Accelerator Availability in the First Half of 2024 and AFT Update

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with thanks to
- J. Uythoven, D. Wollmann
- everybody who provides data for AFT
- the AFT team
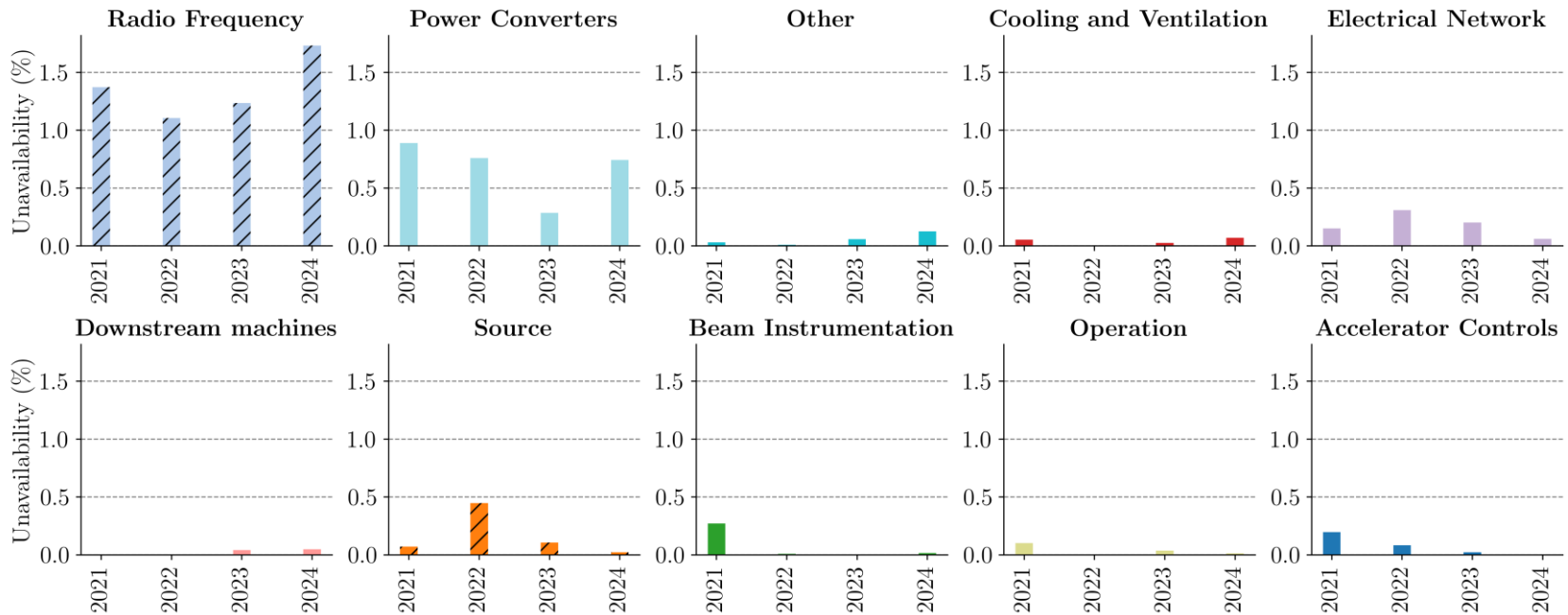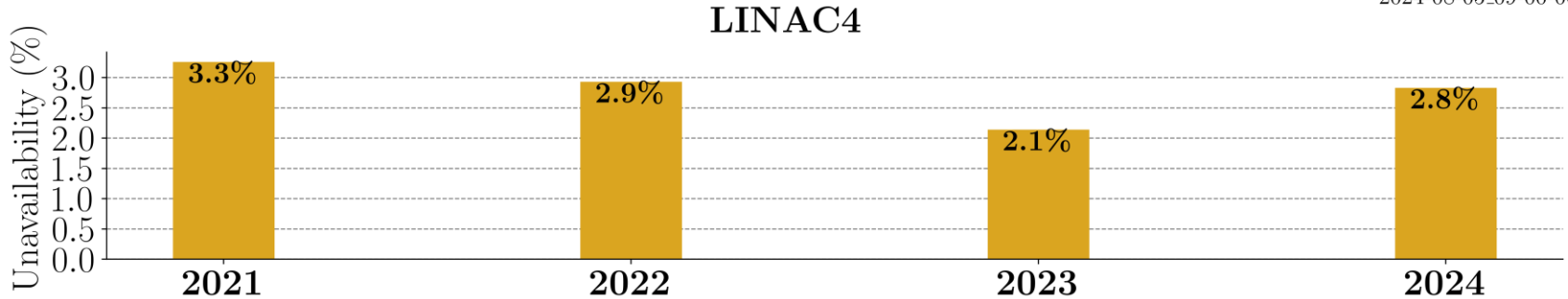- and everybody who constantly checks and validates AFT data

Outline

- Mid-year AFT analysis to help equipment teams reacting within the run to potential trends

  ➢ LHC and proton injector chain

  ➢ Dates: from start of physics to 05/08/2024 9:00:00

  ➢ Usual excluded time periods (TS, dedicated MDs, other scheduled interventions)

  ➢ All graphs shown in the slides are available on Gitlab and will be regularly updated

  ➢ https://gitlab.cern.ch/mpe-reliability-tools/aft_processing/-/tree/master/output

- Feedback concerning AFT expert review rates
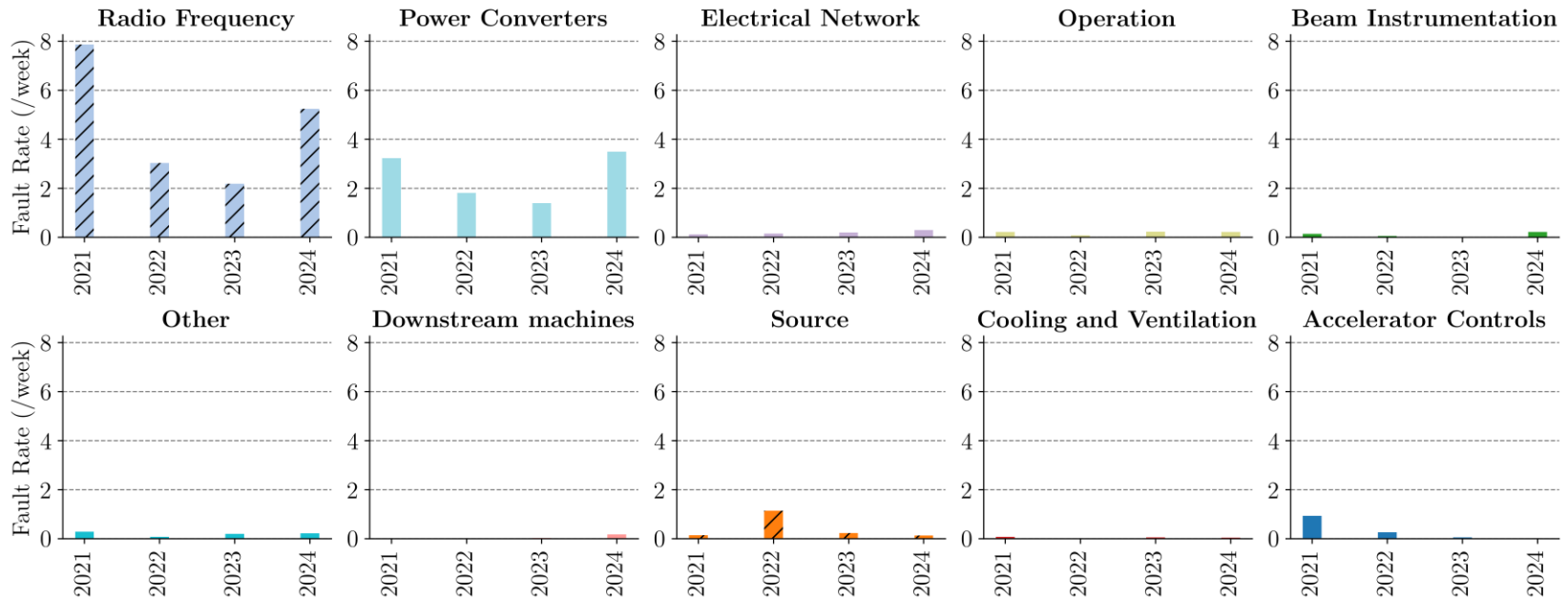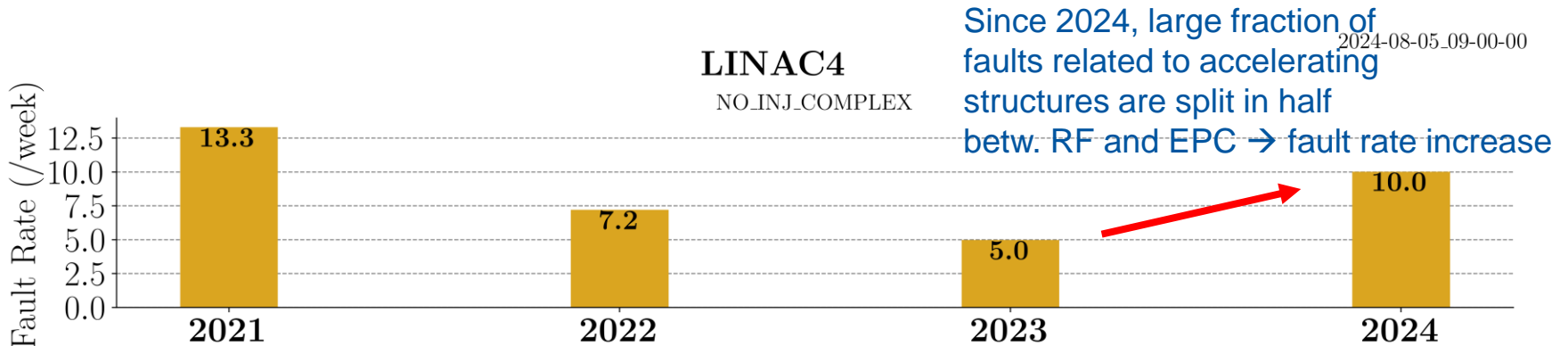
- AFT news

Definitions

- **Fault**: deviation from nominal operation as defined in accelerator schedule

- **Root-cause statistics**: downtime attributed to system causing the fault

- **Availability**: Fraction of scheduled operational time that machine is available for operation
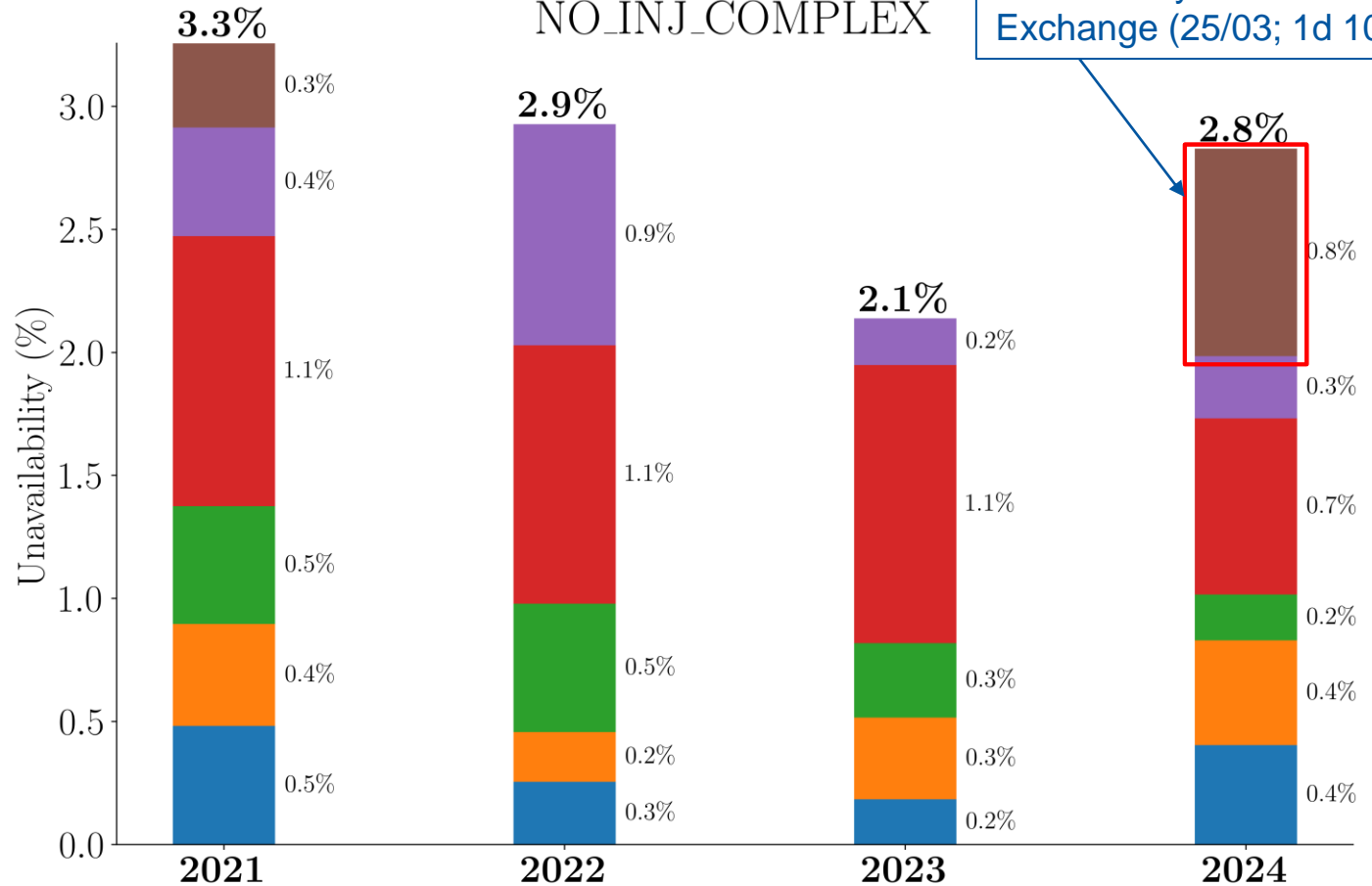
Linac4 Unavailability

Linac4 Weekly Fault Rate

Since 2024, large fraction of faults related to accelerating structures are split in half betw. RF and EPC → fault rate increase

2024-08-05_09-00-00

Linac4 Unavailability by Duration

PSB Unavailability (w/o Inj. Complex)
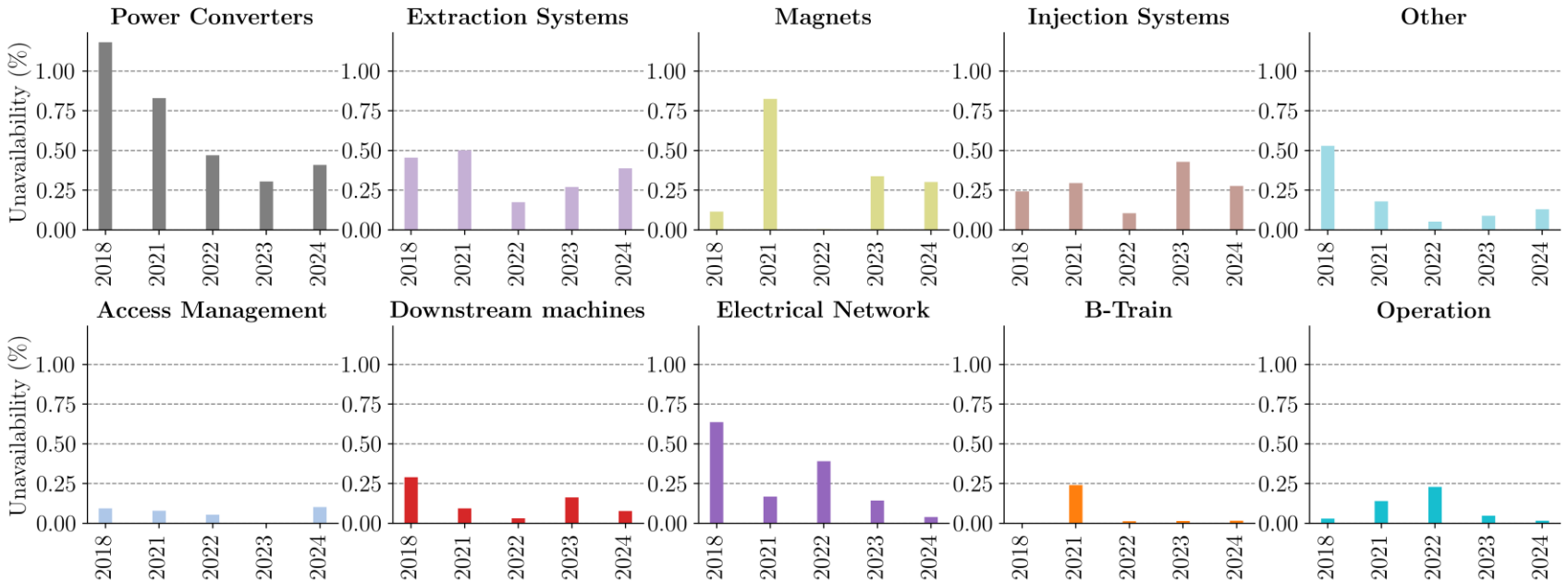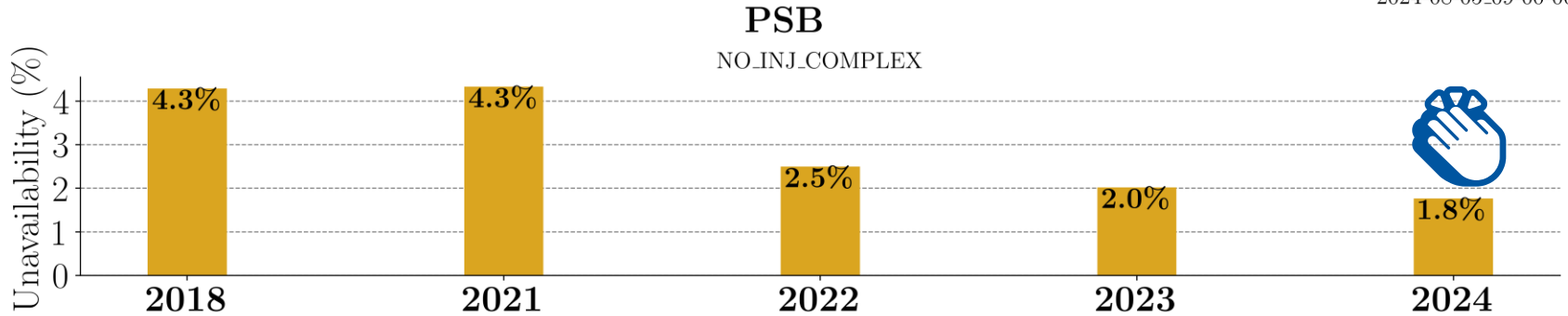
PSB Weekly Fault Rate (w/o Inj. Complex)
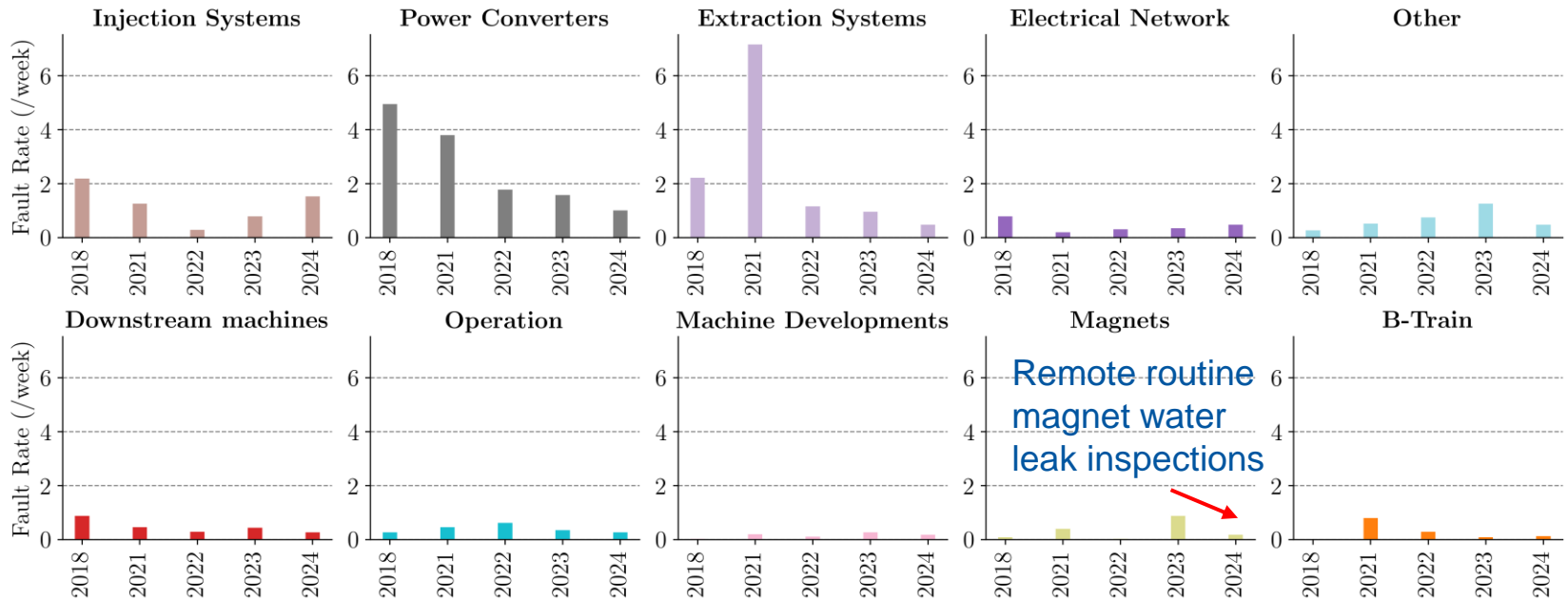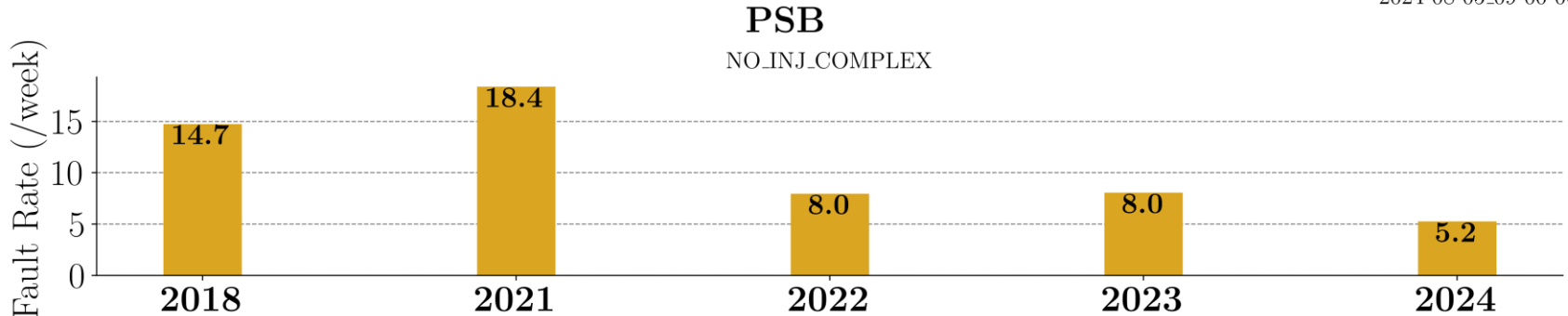
PSB Unavailability by Duration (w/o Inj. Complex)
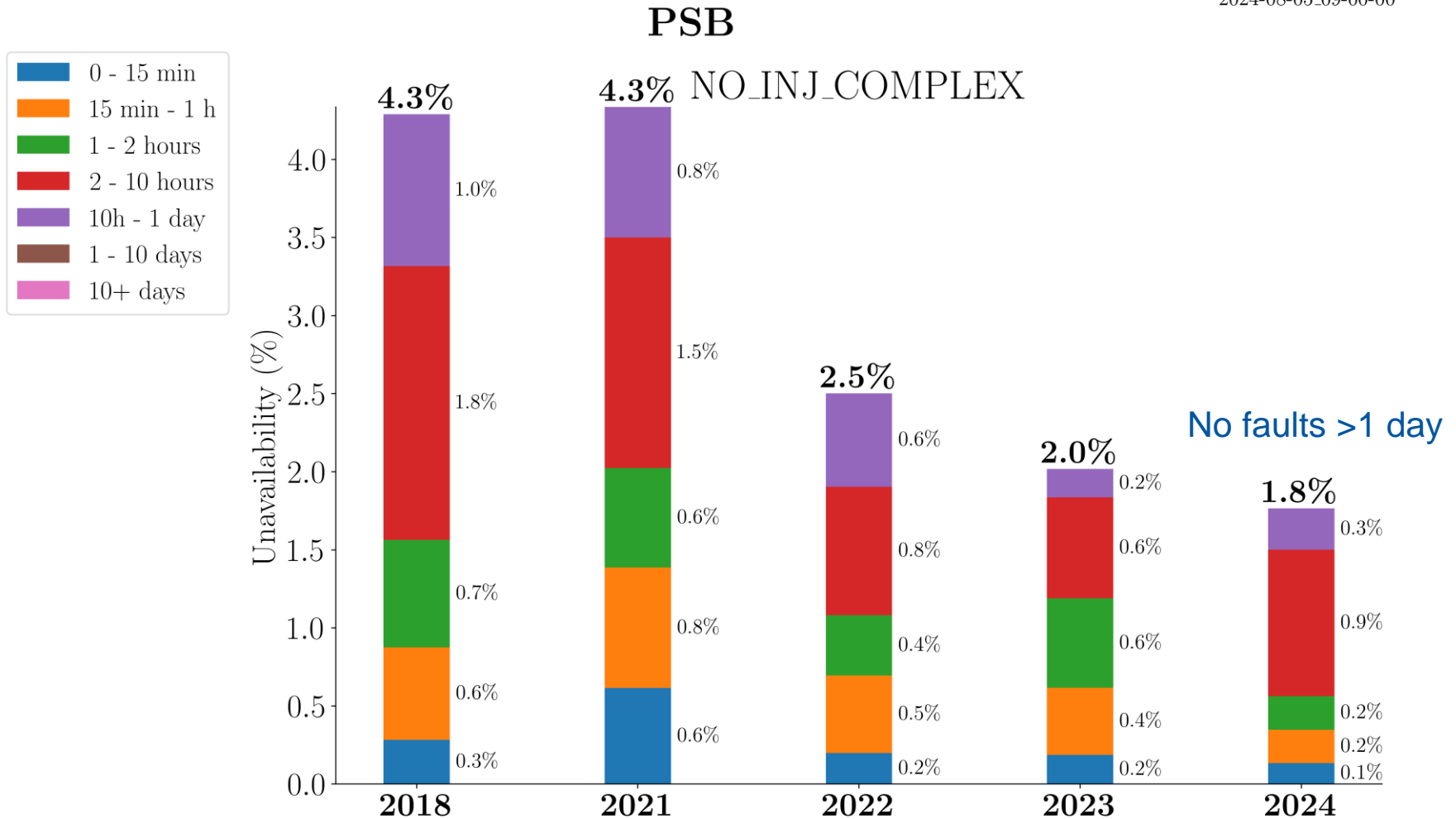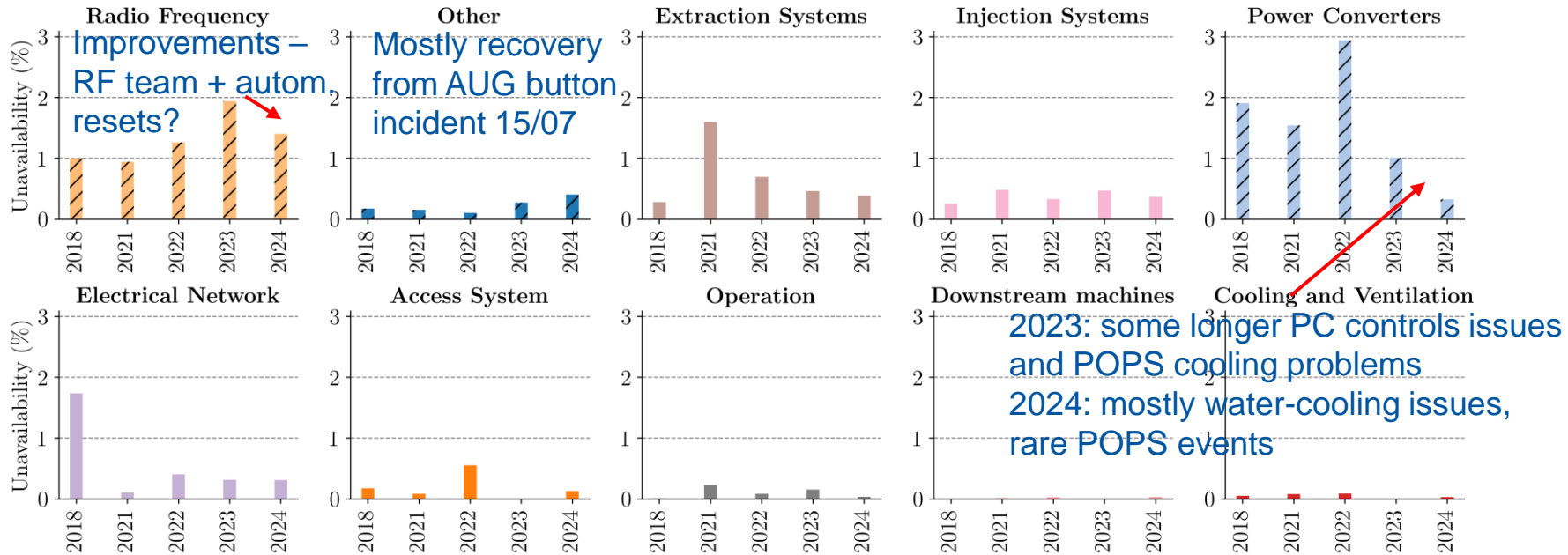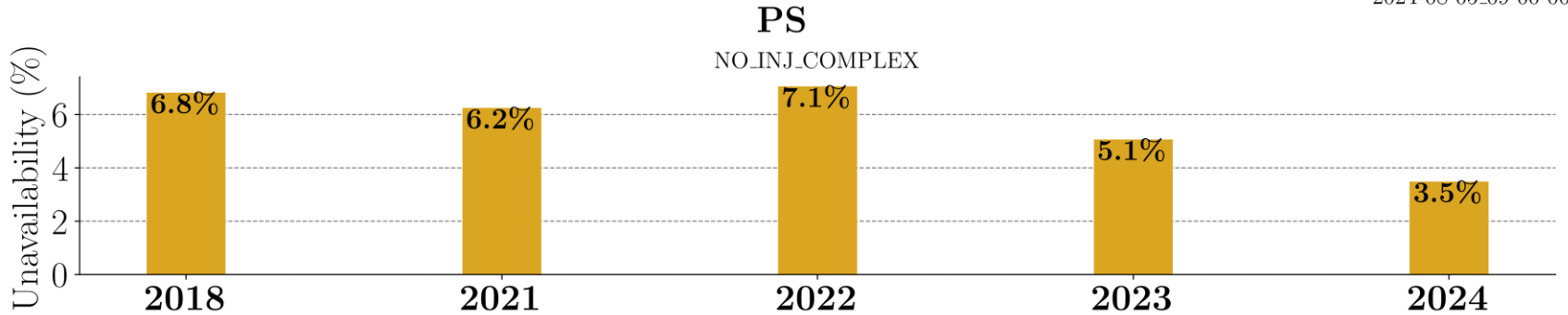
PS Unavailability (w/o Inj. Complex)
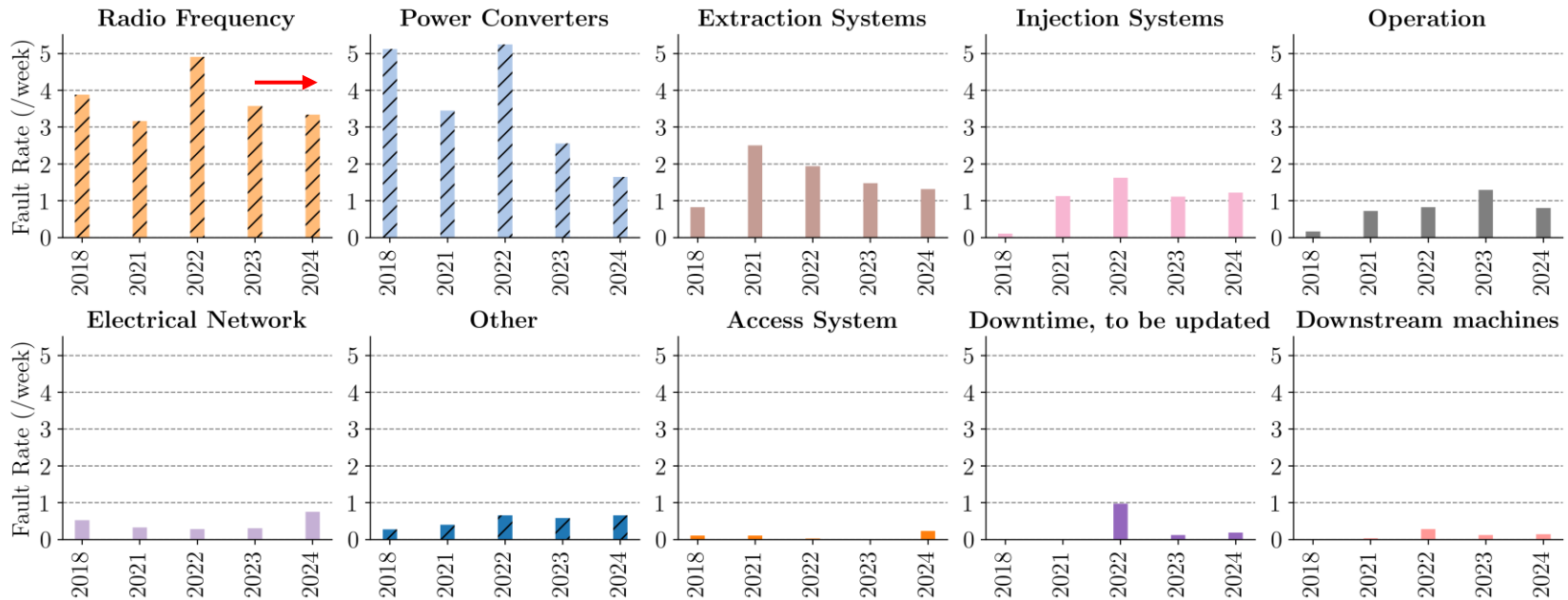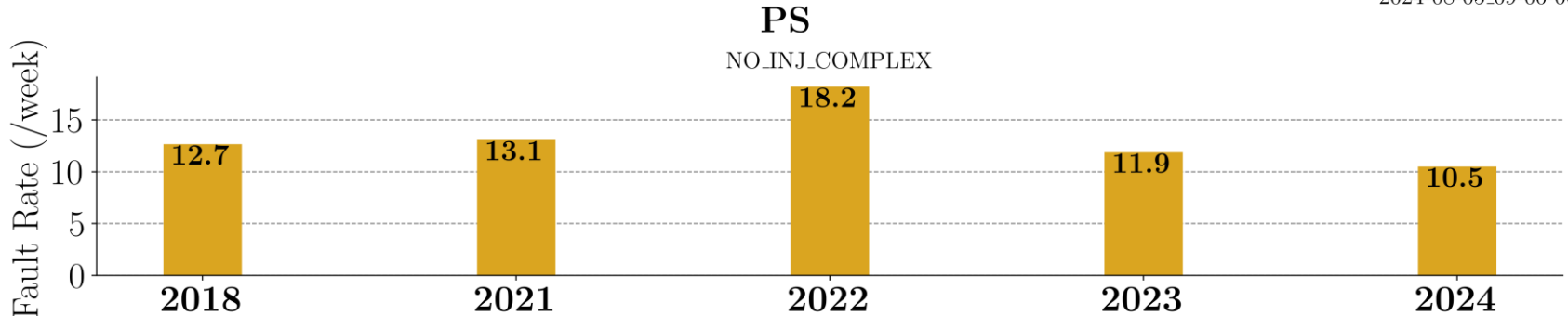
PS Weekly Fault Rate (w/o Inj. Complex)

PS Unavailability by Duration (w/o Inj. Complex)
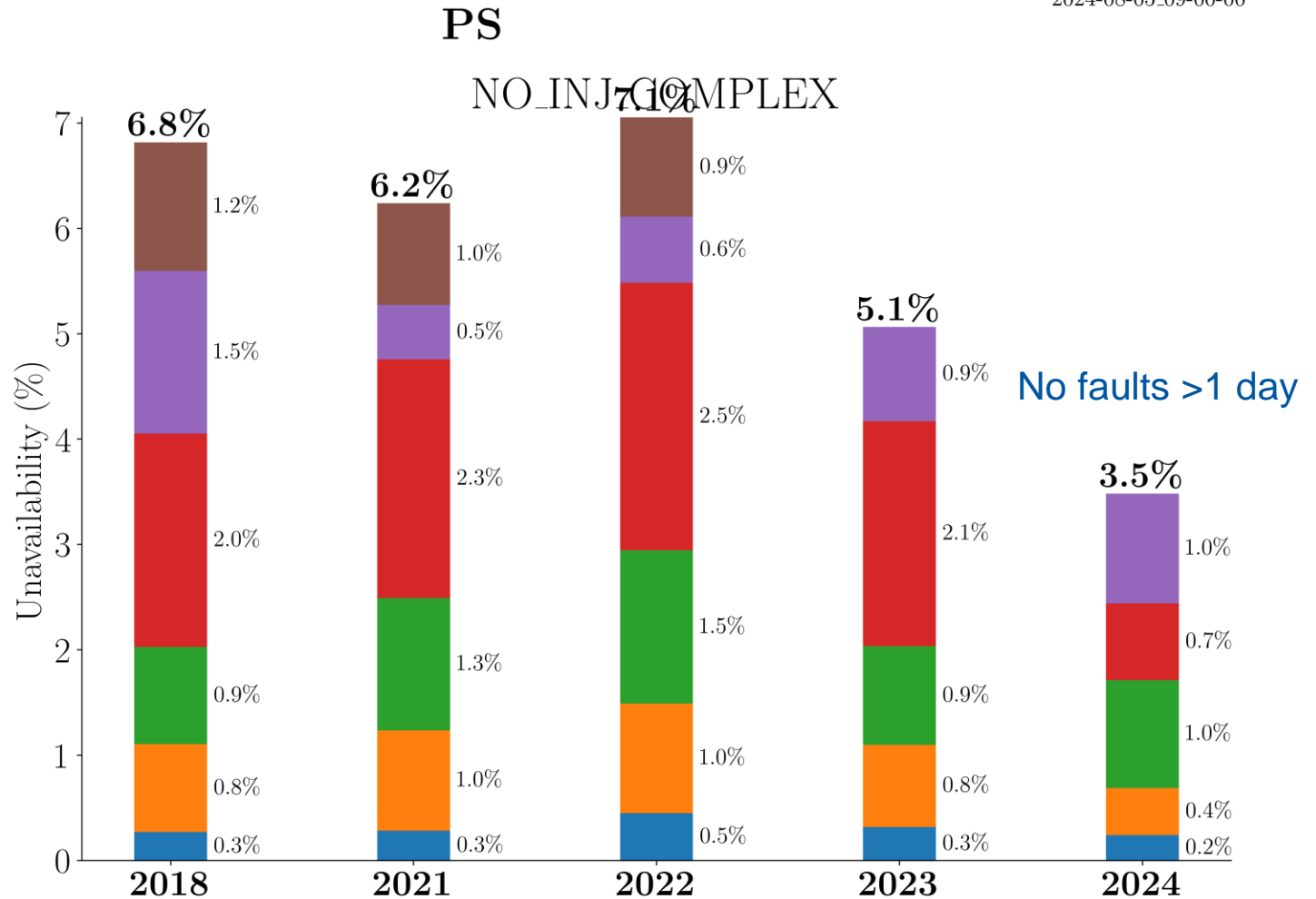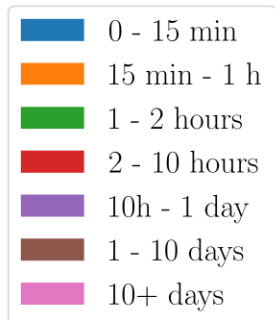
SPS Unavailability (w/o Inj. Complex)
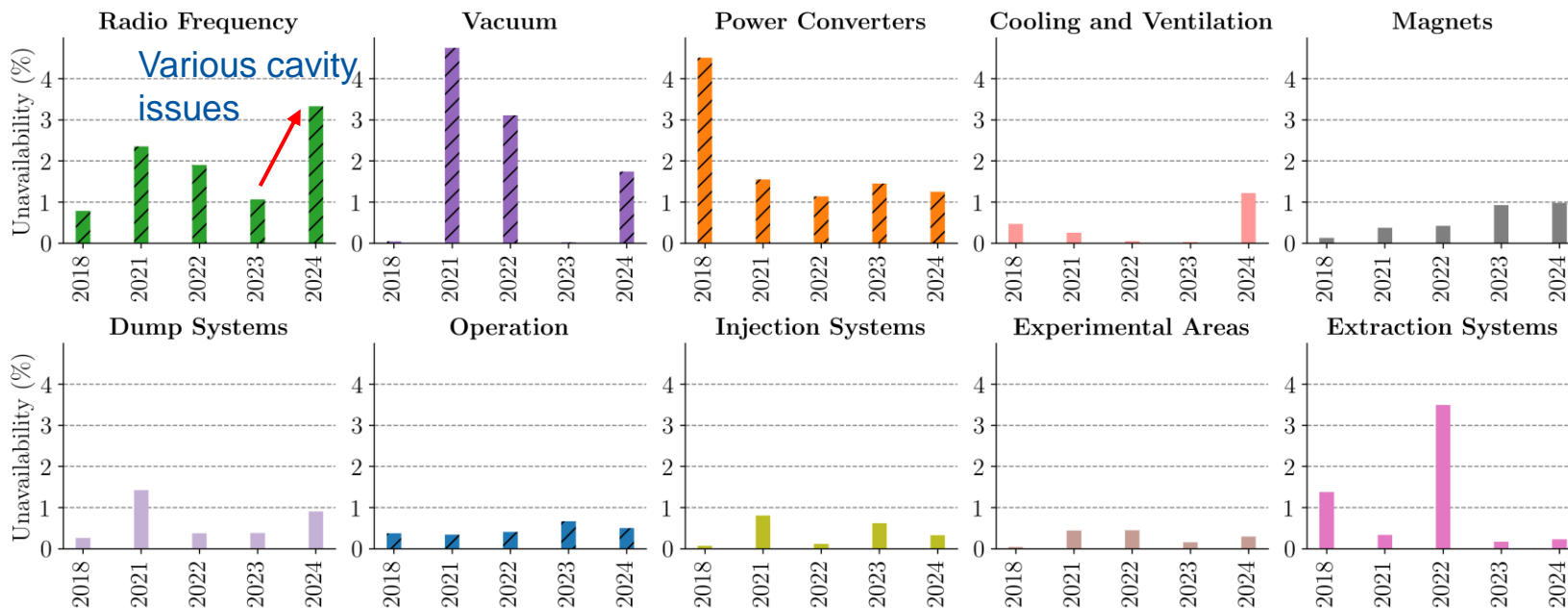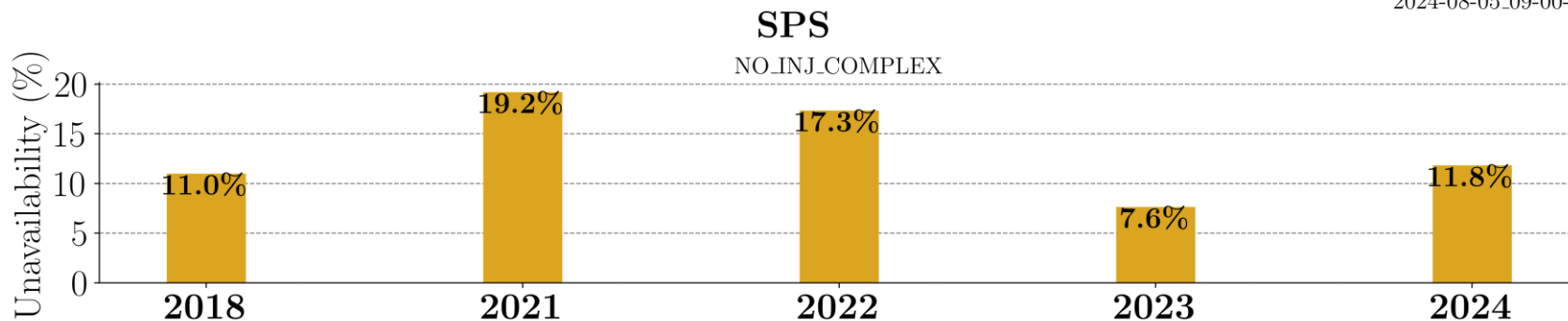
SPS Weekly Fault Rate (w/o Inj. Complex)
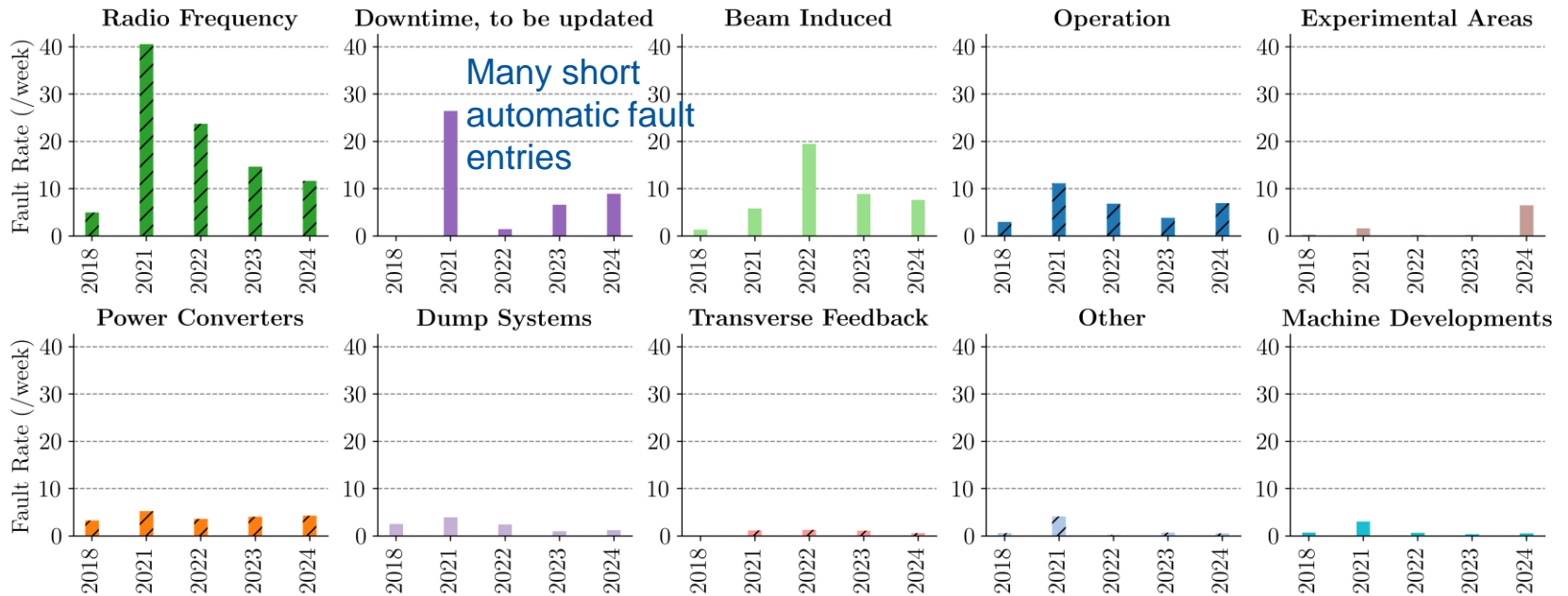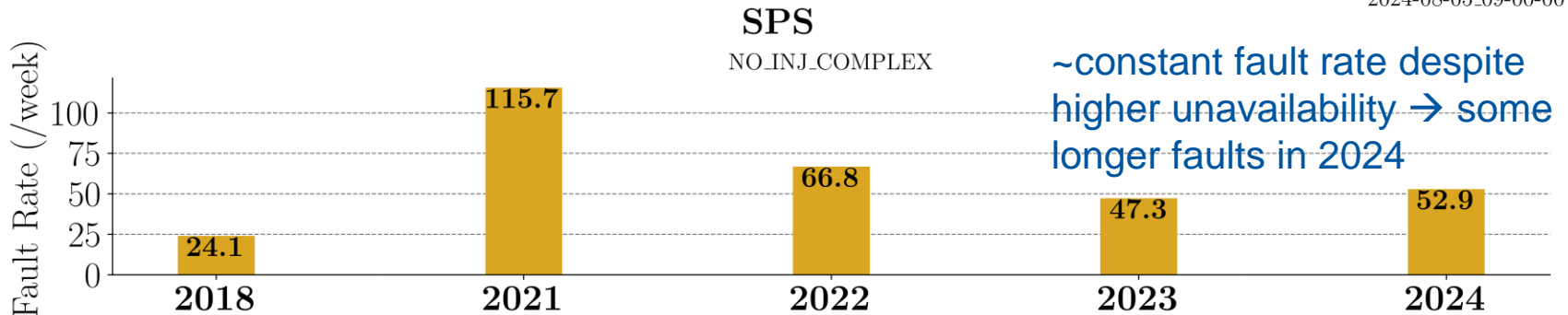
~constant fault rate despite higher unavailability → some longer faults in 2024

Many short automatic fault entries

SPS Unavailability by Duration (w/o Inj. Complex)
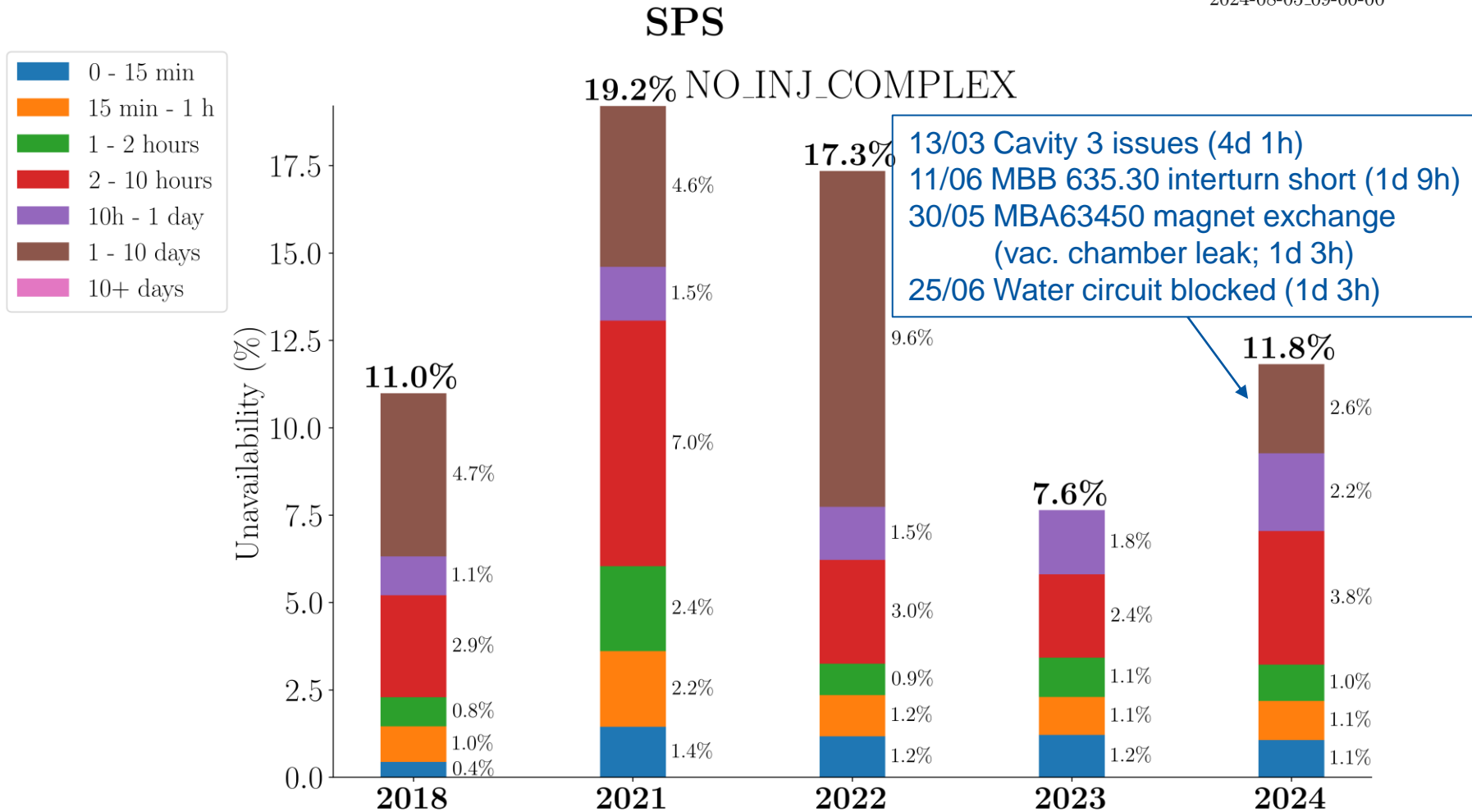
LHC Unavailability (w/o Inj. Complex)

Start statistics with start of Stable Beams; only proton run period

LHC_protons
NO_INJ_COMPLEX

R2E due to lumi push or/and longer repair times?

Accesses, recovery, heat load recovery
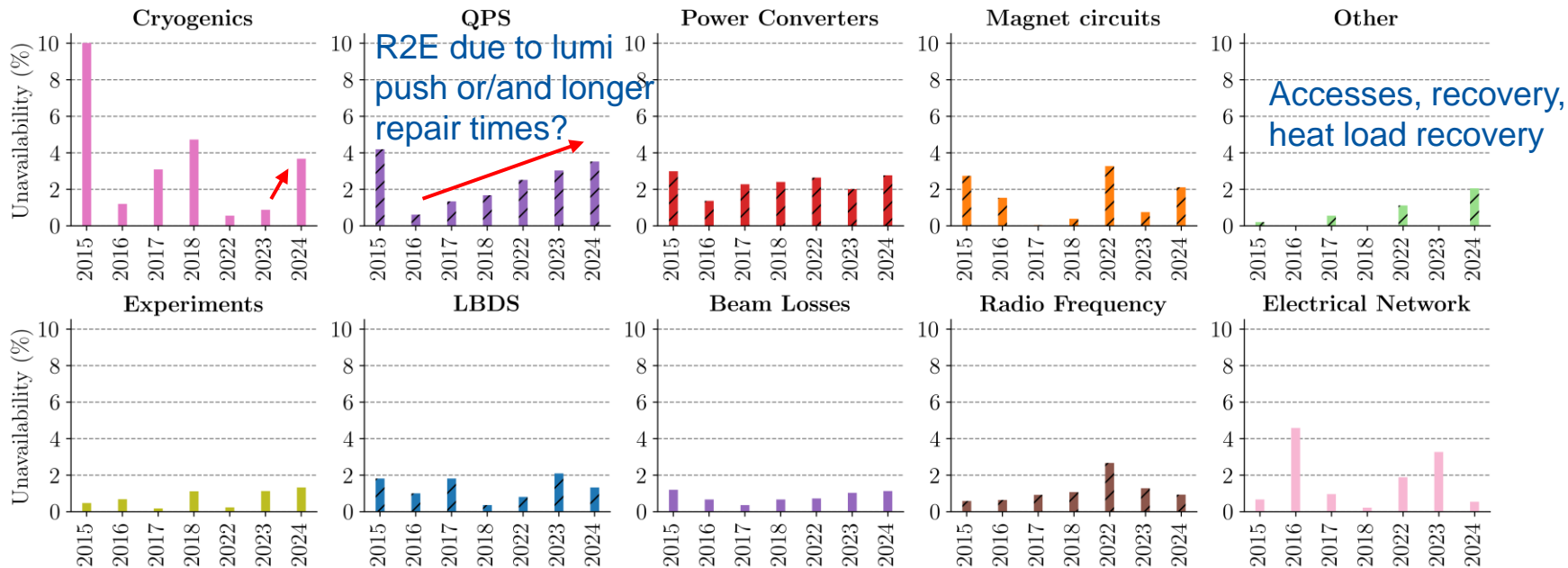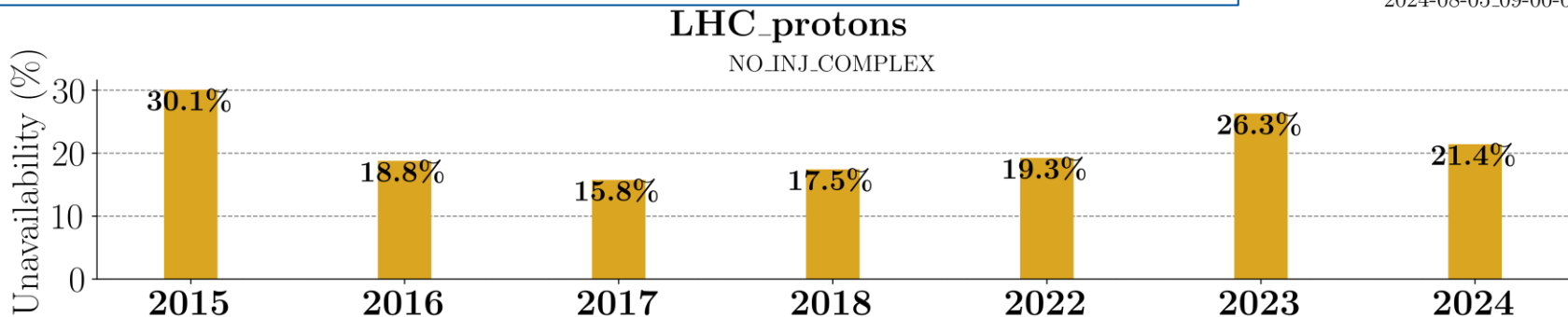
LHC Unavailability (w/o Inj. Complex)

Including turnaround penalty
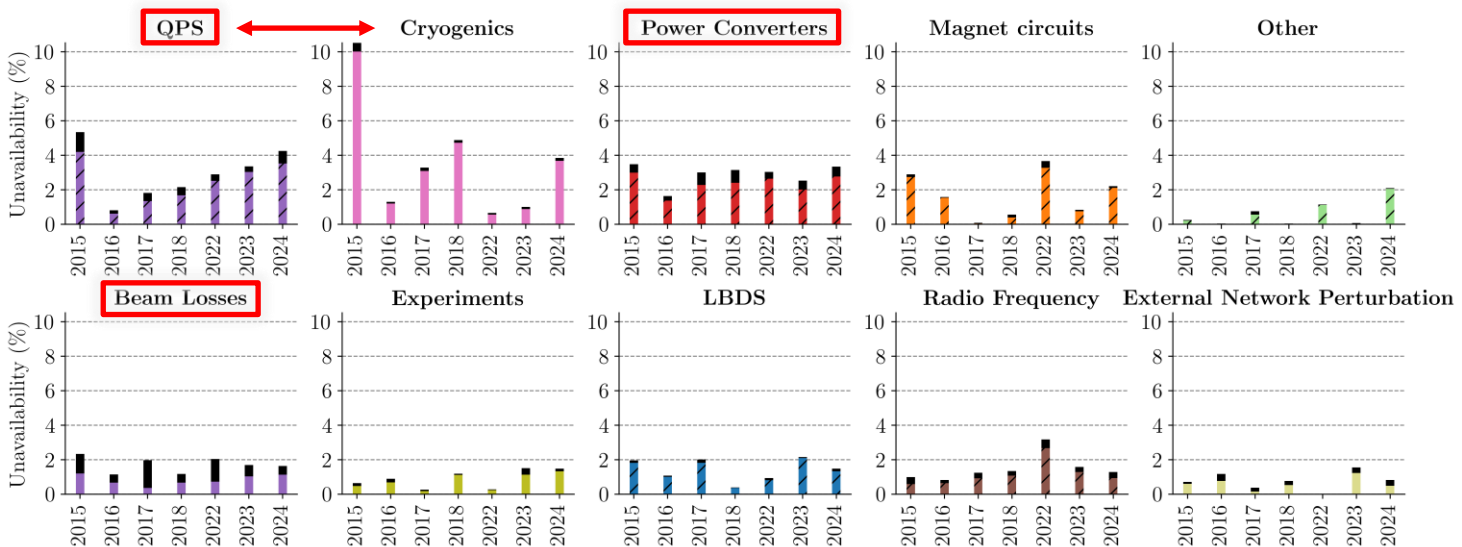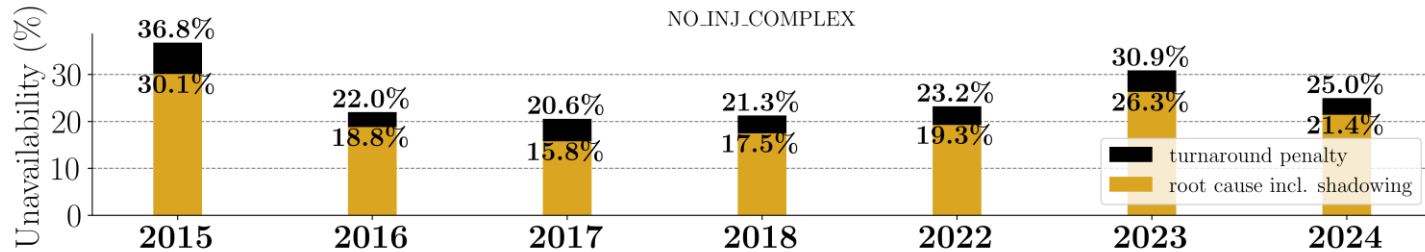
➤ **QPS relatively high turnaround penalty as well as Power Converters or Beam Losses** (short faults e.g. during ramp)

LHC Weekly Fault Rate (w/o Inj. Complex)
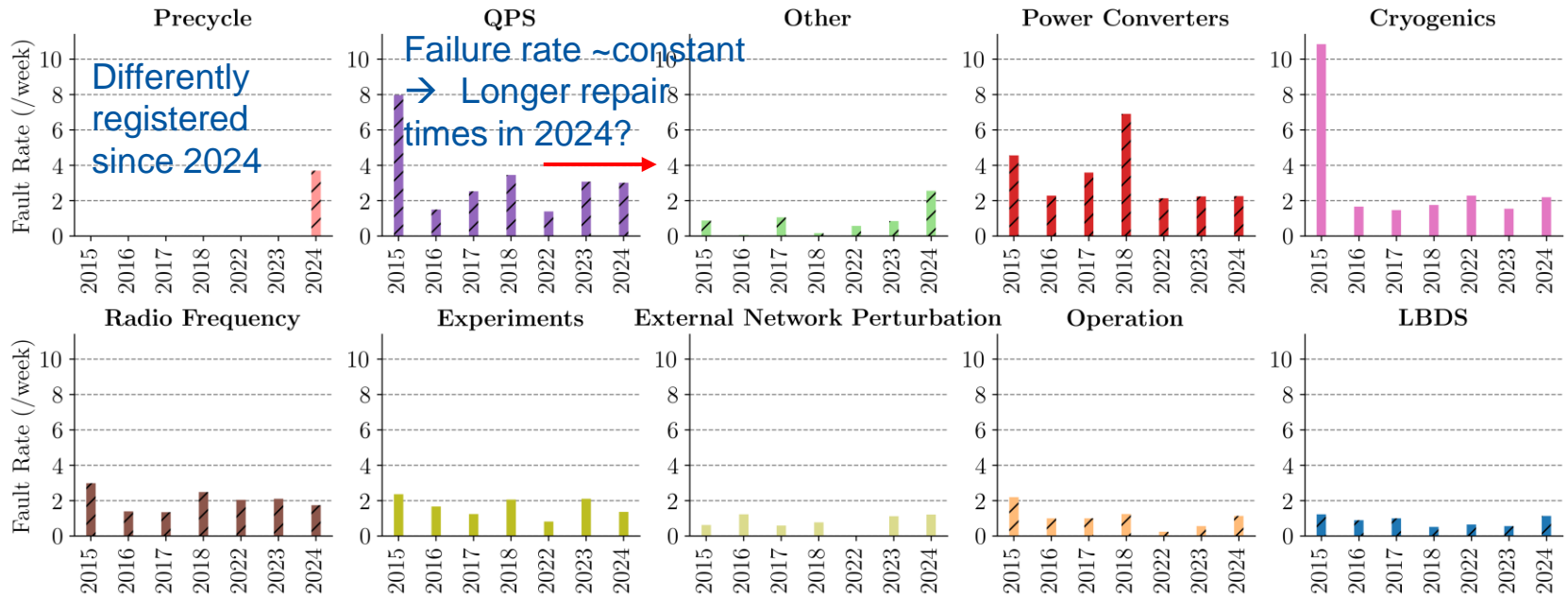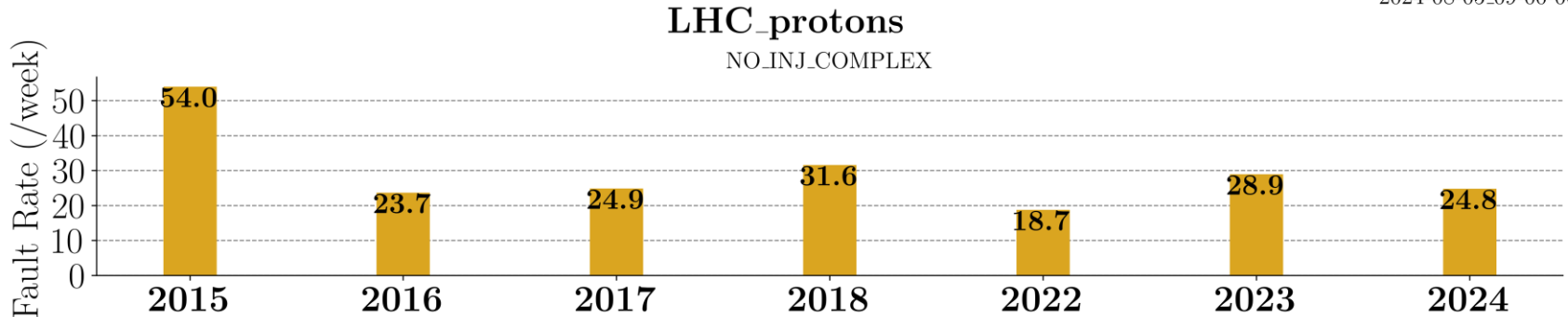
LHC Unavailability by Duration (w/o Inj. Complex)

21/04 Loss of 1.8K pumping unit in LHC8 (1d 17h)
10/05 Magnet quench sector 23 (1d 5h)
24/04 High heat load → switch back to optimal cryo configuration (1d 4h)
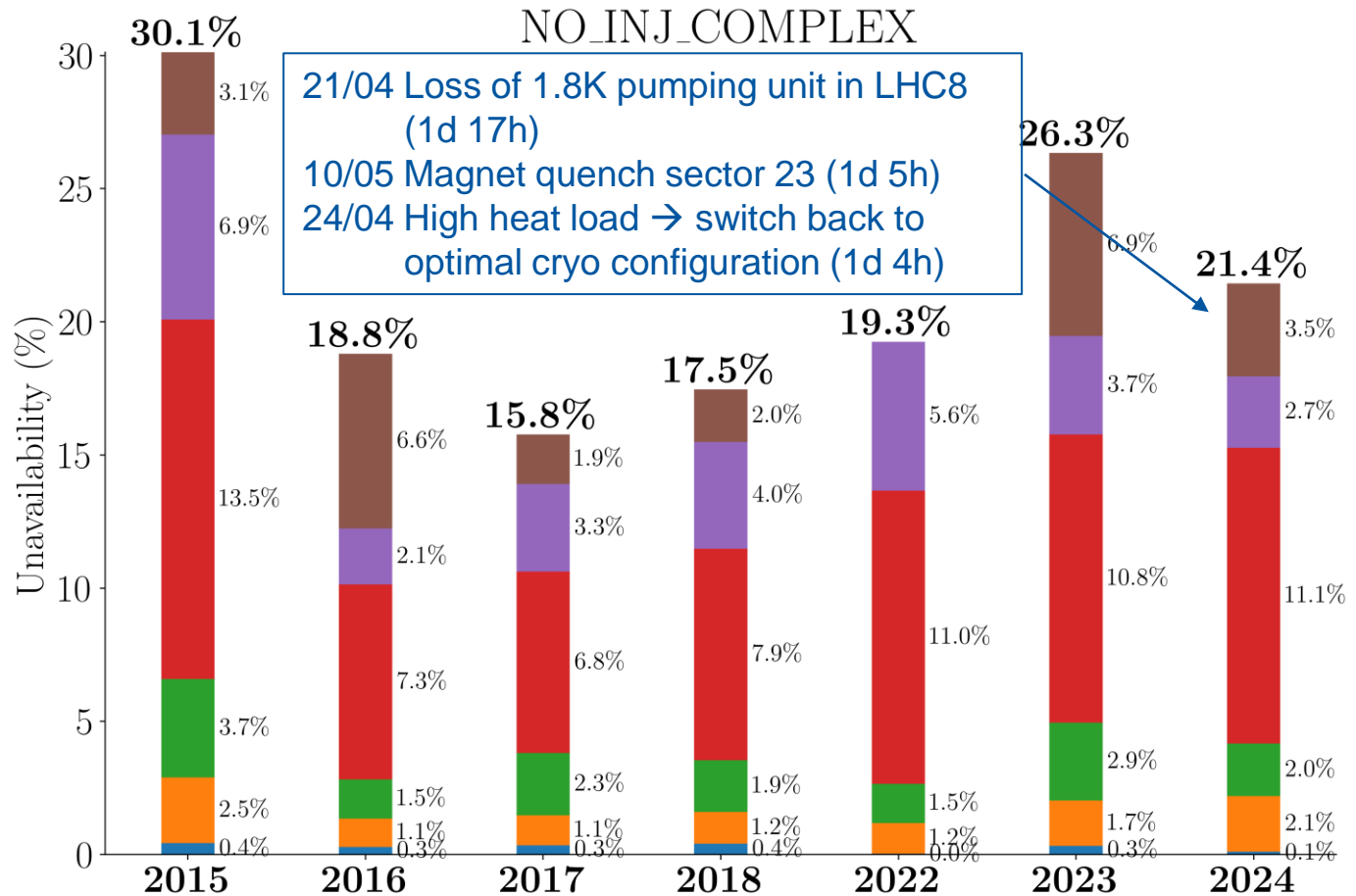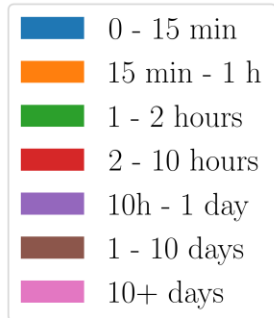
Availability LHC + Injector Chain

	Linac4	PSB	PS	SPS	LHC
2022	97.1%	97.5%	92.9%	82.7%	80.7%*
2023	97.9%	98%	94.9%	92.4%	73.7%*
05/08/2024	97.2%	98.2%	96.5%	88.2%	78.6%

* <u>Mind</u>: LHC schedules have been adapted in 2022 and 2023 to exclude long periods of fault!

- Availability quoted **excluding faults from injector chain**
  - Usual periods of TS, dedicated MDs etc. excluded as well
- **LHC**: data since start of Stable Beams
- **Injectors**: data since start of beam request for downstream beam commissioning
- Up to now, in 2024 solid availability from all machines

AFT Review Rates

- Expert review is important to ensure good data quality for solid analysis

  - For manual fault insertion, mistakes e.g. of system assignment happen or root cause not yet known

  - Automatic fault assignment is still not 100% fail-safe and comprehensive

- **Reviewers should receive automatic emails →** please don't forget to acknowledge the faults in AFT (box 'expert review')

- **Weekly fault reviews every Monday 11am**

  - Ccc glassbox and <u>zoom</u>

- We thank all our reviewers for their efforts!

AFT Overall Review Rates

	Linac4	PSB	PS	SPS	LHC	AD & ELENA	EA	NA
2022	74%	45%	40%	13%	44%	53%	53%	31%
2023	85%	72%	68%	12%	34%	73%	78%	15%
19/07/2024	84%	88%	78%	15%	32%	78%	80%	16%
05/08/2024 After contact	89%	84%	76%	19%	39%	82%	84%	22%

- Includes **equipment review** rates, as well as **OP and RAWG review** rates (injector faults, downtime to be updated, MD, access management, precycle, other)
- Generally good review rates for the faults, increasing over the years
  - SPS, NA and LHC to catch up…
  - SPS: many automatically registered few second-long faults
  - Sometimes confusion that the box 'Expert reviewed' should be clicked

AFT Review Rates – Systems across Complex

Review Rate [%]

Systems with very low fault rate not shown…

Bar chart values (left to right):
- Cryogenics: 97
- Electrical Network: 90
- Extraction Systems: 84
- Power Converters: 77
- QPS: 72
- Experiments: 68
- Injection Systems: 63
- Beam Instrumentation: 56
- Radio Frequency: 54
- Vacuum *: 44
- CV: 42
- Transverse Feedback: 28
- Magnets: 14
- Access System: 13
- Beam Induced: 1
- Transverse Damper: 0

Y-axis: 0, 20, 40, 60, 80, 100, 120

- Equipment expert review rate improved, in particular after contacting experts
- For certain systems might not be clear who should review the faults?
- We can help explaining the technicalities

* Vacuum includes vacuum system of EA, not under VSC responsibility…

Automatic Fault Recording Status

Significant **effort** was put in integrating further machines with **multiple extensions** on the API in order to facilitate the process

A. Asko, L. Felsberger, RAWG 08/11/2023
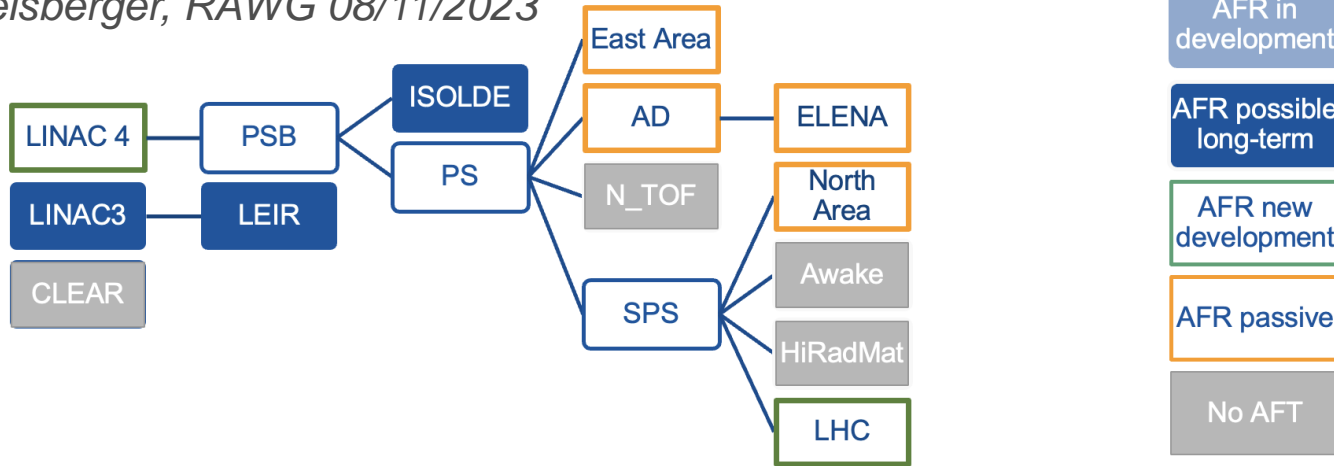
- Linac4/PSB: some improvements for more solid Linac4/PSB fault distinction
- PS: work ongoing to automatically assign systems and destinations
- SPS: steadily refining faulty system assignment + adding certain degraded faults (since mid-July)
- LHC: steadily refining faulty system assignment, adding non-blocking faults and spurious PC trips during periods without beam

Other AFT News

- Minor requests/corrections implemented

  - List of desired improvements available and status being tracked

  - Many good ideas – time for development needed

- **Outcome of AFT survey with equipment groups** on AFT usage and ideas for improvement will be presented on 24th of October (tbc)

- One outcome of survey currently being pursued: **integration of EAM with AFT**

Summary

- First ~half of the year shows mostly excellent availability from the CERN complex machines

  - Long failure events often determine statistics

- OP and expert review rate quite acceptable for ensuring good data quality for most systems

- Work ongoing to improve automatic fault recording and EAM / AFT integration

Thanks to everybody for your continued support in this effort!