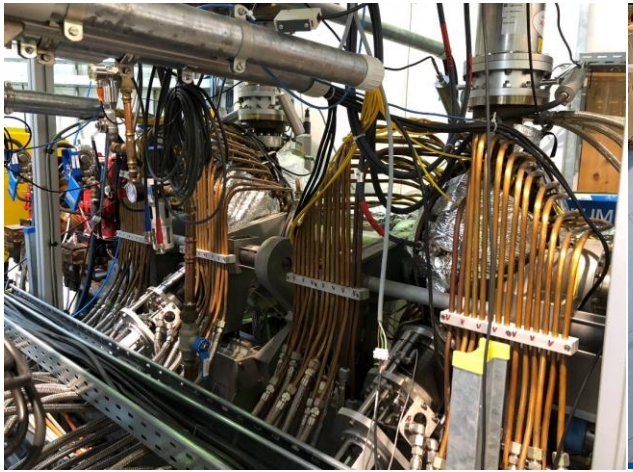
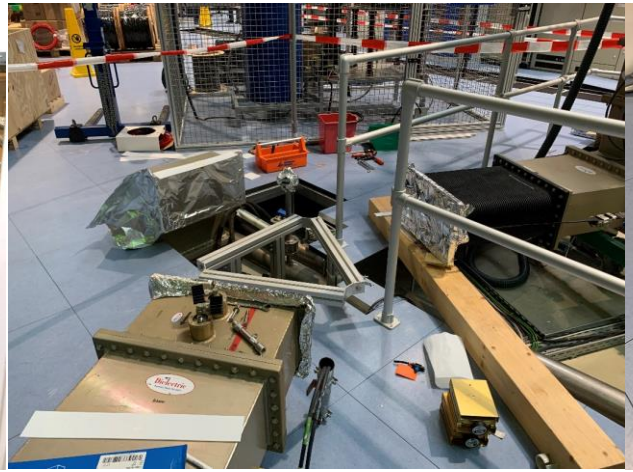
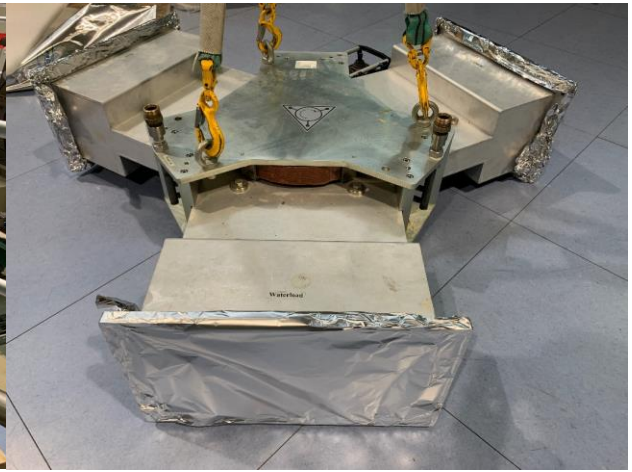
Present Status of KARA RF System

Akira Mochihashi
On behalf of Institute for Beam Physics and Technology (IBPT)
And Laboratory for Application of Synchrotron Radiation (LAS) team at KIT

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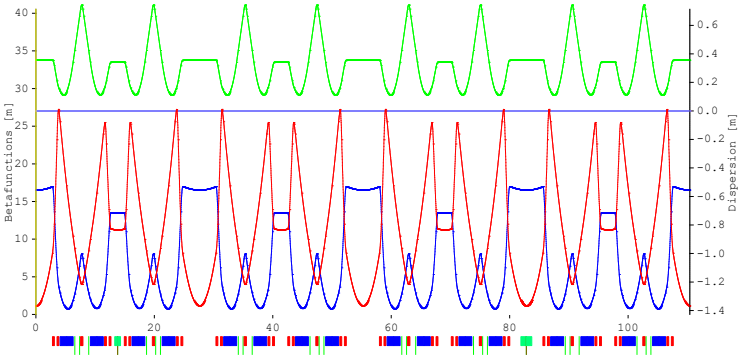
Introduction (1) KArlsruhe Research Accelerator



Extended DBA lattice (dispersion>0 in straight section)
Designed emittance = 59 nm-rad

Beam energy	< 2.5 GeV
Circumference	110 m
RF frequency	499.7 MHz
Harmonic number	184
Number of RF station	2
Number of cavity in 1-station	2
Acc. voltage	1.4 MV (2.5 GeV)
Ring lattice	DBA

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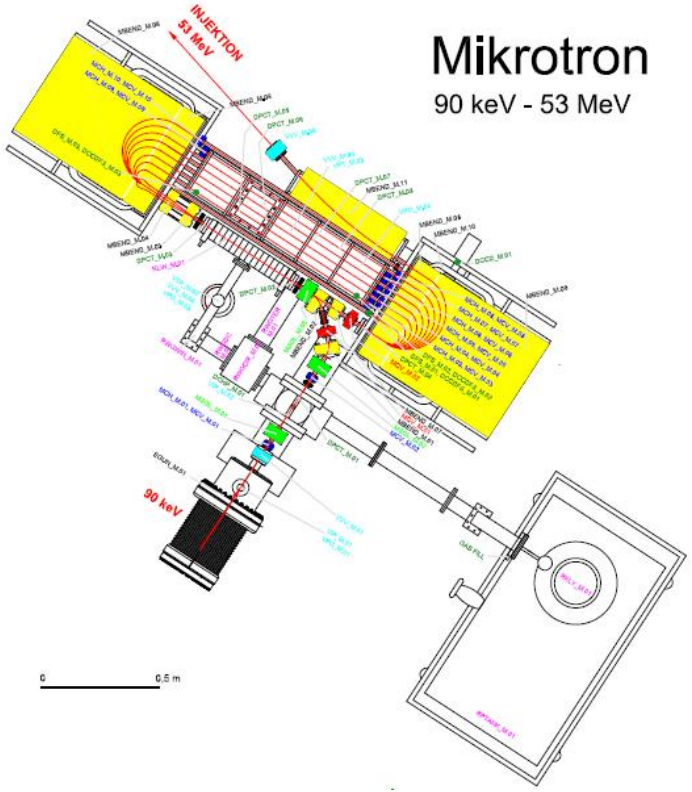
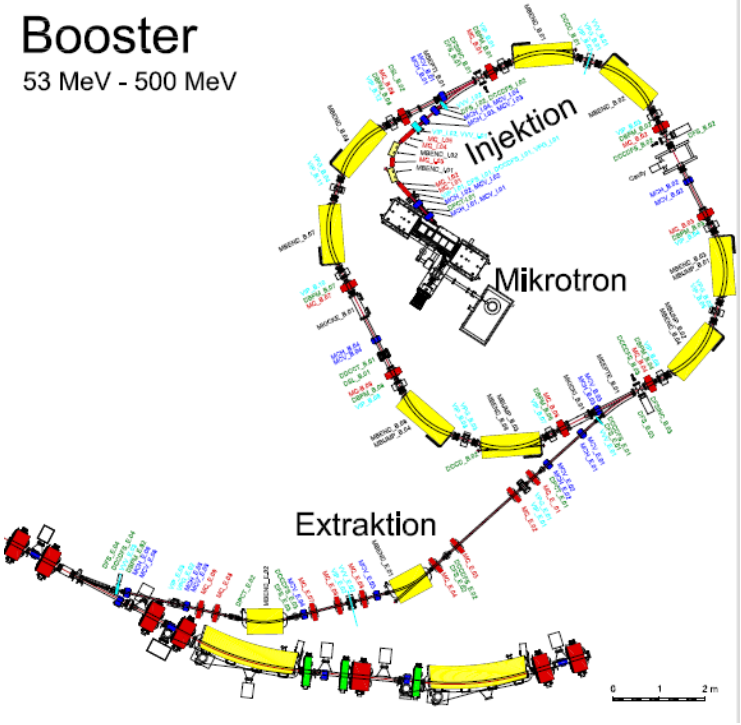
Introduction (2) KArlsruhe Research Accelerator



Beam energy	< 53 MeV
RF frequency	2.999 GHz
Number of turns	10 (up to 53 MeV)
Linac structure	(1/2+7+1/2)Cells, Side Couple
Mode	Π/2 mode

Introduction (3) KArlsruhe Research Accelerator

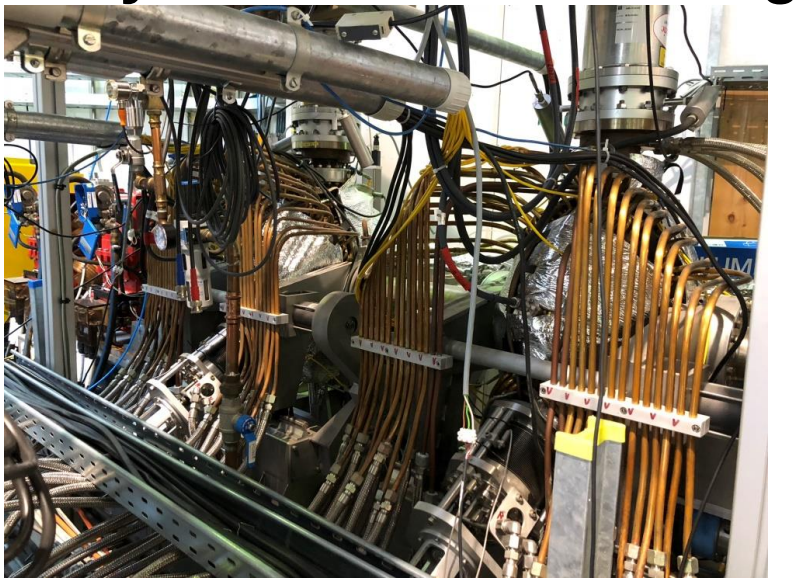


Beam energy	< 500 MeV
Circumference	24 m
Harmonic number	44
Number of RF station	1
Operation rep. rate	1 Hz

RF System in KARA Storage Ring (1)

Parameters	500 MeV (Injection)	2.5 GeV (User Operation)
RF / Revolution freq.	499.7 MHz / 2.72 MHz	
Harmonic number	184	
Total RF voltage	400 kV (Typ.)	1.4 MV (Typ.)
Energy loss per turn	995.9 eV	622.4 keV
Synchronous angle	0.05 deg.	6.38 deg.
Momentum compaction	0.0105	0.00867
Synchrotron frequency	40.0 kHz	34.0 kHz
Energy spread (rms)	1.82×10^{-4}	9.08×10^{-4}
Bunch length (rms)	8.67 ps	36.9 ps
Total klystron output	5.2 kW (150 mA)	140 kW (140 mA)
Ramping time	-	3 minutes
Typical filling pattern	Partial (30~33x3 bunches) or (30~33x4 bunches)	

RF System in KARA Storage Ring (2)

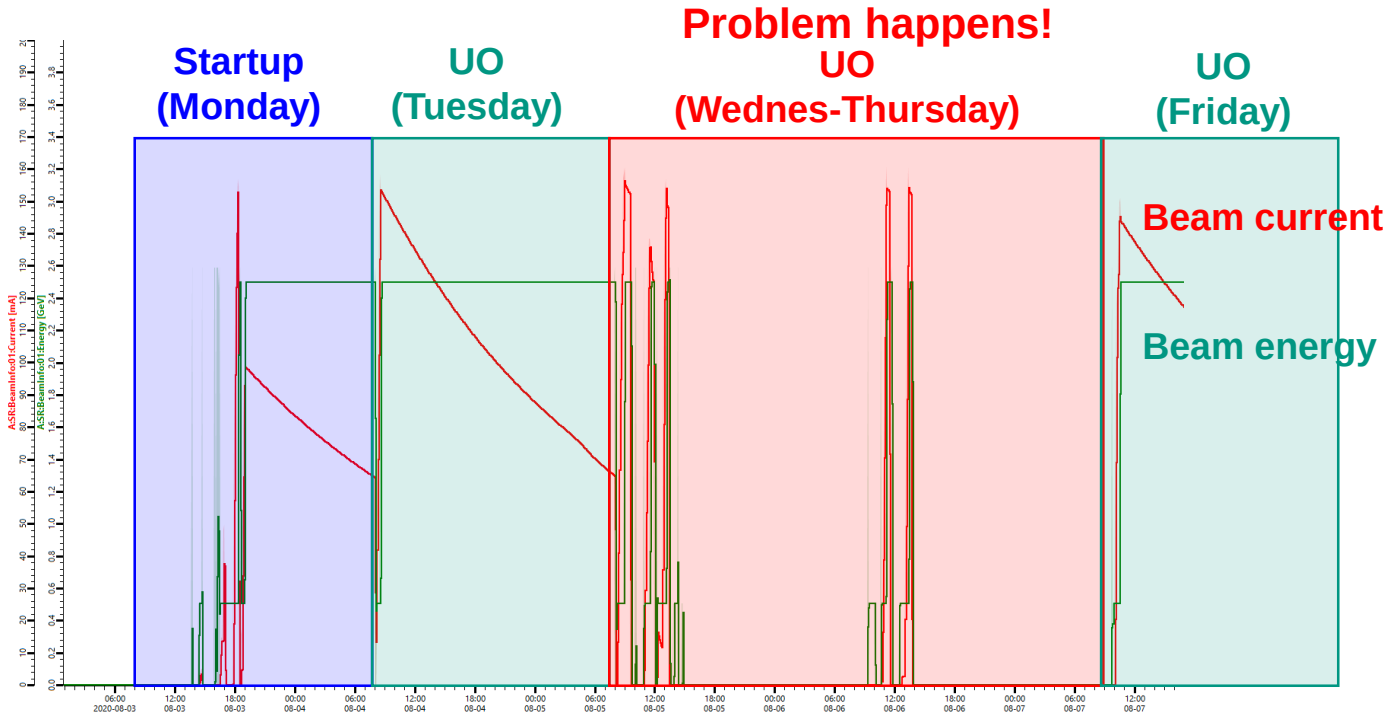


- RF cavity (2cavs/station)
  - ELETTRA type cavity
  - Q_0~40000, R_{sh}~3.3MΩ
  - Vc = 350kV/cavity (@2.5GeV)
- Cavity cooling system
  - 1-chiller for each Cavity
  - Settled temp. = 40~60degree
  - Controllable for each cavity independently

RF System in KARA Storage ring (3)

- Low level RF system (19inch,1-rack)
  - Based on DIMTEL LLRF system
  - (Klystron, cavity tuner) control
- Klystron, circulator and waveguides
  - 250kW klystron (EEV), 1klystron/station
  - Circulator (AFT), magic-T ... split into 2 ports

Trouble Report: Temperature at RF Cavity (1)



05.08.2020 – 06.08.2020

Beam dump happened several times after the energy ramping

Before the issue happened we did not intentionally change the accelerator condition at all.

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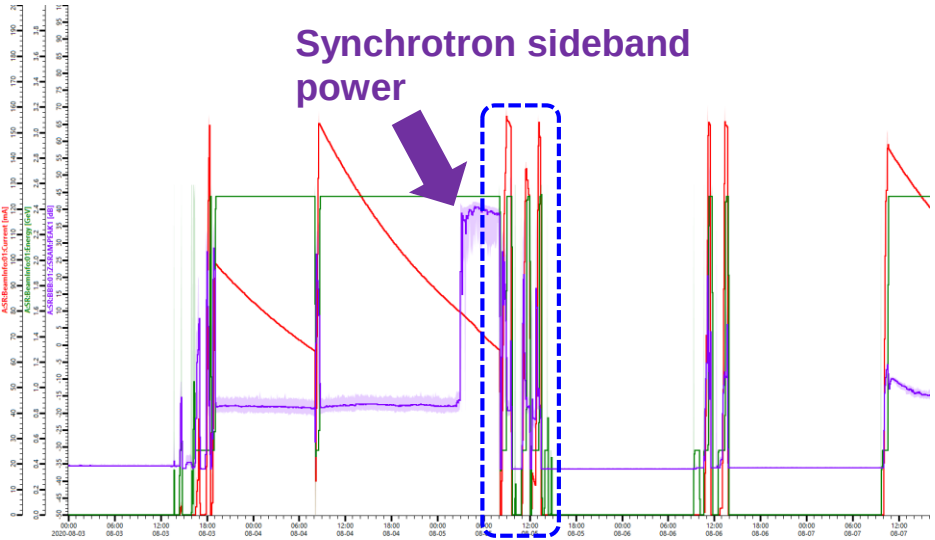
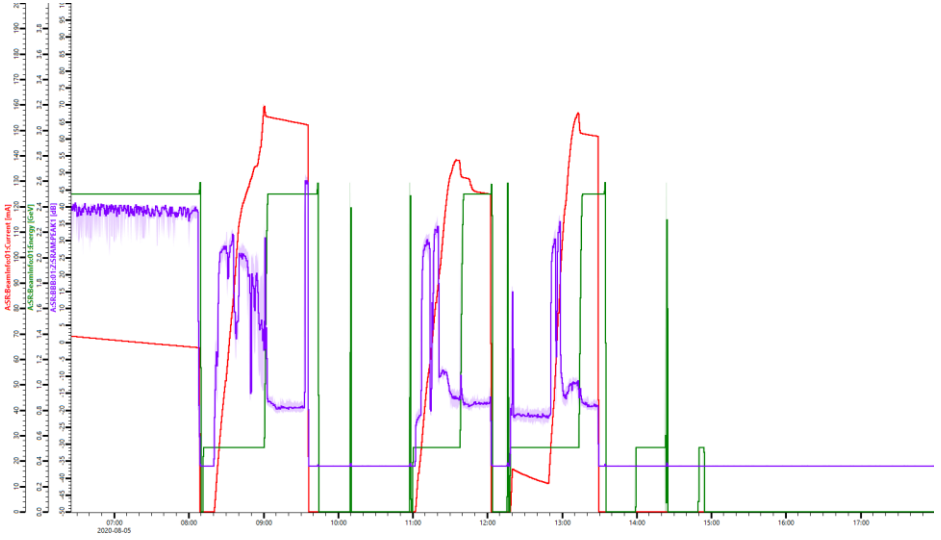
Trouble Report: Temperature at RF Cavity (2)

...probably it might come from beam instability...

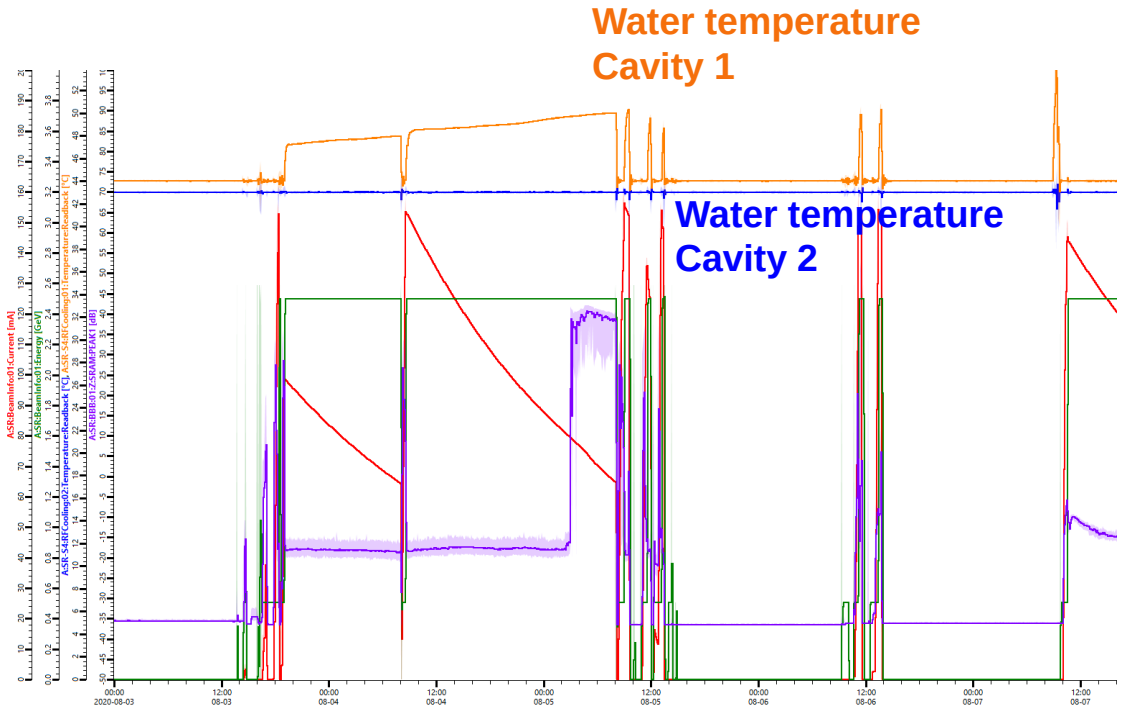


Zoom in



...Sometimes longitudinal instabilities are enhanced, but it is not so clear...

Trouble Report: Temperature at RF Cavity (3)



We found the water temperature from cavity 1 became very high (44 -> 58deg.) though we didn‘t change the set value.

This came from setting of one water valve in the chiller unit of the concerned cavity.

After the adjustment of the water flow rate we could start the user operation.

Should be done

- Including the flow rate and temperature into the device interlock
- Regular check

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Upgrade Report: Renewal of TCU in KARA (1)

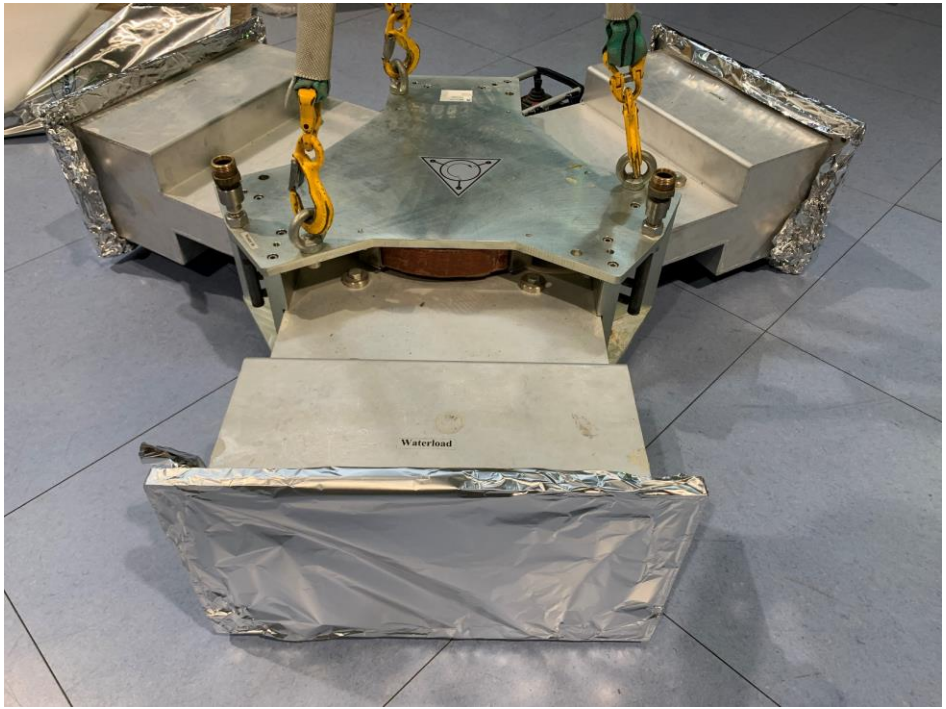
- Renewal of Temperature Compensation Unit (TCU) for 500MHz circulator
  - Two 500MHz circulators are in operation at KARA
  - Two TCUs: around 20 years old and no spare unit

  ⇒ Decided to renew two TCUs

- Two options for the method to adjust parameters of the TCUs
  - AFT comes to KIT ... need to prepare 4-port network analyzer
  - Transport the circulator to AFT ... around 1 hour from KIT to AFT by truck

  ⇒ Decided to transport the circulator to AFT

Upgrade Report: Renewal of TCU in KARA (4)



After the radiation survey by the safety department in KIT, the circulator was delivered directly from KIT to AFT factory by a truck.

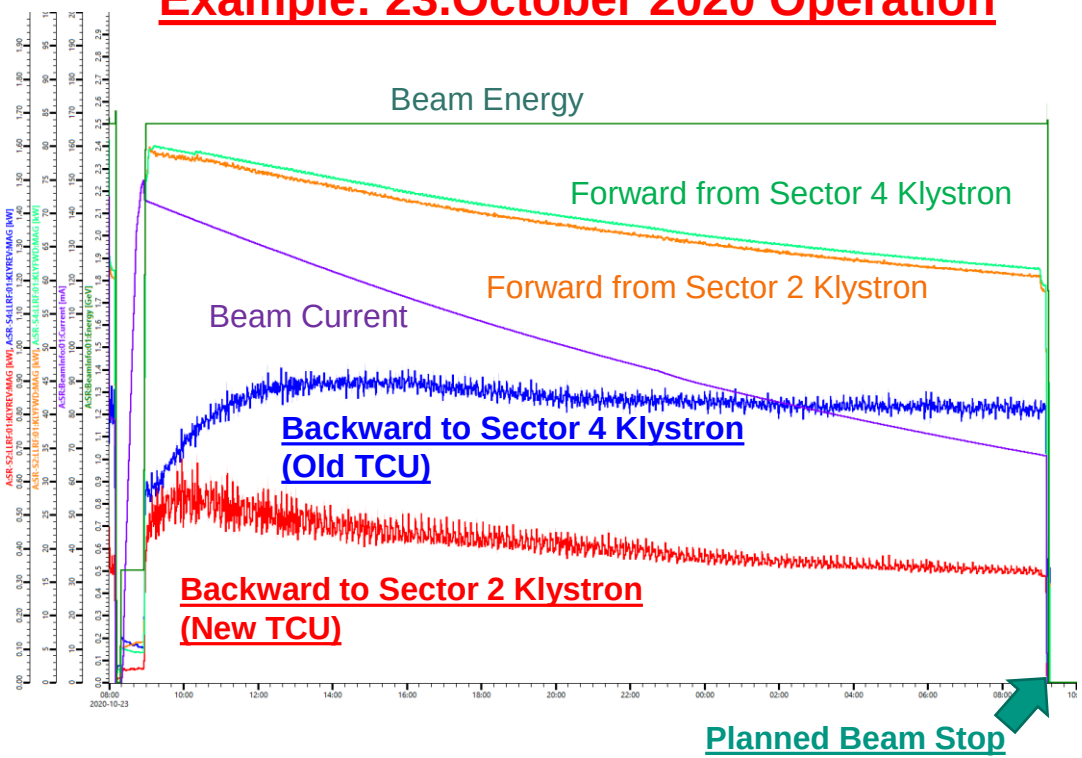
For the transport, one special wooden box was prepared by AFT.

The circulator was deliverd to AFT on 24.August and came back to us with new TCU on 4.September.

Upgrade Report: Renewal of TCU in KARA (5)

Except the parameter ΔT, all of the internal parameters have been adjusted in AFT.
In the high power test on-site, we adjusted ΔT by ourselves.

Example: 23.October 2020 Operation



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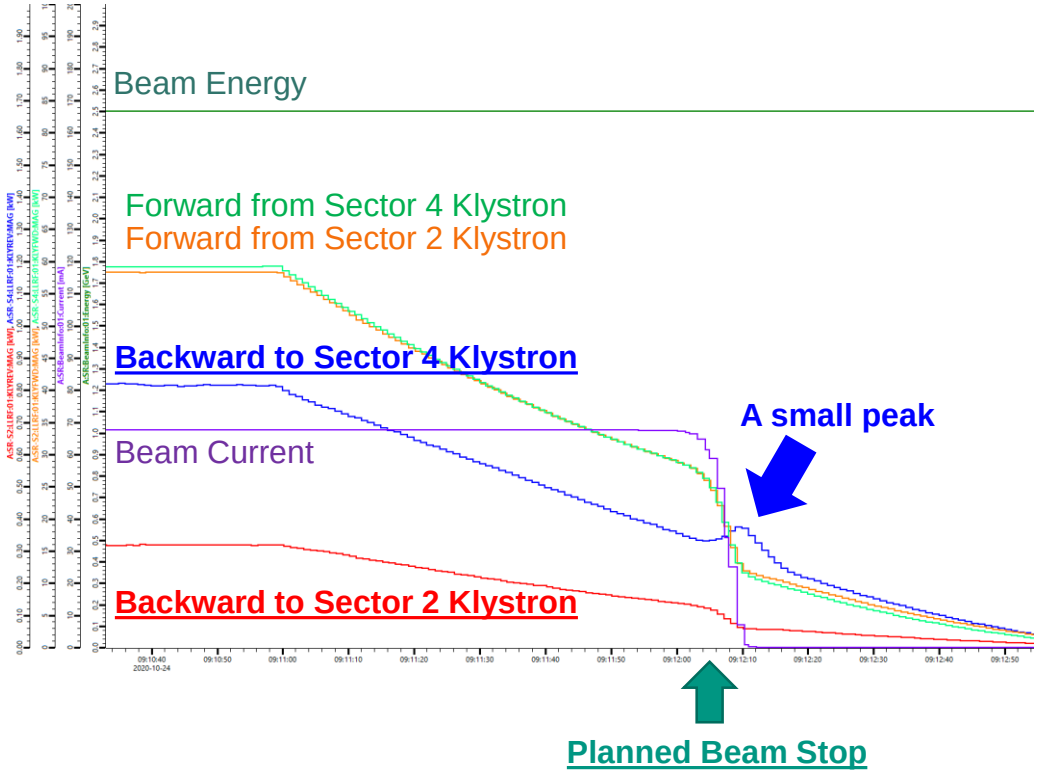
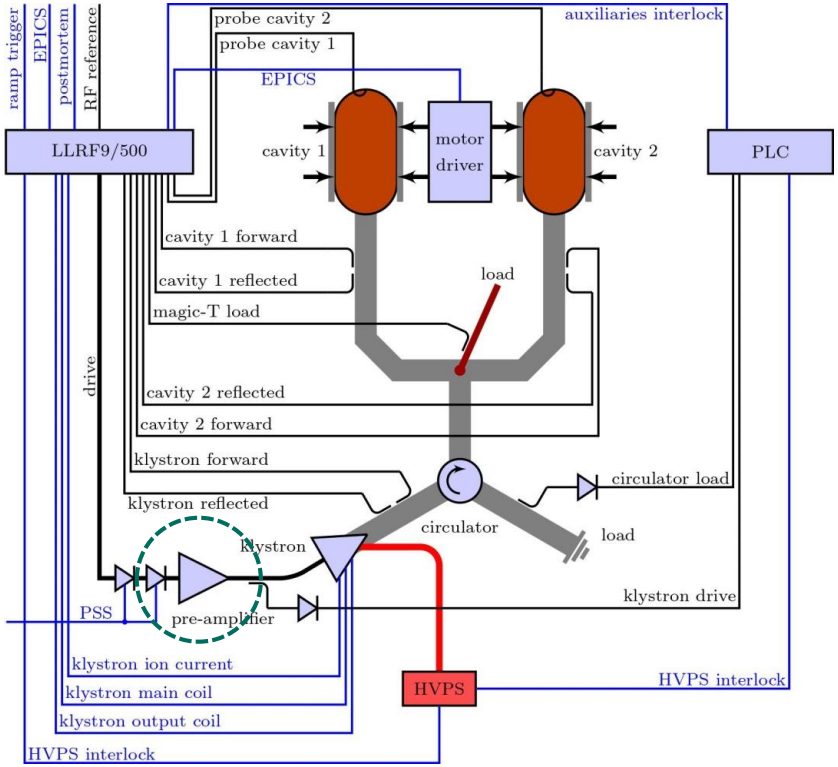
Upgrade Report: Renewal of TCU in KARA (6)



It seems that the new TCU has better time response that the old unit, though the time response depends on the other internal parameters of the unit.

At the beginning of November we delivered sector 4 circulator and will receive it with the new TCU for sector 4.

Next Plan: Renewal of Pre-amplifier for Klystron



Present pre-amplifier (500 MHz, 50 W, CW, home made):

- is not included into the interlock system
- does not have remote control interface

New pre-amplifier (500 MHz, 50 W, CW, HBH in Germany):

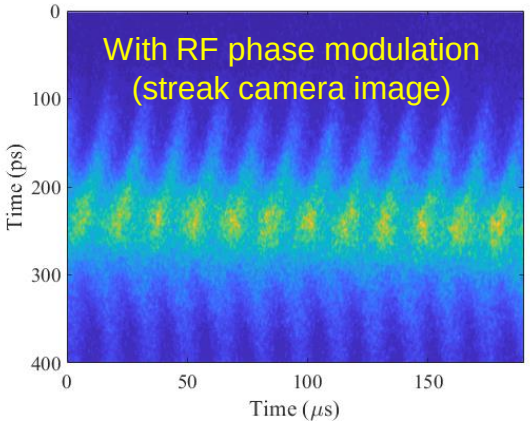
- has analog interface to control internal switches
  - RF switch
  - Switch for power supply of amplifier module
- Has digital interface (ethernet) to control/get the amplifier status
- The pre-amplifiers are already at hand

Should be done

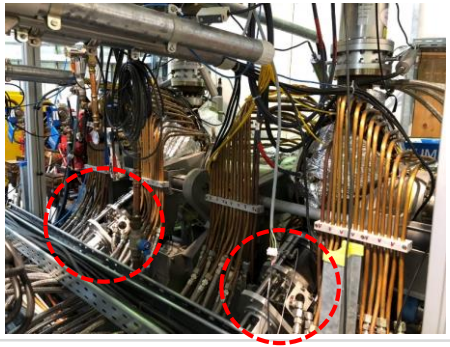
1) Installation the pre-amplifier into KARA-RF
2) Integrating the pre-amplifier into the RF interlock system

Ideas for KARA-RF: Future Possibilities

- Application to machine physics experiments
  - Modulation function in LLRF module (DIMTEL LLRF 9/500)
  - Phase, amplitude modulation with synchronization between other instrumentations



- Using sub-tuner in RF cavities
  - Main tuner ... Pressure type
  - Sub tuner ... Plunger type (deactiveted now)
  - To detune HOMs we now change the water temperature if necessary
  - The sub-tuner might be promising to detune HOMs in the cavity
  - It is necessary to perform the simulation and to prepare the control system



Thank you for your attention!

Karlsruhe Palace

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