Update on BLM specification

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BLM tasks

1. detect potentially dangerous beam instabilities and prevent subsequent injection into main linac and drive beam (machine safety)

2. localize and characterize beam loss distribution at both linacs (diagnostic, daily operation, personel safety, activation)

3. measure beam losses at:
   predamping rings
   damping rings (superconducting undulator),
   bunch compressors,
   turnarounds,
   combiner rings,
   drive beam accelerator,
   beam delivery system (beam-based collimator alignment?)

could be 2 different systems:
BLM and BLPositionM
global and local

4. measure time structure of beam perturbations - fourier analysis

BLTM?

Parameters

- Sensitivity: the smallest signal to be detected (S_{min}):

  calculated from the smallest loss needed to be measured BLM and BLPM

- Dynamic range (S_{max}/S_{min}):

  calculated from the loss at which injection should be prohibited BLM
  (and additional factor f: $S_{max} = f\ S_{threshold}$, for LHC spec: f = 3)

- Energy resolution (σ_E): $S_{threshold} - S_{min} = 7\ \sigma_E$ (from false inhibits?) BLM

- Time resolution (σ_t): below 18 ms – distinguishing between pulses BLM

  or around 0.5 ns – bunch-by-bunch loss analysis

- Spatial resolutions (σ_x and σ_s)

  σ_x - about 0.5 m – discrimination between DB and MB losses BLM and BLPM

  σ_s - not defined for safety, for diagnostic – one module (about 1m)
  BLM BLPM

Other features

- Radiation hardness
- Reliability
- Meant Time Between Failure (MTBF)

Sensitivity – example of calculations

- Assumption: system should be able to see normal losses.
- Beam-gas losses – input from PLACET simulations

H. Burkhard et al.: $2 \cdot 10^{-4}$ of Main Beam will hit spoilers (in BDS)

no data about particles hitting aperture (TBD)

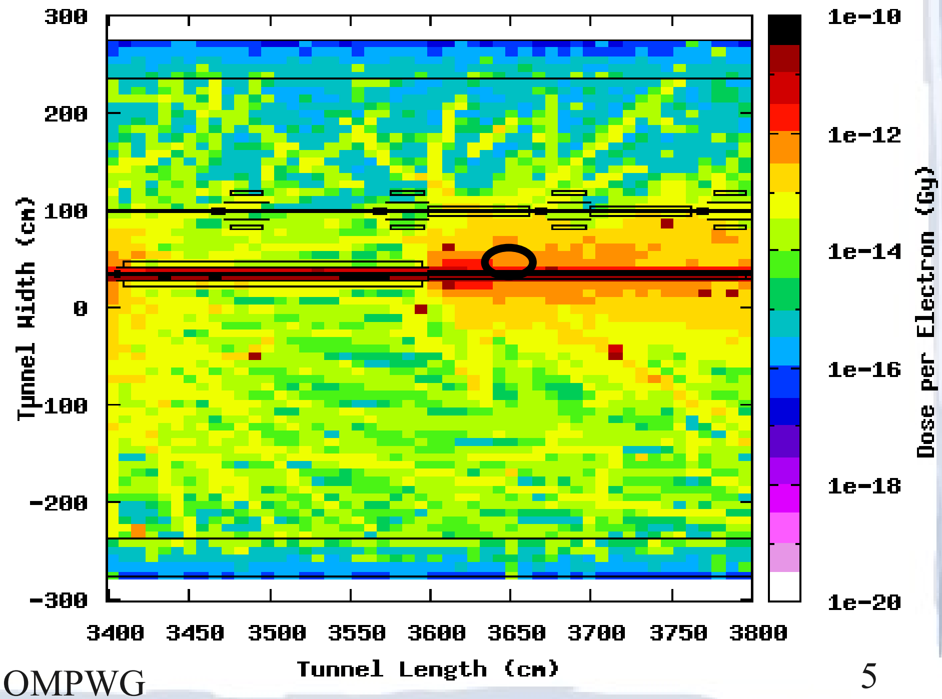
(but also Daniel, private comm: 10^{-3} loss of Main Beam expected)

assuming (pessimistic) that $2 \cdot 10^{-4}$ of MB hits aperture distributed uniformly along the liniac: $1.2 \cdot 10^{5}$ electrons are lost per quadrupole of MB.

for 1.5 TeV:

10^{-11} Gy/electron

$S_{min} = 1.2 \cdot 10^{-6}$ Gy



plot by Sophie, loss distributed uniformly along the linac, BLM position close to MB

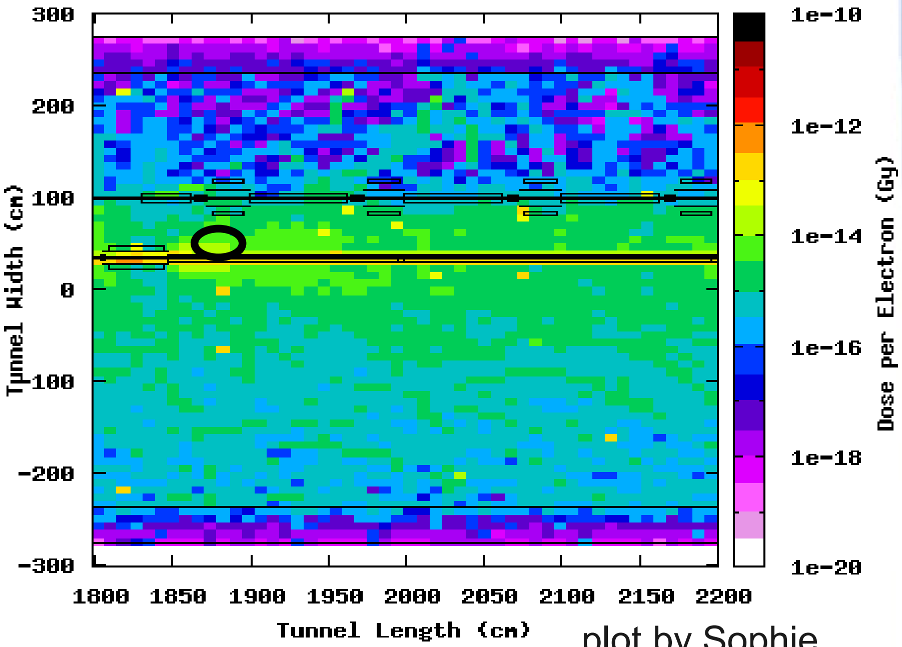
Sensitivity (at 9 GeV)

- 10^{-13} Gy/electron

  i.e. $1.2 \cdot 10^{-8}$ Gy – quite small

  but for instance with LHC IC we observe signals in the μGy range

  (electronic noise of about 0.5 μGy for the shortest integration time)



plot by Sophie

Dynamic range

- Damage for beam in MB at 1.5 TeV: 10^{-4} of whole beam (source: a table from Michel, presented by Barbara),

  i.e. $1.2 \cdot 10^{8}$ electrons lost in a single location,
  i.e. giving signal in maximum of about 10^{-9} Gy/electron (source: old Sophie's paper).

- Therefore the required dynamic range at the end of MB is about **10^{5}**

- These results are preliminary

Time resolution

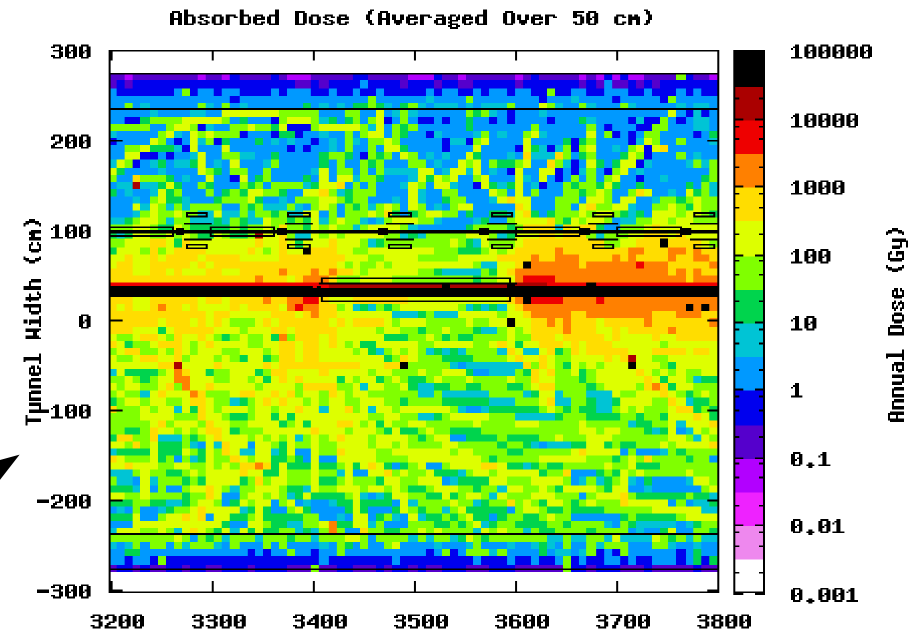
- Time resolution should be better than 18 ms to discriminate between two pulses. This resolution includes time for pulse data analysis and next pulse inhibit.
- One can imagine that data with high time resolution are stored in buffers and extracted on demand (postmortem data).

Radiation environment

Results from Sophie:

- MB at 1.5 TeV: >1 kGy/year (assuming loss on the level of 10^{-3})
- MB at 9 GeV:

  about 100 Gy/year
- DB: 1-10 kGy



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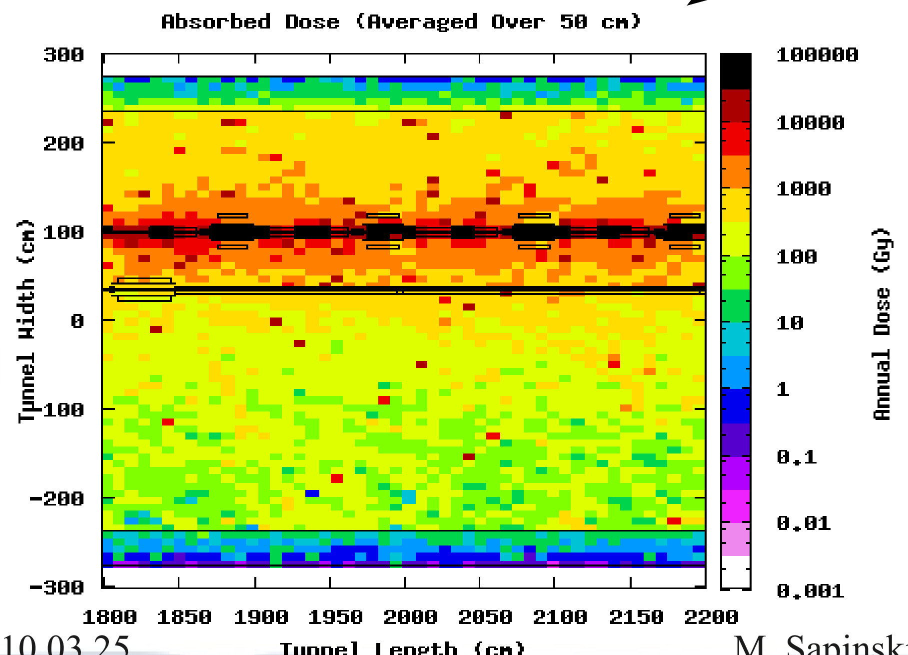
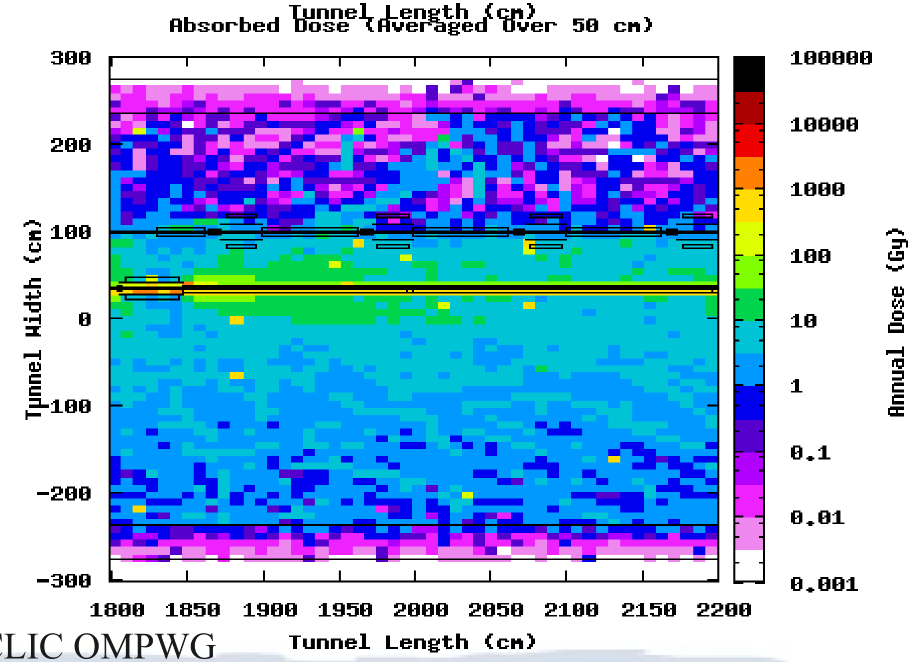




Technologies

- Ionization chamber – well tested on LHC, fulfilling well requirements at the end of MB; can be long tube as in SLAC
- Cerenkov fiber:
  - Sensitivity and dynamic range calculation ongoing (depends on angle of particles in the shower), but is rather about 10^3.
  - Position resolution of a few cm can be reached.
  - Radiation-induced attenuation $RIA(D,\lambda)=a(\lambda)D^{b(\lambda)}$ (A. Intermite)

    a,b – describe radiation hardness

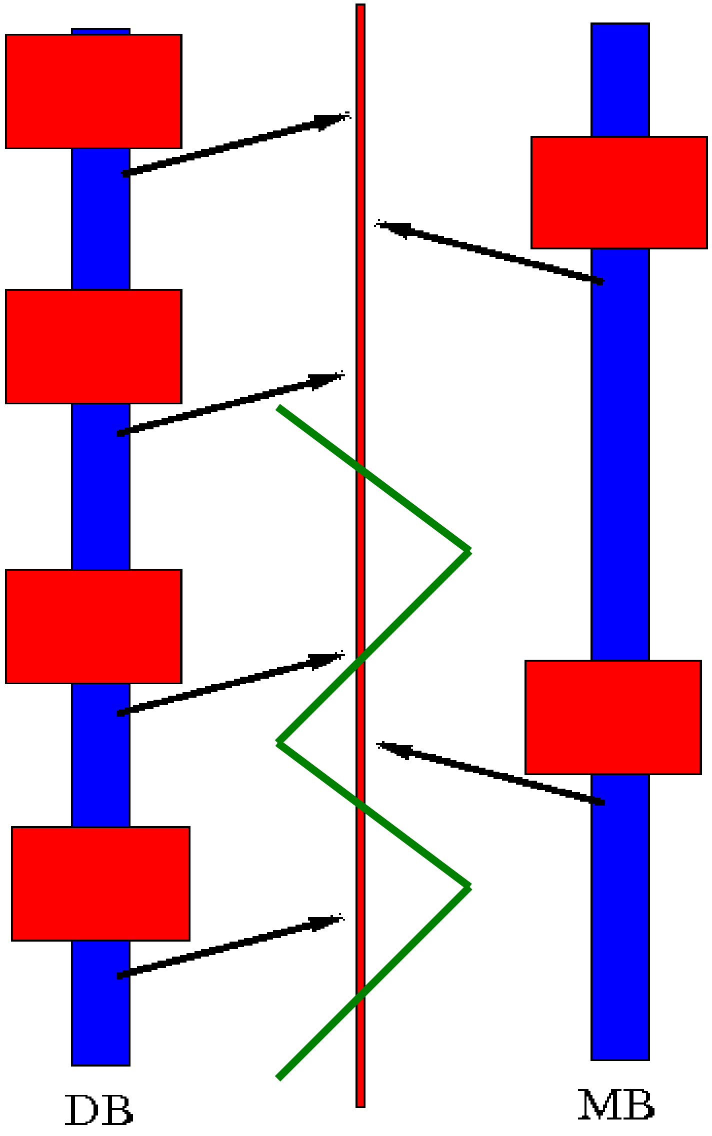
    typical values, for D=100 Gy, RIA=1db/km

    Other sources (F. Wulf, M. Korfer, 2009) report 10^5 Gy

    or even 10^6 Gy (H. Henschel et al., 1994)

Discrimination between DB and MB

- Because of relatively good localization of losses (aperture limitations) and regularity of shielding from the quads, maybe the discrimination between DB/MB losses could be solved thanks to good σ_s
- Further investigations needed, especially because of angular acceptance of fibers



Conclusions and Outlooks

- An example of an exercise leading to estimation of needed sensitivity (10^{-8} - 10^{-6} Gy) and dynamic range (10^5) is presented
- We will follow up with this kind of estimations for various locations in the tunnel
- We still need input about standard losses but also misalignments and especially failure scenarios
- Another input needed: estimation of the actual damage potential of electron beam (exercise TBD by technical student in April)
- Cerenkov fibers: we are working on the first estimation of signals expected in loss radiation field (dependence on distribution of the direction of particles in the shower)
- Geant4 simulations of response function of Cerenkov fibers will start in April.
- I will continue this study but we are also looking for a new UPAS.