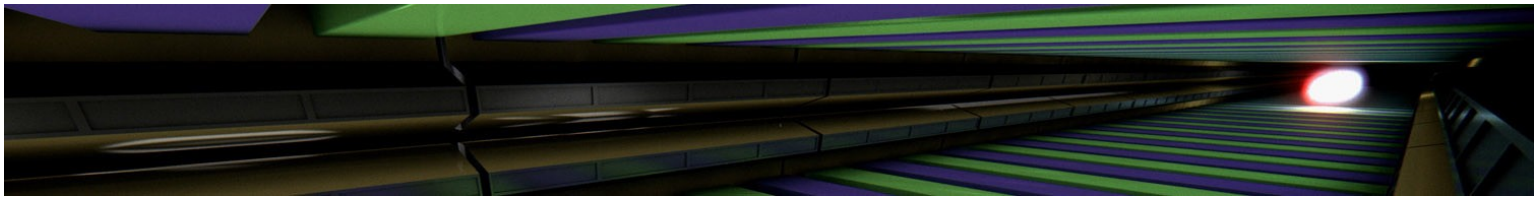
European XFEL



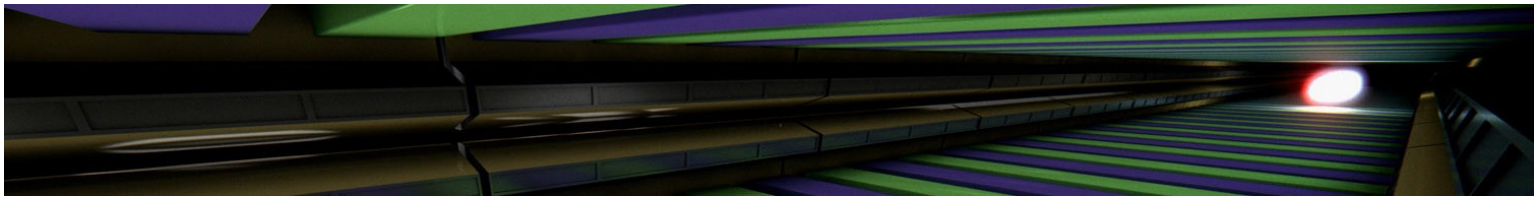
Progress in Finite State Machine Developments at FLASH

Olaf Hensler

MCS

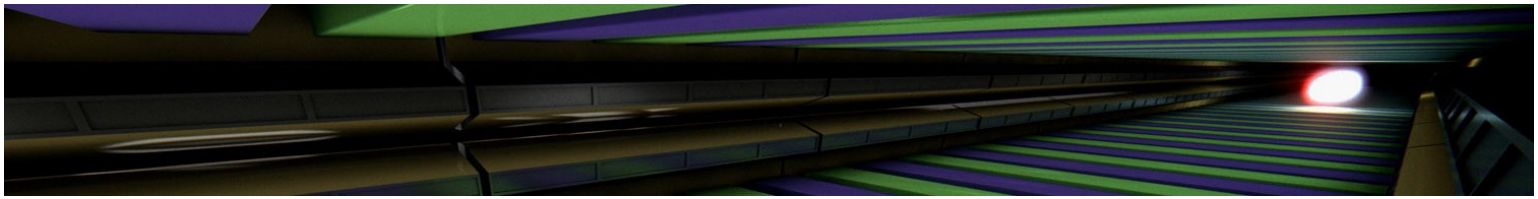
DESY

HELMHOLTZ ASSOCIATION



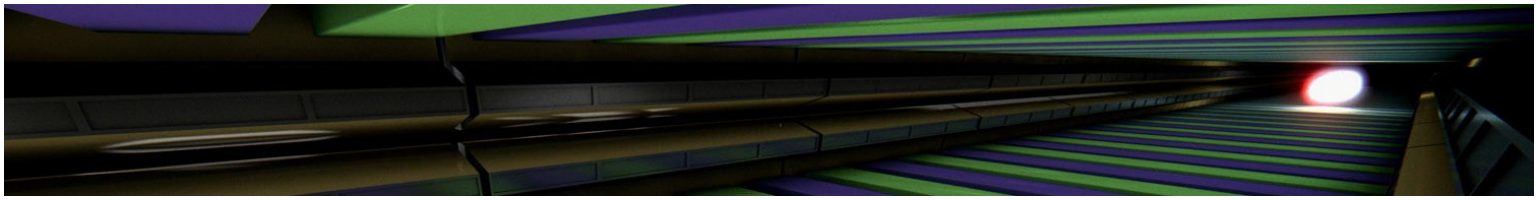
Objective of this simple FSM design

- Start up a system
  - Coupler, klystron, LLRF
- Shut down a system
  - LLRF, Klystron
- Recover from trips
- Monitors some important values from
  - Coupler vacuum, quench, filament ...



The RF **F**inite **S**tate **M**achine (FSM)

- THE central RF control server
- Based on standard DOOCS Server
- Is a Middle Layer Server
- Has one independent Location per RF Station
  - A special location(version) for the GUN
- Allows Operator intervention !
  - Reset- or Setpoint changes
- Runs with 2 Hz reprate



Displays

LLRF
Finite State Machine

Vector Sum
Calibration

DAQ attached middle layer server

Piezo
Calculation

Quench
Detection

LLRF
Statistics

Buffer Mgr

DAQ
multicast

DAQ
multicast

DAQ
multicast

DOOCS communication

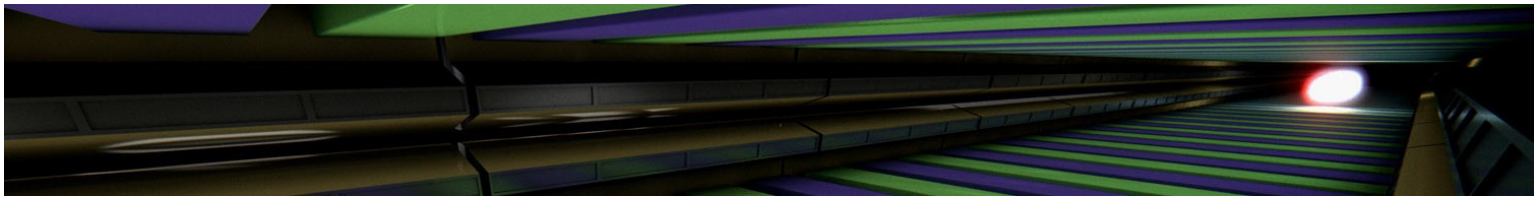
PiezoDOOCS Svr
SimconDSP HW
Piezo HW
VME front-end

ADCRF DOOCS Svr
14Bit ADC
VME front-end

LLRF DOOCS Svr
SimconDSP HW
VME front-end

Kly. DOOCS Svr
Klystron HW
VME front-end

Central timing



DOOCS server

Cryo Intl — Check →
Coupler Vac — Check →
Coupler Intl — Check/Reset ↔
Klystron Svr — Switch ON →, Check Filament →
LLRF Statistics Qloaded/Detuning — Check →
Quench Svr — Check →

RF FSM

Run @ 2Hz

tripaction():
- Blocks laser
- Switch off LFF
- Switch off FB
- Switch off FF
- Amplitude to zero

DOOCS server

LLRF Controller

Status — Check ←
FeedForward (FF) — Switch ON →
Amplitude — recover →
FF Output Matrix — tune →
FeedBack (FB) — Switch ON →
FB Output Matrix — tune →
Learning FF — Switch ON →

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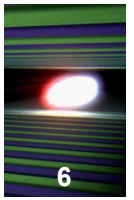
Progress in FSM Developments at FLASH



FSM Main State

- FSM on, call check_status(),save_onstatus()
- Start-up
- State Name
- State Error Message
- tripaction()

If (Startup == 1)

Startup (recover)

else

Shutdown

One DOOCS location
e.g. RF section

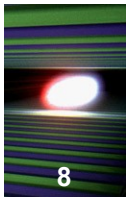
Progress in FSM Developments at FLASH

When switching the FSM on...

- check_status()
  - Check klystron HV > 8000V => in Start-up mode

- save_onstatus() save the current machine status
  - Learning FeedForward (LFF) on/off
  - FeedBack on/off
  - FeedForward on/off
  - Amplitude set-point
  - Klystron HV set-point
  - Output Rotation Matrix correction on/off

Progress in FSM Developments at FLASH



- On tripaction()
  - Blocks the laser
  - Switches off LLRF
    - ➔ Feedback
    - ➔ Feedforward
    - ➔ Learning FeedForward (LFF)
    - ➔ Output Matrix correction
  - Puts amplitude (gradient) set-point to zero

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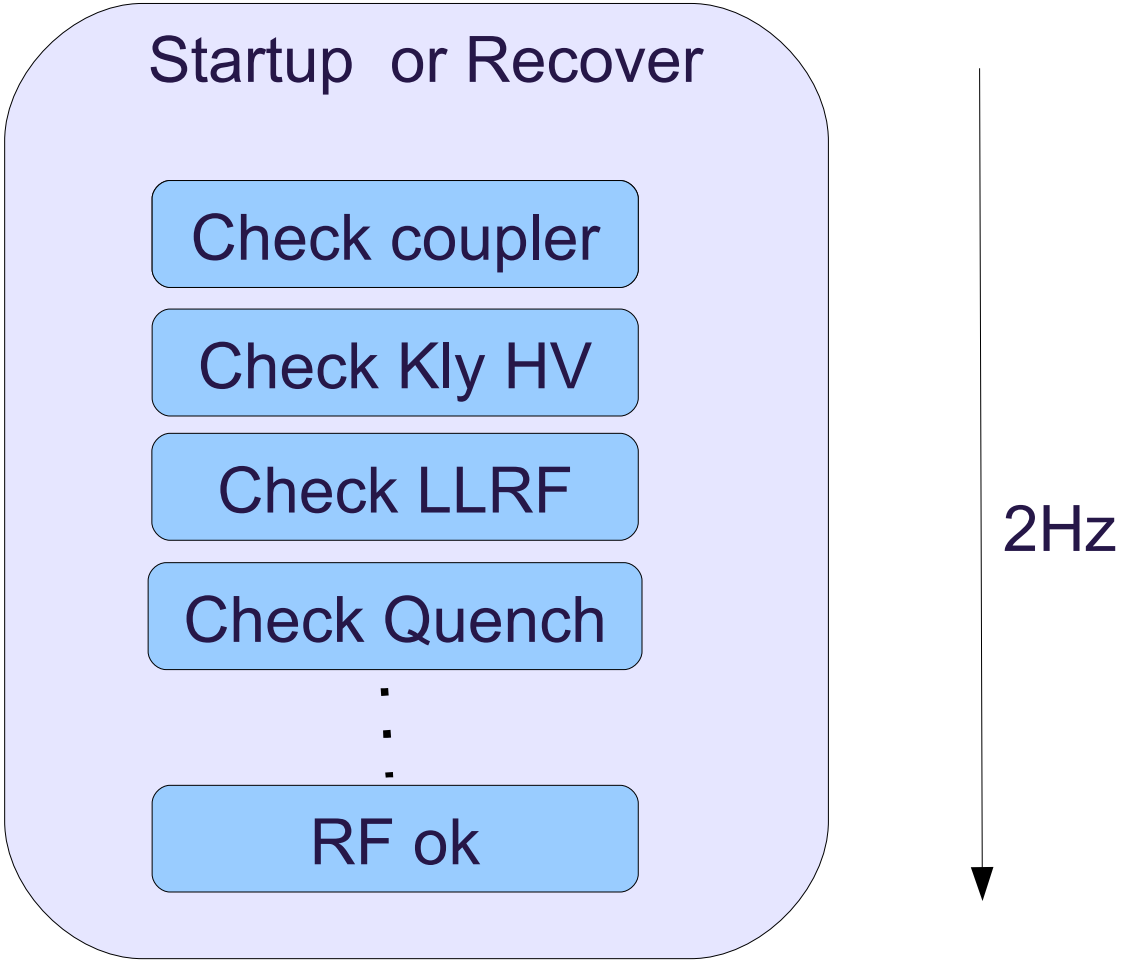

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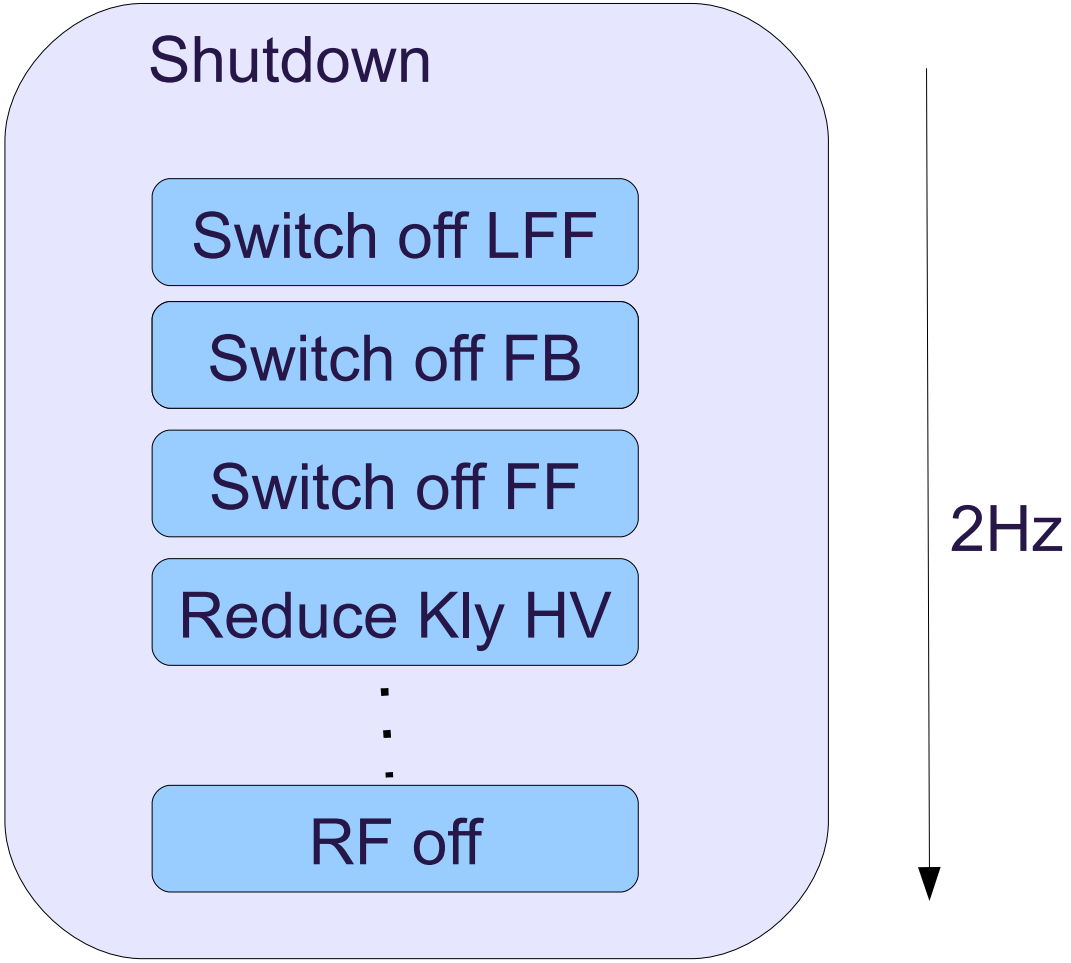
Progress in FSM Developments at FLASH



Progress in FSM Developments at FLASH

Concept of a simple FSM using DOOCS D_functions inside a standard DOOCS server

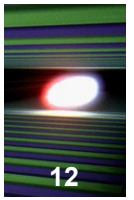
D_FSMreset State
- DOOCS address of monitoring Bit
- DOOCS address of reset Bit
- Retry counter
- Timer in seconds
- Enable Bits

Reset something
e.g. interlock

D_FSMrecover State
- DOOCS address of monitoring Bit
- DOOCS address of recover Bit
- Enable Bits

Switch something on/off
e.g. Feedback

Progress in FSM Developments at FLASH



Concept of a simple FSM using DOOCS D_functions inside a standard DOOCS server

D_FSMmonitor State
- DOOCS address of monitoring Value
- Recover Value
- Tolerance value
- Retry counter
- Enable Bits

Monitor a value
e.g. filament HV
Recover a value
e.g. LLRF Amplitude

D_FSMtimer State
- Timer value in seconds
- Enable Bits

Just wait

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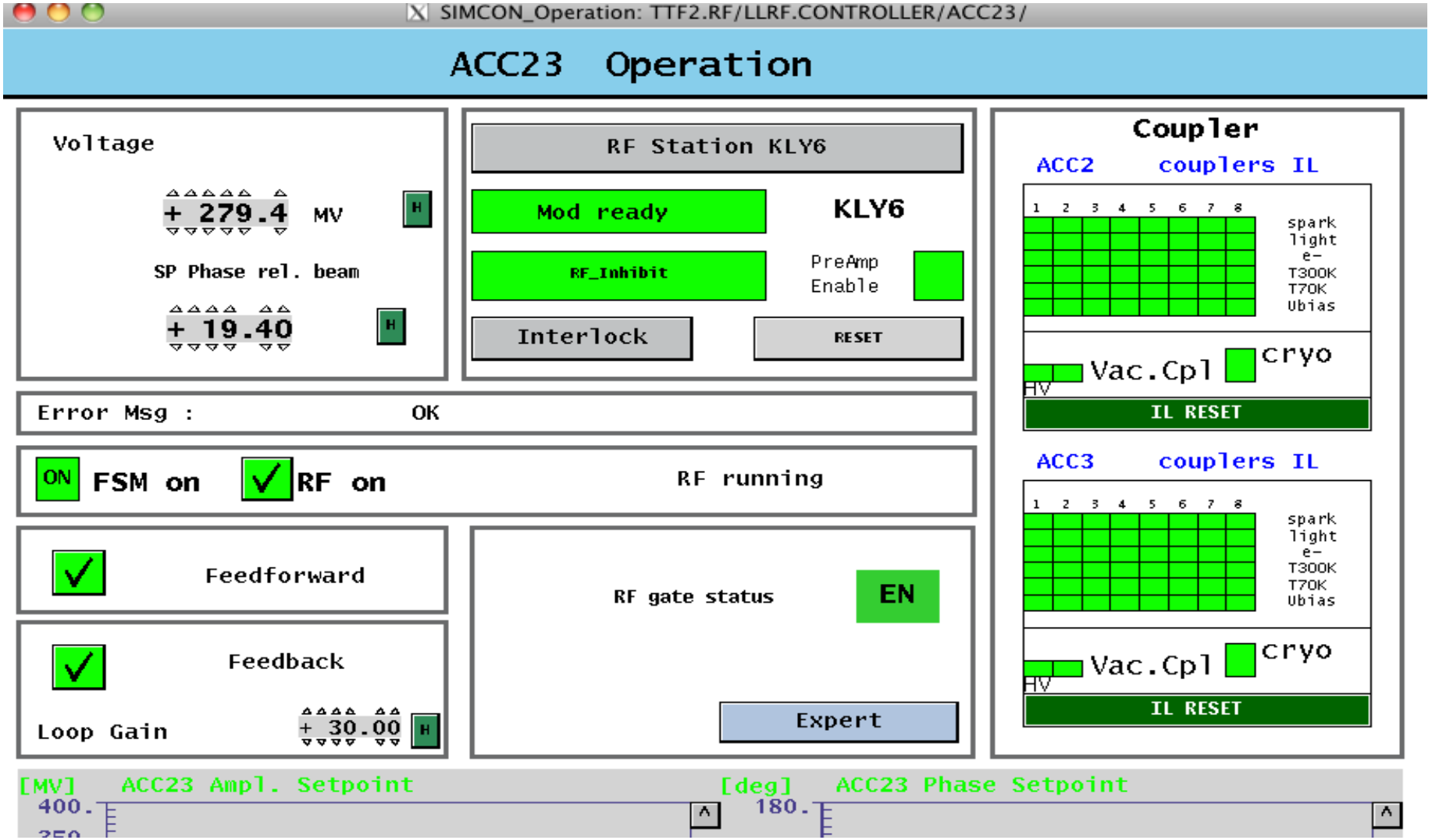
How to use the RF FSM



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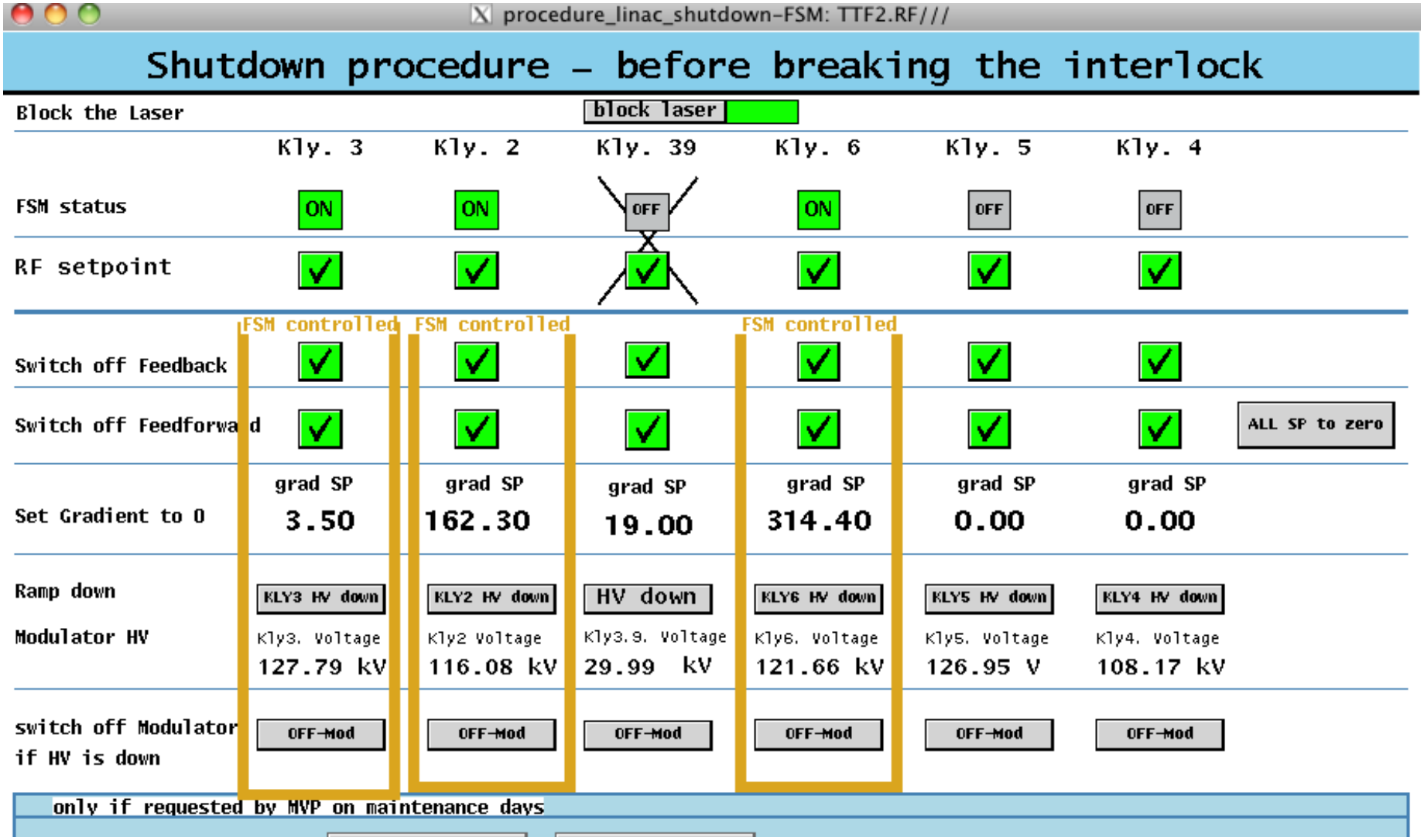
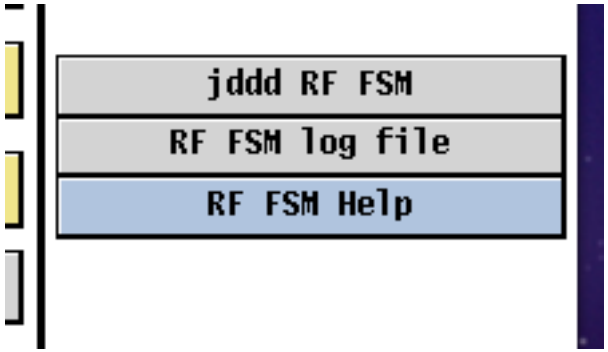
How to use the RF FSM



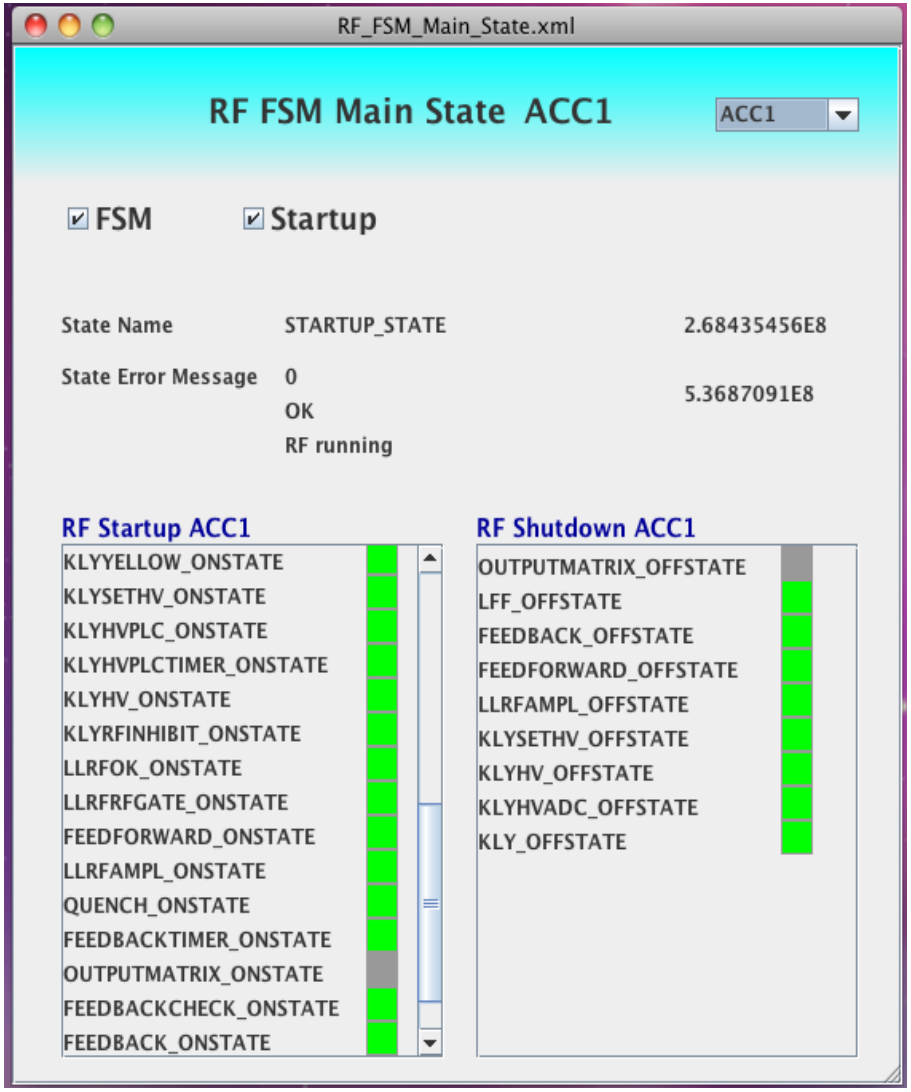
How to use the RF FSM

For experts

main_select → Modules



How to use the RF FSM



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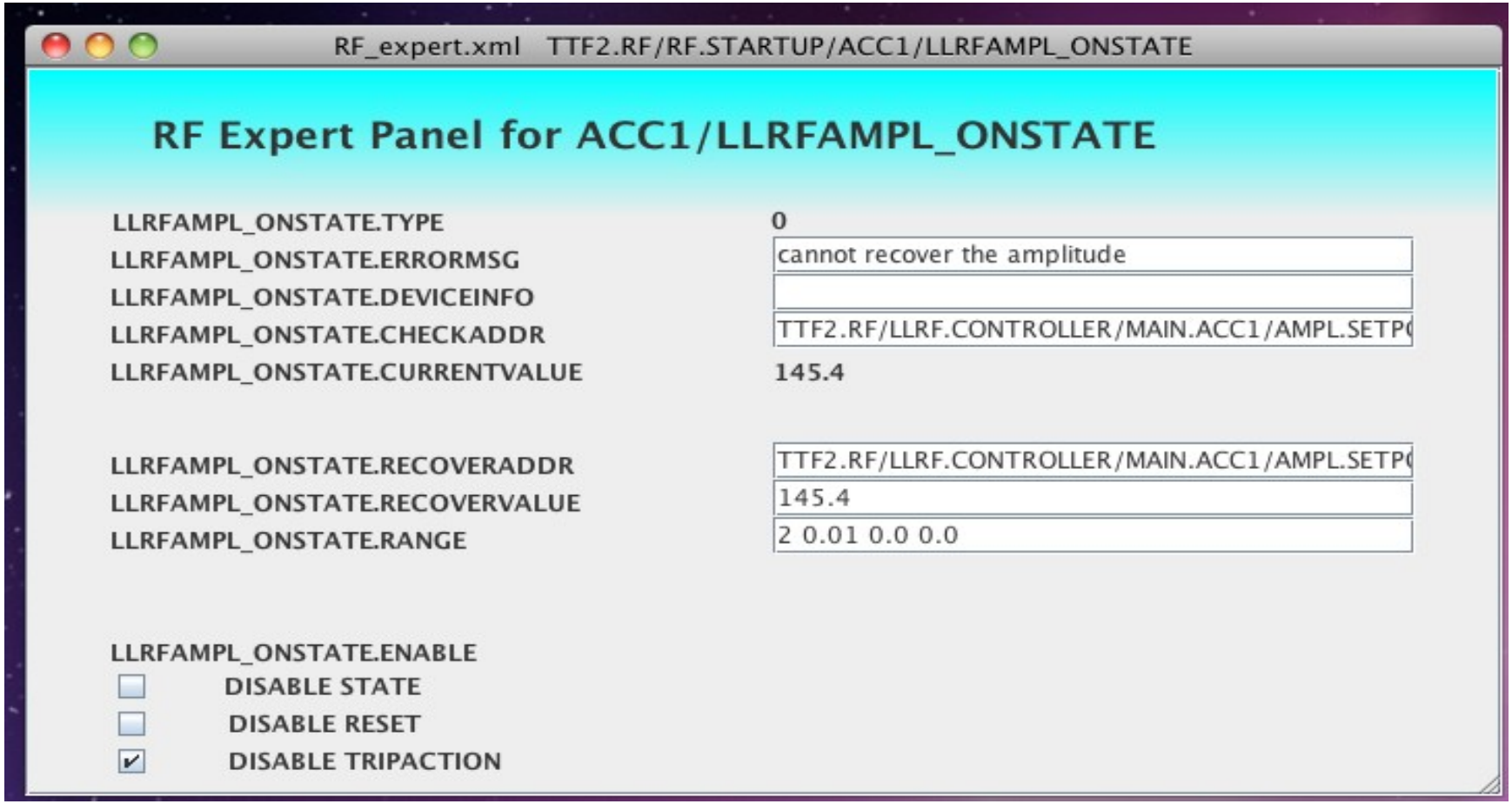
How to use the RF FSM



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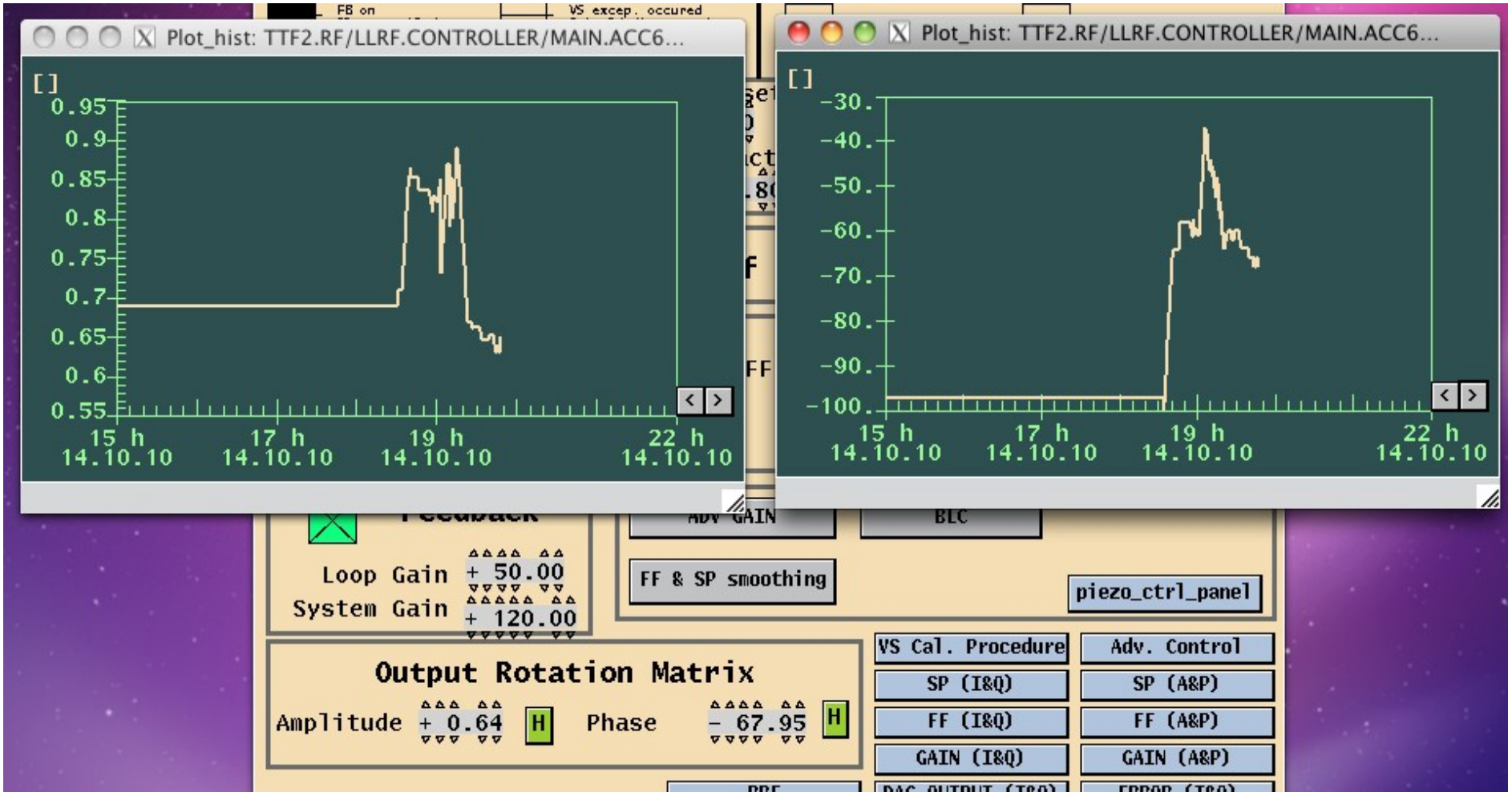
Progress in FSM Developments at FLASH

Output Rotation Matrix correction



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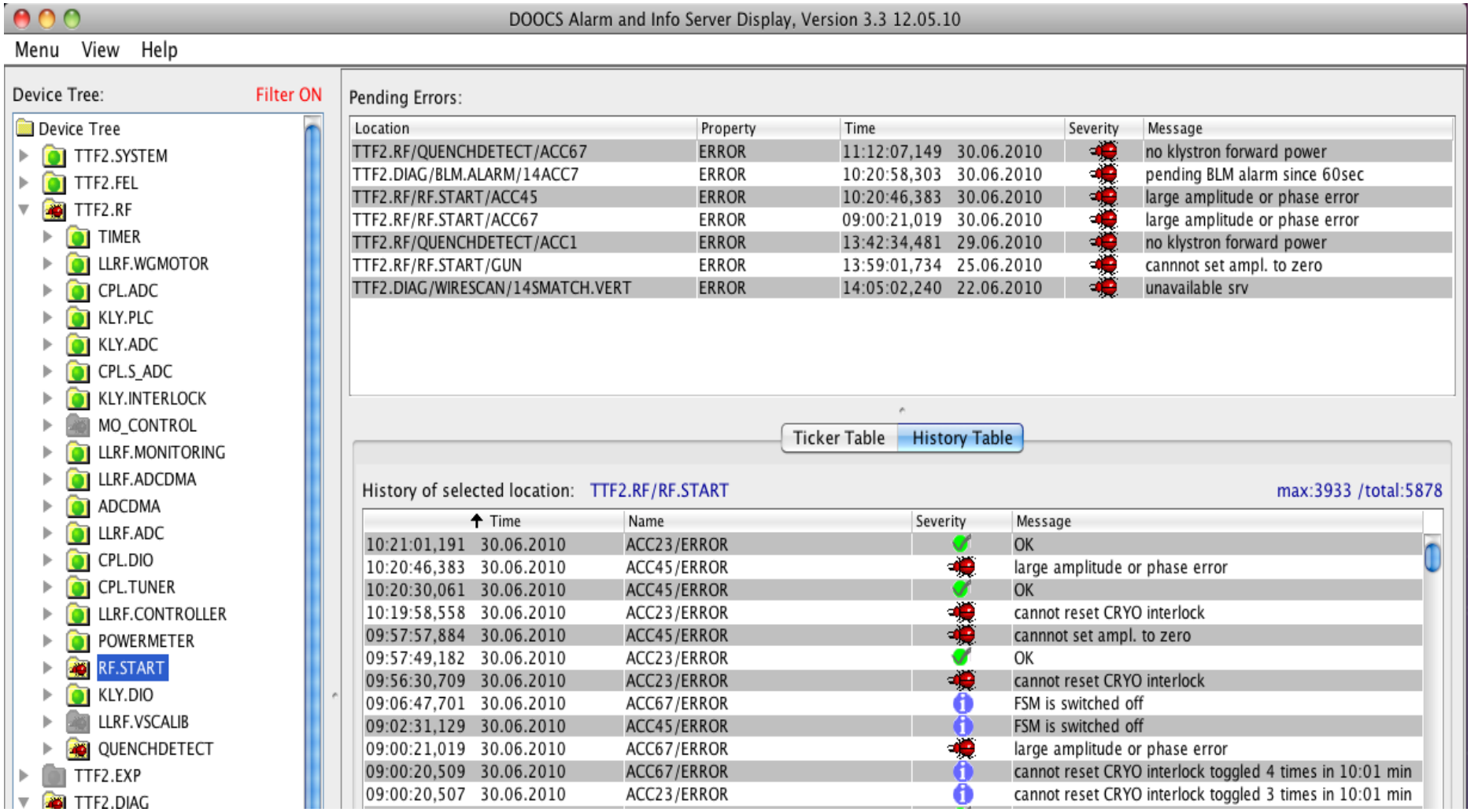
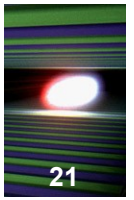
Error messages in Alarm&Info



Status



- GUN location just resets pulse length to 10µs
  - Ramping up to previous pulse length needed
- Integration of klystron 3.9GHz still missing
- Know bugs :
  - Trips, when changing the amplitude set-point
  - Operator intervention not possible, when in recover mode
- Tighter integration with
  - Quench-detection
  - Output Rotation Matrix automation
  - Sequencer
- Train operator to get more confidence

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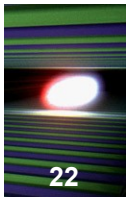
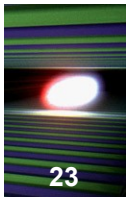
Conclusion



- Concept proven
- Usually in operation for all stations
- Will be the central software for RF automation
- Switching OFF the FSM must be forbitten
- Meanwhile good acceptance by operator crew and LLRF experts
- Found no other applications for this FSM technology yet

Thank you



Thanks for your attention