Overview of the present SMP system

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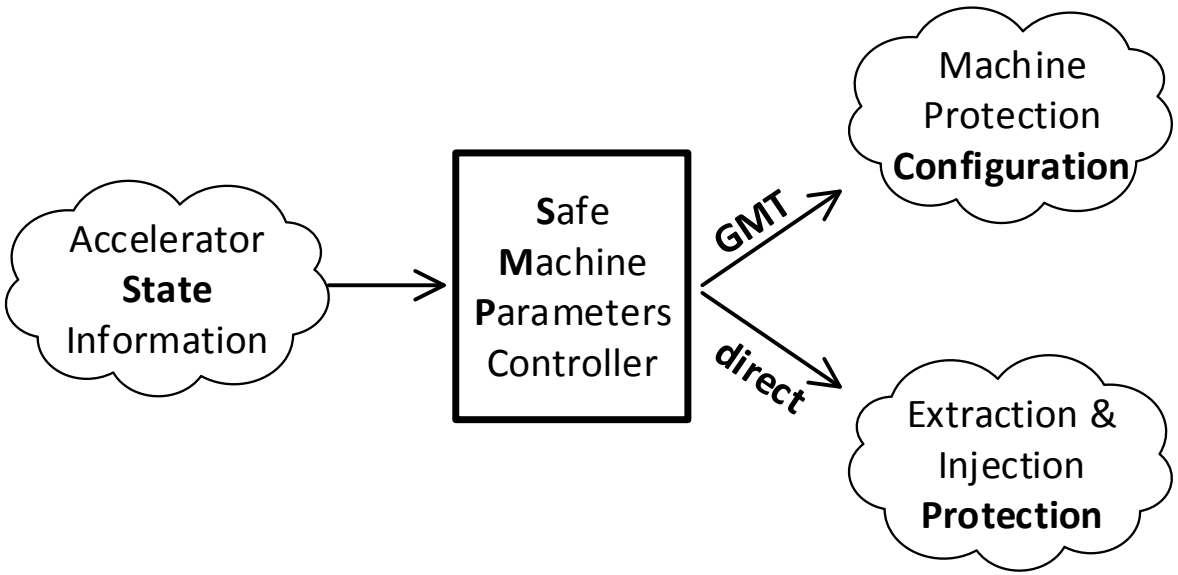
21 June 2019 - Special MPP-SMP2 meeting

Content

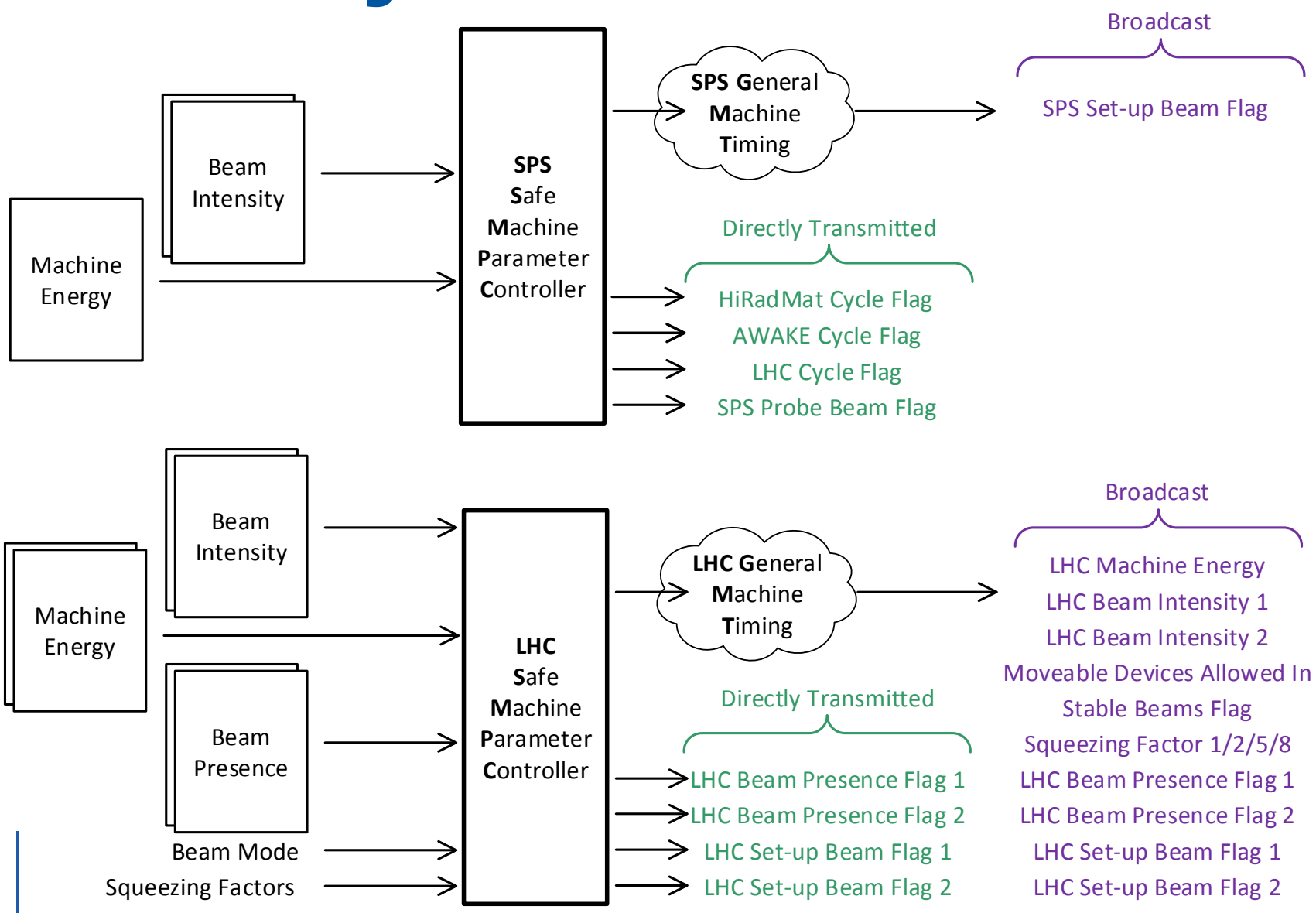
- SMP layout
- Evolution of the system since deployment
- Dependability in RUN1 and RUN2
- Motivation to upgrade

SMP Layout



Fast, safe and reliable

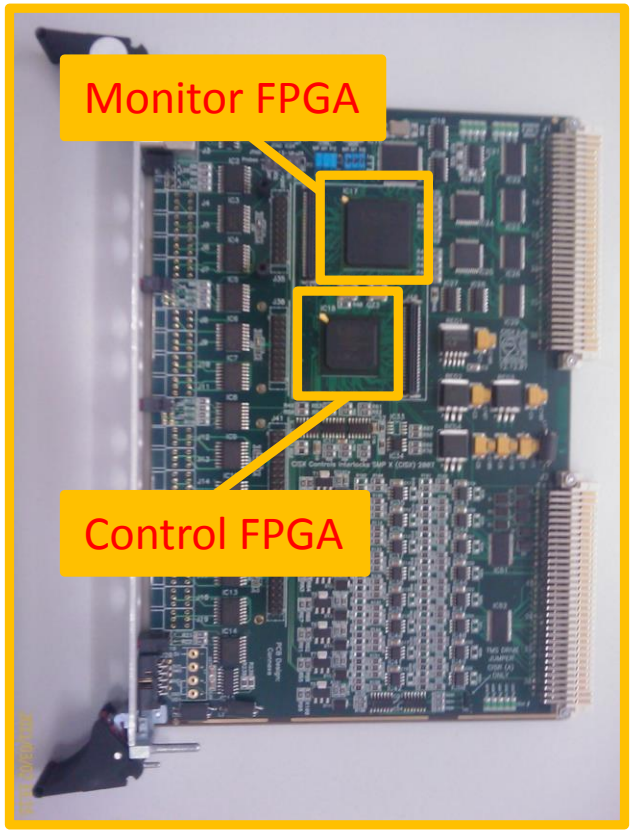
SMP Layout


Machine Energy
Beam Intensity
SPS Safe Machine Parameter Controller
SPS General Machine Timing
Broadcast
SPS Set-up Beam Flag
Directly Transmitted
HiRadMat Cycle Flag
AWAKE Cycle Flag
LHC Cycle Flag
SPS Probe Beam Flag
Machine Energy
Beam Intensity
Beam Presence
Beam Mode
Squeezing Factors
LHC Safe Machine Parameter Controller
LHC General Machine Timing
Broadcast
LHC Machine Energy
LHC Beam Intensity 1
LHC Beam Intensity 2
Moveable Devices Allowed In
Stable Beams Flag
Squeezing Factor 1/2/5/8
LHC Beam Presence Flag 1
LHC Beam Presence Flag 2
LHC Set-up Beam Flag 1
LHC Set-up Beam Flag 2
Directly Transmitted
LHC Beam Presence Flag 1
LHC Beam Presence Flag 2
LHC Set-up Beam Flag 1
LHC Set-up Beam Flag 2


CIBF – LASER
CIBF LASER

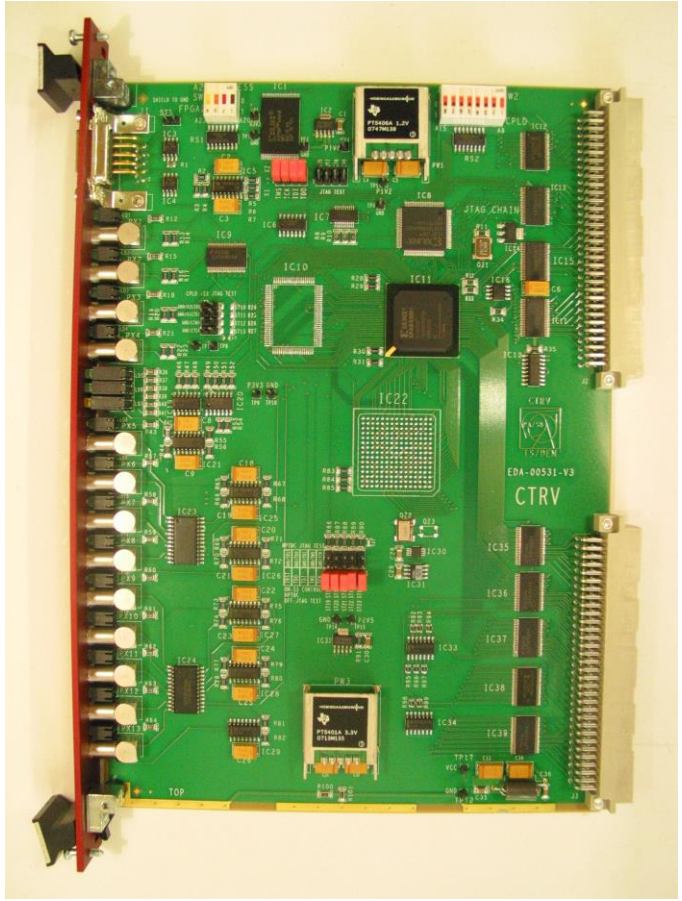
Hardware

- Hardware based on **VMEbus**
- Physical **separation of critical / monitoring**
- Redundant implementation for **high safety**
- **Common HW design** for all SMP boards (CISR, CISG, CISA and CISC)

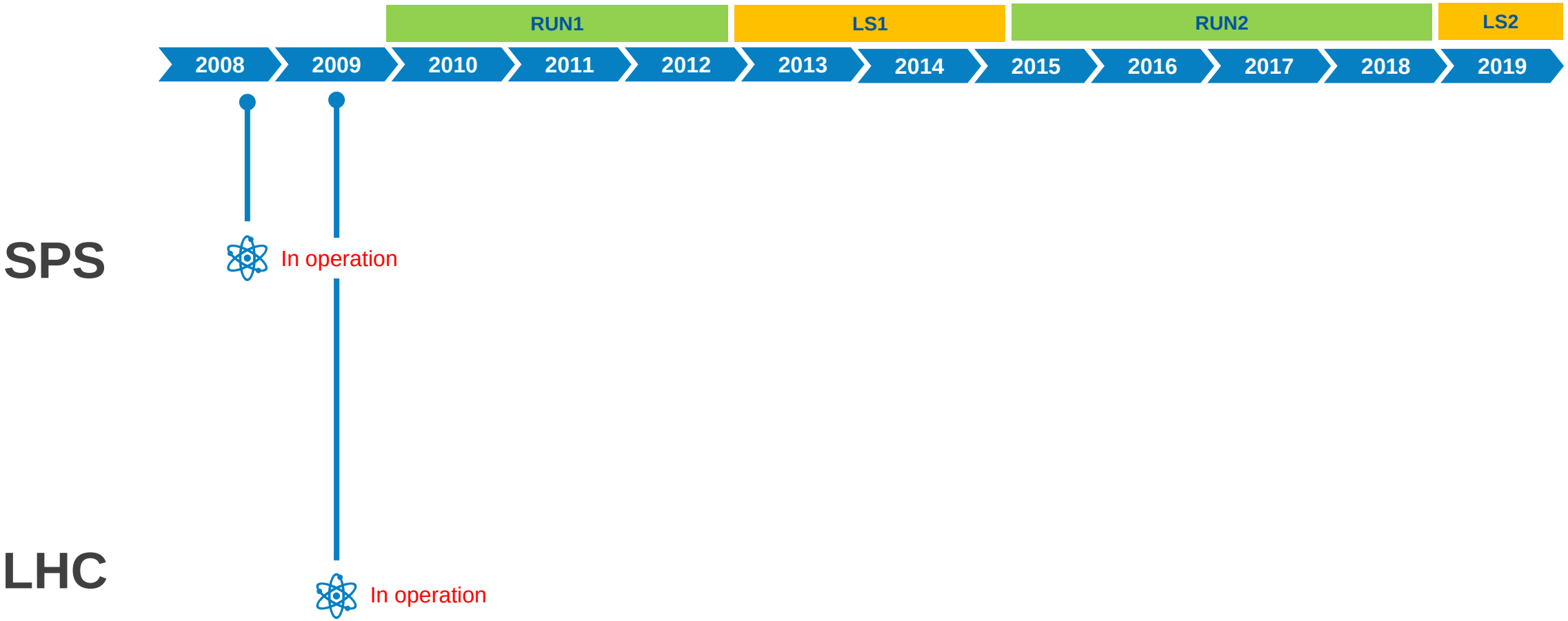


Hardware to receive SMP flags

- CISV is used to **decode LHC-SMP flags** distributed over the GMT
- **CISV based on standard CTRV** (BE-CO) with dedicated firmware maintained by TE-MPE
- **44 CISV boards in operation** (BIS, BLM, MKI, TCD, ATLAS, ALICE, CMS and LHCb)
- A hardware cross-check (CISC) ensures that **no discrepancies are observed between SMP and GMT**



Evolution of the system



Evolution of the system

SPS

In operation

Specifications rewritten (HiRadMat cycle flag added)
External safety review

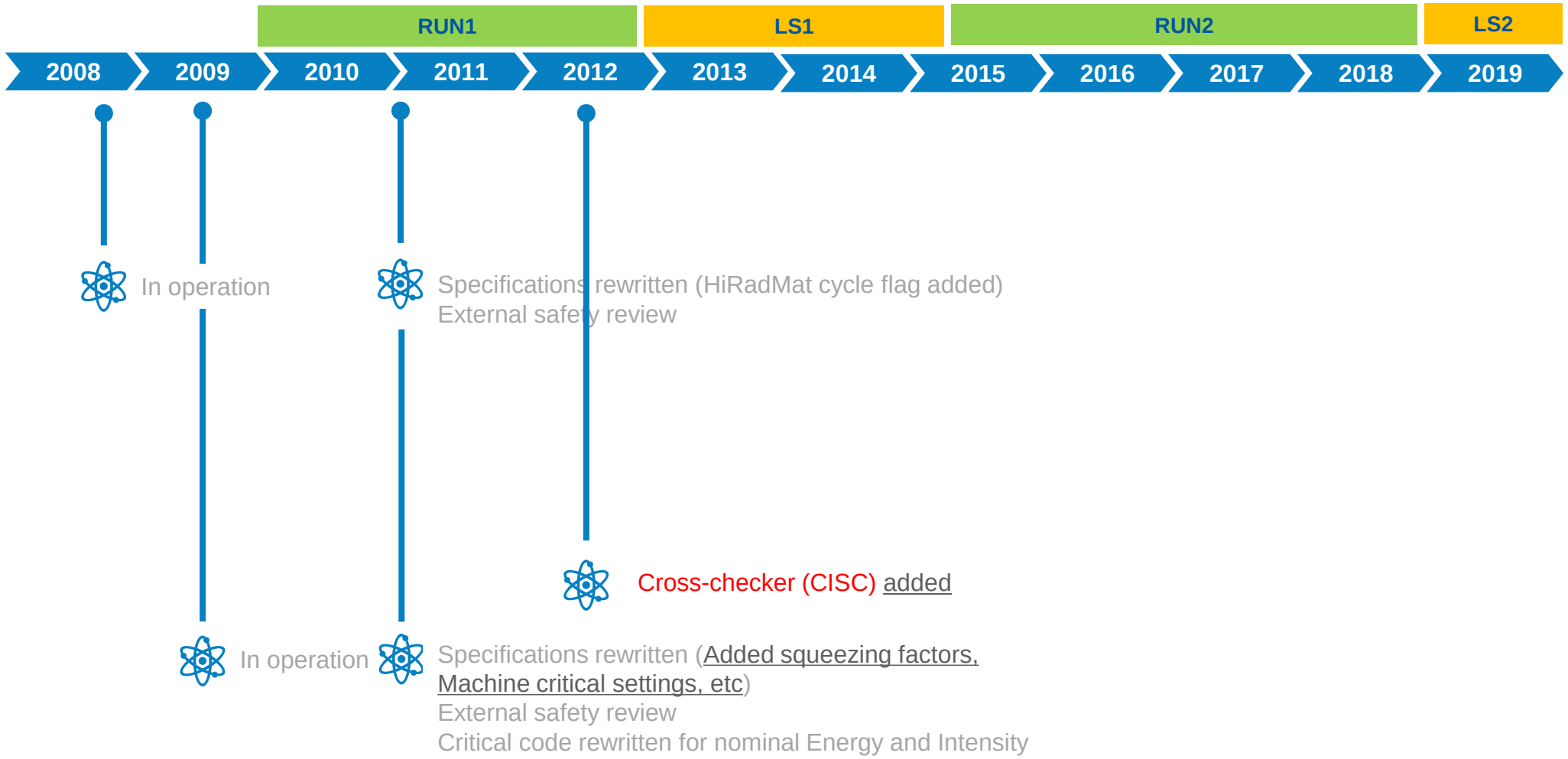
LHC

In operation

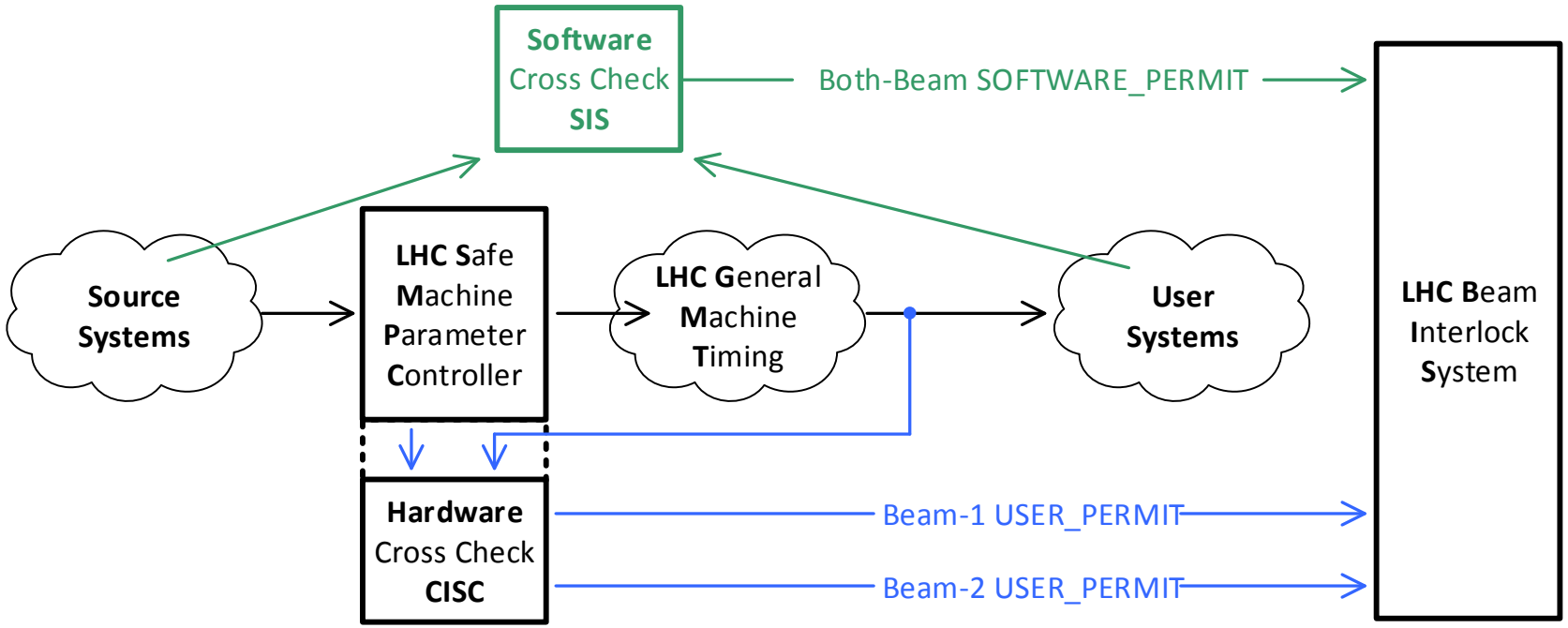
Specifications rewritten (Added squeezing factors, Machine critical settings, etc)
External safety review
Critical code rewritten (*) for nominal Energy and Intensity

(*) Methods for the Application of Programmable Logic Devices in Electronic Protection Systems for High Energy Particle Accelerators, PhD Thesis, M. Kwiatkowski, 2013

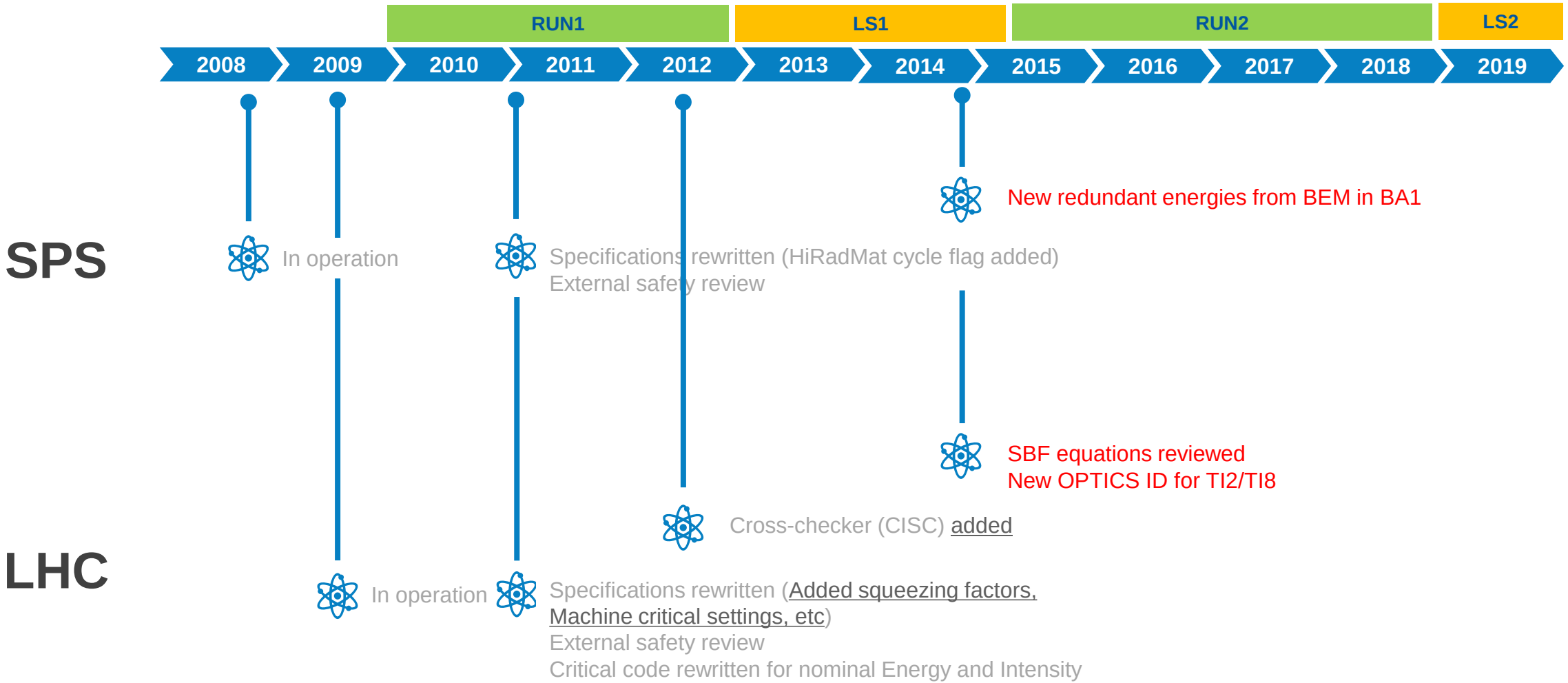
Evolution of the system



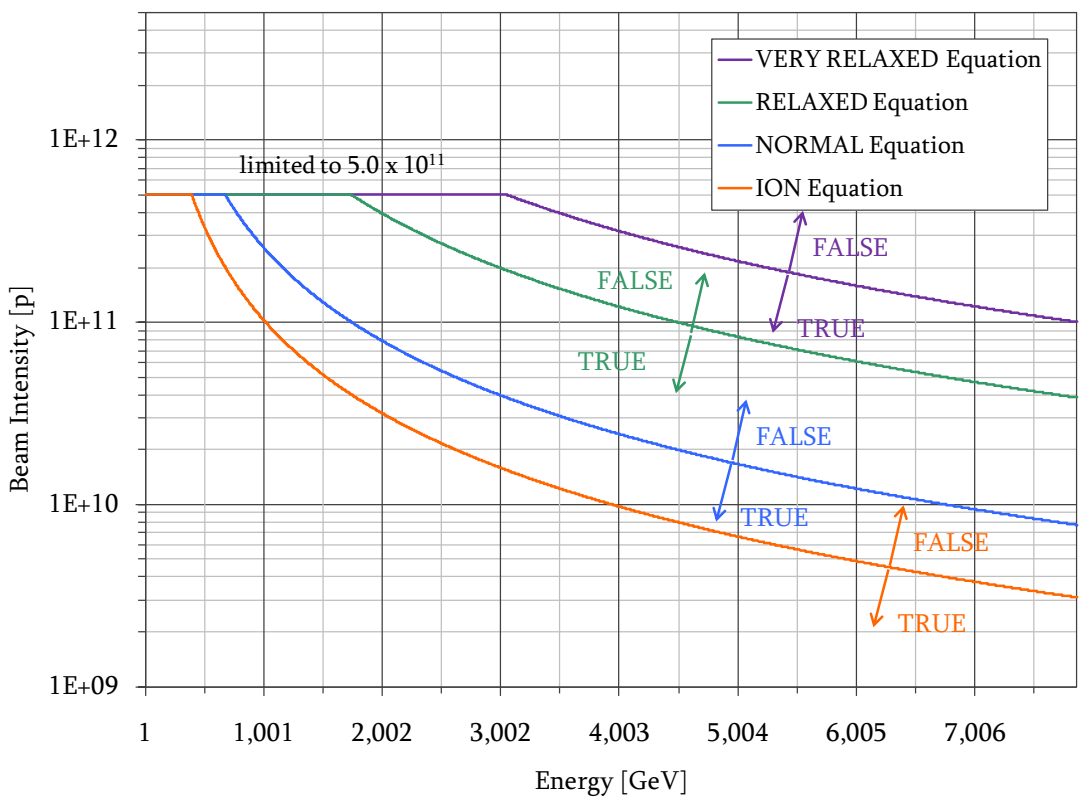
LHC: Cross-checker



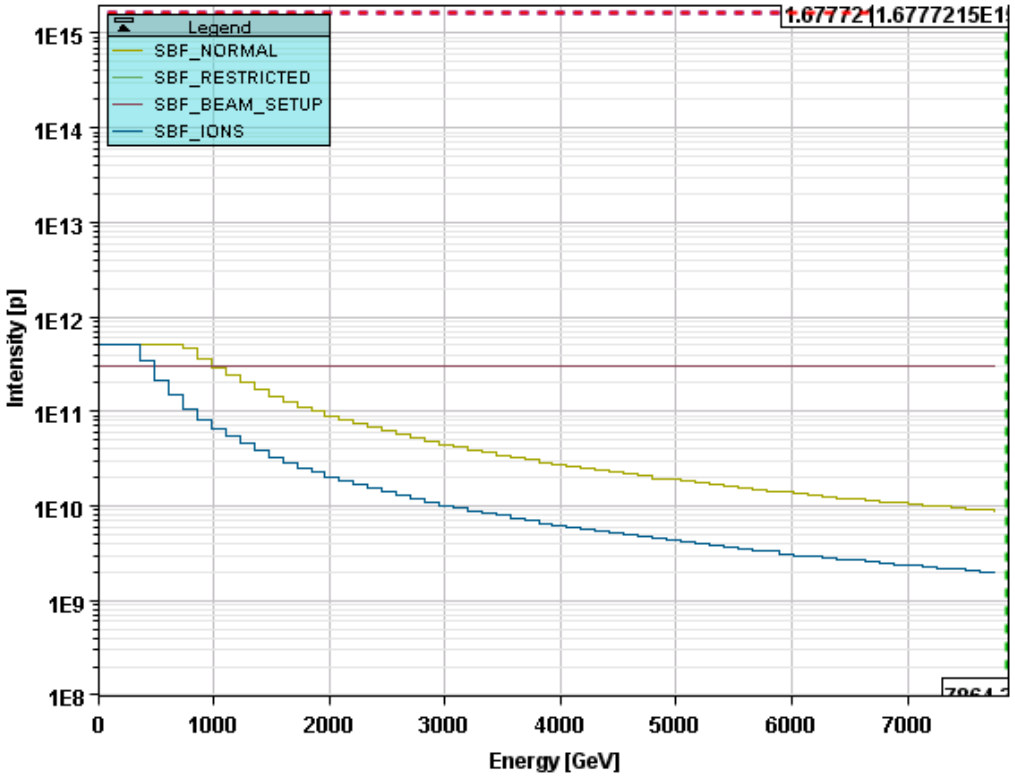
Evolution of the system



LHC: SBF equations

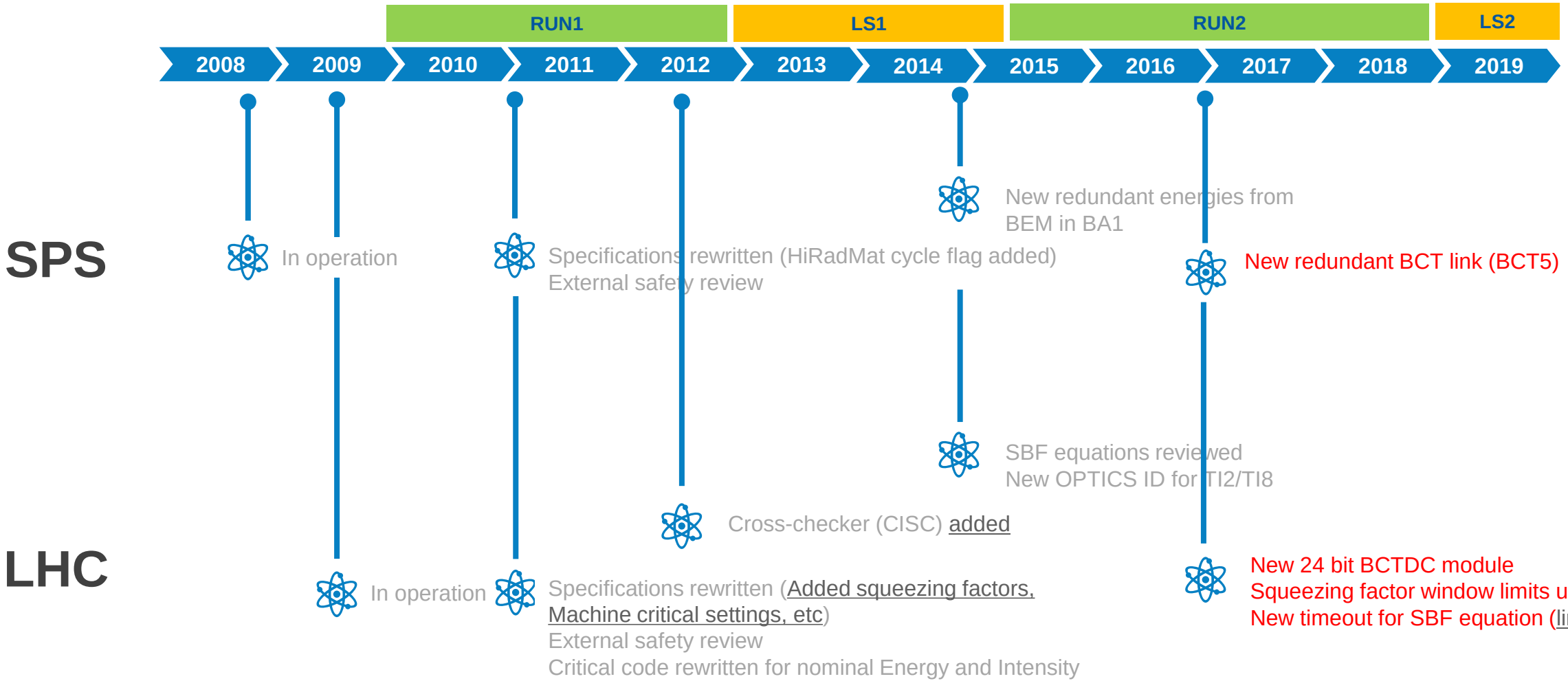


SBF equations in RUN1

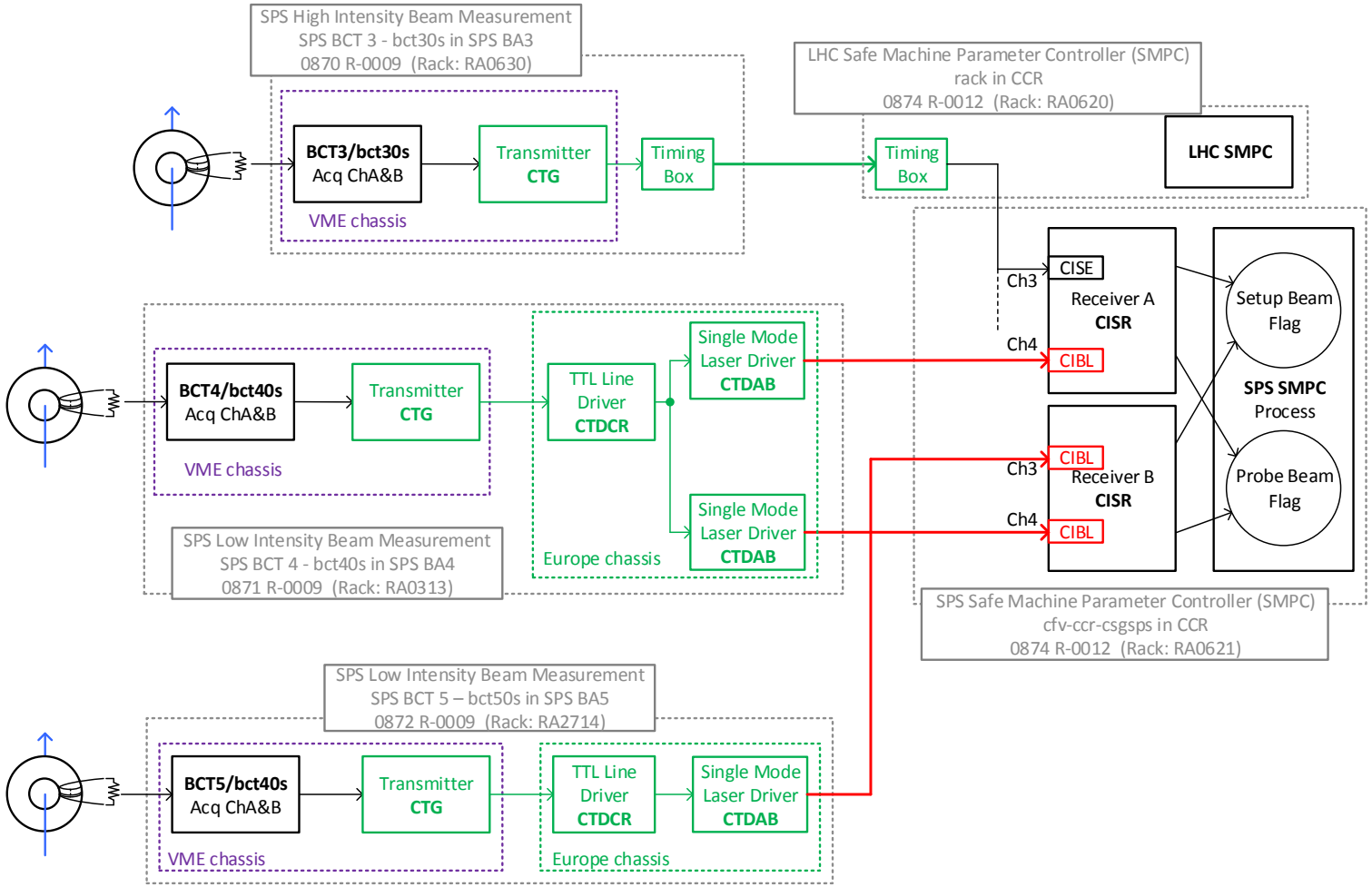


SBF equations in RUN2

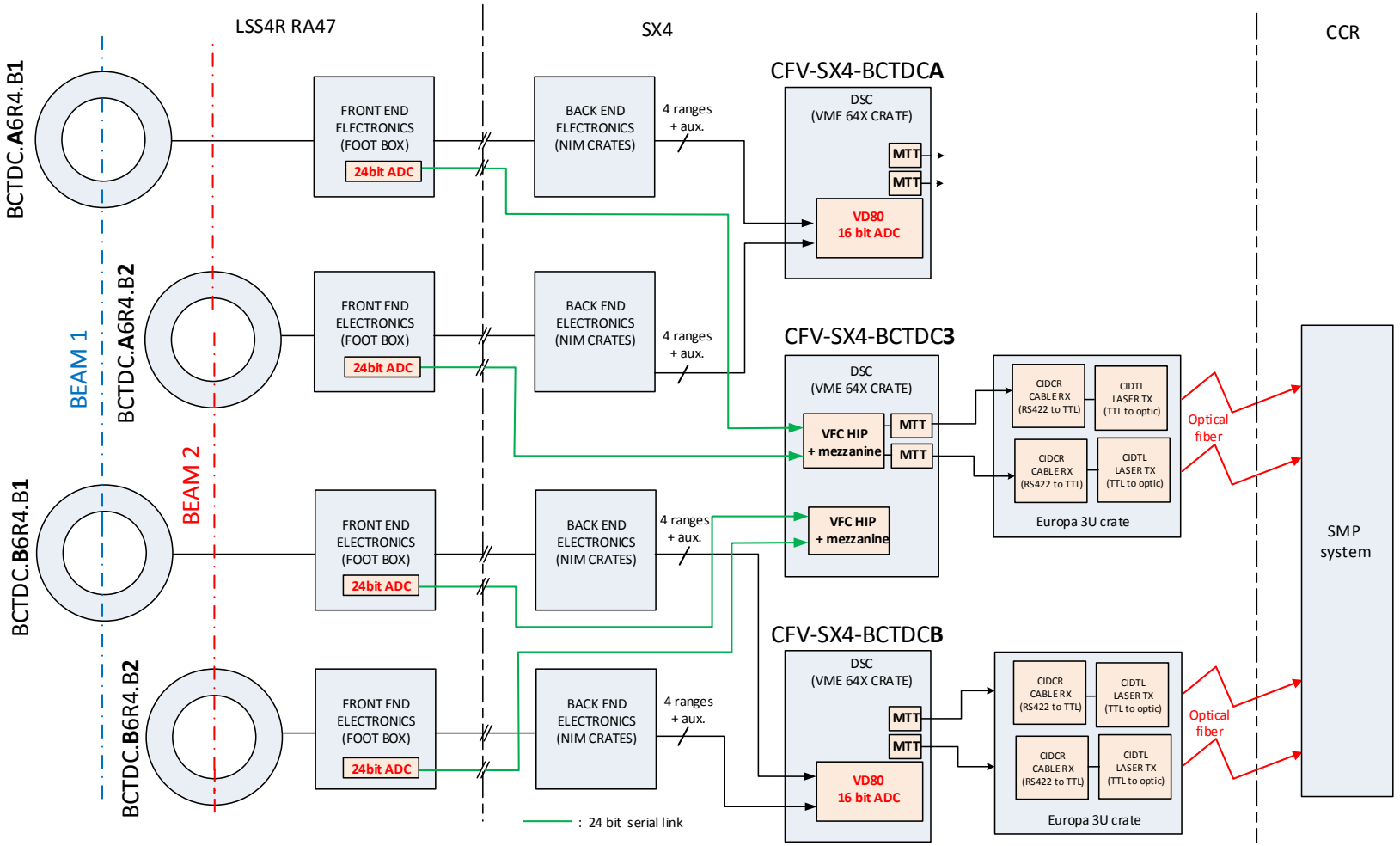
Evolution of the system



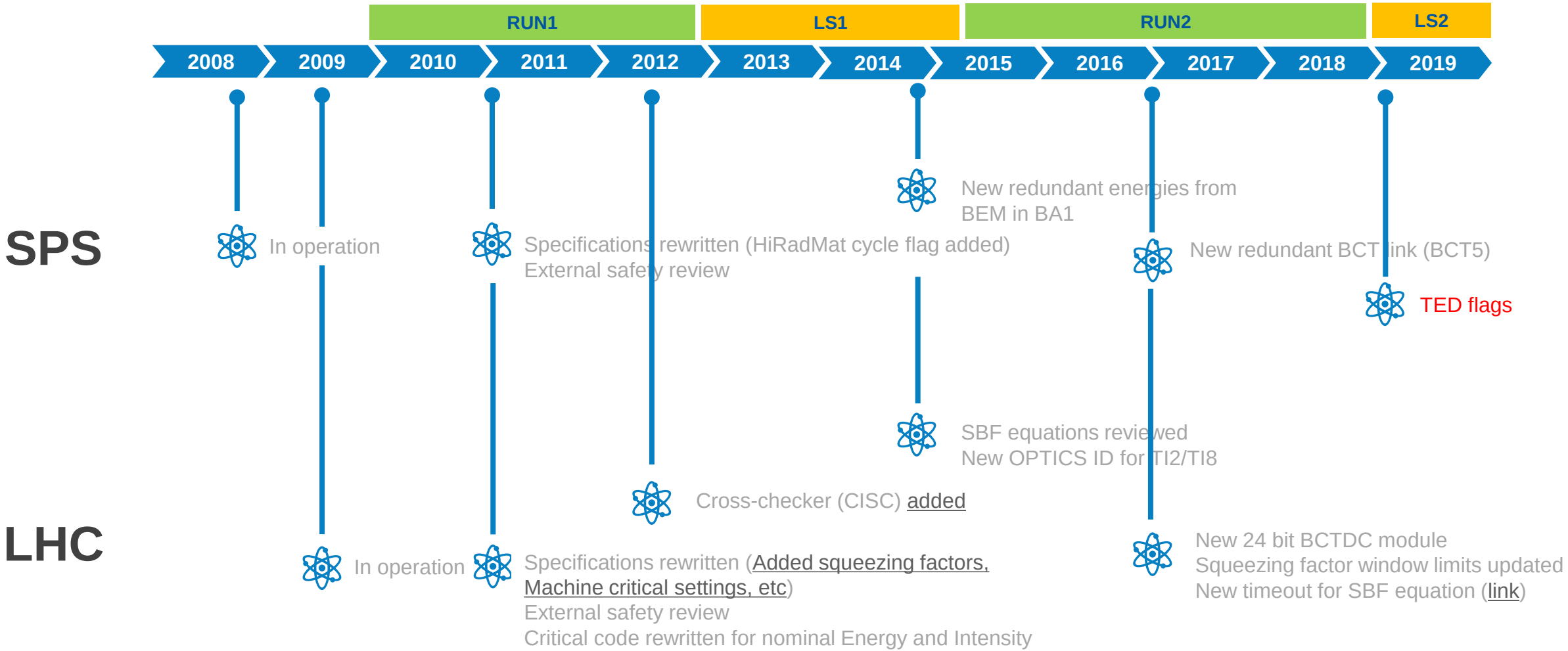
SPS: Layout of BCTDCs since 2017



LHC: Layout of BCTDCs since 2017



Evolution of the system



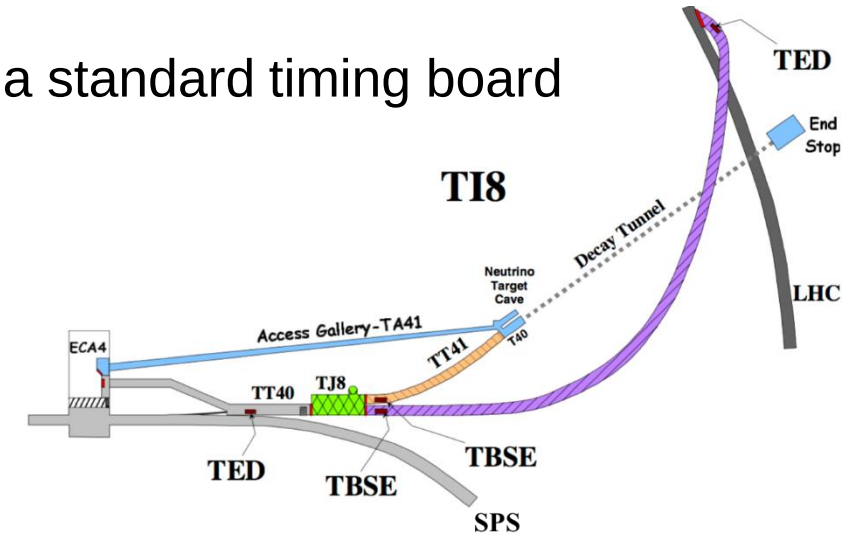
SPS: TED flag

- TEDs will not be able to withstand a full 25 ns LIU batch consisting of 288b
- New machine protection strategy with LHC beams after LS2 (SPS-OTH-ES-0001)
- The maximum intensity to be extracted with TED in beam ≤ 3.34 x 10^{13} protons

- Logic:

  SPS_TBF = true when (SPS_INTENSITY ≤ 3.5 x 10e13)

  else SPS_TBF = false
- SPS_TBF transmitted over the GMT and received via a standard timing board (CTR)
- 4 ELMA 3U VME chassis to be installed



Dependability in RUN1 and RUN2

- **2010 March** – Beam dump triggered by SBF B1-A going erroneously false for 100 ms (MPP link), which led to the replacement of the external SBF threshold board by internal ROM in the FPGA. Fixed!
- **2010 April** – Availability issues due to Beam Presence Flag oscillating. Intensity close to the threshold (MPP link). Not an SMP fault, BCT responsible for the flag generation. SMP re-transmission only. BPF filter implemented on SMP.
- **2012 March** – Beam dump due to SBF B2 going false. Could not confirm the cause but hypothesis is that BCT B2 sent spurious high intensity value
- **2018 February** – Issues with transmission of SMP flags to GMT during HWC. Faulty cable, switched to spare cable
- **2018 July** – Redundant power supplies from laser transceivers (CIBF) preventively replaced to avoid availability issues

Motivation to upgrade

- **Obsolescence**
  - **Discontinuity** of critical electronic components – Xilinx Spartan 2 / 3
  - **Full occupancy** of FPGA logic cells – no space for new features
  - **Aging** of the present system -> support until end of HL-LHC

- **Implementation of new requirements**
  - Transmission of **Energy and Intensity in the SPS**
  - Transmission of **bunch intensity in both SPS and LHC**?
  - Implementation of **TED flags in LS2** required optimization

See Raffaello's talk

Conclusions

- **Dependability** of the present SMP system was **extremely good** during the RUN1 and RUN2, in particular after the major firmware upgrade in 2012

- The broadcast of mission critical flags over the **GMT was proven to be adequate and reliable**, thanks to the implementation of a hardware cross-checker

- An **upgrade** of the system is needed **to guarantee the long-term maintenance** (including implementation of new requirements) and to follow the BIS developments

Thank you for your attention!