MDSH interlock and operation after LS2

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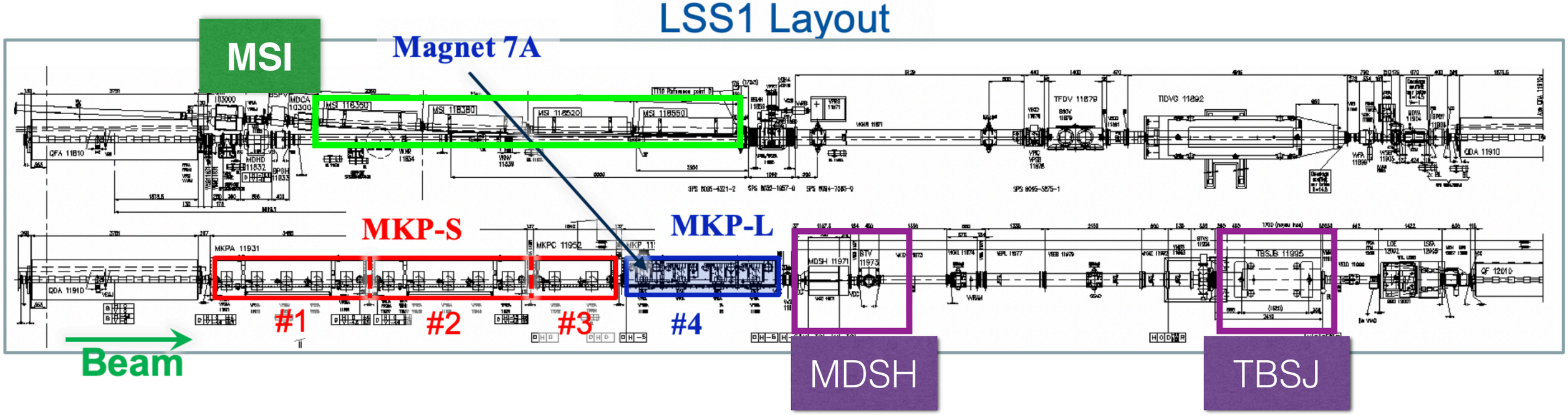
J. Uythoven, C. Wiesner

SPS injection system

Pre-LS2



→ MSI is made of 4 tanks => 8.4 m

→ MKP is composed of 4 tanks:

↳ The first 3 are made with "S type" magnets (5 + 5 + 2 =12) => 150 ns rise time (from specs), long pulse but weaker than the L type

↳ The last tank is made with "L type" magnets (4) => 225 ns rise time (from specs), short pulse but stronger than the S type

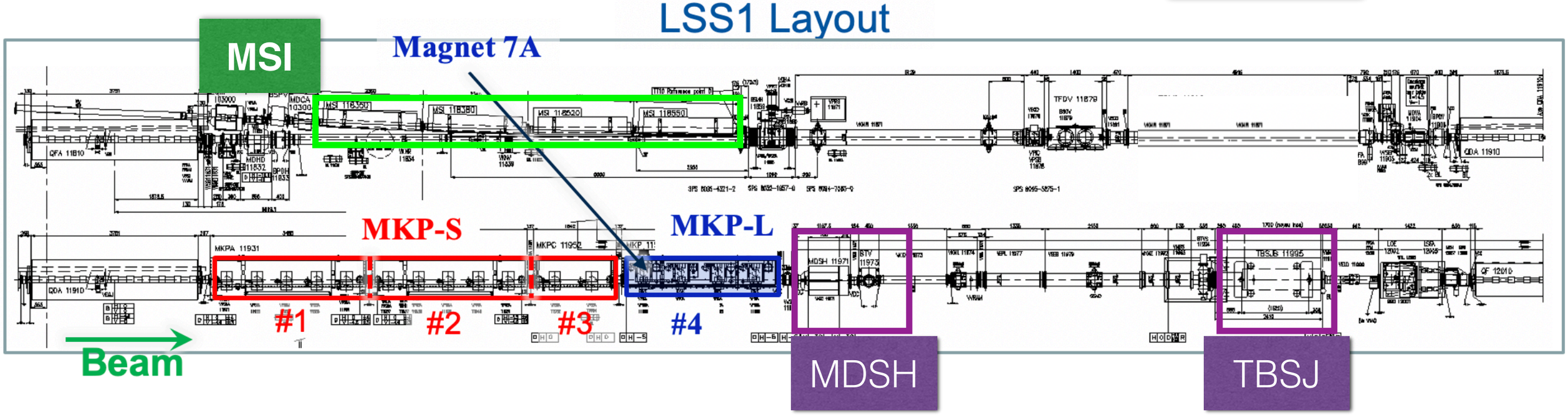
→ 8 switches for 4 HV generators => the first 3 power the first 3 tanks and the last powers the 4th tank

→ MDSH is a strong horizontal corrector used to help deflection of un-kicked beam onto the TBSJ

→ TBSJ is the injection dump

SPS injection system

Post-LS2



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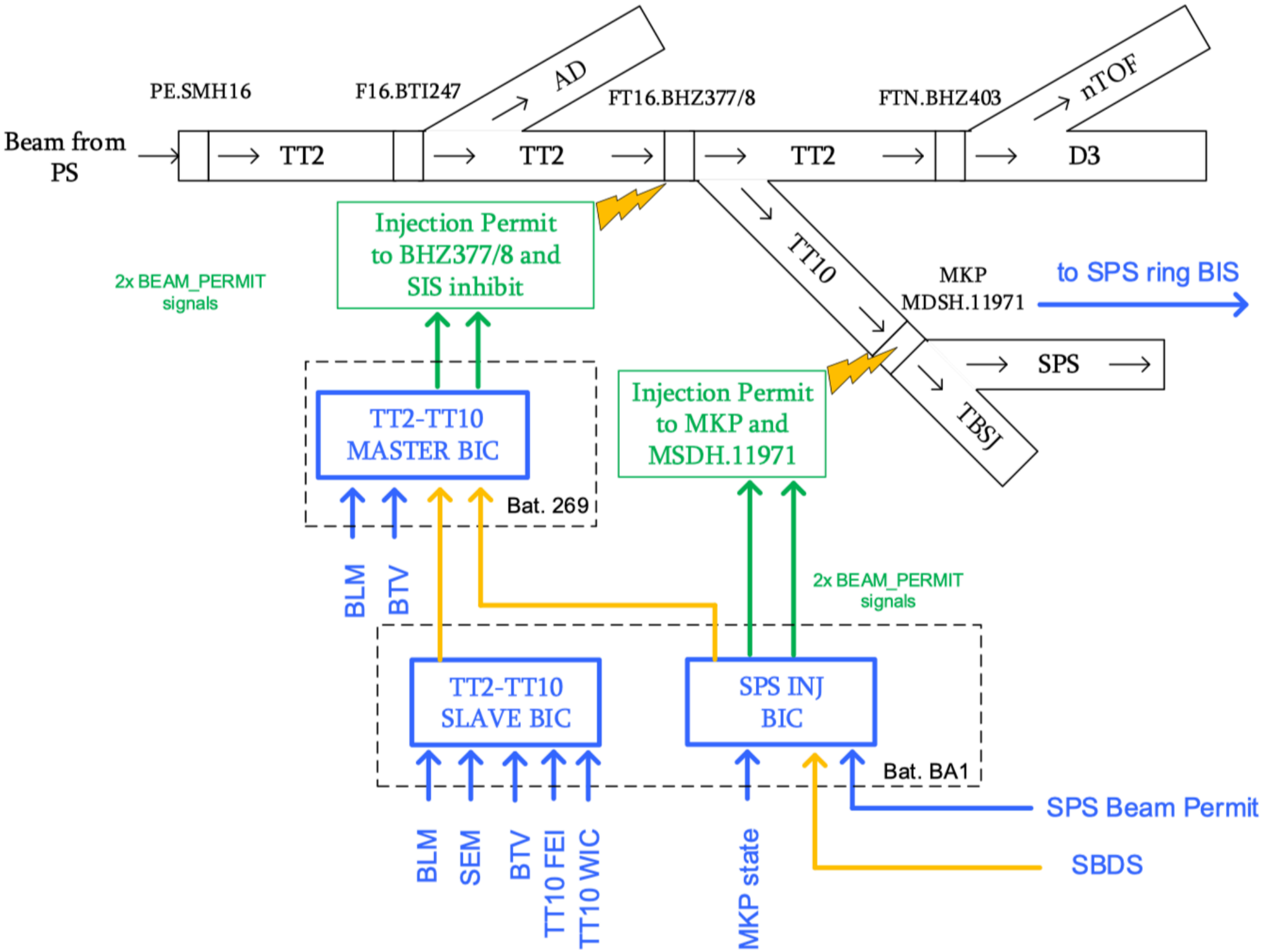
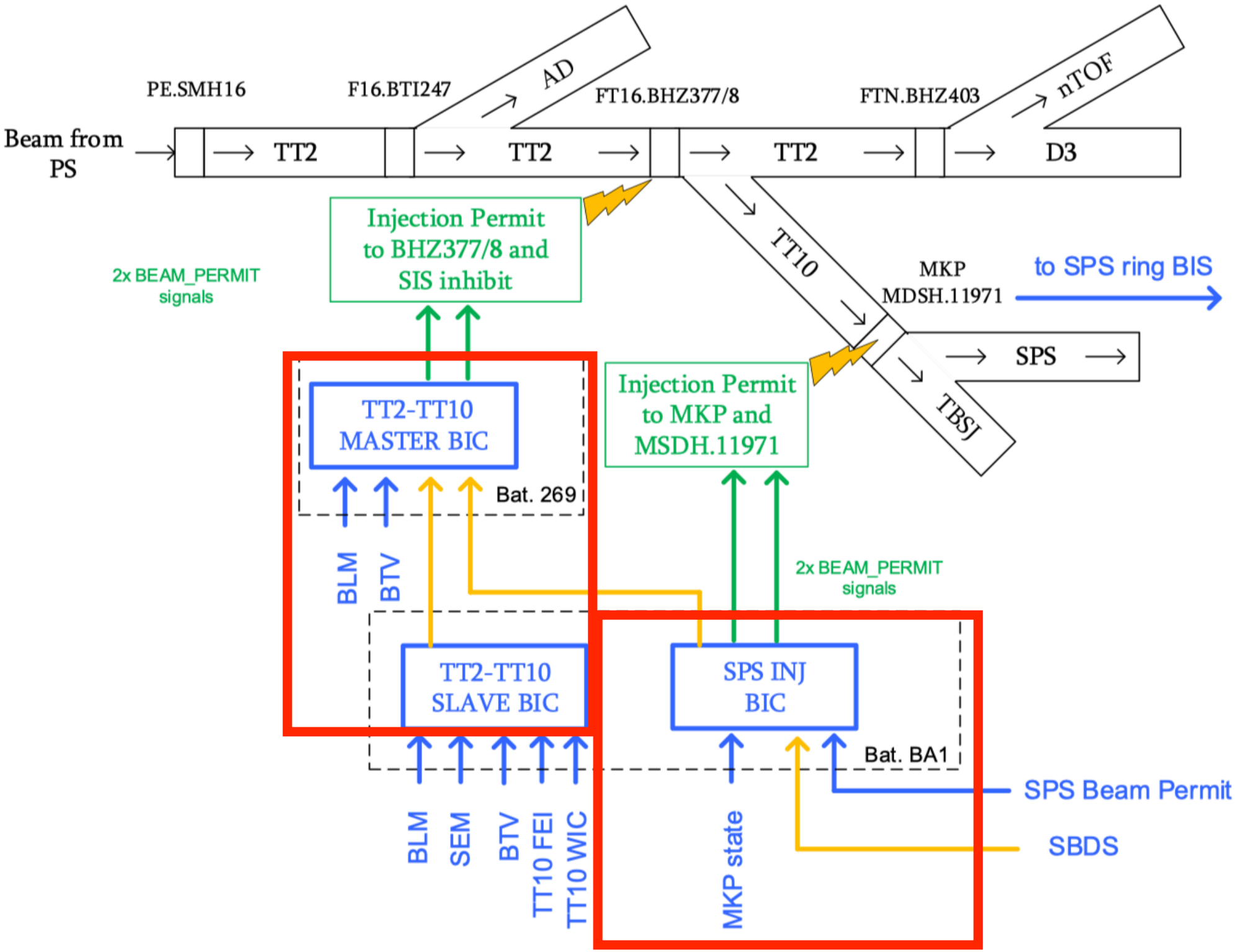
What will be new after LS2 - injection

- → No horizontal nor vertical dog-leg in LSS1
  - ↳ TIDVG moved to LSS5 => **only vertical dog-leg will stay!**
- → **MKP 7 and 8 will be equipped with bleeding resistors**
- → **New injection interlock** (SPS Injection BIC and TT2-TT10 slave and master BIC)
  - ↳ Added new functionalities to the MDSH

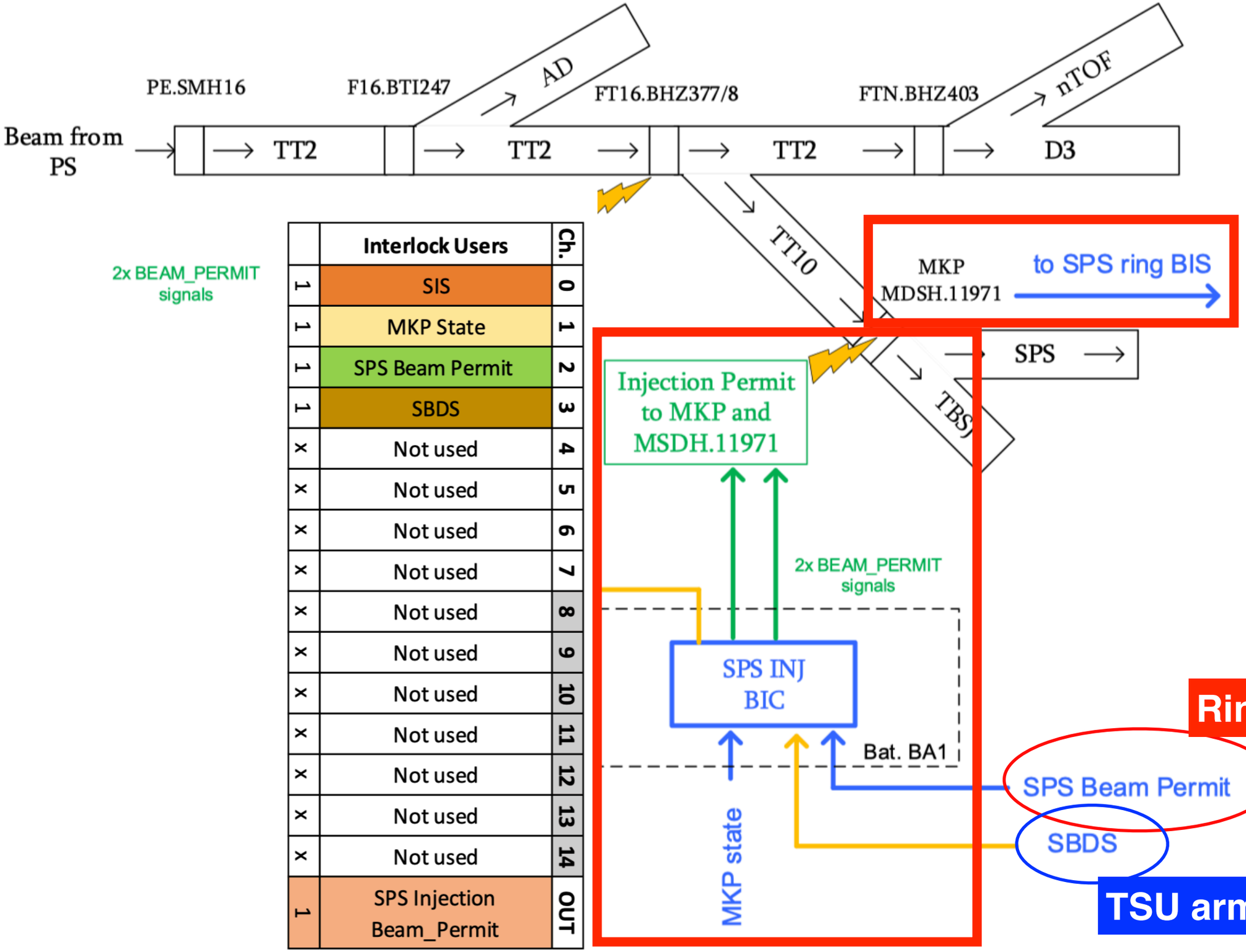
SPS Injection interlock



SPS Injection interlock



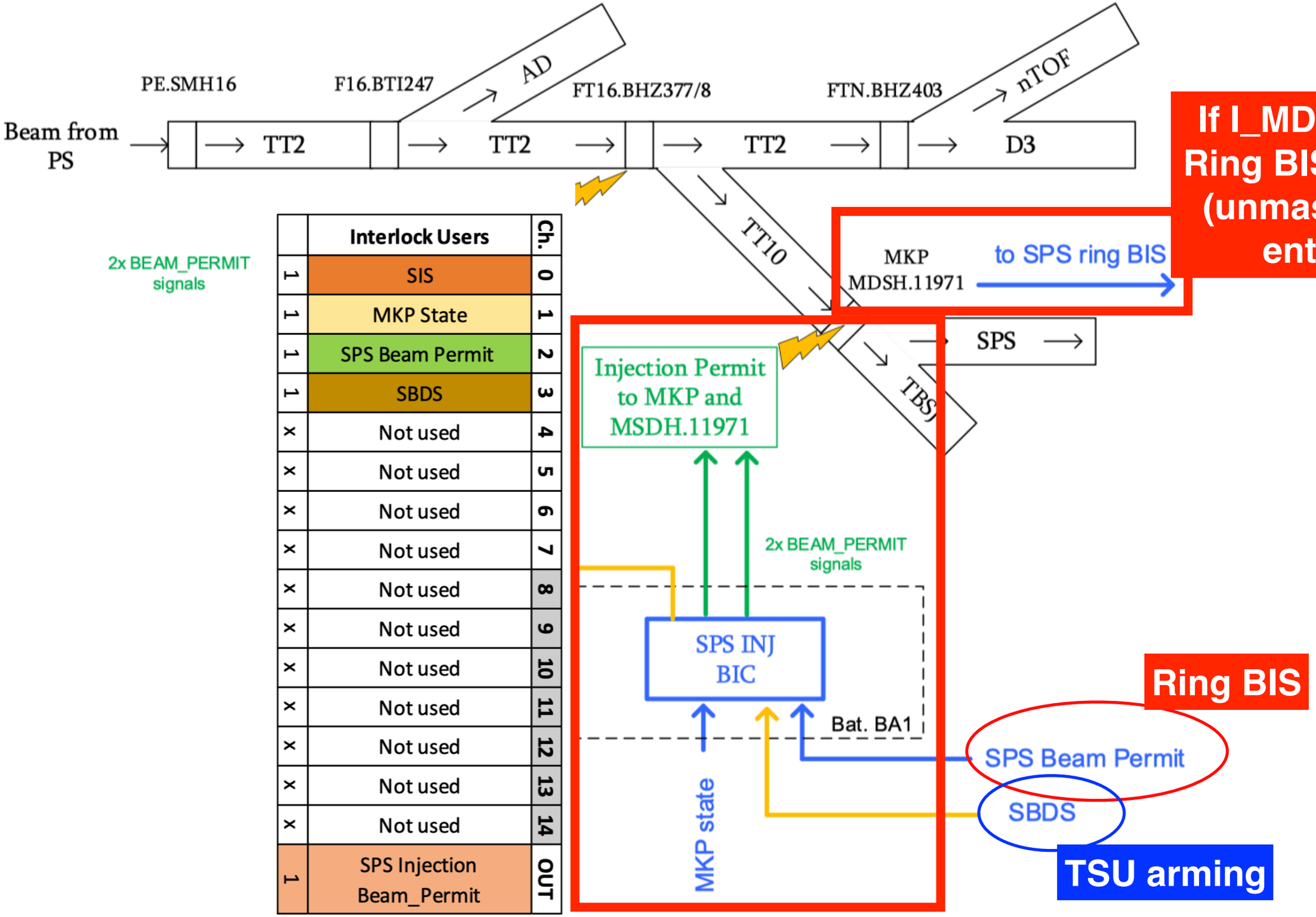
SPS Injection interlock



2x BEAM_PERMIT signals

	Interlock Users	Ch.
1	SIS	0
1	MKP State	1
1	SPS Beam Permit	2
1	SBDS	3
x	Not used	4
x	Not used	5
x	Not used	6
x	Not used	7
x	Not used	8
x	Not used	9
x	Not used	10
x	Not used	11
x	Not used	12
x	Not used	13
x	Not used	14
1	SPS Injection Beam_Permit	OUT

SPS Injection interlock



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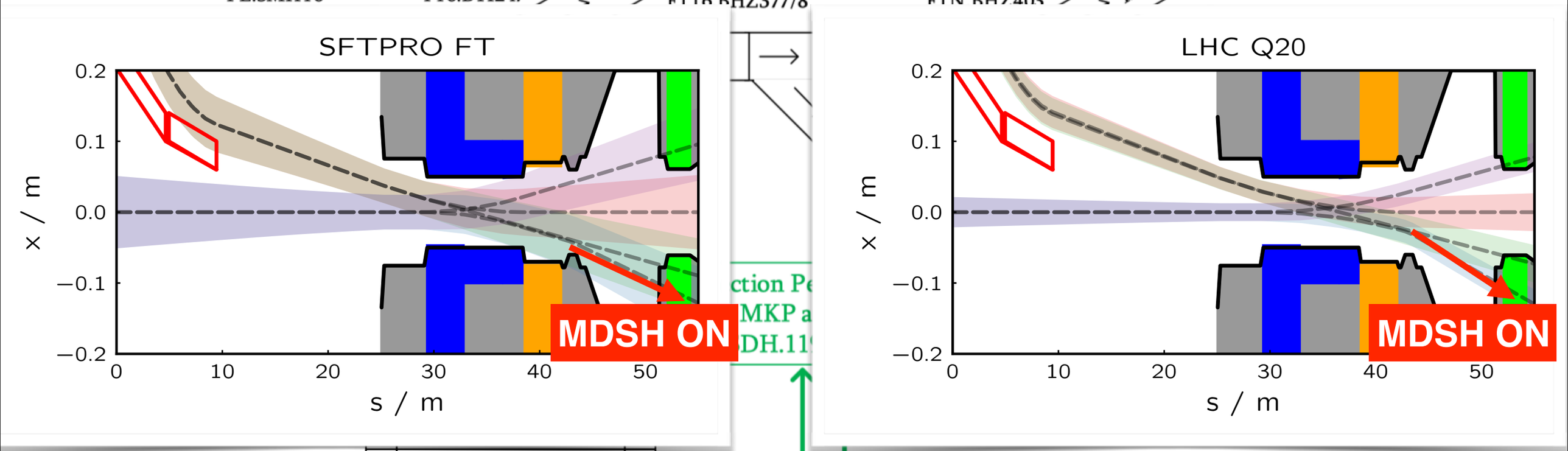
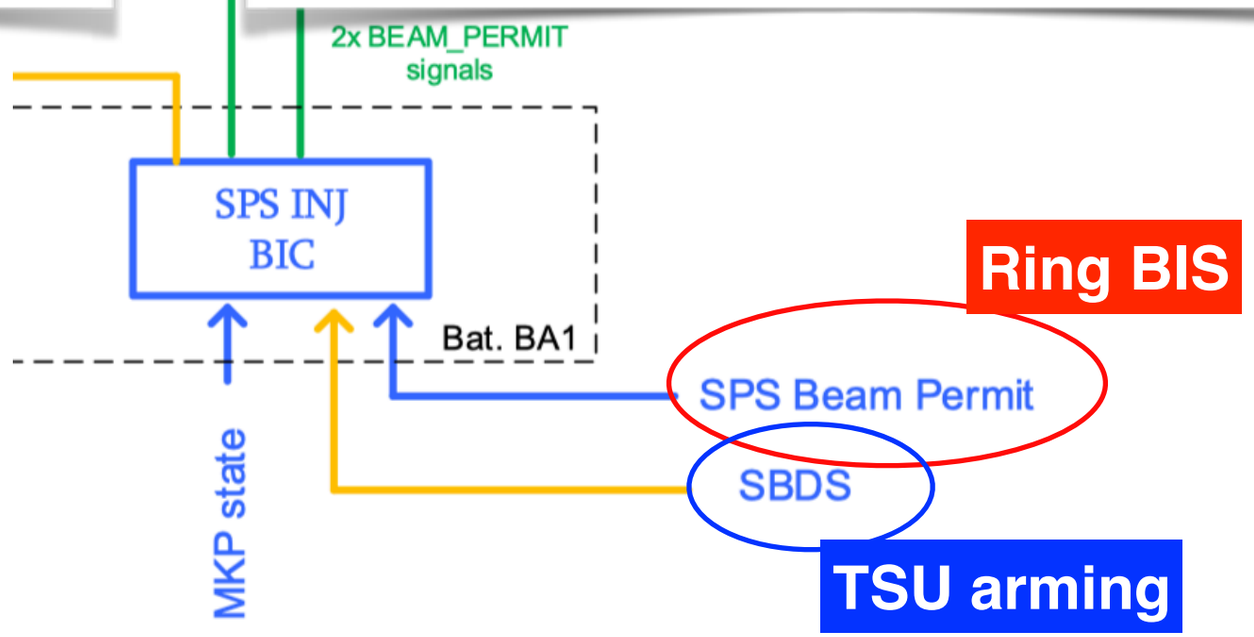
x	Not used	6
x	Not used	7
x	Not used	8
x	Not used	9
x	Not used	10
x	Not used	11
x	Not used	12
x	Not used	13
x	Not used	14
1	SPS Injection Beam_Permit	OUT

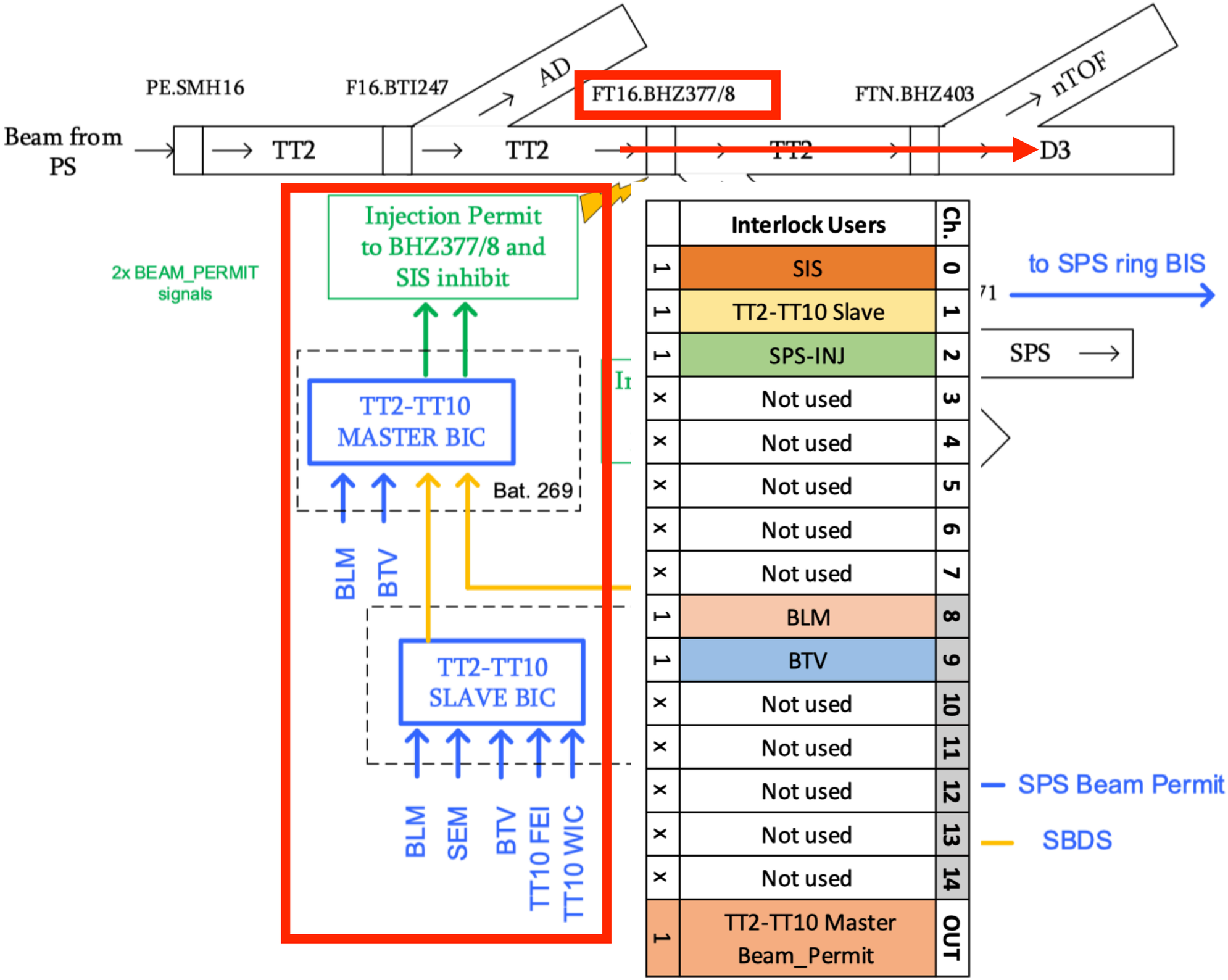
SPS Injection interlock



×	Not used	7
×	Not used	8
×	Not used	9
×	Not used	10
×	Not used	11
×	Not used	12
×	Not used	13
×	Not used	14
1	SPS Injection Beam_Permit	OUT

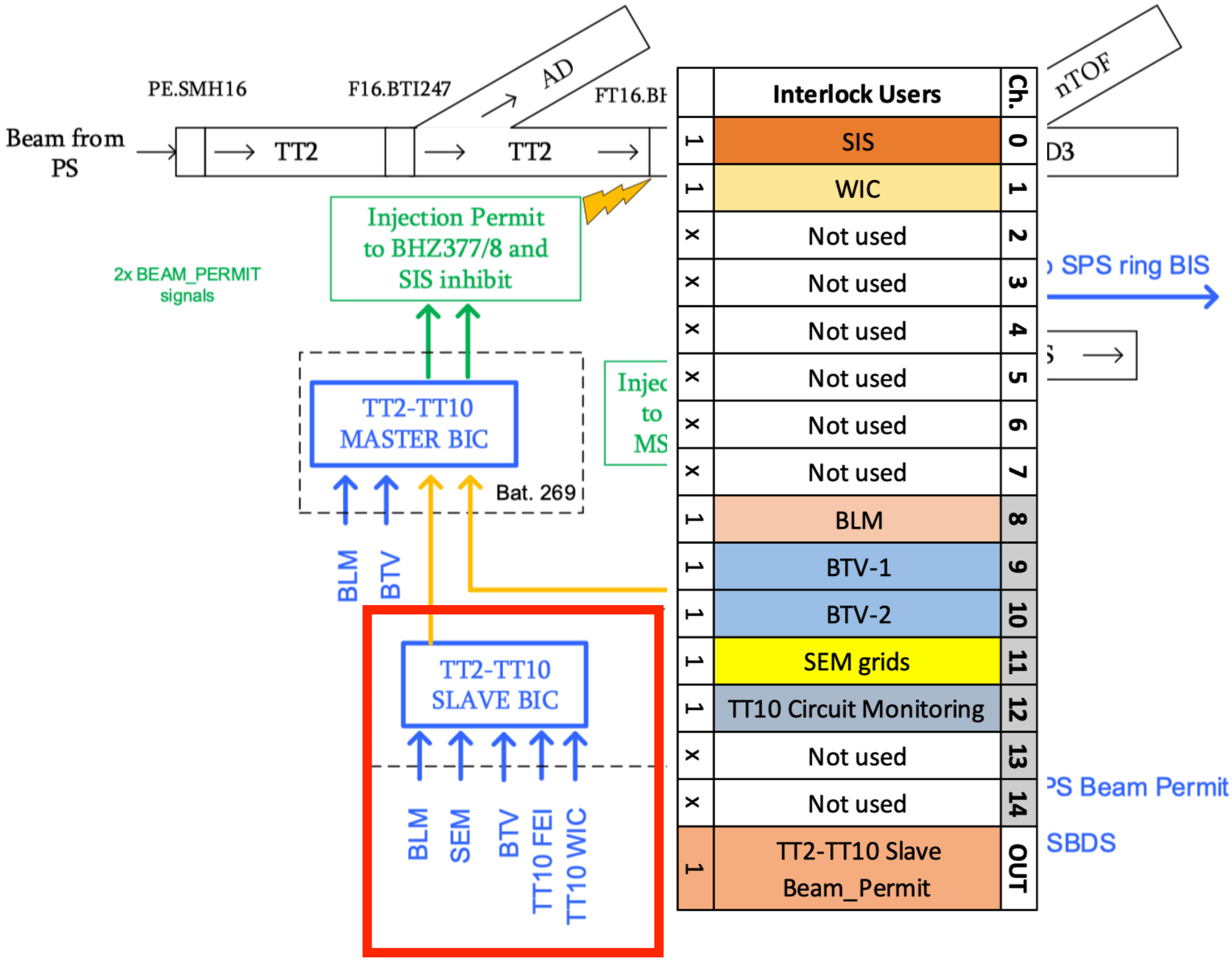


SPS Injection interlock



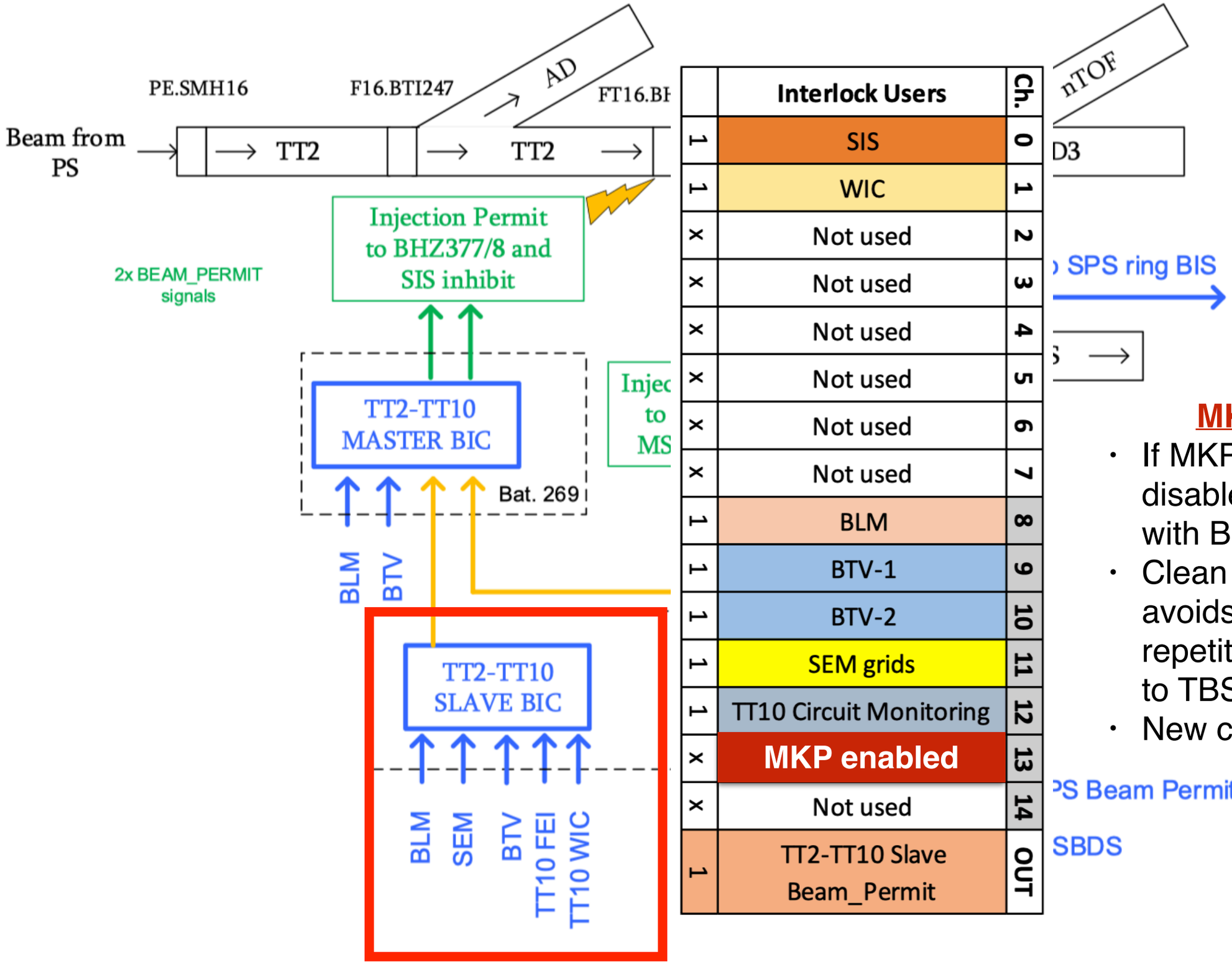
	Interlock Users	Ch.
1	SIS	0
1	TT2-TT10 Slave	1
1	SPS-INJ	2
x	Not used	3
x	Not used	4
x	Not used	5
x	Not used	6
x	Not used	7
1	BLM	8
1	BTV	9
x	Not used	10
x	Not used	11
x	Not used	12
x	Not used	13
x	Not used	14
1	TT2-TT10 Master Beam_Permit	OUT

SPS Injection interlock



	Interlock Users	Ch.
1	SIS	0
1	WIC	1
x	Not used	2
x	Not used	3
x	Not used	4
x	Not used	5
x	Not used	6
x	Not used	7
1	BLM	8
1	BTV-1	9
1	BTV-2	10
1	SEM grids	11
1	TT10 Circuit Monitoring	12
x	Not used	13
x	Not used	14
1	TT2-TT10 Slave Beam_Permit	OUT

SPS Injection interlock



	Interlock Users	Ch.
1	SIS	0
1	WIC	1
x	Not used	2
x	Not used	3
x	Not used	4
x	Not used	5
x	Not used	6
x	Not used	7
1	BLM	8
1	BTV-1	9
1	BTV-2	10
1	SEM grids	11
1	TT10 Circuit Monitoring	12
x	**MKP enabled**	13
x	Not used	14
1	TT2-TT10 Slave Beam_Permit	OUT

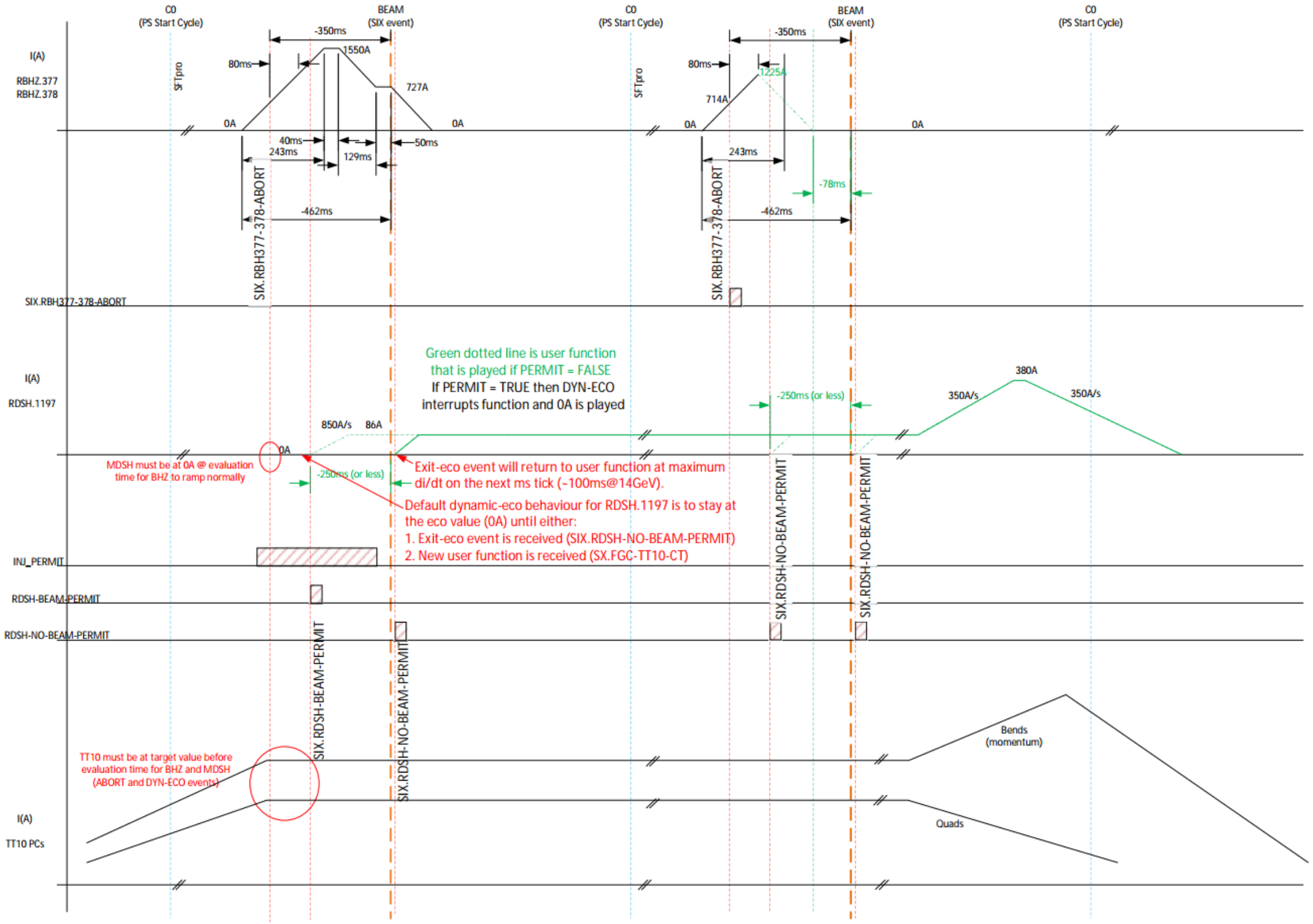
MKP enabled:

- If MKP state is OK, but disabled, stop beam with BHZ already
- Clean solution which avoids to send repetitively send beam to TBSJ
- New cable needed

MDSH link to injection and SPS interlock

- The MDSH will be now a key element of the SPS injection operation, more than it was until now
- Its PC will be interlocked via the WIC in TT2TT10-BIC (see Ivan's presentation)
- Its measured current will be interlocked via a PC entry to the SPS-BIS => current must be at 0 A to allow beam in the machine
- The MDSH will become one of the actuators of the SPS-INJ BIC, together with the MKP
- The MDSH will check for the beam permit twice: **270 ms before injection (LTIM with delay wrt inj-forewarning) and 100 us after injection**
  - In the first case, if the injection permit is removed between 350 and 270 ms before injection, then the beam is safely directed on the TBSJ
  - In case a beam is injected into a machine where the SBDS is not armable, then the MDSH will be triggered and the beam will be lost at injection energy being scraped off by the MDSH (see next slide)

MDSH and BHZ - D. Nisbet



D. Nisbet 4th March 2020

“New discovered” SBDS failure

→ A new failure, as a combination between erratic firing of the MKDV/H (SBDS) while MKP ready to pulse and only waiting the ~40/70 us after pre-pulse =>
a new beam could be injected without SBDS!

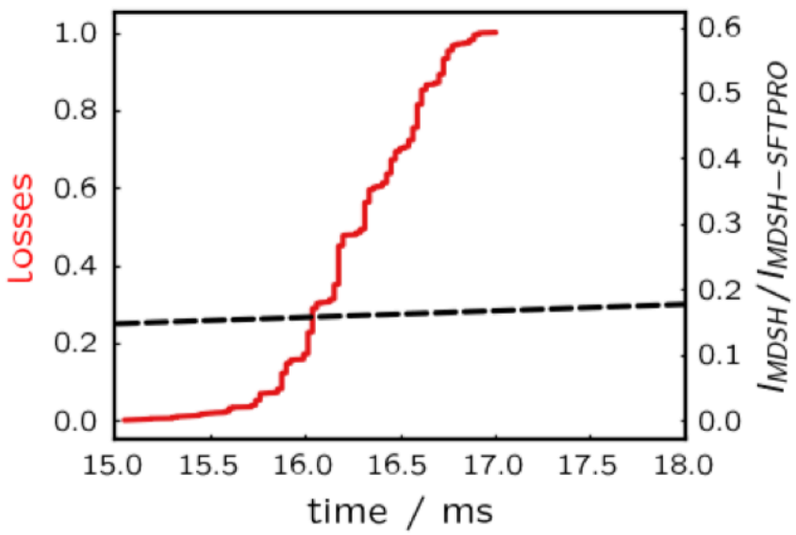
↳ This is now solved (present since the beginning of SPS operation!) using the MDSH:

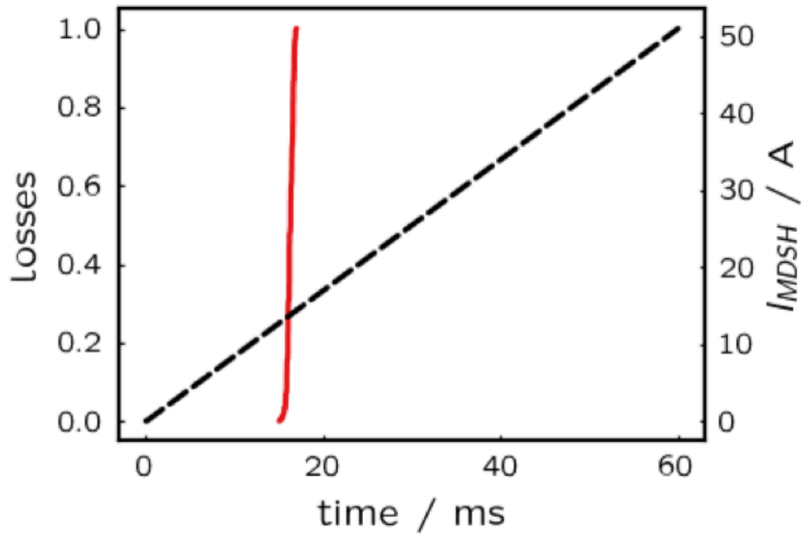
↳ In order to avoid to accelerate a beam without SBDS, the MDSH can be used to lose the beam before start ramping

- This is done having the MDSH control to check twice per injection if it should play economy (0 A) or exit (play != 0 A current)
- **One check of the beam permit is done 270 ms before injection (1) and one ~100 us after injection (2)**

1. **In case INJ-PERMIT = False, event RDSH-NO-BEAM-PERMIT emitted, otherwise RDSH-BEAM-PERMIT event emitted and 0A function played**

- In case, it will then pulse diluting the circulating beam (at injection energy) all around the machine





Commissioning test - tricky cases

→ Need to test as much as possible during commissioning

→ Injected beam on the TBSJ w/o the MDSH pulsing:

- Disable MKP and mask "MKP enabled" in TT2/TT10 BIC

→ Injected beam on the TBSJ w/ the MDSH pulsing

- Inject single bunch twice in the same cycle (2 injections)
- Mask "MKP enabled" in TT2-TT10 BIC
- Program early dump 280 ms before second injection

→ The same "trick" as the one above could be thought to be used to test the MDSH reaction to the previously discussed failure mode...to be seen if possible with the accuracy of the early dump event (under investigation)

Summary

- → The MDSH will be playing an essential role in the SPS injection system and its protection

- → The MDSH current will be monitored by the SPS-BIS, as even small field in the MDSH will cause large CO deviation

- → The operation of the MDSH will be based on 2 injection-permit checks per injection:
  - ↳ One 270 ms before injection and one 100 us after injection

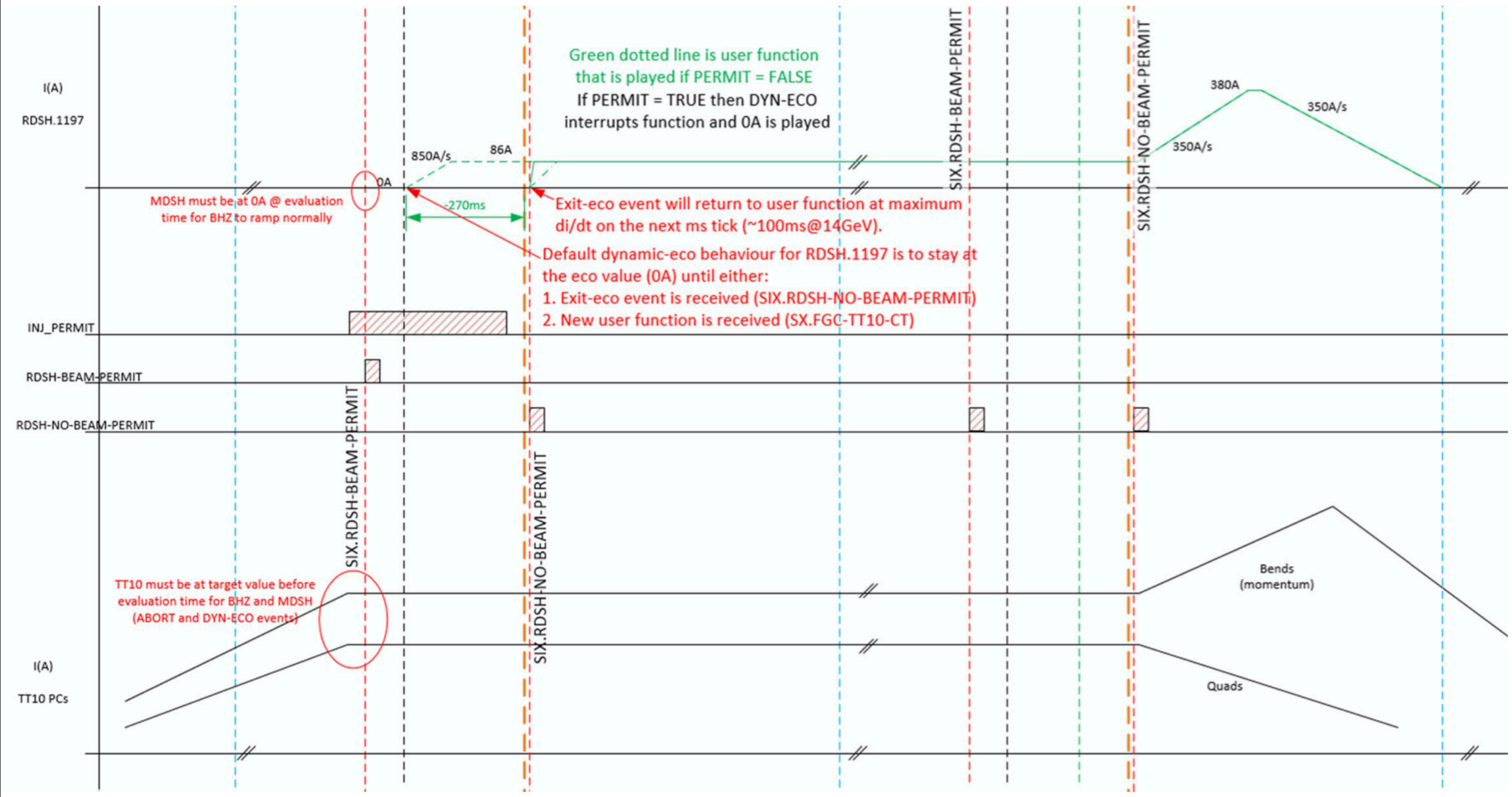
- → The first check ensures to have the MDSH pulsing in case the beam permit is removed after the BHZ decision of pulsing has been taken (window of 80 ms…)

- → The second check is to ensure to lose a beam injected in a machine w/o SBDS at injection energy

Thanks!

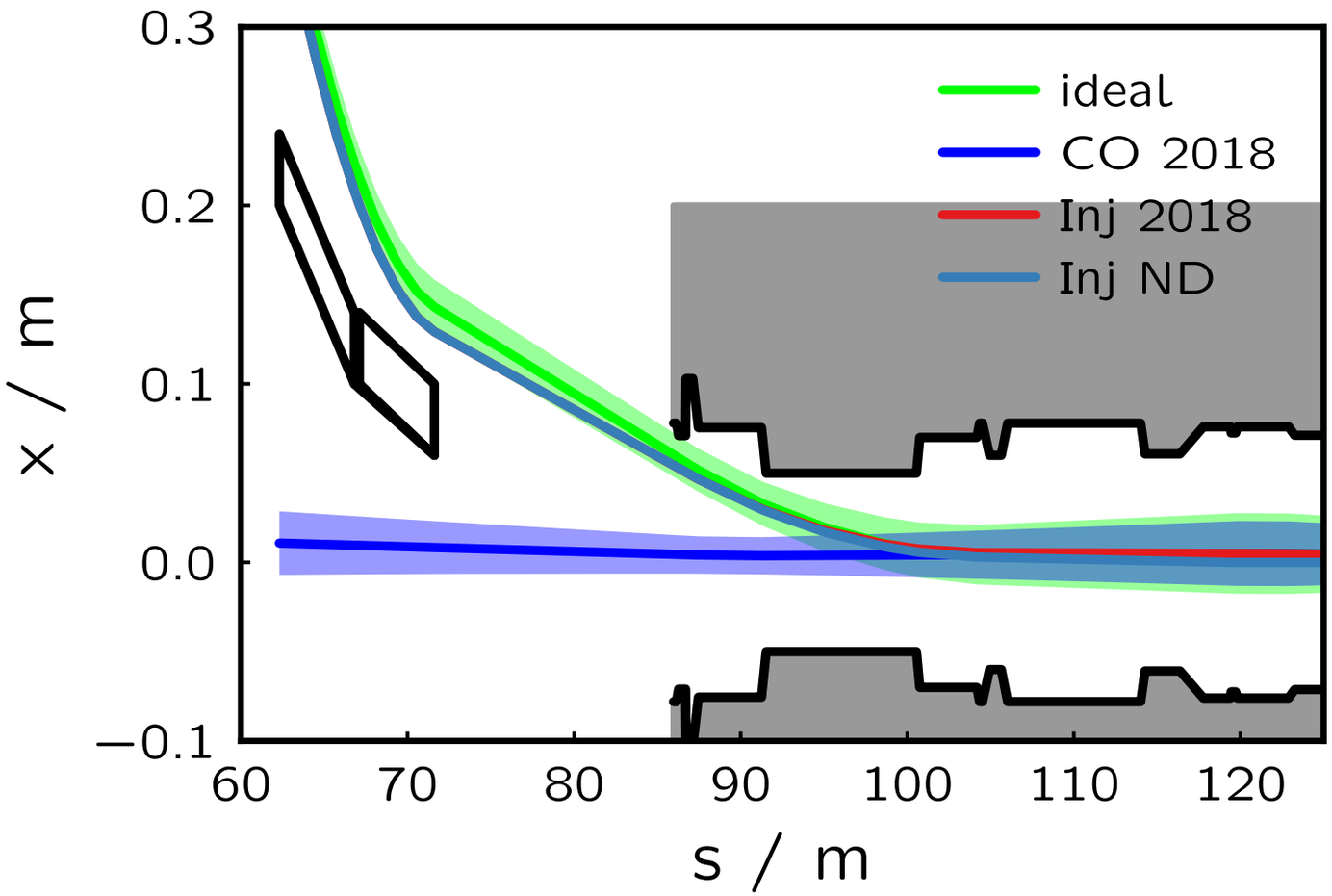
Backup

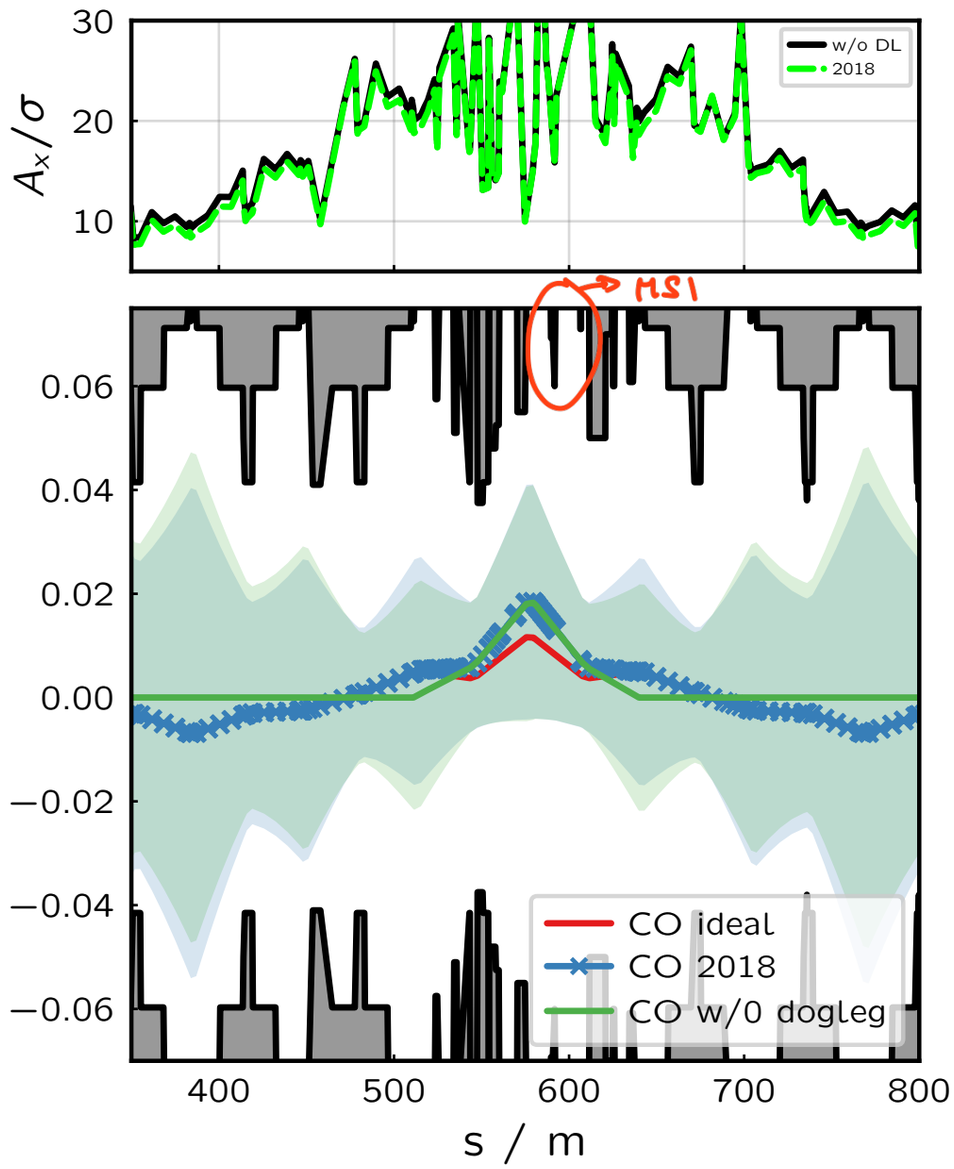
MDSH functioning - D. Nisbet



LHC

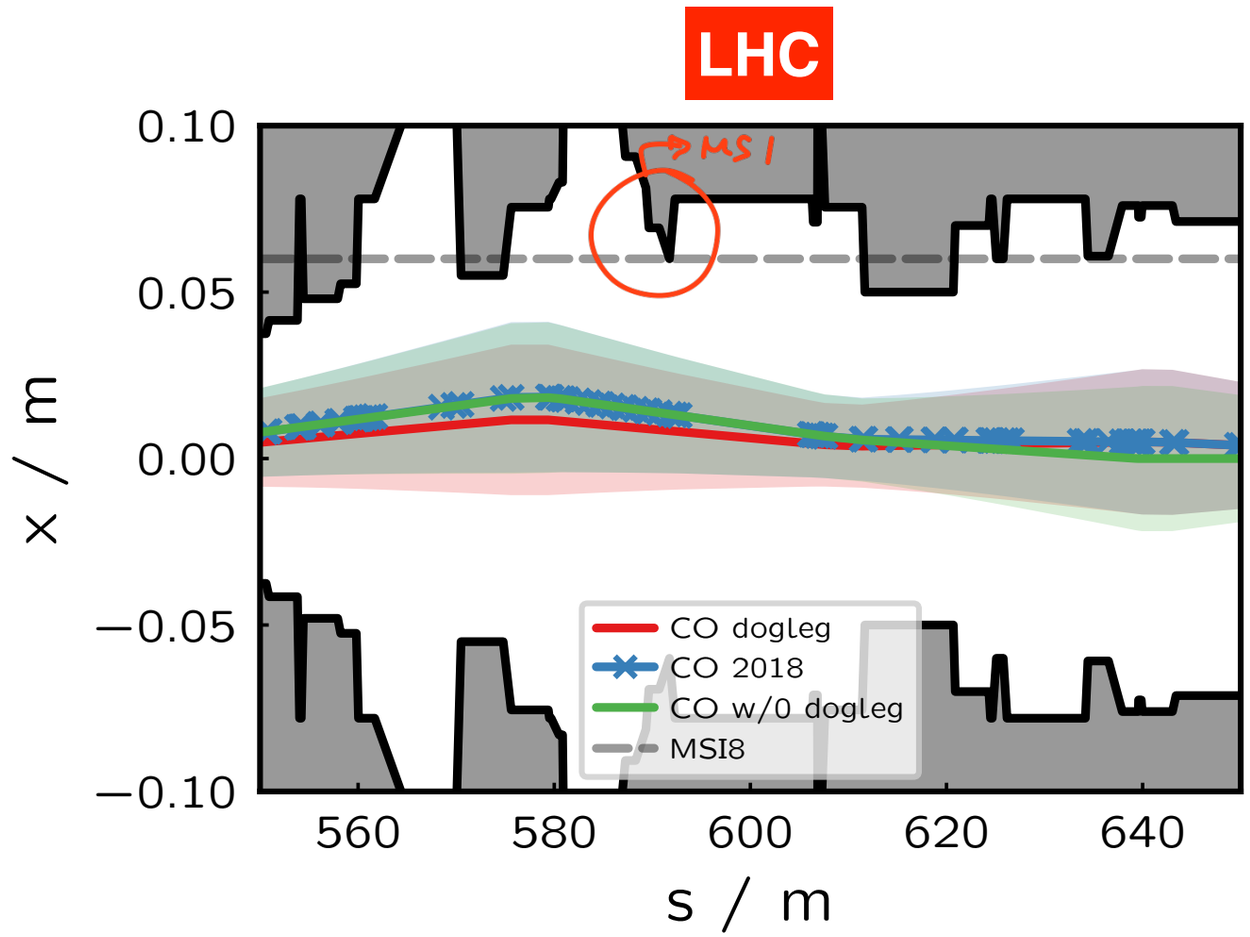
- With the PFN load balancing in place, an injection bump was needed during last years run
  - In 2018, 5mm bump used for golden orbit
  - **Removing the dog-leg in LSS1** would require a bump of **13 mm (settings)** to conserve the same acceptance at the last MSI for the injected beam
    - **This is basically to bring the beam back where it is now!**
    - **No reduction of acceptance for circulating beam!**

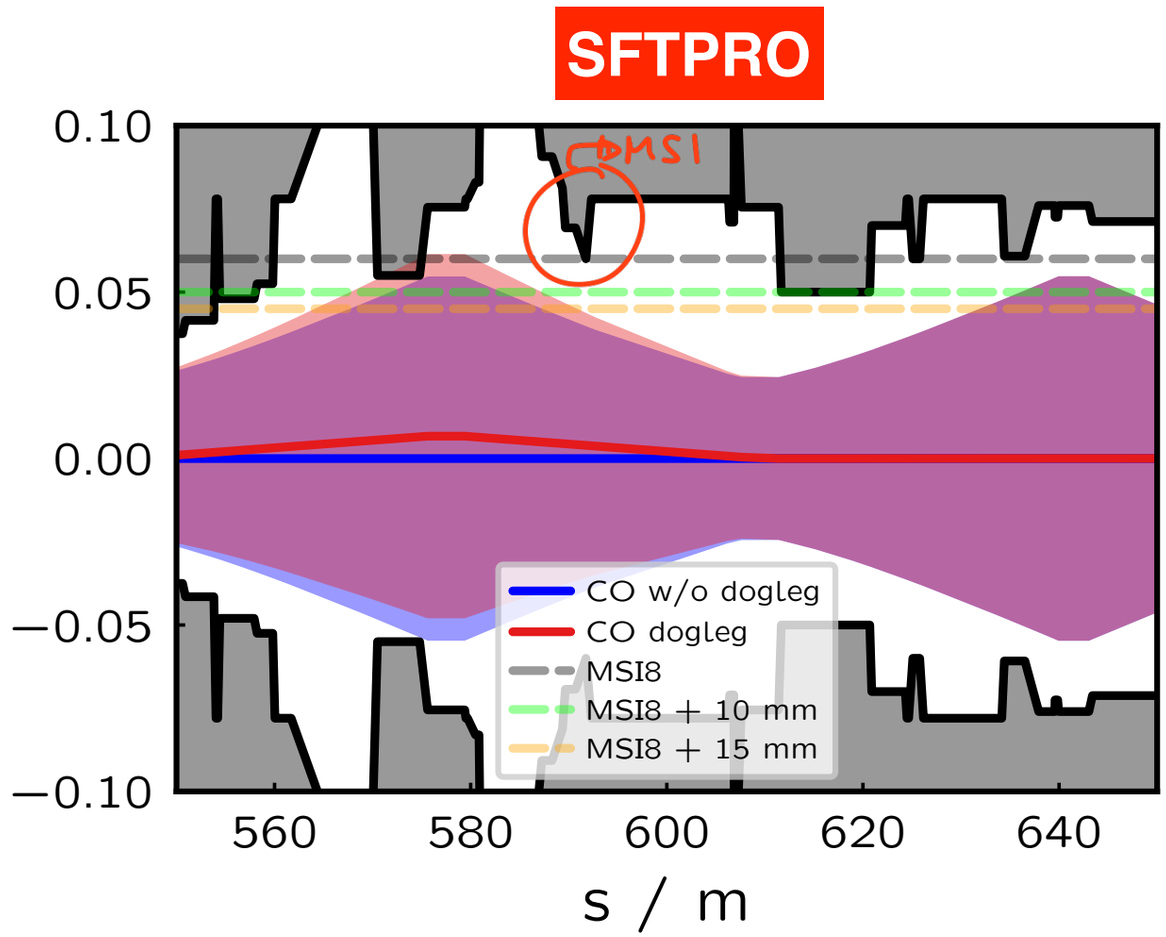




Misalign MSI for new trajectory

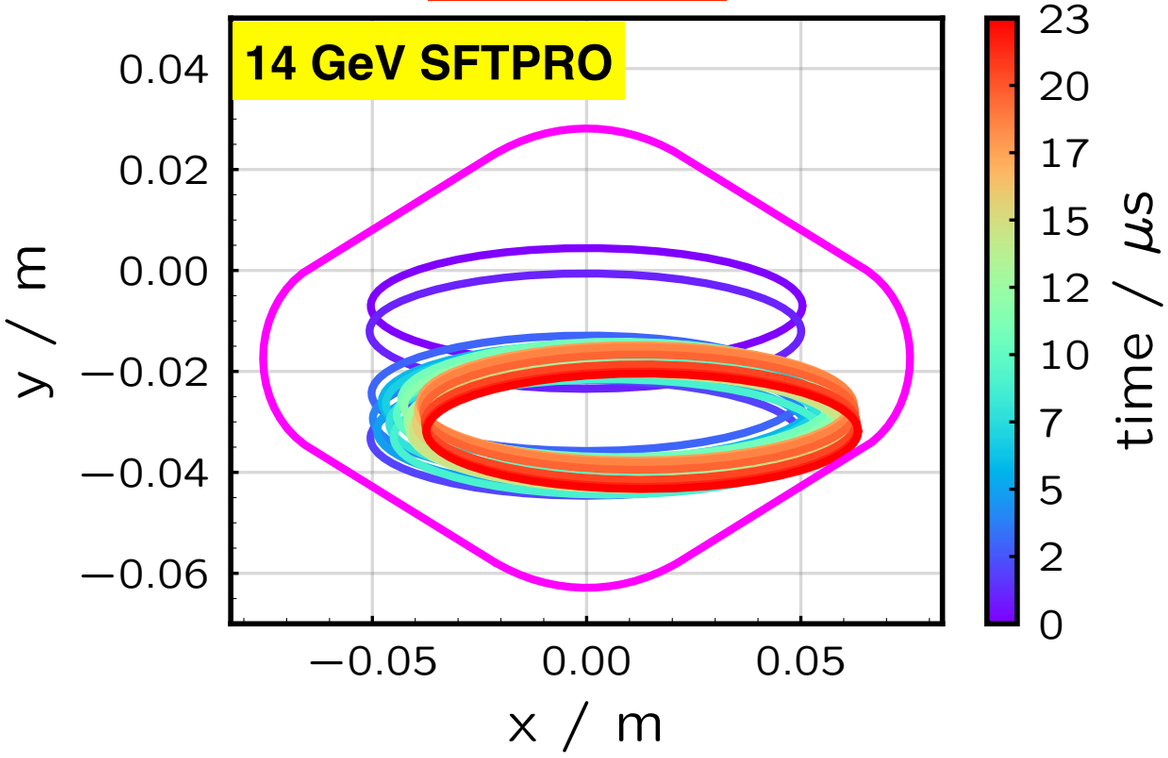
- If we want to optimise the aperture for the injected beam, following the removal of the dogleg, this could be done misaligning the last MSIs (7-8)
  - 10 mm is needed to have the same acceptance as in 2018, also having still the same bump (5 mm)…is it worth it?
  - 15 mm to remove completely the injection bump…just above 6 sigma clearance for the SFTPRO…is it worth it?



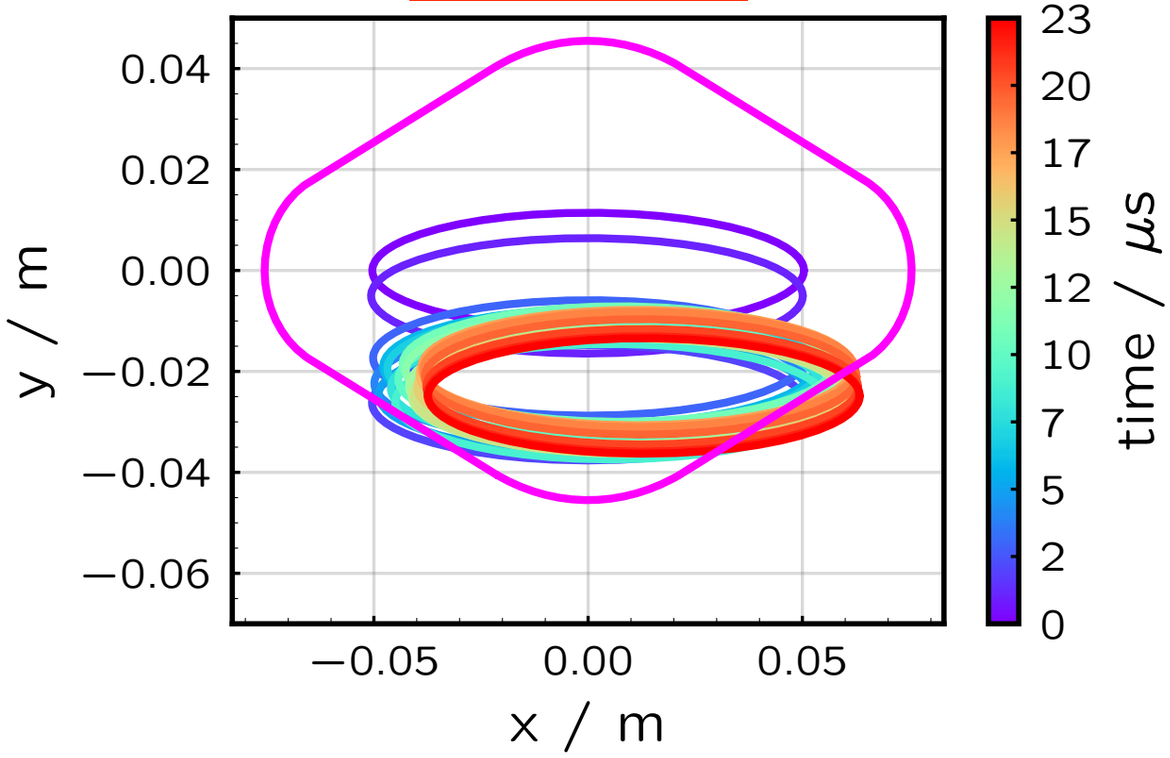


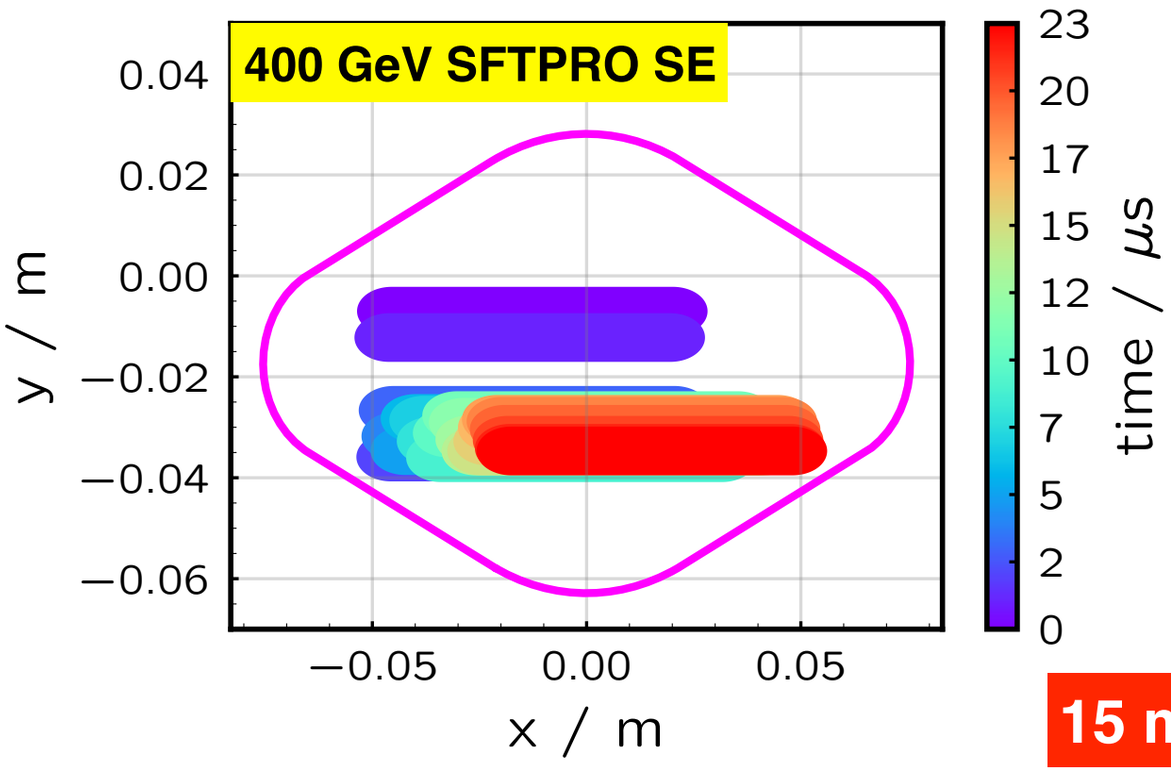
Why we need the V dog-leg in LSS5

V dog-leg

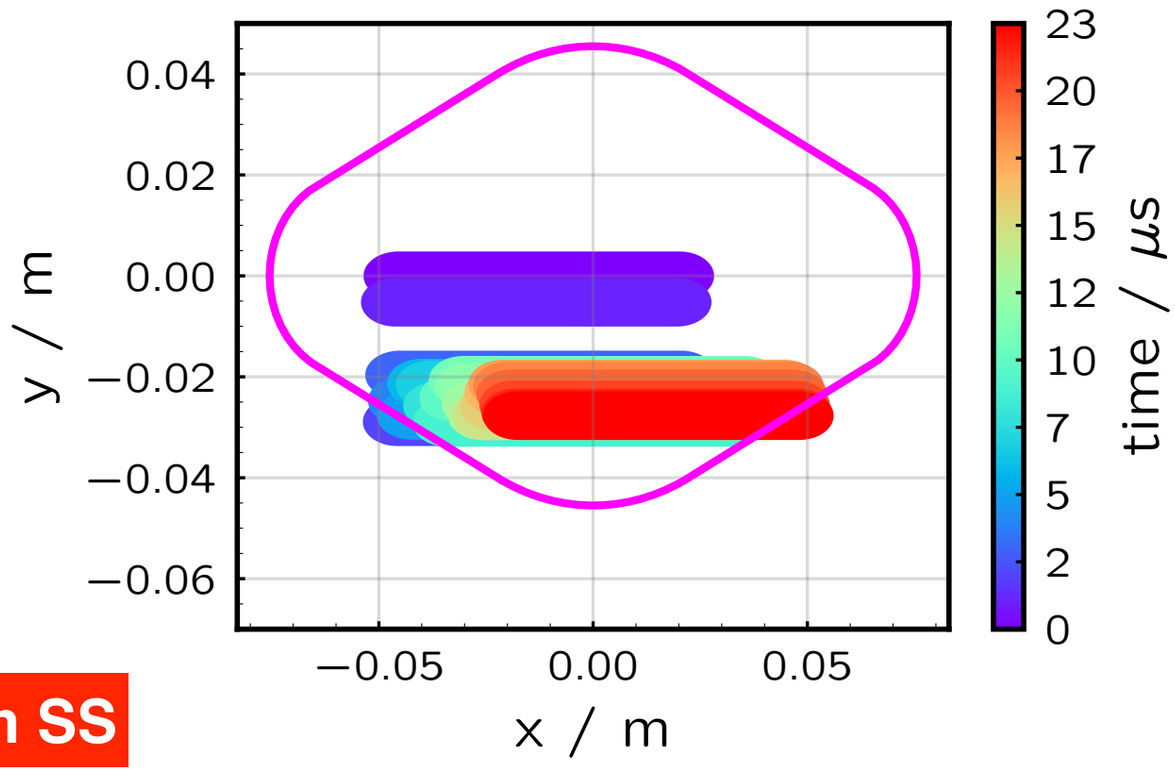


No dog-leg





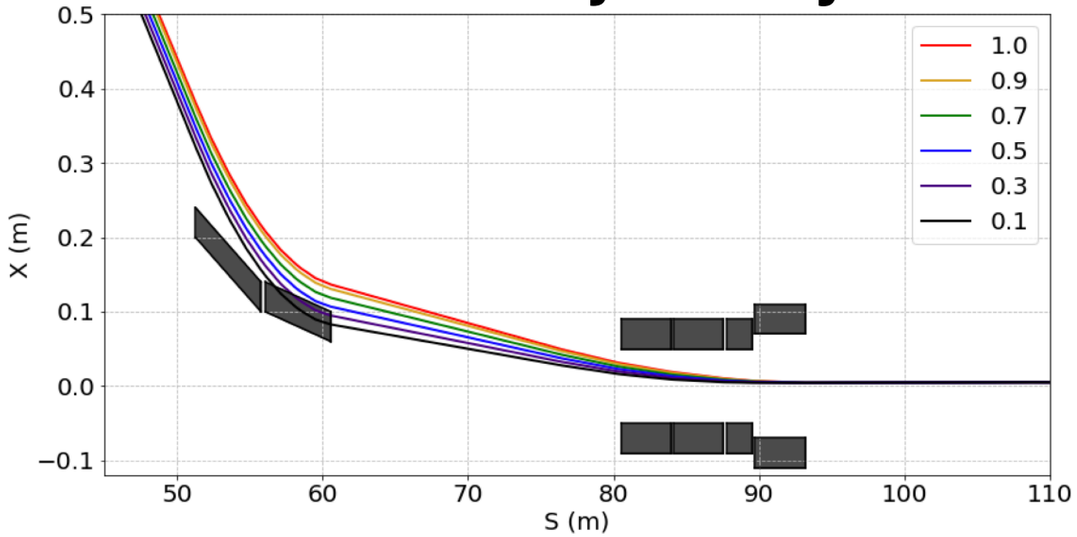
15 mmm SS



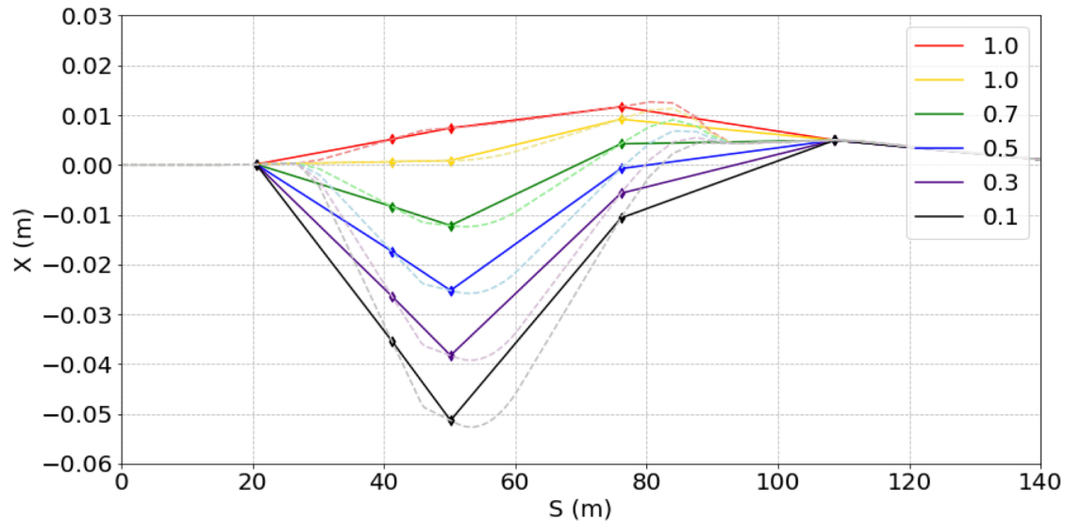
MKP voltage balancing

→ Effect of voltage re-balancing:

Actual trajectory

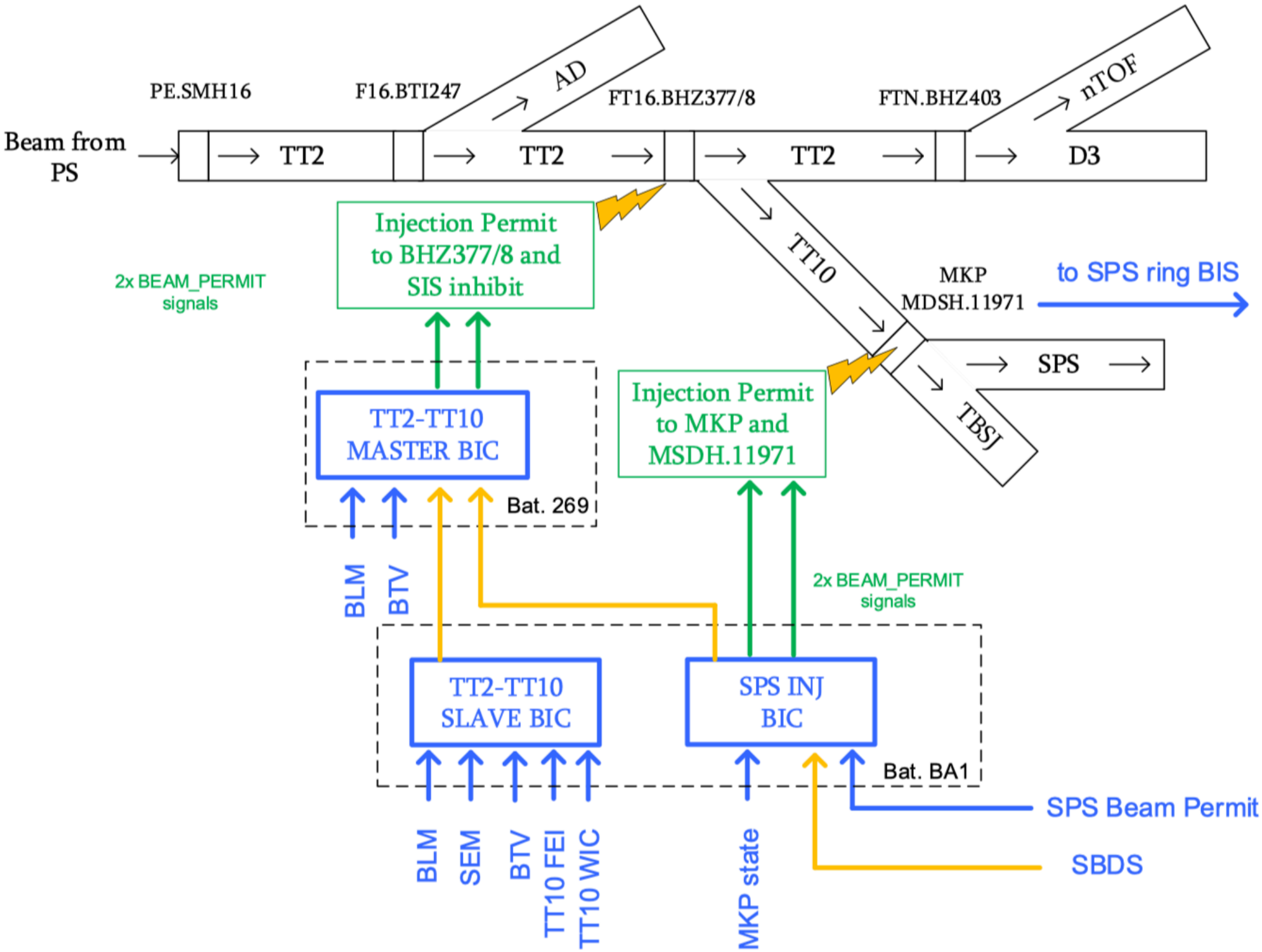


BPM readings

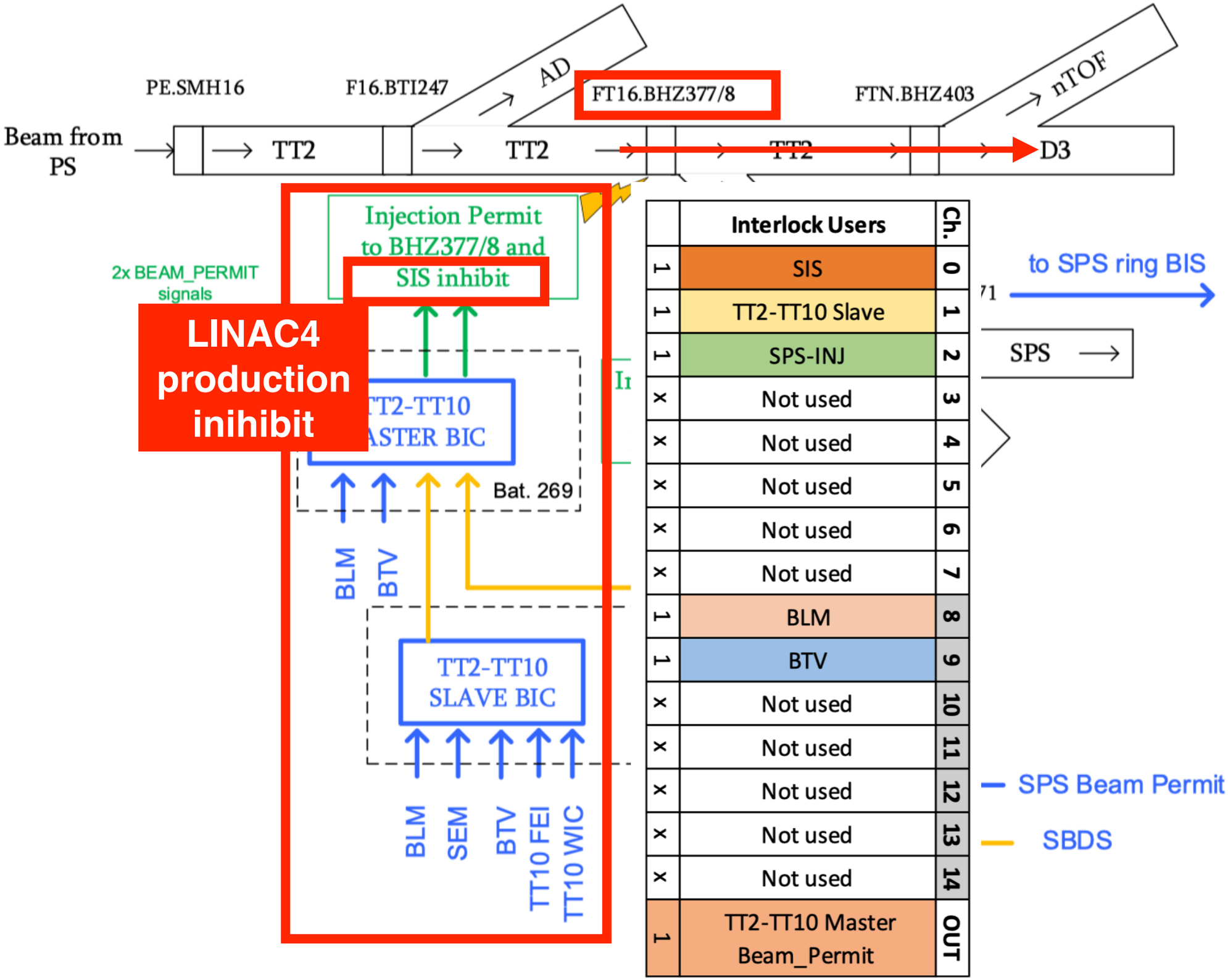


Re-balancing factor	KMSI (mrad)	KMAL (mrad)
1.0	41.6685	-0.352694
0.9	41.9773	0.00542145
0.7	42.5949	0.721653
0.5	43.2125	1.43788
0.3	43.8302	2.15411
0.1	44.4478	2.87035

SPS Injection interlock



SPS Injection interlock



	Interlock Users	Ch.
1	SIS	0
1	TT2-TT10 Slave	1
1	SPS-INJ	2
x	Not used	3
x	Not used	4
x	Not used	5
x	Not used	6
x	Not used	7
1	BLM	8
1	BTV	9
x	Not used	10
x	Not used	11
x	Not used	12
x	Not used	13
x	Not used	14
1	TT2-TT10 Master Beam_Permit	OUT

SPS Injection interlock

- So far, direct link between the MKP and SBDS
- Re-location of SBDS => needed for something else => SPS Injection BIS
  - Also, LIU brightness means that the number of dumps on the TBSJ has to be limited!

TT2-TT10 BIC	SPS-INJ BIC	Allowed beam destination
TRUE	TRUE	SPS
TRUE	FALSE	TBSJ
FALSE	Don´t care	D3, n-TOF