

Chamonix 2011, 24. – 28.1.2011

## Session 5: “High Intensity: Present and Future”

R. Assmann & S. Redaelli

Thanks to Frank Z. for his notes...

*Courtesy M. Brugger*





# A. Bertarelli: “Limits for Beam-Induced Damage: Reckless or too Cautious?”

- State of the art tools to look at accidents.
- Conservative parameters and scenarios:
  - Up to 5 TeV, up to  $1.3 \times 10^{11}$  p per bunch, down to half nominal emittance.
  - Collimator setup with single bunch as listed above.
  - Asynchronous dump with wrong collimator hierarchy; all bunches impacting on same spot.
- Excellent news:
  - **Single bunch accident (most likely): Collimator need not be replaced.**
  - 2-4 bunch accidents (unlikely): Change collimator with spare.
  - 8 bunch accident (very unlikely): Severe: water leak into vacuum.
- Tests in HiRadMat to improve material models.
- Follow-up:
  - Realistic simulation for 2011 parameters → 1 month from FLUKA inputs.
  - Simulate onset of damage → damage threshold (emittance).
  - Can we get additional material properties from Los Alamos?



# R. Assmann: “LHC Collimation – Too Good or Too Bad?”

- Summarizing results R. Bruce, D. Wollmann, A. Masi et al (→ Evian)
  - Results 2010 and parameters for 2011 (new collimator settings).
  - **Collimation performance models confirmed (factor 2).**
  - Good surprise: **6 times better beam lifetime than specified.**
- Collimation 2011:  $N_{\text{tot}} (p)$  no limit 3.5/4 TeV (within injector param.)
    - $N_p/\varepsilon \leq 3.4 \times 10^{20} \text{ m}^{-1}$
    - $T_{\text{setup}} \approx 94 - 114 \text{ h}$
    - $T_{\text{validity}} \approx 4 - 5 \text{ months}$
    - $T_{\text{uptime}} = 99.5 \%$
  - Orbit & coll.:  $\beta^* \geq 1.6 \text{ m}$  (1.4 m @ 4 TeV)
  - 2011 risk: 1/30,000 y for triplet, 1/300y for tertiary collimator.
  - Limit for 7 TeV: now extrapolated to ~ 30% of nominal intensity.
    - Collimation upgrade to guarantee nominal intensity.

- Probability of damage to TCT (conservative):
  - CAT 1: **Asynchr. dump + coll. setup** –  $P < 50 \text{ h} / 1,600 \text{ h}$  → 1 / 32 y
  - CAT 2: **Asynchronous dump + wrong setup:** → 1 / 300 y
- With news of “acceptable” damage: How much can we gain in  $\beta^*$  by accepting higher probability for CAT 2 failure?
  - We can gain by reducing tolerances (TCDQ → TCT) without impact on triplet protection (but higher probability that orbit out of tolerance).
  - Gain  $\sim 0.2 \text{ m}$  in  $\beta^*$  for every sigma in tolerances that we give up.
  - Proposed 2011 tolerance is 2.5 sigma → can gain max  $\sim 0.3 \text{ m}$ ... (going down to 1 sigma). **Maybe 1.3 m** at 3.5 TeV!?
  - Other gains from local IR aperture measurement, ...
  - **Detailed follow-up to be done.**
- Then in case of accident: minor damage but still unlikely.



# S. Redaelli: “Collimator Improvements 2011 and Upgrade 2012: What Do We Plan?”

- Several improvements in 2010/11 christmas break:
  - close few unlikely loop-holes in MP logic
  - Semi-automatic collimator setup (less human errors and fewer fills req.)
- Collimation upgrade (phase 1) in IR3 in full preparation for installation in long shutdown:
  - Losses at predicted locations for protons and ions → need to protect DS magnets sooner or later.
  - Ensures that we can **reach nominal intensity** after long shutdown at 7 TeV
  - Implements **flexibility in loss location** → losses to IR3 if intensity limited by R2E in IR7 (to few %)... → impedance issue being followed up
- Collimators with integrated buttons:
  - Works very well with LHC prototype collimator in SPS
  - Can **reduce setup time from 100 h to a few minutes** (if all equipped).
  - No special fills, can follow operational changes, improves MP monitoring,  
...



# Questions & Follow-up (to SR + RWA)

- Do we really need to collimate losses in DS or can we live with it up to the second long shutdown?
  - 30% estimate has no safety margin and extrapolates based on 9 fills at 10% intensity, half beam energy, half emittance, ... → WATCH out!
  - Sooner or later we anyway need to protect DS's and why to accept a likely intensity limit up to ~2018?
  - Put all on table for prioritization with resources for first long shutdown.
- Can adv. collimators with buttons be ready for 1<sup>st</sup> long shutdown?
  - Gains in integrated luminosity (5-10%) and flexibility. Improves MP safety.
  - Resources for finalization of design and for prototyping critical.
- Investigate intermediate ways to speed up setup & verification.
- Stay on agreed plan: continue preparation of upgrade work for 2013, **review and final decision in June 2011**, follow-up in collimation project & departments



# M. Brugger: "Radiation to Electronics: Reality or Fata Morgana?"

- 2010 beam experience was used to benchmark R2E predictions.
  - Factor 3 improvement but no change in conclusion.
  - R2E remains a serious concern on the way towards design intensity.

	2010 (from Meas.)		2010		2011		2012		nominal	
	SUM	MTBF [days]	SUM	MTBF [days]	SUM	MTBF [days]	SUM	MTBF [days]	SUM	MTBF [days]
immediate dump and access	<b>20</b>	<b>18</b>	<b>2</b>	<b>150</b>	<b>98</b>	<b>4</b>	<b>166</b>	<b>2</b>	<b>2500</b>	<b>0.14</b>
immediate dump	<b>7</b>	<b>53</b>	<b>1</b>	<b>570</b>	<b>19</b>	<b>19</b>	<b>33</b>	<b>11</b>	<b>440</b>	<b>0.8</b>
Scheduled access	<b>11</b>	<b>33</b>	<b>2</b>	<b>220</b>	<b>35</b>	<b>10</b>	<b>60</b>	<b>6</b>	<b>740</b>	<b>0.5</b>
Other	<b>7</b>	<b>56</b>	<b>1</b>	<b>480</b>	<b>30</b>	<b>12</b>	<b>52</b>	<b>7</b>	<b>740</b>	<b>0.5</b>

- Follow-up:
  - Prepare as much improvement as possible for 2011/12 shutdown.
  - Change B2 dispersion (IR7L): shorten region with cleaning losses into DS (ions).
  - Continue efforts to reduce uncertainty in equipment sensitivity.
  - Beam tests (quench test location + injection region) requested to improve radiation field calibration (2 shifts, 2 weeks preparation time + 8h installation).



# S. Roesler: "Radiation Protection: How (radio)active are we going to be?"

- Activation from 2010 beam run reviewed and all as expected.
- **RP OK for longer running and estimated performance from OP.**
  - 2011: factor 4-10 higher activation vs 2010
  - 2012: another factor 2
  - Air activation: to be ready for nominal intensities modifications to be implemented in next long shutdown.
  - OK for foreseen activities in the tunnel, whether long shutdown is 2011/12 or 2012/13.
- OK without remote handling up to 2016.
- Energies 3.5 TeV and 4 TeV OK.





- RF performance in 2010 was fine:
  - Affected by klystron trips.
  - Uncaptured beam below spec (1% vs 5%) but issues for injection.
  - Noise on the loops analyzed.
- **2011 RF parameters defined and ready** for commissioning.
  - No RF issue for higher intensities nor 3.5 TeV and 4 TeV.
  - No RF issue for various bunch spacings expected.
- Follow-up:
  - Dedicated time required for higher voltage commissioning in 2011.
  - Above half nominal: Interlock strategy for RF trips (cavity, klystron, ...) to be decided but probably require beam dump.



# Ready for LHC Jam Session with Beam #2...

