Redundancy of the SIS DOROS front-ends

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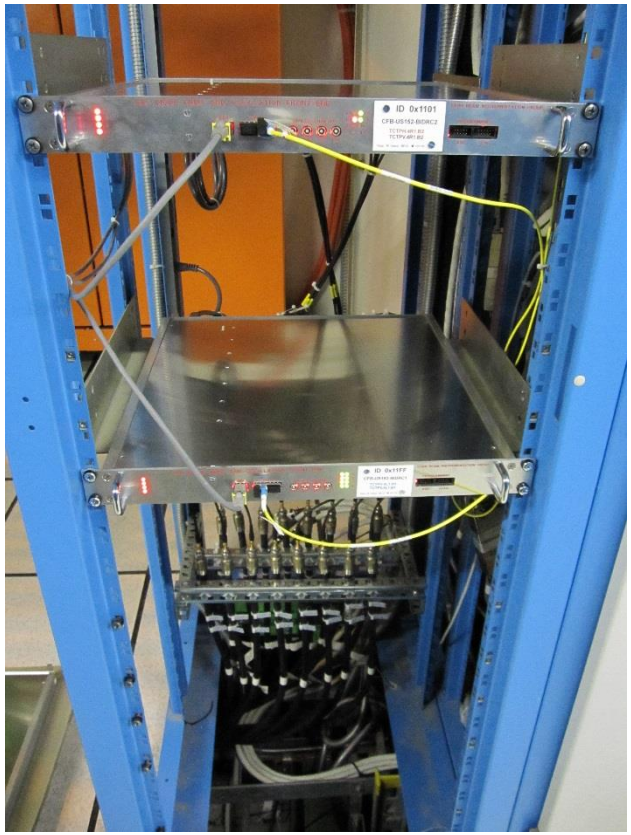
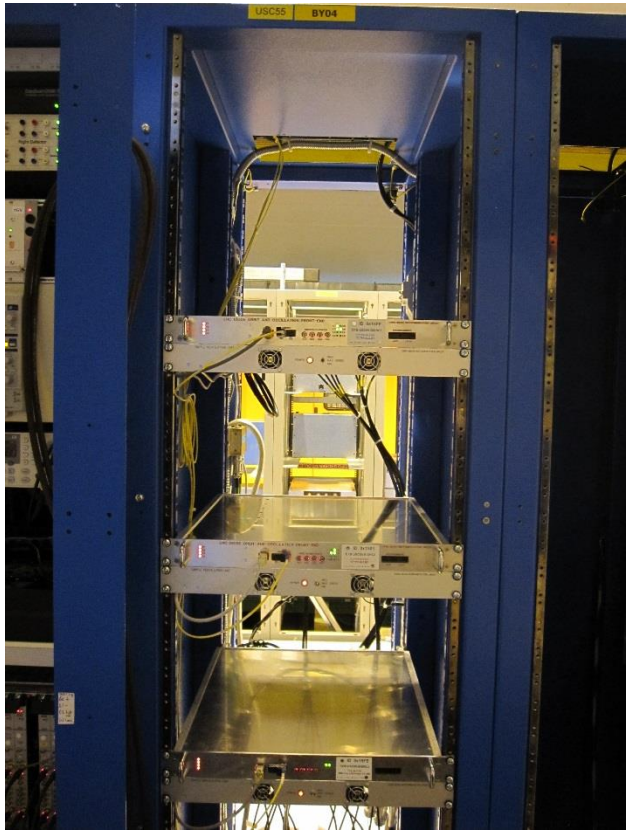
6 collimator DOROS front-ends used by the SIS

- Reliable operation since TS2, but one day it will happen. The current estimate of the DOROS front-end MTBF is some 50 years. This is based on a very limited statistics: one hardware fault since the beginning of the 2015 run, taking into account all 28 front-ends currently installed in the LHC and the SPS.

- P1: 2 front-ends located in one rack and processing signals from 4 TCTP collimators: H+V.4L1.B1, H+V.4R1.B2
- P5: Like in P1, 2 front-ends located in one rack and processing signals from 4 TCTP collimators: H+V.4L5.B1, H+V.4R5.B2
- P6: 2 front-ends, one per rack located on each side, processing signals from 2 TCSP collimators 4L6.B2, 4R6.B1



BY01.US152



BY04.USC55

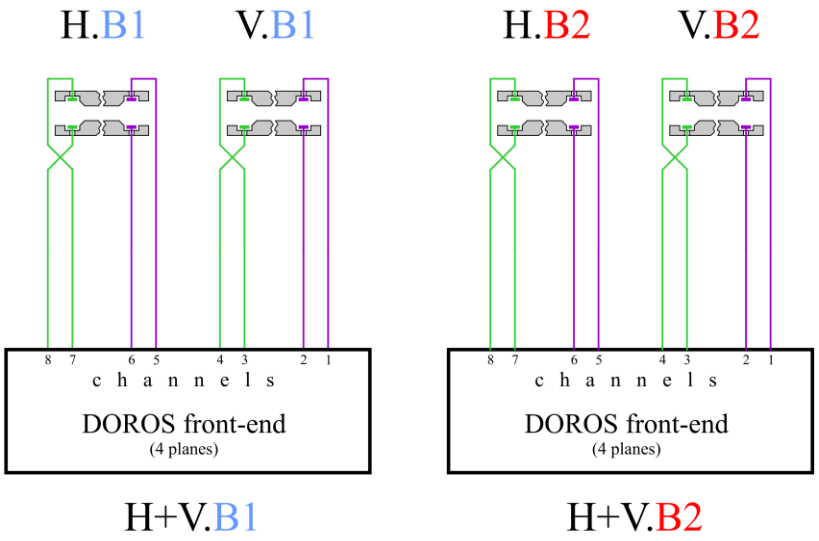
BY02.UA63

BY02.UA67

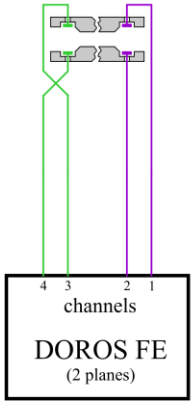
The current situation

- Signals from upstream and downstream BPMs of each collimator are processed with one DOROS front-end
- If one front-end does not work, then:
  - In P1 and P5 position data from 4 BPMs of 2 collimators is lost = beam dump or injections blocked
  - In P6 data from 2 BPMs of one collimator is lost = beam dump or injections blocked
- Hardware redundancy can be based on the implemented SIS logic “downstream OR upstream BPM”.
  Then to have redundancy it is enough to process the signals from the upstream and downstream BPMs with different DOROS front-ends. If one front-end does not work, the orbit data from only one BPM per collimator is lost and the second BPM still can drive the SIS.
- The broken front-end can be replaced at a convenient occasion. The intervention time should be about 1 hour.
  SIS DOROS front-ends are located in US152, USC55 (access possible even with circulating beam), UA63 and UA67.

BPM signal arrangement in P1 and P5
(2 front-ends per point)



BPM signal arrangement in P6L and P6R
(1 front-end per side)

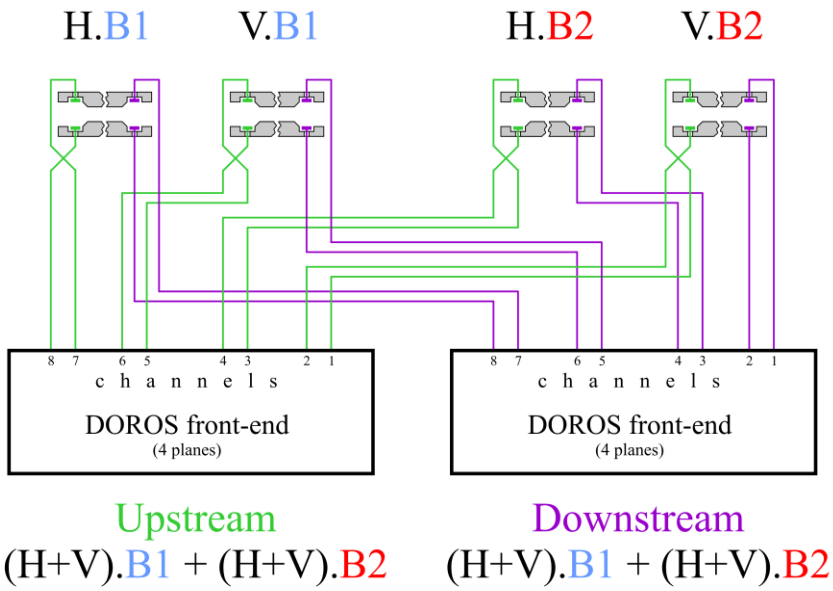


Redundancy option 1

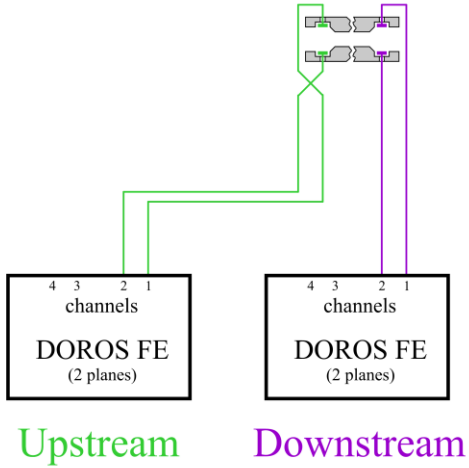
- In P1 and P5 there are already two front-ends in one rack, so it is enough to re-arrange the BPM signals in such a way that the upstream signals are processed by one front-end and the downstream signals by the second front-end
- In P6 two additional front-ends should be installed for independent processing of the upstream and downstream signals

- Cost:
  - 2 additional DOROS FEs (P6L, P6R)
  - The gain control is done in channel groups 1+2+3+4 and 5+6+7+8, so in this configuration the gain of the H and V collimators is coupled
  - Exotic software configuration for the interlocked BPMs

P1 and P5



P6L and P6R

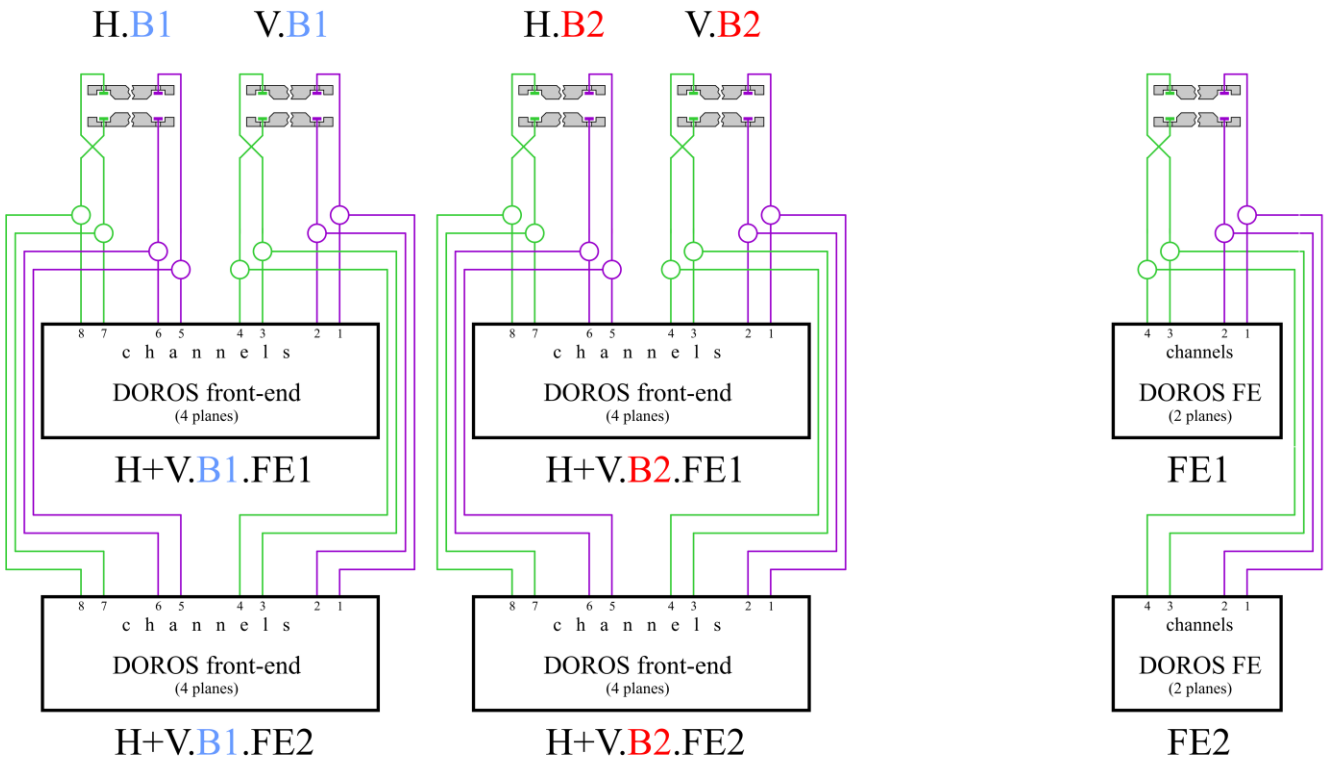


Redundancy option 2

- BPM signals are split and processed by separate DOROS FEs

- Cost:
  - 6 additional front-ends: 2 in P1, 2 in P5, 1 in P1L and 1 in P6R
  - 40 % less signal: transparent for the nominal bunches, visible with the pilots and ions

P1 and P5



P6L and P6R

Options summary

- Option 1:

Advantages:

- same signal levels
- only 2 extra front-ends needed

Cost:

- coupled gain of the H and V collimators
- exotic software configuration

- Option 2:

Advantages:

- same software configuration
- the standard coupled gain of the upstream and downstream BPMs

Cost:

- 6 extra front-end needed
- 40 % less signal, visible with the pilots and ions

Redundancy outlook

- If the DOROS front-end MTBF is 50 years, then on 6 front-ends we should expect 1 fault every 8 years.
- The proposed redundancy helps only for hardware faults of the SIS DOROS front-ends
- This redundancy increases the reliability of the software orbit interlocks only if the DOROS front-ends are the limiting factor
- Redundancy can be potentially extended to tolerate also other faults:
  - redundant 230 V sockets
  - redundant Ethernet sockets connected to different switches
  - redundant FESA servers
- Before LS2 we should have enough statistics to decide whether it makes sense to think about other redundancies. Potentially they could be introduced during LS2

- Is it planned to use any other collimators for SIS ?