BDS and IR Alignment Issues

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ILD MDI/Integration Pre-Meeting, 21-22 May 2012,

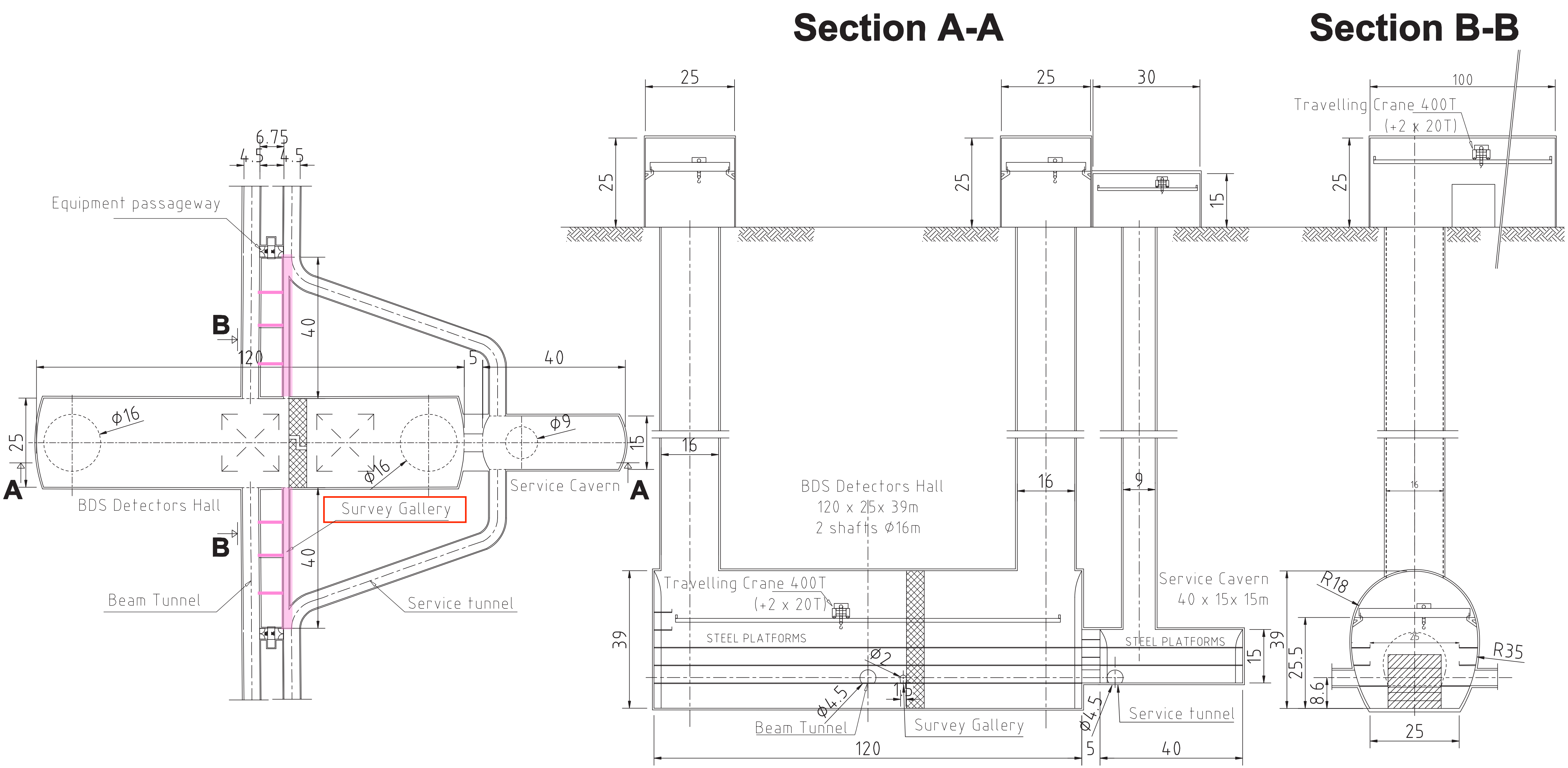
Kyushu University, Hakozaki Campus, Fukuoka

RDR : Alignment Tolerances

TABLE 4.7-1
Component alignment tolerances.

Area	Type	Tolerance
Sources, Damping Rings and RTML	Offset	150 μm (horizontal and vertical), over a distance of 100 m.
	Roll	100 μrad
Main Linac (cryomodules)	Offset	200 μm (horizontal and vertical), over a distance of 200 m.
	Pitch	20 μrad
	Roll	
BDS	Offset	150 μm (horizontal and vertical), over a distance of 150 m around the IR.

RDR : Exp. Hall and BDS/IR Alignment



To reach and maintain the positioning tolerances of the final doublets in the BDS IR, a 150 m straight reference line is set up as close as possible to the beam components. This line, consisting of a laser or stretched wire and hydrostatic levels, is housed in a dedicated gallery built parallel to the beam tunnel, and goes through the experimental cavern. This allows for the geometrical connection between the beam lines and the detector.

20 May, 2011

Engineering Specifications (3) : QD0 Issues	unit	value	
Mover : number of degrees of freedom		5	horizontal x, vertical y, pitch φ, yaw ψ, roll α
Mover : Range per x,y degree of freedom	mm	± 2	
Mover : Range per φ, ψ degree of freedom	mrad	± 1	
Mover : Range per α degree of freedom	mrad	± 30	
Mover : Step size per degree of freedom of motion	μm	± 0.05	
Before BBA : Accuracy per x,y degree of freedom	μm	± 50	
Before BBA : Accuracy per φ, ψ degree of freedom	μrad	± 20	
Before BBA : Accuracy per α degree of freedom	mrad	± 20	
BBA : alignment accuracy per x,y	nm	± 200	from a line determined by QF1s for 200ms
BBA : Accuracy per α degree of freedom	μrad	± 0.1	from a line determined by QF1s for 200ms
Vibration stability : $\Delta(QD0(e^+)-QD0(e^-))$	nm	50	within 1ms long bunch train

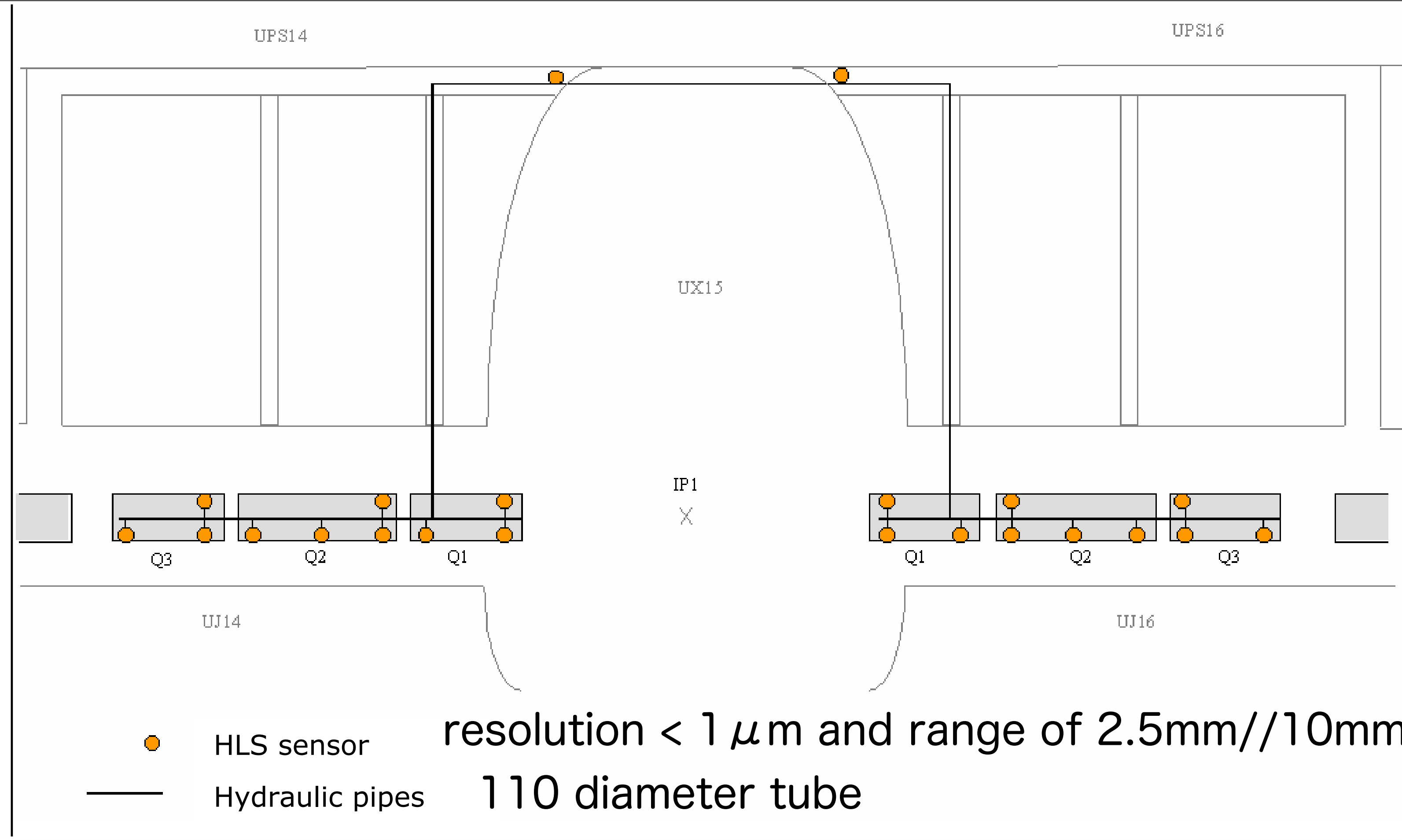
Engineering Specifications (4) : Radiation shield	unit	value	
Self shielding		must	
Normal operation : anywhere beyond the 15m zone housing the off-beamline detector	μSv/hour	0.5	
Accidental beam loss : dose for occupational workers	mSv/hour	250	The acident is defined as the simultaneous loss
Accidental beam loss : integrated doze for occupational workers	mSv/accident	1	of both e^+ and e^- beams at 250 GeV/beam
Accidental beam loss : beam shut-off time after the accident	beam-train	1	anywhere, at maximum beam power.

Engineering Specifications (5) : Vacuum	unit	value	
in the 200m upstream of the IP	nTorr	1	$=1.3 \times 10^{-7}$ Pa
in the remainder of the BDS system	nTorr	10	$=1.3 \times 10^{-6}$ Pa
in the 18m zone of the detector			not specified in the IR document

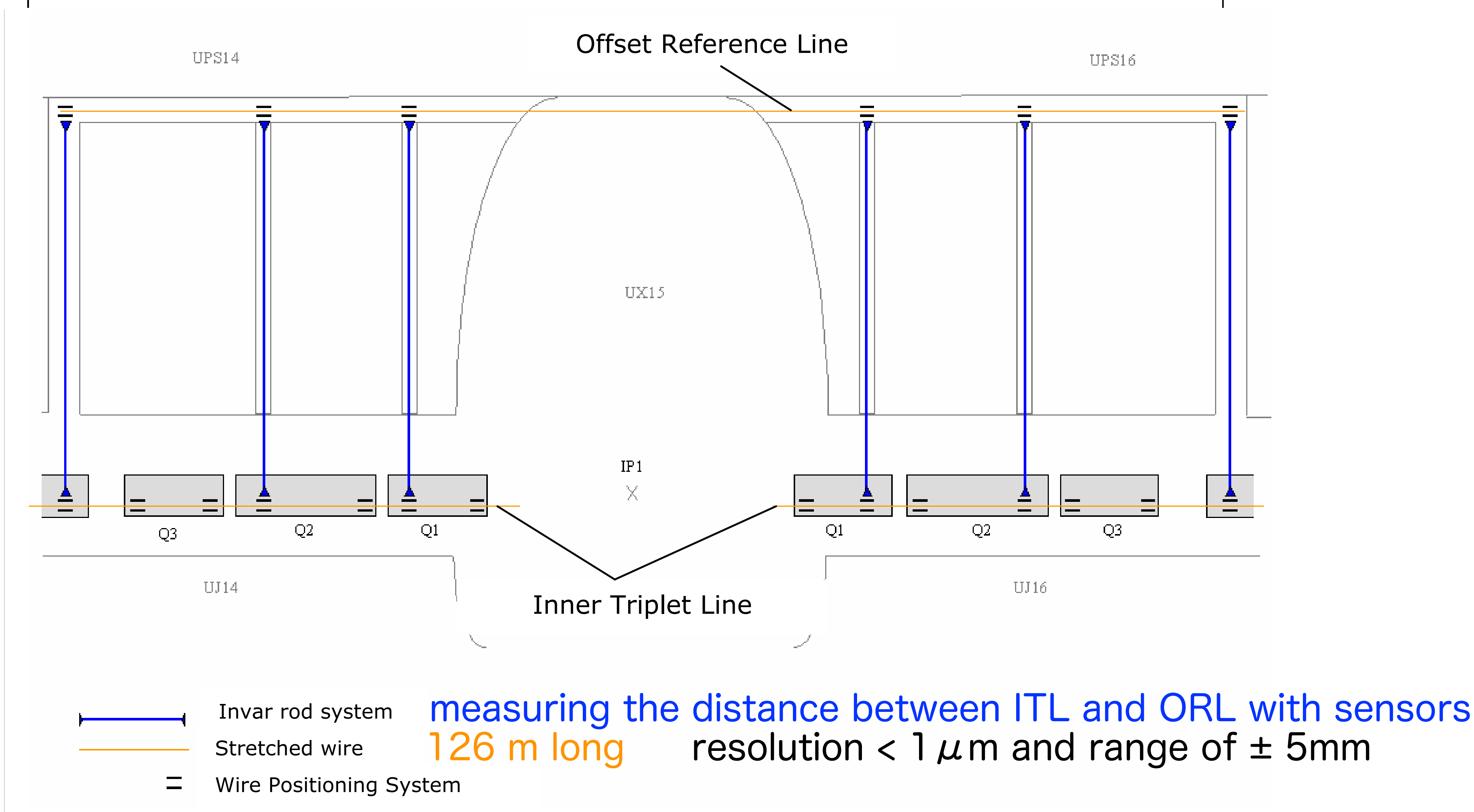
Engineering Specifications (1) : Push Pull Issues	unit	proposed	SiD	ILD
Time for Exchange experiments with rough alignment (mm)	day	1		
Time for Fine alignement, vacuum evacuation	day	1		
Time for Restart the machine and experiment	day	1		
Time for Beam calibration and alignment for the nominal luminosity	day	1		
Number of Pushpull operation	/year	10		10
Number of Pushpull operation for 15 years	times	150	100	150
Detector total weight	tons	15,000	10,000	15,500
Detector beam level	m	9	9	9
Maximum acceleration on the detectors during the movement	G	0.05		
Total moving distance from IP to the garage position	m	15		25
Residual magnetic field at IP from detector in the garage	Gauss	50		50
Pulling forces with two lines (multiple anchoring points?)	tons/line	300		
Number of anchoring points		4		
Movement speed	cm/min	10	6 to 30	
Displacement due to the movement : radius	mm	20		
Displacement due to the movement : angle	mrad	2.5		
Adjustment of the movement : x,y	(±)mm	1		
Adjustment of the movement : angle	mrad	0.1		
Slow downward movement of the floor within ±50m around IP (for several weeks?) with feedback system	mm	5		
Platform : width	m		20	14
Platform : length	m		20	14.8
Platform : thickness	m			2.2
Platform : wall clearance	mm		10	
Platform : max. vibration transfer function for microseisms	1<f<100Hz		1.5	
Platform : pulling force in locomotion system with rollers	tons	750	500	750
Platform : pulling force in locomotion system with airpads	tons	300		300
Roller : a roller system must be supplemented by another system that allows a 3-axis movement on IP. A good candidate would be a grease-pad system on top of the roller supporting platform.				
Airpad : Standard airpad systems have the disadvantage of requiring a slight lift of the load of around 5 mm. However as the landing is obtained by leaking air through orifices this landing is very smooth as it had been verified by installing accelerometers on CMS elements.				
hydraulic jacks :				

LHC Alignment

Uncertainty of measurement w.r.t the water surface: ± 3 μm + 1 μm / month



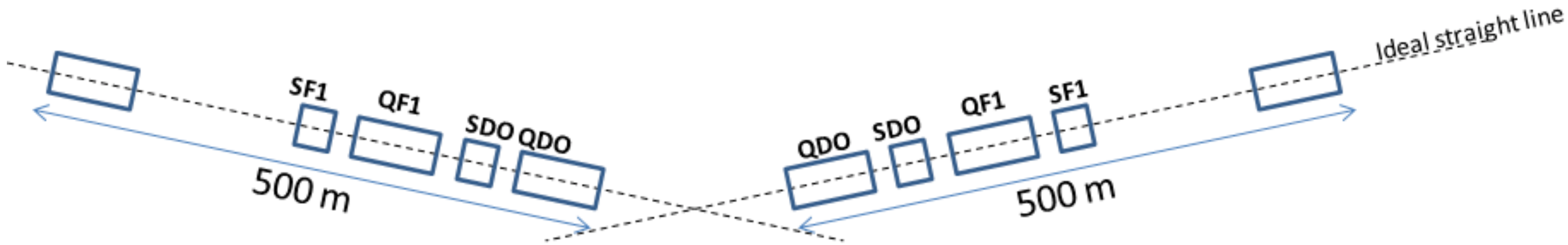
Uncertainty of measurement w.r.t the wire: ± 3 μm + 1 μm / month



Alignment approach in MDI area CLIC

by H. Gerwig (CERN) .KILC12

Determination of the position of QD0 w.r.t other components of the BDS (1)



Requirements:

- ✓ Position of the zero of QD0 w.r.t ideal straight line of the 500 last meters of BDS: ± 10 μm rm (including fiducialisation)
- ✓ Longitudinal relative position between QD0 and QF1: ± 20 μm rms

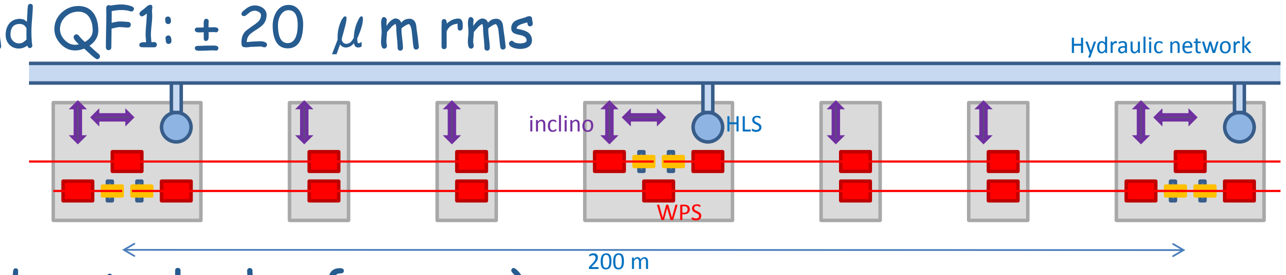
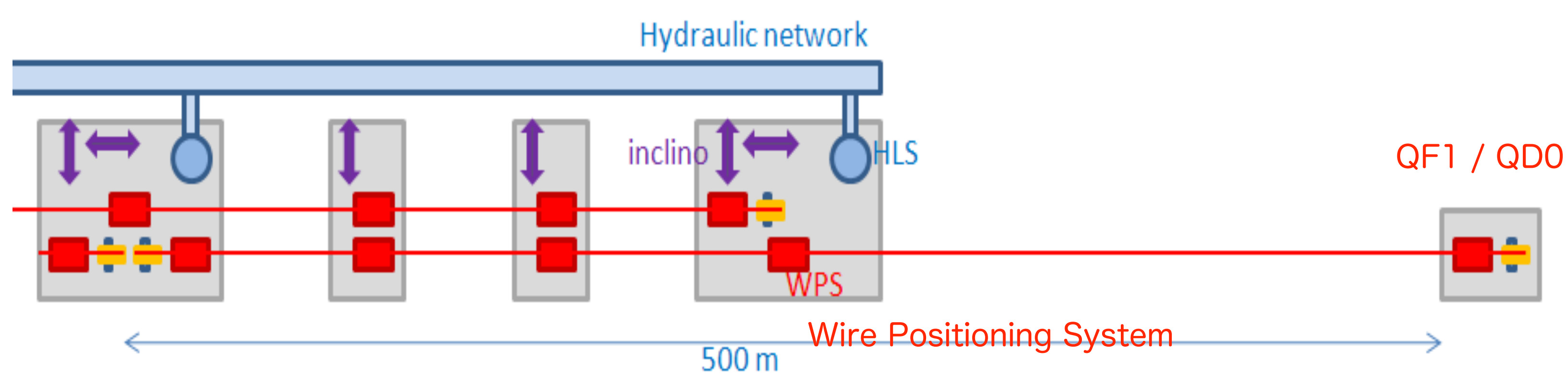


Fig. 5.261: Metrological plates of MRN network

Solutions: Metrological Reference Network (MRN)

- ✓ Main difference concerns the MRN network (due to lack of space):
  - ○ No overlapping of stretched wires in the last 250 m
  - ○ No HLS system needed for modeling of the sag; will be extrapolated on the last 250 m.
  - ○ Longitudinal monitoring of QD0 w.r.t QF1: capacitive sensors and CFRP bar



WPS determines radial, vertical, yaw and pitch position of QD0

MDI - Survey mini galleries

CLIC

Left side w.r.t right side

by H. Gerwig (CERN) .KILC12

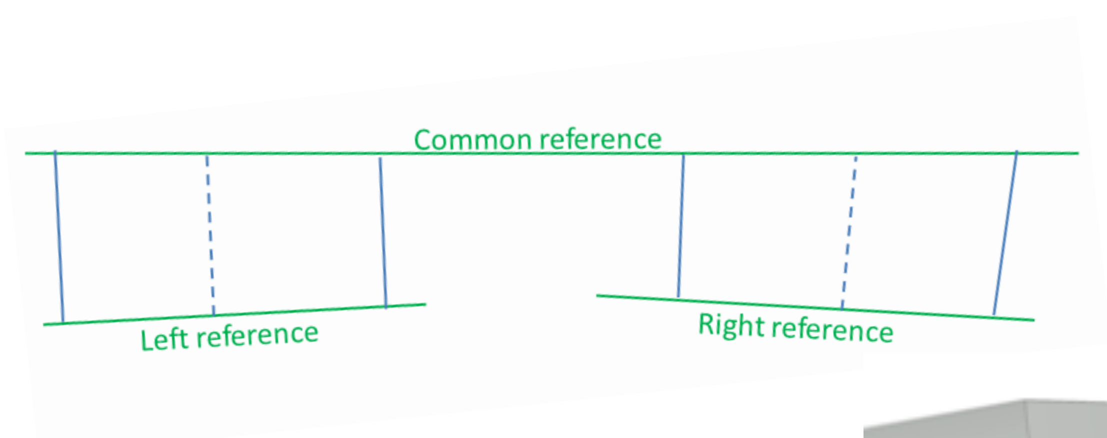
Requirements:

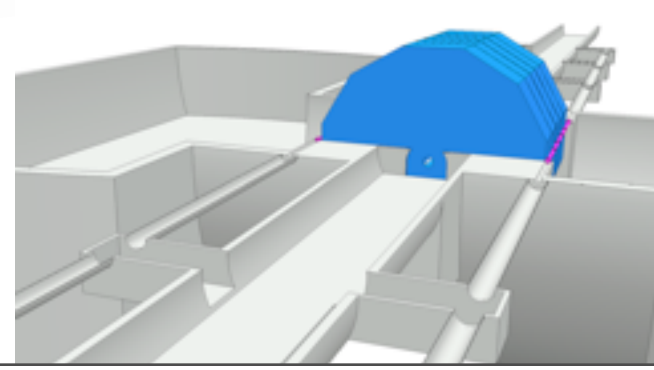
- ✓ Determination of left reference line w.r.t right reference line : within ± 0.1 mm rms
- ✓ Monitoring of left reference line w.r.t right reference line : within a few microns
- ✓ Monitoring of the position of left QD0 / right QD0 within ± 5 μm rms

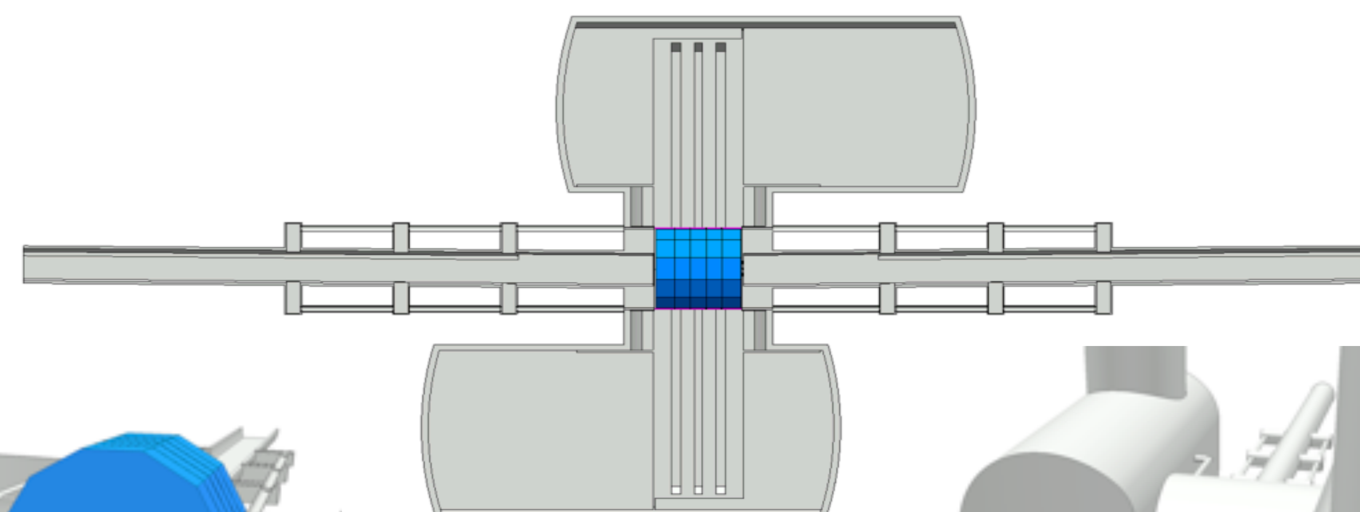
Solutions:

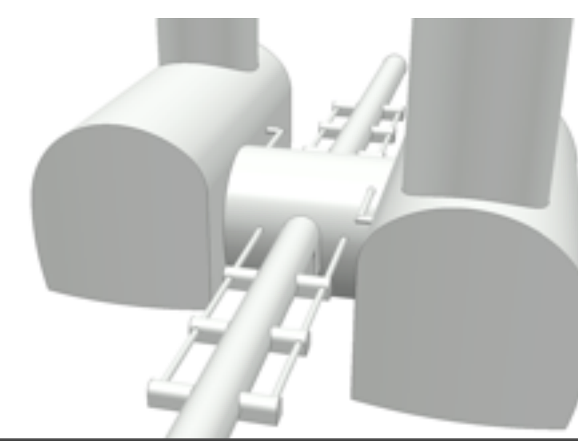
- ✓ Determination of left reference w.r.t right reference line & monitoring of one BDS w.r.t other:
- ✓ stretched wires/optical system on both side by a common reference (as in the LHC), using the survey galleries

40cm diameter









QD0's relative position CLIC

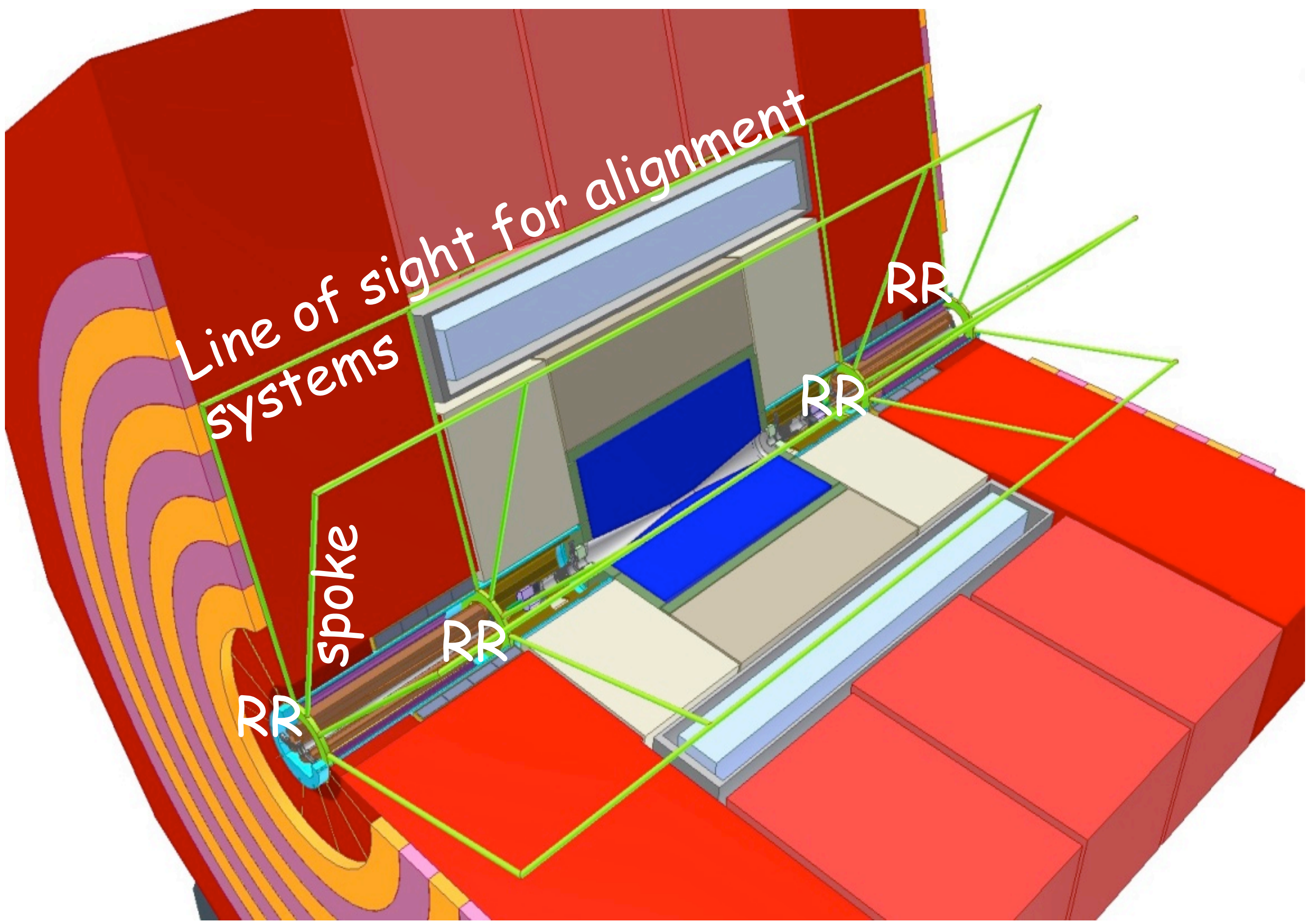
NIKHEF

Left side w.r.t right side

by H. Gerwig (CERN) .KILC12

Monitoring of the position of left QD0 /right QD0: Concept

- ✓ 4 Reference Rings (RR) located at each extremity of QD0, supported from outer tube
- ✓ 6 radial spokes per RR

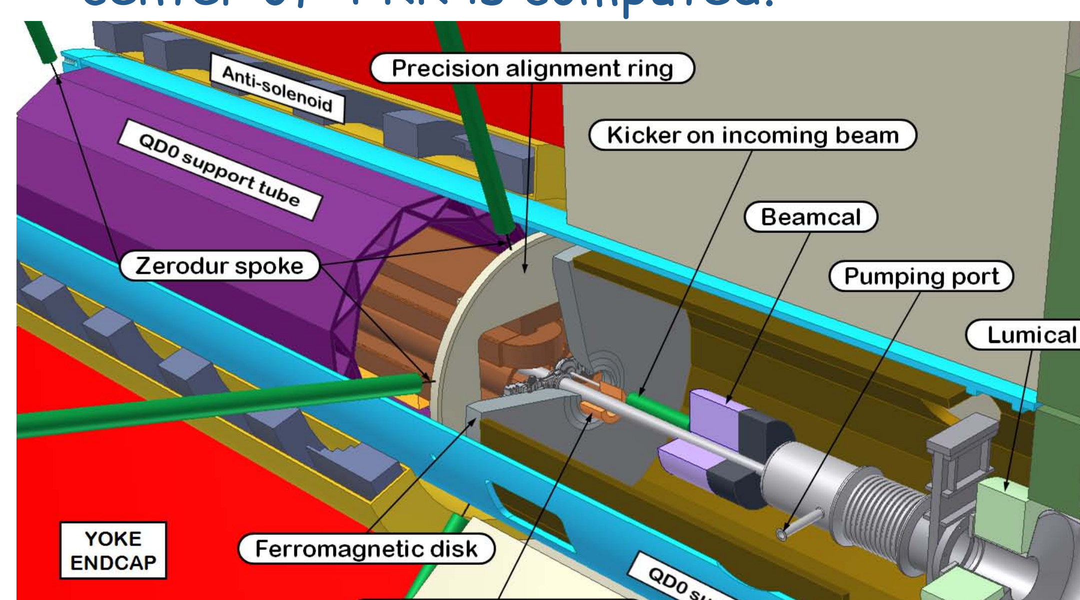


6 x6 mm^2 radial spokes made of ZERODUR, housed in 60 mm channels(zero expansion glass ceramic)

In two steps:

Rasnik system
(proximity sensors & spokes alignment)

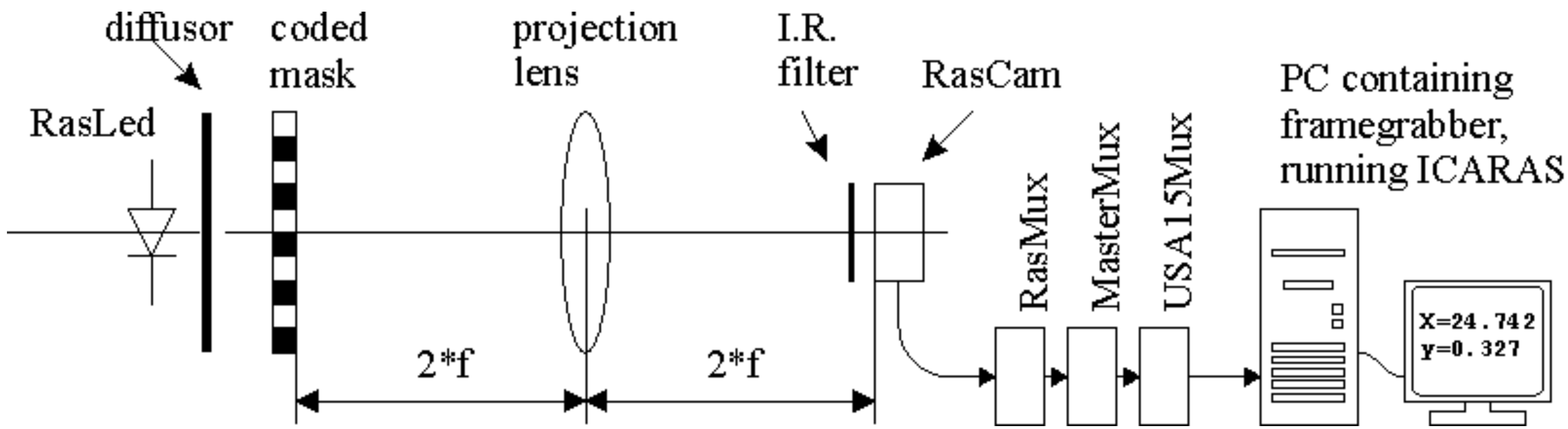
- ✓ A monitoring of the position of QD0 w.r.t RR thanks to proximity sensors. (initial calibration of their position performed on a CMM)
- ✓ A transfer of the position of RR thanks to 12 spokes to alignment systems. By combination of redundant information, the position of the center of 4 RR is computed.



http://www.nikhef.nl/pub/departments/et/experiments/atlas/rasnik/

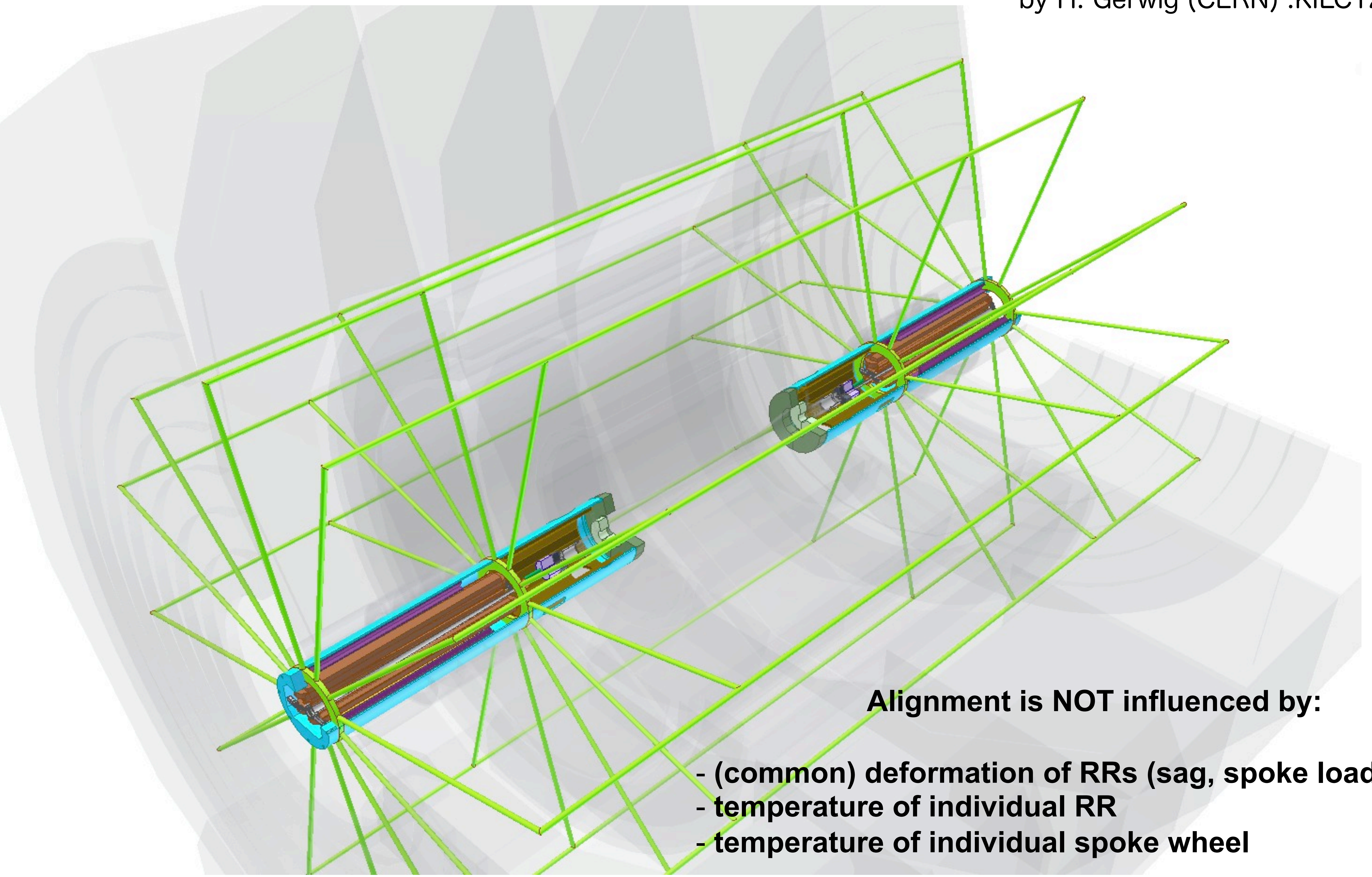
Rasnik (copyright) is a wide range, high precision alignment monitoring system, developed at NIKHEF.

The basic idea is to create an image of a coded mask on a CMOS sensor by means of a lens. The mask is lit by infrared LEDs. A diffuser is used to minimize effects of imperfections of the light source. In this set up the relative position in X and Y direction is measured along the line mask, optical center of the lens and the CMOS sensor. Also (relative) rotation of the mask or the sensor can be measured. By calculating the actual image spot size and comparing this with the mask spot size, the position of the lens along the Z-axis can be calculated. Also the relative rotation around the X, Y and Z-axis of the mask in respect to the CMOS sensor can be calculated.
The standard video signal from the CMOS sensor is digitized by means of a frame grabber.
The system has a measurement range of several cm's with an absolute accuracy of less than 1 micron.



QD0 - Relative alignment CLIC

by H. Gerwig (CERN) .KILC12

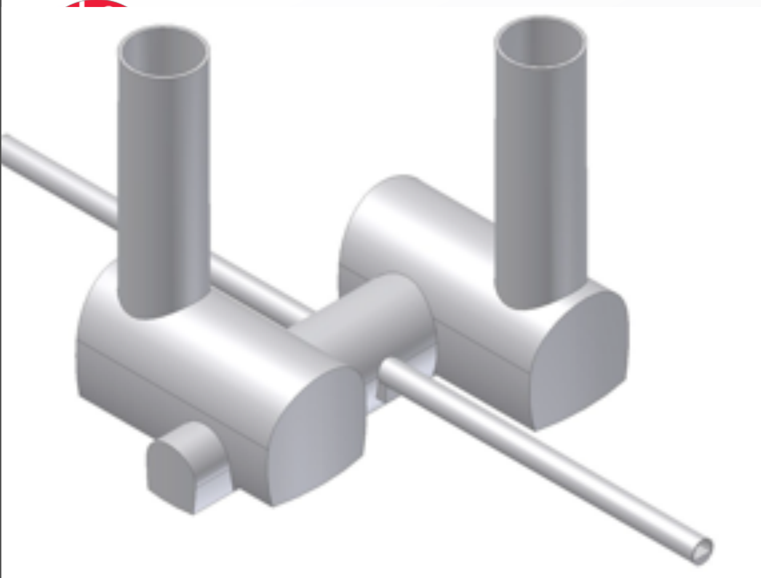


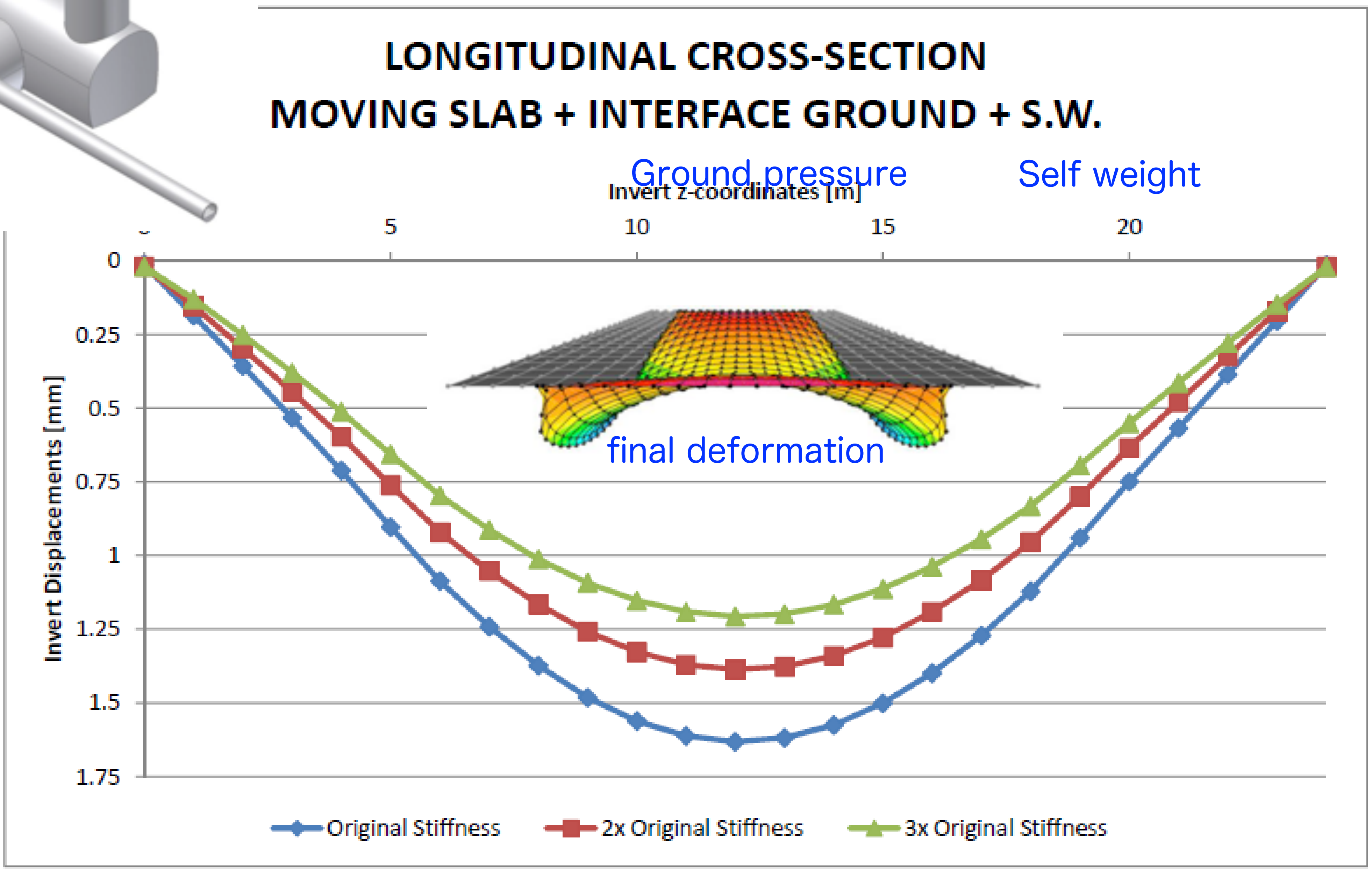
Alignment is NOT influenced by:

- **(common) deformation of RRs (sag, spoke load)**
- **temperature of individual RR**
- **temperature of individual spoke wheel**

2012年 5月 19日 土曜日

CLIC Experimental Area Layout





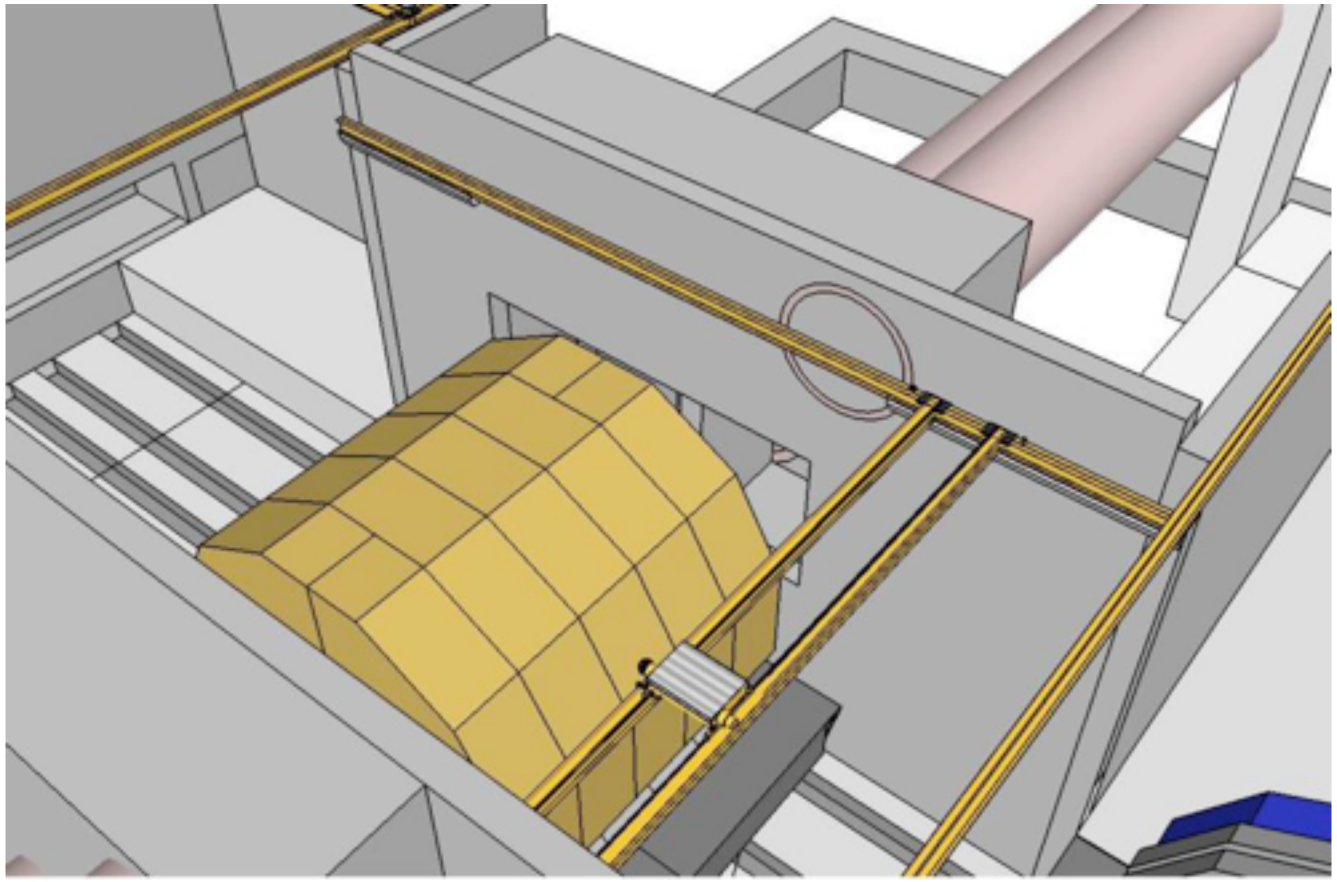
2D FE model stiffness	2x FE Stiffness	3x FE Stiffness
1.6 mm	1.4 mm	1.2 mm

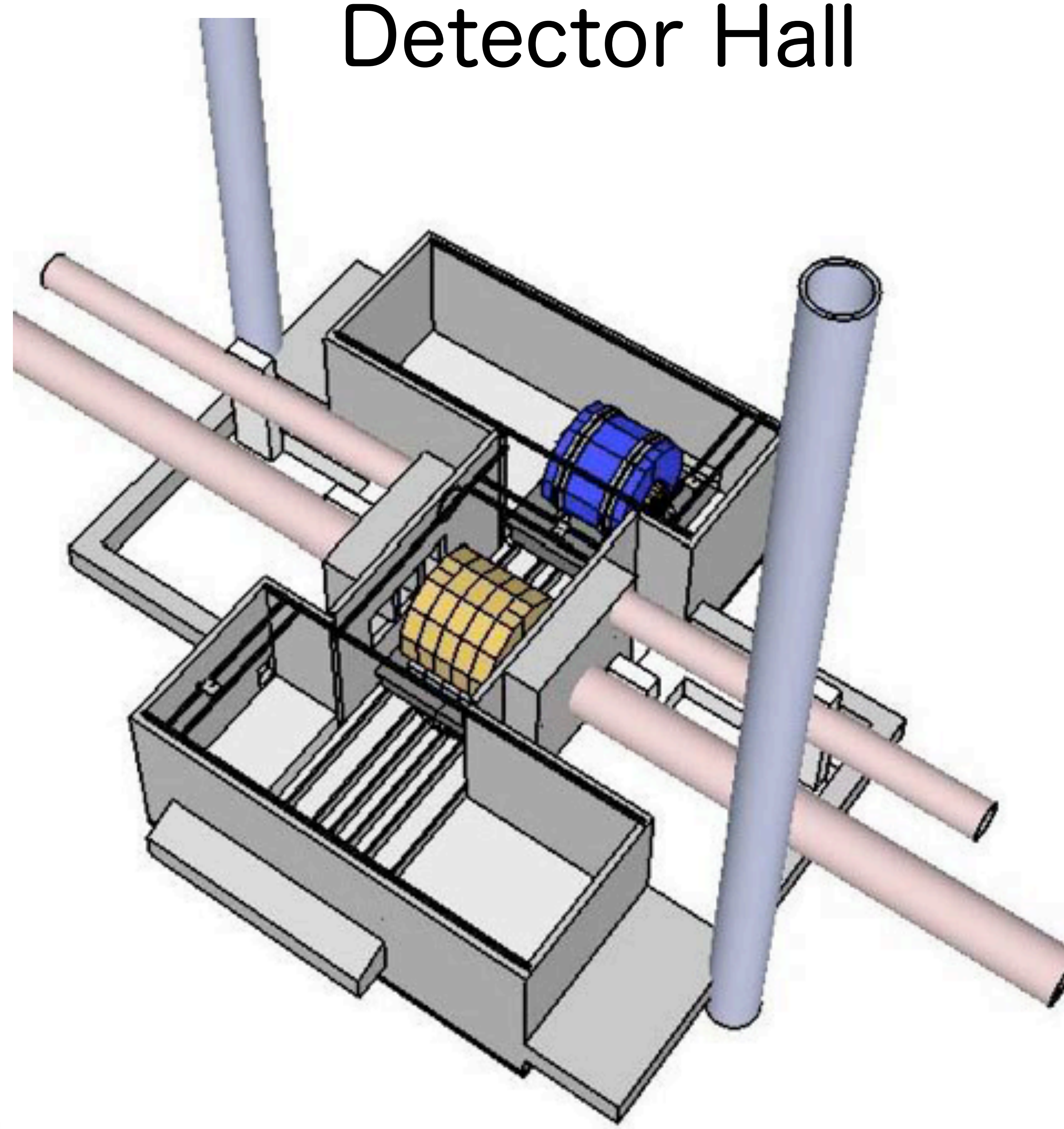
Conclusion CLIC

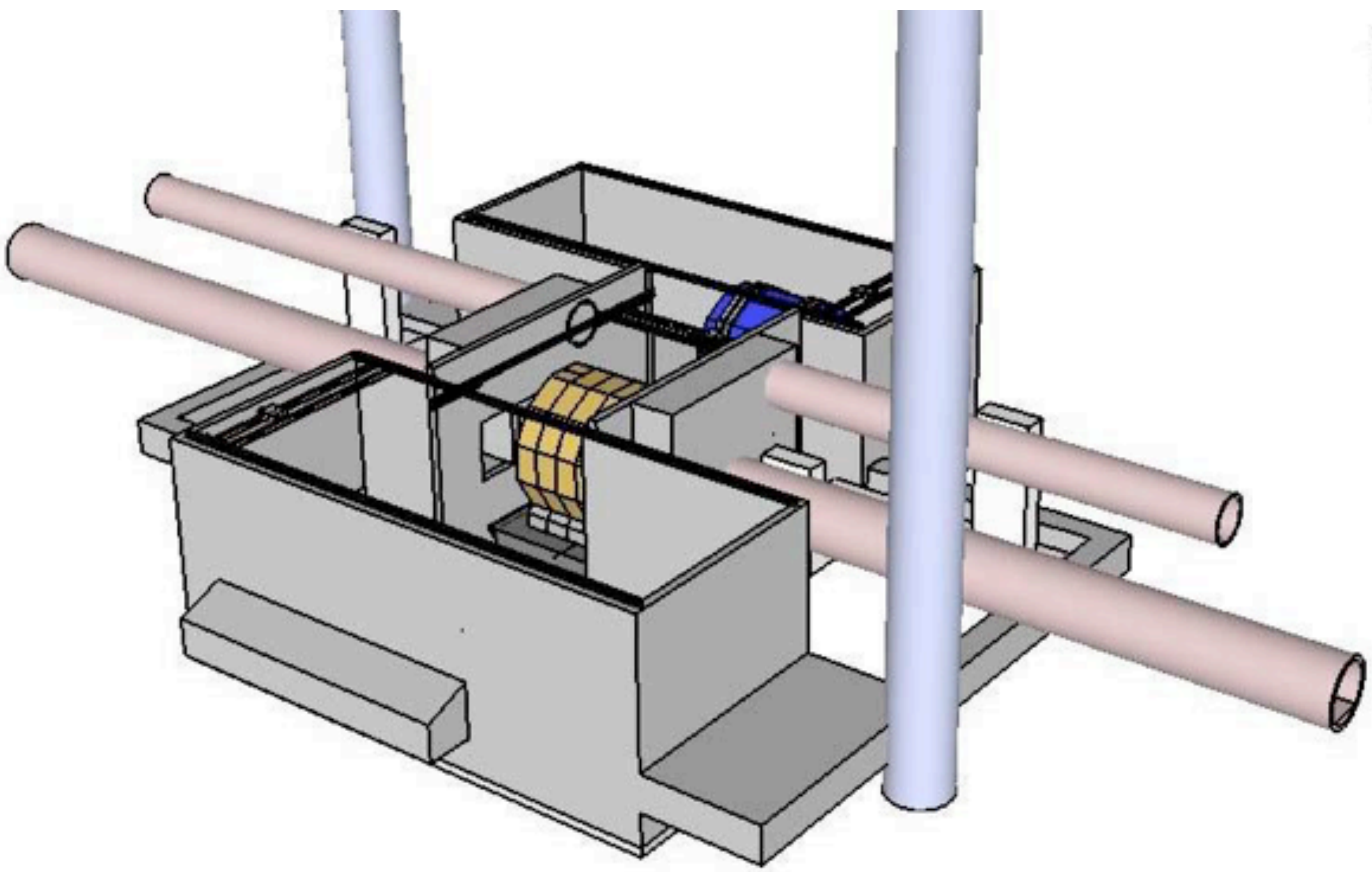
by H. Gerwig (CERN) .KILC12

- ✓ Same strategy of pre-alignment in BDS and main linac (stretched wire, overlap)
- ✓ tighter requirements for position and adjustments in BDS
- ✓ Active pre-alignment with cam movers
- ✓ Special solutions required for final focus and stretched wire around QD0
- ✓ Relative position of QD0 monitored through detector by Rasnik/ Rasdiff (NIKHEF)
- ✓ Due to ground movements induced by push-pull CLIC prefers a solution with mini survey galleries
- ✓ Allows survey link of both BDS ends when detector is on IP

Americas Region Detector Hall



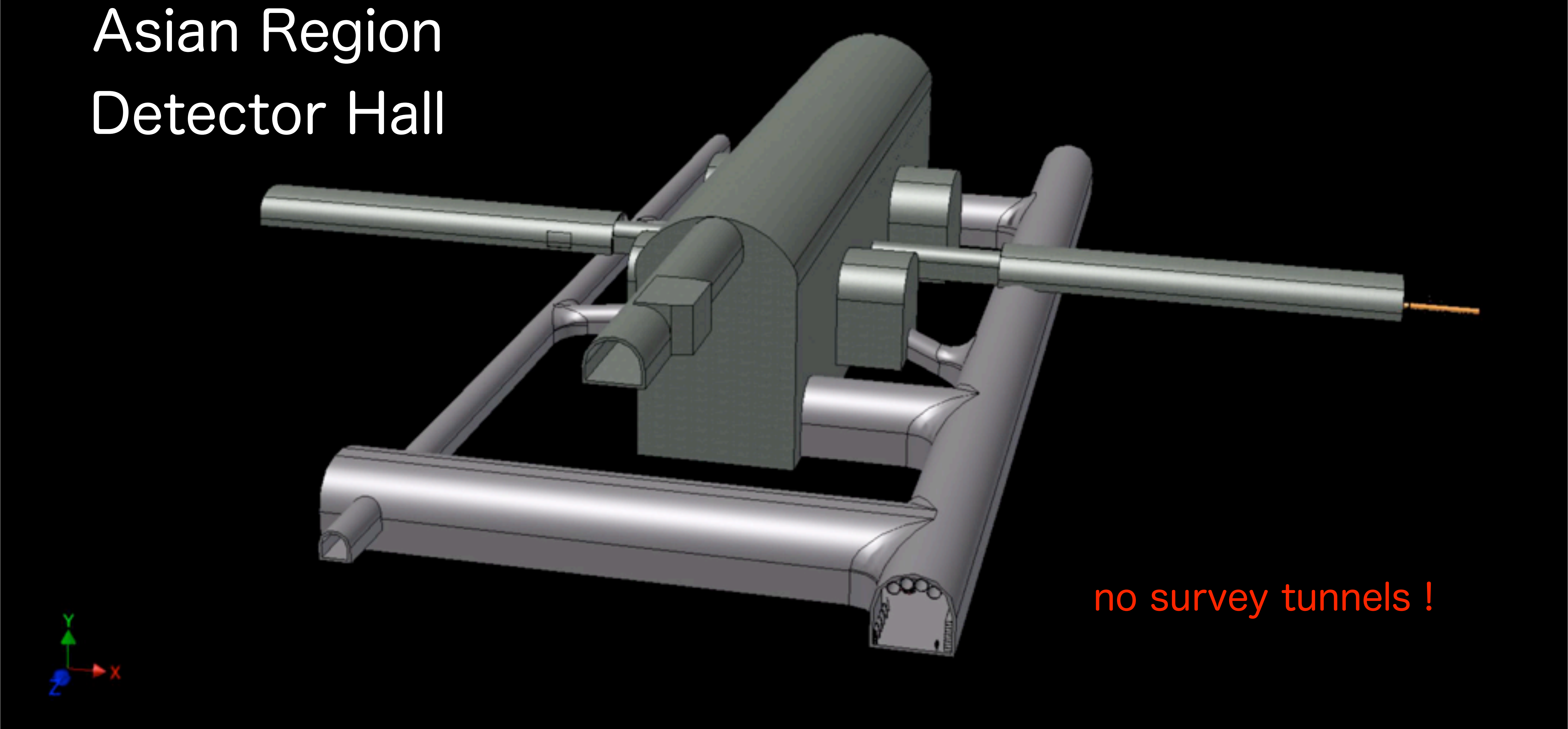


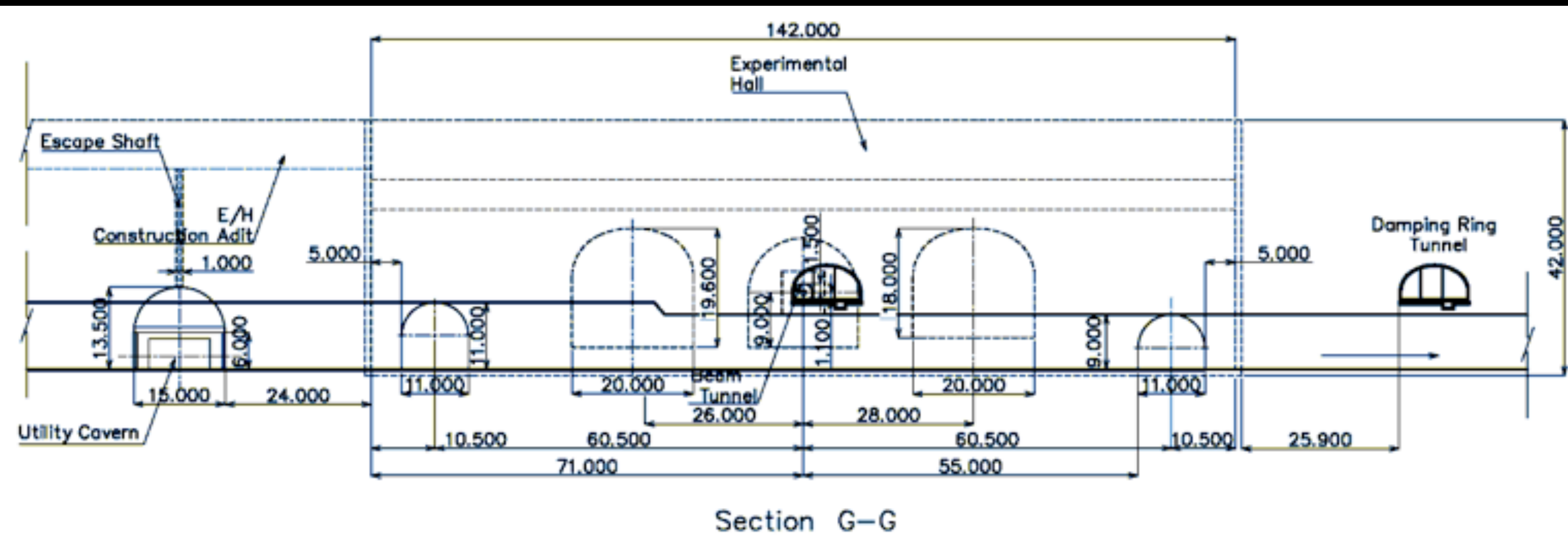


no connection between the main and service tunnels !

asked ARUP for calculation of deformation on the floor.

Asian Region Detector Hall

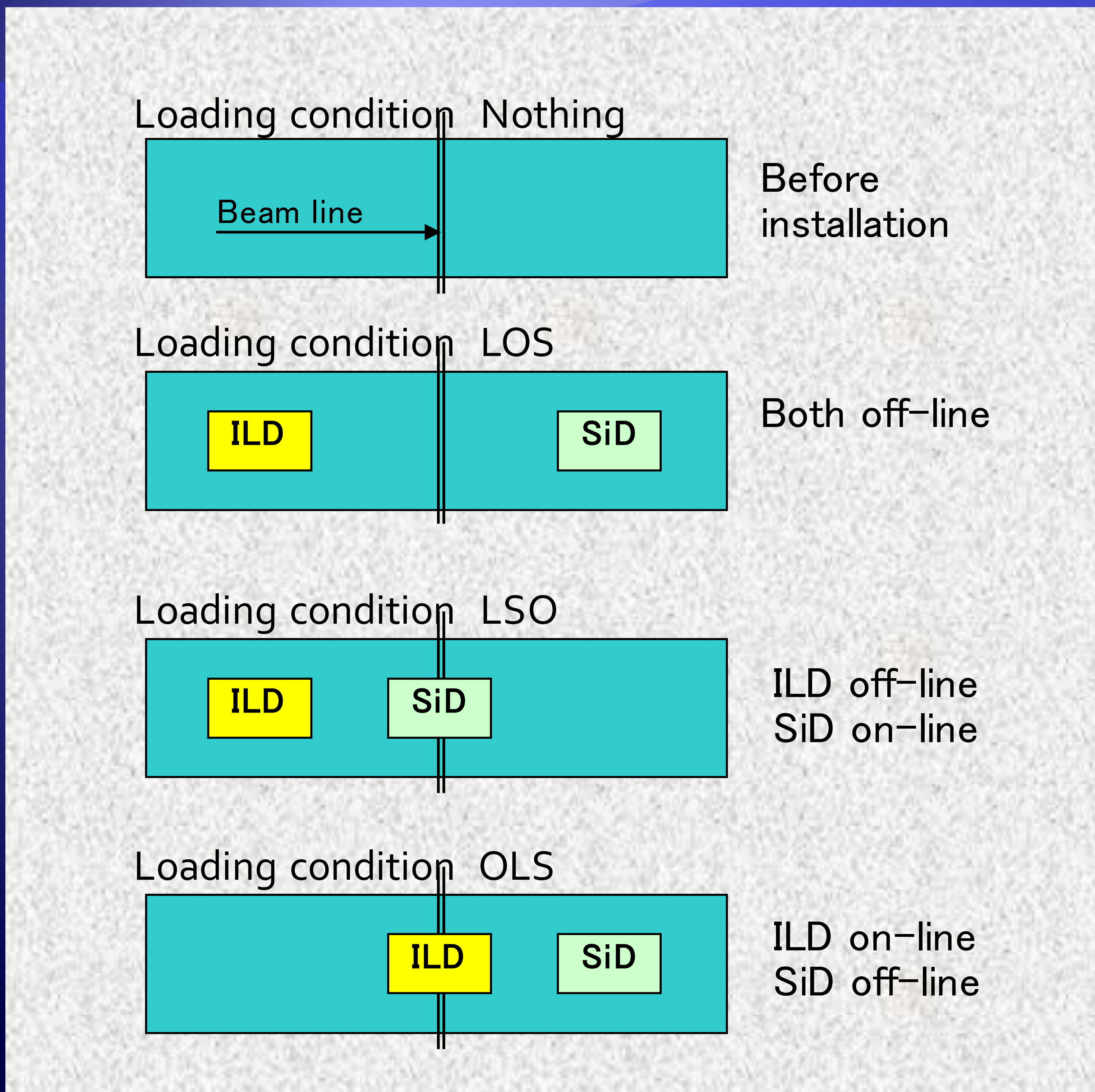


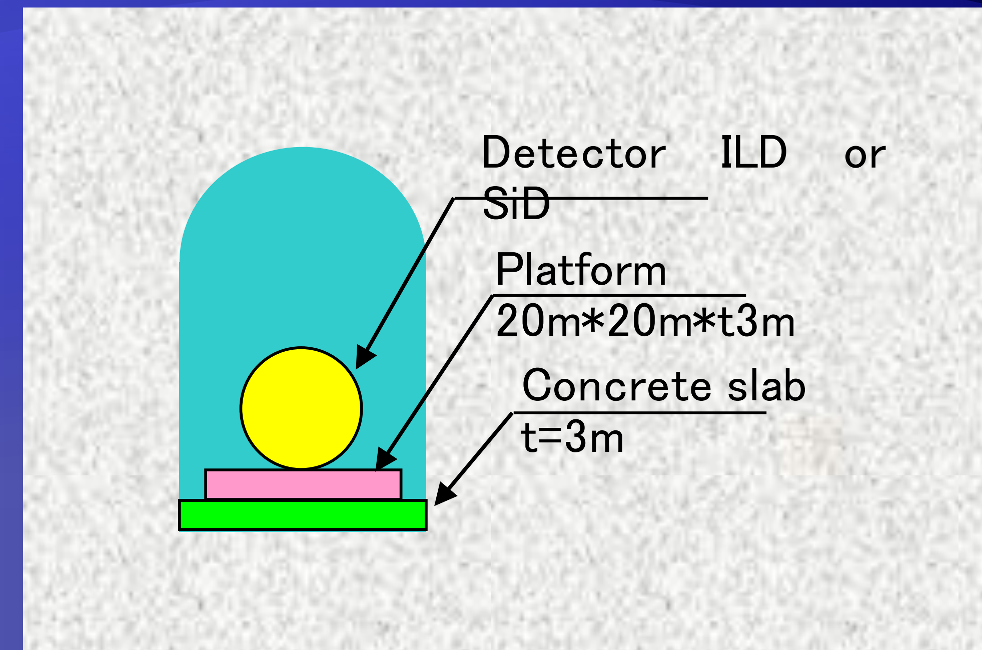


Asian Region Detector Hall

Push-Pull

by G.Orukawa (Jpower), CFS-BTR, CERN, 22 March, 2012

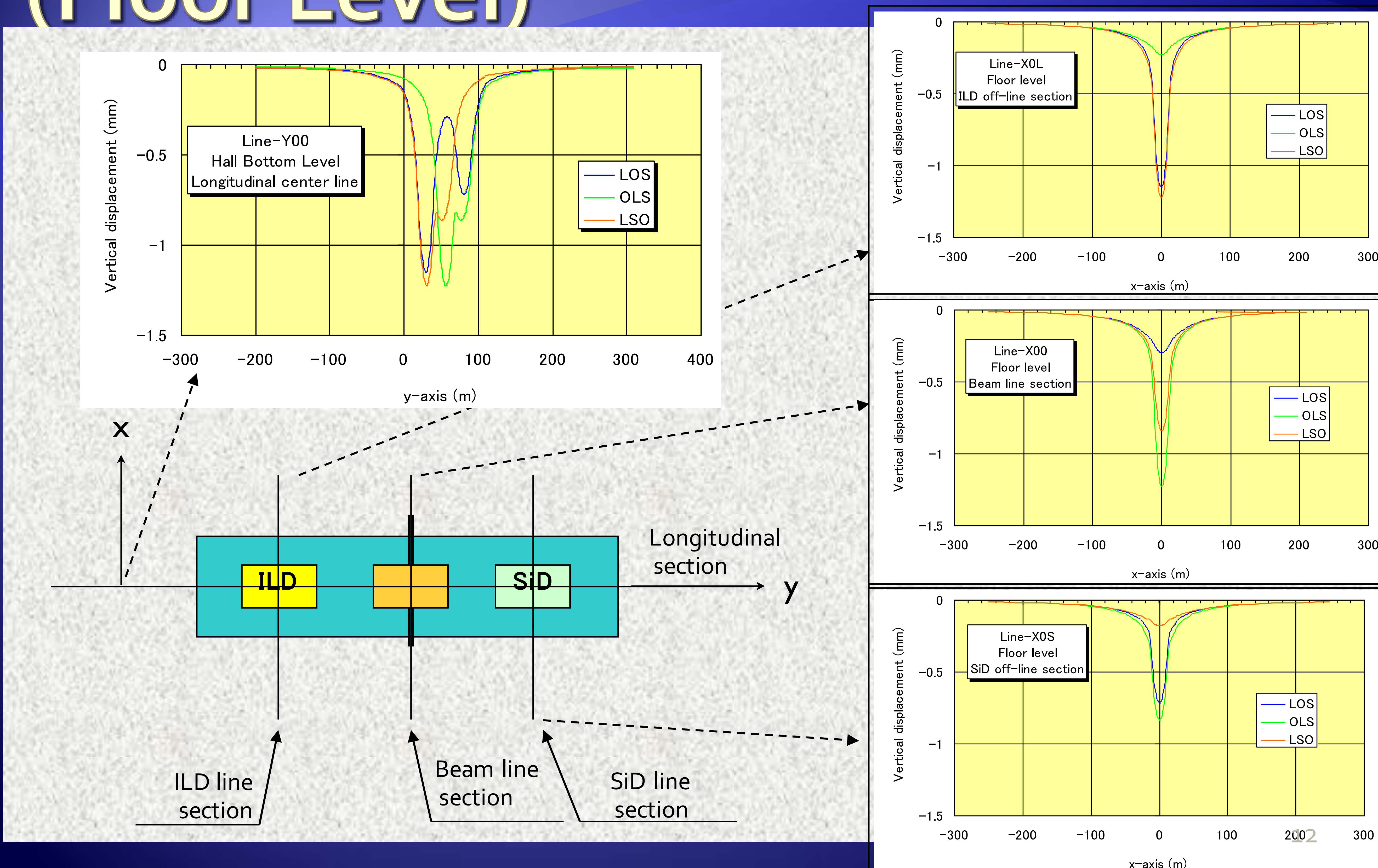


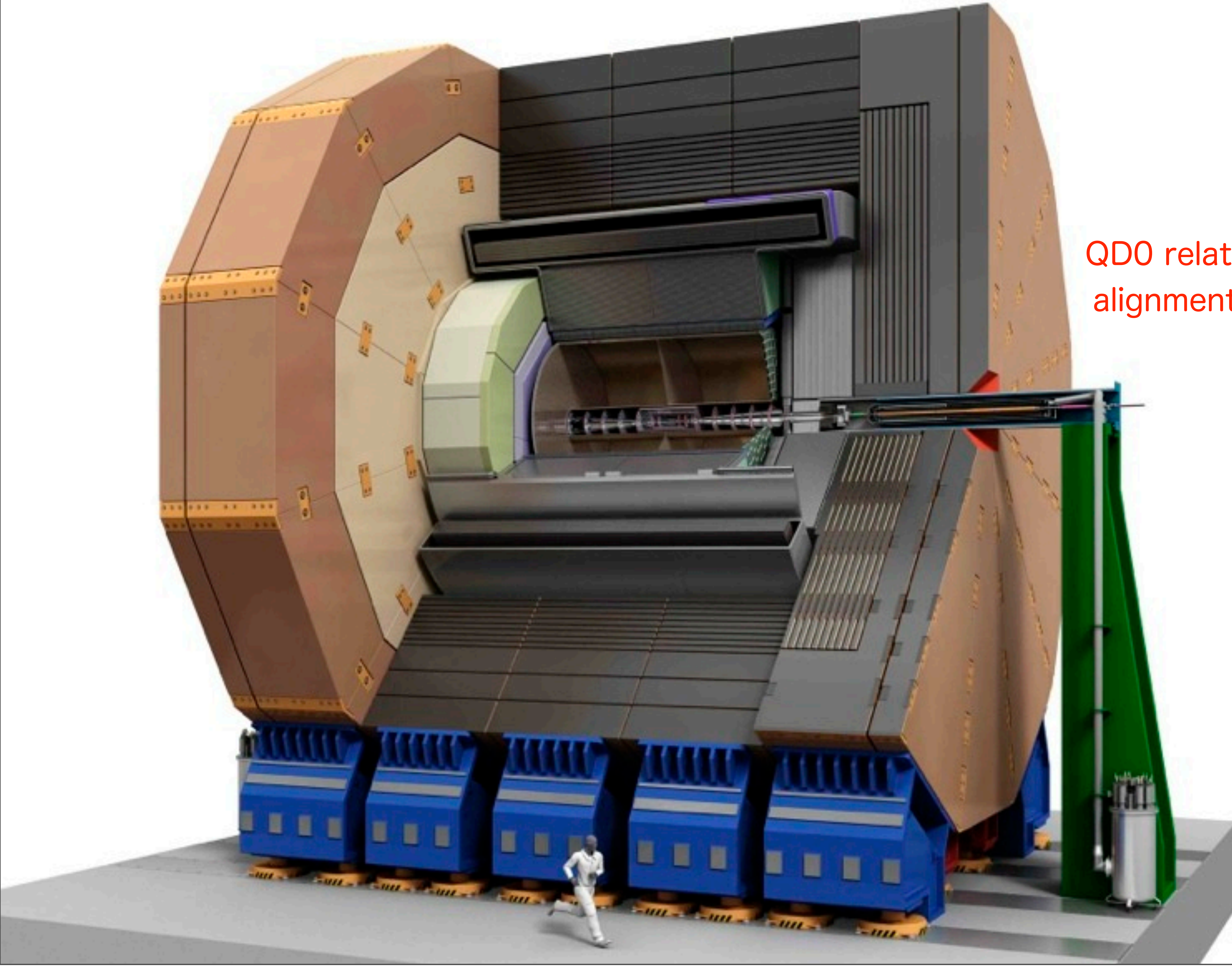


- ILD: 14,700 tons
- SiD: 8,600 tons
- Detector is sit on a platform (concrete, t=3m)
- Loaded on the platform as a uniformly-distributed load

Displacement for each section (Floor Level)

by G.Orukawa (Jpower), CFS-BTR, CERN, 22 March, 2012

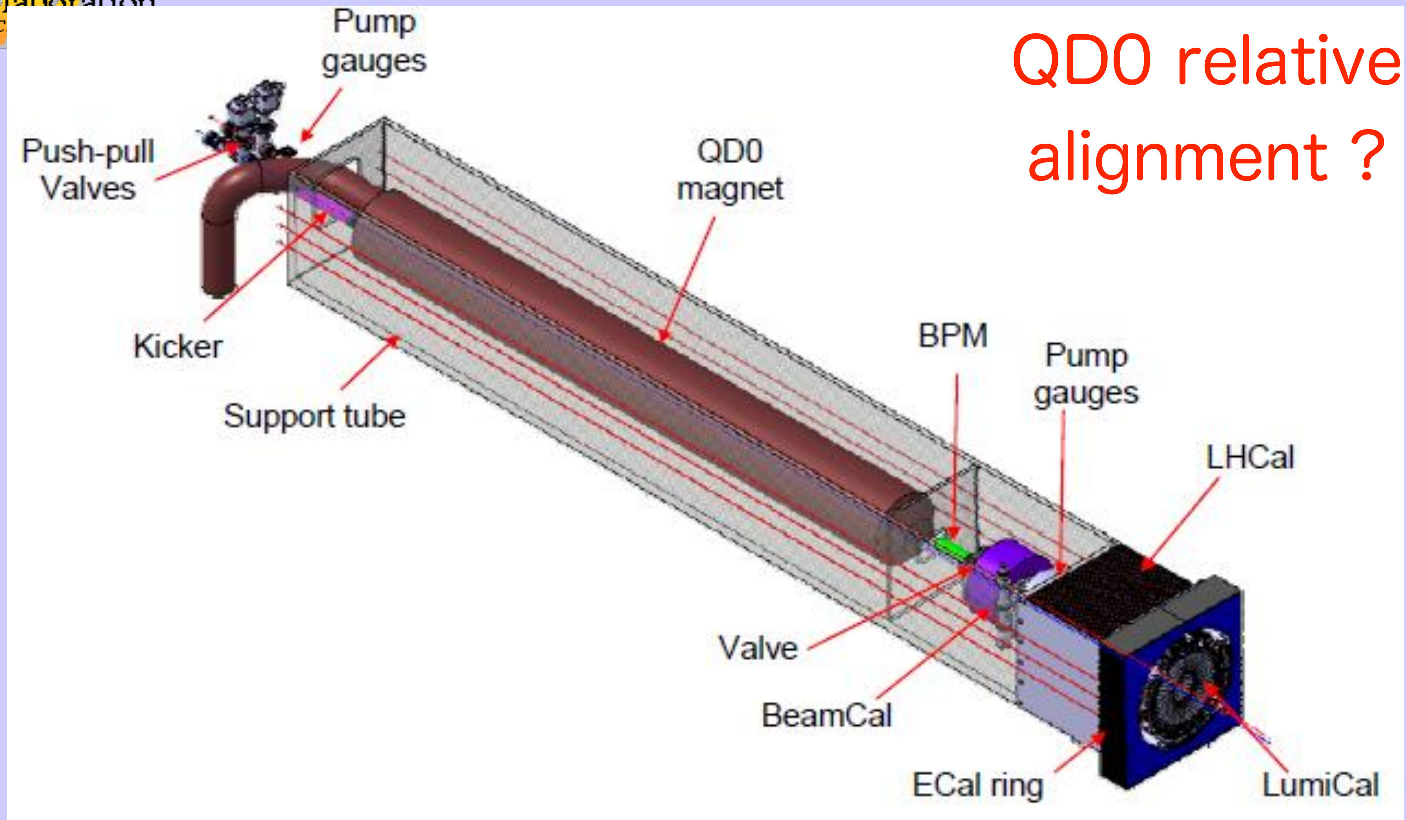


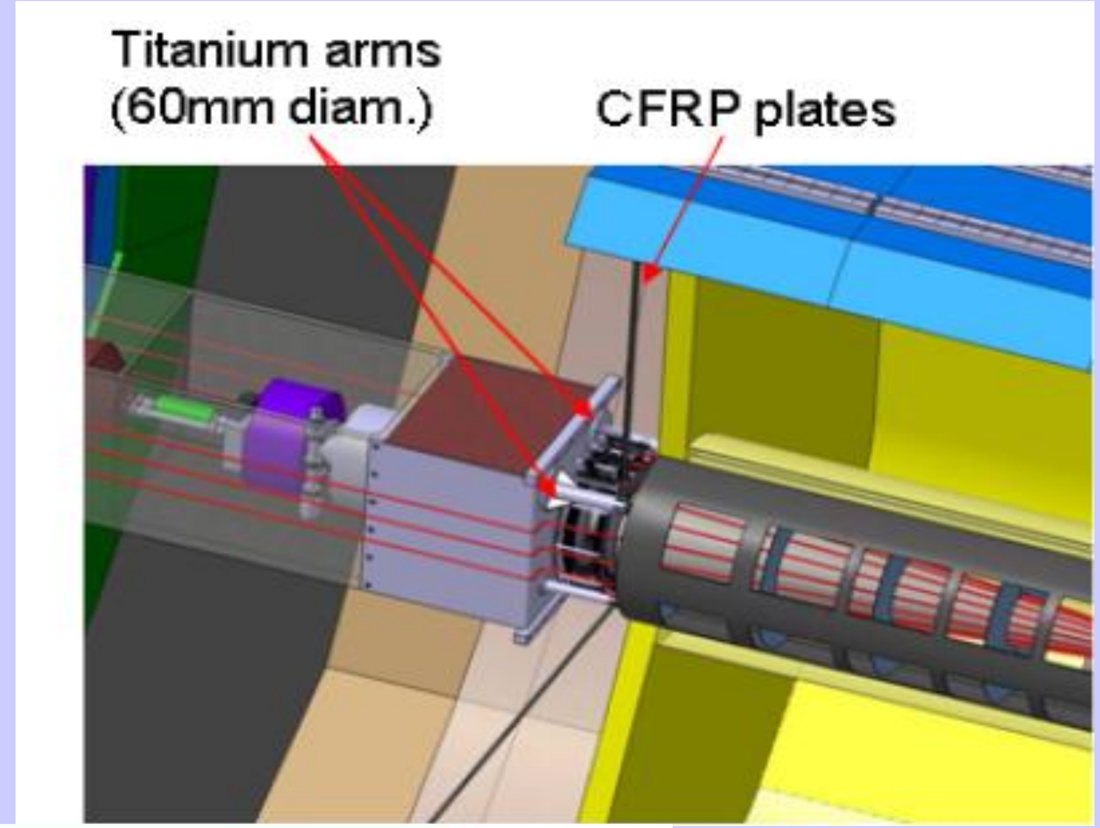


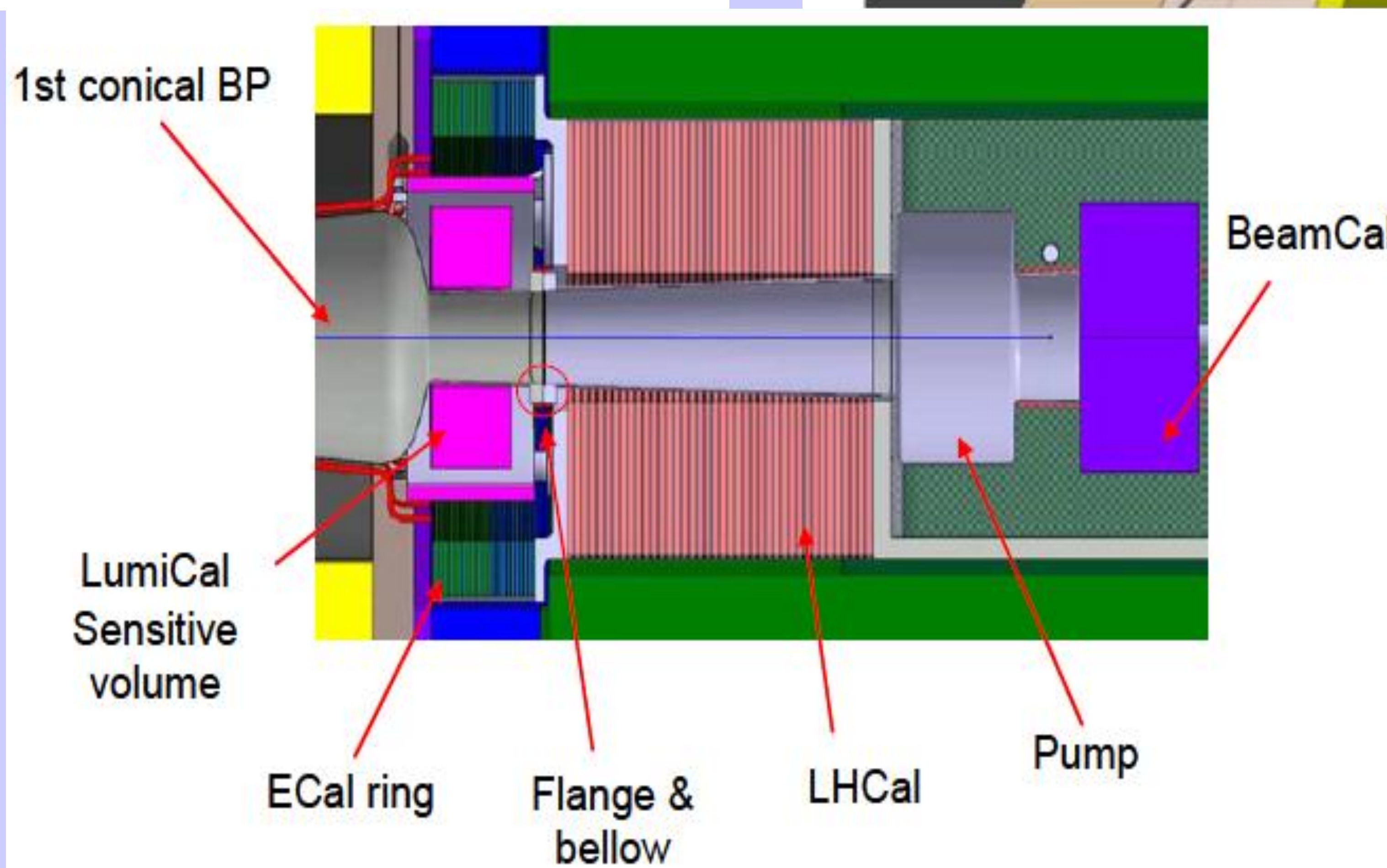
QD0 relative
alignment ?

Vorward Region Design, ILD

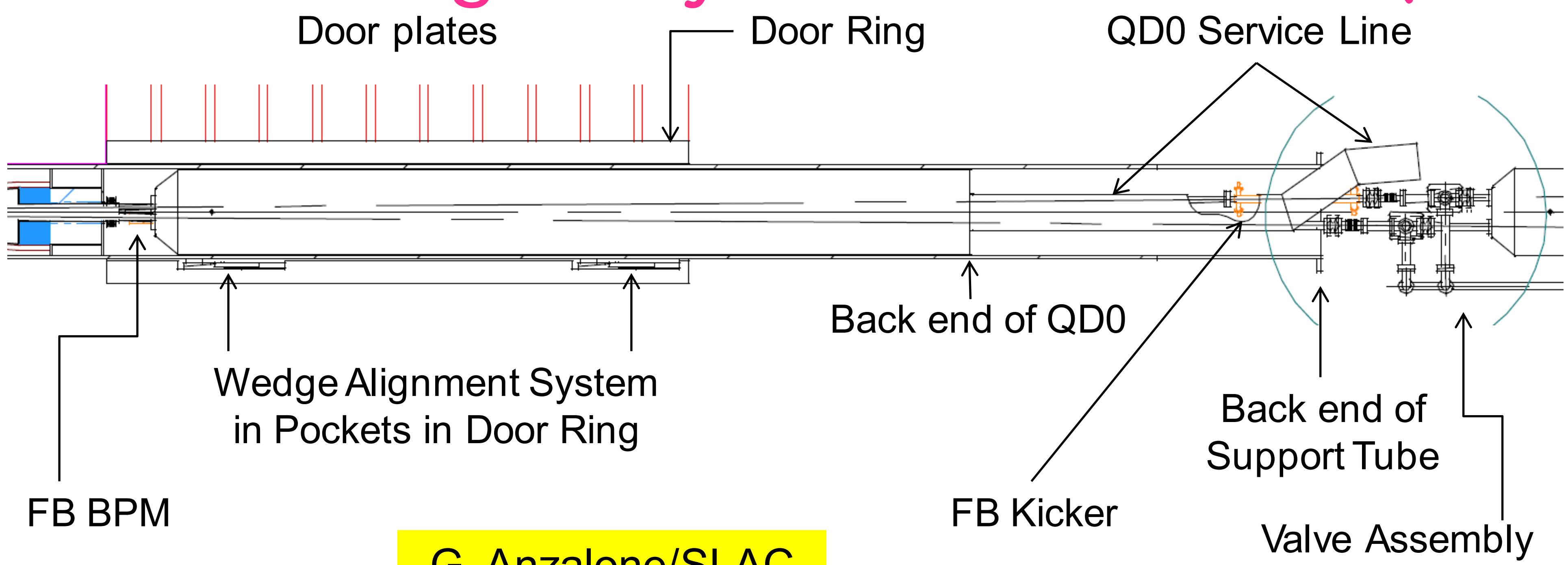
QD0 relative alignment ?



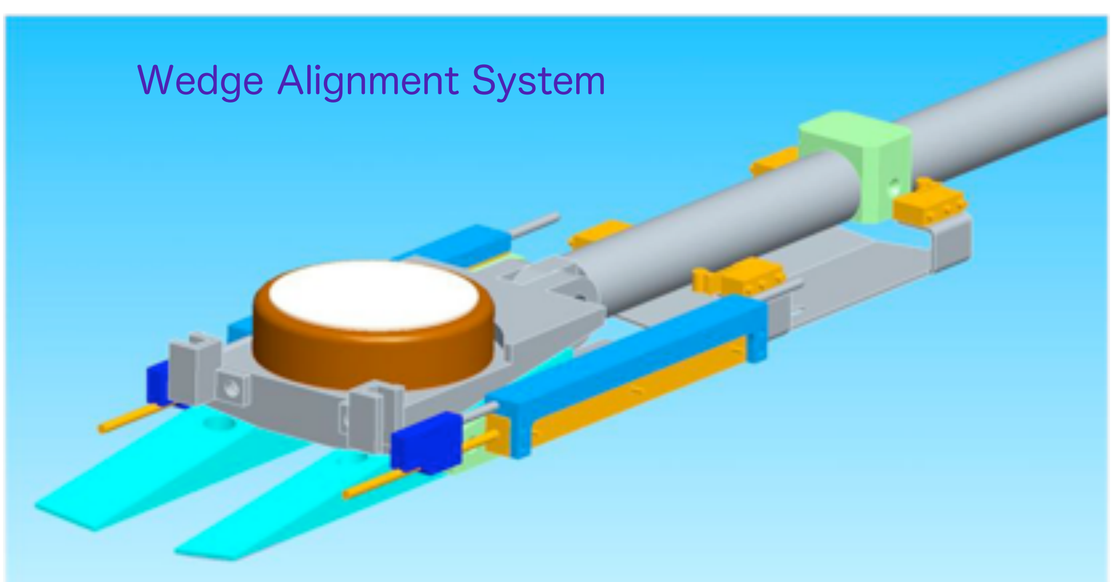




SID Forward Region by Tom Markiewicz (SLAC)



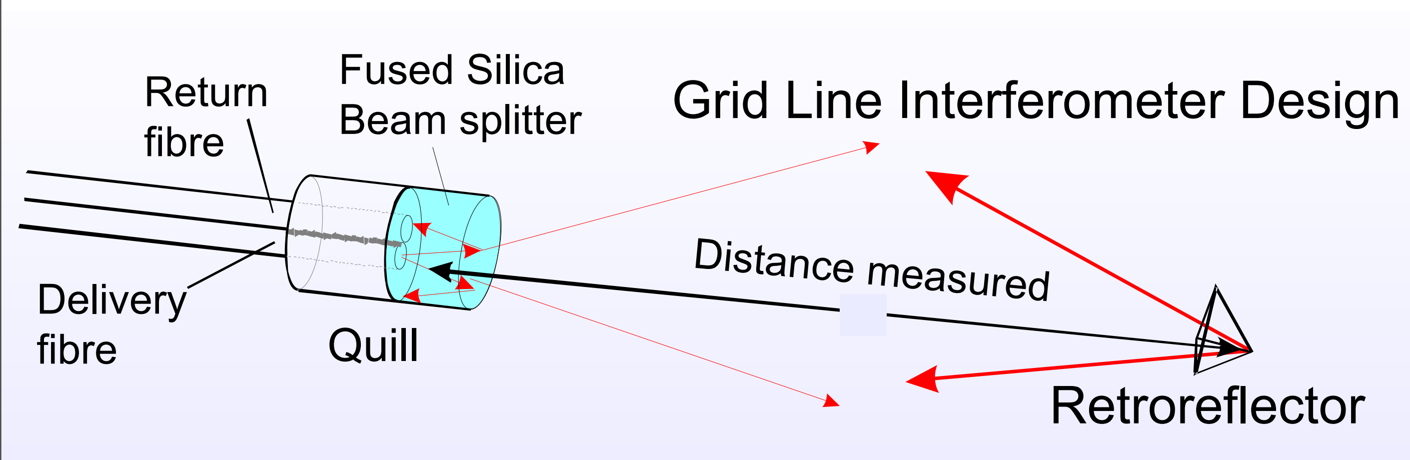
G. Anzalone/SLAC



Summary of SiD Forward Status

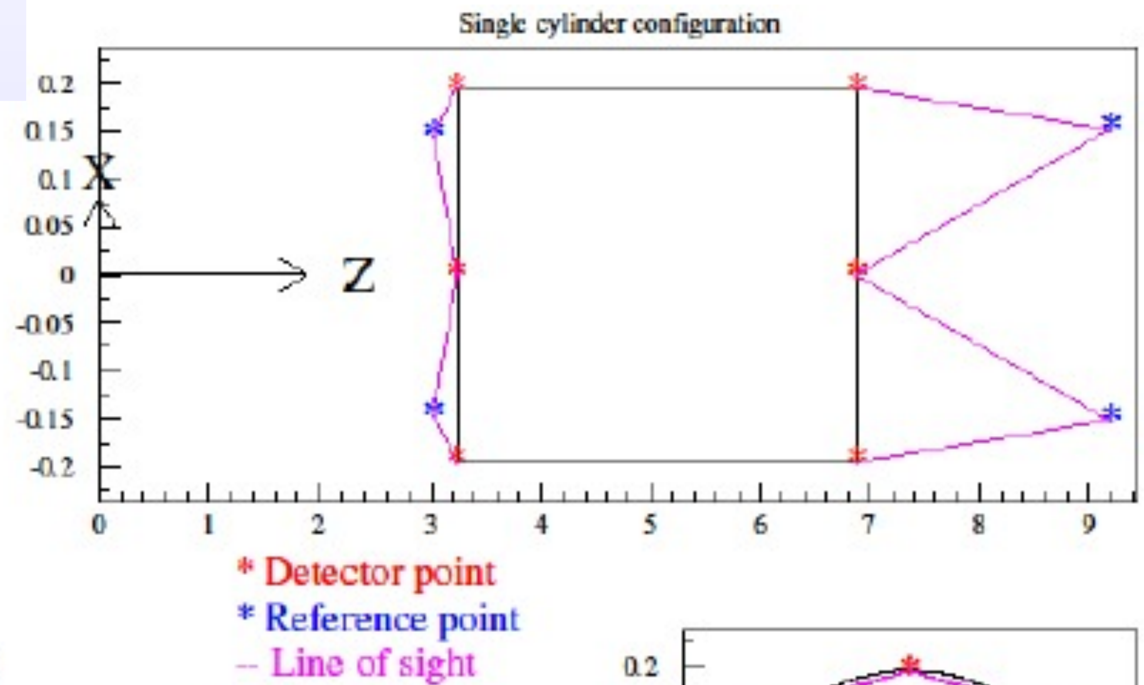
- The 2009 LOI **conceptual** design of the SiD Forward Region has been improved to an appropriate level for the DBD.
- Much more work needed

FSI Alignment Monitoring (SiD)



Frequency Scanning Interferometry (FSI) for distance measurements between grids with respect to a reference interferometer

$$L_{grid} = L_{ref} \frac{\Delta\phi_{grid}}{\Delta\phi_{ref}}$$



16 lines probably fine

- Precision better than needed
- Tolerant of channel loss

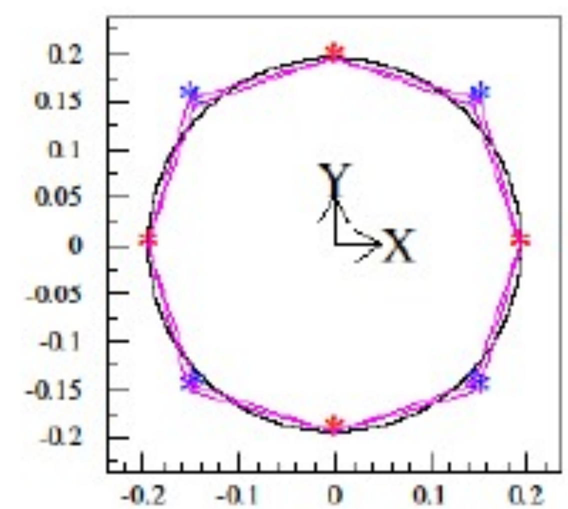
→ Need four retroreflectors on each end of QD0
→ Need four launch points (2 beams each) on QF1 and Hcal

Cylinder dimensions
Radius = 0.195 m
Half-length = 1.825 m

Refer. offsets from cylinder ends
r = 2.0 cm z = 231.4 cm
r = 1.1 cm z = -20.8 cm

CM position precisions (µm)
x = 1.3 y = 1.3 z = 0.1

Axis rotation precisions (µrad)
pit = 0.6 yaw = 0.6 roll = 1.6



Caveats:

- **Assumes reference points on Hcal known!**
- **Bridging detector gap is important → Future simulation**

Keith Riles, Hai-Jun Yang/U. Michigan

ILC : QD0 Alignment

ILD : Monalisa (FSI) at LoI

FSI or a reference frame of spokes(Rasnik) ?

QD0 is supported from the platform

SiD : FSI

QD0 is supported by the detector

Key issues: how to align both QD0s and BDS lines

QDO must be aligned with respect to QF1.

- CLIC : capacitive sensors and CFRP bar

Conclusion & Issues to be discussed

We need a reference line to connect the both BDS lines, since the floor level will be changed at the push-pull operations.

A solution is a survey galley with 3 connections to each BDS tunnel as the RDR, also LHC and CLIC.

Relative alignment of QD0s is needed by Rasnik or FSI (Monalisa, LiCAS) systems.

Alignment of QD0 with respect to QF1 is needed.