BLM thresholds and UFOs: Summary of 2016 and outlook for 2017

A. Lechner, M. Albert, B. Auchmann, C. Bahamonde Castro, L. Grob, E.B. Holzer, J. Jowett, M. Kalliokoski, S. Le Naour, A. Lunt, A. Mereghetti, G. Papotti, R. Schmidt, R. Veness, A. Verweij, G. Willering, D. Wollmann, C. Xu, M. Zerlauth

on behalf of the BLMTWG

in close collaboration with MPP, MP3, Collimation Team, TE/ABT, TE/MSC

7th Evian Workshop

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Introduction

- **Presently, there are 3518 BLMs connected to the BIS**
- **In 2016, we changed the thresholds of**[†]
  - ∼**2000** BLMs for **proton operation** (∼**500** changed twice during the year)
  - ∼**50** BLMs for **ion operation**

(**2015:** >5700 changes)

- **Reminder:**
  - **Applied Thresholds**(E, t) = **Master Thresholds**(E, t) × **Monitor Factor**

The same for all BLMs in a family

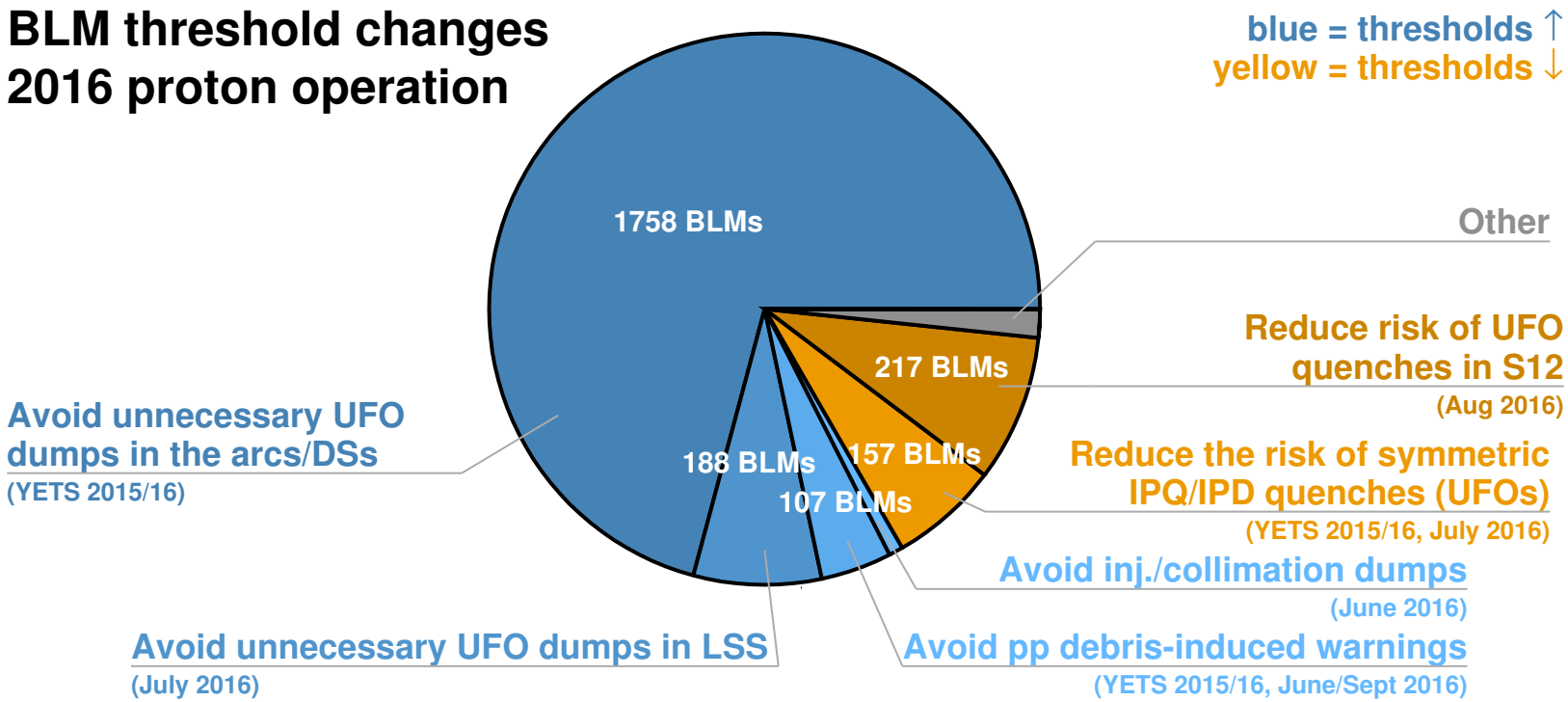
Can differ for individual BLMs in a family

- **Master Threshold vs Monitor Factor changes in 2016:**
  - In ∼**83%** **both** were changed
  - In ∼**6%** only the **Master Thresholds** were changed
  - In ∼**11%** only the **Monitor Factor** was changed

[†] *Not included: reversal of 2015 Pb thresholds, temporary changes for RP alignment*

Overview of the changes for 2016 proton run

With input from C. Xu and M. Kalliokoski.



- **Remarks:**
  - All **Master Threshold** changes were **empirical corrections** based on 2015+2016 experience, i.e. did not change the **models established in LS1**
  - With only a few exceptions (S12, TDI losses), all changes were **scheduled changes** (**BLMTWG** → **ECR+MPP&LMC approval** → **implementation**)

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2015 vs 2016: evolution of arc UFO rates

# of arc UFOs (cells $\geqslant$12) per hour of stable beam

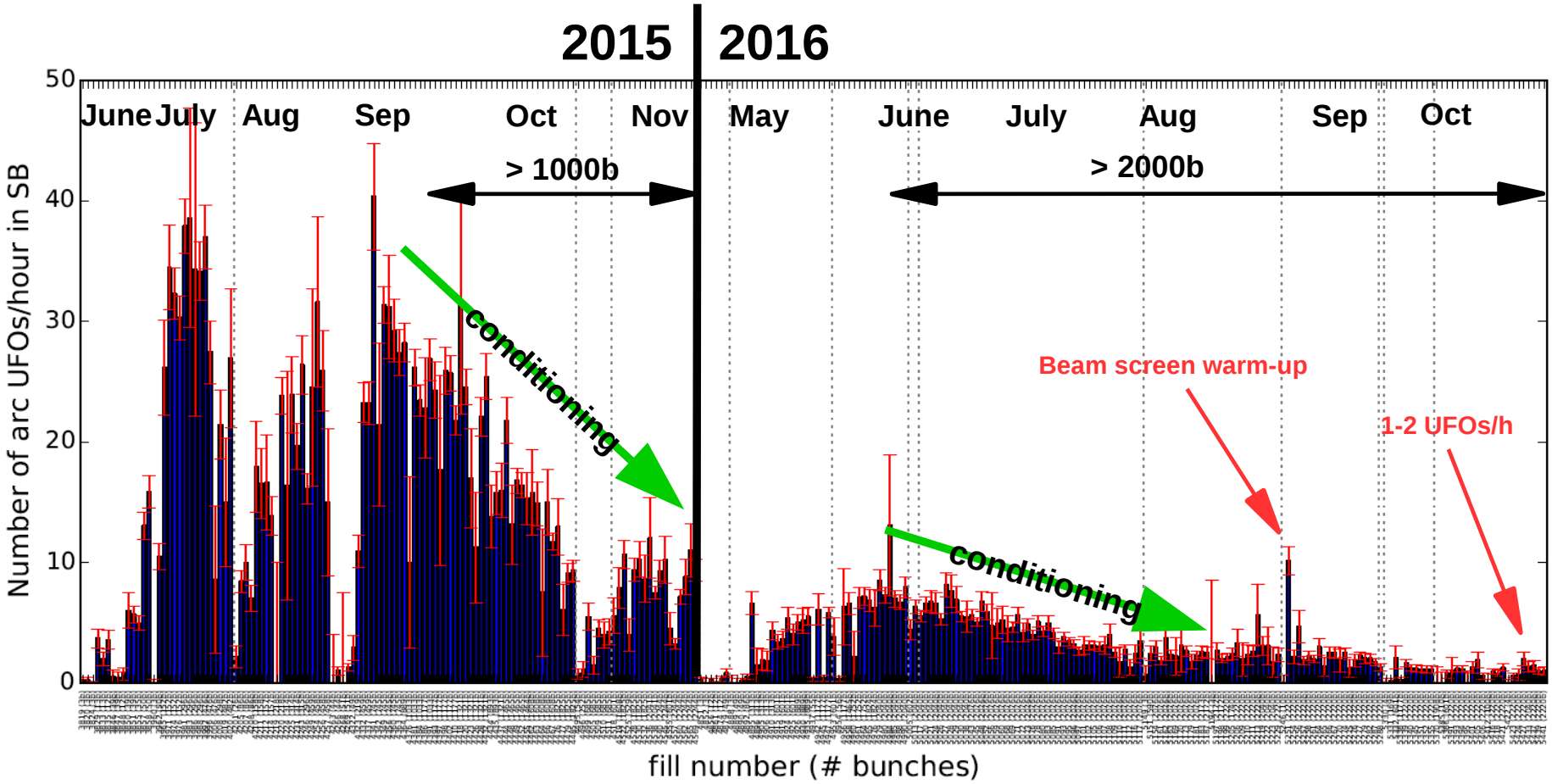
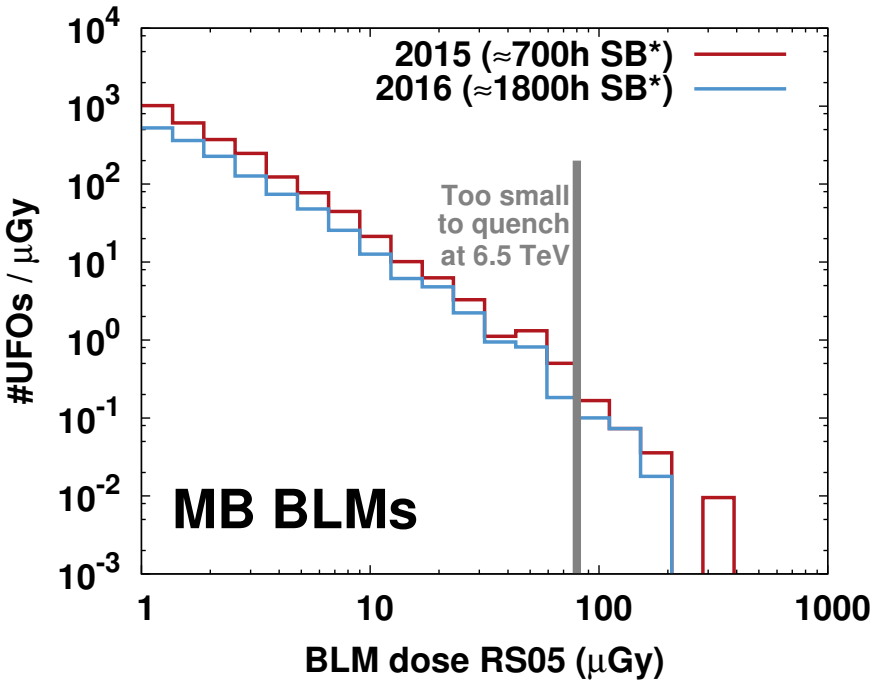


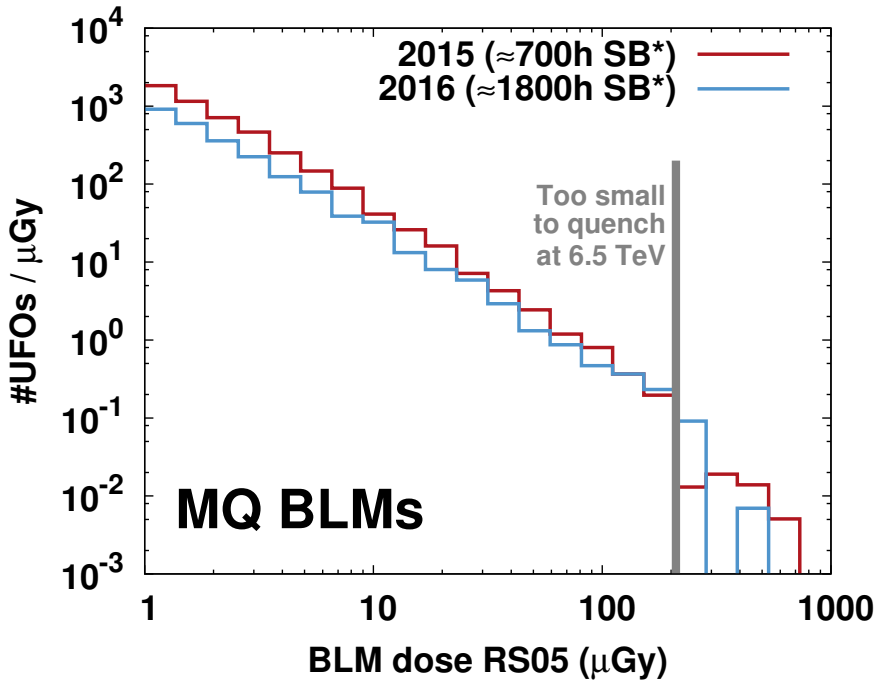
Figure from G. Papotti and M. Albert, based on data from "UFO Buster" (same counting algorithm used in 2015 and 2016).

2015 vs 2016: yearly integrals of arc UFOs

lower rates $\rightarrow N_{2016}^{UFOs} \; / \; N_{2015}^{UFOs} \sim$ **0.54**†, despite **many more hours in SB** in 2016

# of arc UFOs integrated over the year (cells $\geqslant$12), as a function of BLM dose





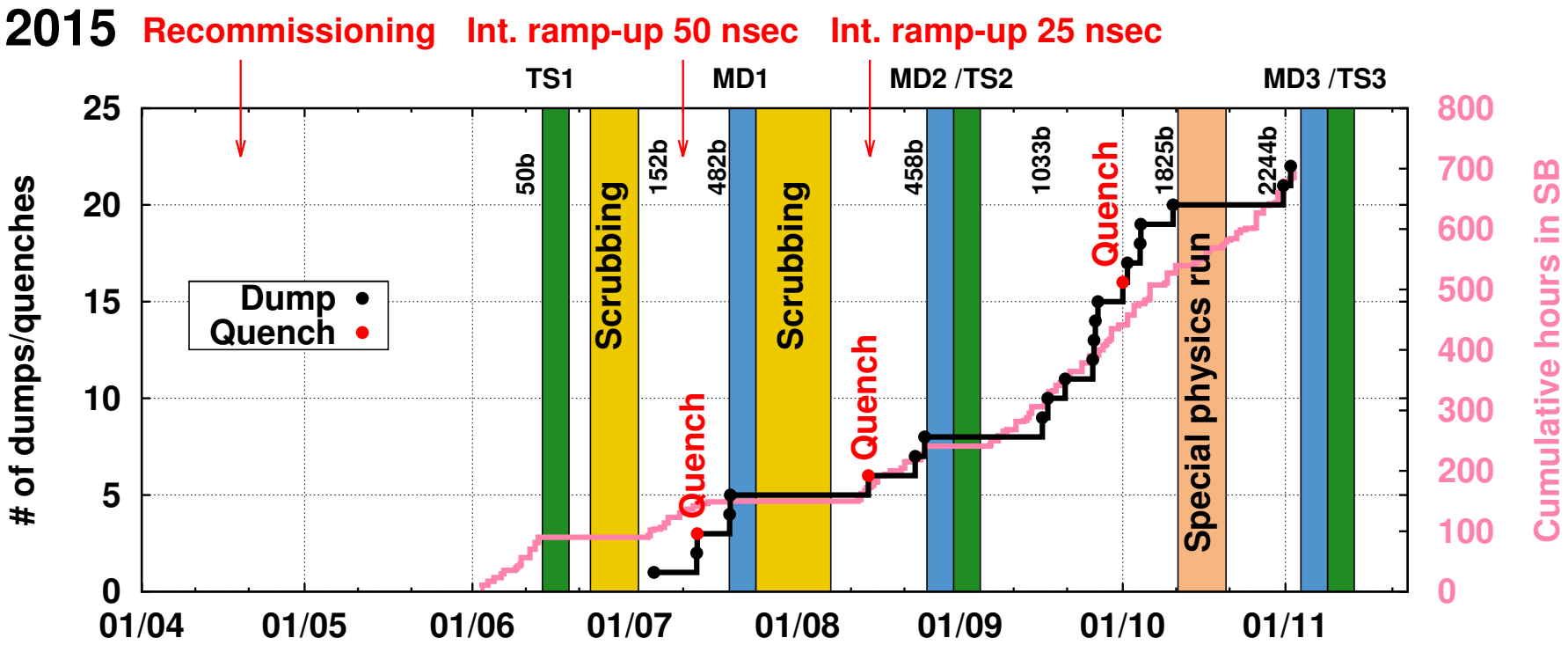
Based on data from "UFO Buster" (only UFOs at top energy).

* *Including intensity ramp-up and high-β run.*

† *2016/2015 ratio of the total number of arc UFOs in cells $\geq$12 with a BLM dose $\geq 1\mu$Gy.*

2015: UFO-induced BLM dumps and quenches

~700 h of SB@6.5 TeV

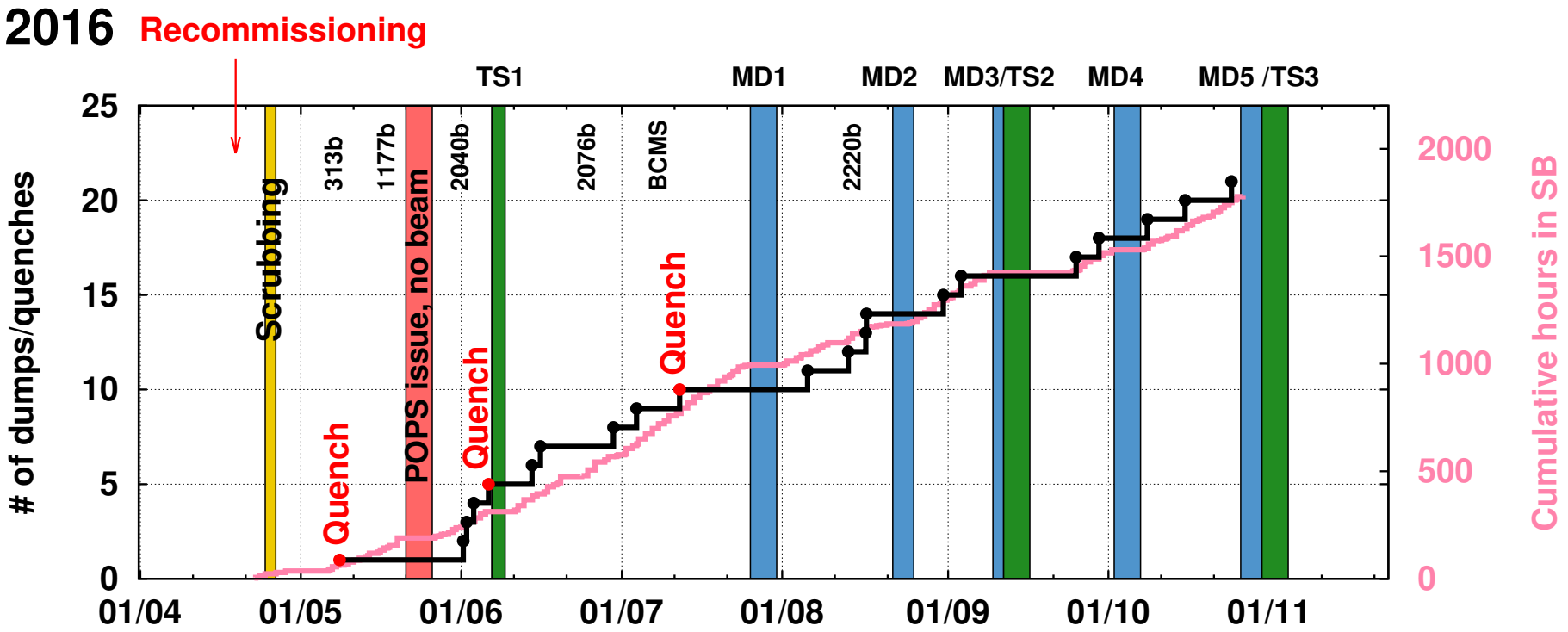


UFOs: **19 BLM/BCM dumps (w/o quench)**, **3 quenches** (without ULO in 15R8)

Data from B. Auchmann (all beam modes).

2016: UFO-induced BLM dumps and quenches

~1800 h of SB@6.5 TeV

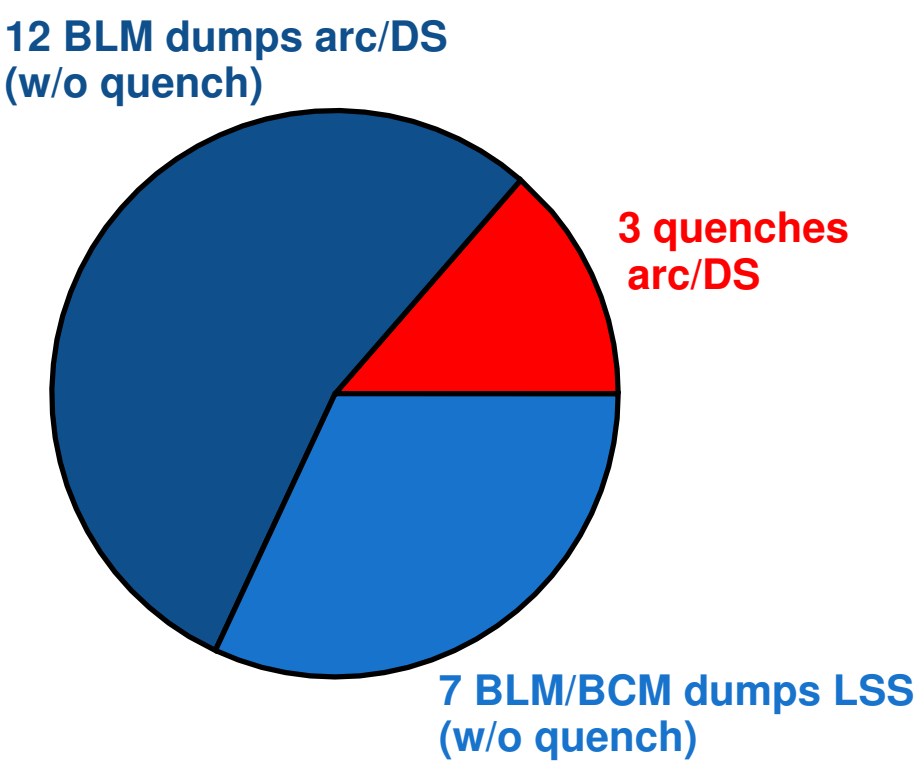


UFOs: **18 BLM/BCM dumps (w/o quench)**, **3 quenches**

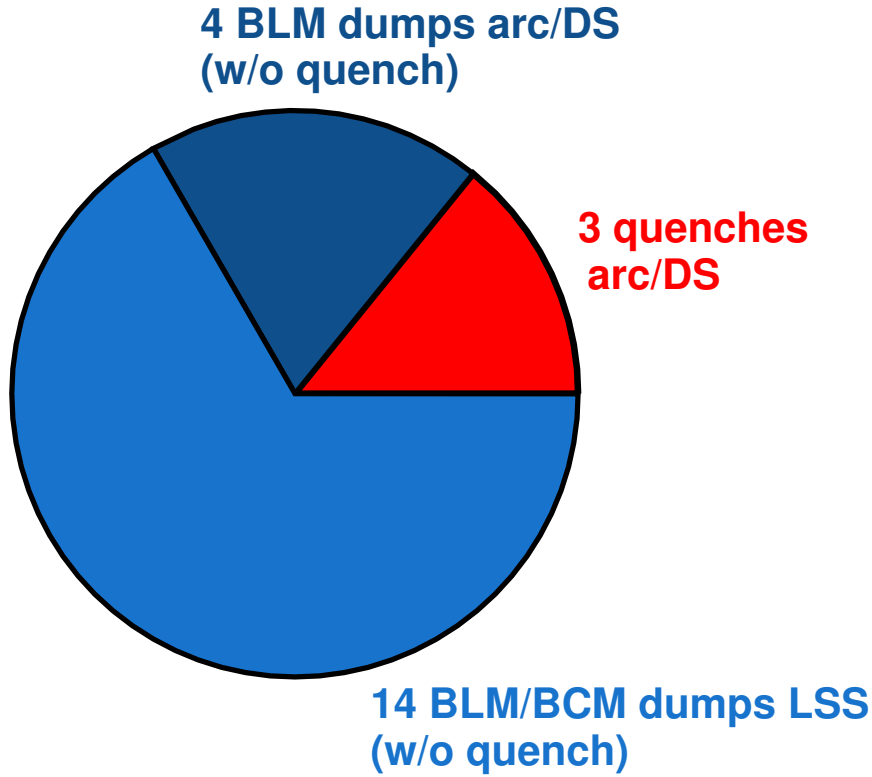
All beam modes (14 out of 21 events during SB).

2015 vs 2016: LSS $\leftrightarrow$ arc/DS

2015 (22 events - 700h SB)



2016 (21 events - 1800h SB)



$\Rightarrow$ **Evidently the # of dumps & quenches depends on how we set the thresholds**

$\Rightarrow$ **See next slides for more details**

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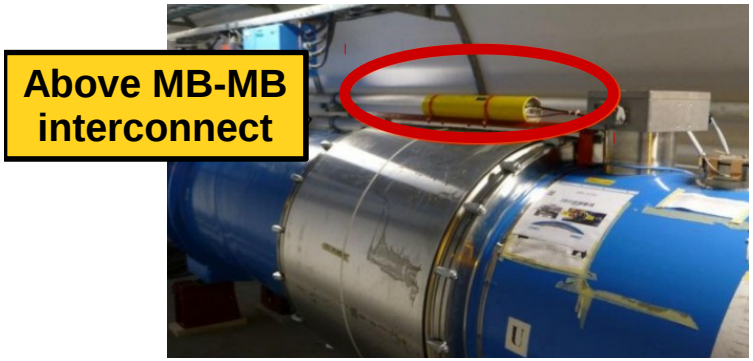

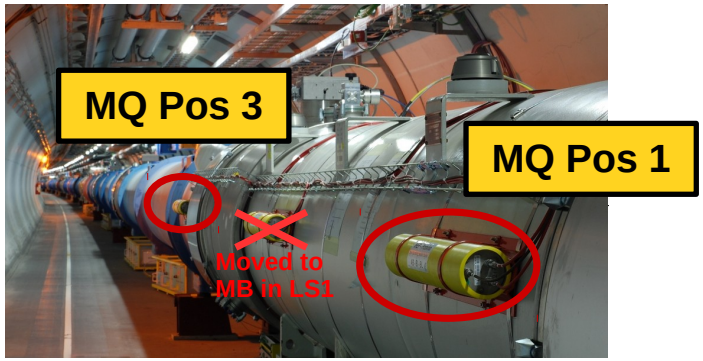

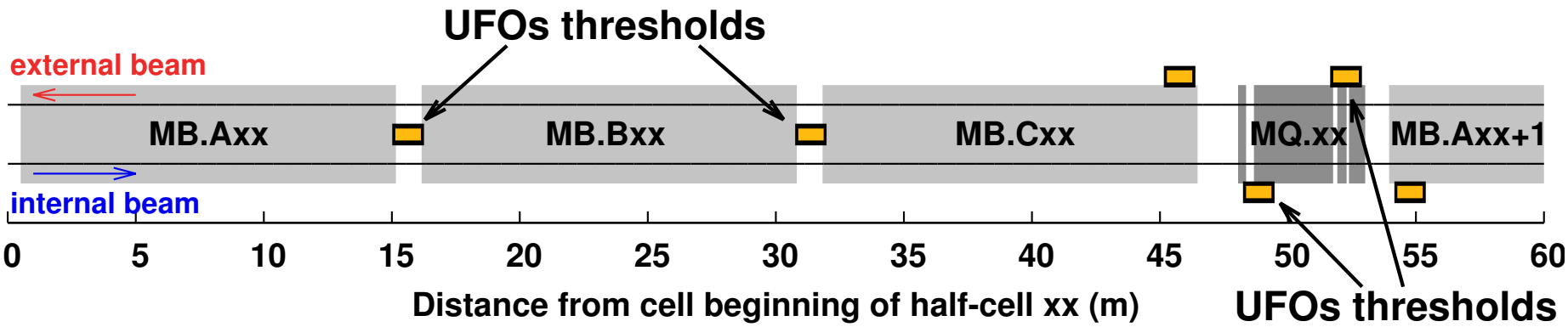

⇒ depending on the **UFO position** in the cell, BLM signals can **vary by a factor 3 - 4**

⇒ if we want to protect against UFO-induced quenches we also get **unnecessary dumps**

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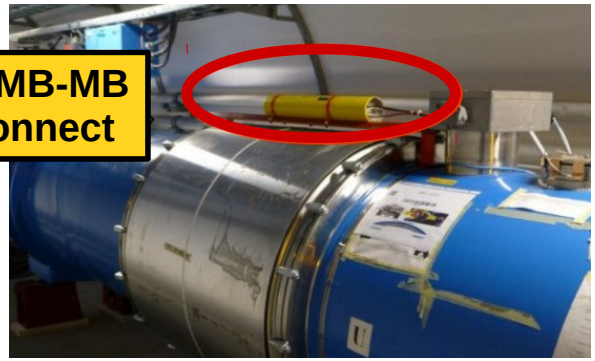

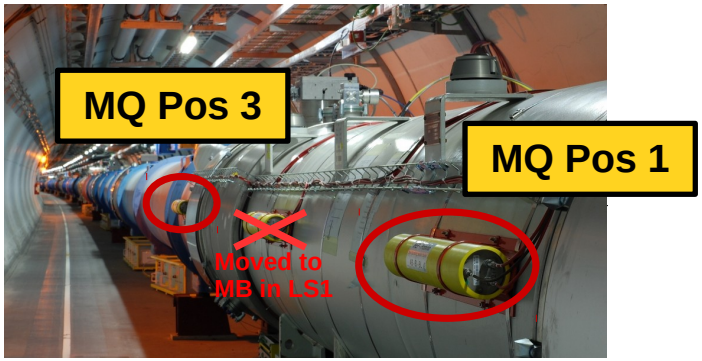

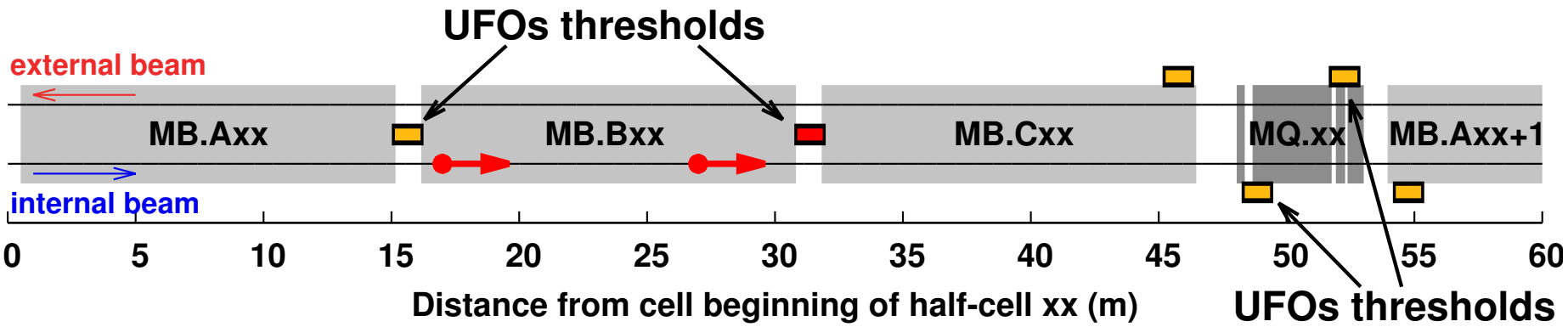

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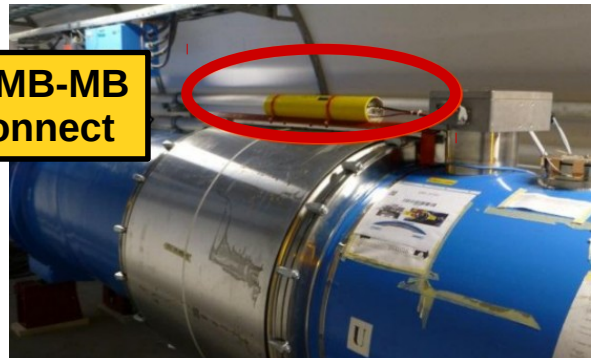

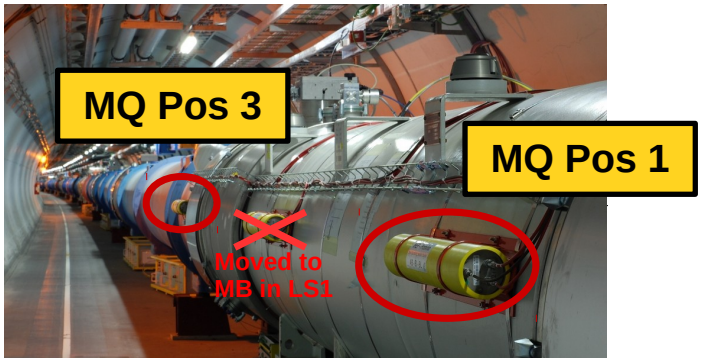

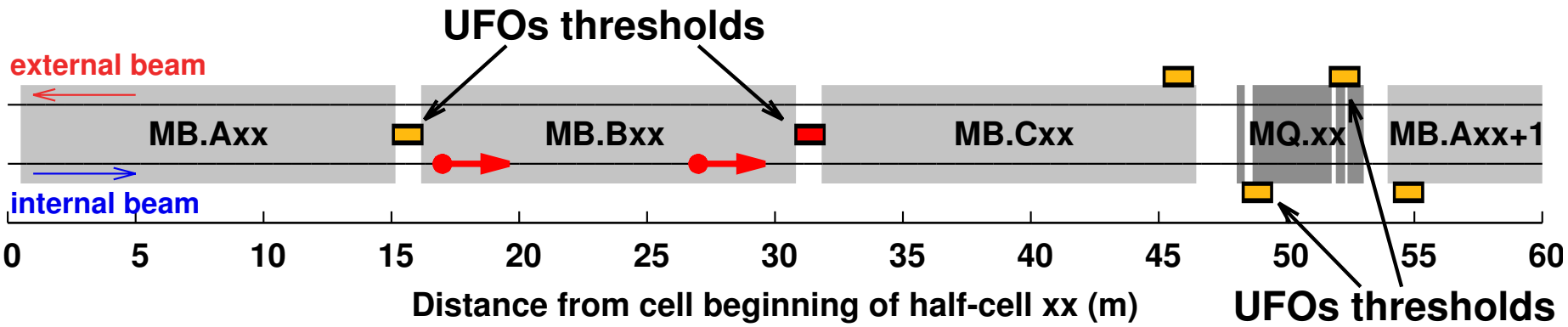

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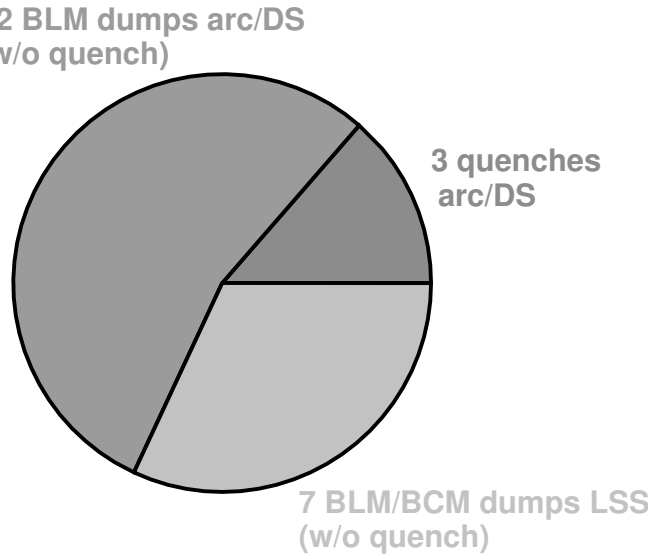
UFO-related threshold changes arc/DS 2016

- **What did we learn in 2015?**
  - Most of the UFO dumps were **unnecessary**
    - → *No quench would have occurred, except possibly in one case*
  - At the same time, thresholds were **still too high** to prevent most quenches
    - → *Thresholds ∼ at quench level, but it takes 1-3 turns until beam is extracted*
    - → *But: if thresholds would have been lower, would have had many more unnecessary dumps*

2015 (22 events - 700h SB)



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  - Availability: better to **avoid unnecessary dumps** than to prevent all quenches
- **Revised strategy in 2016 (B. Auchmann, Evian 2015, Chamonix 2016):**
  - Increased arc/DS thresholds to be **3 times above quench level**
  - Implemented in YETS15/16 (**>1700 BLMs**)

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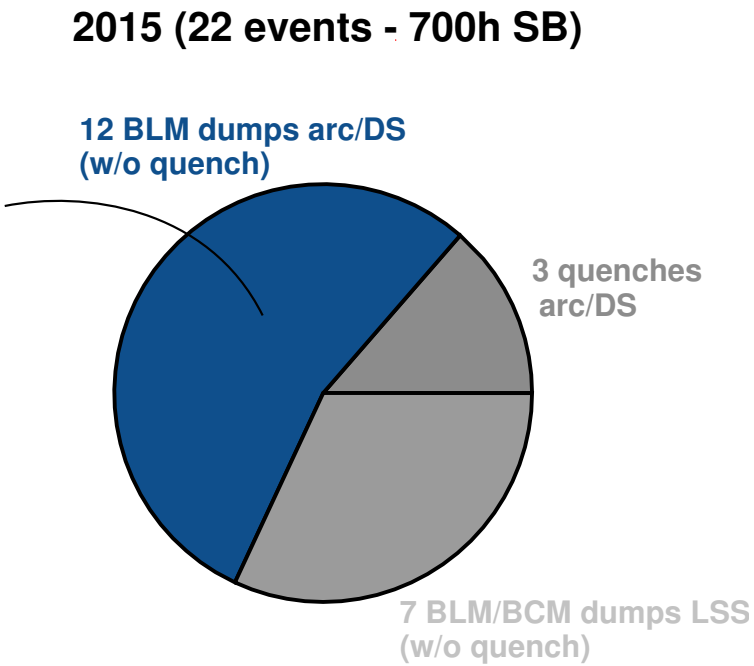

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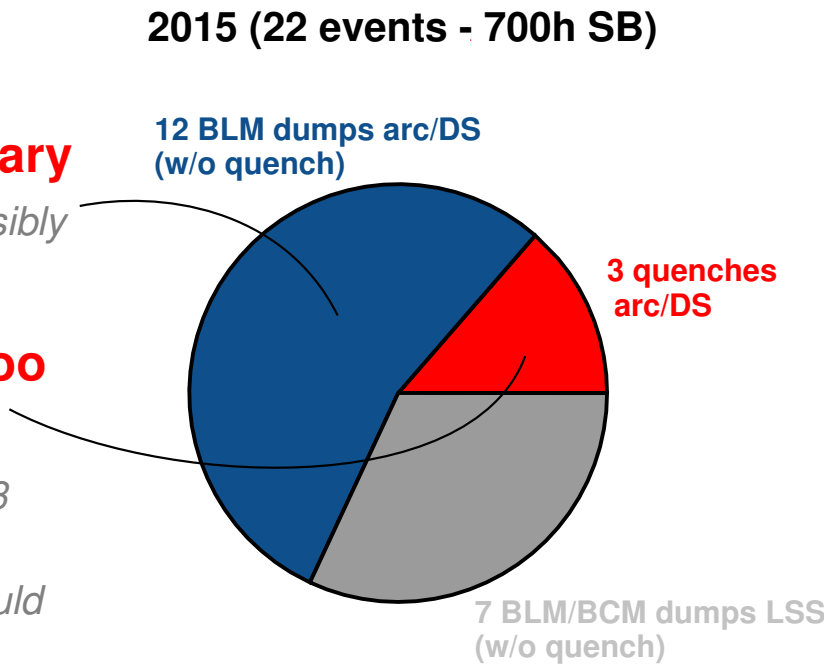

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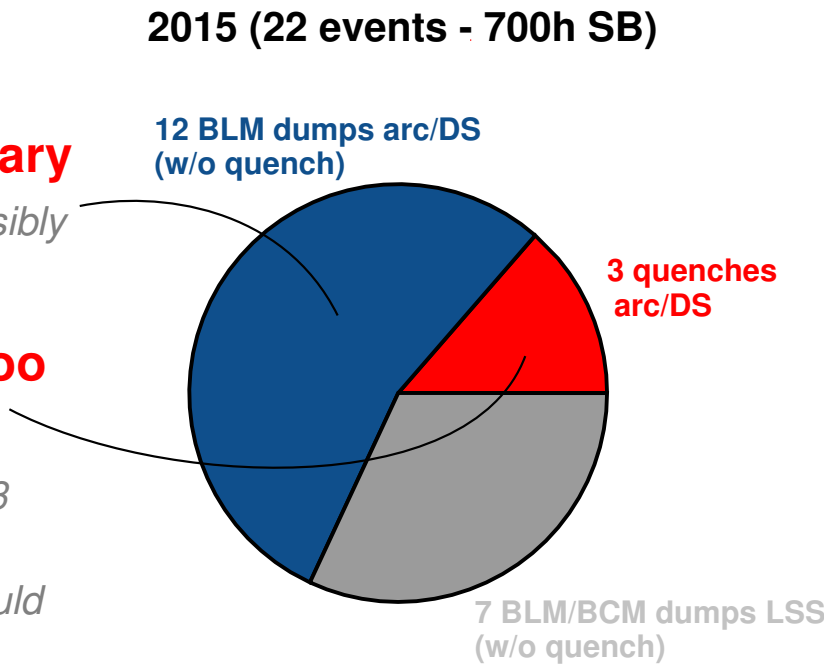

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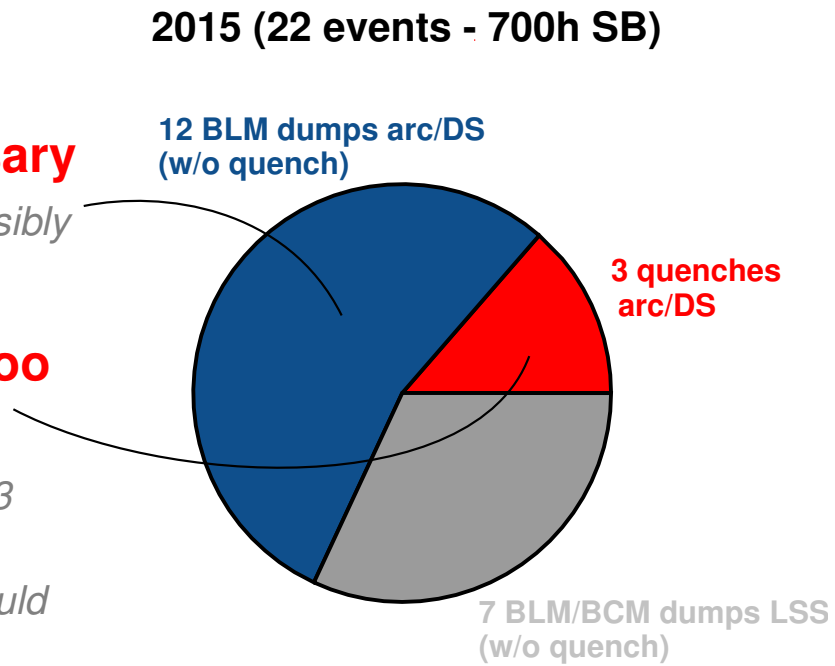

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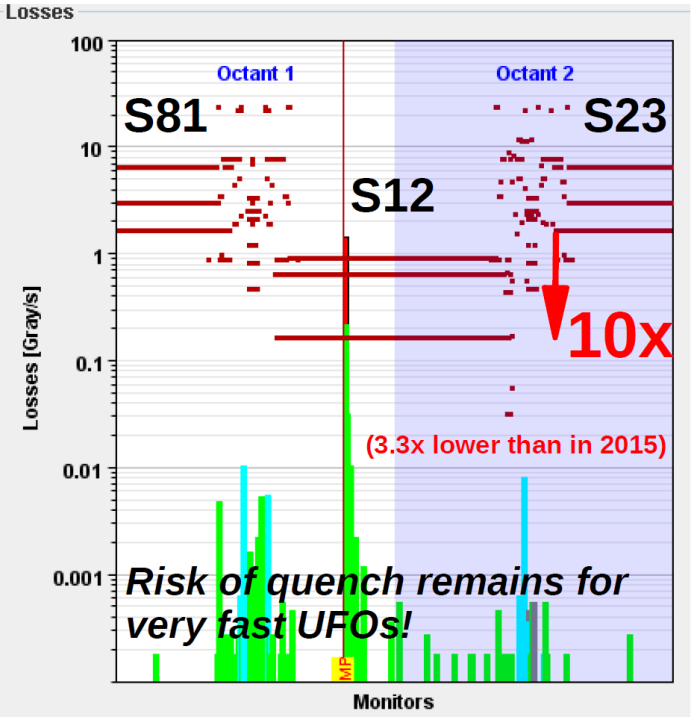
  - **Q10 magnets** (July 2016, **58 BLMs**)
    → *reduce the risk of symmetric quenches*
  - **S12** (August 2016, **217 BLMs**)
    → *reduce probability of UFO quenches and hence of a FPA which could damage MB.A31L2 (suspected inter-turn short)*



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  - The impact of Q10s/S12 on availability **was minimal** (3 dumps in S12)
  - The overall strategy of **higher arc/DS thresholds paid off**

	Actual 2016	If we would have kept the 2015 threshold	If we would have applied a quench-preventing strategy a la S12 in all sectors
Dumps	4	11	71*
Quenches	3	3	1 (UFO too fast)

* *Simple count of 2016 fills which would have been prematurely dumped if post-August S12 thresholds would have been applied in all sectors troughout the whole year. Multiple occurrences per fill are only counted once. Any consequences of premature dumps on availability and hence the number of fills is not reflected in this projection.*

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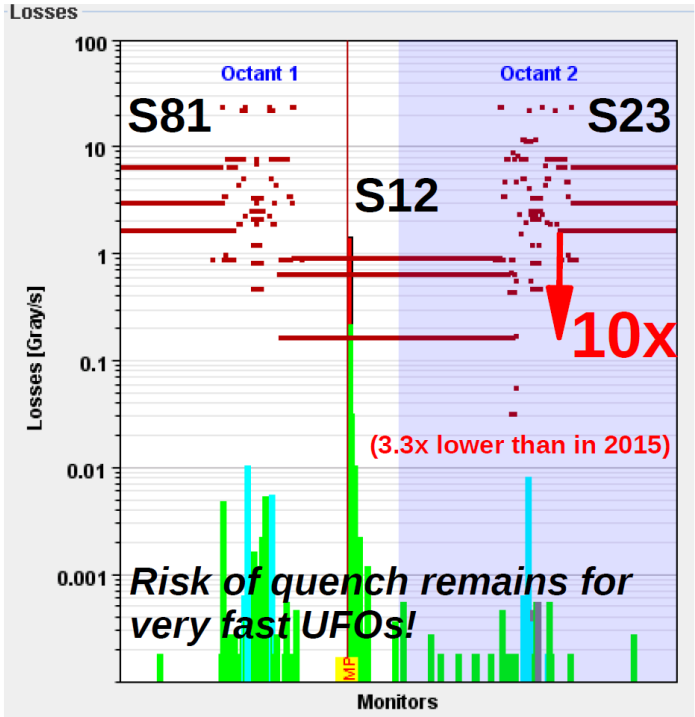

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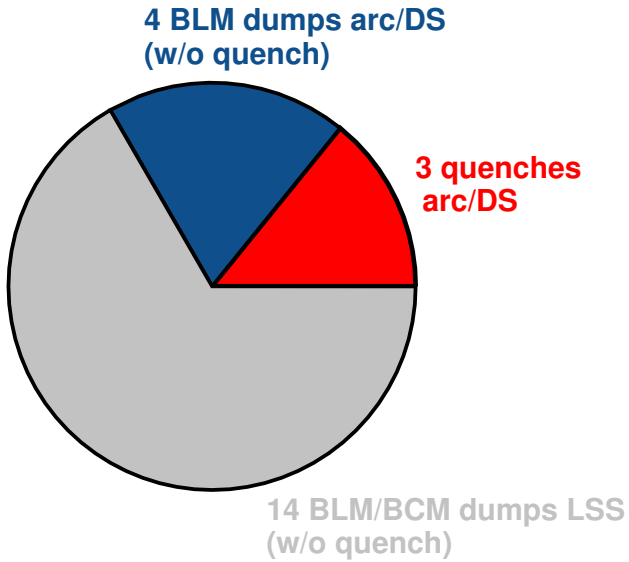

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UFO-related threshold changes LSS 2016

- **UFO dumps LSS 2016**
  - In **5 cases**, beams dumped by **Beam Condition Monitors (BCMs)**
    - → 1×ALICE, 1×ATLAS, 1×CMS, 2×LHCb
    - → UFOs around triplet/D1
    - → Ring BLMs below thresh. (3 cases: <10%)
  - In **5 cases**, dumps caused by UFOs in **cell 5L1 (B2)**
    - → UFOs must have been in TCL5-Q5 region
    - → Dumped at Q5/Q6/TCL6

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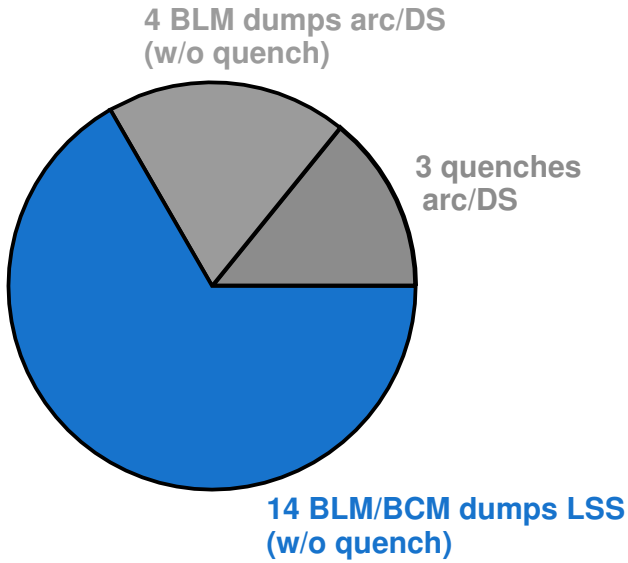
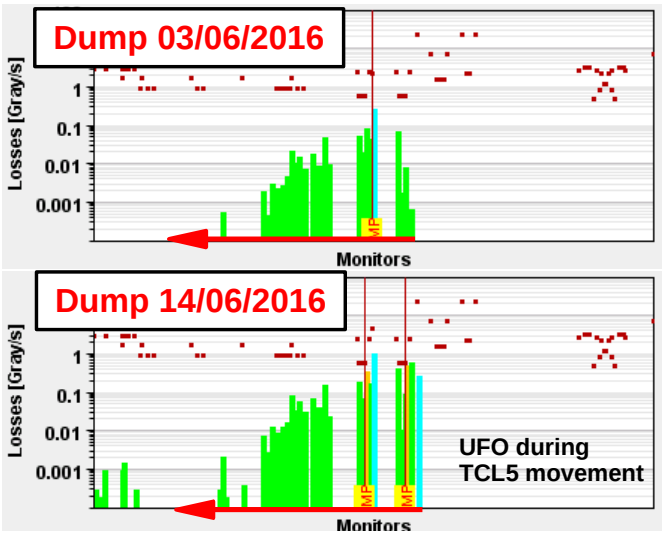
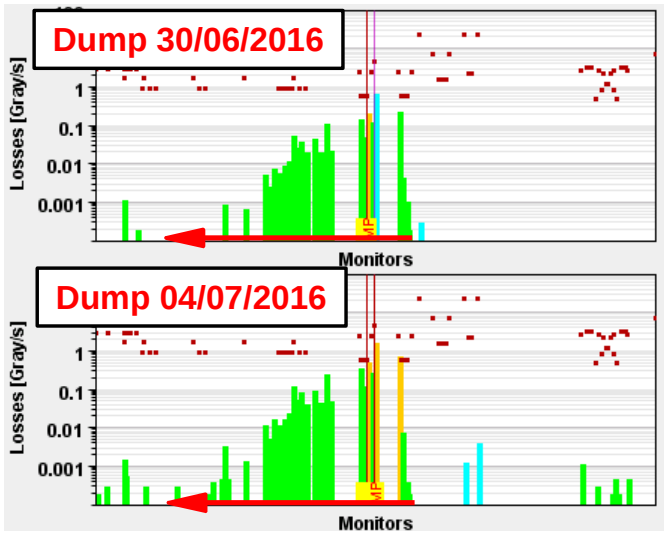
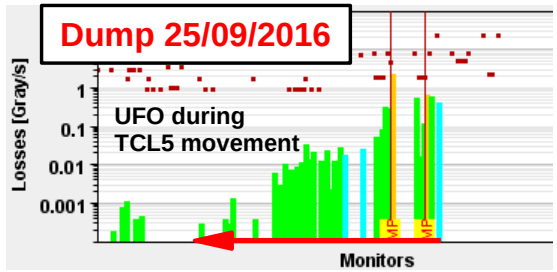






UFOs in TCL5-Q5 region (L1)



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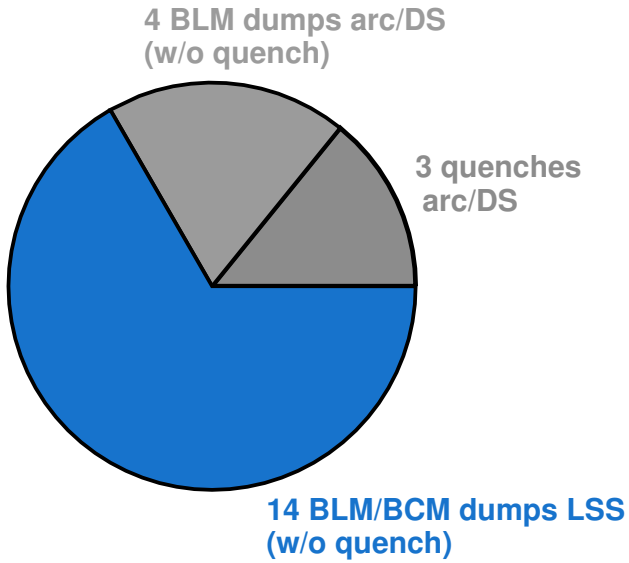

- **UFO-related threshold changes LSS 2016** (July 2016, **188 BLMs**):
  - Increased **IPQs** thresholds (up to Q6) to the **quench level**
  - Introduced UFO corrections at **TCLs**, **TCTs** and **TOTEM XRPs**

→ *only one dump in L1 after threshold increase*

→ *with the increased thresholds would have been avoided 6 dumps before 05/07*

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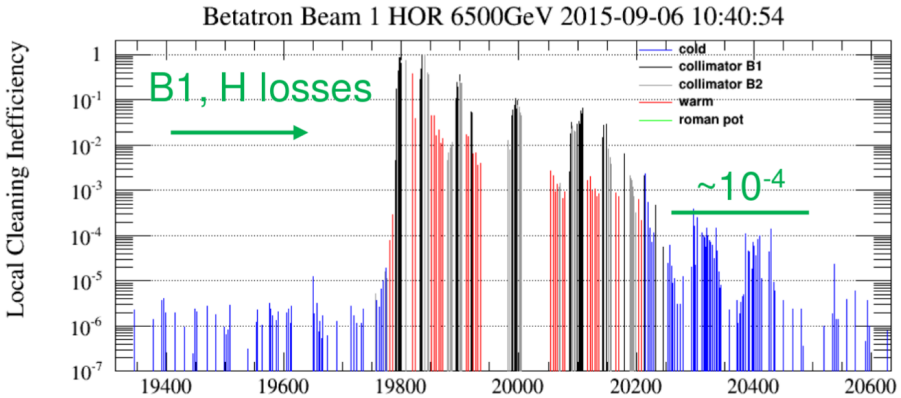
Towards customized Pb thresholds in IR7

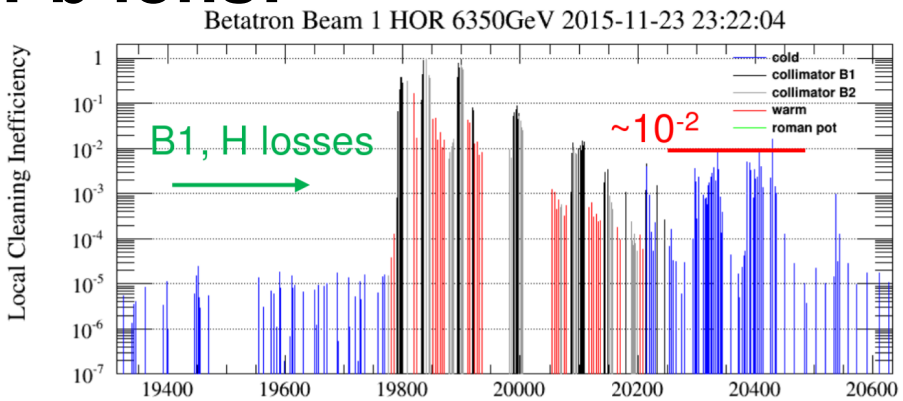
- **Cleaning inefficiency p vs Pb (IR7):**
  - About a factor 100 worse for Pb
  - With proton thresholds, would **dump first in DS** in case of Pb coll losses
- **New strategy in the 2016 p-Pb run:**
  - **Increased** thresholds in **DS** to the quench level (collimation QT 2015)
  - **Reduced** thresholds at selected **collimator BLMs** such that they dump first

→ *New dump hierarchy worked as intended (transverse instabilities: dumped at TCSGs instead of DS)*

Protons:



Pb ions:



A Mereghetti.

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UFO trends, dumps & quenches: 2015 vs 2016

UFO-related threshold changes for the 2016 proton run

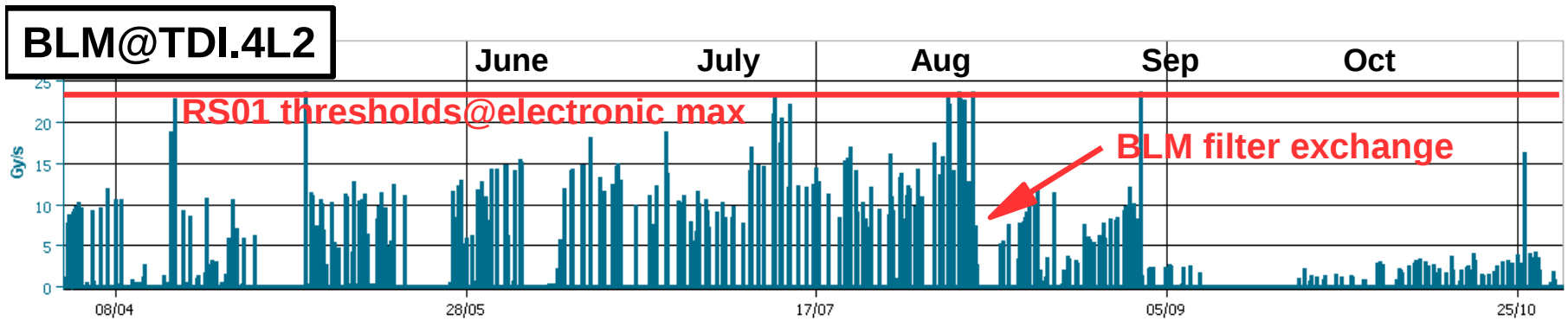
Threshold changes for the 2016 p-Pb run

Outlook 2017

Backup

2016 threshold changes for injection and collimation losses

- **Injection losses at TDI (satellites)**
  - With BCMS beams, close to dump thresholds during injections (satellites)
  - Had to exchange BLM filter as TDI thresholds were already at electronic max.
    ($\rightarrow$ in addition, injection cleaning extended to rising MKI pulse edge)



- **Betatron collimation losses:**
  - Thresholds tuned in 2015 to dump at:

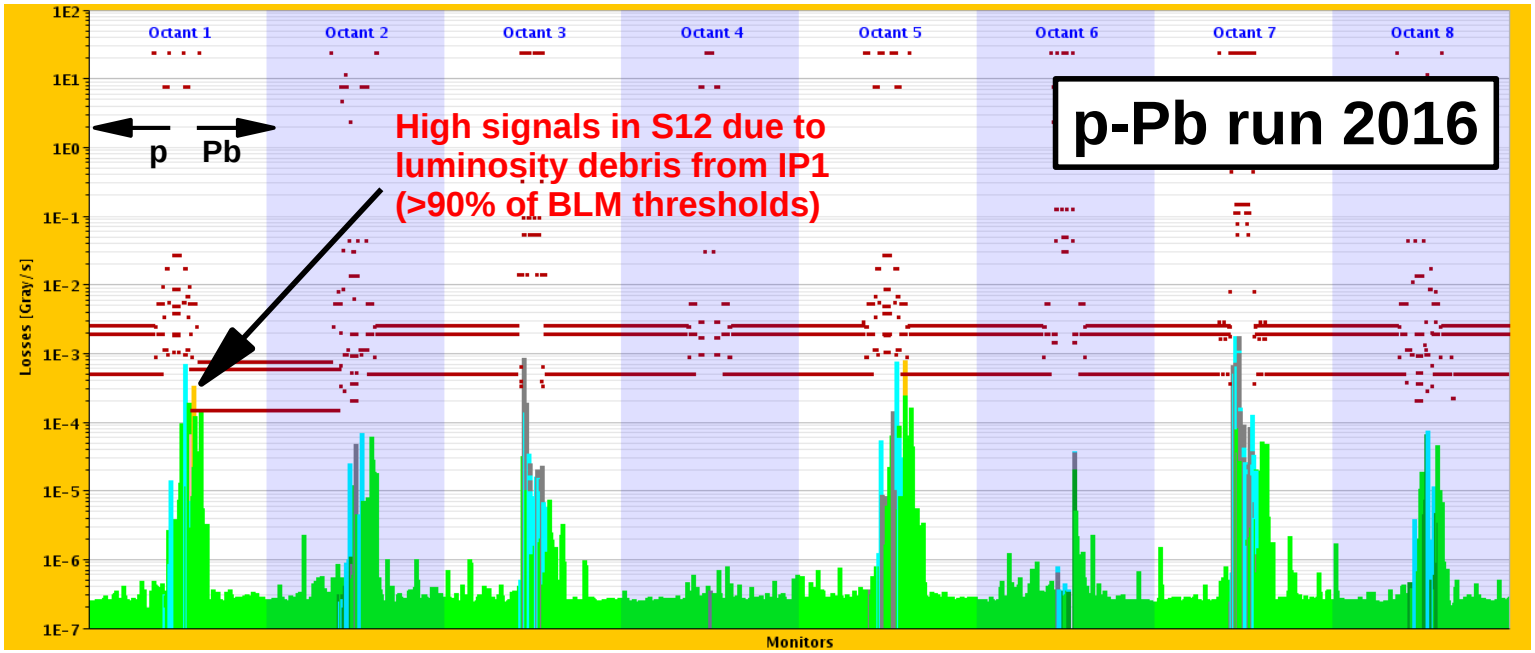
    $\rightarrow$ **200 kW** for **1-10 sec/40 kW** for **steady-state losses**
  - Tighter collimator gaps in 2016:

    $\rightarrow$ BLM response $\uparrow$ (up to 6$\times$@TCTs)

    $\rightarrow$ Required threshold corr. in IR7 and at TCTs to re-establish 2015 policy

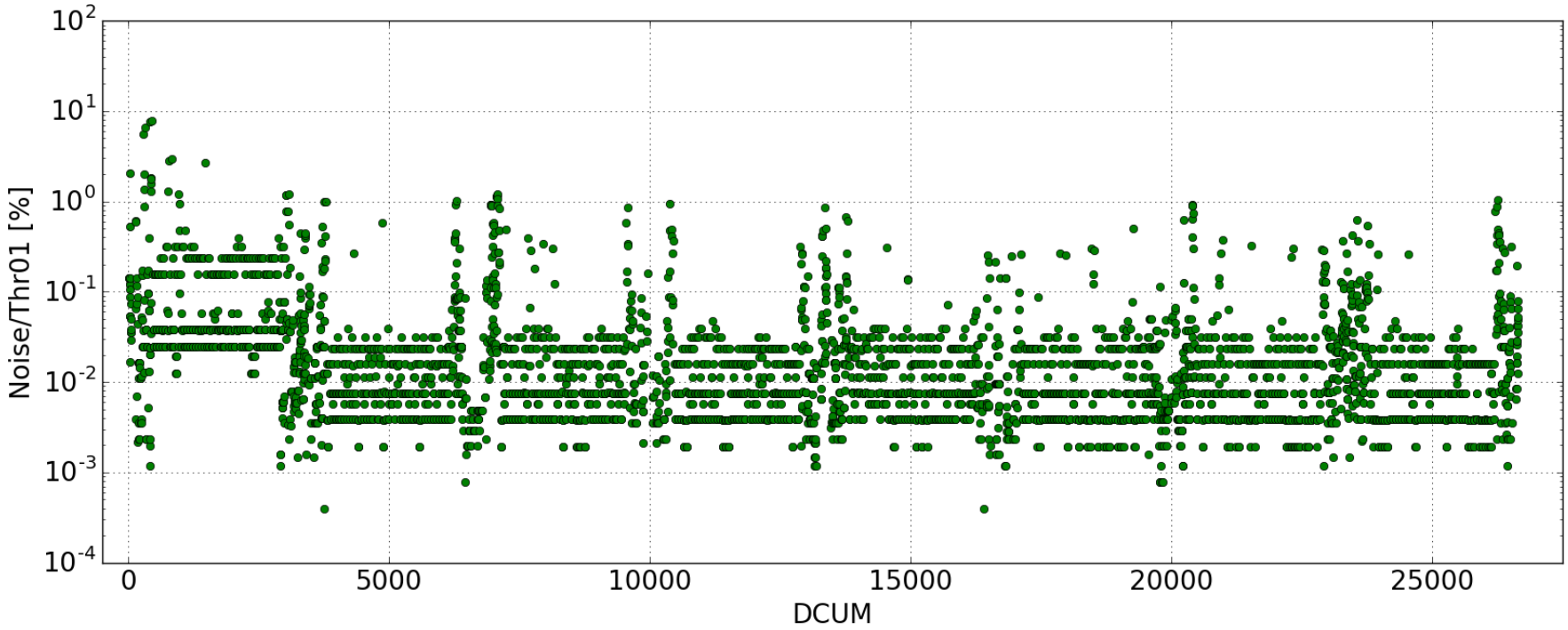
2016 threshold changes for luminosity losses

- **Luminosity losses:**
  - **Proton run:**
    - → policy: debris-induced signals $\leq$ warning level (avoid flood of messages)
    - → several threshold adjustments needed (triplet&TCLs)
  - **p-Pb run:**
    - → record lumi in p-Pb run & low S12 thresholds → **$>$90% in 8R1**
    - → decision together with MPP not to increase thresholds (local loss of certain ion species?)



Threshold/noise ratio in 2016 (for 7 TeV thresholds)

- **Noise:**
  - BLM data accumulated through out this year's proton run between August and September (200 hours of BLM RS01 data in absence of beam)



Courtesy of C. Xu