Machine Detector Interface Issues

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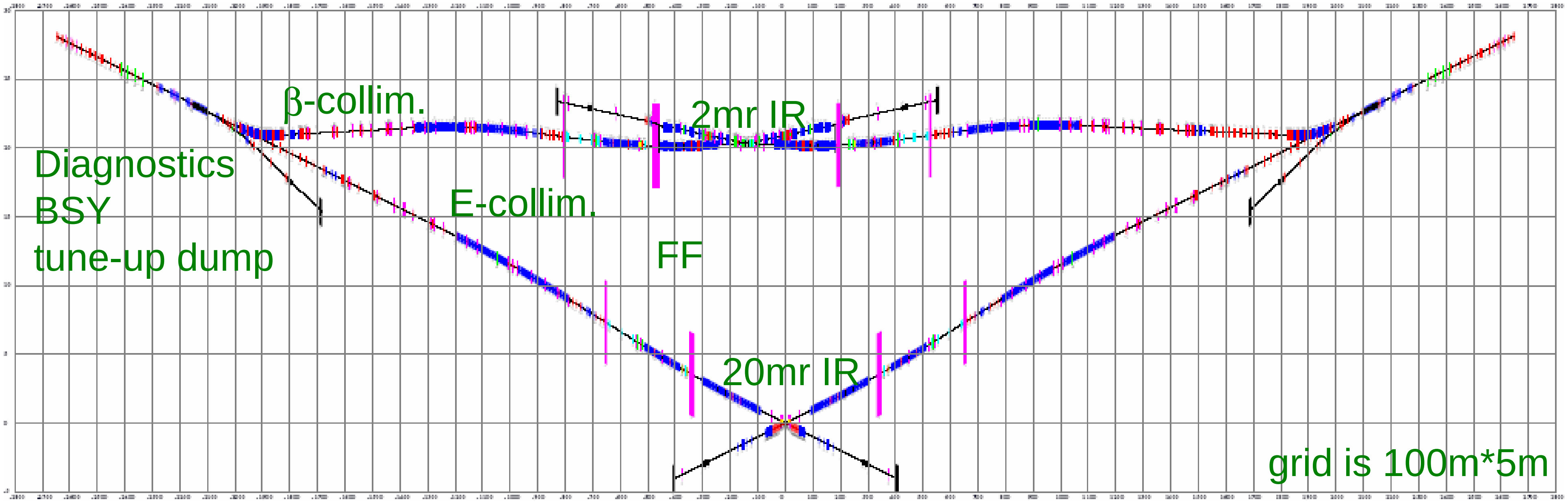
Outline

- **Beam Delivery / MDI updates since Vancouver:**
  crossing angle change
  single IR hall
  muon walls
- **Under active discussion:**
  surface assembly model for detector
  ‘push-pull’ of two detectors at single IR
- **Low-P machine parameters option**

Vancouver BDS baseline



Two IRs:

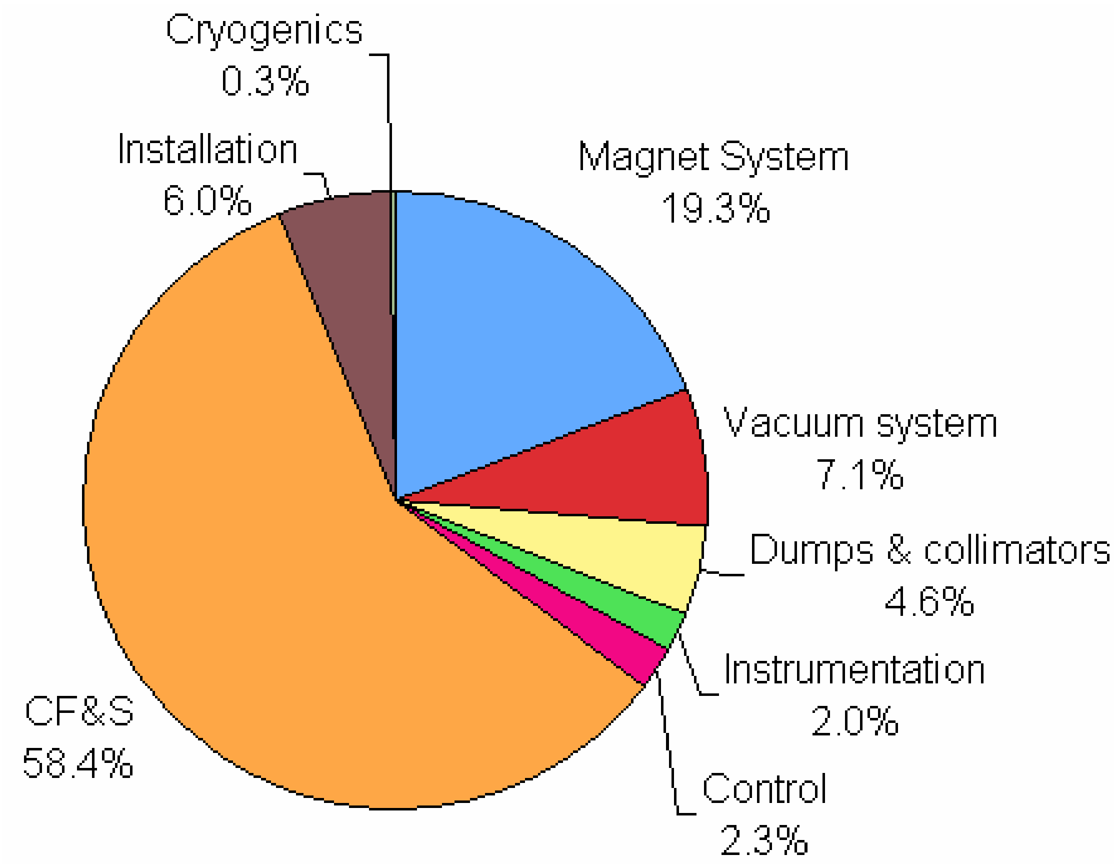
20 / 2 mrad

longitudinal separation

Vancouver BDS cost

Cost drivers

- CF&S
- Magnet system
- Vacuum system
- Installation
- Dumps & Collimators
- Control
- Instrumentation



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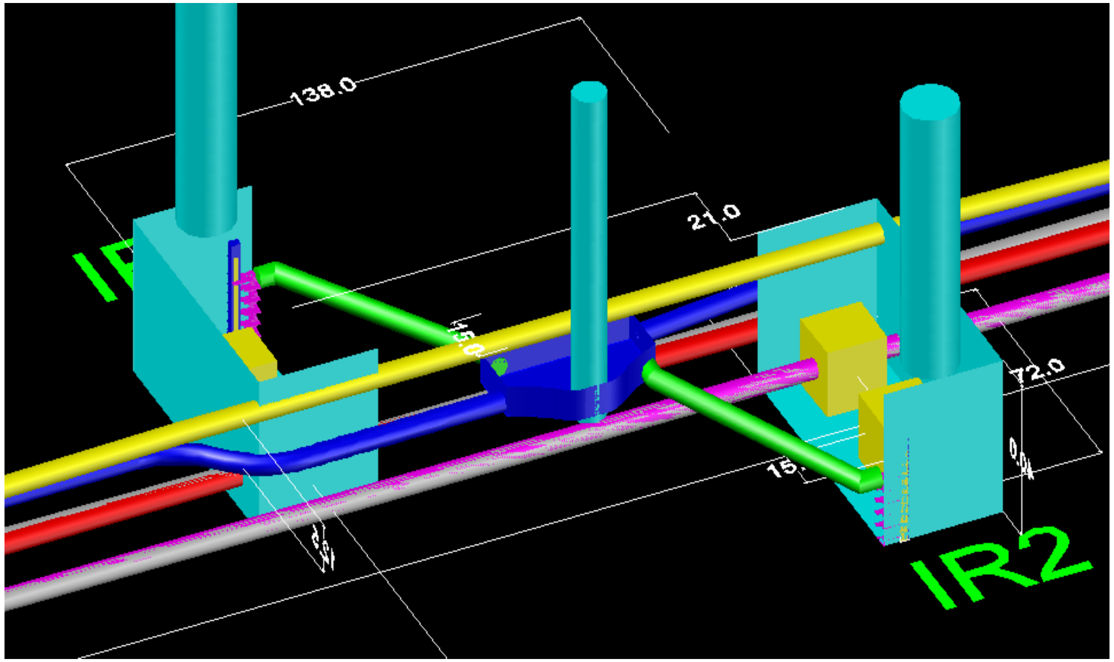
CF&S conceptual layout



20/2 two IR halls

Vancouver BDS Cost by IR

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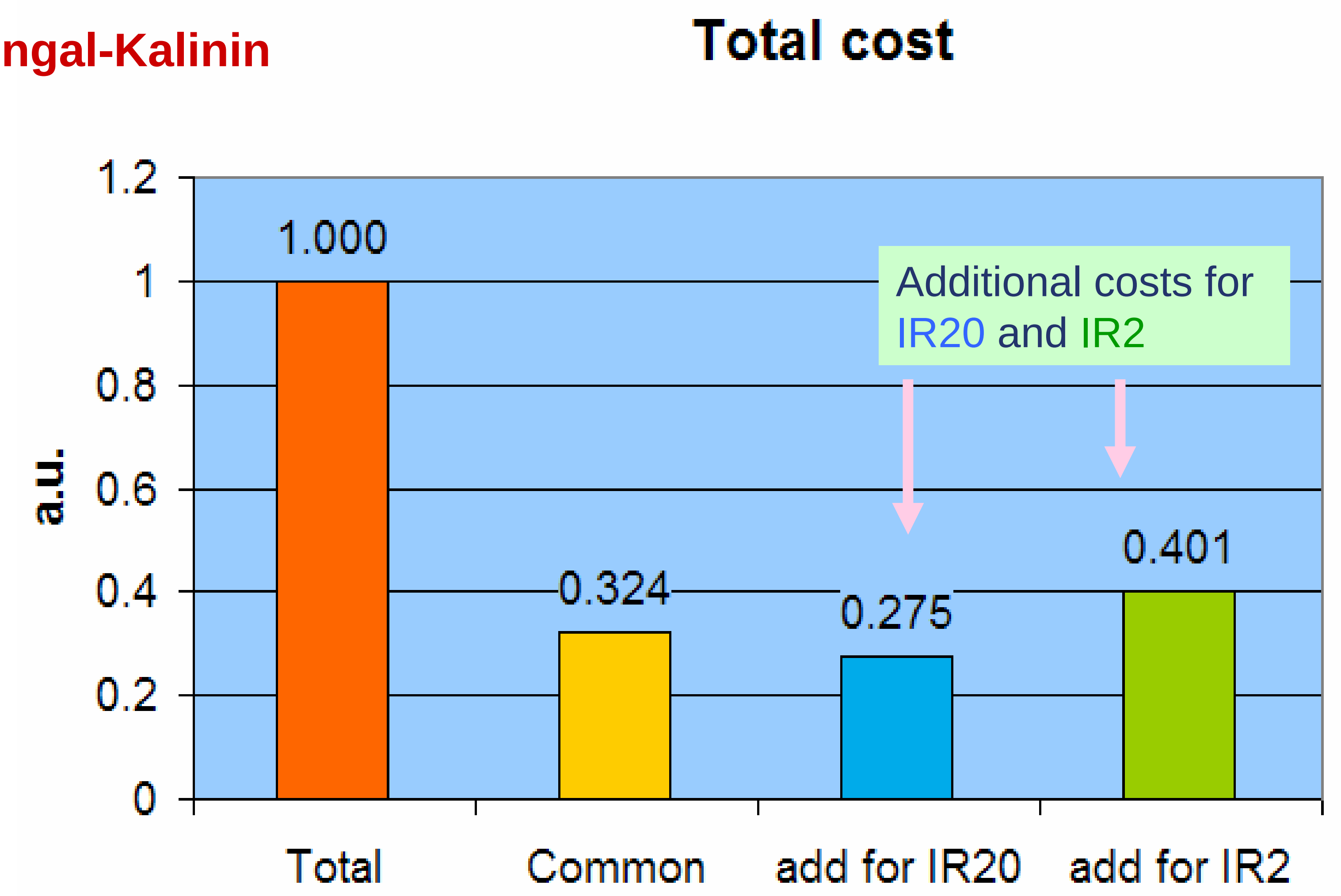
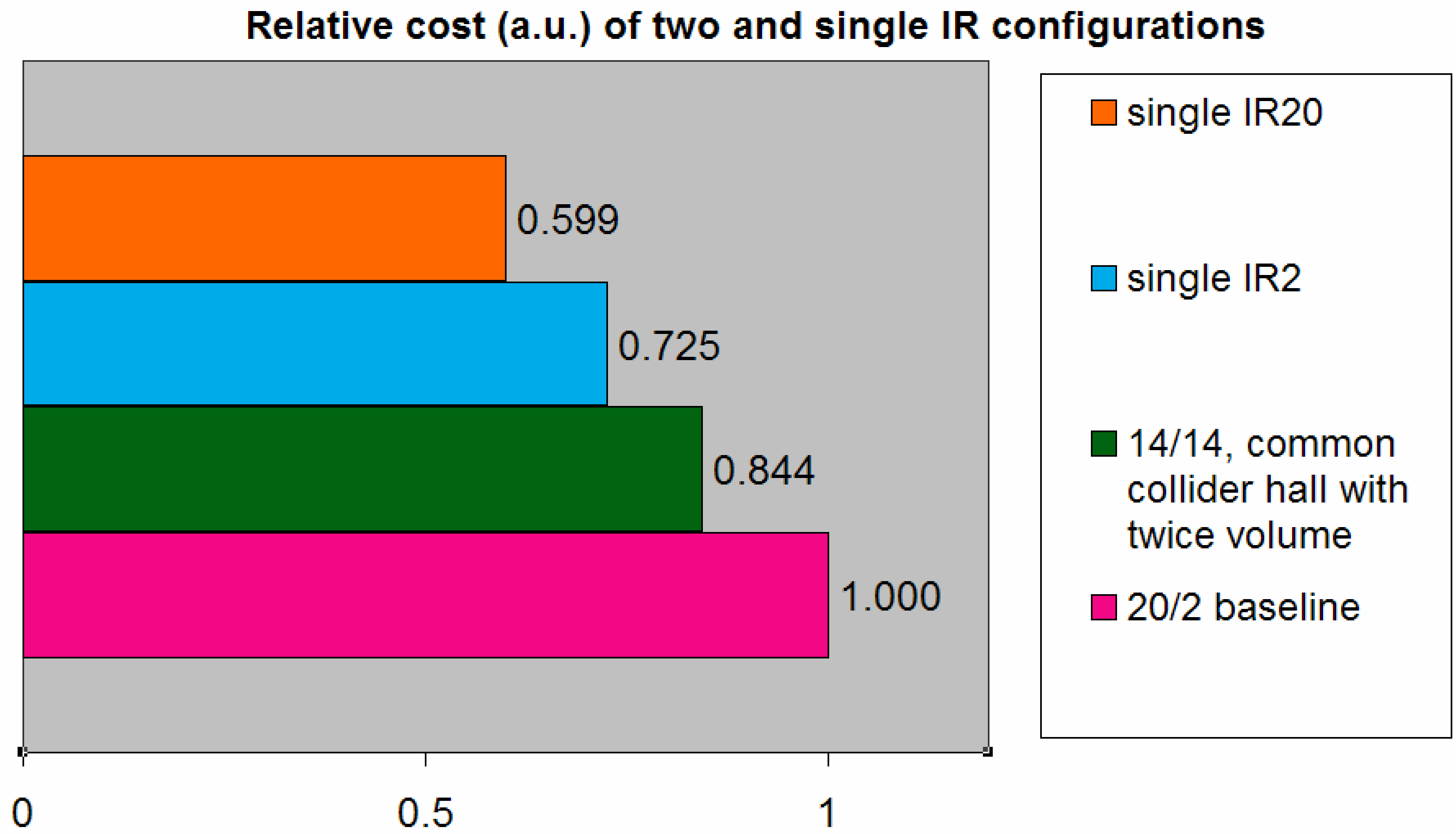


Costs of different configurations



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2 mrad and 20 mrad IRs

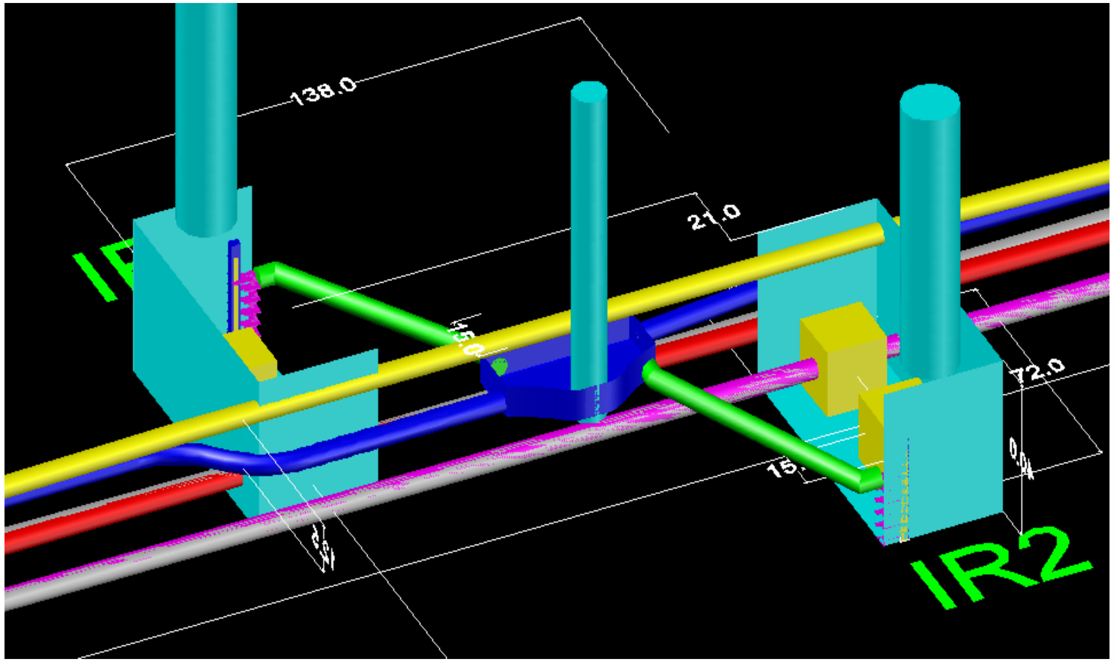
2 mrad: small separation of extraction and incoming beams:

- Complicated magnets
- Backscattered radiation in IR
- Long extraction line with larger apertures
- Higher cost and technically more difficult

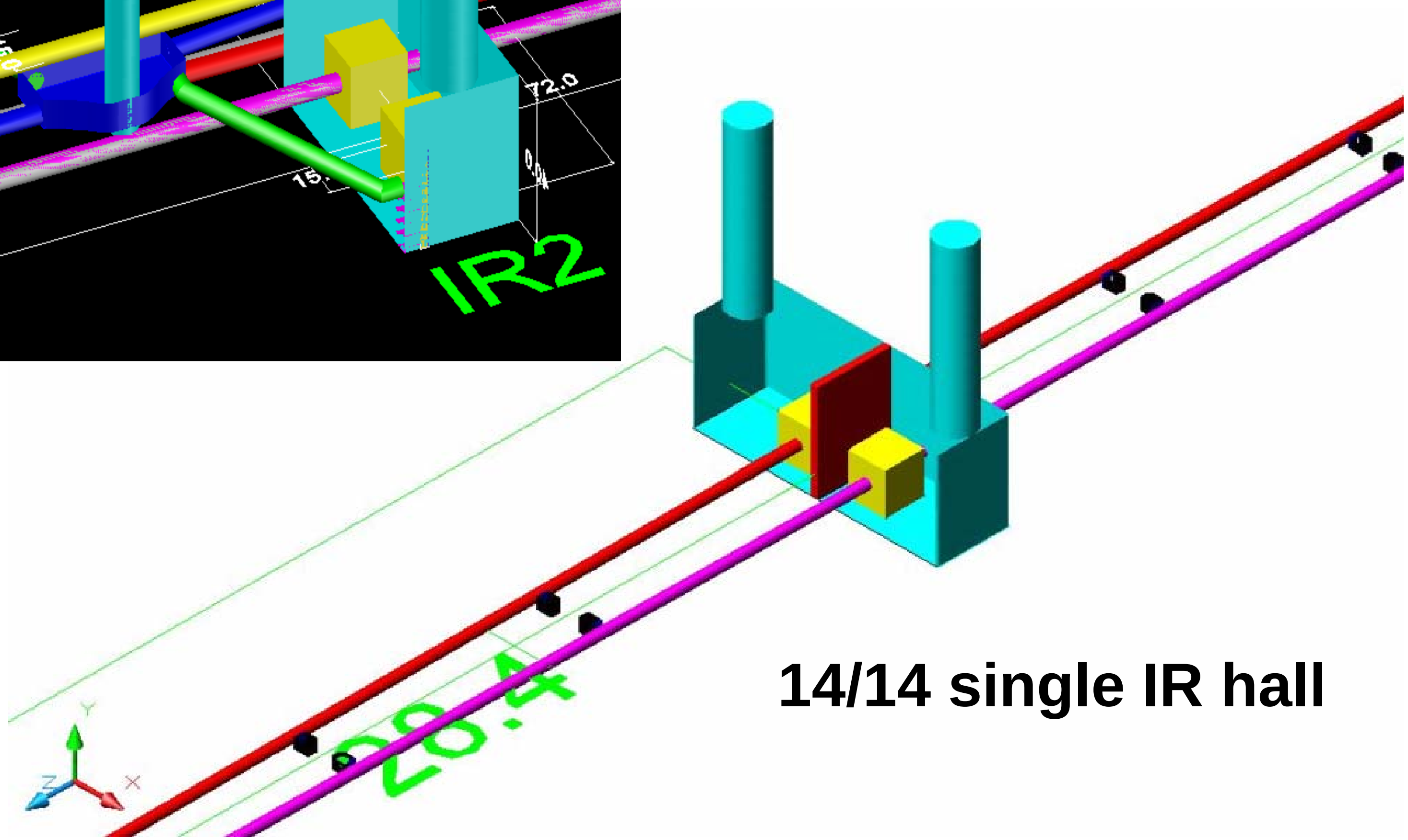
20 mrad based on compact SC quadrupoles developed at Brookhaven:

- Technology works down to ~14 mrad crossing
- Physics impact of 14 mrad vs 2 mrad is small
- Design well studied and developed

CF&S conceptual layout



20/2 two IR halls



14/14 single IR hall

Change Control Requests

CCR for 14/14 configuration + single IR hall submitted on July 28

MDI panel meeting on Aug. 15 to discuss

- **14/14 configuration**
- **single collider hall**
- **5m muon spoilers instead of 9m+18m: CCR subm. Sept 8**
- **on-surface detector assembly: CCR subm. Sept 21**

The MDI panel accepted those changes. The conclusions were sent to WWS and CCB.

The WWS OC was asked to comment on first two items and also accepted them.

Change Control Requests

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- 14/14 configuration **APPROVED**
- single collider hall **APPROVED**
- 5m muon spoilers instead of 9m+18m **APPROVED**
- on-surface detector assembly: CCR subm. Sept 21 **WITH WWS**

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From minutes of MDI panel

(abridged quote)

The (physics) mode most affected by crossing angle is the slepton pair production where the slepton-LSP Δm is small. The main background is 2-γ processes and an efficient low-angle electron tag by BEAMCAL is needed to veto them.

For a large crossing angle (14 or 20mrad), anti-DID is needed to collimate the pair background along the outgoing beam. For 14mrad crossing with anti-DID, the … background is expected to be comparable to the 2mrad case while the signal efficiency reduces by about 30% to 40%. This is mainly due to the 2nd hole of BEAMCAL that is needed for the large crossing angle which will force additional cuts to remove the 2-photon and other backgrounds.

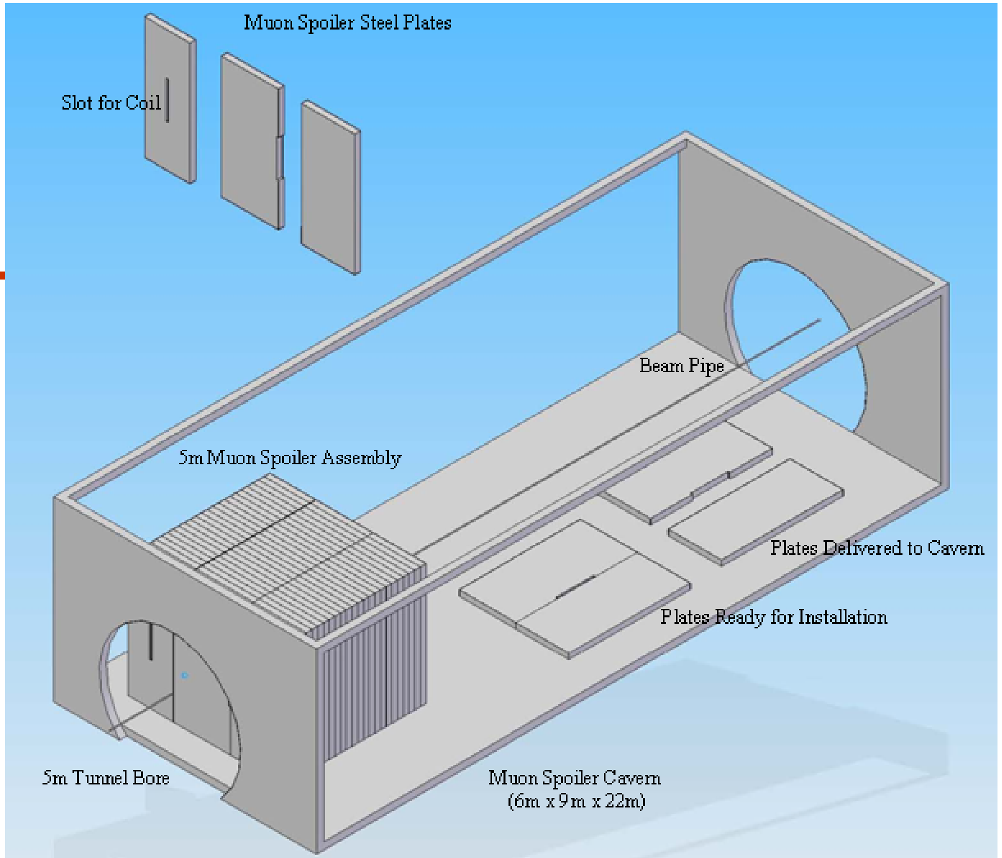
This is not based on a complete analysis but on a study of the pair background distribution on the BEAMCAL: that for 20mrad crossing with anti-DID was found to be essentially the same as the 2mrad case. A complete analysis is needed for 14mrad with anti-DID, also covering different values of the mass difference (namely, for different SUSY parameter space). Backgrounds considered here are mainly the pair background and a lesser extent Bhabha events. More studies are sorely needed in this area.

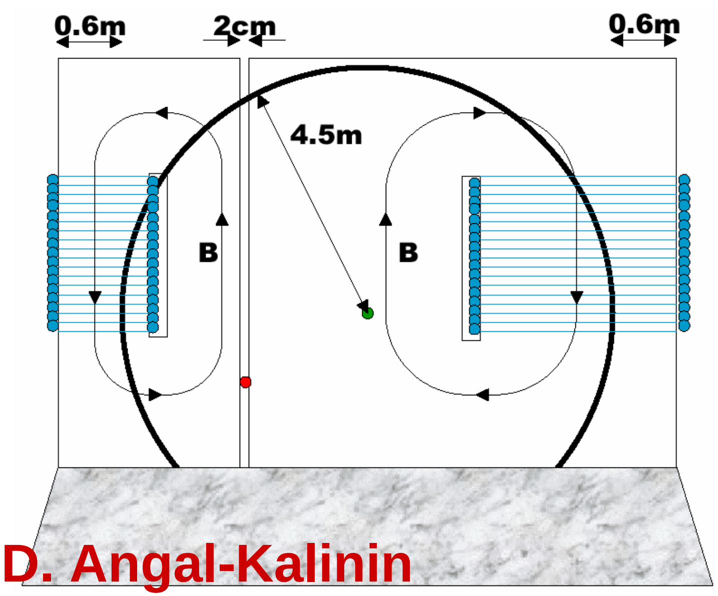
With this limited information, the MDI panel thinks that the 14mrad is acceptable as the baseline at this time. However, we would like to stress that the 2mrad crossing angle is clearly desirable than larger crossing angles for the slepton search, and R&Ds related to 2mrad should be encouraged.

Muon walls

Purpose:

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





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Scheme of a muon wall installed in a tunnel widening which provides passage around the wall

Baseline configuration:
18m and 9m walls in each beamline

Muon walls CCR

Baseline (18m+9m walls) reduce muon flux to < 10muons/200bunches if 0.1% of the beam is collimated

Considered that

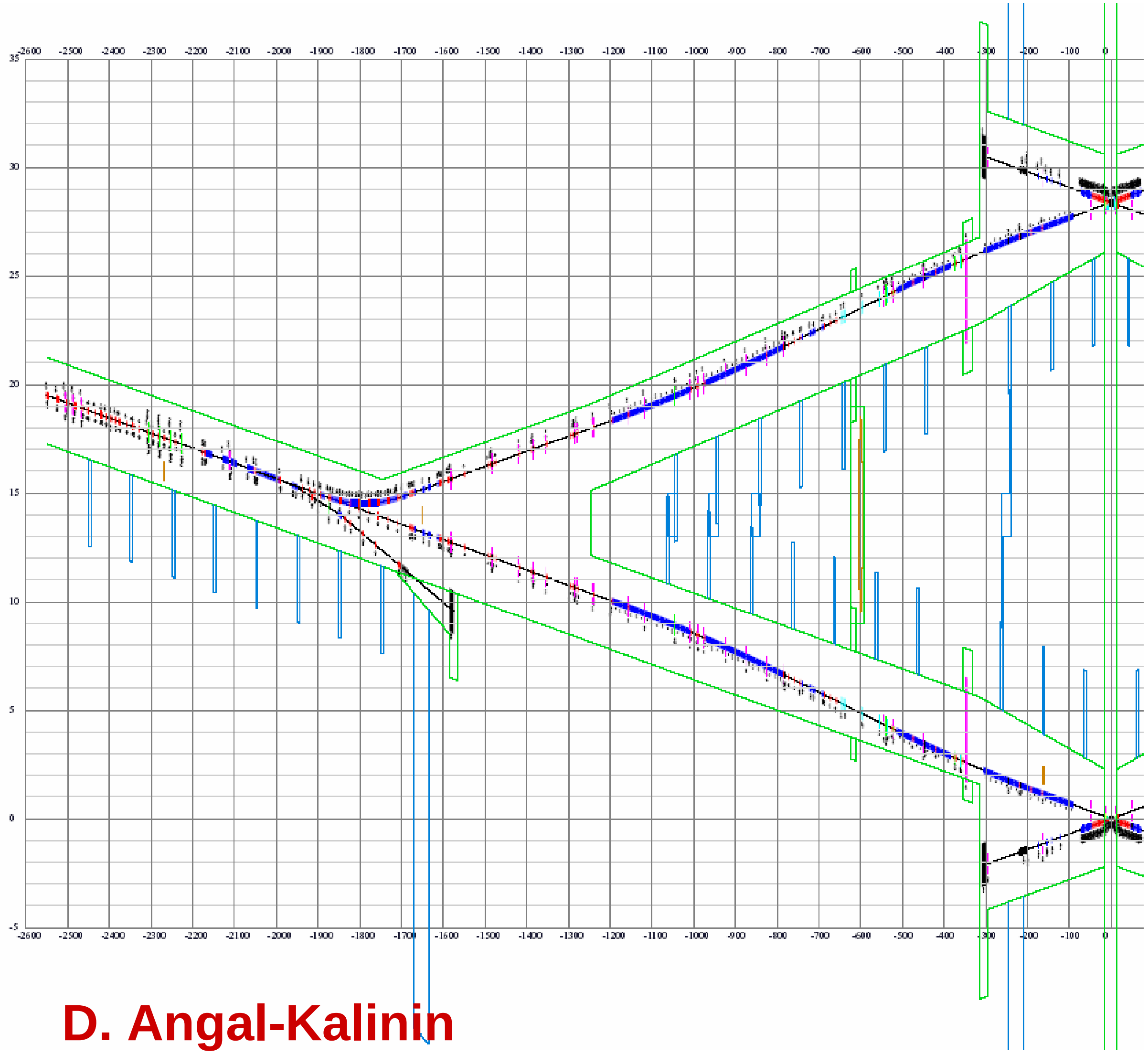
- The estimation of 0.1% beam halo population is conservative
- The min muon wall required for personnel protection is 5m
- Detector can tolerate higher muon flux
- Cost of long muon spoilers is substantial

Suggested CCR to install initially only 5m single walls

- The caverns will be built for full length walls, allowing upgrade
- Such upgrade could be done in ~3month

With single 5m wall there is ~400muon/200bunches (500 GeV CM, 0.1% of the beam collimated) which corresponds to ~0.15% occupancy of TPC

Tentative layout of 14/14 configuration



Common IR hall ~100m (L) x 30m (W) at z=0 with 28.4m ΔX

- 4m tunnels in all BDS
- Alcoves 4*6m every 100m, no service tunnel
- Small 0.8m shaft for lasers near laser wire, upstream and downstream diagnostics
- Long muon walls (9m & 18m) replaced by single 5m wall
- Passages near muon walls (main and spare one)
- 9m machine access shaft in the "BDS triangle"
- Shortened extraction line
- Shorter tapered tunnels

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On-surface (a la CMS) detector assembly

According to tentative CF&S schedule, detector hall would not be ready for detector assembly until 4y11m after project start

If so, cannot fit into the goal of “7 years until first beam” and “8 years until physics run”

Surface assembly allows earlier start by 2-2.5 years and meets this goal

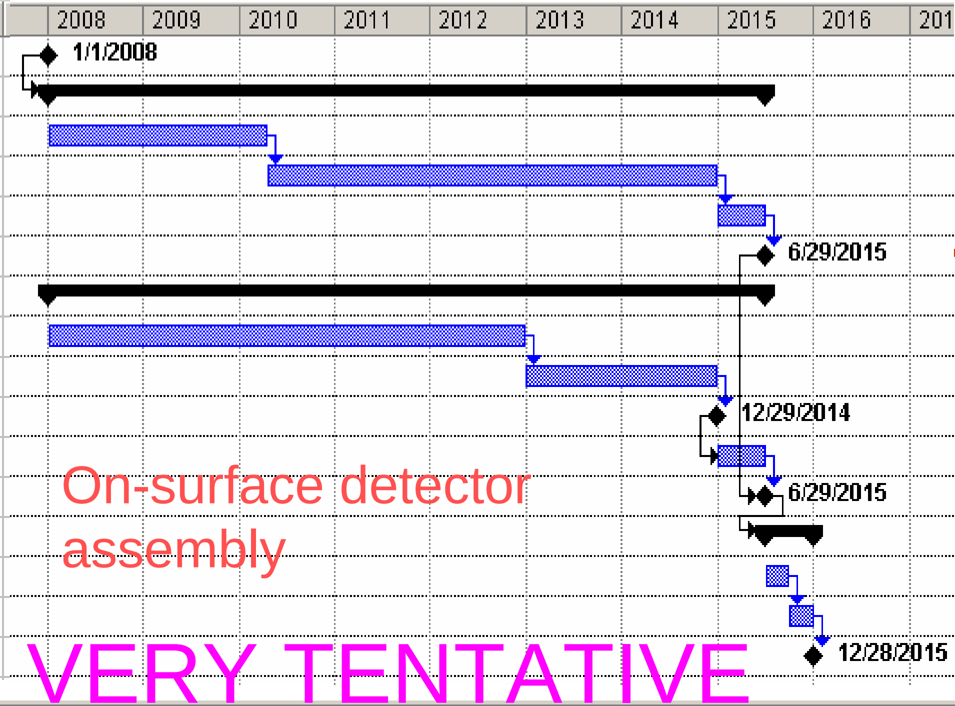
The collider hall size is also smaller in this case

- surface building needed, but potential savings still substantial

Details of sizes of underground hall + surface building, shafts, cranes above and below ground … TBD

- needs serious engineering study of assembly, installation, access, safety, services, cabling …

Task Name	Duration	Start	Finish
Project approved	0 days	1/1/2008	1/1/2008
⊟ **Construct detector**	**391 wks**	**1/1/2008**	**6/29/2015**
prepare surface building for detector	120 wks	1/1/2008	4/19/2010
detector assembly	245 wks	4/20/2010	12/29/2014
detector surface commissioning	26 wks	12/30/2014	6/29/2015
Detector ready for BDS	0 days	6/29/2015	6/29/2015
⊟ **Construct beamlines**	**391 wks**	**1/1/2008**	**6/29/2015**
prepare underground tunnels	260 wks	1/1/2008	12/24/2012
beamline hardware installation	105 wks	12/25/2012	12/29/2014
Start of beam commissioning	0 days	12/29/2014	12/29/2014
BDS beamline pre-commissioning	26 wks	12/30/2014	6/29/2015
BDS ready for detector	0 days	6/29/2015	6/29/2015
⊟ **Final assembly & commissioning**	**26 wks**	**6/30/2015**	**12/28/2015**
Detector underground assembly	13 wks	6/30/2015	9/28/2015
Final beam commissioning	13 wks	9/29/2015	12/28/2015
Ready for physics run	0 days	12/28/2015	12/28/2015



Task Name	Duration	Start	Finish
Project approved	0 days	1/1/2008	1/1/2008
⊟ **Construct detector**	**297 wks**	**12/25/2012**	**9/3/2018**
detector assembly	271 wks	12/25/2012	3/5/2018
detector underground commiss.	26 wks	3/6/2018	9/3/2018
Detector ready for IP	0 days	9/3/2018	9/3/2018
⊟ **Construct beamlines**	**557 wks**	**1/1/2008**	**9/3/2018**
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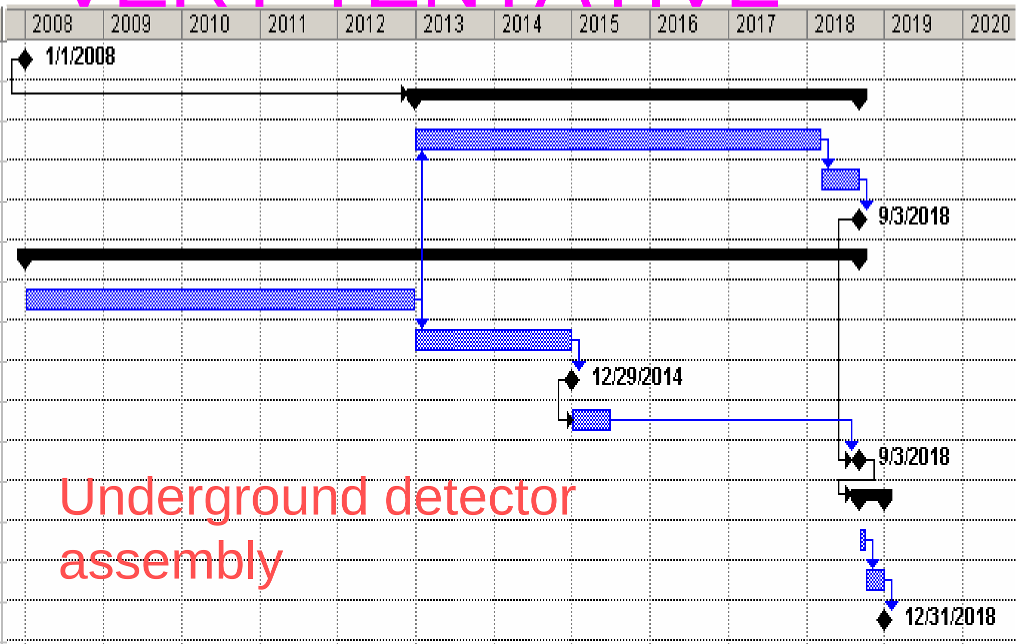
beamline hardware installation	105 wks	12/25/2012	12/29/2014
Start of beam commissioning	0 days	12/29/2014	12/29/2014
BDS beamline pre-commiss.	26 wks	12/30/2014	6/29/2015
IP ready for detector	0 days	9/3/2018	9/3/2018
⊟ **Final assembly & commissioning**	**17 wks**	**9/4/2018**	**12/31/2018**
Detector moved to IP	4 wks	9/4/2018	10/1/2018
Final beam commissioning	13 wks	10/2/2018	12/31/2018
Ready for physics run	0 days	12/31/2018	12/31/2018



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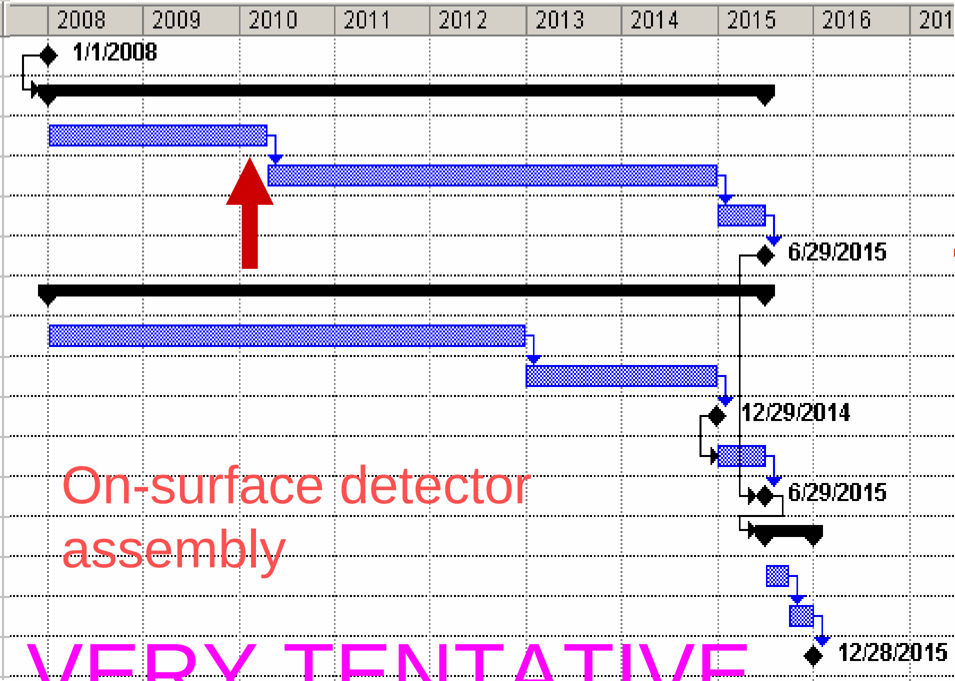

On-surface detector assembly

VERY TENTATIVE

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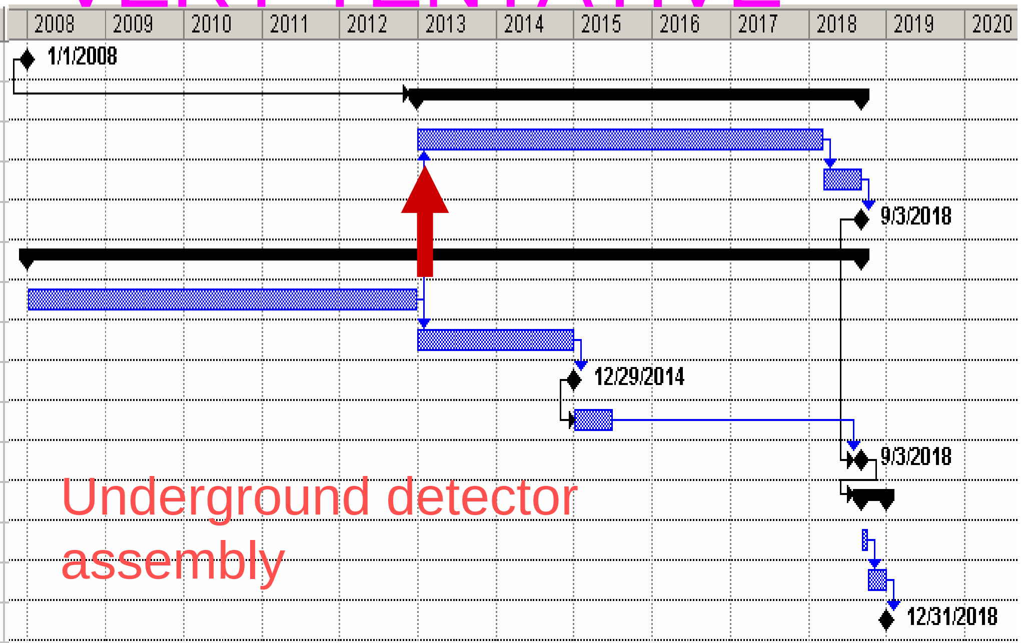
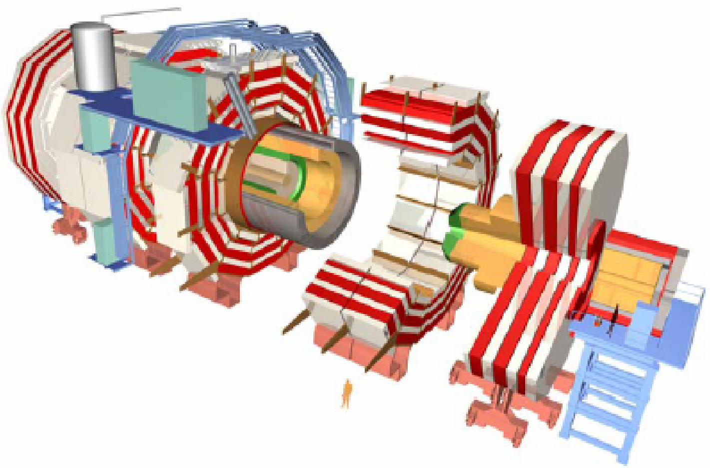
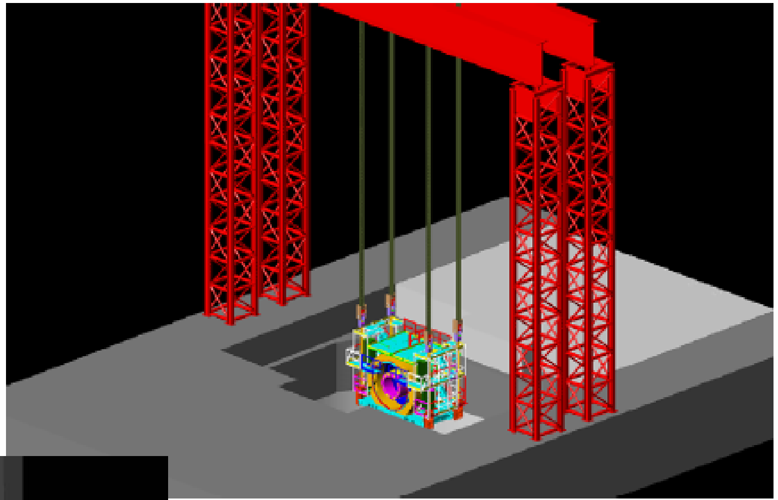
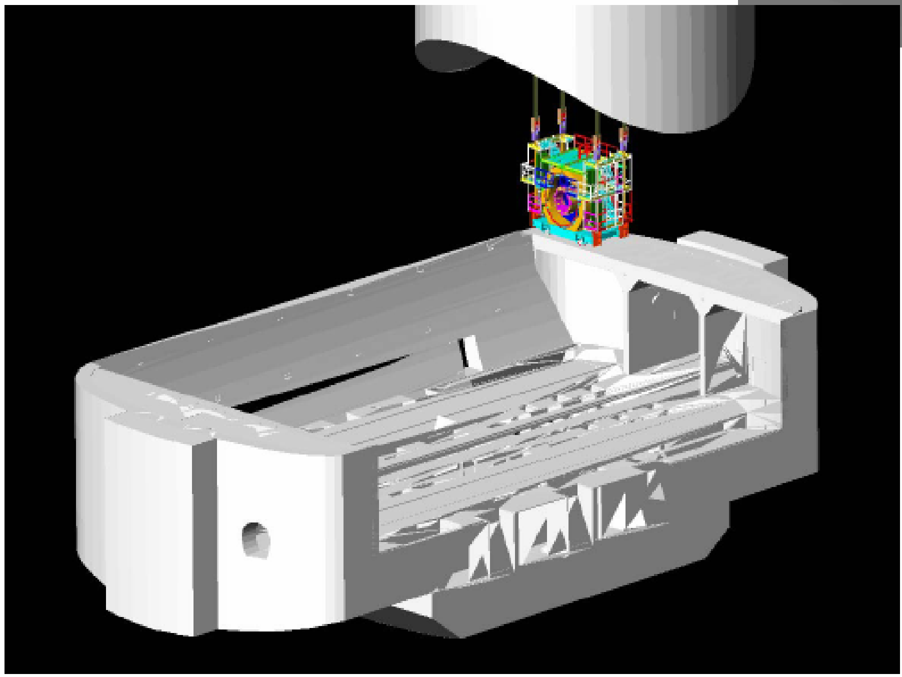
Final beam commissioning	13 wks	10/2/2018	12/31/2018
Ready for physics run	0 days	12/31/2018	12/31/2018



Underground detector assembly







CMS assembly approach:

- Assembled on the surface in parallel with underground work
- Allows pre-commissioning before lowering
- Lowering using dedicated heavy lifting equipment:

  15 loads, 300-> 2000t
- Potential for big time saving
- Reduce size of underground hall required

D. Angal-Kalinin

MDI panel CERN visit (Oct. 12,13)

- PB, HY, WL, TT, JU met with ATLAS + CMS installation engineers
- Presentations on:

  radiation protection issues

  CMS services

  ATLAS installation

  CMS installation + infrastructure
- Impressive experience and powerful lessons

Some souvenirs of CERN visit

- Radiation safety levels are (downwards) moving targets:

    extreme conservatism + pessimism built in from start

    integrated machine/detector approach from start

    significant personnel required (LHC: 2-4 staff, 12 years)

    waste management …

- Everything takes 'twice as long' below ground as on surface:

    scheduling of contractors, crews, cranes …

- Efficient crane scheduling difficult: two cranes (hooks) allow for flexibility
- Two access shafts 'mandatory' for personnel safety
- CMS: sub-floor passages for cables + detector access, service tunnels for power supplies, electronics, alignment across final-focus, etc.
- They were very sceptical about fast push-pull

Starting to think about surface assembly

- Sensible, plausible model needed for CF&S costings for RDR
- Does the concept make sense for SiD?
- If so, need estimates of:

  size of surface building

  size of underground cavern (assembly, access, opening …)

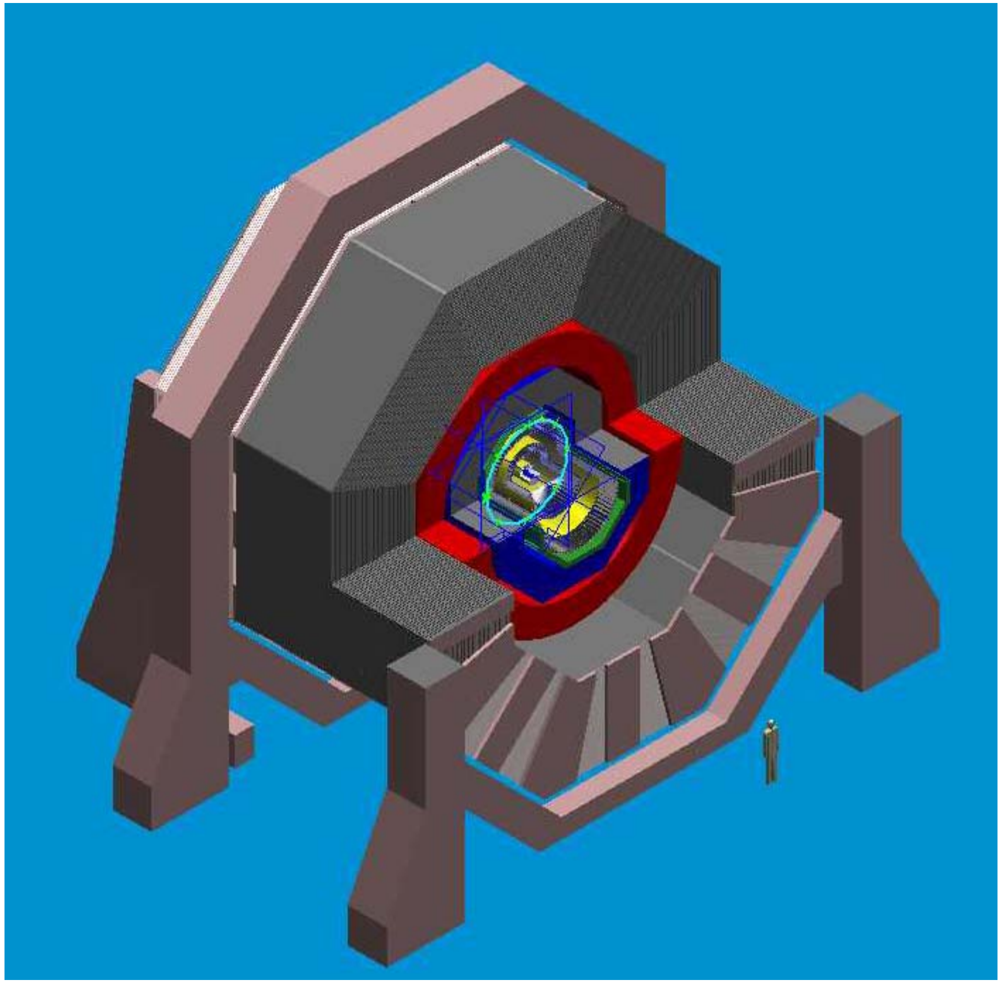
  diameter of shaft(s) for lowering

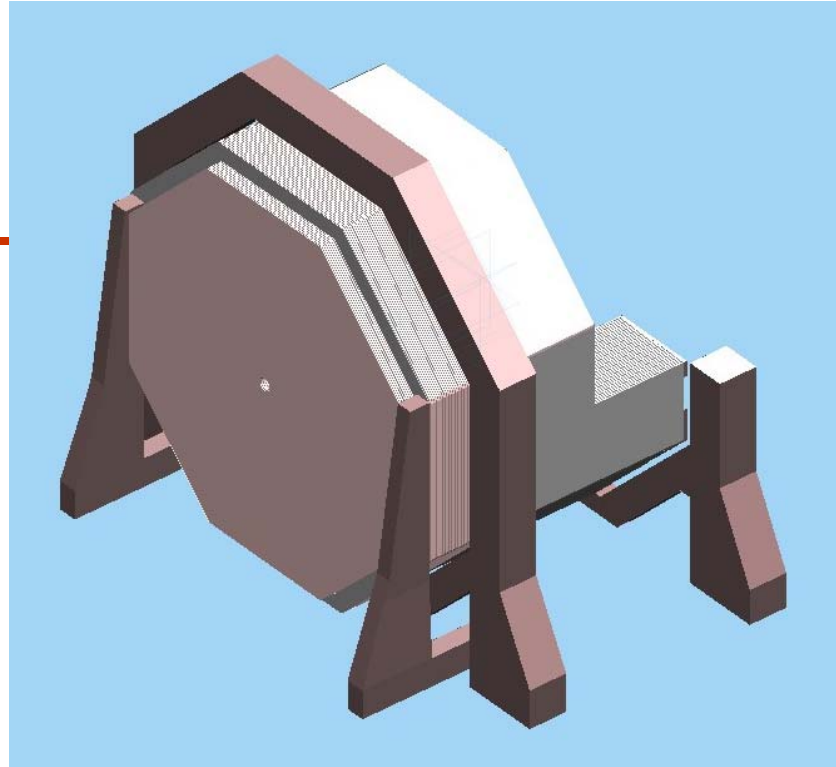
  crane capacity above and below ground

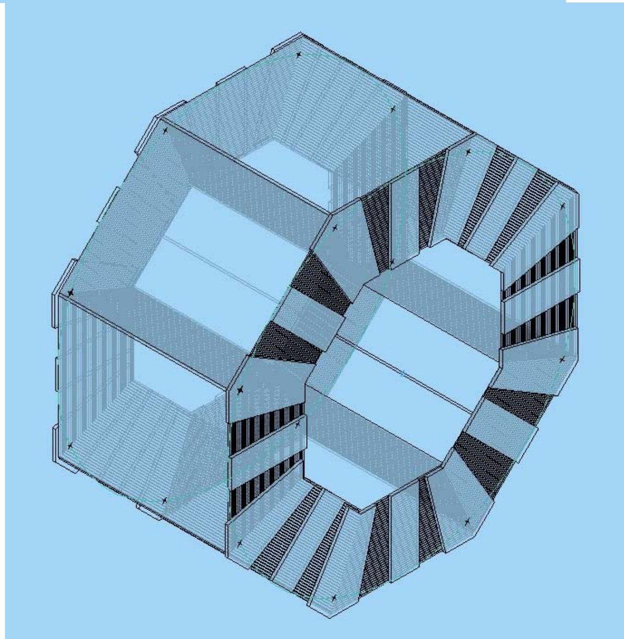
  …

SiD surface assembly considerations (Marty)

Solid Edge Model







SiD Installation Mass, Stainless HCal

Installation								
		R_Trkr =	1.25	m		Stainless	Hcal Radiator	
	Component masses (tonnes)							
	Barrel	Endcap						
EMCal	59	19						
Hcal	354	33						
Coil	160							
Iron	2966	2130		Support structure is not included. Probably ~10% more				
Coil Installation Package Mass				574				
Endcap Package Mass				2182				

SiD Installation Mass, Stainless HCal

Installation								
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	Component masses (tonnes)							
	Barrel	Endcap						
EMCal	59	19						
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Coil	160							
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Coil	160							
Iron	2966	2130		Support structure is not included. Probably ~10% more				
Coil Installation Package Mass				574				
Endcap Package Mass				2182				

SiD Installation Mass, Tungsten HCal

Installation								
		R_Trkr =	1.25	m		W	Hcal Radiator	
	Component masses (tonnes)							
	Barrel	Endcap						
EMCal	59	19						
Hcal	438	46						
Coil	140							
Iron	2370	1690		Support structure is not included. Probably ~10% more				
Coil Installation Package Mass				637				
Endcap Package Mass				1755				

A Starting Plausible Sequence (Marty)

On the surface

- Flux return modules are assembled and muon trackers tested.
- HCal & EMCal modules are assembled and tested.
- Assemble upper halves of end frame and lower segments of flux return to form nest for the coil.
- Install coil in nest (temporarily). Test coil at low excitation.
- Insert HCaL using threaded beam. Load is taken by the cryostat.
- Insert EMCal using threaded beam. Load is taken by HCal.

A Starting Plausible Sequence (Marty)

Lower:

- **Lower halves of end frame into pit and temporarily brace. Lower flux return segments are attached to the frames.**
- **Coil into new nest and attach.**
- **Upper frame segments and attach.**
- **Upper flux return segments and attach.**

It is assumed that the tracker and the VXD are too late for surface assembly, and they must be installed in the pit!!

Doors (Marty)

The strategy depends on the hoist capacity. It appears each door weighs ~ 2200 tonnes. If the hoist can manage this mass, each door can be lowered totally pre-assembled.

Each door (might, maybe, possibly could) consist of two leg assemblies and 4 flux return segments. Each goes down individually.

Comments (Marty)

The diagonal of the coil package is 8.7 m.

(Presumably the coil goes down with its axis horizontal!)

The "diagonal" of the door is ~11 m, with ~2 m more needed for leg extensions. Probably the door should go down in pieces.

Appears that 1000 tonne hoist should be adequate.

– It is not obvious that a traveling gantry would be more expensive than a traveling floor over the shaft (cf CMS). If the detectors are self-shielded, then a cover is not required.

A surface building ~30 x 40 m seems adequate. Careful study is needed before committing!

A super crude guess is ~ 2 years of pit access would be enough for final assembly and commissioning.

This scenario is plausible but far from unique. Real engineering is needed.

Surface assembly seems ok, but will require careful planning.

For reference: IR-related facilities for detector

Item	SiD	LDC	GLD	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	26.5 x53 max	32x72	25x110	25x110	Detector concepts
Beam height above IR hall floor (m)	7.5	8	8.6	8.79 m	8.6	8.6	8.6	Concepts, BDS
IR Hall Crane Maximum Hook Height Needed(m)	5m above top of detector	19	20.5	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	20t install tool 7x4 m		400t	100t	Detector concepts
IR Hall Crane	100t/10t aux.	80t (2x40t)	400t	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	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	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	1950 t		9*9m 400t	4*16m 2000t	Detector concepts

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Push-pull IR model

- The cost of each BDS is several 100M$
- In order to save cost of one BDS the push-pull model has been suggested:

  one IR

  two detectors, in beamline in turn (push-pull mode)

  (The alternative, for a single IR, is ONE DETECTOR)
- A panel has been charged by GDE/WWS to investigate technical feasibility:

  Demarteau, Haller, Breidenbach, Burrows (SiD)

  Brau (WWS)

  Seryi (Chair)

  Draft report due at Valencia
- No formal CCR (yet)

Some of questions (1)

Is there, in the beamline, a natural breaking point?

Do we need to redesign the beamline to optimize location of breaking point?

Does part of beamline (part of FD) remain in detector when it moves?

What vacuum connections are needed at breaking point?

Do we have to use the same L* for both detectors or it can be different?

How are the connections of electrical, cryo, water, gas, etc, arranged?

Some of questions (1)

Is there, in the beamline, a natural breaking point?

- **yes, it can be arranged, between QD0 and QF1**

Do we need to redesign the beamline to optimize location of breaking point?

- **yes and a first version of optics already produced**

Does part of beamline (part of FD) remain in detector when it moves?

- **yes, this seems to be the most optimal way**

What vacuum connections are needed at breaking point?

- **two vacuum valves with RF-shield, details are being worked out**

Do we have to use the same L for both detectors or it can be different?*

- **Different L* is possible, but same L* gives benefits**

How are the connections of electrical, cryo, water, gas, etc, arranged?

- **Part of electronics and services can be placed on a platform which moves with detector. Flexible connections to stationary systems needed.**

Some of questions (2)

What is a suitable way to move the detector (rails, air-pads) ?

For quick change-over, do we need to make detector self shielding?

What are the design changes needed to make the detector self shielding?

If there is a need for shielding wall between detectors, what is the method of its removal and assembly?

What arrangements or reinforcements (such as imbedded steel) are needed for the floor of the collider hall?

Is there a need to open detector when it is on the beamline, or it would only open in the off-beamline position?

http://www-project.slac.stanford.edu/ilc/acceldev/beamdelivery/rdr/docs/push-pull/

Some of questions (2)

What is a suitable way to move the detector (rails, air-pads) ?

- **air-pads seems a good possibility**

For quick change-over, do we need to make detector self shielding?

- **It would help, but self-shielding is not absolutely required**

What are the design changes needed to make the detector self shielding?

- **For GLD, self-shielding has been shown in simulations. For the fourth detector concept implementing self-shielding may be difficult**

If there is a need for shielding wall between detectors, what is the method of its removal and assembly?

- **The shielding wall can consist of two parts and move on air-pads**

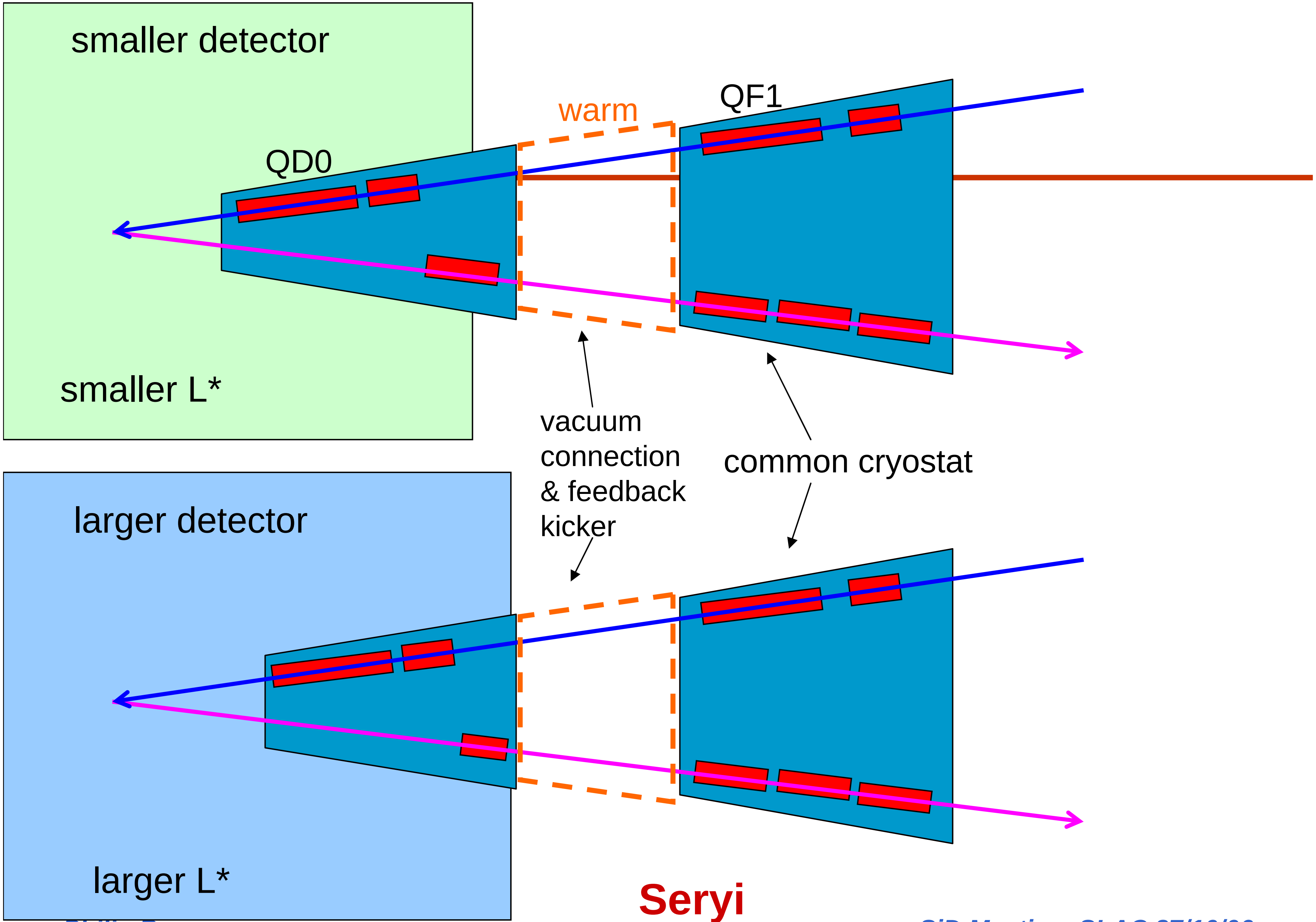
What arrangements or reinforcements (such as imbedded steel) are needed for the floor of the collider hall?

- **Steel plates (~5cm thick, welded) to cover the collider hall floor**

Is there a need to open detector when it is on the beamline, or it would only open in the off-beamline position?

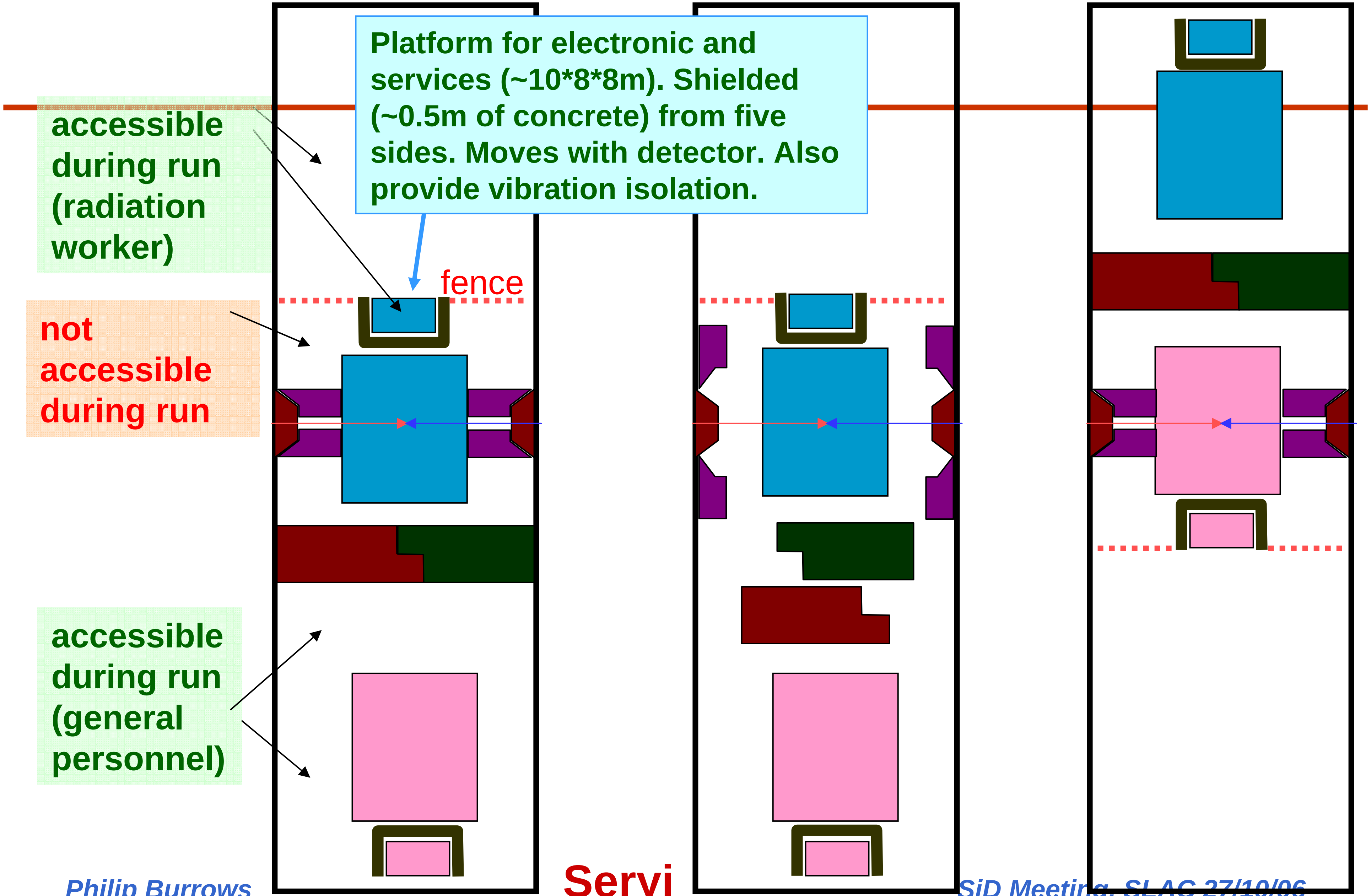
- **TBD**

http://www-project.slac.stanford.edu/ilc/acceldev/beamdelivery/rdr/docs/push-pull/


smaller detector
warm
QF1
QD0
smaller L*
vacuum connection & feedback kicker
common cryostat
larger detector
larger L*

Seryi

Concept which does not rely on self-shielding detector



Seryi

Air-pads at CMS

Single air-pad capacity ~385tons (for the first end-cap disk which weighs 1400 tons). Each of air-pads equipped with hydraulic jack for fine adjustment in height, also allowing exchange of air pad if needed. Lift is ~8mm for 385t units. Cracks in the floor should be avoided, to prevent damage of the floor by compressed air (up to 50bars) – use steel plates (4cm thick). [Alain Herve, et al.]

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

Seryi

‘Low P’ machine parameter option

- Halve installed RF power
  - -> half # bunches, half L
- Squeeze IP bunch sizes to recover L
  - -> increases beamstrahlung
  - -> higher backgrounds (roughly x2)
  - -> larger beam-energy spread (roughly x3)
- Things to watch:
  - -> occupancy in VXD
  - -> effect on precision measurements
- MDI panel:
  - ‘fundamentally reduces physics capability of machine’

Parting comments

- Never a dull day in Beam Delivery!
- Adoption of surface assembly concept imminent

    there are a lot of details to work out (we have time)
- Descope to 1 BDS is very likely to be proposed formally

    If two detectors: require push-pull at some duty cycle

    Input on technical issues to push-pull to Task Force
- Detector community must push hard against low L options
- All will be discussed at Valencia

    MAKE YOUR INPUT!