# Beam Loss Monitors, Specification

- **BLM main scope and challenges**
- **types of BLM Collimation, Special, Arc**
- **Sensitivity and Time Resolution**
- **Summary**

largely based on work of

Jean Bernard J., Bernd D., Rüdiger S., et al.

and discussions in BIreview team with J.J.Gras, JPK et al.

# Main scope and challenges

**• substantial energy stored in LHC beams,**

**uncontrolled loss would do major damage**

**nominal LHC 7 TeV, 1.07 A (6 x $10^{14}$ prot.,** $10^{11}$/bunch)

**in beam power, this is about**

**12000 • LEP2 (100 GeV, 6 mA),**

18 • LEP2 in single bunch power (4x$10^{11}$ el. / bunch)

**50 • SPS (450 GeV, .33 A) ,**

**80 • HERA (920 GeV, .096 A)**

**• major energy stored in superconducting magnets, avoid quenches**

**beam loss detection is a very important issue for the LHC**

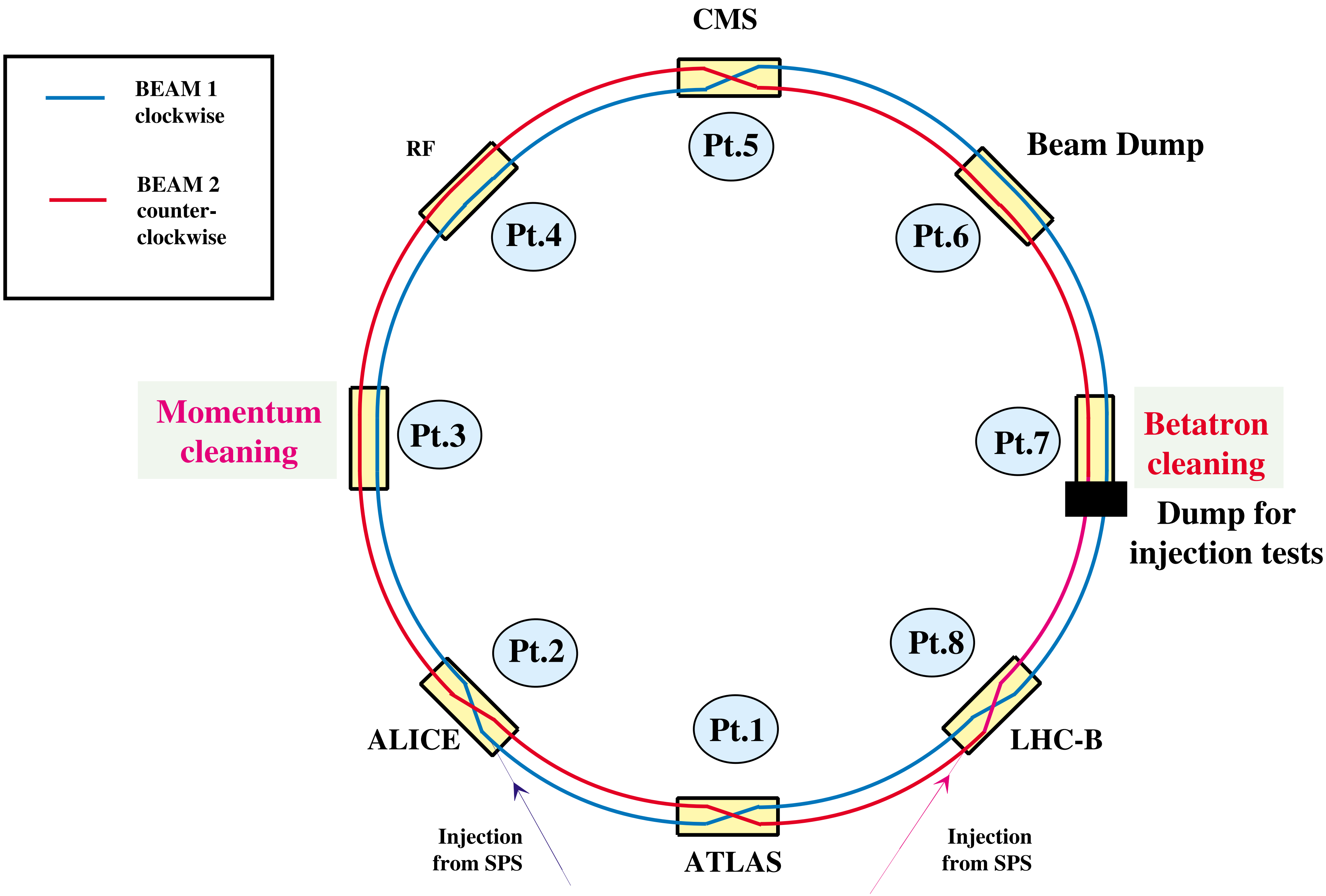
**• realiable machine protection**

**dump beam before any damage**
**and to avoid quenches**

**• challenge: good protection but also**
**dump only if really necessary**

**--> absolute calibration in terms of quench level**

BIReview/Scope.eps




(adapted from Rüdiger) BIReview/LHCscheme.eps

# Different classes of Beam Loss Monitors

**with different requirements from different anticipated losses and use**

different thresholds, geometry, calibration (monitor itself may well be the same)

- **BMLC Collimators in cleaning sections** **(warm except dfba)**
  8 x 2 in IR3 ( β- collimation 1 prim, 6 sec, 1 dfba start of cold section),
  21x 2 in IR7 ( Δp/p - collimation, 4 prim, 16 sec, 1 dfba )

- **BMLS Special, large β around experiments IR 1,5, 2,8**
  **and near dump devices (TAS, TAN in IR 1,5) and injection 2,8**
  **dump ( IR6 )**
  7 in IR2 and 8 with Exp. (2BLM) . and inj (5 BLM)
  8 in IR1 and IR5 with Exp. (2BLM) and TAS, TAN
  6 IR6 dump msd, tcdq, dfba

- **BMLA all other locations, arcs and dispersion suppressors**
  392 x2 (all main quads) ( 90 % BLMA of in total 900 - 1000 )

BIReview/BLMTypes.eps

**Consider two complementery situations**

**1) Basically good conditions: orbit, optics, standard collimator settings**
**one parameter bad or going out of control (magnet failure)**
(can go quickly, warm D1 dipole trip, 2 mm in 5 turns; kicker problems, ~ 1 turn)
**seen with BMLC**

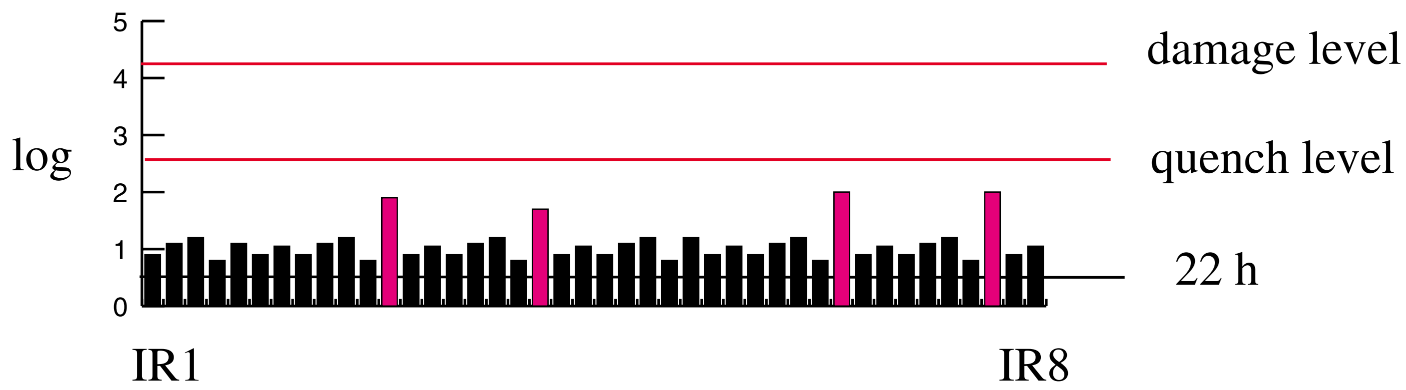
**2) Generally poor or not well known conditions, non-standard conditions, like setup.**
**likely reduced collimation efficiency → BLMS**
**In addition possibility of local problems vacuum bumps, orbit bumps, aperture reductions.**
**Complete coverage with loss monitors → BLMA**

# Use

## 1) BLMC, S   protection and   guide to operation under normal conditions

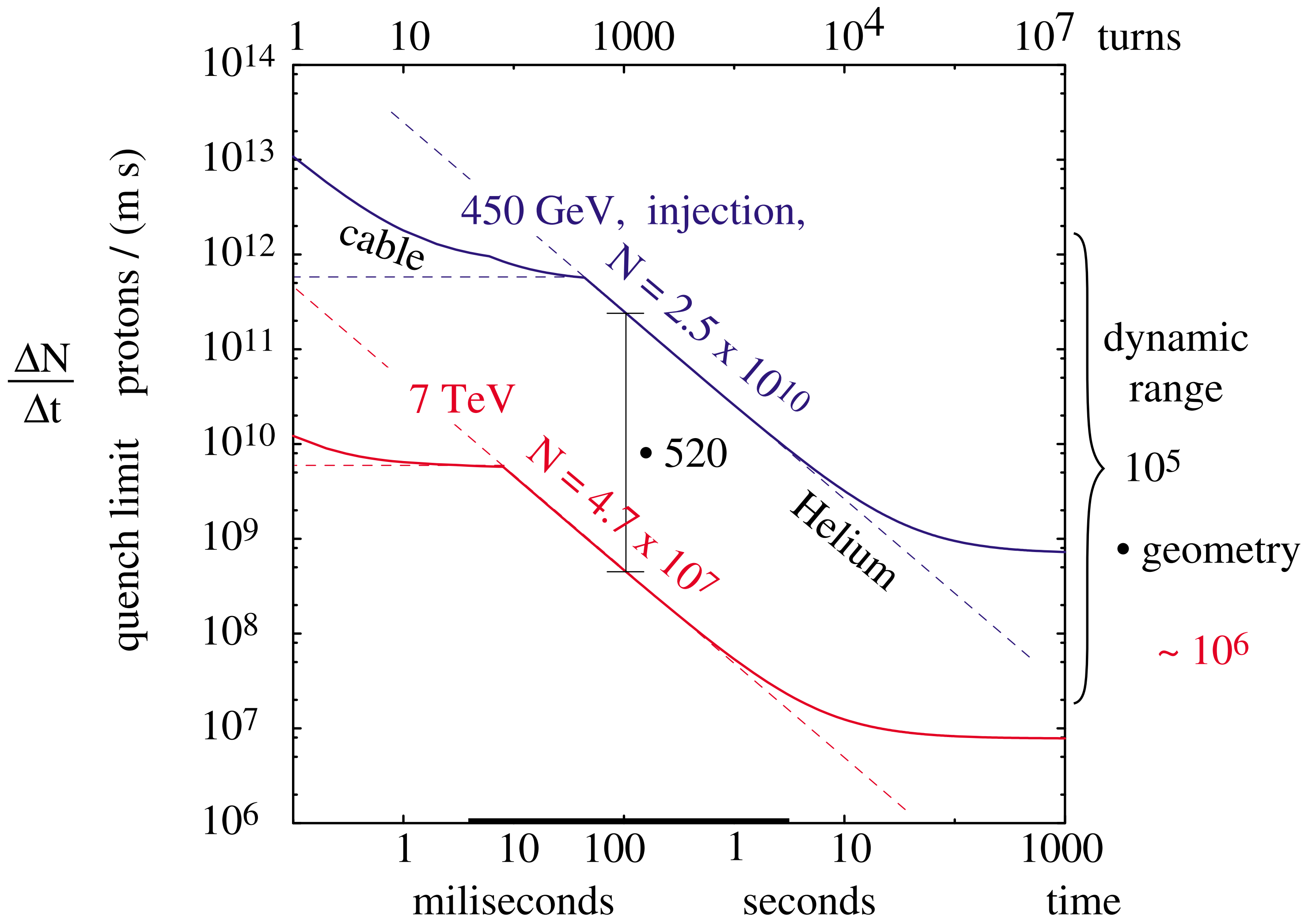
## 2) BLMA     protection for abnormal conditions with local problems

- continuous, real time  (some sec. ) updating normalized display




- post mortem  info     (buffer last 100-1000 turns + rates for last seconds)

Anticipated **quench levels** (dipoles, JBJ, E.Gschwendtner)




| dump if | in last 10 sec | $\Delta N / \Delta t$ |
|---|---|---|
| 450 GeV | $N > 2.5 \times 10^{10}$ | $> 7 \times 10^{11}$ |
| 7 TeV | $N > 4.7 \times 10^7$ | $> 7 \times 10^9$ |

BIReview/QuenchLevel.eps

# Main Requirements

| | time resolution |
|---|---|
| BLMC | 1 turn (89 μs) |
| BLMS | 1 turn |
| BLMA | < 2.5 ms |

} required to be **always all** working

(drive speed / loss rise for local orbit bumps)

**absolute calibration:** aim for **knowledge to factor 2 in quench level**

**dynamic range ~ $10^6$**

**distinguish losses from ring 1/2**

also foreseen: a bunch to bunch loss monitor (not in dump/protection) in cleaning section

# The calibration issue

**How to obtain an absolute (quench threshold) calibration for about 1000 BLM ?**
**Moreover, calibration:   function of energy and loss duration**

**Non-trivil task,**      choose BLM hardware/length/positioning in order to / for

- **minimize different types of monitors and geometries**
- **good a priori knowledge from simulation and choice of BLM system, tests in SPS**

**Calibration with beam:**

- **calibration vs lifetime in collimator setting**    (comparable to LEP tail scans)
  **only possible in cleaning sections,   BLMC**
- **rest:  check quench levels  for BLMS and representative subset of  BLMC**
  how ?       ( **local bumps**  - restricted to injection ? , really quench in some cases  ?)

# Summary

- **good Beam Loss Monitoring, quench and damage protection essential for LHC**

- **best sensitivity/dynamic range/resolution (time res. down to 1 turn) at collimation and few sensitive places BLMC,S**

- **full coverage of all the rest (BMLA each quad), with ms resolution,**

**high dynamic range ~ $10^6$**

**major challenge: knowledge** (absolute calibration) **in terms of quench level** (E,t)

(minimize different geometries, good uniformity and stability and a priori knowledge from simulation,

+ tests with beam)