WG-D: Commissioning, Operations and Performance

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(See program for list of talks)

<u>Initial charge for this group:</u>

- What are the challenges in the light of very high intensity proton beams (dynamic range, losses …) ?
- tuning procedures and interlock systems for high intensity machines ?
- reliability, practical experience from operating facilities highly appreciated ?

LHC

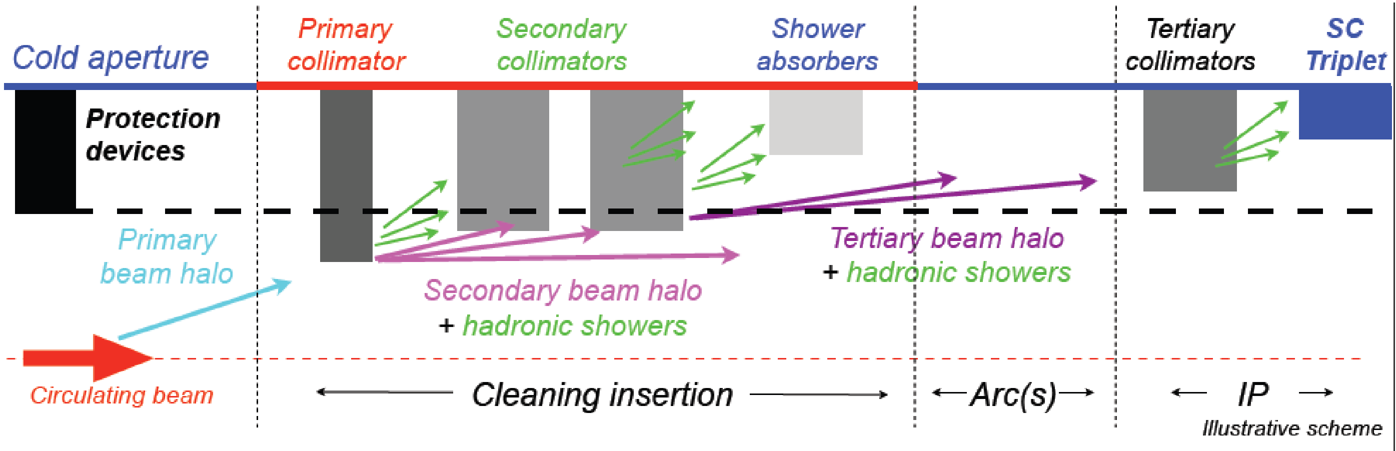
- **Initial commissioning progressing quite well -**

20th Nov	Day 0	Both beams circulating after 6 hours
23rd Nov	Day 3	First pilot collisions at 450 GeV
29th Nov	Day 9	Beams ramped to 1.18 TeV
6th Dec	Day 16	Stable collisions @ 450 GeV for the experiments
8th Dec	Day 18	Both beams ramped to 1.18 TeV – first collisions

- **The intensity is being ramped up carefully, under controlled conditions**
  - Low intensity MPS setup, then beam with no crossing, crossing
  - 150 bunches to date (aiming for 400 this year)
  - 10 MJ stored energy achieved (~30 MJ aimed for by end of year, 360 MJ final)
  - No magnet quench yet with stored beam
  - Average store is ~ 8 hrs
  - Are occasional fast local scattering source loss events that are not understood
- **Goals**

2009			2010			2011		
Repair of Sector 34	1.18 TeV	nQPS 6kA	3.5 TeV $I_{safe} < I < 0.2\ I_{nom}$ $\beta^* \sim 3.5$ m	Ions		3.5 TeV $\sim 0.2\ I_{nom}$ $\beta^* \sim 3.5$ m	Ions	
No Beam	B		Beam			Beam		

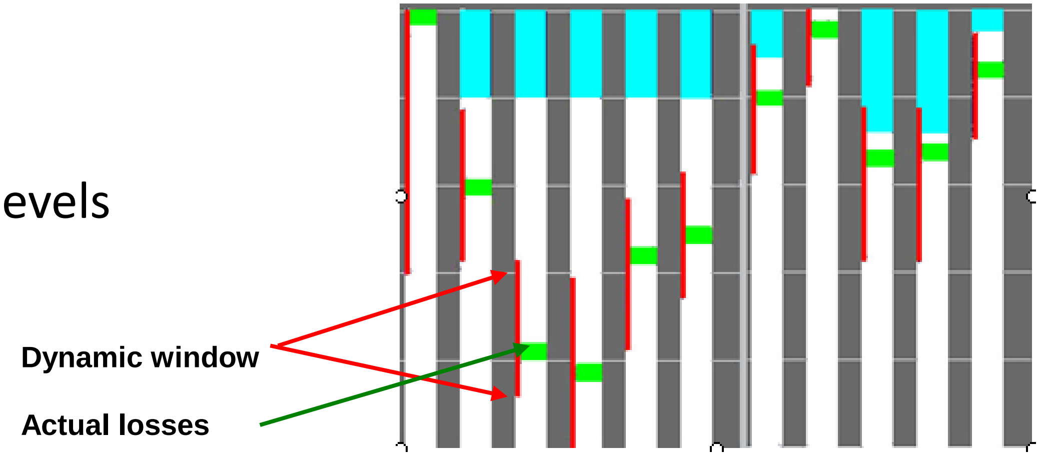
LHC Multistage Collimation



- **Careful collimator setup, using empirically determined settings for a given beam setup**
  - Complex pre-programmed algorithm to follow beam through ramp stages
  - Many interlocks to assure this complicated system is working properly
  - 1 week to setup process, not expected to hinder progress rate
- **Repeatability is critical**
  - appears to work within spec (10 μm)
  - Present setup used for ~3 months
- **Efficiency / performance is close to predictions**

Machine Protection Systems

- **Need a "tune-up" mode**
  - Intensity dependent trip levels



- **All facilities employ redundant beam shut-off systems**

- **Varying levels of bypass control**
  - LHC has high level of control- cannot run with inputs by-passed, signatures, ….
  - Others are less formal, but all facilities have some control
  - Sophistication and configuration control of the protection system seems to be proportional to the investment being protected

Machine Protection

- **Protect against direct damage from beam, activation buildup and satisfying environmental regulations**

- **Many inputs to MPS**
  - LHC has 10^4, order of magnitude more than other high power devices

- **Response times**
  - 1-10 ms : CW machines (PSI)
  - 10s of μs: pulsed machines (SNS, LANSCE, J-Parc)

- **Some facilities employ slow and fast protection systems (SNS, LANSCE)**
  - Fast hardware based system protects machine from direct damage (RF, BLMs, ….)
  - Slow system integrates loss to prevent excessive activation (integrated loss over 1-10 seconds)
    - Limits set closer to operational loss levels than the fast limit

- **Fast protection integrated systems are in-house developments – not commercially available**
  - Less formal controls than nuclear industry

Residual Activation

- **Machines are hand's-on maintainable with > 1-10 uSv/hr at 30 cm "Hot spots"**
  - Newer facilities have not had time to mature to this level
  - J-Parc activation is quite low
  - Some facilities have areas of controlled beam loss (higher activation) which require special care
- **Annual workforce doses : 10's of mSv**
  - SNS: 20, LANSCE: 50, J-Parc: 5, FNAL: 30
- **Models are successfully used to predict expected residual activation**
  - Simple models (FNAL)
  - Complex simulations (e.g. WG-G)
  - Important to model activation levels during design stage for high-intensity machines
- **Mature facilities can accurately predict post-operational residual activation levels from experience**
  - With modest power ramp-up factors (10's of %), one can also predict activation levels with reasonable confidence

Availability

= (time beam is provided) / (time beam promised to be on)

- **High power facilities annual average last year**
    - SNS - 86% (increasing)
    - PSI – 90%
    - LANSCE / Lujan– 85%
    - ISIS – 88% (1998-2008 average)
    - FNAL – 95% (MR only)
    - J-Parc – annual average NA, but 92% for 5 recent runs
  - Difficult to exceed 90%

- **High Intensity Machine**
  - LHC is just starting, ~40% time spent with stored beam

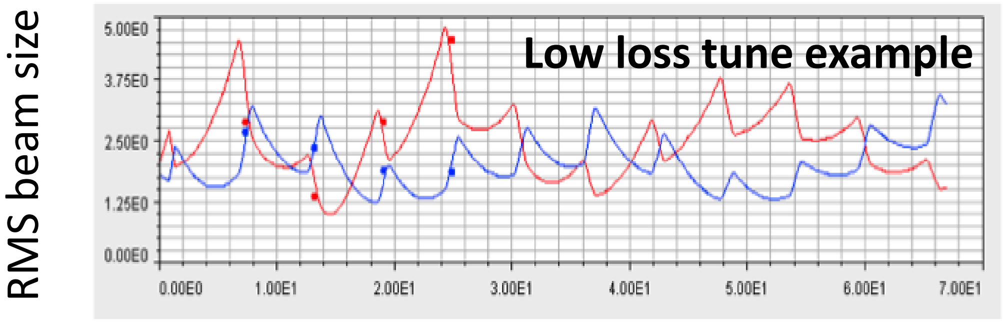
Availability

- **Lower availability at the start of runs is typical**
  - Try and schedule long runs if possible
- **Beam setup time after extended maintenance**
  - SNS: 1 week
  - LANSCE: 3-4 weeks
  - PSI: 2 weeks
  - FNAL: 2-3 days
  - ISIS: 1 week/(month of downtime)

- **long outages are generally the largest cause on non-availability**

Loss Tuning

- **Setups are physics based initially, but subsequent empirical loss based tuning is common**
  - Control room physicists cannot yet reproduce model predictions



Annual User Operation Hours Planned

- PSI: 5600 hrs (64% of year)
- SNS: 4900 hrs (56% of year)
- LANSCE/Lujan: 3300 hrs (funding limited)

- **Where is the rest of the time spent (SNS, PSI)**
  - Maintenance / upgrades (25 - 30%)
  - Beam studies, Training (10%)
  - Startup (3%)

Summary

- Exciting to hear about initial LHC runs
- Great deal of commonality in operation of high intensity, high power proton machines