Safety Consolidation in and around the Injector chain*

S Baird

On behalf of

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T Otto & the PS Radiation Working Group (PSRWG)

P Bonnal (Risk analysis procedures)

* Safety Consolidation at the PS

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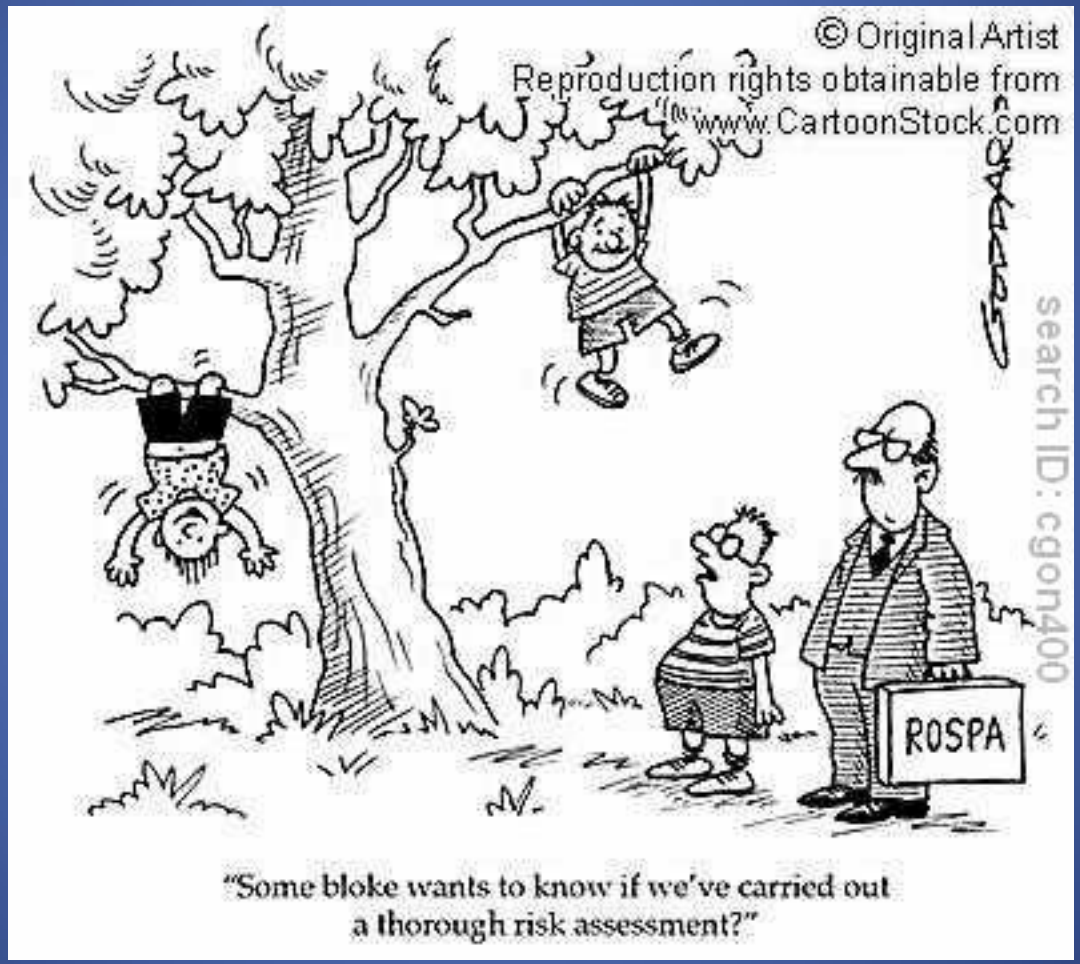


Safety Consolidation at the PS

- In view of the decision to keep the PS as LHC Injector for 25 years*
- PS Safety review (F Szoncso)
  - Snapshot of the situation today
  - Aiming to identify Hazards
- Risk analysis (P Bonnal)
  - Establish a prioritized action list for risks identified by the PS Safety Review
- Input from the PS Radiation Working Group (T Otto)
  - Evaluation of beam intensities and loss rates
  - Identification of main radiation hazards
  - Impact on operations & tunnel interventions
  - Recommendations

* Decided after Chamonix 2010

PS Safety review

- Mandated by S Myers & R Trant to:
  - 'establish the facts related to the safety of the CERN PS and assess the safety compliance of the PS in view of it's long-term operation as LHC injector'
- Members: EN/MEF, HSE, BE/OP, TSO
- Aim to identify hazards whilst avoiding any prejudgment
  - Groups involved in the operation, maintenance, modification and emergency handling at the PS were contacted individually
  - Standard questionnaire plus specialized questions
  - Report the situation as it is today (as seen by those intervening in the tunnel)
- The results can be found in the CERN Proton Synchrotron Safety Review
  - https://edms.cern.ch/document/1119511/1

PS Safety Review: Teams contacted

- Civil Engineering, buildings, tunnel structures
- Services: Tunnel cooling and ventilation, Electricity, Cabling, Transport
- Beam related equipment: Vacuum, RF, Beam instrumentation, Kickers & Septa, Magnets
- Safety systems: Interlocks, Access and Safety systems, Fire Brigade, Environment
- Shutdown Coordination

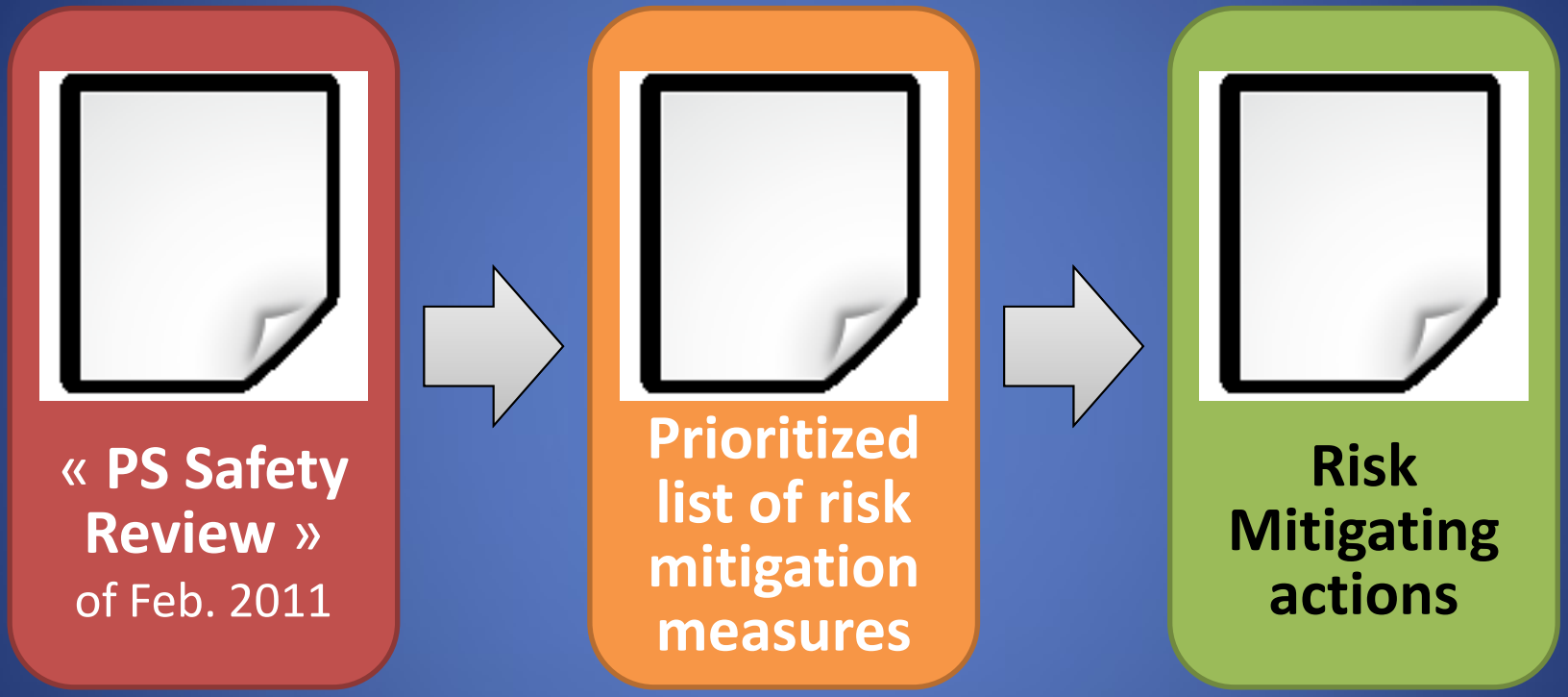
PS Safety Review: Hazards indentified 1/2

- 41 potential hazards identified including…
  - Asbestos pipe insulation
  - Safety communication for personnel intervening in the tunnel (CERN and external contractors)
  - Leakage of air from the tunnel, smoke extraction system has no filter, problems to maintain constant pressure differentials in the tunnels
  - Possibility of corrosive smoke in case of fire (cables, batteries…)
  - No flooding warning interlock in presence of pressurized water systems
  - HV is present on ion pumps permanently (during access)
  - Many of the procedures for testing magnets and other elements rely on expert knowledge and not written instructions

PS Safety Review: Hazards indentified 2/2

- Cable deterioration due to radiation, overfilled cable trays & un-identified cables
- Lack of building/tunnel maintenance (leaks, water infiltrations)
- Some walkways and stairs are unsuitable and difficult to use
- Tunnel concrete floor slabs damaged
- The AUG layouts and the action of individual buttons are not clear
- Few systems have individual emergency stop buttons (not coherent approach)
- Lack of safety exercises and evacuation drills
- Radiation issues are covered by the PSRWG

Prioritizing risk mitigation measures



Possible measures that will most improve outstanding safety issues → Top of the list

Actions that are to be taken **within budgetary limits**

Evaluation and analysis phase

- **Identify** all safety risks from the hazards listed in the *PS Safety Review Report*
- **Evaluate** those risks from to 2 perspectives:
  - **Probability** of occurrence
  - **Impact** on health, safety and environment

Risk = P × I

- **Analyze** those risks:
  - List the **existing mitigation measures** (already in place):
    - Preventive measures (🡻 probability)
    - Protective measures (🡻 impact)
  - List possible **additional mitigation measures**
  - Estimate their feasibility (cost, manpower, schedule…).

Evaluation and analysis phase

- Review **existing mitigation measures**, i.e. those already in place

  (risks are weighed taking these measures into account)

  1st ranking (before new measures are implemented)
  sorting = from highest risk to lowest risk
- Identify **additional mitigation measures**

  (incl. their cost estimate, the manpower required, their feasibility from a schedule point of view…)

  Risks are then re-weighed considering the implementation of these additional mitigation measures

  2nd ranking (after new measures are implemented)
  sorting = from highest risk improvement to lowest.

PSRWG: PS Beam Intensities and Loss

The PSRWG evaluated beam intensities and loss rates for 2010 operation of the PS.
This allowed a correlation between beam loss and the observed radiation hazards

Calculated from intensity & loss

Average/supercycle

	Intensity	Relative Loss	Loss rate
Injection	8.2 10^{12} s^{-1}	6 %	5 10^{11} s^{-1}
Extraction (high.int. beams)	6.4 10^{12} s^{-1}		
CT		10 %	6.4 10^{11} s^{-1}
MTE		1 – 2 %	Up to 1.3 10^{11} s^{-1}

Not including nTOF, LHC, EAST HALL

Main Radiation Hazards in PS

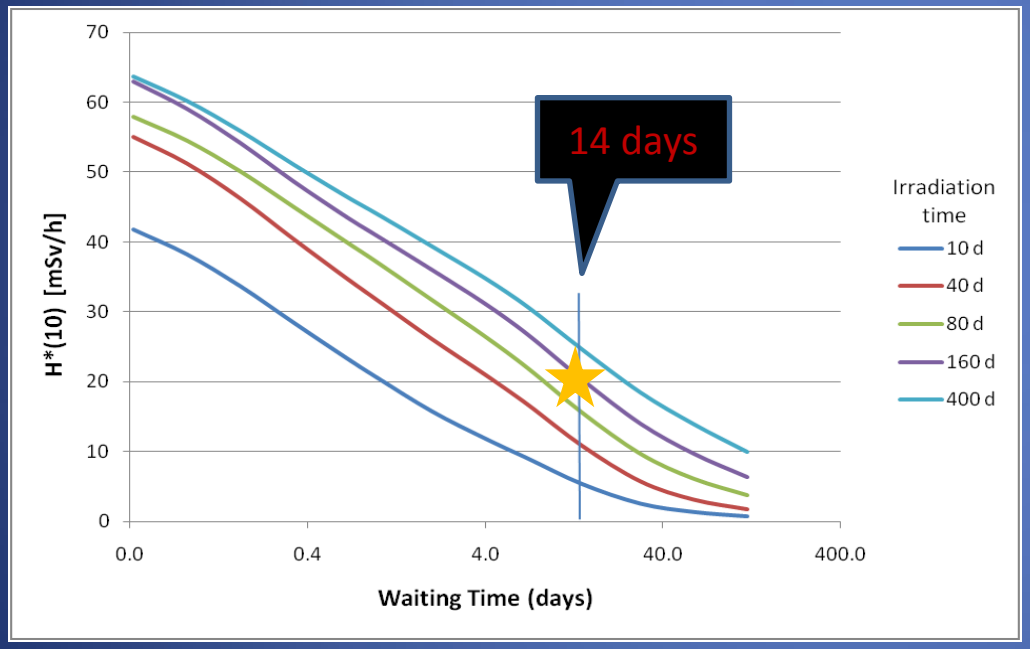
Not measured today

Hazard	Main Locations	Concern	Mitigation*
Air activation	Whole PS, numerous pathways	Release to environment, radiation dose to workers and public	Assessment to demonstrate negligibility
Stray radiation	Route Goward Downstream of South-hall	External irradiation of personnel on-site and of public	Shielding
Activation of material in the tunnel	SMH16 (MTE) Downstream SEH31 (CT)	External irradiation of workers during access	Allow decay time

* other than reduction of beam loss

Activation: Ambient dose rates **limit** the possibility for urgent interventions

E.g. Replacement of SMH16



14 days after accelerator stop:
$H^*(10) \approx 20$ mSv h^{-1}

↓

Septum exchange possible without breaking internal RP rules

Solutions:

- Hardware upgrade to allow remote handling
- Wait longer (unrealistic due to logarithmic decay characteristics)
- **Reduce and/or constrain beam loss**

PSRWG Recommendations (1)

- Air activation
  - Cost an upgrade of ventilation allowing proper assessment of releases, in terms of CHF and of person-mSv
  - Take an informed decision

- Stray Radiation
  - Homogenise radiation shielding on top of PS, allowing for probable intensity upgrades: Linac 4 and 2 GeV PS Booster at full capacity
  - + 180 cm earth downstream of South-Hall
  - +180 cm concrete on Route Goward

PSWRG Recommendations (2)

- Accelerator Activation
  - Reduce loss focalized on SMH16 by various means (dummy septum, barrier buckets, …)
  - Introduce a beam loss constraint for routine operation:
    - $< 10^{10}$ s^{-1} at any location (without septa)
    - $< 10^{11}$ s^{-1} at septa
    - $< 10^{12}$ s^{-1} overall
  - These constraints allow major interventions after a breakdown (magnet or septum exchange) with 14 days decay time

Actions for the future

- Hazards identified in the PS Safety review
  - Risk analysis to assess the hazards identified and produce a set of prioritized actions
  - Implement inside an Injector Consolidation program?
- PSRWG
  - Modify ventilation system to allow measurement of air activation
  - Additional shielding requirements identified
  - Remote handling for certain elements?
  - Reduce localized losses with “technical or beam” solutions
  - Use a beam loss constraint rather than an extracted intensity limit

Questions asked 1/3

- Do you believe that your equipment is operationally safe today?
- What risk does your equipment pose for the safe operation of the PS?
- Does your equipment pose any safety issue to other personnel?
- Do you believe your equipment will degrade in terms of safety and will require replacing or even redesigning?
- How could your equipment be improved to make it safer than it is today?
- When making interventions on your equipment, do you consider the procedures you follow today are safe?
- To make your interventions safer, what procedures should be improved?

Questions asked 2/3

- Do you consider the PS tunnel to be a safe working environment?
- What elements of the tunnel do you consider to be either unsafe or a potential risk to your health and safety?
- Do you consider any other PS hardware to be unsafe?
- Are you aware of any environmental issue in the PS that should be addressed?
- Are you and your team fully aware of the emergency equipment and procedures while working in the tunnel?
  - Emergency exits?
  - Emergency lighting?
  - Emergency phones and numbers?
  - Emergency stop buttons (AUG)?
  - Fire fighting equipment? Extinguishers, what type and how to use them?

Questions asked 3/3

- Specific questions….
  - Can beam losses affect your equipment?
  - Does induced radio-activity affect interventions on your equipment?
  - Is your equipment protected by specific interlocks?
  - Do you use/store dangerous chemicals/materials
  - Do you have dangerous systems which must remain on during a shutdown period?
  - Is the tunnel equipped with smoke extractions systems?
  - Do your equipment present a particular fire risk?
  - How is the AUG system laid out?
  - ……