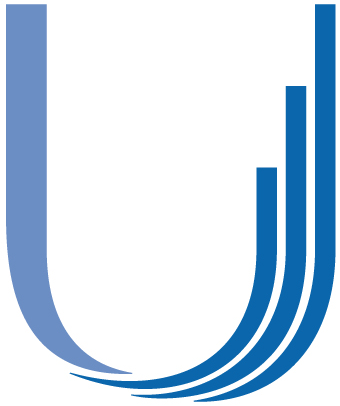


LHC Injectors Upgrade

LHC Injectors Upgrade

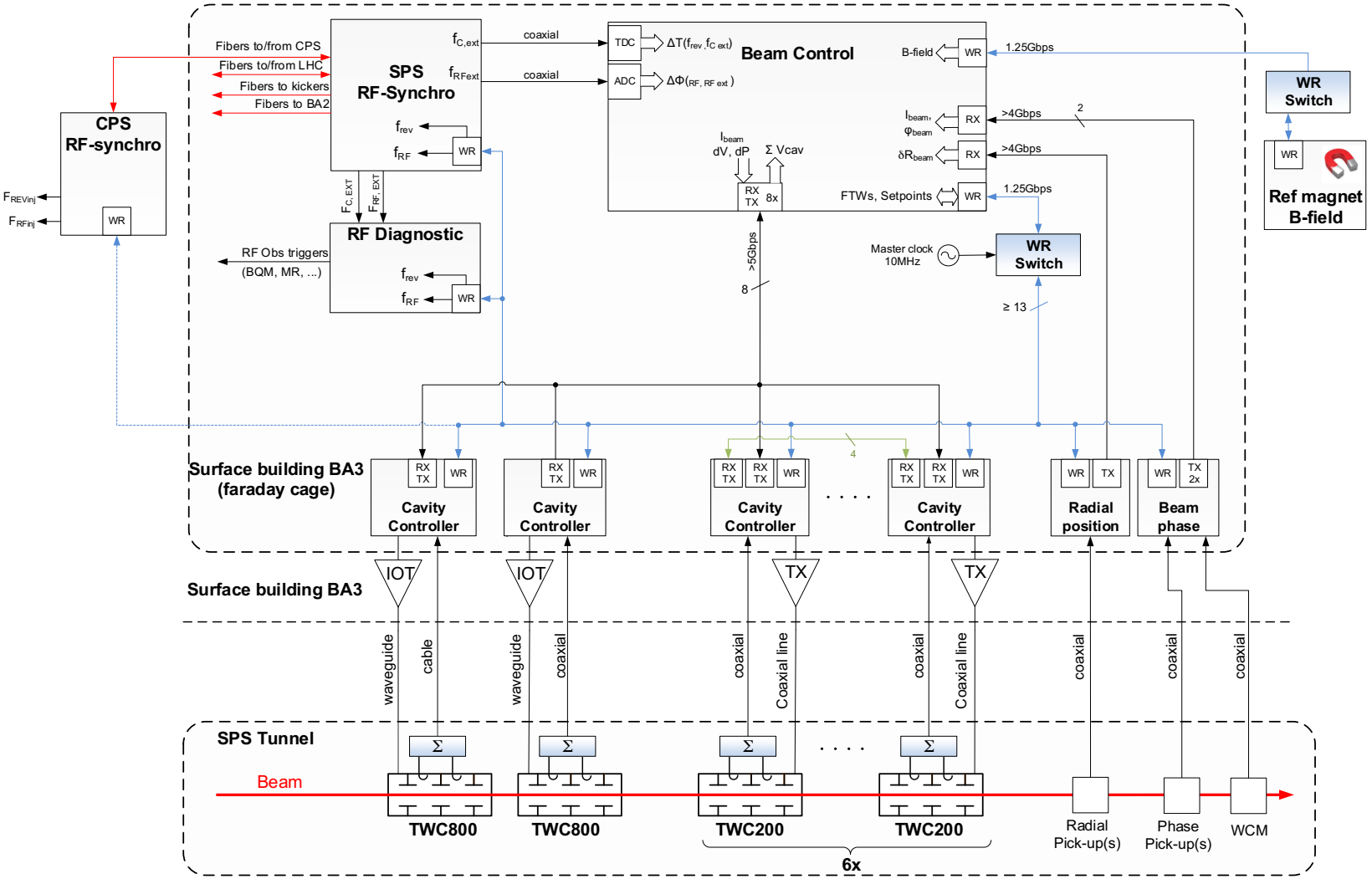
LIU – SPS Low level RF

Slip stacking implementation

Arthur Spierer, 18.04.2018

CERN

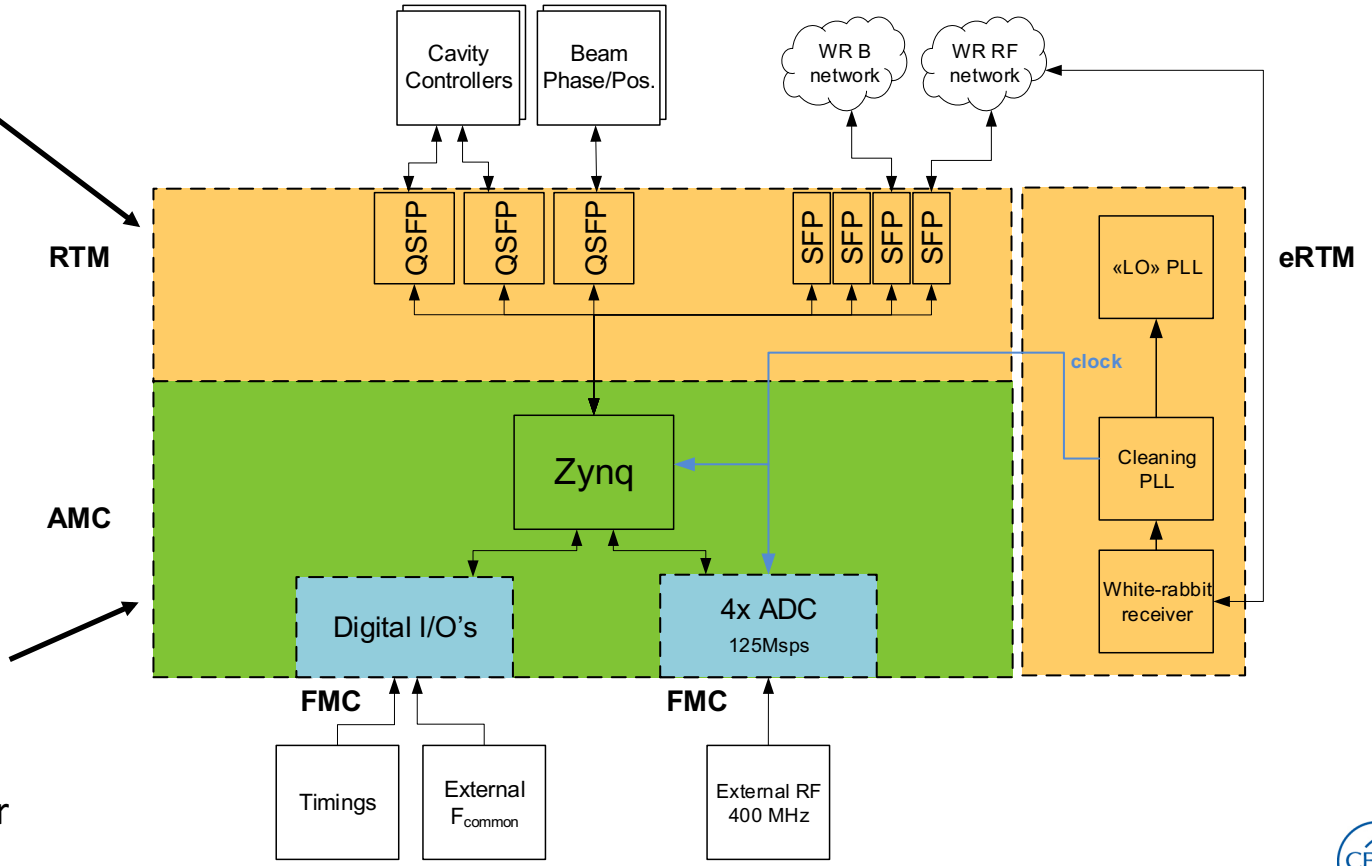
SPS LLRF overview



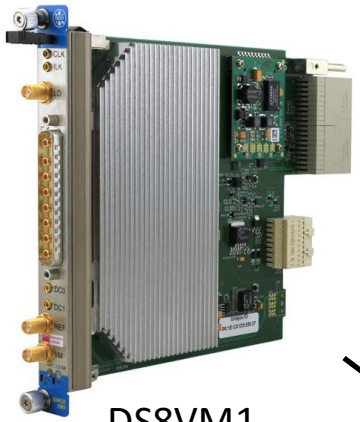
Beam control Hardware overview

16 SFP+ RTM

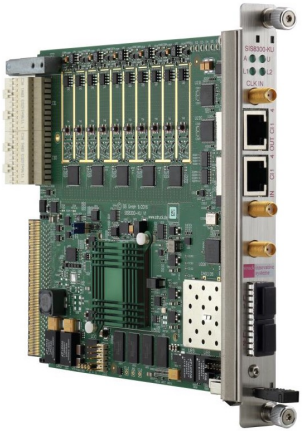
AFCZ FMC Carrier



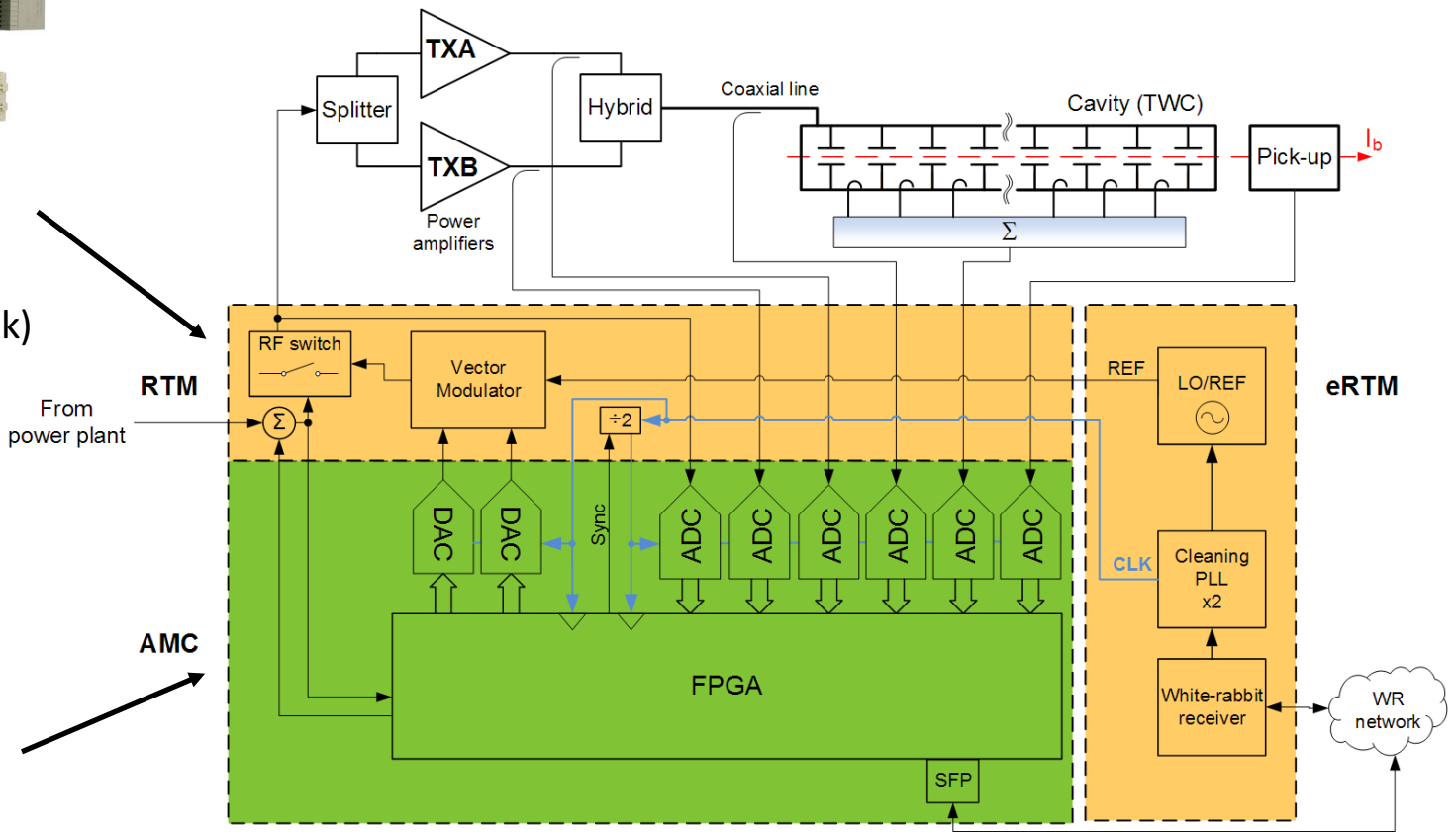
Cavity controller overview



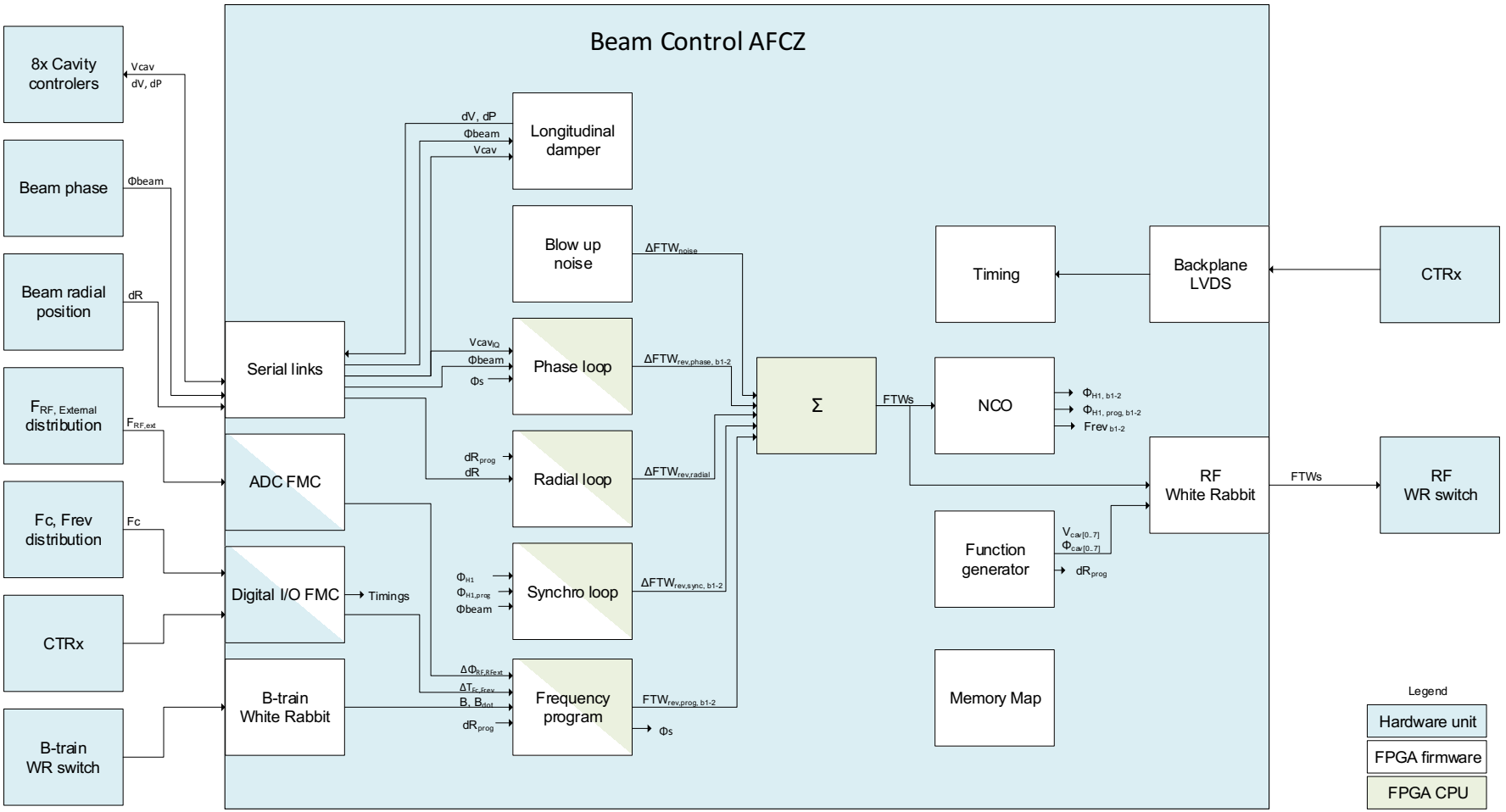
DS8VM1
(Desy/Struck)



SIS8300-KU
(Desy/Struck)

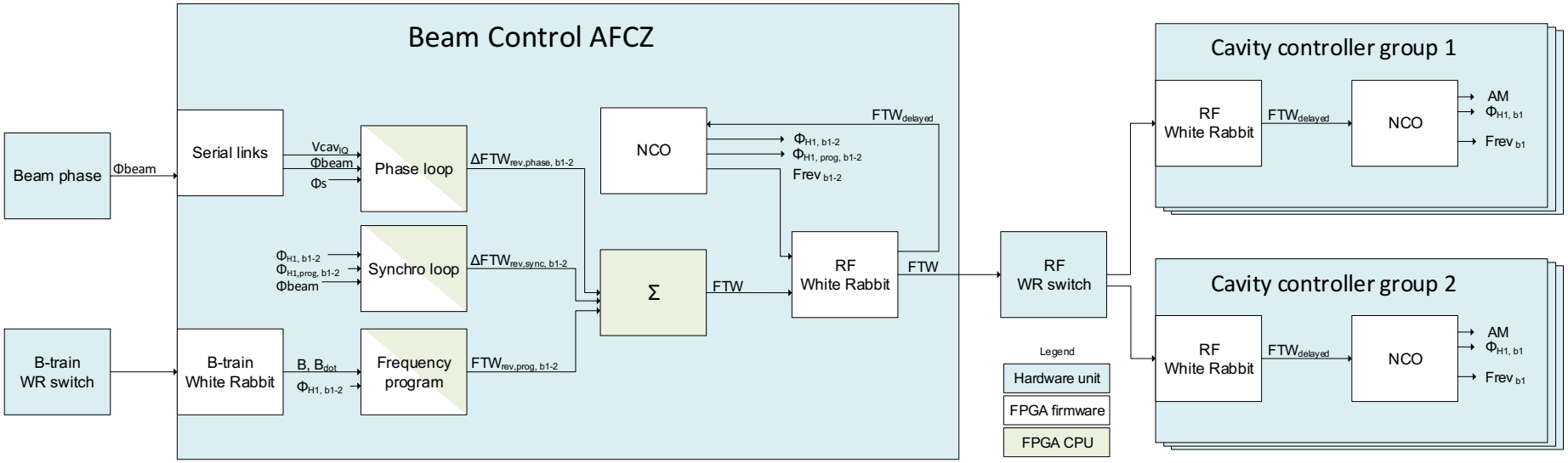


Beam Control



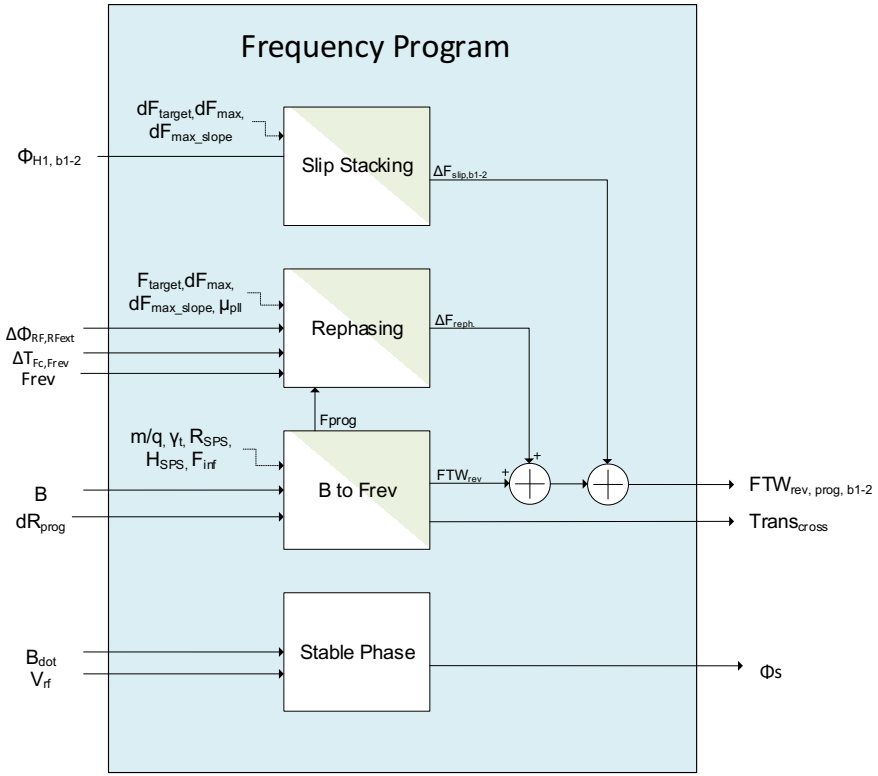
Beam Control Slip Stacking

- Slip Stacking is part of the frequency program
  - Frequency and voltage ramps are computed in real-time or recorded
- Two phase loops and synchro loops during Slip Stacking
  - Bunch by bunch phase measurement for each super-batch
- NCOs are synchronised and updated through White-Rabbit



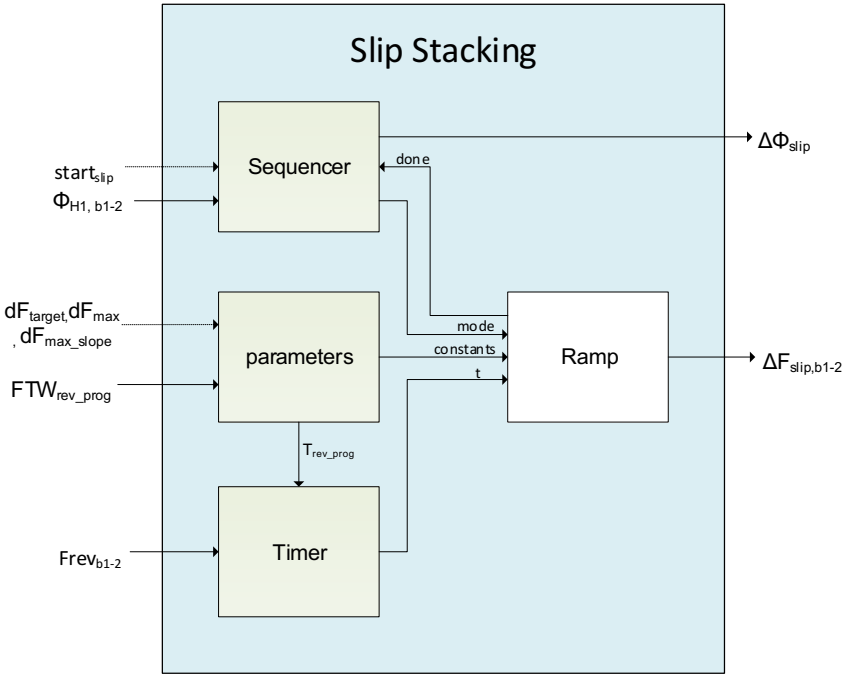
Frequency Program Slip Stacking

- Ramps are computed (real time or recorded) based on parameters
  - Maximum slope, Target frequency, Maximum frequency offset, …
- The slippage can be monitored in real time for the two super-batches
  - Allows detection of the recapture time



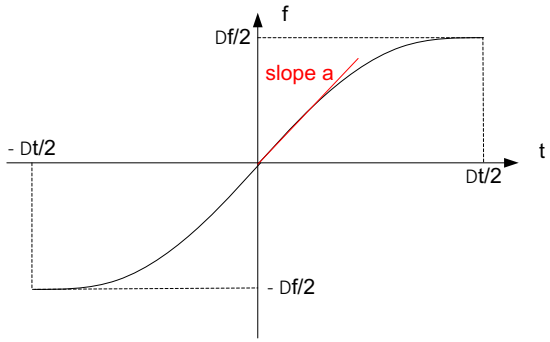
Real time computation

- Allows a turn by turn resolution without interpolation
- Straight forward for frequency, to be studied for voltage



Frequency trim function candidate

- SPS Rephasing trim function



$$f(t) = a.t - \frac{2^4}{3^3}\frac{a^3}{\Delta f^2}t^3$$

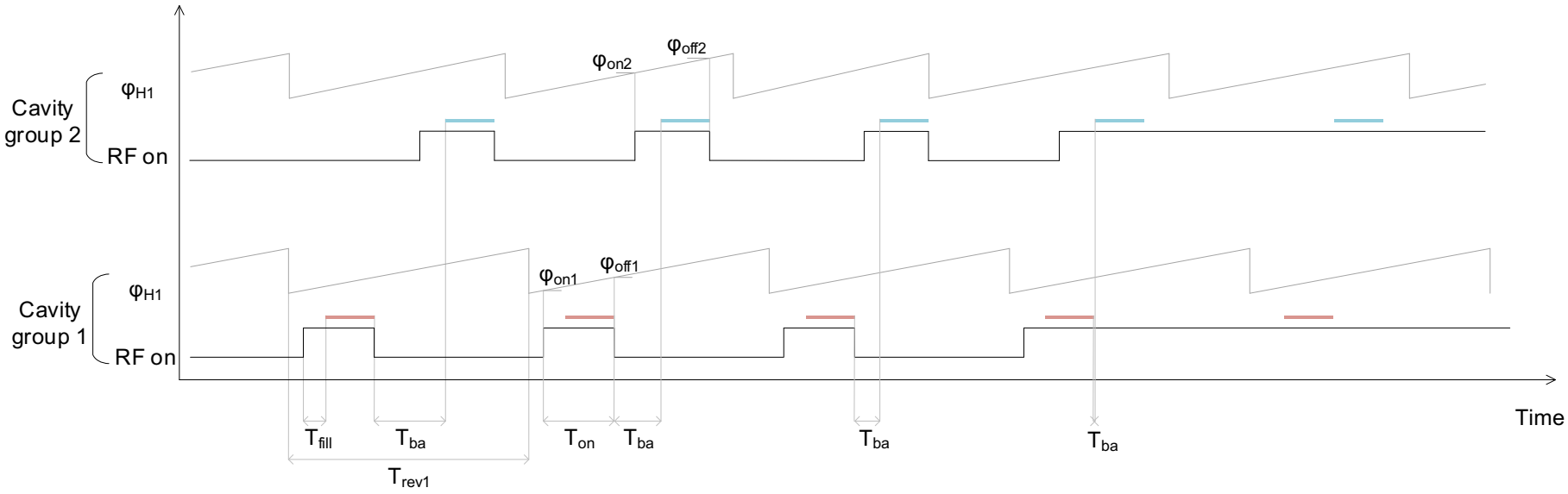
- Trim functions are symmetrical for each cavity group

Voltage trim function

- Voltage function is
  - Derived from the frequency ramp and …
  - Meant to keep a constant bucket filling factor

Amplitude modulation

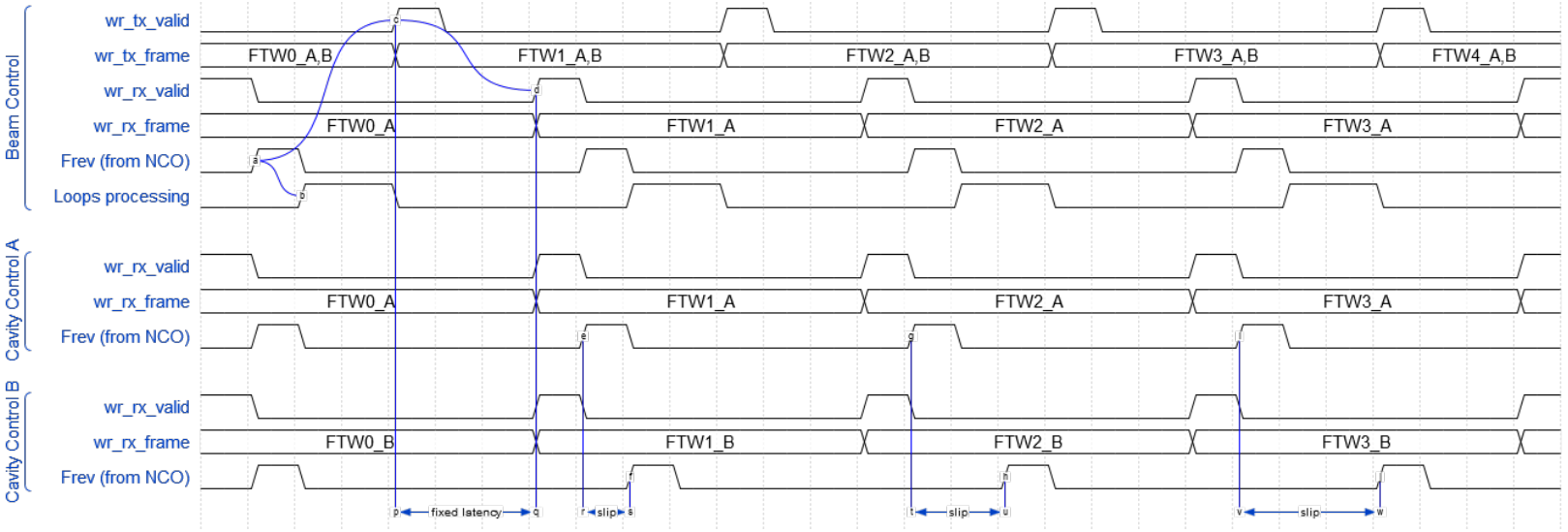
- Each cavity group RF is amplitude modulated (ON/OFF)
  - To separate the two super-batches injected at the same frequency
  - To decrease interferences between group 1 & 2 RF and batches
- Once the super-batches are too close, RF is kept ON



Frequency Tuning Words transmission

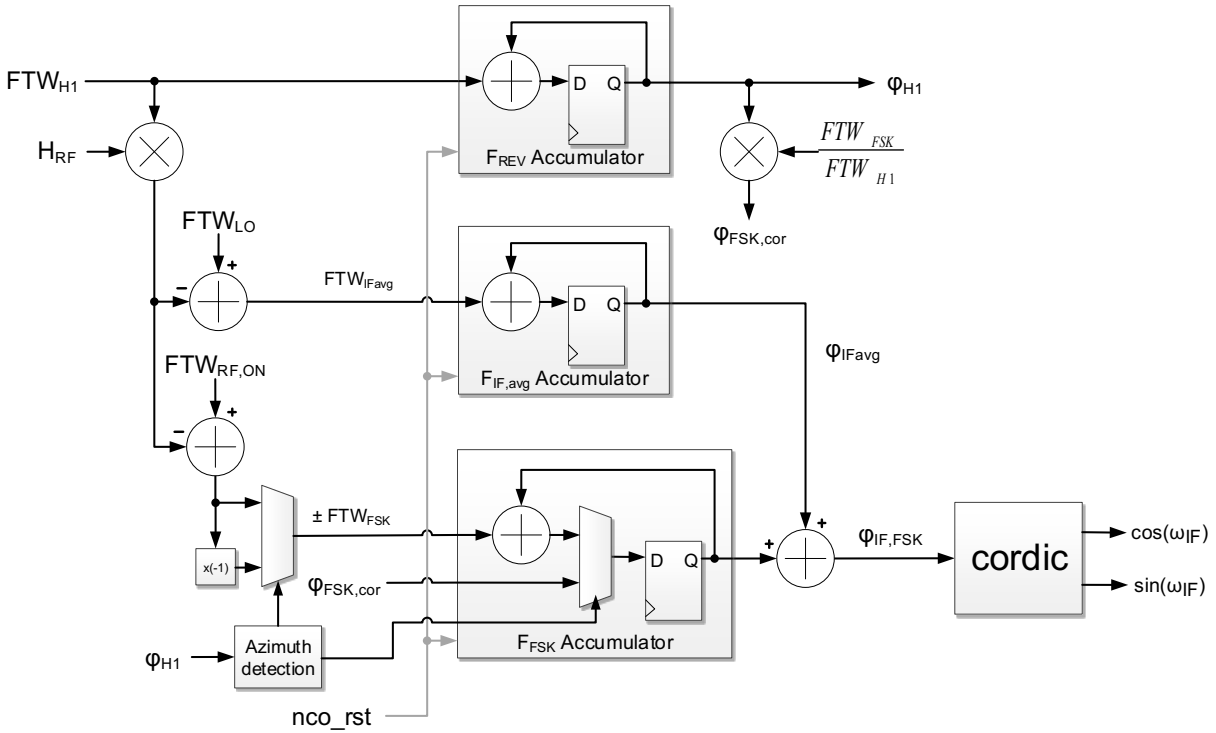
- Using White Rabbit link
  - Keep all nodes synchronised
  - Fixed Latency
  - One update per turn

Name	Size (bits)	Description
FTW_H1	48	FTW Harmonic 1 main
FTW_H1[0..7]	8x48	FTW Harmonic 1 for each cavity
FTW_ON	49	FTW when RF is on during Fixed frequency Acceleration (Ions)
OFFSET_H1	48	Offset on H1 phase
Vcavity[0..7]	8x2x16	Cavity voltage setpoint in Amp/phase or IQ
Control Status	16	Control and status: bit 0: NCO_rst bit 1: trigger capture bit 2: NCO modulation on/off bit 4-3: NCO modulation rate
Phase_H1	48	Current H1 phase in beam control for synchronisation check



Numerically Controlled Oscillator (NCO)

- Reset and updated synchronously in every nodes
- Runs with the same clock on every nodes
- Phase comparator for amplitude modulation



Phase Loop

- Two independent phase loops
  - Bunch mask for averaging on each super-batch
  - Stopped when batches start to superpose
- Readings of the bunch per bunch phase are not coherent when the batches are superposed
  - No phase loops
  - Can help defining recapture time

LHC ion cycle