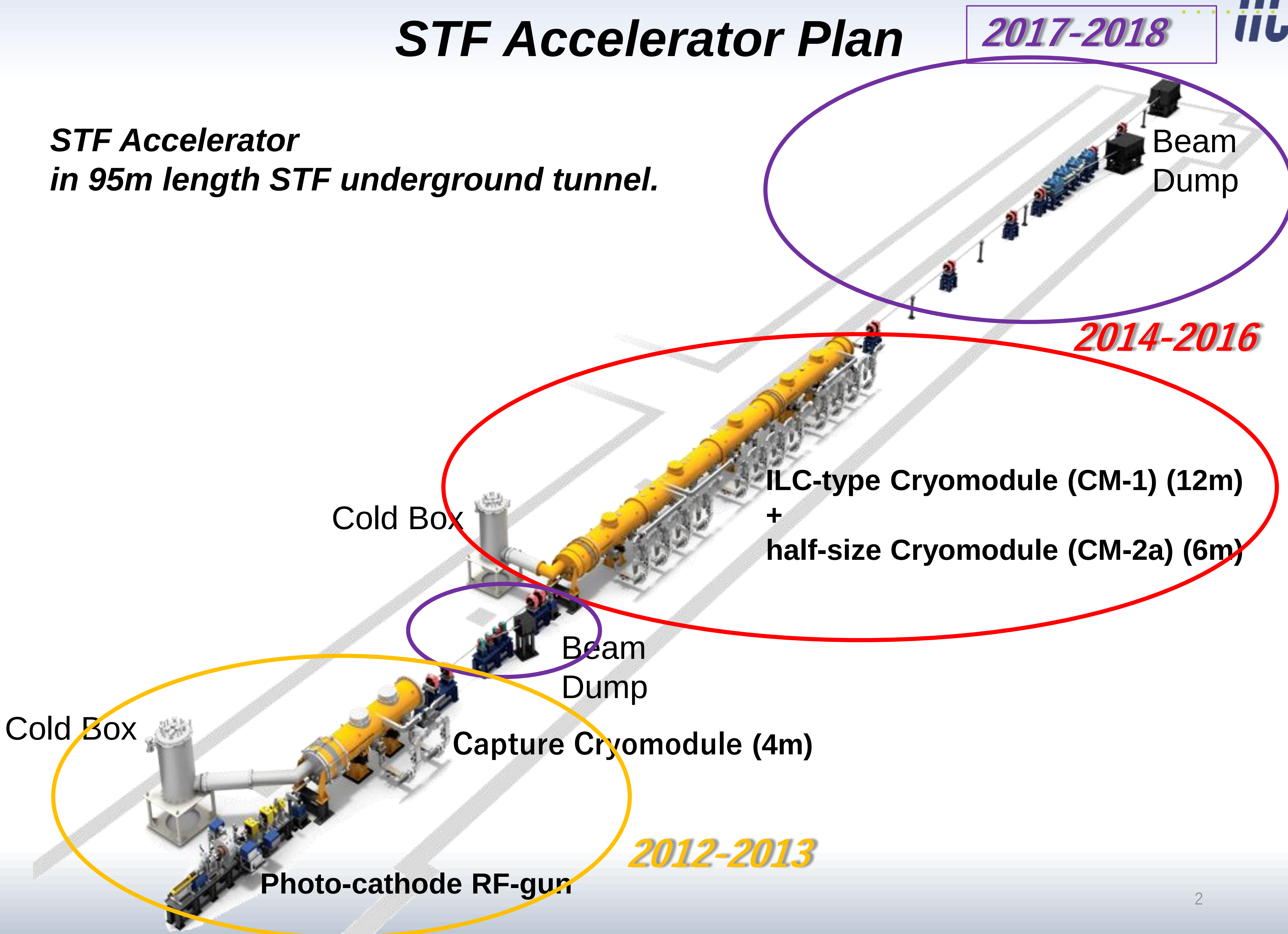
Status of STF Accelerator

H. Hayano, KEK

STF Accelerator Plan

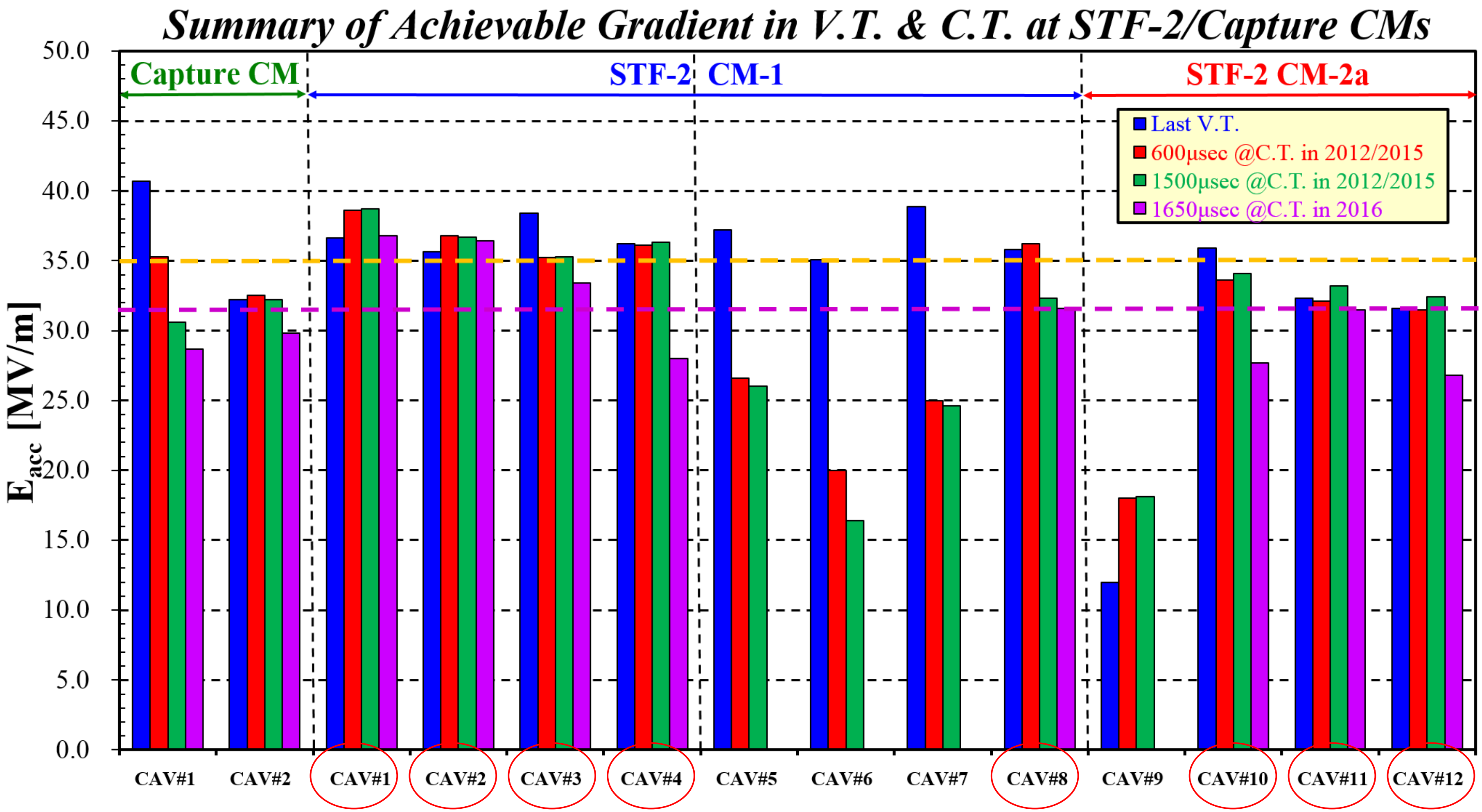
STF Accelerator
in 95m length STF underground tunnel.



RF power distribution and vector-sum operation

Cryomodule : Cavity Performance

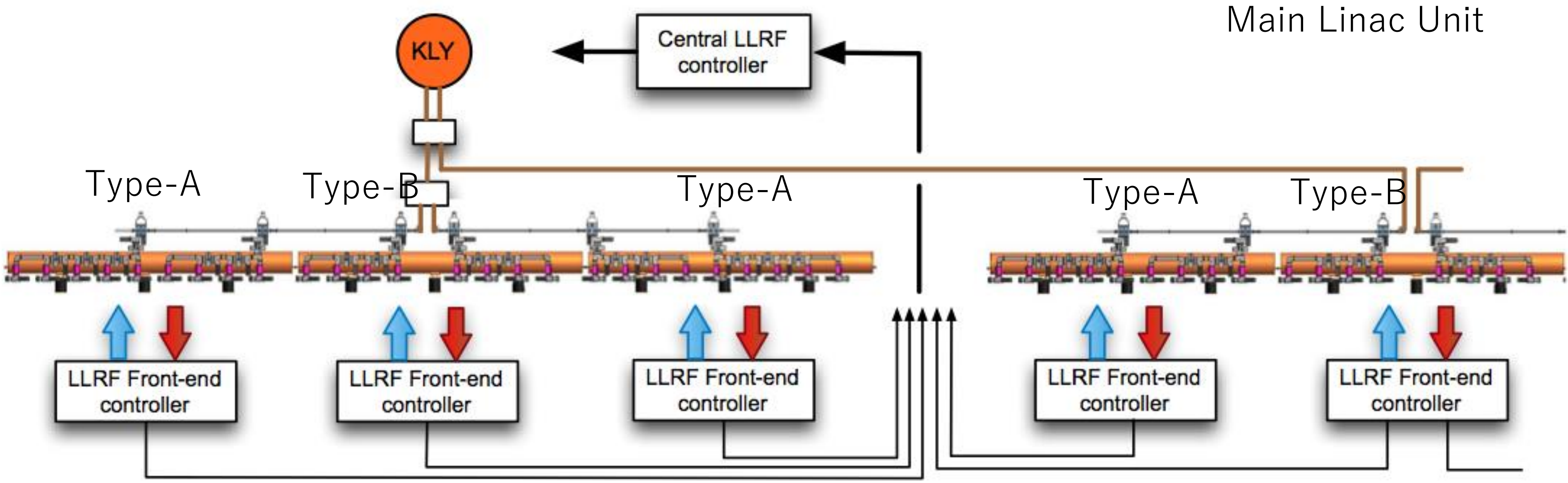
CM-1+CM-2a: the last Cool-down Test :Oct-Nov, 2016



<u>8 cavities combined test in CM-1&CM-2a</u>

<u>vector-sum feedback operation at 30.5 MV/m</u>

ILC Basic RF unit of Main Linac



Basic unit（RF power supply unit）

10MW Klystron 1

Klystron pulse power supply 1

Cryomodule 4.5

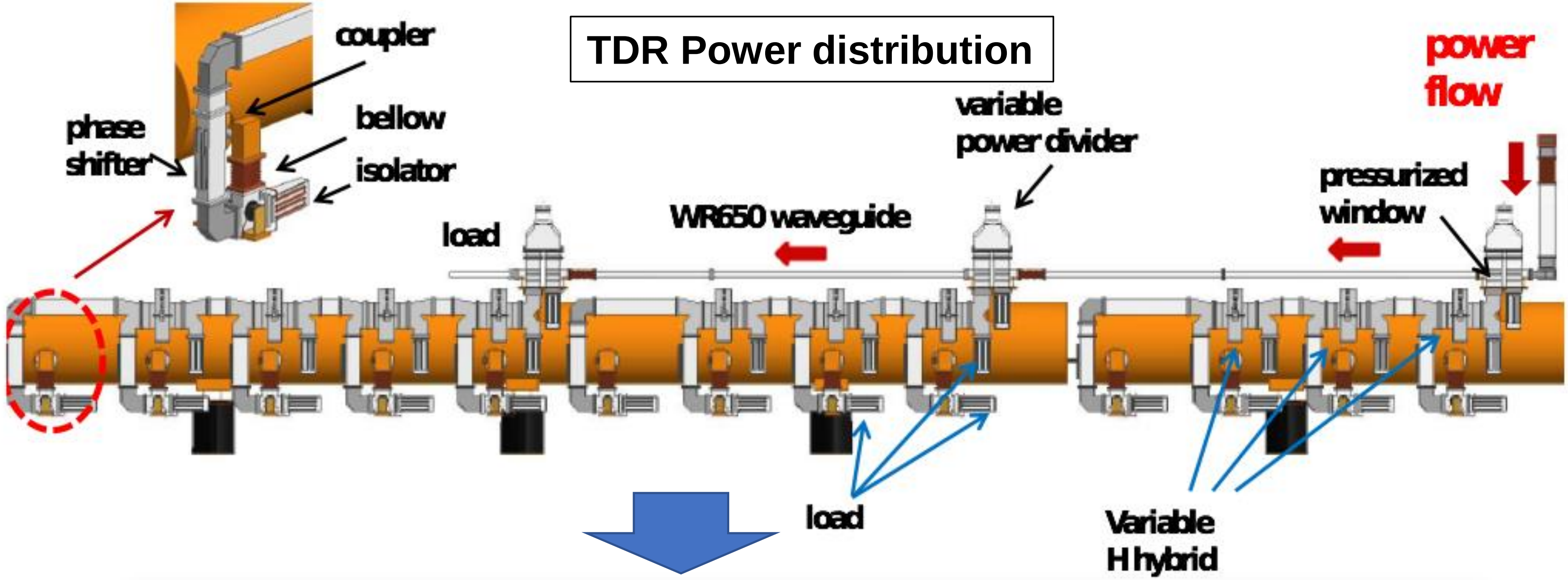
SC cavity 39

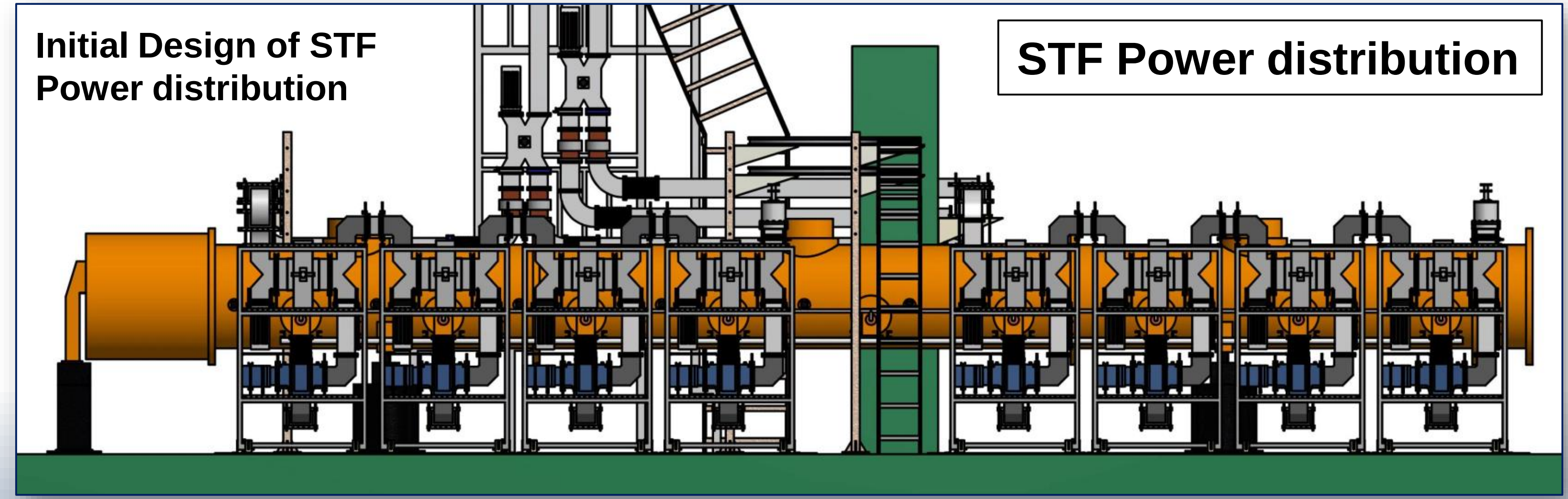
SC Quadrupole magnet 1.5

Digital LLRF control 1

Vector-Combined signal of 39 cavities is fed back to klystron input

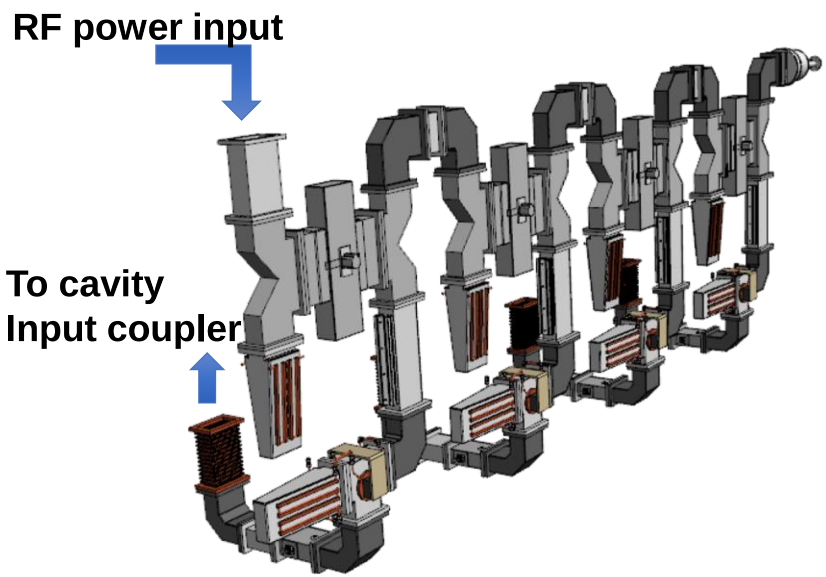
TDR RF power distribution to STF

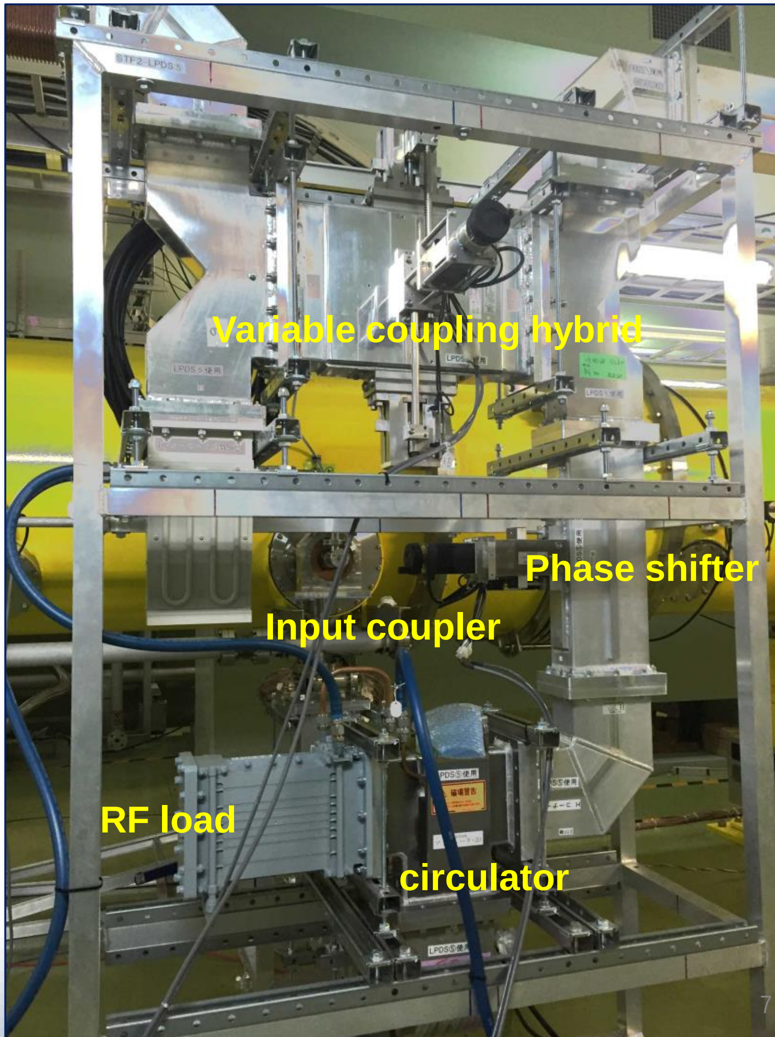




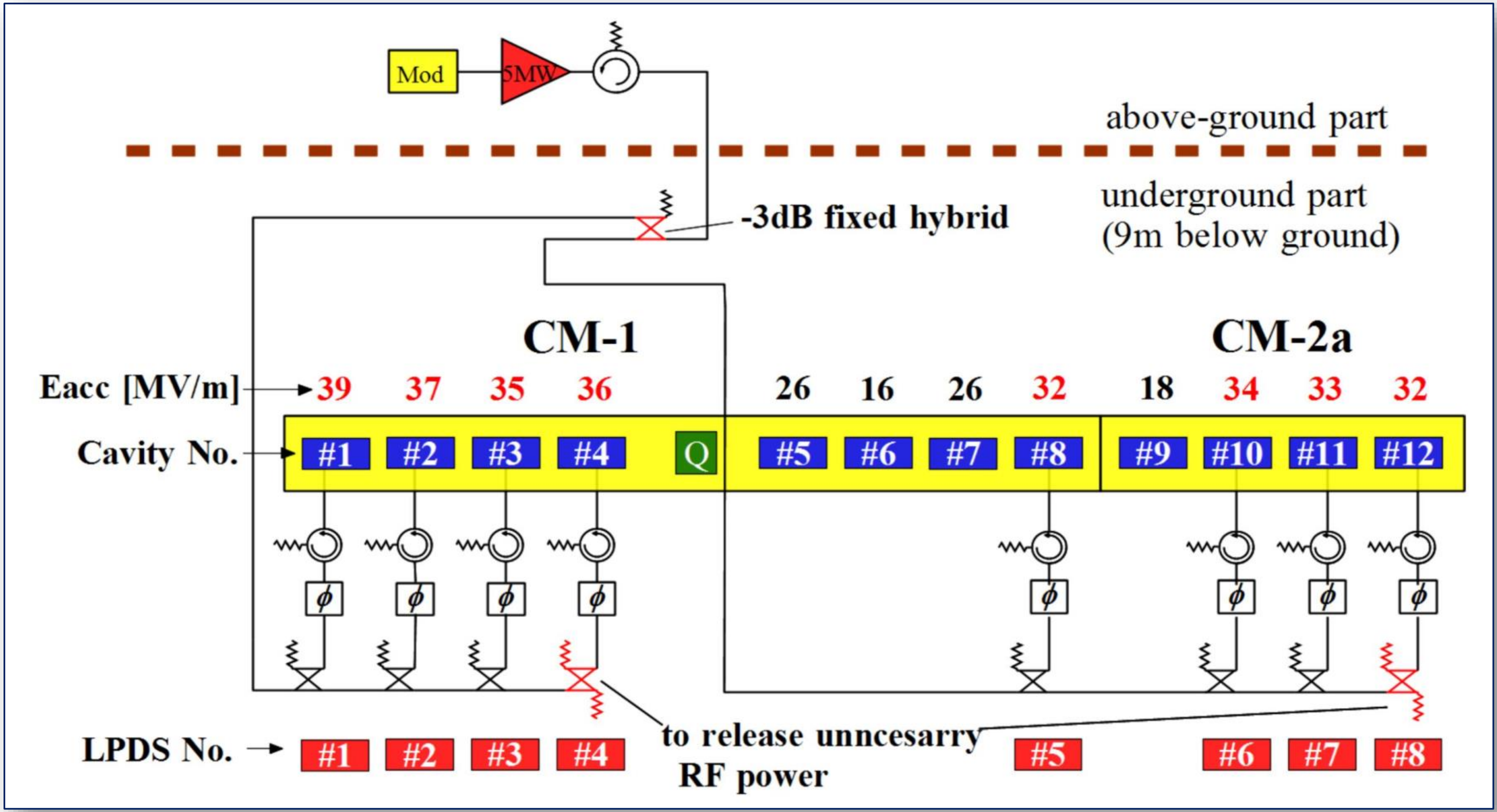
STF RF power distribution (based on TDR)

By using Variable power divider hybrid, phase shifter, couper coupling tuning, maximum acceleration can be attaianed for ±20% gradient variation of cavities.



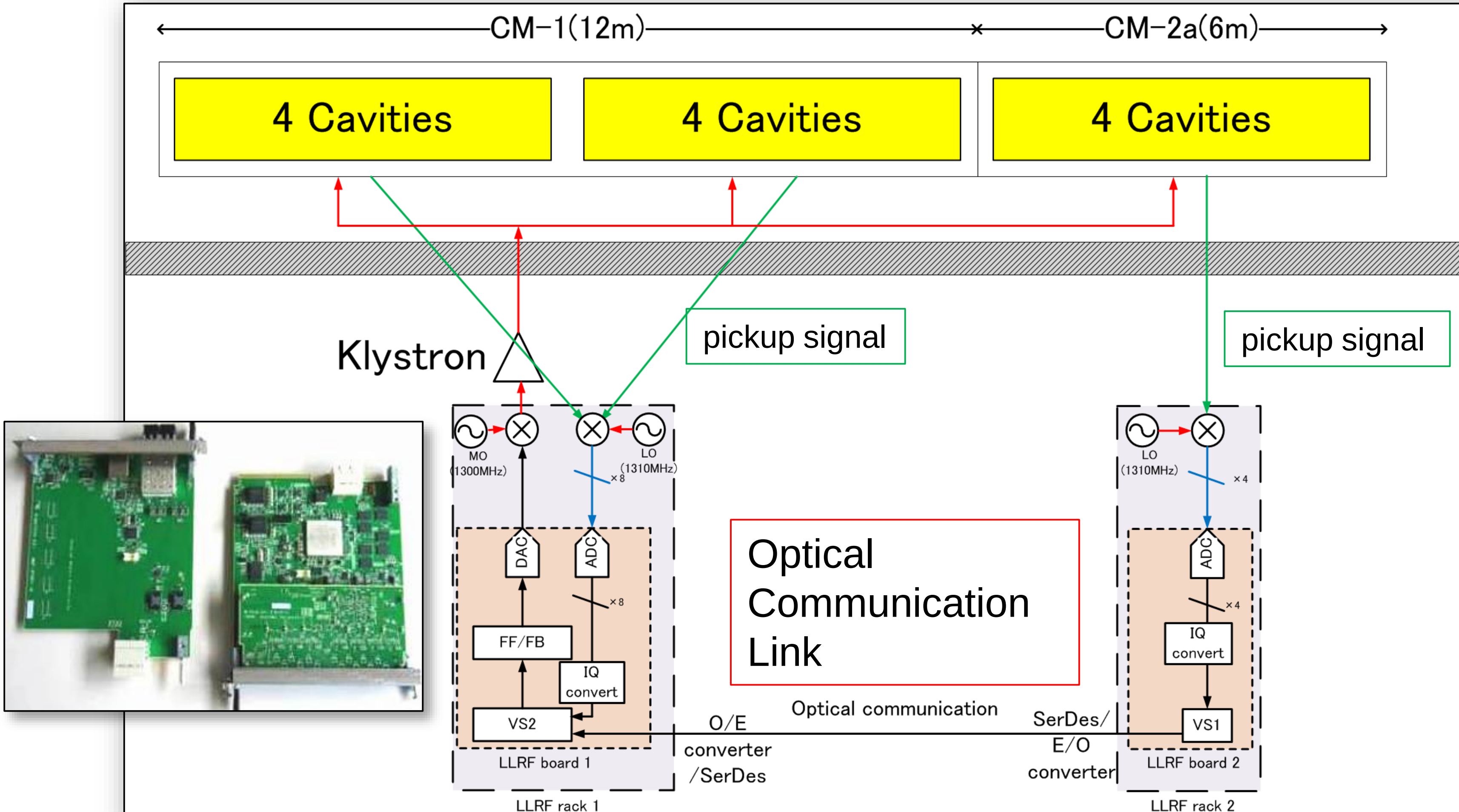


Selection of 8 good performance cavities



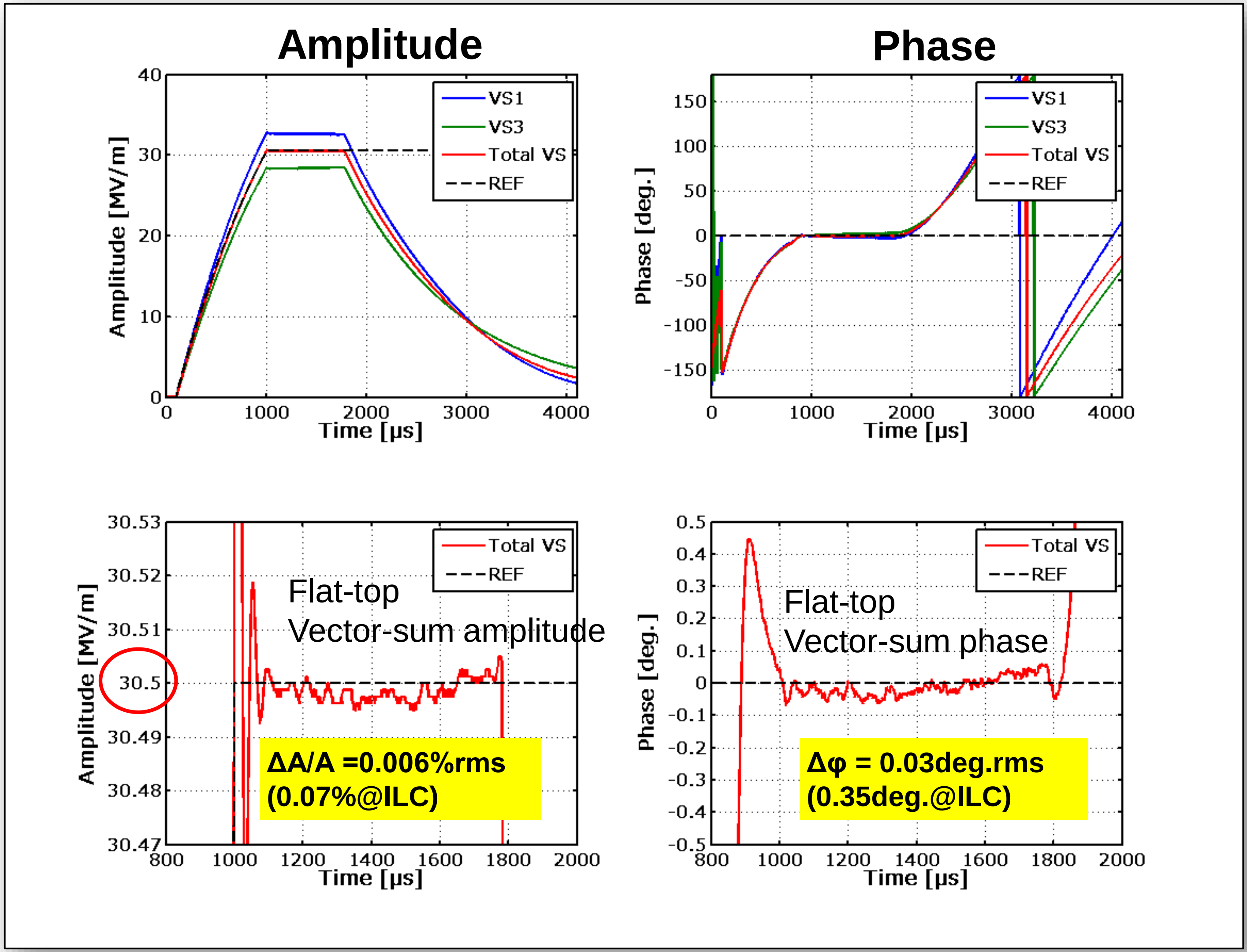
8 good performance cavities were selected for vector-combined operation. RF power was provided from one klystron, LLRF feedback was applied using vector-sum of pick-up signals. Test was done in Oct.-Nov. 2016.

STF 8 cavities vector-sum operation



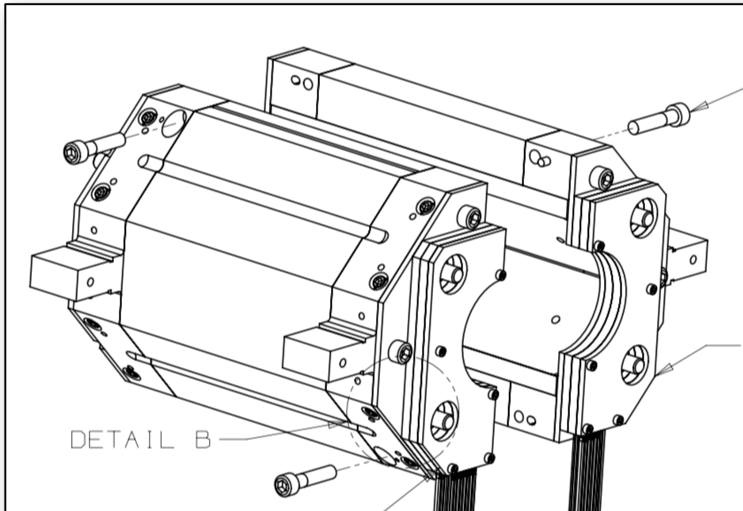
LLRF ： MTCA.4 standard board, RTM module,
optical communication for boad-to-boad connection

Amplitude and phase of 8 cav. vector-sum operation



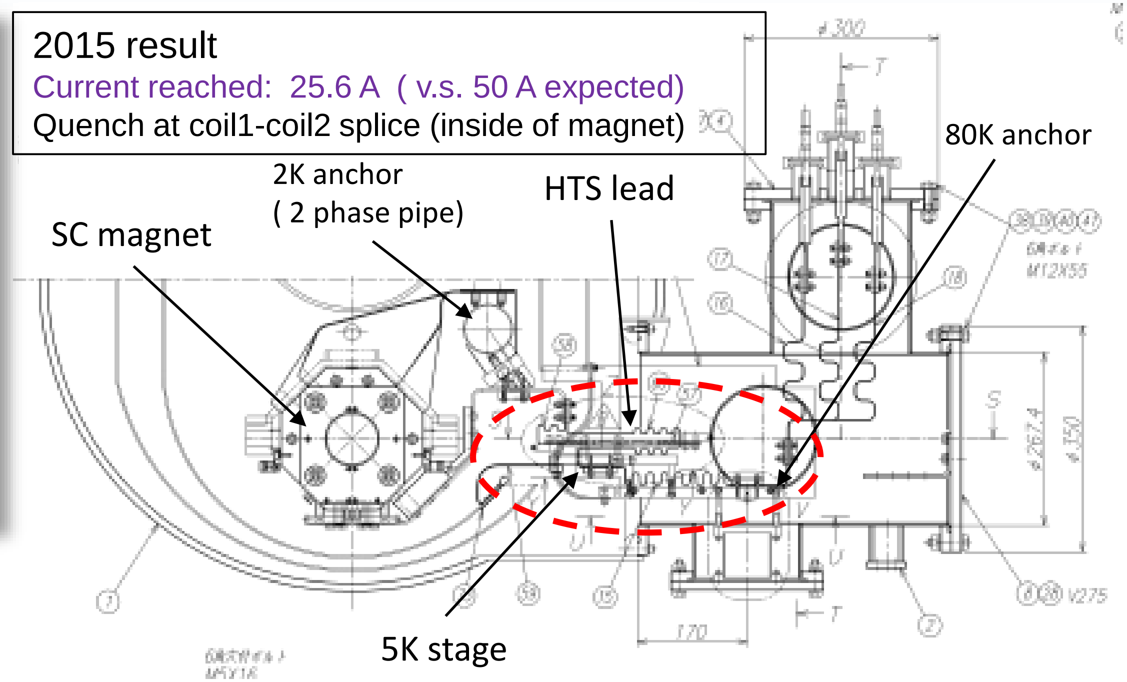
Conduction cooled Q-magnet in cryomodule

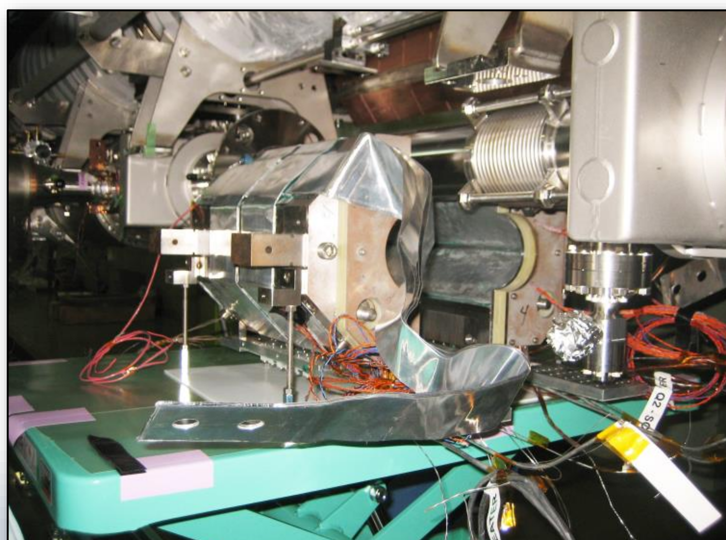
Conduction cooled SC Q-magnet : *FNAL-KEK*



Conduction cooled quadrupole magnet
was fabricated by FNAL,
installed into CM-1 at STF.

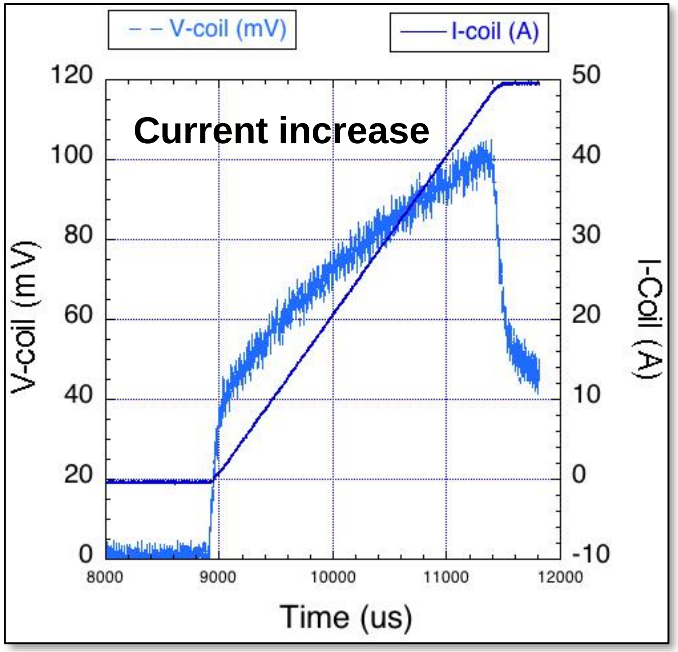
2015 result
Current reached: 25.6 A (v.s. 50 A expected)
Quench at coil1-coil2 splice (inside of magnet)

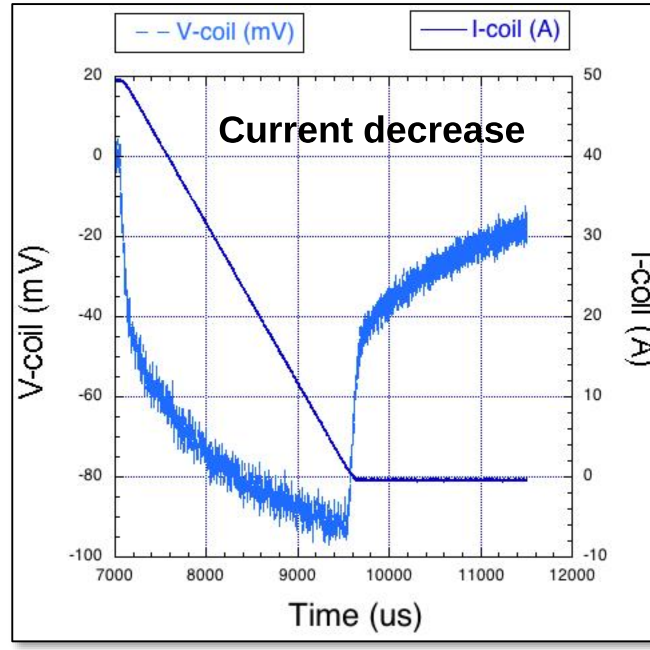


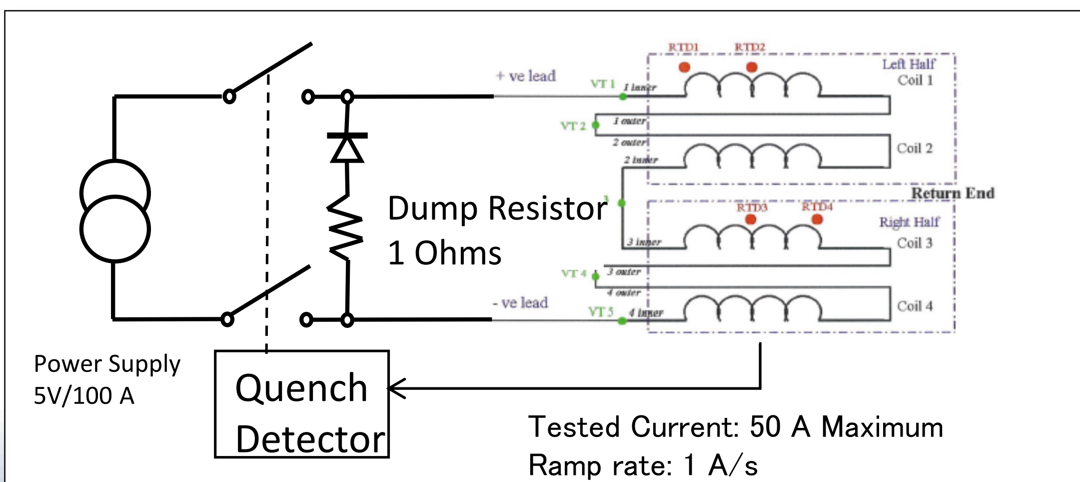


- **Improvement**
  - **tight connection and connection position change for each anchor**
  - **only 2 coils were excited (other has splice-connection problem)**
  - **add 4 more HTS lead for each coil excitation**
- **2016 Excitations**
  - **Current reached: 50A (reached to specification)**
  - **No Quench**
  - **little high coil temperature than 2015 (7.1K -> 7.5K)**
  - **RRR =100, coil inductance=6mH as designed.**

Excitation of Conduction-cooled Q-mag in CM-1







50A excitation with ramping speed 1A/s was confirmed. Coil temperature was 7.5K, Inductance was 6mH (designed value).

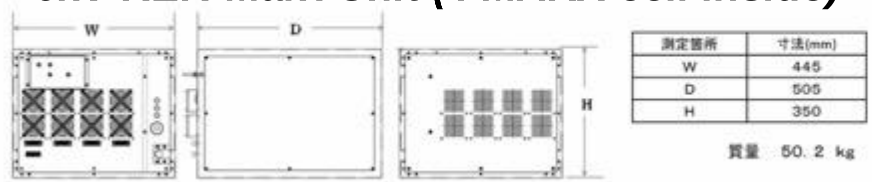
MARX Modulator

KEK-MARX modulator development (1)

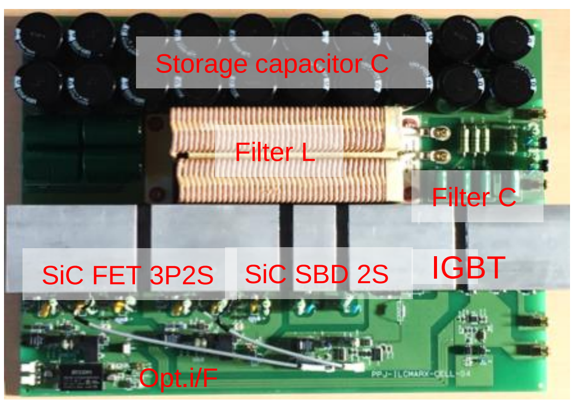
KEK-Marx modulator

- ***(1) Low charging voltage (~2kV) for each board onto low voltage parts.***
- ***(2) Chopped discharge output with FPGA precise timing control.***
- ***(3) High efficiency SiC power device are used.***
- ***(4) Droop compensation by PWM.***
- ***(5) Ripple cancelation by phase shift control.***

6kV KEK-Marx Unit (4 MARX cell inside)



MARX Cell



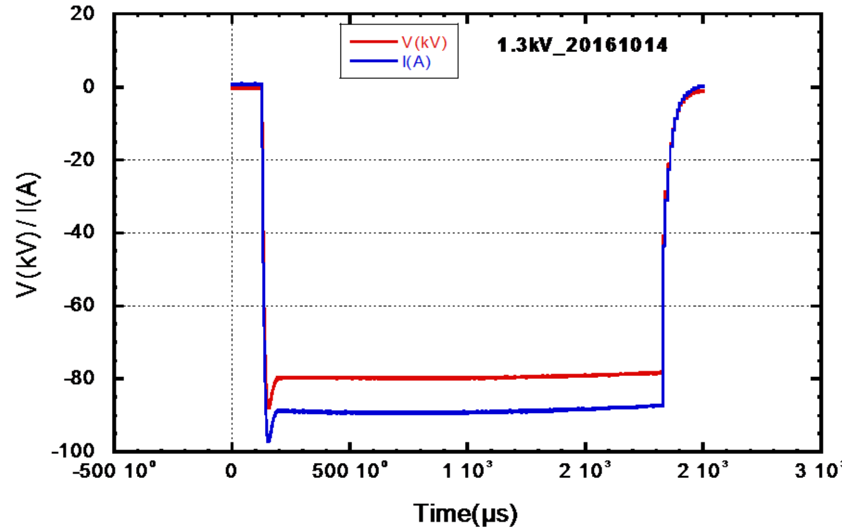
Opt.i/F

400mm×300mm×75mm(H)

20 KEK-Marx Unit combination for 120kV.

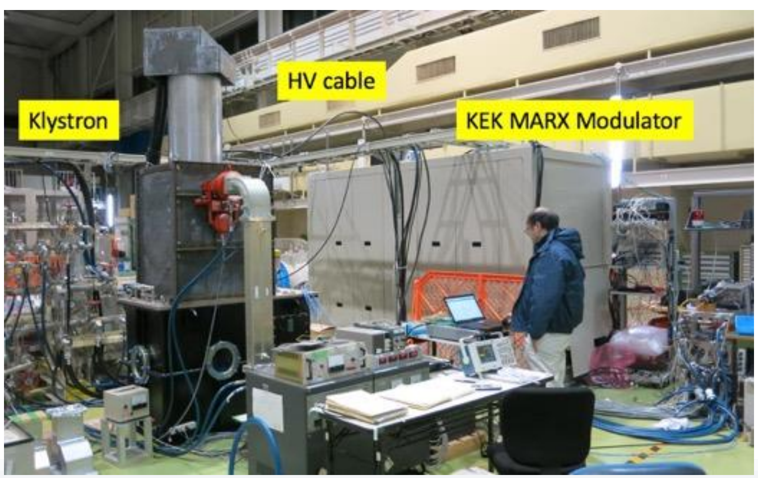
KEK-MARX modulator development (2)

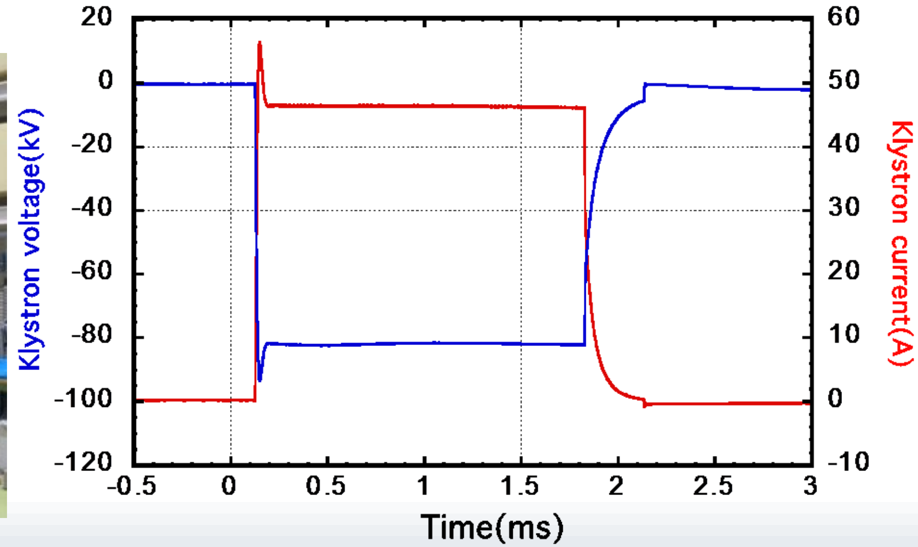
Test of MARX modulator with dummy load; 1.3KV charging, 80kV 1.7ms output was demonstrated.



Vp=80 kV, Ip=90 A, Pw=1.7 ms, Ripple=0.6%(p-p),Charging voltage=1300 V

Test of MARX modulator with 5MW klystron conection





82kV, 46A, 1.7mA, Ripple 0.3%, Duty cycle 86-97%, Flatness 1%(p-p), Charging voltage 1200V

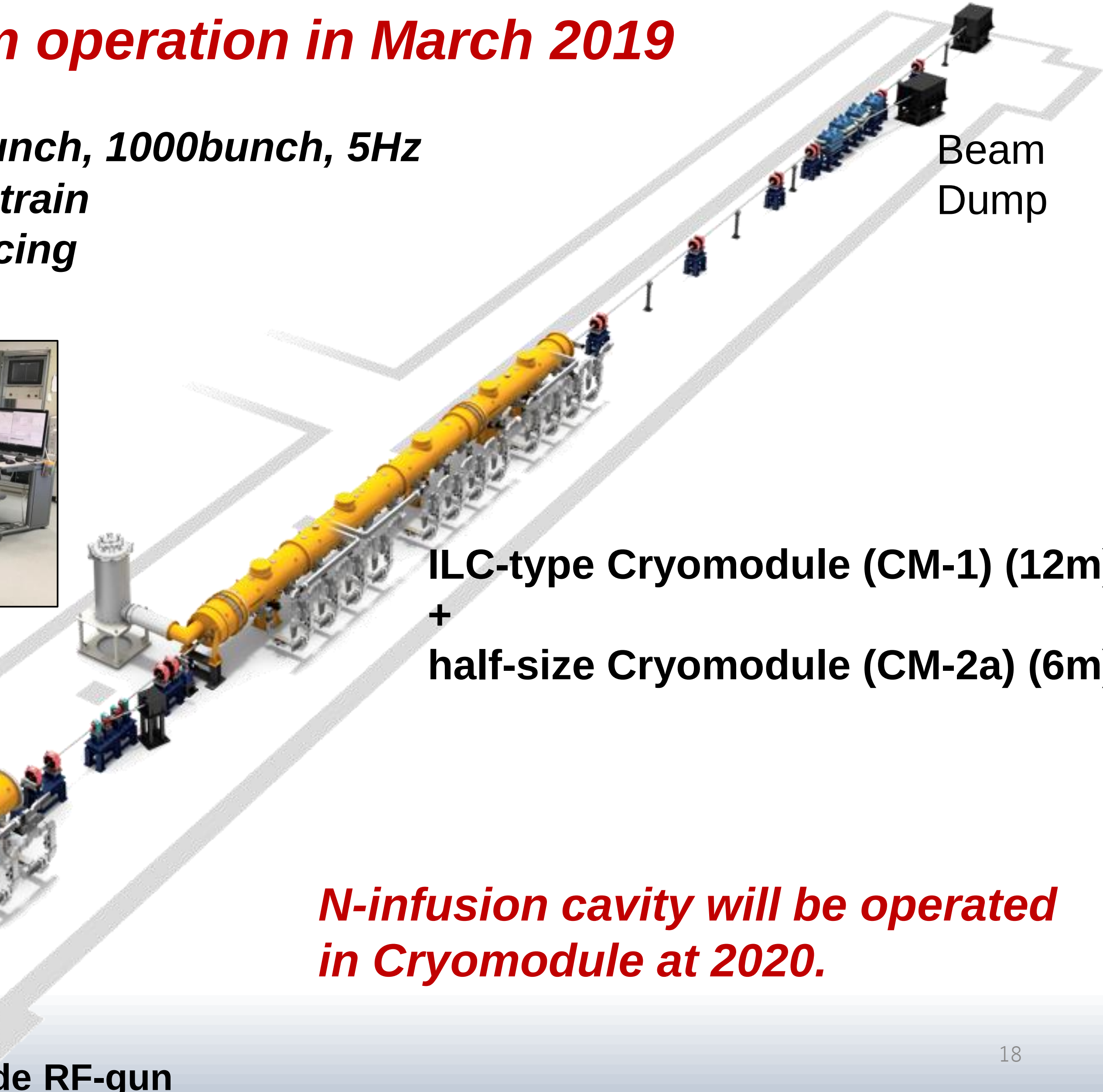
2018-2020 STF Accelerator Plan

STF accelerator beam operation schedule

Small current Beam operation in March 2019

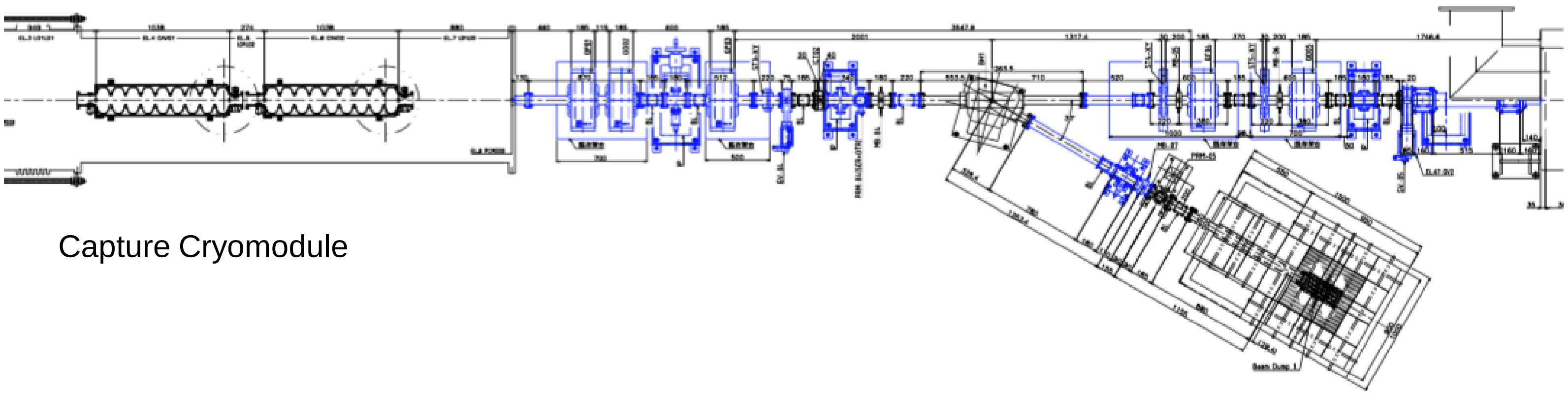
Beam Energy ：292MeV
Beam Charge ： 60pC/bunch, 1000bunch, 5Hz
Beam current: 250nA in train
Bunch train: 6.15ns spacing

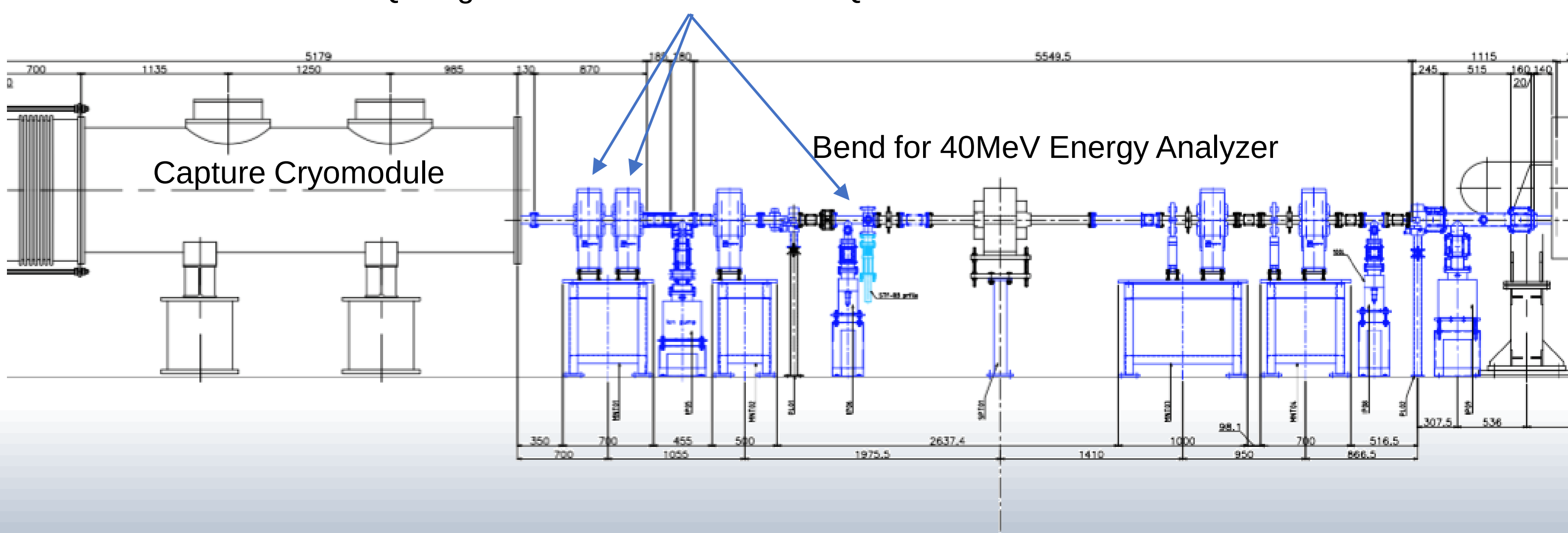
STF control room



N-infusion cavity will be operated in Cryomodule at 2020.

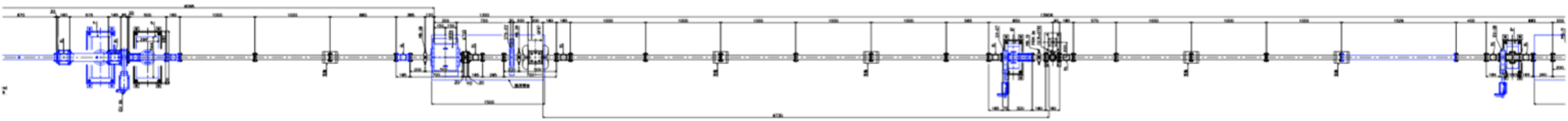
Beam Line of STF Accelerator (1)





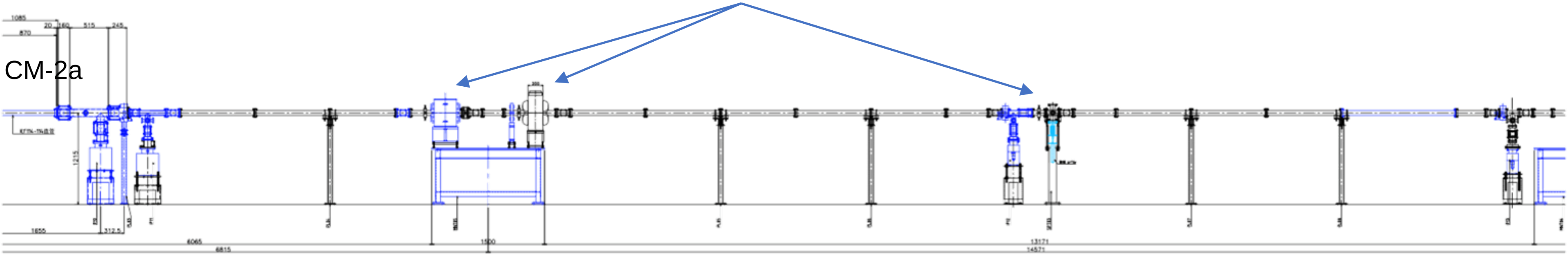
Beam Line of STF Accelerator (2)

CM-2a

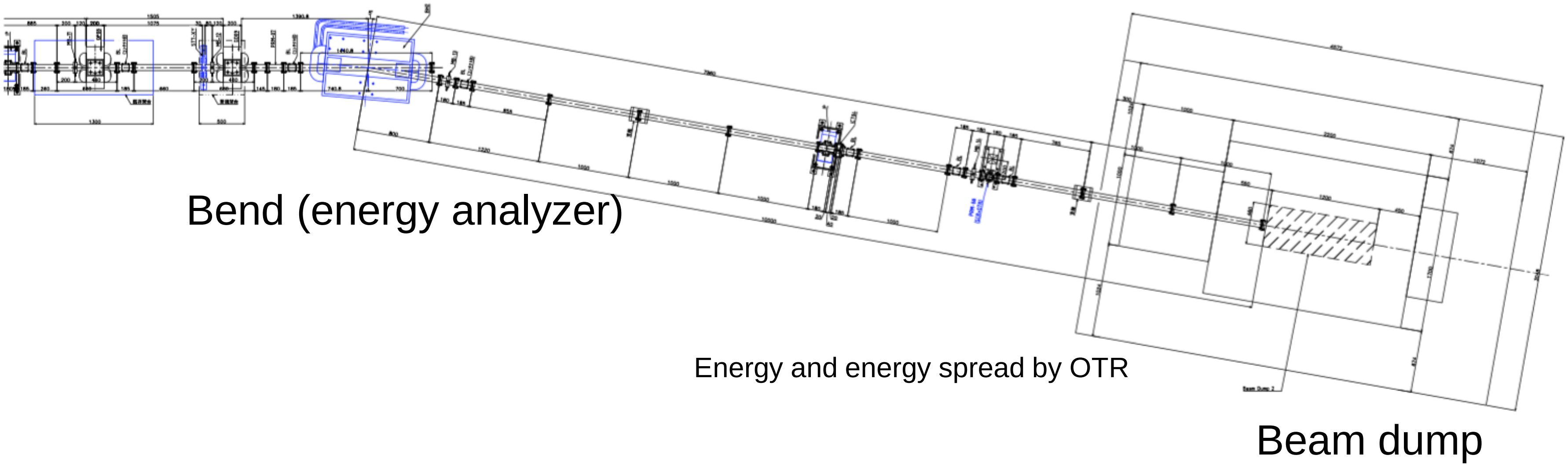


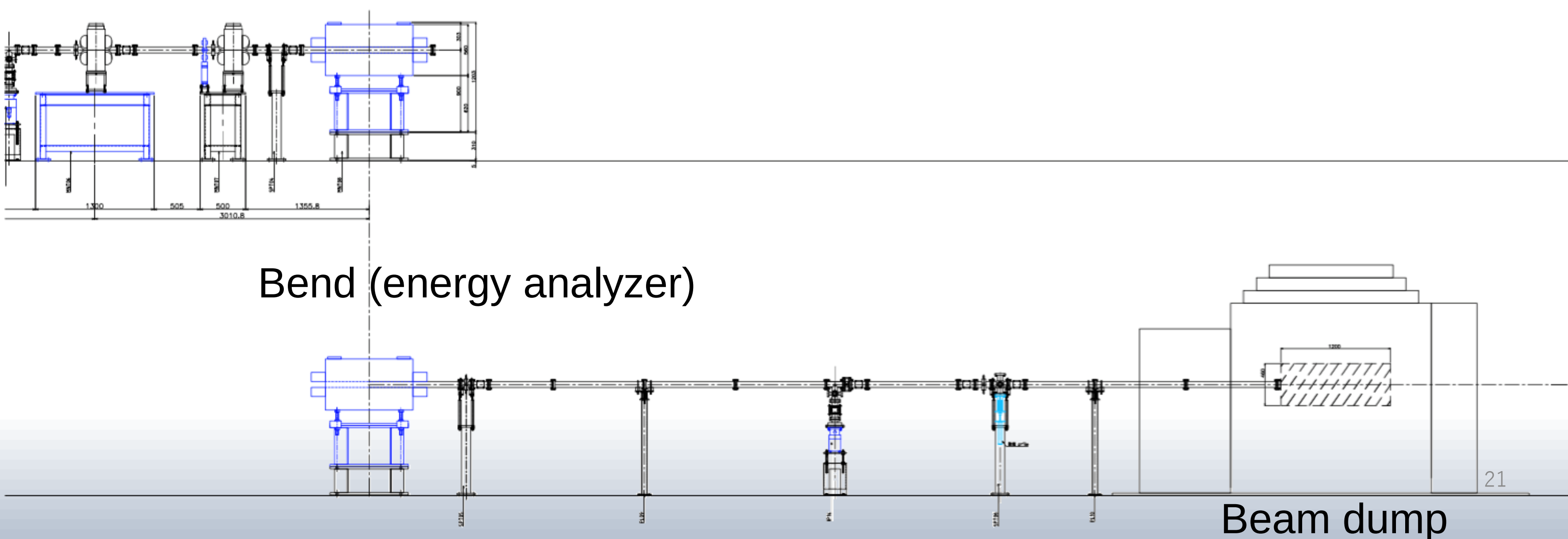
Q-magnets and OTR monitor for emittance measurement

CM-2a



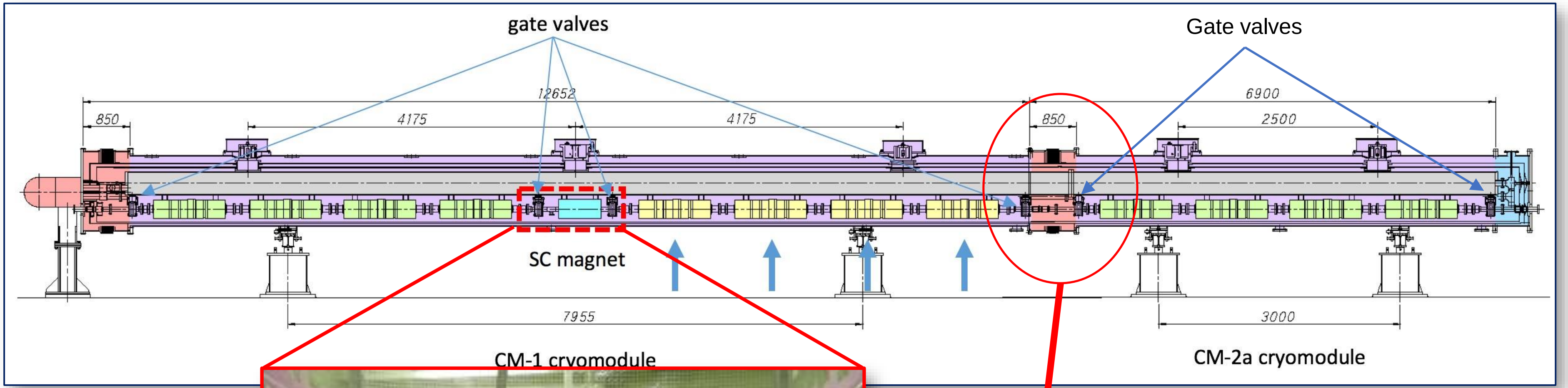
Beam Line of STF Accelerator (3)



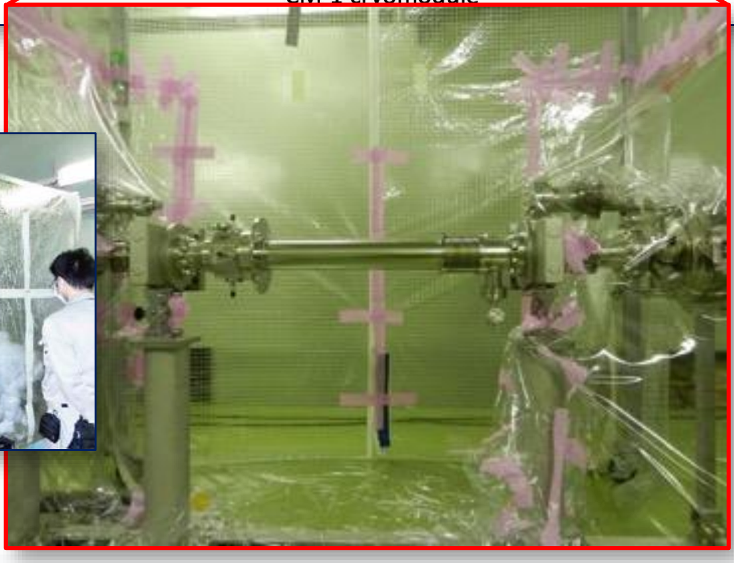


Vacuum Chamber refreshment between CM-1 and CM-2a

(GV - 4cavity - GV) – BPM – (GV - 4 cavity - GV)



Local clean-room
with down flow clean air



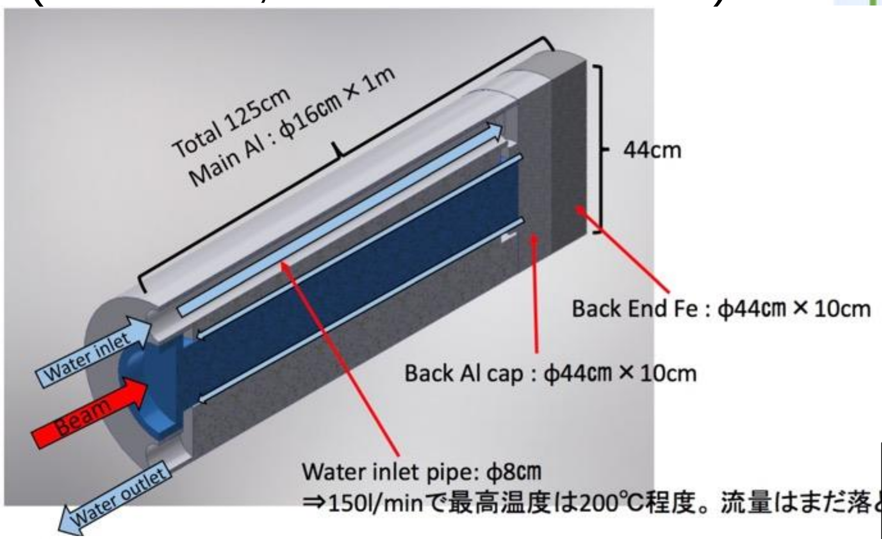
Not so clean inside?
BPM chamber miss-installation made contamination happen?
GV-open procedure was wrong?

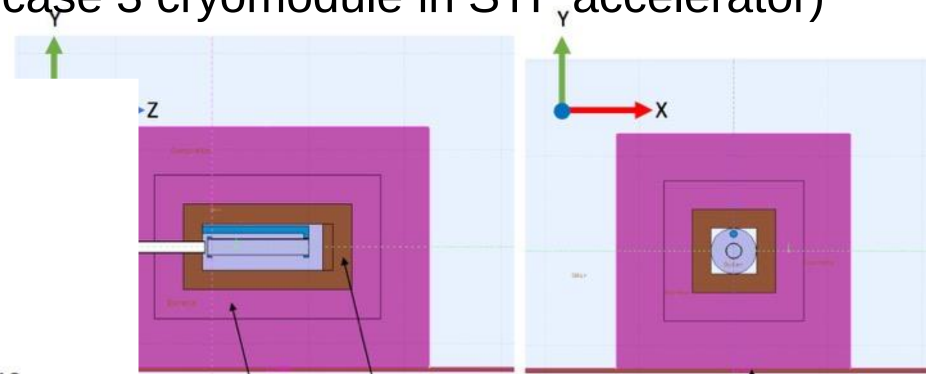
Remove the chamber between GV, HPR refreshment, assembly again, using new clean-fan-filter, slow pumping with vacuum particle counter build-in. (December 2018)

New clean-fan-filter

Design of STF Accelerator: Beam dump

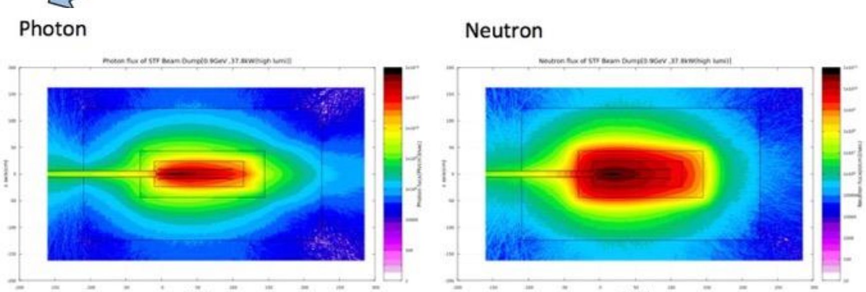
Design: 900MeV, 37kW dump (in the case 3 cryomodule in STF accelerator)
(Aluminum, 150L/min water cool)

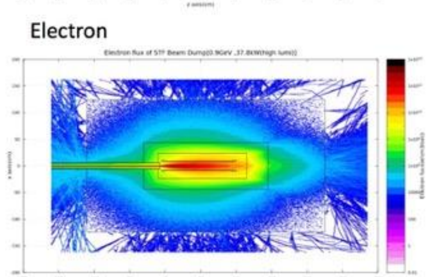




B concrete
(80cm)

Steel(20cm)

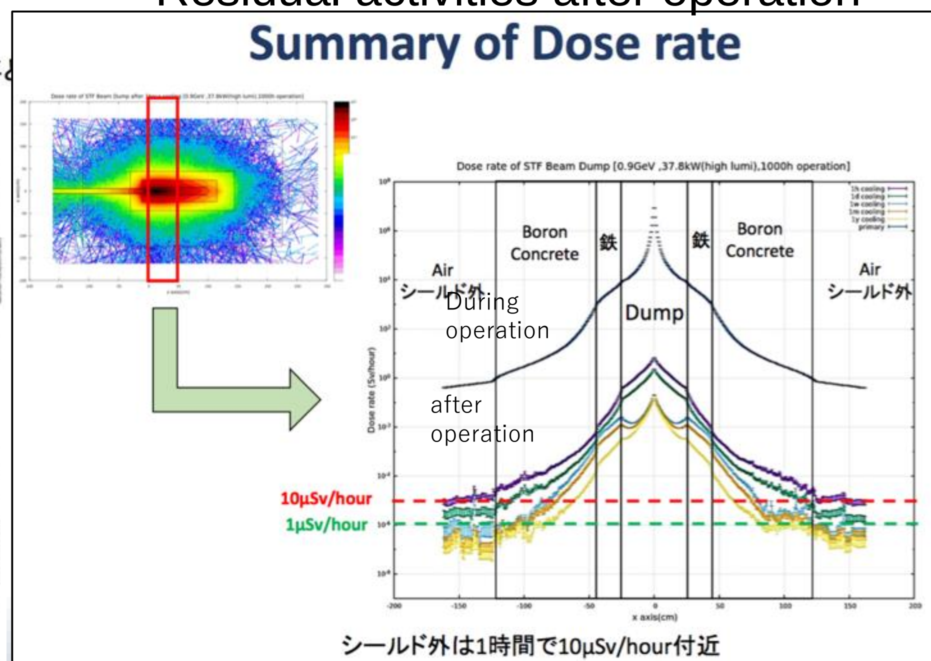




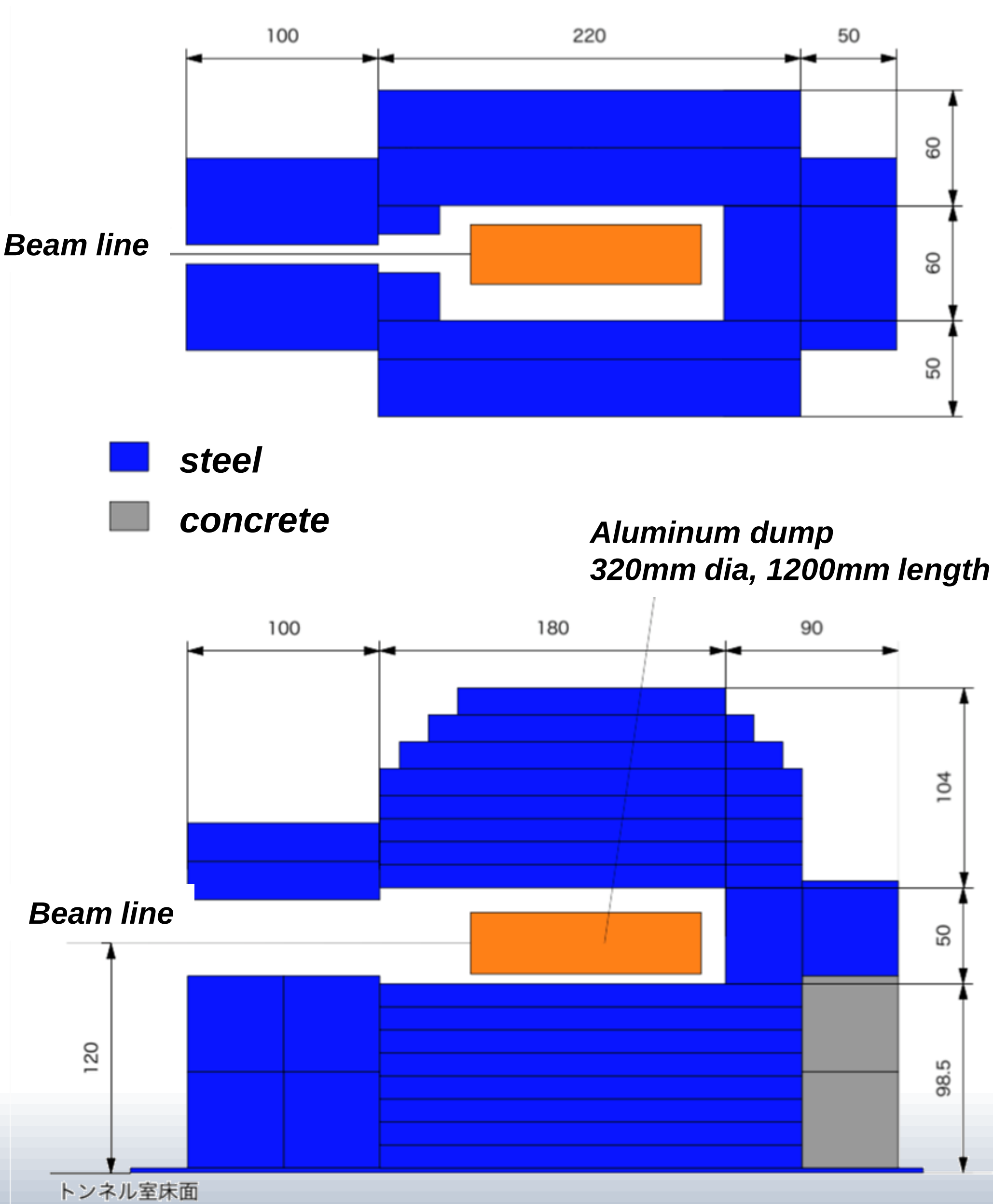
Activities
during operation

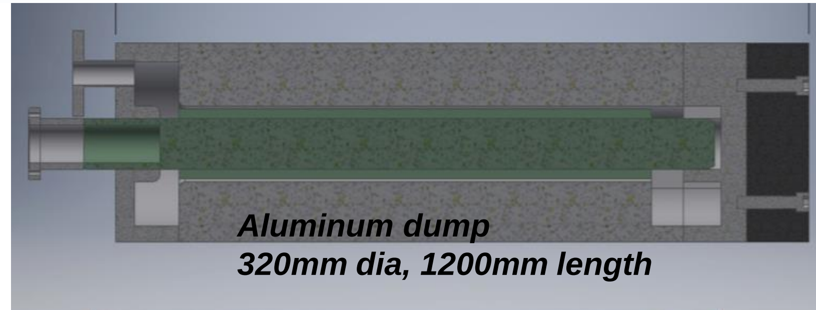
X
Z

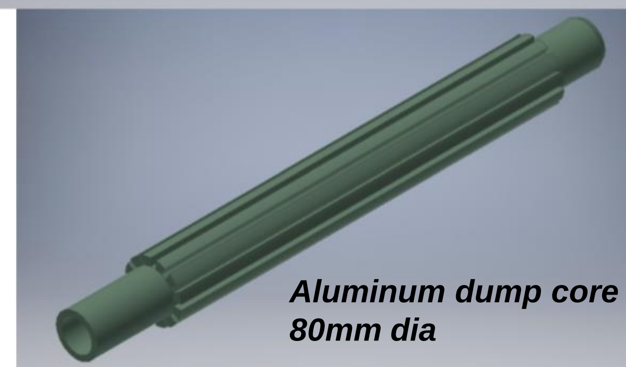
Residual activities after operation

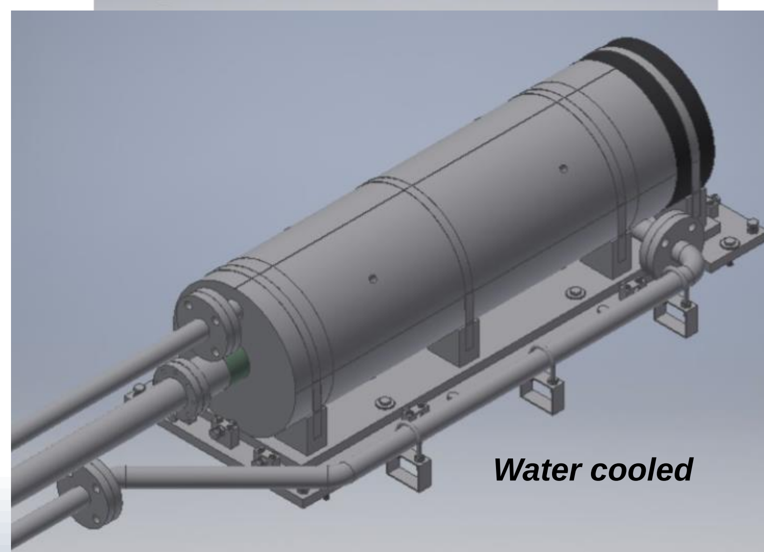


Actual design of Al-Beam dump and Steel Shield







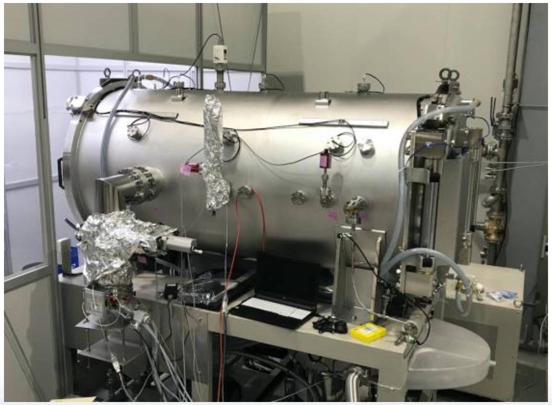


Cavity fabrication for cost-down study

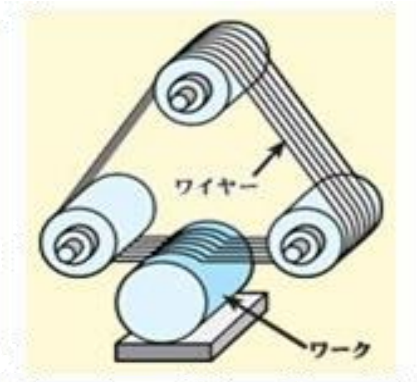
<u>9-cell Cavity Fabrication plan in 2018 to 2019</u>

- ***N-infusion technology development*** ***4 of 9-cell Cavity (inductry)***
- ***Ingod Slice technology development (LG)***
  1 of 9-cell cavity (industry)
  1 of 9-cell cavity (KEK-CFF)
- ***Cryomodule cavity development (High-pressure-regulation passed)****
  1 of 9-cell cavity (industry)
  1 of 9-cell cavity (KEK-CFF)

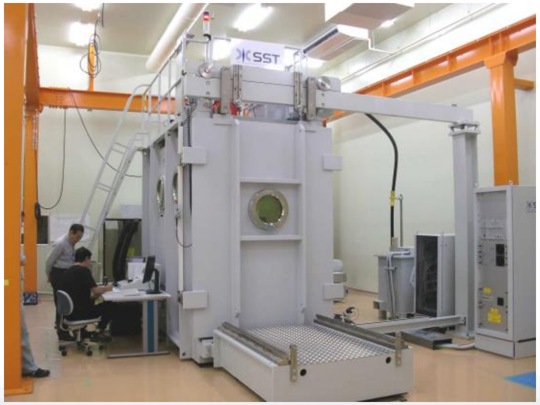
*** Cavity replacement of bad cavity in STF cryomodule**



Introduction of New Vacuum furnas

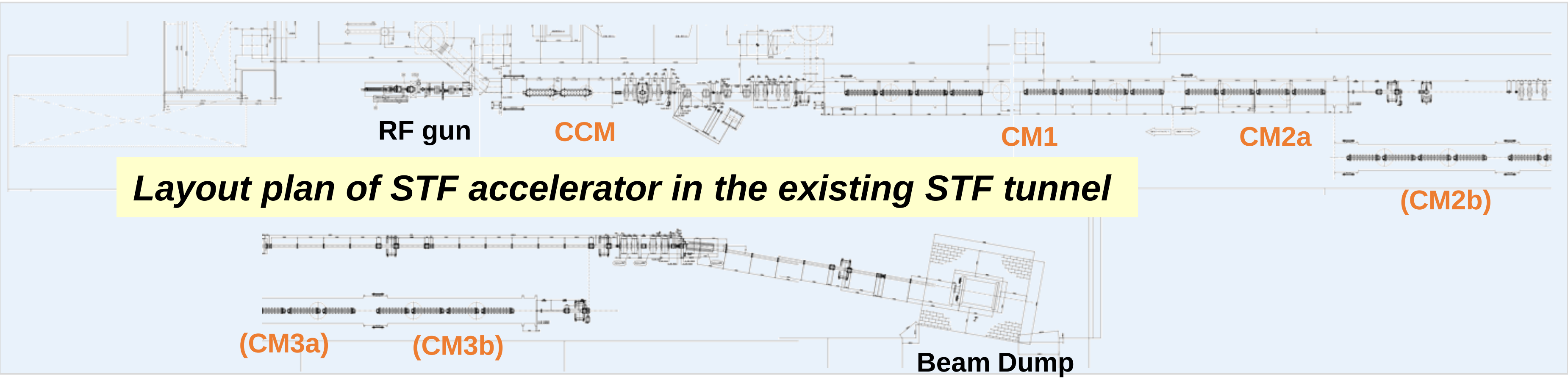


Ingod slice

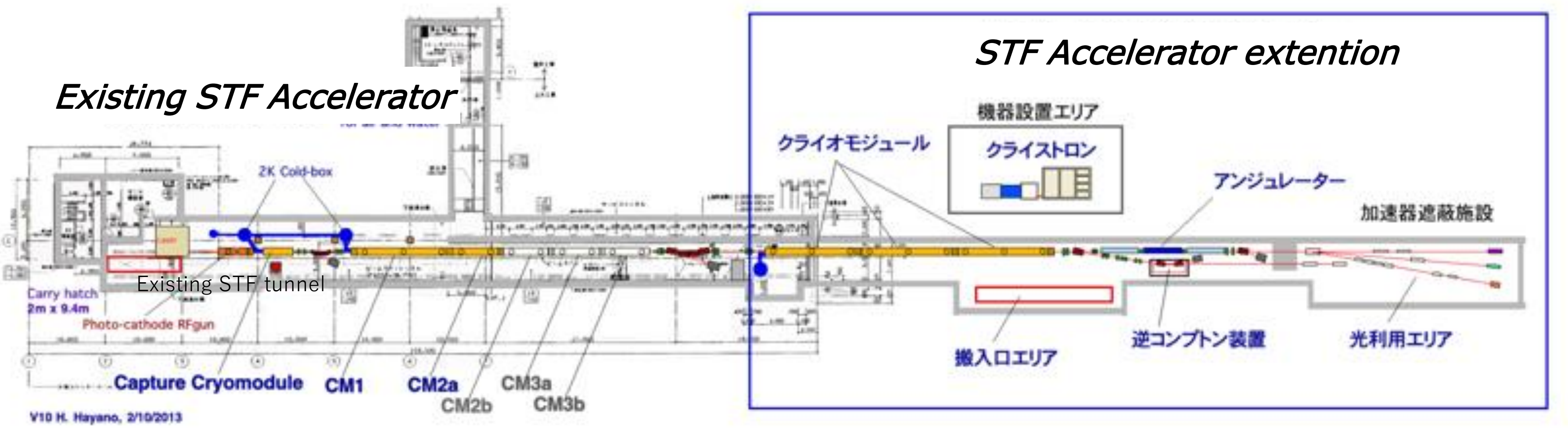


Using CFF EBW

STF Extention in case of ILC go-sign



Design study of STF accelerator optics and layout considering 1GeV SASE-FEL extention later, was done.



100m Extention:
- 3 more cryomodules,
- 25m undulator space at downstream,

0.01% slice energy spread, 0.5nC bunch charge, 50µm bunch length at 1GeV beam is required (2-stage bunch compressor)
1µm emittance required at RFgun (need more high gradient at gun cavity -> more high power)

Summary

- ***Step-wise operation of STF accelerator is now in the stage of beam acceleration through CM-1 and CM-2a with small beam current for the initial start-up.***

- ***8 good cavities combined operation (30.5MV/m) is ready to go.***

- ***Vacuum chamber refreshment work between CM-1 and CM-2a, is planned in December 2018.***

- ***For the US-Japan cost down development, N-infusion vacuum furnas was introduced, and total 8 9-cell cavities are under fabrication and development. Several will be tested in the STF cryomodule.***

End of slide