

High Gradient Research at KEK / Nextef

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The 13th Workshop on Breakdown Science and High-Gradient Accelerator Technology (HG2021)

April 2021

Nextef's Past, Present, and Future

■ Past

- HG tests at Nextef / Shield-A, B
 - in collaboration with CERN and SLAC

■ Present (recent)

- Serious fire on April 3, 2019
- In process of recovery

■ Future

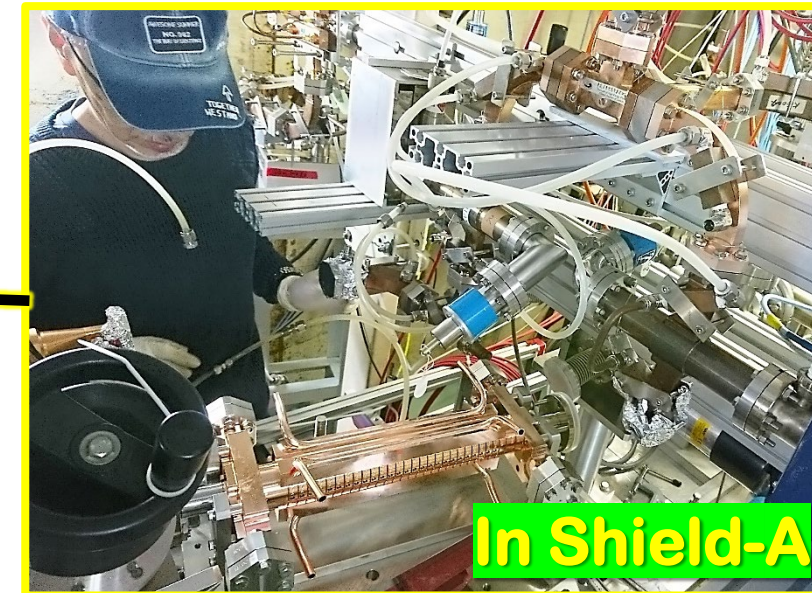
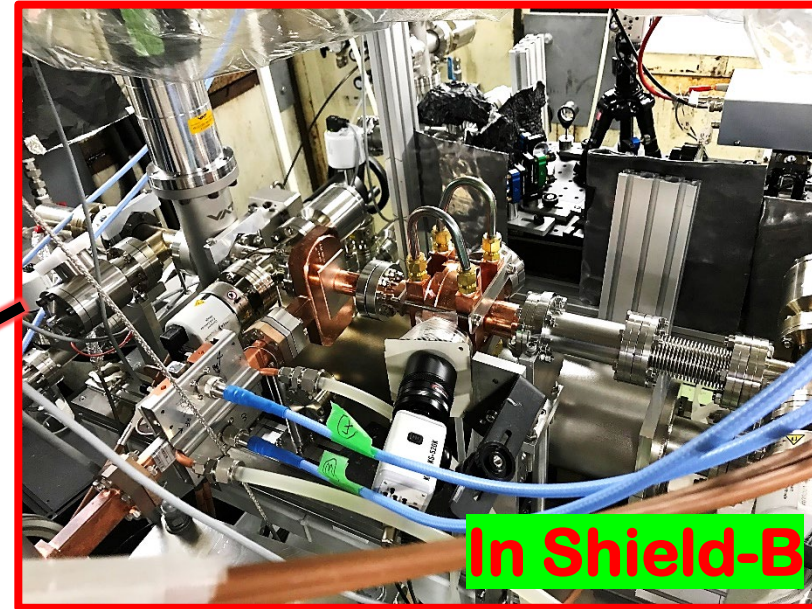
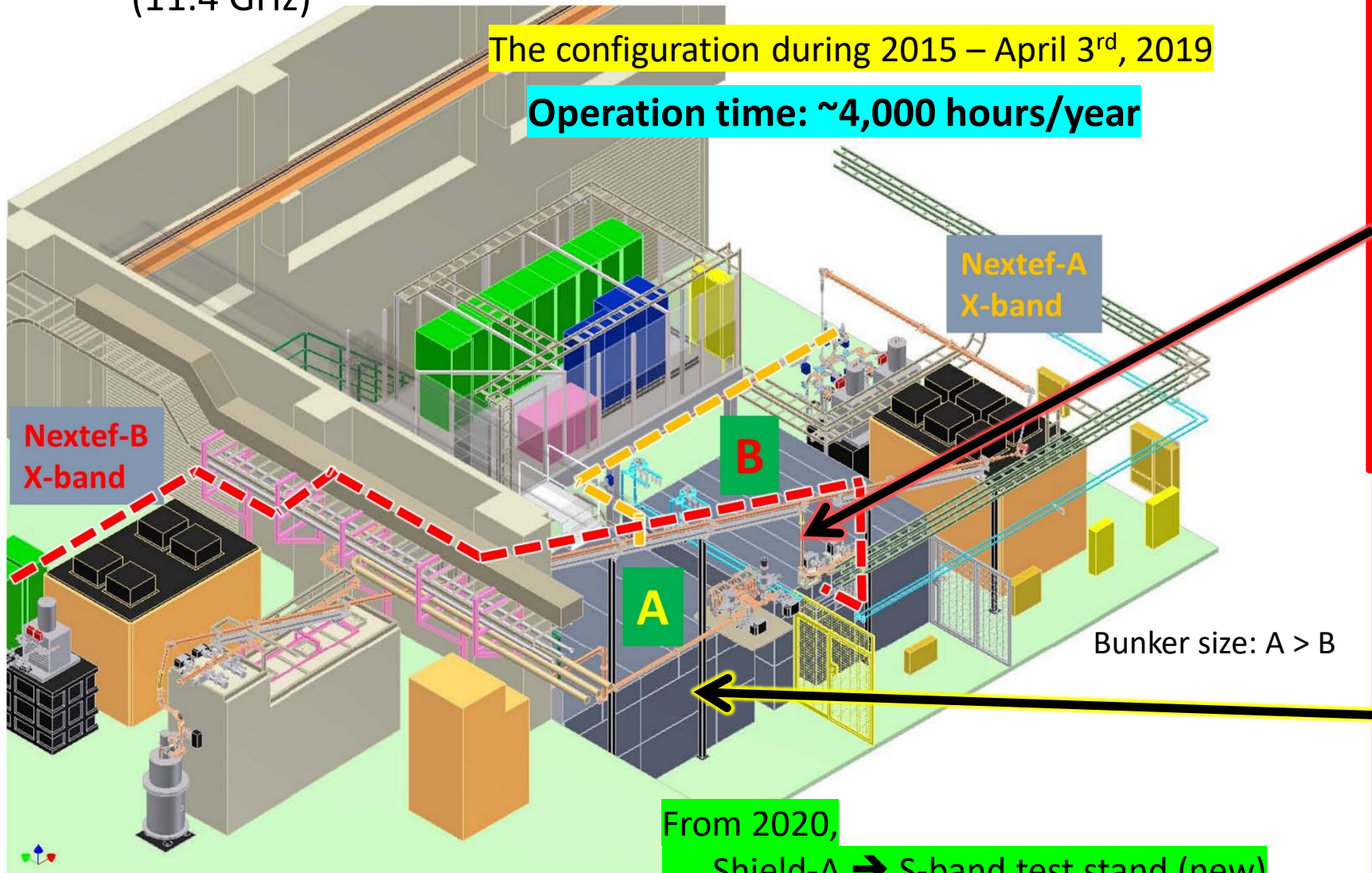
- Plans...

X-band HG test facility: Nextef (New X-band Test Facility)

(11.4 GHz)

The configuration during 2015 – April 3rd, 2019

Operation time: ~4,000 hours/year



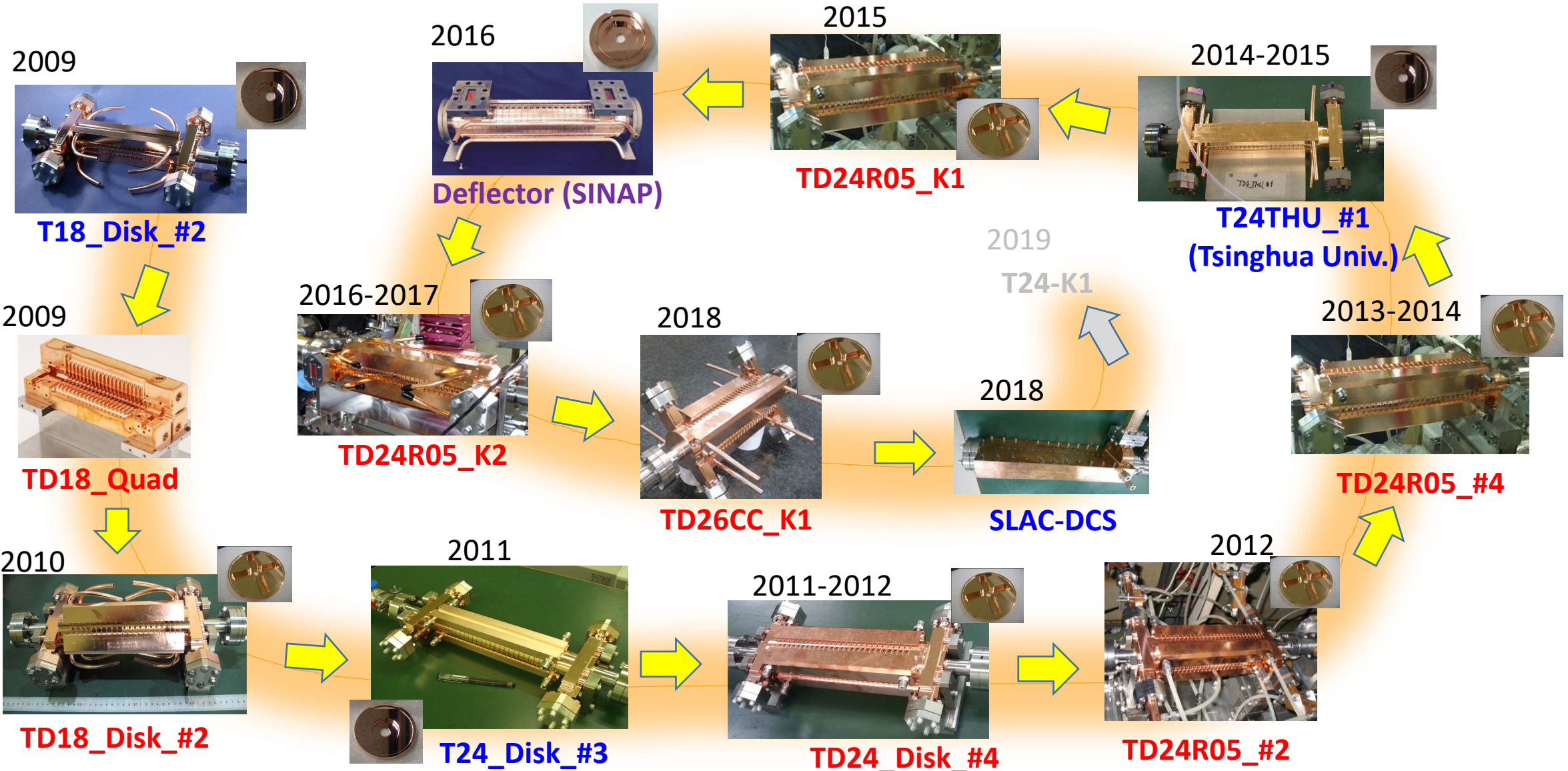
From 2020,

Shield-A → S-band test stand (new)

Shield-B → X-band test stand (renewed)

X-band accelerating structures tested at KEK/Nextef/ **Shield-A**

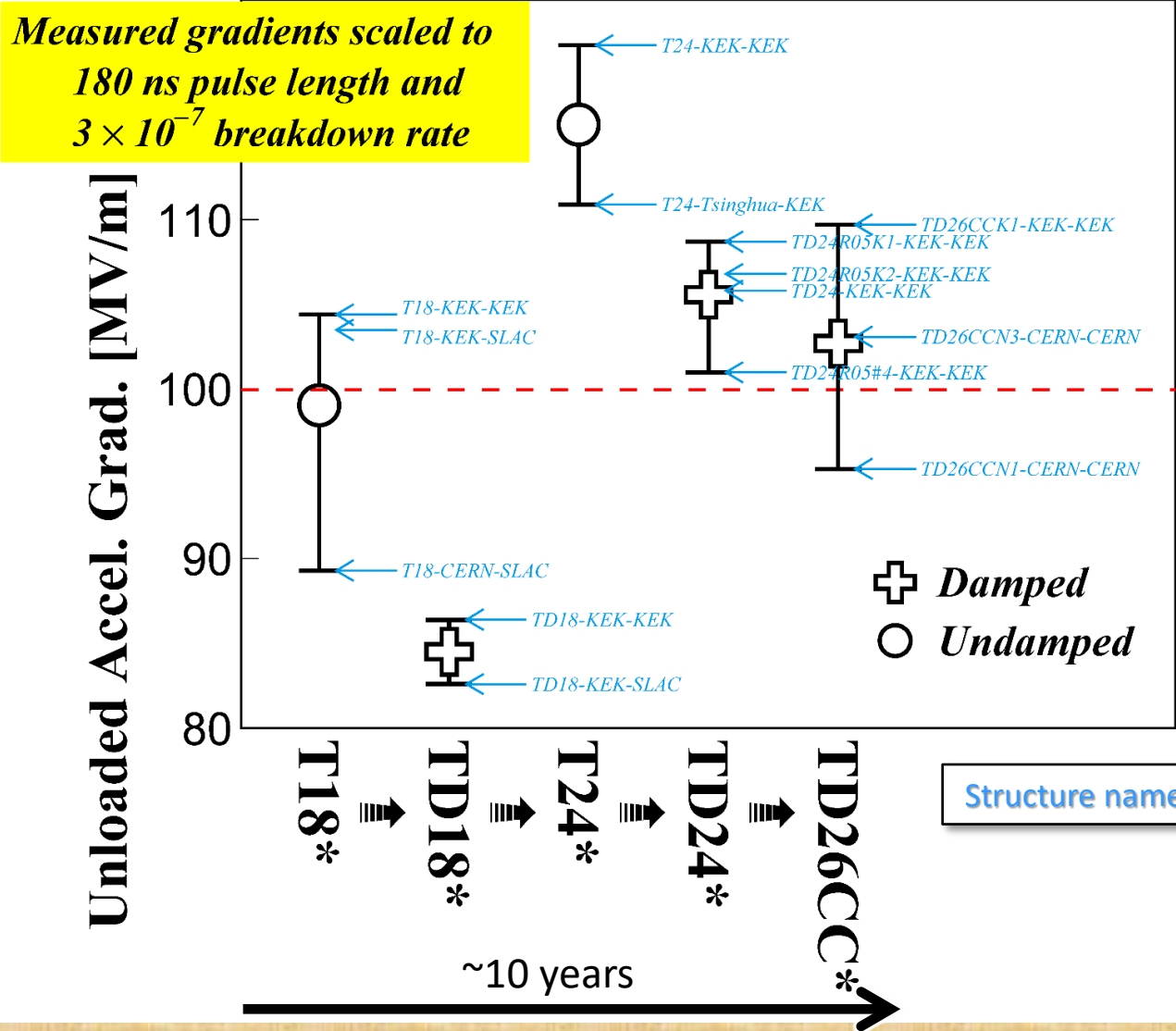
T18 → Quad → TD18 → T24 → TD24 → TD24R05 → TD24R05 → T24THU → TD24R05 → Deflector → TD24R05 → TD26CC → DCS → T24-K1 (terminated by fire)



History of Improvement of HG Performance of CLIC Prototype Structures

CLIC Prototype Structures

Data from Jan Paszkiewicz (CERN)
Compiled by T. Abe (KEK)



Significant result from Nextef / **Shield-B** from the HG test of the single-cell cavity with improved quads

The chamfer radius and small-gap size were optimized based on simulation to minimize

- A) Field enhancement at the corner of the quadrants ($\rightarrow +25\%$)
- B) Deterioration of the shunt impedance ($\rightarrow -2\%$)

For details, see [T. Abe et al., "Fabrication of Quadrant-Type X-Band Single-Cell Structure used for High Gradient Tests," presented at the 11th Annual Meeting of Particle Accelerator Society of Japan \(2014\), Paper ID: SUP042.](#)

[T. Abe et al., "High-Gradient Test Results on a Quadrant-Type X-Band Single-Cell Structure," presented at the 14th Annual Meeting of Particle Accelerator Society of Japan \(2017\), PaperID: WEP039.](#)

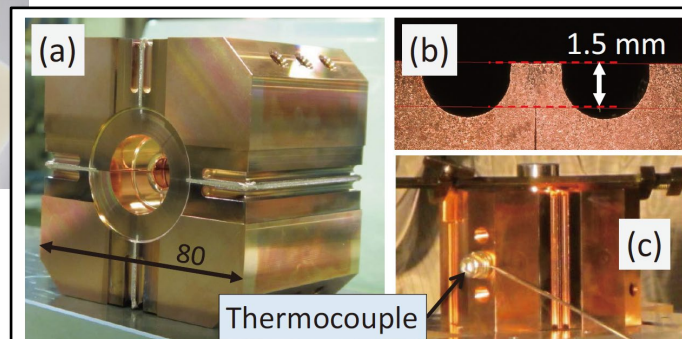
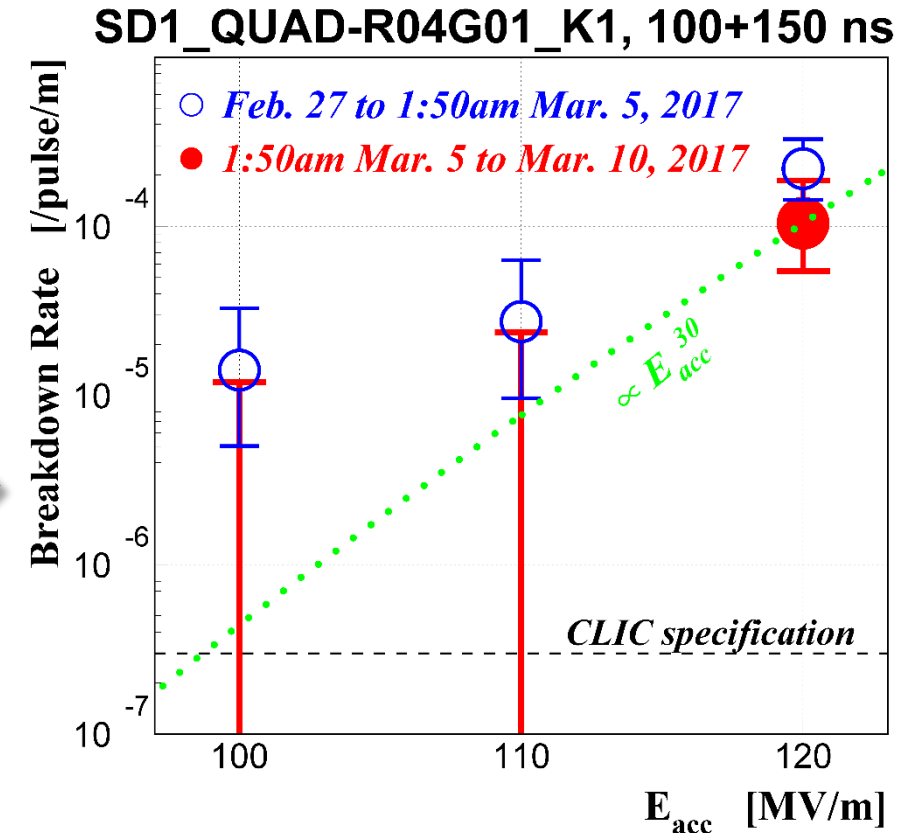
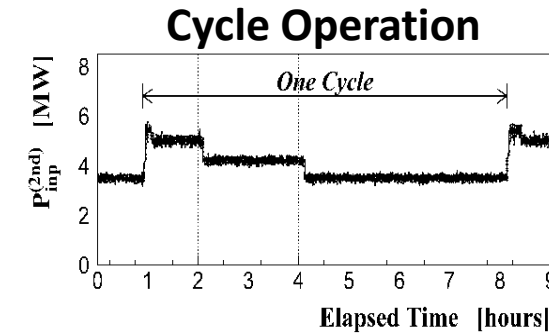
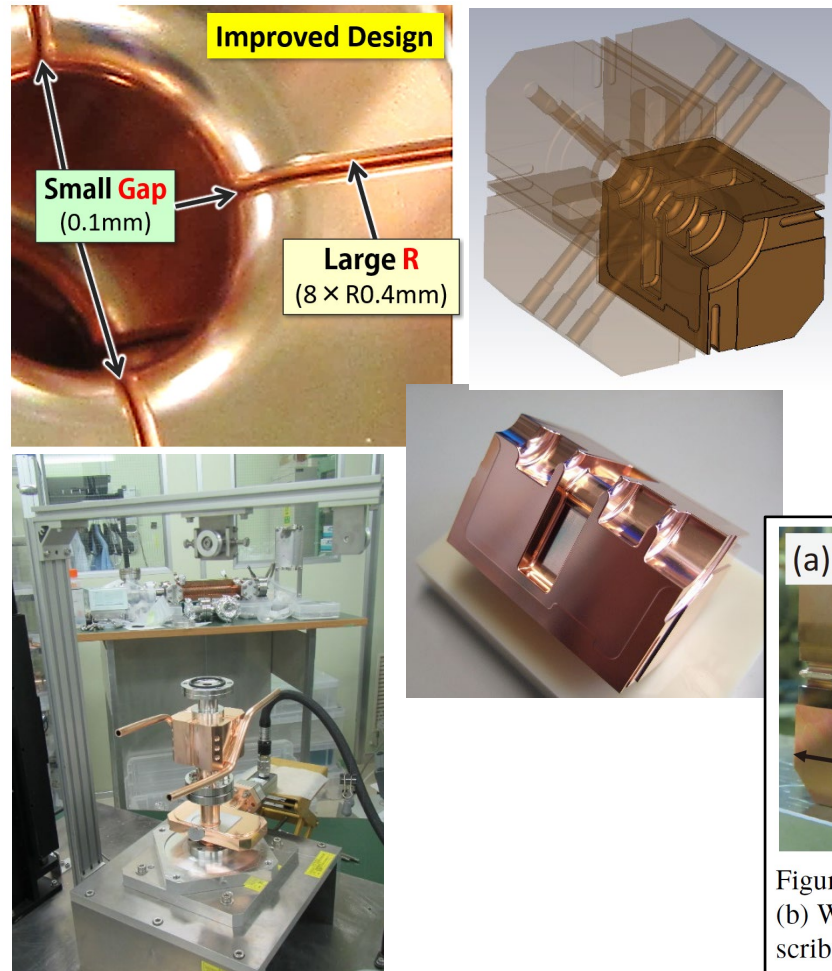
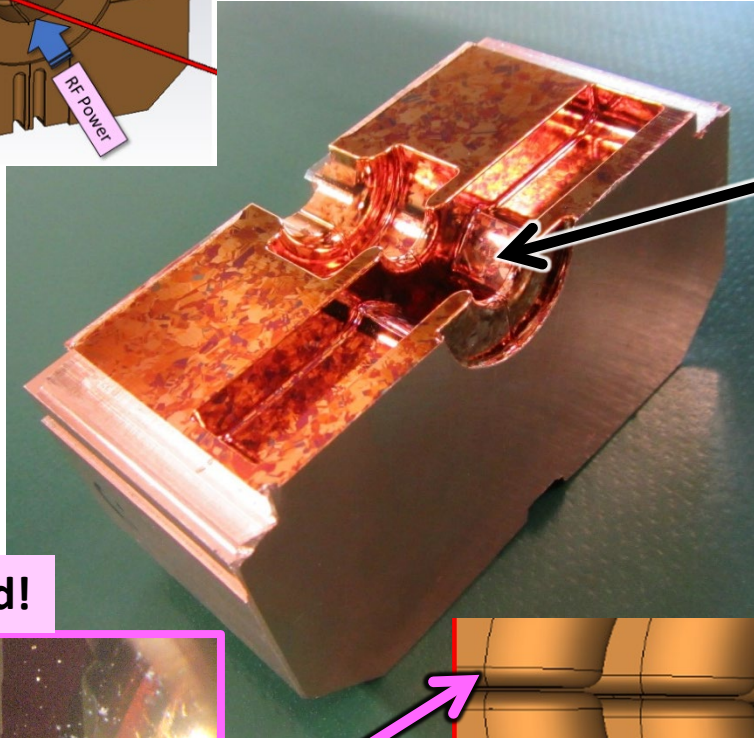
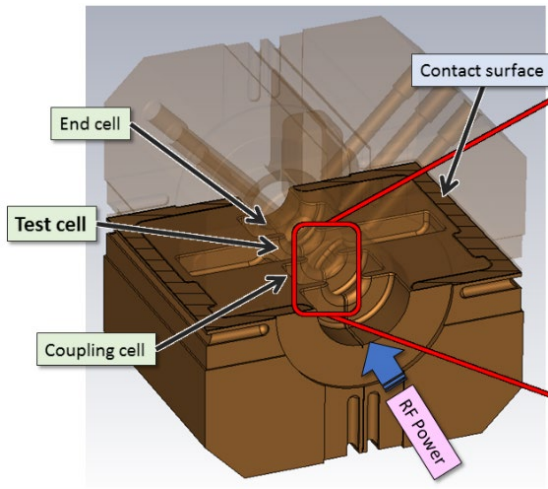


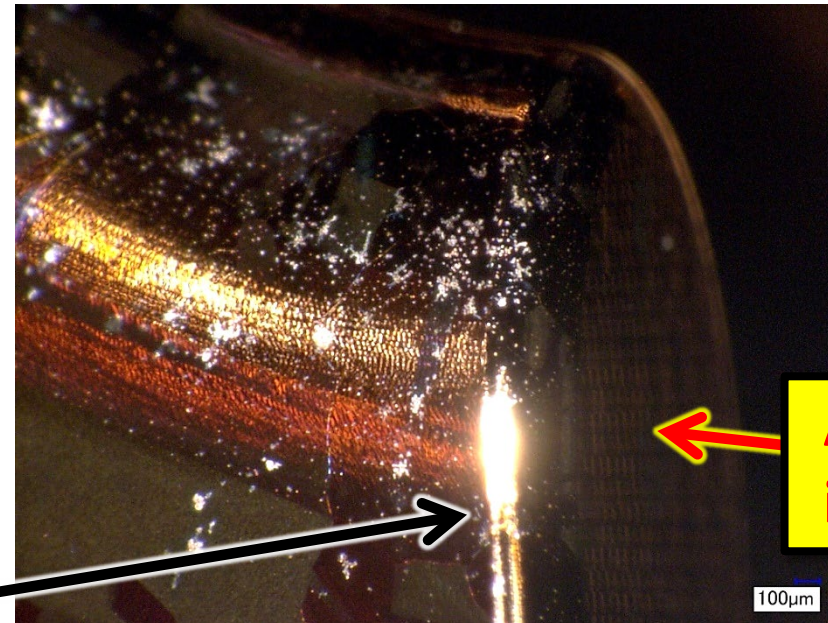
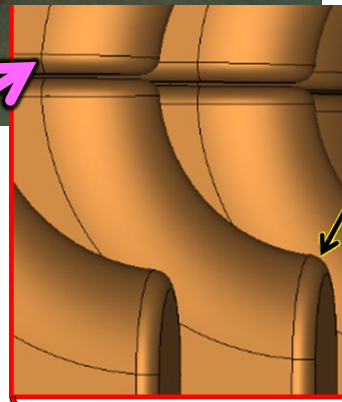
Figure 12: EBW of the quadrants. (a) After the EBW. (b) Welding penetration depth for the EBW conditions described in [13]. (c) A thermocouple is attached.

Good high-gradient performance demonstrated

Postmortem of SD1_QUAD-R04G01_K1



BD spots aligned!

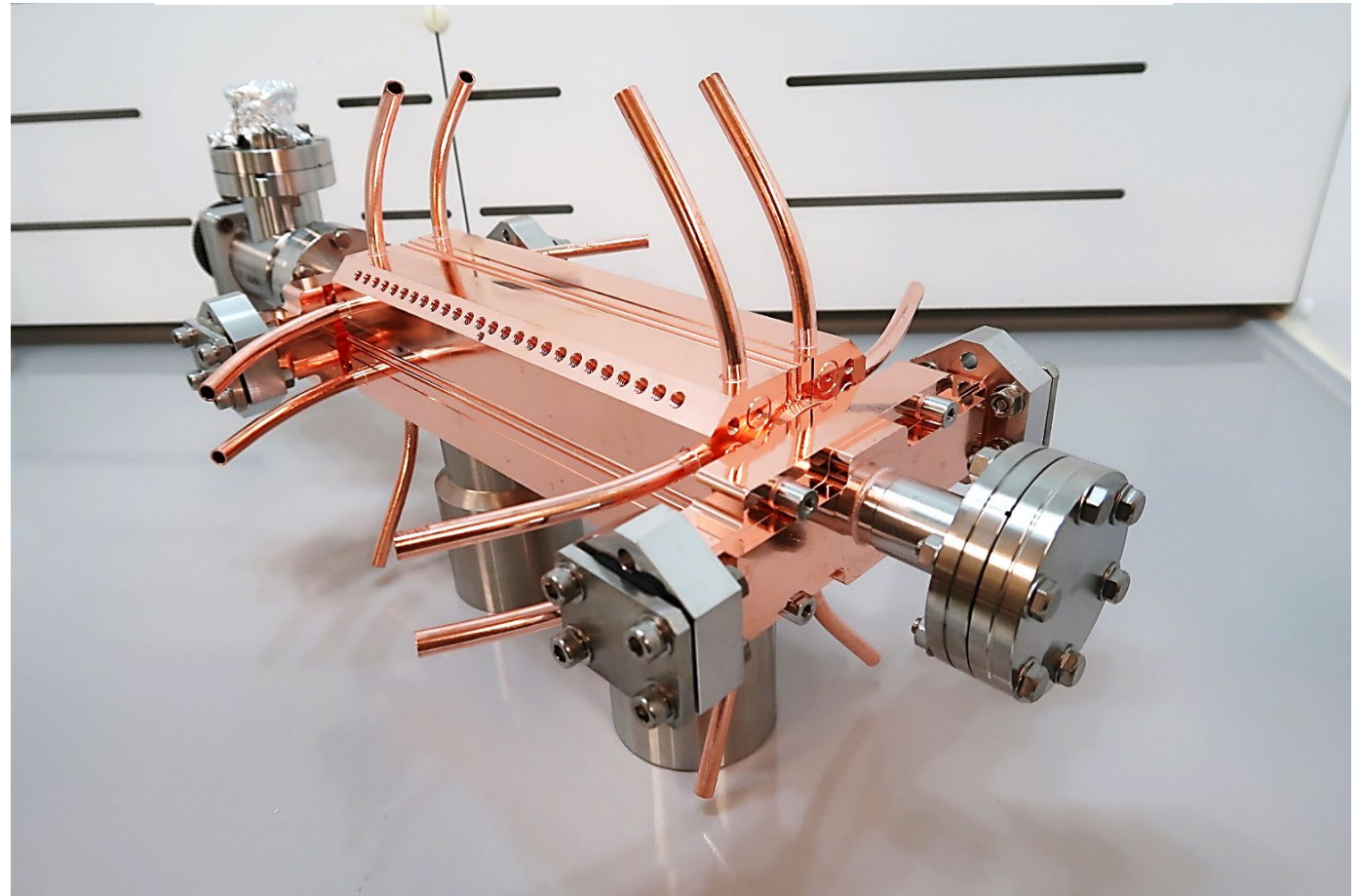
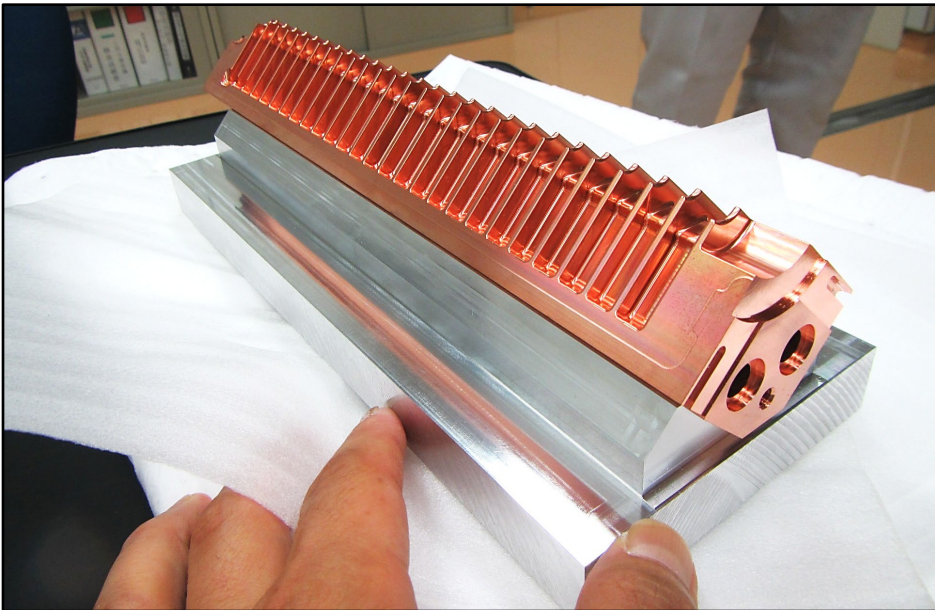
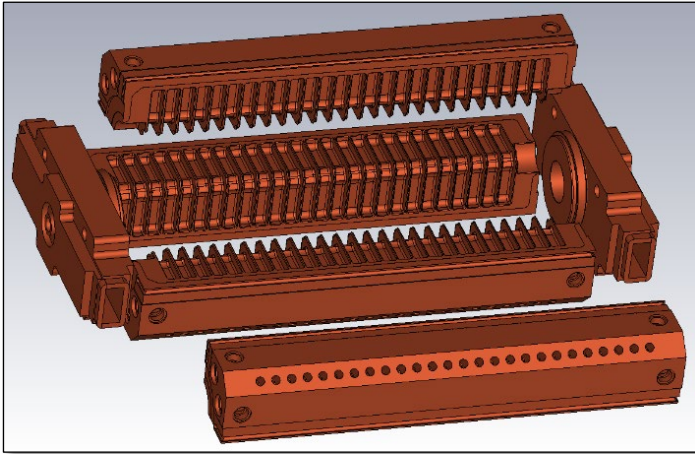


Almost no damage
in the 0.1-mm gap!

The small 0.1-mm gap successful!

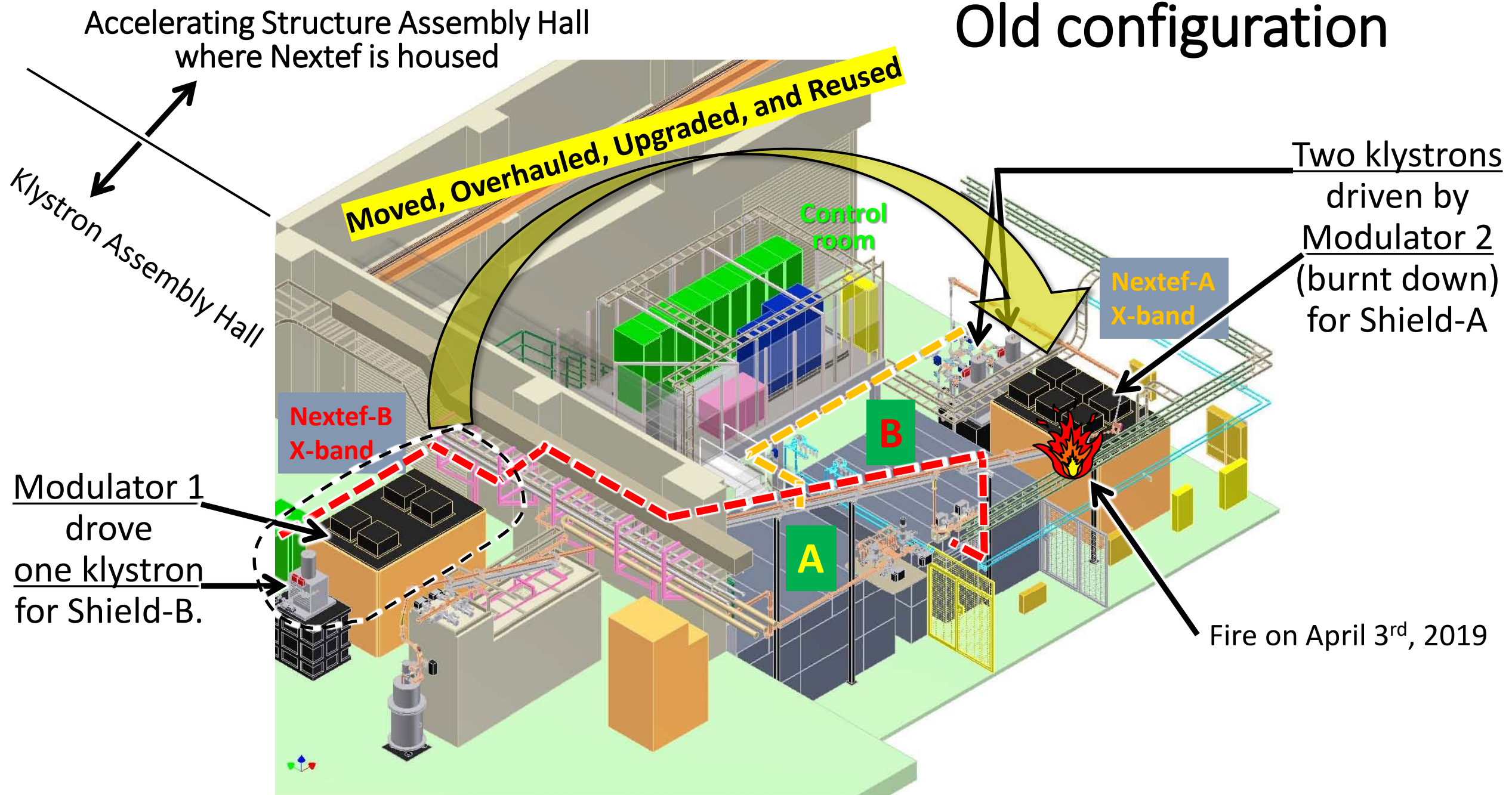
Multicell traveling-wave tube with improved quad.

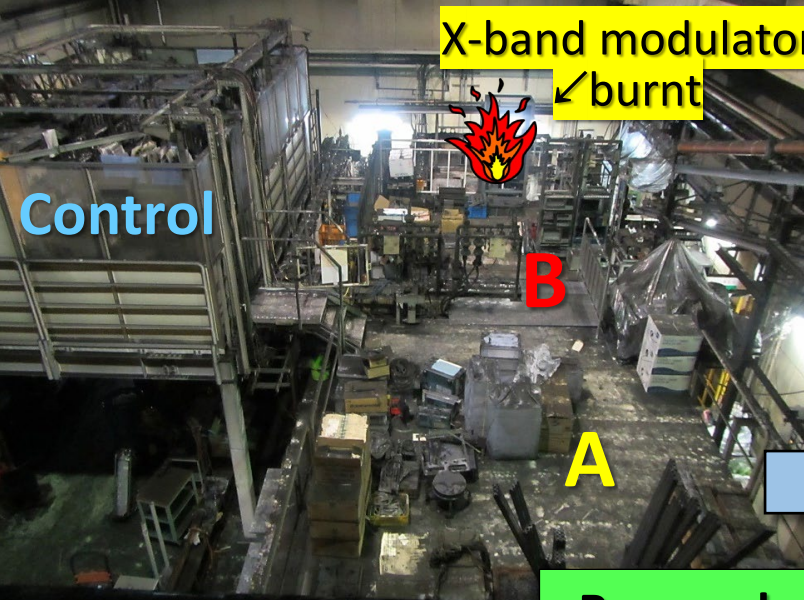
TD24R10_QUAD-R04G01_K1



To be HG tested at new Nextef / Shield-B ?

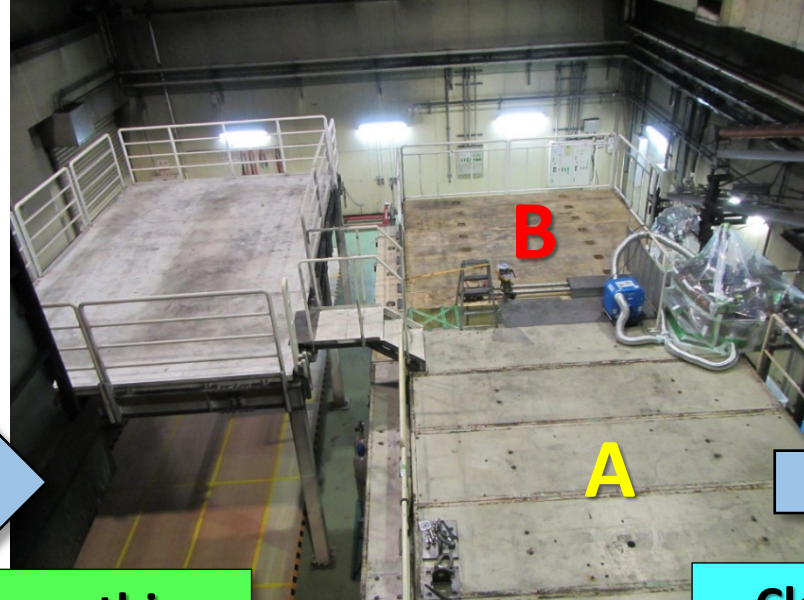
Old configuration





(April 2019,
immediately after the fire)

Removal of everything



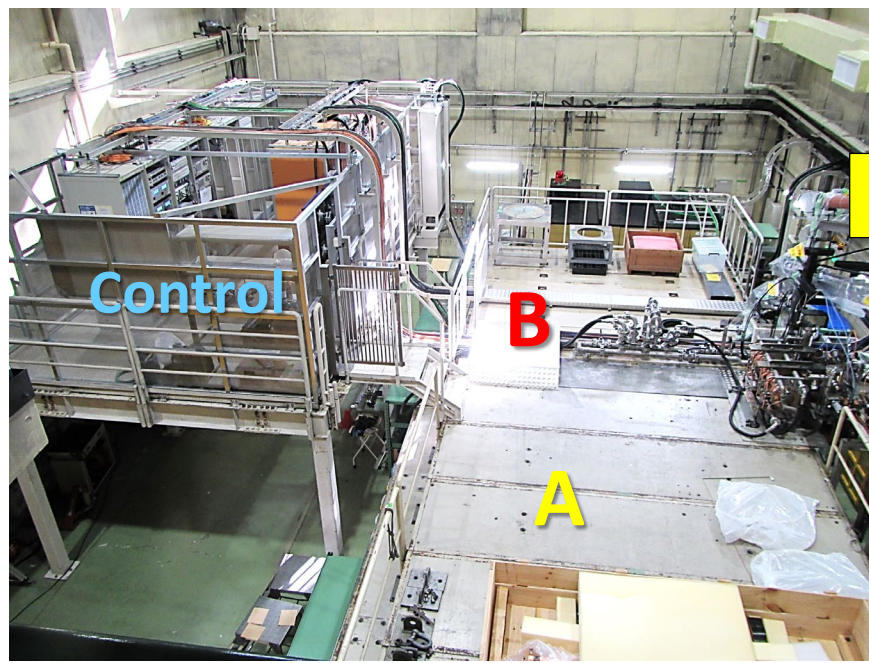
(June 2019)

Cleanup

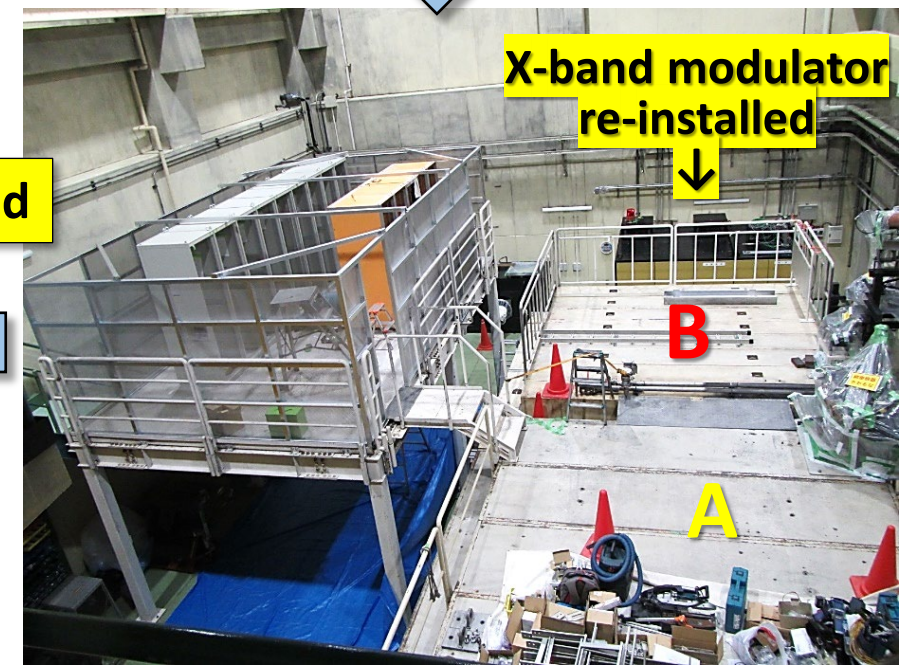


(January 2020)

(December 2020)

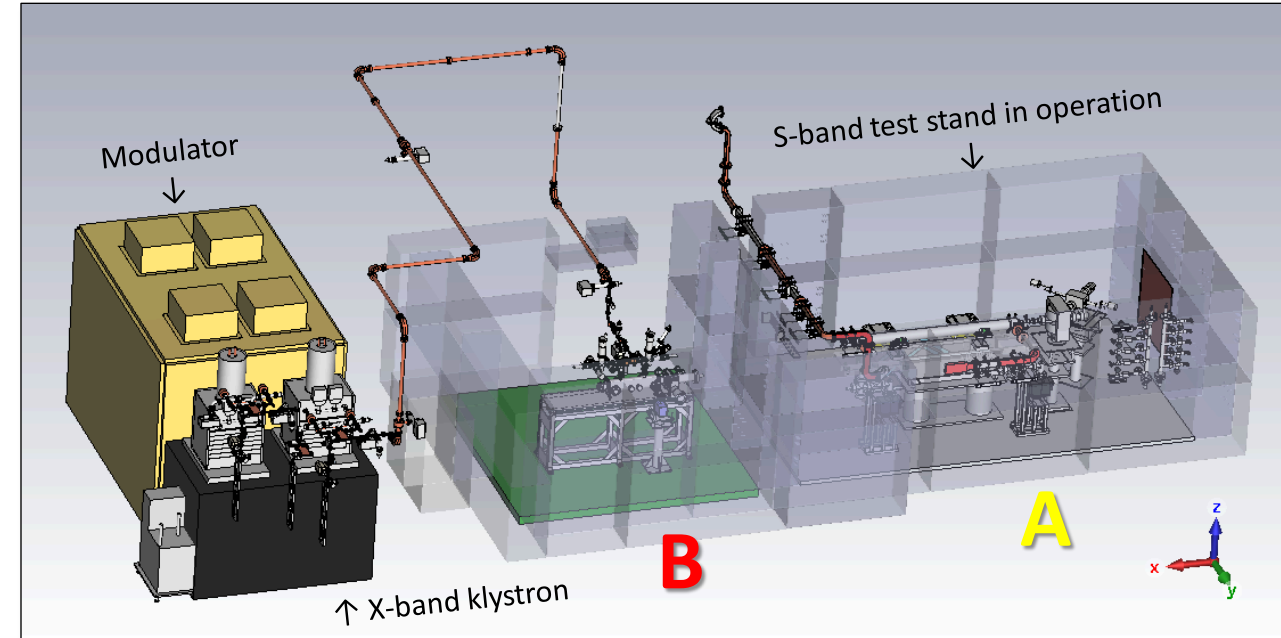
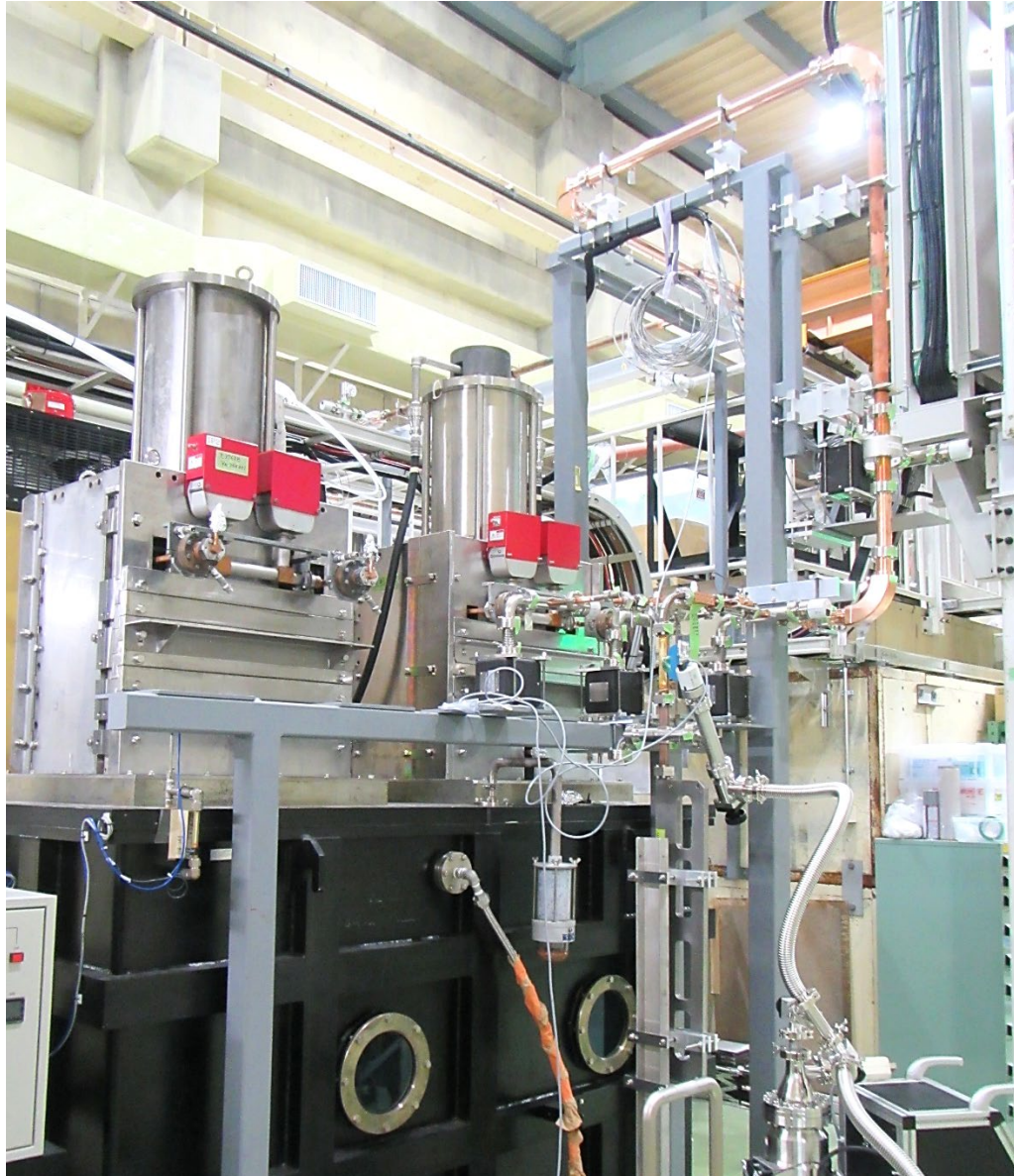


Reconstructed



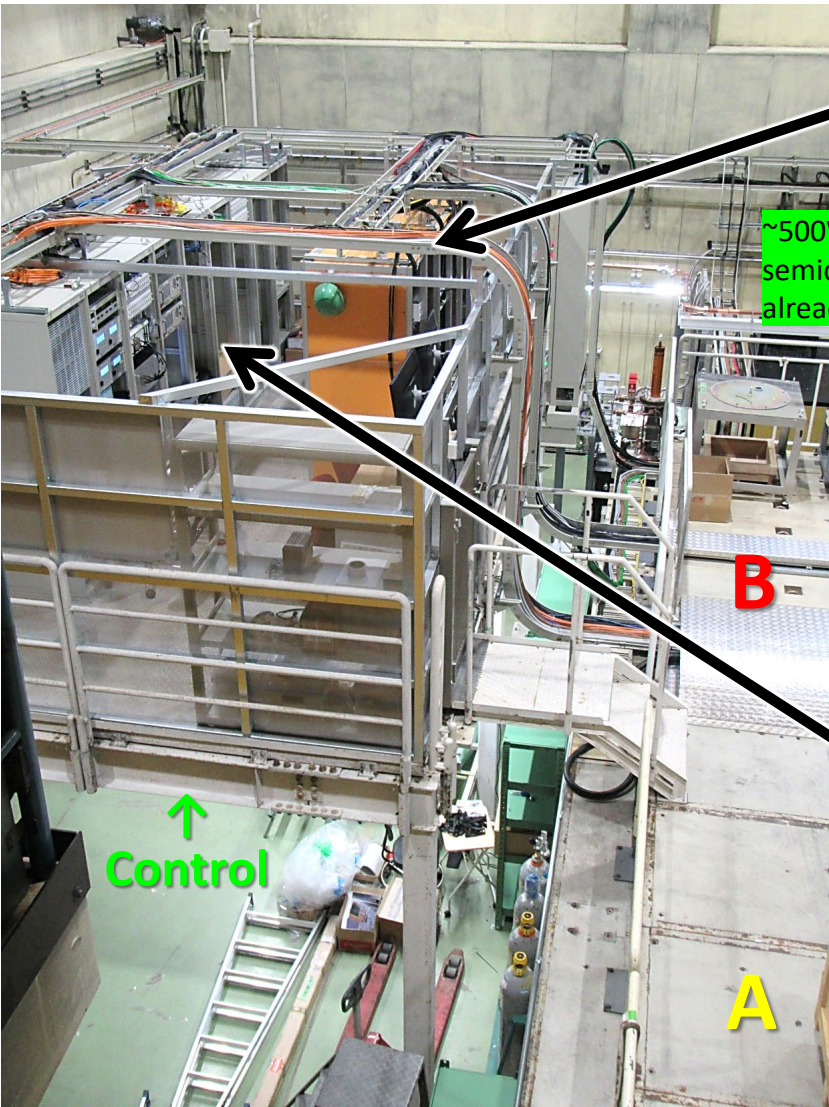
(February 2020)

High power line reconstruction completed

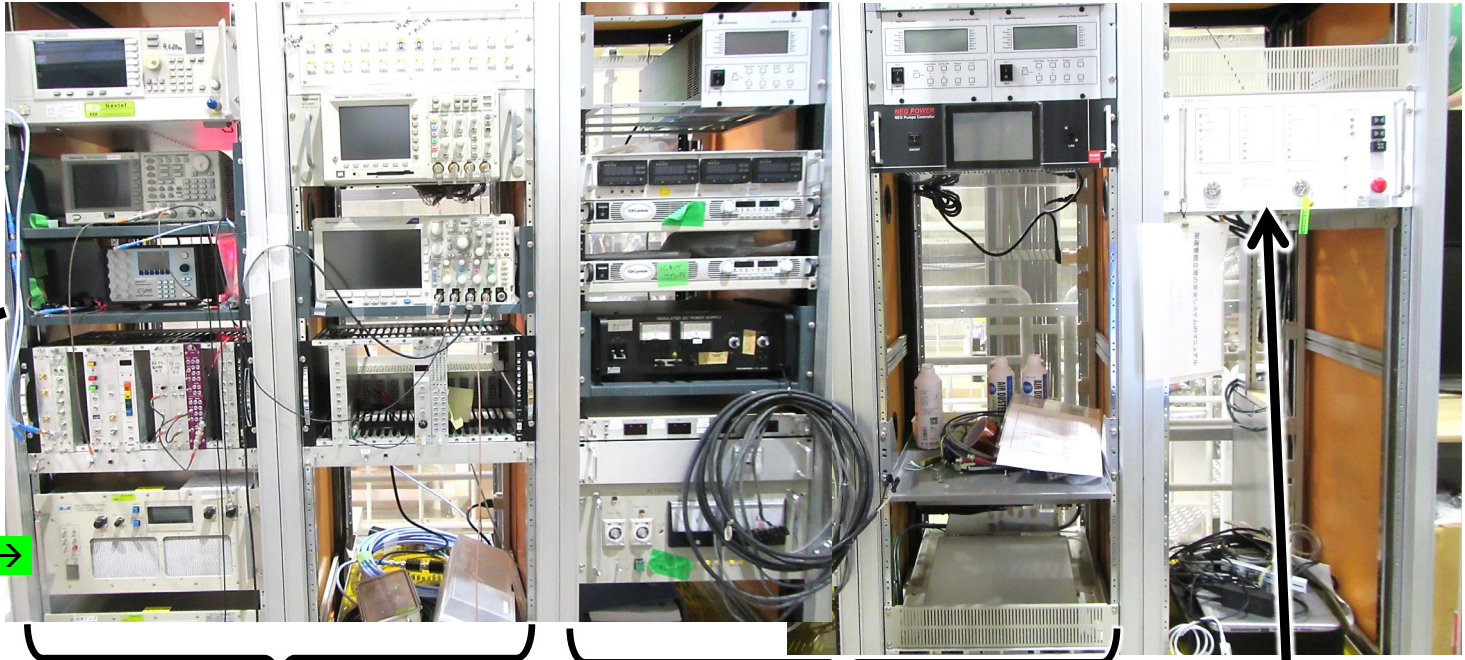


April 2021

Control and DAQ



~500W output from the semiconductor amp. already checked →



X-band LLRF

Power supplies
For Ips, vac. Gauges, kly.
Heaters, kly focus coils, etc.

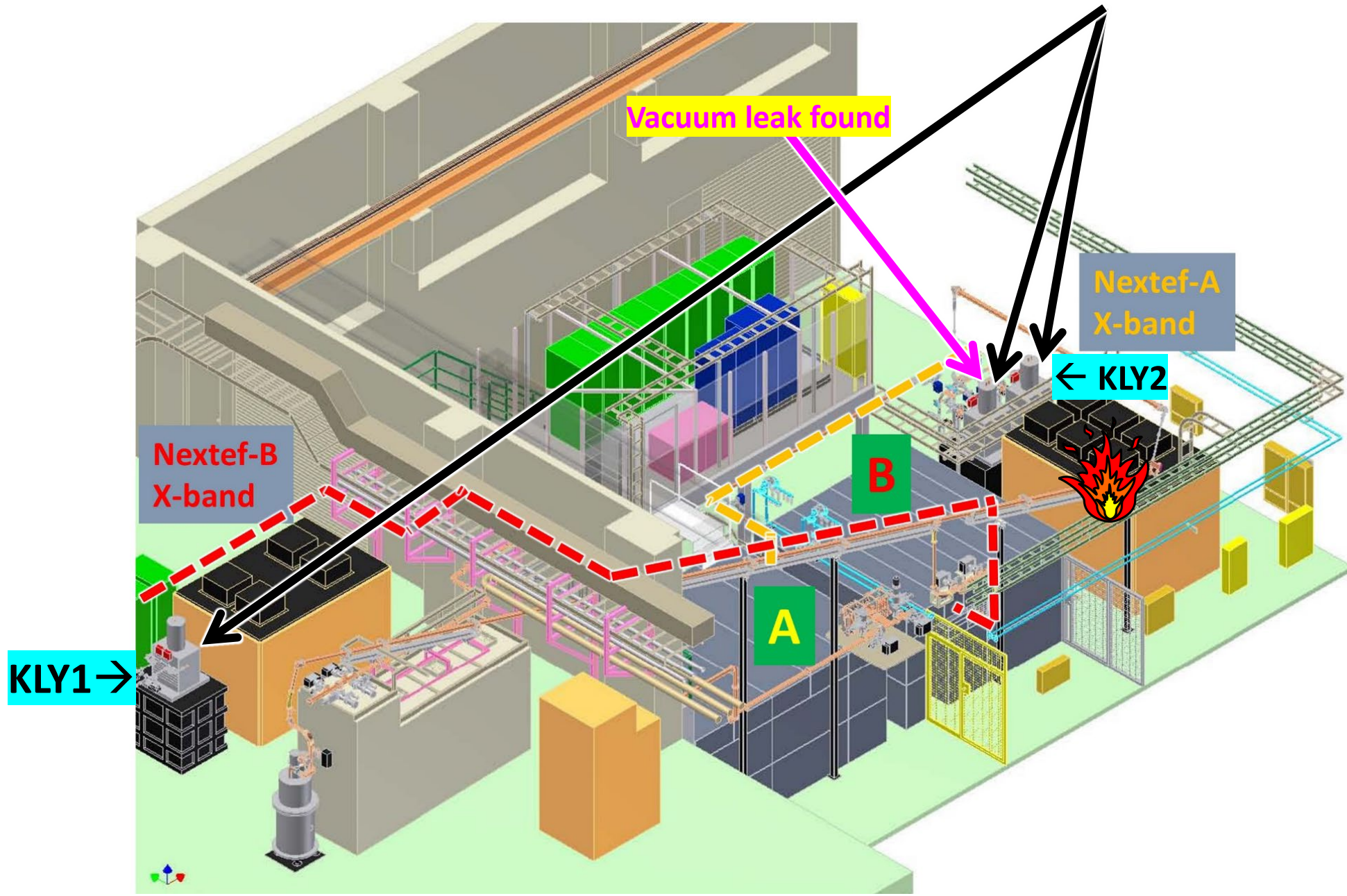
Rad. Safety System
in operation

DAQ for Shield-A

DAQ for Shield-B not yet installed

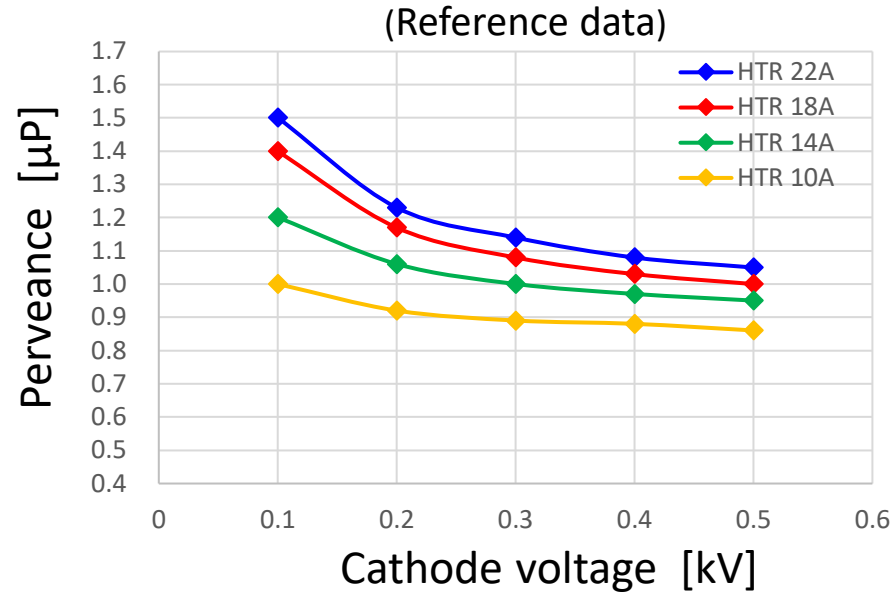
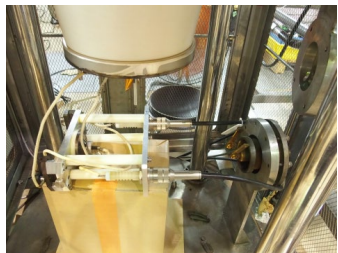
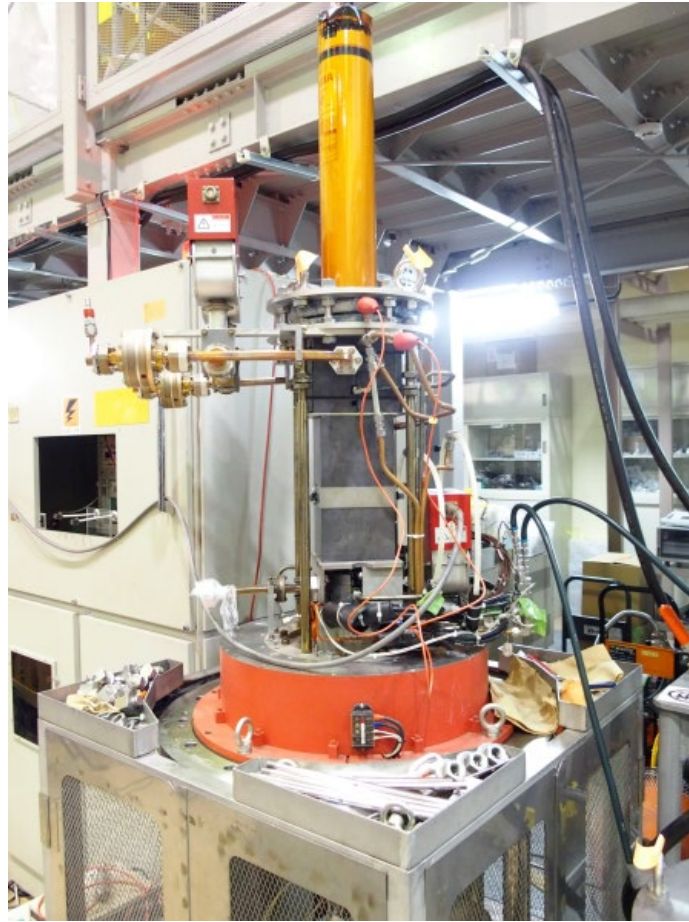


Three X-band klystron tubes from GLCTA



Low-voltage emission measurement for the two klystron tubes with no vacuum leak

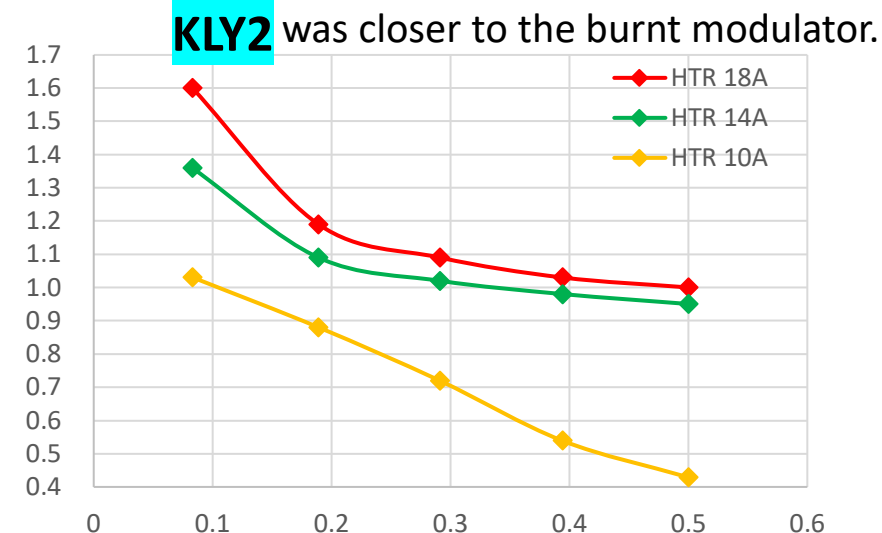
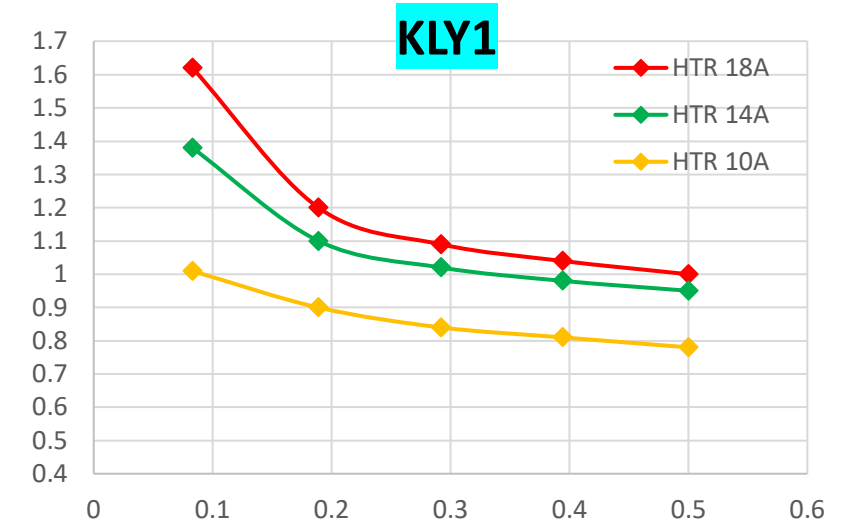
Test bench



- ✓ Both of the two tubes can be used for high-power operation.
- ✓ Significant deviation seen at the low HTR curr. or low cathode voltage

← Heater (HTR) (rated curr.: 18 A)

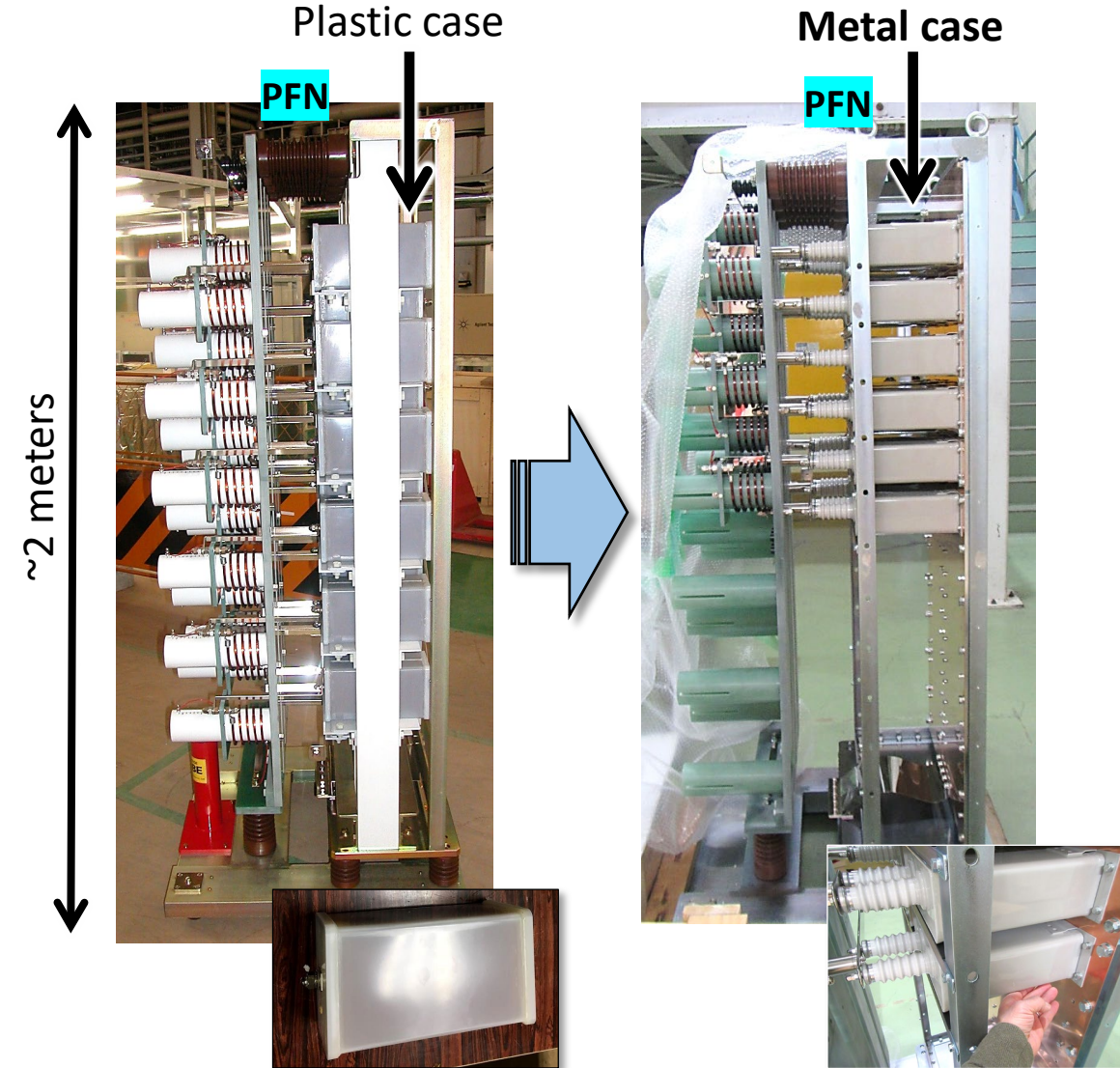
(Measured in January 2021)



Two significant changes on the modulator

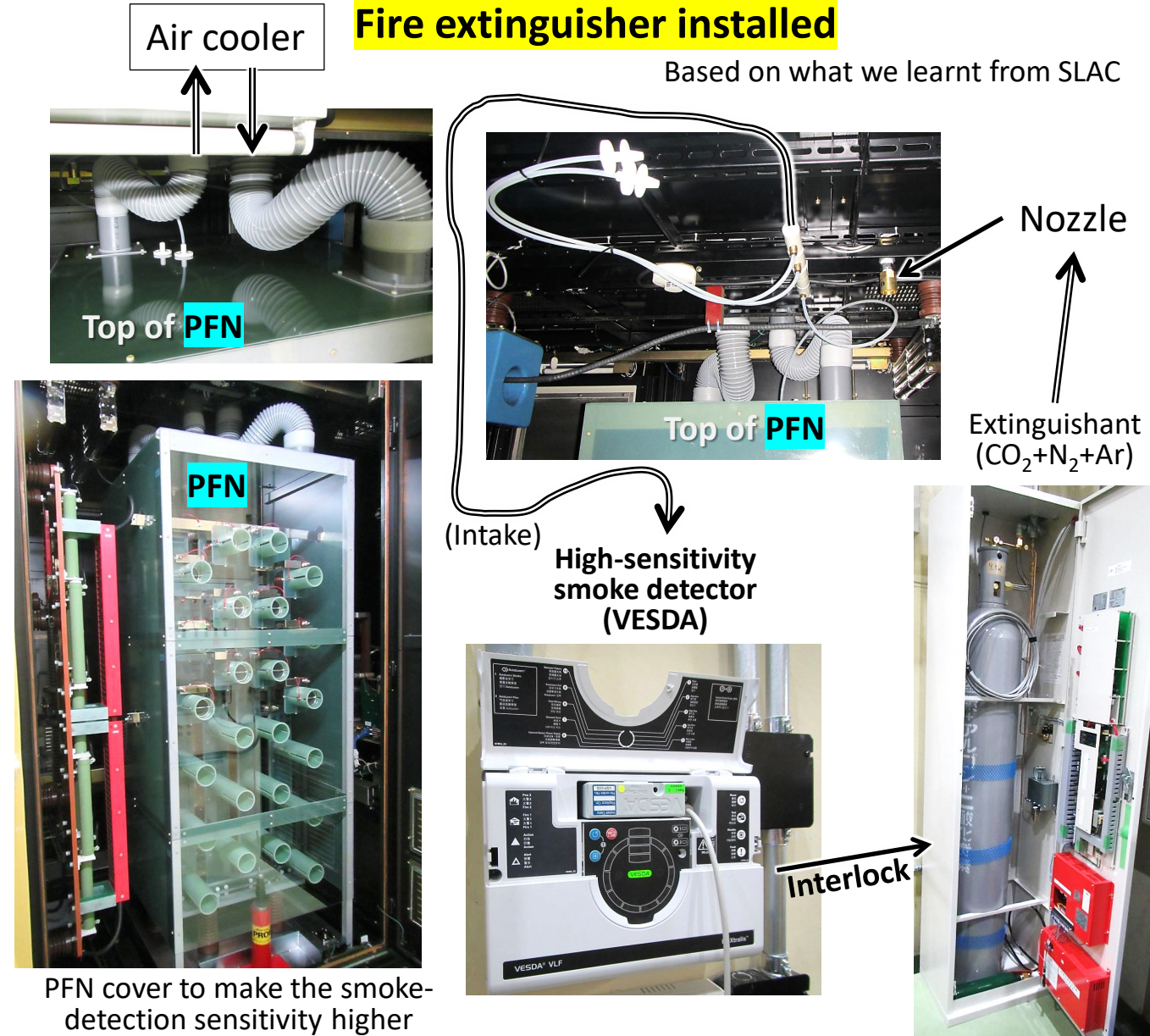
(PFN: Pulse Forming Network)

Capacitors replaced



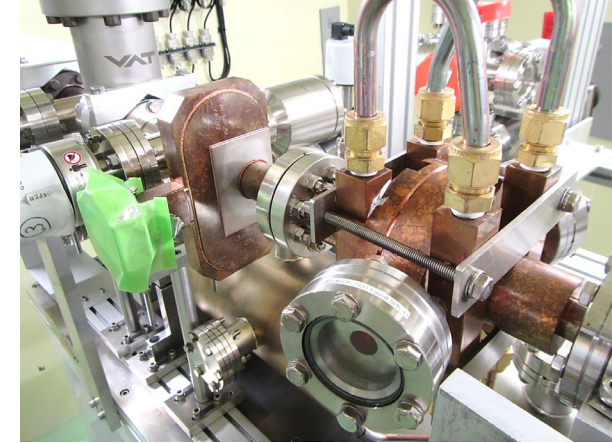
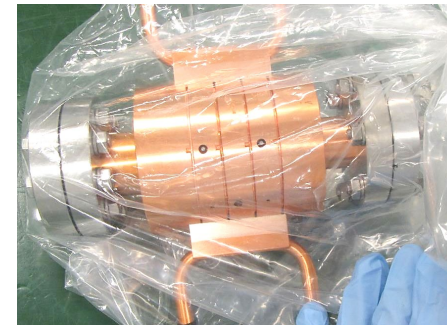
Fire extinguisher installed

Based on what we learnt from SLAC



Future plan

- Resume basic study using single-cell cavities
 - SLAC full-choke cavity (still in Shield-B)
 - Brazed cavities, all-milling, large-grain, ...



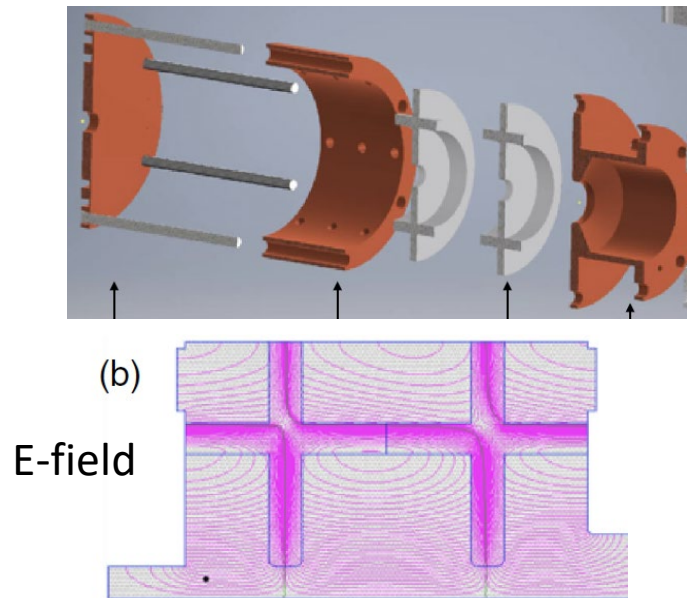
- Development of cutting-edge accelerating structures
 - E.g. X-band dielectric assist accelerating structure (next page)

Dielectric-assist accelerating test structure

for X-band (11.4 GHz)

- $\sim 10 \times Q_0^{(conventional)}$
- Developed with C-band structures so far at KEK

- ✓ Ready for low-power RF meas.
- ✓ To be HG tested at new Nextef / Shield-B



Figures excerpted from
[Shingo Mori, Mitsuhiro Yoshida, and Daisuke Satoh,](#)
["Multipactor suppression in dielectric-assist accelerating structures via diamondlike carbon coatings",](#)
[Phys. Rev. Accel. Beams 24, 022001 – Published 12 February 2021](#)

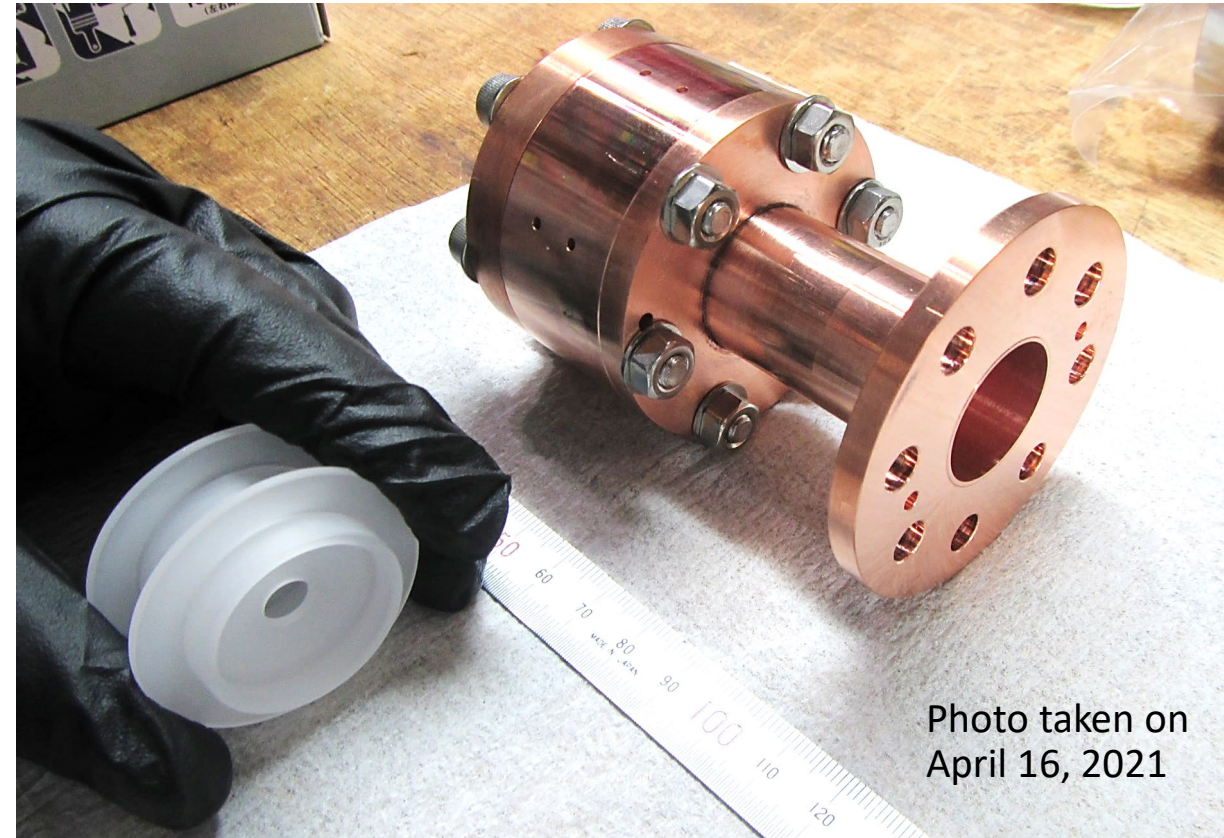


Photo taken on
April 16, 2021

Courtesy of Mitsuhiro Yoshida (KEK)

Summary

- We performed many HG tests at Nextef / Shield-A&B.
- The serious fire on April 3rd 2019 terminated old Nextef.
- We will start high-power test operation at new Nextef around June 2021.



Thank you for your attention!