International Linear Collider Interaction Region Design *(Machine Detector Interface)*

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SLAC

JLAB, May 6, 2010

MEIC at JLab: Machine Design Status

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Jefferson Lab

For the JLab EIC Study Group

EIC Collaboration Meeting, Stony Brook University, Jan. 10-12, 2010

Jefferson Lab
Thomas Jefferson National Accelerator Facility

ELIC Main Parameters

Beam Energy	GeV	250/10	150/7	60/5	60/3	12/3
Collision freq.	MHz			499		
Particles/bunch	10^{10}	1.1/3.1	0.5/3.25	0.74/2.9	1.1/6	0.47/2.3
Beam current	A	0.9/2.5	0.4/2.6	0.59/2.3	0.86/4.8	0.37/2.7
Energy spread	10^{-4}			~ 3		
RMS bunch length	mm	5	5	5	5	50
Horiz.. emit., norm.	µm	0.7/51	0.5/43	0.56/85	0.8/75	0.18/80
Vert. emit. Norm.	µm	0.03/2	0.03/2.87	0.11/17	0.8/75	0.18/80
Horizontal beta-star	mm	125	75	25	25	5
Vertical beta-star	mm			5		
Vert. b-b tune shift/IP		0.01/0.1	0.015/.05	0.01/0.03	.015/.08	.015/.013
Laslett tune shift	p-beam	0.1	0.1	0.1	0.054	0.1
Peak Lumi/IP, 10^{34}	$cm^{-2}s^{-1}$	11	4.1	1.9	4.0	0.59

High energy | Medium energy | Low energy

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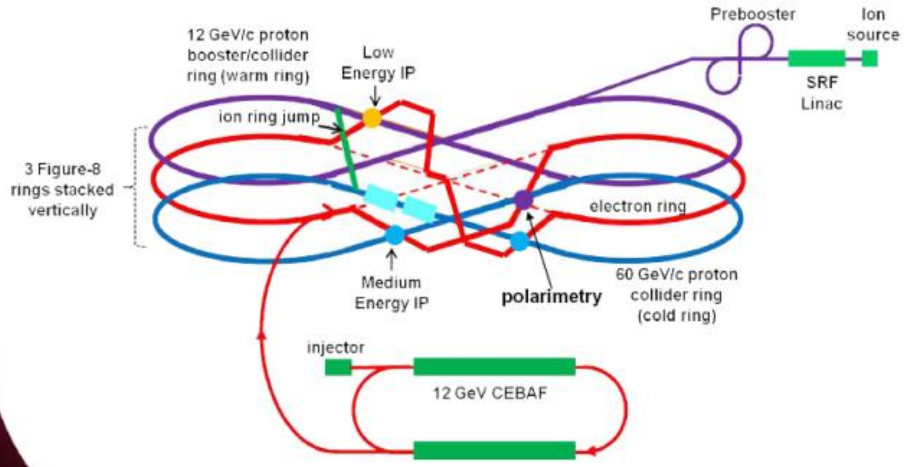
MEIC: Detailed Layout



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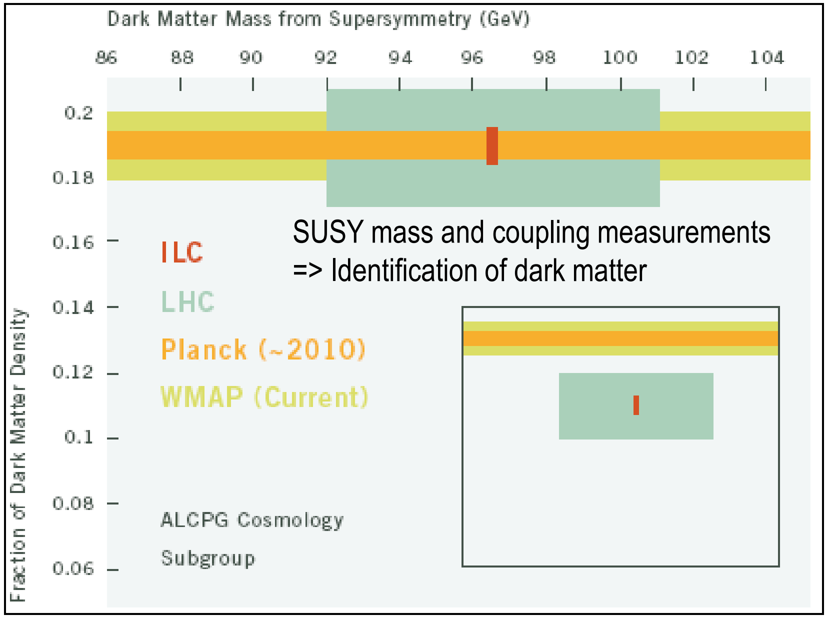
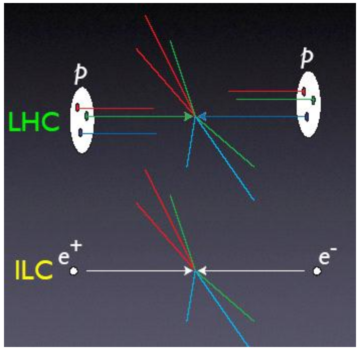
MEIC Critical Accelerator R&D

We have identified the following critical R&D for MEIC at JLab

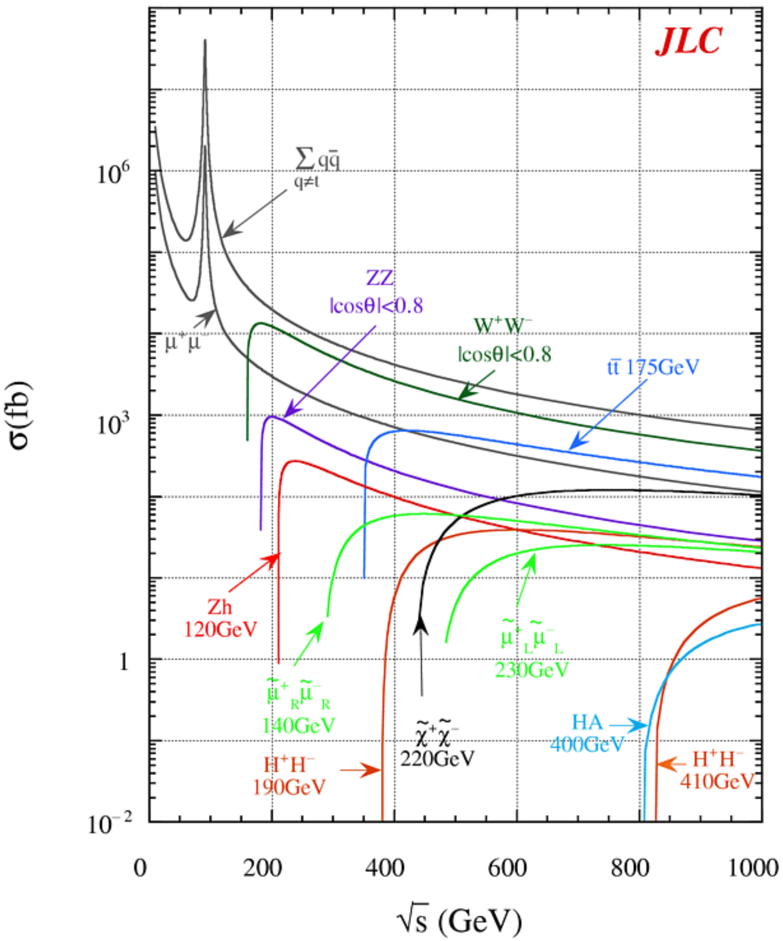
- Interaction Region design with chromatic compensation
- Electron cooling
- Crab crossing and crab cavity
- Forming high intensity low energy ion beam
- Beam-beam effect
- Beam polarization and tracking
- Traveling focusing for very low energy ion beam

Level of R&D	Low-to-Medium Energy (12x3 GeV/c) & (60x5 GeV/c)	High Energy (up to 250x10 GeV)
Challenging		
Semi Challenging	IR design/chromaticity Electron cooling Traveling focusing (for very low ion energy)	IR design/chromaticity Electron cooling
Likely	Crab crossing/crab cavity High intensity low energy ion beam	Crab crossing/crab cavity High intensity low energy ion beam
Know-how	Spin tracking Beam-Beam	Spin tracking Beam-beam



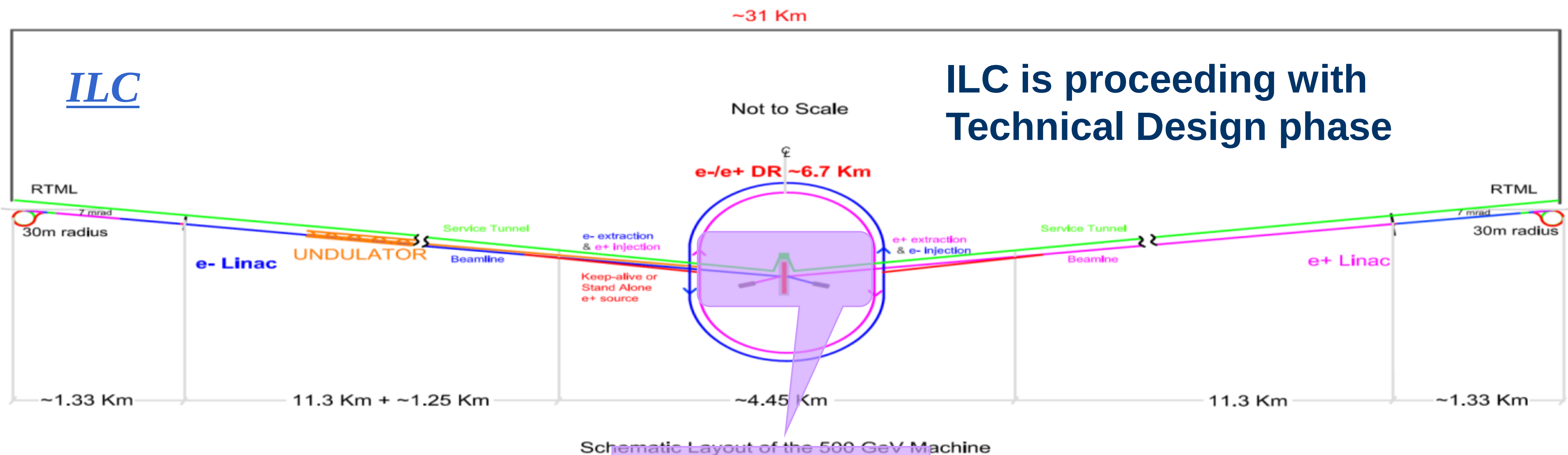


- Higgs Mechanism
- Supersymmetry
- Strong Electroweak Symmetry Breaking
- Precision Measurements



Realization of ILC experimental potential requires rigorous design of detectors and robust MDI

Beam Delivery System & MDI in ILC

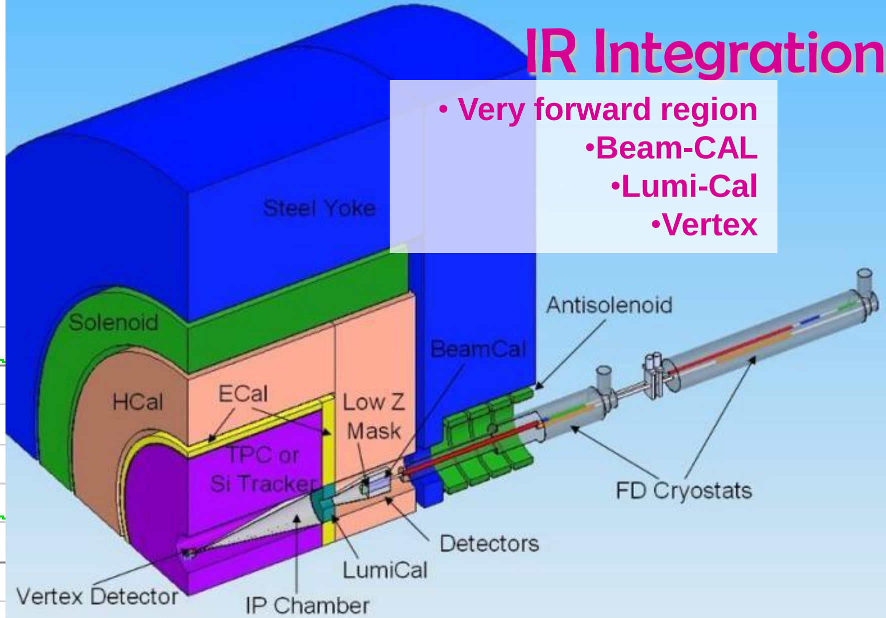


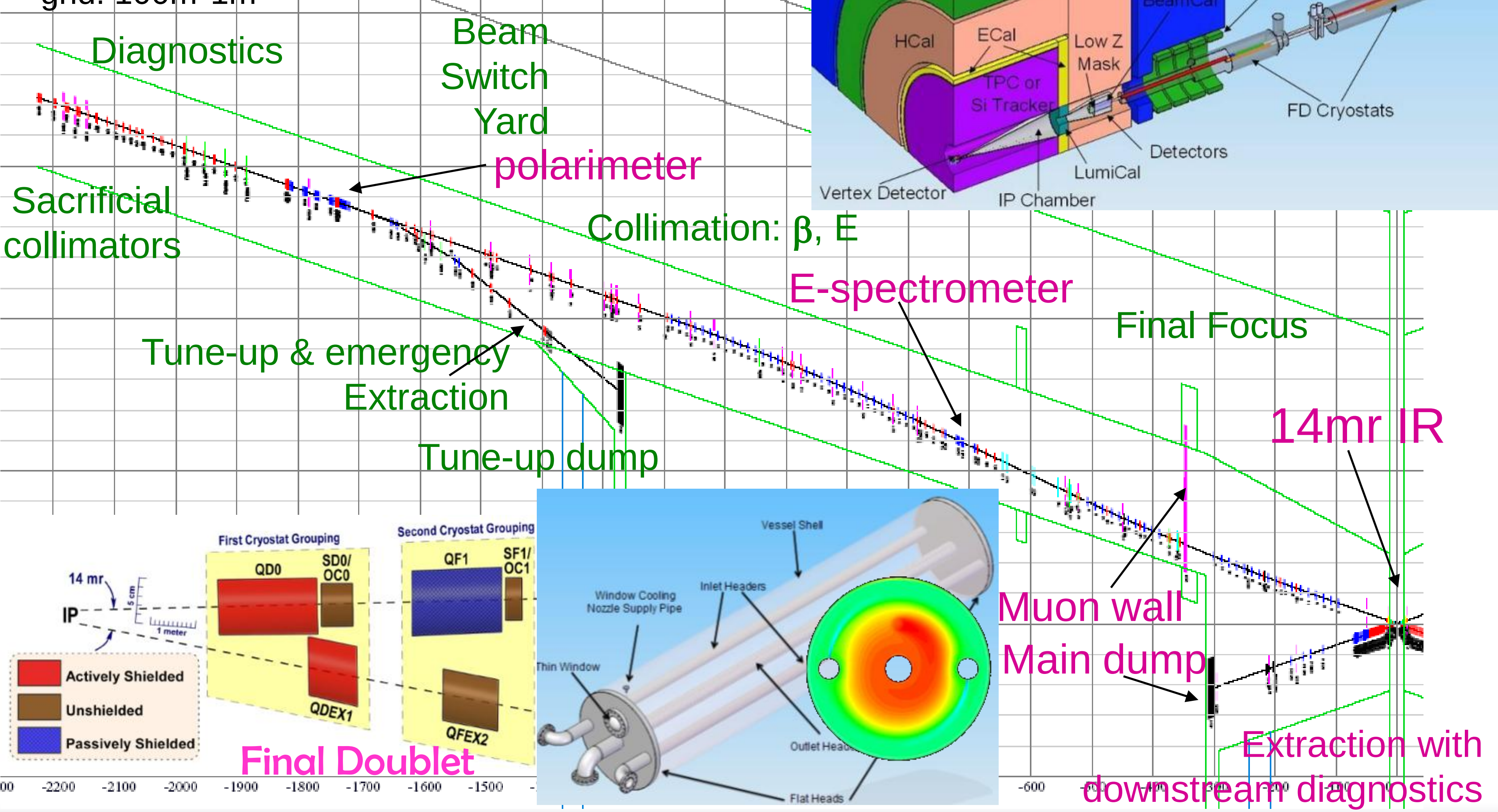
ILC is proceeding with Technical Design phase

BDS =>MDI

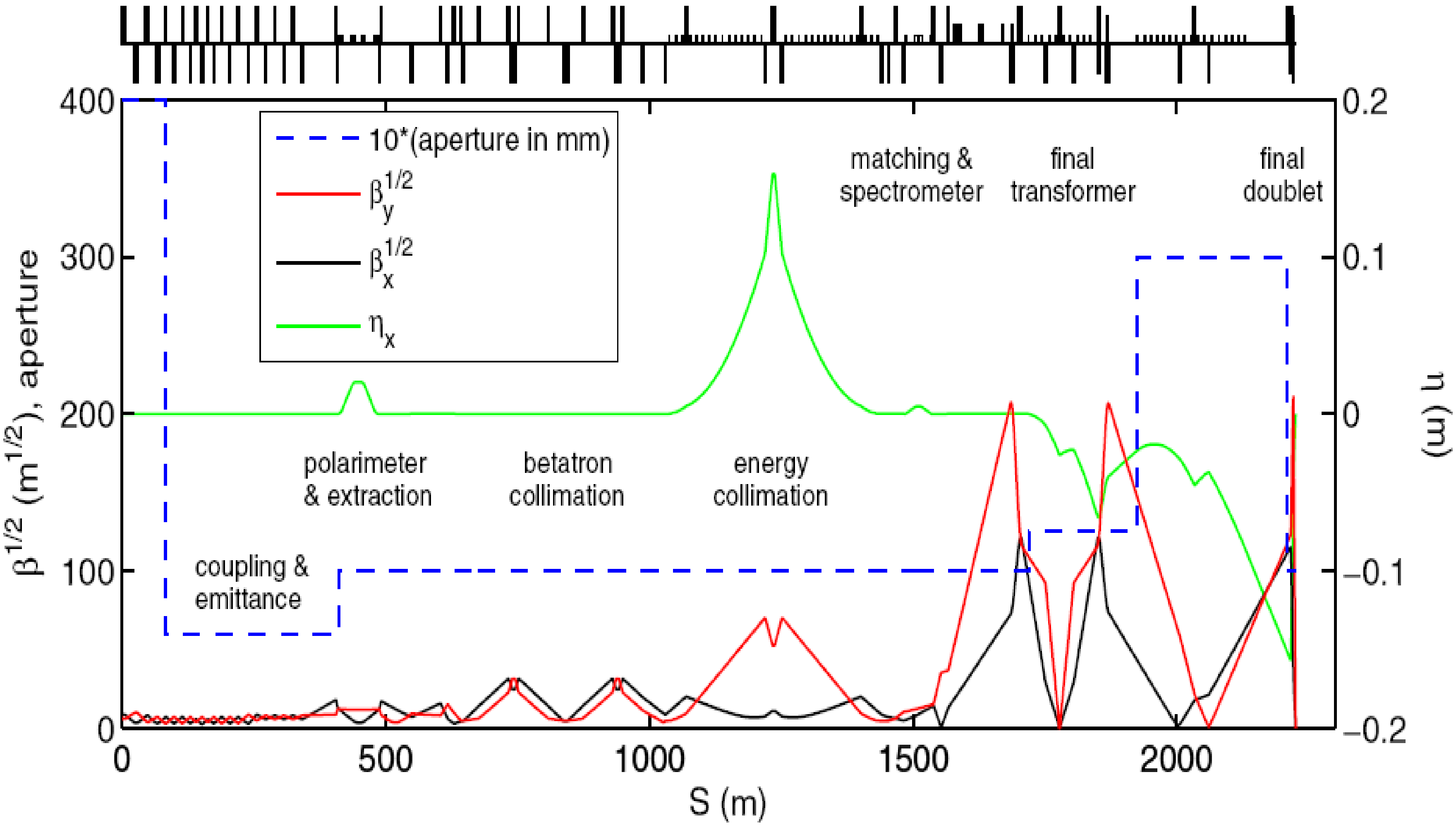
Beam Delivery & MDI elements

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





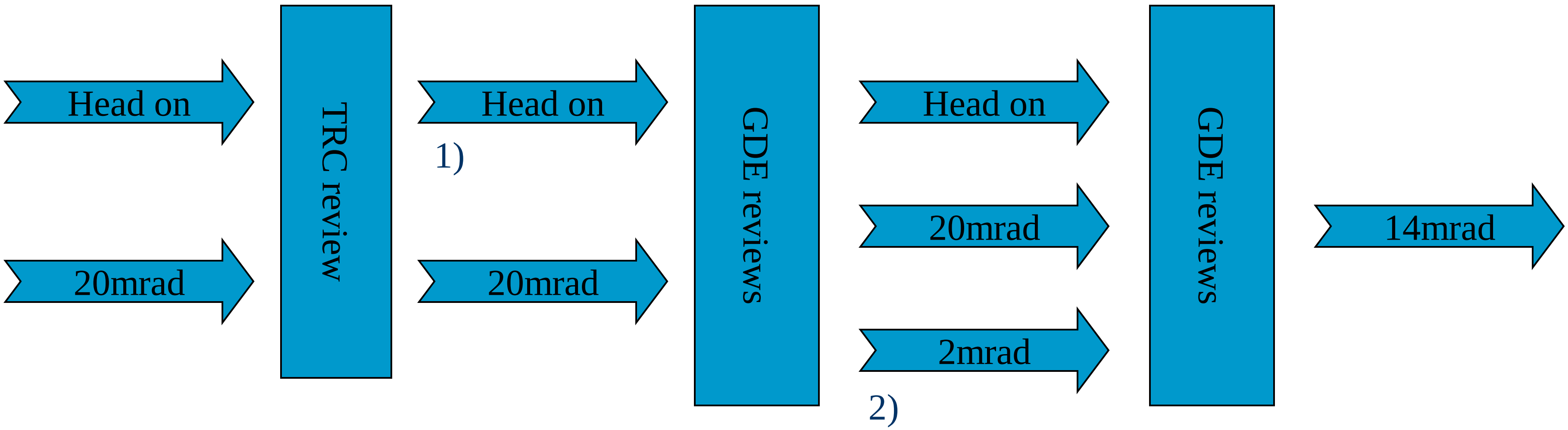
ILC BDS Optical Functions



ILC BDS RDR Parameters

Length (linac exit to IP distance)/side	m	2226
Length of main (tune-up) extraction line	m	300 (467)
Max Energy/beam (with more magnets)	GeV	250 (500)
Distance from IP to first quad, L*	m	3.5-(4.5)
Crossing angle at the IP	mrad	14
Nominal beam size at IP, σ^*, x/y	nm	655/5.7
Nominal beam divergence at IP, θ^*, x/y	μrad	31/14
Nominal beta-function at IP, β^*, x/y	mm	21/0.4
Nominal bunch length, σ_z	μm	300
Nominal disruption parameters, x/y		0.162/18.5
Nominal bunch population, N		2×10^{10}
Max beam power at main and tune-up dumps	MW	18
Preferred entrance train to train jitter	σ	< 0.5
Preferred entrance bunch to bunch jitter	σ	< 0.1
Typical nominal collimation depth, x/y		8–10/60
Vacuum pressure level, near/far from IP	nTorr	1/50

BDS & MDI Configuration Evolution

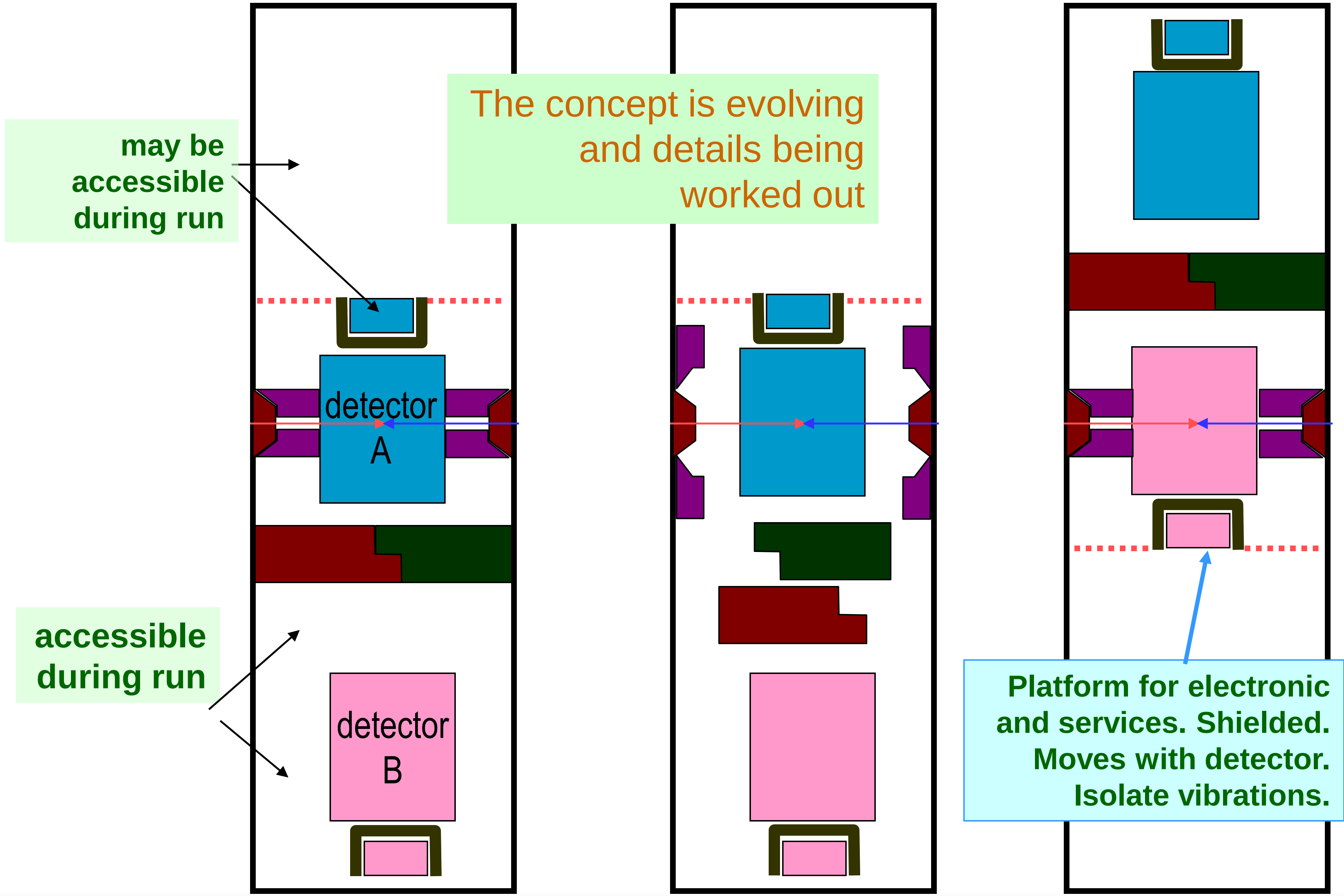


- **Evolution of BDS MDI configuration**
  - Head on; small crossing angle; large crossing angle

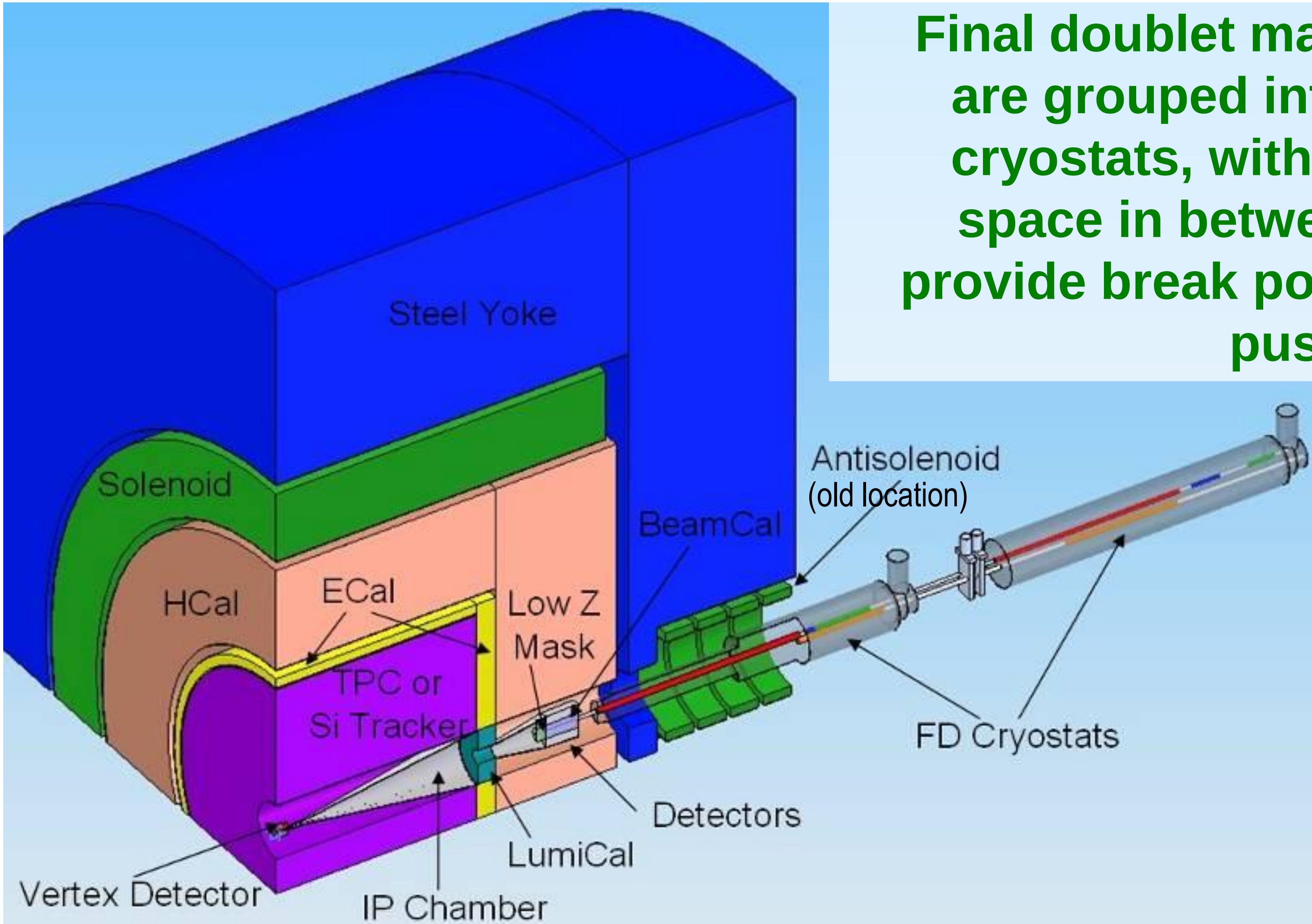
- MDI & Detector performance were the major criteria for selection of more optimal configuration at every review or decision point

1) Found unforeseen losses of beamstrahlung photons on extraction septum blade
2) Identified issues with losses of extracted beam, and its SR; realized cost non-effectiveness of the design

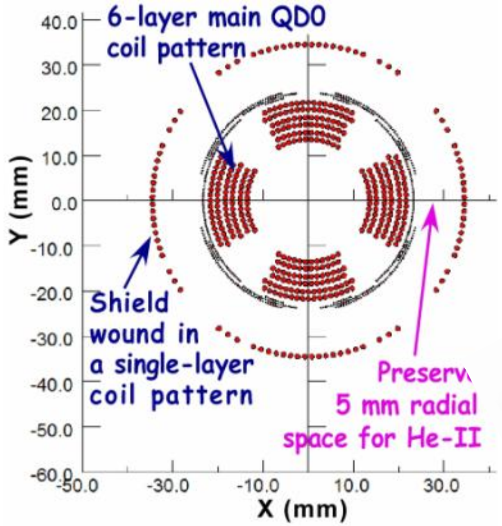
Concept of single IR with two detectors



IR integration

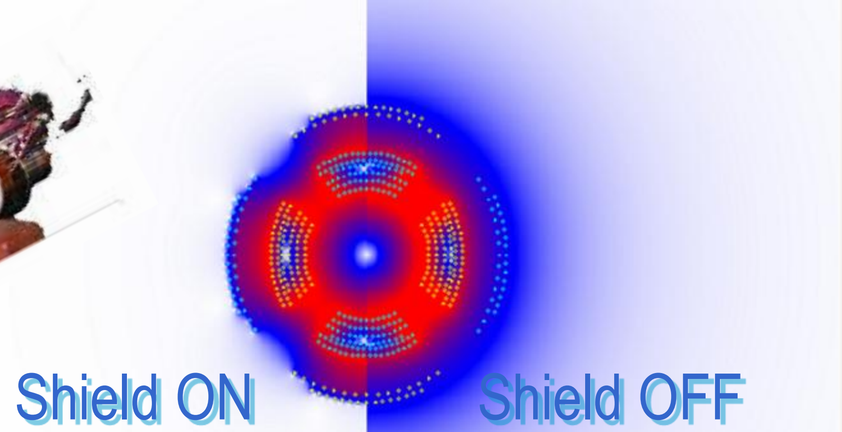


Final doublet magnets are grouped into two cryostats, with warm space in between, to provide break point for push-pull

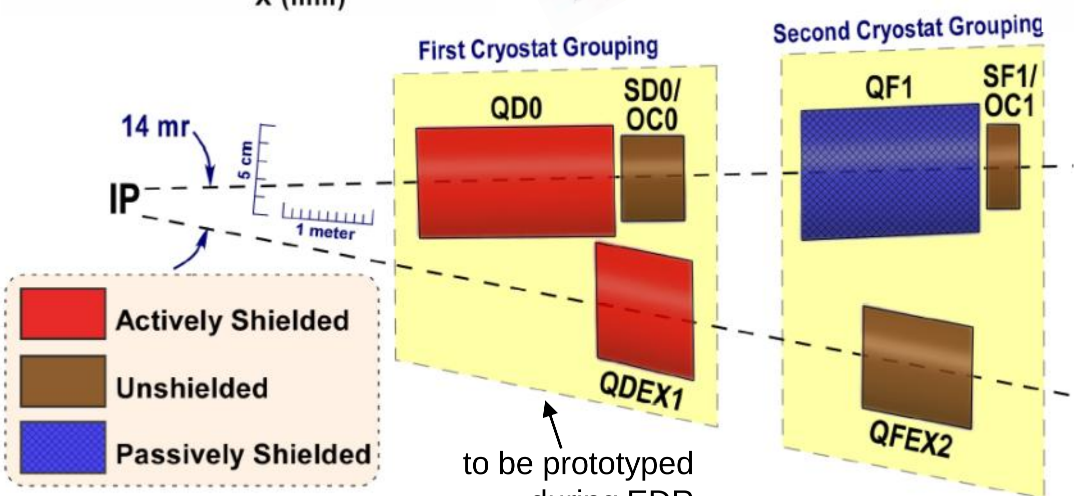


Actively shielded QD0

BNL



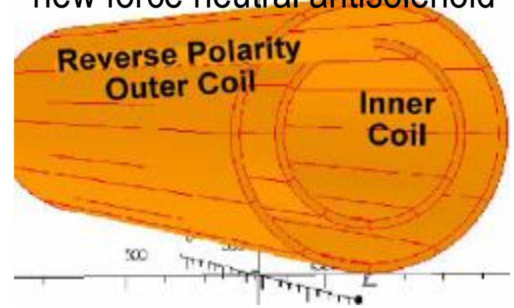
Intensity of color represents value of magnetic field.



to be prototyped during EDR

Two Coils; Different Radii

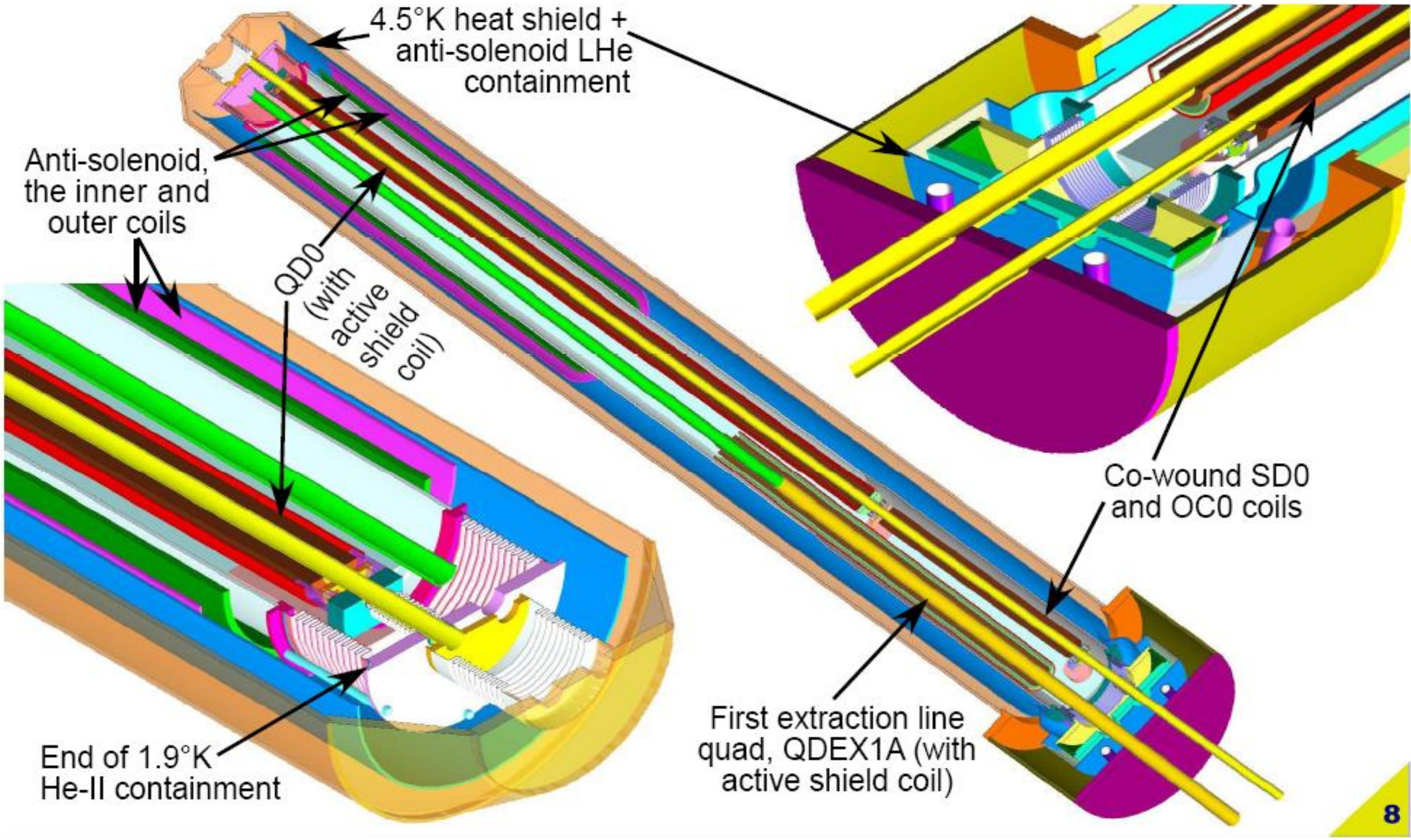
new force neutral antisolenoid

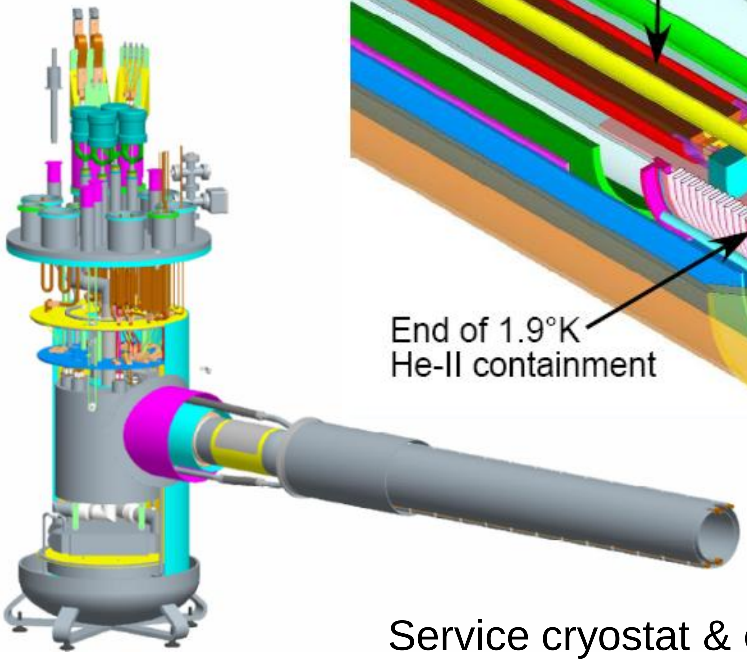


- Interaction region uses compact self-shielding SC magnets
- Independent adjustment of in- & out-going beamlines
- Force-neutral anti-solenoid for local coupling correction

IR Magnets

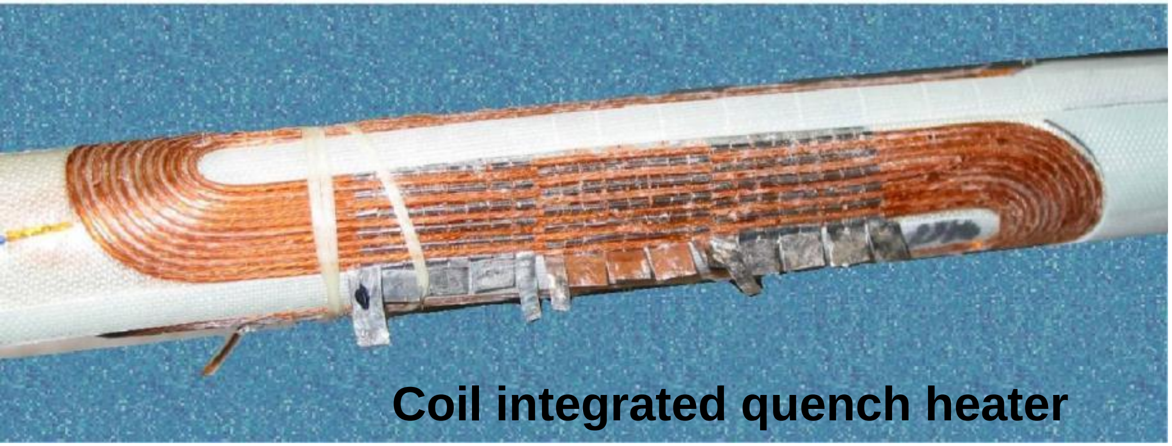
BNL



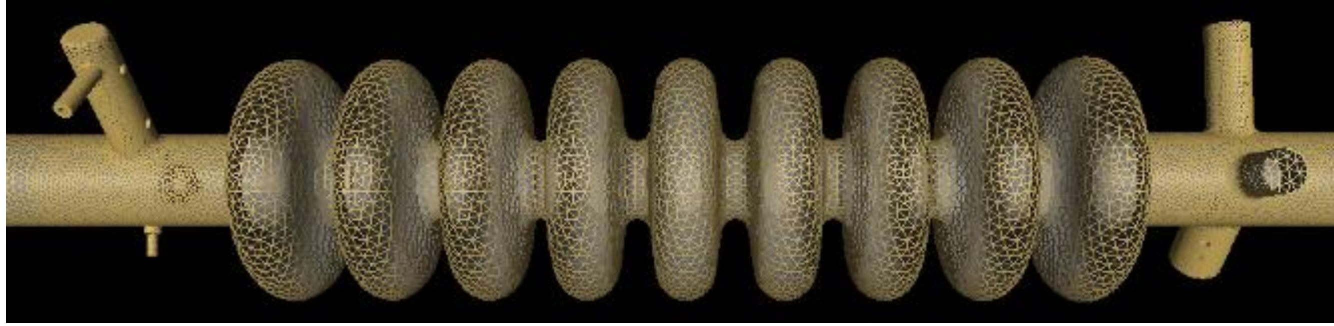


Service cryostat & cryo connections

IR magnets prototypes at BNL

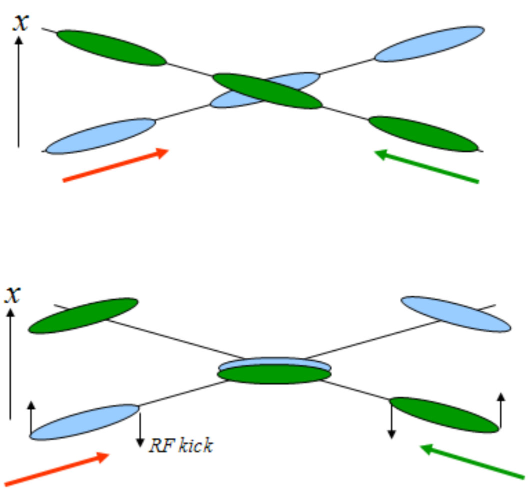


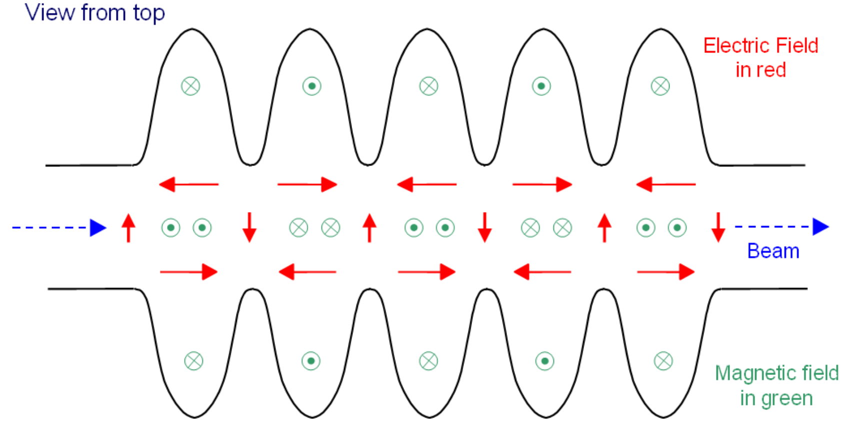
Crab cavity design



FNAL 3.9GHz 9-cell cavity in Opega3p. *K.Ko, et al*

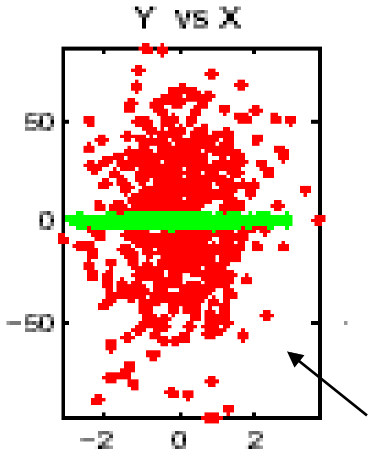
- Prototypes of crab cavity built at FNAL and 3d RF models
- Design & prototypes been done by UK-FNAL-SLAC collaboration





TM110 Dipole mode cavity

IR coupling compensation

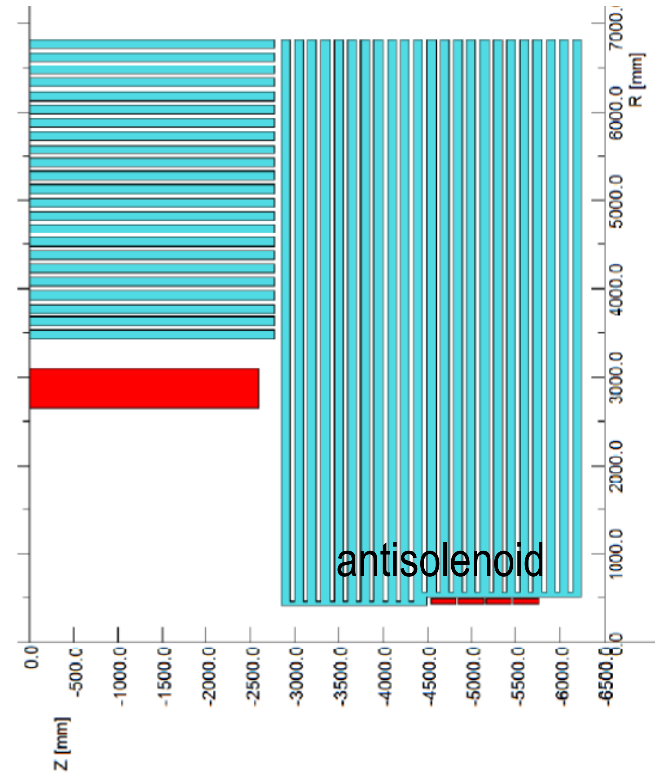


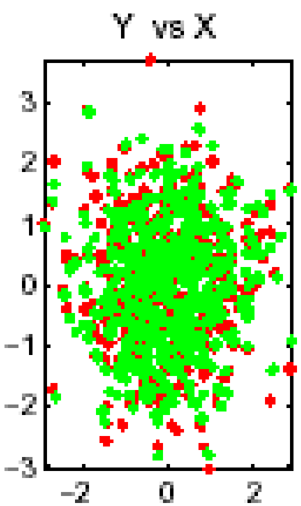
without compensation

$\sigma_y / \sigma_y(0) = 32$

When detector solenoid overlaps QD0, coupling between y & x' and y & E causes large (30 – 190 times) increase of IP size (green=detector solenoid OFF, red=ON)

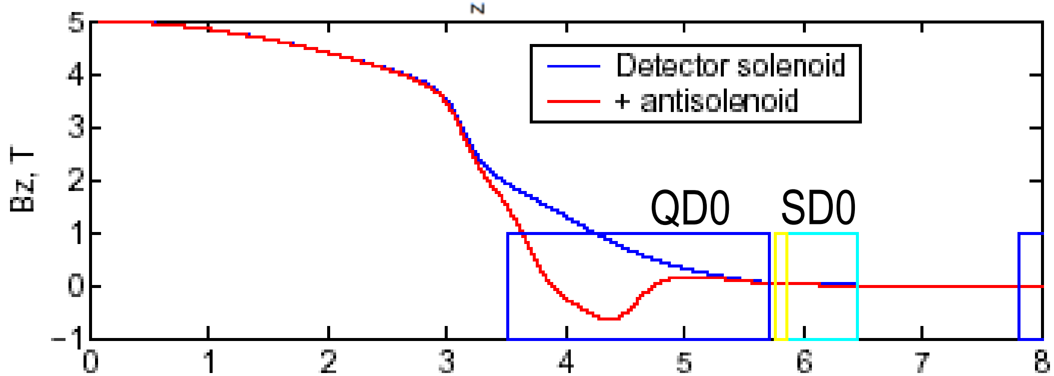
Even though traditional use of skew quads could reduce the effect, the local compensation of the fringe field (with a little skew tuning) is the most efficient way to ensure correction over wide range of beam energies





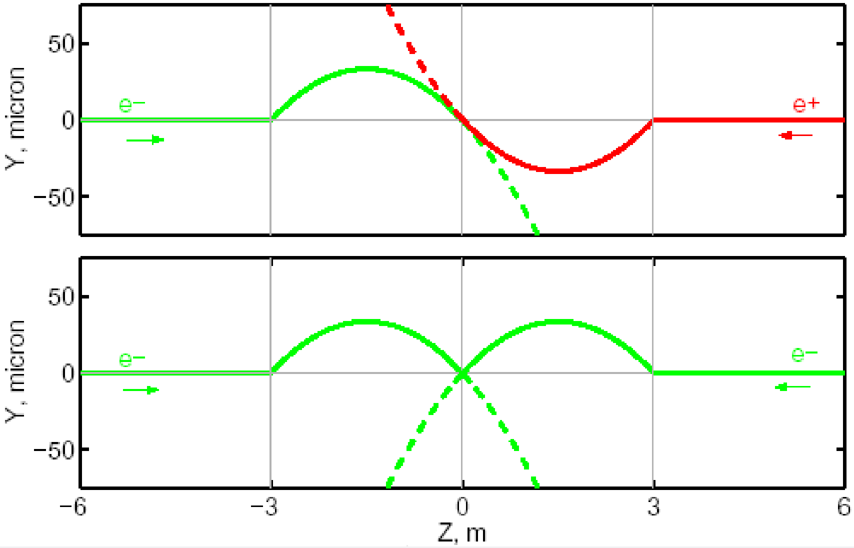
with compensation by antisolenoid

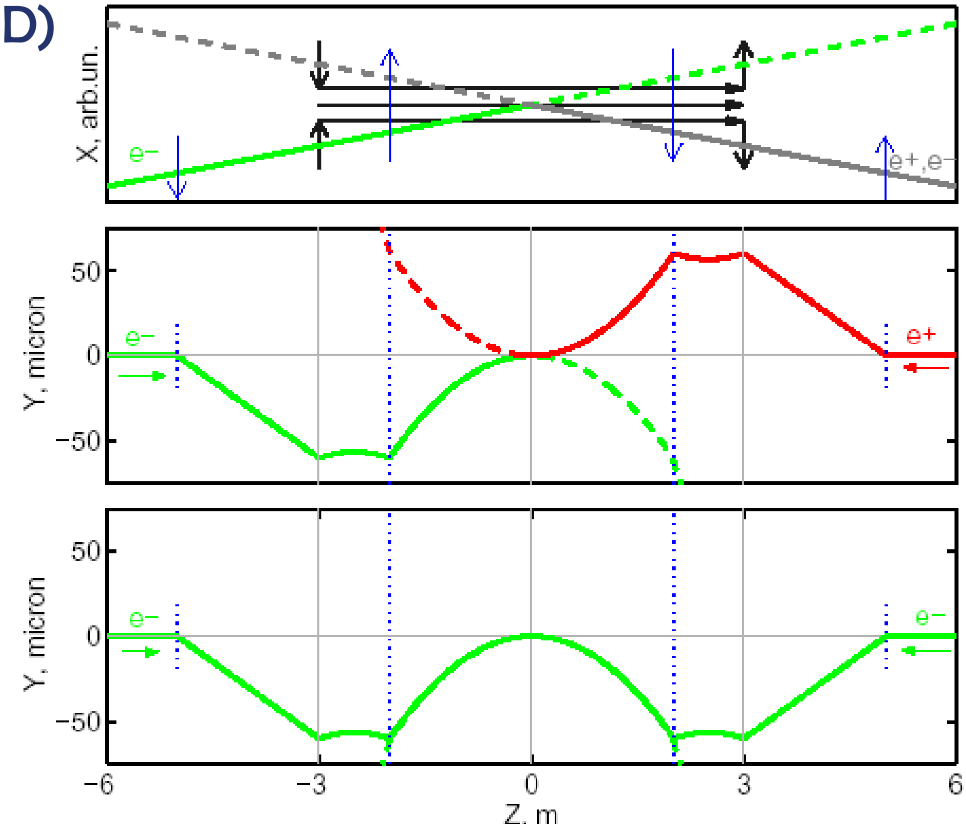
$\sigma_y / \sigma_y(0) < 1.01$



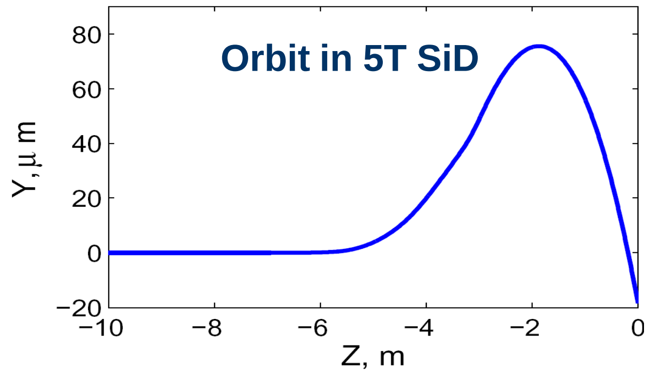
Detector Integrated Dipole

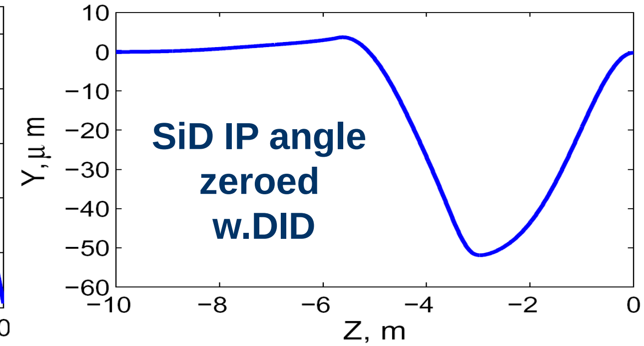
- With a crossing angle, when beams cross solenoid field, vertical orbit arise
- For e+e- the orbit is anti-symmetrical and beams still collide head-on
- If the vertical angle is undesirable (to preserve spin orientation or the e-e- luminosity), it can be compensated locally with DID
- Alternatively, negative polarity of DID may be useful to reduce angular spread of beam-beam pairs (anti-DID)





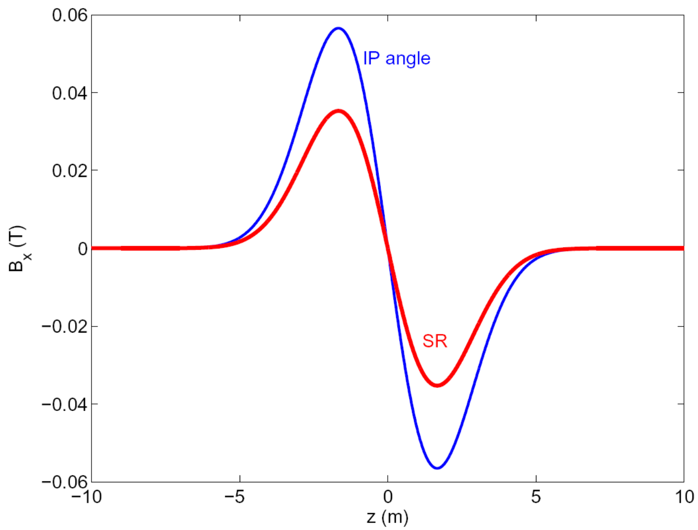
Use of DID or anti-DID

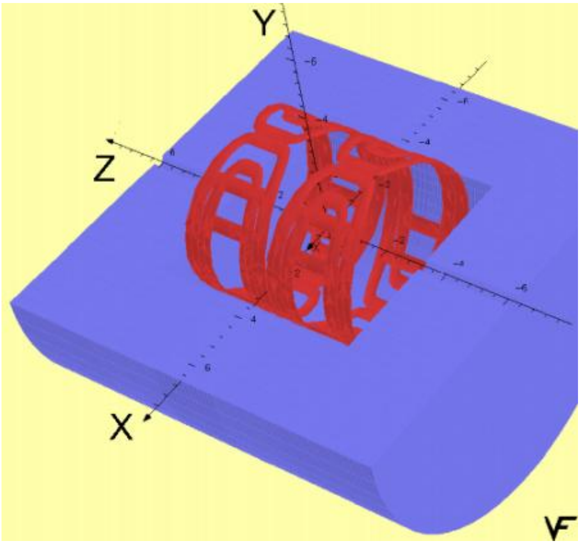




DID field shape and scheme

DID case





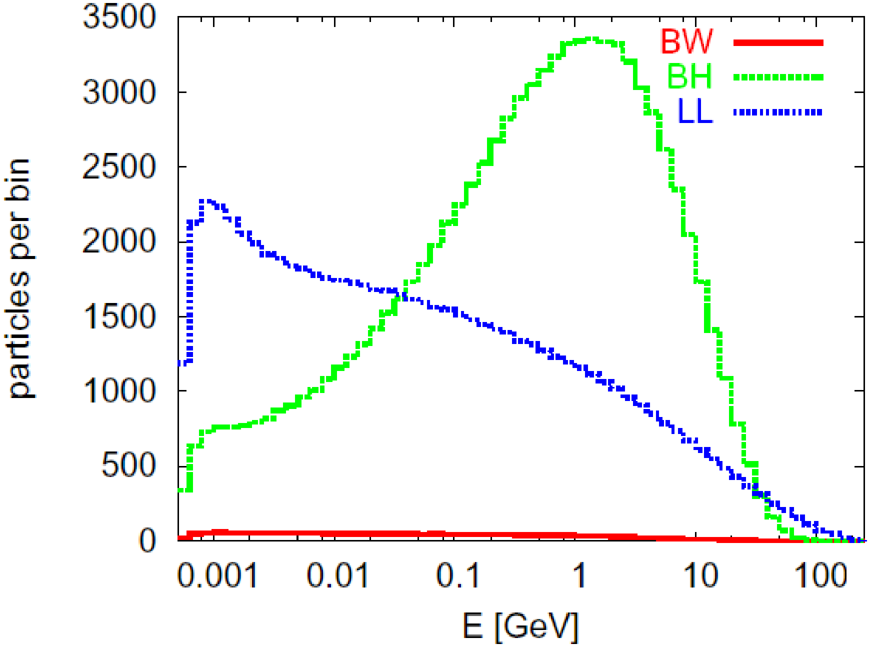
- The negative polarity of DID is also possible (called anti-DID)

- In this case the vertical angle at the IP is somewhat increased, but the background conditions due to low energy pairs (see below) and are improved

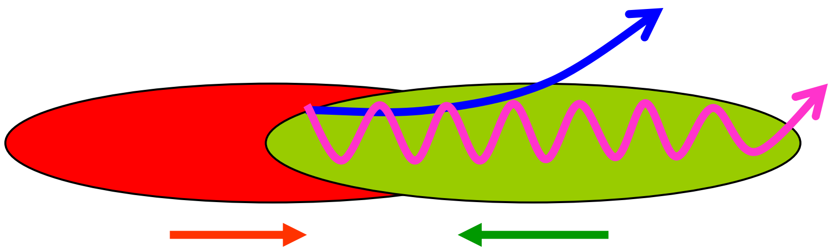
Pair production

- Beamstrahlung photons, particles of beams or virtual photons interact, and create $e^+ e^-$ pairs.
- Three processes are important for incoherent pair production (Υ<0.6):
- Breit-Wheeler process ($\gamma\gamma \rightarrow e^+e^-$)
- Bethe-Heitler process ($e^\pm\gamma \rightarrow e^\pm e^+e^-$)
- Landau-Lifshitz process ($e^+e^- \rightarrow e^+e^-e^+e^-$)

Spectrum of pairs



Pair production



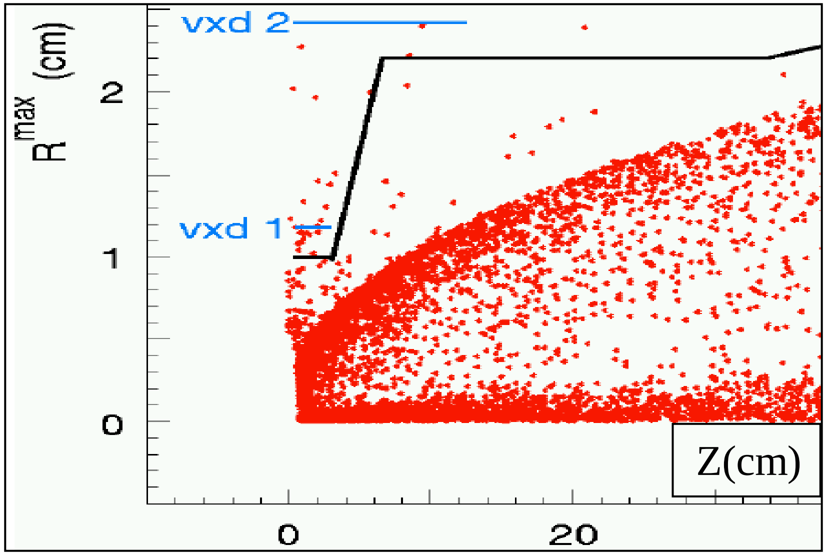
Pairs are potential source of background.

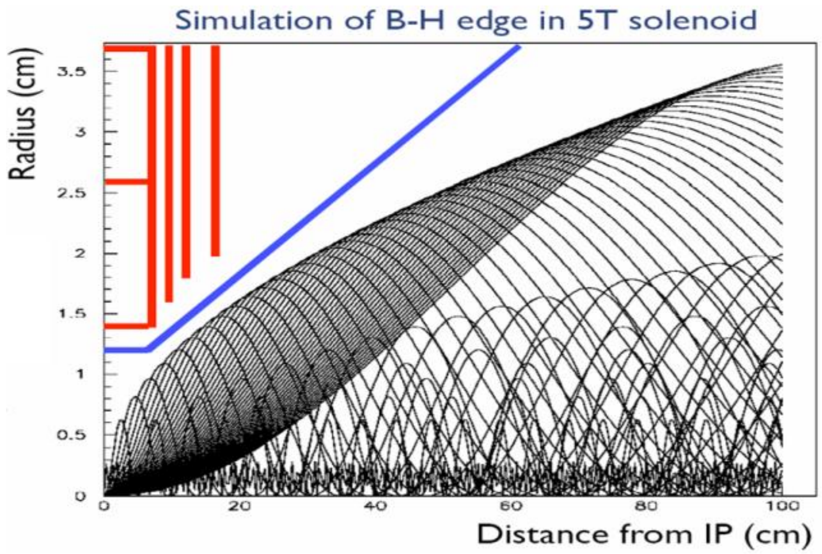
Pairs are affected by the beam (focused or defocused)

Most important: angle with beam axis (θ) and transverse momentum P_T.

Pairs are curled by the solenoid field of detector.

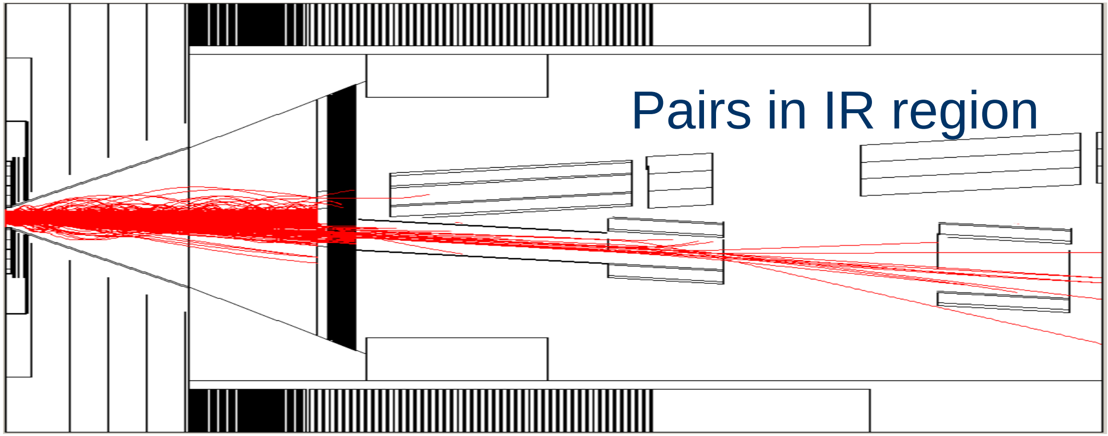
Geometry of vertex detector and vacuum chamber chosen in such a way that most of pairs do not hit the apertures.

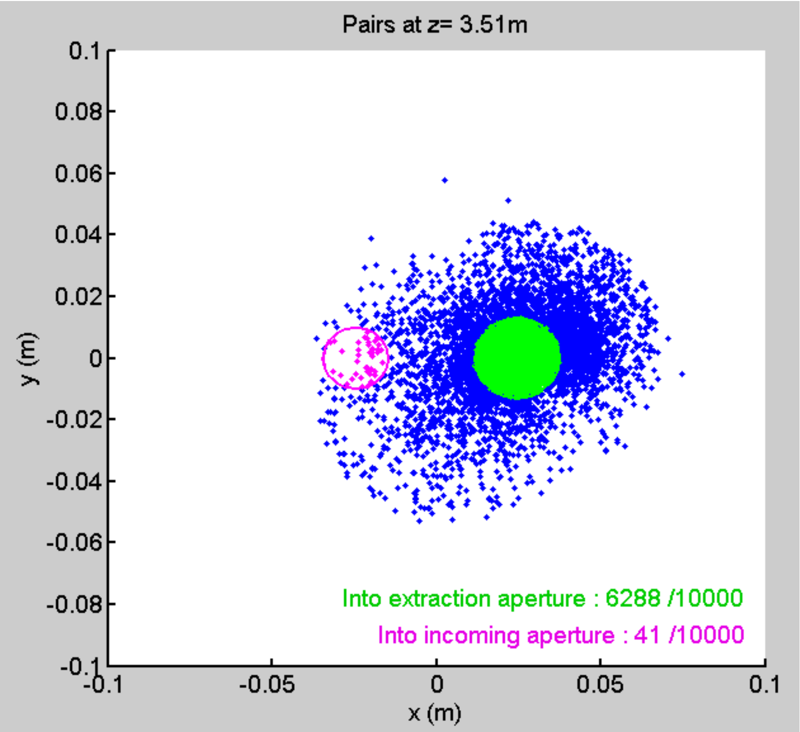


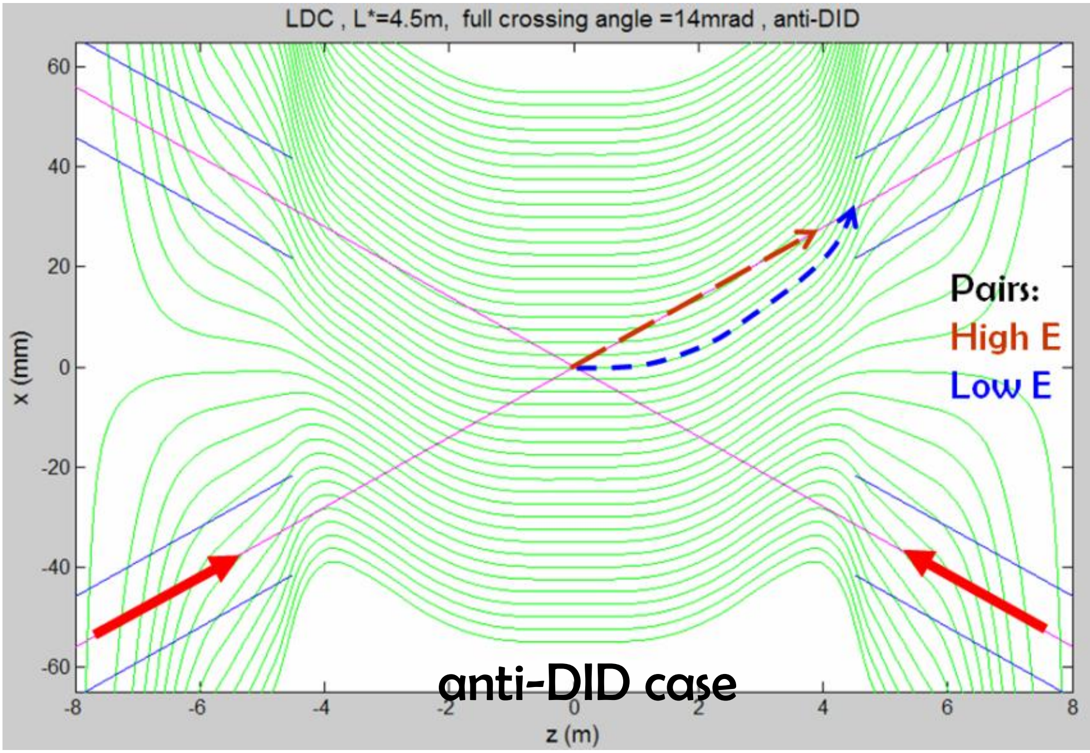


Use of anti-DID to direct pairs

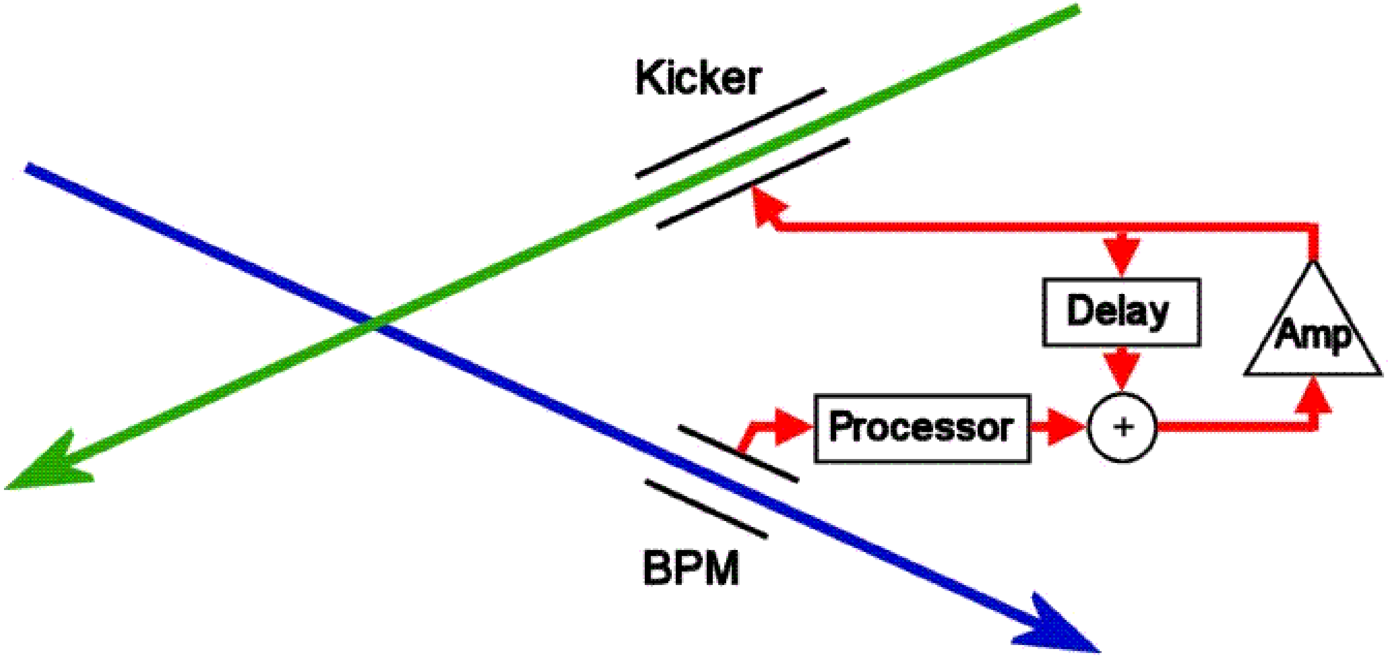
Anti-DID field can be used to direct most of pairs into extraction hole and thus improve somewhat the background conditions







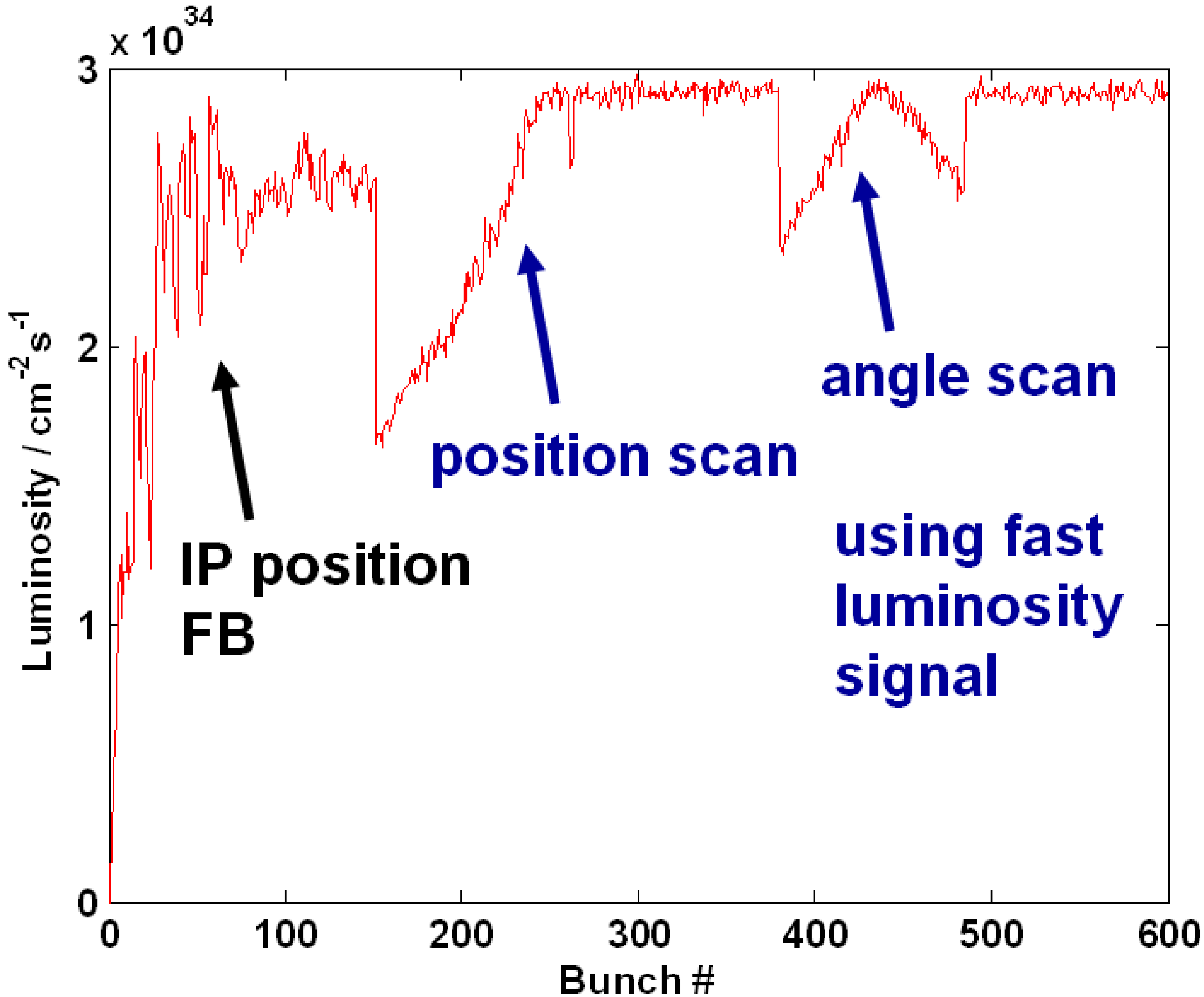
Beam-Beam orbit feedback



use strong beam-beam kick to keep beams colliding

ILC intratrain simulation

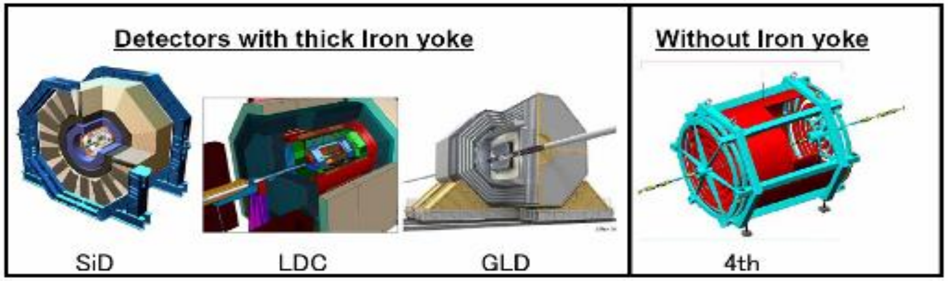
ILC intratrain feedback (IP position and angle optimization), simulated with realistic errors in the linac and "banana" bunches.

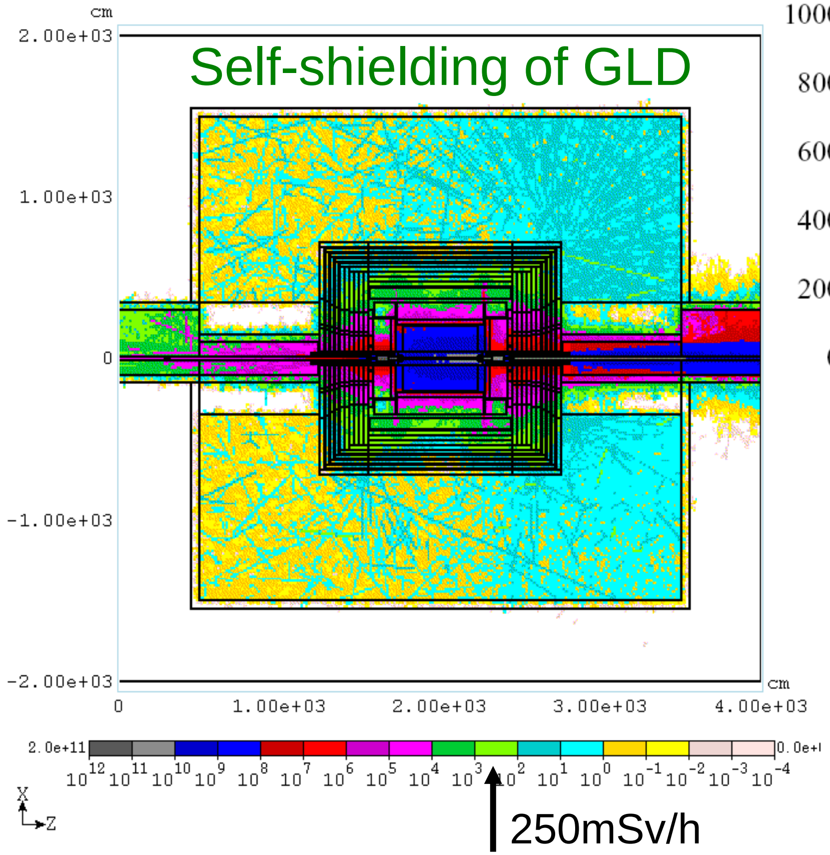


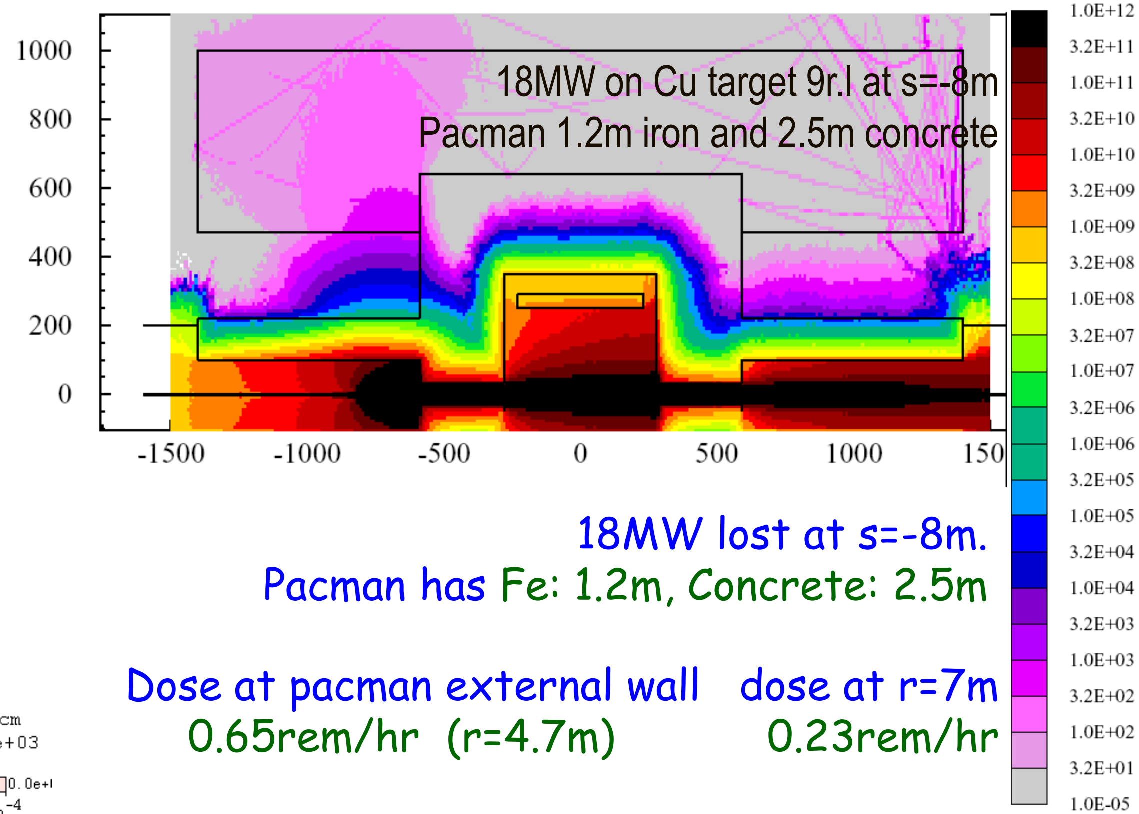
Shielding the IR hall

Detector itself is well shielded except for incoming beamlines.

A proper “pacman” can shield the incoming beamlines and remove the need for shielding wall.







18MW lost at s=-8m.

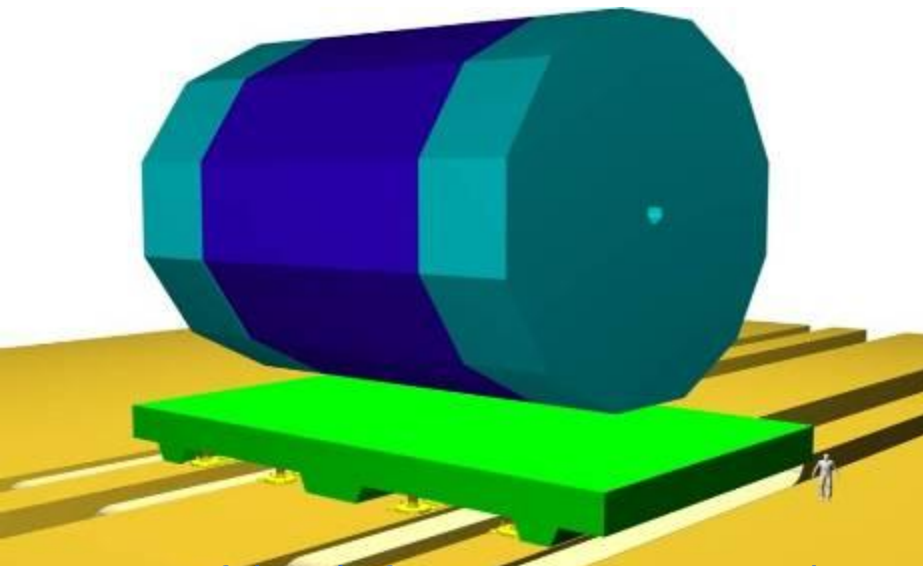
Pacman has Fe: 1.2m, Concrete: 2.5m

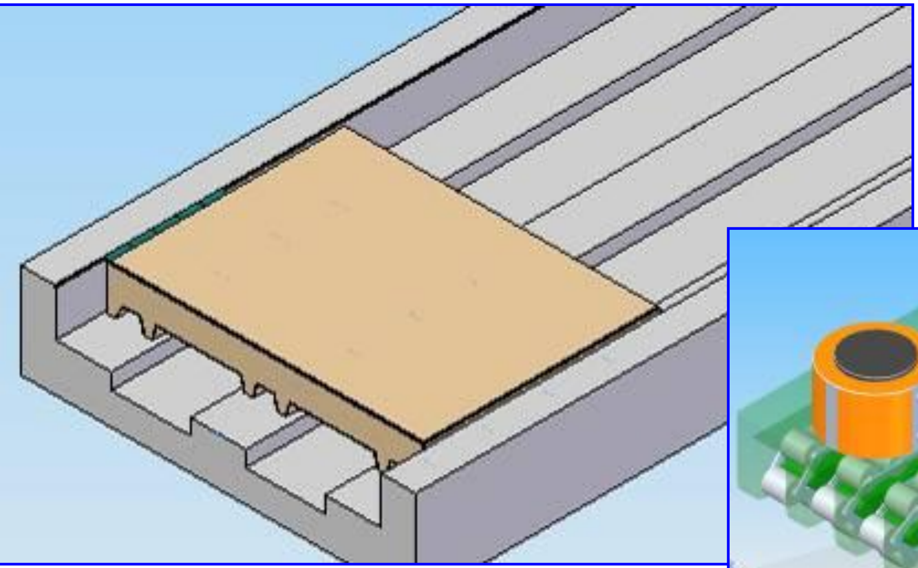
Dose at pacman external wall 0.65rem/hr (r=4.7m)

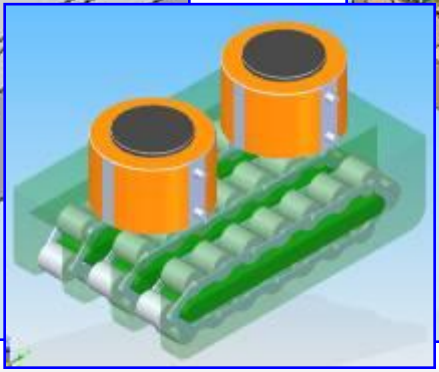
dose at r=7m 0.23rem/hr

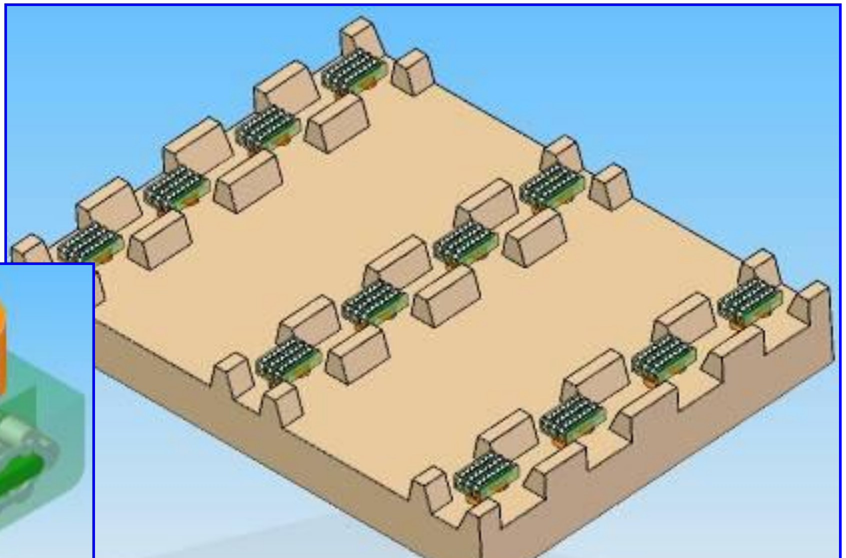
Moving the detector


Air-pads at CMS – move 2000k


Concept of the platform, A.Herve, H.Gerwig

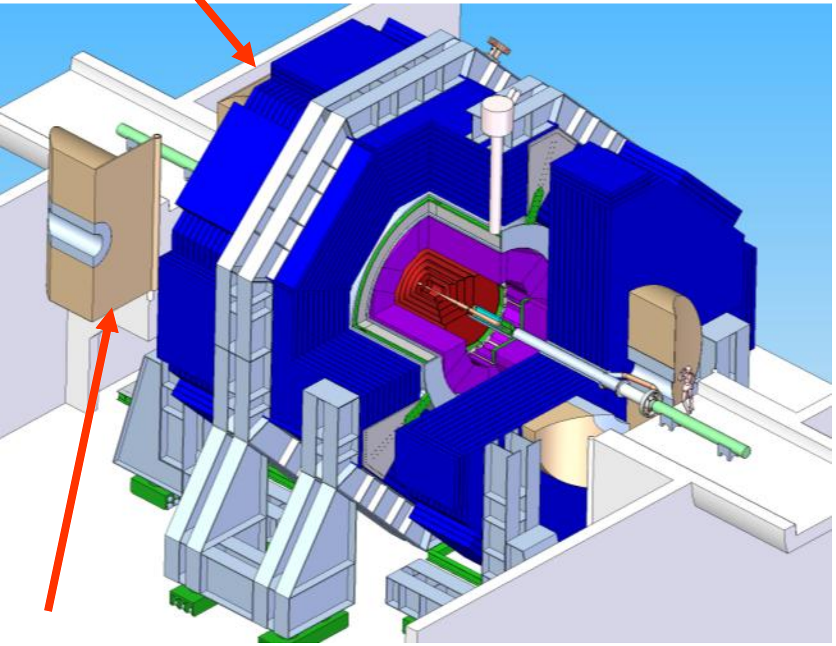




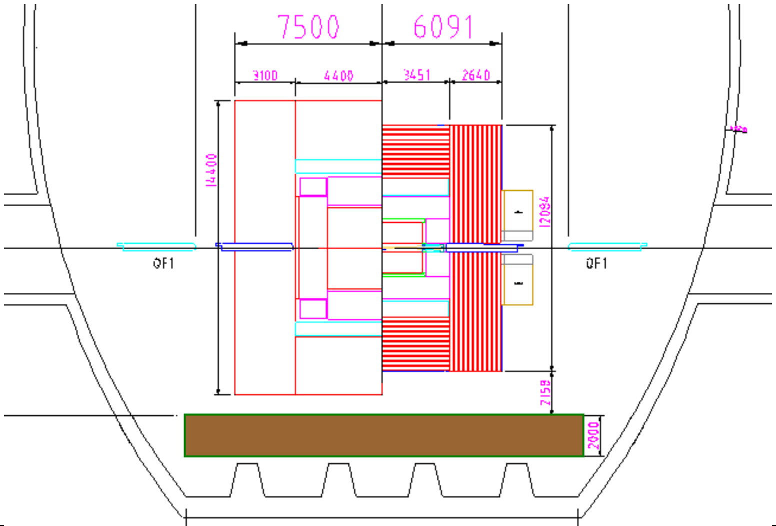

J.Amann

Example of MDI issues we are working on

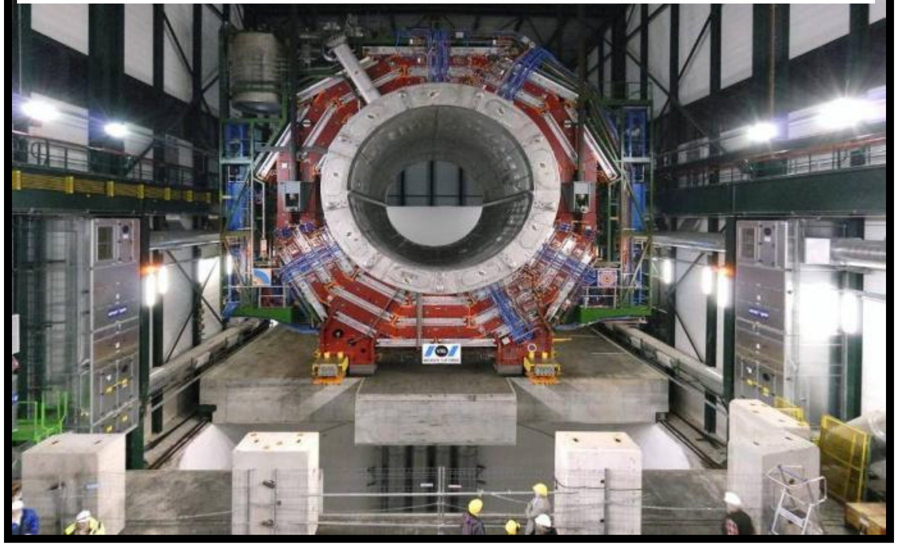
Detector motion system with or without an intermediate platform



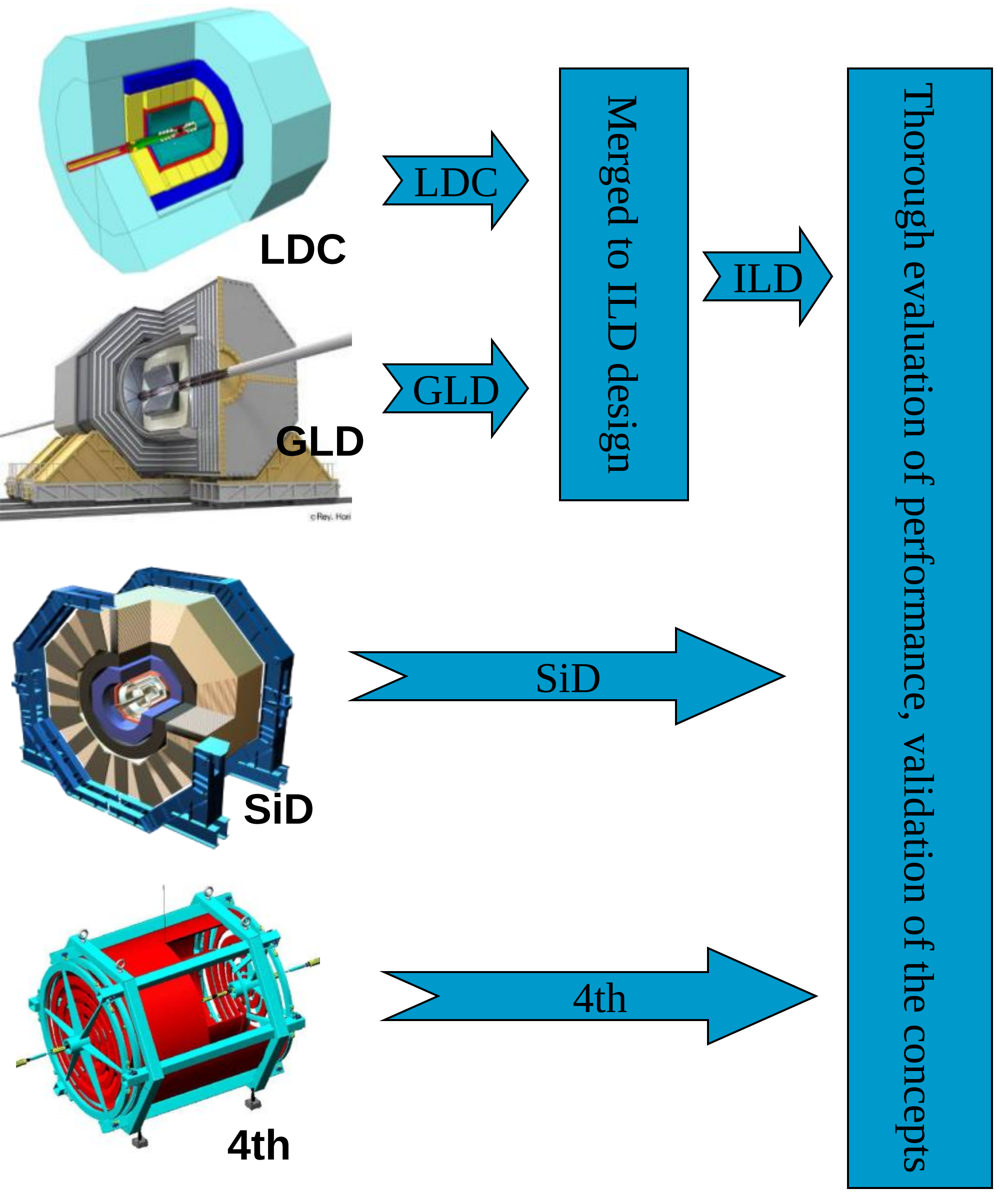
Detector and beamline shielding elements

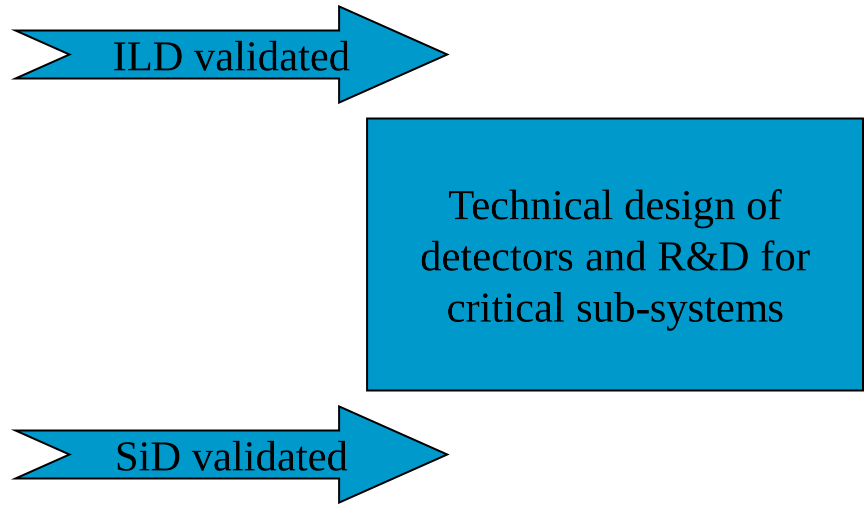


CMS platform – proof of principle for ILC

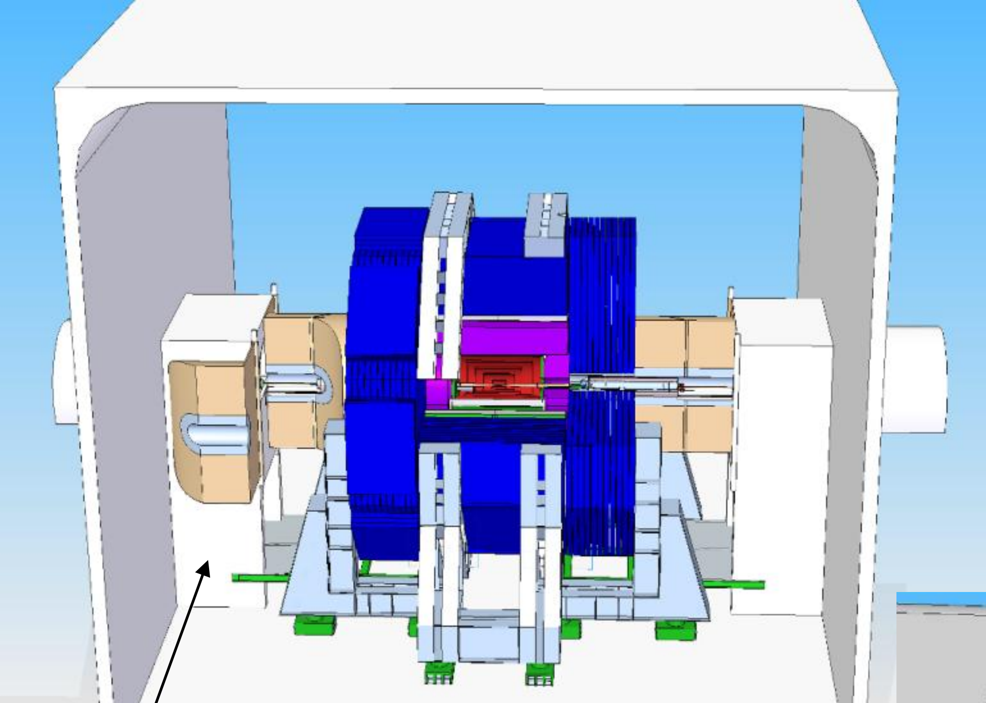


Evolution of ILC Detectors



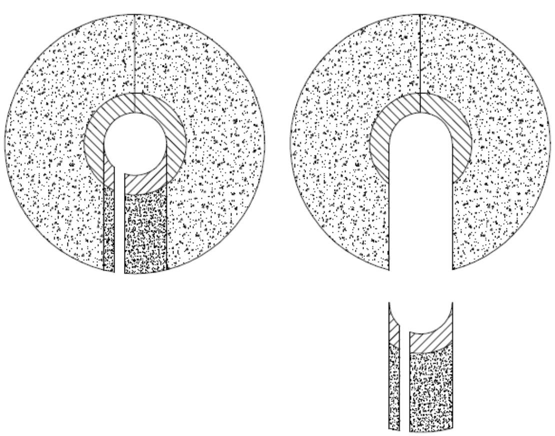


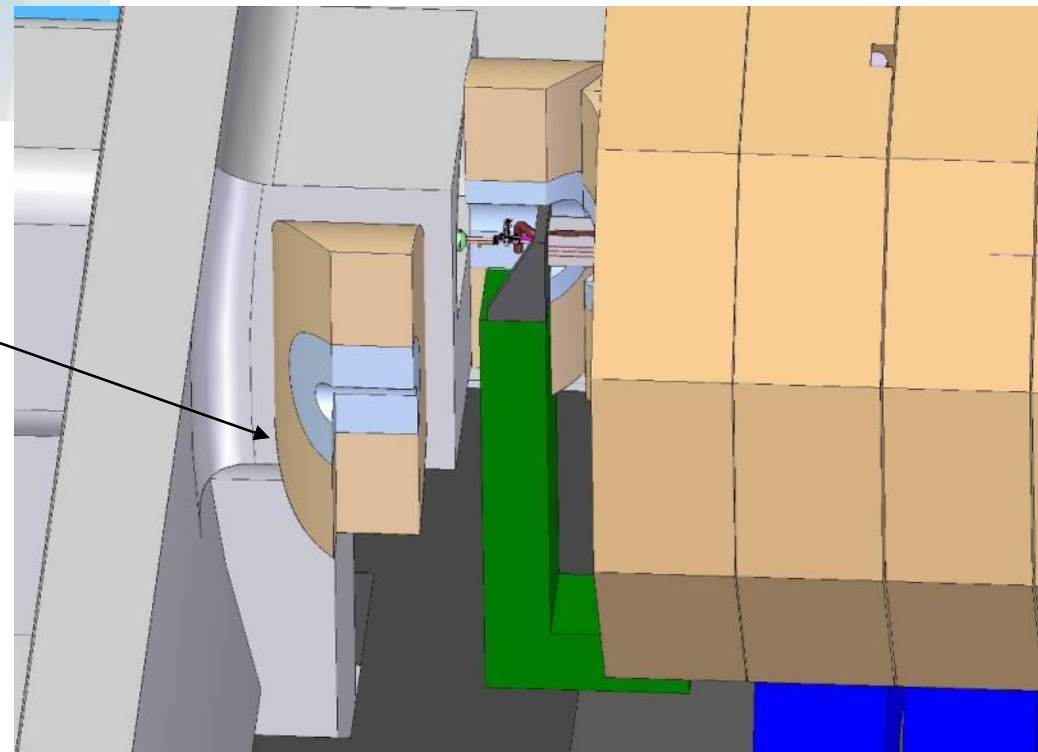
- **Evolution, self-review and selection process are essential for meeting the challenging detector requirements motivated by physics**
  - Triggerless event collection (software event selection)
  - Extremely precise vertexing
  - Vertex, tracker, calorimeters integrated for optimal jet reconstruction



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

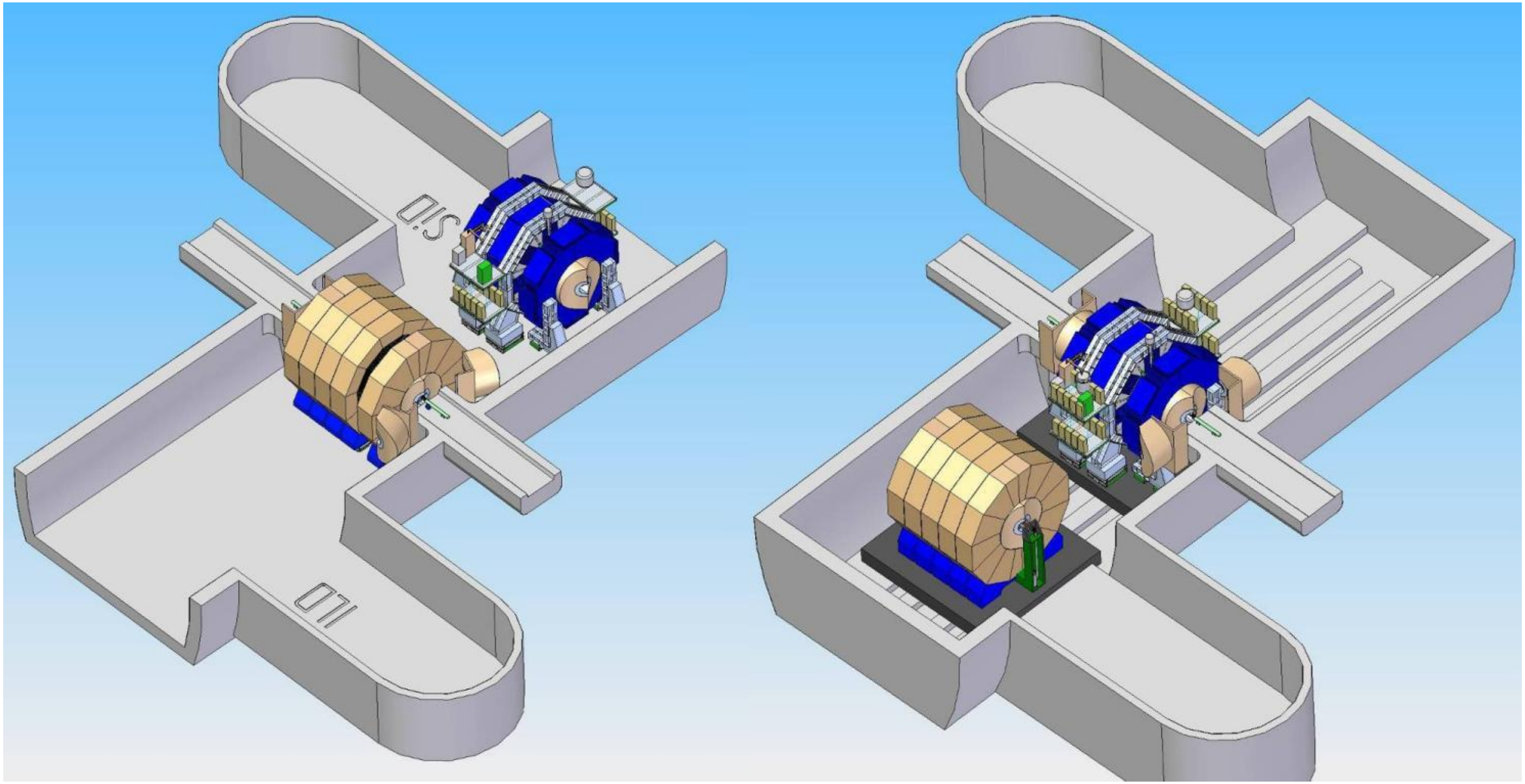
SiD ILD



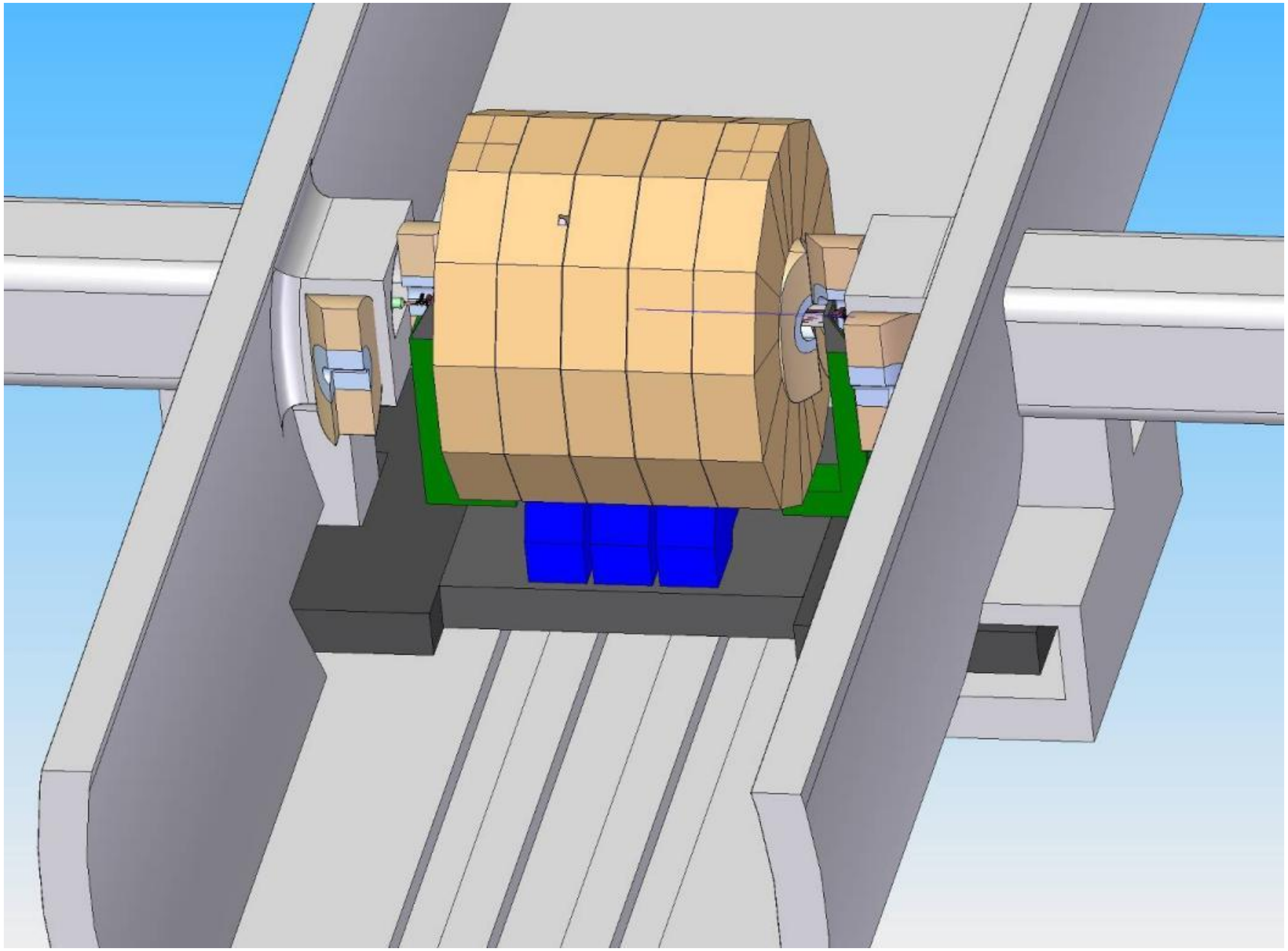


M.Oriunno, H.Yamaoka, A.Herve, et. al

All detectors without / with platform

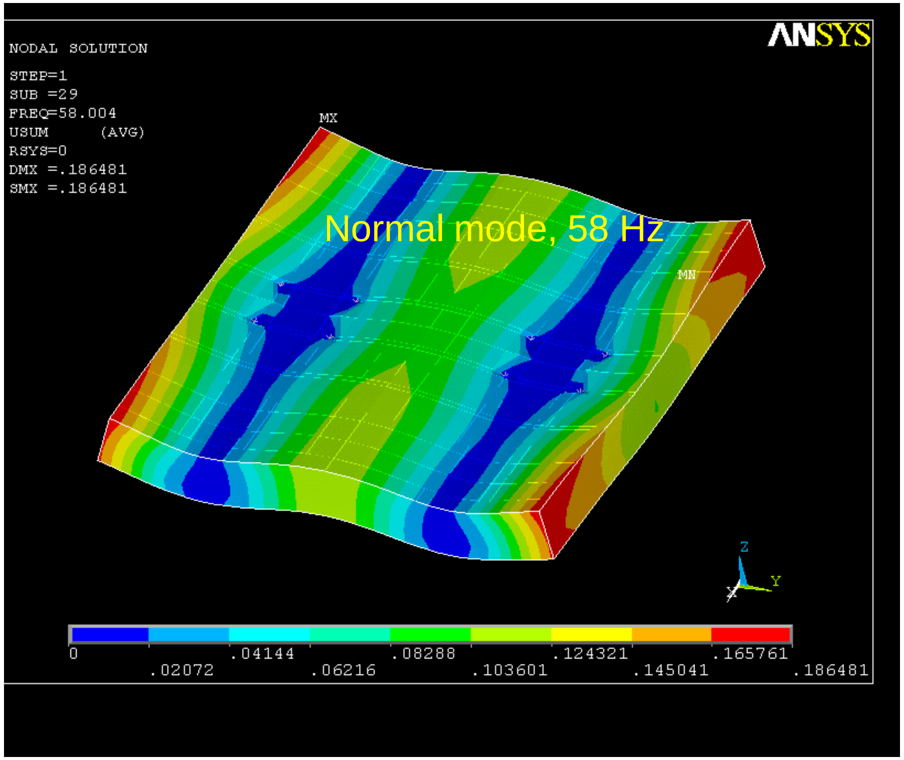


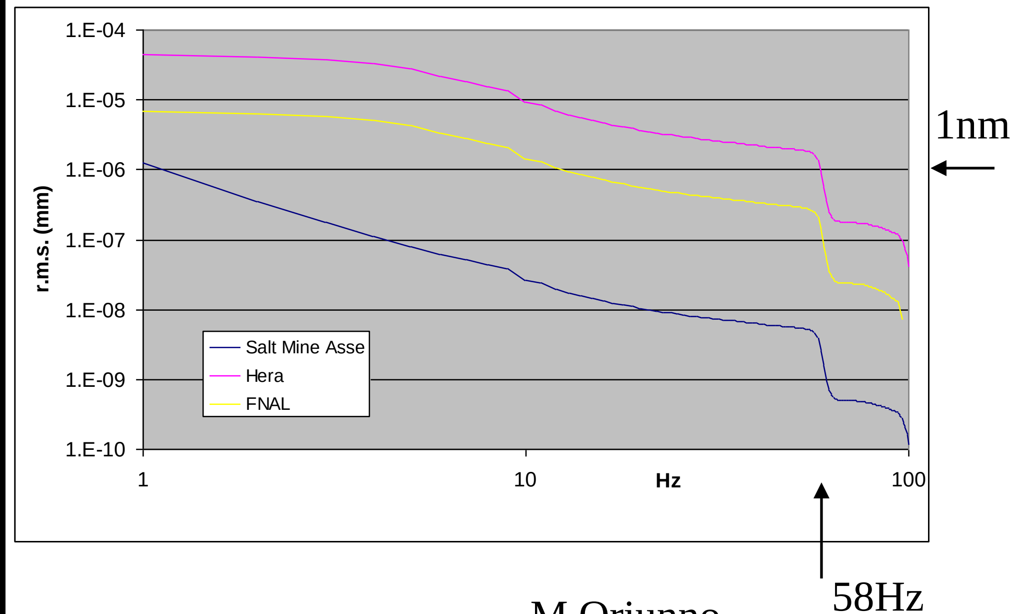
Half Platform w/ Pocket Storage



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

Preliminary
ANSYS analysis of Platform

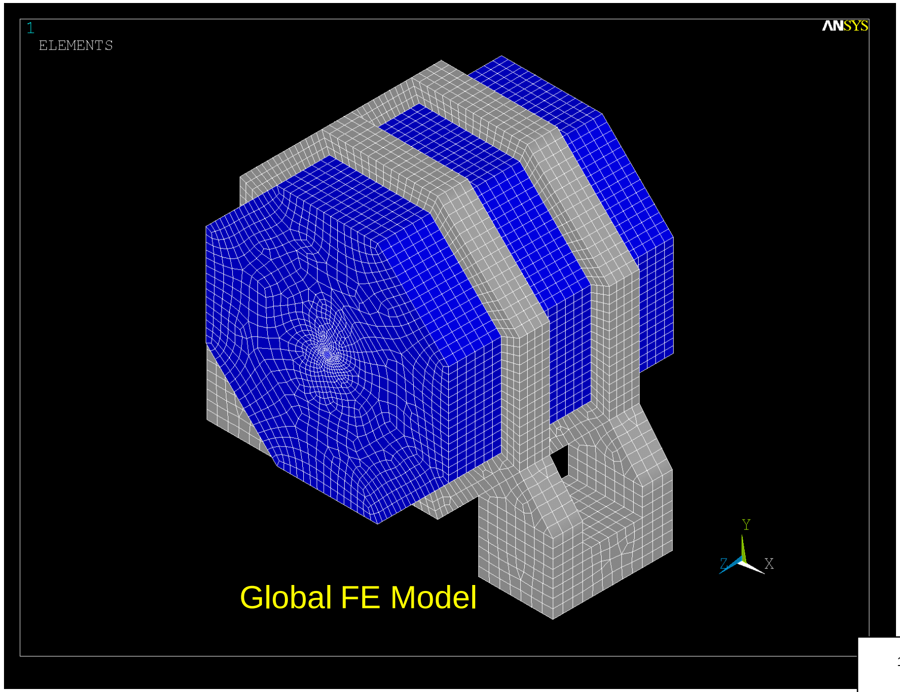


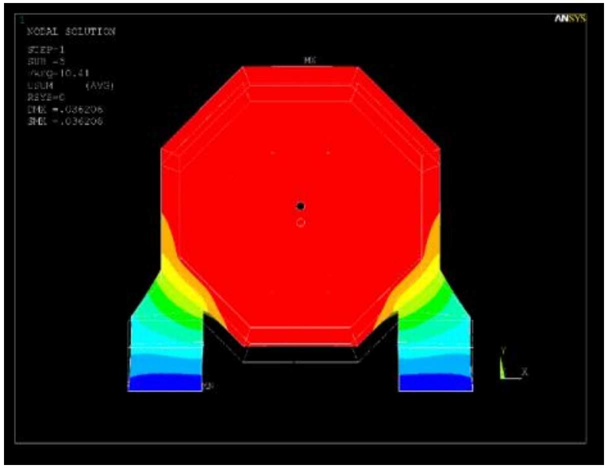


M.Oriunno

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

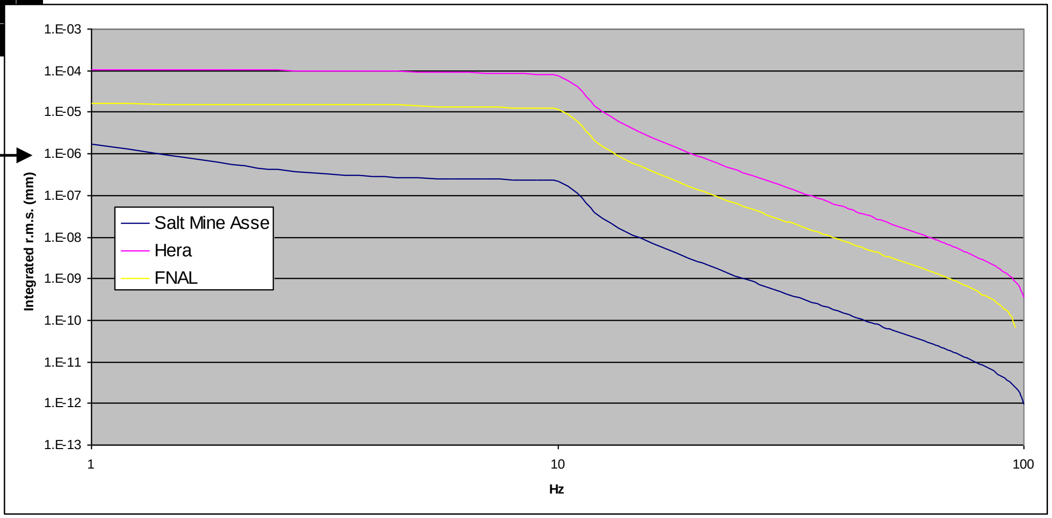
Detector stability analysis (SiD)



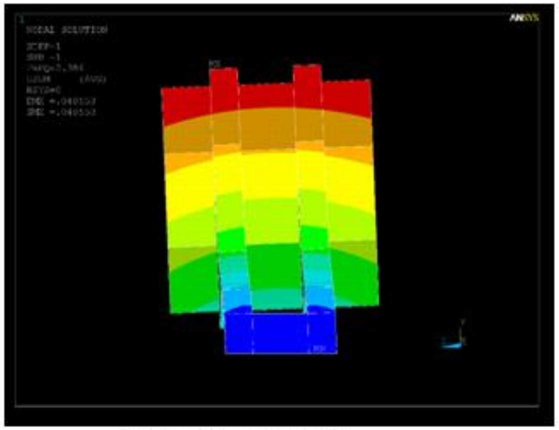


First vertical motion mode, 10.42 Hz

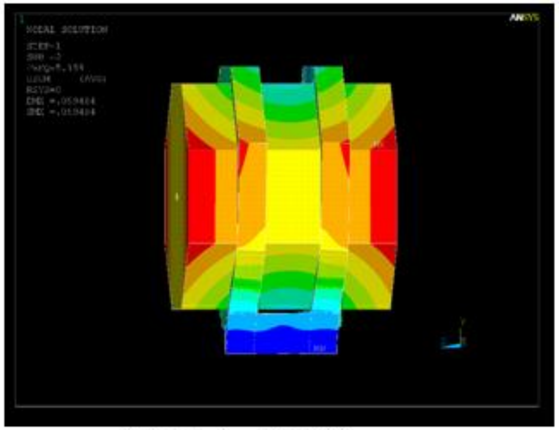
- First analysis shows possibilities for optimization
  - e.g. tolerance to fringe field => detector mass => resonance frequency



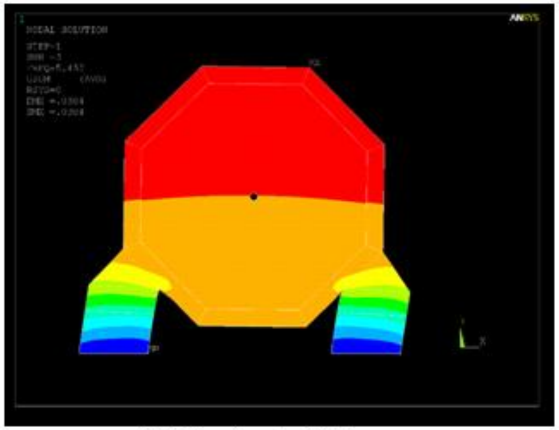
Free vibration modes of SiD



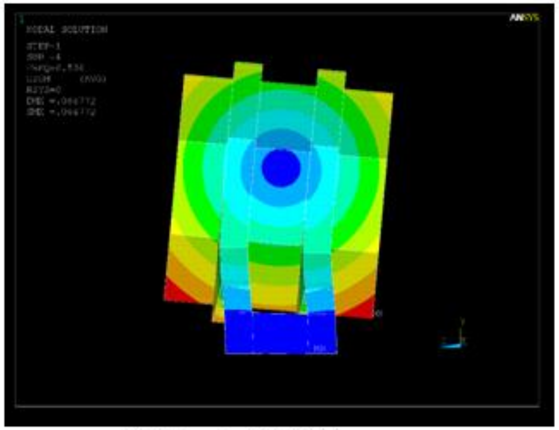
1st Mode, 2.38 Hz



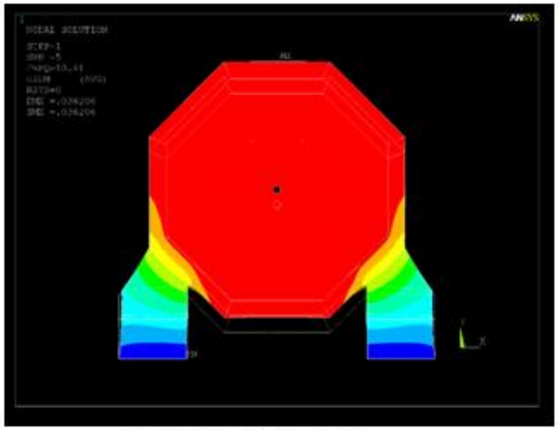
2nd Mode, 5.15 Hz



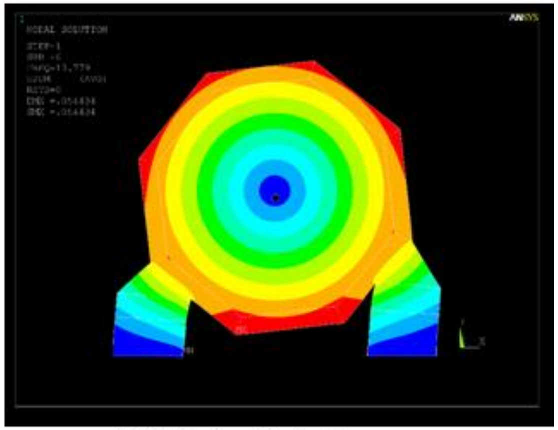
3rd Mode, 5.45 Hz



4th Mode, 6.53 Hz



5th Mode, 10.42 Hz

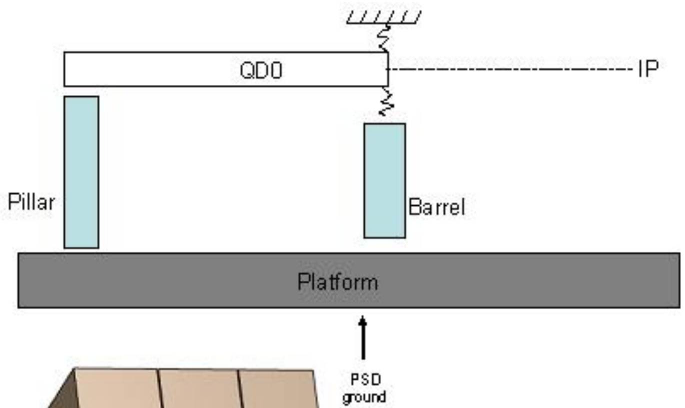


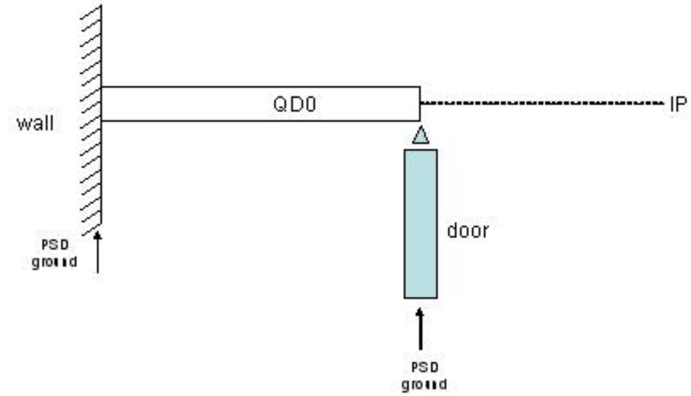
6th Mode, 13.7 Hz

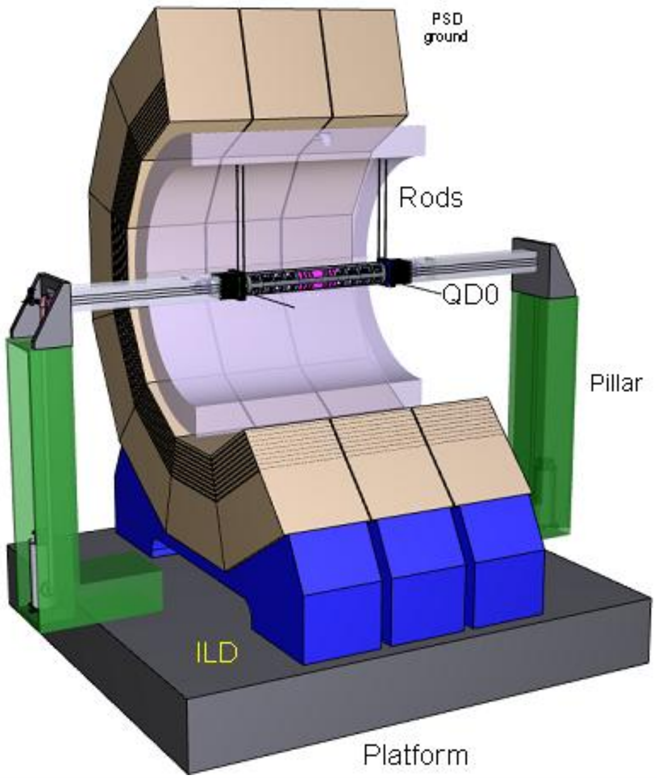
Vertical motion

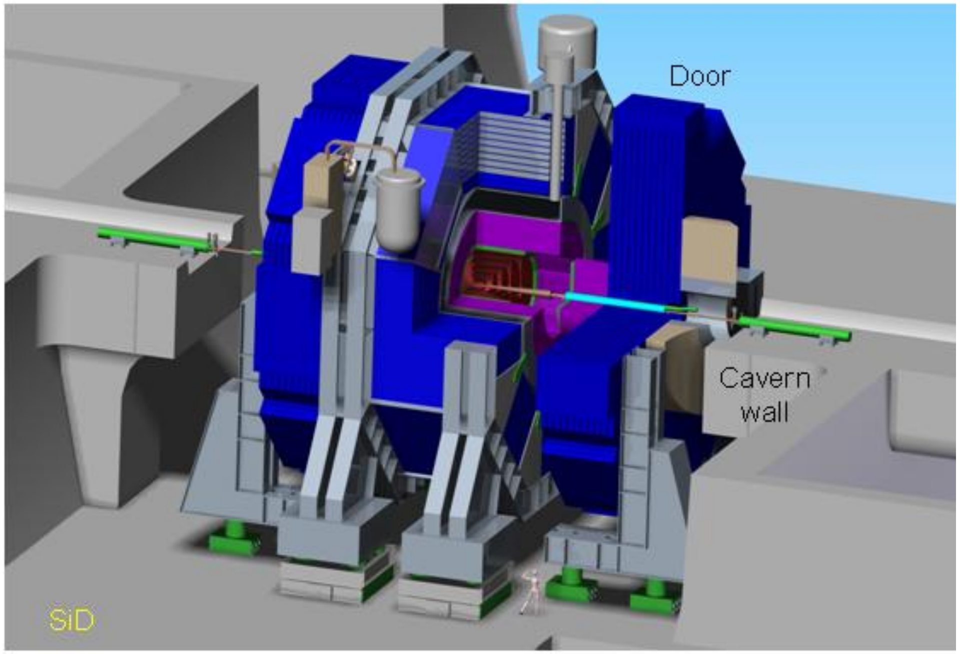
M.Oriunno

QD0 supports in ILD and SiD

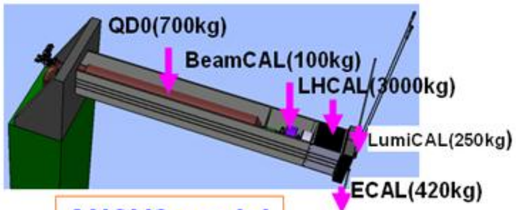




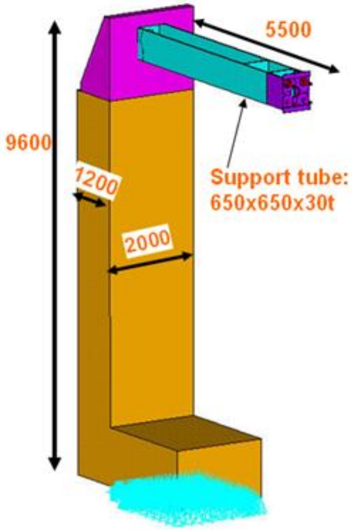




ILD FD stability analysis results

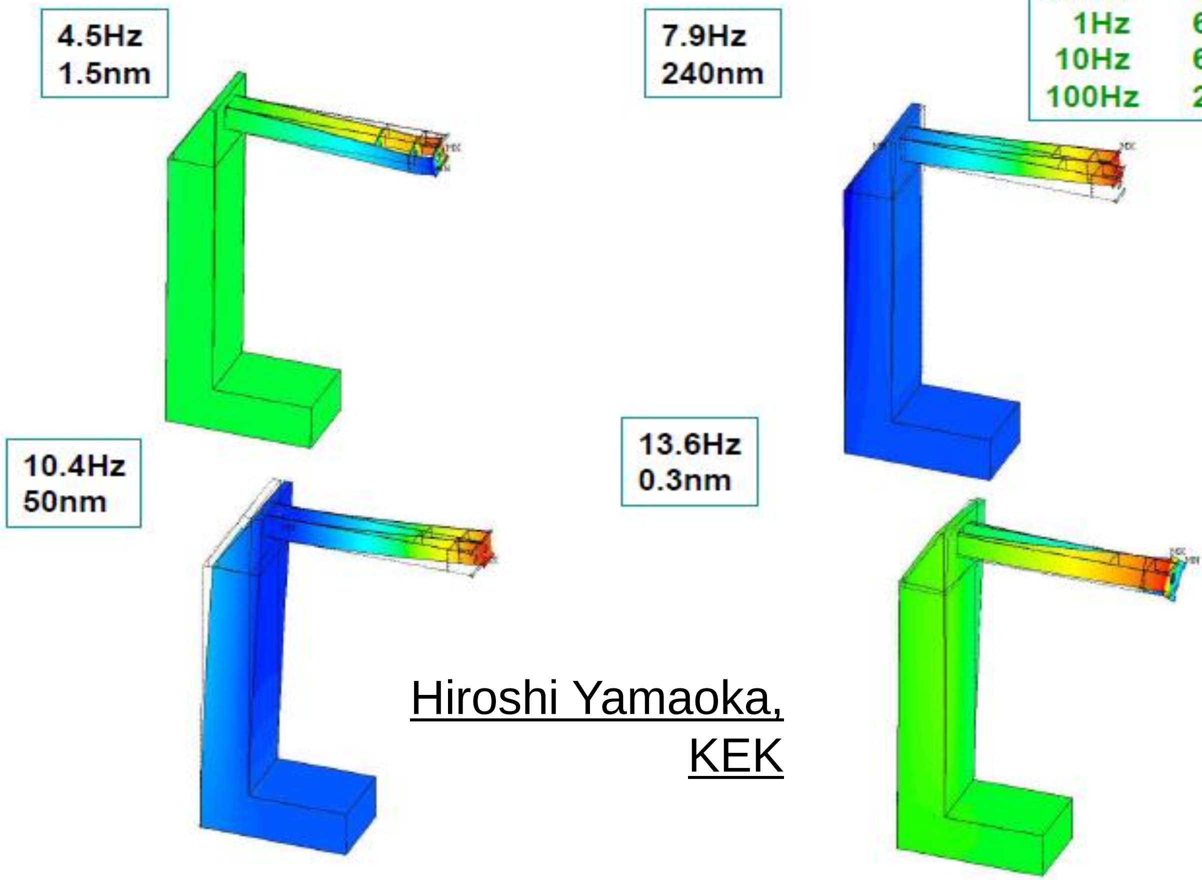


ANSYS model



Results: Responded amplitude at each resonance.

@ KEK-ATF	
0.1Hz	1e-5m/s^2
1Hz	6e-4m/s^2
10Hz	6e-4m/s^2
100Hz	2e-3m/s^2



Hiroshi Yamaoka,
KEK

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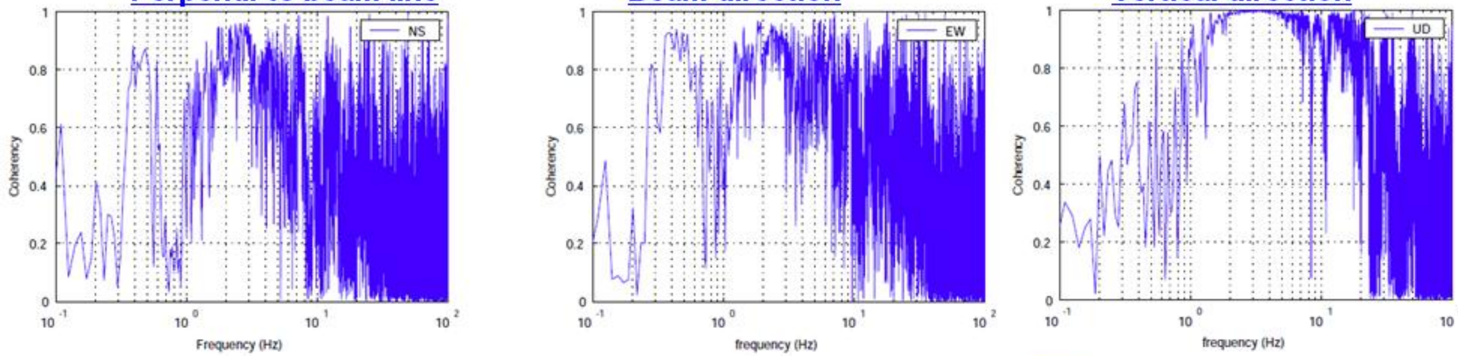
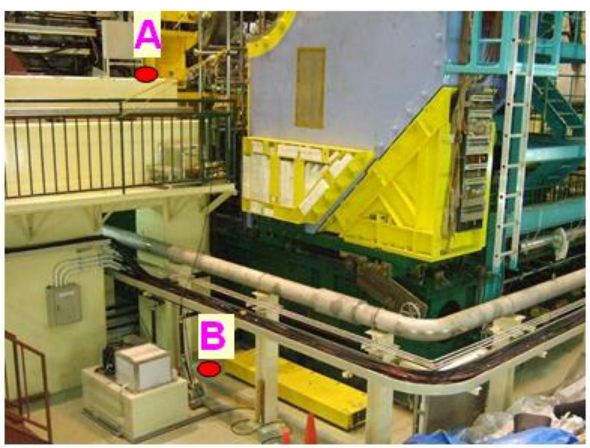
Stability studies at BELLE

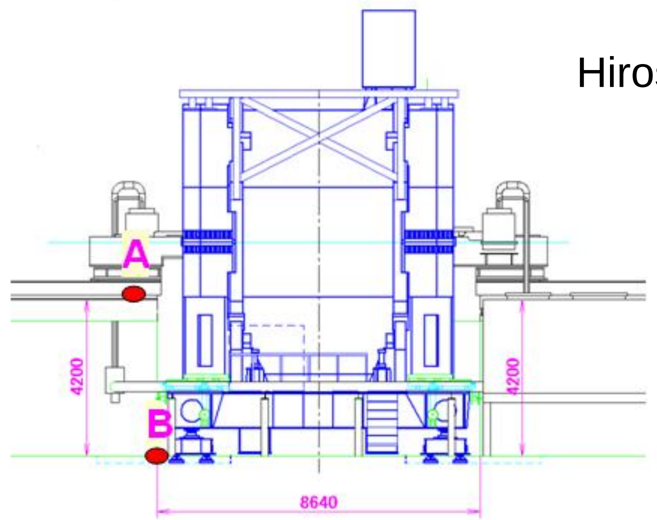
Measurement: B

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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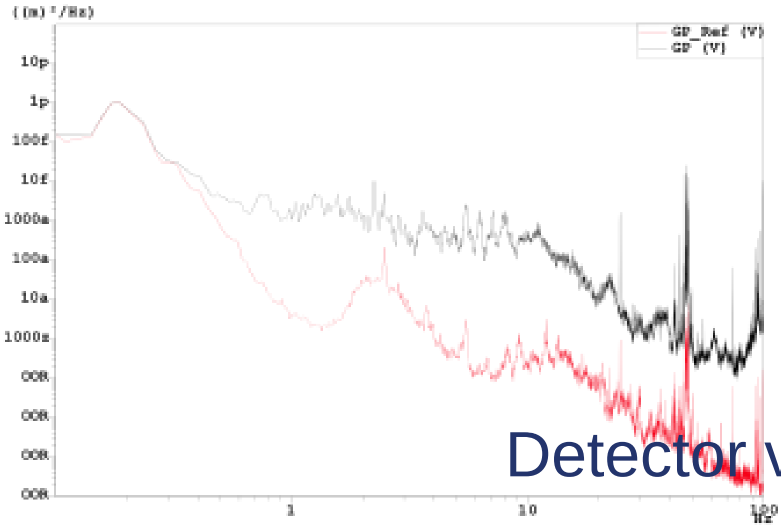
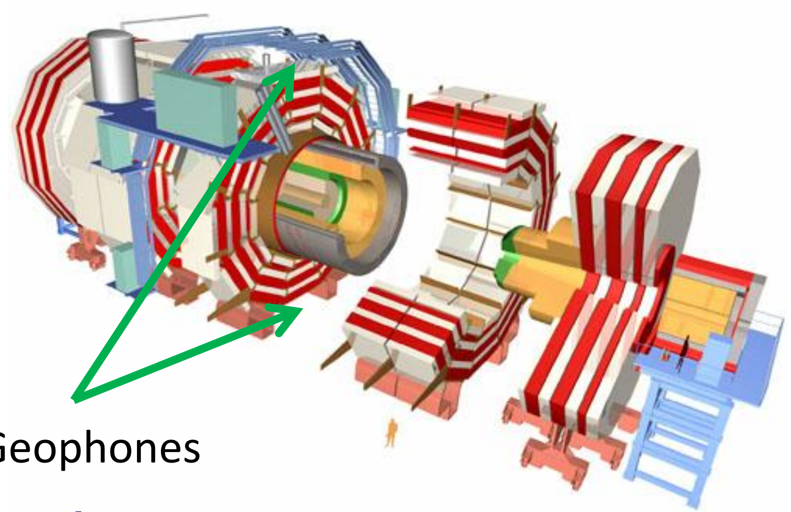
CMS top of Yoke measurement

PSD of the signals Vertical direction



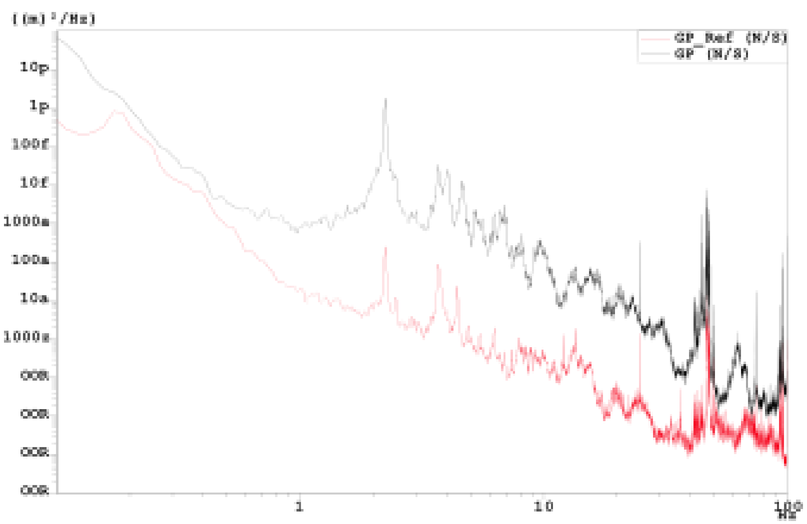


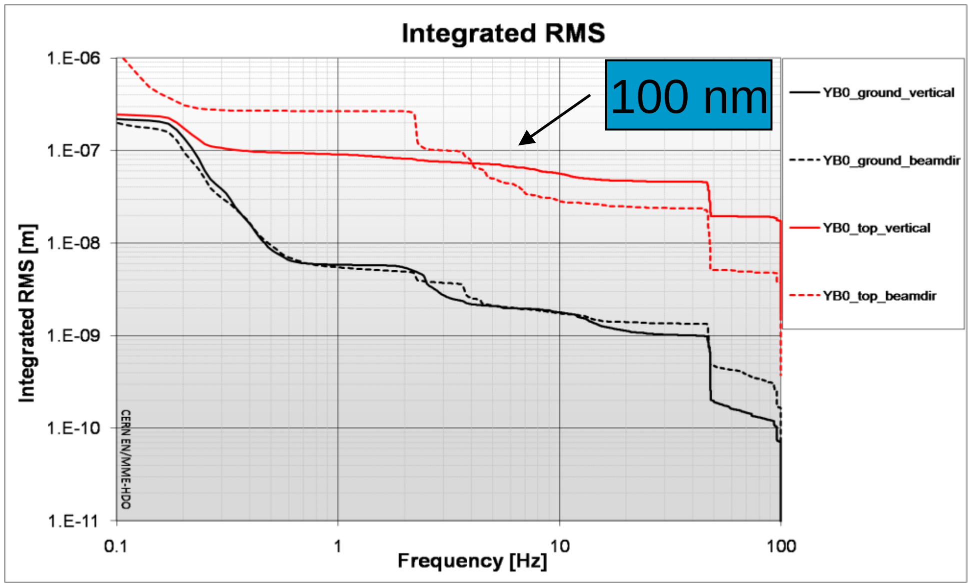
Detector vibrations and QD0 support

Cooling system OFF

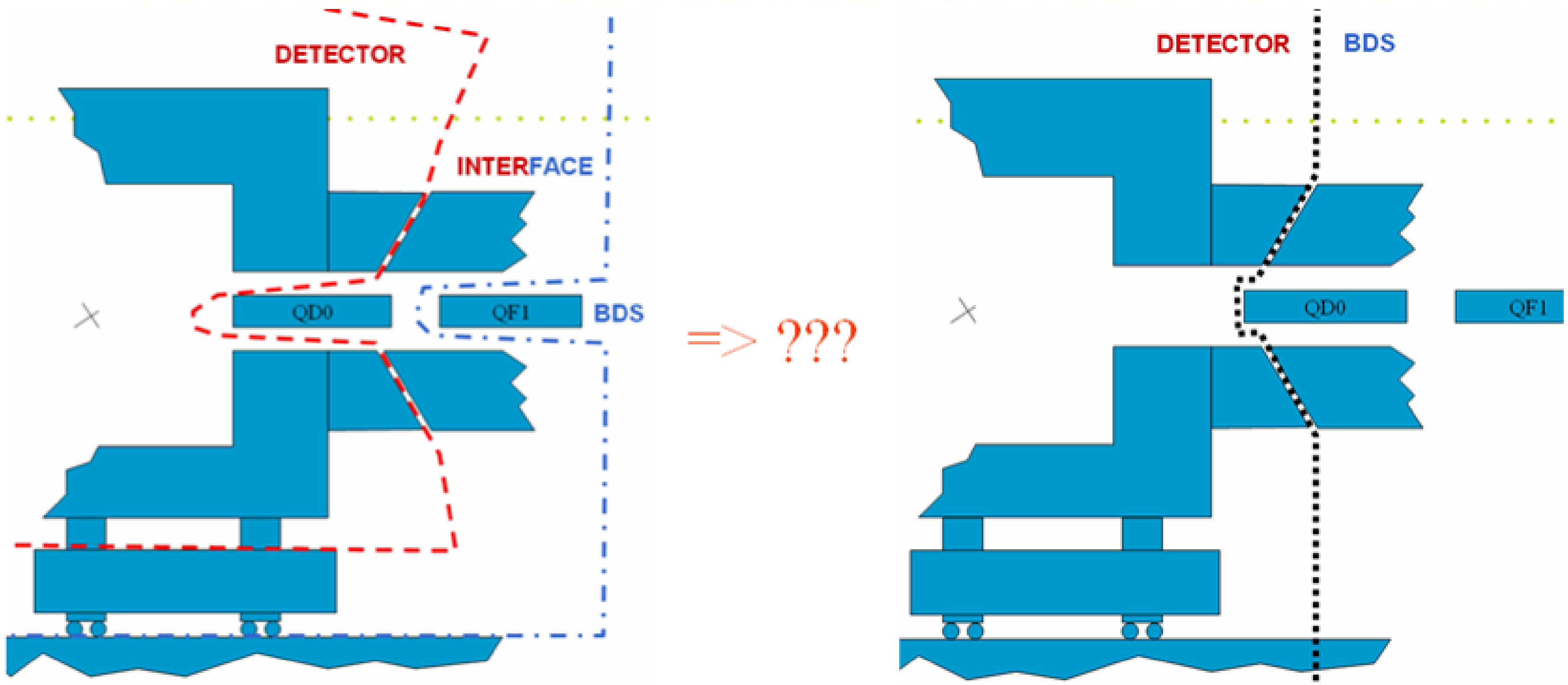
Alain Herve (ETH Zurich)

PSD of the signals Beam direction





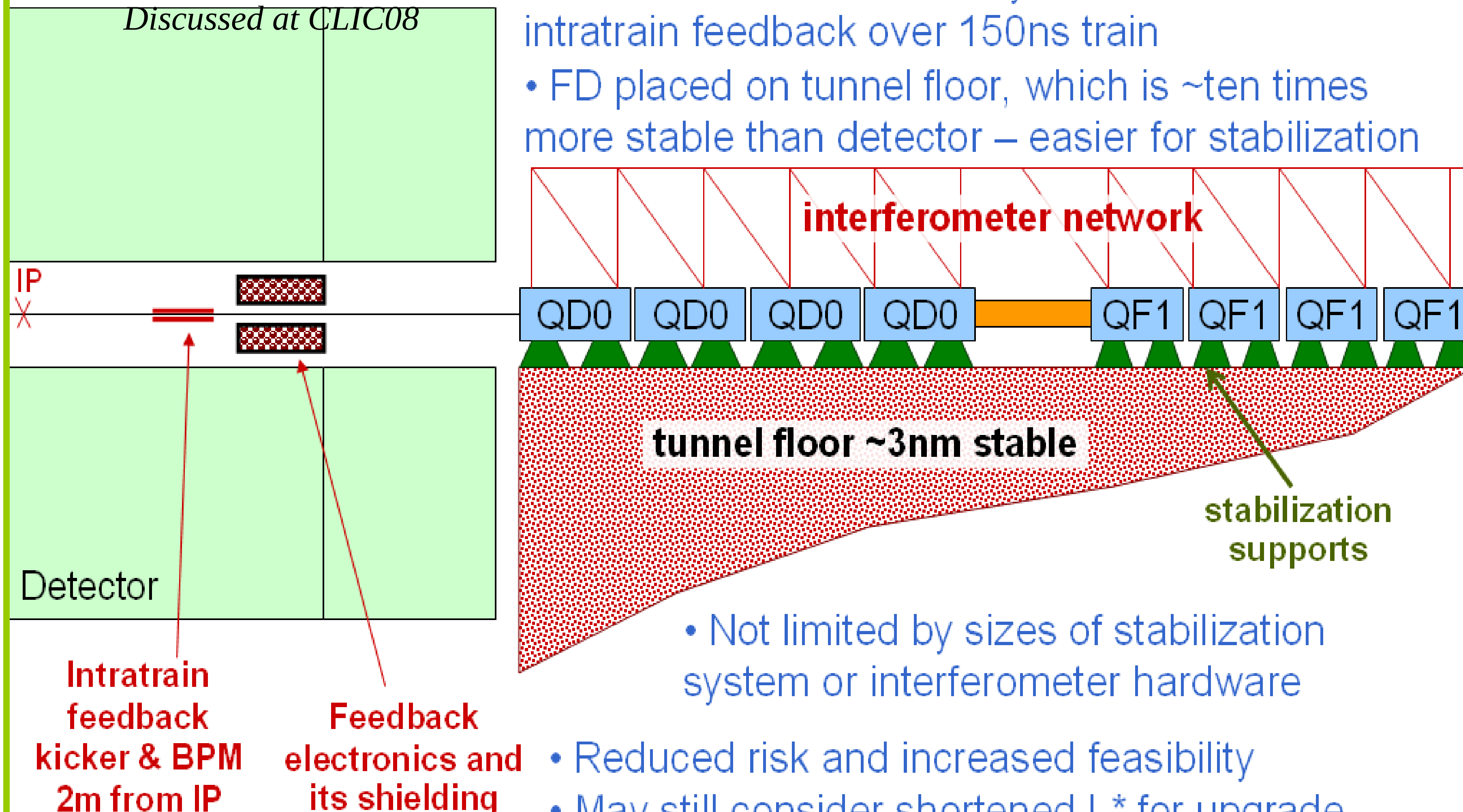
Longer L* → Simplified MDI?



- If doubled L* is feasible and acceptable then the MDI may be simplified tremendously
  - » and cost is reduced – do not need two extra sets of QD0
- An option of later upgrade for shorter L* may always be considered
- Has to be studied further

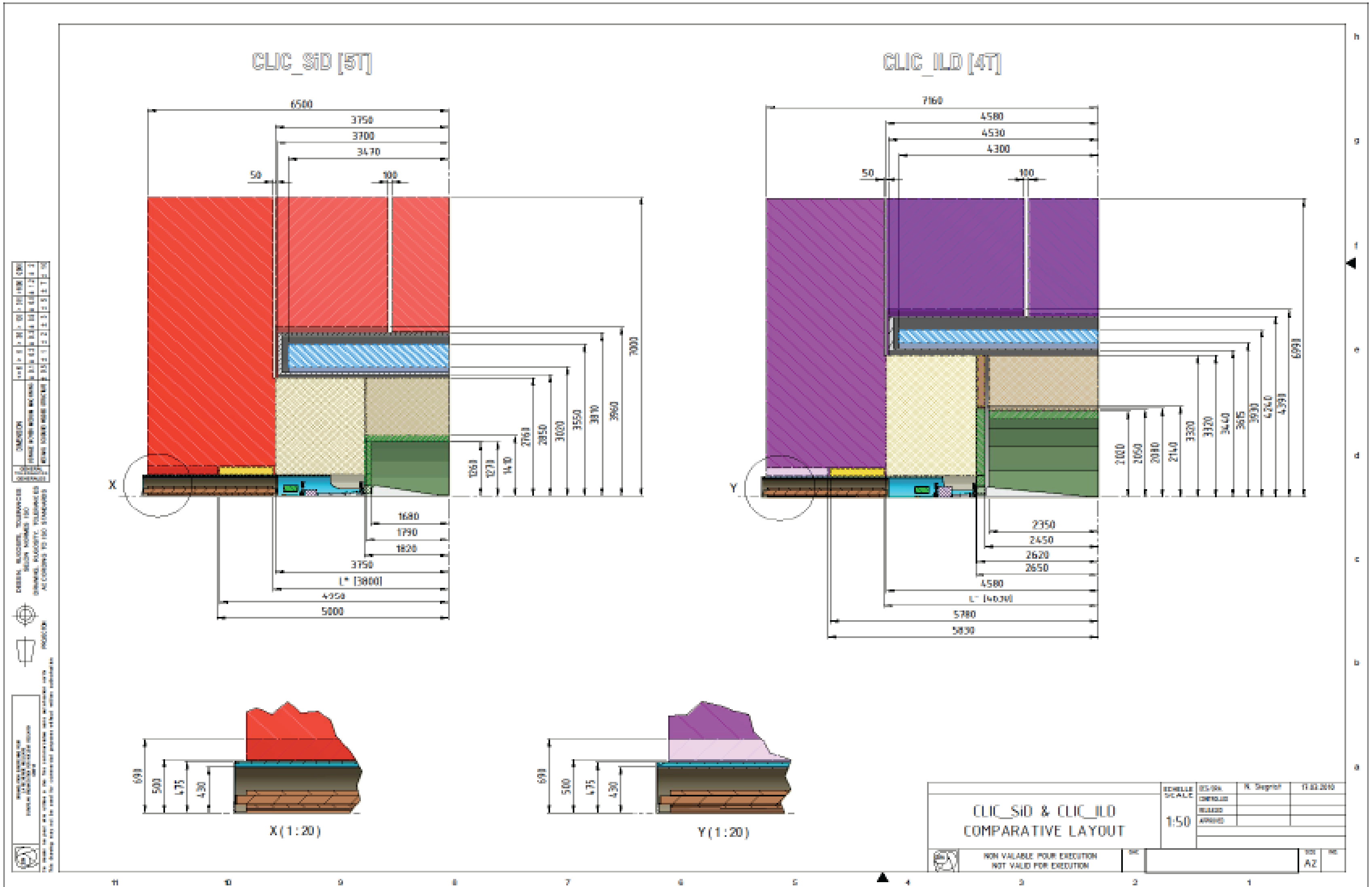
Doubled L* perhaps **necessary** for CLIC, where the FD stability requirement is ~0.1 nm

- Slower than 1/L* dependence of Lum => ↑L*
- Reduced feedback latency – several iteration of intratrain feedback over 150ns train
- FD placed on tunnel floor, which is ~ten times more stable than detector – easier for stabilization

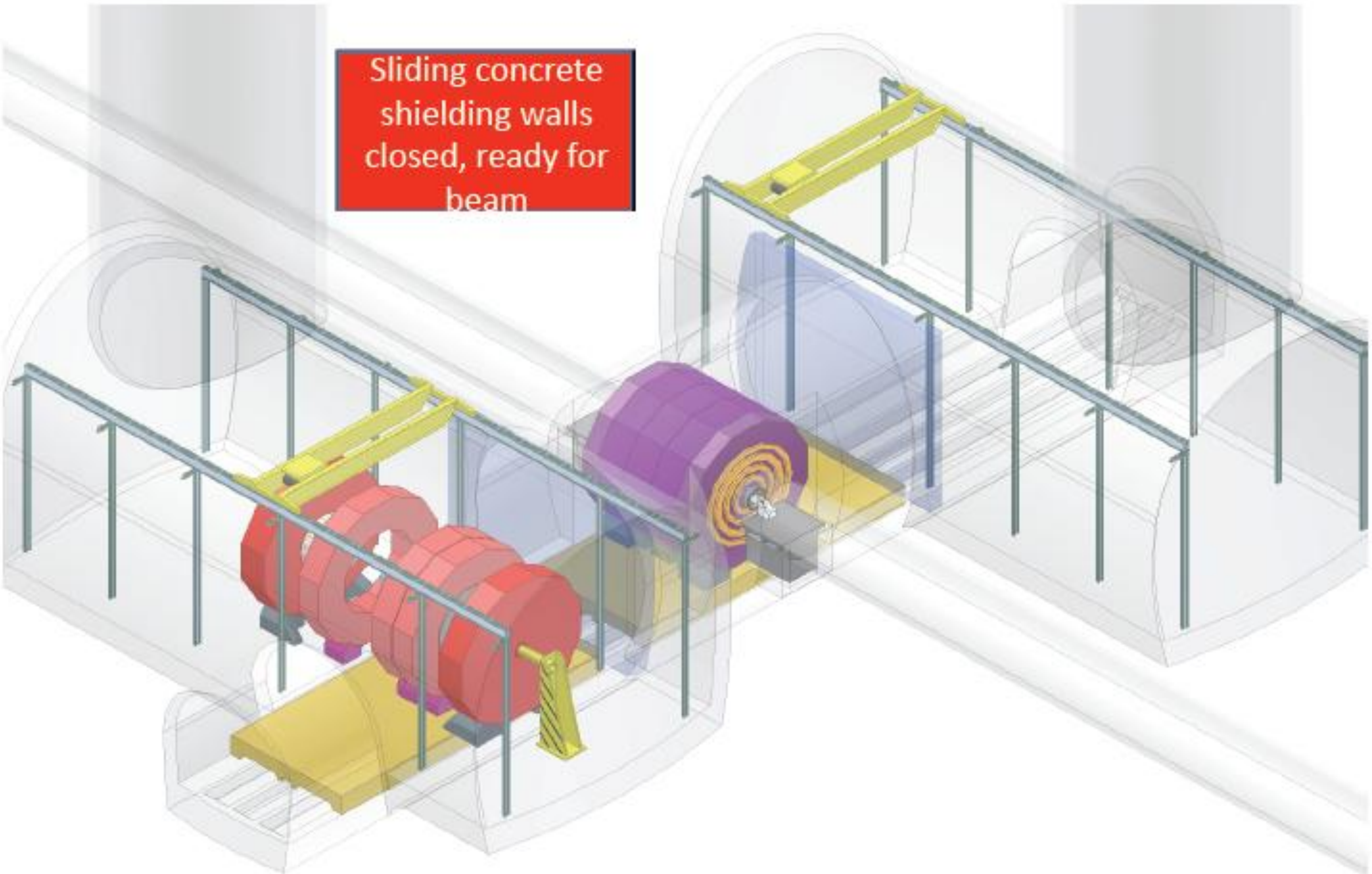


- Not limited by sizes of stabilization system or interferometer hardware
- Reduced risk and increased feasibility
- May still consider shortened L* for upgrade

CLIC detector comparison

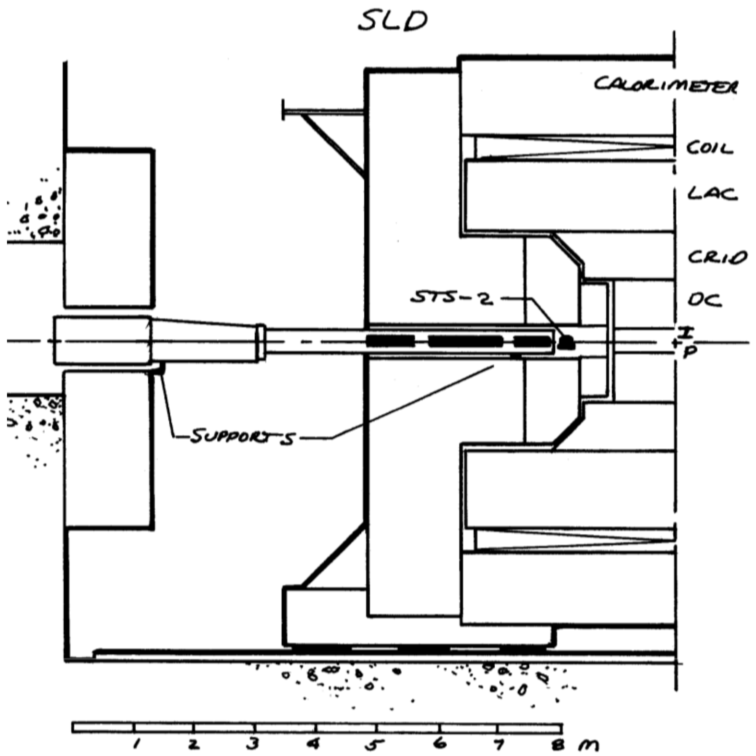


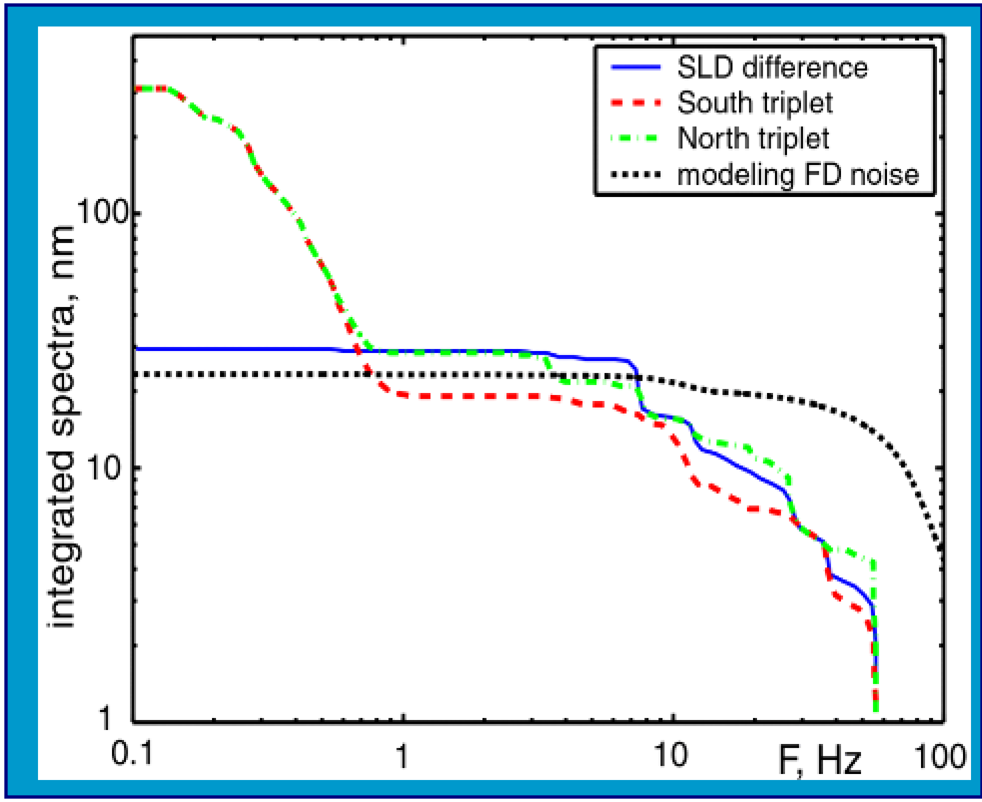
Experiment 2 sliding on IP, shielding walls closed



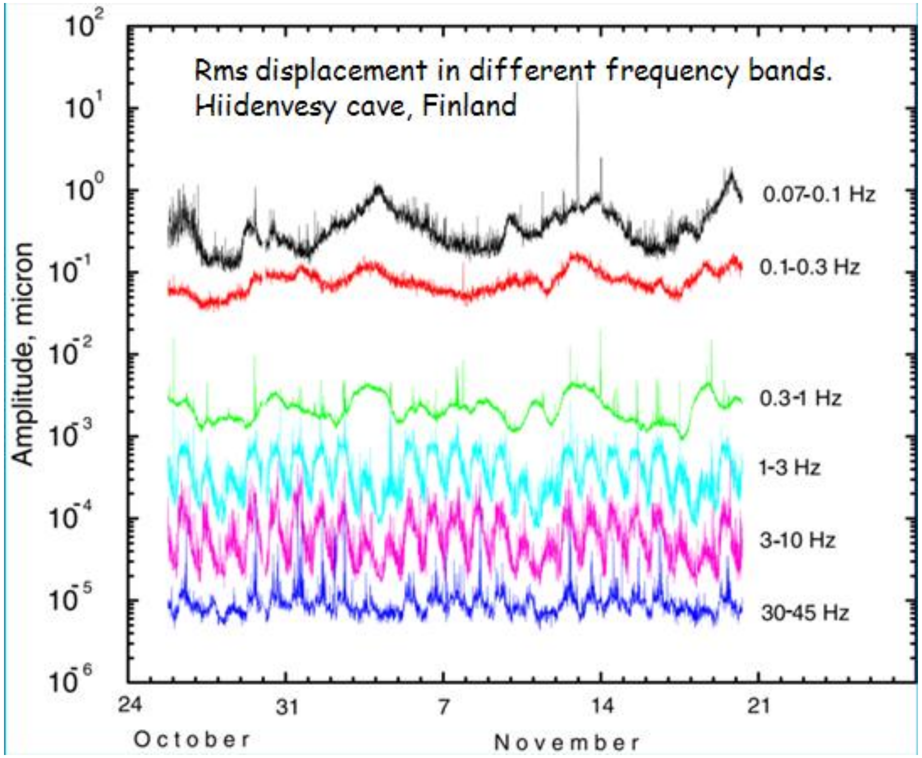
March 28, 10 H. Gerwig - LCWS10/ILC10 28

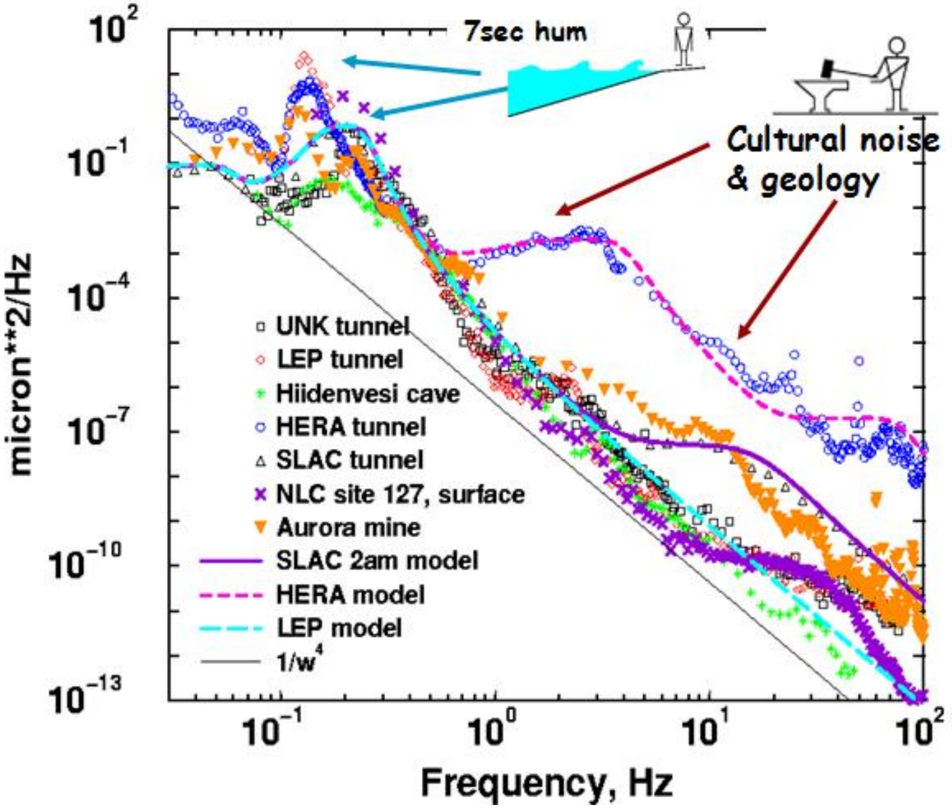
Detector is a "noisy ground"

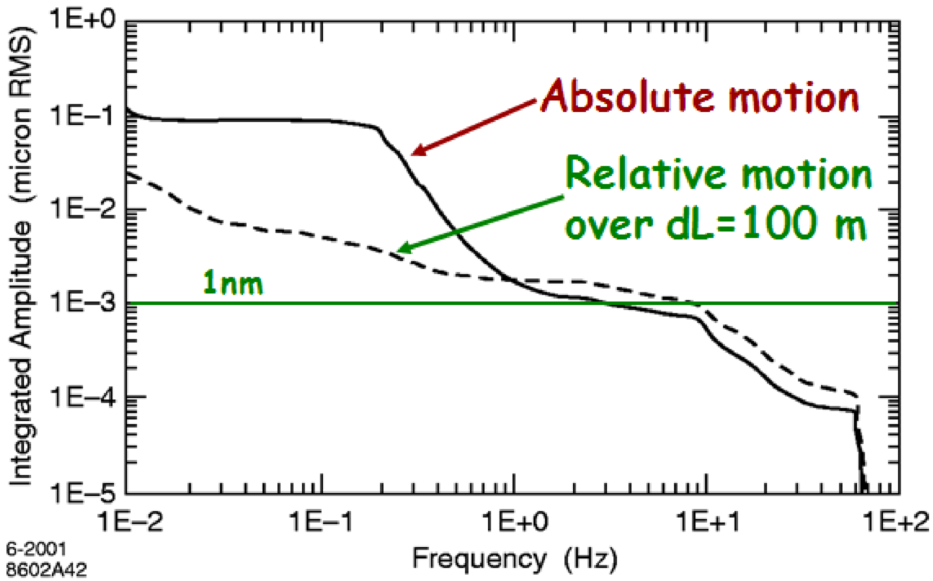




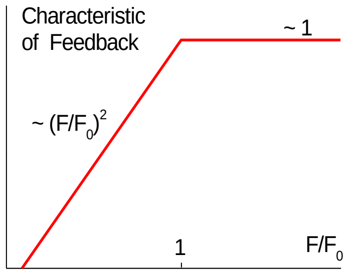
Measured ~30nm relative motion between South and North final triplets of SLC final focus. The NLC detector will be designed to be more quiet. But in modeling we pessimistically assume the amplitude as observed at SLD

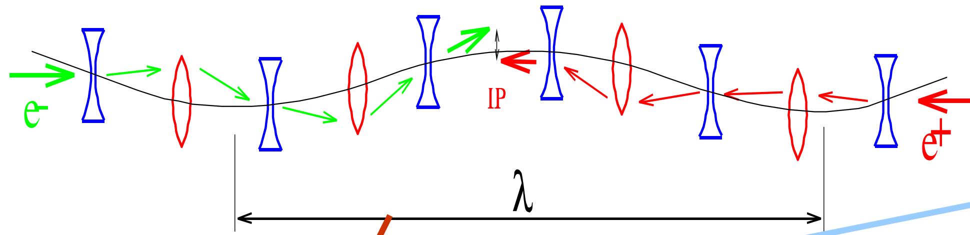

Rms displacement in different frequency bands.
Hiidenvesy cave, Finland
Amplitude, micron
0.07-0.1 Hz
0.1-0.3 Hz
0.3-1 Hz
1-3 Hz
3-10 Hz
30-45 Hz
24
31
7
14
21
October
November

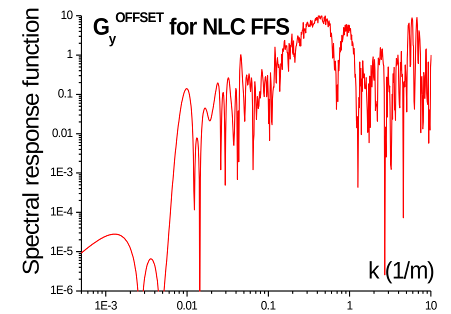

7sec hum
Cultural noise
& geology
micron**2/Hz
UNK tunnel
LEP tunnel
Hiidenvesi cave
HERA tunnel
SLAC tunnel
NLC site 127, surface
Aurora mine
SLAC 2am model
HERA model
LEP model
1/w^4
Frequency, Hz


Absolute motion
Relative motion
over dL=100 m
1nm
Integrated Amplitude (micron RMS)
Frequency (Hz)
6-2001
8602A42

Spectral approach possible in case of use of feedbacks and beam based alignment procedures



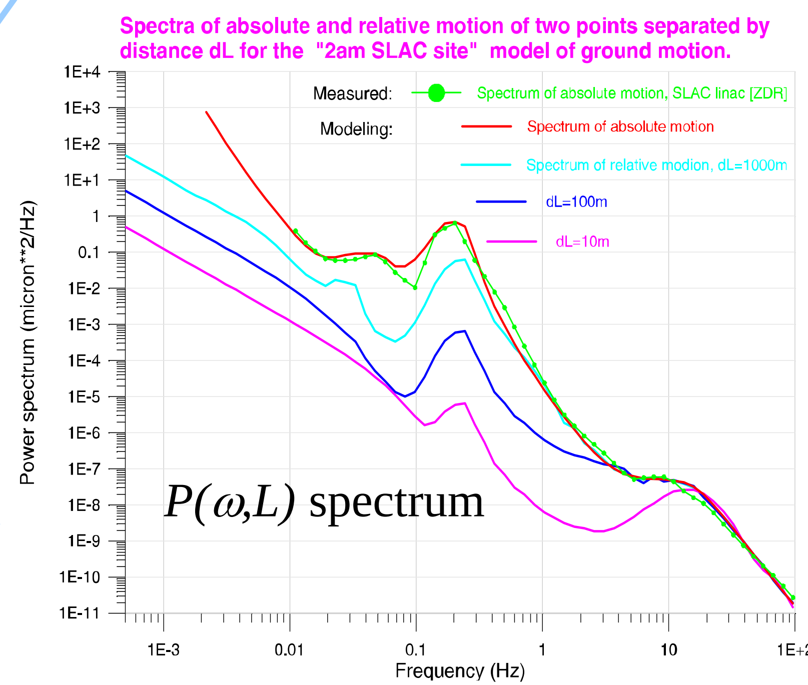




rms beam offset at IP:

$$\propto \iint P(\omega,k)\cdot G(k)\cdot F(\omega)\cdot dk\cdot d\omega$$

$G(k)$ - spectral response function

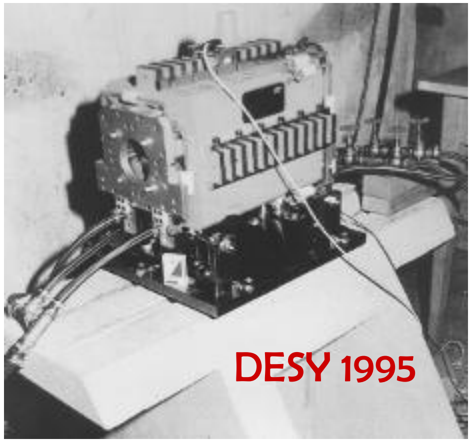


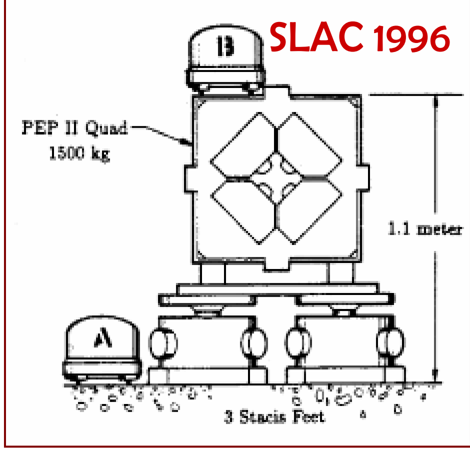
$F(\omega)$ - performance of inter-bunch feedback

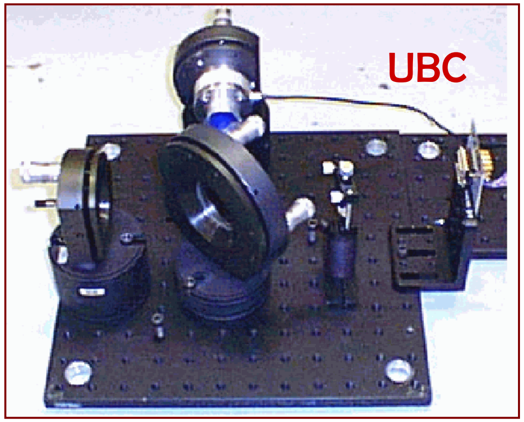
$P(\omega,k)$ - 2D spectrum of ground motion

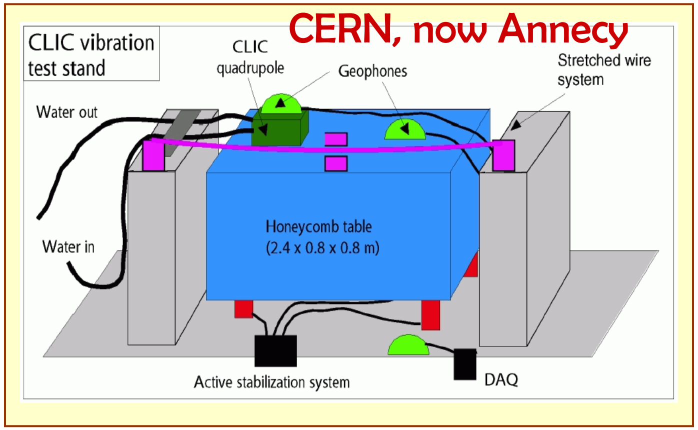
Stabilization studies

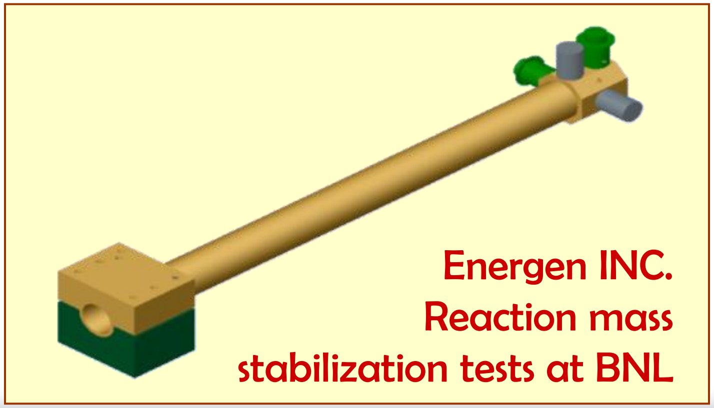
- Anticipated the need of active stabilization for final doublet of warm collider – pursued on several fronts





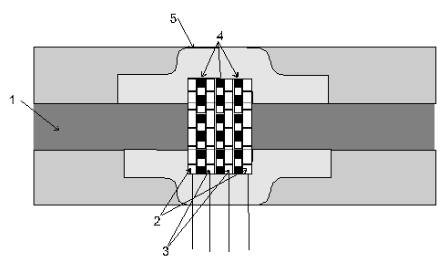




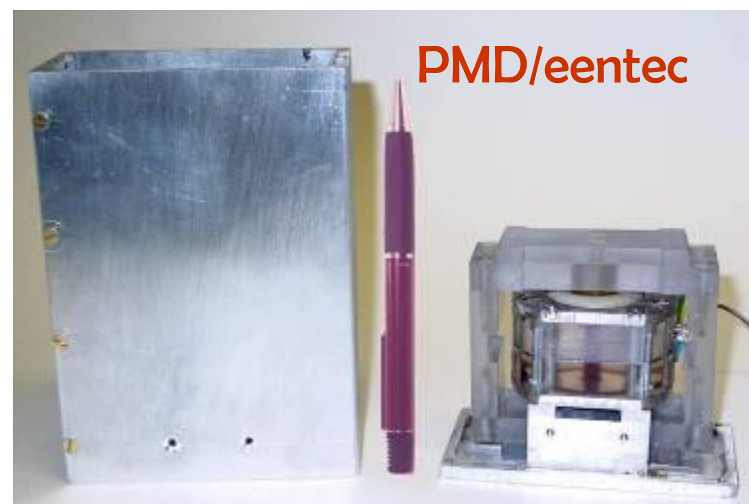


Development of sensors for IR

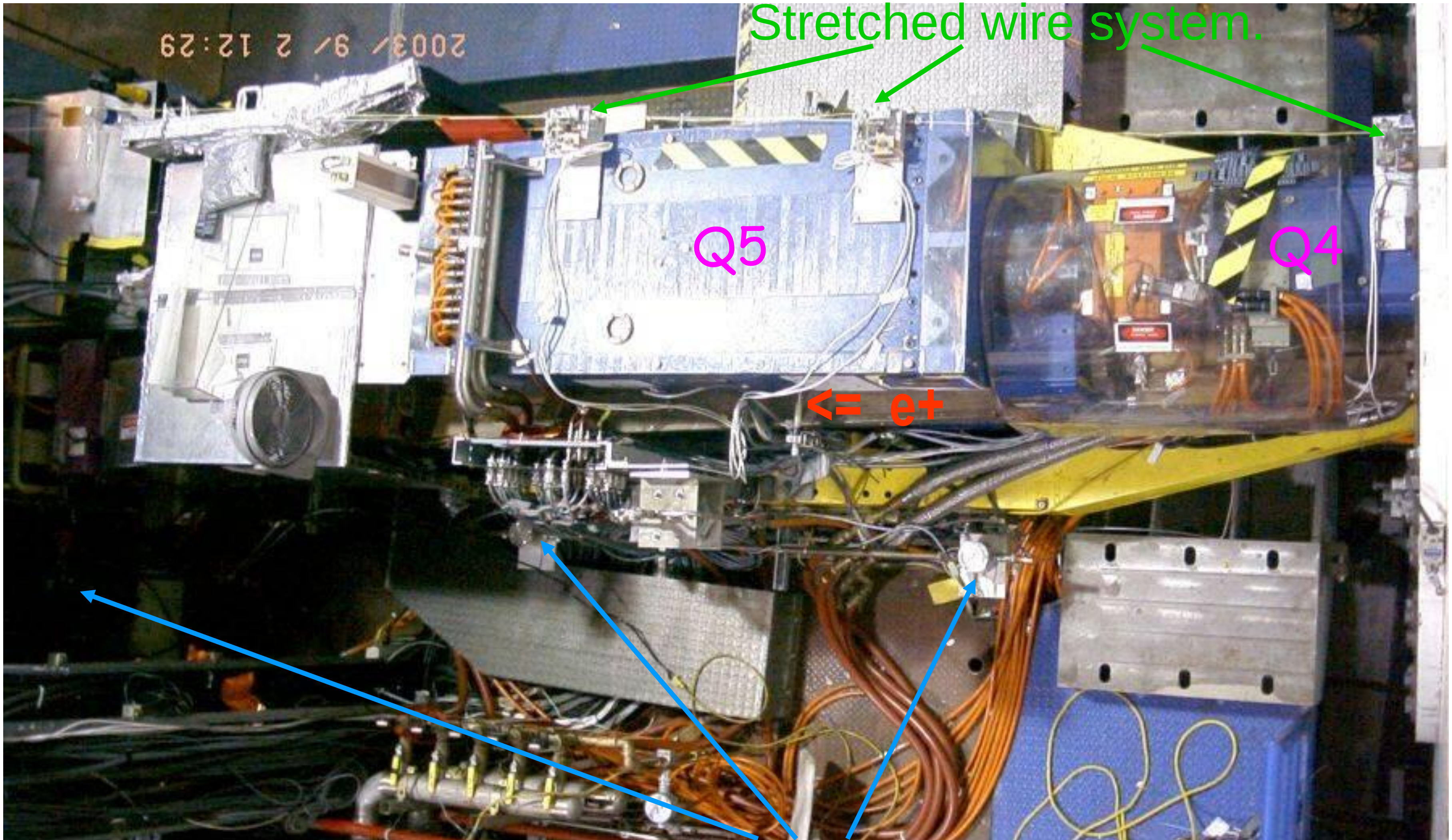
- Nonmagnetic inertial seismometers
  - SLAC home built – low noise, as good as Mark4 geophone or better
  - Molecular Electronic Transfer sensor – low noise, tested in 1.2T field
- Interferometer methods
- Will need to use these or more advanced sensors to monitor FD motion



1 - Electrolyte channel
2 - Platinum mesh anodes
3 - Platinum mesh cathodes
4 - Microporous spacers
5 - Housing



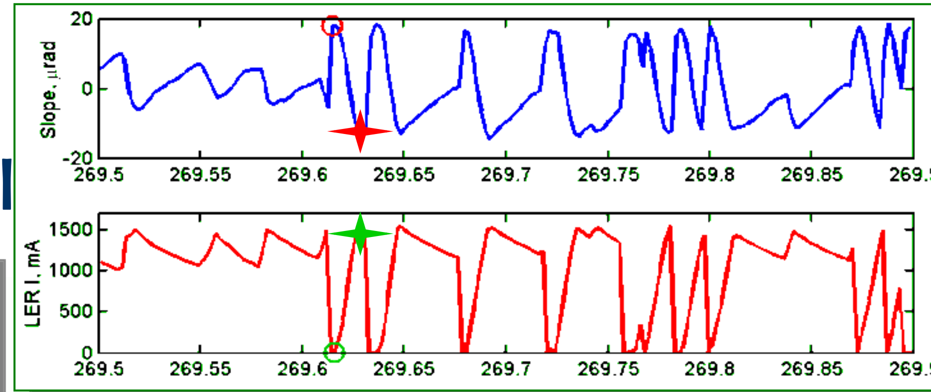
Study motion of PEP-II IR2 magnets using HLS (SR from LER heating chambers=> 0.1mm motion)

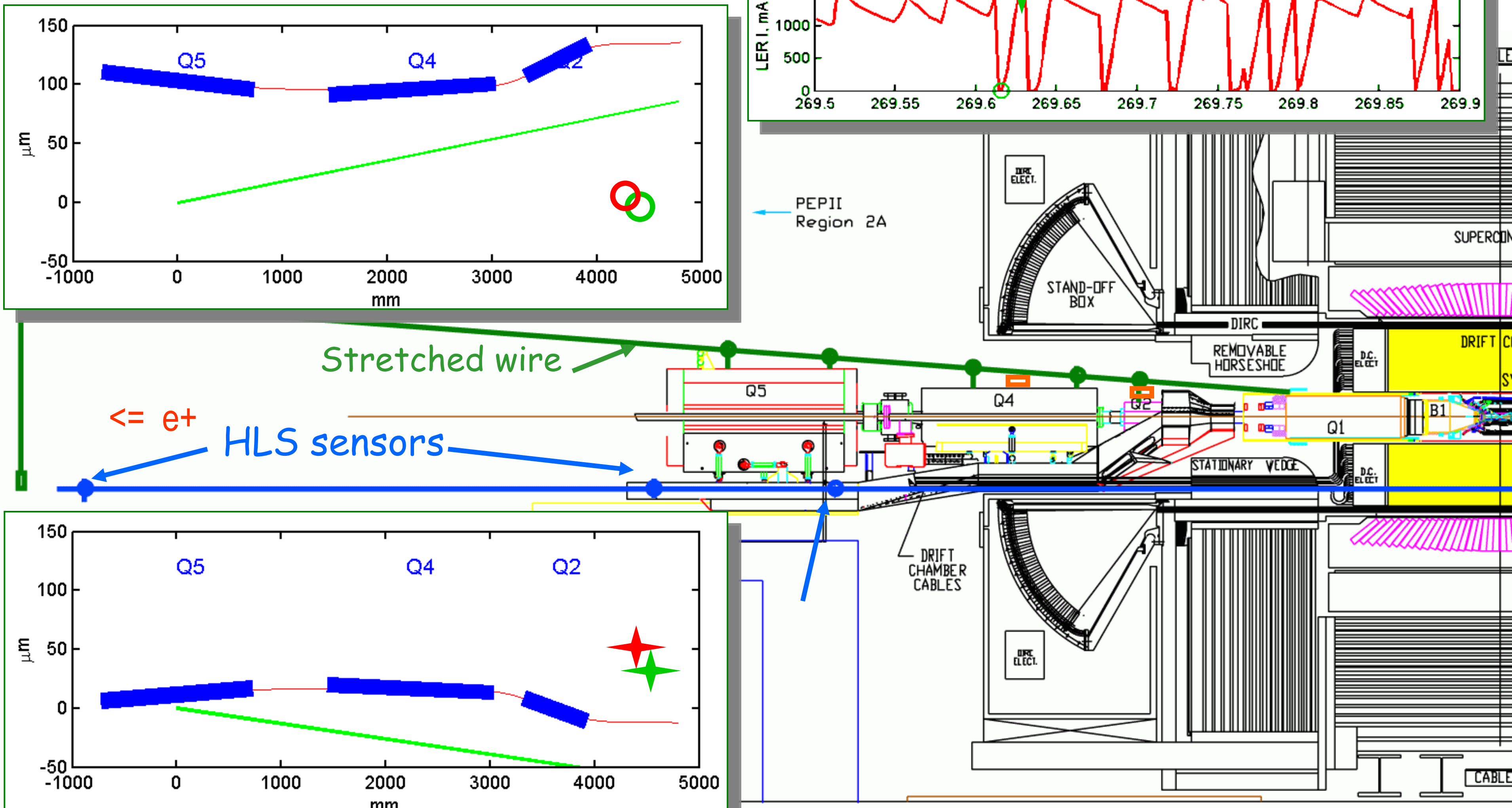


PEP-II IR-2 Left side

Hydro sensors (developed by BINP for NLC)

PEP-II Left raft IR2 magnet motion model





Example of magnet position for two extremes. The raft pitch change by about 30 µrad, the magnet position change by about 120 µm.

Section through
For information only

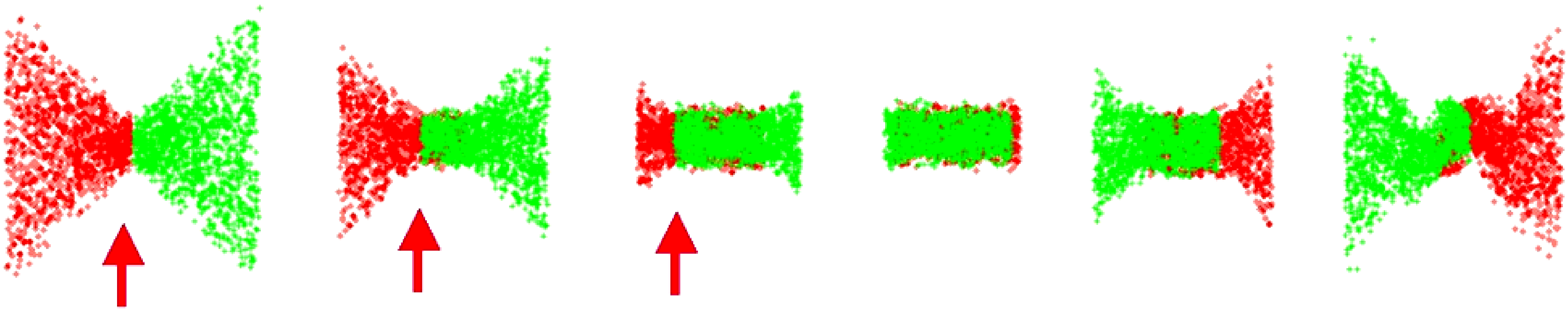
ILC Nominal and Low Power RDR

	Nom. RDR	Low P RDR
Case ID	**1**	**2**
E CM (GeV)	500	500
N	2.0E+10	2.0E+10
n_b	2625	1320
F (Hz)	5	5
P_b (MW)	**10.5**	**5.3**
$\gamma\varepsilon_X$ (m)	1.0E-05	1.0E-05
$\gamma\varepsilon_Y$ (m)	4.0E-08	3.6E-08
βx (m)	2.0E-02	1.1E-02
βy (m)	4.0E-04	2.0E-04

Z-distribution *	Gauss	Gauss
σ_x (m)	6.39E-07	4.74E-07
σ_y (m)	5.7E-09	3.8E-09
σ_z (m)	3.0E-04	2.0E-04
Guinea-Pig $\delta E/E$	**0.023**	**0.045**
Guinea-Pig L ($cm^{-2}s^{-1}$)	**2.02E+34**	**1.86E+34**
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34

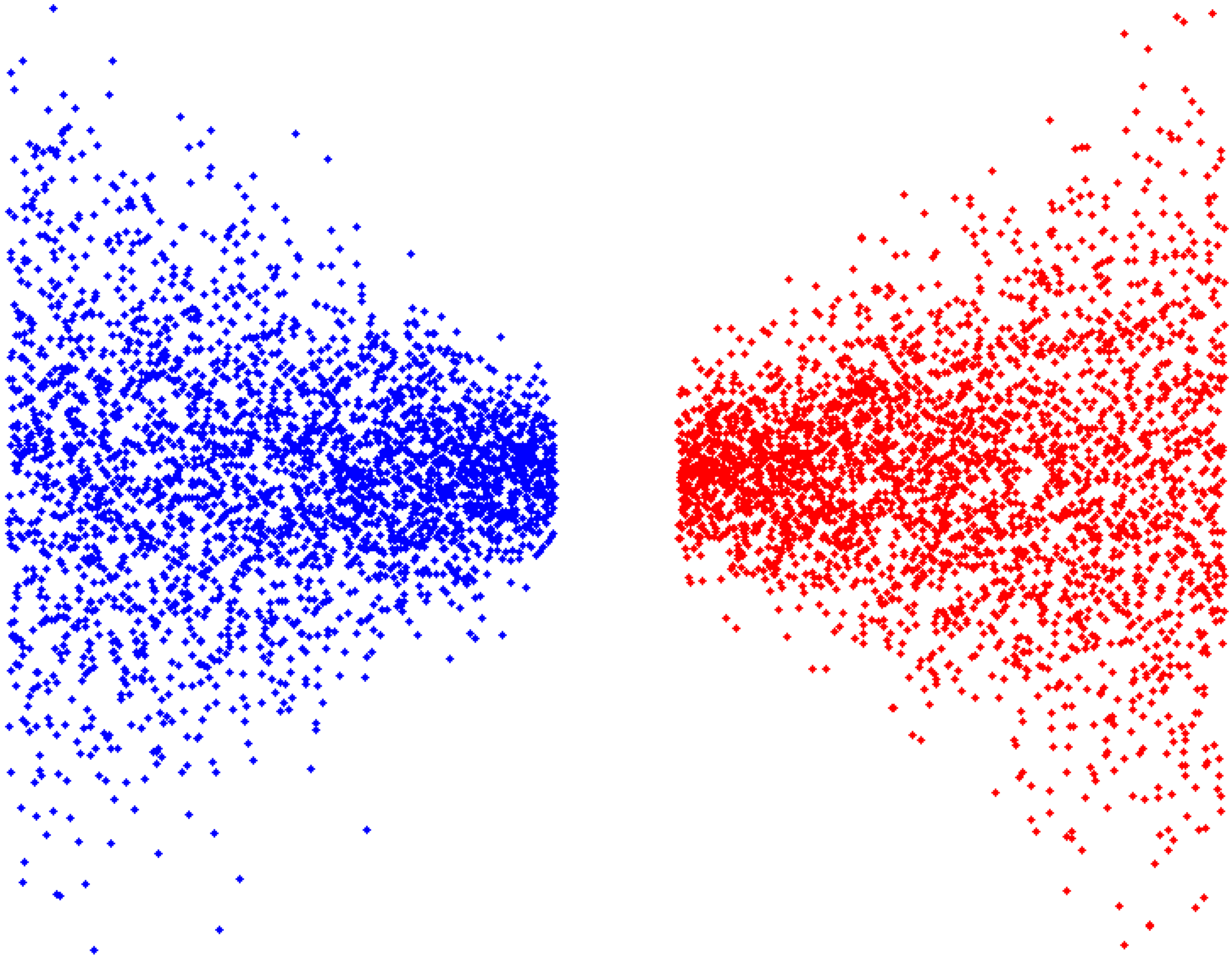
* The RDR "low power" option has large "beamstrahlung energy spread" (beam-beam phenomena) and cause larger background in detectors

Beam-beam: Travelling focus



- Suggested by V.Balakin in ~1991 – idea is to use beam-beam forces for additional focusing of the beam – allows some gain of luminosity or overcome somewhat the hour-glass effect
- Figure shows simulation of traveling focus. The arrows show the position of the focus point during collision
- So far not yet used experimentally

Collision with travelling focus



New Low P parameter set

	Nom. RDR	Low P RDR	new Low P
Case ID	**1**	**2**	**3**
E CM (GeV)	500	500	500
N	2.0E+10	2.0E+10	2.0E+10
n_b	2625	1320	1320
F (Hz)	5	5	5
P_b (MW)	**10.5**	**5.3**	**5.3**
$\gamma\varepsilon_X$ (m)	1.0E-05	1.0E-05	1.0E-05
$\gamma\varepsilon_Y$ (m)	4.0E-08	3.6E-08	3.6E-08
βx (m)	2.0E-02	1.1E-02	1.1E-02
βy (m)	4.0E-04	2.0E-04	2.0E-04
Travelling focus	No	No	**Yes**
Z-distribution *	Gauss	Gauss	Gauss
σ_x (m)	6.39E-07	4.74E-07	4.74E-07
σ_y (m)	5.7E-09	3.8E-09	3.8E-09
σ_z (m)	3.0E-04	2.0E-04	3.0E-04
Guinea-Pig $\delta E/E$	**0.023**	**0.045**	**0.036**
Guinea-Pig L ($cm^{-2}s^{-1}$)	**2.02E+34**	**1.86E+34**	**1.92E+34**
Guinea-Pig Lumi in 1%	1.50E+34	1.09E+34	1.18E+34

*for flat z distribution the full bunch length is σ_z*2*3$^{1/2}$

Travelling focus allows to lengthen the bunch

Thus, beamstrahlung energy spread is reduced

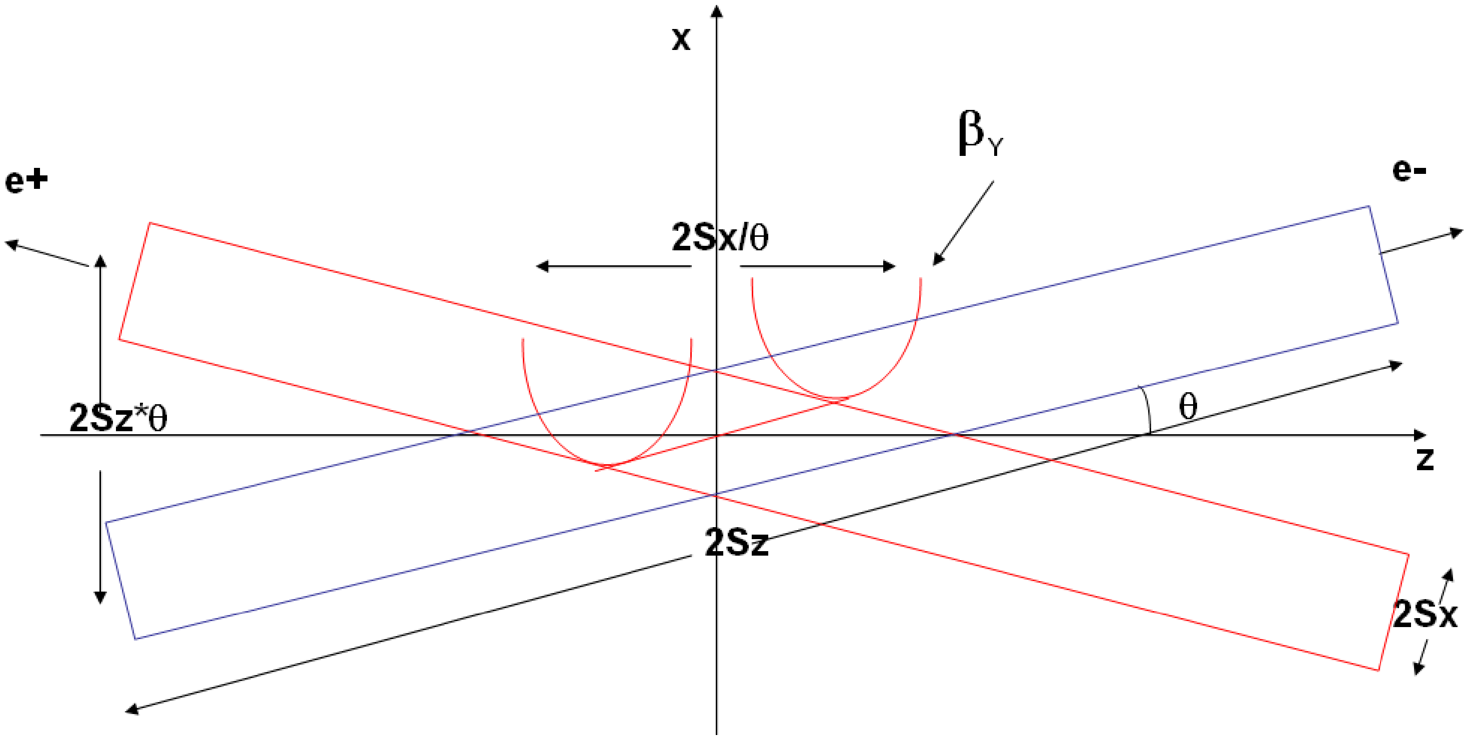
Focusing during collision is aided by focusing of the opposite bunch

Focal point during collision moves to coincide with the head of the opposite bunch

Creating travelling focus, 2 ways

- Small (~%) uncompensated chromaticity and E-z correlation
- Transverse deflecting cavity giving z-x correlation in one of FF sextupoles

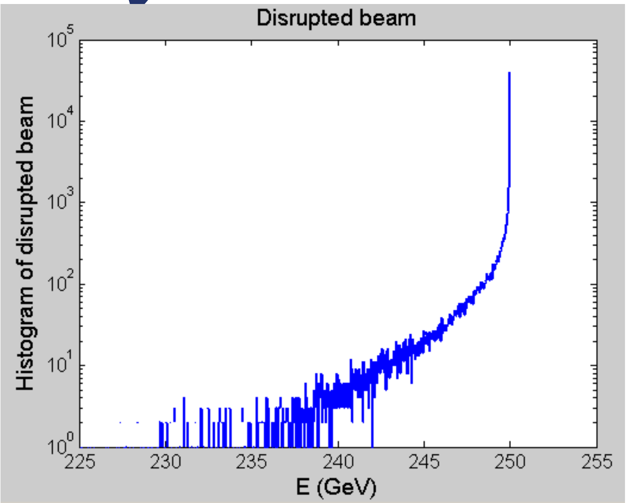
Beam-beam: Crabbed-waist

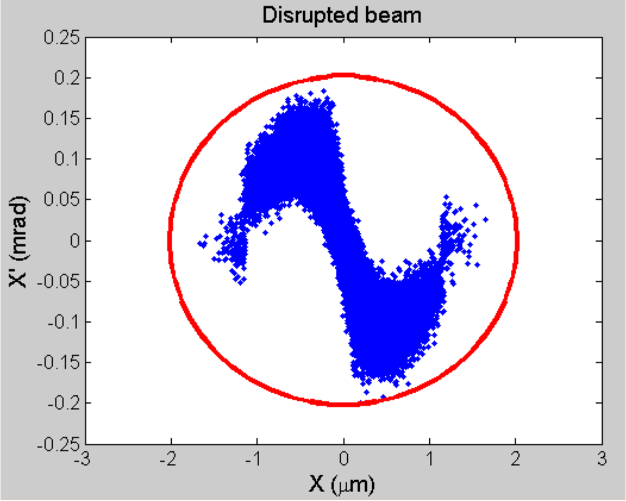


- Suggested by P.Raimondi for Super-B factory
- Vertical waist has to be a function of X. In this case coupling produced by beam-beam is eliminated
- Experimental verification at DAFNE

	Nominal	E-Recycle
E CM (GeV)	500	500
N	2.0E+10	**5.0E+09**
n_b	2625	**11000**
Tsep (ns)	369.2	90.0
Iave in train (A)	0.0087	0.0089
f_{rep}(Hz)	5	5
P_b (MW)	**10.5**	**11.0**
$\gamma\varepsilon_X$ (m)	1.0E-05	4.0E-06
$\gamma\varepsilon_Y$ (m)	4.0E-08	2.0E-08
β x/y (mm)	20 / 0.4	20 / 0.4
σ x/y (nm)	639 / 5.7	404 / 4.0
σ_z (mm)	0. 3	**0.6**
Dy	19.0	21.2
Uave	0.047	0.009
δ_B	**0.023**	**0.002**
P_Beamstrahlung (MW)	0.24	0.024
ngamma	1.29	0.53
Hd	1.70	**1.53**
Geom Lumi (cm-2 s-1)	1.14E+34	6.69E+33
Luminosity (cm-2 s-1)	**1.95E+34**	**1.02E+34**

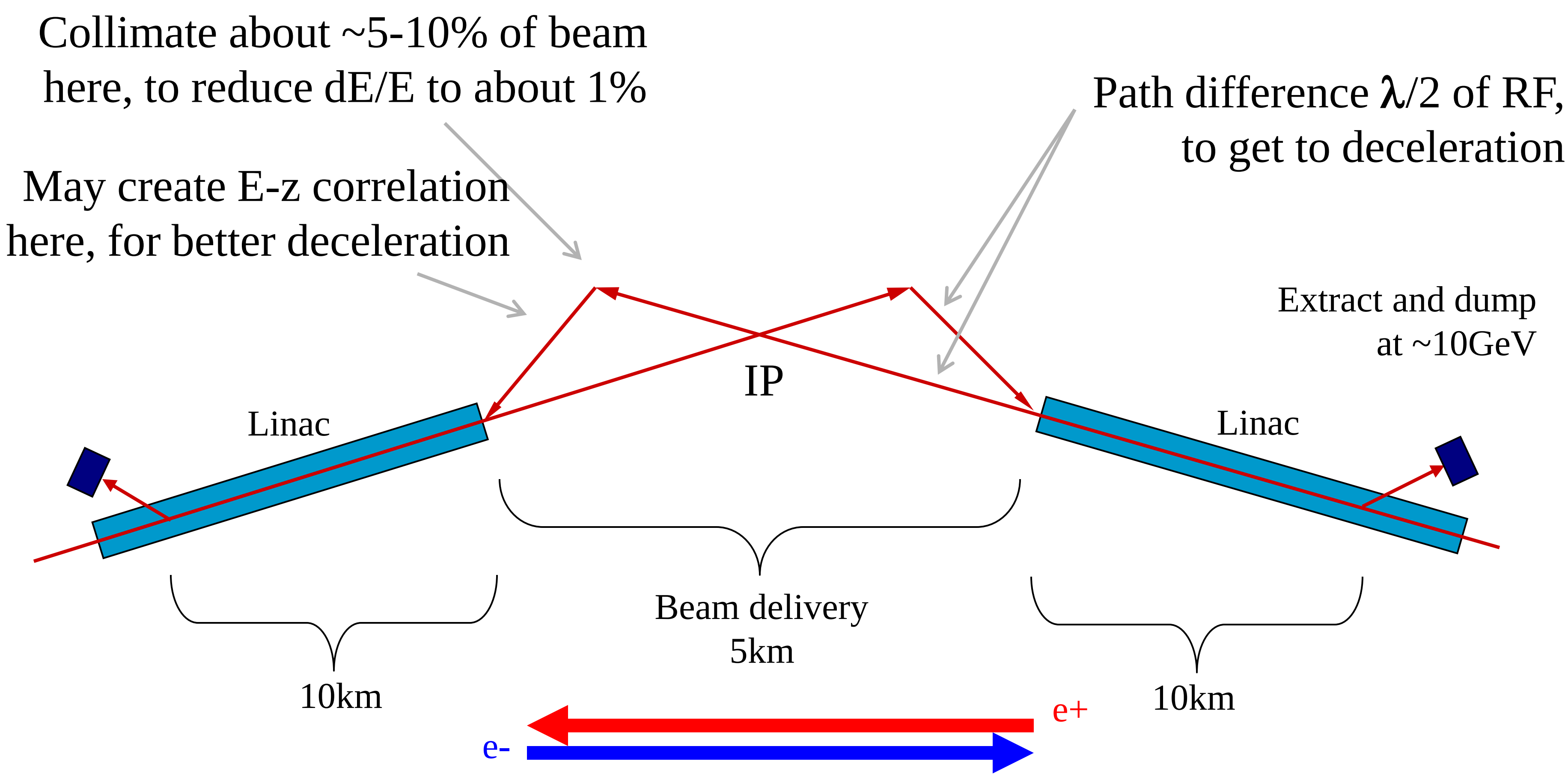
- Parameter sets with TF & **very** low beamstrahlung





- About 92% of outgoing beam dE/E < 1%
- Outgoing beam within γε=200mm*mrad
- Can decelerate 92% of the beam to 10 GeV

Layout and train format



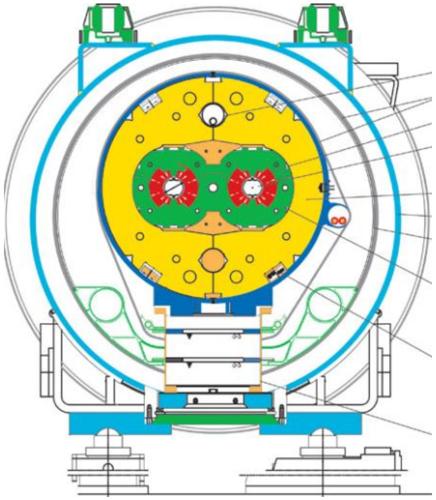
Require that incoming and outgoing bunches do not collide in the linac:
→ length of mini-trains equal to full length of beam delivery
→ gap between mini-trains = 2* linac length to extraction point + BDS length

More options on train format

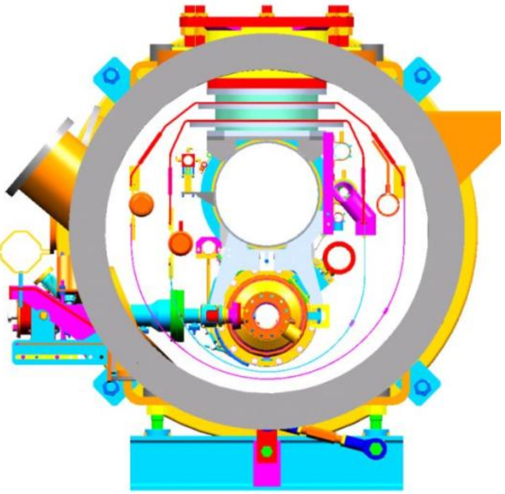
- Longer pulse with mini-trains increases the cryo-losses
- May be more attractive to have continuous train and decelerate the beam in a separate acc. structure in the same cryomodule

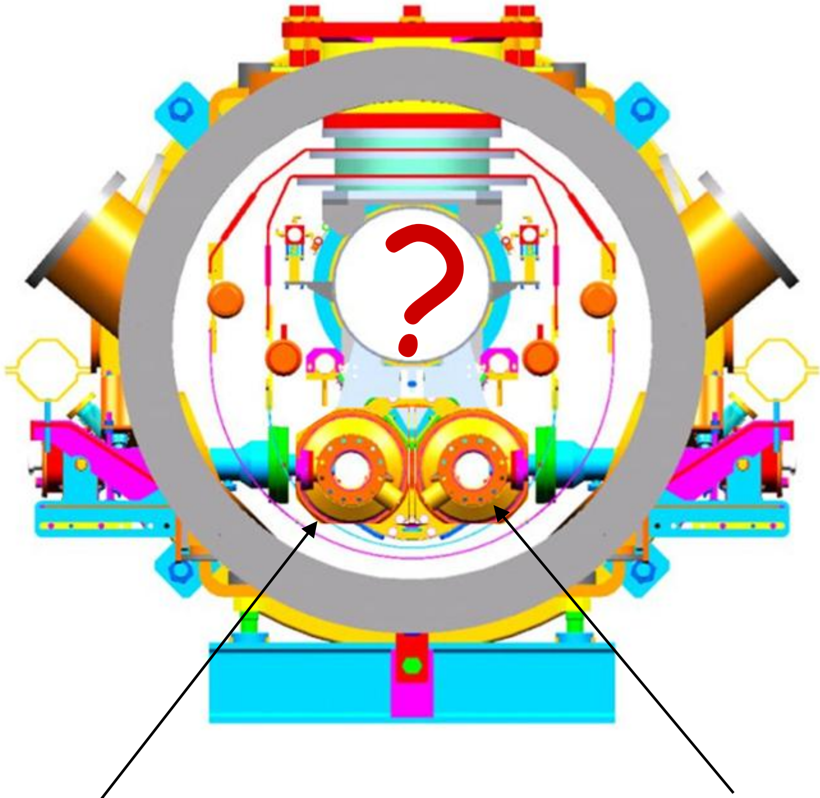
Picture below not real (Photoshop engineering)
But is it possible to make a cryomodule with two beam apertures ? If it were, would there be other applications?

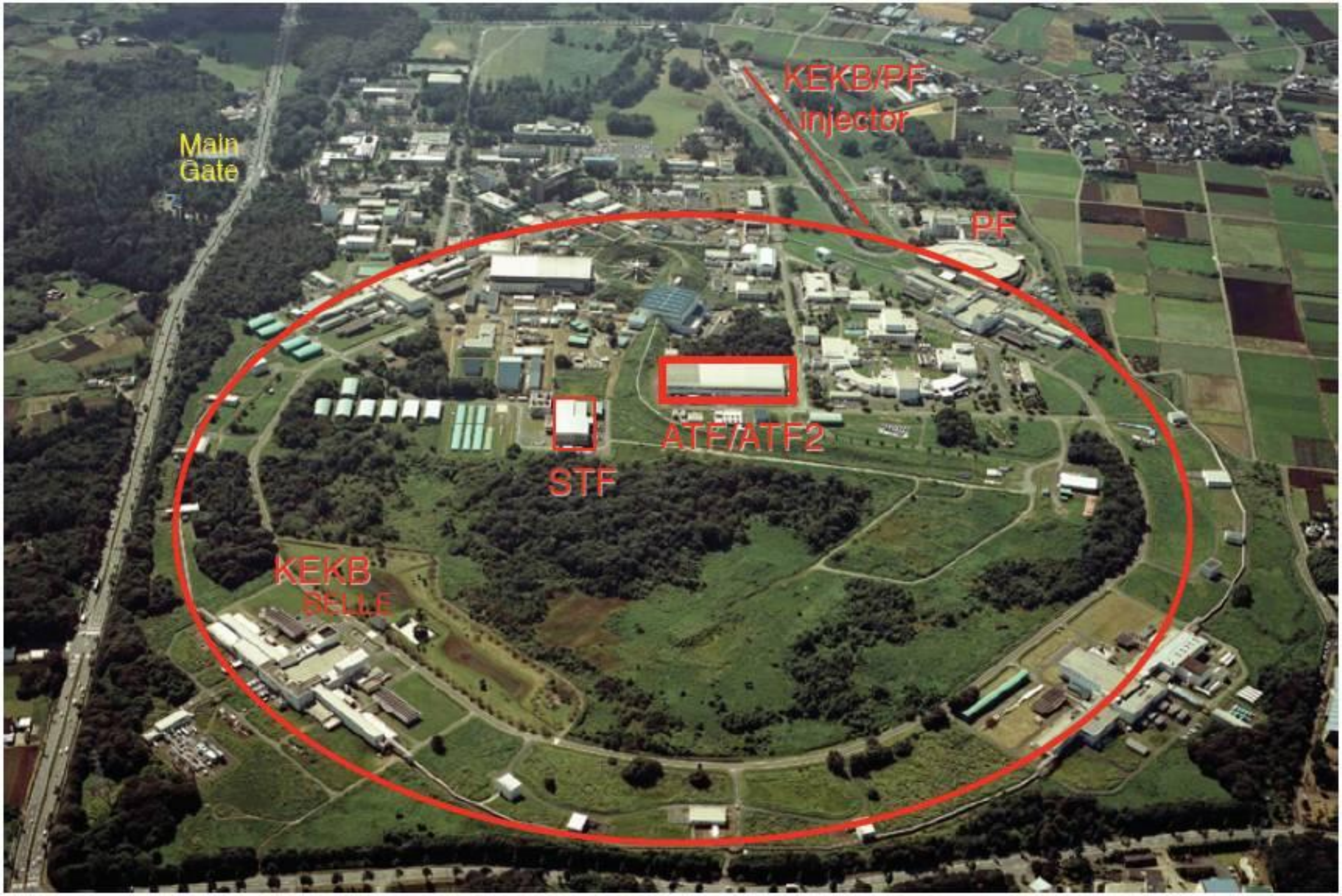
LHC magnet, two beam apertures



Standard cryomodule, single beam aperture



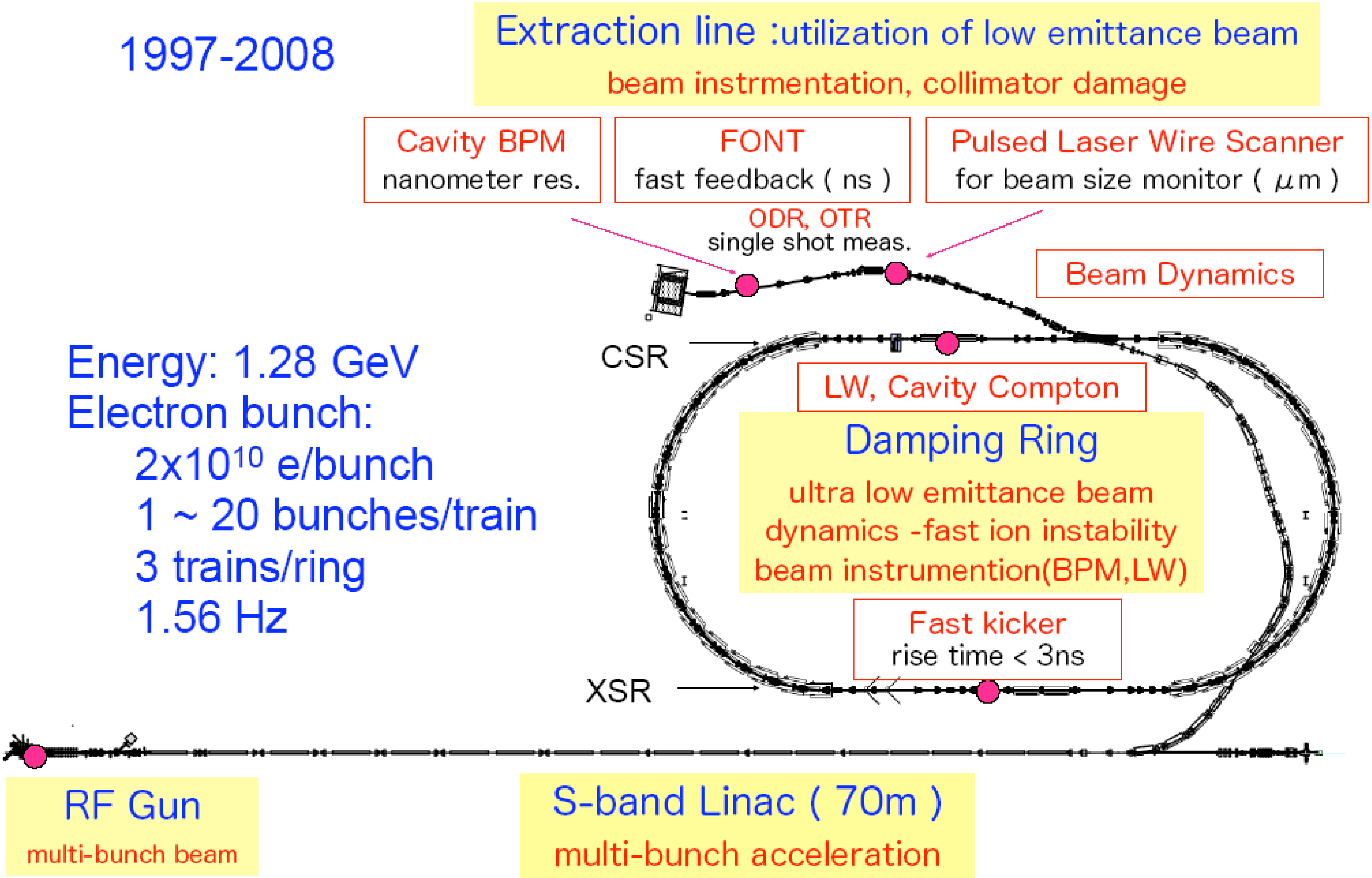



KEKB/PF injector
Main Gate
PF
ATF/ATF2
STF
KEKB
BELLE

Accelerator Test Facility, KEK

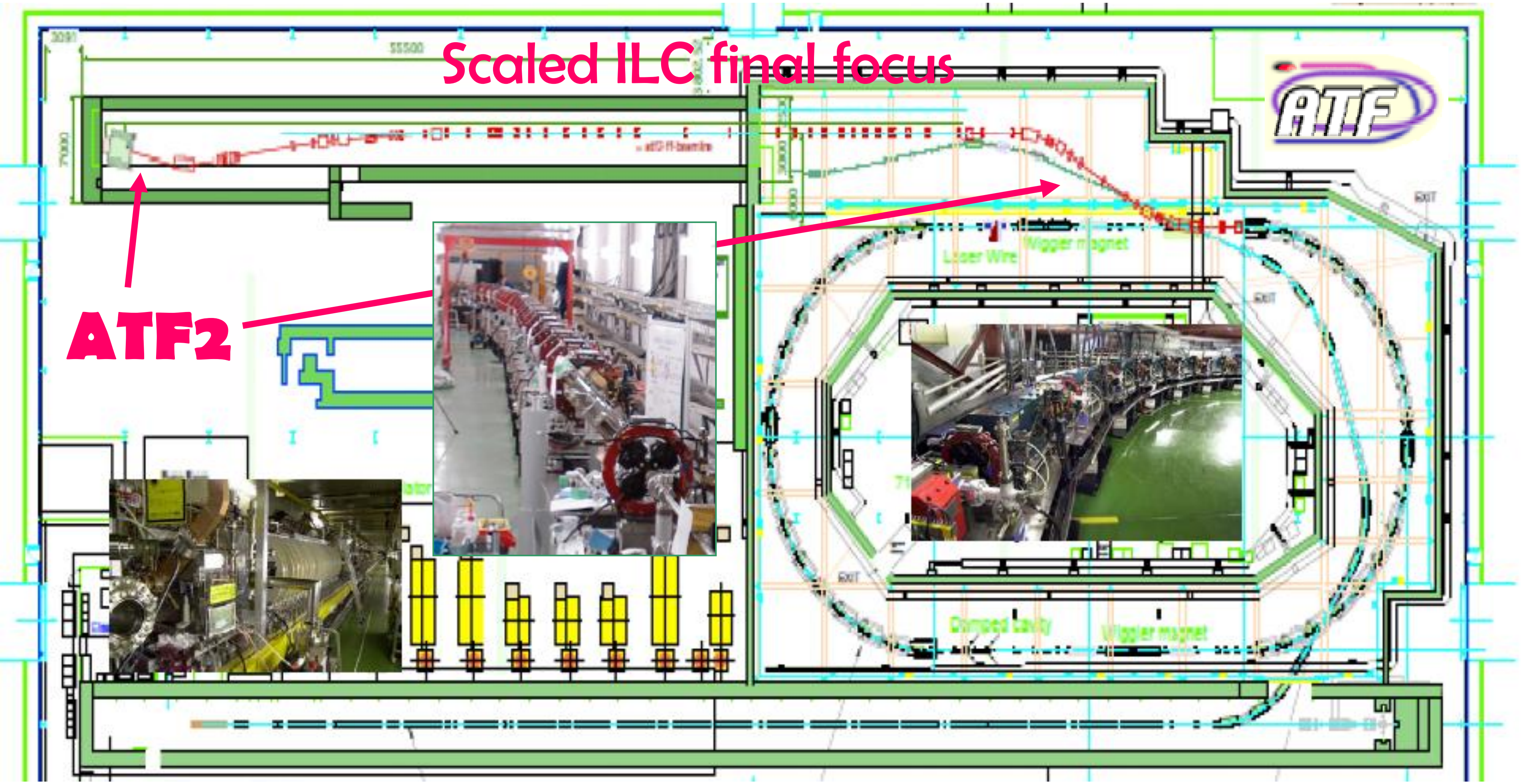
1997-2008

Energy: 1.28 GeV
Electron bunch:
- 2×10^{10} e/bunch
- 1 ~ 20 bunches/train
- 3 trains/ring
- 1.56 Hz

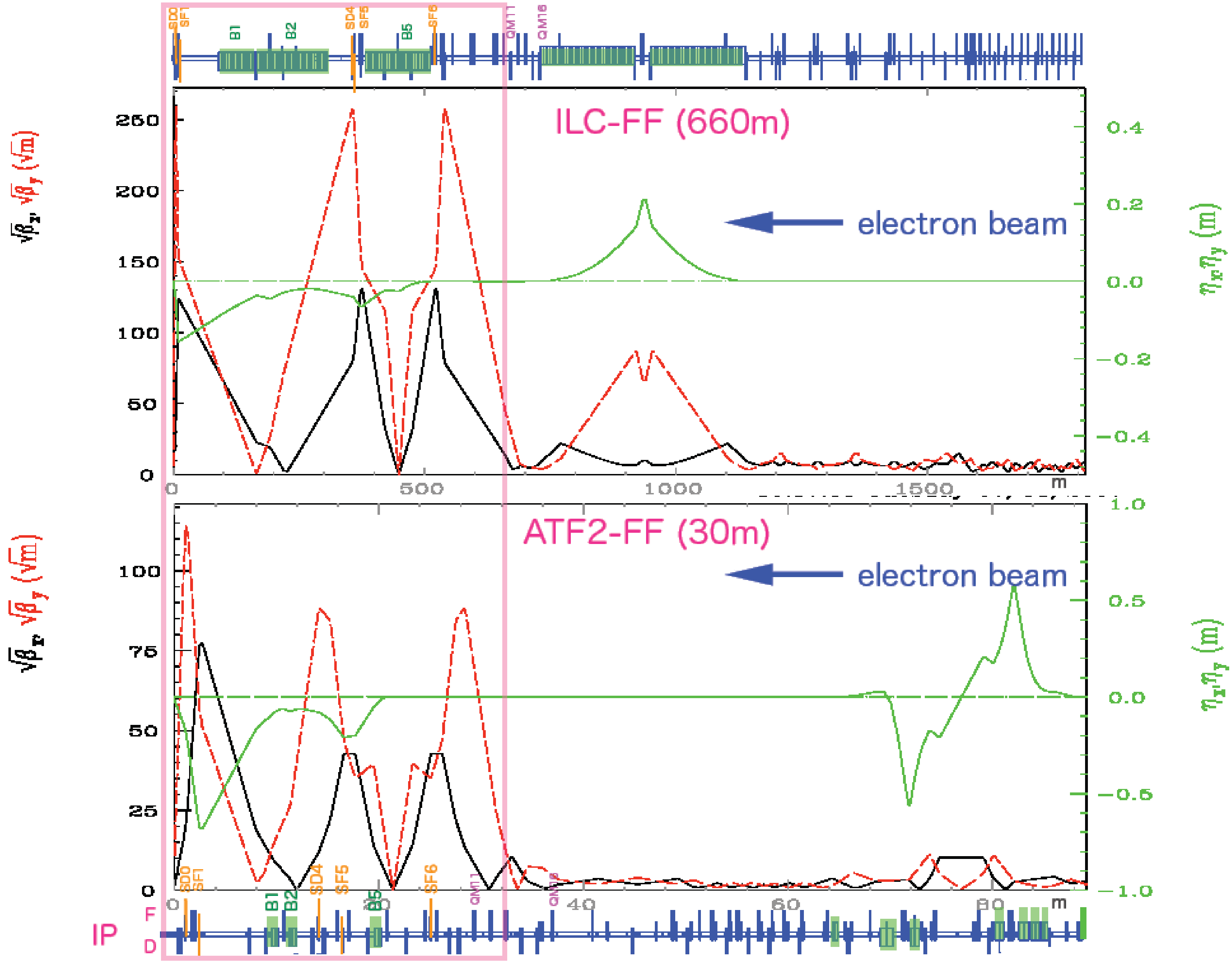


ATF2: model of ILC beam delivery

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


ILC-FF (660m)
electron beam
ATF2-FF (30m)
electron beam
IP
F
D
SD0
SF1
B1
B2
SD4
SF5
B5
SF6
QM11
QM16

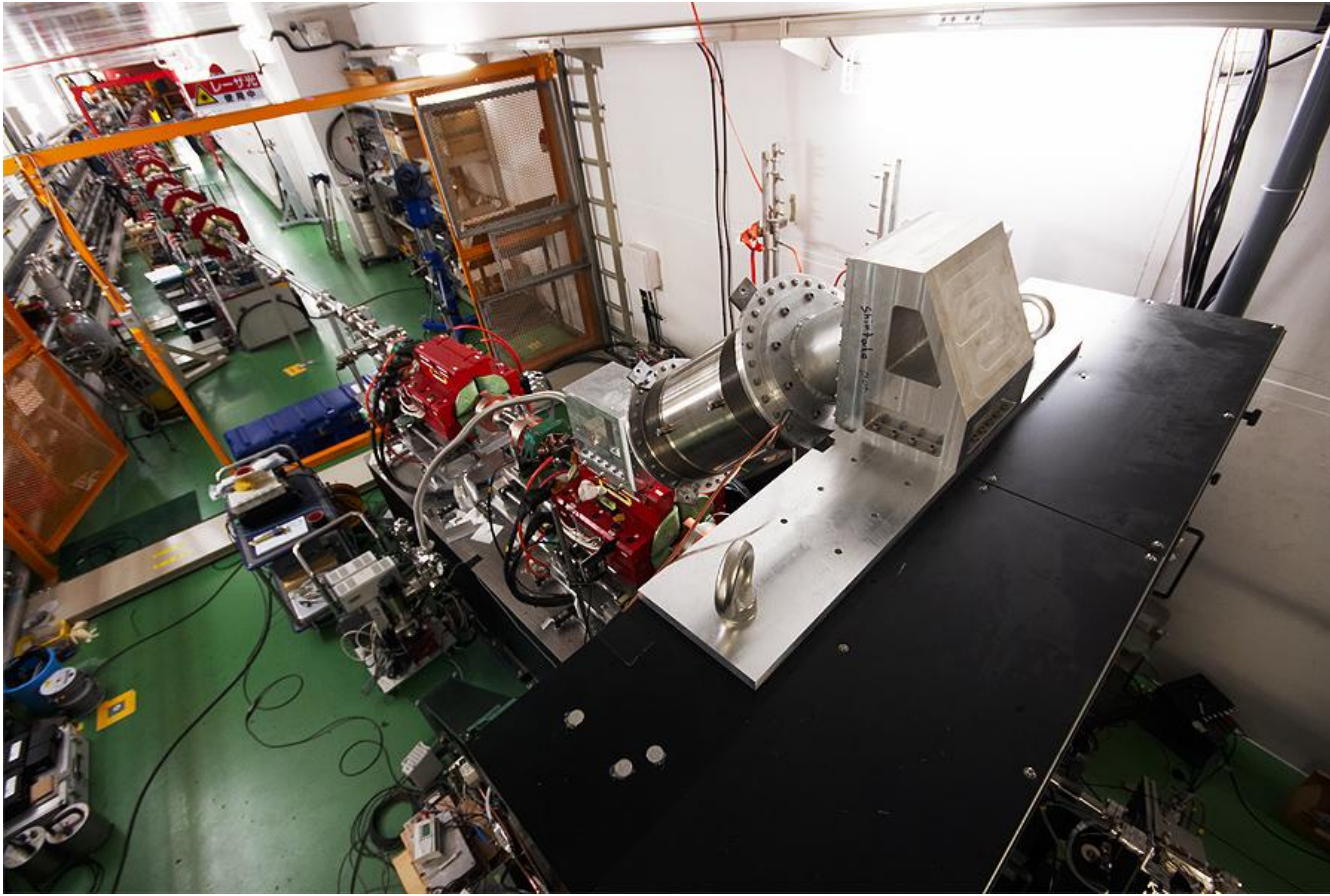
ATF2 parameters & Goals A/B

Beam parameters achieved at ATF and planned for ATF2, goals A and B. The ring energy is E0 = 1.3 GeV, the typical bunch length and energy spread are σ_z =8 mm and $\Delta E/E$ = 0.08 %.

	Measured	(A)	(B)
Single Bunch			
N_{bunch} $[10^{10}]$	0.2 – 1.0	0.5	0.5
DR $\gamma\varepsilon_y$ $[10^{-8}\text{m}]$	1.5	3	3
Extr. $\gamma\varepsilon_y$ $[10^{-8}\text{m}]$	3.0 – 6.5	3	3
Multi Bunch			
$n_{bunches}$	20	1 – 20	3 – 20
N_{bunch} $[10^{10}]$	0.3 – 0.5	0.5	0.5
DR $\gamma\varepsilon_y$ $[10^{-8}\text{m}]$	3.0 – 4.5	3	3
Extr. $\gamma\varepsilon_y$ $[10^{-8}\text{m}]$	~ 6	3	3
IP σ_y^* [nm]		37	37
IP $\Delta y/\sigma_y^*$ [%]		30	5

ATF2 proposed IP parameters compared with ILC

Parameters	ATF2	ILC
Beam Energy [GeV]	1.3	250
L^* [m]	1	3.5 – 4.2
$\gamma\,\epsilon_x$ [m-rad]	3×10^{-6}	1×10^{-5}
$\gamma\,\epsilon_y$ [m-rad]	3×10^{-8}	4×10^{-8}
β_x^* [mm]	4.0	21
β_y^* [mm]	0.1	0.4
η' (DDX) [rad]	0.14	0.094
σ_E [%]	~0.1	~0.1
Chromaticity W_y	$\sim 10^4$	$\sim 10^4$


レーザ光
使用中

Magnets and Instrumentation at ATF2

22 Quadrupoles(Q), 5 Sextupoles(S), 3 Bends(B) in downstream of QM16

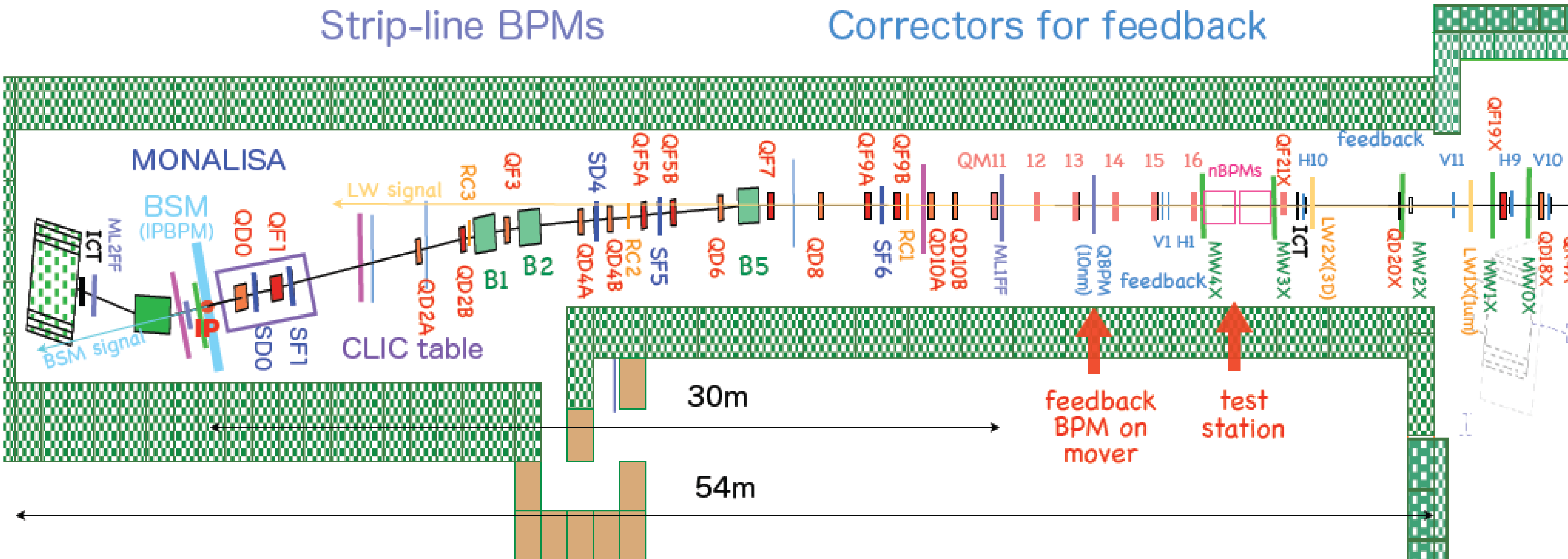
All Q- and S-magnets have cavity-type beam position monitors(QBPM, 100nm).

3 Screen Monitors

5 Wire Scanners, Laserwires

Strip-line BPMs

Correctors for feedback



Shintake Monitor (beam size monitor, BSM with laser interferometer)

MONALISA (nanometer alignment monitor with laser interferometer)

Laserwire (beam size monitor with laser beam for 1 μm beam size, 3 axies)

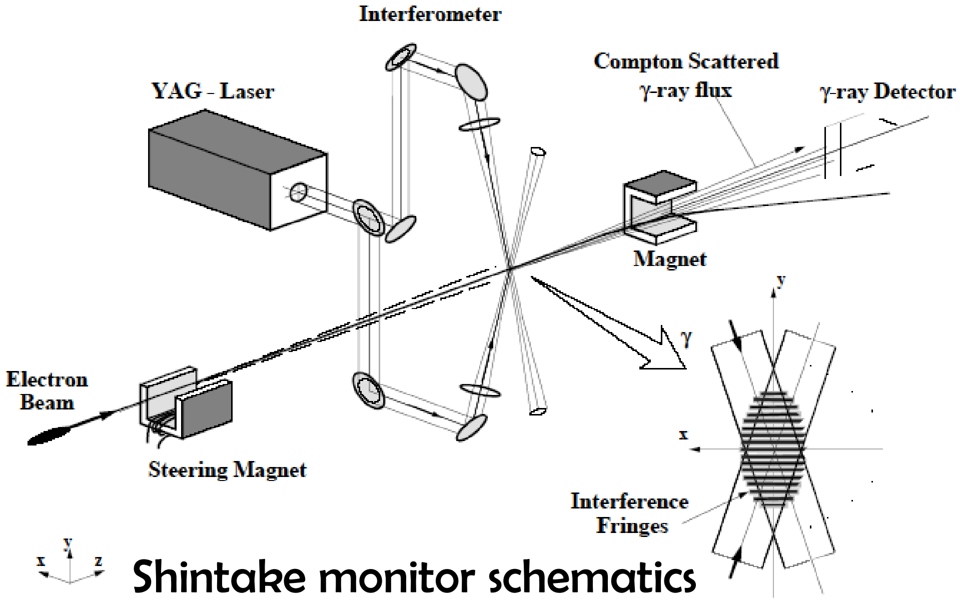
IP intra-train feedback system with latency of less than 150ns (FONT)

Magnet movers for Beam Based Alignment (BBA)

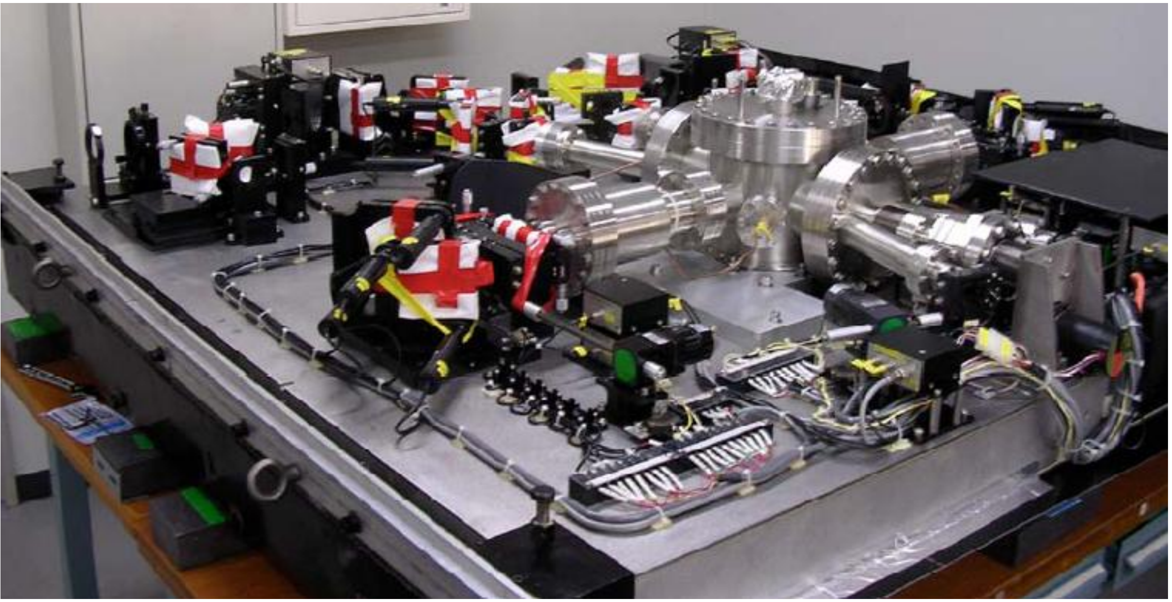
High Available Power Supply (HA-PS) system for magnets

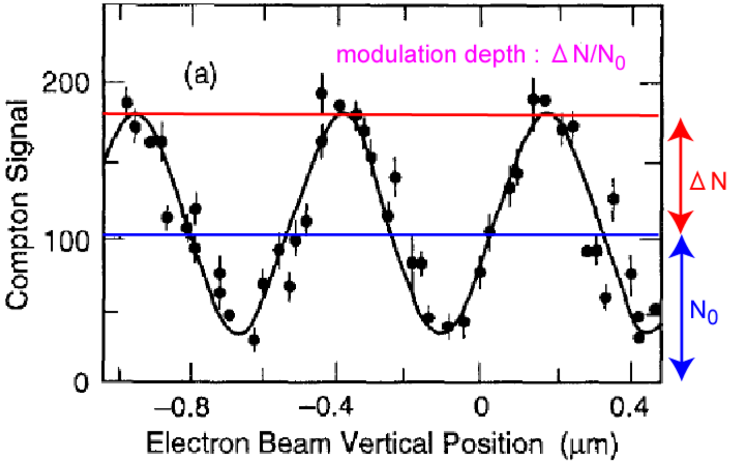
IP Beam Size monitor

- Initial plan:
  - refurbish & improve FFTB Shintake BSM
  - 1064nm=>532nm

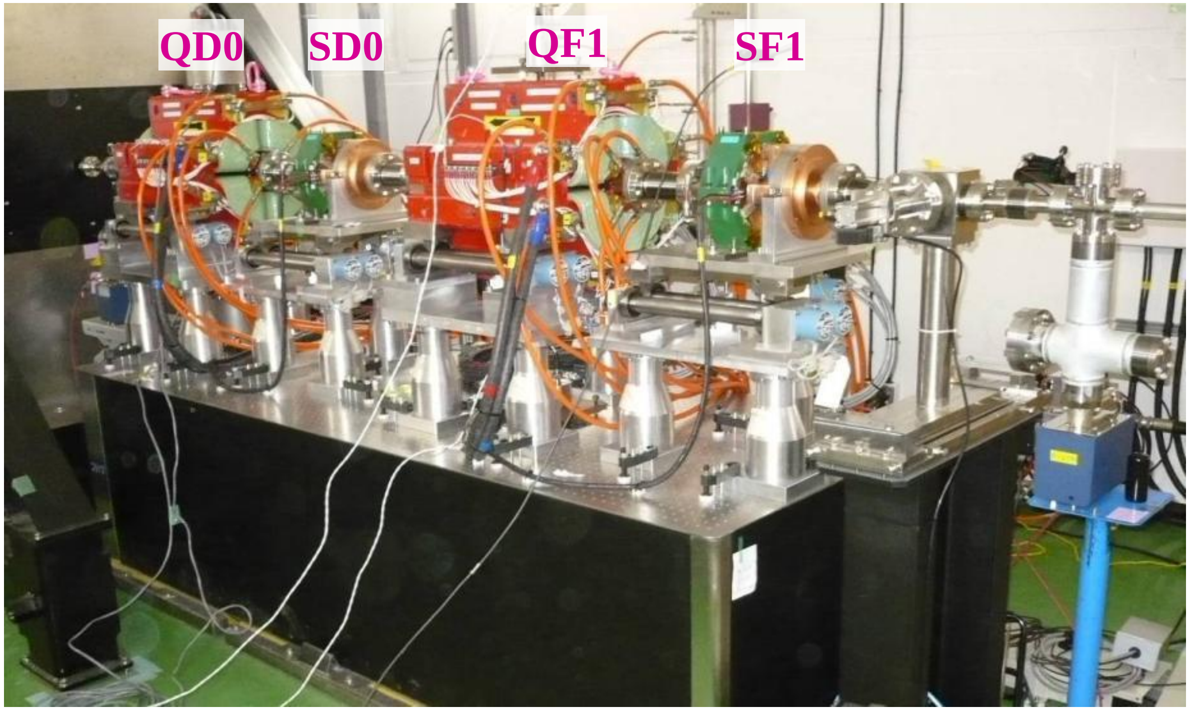


Shintake monitor schematics

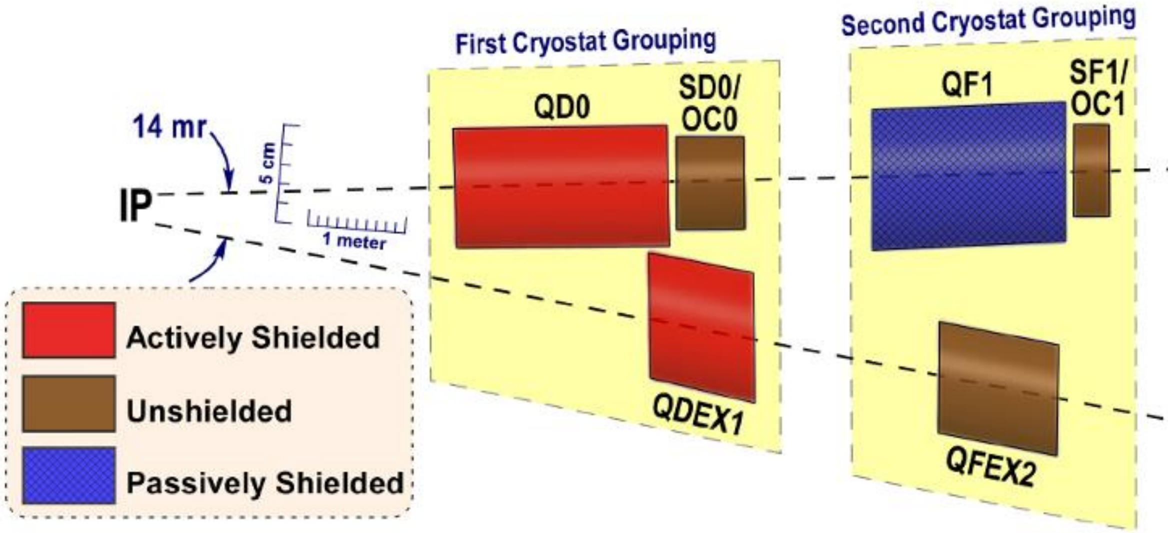

Jul 2005: BSM arrived to Univ. of Tokyo



FFTB sample : σ_y = 70 nm



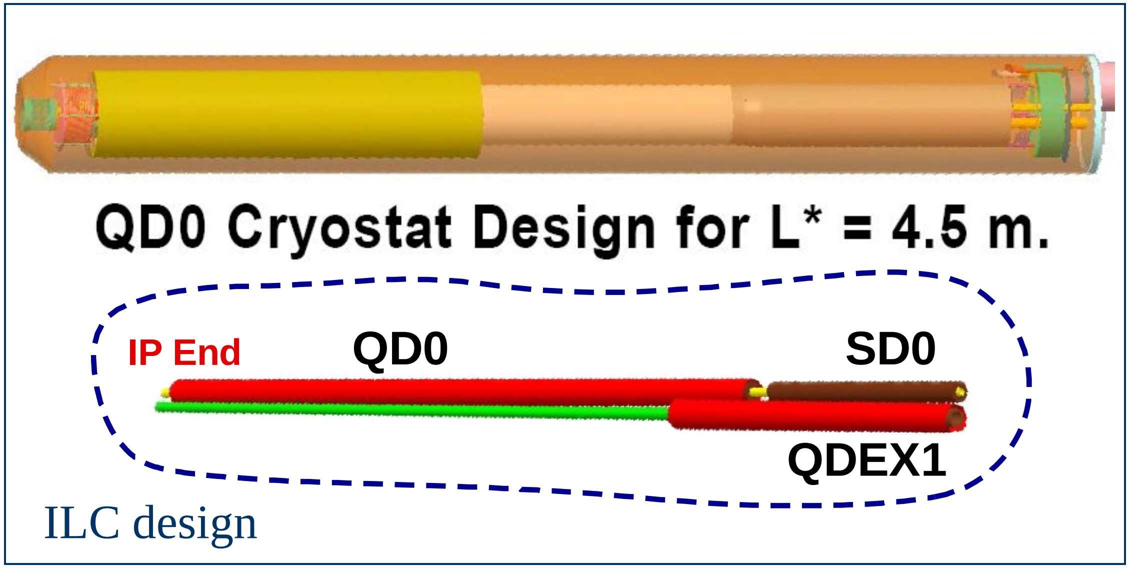
ATF2 final doublet



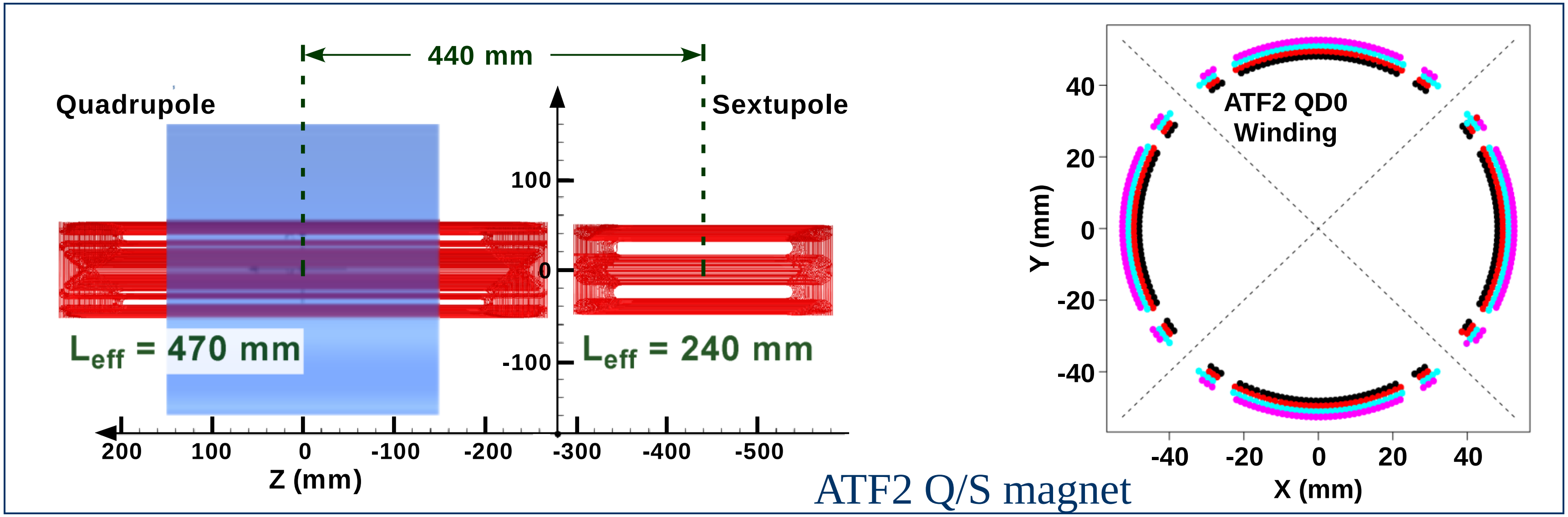
ILC Final Doublet layout

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

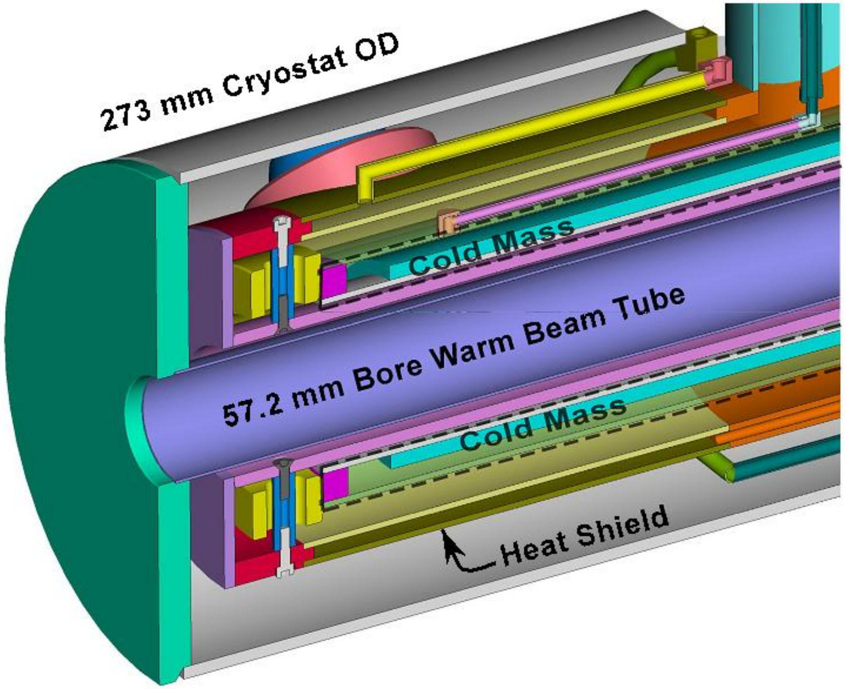


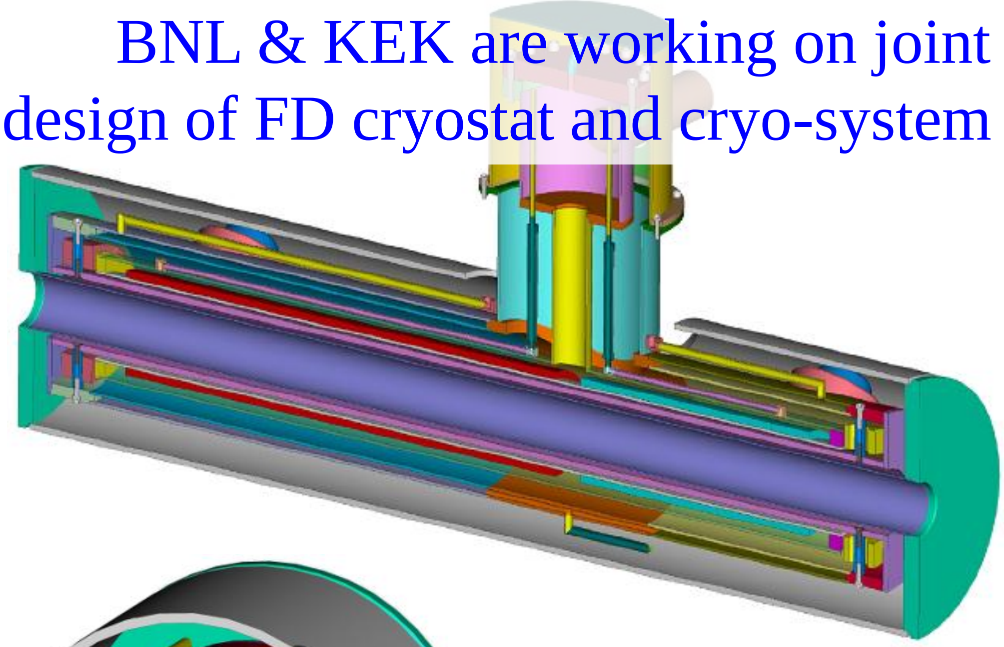
Brett Parket, at al, BNL

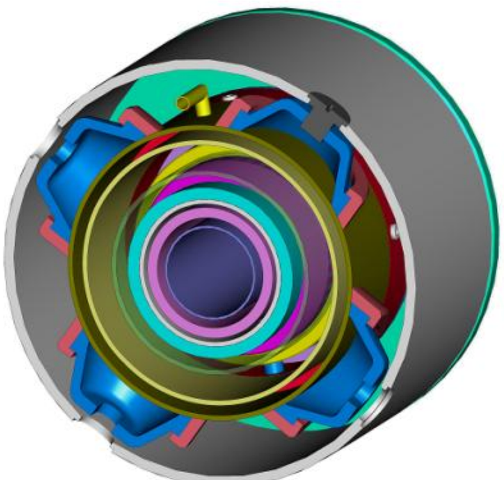


SC FD for ATF2

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

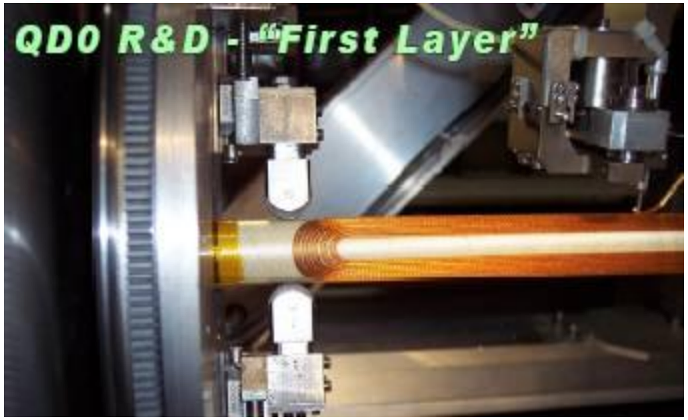




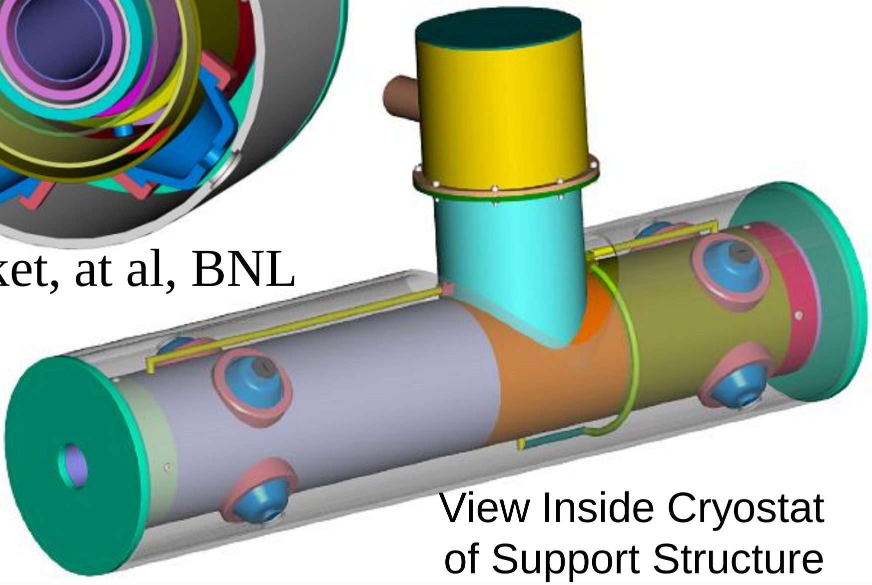


Cross Section View at Support Location

Brett Parket, at al, BNL

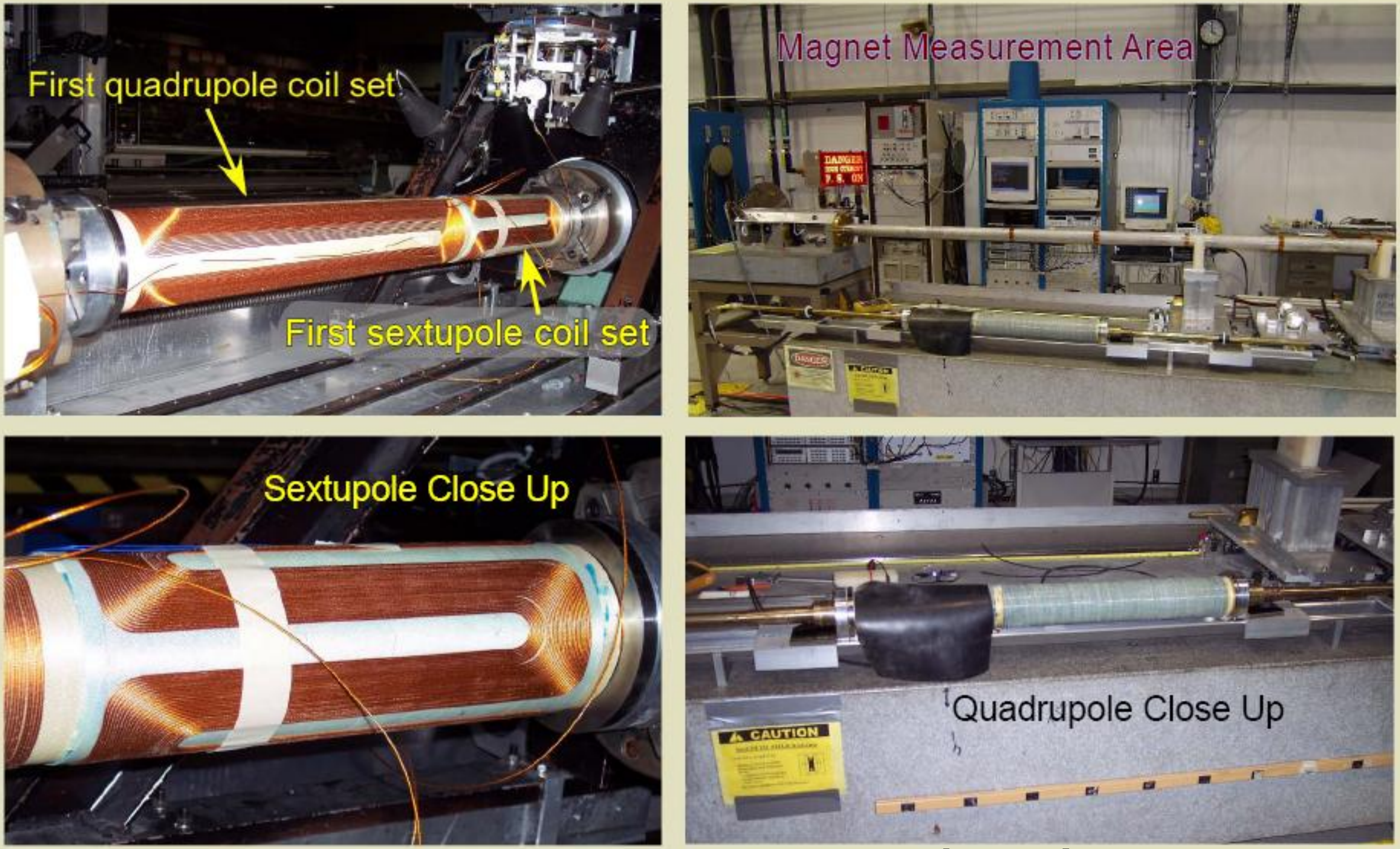


Long coil winding



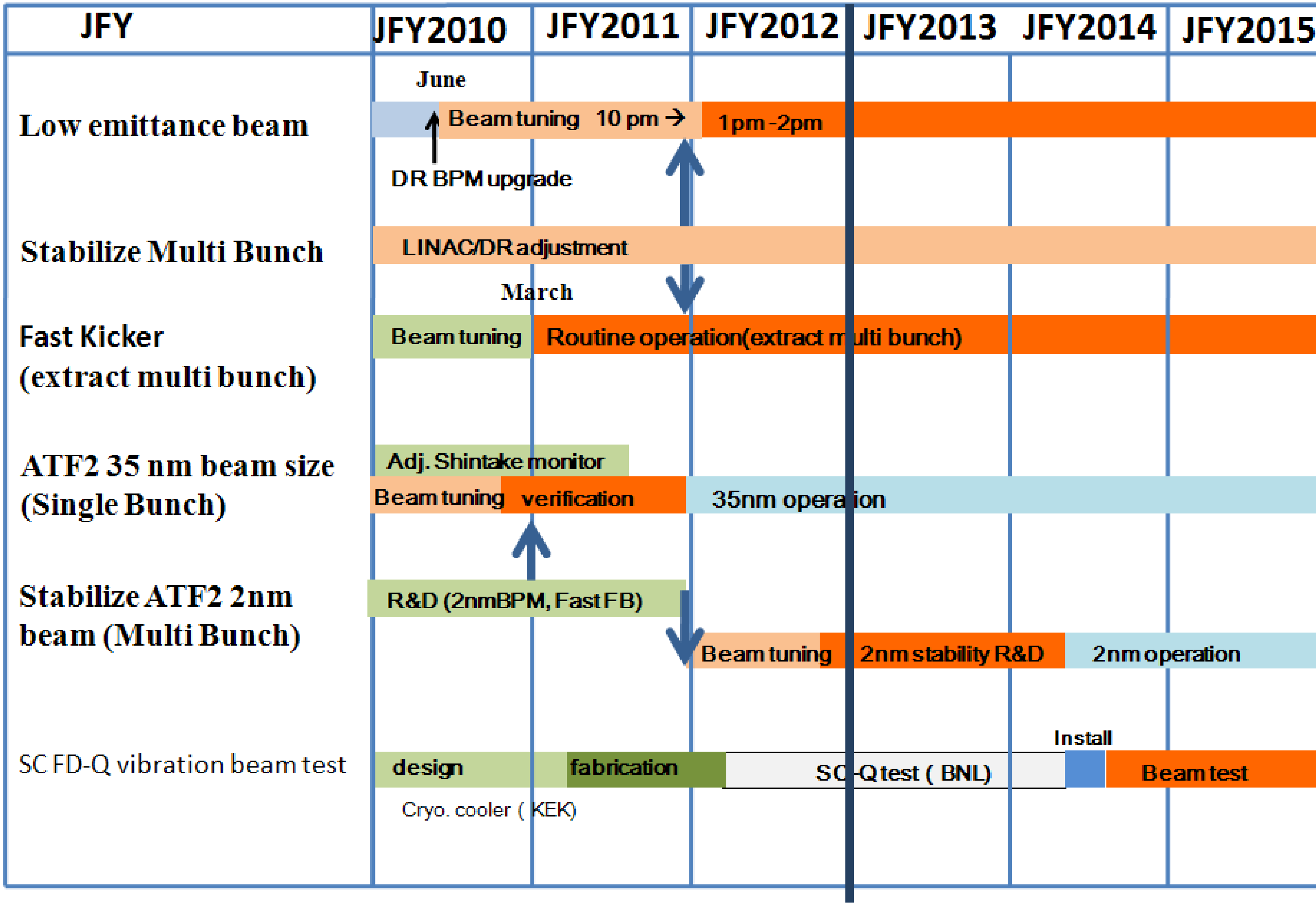
View Inside Cryostat of Support Structure

Start of ATF2 coil production & measurement



BNL, Brett Parker et al

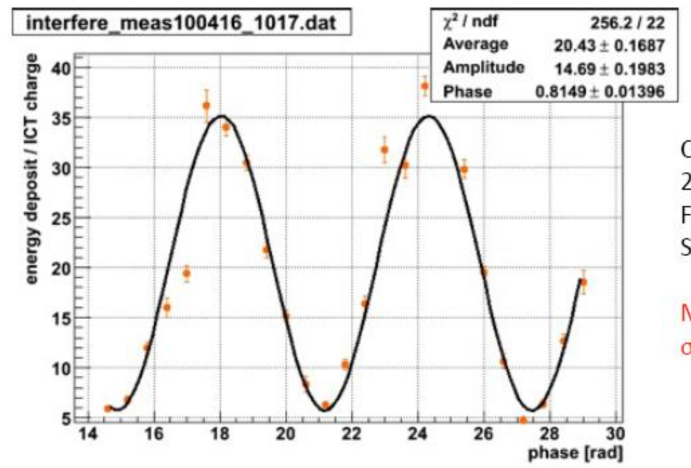
ATF Schedule



Ongoing R&Ds at ATF/ATF2

- **ATF**
- **low emittance beam**
  - Tuning, XSR, SR, Laser wire,…
- **1pm emittance** (DR BPM upgrade,…)
- **Multi-bunch**
  - Instability (Fast Ion,…)

  Extraction by Fast Kicker



Crossing angle :4.12 [deg]
20 average
Fringe pitch 600 mrad
Scan range 13.2[rad]

Modulation ~ 0.72
σ_y ~ 950[nm]

Others

- Cavity Compton
- SR monitor at EXT

- **ATF2**
- **35 nm beam size**
  - Beam tuning (Optics modeling, Optics test, debugging soft&hard tools,…)
  - Cavity BPM (C&S-band, IP-BPM)
  - Beam-tilt monitor
  - IP-BSM (Shintake monitor)
- **Beam position stabilization (2nm)**
  - Intra-train feedback (FONT)
  - feed-forward DR->ATF2

Others

- Pulsed 1um Laser Wire
- Cold BPM
- Liquid Pb target
- **Permanent FD Q**
- **SC Final doublet Q/Sx**

Summary

- Challenges of IR design & Machine Detector Interface optimization is one of the critical areas which is mutually interested and may be one of the direction of future collaboration