

# Hardware transmission of DC-BCT intensity to SMP SPS and LHC

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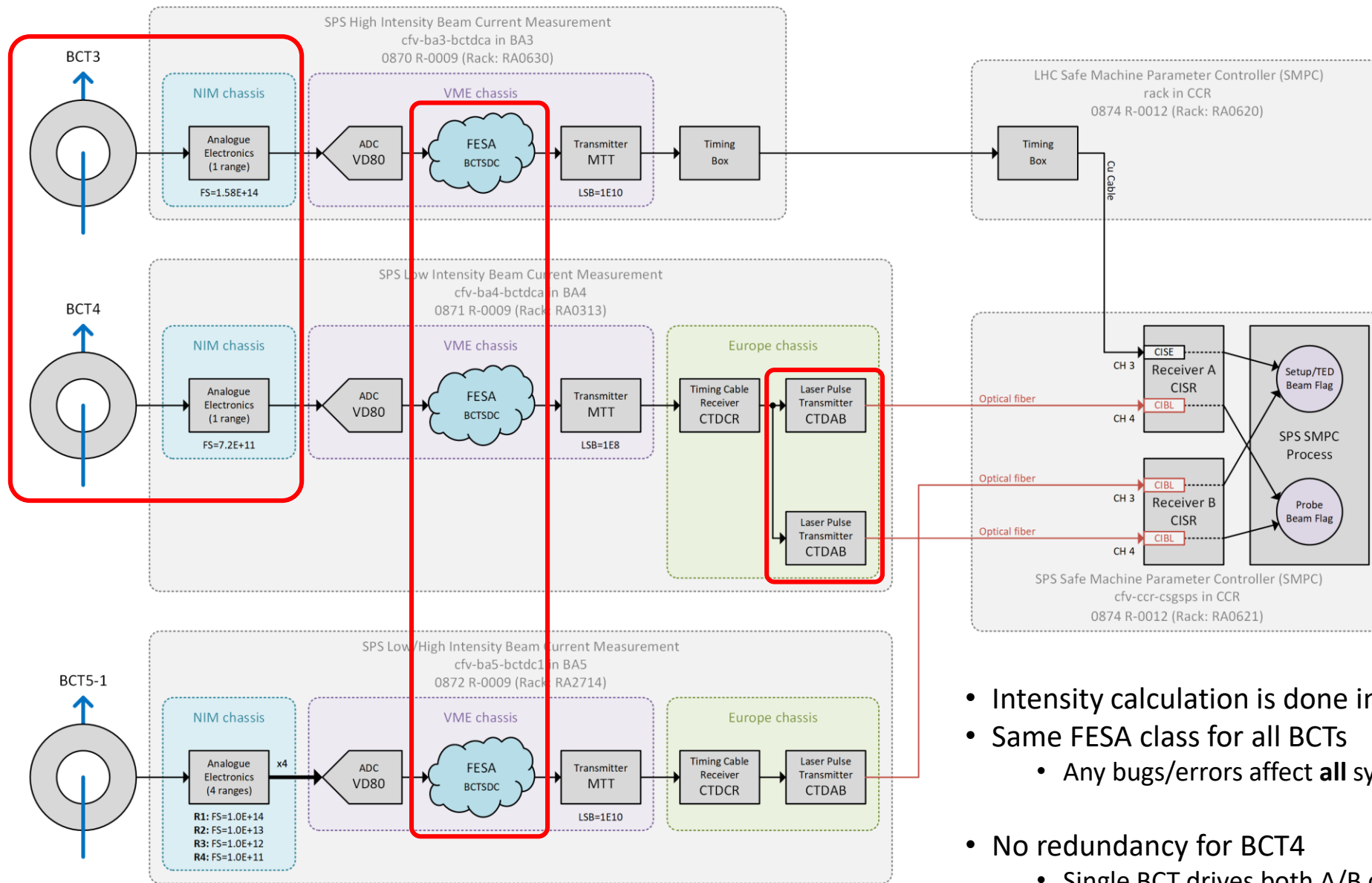
SY-BI-IQ

SPS

# Reminder

- Issue with SMP probe beam flag during 2021 LHC pilot run
  - Probe beam flag was **true** even for nominal bunch intensity
  - Allowed injection of a nominal beam into an empty LHC
- SMP flags are generated from 3x SPS BCT intensities measured at flat-top
  - “Low intensity” BCT4 transmit to SMP **with LSB=1e8** → **probe beam flag**
  - “High intensity” BCT3/5 transmit to SMP **with LSB=1e10** → **setup/TED beam flags**
- Bug in FESA3 upgrade during LS2 meant BCT4 also encoded frame with LSB=1e10, but frame was interpreted by SMP as having LSB=1e8
  - **BCT:**  $1.2e11 \text{ charges} \div 1e10 \rightarrow \text{frame } 0x00000C$
  - **SMP:**  $\text{frame } 0x00000C \times 1e8 \rightarrow 1.2e9 \text{ charges} < 1.4e10 \rightarrow \text{probe beam flag} = \text{true}$
- Quickly fixed (after it was noticed) but reminded us of important weaknesses in the system...

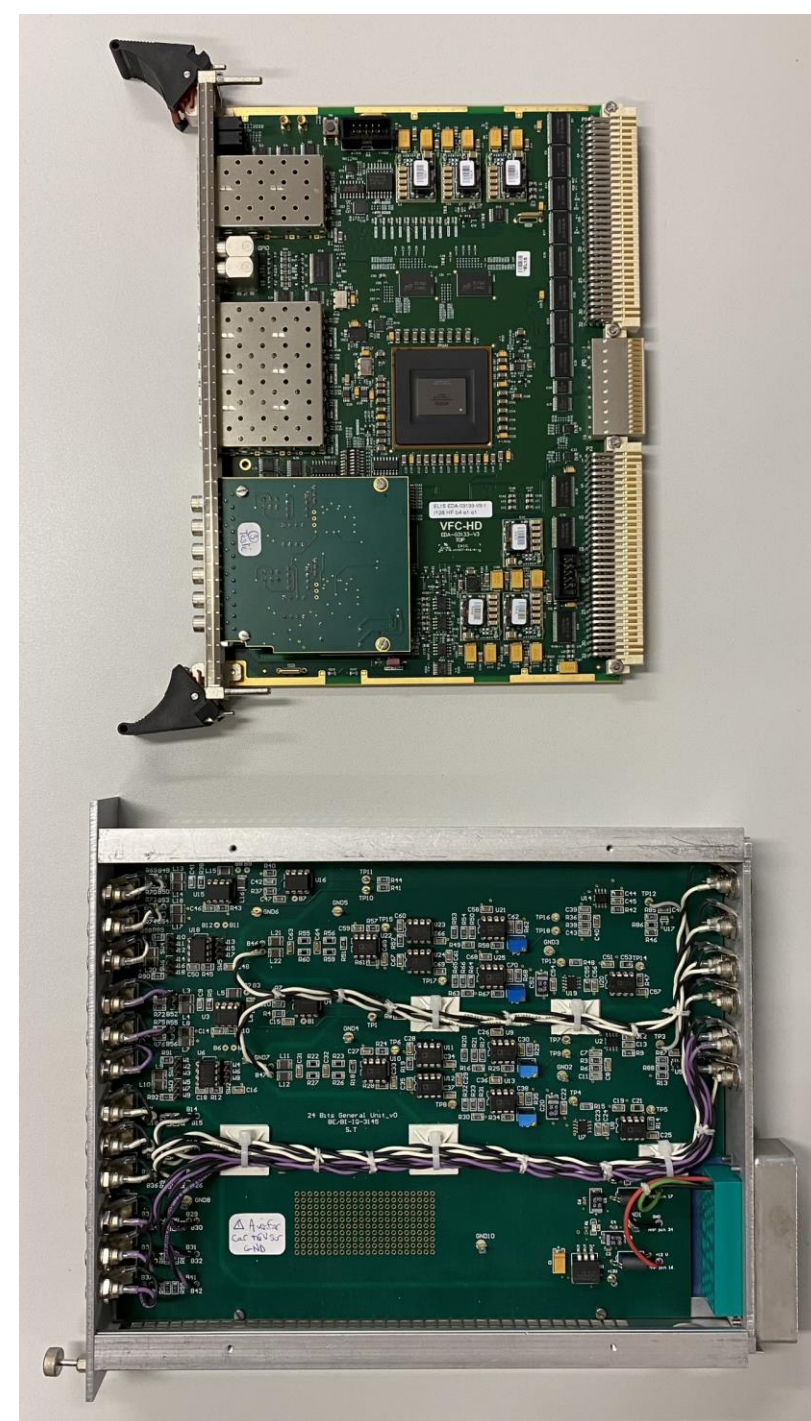




- Intensity calculation is done in SW
- Same FESA class for all BCTs
  - Any bugs/errors affect **all** systems
- No redundancy for BCT4
  - Single BCT drives both A/B channels of SMP
- Note: BCT3/4 have very old sensors & electronics
  - And are “black box” commercial systems

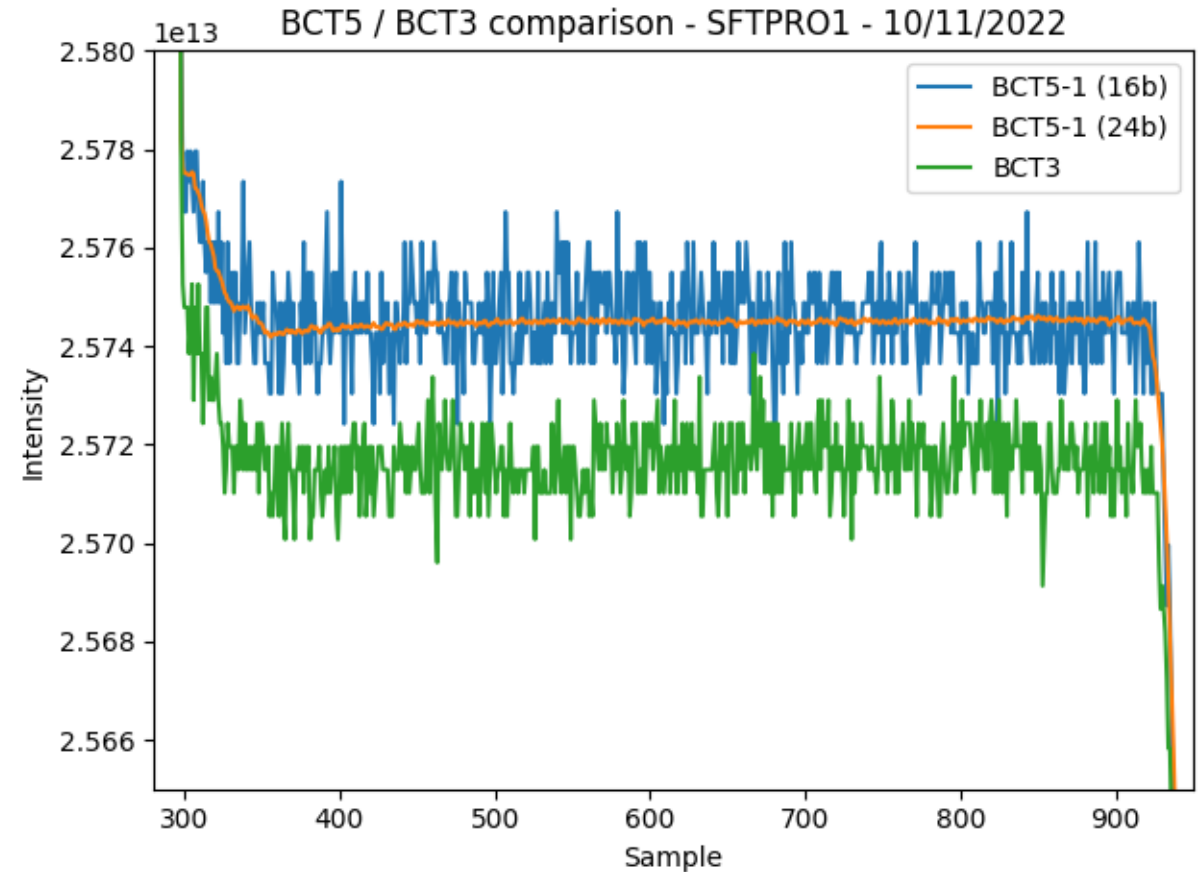
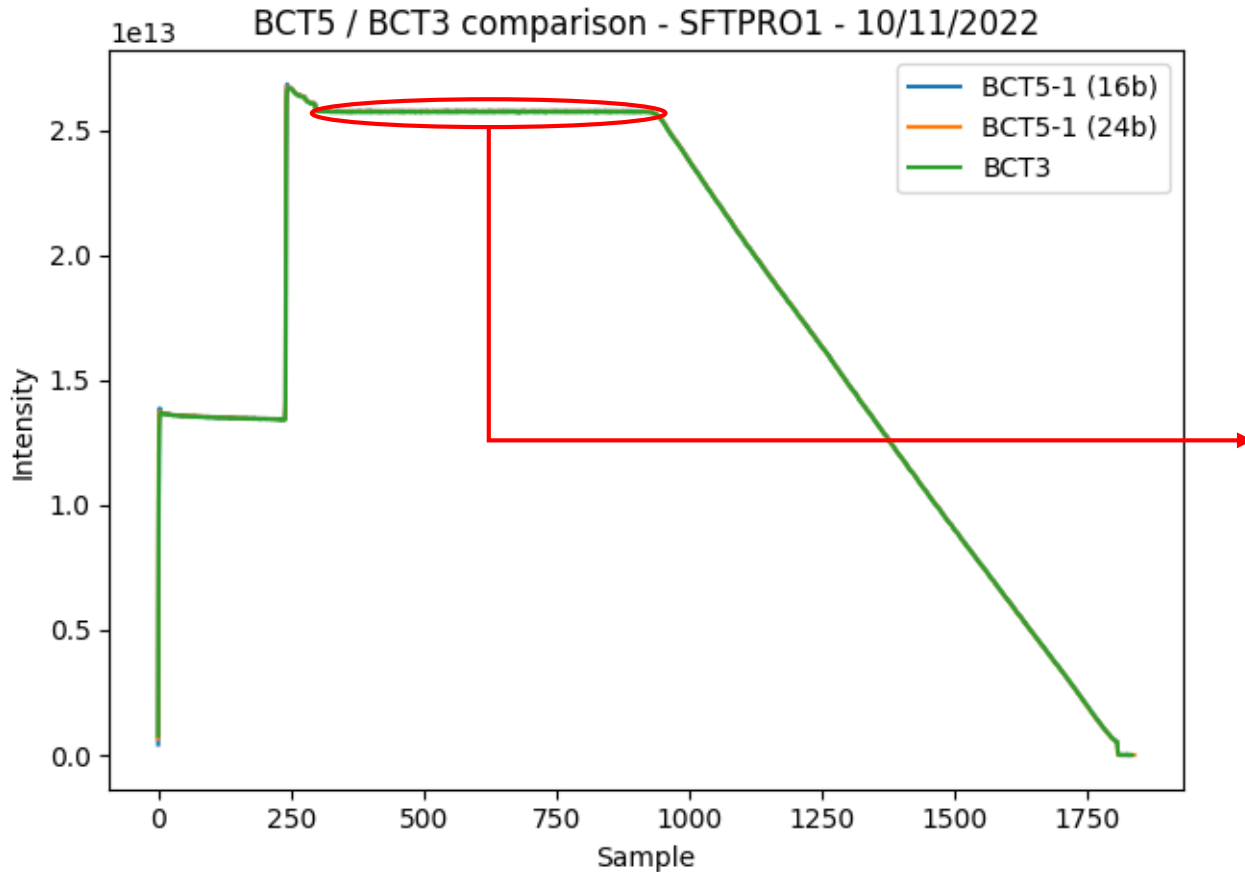
# SPS 24-bit acquisition system

- 24-bit acquisition system installed on BCT5 during LS2 for  $di/dt$ 
  - Note that (unlike LHC) ADC is located on surface as it is not rad. hard
  - Acquiring only BCT range 1 ( $FS=1e14$ )
  - Using BI-standard VFC-HD platform for FPGA processing
- Medium-term desire to consolidate the DC-BCT acquisition
  - VD80 module: limited performance and pending obsolescence
- SMP issues raised the priority of this consolidation for the SPS
  - From discussions with MPE: aim to have a demonstrator for YETS22-23
  - Luckily we have the  $di/dt$  acquisition – no HW development required!
  - VFC-HD FPGA allows direct implementation of SMP transmission logic
- BCT range 1 cannot cover full dynamic range  $\rightarrow$  addition of range 3 ( $FS=1e12$ ) to cover requirements for low intensity measurements



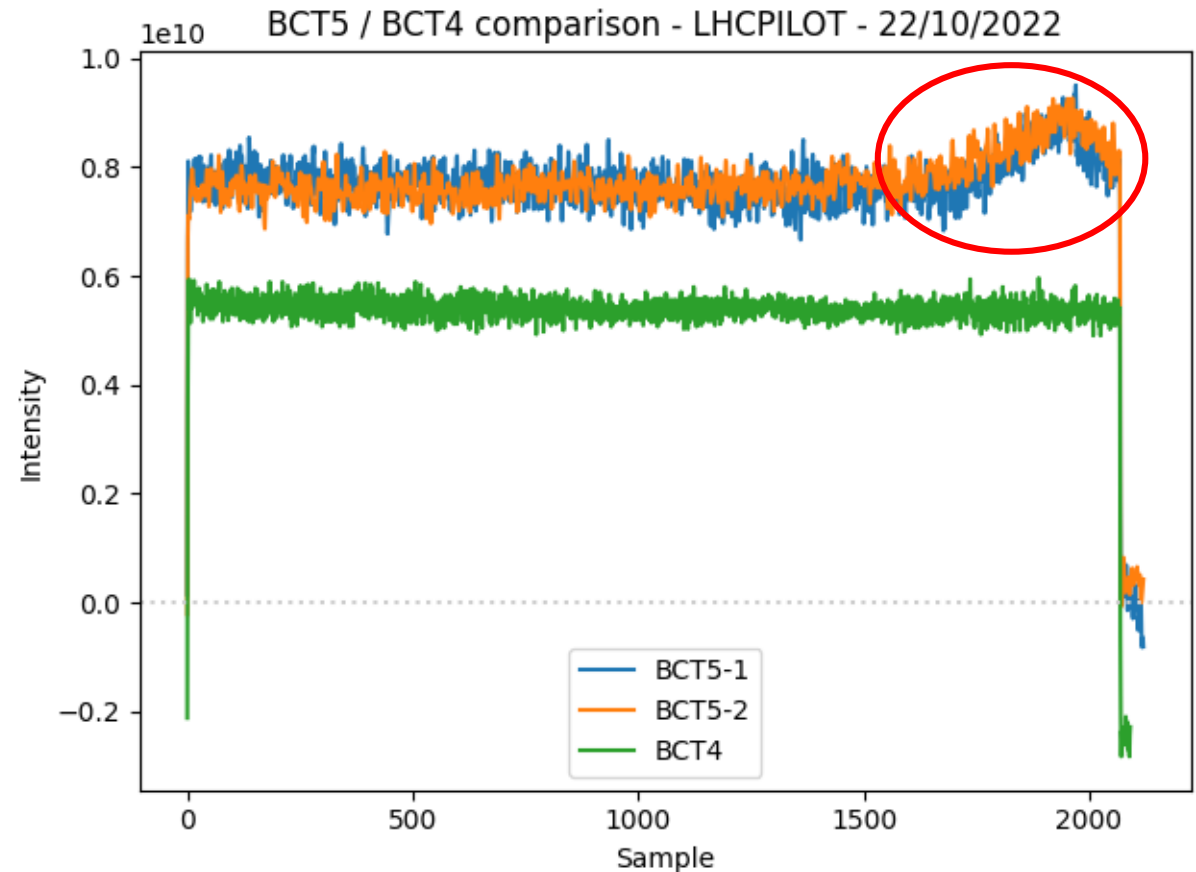
# BCT5 signal quality

- For high intensity beams: noise level **significantly** lower with 24-bit acquisition

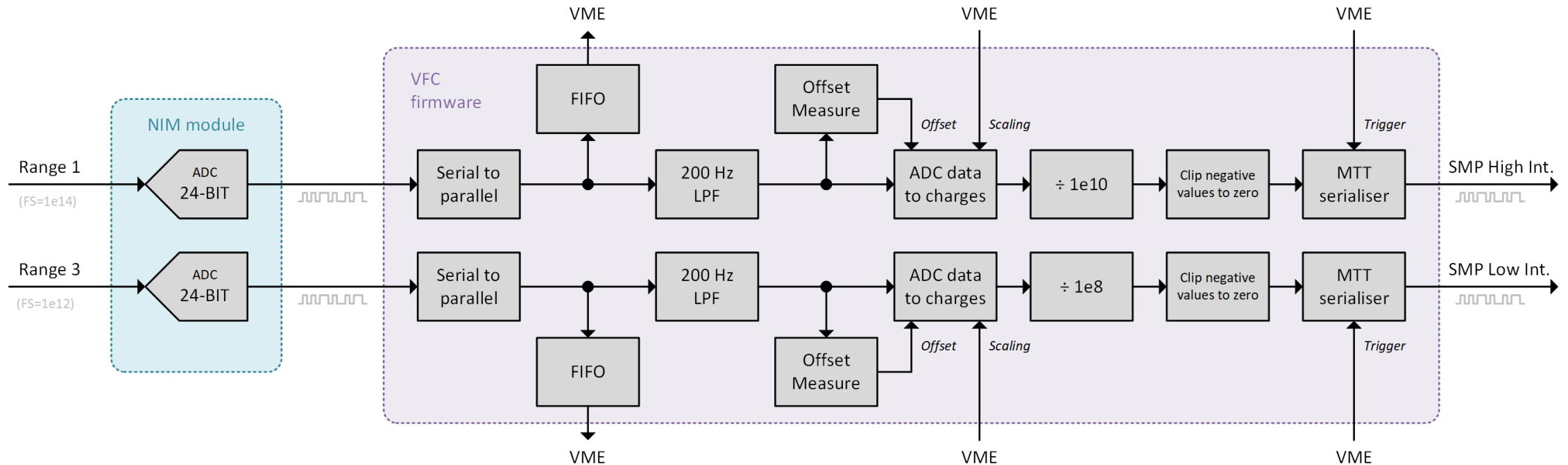


# BCT5 signal quality

- For low intensity beams: comparable noise levels between BCT5 and BCT4
- (Magnetic?) interference at flat top since BCTs were moved during LS2
  - Results in intensity increase by  $\sim 1e9$
  - We are working on finding the source
    - Investigations planned during YETS
  - We do not think it is a showstopper for this application as:
    - BCT4 regularly has offsets that are greater than this (currently around  $-2e9$ )
    - It causes an over-estimate the intensity



# SPS 24-bit FPGA implementation

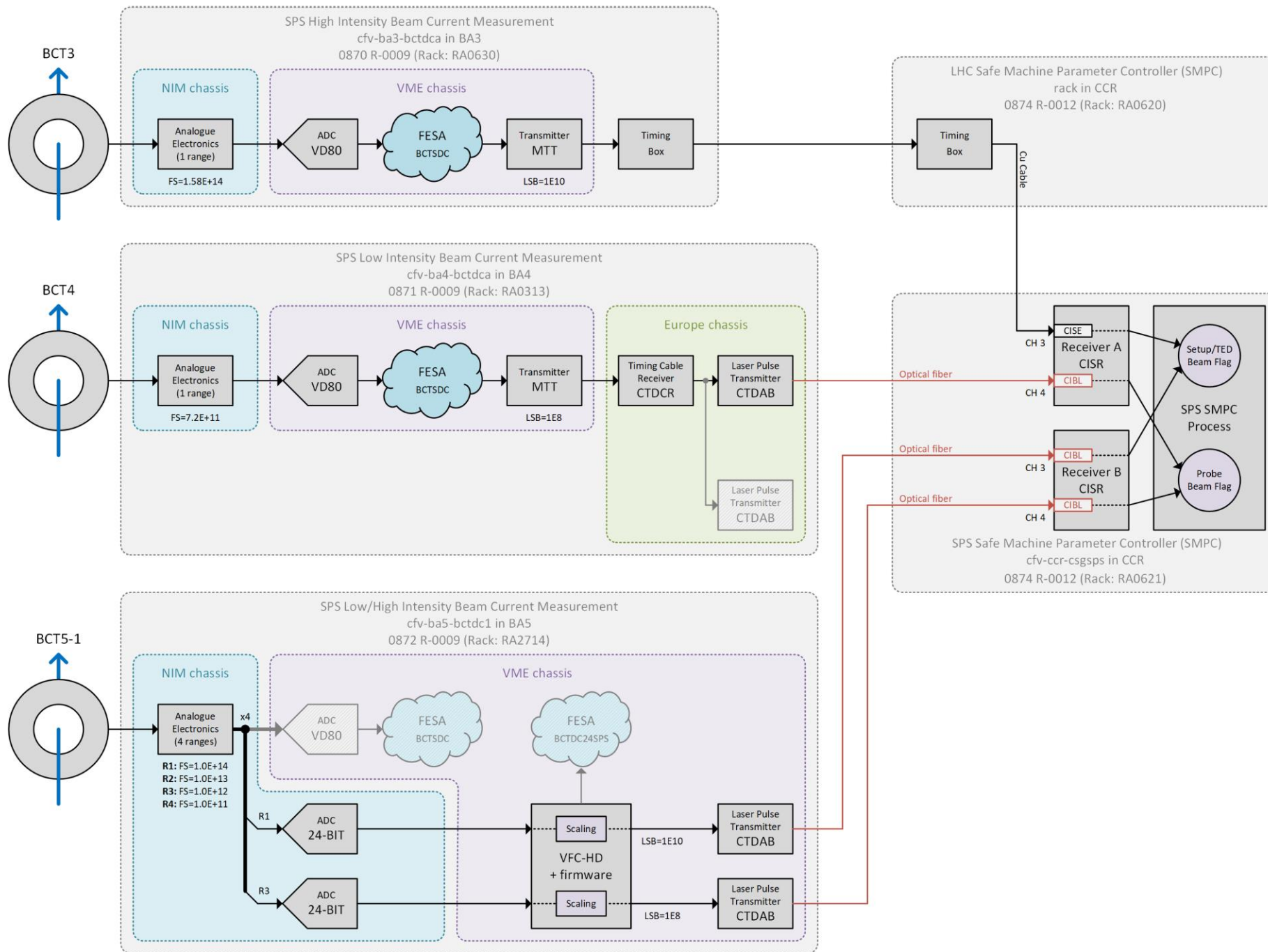


- Two independent channels for the SMP frames:
  - BCT range 1 → high intensity
  - BCT range 3 → low intensity
- The SMP LSB value and headers are hard-coded in firmware



# Proposal

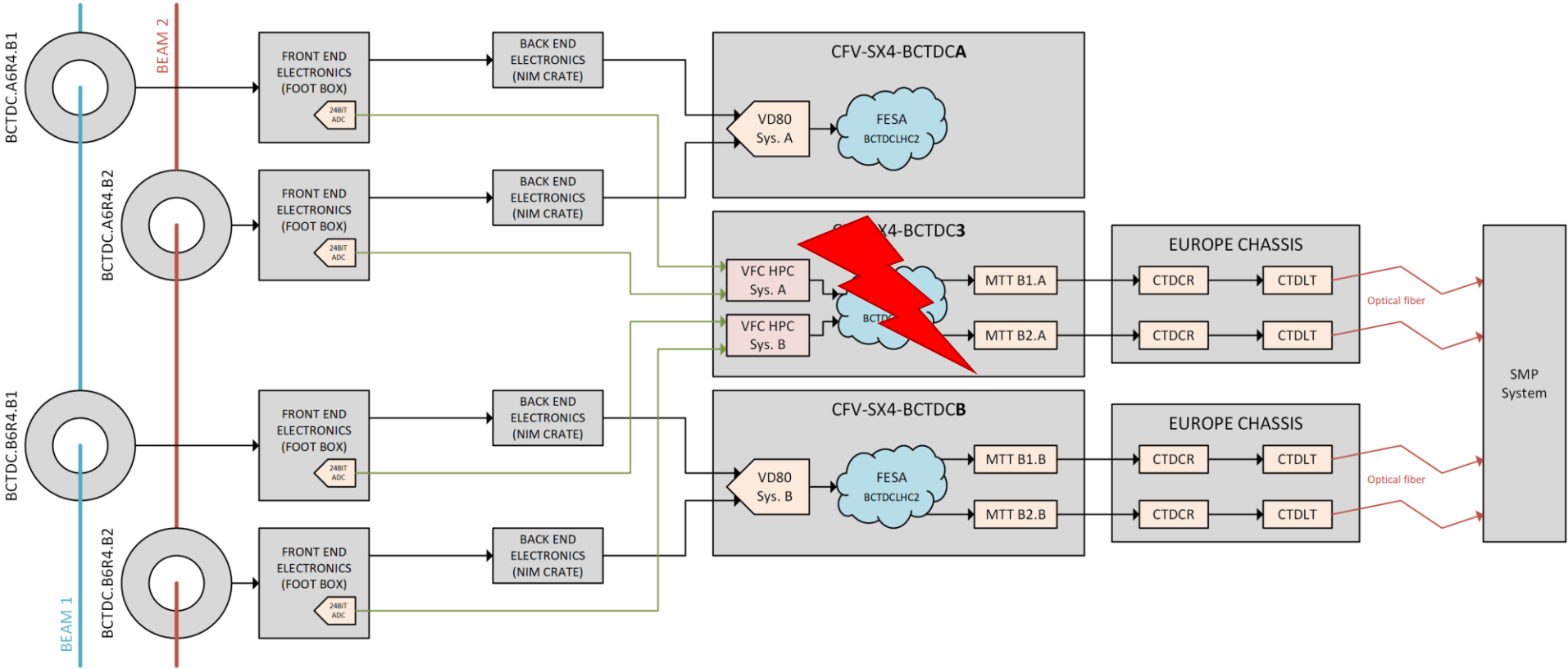
- Keep BCT3/BCT4 as they are now (i.e. transmission via FESA/MTT)
  - BCT3 → high intensity channel 3A
  - BCT4 → low intensity channel 4A
- Modify BCT5-1 connections to send SMP directly from VFC-HD
  - BCT5-1 range 1 → high intensity channel 3B
  - BCT5-1 range 3 → low intensity channel 4B
- Note: SPS SMP modifications are also required (see talk of Raffaello)



LHC

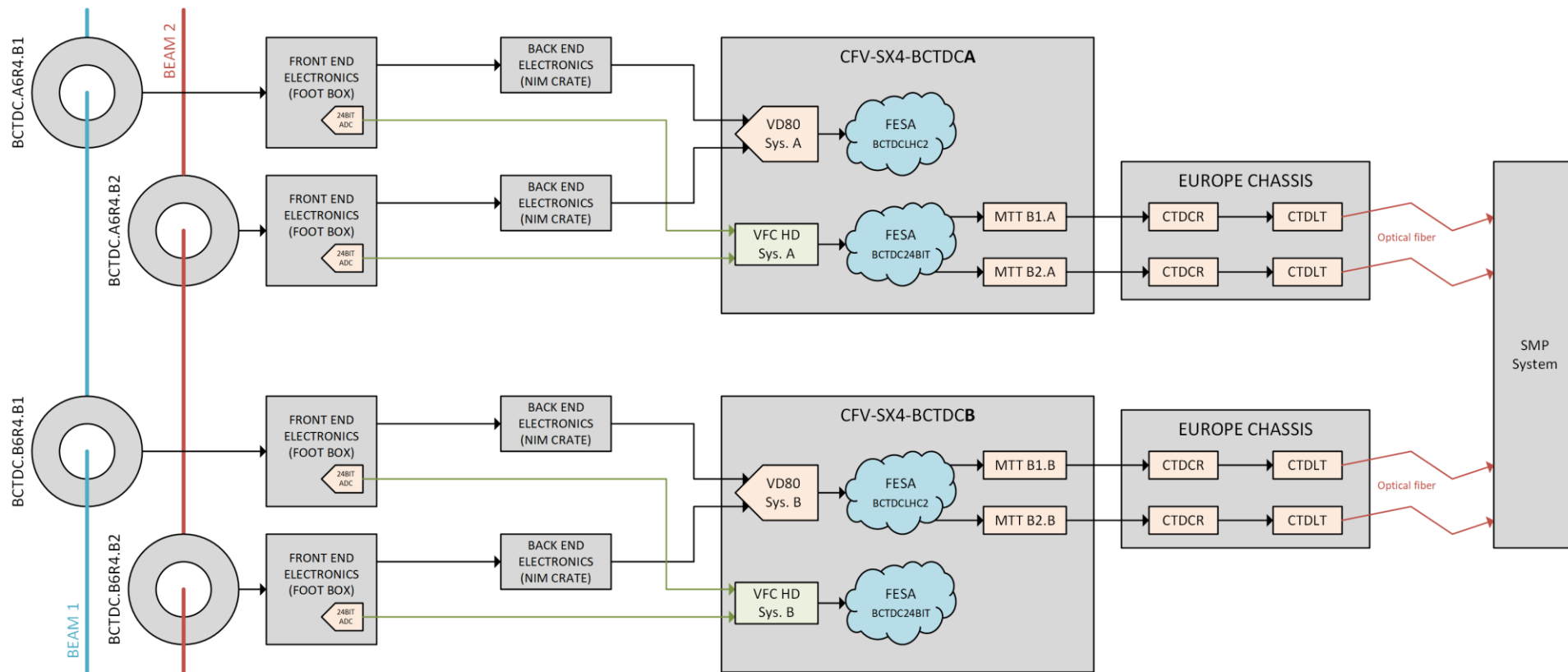
# LHC BCT-SMP

- Historically: the 24-bit DC-BCT acquisition was developed in a 3<sup>rd</sup> FEC to avoid disruption of 16-bit systems
- In LS2 we tried to move it to the A/B FECs, but an incompatibility was discovered between VFC-HPC & VD80
- Today there is still no redundancy for the 24-bit system, any issue takes out both systems



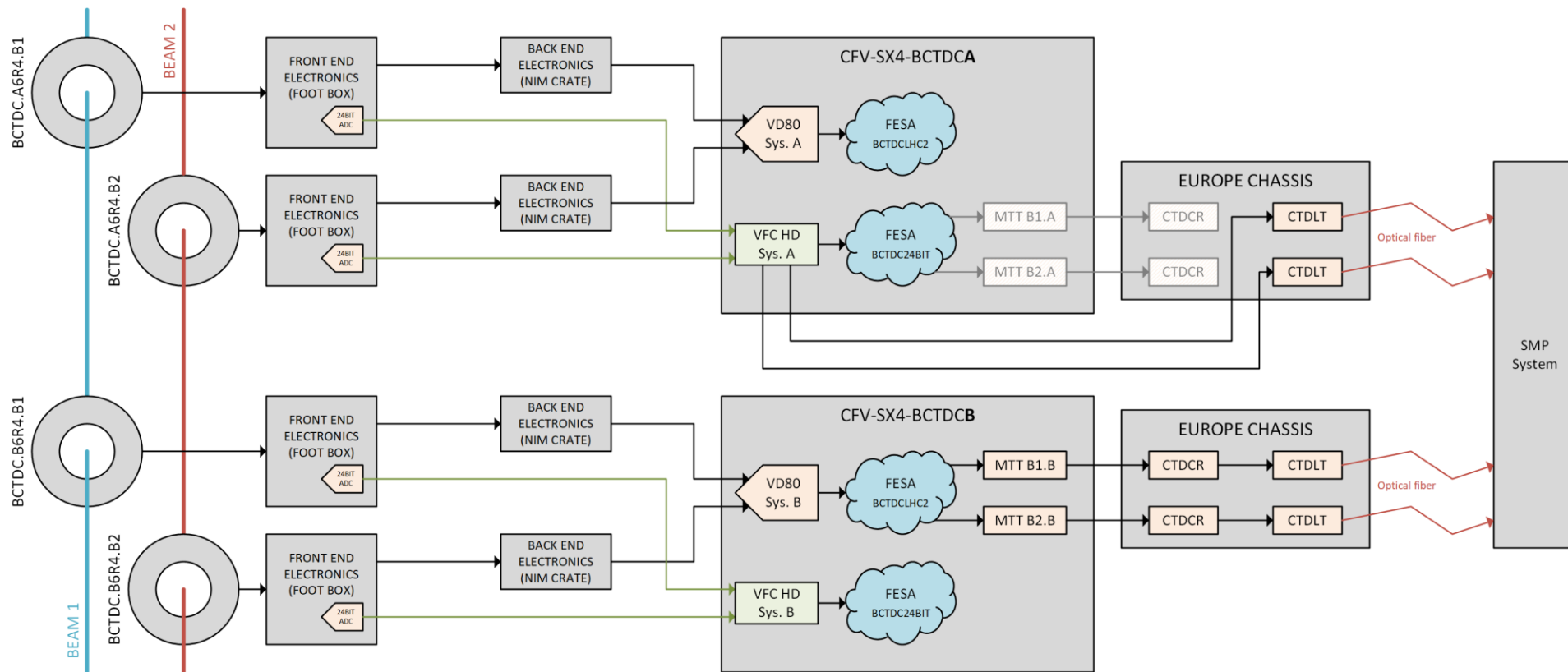
# LHC BCT-SMP after YETS 22-23

- The old VFC-HPC firmware has been re-worked on the new BI-standard VFC-HD platform
- Cohabitation between VD80 & VFC-HD has been tested in lab over the past months and is working reliably
- **During YETS 22-23:** plan to replace VFC-HPC by VFC-HD and move them to A/B FECs to restore redundancy



# LHC BCT-SMP after YETS 22-23

- The new firmware for VFC-HD also has the direct SMP transmission logic implemented
- Note that no change on the SMP side is needed – we will use the same headers



# Conclusions

- Issues seen with SPS probe-beam flag after LS2 due to a bug in the FESA update.
- Direct transmission of the SMP frames has been implemented in the firmware of both the SPS and LHC 24-bit DC-BCT systems.
- SPS:
  - Propose to connect BCT5 to both high and low intensity channels of SPS-SMP to provide improved redundancy for BCT3/BCT4.
- LHC:
  - New VFC-HD will be installed during YETS to remove 3<sup>rd</sup> FEC and improve redundancy.
  - The direct transmission from the 24-bit system to the LHC-SMP would also be possible.