



# Joint Accelerator Performance Workshop

5-8 December 2022

<https://indico.cern.ch/event/1194548/>



# Session 6: Beam related issues throughout the complex

Speakers: Denis, Nicolo, Mihaly, Pablo, Rebecca, Alex, Athanasios

Chairs: B. Holzer, A. Lasheen

Many thanks for everybody who contributed to the talks and preparation! (and Simon for running with us!)

# Overview of the session

## Arc 1 – Beam delivery and limitations across the complex

- *How do we deliver beam for our many different users across the complex and how are we managing limitations? Where could we go beyond? Are there systematic or remaining issues that need to be tackled in 2023?*
- **Proton and duty cycle sharing for the CPS and SPS destinations – Denis Cotte**
- **Lead ions throughout the complex: Fixed Target and LHC beams – Nicolo Biancacci**

# Overview of the session

## Arc 2 – Beam loss control and mitigation

- *Where do we lose beam, what are the consequences for the machine activation and performance, what could we do to mitigate losses?*
- Beam loss and transmission along the chain – Mihaly Vadai
- Slow extraction improvements – Pablo Arrutia
- Beam transfer and splitting improvements – Rebecca Ramjiawan

# Overview of the session

## Arc 3 – Beam observation and characterization

- *What are our metrics to qualify beam performance and beam quality? How do we know beam is bad and requires adjustments, optimization? What observables are we missing?*
- **Beam performance characterization across the complex – Alexander Huschauer**
- **New, proposed and still missing diagnostics – Athanasios Topaloudis**

# Parallel vs. dedicated operation

- Improve proton sharing for EAST with more systematic Normal/Spare switching
- Possibilities to combine more cycles (tests with double TOF in 2023)...

Timing App Suite



... Caution not to make room for more ZERO cycles! -> Session 7 on Efficiency

- Request for SPS in 2023 for high duty cycle / dedicated runs for LHC, AWAKE...
- Work forward automated LHC fill preparation

- Interest for AWAKE to run in fully dedicated mode for a shorter time period?
- Changing the mode of operation -> number of shots vs. number of hours?

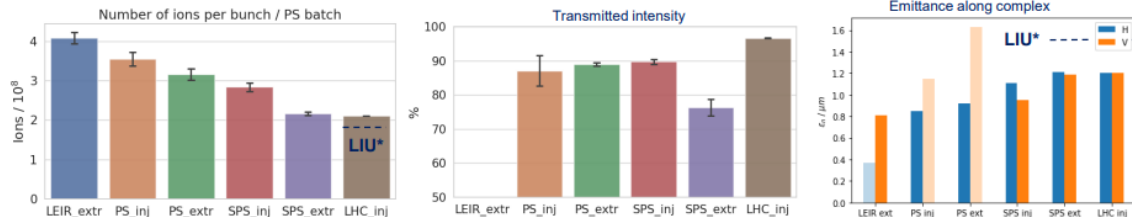
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Phone: 77500 or 70475  
Comments (26-Nov-2022 17:53:54)

- Fine tuning of EA and NA user requirements (ASM?) and rate limitations
- SFTPRO tests of multi-user flat top in 2023

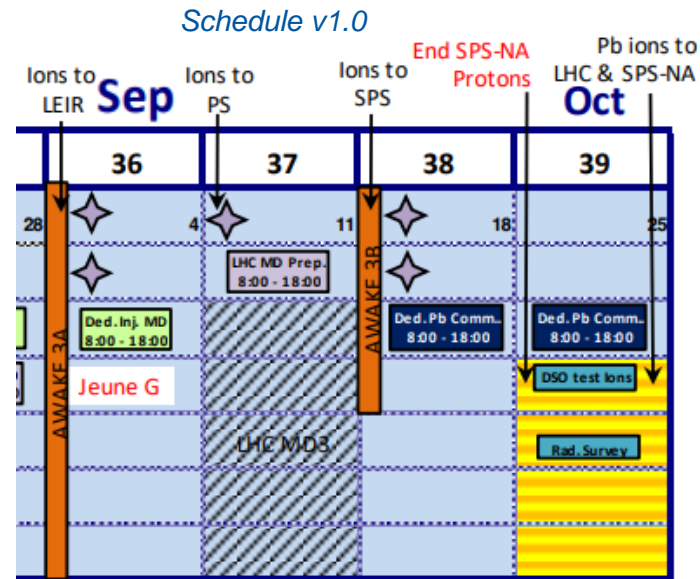
# Ions in 2023

## Intensity/Emittance evolution



- Intensity**
- Intensity above 14-injections LIU target ( $1.9 \cdot 10^8$  ions/bunch).
  - Transmission will reduce with 14 injections → to be tested/measured in 2023.
  - Can get more margin optimizing transfer in downstream machines → 2023.

- Emittance**
- Emittance below LIU target ( $1.5 \mu\text{m}$ )
  - Growth in V mainly in SPS, in H distributed from PS-SPS → input for machine models.
  - No yet reliable data for LEIR H, and PS V from BGI's → check/improve in 2023.



(\*) LIU target refers to 14 injections.

**LIU beam on track, efficient commissioning in 2022**  
**Enough time in 2023 for remaining items (14 inj + slip stacking with LLRF wideband pickup) and backup solutions from injectors (75ns) ?**  
**Schedule hand-over and training of ion experts**





# “Protons Not On Target”

Energy spent just to activate the machine?

30x beam loss reduction in straight section 15

buckets during the pilot run  
carrier, dummy septum in  $N_c = 30114$ ,  $N = 1757 \pm 13 \times 10^{10}$  ppp  
ier. d

- Measured dose rate at the TCSC of **80 mSv/h** at approximately 40 cm distance, after 30 hours cool down [5].

Combining both local and non-local systems brings losses down by 51%!

TECS in VR + TECA

- Non-local shadowing. Exploit non-linearities and implement beam to optimise loss reduction at the ZS via the
- To obtain a x4 loss reduction, simulations needed.
- Only crystals
- Installed in

Splitting efficiency improvements

Simulations in MADX suggest that a **5-crystal array** (1.8-mm-thick crystals) aligned in volume reflection may offer **5.5 times loss reduction**, but technology not available in near term.

TCSC front-face P. Arrutia

Improving transmission to experimental facilities  
Reducing activation of the machine

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Slow extraction improvements  
P. Arrutia

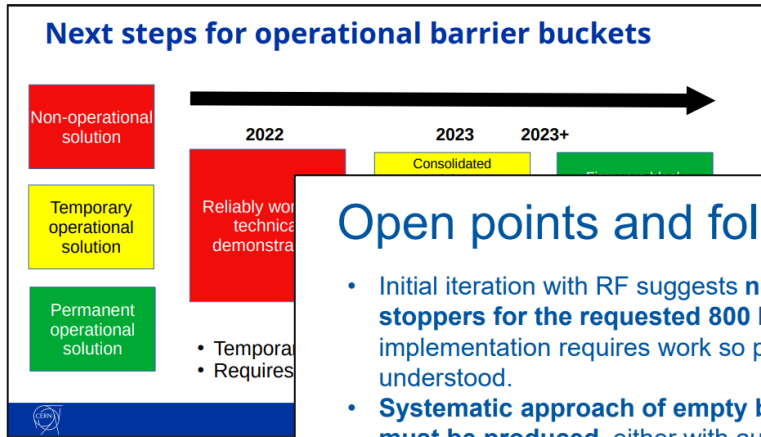
- angular acceptance (20  $\mu$ rad) and efficiency (70%).
- Simulations by the end of the year to characterize loss reduction with a 1.8-mm-thick
- Phase space folding** (longer-term)
- Manipulate the vertical phase space with non-linear magnets to flatten the
- Vertical distribution ideally preserved in the horizontal plane.

Important improvements developed during MDs -> MD format to be discussed at IPP MD days?



# Operational? What does that mean for new techniques?

~~Open BE-SY projects?~~



## Open points and follow-up

- Initial iteration with RF suggests **no apparent show-stoppers for the requested 800 MHz feature**, but implementation requires work so priority must be understood.
- **Systematic approach of empty bucket re-alignment must be produced**, either with automated tools or with written procedure. Consists of simple trim offset on frequency. Goes hand-in-hand with machine stability improvements (hysteresis)

Joint Accelerator Performance Workshop 2022  
Slow extraction improvements  
P. Arruti



15

## *My Bucket List*

- *Get an Empty Bucket*
- *Get a Barrier Bucket*

**What does it take to make them run for the next decade?**

# Operational? What does that mean for equipment?

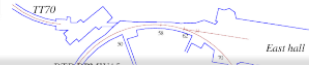
- **Common effort needed: BI/OP benchmarking campaign between BGIs and WS**
  - To find optimum settings for different cycles, different energies, different intensities/beam sizes
    - **initial focus on measurements at LHC flat top**



During 2022:

BGI-H: 2,049,174 profiles  
from 26,520 beam cycles  
BGI-V: 488,076 profiles  
from 8,659 beam cycles

ring



- New BGI:
  - BGI-Horizontal (PR.BGI82) is fully operational -

An extended BWS/BGI benchmarking campaign is needed in 2023 among BI, OP, ...

- Find common grounds between equipment groups and operations  
- Acceptance tests as part of the integration/commissioning?  
- Important also across the complex (BGI deployment...), requests for new equipment, extend use cases of available HW.

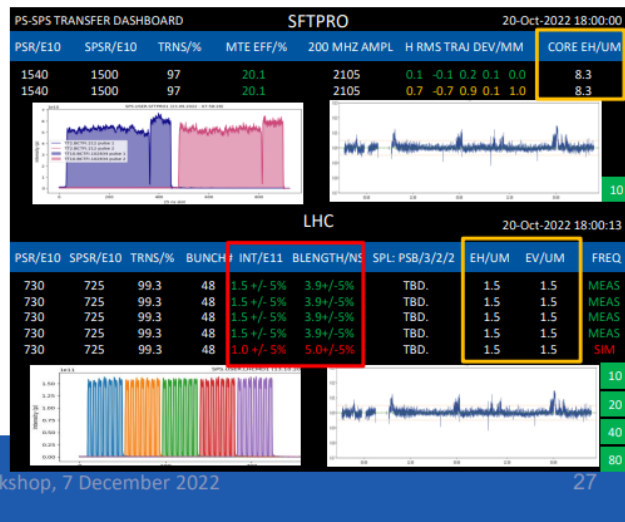
# Cross complex information transmission

## A concrete example to improve communication

### • PS-SPS transfer dashboard

- extension of SPS LARGERS to be used by PS and SPS
- main LHC and SFTPRO quantities on a single screen
  - splitting quality
  - transmission
  - cavity status
  - bunch number
  - RMS trajectory deviation in TT2/TT10
  - frequency (simulated vs. real)
  - fast BCT comparison TT2/TT10
  - ....
- including **history plots** for e.g. intensity, cavity status, PSR-SPSR transmission, etc.
- color coding to indicate status, values exceeding limits (tolerance definition!), etc.

- Agree together on most useful quantities





[www.cern.ch](http://www.cern.ch)

# Charge questions

- Understanding the requirements
- Where are the limits?
- Where should we put our attention?
- What's the vision for the future?
- Actions for follow up

# Understanding the requirements

- Most important lessons from 2022
- Key experiment/client desiderata for 2023
- Experiment preferences, i.e. peak performance vs. reproducible performance, etc.
- Are there new experiment/client requirements for 2023 or beyond? What do these imply for the machines?

# Where are the limits?

- Review of performance ramp-up progress (LIU beams, LHC)
- What are bottlenecks to performance, in terms of maximising beam for physics and data-taking? How can these be improved?
- What needs to be improved for more efficient, reproducible operation?
- Where should availability get even better?
- Are the measurement metrics, instrumentation and tools adequate? If not, what needs to improve?
- What are the priorities for overall performance improvement (in terms of useful physics beam delivered)?



# Where should we put our attention?

- Where should the main focus be in 2023 (and possibly beyond) for the key performance improvement threads?
- What are the specific recommendations on fixes/upgrades/additions for improving equipment (HW, SW) ?
- What are the specific recommendations for improving operating the complex (tools, procedures, schedule, coordination)?
- What needs a specific decision process (e.g. on longer-term perspective)?

# What's the vision for the future?

- What are the longer-term prospects for doing more physics with less time and less overall power consumption?
- Is increased beam intensity per cycle compatible with beam losses, equipment and experimental limits?
- What are the priorities for CONS or for new developments/breakthroughs?
- Are there any new ideas for performance improvement or synergies to explore?
- What is holding us back in terms of communication, meetings and our decision process?
- Has it made sense to treat injectors and LHC together in this workshop? What are options for the future?

# Actions for follow up

- What are the specific actions (including deadline and responsible group)?