
CERN

MD2036: UFO dynamics studies and UFO fast detection

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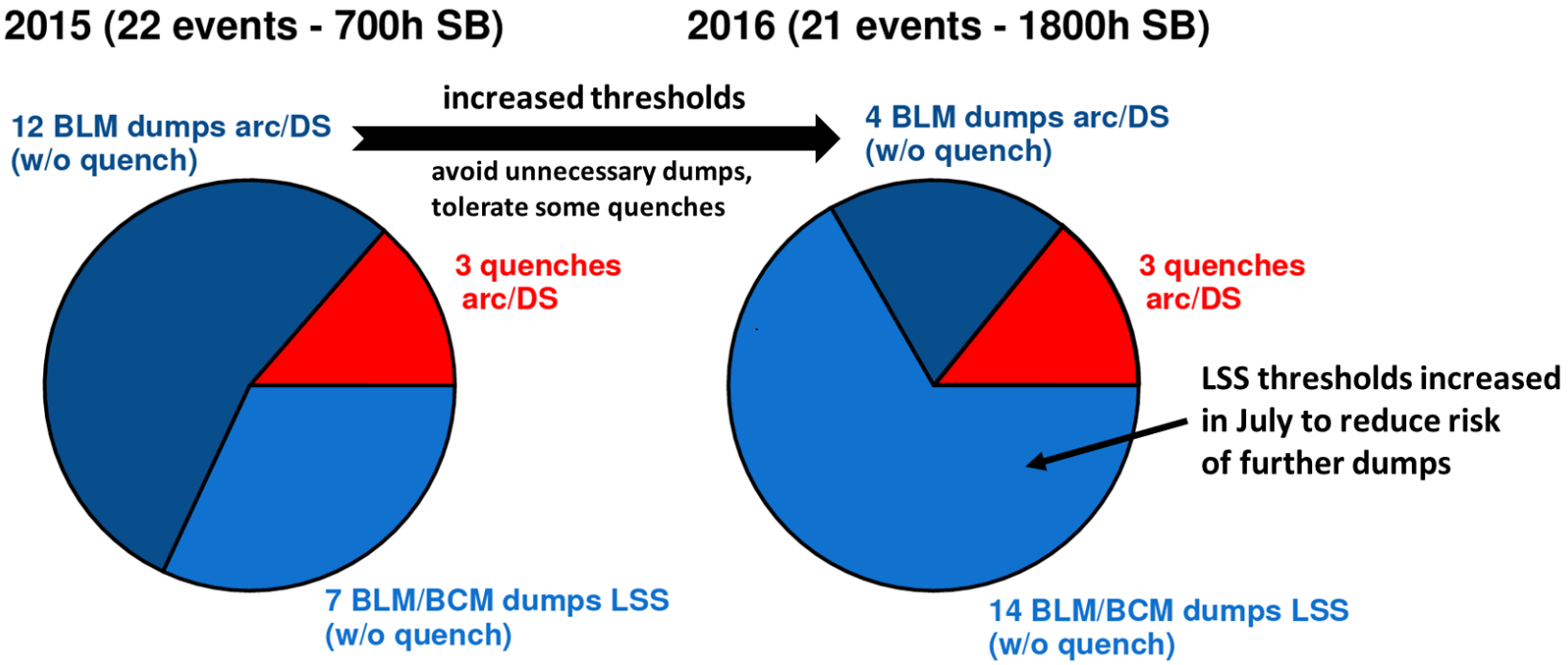
Reminder

- UFOs remain one of biggest unknowns related to LHC operation
- UFOs can severely affect LHC availability by
  - Triggering premature dumps due to beam losses
  - Causing beam-induced quenches
- It is fundamental to achieve a better understanding of UFO dynamics and improve their detection methods in view of operation with higher beam intensities and energy

UFO-induced Dumps & Quenches in 2015/16

A. Lechner



- Number of dumps & quenches depends on:
  - BLM threshold settings
  - UFO rates -> strong conditioning observed since Oct 2015, rates much lower in 2016 than in 2015

BLM threshold strategy for UFOs

A. Lechner

- Arcs and dispersion suppressors:

  If we try to prevent quenches, unnecessary dumps are unavoidable

  For availability it is better to avoid unnecessary dumps, tolerate some quenches, as confirmed by 2016 experience:

	Actual 2016 - Thresholds 3x above quench level	If we would have applied a quench-preventing strategy
Dumps	**4***	**71****
Quenches	**3**	**1 (UFO too fast)**

*3 out of 4 dumps were in S12 (temporary reduction of thresholds due to suspected inter-turn short)

** Simple count of 2016 fills which would have been prematurely dumped if tenfold lower thresholds would have been applied in all sectors throughout the whole year. Multiple occurrences per fill are only counted once.

Would adopt same strategy at 7 TeV -> “only” consequence is increased risk of quenches

- Long straight sections:

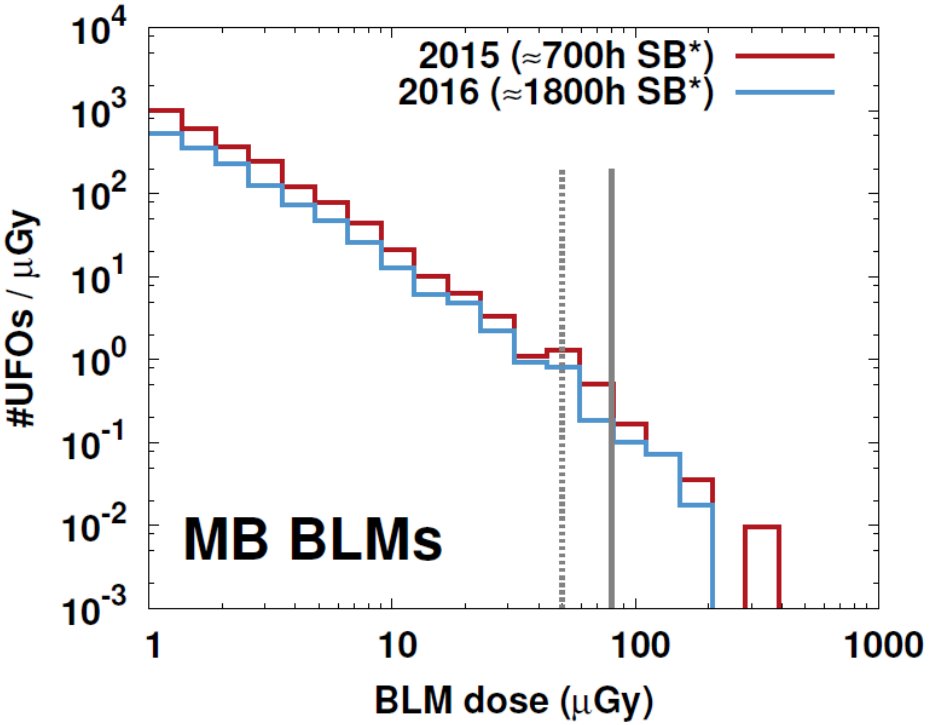
  Expect that local UFO hot spots can be mitigated with threshold increase (as done in 2015 and 2016)

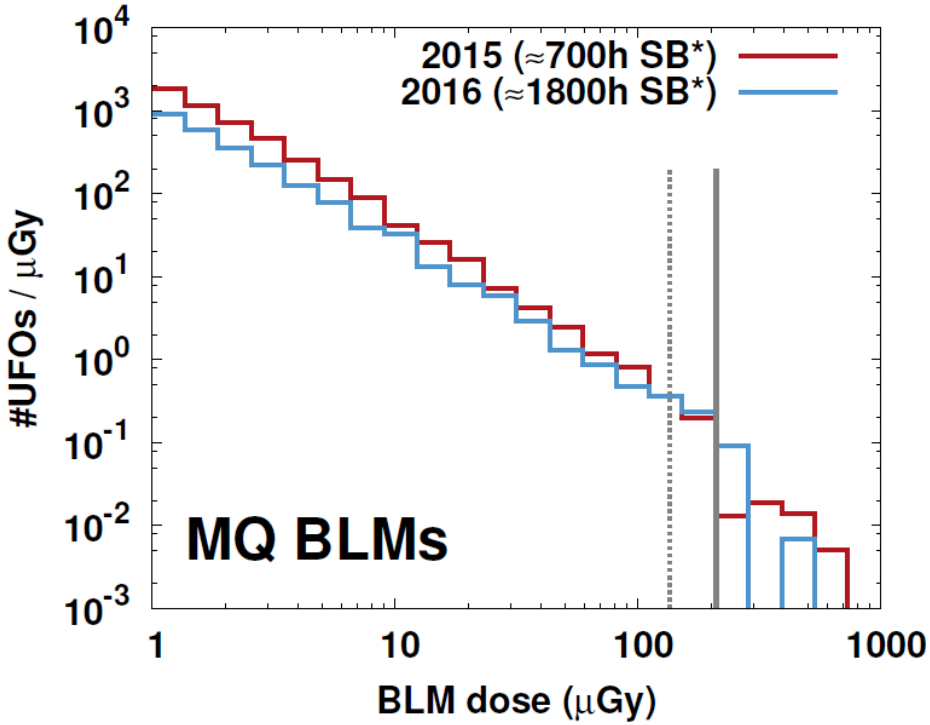
6.5 vs 7 TeV: Increased Risk of UFO Quenches

A. Lechner

Quench levels: 20-30% decrease
Energy density in coils per proton lost: ~12% increase

For a given UFO rate, # of UFOs which have potential to induce a quench increases by a factor of 2-4





- The strong dependence of the UFO rate on the machine conditioning status implies that the impact of UFOs on operation at 7 TeV will be critical in the first year following a long shutdown

Goal of the MD

- Validate modelling and simulation of UFO events
  - Produce UFO-like losses UFO by flying wire scanners
  - Monitor losses produced by elastically scattered particles at the TCP with diamond BLMs in IP7
  - Change bunch parameters (emittance, orbit) and see effect on loss pattern (injection and flat-top)

- Validate diamond BLM setup for UFO recording
  - Verify triggering and acquisition system
  - Set thresholds for injection and flat-top events
  - Evaluate possibility to include dBLM data in the UFO buster

Readiness of the MD

- Setup and triggering of dBLMs validated with:
  - Emittance calibration fill (flat-top)

- ADT settings (preparation required with D. Valuch):
  - Option 1: AC dipole mode at equilibrium between excitation and damping
    - Pros: known settings (21/5/2017)
    - Cons: not constant displacement at the TCP
  - Option 2: AC dipole mode with low excitation frequency (<10 Hz)
    - Pros: quasi-constant displacement at the TCP
    - Cons: a bit more complicated to prepare (requires synch with wire scanner timing event)

450 GeV

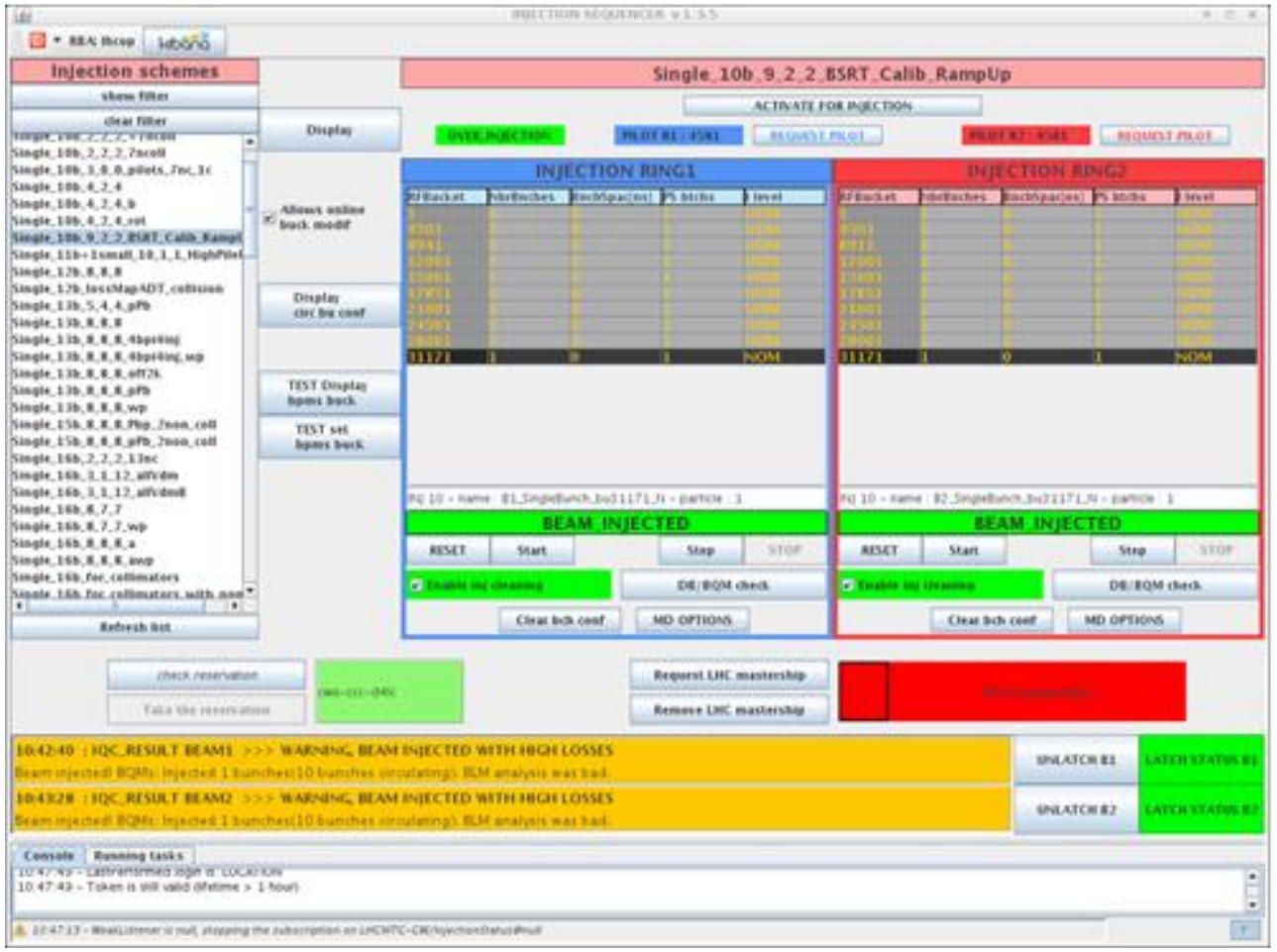
Location	Beam 1	Beam 2
Wire scanner	237 μm x / 315 μm y	232 μm x / 349 μm y
TCPC/TCPD	209 μm x / 156 μm y	210 μm x / 155 μm y

6.5 TeV

Location	Beam 1	Beam 2
Wire scanner	62 μm x / 83 μm y	61 μm x / 92 μm y
TCPC/TCPD	55 μm x / 41 μm y	55 μm x / 41 μm y

MD Preparation

- Unlink B1 and B2 in the BIS (no other interlock modification required).
- Prepare the filling scheme “Single_10b_9_2_2_BSRT_Calib_RampUp”
- Verify diamond triggering and acquisition at injection.
- Verify that the selected ADT mode is working as expected at injection.



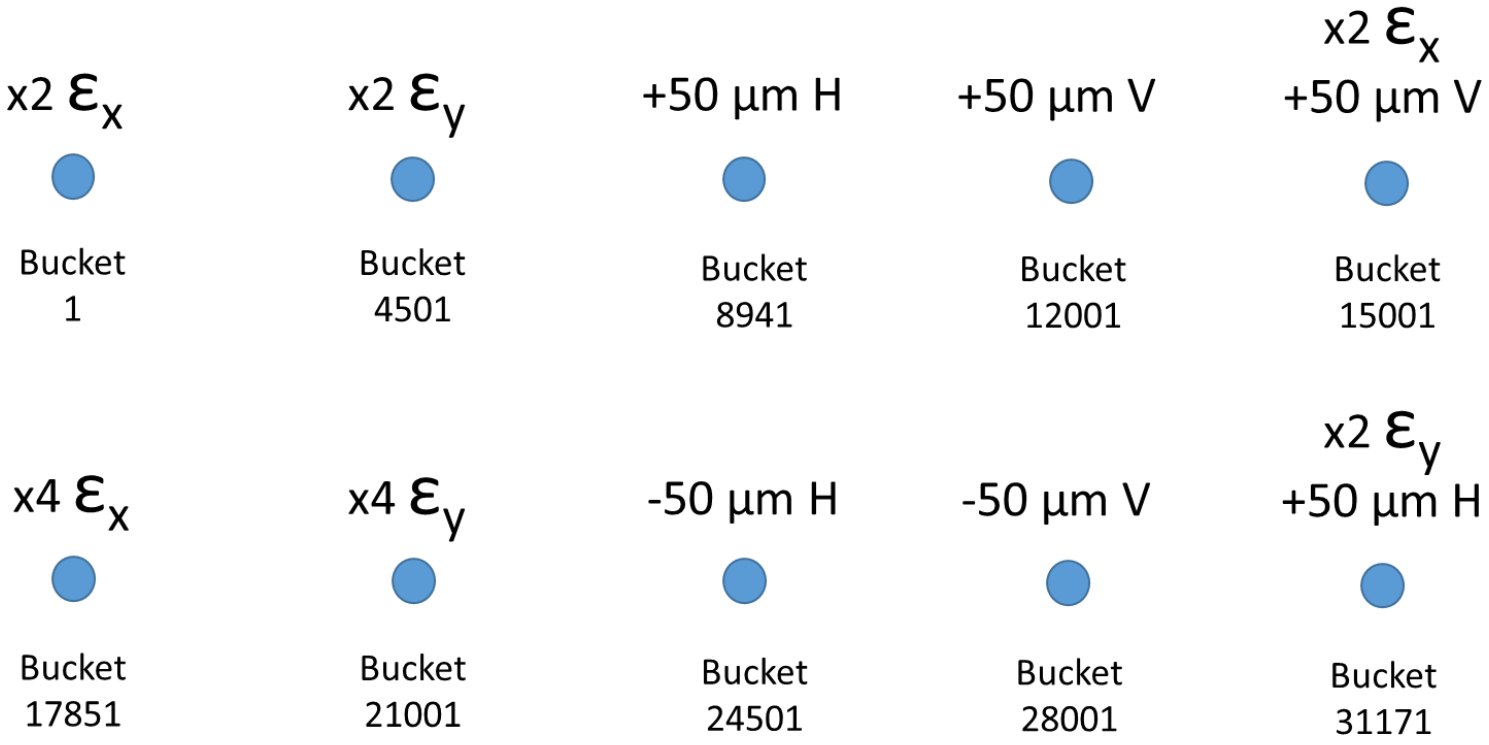
MD Steps (450 GeV)

- Inject 10 nominal bunches (B1 and B2)
- Perform a vertical and a horizontal wire scan and verify correct triggering and acquisition of the diamond detector
- Perform a vertical and a horizontal wire scan following each of the following manipulations (done independently and subsequently)
- Repeat for the second beam
- Dump

x2 ε_x	x2 ε_y	+200 µm H	+200 µm V	x2 ε_x +200 µm V
Bucket 1	Bucket 4501	Bucket 8941	Bucket 12001	Bucket 15001
x4 ε_x	x4 ε_y	-200 µm H	-200 µm V	x2 ε_y +200 µm H
Bucket 17851	Bucket 21001	Bucket 24501	Bucket 28001	Bucket 31171

MD Steps (6.5 TeV)

- Inject 10 nominal bunches (B1 and B2) and ramp to 6.5 TeV
- Correct orbit, then swtich-off orbit feedback and tune feedback
- Perform a vertical and a horizontal wire scan following each of the following manipulations (done independently and subsequently)
- Repeat for the second beam
- Dump



Recovery

- Ramp-down
- Restore ADT settings
- Set dBLMs to default settings

- Total time 4 h + 2 h

Conclusions

- UFOs → Very interesting topic and MD programme
- Scope is two-fold
  - Investigate UFO dynamics
  - Validate dBLMs for monitoring UFO-induced losses
- Added value: more experience with ADT advanced settings

Thank you!

Questions?