Session 1: Lessons from 2011

Chairman: M. Lamont

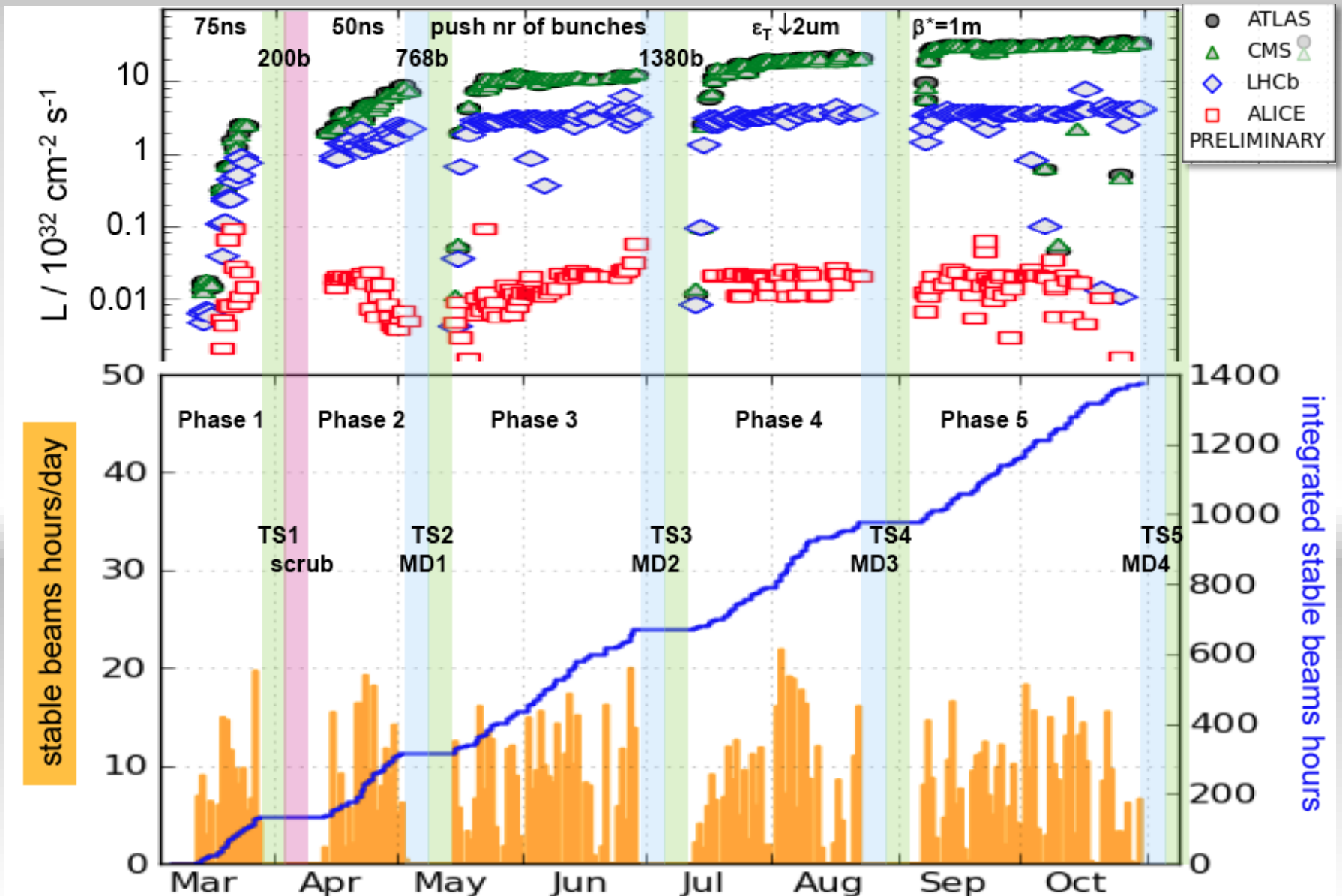
Scientific Secretary: C. Bracco

Talks and Speakers

- **Review of 2011 LHC run from the experiments** (M. Ferro-Luzzi)
- **Input from Evian** (M. Lamont)
- **2011 availability analysis** (A. Macpherson)
- **Injection and lessons for 2012** (C. Bracco)
- **Machine Protection** (M. Zerlauth)
- **Vacuum performance and lessons for 2012** (V. Baglin)
- **Emittance preservation** (V. Kain)

M.Ferro-Luzzi

2011 – good year



M.Ferro-Luzzi

Exciting stuff

see F. Gianotti & G. Tonelli, CERN public seminar Tue 13 dec 2011
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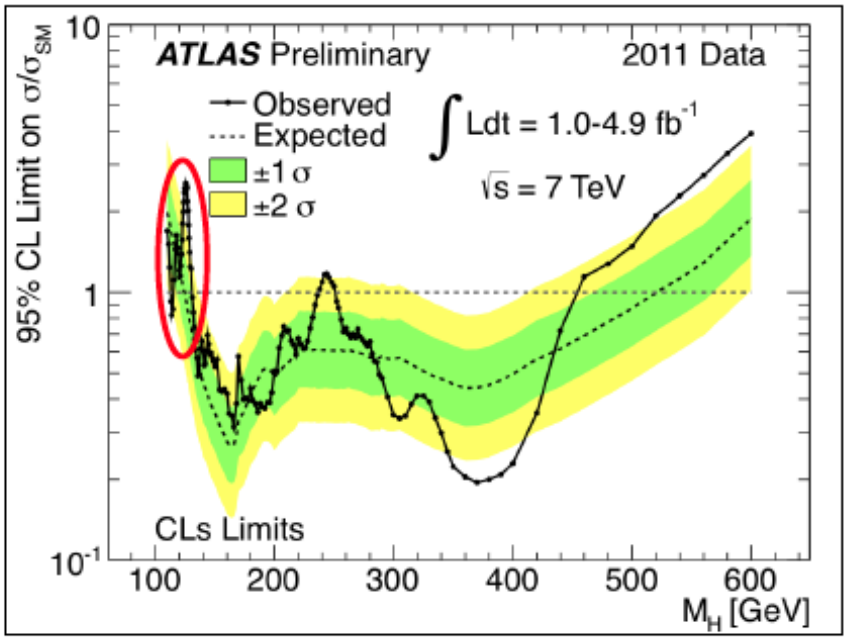
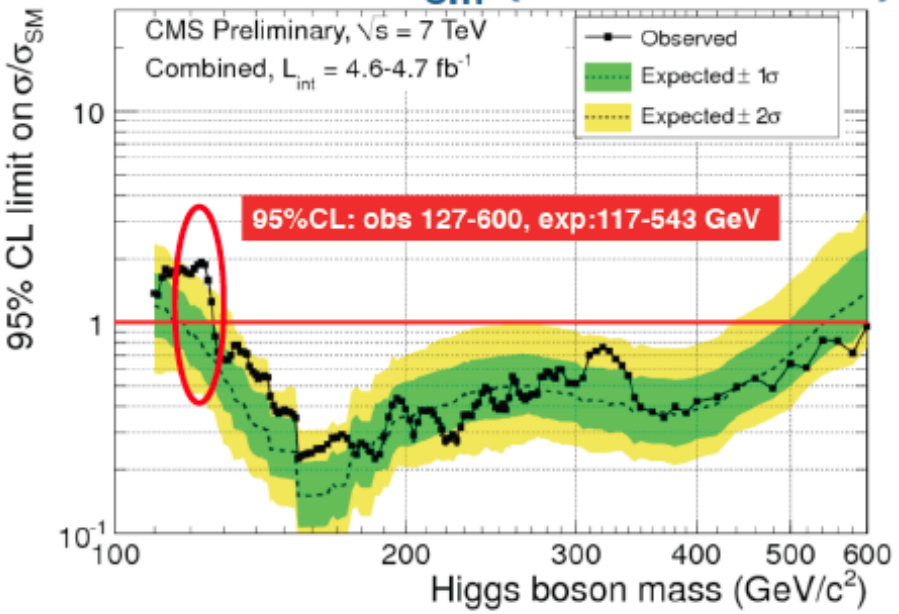


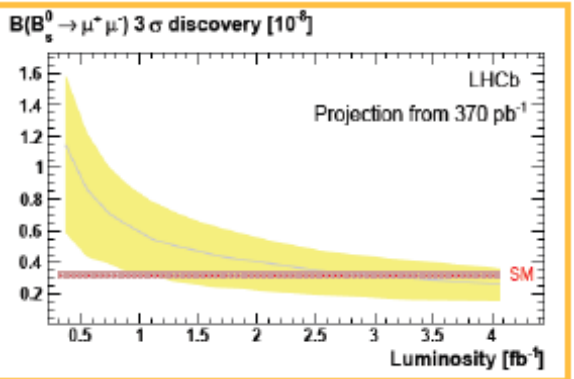
Limits on σ/σ_{sm} (CLs method)



LHCb search of Flavour Changing Neutral Currents:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 1.2\,(1.4) \times 10^{-8} \text{ at } 90\,\%\,(95\,\%)\ \text{CL}.$$

The SM predictions for the branching fraction $(3.2 \pm 0.2) \times 10^{-9}$



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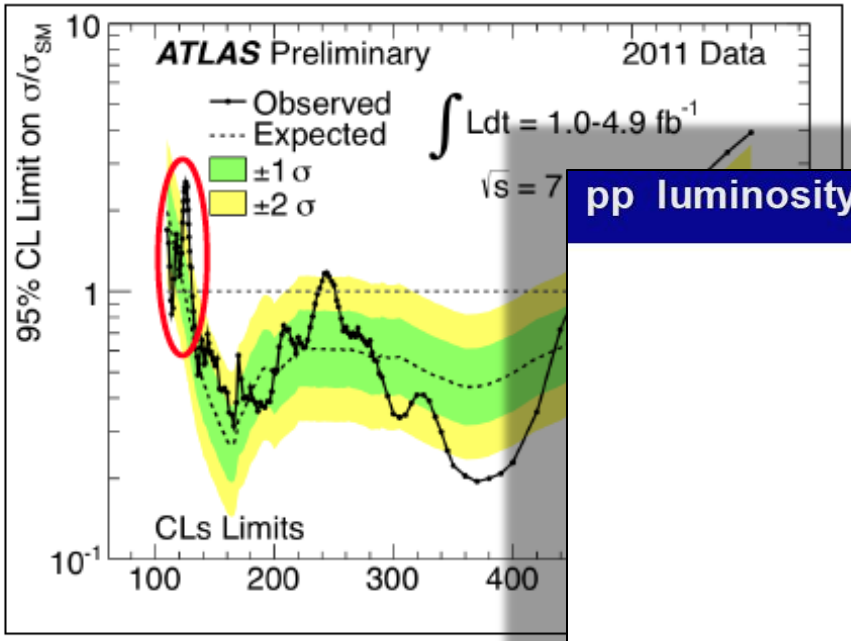

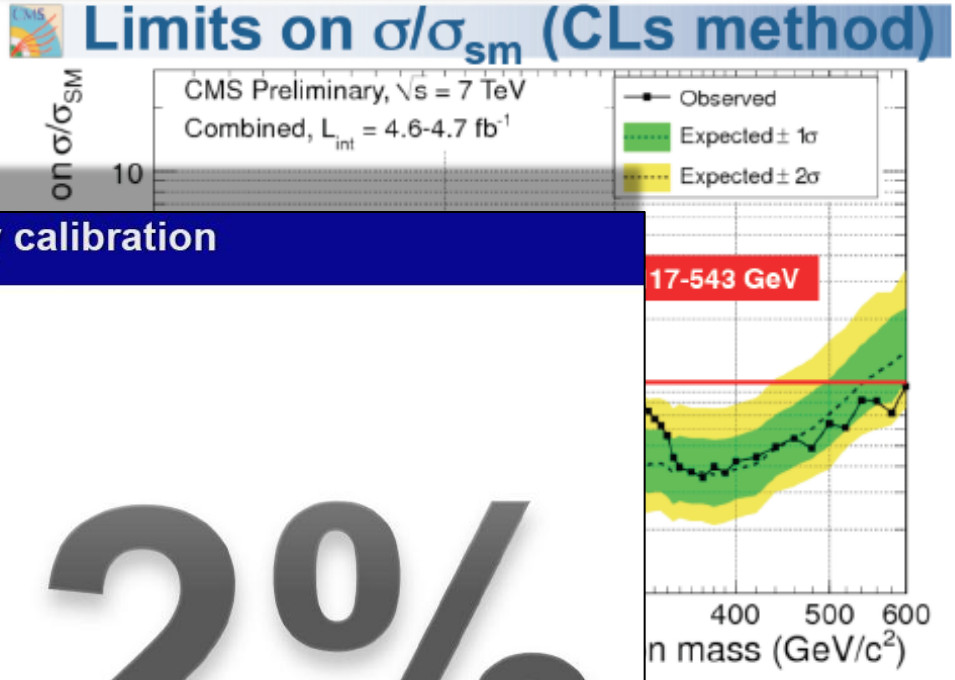

pp luminosity calibration

2%

LHCb search of Flavou

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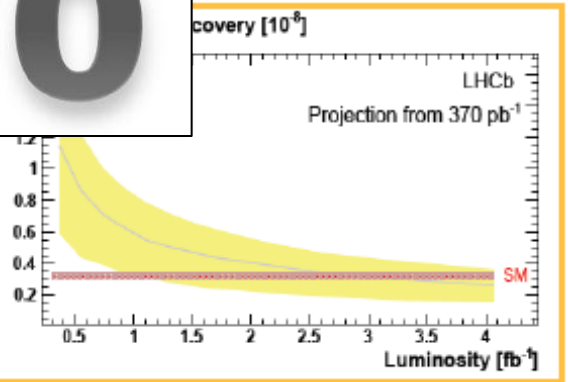


M.Ferro-Luzzi

Big hand to the man

M.Lamont

2011

- Remarkable year: no real show stoppers
- Operational robustness: reproducibility, stability, lifetime, good control of optics, excellent performance of Machine Protection system (MPs), tools, sequences, procedures and SW
- Successfully took on:
  - Total intensity & 110 MJ
    - Intensity ramp up safely executed in 2011 (11 weeks - many issues)
    - should be faster in 2012 (~3 weeks)
  - Bunch spacing 50 ns – good choice after scrubbing
  - Bunch intensity
  - Emittance

  } Excellent beam from injectors
  - Beta* & aperture (better than estimates)

M.Lamont

System performance

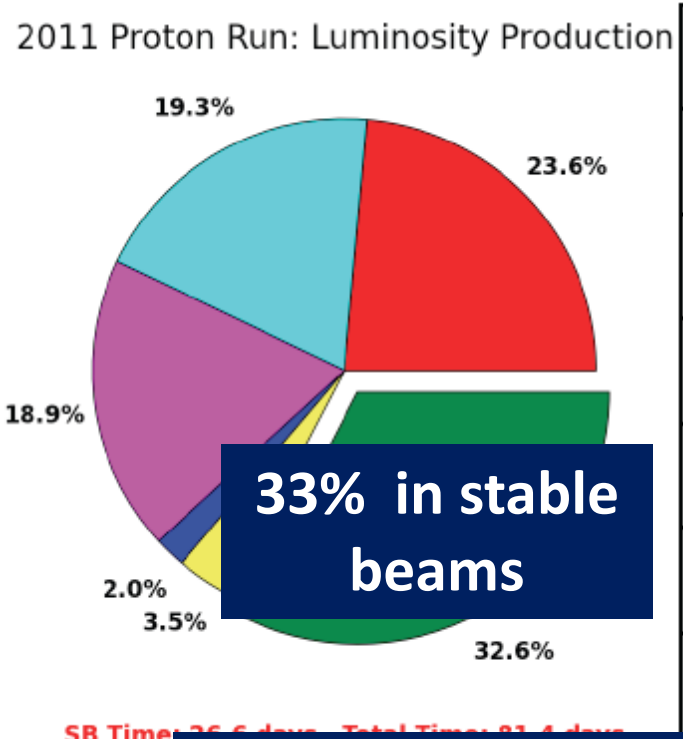
- Cryogenics
- QPS
- Injection and dump systems
- Transverse feedback
- Collimation
- Orbit and tune feedback
- Beam instrumentation
- Vacuum

} Availability/issues examined

- Good to excellent performance all around
- All systems made “discoveries” related to high intensities and luminosity (impendence, beam heating, e-cloud and vacuum instabilities, R2E and UFOs rate)
- Mitigation measures and other improvements should improve availability and performance in 2012

A.Macpherson

LHC Availability and Performance in 2011



	Days	NB %	SET UP %	INJ %	RAMP %	FT+SQ +AD %	SB %
2011	299.3	25.7	30.5	17.4	1.7	4.3	**20.5**
2011-TS	277.9	23.3	29.5	18.7	1.9	4.7	**22.0**
p-p	156.6	22.0	20.4	19.2	2.2	3.8	**33.8**
p-p LP	**81.4**	23.6	19.3	18.9	2.0	3.5	**32.6**
Pb-Pb	**24.1**	25.0	20.8	13.6	2.2	5.5	**32.9**
MD	33.2	22.9	32.3	36.8	1.2	6.0	**0.8**
							1.1

Availability issues clearly identified – systems targeted improvements through 2011 and Christmas technical stop

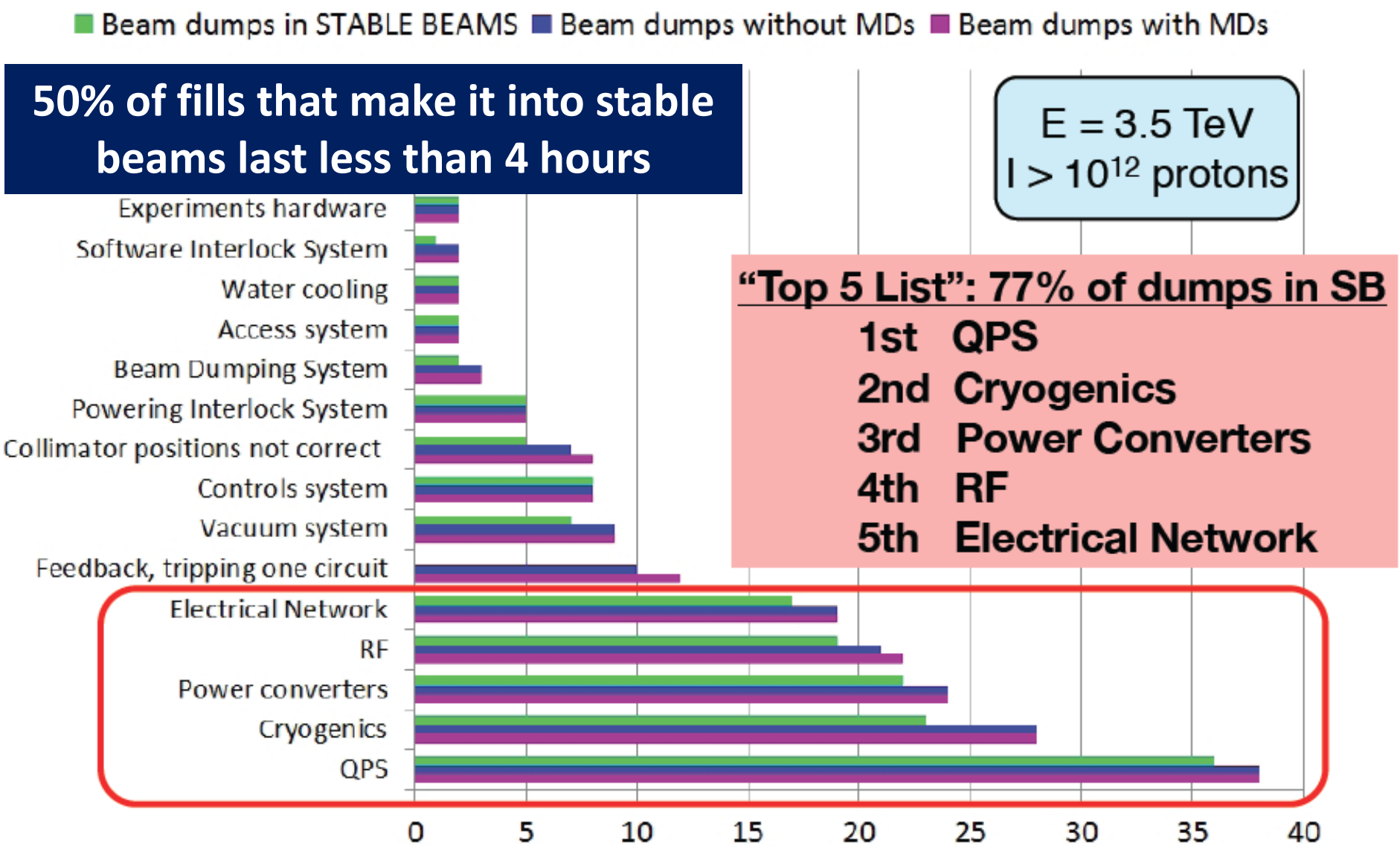
Hubner factor: $H = 11.57 \times L_{Del} / (D \times L_{Peak})$ **$H_{\_Expected} = 0.2$**

p-p (LP): 81.4 days $L_{Peak} = 2572\ (\mu b.s)^{-1}$ $L_{Del} = 4.01\ fb^{-1}$ => **H = 0.22**

Pb-Pb: 24.1 days $L_{Peak} = 512\ (b.s)^{-1}$ $L_{Del} = 167.6\ \mu b^{-1}$ => **H = 0.24**

A.Macpherson

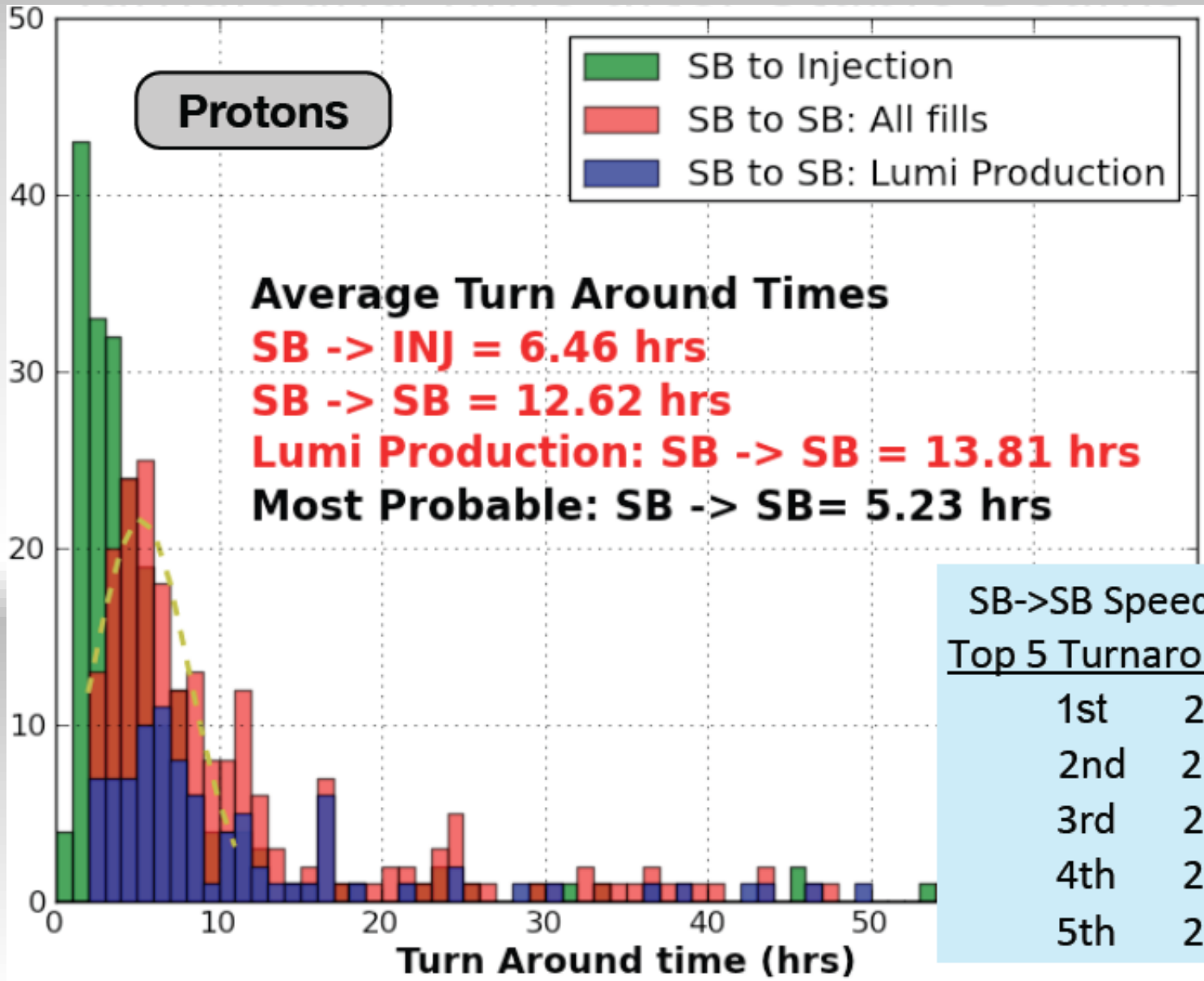
Premature dump in Stable beams



A.Macpherson

Turnaround

Better – still room for improvement (Injection…)



SB->SB Speed records	
Top 5 Turnaround times	
1st	2h07
2nd	2h13
3rd	2h28
4th	2h29
5th	2h29

C.Bracco

Injection and Lessons for 2012

- Injection of **144 bunches fully operational**
- **Successful injection of 288 bunches** (during MD) for both beams ➔ still need to optimise beam in injectors and accumulation in LHC
- **TL steering was complicated** (shot-by-shot, bunch-by-bunch variations and long term drifts)

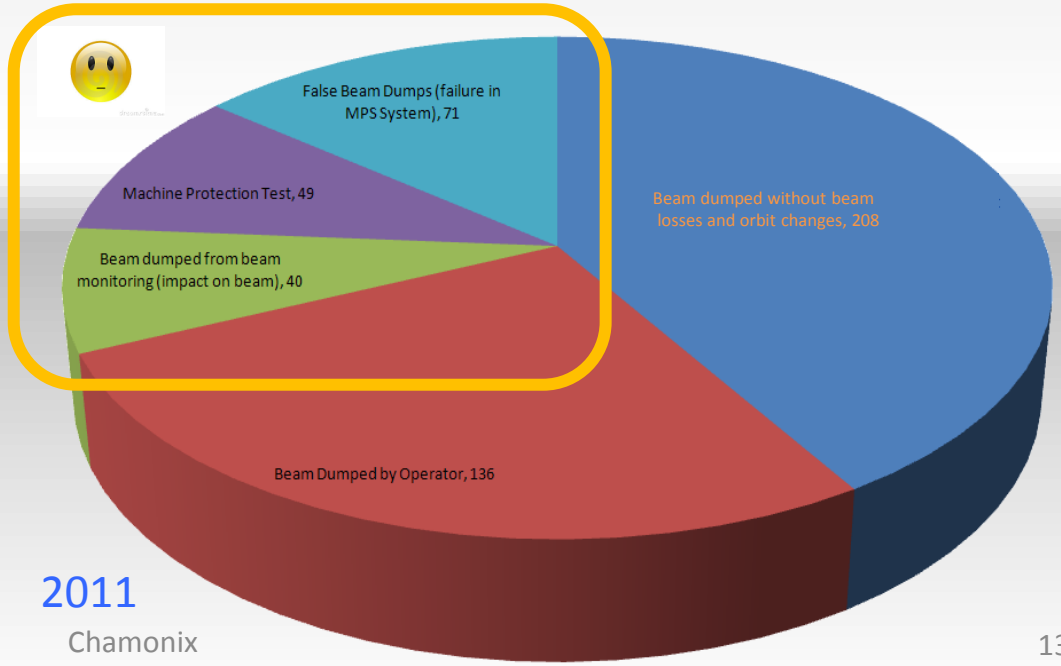
→In 2011: ~ 30 min – 2 h to steer (excluding some big outliers) every 2-3 days
Estimate 2012 if stability is not improved:
1h steering × 0.5/days × 120 days = 60h!
This can be improved (reduce sources of instabilities, improved references)

- Injection failures – machine protected:
  - **MKI-IR8 Flashover** (bad vacuum) ➔ **11 magnets quenched**
  - **MKI-IR2 Erratics ➔ 3 magnets quenched**, **permanent effects on ALICE** Silicon Drift Detector
- Follow-up: hardware and diagnostics improvements, HW and SW more severe interlocks (**vacuum and temperature**), instructions for safer operation deployed!

M.Zerlauth

Machine Protection

- 10.000 interlock conditions, continuously evolving architecture (operation, MD, special runs..)
- About 1200 clean beam dumps in 2011 (-10% wrt to 2010)
- No beam induced quench with circulating beams (>100MJ!!)
- No equipment damage observed (except ALICE SDD)
- MPS response of all dumps from 3.5TeV meticulously analyzed and validated
- Complexity and high level of safety in MPS ➔ False positive (QPS + R2E), related to **increasing beam intensities**



2011

M.Zerlauth

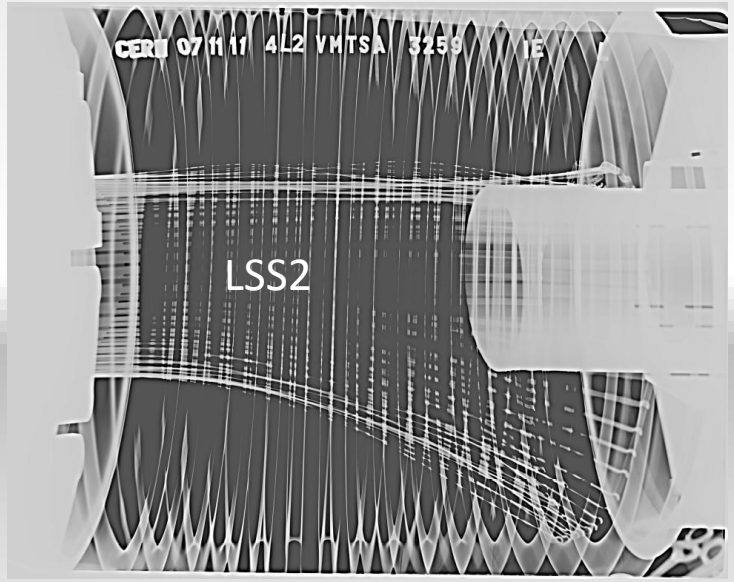
MPS Improvements

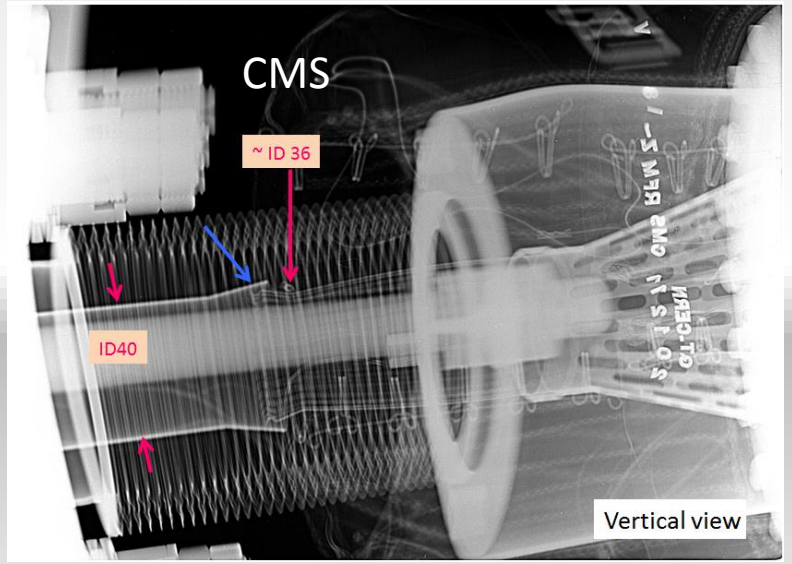
- Additional active protection will provide further essential redundancy for next years of running:
  - Beam Current Change Monitors (DIDT)
  - PC interlock to protect against operations and feedback failures
  - ADT: Selective bunch blow-up + abort gap cleaning (new procedure)
  - Procedure for 'non-working dump trigger'
- Maintaining present good level of orbit stability is a primary importance when moving to <β* + tight collimator settings (2012 goal)
- Remain vigilant in order to maintain current level of safety of MPS systems while increasing efforts on increasing MPS availability

V. Baglin

Vacuum

- Dynamic effects: synchrotron radiation, e-cloud ➔ Scrubbing ➔ reduction of the LHC pressure
- Unexpected pressure rise (10^{-6} mbar) observed in LSS2-LSS8 (D1) and close to CMS: bad RF contact (x-rays inspection) ➔interventions done in 2 & 8 & CMS to resolve RF finger issues - shouldn't be a problem in 2012.





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- Recommendations and perspectives:
  - Previously scrubbed and air exposed surface scrubs 10 x faster than as received surface
  - 50 ns operation:
    - Start up to 1.45 10^{11} ppb possible while scrubbing in the shadow of intensity ramp-up
    - Start up to 1.6 10^{11} ppb will require a couple of days of scrubbing
  - 25 ns operation:
    - Requires a dedicated scrubbing run with 25 ns

V. Kain

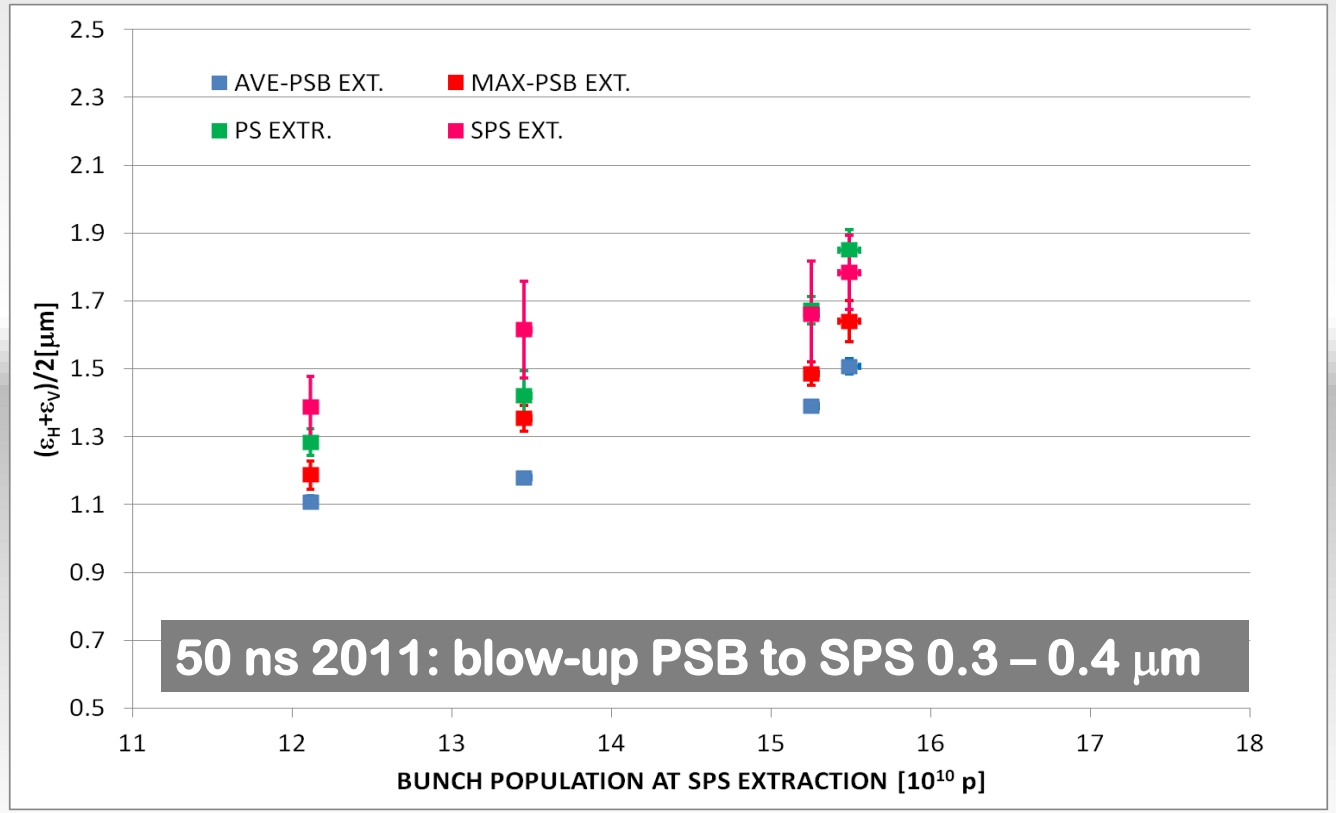
Emittance Preservation

$$L = \frac{kN^2 f \gamma}{4\pi \beta^* \varepsilon} \cdot F$$

Small ε to maximize luminositiy

Produce small ε in injectors → need to keep ε small in the LHC

Impressive performance of injectors !!



V. Kain

Emittance Preservation in the LHC

- **Different** measurement **methods**: wire scanner, BSRT, luminosity
- **Main observations**:
  - **Injection**: emittance **conserved** within measurements
  - **450 GeV** plateau: Emittances growth **~ 10 % in 20 minutes** (reasonably consistent with IBS but slightly faster)
  - **Ramp**: **~20% Blow-up** for all planes (effect of reduced damper gain?)
  - **3.5 TeV**: **Blow-up >20% during squeeze only for beam 1 horizontal** between β^* 5 m and 1.5 m. No obvious source.
  - Same behavior for ions run
- Many measurement **improvements** are foreseen for 2012 (instrumentation, methods and analysis)

Conclusions

Exciting year with excellent performance of injectors, machine and experiments!

- Good performance of all the systems
- Improved and robust knowledge of high intensities and luminosity effects on the different systems
- All the experiments provided with luminosity higher than expectations!
- Mitigation measures and other improvements have been implemented and should improve availability and performance in 2012
- Potential performance gain of ~20% if emittance growth can be understood and reduced in ramp/squeeze