What Do We Want To Measure (in 2009)

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26/3/2009

CC09

➔ **See also the presentation of Walter on UA9, including his remarks on goals and possible achievements.**

Motivation: Improve LHC Collimation

Collimation upgrades part of our 2003 collimation plan and effort put into place (White Paper, FP7) to find solution.

Outside of collimation phase II project: Crystal R&D tests in Tevatron and SPS. But we collaborate…

Once proven, will integrate into LHC upgrade plan.

Crystal enhanced collimation likely needed for major LHC upgrade (phase II IR upgrade)…

For example, see SPC report:

CERN/SPC/883
Original: English
21 March 2007

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Report of the SPC Review Panel on extra resources 2008-2010

1.6 Collimation System

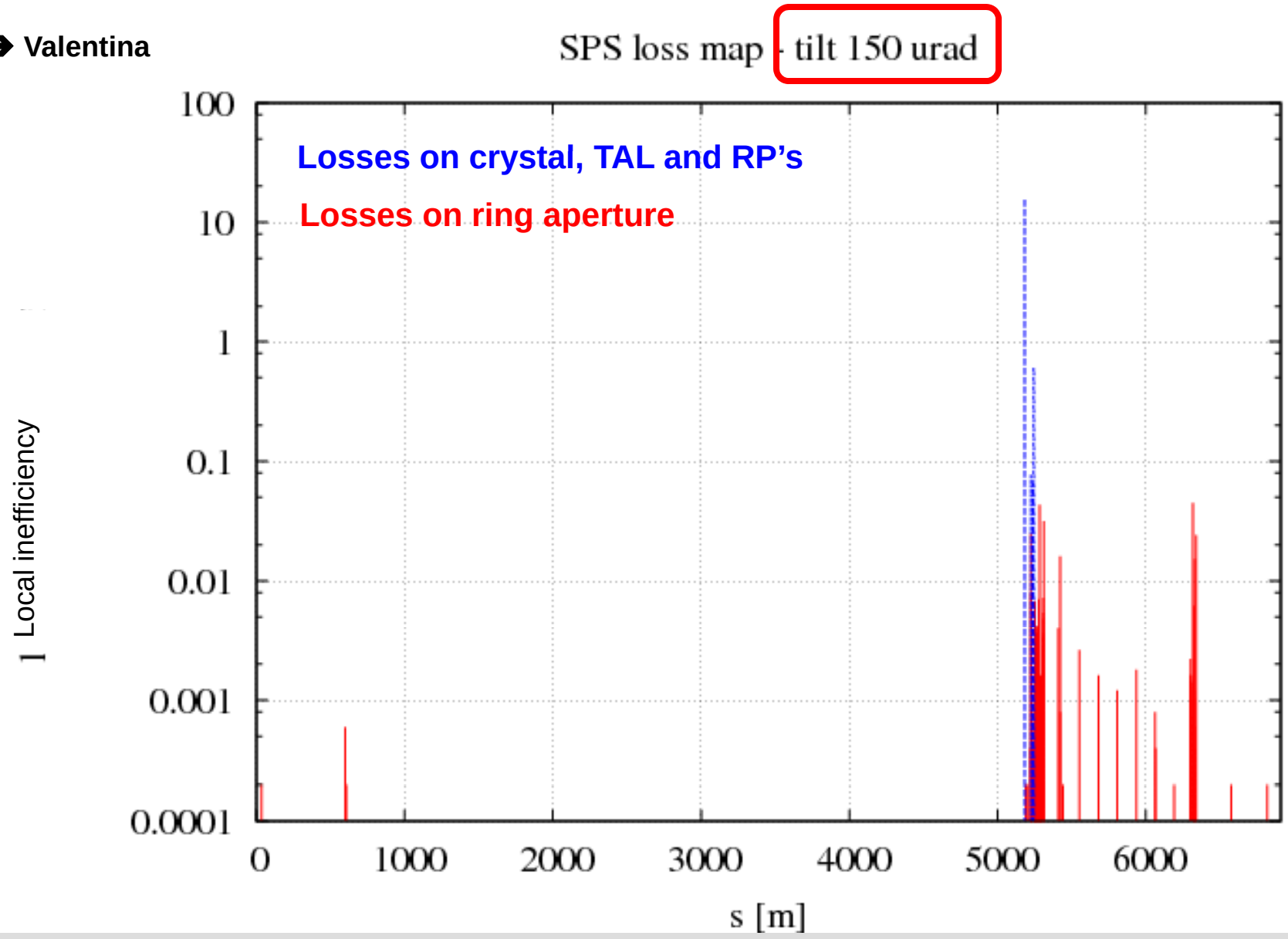
Luminosity improvement in the short term will require an upgrade of the initial collimation system. The phase I collimation system is adequate for lower beam intensities, but only the Phase II collimation system will be able to handle the nominal beam intensities.

Our Goals

- Experimentally assess the cleaning behavior of a bent crystal, acting as primary collimator ➔ Understand crystal as primary collimator.
- Do this with parameters relevant to the LHC such that we can extrapolate SPS crystal results to the LHC regime. This leads us to variations in a number of parameters.
- Mostly interested in losses around the ring, in particular losses in the SPS magnets. Therefore we put the focus on the loss measurements with Beam Loss Monitors (BLM's). Also interested in Roman Pots.
- Approach very successful for LHC collimator tests with loss maps.
- Want to prove that we can reproduce in simulation the measured losses in the accelerator with a bent crystal as primary collimator.
- Not so important to minimize losses, as long as we can get reliable measurements, proving that we understand the crystal physics and cleaning process.

Predictions for the SPS

➔ **Valentina**

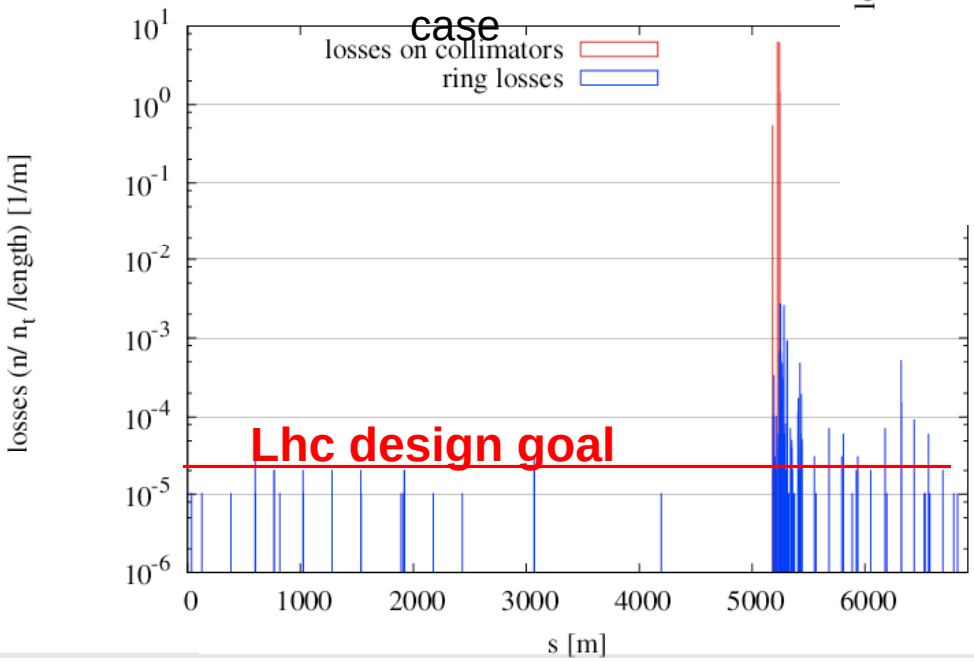


Sixtrack results (**Preliminary**)

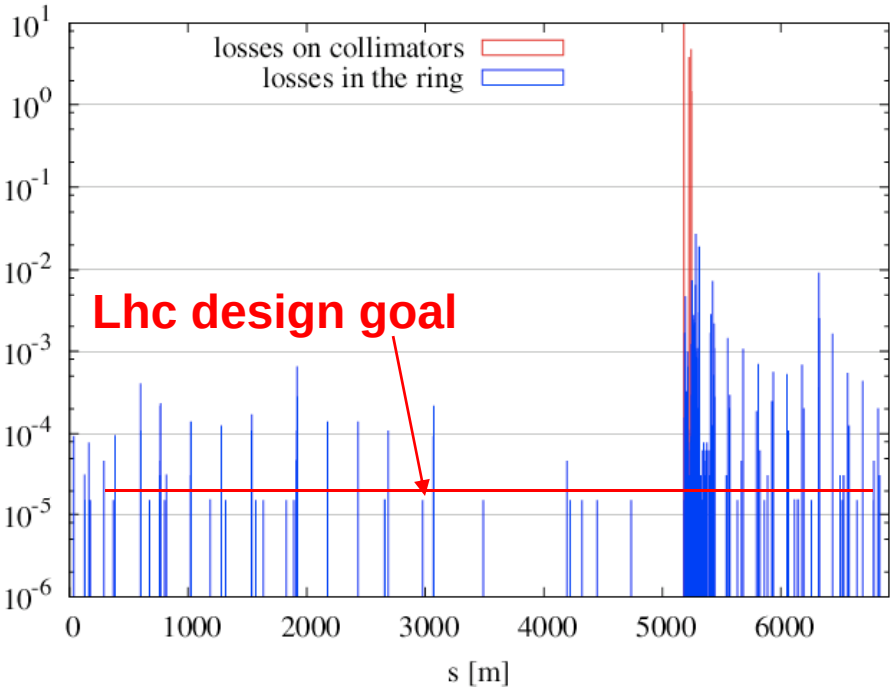
➔ **Valentina**

- Up to now: linear machine, no energy spread
- Much higher statistic (5 million particles - 1000 turns)
- Colltrack results are reproduced

Channeling case



Volume reflection case



The factor 20 improvement is confirmed

LHC goal can only be reached with multi stage conventional cleaning downstream?!

Measurements

- In principle, we want to measure the loss maps for different parameters and compare them to simulations (see examples shown before).
- Simulation tools are ready to simulate all effects, including off-momentum behavior of particles, …
- In the next slides show lists of measurements that we ***want*** to do. This does not mean that all can be done in 2009. Needs more discussion and scheduling work…
- Also: We collaborate also with Tevatron experiment. Similar measurements can be done there as well to get more complete coverage (different energies, different diffusion properties, different crystals, …).
- Conditions too different to split up measurement program ➔ want to do full program in the SPS, even if parts are done also in Tevatron.

(A) Static Loss Maps

1. Assume basic crystal adjustment tests have been completed and we have understood how the crystal can be aligned reliably.
2. Then measure for full crystal scan (many crystal angles) all BLM's, BCT (stored intensity) versus:
   - **a)** **dε/dt** Emittance growth rate: Allows to assess influence of impact parameter and surface properties.
   - **b)** **I** Intensity: Allows to assess influence of intensity (none expected), e.g. through temperature, impedance (measure tune shift/orbit change versus intensity), … Allows to determine BLM response.
   - **c)** **E** Energy: Allows to assess understanding of energy dependence.
   - **d)** **TAL position:** Important input to simulations. Retract to position furthest out, still allowing to catch extracted halo.
3. Measure same data for short W target and for LHC collimator (required to recalibrate model for 120 GeV).
4. Calculate local cleaning efficiency around ring (as used for LHC).

Local Cleaning Inefficiency

- Used for LHC assessment of collimation performance (required not to quench any given element). Defined as:

$$\text{Local Inefficiency} = \frac{\text{Number of p lost at element}}{\text{Total number of p intercepted at crystal}} \times \frac{1}{\text{Length of element}}$$

- Should not depend on intensity.
- Should depend on impact parameter.
- Should depend on TAL position.
- Requires knowledge/calibration of BLM response.
- Most important: **Should depend on primary intercepting device used.**
- Proposed program will allow to directly demonstrate improvement of local cleaning inefficiency with crystal over LHC collimator.

(B) Transient Loss Maps

1. Assume basic crystal adjustment tests have been completed and we have understood how the crystal can be aligned reliably.
2. Use fast response (40 μs ➔ 20 ms) of BLM's.
3. Then measure:
   a) BLM signal stability for not moving crystal: Assess possible vibrations. Determine frequency spectrum of losses. Expect machine tunes.
   b) BLM signal stability during crystal movement: Assess possible vibrations.
4. Calculate local cleaning efficiency around ring on a fast time scale.

(C) Operational Efficiency

1. Will be bad in the beginning as we learn how to use the crystal.
2. However, at some point expect to be more or less operational in using a crystal.
3. Based on **SPS crystal adjustment times** we can then estimate expected operational efficiency for the LHC (time and frequency for adjustments, …).
4. Done the same way for LHC prototype collimator.
5. Measurements:
   a) Reproducibility from fill to fill.
   b) Stability versus time.

Readiness and Time Required

- Readiness:
  - We are ready to take the data as described before. Stefano followed up on additional BLM's.
  - ABP/OP data analysis in place from past collimation tests.
  - Simulation tools ready for the SPS and proven in past studies. Extended for crystal routine (➔ Valentina et al). Preliminary predictions exist.
  - If required we might *put some additional resources from the ABP collimation team* (new fellow for collimation upgrades), also to help Valentina during the time when she completes her thesis.
- Time required:
  - No detailed estimates.
  - Will see with experience.
  - Described measurements might require more than one year of tests.
  - As said before: Scheduling and prioritization beyond scope of this talk.

From SPS/Tevatron Measurements towards LHC… (My Guess for Discussion)

- SPS/Tevatron:
  - Characterization of **crystal as primary collimator with stored beam and diffusive beam halo.**
  - Verification of predictive tools and models.
- LHC predictions:
  - Based on experimental data predict LHC collimation performance with crystal enhancement (at the moment simulations look promising).
  - Based on operational experience predict operational efficiency with 8 crystals for the LHC.
- Based on predictions, decide. If crystal upgrade confirmed:
  - Start prototyping of LHC crystal.
  - Modify cleaning insertions to implement power dump etc.
  - Test, produce all, install and commission.
- Timeline: **Phase II upgrade of the LHC** (2016?) or before?