

Transmission of proton fixed target beams in 2023 and beyond

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JAP23 Workshop

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Transmission of proton fixed target beams in 2023 and beyond

How did the fixed target cycles perform in 2023?

Where do we lose protons across the complex?

What are the ongoing and future studies?

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transmission of proton
fixed target beams in 2023

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Part II

...and beyond

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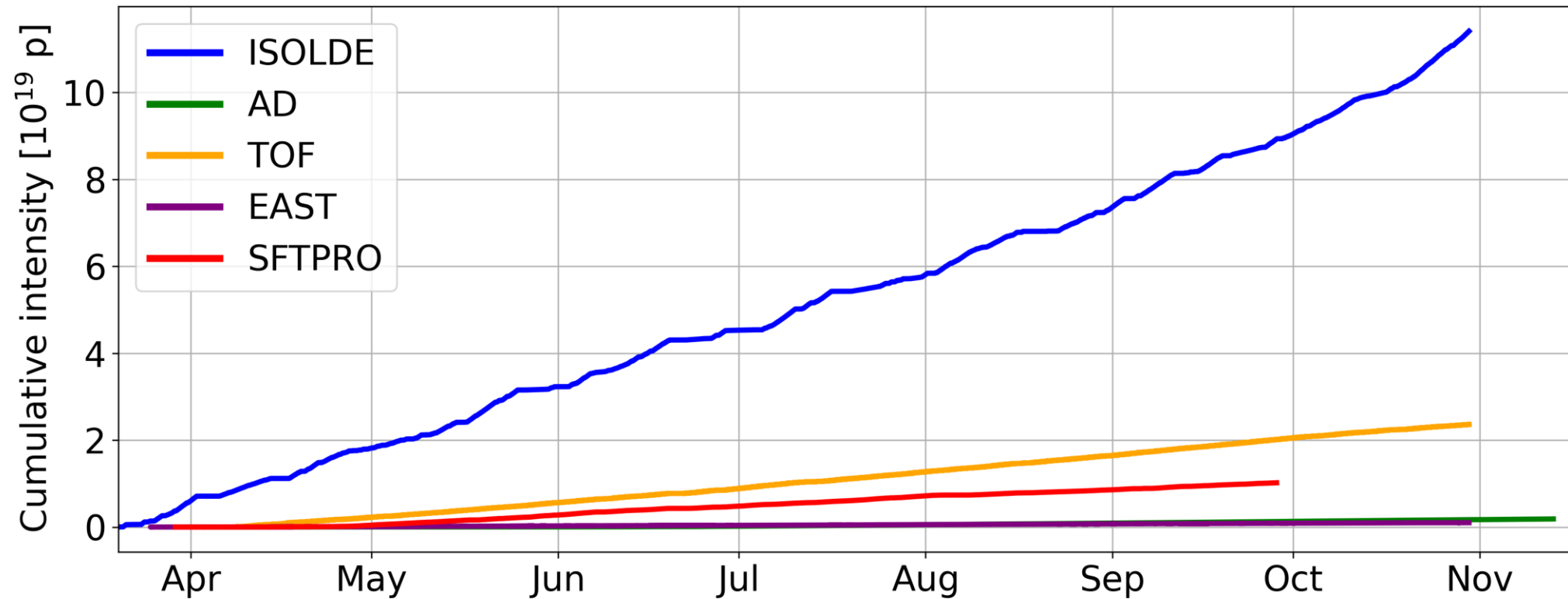
An aerial photograph of a large industrial or research facility, likely a particle accelerator. The image shows a large, dark, dome-shaped structure on the left, several long, cylindrical structures in the center, and various buildings and parking lots. The scene is overlaid with a dark blue tint.

Part I

transmission of proton
fixed target beams in 2023

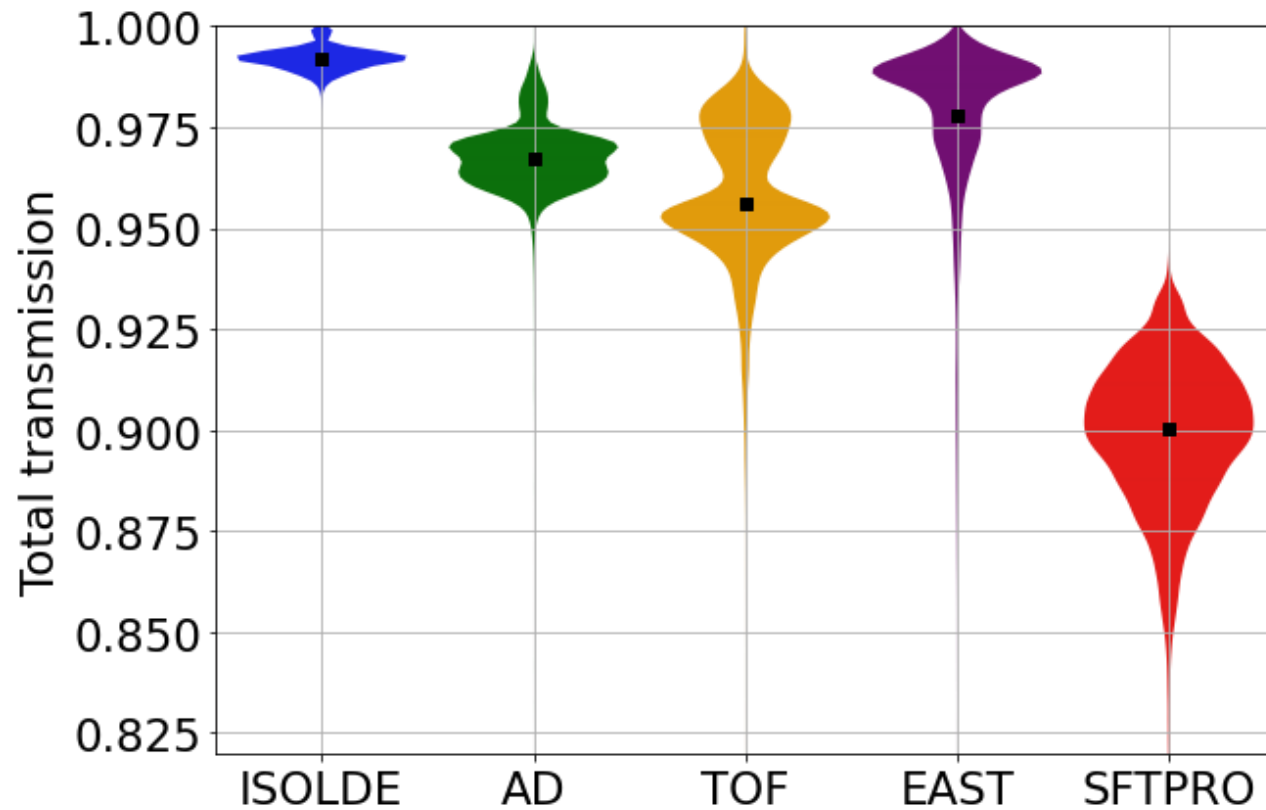
Intensity in 2023

Cumulative intensity until extraction of last synchrotron.



This talk will **not cover** transfer between last synchrotron and target: see session 6.

Transmission in 2023



$$\text{Total transmission} := \frac{\text{Last synchrotron BCT @ extraction}}{\text{PSB BCT @ injection}}$$

At a glance:

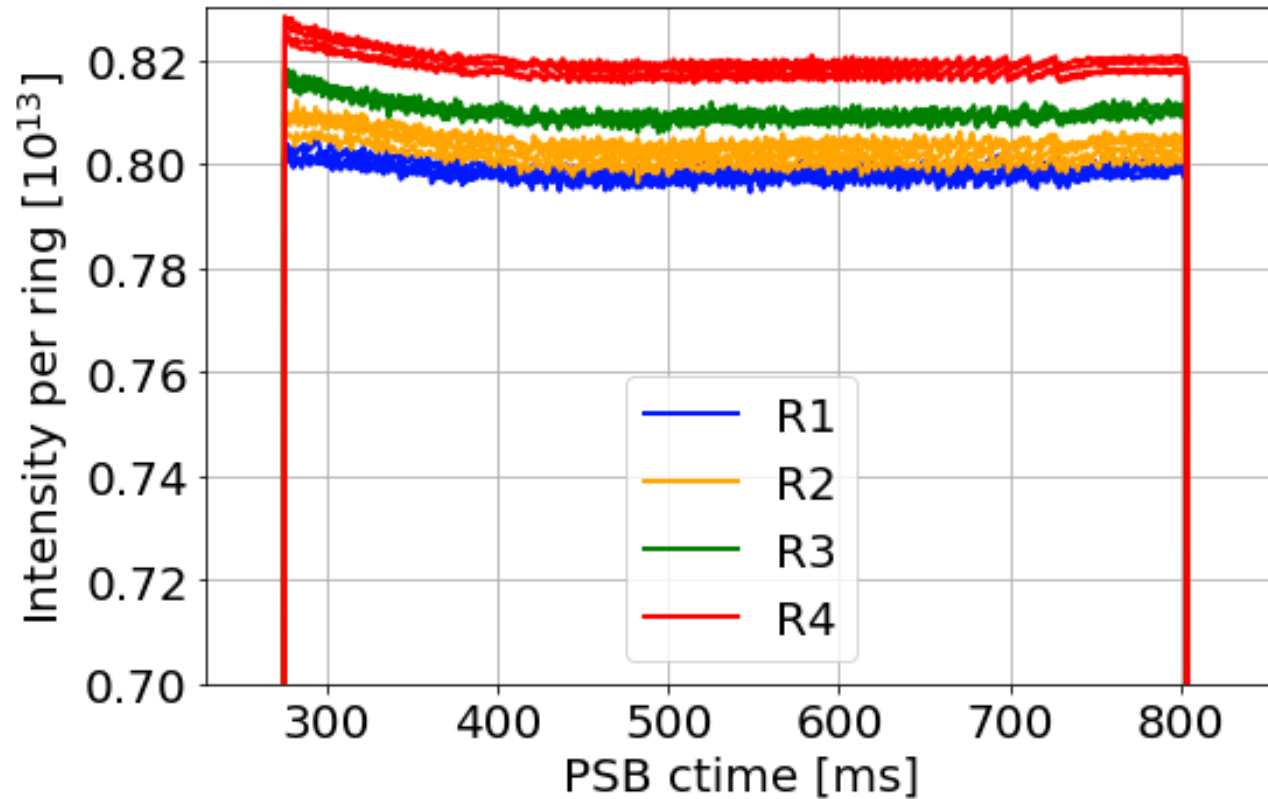
- **ISOLDE > 99%**
- **AD ~97%**
- **TOF ~96%**
- **EAST ~98%**
- **SFTPRO ~90%**

Where do we lose protons across the complex?



ISOLDE

ISOLDE cycle

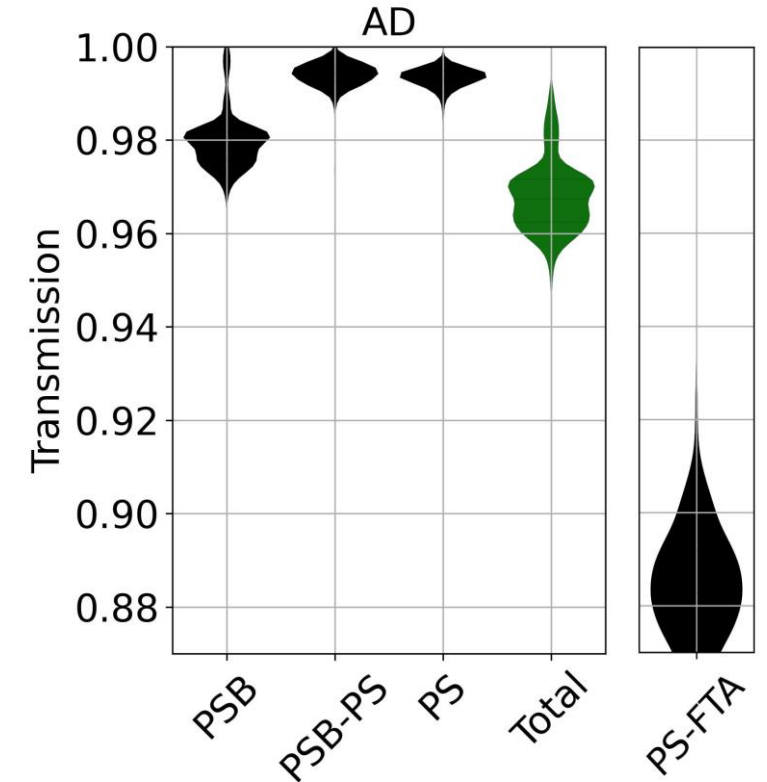
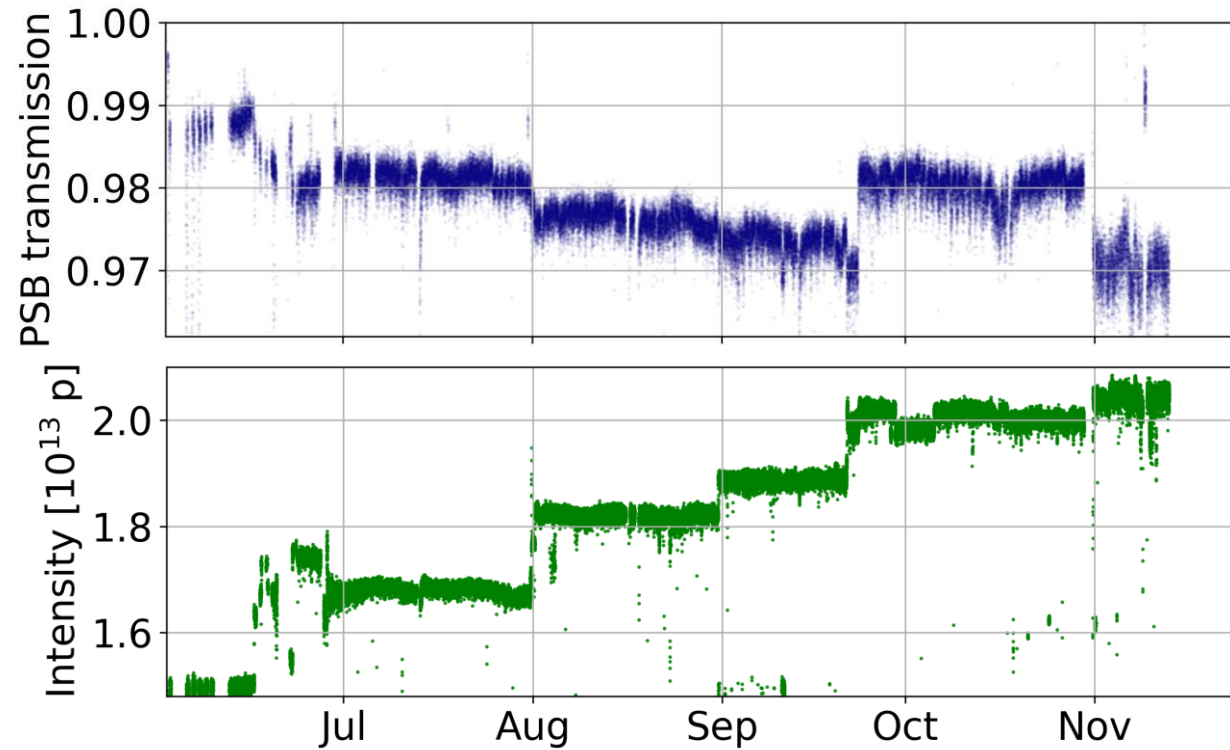


- PSB transmission $> 99\%$!
- Transverse and longitudinal optimizations in place (transverse painting, working point, resonance compensation, double harmonic, ...).



A D

AD intensity ramp-up

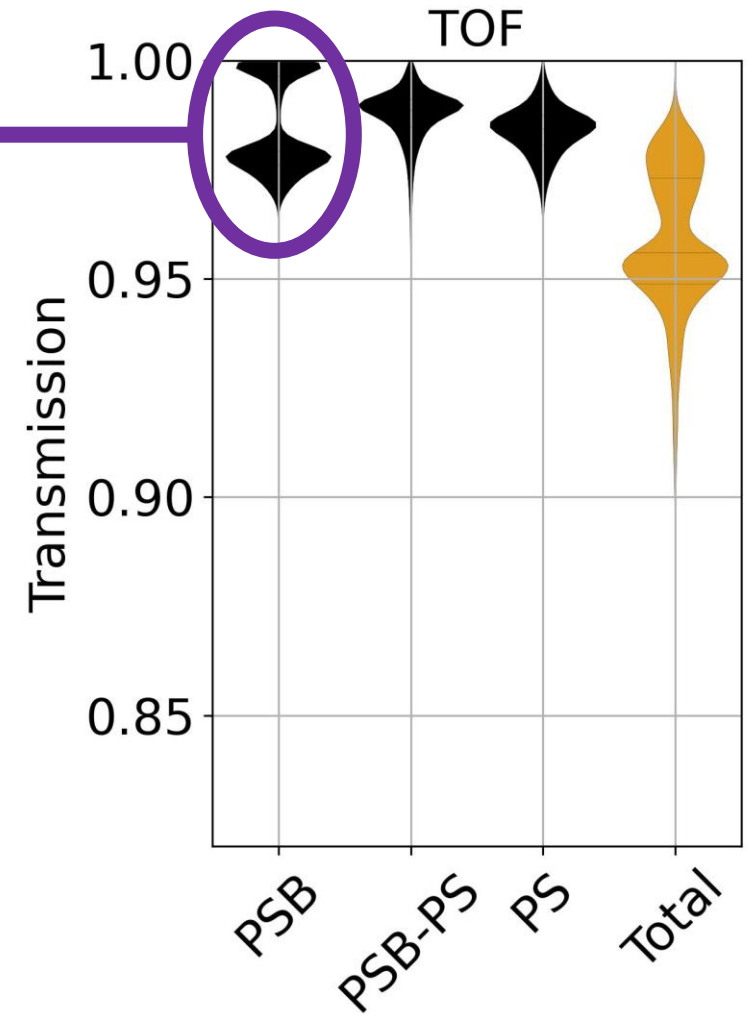
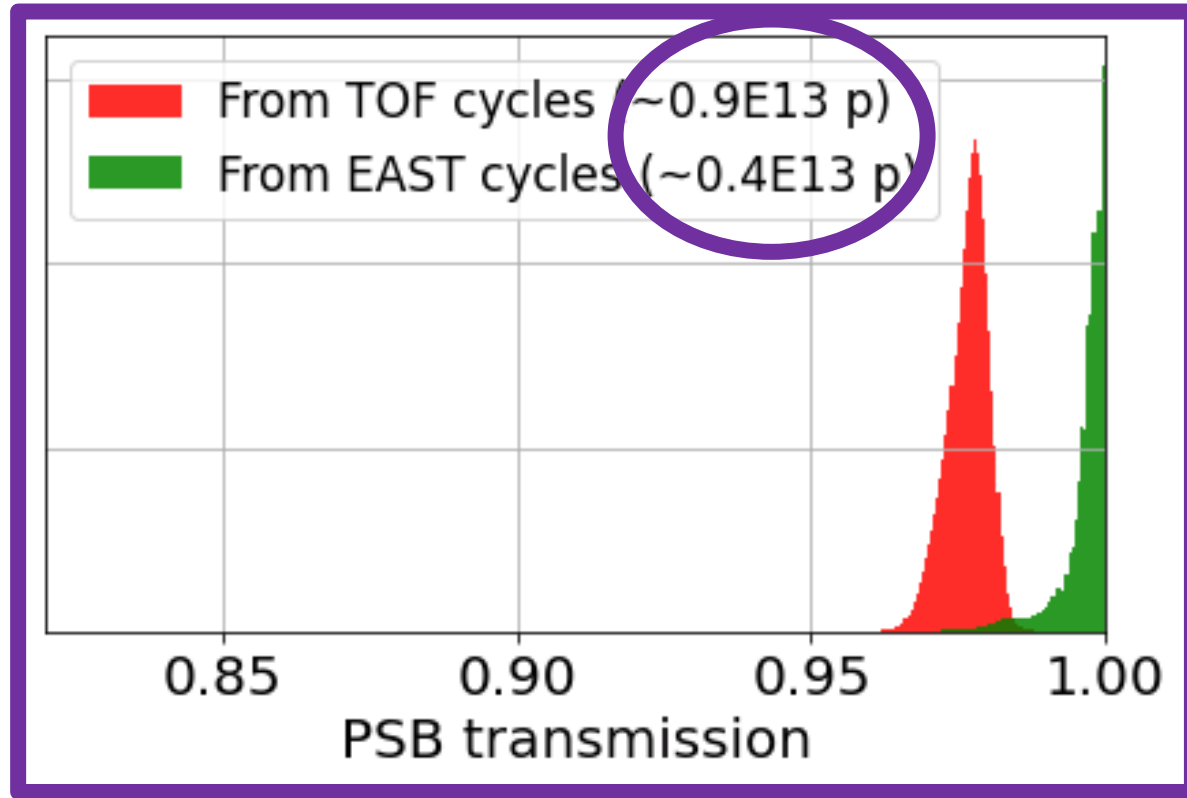


- Transmission degradation in PSB correlated with intensity ramp-up: **beam setup at low intensity**; further optimizations applied later on.
- Unprecedented intensity delivered to AD!
- Significant loss **after PS extraction**: to be discussed in D. Gamba's talk.



nTOF

TOF

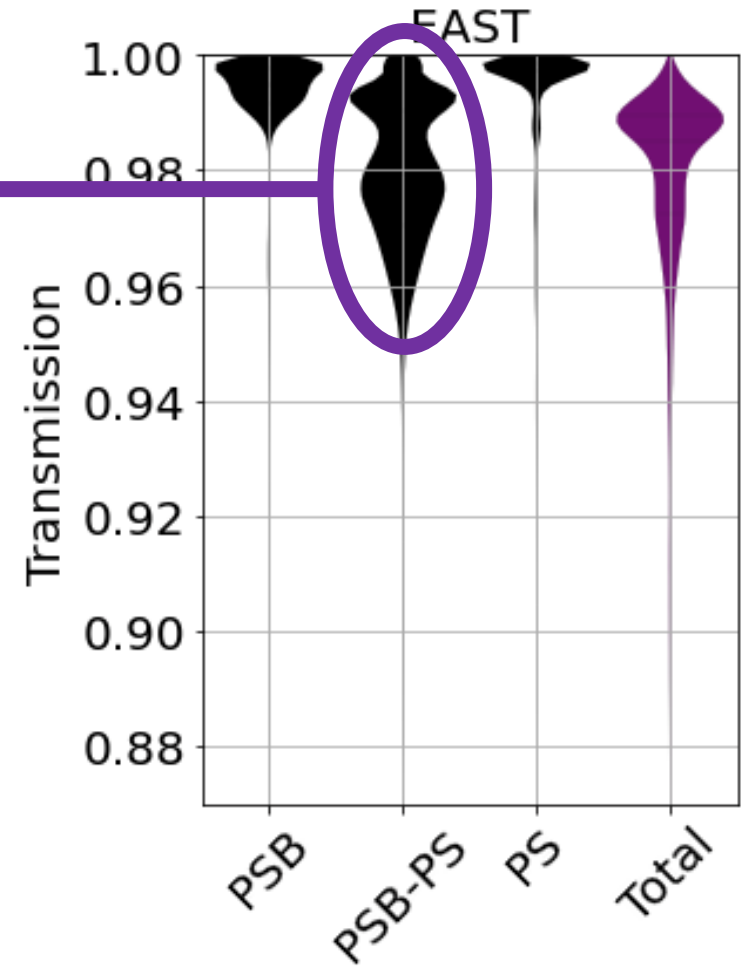
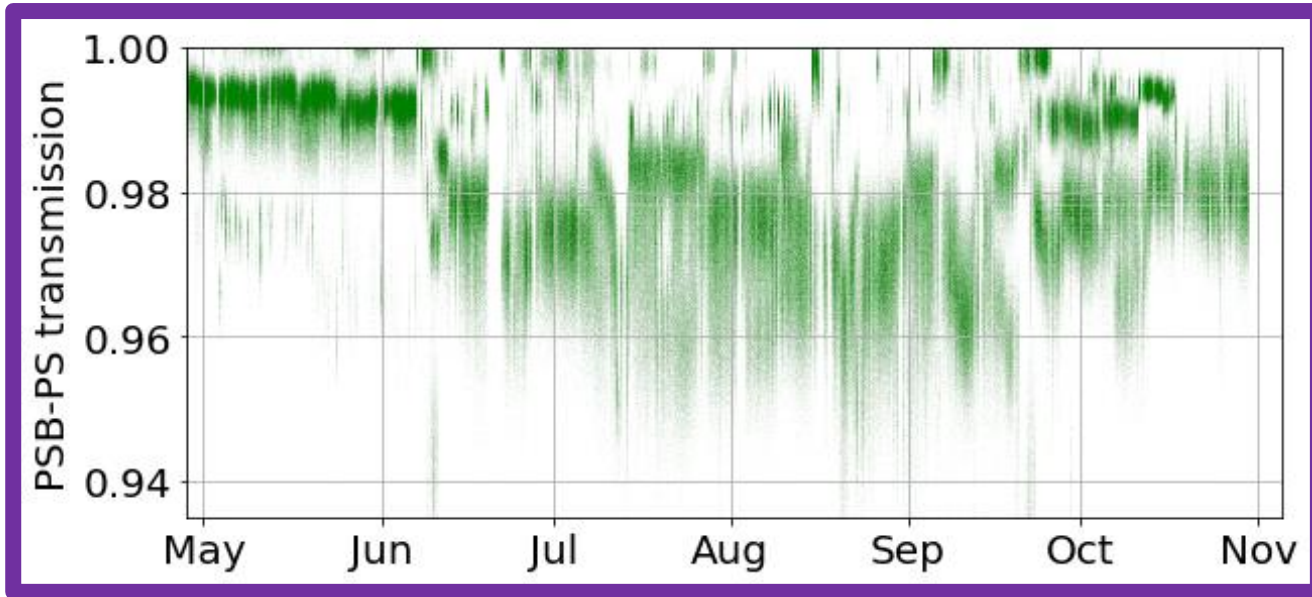


- TOF cycles: highest intensity/ring in PSB.
- Loss mostly at beginning of cycle (high space charge): still **~98% transmission** in PSB.

A 3D architectural rendering of a large industrial facility, possibly a power plant or refinery, shown from an elevated perspective. The structure is complex, with multiple levels, pipes, and structural elements. The word "EAST" is overlaid in large, white, sans-serif capital letters in the center of the image. The overall color palette is muted, with greys, blues, and greens, and the scene is lit from the top left, creating soft shadows.

EAST

EAST

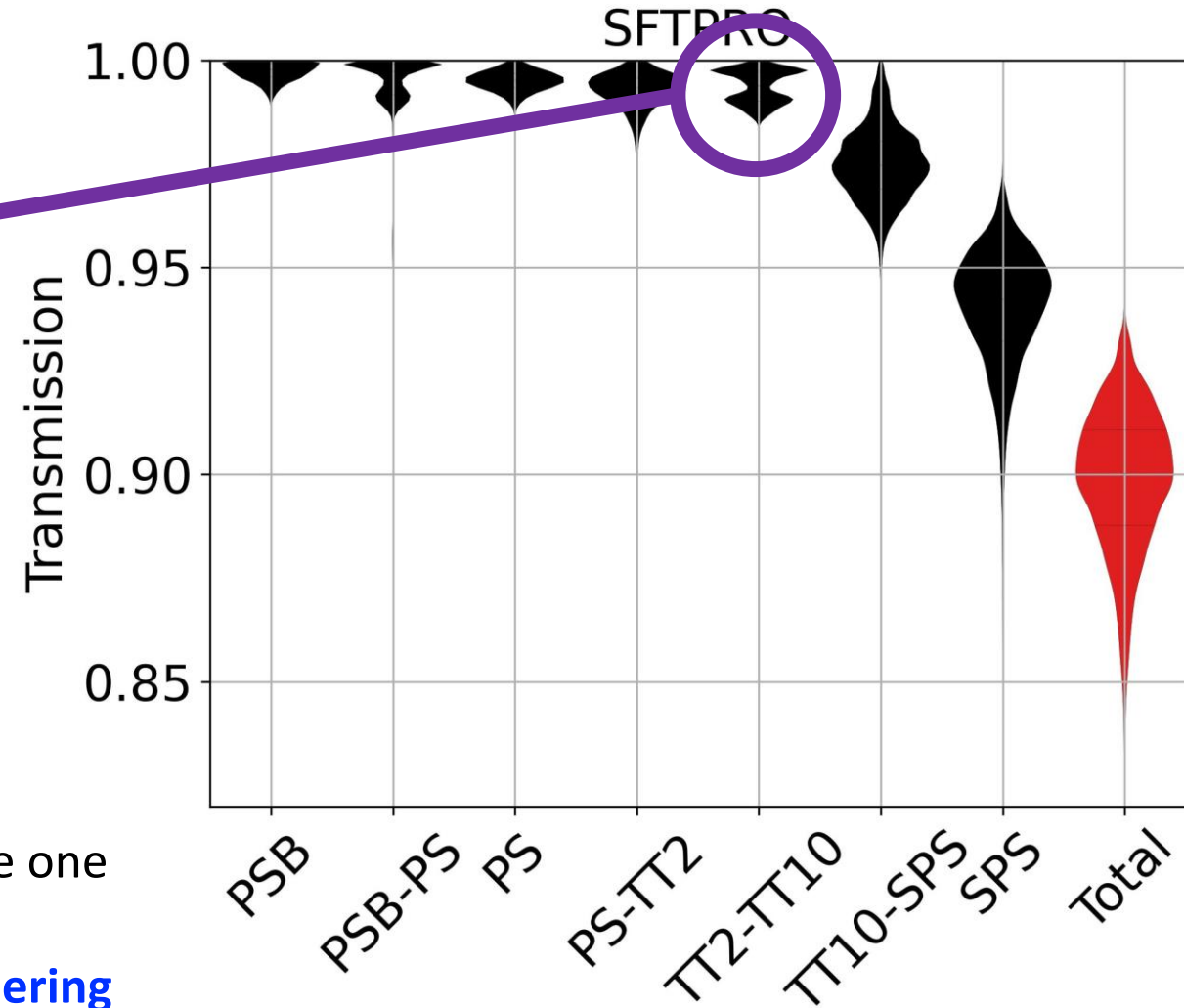
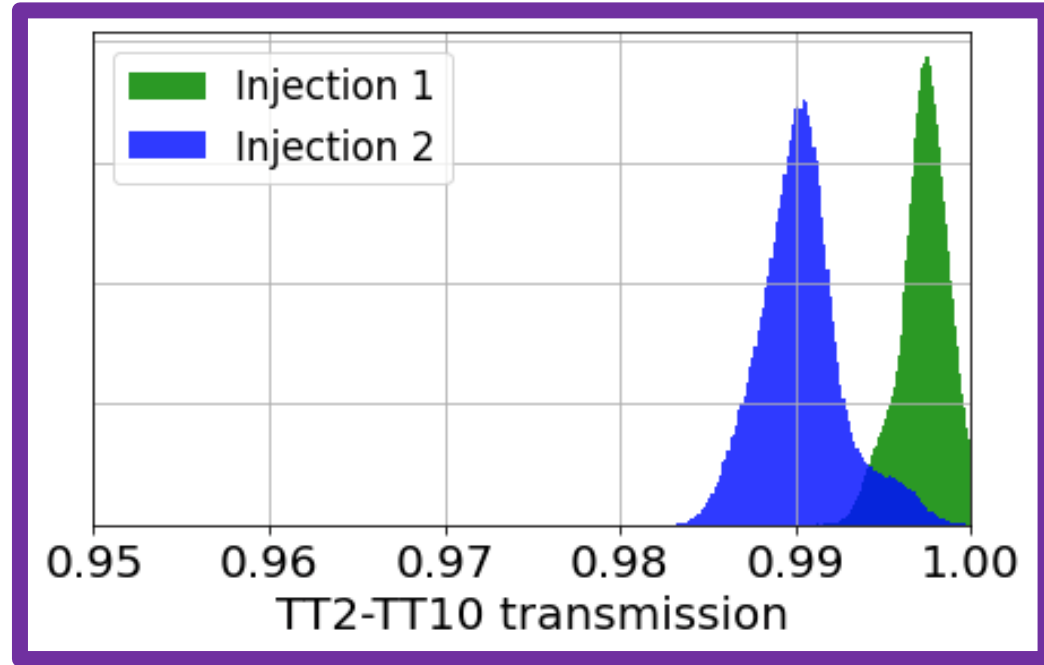


- **> 98%** overall transmission!
- Some spread in transmission between PSB-PS: to be understood.



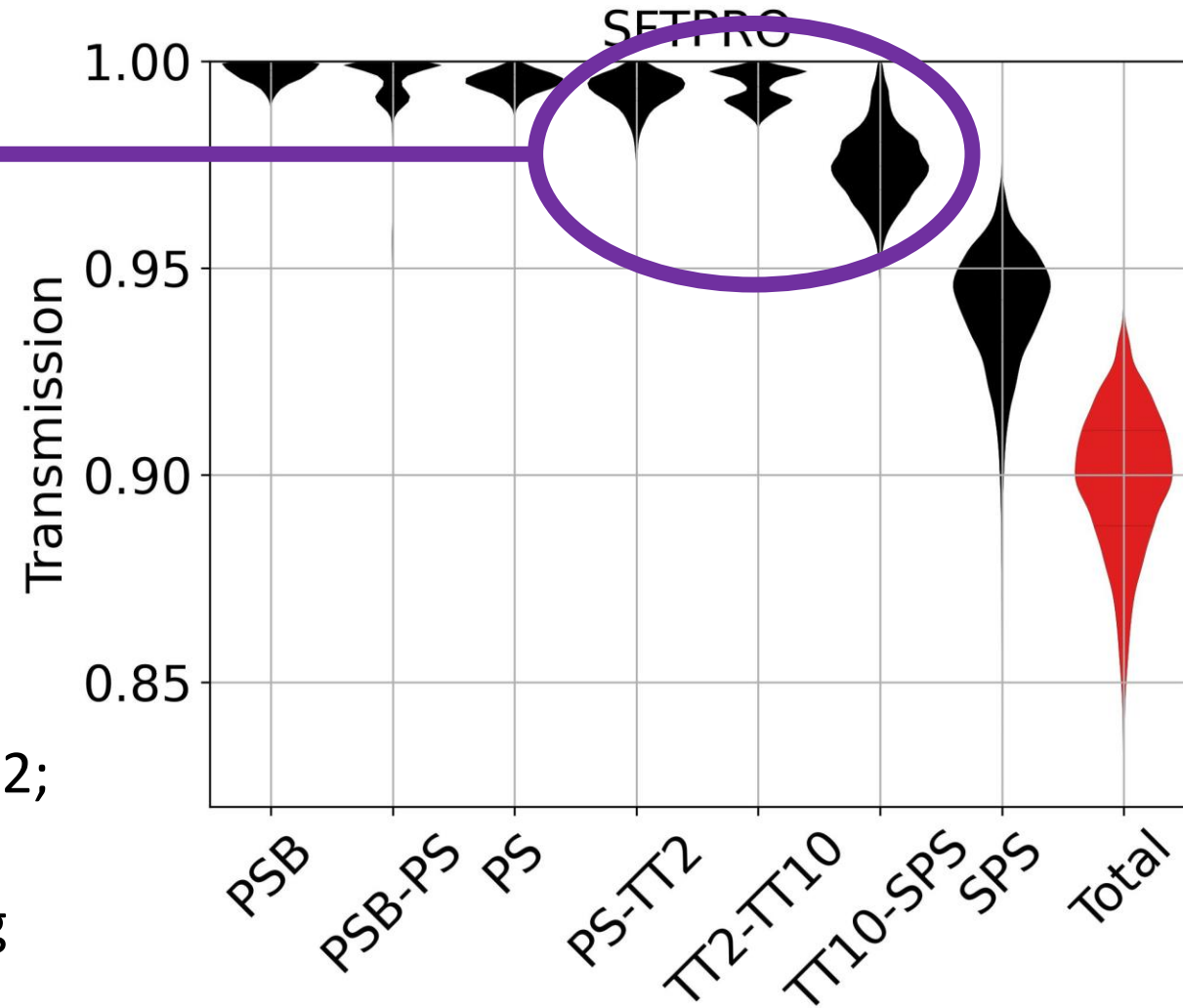
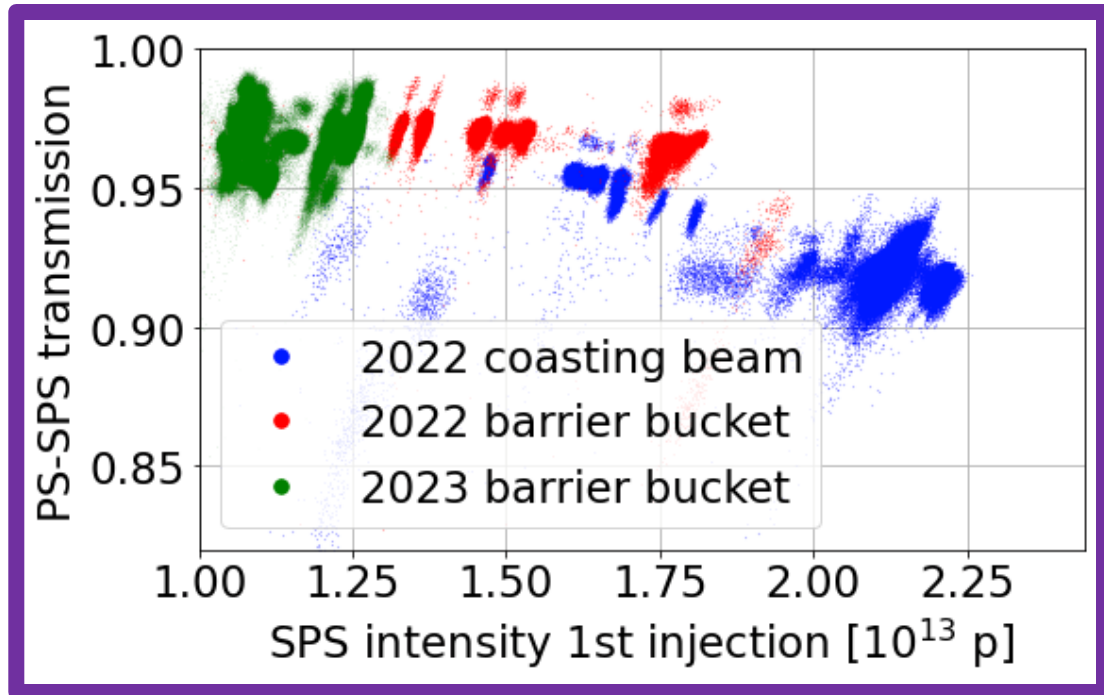
SFT PRO

SFTPRO transmission breakdown



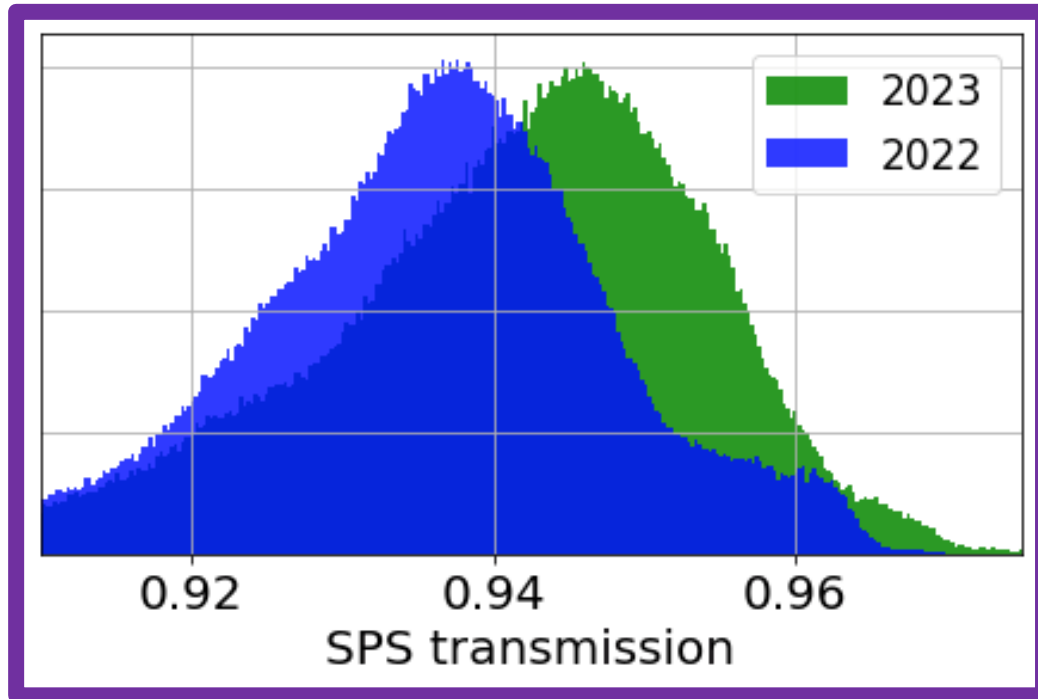
- Reason for difference in transmission not completely understood.
- Difference in extraction/steering of two injections can be one of the causes (steering is optimized for 1st injection).
- Plans for: fine **calibration** of extraction, **independent steering** correction, **automatic steering framework**.

SFTPRO transmission breakdown

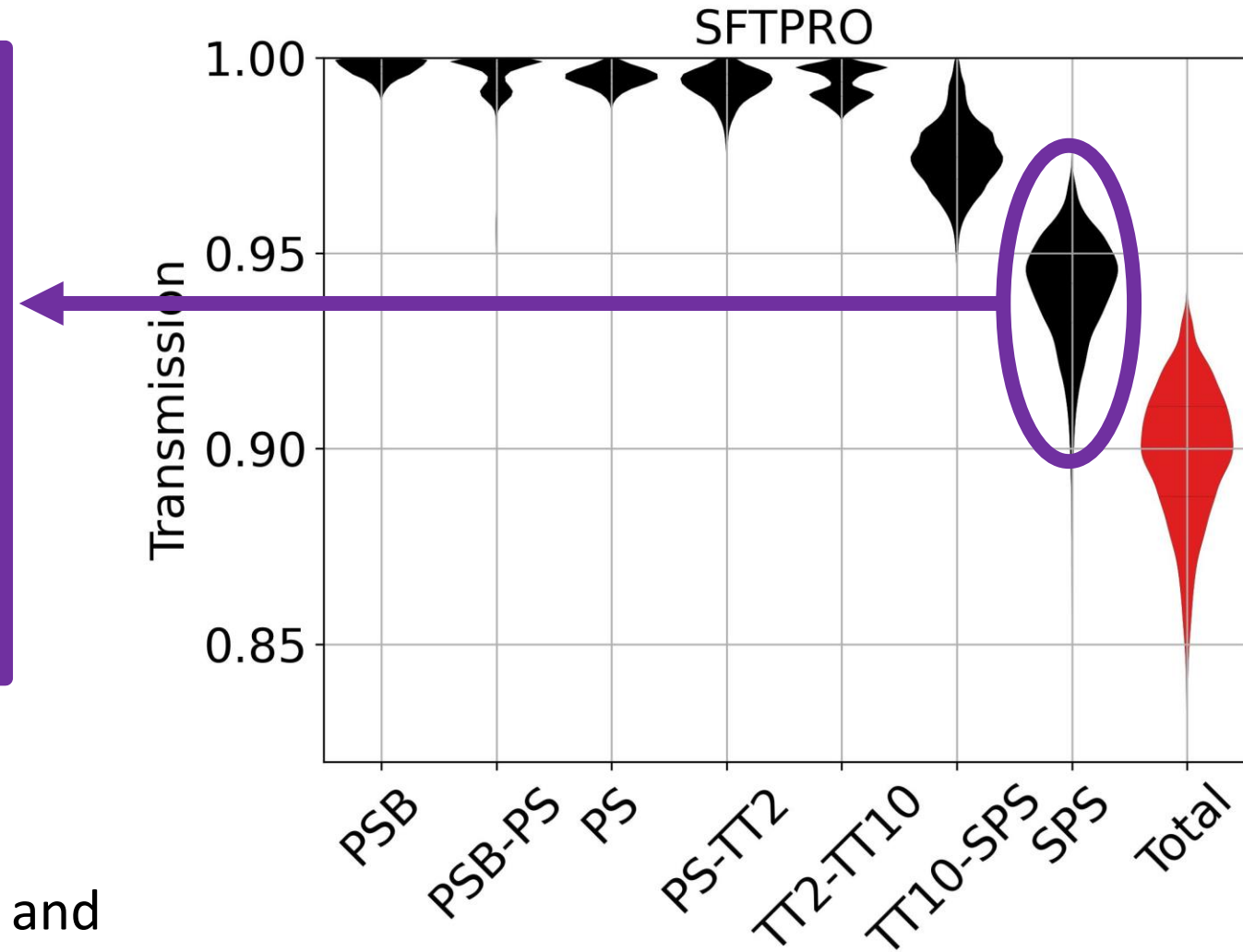


- Barrier bucket used since mid-October of 2022; operational in 2023.
- Barrier bucket creates longitudinal gap during rise time of extraction kicker: gain in PS-SPS transmission of $\sim 1 - 1.5\%$.

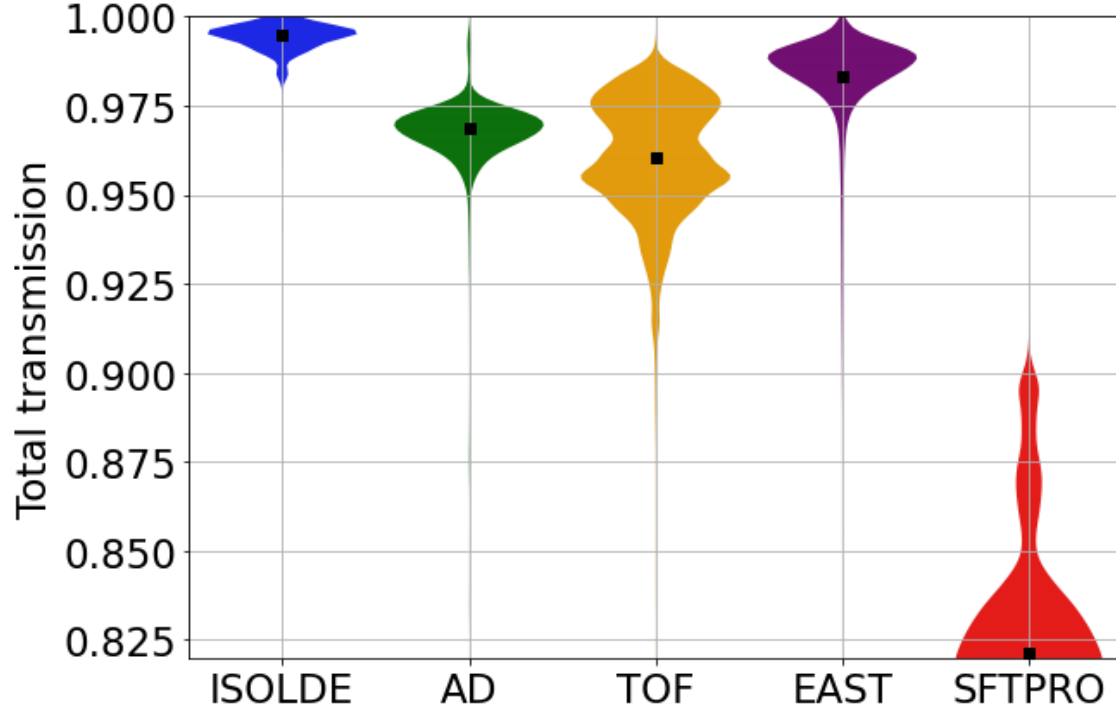
SFTPRO transmission breakdown



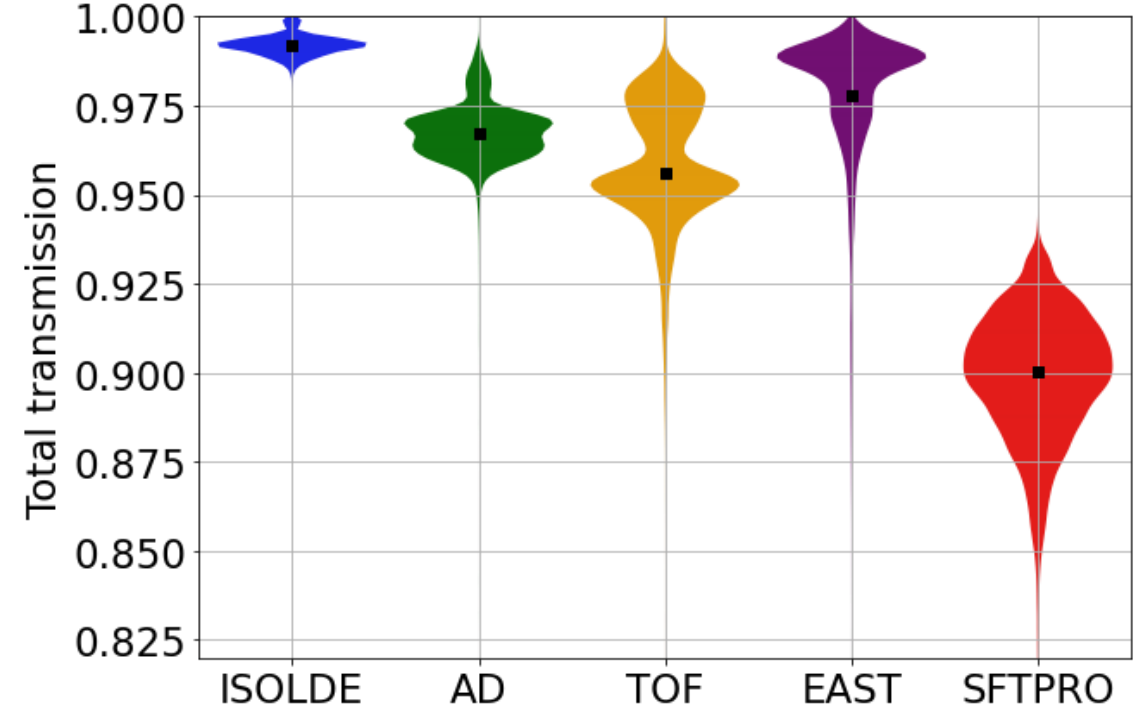
- Better overall SPS transmission (in-ring) compared to 2022.
- Compromise between **SPS transmission** and **splitter losses** (see [IPP 14/07/2022](#)).



2022



2023



(Lower intensity than 2022)

In 2023, we matched or even surpassed transmission performance of 2022.

What can we expect for the next years?

An aerial photograph of a modern transit station, likely a light rail or tram station. The station features a prominent, large, dome-shaped structure on the left side, which appears to be a central hub or a large shelter. To the right, there are elevated tracks with a train or tram visible. The station is surrounded by various buildings, including a large, modern building with a flat roof and a glass facade. The overall scene is captured in a blue-tinted, high-angle view, giving it a futuristic and architectural feel.

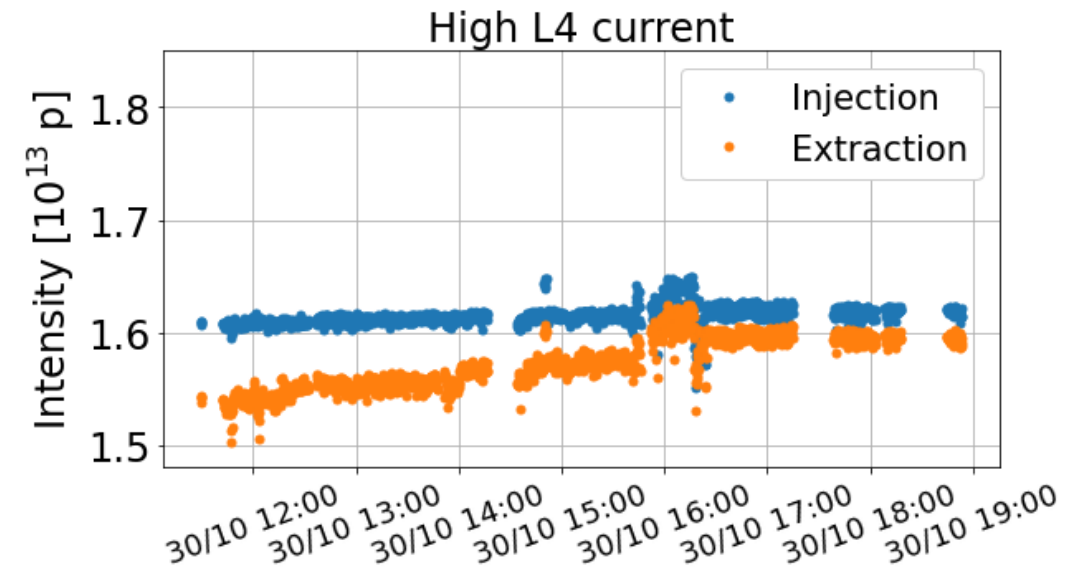
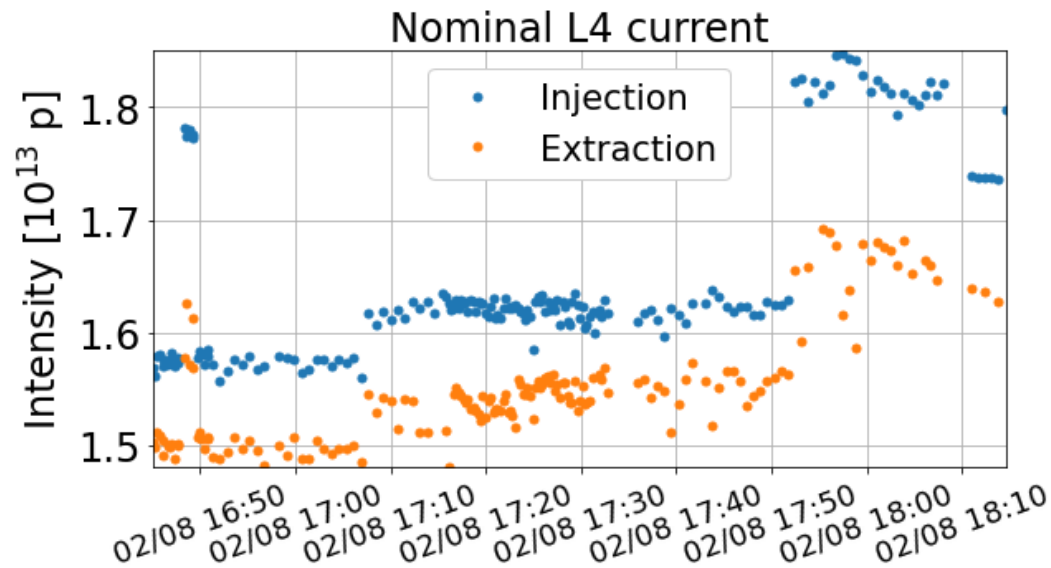
Part II

...and beyond

Can we push PSB intensity?

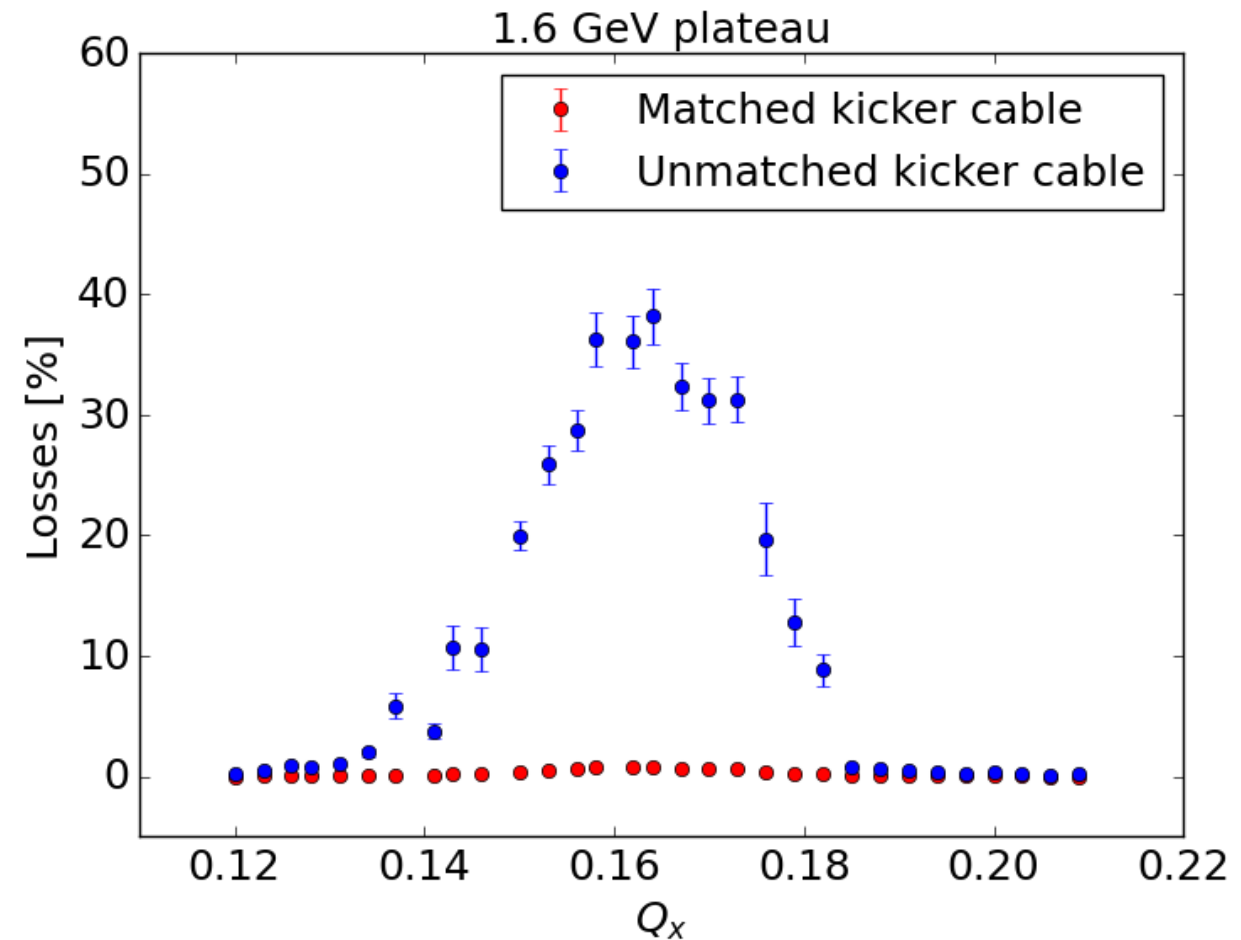
High-intensity [parallel](#) and [dedicated](#) MDs in PSB during 2023:

- **Achieved:** 1.7×10^{13} (nominal L4 current; transmission fluctuations) and 1.6×10^{13} (high L4 current; > 98% transmission) extracted protons.
- **Key optimizations:** painting, working point, resonance compensation, field correction, RF voltage increase + tripleH.
- **2024 plan:** keep high-intensity cycle in supercycle and/or have semi-dedicated days with high L4 current (produce operational beams with high current).



PSB instabilities at high intensities

- New instability observed at ~ 1.6 GeV and high intensities.
- Current mitigation strategy is **coupling resonance**: can lead to higher emittances and losses.
- Dedicated **MD** showed that instability is coming from extraction **kicker termination**.
- Kicker cannot pulse with matched cable: **working point adjustments** may help in the short term. Hardware **modification** options are considered.

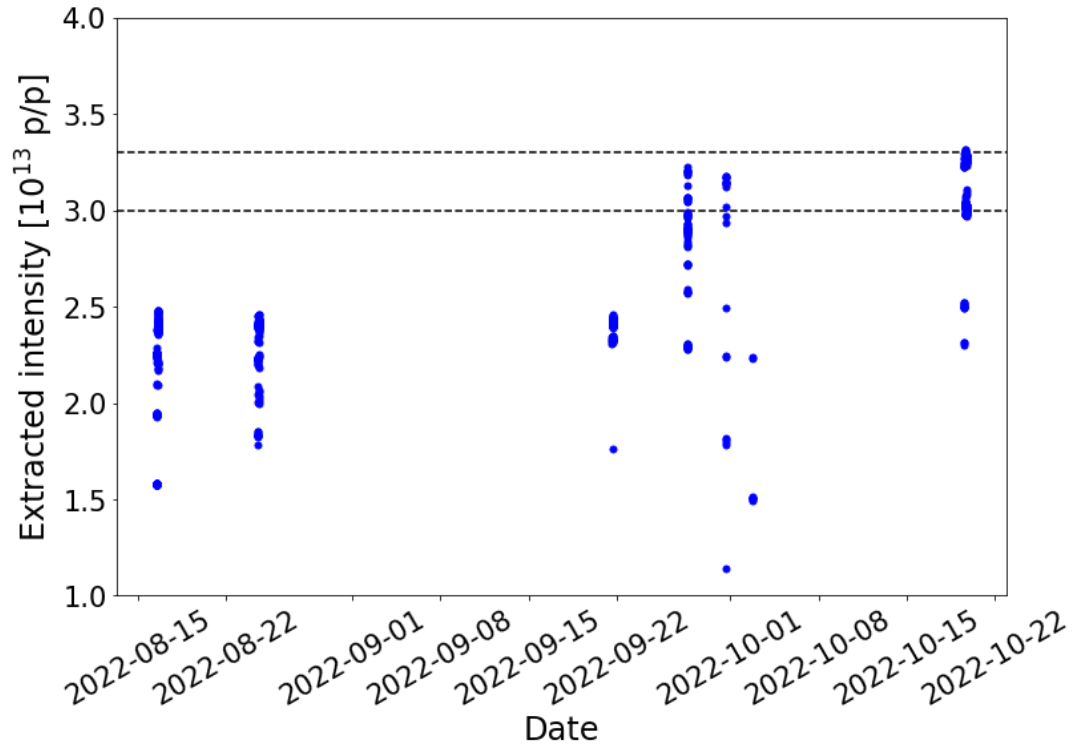


C. Antuono, F. Asvesta, C. Zannini

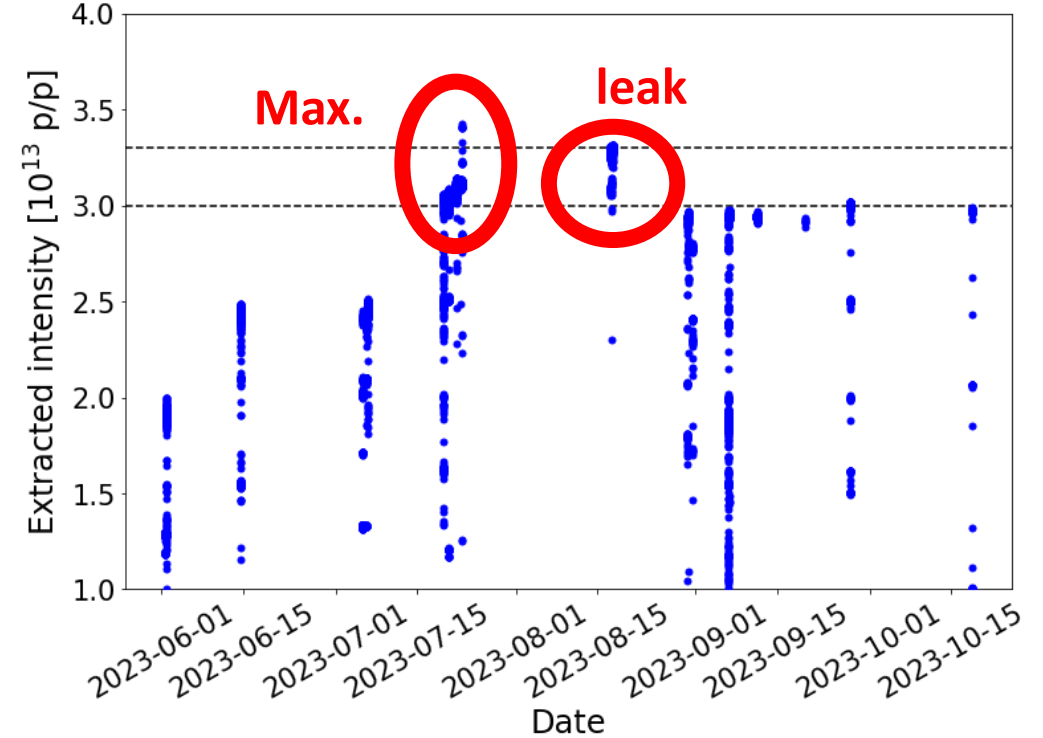
Pushing MTE intensity in the PS

High-intensity tests in the PS:

2022: no barrier bucket



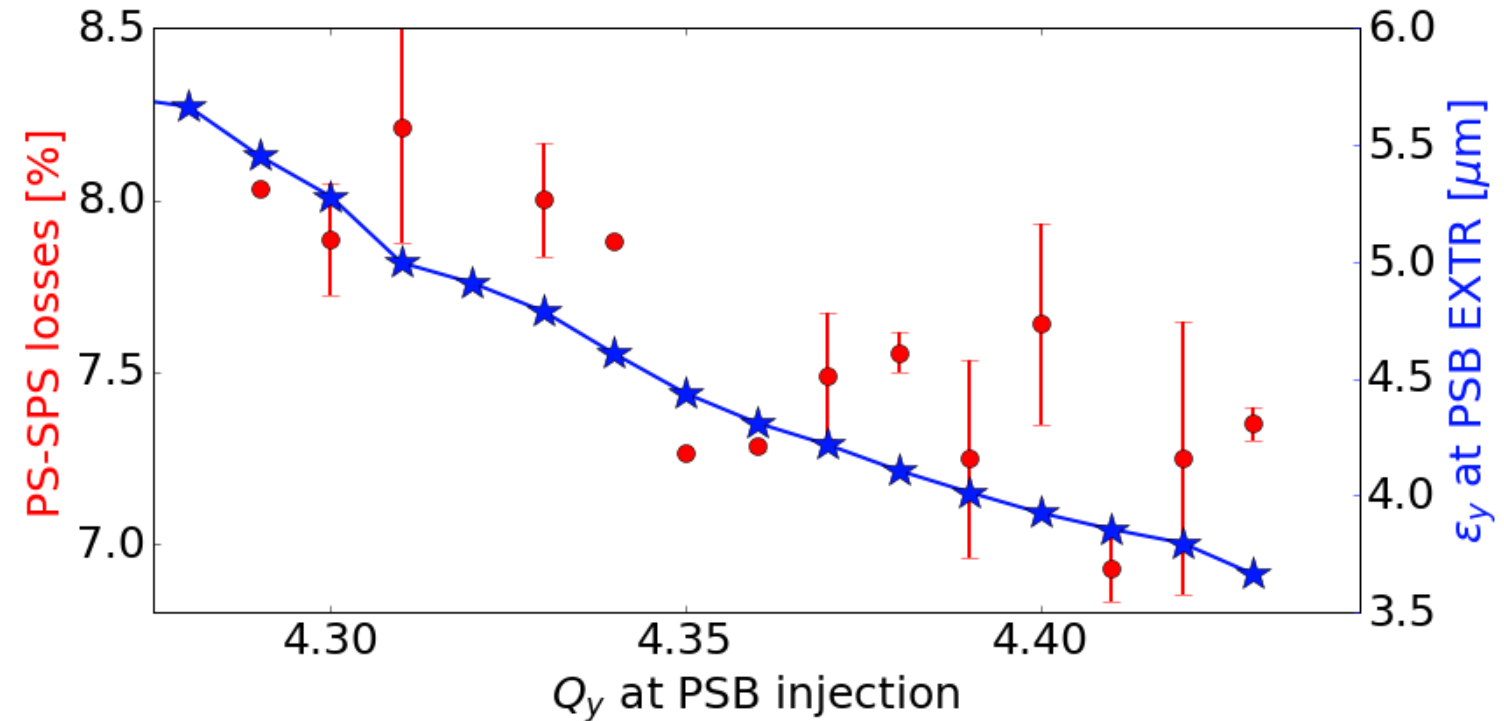
2023: with barrier bucket



- Non-conformity with RF bypass: decided not to exceed 3×10^{13} protons during ion run.
- Explore **intensity reach** of barrier-bucket MTE up to maximum digestible intensity in SPS.

SFTPRO transmission along the chain

- Short parallel [MD](#) ongoing to **understand** behavior of **SFTPRO transmission**.
- Tailoring **emittances in PSB** to determine impact of beam size and shape.
- Optimizing TFB frequency and tune to **reduce TFB gain** in the PS.





Summary

Summary

How did the fixed target cycles perform in 2023?

- Excellent transmission throughout the complex: $> 96\%$ for all beams but SFTPRO (90%).

Where do we lose protons across the complex?

- Different processes lead to losses in different locations (rings and transfer lines):
 - Example of space charge related loss of TOF early in the PSB cycle.
 - Example of barrier-bucket transmission gain.
- Need of better **monitoring along the year** to tackle issues as they arise:
 - Example of transmission degradation with intensity ramp-up in AD.
 - Example of transmission discrepancy of SFTPRO injections: independent steering correction for injection #1 and #2, automatic steering framework.

What are the ongoing and future studies?

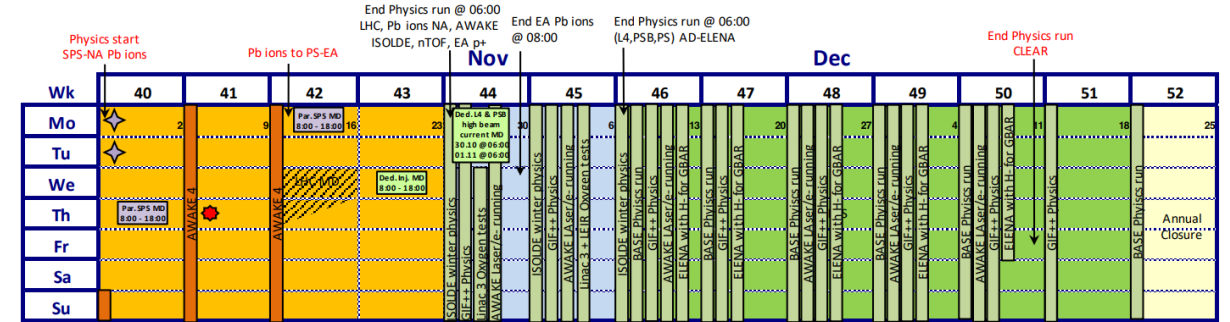
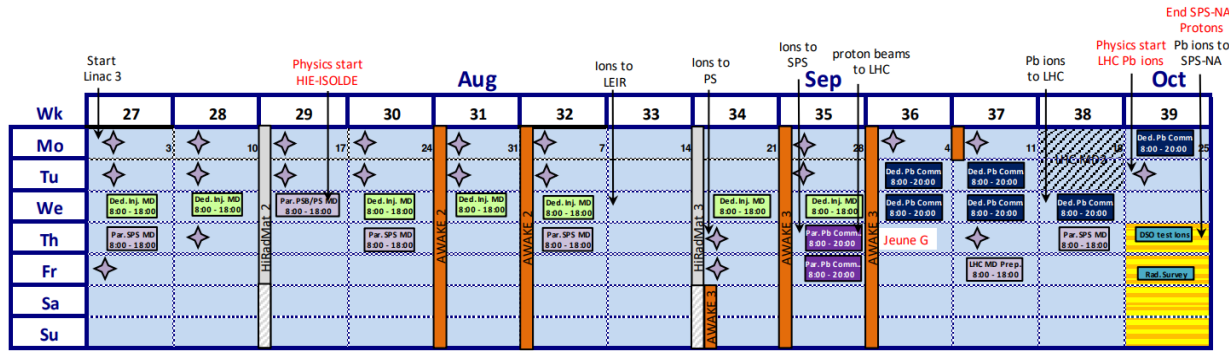
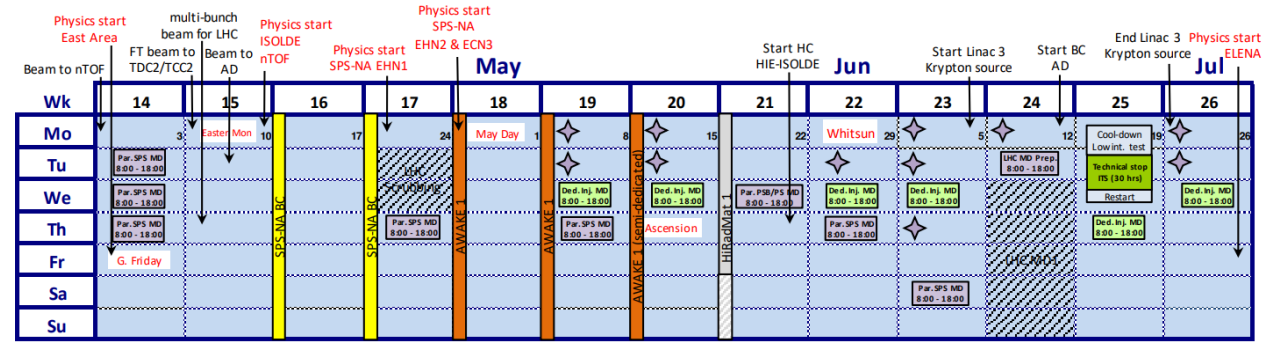
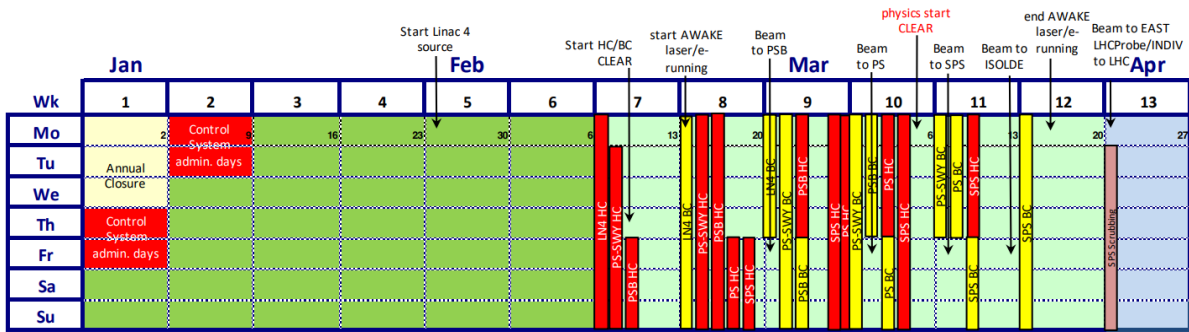
- Intensity reach in PSB: $> 1.6 \times 10^{13}$ p/ring (nominal or high L4 current)!
 - Stability and reproducibility to be tackled in 2024.
- Intensity reach in PS for MTE: $> 3 \times 10^{13}$ protons/pulse!
 - RF bypasses will be checked electrically & visually to exclude further non-conformity: validate barrier-bucket MTE up to maximum intensity for SPS.
- SFTPRO: lower transmission and most complicated beam along the chain.
 - More critical beam for **well defined characteristics and margins**.
 - MDs ongoing for **coordinating parameters along PSB-PS-SPS**.

An aerial photograph of a modern university campus, overlaid with a semi-transparent blue filter. The image shows a large, prominent dome-shaped building on the left, a multi-lane road with a train passing through a tunnel in the center, and various other campus buildings and green spaces. The text "Thank you for your attention" is centered in white.

Thank you for your attention

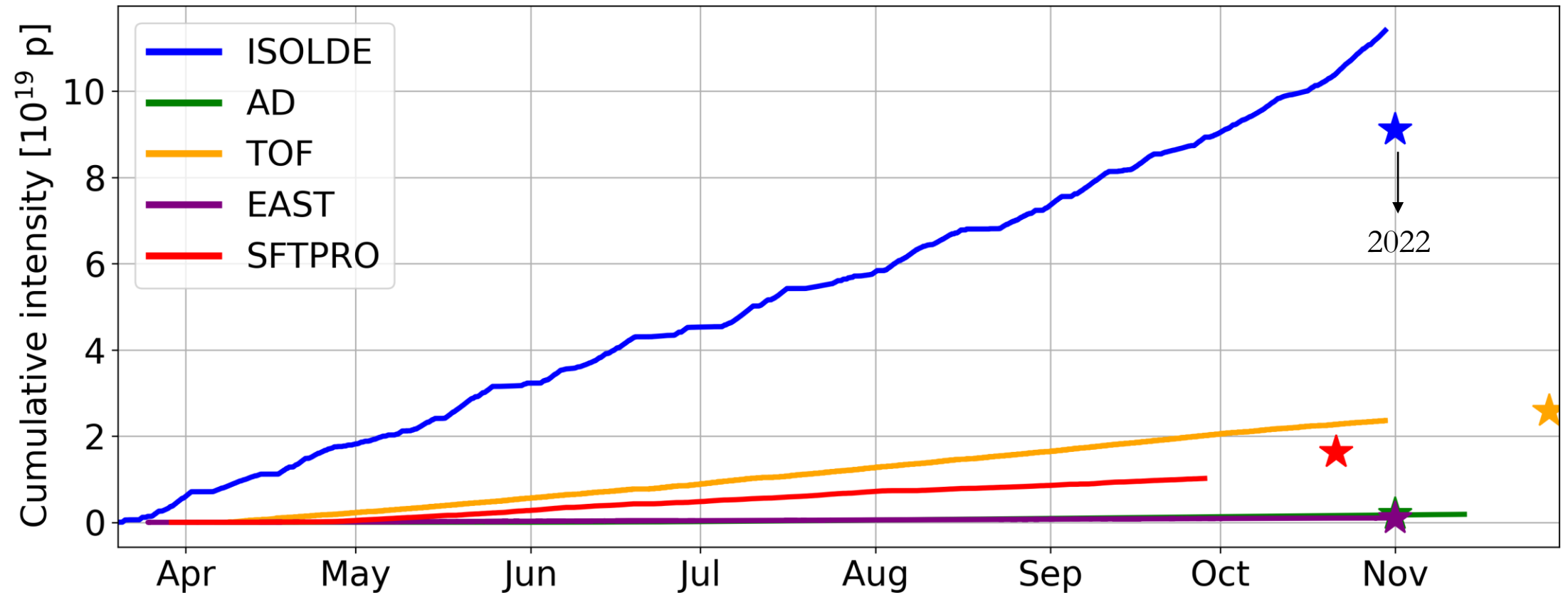
Backup

2023 schedule

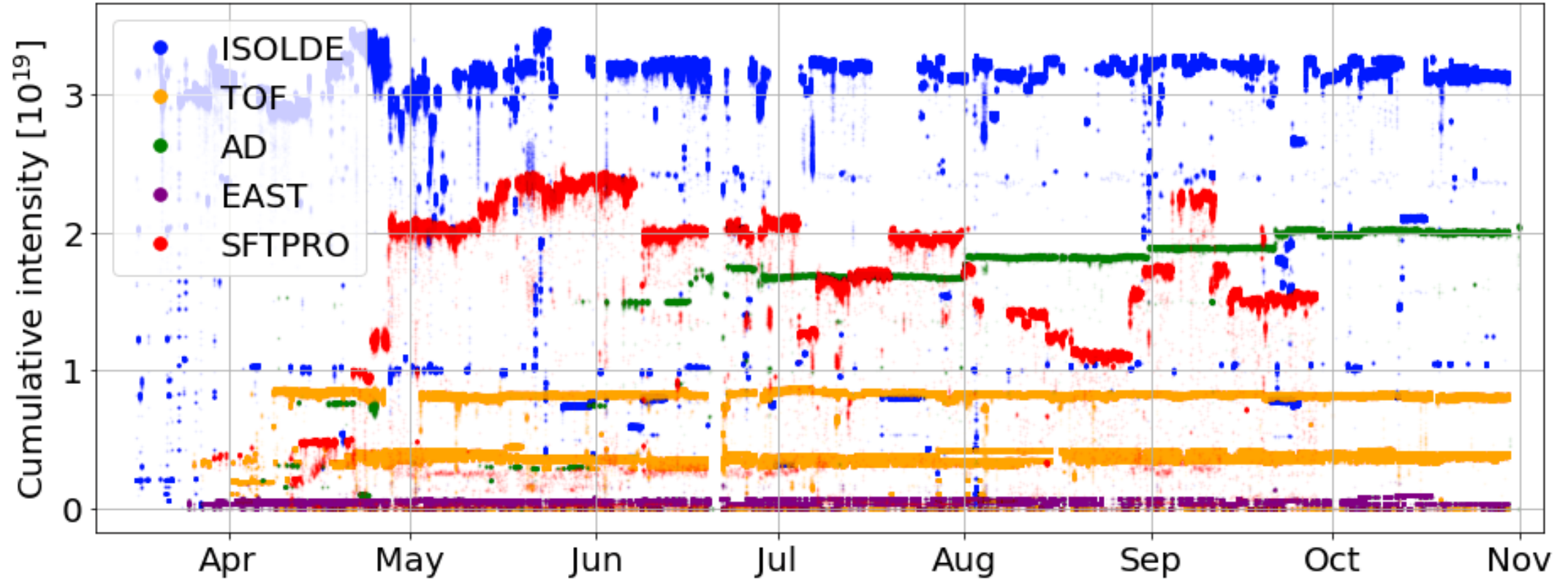


- Proton & Antiproton physics
- Hardware commissioning / Sys. admin days
- Parallel SPS ions beam commissioning
- Pb Ions physics
- Beam commissioning
- Dedicated SPS ions beam commissioning
- Parallel Injectors MD block (08:00 - 18:00)
- Scrubbing
- LHC MD block proton period
- Dedicated Injectors MD Block (08:00 - 18:00)
- AWAKE Run (08:00 - 24:00)
- LHC MD blocks ion period
- YETS & Injector chain Technical Stop
- HiRadMat Run & reserve (08:00 - 24:00)
- Special interventions/stops
- SPS ions Hardware commissioning
- ISOLDE winter physics (no p+ beam)
- CERN Official Holidays
- Annual closure
- SPS short cycle (6-7 bp) parallel MD (08:00-20:00)
- Linac 3 source refill

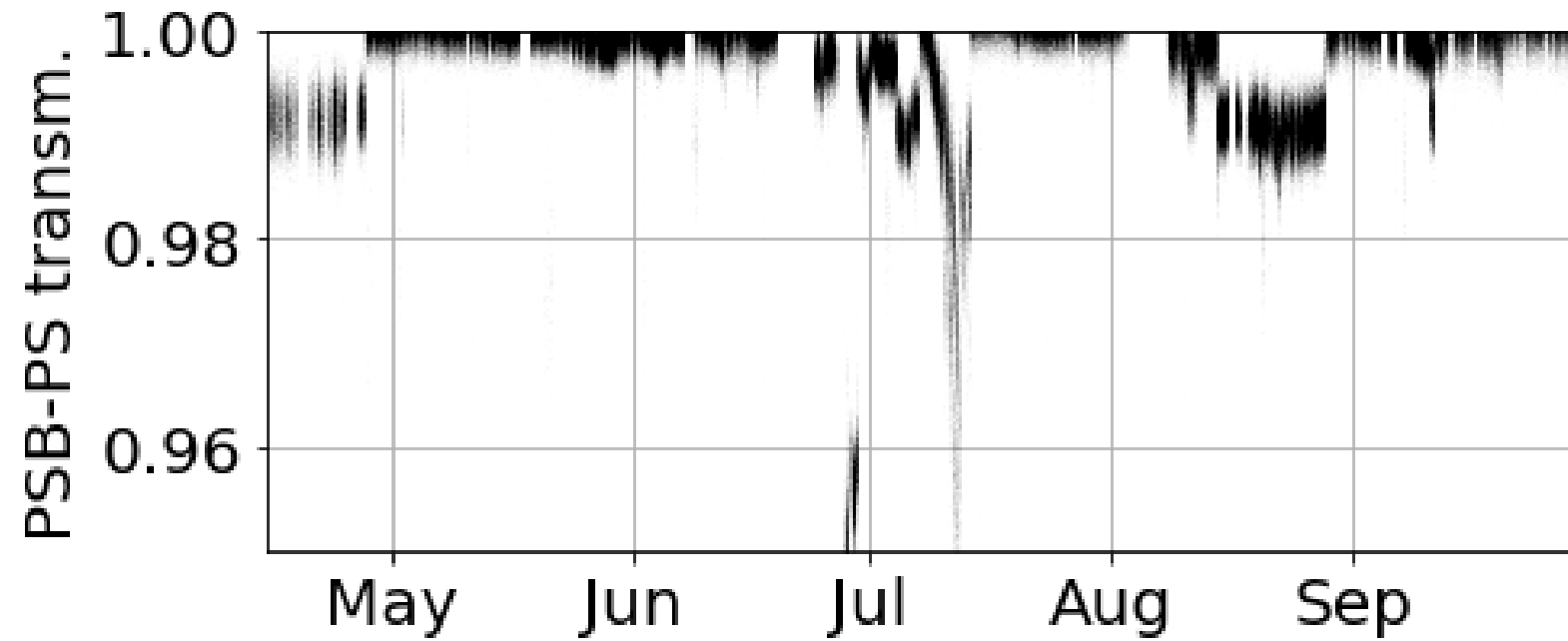
Intensity in 2023 and 2022



2023 intensity per day

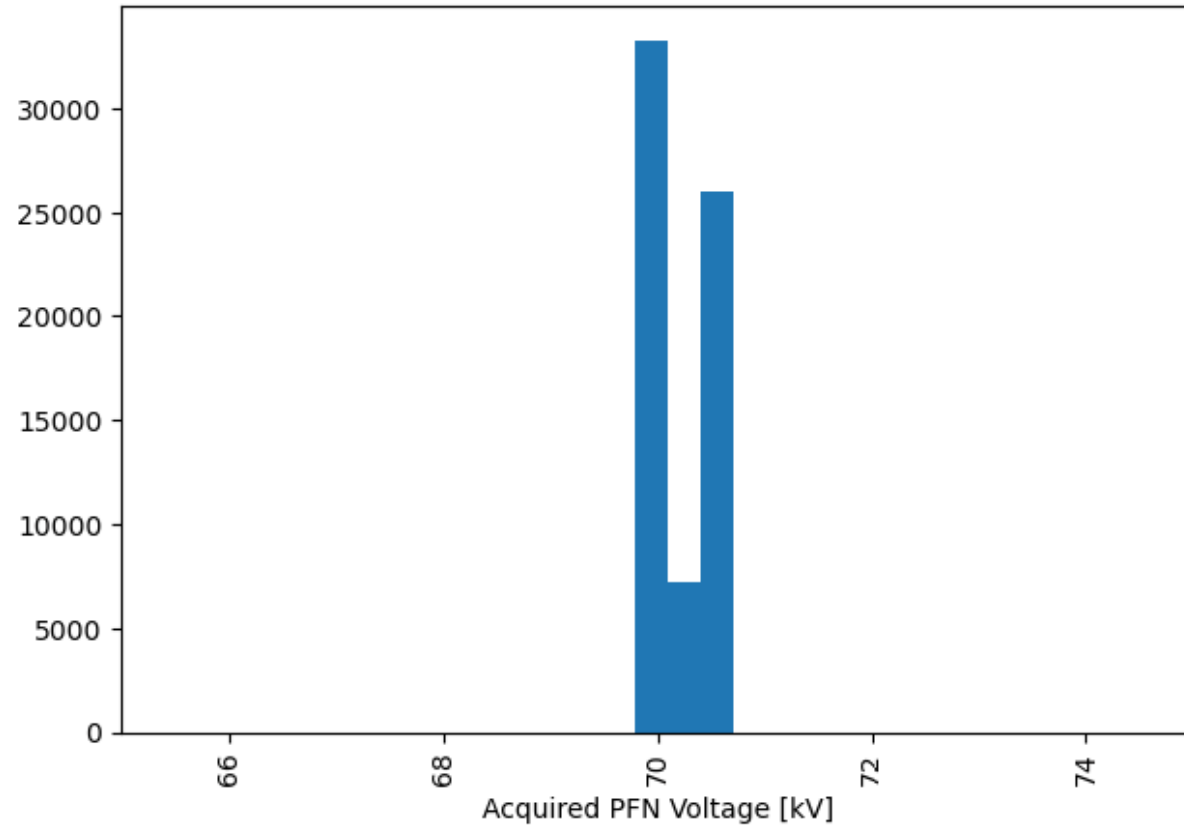


SFTPRO PSB-PS over the year

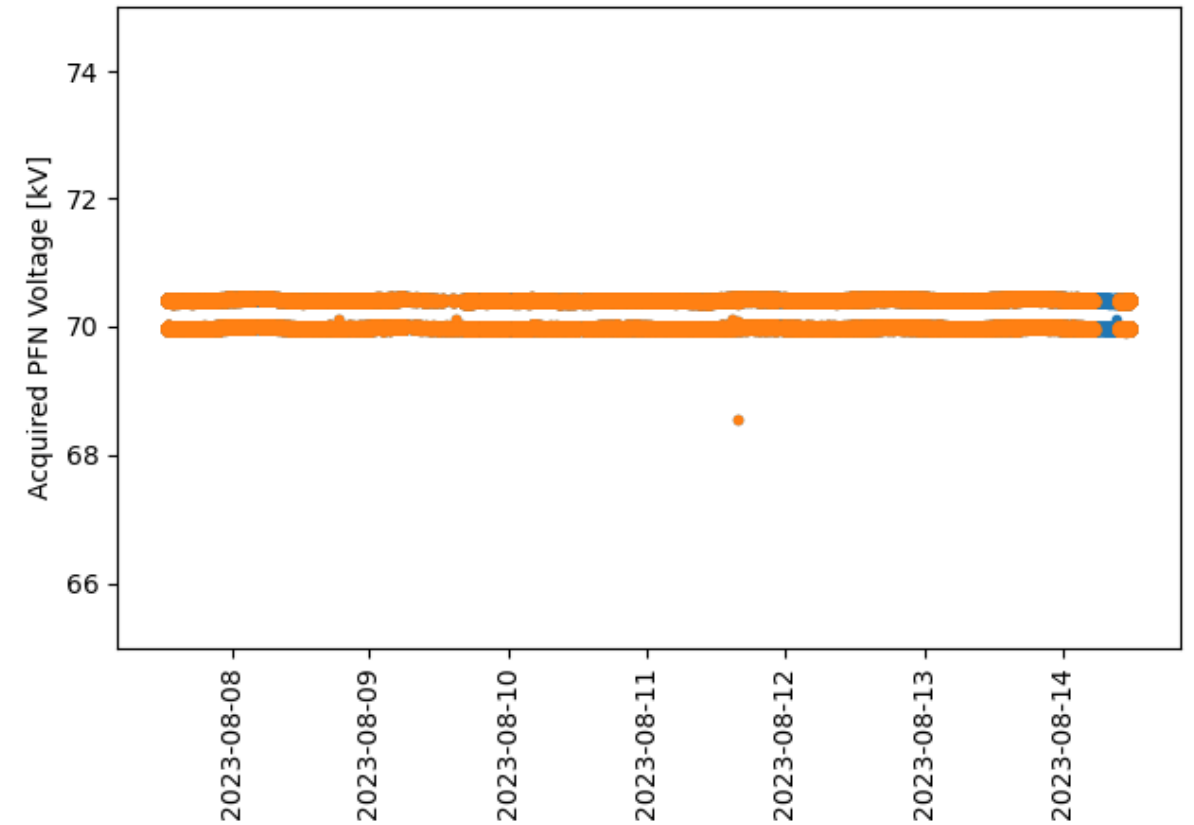


Voltage acquisition of KFA13

KFA13, # of pulses = 66530, $\Delta V_{RMS}/V = 4 \times 10^{-3}$



of pulses = 66533 to NA = 64714

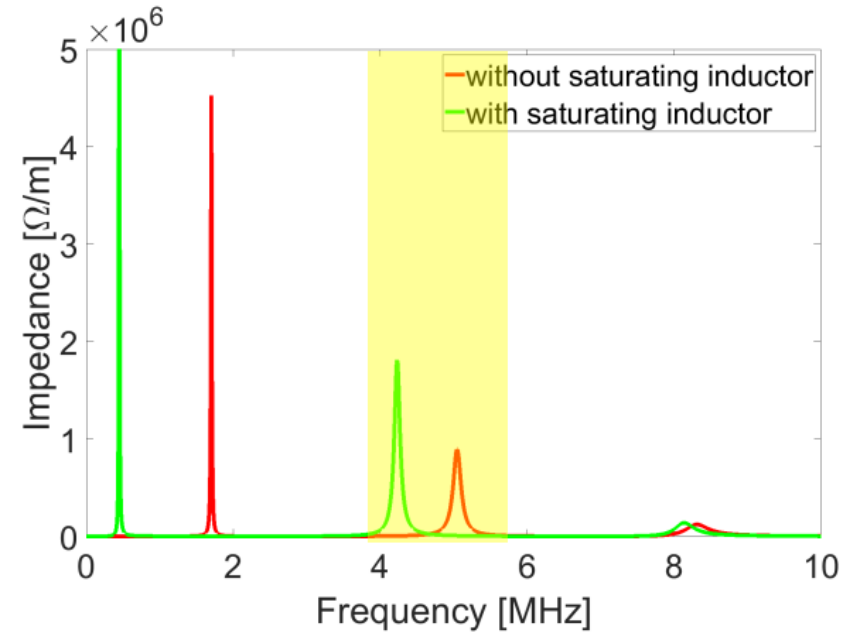


- Two data series correspond to first and second extractions from the PS
- Caused by the two different capacitor banks charging the same PFL.

PSB instability at 1.6 GeV

Expectations from the model: could we cure the instability?

The impedance can be significantly modified inserting a saturating inductor in the kicker circuit (between the kicker and the transmission lines) as proposed by M. Barnes

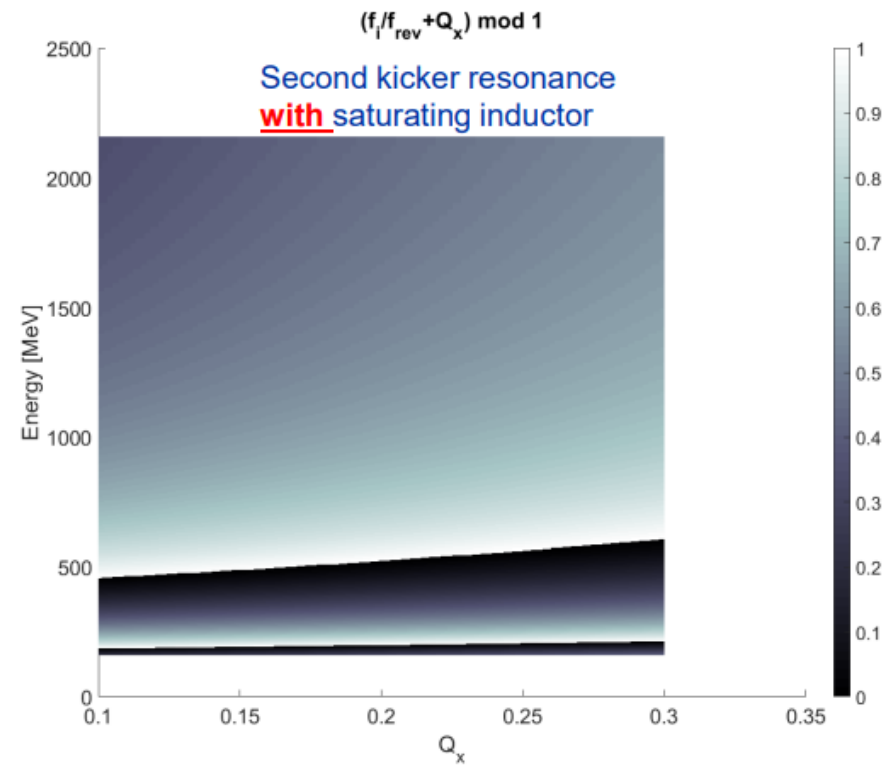
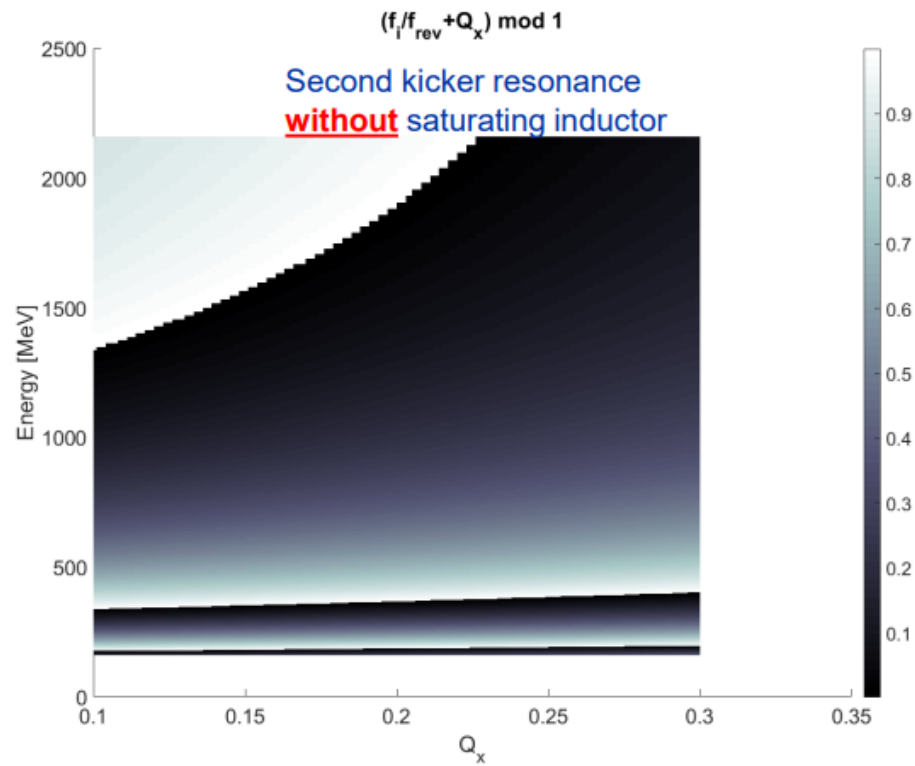


Case study investigated for the suppression of the 160 MeV instability



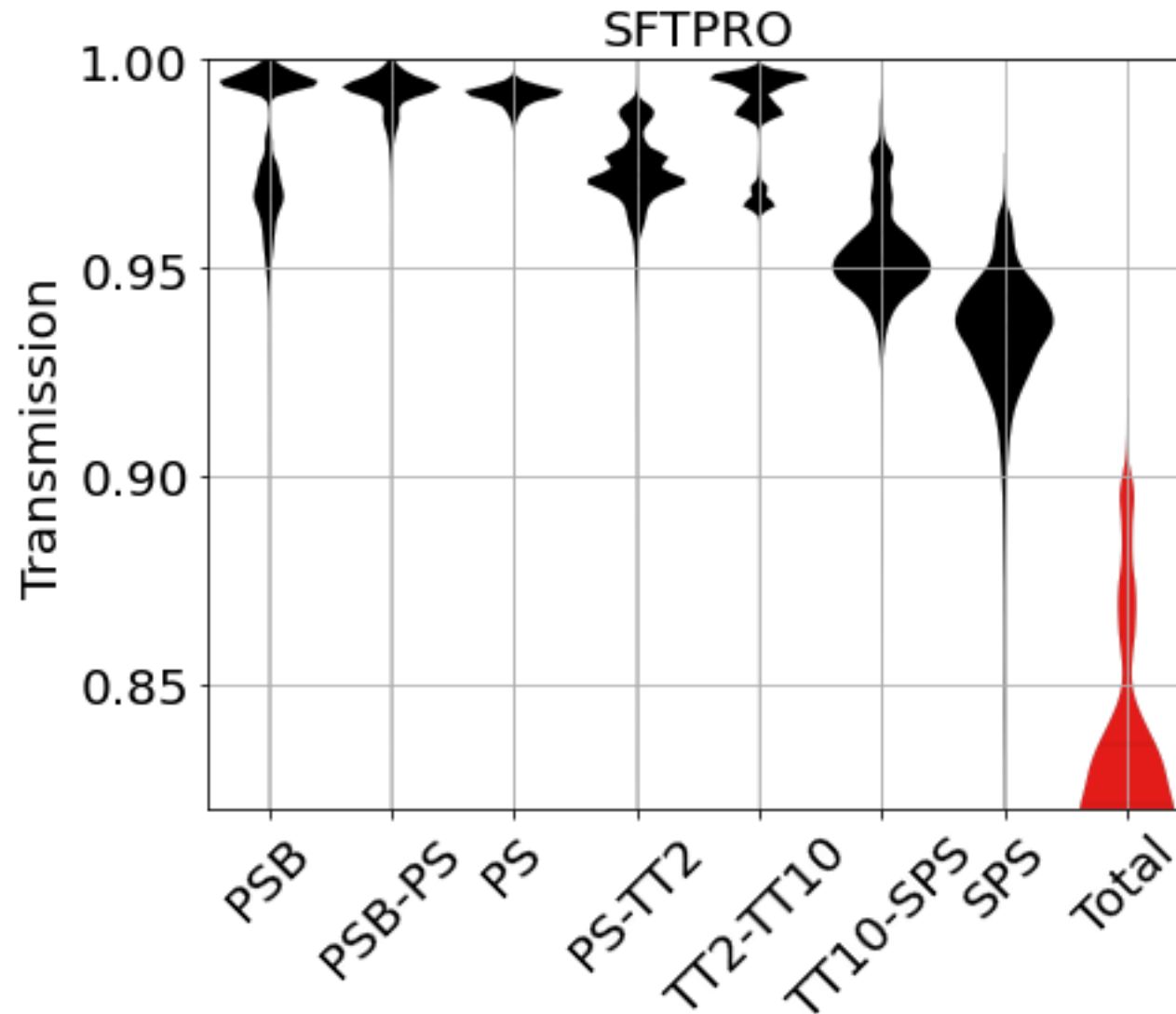
PSB instability at 1.6 GeV

- The instability at 1.6 GeV disappears with the saturating inductor

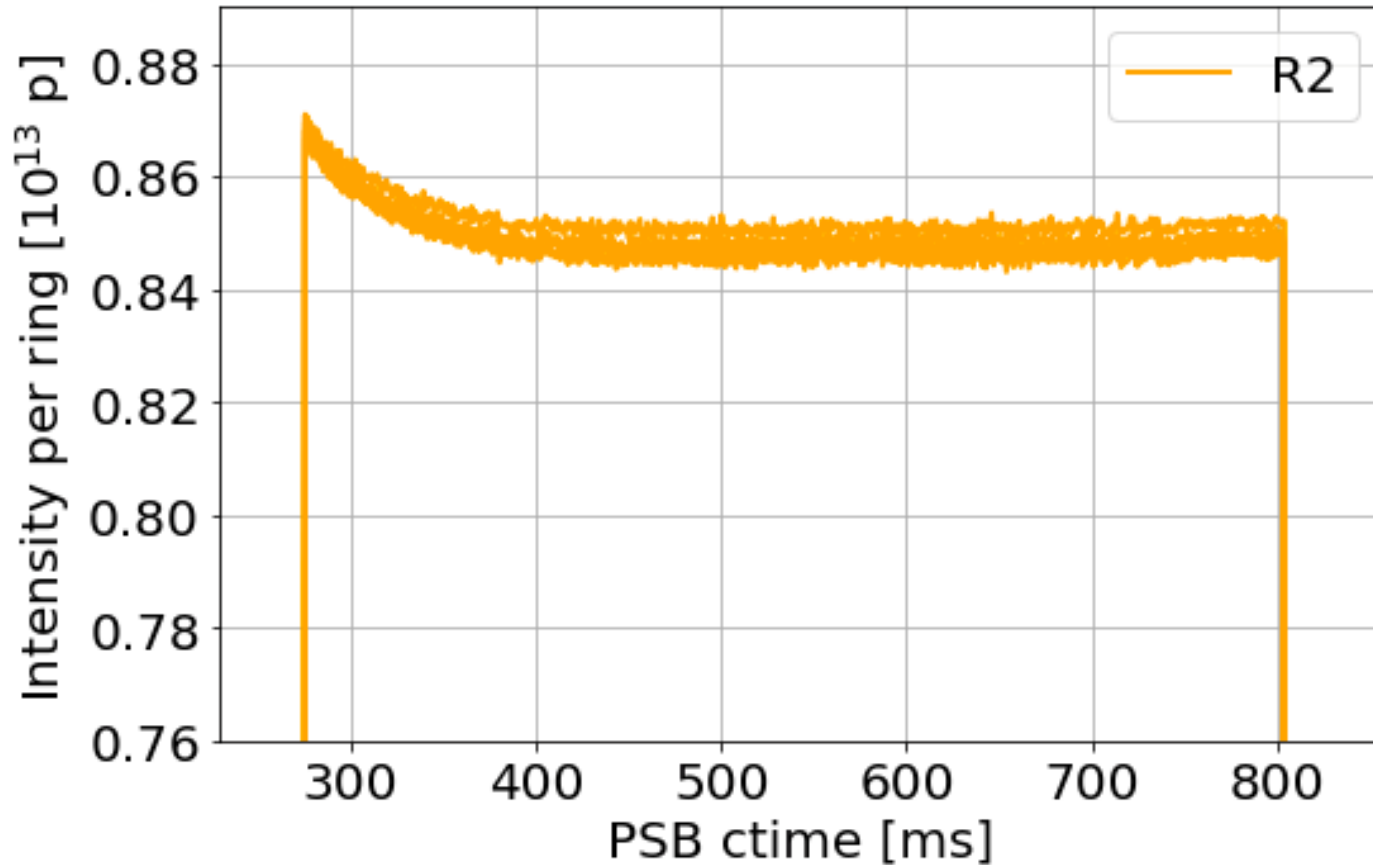


[C. Antuono et al., CEI section meeting 16/11/23](#)

SFTPRO transmission in 2022



TOF



- Loss mostly at the beginning of cycle (high space charge).
- Still **~98% transmission** in PSB.
- New instability observed at ~1.7GeV that TFB cannot cure.
- Instability currently mitigated by **approaching coupling resonance**.

EAST

