Machine Detector Interface

Andrei Seryi
SLAC

PAC review,

November 2, 2009

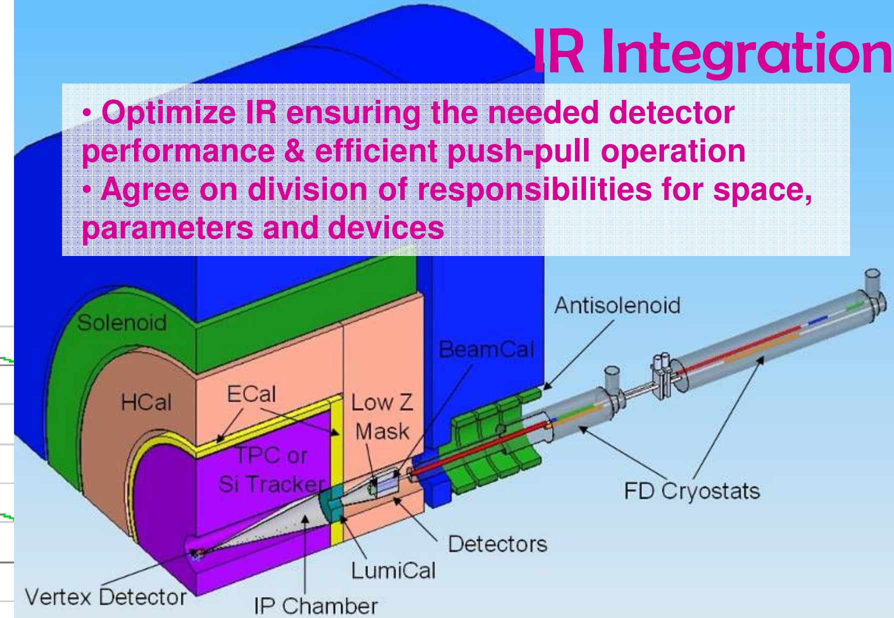
POSTECH
POHANG UNIVERSITY OF SCIENCE AND TECHNOLOGY

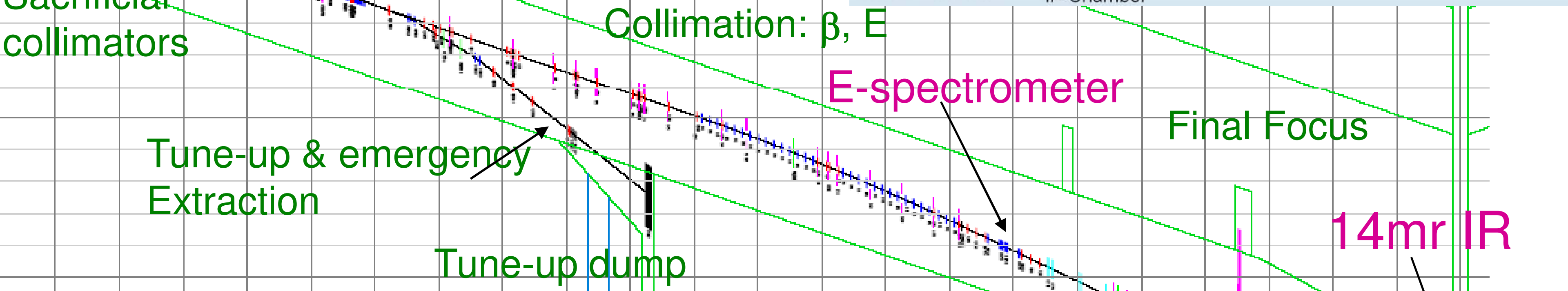
Plan

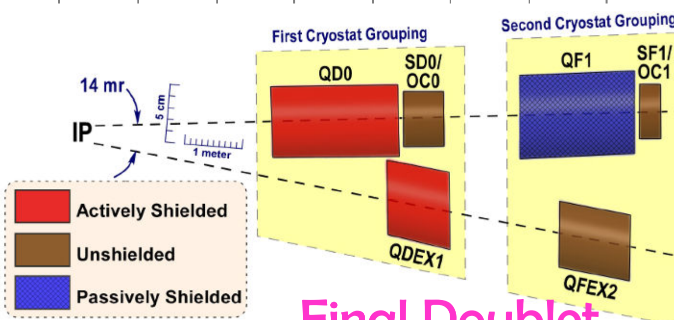
- IR integration
  - Push-pull, detector moving system, stability
  - Final doublet & detector integration and prototype
- Other MDI related systems
  - Beam dump
  - Upstream & downstream diagnostics
- SB2009
  - parameters
  - optics and layout

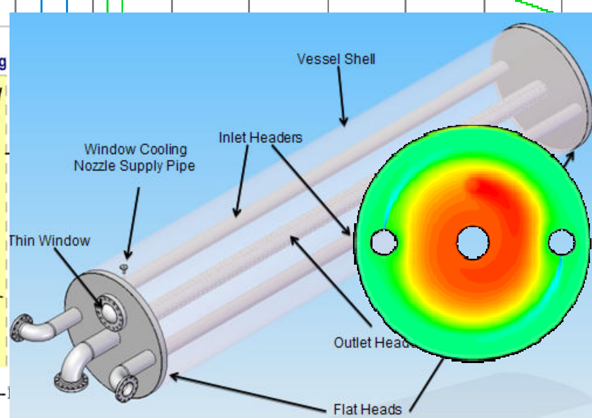
Beam Delivery & MDI items

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



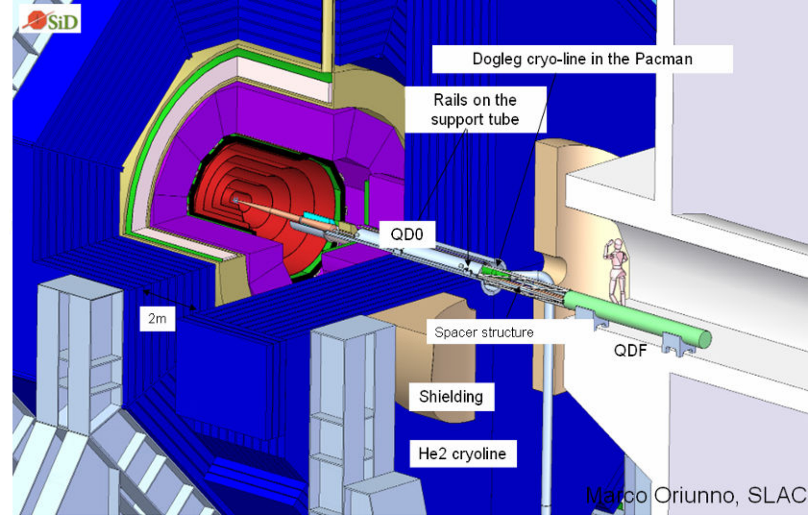


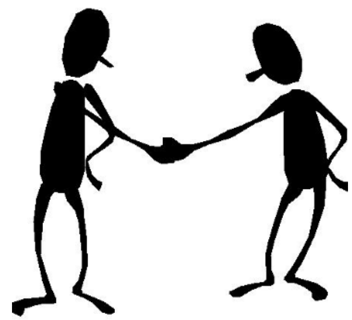




IR integration

- 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 ~2012
    - design according to Interface doc.





ILC-Note-2009-050
March 2009
Version 4, 2009-03-19

Functional Requirements on the Design of the Detectors and the Interaction Region of an e^+e^- Linear Collider with a Push-Pull Arrangement of Detectors

B.Parker (BNL), A.Mikhailichenko (Cornell Univ.), K.Buesser (DESY), J.Hauptman (Iowa State Univ.), T.Tauchi (KEK), P.Burrows (Oxford Univ.), T.Markiewicz, M.Oriunno, A.Seryi (SLAC)

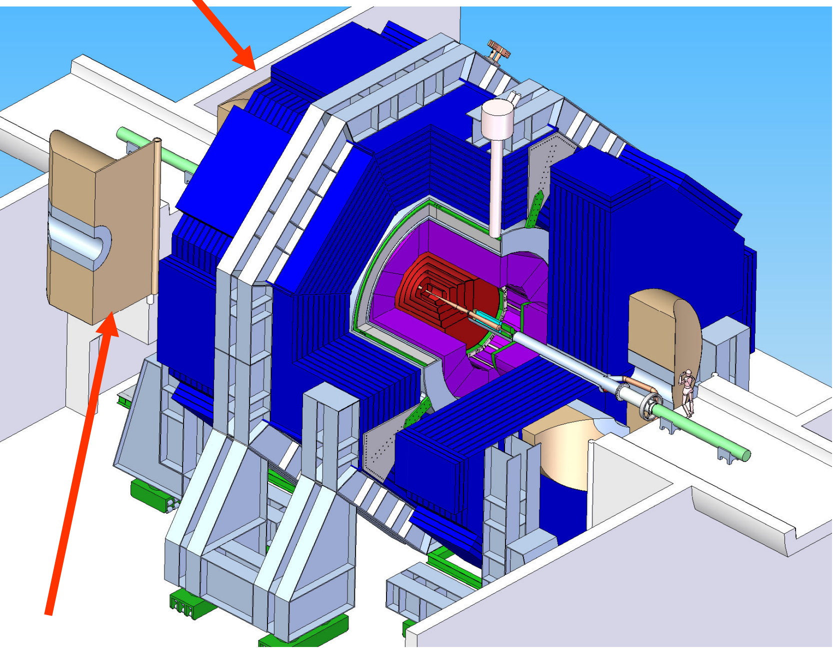
Abstract

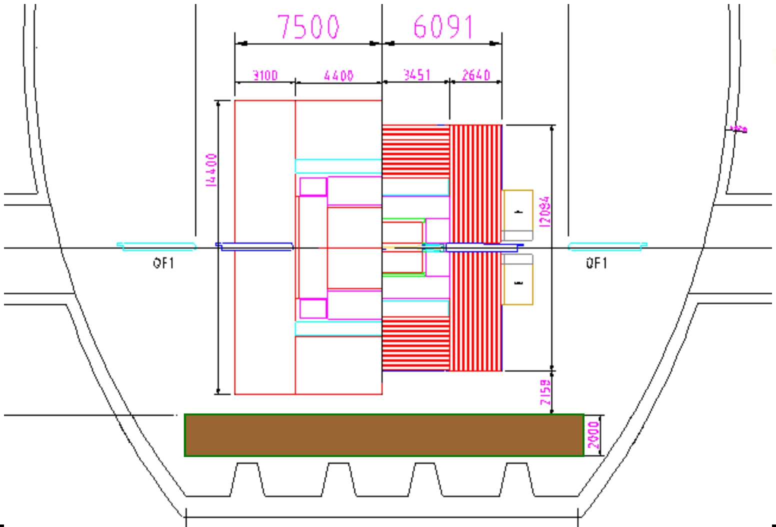
The Interaction Region of the International Linear Collider [1] is based on two experimental detectors working in a push-pull mode. A time efficient implementation of this model sets specific requirements and challenges for many detector and machine systems, in particular the IR magnets, the cryogenics and the alignment system, the beamline shielding, the detector design and the overall integration. This paper

http://ilcdoc.linearcollider.org/record/21354?ln=en

Example of MDI issues we are working on

Detector motion system with or without an intermediate platform



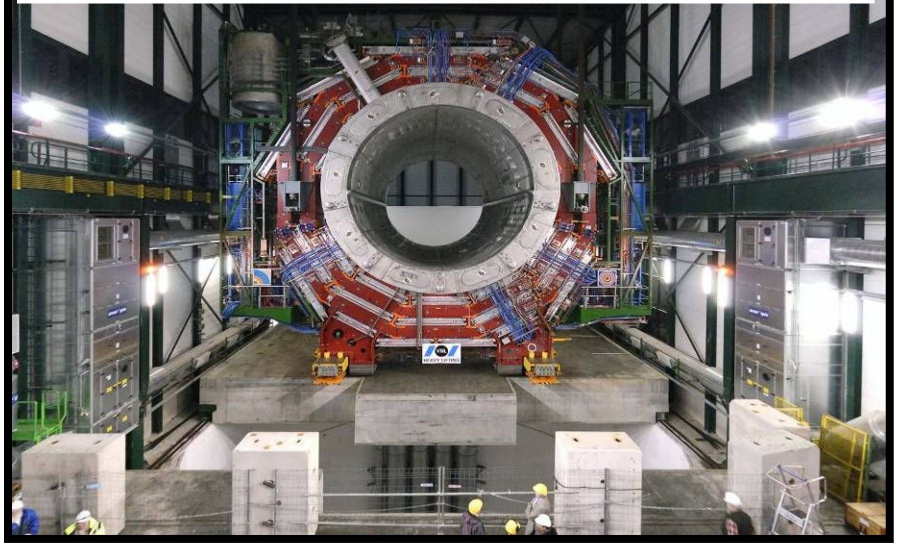


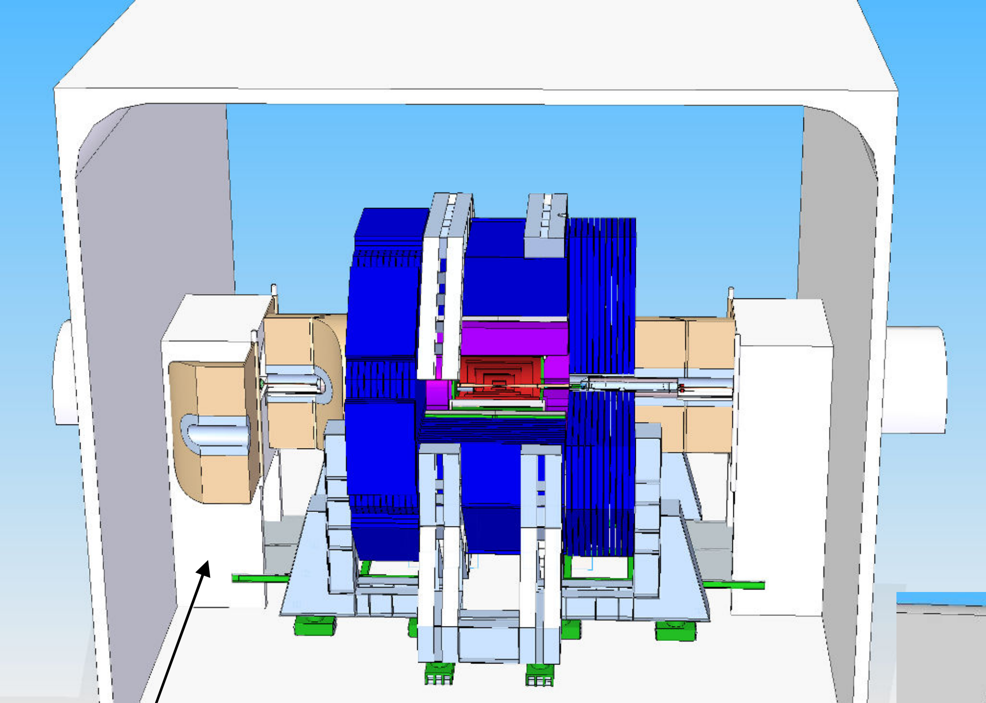
Detector and beamline shielding elements

Significant progress in design of these systems over summer 2009

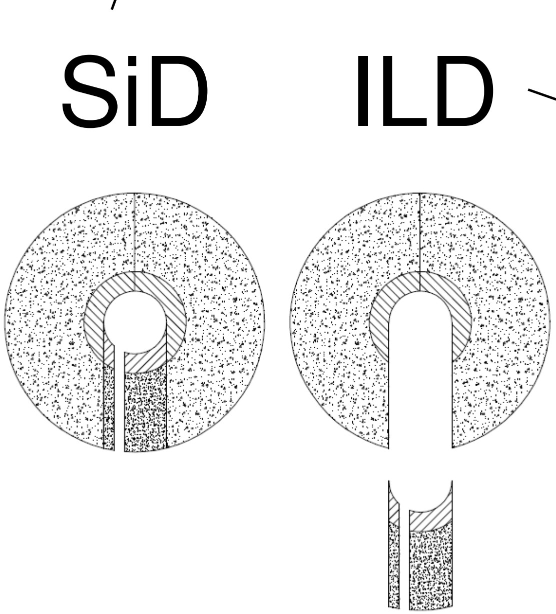
(Working mtg of CERN, DESY, SLAC, FNAL colleagues)

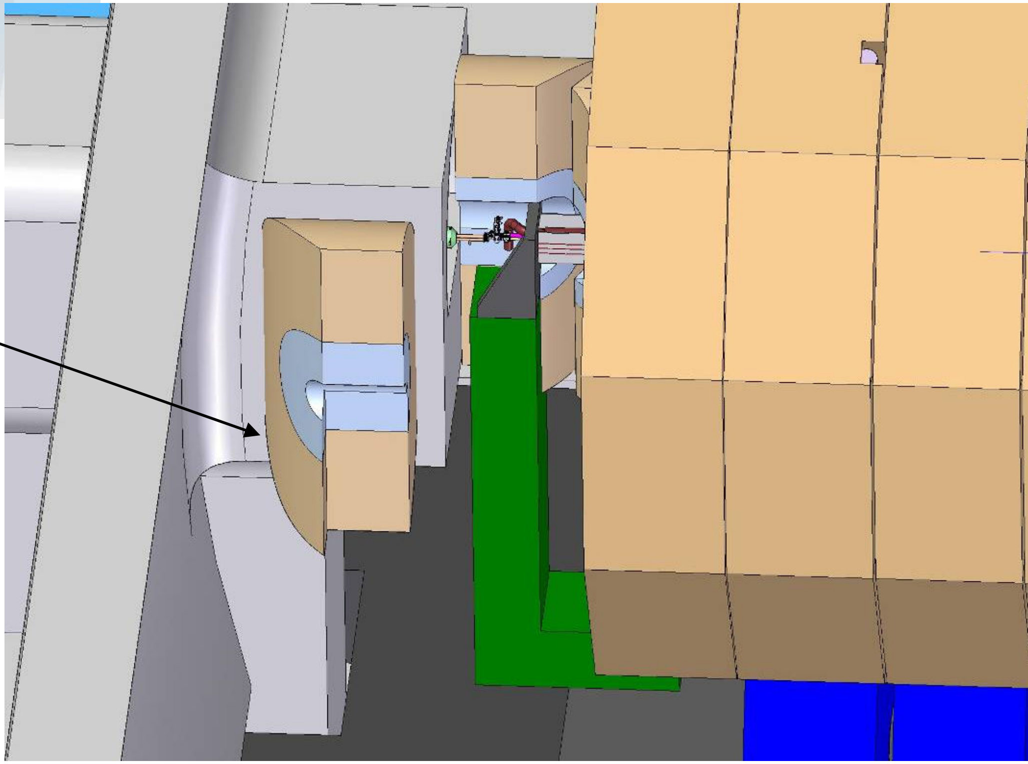
CMS platform – proof of principle for ILC





Example of system where initially different designs converged on a single compatible solution:
CMS-Inspired Hinged PacMan
w/ Cut-outs for ILD Pillar and Plugs

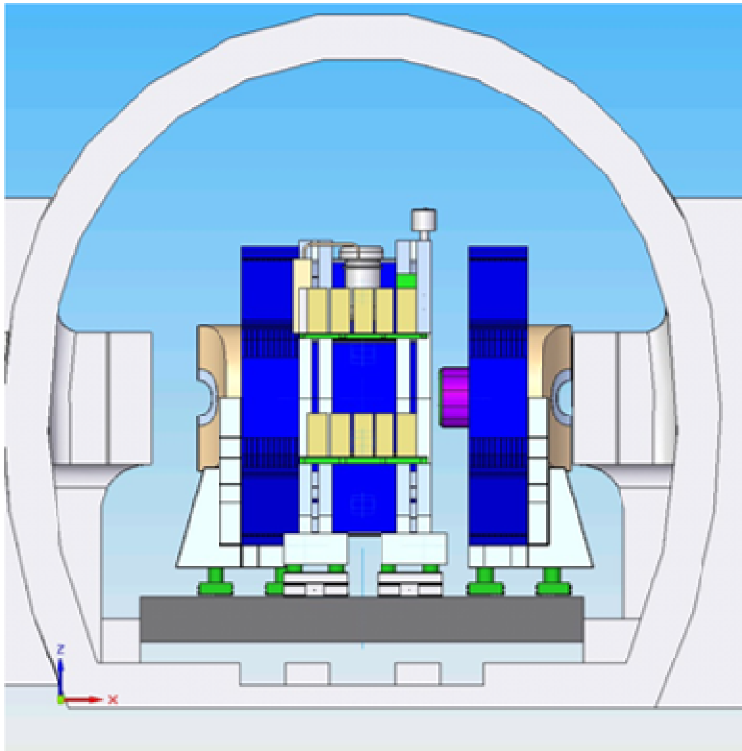




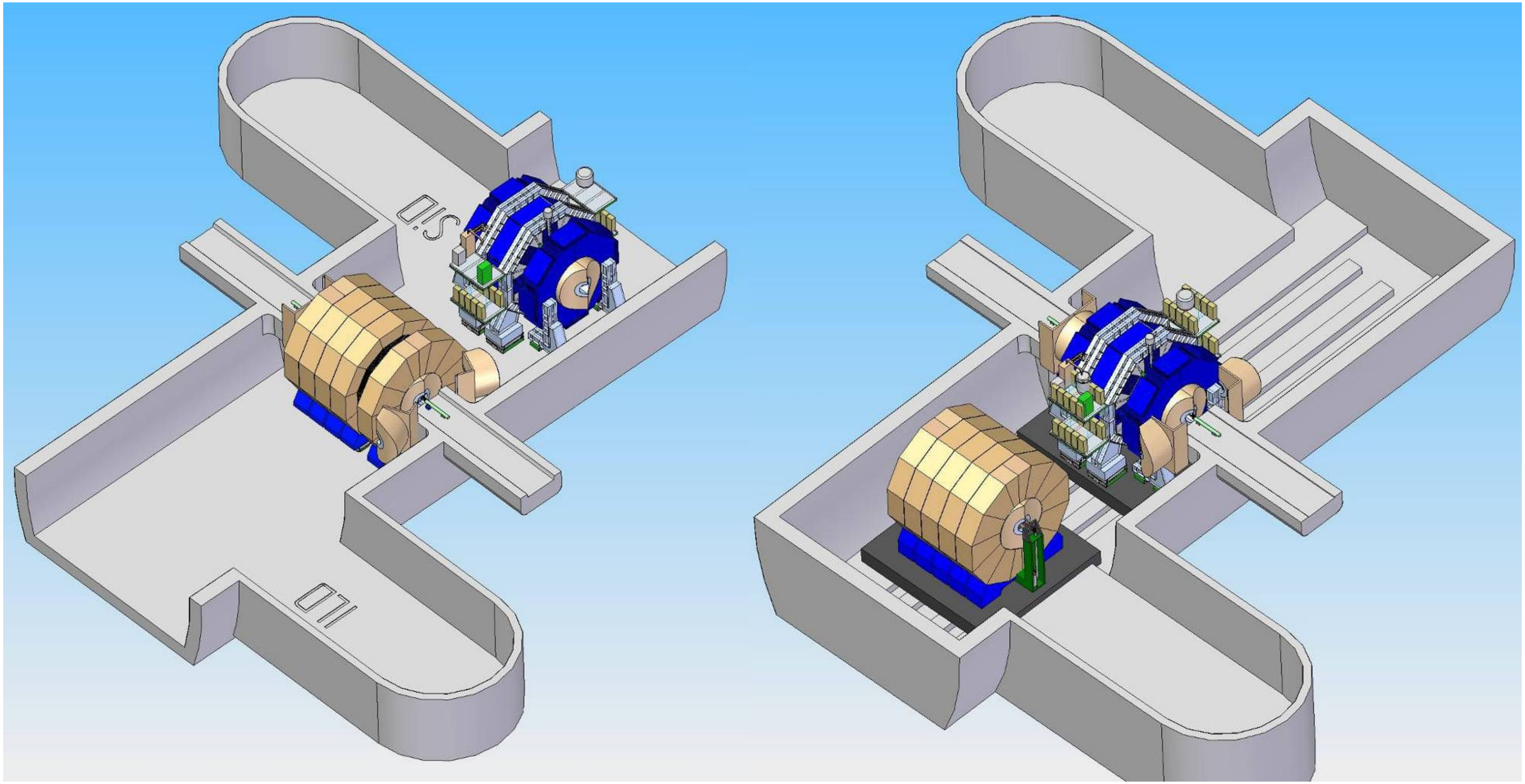
M.Oriunno, H.Yamaoka, A.Herve, et. al

Detector support and motion system

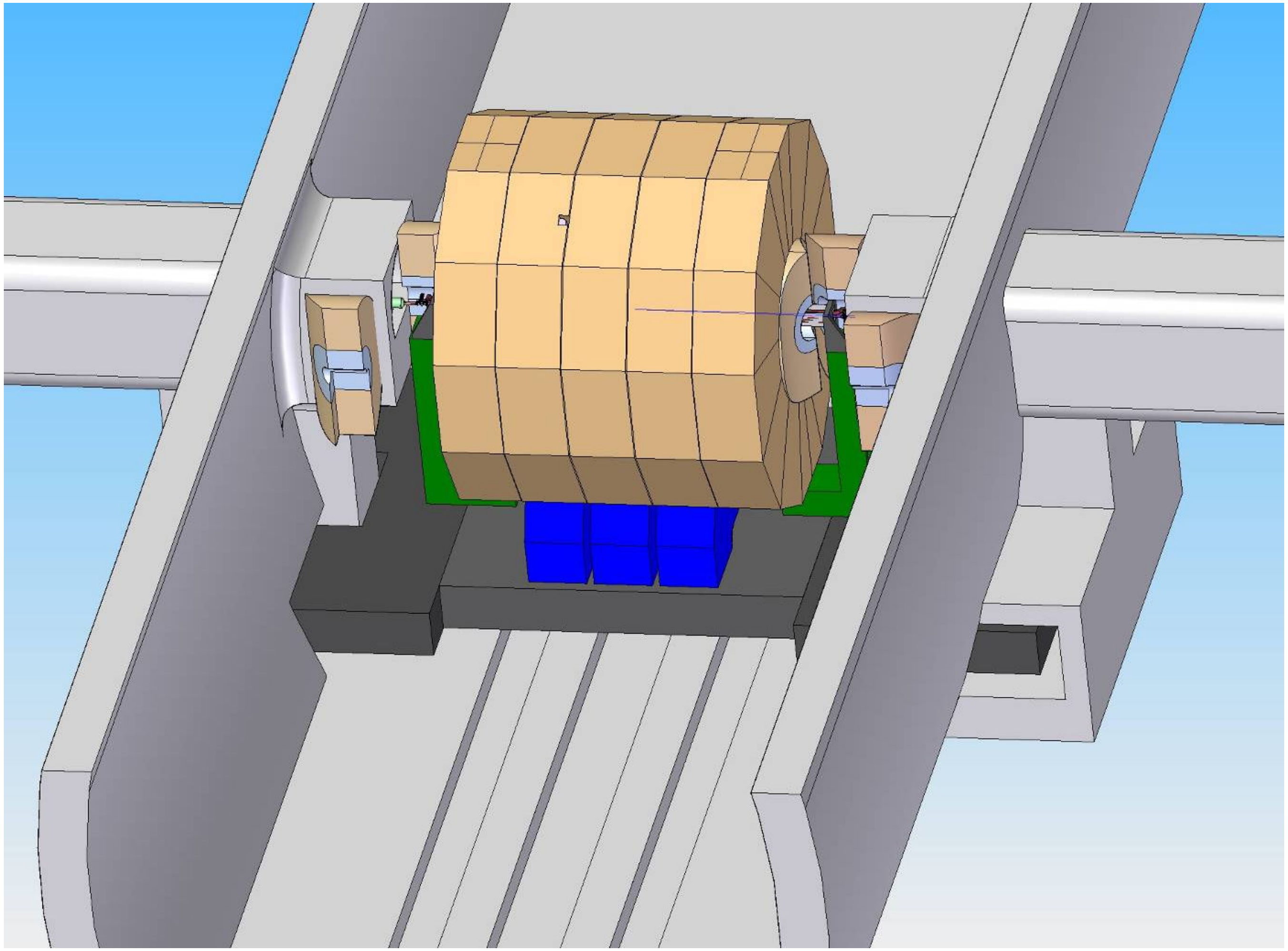
- The Summer working meeting, also focused on detector support and motion system
- Starting assumptions
  - ILD (segmented): use of a platform
  - SiD: without platform
- First step: aim to find a technical solution compatible with two presently different assumptions
- A solution was found (next slides)
- Conclusion: further progress depend on understanding how platform change detector and FD stability
- Consequently, detailed studies of detector stability have started



All detectors without / with platform

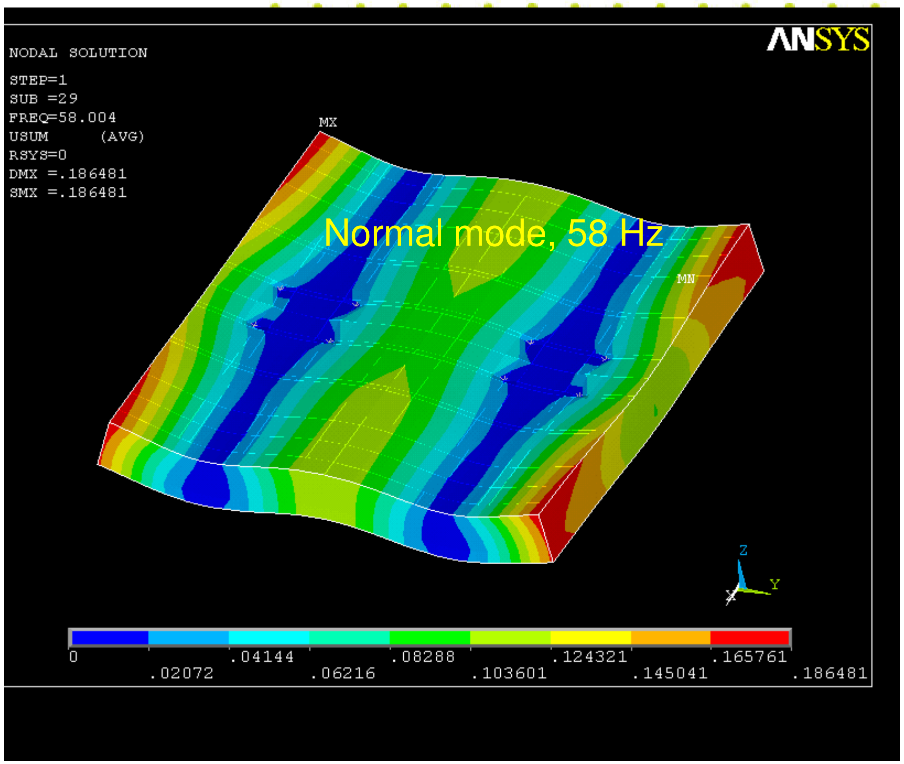


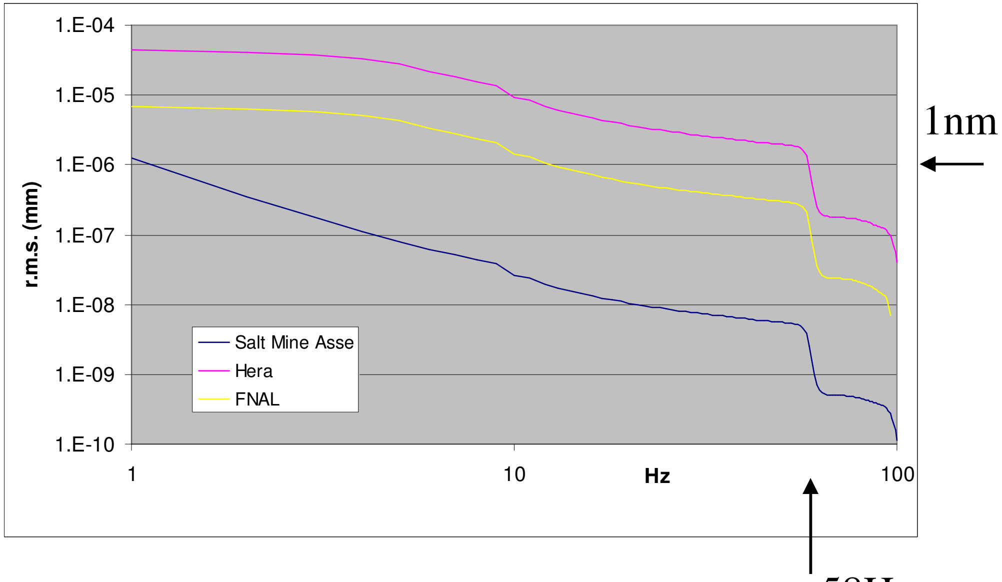
Half Platform w/ Pocket Storage



A.Herve, M.Oriunno, K,Sinram, T.Markiewicz, et al

Preliminary
ANSYS analysis of Platform

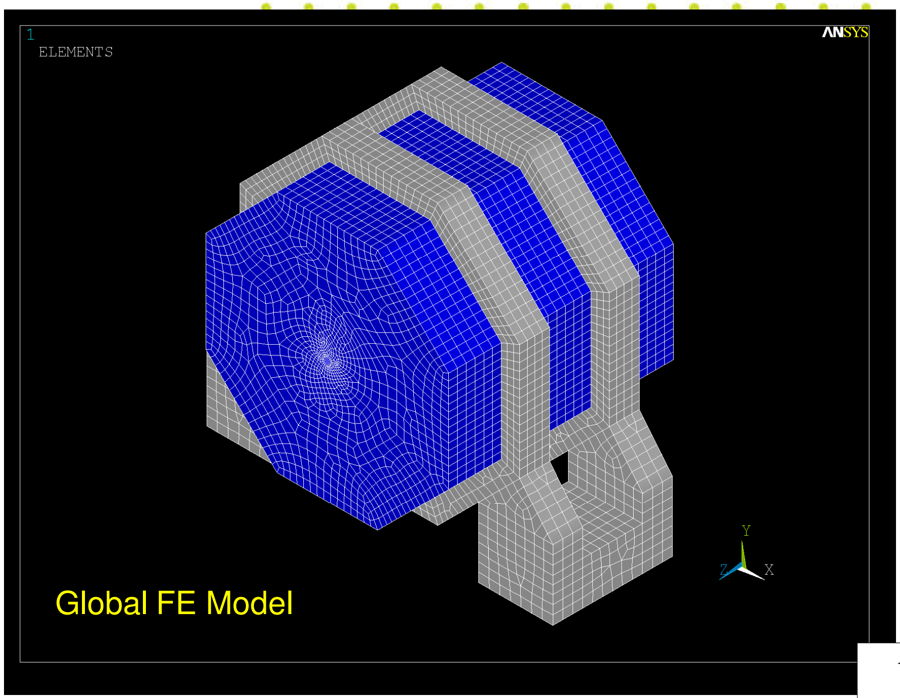


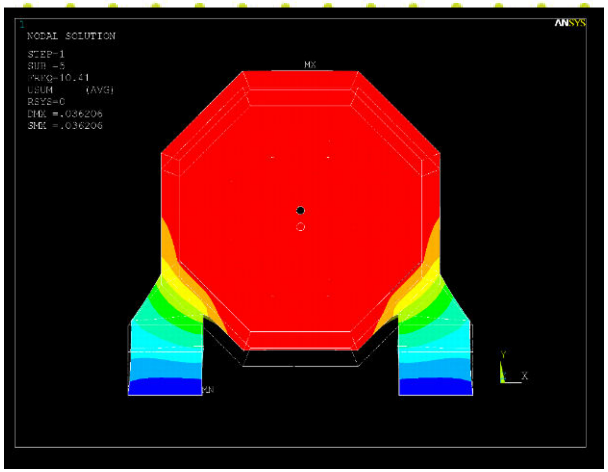


M.Oriunno

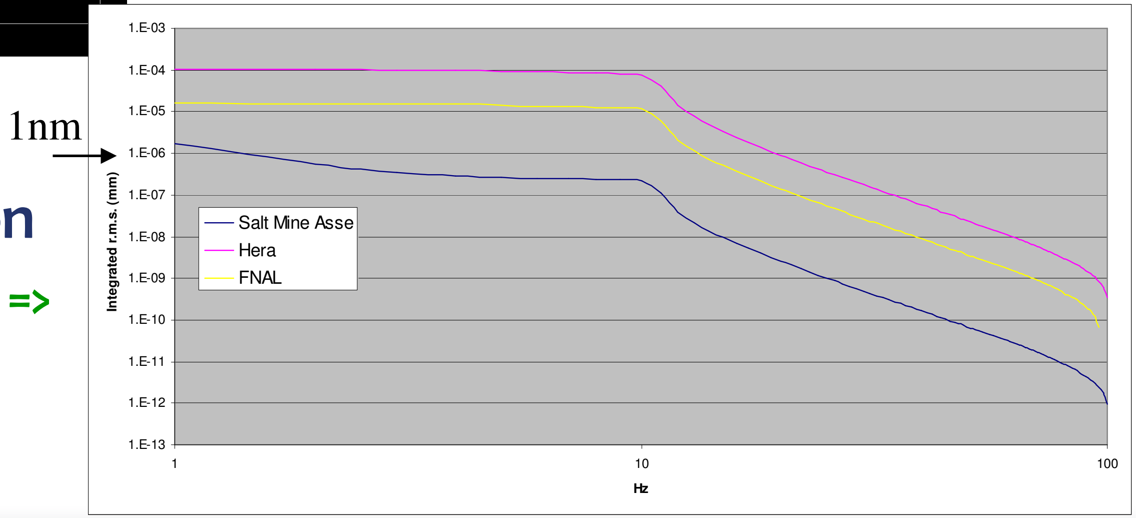
- First look of platform stability look rather promising: resonance frequencies are rather large (e.g. 58Hz) and additional vibration is only several nm

Detector stability analysis (SiD)



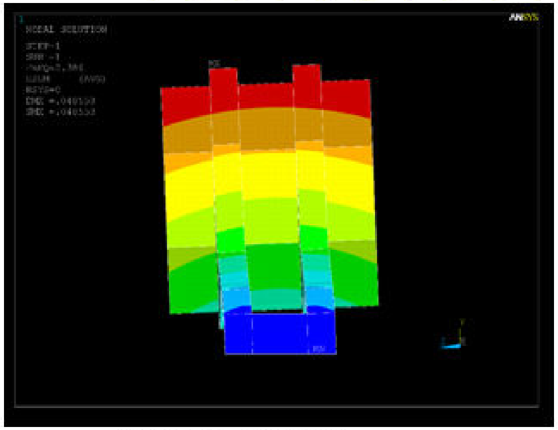


First vertical motion mode, 10.42 Hz

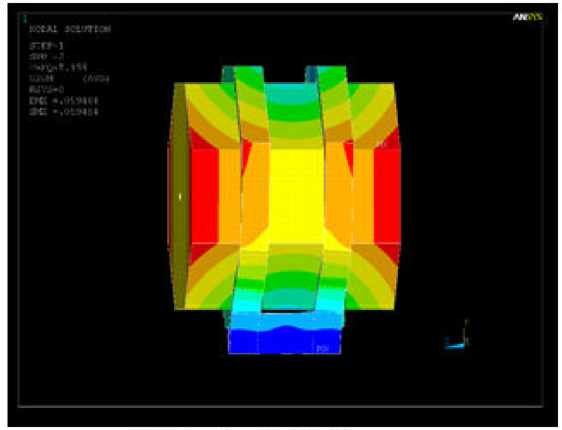


- First analysis shows possibilities for optimization
  - e.g. tolerance to fringe field => detector mass => resonance frequency

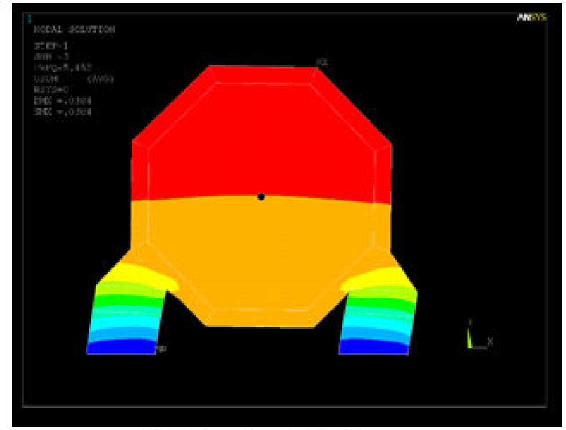
Free vibration modes of SiD



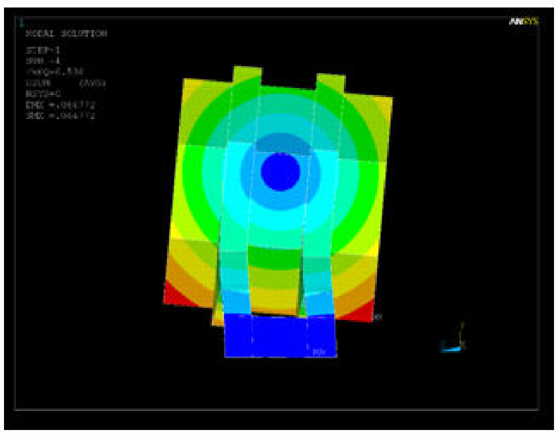
1^{st} Mode, 2.38 Hz



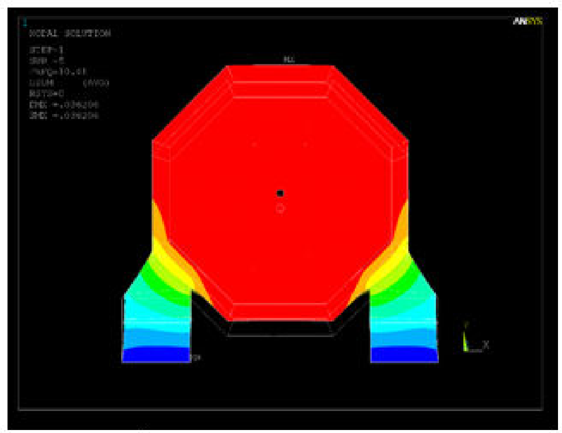
2^{nd} Mode, 5.15 Hz



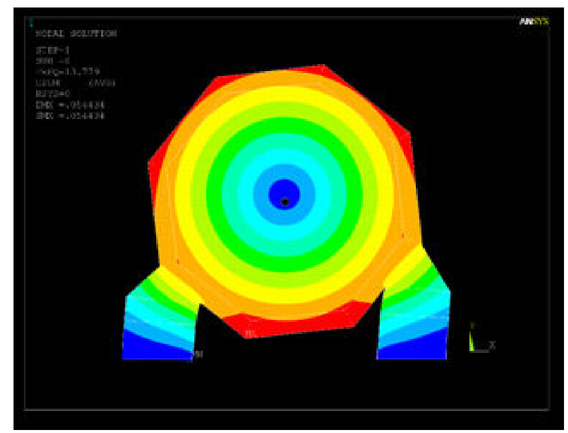
3^{rd} Mode, 5.45 Hz



4^{th} Mode, 6.53 Hz



5^{th} Mode, 10.42 Hz

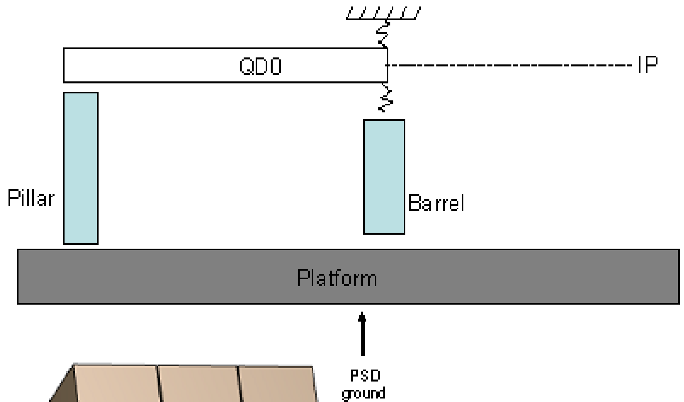


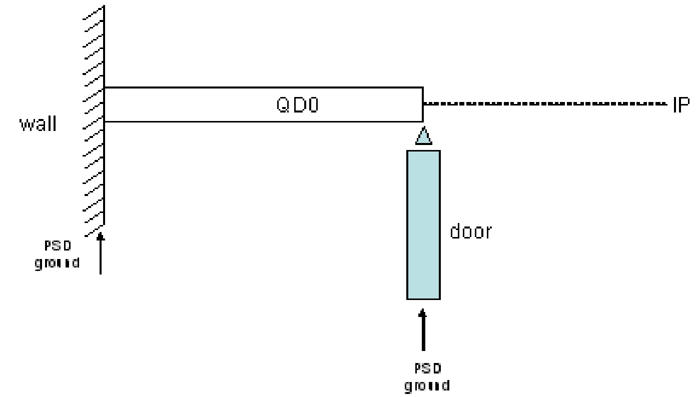
6^{th} Mode, 13.7 Hz

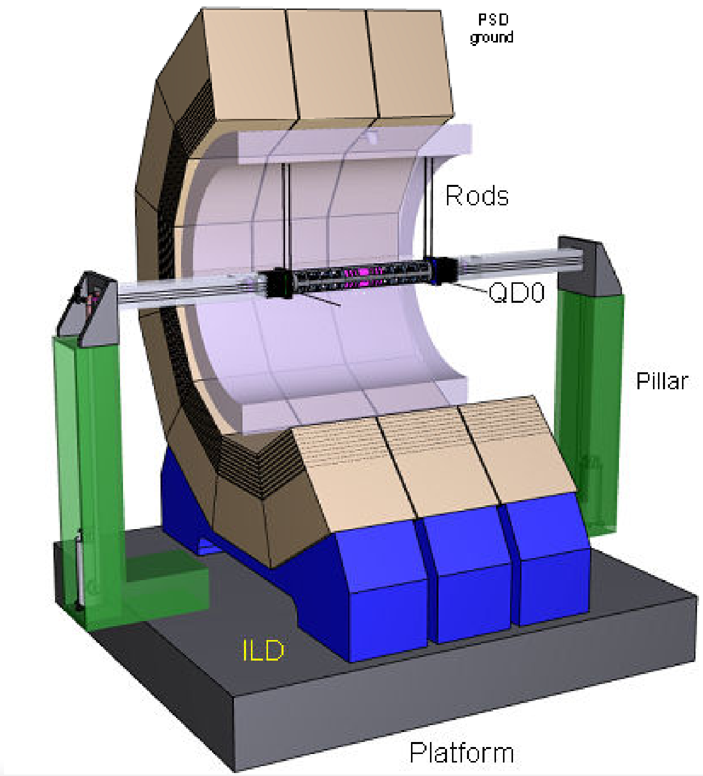
Vertical motion

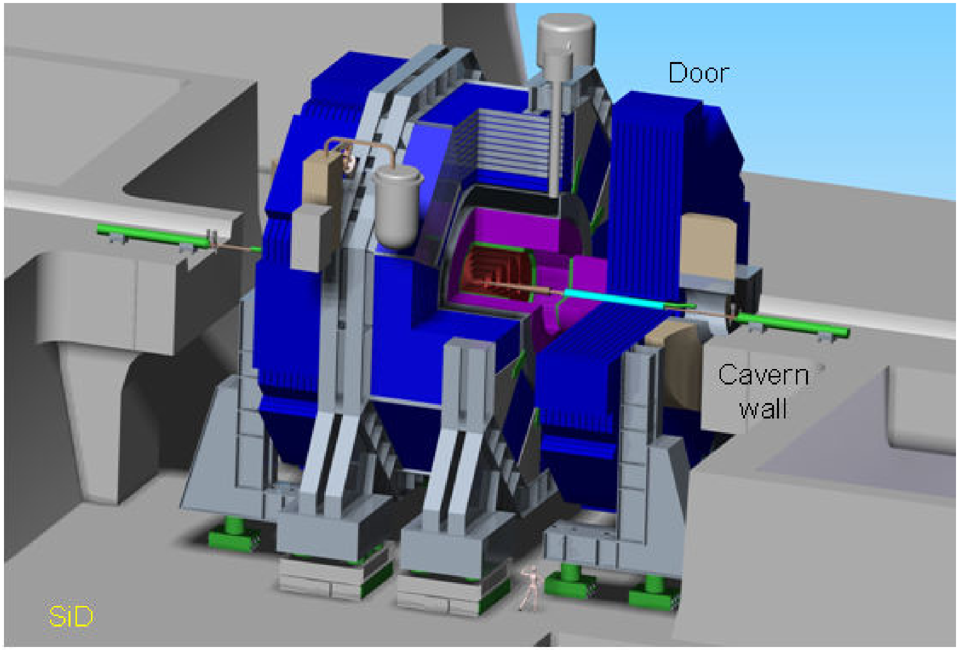
M.Oriunno

QD0 supports in ILD and SiD





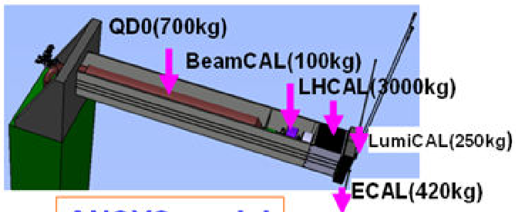




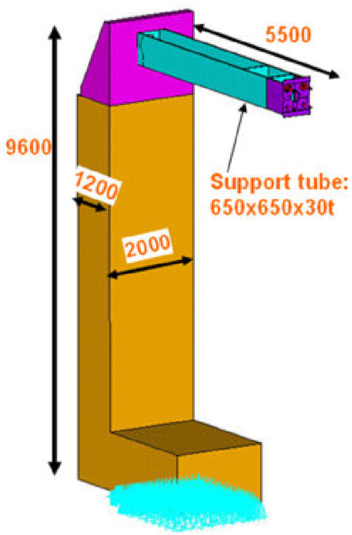
ILD FD stability analysis results

Results: Responded amplitude at each resonance.

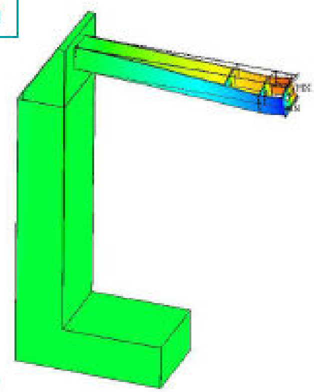
@ KEK-ATF	
0.1Hz	$1e\text{-}5 m/s^2$
1Hz	$6e\text{-}4 m/s^2$
10Hz	$6e\text{-}4 m/s^2$
100Hz	$2e\text{-}3 m/s^2$



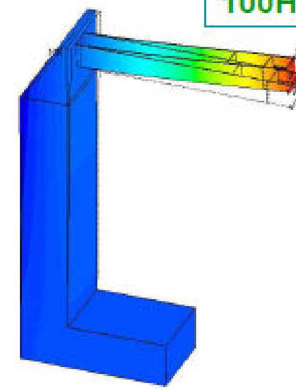
ANSYS model



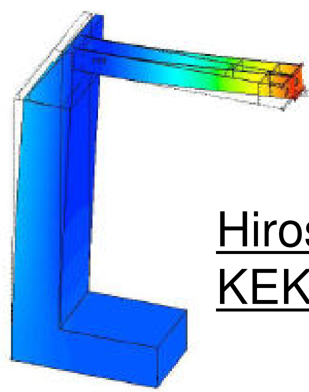
4.5Hz
1.5nm



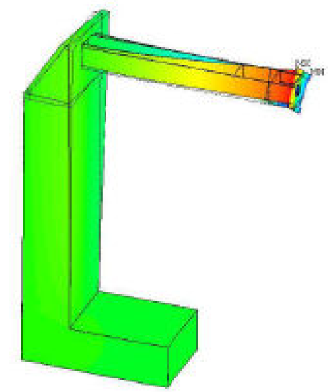
7.9Hz
240nm



10.4Hz
50nm



13.6Hz
0.3nm



Hiroshi Yamaoka, KEK

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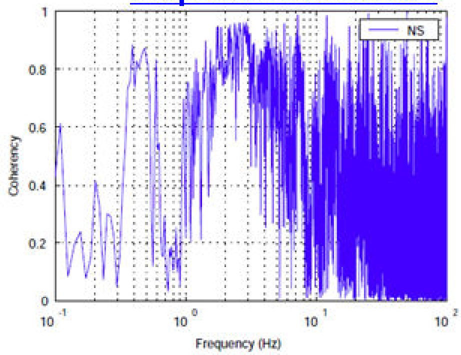
Stability studies at BELLE

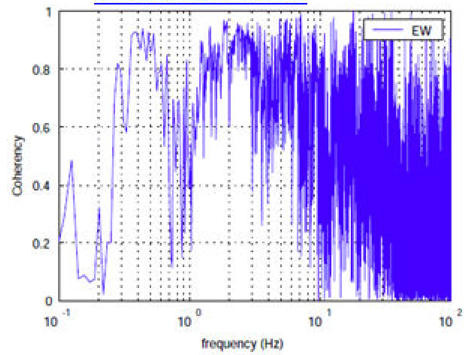
Measurement: B

How is the coherency between the tunnel and floor?

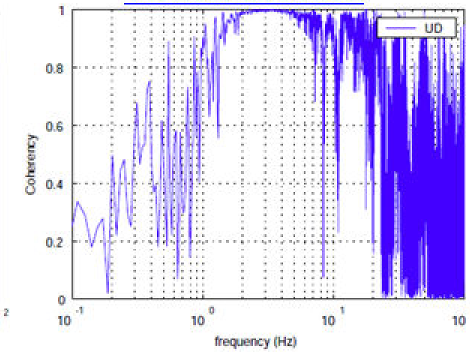
Perpend. to beam line

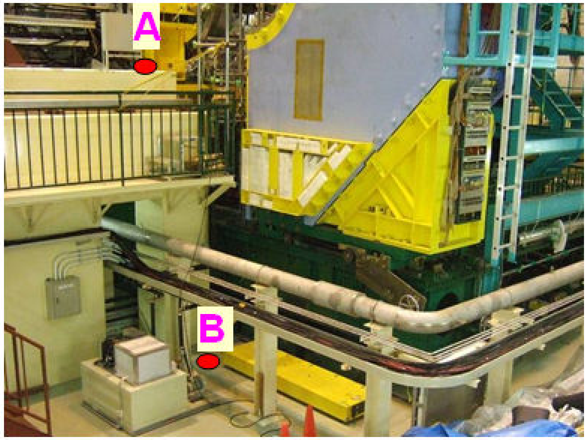


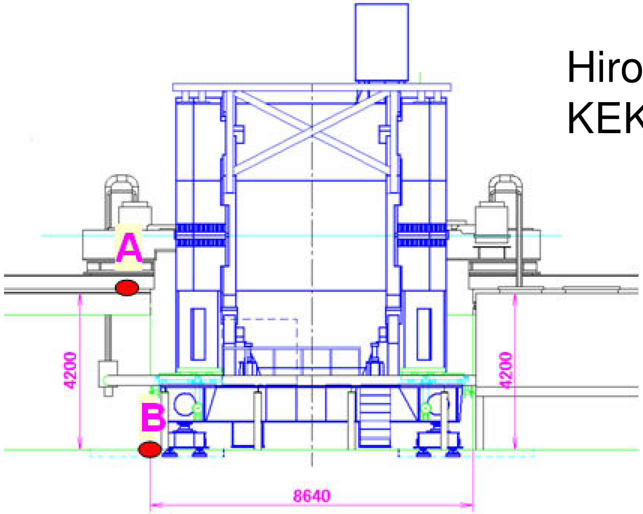
Beam direction



Vertical direction







Hiroshi Yamaoka, KEK

- Horizontal dir.: 0.~Hz, ~3Hz
- Vertical dir.: 1 ~ 20Hz

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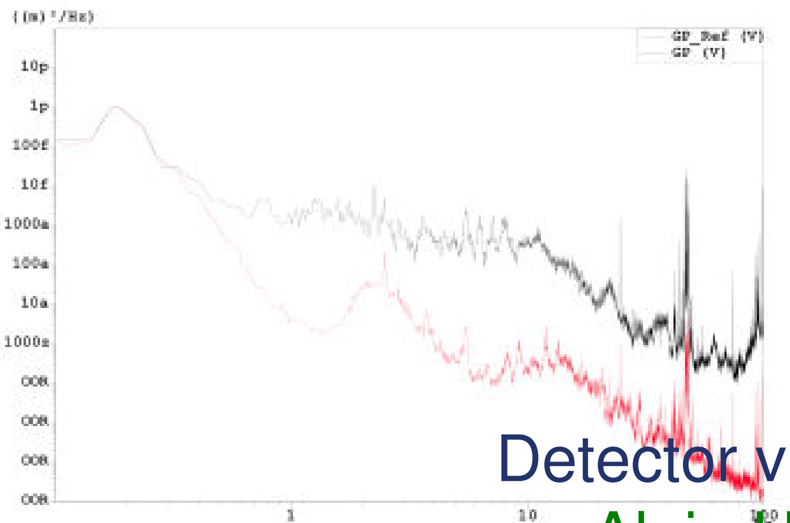
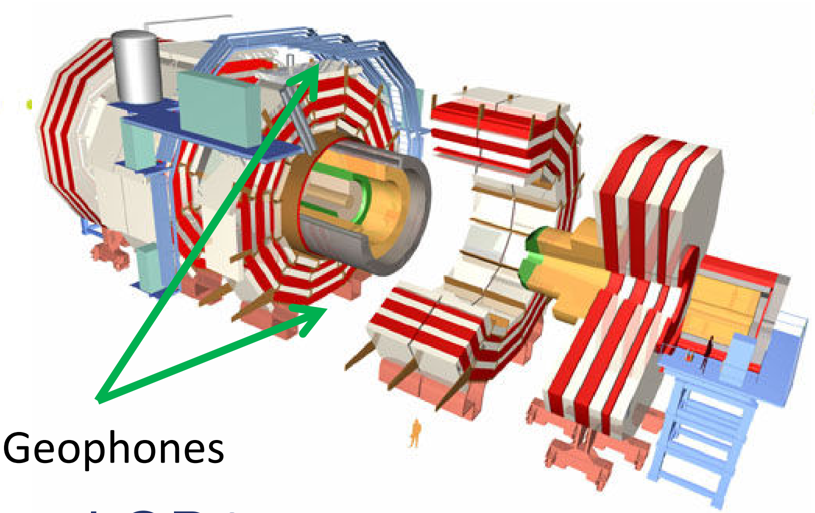
CMS top of Yoke measurement

PSD of the signals Vertical direction



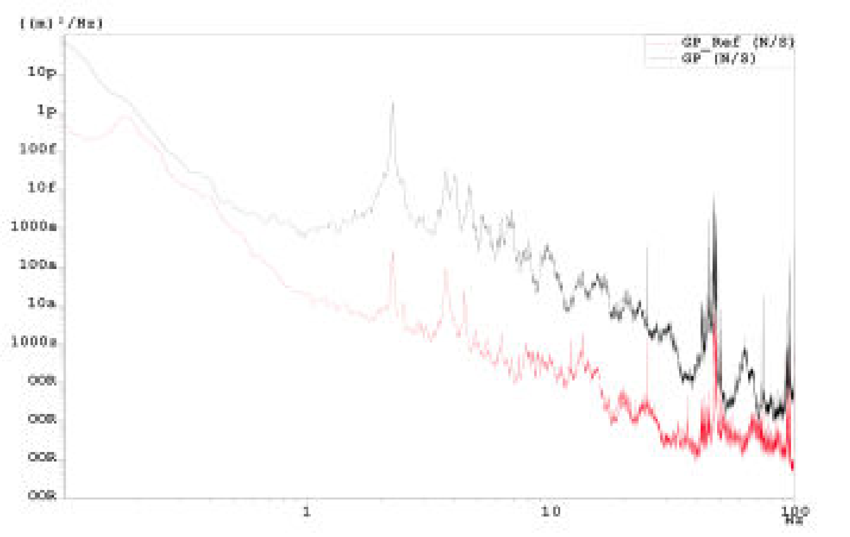


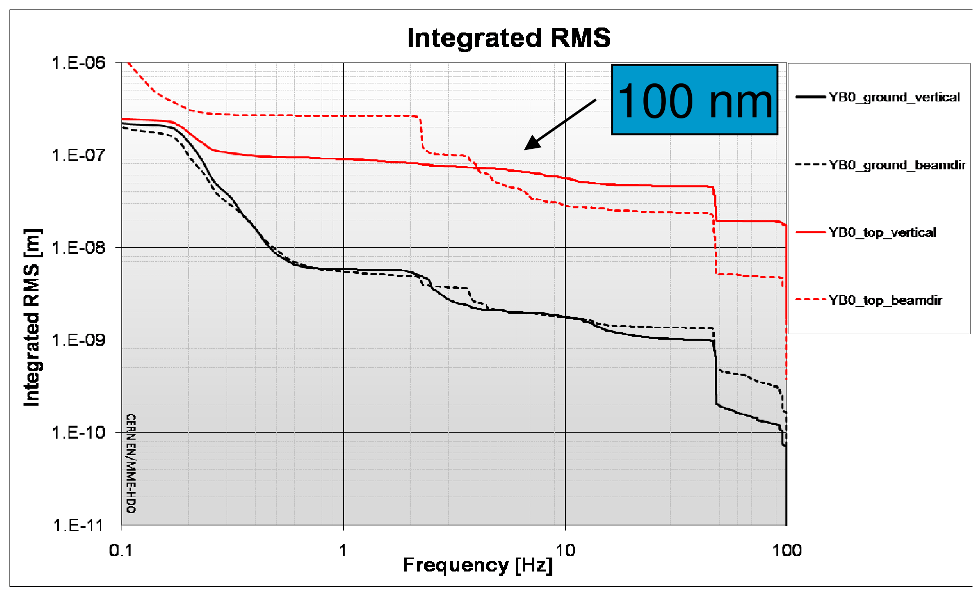
Detector vibrations and QD0 support

Alain Herve (ETH Zurich)

Cooling system OFF

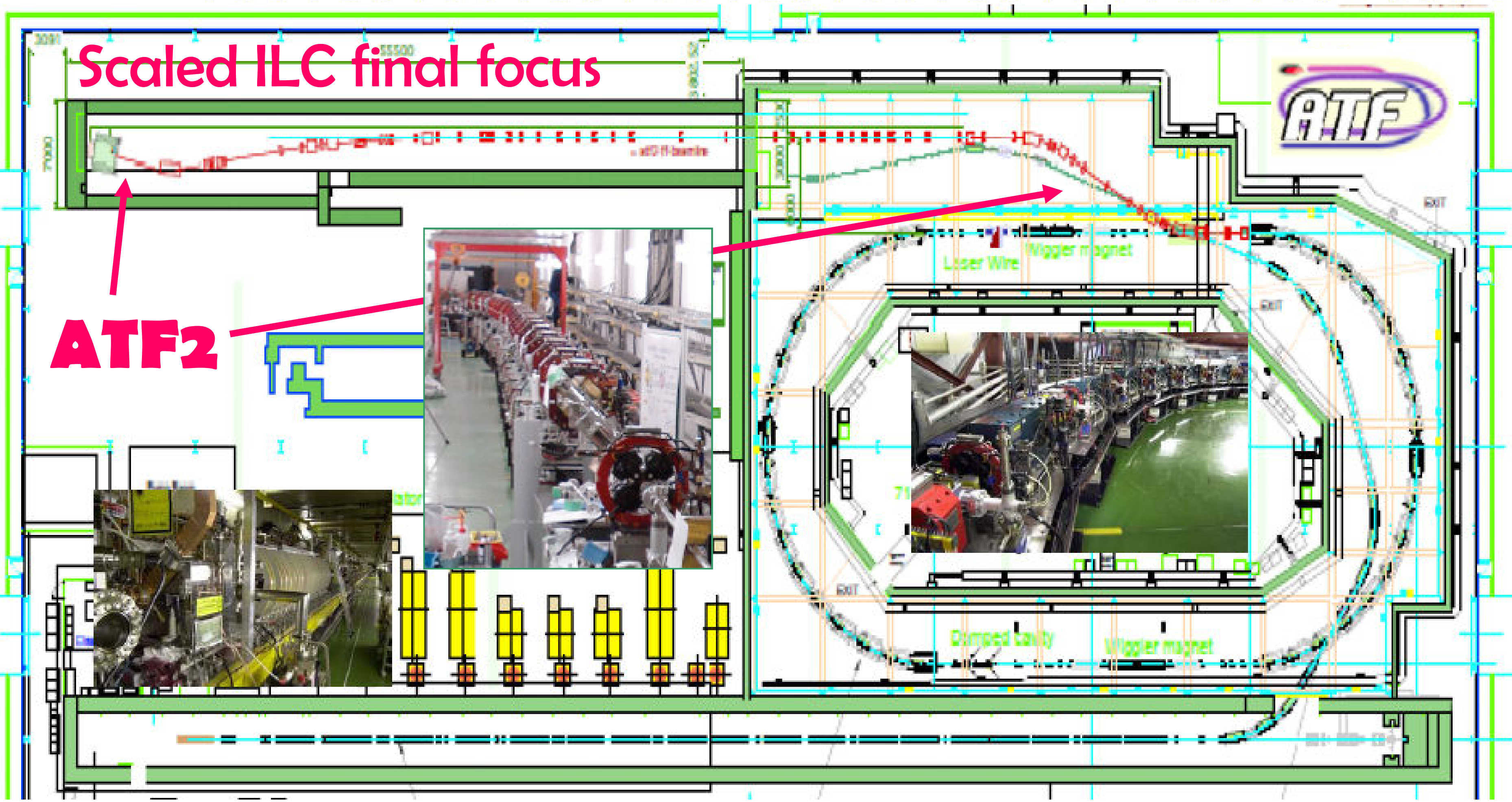
PSD of the signals Beam direction



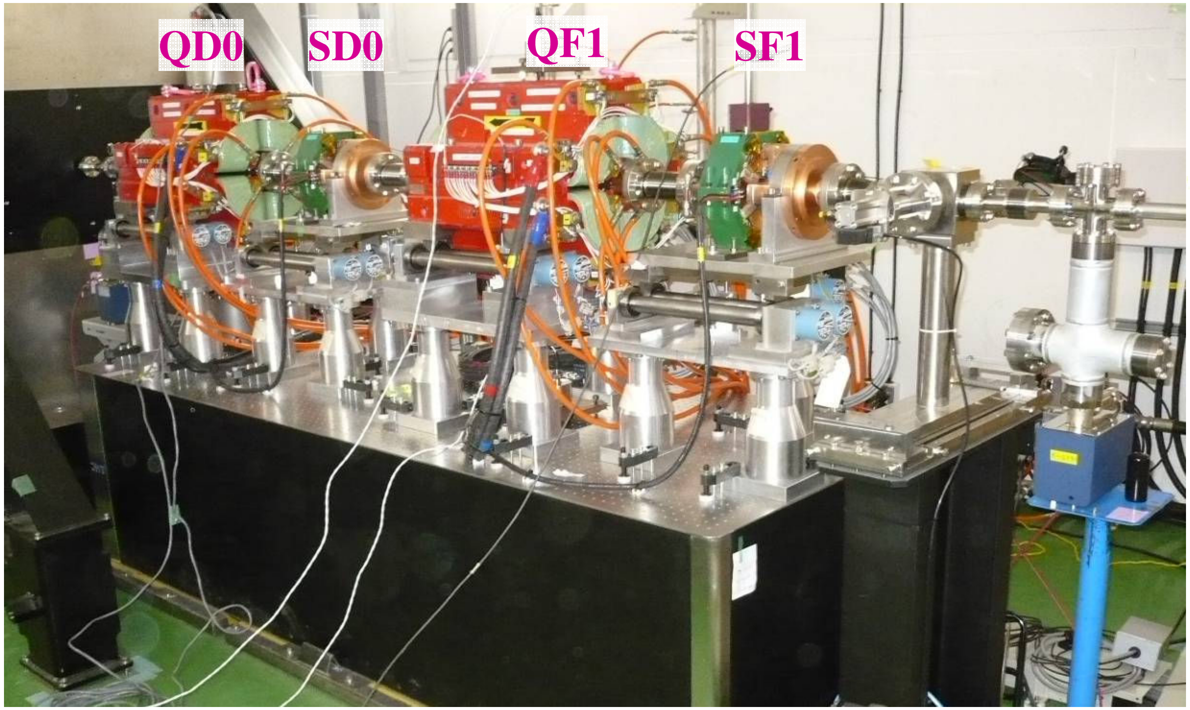


ATF2: model of ILC beam delivery

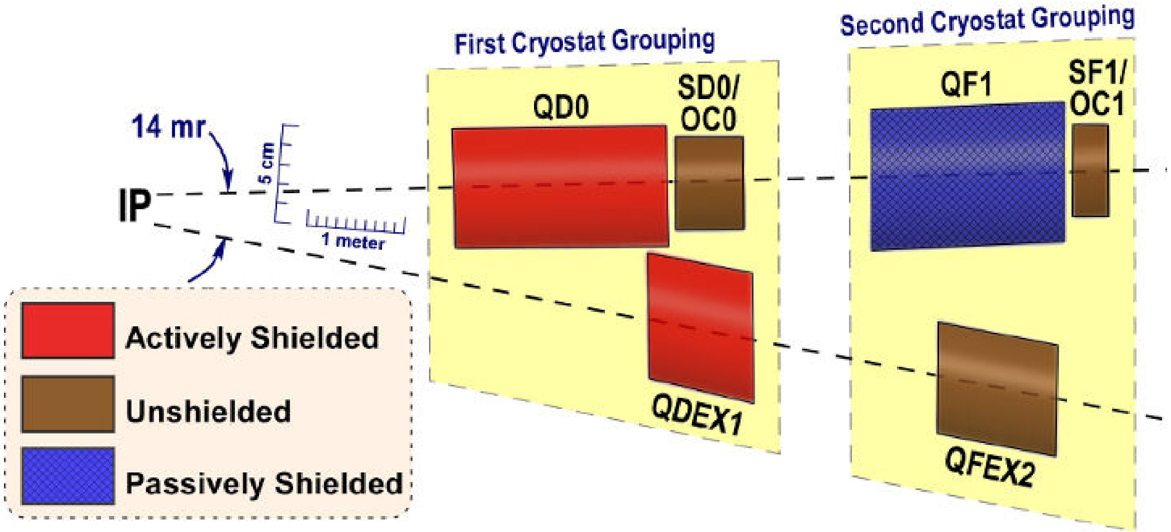
goals: ~37nm beam size; nm level beam stability



- 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



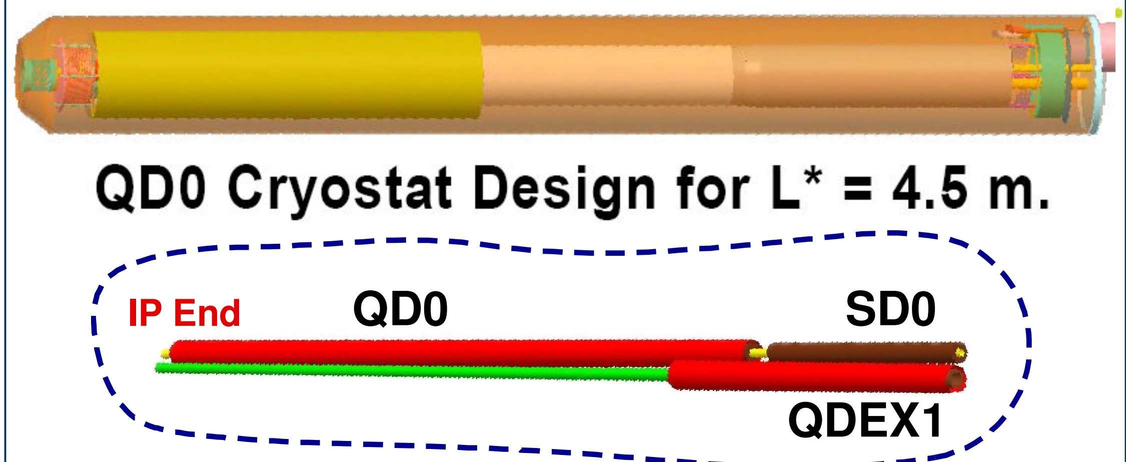
ATF2 final doublet



ILC Final Doublet layout

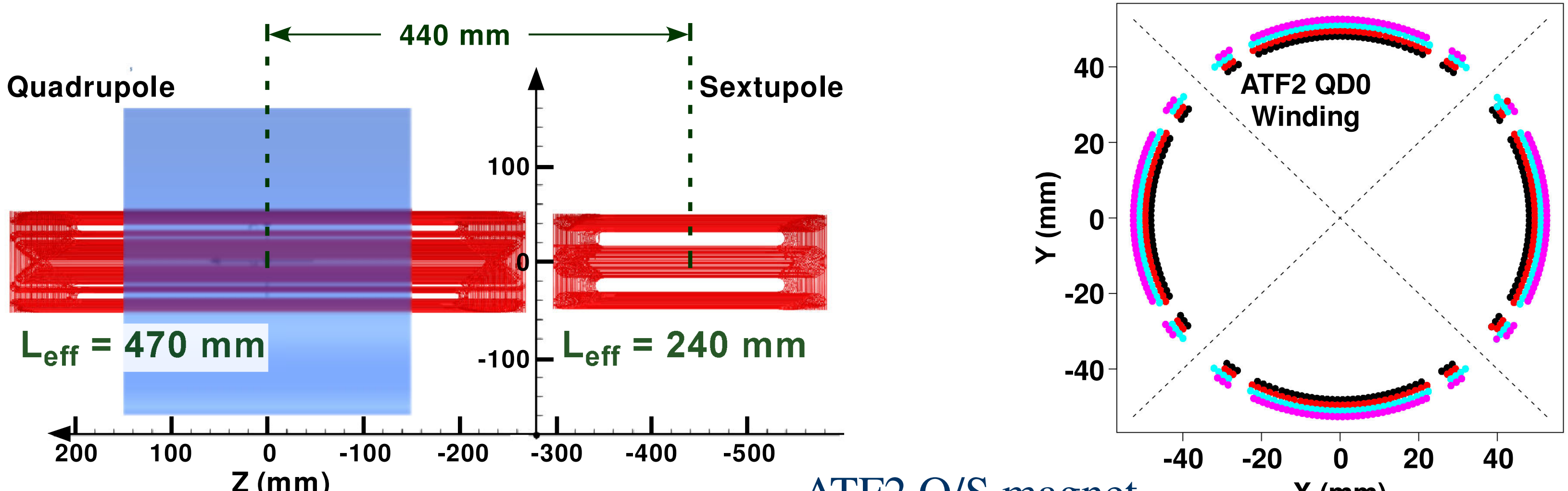
SC Final Doublet and ATF2 tests

- 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



ILC design

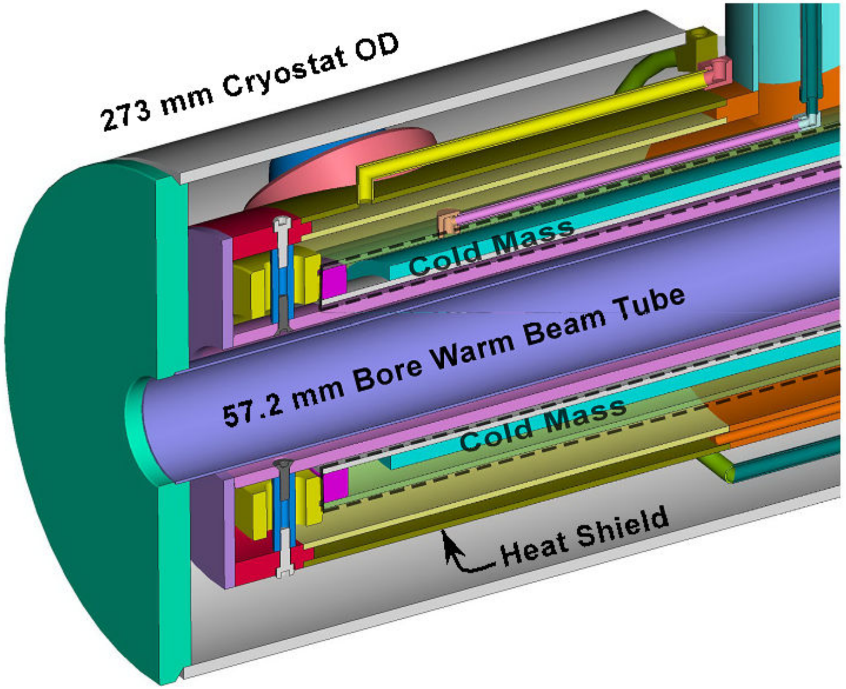
Brett Parket, at al, BNL

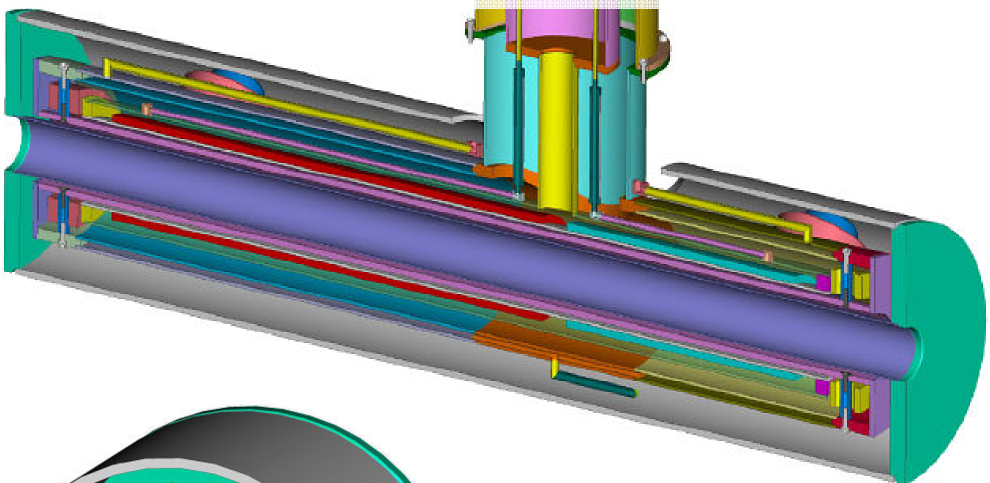


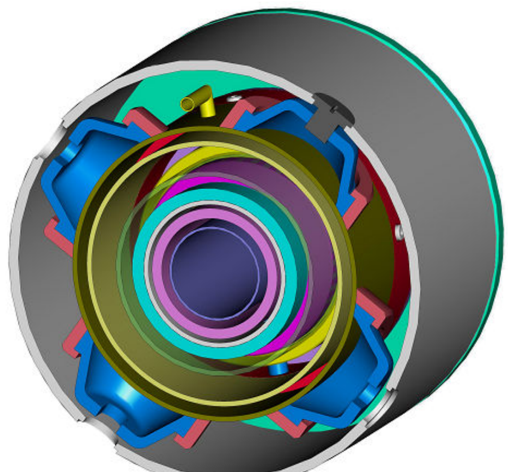
ATF2 Q/S magnet

SC FD for ATF2

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

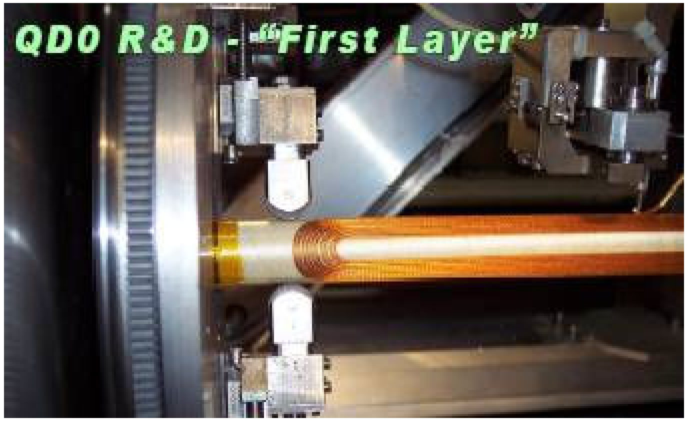




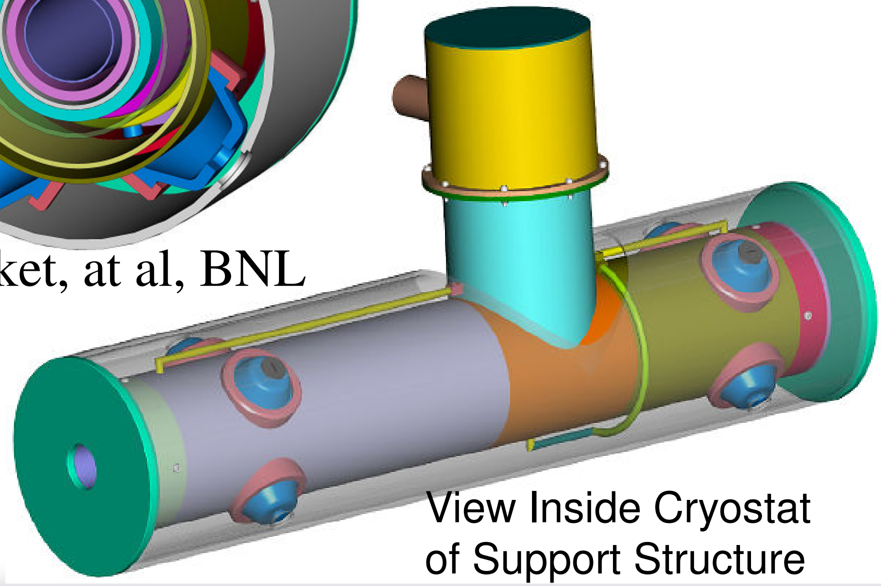


Cross Section View at Support Location

Brett Parket, at al, BNL

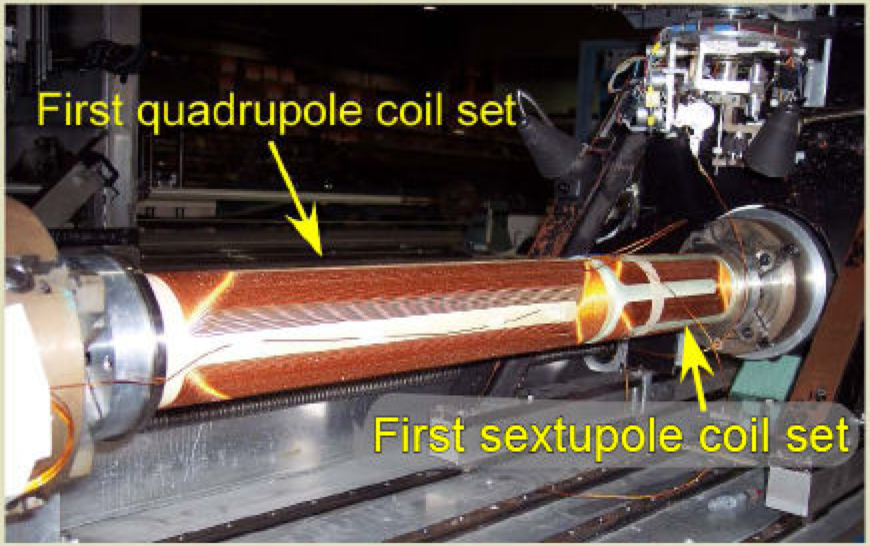


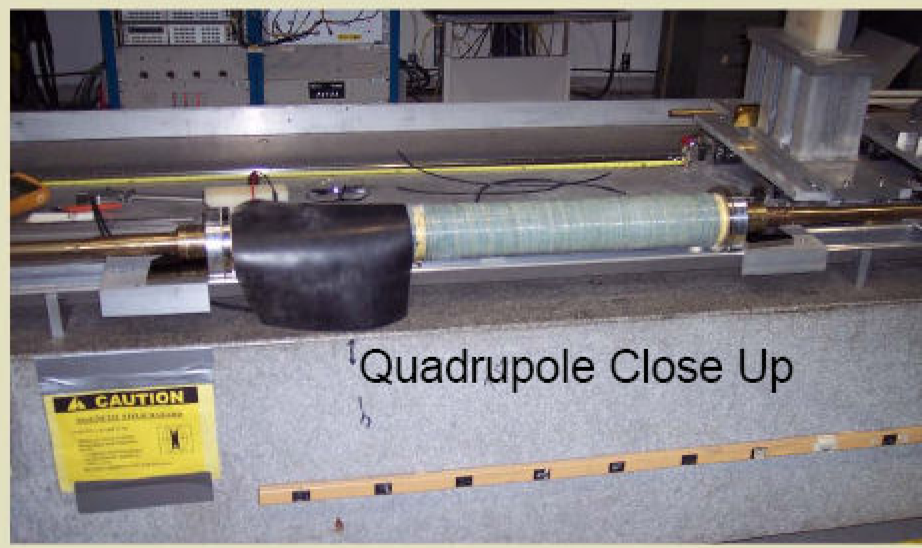
Long coil winding



View Inside Cryostat of Support Structure

Start of ATF2 coil production & measurement





BNL, Brett Parker et al

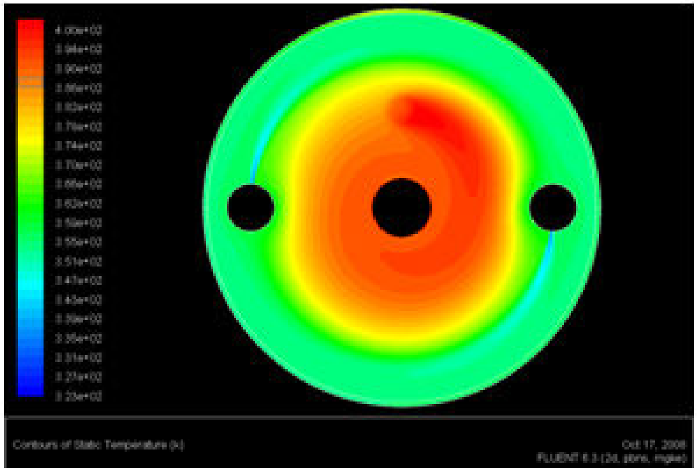
Cryogenic system design

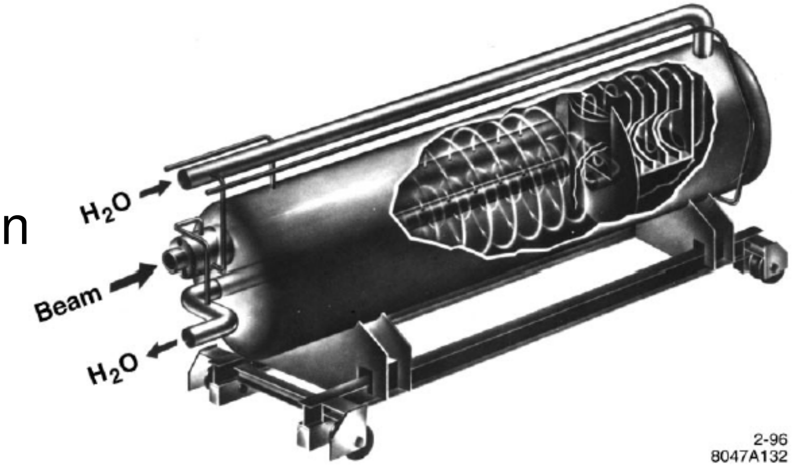
- Design of cryogenic system is critically important
- KEK and BNL colleagues started series of working meetings to develop complete cryogenic system / FD cryostat design
  - Proposal for the cooling scheme @ ATF2: Re-condensation cooling type with low vibration cryo-coolers.
  - Modification of design to the FD cryostat, to reduce heat load is considered, for better match to the cryo-system solution
- Joint plan / budget / schedule will be developed

N. Kimura, A. Yamamoto, T. Tomaru, K. Tsuchiya, and T. Tauchi (KEK), B.Parker, A.Marone, (BNL) et al

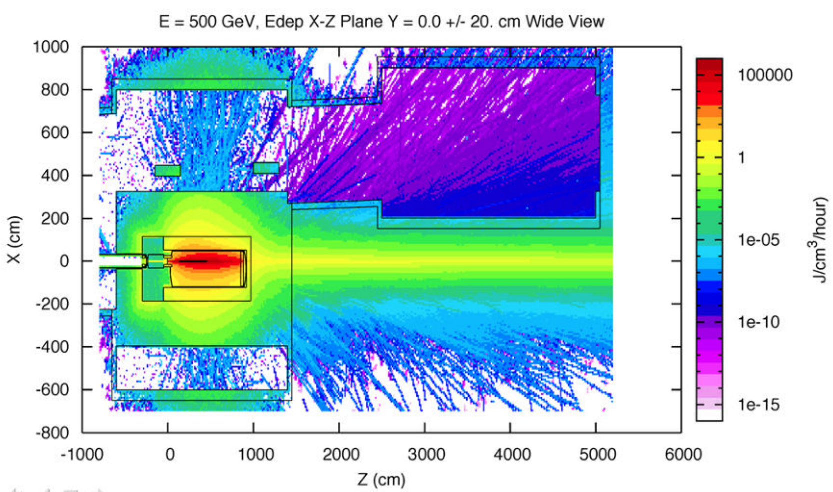
18MW Beam dump

- BARC, India, & SLAC, collaboration





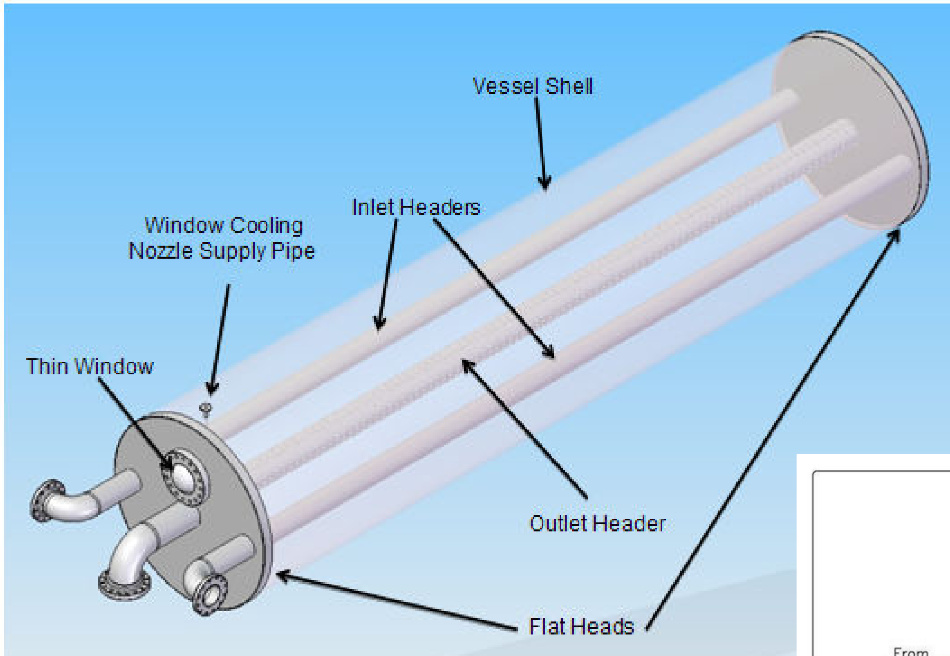
Steady state temperature distribution at z=2.9m (Max. average temperature 127°C)

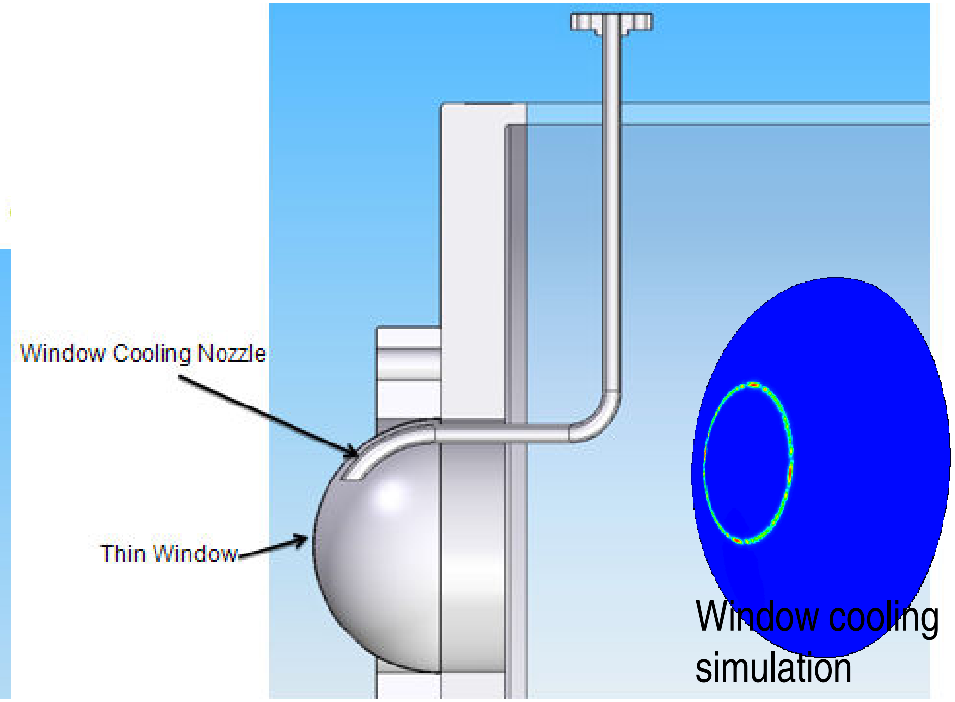


Dieter Walz, Ray Arnold, Satyamurthy Polepalle (BARC, India), John Amann, at SLAC beam dump area (February 2008)

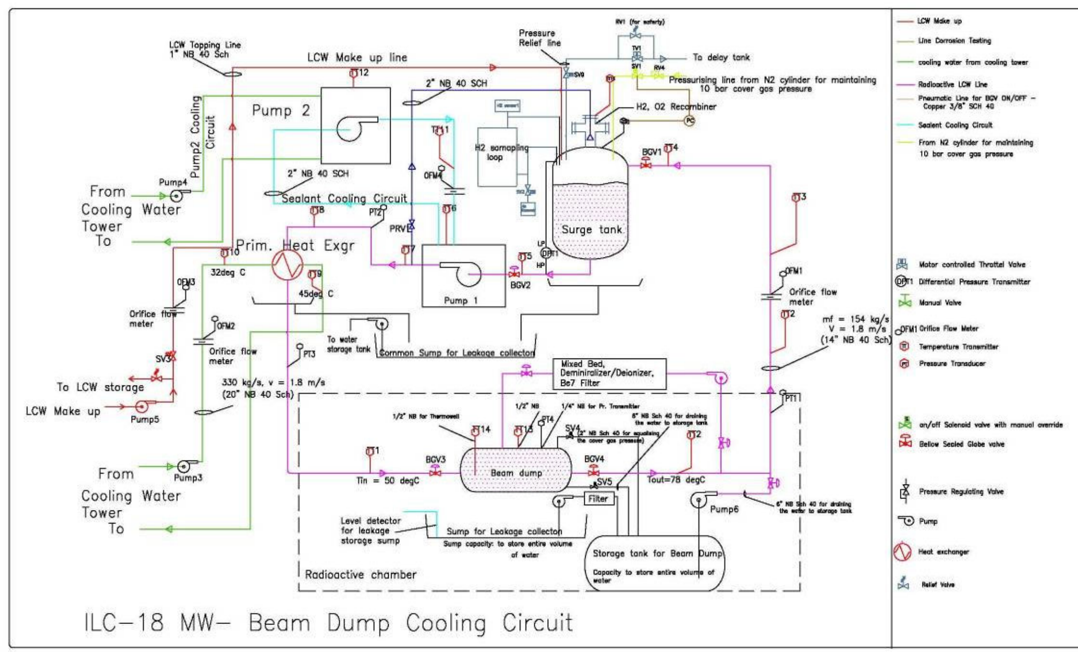
Had working meeting of the task force at SLAC in June 2009, have advanced the work on beam dump design and on its technical design report

Beam dump design



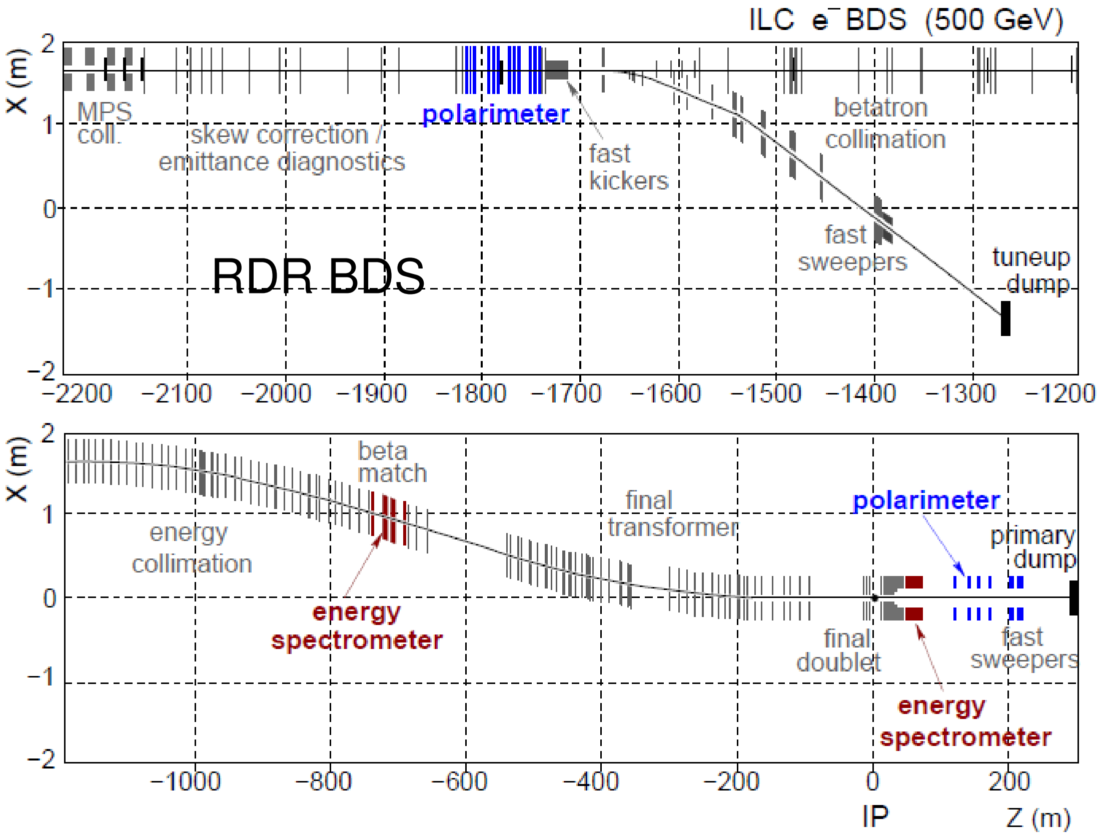


SLAC National Accelerator Laboratory:
J. Amann, R. Arnold, D. Walz, A. Seryi
Bhabha Atomic Research Centre:
P. Satyamurthy, P. Rai, V. Tiwari, K. Kulkarni



Energy and Polarization diagnostics

- Upstream and downstream diagnostics:
  - control systematics, measure effects of beam-beam interaction
  - R&D: system integration tests, reduction of systematic effects

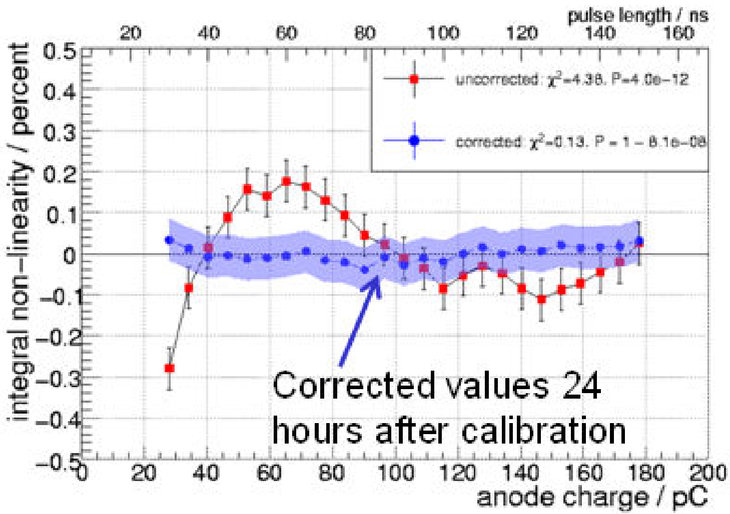


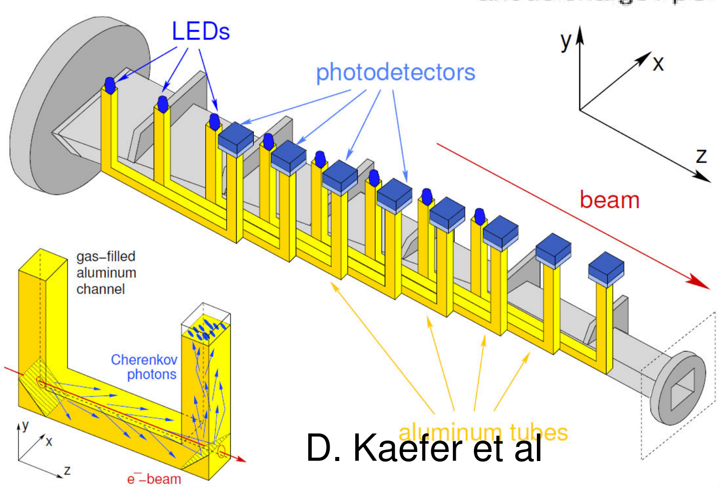
Accuracy driven by Physics:

- $\Delta E_{beam}/E_{beam}$ ~ 100-200 ppm
  - precision measurements of particle masses
  - Spectrometer techniques
- $\Delta P/P$ ~ 0.25%
  - Precision EW
  - Evolution of SLC polarimeter $\Rightarrow$ lower systematics

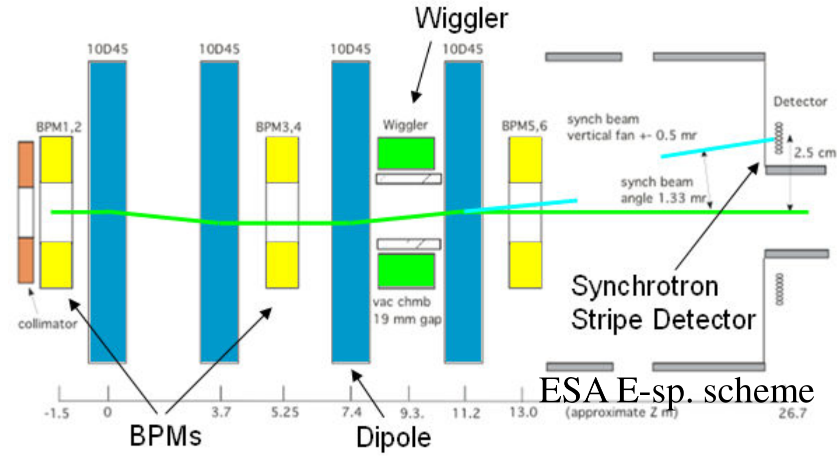
E & P diagnostics: recent R&D

Prototype, measure & correction non-linearities to sub-percent level

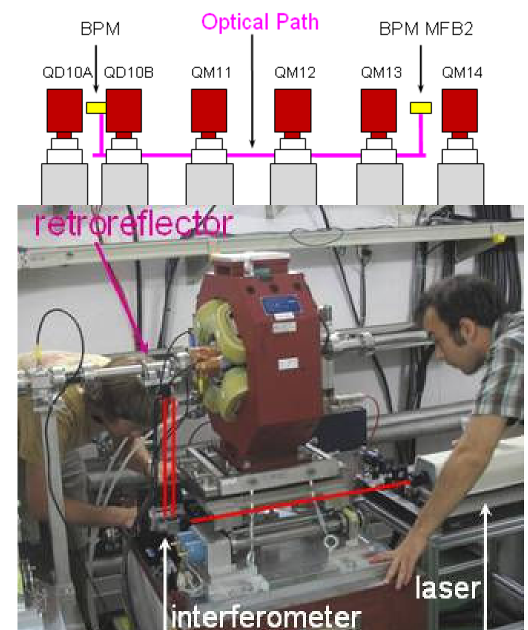




D. Kaefer et al



Installed straightness monitor at ATF2 for studies of E-spectrometer position stability



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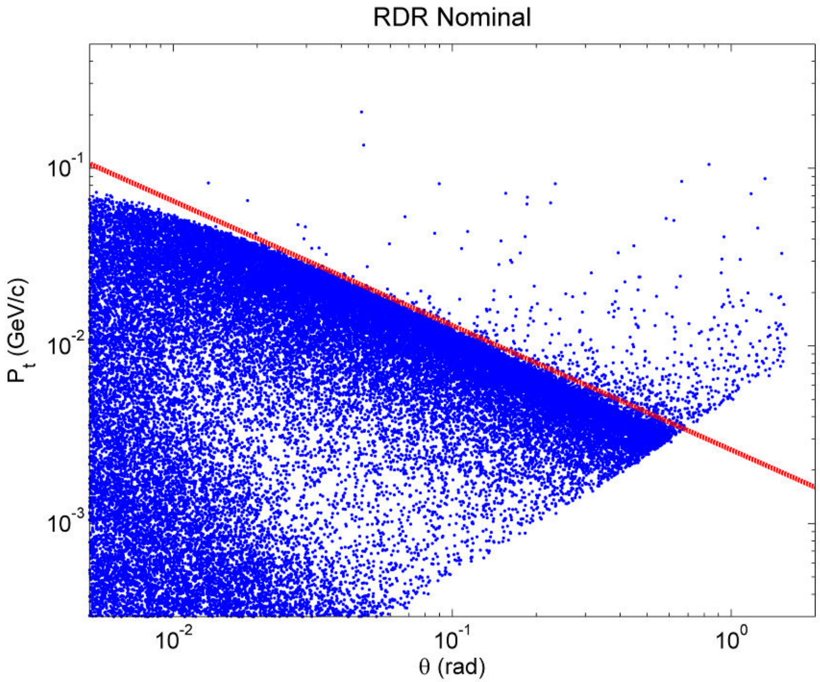
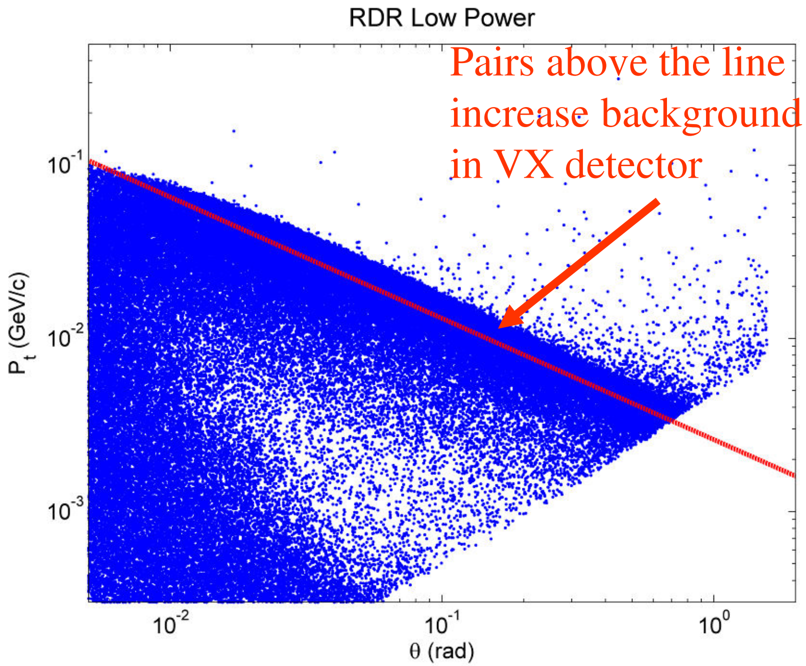
SB2009 Parameters (WA)

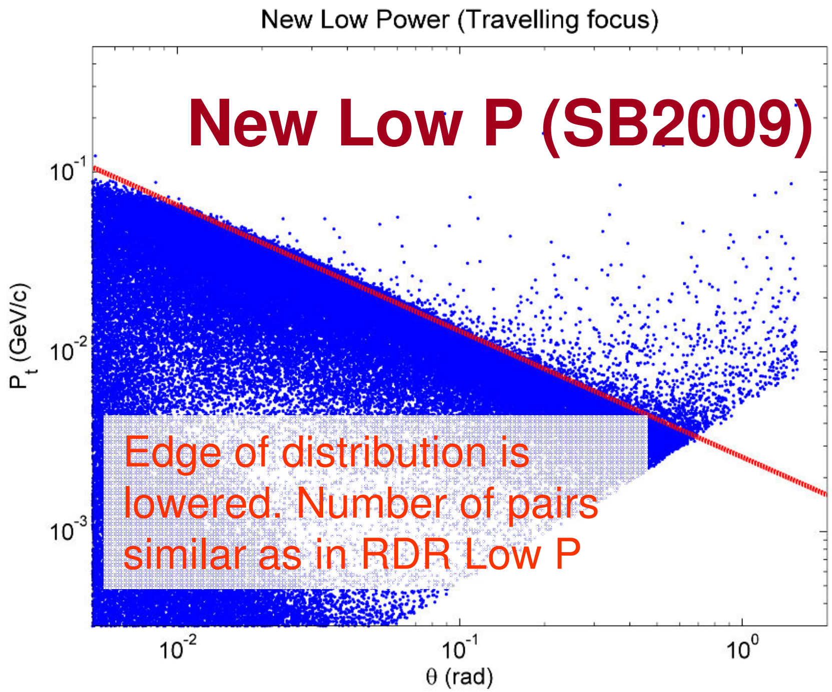
		RDR	SB2009	
Beam and RF Parameters				
No. of bunches		2625	1312	
Bunch spacing	ns	370	740	
beam current	mA	9.0	4.5	
Avg. beam power (250 GeV)	MW	10.8	5.4	
Accelerating gradient	MV/m	31.5	31.5	
P_{fwd} / cavity (matched)	kW	294	147	
Q_{ext} (matched)		3×10^6	6×10^6	
t_{fill}	ms	0.62	1.13	
RF pulse length	ms	1.6	2.0	
RF to beam efficiency	%	61	44	
IP Parameters				
Norm. horizontal emittance	mm.mr	10	10	
Norm. vertical emittance	mm.mr	0.040	0.035	
bunch length	mm	0.3	0.3	
horizontal b*	mm	20	11	
horizontal beam size	nm	640	470	
			no trav. focus	with trav. focus
vertical β^*	mm	0.40	0.48	0.2
vertical beam size	nm	5.7	5.8	3.8
D_y		19	25	
dE_{BS}/E	%	2	4	3.6
Avg. P_{BS}	kW	260	200	194
Luminosity	$cm^{-2}s^{-1}$	2×10^{34}	1.5×10^{34}	2×10^{34}

e+e- pairs

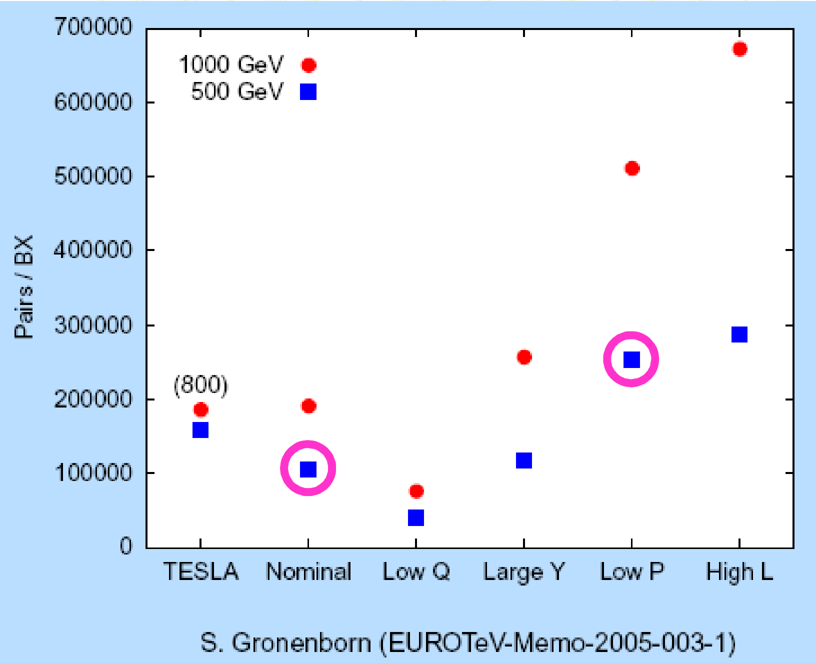
- Edge of pairs distribution in θ-P_t important for VX background
- RDR Low P: edge higher=> unfavorable for background
- New Low P: edge location similar as RDR Nominal

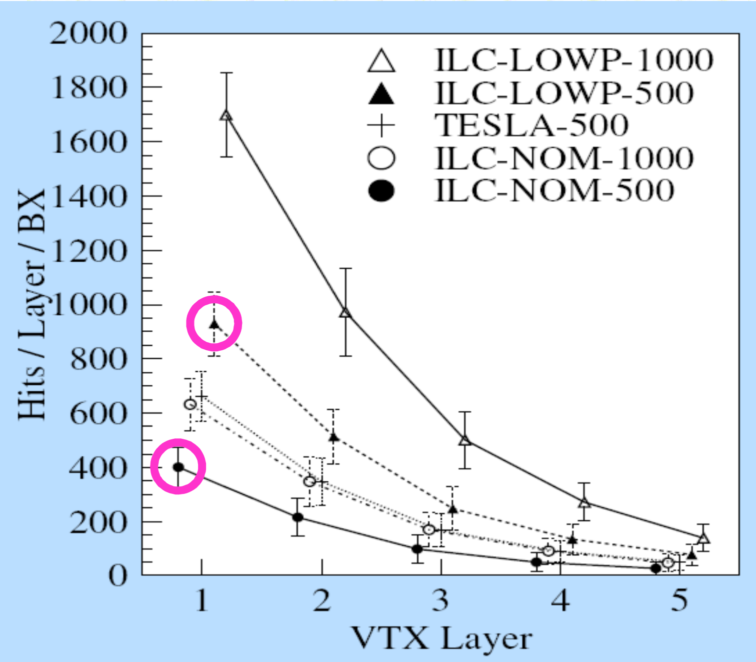






SB2009, pairs background, beamstrahlung

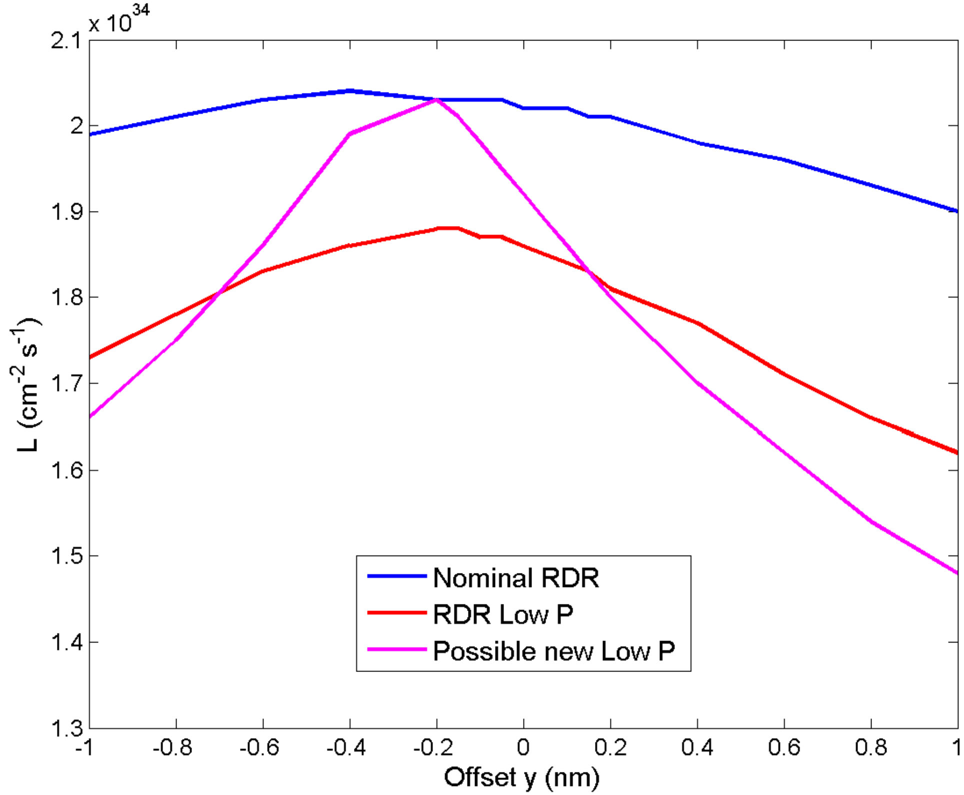




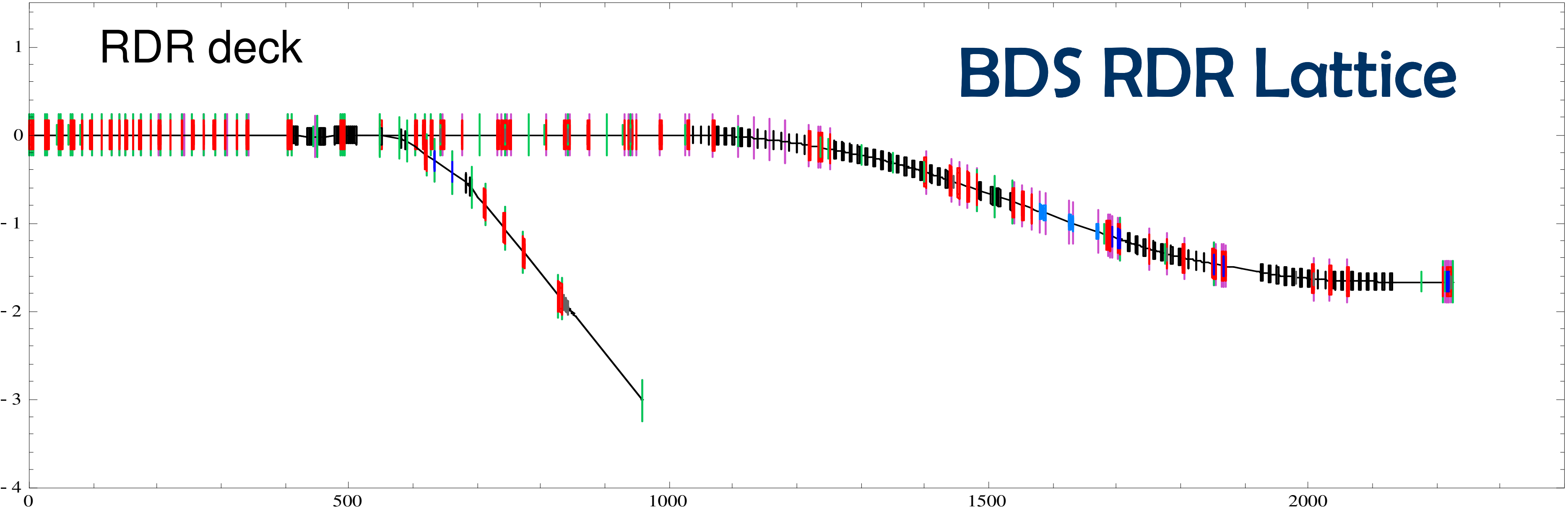
- SB2009 is being studied by detector groups, to evaluate effects on detector performance
  - For particular case of VX hits by pairs, it is expected that the number will be between RDR nominal and RDR Low P
- Beamstrahlung – behaves as $1/\sigma_x^2$ (while $L \sim 1/\sigma_x$) => can decrease dE/E for certain physics processes with small L loss

Low P Parameter Set with Traveling Focus

- Higher Disruption
  - Higher sensitivity to Δy
  - Intratrain Feedback more challenging
  - Vertical bunch-bunch jitter to be <200pm for <5% lumi loss
  - However, twice longer bunch separation will help to improve bunch-bunch uniformity & jitter
- $\beta x(LP) \sim 50\% \ \beta x(RDR)$
  $\beta y(LP\text{-}TF) \sim 50\% \ \beta y(RDR)$
  - Collimation depth 1.4x deeper (smaller apertures)
  - May have more muons
  - however, have space to lengthen muon walls if needed

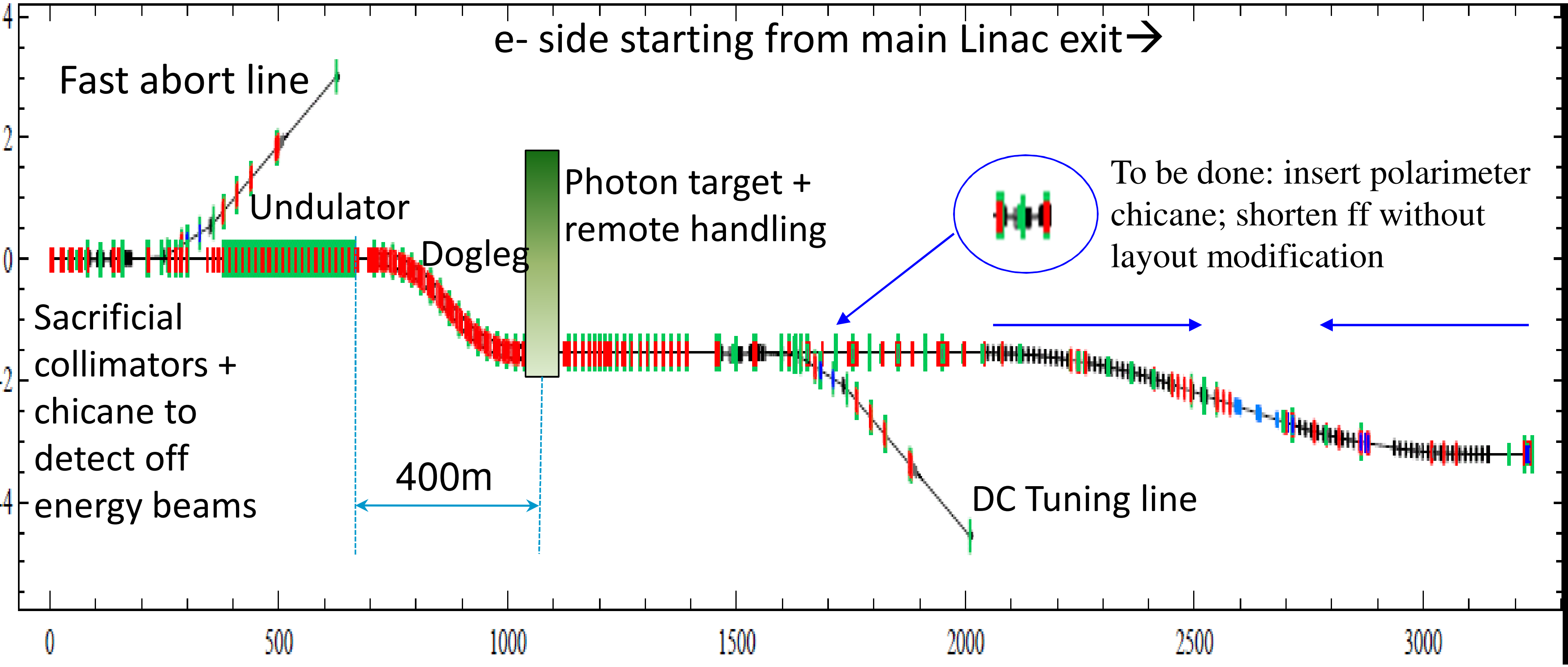


RDR optics layout



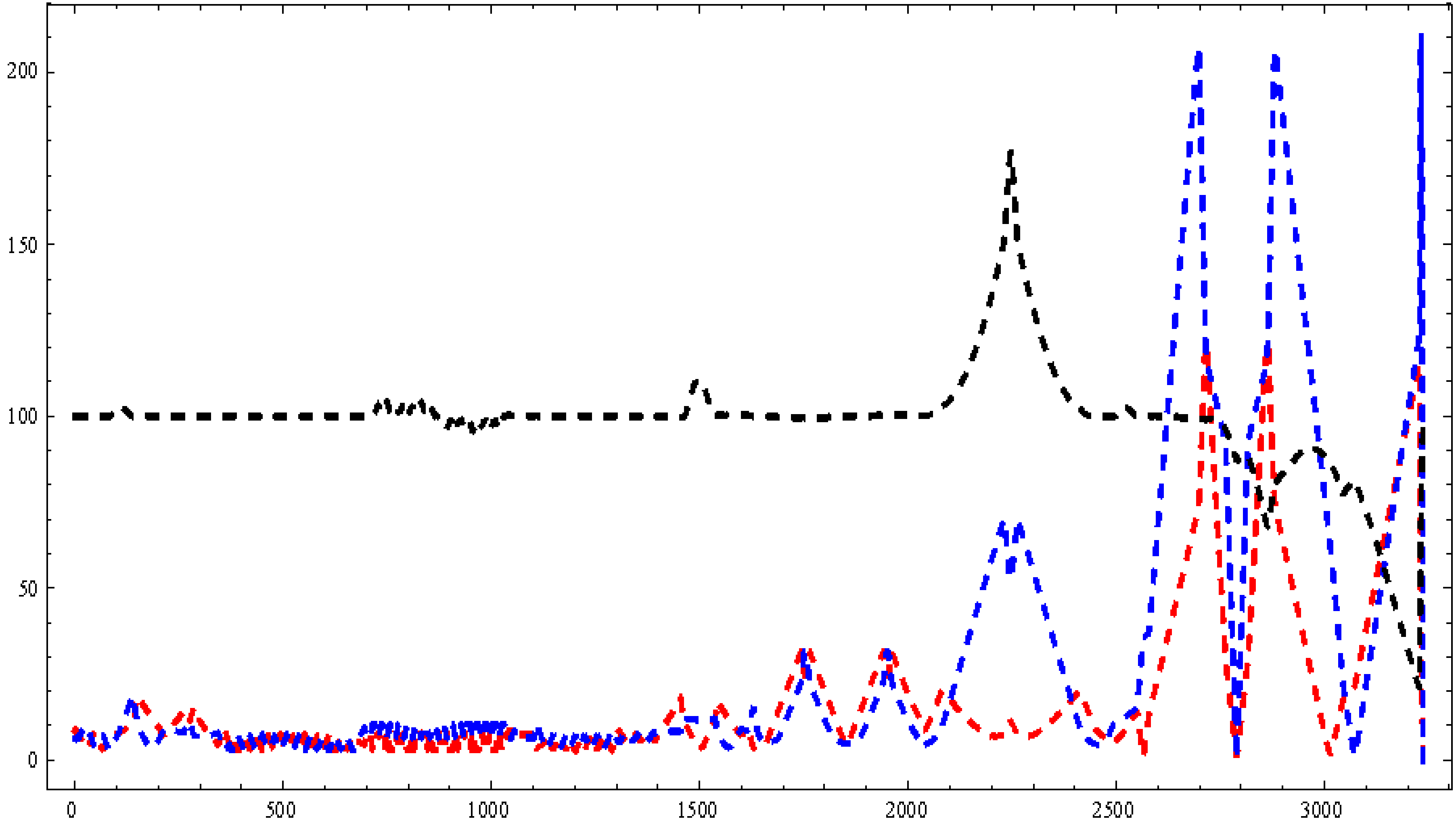
- BDS changes for SB2009:
  - modify e- side to allow central region integration
  - separate combined functionalities of upstream polarisation measurements + laser wire detection + MPS

SB2009 lattice, e- side



Deepa Angal-Kalinin & James Jones
ASTeC, Daresbury Laboratory & The Cockcroft Institute

SB09 optics of e- BDS from exit of Linac to IP



SB2009 at 250 GeV CM

	RDR.250	SB09.250_1	SB09.250_2
Ecms [GeV]	250	250	250
N e-	2.E+10	2.E+10	2.E+10
N e+	2.E+10	1.E+10	2.E+10
nb	2625	1312	1312
f [Hz]	5	5	2.5

- The 250GeV CM luminosity is roughly half of what was projected for RDR 250GeV CM parameters
- Presently studying the way to recover the luminosity loss at 250 GeV, with use of tighter focusing and/or travelling focus

Summary

- The Machine Detector Interface team is focused on
- IR integration
  - Push-pull, detector moving system, stability
  - Final doublet & detector integration and prototype
    - Fruitful collaboration with CLIC MDI team
- Other MDI related systems
  - Beam dump, upstream & downstream diagnostics
- Optimization of parameters, optics and layout