



ILC 1.3 GHz CM, 2022

Design status on 11/16/22,
by Y. Orlov, behalf FNAL and KEK
teams



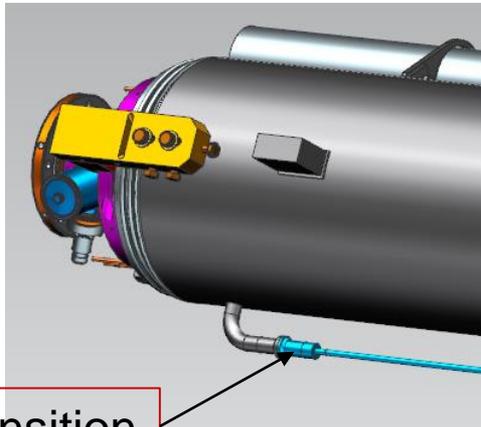
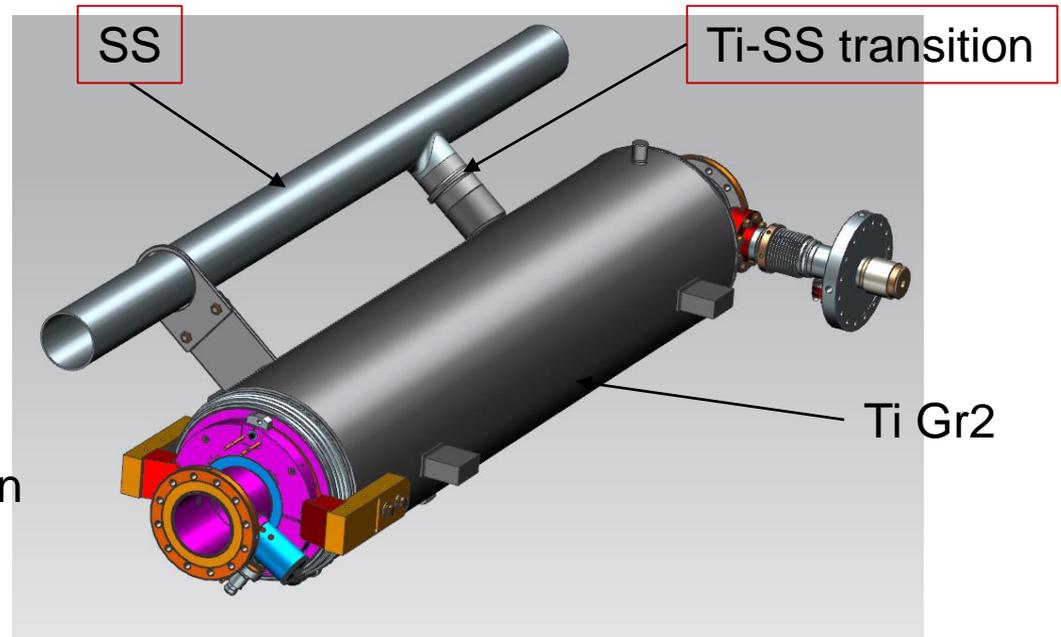
Outline

- **1.3 GHz cavity**
- **SC magnet**
- **Cavity string**
- **Cold mass**
- **Cryogenic piping compare**
- **1.3 GHz CM**
- **Transportation**
- **Interconnection**

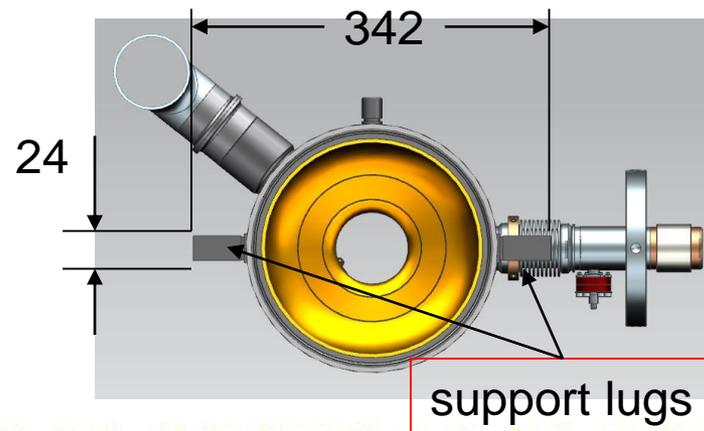


1.3 GHz ILC cavity (short-short)

- 9-cell cavity, TESLA style
- 1247.4mm, flange to flange
- Support lugs - LCLS-II
- He vessel material: Ti Gr2
- 2-phase pipe material: SS316L
- Ti-SS transition joins used:
 - warm up nozzle
 - 2 phase pipe connection

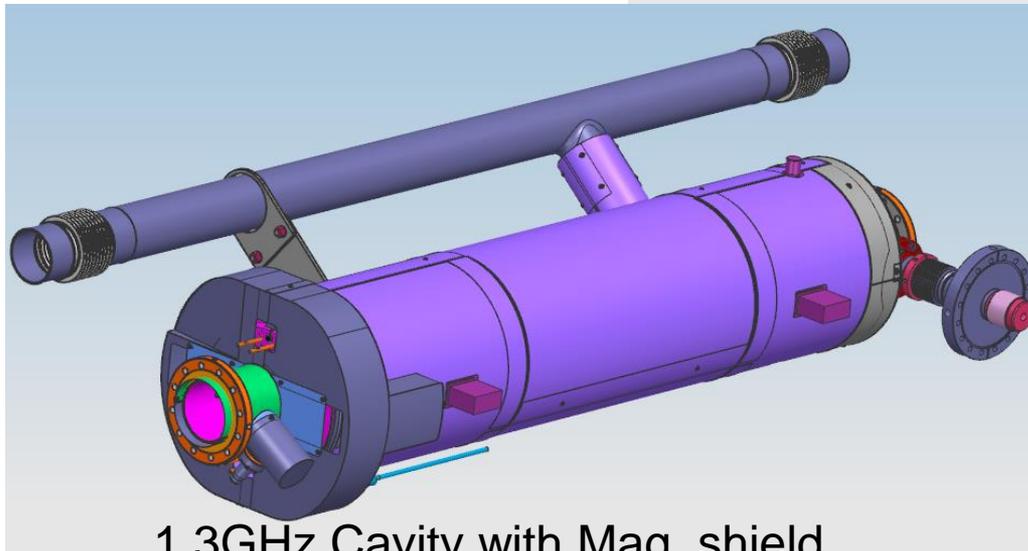
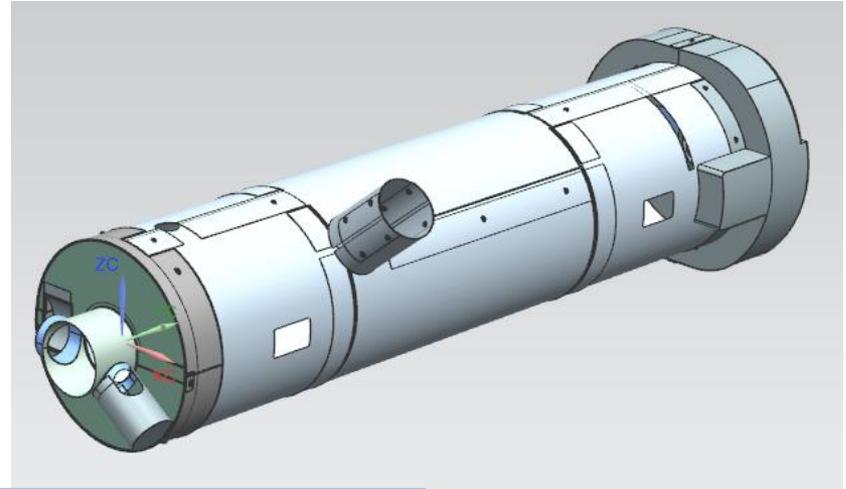
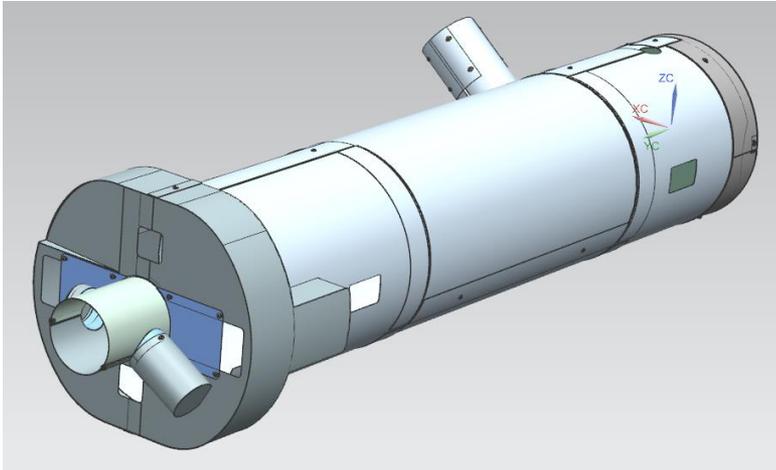


Ti-SS transition



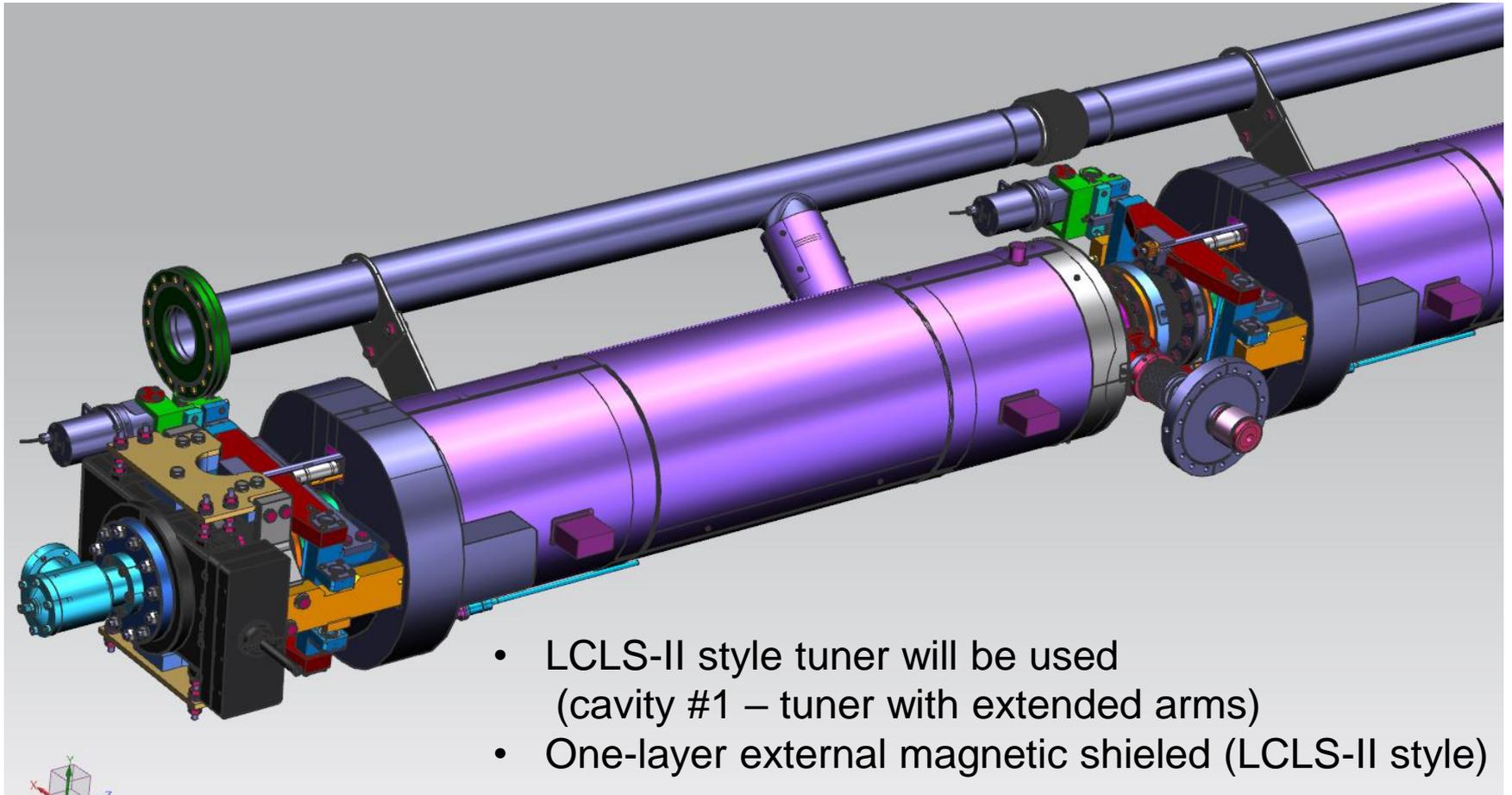


1.3 Cavity Mag. Shielding (one layer)



1.3GHz Cavity with Mag. shield

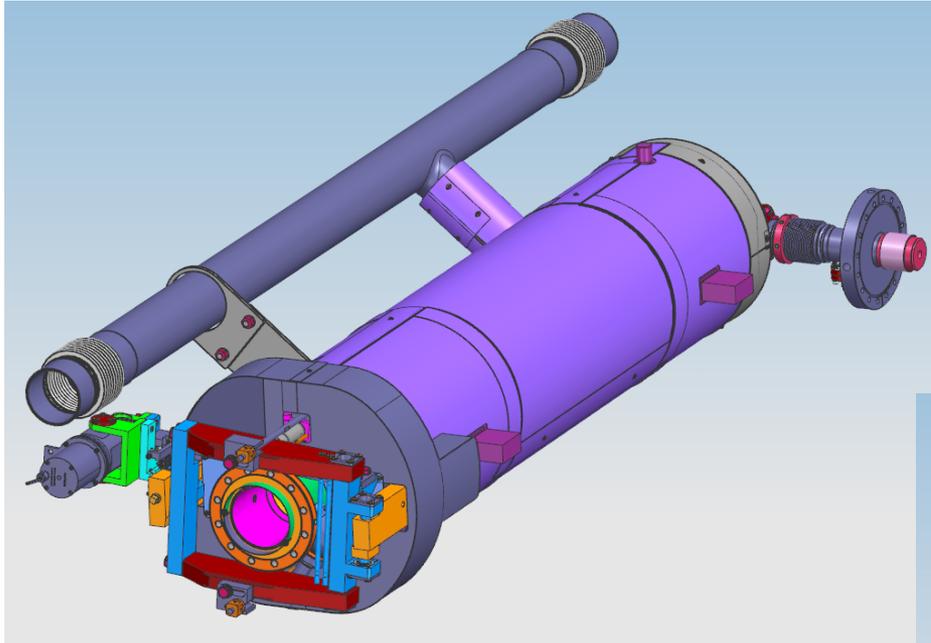
ilc 1.3 GHz cavity #1 (with tuner, magnetic shielding and GV)



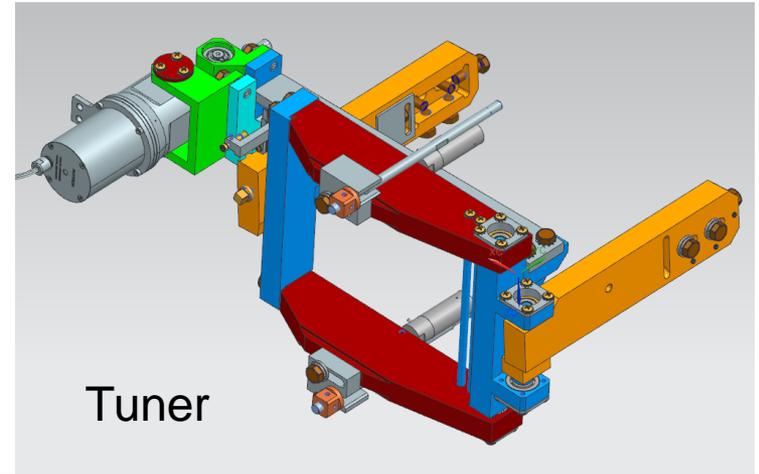
- LCLS-II style tuner will be used (cavity #1 – tuner with extended arms)
- One-layer external magnetic shielded (LCLS-II style)



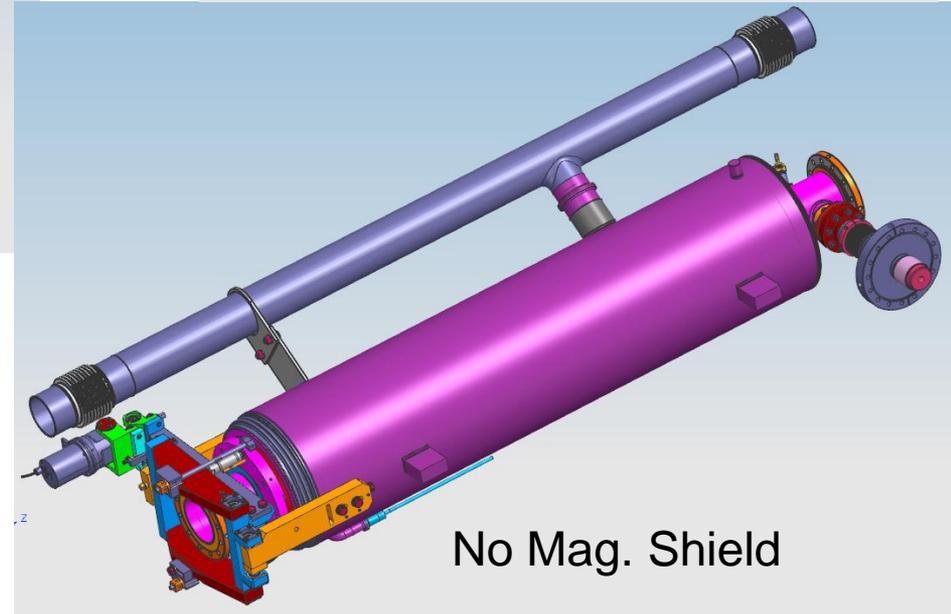
1.3GHz Dressed Cavity with Tuner



With Mag. Shield



Tuner

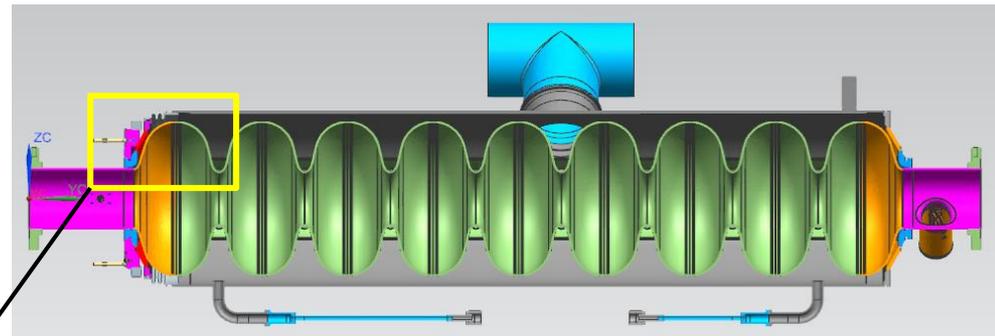
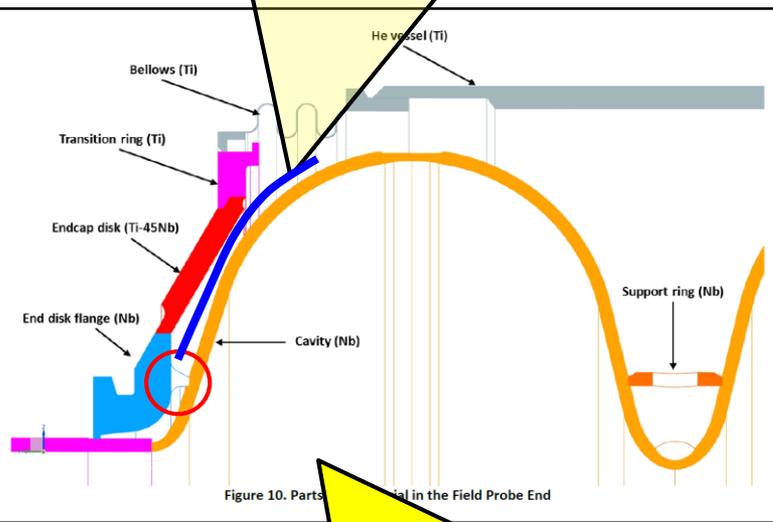


No Mag. Shield



Bellows and Magnetic shield

Mag. Shield inside helium tank as suggested in TDR (KEK)

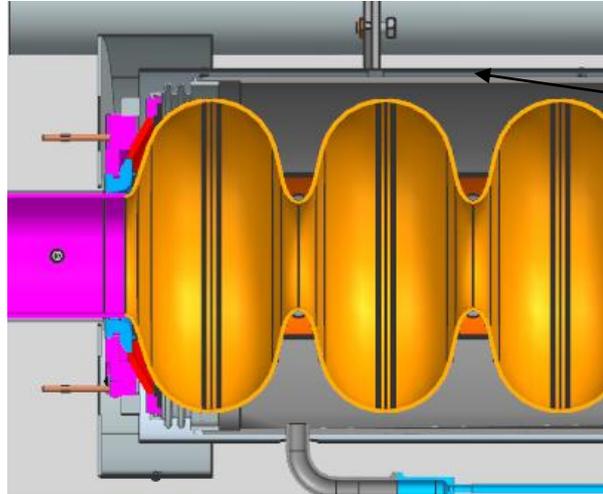


This cross-sectional view is confidential? KEK got from the FNAL document.

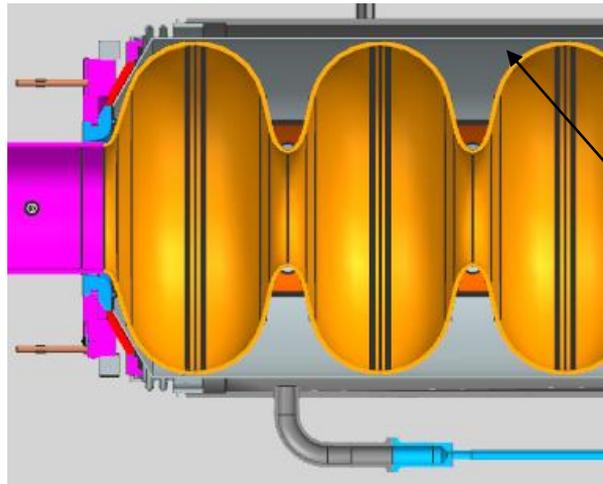
(From Kirk presentation)



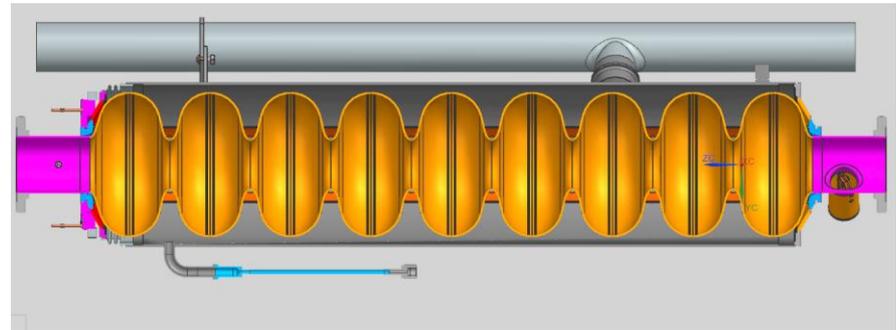
1.3GHz ILC Cavity with Mag shielding (for discussion)



External Mag. Shielding (LCLS II)



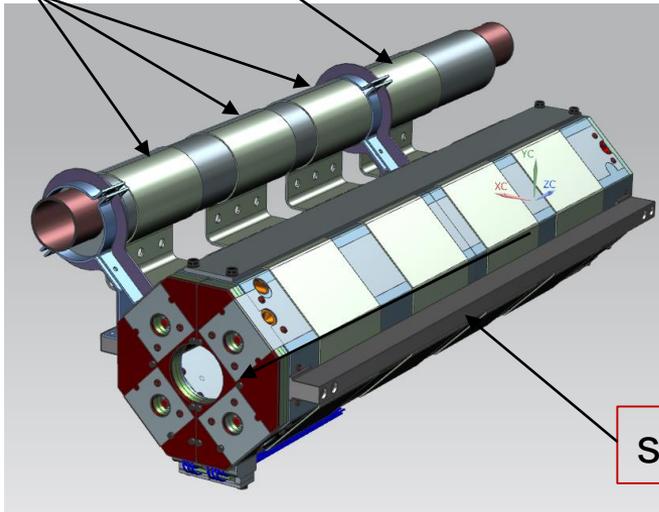
Internal Mag. Shielding (KEK)





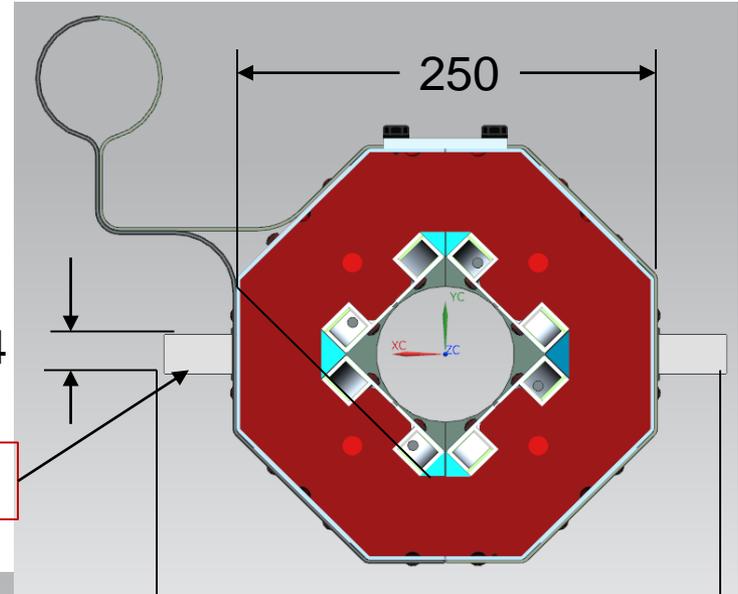
1.3 GHz ILC magnet

Al thermal straps

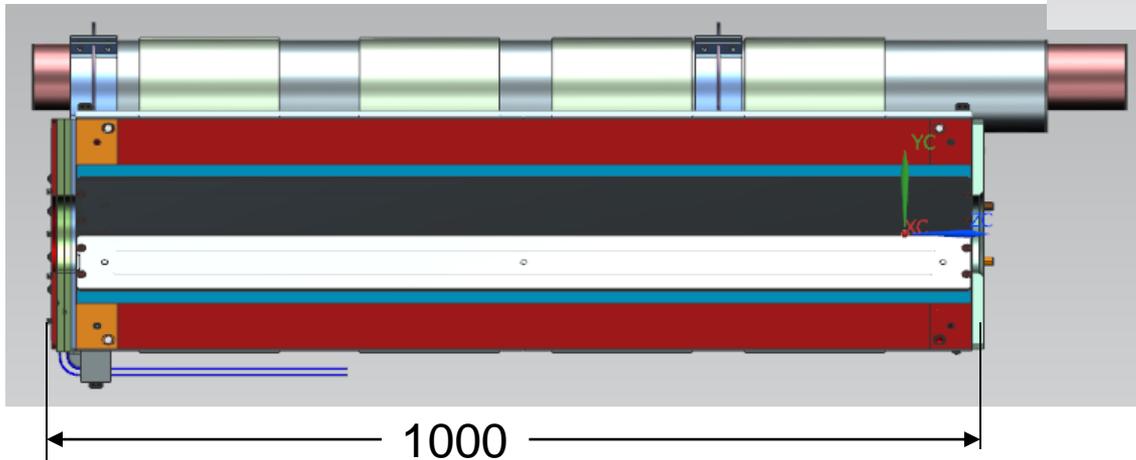


support rails

24



342



1000

- ILC conduction cooled splittable quad, ~1 m
- Magnet 2-phase pipe have extra volume for He
- Optional: Magnet 2phase pipe from Al (Al-SS transition?)

STUDY OF CONDUCTION-COOLED SUPERCONDUCTING QUADRUPOLE MAGNETS COMBINED WITH DIPOLE CORRECTORS FOR THE ILC MAIN LINAC

Y. Arimoto*, S. Michizono, Y. Morikawa, N. Ohuichi, T. Oki, H. Shimizu, K. Umemori, X. Wang, A. Yamamoto, Y. Yamamoto, Z. Zong, KEK, Tsukuba, Japan
V. Kashikhin¹, Fermilab, Batavia, Illinois, USA

Parameters	L.E. type	H.E. type
Beam energy	≤ 25 GeV	≥ 25 GeV
Physical length	0.25 m	1 m
Magnetic length	0.20 m	0.95 m
Radius of inner pole	0.045 m	
Field gradient (G)	19 T/m	40 T/m
G integral	3.8 T	38 T
B_0	0.05 T	0.11 T
B_0 integral	0.01 T m	0.10 T m
Maximum field in coil	~ 1.5 T	~ 3 T
Operation temperature	2 K	

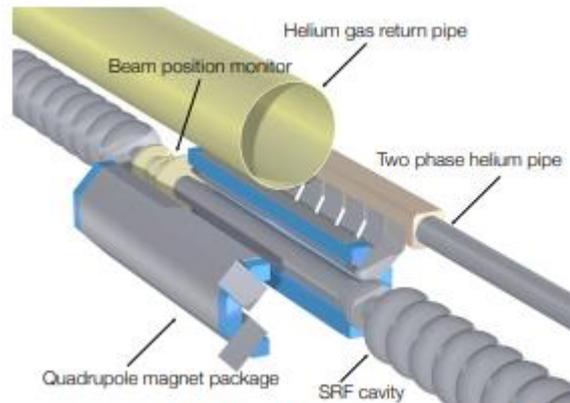


Figure 1: Splittable quadrupole package in CM.

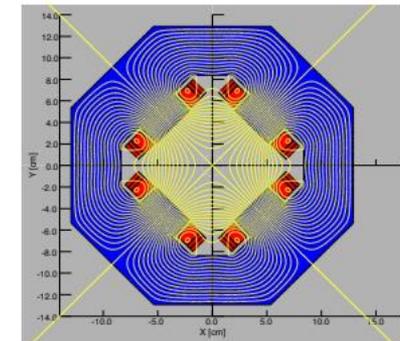


Figure 2: 2D calculation model and flux line at $I_q = 82$ A.

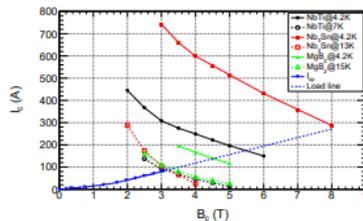


Figure 5: The critical current as a function of the critical B -field for NbTi, Nb₃Sn, and MgB₂ and loadline of the quadrupole magnet package.

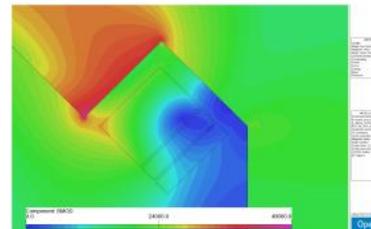


Figure 4: The color contour of the B -field strength around the coils. The current of the quadrupole coil is $I_q = 744 \text{ turn} \times 82$ A, and the current of the both dipole coil is $I_d = 217 \text{ turn} \times 35$ A.

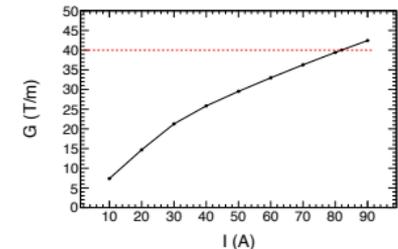
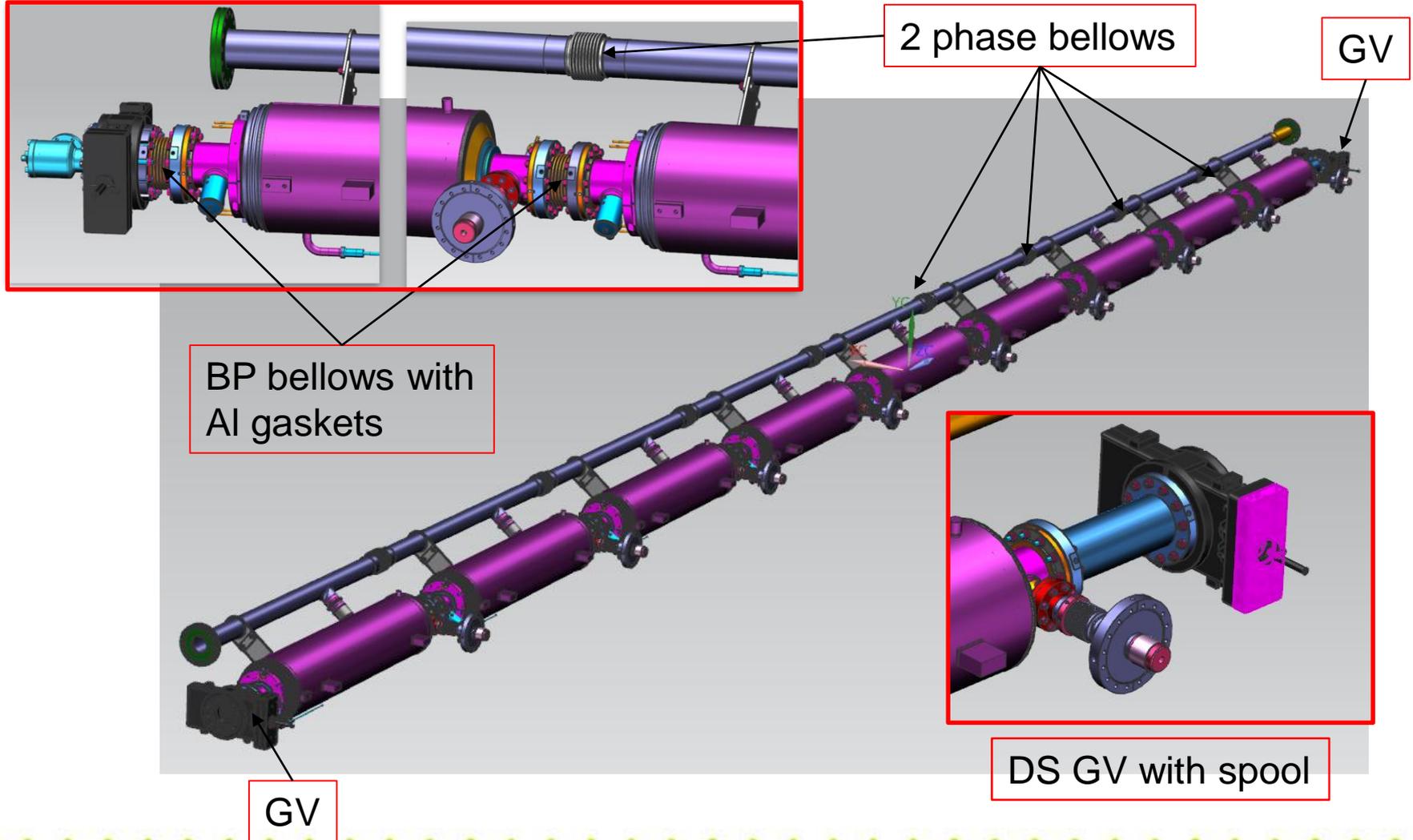


Figure 3: Magnetic field gradient as a function of quadrupole coil current. Horizontal broken line is specification value of the field gradient.

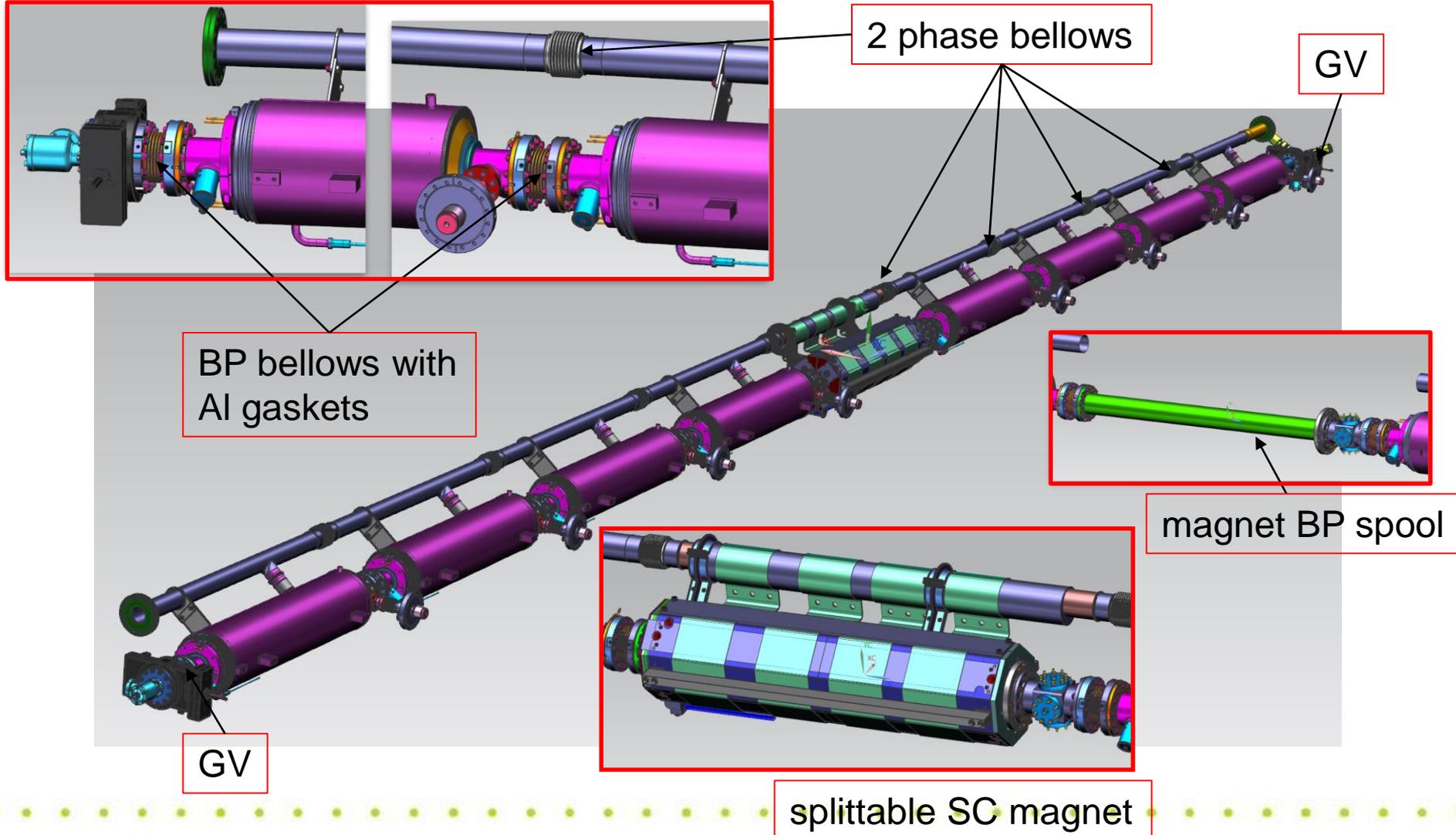


1.3 GHz cavity string-A



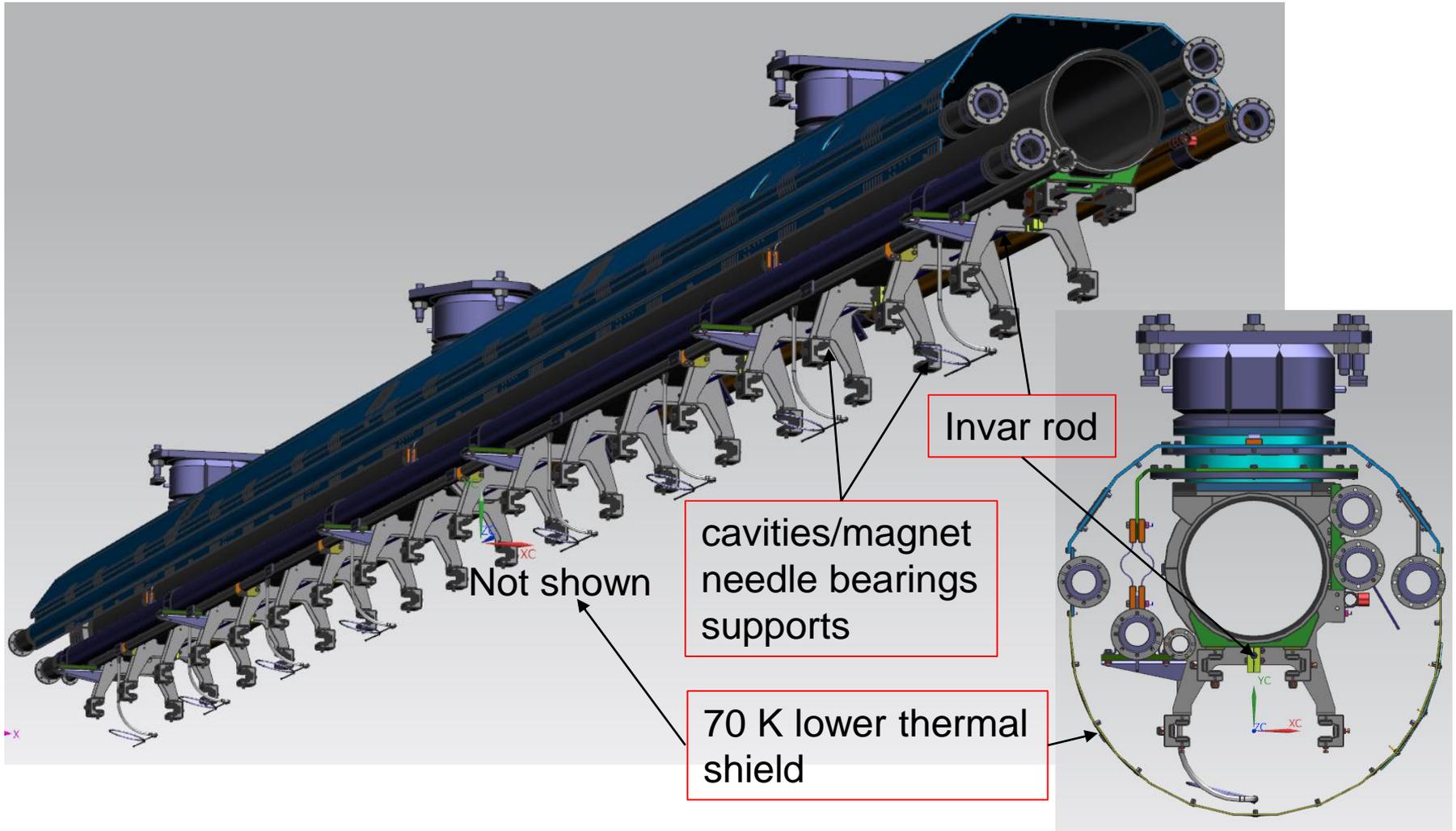


1.3 GHz cavity string-B



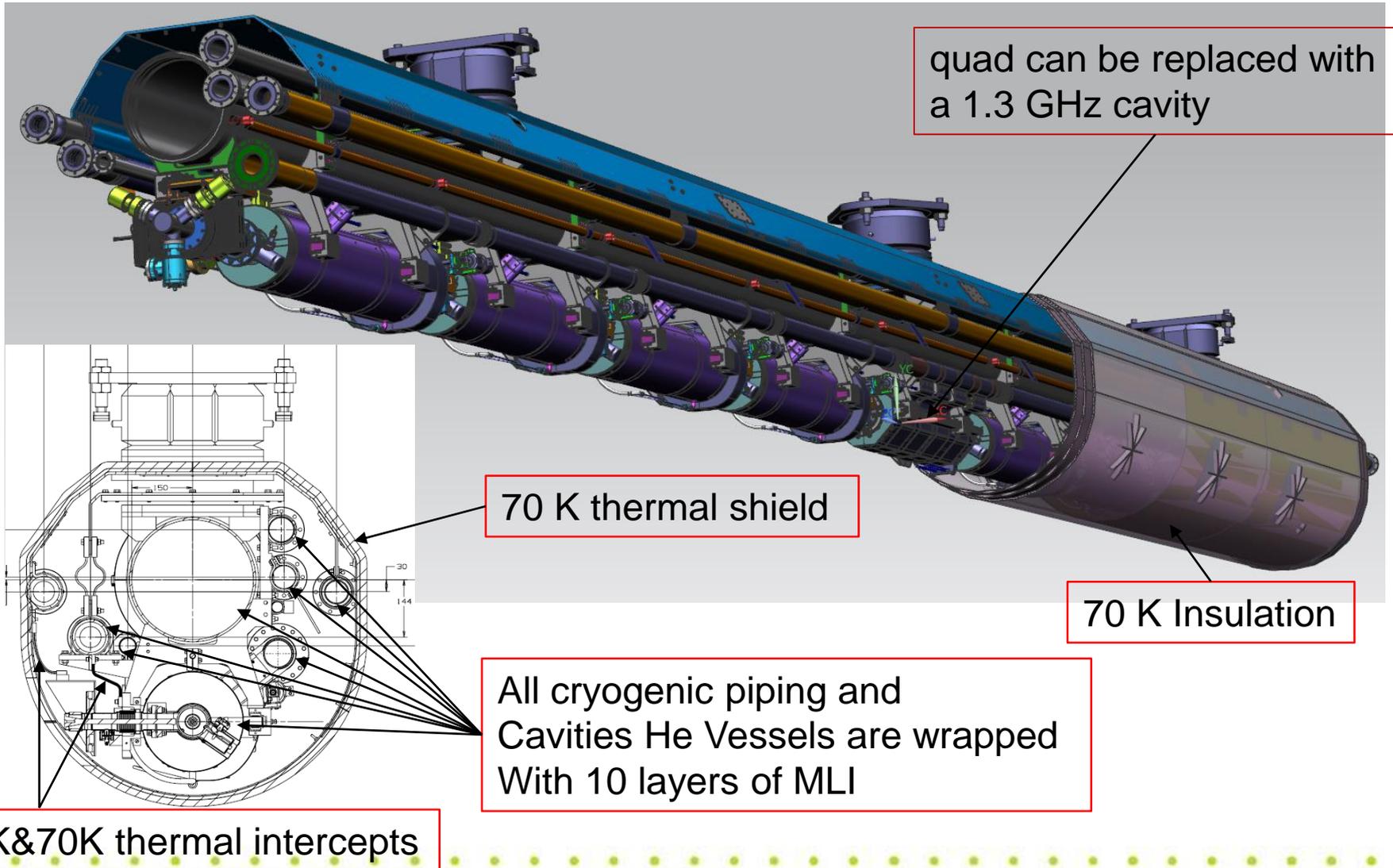


1.3 GHz cold mass upper

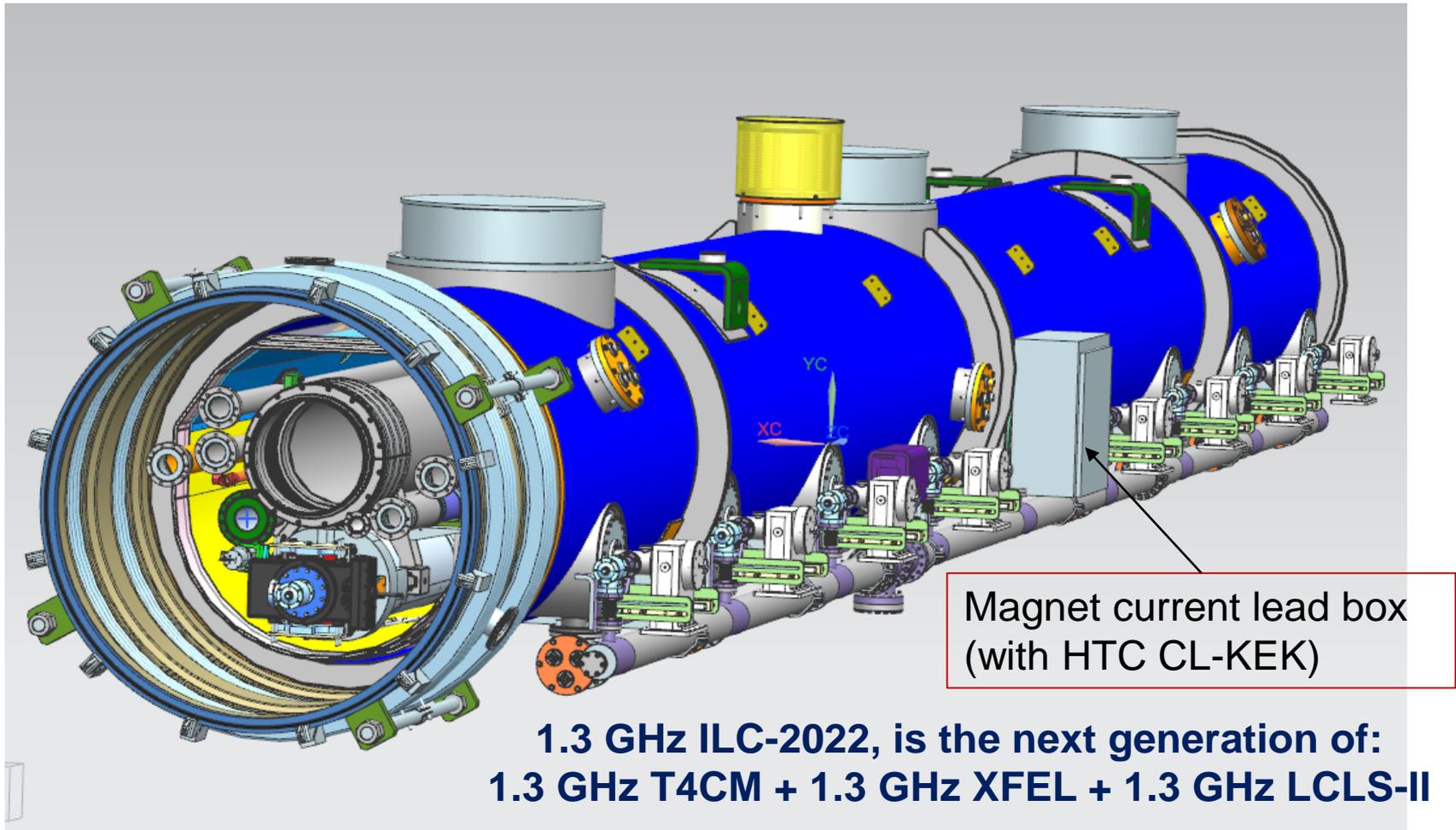


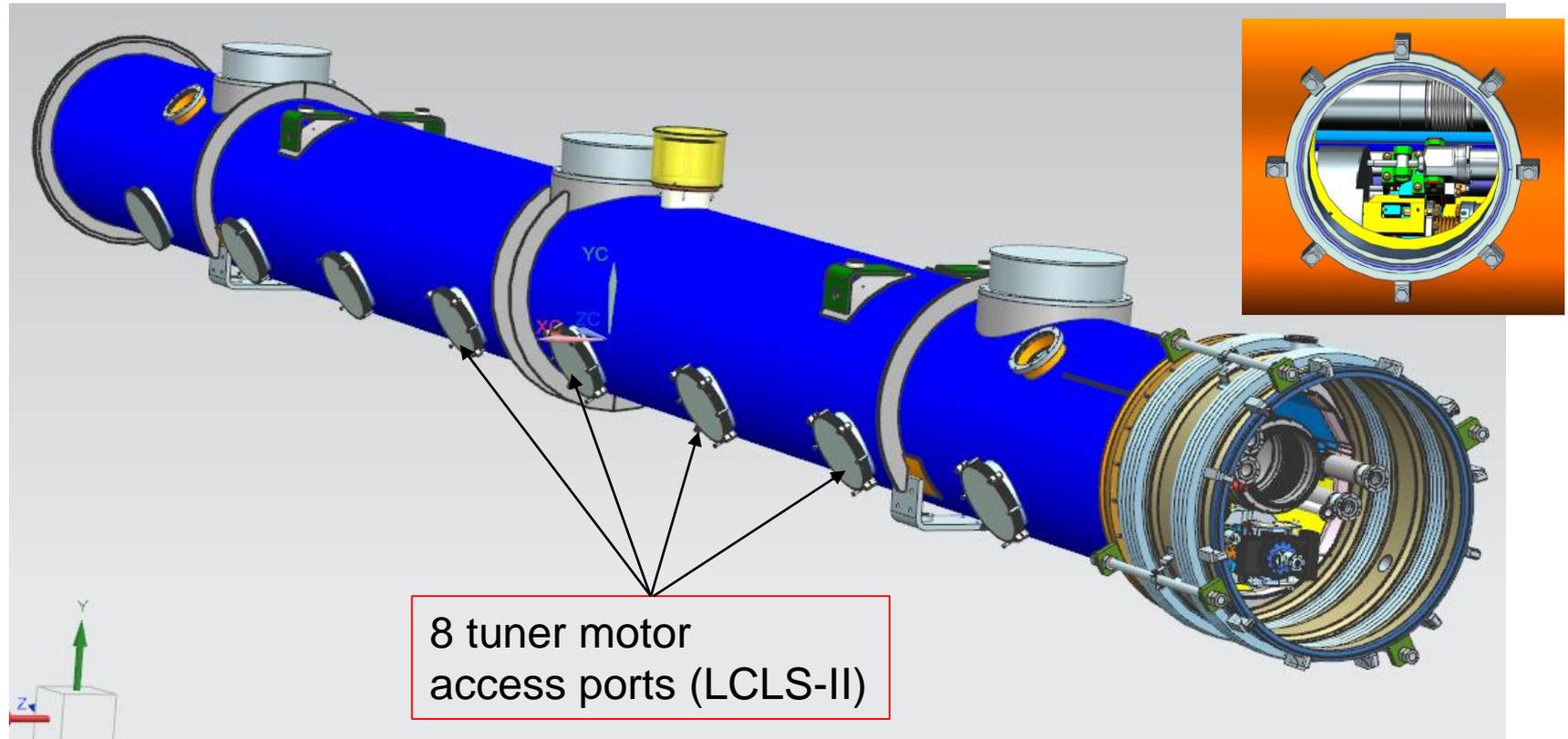


1.3 GHz cold mass – ILC



1.3 GHz ILC CM-B





Vacuum vessel is identical for types “A” and “B”



LCLS-II tuner access port

Active tuner components (electromechanical actuator & piezo-stack) need to be replaceable through special port

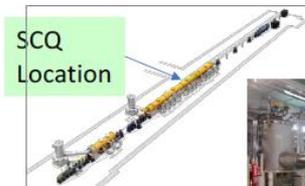
Tuner installed on the CM mock-up at FNAL



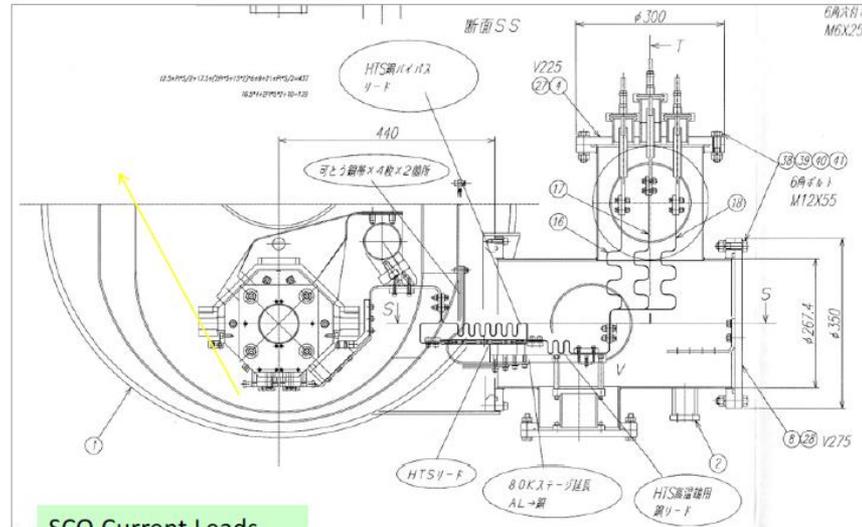
Function of this screw to unload tuner to replace piezo/motor



STF-CM and SCQ Test in Nov. 2016



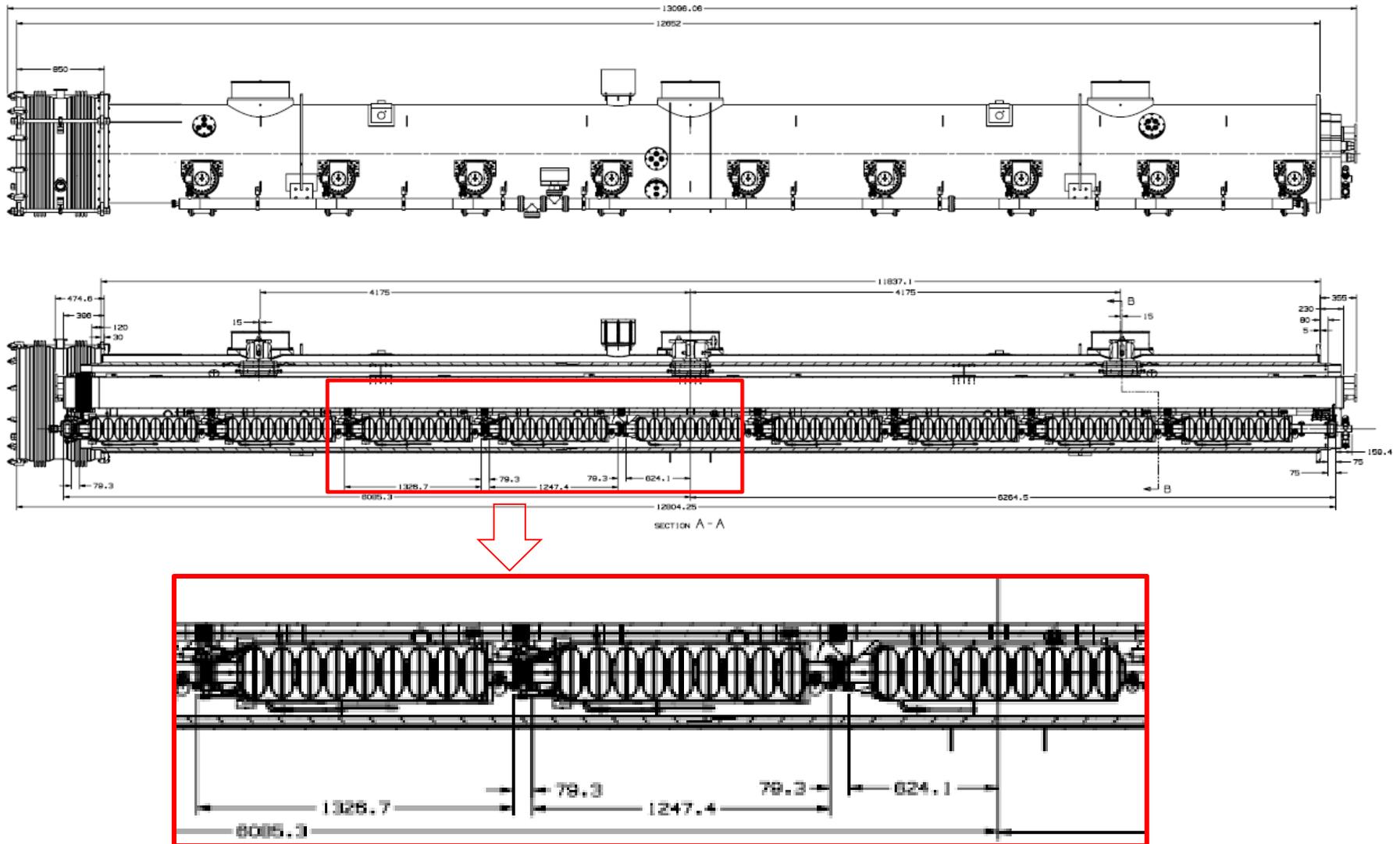
AY-201211



Akira Yamamoto, Hirotaka Shimizu, and Nobuhiro Kimura
 in Cooperation with Vladir Kashikhin, and
 with acknowledgement to Toshiba Corporation
 Date: 2021-8-12

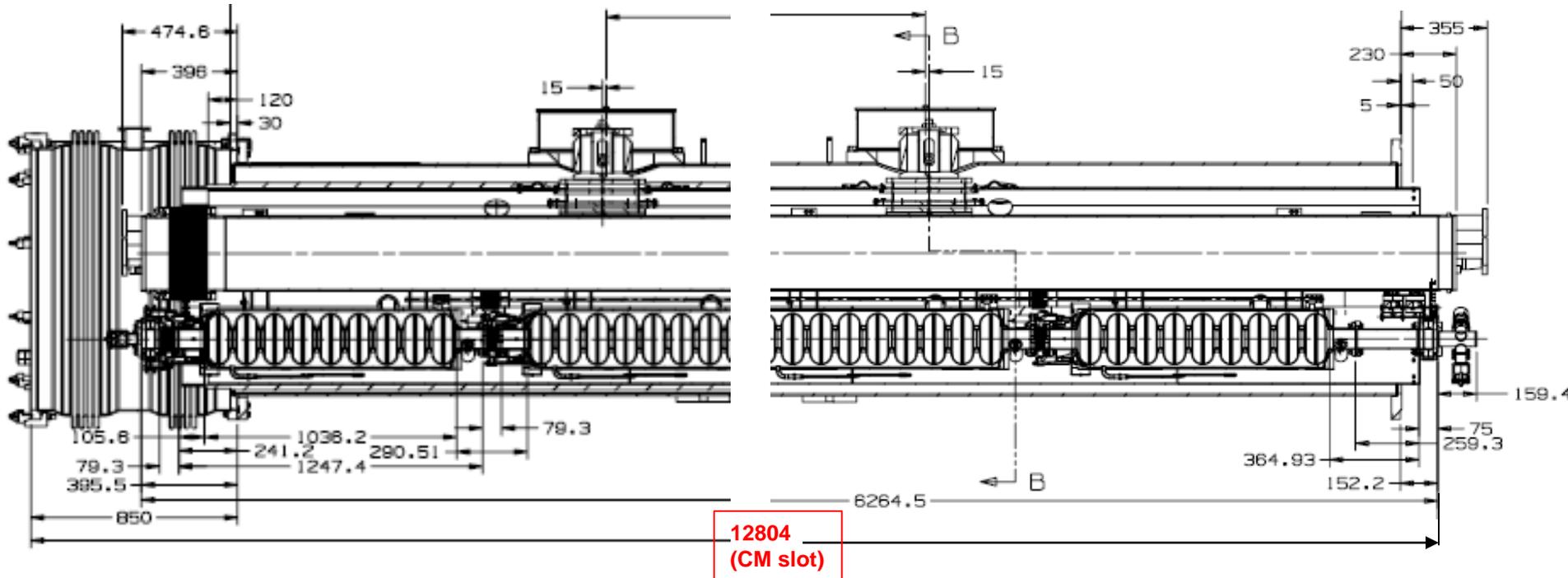


1.3 GHz ILC CM-A, layout



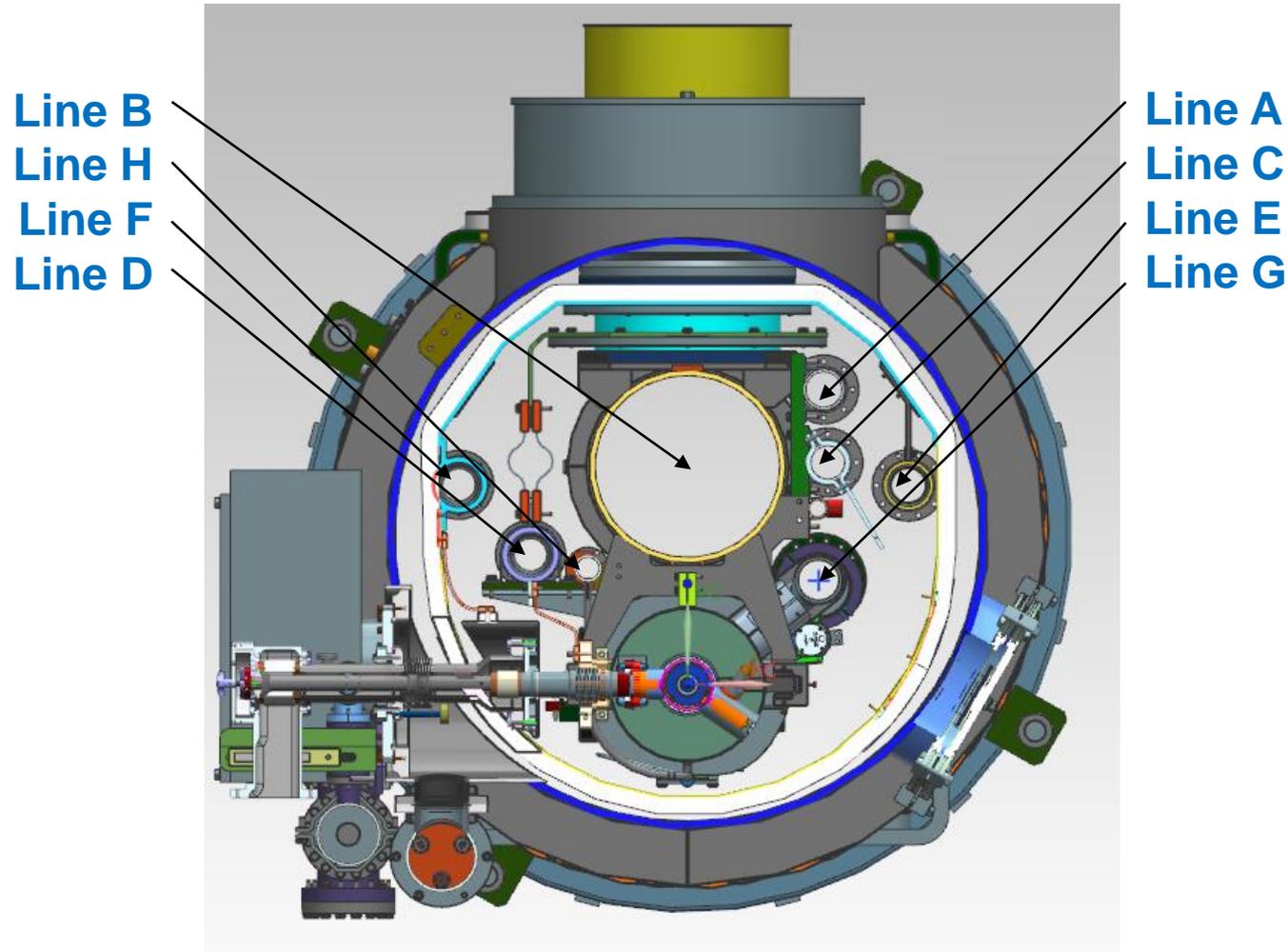


1.3GHz ILC CM-B, layout





ILC CM cryo line designation





ILC CM cryogenic piping sizes

							By Tom P. Calculation
Cryogenic Line	OD, mm	ID, mm	Wall, mm	Material			ID, mm
A	63.500	60.198	1.651	316L St. Steel	Tube, 2.5"-OD, .065" Wall, 316L SS		60.2
B	312.000	300.000	6.000	316L St. Steel	Tube, 300mm-OD, 6mm Wall, 316L SS		300.0
C	63.500	57.404	3.048	316L St. Steel	Tube, 2.5"-OD, .120" Wall, 316L SS		
C	60.325	57.023	1.651	316L St. Steel	Pipe 2", SCH 5S		56.1
D	88.900	76.200	6.350	Al 6061	Tube, 3.5"-OD, .25" Wall, Al 6061		69.9
E	76.200	71.984	2.108	316L St. Steel	Tube, 3"-OD, .083" Wall, 316L SS		72.0
F	88.900	76.200	6.350	Al 6061	Extrusion		79.4
G, 2-phase	73.025	68.809	2.108	316L St. Steel	Pipe 2 1/2", SCH 5S		69.0
"Chimney"-SS	60.325	57.023	1.651	316L St. Steel	Pipe 2", SCH 5S		54.9
"Chimney"-Ti	60.325	57.023	1.651	Ti	Pipe 2", SCH 5S		
H	42.164	38.862	1.651	316L St. Steel	Pipe 1 1/4", SCH 5S		38.9

15

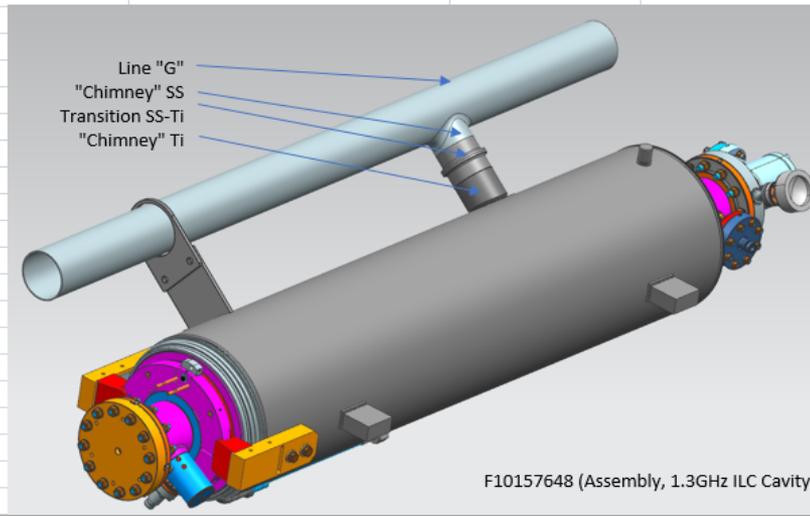
16 Not Used

17 The same OD, wall thickness- because the same Transition Joint from Al to SS

18

19

20



TESLA-style cryomodules compared - 1

Pipe function	BCD <u>name</u>	TTF inner diameter (mm)	XFEL inner diameter (mm)	Type IV (ILC) inner dia (mm)	LCLS-II inner diameter (mm)
2.2 K <u>subcooled</u> supply	A	45.2	45.2	60.2 (60.2)	45.0
Gas helium return header, structural support	B	300	300	300 (300)	300
5 K shield and intercept supply	C	54	54	56.1 (57.0)	55.1
8 K shield and intercept return	D	50	65	69.9 (76.2)	55.1
High temperature shield and intercept supply	E	54	65	72.0 (72.0)	55.1
High temperature shield and intercept return	F	50	65	79.4 (76.2)	52.5
2-phase pipe	G	72.1	>72.1	69.0 (68.9)	95.5
Helium vessel to 2-phase pipe nozzle (“chimney”)		54.9	54.9	54.9 (57.0)	95
Warm-up/cool-down line	H			38.9 (38.9)	38.9

Yuriy Orlov and Tom Peterson for the LCLS-II Team

**LCLS-II CM Assembly Meeting
17 July 2014**

TESLA-style cryomodules compared - 2

Feature	TTF (type 3+)	XFEL	Type IV (ILC)	LCLS-II
Cavity cold slot length (mm)	1383.7	1383.7	1326.9 1326.7	1383.7
Cryomodule slot length (mm)	12450	12220	12652 12804	12220
Magnet style	Bath cooled at 4.5 K	Bath cooled at 2 K	Conductively cooled to 2 K	Conductively cooled to 2 K
Magnet location	End	End	Middle	End
Current leads	Vapor cooled from 4.5 K	Conductively cooled	Conductively cooled	Conductively cooled
BPM style				
5 K thermal shield	YES	YES	YES NO, but retain intercepts	NO, but retain intercepts
Input coupler	TTF3 design	TTF3 modified for better thermal intercepts		Modified TTF3 for CW cooling

Yuriy Orlov and Tom Peterson for the LCLS-II Team
 LCLS-II CM Assembly Meeting
 17 July 2014

BLUE for ILC 2021 CM



Typical 45' container



2,700 mm
8' 10 1/4"



13,556 mm
44' 5 5/8"

2,352 mm
7' 8 5/8"



2,597 mm
8' 6 1/4"

2,340 mm
7' 8 1/8"

Inside Dimension

Measure	Length	Width	Height
Millimeters	13,556	2,352	2,700
Feet	44' 5 5/8"	7' 8 5/8"	8' 10 1/4"

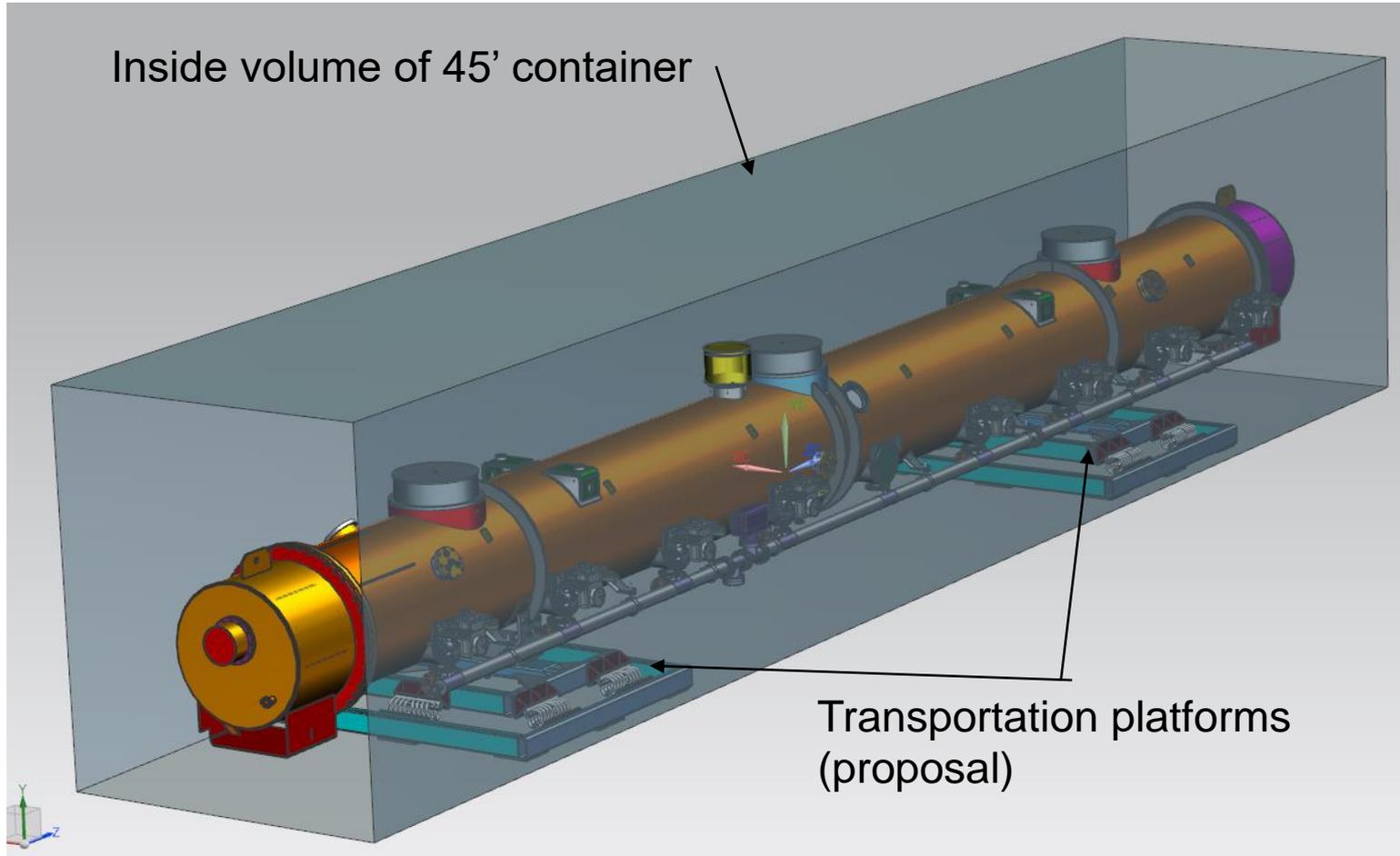
Door Opening

Measure	Width	Height
Millimeters	2,340	2,597
Feet	7' 8 1/8"	8' 6 1/4"

Weight

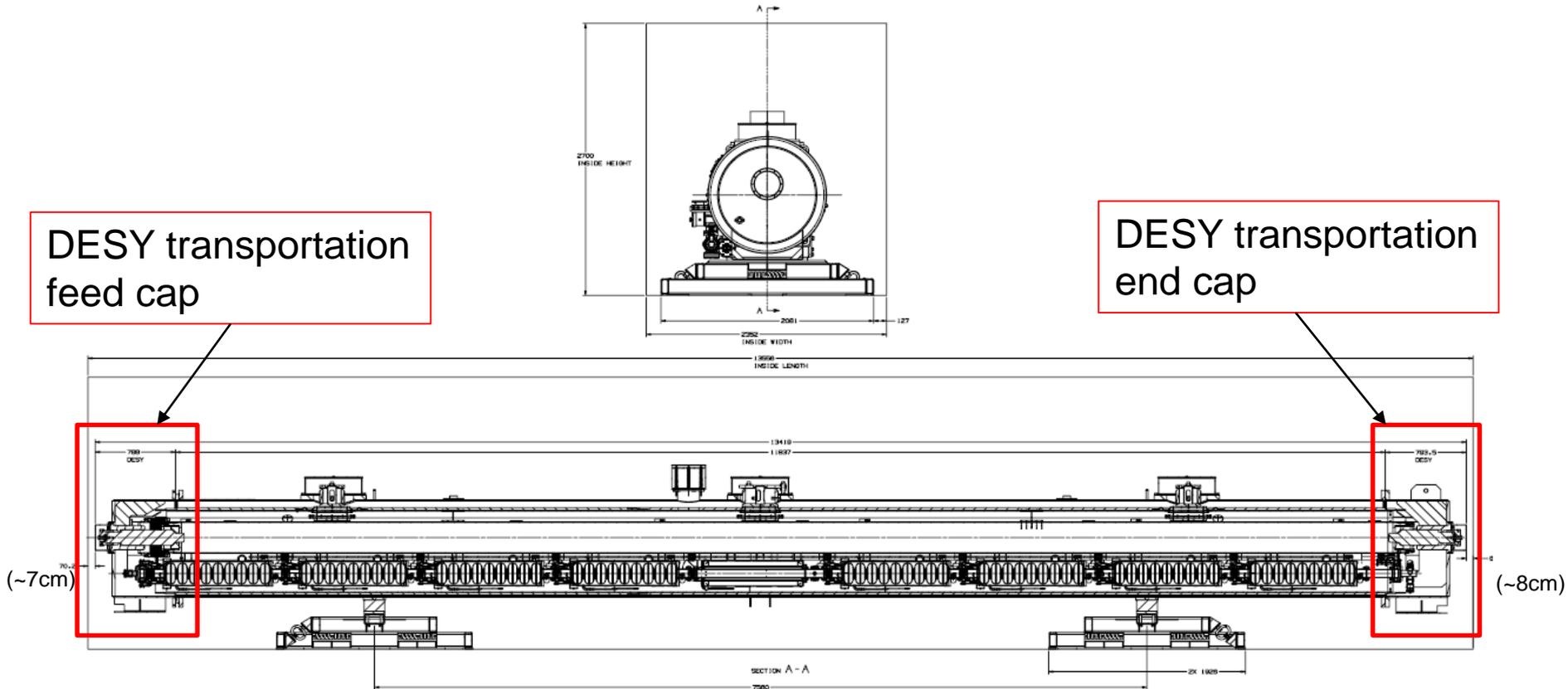
Measure	Max Gross	Tare (Weight)	Max Payload
Kilograms	32,500	4,800	27,700
Pounds	71,650	10,552	61,067

Transportation of 1.3 GHz CM

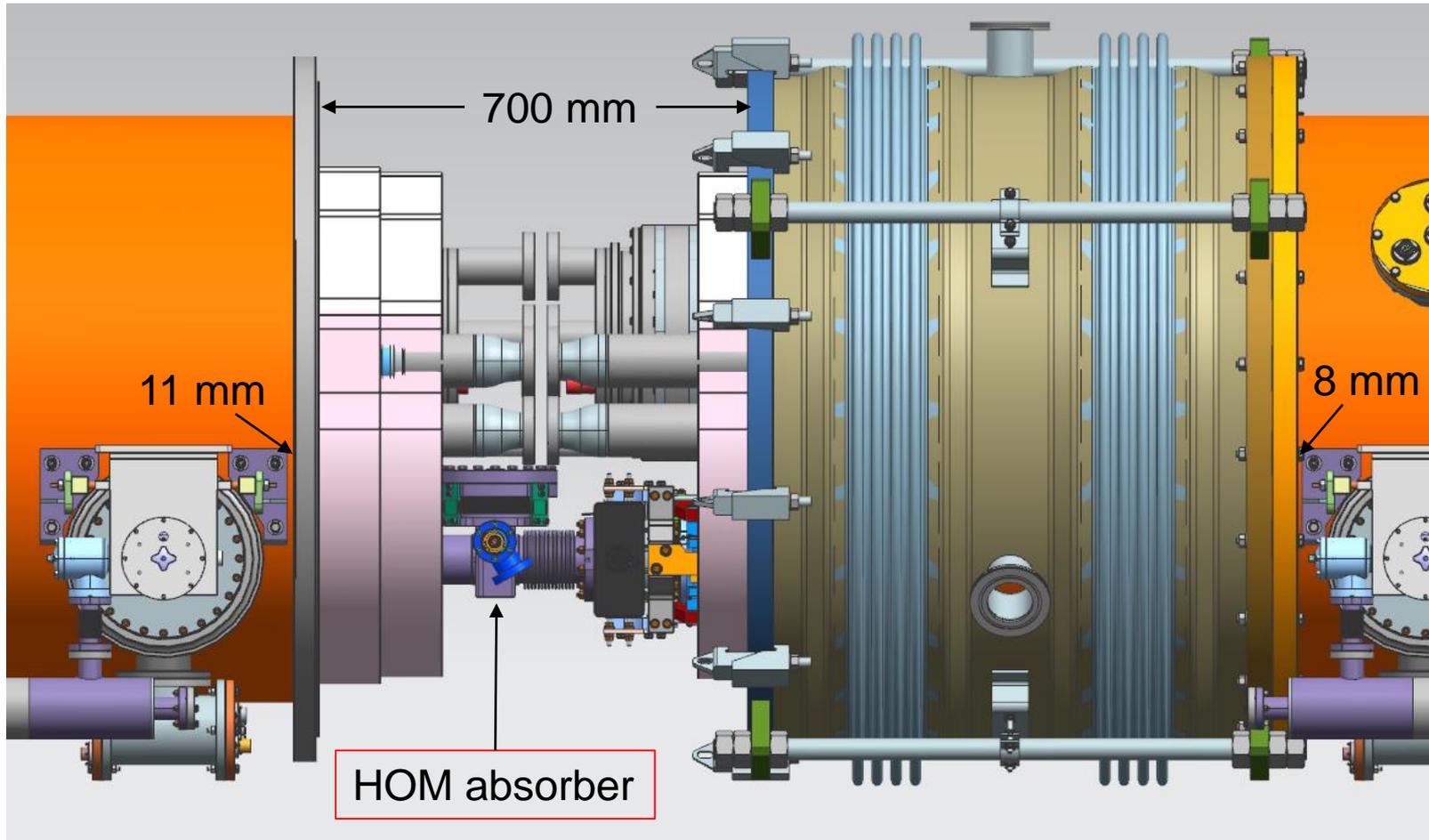




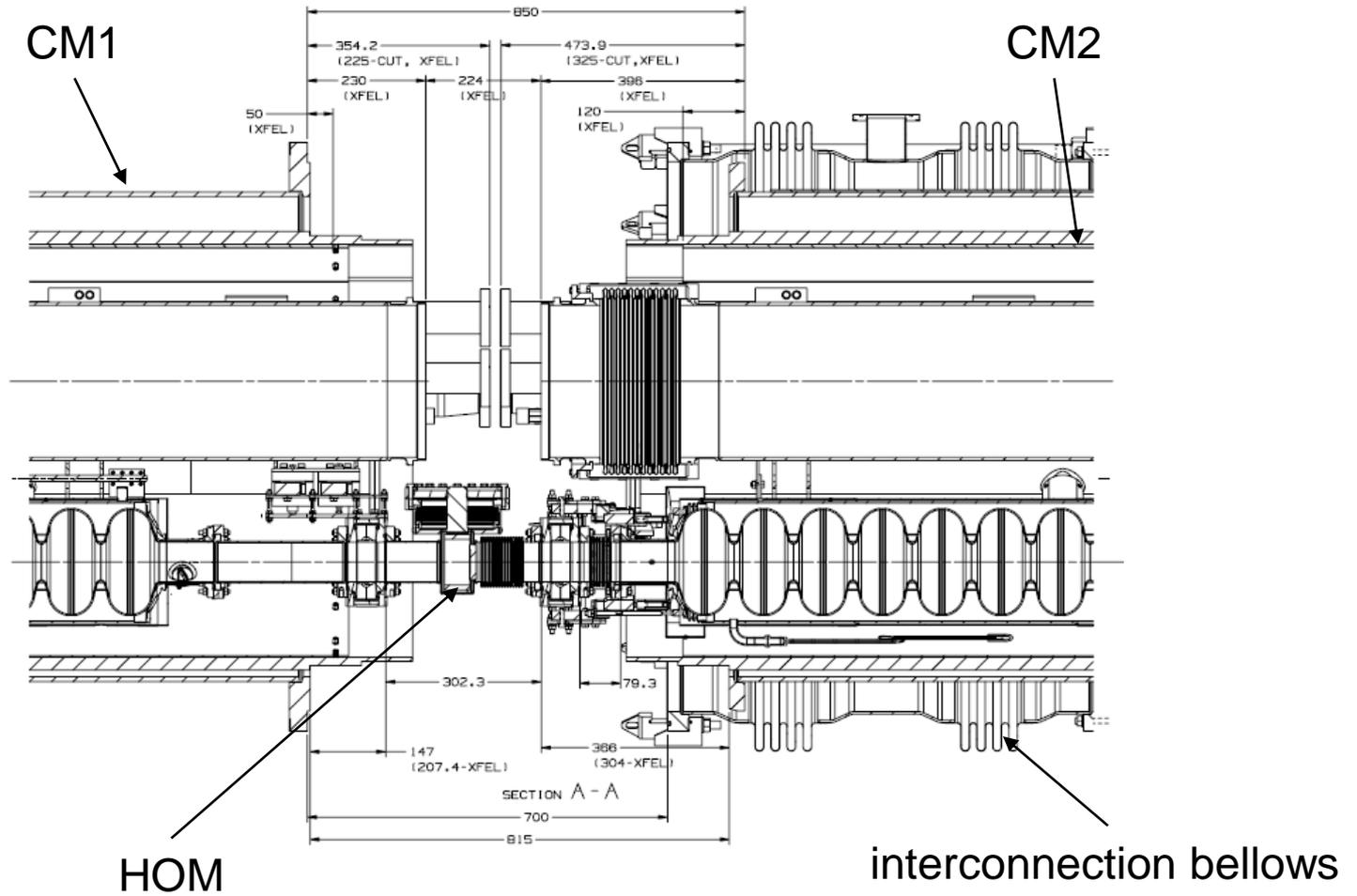
Transportation of 1.3 CM



ilc 1.3 GHz CM's interconnection

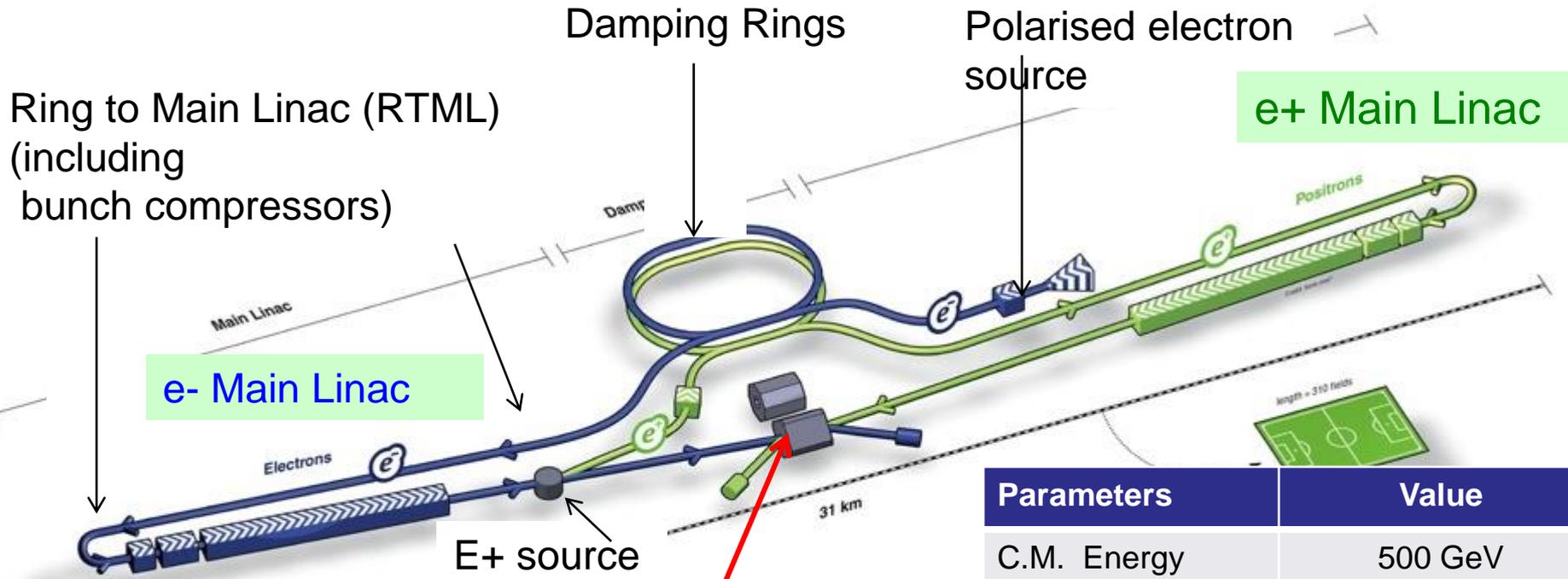


ilc 1.3 GHz CM's interconnection





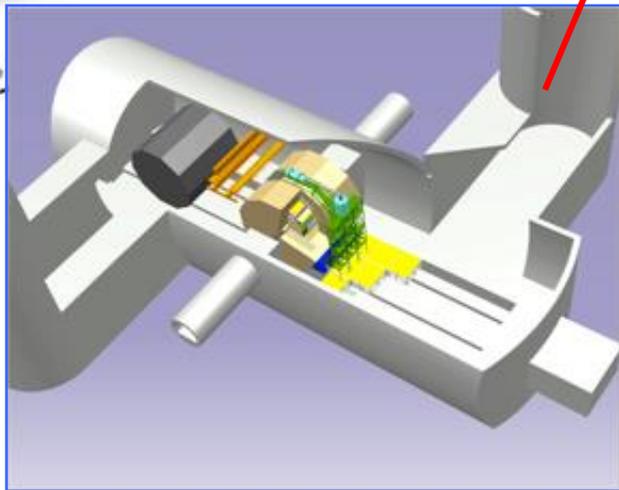
- **Backup slides**



e- Main Linac

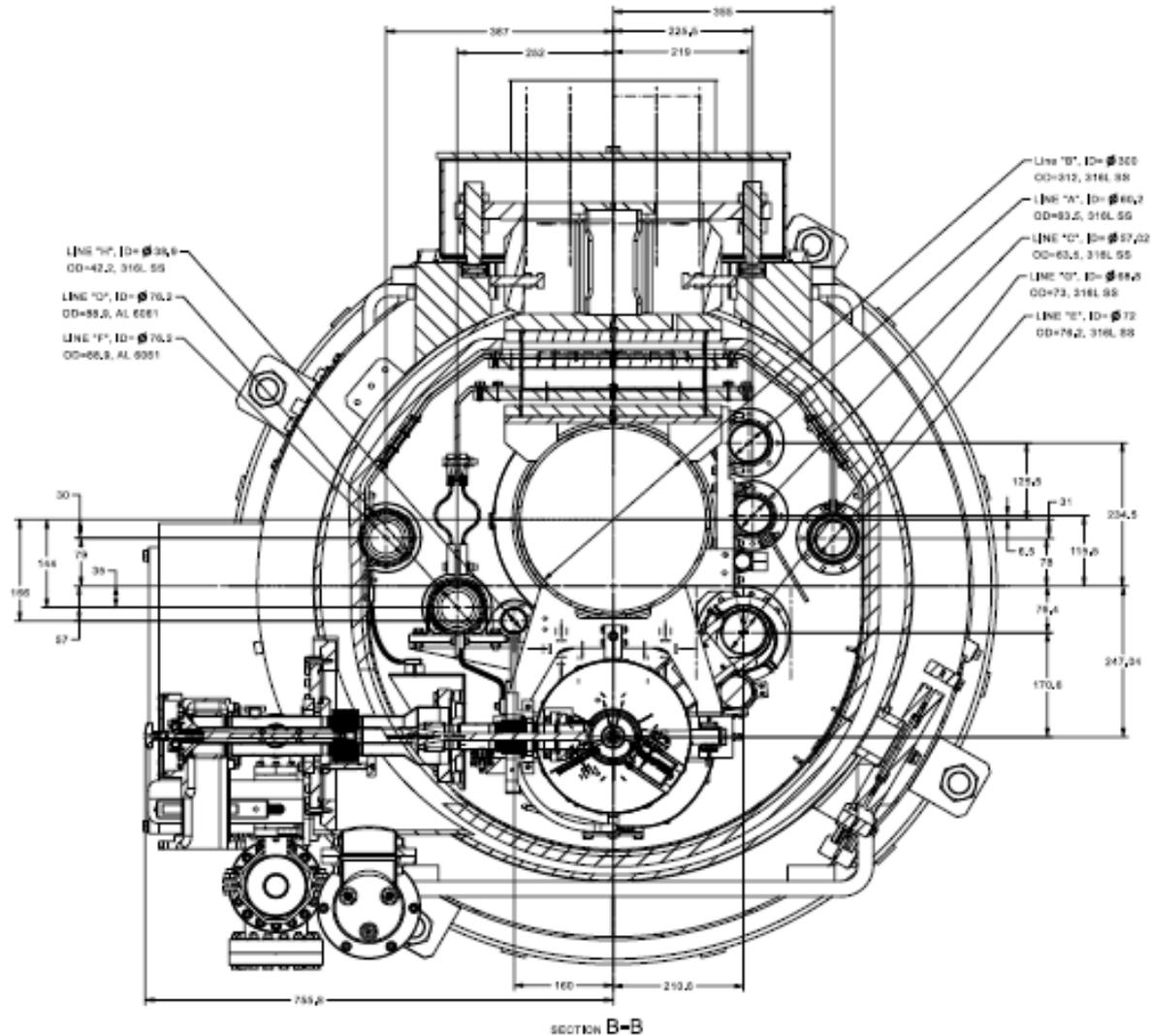
e+ Main Linac

Parameters	Value
C.M. Energy	500 GeV
Peak luminosity	$1.8 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
E gradient in SCRF acc. cavity	31.5 MV/m +/-20% $Q_0 = 1E10$



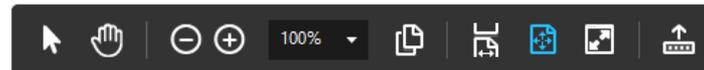
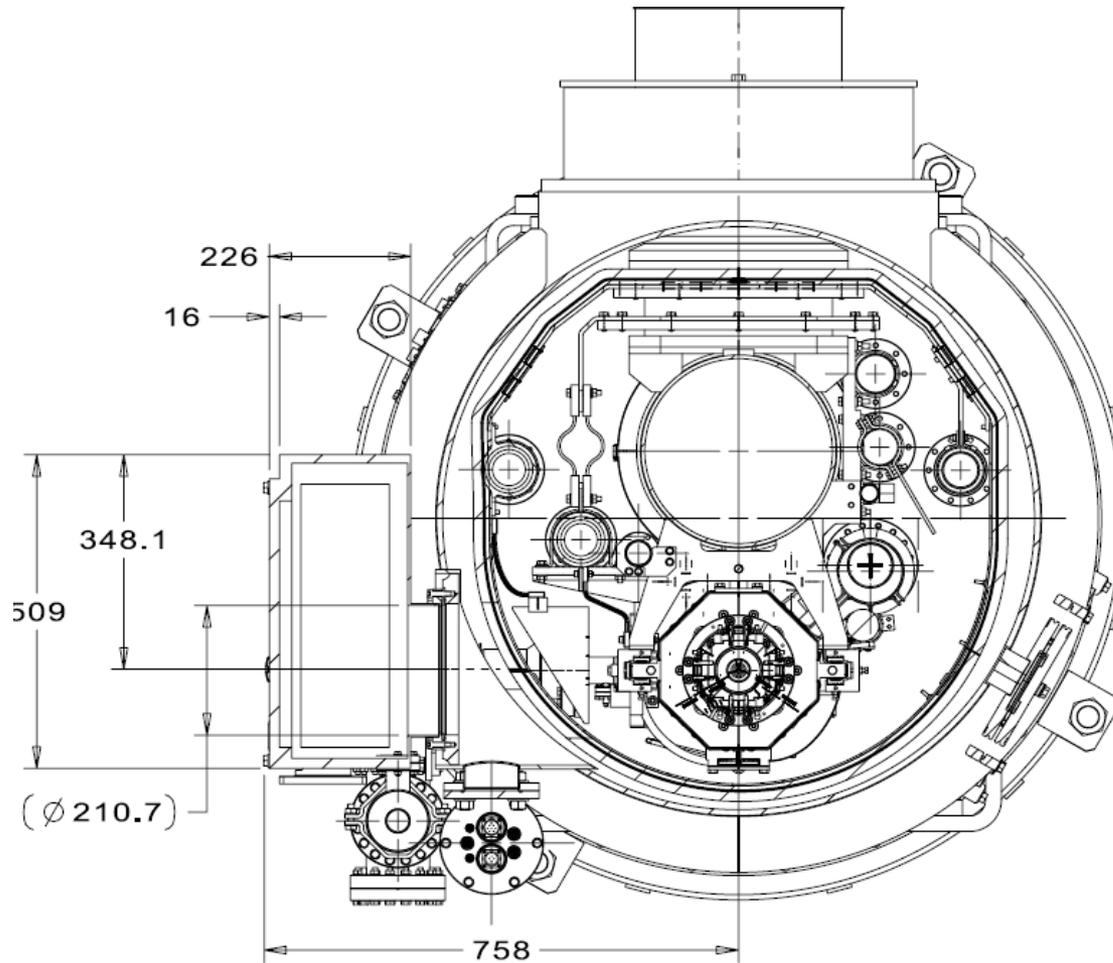


1.3 GHz ILC CM, Section 1



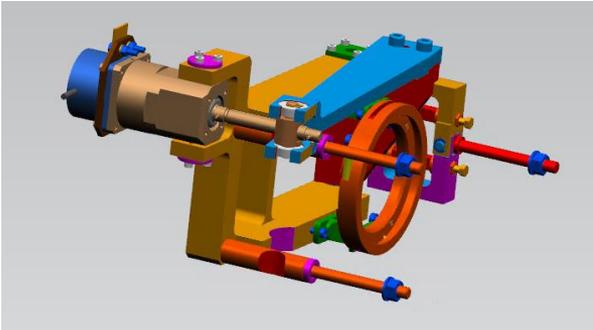


1.3 GHz ILC CM, Section 2

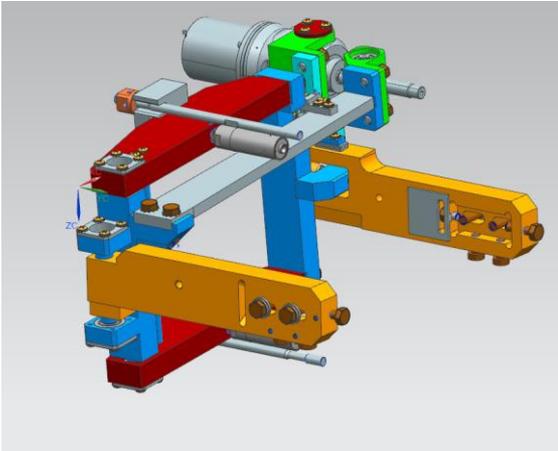




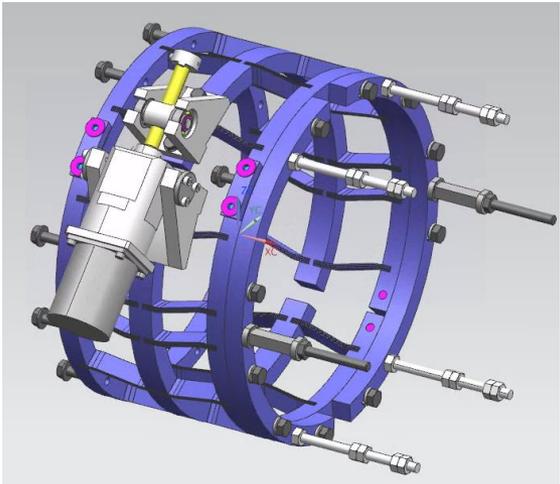
Tuners



XFEL



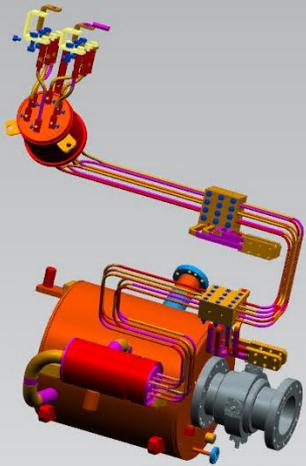
LCLS-II



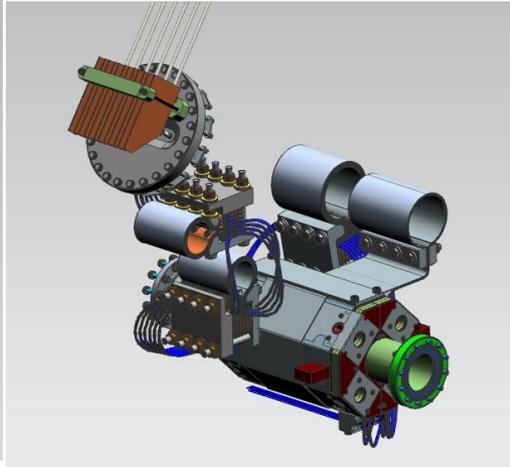
T4CM



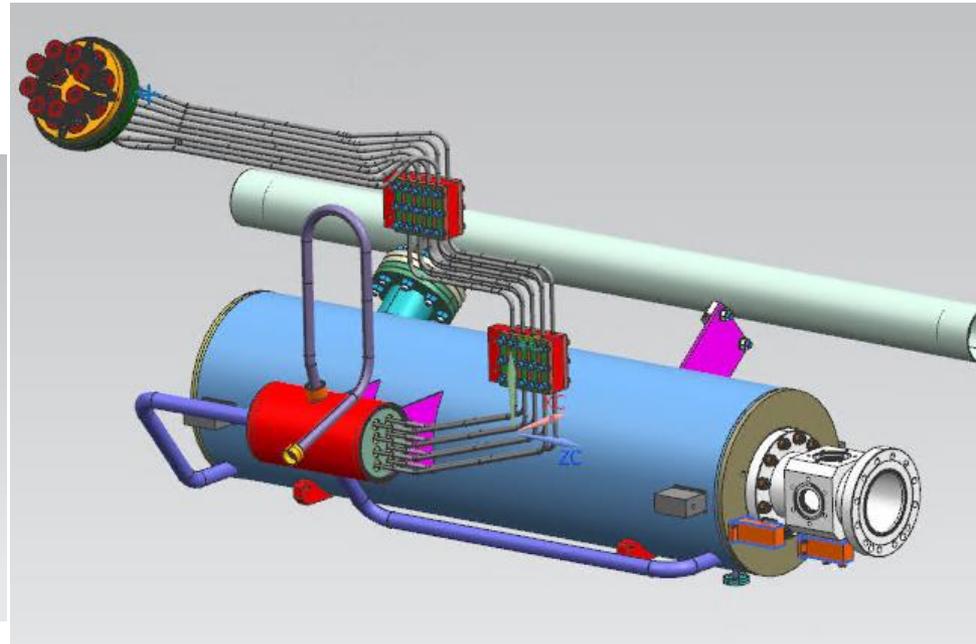
Magnet Packages with BPM



XFEL



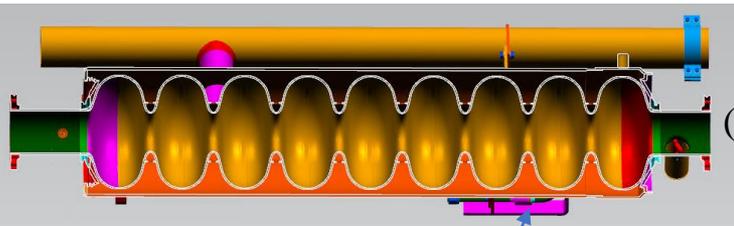
LCLS-II
(BPM before Magnet)



T4CM

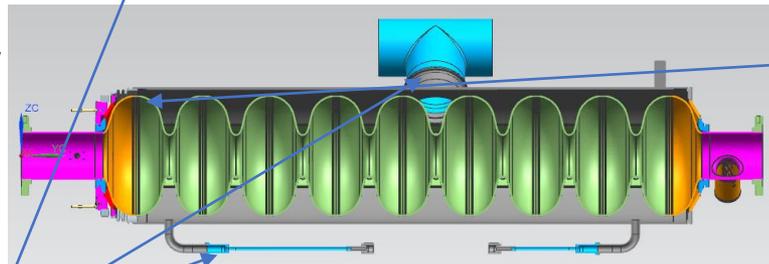


1.3GHz cavities (9 elliptical cells)



(Long-Short)

XFEL

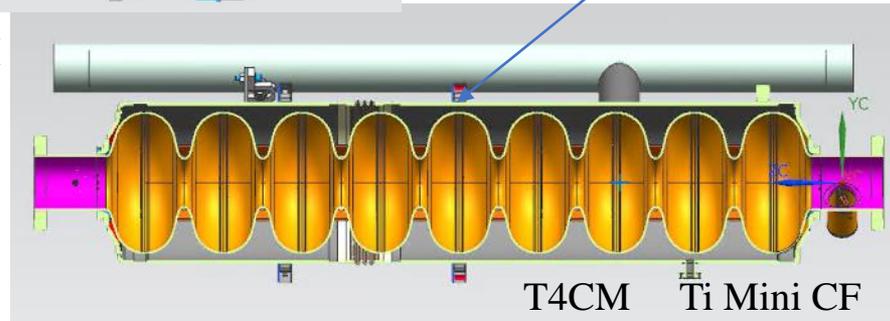


(Long-Short)

LCLS-II

Ti-SS
Transition

He Vessel Bellows



(Short-Short)

T4CM Ti Mini CF

