LCWS13 @ Tokyo, Nov. 2013

# Summary of AWG7 SCRF technologies

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# Discussion Topics

Total 11 time slots

(1)Deep Technical Review of Input Couplers

TTF3 coupler

STF2 coupler

8 slots

DESY, FNAL, SLAC, CERN, Saclay, KEK and 7 industries

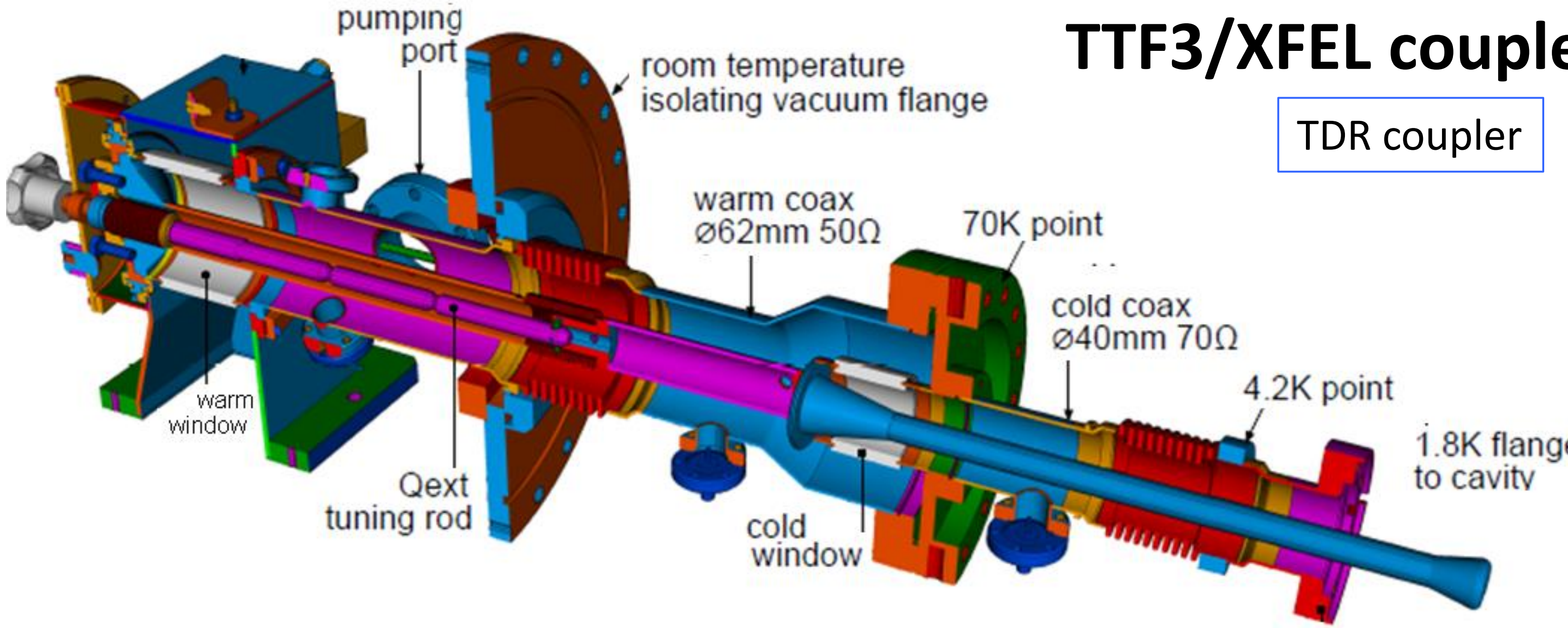
(2)General discussion on Cavity, Cryomodule

3 slots

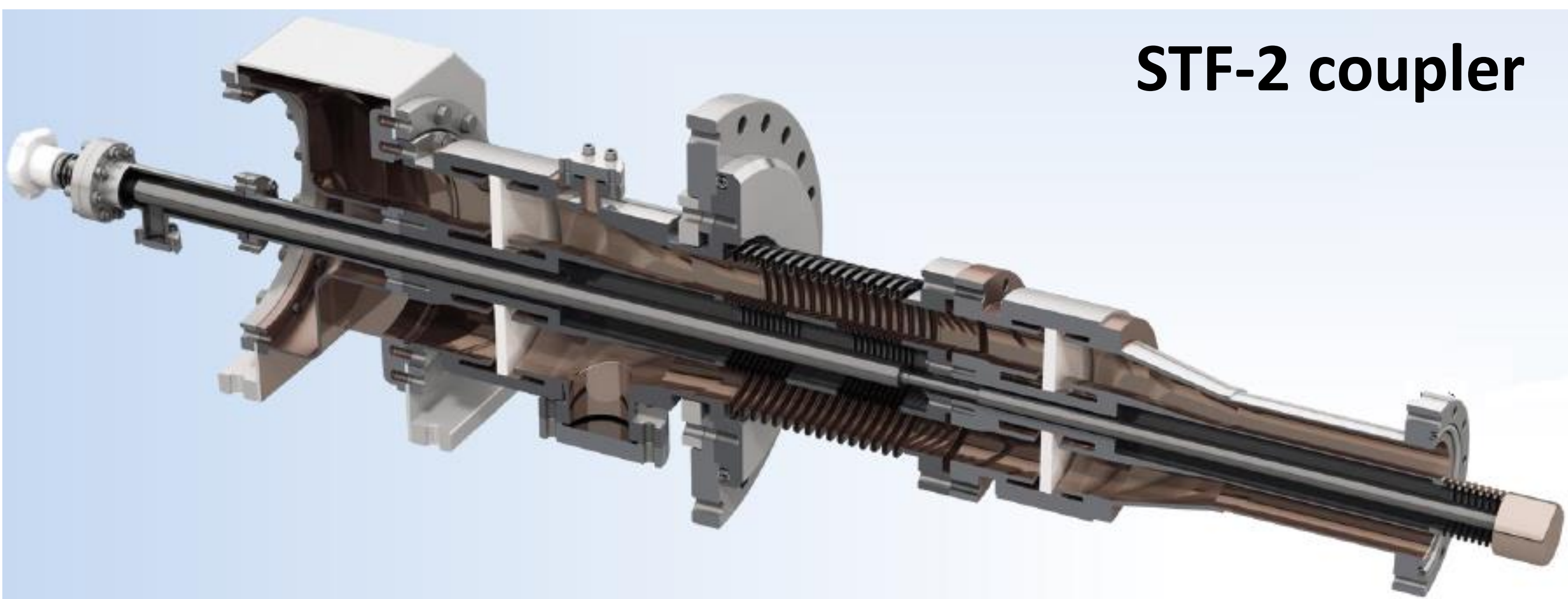
# (1) Deep Technical Review of Input Couplers

## TTF3/XFEL coupler

TDR coupler




## STF-2 coupler



# ILC specification

- Power requirements
  - We recommend to match the coupler to 30 MV/m for reduced filling time and smaller Qext range
  - Max coupler power at operation  450 kW (for 8.8 mA, 10Hz, Eacc=31.5 MV/m ±20%)
  - RF processing to at least four times max input power ~ 1.8 MW up to 500 us at test stand TW
  - Surface field not a problem for both designs, i.e. 40mm and 60mm are both ok
  - Should check flattop regulation at 25 MV/m and Qext ~ 1e7 (LFD)
  - TW testing on test stand up to 1.8MW has to be done for both: TTF3 and STF2
- Q-ext
  - Variable coupling is needed, remote operation
  - QL tuning range:  2-7x$10^6$ is needed, but we recommend 1-10 x $10^6$
  - 1-10·$10^6$ is achieved with TTF3
  - STF2 has to be improved
- Antenna alignment:
  - Design should be +-2mm
  - For TTF3 coupler  the most sensitive  parameter is a horizontal antenna  shift/tilt.  3mm shift change QL by  ~20%.  Vertical tolerances  are relaxed.
  - For STF-2 coupler this is not issue, mechanical design guarantee small shift.
  - TTF3 has to be improved

- Cryogenic loss:
  - Coupler contribution to cryogenic losses at 2K is ~5%. = not critical.
  - Major contribution from coupler is 70K
- Conditioning time
  - Both designs are ok
  - The nominal conditioning time of < 50h is achieved/demonstrated.
- Multipacting
  - DESY and SLAC simulations, tests and operation show no problem with TTF3
  - STF2 will be simulated, tests show no problem
- One vs. two windows
  - Many single window coupler are successful under operation
  - The single window would need to seal-off the cavity before the cavity-string installation into the cryomodule.
  - Single window coupler for ILC would need complete new development and test program of coupler (and module)
  - But it could be a significant cost saving
- Compatibility
  - Cavity and attached parts (power coupler, tuner, HOM coupler, feedthroughs, He vessel, thermal connections, magnetic shield…) are tuned/balanced, it is not easy to exchange only parts of this composition
  - STF2 coupler design does not fit in the compatibility requirements of the TDR (40mm cavity coupler flange)

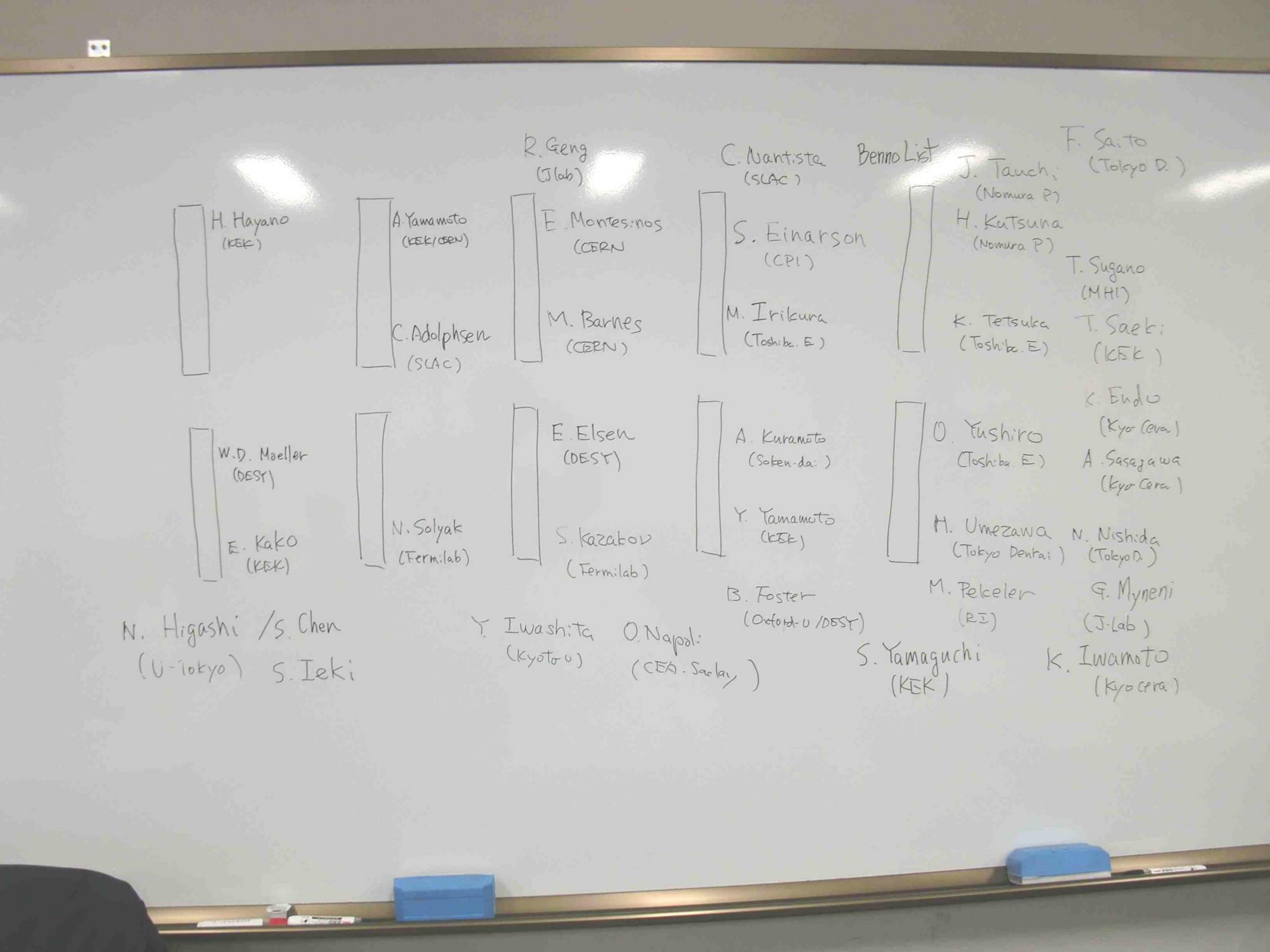
- Cost
  - CPI: STF2 price is 1.9 higher
  - Toshiba: STF2 slightly lower price
  - RI: about same price
  - Industrial study of STF2 for design optimization and cost reduction is recommended
  - The TTF3 coupler mass fabrication has to be investigated

# Recommendation:

- STF2 coupler has to demonstrate stable long time (>6 month) beam operation in a CM (TTF3 coupler has a long history in FLASH)
- The ILC management recommend an adapted STF2 design with 40mm cavity flange. In this case more development steps have to follow in order to realize the compatible design. The new design has to be proven with beam operation.
- The concept of plug compatibility has to be further developed in view of a spare part concept. We recommend spare modules, not individual parts.
- An industrial study of mass production for both designs is recommended
- Industrial study of STF2 for design optimization and cost reduction is recommended.

# ILC RF Power Coupler design criteria comparison

| | ILC Spec | TTF3 / XFEL | STF-2 |
|---|---|---|---|
| Frequency | 1.3 GHz | 1.3 GHz | 1.3 GHz |
| Operating pulsed RF power | 450 | 100 .. 600 kW | 450 |
| Operating RF pulse length / rep.rate | 1.65 ms / 5 Hz | 1.3 ms / 10 Hz | 1.5 ms / 5 Hz |
| Max. RF conditioning power (20 .. 500µs) | 1.8 MW | 1 MW | 1.2 MW |
| Max. average power | 3.7 kW | 4.5 kW (tested and calculated limit) | 3.0 kW (not the limit, but tested) |
| copper coating inner/outer conductor | nn | 30 µm / 10 µm | 25 µm / 10 µm |
| copper coating RRR | nn | 30 .. 60 | 10-20 |
| Max. cryogenic losses at 2K / 4.2K / 70K dynamic + static | need to check | 0.06 W / 0.5 W / 8 W static+dynamic | 0.06W / 0.8 W / 9 W simulated static |
| window | 2 windows | 2 cylindrical | 2 disc |
| Warm coax | | 60 mm, 50 Ohm | 82 mm, 50 Ohm |
| Cold coax | | 40 mm, 75 Ohm | 60 mm, 43 Ohm |
| Qext range | 1.0 – 10 x10^6 | 1.0 – $15\times10^6$ | 2.0 – $6.0\times10^6$ |
| bias | yes | yes | no |
| lateral movement | 5mm (including fabr. Error) | ± 15mm | ± 5mm |
| max surface field (inner cond cold part) @500kW TW | | 1MV/m | 0.5MV/m |
| max voltage, (inner cond cold part) @500kW TW | | 14kV | 7.5kV |
| MP levels | | 150 kW, 250 kW, 450 kW | |
| Insertion loss | | less 0.1 dB | |


R. Geng
(Jlab)
C. Nantista
(SLAC)
Benno List
F. Saito
(Tokyo D.)
J. Tauchi
(Nomura P)
H. Hayano
(KEK)
A. Yamamoto
(KEK/CERN)
E. Montesinos
(CERN)
S. Einarson
(CPI)
H. Kutsuna
(Nomura P)
T. Sugano
(MHI)
C. Adolphsen
(SLAC)
M. Barnes
(CERN)
M. Irikura
(Toshiba E)
K. Tetsuka
(Toshiba E)
T. Saeki
(KEK)
C. Endo
(Kyo Cera)
W.D. Moeller
(DESY)
E. Elsen
(DESY)
A. Kuramoto
(Soken-dai)
O. Yushiro
(Toshiba E)
A. Sasagawa
(Kyo Cera)
Y. Yamamoto
(KEK)
N. Solyak
(Fermilab)
S. Kazakov
(Fermilab)
E. Kako
(KEK)
H. Umezawa
(Tokyo Denkai)
N. Nishida
(Tokyo D.)
B. Foster
(Oxford-U/DESY)
M. Pekeler
(RI)
G. Myneni
(J-Lab)
N. Higashi
(U-Tokyo)
/S. Chen
S. Ieki
Y. Iwashita
(Kyoto U)
O. Napoli
(CEA-Saclay)
S. Yamaguchi
(KEK)
K. Iwamoto
(Kyocera)

# (2)General discussion on Cavity, Cryomodule

## Cavity

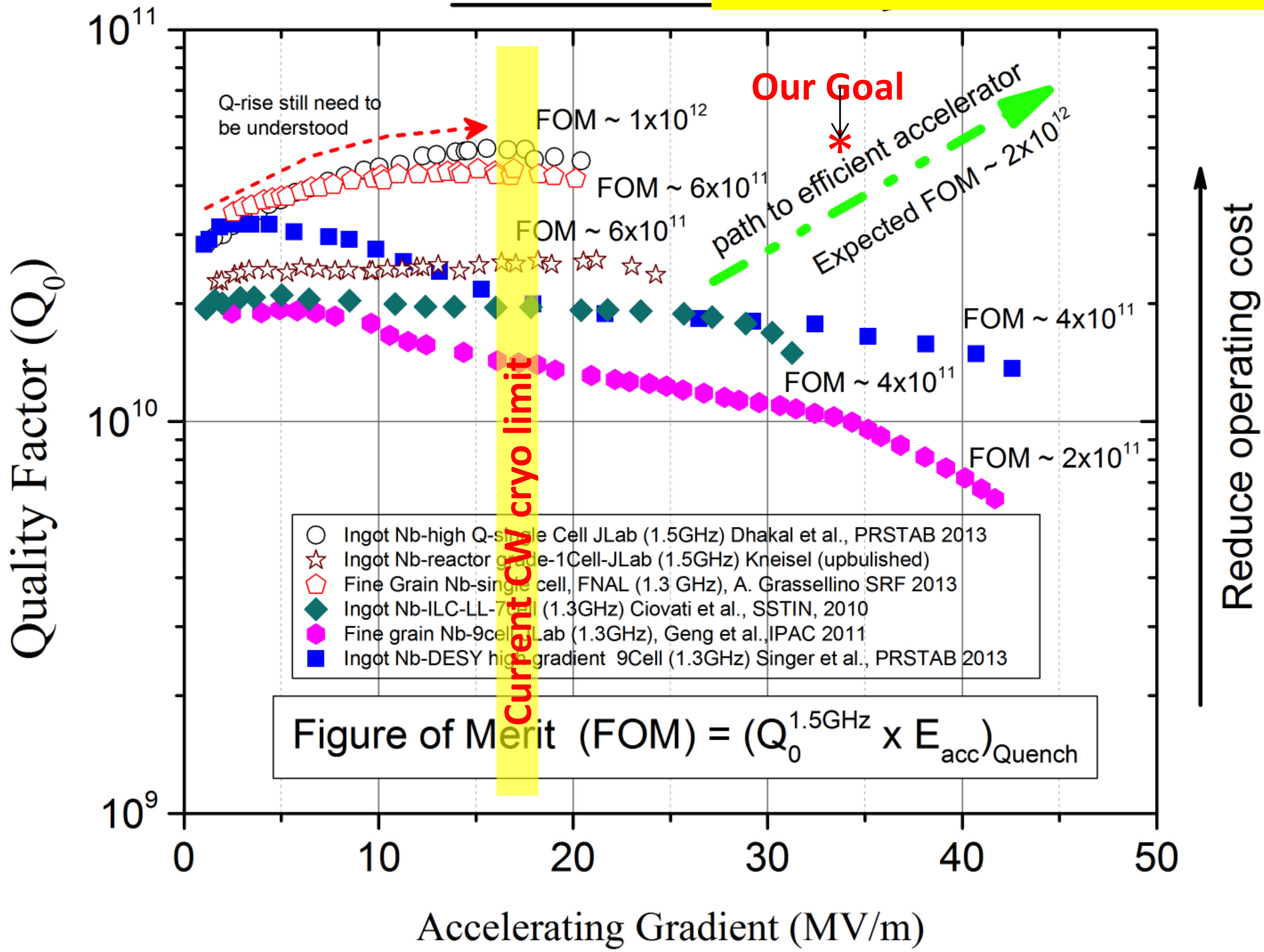
Low RRR material : G. Myneni (Jlab)
towards High Eacc, Q0 : R. Geng (Jlab)

## Cryomodule

XFEL cryomodule assembly : O. Napoly (Saclay)
FNAL-ASTA, CM-2 status : E. Harms (FNAL)
Splittable Q development : M. Tartaglia (FNAL)
LCLS2 SCRF Linac plan : C. Adolphsen (SLAC)
STF CM-1 status : H. Nakai (KEK)
Cryomodule earthquake response : H. Hayano (KEK)

# Present state of the art

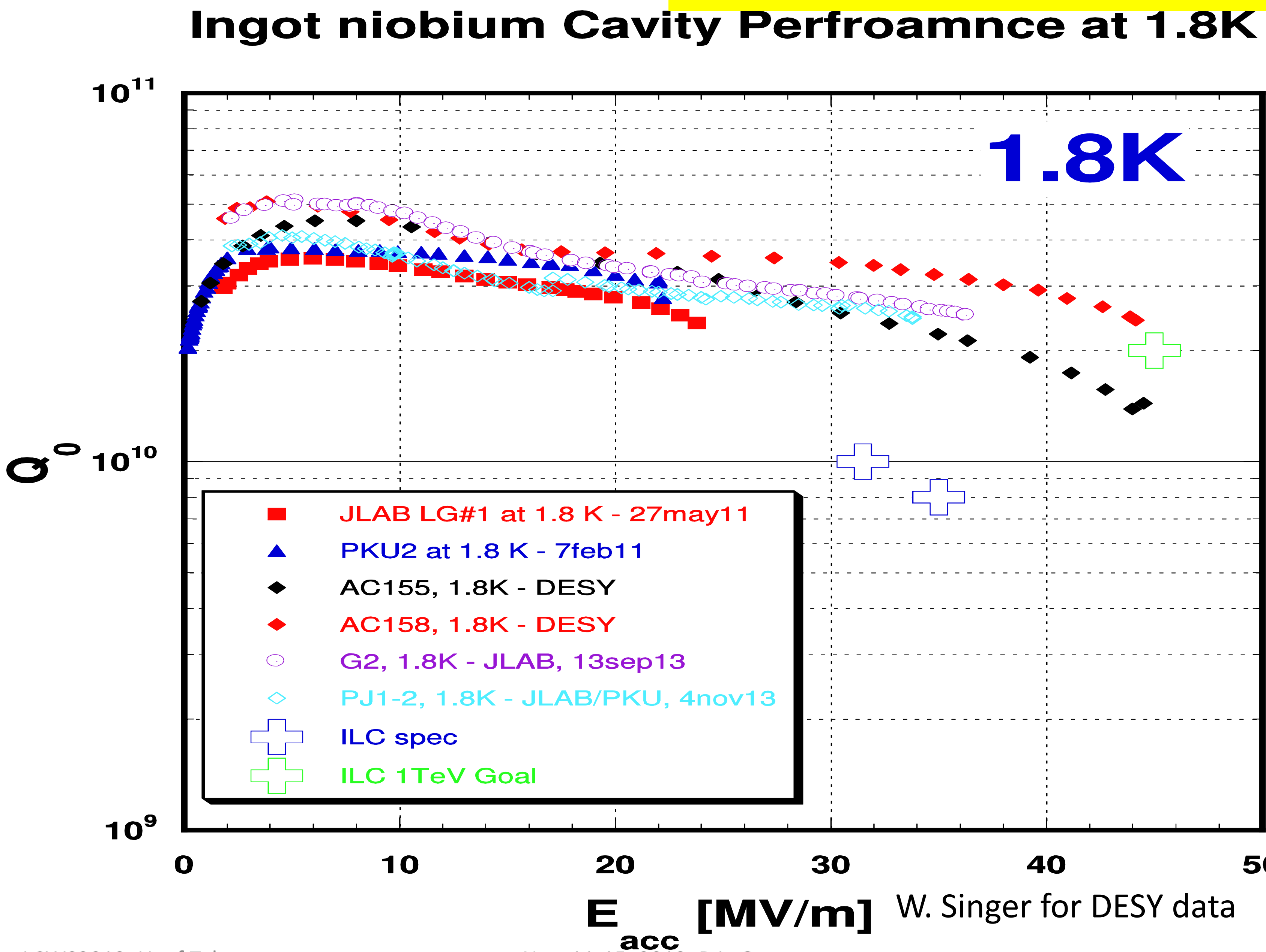
# G. Myneni: Low RRR material




**Ingot niobium Rs is low and phonon peak improves thermal stability**

**Our goal is to improve both $Q_0$ and $E_{acc}$**

# R. Geng: Toward High Eacc, Q




W. Singer for DESY data

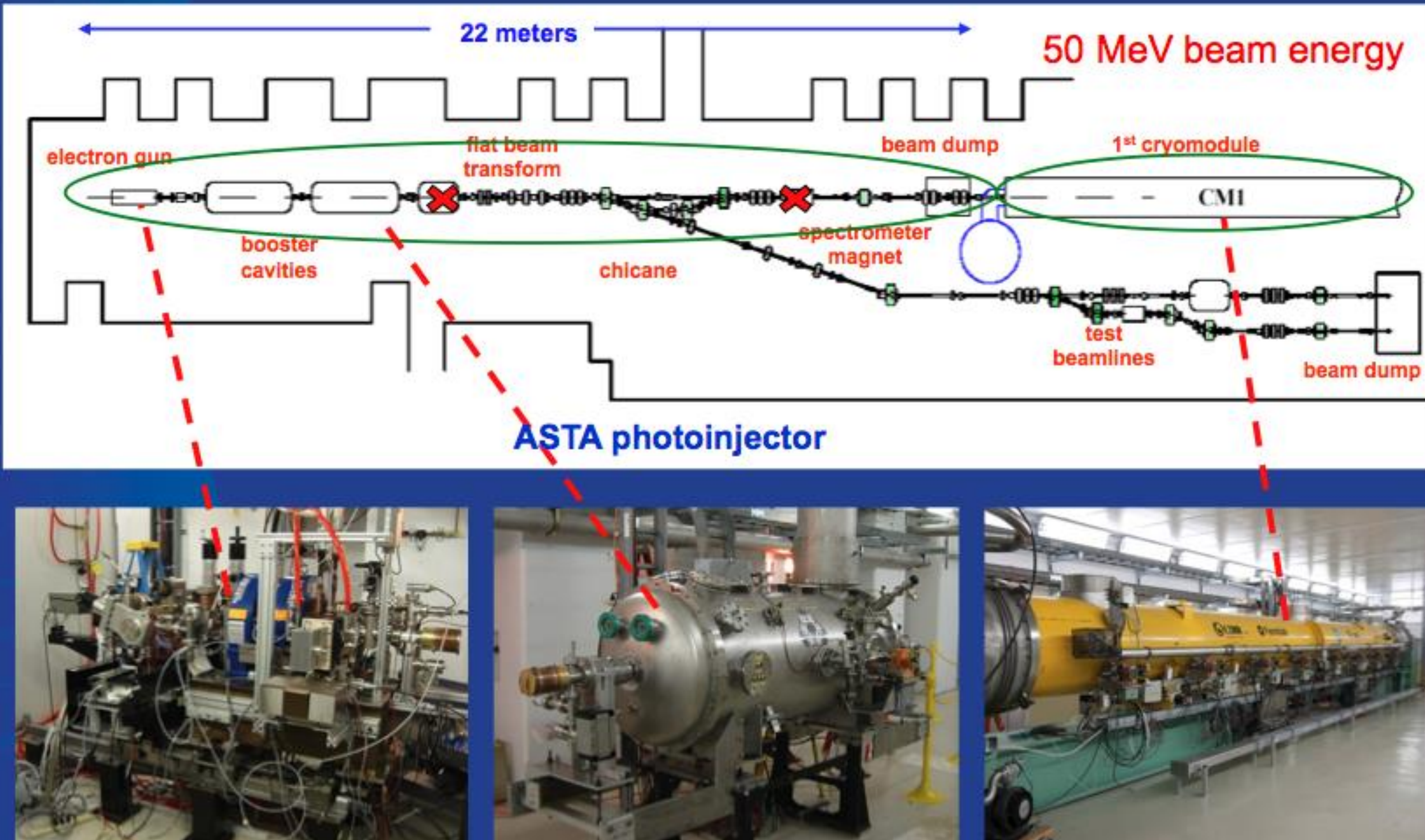
O. Napoly: XFEL cryo assey

# Challenges and Status of XFEL Module Assembly

O. Napoly, CEA-Saclay, Irfu/SACM

# Stage I.0: Expected Configura
# (Completed 50 MeV Beamline)

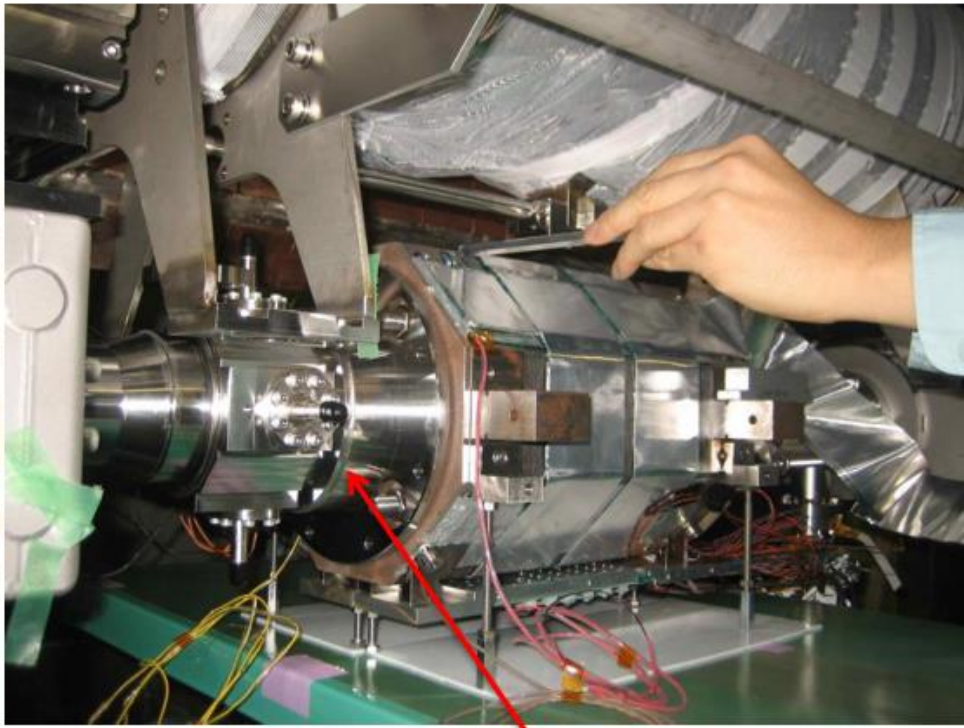
E. Harms: ASTA and CM-2



# Step by Step Mechanical Installation

5.

6.



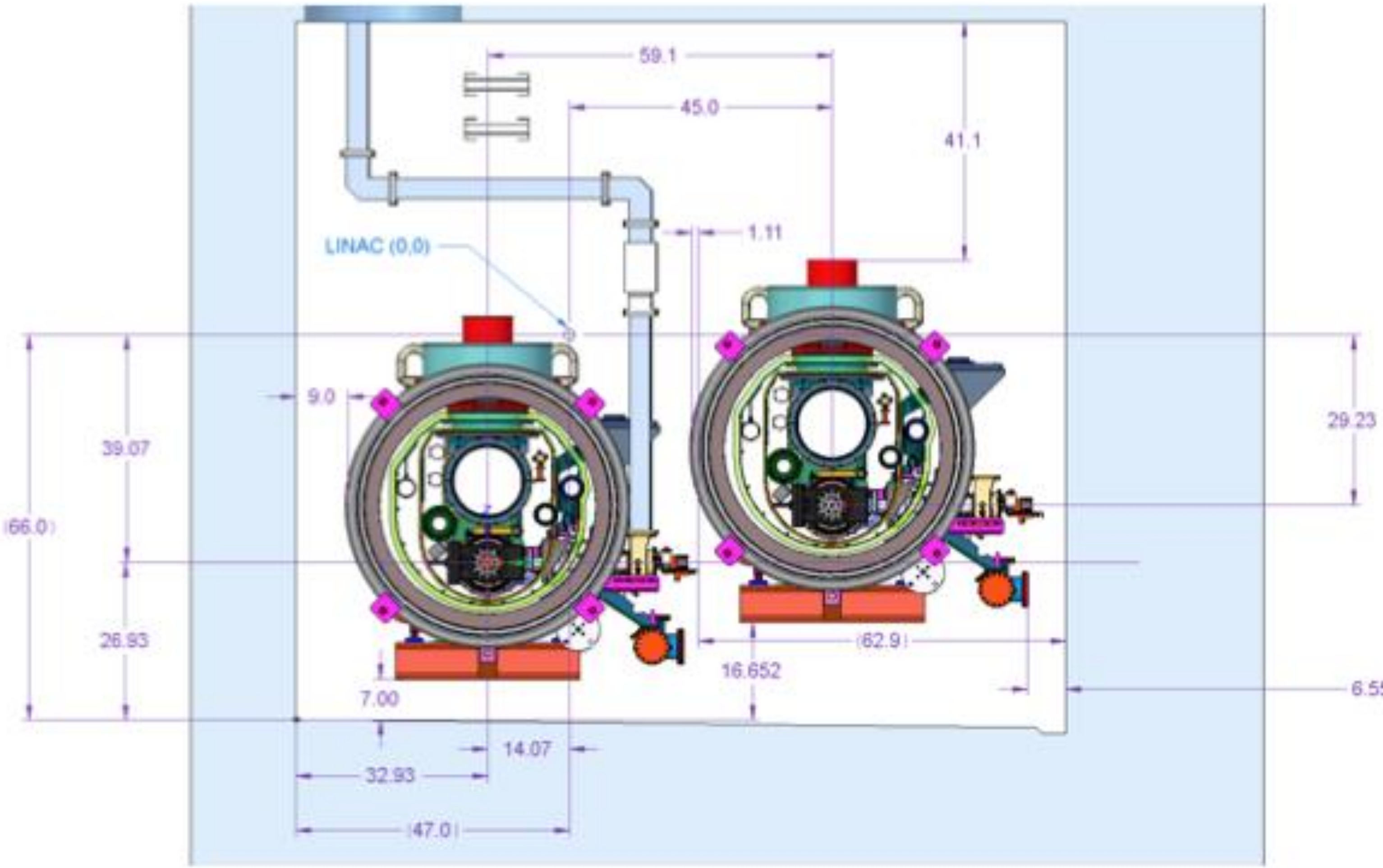
BPM

5. Lift up the magnet to right position.
6. Align the  iron yoke halves, and couple them.

# Cryomodules in SLAC Tunnel

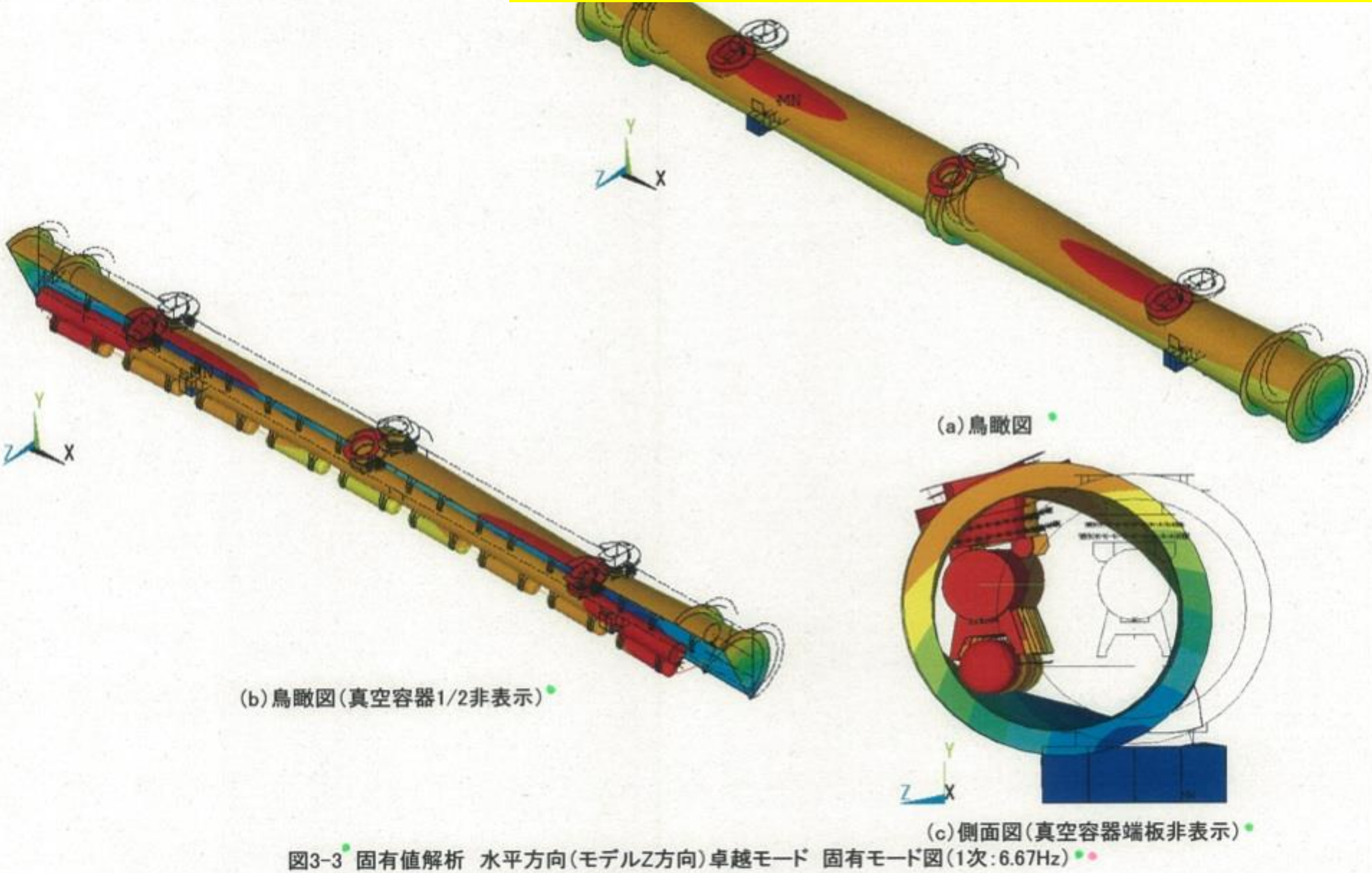
SLAC

SLAC Linac Tunnel (11 feet wide x 10 feet high) (3.35 m x 3.05 m)



# GRP and 8 Superconducting Cavities

# H. Hayano: CM Earthquake simulation




Main mode of Z-direction (horizontal axis) : 6.67Hz

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