Beam Delivery System Updates

Andrei Seryi for BDS design and ATF2 commissioning teams

LCWS 2010 / ILC 2010

March 28, 2010

Plan of the program at ILC2010

- Focus of efforts
  - Work on parameter set for a possible new baseline
  - Work on a prototype of the final focus at ATF2
  - Work on design of key technical systems of BDS

Focus of efforts and sessions

- Work on parameter set for a possible new baseline
  - Joint plenary on parameters & scope
    - Saturday morning
  - SB2009 details and implications on physics (Higgs mass, stau search, etc)
    - Joint with MDI, Sun 1100-1230
  - Discussion of implication of double rep rate (10Hz) at lower energy (e.g. 250GeV CM) for SB2009
    - Sat 1600-1800 – joint with DR and Sources
    - Sun 1700-1800 – joint with Linac, HLRF & Cryogenics experts

Focus of efforts and sessions

- Work on final focus prototype ATF2
  - ATF/ATF2 ICB (International Collaboration Board)
  - Progress report, TB (Technical Board) report
  - ICB closed session
    - Joint with DR, Monday 1100-1230
  - ATF2 detailed technical discussions
    - Sun 1400-1530
  - SC FD upgrade design for ATF2
    - Sat 1100-1230

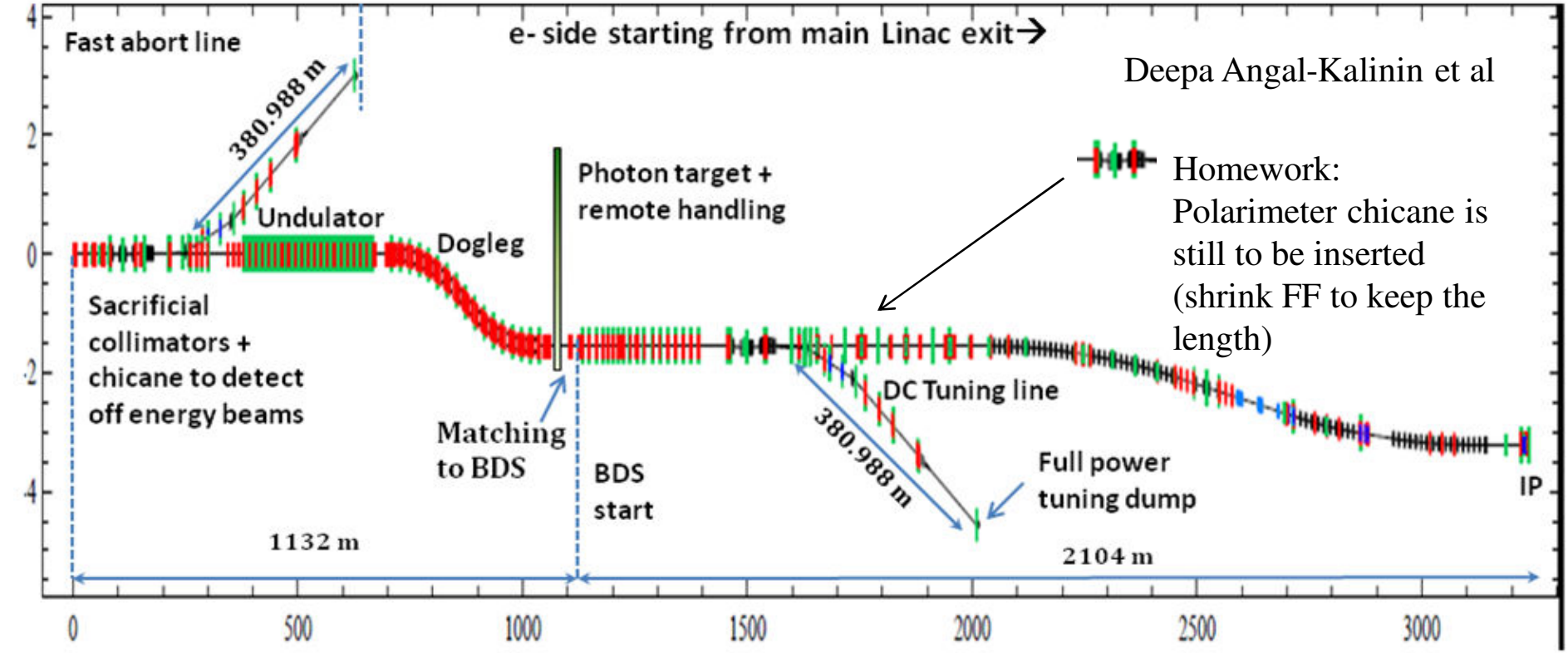
Focus of efforts and sessions

- Work on design of key technical systems of BDS
  - Machine detector interface design of Concepts
    - Joint with MDI, Sunday 0900-1030
  - IR stability and vibrations
    - Joint with MDI, Monday 0900-1030
  - SC FD design and prototype progress
    - Saturday 1100-1230
  - MDI diagnostics and backgrounds
    - Joint with MDI, Monday 1400-1530
  - Beam dump design update
    - Saturday 1100-1230

SB2009 BDS Updates

- Changes in the subsystem integration of the central region: As of the RDR, the BDS, the electron source and the damping rings are clustered in the central region of the ILC accelerator complex. The proposed changes in the baseline envisage relocation of the positron source system to the downstream end of the electron main linac, so that they also join this central region. This impacts the subsystem layout in ways that affect the implementation of electron side BDS.

- Changes in the baseline parameter set: Proposed adoption of the low power beam parameter set (same machine pulse repetition rate and the same bunch intensity, but a reduced number of bunches per pulse) leads to a desire to push the beam-beam parameter, so that the same luminosity as in RDR can be achieved. As a solution the so-called *travelling focus scheme* is being considered.



- The central integration includes the sources in the same tunnel as the BDS. Relocation of the positron production system to the downstream end of the electron linac means placing it just before the beginning of the electron BDS. These changes need suitable design modifications to the layout of this area. Figure above shows the proposed new layout of the electron BDS

Features in the new e- BDS:

- Sacrificial collimator now located at the linac end rather than in the BDS upstream end
  - The RDR has sacrificial collimators in the beginning of e- and e+ BDS to protect the BDS from any beam with error to enter from the large aperture of the main linac (r=70mm) into small aperture (r=10mm) of the BDS. In the new layout, the small aperture undulator (~8mm full) is located immediately after the linac and thus it needs to be protected against any error beam entering the undulator. This is done by moving the sacrificial collimator section and an energy chicane to detect the off energy beam in front of the undulator which reduced the electron BDS length to 2104m from 2226m as shown in Figure 4.7.1. Any beam entering this section with errors will be detected and sent to the fast abort line just before entering the undulator. The fast abort line is presently the same length as the RDR abort line, which was designed as a fast abort + tuning line (the positron BDS side still has this combined functionality), however the fast abort beam dump needs to be able to take only the number of bunches between abort signal and stopping the beam at the extraction of the damping ring and does not need to be a full power beam dump. The exact rating for this dump remains to be determined
- Matching line after the fast abort detection energy chicane into the undulator and design requirements for positron target location
  - The matching line to the undulator needs to allow sufficient transverse separation for the abort line and then matches into the undulator FODO cells. The photons generated in the undulator will pass through a drift length of 400m up to the positron target (~1070m point in Figure 4.7.1). To implement the positron target and the remote handling of the components in this area, a transverse offset of 1.5m is required between the electron beamline and the photon target. The remote handing area needs a drift space of approximately 40m in length. No BDS component are placed in this space. This is achieved by using a matching section after the undulator to match into a dogleg, a dogleg itself giving a transverse offset of 1.5m and a 40m long drift at the end

Features in the new e- BDS:

- Dogleg lattice to create the required separation between the photon target and the electron beamline
  - The dogleg lattice has been designed to be a TME (Theoretical Minimum Emittance) lattice. This keeps the emittance growth due to synchrotron radiation at 1 TeV CM to be within few percent. The dogleg provides an offset of 1.5m in 400m as required and the emittance growth at 1 TeV CM is ~3.8%. The dipoles in the dogleg are presently not decimated but can be decimated similar to the rest of the BDS so that only few dipoles are installed at 250 GeV. The beam dynamics and tuning effects on the BDS due to the presence of the dogleg need to be assessed
- Matching section into the BDS diagnostics section
  - The 40m long drift is followed by a matching section into the skew and coupling correction section, chicane for detection of the laser wire photons and a slow tune-up (DC tuning) line leading to a full power beam dump. Since the fast abort functionality is being taken care of by the fast abort line before the undulator, the energy acceptance of the DC tuning line is much reduced and thus the DC tuning line can be shortened using only DC magnets. This optimisation will be done during the TDP2 phase.
- Polarimeter chicane, collimation, energy spectrometer and final focus
  - The polarimeter chicane will be located just after the take-off section for the tuning line, which is not shown in the layout. This will need some additional length but will be accommodated by slightly reducing the final focus length allowing some emittance growth at 1TeV CM. The polarimeter chicane will be followed by the betatron and energy collimation, energy spectrometer and final focus sections similar to the RDR.
- Post collision extraction line and main dump
  - Similar as in RDR

Effect of changes for running at lower energies

following the

Physics Questions Committee's Status Report provided to the SB2009 Working Group of Detector colleagues

- B. Foster — Co-Chair
- A. Seryi — Co-Chair
- J. Clarke
- M. Harrison
- D. Schulte
- T. Tauchi

Brian Foster, Jim Clarke, Andrei Seryi
for the Physics Question Committee

AAP Review
Oxford, January 6-8, 2010

Questions from SB2009 WG

1. To assess the physics impact, we need beam parameters at several key energies:
   1. 250 GeV (to compare with LoI),
   2. 350 GeV (a likely operating energy for SB2009),
   3. 500 GeV (again to compare with the LoI).
2. Beam parameters should include electron/positron beam energy spread.
3. We would like to understand the effect on backgrounds/luminosity spectrum for SB2009 with vs without traveling focus.
4. Despite the questions of feasibility, the conventional positron source remains very interesting in order to maximize yield and therefore luminosity. Please provide estimates of the expected luminosity and beam energy spread that would be possible with either a conventional positron source, or an undulator source, at cms energies between 200 and 300 GeV. Will the conventional source possibility remain an option in the re-baselined design? What R&D will be pursued either within the GDE or by other groups to ensure its development?
5. How stable would the Luminosity, Energy spread, and positron polarization be during a threshold scan, for example for ttbar or Susy?
6. Can you provide a rough sketch of L(Ecm), Energy spread(Ecm), and Pol e+(Ecm) showing how they might be expected to vary between Ecm=91 and 500 GeV?

Beam Parameters

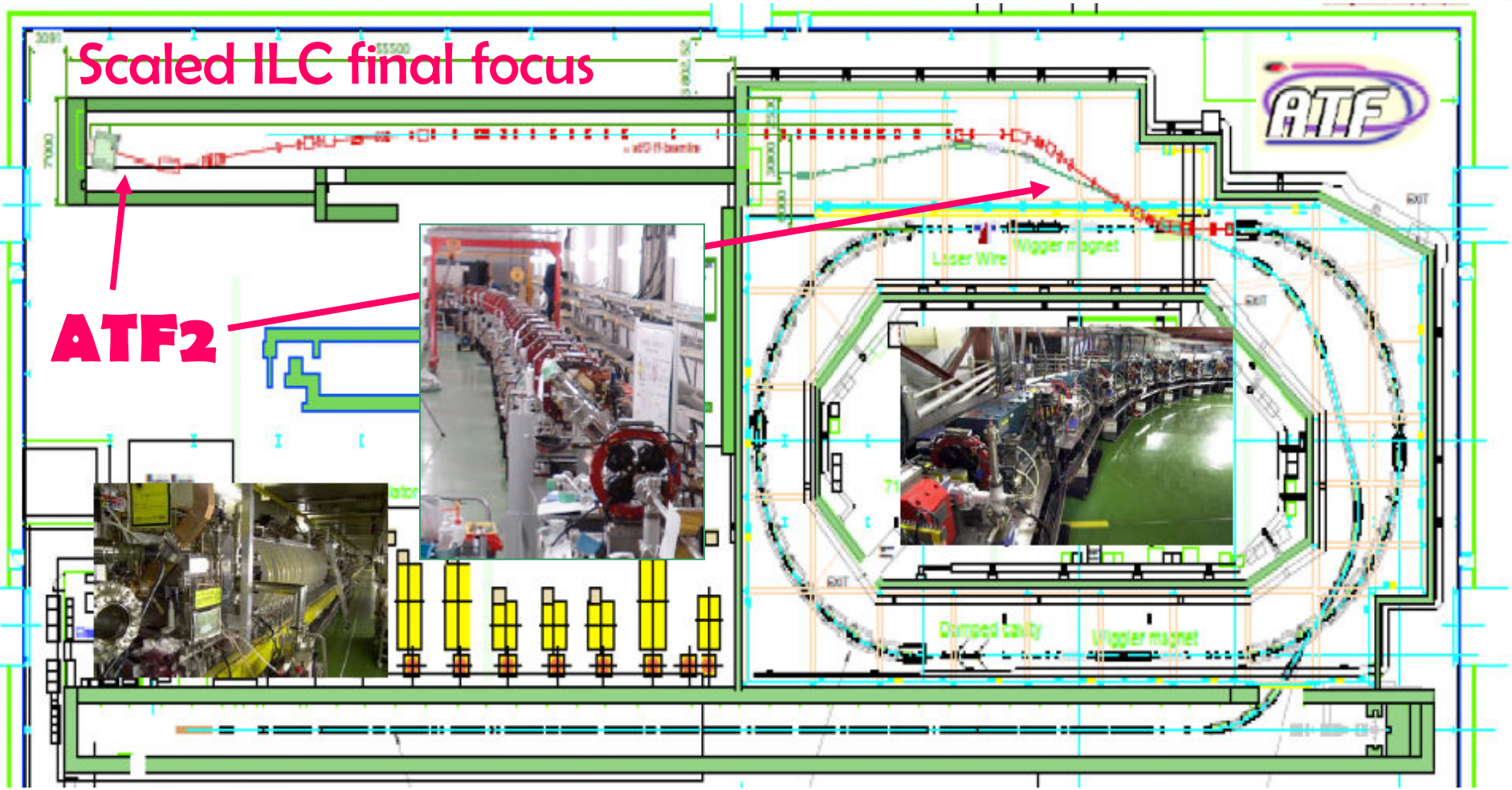
	RDR			SB2009 w/o TF				SB2009 w TF			
CM Energy (GeV)	250	350	500	250.a	250.b	350	500	250.a	250.b	350	500
Ne- (*10^{10})	2.05	2.05	2.05	2	2	2	2.05	2	2	2	2.05
Ne+ (*10^{10})	2.05	2.05	2.05	1	2	2	2.05	1	2	2	2.05
nb	2625	2625	2625	1312	1312	1312	1312	1312	1312	1312	1312
Tsep (nsecs)	370	370	370	740	740	740	740	740	740	740	740
F (Hz)	5	5	5	5	2.5	5	5	5	2.5	5	5
γex (*10^{-6})	10	10	10	10	10	10	10	10	10	10	10
γey (*10^{-6})	4	4	4	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
βx	22	22	20	21	21	15	11	21	21	15	11
βy	0.5	0.5	0.4	0.48	0.48	0.48	0.48	0.2	0.2	0.2	0.2
σz (mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
σx eff (*10^{-9} m)	948	802	639	927	927	662	474	927	927	662	474
σy eff (*10^{-9} m)	10	8.1	5.7	9.5	9.5	7.4	5.8	6.4	6.4	5.0	3.8
L (10^{34} $cm^{-2}s^{-1}$)	0.75	1.2	2.0	0.2	0.22	0.7	1.5	0.25	0.27	1.0	2.0

We will discuss possible mitigations of L(E) at low E at the next session

ATF2

ATF2: model of ILC beam delivery

goals: ~37nm beam size; nm level beam stability



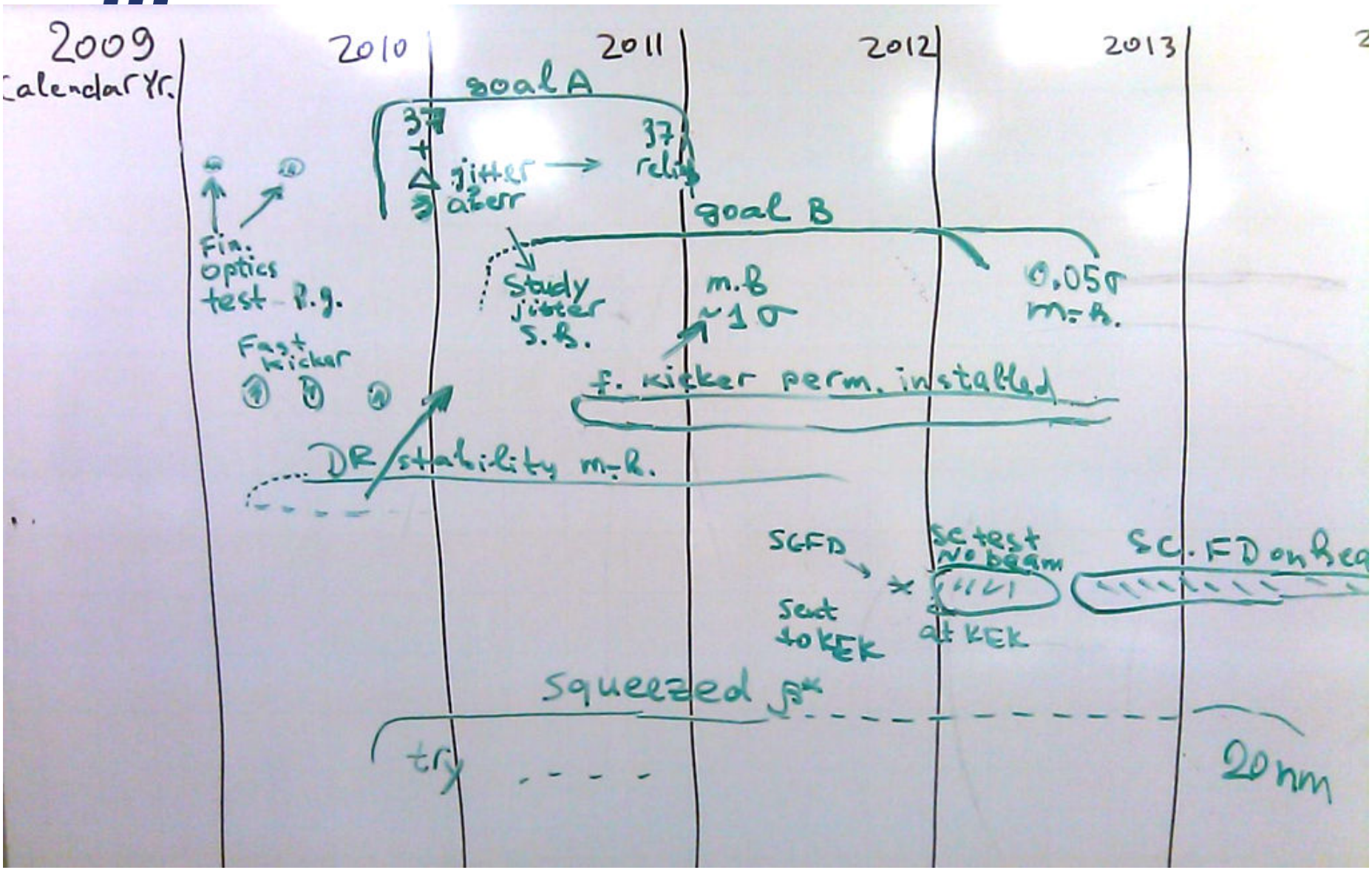
- Dec 2008: first pilot run; Jan 2009: hardware commissioning
- Feb-Apr 2009: large β; BSM laser wire mode; tuning tools commissioning
- Oct-Dec 2009: aim to commission interferometer mode of BSM, sub μm beam

Necessary Deliverables from TF for BDS and DR

This is ILC GDE request.

Test Facility	Deliverable	Date
Hardware development, Optics and stabilisation demonstrations		*JFY*
ATF	Demo. of reliable operation of fast kickers meeting the specifications for the ILC damping ring.	2010
	Generation of 1 pm-rad low emittance beam	2009
ATF2	Demo. of compact Final Focus optics (design demagnification, resulting in a nominal 35 nm beam size at focal point).	2010
	Demo. of prototype SC and PM final doublet magnets	2012
	Stabilisation of 35 nm beam over various time scales.	2012
Electron cloud mitigation studies:		
CESR-TA	Re-config. (re-build) of CESR as low-emittance e-cloud test facility. First meas. of e-cloud build-up using instrumented sections in dipoles and drifts sections (large emittance).	2008
	Achieve lower emittance beams. Meas. of e-cloud build up in wiggler chambers.	2009
	Characterisation of e-cloud build-up and instability thresholds as a func. of low vertical emittance (≤20 pm)	2010
DAΦNE	Fast kicker design and pulser reliability check	2010
	Characterisation of e-cloud build-up and instability thresholds	2010
SLAC/LLNL	Fast kicker pulser development	2010

Schedule as of Dec 14, 2009



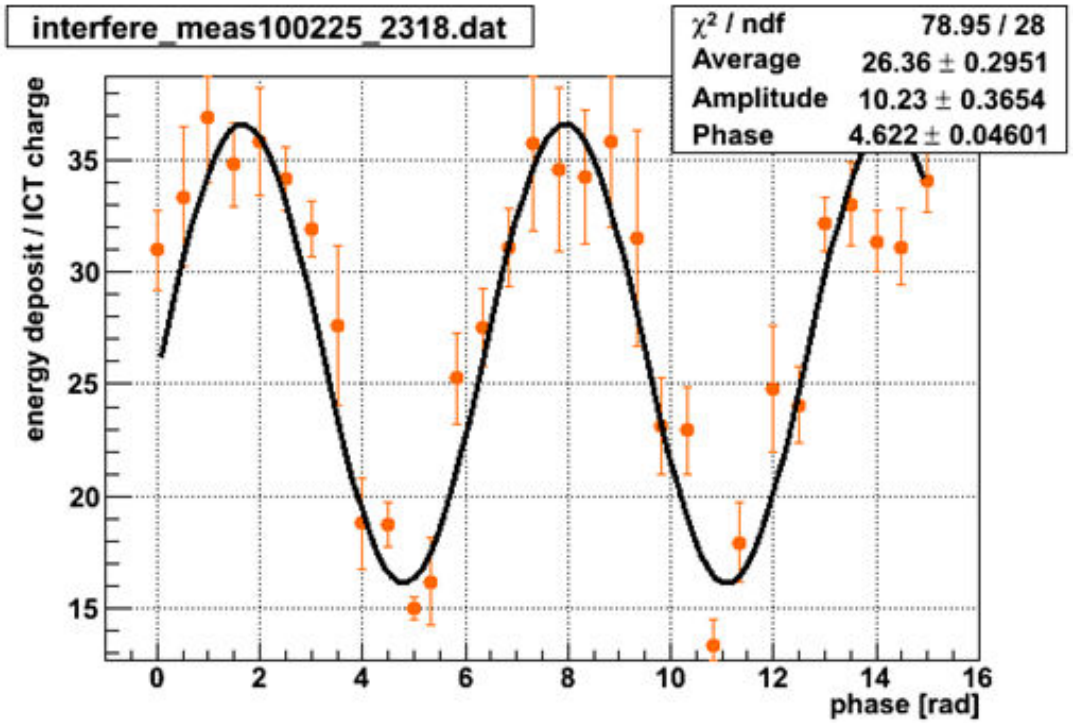
Tentative overall schedule as of Dec 15, 2009.

Beam size goal: 1st priority

- The aim for 37nm at the end of 2010 remains
  - This address, partly, tests of demagnification
- Accept that measured beam size may contain contribution from jitter and remaining aberrations
  - One more year needed to understand the jitter, and get to reliable observation of the beam size
- On the way to end of 2010, will try-out nominal optics in early 2010, for background study, to evaluate the pace of the progress

Beam Size monitor team: Feb 2010

Interfere mode scan



Beam size ~ 2.4 μm

Wire scanner measurement ~ 3.1 μm

Working with large beta*. Preparing hardware & tuning software for tuning down to smaller size. Next runs: April & May

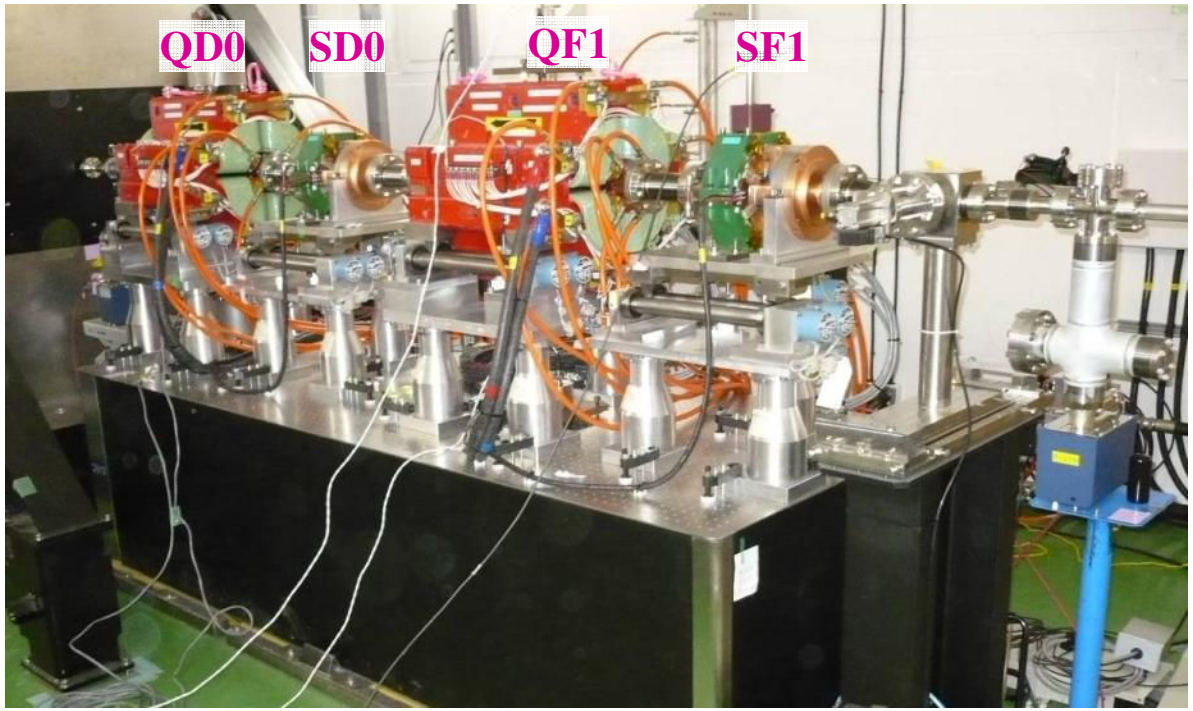
Stability goal

- Goal B is focused first on understanding the single bunch stability on the level of 1 sigma, needed for goal A, gradually working towards 1σ and 0.05σ of multi-bunch stability
- This is supported by:
- Damping ring m.b. stability study
- Fast kicker tests, followed by its permanent installation in second half of 2011

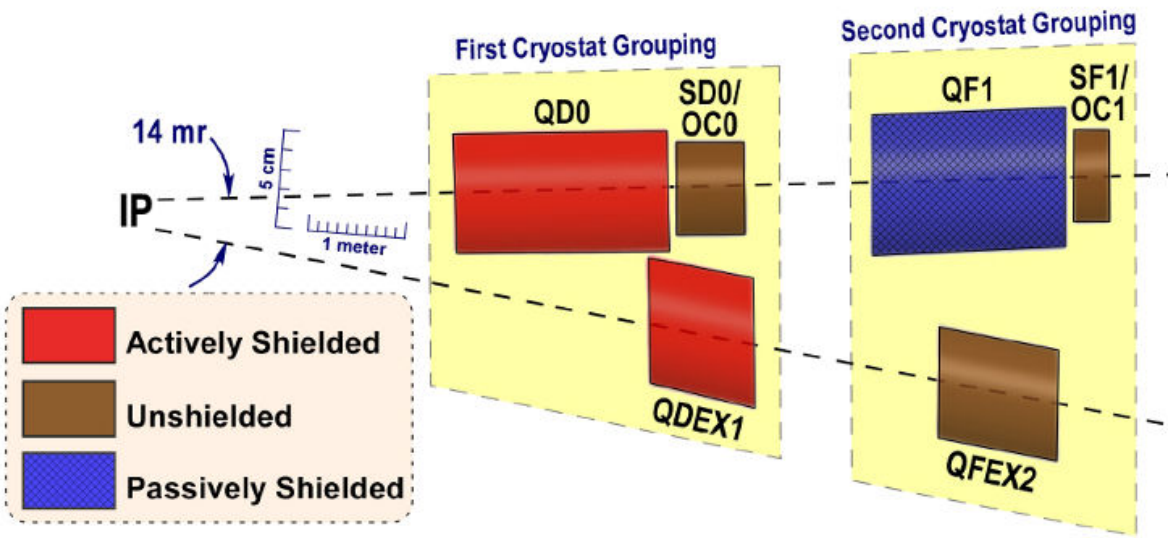
SC FD tests & low β

- Tests of SC FD at KEK, off-beamline, are in first half of 2013
- Installation on beamline during summer shutdown of 2013
- Start work with SC FD on beamline in Autumn of 2013

- Low b tried in late 2010, continue throughout, and aim for 20nm in 2014



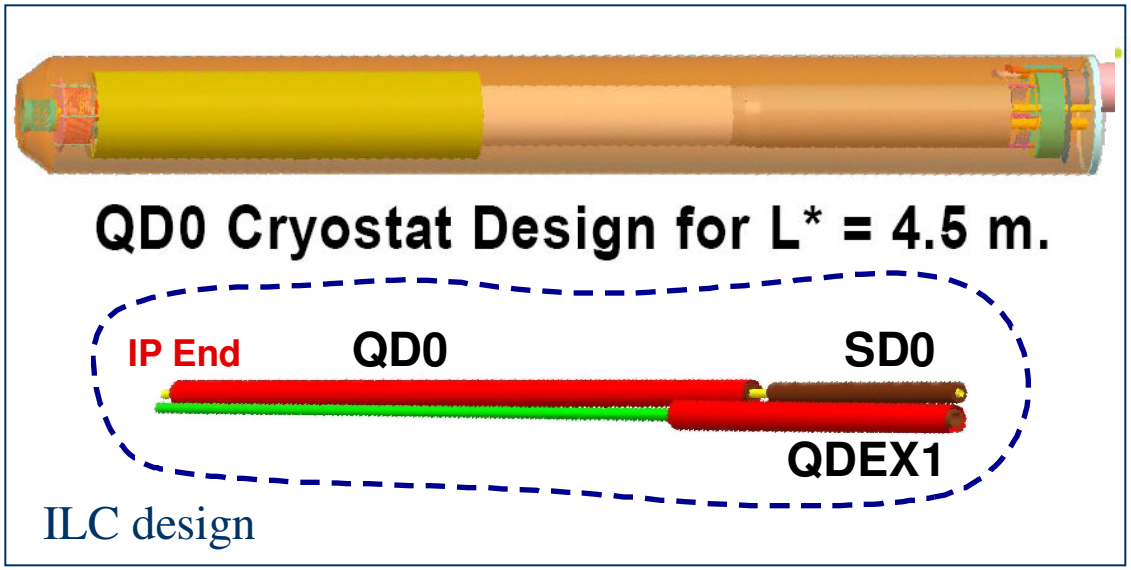
ATF2 final doublet



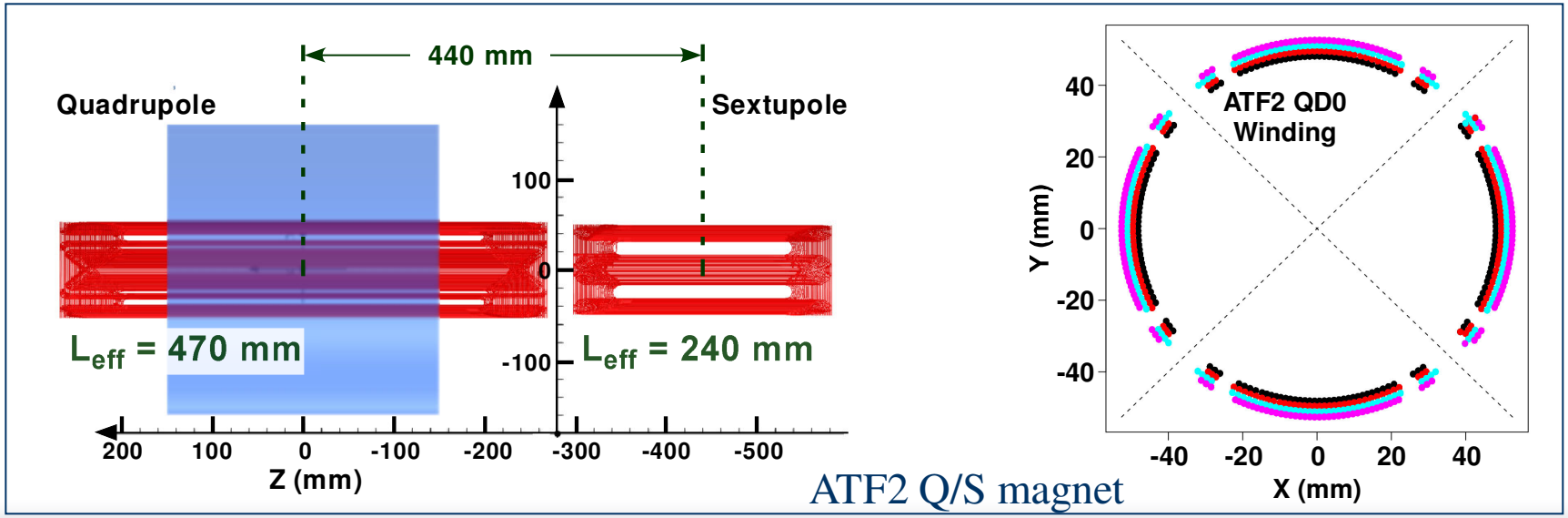
ILC Final Doublet layout

SC Final Doublet and ATF2 tests

- SC FD prototype at BNL
  - make long coil test of ILC-like FD prototype; long cold mass & its field tests
  - ILC-technology-like SC Final Doublet for ATF2 upgrade
  - Will test FD SC stability at BNL and system test with beam at ATF2

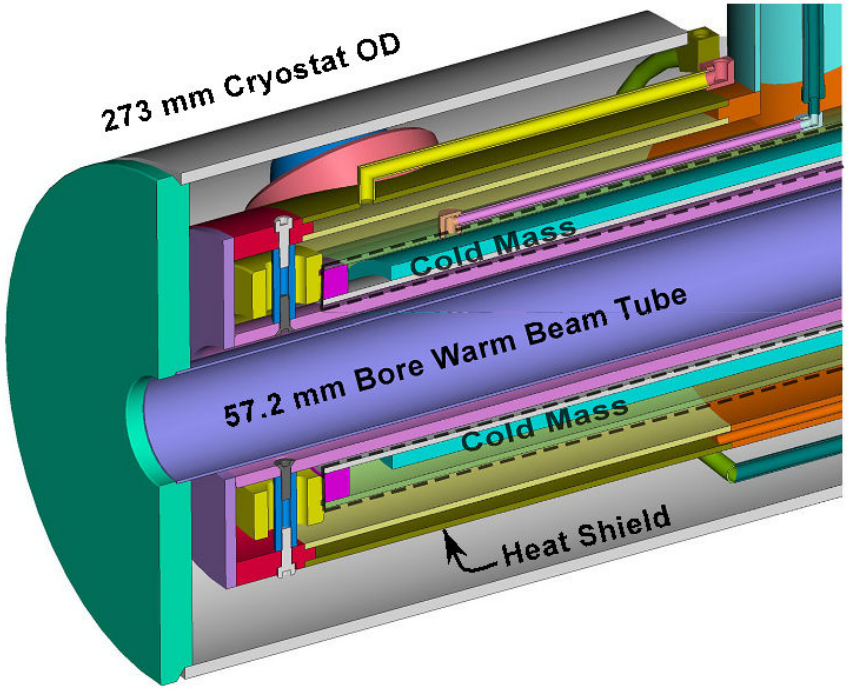


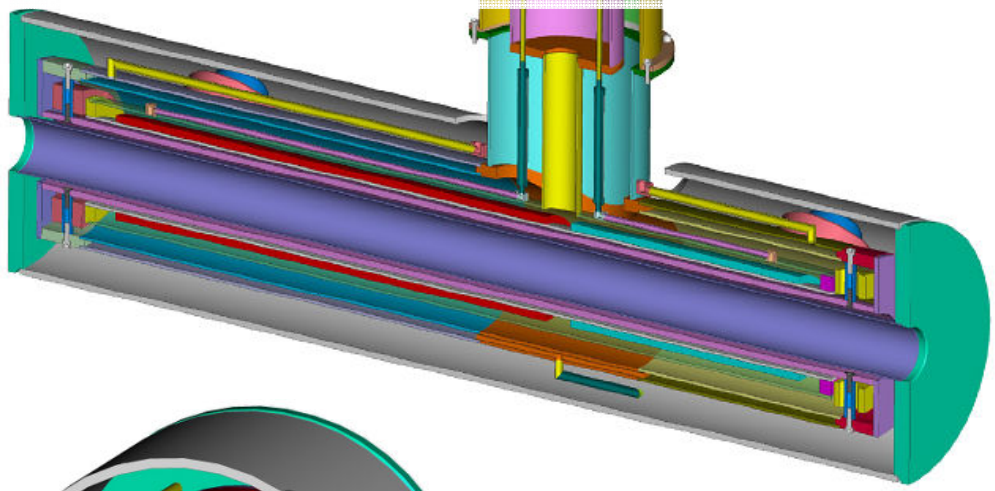
Brett Parket, at al, BNL



SC FD for ATF2

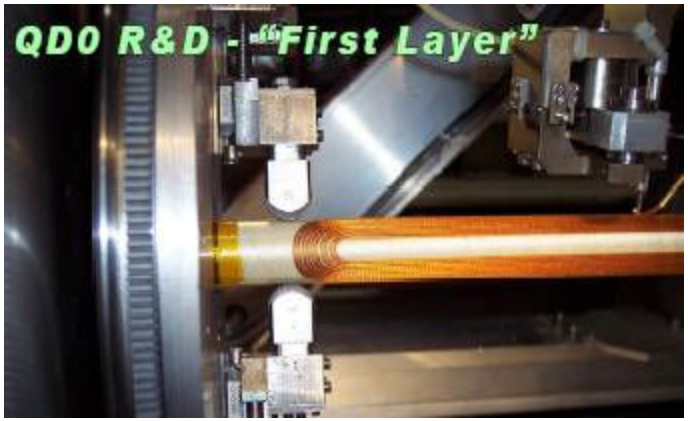
BNL & KEK are working on joint design of FD cryostat and cryo-system



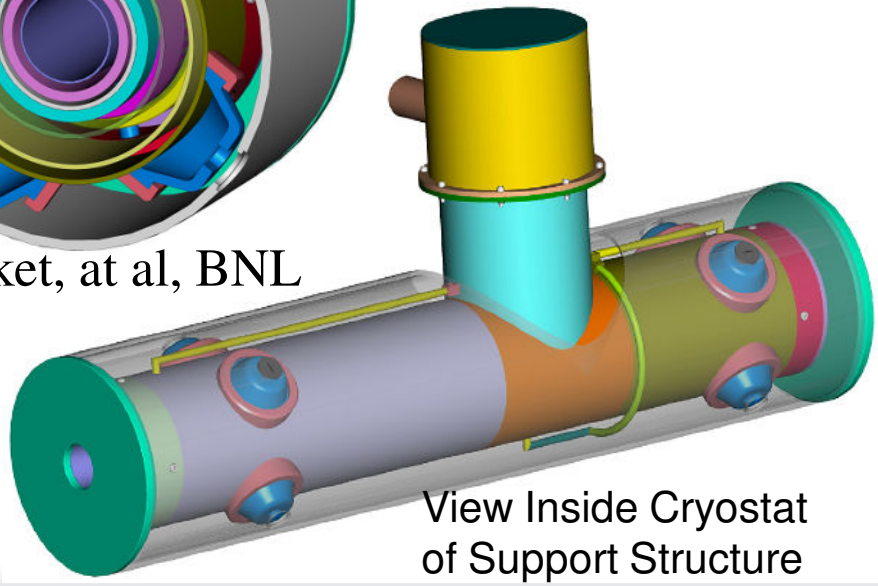


Cross Section View at Support Location

Brett Parket, at al, BNL

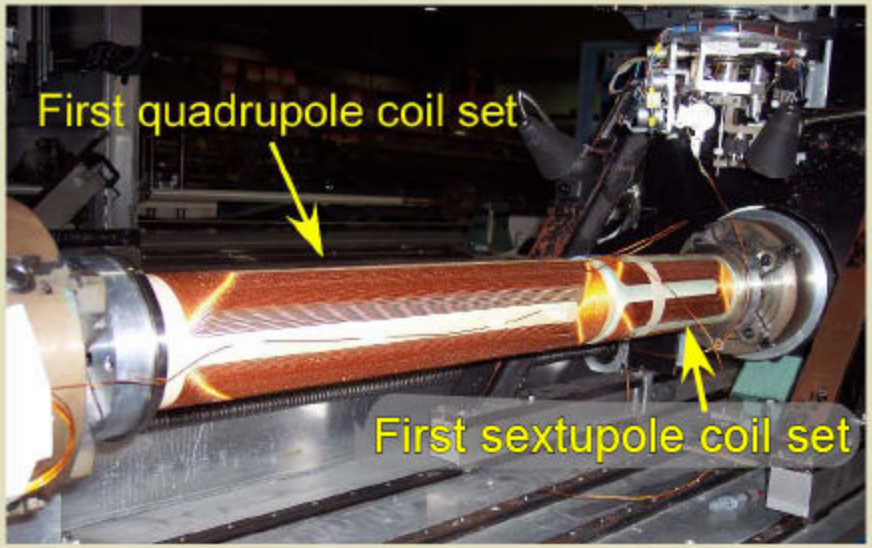


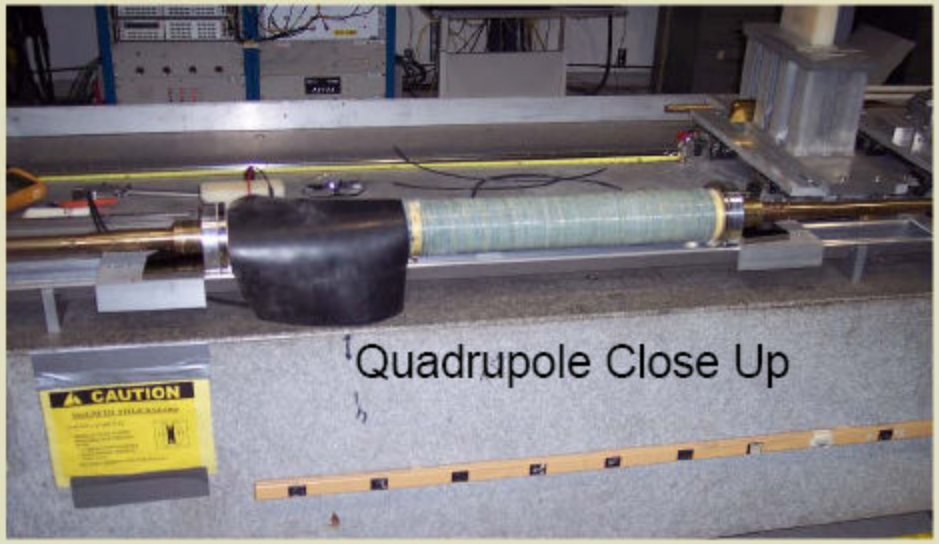
Long coil winding



View Inside Cryostat of Support Structure

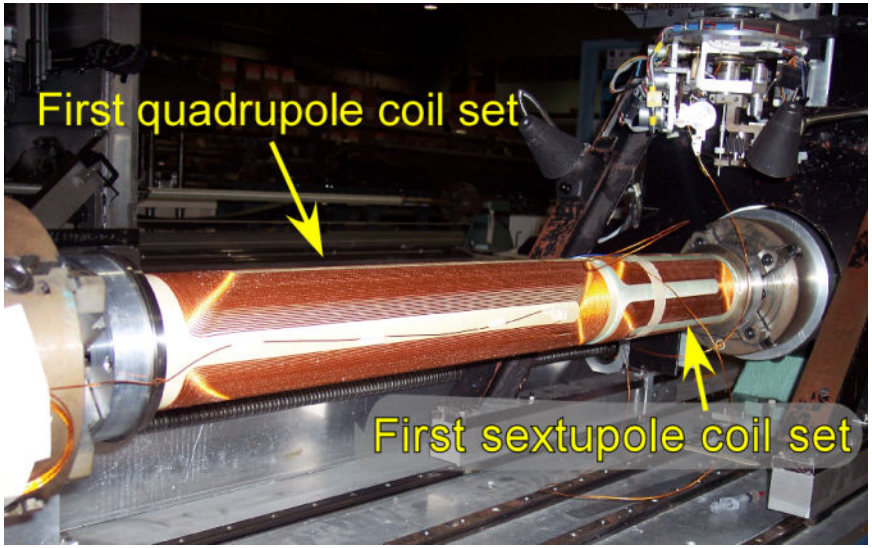
Start of ATF2 coil production & measurement

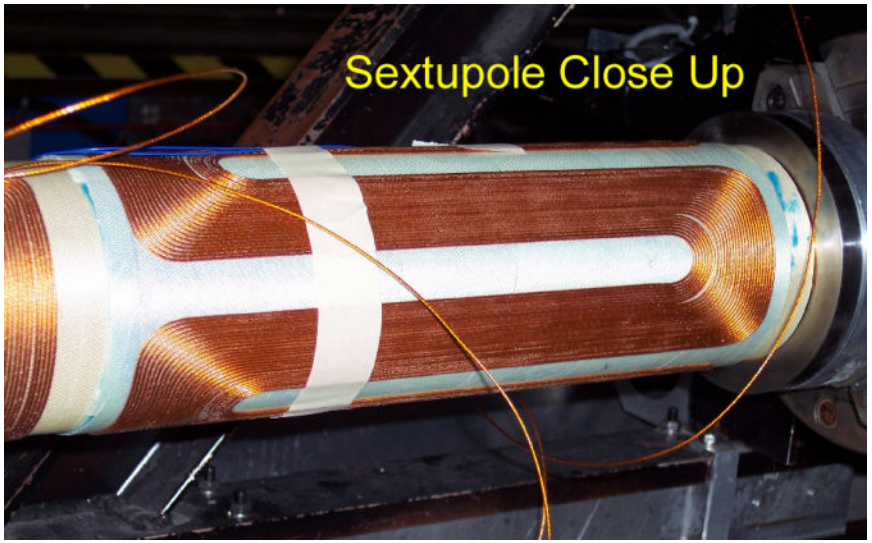




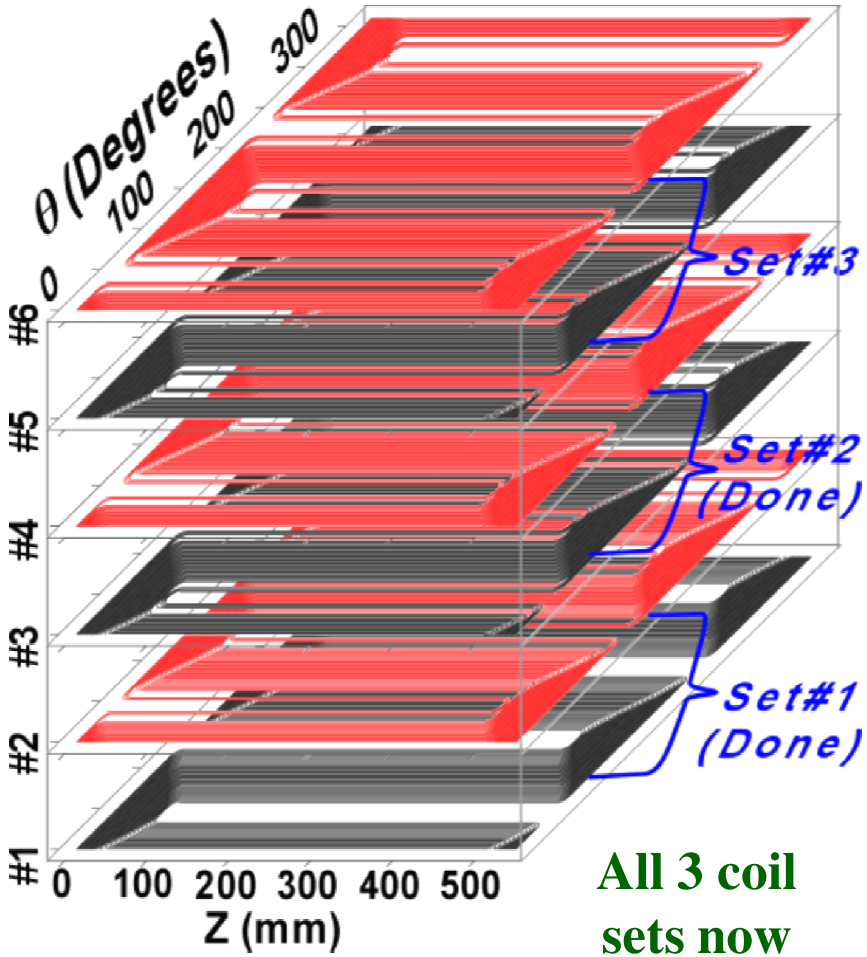
BNL, Brett Parker et al

ATF2 Coil Winding Status





Winding Schematic for ATF2 Quad



All 3 coil sets now complete

"Update on ATF2 SC Magnets"
Brett Parker, BNL-SMD

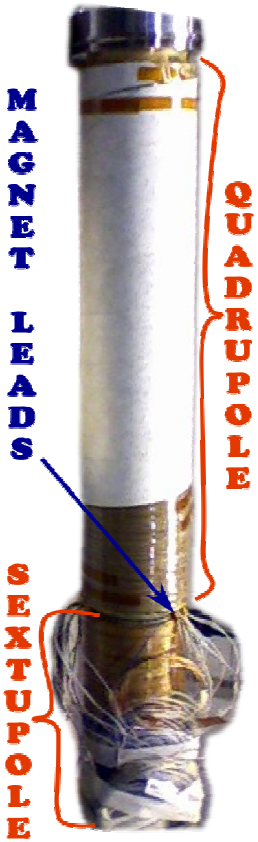
Summary of Integral Field Quality in ATF2 Magnet

Normal	Quadrupole	Sextupole
I.T.F.	26.959	194.00
Fld. Ang. (mr)	-12.5	14.8
Leff(m)	--	--
b1	--	-0.3
b2	10000.0	--
b3	1.2	10000.0
b4	-1.3	0.6
b5	0.4	-0.8
b6	0.7	0.1
b7	0.0	0.2
b8	-0.1	0.4
b9	0.0	0.4
b10	0.0	0.1
b11	0.0	0.5
b12	0.0	0.1
b13	0.0	0.0
b14	0.0	-0.1
b15	0.0	-0.5

Skew	Quadrupole	Sextupole
I.T.F.	26.959	194.00
Fld. Ang. (mr)	-12.5	14.8
Leff(m)	--	--
a1	--	-8.6
a2	--	--
a3	-1.2	--
a4	-2.2	-2.0
a5	-0.3	-1.5
a6	0.1	-4.2
a7	0.2	-0.4
a8	0.1	0.2
a9	0.1	0.3
a10	-0.2	0.2
a11	0.0	0.1
a12	0.0	-0.2
a13	0.0	-0.1
a14	0.0	0.0
a15	0.0	0.0

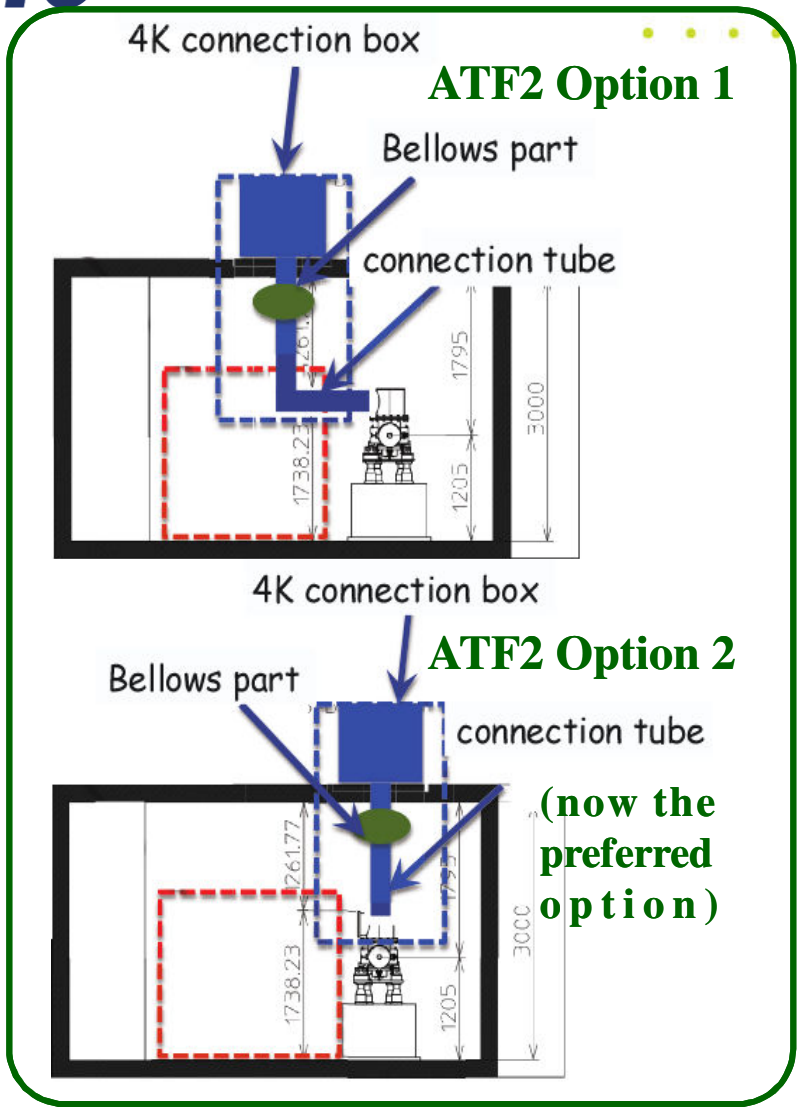
Harmonics are in "Units" of 10^{-4} of the main field at 25 mm as seen from the lead ends of respective magnets (yielding opposite sign of field angle in the two magnets). I.T.F for Quadrupole is in T/kA; ITF for Sextupole is in T/m/kA (Integral of B'' in sextupole is two times the value reported for the I.T.F).

ATF2 Coils



"Update on SC Magnets and Schedule,"
Brett Parker, BNL-SMD

Cryogenics Interface Update



ATF2 SC FD face-to-face meeting at BNL

Tuesday 24 November 2009
from 08:00 to 18:00
US/Eastern
at BNL, USA (*902A Conference Room 63*)
support: parker@bnl.gov

Material:

Our last meeting at BNL

Tuesday 24 November 2009 top

08:00->*09:00* **Setup and Welcome**
Description:
1) Time for preparation before start of meeting
2) Welcome and Introductions

09:00->*12:00* **Morning Session**

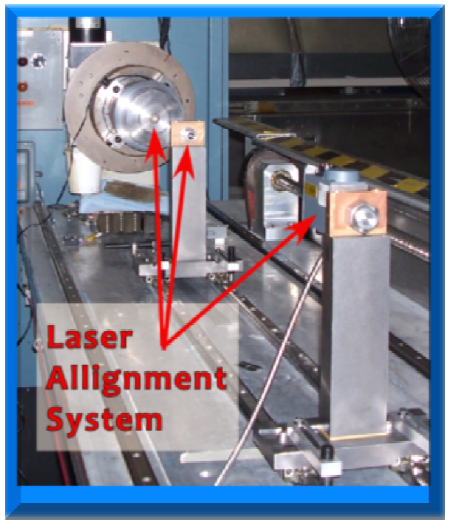
09:00	ATF2 Superconducting Upgrade Introduction & Overview (30') (Slides) 1) Review work that has already been done. 2) Discuss work needed for the next ATF2 TB review 3) Discuss plan for today's meeting	Brett Parker
09:30	Status of the KEK Cryogenic Design (30') (Slides)	Nobuhiro Kimura and Takayuki Tomaru
10:00	Review and Discussion of the BNL Mechanical Design (1h00') (Slides) Short presentation plus viewing of CAD model	Andy Marone and Henry Hocker
11:00	Discussion of Laser Access Ports (30')	Brett Parker (David Urner and Paul Coe via webex)
11:30	Discussion of Supports/Stabilization Structure (30') (Slides)	Brett Parker (Andrea Jeremie and Benoit Bolzon via webex)

Face-to-face meeting at BNL was very productive; do we need to schedule a new meeting? At KEK?

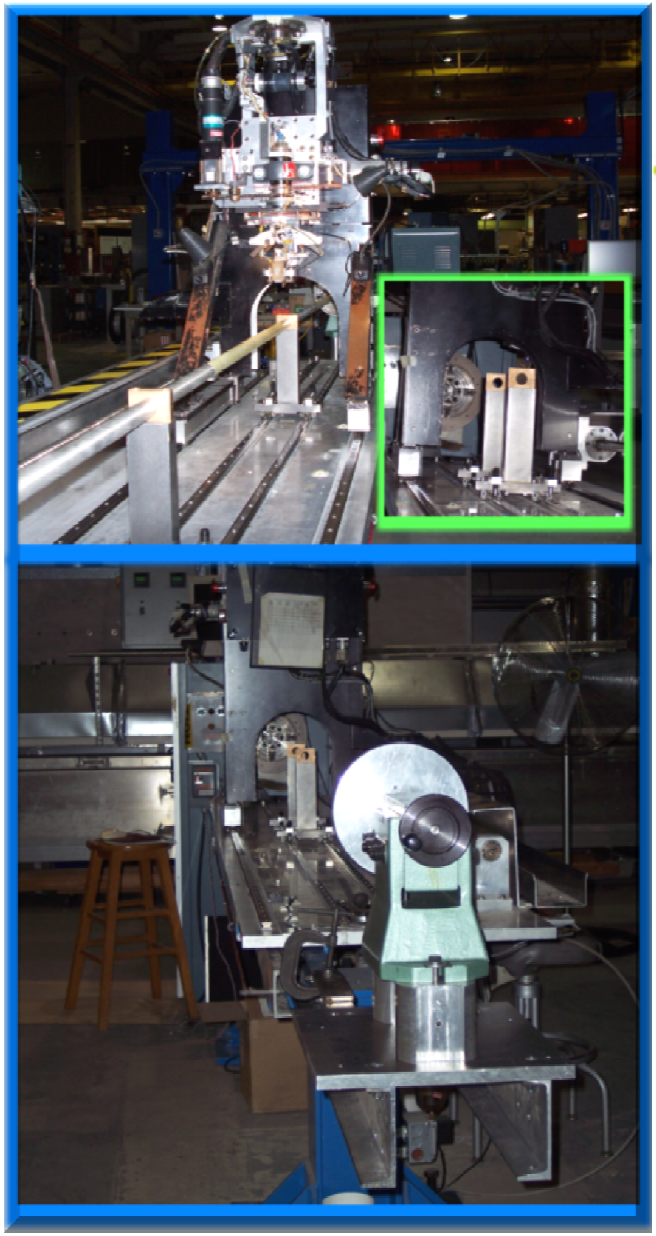
ILC QD0 R&D Prototype

Long Coil Winding Challenges

- We did not adequately control the coil support tube position (even with orthogonal machine-controlled rolling supports). Our first R&D coils had substantial harmonic errors.
- We have therefore decided to go back to using a few fixed, rigid supports and have made modifications (shown here) to the ATF2 short coil winding machine.



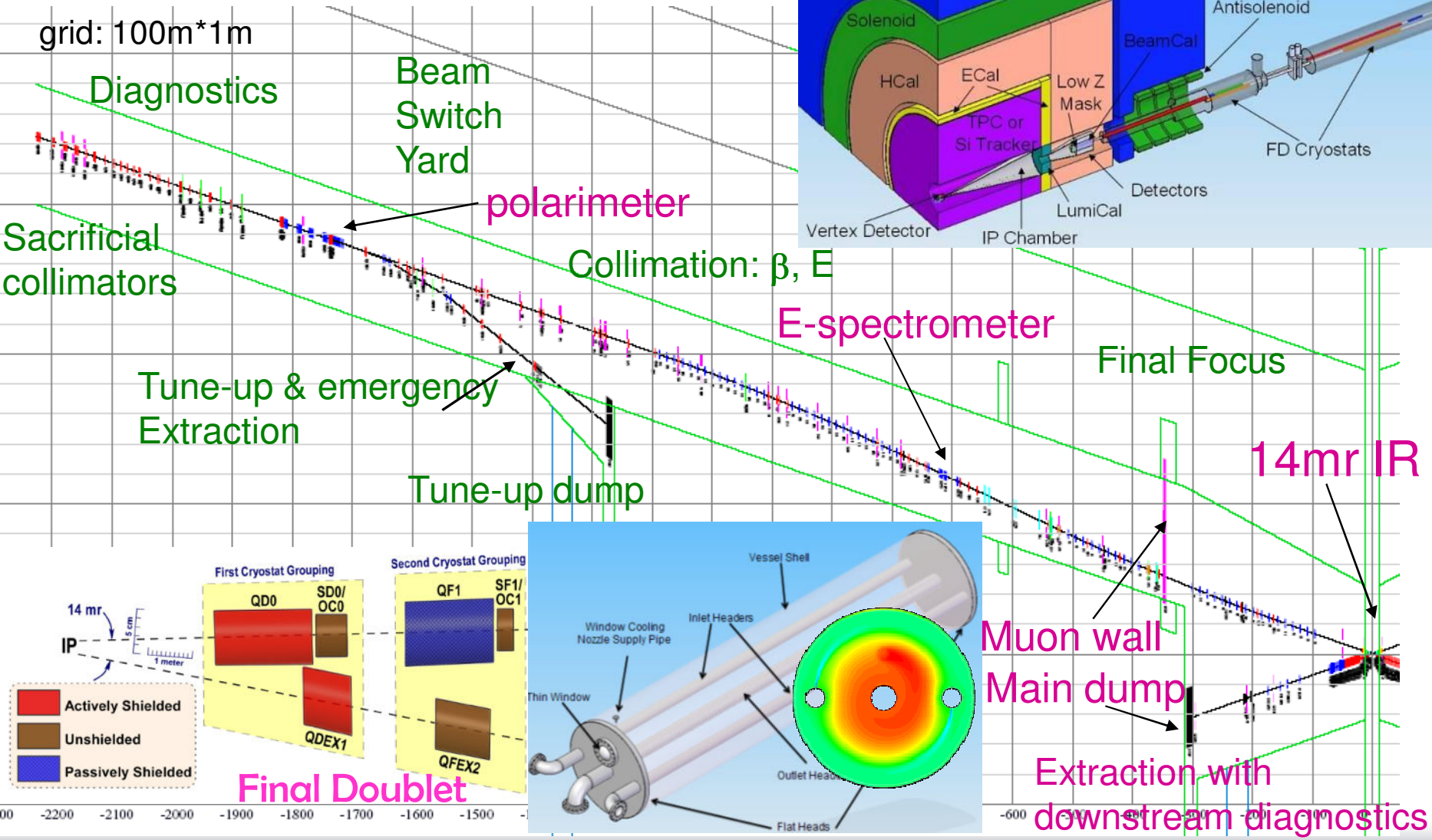
- We extended the machine & carefully positioned fixed supports between the coils.
- The 2.2 m long QD0 R&D coil will be wound in two sections on a common tube.



"ILC SC FD & ATF2 SC Magnet Upgrade – Update," Brett Parker, BNL-SMD

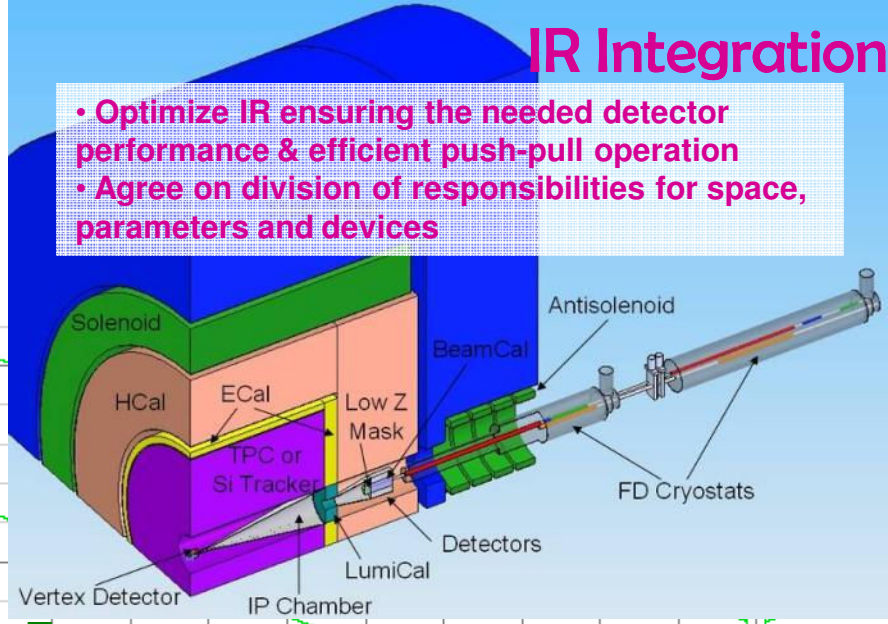
Beam Delivery & MDI items

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



IR Integration

- Optimize IR ensuring the needed detector performance & efficient push-pull operation
- Agree on division of responsibilities for space, parameters and devices



More…

- MDI work – next presentations
- SB2009 optimization – next session