Process of change of BDS baseline to 14/14 configuration

BDS Area leaders

Deepa Angal-Kalinin, Hitoshi Yamamoto, Andrei Seryi

ILC MAC meeting, September 20-22, 2006, KEK

Contents

- Brief overview of Vancouver baseline
  - Two IRs, 20/2 mrad

- Process of technical evaluation pre-Vancouver
  - physics reach, beamline conditions & operability, technical feasibility

- Vancouver cost estimation
  - difference of costs for 2mr and 20mr

- Interactions at and after Vancouver
  - configuration change request for 14/14 baseline
  - evaluations by WWS, MDI panels & CCB

- Further cost optimizations of baseline

Overview of Vancouver baseline

Diagnostics
BSY
tune-up dump

β-collim.

E-collim.

2mr IR

FF

20mr IR

grid is 100m*5m
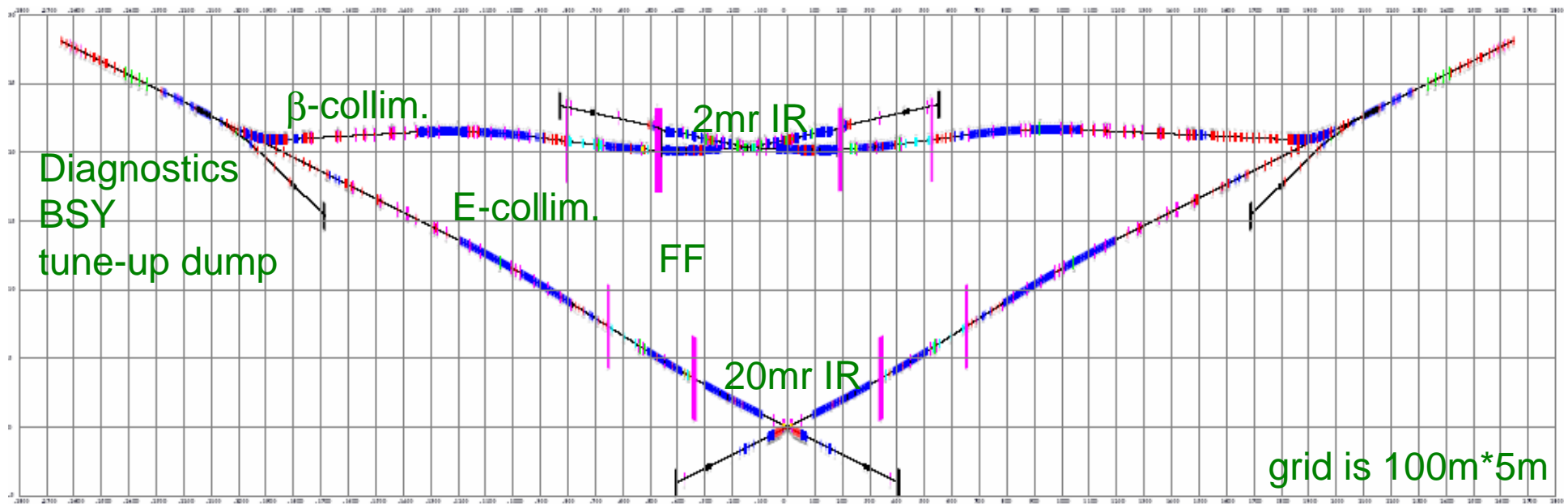
- Two IRs with 20mrad and 2mrad crossing angle
- Two collider halls separated longitudinally by 138m

- Evaluation is focused on the differences between 20mr and 2mr branches, and focused on
  - **study of physics reach**
  - **background conditions in IR**
  - **radiation conditions in extraction lines**
  - **performance of downstream diagnostics**
  - **technical feasibility of magnets**
  - **power consumption and cost**

- Next, flash through some examples of such comparisons, presented at Vancouver
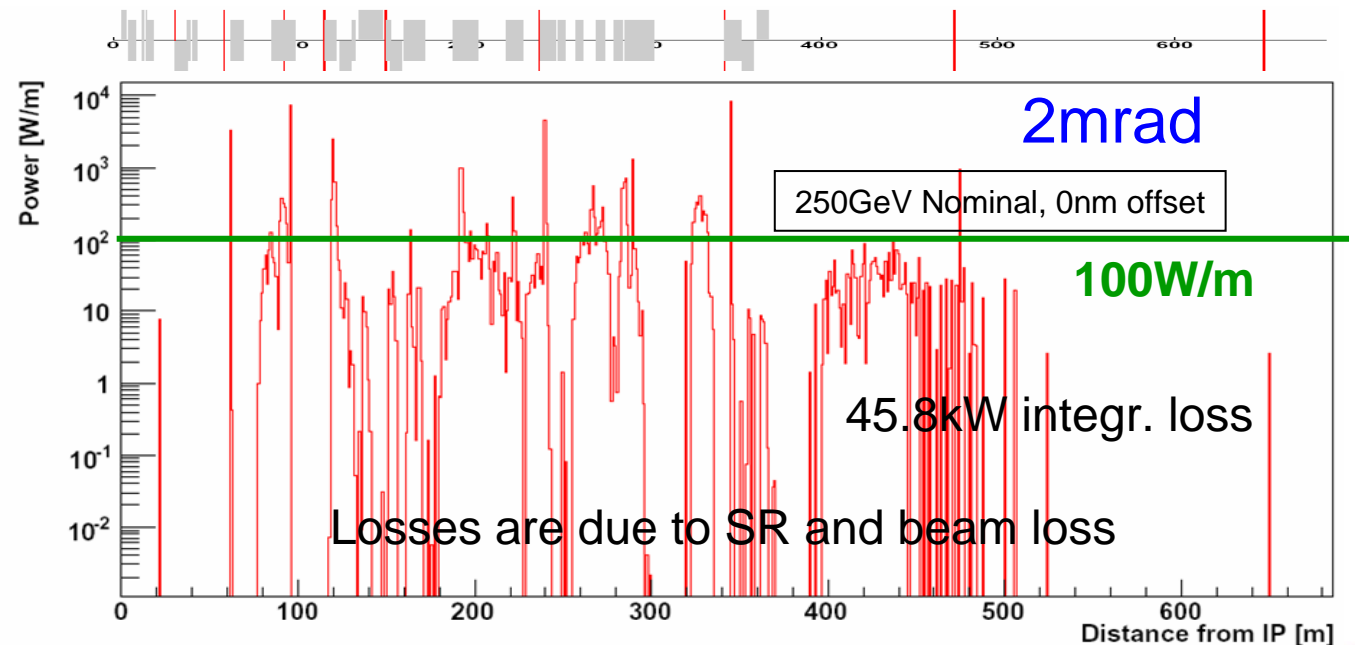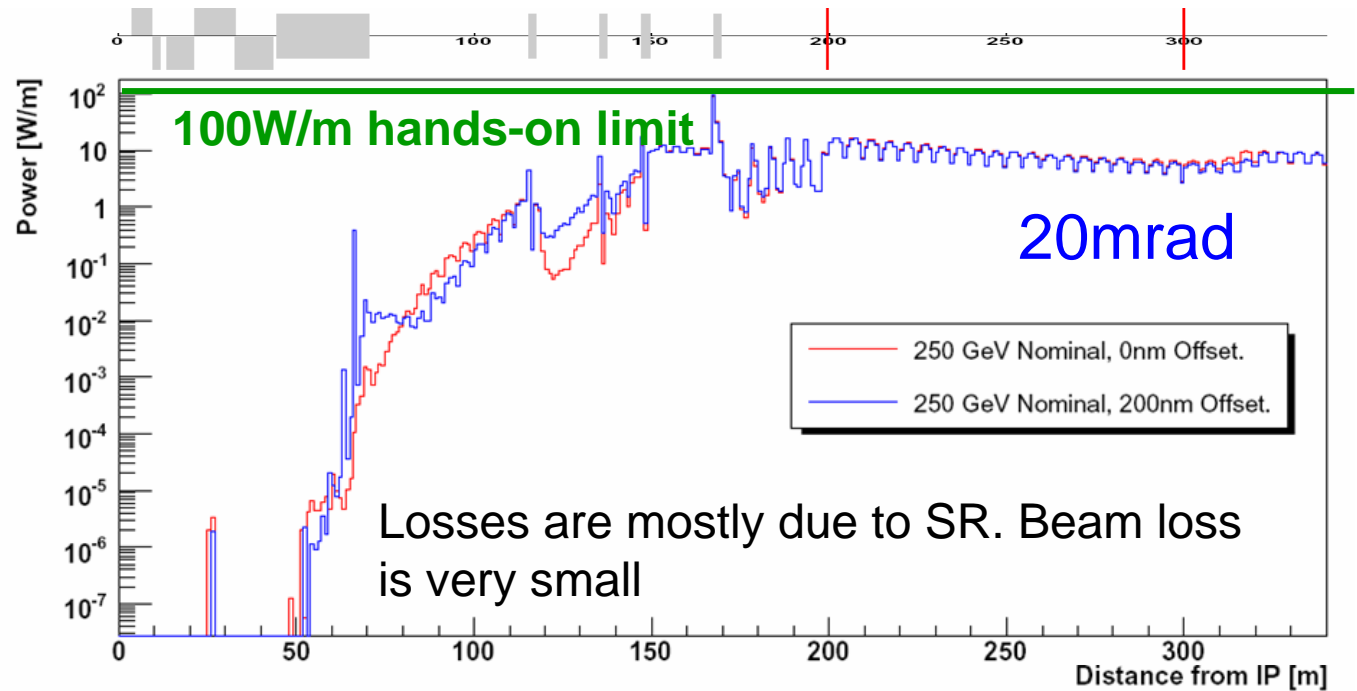
Losses in extraction line

20mr: losses < 100W/m at 500GeV CM and 1TeV CM

2mr: losses are at 100W/m level for 500GeV CM and exceed this level at 1TeV

Radiation conditions and shielding to be studied

100W/m hands-on limit

20mrad

250 GeV Nominal, 0nm Offset.
250 GeV Nominal, 200nm Offset.

Losses are mostly due to SR. Beam loss is very small

2mrad

250GeV Nominal, 0nm offset

100W/m

45.8kW integr. loss
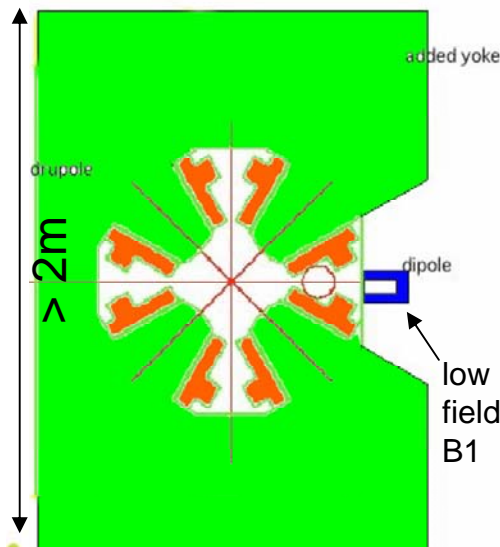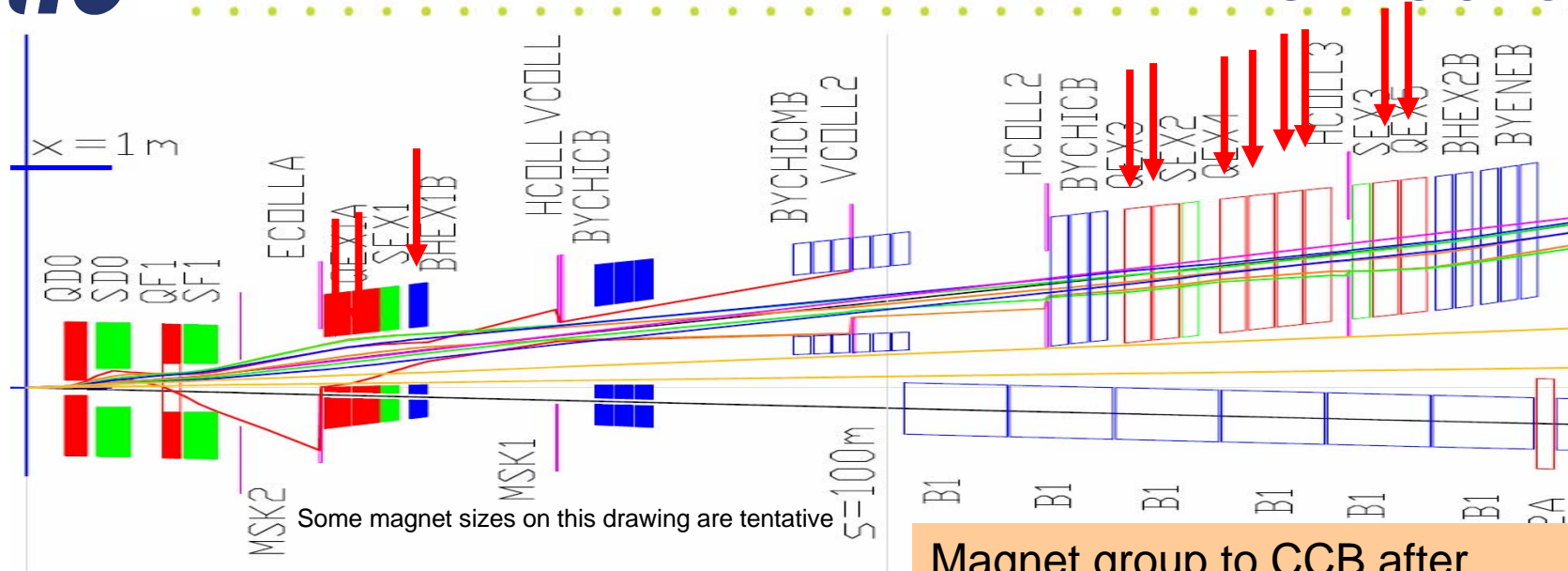
Losses are due to SR and beam loss

Study of SUSY reach

- Reaction which cares most about crossing angle is $ee \rightarrow \tilde{\tau}_1^+ \tilde{\tau}_1^-, \tilde{\chi}_1^+ \tilde{\chi}_1^-$
- Main background is due to copious two photon processes $ee \rightarrow \tau\tau ee$ which require low angle tagging
- Tagging is challenged by pairs background and presence of exit hole

- SUSY reach is challenged for the large crossing angle when Δm (slepton-neutralino) is small
- Studies presented at Bangalore (V.Drugakov) show that for 20mrad+DID (effectively ~40mrad for outgoing pairs), due to larger pairs background, one cannot detect SUSY dark matter if Δm=5GeV
- The cases of 20 or 14mrad with anti-DID have same pairs background as 2mrad. Presence of exit hole affects detection efficiency slightly. The SUSY discovery reach may be very similar in these configurations
- Several groups are studying the SUSY reach, results may be available after Vancouver
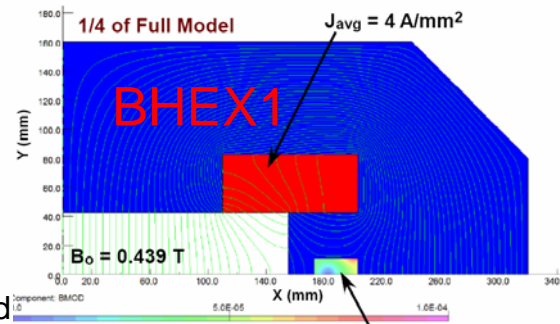
Some magnet sizes on this drawing are tentative

Recent suggestions by magnet tech group

added yoke

dipole

low field B1

Clear aperture is 305 x 80 mm for a 2.5 mm wall thickness

1/4 of Full Model

J_{avg} = 4 A/mm²

BHEX1

B_0 = 0.439 T

|B| is about 1 gauss inside cutout region

Make simple racetrack coils that go around poles and insert right/left cutouts with beam pipes during final assembly.

Magnet group to CCB after Vancouver: "…there is still work that could be done to improve them further … but that by the nature of their aperture requirements and relative beamline spacing which arises naturally in the 2 mr layout, they will always be very challenging magnets that many experienced magnet designers place at the cusp of feasibility."
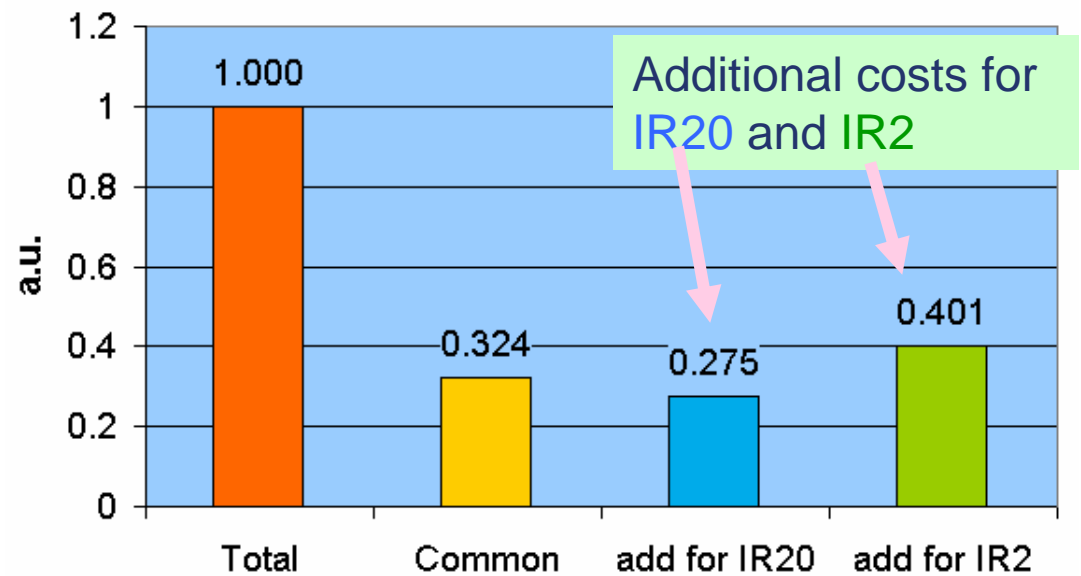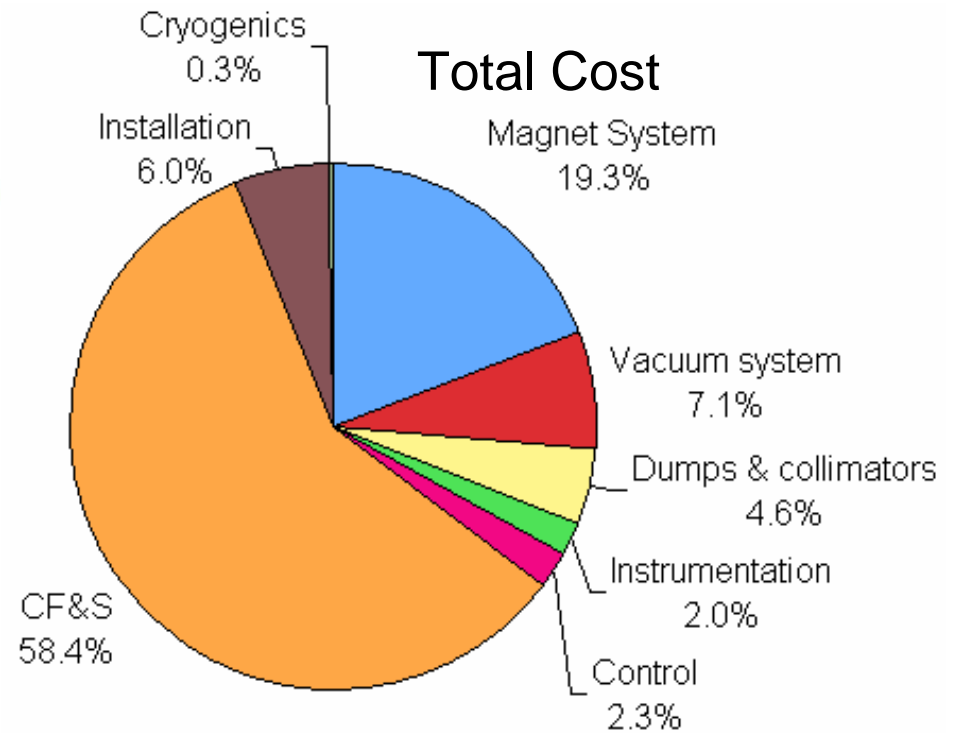
Drivers of the cost and Δcost

- **Cost drivers**
  - **CF&S**
  - **Magnet system**
  - **Vacuum system**
  - **Installation**
  - **Dumps & Colls.**

- **Drivers of splits between 20/2:**
  - **CF&S**
  - **Magnet system**
  - **Vacuum system**
  - **Dumps & collimators**
  - **Installation; Controls**

Total Cost

Cryogenics 0.3%

Installation 6.0%

Magnet System 19.3%

Vacuum system 7.1%

Dumps & collimators 4.6%

Instrumentation 2.0%

Control 2.3%

CF&S 58.4%

Additional costs for IR20 and IR2

Total — 1.000

Common — 0.324

add for IR20 — 0.275

add for IR2 — 0.401

a.u.

Vacuum, Dumps & collimators: BDS 20/2
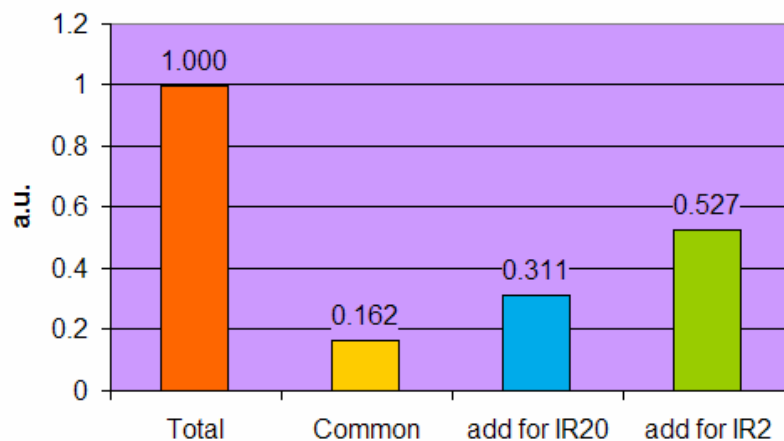
Vacuum System
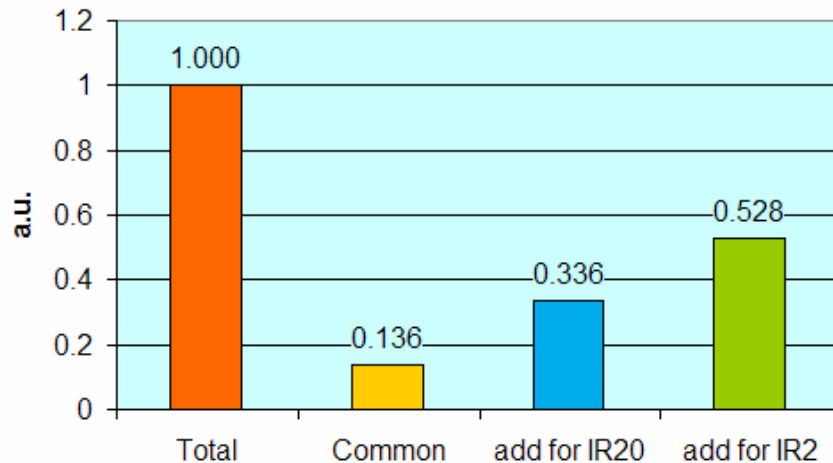
Chambers of longer 2mr extraction line and additional chamber for beamstrahlung photons cause the cost difference
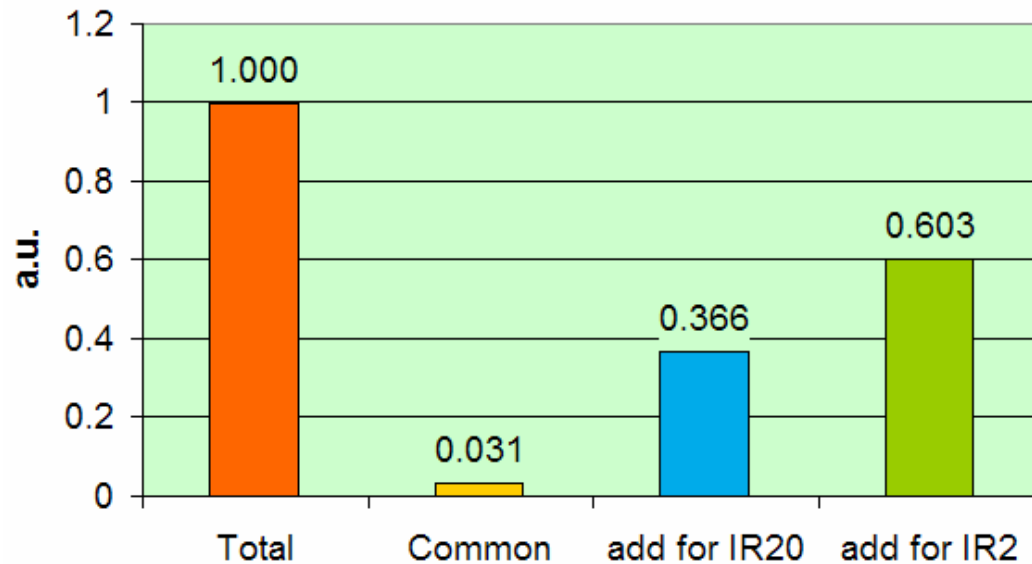
Dumps & Collimators

Larger number of collimators in 2mrad extraction line and additional photon dump cause the difference
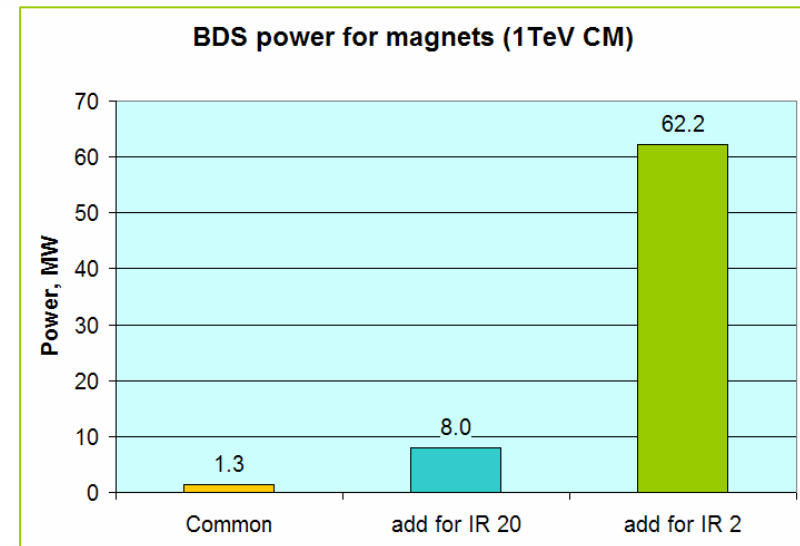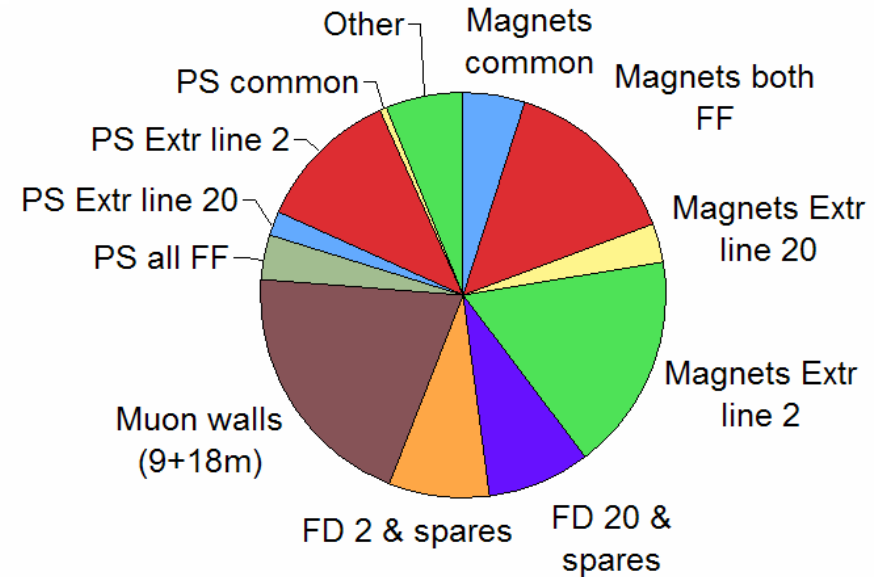
Magnet System
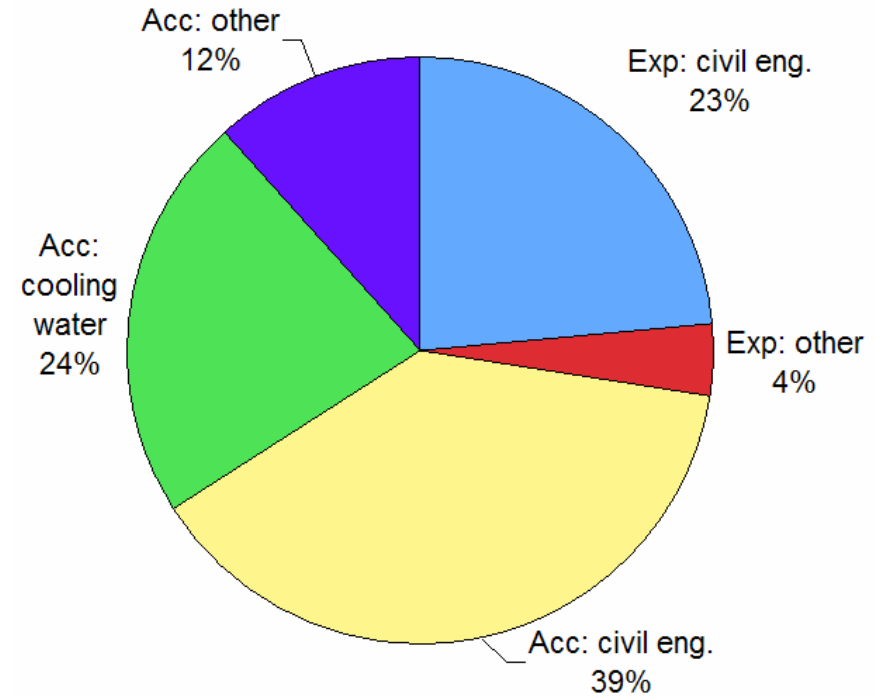

Larger number of huge extraction line magnets, and its power supplies (PS) cause the cost difference

CF&S
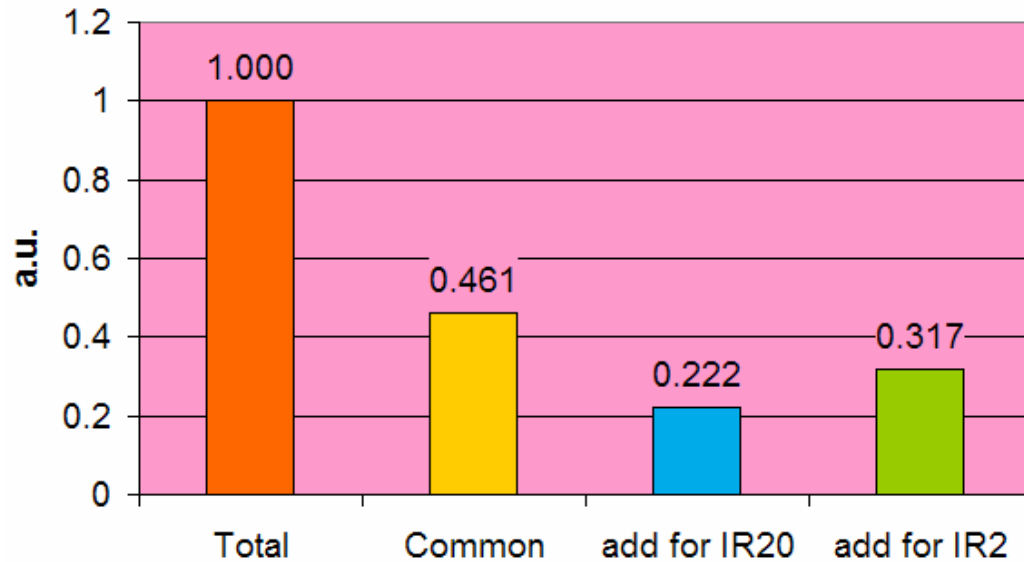
The common fraction is quite large. The difference come from beam dump halls and mostly (~90%) from cooling water

- Discussion of 20/2 baseline situation
  - **by BDS area leaders**
  - **with present colleagues from BDS group**
  - **with MDI panel (plus those connected remotely)**
  - **with WWS organizing committee**
  - **with EC and GDE director**
- It was decided to cut the Gordian knot of the cost, technical and non-technical issues and propose to change the baseline to two IR with 14/14 configuration

  - **Design & cost of 14/14 with common collider hall & z=0**
    - Design of 14mr beamline is almost the same as for 20mrad
    - In the 14/14 cost estimation, the following adjustments were estimated and taken into account: removed stretches in optics; shorter (~11mr/14mr) tapered tunnels; remove one surface building; savings due to common hall (but volume still twice the single volume); add cost of 42% more gradient bends (for 14mrad bend), their PS, BPMs, movers, etc
- The two IR config with 14mrad in both IRs reduces the cost by 15.6%

After Vancouver: submission of CCR, evaluation by WWS, MDI and CCB

- CCR (Class 2) for 14/14 configuration submitted on July 28
- MDI panel meeting on Aug. 15 (link to agenda), to discuss
  - **14/14 configuration**
  - **single collider hall**   <= CCR submitted on July 28
  - **on-surface detector assembly**   <= CCR in preparation
  - **5m muon spoilers instead of 9m+18m**   <=CCR submitted on Sept. 8
- The MDI panel accepted those changes. The conclusions were sent to WWS and CCB. (Link to MDI panel minutes)
- The WWS OC was asked to comment about the first two items and also accepted them

- CCB considered the CCR for 14/14, and on September 8 issued a recommendation for EC to adopt the CCR as is
  - CCB noted that it was the first Class-2 request and part of the time was spent on nailing down the protocols for cost information handling

- 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.

- Difference in expected background (is due to) different levels of veto efficiency. Signal to noise will be ~4 to 1 with 2mrad crossing angle.

- 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 is 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.

* LSP= lightest super-symmetric particle
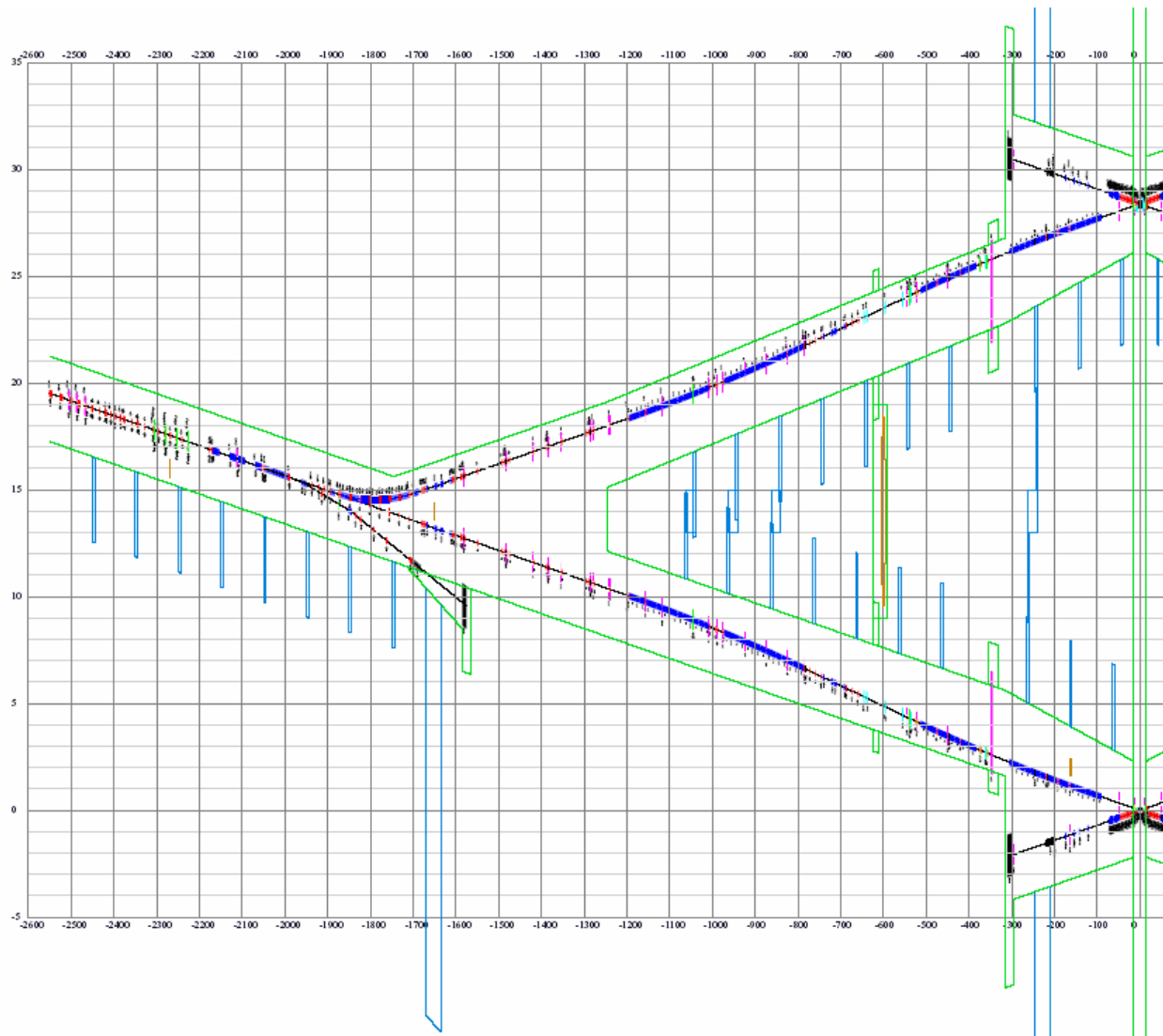
Common IR hall ~100m (L) x 30m (W) at z=0 with 28.4m ΔX
- 15m shafts equipped with elevator and stairs in IR hall
- 4m tunnels in all BDS
- Alcoves 4*6m every 100m, no service tunnel
- Halls for dump cooling system 35*20m
- Small 0.8m shaft for lasers near laser wire, upstream and downstream diagnostics
- 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. Etc.

Further work baseline cost

- Optimizing the IR hall requirement and detector assembly procedure
  - **considering pure-CMS and modified CMS approached**
- Optimizing CF&S design
- Working on installation model and refining the cost
- Reviewing systems for possible cost reductions
- Discussing other possible cost saving strategies

Summary

- The process of change of baseline from 20/2 to 14/14, briefly outlined in this talk, included
  - **Development of baseline design**
  - **Evaluation of backgrounds & physics reach**
  - **Study of beamline conditions & operability**
  - **Engineering evaluation of the design**
  - **Comparison of cost and operational expenses**
  - **CCR for change of baseline**
  - **Evaluation by WWS & CCB**
  - **Further optimization of new baseline**

END

Backup slides

- Several slides related to
  - **estimated error of Δcost**
  - **CCR on muon walls (submitted)**
  - **CCR for on-surface detector assembly**
  - **Some other example of comparative studies**

- ## Estimated errors of Δcost

	Δcost	+error	-error
total initial	15.6%		
vacuum		+1.4%	-0.7%
D&C		+1.0%	-0.5%
Magnet		+1.7%	-0.6%
CF&S water		+0.1%	-2.5%
CF&S other		+2.0%	-0.1%

- ## It is unlikely that the errors in different systems are correlated, but if they are, we get

$$\Delta\text{cost} = 15.6\% \qquad +6.2\% \qquad -4.4\%$$

Muon walls

- Purpose:
  - **Personnel Protection: Limit dose rates in one IR what beam sent to other IR or to the tune-up beam dump**
  - **Physics: Reduce the muon background in the detectors**
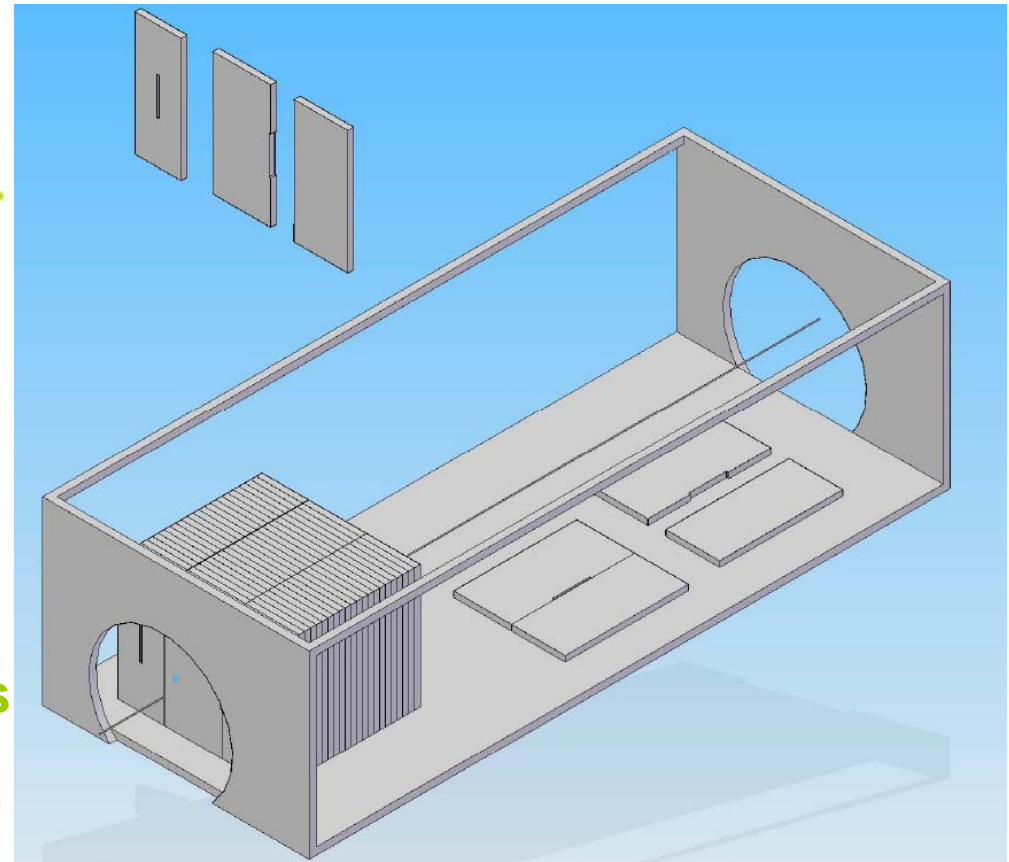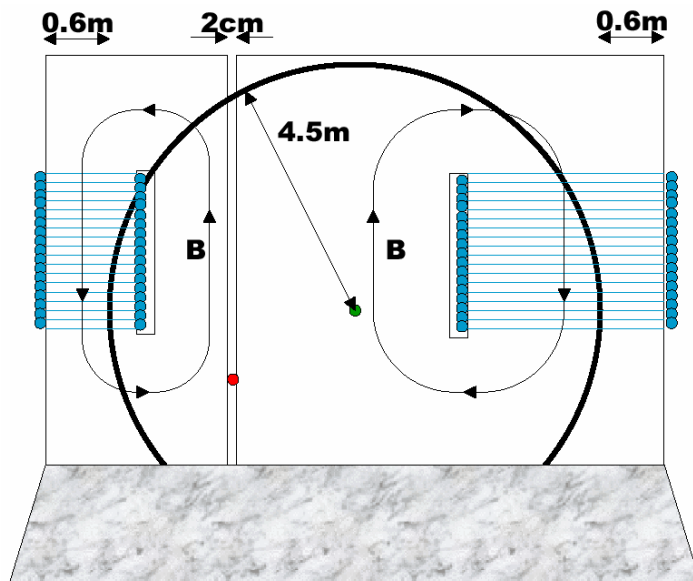
Scheme of a muon wall installed in a tunnel widening which provide passage around the wall

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

Muon walls CCR

- Baseline config (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 and such high amount is not supported by any simulations**
  - **The min muon wall required for personnel protection is 5m**
  - **Detector can tolerate higher muon flux. 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**
  - **Cost of long muon spoilers is substantial, dominated by material cost and thus approximately proportional to the muon wall length**
- Suggested CCR to install initially only 5m single walls
  - **The caverns will be built for full length walls, allowing upgrade if higher muons flux would be measured**
  - **Such upgrade could be done in ~3month**
- MDI panel accepted this change
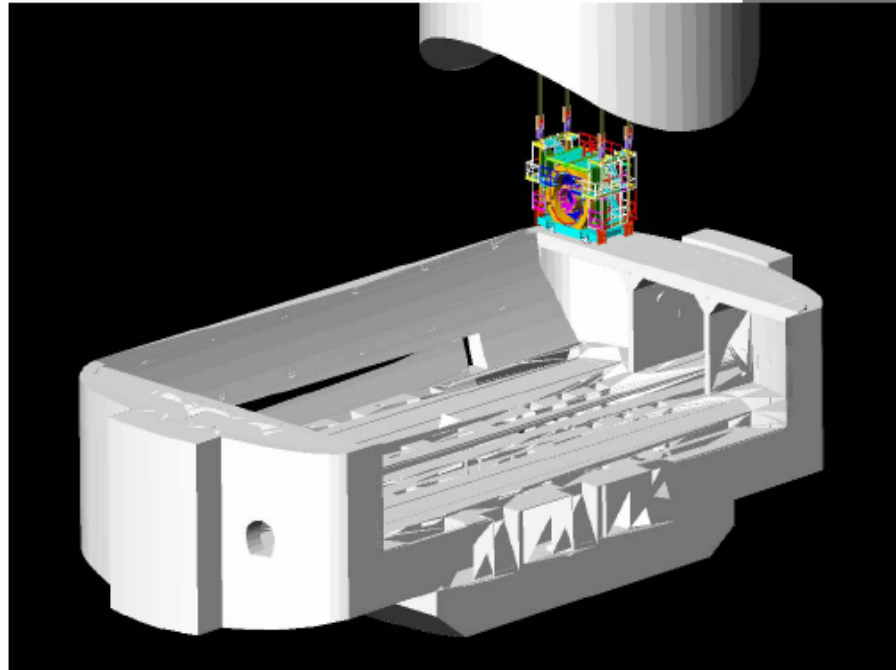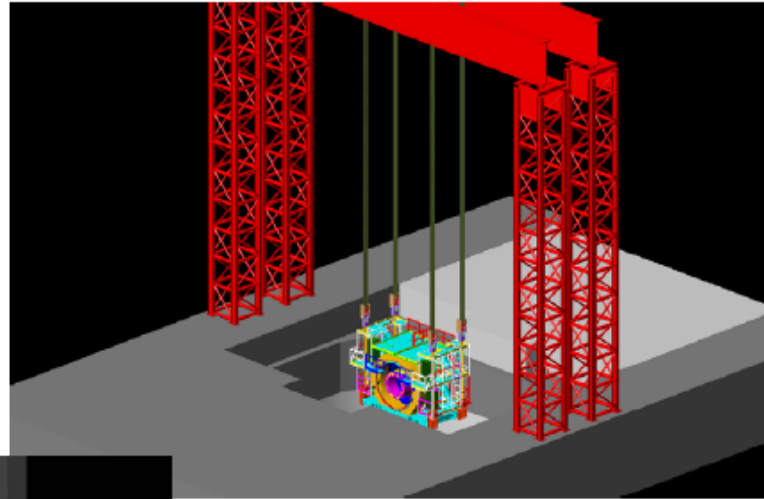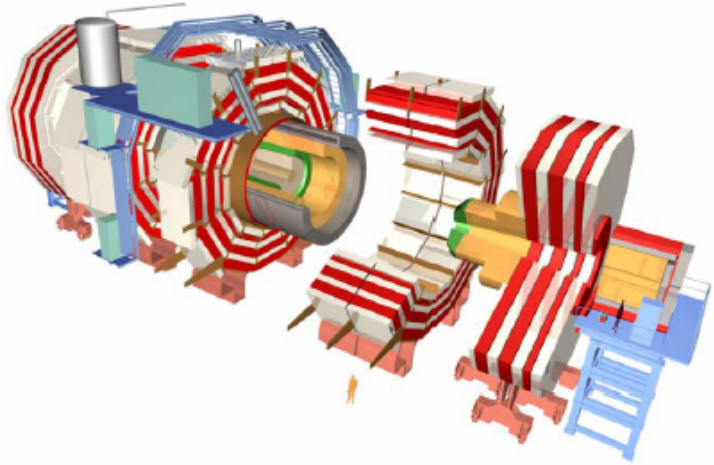
CMS detector assembly approach:

• Assembled on the surface in parallel with underground work

• Allows pre-commissioning before lowering

• Lowering using dedicated heavy lifting equipment

• Allows saving up to 3years of time

• Reduce size of underground hall required

• Accepted by MDI panel for ILC

On-surface (a la CMS) assembly

- According to tentative CF&S schedule, the detector hall is ready for detector assembly after 4y11m after project start

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

- Surface assembly allows to save 2-2.5 years and allows to fit into this goal

- The collider hall size is also smaller in this case
  - **A building on surface is needed, but savings are still substantial**

Top Gantt chart:

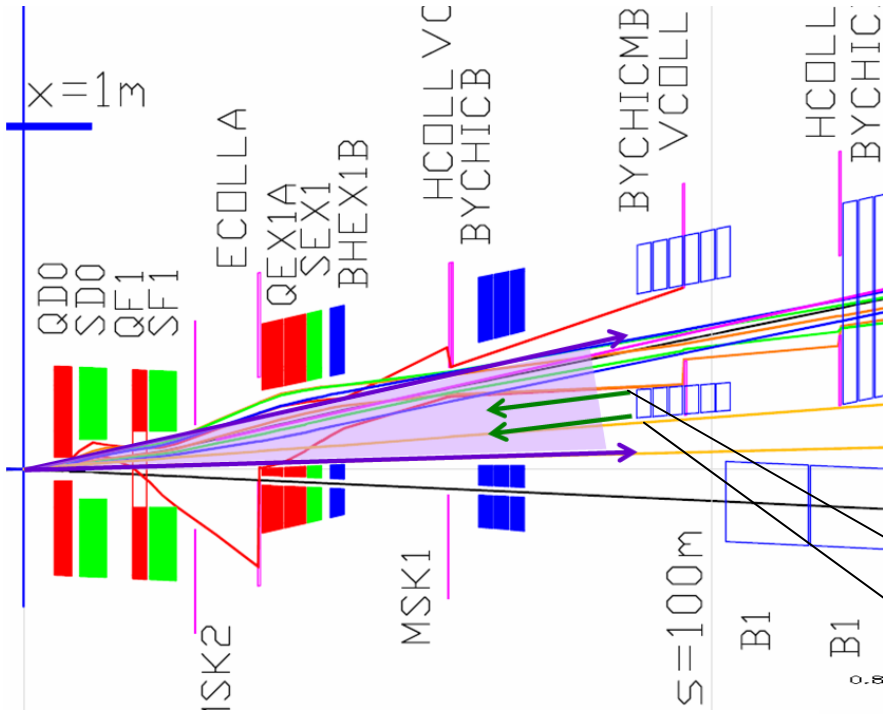| Task Name	Duration	Start	Finish
Project approved	0 days	1/1/2008	1/1/2008
Construct detector	391 wks	1/1/2008	6/29/2015
prepare surface building for detector	120 wks	1/1/2008	4/19/2010
detector assembly	245 wks	4/20/2010	12/29/2014
detector surface commissioning	26 wks	12/30/2014	6/29/2015
Detector 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

On-surface detector assembly

VERY TENTATIVE

Bottom Gantt chart:

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
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-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

Underground detector assembly

September 20, 06

Global Design Effort

start date arbitrary

BDS: 25

Backscattering of SR

Photon flux within 2 cm BeamCal aperture:

	Rate	#γs at IP/BX	#γs in SiTracker from pairs
250 GeV	1.1×10^{-8}	2200	700
500 GeV	2.9×10^{-8}	11700	1900

Flux is 3-6 times larger than from pairs. More studies & optimization needed

FD produce SR and part will hit BYCHICMB surface Total Power = 2.5 kW $\langle E_\gamma \rangle$ = 11MeV (for 250GeV/beam)

SR from 250 GeV disrupted beam, GEANT

From BYCHICB
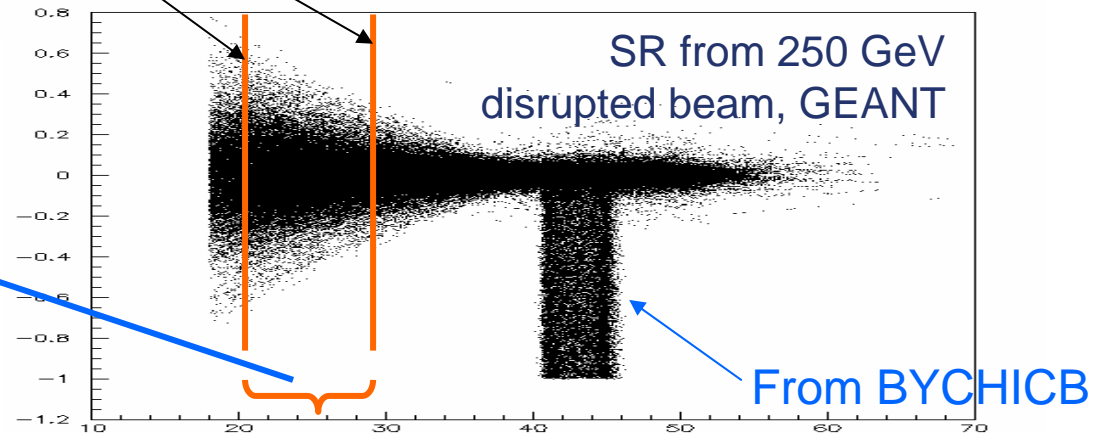
Takashi Maruyama

Downstream diagnostics evaluation

Comparisons for 250GeV/beam	20mr	2mr
Beam overlap with 100mm laser spot at Compton IP	48%	15%
Polarization projection at Compton IP	99.85%	99.85%
Beam loss form IP to Compton IP	<1E-7	>2.6E-4
Beam SR energy loss from IP to middle of energy chicane	119MeV	854MeV
Variation of SR energy loss due to 200nm X offset at IP	< 5MeV (< 20 ppm)	25.7MeV (~100 ppm)
The need for SR collimator at the Cherenkov detector	yes	No

comparable with the goal for E precision measurements