

Consequences and opportunities of Run 3 extension

With a focus on commissioning

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Content

- Context & Motivation
- Key opportunities & challenges in the Injector's complex
- Machine-specific impacts
- LIU Reliability Run proposal
- Conclusions

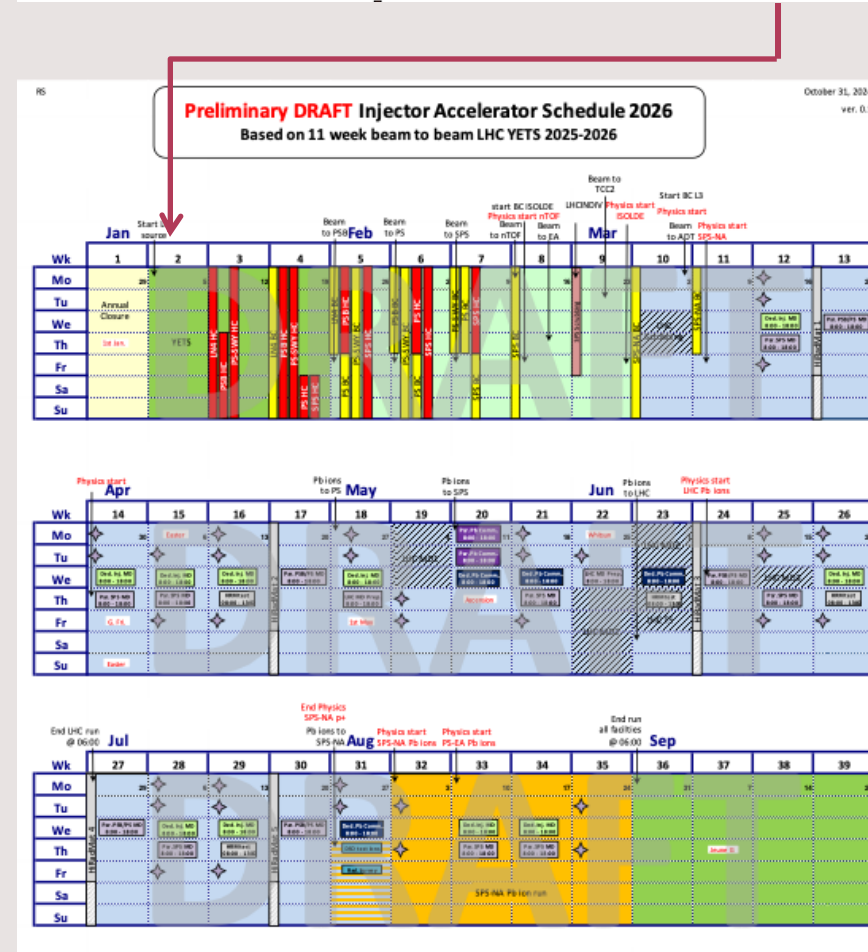
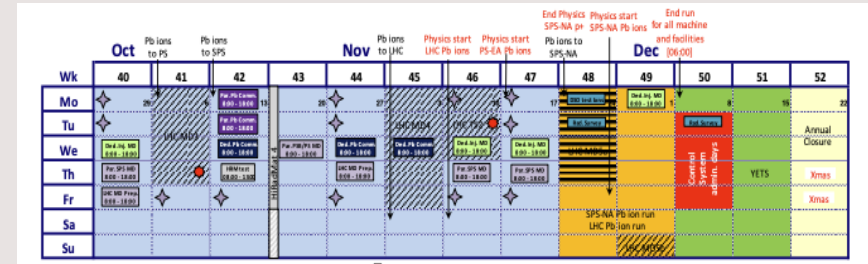
Context

Long Shutdown 3 (LS3) postponed from
17 November 2025 to 31 August 2026

For Injectors this means around 9 months
of extended Run 3

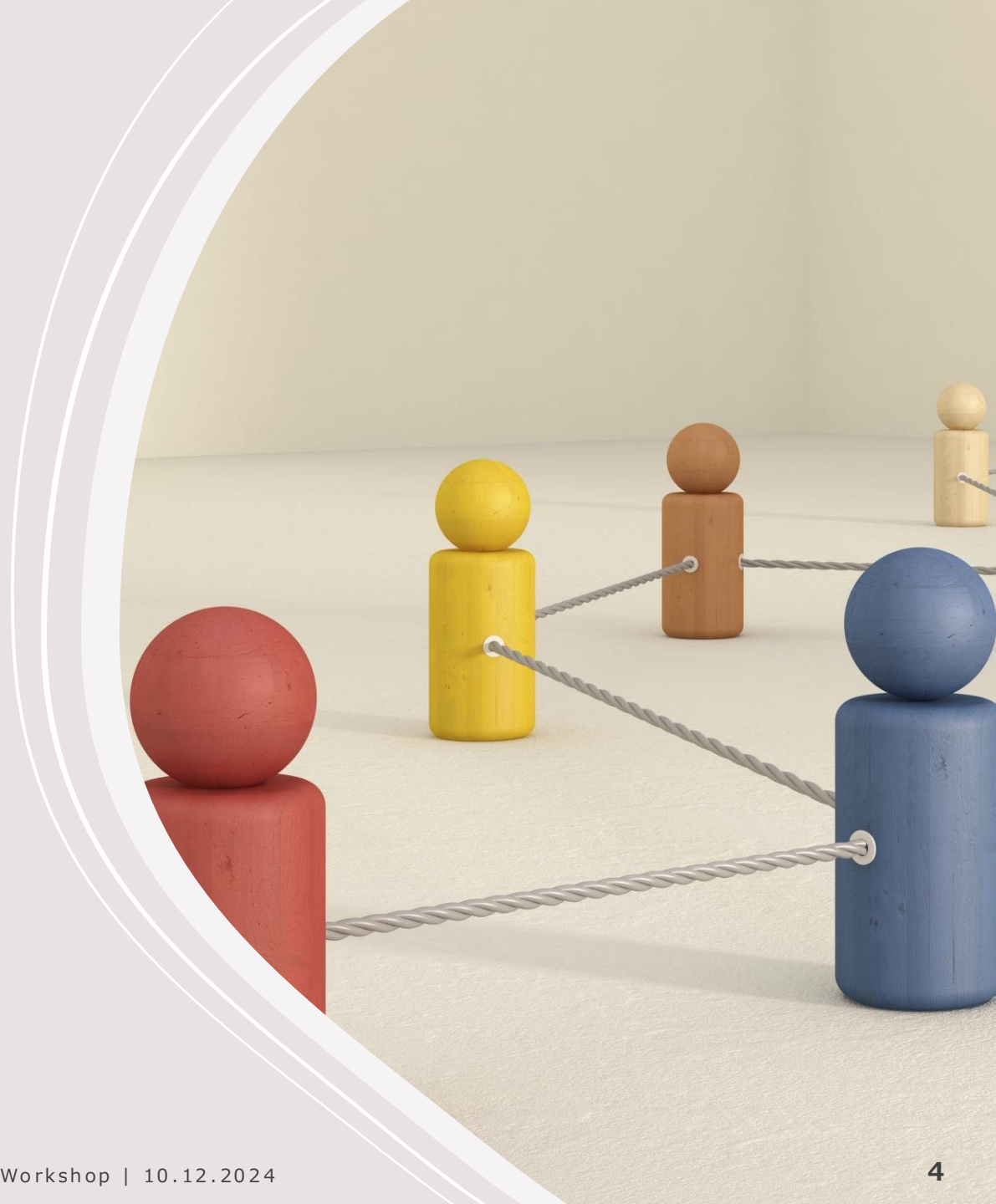
YETS 25/26: 11 weeks beam-to-beam for
the LHC

Commissioning: Unknown duration for
now but anticipated to be short



Motivation

- Run 3 extension opens **opportunities & challenges** for **all machines** in the Injectors Complex in terms of operation & maintenance
- The goal of this presentation is to **highlight potential gains** and **risks** from the 2026 schedule modifications
- **Gathered input** from key **stakeholders** on the implications for their areas of responsibility
- Disclaimer: Final decisions are pending **careful assessments** from various teams & 2026 schedule **is not finalized yet**





The big picture



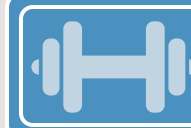
Overview of opportunities from 2025/2026 schedule changes



Commissioning new software & hardware



Additional MD and preparation time (SHiP beams, LIU beams)



Extend training for new staff



LIU Reliability Run

Overview of consequences from 2025/2026 schedule changes



Short YETS

No large-scale interventions

Limited intervention time

Preventive maintenance only for critical equipment

Short commissioning period

Limited time for fine-tuning settings

Aggressive commissioning
[see Piotr's talk in JAP 22]

Limited pool of experts

Extended injectors run

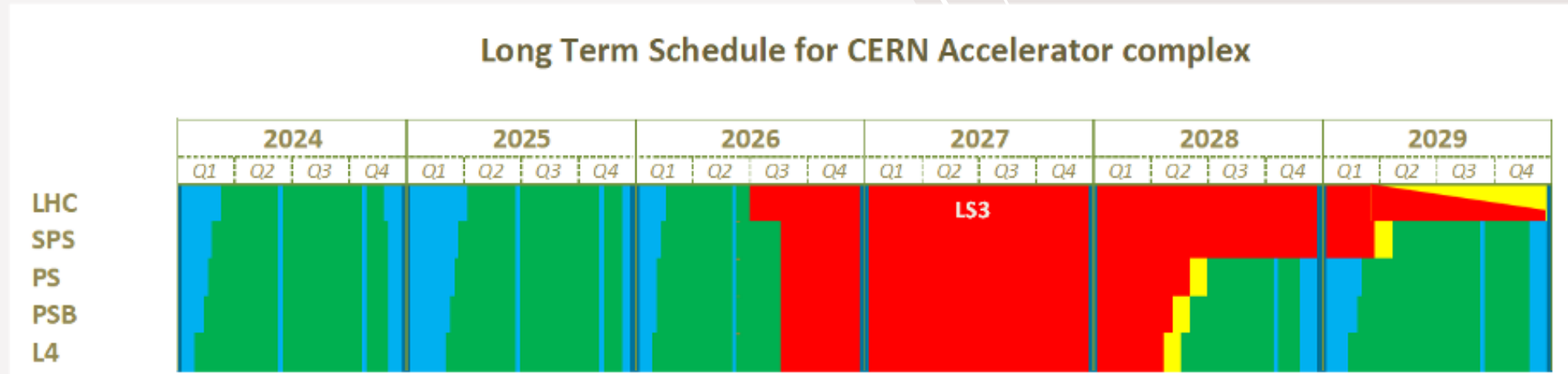
Downtimes from aging equipment

Strategy for critical spares inventory

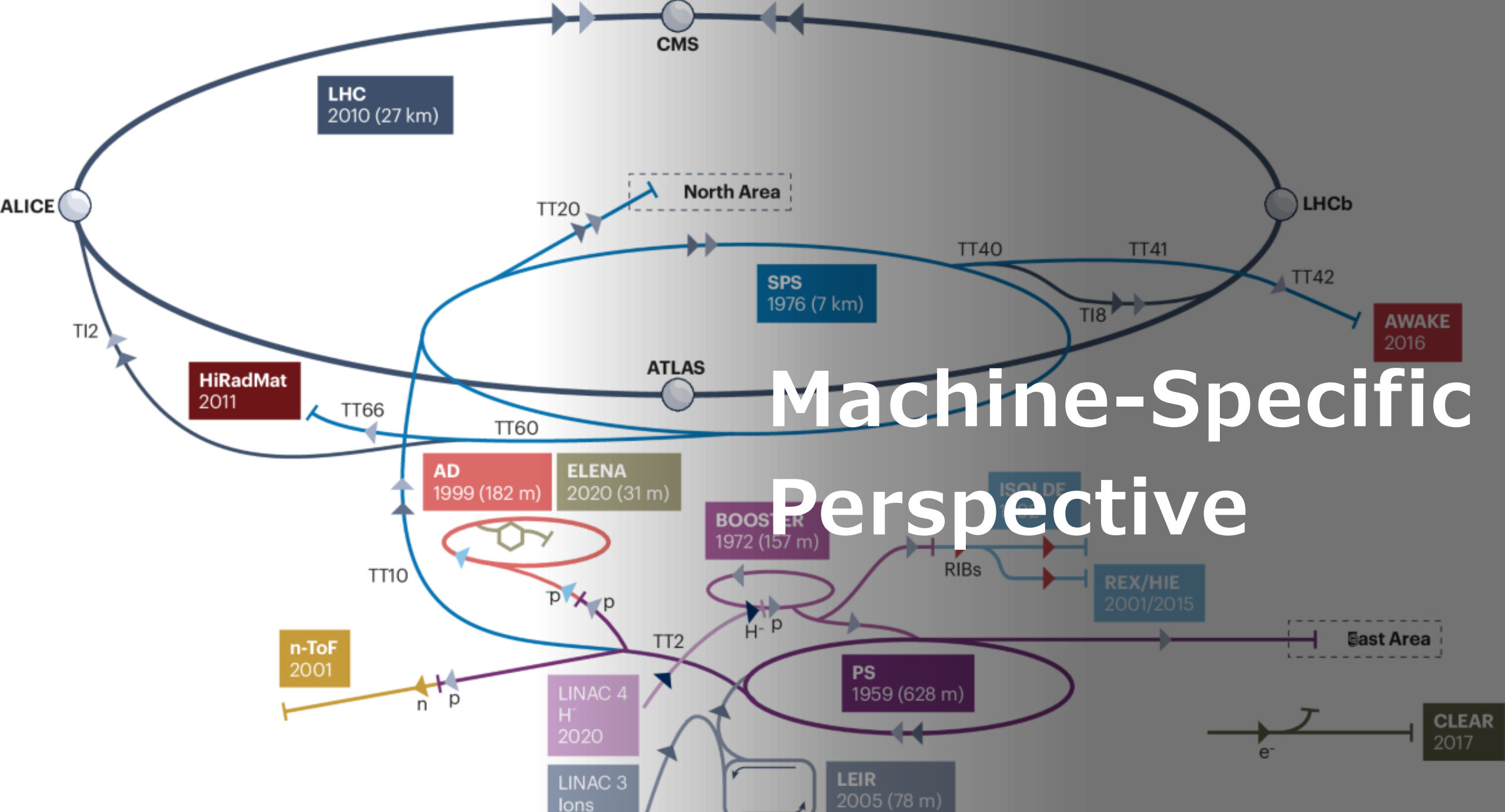
Longer downtimes cost more

* Truth or Consequences, NM, USA
[33°08'07"N 107°15'10"W](#)

LS3 Extension and resources



- LS3 has been **extended by one year** beyond the original schedule
- **LD Staff:** Many recently hired LD staff have contract end dates falling within shifted LS3, creating a gap in operational resources.
- **IC Staff:** Senior IC staff who were expected to remain operational until 2028 may now retire during LS3, reducing operational experience.
- Ensuring **sufficient operational manpower** in 2029 will require planning for contract extensions and resource allocation.



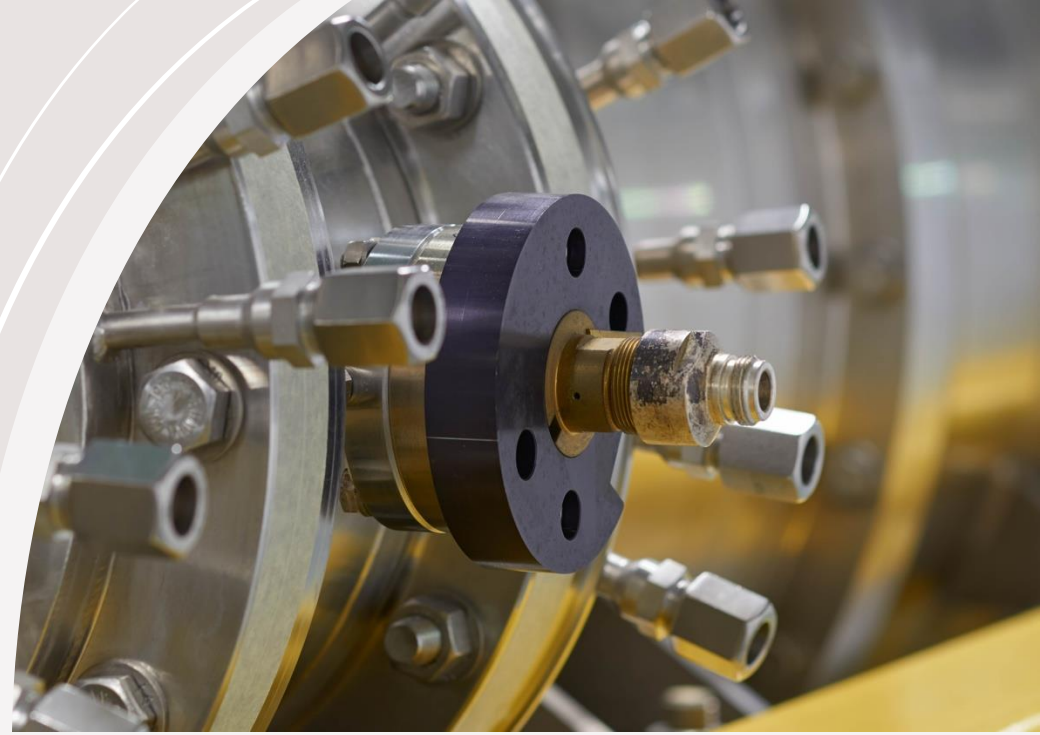
Linac 4 & PS Booster

Consequences

- **Short** YETS restricts the time window for checks of critical components (e.g. water leaks in magnets is a recurring issue in PSB)
- **Critical to perform maintenance** on Linac 4 source and PSB main magnets during YETS 2025/2026 but this leaves less space for other tasks

Opportunities

- Opportunity to **increase LN4 output current** and gather **operational experience** in 2026 extension run
- **Check-point** in 2025 to assess the situation, final LN4 strategy in 2025-2026 YETS
- **ISOLDE** will not run in 2026 so additional time can be invested in **refining PSB operations** (less populated supercycle)
- **Consolidate & optimize** operational settings (e.g. transverse shaving of the beams, RF interlocks)
- **Development & deployment** of new tools for HI beams (e.g. orbit optimization)
- **Injection bumpers:** End of life unknown, operation during 2026 extension **could bring better understanding** on their behaviour



Proton Synchrotron

Consequences

- **Limited RF cavities intervention time** during YETS 2025/2026 considered a **risk for operational downtimes** during short 2026 run
- **Tight beam commissioning anticipated:** If this is the case, LIU beams should become a priority to deliver for scrubbing in SPS
- **Aging KFA71 controls:** In good shape but **due for replacement in LS3**, meaning any delay extends reliance on current capabilities

Opportunities

- **BGI detector** should be ready in 2025 and **become operational** in 2026 run
- **SMH16 new eddy current septum:** Possibility to be installed during YETS 2025/2026 (a **reduction of average flux to n_TOF** in last week of proton run would be beneficial) **but** risks of **compromising 2026 PS run** should be carefully evaluated by experts
- **Consolidation** of the **HV generators** for electrostatic septa during YETS 2025/2026 and their **evaluation before LS3**



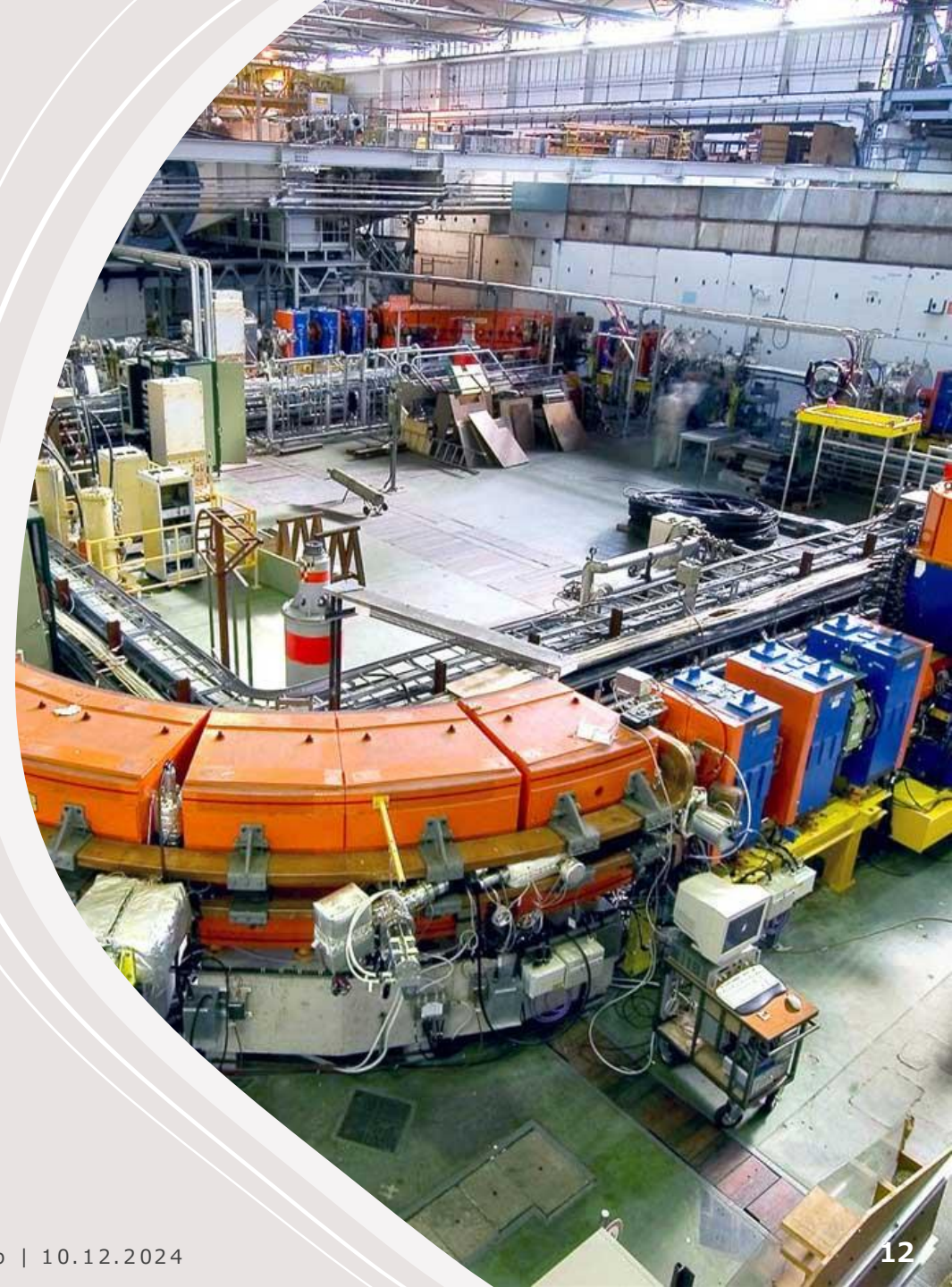
Low Energy Ion Ring

Consequences

- Delay of LS3 and short YETS will put **additional fatigue** in aging equipment
- **IPM sensors:** Earlier LS3 or longer YETS would have provided a better opportunity for **maintenance** and **upgrades**

Opportunities

- **Beam dynamics studies** on incoherent effect and optics in 2025 & 2026
- **Hand-over to OP** new tools such as **ML Optimizers** & **BPM-based ToF system** extensively used by experts during 2024 ion run for injection, RF capture, energy measurements
- **Optimize operational settings in synergy** with Linac 3 during ion commissioning in 2026



Super Proton Synchrotron

Consequences

- **Shorter scrubbing period & No Inj. Dedicated MDs** in 2026 before Physics which could be used as additional scrubbing slots
- Ongoing improvements to SPS RF cavities **can mitigate impact of a shortened scrubbing period** [see Sam's talk in this workshop]

Opportunities

- **Ion commissioning** in parallel with **proton commissioning** [see Kevin's [talk](#) in JAP 2023]– Not possible in 2025 (O Run) but could be **demonstrated** in 2026 commissioning (**2026 schedule should be finalized and assessed from LN3 & LEIR experts**)
- **Operational tests of BGI detector** planned in Q4 2025 [see Jame's [talk](#) in SPS MPC #71]. **Opportunity** for extensive use from OP in 2026
- **Crab Cavities** work on going, MDs to be scheduled in 2025. Run 3 extension provides additional time for further studies/MDs [see Rama's [talk](#) in SPS MPC #74]
- **New crystal** for slow extraction in 2026 and this is the **only** opportunity to test it before LS3
- Many **optimizers** available in the SPS (ZS alignment, splitter losses etc.) extended run could be used for **automatization** work (**EPA WP8 task force** [see Kostas' [talk](#) in JAP 23])
- **SHiP project: Important milestone** in **2026** to perform **MDs in the SPS** (SHiP cycle, novel extraction techniques [see Matt's [talk](#) in IEFC #357])



Opportunities revisited: LIU Reliability Run proposal

When & How?

- During 2026 Run 3 extension, fill Injectors with LIU beams periodically for 3 months (flexible)

What to check?

- Define & monitor KPIs e.g. emittances @ PSB, splitting @ PS, stability @ SPS

How will it help?

- Characterize beam quality as well as critical equipment performance before LS3

Why it matters?

- Get LIU beam in operational state and hand-over to OP



Opportunities revisited:

LIU Reliability Run proposal

- **Simulate** LIU fillings for **HL-LHC** after **LHC fills in 2026 Run**, if SPS is not in a **dedicated MD** slot
- Flexible 30-minute checks from OP of **LIU beams up to flat-top** with up to **10 hours of total testing time per week**
- **Mid 2025 checkpoint** to assess beam progress and ensure readiness for 2026 goals
- **Possibility** to allocate part of **long parallel MDs** focused on beam optimization, if needed
- Leverage **BPT tools** for monitoring of KPIs & **work on global monitoring tools** (e.g. emittances along the Injector's chain)
- Need to decide on **beam flavour** (standard, BCMS, 8b4e, ..?)
- The LIU RR supports "out-of-comfort zone" operation for **critical systems like RF** to improve robustness and operational readiness



Conclusions

- Extended Run 3 allows for **commissioning, fine-tuning operational settings,** and conducting **beam studies** to strengthen **post-LS3 readiness**
- Leverage the **LIU Reliability Run** to prepare for HL-LHC, prioritize **risk mitigation** for critical systems, and **train new staff** to ensure smooth post-LS3 restart
- Risk of losing **experienced** LD and IC staff due to contract expirations and retirements during LS3, **requiring early planning** for 2029 restart
- Tight 2025/2026 YETS & commissioning **reduces intervention time, limits preventive maintenance** and **increases dependence** on 2025 operational settings
- **Delays** in LS3 replacements of **aging equipment** increase the risk of failures

A scenic view of a city built on a hillside overlooking a large body of water. The city features a prominent white skyscraper and various residential buildings. The foreground is filled with vibrant yellow and blue flowers. The sky is clear and blue.

Thank you for your attention