Safety during powering tests

- Many safety issues were discussed during the LHC Safety Day on 18 October 2007:

  => http://indico.cern.ch/conferenceTimeTable.py?confId=22150

- In particular, the procedures that were used to ensure electrical safety when working on equipment remain in place (locking-off circuits etc.)

What is new?

- **How can we perform the powering tests in the future?**
- **Lessons learned from 19/9/2008**

This talk has been requested recently

- Prepared with input from Laurette Ponce, Magali Gruwe, Markus Zerlauth, Matteo Solfaroli, Antonio Vergara, Boris Bellesia and Mirko Pojer
- Some material from Laurette, Magali and Markus

LHC Safety Day

- Safety for the LHC, John Robert Etheridge
- Safety during Hardware Commissioning, Matteo Solfaroli Camillocci
- Safety during the interventions, Hugues Thiesen
- Electrical works vs Not electrical works in electrical environment, Valerie Montabonnet
- Special cases of cryogenic intervention, Serge Claudet
- ElQA activities, David Bozzini
- Energy Extraction system, Knud Dahlerup-Petersen
- QPS system and its risks, Reiner Denz
- New documentation, Hugues Thiesen
- General CERN safety, Marc Vadon

Access during Powering Tests before 19/9/2008

Access to most underground areas of the LHC were in restricted mode

- Current in a circuit above 1 kA: no one in the tunnel
- Current in a circuit below 1 kA: access for people involved in the powering tests was possible, and for urgent interventions
- Access to the experiments was not restricted (left to the experiments)
- Access to other underground areas was possible, for people involved in the powering tests (UJ, UA, …)
- Access to adjacent sectors was possible

Access during Powering Tests after the incident 19/9/2008

Access restrictions when powering for any circuit at any current

- No one in tunnel and underground areas of the sector
- In case of incident, helium might flow into adjacent sector: No one in the tunnel of adjacent sectors could access, if there was no buffer between (such as an experiment)
- No one in the experiments
- Sectors that were not concerned could be accessed

Comments

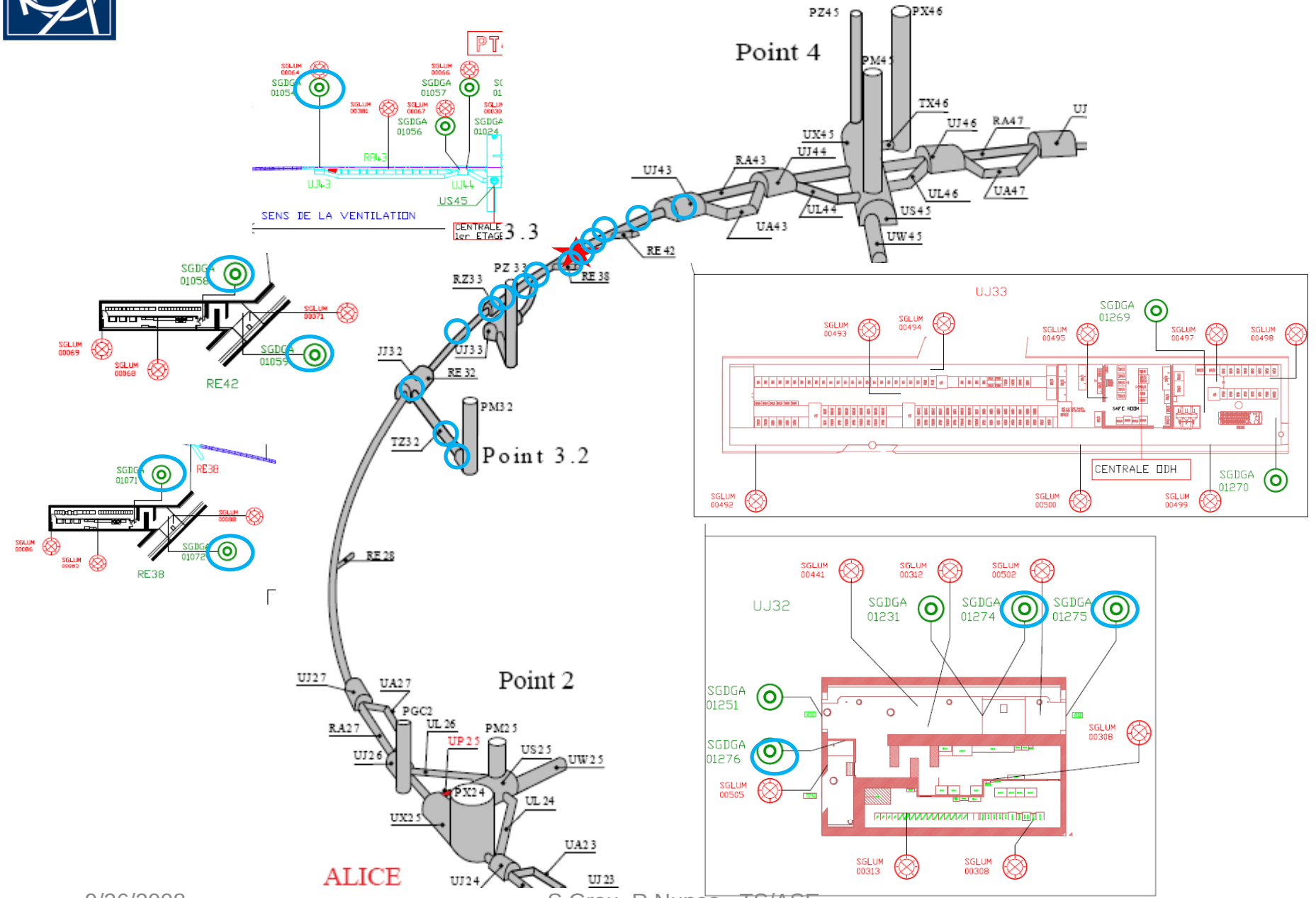
- Tests were performed during late afternoon and in the evening
- Very heavy overhead, frequent patrols
- Difficult for hardware commissioning team, shutdown coordination, operation and experiments
- Very heavy, difficult to organise, not efficient - not to be repeated

Observation from the incident

- The incident happened at a current of 8.9kA, in a circuit that had not been powered to this current before
- Since no one was in the tunnel (current was above 1kA), there was no risk for personnel
- The tunnel sector 34 was filled with helium (measured by the ODH system), even some hours after the incident no access for personnel
- UJ 33 – ODH detectors did not show lack of oxygen
- Indication that there was no lack of oxygen in the underground areas at point 4 (no ODH monitors in UA43)
- Some risk due to one door that tripped over
- A preliminary analysis of the data indicates that even with such massive helium release oxygen deficiency was limited to the tunnel

Very interesting data that needs to be better understood for a risk assessment for people during powering

Localisation des détecteurs ODH qui ont vue la fuite d'Helium au secteur 3-4 le vendredi 19.09.2008



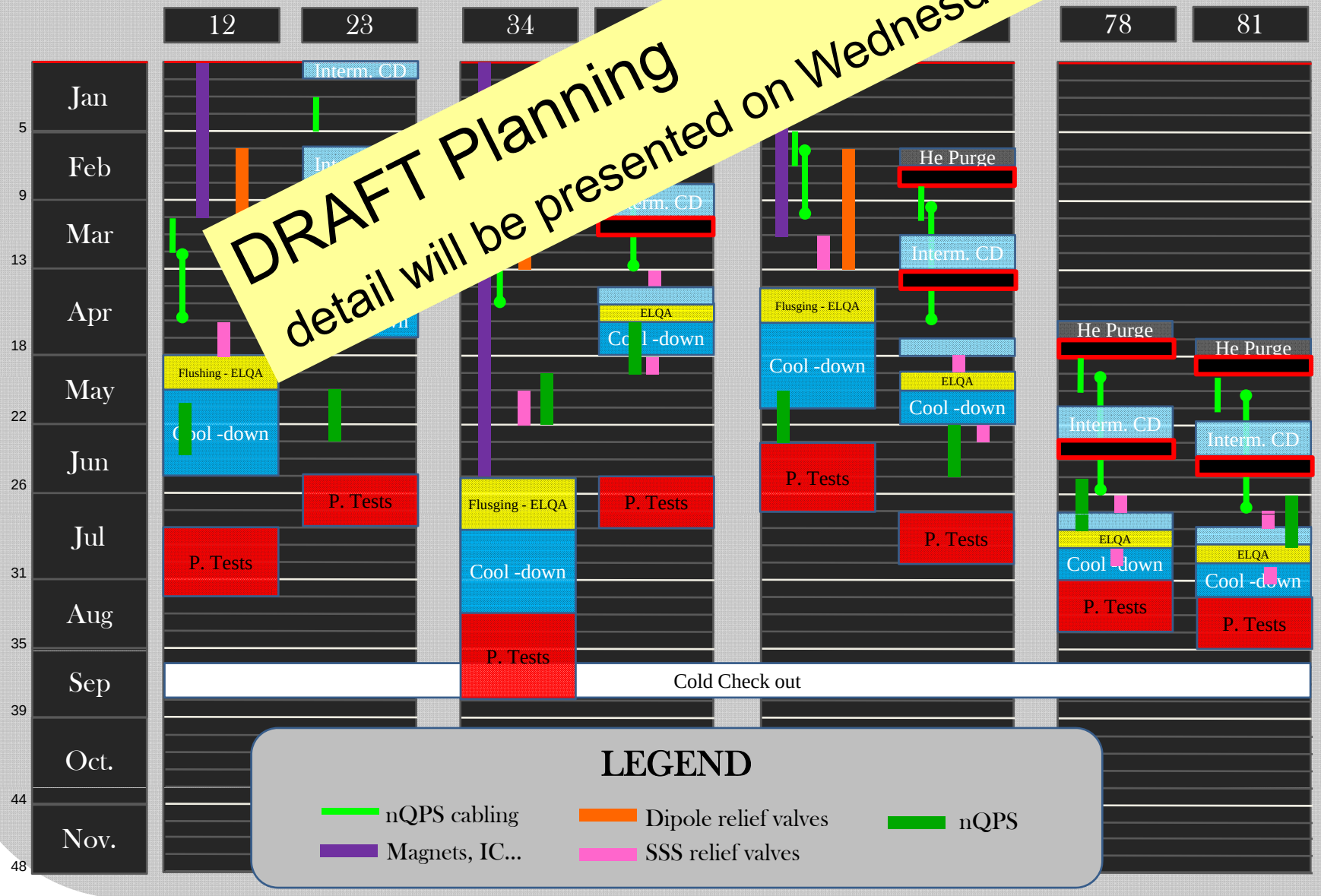
Powering test and tunnel access

Simplest option: close entire LHC before starting powering tests, as for beam operation

- will delay beam commissioning by several months
- would require many activities in parallel
- frequent access for fixing problems would still be required
- some steps in the powering test procedures require access (switching off water, qualifying energy extraction system, ..others?)

Standard (18 Jan 09) – ar

LSD 08-09



Planning and powering test

- The planning considers rules for access as after 19/9/2008
- No powering during activities in adjacent sectors
- Powering tests start very late, not before mid June
- Powering tests are performed during a relatively short period
- Procedures for powering still need to be updated
  - upgrade of the QPS system
  - possibly other steps to minimise the risk
  - time for tests not to be underestimated
- The cryogenic conditions would permit start of powering about six weeks earlier

Powering tests and other activities will be performed in parallel, depending on the sector

Access mode to LHC depends on the sector

Some of the **sectors** will remain for a long time in **general access mode** (e.g. sector 34)

- General access requires several safety courses (not anybody can enter)
  - first option: people can access that are included in general list
  - second option: only those people can access that are in a restricted list (updated daily), as done for sector 34 after the incident
- no operators required to give access

Some of the **sectors** will be in **restricted** or **closed access mode**

  - during (first) cool-down
  - during powering tests and machine-checkout
  - during other activities
- need operator to give access

From shutdown to operation

- Shutdown: access in general mode, responsibility with shutdown coordination
- Transition to restricted mode, responsibility with commissioning and operation
  - Powering tests: restricted/closed (coordination of access by hardware commissioning team)
  - Machine checkout: restricted/closed (coordination of access by machine checkout team)
  - Beam (coordination of access by machine coordinator + EiC)
- Proposal for transition from shutdown to commissioning and operation
  - warm sectors: general access before ELQA-HV qualification at warm, then remain in restricted mode
  - cold sectors: either before ELQA HV tests, or when electrical systems are de-condemned (power converters, QPS heater power supplies)
  - to be discussed, might be optimised, some flexibility required

Access to the tunnel in restricted mode

- ADI (Avis d'Intervention) for all scheduled interventions (approved by point owners)

- Some interventions cannot be scheduled
  - interventions that are related to the tests (typically, QPS team needs to access their equipment)
  - interventions that are urgent (for example, for vacuum or cryo teams to ensure correct conditions)

- EIC on shift takes the decision on the spot for access requests (if there is no ADI)
  - Get input from point owners
  - Inform point owners
  - WEB interface for help

Other access considerations

If there is a long (at least few days) interruption of the tests, several possibilities:

- Restricted access with ADI, requiring an operator
- Restricted list automatically filled from ADI (when signed)… feasibility to be checked
- General mode with restricted list at **P**ersonnel **A**ccess **D**oor (PAD) level (LHC-TNL34 like that was used for sector 34)
- Without an operator giving access, what about urgent access (piquet), or replacement of a team member with ADI permission?

Ideas for accesses

- Grouping accesses?
- What about one day with most accesses?
- Rest of the week: powering tests and NO access (except if required for fixing up for continuing test)

Circuits types and parameters

- Risks for helium release depends on the circuit, on the commissioning step (current) and on the circuit location
- Different types of circuits
  - orbit corrector magnets (max current 60A)
  - orbit corrector magnets (max current 80-120A)
  - corrector magnets (max current 600A)
  - quadrupole and dipole magnets (some kA)
  - main dipole and quadrupole magnets (max current 12kA)
- Different locations
  - arc cryostats
  - stand alone cryostats
  - triplet cryostats

- A large fraction of the tests is being done at low current (e.g. tests of the interlock systems, …..)
- Debugging requires frequent access, in particular in the phase of low current tests

Suggestion: Two phases during the powering tests

- **PHASE I - Low current powering tests:** current limited to a value to be defined, taking the risks into account
  - Underground access is in restricted mode
  - Limitations for access to tunnel to be discussed (closed or restricted)
  - No limitations for access to experiment
  - No limitations for access to adjacent sectors
- **PHASE II - High current powering tests:** the current in the circuits is not limited
  - Access is closed & all necessary areas patrolled
  - Access to experiments to be defined
- For each circuit type, it is required to define “High Current”
- For each circuit powered with “High Current” is required to define what areas need to be closed and patrolled (Task Force chaired by R.Trant)
  - Adjacent tunnel areas ? Service areas ? Experiments ?

Risks during powering

- It is the responsibility of the EiC to ensure that no one is in the areas during high current powering

Low current powering tests

- Risk that the current in a circuit is increased above the limit **AND** an there is catastrophic helium release **AND** there are people in the tunnel
- The way of ensuring the limitation of the current needs to be defined. It must be easy to verify this limitation

High current powering tests

- It must be made sure that no one enters into the area (…as far as possible)
- Risk that someone enters the closed area (violating the rules) **AND** there is catastrophic helium release

- The EiC needs tools in order to have a clear view
  - are the areas concerned by high current powering tests closed?
  - is the current during low current powering tests below the limit?

Starting powering tests

- Start **high current powering tests** only when
  - patrol SAFE
  - no keys out
  - closed mode

- Start **low current powering tests** only when
  - Patrol SAFE?
  - OR envelop doors are all closed and emergency handles armed?
    .... to be discussed

- During low current powering tests, if a circuit exceeds the current limit
  - Interrupt test? How? Under which conditions?

- During high current powering tests, if an access areas is violated
  - Interrupt test? How? Under which conditions?

Powering Phase I at low current

- a sector is defined to be in "**Powering Phase I**"
- the **current** in the circuits in the sector **is limited** to low current
- during this phase **underground access of the concerned areas** (to be defined) are in **closed or** in **restricted mode**
- **access can be granted** to these areas to **colleagues** that are **involved in the powering tests**, and to other colleagues for **urgent interventions**
- the method **ensuring the limitation of the current needs to be defined** (possibly using the FGC parameter). It must be easy to verify this limitation. Only authorised people can change this limitation
- the **maximum current** for each circuit is **read out**
- the **access conditions** and the **powering phase** derived from the current **are shown** on a screen
- if the **access conditions** and the **maximum current** are **not compatible**, powering **could be stopped** performing a Slow Power Abort

Powering Phase II at high current

- a sector is defined to be in "**Powering Phase II**"
- the **current** in the circuits **is not limited**
- for each sector, the **areas concerned by the powering tests** need **to be defined**
- the **access mode** of these areas is **'closed'** after a patrol has been done
- the **access conditions are published** and the **powering phase** is shown on a screen
- if the access conditions **are not compatible** with this phase of high current powering, the **interlock process could stop powering**
  - the detailed mechanism to stop powering needs to be defined
- if there is **any violation of the access zone**, **people must be informed** (e.g. in case of some breaking into the zone)
- **Vital matrix between maximum current for circuits and access conditions**

Conclusions

- If there is an agreement on the two phases of powering, work to define and implement tools for operation can go ahead
  - there are several open questions to be addressed

- **Most urgent: matrix between maximum current for circuits and access conditions needs to be defined**

- Circuits with normal conducting magnets are not considered as no risk for helium release and electrical protection is done according to IP regulations