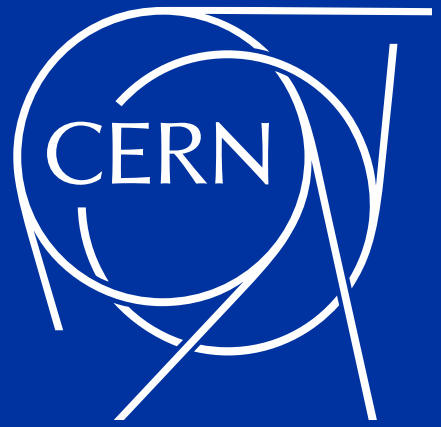


Outcome of SPS Collimation MD

Frederik Van der Veken, R. Alemany Fernandez, M. Patecki, A. Lasheen, J. Flowerdew, K. Paraschou, I. Mases Sole, K. S. Bruce Li

on behalf of the collimation, OP, and RF teams

Injectors Performance Panel 27/09/2024

Outline

Introduction and Motivation

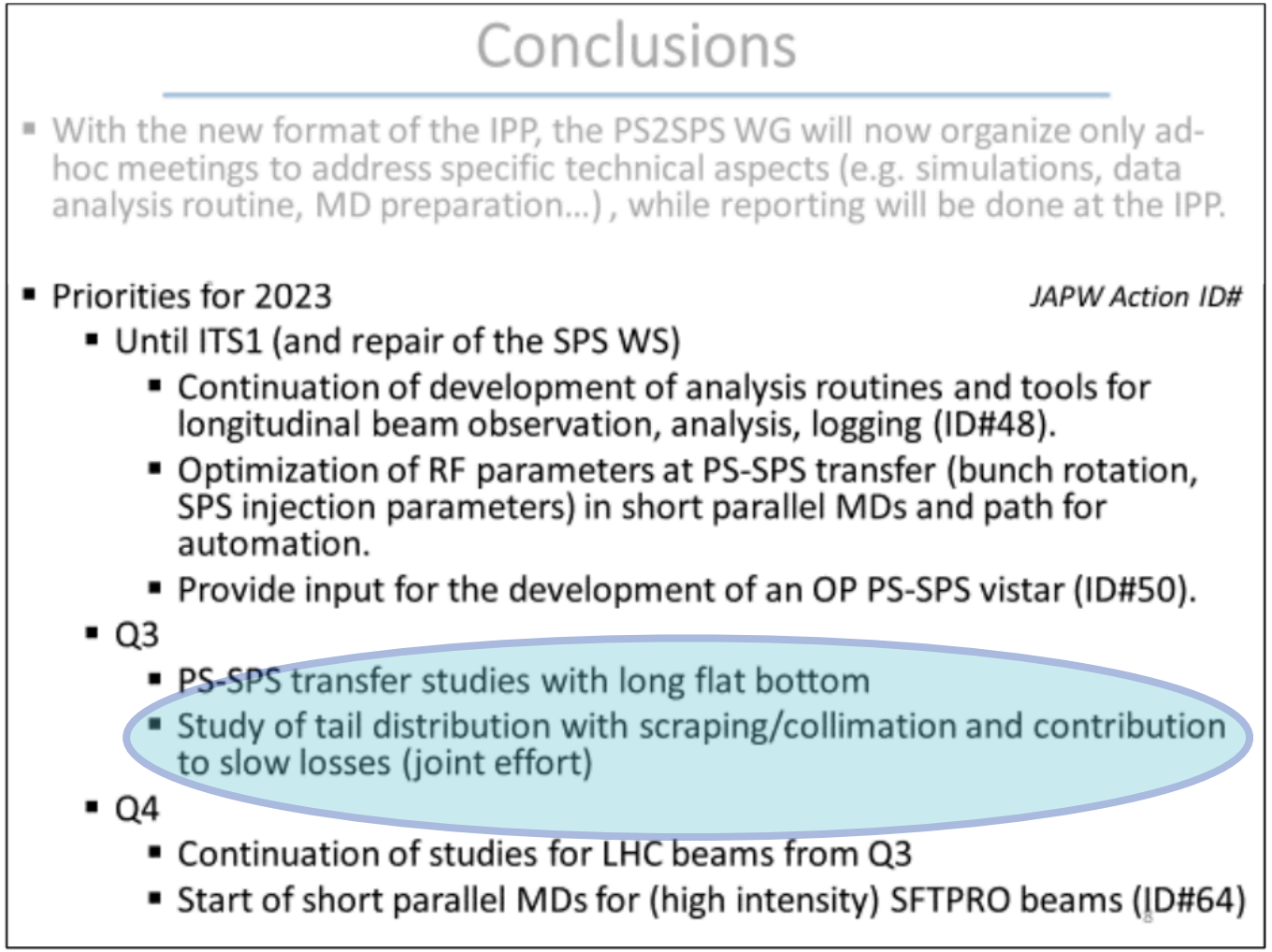
Setup and Goals

Results of Last MD

Conclusions and Backup Slides

Introduction

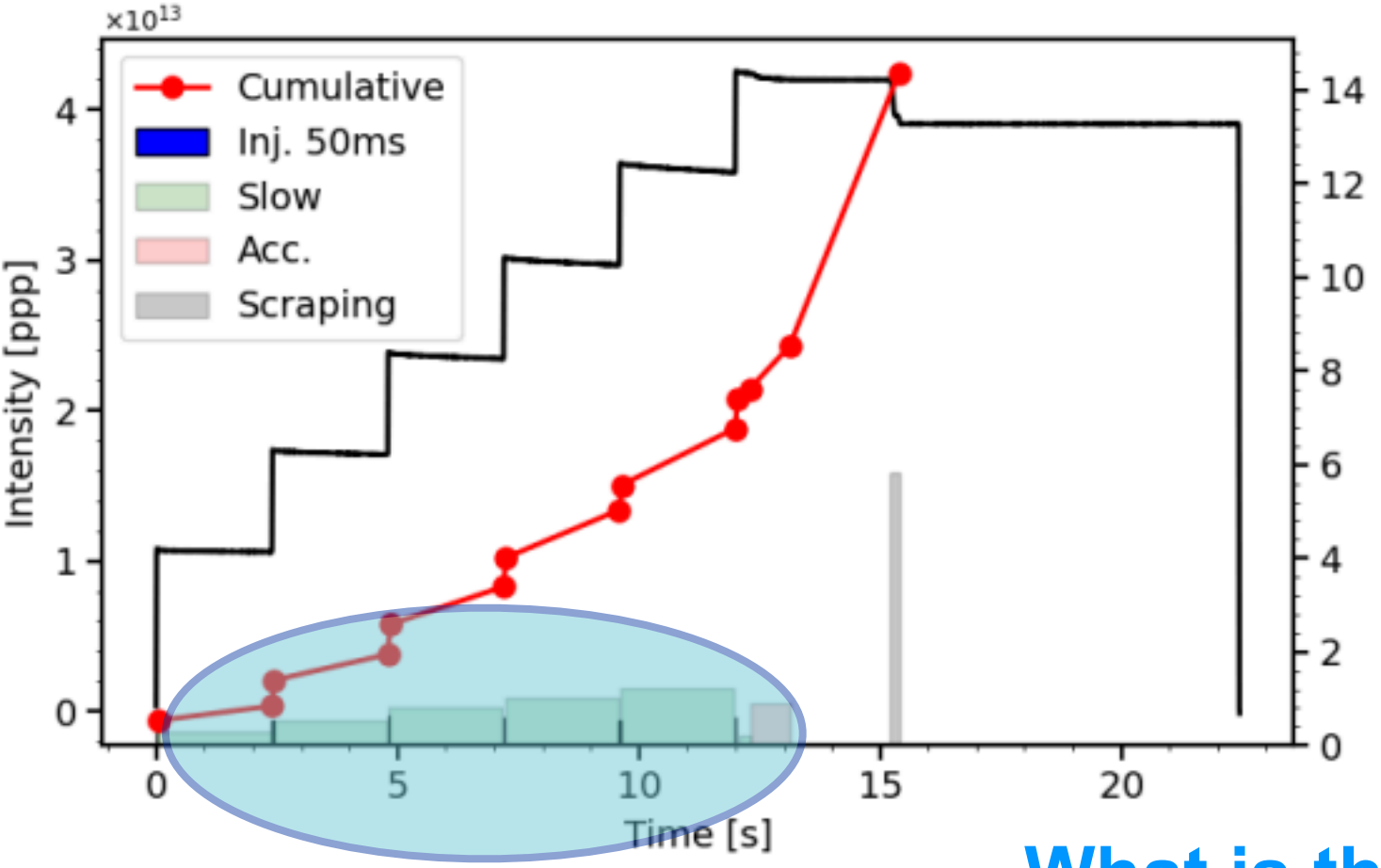
- Priority for PS2SPS losses studies set at IPP 17/05/2023
- Reiterated and progress reviewed by A. Lasheen at IPP 03/11/2023)
- Focus on:
  - Development of online tools for MDs
  - **Dedicated collimation/scraping MD** to study slow losses

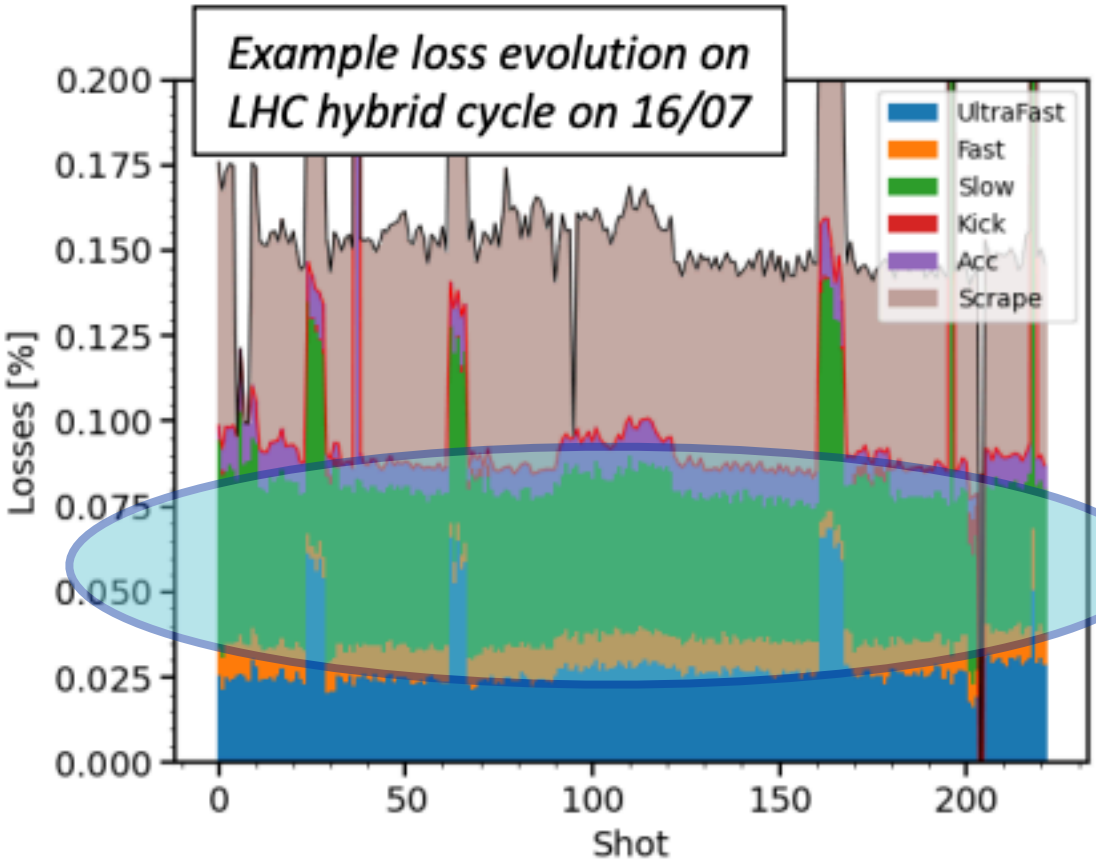


Conclusions

- With the new format of the IPP, the PS2SPS WG will now organize only ad-hoc meetings to address specific technical aspects (e.g. simulations, data analysis routine, MD preparation…) , while reporting will be done at the IPP.
- Priorities for 2023 *JAPW Action ID#*
  - Until ITS1 (and repair of the SPS WS)
    - Continuation of development of analysis routines and tools for longitudinal beam observation, analysis, logging (ID#48).
    - Optimization of RF parameters at PS-SPS transfer (bunch rotation, SPS injection parameters) in short parallel MDs and path for automation.
    - Provide input for the development of an OP PS-SPS vistar (ID#50).
  - Q3
    - PS-SPS transfer studies with long flat bottom
    - Study of tail distribution with scraping/collimation and contribution to slow losses (joint effort)
  - Q4
    - Continuation of studies for LHC beams from Q3
    - Start of short parallel MDs for (high intensity) SFTPRO beams (ID#64)

Different Types of Losses - Slow Losses





What is the main mechanism?

Performed MDs

- **Previous MDs were plagued by several technical difficulties**

- **First useful results during last MD (19/06/2024):**

  - **Morning:**
    - Scrubbing (needed as beam quality was degraded)
    - LHC filling (loss maps)
    - Taming instabilities => huge thanks to the team (Kevin, Kostas, and Ingrid)
  - **Afternoon**:
    - Linac4 source change
    - LHC filling (ramp up)
    - **Multiple successful measurements!**

Last MD: 19/06/2024 - Succesful Campaigns

COAST 1	12:36:49	13:08:07	*alignment*	TCSM (close to core)
COAST 2	13:12:42	13:33:25	*alignment*	TCSM (further out in the halo) - result confirmed
			scraping (end)	TIDP -5mm to -28mm (in steps of 1mm)
CYCLEs	15:20:05	15:48:23	*calibration*	TIDP bumps -30mm to -20mm (in steps of 1mm, 3 times each)
COAST 3	15:53:50	16:18:14	*repopulation*	TIDP IN/OUT -20mm and -25mm (TCSM @5σ)
			scraping (end)	TCSM 5σ to 0.5σ (in steps of 0.25σ)
COAST 4	16:22:21	16:41:14	*repopulation*	TCSM IN/OUT 3σ (TIDP OUT)
COAST 5	17:14:35	17:44:02	*repopulation*	TCSM IN/OUT 3σ (TIDP @ -20mm)
			scraping (end)	TIDP bumps -20mm to -30mm (in steps of 0.25mm)
COAST 6	17:47:14	17:56:00	*scraping*	TCSM 5σ to 0.5σ (in steps of 100μm) TIDP @ -10mm
COAST 7	17:57:49	18:15:47	*scraping*	TIDP -7mm to -30mm (in steps of 0.25mm)

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Collimation in the SPS

- SPS has one (horizontal) betatron collimator: **TCSM.51932** (SP.BLML.52108)
  - This is a prototype that was meant to test/develop control system
  - Same software as LHC collimators
  - Movement speed ~1.5 mm/s
  - Hollow inside, so limited intensity (~72 bunches ok)

- SPS has a block in high-dispersion region to clean off-momentum: **TIDP.11434** (SP.BLML.11451)
  - Can only be reached by orbit bumps

- Standard SPS cycle ~27.6 s not long enough to move TCSM in and out during flat bottom
  - **COAST** allows us to stay as long as we want (by glueing cycles)
  - Intensity-limited: dead zone of 100 ms in BLM read-out

Goals

- Can we get an indication of the **nature of the losses**?
  - Off-momentum, betatronic, or mixed?

- Understanding the mechanism behind the losses:
  - might help creating **mitigations** (prevent a potential increase in the future)
  - investigate potential relationship to scraping losses
  - are those losses affecting the ion beams as well?

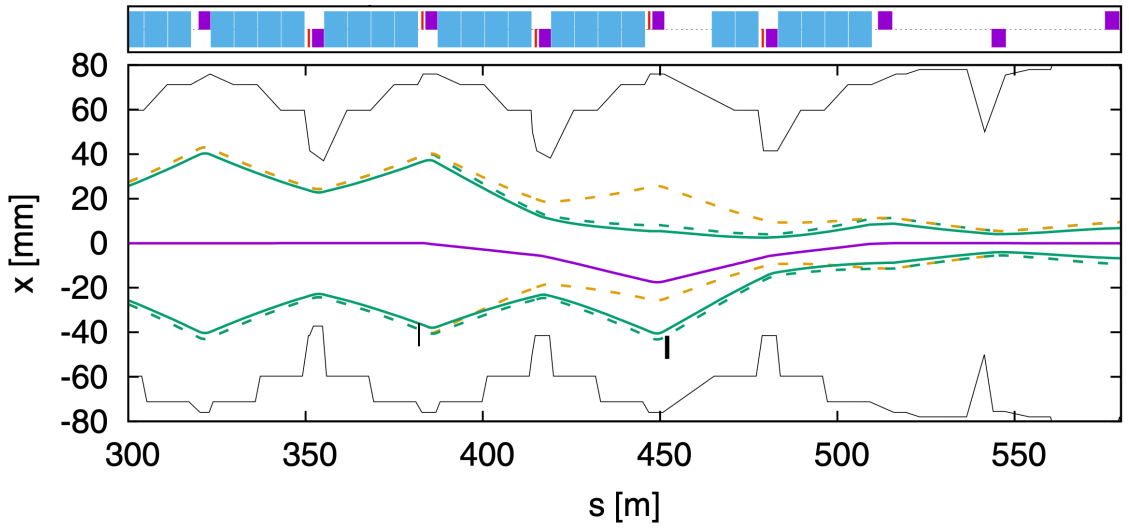
- Do we need the installation of **extra hardware**?
  - See e.g. PhysRevAccelBeams.24.093002

- Can we use an **orbit bump** at the TIDP in operation?

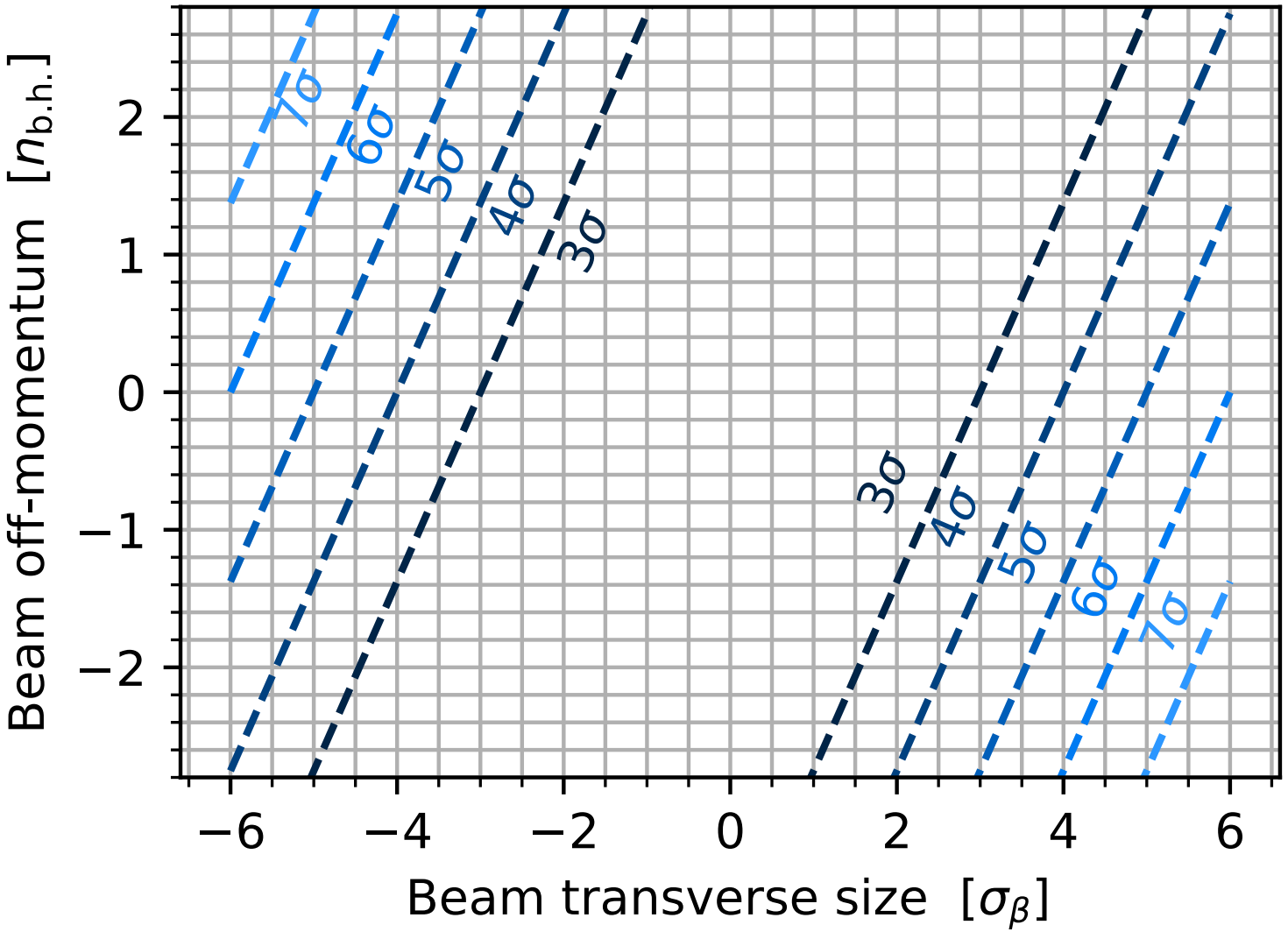
Optics at the Collimators

	β_x	σ 3.5μm	σ 2μm	D_x	1/2 bucket
TCSM	36.2 m	2.141 mm	1.618 mm	-0.42 m	-1.596 mm
TIDP	80.3 m	3.189 mm	2.410 mm	2.5 m	9.500 mm

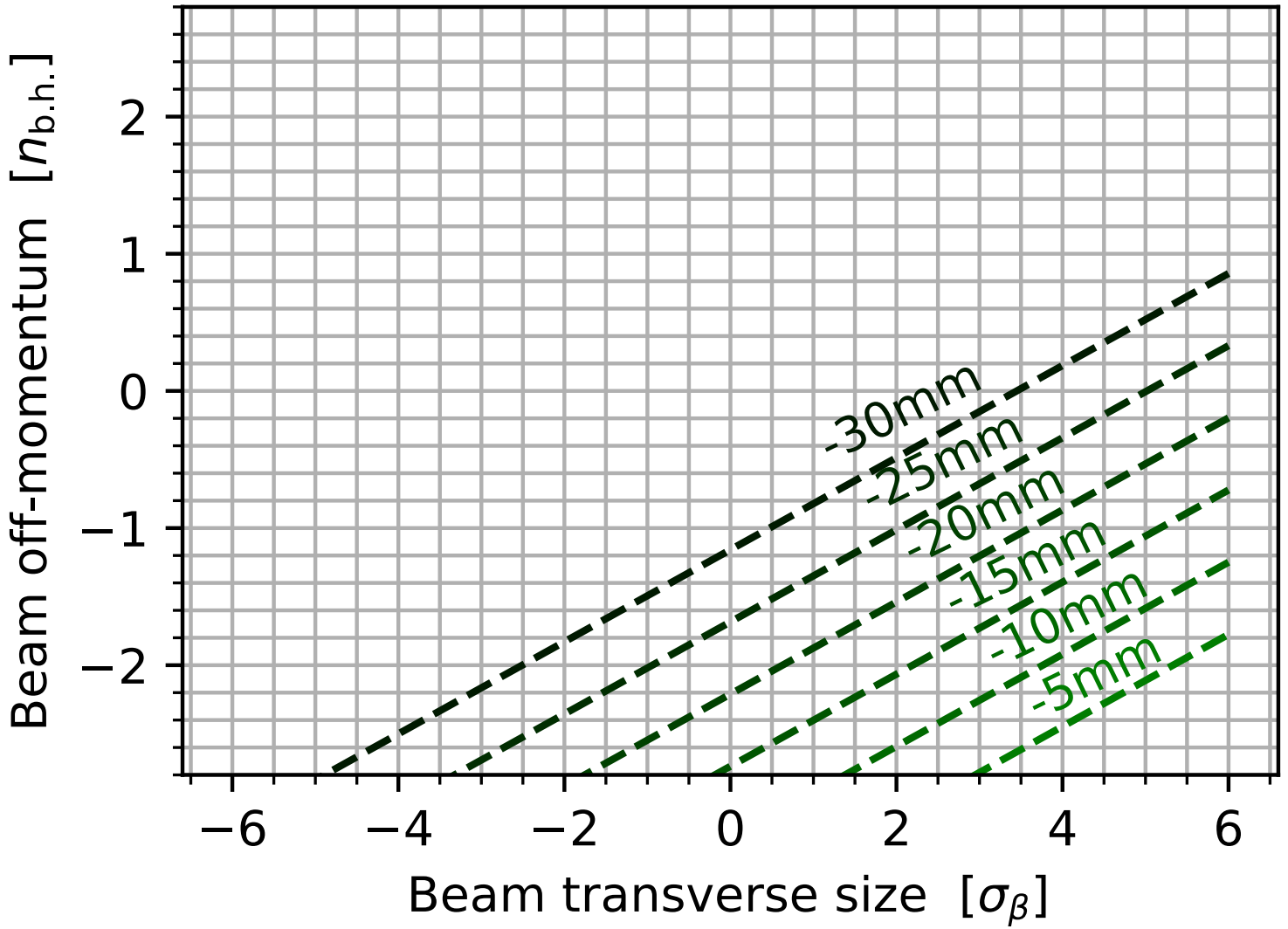
TIDP negative jaw is at -41mm
Need orbit bump to reach it



TCSM Cut of Beam Distribution



TIDP Cut of Beam Distribution



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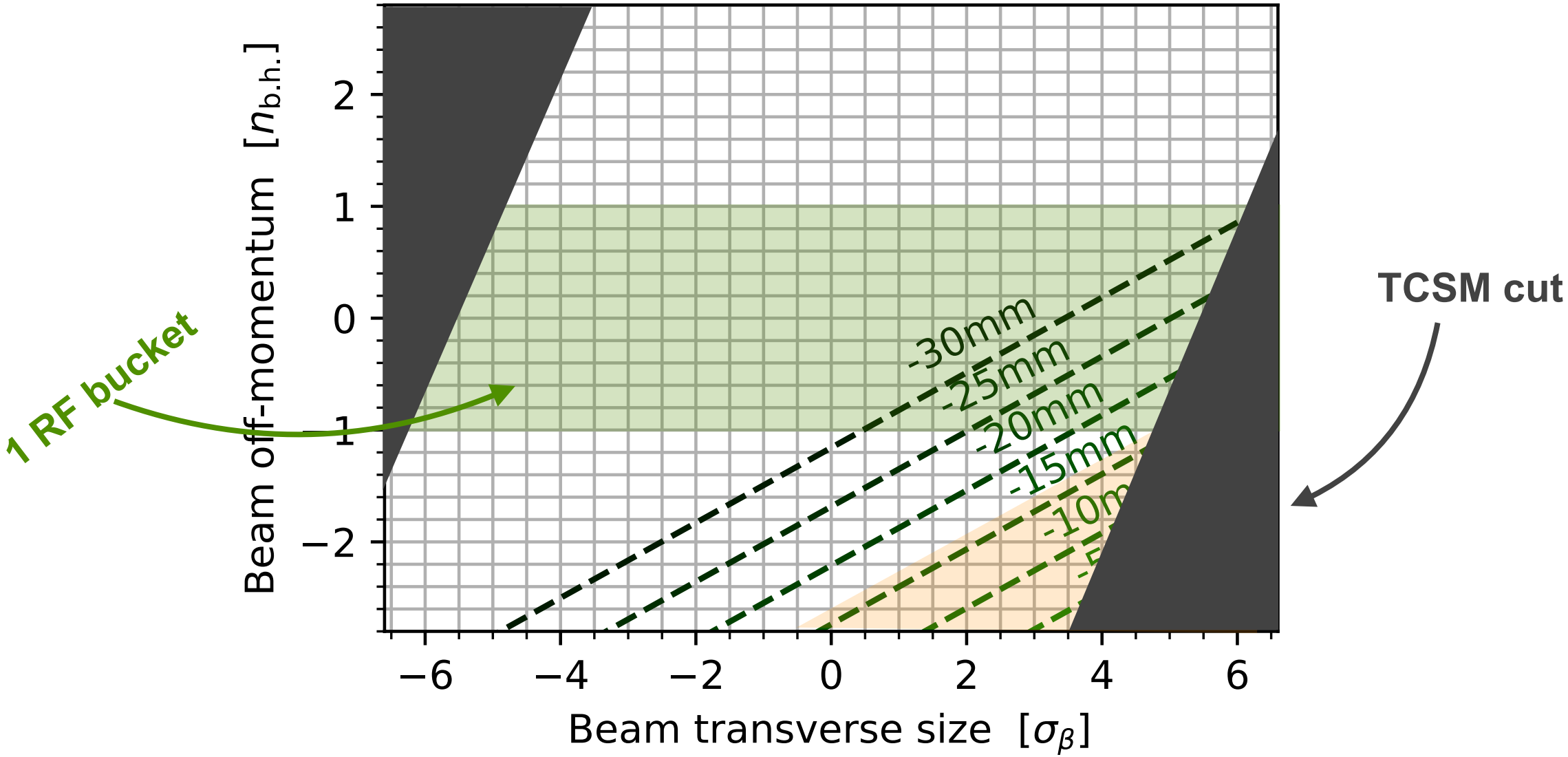
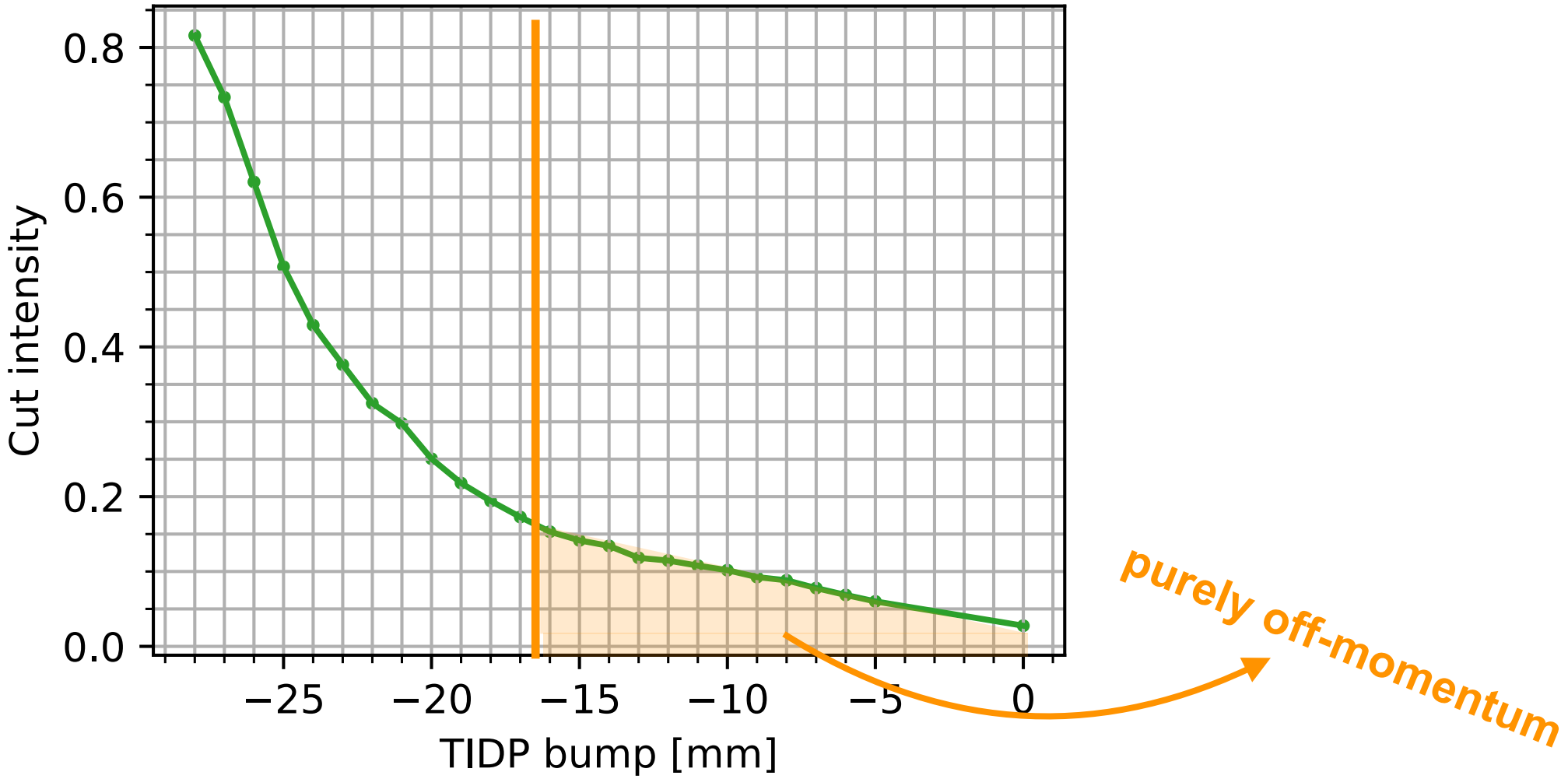
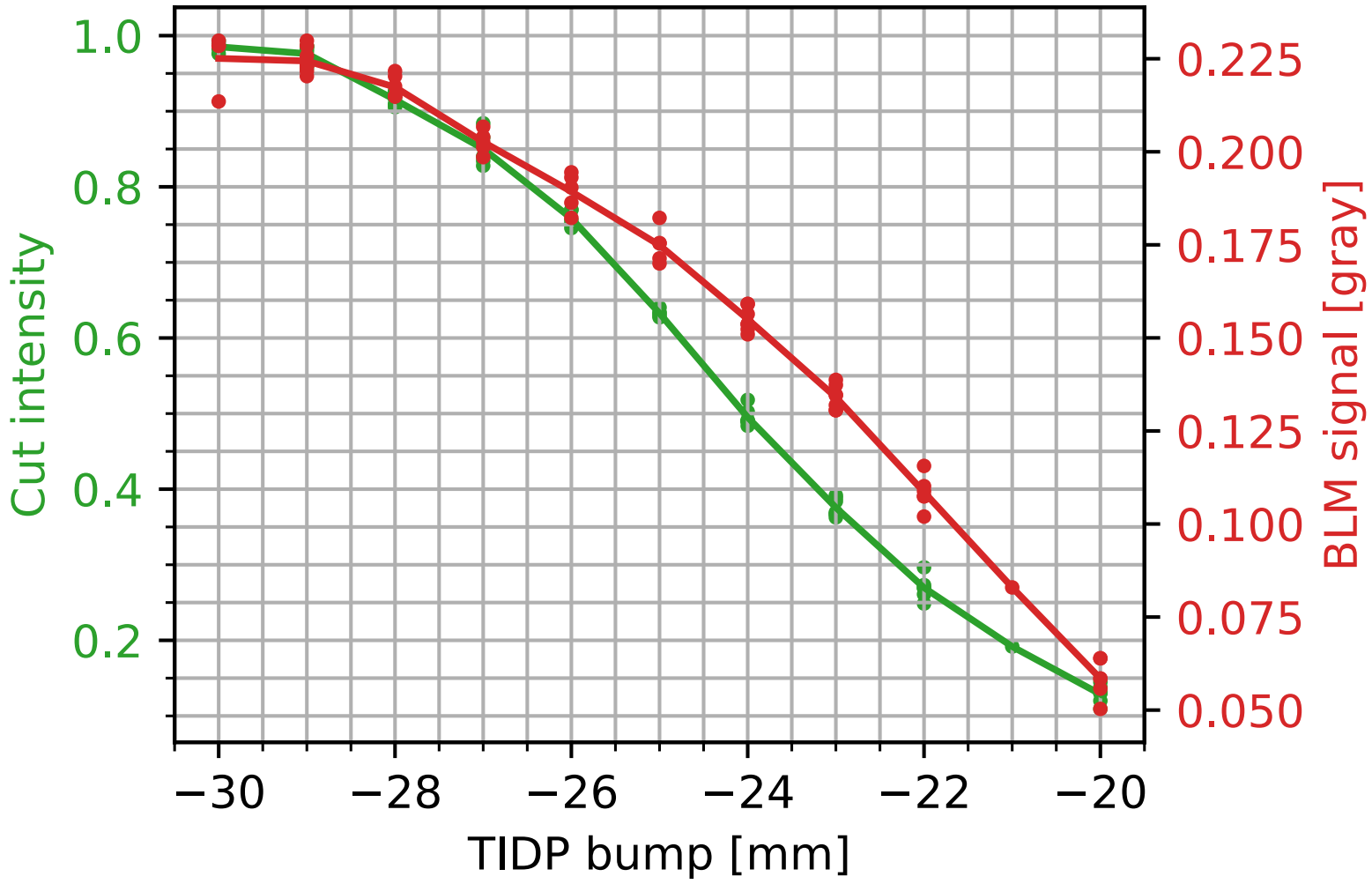
TIDP - Scraping (COAST 2 - TCSM @ 5.4σ)



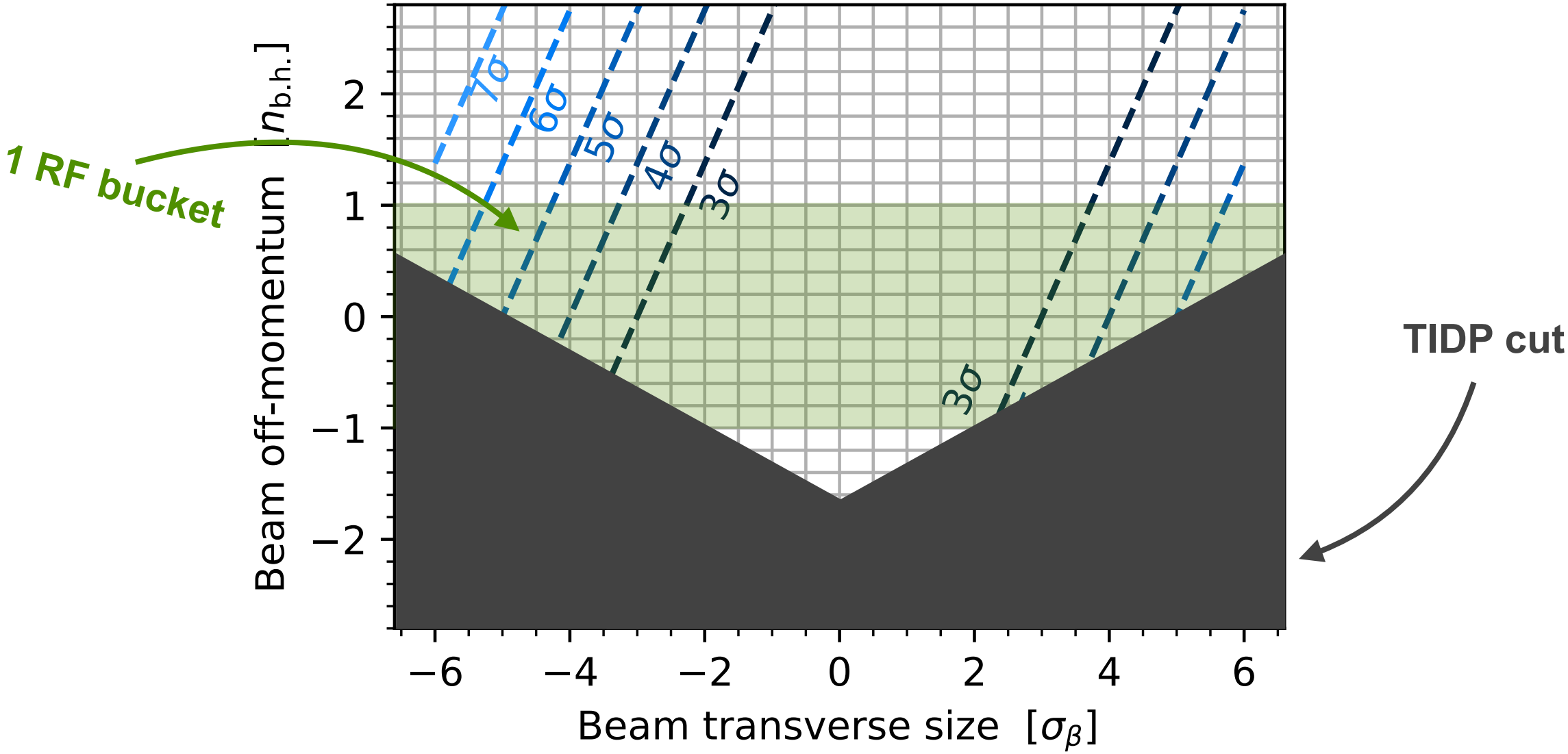
TIDP - Scraping (COAST 2 - TCSM @ 5.4σ)



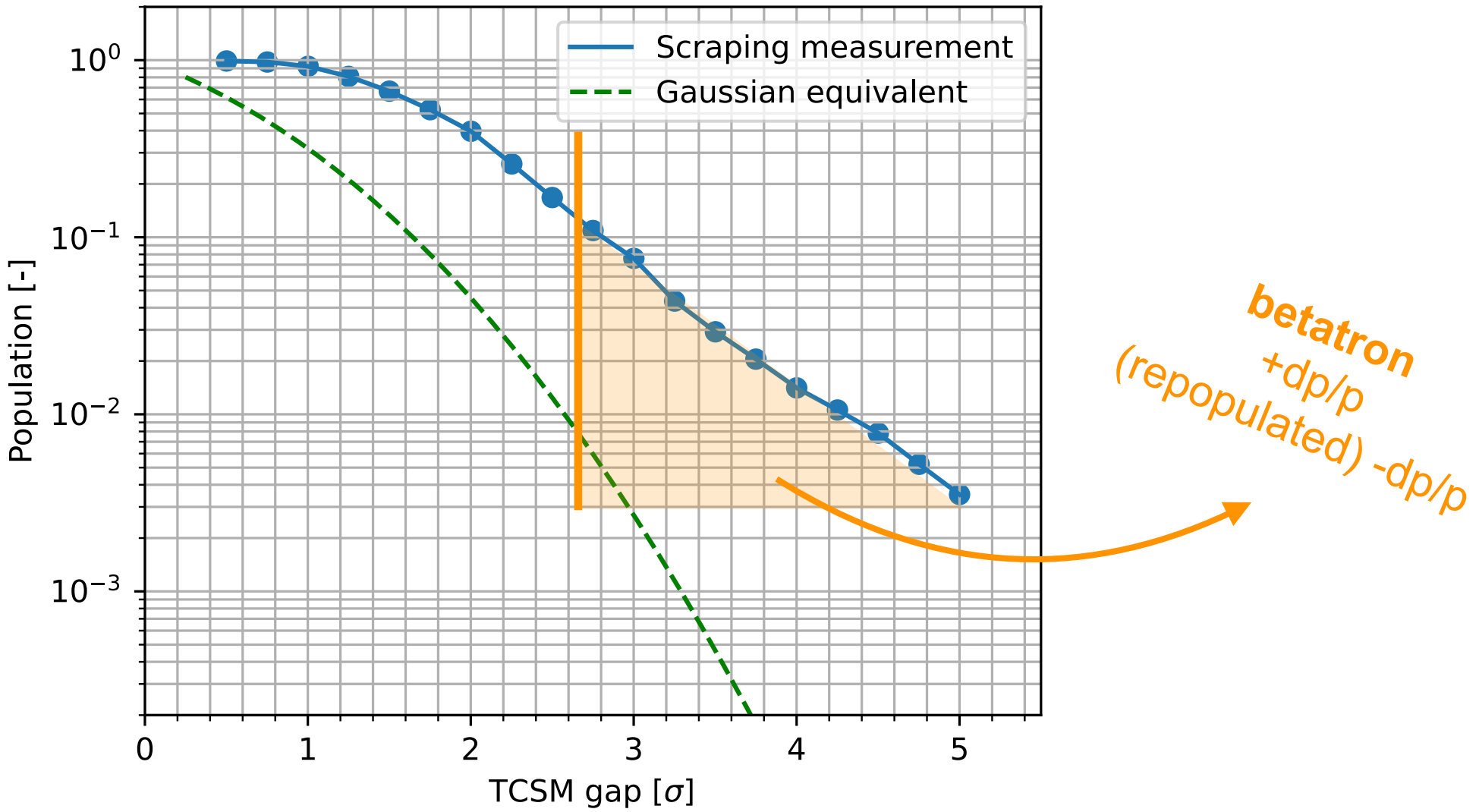
TIDP - Repeated Bumps in CYCLEs (TCSM OUT)



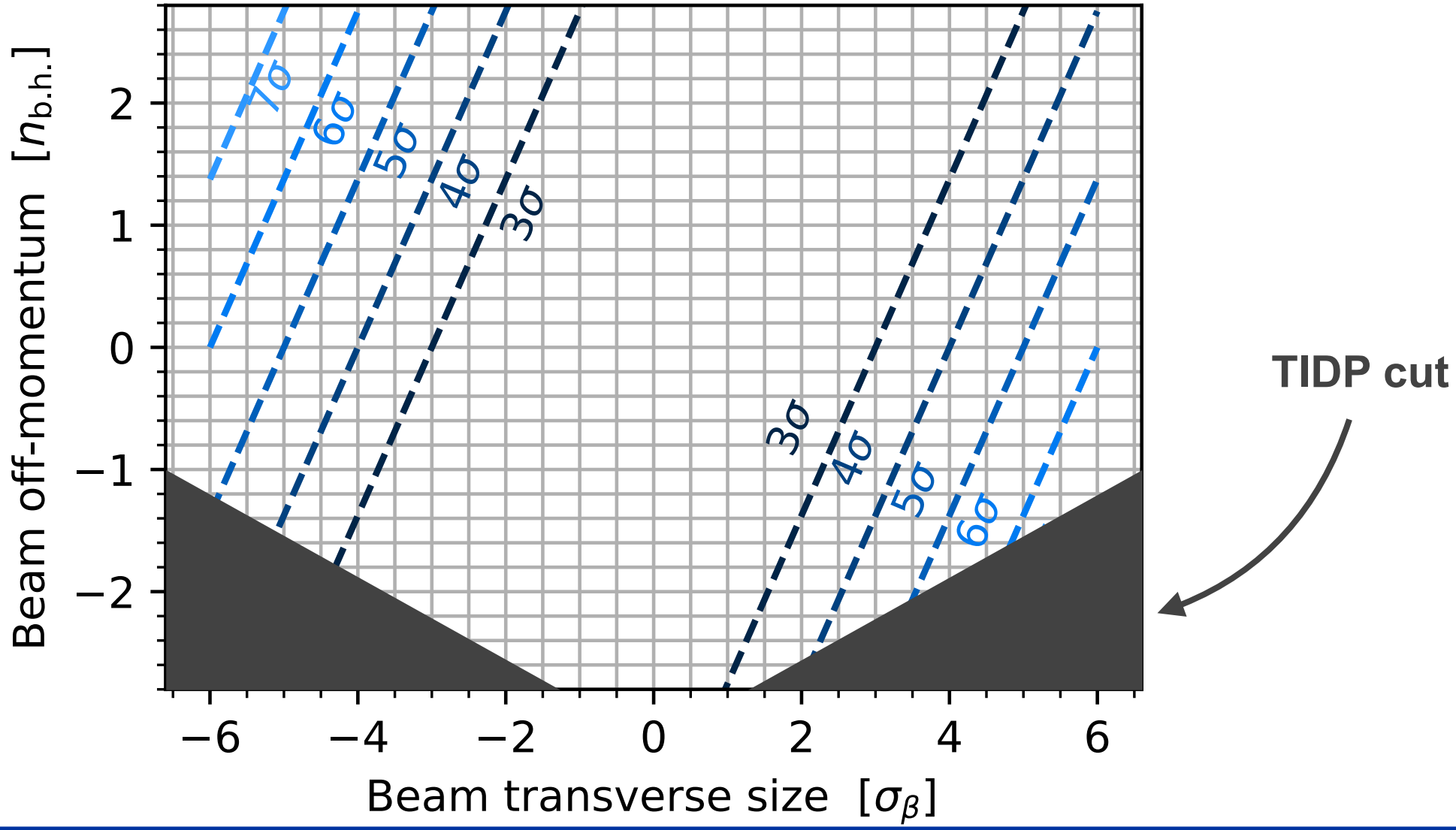
TCSM - Scraping (TIDP IN/OUT@ -25mm, then OUT)



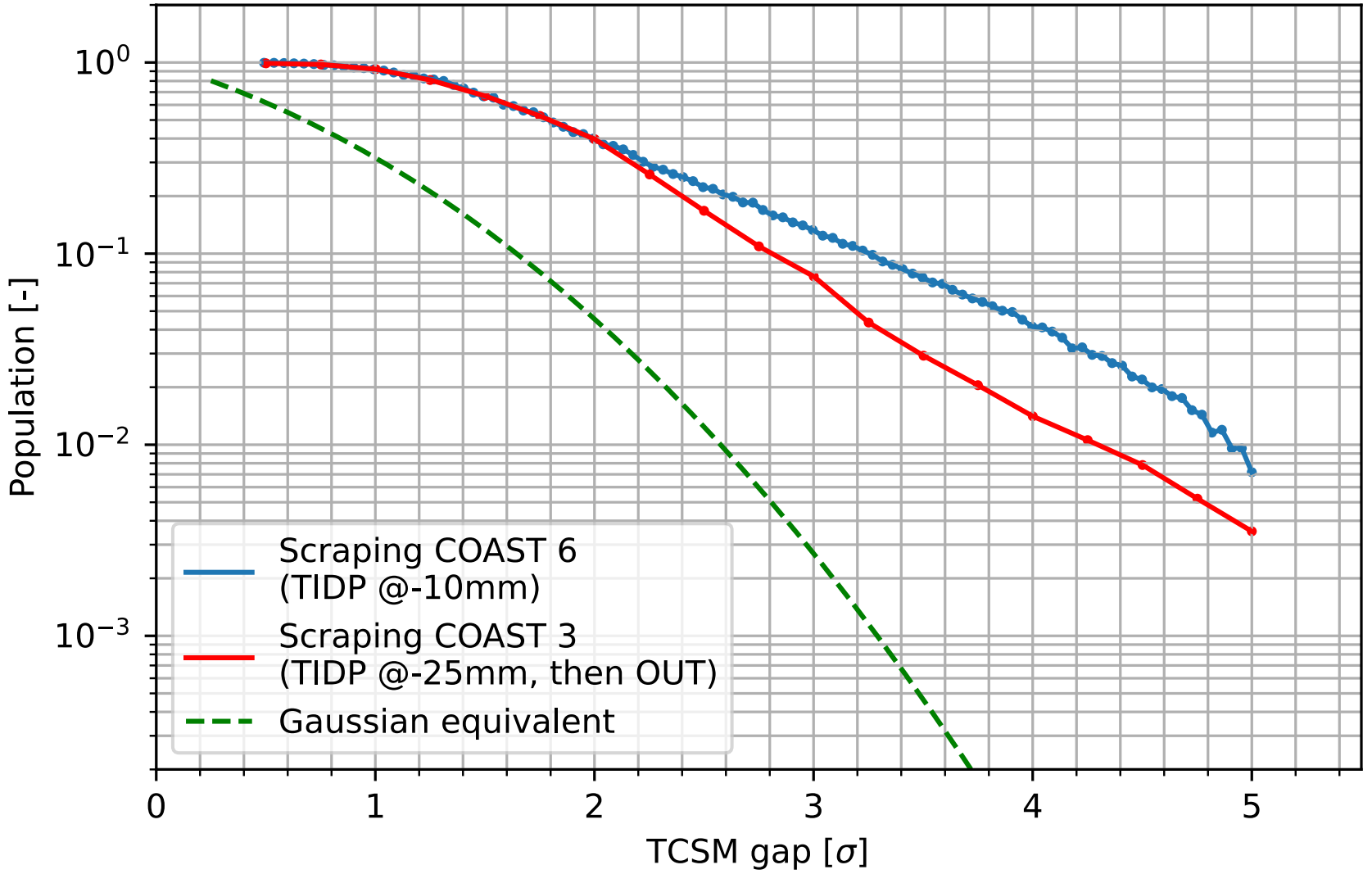
TCSM - Scraping (TIDP IN/OUT@ -25mm, then OUT)



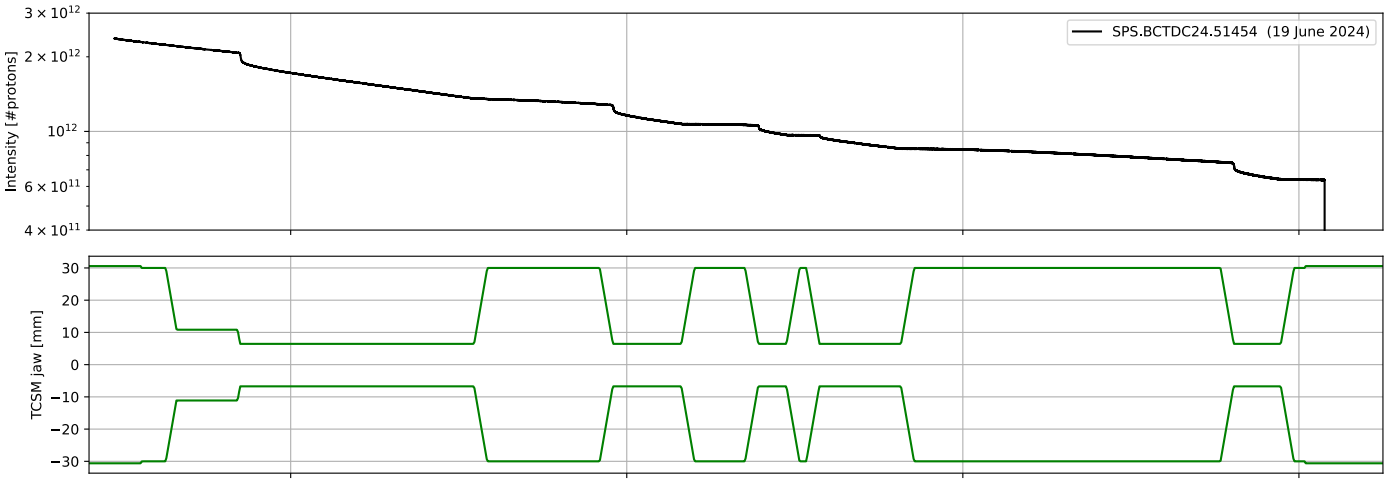
TCSM - Scraping (TIDP @ -10mm)

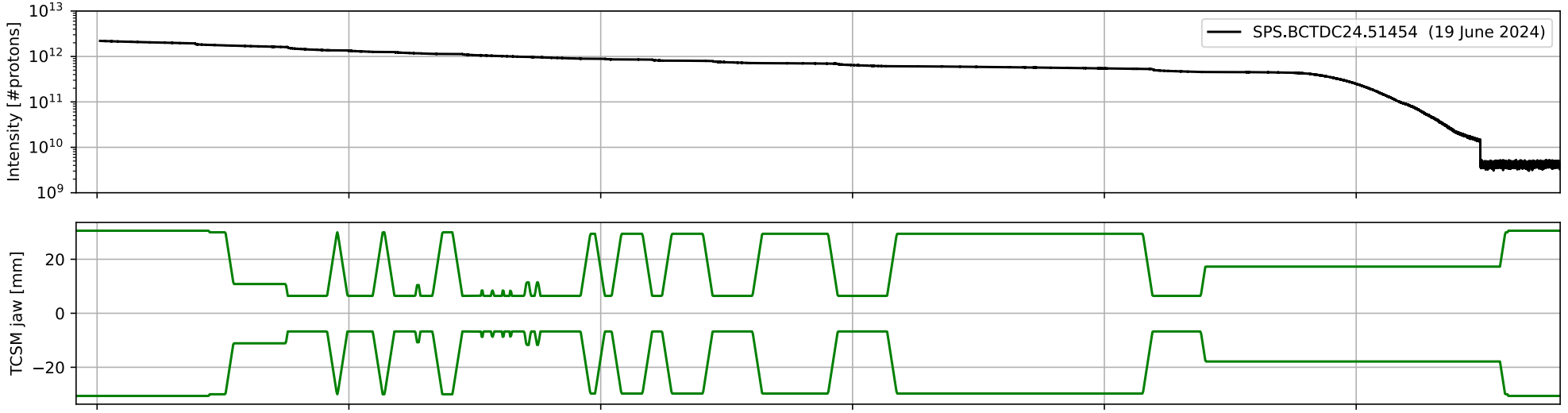


TCSM - Scraping (TIDP @ -10mm)

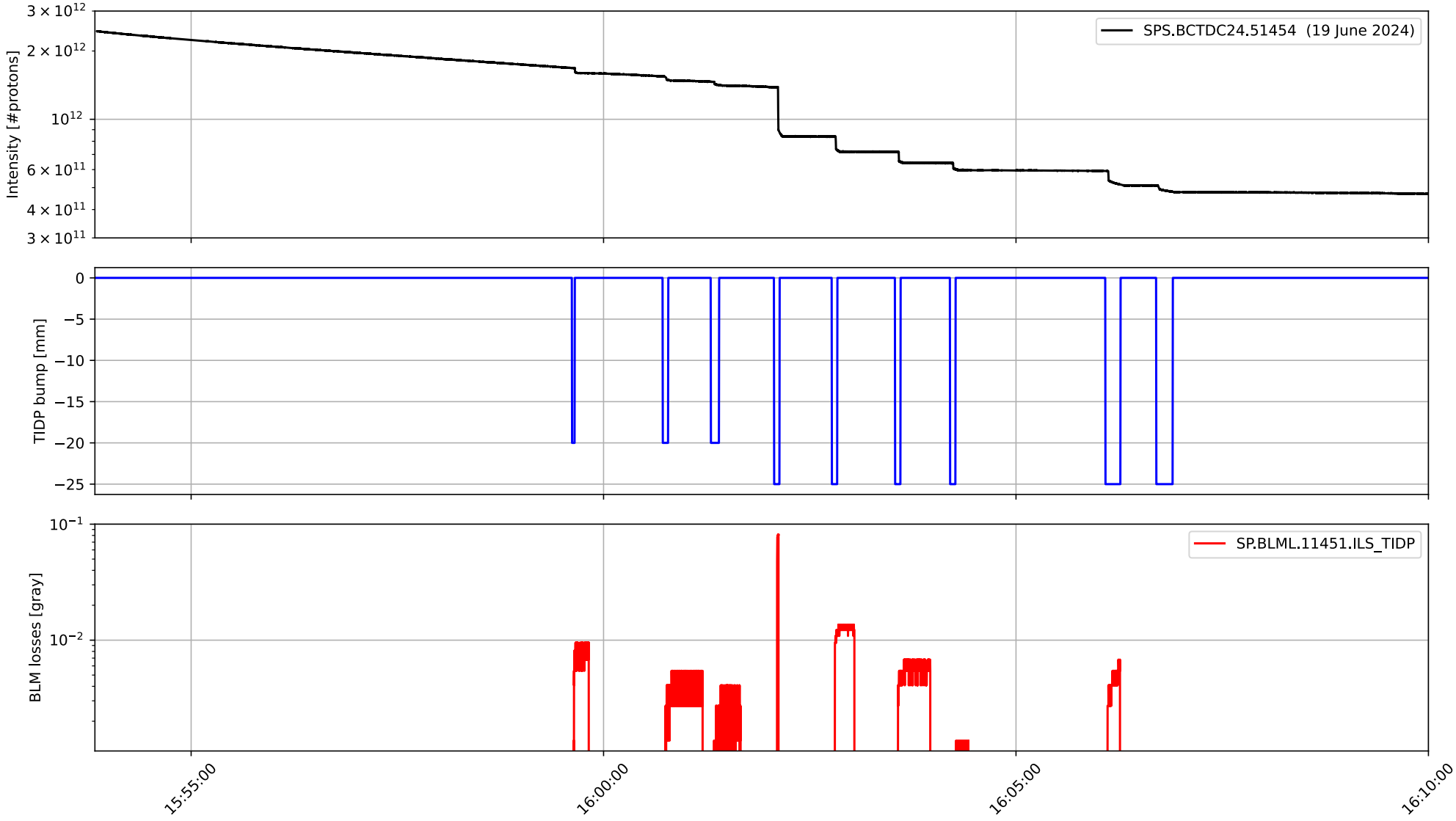


TCSM - Repopulation





TIDP - Repopulation



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Conclusions

- This MD was a succesful exploration, with a decent set of first results
- Multiple lessons learned concerned technical difficulties and caveats

- Interesting observations and first indications
  - Continuous steady slow losses clearly visible and large (beam lost in ~20 minutes)
  - Repopulation, both betatronic (TCSM) and off-momentum (TIDP)
  - TIDP scraping indicates largely populated off-momentum tails
  - TCSM scraping indicates populated betatronic tails (q-Gaussian, see Ingrid's talk)
  - Scraping results seem to indicate correlation between betatronic and off-momentum losses

Outlook

- Perform an "off-momentum" loss map, by looking at the ring losses when using a TIDP bump
  - Need to increase the gain of the BLMs to get them in high-sensitivity mode
  - Probes viability of using bump in operation

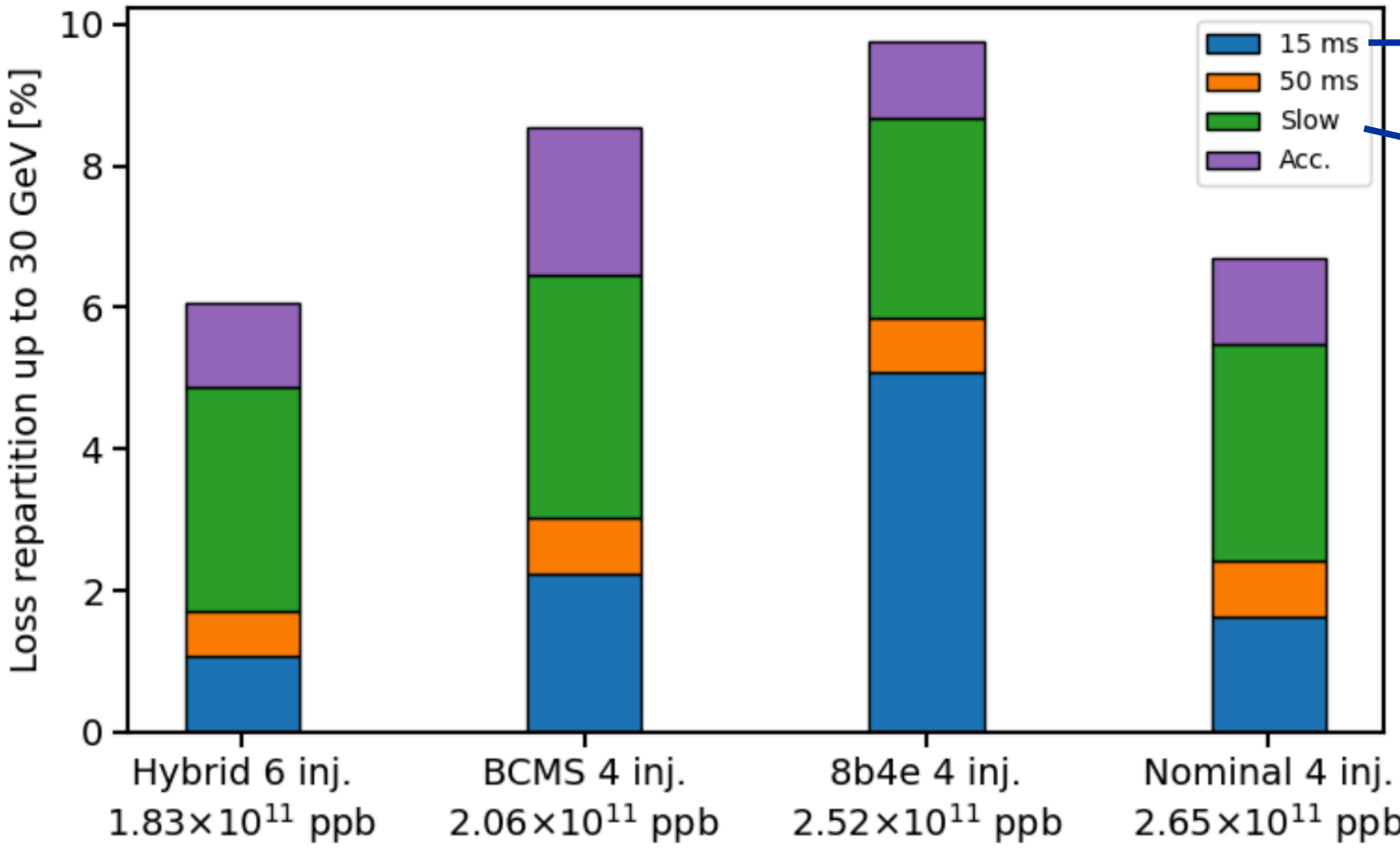
- Need in-depth internal discussions:
  - To draw conclusions on need for hardware and decide on future plans
  - To correlate analysis with wire-scanner data etc

- Ideas for potential tests:
  - Ask PS for a beam with low dp/p
  - Do a COAST with RF switched off, investigate lifetime of DC beam
  - COAST at Flat Top (or 200GeV) and compare losses

Thanks a lot for the combined effort of a lot of people!

Backup Slides

Losses Repartition



in transfer line or at injection

not understood

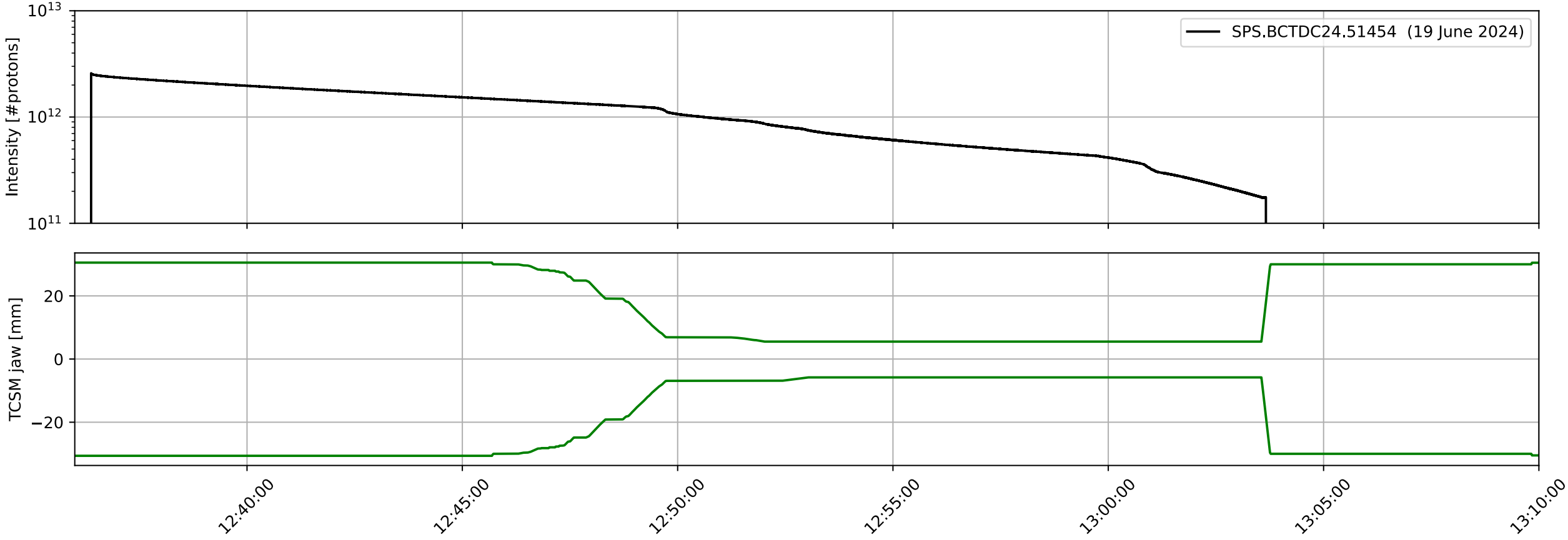
Previous MDs 2023-2024

- **05/07/2023**: Issue with dedicated MD for STFPRO: negotiated to share the day (2 x 6h)
  - Very low beam availability due to LHC filling (**FAULT 8:50 - 11:45**) only could start at 12:30
  - Collimator got stuck due to FESA class issue (energy limit), had to wait for piquet
  - COAST not working: cavities were not following (continued to pulse), beam lost every time
  - **First tests only after 14:00**, but no more time for measurement

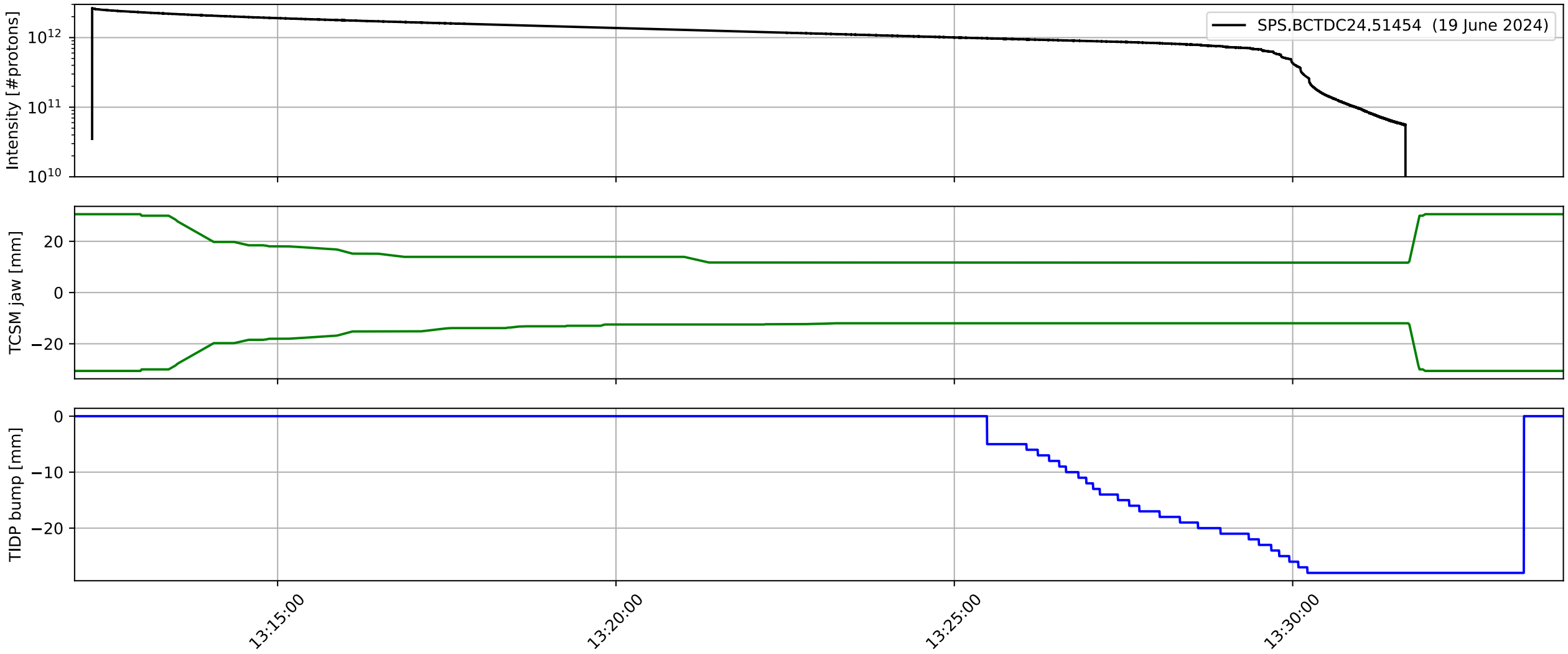
- **12/07/2023**: half day as recompensation (6h)
  - Even less beam availability: LHC beam dumps/refills, radiation alarm in PS, POPS trips, ...
  - MD lost entirely

- **17/04/2024**:
  - Issues in the morning (LINAC MD, PS poor beam quality, unforeseen COAST issues)
  - Around noon: calibrated TIDP and aligned TCSM
  - Rest of afternoon plagued by instabilities, very few measurements (and not reproducible)

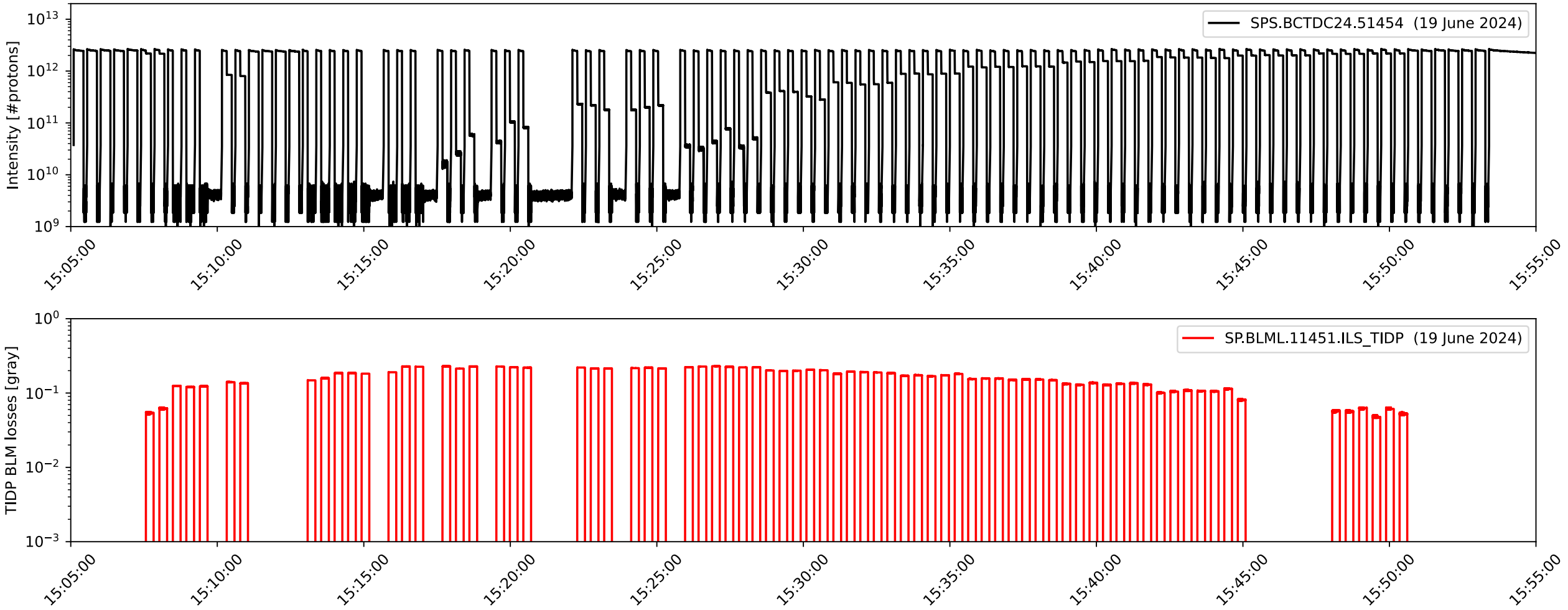
COAST 1


SPS.BCTDC24.51454 (19 June 2024)
Intensity [#protons]
10^{13}
10^{12}
10^{11}
TCSM jaw [mm]
20
0
−20
12:40:00
12:45:00
12:50:00
12:55:00
13:00:00
13:05:00
13:10:00

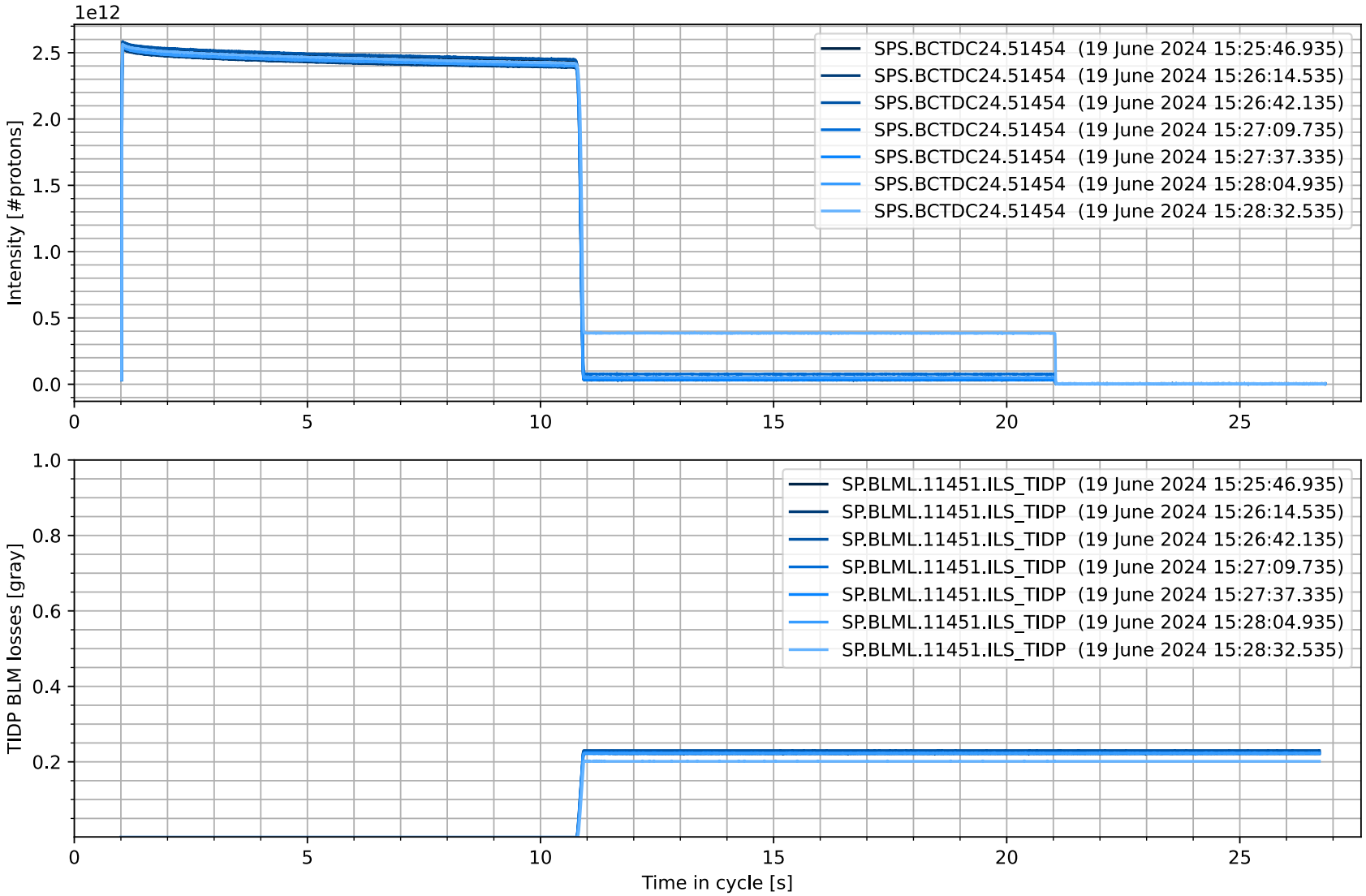
COAST 2


SPS.BCTDC24.51454 (19 June 2024)
Intensity [#protons]
10^{12}
10^{11}
10^{10}
TCSM jaw [mm]
20
0
−20
TIDP bump [mm]
0
−10
−20
13:15:00
13:20:00
13:25:00
13:30:00

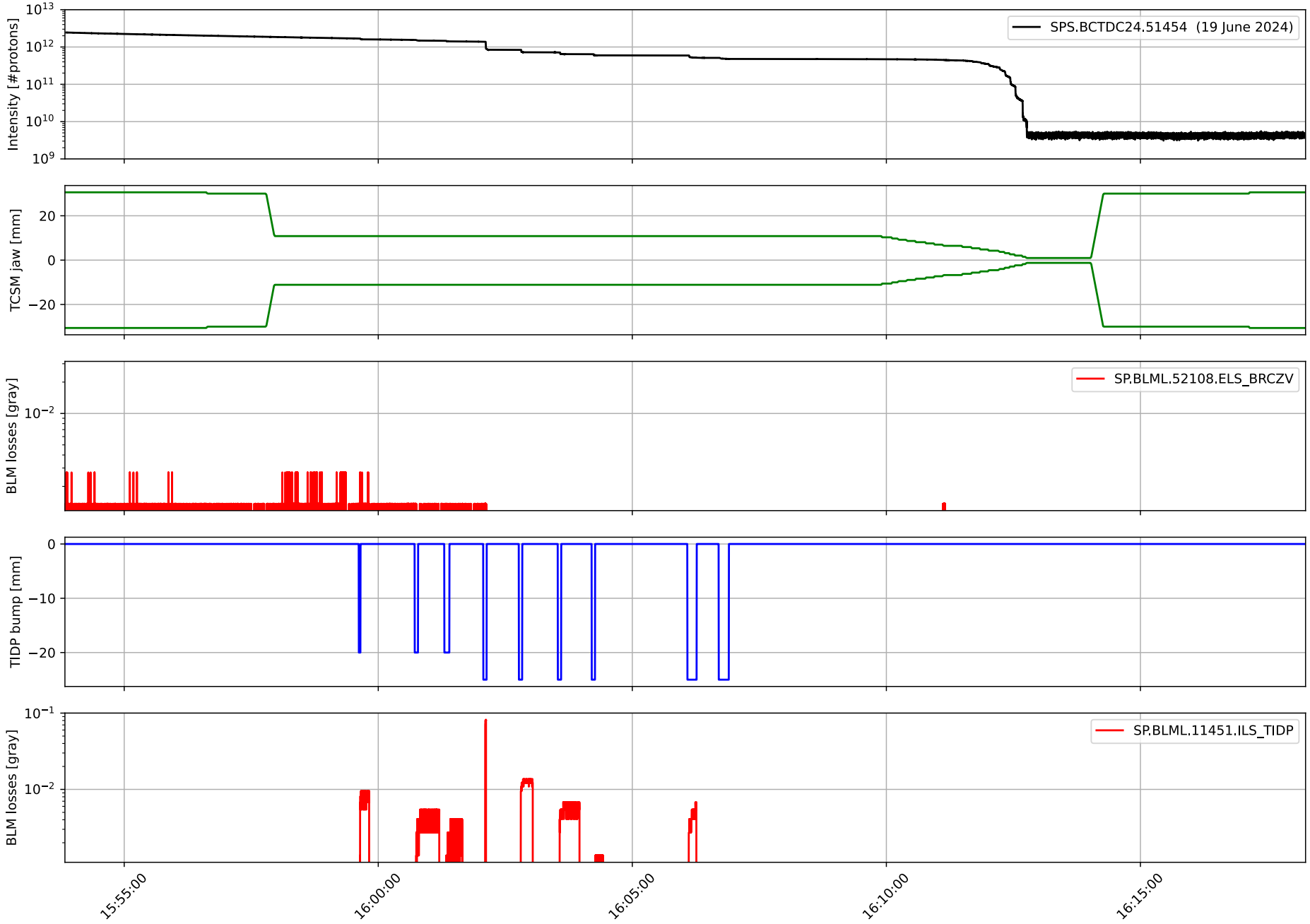
Cycles


SPS.BCTDC24.51454 (19 June 2024)
Intensity [#protons]
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
15:05:00
15:10:00
15:15:00
15:20:00
15:25:00
15:30:00
15:35:00
15:40:00
15:45:00
15:50:00
15:55:00
SP.BLML.11451.ILS_TIDP (19 June 2024)
TIDP BLM losses [gray]
10^{0}
10^{-1}
10^{-2}
10^{-3}
15:05:00
15:10:00
15:15:00
15:20:00
15:25:00
15:30:00
15:35:00
15:40:00
15:45:00
15:50:00
15:55:00

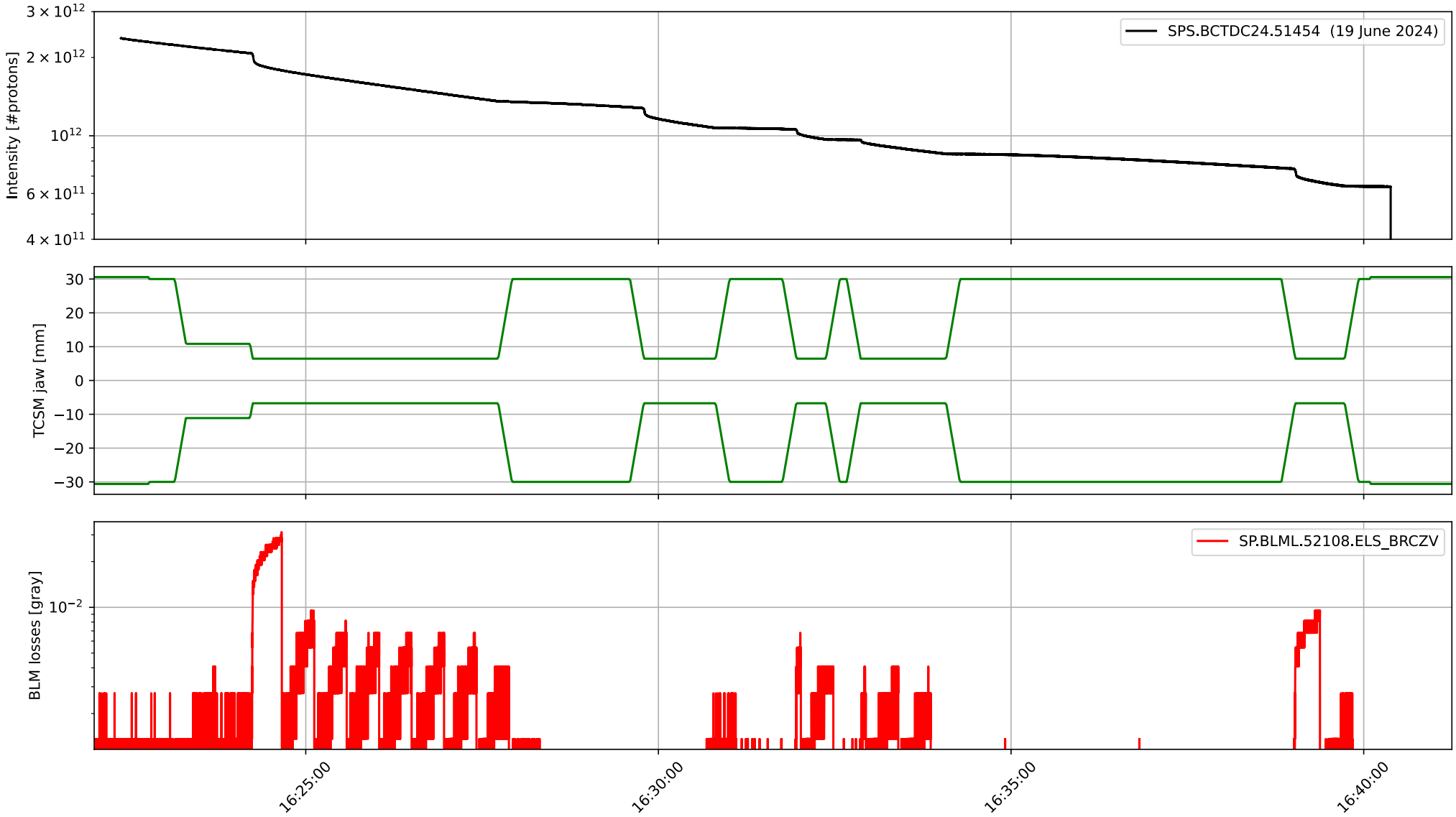
Cycles - TIDP Bump



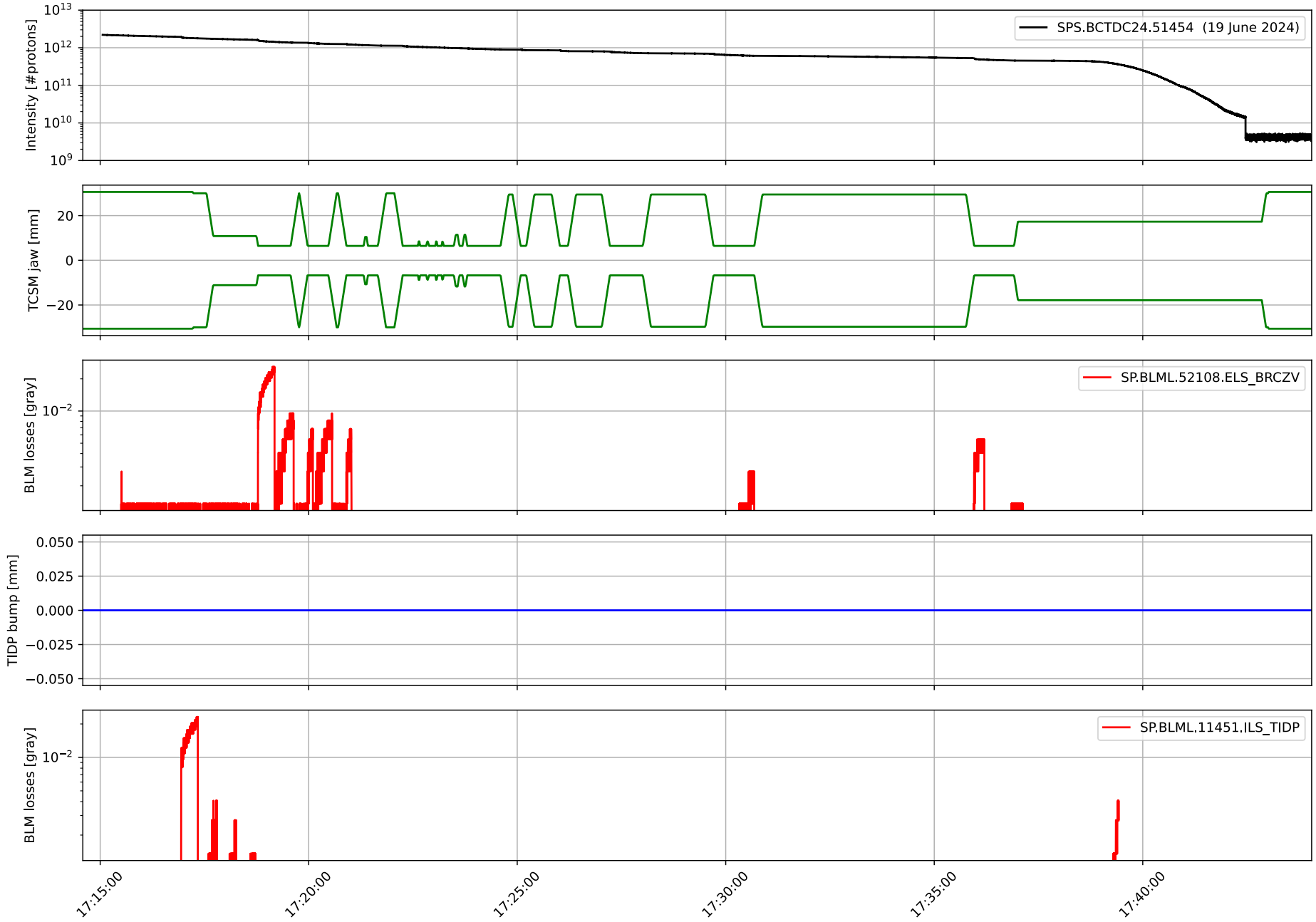
COAST 3


Intensity [#protons]
SPS.BCTDC24.51454 (19 June 2024)
TCSM jaw [mm]
BLM losses [gray]
SP.BLML.52108.ELS_BRCZV
TIDP bump [mm]
BLM losses [gray]
SP.BLML.11451.ILS_TIDP
15:55:00
16:00:00
16:05:00
16:10:00
16:15:00

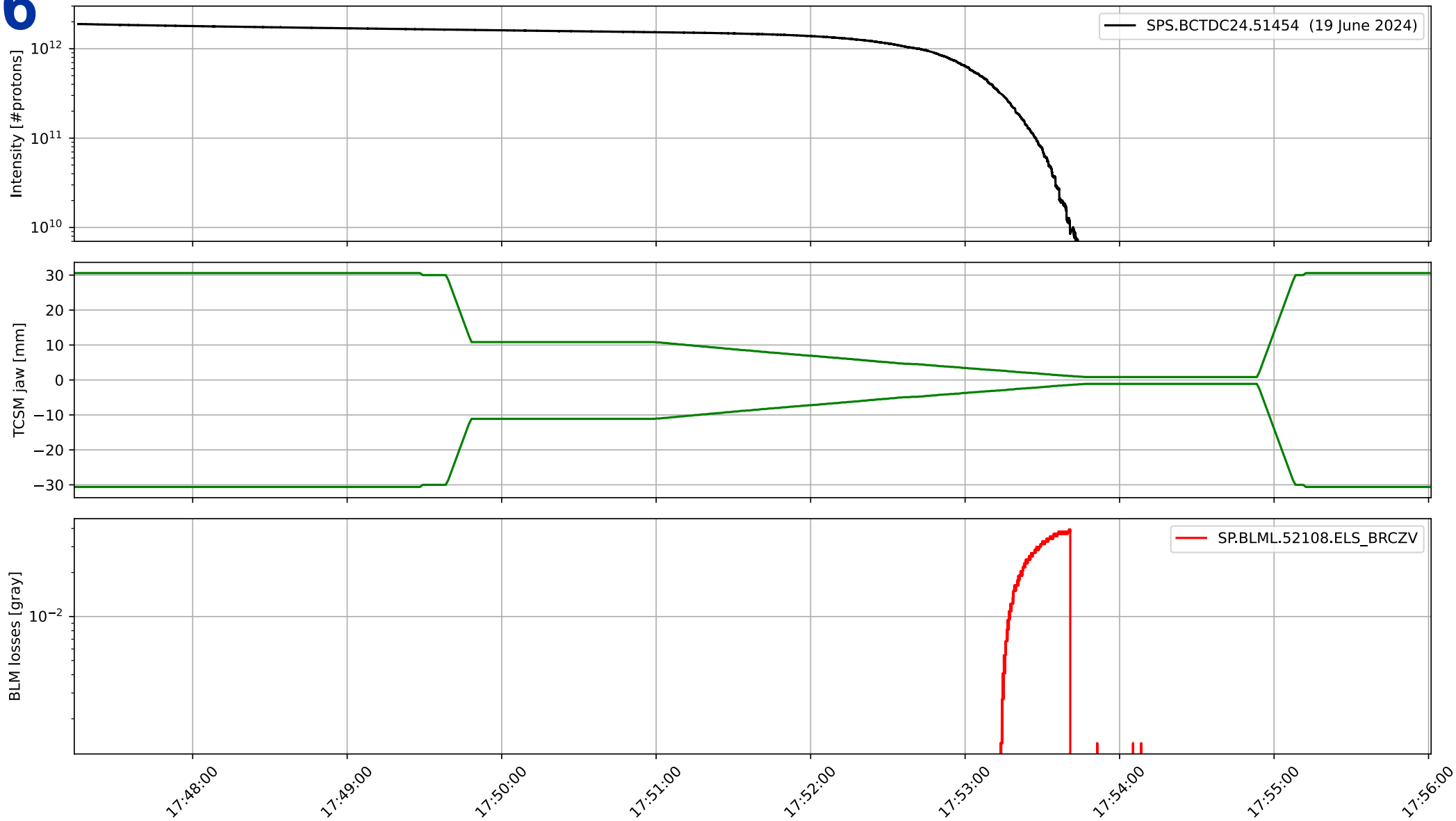
COAST 4


SPS.BCTDC24.51454 (19 June 2024)
Intensity [#protons]
3×10^{12}
2×10^{12}
10^{12}
6×10^{11}
4×10^{11}
TCSM jaw [mm]
30
20
10
0
−10
−20
−30
SP.BLML.52108.ELS_BRCZV
BLM losses [gray]
10^{-2}
16:25:00
16:30:00
16:35:00
16:40:00

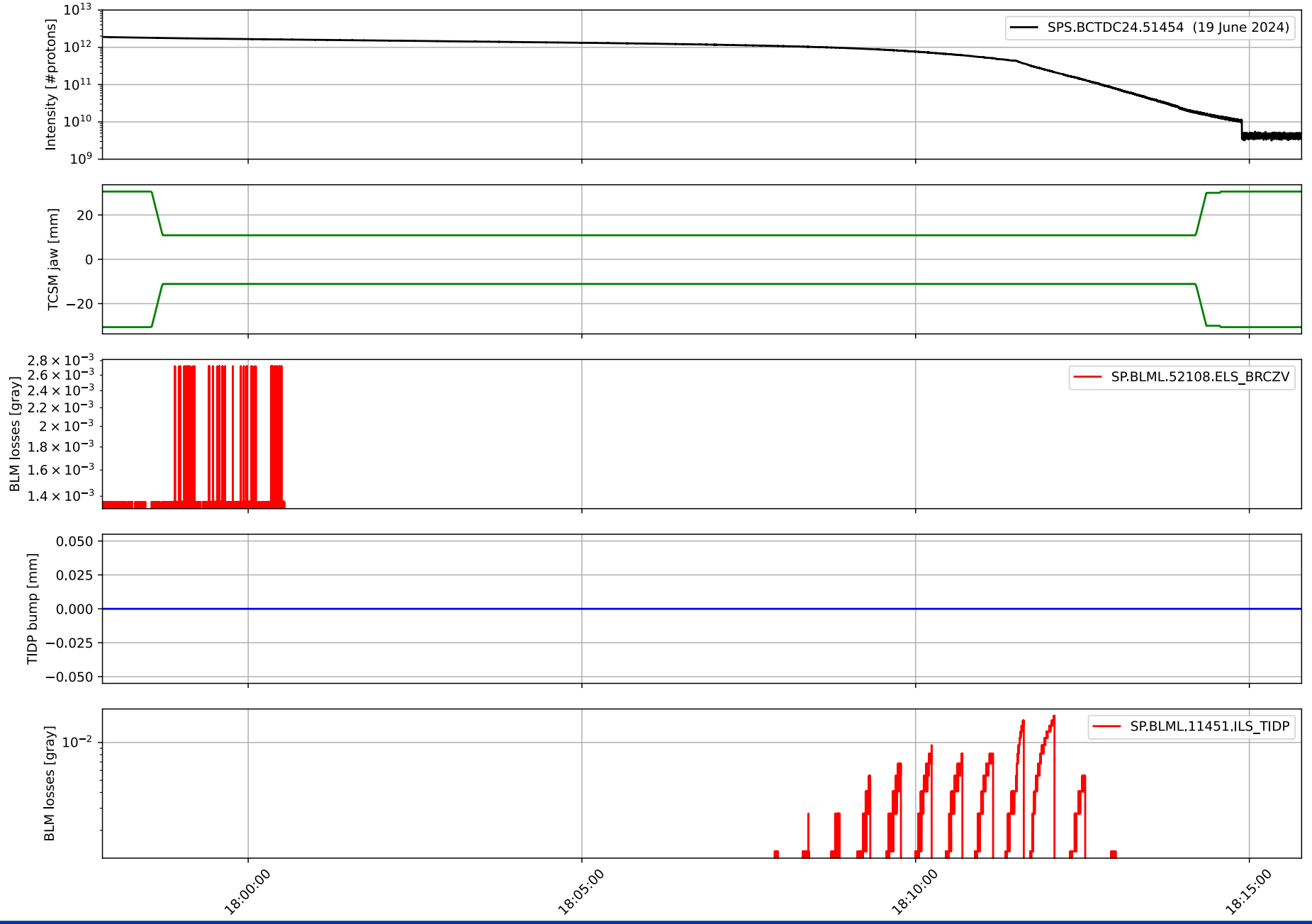
COAST 5


Intensity [#protons]
SPS.BCTDC24.51454 (19 June 2024)
TCSM jaw [mm]
BLM losses [gray]
SP.BLML.52108.ELS_BRCZV
TIDP bump [mm]
BLM losses [gray]
SP.BLML.11451.ILS_TIDP
17:15:00
17:20:00
17:25:00
17:30:00
17:35:00
17:40:00

COAST 6


SPS.BCTDC24.51454 (19 June 2024)
Intensity [#protons]
10^{12}
10^{11}
10^{10}
TCSM jaw [mm]
30
20
10
0
−10
−20
−30
SP.BLML.52108.ELS_BRCZV
BLM losses [gray]
10^{-2}
17:48:00
17:49:00
17:50:00
17:51:00
17:52:00
17:53:00
17:54:00
17:55:00
17:56:00

COAST 7


Intensity [#protons]
SPS.BCTDC24.51454 (19 June 2024)
TCSM jaw [mm]
BLM losses [gray]
SP.BLML.52108.ELS_BRCZV
TIDP bump [mm]
BLM losses [gray]
SP.BLML.11451.ILS_TIDP
18:00:00
18:05:00
18:10:00
18:15:00

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