BDS plans for EDR
DRAFT

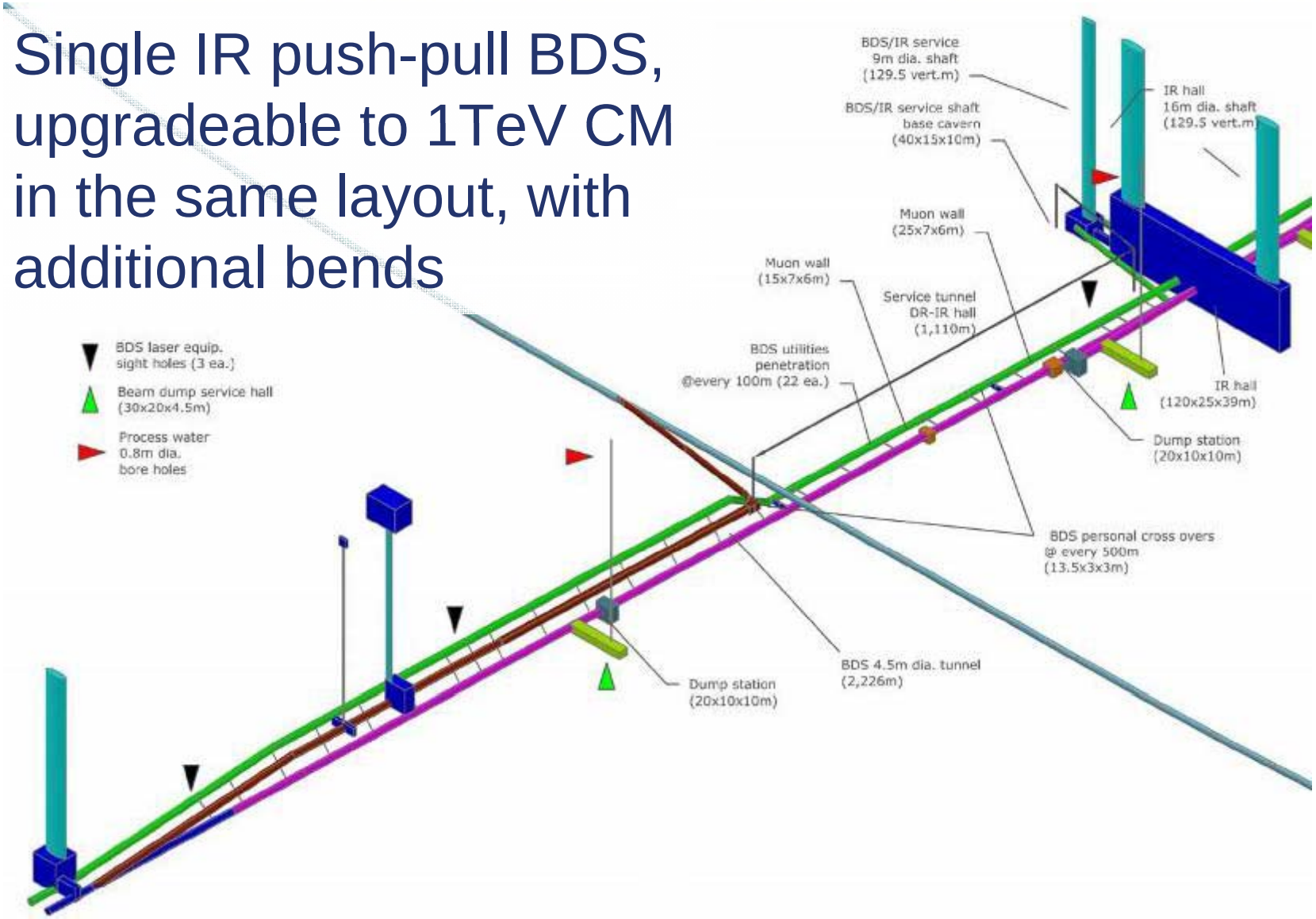
April 18, 2007

Plan of the talk

- Design features (dispersed throughout the talk)
- Strategic planning for EDR
  - **overall assumptions on schedule and EDR goal**
  - **S4 task force planning, expanded meetings**
  - **S4 conclusions and recommendation**
  - **taking into account ongoing BDS risk analysis**
- Ongoing detailed planning Work packages & resources
  - **to be prepared for May GDE/LCWS meeting**

Design

- Single IR push-pull BDS, upgradeable to 1TeV CM in the same layout, with additional bends



Schedule & EDR assumptions

- Assume *technically limited* schedule (~3year for EDR, two years for Approval phase and 7 years for construction)

- EDR planning – focus on cost uncertainty reduction, & performance uncertainty reduction, i.e. :
  - **design of systems at appropriate level of details**
  - **build and test critical prototypes to ensure performance**

- For EDR, can't & don't need to complete all the work & tests to 2010. Plan to continue optimization and final design after EDR and during earlier years of construction
  - **A tentative table is shown for discussion on next pages**

S4 strategic planning for EDR

- S4 task force went through a series of *expanded* meetings, with participation of leaders or representatives of “work packages” or of collaborations working on sub-systems

- Goal – to discuss plans for EDR and beyond, to help GDE and funding agencies, via S4 and Global R&D board, to focus resources in most suitable way

S4 meetings in 2007 (*expanded*)

- S4 planning – Jan 11
- S4 planning – Feb 26
- *Americas plan in 07-09, overview – Feb 26*
- *Interaction region work, magnets & stability – Mar 5*
- *Beam dump and collimation work – Mar 12*
- *Crab cavity work – Mar 19*
- S4 conclusions – Mar 26
- S4 conclusions, risk & WP – Apr 1
- *ATF2 work – Apr 10*
- *IR alternatives – Apr 17*

agendas: http://ilcagenda.linearcollider.org/categoryDisplay.py?categId=80 access “s4meeting”

S4 outcome

- List of things to focus in EDR
- Overall schedule
- Recommendations for particular Work Packages and for GDE

- Real budget situation is taken into account

- BDS risk cost analysis is taken into account inasmuch as it is relevant for EDR planning

Focus of EDR work (*hardware*)

- Integrated design of IR, development of IR superconducting magnets, *build engineering prototype of FD magnets*, design study to ensure IR mechanical stability, design of push-pull arrangements
- development of crab cavity systems, *test phase control system with two single cell cavities, build single cavity*
- design, *construction, commissioning and operation of ATF2 test facility*
- development of laser wires for beam diagnostics, *prototype laser wires at ATF2*
- development of intra-train feedback, *prototype at ATF2*
- development of collimator design, *verification of collimation wake-fields with measurements and verification of collimation beam damage*
- development of beam dump design and *study of beam dump window survivability;*
- development and *tests of MDI type hardware such as energy spectrometers*;
- and other, as shown in materials referenced in the appendices.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	EDR			Approval		Construction							Commiss.
				LHC physics									
				total length frozen			tunnel layout frozen				tunnels ready for install-n		
							optics layout frozen		optics details frozen				
Beam dumps	beam dump conceptual design and critical tests			pre approval		beam dump final engineering			b.dump design frozen	beam dump construction		beam dump installed	
crab cavity	crab cavity design work & developments and tests of conceptual phase control system; cavity fabrication; conceptual cryostat design; LLRF develop and test with single cells			design of cryostat; cavity integration; beam test of one cavity		beam tests of two cavities		final engineering		production		installed	
ATF2	ATF2 construction and installation. Start of commissioning		Commissioning	Beam size and optics results	Beam stability results	Second phase, e.g. SC final doublet; smaller emittance & beam size		Instrumentation developments and tests at beamline					
Final Doublet	Engineering design; full length prototype; stability design study and initial stability tests			Stability tests & design optimization		final design		production		lab tests	installation and pre-commissioning		
Detectors	Conceptual design; selection of two concepts; continue design			Design optimization		final design and start of production		Construct, assemble and pre-commission on surface				Lower down & commiss.	
IR integrated	Conceptual eng. design of IR vaccum chambers; supports; pacman and moving shielding; cryogenic; service platform; detector moving system; cranes; etc.			Detailed eng. design of integrated IR with finalized choice of two detectors for final design		final design and start of production		production			installation and pre-commissioning		
Magnets	Optimization of number of styles; conceptual design of most magnets; definition of interfaces; Detailed design of low field and other special magnets; Vibration -wise design			Design and cost optimization; layouts with real space allocation, and detailed interfaces.		final design & needed prototypes		production			installation and pre-commissioning		
Collimation	Tests of collimation wakefields and beam damage tests; conceptual eng. design			Detailed eng. design; optimization & integration into beamline		final design & pre-production prototypes		production			installation and pre-commissioning		
Instrumentation	Develop laser wires; test feedback BPMs with secondary beam; conceptual eng. design			Detailed eng. design; optimization & integration into beamline		final design & pre-production prototypes		production			installation and pre-commissioning		
Vacuum systen	Physics and conceptual eng. design. Detailed design of IR vacuum chamber.			Detailed eng. design; optimization & integration of beamlines		final design		production			installation		

Overall tentative schedule to get general idea. Detailed tables for several systems will be shown

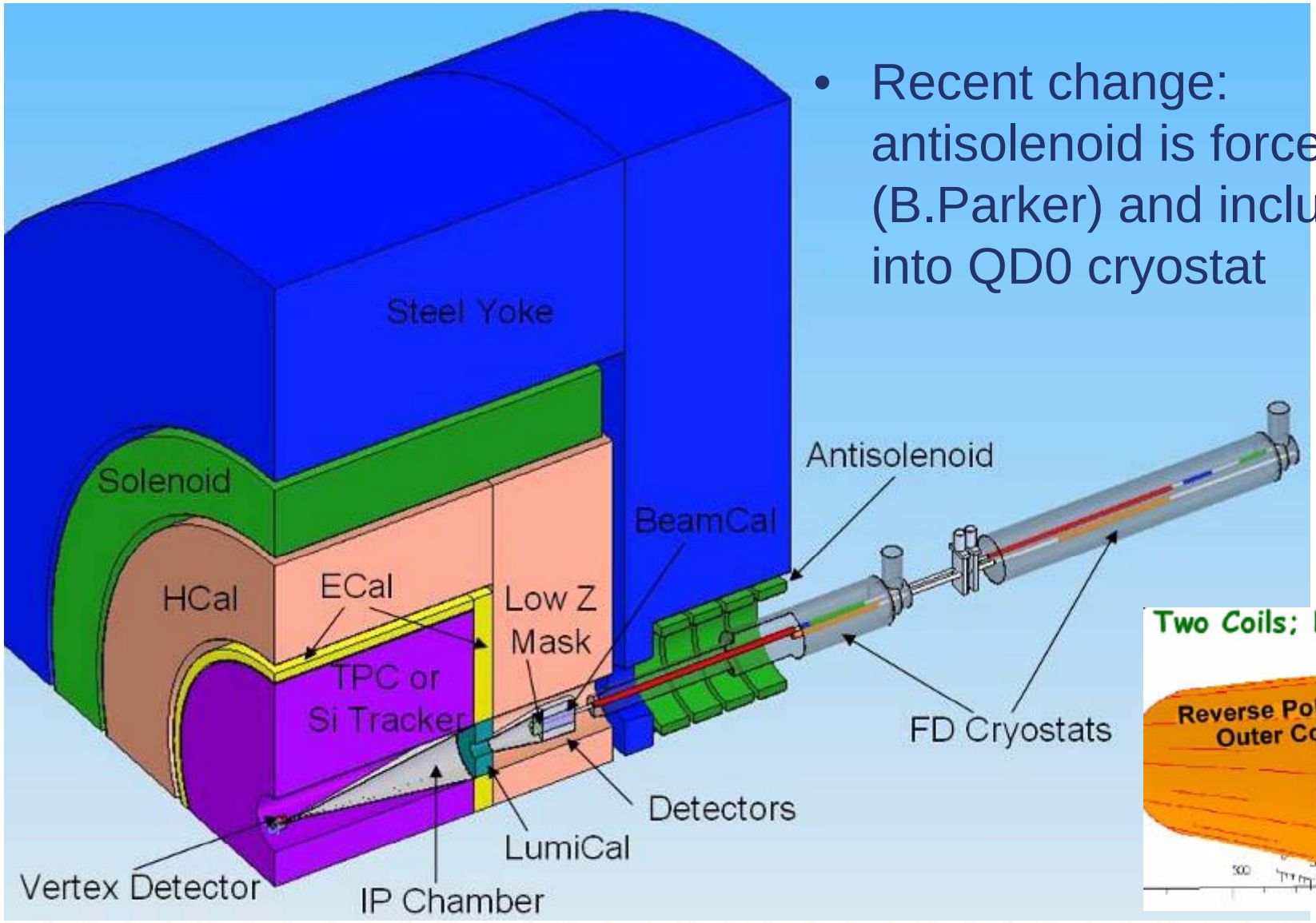
FD magnets & IR integration

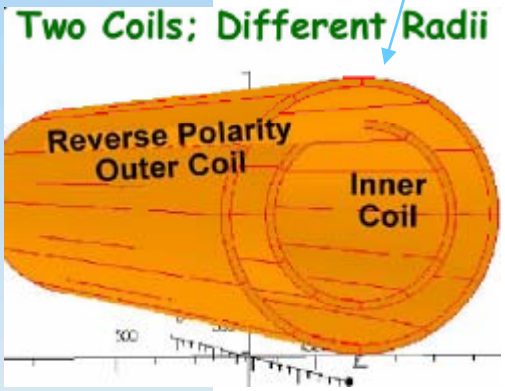
	2007	2008	2009	2010	2011	2012	2013
	EDR			Approval		Construction	
DEVELOP ENG. PROTOTYPE OF FD MAGNETS							
Design & build long coil tooling							
Do long coil winding tests							
Perform coil quench threshold tests (non-ILC funds)							
Prototype magnet design							
Design He heat exchanger / lead assembly							
Build & vert. cold test prototype QD0/SD0 coil							
Design magnet tooling							
Buy magnet parts							
Fabricate/Build magnet tooling							
Build insertion region cryostat							
Buy He heat exchanger parts							
Build He heat exchanger / lead assembly							
Buy vibration hardware based on earlier results							
Magnet Assembly							
Perform horizontal cold test							
Do vibration msmts on magnet							
Update reference design as needed based on results							
Final design							
Production							

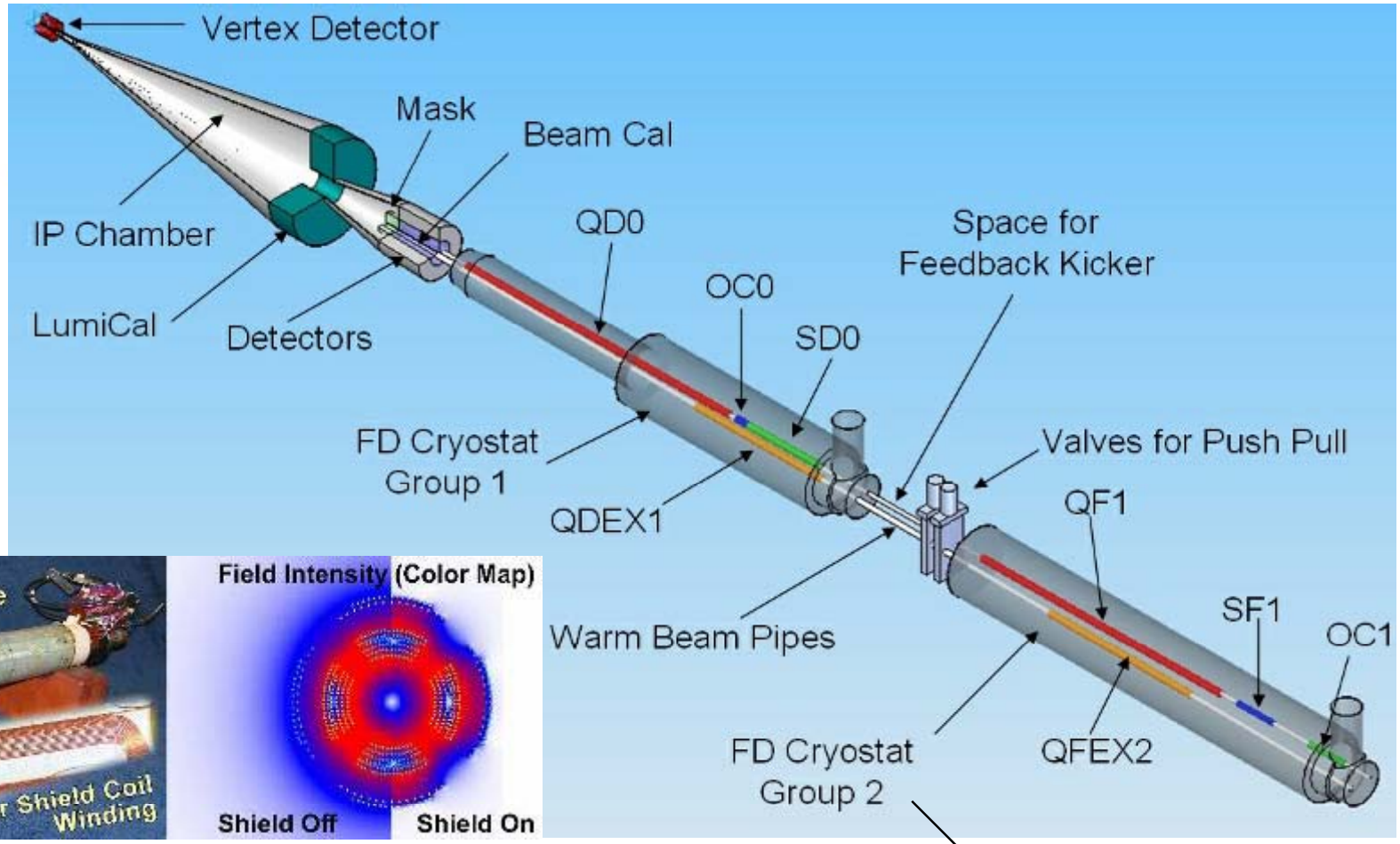
- Focusing on prototype, delay vibration study until prototype is built
- Concern that funding pushes prototype after EDR and not sufficient funding to cover increase scope of work with push-pull IR => asking GDE for additional resourses

Push-pull IR

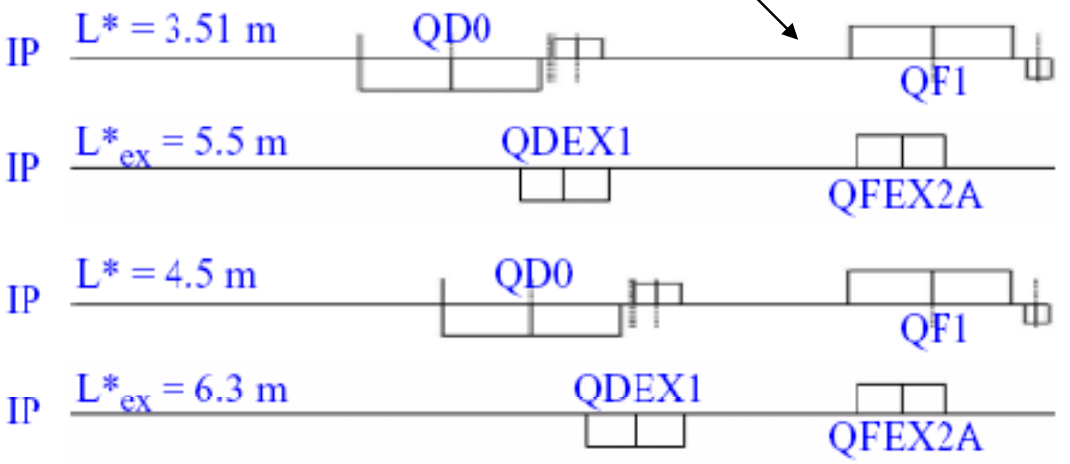
- Recent change: antisolenoid is force-neutral (B.Parker) and included into QD0 cryostat



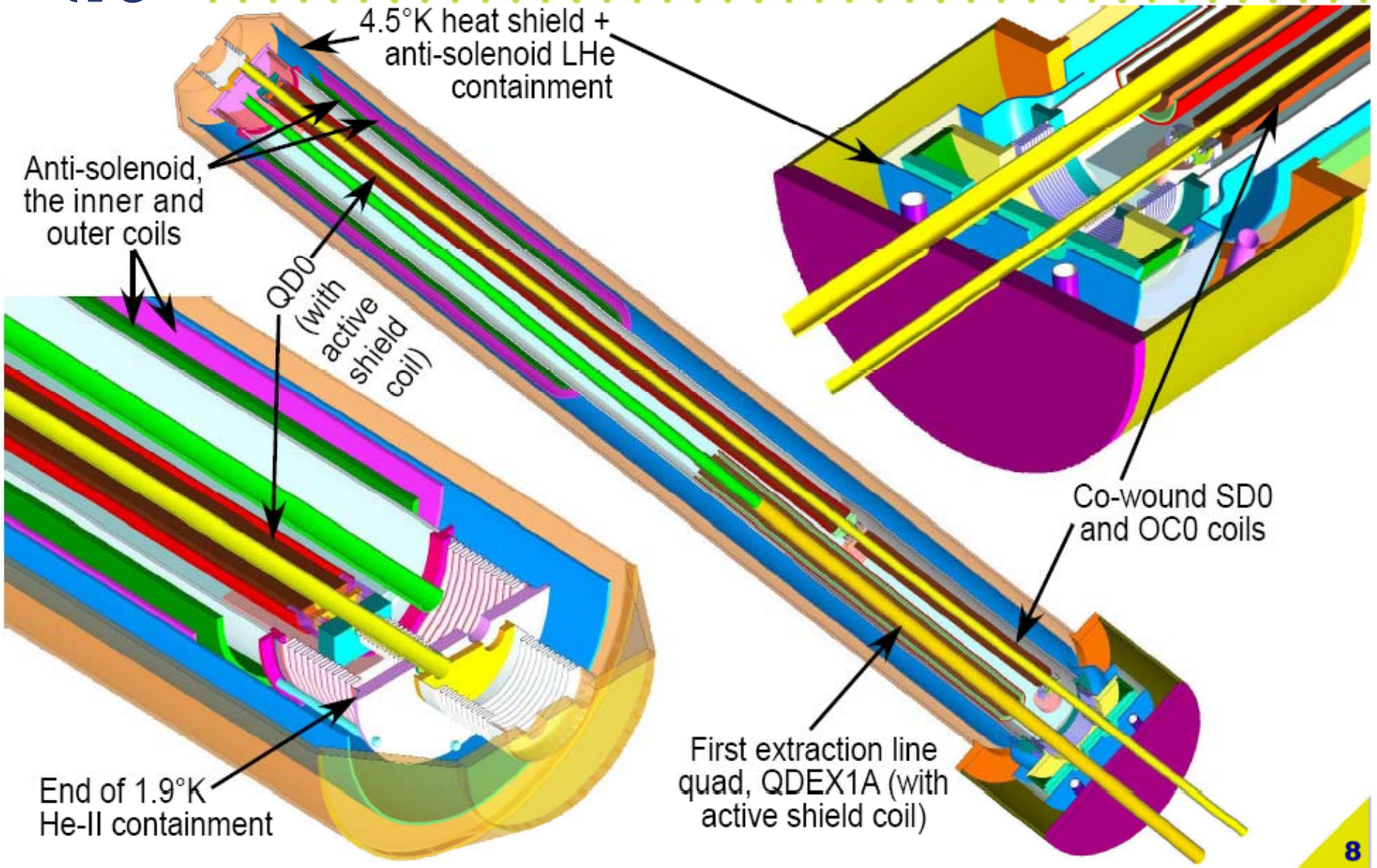




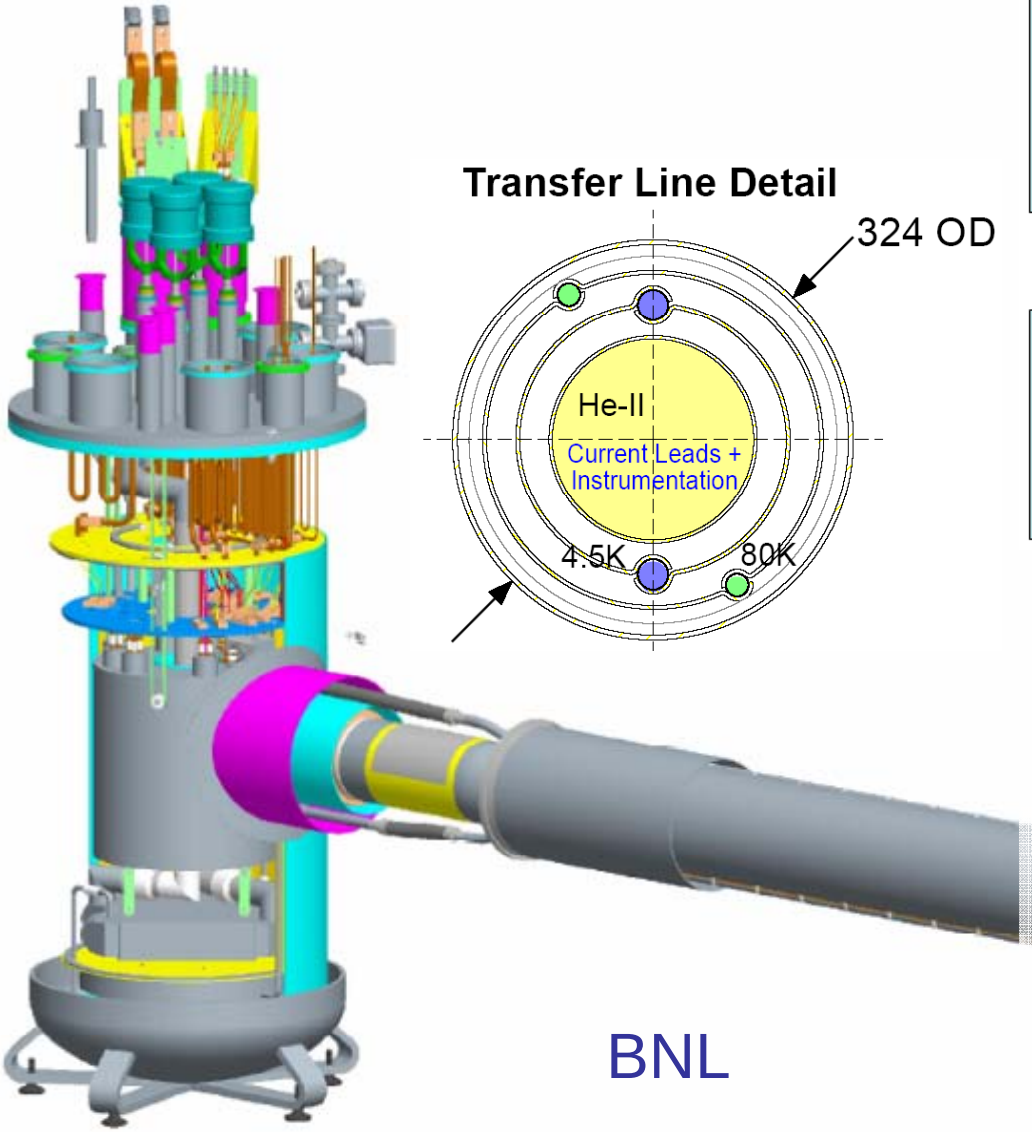
Study versions of different L* for different detectors.
QD0 cryostat different & move with detector, QF1 cryostat fixed.

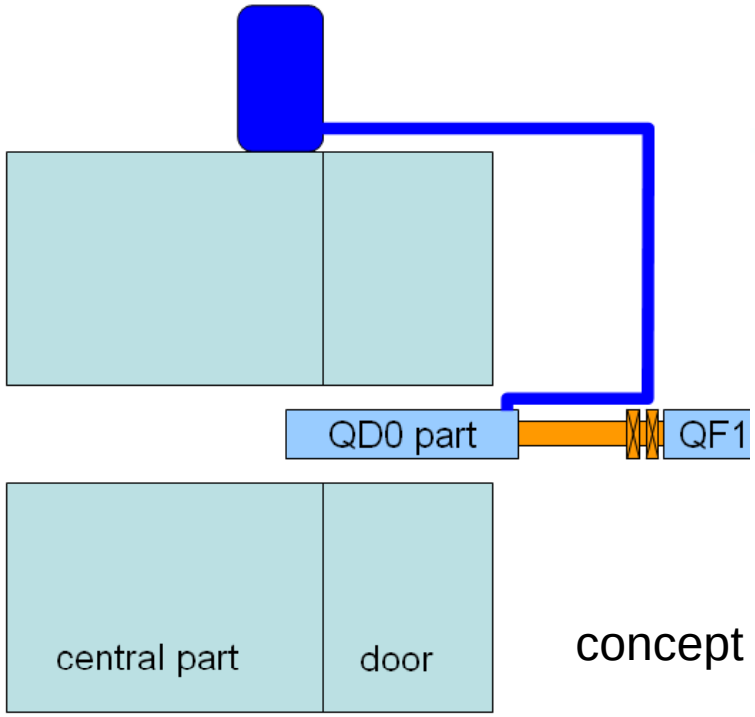


FD (QD0/SD0) design, BNL



Service cryostat





concept

Design constraints: do not disconnect cryo line in push-pull operation and place it so that it does not interfere with detector door opening on the beamline

BNL

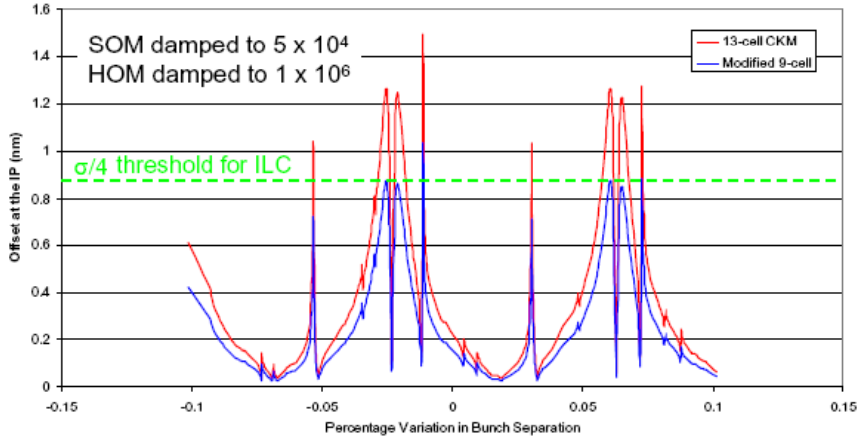
Crab cavity

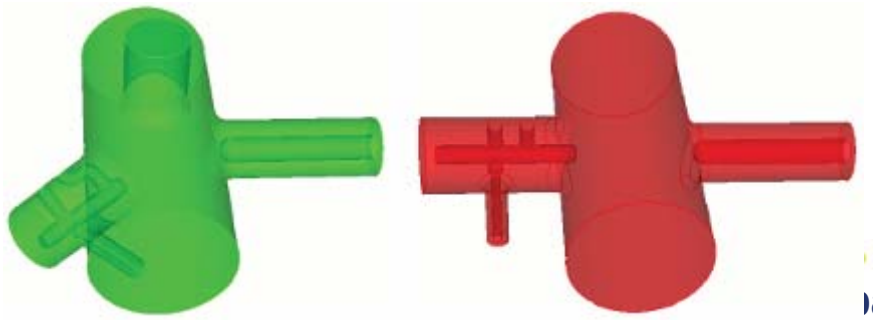
	2007	2008	2009	2010	2011	2012	2013
	EDR			Approval		Construction	
DEVELOP CRAB CAVITY SYSTEM							
Design of cavity & couplers							
Develop conceptual phase control system							
Build two single cells for phase control tests							
Tests concept. phase control system w.2 single cells							
Cavity fabrication							
Cavity tests in vertical dewar							
adjustment of CKM cryostat for crab cavity tests							
buld RF power system							
cavity integration into cryostat							
cavity integration into ILCTA beamline							
beam test of one cavity							
design of optimized cryostat							
build optimized cryostat							
build second crab cavity							
beam test of two cavities							
final engineering							

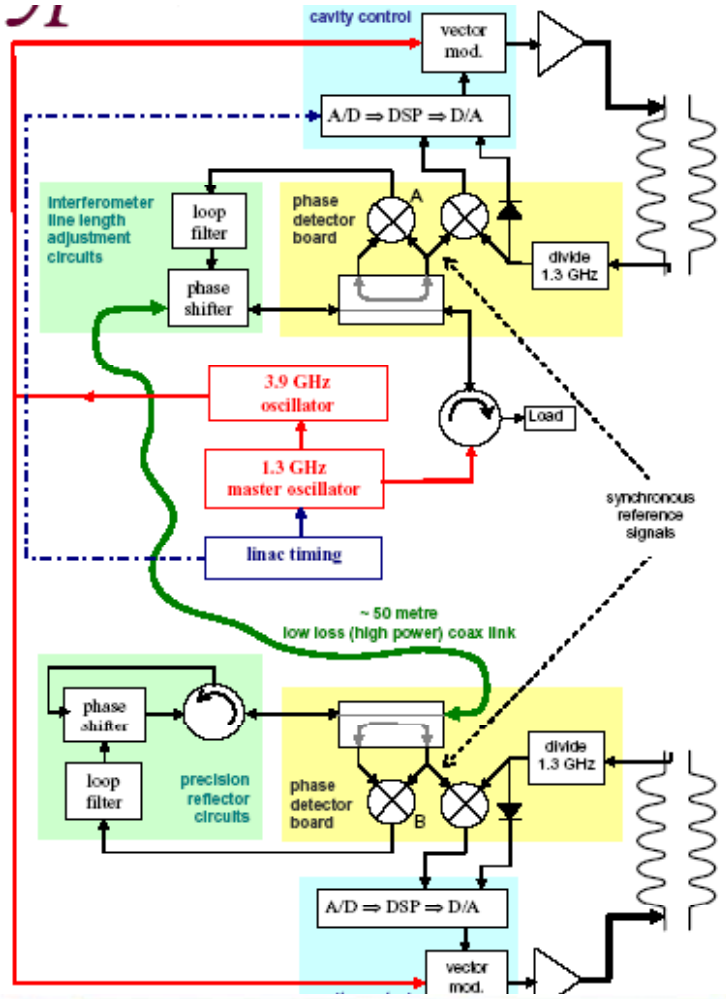
- Assume additional support for SLAC ACD in 2007=>
- Assumes that funding in UK go as presently outlined (not a guarantee)
- Success oriented plan & relies on synergic developments (3rd acc cav., ERLP, …)

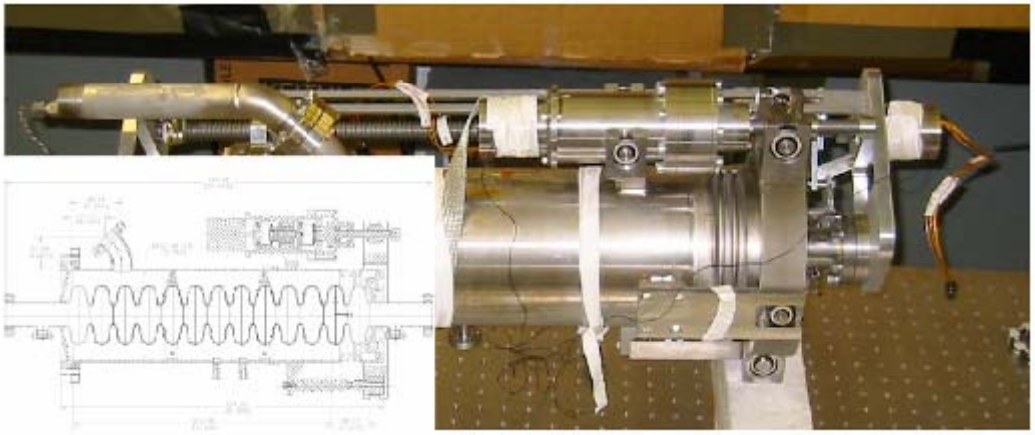
ILC Crab Cavity Collaboration

- **Cockcroft Institute :**
  - Graeme Burt (Lancaster University)
  - Richard Carter (Lancaster University)
  - Amos Dexter (Lancaster University)
  - Philippe Goudket (ASTeC)
  - Roger Jones (Manchester University)
  - Alex Kalinin (ASTeC)
  - Lili Ma (ASTeC)
  - Peter McIntosh (ASTeC)
  - Imran Tahir (Lancaster University)
- **FNAL**
  - Leo Bellantoni
  - Mike Church
  - Tim Koeth
  - Timergali Khabiboulline
  - Sergei Nagaitsev
  - Nikolay Solyak
- **SLAC**
  - Chris Adolphson
  - Kwok Ko
  - Zenghai Li
  - Cho Ng
  - Andrei Seryi
  - Liling Xiao









Beam dumps

	2007	2008	2009	2010	2011	2012	2013	2014
	EDR			Approval		Construction		
DEVELOP BEAM DUMP								
Window material study & design dump widow								
Design dump widow remote replacement mechanism								
Eng. design of beam dump rad water system								
Eng. design of beam dump shielding								
Eng. design of beam dump vessel								
Physics design of beam dump								
Prototyope beam dump window								
Irradiation tests of dump window prototype								
Pre approval								
Beam dump final engineering								
Beam dump construction								

- Most of tasks not assigned, program almost cut in UK, under funded in US, and is at risk
- S4 suggest for collaboration leaders to focus on baseline & for GDE to search for ways to augment the beam dump collaboration with additional funds and especially human resources with relevant prior experience of engineering design

Beam dump work & mitigation

- If concentrated in one place, require, for 3 years:
  - **3 mech. eng./yr + 3 des./yr +1.5 phys./yr + 1M m&s**
- Splitting in two regions add inefficiencies
- Concentrating only on BDS dumps, => *50%
- This would be ~890K$/year efforts, cannot fit now

- Suggest: try to fix 2007, with additional funds from reserve to SLAC on the level ~2-2.5FTE
- Considering: involvement new labs. E.g. discussion with TRIUMF indicated that remote handling may be designed by TRIUMF colleagues

ATF2 facility

	2007	2008	2009	2010	2011	2012	2013
	EDR			Approval		Construction	
ATF2 FACILITY							
ATF2 construction and installation							
Commissioning							
Optics and beam size study							
Beam stability study							
Possibly, SC final doublet							
Possibly, smaller DR emittance							
Instrumentation developments and tests at beamline							

- ATF2 will: prototype FF, help development tuning methods, instrumentation (laser wires, fast feedback, submicron resolution BPMs), help to learn achieving small size & stability reliably, potentially able to test stability of FD magnetic center. ATF2 is one of central elements of BDS EDR work, as it may address noticeable fraction of the BDS technical cost risk.
- S4 is concern about so far not fixed budget at KEK, which is CFS contribution of the host country, & asking GDE's assistance
- S4 is also recommending ATF2 & BDS leaders to enhance work on preparation for ATF2 integration and commissioning

ATF
Accelerator Test Facility

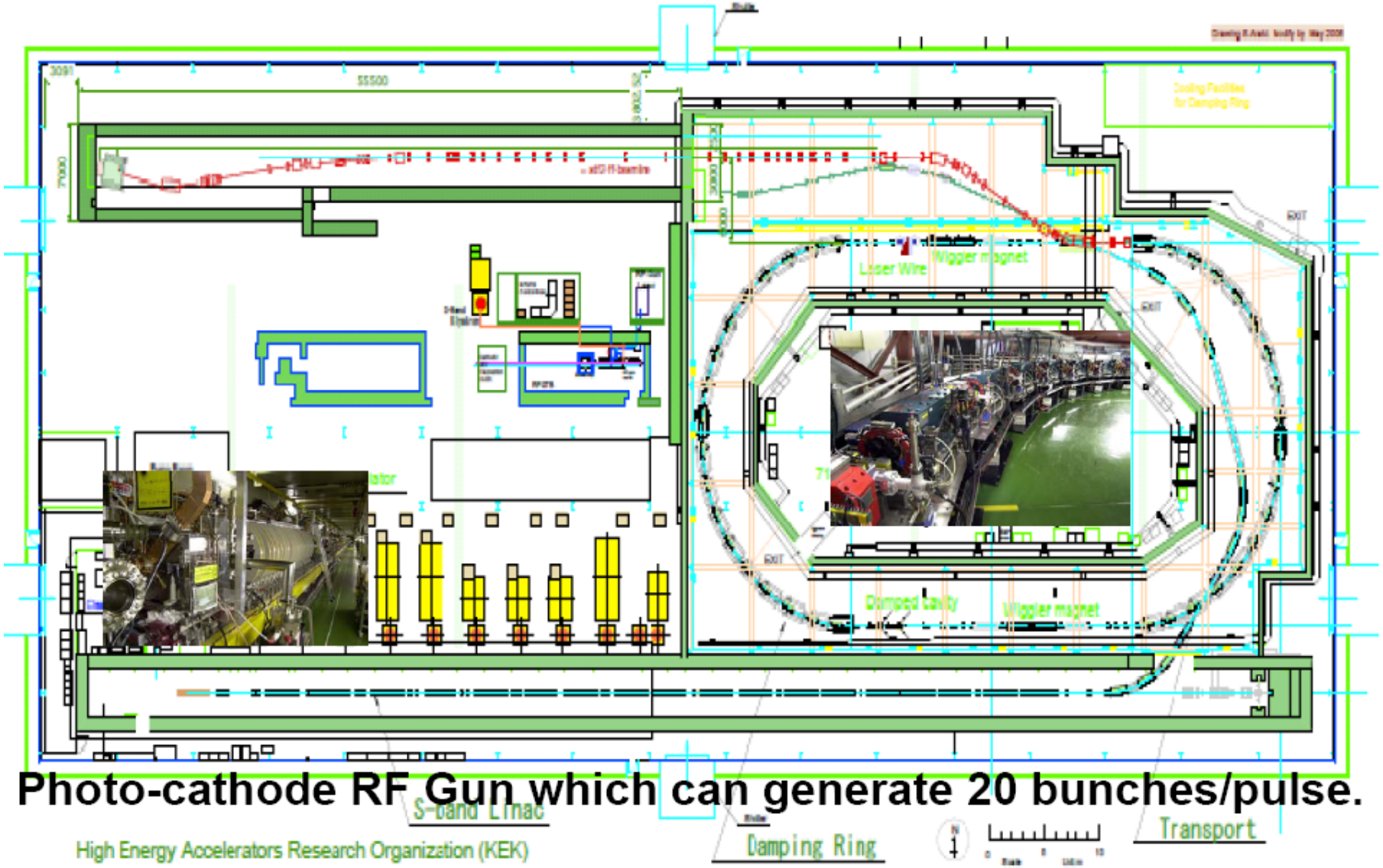


Photo-cathode RF Gun which can generate 20 bunches/pulse.

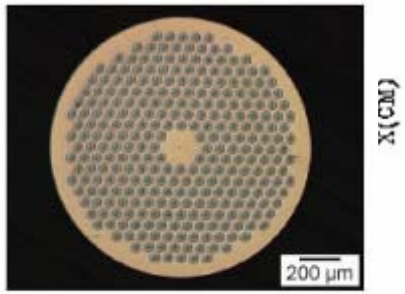
To fill in

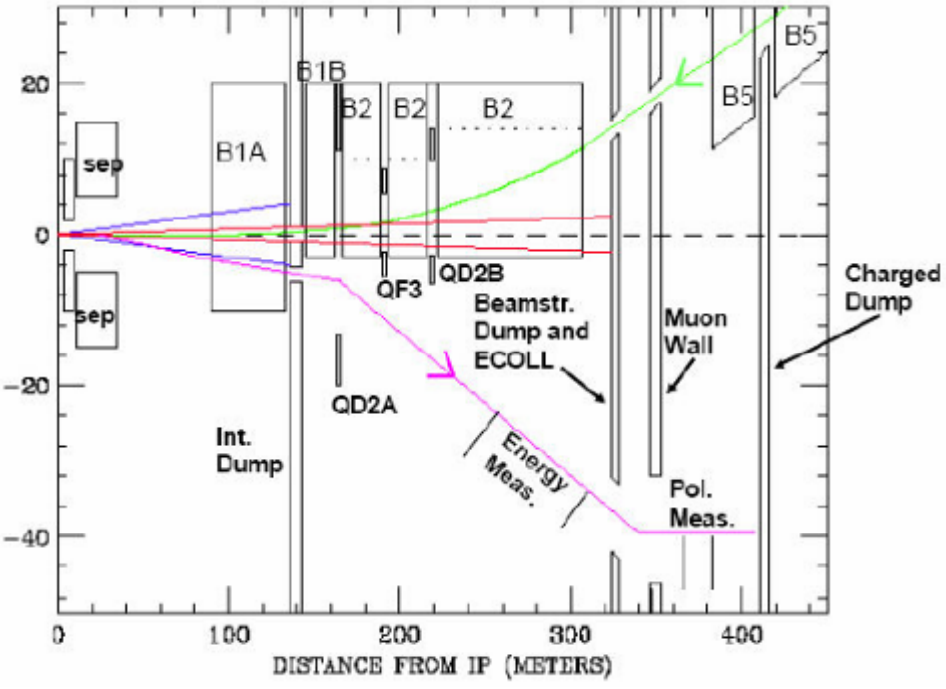
- work on design of vacuum, magnets, MDI work at ESA, etc, …

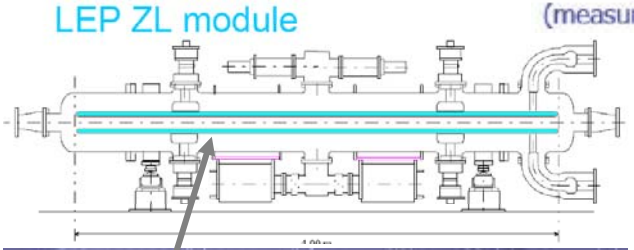
Work on IR alternatives

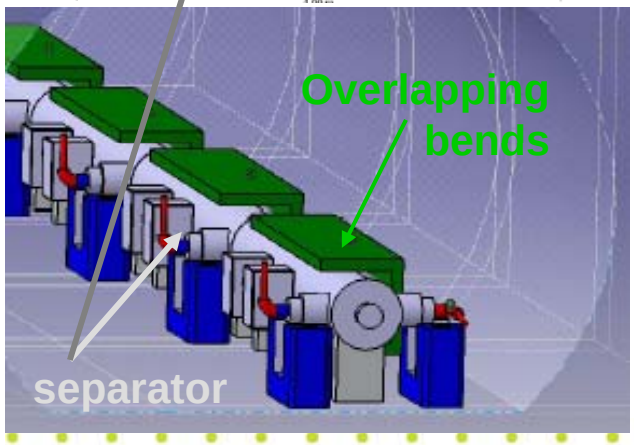
- S4 acknowledged that the optics, background and similar design work on small and zero crossing angle alternative schemes, at reasonable level, should continue; while hardware development are not requested for alternatives in EDR (there is a lot of synergy with LARP & European programs on large aperture SC magnets)

IR alternatives, 0mrad



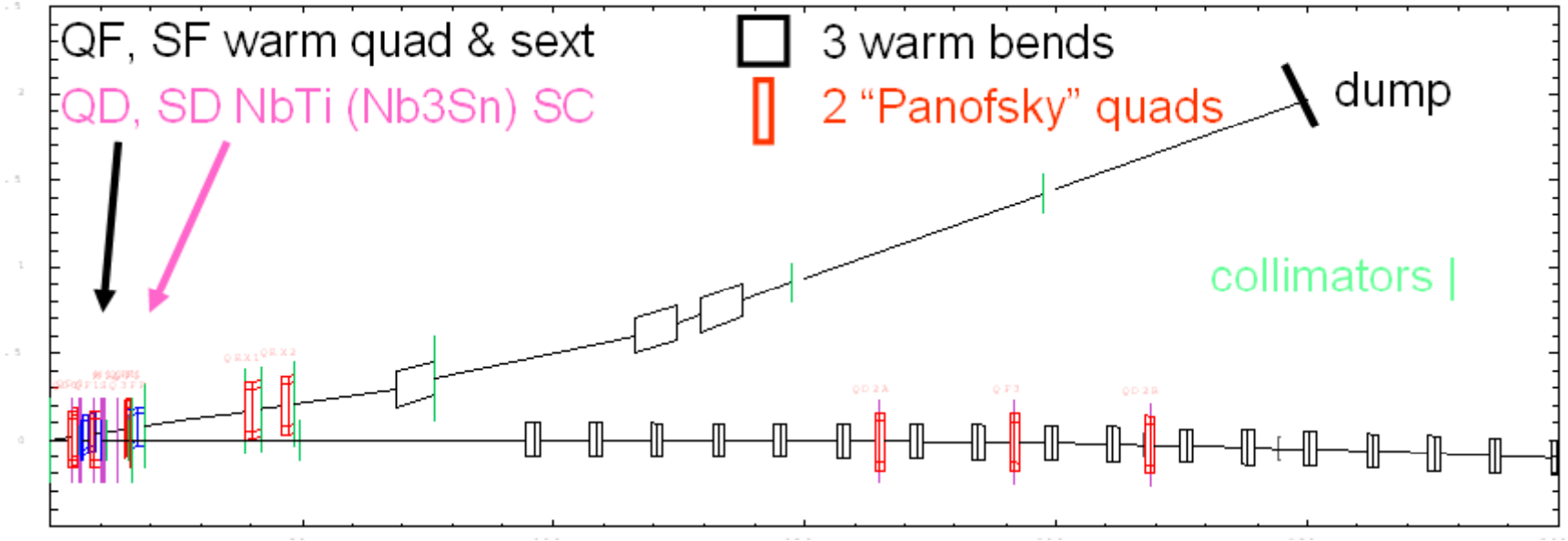






- FD: NbTi @ 500GeV CM (250T/m, 7T/bore); Nb_3Sn @ 1TeV CM (~370T/m, 10.5T/bore)
- Separator: Δ=12mm at 55m from IP (to control parasitic crossing beam-beam instability) => 2.6MV/m (±130kV over 100mm gap) & *2 at 1TeV CM), split gap, overlapped with dipole field; low spark rate is essential
- Challenges: intermediate ~1MW dump, possible back shine to detector; design of downstream diagnostics

IR alternatives, 2mrad



- Focus of latest optics work: trying to design minimal system, shortest, most economical, without downstream diagnostics (added later if new ideas found)
- FD reoptimized with new ILC parameters: SC QD0/SD0 &warm QF1/SF1
- FD is NbTi at 500GeV CM (225T/m, 6.3T/bore) and Nb_3Sn at 1 TeV CM (350T/m, 8.8T/bore)
- Beamline downstream of FD to be designed & studied. Study feasibility of downstream diagnostics, study beam & SR losses and evaluate backscattered background

BDS cost risk analysis

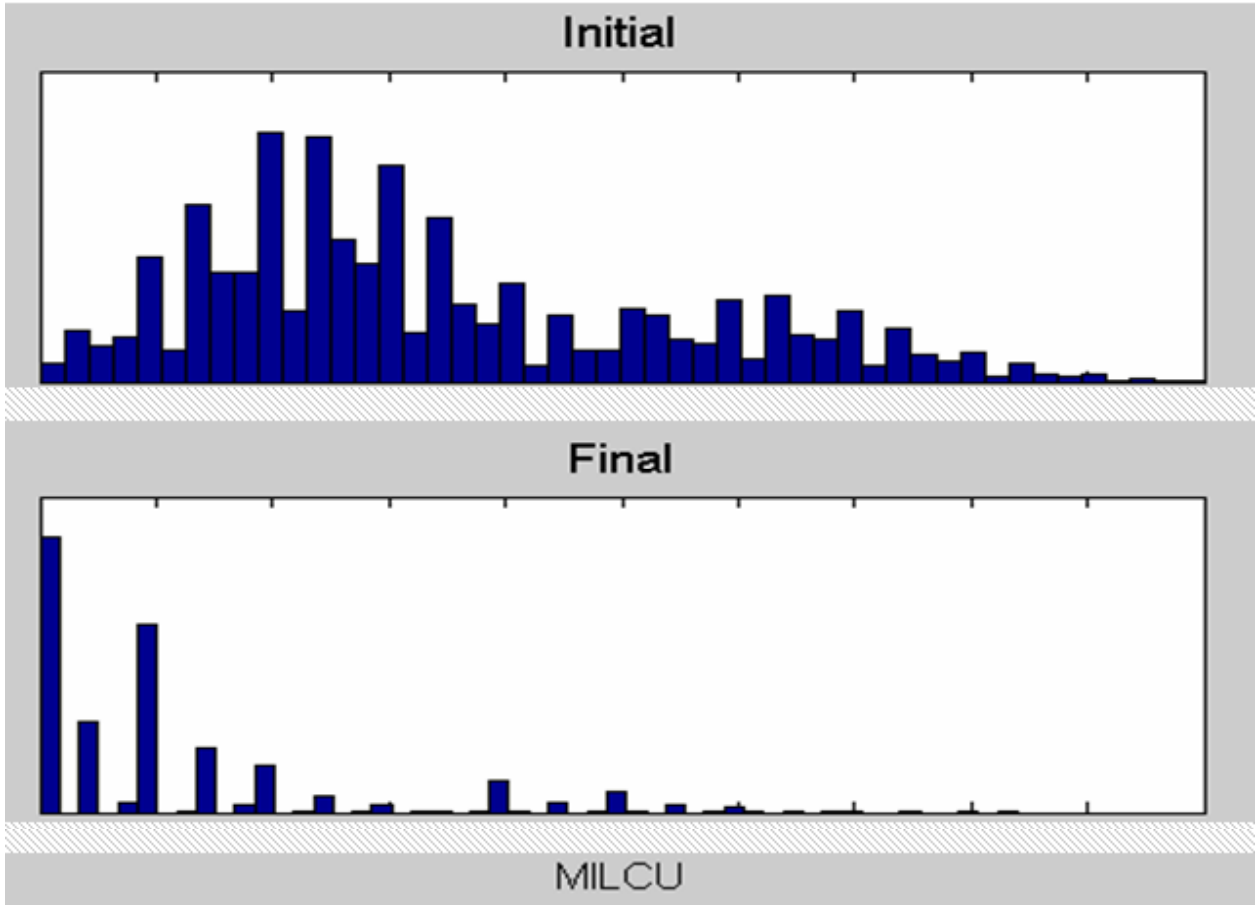
- Ongoing work. To be finished in May
- Assumed risk gradations: high (~50%), medium (~25%), low (~10%) and very low (~1%)
- Have in the list
  - **Risk: FD jitter**
  - **Risk: Beam halo**
  - **Risk: Prompt push-pull operation**
  - **Risk: Beam dump performance**
  - **Risk: Laser wire diagnostics**
  - **Risk: Collimation performance**
  - **Risk: Crab cavity system performance**
  - **Risk: Fast feedback performance**
  - **Risk: Energy and polarization diagnostics**
  - **Risk: Final focus optics performance**
  - **Risk: FD compactness**
- Consider to add
  - **Risk: Incoming beam quality**
  - **Risk: IR synchrotron radiation**

Example: Risk: Beam dump performance

- Assumption in RDR / Initial Risk
  - **Assumed that beam dump can perform as expected in the present design, with window surviving the beam density, shielding providing adequate conditions, water system providing adequate internal and external environmental conditions, and that the cost of decommissioning was not needed to be included. The initial risk is estimated as medium.**
- Mitigation/detection in EDR
  - **Engineering design and beam studies of a window prototype. May find that need to lengthen the extraction line to increase the beam size, include more shielding, and redesign the radiation water handling system.**
- Remaining probability of failure at the end of EDR & cost impact
  - **After EDR studies the risk may be reduced to low, provided that real site was considered. If not, it remains medium. If design changes would need to be done, the impact is XXM.**
- Mitigation/detection in pre-construction
  - **Engineering design for real site, continuation of detailed design and prototyping.**
- Remaining probability of failure at the end of pre-construction
  - **The risk reduced to low.**
- Mitigation/detection in construction & commissioning
  - **Further decreasing the risk.**
- Probability of failure in construction & commissioning & final cost impact
  - **Remaining risk is estimated as very low. In case of failure and the need of fixes, impact may be XXXM.**

BDS cost risk analysis outcome

- Tentatively: the EDR and pre-construction efforts would reduce the BDS cost risk by a factor of three.



Detailed WP planning

- Work is started, may show an example to MAC, without going into much details

Summary

- …