MD2889 – 16L2 event dynamics and UFO nature investigation

B. Lindstrom, A. Apollonio, P. Bélanger, A. Gorzawski, L. Grob , E.B. Holzer, A. Lechner, T. Medvedeva, R. Schmidt, M. Valette, D. Valuch, D. Wollmann

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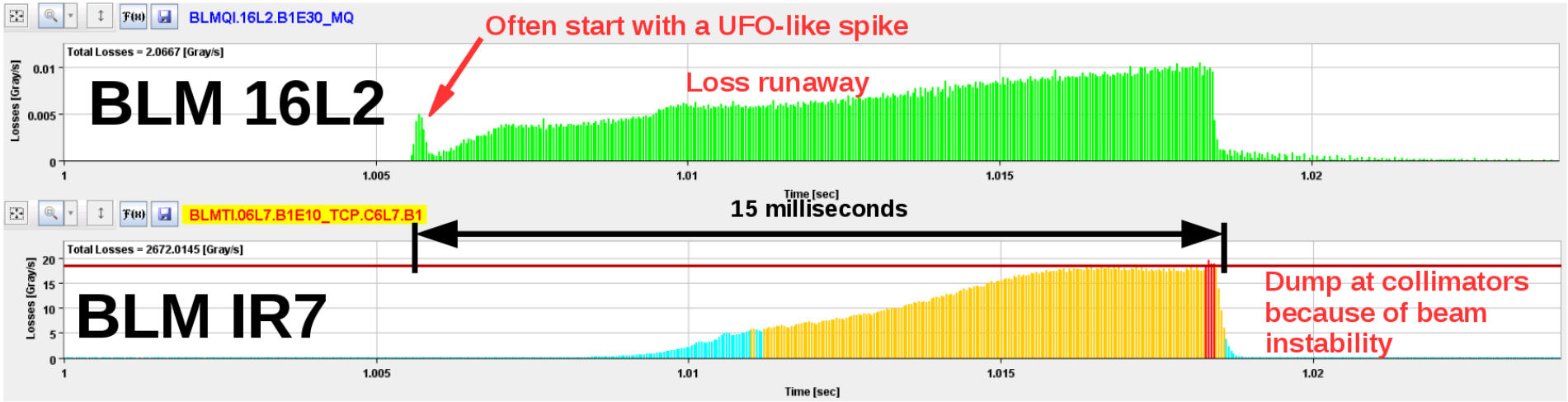
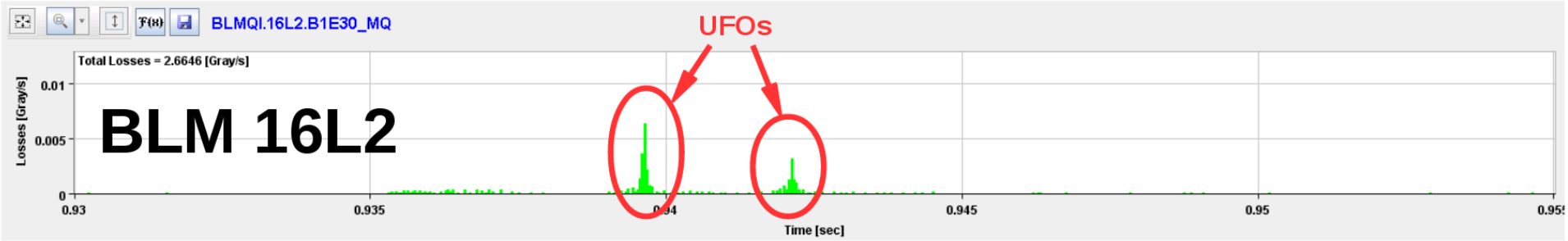
Recap on 16L2 events

- 16L2 refers to loss events in an interconnection in LHC sector 16L2
- Three types:
  - Steady state losses
  - UFO-like losses causing beam instability (fast loss rise, beam dump, quench)
  - UFO-like losses not causing instabilities (do not dump)

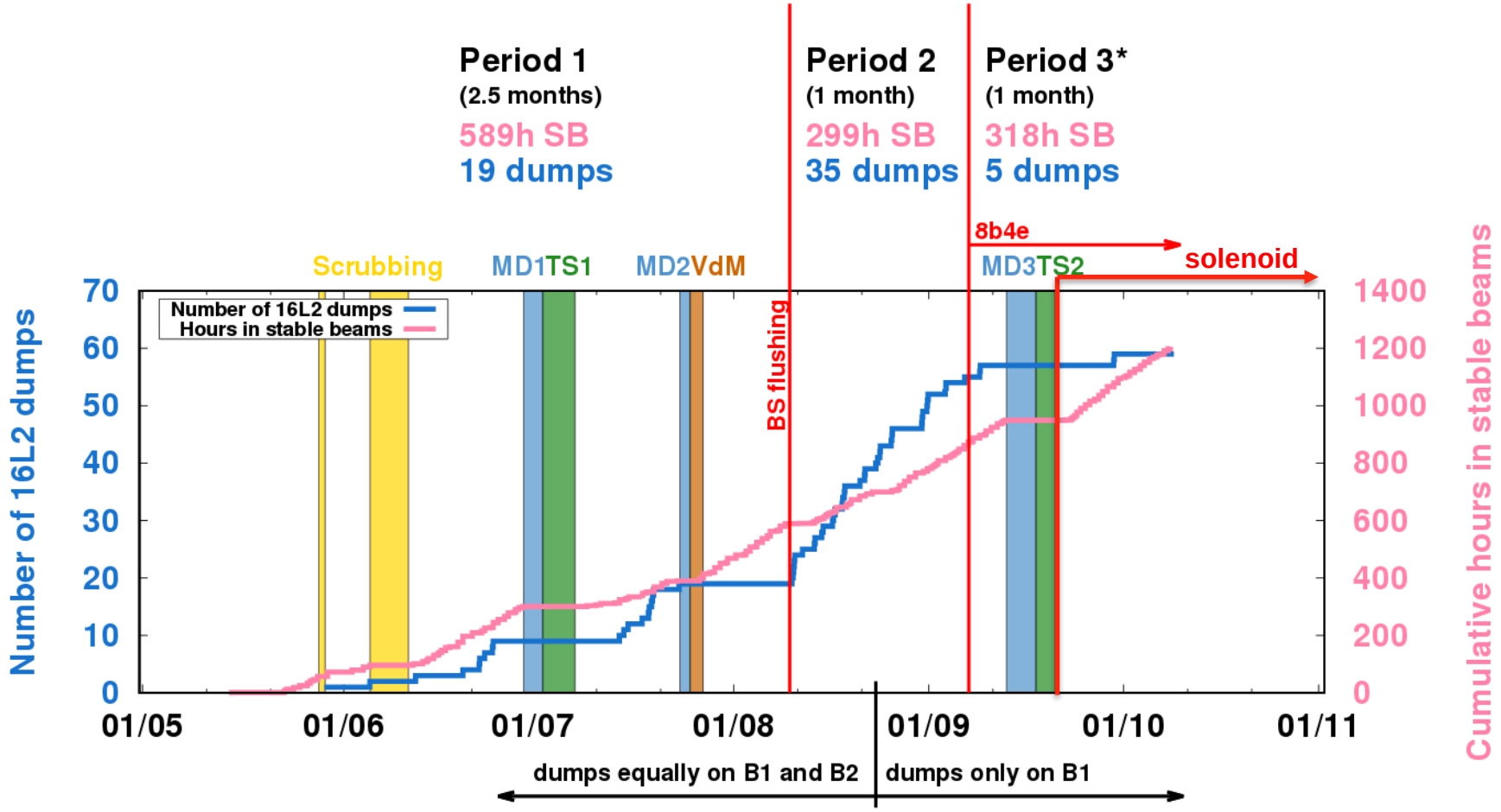




Courtesy of A.Lechner

Introduction

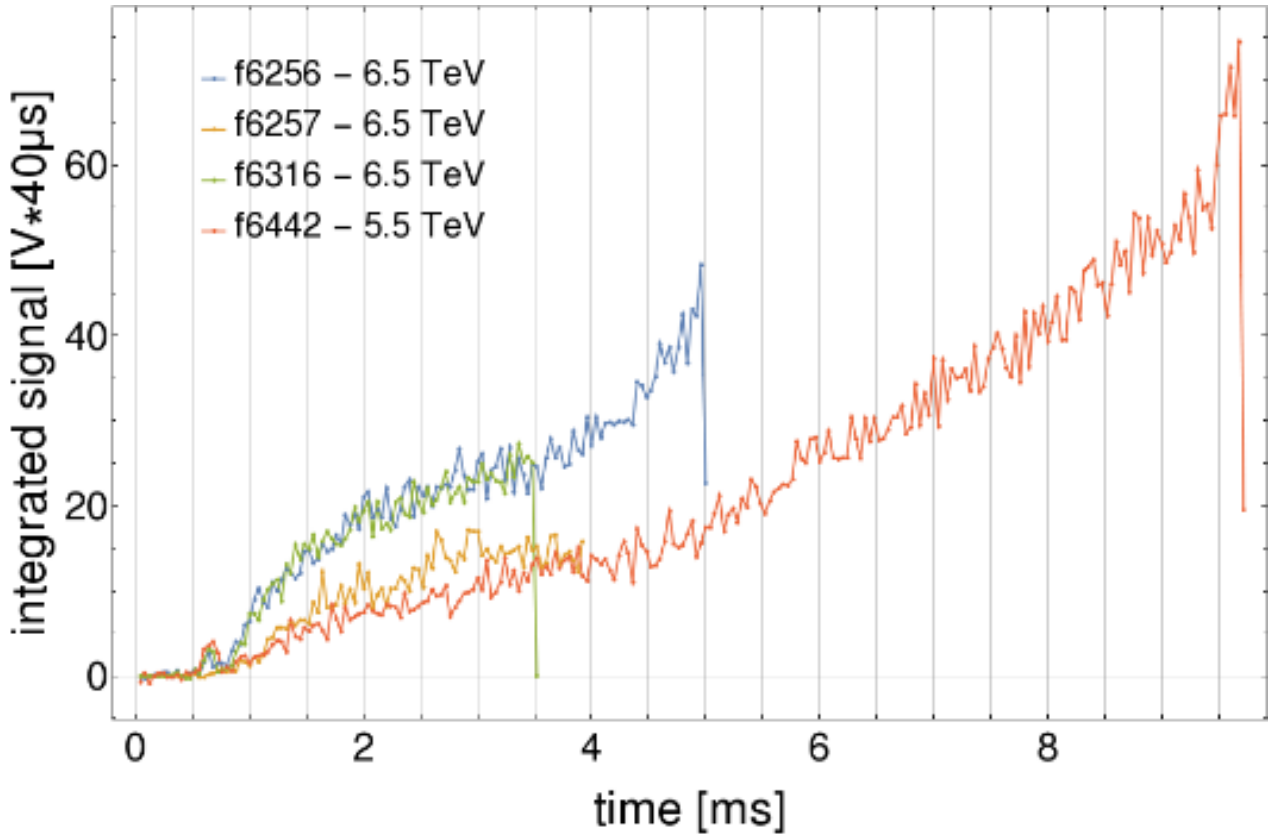
- 67 dumps in total



Courtesy of A.Lechner

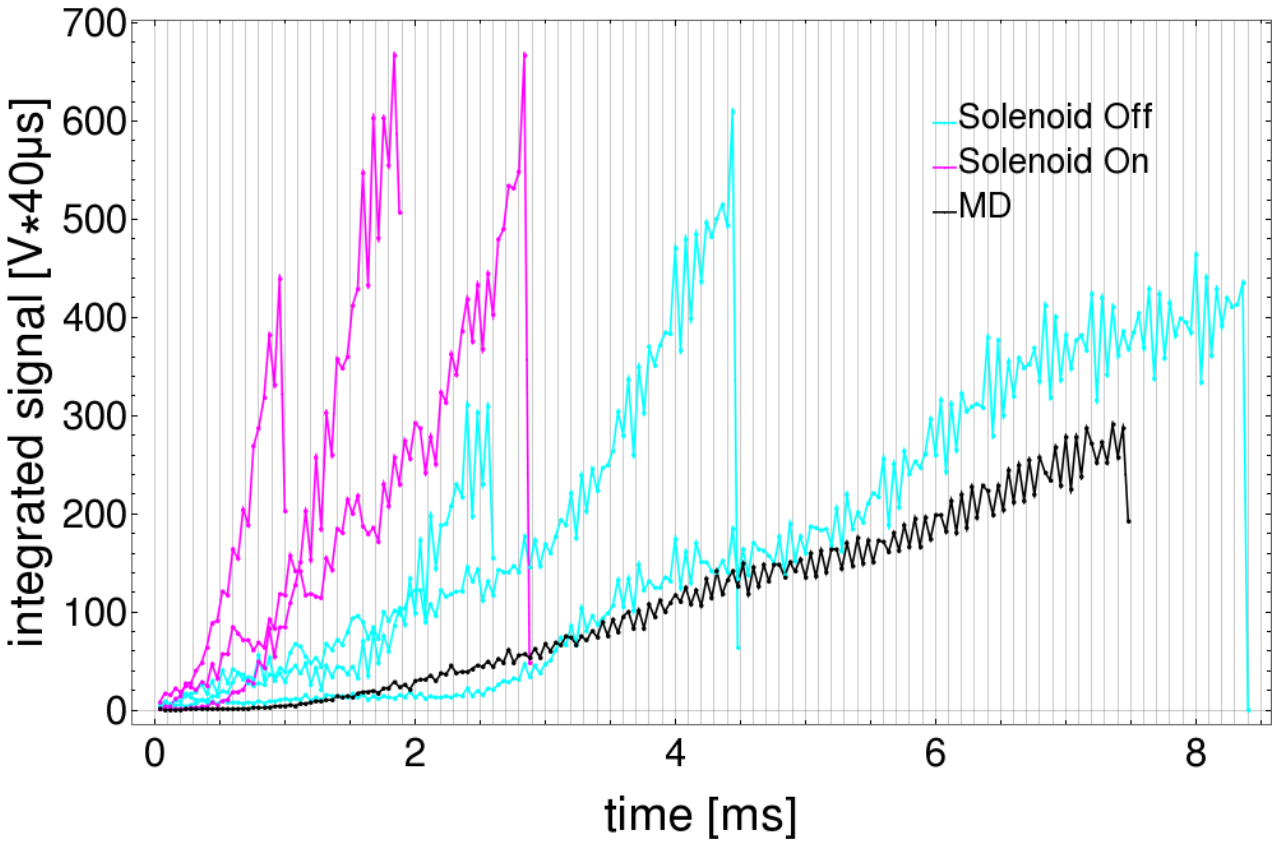
Integrated local dBLM data

- MD event was slower
  - Possibly because solenoid was switched off
- Otherwise similar pattern



IR7 integrated data

- Comparing events with solenoid off/on indicates that solenoid might lead to quicker instability build-up
- Loss pattern different between MD fill and the others (to be explained...)

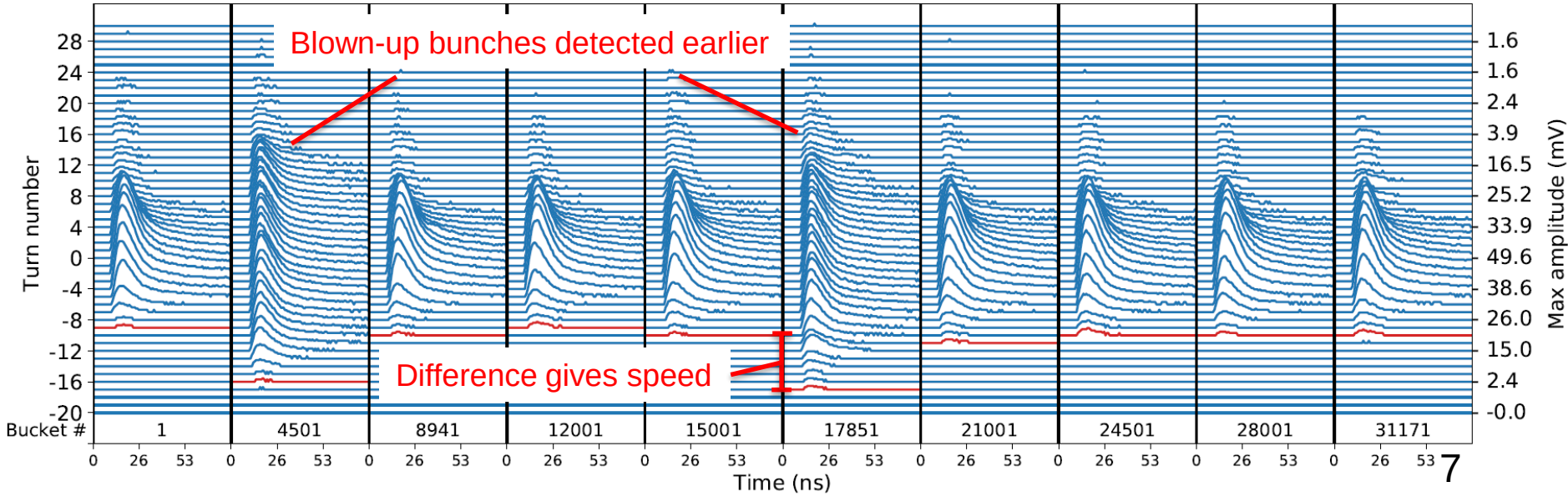


16L2 events summary

- Total of 67 induced dumps by 16L2
  - IR7 dBLM data: 43 events
  - Local dBLM data: 8 events
- 1 event during MD with blown-up bunches
- Solenoid on in all events with local data, except MD

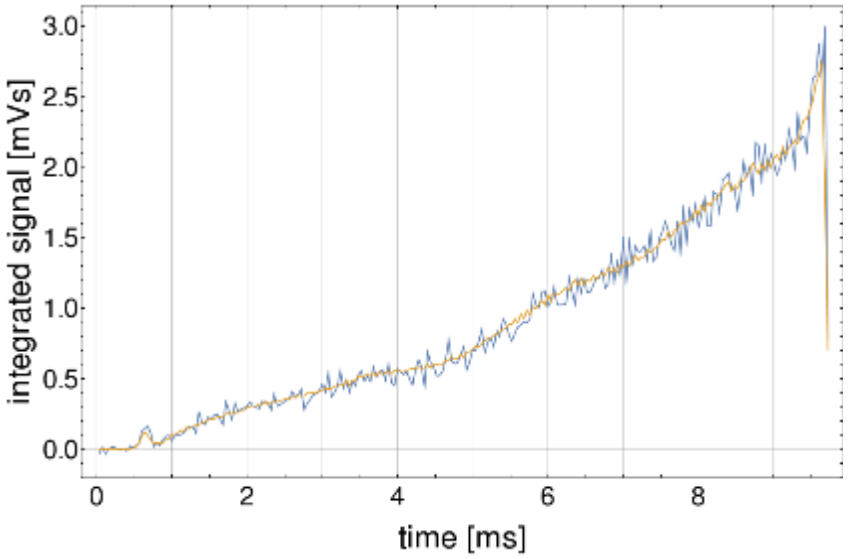
Motivation

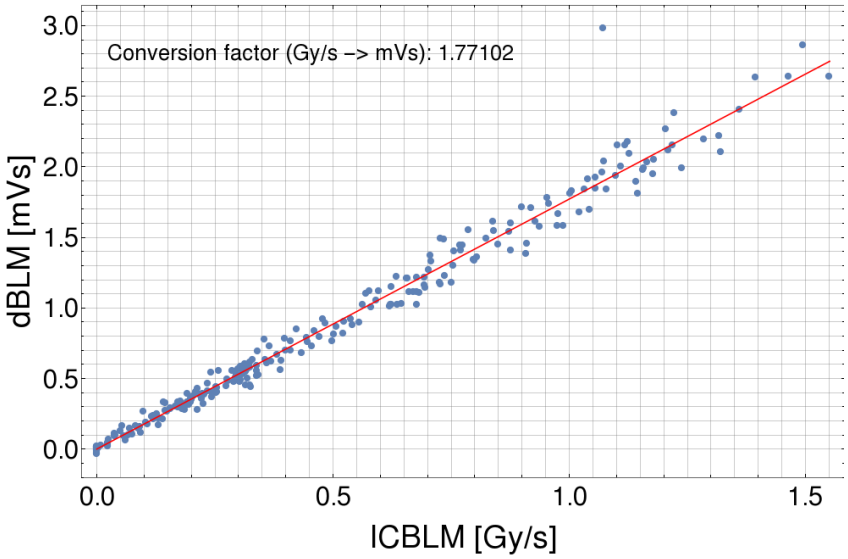
- Successful demonstration that blown-up bunches can be used to determine UFO dynamics in MD2036
- Wirescanner was used to simulate a UFO
  - Elastically scattered protons create showers in IR7, detected by dBLMs with bunch-by-bunch resolution
- Can reconstruct WS velocity (by assuming a bunch distribution)
- 16L2 gave opportunity to study real UFOs



Signal acquisition

- Local losses relatively low
- dBLM only 1 cm^2; small angular acceptance
  - Significant probability to not detect signal
- Solution: use many bunches
- Integrating in 40 µs shows good correlation with ICBLM

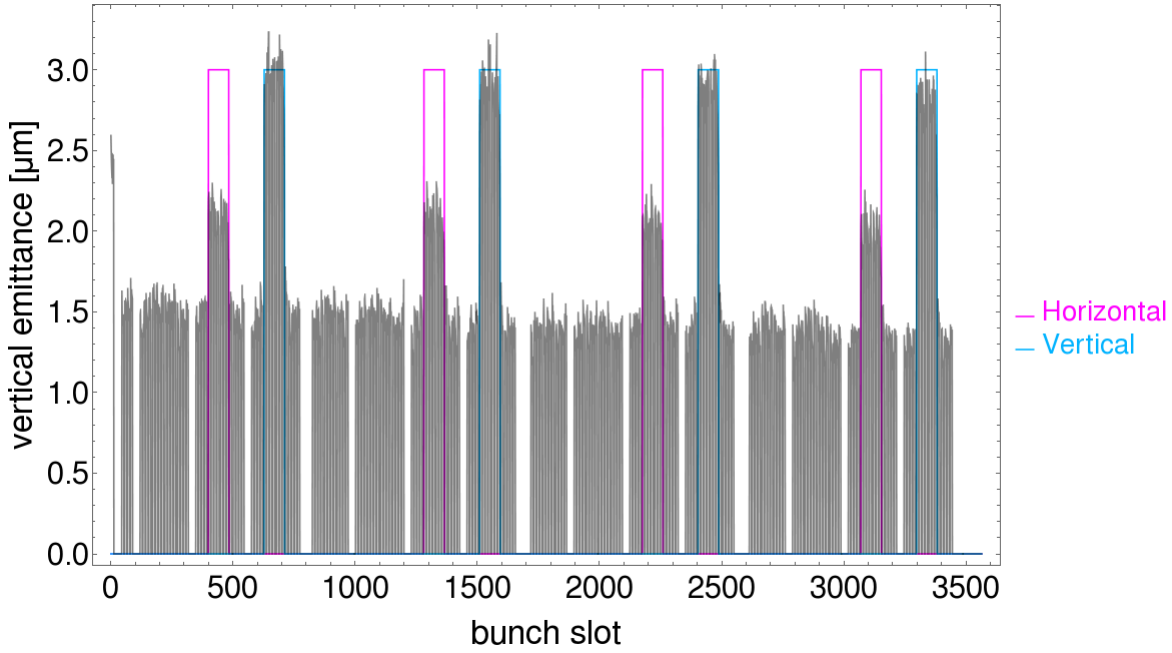




MD procedure

- 8b4e beam of 1868 bunches * 1.25e11 protons, ramp to 6.5 TeV, solenoid off
  - Parameters chosen for high probability of triggering 16L2 event
- Total of 512 bunches blown up to ~1.4x beam size (256 per plane) before ramp using LHC transverse damper
  - Many bunches required for statistical significance

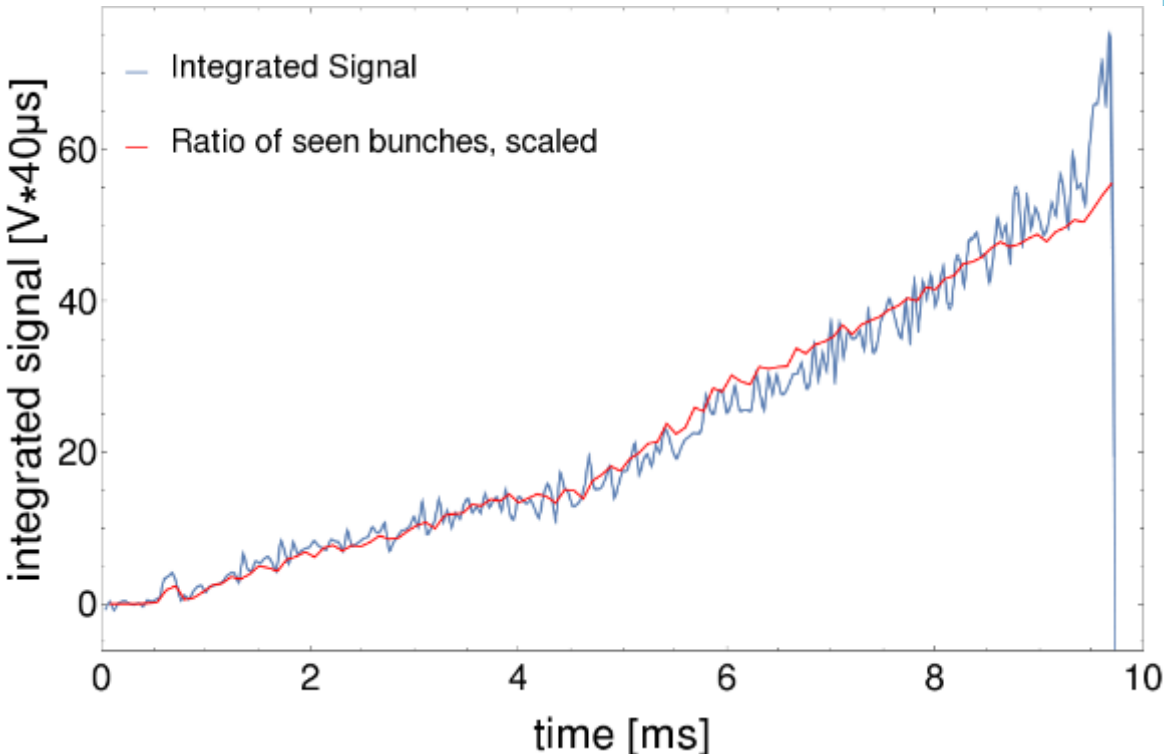
Dump occurred at 5.5 TeV due to 16L2 event (only one event)



Bunch detection probability

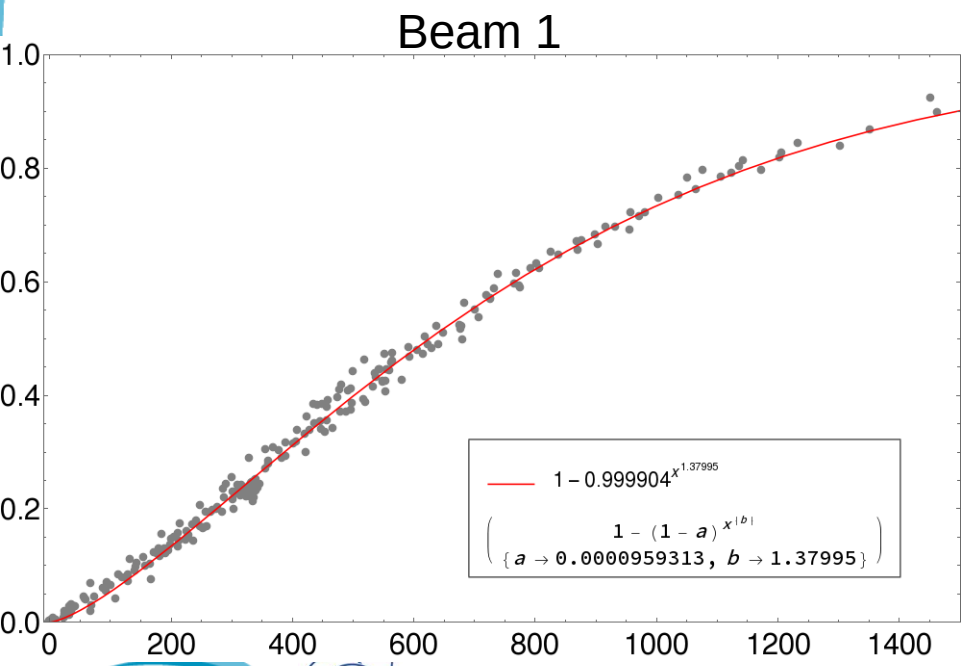
- Probability of detecting a bunch is related to the total losses per bunch, which in turn is related to the bunch particle density at interaction point

- Ratio of detected bunches is a good measure of the per bunch losses



Bunch Detection Probability

- Plotting ratio detected bunches vs ICBLM signal (Gy/s) shows good consistency between events
- Approximately linear for low losses



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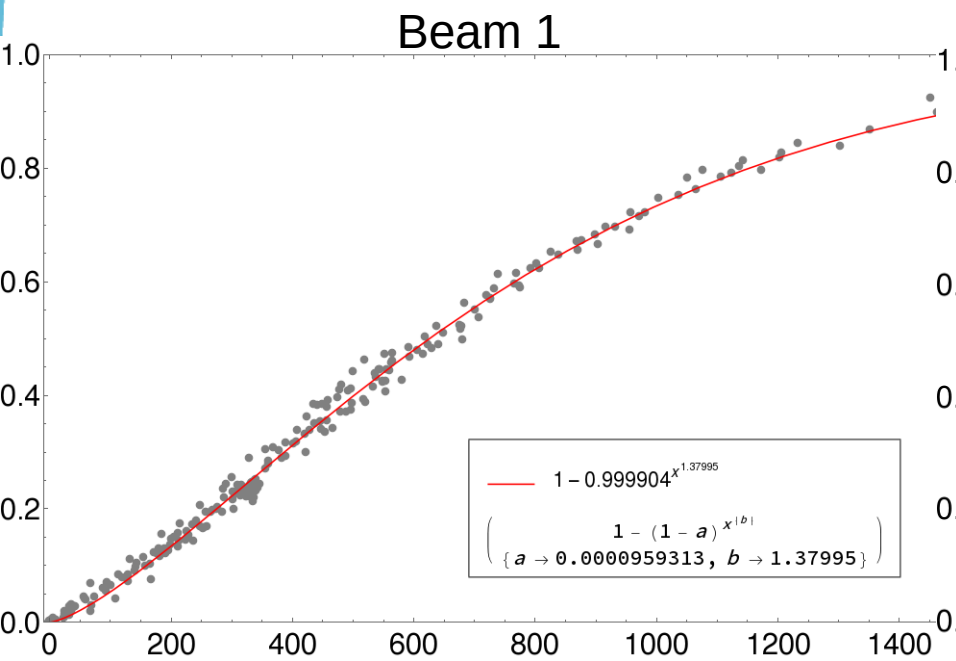
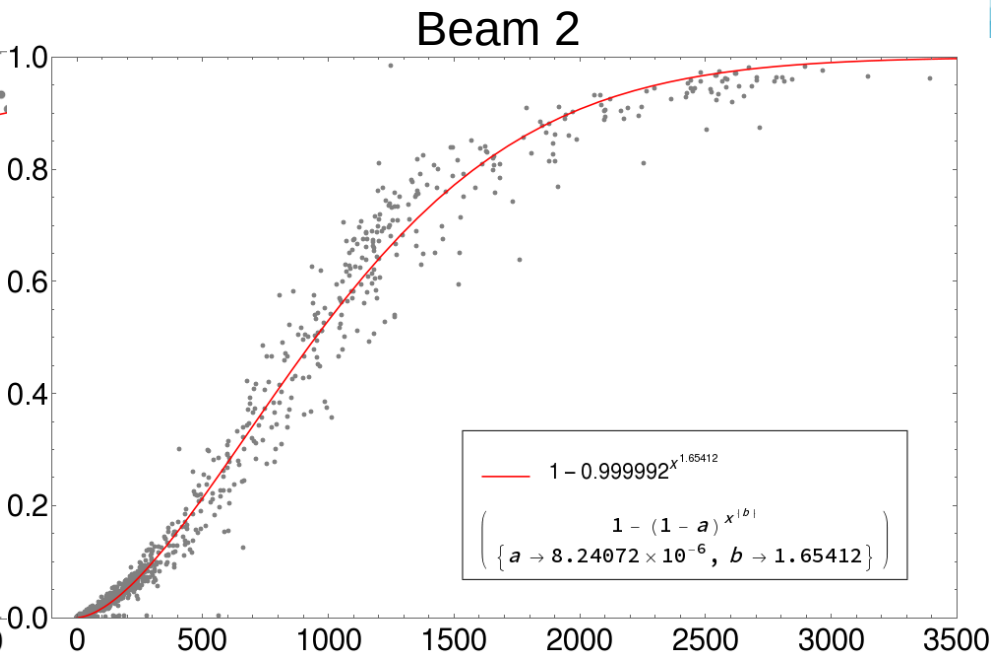
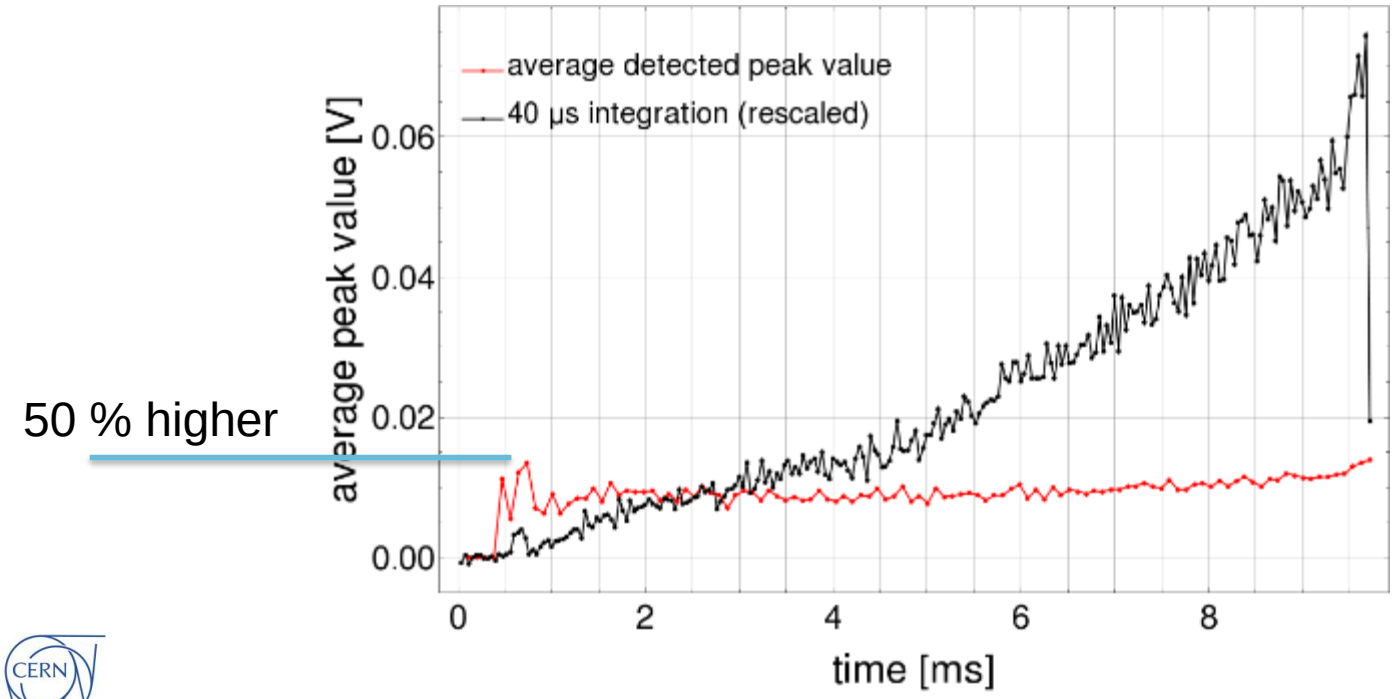




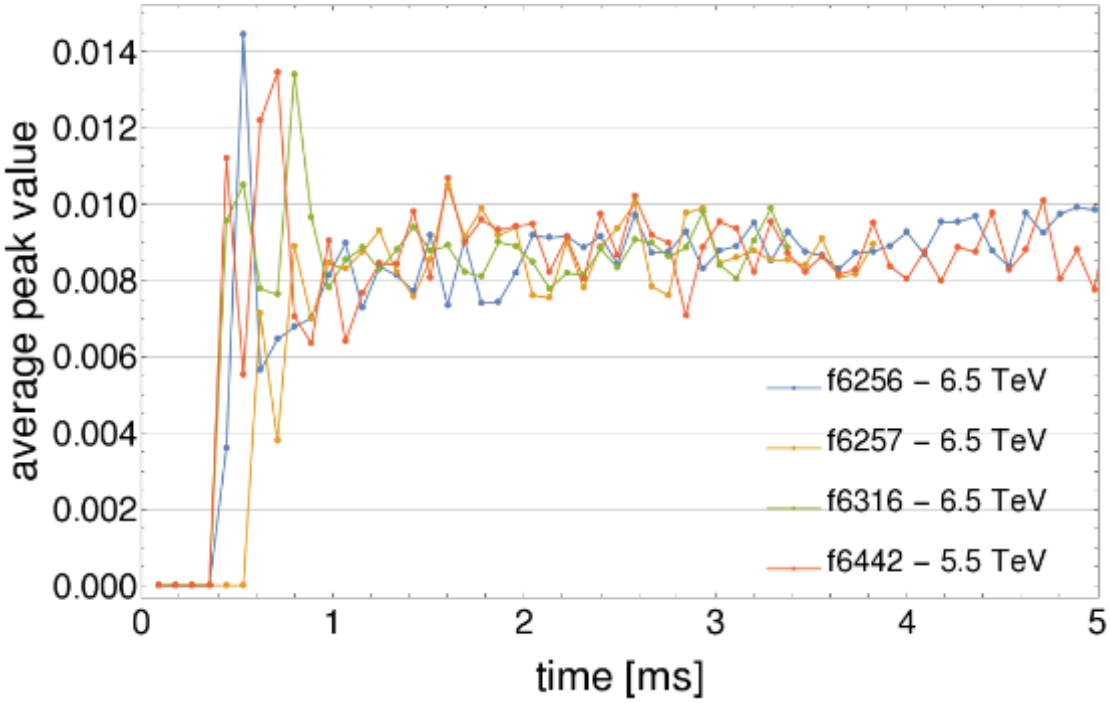
UFO average signal per detected peak

- Average value higher during UFO spike
  - Supports hypothesis of beam first interacting with solid object and then with a gas
- During the instability phase the contribution to higher integrated signal (in dBLM) comes from more bunches being detected, and not higher signal per bunch



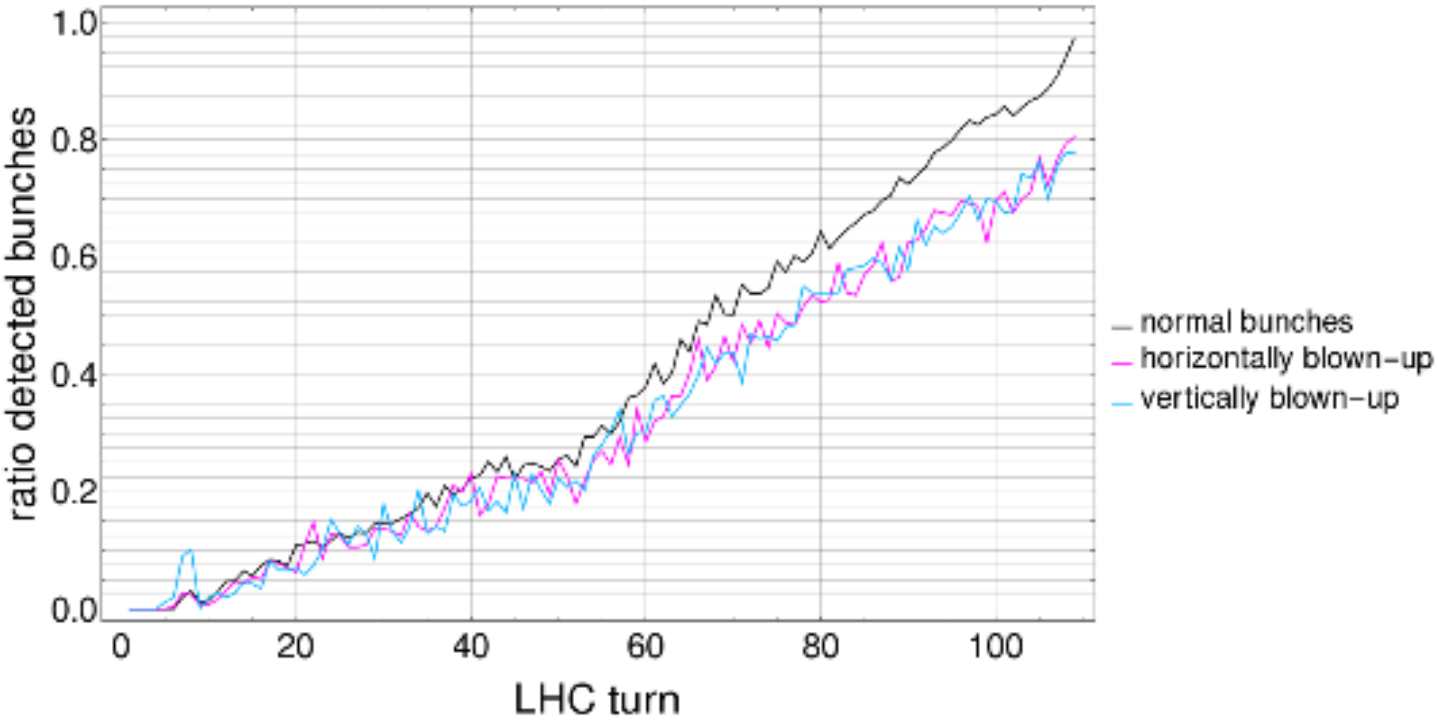
Average signal per detected peak

- Similar behavior in other events
- Deposited energy in diamond per bunch-crossing on average the same



UFO plane of movement

- Vertically blown-up bunches are detected earlier
  - **UFO movement in vertical plane**
- Vertically blown-up bunches more probable to detect throughout UFO spike
  - **UFO particle does not enter beam core (repelled or evaporated)**
- Normal and blown-up bunches diverge towards the end (to be explained)



Conclusions

- First successful study of (real) UFO movement with blown-up bunches and fast loss detection system
- UFO particle was moving in **vertical plane** and **did not enter beam core** before being repelled/evaporated
- While severity of instability build-up varies between the events, the measurements show otherwise many similarities
- Spike in average bunch signal when UFO particle present consistent with hypothesis of solid particle

- Interaction with UFO type 1 particles (”normal” UFO events) can be detected by IR7 diamonds
  - Blown-up bunches during normal fills would allow to study the dynamics of UFOs

- Spoiler: Daniele Mirarchi’s presentation in Chamonix next week, approximately 7 liters of atmospheric air confirmed in 16L2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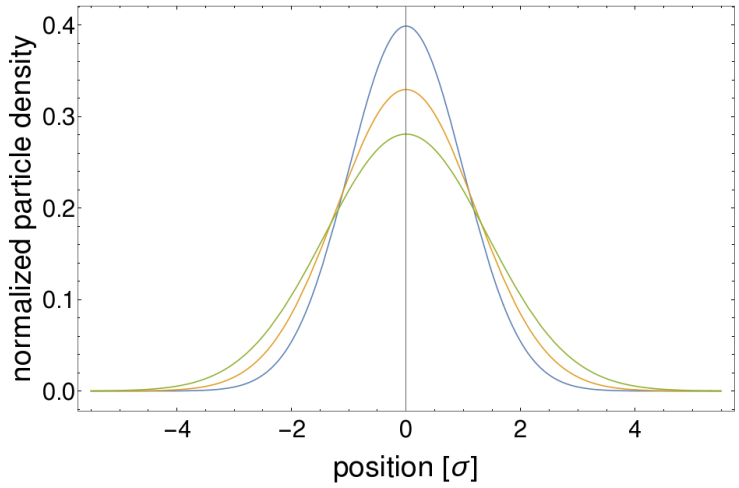
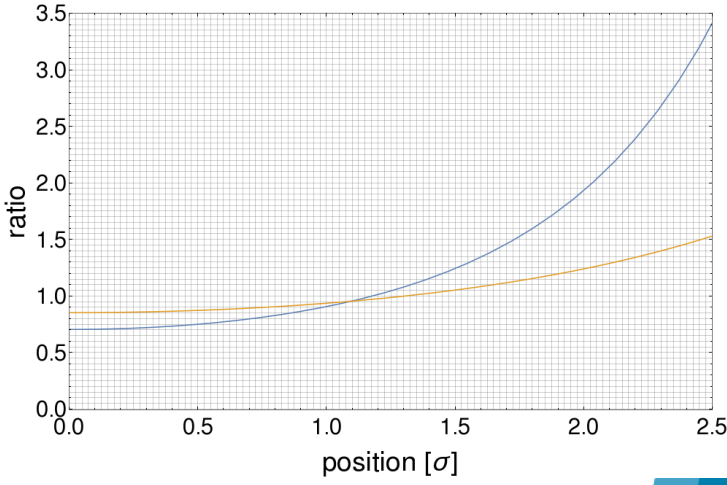
UFO dynamics simulation model

- By assuming a bunch distribution, the position of the UFO particle can be estimated for different moments in time
- Can be compared with the simulation model
- Ongoing work

Bunch distribution



Ratio between bunch signal gives position



Statistical test of losses during UFO-spike

Null hypothesis: Detection rate of vertically blown-up bunches is the same as of reference bunches
Assuming a constant probability that a bunch will be detected and that all bunches are independent (detection of one does not affect detection of others) -> **Binomial distribution**
Can use **a z test** to test the null hypothesis (since the number of bunches is large),

Test statistic $z = \frac{\widehat{p_1} - \widehat{p_2}}{\sqrt{\hat{p}(1-\hat{p})(\frac{1}{n_1}+\frac{1}{n_2})}}$

where p-hat is the estimated probability (ratio of detected bunches), n the number of bunches and

$$\hat{p} = \frac{n_1\widehat{p_1} + \mathrm{n}_2\widehat{p_2}}{n_1 + n_2}$$

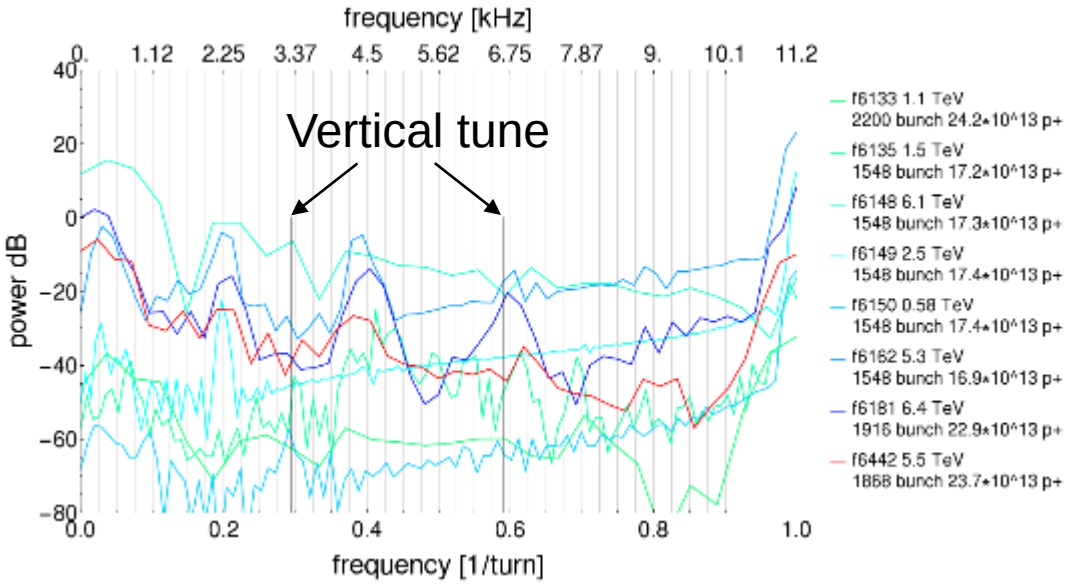
for critical region $Z > \Phi^{-1}(1 - \frac{\alpha}{2}) \wedge \Phi^{-1}(\frac{\alpha}{2})$

Averaging over the UFO spike, the Z value for comparing vertically blown up with normal is 4.27, leading to significance level < 0.0001

Conclusion: measurement is statistically significant, vertically blown up bunches are more probable to detect during the UFO-spike

Spectral analysis of IR7 losses – b1

- A peak at ~2x betatron tune present in most fills (expected, since TCP has two jaws, giving twice the frequency as a bunch oscillates transversally)
- A peak at ~0.2 (=5 turn period) and ~0.4 is present for b1
  - Unexplained, has not been reported from ADT ObsBox data



Spectral analysis of IR7 losses – b2

- In b2, peaks are seen at ~0.15 and ~0.3