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Update on UFOs

Tobias Bär

MPP

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Acknowledgements: E. B. Holzer, S. Jackson, M. Misiowiec, E. Nebot, A. Nordt, J. Wenninger, C. Zamantzas

Content

1. UFO Detection and Data Processing
2. Observations
3. Outlook and Summary

Content

UFOs in 2011

- UFO Buster detects UFOs online in 1Hz concentrator data.

  *Losses (RS 4) of **two BLMs in 40m** are above **1E-4 Gy/s.***

  RS 2 / RS 1 > 0.55 (UFO average : 0.89).

  RS 3 / RS 2 > 0.45 (UFO average: 0.79).

- **Over 4000 triggers** by the UFO Buster so far.
  - From subset of 230 manually verified triggers:

    About 70% are UFOs, 10% ambiguous cases, 20% are false triggers.

  - For most analysis additional cut. E.g.:

    Only flat top UFOs, loss of UFO BLM (RS05) > $5{\cdot}10^{-4}$ Gy/s (≈ 5 ‰ of threshold).

    53 events remain of subset, of which 51 are clear UFOs (96%) and 2 are ambiguous cases.

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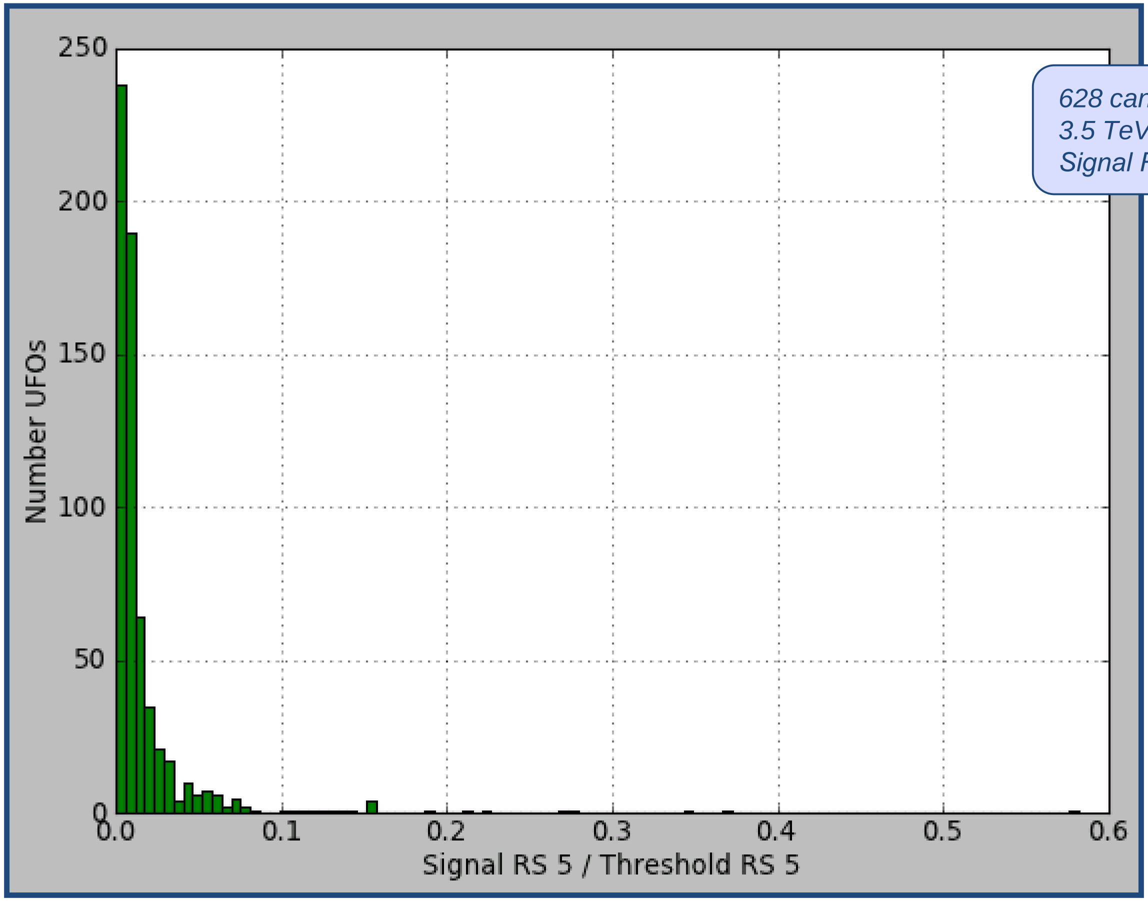
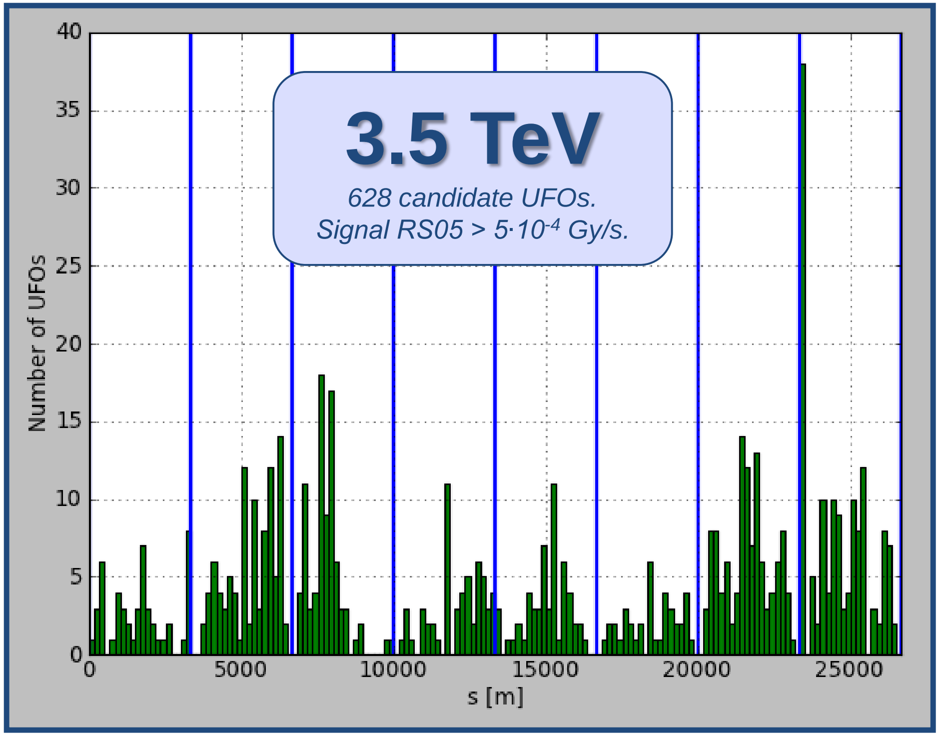
UFOs Below Threshold

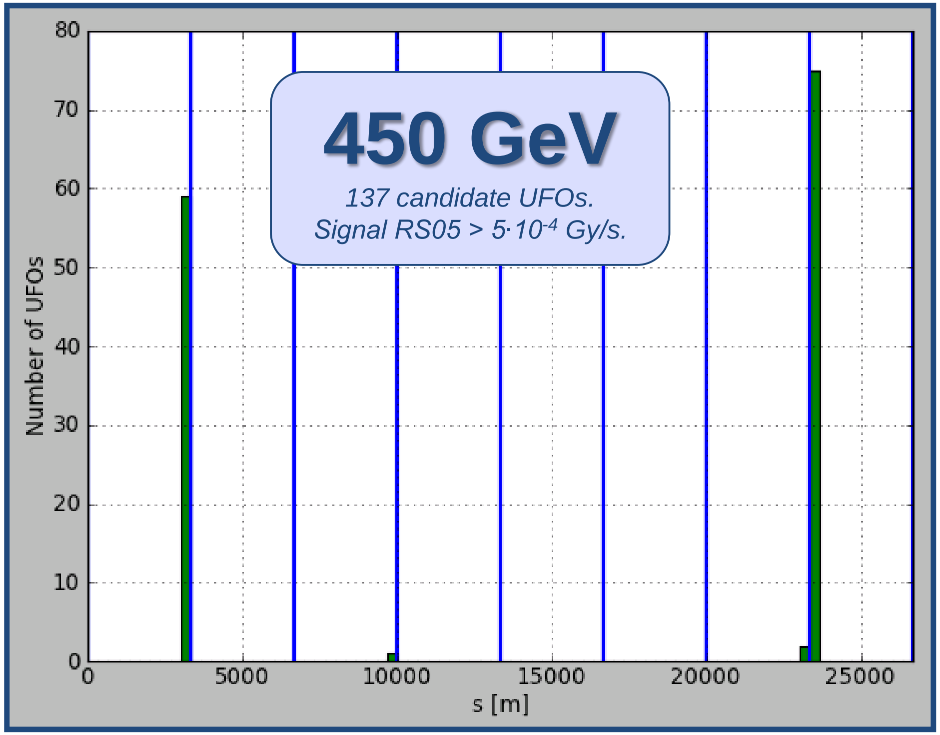


628 candidate UFOs at 3.5 TeV.
Signal RS05 > $5 \cdot 10^{-4}$ Gy/s.

Most UFOs are much below threshold.

Spatial UFO Distribution



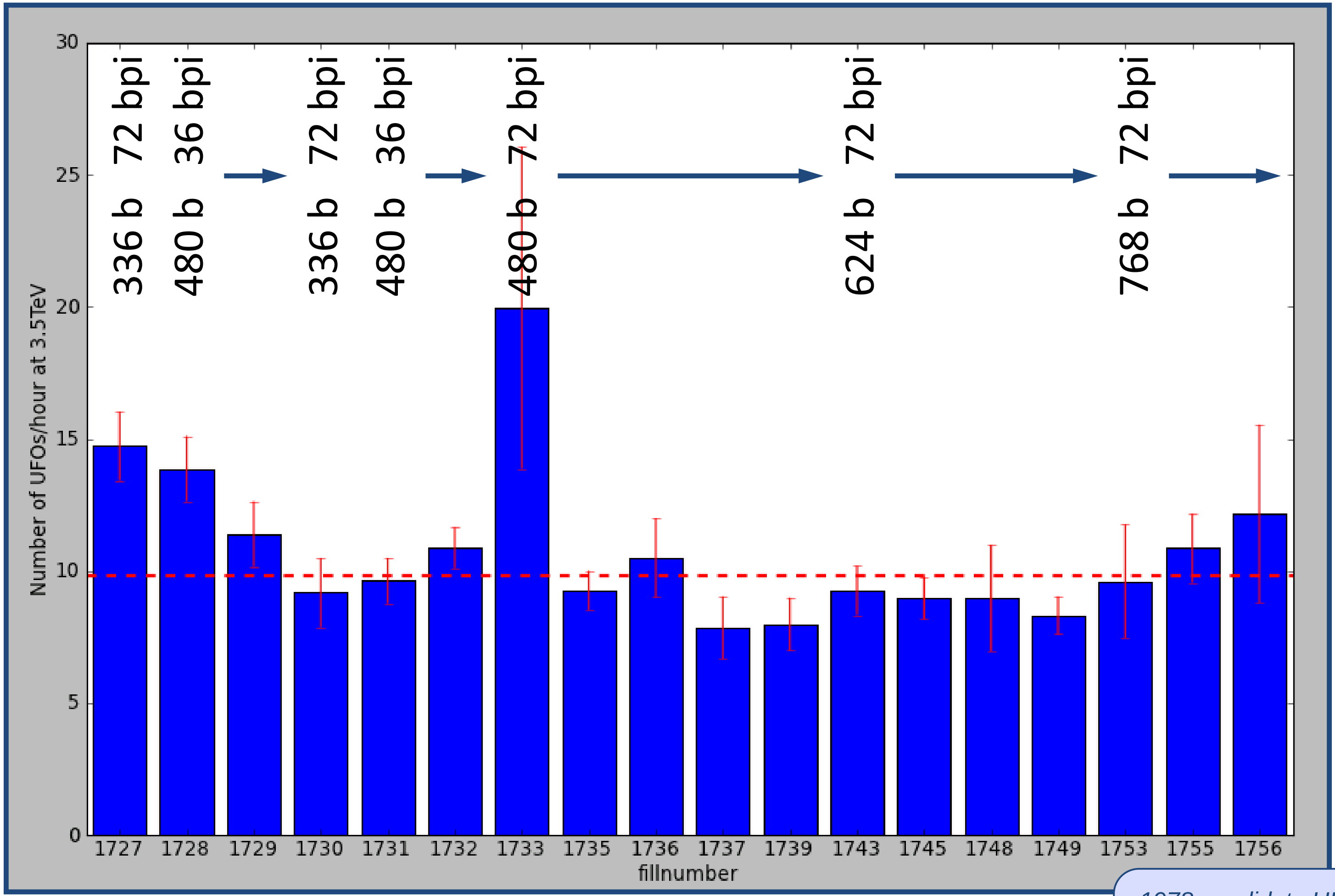


The UFOs are distributed all around the machine.

38 candidate UFOs at MKI for Beam 2.

Mainly UFOs at MKIs

UFO rate



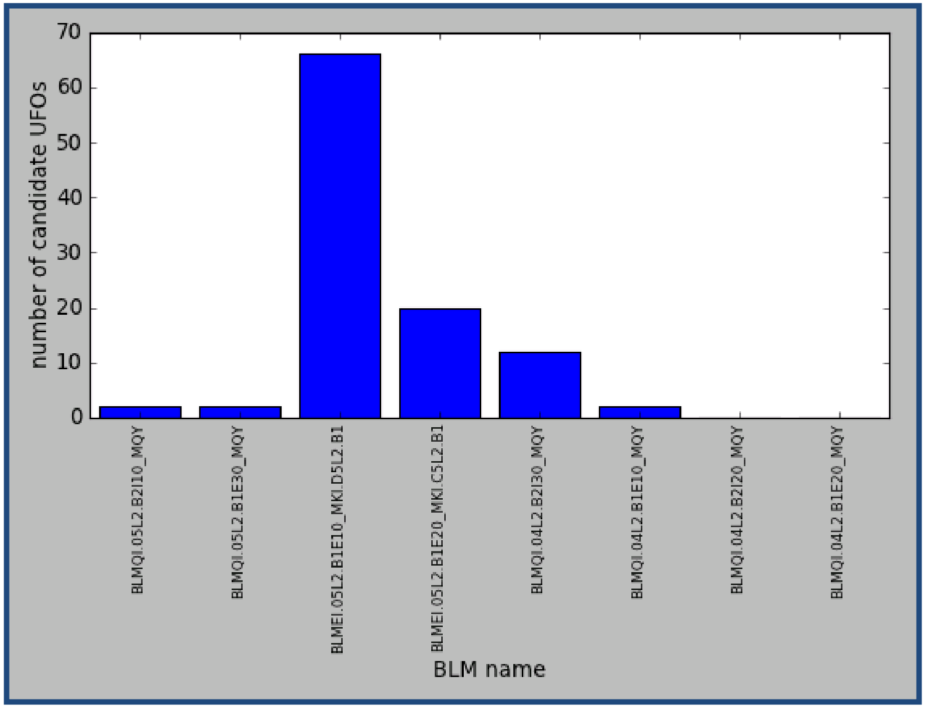
On average: **10 UFOs/hour**

1978 candidate UFOs at 3.5 TeV. Data scaled with 0.7669 (detection efficiency from reference data)

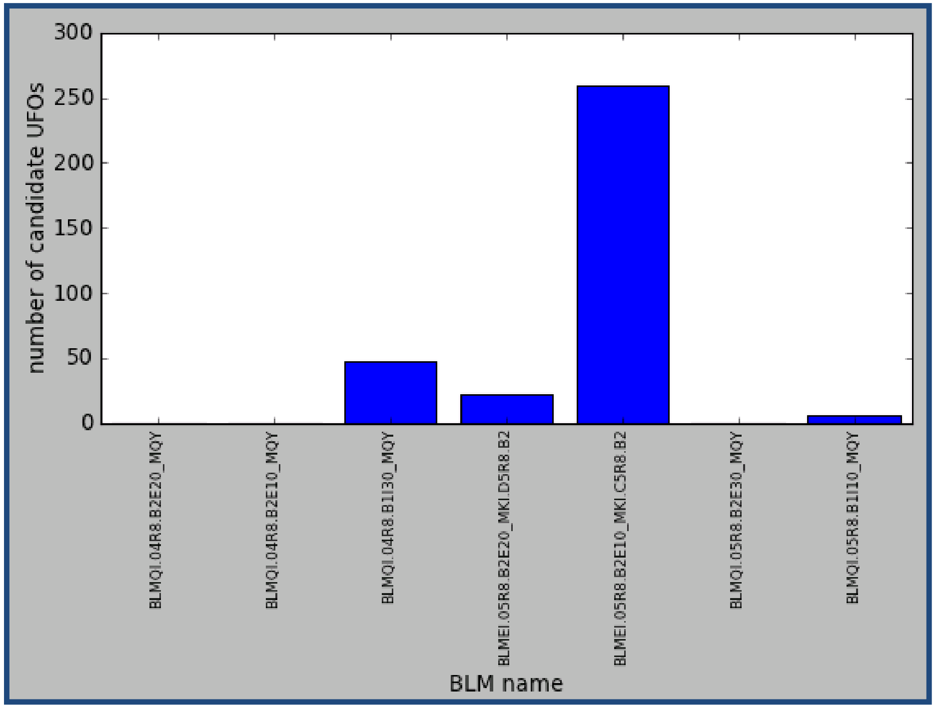
UFOs at MKIs

- Since 08.04.2011 in total **460** fast loss events around MKIs. (**104** around MKI in IP2, **336** around MKI in IP8).

Distribution of first BLM which sees the loss:

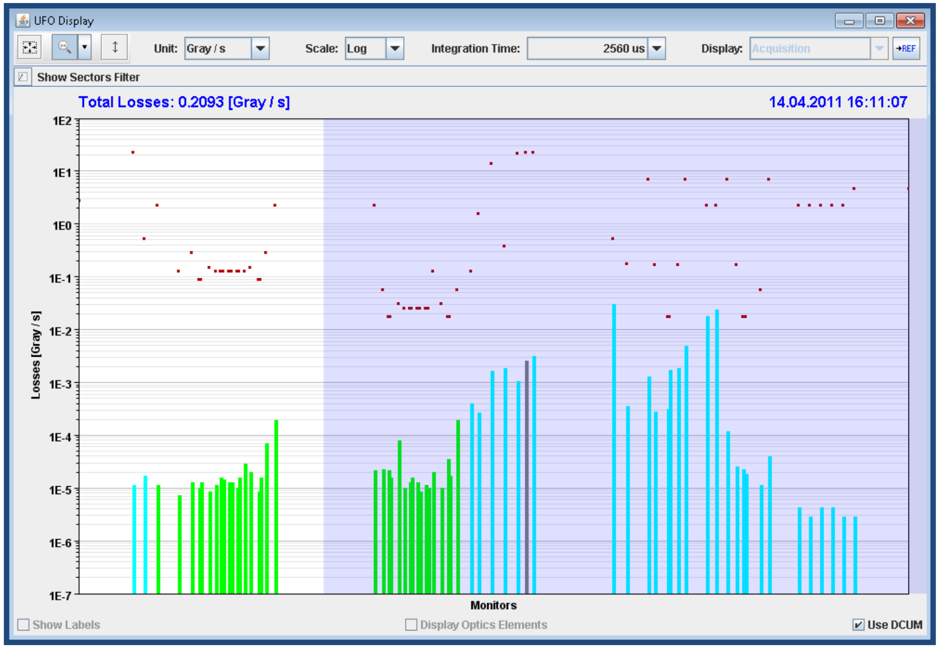


Left of IP2

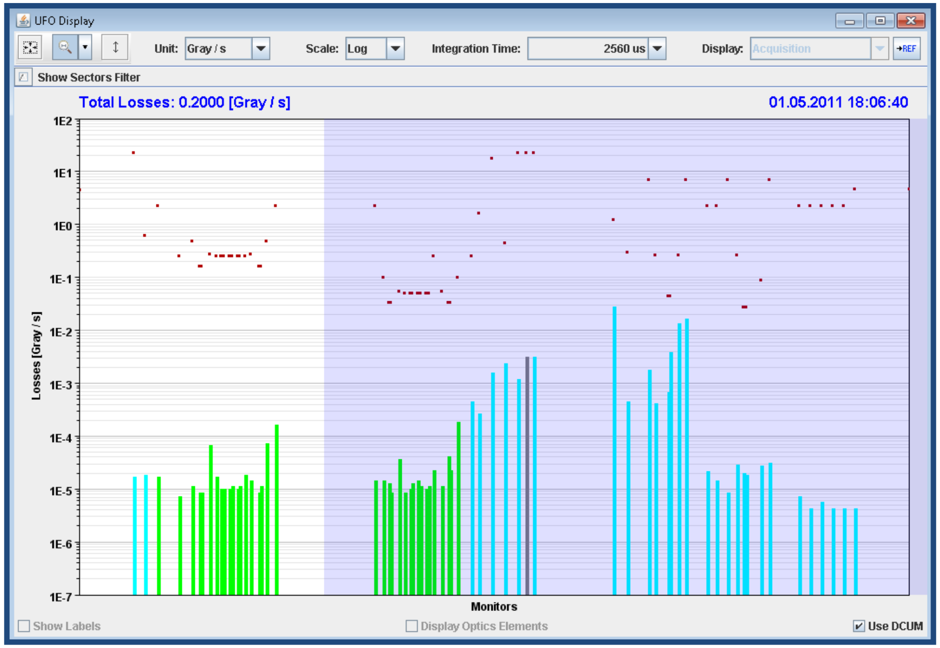


Right of IP8

Example: UFOs at MKI R8

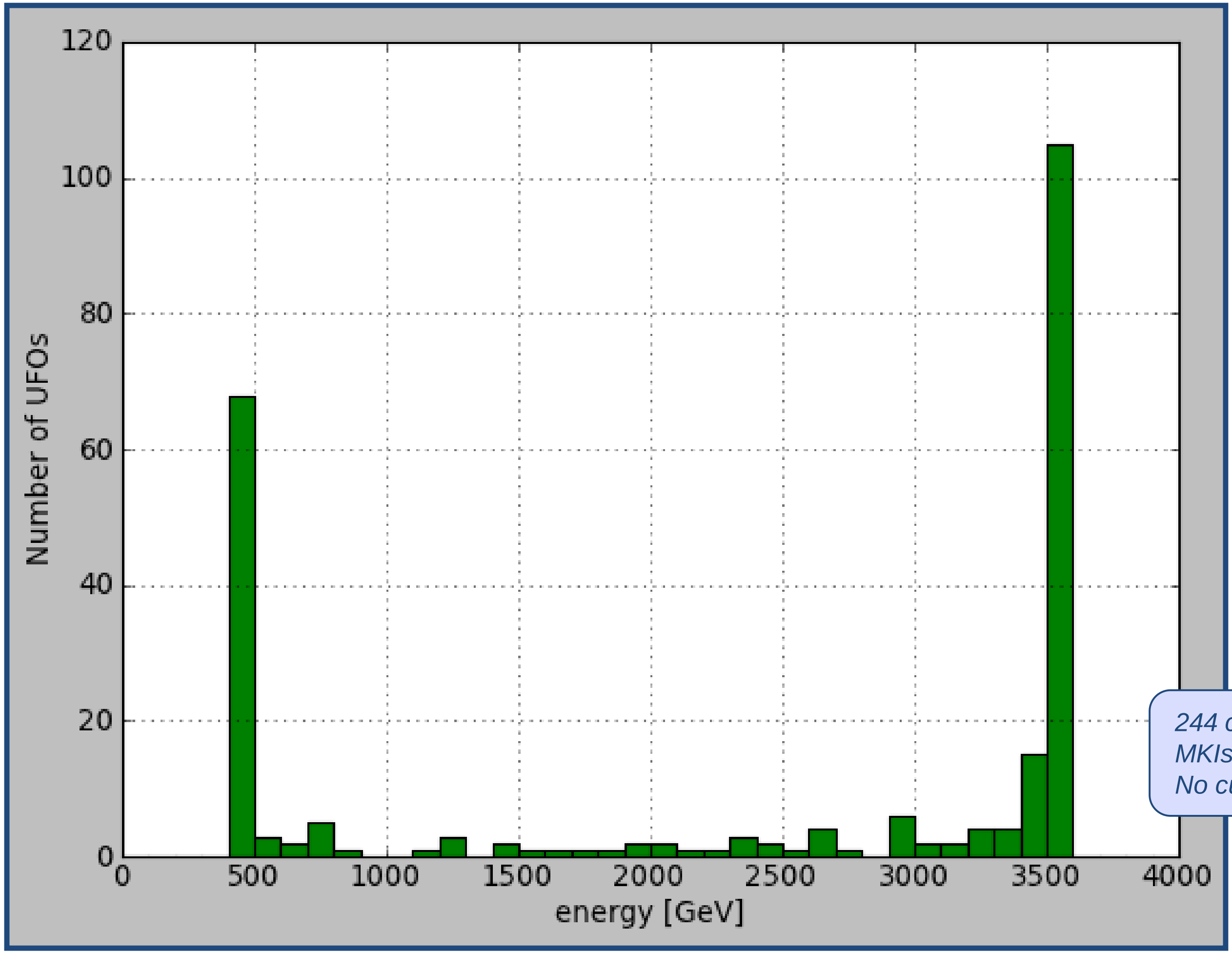


UFO at 2352 GeV, 228 bunches. Loss starts at BLMEI.05R8.B2E10_MKI.C5R8.B2.



UFO at 1424 GeV, 768 bunches. Loss starts at BLMQI.04R8.B1I30_MQY.

Energy Distribution of MKI UFOs

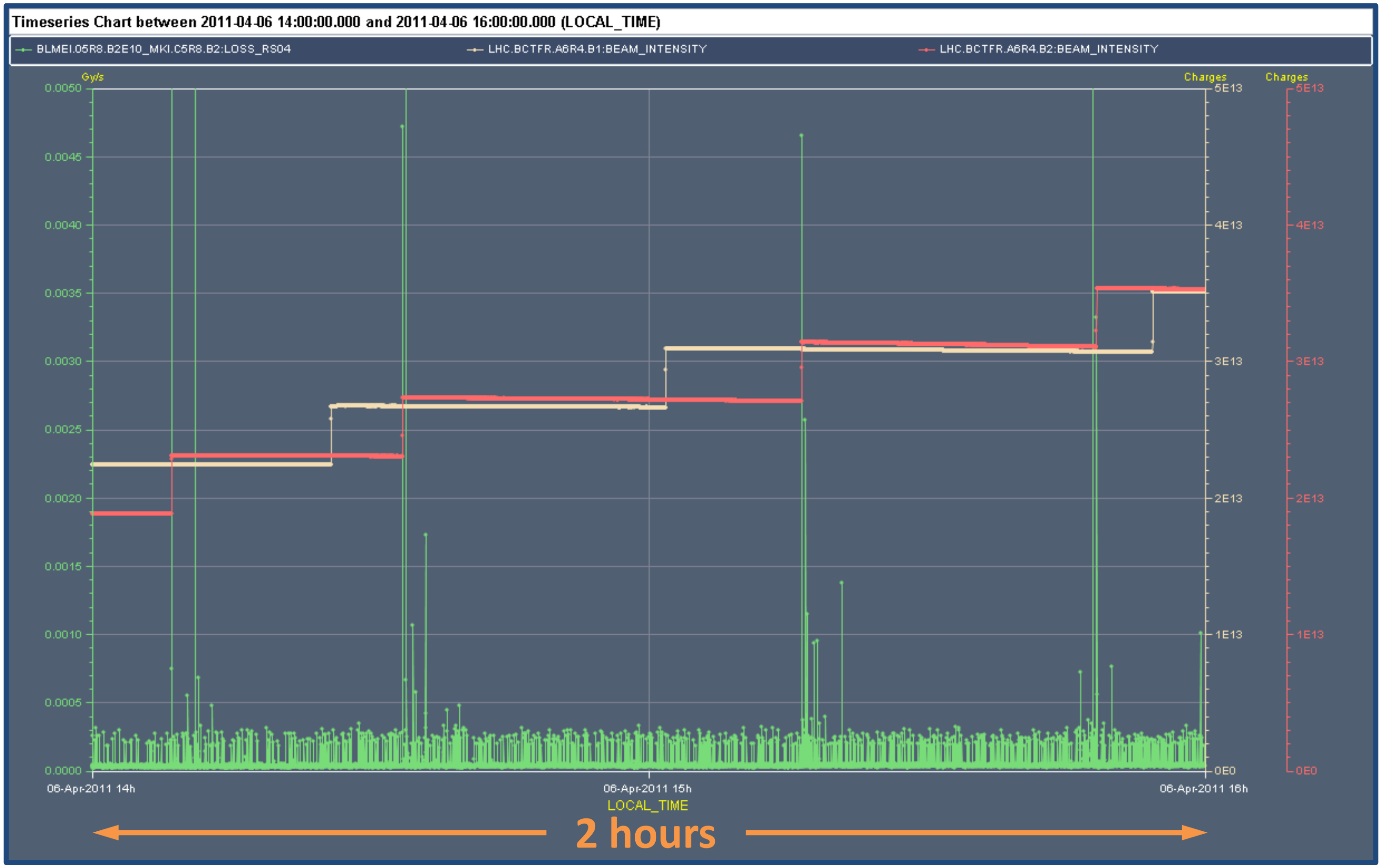


244 candidate UFOs at MKIs after scrubbing run. No cuts.

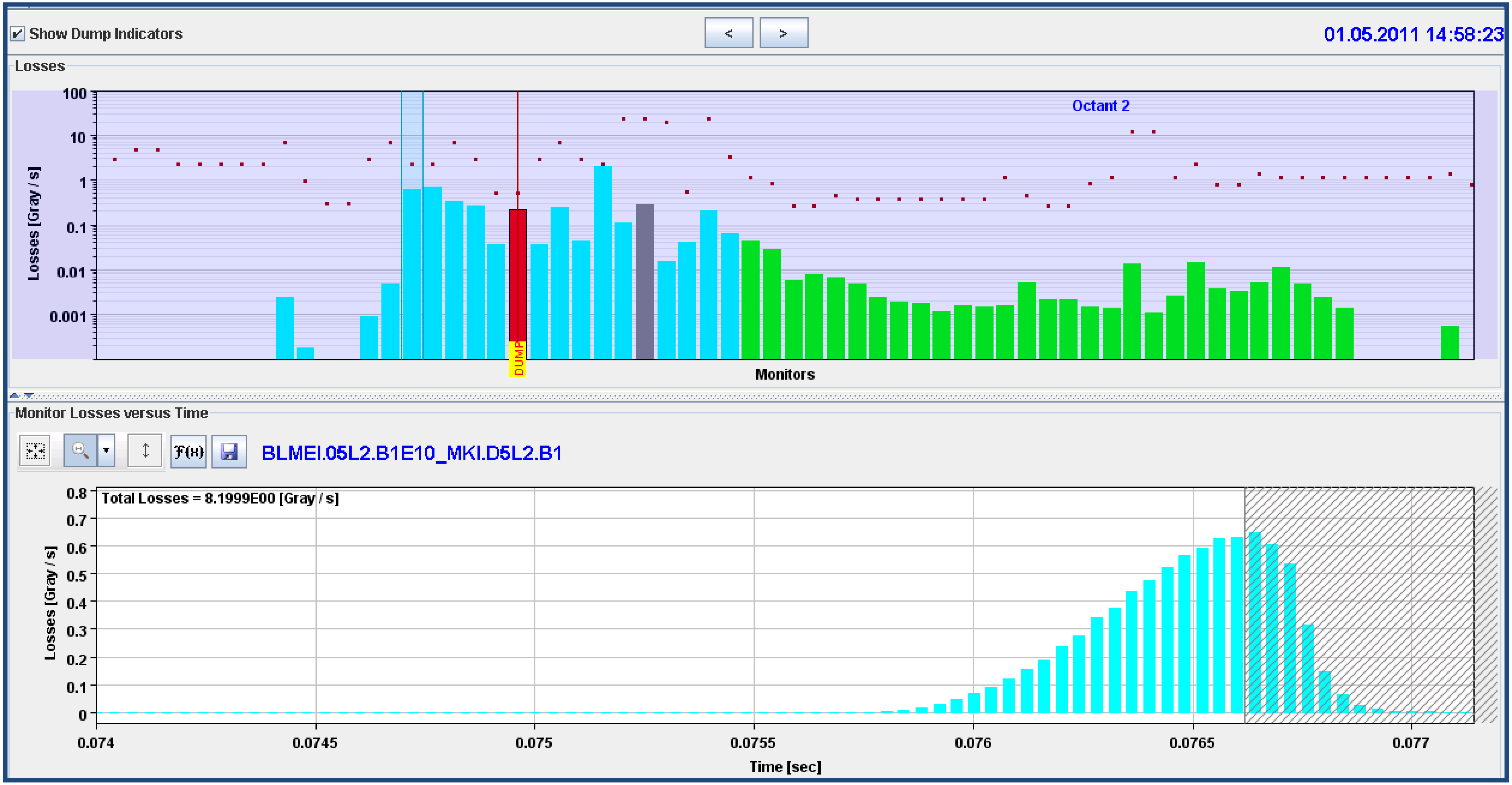
Many events at 450 GeV.

MKI UFOs During Scrubbing

- Typical scenario for MKI UFOs during scrubbing: Loss spikes occur in first few minutes after an injection and go away then.



Dump on 01.05.2011



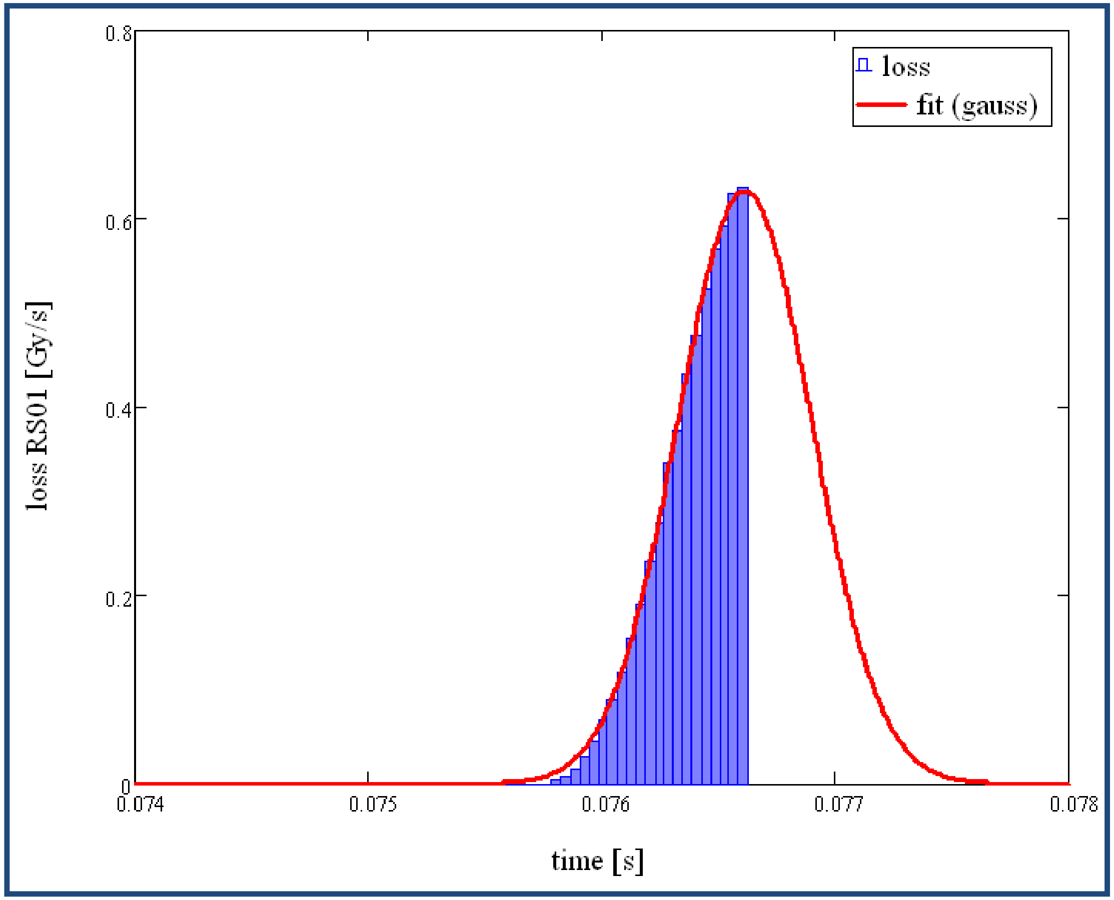
Dump of BLMQI.04L2.B1E20_MQY on RS 3, 4 and 5

Dump on 01.05.2011

- From fit of PM data
  (BLMEI.05L2.B1E10_MKI.D5L2.B1):

  Amplitude: 0.63 Gy/s

  Width: 0.29 ms



Dump by ALICE on 14.04.2011

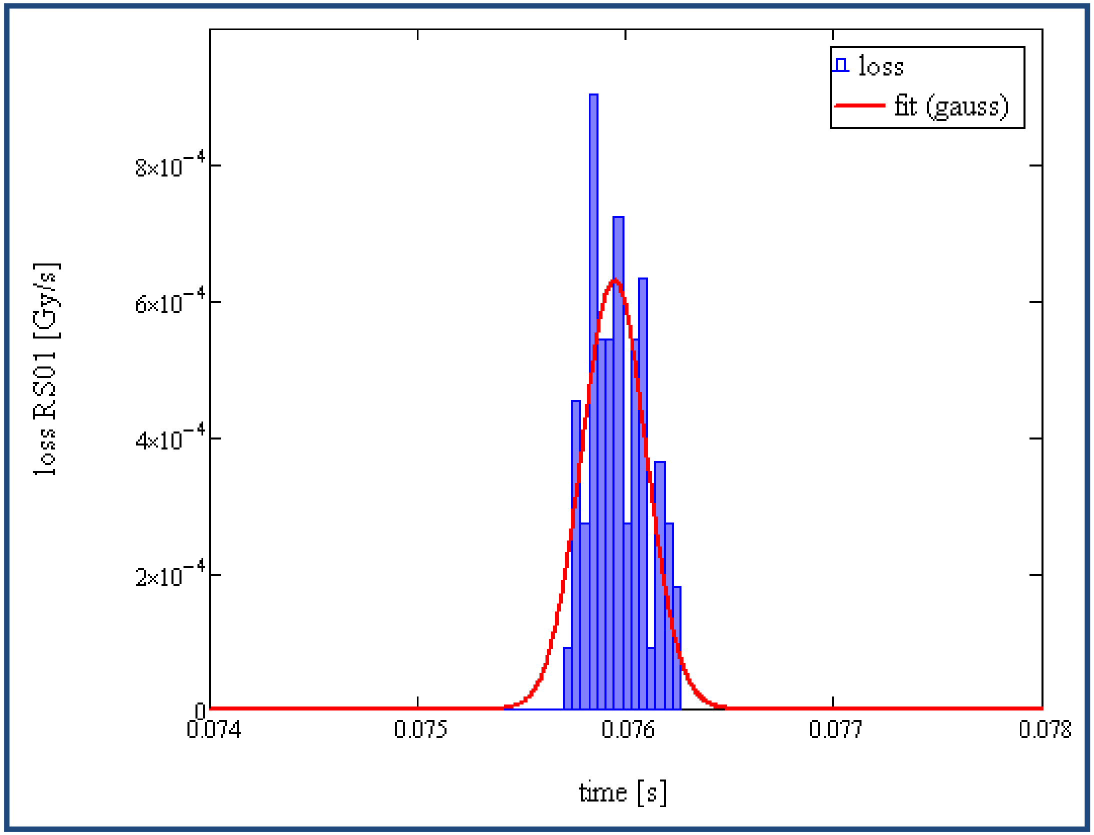
Could be a UFino

Dump by ALICE on 14.04.2011

- From fit of PM data
  (BLMEI.01L2.B1I10_MBWMD):

  Amplitude: $6.3 \cdot 10^{-4}$ Gy/s

  Width: 0.16 ms



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Next Steps

- Trigger acquisition of turn-by-turn data.

  UFO Buster kernel integrated in BLM Concentrator.

  Successful test during technical stop.

- Better localization of MKI UFOs

  Simulations (Yngve – BDSIM)

  Additional BLMs

Summary

- **About 3000 candidate UFOs** in 2011 so far.
  2 UFOs were dumping the beam.
  Most events at 3.5 TeV.

- UFO rate in last weeks constant.
  10 UFOs/hour at 3.5 TeV.

- Many UFOs at MKIs.

- Next step: improve the diagnostics
  UFO Buffer with 80μs BLM data.
  Additional BLMs at MKIs.

Thank you

for your Attention

Tobias Baer
CERN BE/OP
Tobias.Baer@cern.ch
Office: +41 22 76 75379

Further information:

- E.B. Holzer, “Losses away from collimators: statistics and extrapolation”, LHC Beam Operation Workshop, Evian, December 2010.
- T. Baer, “LHC Machine Protection and UFOs”, DPG Spring Meeting, Karlsruhe, March 2011.
- J. Wenninger, “Analysis attempt of dump UFOs”, LHC Machine Protection Panel, Geneva, March 2011.

Backup slides

UFO Detection

- UFO Buster detects UFOs online in 1Hz concentrator data.

1. Losses (RS 4) of at least **two BLMs within 40m** are above ***1E-4 Gy/s*.**

2. A BLM is not taken into account if

   It is a BLMES, BLMCC, BLMDS, BLMDI.

   It is at a TCT or TDI.

   It is in IP3, IP6, IP7 or IP8 (between TCTs).

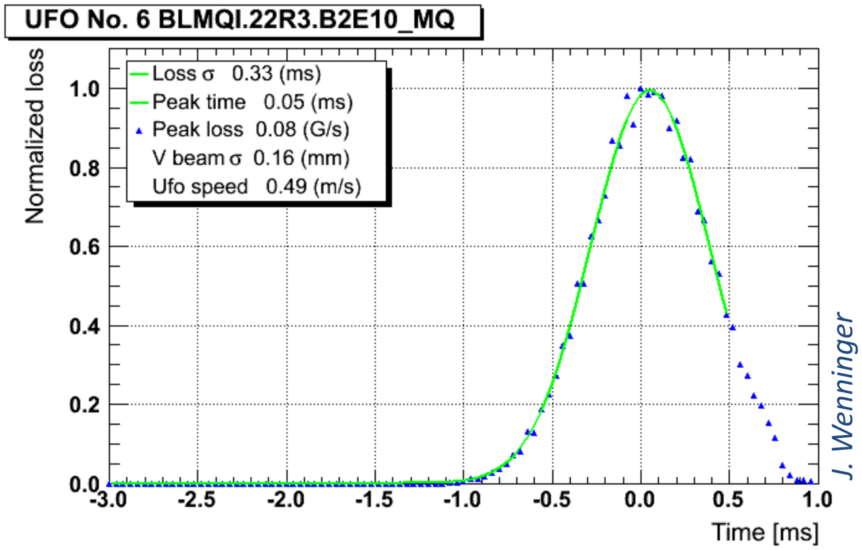
   RS 2 / RS 1 < 0.55 (UFO average: 0.89).

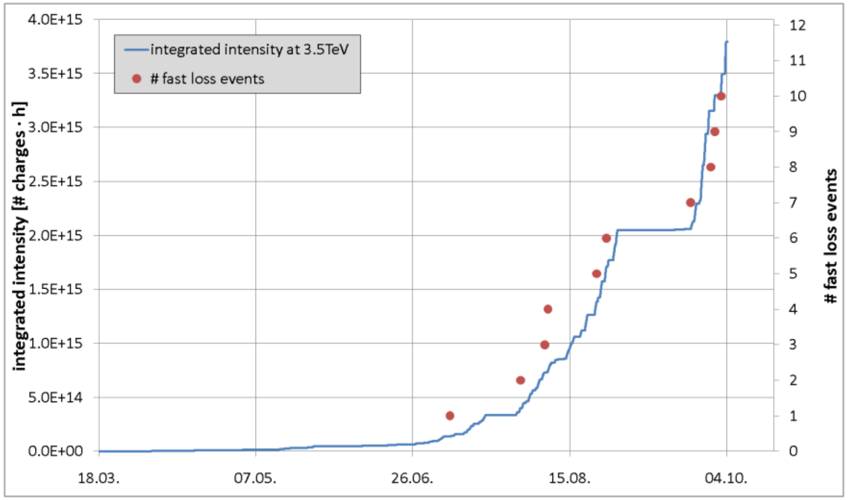
   RS 3 / RS 2 < 0.45 (UFO average: 0.79).

3. The acquisition is skipped for a few seconds after injection warning and beam wire scan timing event.

UFOs in 2010

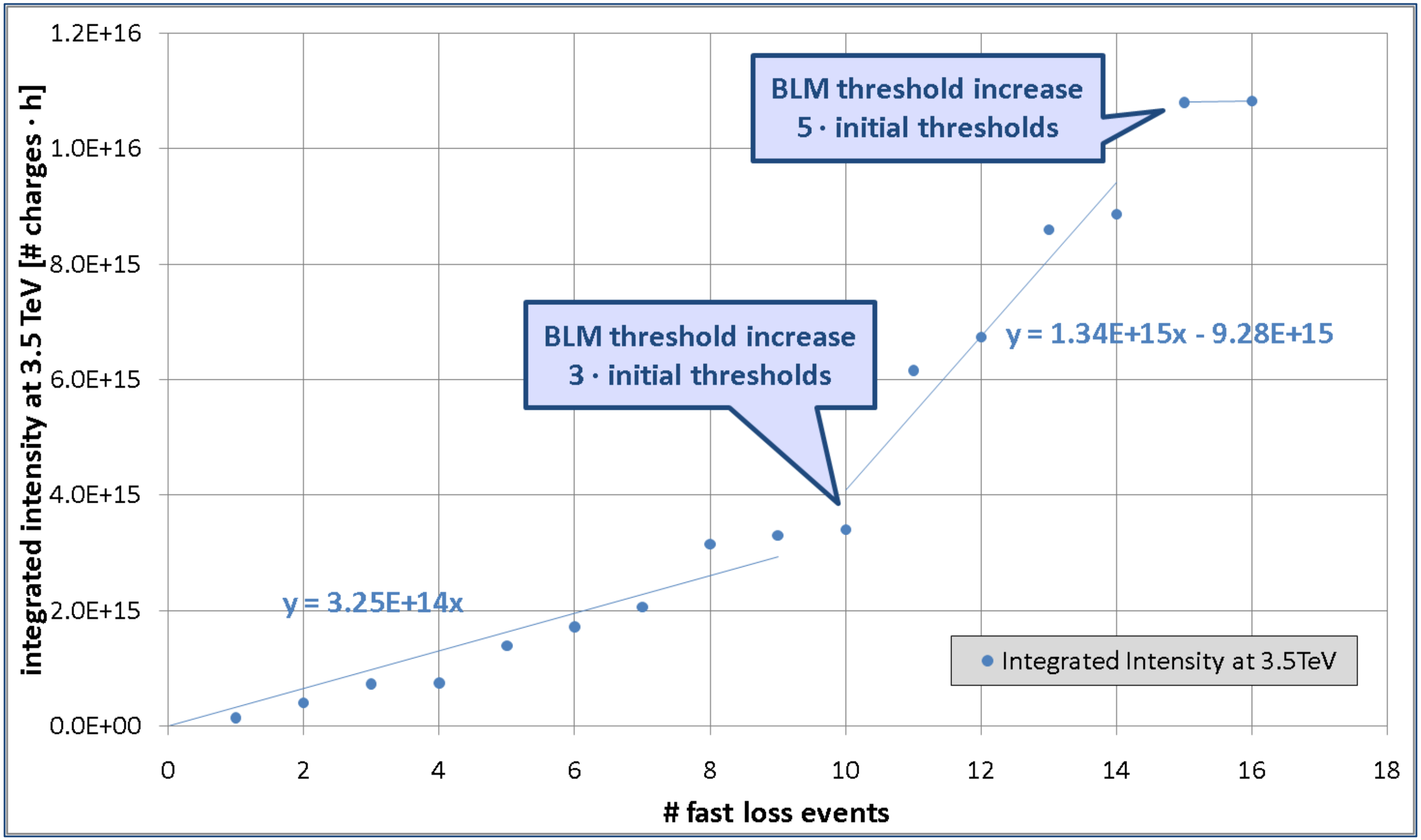
- **18 beam dumps** due to UFOs.
  (since 07.07.2010)
- 113 UFOs below threshold found in logging database. *(E. Nebot)*
  (03.08.2010 - 28.10.2010)
- UFO rate proportional to intensity.
- No dependency of peak signal on intensity. *(cf. E.B. Holzer at Evian Dec. 2010)*
- Loss duration has tendency to become faster with higher intensity. *(cf. E.B. Holzer at Evian Dec. 2010)*





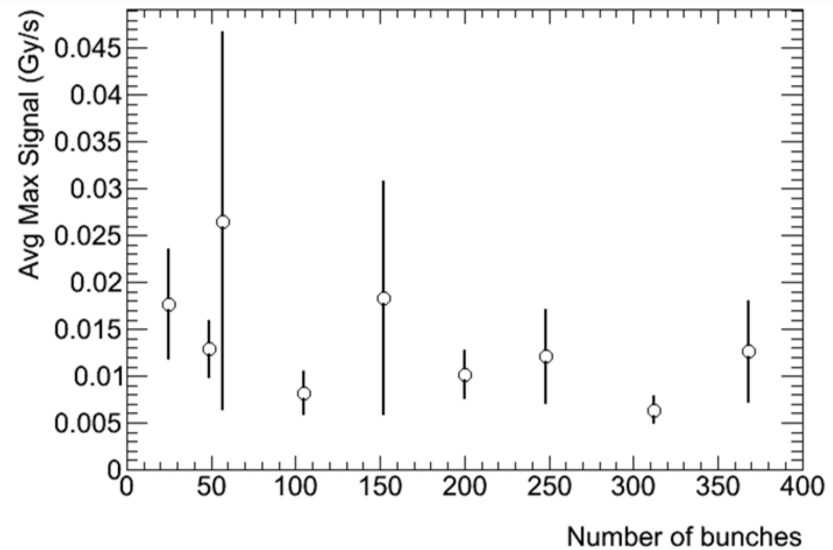
Fast Loss Event Rate

- After the increase of the BLM Threshold by a factor of 3 there were about **4.1 times less beam dumps** due to fast loss events.

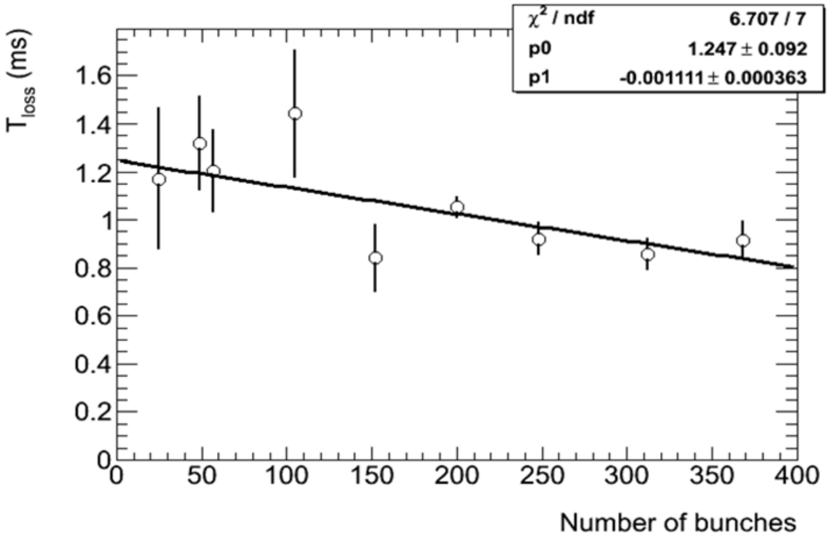


Peak Signal and Loss Duration

- **Average UFO signal**: no clear dependence on intensity

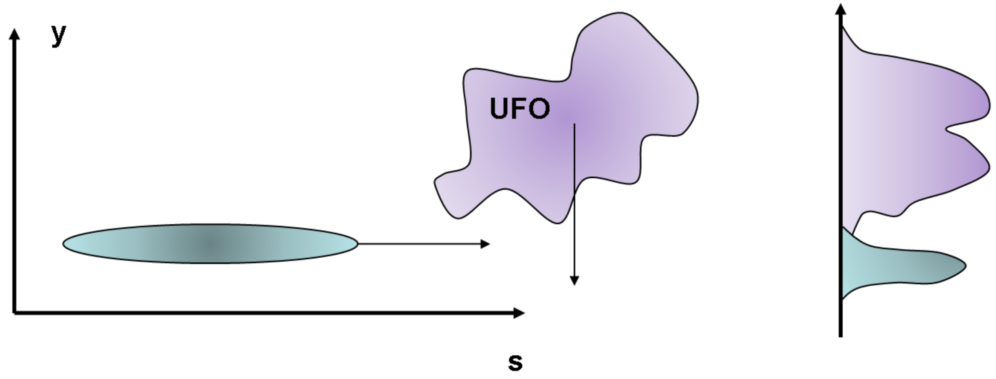


- **Loss duration**: tendency to decrease with intensity



courtesy of
E. B. Holzer and E. Nebot

UFO size



- Two extreme cases:
  - UFO much larger than beam: the beam is imaging the UFO.
  - UFO much smaller than beam: the UFO is imaging the beam.

Most UFO shapes are Gaussian, thus most UFOs are expected to be smaller than the beam.

courtesy of
J. Wenninger
(cf. MPP 25.03.2011)

- From FLUKA simulations: size ≈ 1 µm.

(cf. M. Sapinski, F. Zimmermann at Chamonix 2011)

UFO Speed

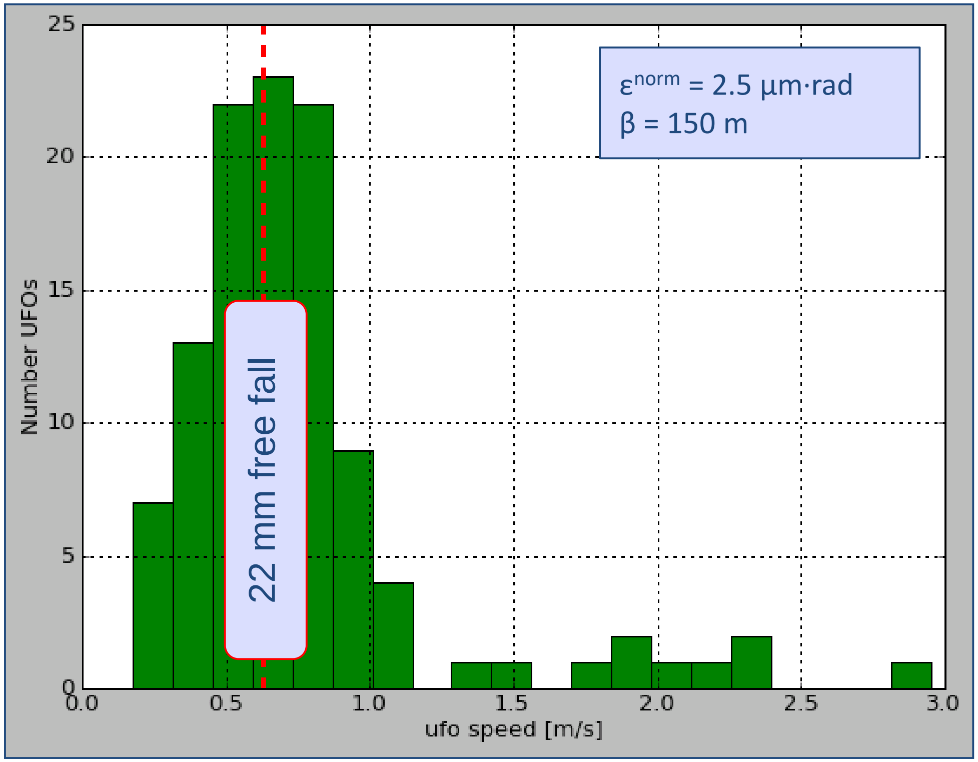
- UFO speed:

$$v_U = \frac{\sqrt{\sigma_b^2 + \sigma_U^2}}{\sigma_T} > \frac{\sigma_b}{\sigma_T}$$

v_u: UFO speed, σ_b: transverse beam size, σ_u: UFO size, σ_T: temporal width of loss.

- From free fall:

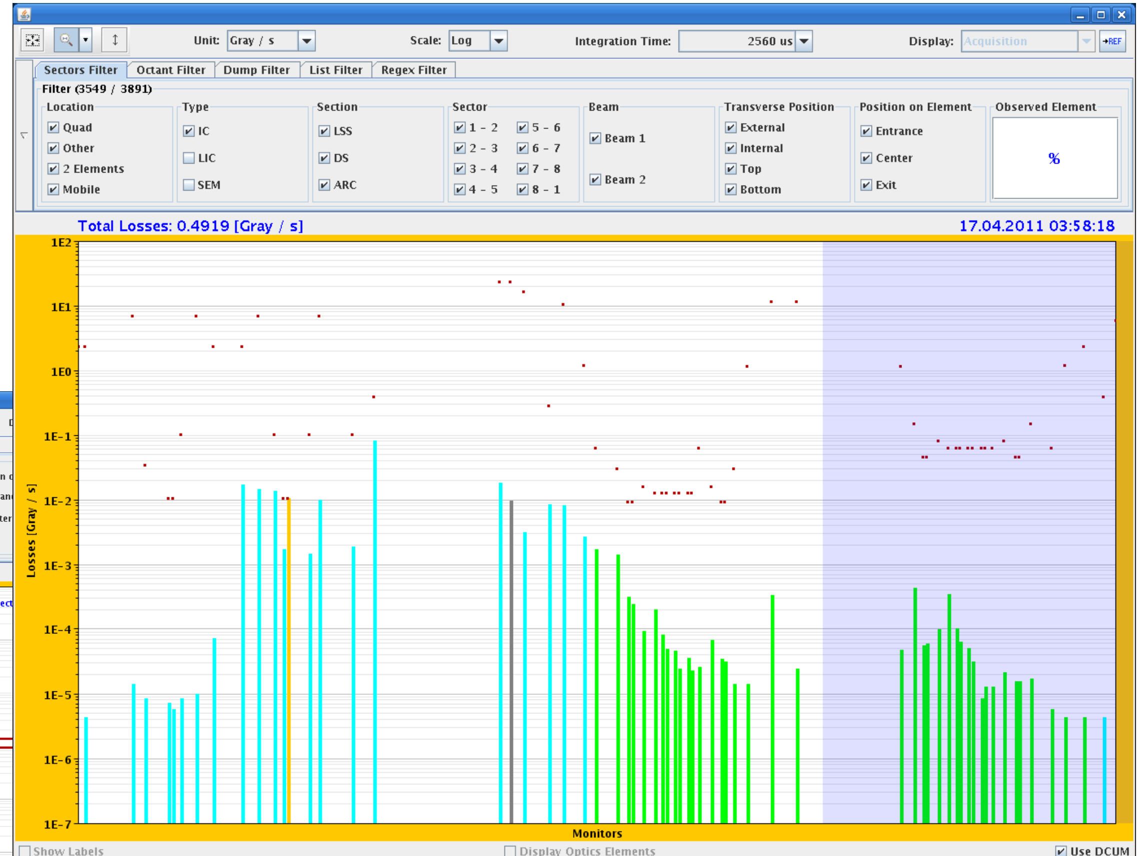
$$v_U = \sqrt{2 \cdot g \cdot h} = 0.63\,\frac{m}{s}$$

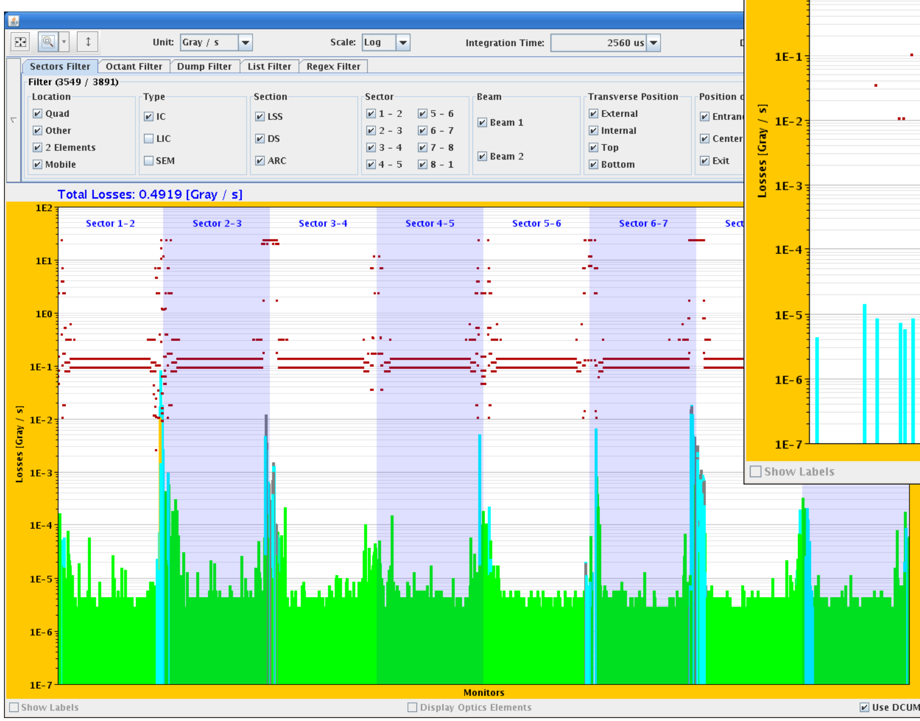


The UFO speed corresponds to the expected speed for a free fall from the aperture.

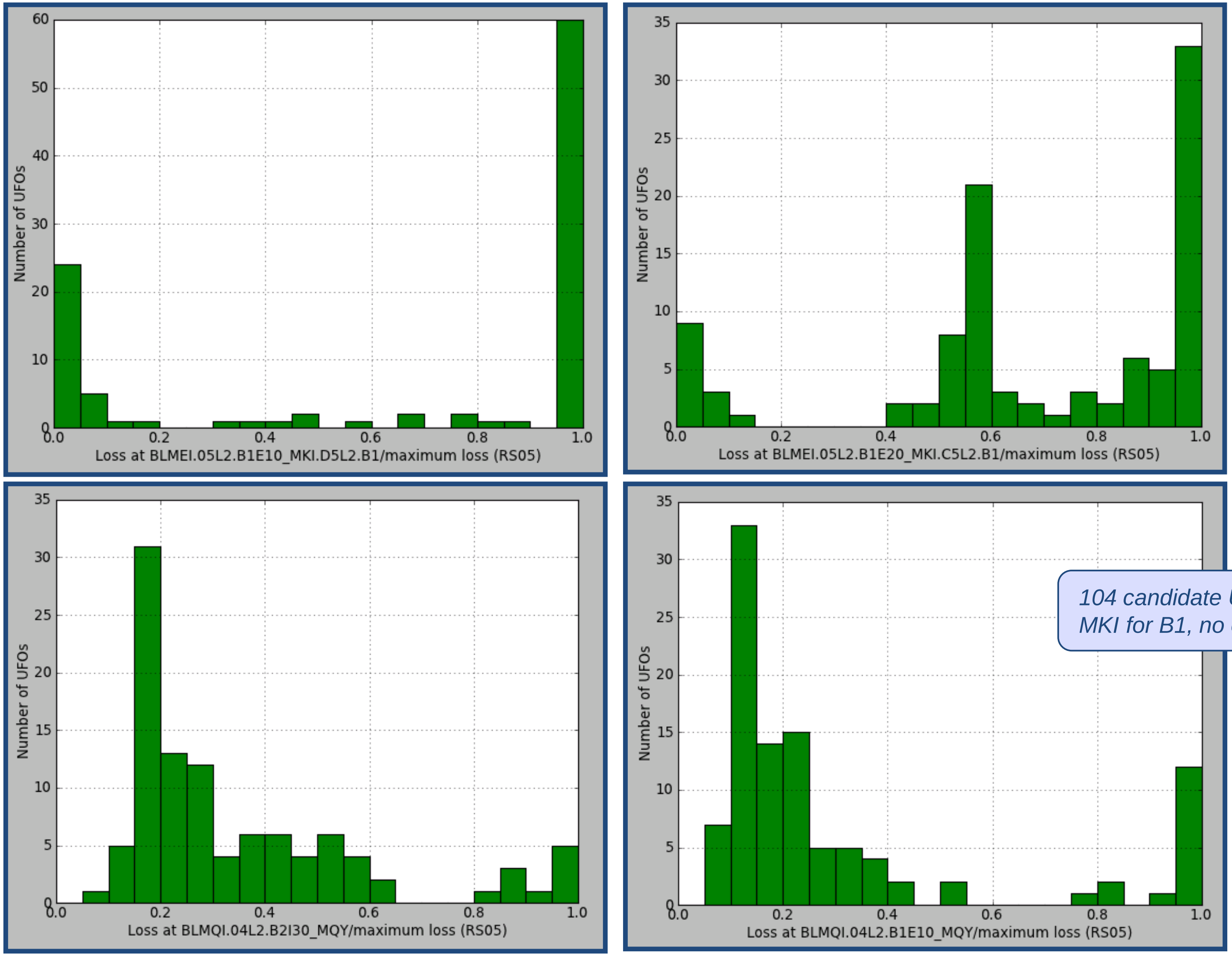
Example: Loss at MKI for B1

- Loss starts at BLMEI.05L2.B1E20_MKI.C5L2.B1
- BLMQI.04L2.B1E20_MQY at **98%** of dump threshold (RS5)
- At 3.5 TeV stable beams.



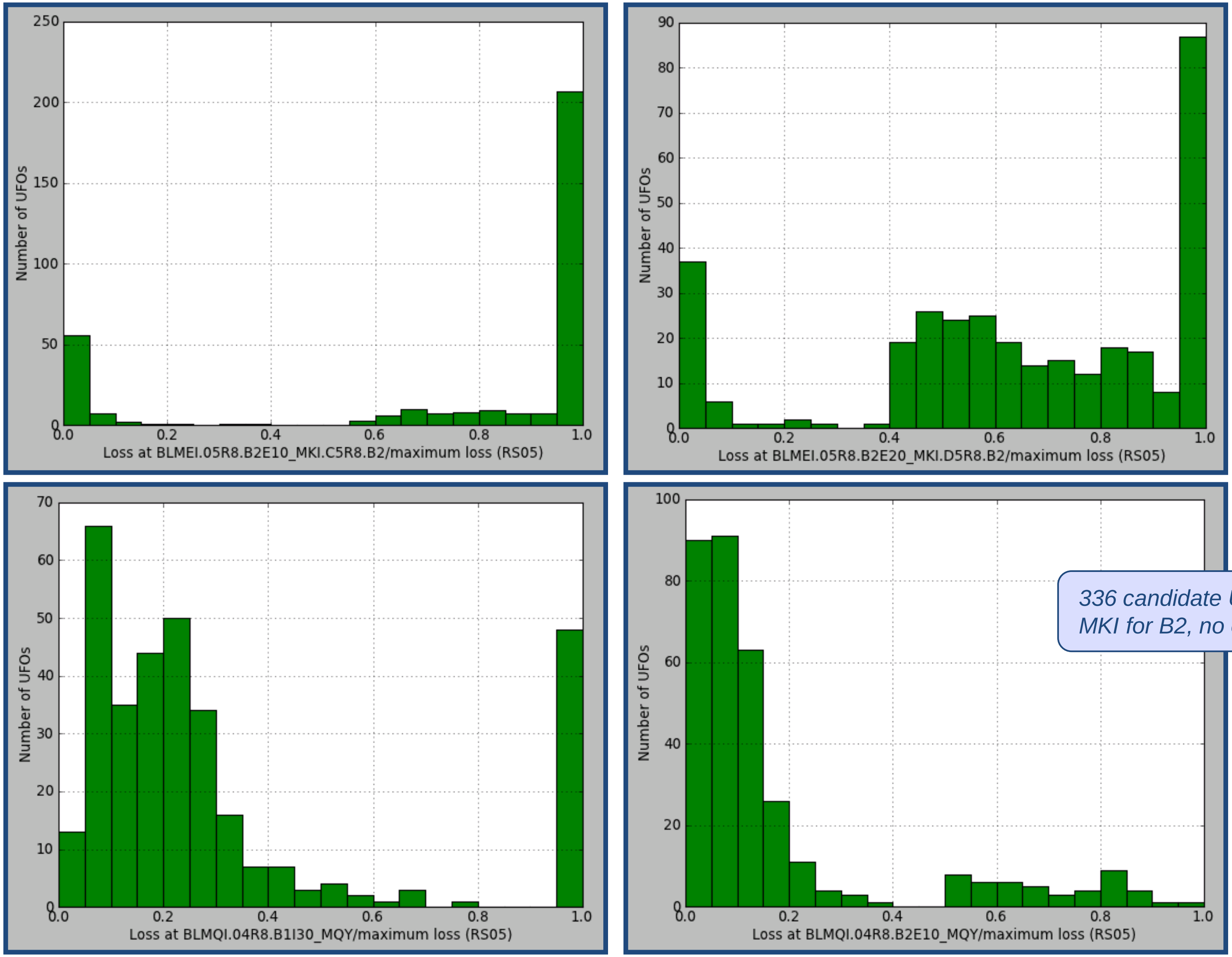


Lossratio for MKI UFOs B1



104 candidate UFOs around MKI for B1, no cuts.

Lossratio for MKI UFOs B2



336 candidate UFOs around MKI for B2, no cuts.

Dynamics of Dust Particles

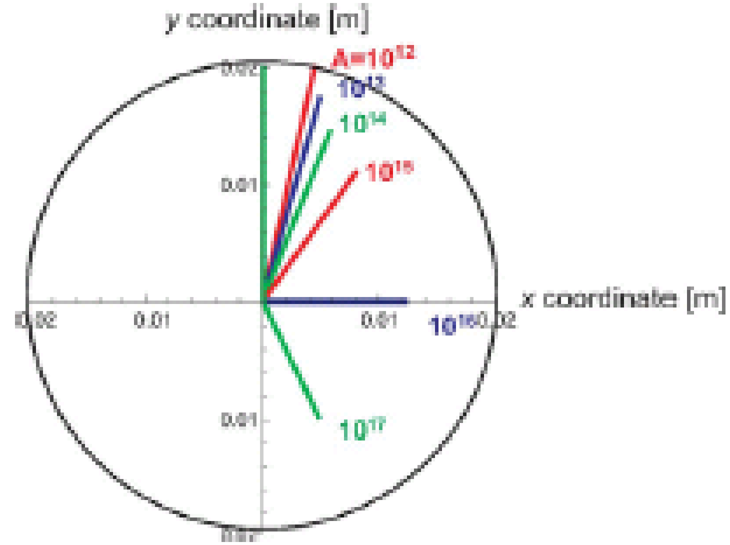
From **simulations**:

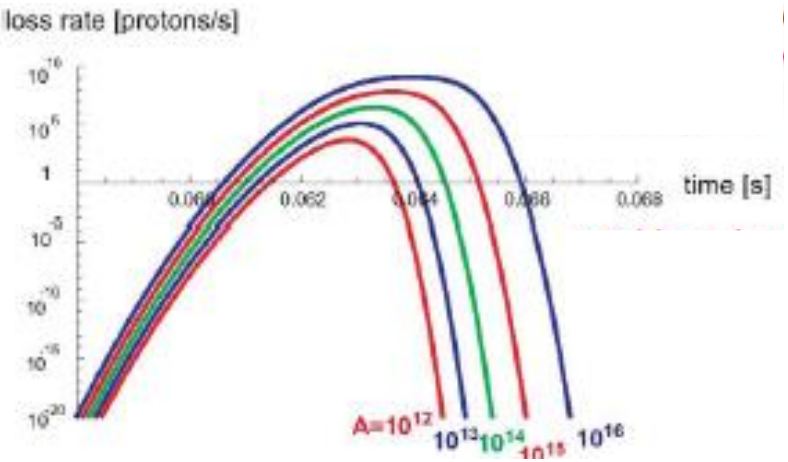
- Dust particle will be positively ionized and be repelled from the beam.

    Beam intensity: $2.3 \cdot 10^{12}$ protons, Al object.

- Loss duration of a few ms.

    Losses become shorter for larger beam intensities.





courtesy of
F. Zimmermann

Known Dust Particle Sources

- Distributed ion pumps (PF-AR, HERA).
- Electrical Discharges (PF-AR).
- Movable Devices.
- Particles frozen or condensated at cold elements. (ANKA)