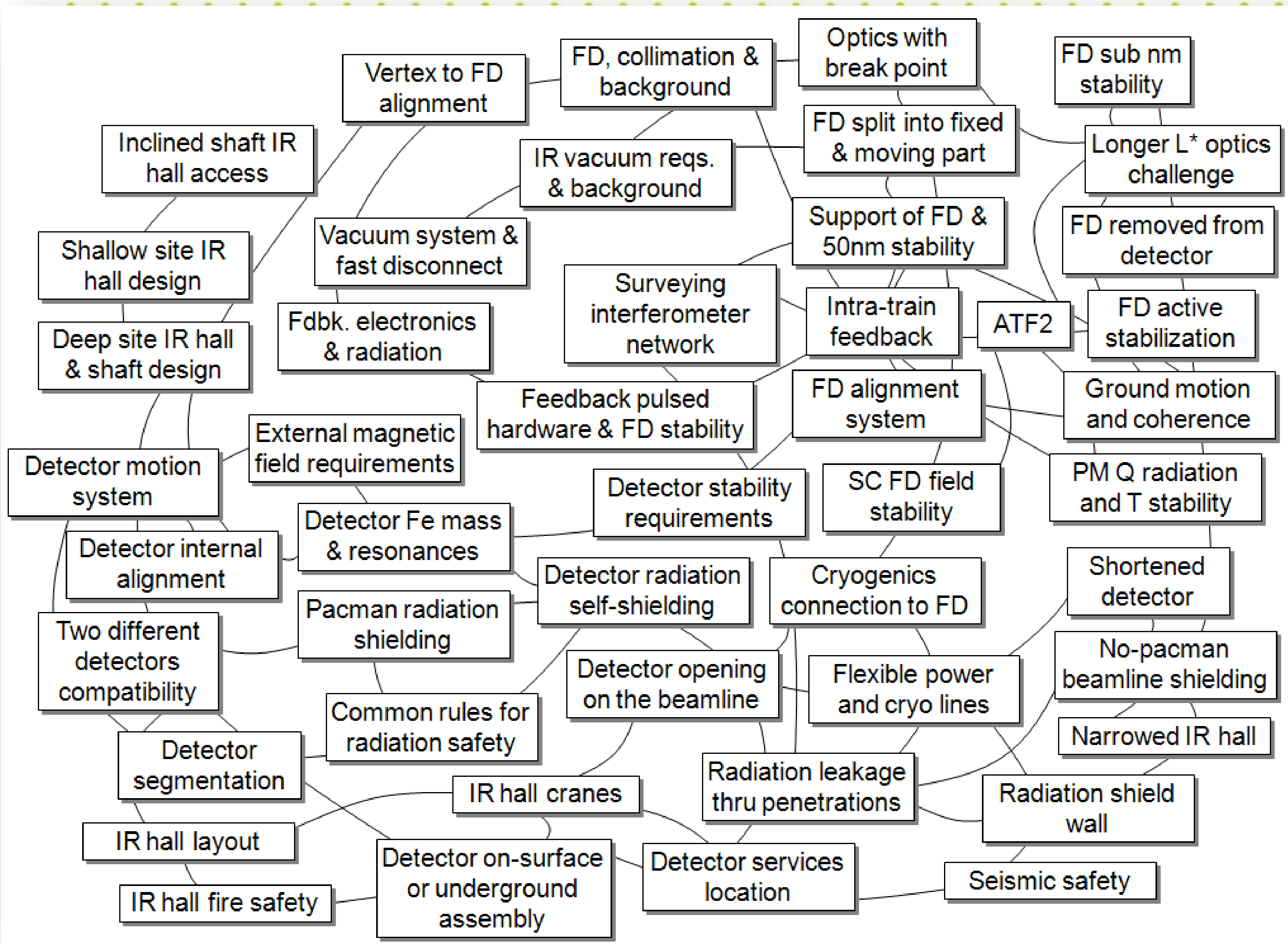
Accelerator WG 5 summary Interaction region, ATF2 and MDI

Deepa Angal-Kalinin, Lau Gatignon,
Andrei Seryi, Rogelio Tomas

IWLC2010

22 -10 - 2010

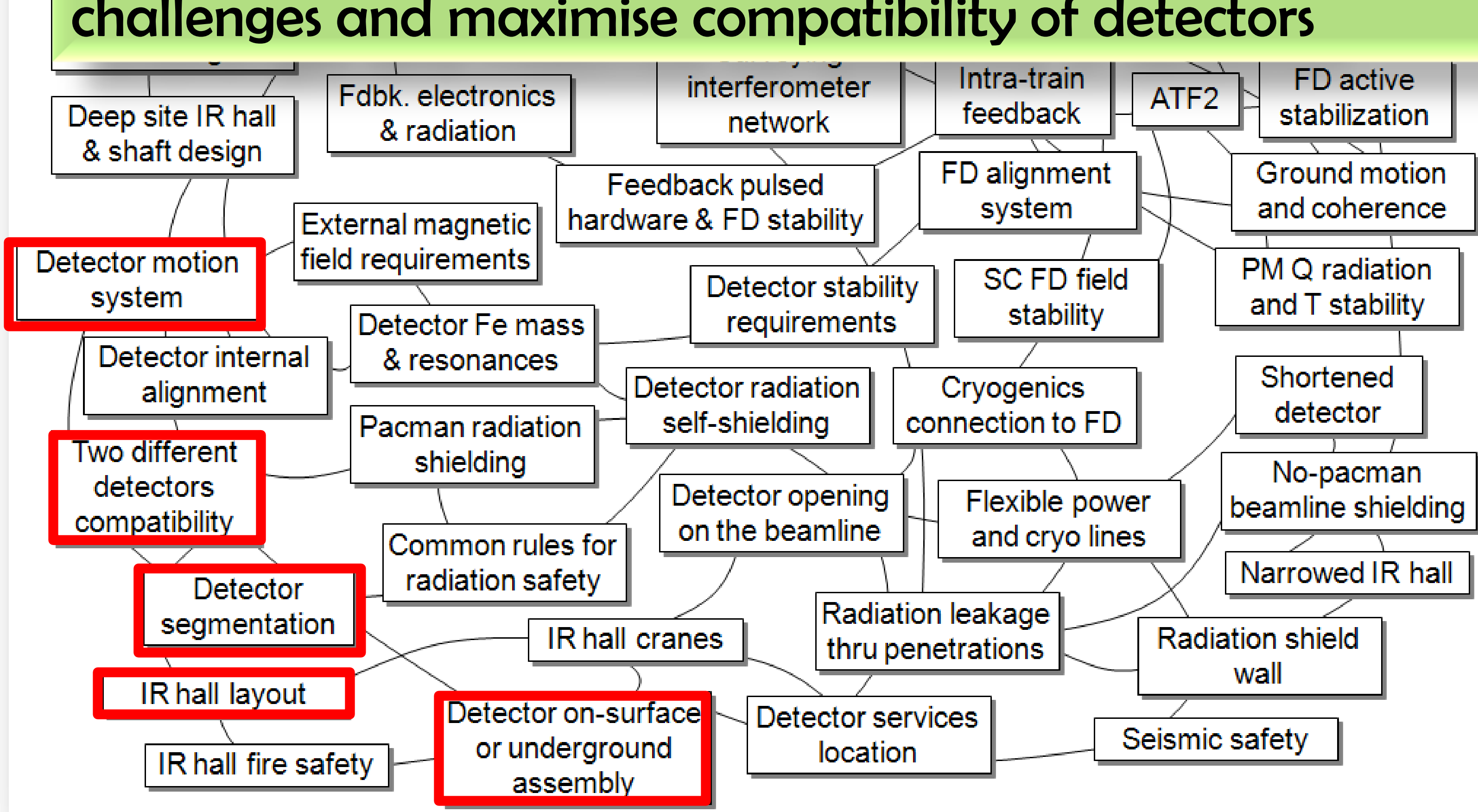
Interrelation of technical challenges for the push-pull system



Illustrations of interrelations

• Differences of approaches for detector assembly lead to differences in segmentation and rigidity, resulting in different assumptions on requirements for a detector motion system

• The motion system and IR hall design need to mitigate the challenges and maximise compatibility of detectors



Reminder

- The push-pull project is a very ambitious one.

- In size of loads to be moved > 10'000 tons, number of movements > 150 over 15 years.

- It is even more demanding when considering the environment, final precision, and time constraints, say a full exchange in less than three or four days.

- This is a very challenging task, and there is no example of such a system.

Roller / Airpad consideration

- The flatness of the rail under the load maybe a problem.
- Airpads are very tolerant with respect to the rail geometry and do not need a hardened rail.
- At the contrary, a figure of a few tenths of mm has been mentioned for the allowed deformation of the hardened rail under the full area of a loaded Roller to ensure that most rolls are loaded.
- I think that, if rollers are used, additional piling has to be foreseen below the underground hall to guarantee the rail flatness.

Steel reinforcement of CMS Plug ⇒ Models need benchmarking to evaluate damping and Young's modulus

24

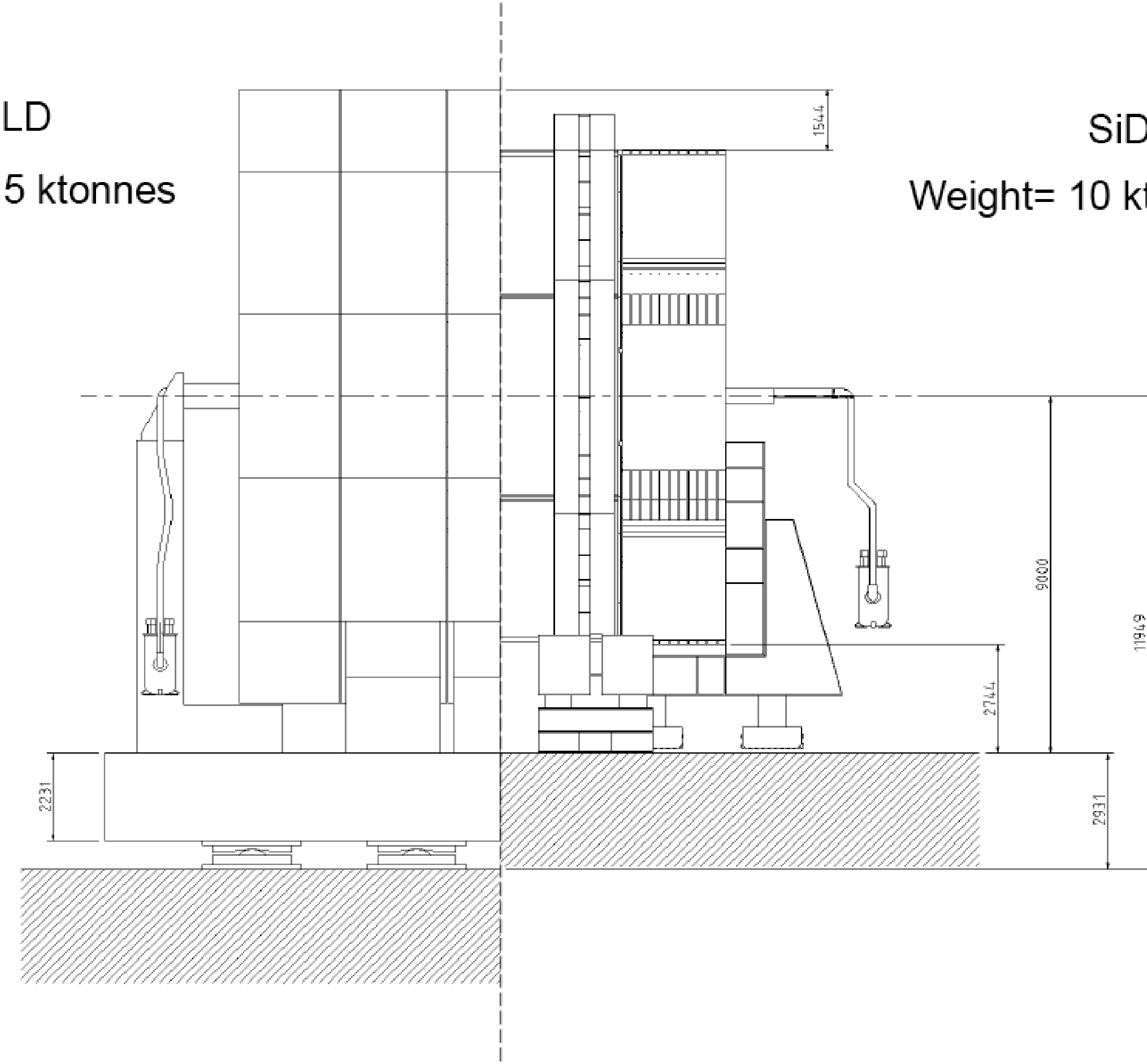
ILD and SiD differences

ILD

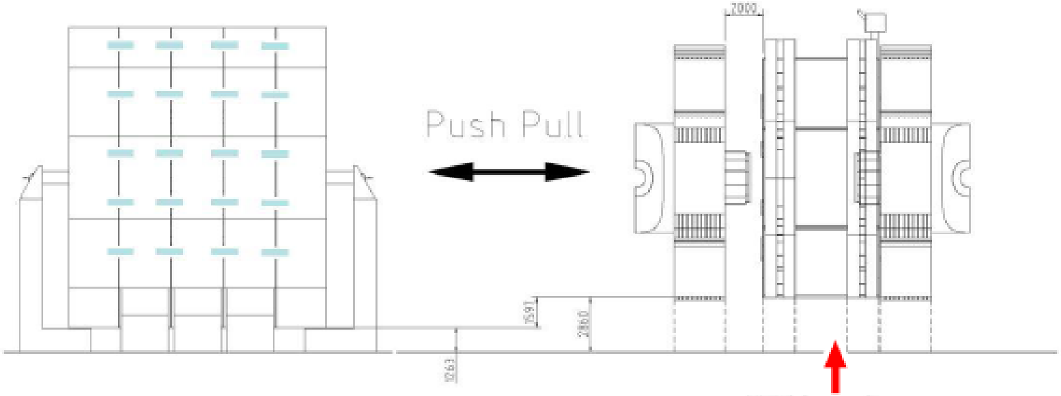
Weight= 15 ktonnes

SiD

Weight= 10 ktonnes



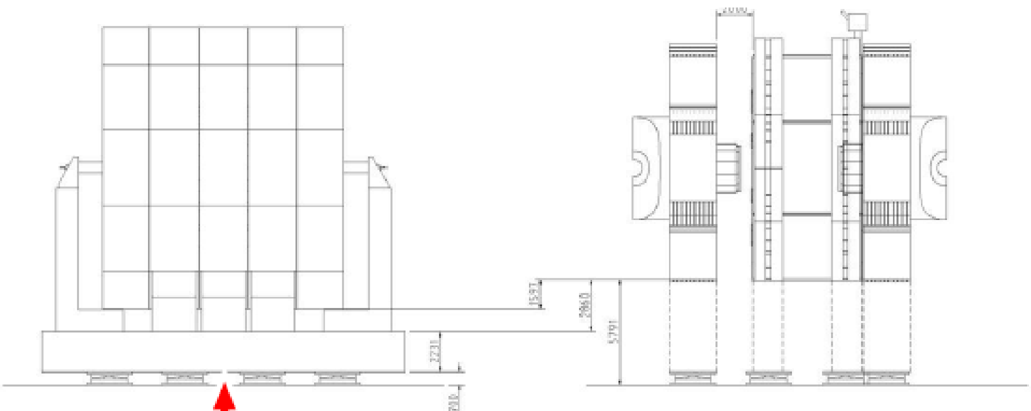
Option 1, ILD and SiD moving on the floor



SiD baseline

It requires to inter latch the rings during the push pull

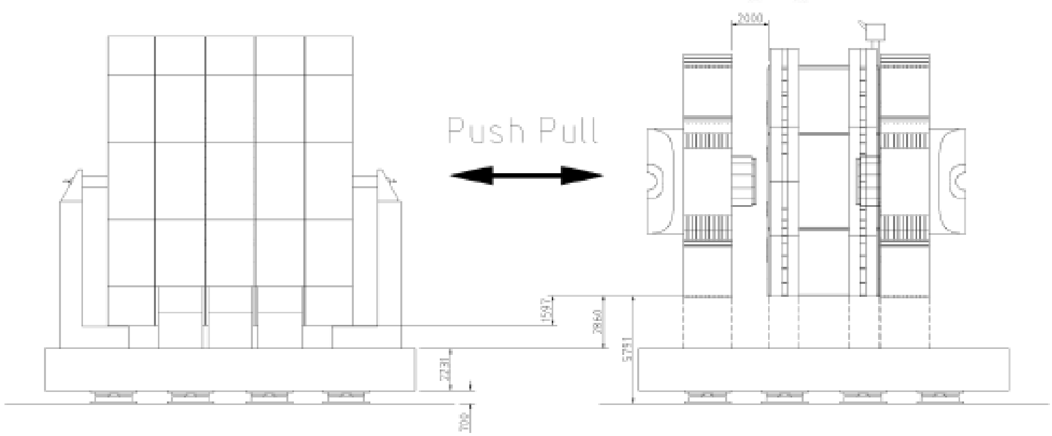
Option 2, ILD on a platform, SiD moving on the floor



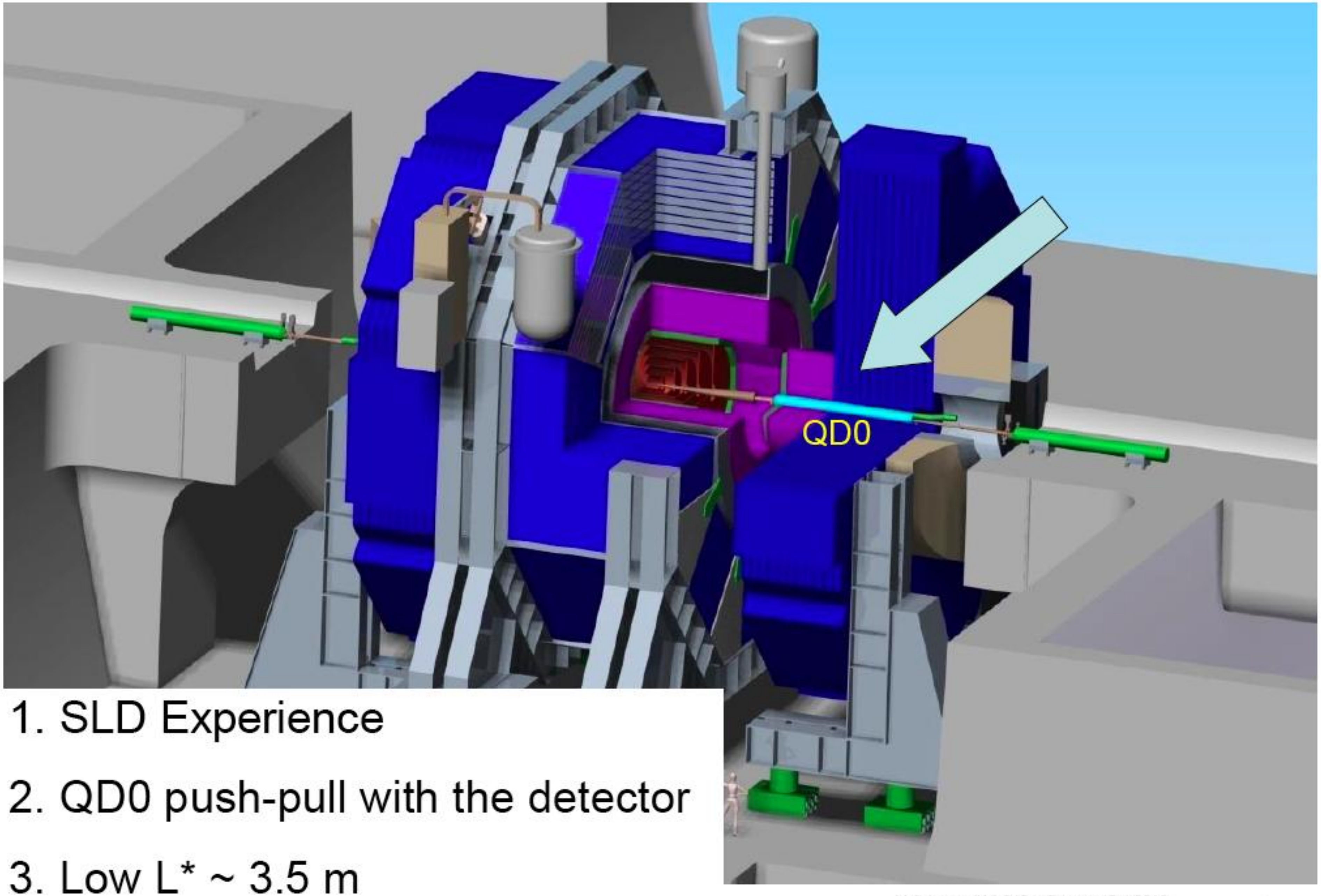
ILD baseline

Long legs for SiD

Option 3, ILD and SiD on platforms



SiD: QD0 supported from the doors



1. SLD Experience
2. QD0 push-pull with the detector
3. Low L* ~ 3.5 m

Push-Pull using Platform

- Reduce vibrations during movement
  - Initial concern was vibrations on cold mass during movement while solenoid cold
- Keeping inter-alignment of detector parts
  - Barrel wheels and end-cap parts can be aligned on platform in parking position
  - Time for alignment in beam position is reduced
  - Calibration requirements are reduced
- Movement directions are decoupled
  - Push-pull movement (transverse) is done by platform
  - Detector opening is done by longitudinal movement of end-caps or barrel wheels
  - One dimensional movement systems easier, can be optimized
- Floor behavior is decoupled from detector mounting
- Damping or earth quake damping systems could be implement underneath platform
- Best compatibility with ILD assembly and opening procedures

Push-Pull without Platform

Common rigid frame for barrel wheels, barrel end-caps and inner outer end-caps connection

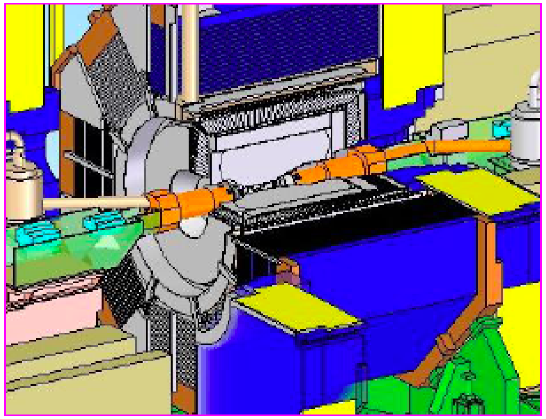
- Fixed frame should severely limit access when detector is open
  - Access between barrel and end-cap, access between barrel wheels ("Cherry picker", scaffolding or crane access like at CMS)
- Mounting/dismounting removable frame would be too time consuming for fast push-pull operation
- Outer frame would add added magnetic material and weight
  - Adding iron would modify the magnetic stray field and forces (CMS experience)
- Outer frame may lead to re-design of the assembly procedure
- Distribution of outer forces during movement must more complicate with outer frame. Frame coupled to barrel wheels and end-caps
  - Sheering force may result into misalignment of detector parts

H.Yamaoka, BELLE vibration measurements:

Conclusions

Vibration analysis has been performed and compared to measurement data.

1. Detector floor → KEKB floor
   Good consistency, FEM model is simple.
   Vibration effect is small above 1Hz/10Hz because of high natural frequencies.
2. KEKB floor → QCS magnet
   Good consistency.
3. Detector floor → Belle platform
   Relatively good.
   If the FEM model makes more precisely, it will become better consistency.
4. Detector floor → End caps/Barrel yoke: Not yet.
   Some special techniques for FEM needed due to very large model.
   Effect of the magnetic force should be taken into account.



Vibration measurements at KEK

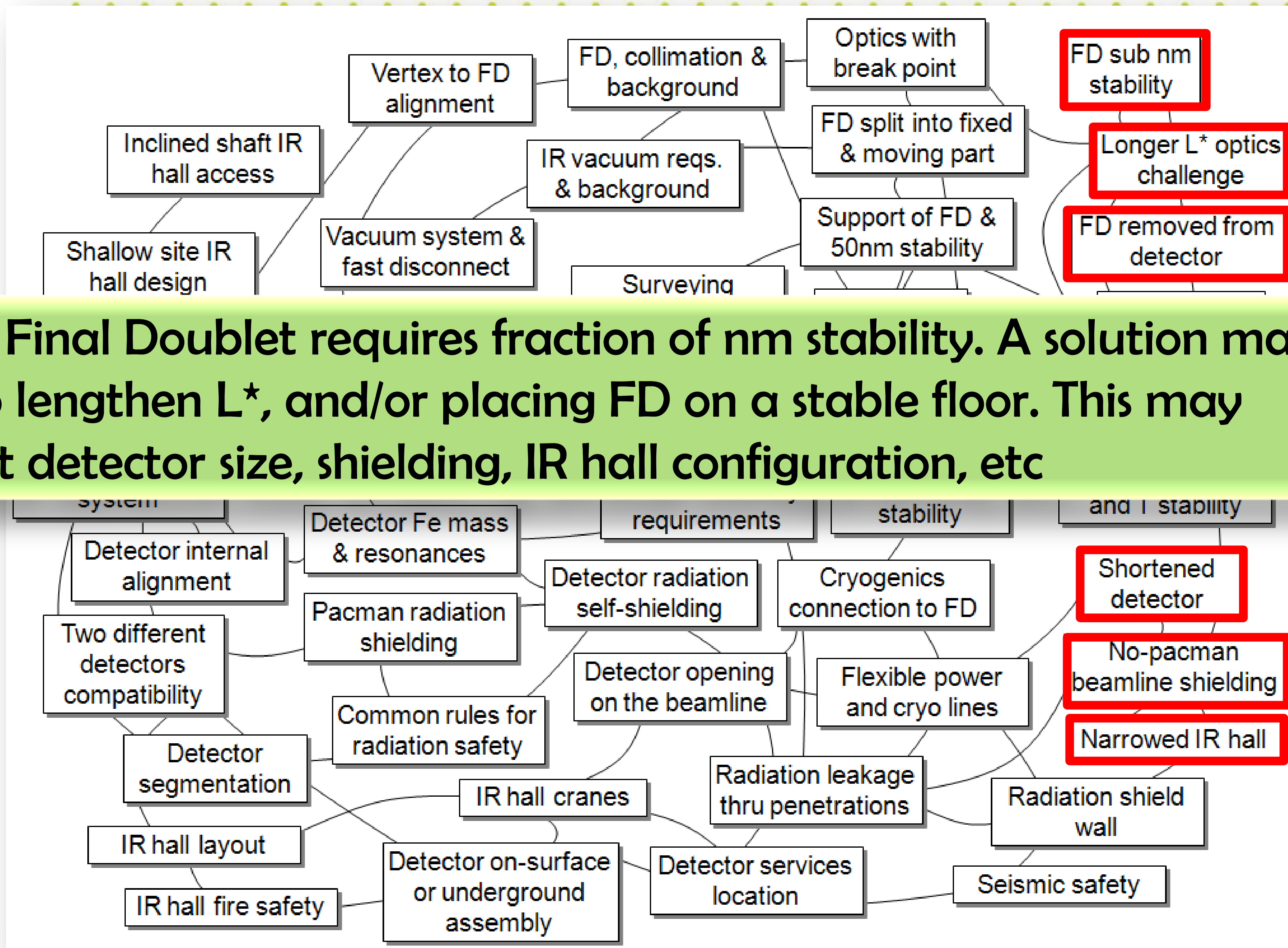
- Belle roll-out will be done in early/middle of Dec.
  → Vibration during roll-out will be measured.
- Vertex detector will be removed from the Belle in mid. Nov.
  → Vibration at central region will be measured.

Detector level was adjusted to the beam level 12 years ago.

Re-adjustment to the beam level hasn't been done so far.
Detector level also hasn't measured.
→ Detector level will be measured before roll-out.

23

Illustrations of interrelations

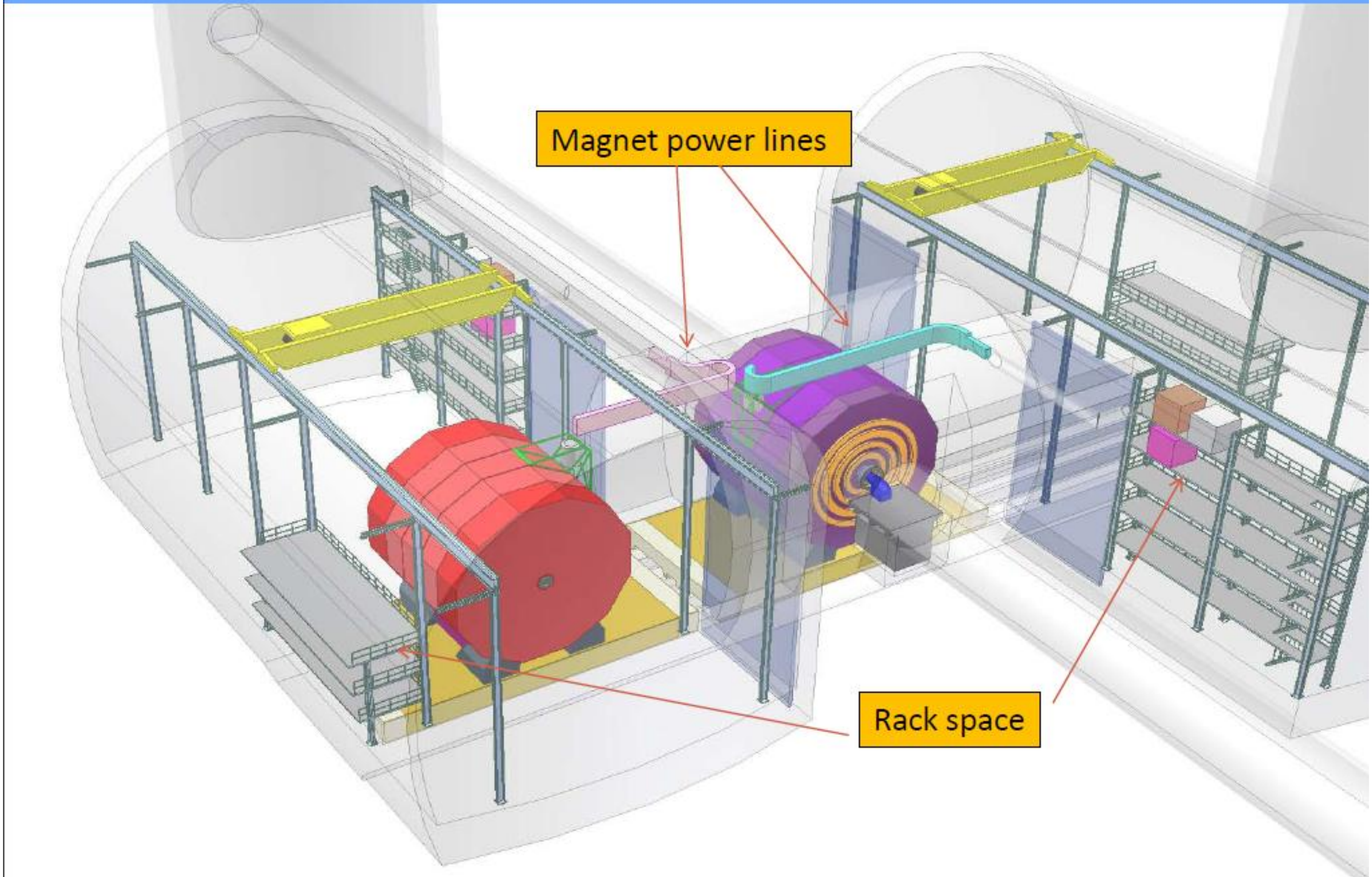


CLIC Final Doublet requires fraction of nm stability. A solution may be to lengthen L*, and/or placing FD on a stable floor. This may affect detector size, shielding, IR hall configuration, etc

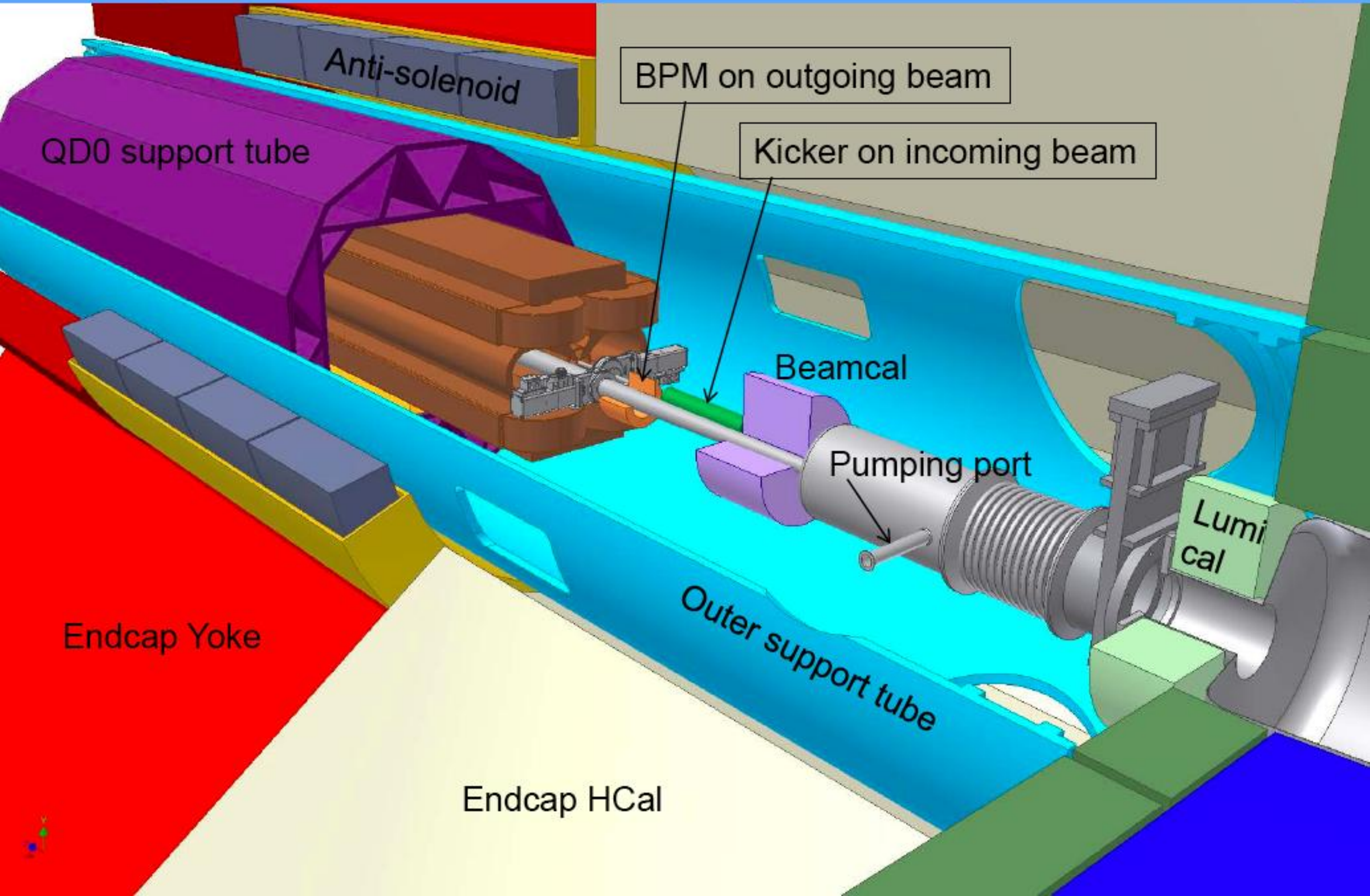
Permanent evolution of CLIC MDI

Parameter drawing for 2 detectors	2 experimental caverns connected via a transfer tunnel	Interface BDS/IP extremely short no pac-man but ring chicane with only linear movement	Each detector on a platform
All FF magnets on a pre-isolator exchangeable via experimental cavern	A two-in-one support tube with eigen-frequencies tuned on function and purpose	A sectorisation of the vacuum that allows pre-pumping, no bake-out, pumping port	Stabilisation directly under QD0 Pre-alignment on pre-isolator in the tunnel
Sectorisation for IP, sliding doors separate data taking & maintenance area	Longer experiment adapts via end coils to shorter experiment	Lumical, Kicker Beamcal, BPM and vacuum valves fully integrated	Survey gallery and emergency escape tunnel integrated in cavern design

Cavern: Magnet powering and Cryoline

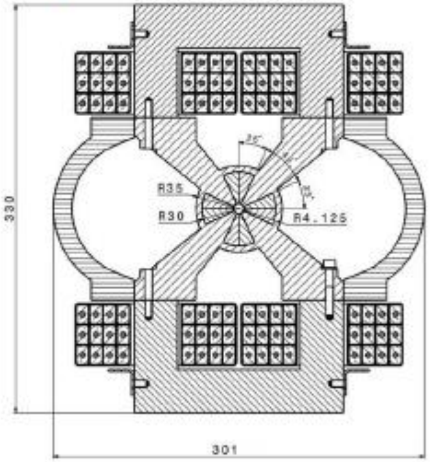


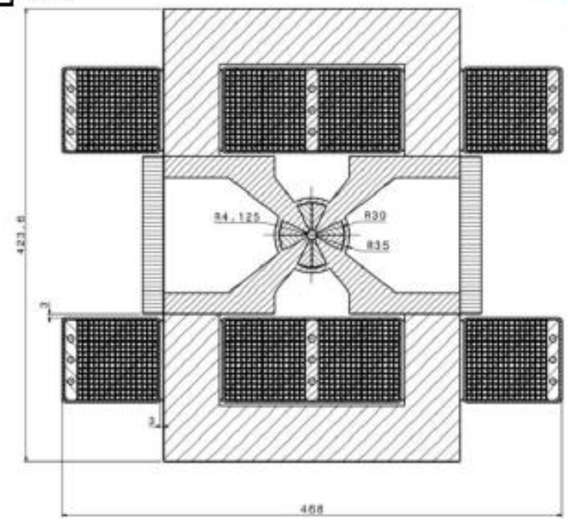
Layout Inner and Outer Support Tube



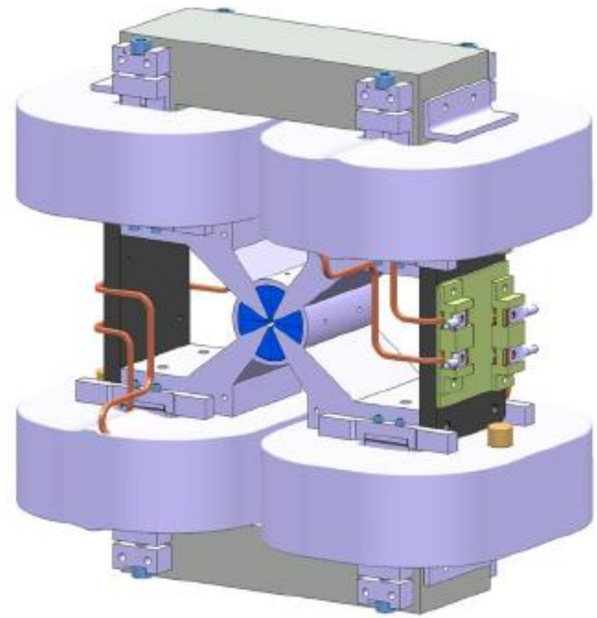
CLIC QD0 Status

...Where we are TODAY with the SHORT Prototype:

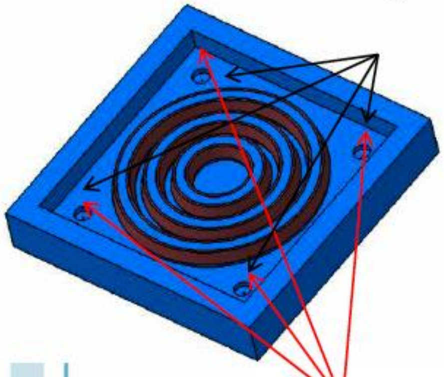




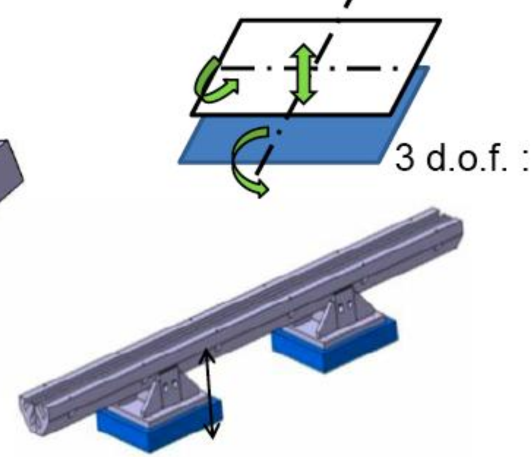
CLIC QD0 Main Parameters		100mm prototype	Real magnet 2.7m
Yoke			
Yoke length	[m]	0.1	2.7
Coil			
Conductor size	[mm]	4×4	4×4
Number of turns per coil		18×18=324	18×18=324
Average turn length	[m]	0.586	5.786
Total conductor length/magnet	[m]	0.586×324×4=760	5.786×324×4=7500
Total conductor mass/magnet	[kg]	26.8×4=107.2	265.2×4=1060.8
Electrical parameters			
Ampere turns per pole	[A]	5000	5000
Current	[A]	15.432	15.432
Current density	[A/mm²]	1	1
Total resistance	[mOhm]	896	8836
Voltage	[V]	13.8	136.4
Power	[kW]	0.213	2.1



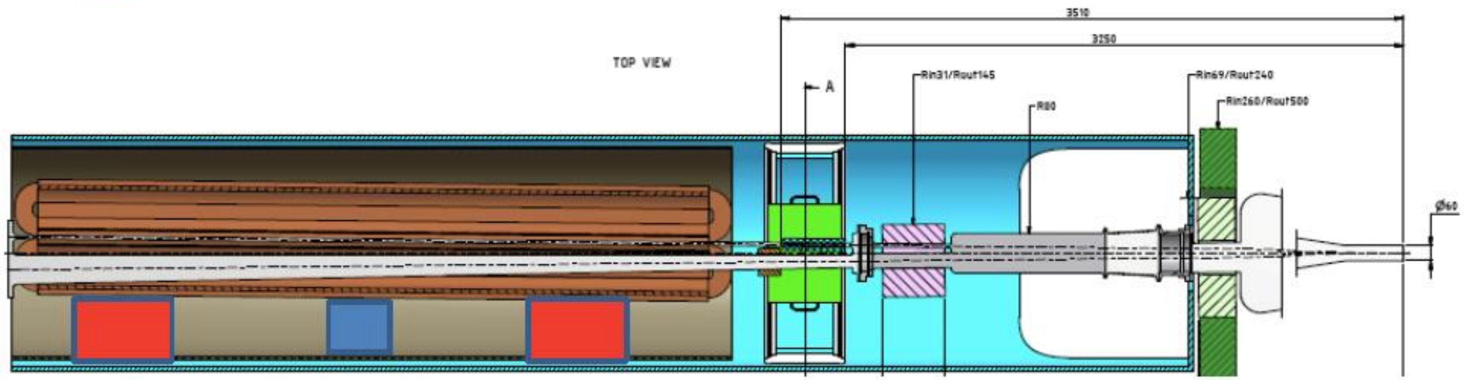
Relative sensors (more compact)



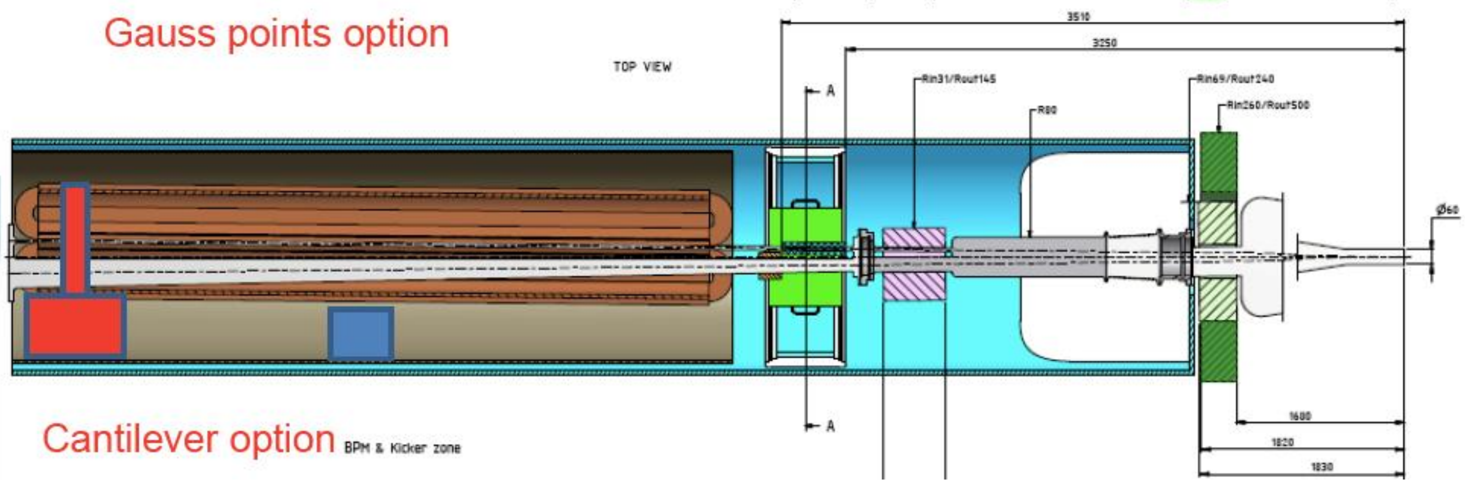
elastomere joint in between for guidance



How to integrate with the rest (cantilever or Gauss points)



Gauss points option



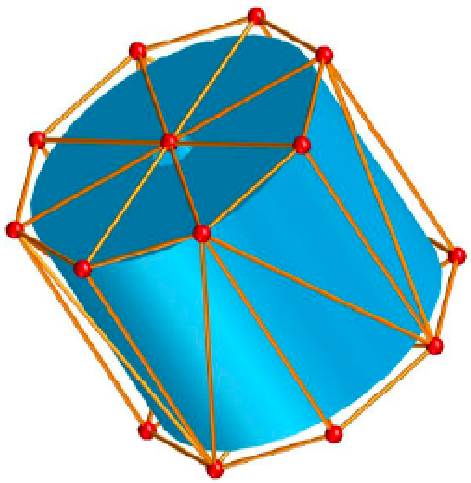
Cantilever option BPM & Kicker zone

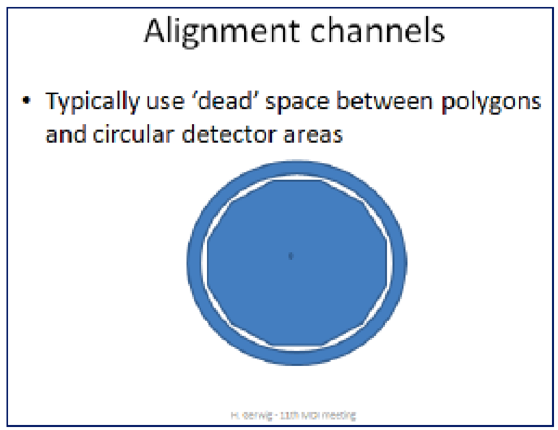
Solutions for MDI area

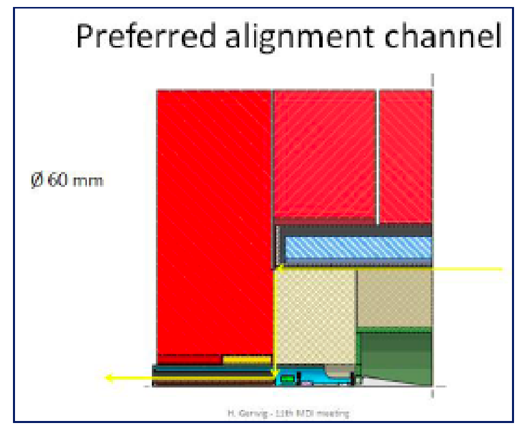
Left side w.r.t right side

✓ Monitoring of QD0:

- Network of over-determined nodes linking each QD0
- Each node consists of a combination of RASNIK systems performing measurements through the detector, using the dead space between polygons and circular detector areas
- RASNIK systems calibrated with a sub-micron accuracy
- This project is part of a collaboration with NIKHEF institute.





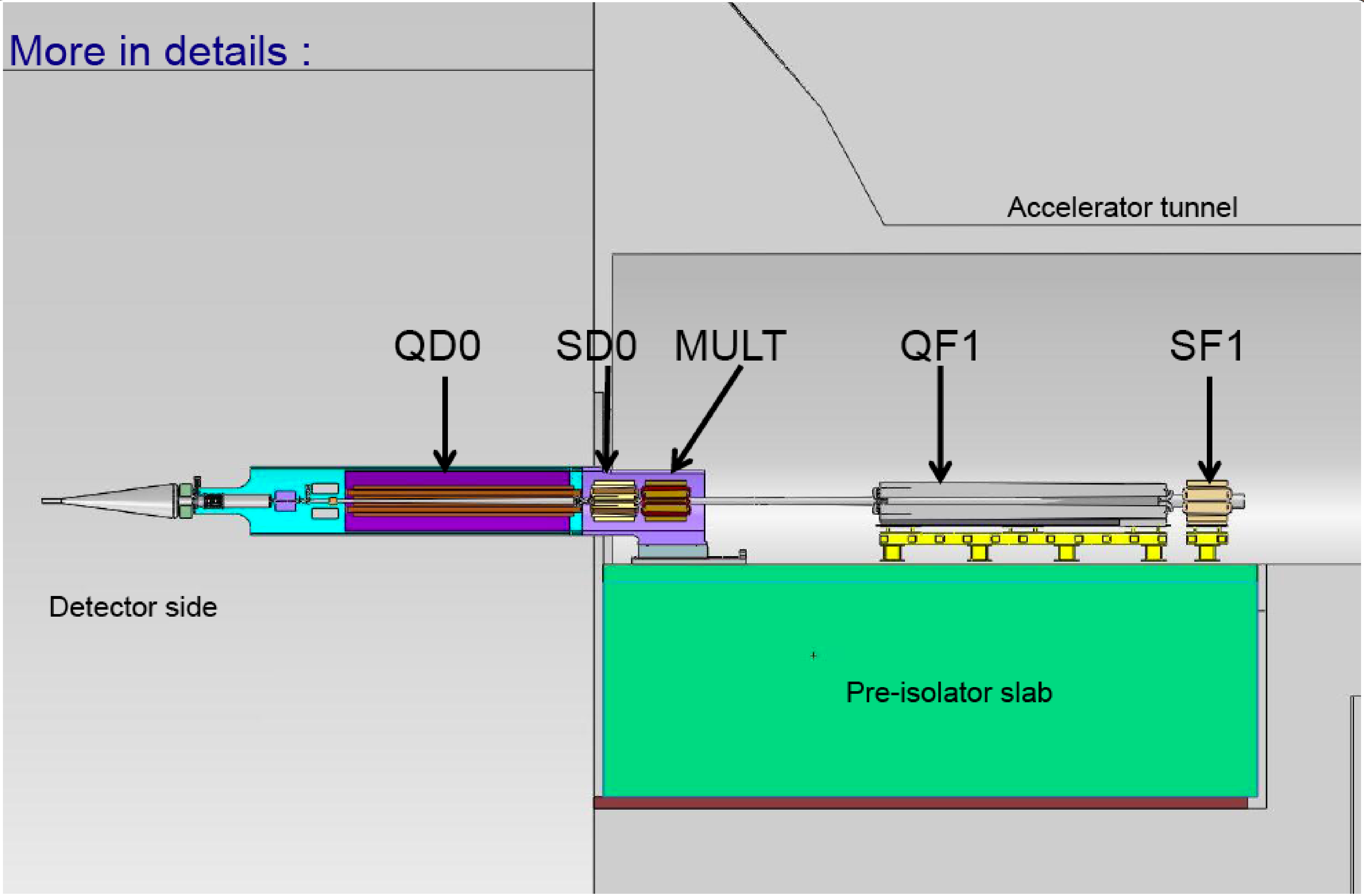


Next steps

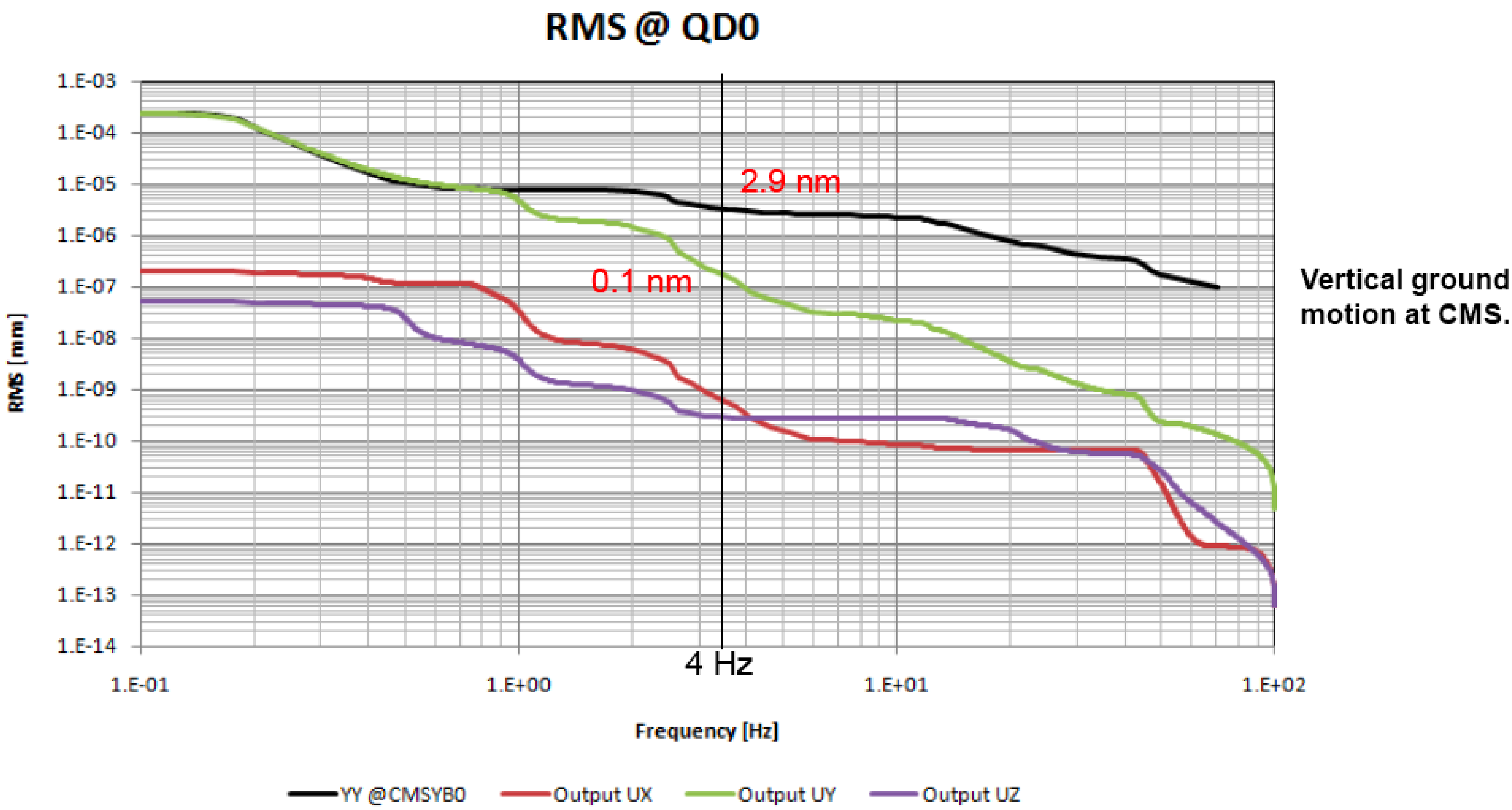
- Perform simulations of configurations
- Design and calibrate nodes of RASNIK
- Validate the solution on a dedicated mock-up

Passive isolation: Pre-isolator for FF quads

More in details :



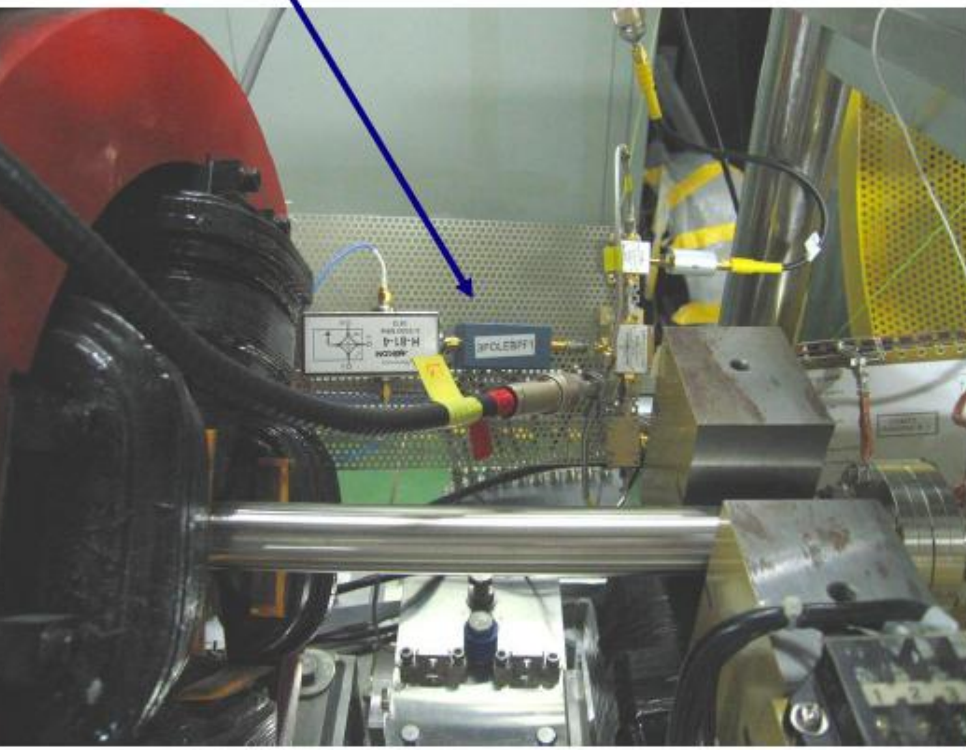
Random vibration response.



Reduction in r.m.s. displacements by a factor 30 above 4 Hz

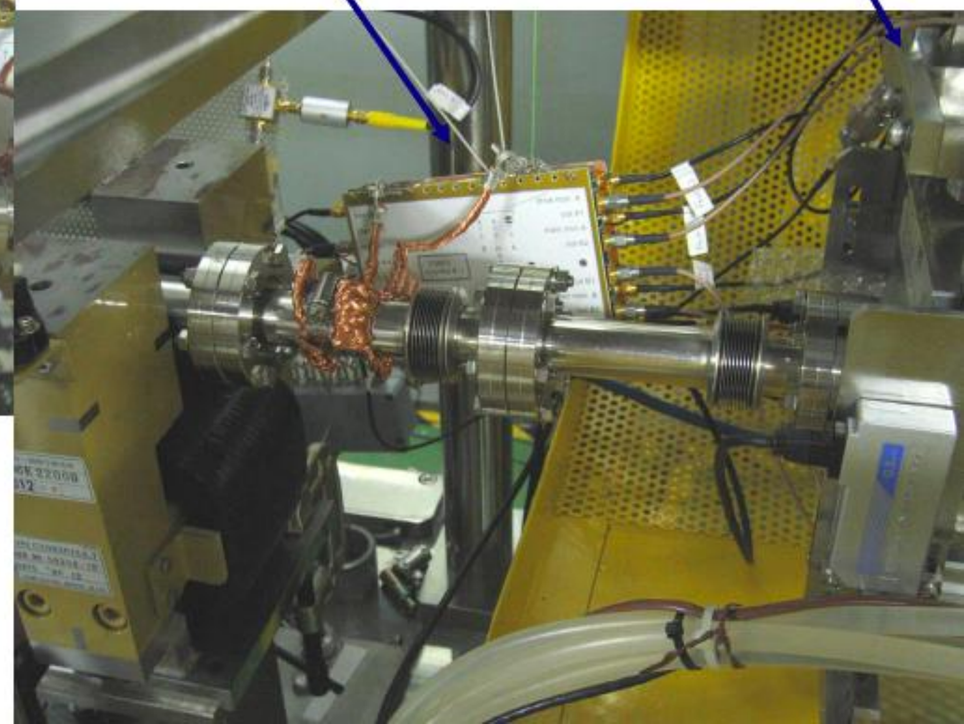
FONT3: BPM processor + amplifier/feedback installation in ATF beamline

BPM processor board



FEATHER kicker

Amplifier/FB board



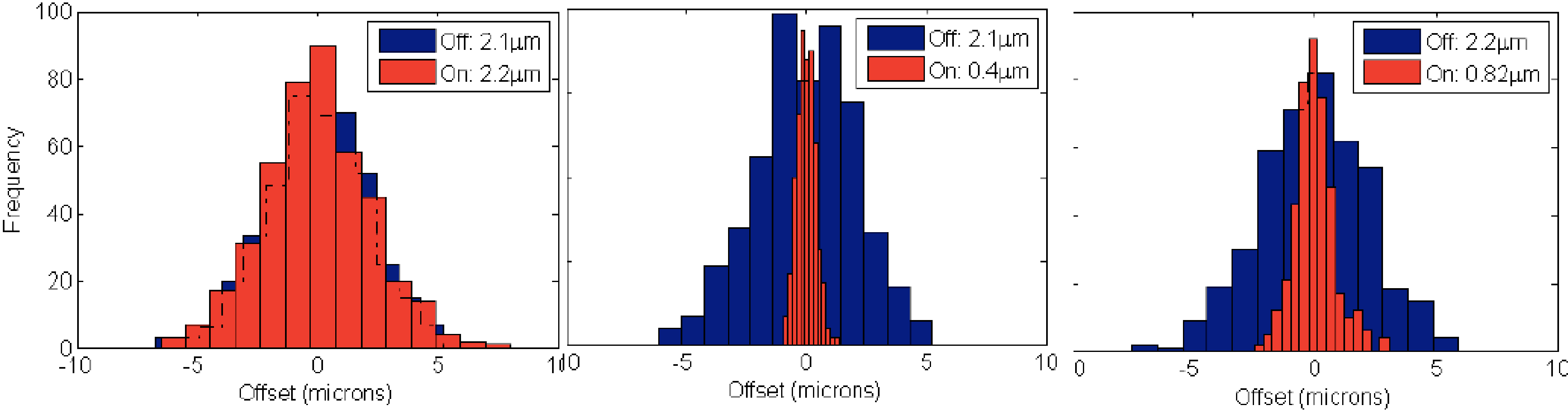
Expected latency at CLIC: 37 nsec

Test of a digital system (for ILC) at ATF2:

P2 → K1 loop jitter reduction

(April 2010)

Bunch 1 | Bunch 2 | Bunch 3



2.1 um → 0.4 um → 0.8 um

Factor of 5 jitter reduction

Progress on CLIC BDS static tuning:
87% probability of reaching 80% luminosity.
Need to learn from ATF2

Barbara Dalena

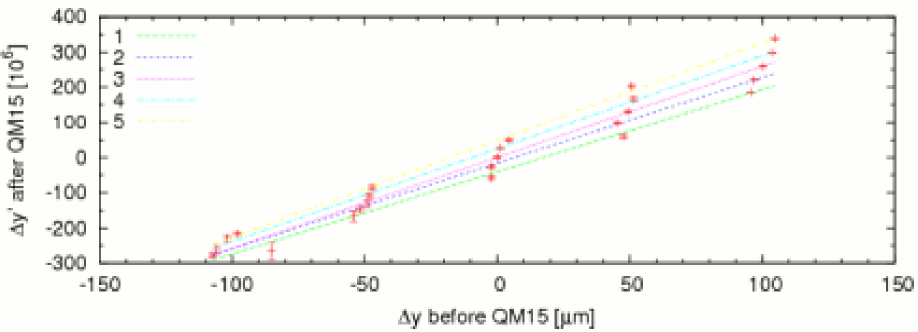
pre-alignment H&V [μm]	Relative Success rate %	Absolute Success rate %	lattice	comments
10	55	80	L* = 3.5 m	nominal
10	58	84	L* = 3.5 m	Higher energy bandwidth
10	65	87	L* = 3.5 m	Tuning + horizontal knobs

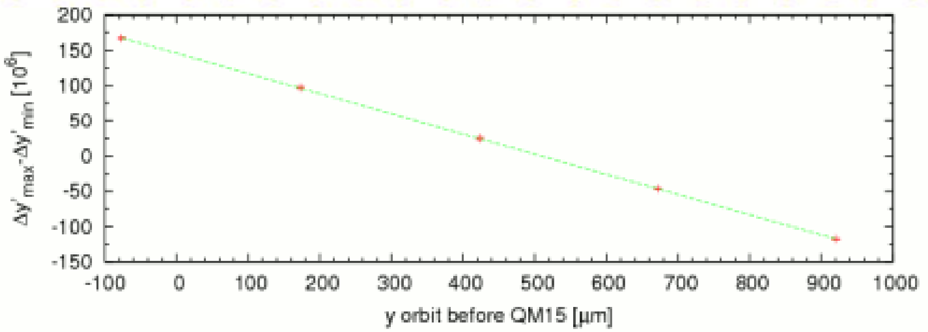
Glen probably found the solution to better tune the CLIC FFS via the "pushed ATF2"

- **Used for developing tuning strategy for ATF2.**
- **Next plan to attempt to develop tuning strategy for "pushed beta" optics.**
  - Non-linear knobs required with increased FFS chromaticity?

ATF2 is an example of true ILC-CLIC collaboration where both projects benefit from each other.

Eduardo Marin



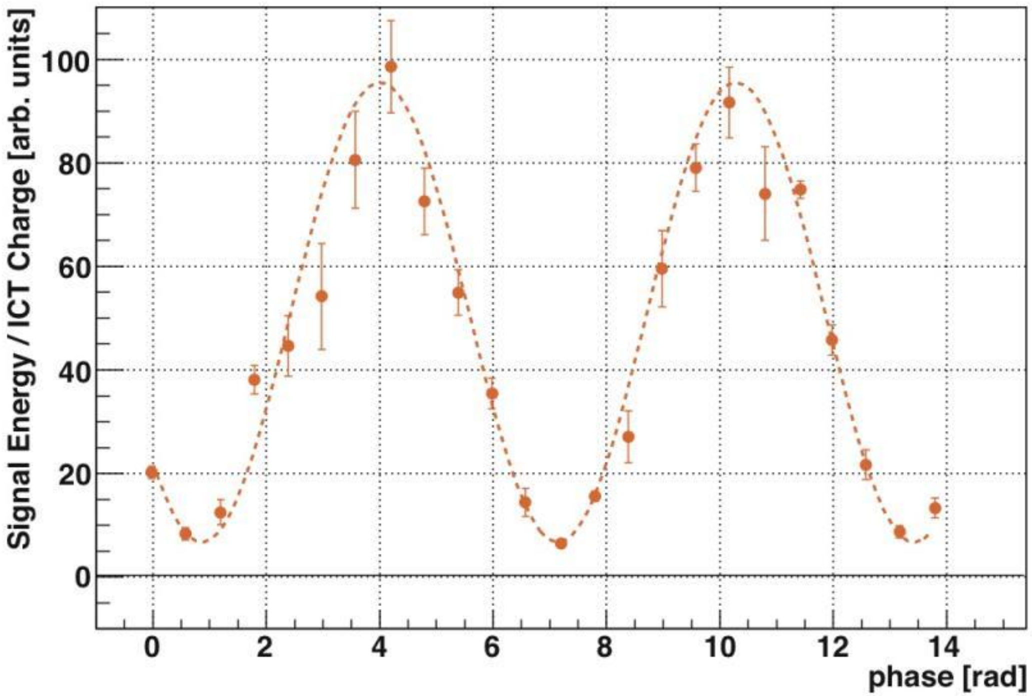


	1st Measurement Type 1	2nd Measurement Type 1*	3dt Measurement Type 2	4th Measurement Type 2
Offset [μm]	110 ± 40	135 ± 86	114 ± 18	510 ± 1.6

Quad shunting can get to the micron resolution in ATF2!

In 2010 spring run,

we performed 1st trial of the ATF2 continuous operation with 4cm βx and 1mm βy optics.



Okugi san

In the continuous operation,
we achieved the 0.87 of the modulation depth at 8.0 deg. Mode.

The evaluated vertical beam size is 310 +/- 30 (stat.) +0-/40 (syst.) nm.
(The design beam size is 114nm)

Optimisation of Optics Including Multipole Data

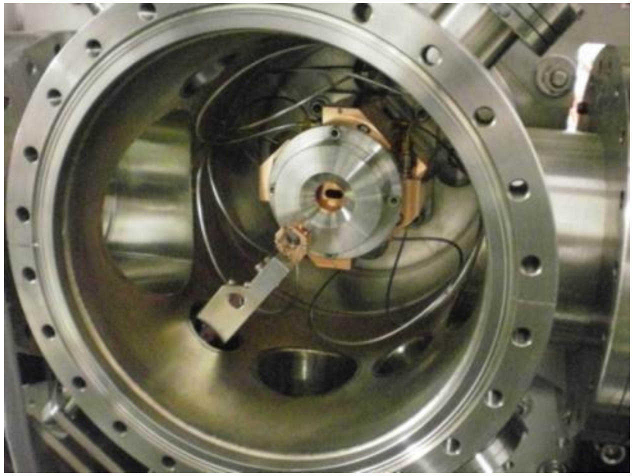
Using CLIC codes

- MAPCLASS used to rematch and optimise lattice including multipole fields to try and recover nominal IP vertical beam size.
- Quantities on the right are re-matched values different from initial nominal lattice. *Note the inclusion of design sextupole rolls.*
- The vertical beta function was left unchanged at 0.1mm, but horizontal had to be increased by a factor of 2.5 to 1cm.

```
ksf6ff =       45.02265407 ;
ksf5ff =       -26.9434435 ;
ksd4ff =       152.5391892 ;
ksf1ff =      -22.38137452 ;
ksd0ff =       41.20558391 ;
sf6tilt =   -0.01246444319 ;
sf5tilt =   0.009102481889 ;
sd4tilt =   -0.01427832723 ;
sf1tilt =   -0.04258038011 ;
sd0tilt =   -0.03147326184 ;
kqm16ff =      2.924170943 ;
kqm15ff =    -0.2795777162 ;
kqm14ff =     -4.768046545 ;
kqm13ff =      4.508634198 ;
kqm12ff =      1.469984966 ;
kqm11ff =     0.4389927394 ;
kqd10ff =     -1.465121307 ;
kqf9ff =       1.853857007 ;
kqd8ff =      -3.074271679 ;
kqf7ff =       2.717880616 ;
kqd6ff =      -3.050190084 ;
kqf5ff =       1.949024326 ;
kqd4ff =      -1.555892097 ;
kqf3ff =       2.830240649 ;
kqd2aff =     -1.361293174 ;
kqd2bff =     -1.369873894 ;
kqf1ff =       1.566624722 ;
kqd0ff =       -2.87401948 ;
```

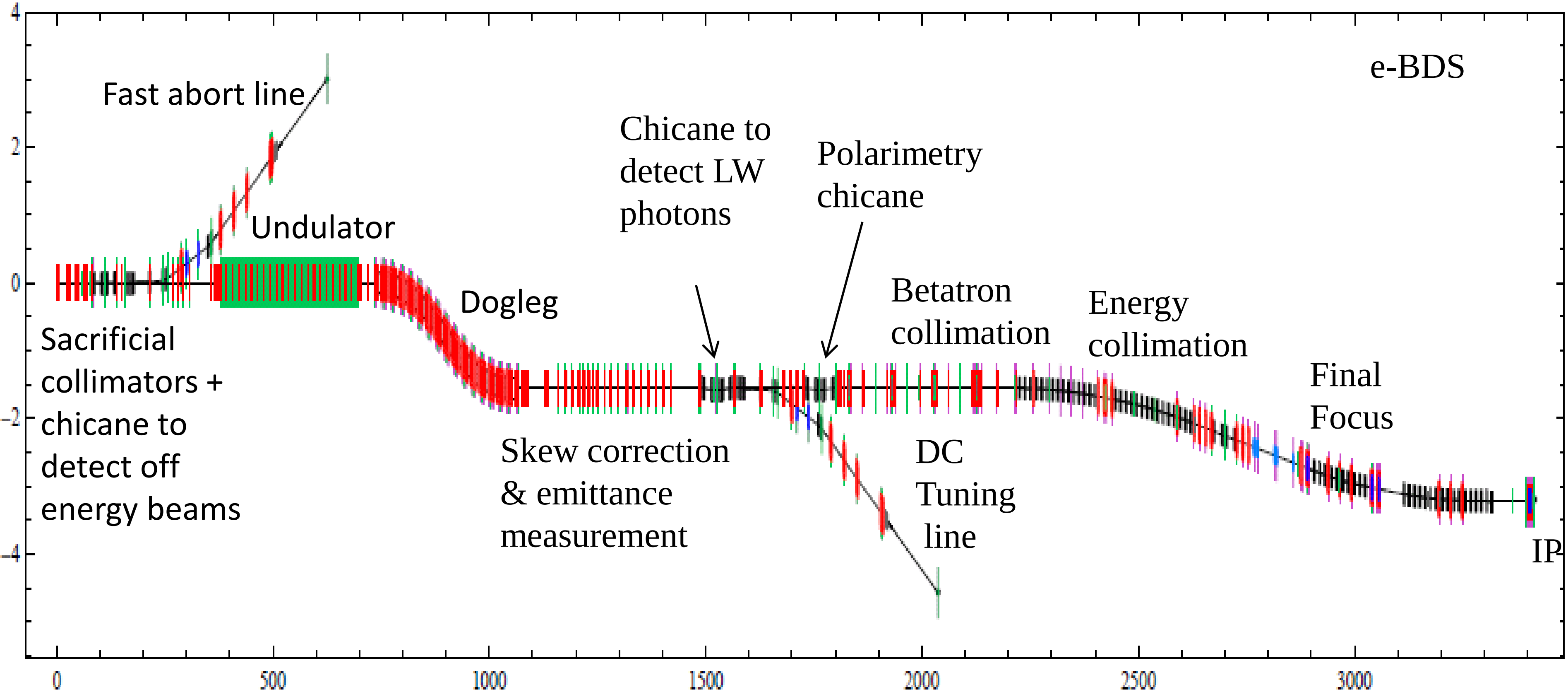
Okugi san

IP-BPM



ATF2 is getting ready for the Winter 2010 run

SB2009 e- BDS



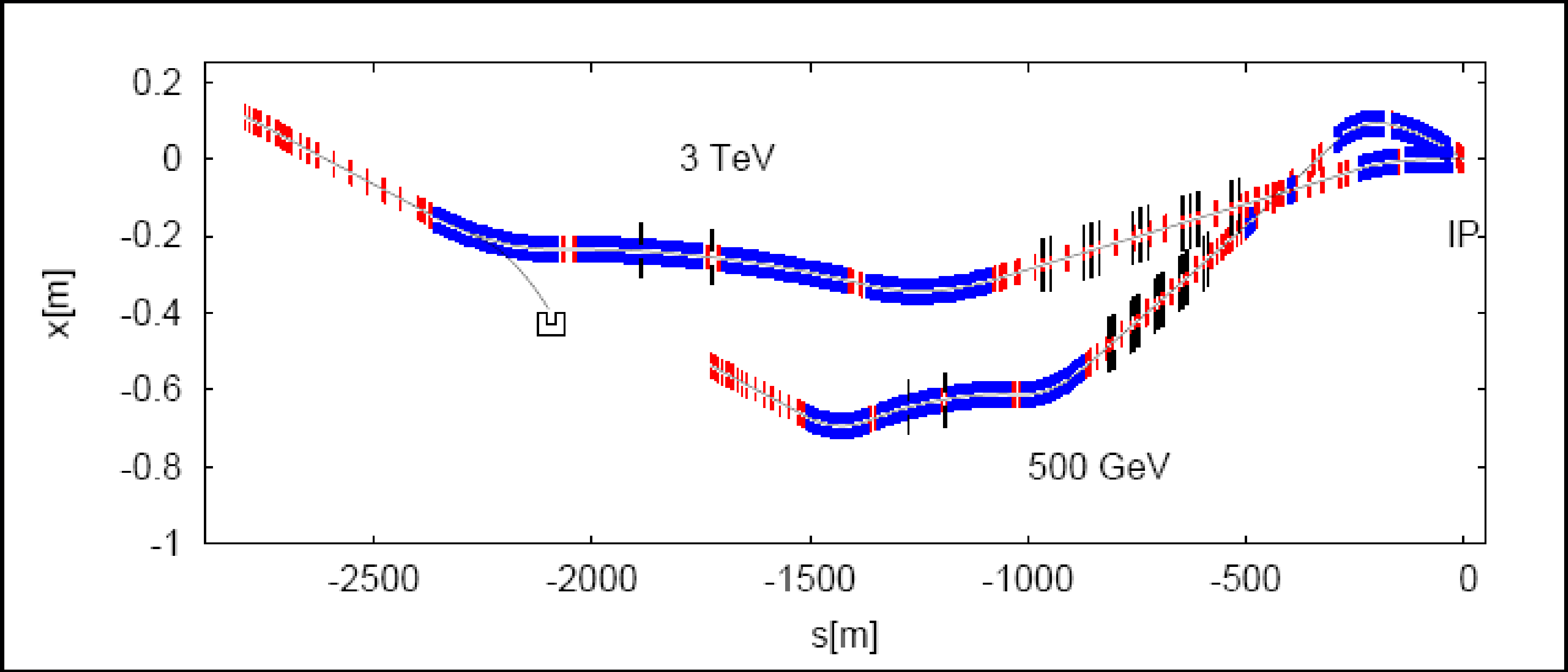
Changes on e- side due to central integration : dogleg design & tolerances

Separated polarimeter chicane from RDR combined functionalities.

D. Angal-Kalinin

The BDS layouts at 3 TeV and 500 GeV

Guillermo Zamudio



3 TeV needs weak dipoles (20-120 G) due to SR. To keep the linac unchanged the IP crossing angle at 500 GeV is reduced to 18.6 mrad.

Both BDS easily fit in same tunnel.

L* alternatives and performance

L* m	total lumi 10^{34}cm^{-2}s^{-1}	peak lumi 10^{34}cm^{-2}s^{-1}
3.5	6.9	2.5
4.3	6.4	2.4
6	5.0	2.1
8	4.0	1.7

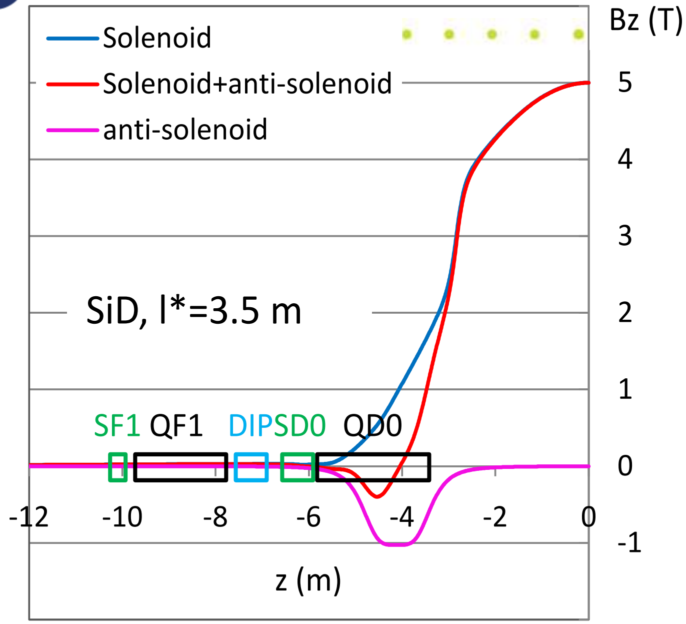
Tuning performance for different L*

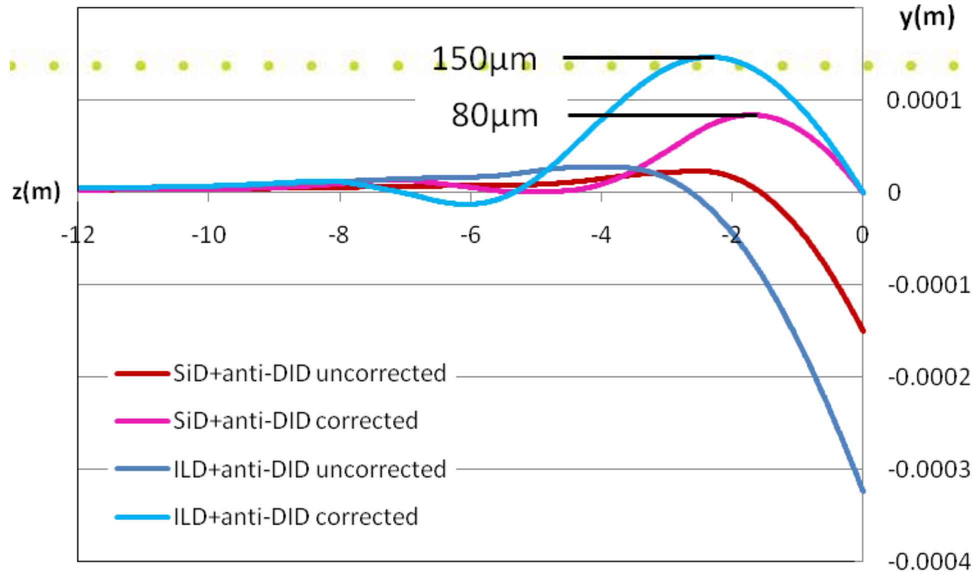
B. Dalena & G. Zamudio

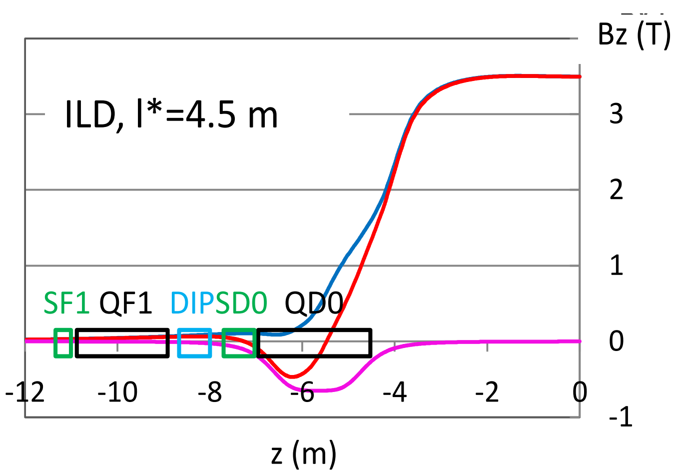
L* [m]	prealignment [μm]	relative success [%]	absolute success [%]
3.5	10	65	87*
4.3	10	80	100
6	8	80	90
8	2	80	46

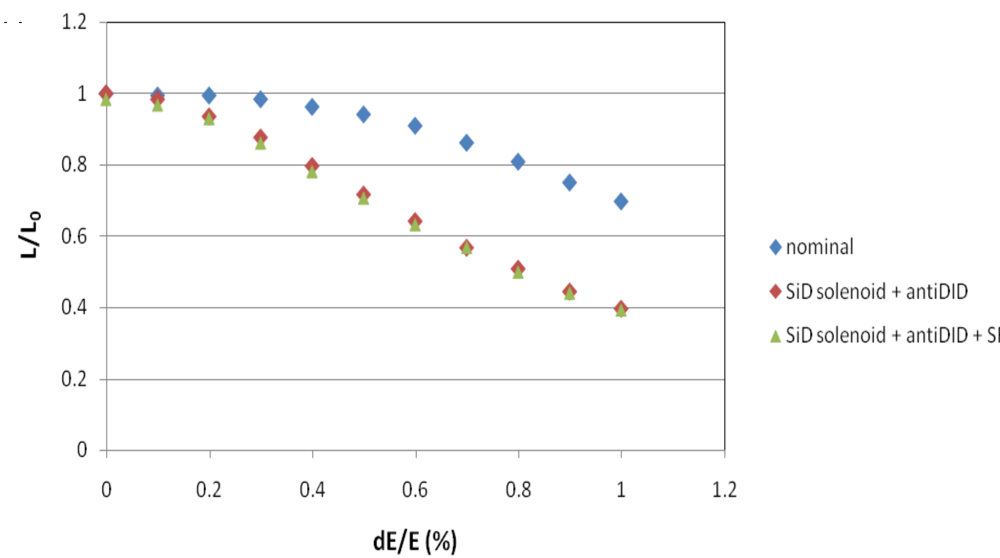
* Recently improved by a better design and th use of knobs

ILC : Compensation of beam size growth and vertical orbit at the IP









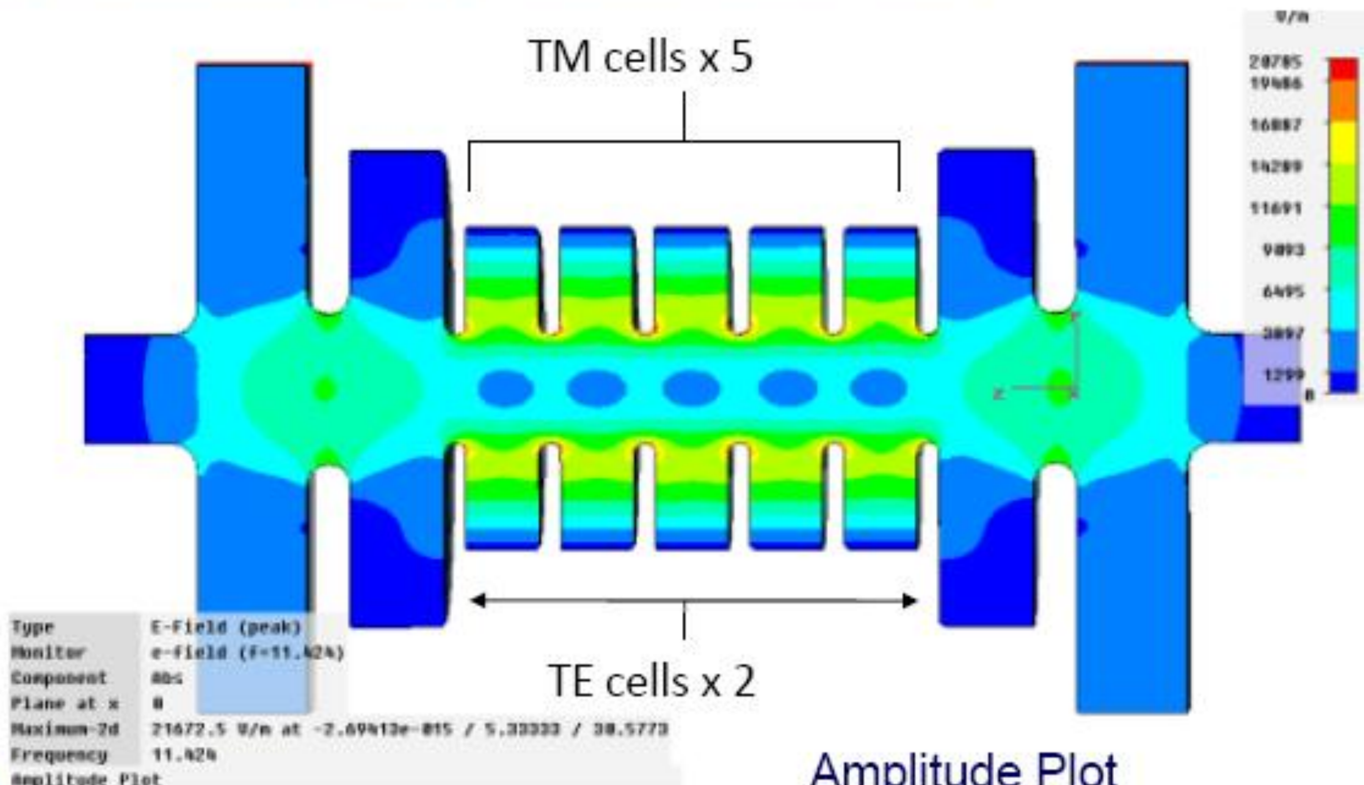
Luminosity Loss due to incoherent synchrotron radiation

Field Map	Bz [T]	Lumi loss [%]
CLIC_SiD	5	~14.0
CLIC_SiD + Antisolenoid	5	~10.0
CLIC_ILD	4	~10.0
CLIC_ILD + Antisolenoid	4	~10.0
ILC_ILD at 3 TeV + AntiDiD	4	~25.0
ILC_4th at 3TeV concept	3.5	~20.0

- Luminosity calculation by GUINEA-PIG
- CLIC half horizontal crossing angle 10 mrad
- $\Delta\sigma^*_y \propto (B\theta_c L)^{5/2}$ P.Tenembaum et al., PRST-AB 6, 061001 (2003)
- CLIC-BDS budget: 20% luminosity loss

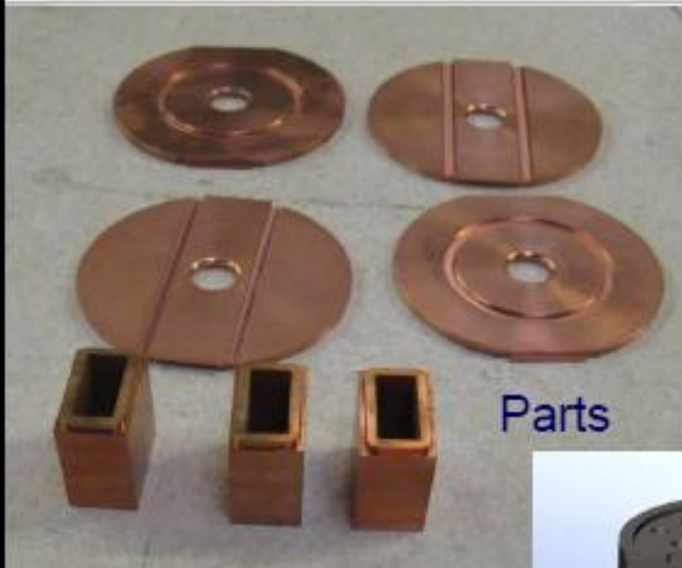
Gradient Testing

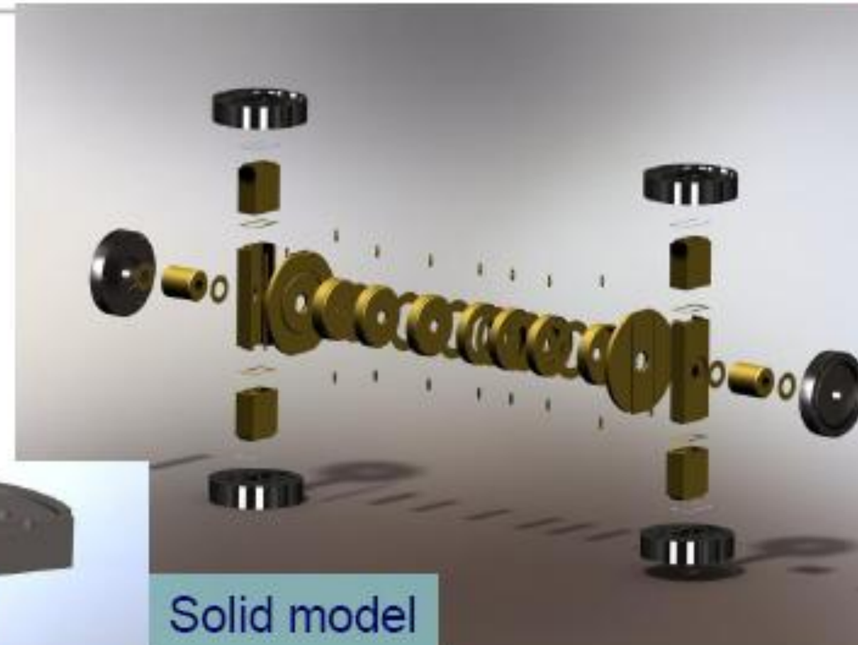
- To determine the maximum operating gradient for the CLIC crab cavity a special design of test cavity, compatible with the SLAC high power klystron and test stand is needed. It has been designed and is being manufactured.
- The mid cells operate at TM_{110} dipole mode for maximum axial field while the matching end cells at TE_{111} dipole mode so that axial field =0



Amplitude Plot

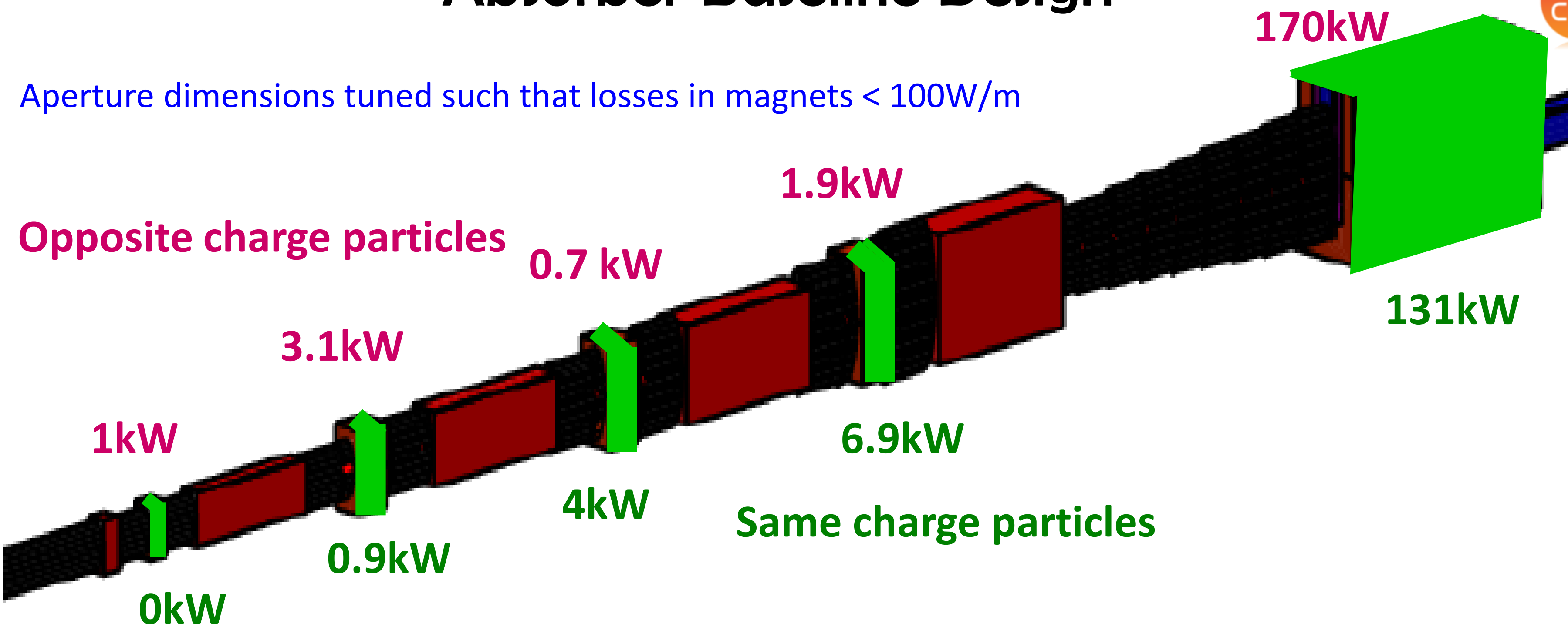
Cavity Under Construction


Parts


Solid model

Absorber Baseline Design

Aperture dimensions tuned such that losses in magnets < 100W/m



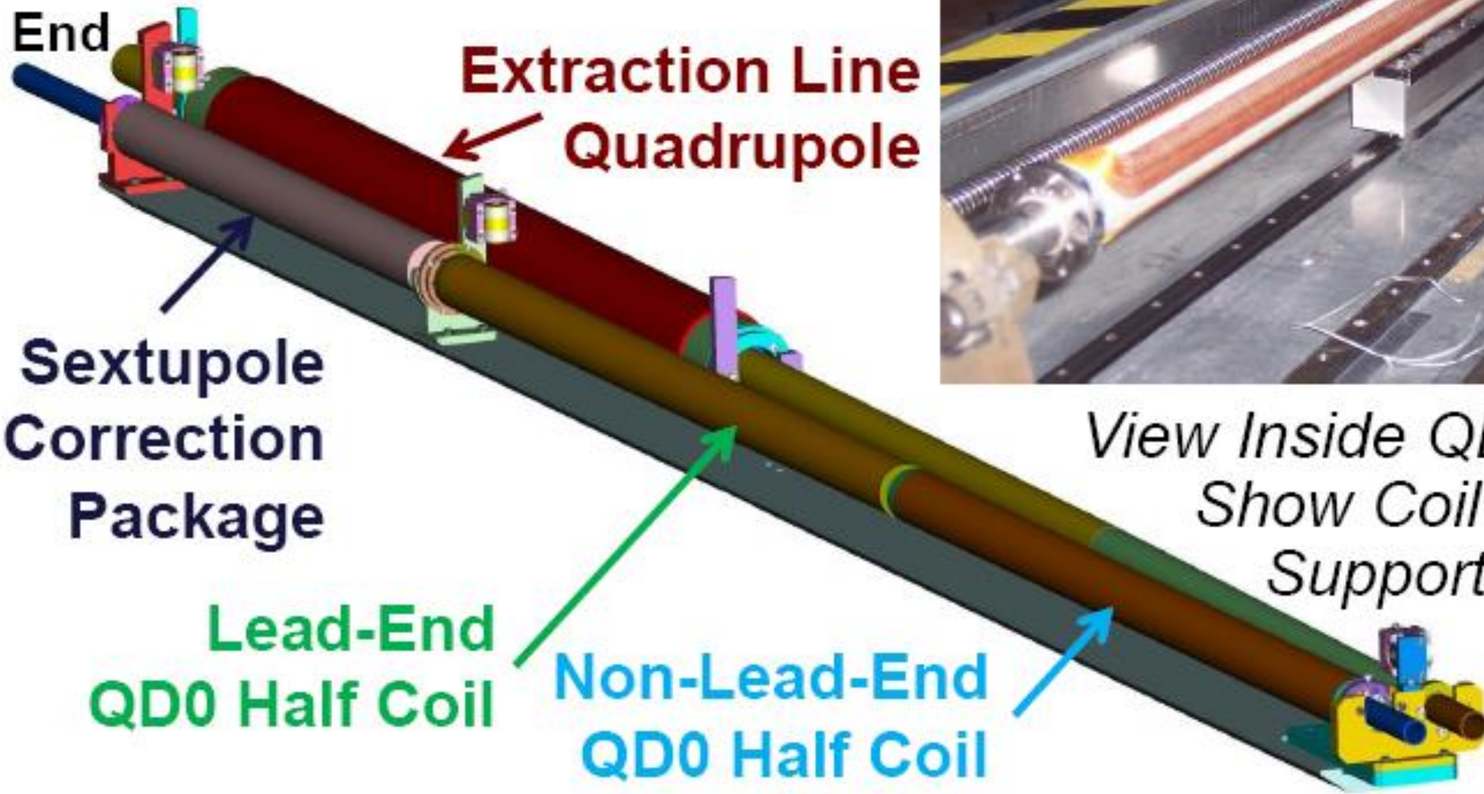
Magnet protection:
Carbon absorbers:
Vertical apertures between 13cm and 100cm

Intermediate dump (CNGS style):
carbon based absorber, water cooled aluminum plates, iron jacket
3.15m x 1.7m x 6m
→ aperture: X=18cm, Y=86cm

→ Non-trivial, but solutions for absorbers exist (see dumps in neutrino experiments: 4MW)

QD0 Split Coil Winding Implementation

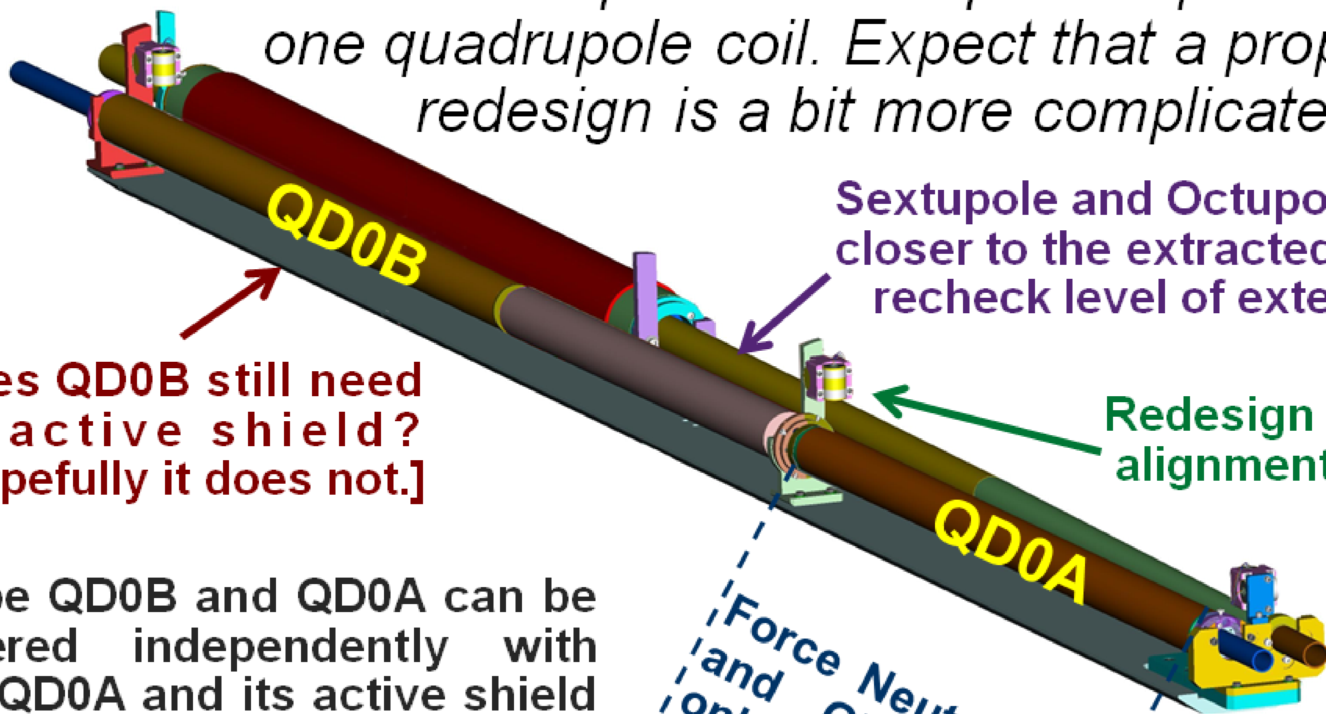
QD0 split coil variant may be useful for low-energy running as a Universal Final Focus.



View Inside QD0 Cryostat to Show Coil Positions and Support Infrastructure

Universal Final Focus (Cartoon) Issues

Here I took the CAD layout from slide #7 and did cut/paste to swap sextupole and one quadrupole coil. Expect that a proper redesign is a bit more complicated.



Sextupole and Octupole coils are now closer to the extracted beam; so must recheck level of external B-field.

Does QD0B still need an active shield? [Hopefully it does not.]

Redesign support & alignment scheme.

Force Neutral Anti-Solenoid Shield and QD0A Active only need to extend over this region?

Maybe QD0B and QD0A can be powered independently with only QD0A and its active shield run in series?

Do QD0A and QD0B have to have the same coil structure and magnetic length?

Conclusion

- A lot of progress and strong CLIC-ILC collaboration in the area of MDI, BDS and ATF2
  - Further opportunities for joint work arising
- A lot of attention and recent progress in push-pull system design
  - Vibration studies and measurements
  - Preparing quantitative process for selection of detector motion system
- ATF2 extremely valuable, a lot of lessons, real-life BDS experience, essential for low-beta for ILC & CLIC