CERN Meeting on Absorbers and Collimators for the LHC Beam on 25.1.02

Preliminary Summary

R. Assmann, SL/AP

Complete summary being prepared by R. Assmann, C. Fischer, J.B. Jeanneret, R. Schmidt (meeting yesterday).

Goals:

- Bring together the CERN expertise on collimators and absorbers.
- Confront the requirements with this expertise.
- Collect ideas on solutions and most urgent studies.

Part of the activity of the LHC Beam Cleaning Study Group.

Our input:

LHC Project Note 277

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Preliminary Beam-based Specifications for the LHC Collimators

R. Aßmann, I. Baishev, M. Brugger, H. Burkhardt, G. Burtin, B. Dehning, S. Fartoukh, C. Fischer, E. Gschwendtner, M. Hayes, J.B. Jeanneret, R. Jung, V. Kain, D. Kaltchev, M. Lamont, R. Schmidt, J. Wenninger

Keywords: Collimation, Beam Loss, Machine Protection

Expertise from SL/AP, SL/BI, SL/OP, AC/TCP, TIS/RP, and collaborators.

Response to our initiative: **Strong interest and support**

(~ 45-50 participants)

We asked for: **Short talks (5-15 min) for quick summary of relevant experience and knowledge.**

Great support from CERN experts… (all agreed to give a talk)

20 talks ranging from the ISR …

… over the Booster, ISOLDE, SPS, LEP…

… to the LHC.

- *Requirements from the Beam Cleaning SG, Machine Protection, impedance, vacuum.*
- *Materials (from Be, C to fiber reinforced ceramics, Boron Nitride). Beryllium OK?!*
- *Technical solutions for handling the LHC beam for injection and dump.*
- *Experience with damage and fatigue.*
- *Computer tools.*
- *Possibilities for experimental tests.*

Talks will be put on web. **Valuable archive of CERN expertise…**

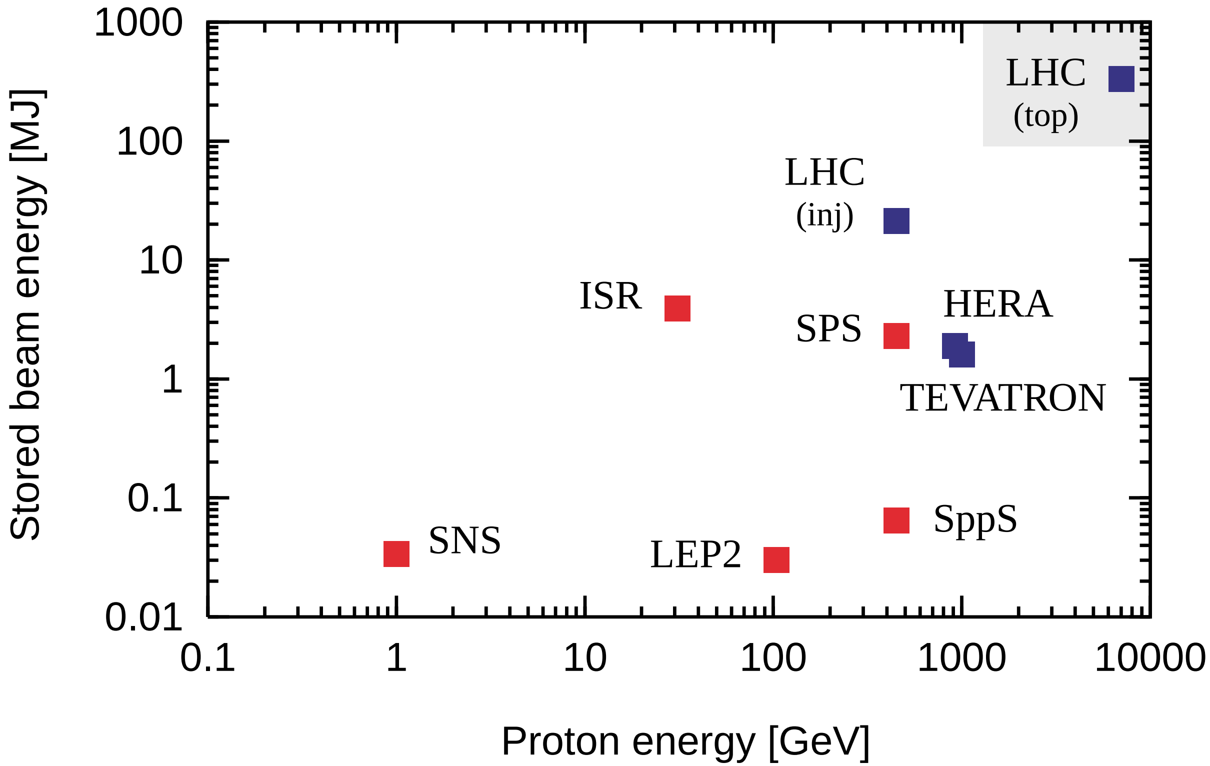
The Challenge:

Talks explaining the challenge and the specific requirements:

J.B. Jeanneret
R. Schmidt
C. Fischer
R. Assmann

Complemented by talks on impedance and vacuum issues:

D. Brandt
N. Hilleret



Step from previous accelerators:

Factor 7	in proton energy
Factor 100	in stored beam energy

The powerful LHC beam must be handled in sensitive super-conducting environment!

Beam and Power Deposition During Regular Operation:

Lifetime reductions during machine cycle (ramp, squeeze, …) and tuning…

Relax with slower ramp!

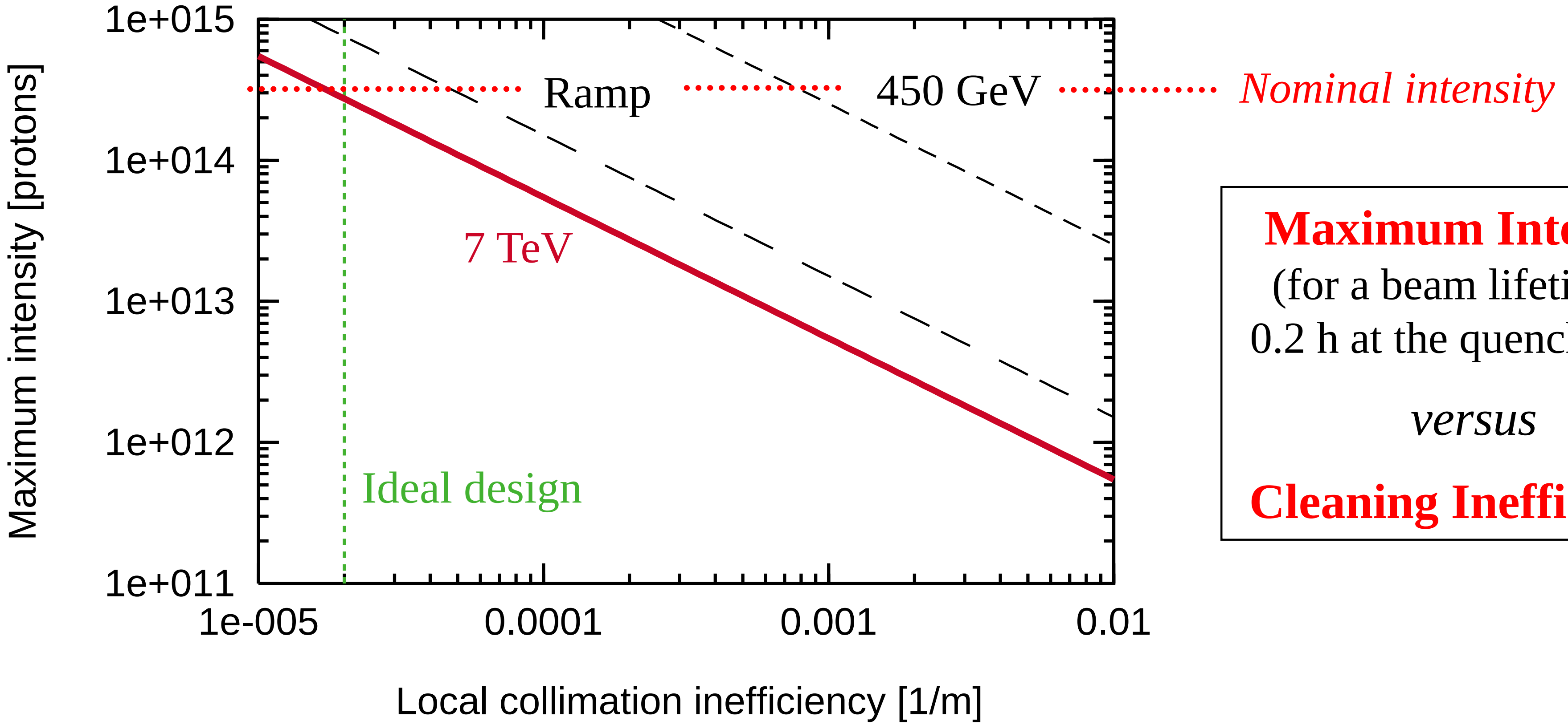
Mode	Energy [TeV]	Duration [s]	Req. min. lifetime [h]	Beam deposition [protons/s]	Power deposition [kW]
Injection	0.45	cont	1.0	0.8×10^{11}	6
		10	0.1	8.2×10^{11}	60
Ramp	0.45-7.00	10	0.1-0.2	$8.2\text{-}4.1 \times 10^{11}$	60-465
	0.45	≈ 1	0.006	1.3×10^{13}	1000
Top energy	7.00	cont	$\boxed{1.0}$	0.8×10^{11}	$\boxed{93}$
		10	$\boxed{0.2}$	4.1×10^{11}	$\boxed{465}$

Most severe: Top energy (up to 0.5 MW) to be absorbed in collimators and down-stream material. Dump beam below 0.2 h (top).

Ensure: Keep tolerance for collimation efficiency **(~ 100 µm flatness)**. (important DIFFERENCE to BT absorbers)

Cleaning Efficiency:

Quench levels of magnets require **excellent cleaning of beam halo** from injection all the way to top energy.



Maximum Intensity
(for a beam lifetime of 0.2 h at the quench limit)

versus

Cleaning Inefficiency

Good efficiency with "good" collimators (cannot run with damaged/deformed collimators)!

E.g.: tolerance on surface flatness: **~ 100 μm**

mm "mountains" on HERA-p collimators…

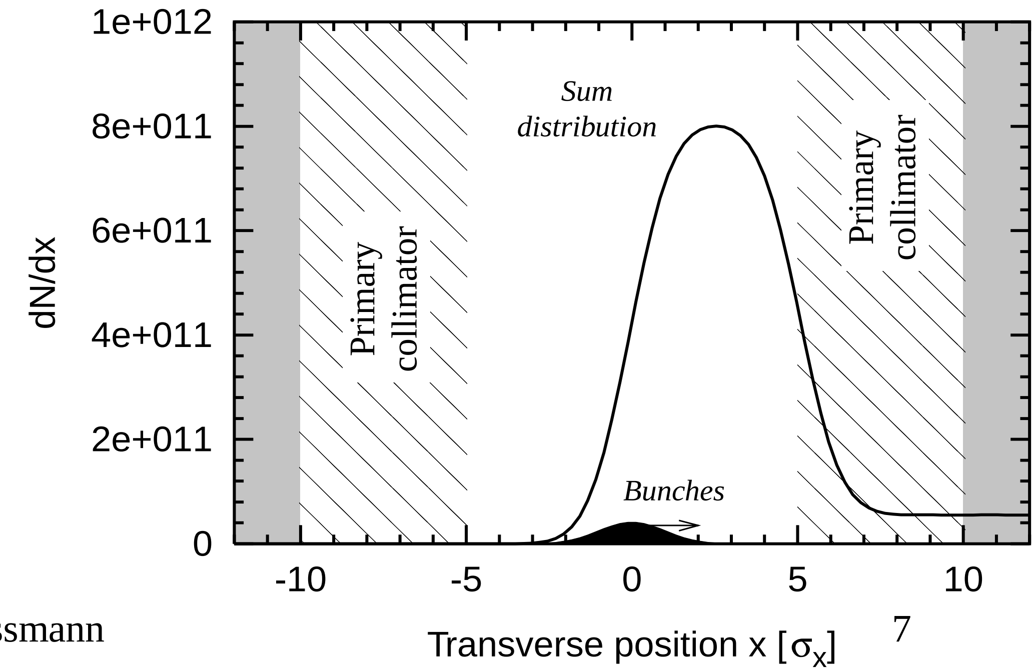
Failures:

Failure description	Beam energy [TeV]	Intensity deposit [protons]	Energy deposit [kJ]	Transverse dimensions [mm×mm]	Impact duration [ns]
Injection oscillation	0.45	2.6×10^{13}	1875	1.0×1.0	6250
Asynchronous beam dump (all modules)	0.45	1.1×10^{12}	78	$\boldsymbol{5.0} \times 1.0$	275
	7.00	2.8×10^{11}	311	$\boldsymbol{1.0} \times 0.2$	75
Asynchronous beam dump (1 out of 15 modules)	0.45	1.1×10^{12}	78	$\boldsymbol{5.0} \times 1.0$	275
	7.00	$\boxed{6.0 \times 10^{11}}$	$\boxed{667}$	$\boldsymbol{1.0} \times 0.2$	$\boxed{150}$

Relax with coll. system in transfer line!?

About 6 full LHC bunches:

- 0.2% of LHC beam
- 30% of HERA-p beam
- 2200% of LEP2 beam



Our goal:

Collimator jaws that can withstand this beam impact.

Preliminary summary: (final summary from JBJ, RS, CF, RA)

- Preliminary beam-based requirements presented as a **basis for hardware choices**. (Propose a talk in LCC on this issue in 4 weeks time).
- Several materials appear promising (**Be**, **C**, Boron Nitride, fiber reinforced ceramics?, diamond coating?). Would coating or plating be an option for collimators?
- Worries on materials (toxicity, brittleness, conductivity, **shock resistance, flatness control, dust, thermal expansion, surface cracks,** fatigue). Careful trade-off required.
- Damage mechanics (**shock waves, fatigue**) are crucial! Tools and expertise available…
- Experimental tests (**tests with beam**) are mandatory: ISOLDE, SPS?
- Collaborate with **vacuum** group on choice of material!
- **Do not consider constraints from impedance** for now (coating for insulator).
- Think on methods to **find damaged collimator** (tomography, RF, temp., beam based,…).
- Protection of LHC collimators require **TCDQ (BT) at 10σ**! Ensure consistency!
- Other concepts: wire septum, non-linear collimation, increased beta functions?

The **damage/deformation and fatigue of collimators** will depend on the **machine running**:

- **Collimation depth (aperture)**
- **Machine protection (beam dump)**
- **Intensities, bunch schemes**
- **Beam lifetimes**
- **Flashes of beam loss (start of ramp)**
- **Failures**

Close **interconnection** between:

accelerator physics
operational scenarios
machine protection
radiation issues
collimator hardware design

Beam Cleaning Study Group + further collimation meetings?