

Update on the LLRF operations status at the European XFEL

On behalf of the MSK LLRF group and the XFEL Linac team

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LLRF workshop 2022
Brugg-Windisch
11.10.2022

Contribution ID 34

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

Low Level RF Workshop 2022

9-13 Oct 2022, Brugg-Windisch, Switzerland

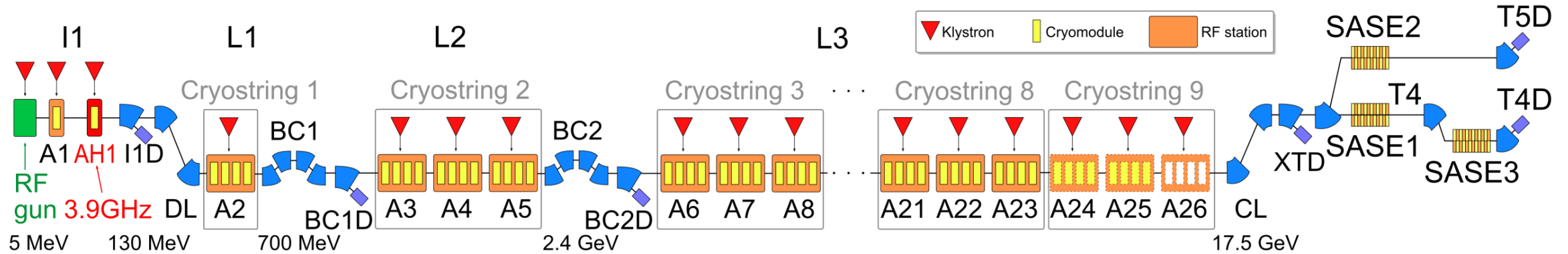


Low Level
RF
Workshop
2022

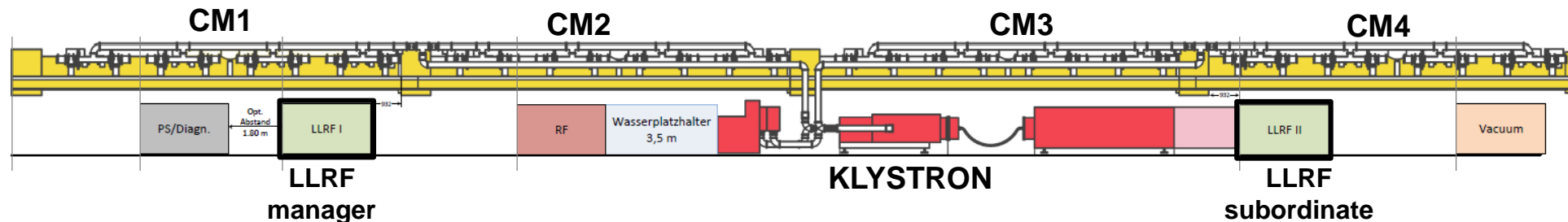


The European X-ray Free Electron Laser (EuXFEL)

RF system



- 26 RF stations (4 cryomodules each, 1 in A1 and AH1)
- 98 cryomodules (8 cavities each)
- 776 superconducting 1.3 GHz TESLA RF cavities +8 3.9 GHz SRF cavities
- 1 LLRF system / RF station (i.e. per klystron) split in Manager and Subordinate

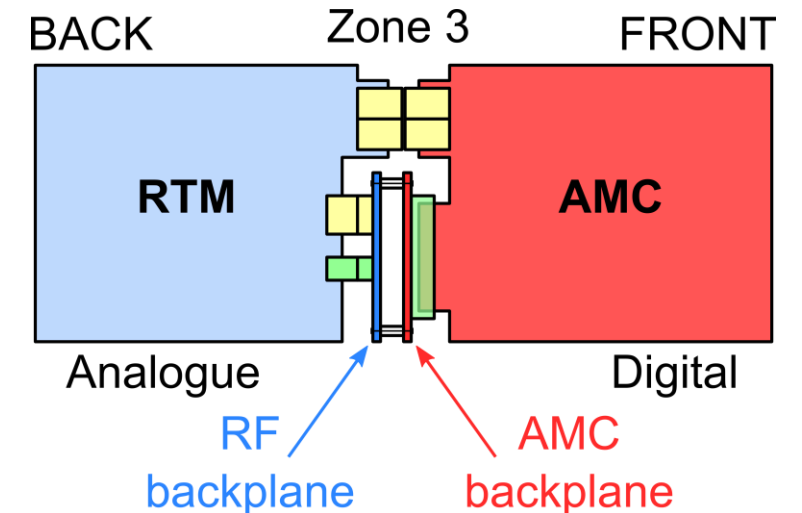
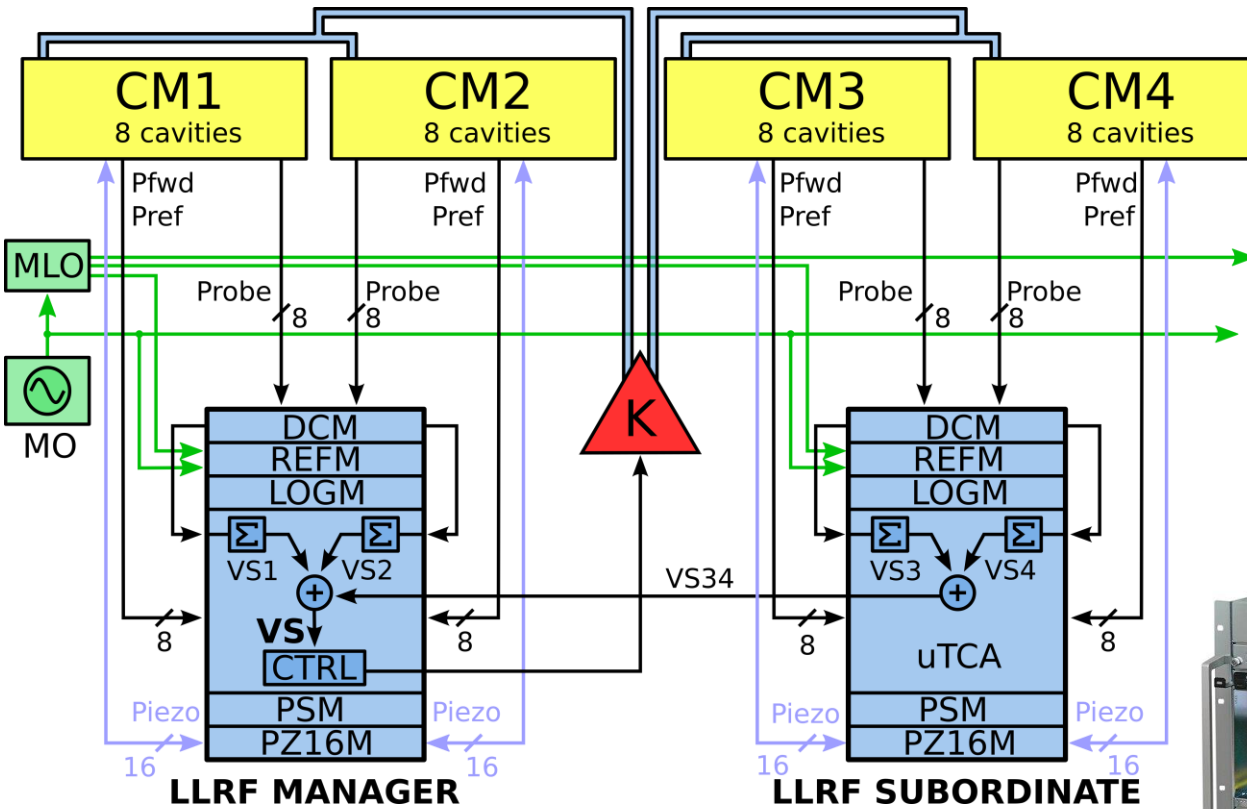


The European X-ray Free Electron Laser (EuXFEL)

The LLRF multicavity system

Based on MTCA.4 standard

- AMC: Advanced Mezzanine Card
- RTM: Rear Transition Module
- 12 slots, hot swap
- Redundant power supply



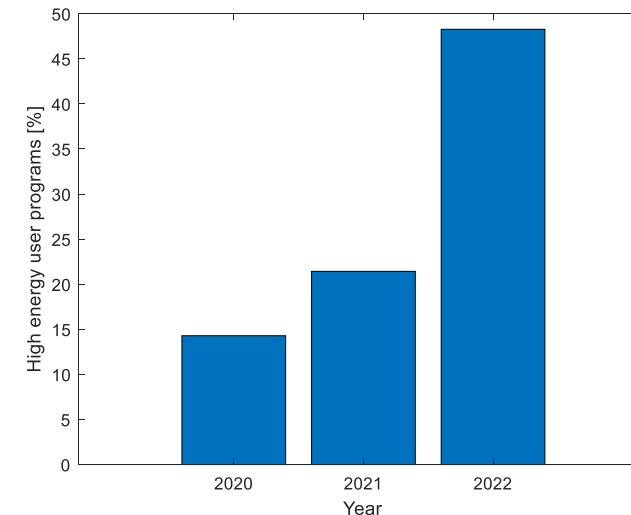
The European X-ray Free Electron Laser (EuXFEL)

Schedule



4 energy settings and 2 RF configurations

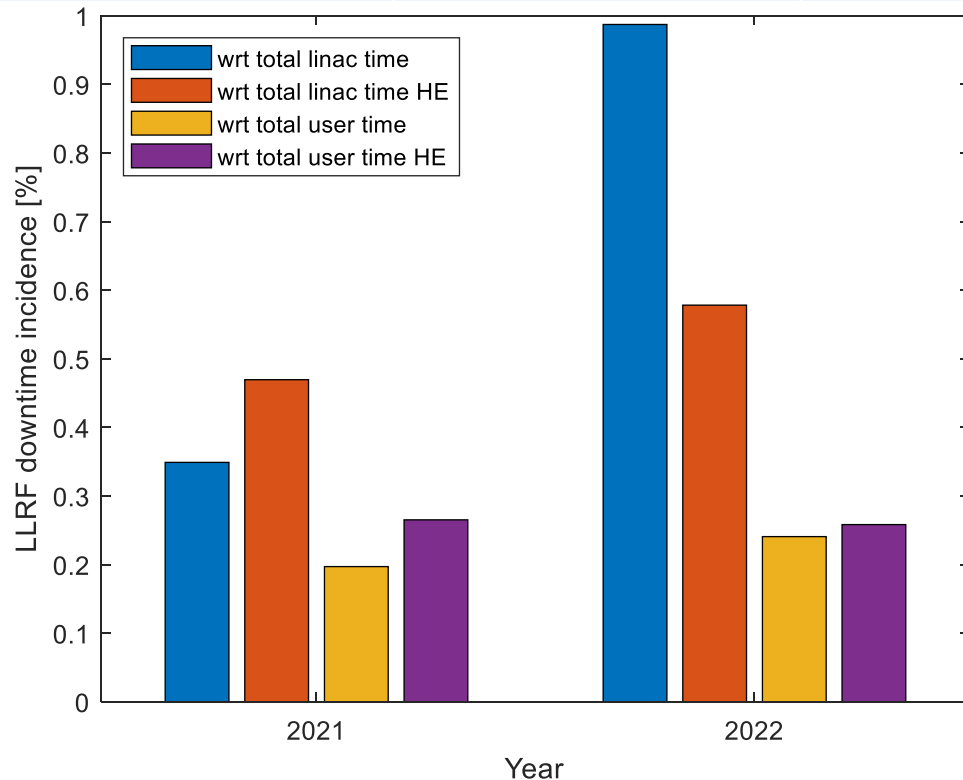
- 8, 11.5 and 14 GeV -> Reduced-energy conf.
- Low-gradient and low-radiation
- Low number of rf trips
- 16.3 GeV -> High-energy conf.
- High-gradient and high-radiation
- Higher incidence of rf trips (mainly SEUs)
- Highly requested by users!



The European X-ray Free Electron Laser (EuXFEL)

LLRF statistics

Year	Total linac time [days]	Total LLRF downtime [hours - days]	Total user time [days]	User LLRF downtime [hours - days]	User HE weeks
2021	277.36	23.23 - 0.97	168.00	7.94 - 0.33	6
2022 (until 18.09)	236.21	55.97 - 2.3	136.00	7.86 - 0.33	14



Some conclusions

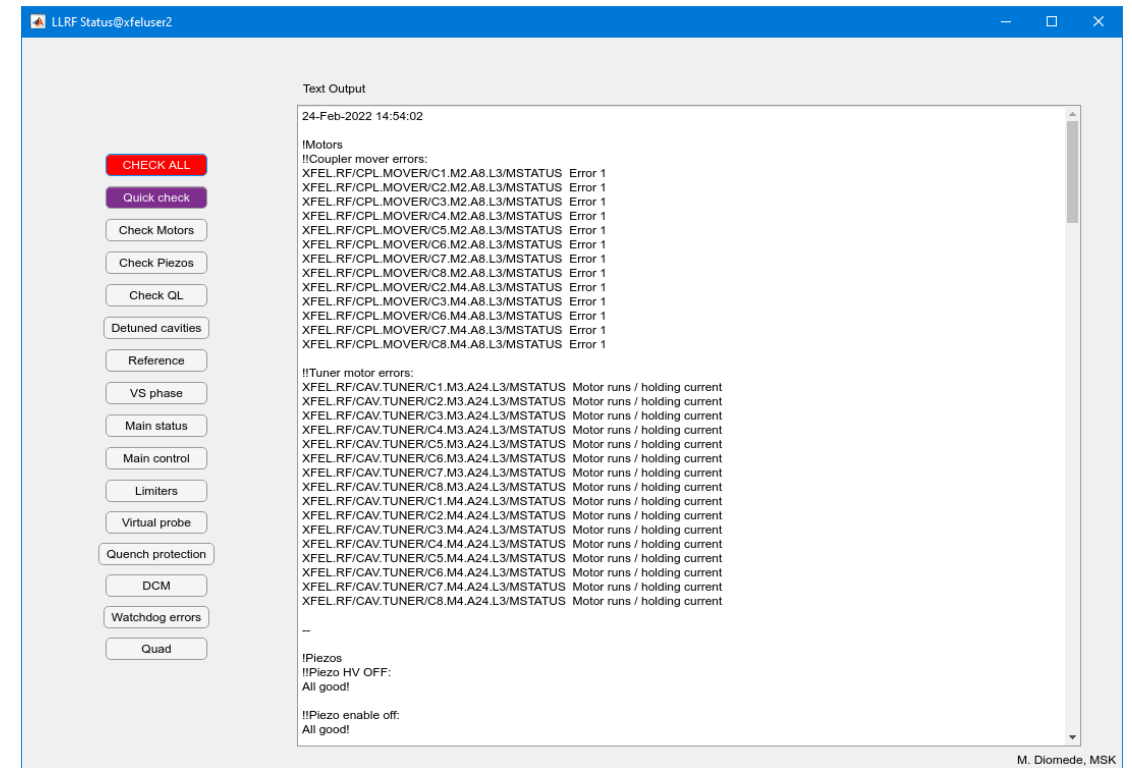
- High-energy makes things more complicated but still manageable
- Weekly maintenance is of great help
- Off-beam stations are a great way to test and study the machine even during user run and maintain the linac well setup
- LLRF downtime incidence during user runs is still pretty good (<0.3%)

LLRF status tool

LLRF maintenance

- Performed (usually) every Monday morning for 1 hour
- Power-cycle of faulty MTCA boards, CPUs, crates
- Piezo relaxation (reduction of piezo DC voltage to extend its lifetime)
- QI tuning
- Beam transient calibration
 - RF module phase alignment
 - Vector Sum scaling

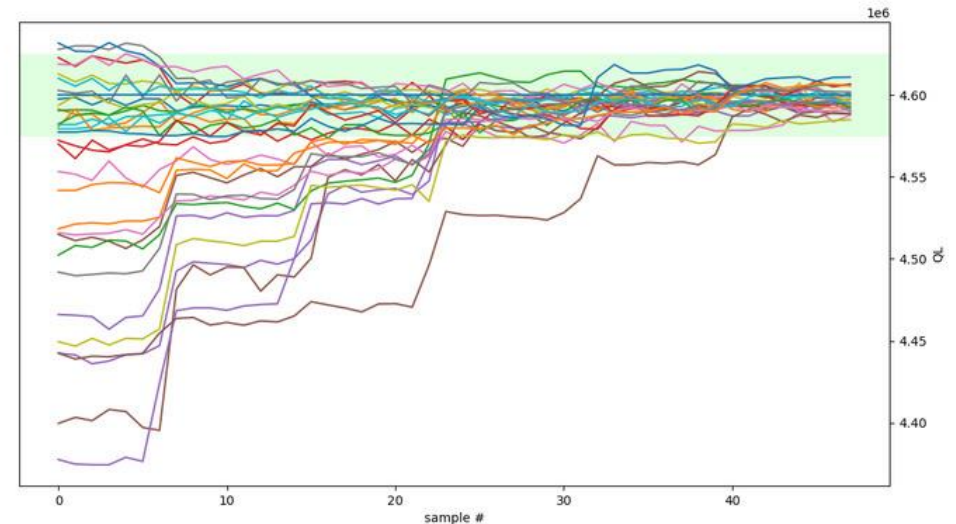
Implemented a MATLAB tool that checks hundreds of LLRF DOOCS properties and generates and sends health reports.



Cavity QI tuner

LLRF maintenance

- It mainly needs to be done at every change in energy configuration
- Similar approach to the already existing Cavity Resonance Frequency Tuner script
- It acts on all the modules of a selected RF station
- One module per time with the previous tool -> tuning is faster now (one button solution)



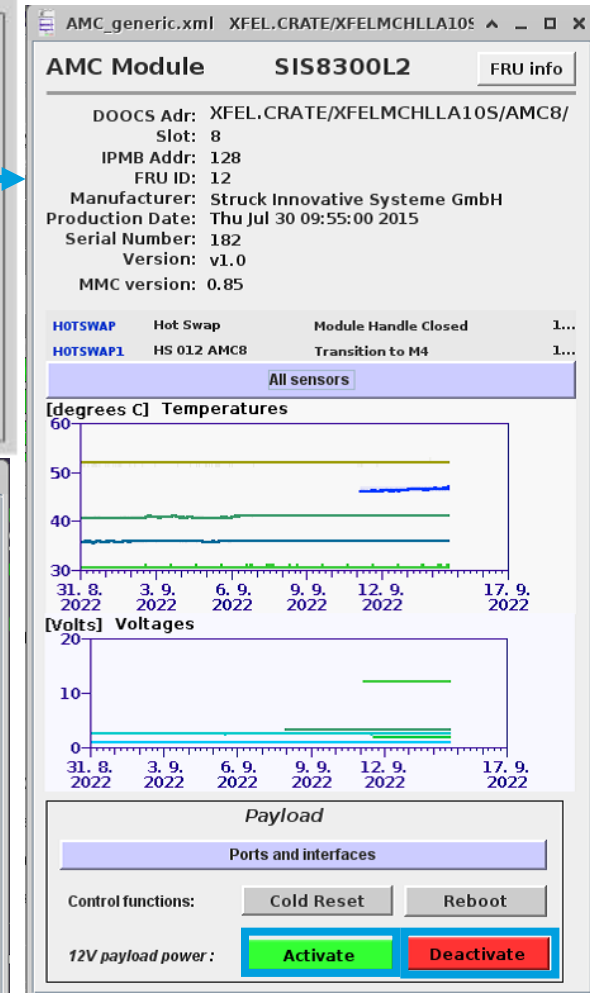
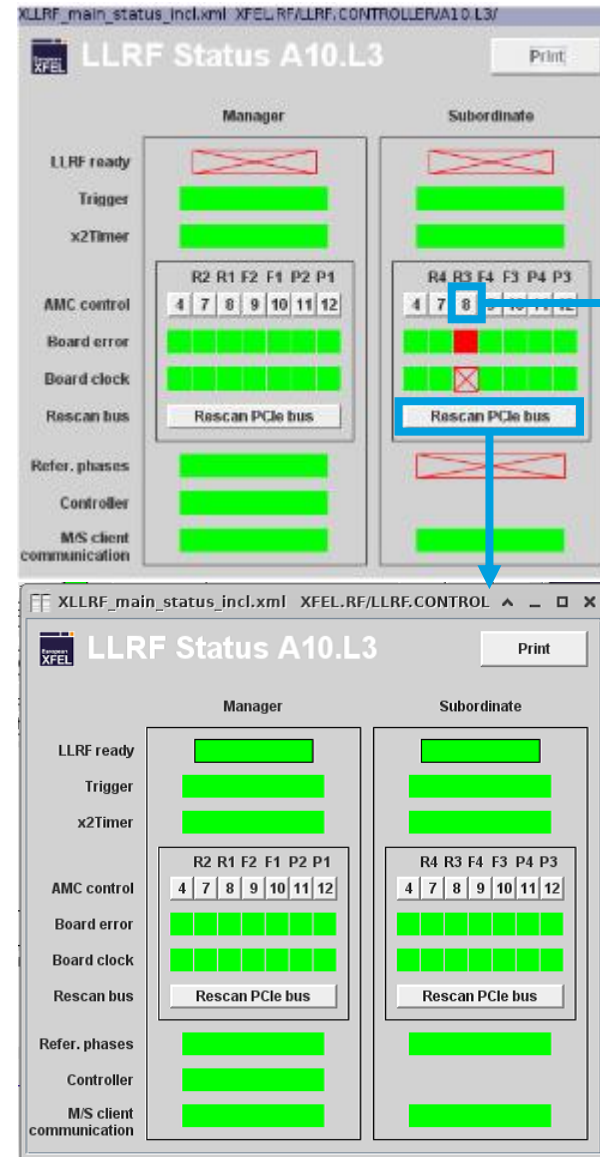
I use: pydoocs and matplotlib, getting data in 160 ms

V 1.6, M.Grecki, MSK, DESY, 2022

Handle MTCA boards failures

MTCA hot-plug feature

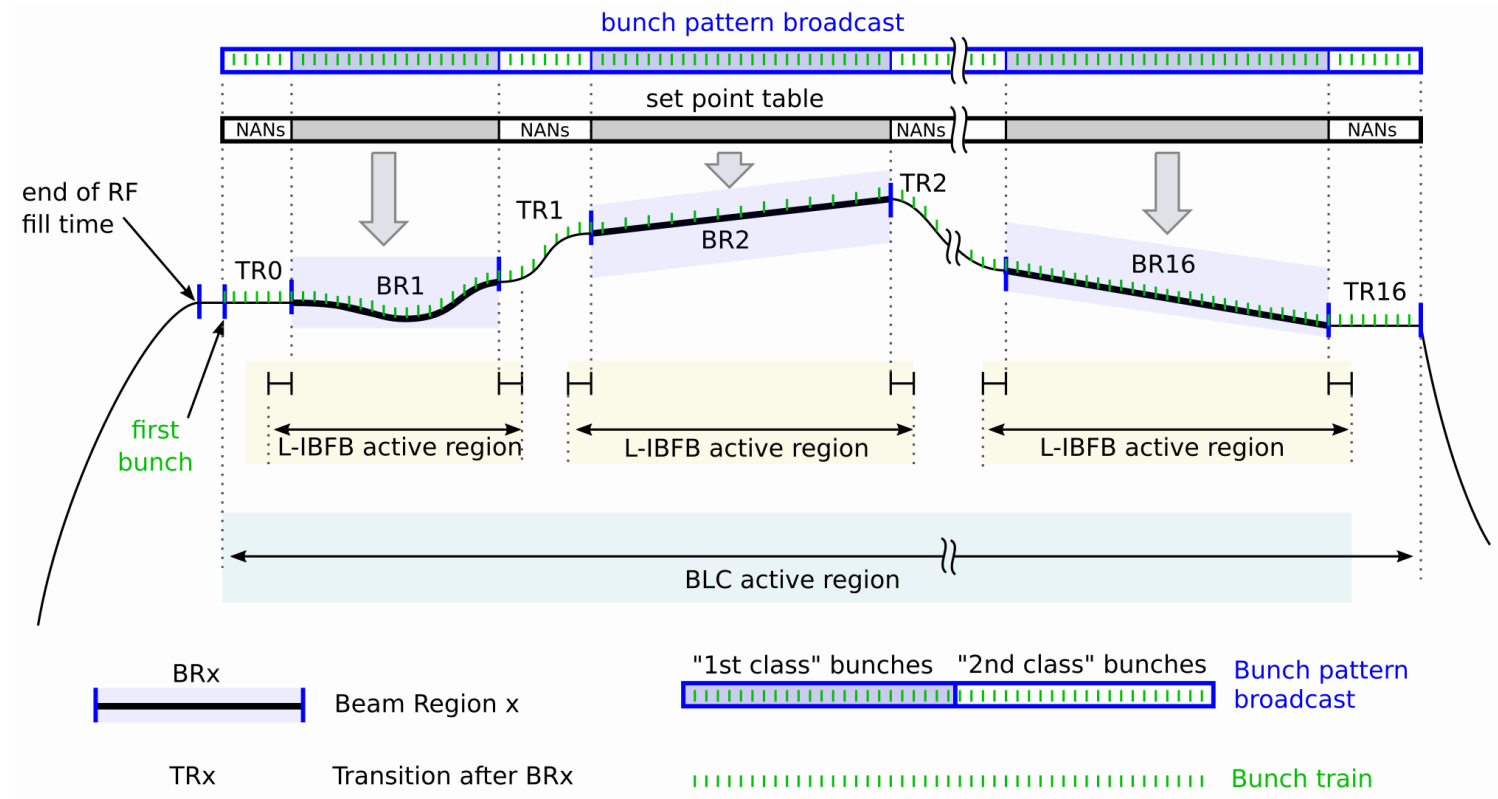
- This happens especially during high-energy runs
- SEUs cause RF trips if probe boards are affected
- The RF station might survive the whole week before maintenance if forward and reflected boards are affected
- In the past, the only way to fix it was to power-cycle the MTCA crate
- Recently, the hot-plug support has been enabled in all MCHs
- It is sufficient to power-cycle the board and rescan the PCIe bus on the relative CPU
- The whole procedure can be performed directly from the jddd panel. Much faster than the past



Beam regions

A new feature

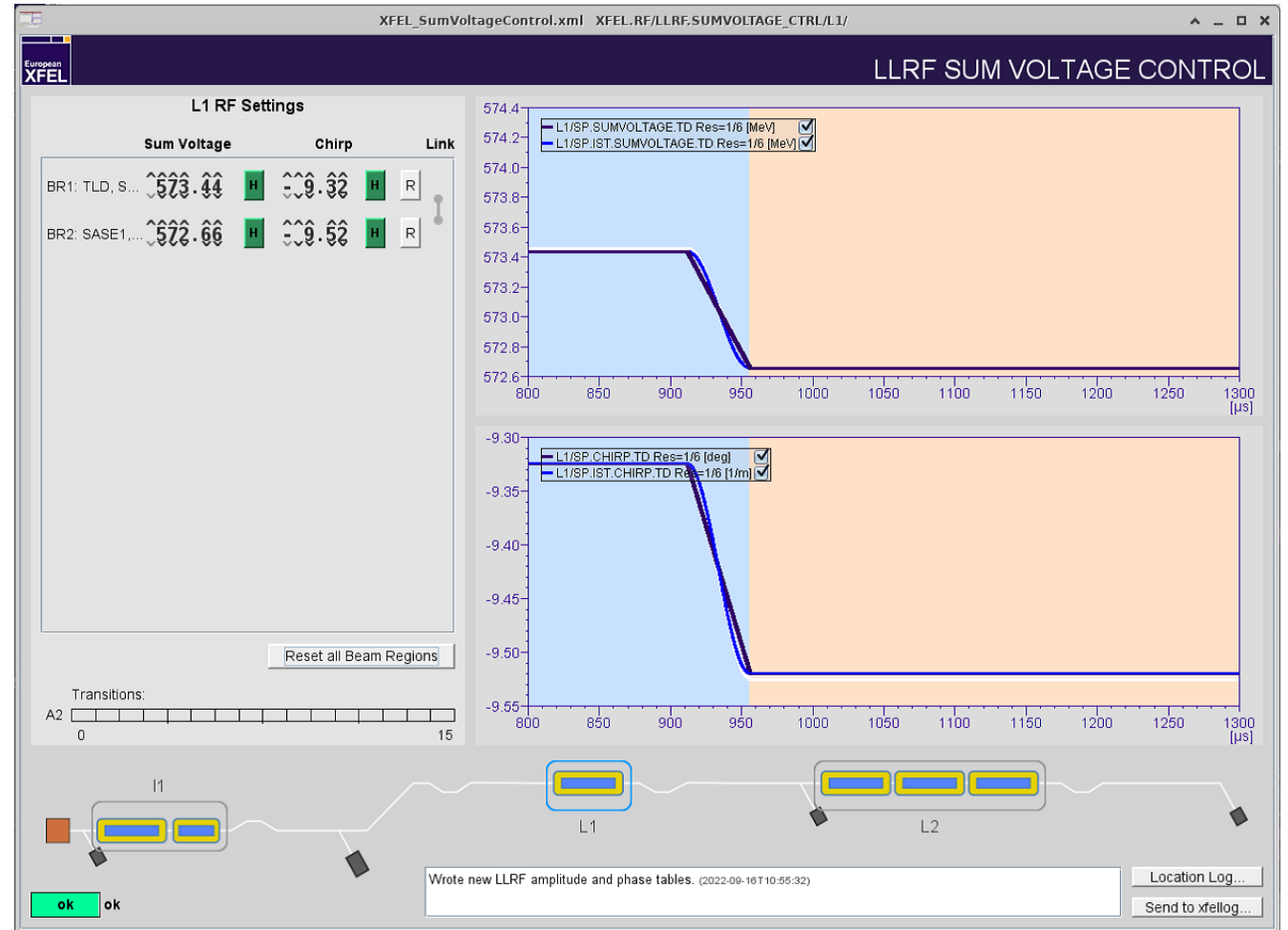
- Upgrade/change wrt 3 flat tops (FTs)
- Released after the last shutdown in August
- Up to 16 beam regions (BRs) are possible
- Arbitrary shapes of the BRs are possible (rf station is in so-called "table mode")
- The BRs are separated by transition regions (TRs)



Beam regions

A new feature

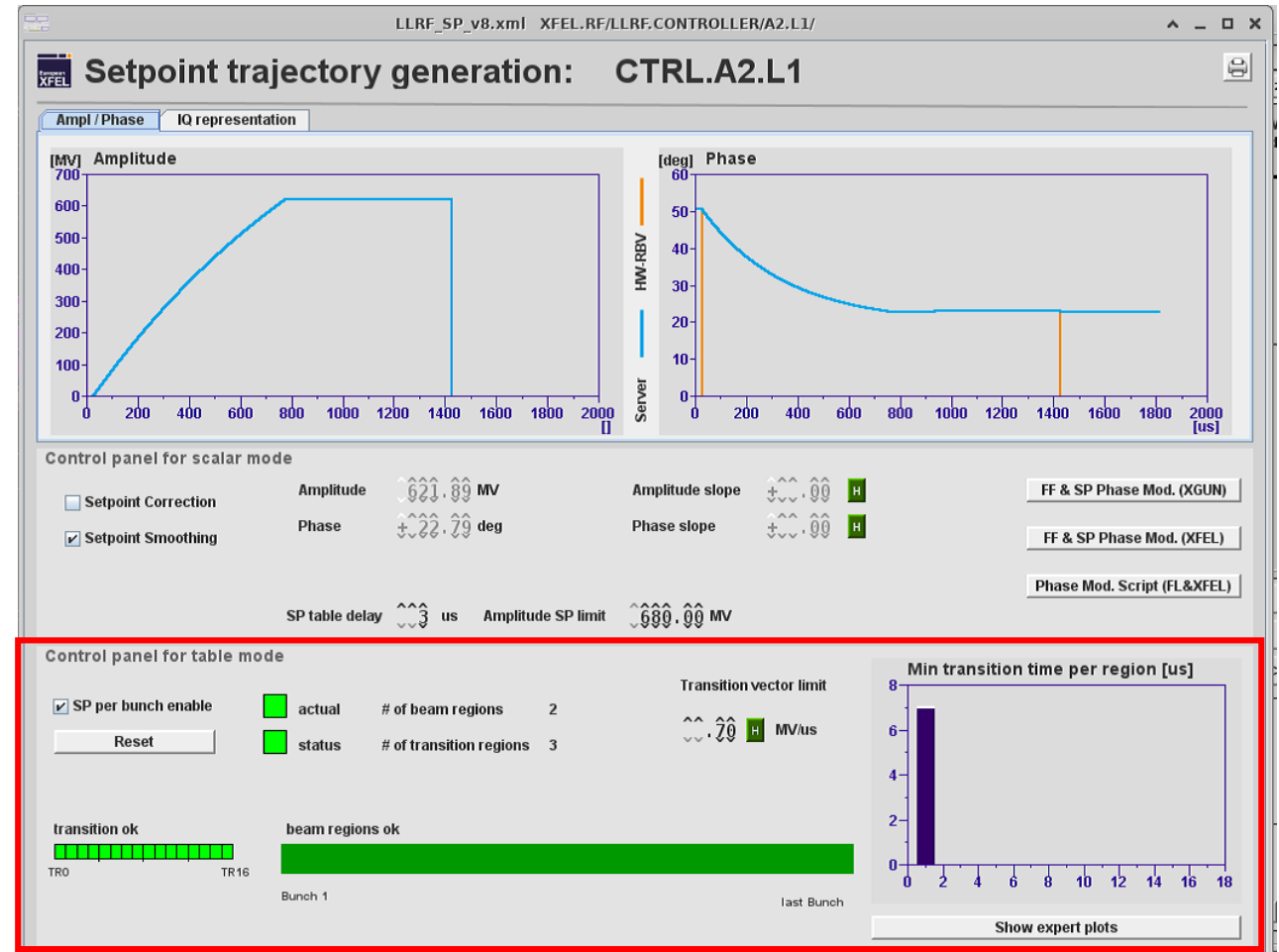
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- The BRs are separated by transition regions (TRs)
- The idea behind the BRs is also to control multiple stations from a high level software called Sum Voltage Control
- Control beam parameters which are then translated into amplitude and phase set points on the LLRF stations



Beam regions

A new feature

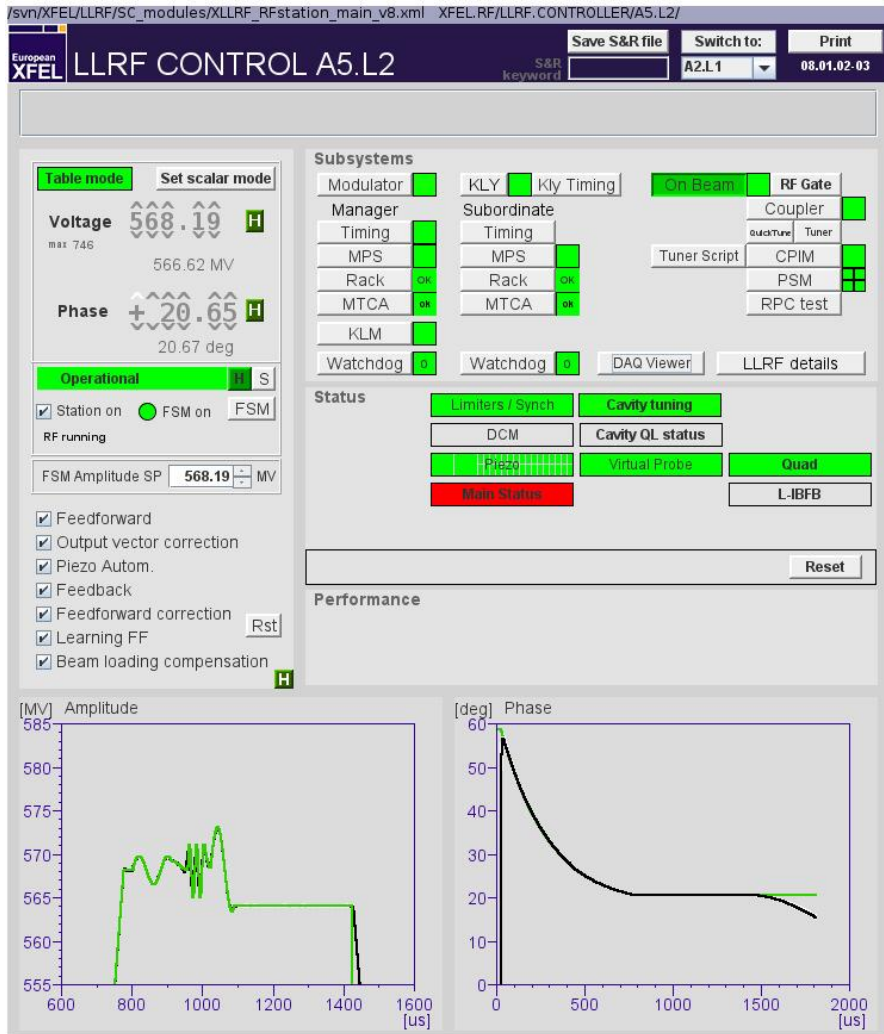
- The setpoint (SP) tables are generated by the llrfCtrl server
- The vector sum SP amplitude defines the value at the beginning of the beam region
- The llrfCtrl server rejects BR requests that correspond to exceeding the threshold of 0.7 MV/us
- It is considered to be the maximum deviation, in the complex plane, that is sustainable by the klystron bandwidth



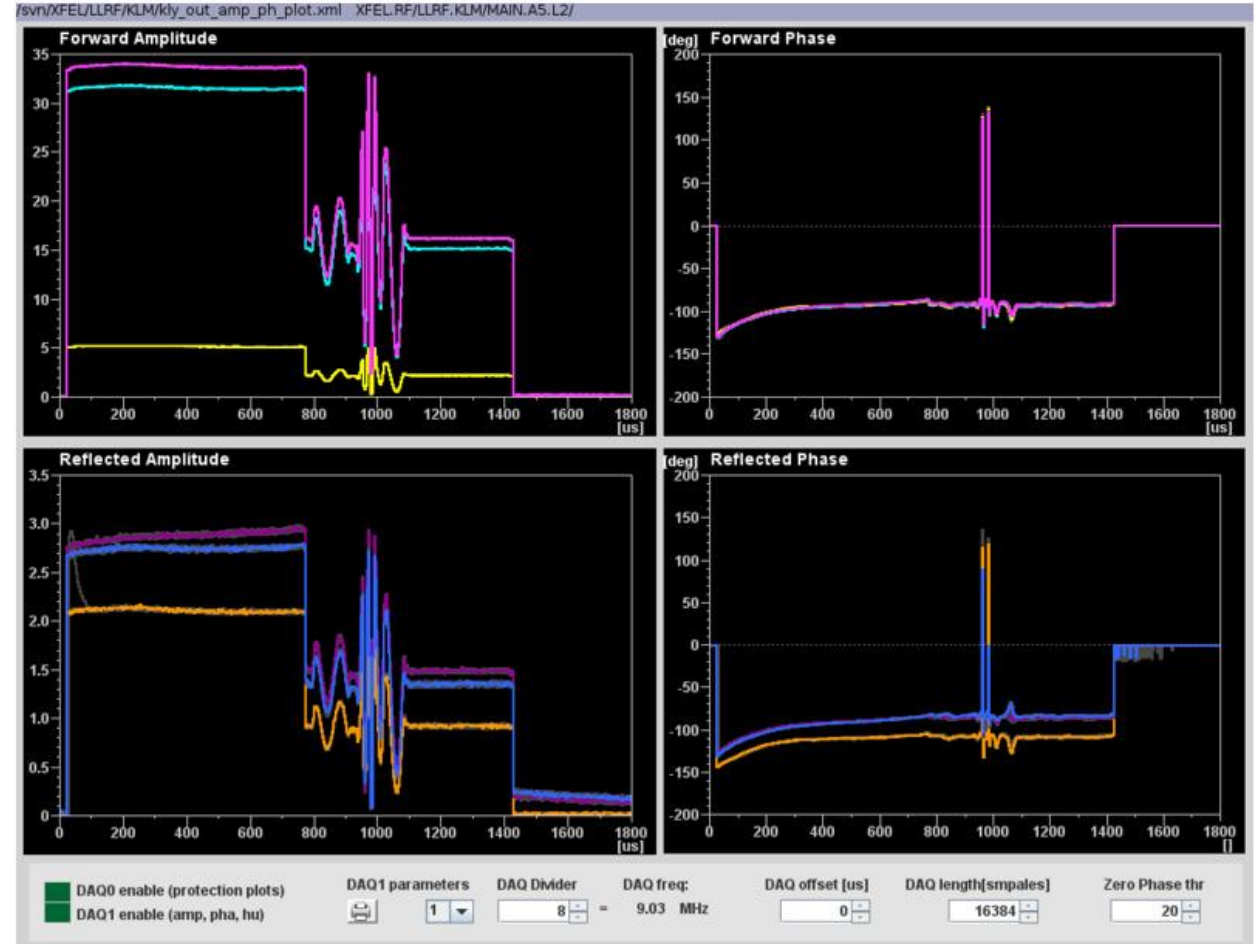
Beam regions

An example

LLRF control panel



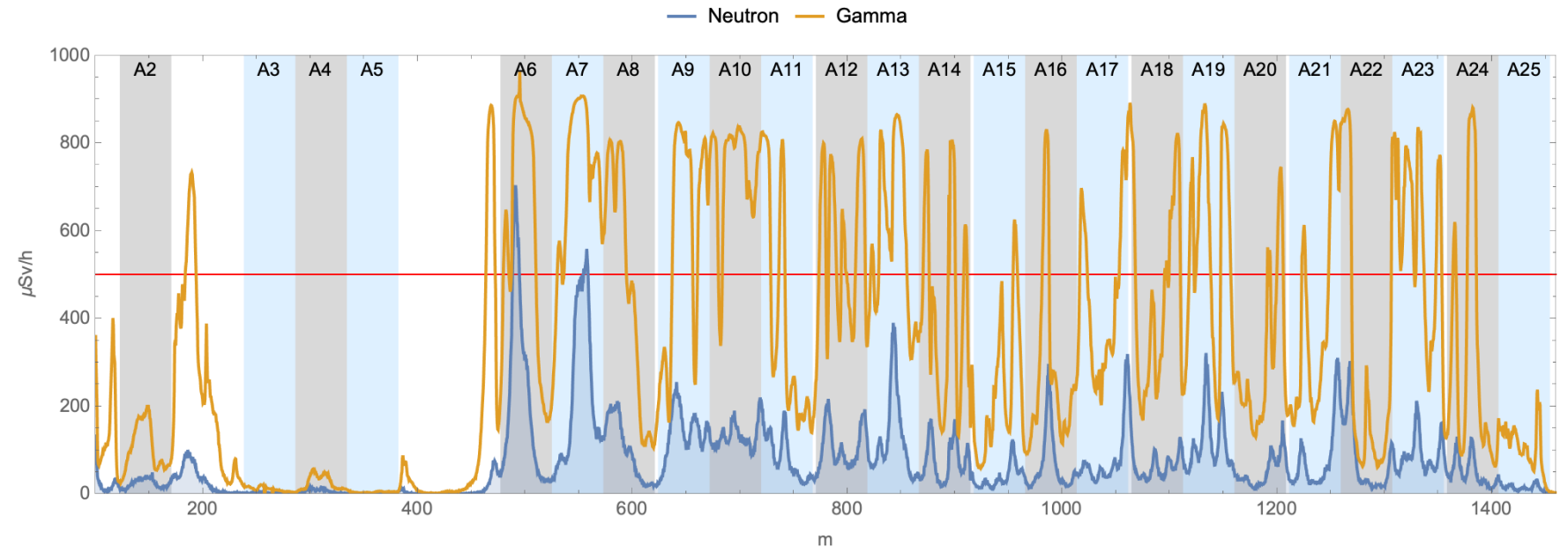
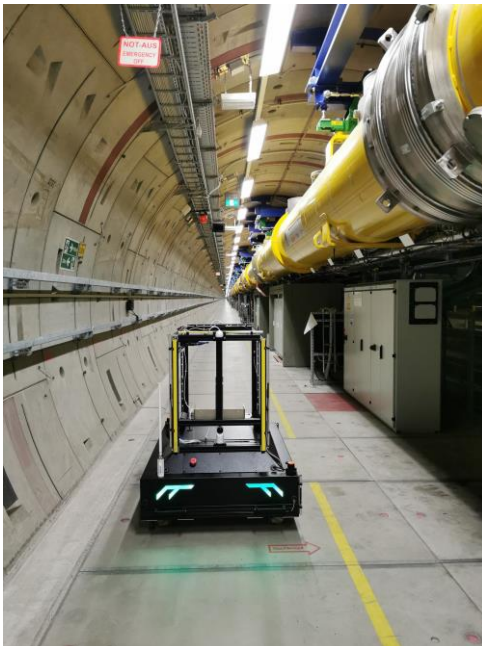
Klystron output waveforms



MARWIN XTL radiation scans

Radiation issues

- During high-energy runs, weekly radiation scans of the XTL tunnel (A2-A25) are performed
- MARWIN is the robot used for these scans
- If the neutron radiation of a station constantly exceeds the administrative limit of 500 $\mu\text{Sv/h}$, its accelerating gradient is reduced or the emitting cavity detuned
- Over the years, several field emitters have been discovered



Thank you

Contact

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