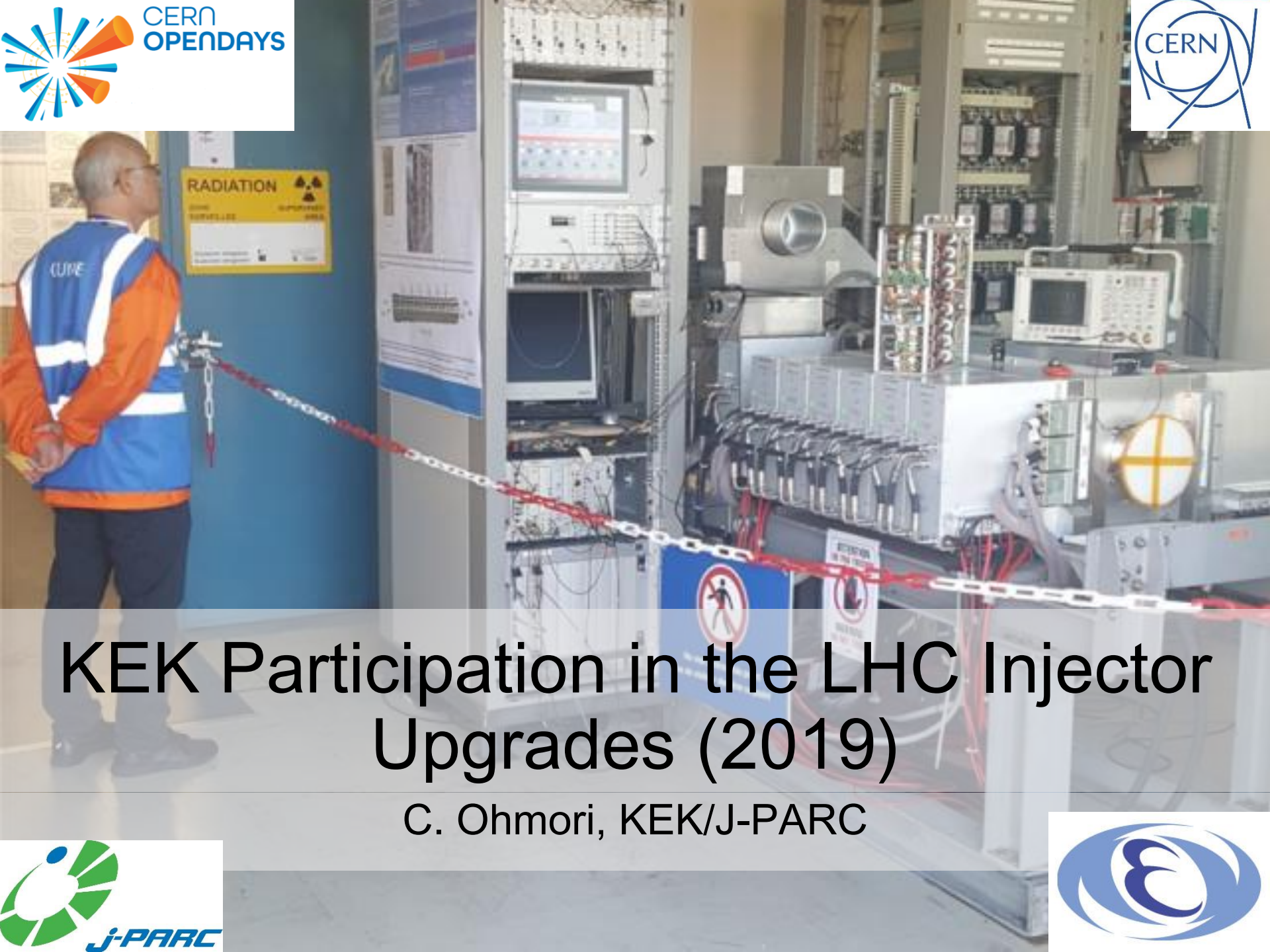


KEK Participation in the LHC Injector Upgrades (2019)

C. Ohmori, KEK/J-PARC

Contents

- LIU(LHC Injector Upgrade)
- Booster RF
  - Cavity
  - Rad-Hard Solid-State AMP
- PS Damper RF
- Contribution to Society
- To do
- Summary

Injectors(Linac4,PSBooster,PS,SPS)

A quick overview on the LIU project

LHC Injectors Upgrade

- Main **RF** system (200 MHz) upgrade → Increased RF power and improved controls
- Longitudinal **impedance** reduction & partial a-C coating → Increased instability thresholds
- New **beam dump** and protection devices

- **160 MeV** H^- charge exchange injection → Reduced space charge at PSB injection
- Acceleration to **2 GeV** with new main power supply and new RF systems - KEK/J-PARC Japanese Contribution

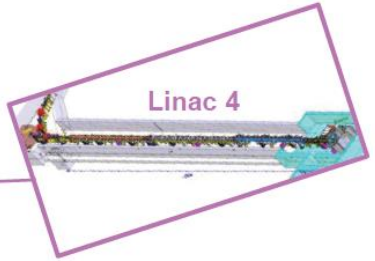
Super Proton Synchrotron (SPS)
C = 6.9 km
E_{kin}^{out} = 450 GeV

- **2 GeV** injection → Reduced space charge at PS injection
- New **RF** equipment including broad-band feedback → Increased instability threshold

- Acceleration of H^- to **160 MeV**
- Target 25 mA within 0.3 μm

PS-Booster (PSB)
4 rings of C =157 m
E_{kin}^{out} = 2.0 GeV

Proton Synchrotron (PS)
C = 628 m
E_{kin}^{out} = 25 GeV

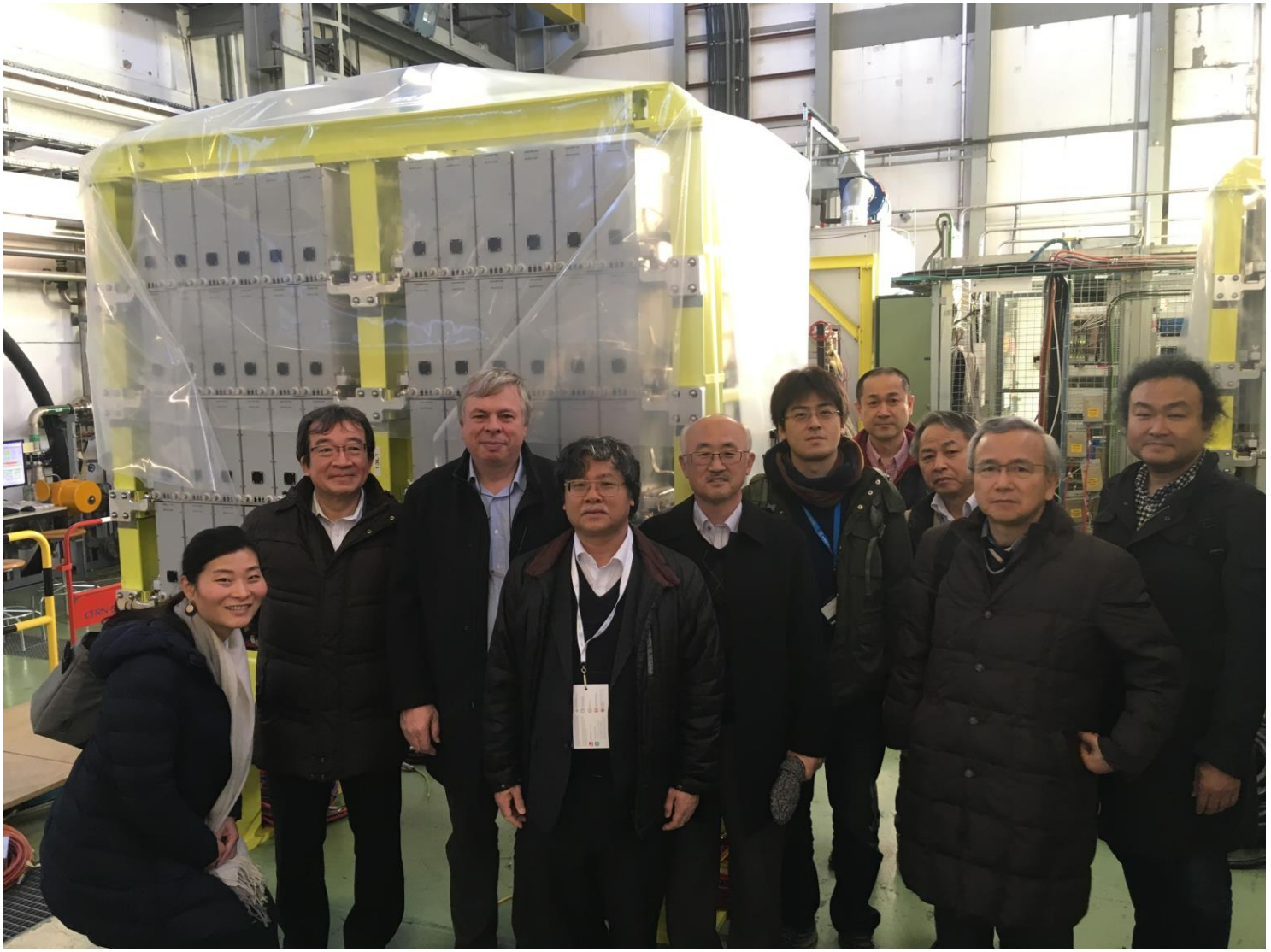


Linac 4
E_{kin}^{out} = 160 MeV

Linac 2
E_{kin}^{out} = 50 MeV

23/05/2019 IPAC, Melbourne, 19-24 May 2019 Malika Meddahi 10

PS Booster New RF systems



PS Booster New RF systems

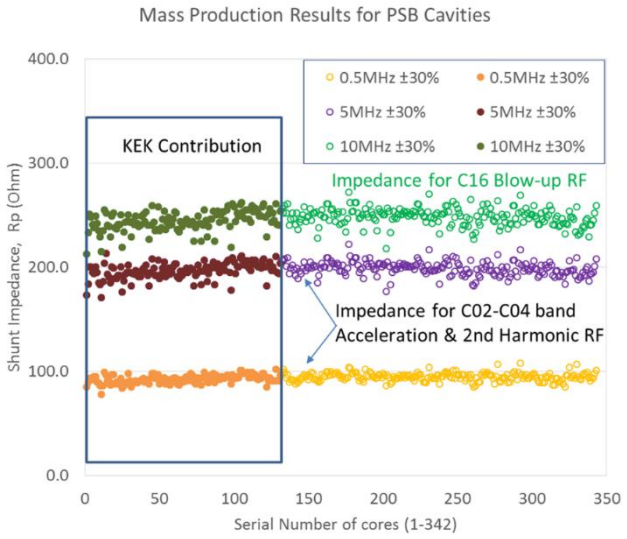
- **New RF systems were installed !**

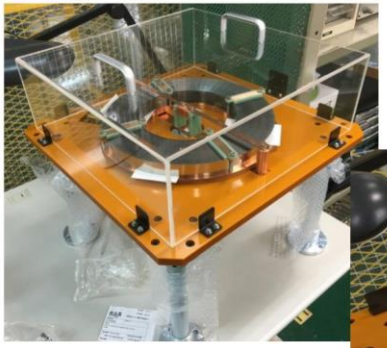
https://home.cern/news/news/accelerators/ls2-report-new-components-installed-ps-booster

Please see cavity in OPEN DAYS video (~8min.)
https://www.youtube.com/watch?time_continue=4640&v=U3vutvLlo-8

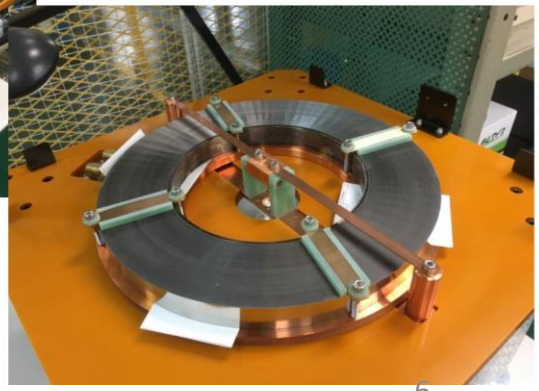
Contributions

- High impedance core by J-PARC-made Magnetic-annealing oven
- Contribution to mass production from ATLAS-Japan
- Quality check
- Beam loading Test at J-PARC in 2013
- Rad-Hard SSA developments





Power test of core at company



Rad-Hard Solid-State AMP

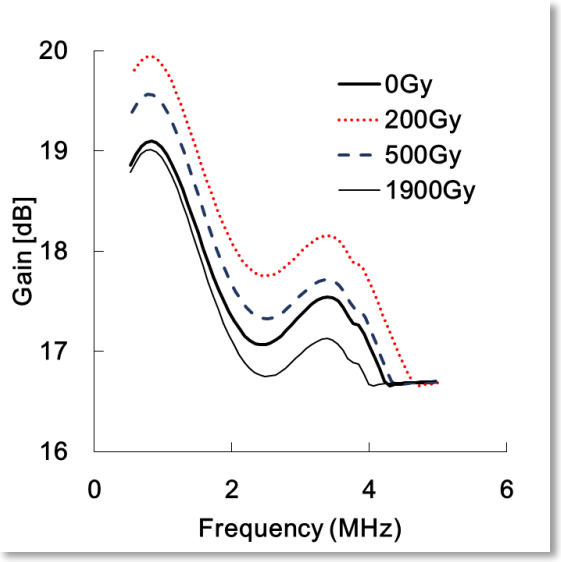
- **Mitigation of Radiation effects was applied.**
  - So far, gain variation is ~1 dB up to ~2 kGy in mixed field and 8.8 kGy by Co60 !
    - 2 kGy means 100 years in PSB RF areas !
      - Results are published in IEEE TNS.

2188 IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 66, NO. 10, OCTOBER 2019

Development of Radiation-Hard Solid-State Amplifiers for Kilogray Environments Using COTS Components

Chihiro Ohmori and Mauro Paoluzzi

DOI:10.1109/tns.2019.2937603



Rad-Hard Solid-State AMP

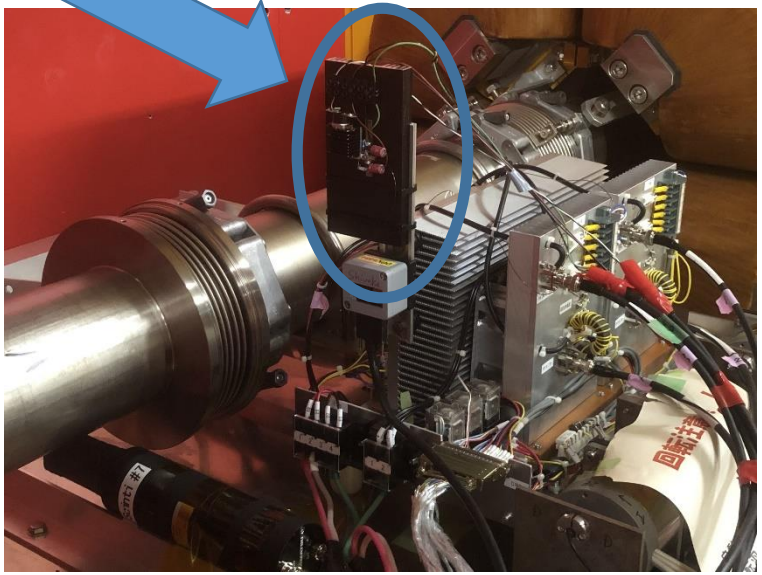
- **PS feedback AMPs in 1k Gy/year environment to improve feedback gain.**
  - **Si-MOSFET**
  - **New! GaN**

GaN Process Space Qualification Activities

Radiation Hardness

Activity	Description	Status
Total Ionizing Dose	Goal to Operate without radiation induced failures in a gamma radiation environment of a least 10^6 rads.	Complete
Total Ionizing Dose Testing	GaN25 has been subjected to Ionizing (Co-60) gamma radiation testing using the T1G4003532-FL GaN devices. These devices were subjected to Cobalt-60 radiation at doses ranging from 10 kRad to 500 kRad under bias conditions corresponding to normal amplifier operation. No significant changes were observed. Testing passed. 500kRads is the equivalent of 11.9 years at GPS orbit.	Testing completed by a lead customer/partner.
Proton Radiation Testing	2MeV Proton radiation testing of 2x50um GaN15 test FET structures was conducted by customer/partner to evaluate displacement damage effects. The fluence schedule ranged from $1x10^{12}$ to $6x10^{14}$ H^+/cm^2 and was designed to induce clear degradation in the DC FET characteristics. The onset of degradation occurred at ~$1x10^{14}$ $H+/cm^2$, approximately the equivalent of 1,000 years in low earth orbit.	Testing completed by a lead customer/partner.
Heavy Ion Testing (SEE)	Customer performed heavy Ion radiation testing on the TGA2214 (GaN15) at Vd = 22v & 28V with the following ions: Ar, Cu, Kr and Xe. The result showed this part does not latch under any pulsed exposure up to and including the heaviest ion of Xe (LET = 58.8 MeV/cm/g/cm^3) An enhanced RF power condition of Pin ~ +17 dBm was also tested and no latch-up occurred. Temporary current changes occurred most significantly at the highest ion level of Xe pulse. Nevertheless the post radiation testing showed no permanent performance change on any device.	Testing completed by a lead customer/partner.

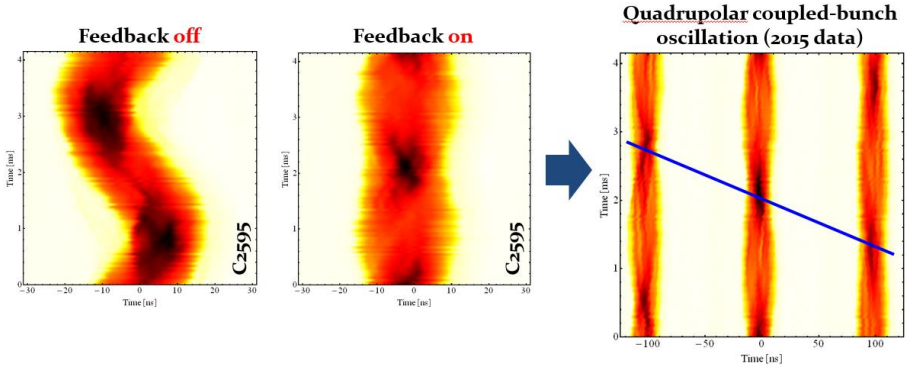
So far ~2kGy was irradiated. GaN seems very stable without active compensation.



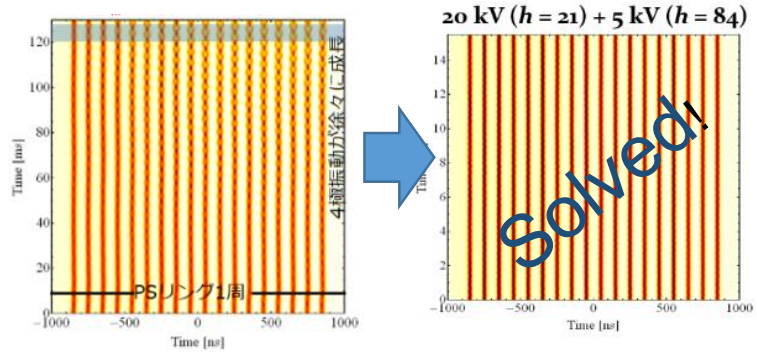
Collimator section in the J-PARC Main Ring is used for irradiation test.

PS Damper system

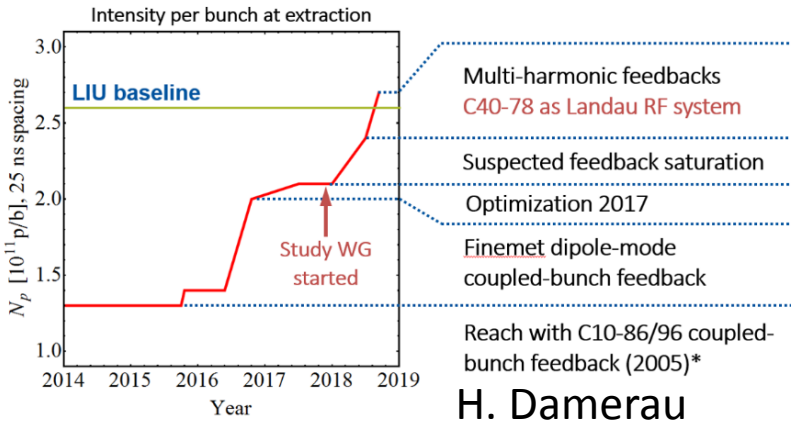
- Suffered by longitudinal coupled bunch instability.
- **HL-LHC needs 2.6 x 10^{11} ppb**



Damper Cavity



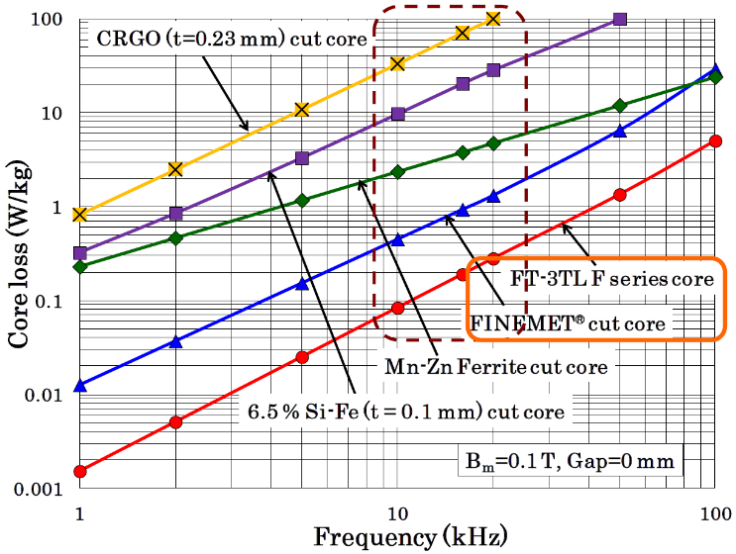
Damper& 40 MHz Landau Cavities



H. Damerau

Technology Transfer and Contribution to Society

- J-PARC/KEK developed a large core production system- magnetic annealing oven in 2013.
- The oven may be used to produce transformer cores for power supplies of **transportation systems**. **KEK** and **Hitachi Metal Ltd.** agreed to use the system and R&D has been started in 2018.



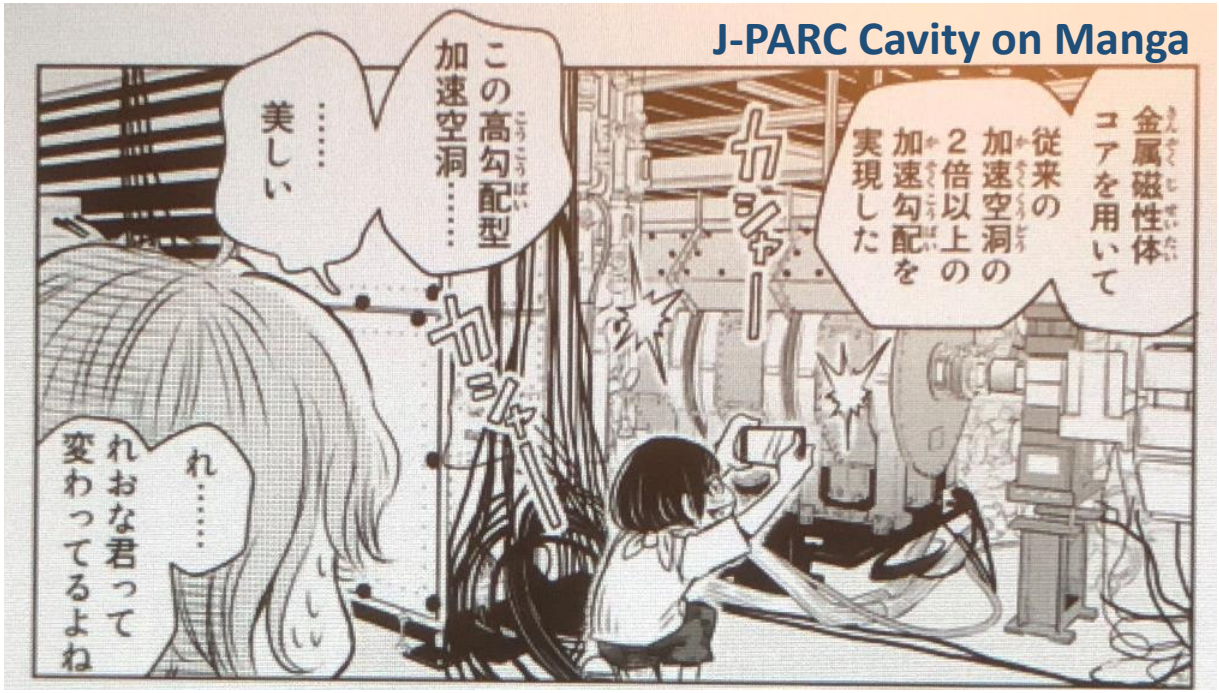
Wideband Cavity Technology may contribute to downsize transformers, to reduce power consumption and to Conservation of the global environment.

2020- Plan

- Rad-Hard SSA R&D continues
  - **Especially, GaN-base amplifiers looks promising.**
  - Rad-test place: CHARM, PSI, J-PARC MR Col. and γ-ray
- Hardware, Beam tuning and study after LS2
  - JSPS budget for the CERN-KEK wideband RF collaboration (4.5Years)

Summary

Collaborating for many years for ring RF.
A lot of Benefits for both laboratories.



“you are … different.”

“Using Magnetic Alloy cores, more than 2 times field gradient than before. This high-field gradient cavity is beautiful.”

From “アルキメデスのお風呂“

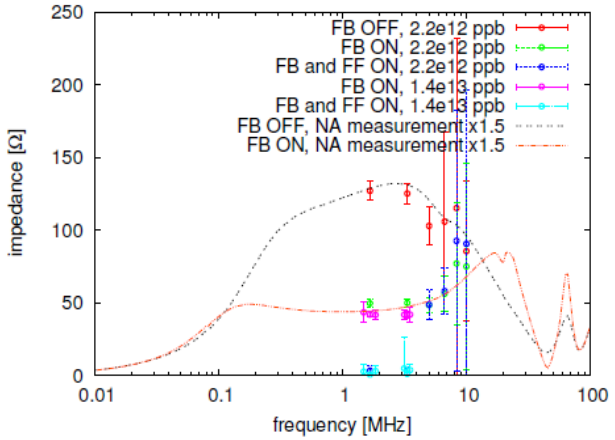
Back up

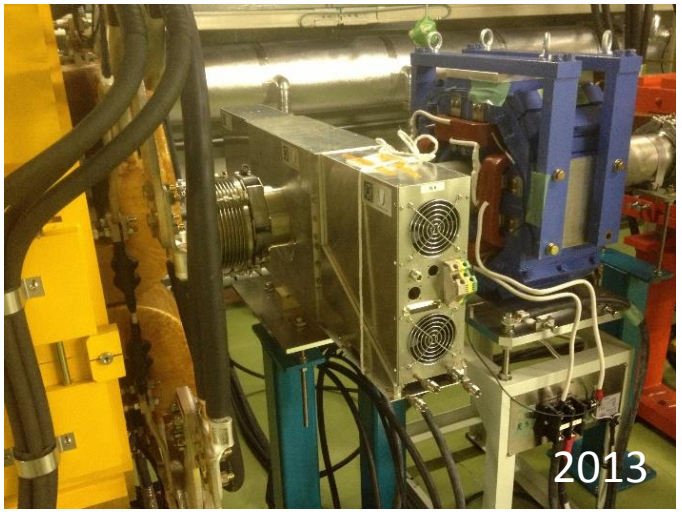
PS Booster New RF systems

- Test of broadband RF system
  - At J-PARC (3GeV injection) in LS1

beam intensity 1.4 x 10^{13} ppb, 8 bunches

F. Tamura@Finemet Review





  - At PSB, beam test after LS1
    - Beam Loading
    - Reliability (>99%)
    - Multi-harmonic RF
  - Braodband system was approved!