PRELIMINARY ANALYSIS OF QUENCH TESTS

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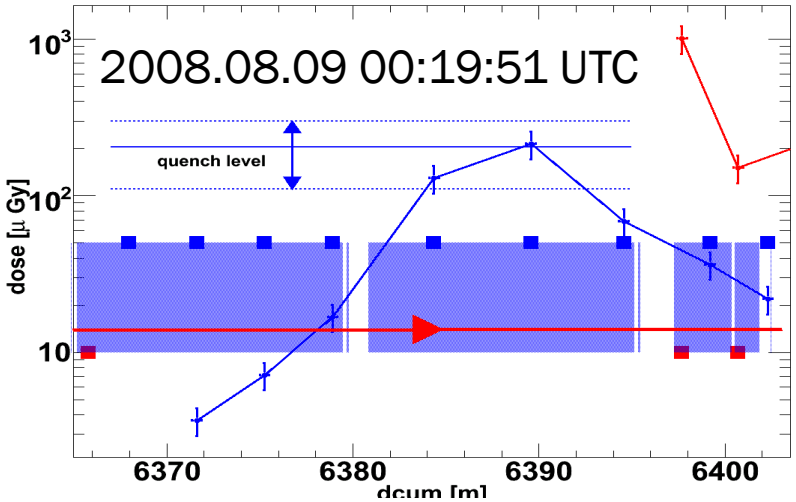
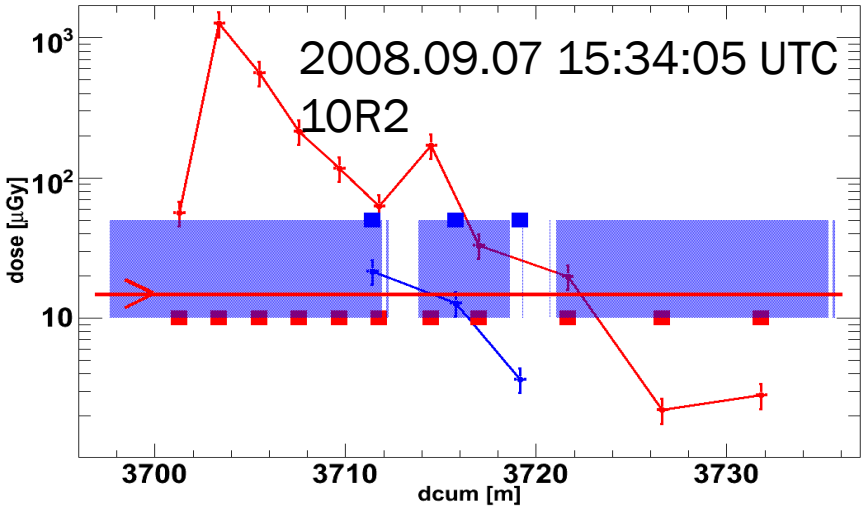
CERN, MPP, 2010.10.29

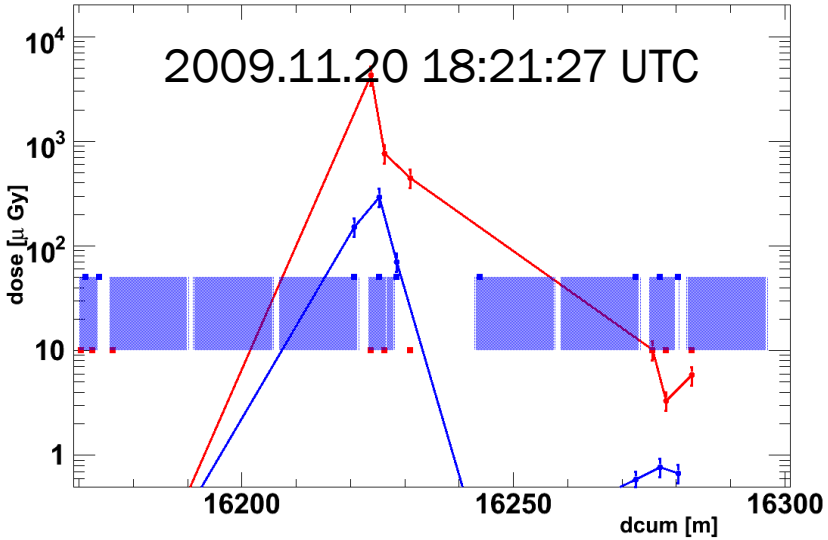
OUTLOOK

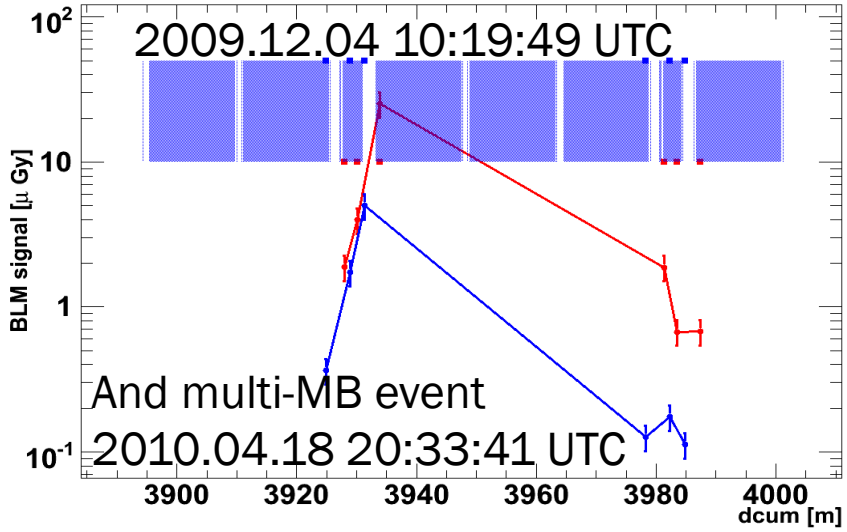
1. Quenches before September 2010 – reminder
2. “Golden” quenchino
3. MQ quench levels and Geant4 simulation status
4. MQ present thresholds
5. MQ fast quench test
6. MQ/MB slow quench test at 450 GeV
7. MQ slow quench test at 3.5 TeV
8. What have we learned about quench levels?
9. What else do we need to know?

QUENCHES BEFORE SEPTEMBER 2010







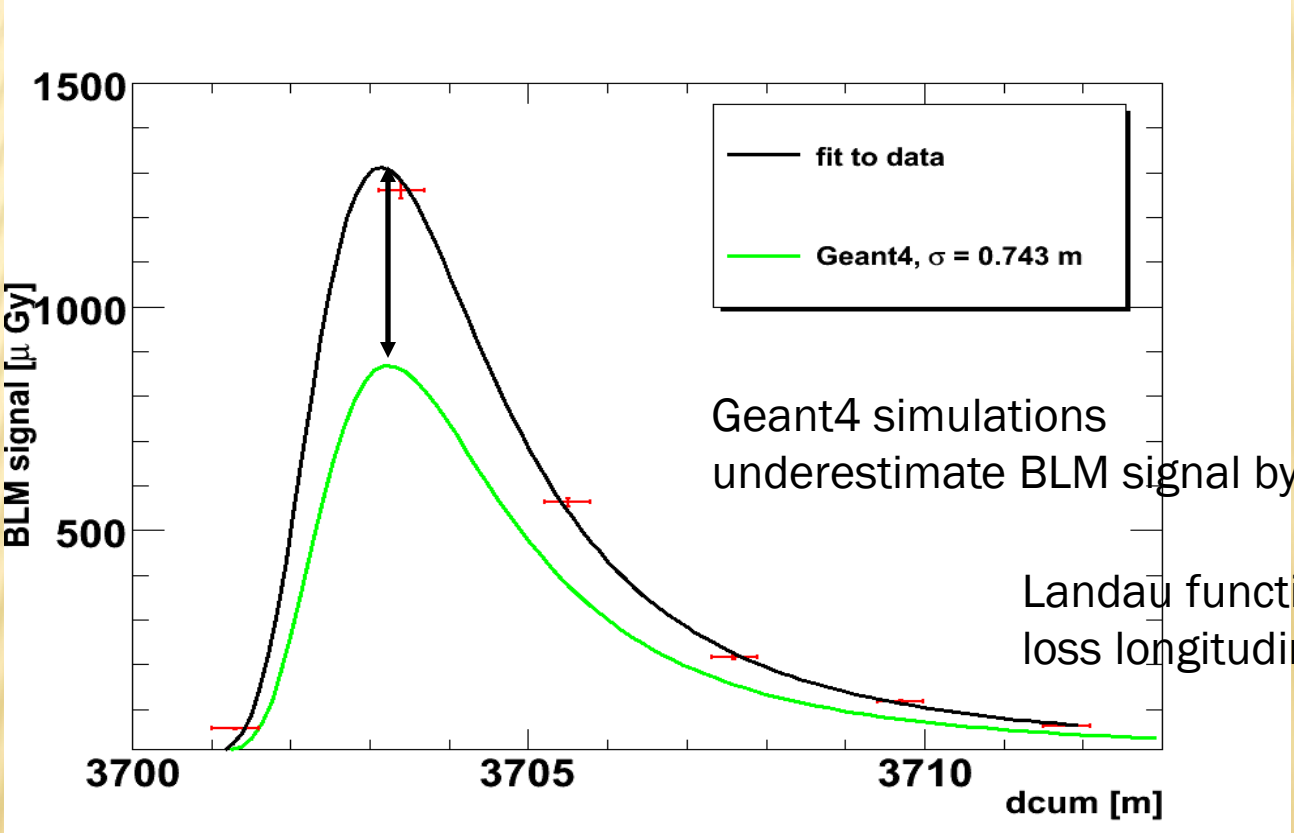


OLD QUENCHES: SUMMARY

- All MB quenchinos
- All, except one, vertical losses
- All at injection energy
- All within the first turn
- All beam 1

for fast (vertical?) loss with beam 1 at injection energy it is easier to produce quenchino in MB than in MQ

GOLDEN QUENCHINO



Geant4 simulations underestimate BLM signal by 50%

Landau function is fitted to the loss longitudinal shape

Relatively good accuracy, but simulation for interconnection is more tricky, and therefore more uncertain

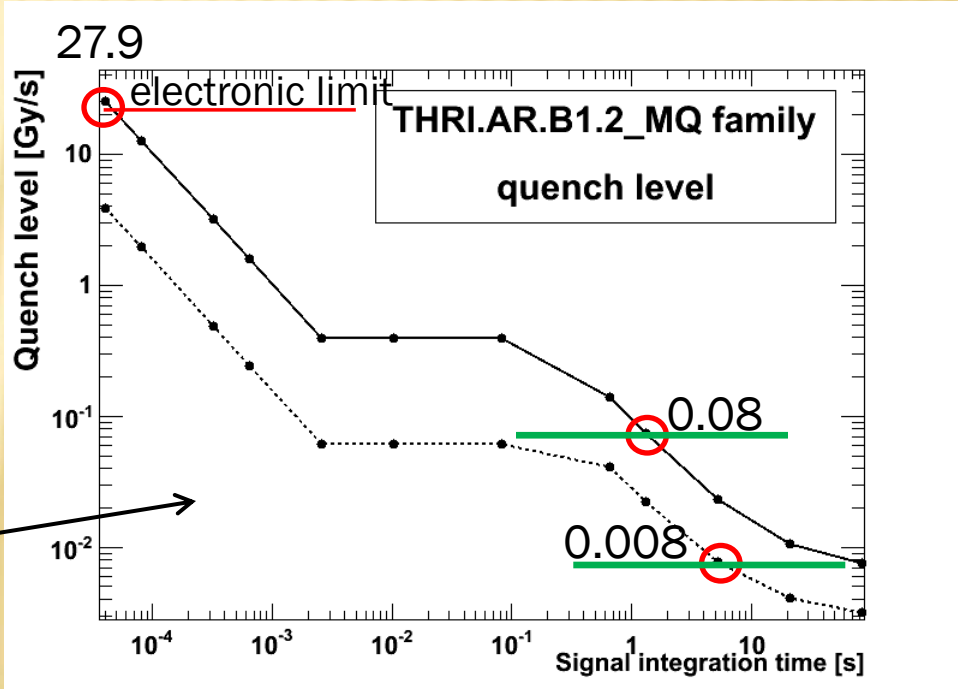
PRESENT MQ THRESHOLDS

- Based on Geant4 simulations:
  - Agnieszka Priebe – geometry
  - Christoph Kurfuerst – simulation and threshold calculation
- Thresholds based on horizontal loss on defocusing quadrupole

$$T = Q_{BLM} \frac{QL}{E_D}$$

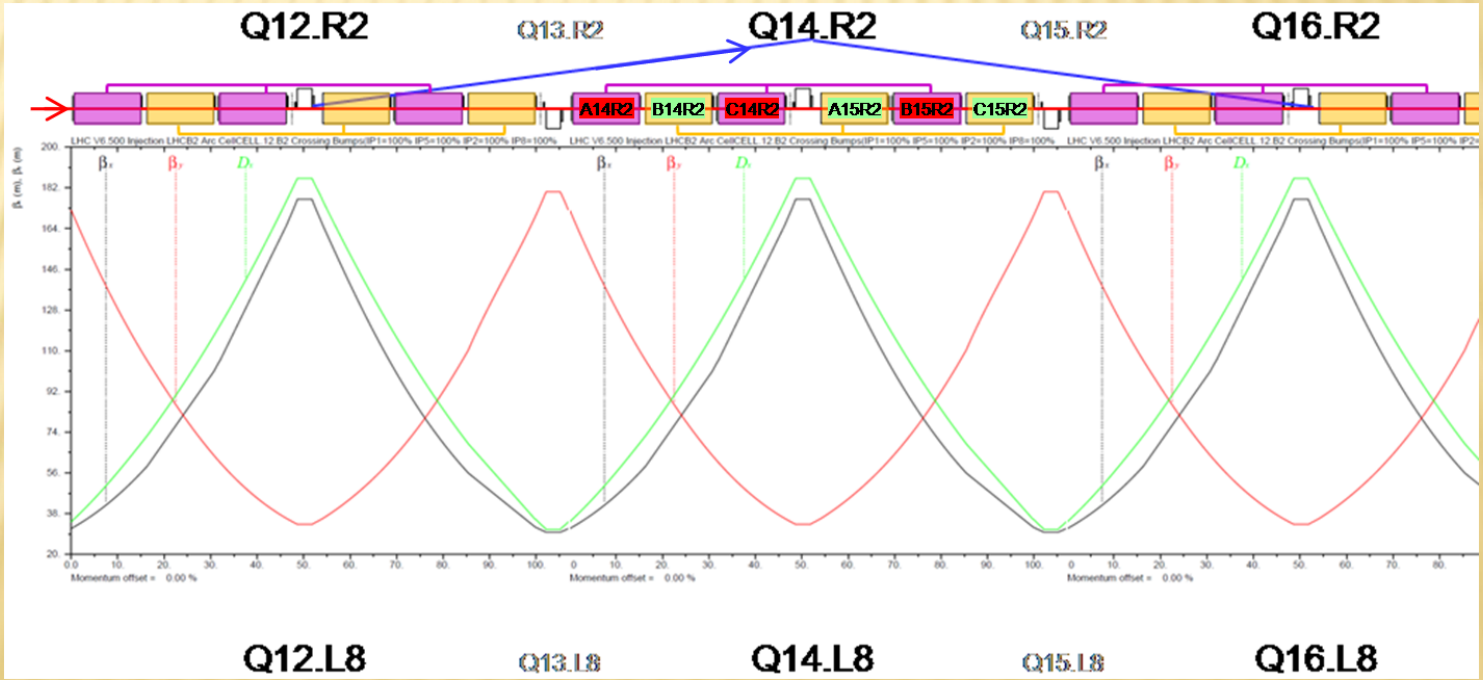
In LSA now

These are signals expected at quench! Actual thresholds we usually set at 30% of this signals.



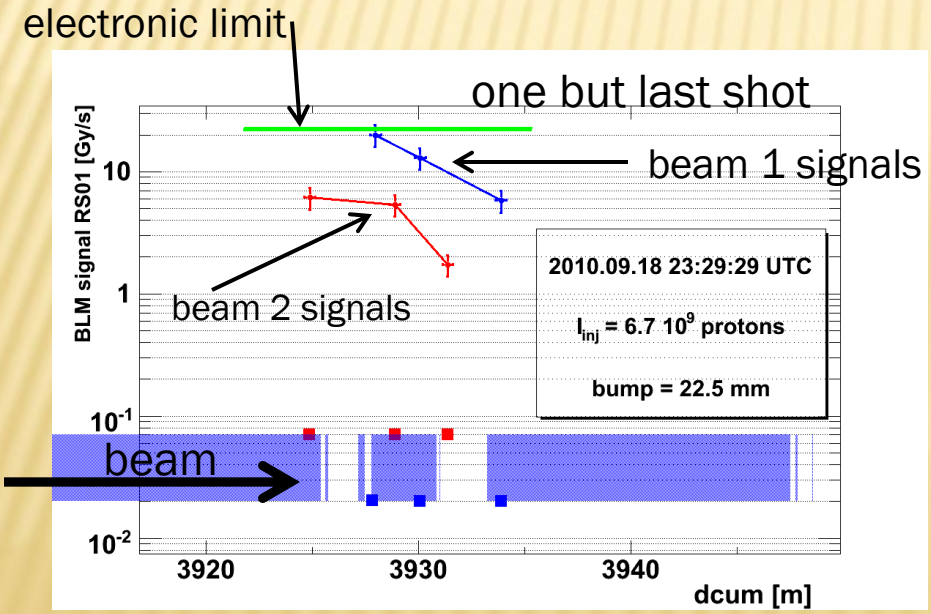
TESTS IN AUTUMN 2010

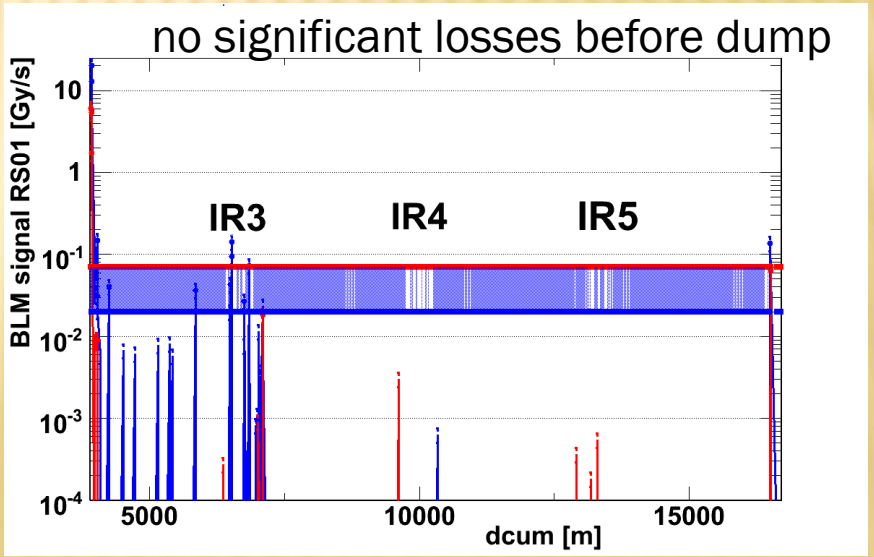
- 450 GeV, 40 μs, beam 1 horizontal
- 450 GeV, about 1 s, beam 1 horizontal and beam 2 vertical
- 3.5 TeV, about 10 s, beam 2 vertical
- … hope for a bit more …



450 GeV, FAST LOSS

- September 18/19
- Horizontal bump, about 50 injections, size 19-24.3 mm, intensity 0.3-0.8 · 10^{10} protons
- No quench, QPS crate got too much radiation – reset needed
- Loss shape suggests significant loss before interconnection



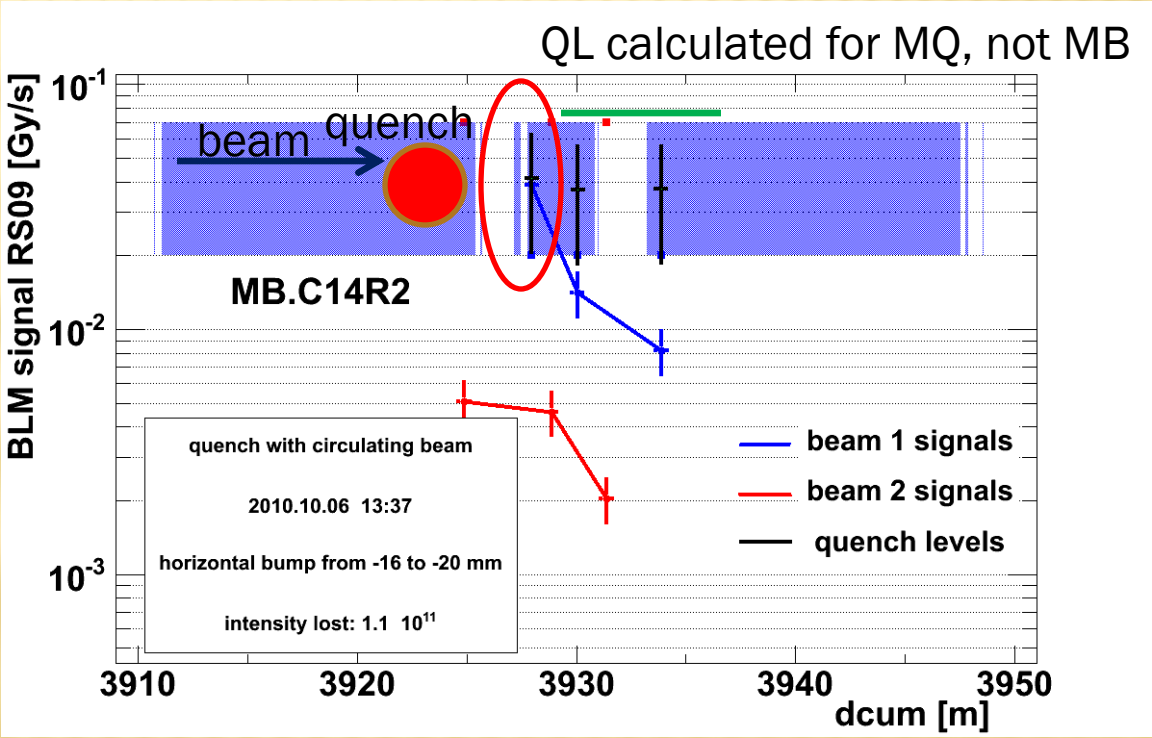


450 GeV, 1s –LOSS HORIZONTAL

- October 6th, horizontal bump, increasing from -16 to -20 mm
- Upstream MB quenched
- No signal on MQ

RS09 = 1.31 s
Signal at quench = 0.039 Gy/s
Theoretical Quench Level on BLM1= 0.041 Gy/s

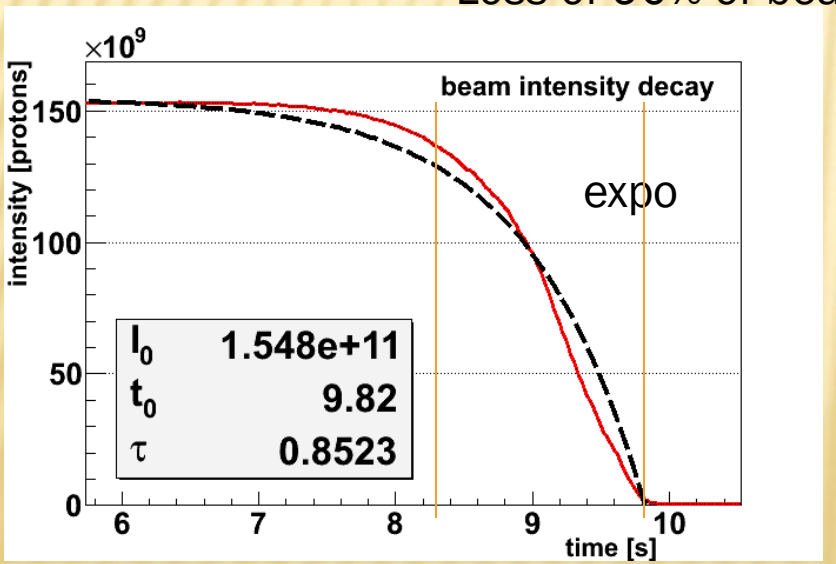
again loss shape suggests significant loss before interconnection!

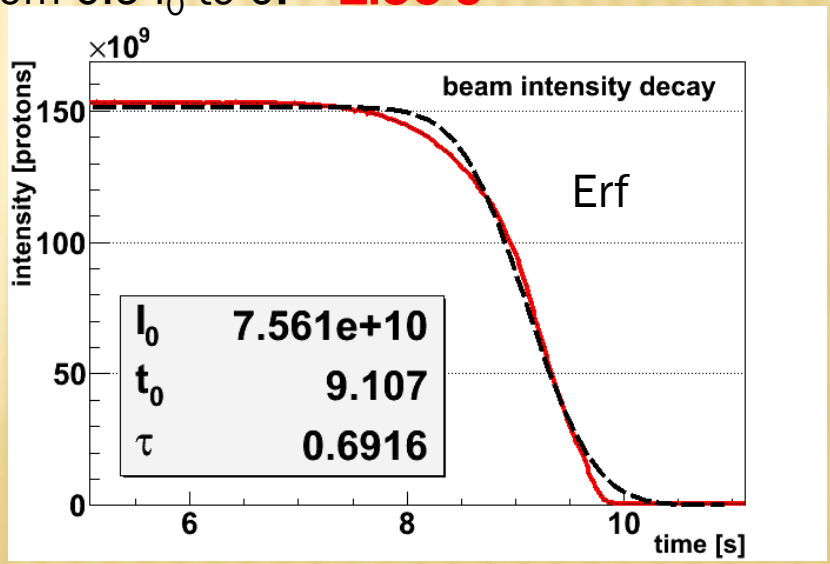


450 GeV, 1s –LOSS VERTICAL

- October 6th, vertical bump, increasing from 13 to 18 mm (upward direction)
- We have done vertical because beam 1 was unavailable
- MQ developed resistive zone, bus-bar QPS dumped the current, quench heaters did not fire.
- $1.55 \cdot 10^{11}$ protons lost
- Beam decay:

Loss of 90% of beam from 0.9 I_0 to 0: **1.55 s**



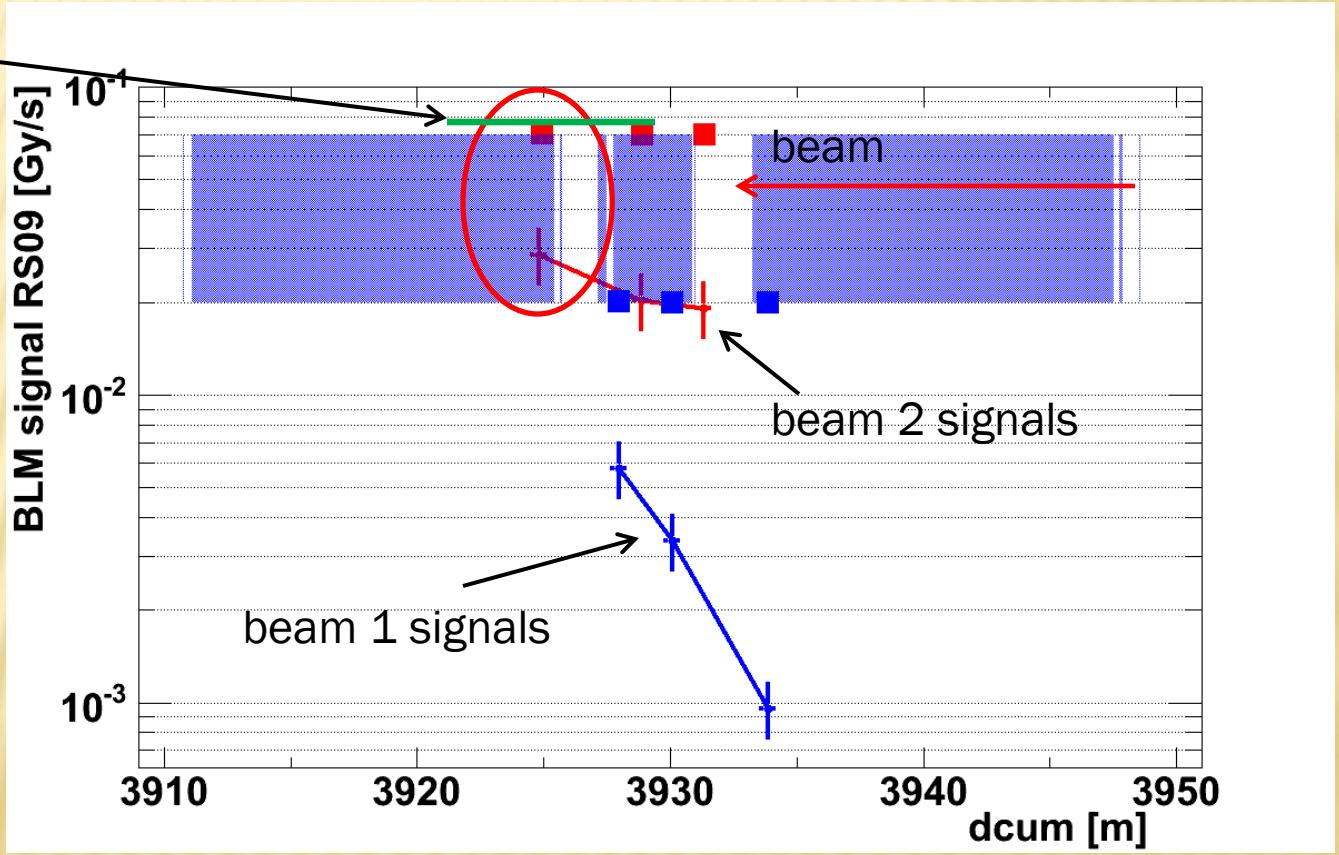


450 GeV, 1s –LOSS VERTICAL (II)

RS09 = 1.31 s
Signal at quench = 0.028 Gy/s
Theoretical Quench Level = 0.080 Gy/s

we were too optymstic by factor 2.9 (or more, if taking middle monitor)

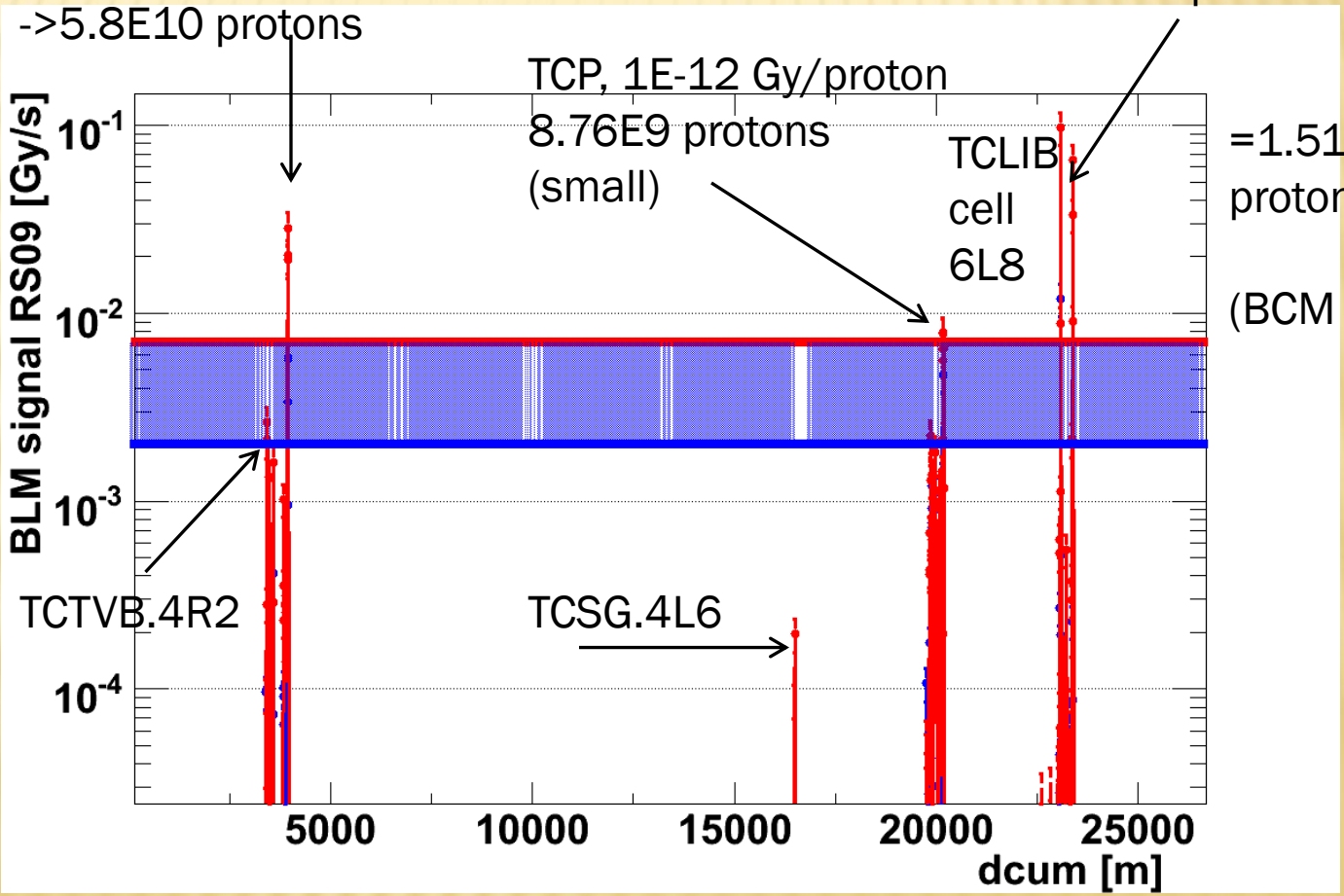
Signal expected at quench



Loss shape: not so much loss before interconnection

450 GeV, 1s –LOSS VERTICAL (III)

Global view – how many protons have been lost on the magnet actually?



450 GeV, 1s –LOSS VERTICAL (IV)

Assuming the risky math is not too far from reality:

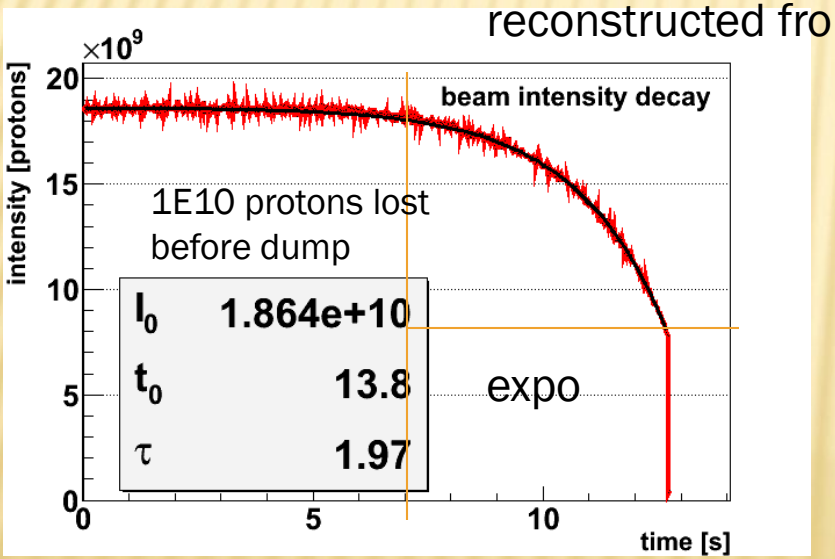
we lost 6E10 protons in 1.6 seconds
on the magnet which is 3 meter long:

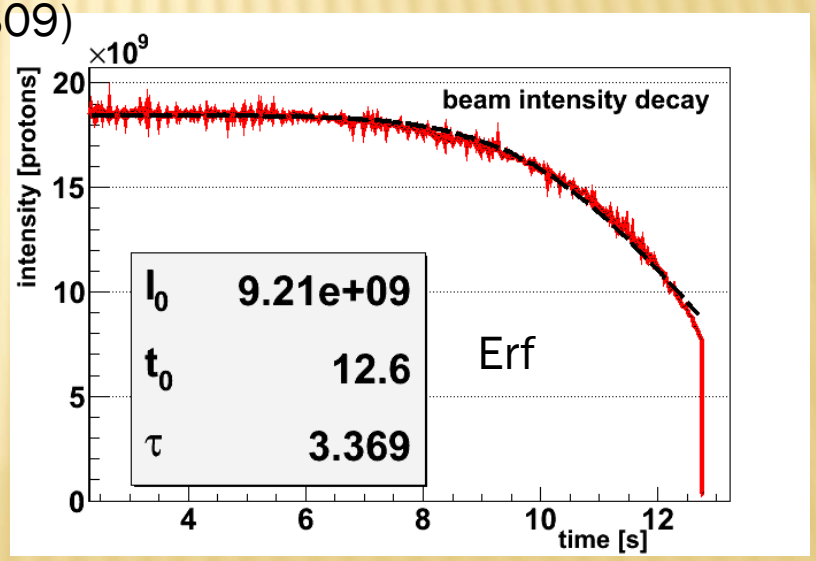
Quench level: $1.3 \cdot 10^{10}$ protons/m/s at injection

3.5 TeV, 10 s LOSS

- October 17th, vertical bump (as before) increasing from 15 to 21 mm
- MQ quenched (Quench heaters fired)
- Beam decay:

90% of the intensity which were not dumped were lost during 5.6 s (RS10: 5.2 s, we do not log it, but it can be reconstructed from RS09)

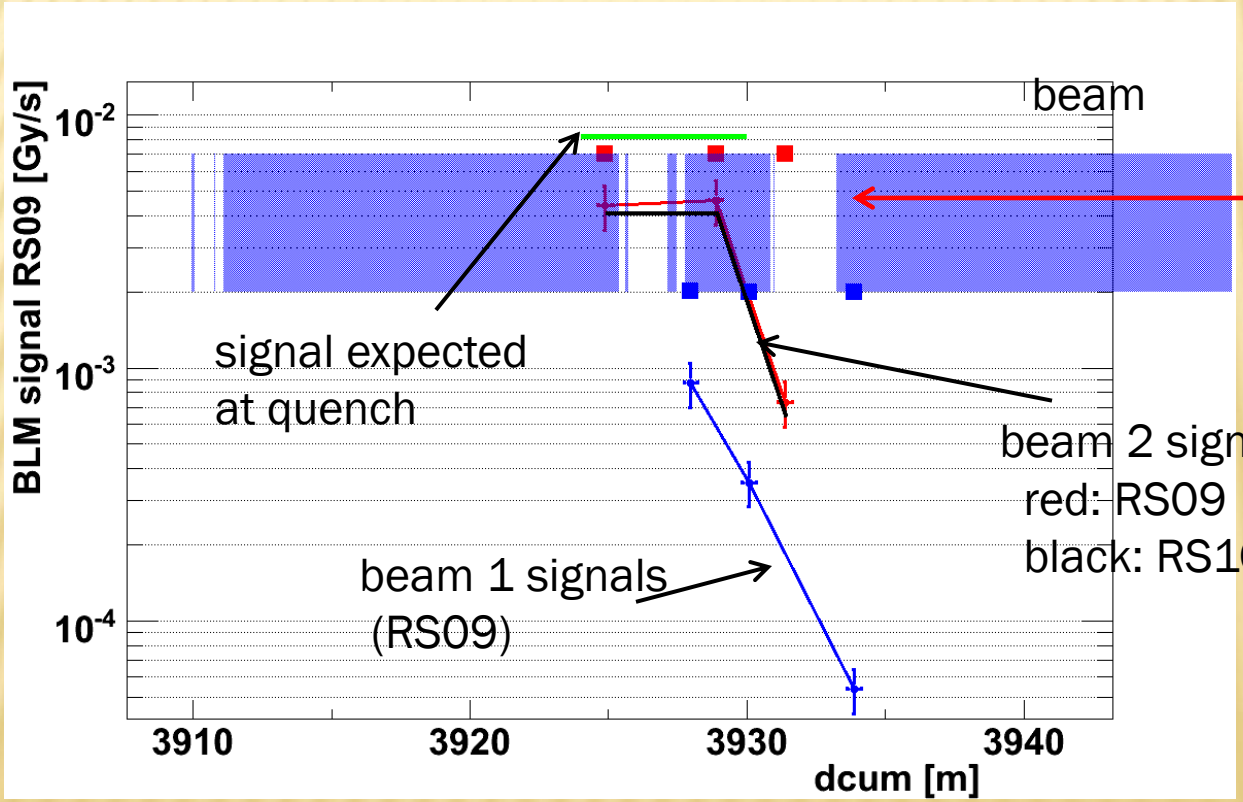




3.5 TeV, 10 s LOSS (II)

RS10: 5.2 s
Signal at quench (estimated from RS09): 0.0041 Gy/s
Theoretical Quench Level = 0.0082 Gy/s

we are too optimistic by factor 2

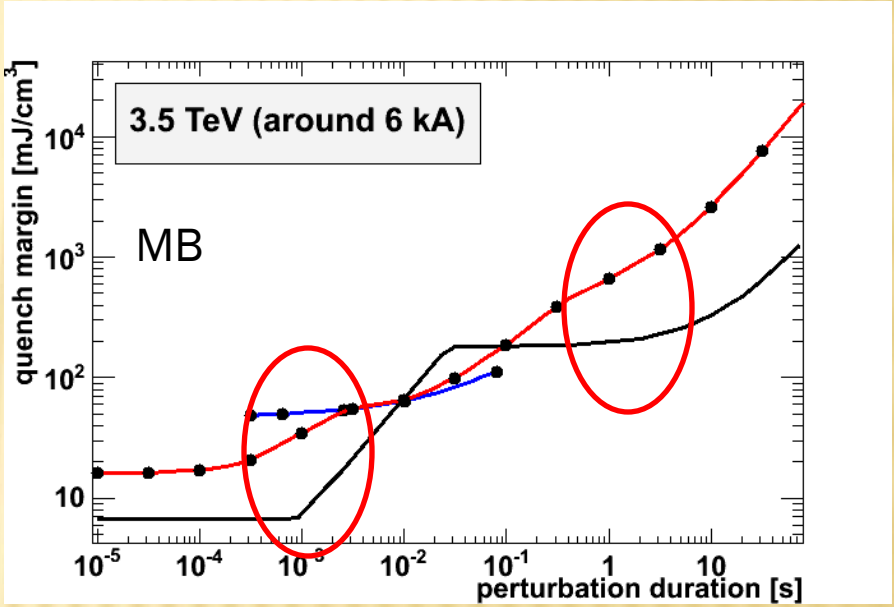


CONCLUSIONS AND PLANS

- Fast transient quench test at 450 GeV with beam 1 – not conclusive, no quench, QL expected in BLM electronic saturation anyway – it seems to be difficult to hit MQ only.
- 1 s horizontal loss of beam 1 at 450 GeV: MB quenches first
- 1 s vertical loss of beam 2 at 450 GeV: MQ quenches with BLM signal about factor 3 lower than expected signal at quench.
- 5 s vertical loss of beam 2 at 3.5 TeV: MQ quenches with BLM signal TeV about factor 2 lower than expected signal at quench.

CONCLUSIONS AND PLANS (II)

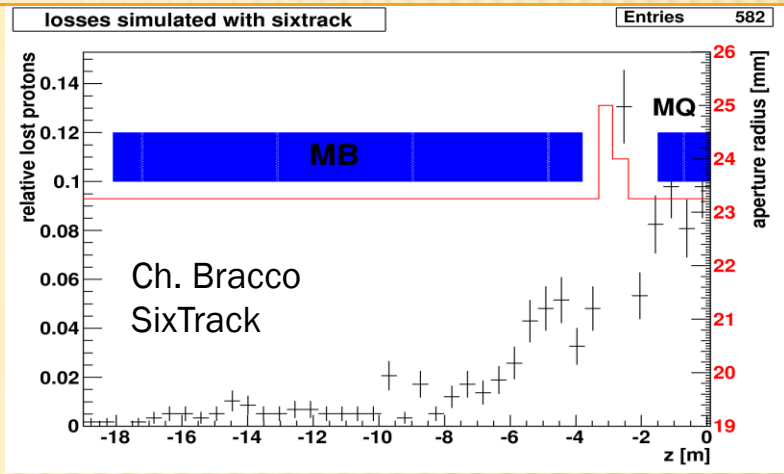
- QP3 code (Arjan Verweij) – more optimistic for UFO timescale
- Although not too compatible with test results
- we continue analysis:
  - Global analysis of losses
  - Geant4 with focusing quadrupole
  - Exercise QP3 code



- The 1-5s timescale is not limiting us now – we need to investigate 1 ms timescale – wire scanner test

EXTRA SLIDES

450 GeV, FAST LOSS (II)



- Let's try some math for this event:
- $I_{inj} = 6.7 \cdot 10^9$ protons
- $I_{dump} = 1.2 \cdot 10^9$ protons
- BLM1 = 2 mGy = $2 \cdot 10^9$ protons
- BLM2 = 0.88 mGy = $1.9 \cdot 10^9$ protons
- I_{inj}-I_{dump} = $5.5 \cdot 10^9$ protons
- BLM1+BLM2 = $3.9 \cdot 10^9$ protons
- Missing $1.6 \cdot 10^9$ (25%) protons:
  - leak from BLM coverage, most likely in upstream MB – there is correlation between the size of bump and fraction of "leaking" protons
  - simulations can be wrong

	Calibration
BLM1	9.8E-13 Gy/proton
BLM2	4.6E-13 Gy/proton

$(I_{inj}-I_{dump})/(BLM1+BLM2) = 1.4$

MISSING PROTONS VS BUMP SIZE