



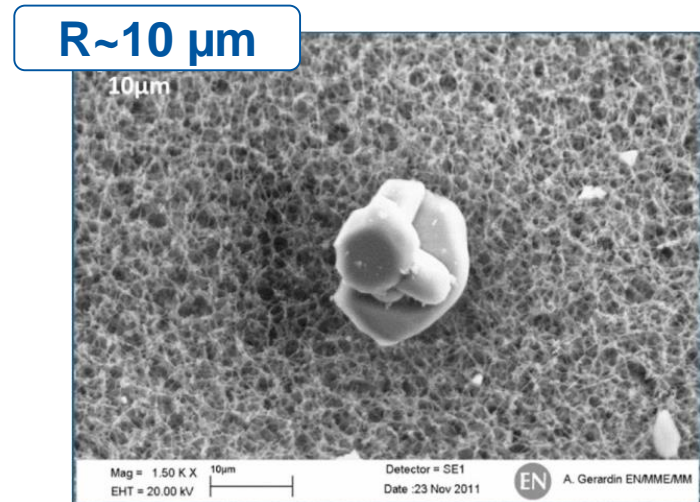
“How to Survive a UFO Attack”

B. Auchmann, J. Ghini, L. Grob, G. Iadarola, A. Lechner, G. Papotti
Evian, December 15, 2015



Outline

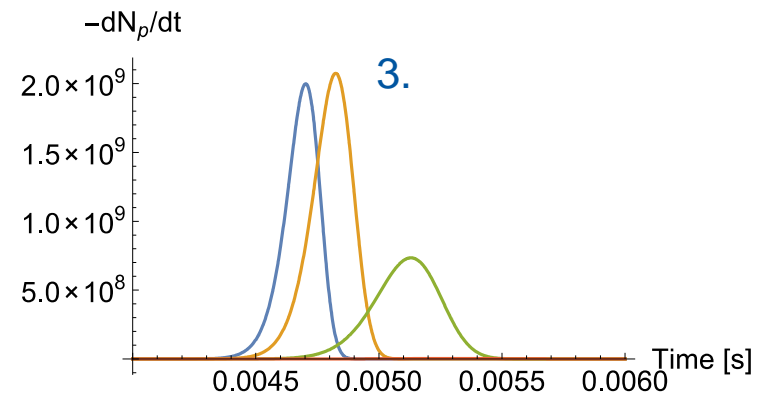
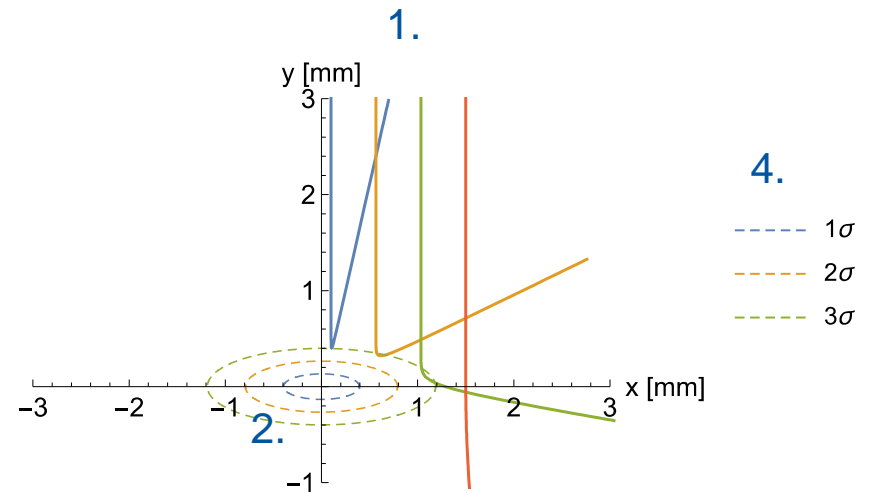
- Quantification of the UFO threat
- BLM signals and threshold strategy
- Continued UFO studies



UFOs Introduction

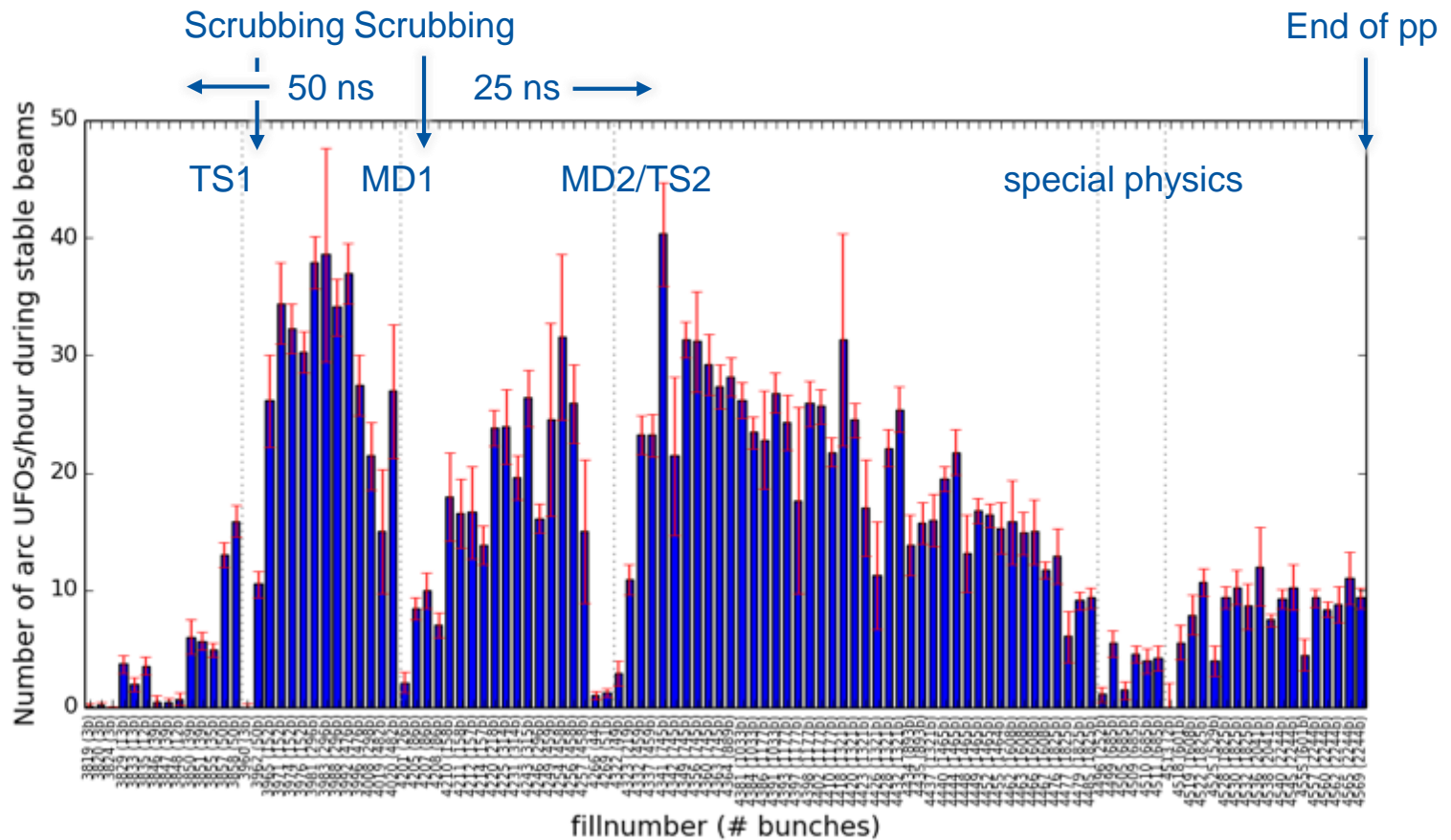
An explanation for UFO events is as follows:

1. A **macroparticle** falls from the top of the beam screen. The mechanism for the release of the particle is not well understood.
2. The **macroparticle** is ionized by the primary the protons in the beam.
3. At the same time, inelastic **collisions** result in particle showers that heat the SC coils and are registered in the BLMs.
4. The positively ionized **macroparticle** is subsequently **repelled** from the beam due to the beam electric field.



UFO Rates 2015 pp Run

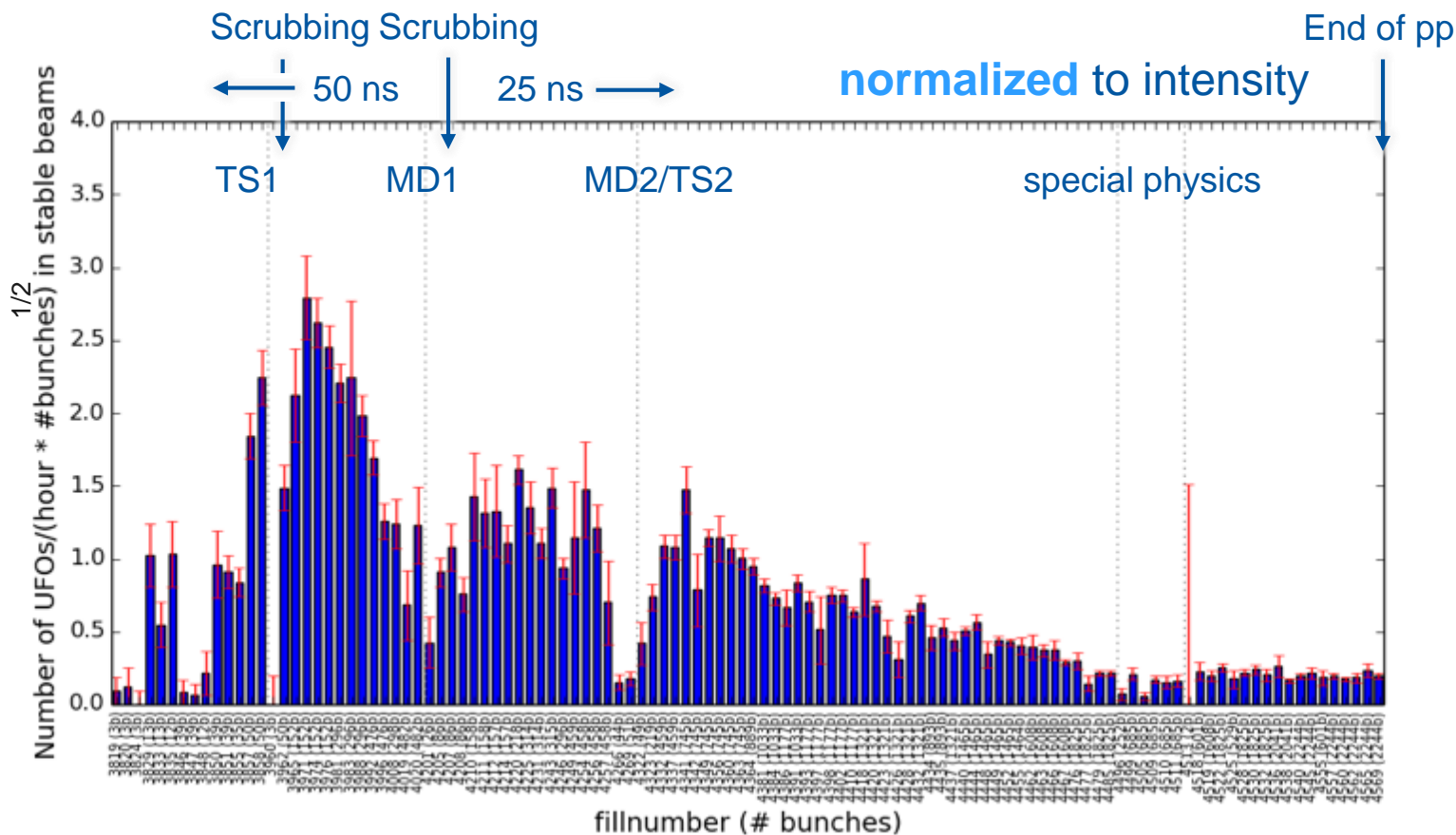
Rates of registered UFOs in Arcs and DSs at 6.5 TeV.



Is a ratio of 10 UFOs/hr already the asymptote?

UFO Rates 2015 pp Run

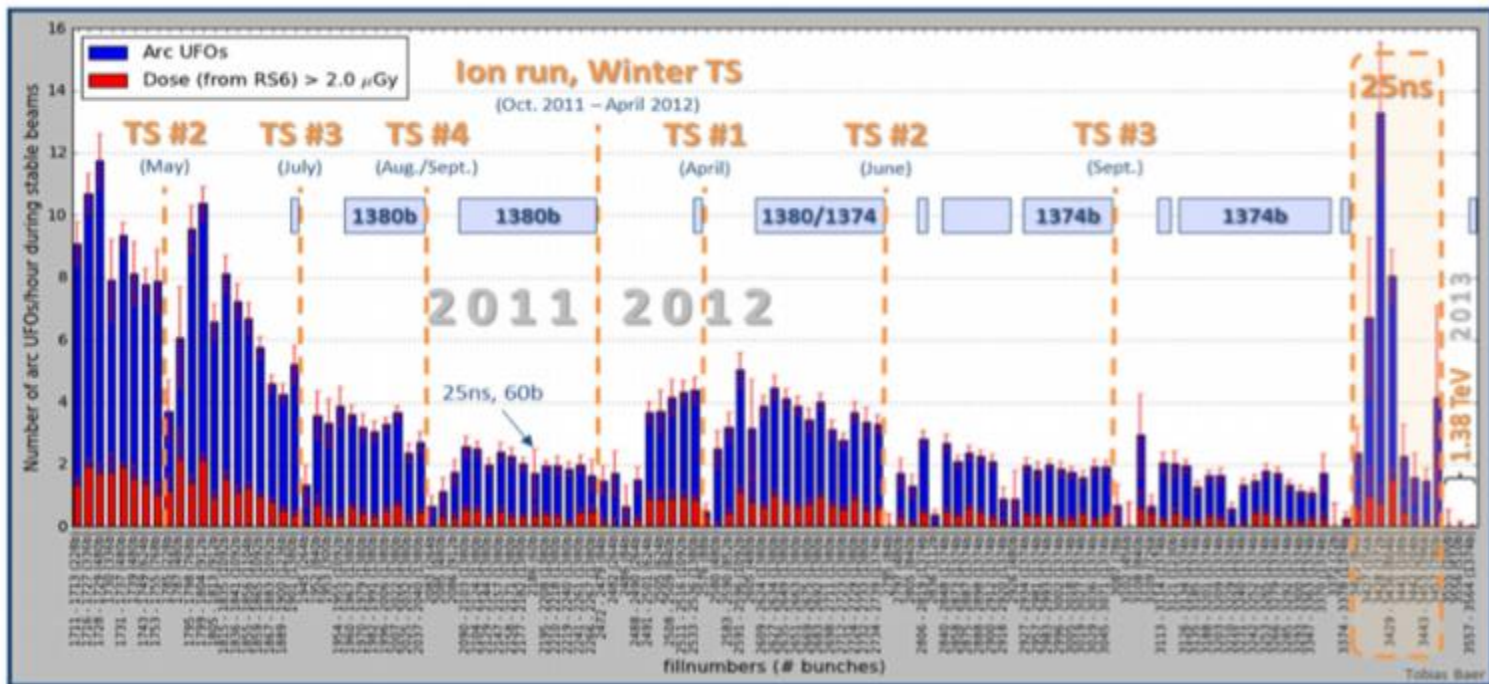
Rates of registered UFOs in Arcs and DSs at 6.5 TeV.



Is a ratio of 10 UFOs/hr already the asymptote?

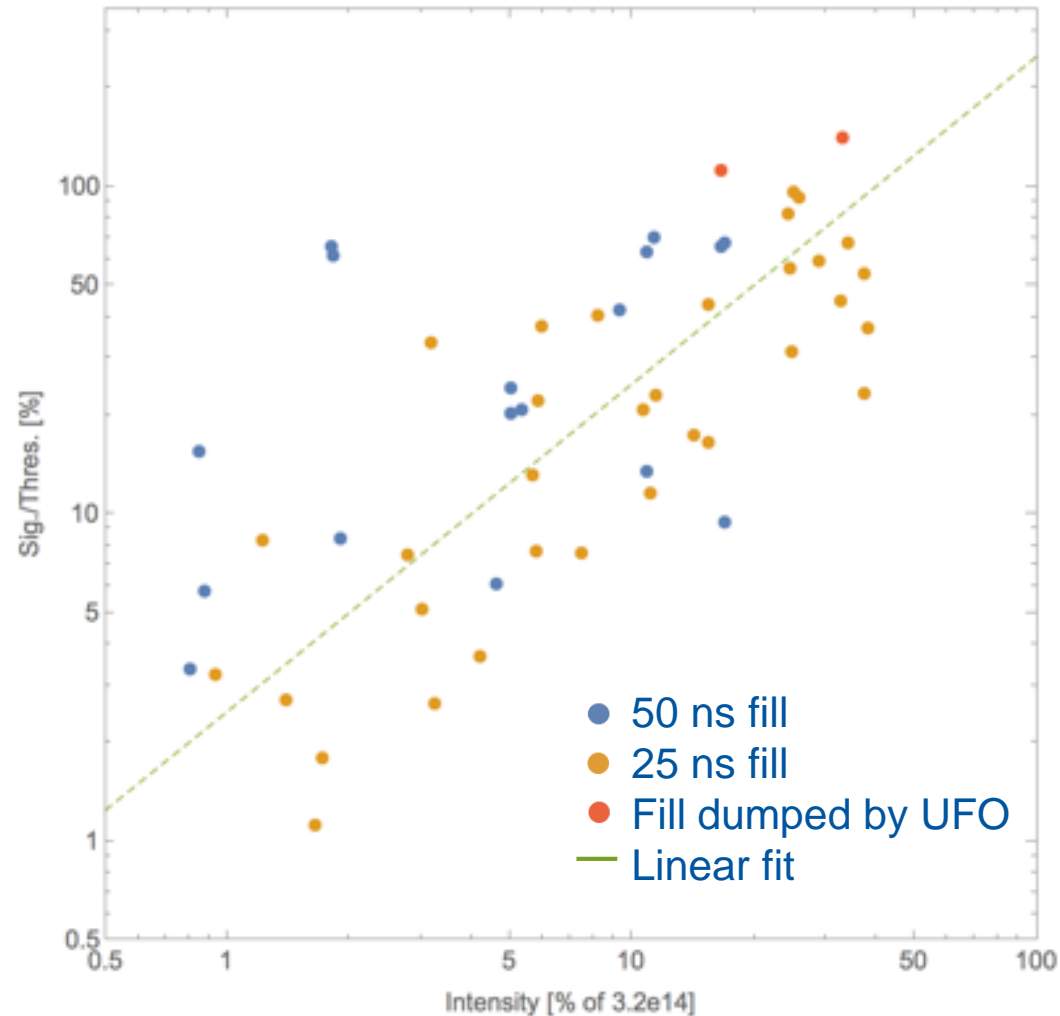
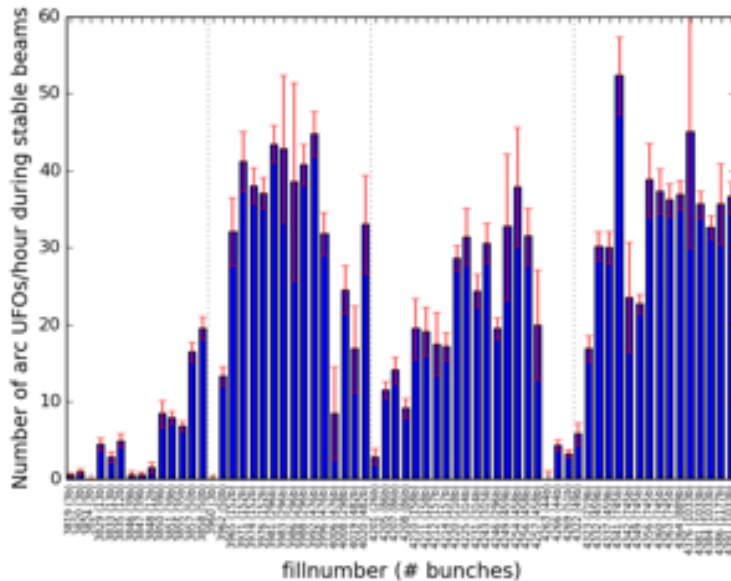
2011-2012 Experience

- UFO buster in 2011 starts at 10/h and reaches an asymptote at 2/h.
- This was with a different BLM distribution in the arc/DS cells and at a different energy.
- We may expect an increase in rate after YETS.



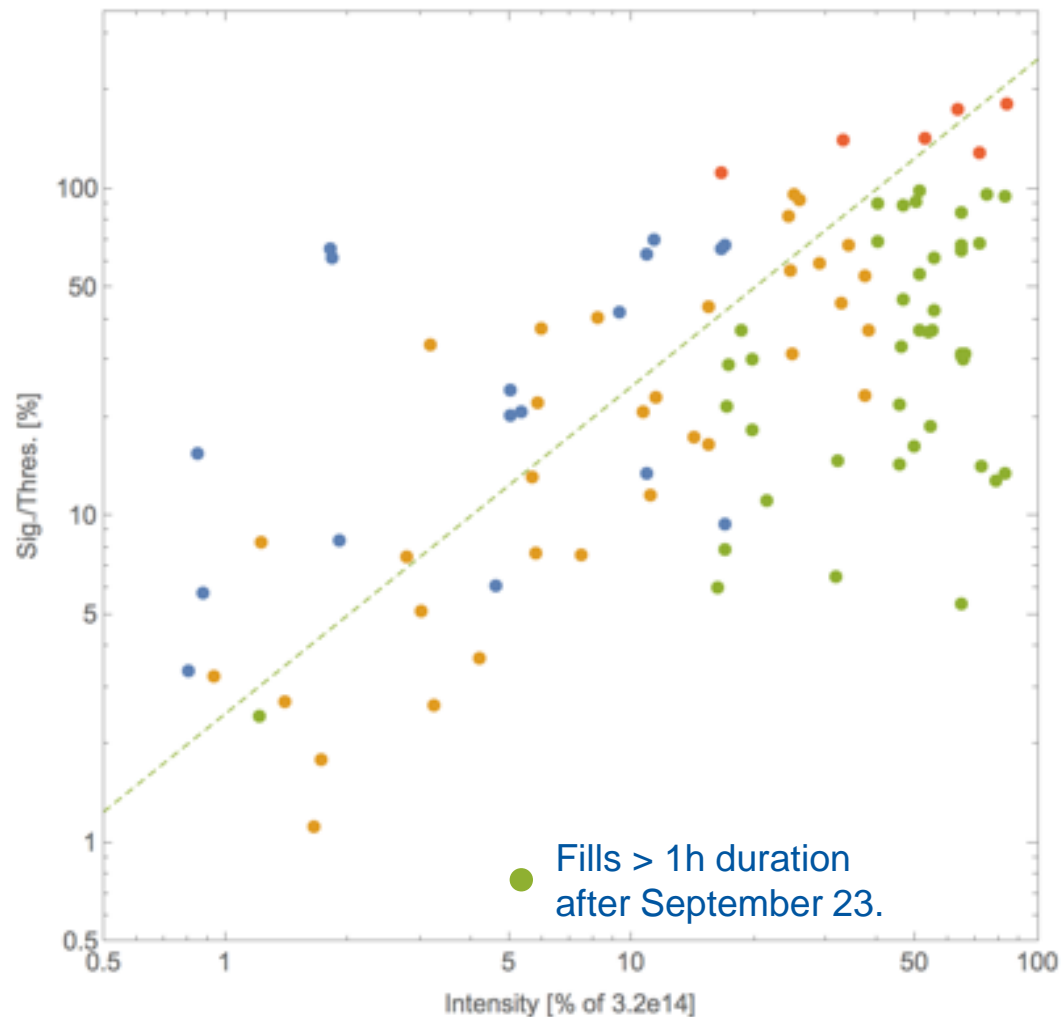
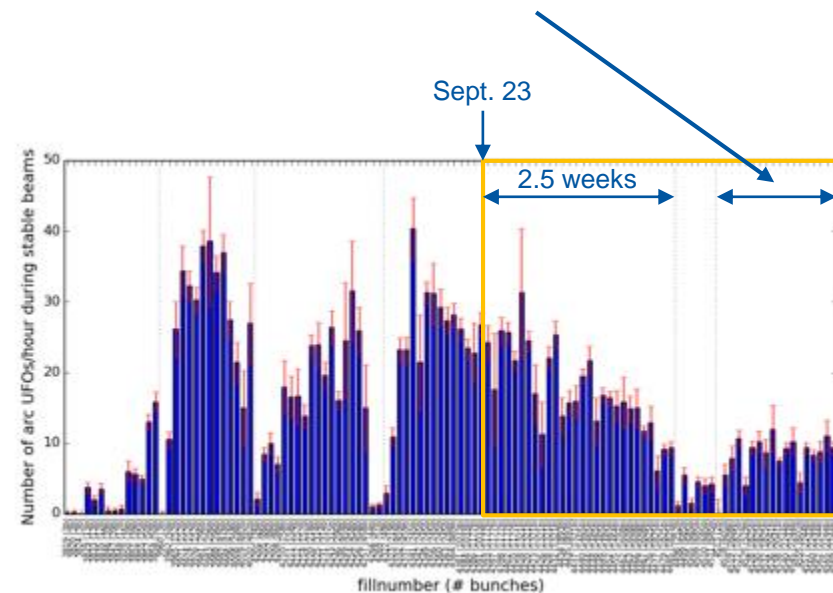
BLM Signal vs. Intensity

- Pessimistic outlook at LMC September 23, at first confirmed by
 - 8 UFO dumps within 2 weeks (Sept. 20 to Oct. 5).
 - 5 UFO dumps on Sept. 26-27 alone.



BLM Signal vs. Intensity – UPDATE

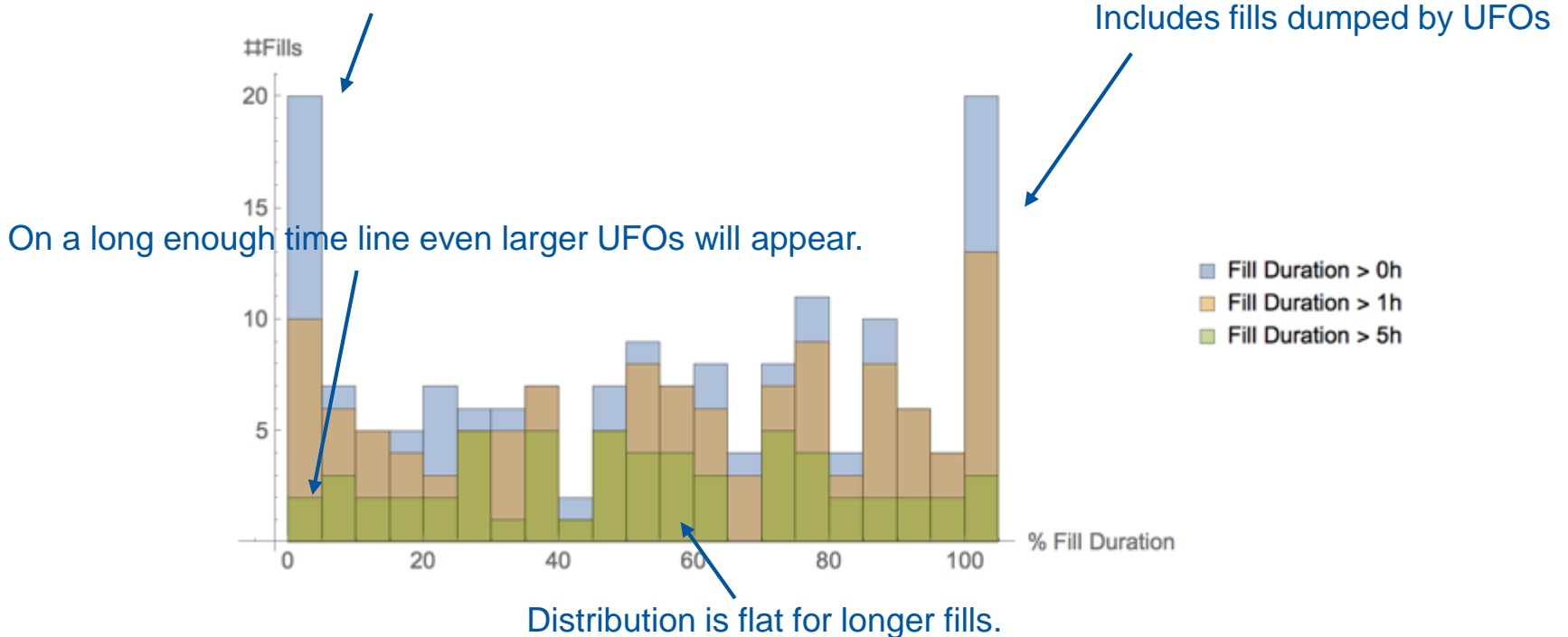
Since then, UFO rates dropped. Most fills now have lower loss peaks.
Only 1 UFO-related dump
from 20.10. to 2.11.



Timing of Peak Loss in Fill

- When is the maximal Signal/Threshold ratio registered over the flat-top duration of a fill?

Higher probability for larger events upon arrival on flattop.



- For fills longer than 1h, the distribution basically is flat.

Other Studies: BCMS, E-Cloud Effect

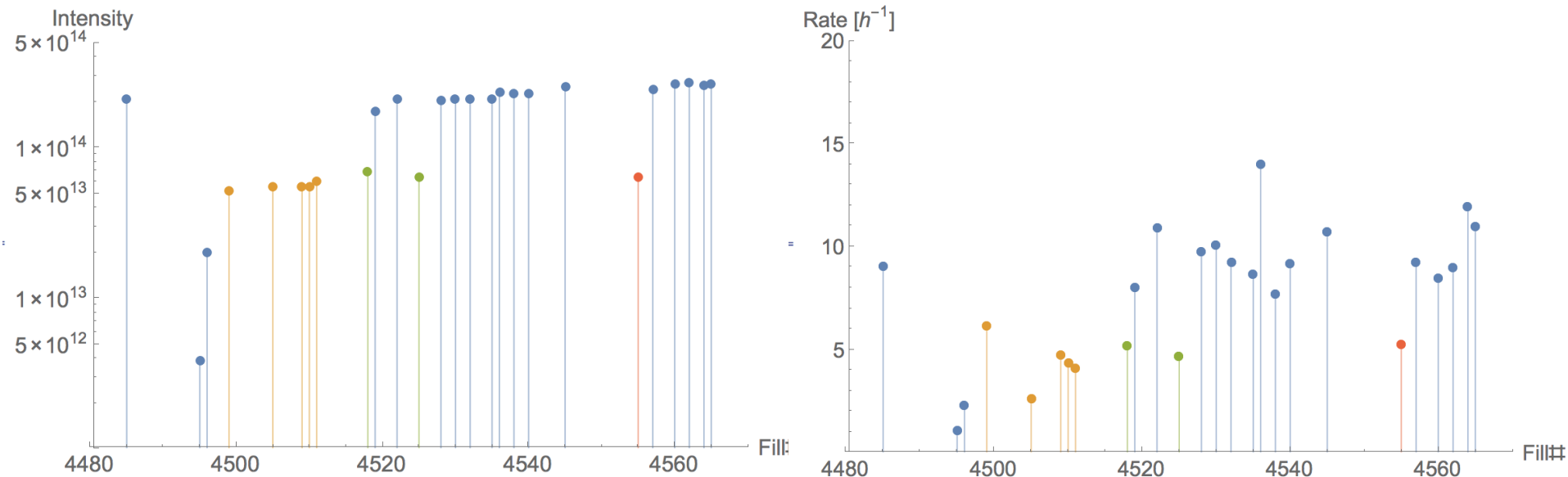
90-m run with $\sim 1/5$ e-cloud-related heat load (100 ns bunch length).

- UFO rate roughly the same.

BCMS fill with $\sim 1/4$ lower emittance.

- UFO rate roughly the same. (Only 1 fill.)

- 90-m run
- BCMS fill @ 6.5 TeV
- comparable intensity fills
- other fills



Other Studies: BCMS, E-Cloud Effect

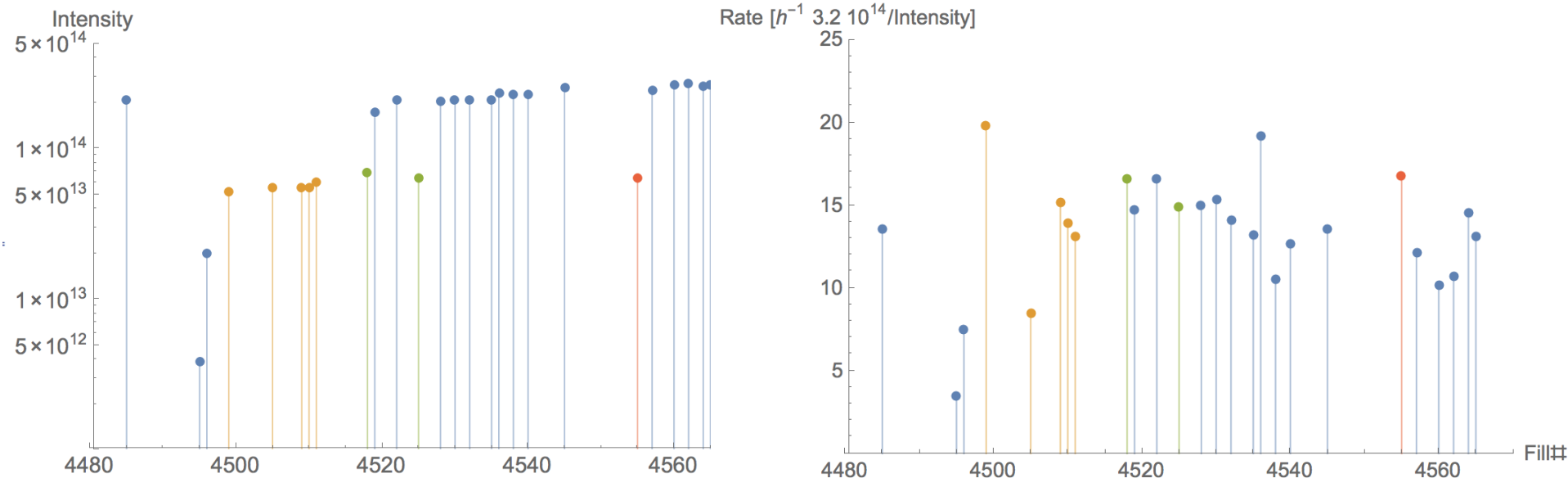
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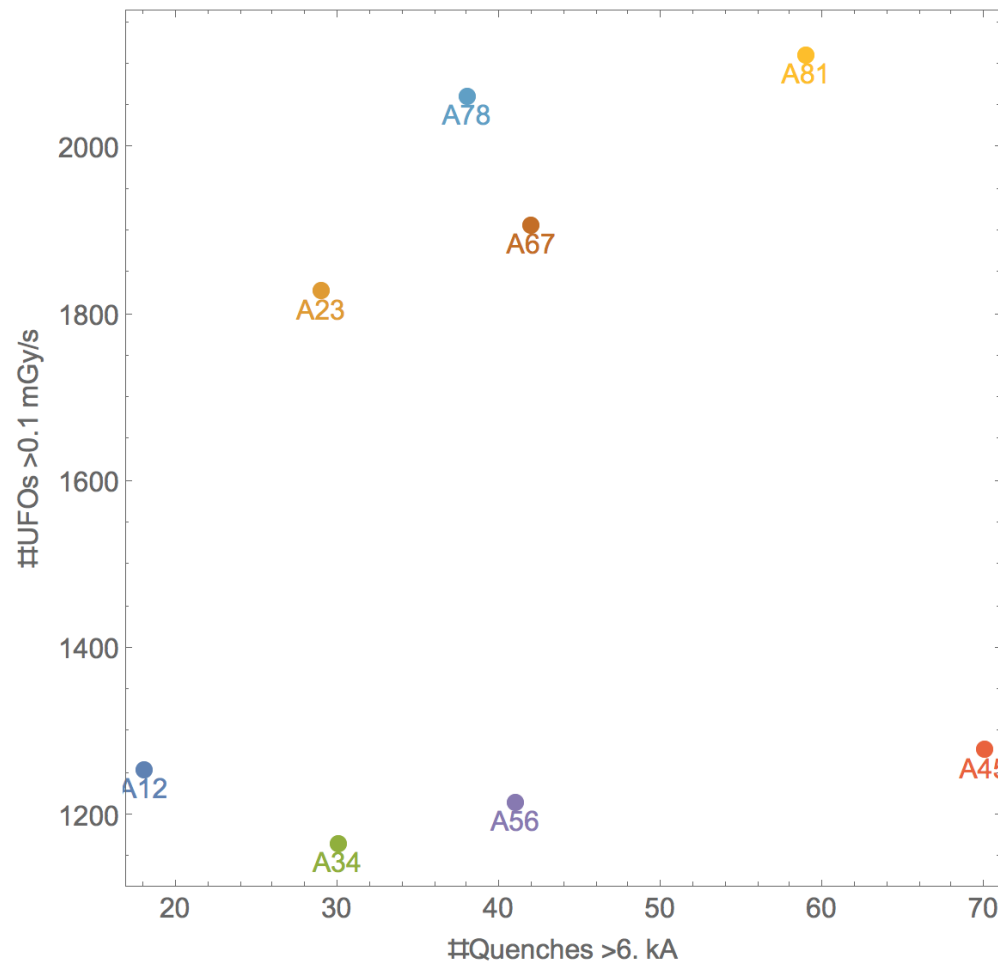
- UFO rate roughly the same. (Only 1 fill.)

- 90-m run
- BCMS fill @ 6.5 TeV
- comparable intensity fills
- other fills



Other Studies: Training Quenches

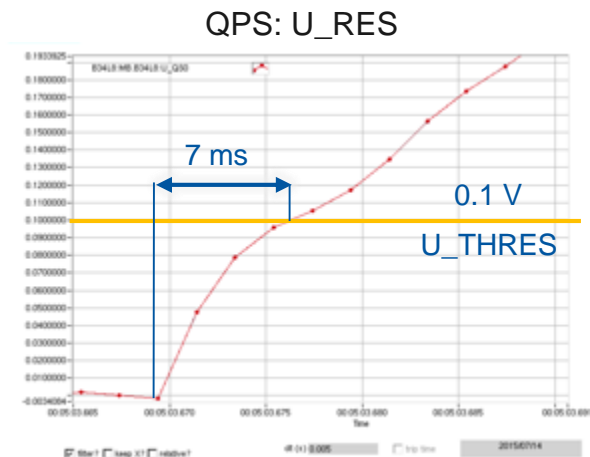
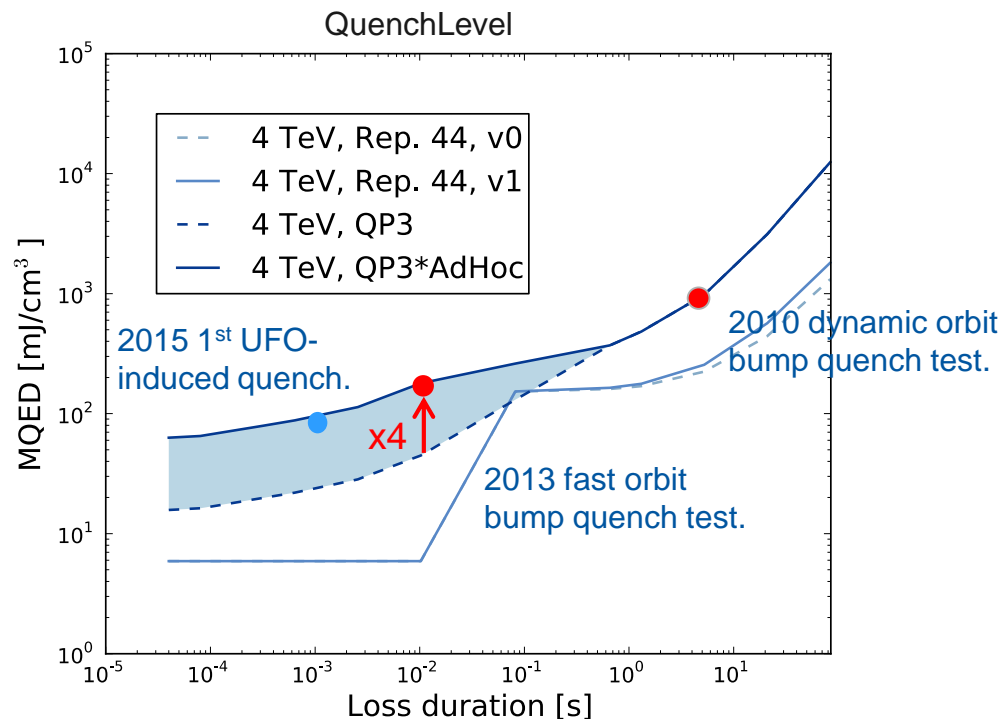
Analysis per sector revealed no correlation.



BLM Thresholds Strategy

Initial Run 2 Settings

- BLM thresholds in arcs and DS were set to the quench level for UFO locations with min. BLM sensitivity.
- UFO-induced quench of July 14th confirmed quench level (quench at 91% of threshold) in least sensitive location.

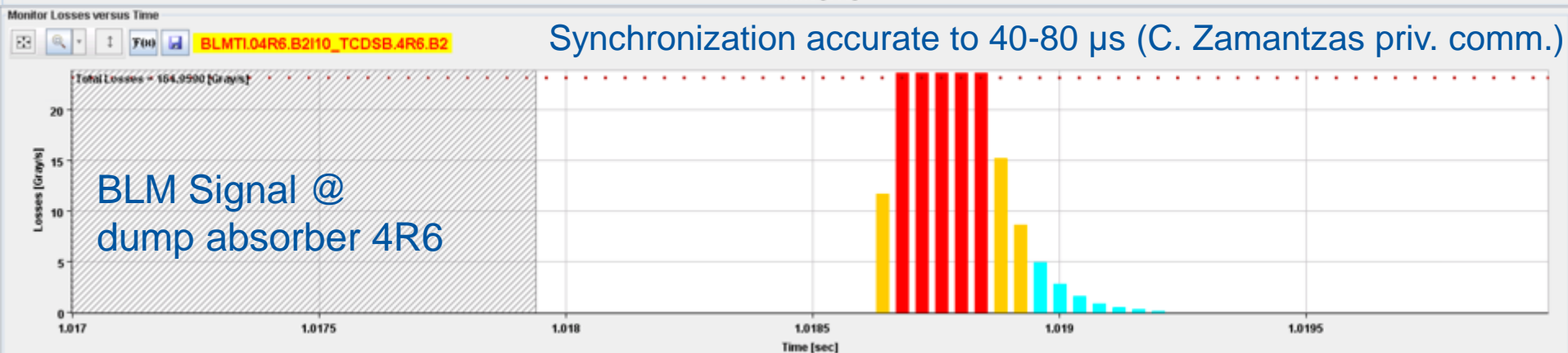
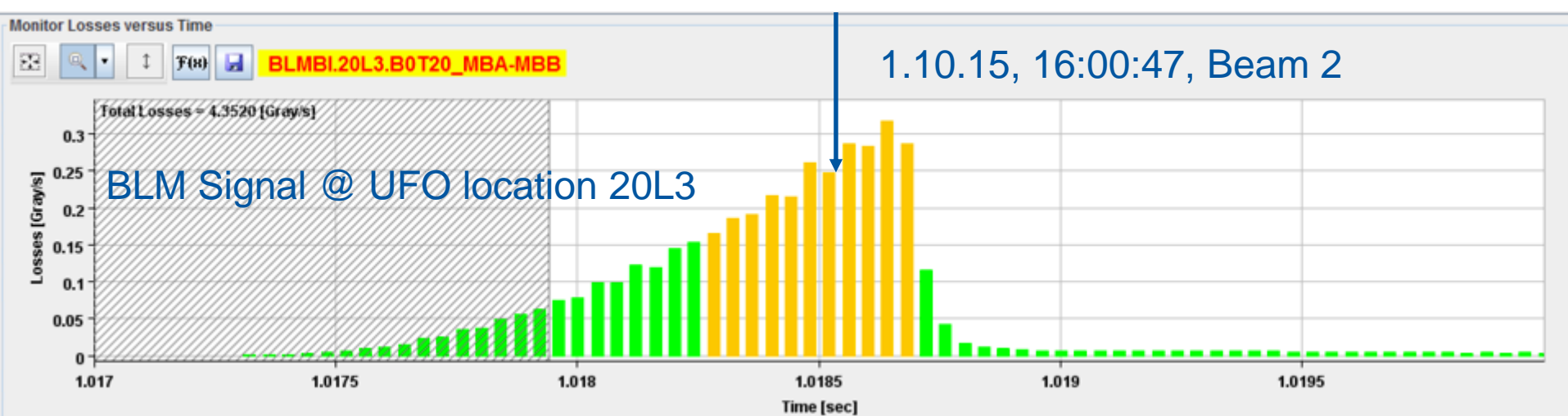


Relatively slow voltage-rise indicates small quenched volume.

50% Threshold Increase

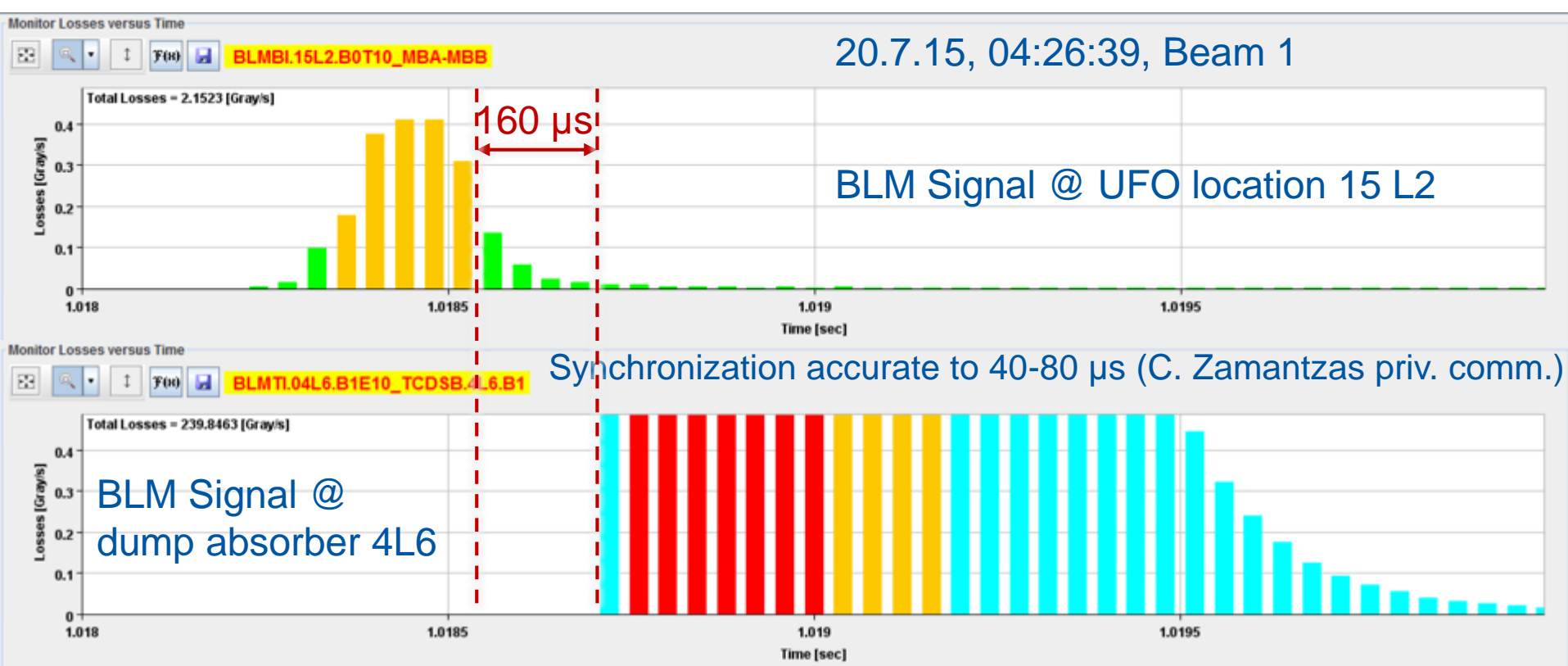
- Thresholds could not prevent 3 quenches.
- Sufficiently lower thresholds would add > 20 unnecessary dumps.

Thresholds reached in RS3



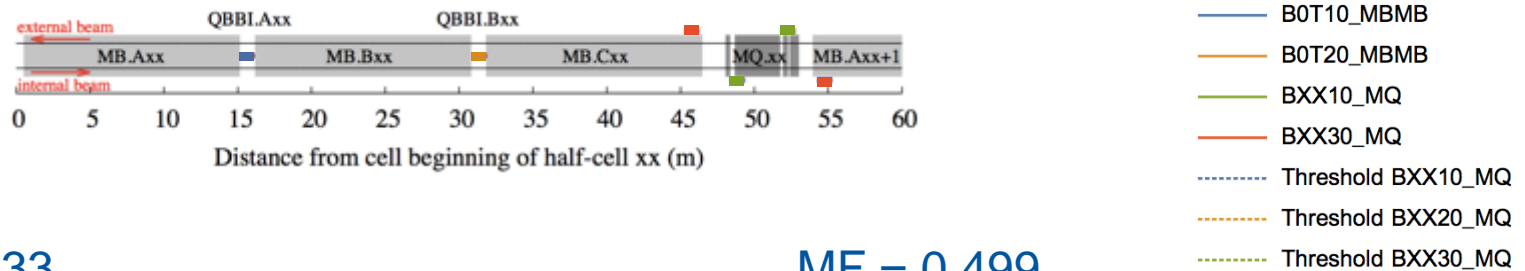
50% Threshold Increase

- 11 Arc/DS dumps without quench, 1 might have avoided a quench.
- Given ~3h lost physics for dump and >8h for quench (see A. Apollonio), **elimination of unnecessary dumps has priority.**
- Thresholds were increased by 50% (Monitor Factor) on 14 Oct.



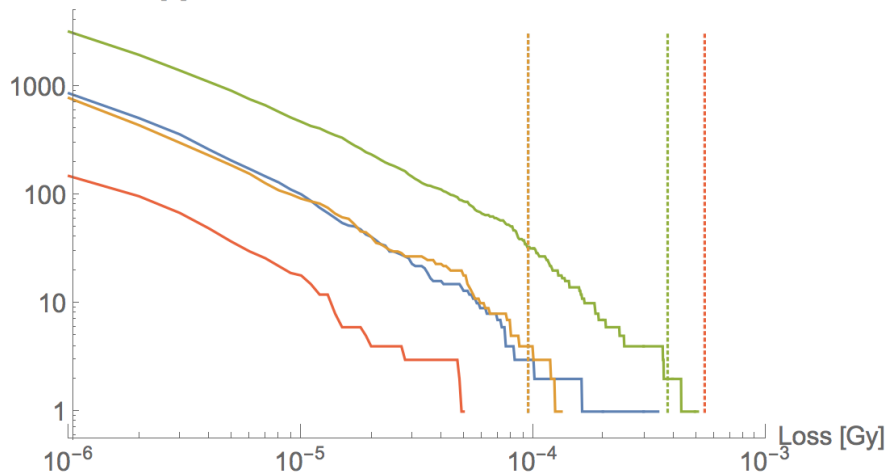
Impact of Threshold Changes

With increased thresholds, most dumps would have been avoided.
In the last 2 pp weeks, one dump was avoided (24h record fill).



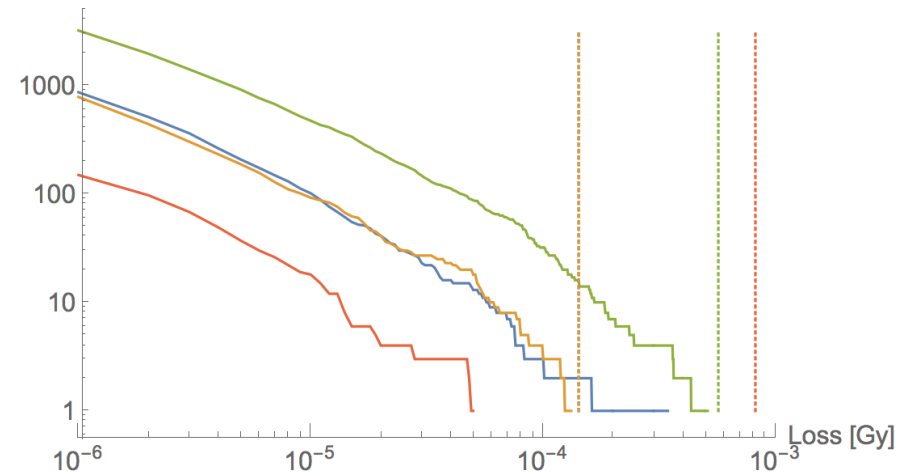
MF = 0.33

N_{UFO} above Loss [1]



MF = 0.499

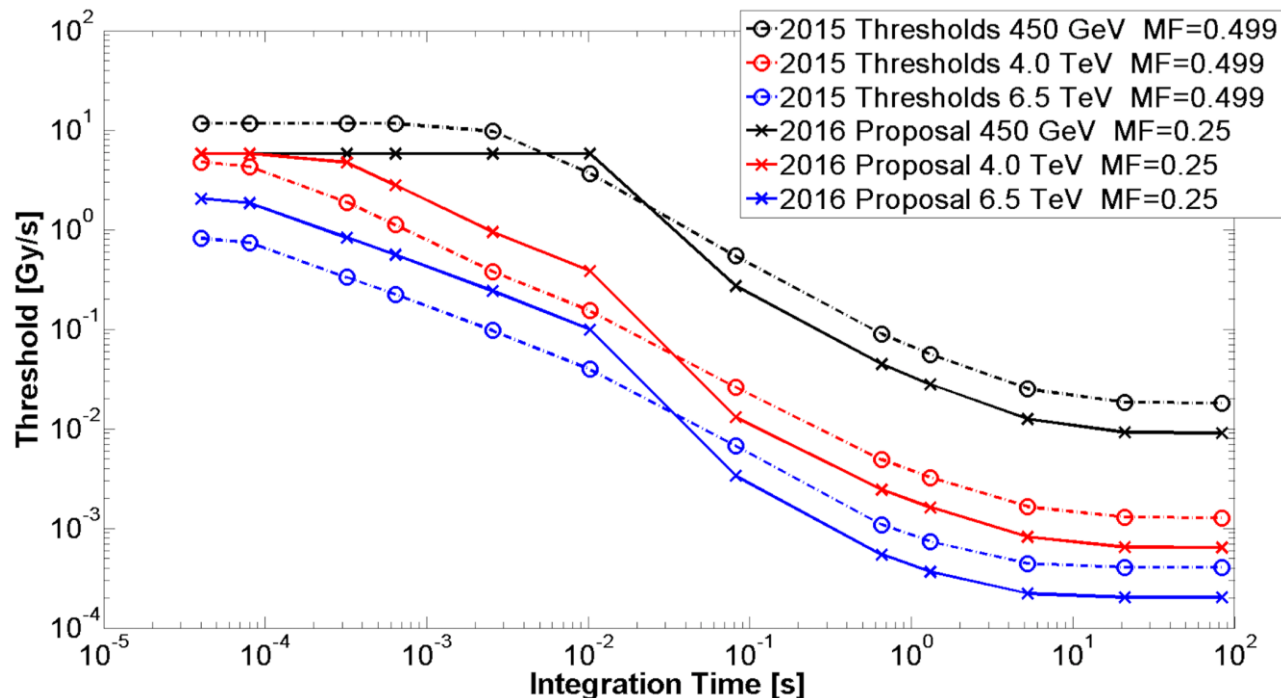
N_{UFO} above Loss [1]



Post-YETS Changes

BLMTWG proposes to

- increase the short Running Sums (RS 1-6) by another factor 2, while reducing the longer Running Sums to conservative values.
 - Monitor factor (MF) from current 0.5 to 0.2.
 - RS 1-6 Master Threshold increase x5.
 - (Possible decrease of long Running Sums in Master Table due to BFPP quench-test result. See Matti Kalliokoski's presentation.)



Post-YETS Changes

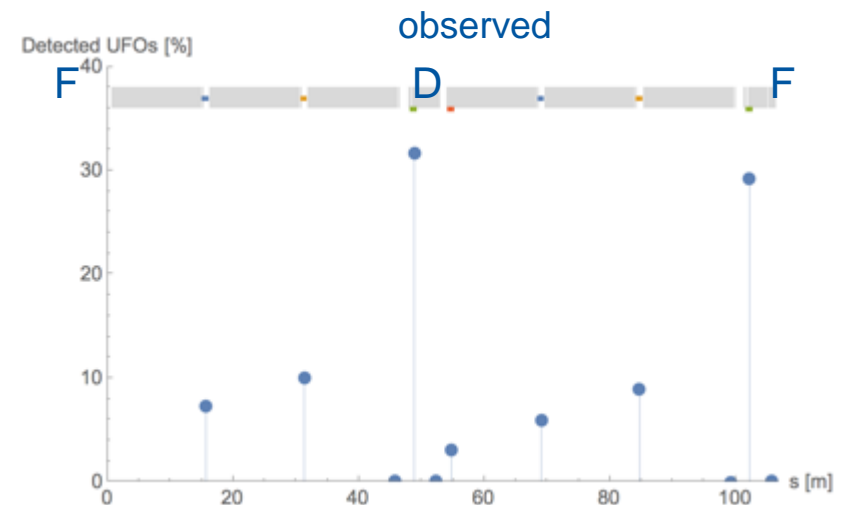
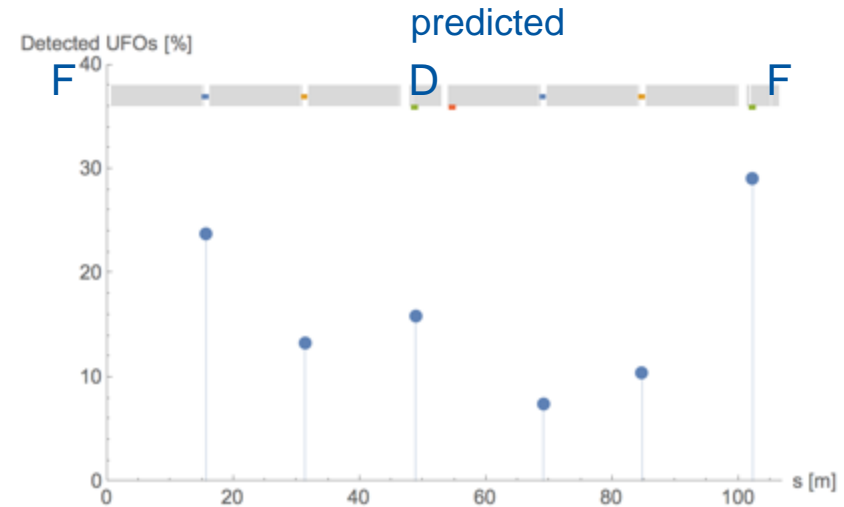
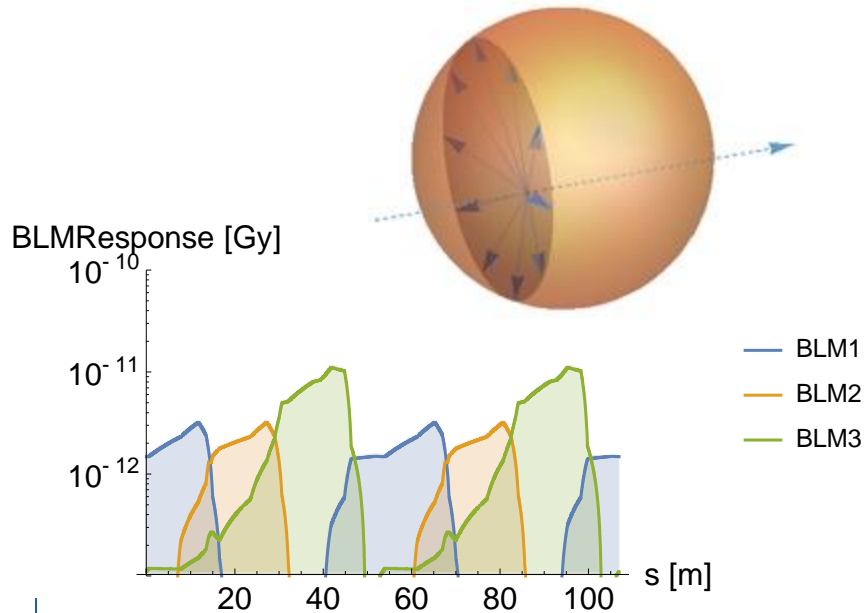
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 - RS 1-6 Master Threshold increase x5.
 - (Possible decrease of long Running Sums in Master Table due to BFPP quench-test result. See Matti Kalliokoski's presentation.)
- use conservative thresholds next to magnets with heater problems.
- keep this setting (or even increase the MF) provided that UFOs cause no more than ~15 quenches per year.
 - 15 quenches is comparable to expected flattop training, much lower in terms of heater firings than spurious QPS triggers (resets, etc.).
 - (post-Evian update: Note: “15 quenches” is not a predicted number, but rather an envelope that shall not be exceeded without renewed discussion and approval.)
- in short: avoid dumping on UFOs all-together as a strategy to maximize availability.

Continued UFO Studies

UFO-Understanding Shortcomings

- Predominance of UFOs registered in quadrupole-BLMs still not explained.
- MD with MKIs indicated negative initial charge of UFOs. (CERN-ATS-Note-2011-065)
- Need to identify release mechanism and initial condition.



UFO Study Team

BE-ABP, BE-OP, EN-STI, TE-MPE, TE-VAC work together.

Goals:

- understand the phenomenology of UFOs
 - BLM signals in strength, duration, multiplicity; physical distribution of recorded UFOs; correlations with beam parameters; conditioning; etc.
- provide predictions for HL-LHC / 7-TeV operation;
- study potential mitigation/prevention strategies

Lines of attack:

- Recall previous work
 - (T. Baer thesis, UFO WG, MDs, UFO model, collected dust, etc.)
- UFO buster data (timing data, lower energy data, LSS, etc.)
- Dust literature
- Experimental setup
- Improved numerical model
- Parasitic studies in operation (e.g., defender bunches)

Conclusion

- Conditioning in early October has reduced the threat to availability.
- Initial UFO rates may increase after YETS.
- We propose to further increase BLM thresholds x2 in UFO running sums to maximize availability.
- This strategy will be reviewed with 2016 experience.
- No major threat from UFOs to availability is expected for Run 2.
- The further evolution of the UFO rate remains unknown.
- We shall continue to push for improved understanding of the UFO phenomenology.

How to survive a UFO attack?

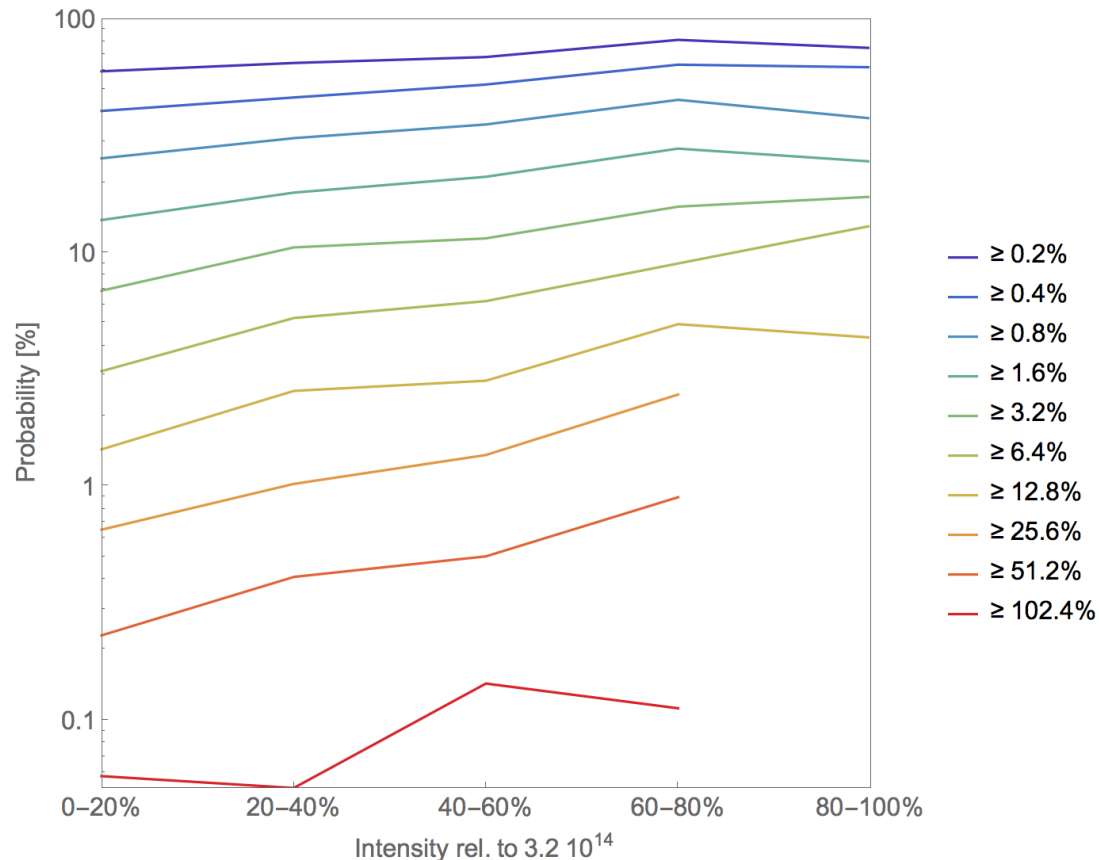
- The UFO model involves
 - $\sim 10^{-7}$ mJ/(cm³, iel coll.) energy deposit per inelastic collision,
 - $\sim 10^9$ iel coll. / s rate of inelastic collisions,
 - ~ 10 mJ/cm³ quench level, 4x of initially expected, and
 - a UFO rate reduction of 1/3 by conditioning,
- which decide whether we can operate at nominal intensity at 6.5 TeV.
- Small changes could have a major impact.
- *Luck seems to be a factor* when it comes to surviving a UFO attack.



Extra Slides

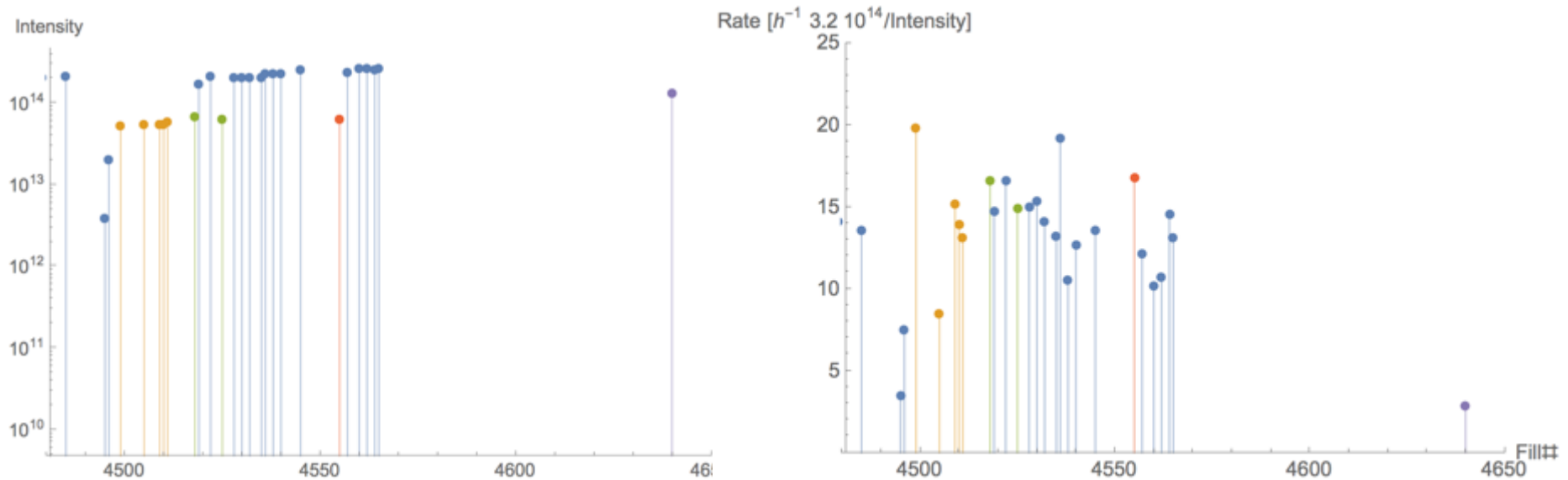
BLM Signal vs. Intensity

- Probability to reach percentage of BLM-Signal@Quench (threshold up to 14 Oct.) as function of beam intensity.
- Plot shows correlation with intensity, irrespective of the UFO rate.



2.51 TeV Run

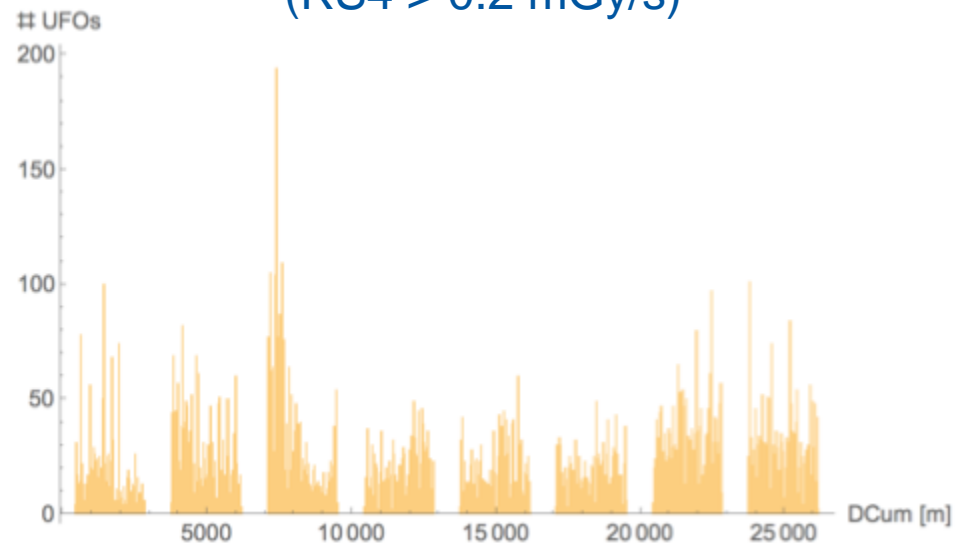
- Very few (8) registered UFOs during reference run.



Location Around the Ring

The peak in Sector 34 disappears for larger UFOs.

All recorded UFOs
(RS4 > 0.2 mGy/s)



UFOs with RS4 > 10 mGy/s

