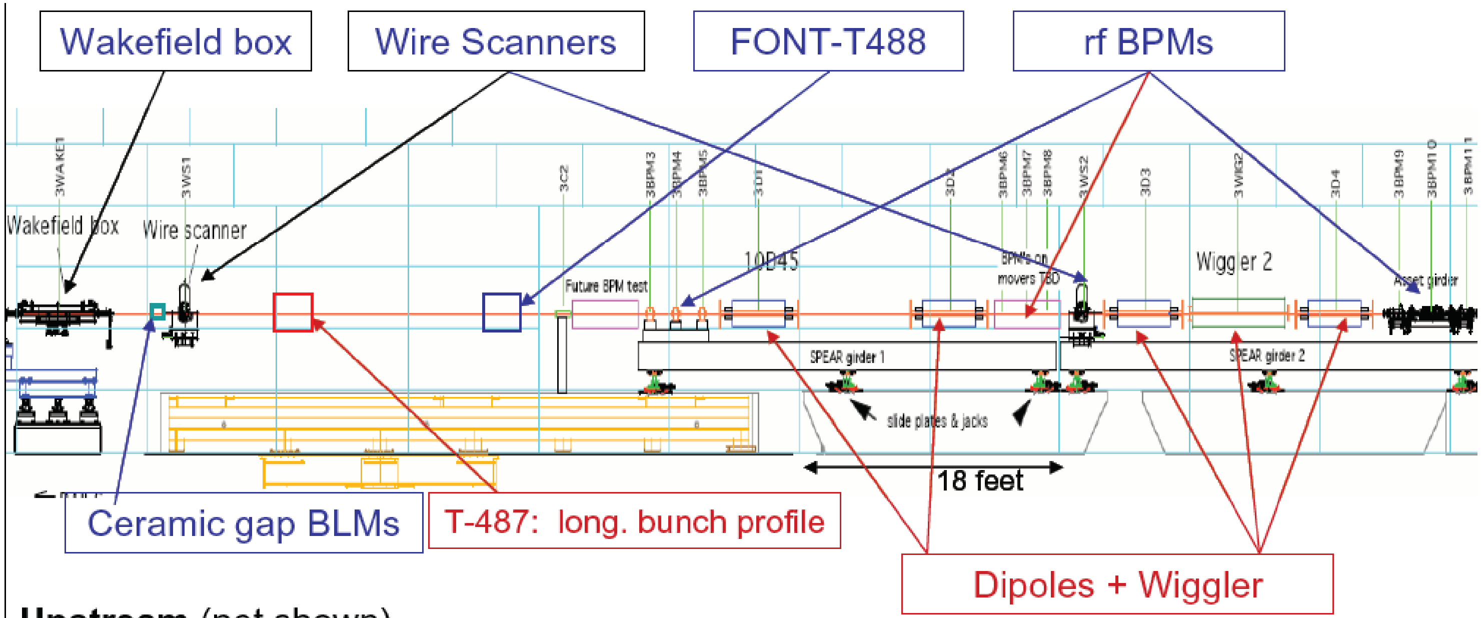
Synch Stripe energy spectrometer

Collimator design, wakefields

IP BPMs/kickers—background studies

EMI (electro-magnetic interference)

Bunch length diagnostics



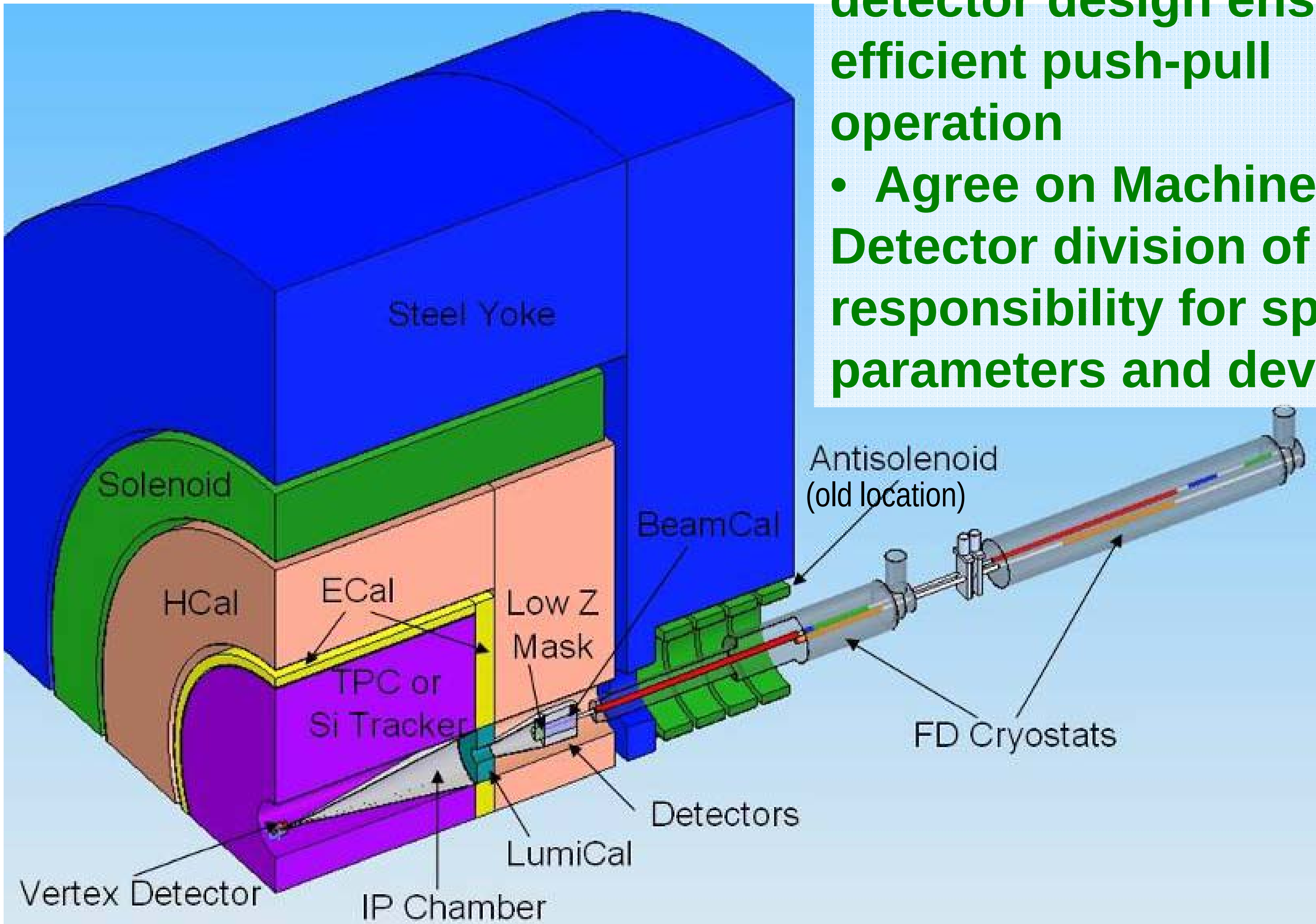
Upstream (not shown)

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

IR integration

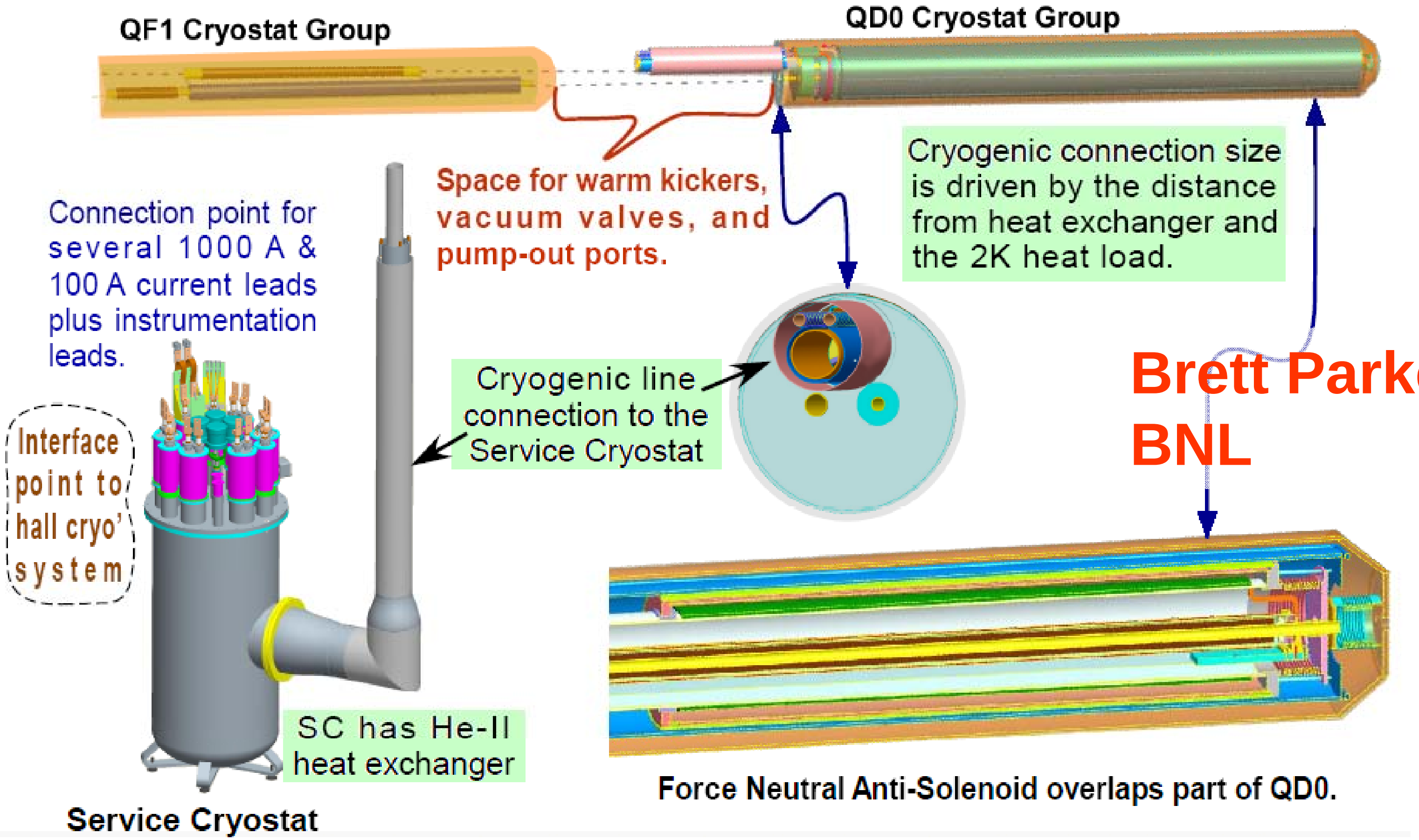


Challenges:

- **Optimize IR and detector design ensuring efficient push-pull operation**
- **Agree on Machine-Detector division of responsibility for space, parameters and devices**

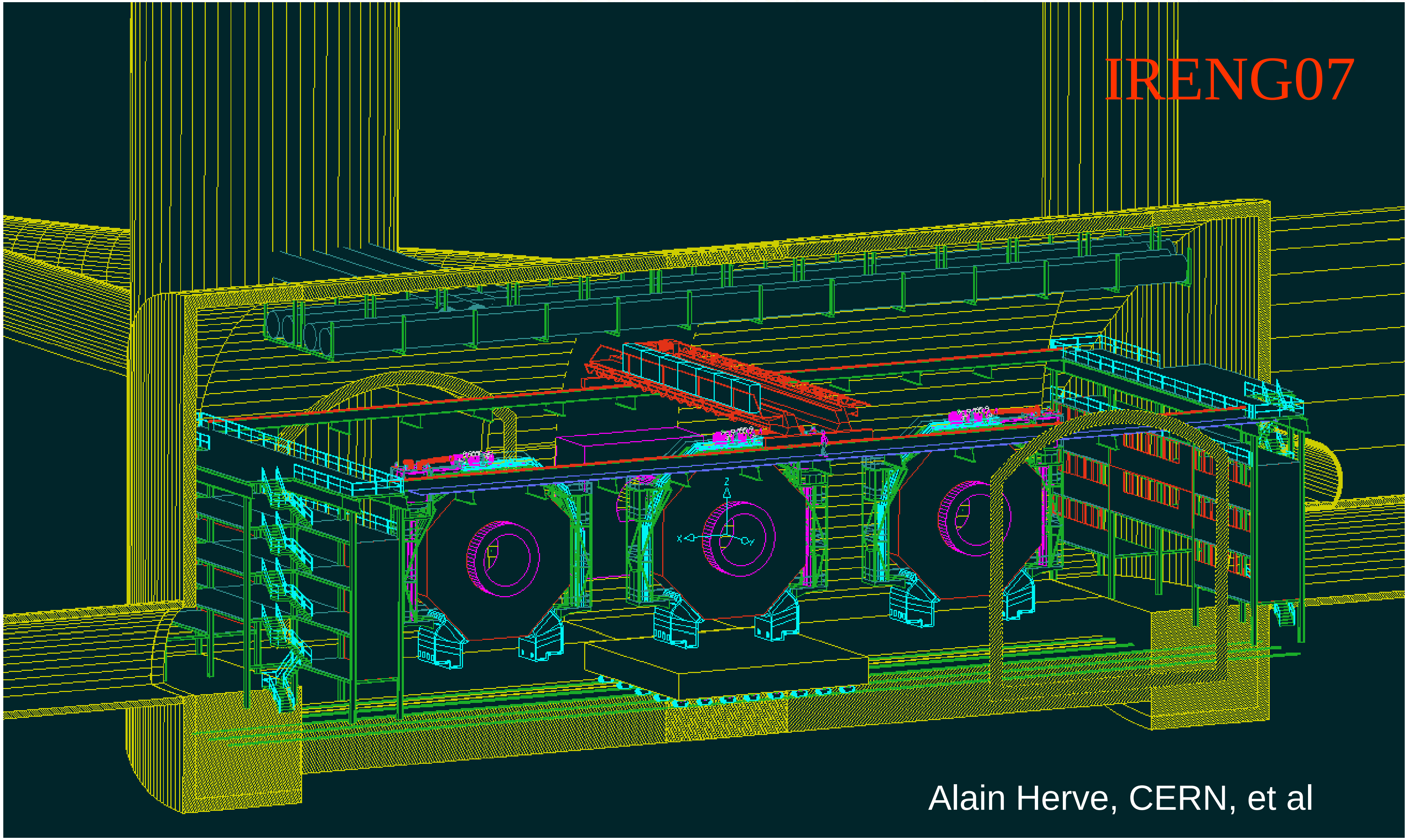
SC final double & its cryo system

Great progress (2007) on consistent design of the SC Final Doublet, suitable for push-pull operation ("IR Eng. workshop, IRENG07")



Brett Parker et al BNL

Optimization of Push-Pull design



BDS strategy

In TDP I & II plan, the scope of work changed, and the focus is shifted

Earlier planned detailed design & engineering will not be performed

→

- Focus on a few critical directions. Selection criteria:
  - –Critical impact on performance versus cost;
  - –Advanced ideas promising breakthrough in performance;
  - –Broad impact and synergy with other worldwide projects

Areas of key ART involvement indicated in bold font

→

- Three critical directions:
  - –General BDS design
  - –Test facilities, ATF2
  - –Interaction Region optimization

General BDS design:

beam dump
photon collider
crystal collimation
crab cavity
MDI diagnostics …

Test facilities, ATF2:

ATF2 commissioning & operation
Develop methods to achieve small beam size
Diagnostics, Laser Wires, Feedbacks …

Interaction Region optimization:

IR interface document & design
SC FD prototyping and vibration test
ILC-like FD for ATF2 …

FY2008 achievements

- ATF2 progress
  - Delivery of committed hardware to ATF2 and its commissioning (HA PS; FD; BPM electronics)
  - Initiated innovative Flight Simulator framework
- Beam dump design
  - started new collaboration with India, BARC
- Started development of "Interaction Region Interface Document"
- Developed R&D plan for photon collider option
- Initiated synergy explorations
  - CLIC BDS design
  - LHC crab cavity design
  - Crystal collimation
- Engaged in cost reduction explorations

High Availability Power Supplies

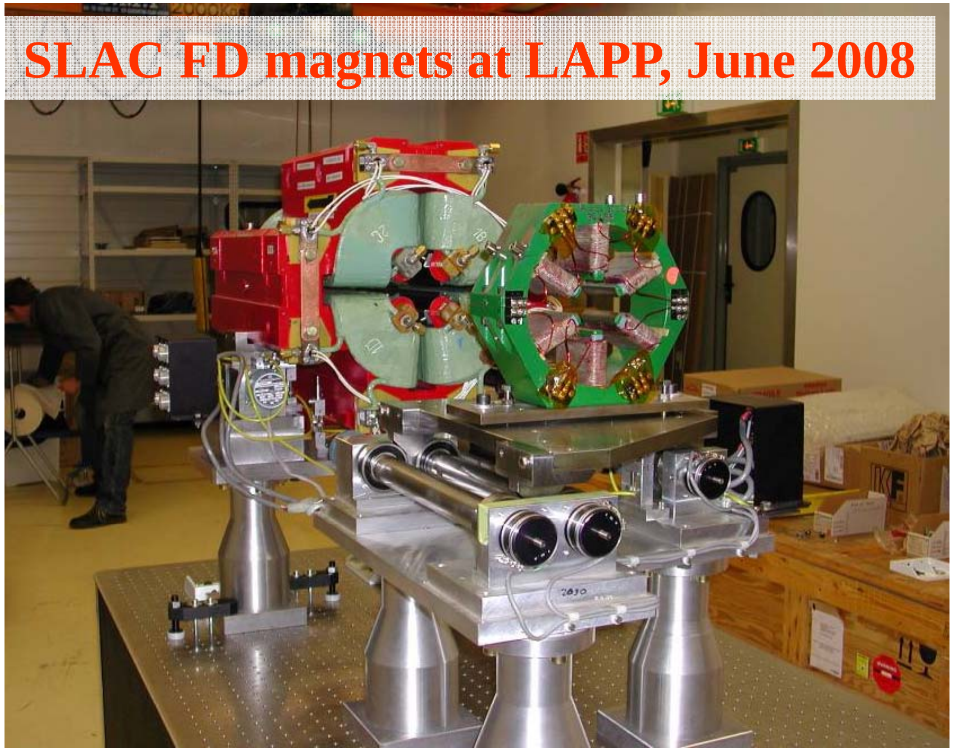
High Availability Power Supplies delivered, installed, connected and tested at ATF2 (May 2008)

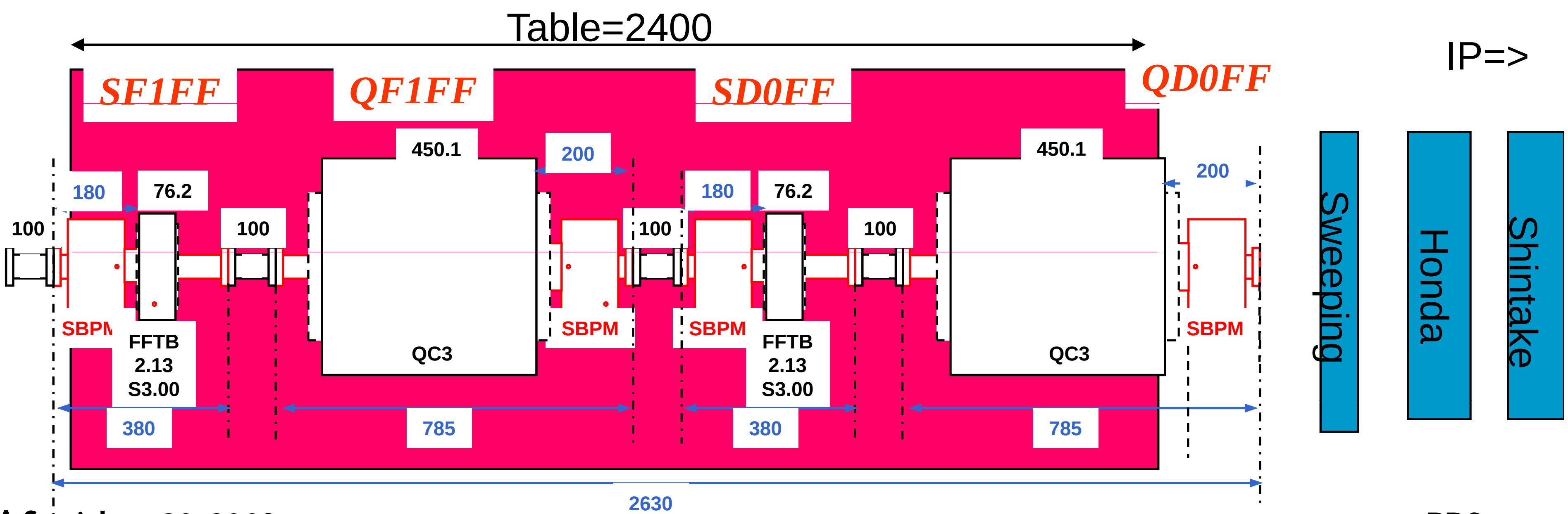
SLAC High Availability Power Supplies are applicable to many future projects such as NSLS-2, LCLS…)

ATF2 final doublet

Modified FFTB quads* and sextupoles delivered to LAPP, Annecy, for final integration and stability study

*) modification involved increase of aperture and adjusting pole shape with shims

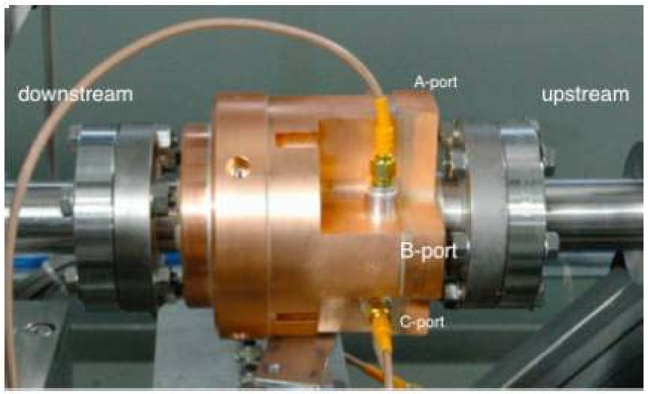




Cavity BPMs

Cavity BPMs and SLAC front-end electronics modules will provide sub-micron resolution of beam position at ATF2

ATF2 is one of the first beamlines to rely only on cavity BPMs
Experience applicable to LCLS cavity BPM system, etc



Prototype at PAL

ATF2 "Flight simulator"

Remote participation, first used for ATF in 2007, is used more and more, and facilitate participation of collaborators in ATF2 work

SLAC-KEK remote participation shift for BBA at ATF ring

Flight Simulator address the next challenge: creating a method how collaborators can contribute to development of tuning tools without being at ATF and without connection to ATF control system

FS based on Matlab and Lucretia accelerator toolbox

First tests of FS performed in May 2008

For details, see ATF2 Software review workshop, June 2008, LAL, Orsay

http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=2797

Flight Simulator Goals

Glen White (LAL / SLAC)

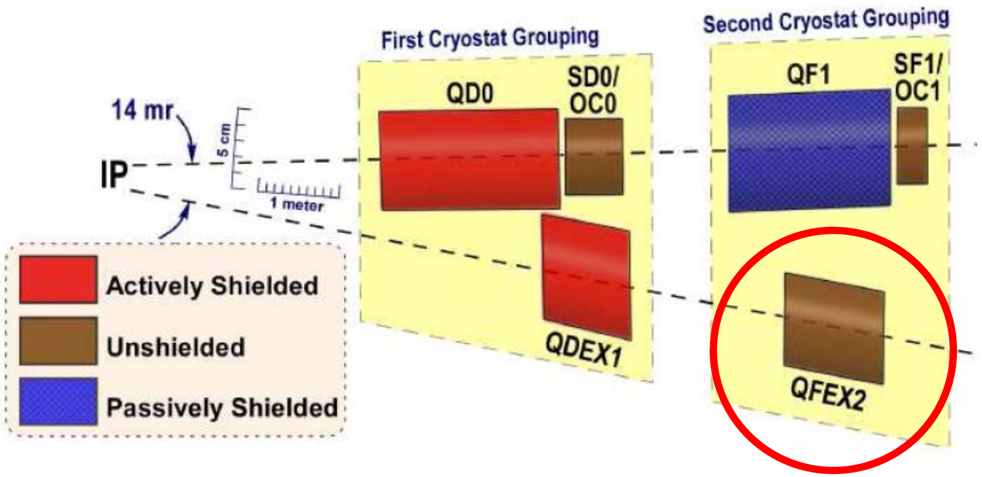
- Provide simple to use, beam dynamics oriented, portable control access framework for ATF2 tuning tasks.
- Simple and reversible transition from beam dynamics simulation to accelerator-ready code.
- Ability for international collaborators to develop beam tuning tools without need for expert-level knowledge of control systems.
- Flight simulator operates in simulation mode at external location in the same way as the production system deployed at ATF2.

Study of FD EXT quads

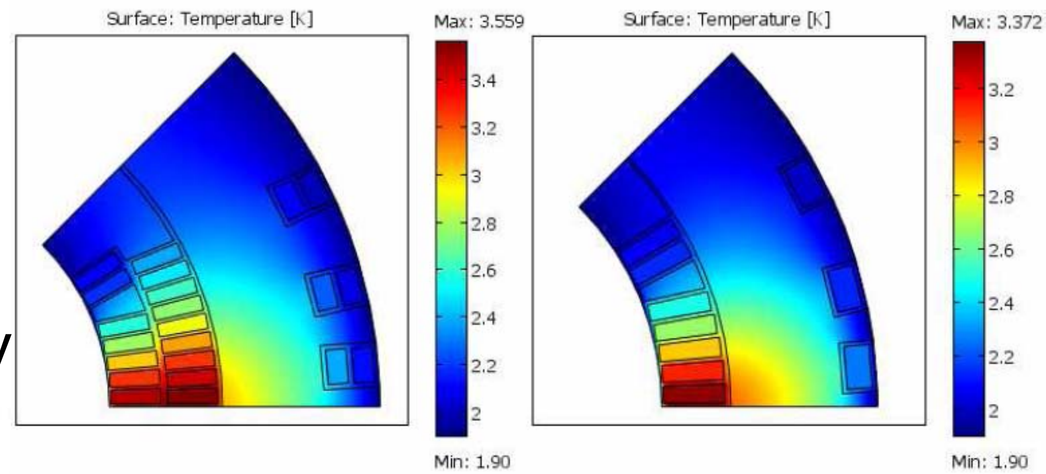
Radiation and thermal analysis of the ILC IR quads based on Rutherford type cables

Most of losses are in QFEX2

While direct wind QFEX2 has sufficient margin, the Rutherford cable QFEX2 allow increase of margin and thus more parameter flexibility



June 2008



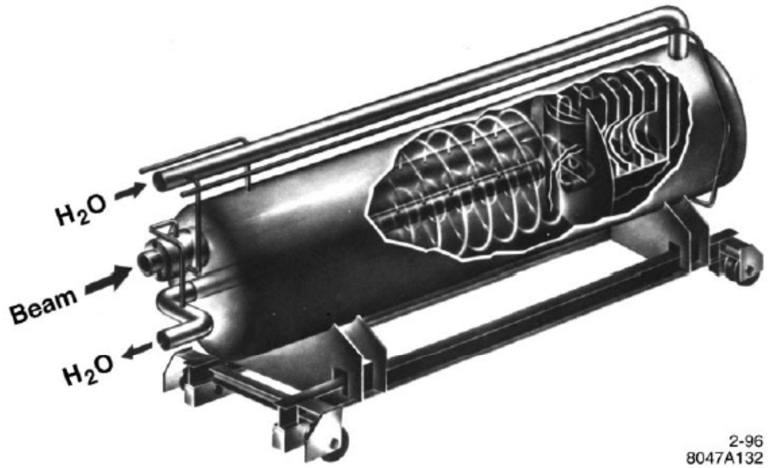
Calculated temperature profile in the 4-layer and 2-layer QFEX2 quadrupole magnets

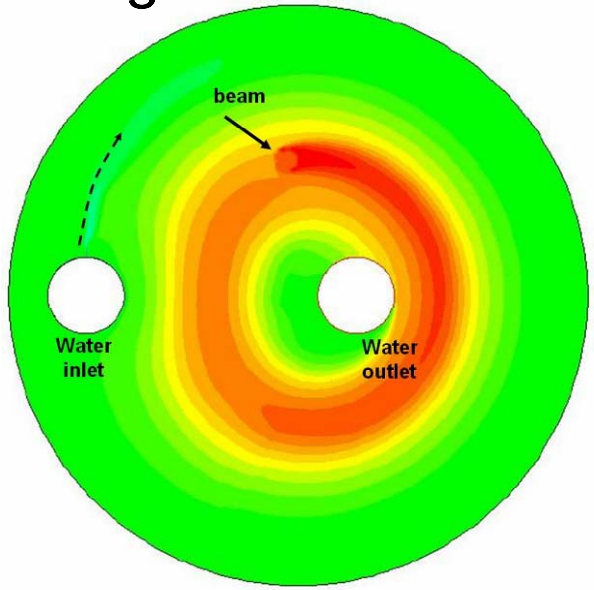
A.Drozhdin, V.V.Kashikhin, V.S.Kashikhin, M.Lopes, N.Mokhov, A.Zlobin, Fermilab

Beam dump design

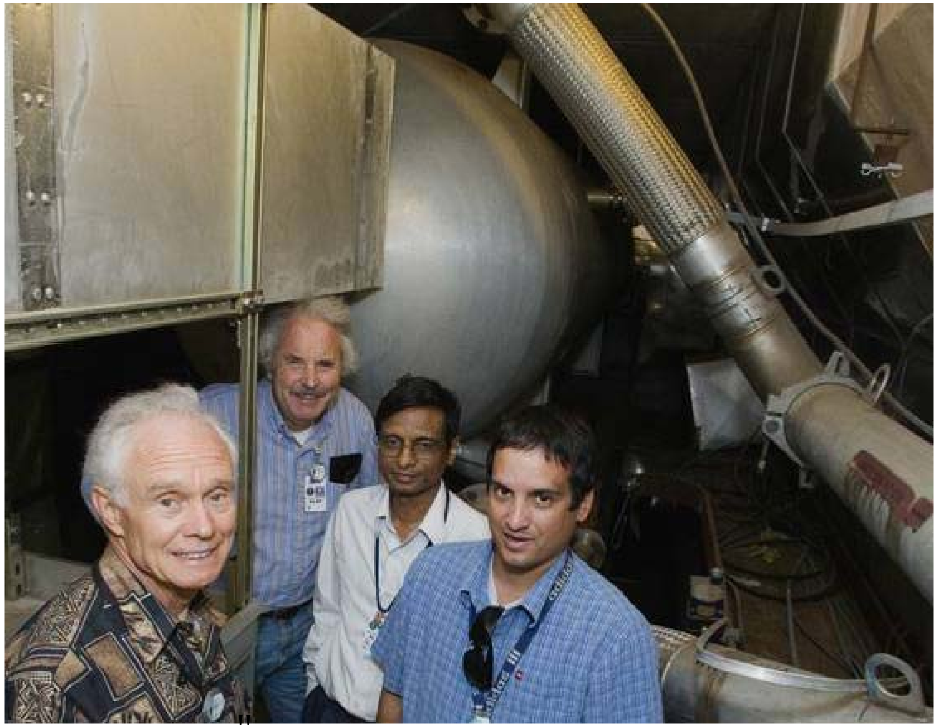
Initiated collaboration with BARC, India, on beam dump design

Ongoing work on optimization of design for 17MW dump



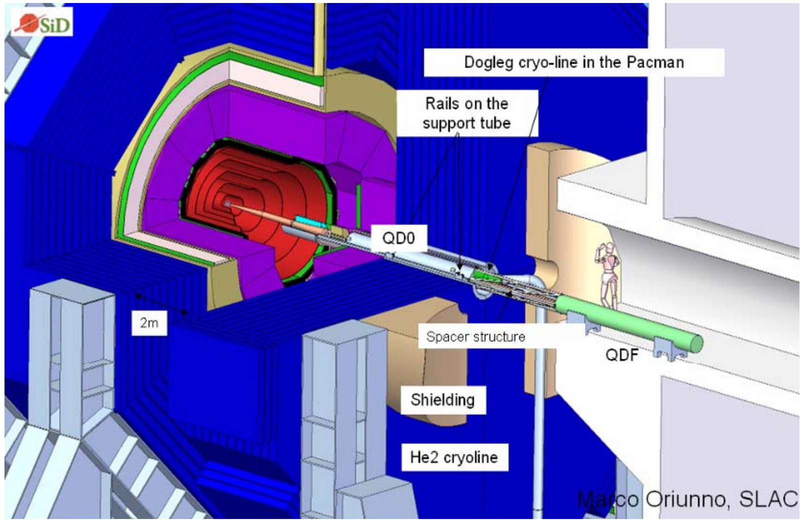


Computational fluid dynamics study of heat removal by water vortex. The color map show temperature increase of 30 C. BARC



Dieter Walz, Ray Arnold, Satyamurthy Polepalle (BARC, India), John Amann, at SLAC beam dump area (February 2008)

IR integration



- Machine – Detector work on Interface issues and integration design is a critical area and a focus of efforts
- IR integration timescale
  - EPAC08 & Warsaw-08
    - Interface document, draft
  - LCWS 2008
    - Interface doc., updated draft
  - LOI, April 2009
    - Interface document, completed
  - Apr.2009 to ~May 2010
    - design according to Interface doc.
  - ~May 2010: LHC & start of TDP-II
    - design according to Interf. doc and adjust to specific configuration of ILC

EPAC08

CHALLENGES AND CONCEPTS FOR DESIGN OF AN INTERACTION REGION WITH PUSH-PULL ARRANGEMENT OF DETECTORS – AN INTERFACE DOCUMENT*

B.Parker (BNL), A.Herve, J.Osborne (CERN), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), B.Ashmanskas, V.Kuchler, N.Mokhov (Fermilab), A.Enomoto, Y.Sugimoto, T.Tauchi, K.Tsuchiya (KEK), J.Weisend (NSF), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi, M.Sullivan (SLAC), D.Angal-Kalinin (STFC), T.Sanuki, H.Yamamoto (Tohoku Univ.)

Abstract

Two experimental detectors working in a push-pull mode has been considered for the Interaction Region of the International Linear Collider [1]. The push-pull mode of operation sets specific requirements and challenges for many systems of detector and machine, in particular for

The speed of push-pull operation is the first defining assumption. We set as the goal that hardware design should allow the moving operation, reconnections and possible rearrangements of shielding to be performed in a few days, or less than a week.

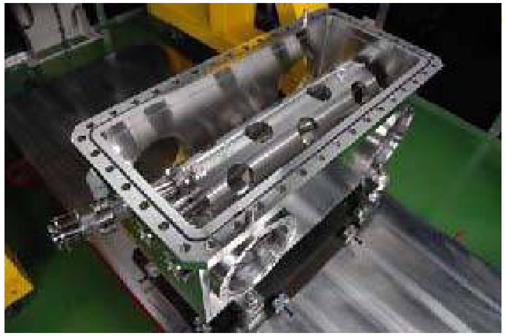
The range of detector sizes considered in the design

R&D plan for e→γ

Public Note / ACCDT / BDS   LLNL-TR-403955   ILC-NOTE-2008-043

Photon Collider Technology Readiness and Near Term Plans

Gronberg, J. ; Omori, T. ; Seryi, A. ; Takahashi, T. ; Telnov, V. ; Urakawa, J. ; Variola, A. ; Woods, M. ; Zomer, F.

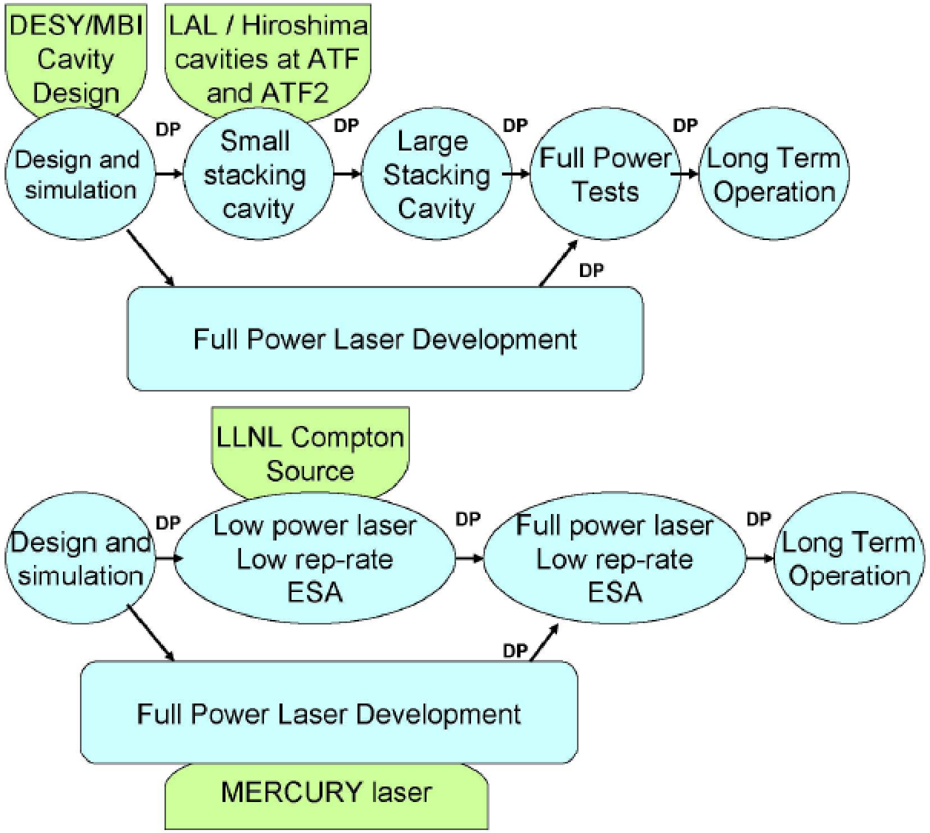


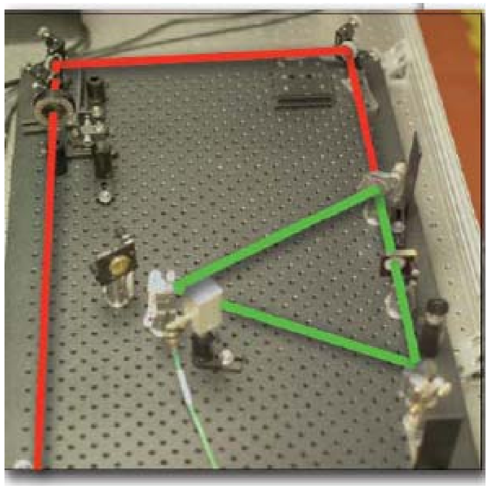
Pulse Stacking Cavity

(R&D for Positron source KEK-LAL-Hiroshima-Waseda-Kyoto-IHEP)

enhancement: 300-1000,

tight motion tolerances





I. Jovanovic, LLNL

RING (Recirculation Injection by Nonlinear Gating) Cavity LLNL

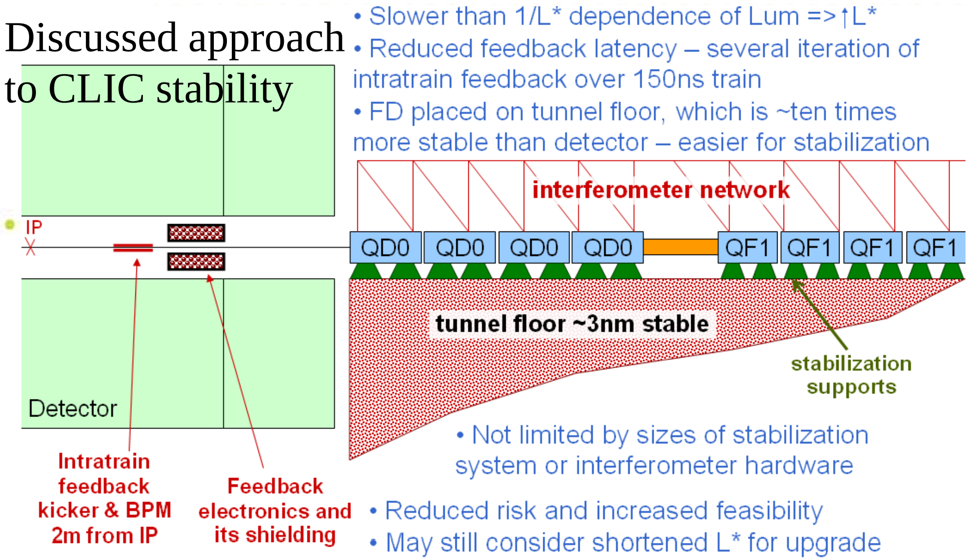
recirculation of a pulse ~50 times

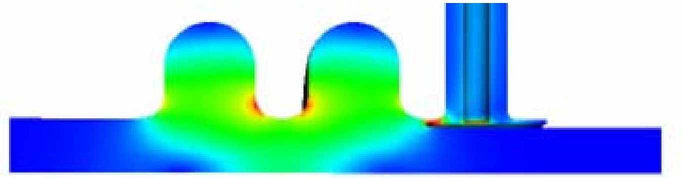
compensation of circulated pulse decay

Synergy explorations

- CLIC BDS design
  - BDS/MDI design
  - Stability study
- LHC crab cavity design
  - ILC-LHC initiative: Oct. 2007
  - Ongoing collaborative design
- Crystal collimation
  - Potential for more robust & shorter collimation system
  - Application as photon source

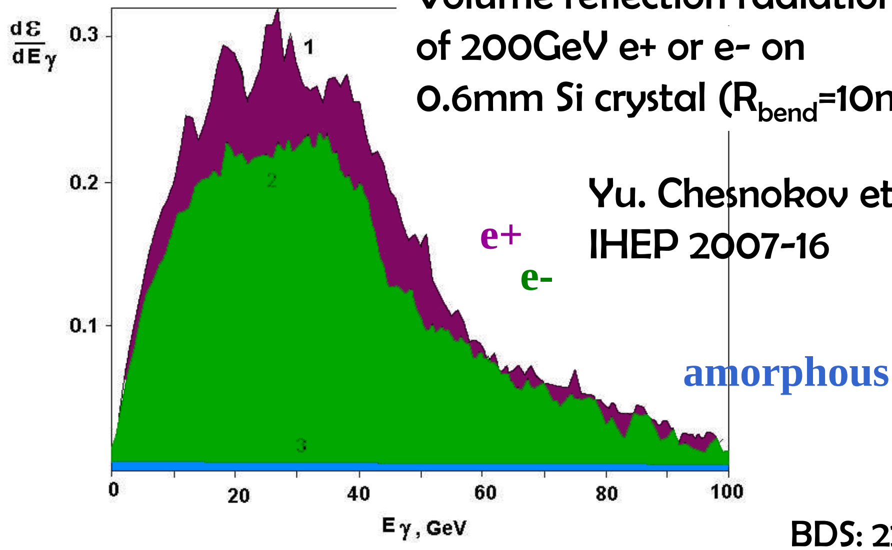
Discussed approach to CLIC stability





One of LHC-CC designs, L.Xiao, et al, SLAC

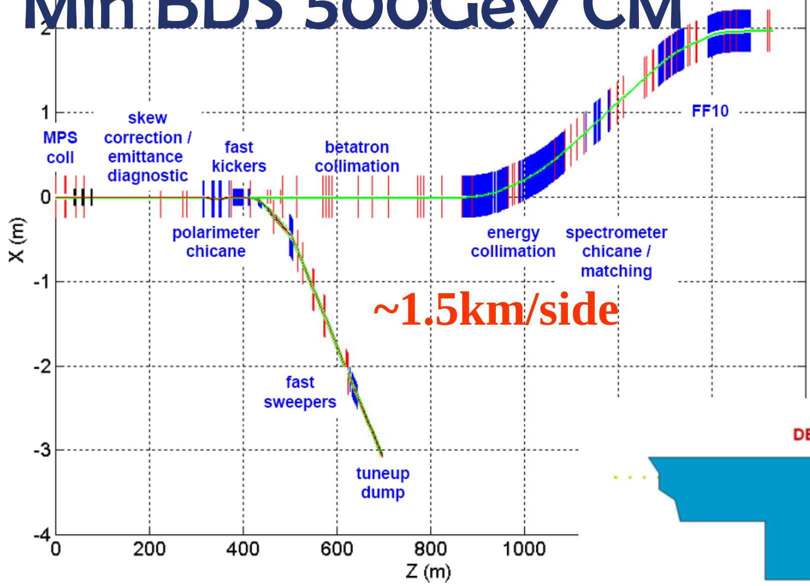
Volume reflection radiation of 200GeV e+ or e- on 0.6mm Si crystal (R_{bend}=10m)



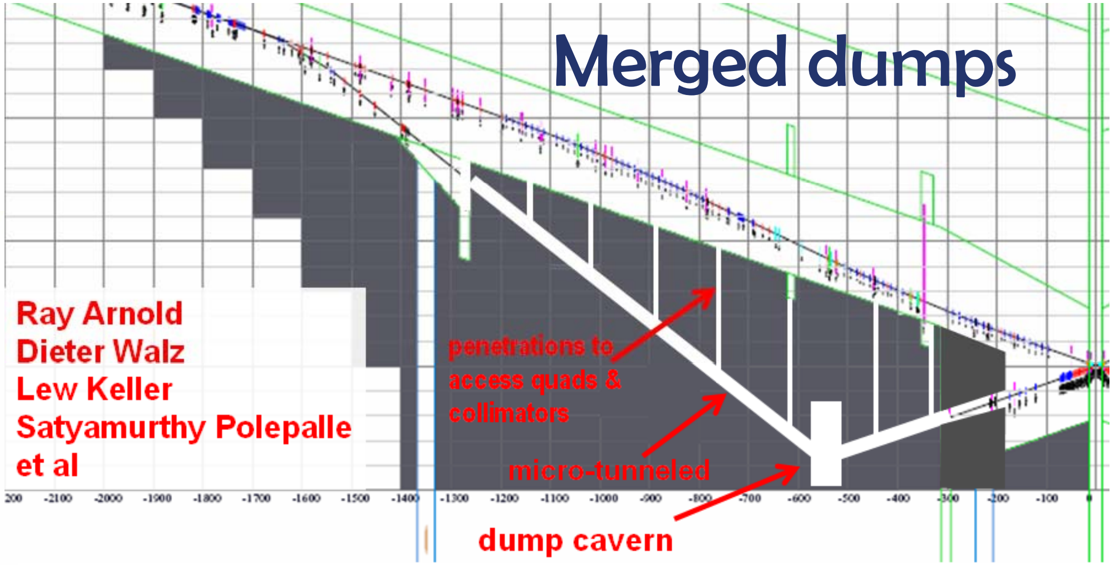
Yu. Chesnokov et al, IHEP 2007-16

Cost reduction explorations

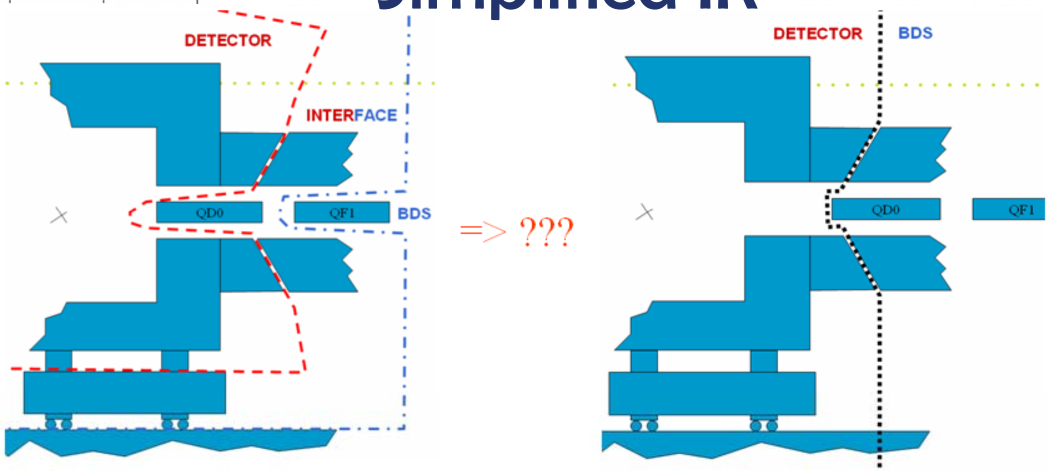
Min BDS 500GeV CM



Merged dumps



Simplified IR



- Longer L*, long enough to have QD0 outside of detector, separating M/D more cleanly and simplifying push-pull
  - Some impact on luminosity is unavoidable; Rvx may need to be increased
- If a longer L* design will be found viable, a question will be
  - whether to consider it as a permanent solution
  - if a Luminosity upgrade, by shortening the L*, would be considered later, after operational experience will be gained with a simpler system

Table 3.4: TD Phase Beam Test Facilities Deliverables and Schedule.

Test Facility	Deliverable	Date
Optics and stabilisation demonstrations:		
ATF	Generation of 1 pm-rad low emittance beam	2009
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final doublet magnets	2012
	Stabilisation of 35 nm beam over various time scales.	2012

3.3.5 Beam Delivery System

The main R&D focus for the BDS is the ATF-2 programme at KEK which will allow demonstrations of many of the key BDS components and design concepts, the Machine-Detector activity for optimization of the Interaction Region, and design for those BDS subsystems which are critical for system performance or which may expand the physics capabilities of the collider. Examples of R&D are:

- Development of instrumentation (e.g. laser-wires), algorithmic control software, beam-based feedback systems and emittance-preservation techniques to achieve the small beam-size goals (2010)
- Developing of IR Interface Document defining MDI specifications and responsibilities (2010) and design or optimised IR (2012)
- Development of the prototype of the Interaction Region SC Final Doublet (2012)
- Development of Interferometer system for FD stability monitoring (2012)
- Design of the beam dump system (2012)
- Tests of SC and PM Final doublet at second stage of ATF2 (2012)
- Design studies for the photon collider option (2012)
- Collimation and dump window damage tests at ATF2 (2010)
- Development and demonstration of the SCRF crab-cavity system (2010)

BDS in GDE Technical Design Phase plan

Key ART contributions highlighted

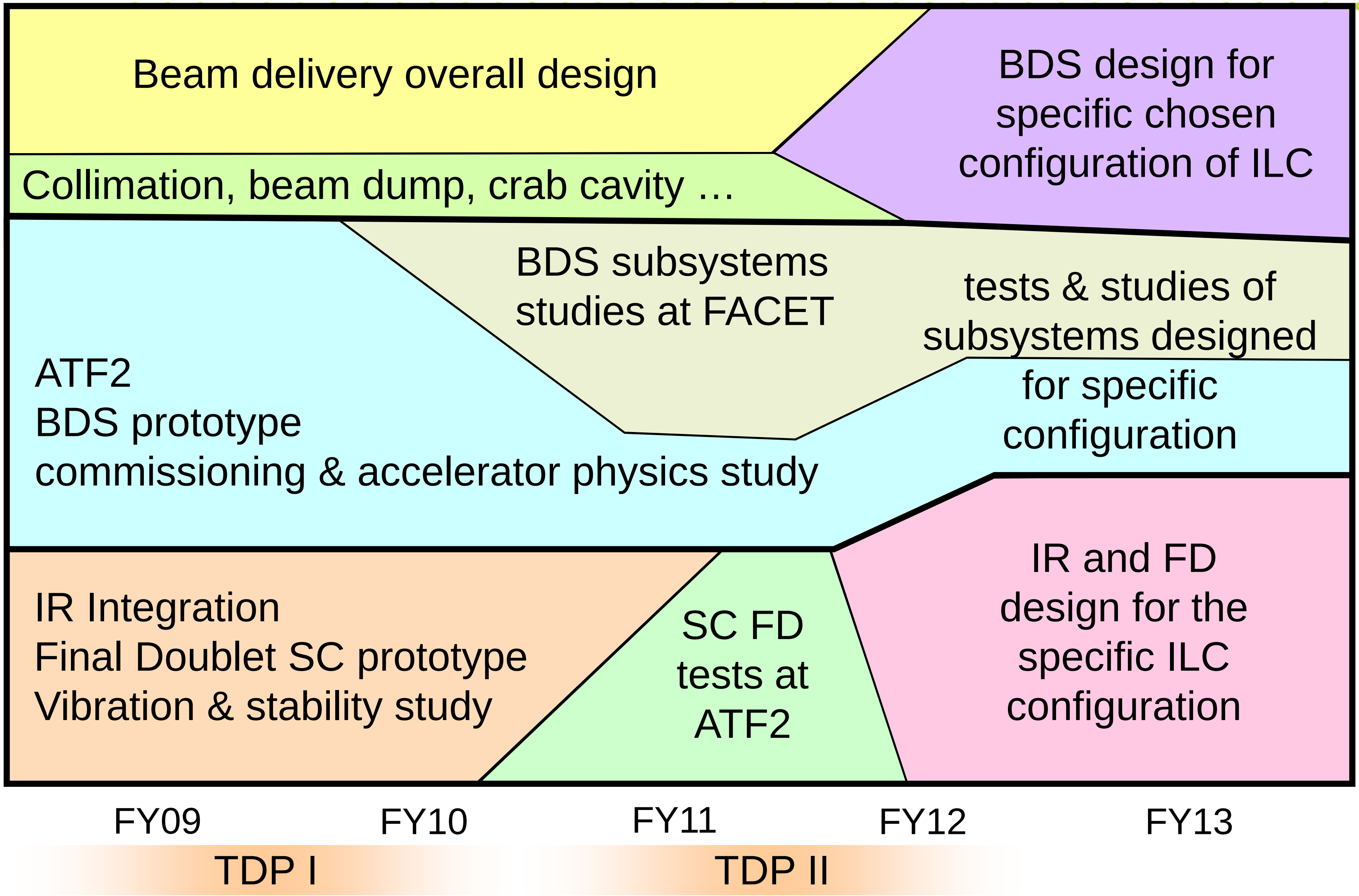
FY2009 resources

L2 Title	1.6 Beam Delivery Systems

			Data				
L3 Title	WBS L4	Description	Sum of FY09 FTE	Sum of FY09 Dir Labor (K$)	Sum of FY09 Dir M&S (K$)	Sum of FY09 Indir (K$)	Sum of FY09 Total (K$)
1.6.1 BDS R	1.6.1.1	BDS Design @ SLAC	4.50	$600	$0	$382	$982
	1.6.1.2	IR CFS Design (Value Engineering)	2.15	$300	$30	$199	$529
	1.6.1.3	ATF/ATF2 Construction & Operation	4.65	$580	$85	$391	$1,056
	1.6.1.5	BDS Collimation Design	0.00	$0	$0	$0	$0
	1.6.1.6	BDS IR Design & MDI	4.35	$570	$279	$651	$1,500
	1.6.1.7	BDS Design @ LLNL	0.50	$120	$0	$83	$203
1.6.1 BDS R&D Total			16.15	$2,170	$394	$1,705	$4,269
Grand Total			16.15	$2,170	$394	$1,705	$4,269

- Allow continuation of work where ART possess essential leadership and expertise and unique facilities
- Direct benefits: maintain leadership in key areas of US expertise, needed to reach the energy frontier
- Indirect benefit: synergy with US science
  - ATF2: advanced accelerator study and beam handling applicable to any single path beamlines such as LCLS, XFEL...
  - Instrumentation, high availability power supplies, etc., are applicable to many future projects such as NSLS-2, LCLS...
  - IR and and FD design: synergy with LHC IR upgrade and Super-B IR
  - Collimation and crab cavity research: synergy with LHC

BDS five year plan



Conclusion

- RDR design of BDS was produced by international team with essential contribution of ART
- In TDP I and II, the strategy has changed
- BDS activities are focused on three critical directions
- Focus on key areas of US expertise
- Direct and indirect benefit for US science
- BDS plans are integrated into TDP