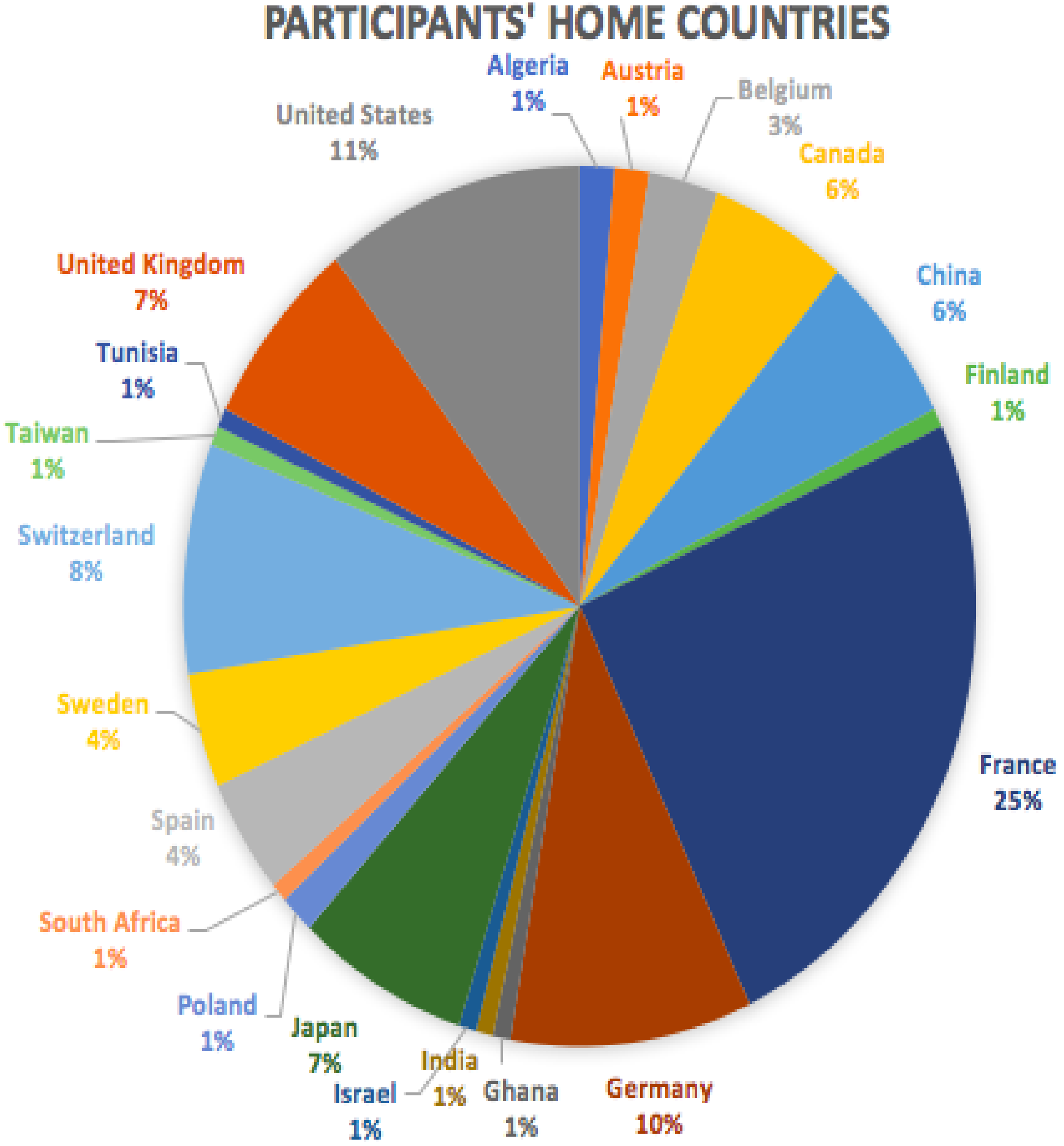
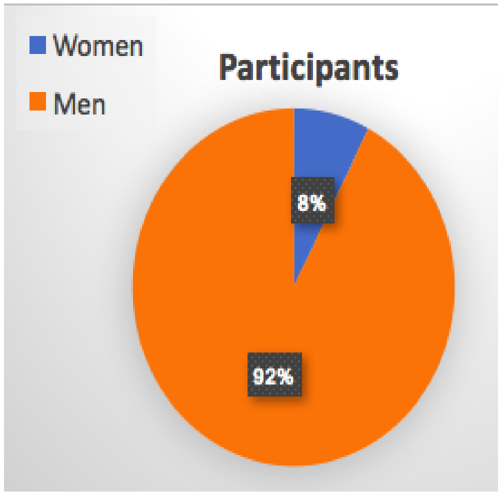
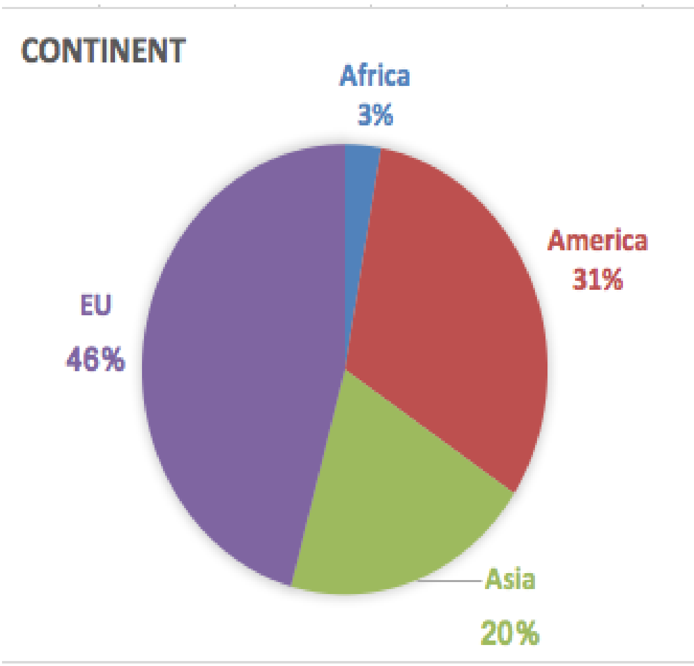
Sessions Summary

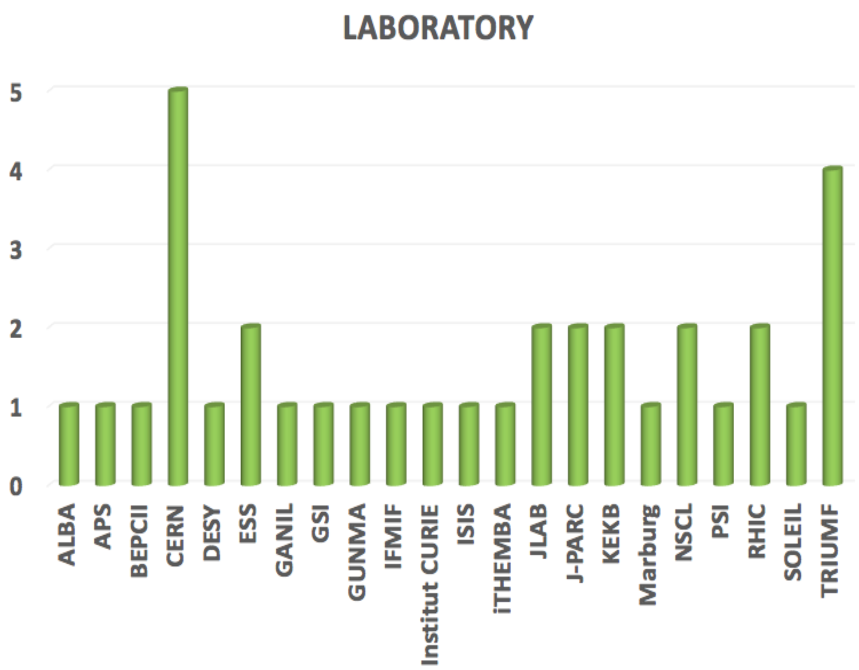
https://indico.cern.ch/e/arw17


PARTICIPANTS' HOME COUNTRIES
Algeria 1%
Austria 1%
Belgium 3%
Canada 6%
China 6%
Finland 1%
France 25%
Germany 10%
Ghana 1%
India 1%
Israel 1%
Japan 7%
Poland 1%
South Africa 1%
Spain 4%
Sweden 4%
Switzerland 8%
Taiwan 1%
Tunisia 1%
United Kingdom 7%
United States 11%


Women
Men
Participants
8%
92%

ARW Oral Contributions

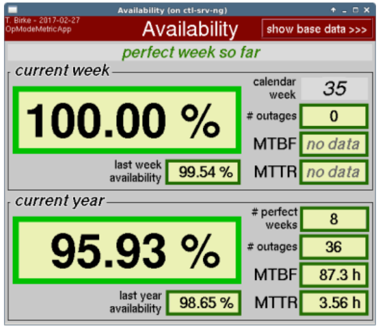




Availability Tracking & Metrics

Michael Bieler, Randy Flood, Ben Todd

- High reliability is one of the key requirements for a synchrotron radiation facility. Key performance indicators are ***availability*** and ***Mean Time between Failures*** (MTBF).
- Goals:
  - ***We need a world wide common standard on accelerator reliability!***
  - ***A Common Operation Metrics for 3rd Generation Light Sources***



- Mean Time Between Distortions is the important number
- **Bessy 2** is using online the Common Metrics
- Proposed a simple, distinct and standardized operation metrics

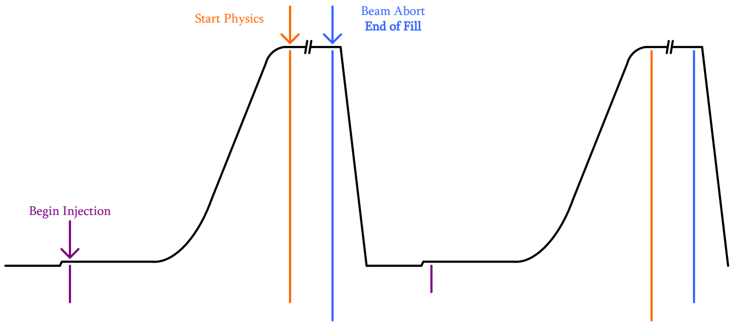
- **where do we go now…?**

- AT **APS** weather can play an important role on Downtime.
- “The truth is, our users would stay at their experiment as the building disintegrated around them to collect that last data point. Removing shutter permit forces them to leave the area”

- APS is a very reliable facility. **For 15 consecutive years 97% beam availability, above 70 hours MTBF since 2004, consistently closer to 100 hours than 70**.

Availability Tracking & Metrics

- **At LHC Integrated luminosity is a function of…**
  1. time colliding physics beams
  2. turnaround between successive physics beams
  3. time to clear faults
  4. physics performance during colliding beams



Availability : time when machine is ready to accept and accelerate beam, versus run time
Units: scalar [%]

$$\frac{t_{rt} - t_{infault}}{t_{rt}} = \text{availability } 66.7\%$$

Fault Duration =
Integrated time logged for fault

Machine Downtime =
Corrects for parallelism Discounts dependencies

Root Cause Duration =
Corrects for dependencies parent / child / shadow

The tracking of the faults is done by a combine metric & the cardiogram

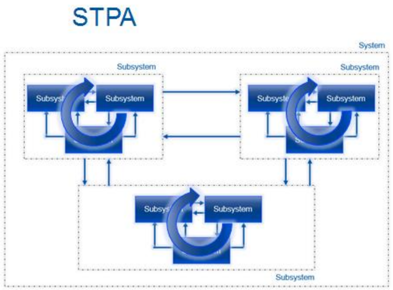
Many different metrics

Machine mode metrics	Duration [h]
Fault / Downtime	470.2
Stable Beams	**308.9**
Operations	224.9
Pre-Cycle	28.0

Reliability Before Design

Andrea Apollonio, Sam Varahh, Enric Bargallo

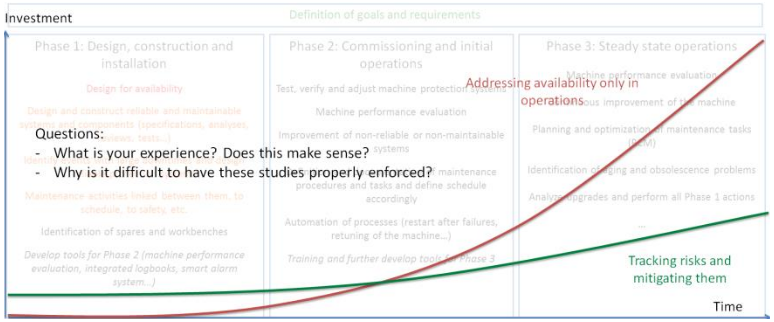
- New methods like System-Theoretic Process Analysis focus on system interaction and show that there is some evolution in the basic methodologies and processes
- Accelerators are complex, but don't have tight regulatory or prescriptive standards for a large part of the equipment – provide forum for evaluation and testing of methods.



- Renovation / extension is an opportunity to do things better
- Replacing or extending like-for-like should just be a basic starting point for any such project. Basic renovation / extension requests are opportunities to try new concepts, do things in a new way, and do a better job.
- The new Rabbit Line Send Station was a nice example of this.

Reliability Before Design

- For better return on investment, address availability as earlier stages.
- Availability issues which get addressed later on in the cycle are costing significantly more to solve.
- Early investment in availability is obvious when initially budgeting a project BUT “Design it to work well" appears to face common fiscal obstacles.



Infrastructure

Laurent Delprat, Andreas Stolz, Yoshio Yamazaki

- 3 talks and discussion:
- Critical Failure Modes
- CRITICAL means a potential unavailability of cryogenics for LHC for weeks or months: breakdown of a critical equipment without alternative scenario.
- MEDIUM & HIGH means that failure is likely to happen with a potential unavailability of cryogenics for LHC for hours or days.

SEVERITY \ PROBABILITY	Remote	Uncommon	Occasional	Frequent
Catastrophic	Critical	Critical	Critical	Critical
Major	Low	Medium	High	High
Moderate	Low	Low	Medium	High
Minor	Low	Low	Low	Low

Infrastructure

- When completing upgrades to infrastructure, ensure proper materials are used-Inspection, work plan and spec.
- Good intentions, not properly communicated, can lead to unintended consequences.

$5

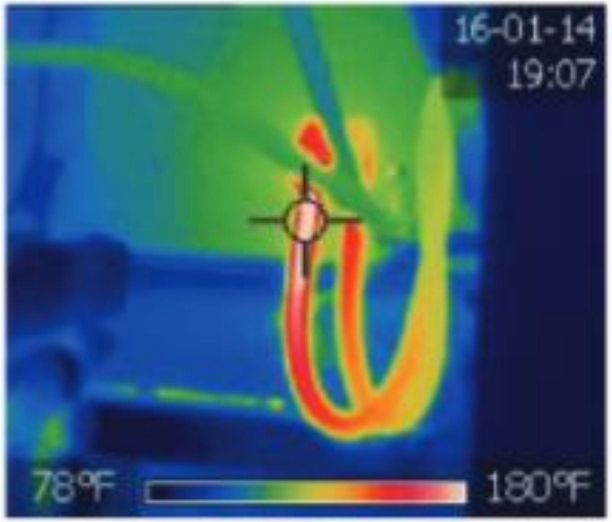
$500000

Infrastructure

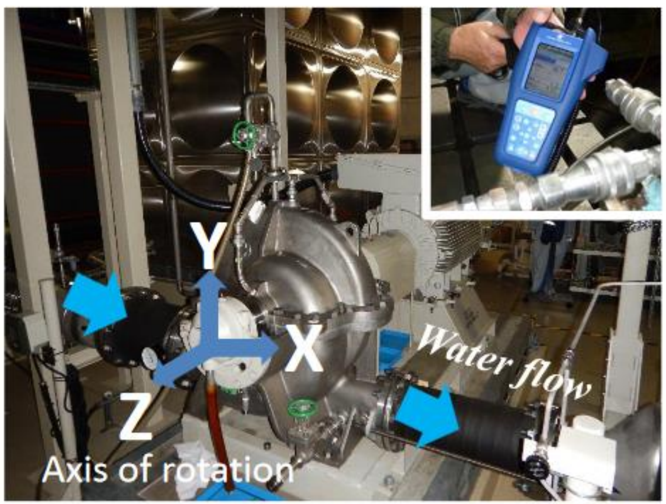
Before start of operations:

Test all electrical lead connections between magnets and power supplies at the Laboratory (459 supercon-ducting and room temperature magnets)

- **Visual Inspection**
  (you can see a lot by just looking)
- **Measurement of resistance with milli-Ohm meter**
- **Thermal imaging with infrared imaging system**
  (operate magnet at high current and inspect temperatures of electric connections)

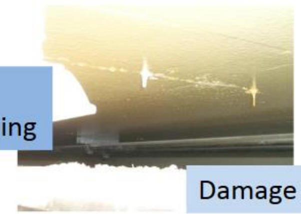


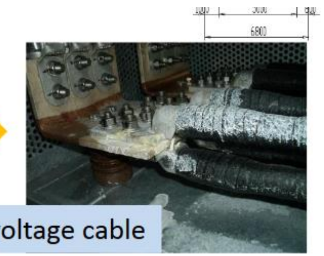
- J-PARC infrastructure and earthquake affects



Water pump violation measurement

Water Leakage
from RCS Sub tunnel ceiling





Damage to high voltage cable

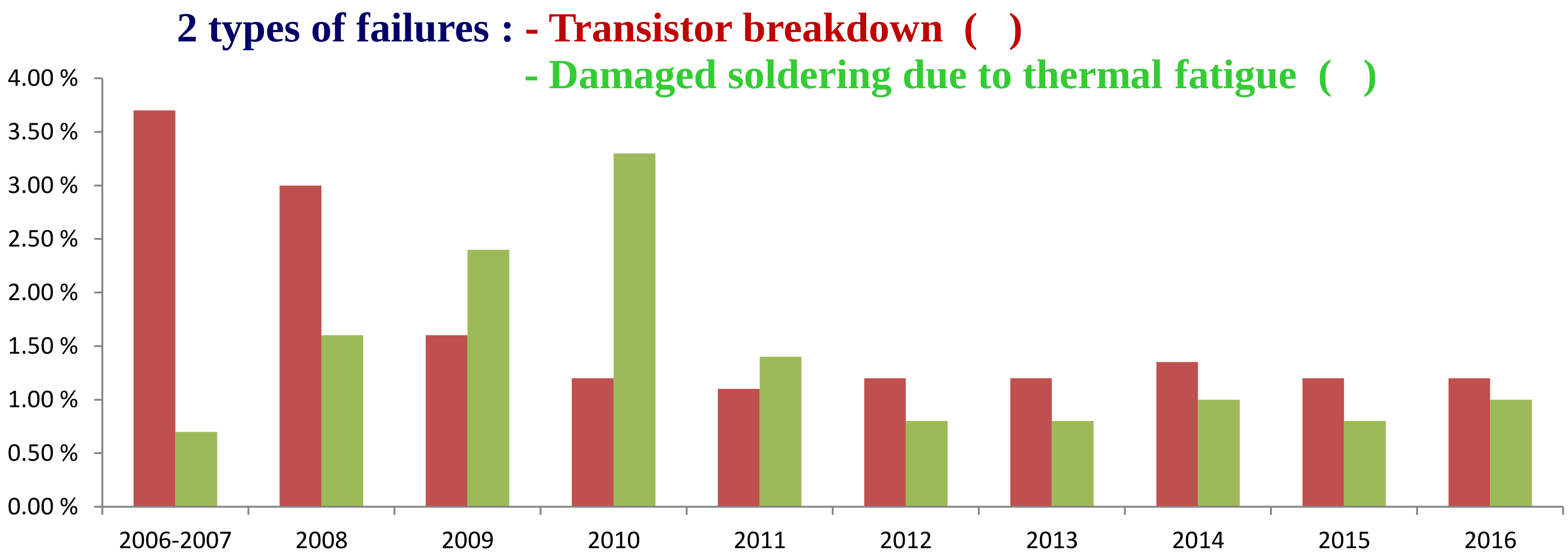
Enhance monitoring system → **Time series visualization of operation parameter (Flow, Pressure, Temperature, etc.)**

Mechanical vibration monitoring → **Vibration measurement of rotating equipment(Pump, Fan, Motor, etc.)**

Vibration data : displacement, velocity, acceleration
-> FFT analysis

Water quality monitoring → **Water conductivity -> Ion detection in water**
Dust trapping by Filter
-> Micro particle detection

- The session had 4 talks
- The first talk described the advantages of using solid state RF amps and the role SOLIEL has played and will play in the further developments.



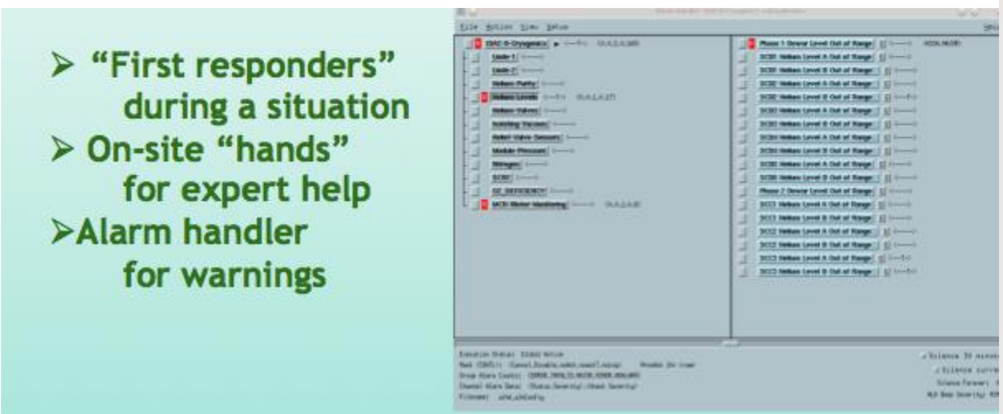
Accelerator Systems

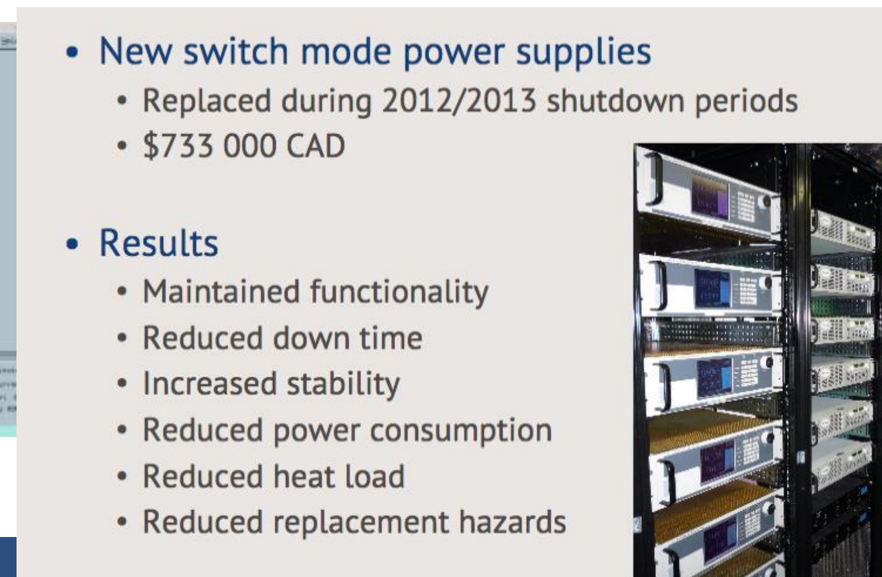
- The second talk, from KEK, presented some of the issues associated with beam commissioning with a focus on power supplies

Failures in Large class PS	# of event	comment
AC input over current	3	AC distortion (RF system crowbar work)
AC input over current	6	AC distortion (VAR system[#] work in line facility)
AC input Stop, CB Fault	2	Earthquake

Accelerator Systems

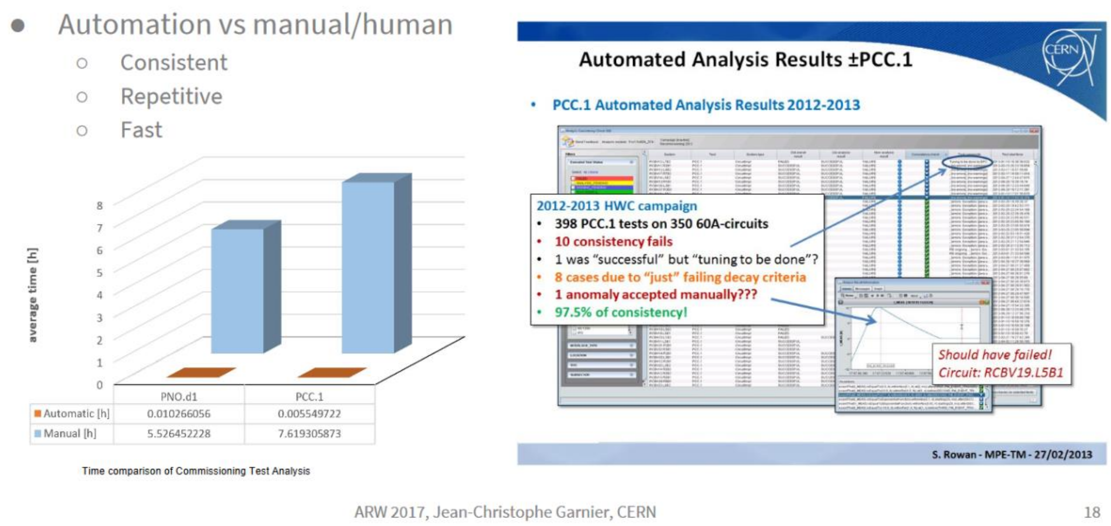
- Third talk, from TRIUMF, presented the role of operators in improving cryogenics availability
- The last talk of the session presented a High Level Application (HLA) written for the automation of magnet power supplies optimization





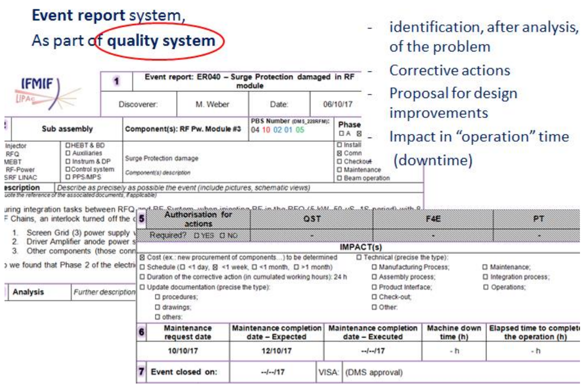
Jean Christophe Ganier, Alvaro Marqueta, Ferran Fernandez

- CERN’s machine protection team’s success maintaining legacy code and developing new software tools was presented.
- There is high confidence for both the software developers and end users, using Continuous Delivery Workflow at CERN.
- >50% test result analysis is automated and >1M lines of code!

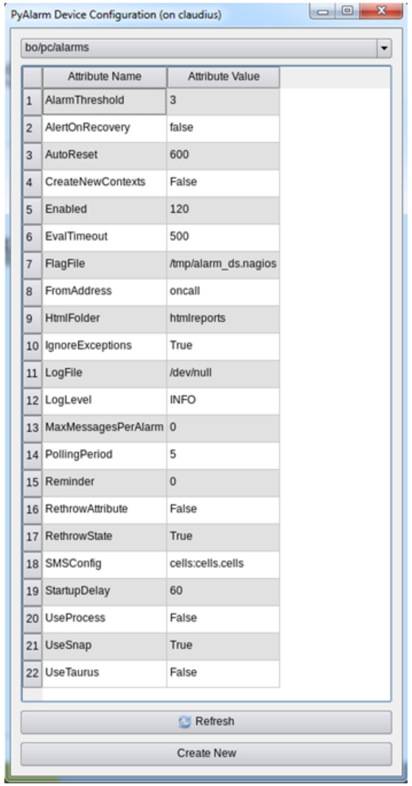


Accelerator Controls

- LIPAc Control Systems and Reliability Improvements were discussed. We heard about the successes and some of the difficulties involved in the upgrade reliability analysis of the prototype accelerator with an eye on setting reliability figures.



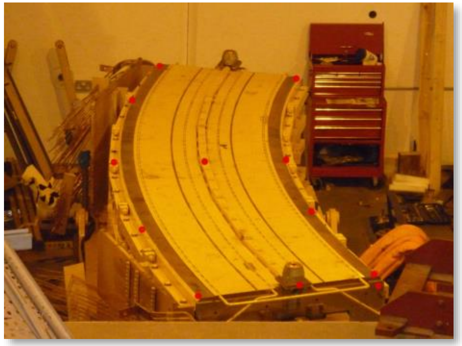
- We heard how a good alarm system is very useful in "The Use of PANIC Alarm System at ALBA" presentation.
- Alerts users of problems and abnormal machine conditions, even taking automatic actions in response to problems, and above all it needs to be easily configurable by the user.



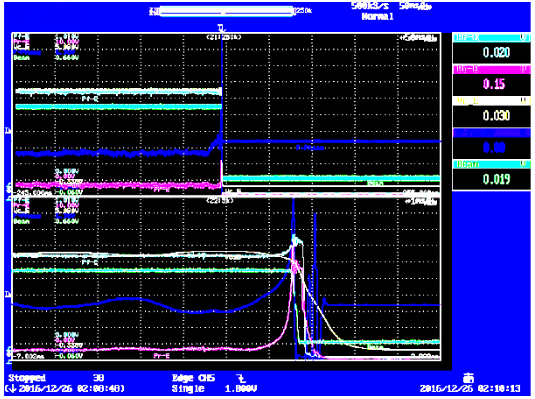
Failure Investigation

Julian Brower, Jun Xing, Violeta Toma

- Diagnostic data should be used to improve performance.
- Harmonic analysis of vibration dampening shows good promise to providing a path to improved performance.
- We don’t always need to reinvent the wheel. If someone has done it already, why not utilize that expertise.
- What are the obstacles to wider collaboration?



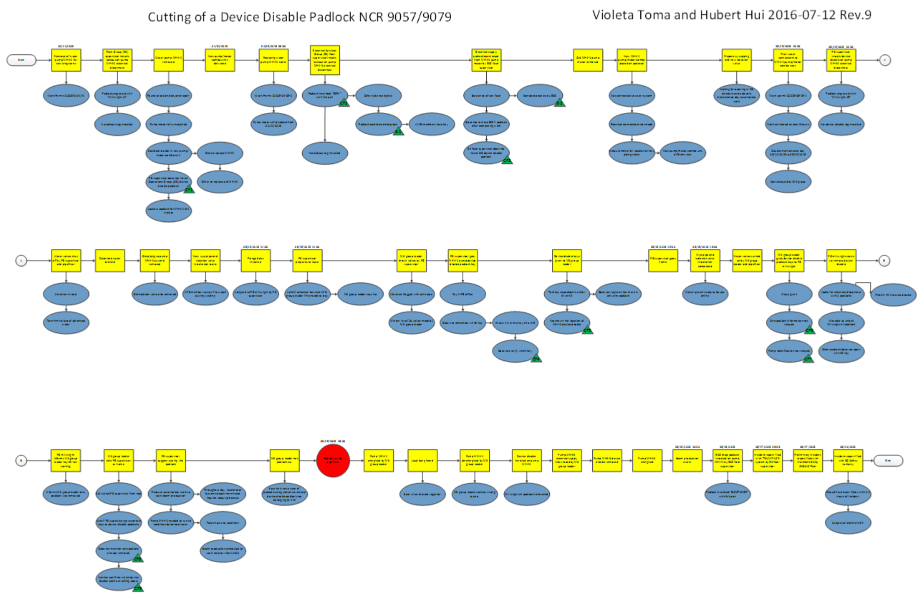
- New diagnostic tools provide mechanisms to track down simple, but hard to find, problems
- 16 Channel o-scope tool was a good example of improved diagnostics analyzing system reliability.
- Identified issues in RF system and led to resolving a terminal block issue causing intermittent trips.



Failure Investigation

- Formal investigation tools provide a formal mechanism to conduct investigations and get a the root of a real problem.
- TapRoot example was presented as a means to capture systemic, cultural & organizational causal factors.
- Despite training and policy, human factors and (mis)communication can often lead to unpredictable situations.

13 SnapChart®



Maintenance For High Reliability

Jacobus Lodewikus Conradie, Petra Schuett, Paul Sampson

- Many facilities face maintenance crossroads.
- Do you maintain the status quo or embark on infrastructure renewal – Repair or Replace?
- Issues: Part availability, in house design, manpower and lead time
- The problem: management expects to see immediate improvement in performance after their investment.
- When is a plan not a plan?
- Things quickly fall apart when subject to schedule changes of projects, users, and other external forces.
- When 40 planned accelerator changes/upgrades are reduced to 8 due to program schedule changes, performance and reliability are going to suffer.
- Sharing of operators with technical staff adds complexity.
- Frequent meetings and schedule updates are necessary to track shutdown progress and to keep everyone informed. Fortunately experiment requirements were temporarily reduced to accommodate compromised machine operation.
- <u>You may not be able to complete necessary work, but everyone will be aware of it.</u>

Maintenance For High Reliability

- Paul reinforced the need for detailed planning and communication. Prioritizing, planning, sequencing work, testing/commissioning while shutdown, construction, upgrades, and maintenance must all be integrated.
- Everybody thinks their system is 1st priority

  Subsystems want their work completed regardless of the availability or impact on other systems. (Well known in systems engineering as the “Sub-optimization Principle”)
- Meetings, planning and good communication are all key elements along with a good job entry, approval, and tracking system.

Invited Speakers

- Methods for achieving the very high reliability necessary for use in space was discussed by Jean Fontignie – PA/QA manager at CEA/IRFU

Complex organization, mixing different cultures
Space Agencies impose a common reference to all "contractors"
European Coordination for Space Standards (doc tree : bonus slide / www.ecss.nl)

  Dependability , Electronic components procurement & Rad hardness
  Material & Mechanical parts & processes procurement , Software

Rule : Each lab in charge of a "flight deliverable" identifies a "PA/QA manager" in charge of those matters + Quality Assurance

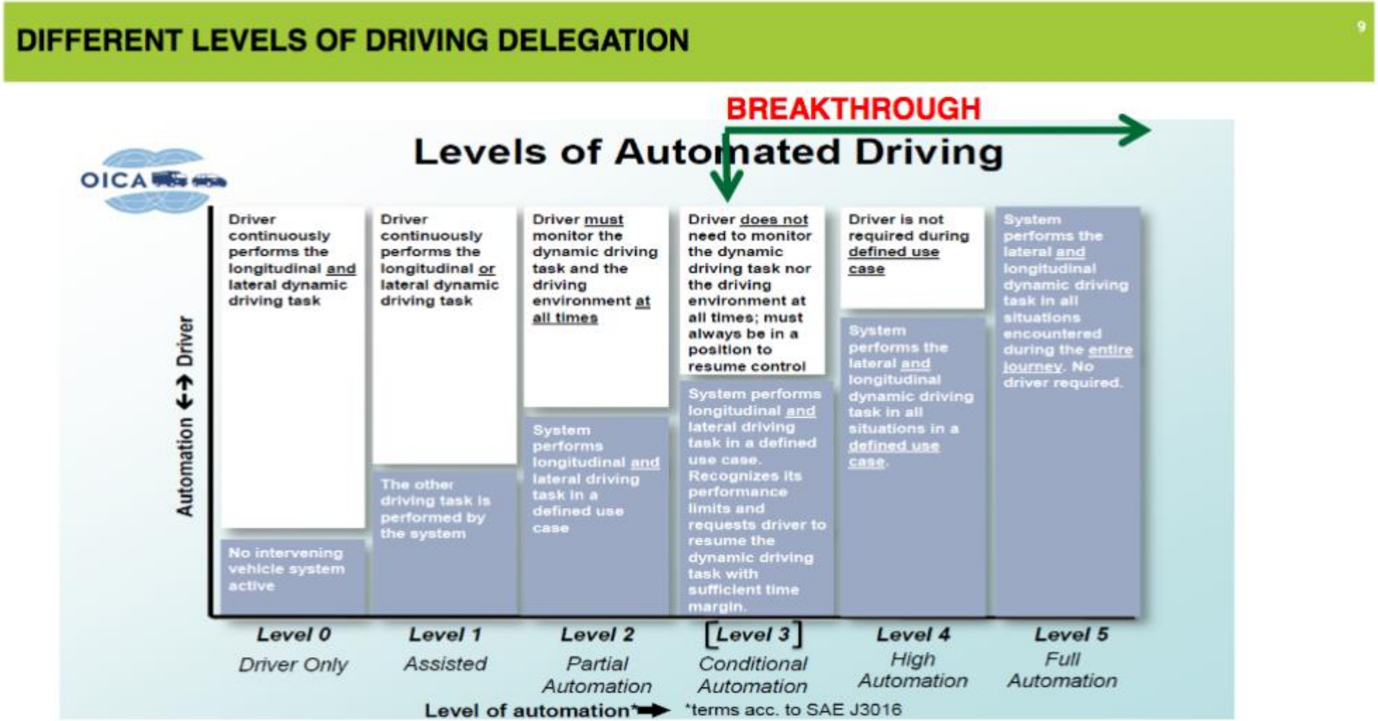
Space mission duration
- 100% ON - availability without maintenance
- > 100.000 hours

Compare to well known object
- A car : 150.000km @50km.h^{-1}
- 3000 hr with maintenance

Gold rule for space instrumentation : Schmitt axiom (lesson learnt)
- part I : What is not identified as a requirement is not verified
- part II : What is not verified, don't expect it to work properly
- Part III : Early verification will lower failure consequence

Invited Speakers

- Gilles LE CALVEZ–ITE VEDECOM Vehicle Program Director gave a nice overview of the state of automated car development



Medical Session

Specificities of the Particle Therapy machines:

- Short breakdowns admissible, long breakdowns very perturbative
- continuous process, very short shutdowns allowed
- High level of safety required, documentation for conformity

Benno KRÖCH (Marburg - Germany)

-The constraints related to E.U. Medical Directive

-The different steps of an upgrade of the control system (risks analysis, …, roll back, tests, QA …)

-The different stakeholders: eng., companies, med physics, ...

Hikaru SOUDA (Gunma - Japan)

To prevent failure:

- Share troubles with other facilities
- Machine time for trouble shooting
- Evaluation of criticity - FMEA

Samuel MEYRONEINC (Curie-France)

- The case of a contract of shared maintenance with the supplier
- The different issues of the contract
- The lessons learned: interfacing, technical- temporality, monitoring

Ensuring Long Term Reliability

Randy Michaud, Slawosz Uznanski, Peter Ingrassia, Jon Bonofiglio,

- **At Jefferson Lab, the** director set up a lab reliability task force to administer a lab based reliability program.
- Their mandate was to provide a graded approach to corrective actions and to provide a comprehensive planning schedule.
- This was in response to commissioning problems during the 6-12 GeV upgrade.

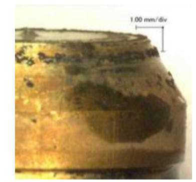
- **Available considerations for an Accelerator System Based on the LHC Power Converter Controls was discussed.**
- Previous power converters were not reliable. Radiation resistant and high reliability converters were to be designed, built and tested prior to being deployed.
- Results of the initial deployment brought to light new problems which were corrected. These improvements were used to deploy the second batch and future converters.

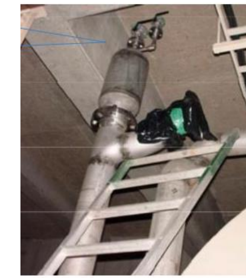
Ensuring Long Term Reliability

- **RHIC continues to face issues with long term reliability.**
- Quench detect diodes protect magnets from discharge from other magnets during a quench.
- Damaged diodes have proved to cause problems during ramp up and do not provide adequate protection to magnets during a quench.
- Temporary techniques and mechanical switches have been implemented to allow the accelerator to run.
- **Age related failure is affecting the K1200 Cyclotron Electrode**
- While ramping up the RF on the cyclotron a number of atypical drop outs were encountered.
- Not sparks - but an internal problem with the upper half of one of the accelerating electrodes was found to be damaged.
- Innovative thinking provided a method of repairing this electrode and plans to machine replacement electrodes are being made.

Experience with the KEK/SuperKEKB Magnet Cooling Water System

- KEKB/SuperKEKB is one typical example of aging facility where is has become a challenge to maintain stable operation with the coooling system of the ~1700 water-cooled magnet.
- To reduce the beam trips at KEKB, a thorough analysis was performed
  - Relocation of purge valves for easy access and remove air bubble in the circuit
  - Add new and finer strainer meshes to avoid clogging
  - Lack of freedom for easy tuning the distribution of the cooling water,
  - Add of Temperature sensor to have alarm precursors before reaching a beam drop





Teachings

- Avoid running pumping station **with little margin**
- **Communication** with workers and contractors and always double check. **Continuous education is a must.**
  - Use of wrong type of seal
  - Grease contamination, etc.

Effort for the Reliable Operation in J-PARC Rapid Cycling Synchrotron

- Thyratrons have very low lifetime and spread
  - Malfunctioning treated
  - Manual retuning
  - Monitor jitter and rise time of the waveform → determine <u>precursor indicator</u> to change the thyratron before failure

- Fixed target catastrophes
  - Redesign and **simplify** the “hot” part of the target
  - Prevent major incident by a **the interlock system** (preventing an extraction of an unexpected beam)
  - **Add monitoring on many systems** including radiation monitors
- **Teachings**
  - Always prepare yourself for the the worse case scenario
  - **Do not underestimate** the number of diagnostics an monitoring/alarms
  - Monitors signal from non accelerator equipment (Radiation safety, etc.).

A Gradient Team to operate CEBAF at larger gradient

Teachings: “We couldn’t score what we didn’t understand so”

- News analysis tools can help a lot such as **Analytic Hierarchy Process**
  - Help setting the right weight on difference tasks
  - Promote discussion, use for convincing management
  - Identify actions with highest added values
- **Interdivision collaboration is the key**
  - Make bridges between groups, avoid work in silo
  - Investing and solving issues together
- **Prioritization**

Operational metrics at PSI proton accelerator facility

We measure operational efficiency by monitoring the following Key Performance Indicators:

- Beam availability
- Current integrals at meson targets, SINQ, UCN, IP2
- Trip rate (number of trips)

Find “Happy-User-Index”!

A. Lüdeke (PSI)

Some steps to achieve higher availability at the complex high-Intensity proton accelerator facility of PSI

- Enough time for the setup after the shutdown (at least 1 week)
- Longer beam time periods (4 weeks between maintenances)
- Continuous updating and modernizing the operational tools (GUI, panels, programs)
- Lessons learned: Dismount of the electrostatic elements at the beginning of the shutdown. Storage of the electrostatic elements in a vacuum and under the high voltage. After RF-conditioning switching on the electrostatic elements and then slowly ramp up

We heard about Modelling of the S3 RIB nuclear facility of Spiral2.

They discussion included how the facility functions and the objectives of their radioactive studies.

Noted a common theme we all face – accelerator environments are very hostile for electronic components.

We heard about the Machine protection at ESS.
They use protection functions, which integrate into several subsystems to provide a full scope of system protection.

Machine Protection – System of Systems

- Many systems are owned by other groups and they hook to them. Integrated system management and communication remains a central theme.

More work is needed on this button!