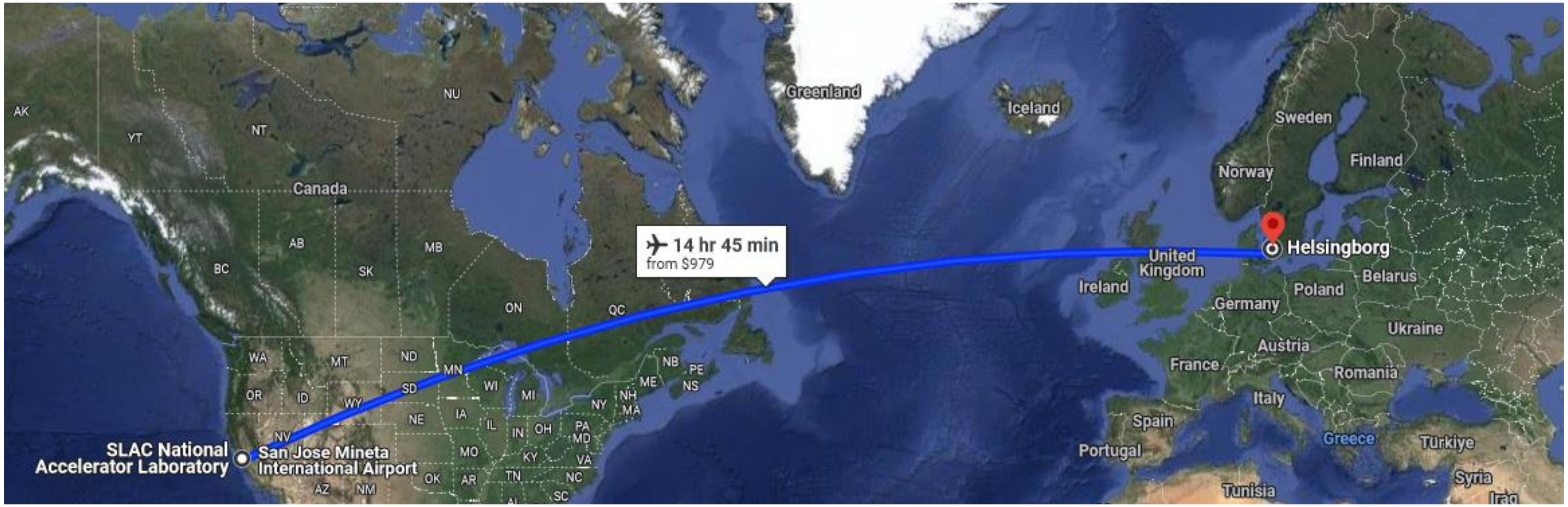
Workshop Highlights

Long flight to beautiful northern city



Workshop overview

About 170 participants from all over the world

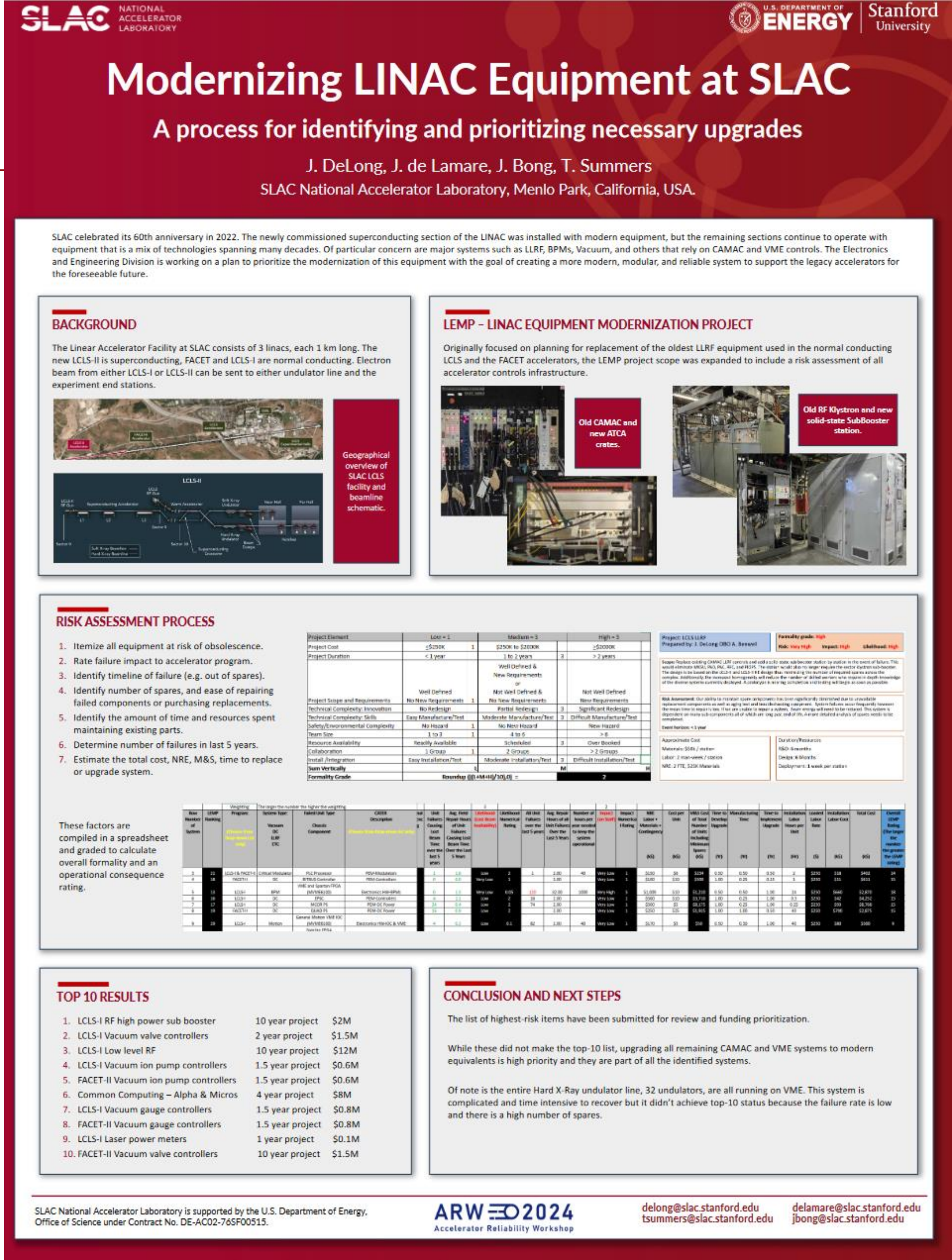
- Presentation sessions:
  - Reliability during procurement, installation, commissioning and upgrades
  - How to establish/ensure/maintain/evolve a reliability integrity culture
  - Machine learning & artificial intelligence & automatic prediction of failures
  - Failures / unintended consequences & analysis techniques
  - Maintenance methodologies (predictive, RCM, preventive)
  - Reliability of medical facilities
  - How to maintain and improve reliability during a facility lifetime
- Breakout sessions:
  - Fewer skilled experts: single source points of failure in personnel
  - Cultivating a reliability-centric culture
  - Issues on infrastructure and their effects on reliability
  - Effective preventative maintenance, balancing operations and projects
  - Reliability for legacy equipment, obsolescence, and eBay
  - Machine learning and AI
- Poster session with about 75 contributions

EED contribution

Presented on the LEMP modernization project

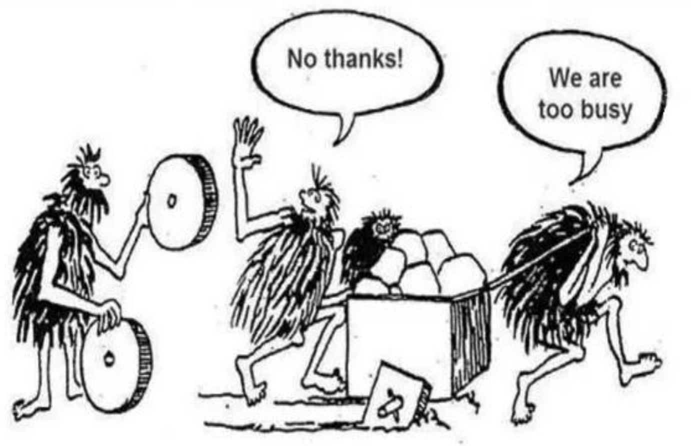
- Tasha Summers, James Bong, Jeff de Lamare, Joe DeLong
- Lots of good discussions, many labs are of the same vintage and working to update their equipment.

We won the best poster award!



Big-picture themes

- Many labs are trying to move from reactive to strategic maintenance planning.
- Most labs find it challenging to find the right balance between spending money on maintenance and upgrades vs. new projects – no one has the 'right' answer.
- Several labs emphasizing system engineering, quality management, and environmental sustainability.
- Most labs feel understaffed and struggle with talent retention (many have the "bathtub curve").
- Critical first step is frequent analysis of availability and failure data – this helps guide decisions.
  - SLAC has not prioritized this in recent years while focused on LCLS-II, but it is becoming important again!
- Identification of looming problems is key to prioritizing upgrades and reducing technical debt.
  - Think of our LEMP project and software modernization efforts.
- Lack of high-level coordination leads to inefficiencies and duplicated effort (E.g. multiple SW groups across the lab)
  - **One audience member commented that SLAC's controls looked too disjointed to ever be reliable – ouch.**
  - Have to be willing to put in the time to make long-term improvements.



Images courtesy of Chris Zimmer's fantastic talk on Maintainable HLAs.

Interesting ideas and comments

- Building a Reliability Culture - Key is to disconnect the reliability of a system from blaming the staff.
  - Takes a paradigm shift from skilled-expert, single engineer ownership to one of team effort and responsibility – but not so far that no one feels any ownership at all.
- Be clear about what the reliability/availability metrics are and how we work to them, short & long term.
  - We'll look at this much more in the near future…
- "It takes a long time to recover from an upgrade."

- 4 parts to improving availability
  - Identify systemic issues with scheduling, project prioritization, resource skill and effort loading
  - Identify and minimize human factors with training, engineering practices and culture improvements
  - Work on continuous improvement with weekly reviews for immediate action, and run reviews for larger efforts
  - Make the necessary data easily accessible - real-time reporting, logbooks and equipment fault reports.
- Enterprise Asset Management (EAM) or Computerized Maintenance Management Systems (CMMS) are used by many labs for equipment management, technical documents, and maintenance scheduling.

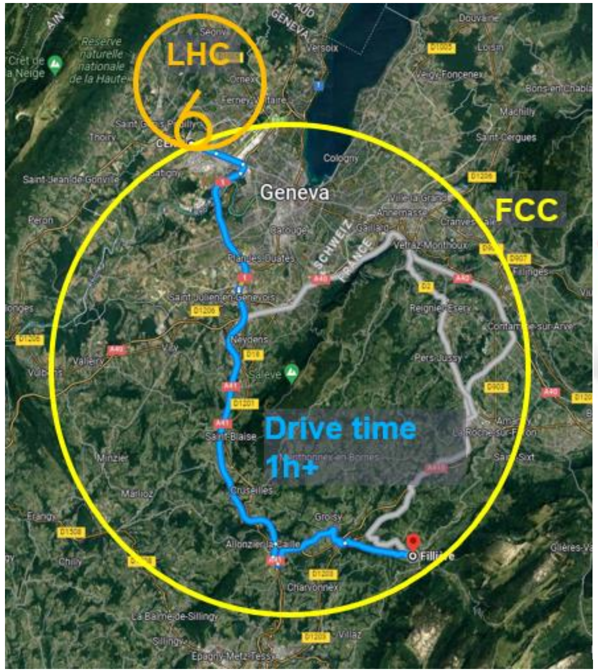
Interesting Talk – FCC-ee Availability Challenge (CERN)

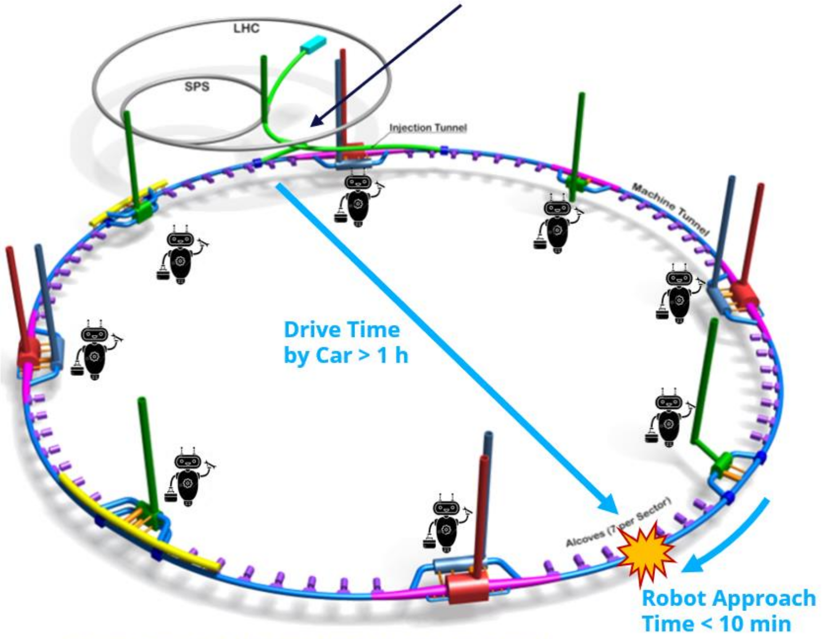
CERN's proposed 91 km Future Circular Collider!

- Maybe start construction in 2030, running from 2044-2060 followed by an energy upgrade running from 2070-2095
- Goal for 185 delivery days, 80% availability: Infrastructure 97.1%, Injector 96.1%, Accelerator 85.8%
- Created simulation for relationship between availability and luminosity
  - William Colocho collaborated with ESS on AvailSim2

AvailSim4

- Start with availability target, determine reasonable forecasts, and identify shortfalls to focus on solving now
  - Considering robots to do initial repair while humans are in transit!





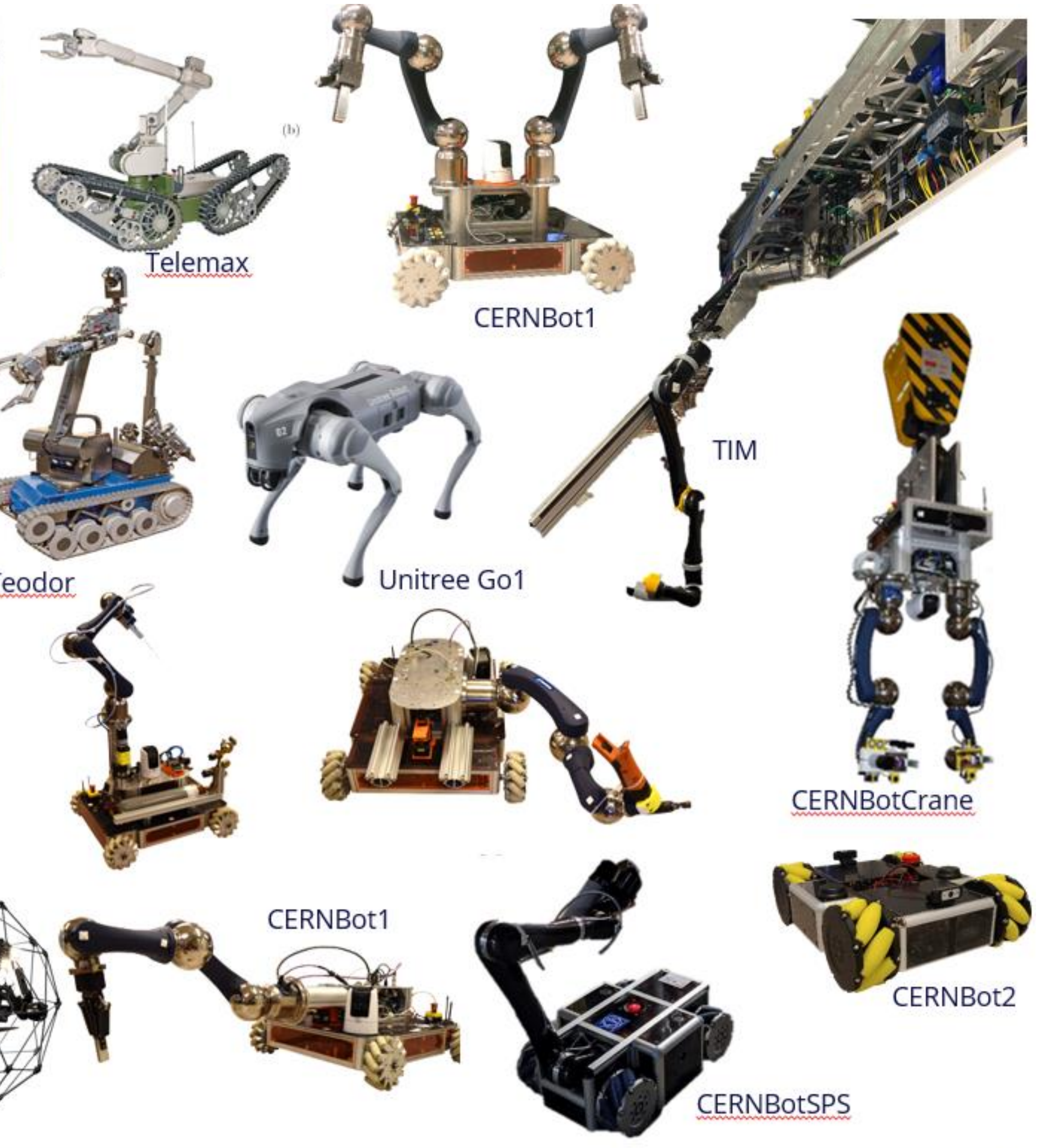
Future Circular Collider: 100 TeV, 100 km Tunnel

Interesting Talk – CERN's Robots

Robotic Service at CERN

- Infrastructure not designed to host robotics
- Need to adapt robots to environment
- Highly versatile systems / relatively low efficiency
- > 20 robotic systems operational in different configurations

KUKA



Flyability Elios

Unitree Go1

Train Inspection Monorail - TIM

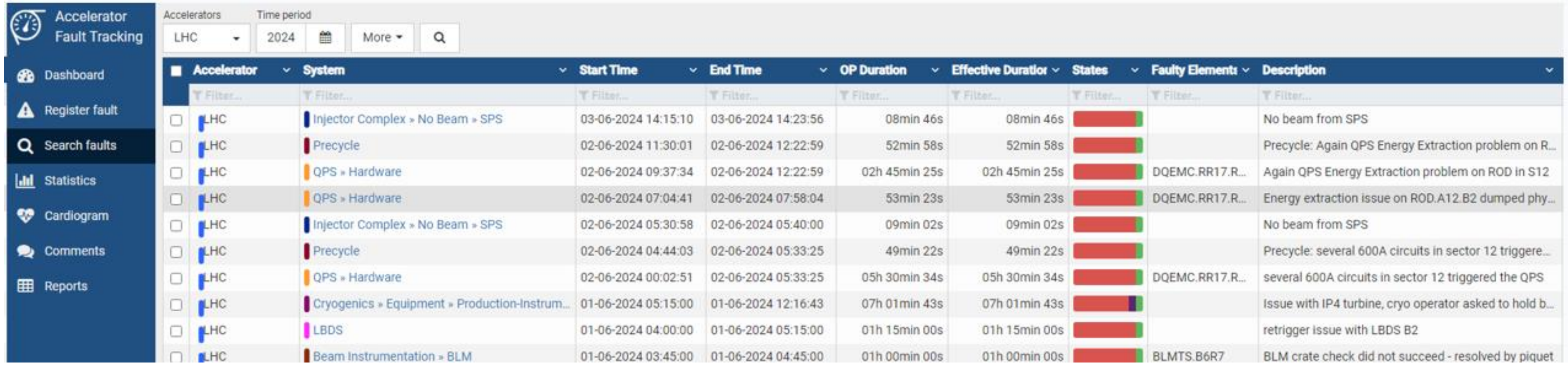
Telerob Teodor X Schunk Arm

CERNBot1

Additional information on the service in academic training lectures: https://indico.cern.ch/event/1055745/

Interesting Topic – Automatic fault identification

- Distinction between the actual fault duration and the effective fault duration (subsequent faults, long recovery), as well as between direct cause (e.g. MPS) and root cause (e.g. temperature switch).
- Good fault tracking tools are essential, with as much automated post-mortem data recording as possible to identify root cause – enables intelligent and consistent review.
  - Understand why systems fail (complexity, aging), emphasize what can be improved not what went wrong.

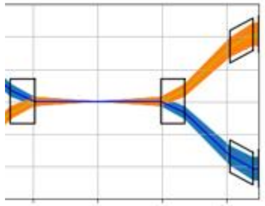


Accelerator	System	Start Time	End Time	OP Duration	Effective Duration	States	Faulty Elements	Description
LHC	Injector Complex » No Beam » SPS	03-06-2024 14:15:10	03-06-2024 14:23:56	08min 46s	08min 46s			No beam from SPS
LHC	Precycle	02-06-2024 11:30:01	02-06-2024 12:22:59	52min 58s	52min 58s			Precycle: Again QPS Energy Extraction problem on R...
LHC	QPS » Hardware	02-06-2024 09:37:34	02-06-2024 12:22:59	02h 45min 25s	02h 45min 25s		DQEMC.RR17.R...	Again QPS Energy Extraction problem on ROD in S12
LHC	QPS » Hardware	02-06-2024 07:04:41	02-06-2024 07:58:04	53min 23s	53min 23s		DQEMC.RR17.R...	Energy extraction issue on ROD.A12.B2 dumped phy...
LHC	Injector Complex » No Beam » SPS	02-06-2024 05:30:58	02-06-2024 05:40:00	09min 02s	09min 02s			No beam from SPS
LHC	Precycle	02-06-2024 04:44:03	02-06-2024 05:33:25	49min 22s	49min 22s			Precycle: several 600A circuits in sector 12 triggere...
LHC	QPS » Hardware	02-06-2024 00:02:51	02-06-2024 05:33:25	05h 30min 34s	05h 30min 34s		DQEMC.RR17.R...	several 600A circuits in sector 12 triggered the QPS
LHC	Cryogenics » Equipment » Production-Instrum...	01-06-2024 05:15:00	01-06-2024 12:16:43	07h 01min 43s	07h 01min 43s			Issue with IP4 turbine, cryo operator asked to hold b...
LHC	LBDS	01-06-2024 04:00:00	01-06-2024 05:15:00	01h 15min 00s	01h 15min 00s			retrigger issue with LBDS B2
LHC	Beam Instrumentation » BLM	01-06-2024 03:45:00	01-06-2024 04:45:00	01h 00min 00s	01h 00min 00s		BLMTS.B6R7	BLM crate check did not succeed - resolved by piquet

- At SLAC we have proposed PVs for the control system to track what state the accelerators are in – User delivery, Fault, Machine Development, Maintenance, Downtime.
  - These can be used for automatic tracking and analysis as well as automatic alarm filtering.

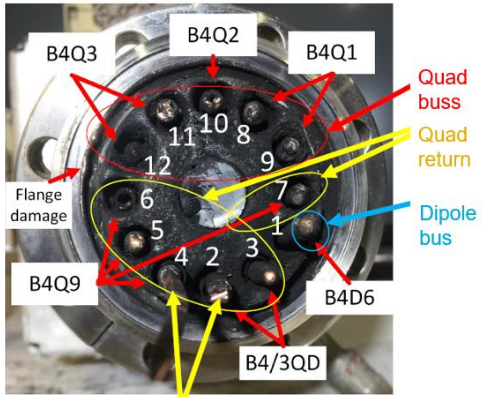
Best disaster Story: **BNL-RHIC SC Valve Box Failure**

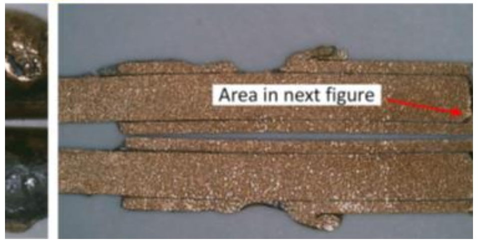
Foreshadowing!



- 25 year old collider in NY - two rings, with big ‘DX’ magnets to bring the beams together at detectors.
- Cryogenic service buildings are where warm power supply leads are transitioned to the SC leads
- DX magnets have special heaters to flash helium in case of a quench to distribute the heat load
- Aug. 2023, 7 weeks before end of the run the one DX magnet quenched and the heaters fired…
- Original bad soldering was a time bomb!
- Repaired by Feb. 2024, machine running by May.

Terminal layout at the end flange

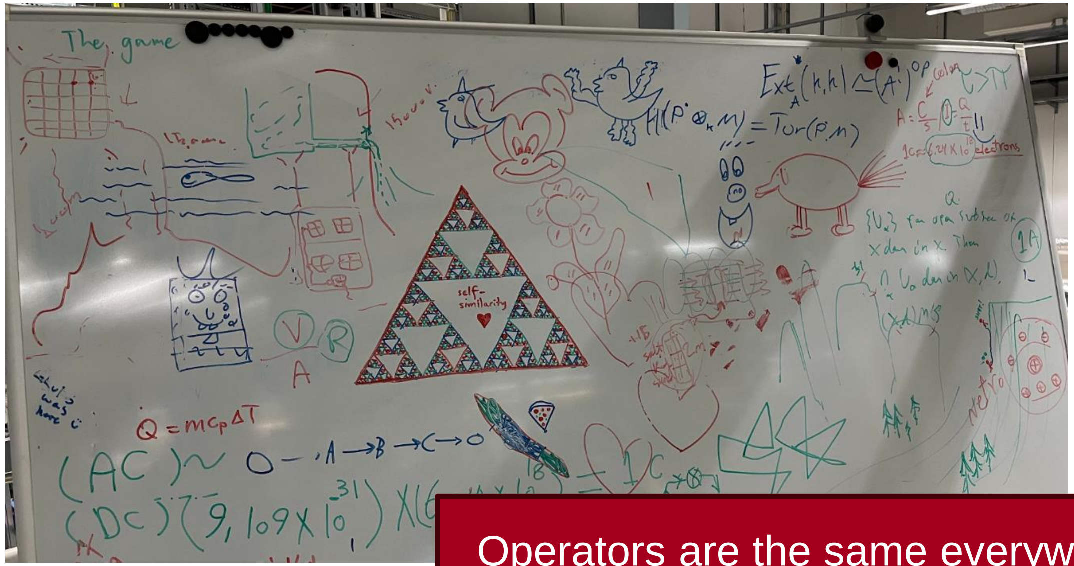




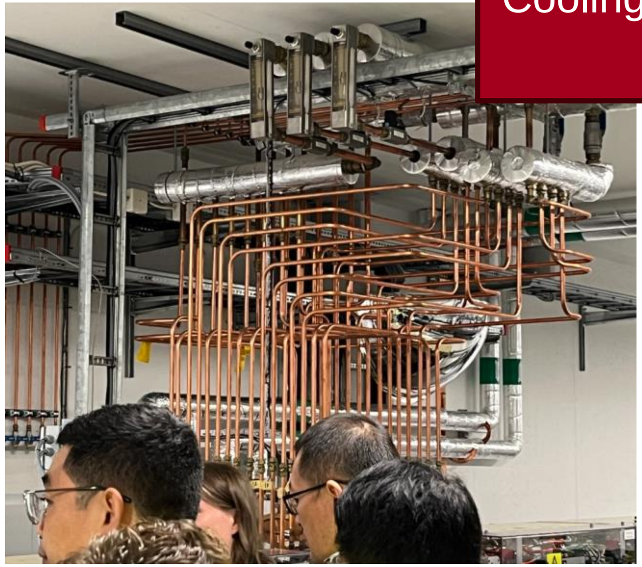
Splice Can #2

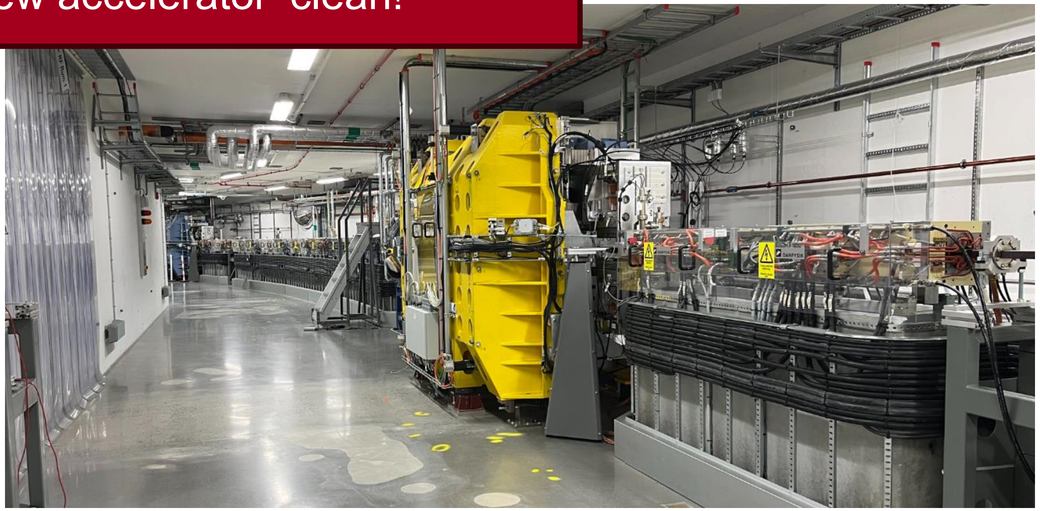
Host Facilities – **Max IV** and ESS

- MAX IV is a Swedish national synchrotron laboratory that has operated as a user facility since 2016. MAX IV offers access to 16 beamlines that provide modern X-ray spectroscopy, scattering/diffraction, and imaging techniques. MAX IV employs more than 300 people. MAX IV welcomes 1700+ users annually, expected to double in the coming years.
- The X-ray light at MAX IV is produced by an accelerator complex comprising a linear accelerator as well as 1.5 GeV and a 3 GeV storage ring for electrons. MAX IV is the first worldwide realization of a fourth-generation light source.



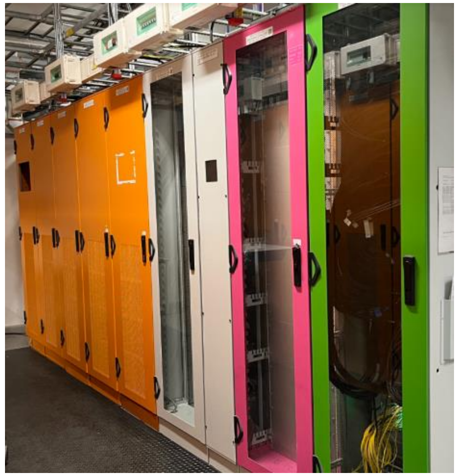
Operators are the same everywhere :)
Cooling water art, air-conditioned racks,
'new accelerator' clean!



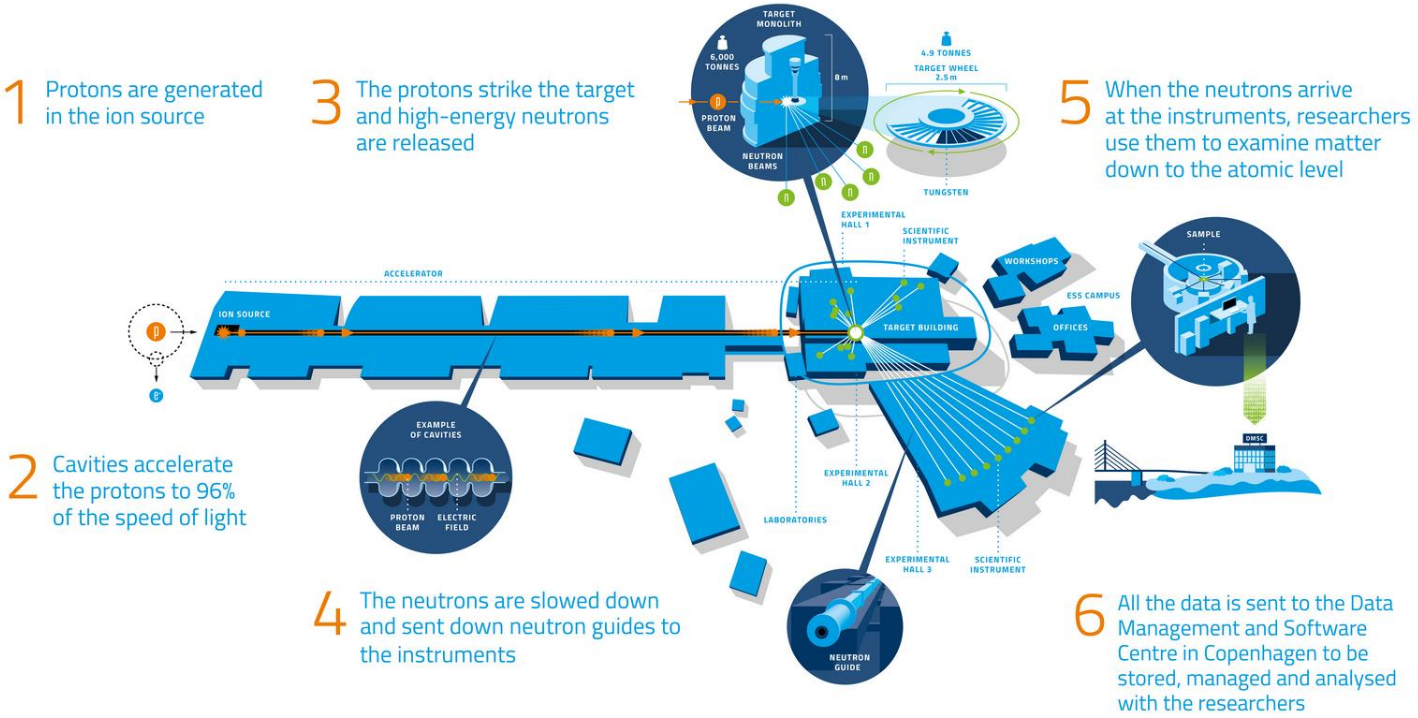


Host Facilities – Max IV and **ESS**

- The European Spallation Source (ESS) is a European Research Infrastructure Consortium (ERIC), a multi-disciplinary research facility based on the world's most powerful neutron source. The facility began construction in 2014.
- Complications due to contributors from 60 countries speaking 60 versions of English!

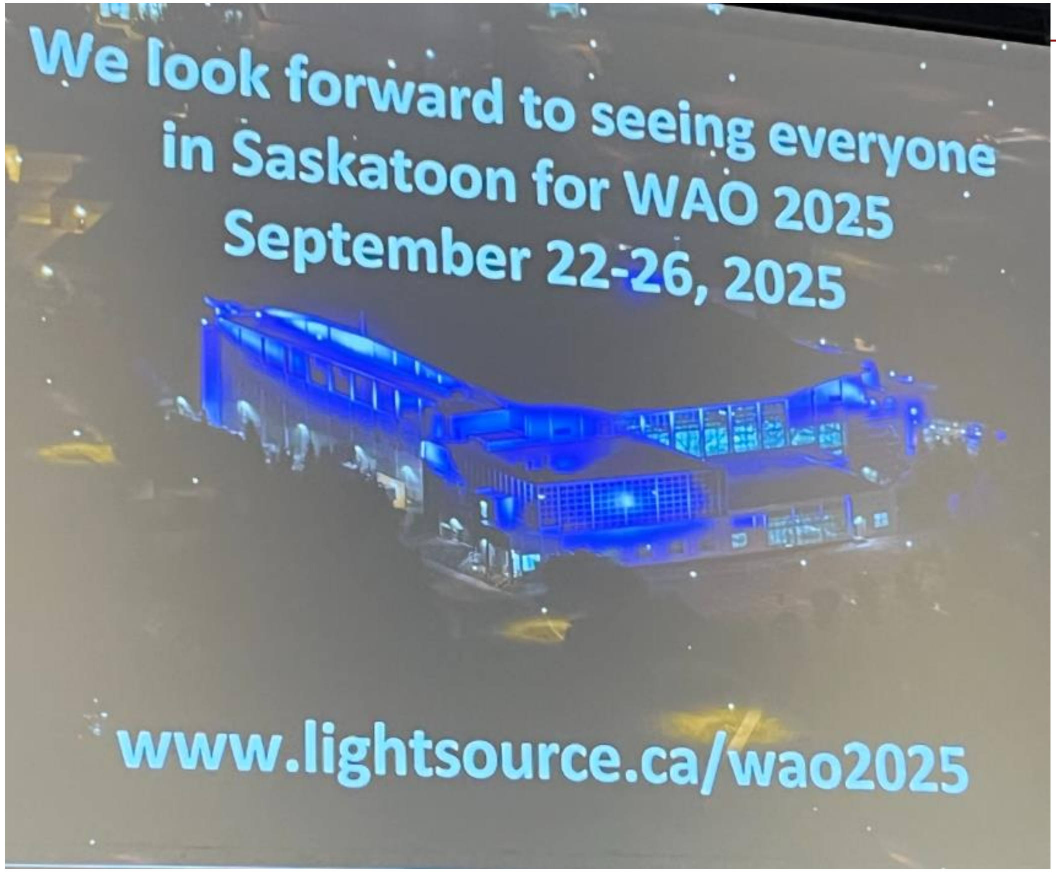


Color coded racks, shiny klystrons.
Fantastic chaos of a proton source front end!



The Accelerator Reliability Workshop alternates with the Workshop on Accelerator Operations

2025 WAO will be in Canada
2026 ARW will be in Japan



Helsingborg at 10 pm!

Excursion to Kronborg Castle, Denmark
UNESCO World Heritage Site