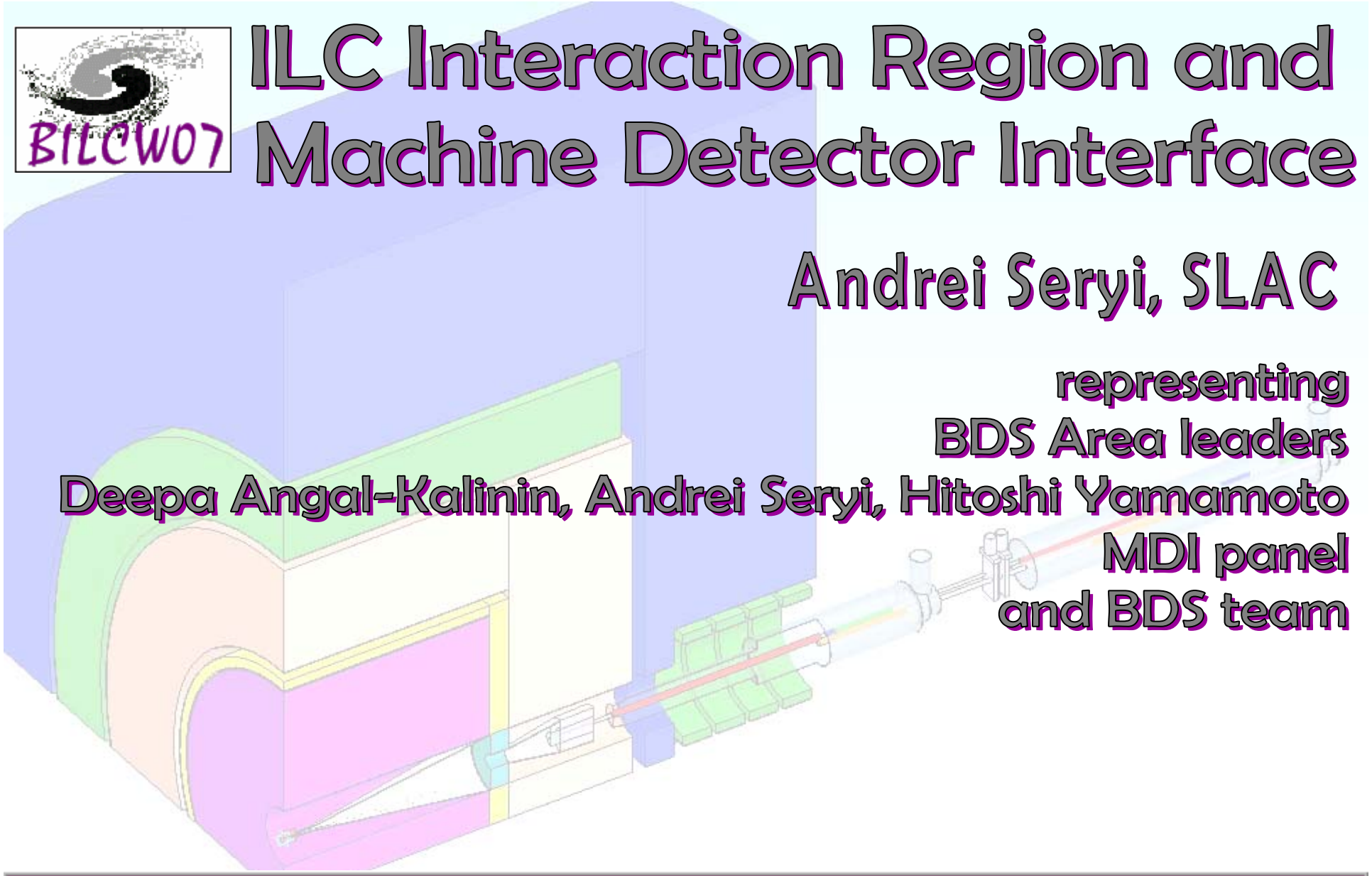


ILC Interaction Region and Machine Detector Interface

Andrei Seryi, SLAC

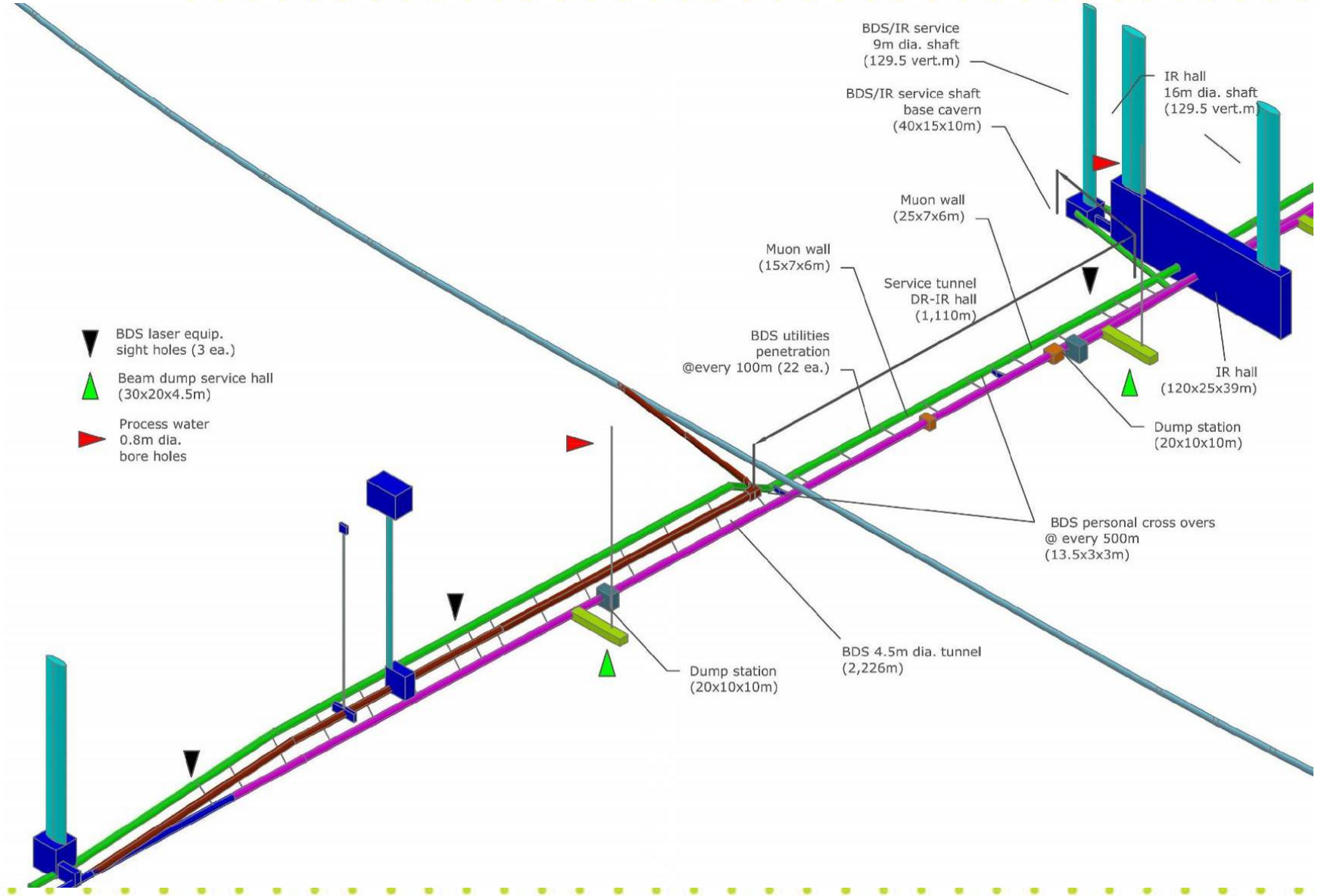
representing
BDS Area leaders
Deepa Angal-Kalinin, Andrei Seryi, Hitoshi Yamamoto
MDI panel
and BDS team

9th ACFA ILC Physics and Detector Workshop & ILC GDE Meeting
Feb. 4-7, 2007, IHEP, Beijing
http://bilcw07.ihep.ac.cn/

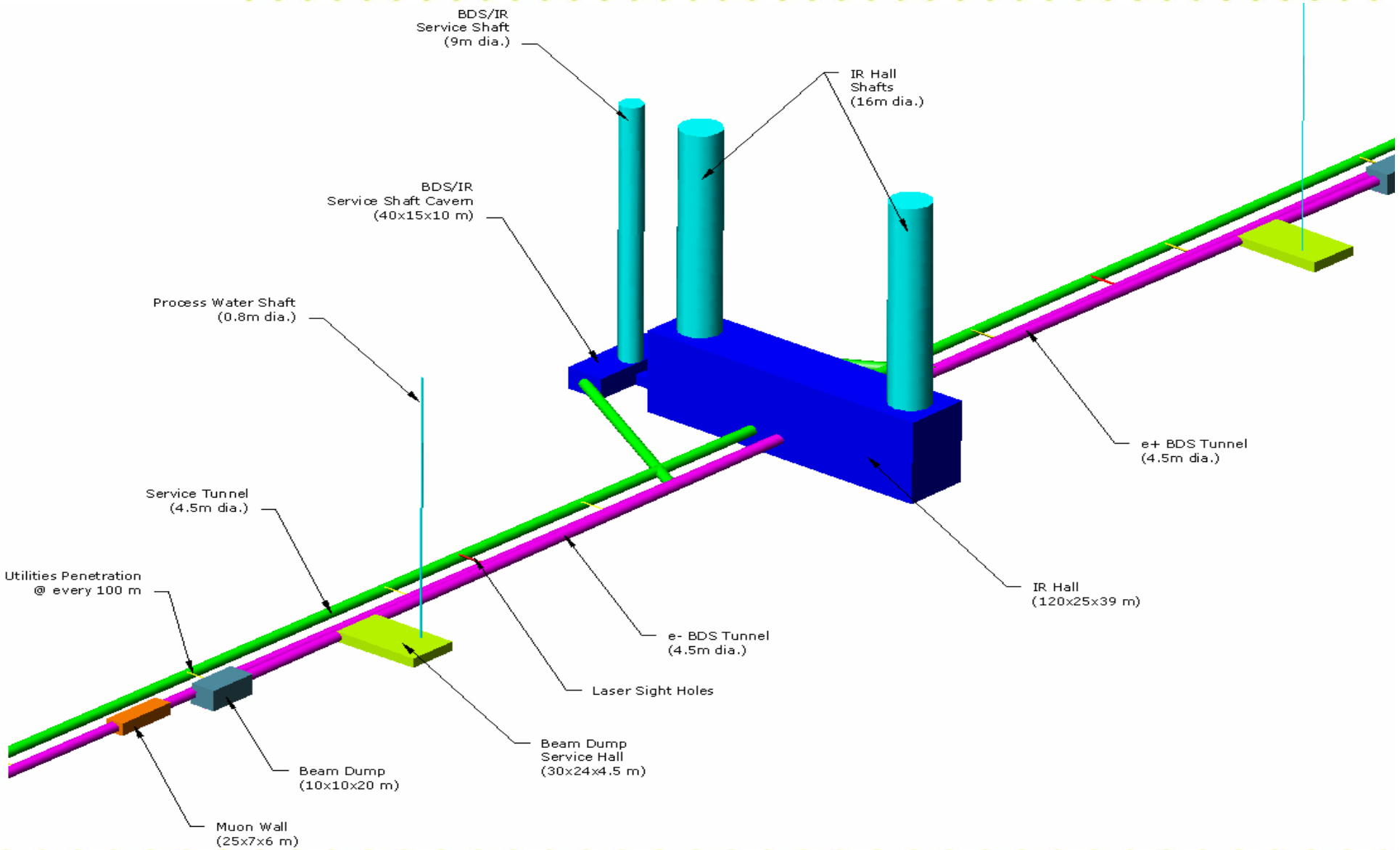
Contents

- Will describe design of Beam Delivery System, focusing in particular on Machine Detector Interface aspects
  - **IR hall and surface buildings**
  - **Detector assembly**
  - **Machine background**
  - **Design of IR and detector**
  - **IR arrangements for two detectors**

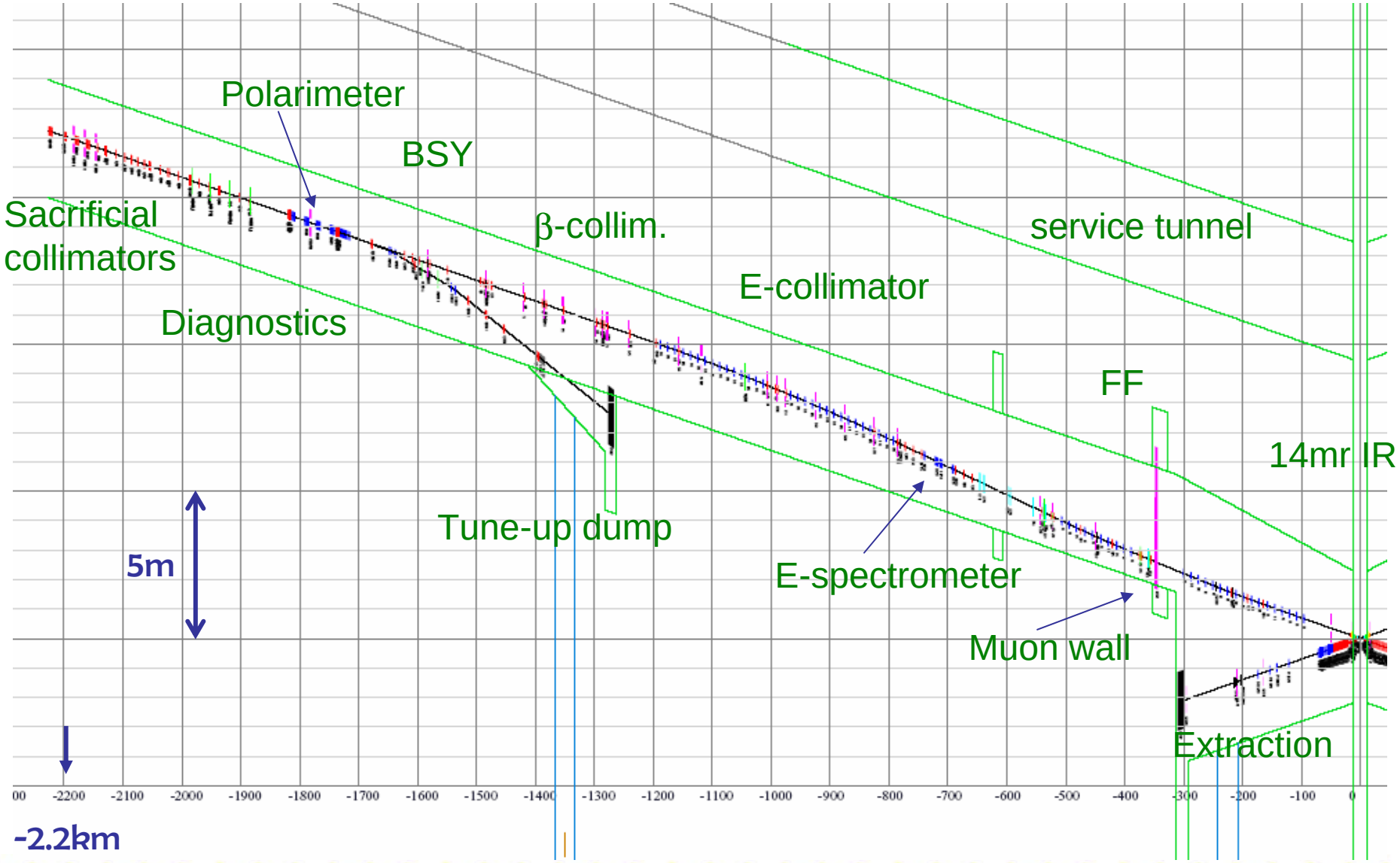
BDS layout


BDS/IR service
9m dia. shaft
(129.5 vert.m)
BDS/IR service shaft
base cavern
(40x15x10m)
IR hall
16m dia. shaft
(129.5 vert.m)
Muon wall
(25x7x6m)
Muon wall
(15x7x6m)
Service tunnel
DR-IR hall
(1,110m)
BDS utilities
penetration
@every 100m (22 ea.)
BDS laser equip.
sight holes (3 ea.)
Beam dump service hall
(30x20x4.5m)
Process water
0.8m dia.
bore holes
IR hall
(120x25x39m)
Dump station
(20x10x10m)
BDS personal cross overs
@ every 500m
(13.5x3x3m)
BDS 4.5m dia. tunnel
(2,226m)
Dump station
(20x10x10m)

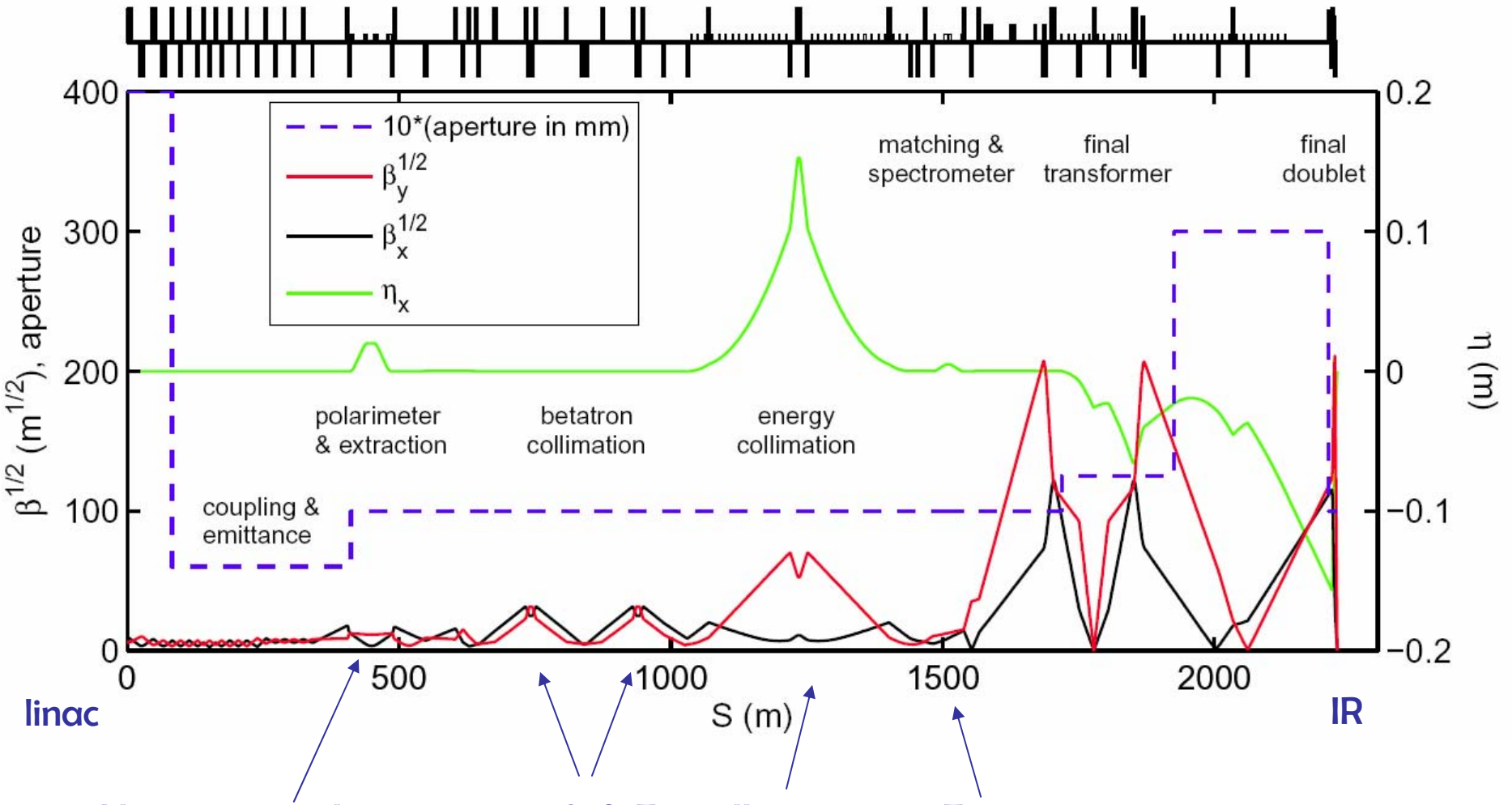
IR hall region



BDS beam-line layout



BDS optics

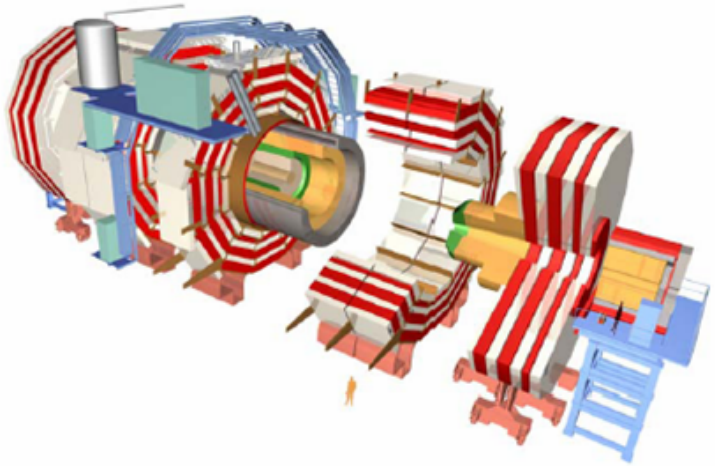


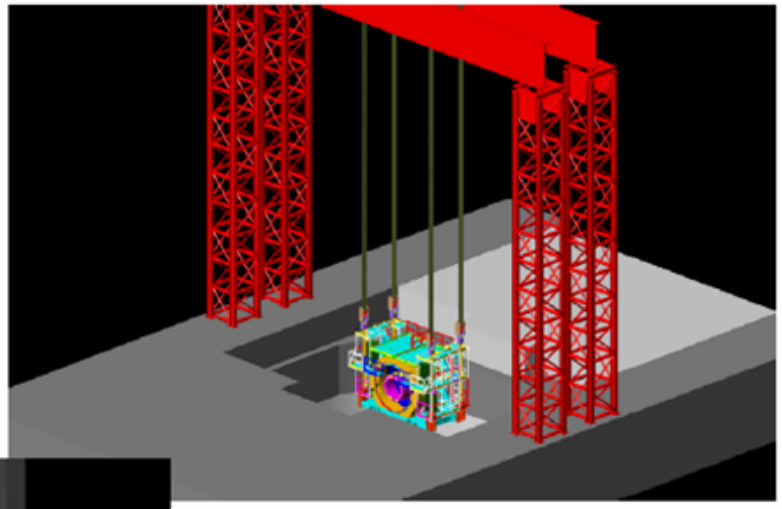
Upstream polarimeter; β & E –collimation ; Energy spectrometers are of particular MDI interest

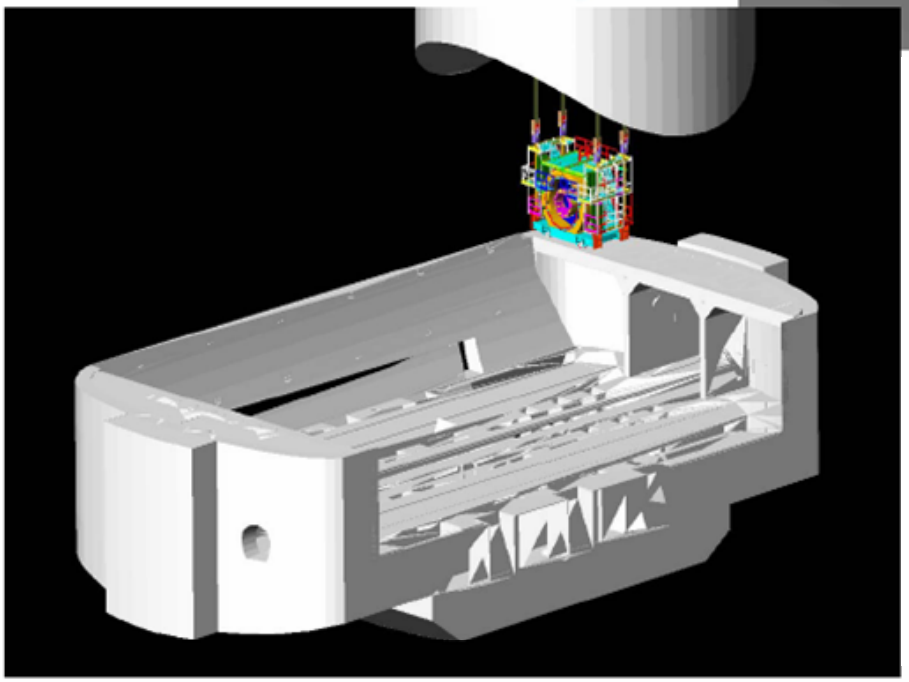
BDS parameters

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	639/5.7
Nominal beam divergence at IP, θ^*, x/y	μrad	32/14
Nominal beta-function at IP, β^*, x/y	mm	20/0.4
Nominal bunch length, σ_z	μm	300
Nominal disruption parameters, x/y		0.17/19.4
Nominal bunch population, N		2.05×10^{10}
Beam power in each beam	MW	11.3
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

On-surface assembly of ILC detectors
CMS approach



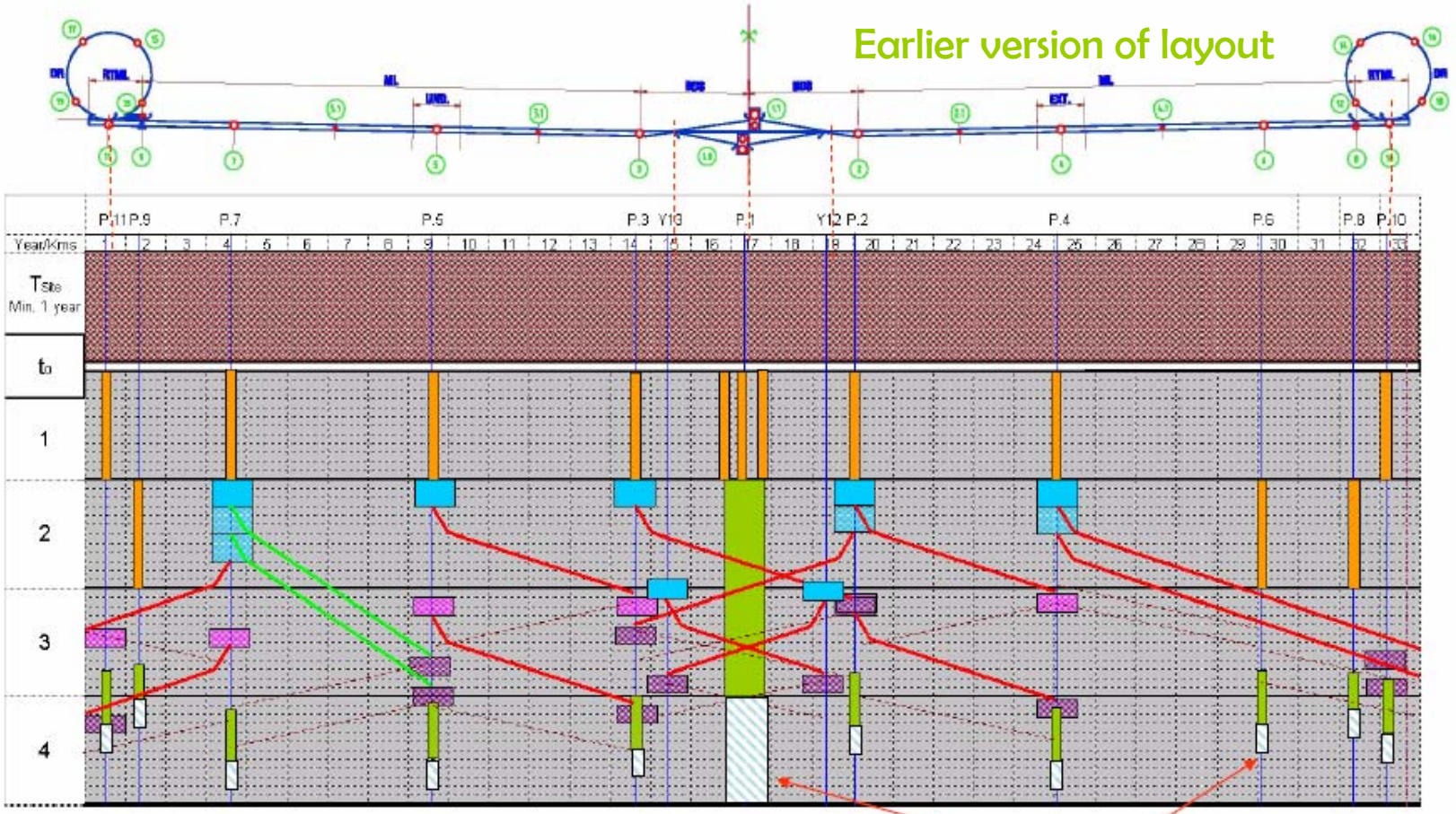




CMS assembly approach:

- **Assembled on the surface in parallel with underground work**
- **Allows pre-commissioning before lowering**
- **Lowering using dedicated heavy lifting equipment**
- **Potential for big time saving**
- **Reduces size of required underground hall**

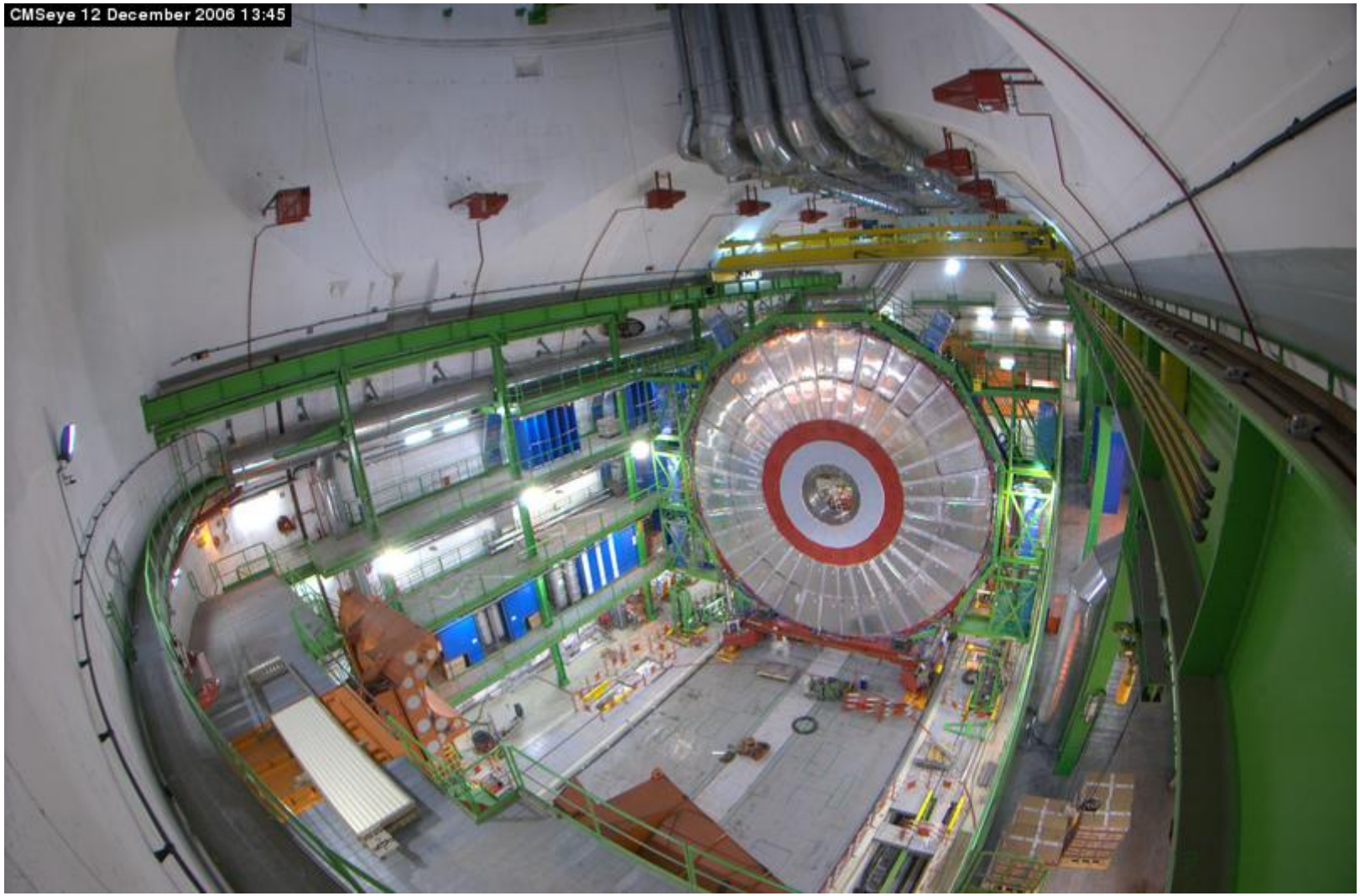
ILC Underground schedule



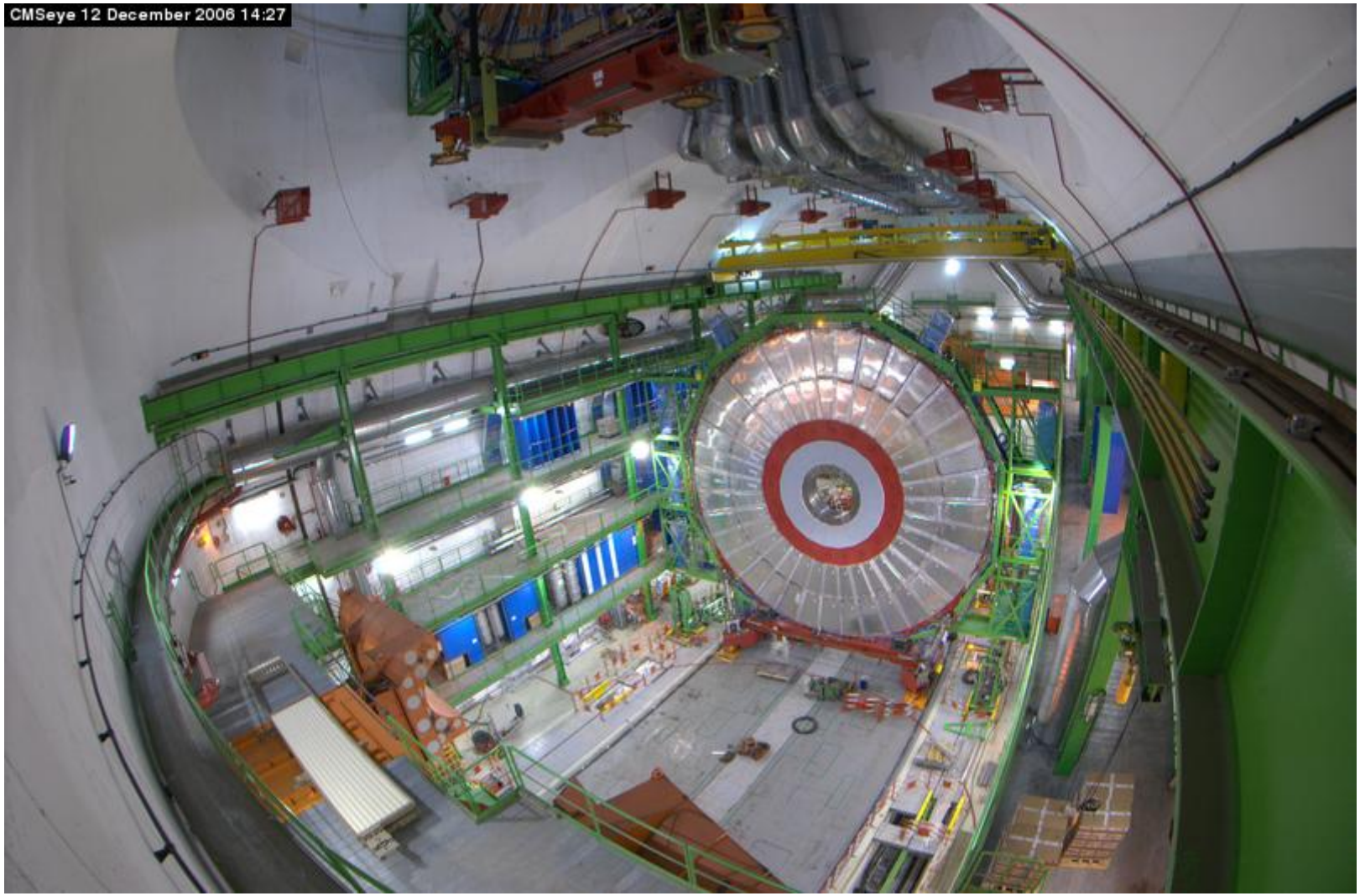
On-surface assembly of ILC detectors

- Adopted CMS on-surface assembly approach for ILC detector
  - **This allows saving more than two years and fitting into the goal of “7years until first beam” and “8years until physics run”**
- CMS assembly and lowering the detectors parts in the hall is presently ongoing, according to the plan
  - **Information and images on next pages are courtesy of CERN colleagues Alain Herve, Martin Gastal, et al.**

CMS Assembly



CMS Assembly



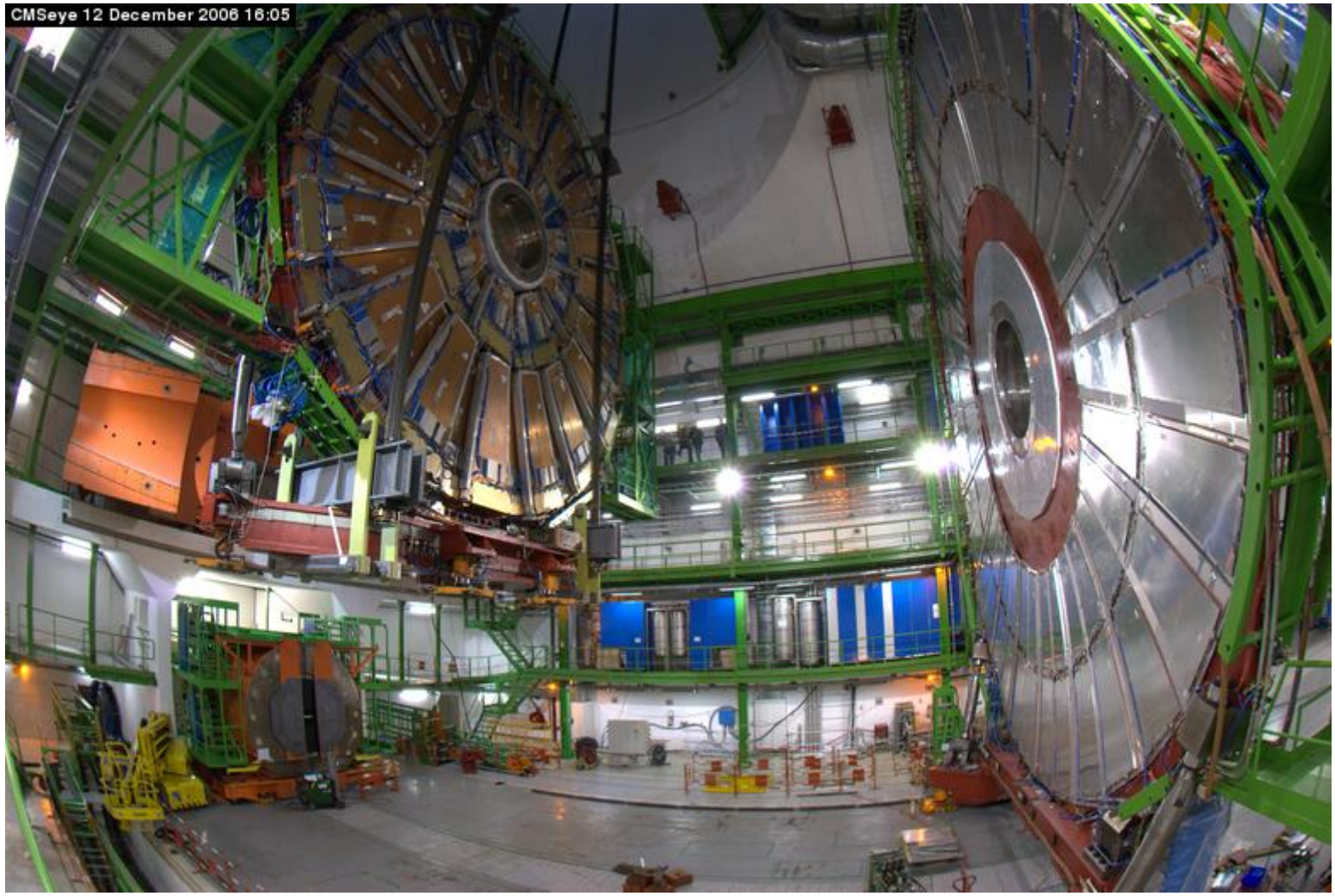
CMS Assembly

CMS Assembly

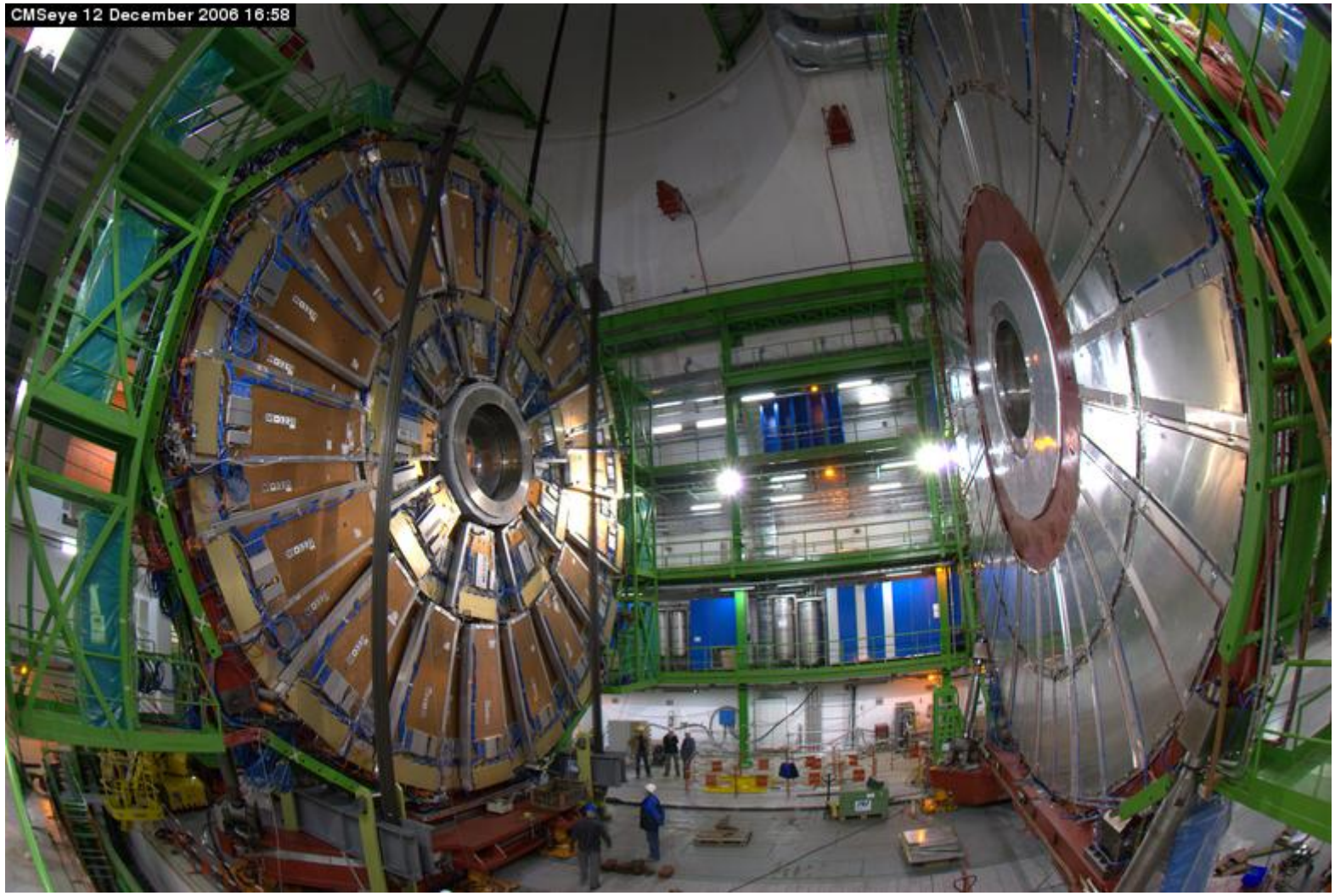
CMS Assembly

CMS Assembly

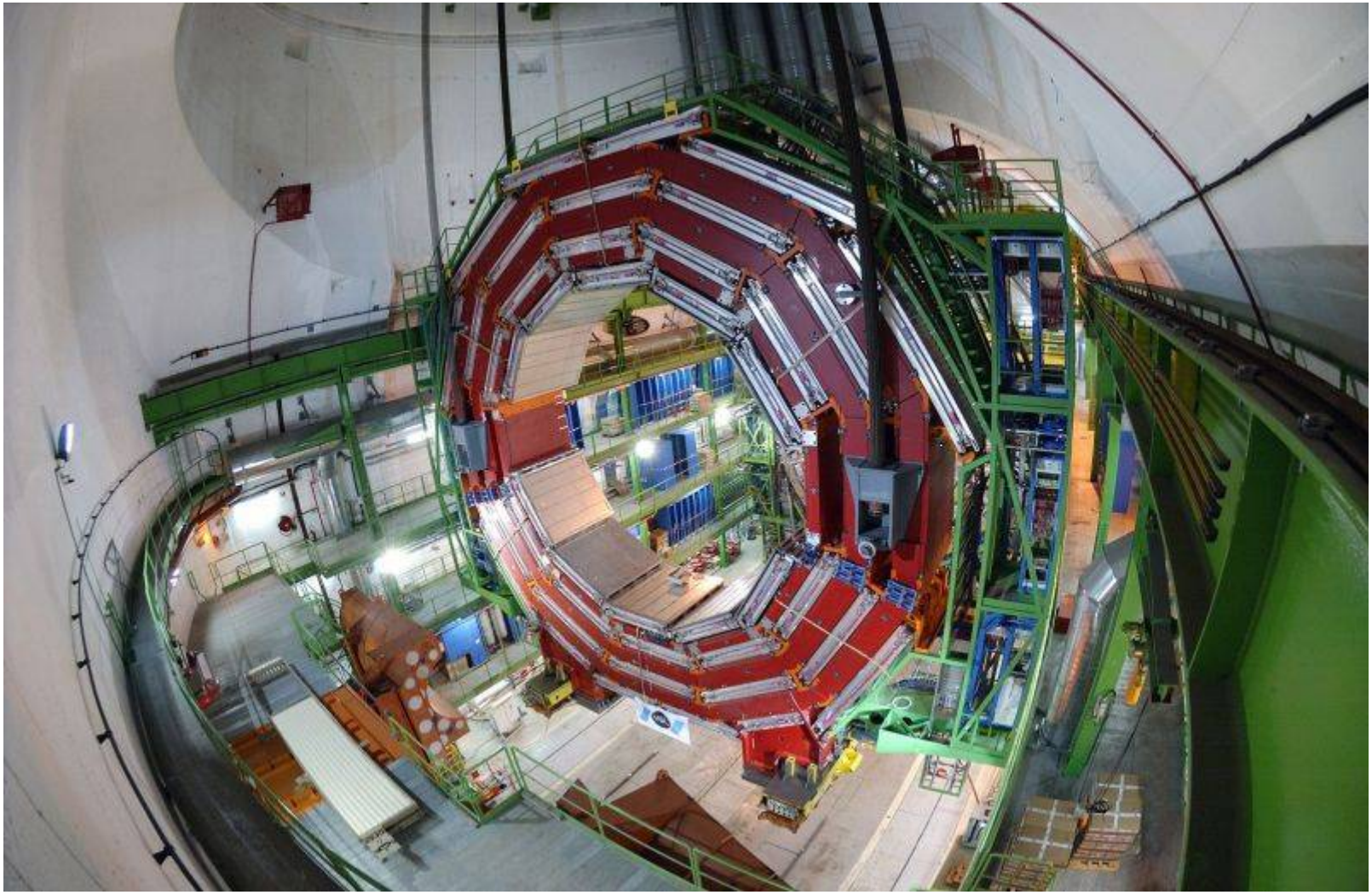
CMS Assembly



CMS Assembly

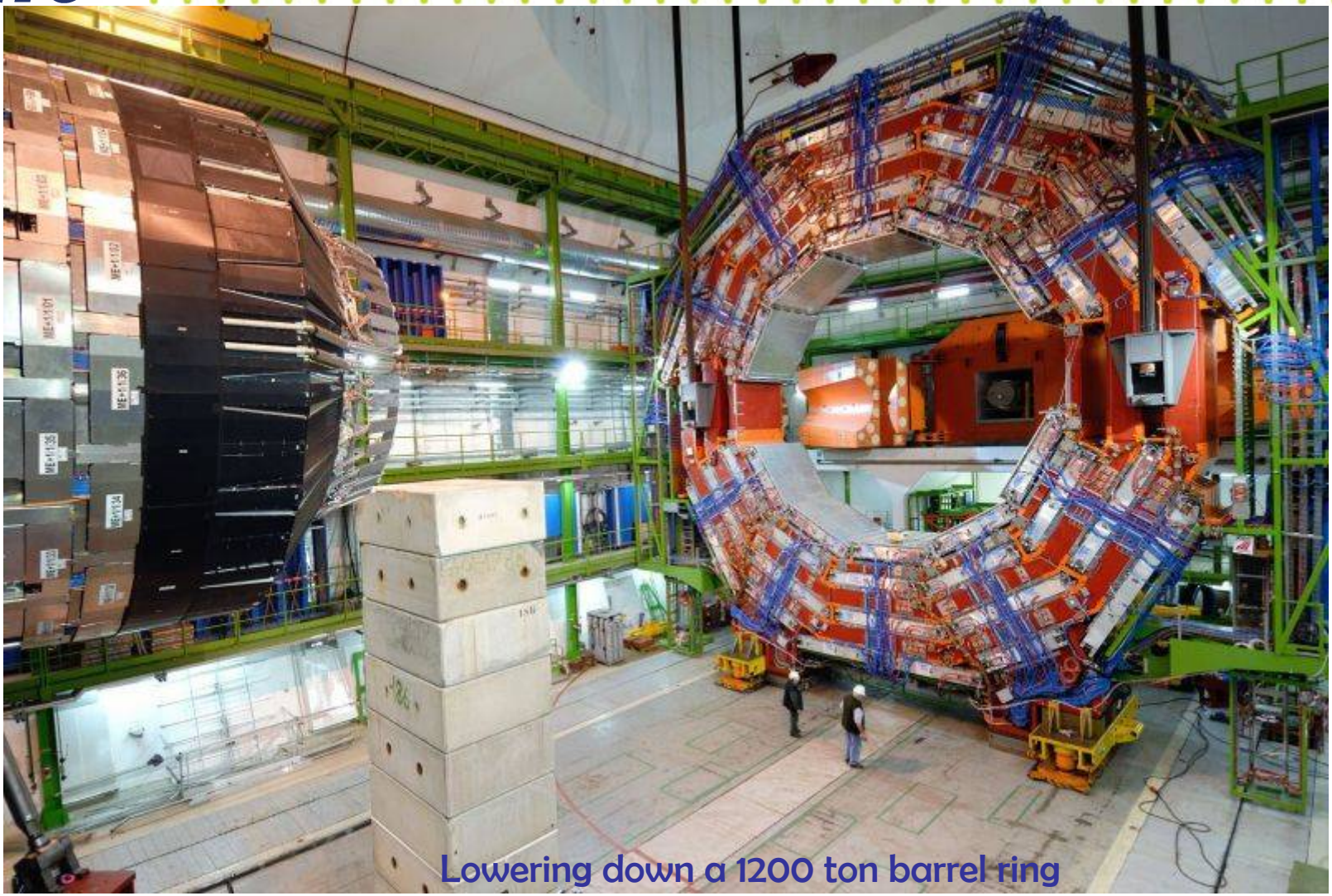


CMS Assembly



February 1. Lowering down a 1200 ton barrel ring. Photo and info courtesy Alain Herve

CMS Assembly



Lowering down a 1200 ton barrel ring

CMS is at half process. Next -- lowering 2kt central barrel by the end of February. **Alain Herve**

Optimization of IR hall and assembly procedure

- For RDR, discussing possible variations of assembly procedure
  - **pure and modified CMS assembly (configs. A and B in the table on next slide)**
    - Difference being how large pieces are assembled on surface
- Present RDR does not intend to finalize all the details for the schedule, hall sizes, capacity of cranes, etc.
- Optimization will be done in details by BDS, CF&S and Detector concept groups in EDR phase

Table of IR assumptions

Item	SiD	LDC	GLD	4-th Concept	CMS	Vancouver WBS (for each hall)	For Valencia Config.A (for single common hall)	Config.B (for single common hall)	Determined by
Parameters that define the underground hall volume									
IR Hall Area(m) (W x L)	28x48 (18x48)	30x45	25x55	30x50	26.5x53 max	32x72	25x110	25x110	Detector concepts
Beam height above IR hall floor (m)	7.5	8	8.6	7.5	8.79m	8.6	8.6	8.6	Concepts, BDS
IR Hall Crane Maximum Hook Height Needed(m)	5m above top of detector	19	20.5	20	18m	30	20.5	20.5	Detector concepts
Largest Item to Lift in IR Hall (weight and dimensions)	100t PACMAN shielding	55t, 3m x 3m x 1,5m, E/HCAL end cap quadrant	Pieces of yoke 400t	Coil with cryostat -100t** Hadron Calorimeter-	20t instal tool 7x4m		400t	100t	Detector concepts
IR Hall Crane	100t/10t aux.	80t (2x40t)	400t	100t	20t	20t x 2	400t +2*20t	100t +2*20t	Detector concepts
IR Hall Crane Clearance Above Hook to the roof (m)	TBD by engineering staff	6	TBD	TBD by engineering staff	5 m	5	14.5 (includes arch)	12.5 (includes arch)	CF&S group
Resulted total size of the collider hall (W x L x H)	28x48x30 (18x48x30)	30x45x25	25x55x35	30x50x30	53x26x25	32x72x35	25x110x35	25x110x33	Concepts & CF&S group
Parameters that define dimensions of the IR hall shaft and the shaft crane									
Largest Item; Heaviest item to Lower Through IR Shaft (weight and dimensions)	Coil package 600t – size End-dors 2000t each/halfs	Central Part ~2000t; 12-14m x 7m;	270t coil 9*9m Iron-15m	Detector chassy-φ14.5x12.2mx17 ~40t Muon spectrometer coil-φ10x10m	1950t		9*9m 400t	4*16m 2000t	Detector concepts
IR Shaft Size(m)	9 may work	φ18,4 (16x9)	20 Surface 16 Hybrid	φ15	20.4m	15	16	20	Detector concepts
IR shaft fixed surface gantry crane. If rented, duration	1kt * 1.5years?	2kt * 1.5years?	2kt*1.5yr/ 400t	TBD by engineering staff	2kt * 1year	1kt * 1.5years?	None	2kt* 1.5years	Detector concepts

continued …

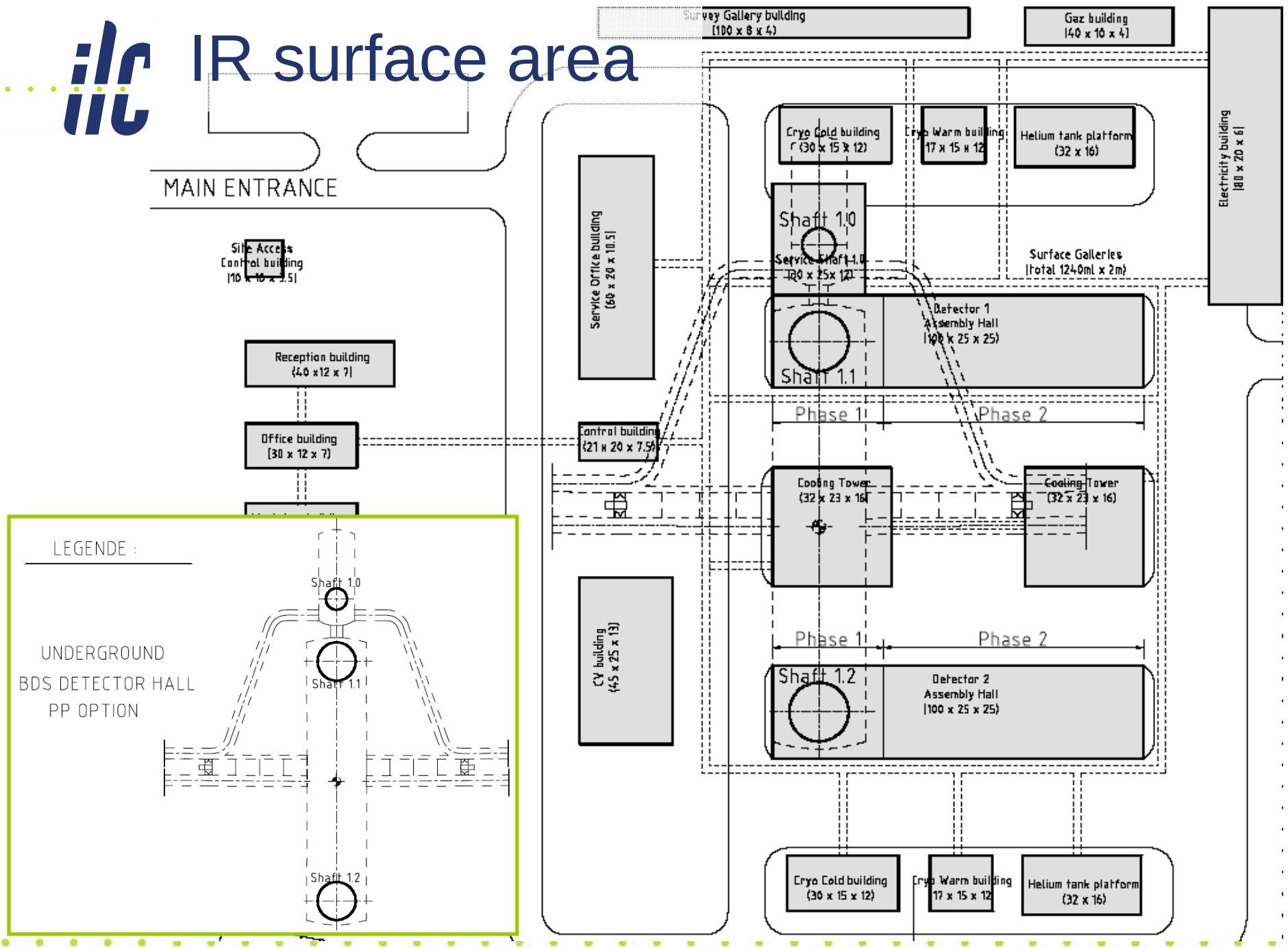
Item	SiD	LDC	GLD	4-th Concept	CMS	Vancouver WBS (for each hall)	For Valencia Config.A (for single common hall)	Config.B (for single common hall)	Determined by
Surface hall crane should serve IR shaft		Yes		Yes			Yes	Yes	Detector concepts
Other shafts near IR hall for access	TBD	Yes		TBD	Yes 12m	9m in service cavern, one per two halls	No	No	Detector concepts & BDS area
Elevator and stares in collider hall shaft	Cost decision	?		Yes	no	No	Yes	Yes	Detector concepts & BDS area
Parameters that define dimensions of the surface assembly building and its crane									
Surface Assembly Building Area(m) (W x L)	TBD	30 x 60	TBD	30x50	23.5 x 93 inner, 23.5 x 140 outer	25 x 100	25x200	25x200	Detector concepts
Largest Item To Lift in SurfAsm. Bldg. (weight and dimensions)	100t	70t *;7,5x7 inner vac tank 60t one coil module 55t; 3m x 3m x 1,5m E/HCAL end cap quadrant		Detector chassy-φ14.5x12.2mx17 ~40t Muon spectrometer coil-φ10x10m	120t 13x7 inner vac tank 60t one coil module		400t	100t	Detector concepts
Surface Assembly Crane	100t/10t aux. (TBD)	2x80t* min 2x60t	400t	100t	80t x 2	80t x 2	400t + 2*20t	100t + 2*20t	Detector concepts
SurfAsm. Crane Maximum Hook Height Needed(m)	20m TBD	19 m *		20	18.3 m	18	18	18	Detector concepts
SurfAsm. Crane Clearance Above Hook to the roof (m)	ME/Civil to determine	5 m to ceiling*		5	5.7 m to outside	5	8	6	CF&S group
Resulted volume of surface assembly building (m) (W x L x H)		30 x 60 x 24		30x50x25	23.5 x 100 x 23.5 outer	25 x 100 x 23	25 x 200 x26	25 x 200 x24	Concepts & CF&S group
Parameters that define crane access area and clearance around detector									
SurfAsm. crane accessible area (needed) / available (m) (W x L)	CG of load on 150ton trailer	56 x 28		28x45	19 x 92 m		(20x102m?) 15 x 184 m	(20x102m?) 20.5 x 192 m	Detector concepts & CFS
IR hall crane accessible area (needed) / available (m) (W x L)	TBD	28 x 41 min 25 x 35*		28x45	17 x 42		(20x102m?) 19 x 96 m	(20x102m?) 22 x 98 m	Detector concepts & CFS

... continued ...

Included in IR hall and surface buildings:

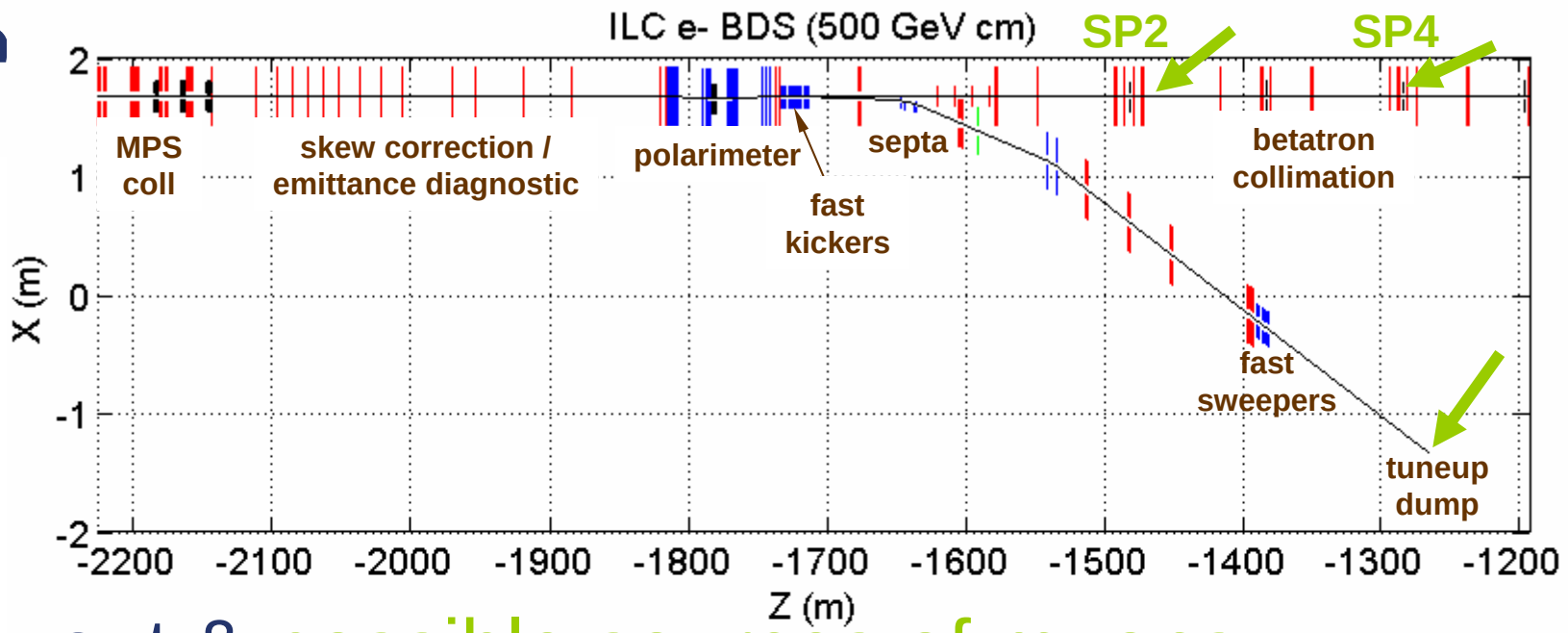
- IR hall:
  - **detectors hall of 120x25x39m**
  - **service cavern 40x15x10m**
  - **finished civil engineering works, plus**
  - **movable concrete shielding wall in two parts (on air pads)**
  - **steel platforms with staircases and all fittings**
  - **two 1.6t elevators between steel platforms plus two 2.8t in shafts,**
  - **steel plates on the floor of the Hall**
  - **one 400t and two 20t overhead cranes in Hall**
  - **etc…**
- Included in surface assembly building:
  - **two assembly buildings 100x25x25m**
  - **400t and 20t overhead cranes**
- This choice can suite some detectors better than other (one size does not fit all) and may cause some concerns
- Further adjustments of IR hall and surface buildings will be done, in close connection with detector colleagues, during EDR phase

IR surface area

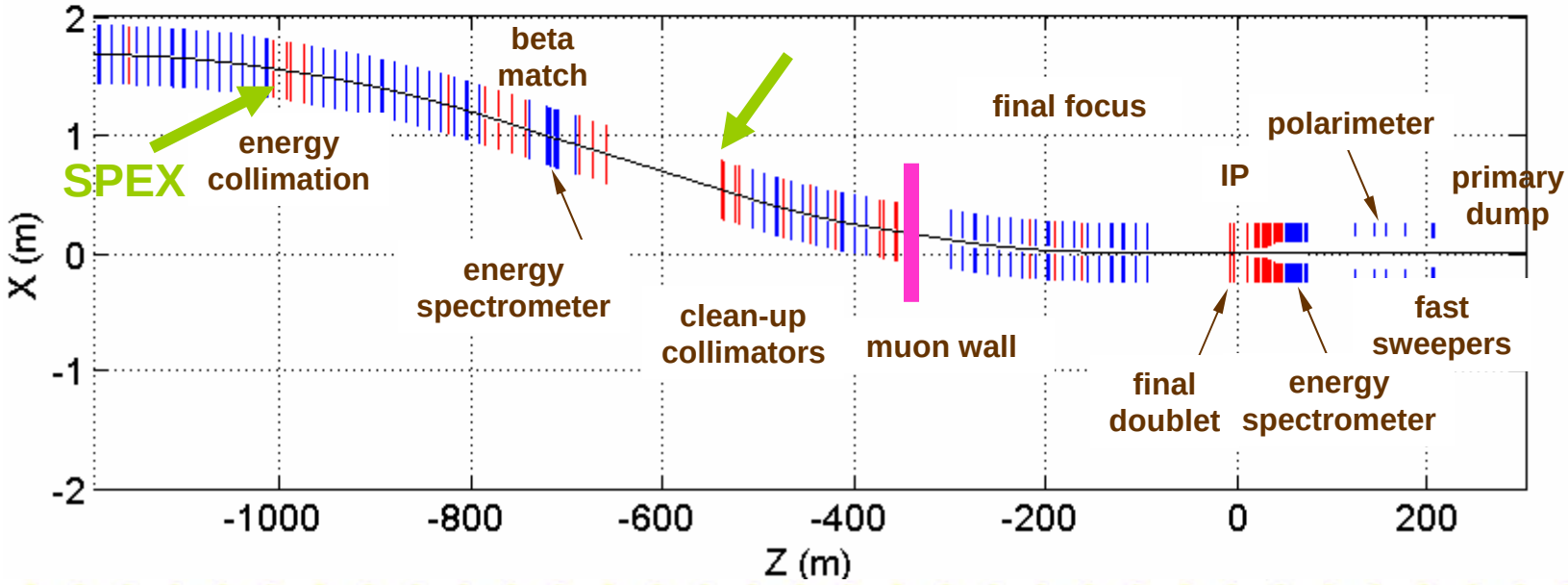


Next slides

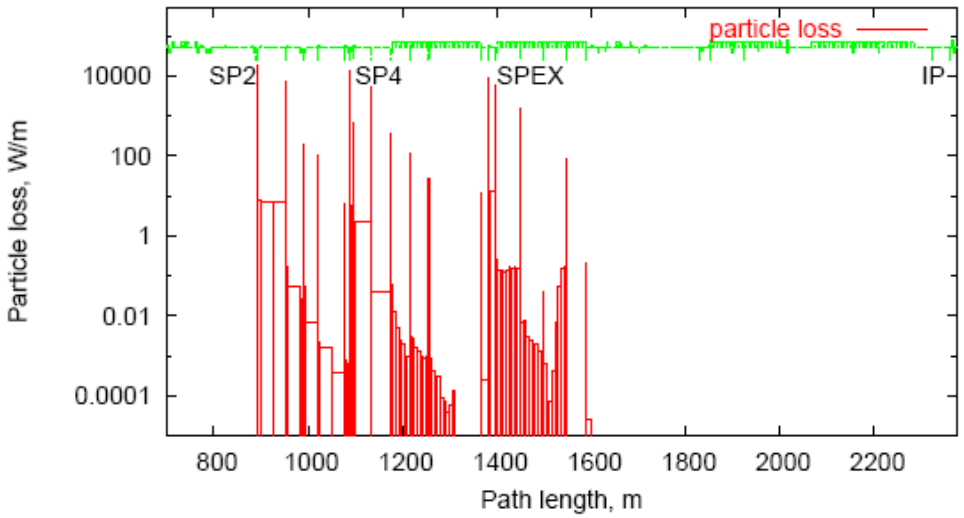
- Will discuss
  - **Machine background**
    - muons
    - Synchrotron Radiation
    - Beam-gas
    - Extraction line losses
  - **IR design**
    - Detector Integrated Dipole (DID)
    - Antisolenoids

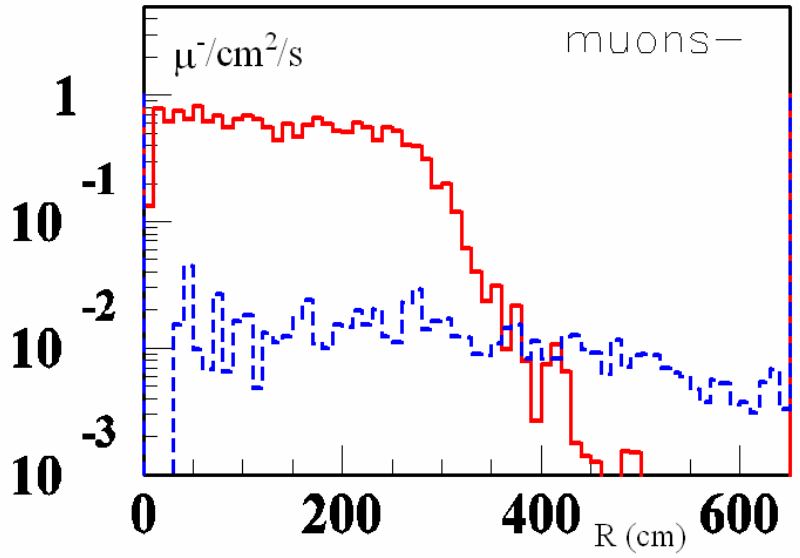


BDS layout & possible sources of muons

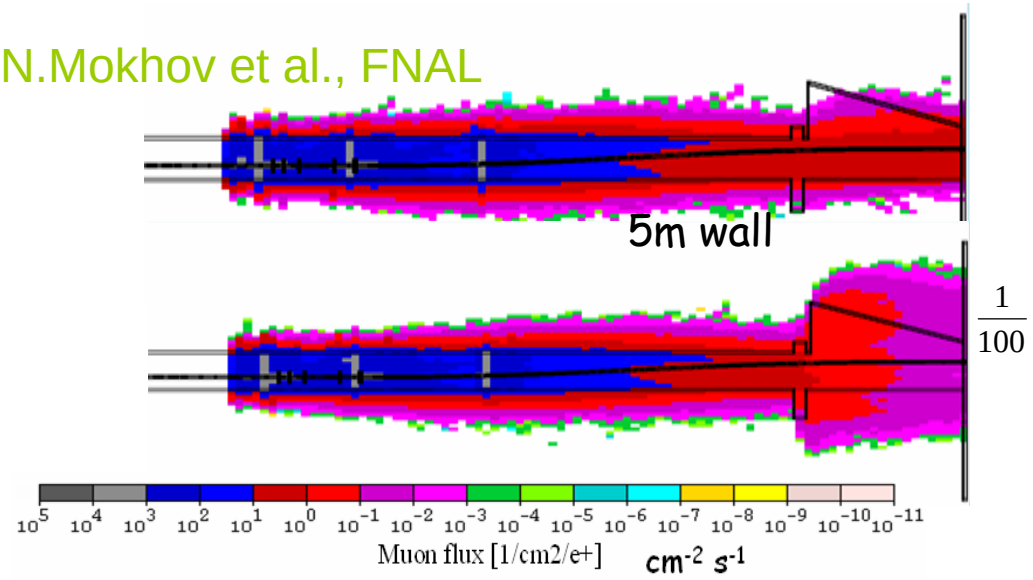


Muon reduction





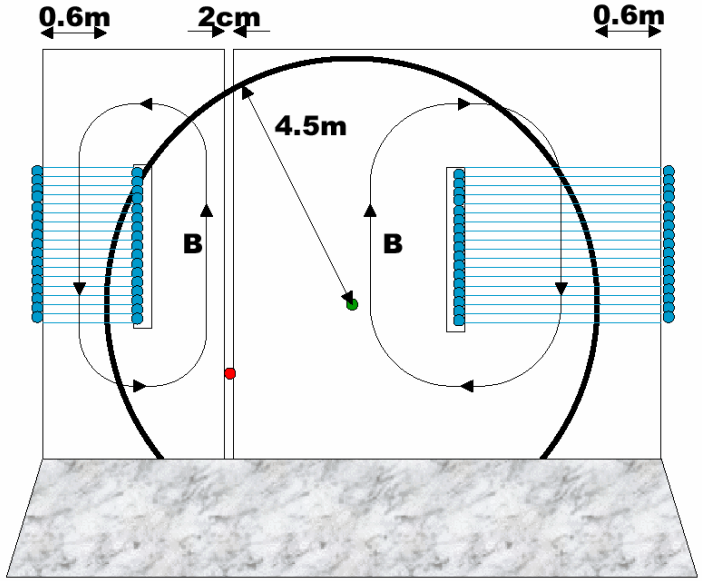
N.Mokhov et al., FNAL

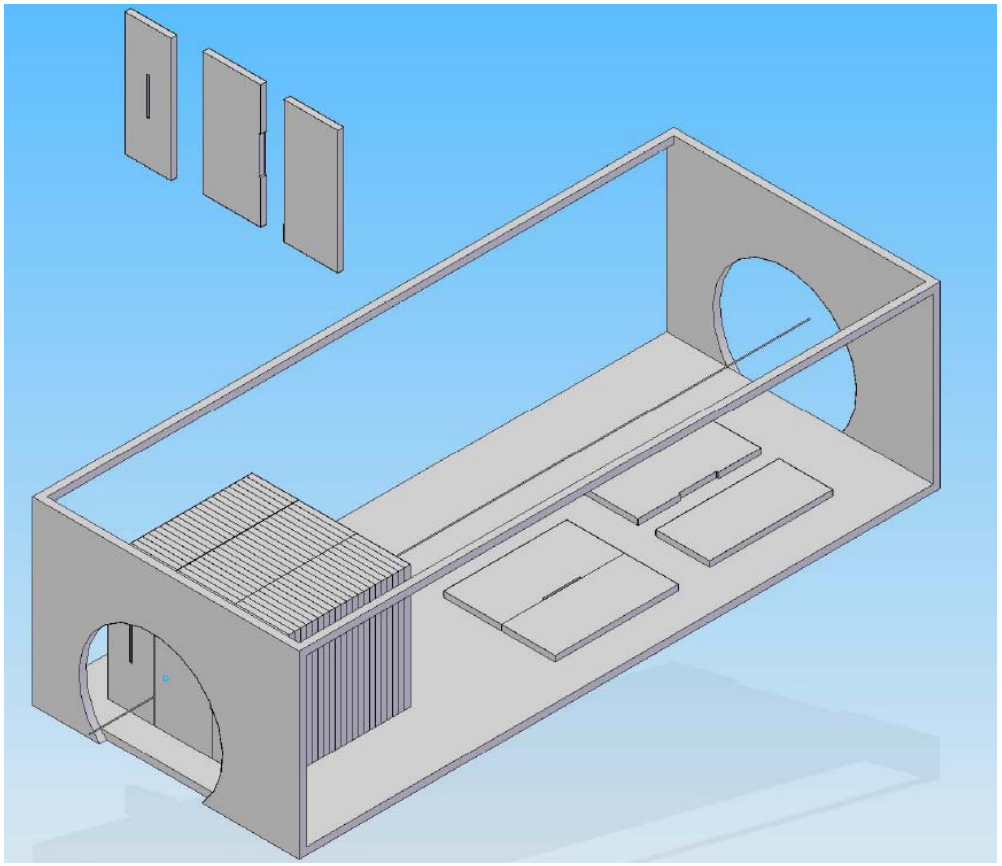


- Muon flux in BDS & IR with and without 5m muon wall
- Allows reducing flux in TPC to a few μ per ~100 bunches

Muon walls

- Purpose:
  - **Personnel Protection: Limit dose rates in IR when beam sent to the tune-up beam dump**
  - **Physics: Reduce the muon background in the detectors**



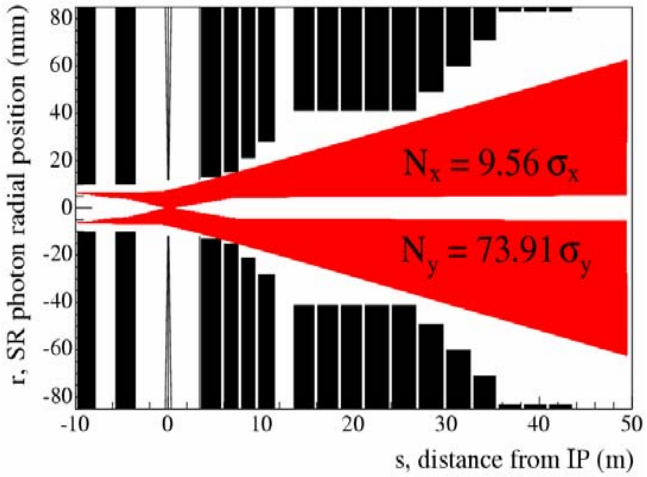


5m muon wall installed initially

If muon background measured too high, the 5m wall can be lengthened to 18m and additional 9m wall installed
(Local toroids could be used also)

Beam gas & SR in IR

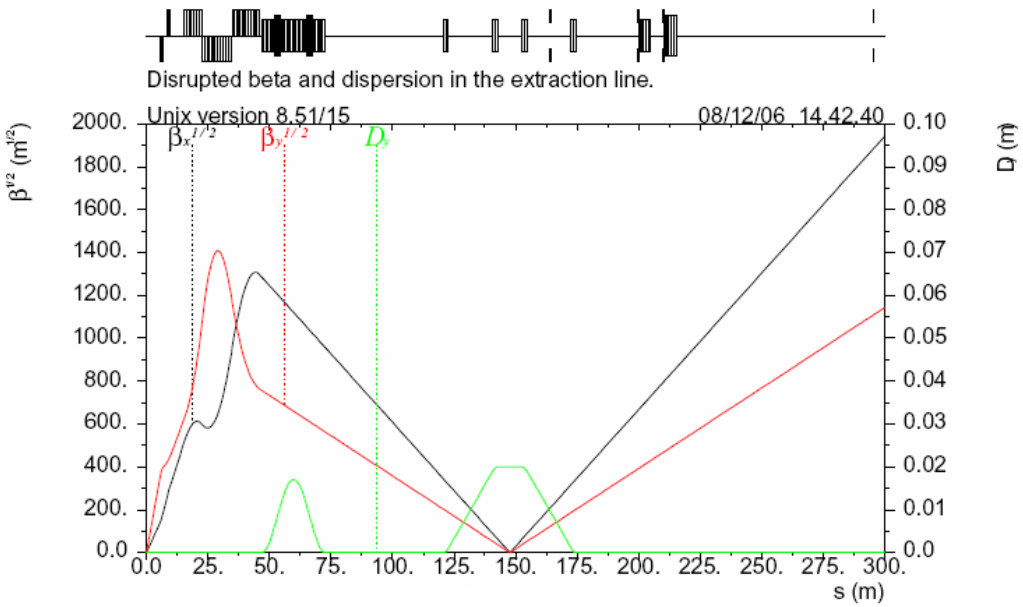
- Beam gas
  - **is minimized by controlling the pressure near IP within 1nTorr level, 10nTorr in 200-800m from IP and ~50nTorr in the rest of the system**
- SR in IR
  - **due to upstream collimation is contained within a defined cone which is extracted away**



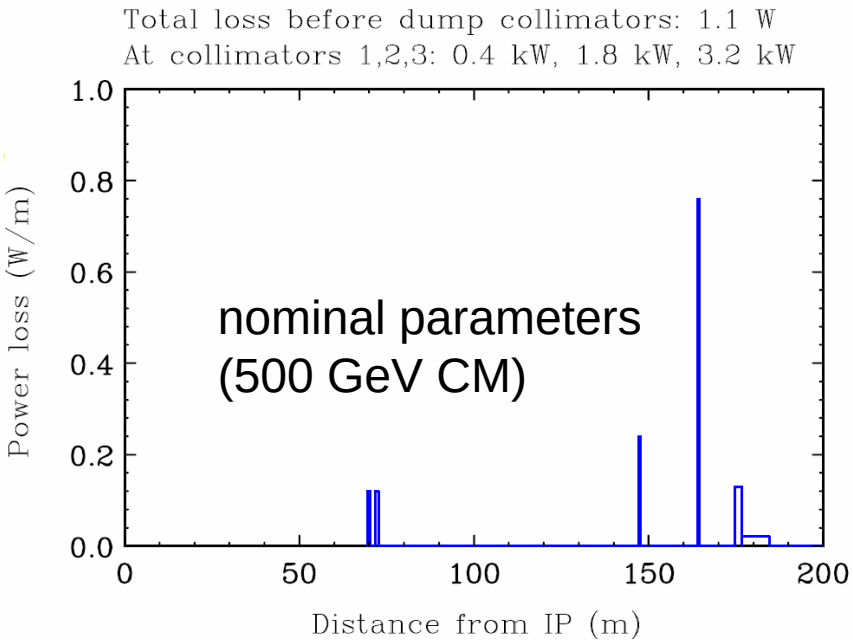
Example of SR rays from beam halo in IR apertures

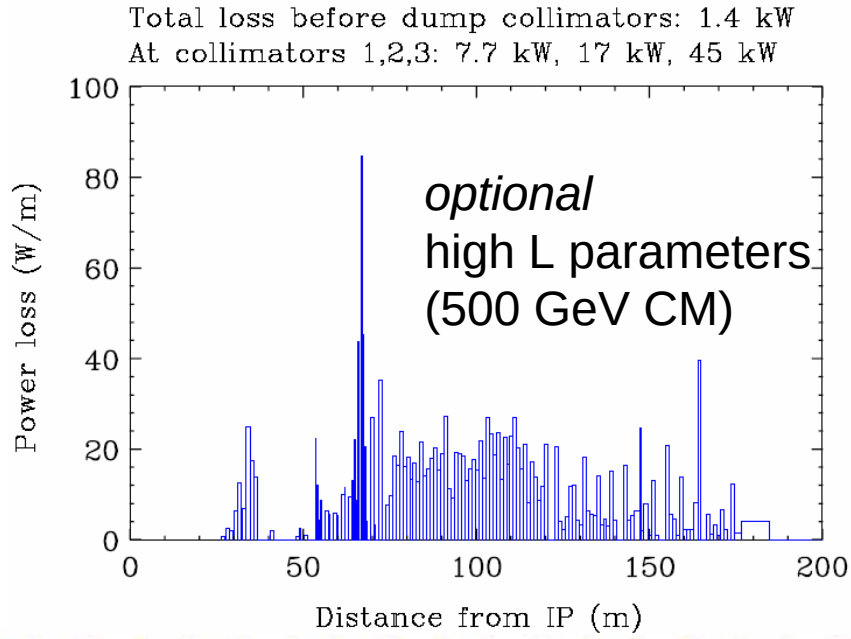
F.Jackson, et al

Extraction Lines



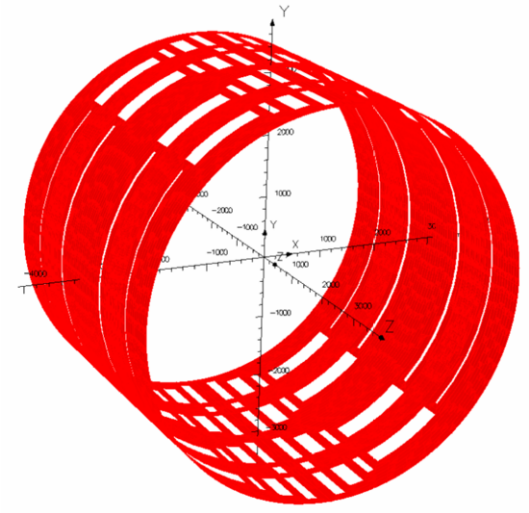
Y.Nosochkov, et al





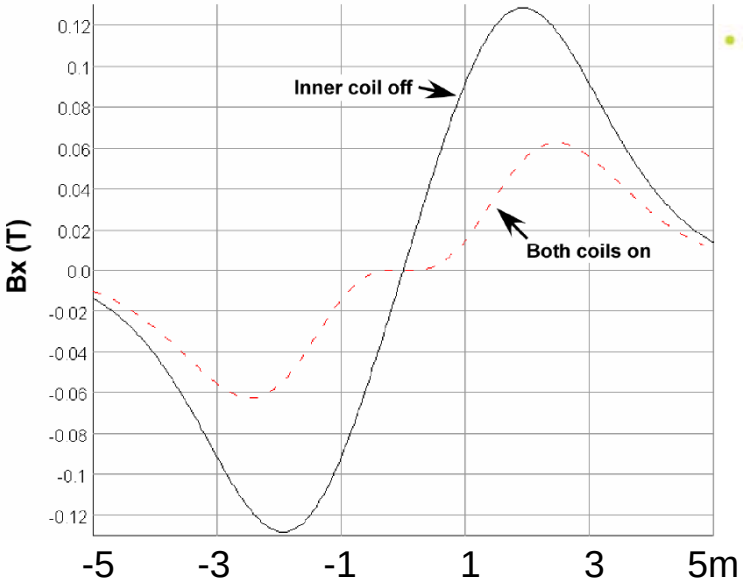
- Losses for the nominal case are negligible (~1W for 200m from IP)
- Even for High L parameters is within acceptable levels
- Small losses in extraction and separation from dump are important to keep the back-shine low

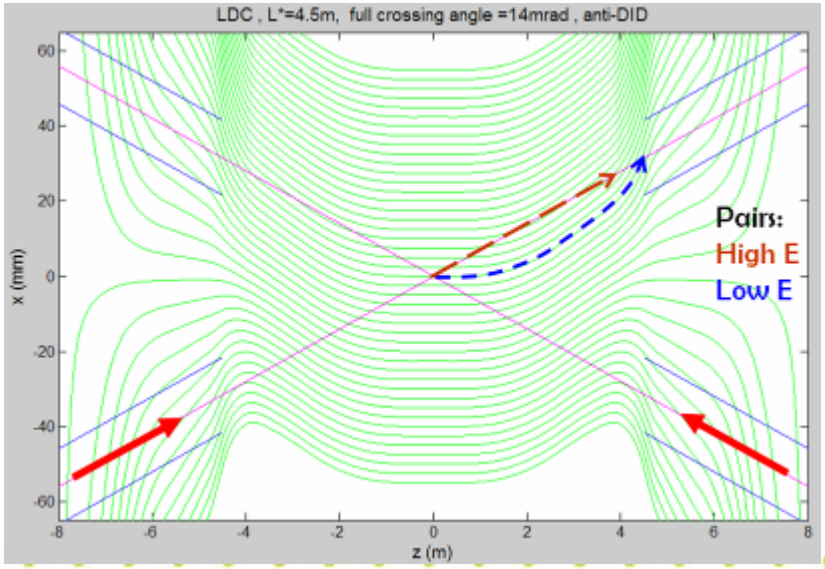
Anti-DID coils

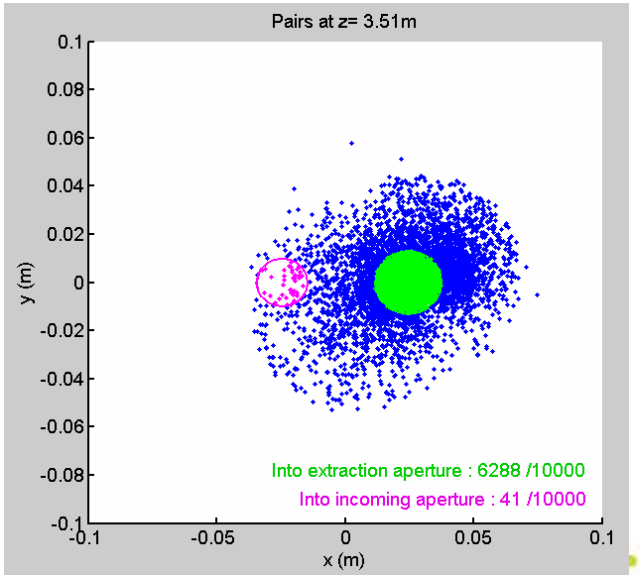


B.Parker, et al, BNL

Two overlapping Detector Integrated Dipole coils create field flattened in the IR region

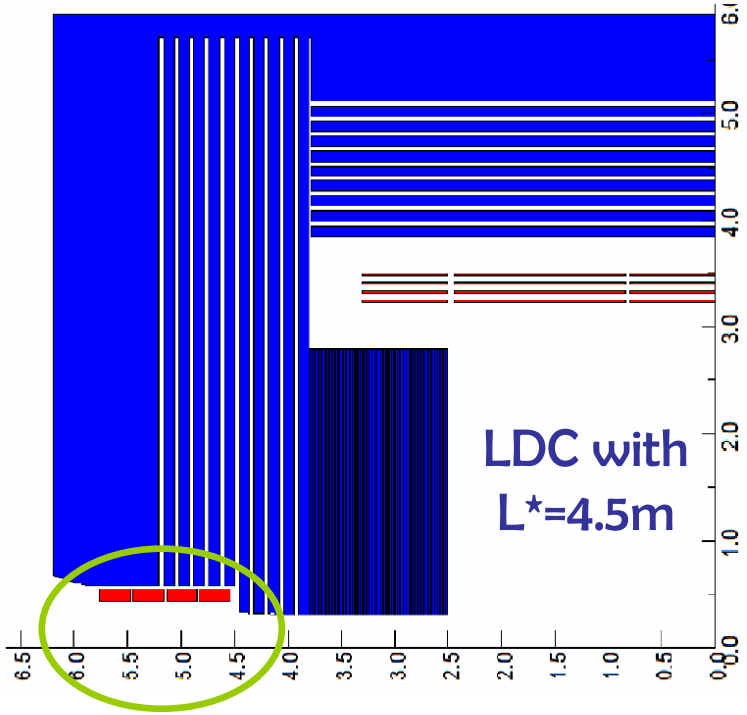


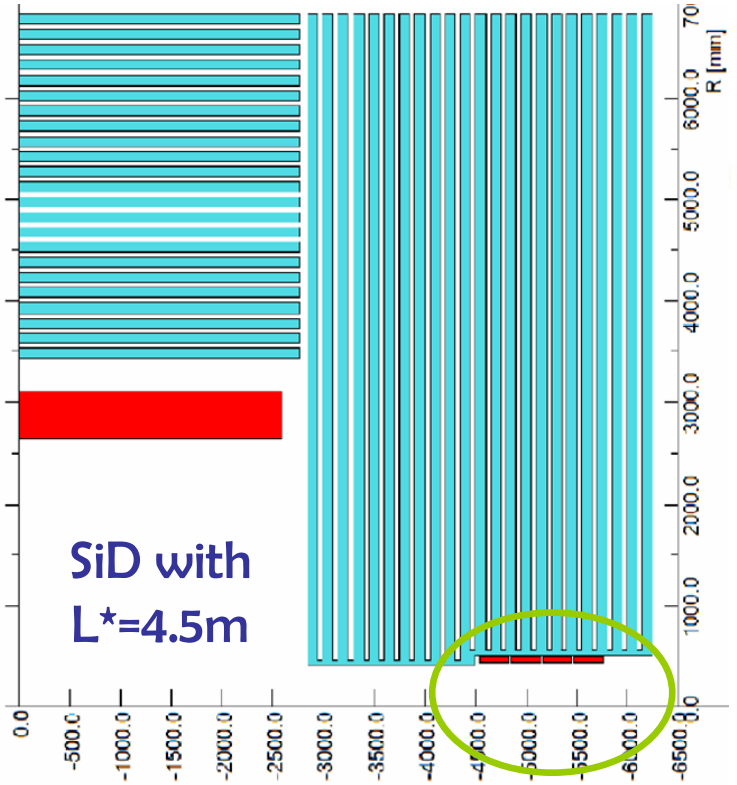




Application of anti-DID to guide pairs to the exit hole

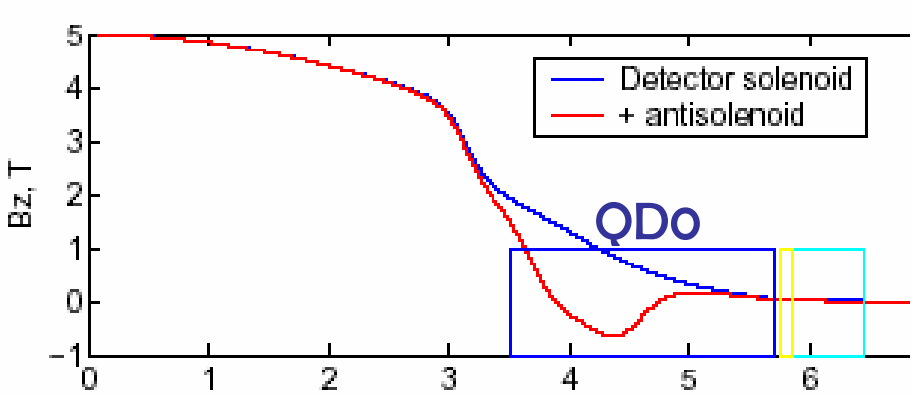
Antisolenoids





- Antisolenoids for local compensation of beam coupling
- Depend on all parameters (L*, field, sizes, etc) and is a delicate MDI issue

B.Parker, BNL

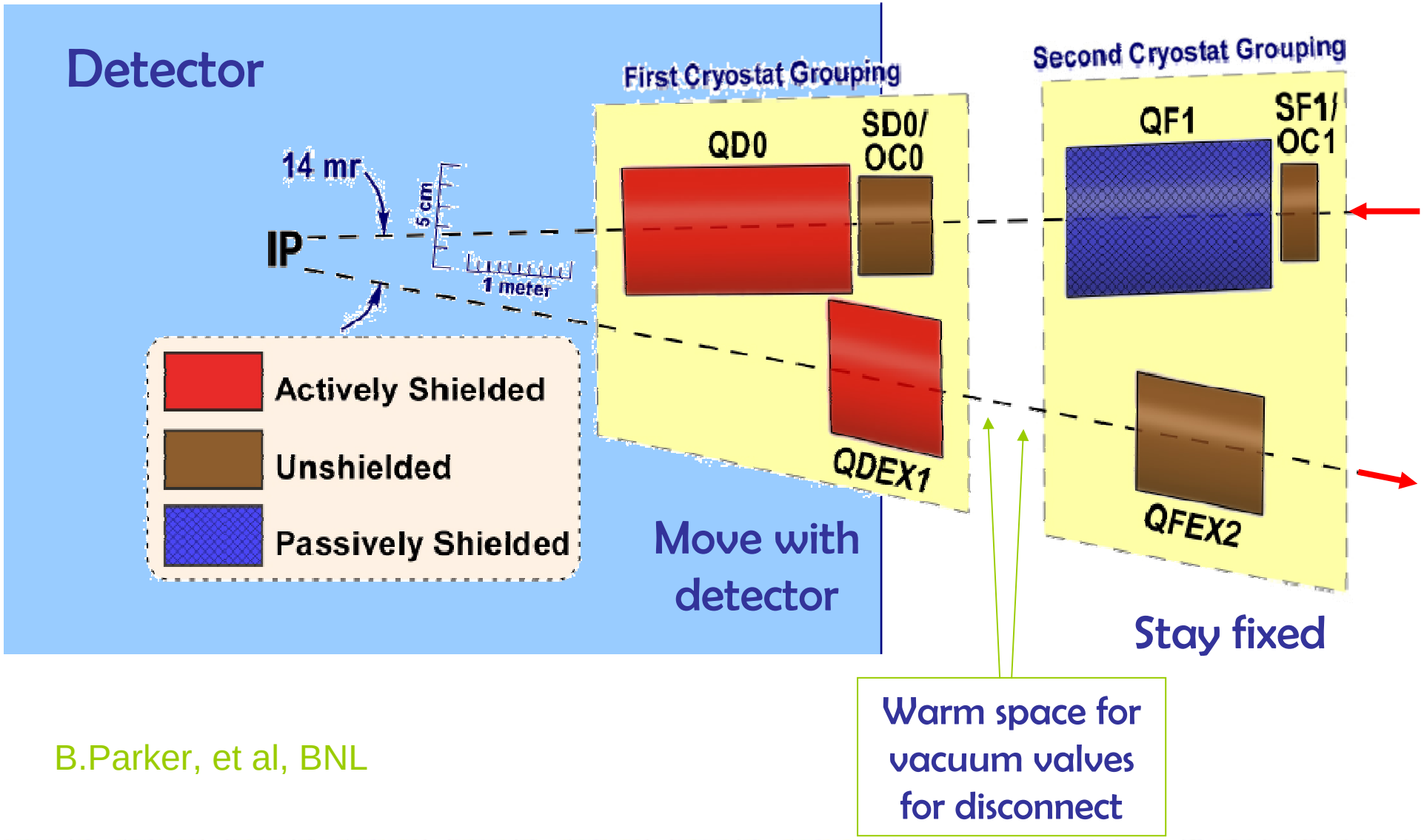


Example of optimal field for local compensation of coupling (SiD, L*=3.5m)

Arrangements for two detectors

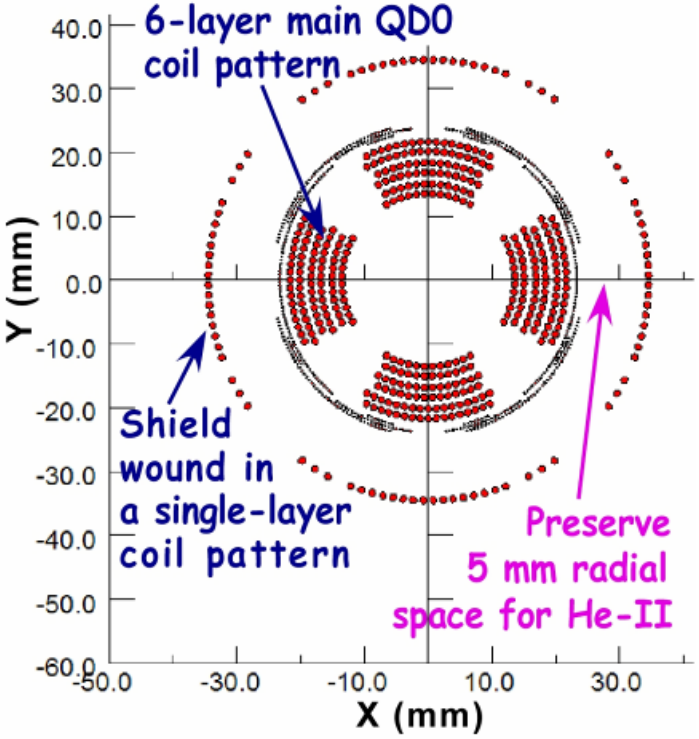
- IR design
- Shielding
- Moving the detectors
- Services
- Opening
- Connections
- etc

IR conceptual design

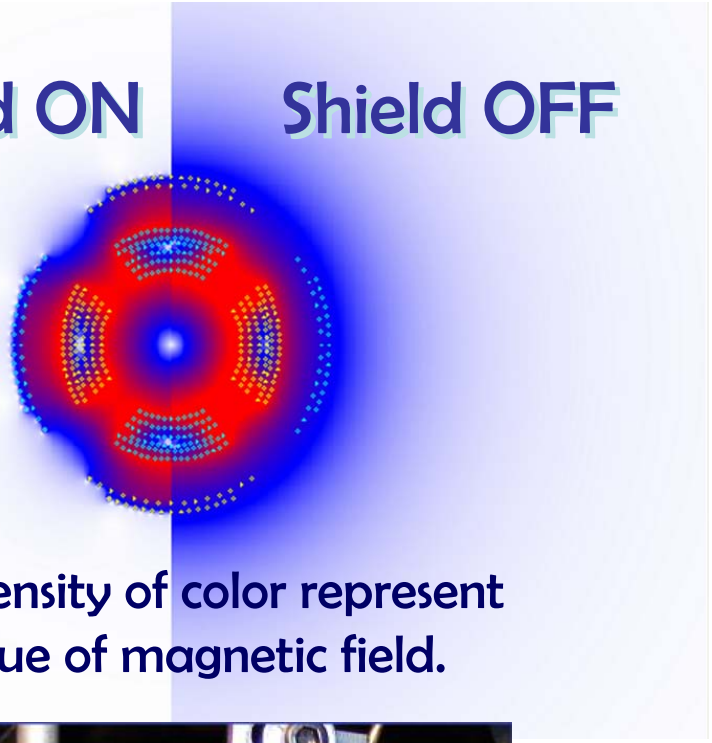


B.Parker, et al, BNL

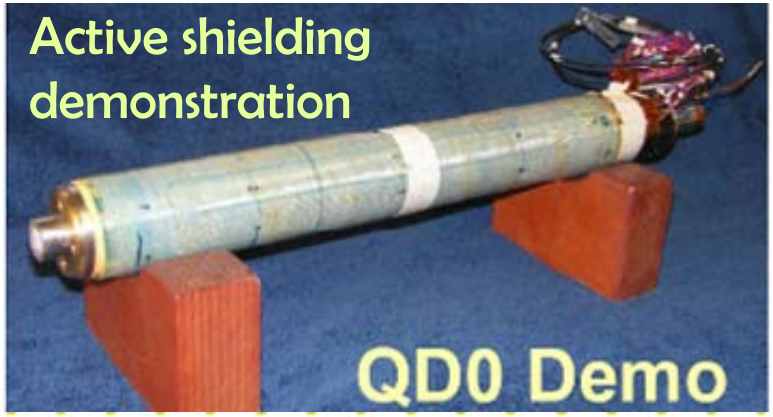
IR magnet design

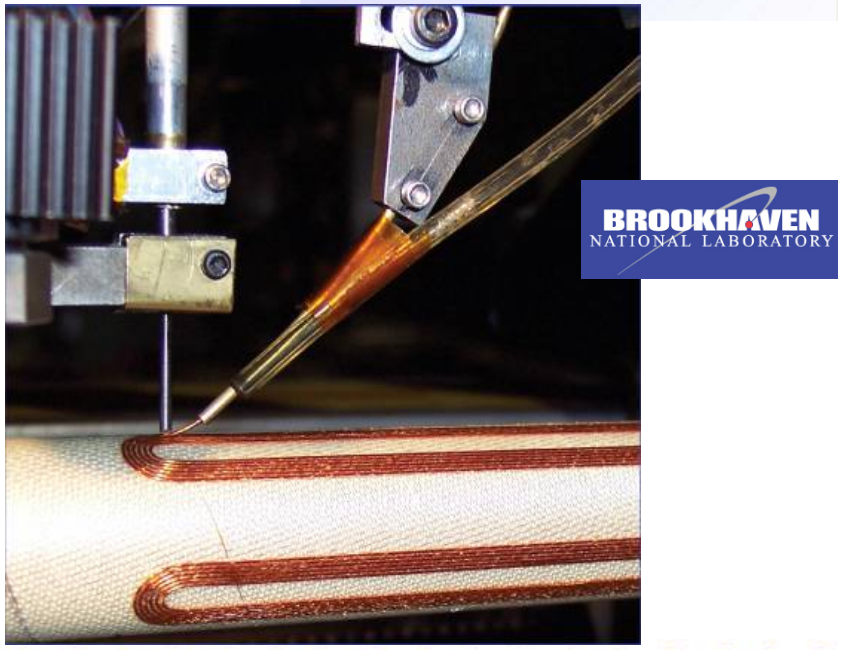


Actively shielded QD0

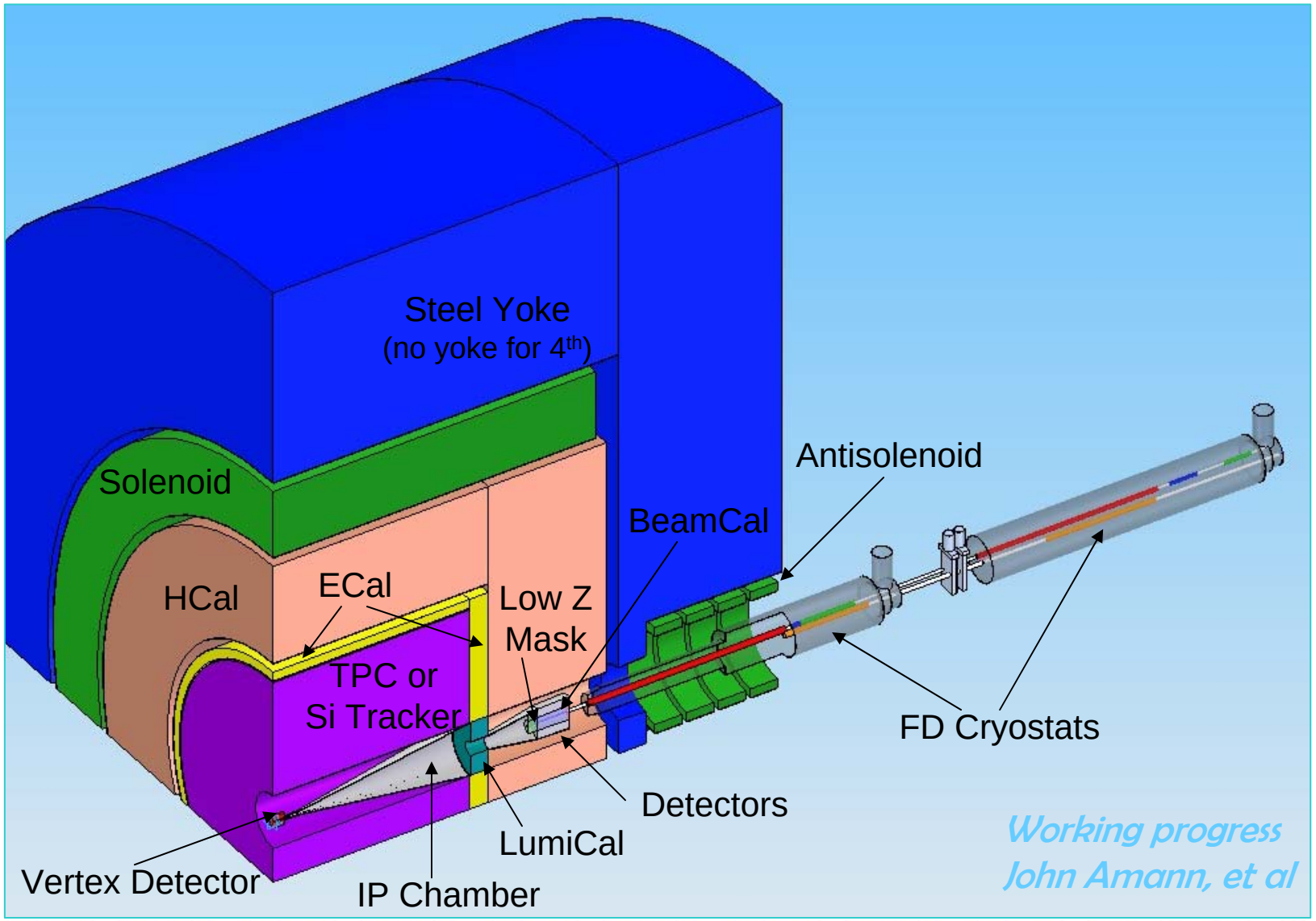


Intensity of color represent value of magnetic field.

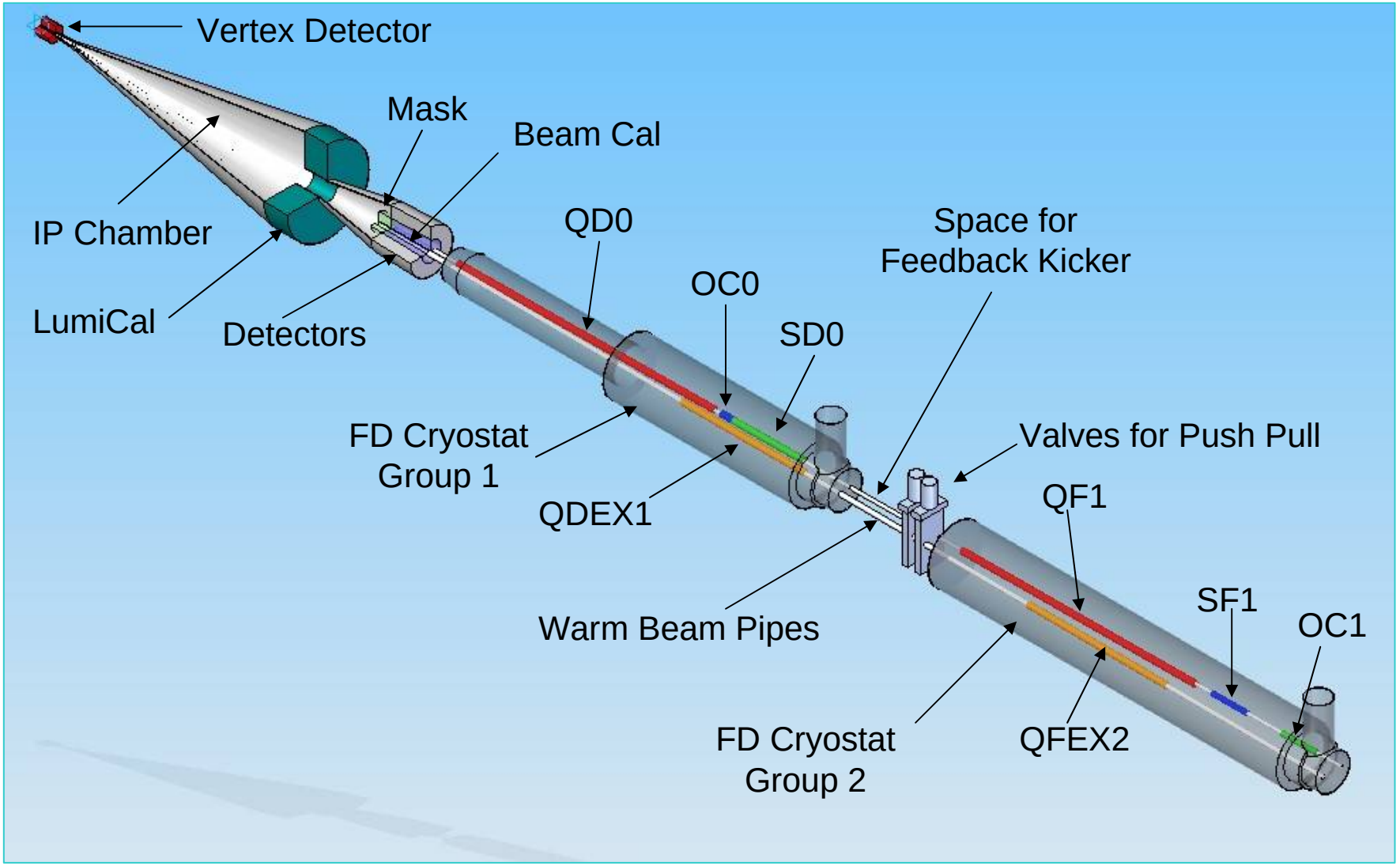




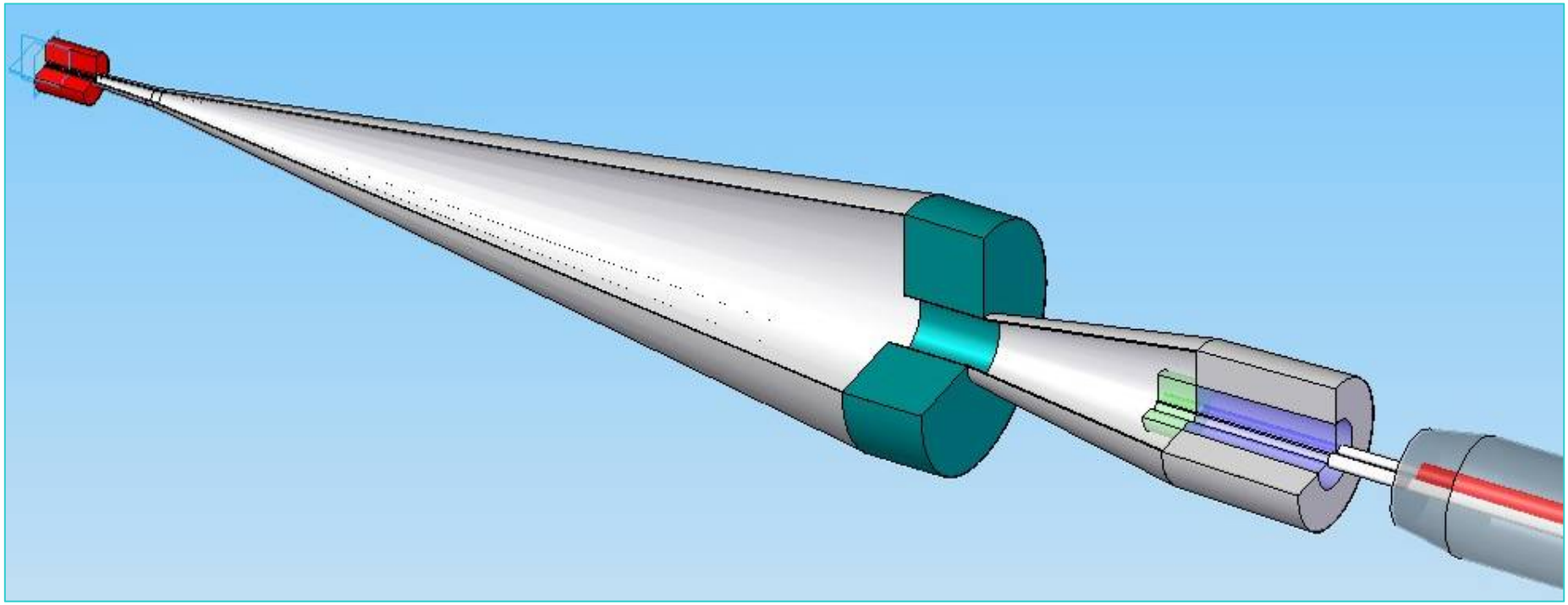
Generic Detector - IR Details



Generic IR layout

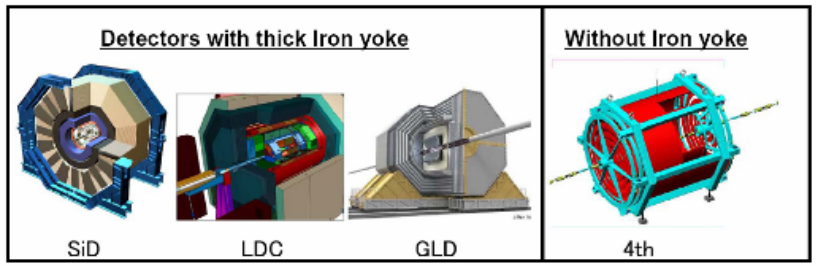


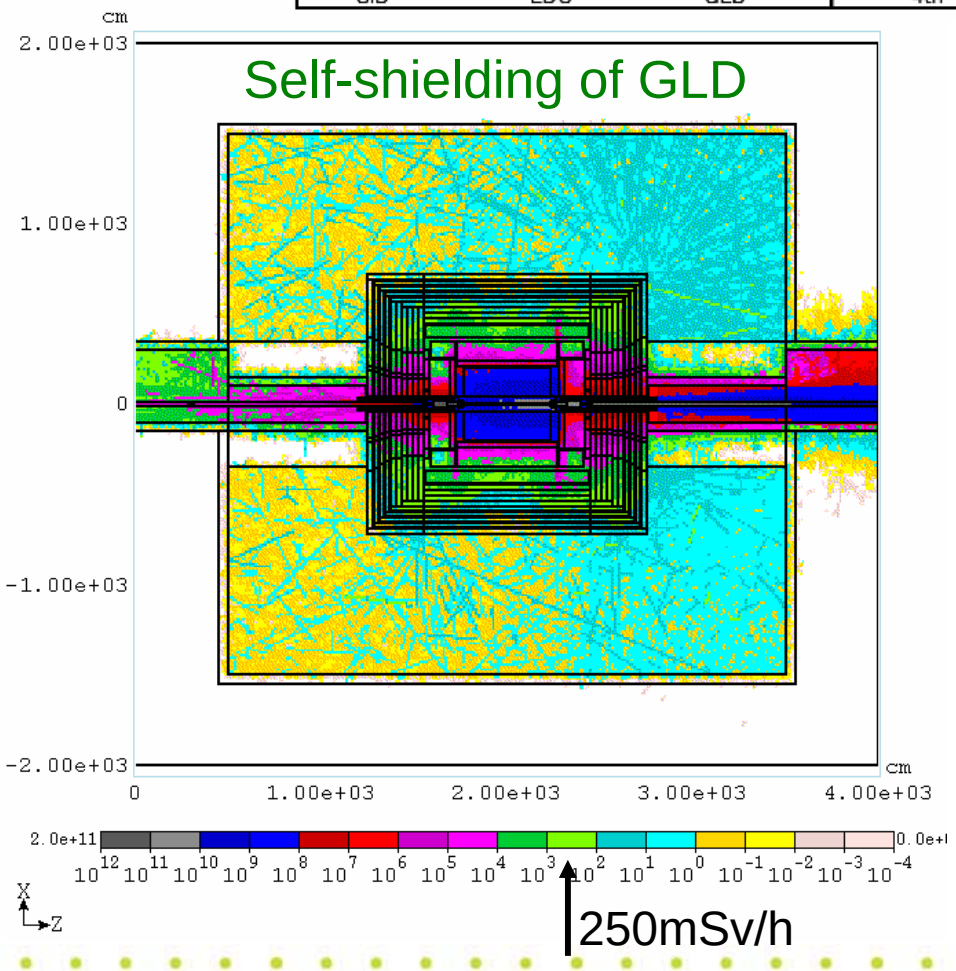
IR forward region and chambers



- Watch in study & design:
  - **integration; support; assembly; wake-fields and EMI; location of BPMs; vacuum & pumping; cold-warm transitions; etc.**

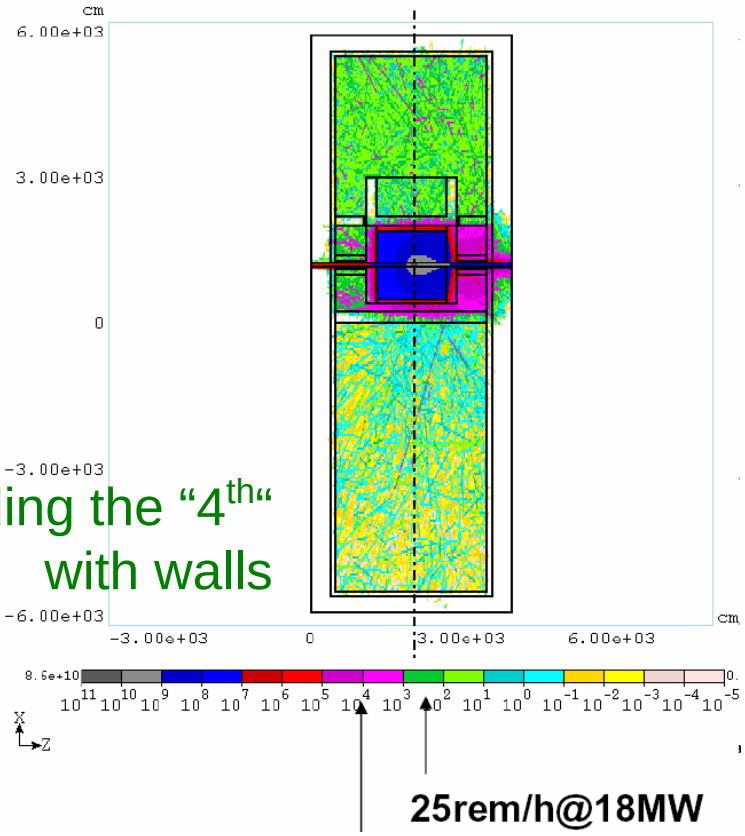
Shielding the IR hall

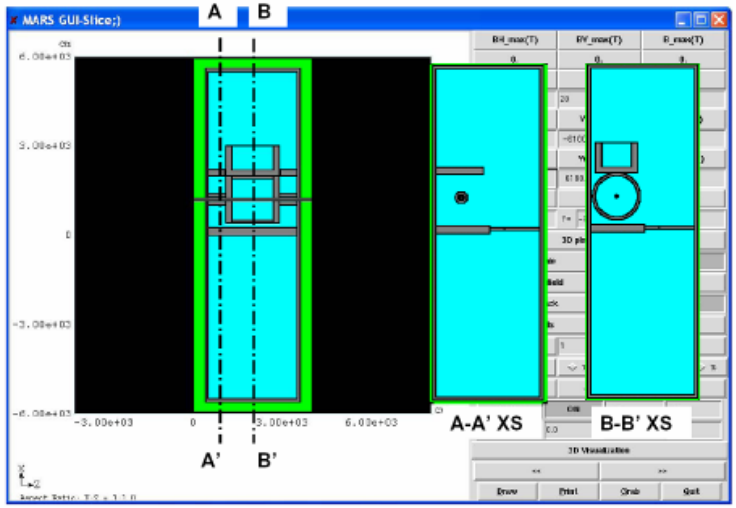




Self-shielding of GLD

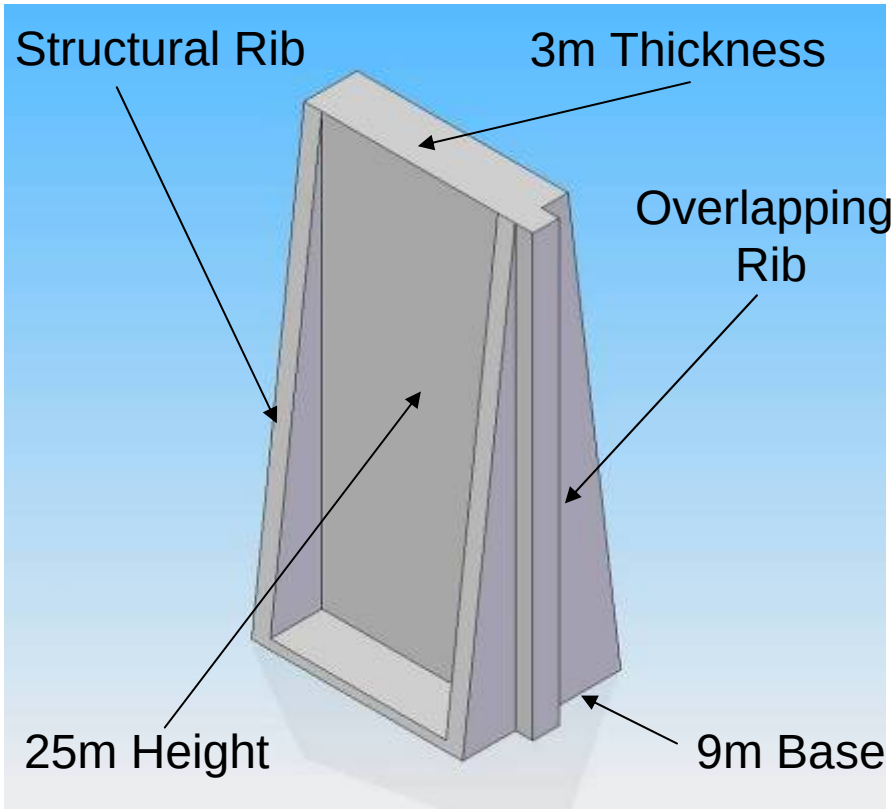
Shielding the "4th" with walls

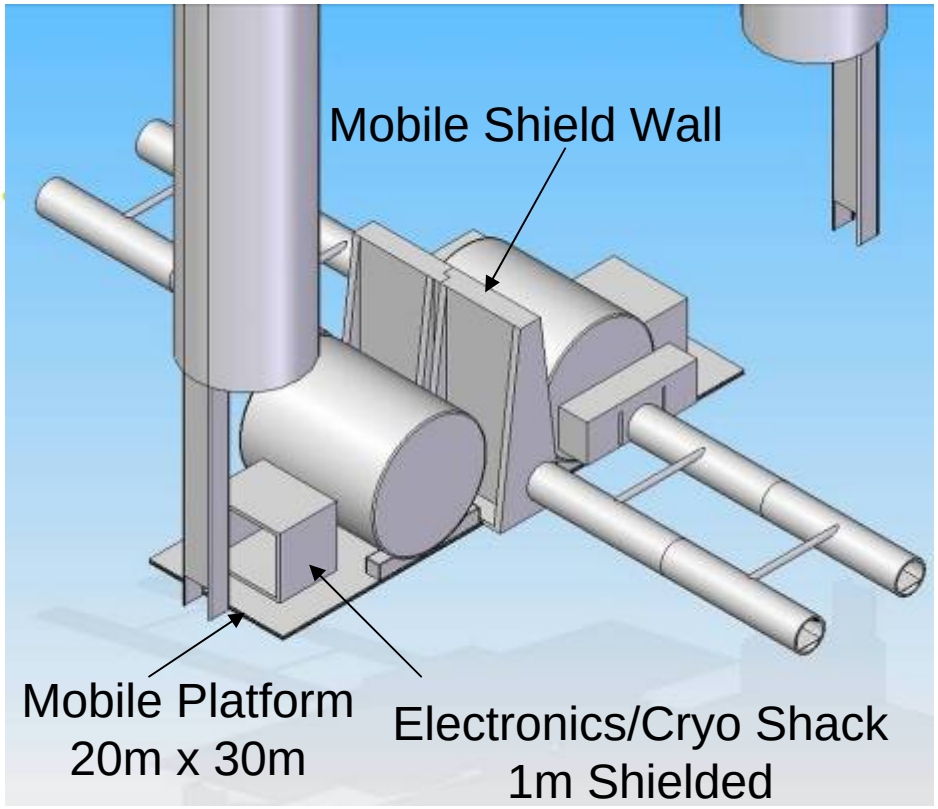


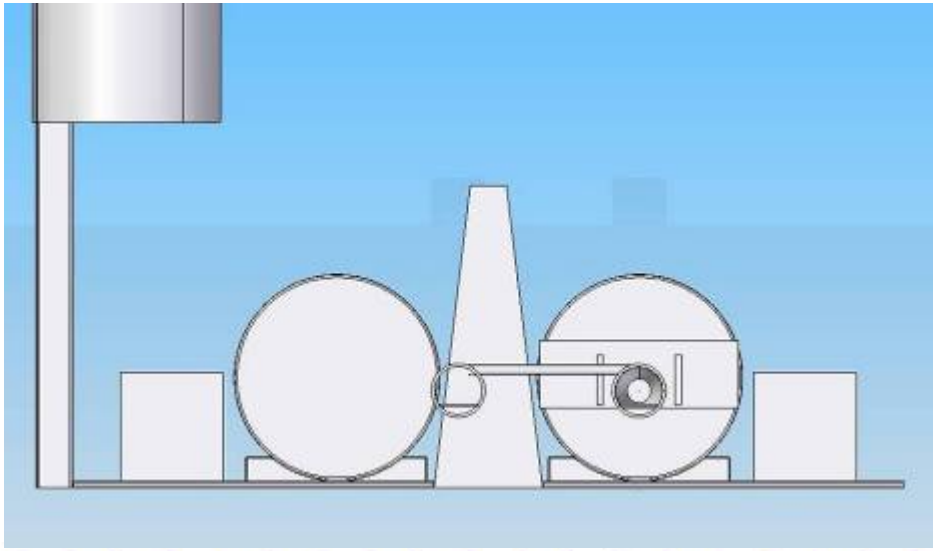


Working progress on IR design…

Illustration of ongoing work…
Designs are tentative & evolving



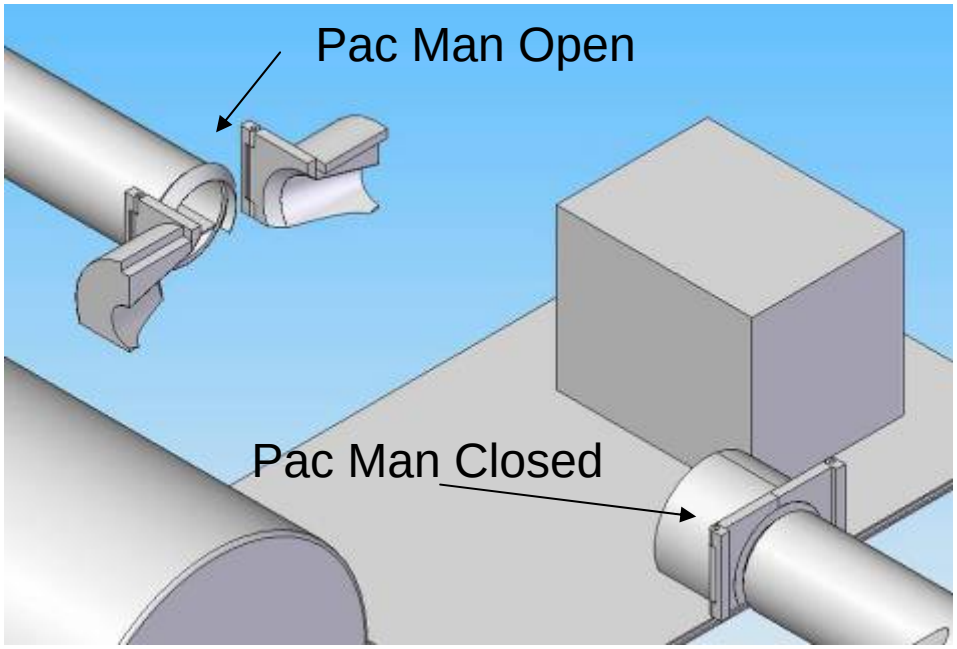


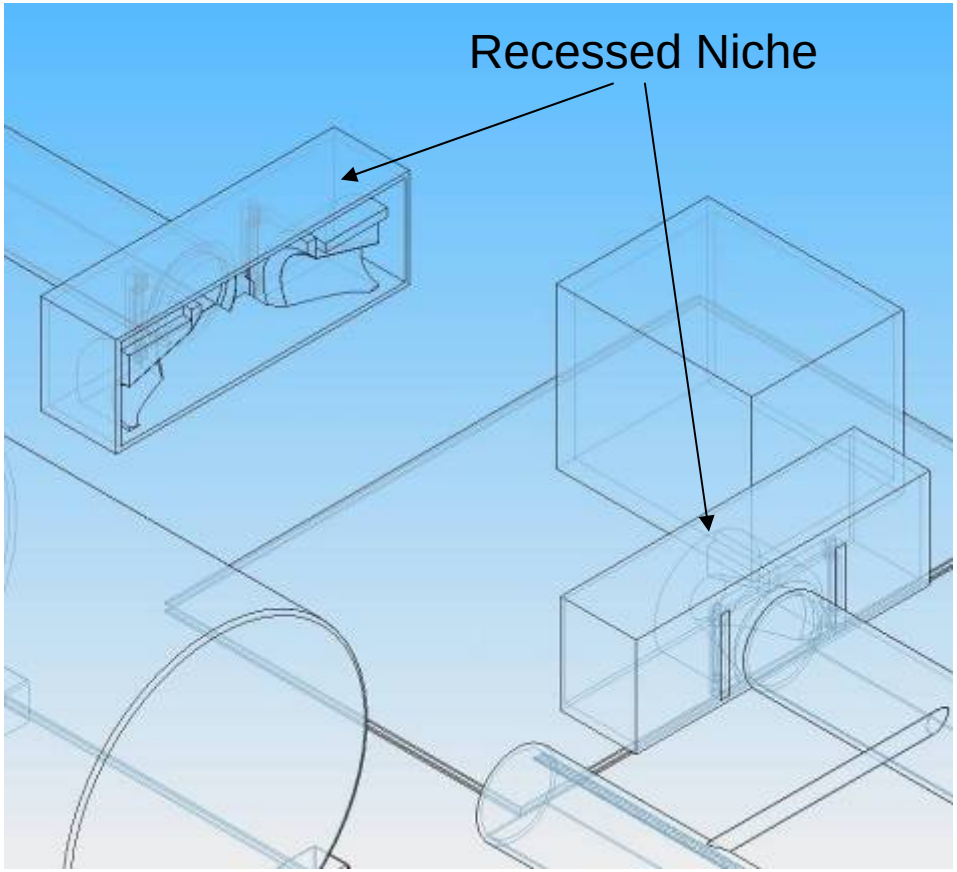


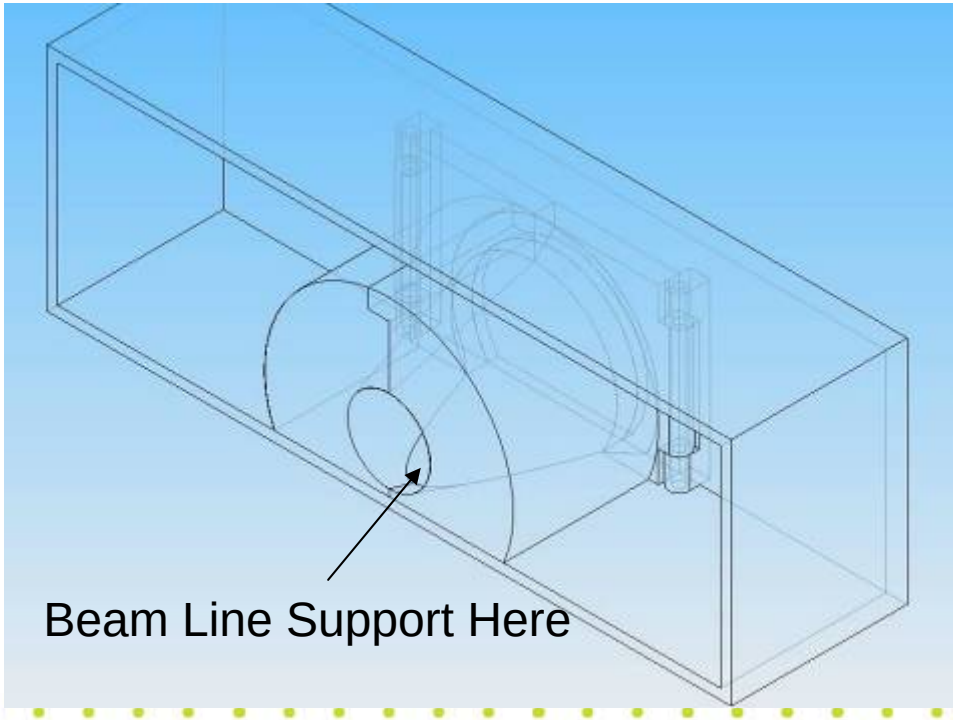
John Amann

Beamline shielding

Illustration of ongoing work…
Designs are tentative & evolving

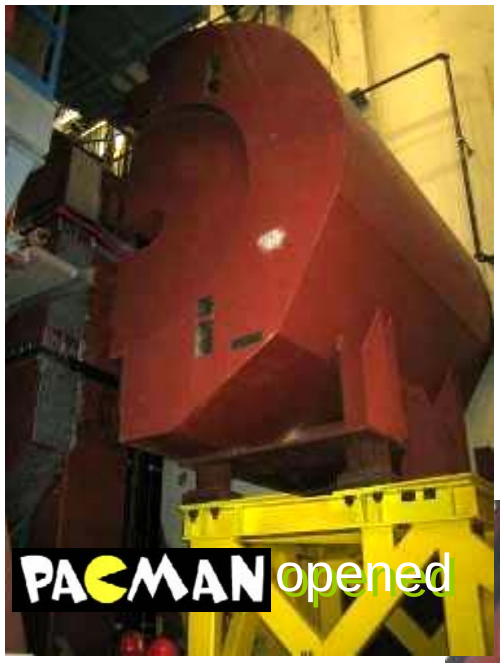






John Amann

Beamline shielding



Looking into experience of existing machines…

Air-pads at CMS

- Single air-pad capacity ~385tons
- Air-pads equipped with hydraulic jack for height adjustment & service
- Lift is ~8mm for 385t units
- Steel plates (~4cm) on the floor (compressed air 50bars)
- Inclination of ~1% of LHC hall floor is not a problem
- Last 10cm of motion on grease pads

Photo from the talk by Y.Sugimoto,
http://ilcphys.kek.jp/meeting/lcdds/archives/2006-10-03/

[Alain Herve, et al.]

14kton ILC detector would require ~36 such air-pads

Displacement, modeling

Idealized models

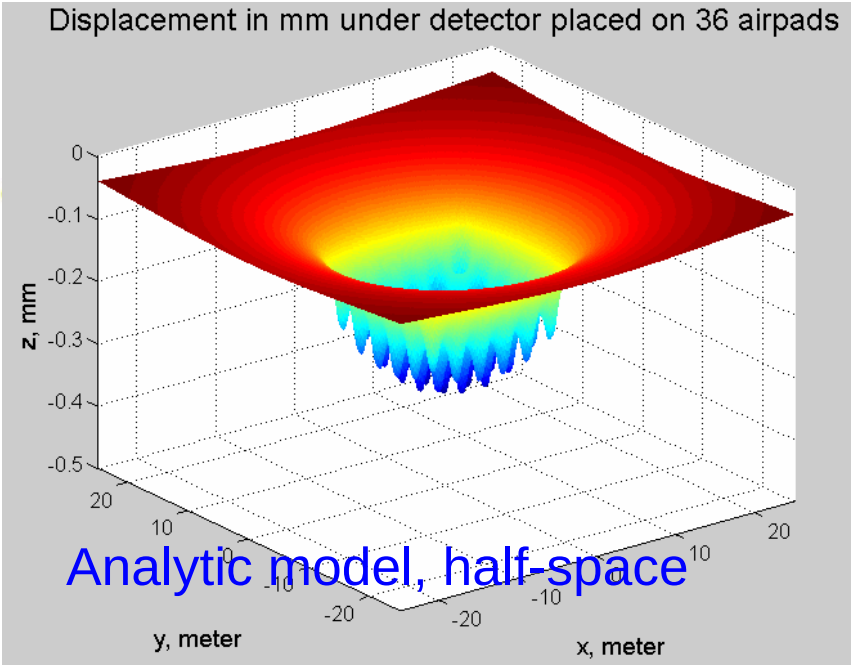
Short range deformation (~0.1mm) is very similar in both models.

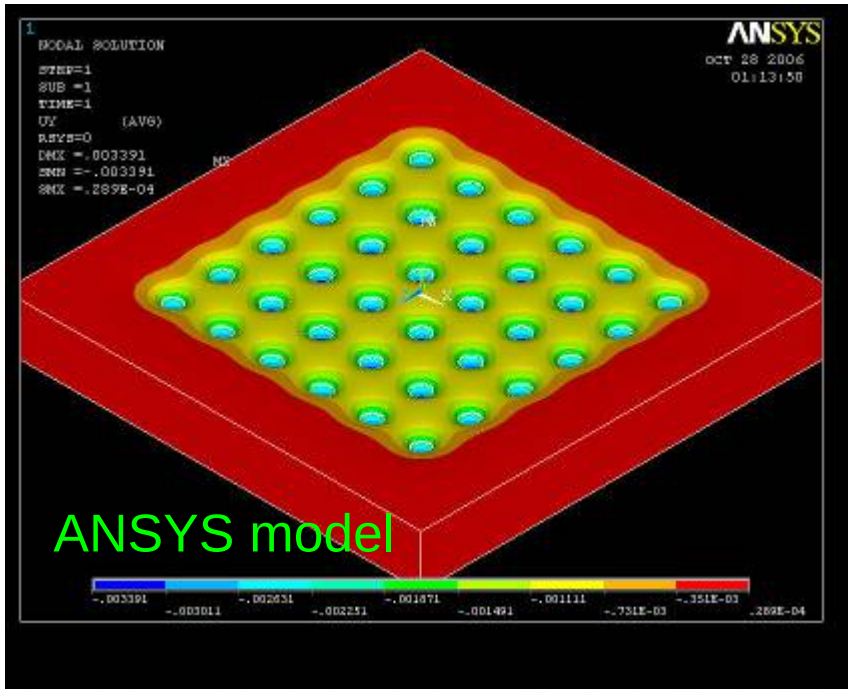
Long range (1/r) deformation (~0.3mm) is not seen in ANSYS because too thin slab in the model

More details (3d shape of the hall, steel plates on the floor, etc.) to be included.

Long term settlement, inelastic motion, etc., are to be considered.

Parameters: M=14000 ton; R=0.75m (radius of air-pad); E=3e9 kg/m^2, n=0.15 (as for concrete); Number of air-pads=36

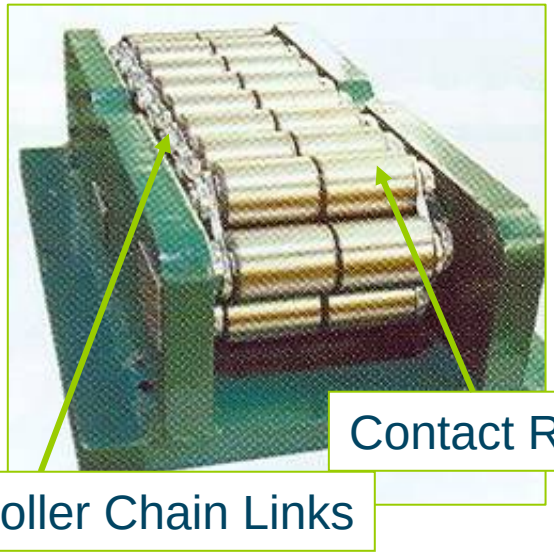


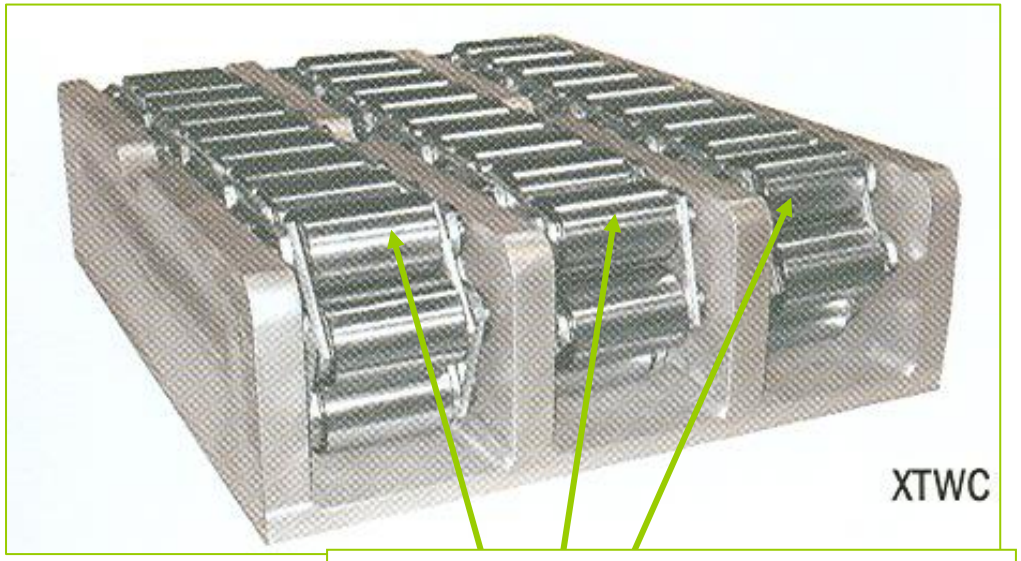


J.Amann, http://ilcagenda.cern.ch/conferenceDisplay.py?confId=1225

Hilman rollers is also a possibility

- For pre-determined path of motion for detector exchange, Hilman rollers may be suitable

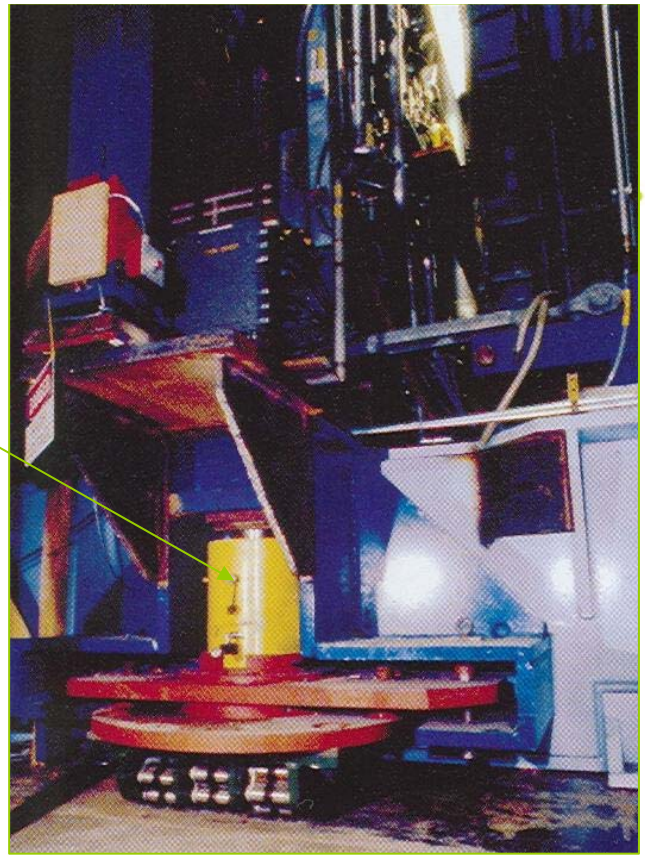


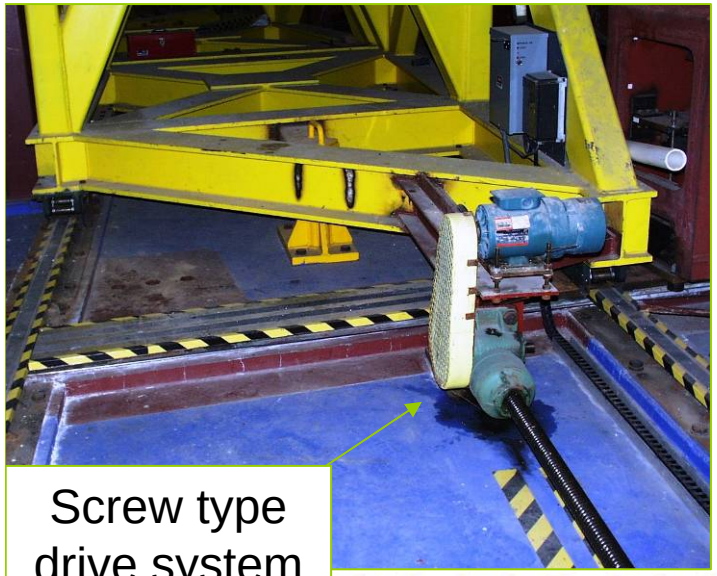


- Standard capacity to 1kton
- While not standard items, the 5kton capacity rollers have been manufactured
- Durability is important and to be studied

Other considerations

Hydraulic Jacks/Shims

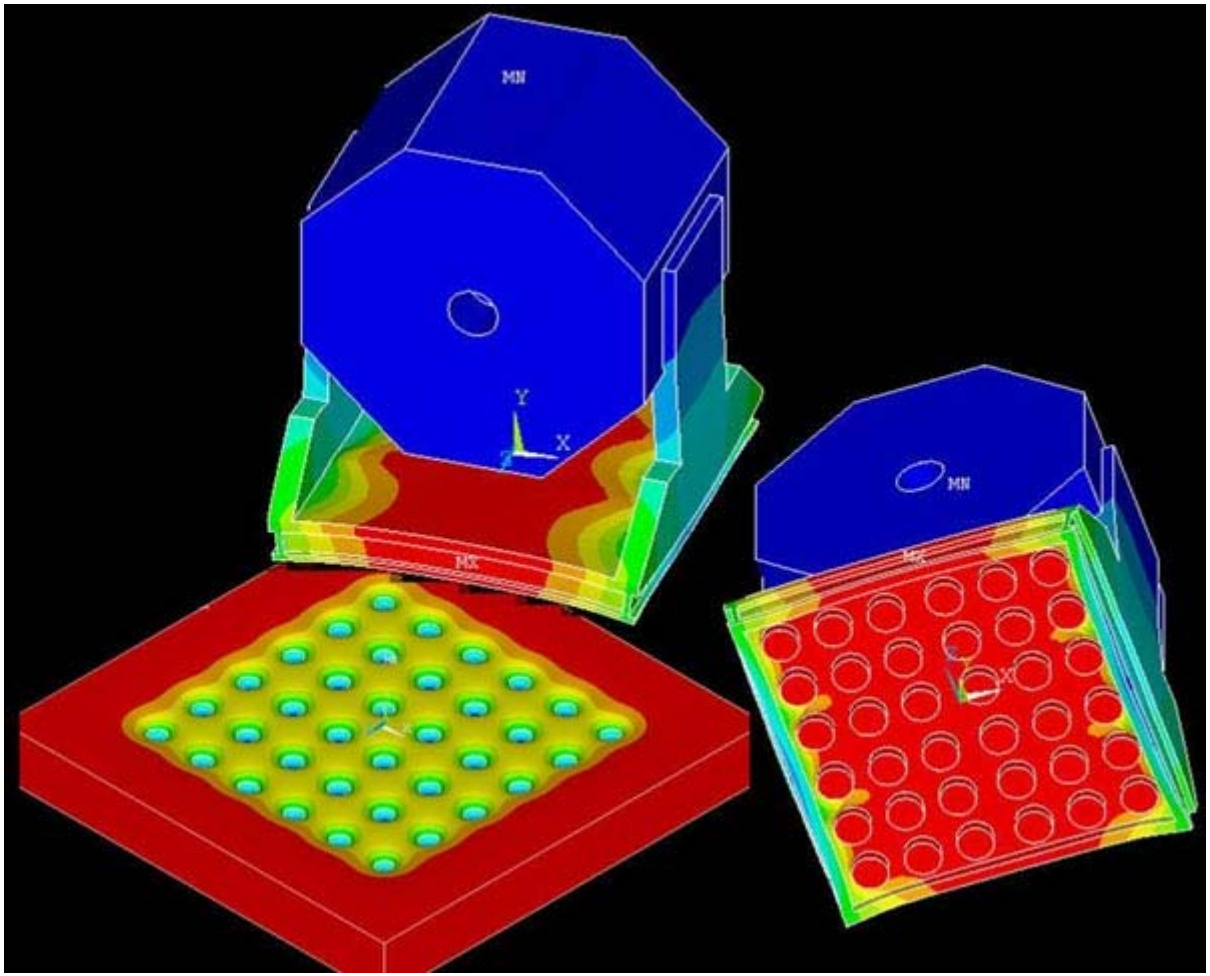




Screw type drive system

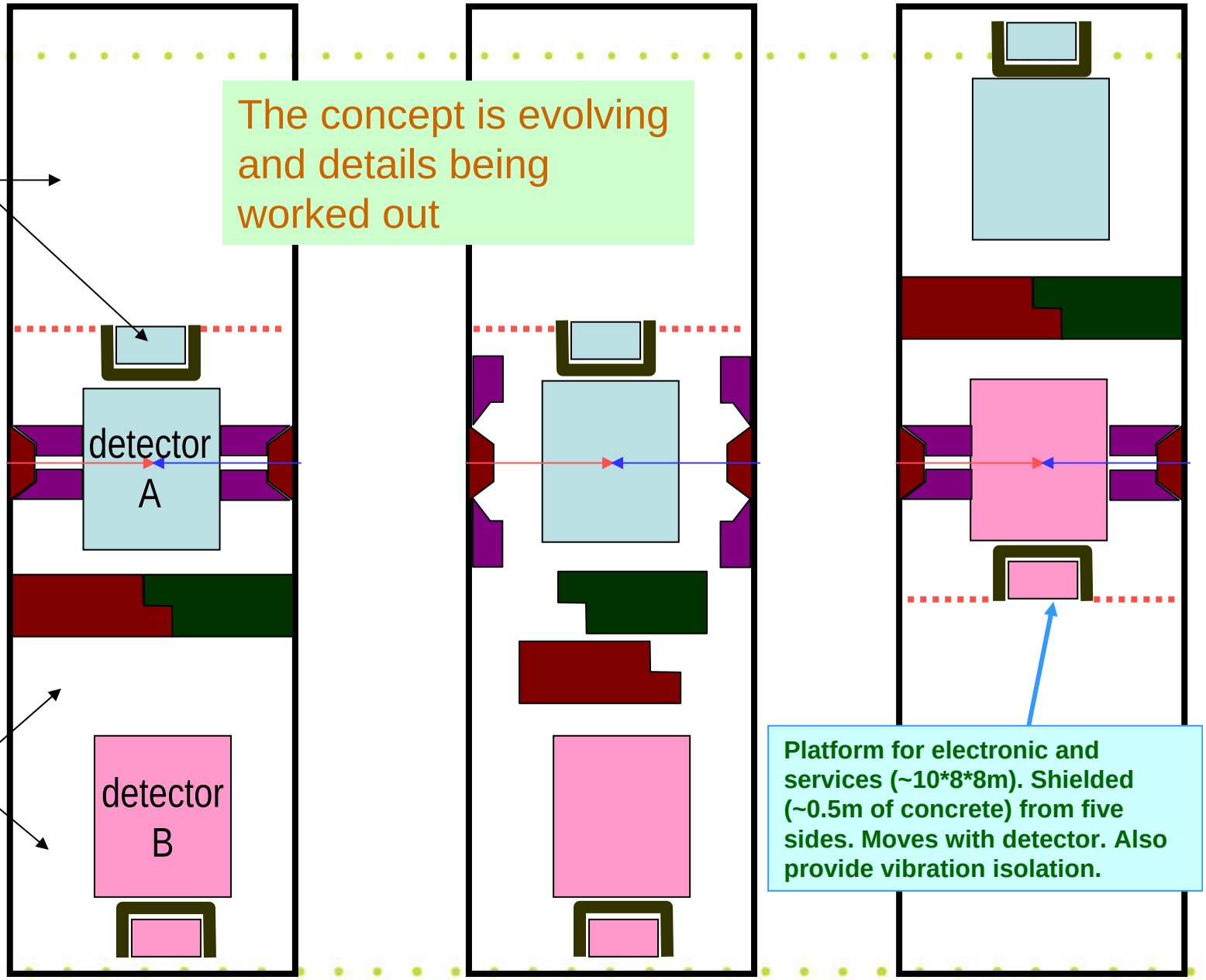
- Hydraulic jacks for adjustment
- Drive systems
- Guiding mechanism
- Alignment, etc

Detector support

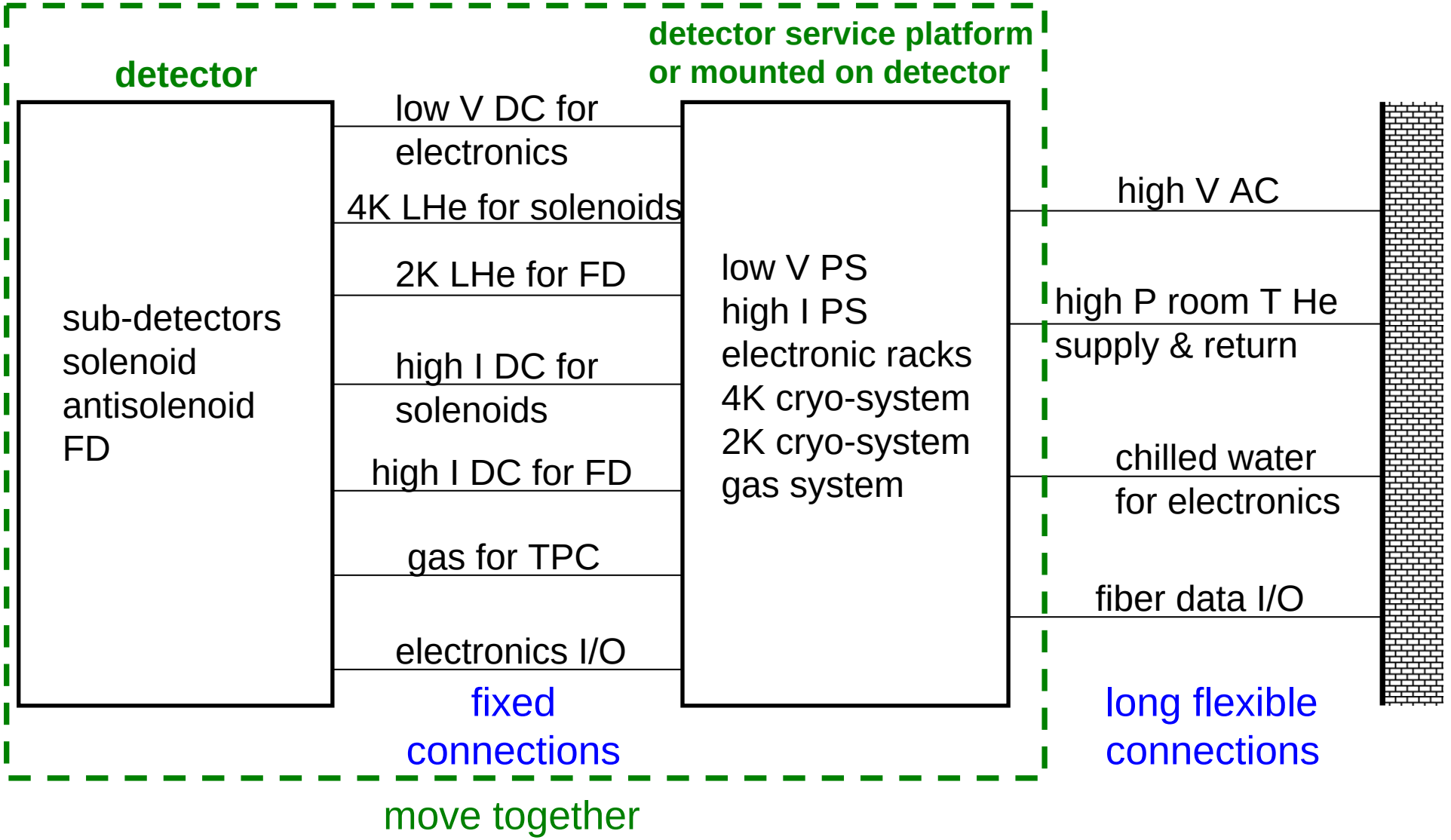


- Detector may have a supporting platform
  - **size of IR hall increased to allow for this**

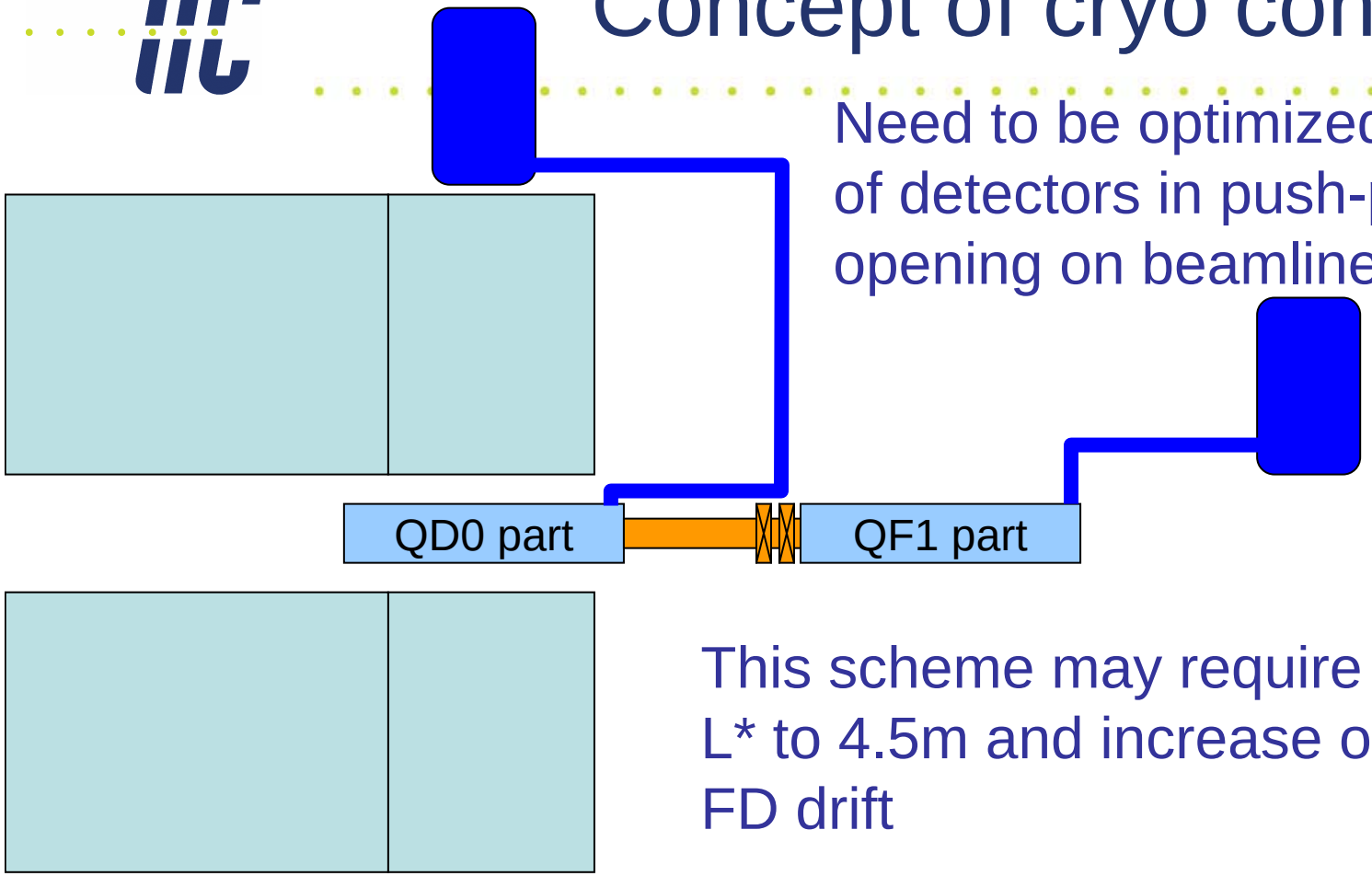
Concept of IR hall with two detectors



Concept of detector connections



Concept of cryo configuration



Need to be optimized for fast switch of detectors in push-pull and fast opening on beamline

This scheme may require lengthening L* to 4.5m and increase of the inner FD drift

Opening of detectors on the beamline (for quick fixes) may need to be limited to a smaller opening (MDI negotiation issue!) than what could be done in off-beamline position

Finishing up…

- Machine Detector Interface issues which require careful balance of very different constrains from Detectors and Machine
  - **IR design, FD, support, connections, alignment**
  - **Detector design, opening, movements**
  - **Backgrounds, machine and beam related**
  - **Conventional facilities**
  - **Stability**
  - **Services**
  - **Radiation safety**
  - **etc**

Summary

- Interaction Region is a machine area where balance of design constraint from many groups is especially important
- The Beam Delivery Design group is looking forward to work on IR design together with Detector colleagues in the EDR phase of ILC

Thanks

- BDS design team
- MDI panel
- Detector colleagues
- Push-Pull evaluation task-force
- Colleagues from LHC, CERN
- All colleagues involved in BDS & MDI work