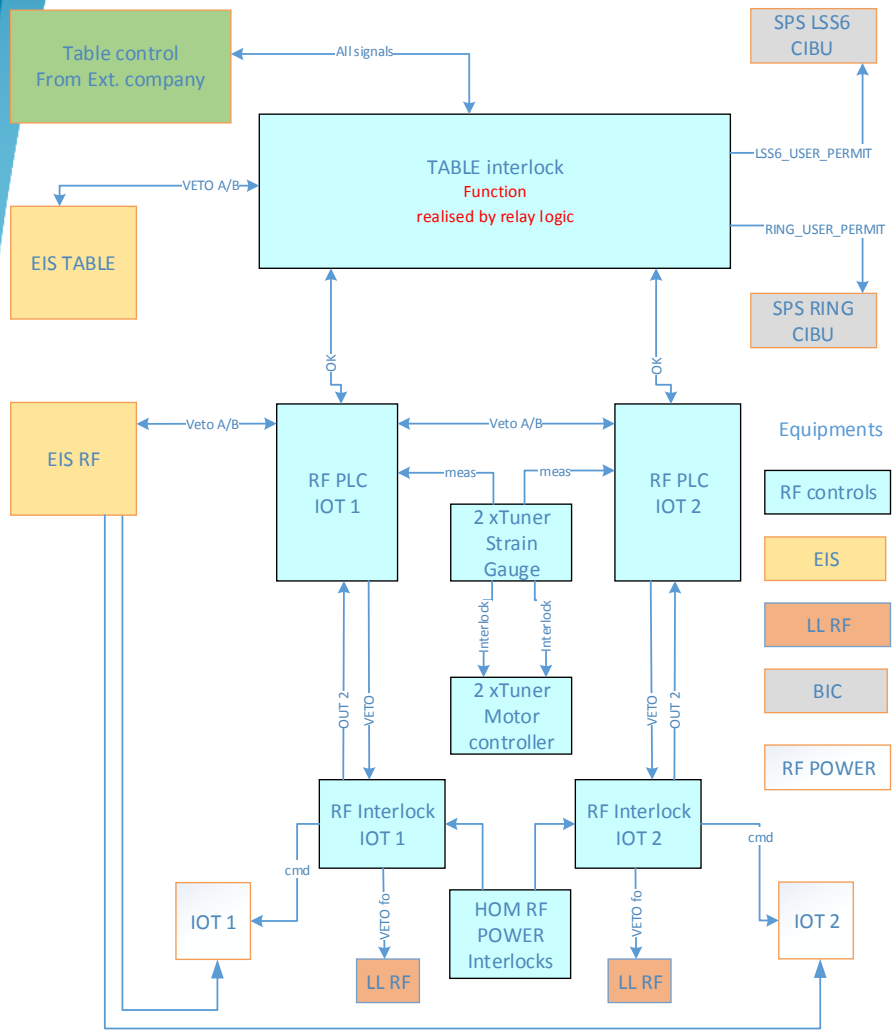
SPS-CC Interlocks and Automation



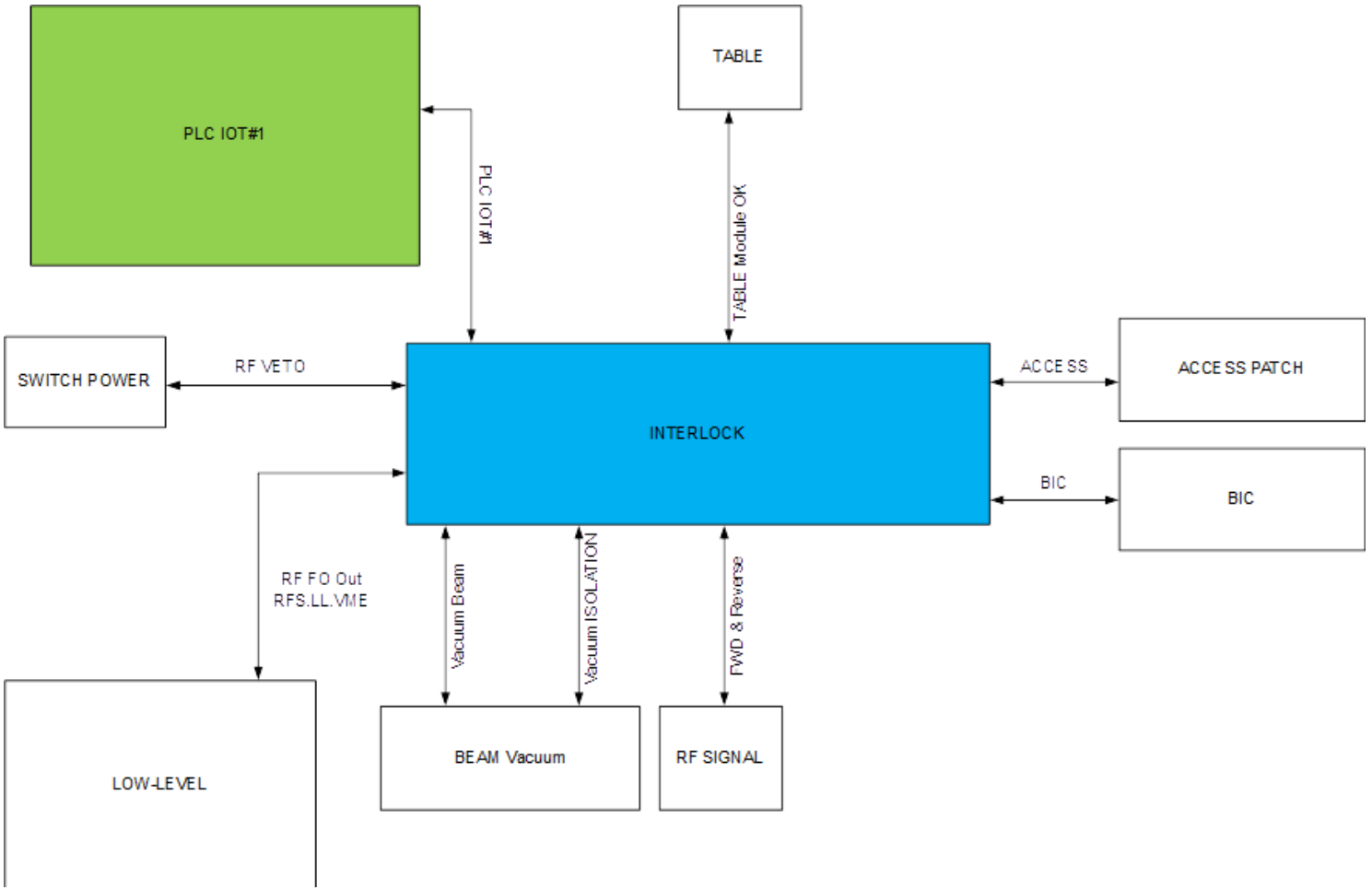
Main elements:

- One PLC + one fast interlock to control **each IOT / Cavity**
- One table interlock relay and PLC monitoring
- One dual RF power interlock for up to 8 HOM signals
- One dual Motor controller for tuner movement
- Dual strain gauge conditioner with interlocks

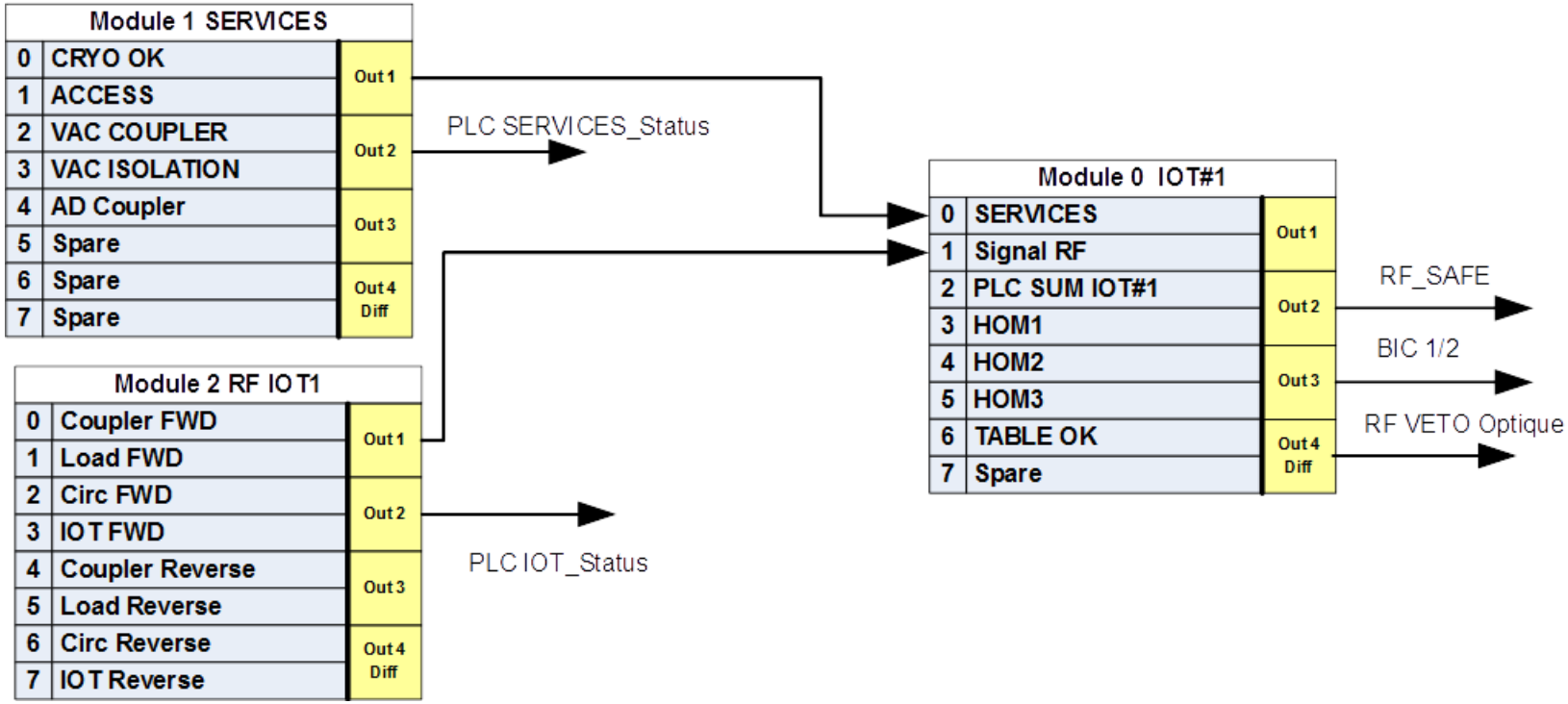
Main external connections:

- Table control system with local and tunnel remote control possibility
- Cryogenic control interface for hardware Cryo OK signal
- Separate access system interface for RF controls and for table control
- Dual Beam interlock link for LSS6 and RING
- Low level RF (LLRF) VETO fibre link and extra contact for conditioning RF VETO

Interlock Overview

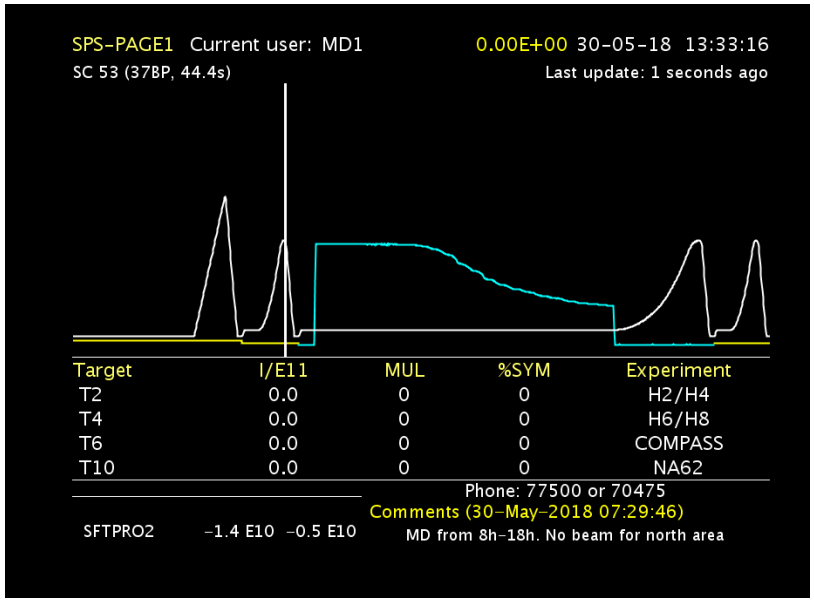


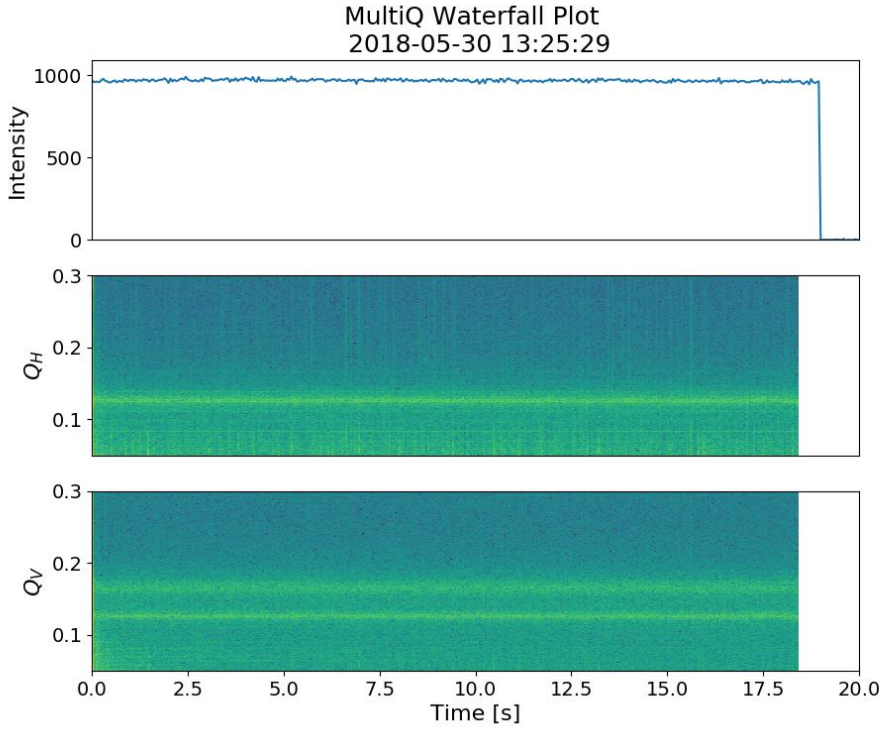
Interlock Overview, Contd.



Slow Losses at 26 GeV

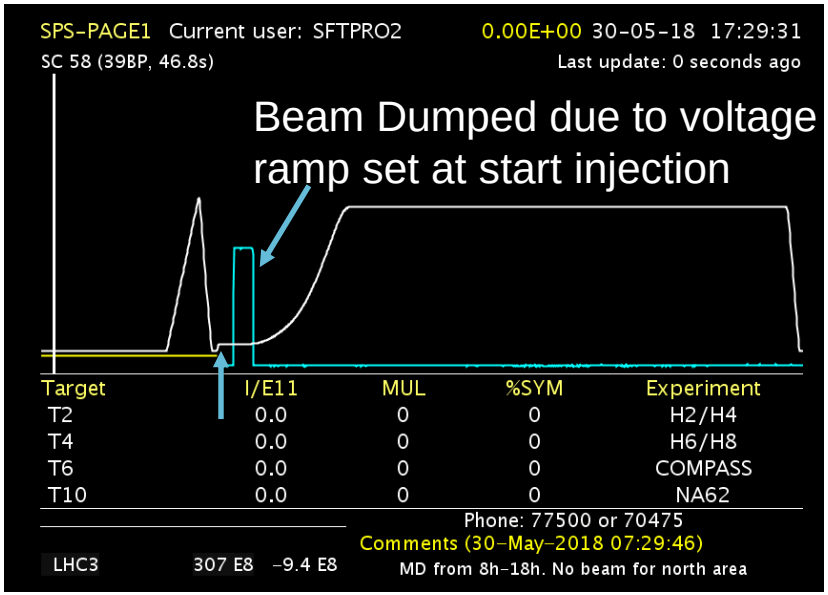
- Cav 1 tuner loop setup and crossed the vertical tune

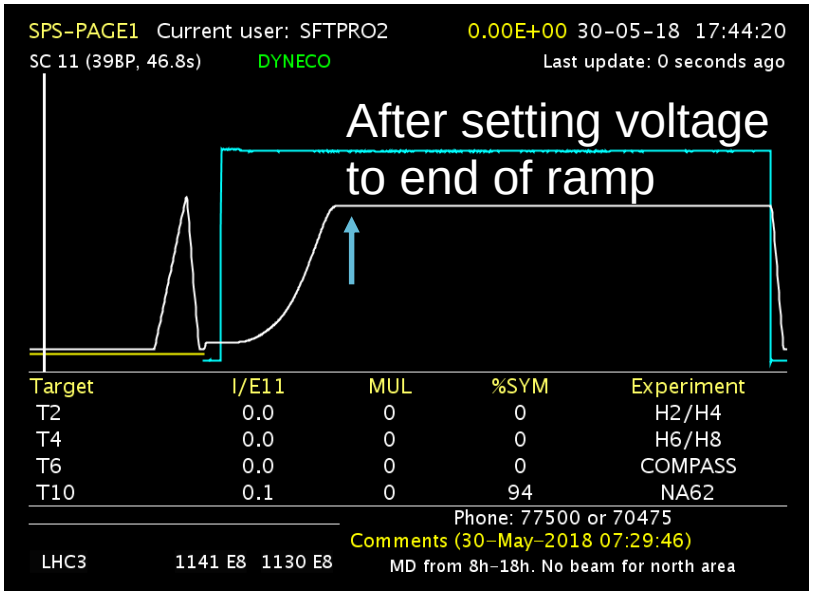




270 GeV Ramp

Cav1 ~1MV (400.787 MHZ), Cav2 off (400.528 MHz)





- Checked with and w/o transverse feedback beyond nominal bunch
- Longitudinally unstable w/o 800 MHz

Ramp to 270 GeV

Vertical tune: $Q_y = 0.18$

RF Freq:

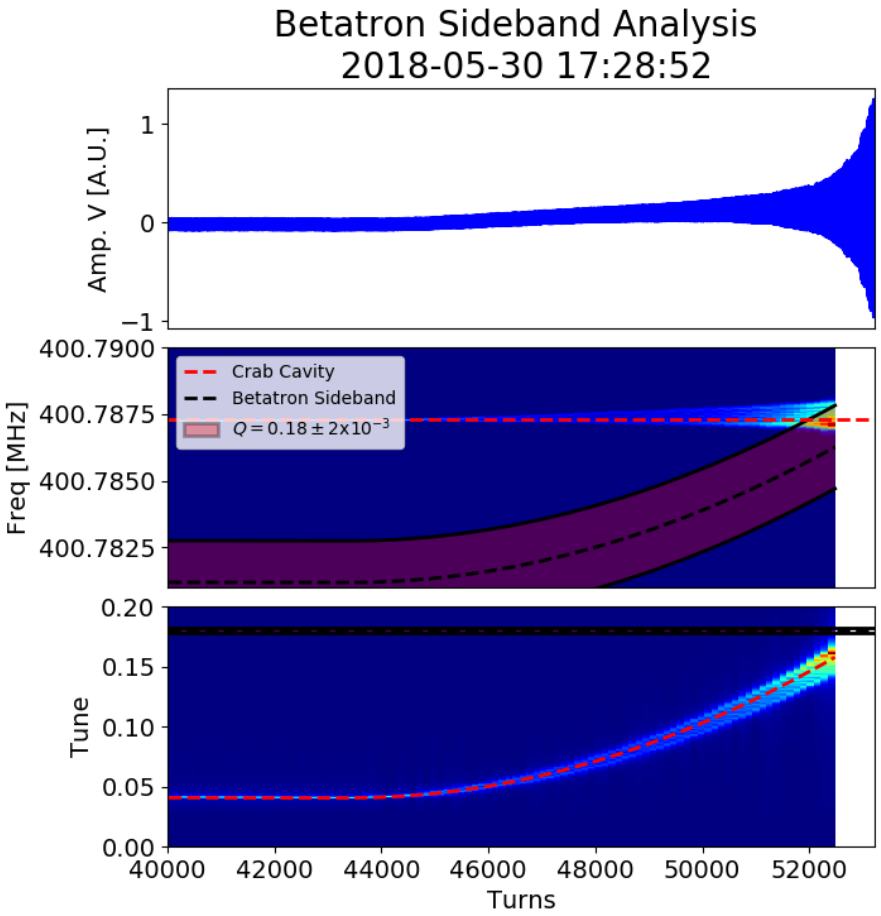
Cavity 1: 400.787 MHz (~1 MV)

Cavity 2: 400.528 MHz (almost zero)

Resonant excitation observed as we cross the vertical tune (black dotted lines).

Kicking the beam at 270 GeV equivalent frequency , while sweeping the beam frequency from 26-270 GeV

After setting the correct cycle start voltage to 270 GeV equivalent, beam circulated w/o any issue



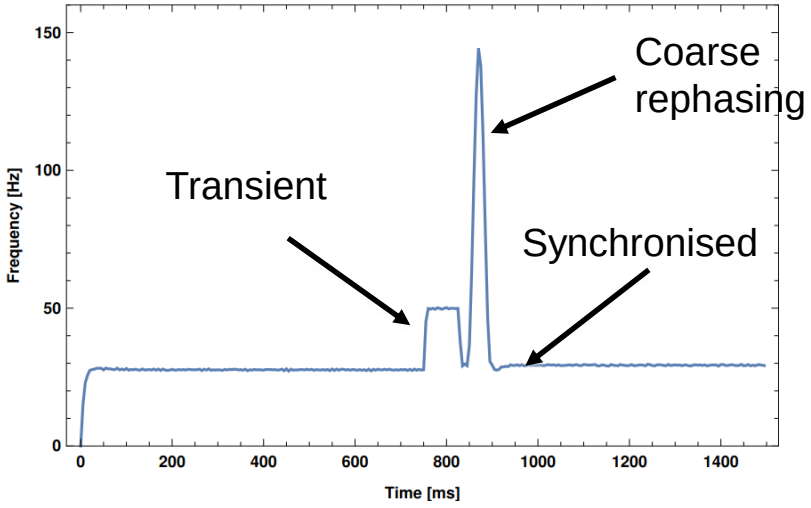
New Fast Interlocks

- Two types of interlocks discussed
  1. Synchro between BA6-BA3 frequency: If the Δf main RF and crab is close to the β-tune (~8 kHz) to avoid resonant excitation in few 10's of turns.
  2. New interlocks in BA6: Amplitude & phase drifts of the cavities exceeding a max value – for ex quench
- Resources
  - For 1) only 1 set of spares available – new hardware needs to be built. Beat freq detector + window detector and output to existing SPS QUAD Interlock Interface SPS
  - For 2) detailed studies with MPP in the coming MDs needed to understand which signals from LLRF can be robustly used. Then see what hardware is needed. Doesn't look practical for 2018 run
- Bottom line is we stay safe limit unless 1) or 2) can be safely implemented in a short time!

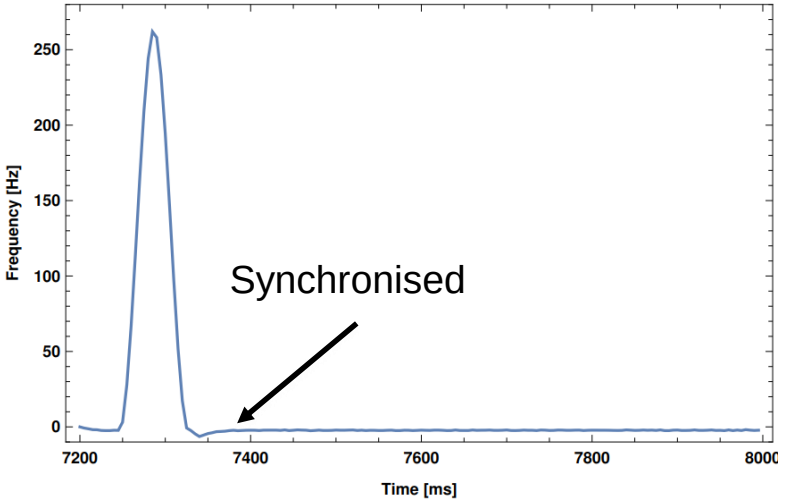
Crab-RF Sychronization

- Crab cavity rf set point from BA6 to BA3
- CC ~400 MHz, SPS RF ~200 MHz
- Rephasing of SPS RF to become synchronous with crab signal.

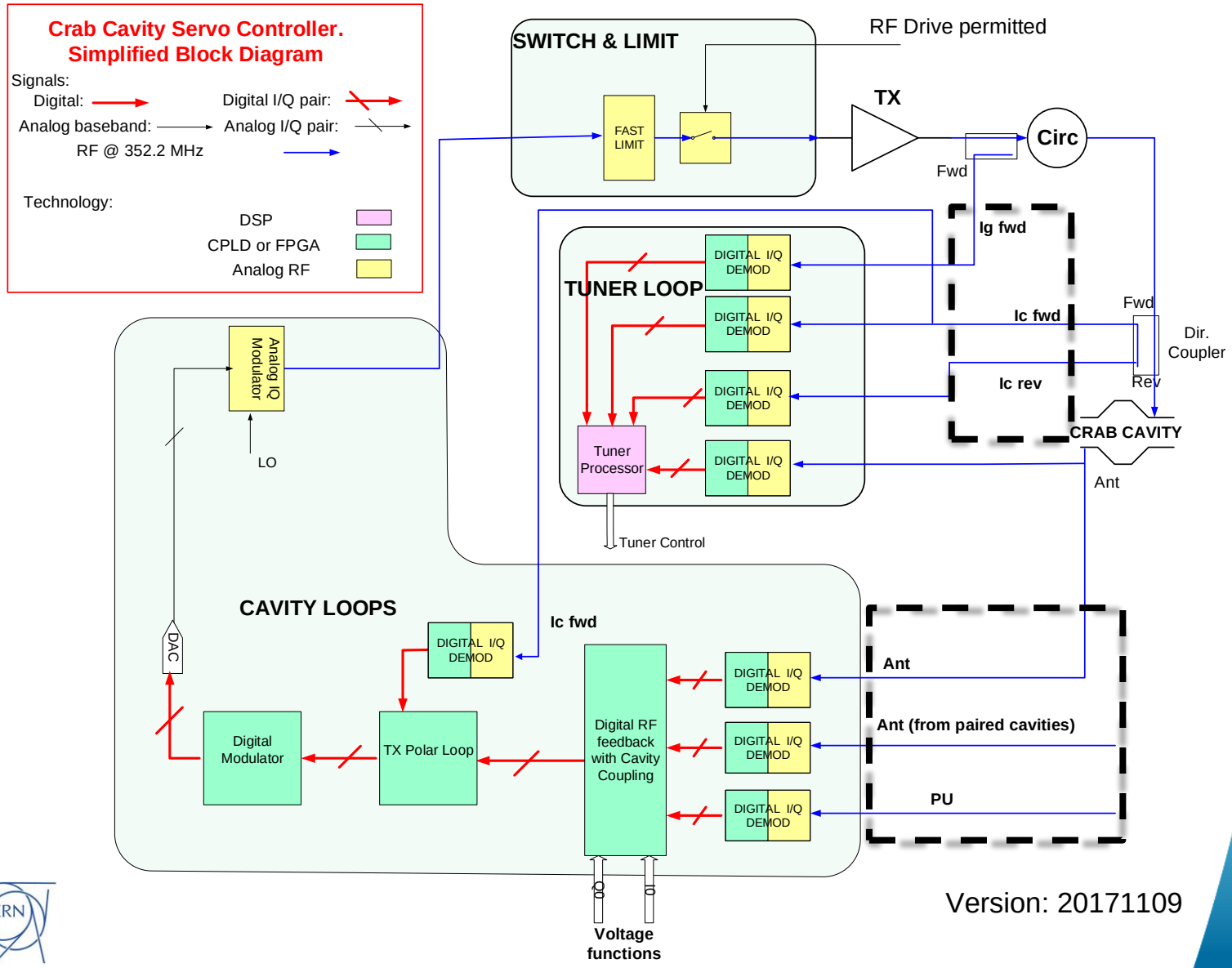
26GeV rephasing
Synchronised from ~1s
after injection



270GeV rephasing
Synchronised from ~7.4s
i.e. 0.2s after reaching flat top



SPS CC LLRF, Simplified

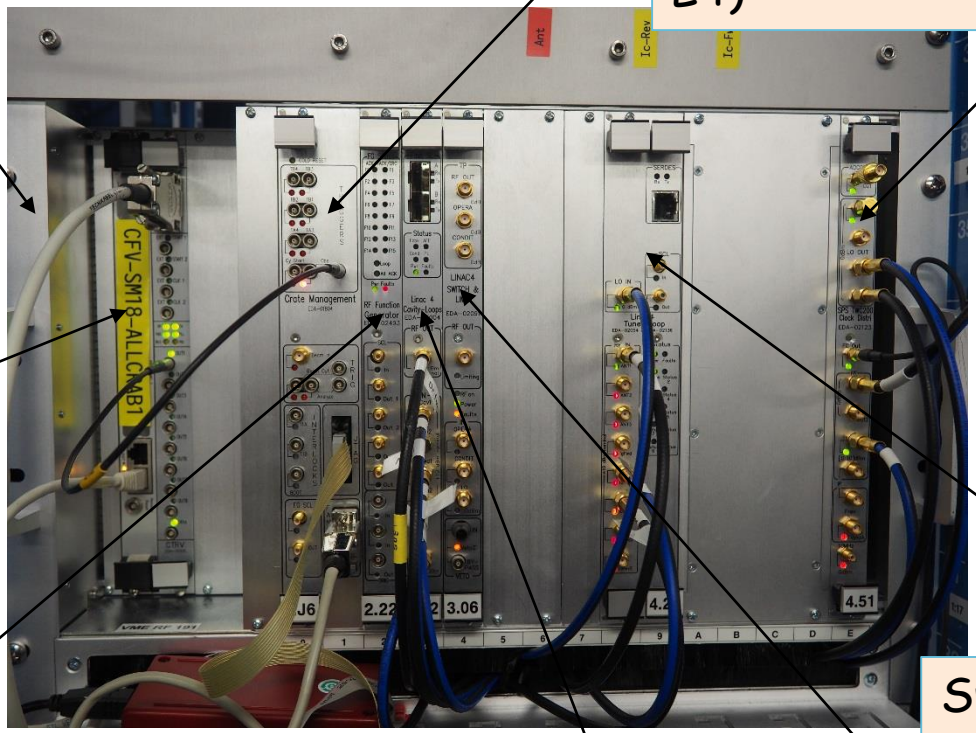


Version: 20171109

Custom-designed RF VME crate (same as LHC and L4)

Standard CO-supplied CPU with timing card (CTRV/P)

Function generator (same as SPS LLRF)



Crate Management module (same as LHC and L4)

Clock Distributor module. Generates the harmonically related LO and ADC clocks. Adapted from L4

Tuner module. Adapted from L4

Switch and Limit module. Receives the RF power interlock. (adapted from LHC and L4)

Cavity Loop module (MIMO feedback). Hardware adapted from L4 module (352.2 MHz)

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