Beam Delivery system design and plans

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SLAC
on behalf of BDS design team

ILC08 and LCWS08
17 November 2008

Illustration of beam dump with double header is from Satyamurthy Polepalle et al (BARC-SLAC)

Beam Delivery Systems strategy in TDP

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

→

- 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

→

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

beam dump
photon collider
crystal collimation
crab cavity
MDI diagnostics …

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

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

BDS five year plan

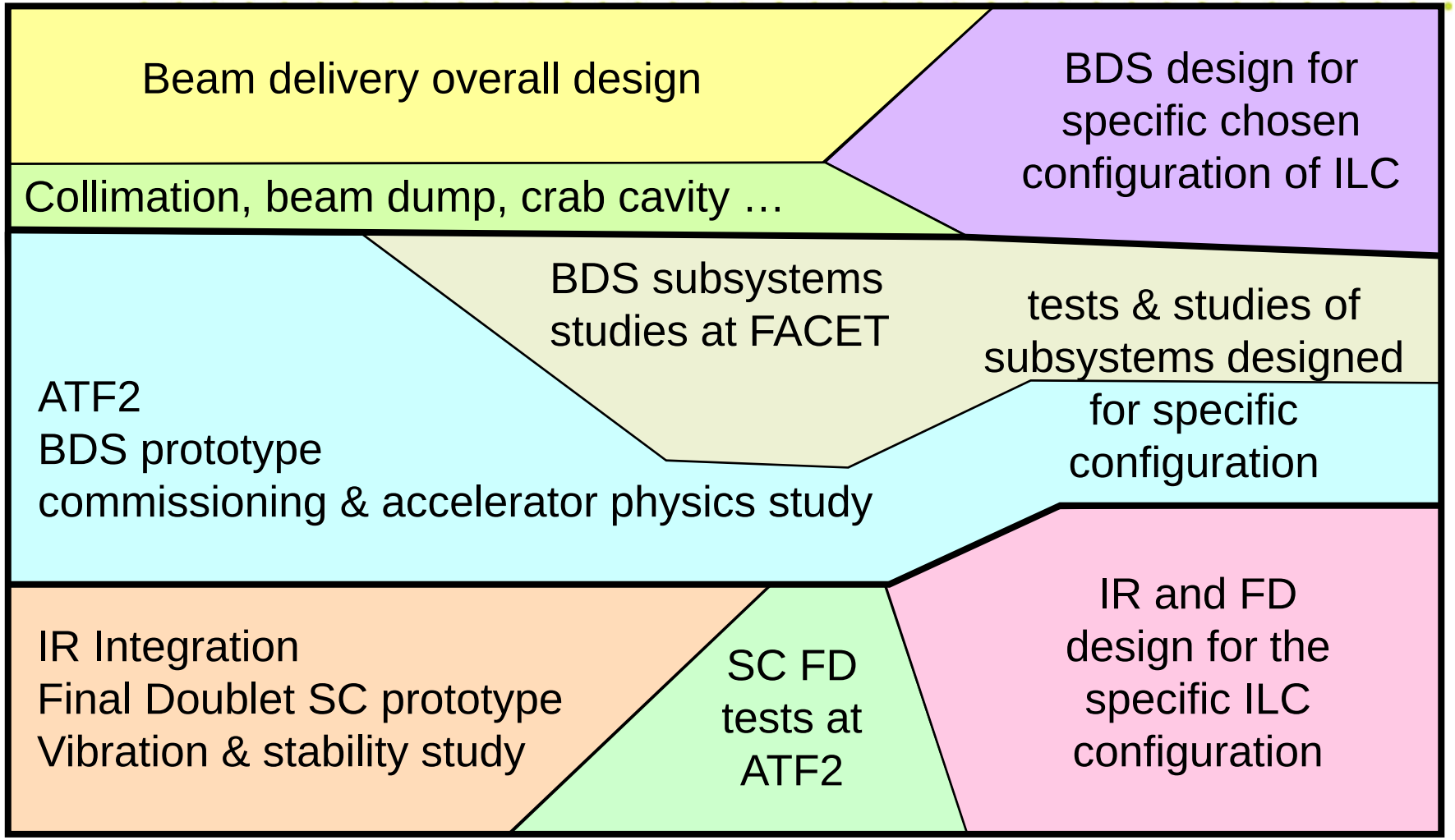


Table 3.4: TD Phase Beam Test Facilities Deliverables and Schedule.

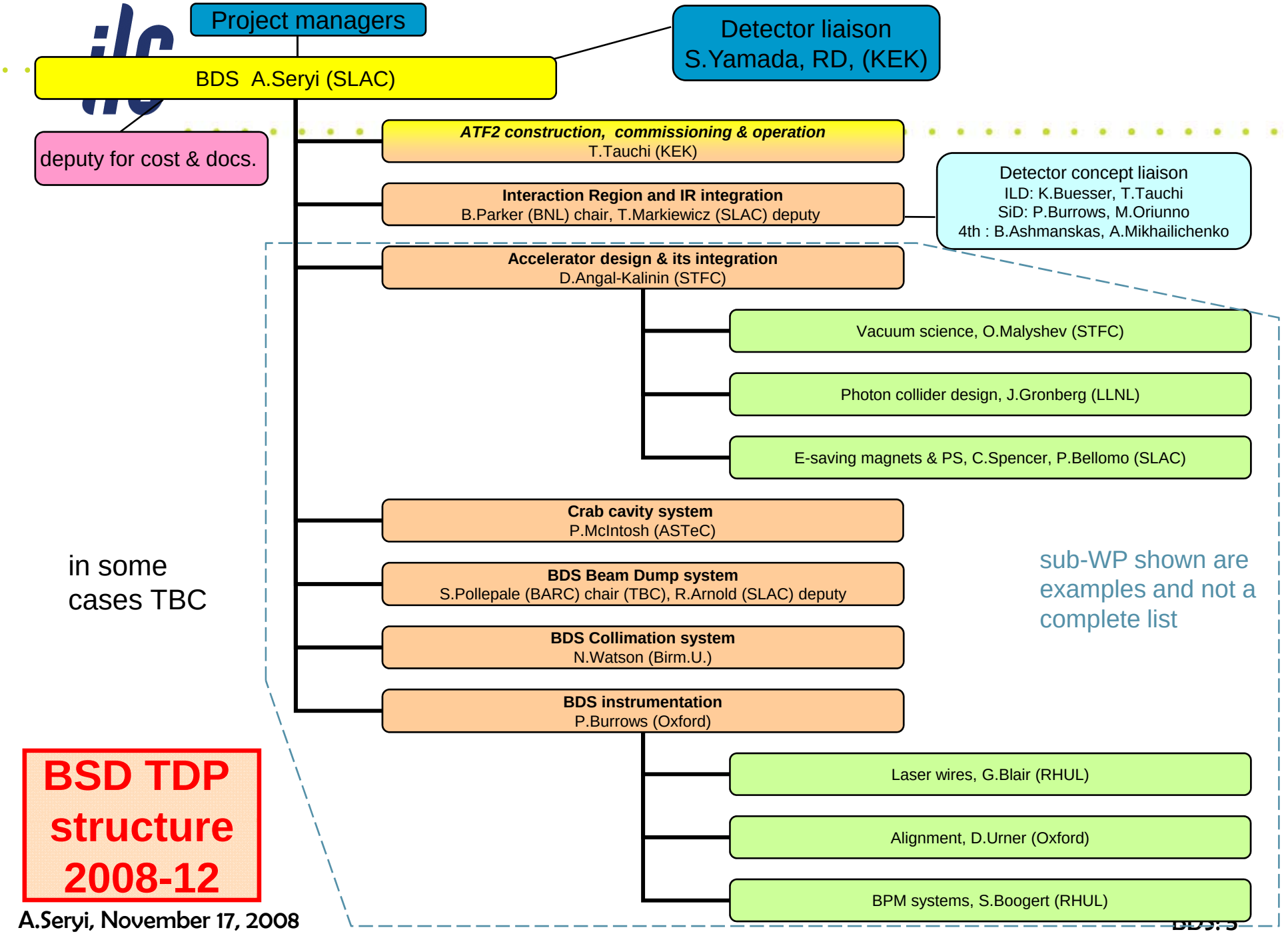
Test Facility	Deliverable	Date
Optics and stabilisation demonstrations:		
ATF	Generation of 1 pm-rad low emittance beam	2009
ATF-2	Demonstration of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demonstration of prototype SC and PM final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

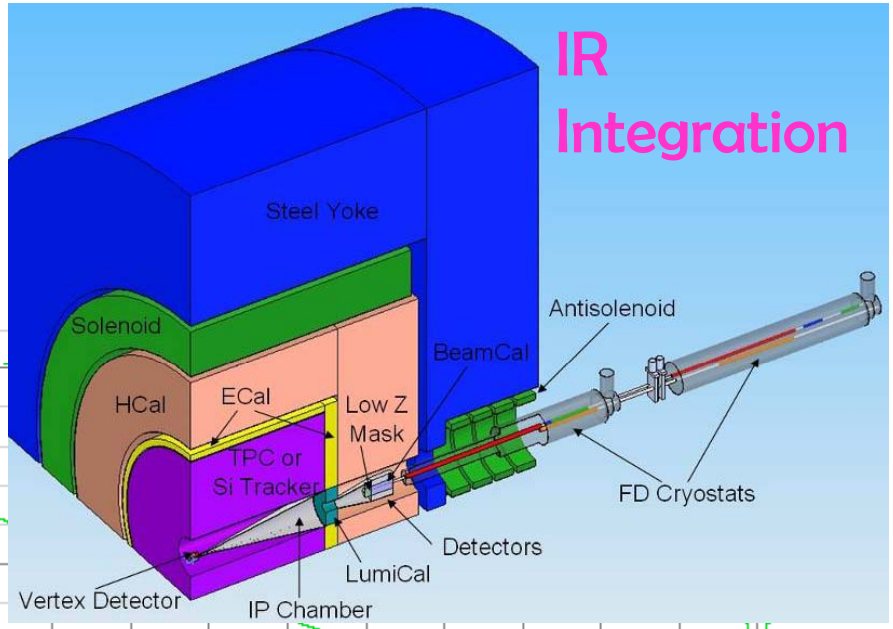
- Development of instrumentation (e.g. laser-wires), algorithmic control software, beam-based feedback systems and emittance-preservation techniques to achieve the small beam-size goals (2010)
- Developing of IR Interface Document defining MDI specifications and responsibilities (2010) and design or 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


Project managers
BDS A.Seryi (SLAC)
Detector liaison
S.Yamada, RD, (KEK)
deputy for cost & docs.
ATF2 construction, commissioning & operation
T.Tauchi (KEK)
Interaction Region and IR integration
B.Parker (BNL) chair, T.Markiewicz (SLAC) deputy
Detector concept liaison
ILD: K.Buesser, T.Tauchi
SiD: P.Burrows, M.Oriunno
4th : B.Ashmanskas, A.Mikhailichenko
Accelerator design & its integration
D.Angal-Kalinin (STFC)
Vacuum science, O.Malyshev (STFC)
Photon collider design, J.Gronberg (LLNL)
E-saving magnets & PS, C.Spencer, P.Bellomo (SLAC)
Crab cavity system
P.McIntosh (ASTeC)
BDS Beam Dump system
S.Pollepale (BARC) chair (TBC), R.Arnold (SLAC) deputy
BDS Collimation system
N.Watson (Birm.U.)
BDS instrumentation
P.Burrows (Oxford)
Laser wires, G.Blair (RHUL)
Alignment, D.Urner (Oxford)
BPM systems, S.Boogert (RHUL)
in some cases TBC
sub-WP shown are examples and not a complete list
BSD TDP structure 2008-12

BDS RDR design

1TeV CM, single IR, two detectors, push-pull



grid: 100m*1m

Diagnostics

Beam Switch Yard

β-collimator

Sacrificial collimators

E-collimator

Final Focus

Tune-up & emergency Extraction

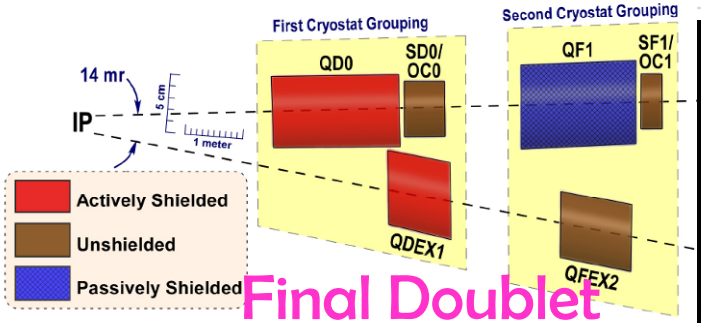
Tune-up dump

14mr IR

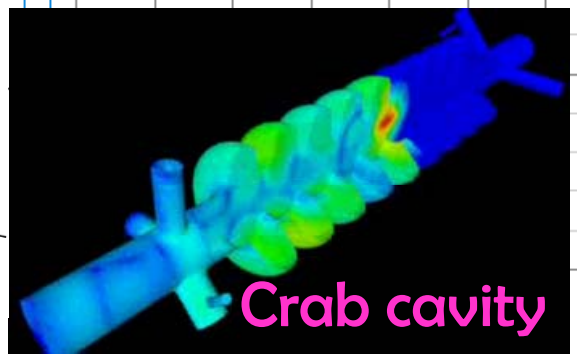
Muon wall

Main dump

Extraction



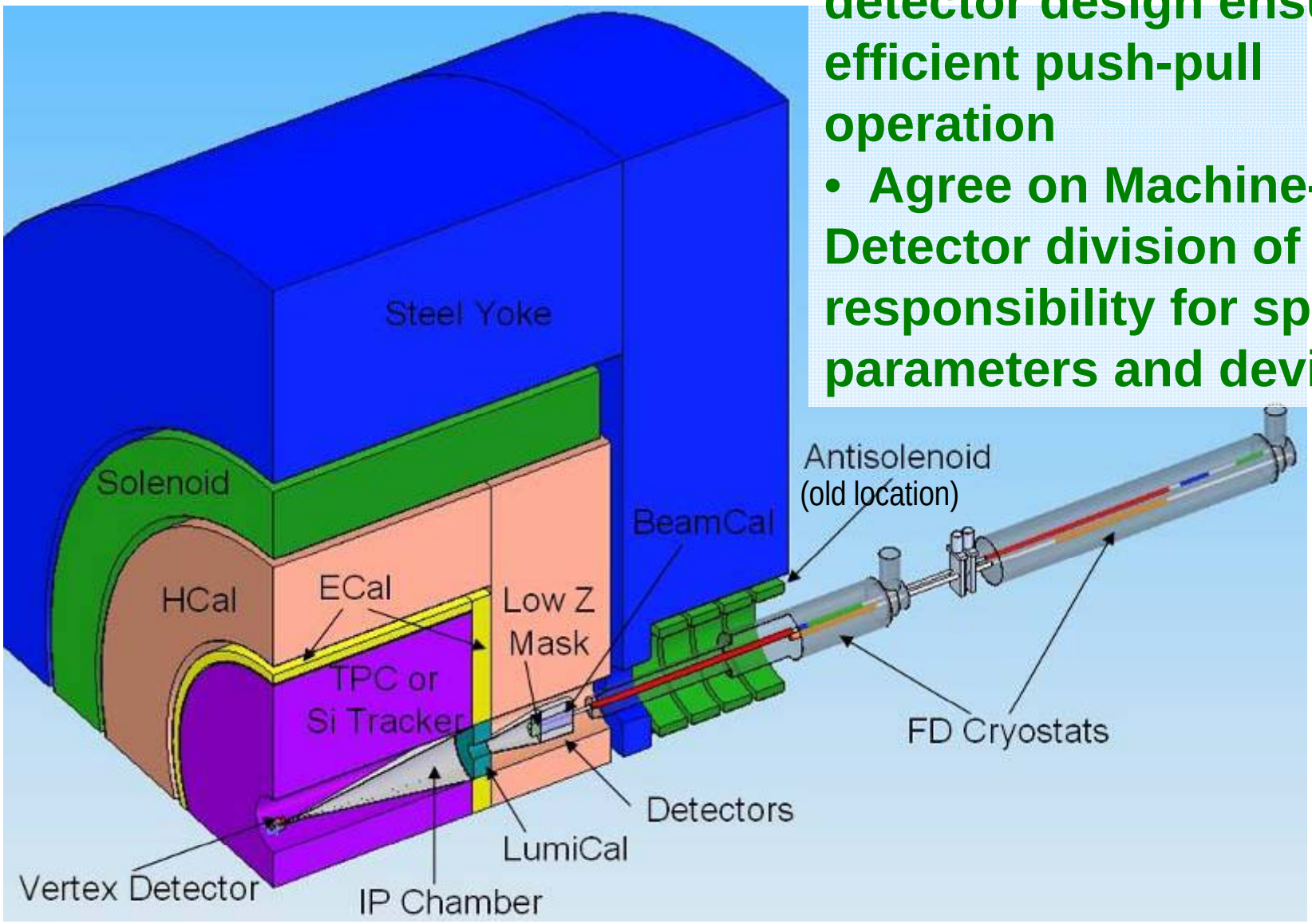
Final Doublet



IR integration

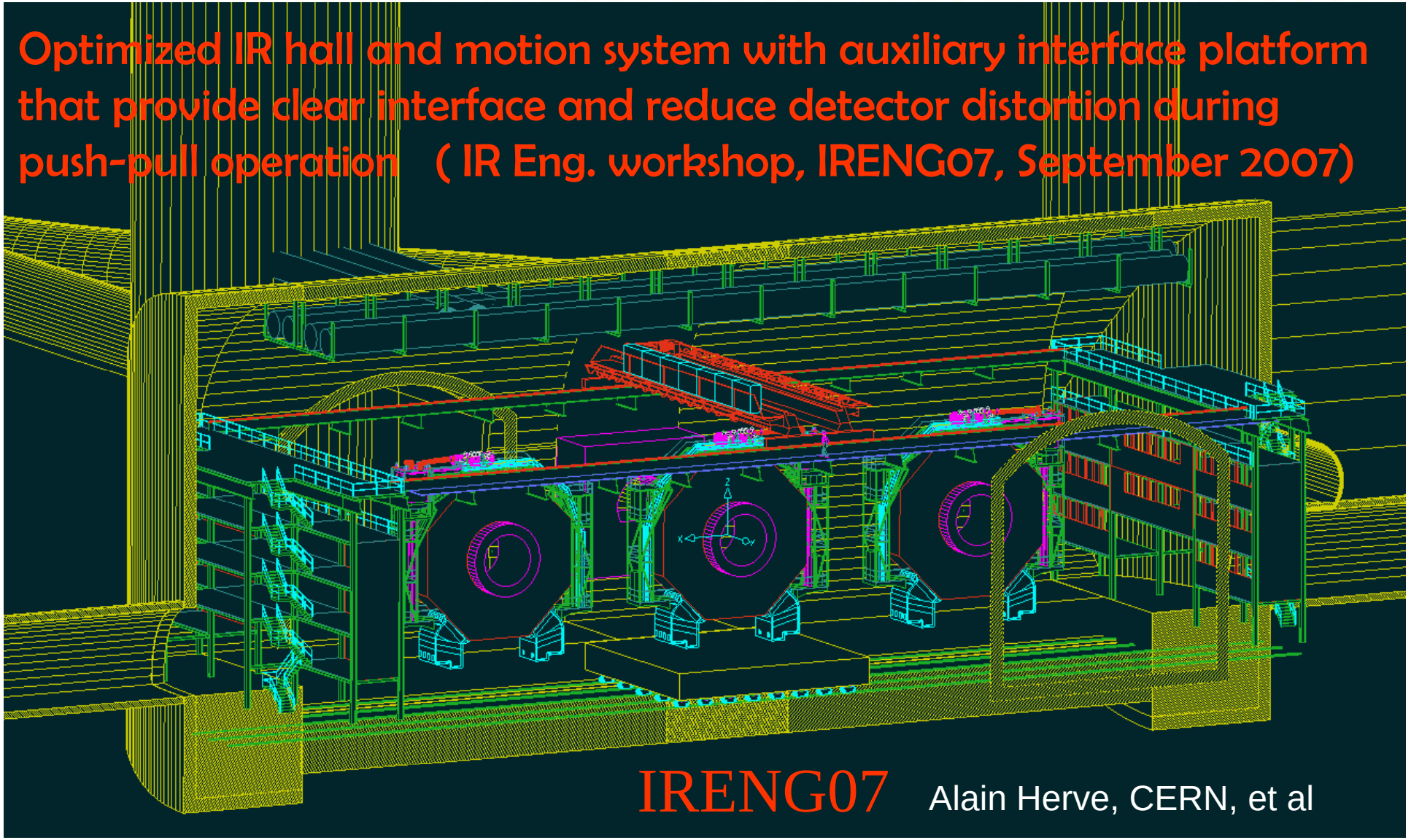
Challenges:

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

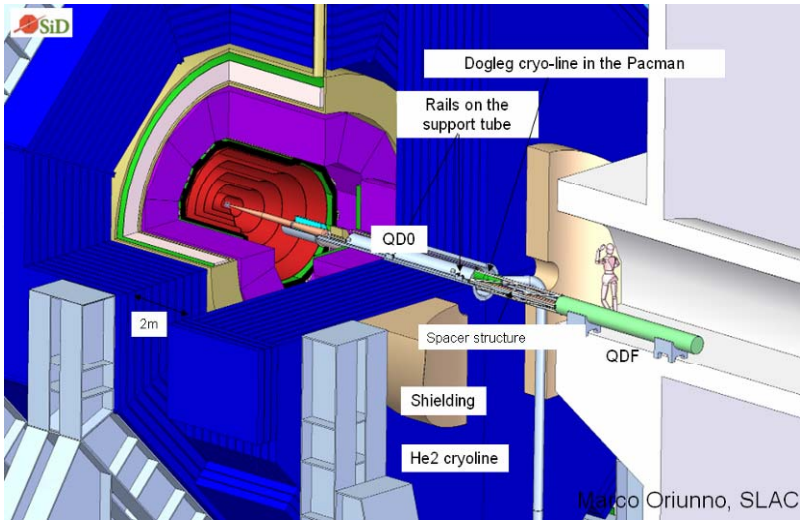


Optimization of Push-Pull design

Optimized IR hall and motion system with auxiliary interface platform that provide clear interface and reduce detector distortion during push-pull operation (IR Eng. workshop, IRENG07, September 2007)



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

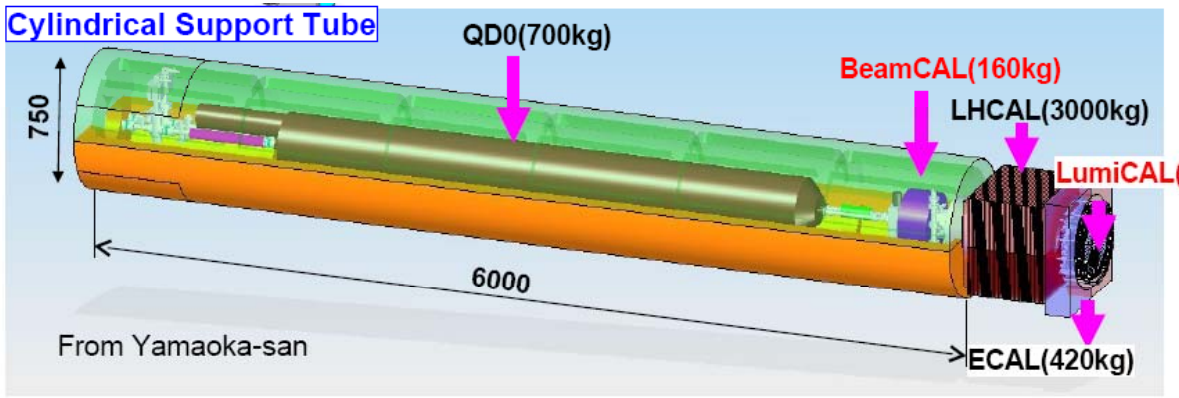
Two experimental detectors working in a push-pull mode has been considered for the Interaction Region of the International Linear Collider [1]. The push-pull mode of operation sets specific requirements and challenges for many systems of detector and machine, in particular for

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.

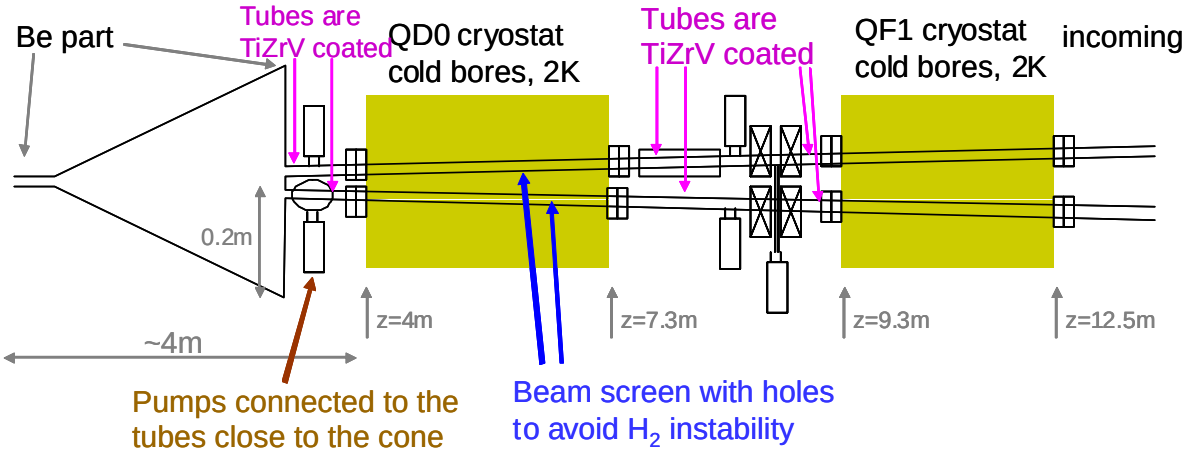
The range of detector sizes considered in the design

http://accelconf.web.cern.ch/accelconf/e08/papers/mopp031.pdf

Hot MDI issues, examples



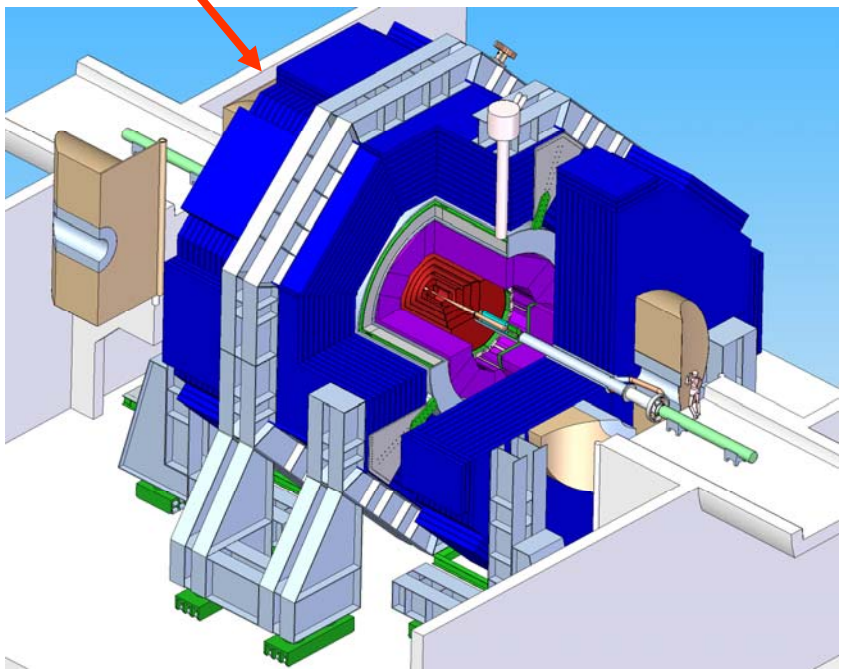
- < 50nm for QD0 stability
- compact movers for QD0
- support ~3t LHCAL mass such that it does not adversely affect the QD0 dynamics

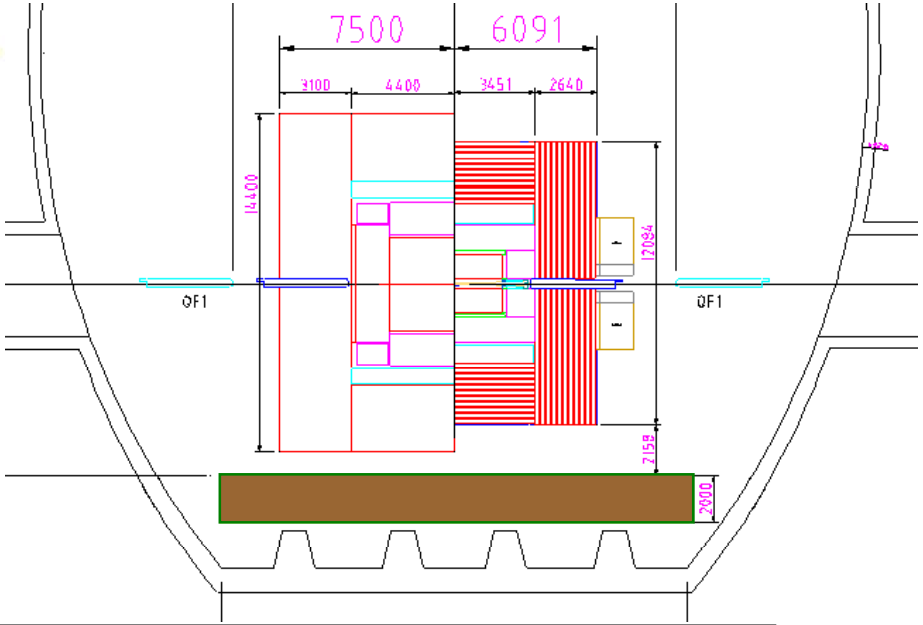


- May need pump close to IP
- Do not rely on QD0 cold bore cryo-pumping
- High Order Modes
- Support and alignment of IR chamber and VX
- Assembly, flanges...

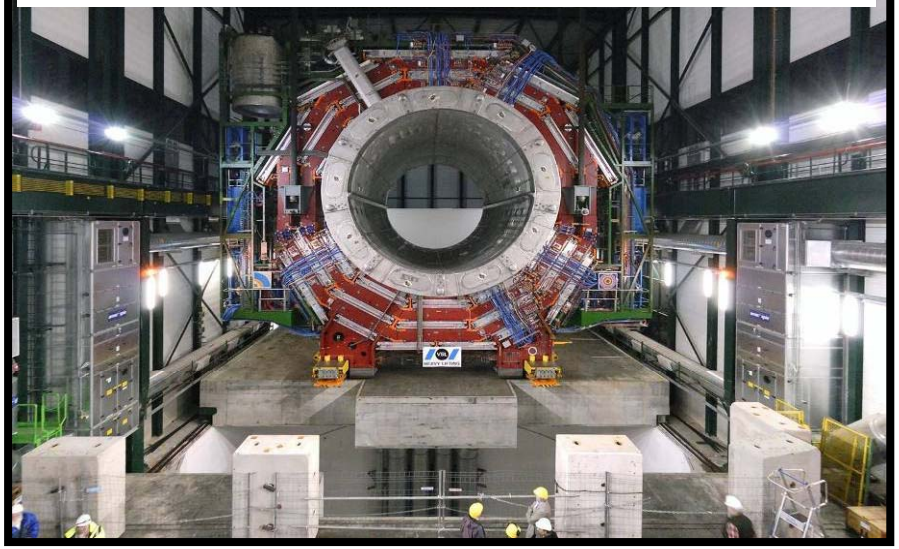
Hot MDI issues, examples

Detector motion system with
or without an intermediate platform





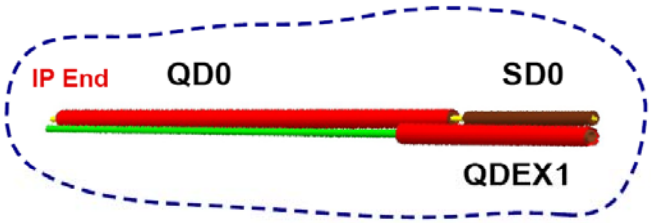
CMS platform – proof of principle for ILC



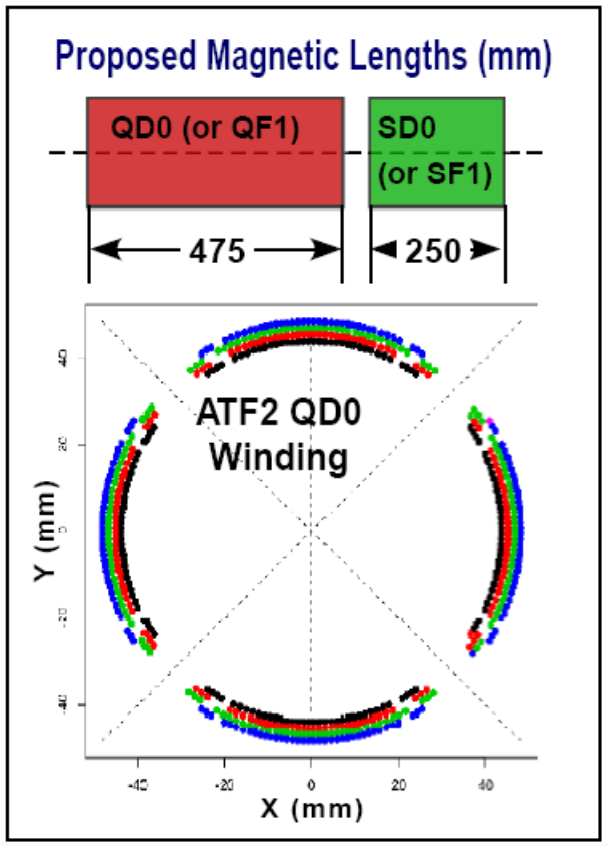
- Working assumption: use platform
- As detector design develops, a feasible and cost effective solution without a platform might be found

SC FD modified plans and ATF2 tests

QD0 Cryostat Design for L* = 4.5 m.



Earlier plan was to prototype ILC-like QD0 magnet with cryostat & study its stability

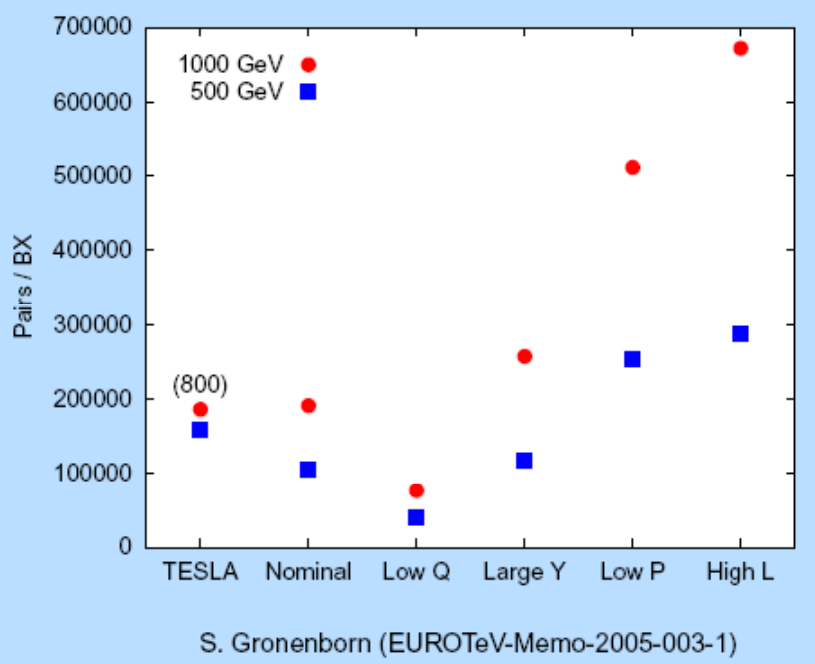


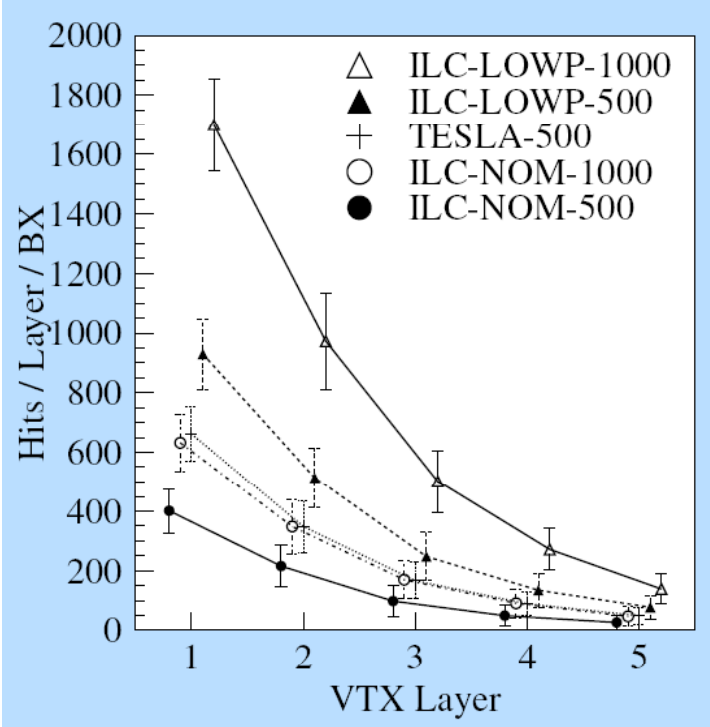
- In TDP, has adjusted the plans for SC FD prototype at BNL
  - reduce efforts on ILC-like FD prototype; make only long cold mass and perform its field & stability tests
  - enhance efforts on ILC-technology-like SC Final Doublet for ATF2 upgrade

- Only produce one quadrupole/sextupole magnet combination (in common cryostat).
- No self-shielding or anti-solenoid (simple).
- KEK Cryogenic system (major challenge).
- 50 mm aperture but with a warm bore (i.e. optimize to limit cold mass heat leak).
- Minimum degrees of freedom (correctors).
- Found it easy to match corrector coils and main coil magnetic lengths.

Support search for optimal IP parameters for min machine

- The "low power" option may be a **machine** "cost saving" set
- The RDR "Low P" is not a favorite set for detectors:

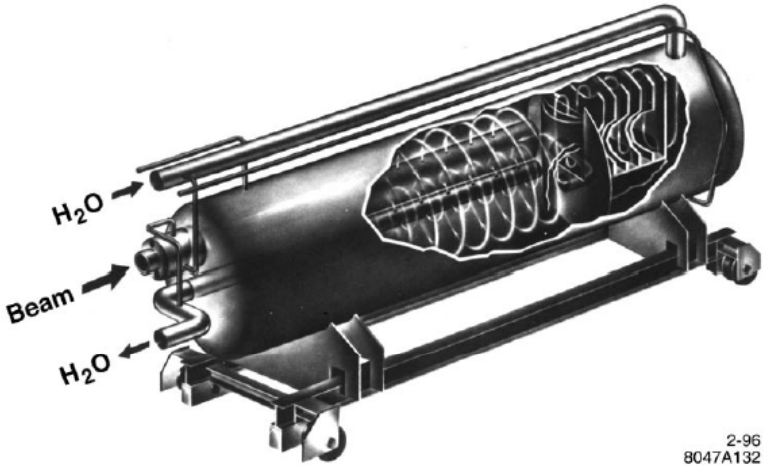




- Improved version of Low Power may require tighter IP focusing, and use of "travelling focus" [V.Balakin, 1990]

Beam dump design

Beam dump is MDI issue via neutrons coming back to IP which affect lifetime of VX detector



New collaboration with BARC, India, on 18MW beam dump design

SLAC/BARC critical expertise for beam dump project:

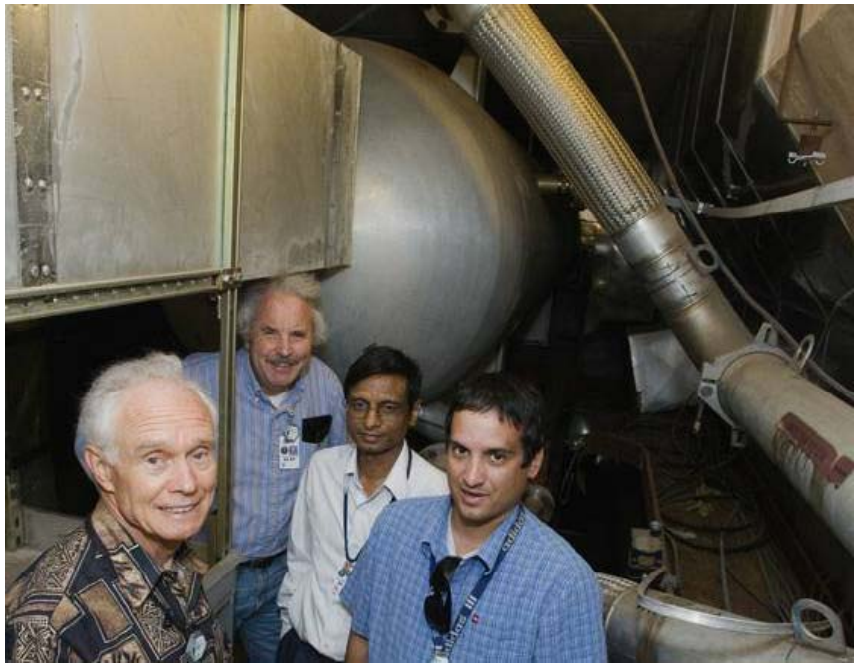
Satyamurthy Polepalle - expert in CFD and thermal hydraulic analysis with numerous successful projects in nuclear physics and power; large technical resources at BARC.

Dieter Walz - expert in beam dump design, materials performance and engineering for particle accelerator applications.

SLAC-BARC Dump Group

J. Amann, R. Arnold, D. Walz
Stanford Linear Accelerator Center
Stanford CA

P. Satyamurthy, S.Pal, P. Rai, V. Tiwari
Bhabha Atomic Research Centre
Mumbai, India



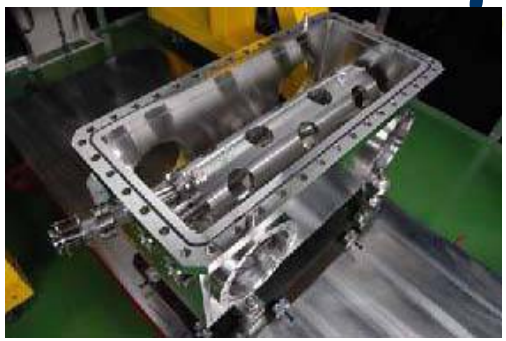
Dieter Walz, Ray Arnold, Satyamurthy Polepalle (BARC, India), John Amann, at SLAC beam dump area (February 2008)

R&D plan for γγ

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

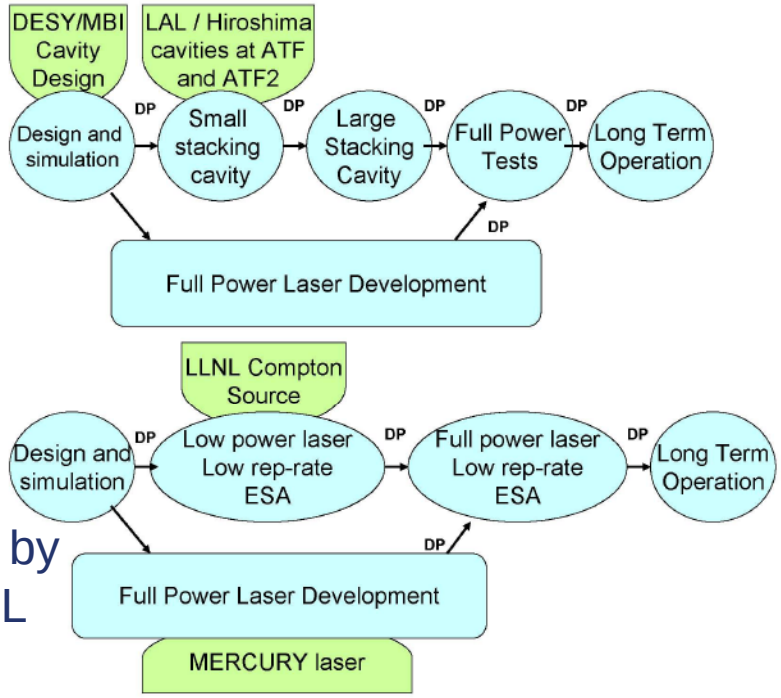
Photon Collider Technology Readiness and Near Term Plans

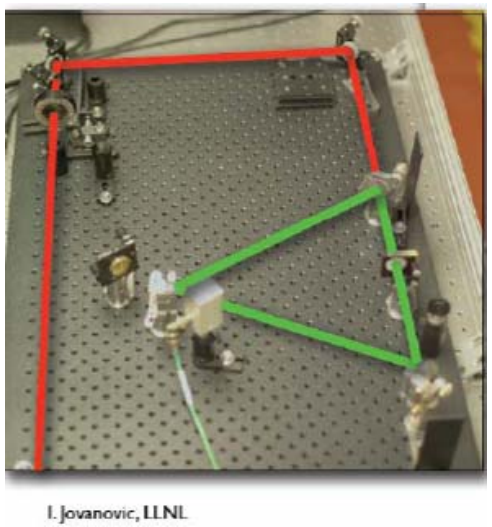
Gronberg, J. ; Omori, T. ; Seryi, A. ; Takahashi, T. ; Telnov, V. ; Urakawa, J. ; Variola, A. ; Woods, M. ; Zomer, F.



Pulse Stacking Cavity
(R&D for Positron source KEK-LAL-Hiroshima-Waseda-Kyoto-IHEP)
enhancement: 300-1000,
tight motion tolerances

- Developed R&D plan based on step-wise approach and large natural synergies with e+ laser cavities R&D





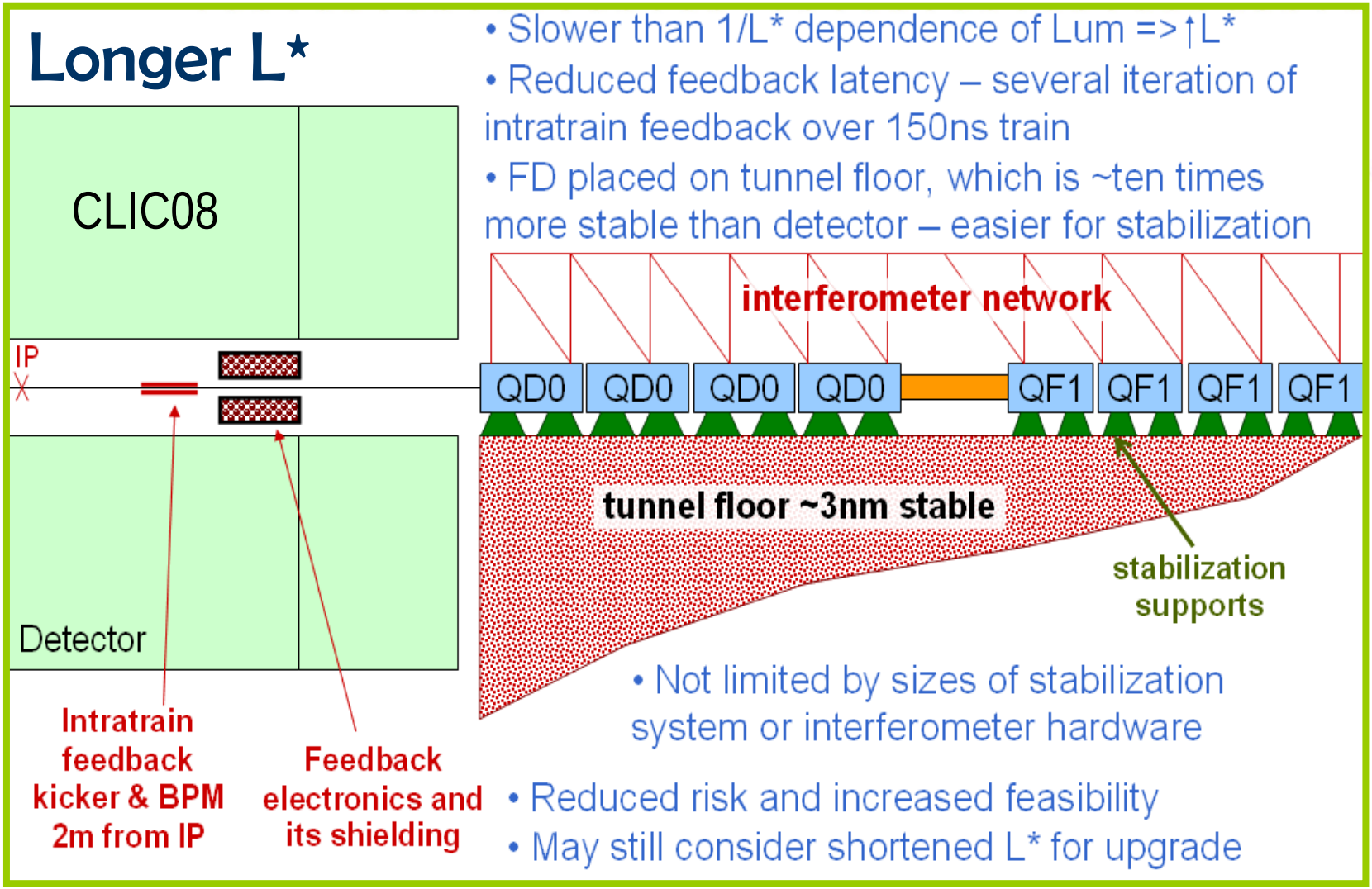
RING (Recirculation Injection by Nonlinear Gating) Cavity LLNL
recirculation of a pulse ~50 times
compensation of circulated pulse decay

Exploration of ideas & tests for more performing machine

- Minimal machine may require tighter focusing at IP
- CERN/CLIC colleagues suggested to study squeezed y-beta* at ATF2 (0.025 mm instead of 0.1 mm nominal)
- Squeezed beta* study at ATF2 is one of example of strong synergy and mutual benefits of ILC-CLIC collaboration
- Such study may support
  - Test of high chromaticity FF, as in CLIC FF design
  - Smaller β^* for "New Low P" parameters of ILC
  - Lengthening L* for easier MDI
- Also evaluating if can test travelling focus at ATF2 (single beam)

- Exploring Volume Reflection radiation in bent crystals as a phenomena to improve the collimation system of linear collider

Longer L*



- Study prompted by the CLIC FD stability challenge (< 0.2nm)
- Double the L* and place FD on a stable floor
- Initial study show that L*=8m optics is possible (CLIC08 workshop)
  - » Some (maybe tolerable) impact on luminosity is still unavoidable

Conclusion

- The BDS group, in TDP phase, will focus on several key areas
- Planned work expected to make significant contribution to TDP efforts on reduction of cost, risk and increase of machine performance
- Discussion, how to make our work more efficient, supposed to follow...