WARM (update) & COLD LOSSES @ 3.5 TeV

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for the FLUKA *team*

Framework

- Conclusions from the 108th CWG Nov. 2009 (F. Cerutti):
  - 3.5 TeV operation at nominal intensity represents a more favorable scenario than top energy as for energy deposition in the Point 7 betatron cleaning warm section:
    - Dose in MBW & MQW coils a factor 2-3 lower than at top energy
    - However, only showers from collimators were studied
    - Direct Proton Losses (DPL) potentially more important at 3.5 TeV
  - The (larger) TCLA aperture makes it worth to evaluate peak power density in the cold section SC magnets (single diffractive)
- **=> Outline of this presentation**
  - **Warm section: Peak dose in MQWs/MBWs coils due to DPL**
  - **Cold section: Peak power density in the DS coils**

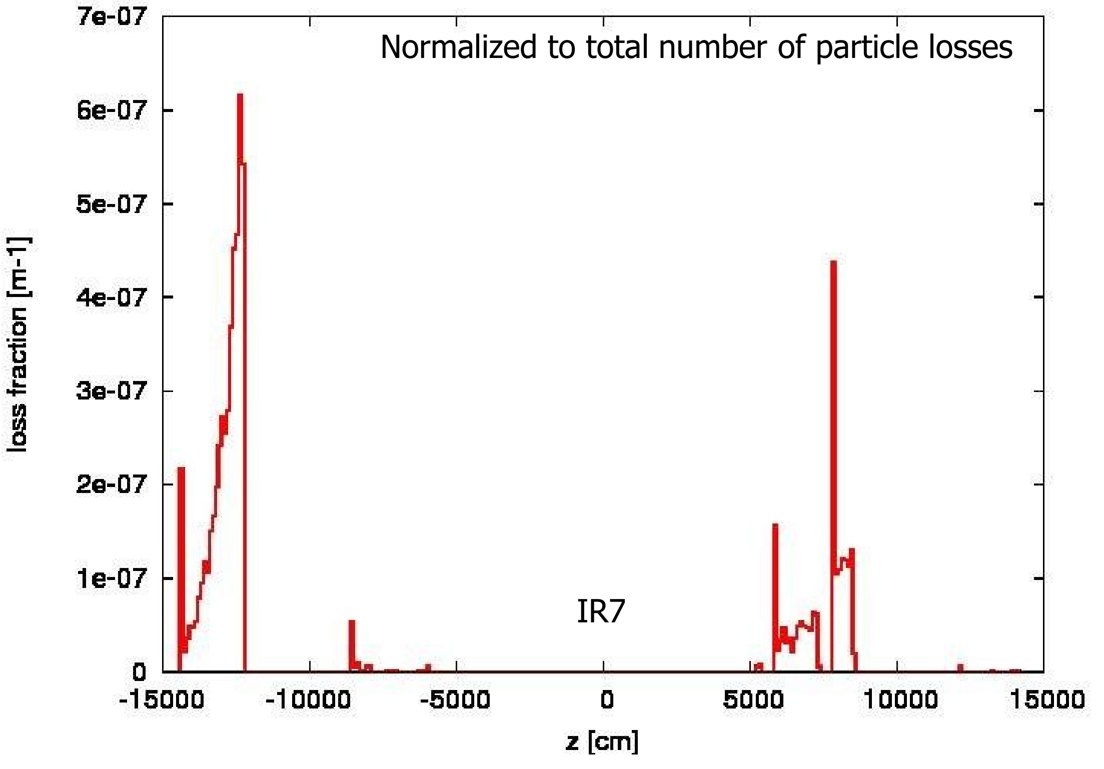
Cross checking limiting aperture of beam pipe

- Comparing FLUKA model to provided SixTrack aperture file:
  - **0.5 mm larger aperture** found in FLUKA for the **MQW**
  - FLUKA found to be consistent with the technical drawings*
    (Thus, SixTrack potentially on the conservative side)
  - For **MBW** both FLUKA and SixTrack models agree with the technical drawings*
  - TCAPC (same aperture as MQW) not included in the tracking simulations

- In FLUKA lost protons are loaded for transport using SixTrack loss coordinates
  - Interaction not forced at this point
  - Potentially impacting in beam pipe further downstream

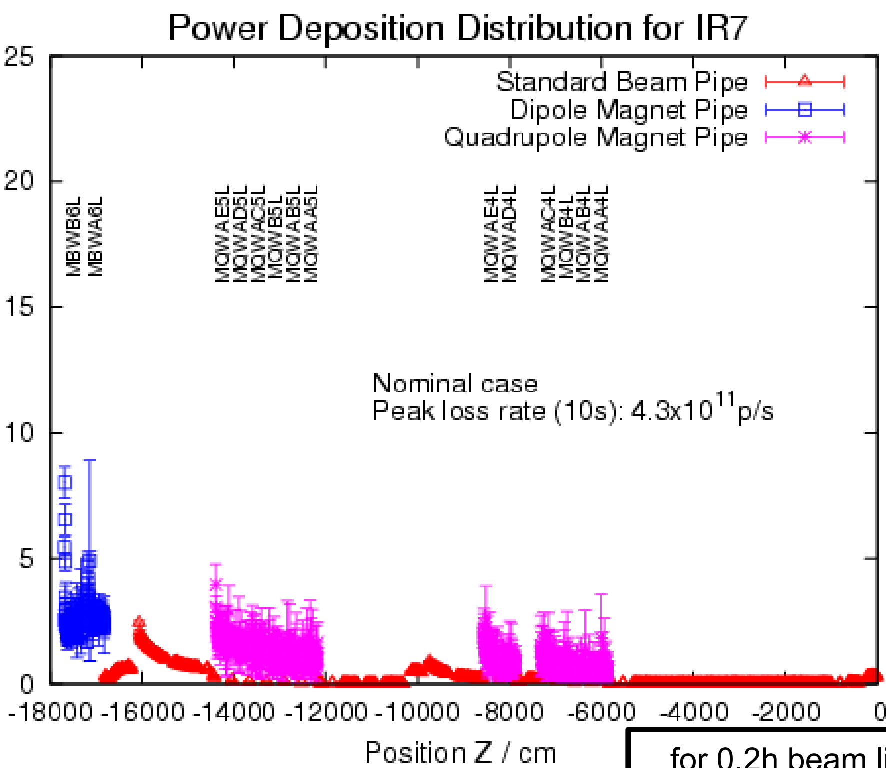
*(i.e. LHCVCELQ0003-vAA.plt, LHCVCELW0001-v0.plt) Thanks to P.A. Thonet, D. Tommasini

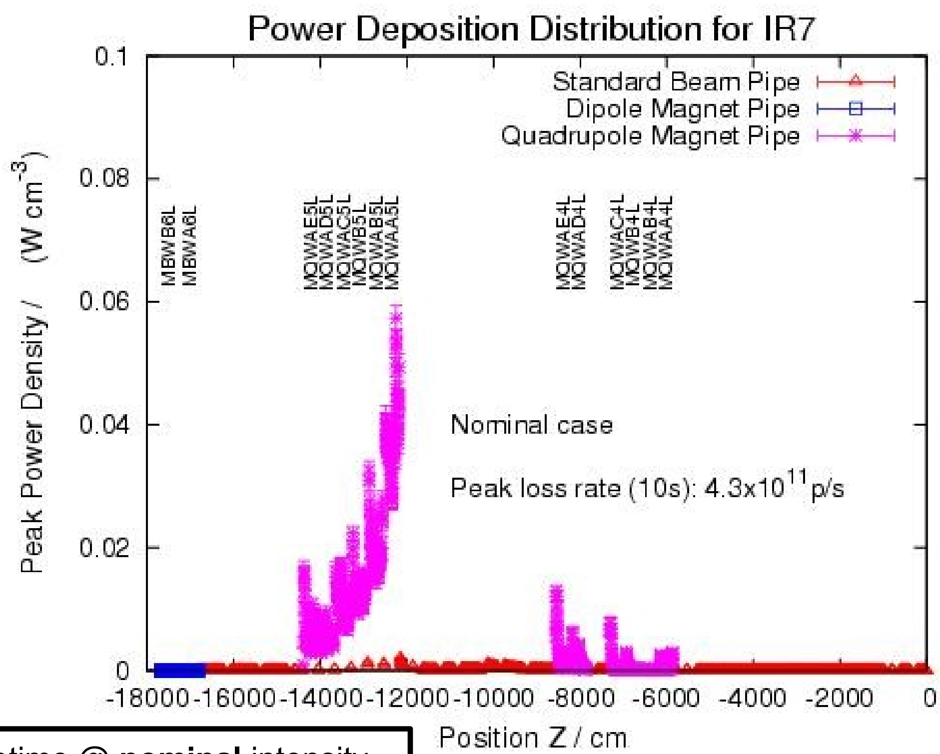
Direct proton loss distribution



- Thanks to Adriana Rossi for providing loss distribution file
- Direct proton losses only make up a fraction of the total particle losses
  - ~ 1 / 1500 (used for normalization)

BEAM PIPE HEATING @ 3.5 TeV



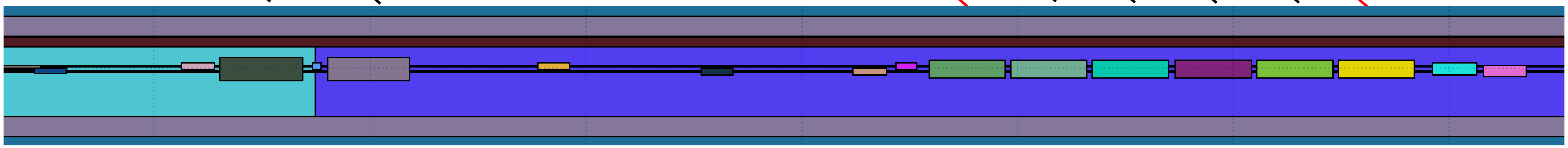


for 0.2h beam lifetime @ **nominal** intensity

Collimator shower losses

DPL

PEAK DOSE IN DS COILS



for 1.15 10^{16} lost protons

	7 TeV*	3.5 TeV *	3.5 TeV (DPL)**
Element	[MGy]		
MBW.B6L7	3.3	**1.7**	-
MQWA.E5L7	0.9	0.3	0.0002
MQWA.A5L7			**0.0013**
MQWA.D4R7			0.0009

* Shower from collimators only ** Direct proton losses only

- For DPL highest load seen by last quadrupole of Q5 (MQWA.A5L7)
- **Peak dose from DPL is negligible with respect to losses induced by collimator showers** (two orders of magnitude lower)

Cold Section Peak Power Density

- The (larger) TCLA aperture possibly allows for more particles to reach and be lost in the cold section (single diffractive)
- How will this impact the peak power density in magnets with respect to 7 TeV?

New loss distribution file

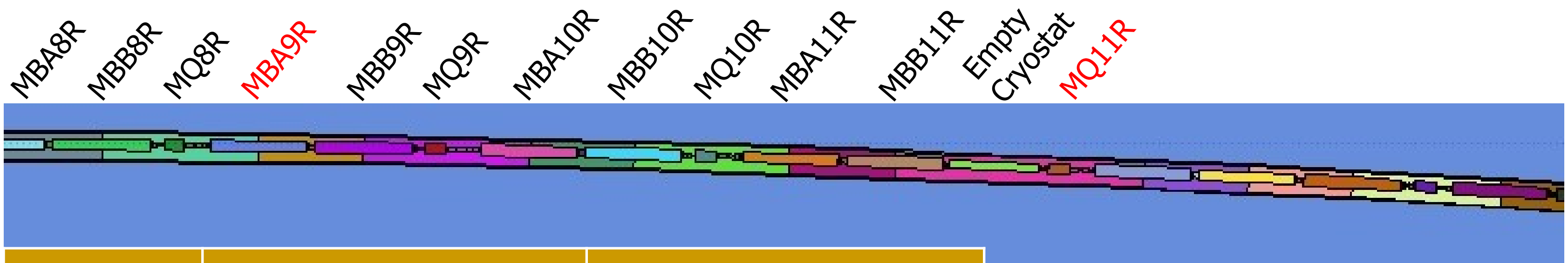
- Flag indicating single diffractive interactions has now been included (Thanks to A. Rossi)
- Particle history may contain multiple events/interactions (SD)
- FLUKA should transport particle from first point of interaction
- Filter out consecutive interactions by the same particle

Analysis of loss distribution file

- From the total number of particles tracked:
  - **96 %** are lost directly through **inelastic interactions (IN)** inside IR7
  - **3.4%** undergo **single diffractive (SD)** before lost through **IN** inside IR7 within the same turn (6.6% in FLUKA)
  - 0.2 % escape IR7, of these:
    - 33 % re-enter and are lost (inelastic) in IR7 in a different turn
    - 44 % have no further history (or are not lost through inelastic int.)
    - 23 % are lost outside IR7
  - Remaining ~0.4 % are directly lost outside IR7

- Loss event filtering:
  - **KEEP** the first interactions of a particle inside IR7, in any independent turn
  - **REMOVE** all consecutive interactions within the same turn.
  - Following this approach, approx. 3% of all events are removed (filtered)

Peak Power Deposition Cold Section



	Peak power 3.5 TeV		Peak power 7 TeV*	
Magnet	[mW/cm^3]	error [%]	[mW/cm^3]	error [%]
MBB8R	**5.2**	12	**0.2**	72
MQ8R	**3.4**	9	**1**	64
MBA9R	**7.4**	9	**0.6**	24
MBB9R	**5.0**	12	**1**	12
MQ9R	**2.3**	9	**1.9**	23
MBA10R	**1.0**	17	**0.4**	25
MBA11R	**4.3**	14	**0.9**	23
MBB11R	**3.1**	11	**1**	16
MQ11R	**0.8**	13	**5**	32

for 0.2h beam lifetime
@ **nominal** intensity

Peak loss rate:
4.3 10^{11} p/s

In FLUKA:
- Probability of SD 2x higher (6.6%)
- Probability of escaping 4x lower
- Escaping particles 2x lower (0.1%)

⇒Conservative side

- Peak power deposition higher at 3.5 TeV with respect to 7 TeV (quench limits ?)

* M. Santana, 17 July 2006

Summary

- **Warm section**
  - **Direct proton losses negligible** compared to losses produced from collimator showers (~2 orders of magnitude lower)
  - Some discrepancies found in the limiting aperture of the beam pipe when comparing FLUKA and SixTrack models

- **Cold section**
  - single diffractive (6%) mainly contribute (90%) to losses in cold section
  - **Operating 3.5 TeV for nominal intensity the peak power deposition in the cold section shows higher values with respect to the 7 TeV (**most likely due to the larger aperture of the warm section collimators)