ILC Central Region Cryogenics for DR, BDS/MDI, and Detectors

Akira Yamamoto (GDE-PM)
in cooperation with
SCRF, BDS, DR, Detector groups, and PMs

GDE-ADI meeting, June 20, 2012

This is outcome from Intensive Meetings, since early 2012

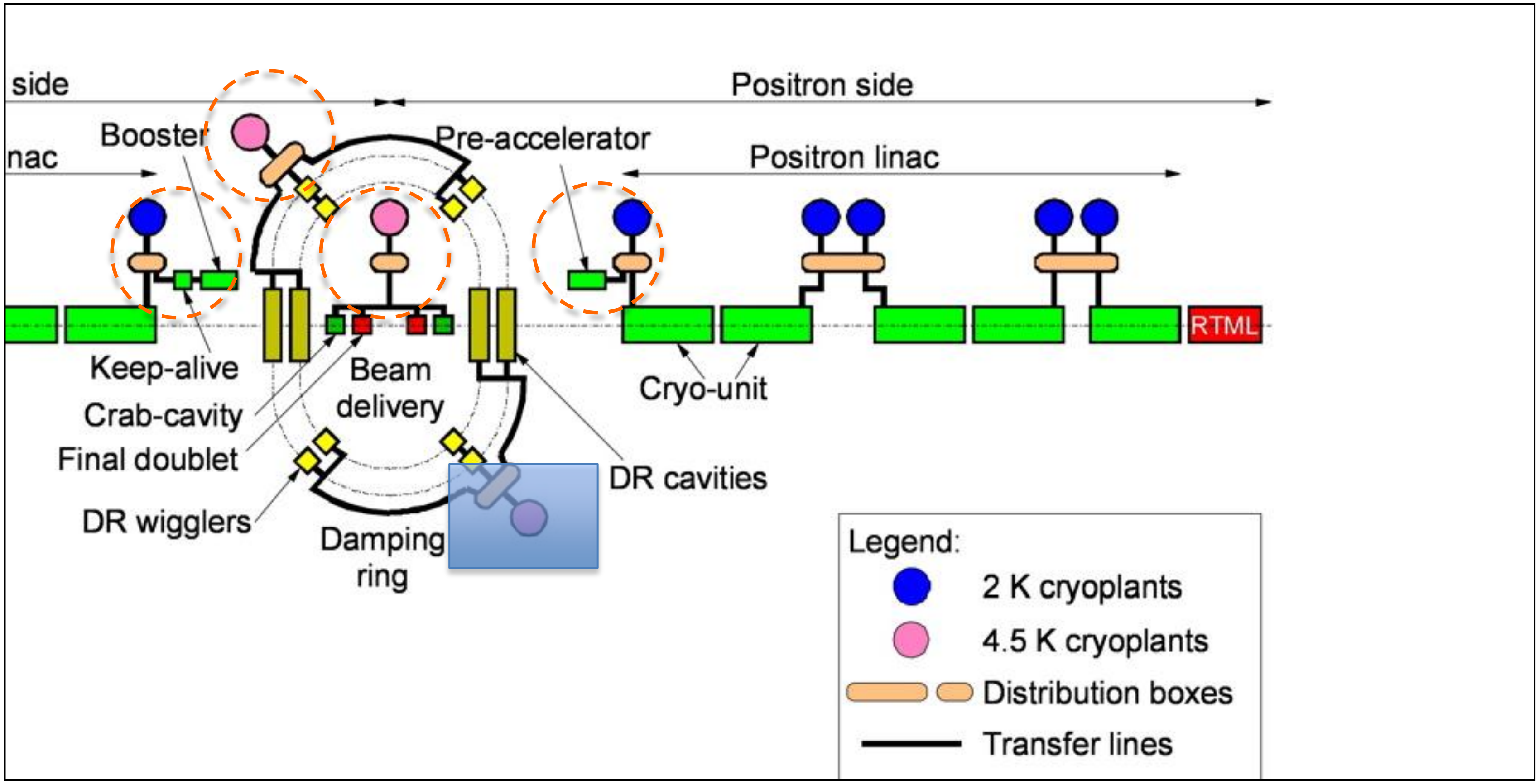
- February GDE, ADI and cryogenics meetings
- March: GDE Cryogenics Meeting
- April: KILC12, Central Region Session
- May : GDE/Detector Cryogenics Meeting
- May: GDE ADI meeting
- June: MDI/Detector Cryogenics Meetings (2~3)
- Today: GDE ADI meeting

We would thank everyone's much effort and contribution for better understanding and discussions.

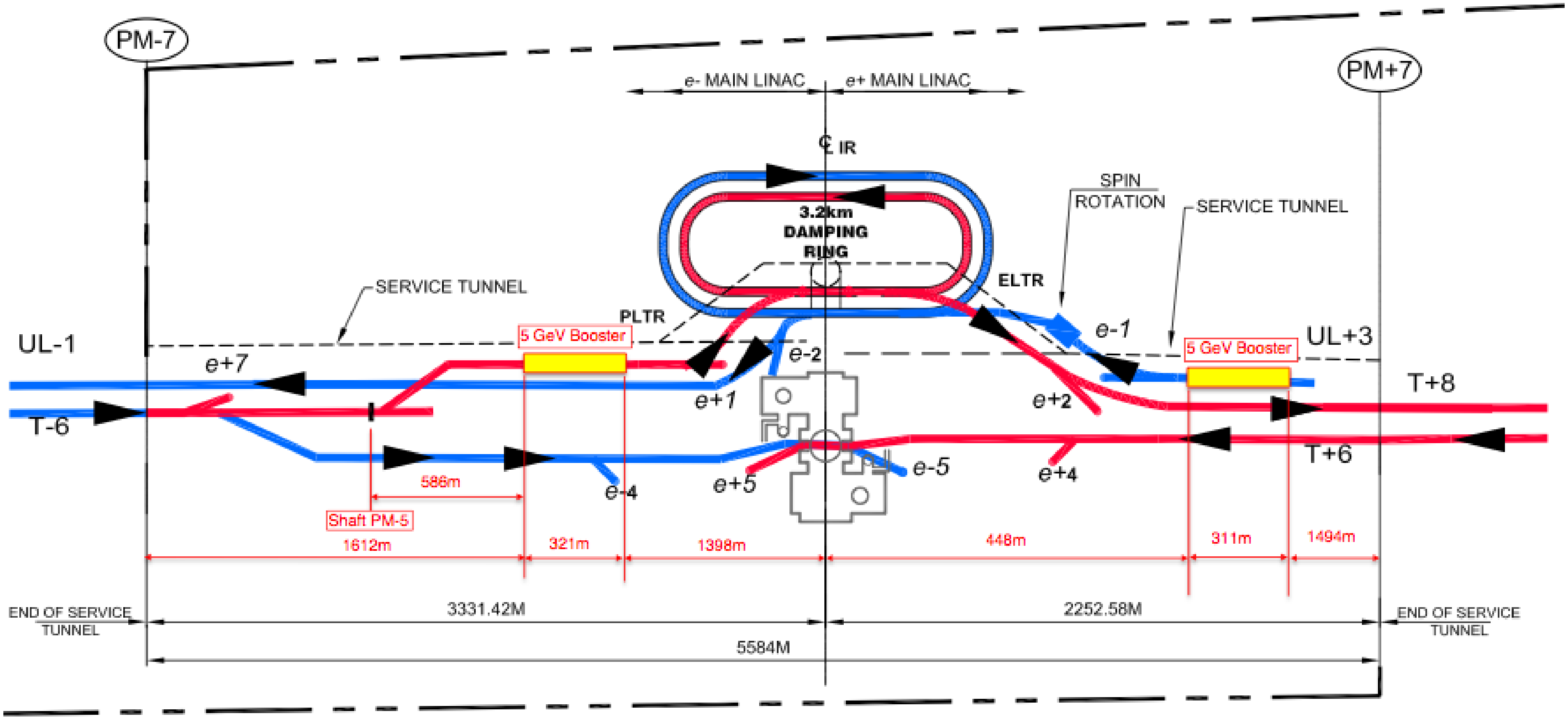
Cryogenic Systems Layout Status

Tom Peterson,
with some contribution by Akira Yamamoto
ILC cryogenics meeting via Webex
31 May 2012, added June 20, 2012

RDR cryogenics layout, for reference



5 GeV booster linac locations



Cryogenics Location in Central Region

Cryogenics at Central Region

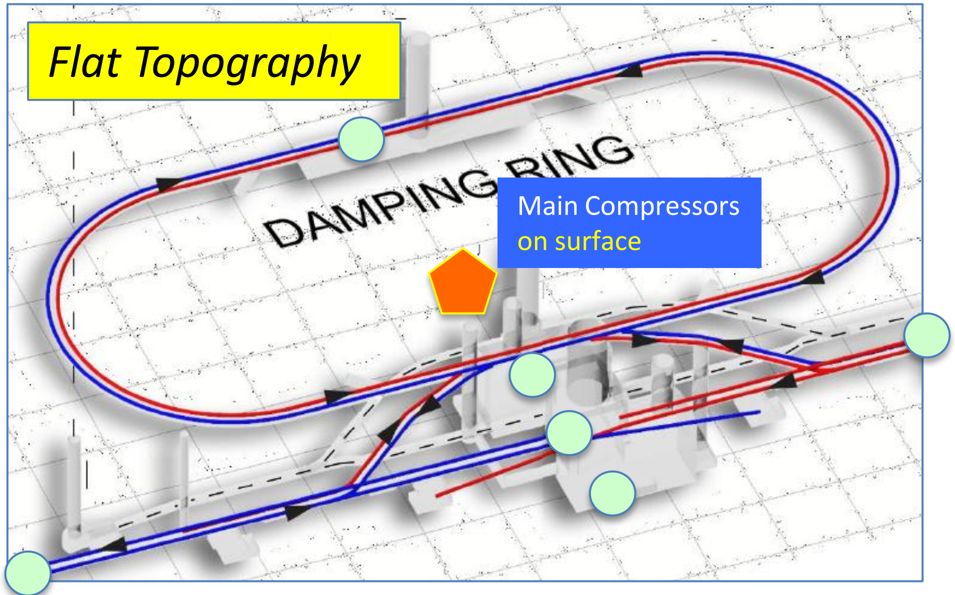
- Damping Ring
- e- source: Booster Linac
- e+source: Booster Linac
- Focusing (QF0) + Crab Cavity

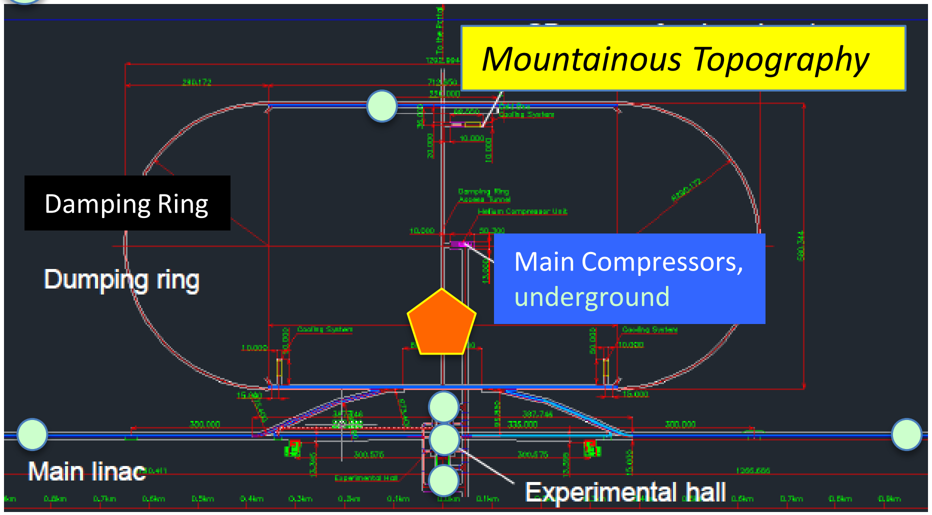
- Focusing (QD0) + Comp. Sol. + **SiD** Solenoid
- Focusing (QD0) + Comp. Sol. + **ILD** Solenoid

An important Concept suggested:

- Distributed Refrigerators (Cold-Boxes)
  - Best efficiency in themodynamics

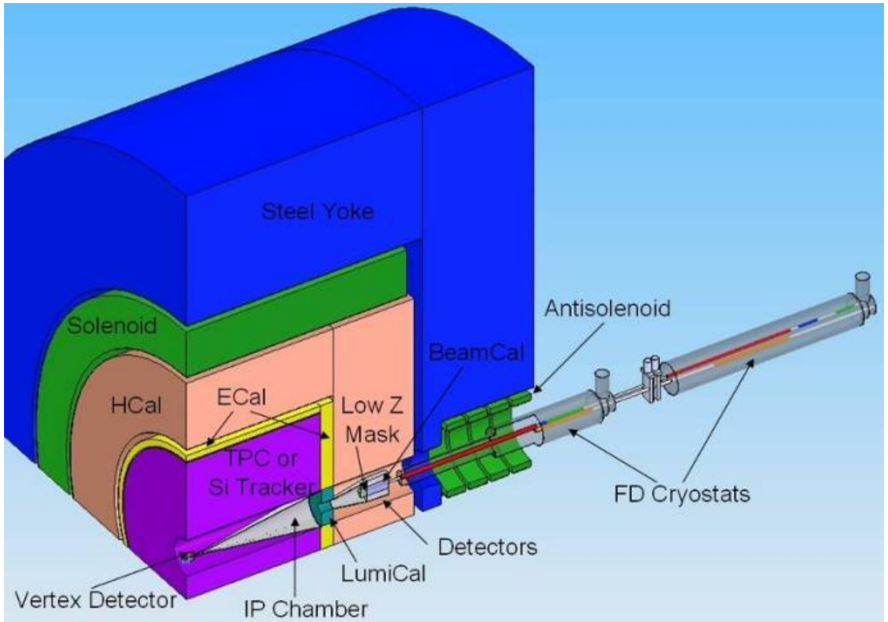
- Centralized Main-compressor station
  - Well isolated from detector hall
    - Major vibration source distanced
  - CFS interface to be unified
    - electricity and water-cooling

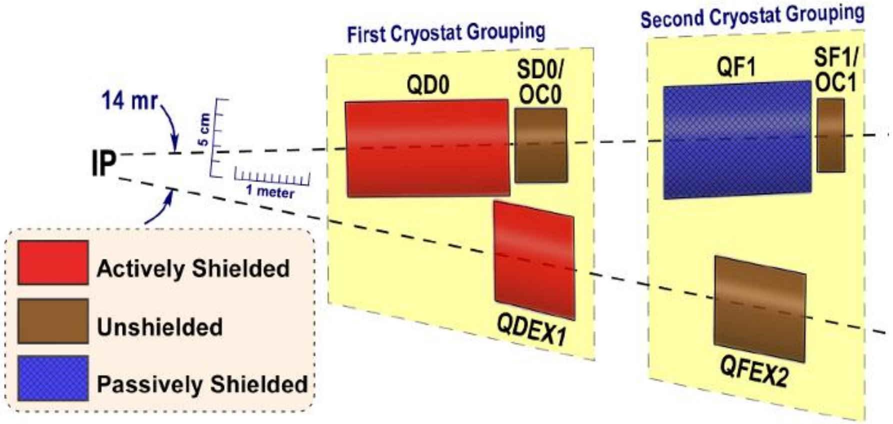


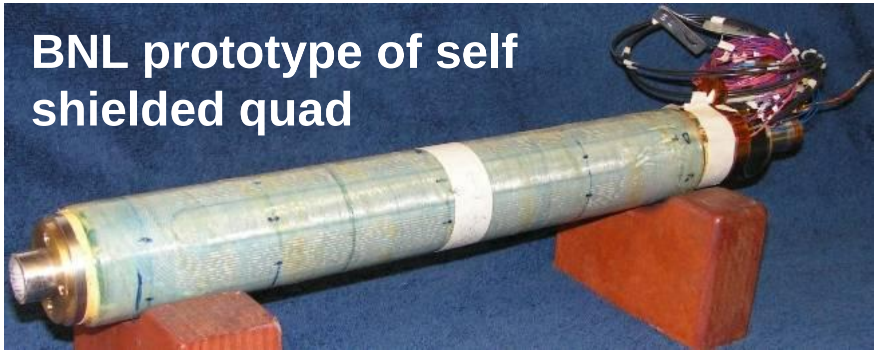


IR Region and Final Doublet

- FD arrangement for push pull
  - different L*
  - ILD 4.5m, SiD 3.5m
- Short FD for low E_{cm}
  - Reduced β_x*
    - increased collimation depth
  - “universal” FD
    - avoid the need to exchange FD
    - conceptual - requires study
- Many integration issues remain
  - requires engineering studies beyond TDR
  - No apparent show stoppers

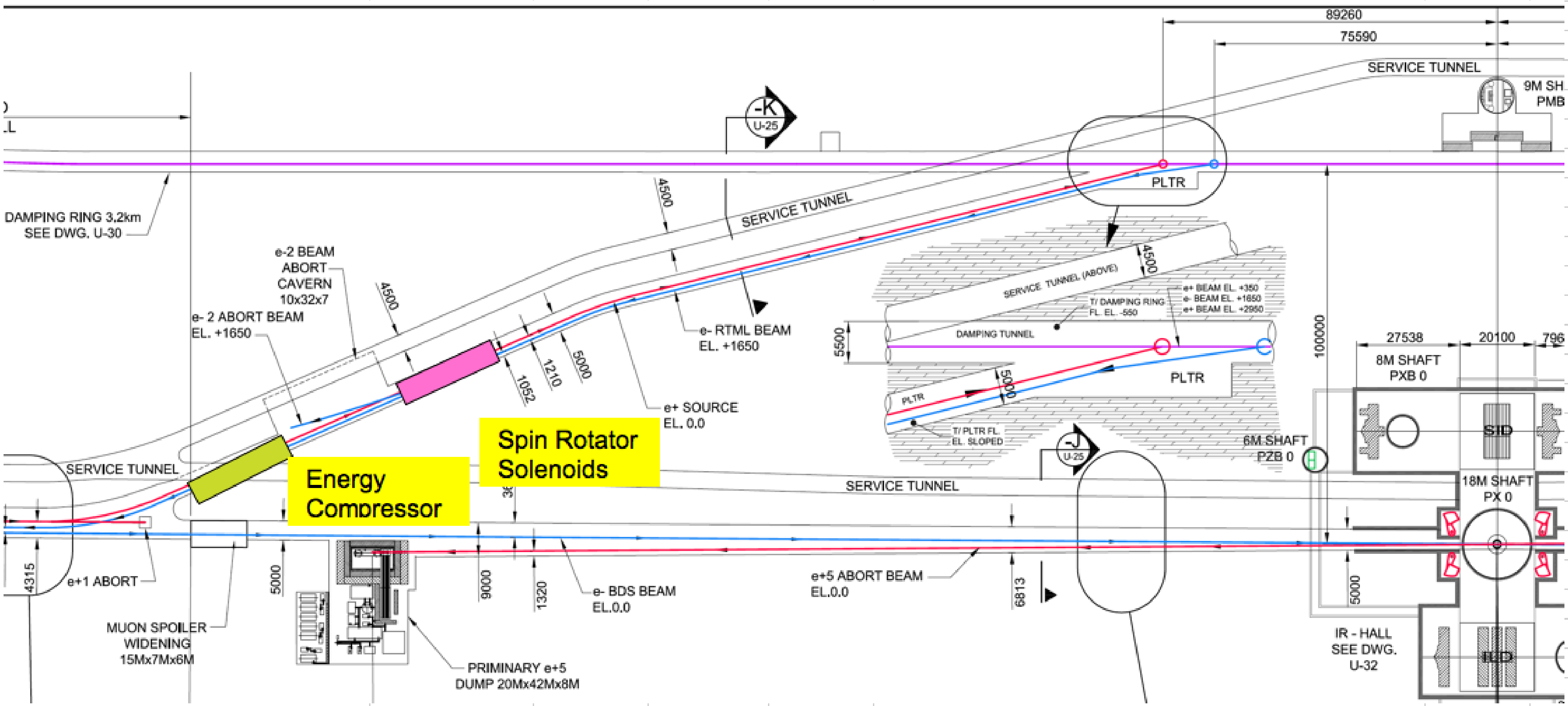






A few other cryogenic devices

Parts	Beamline	z [m], start	z [m], end	Temp.	Explanation	Beam	
42 helical undulators	EUND	-3035.4	-2717.36	4.2K	Helical undulator	e-	See
6xC4Q4 + 8xC8Q2 + 12xC8Q1	PBSTR	-1719.09	-1398.28	2K	Cryomodules, 5GeV booster, see Graphics sheet	e+	
C9 cryomodule	PLTR			2K	Cryomodule, Energy compressor, see sketch	e+	
4 solenoids, 2.6m long	PLTR				Spin rotator solenoids	e+	Assu
					Auxilliary source: Not specified		



Installed cryogenic plant power

Area	Number of plants	Installed plant size (each)	Installed total power	Operating power (each)	Operating total power	
		(MW)	(MW)	(MW)	(MW)	
Main Linac + RTML KCS	12	3.37	40.44	2.63	31.56	
Main Linac + RTML DKS	10	4.16	41.60	3.24	32.40	
e+ 5 GeV linac	1	0.49	0.49	0.35	0.35	
e- 5 GeV linac	1	0.65	0.65	0.48	0.48	
Damping Rings	1	1.45	1.45	1.13	1.13	
BDS	*1*	*0.41*	*0.41*	*0.33*	*0.33*	*still just the old RDR number*
Experiments	*1*	*1.00*	*1.00*	*0.70*	*0.70*	*1 kW at 4.5 K from Tom Markiewicz*
TOTAL with KCS			**45.60**		**35.39**	
TOTAL with DKS			**44.44**		**34.55**	
Total central campus compr power		3.59		2.66		assume BDS+DR+Sources

- KCS and DKS have essentially the same total cryogenic plant power
  - DKS slightly higher due to shorter cryogenic strings, more end boxes. Difference insignificant.
- Undulators and some other odd devices not in this yet

ILC-TDR: CFS Electric Power Balance

Electrical Power (operating-peak) in MW *(conventional numbers distributed by area systems)* [a]

UPDATED JUN 13 2012

RDR (w adjusted cryo Jan 27 2011)

Area System	RF Power	Conventional Power (operating power): Conv (incl racks)	NC Magnets	Cryo	Emerg Power	Total
e-sources	1.05	2.46	0.73	0.59	0.06	4.89
e+sources	4.11	8.59	8.9	0.59	0.21	22.4
DR	14	2.38	7.92	2.52	0.23	27.05
RTML	7.14	5.12	4.74	0	0.15	17.15
Main Linac	75.72	23.40	0.78	42.9	0.404	143.2
BDS	0	4.62	2.57	0.41	0.2	7.8
Dumps	0	3.83	0	0	0.12	3.95
IR	0	0	0	0	0	0
TOTALS	102	50.4	25.6	47.0	1.4	226

TDR 5Hz Full Power (KCS) 5Hz

Area System	RF Power	RF Racks	NC Magnets & Power Supplies	Cryo	Conventional [e]: Normal Load	Emerg Load	Total
e-sources	0.96 [b]	0.09	0.73 [b]	0.59	1.02	0.16	3.55
e+sources	1.39	0.09	4.94	0.59	2.19	0.35	9.6
DR	12.8		4.46	1.45 [m]	2.56	0.14	21.4
RTML	5.64	0.32	1.26	0 [f]	0.15	0.14	7.5
Main Linac	93.2 [h]	4.9	0.914	44.2 [g]	9.99	5.18 [n]	158.3
BDS	0		10.43	0.41	0.24	0.28	11.4
Dumps	0		0	0	1 [d]	0	1
IR	0		1.16 [q]	2.65 [r]	0.09	0.17	4.1
TOTALS	114	5.4	23.9	49.9	17.2	6.4	217

TDR baseline - Low Power (KCS) 10Hz

Area System	RF Power	RF Racks	NC Magnets & Power Supplies	Cryo	Conventional [e]: Normal Load	Emerg Load	Total
e-sources	1.28 [j]	0.09	0.73 [b]	0.80 [k]	1.02	0.16	4.08
e+sources	1.39	0.09	4.94	0.59 [l]	2.19	0.35	9.6
DR	8.67		2.97	1.45 [m]	1.84	0.14	15.1
RTML	4.76 [p]	0.32	1.26	0 [f]	0.12	0.14	6.6
Main Linac	58.1 [h]	4.9	0.914	40.5 [g]	8.10	5.18 [n]	118
BDS	0		10.43	0.41	0.24	0.28	11.4
Dumps	0		0	0	1 [d]	0	1
IR	0		1.16 [q]	2.65 [r]	0.09	0.17	4.1
TOTALS	74.2	5.4	22.4	46.4	14.6	6.4	169

changes compared to APR 19 2012 version

a) Numbers shown are peak operating power gathered per area systems only.

b) e-source numbers are taken from RDR (no detailed load table)

c) Refer to CFS criteria tables for details

d) Main dumps electrical power for associated components are taken from "RDR BDS dump parameters" dated May 2 2006

e) Conventional numbers shown are peak operating power (Low power conventional numbers scaled by low-power technical load)

f) RTML cryo is included with ML Cryo

g) ML/RTML Cryo for full power-5Hz was taken from meeting with T.Peterson on 1/28/2011. The 10Hz cryo was from T.Peterson excel file "ILCcryoTDP25May2012"

h) ML RF full power was taken from Nantista email/slide 2-18-2012. The 10Hz-low power used 413 RF quantity, and included Marx modulator impact, from Nantista slide/M.Ross email 5-30-2012

j) 320 KW was added to 10 Hz e-source RF (per John Sheppard, DAEGU Meeting April 24 2012)

k) Cryo corrections from Tom Peterson May 17 2012 email (5Hz to 10Hz Cryo is multiplied by 1.36 factor). File "ILCcryoTDP25May2012.xls" shows this to be 0.65MW, waiting for confirmation

l) File "ILCcryoTDP25May2012.xls" shows this e+cryo to be 0.49MW, waiting for confirmation

m) DR Cryo corrections from Tom Peterson/Mark Palmer May 17 2012 email

n) MAY 17 2012 meeting (w Tom Peterson & Akira Yamamoto) Cryo-Liquid Storage system 100KW per plant=total 600KW

p) RTML 10 Hz RF update per AlessandroVivoli email May 22 2012

q) Approx 580KW non-cryo load from SiD load table. Email K.Buesser to V.Kuchler on 6/8/2012 confirmed that this number is fine for ILD, for both garage position and and normal operation.

r) 1.3MW cryo load from SiD load table(dated 2010). This number was confirmed on CFS meeting May 22 2012(F.Asiri discussion with SiD) as_approximate & best assumption at the moment, and further discussed by CFS with T.Peterson on May 24 2012, to help confirm the numbers. Email K.Buesser to V.Kuchler on Jun 8 2012 confirmed that ILD cryo for both garage position and normal operation are the same (or double the 1.3MW SiD cryo load)

DRAFT

Helium pipe sizes for remote compressor locations

system	compr power (MW)	distance (m)	low pressure pipe ID (inches)	intermediate pipe ID (inches)	high pressure pipe ID (inches)
KCS ML	3.37	2000	**14.21**	**8.71**	**7.63**
e- 5 GeV	0.65	600	**6.03**	**3.69**	**3.52**
e+ 5 GeV	0.49	1600	**6.68**	**4.09**	**3.88**

- Piping from the central campus to relatively small cryogenic plants such as boosters is not a problem
  - 3 1/2 inch (100 mm) pipe installed cost est in 2006 is $148/meter
  - 6 inch (150 mm) pipe installed cost in 2006 is $275/meter
  - 12 inch (300 mm) pipe installed cost est in 2006 is $716/meter
- Main Linac compressors may be located away from cold boxes with room temperature piping
  - Need to check cost tradeoffs for large pipes versus locations of compressors

Tom's Conclusions
as of May 31, 2012

- Piping to 5 GeV booster linacs and other central region cryogenics from one central compressor location looks practical
- Next step is detailing cryogenic supply to undulators and some of the small isolated devices in the central region
  - Energy compressor, spin rotator solenoids
  - Add those cryogenic cooling powers to total
- Document helium warm pipe lengths and cold transfer line lengths
  - Refine total heat load estimates
  - Include in cost estimates

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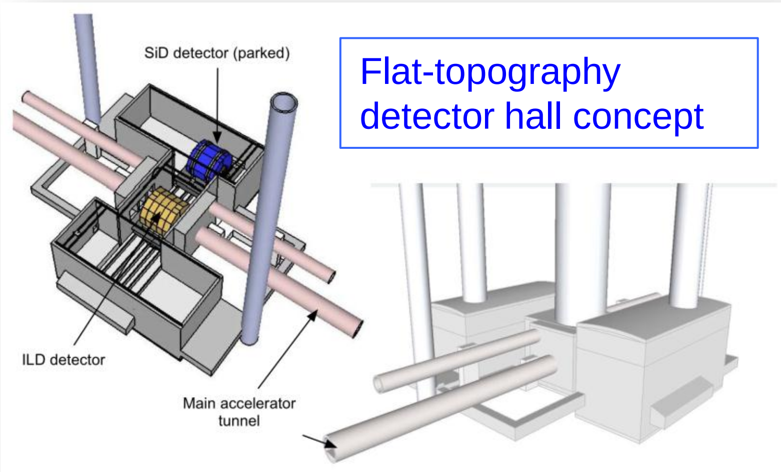
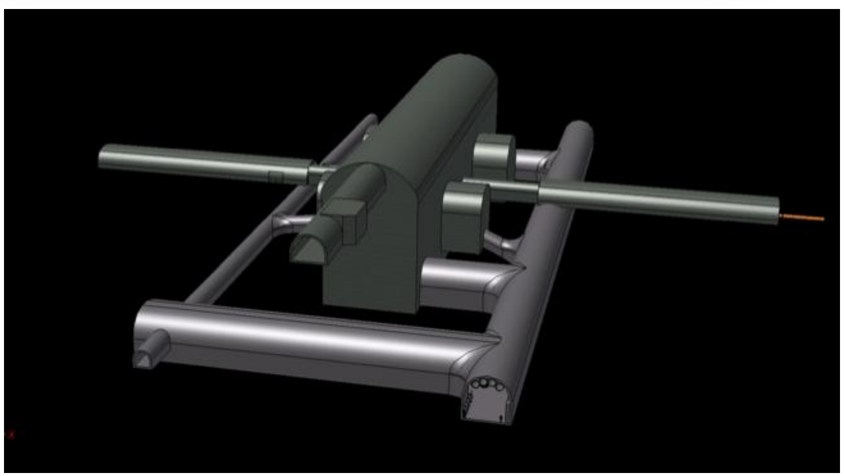
Detector Hall CFS Review





Mountainous topography detector hall

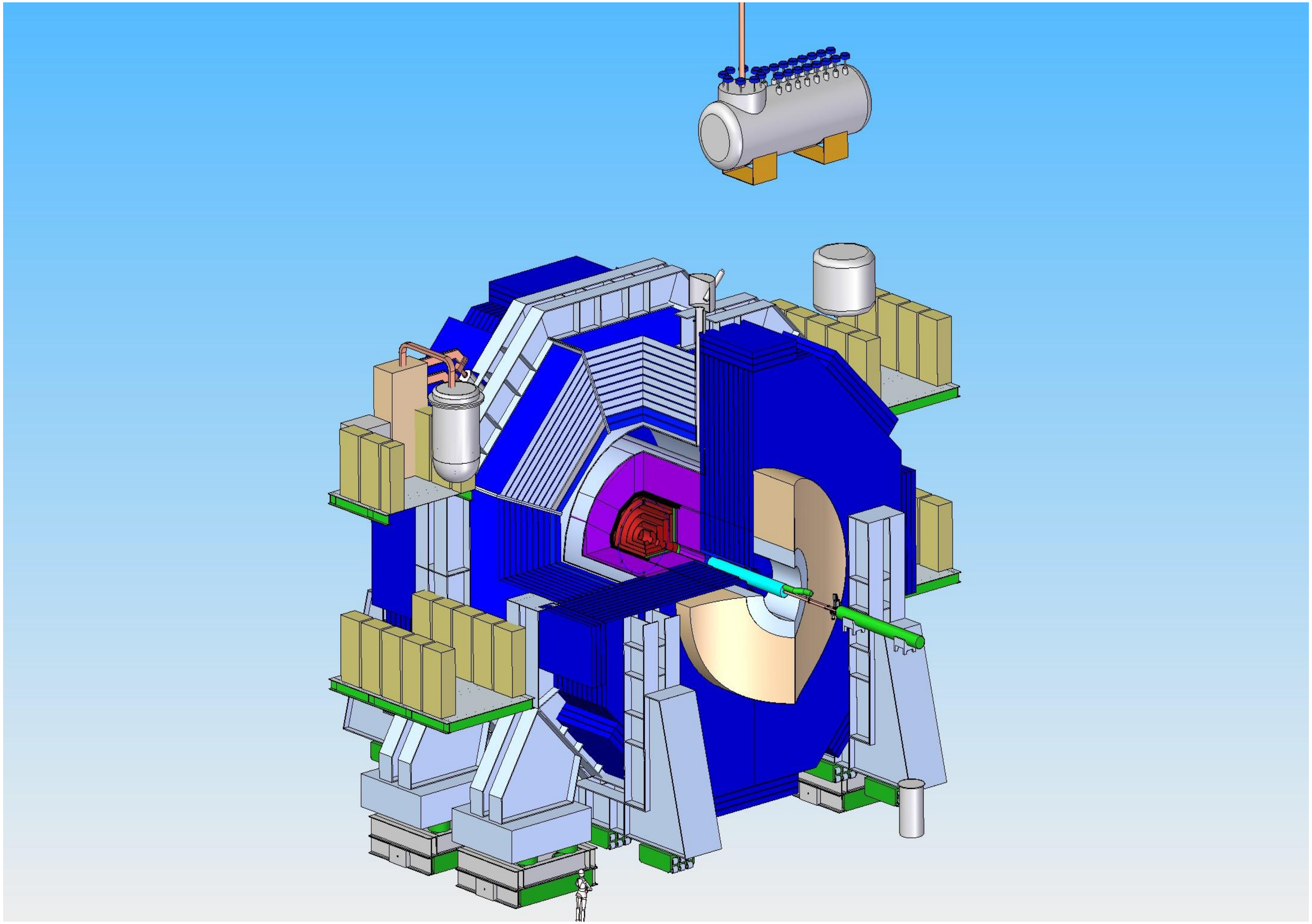
- Review Questions:
  - Criteria understood?
  - Design satisfy the criteria?
  - What are the cost-drivers?
  - What are the outstanding issues?
- Presentations:
  - Alignment requirements (special tunnels)
  - Underground Assembly schemes
  - Cryogenic systems
  - Cost roll-up
- Report to be written.

SLD/ILD Engineering and Detector Interface Working Meeting SiD Cyrogenics

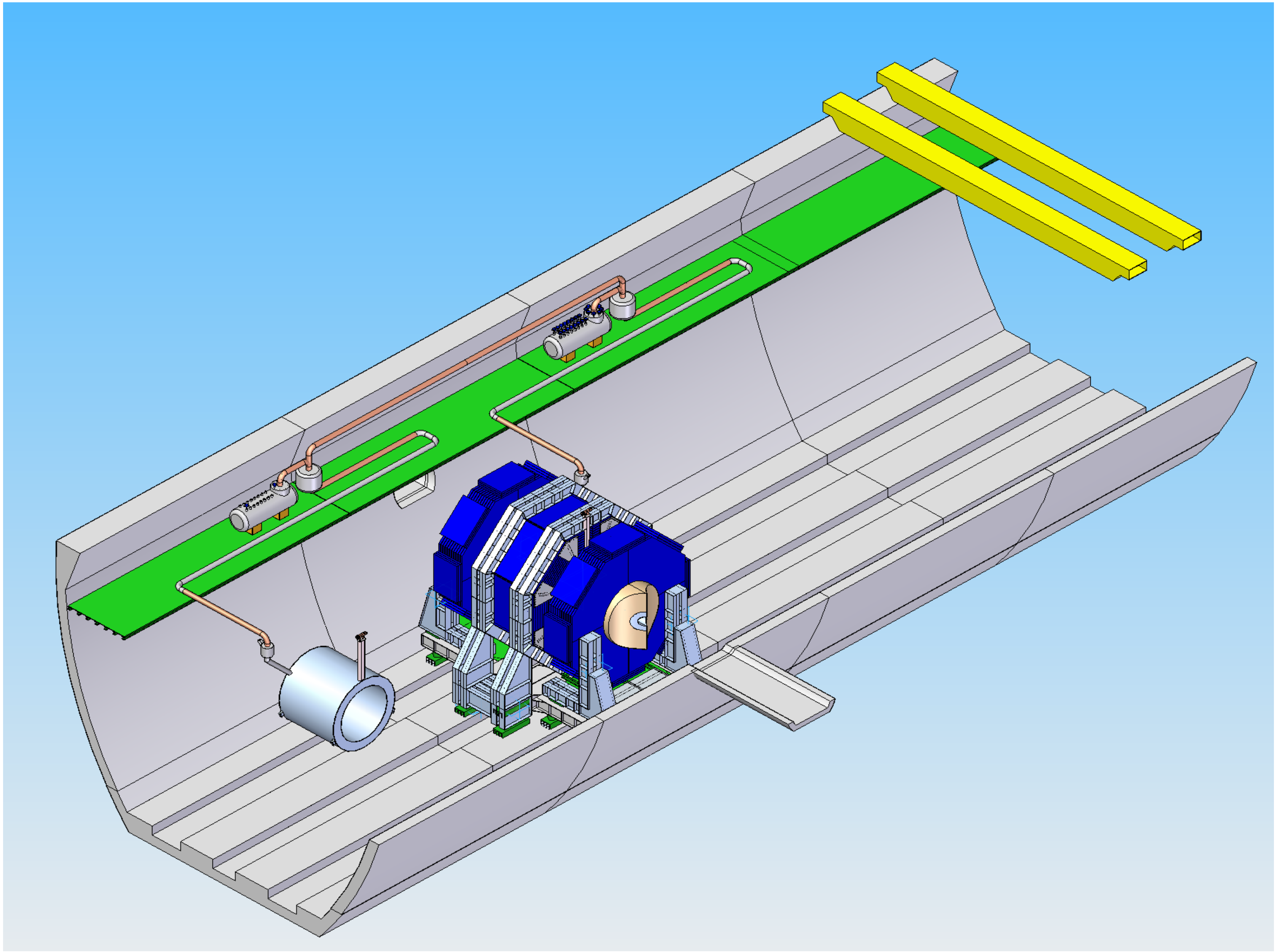
Wes Craddock

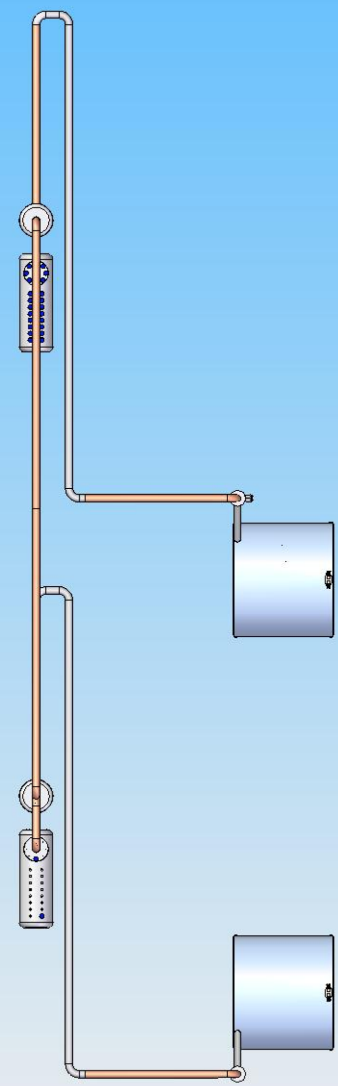
SLAC

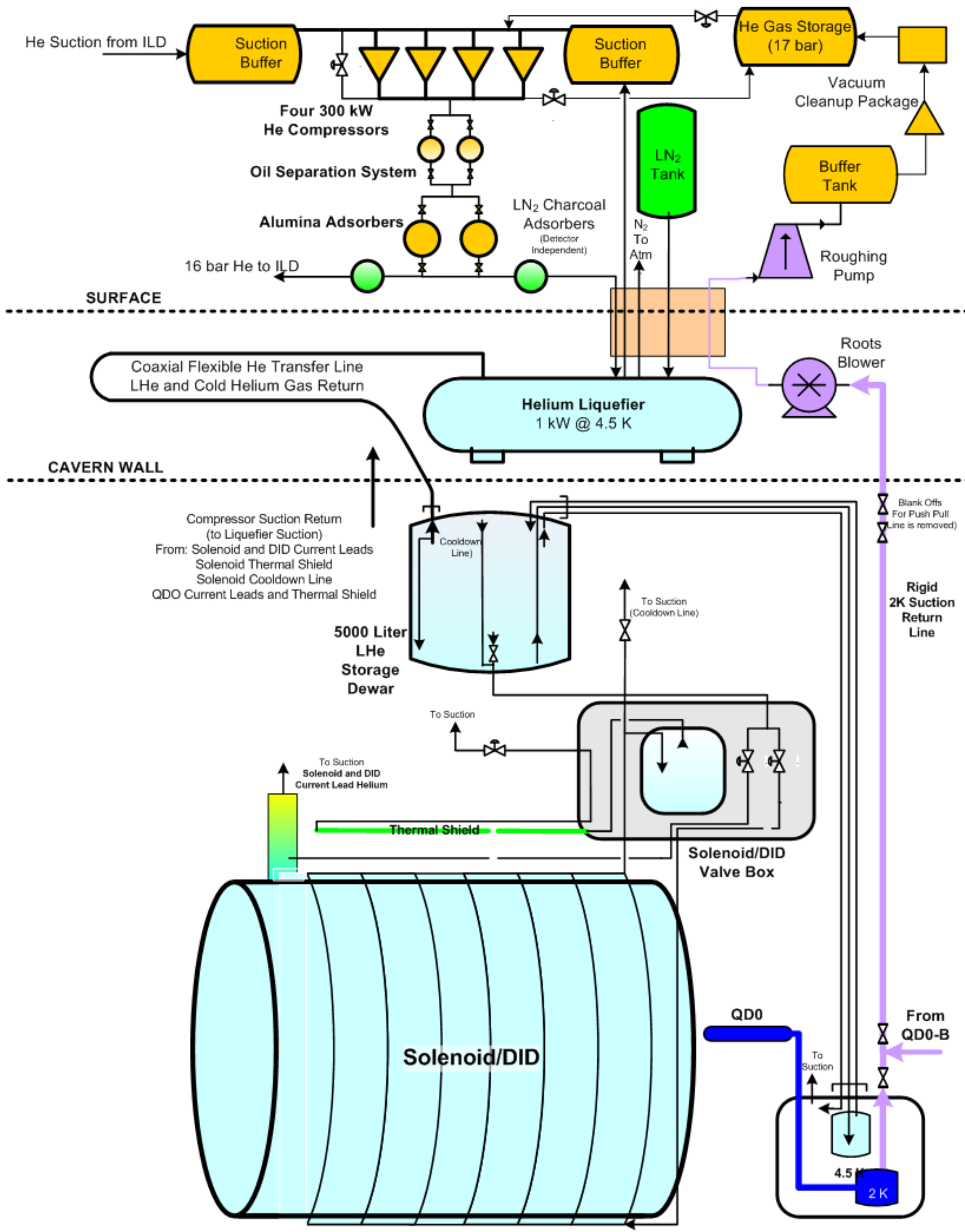
December 12, 2011



SiD Solenoid Status Update
Wes Craddock / SLAC






He Suction from ILD
Suction Buffer
Suction Buffer
He Gas Storage (17 bar)
Vacuum Cleanup Package
Four 300 kW He Compressors
Oil Separation System
Alumina Adsorbers
LN_2 Tank
Buffer Tank
LN_2 Charcoal Adsorbers
(Detector Independent)
N_2 To Atm
Roughing Pump
16 bar He to ILD
SURFACE
Roots Blower
Coaxial Flexible He Transfer Line
LHe and Cold Helium Gas Return
Helium Liquefier
1 kW @ 4.5 K
CAVERN WALL
Blank Offs For Push Pull Line is removed)
Compressor Suction Return
(to Liquefier Suction)
From: Solenoid and DID Current Leads
Solenoid Thermal Shield
Solenoid Cooldown Line
QDO Current Leads and Thermal Shield
Cooldown Line)
To Suction (Cooldown Line)
Rigid 2K Suction Return Line
5000 Liter LHe Storage Dewar
To Suction
To Suction
Solenoid and DID Current Lead Helium
Thermal Shield
Solenoid/DID Valve Box
Solenoid/DID
QD0
From QD0-B
To Suction
4.5 K
2 K

SiD Cryo Questions

QDO:

1) Can we use only one LHe supply to QD0? Do we really need LN2 and a separate cooldown line?
    1) Comment by AY: to be discussed later, not LN2 use.
2) Does the LHe connection from the LHe storage dewar to QD0 every need to be removed for detector servicing?
    1) Comment by AY: we need to understand better the detector opening scenario.
3) What is the routing of the 4 K LHe line to QD0? Is it rigid, flex or a combination?
    1) Comment by AY: rigid is better for stability, but probably combination,

QDO 2K Vacuum Pumping System:

1) Is it possible to use the ILC vacuum pumping system ???
    1) Comment by AY: Probably independent line for reliablity to each other.
2) How is the 2 K suction line made and run, rigid or flex???
    1) Comment by AY: at least it should be vacuum isolated transfer-line.

LN2 System:

1) What is the elevation of the LN2 tank? If it is at a great elevation, a pressure reduction system is needed.
    1) Comment by AY: We will not plan to use LN2 because of safety in long, underground tunnel.

Cryogenic System of Interaction Region (SiD, ILD, QD0, QF1, Crab Cavity) in the Japanese Mountain Site

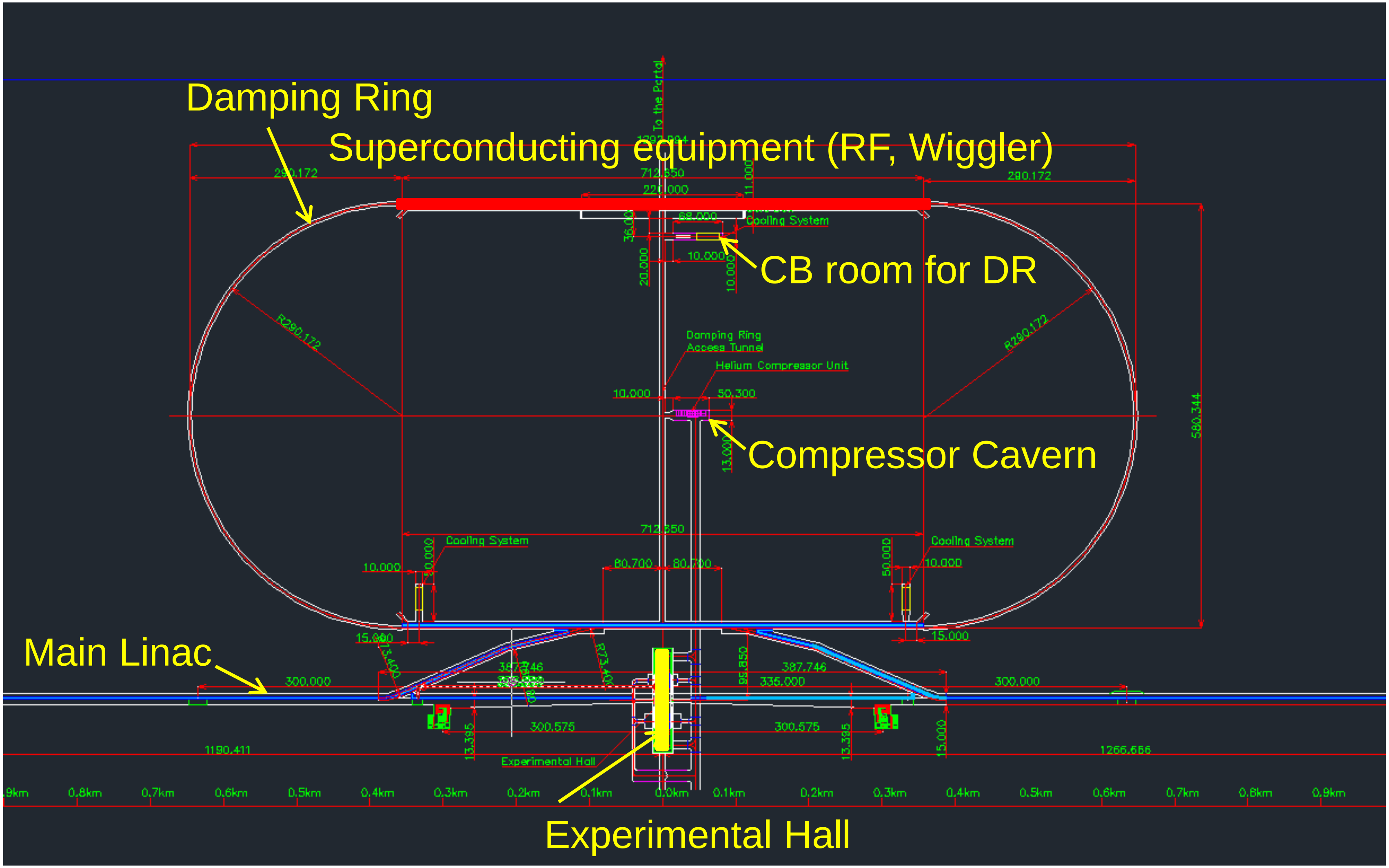
WebEx meeting : ILC Central Region Cryogenics
June 1, 2012

Updated, June 13, 2012

KEK IPNS/Cryogenic Group

T. Okamura, Y. Makida, and M. Kawai

Overall layout of Interaction Region



(Superconducting instruments SID, ILD, QD0, QF1, CC)

Baseline design of central region

commented by AY

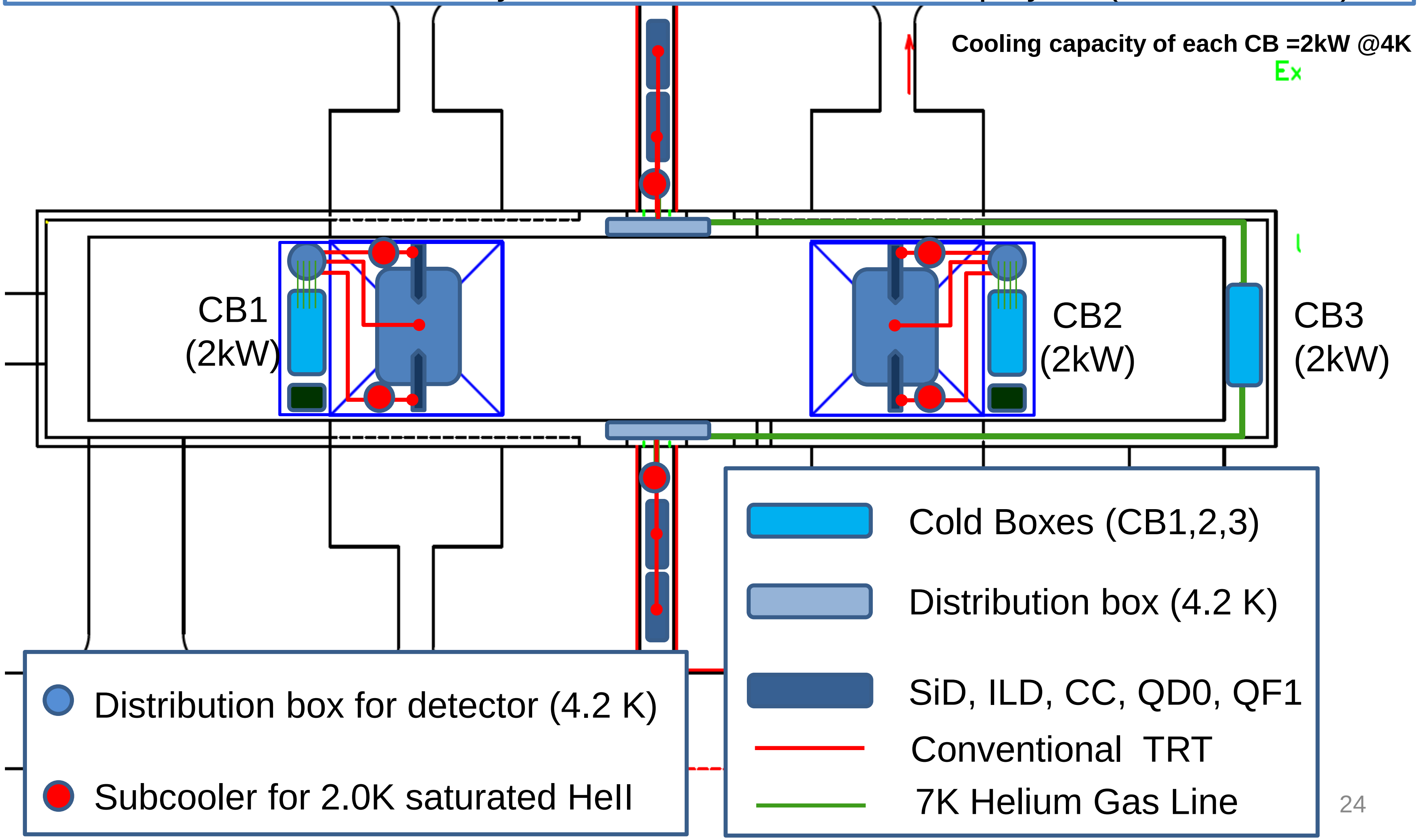
- 3 cold boxes; one for ILD+QD0s, one for SiD+QD0s, and one for QF1s and crab cavities (The scenario has been agreed by both SiD and ILD side

- There are two possibilities of the location of CBs for detectors
  - On the detector/platform (see P3) 🡐 Cryogenic Scenario of mountain site
    - 300K flexible tube along the cable chain in the cable pit or on 6F utility floor (depends on the bending radius)
  - On the side wall (see P4)
    - CB on 5F or 6F utility floor
    - 4K flexible transfer tube on 6F utility floor
      - There is no need to prepare large space for multiple TRT.
    - CB and flexible transfer tube locate above the entrance of the access tunnel in order not to disturb the detector assembly

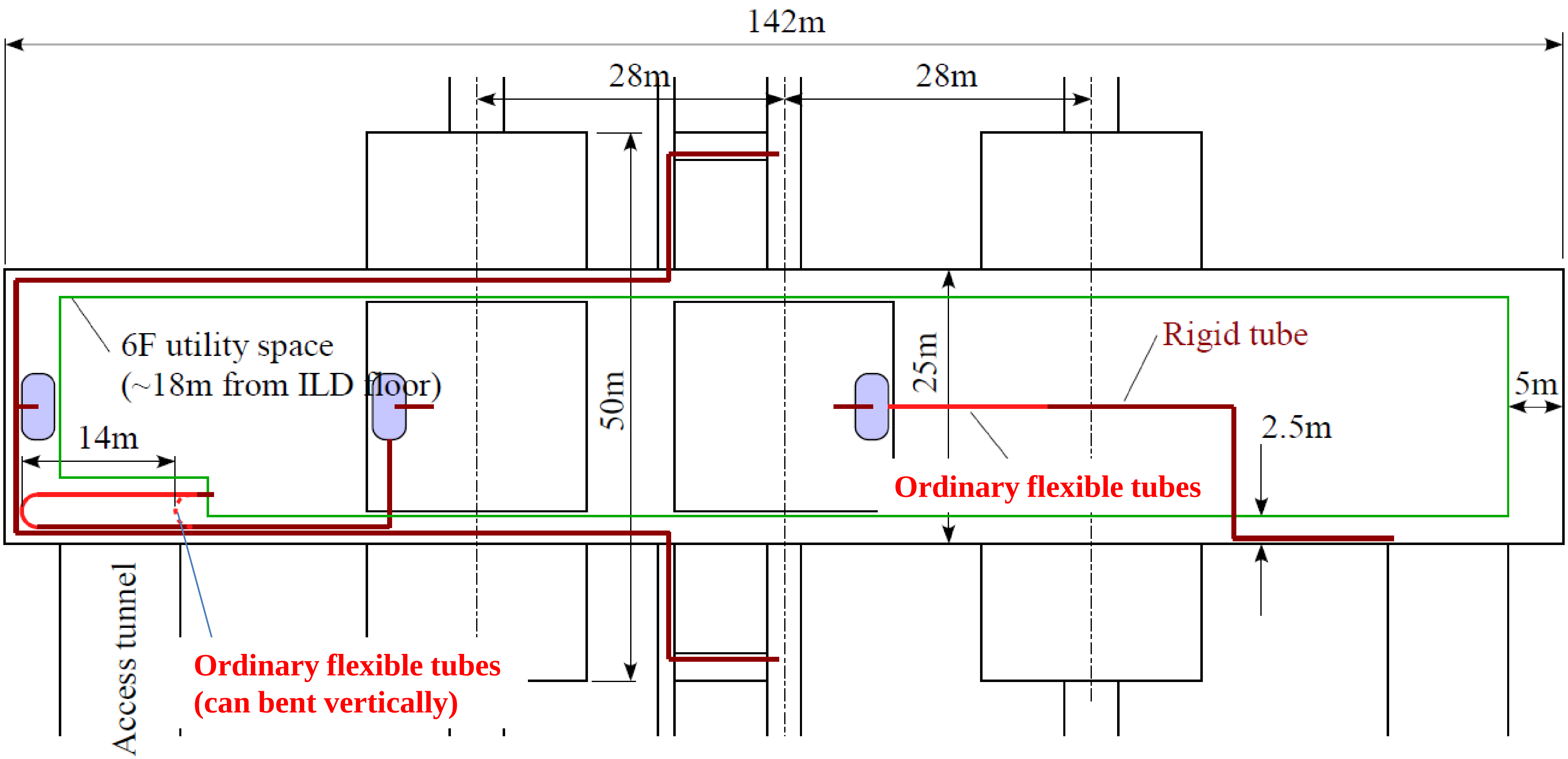
- Choice of the location of the CB is up to each detector group >> not recommended
  - Still need to be discussed and agreed, also with accelerator, because of QD0 (should be common)
- Capacity of the compressor for three CBs has to be defined before AD&I meeting

Cryogenic Layout in the experimental hall

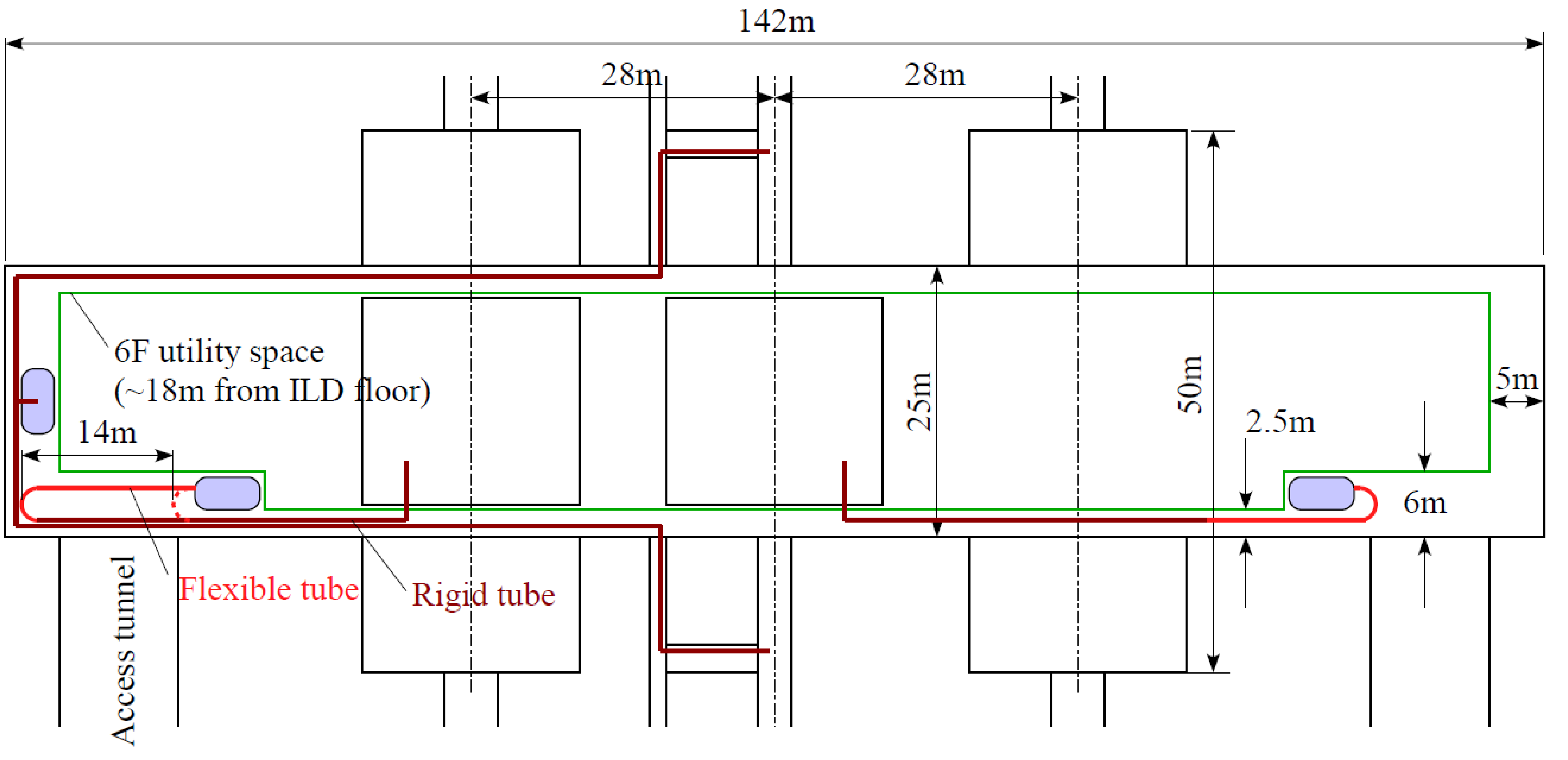
- ✓ CB3 and distribution boxes for CC and QF1 are installed on the 6F.
- ✓ CB1, 2, distribution boxes and PSs are installed on the each platform for detector
- ✓ Several numbers of ordinary flexible tubes have to be employed. (see P8 & P10)



Detector CBs on the detector/platform



Detector CBs on the side wall



Action Item for DBD

We have to estimate following items.

- Total Heat Load

- Practical Flow Diagram and Design of Cryogenic equipment.

- Cost estimation

- Vibration reduction of QD0
  - ✓ Fundamental research of vibration source
  - ✓ Modal analysis of QD0
  - ✓ Development of absorption scheme.

- Laid down method of ordinary flexible tubes (see previous page)
  Now we consider the several schemes.
  - ✓ 5F and 6F by means of Cable chain
  - ✓ 6F utility space
  - ✓ On the floor of experimental hall

Proposal and Home Work

- Cryogenics Layout in the Central Region
  - Distributed cold boxes and centralized main compressor banks for individual cryoplant
    - Unified interface to CFS, better isolated from detector
    - Be an important consensus, today !
  - Individual Cryoplant/cold box to QD0+ anti-solenoid + Detector Solenoid
- Push-pull/Movable option
  - Home work to have common flexible pipe-line design
    - Either cold or warm flexible line
    - Common design needed to adapt it also to adapt to QF0.

Again, This is outcome from Intensive Meetings, since early 2012

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