

XFEL Operator Training

Low Level Radio Frequency (LLRF)

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Contents

1. Introduction

2. What an operator should know

3. Exceptional cases and how to react



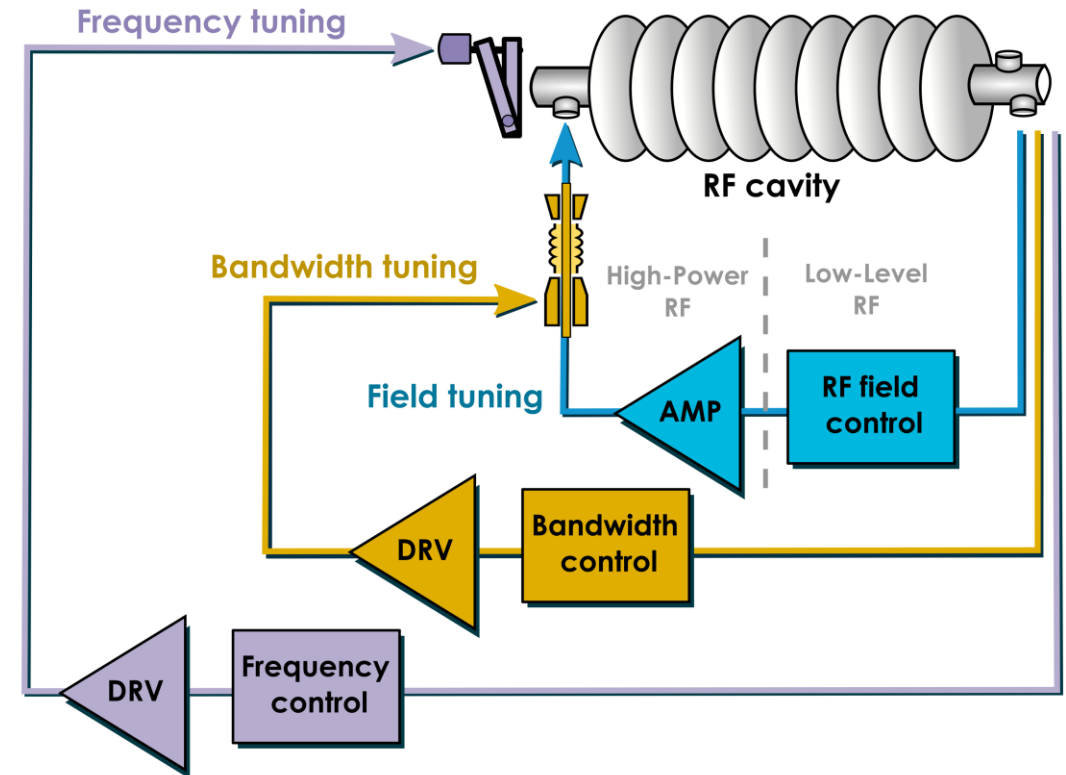
1. Introduction

- What is **LLRF**?
- **RF cavities**: equivalent circuit and main parameters
- Cavity **tuning and coupling**
- LLRF and HPRF **system overview**

Introduction

LLRF system

- Low Level Radio Frequency: **Low Level** means **low power** (i.e. $< 1\text{Watt}$)
- Our task: **digital control of accelerating fields inside the cavities**
 - Normal conducting
 - Gun 1.3 @ GHz
 - TDS Injector @ 3.0 GHz
 - TDS BC2 @ 3.0 GHz
 - Super conducting cavities
 - A1 – A25 @ 1.3 GHz
 - AH1 @ 3.9 GHz



LLRF : measures and controls

- the **accelerating field** inside the cavity
- the **bandwidth** of the cavity
- the **resonant frequency** of the cavity

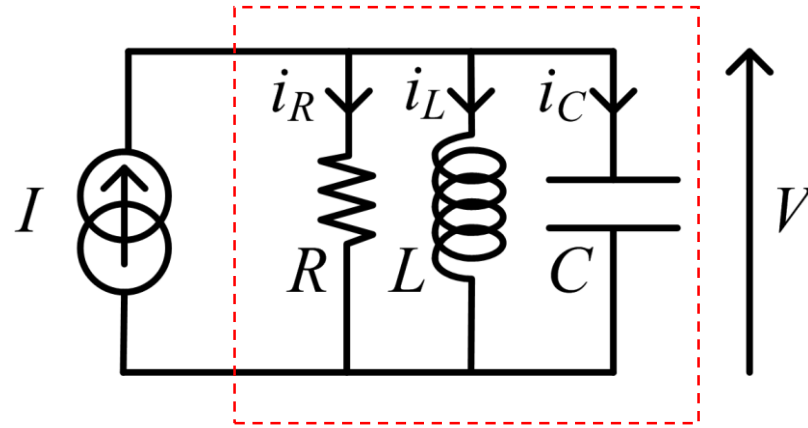
Cavity as an Electrical System

The standard RLC model (simplified)

$$i_R + i_L + i_C = I \quad (1)$$

$$i_R = \frac{V}{R}$$
$$\frac{di_L}{dt} = \frac{1}{L} V$$
$$i_C = C \frac{dV}{dt}$$

(2)



$$(1) \rightarrow \frac{di_R}{dt} + \frac{di_L}{dt} + \frac{di_C}{dt} = \frac{dI}{dt}$$

$$(1) \& (2) \rightarrow \frac{1}{R} \frac{dV}{dt} + \frac{1}{L} V + C \frac{d^2 V}{dt^2} = \frac{dI}{dt}$$

$$\rightarrow \frac{d^2 V}{dt^2} + \frac{1}{RC} \times \frac{dV}{dt} + \frac{1}{LC} \times V = \frac{1}{C} \times \frac{dI}{dt}$$

$$\ddot{V}(t) + \frac{1}{RC} \dot{V}(t) + \frac{1}{LC} V(t) = \frac{1}{C} \dot{I}(t)$$

2nd order linear differential equation has a solution in the form of

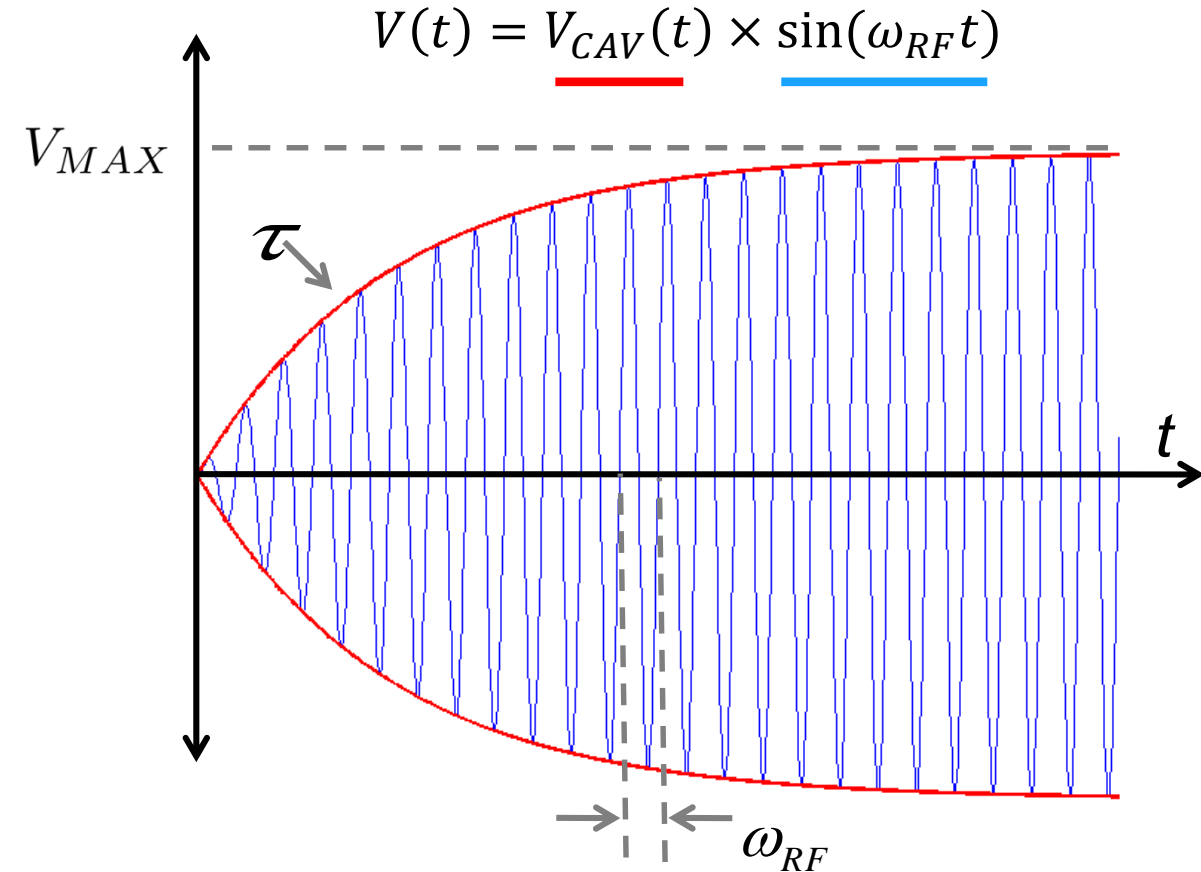
$$V(t) = V_{CAV}(t) \times \sin(\omega_{RF} t)$$

envelope

carrier

Cavity as an Electrical System

The envelope equation



V_{CAV} : envelope

$$V_{CAV} = V_{MAX}(1 - e^{-\frac{t}{\tau}})$$

τ is the **cavity time constant**

it depends on the **cavity bandwidth**

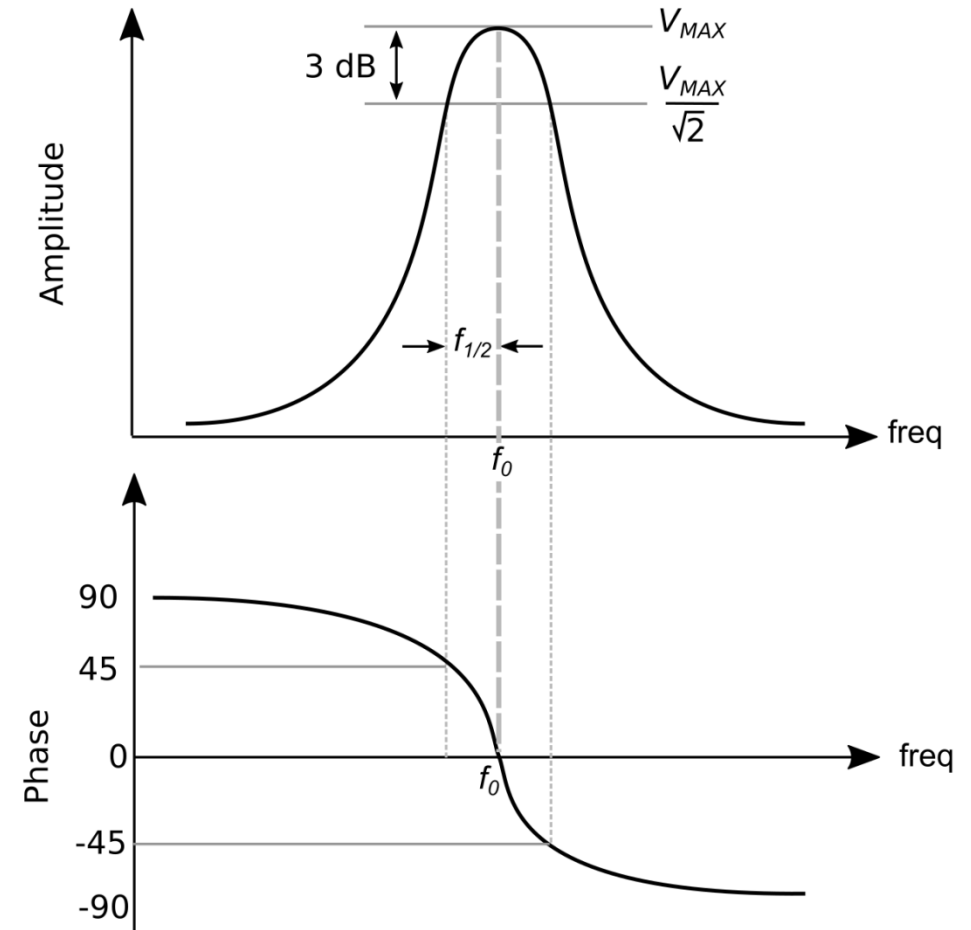
$$\tau = \frac{1}{2\pi f_{1/2}}$$

cavity half bandwidth
(i.e. half of the cavity bandwidth)

Cavity as an Electrical System

In the frequency domain

- Cavity behaves as a **band pass filter**
 - Center frequency f_0
 - Half bandwidth $f_{1/2}$

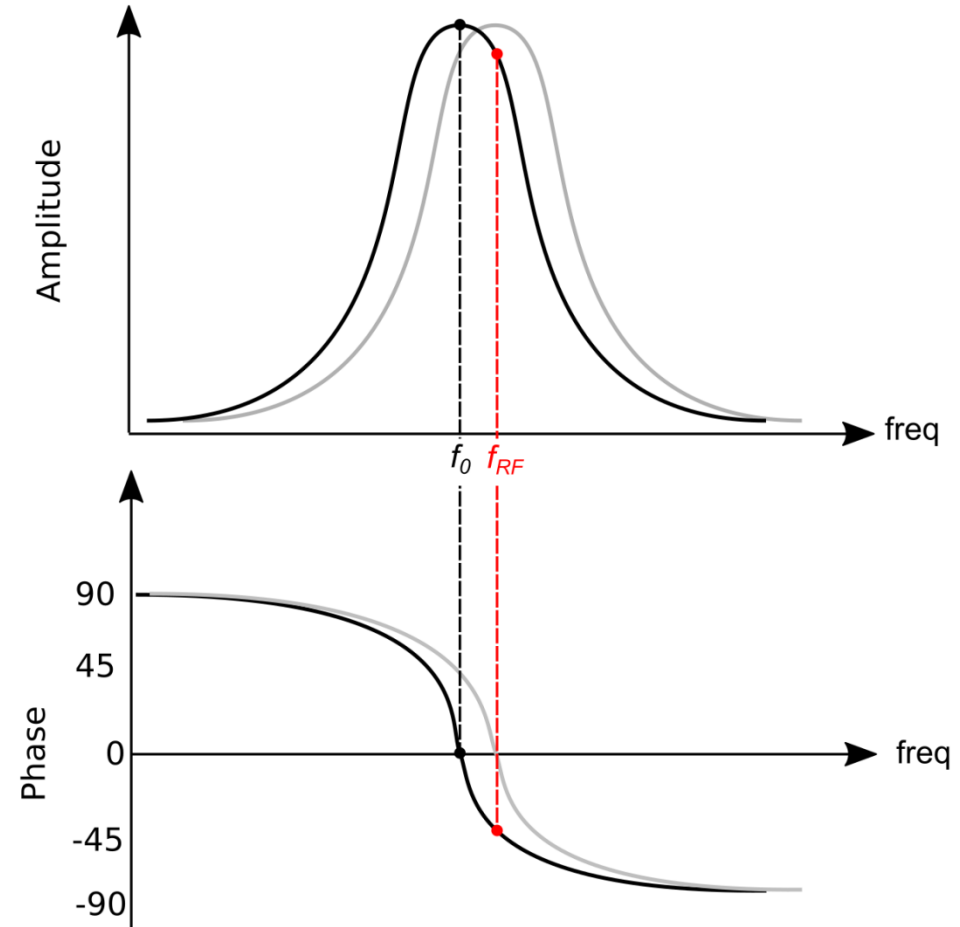


Cavity as an Electrical System

In the frequency domain

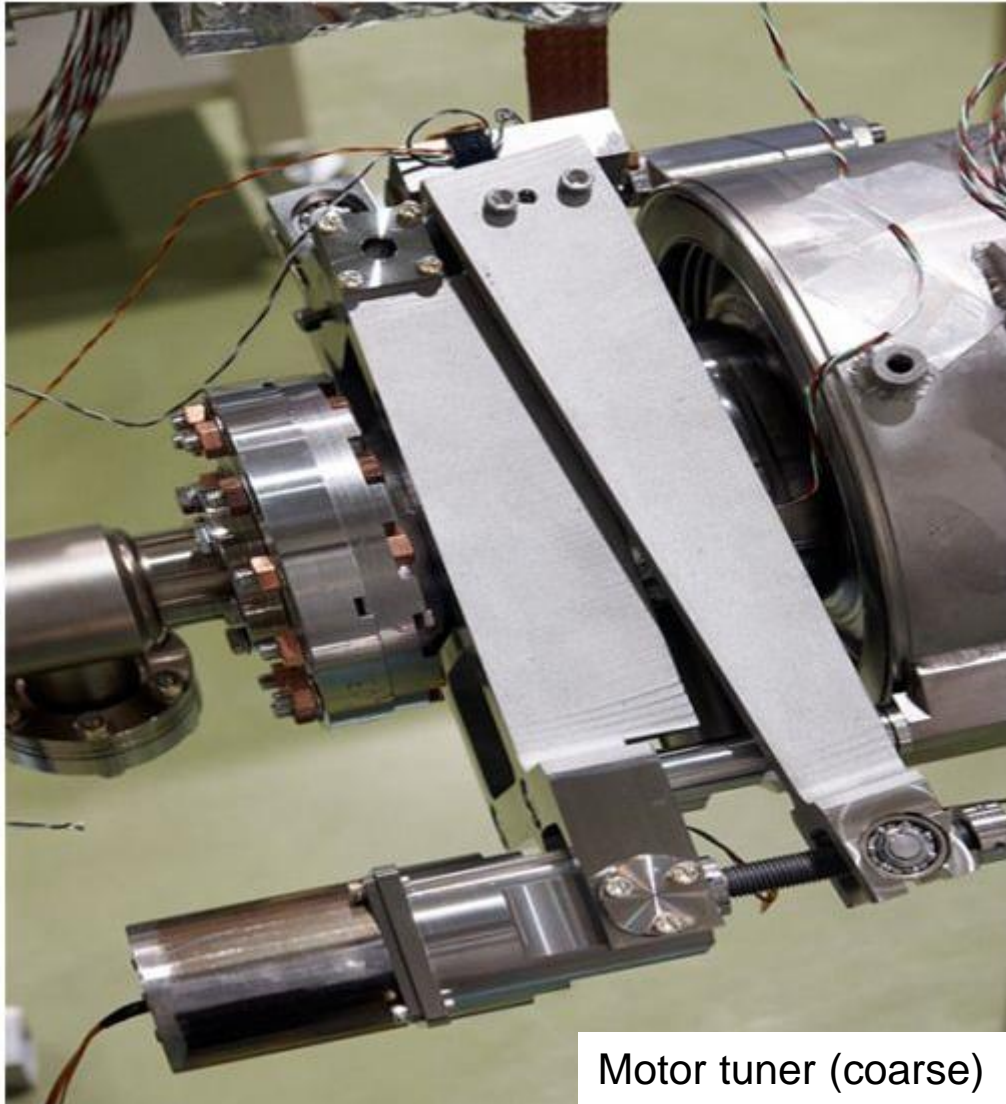
- Cavity behaves as a **band pass filter**
 - Center frequency f_0
 - Half bandwidth $f_{1/2}$
- We can define **detuning** as the difference between the **cavity center frequency** (f_0 = resonance frequency) and the frequency of the **RF drive** (f_{RF})

$$\Delta\omega = \omega_0 - \omega_{RF} = 2\pi(f_0 - f_{RF})$$

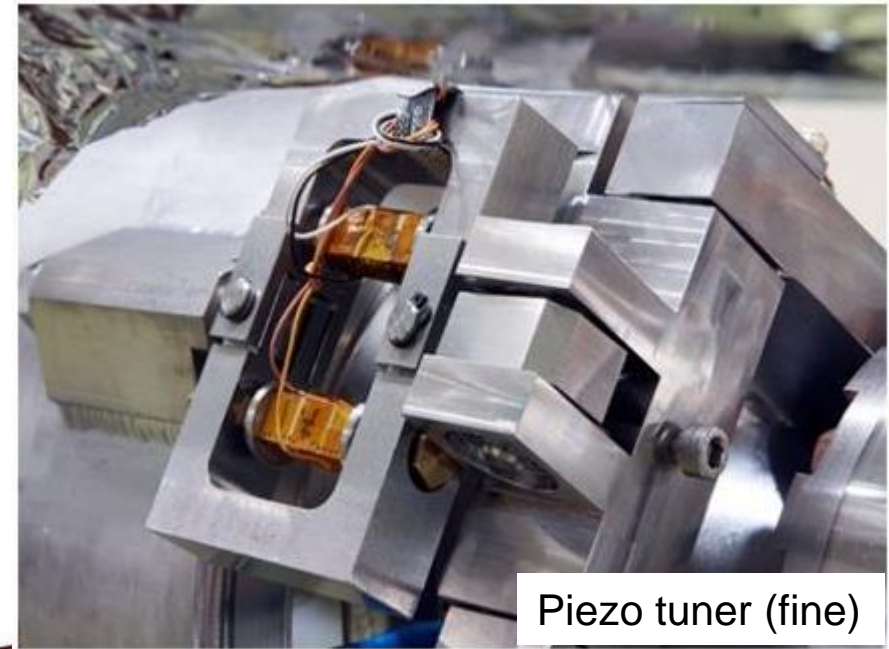


Tuner examples

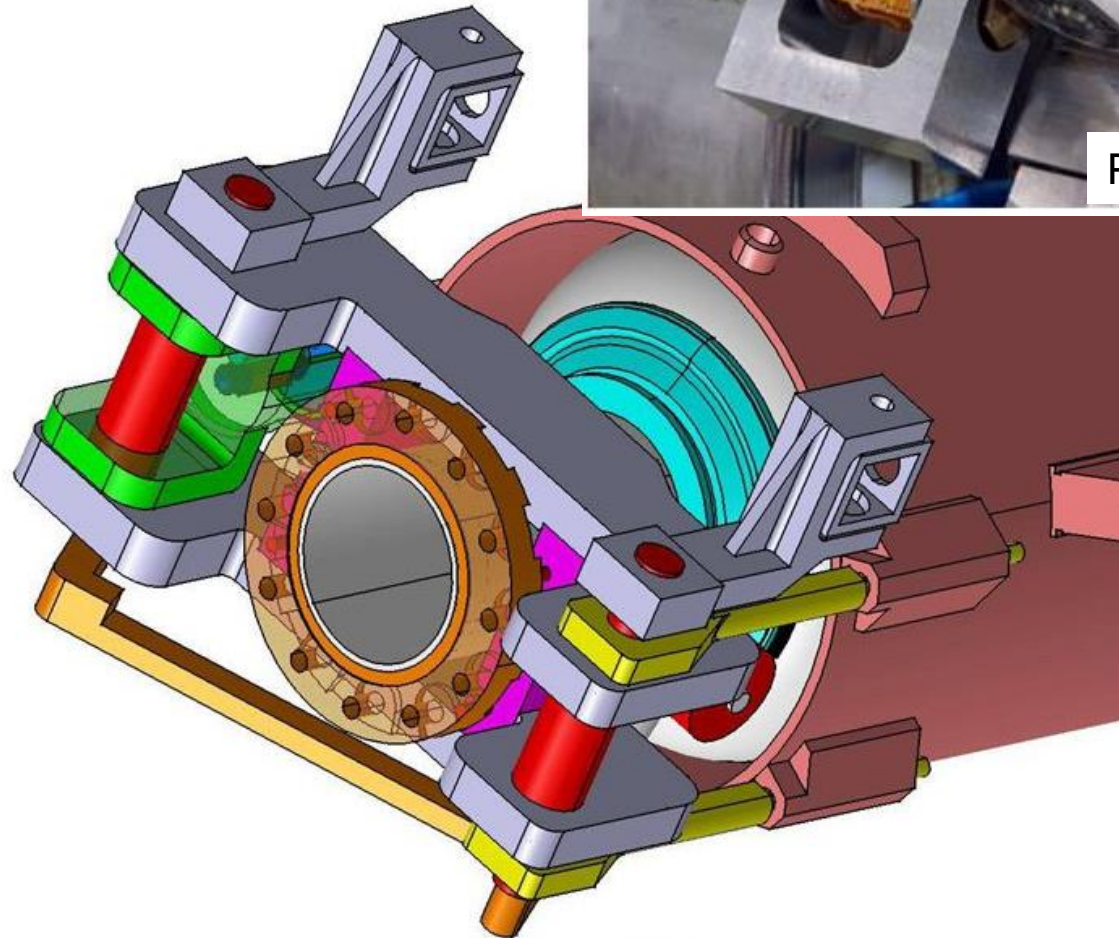
Saclay type (EuXFEL)



Motor tuner (coarse)



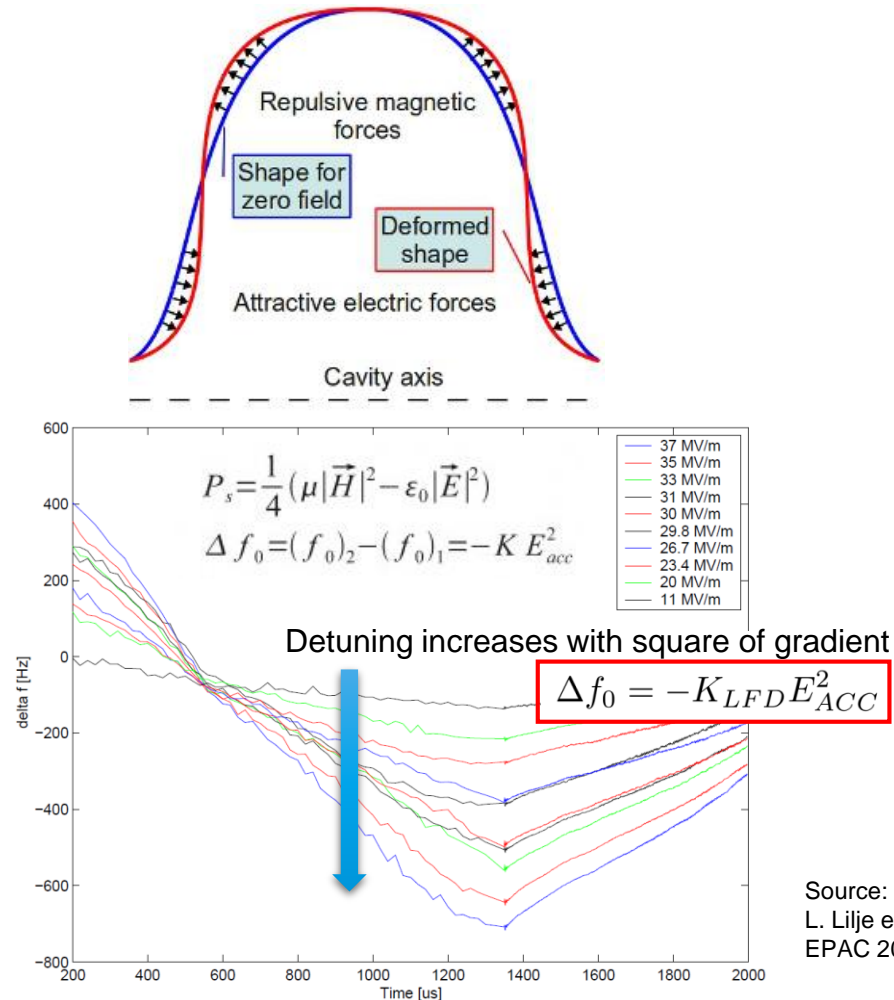
Piezo tuner (fine)



Cavity “fine” tuning

Use of piezo in pulsed mode

- Lorentz Force detuning

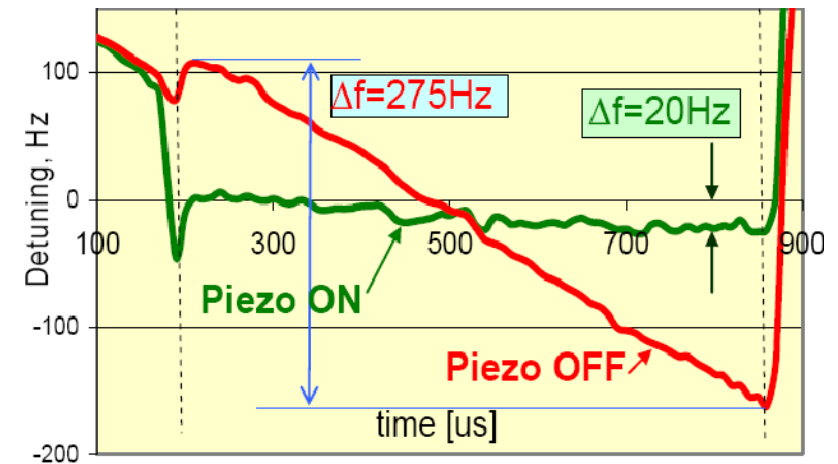
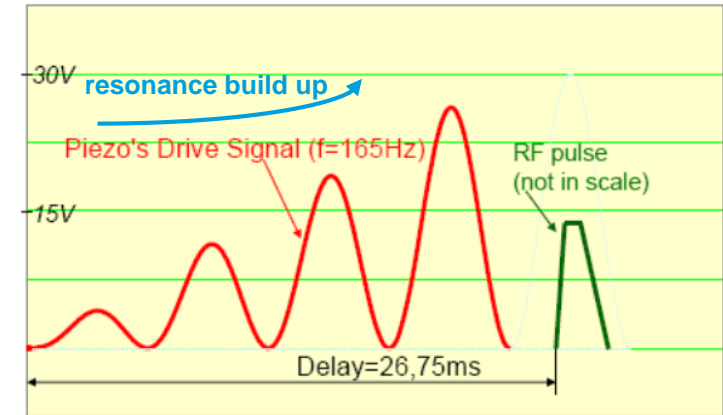


Source:
L. Lilje *et al.*
EPAC 2006

- Lorentz force detuning compensation using piezo

Piezo stimulus:

- Frequency
- Delay
- AC amplitude
- DC offset



Example from FNAL 2007
R. Carcagno *et al.* SRF 2007

Cavity coupling

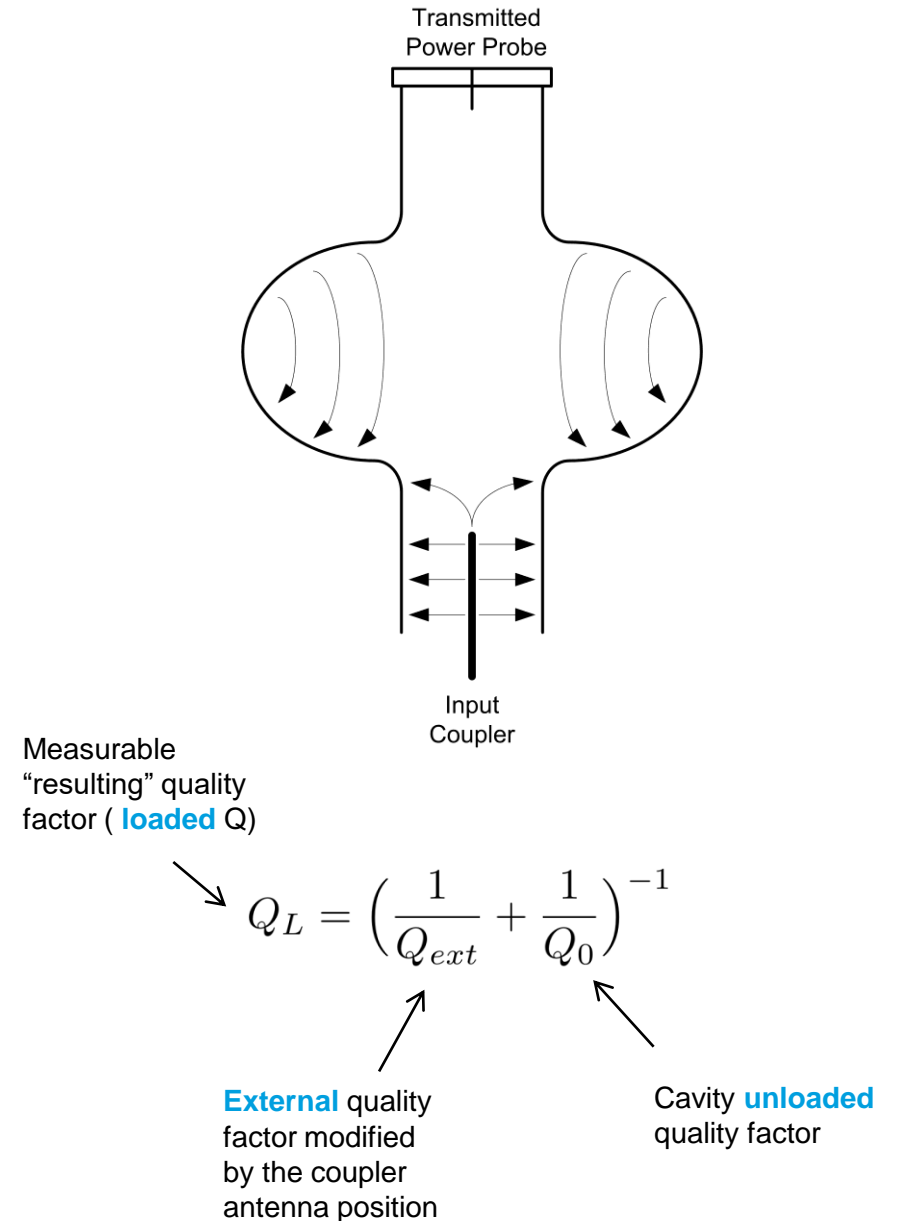
Coupling power in and out of a cavity

Input coupler

- An antenna carries power from an RF source to the cavity
- The strength of the **input coupler** is adjusted by changing the penetration of the center conductor

Output coupler (pick up)

- the **transmitted power probe** (fixed coupler) picks up power transmitted through the cavity



Cavity coupling

Understanding unloaded, loaded and external coupling

- **Q_0 = unloaded** quality factor
 - Measured without the cavity power coupler
 - Is a direct indication of the power dissipated in the cavity walls (high $Q_0 \rightarrow$ low losses)
- **Q_{ext} = external** quality factor
 - Can be changed when moving the coupler antenna
 - Impacts how the incoming RF power couples into the cavity
 - High Q_{ext} means slow response time, but less power required to reach high gradient
- **Q_L = loaded** quality factor
 - “Resulting” or “Effective” quality factor
 - Is what can be measured during operation
 - Changes in Q_0 are masked by Q_{ext}

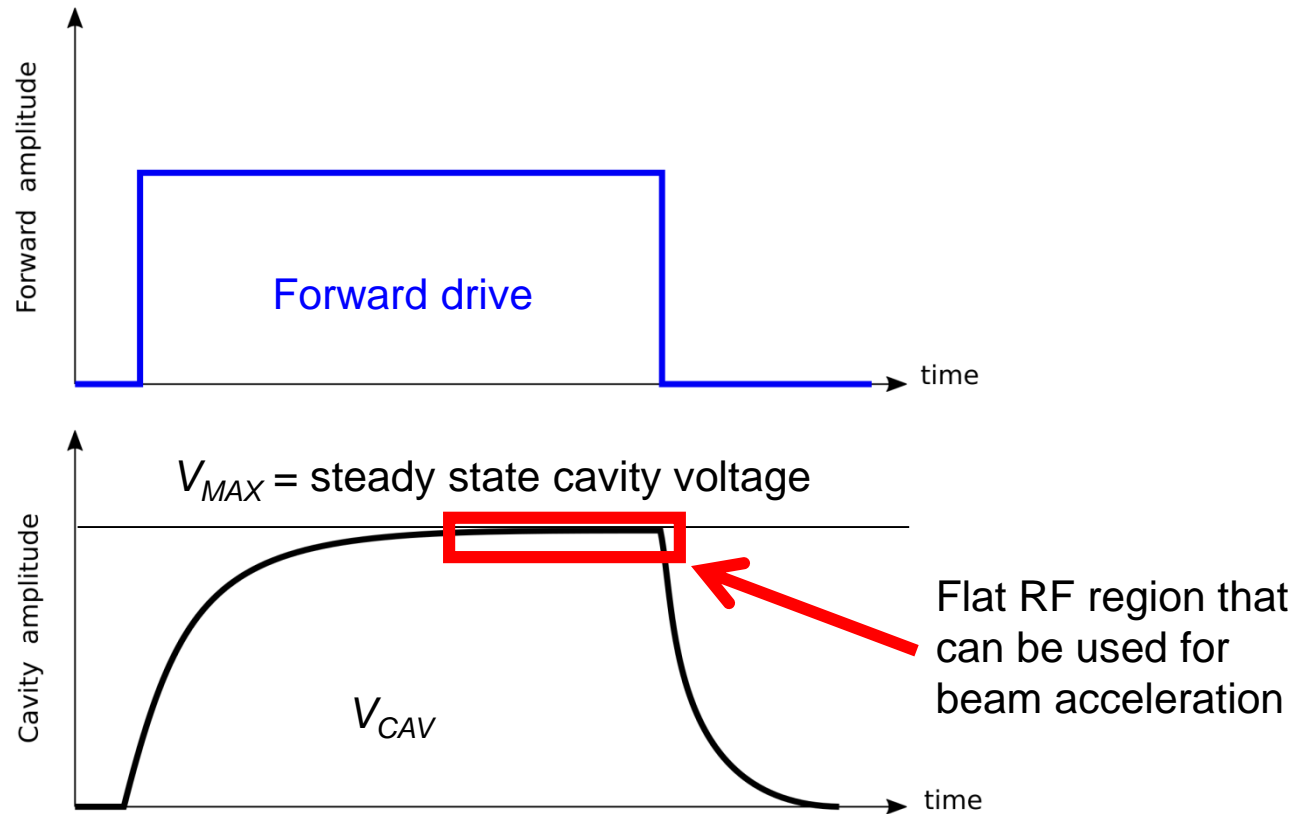
$$\frac{1}{Q_L} = \frac{1}{Q_0} + \frac{1}{Q_{ext}}$$

$\sim 10^6$ $\sim 10^{10}$ $\sim 10^6$

LLRF System

Feed Forward

- Cavity response to a square pulse



Q_L affects the cavity rate of filling and cavity bandwidth

Q_L is there $\rightarrow \tau = \frac{Q_L}{2\omega_0} = \frac{1}{2\pi f_{1/2}}$

$$V_{CAV} = V_{MAX}(1 - e^{-t/\tau})$$

$$V_{MAX} = 2\sqrt{P_{FWD} \frac{R}{Q} Q_L}$$

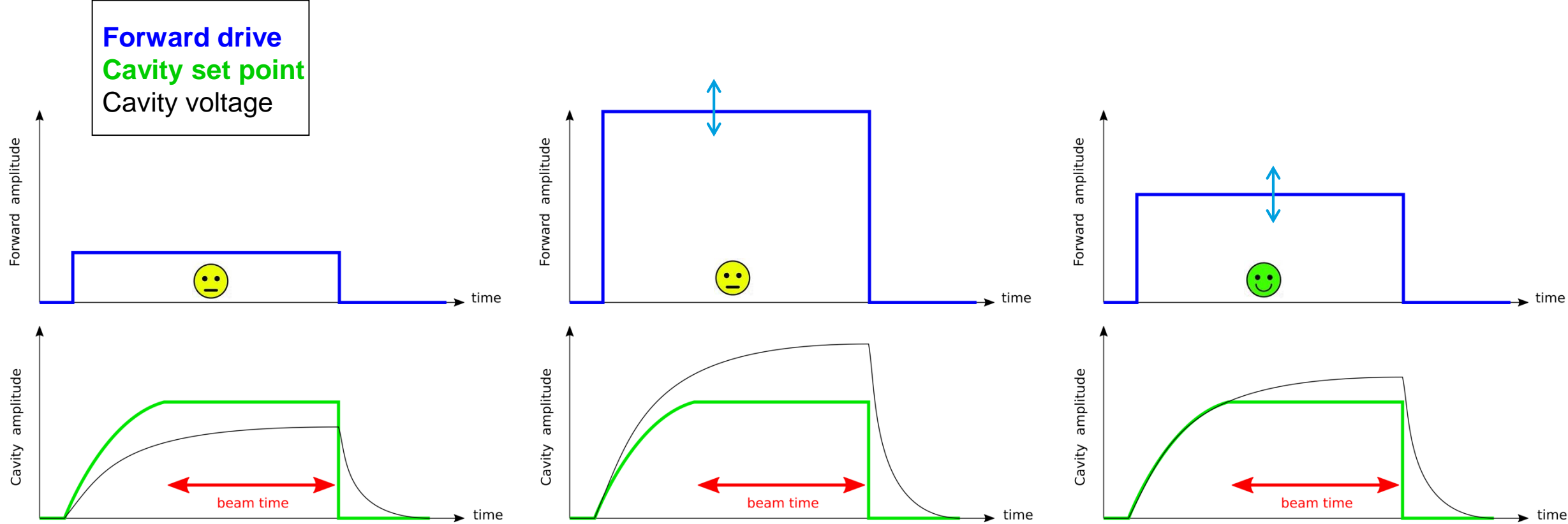
Q_L is there

Q_L affects the cavity maximum voltage (for a given forward power)

LLRF System

Feed Forward

- Adjust amplitude of the **forward drive** to match the set point gradient **at the beginning of the beam time**



OVC amplitude!

Output Vector Correction

☒ On

Ampl

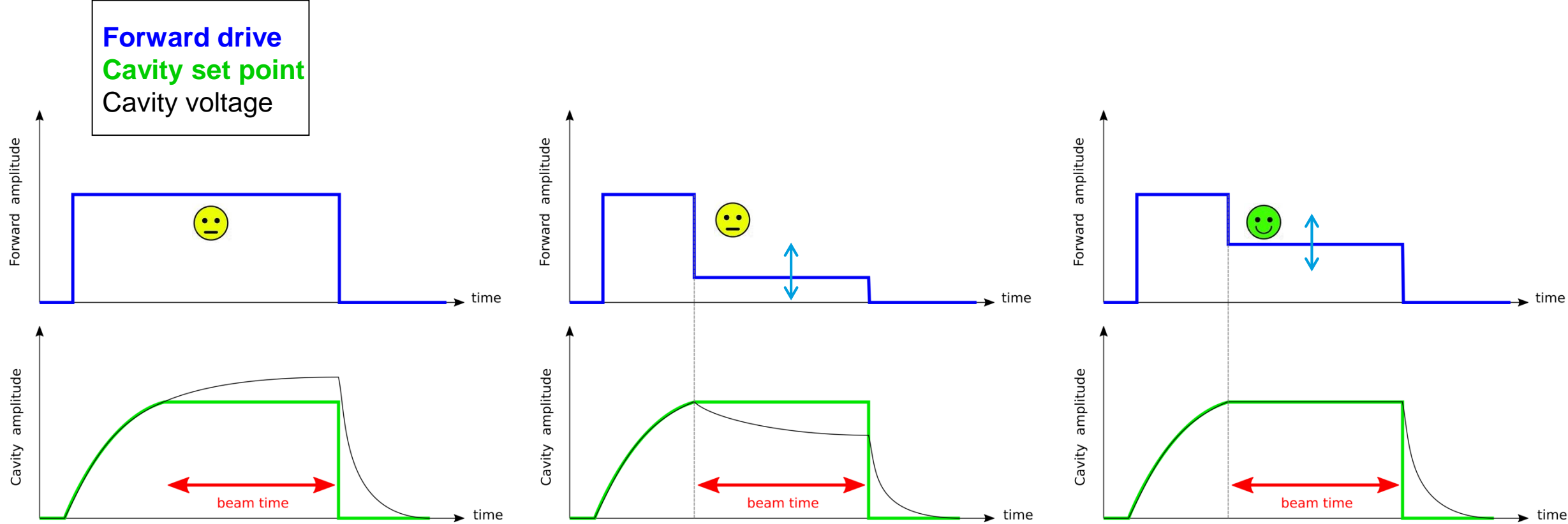
Phase

Ratio

LLRF System

Feed Forward

- Adjust the drive during the beam time to maintain a flat accelerating gradient



OVC ratio!

Output Vector Correction

☒ On

Ampl

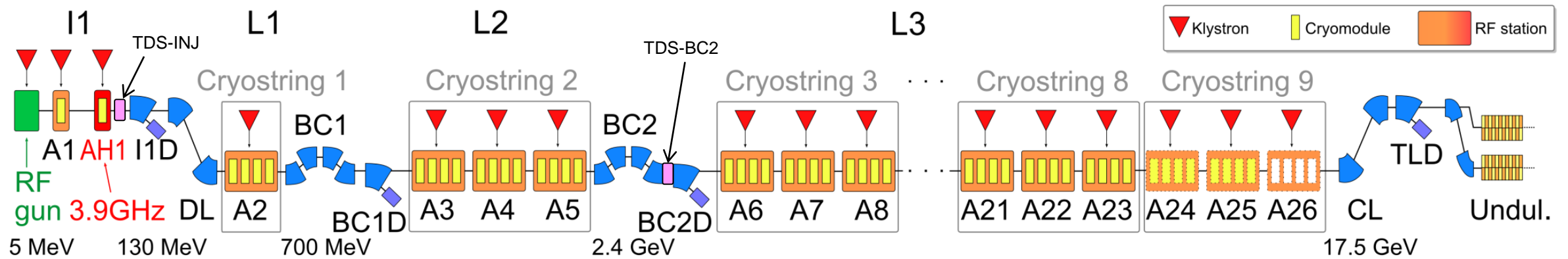
Phase

Ratio

Introduction

LLRF Systems

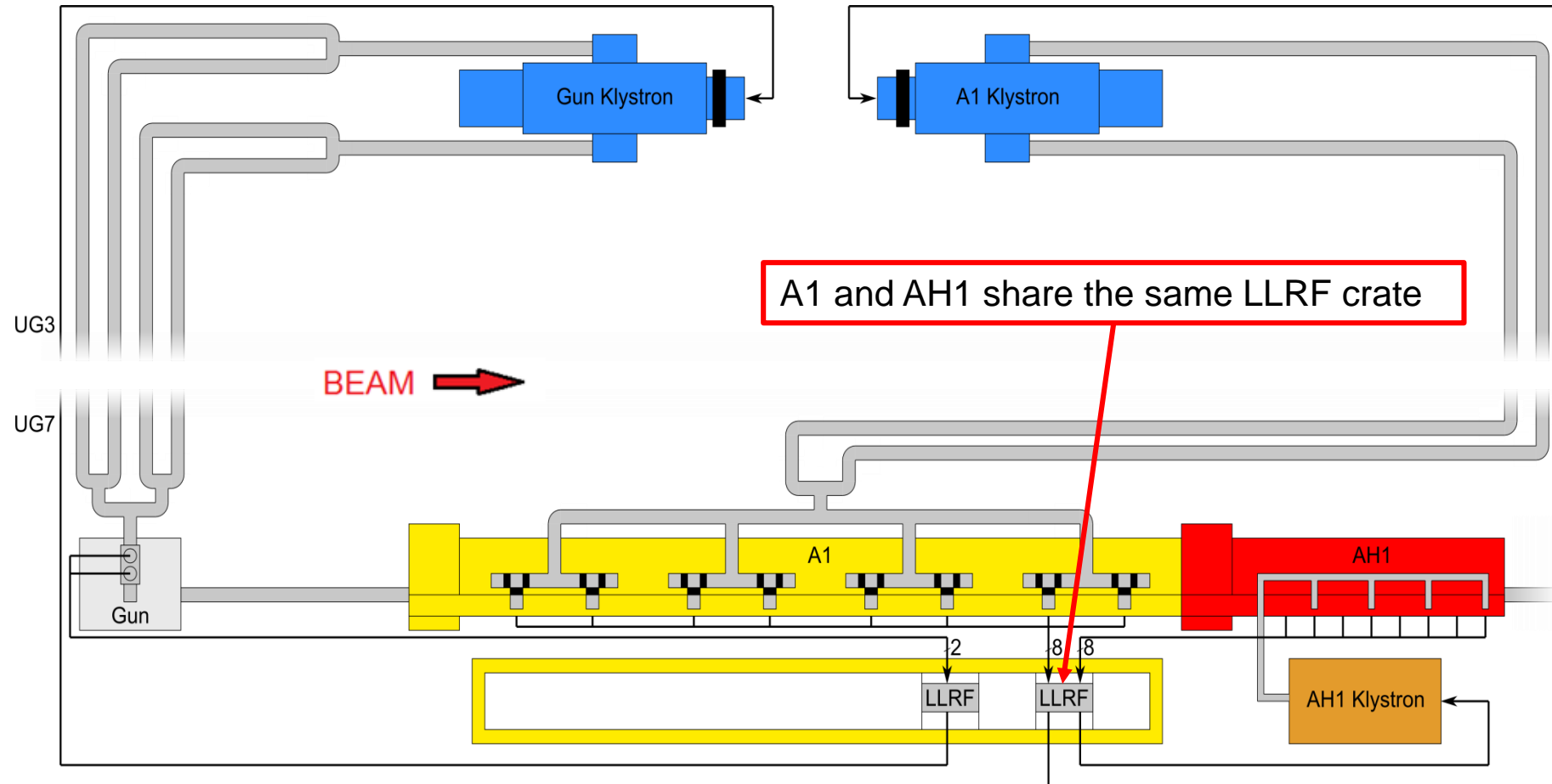
- Where are we involved?
 - In every RF station
 - 29 LLRF systems



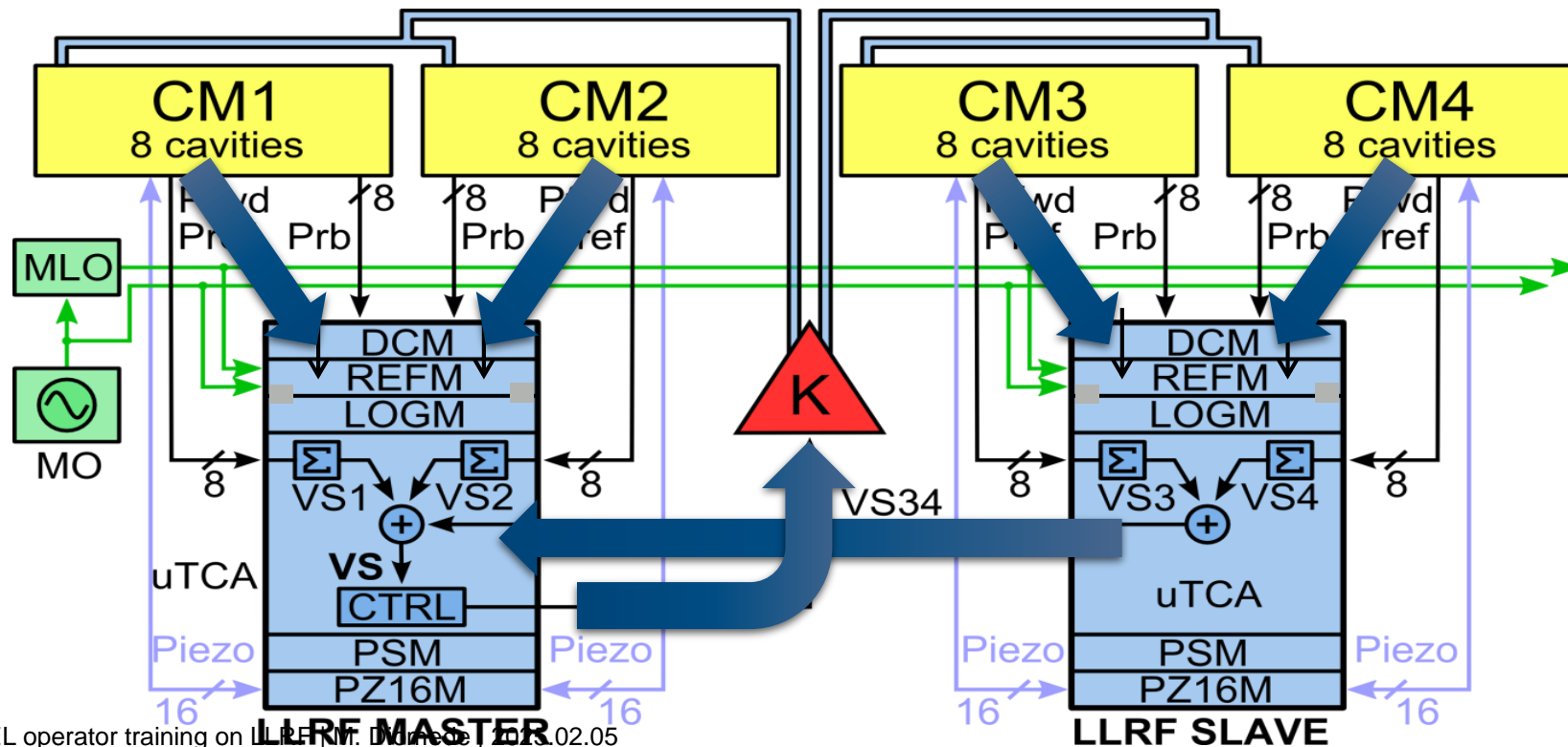
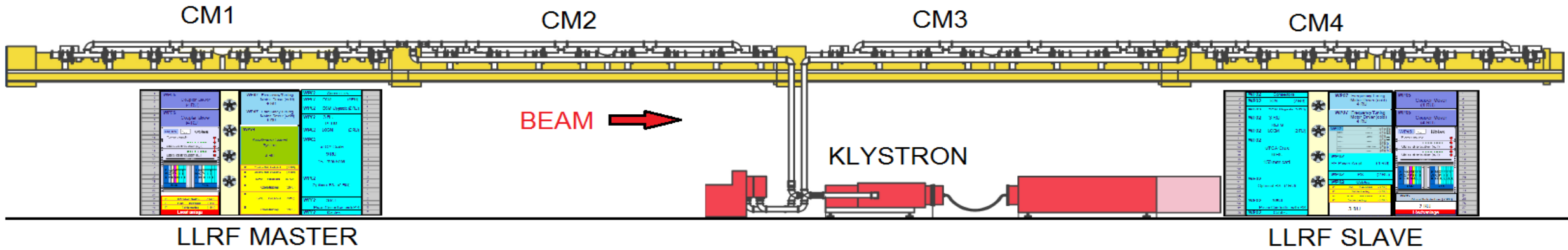
Introduction

LLRF Systems

- RF Stations in the **injector**



Introduction : LLRF Station Overview



DCM
Drift Compensation Module

REFM
RF Reference Module

LOGM
Local Oscillator Generation Module

PSM
Power Supply Module

PZ16M
Piezo Driver Module

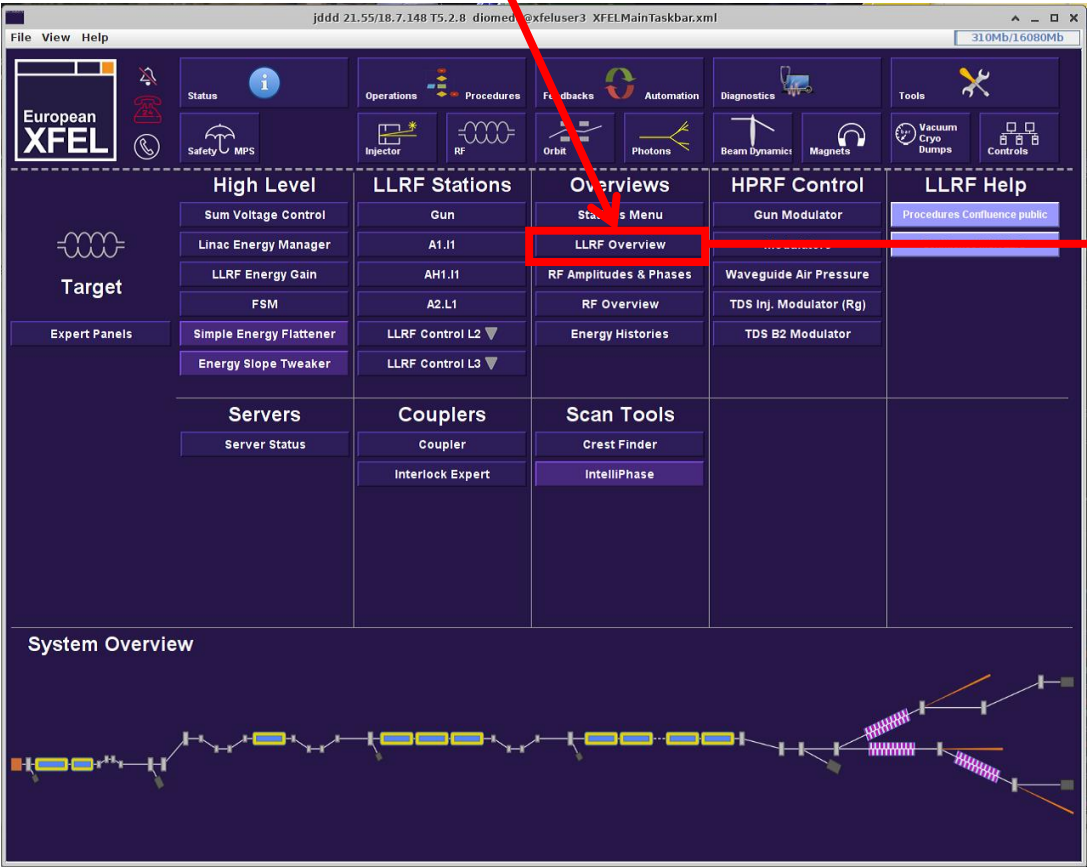
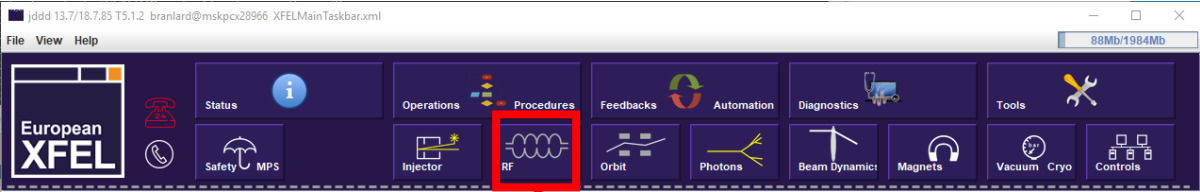
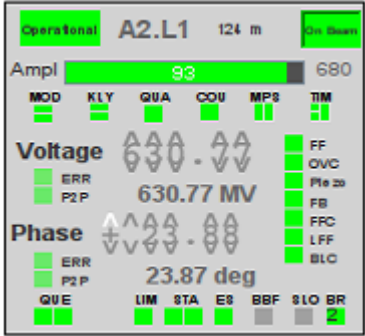
2. What an operator should know

- LLRF tasks of the XFEL operator:
 - Turn an RF station **ON / OFF**
 - Adjust the vector-sum **voltage / phase**
 - **Tune** cavities, if necessary
 - Adjust **output vector correction** and **ratio**, if necessary
 - Set a certain phase as **on-crest phase**

What an operator should know

LLRF overview

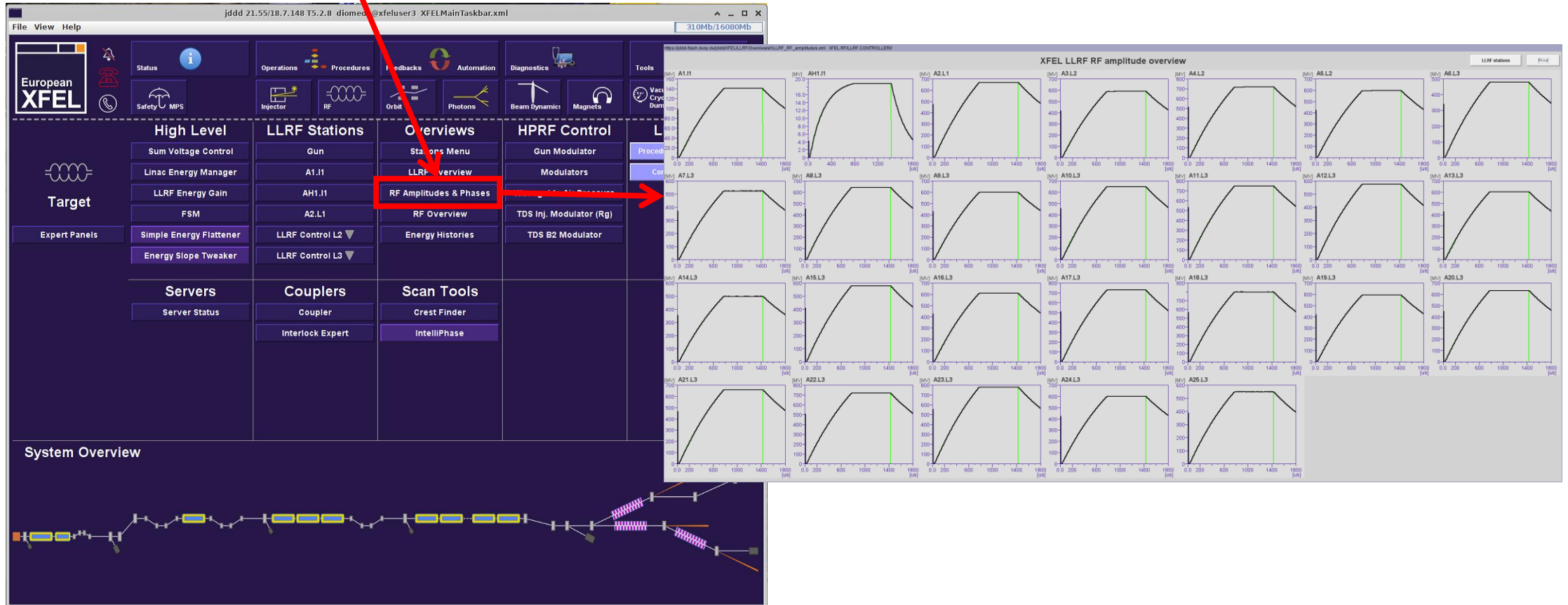
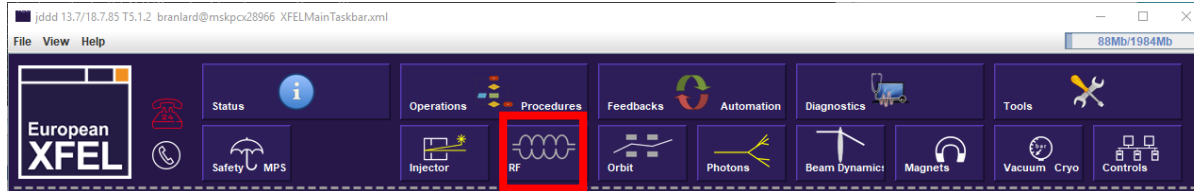
Check amplitude and phase set point, RF control settings and flat tops



What an operator should know

RF Amplitudes

Check waveform profiles
(open loop, glitches, etc...
i.e. deviation from set point)



What an operator should know

LLRF selector

Navigate to the main LLRF panel of a particular RF station: INJ, L1, L2, L3

The screenshot displays the European XFEL LLRF control interface. The top menu bar includes 'File', 'View', and 'Help'. The main interface is divided into several sections:

- Top Panel:** Contains icons for Status, Operations, Procedures, Feedbacks, Automation, Diagnostics, Tools, Safety, MPS, Injector, RF, Orbit, Photons, Beam Dynamics, Magnets, Vacuum, Cryo, and Controls. The 'RF' icon is highlighted with a red box.
- Left Panel:** Contains 'Main Select' (Main Overview, LLRF Status, RF Control, FSM, FSM Logs, LLRF Overview) and 'Other' (LLRF Energy Gain, Sum Voltage Control, Linac Energy Manager, Energy Histories, RF Amplitudes, KLM overview).
- Center Panel:** Contains 'LLRF Stations' (Stations Menu, Gun, A1.L1, AH1.L1, A2.L1, LLRF Control L2, LLRF Control L3) and 'Scan T' (IntelliPh, Set On-Crest Phase, On-crest set (server)).
- Right Panel:** Contains 'XFEL - LLRF overview' (INJ1, L1, L2, B2, L3, TEST/SPARE) and 'LLRF Help' (Commissioning Help, Recommissioning Help, Trouble shooting).
- Bottom Panel:** Contains 'System Overview' and 'LLRF Performance' (RF Stability Monitor).

A red arrow points from the 'RF' icon in the top panel to the 'LLRF Stations' menu in the center panel. Another red arrow points from the 'LLRF Stations' menu to the 'Stations Menu' sub-menu.

What an operator should know

Scalar/Table mode

Voltage setpoint

Phase setpoint

Ramp station with FSM

Check for ON,

FSM should be green

FSM recovery voltage

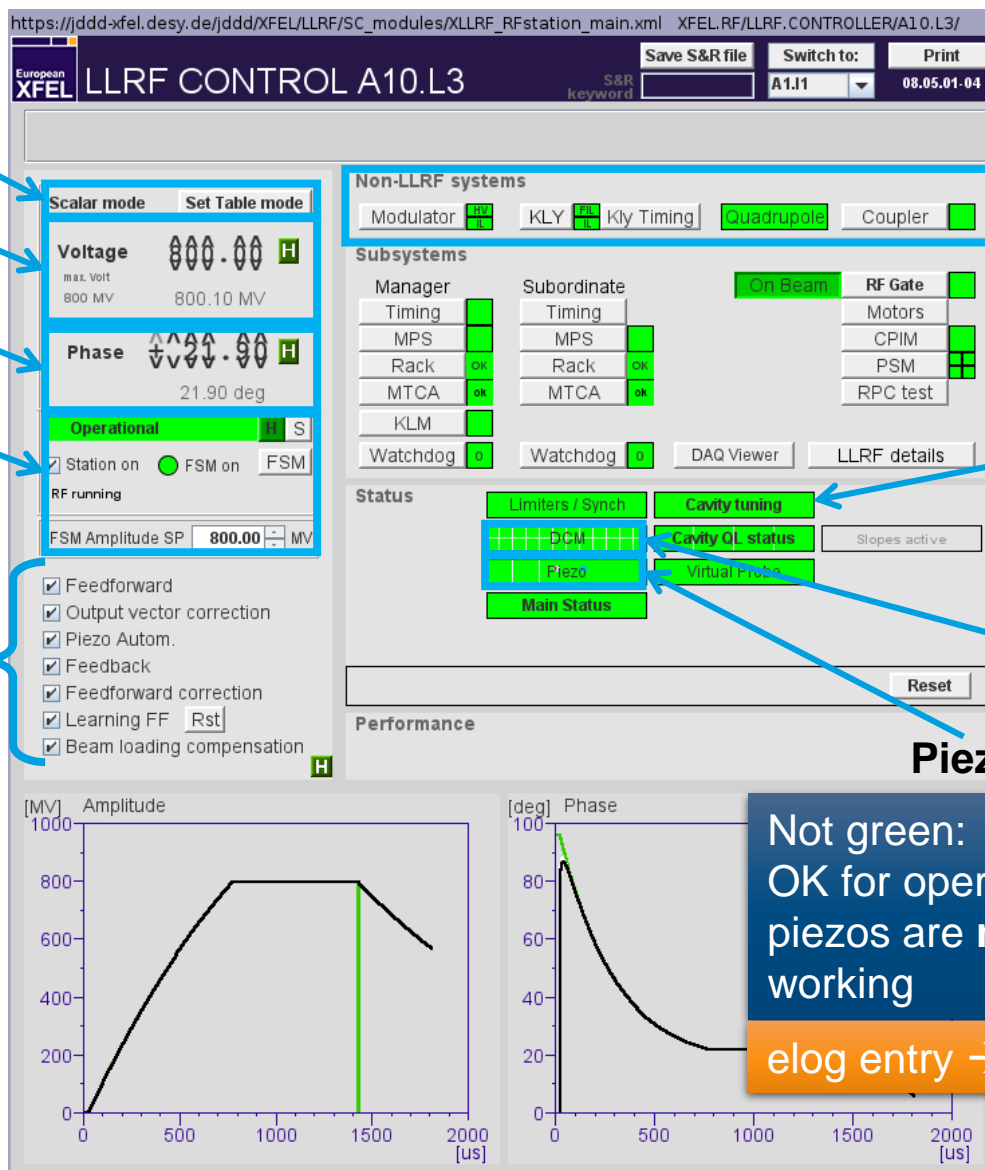
Quench notifications

ALL these settings
should be enabled*

* exception gun

Ramp-down
(open loop)

Ramp-up



Non-LLRF systems!

Cavity tuning
indicator
(should be green)

Drift
compensation
module (DCM)

Piezo

Not green:
OK for operation but
piezos are **not**
working

eelog entry → LLRF

Not green:
OK for operation
but drifts are **not**
compensated

eelog entry → LLRF

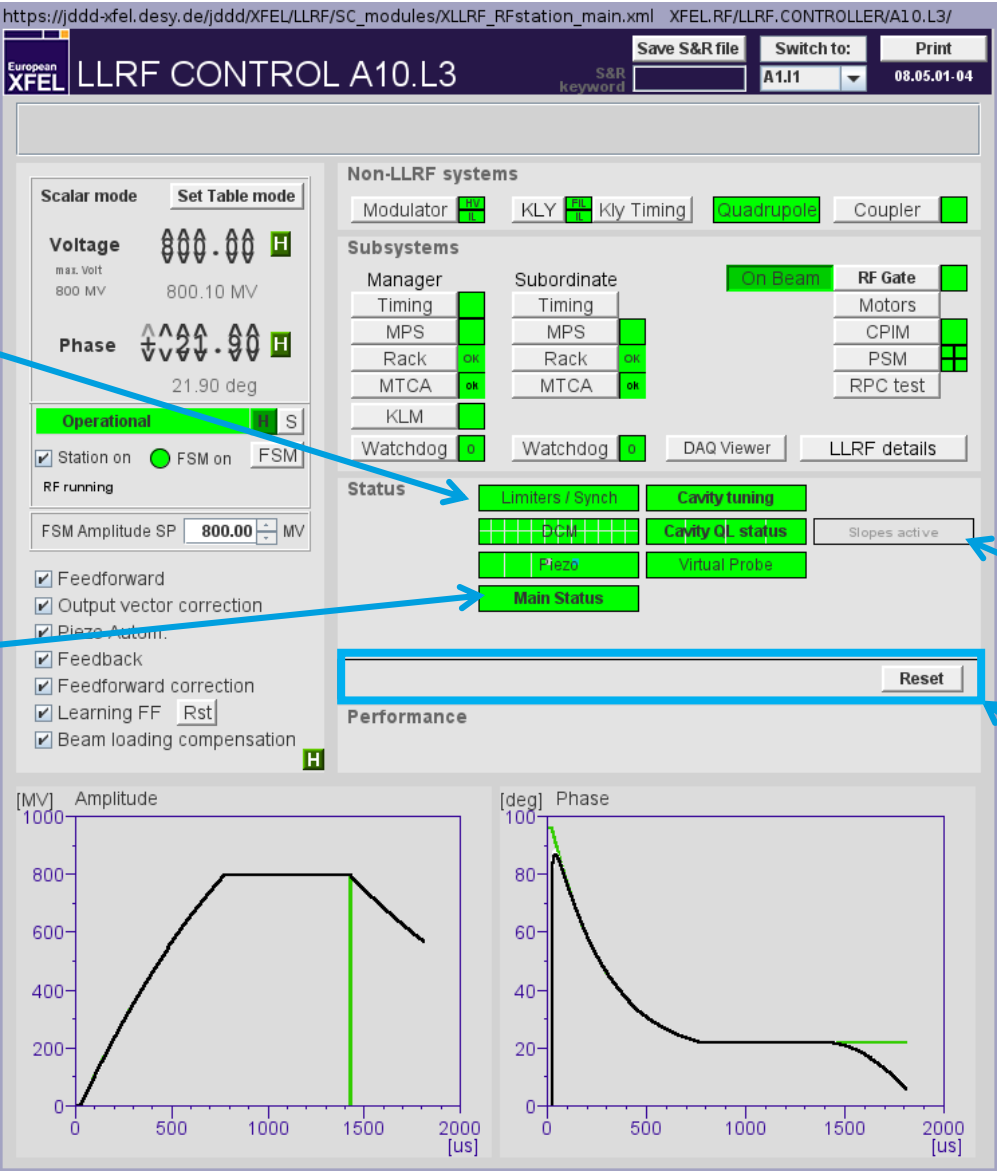
What an operator should know

Limiters

Not green:
Might lead to RF pulse cuts
elog entry → LLRF

Main status

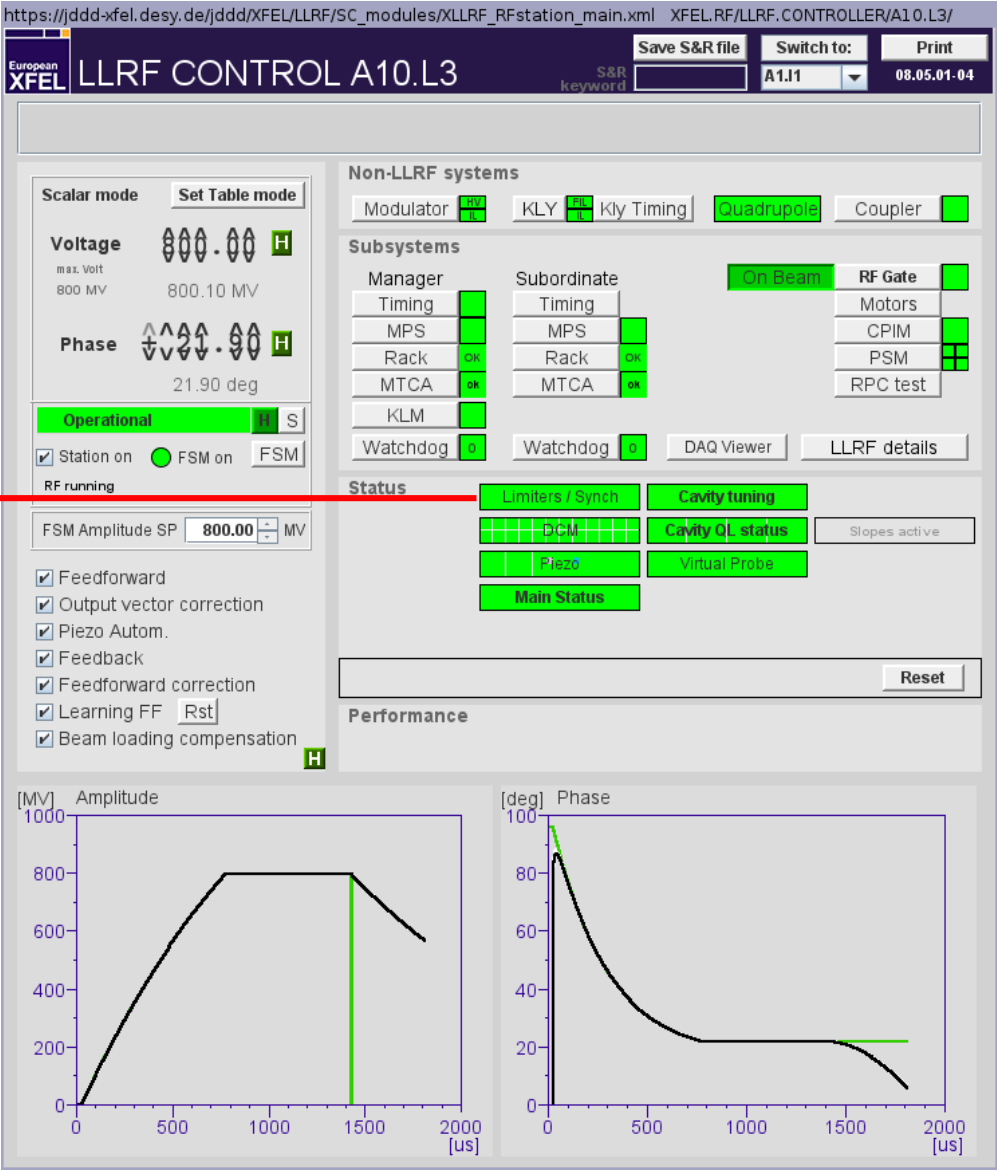
Not green:
Operation might still be possible
elog entry → LLRF



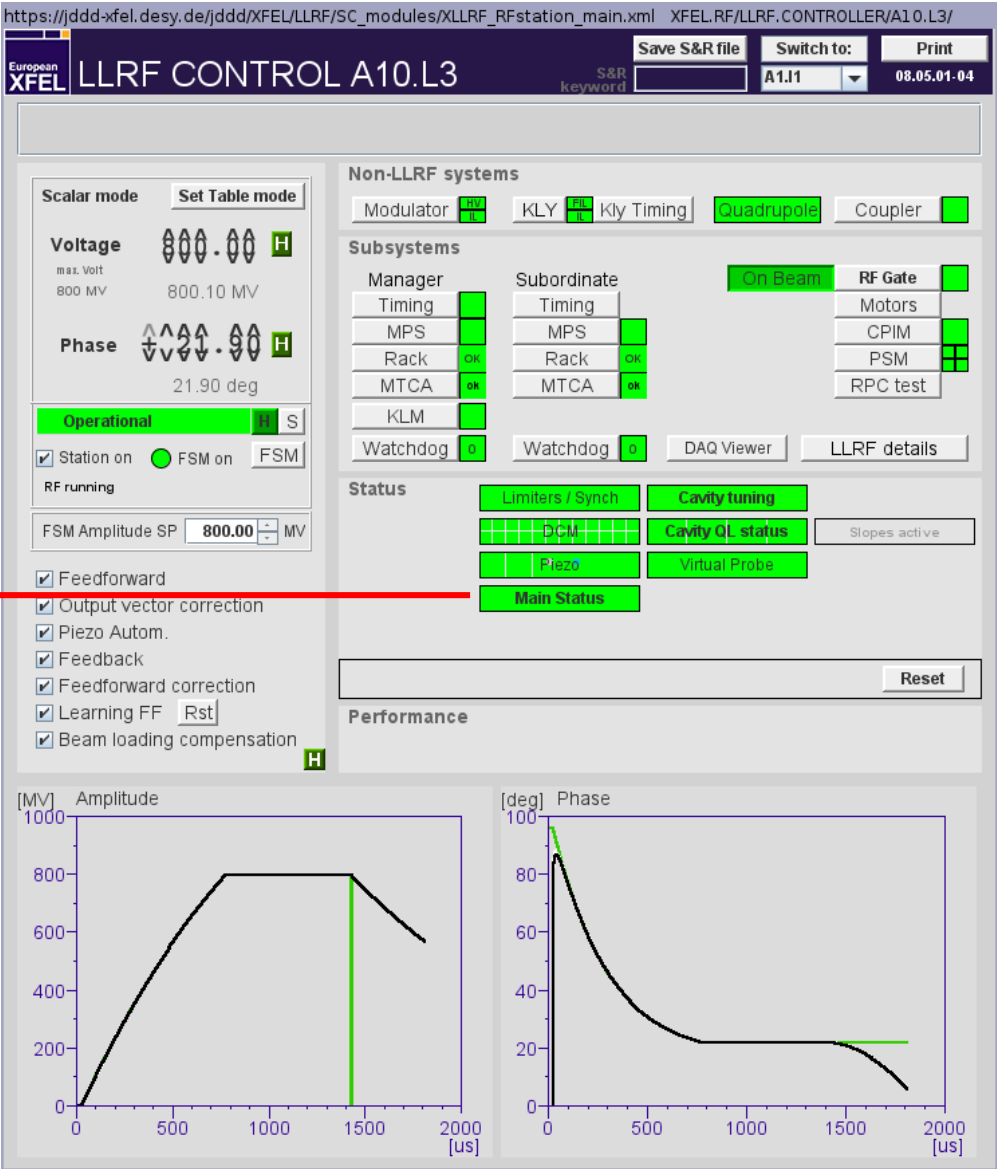
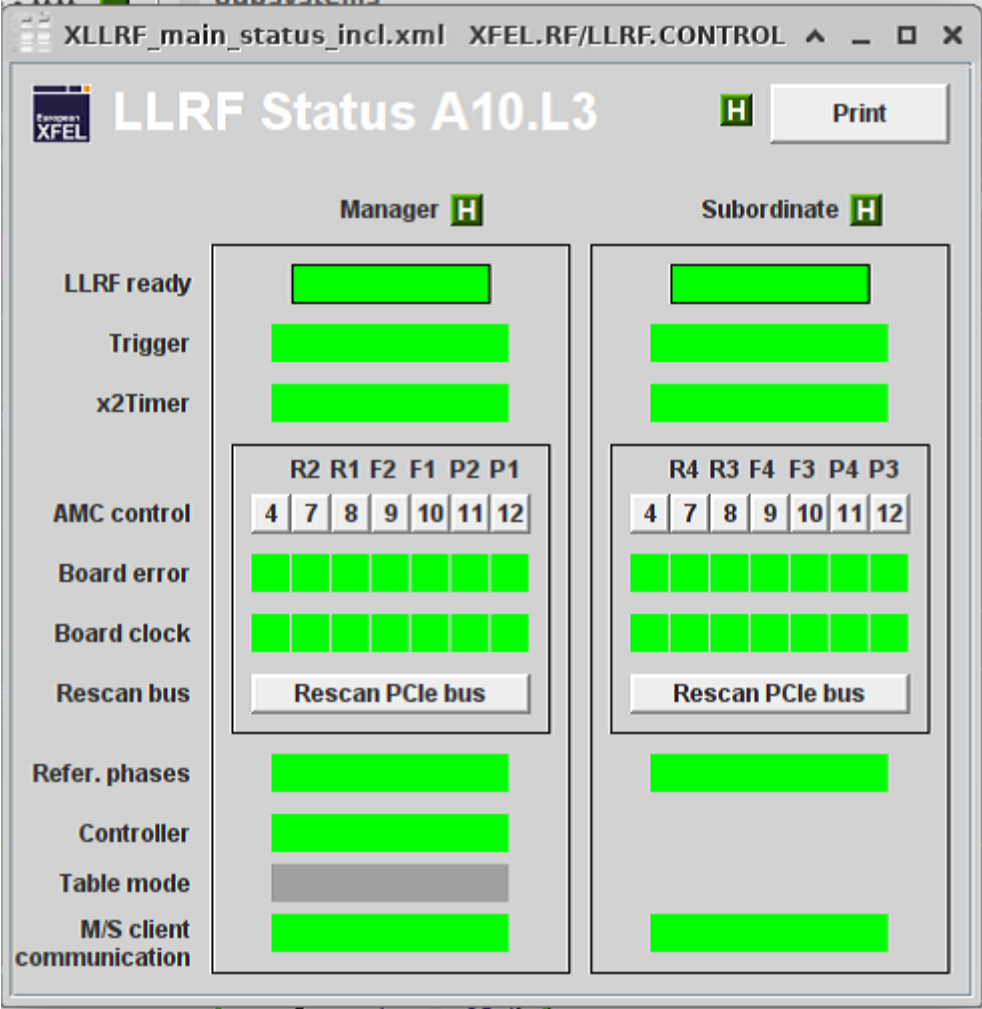
Slopes active (yellow):
i.e. RF slope across the flat top

Error message area
(it self-clears after 5 minutes after the error is gone)

What an operator should know

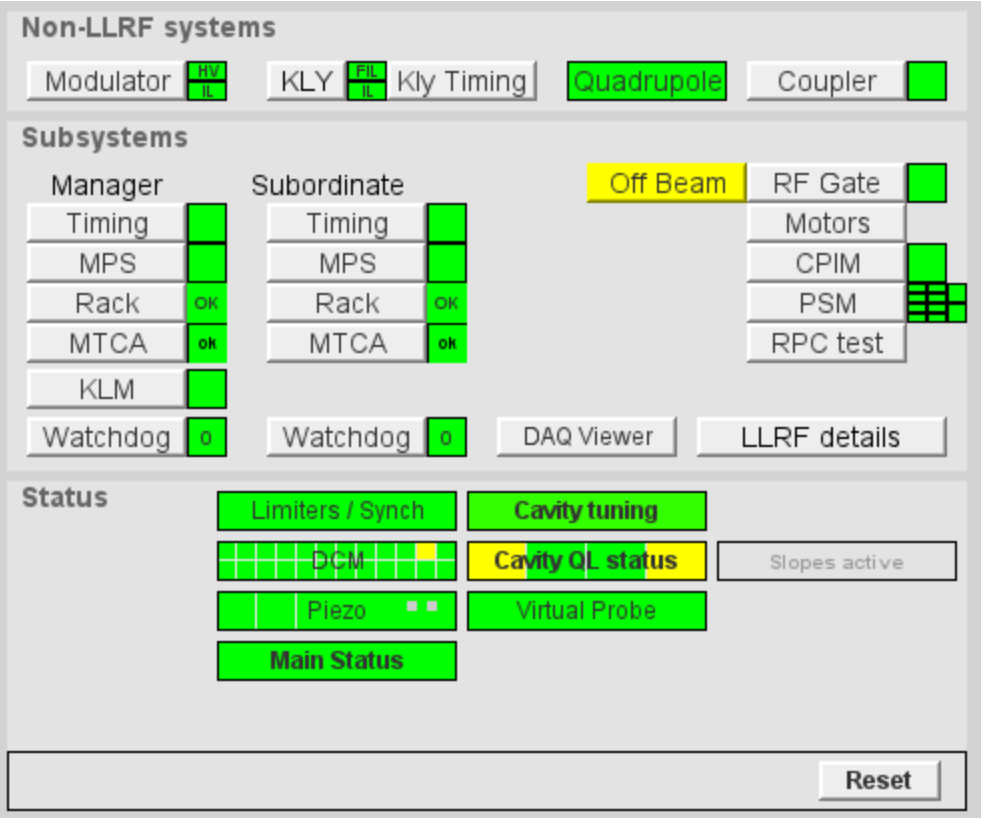


What an operator should know

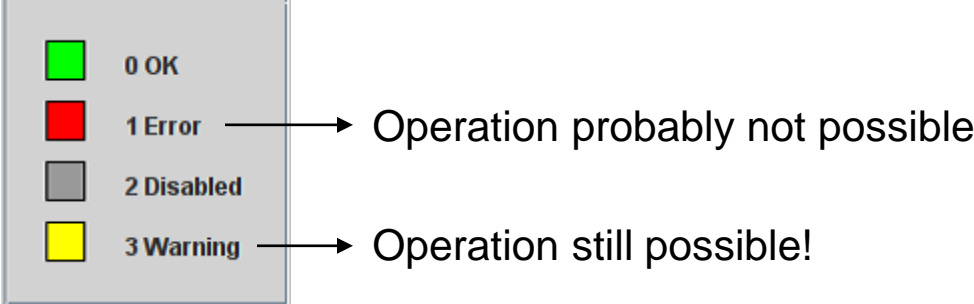


What an operator should know

LLRF color code



Color code

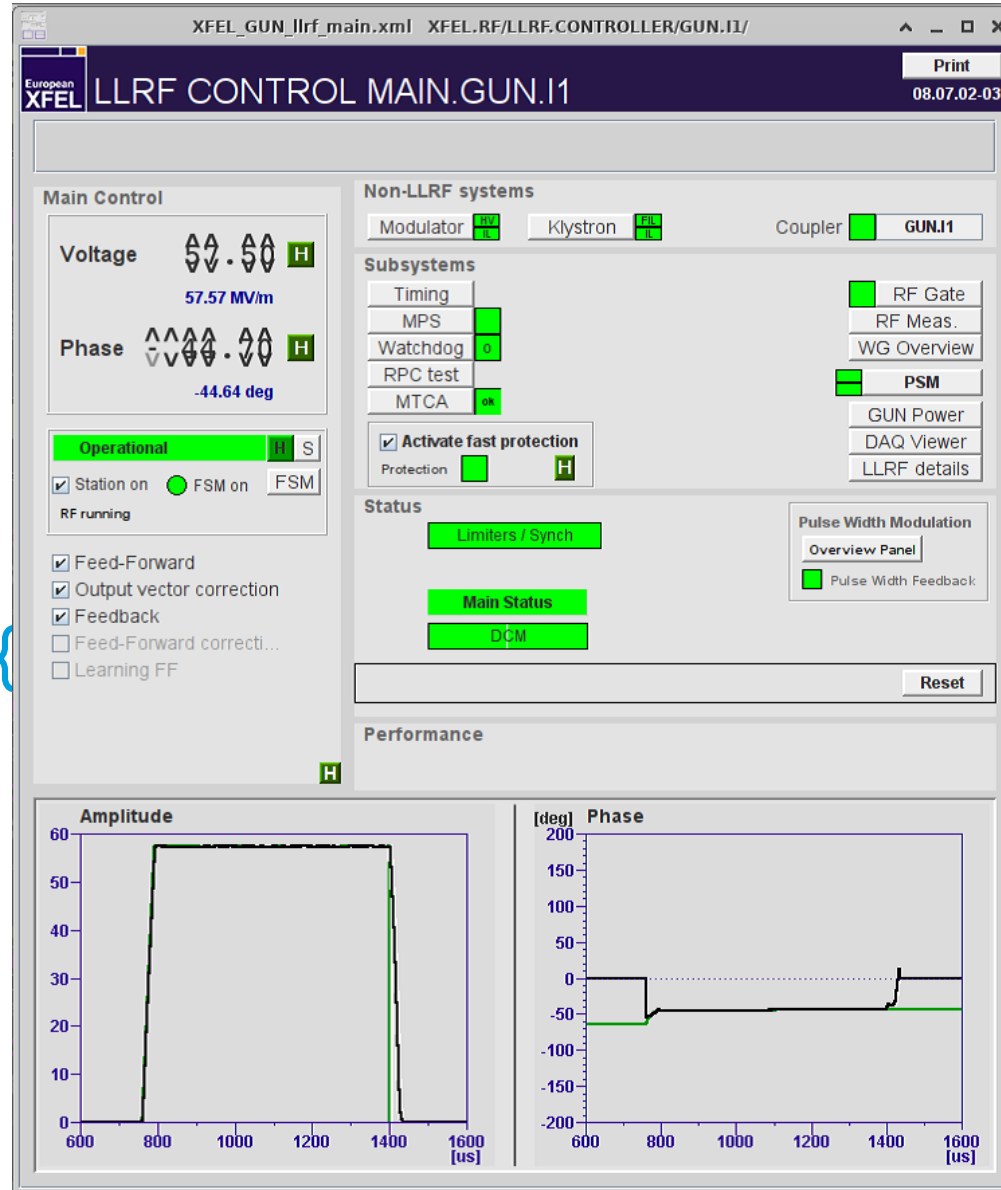


What an operator should know

Special case GUN

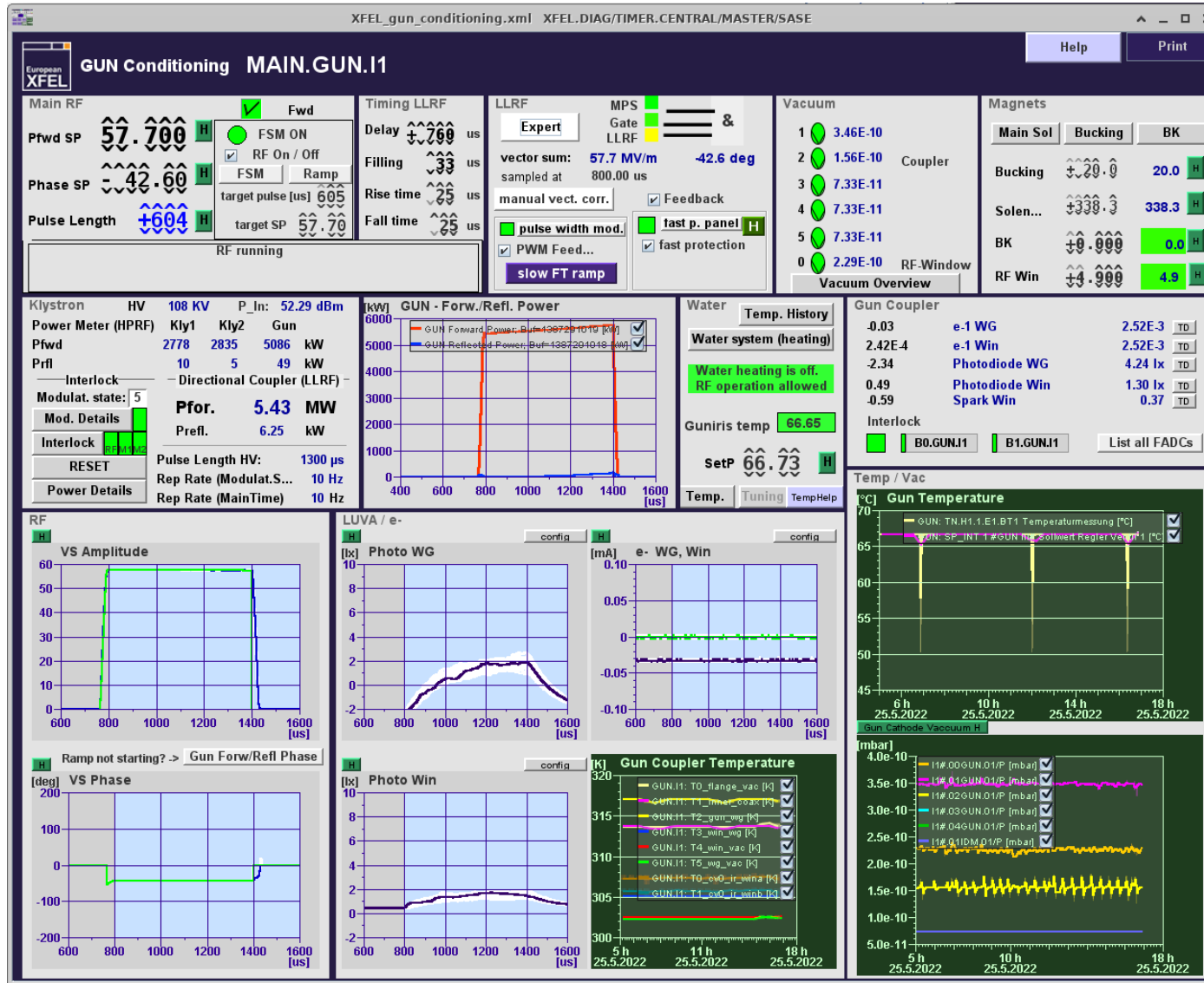
Note that for the gun, the following features are **greyed out** and should stay **disabled**:

- Feed-forward correction
- Learning FF



What an operator should know

Special case GUN



More familiar

What an operator should know

Drive with FF only (i.e. **open loop**)
no feedback trying to minimize error
between signal and set point

Linear scaling of amplitude and phase
drive to minimize error (automation)

Enables cavity tuning using piezos
(including Lorentz force detuning)

Drive with FB (closed loop)

Applies small corrections to FF to
compensate for systematic errors

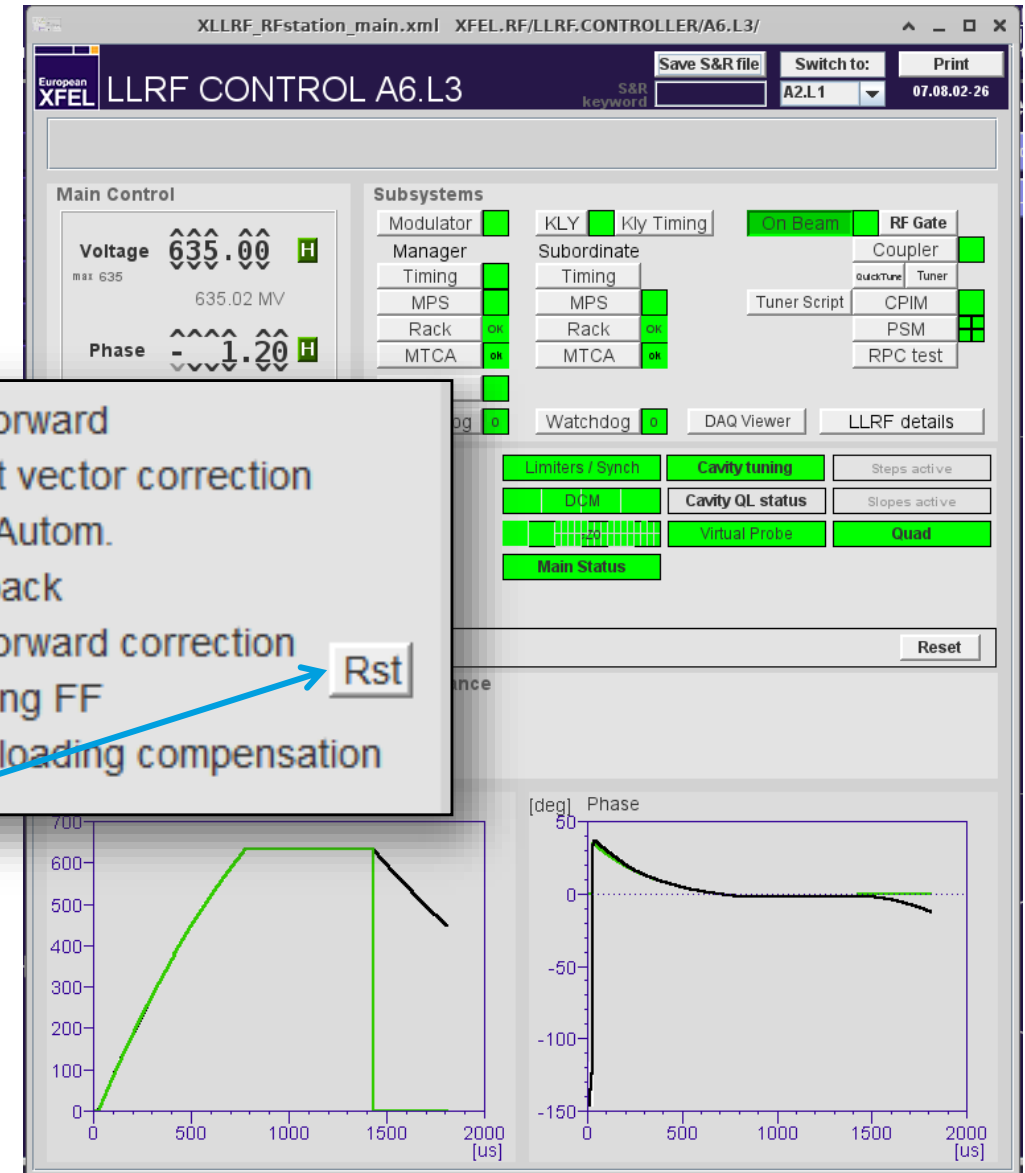
Learns from pulse to pulse to adapt
these small corrections

Re-initialize what has been learnt so
far (i.e. start from empty correction)

Applies small correction to the drive to
compensate for the presence of beam
(i.e. scales with beam parameters)

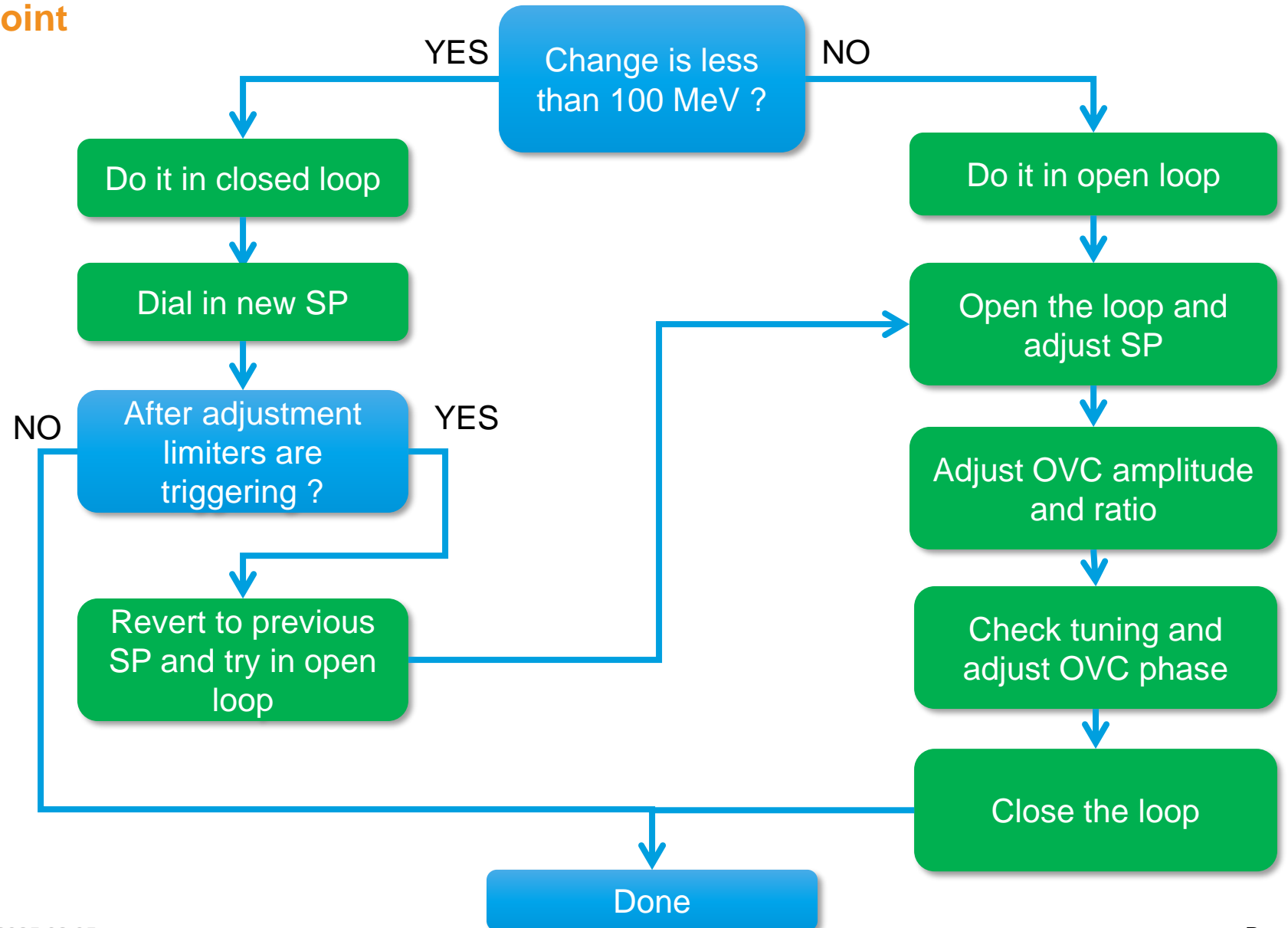
- ☒ Feedforward
- ☒ Output vector correction
- ☒ Piezo Autom.
- ☒ Feedback
- ☒ Feedforward correction
- ☒ Learning FF
- ☒ Beam loading compensation

Rst



What an operator should know

Changing RF amplitude set point



Note:

Changing **SP phase** does not require so much care, but should be also done progressively (i.e. steps of 10 deg.)

What an operator should know

Changing RF amplitude set point in open loop (1/4)

European XFEL

LLRF CONTROL A15.L3

Save S&R file

Print

Switch to: A15.L3

Open in new window

close details

Voltage

580.00

H

max 680

525.71 MV

Phase

14.12

H

-22.30 deg

☒ Station on

☒ FSM on

FSM

large amplitude or phase error (#lrf)

FSM Amplitude SP

580.00

MV

☒ Feedforward

☐ Output vector correction

☐ Piezo Autom.

☐ Feedback

☐ Feedforward correction

☐ Learning FF

☐ Beam loading compensation

Rst

Subsystems

Modulator

Master

Timing

MPS

Rack

KLM

Watchdog

Kly Timing

Slave

Timing

MPS

Rack

Watchdog

On Beam

RF Gate

Coupler

QuickTune

Tuner

CPIM

PSM

RPC test

LLRF details

Status

Limits/Synch ok

RAW ena

PZT

DCM - M1

DCM - M2

DCM - M3

DCM - M4

Cavity tuning status

Cavity QL status

Steps active

Slopes active

Quad

Reset

Performance

Ampl. and Phase readouts lower than SP

LLRF system diagram

Module 1

Module 2

Module 3

Module 4

128.3

14.52

95.29

17.75

112.1

15.26

106.8

15.78

Sca / Rot

PVS

VS

ERR

SP

Beam based Feedback

FF

FFC

LFF

BLC

OVC

COUT

Klystron

Toroid

Legend

☒ Status Ena

→ Signal flow

→ Monitor tap

→ Plot/Panel

Feed Forward + Learning FF

☒ Feed Forward On

☐ Correction tables

Reset

☐ LFF Enable

Output Vector Correction

☐ On

Ampl

0.3735

0.3502

Phase

155.151

155.151

-155.15

-159.54

Ratio

0.346

0.346

Feedback

☐ FB

☒ ML...

Output limiter

☒ Enable

42.00

Detail

Pulse ok?

☒

Pulse settings

Delay

20 us

Filling

750

750

Flattop

650

650

BLC

☐ Enable

Close FB ?

☒

Ampl err

9.370

Phase err

8.234

intra-pulse

dA/A

0.0000

%

dP

0.0000

deg

pulse to pulse

dA/A

0.0000

%

dP

0.0000

deg

FF

SP

FB

LFF

BLC

REF

OVC

VS

Out

VM

MBLS

Cav

KLM

Statistic

Limiter

PIP

Master

Board

Info

DCM

uLOG

Quench

PZ16M

Slave

Board

Info

DCM

uLOG

Quench

PZ16M

Module 1

Module 2

Module 3

Module 4

Detuning

Ref

ADC Delays

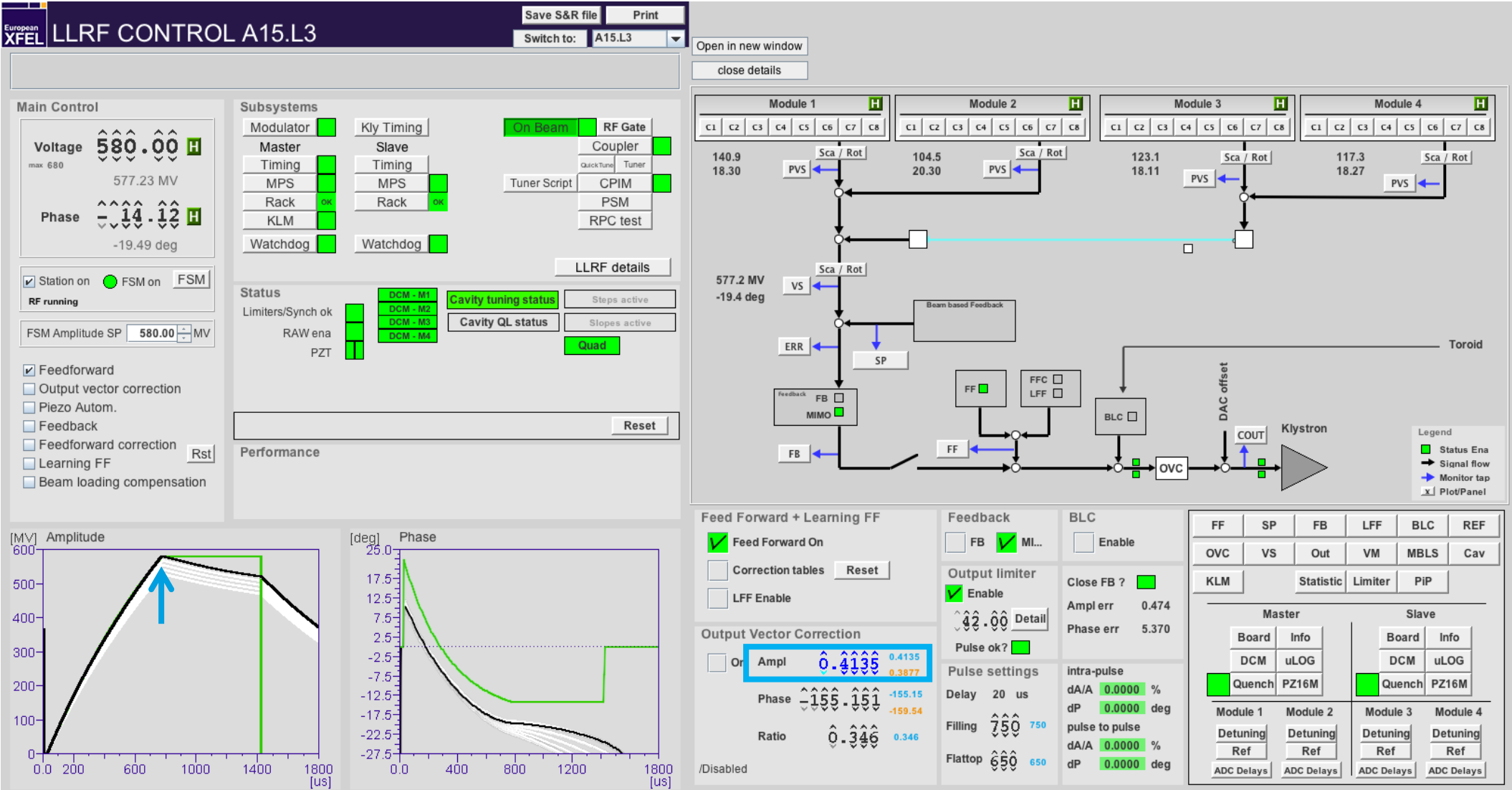
ADC Delays

ADC Delays

ADC Delays

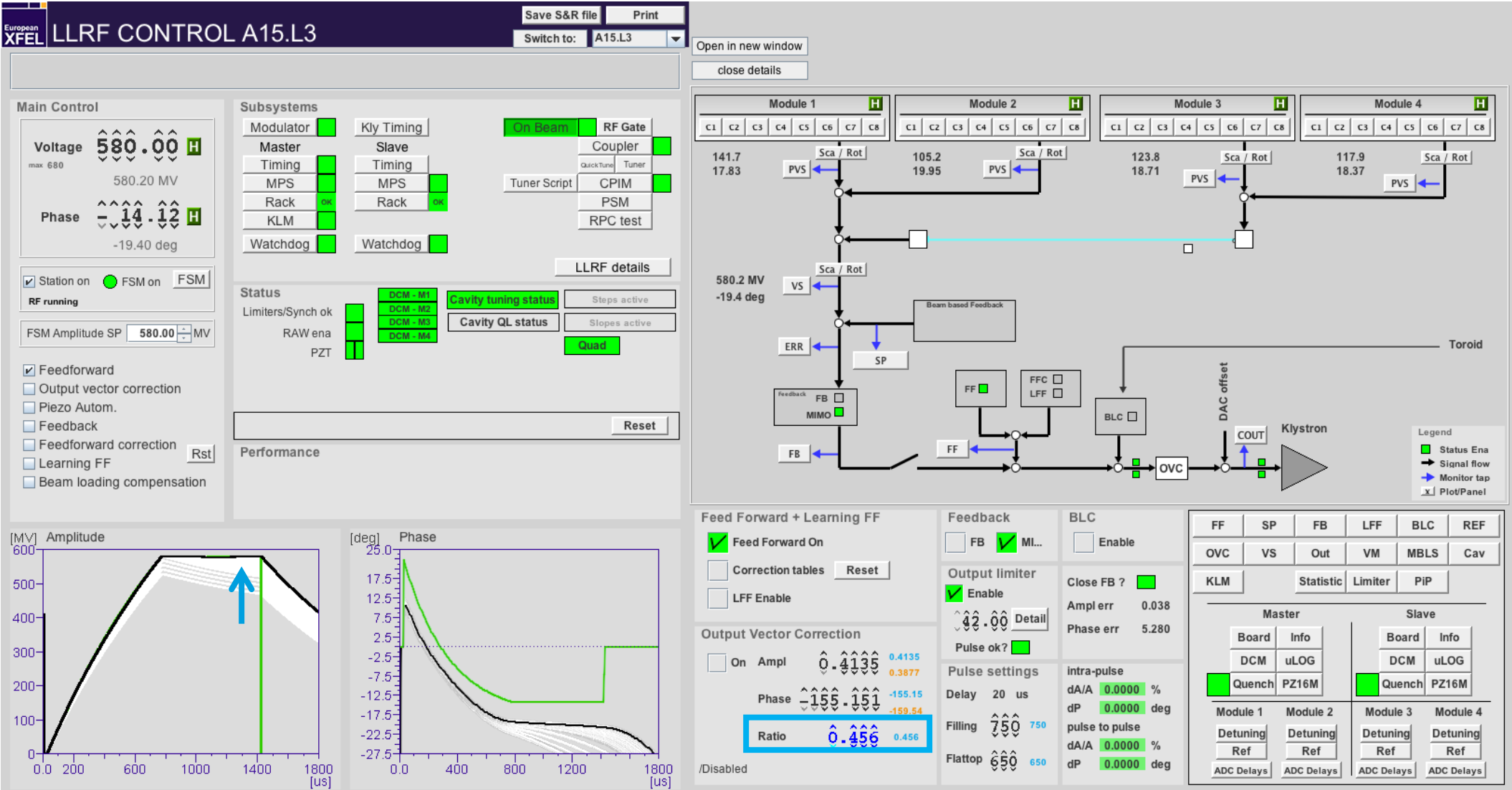
What an operator should know

Changing RF amplitude set point in open loop (2/4)



What an operator should know

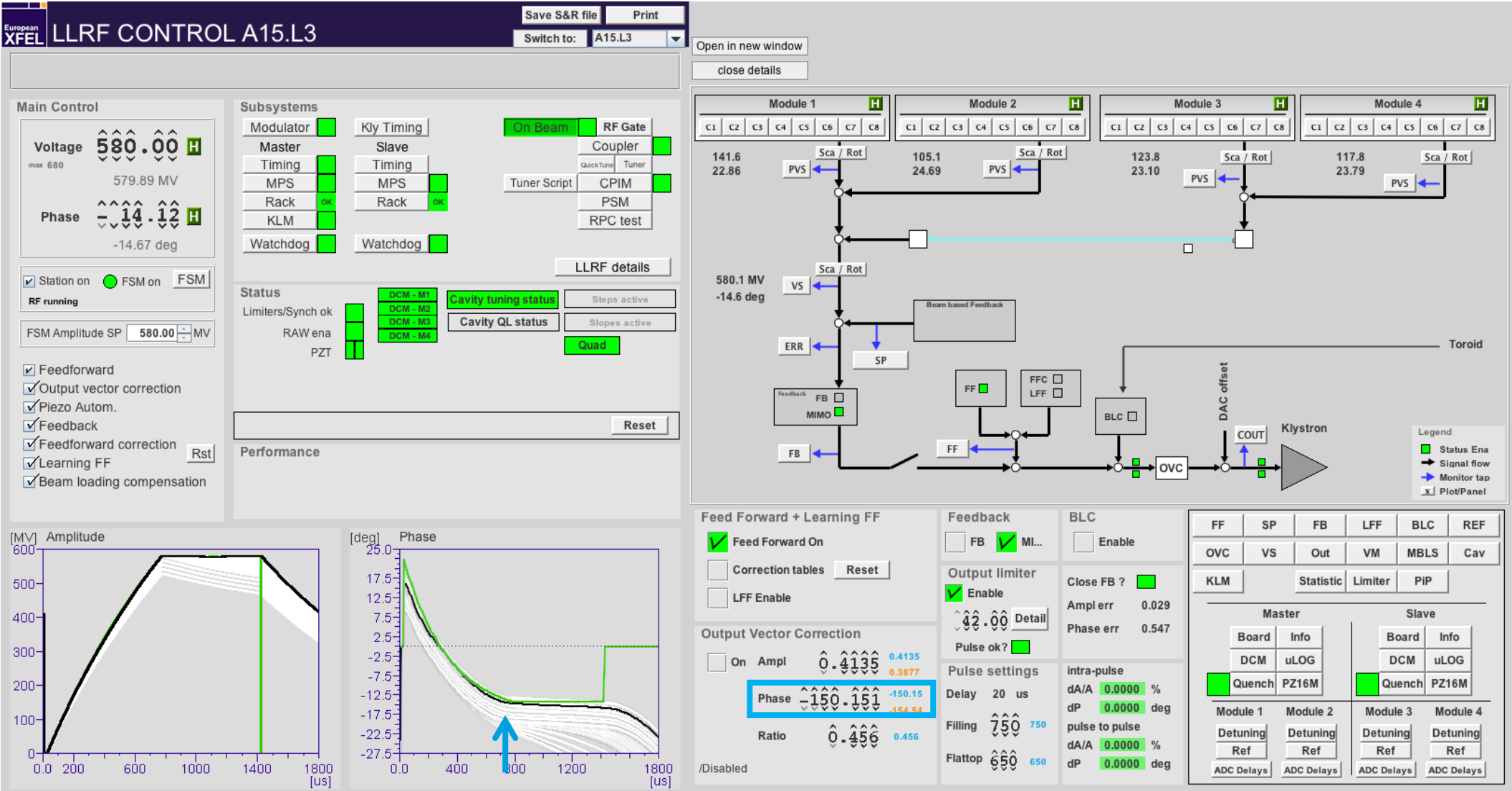
Changing RF amplitude set point in open loop (3/4)



What an operator should know

Changing RF amplitude set point in open loop (4/4)

To close the loop



What an operator should know

Procedures

Procedures for machine operation

→ Daily operation

Description (link)	Author
Switch off the EuXFEL accelerator	@ Winfried Decking
Remote access to BKR consoles	@ Matthias Scholz
Join I1 and XTL	
Load a reference trajectory to the orbit feedback	@ Matthias Scholz
How to switch between the injector lasers of EuXFEL	
Bunch Compression Setup Procedure	@ Bolko Beutner
Setup longitudinal intra bunch-train feedback (L-IBFB) at LLRF station A5	@ Bjoern Lautenschlager
Changing photon energy without a prepared file	@ Matthias Scholz
Tuning Strategy for EuXFEL	@ Matthias Scholz
Lower the gradient SP of RF stations	@ Julien Branlard



2/18/2020

Lower gradient SP - LLRF Operations - MSK project management tool

Wiki » Procedures »

Lower gradient SP ¶

This procedure should be followed when going from a high to a low gradient set point (i.e. lower by 100, 200 MV):

Establish feed forward operation

uncheck the following, in this order:

- Beam loading compensation
- Learning FF
- Feedforward correction
- Feedback

Then lower gradient SP

LLRF CONTROL A17.L3

Low 500 Hz

Prep

Switch to: A2.L1

Main Control

Voltage 530.00

Phase -14.84 deg

Station on: FSB

FSB Amplitude SP: 538.00

Feedforward

Feedback

Beam loading compensation

Subsystems

Monitor

Master

Timing

MPS

Phase

Watchdog

Ky Tuning

Slave

Timing

MPS

Phase

Watchdog

LLRF details

LLRP details

Reset

Amplitude

Phase

Amplitude adjustment

Output Vector Correction

On

Ampl 0.3983

Phase 0.00

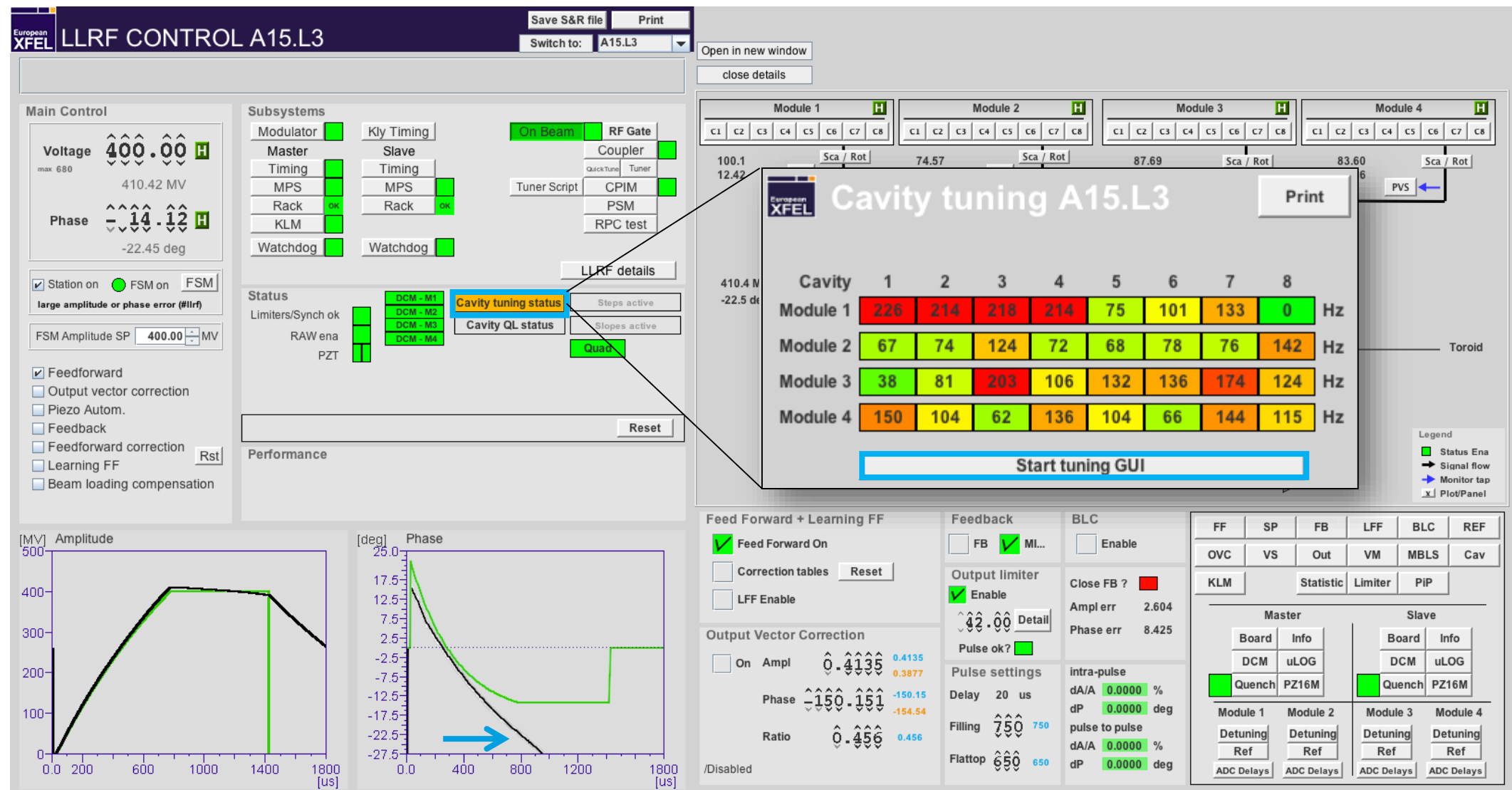
Ratio 0.4023

OVC updated but reached limit

Obtain a flat flat top

What an operator should know

Tuning cavities (1/2)



What an operator should know

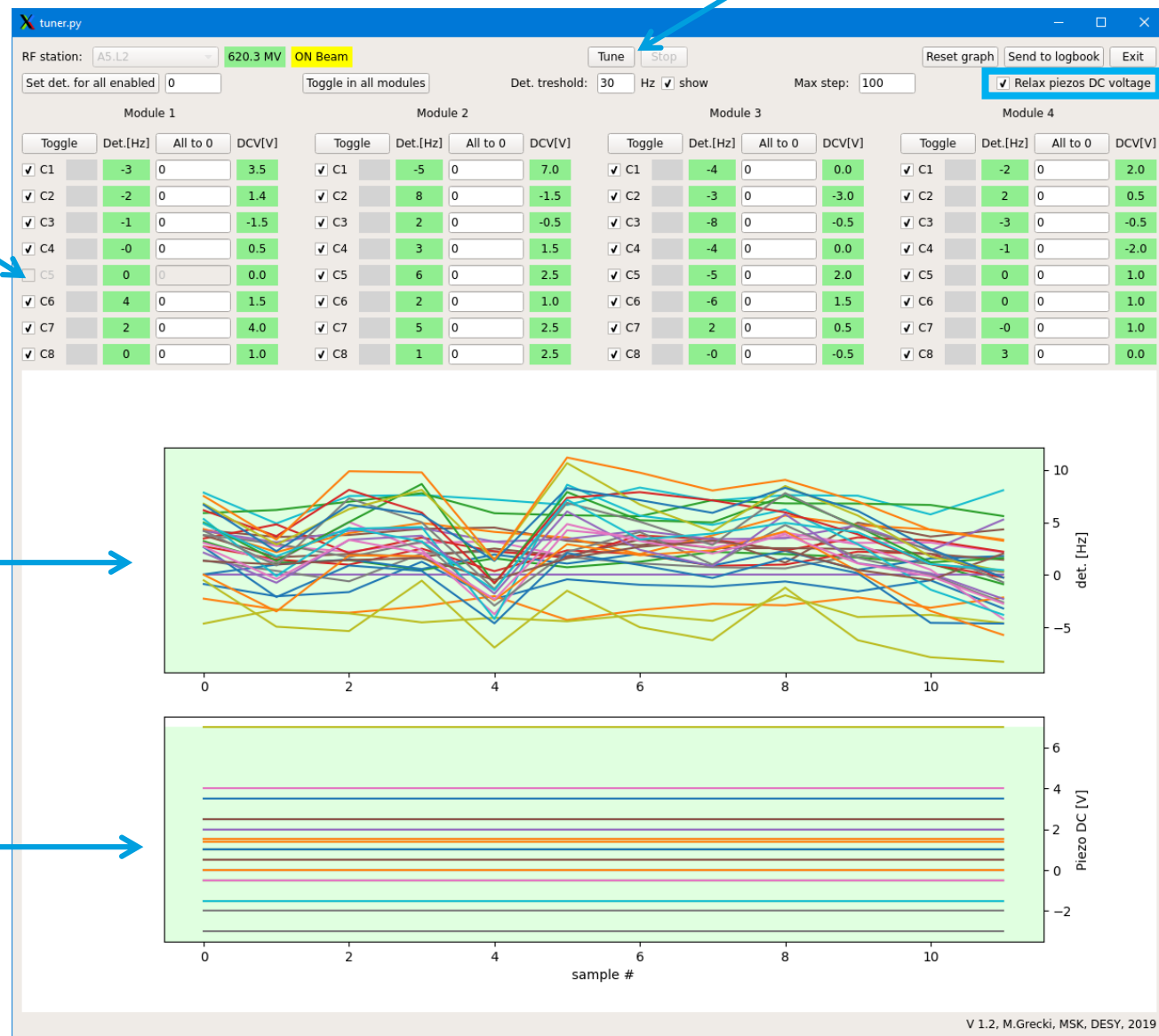
Tuning cavities (2/2)

Some cavities should NOT be tuned (greyed out)

Cavity detuning [Hz]

Piezo voltage (DC bias [V])

Click "Tune"



Relax piezo DC voltage
Shows tuning [Hz] and piezo DC bias [V]

→ both should converge to 0

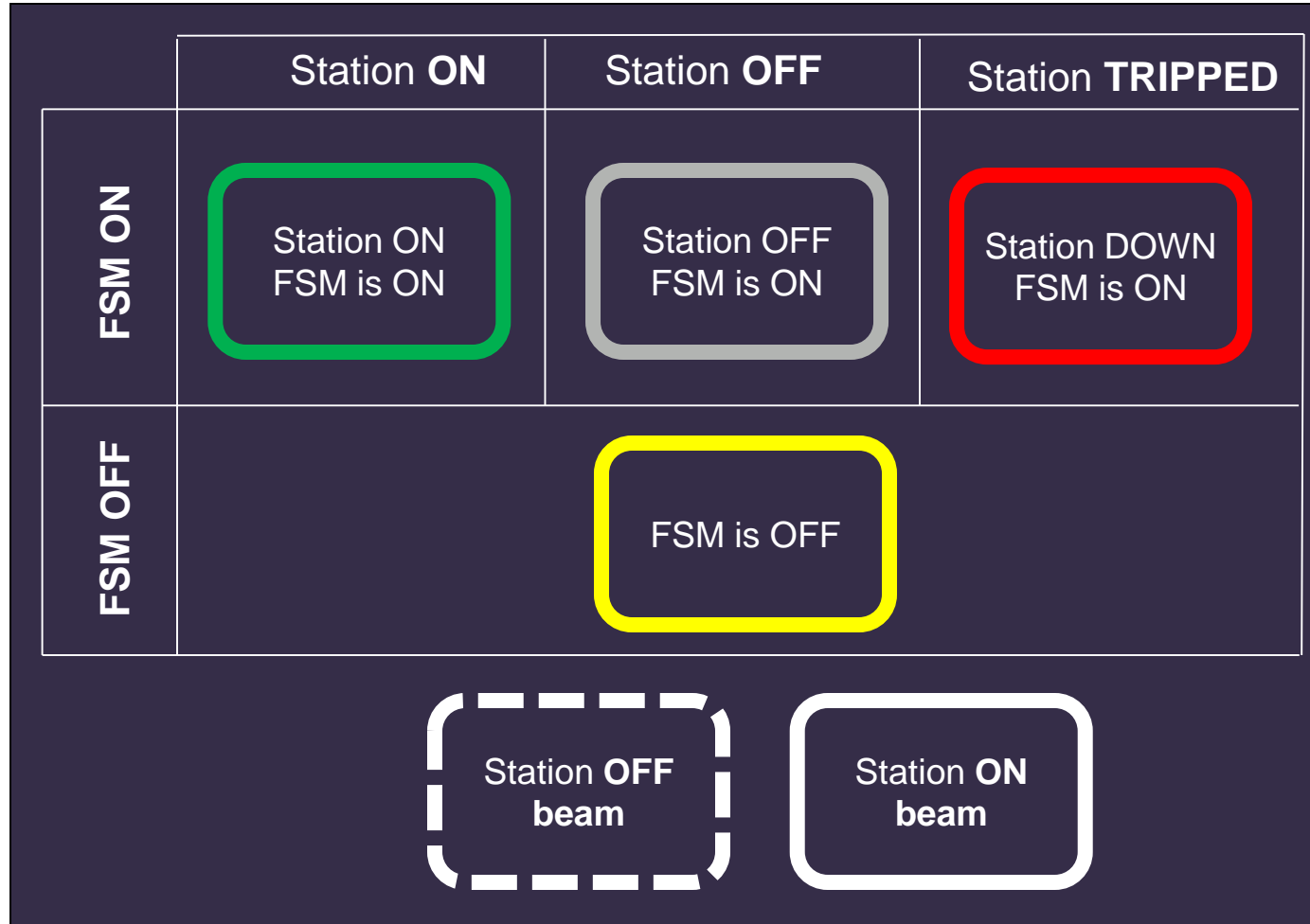
→ "relax piezo DC voltage" is enabled by default

Some error message may pop up

You can choose to ignore once or twice but if problem persists, call expert

What an operator should know

RF station color code



Note 1:

Sometimes, the station is operational but the color indicator on the main display shows yellow/red instead of green

➔ Simply disable / re-enable FSM to force a status refresh

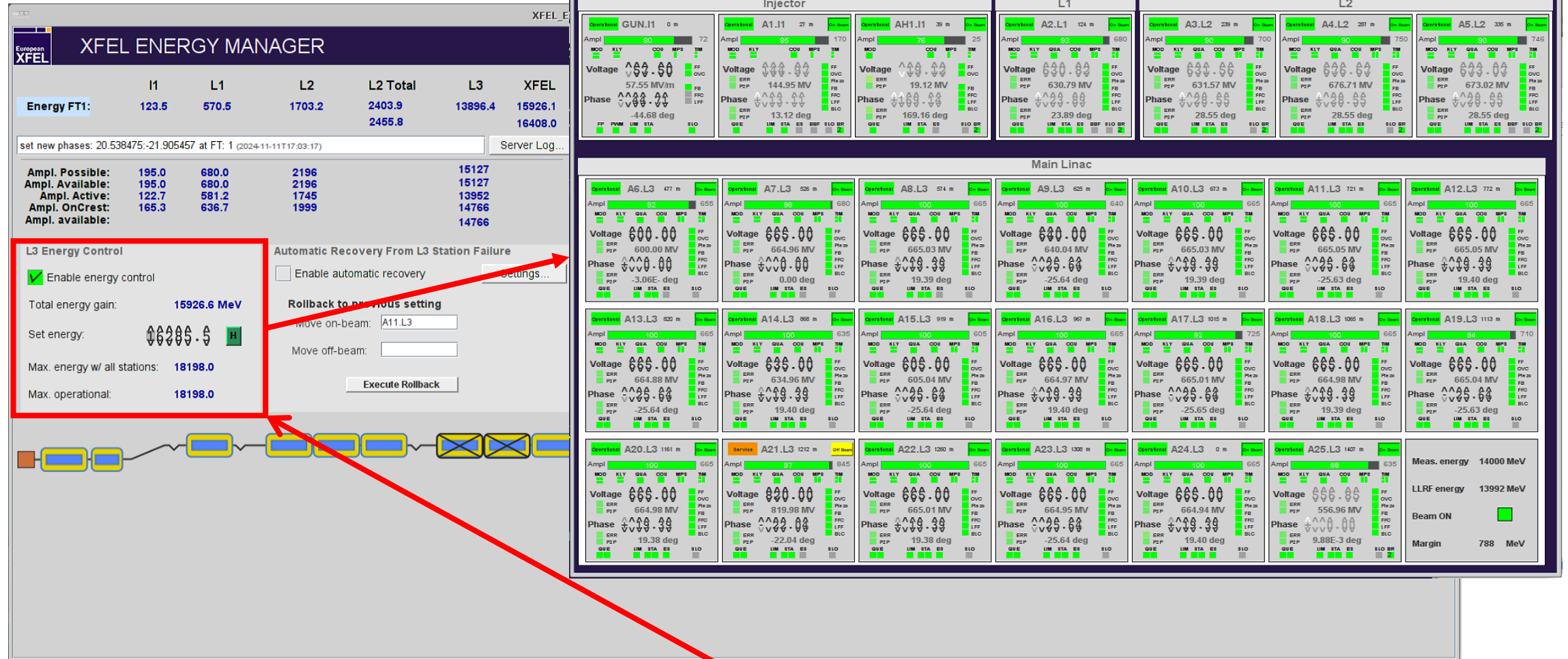
Note 2:

The Status “FSM ON and station in service” is still represented with a green circle but with a label on top (L3 panel)

➔ Unusable stations are now visible from the L3 panel, also the Energy Manager should give this information

What an operator should know

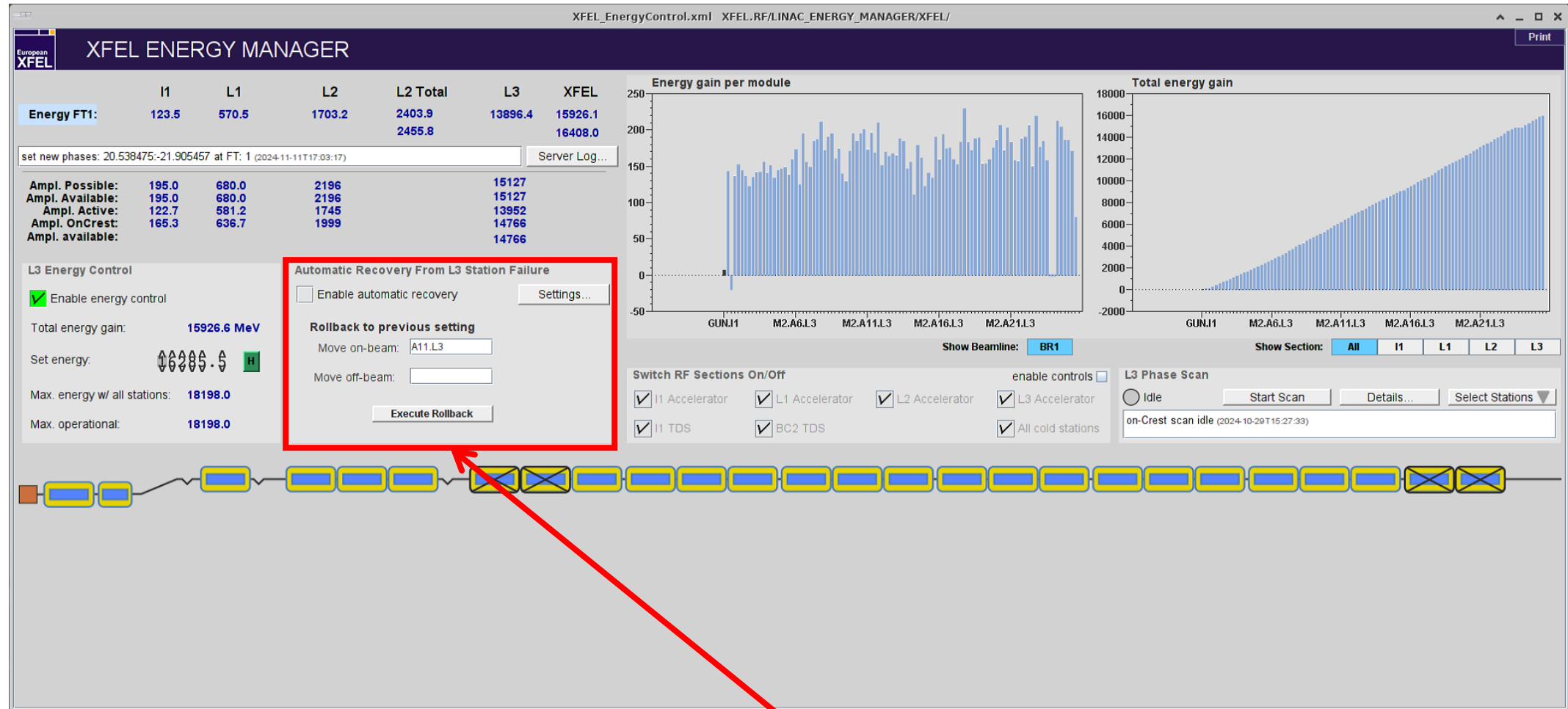
Energy Manager – Energy control



You can set the total RF energy -> It regulates the off-crest phases in L3

What an operator should know

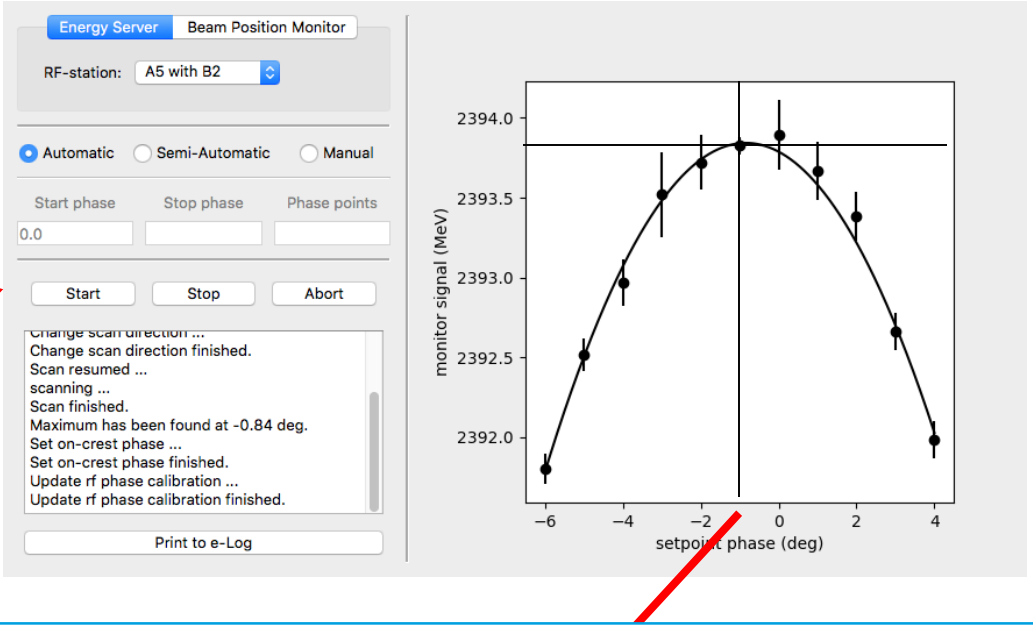
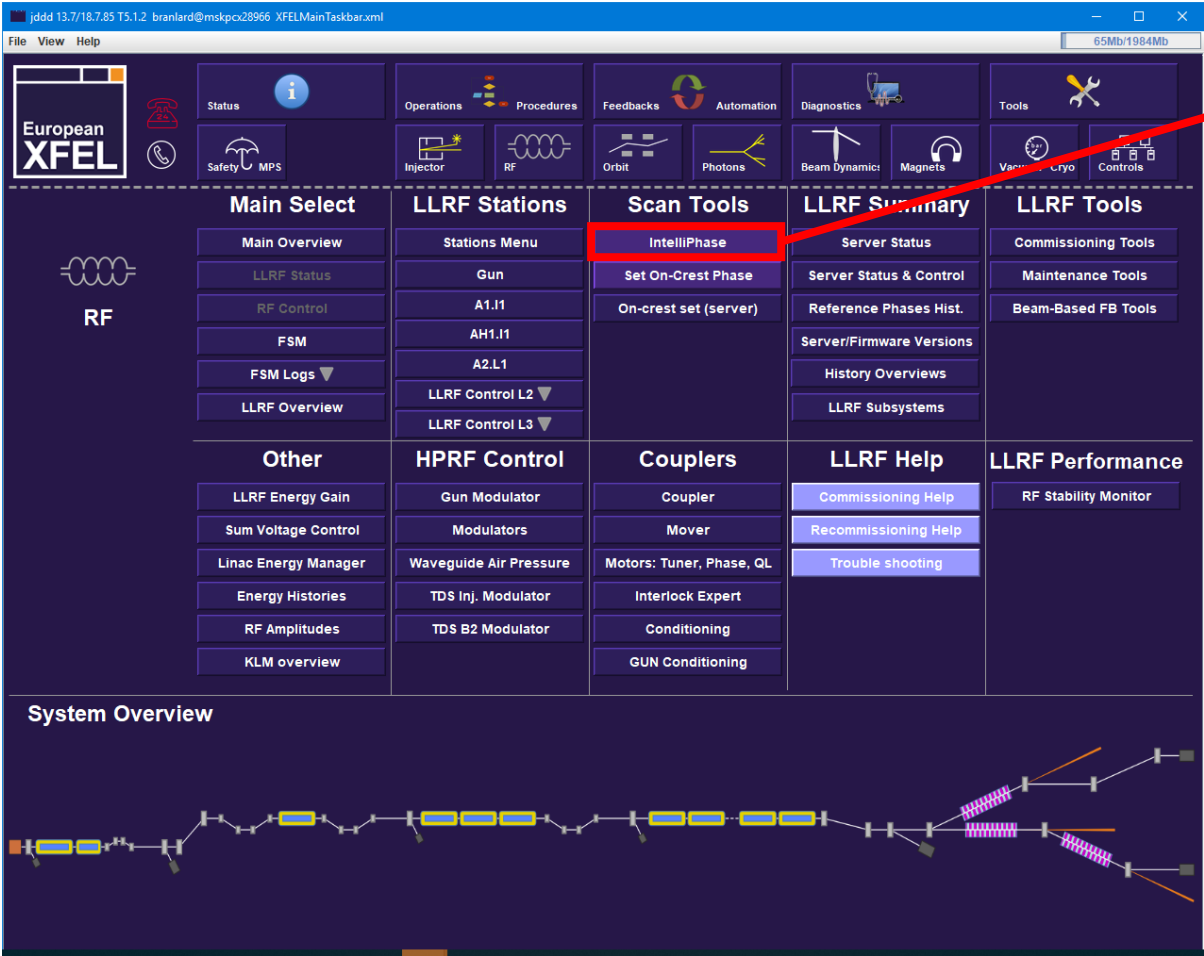
Energy Manager - automatic recovery from failure in L3



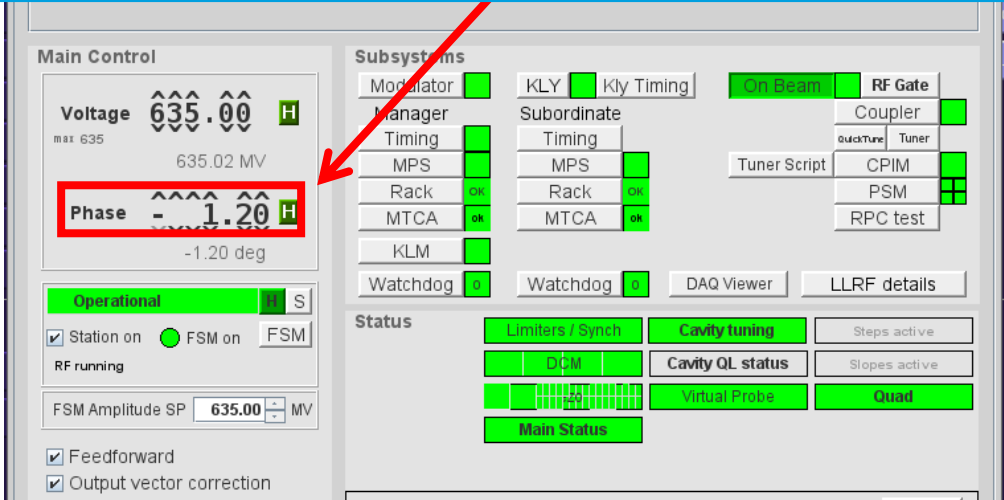
When enabled, if an RF trip is not recoverable within the defined timeout, the RF station is placed off-beam and the magnets scaled (possible to roll back if the station is recovered)

What an operator should know

Setting the on-crest phase

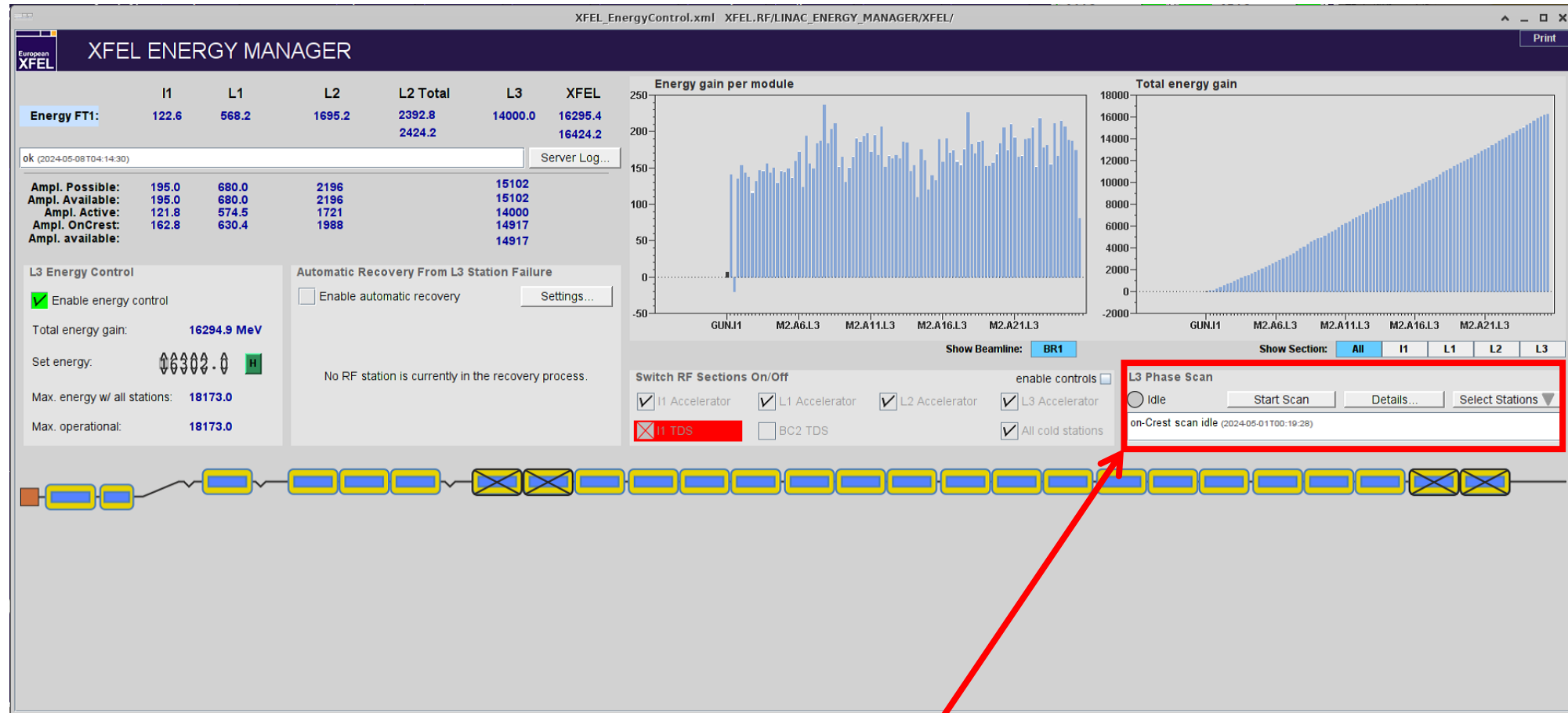


The phase at which the max energy is measured is defined as on crest phase and corresponds to the “new” 0 phase setting in the LLRF controller



What an operator should know

Setting the on-crest phase



For L3 this can also be done “parasitically” with the Energy Manager L3 Phase Scan (slow) -> fine tuning

What an operator should know

Vector Sum Set Point configurations

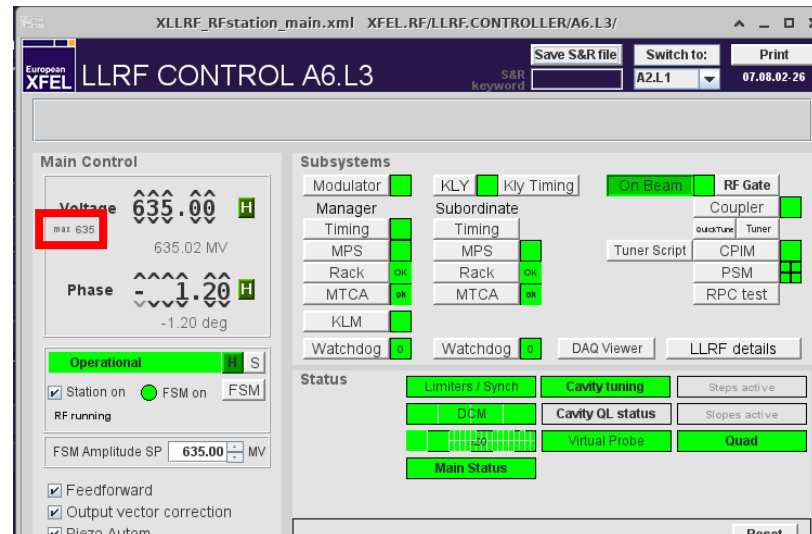
2 RF energy configurations are actually foreseen:

- **Reduced-Energy** (beam energies **up to 14.0 GeV**) -> VS SP 665 MV almost everywhere
- **High-Energy** (beam energy of **16.3 GeV**) -> Max achievable voltage

The purpose of the **Reduced-Energy mode** is to

- **reduce power consumption** (lower modulator HV)
- **lower the radiation level in the tunnel** (e.g. less MTCA issues)

The Maximum SPs are embedded in the LLRF server and they are updated at every change of configuration according to these tables: <https://xwiki.desy.de/xwiki/short/b083a>



What an operator should know

How to deal with failing RF stations

- How to deal with failing RF stations: <https://xwiki.desy.de/xwiki/short/a43a1>

1 Preparation

1. Wait for the Finite State Machine (FSM) to recover the RF station or try it by hand in case the FSM fails. If both attempts did not work out, continue with this procedure.
2. Inform the respective experts of the failed (sub) system and ask them to start fixing the problem. Please request also an update on the progress of the repair within one hour at the latest.

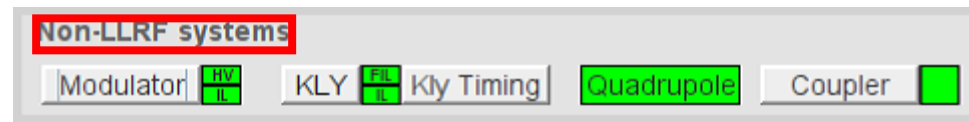
- LLRF problems → LLRF expert on call (also LLRF mailing-list)
- Modulator problems → MPC shift crew (in BKR)
- Coupler problems → MSL expert on call
- Klystron problems → MHFp expert on call (also 1.3 GHz mailing-list)
- HPRF problems at AH1 → MIN expert on call

Quadrupole &



Have a generic RF mailing-list?

- Recognize the root cause



- If you are not sure, please inform all the possible groups (not only LLRF!)

What an operator should know

LLRF on-call service

- LLRF on-call **5588**
- 9 experts, 1 available 24/7 every week
- llrf-expert@desy.de



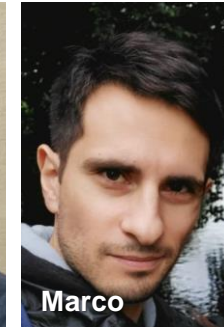
- Send log book entry to LLRF expert list
 - **Write your name / initials**
 - **Edit the title and description**
 - **Use the Tag fields (at least Location)**



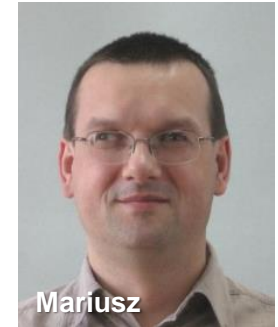
Christian



Julien



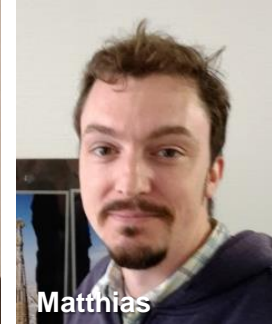
Marco



Mariusz



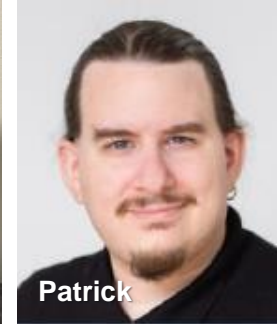
Martin



Matthias



Max



Patrick



Valeri

eLogBook entry

Author	J.Branlard	Severity	ERROR
Date Time	26.02.2020 10:57:49	Keyword	LLRF
		Location	A17.L3

Title: Phase looks strange

File upload
Choose image file
(press button or drag & drop file on button to upload a file)
Choose File No file chosen

Mail to expert
Topics: LLRF
Experts: LLRF Mailing List (llrf-expert@desy.de)
LLRF Mailing List clear
Free recipient: add

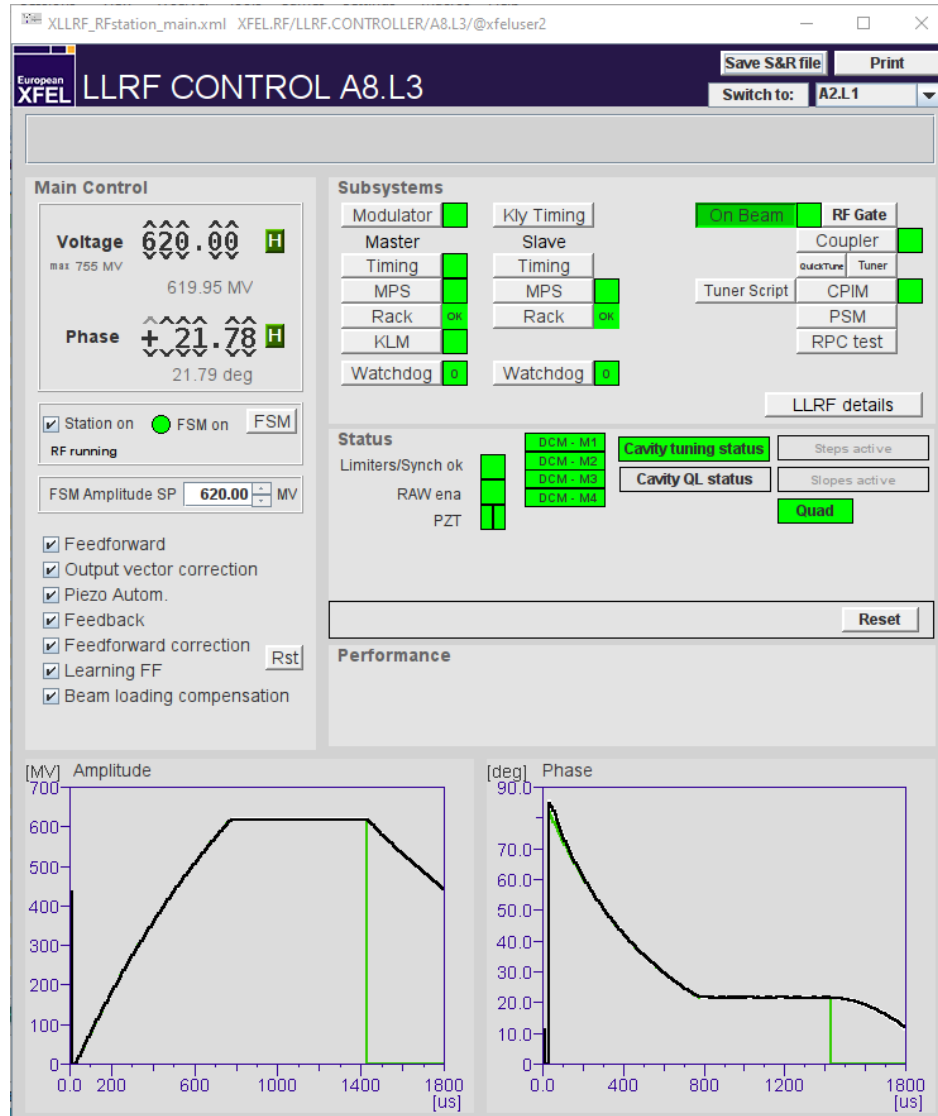
Wiki markup help Save entry

3. Exceptional cases and how to react

- Probe limiter – pulse cut
- KLM limiter – pulse cut
- Output/feedback limiter
- Cavity quenches
- Zombie station
- Lost PCIe connection

Exceptional cases and how to react

Pulse cuts due to gradient limiters



Note:

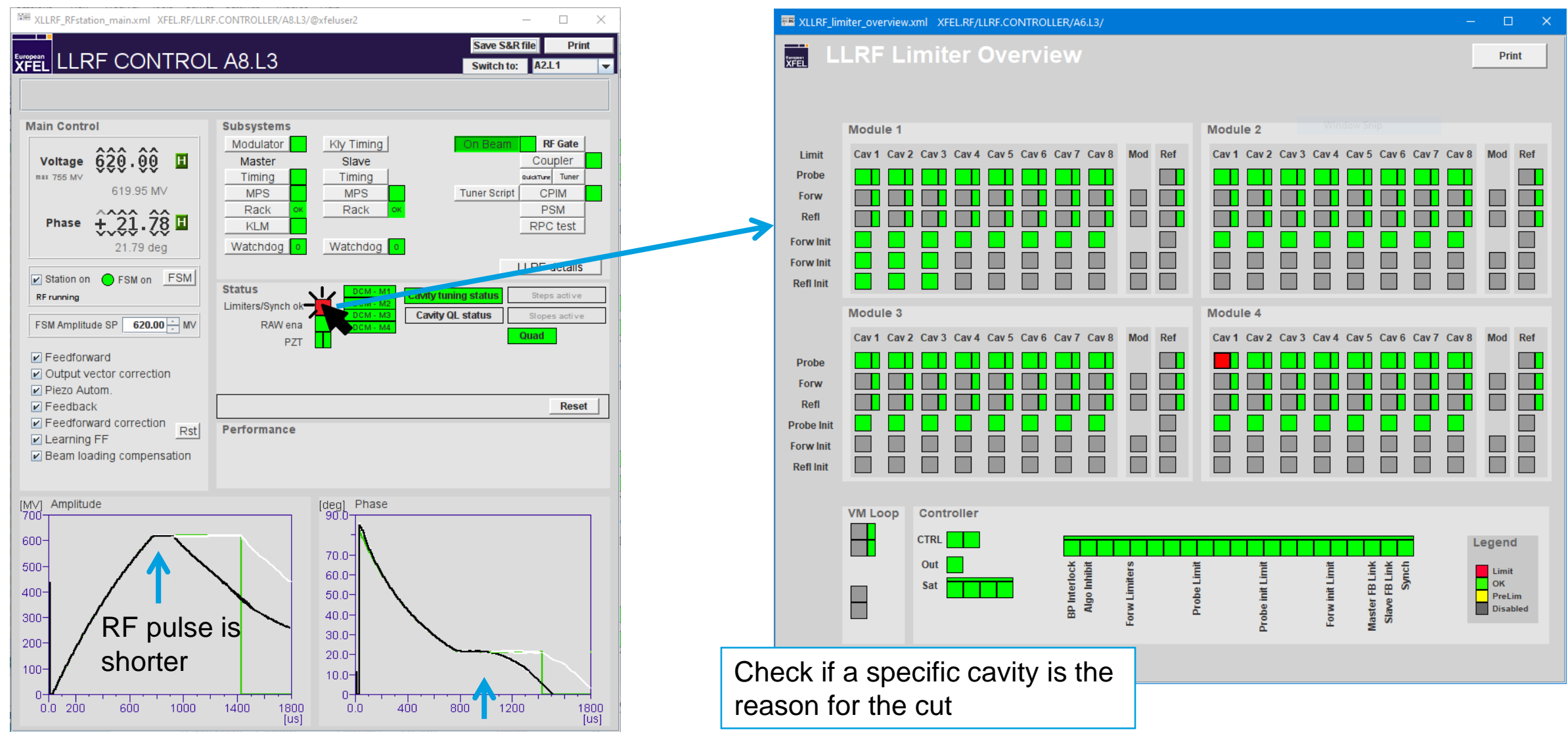
- Pulse cuts are displayed on the main panel (limiter / KLM)
- The beam is cut if the RF pulse is cut

What to do:

1. Document in log book and send to LLRF
2. Open/close loop
3. Lower the gradient if possible
4. If you want, you can check what is the limiting factor (see next 2 slides)

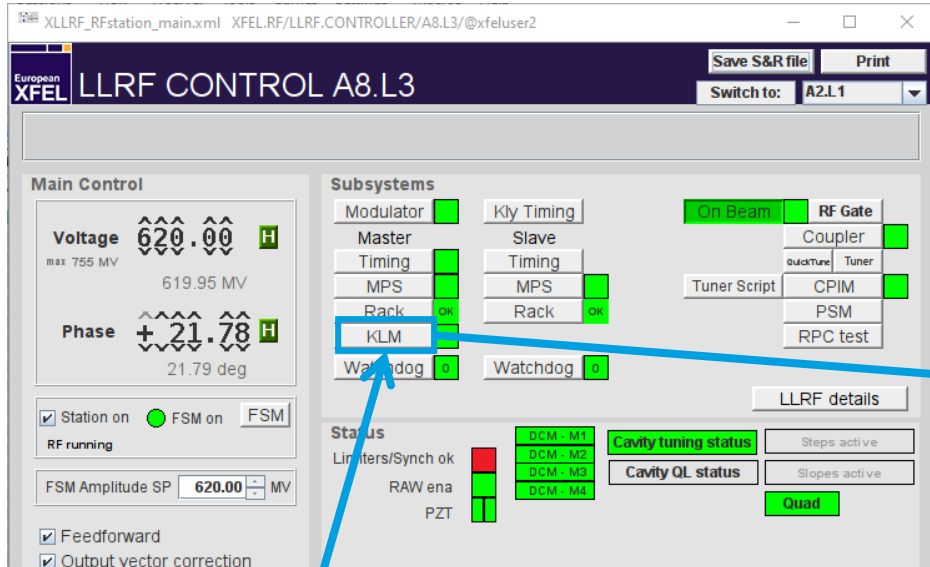
Exceptional cases and how to react

Pulse cuts due to gradient limiters



Exceptional cases and how to react

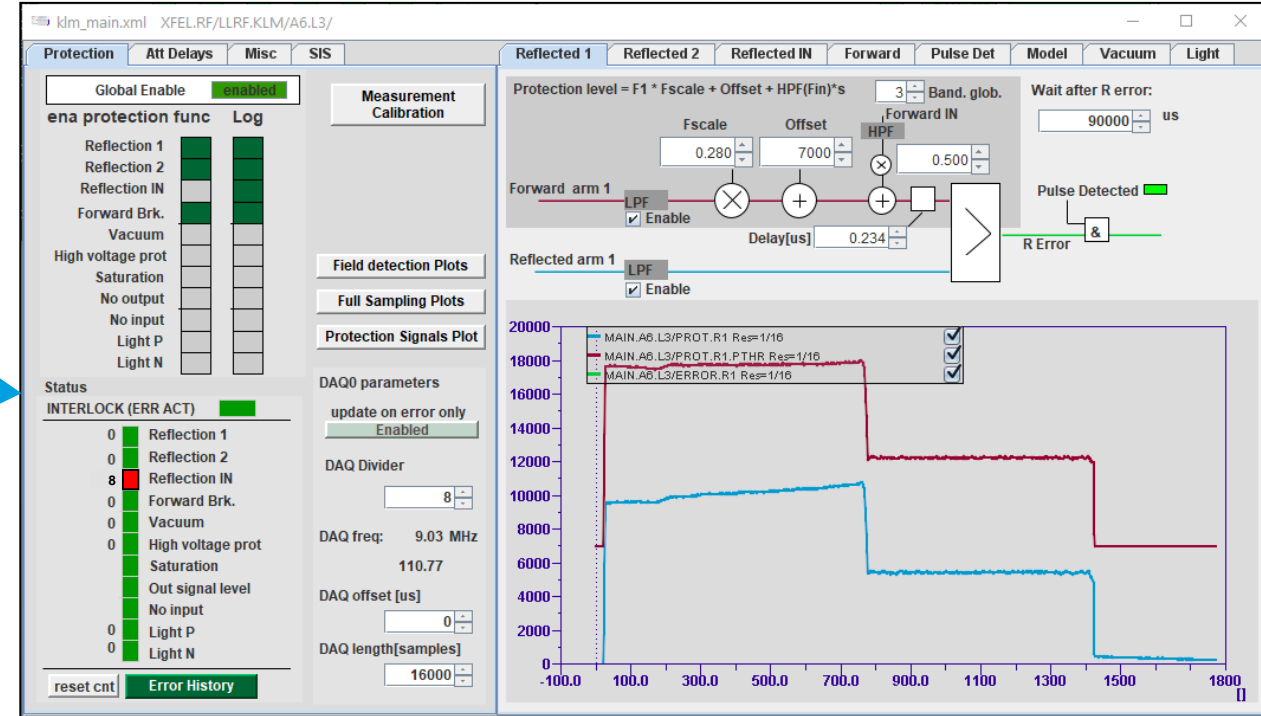
Pulse cuts due to KLM limiters



If all cavity limiters are green, the cut probably comes from the Klystron Lifetime Management (KLM) system.

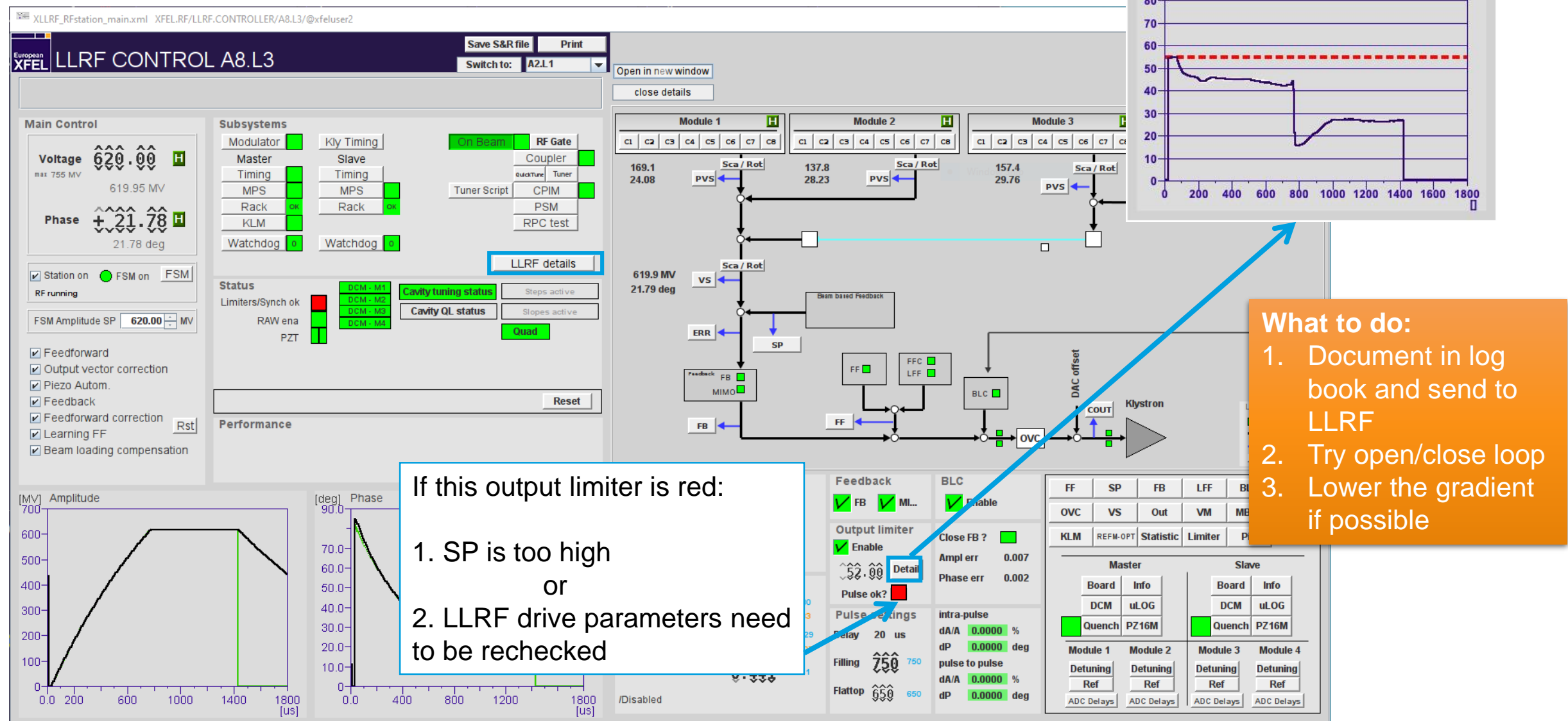
In any case,

1. Document in log book and send to LLRF
2. Lower the gradient if possible



Exceptional cases and how to react

Limiter is red (but no cut)



Exceptional cases and how to react

Cavity quench (1/2)

LLRF CONTROL A5.L2

Save S&R file

Switch to: A1.J1

Print

08.07.02-03

Scalar mode

Set Table mode

Voltage

0.09 MV

Phase

0.00 deg

Service

Station on

FSM on

FSM

stopped after quenches (#quench)

QUENCH

Reset

Feedforward

Output vector correction

Piezo Autom.

Feedback

Feedforward correction

Learning FF

Beam loading compensation

Non-LLRF systems

Modulator

KLY

Kly Timing

Quadrupole

Coupler

Subsystems

Manager

Subordinate

Timing

MPS

Rack

MTCA

KLM

Watchdog

Watchdog

DAQ Viewer

LLRF details

Status

Limiters / Synch

Cavity tuning

DCM

Cavity QL status

Slopes active

Main Status

L-IBFB

Performance

Reset

Amplitude

Phase

L-IBFB ...

VS may jump!

Module 1

Module 2

0.05 MV

0.00 deg

0.05 deg

0.00 deg

0.14 MV

0.00 deg

VS

SP

Beam based Feedback

ERR

Feedback

FB

MIMO

FF

FFC LFF

FFC User

BLC

Dyn. O

OVC

Feed Forward + Learning FF

Feedback

BLC

Close FB ?

Ampl err

Phase err

pulse to pulse

dA/A

dP

control error

dA/A

dP

FF

SP

FB

LFF

BLC

REF

OVC

VS

Out

VM

Cav

KLM

REFM-OPT

Statistic

Limiter

PIP

L-IBFB

Manager

Subordinate

Board

Info

DCM

LOGM

Quench

PZ16M

Quench

PZ16M

Module 1

Module 2

Module 3

Module 4

Detuning

Ref

ADC Delays

ADC Delays

ADC Delays

ADC Delays

History

Quench

section is ok

Press to switch off

C1.M3.A3.L2

C2.M3.A3.L2

C3.M3.A3.L2

C4.M3.A3.L2

C1.M4.A3.L2

C2.M4.A3.L2

C3.M4.A3.L2

C4.M4.A3.L2

C5.M3.A3.L2

C6.M3.A3.L2

C7.M3.A3.L2

C8.M3.A3.L2

C5.M4.A3.L2

C6.M4.A3.L2

C7.M4.A3.L2

C8.M4.A3.L2

Q loaded

Sigma

Q loaded

Sigma

Note:

Place the quench panel instead of the main panel in the log book (more information)

What to do:

1. Document in log book and send to LLRF

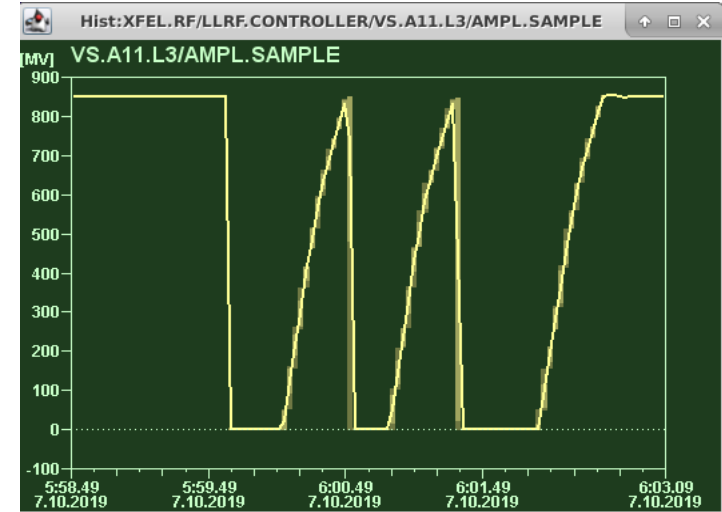
2. Lower the Voltage SP if needed

Exceptional cases and how to react

Cavity quench (2/2)

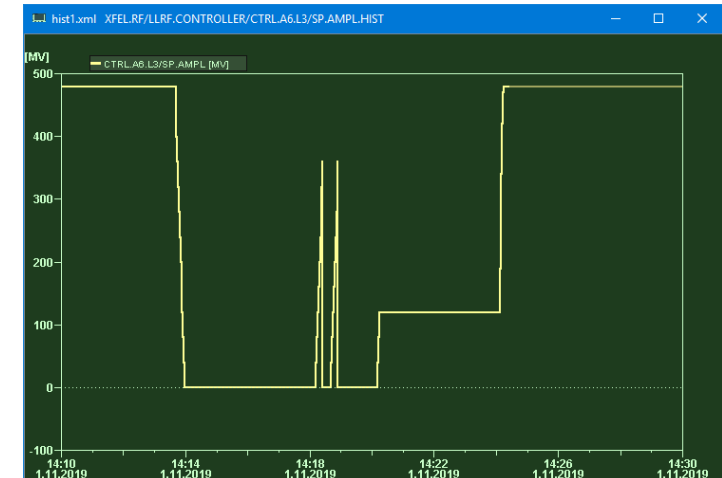
Repetitive quenches

- **Problem description:**
 - The FSM tries to recover a station after a quench, ramps up to the same gradient and quenches again
 - After 3 tries, the FSM gives up
- **What you can try**
 - Lower the recovery gradient in the FSM window (-10 MV ?)



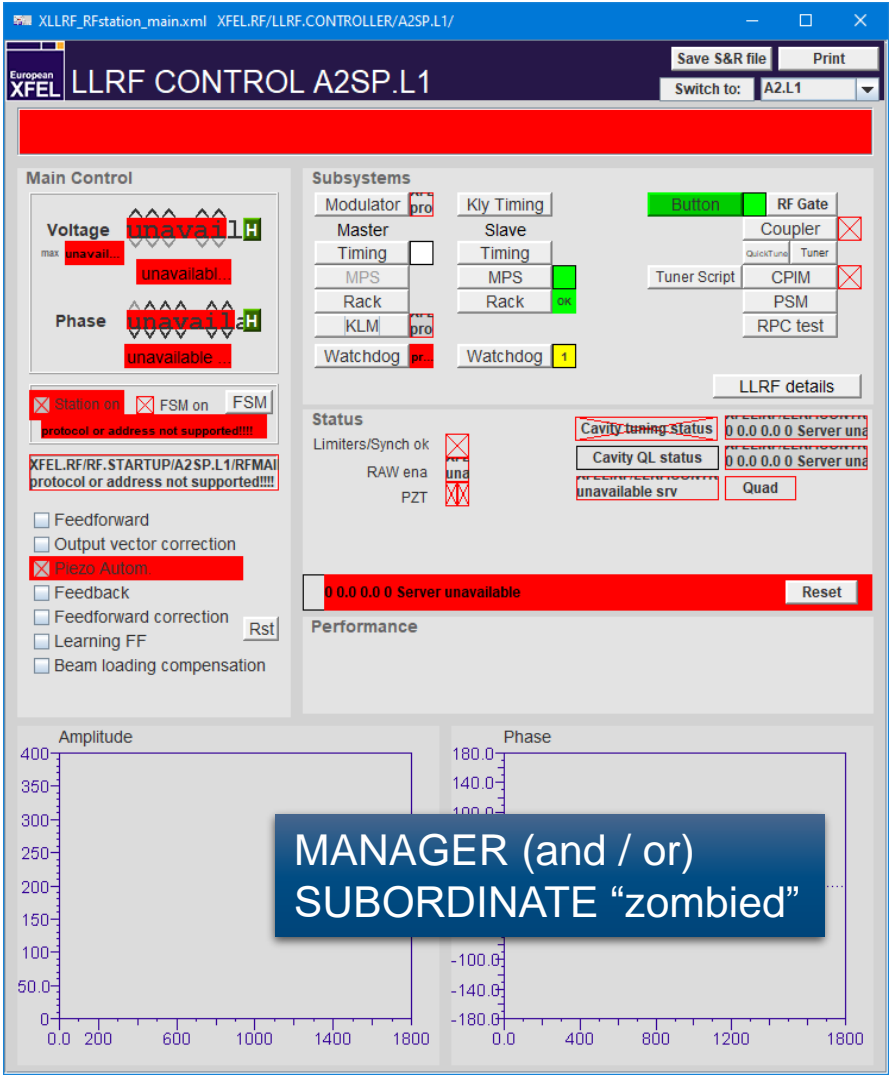
Quench during ramp up

- **Problem description**
 - (After a quench) the RF station trips due to quenches taking place at a much lower gradient
 - Chances are the Q_L computation got corrupted during the quench, hence corrupting the quench detection mechanism
- **What you can try**
 - Disable the FSM, ramp up the station slowly (i.e. 10 MV steps) by hand, and re-enable the FSM

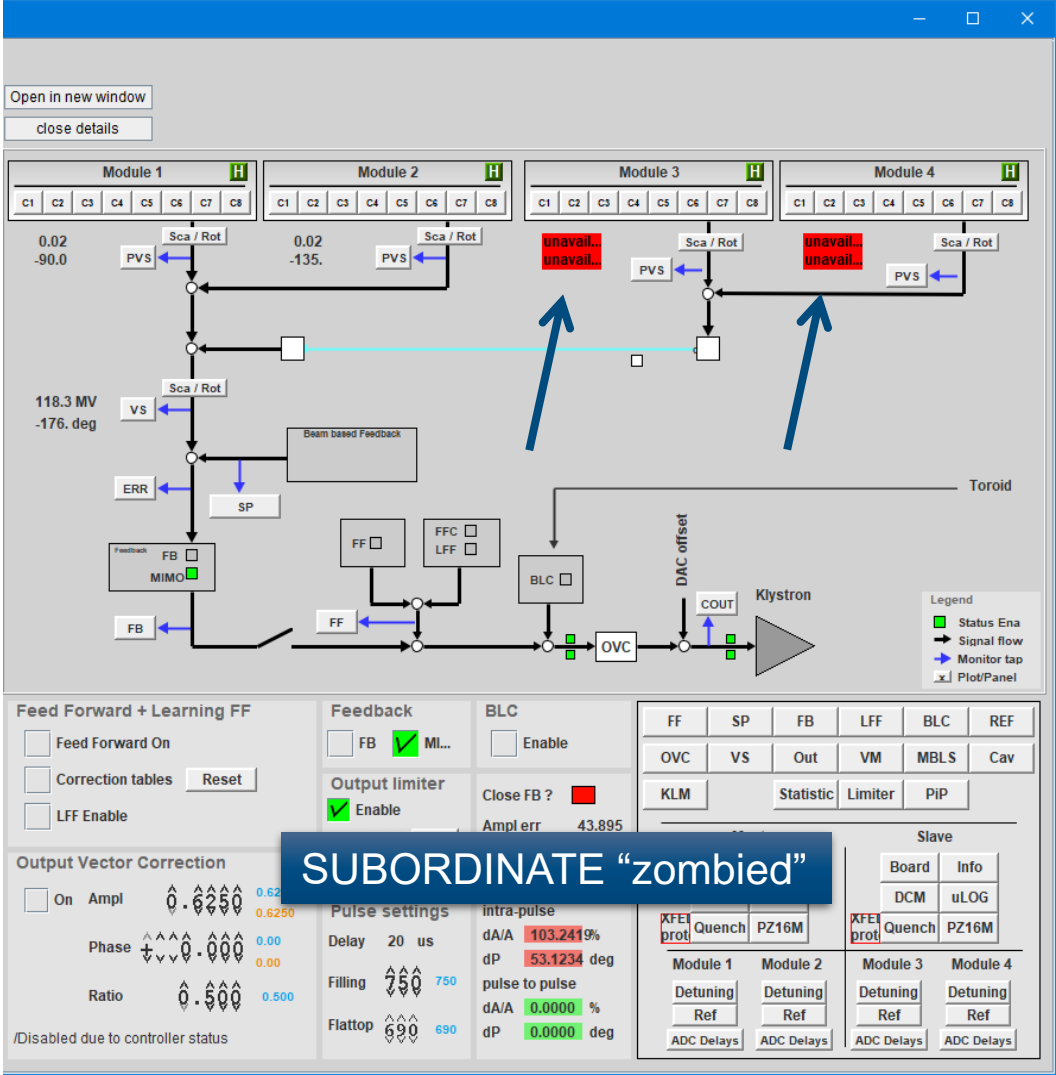


Exceptional case and how to react

“Zombie” station



MANAGER (and / or)
SUBORDINATE “zombied”



SUBORDINATE “zombied”

The llrfCtrl server is not responsive

Chances are the hardware is still working

BUT

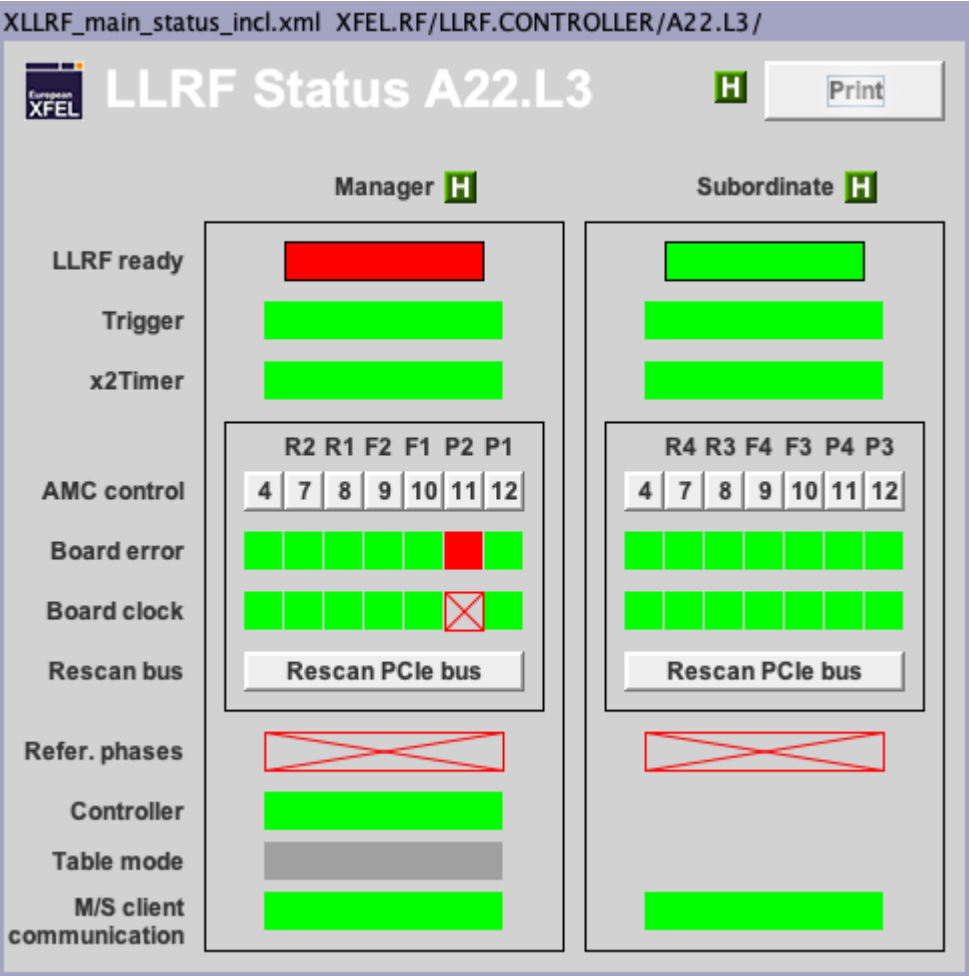
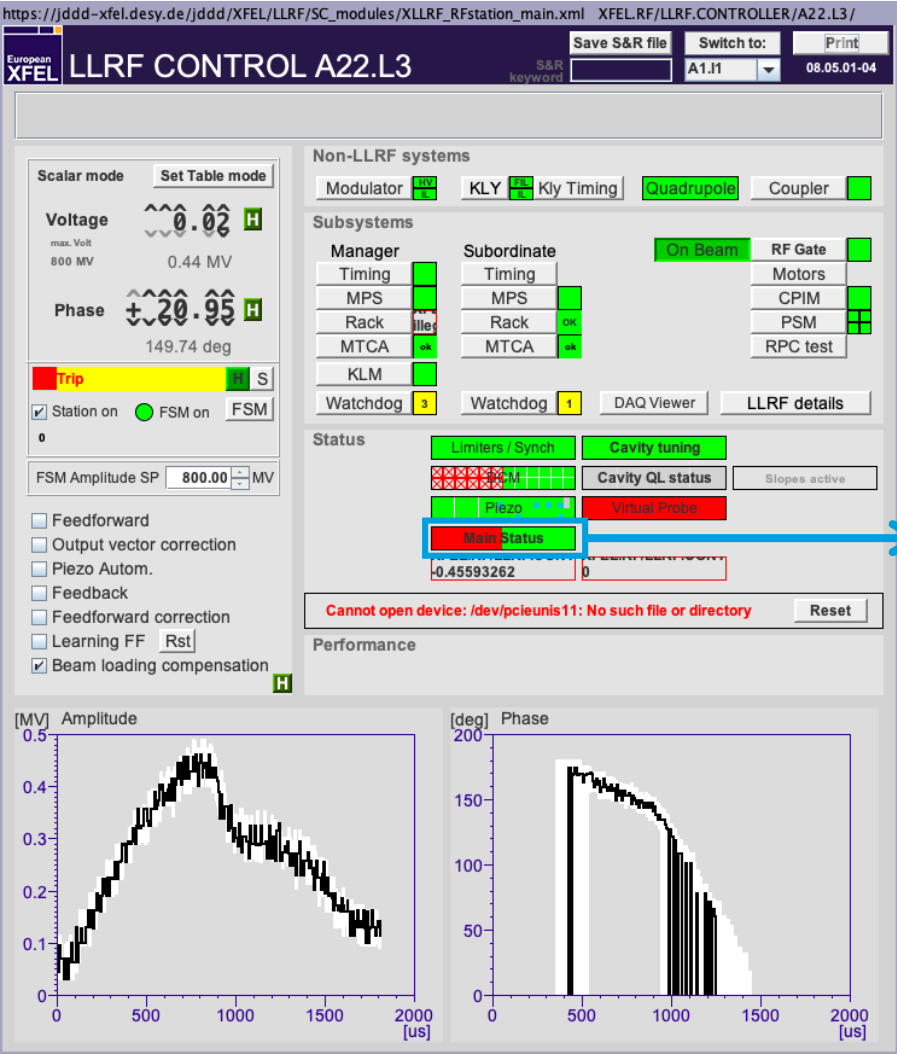
Likely the quench detection is no longer working

What to do:

1. Document in log book and send to LLRF
2. Agree with LLRF on-call and run coordinator when best to recover the station

Exceptional case and how to react

PCIe connection is lost



Main Status panel

PCIe connection with the board is lost

If it involves boards 4, 11 and 12, the station cannot operate

BUT

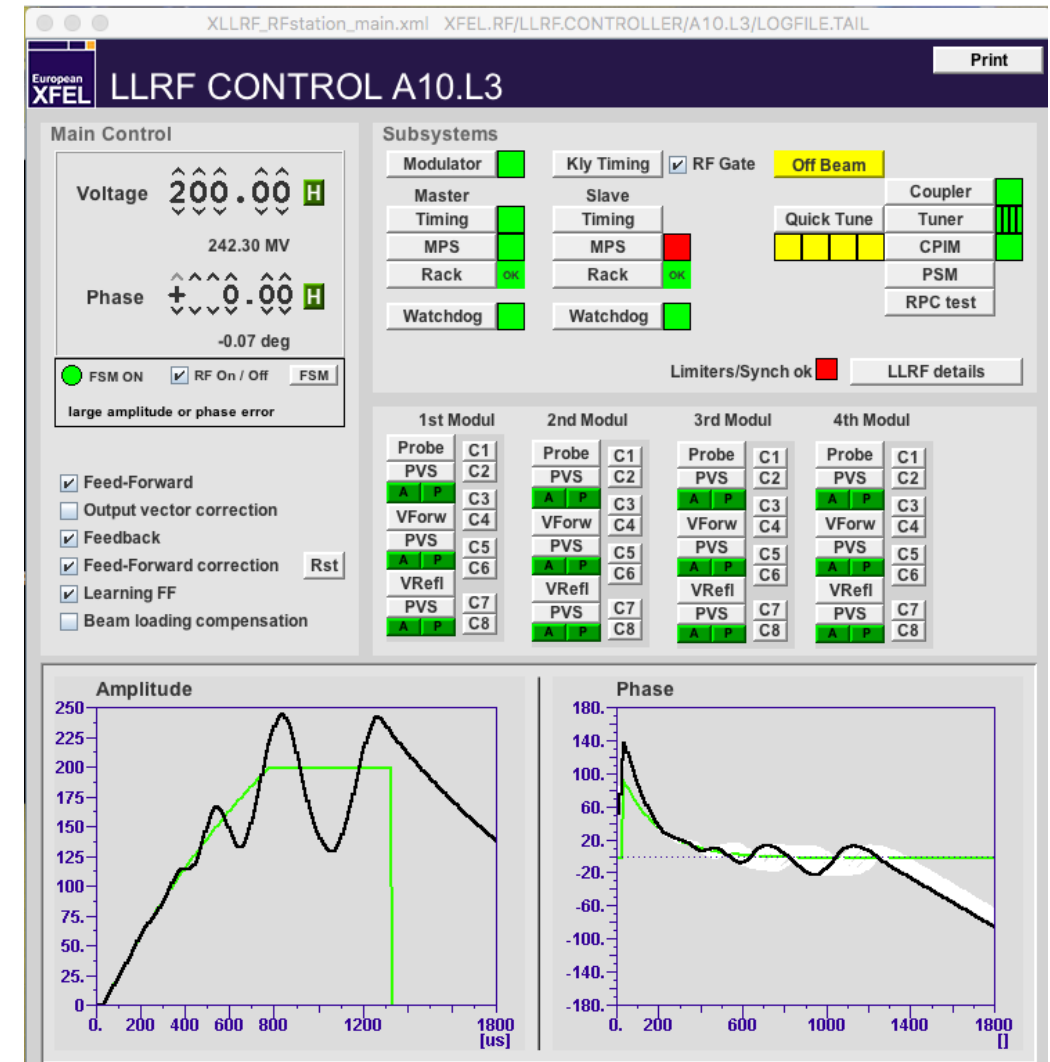
In the other cases, the station might work till fix

What to do:

1. Document in log book and send to LLRF
2. Agree with LLRF on-call and run coordinators when best to recover the station

Summary

- LLRF tasks of the XFEL operator:
 - Turn an RF station **ON / OFF**
 - Adjust the vector-sum **voltage / phase**
 - **Tune** cavities, if necessary
 - Adjust **output vector correction** and **ratio**, if necessary
 - Set a certain phase as **on-crest phase**
- **Special cases**
 - Pulse cut
 - Limiter notification
 - Quench
 - Zombie stations
- **Opportunity for hands-on:**
 - LLRF maintenance ~every Tuesday
 - off-beam stations -> ask LLRF team (& RCs)
- **Document (elog) what you find not normal**
 - **Please include your name, title and description!**



Thanks to Julien for the material

Thank you



Contact

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Elektronen-Synchrotron

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