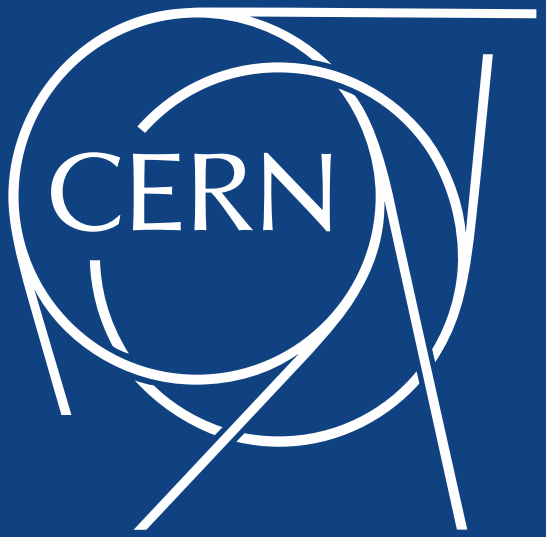
CERN

BLM Thresholds and Damage Limits for Collimators

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Aknowledgements: B. Auchmann, R. Schmidt, D. Wollmann, M. Zerlauth

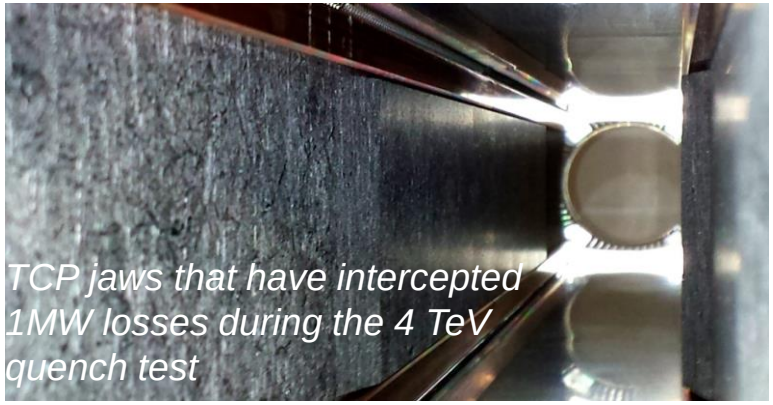
Overview

- Introduction;
  - Strategy of BLM thresholds at collimators
- 2015: updates;
  - Collision debris (IR1/5/8);
  - Operational scaling (IR7);
  - UFOs (IR1/5/8);
  - Bits here and there;
- 2016: plans;
  - Start-up;
  - Review of thresholds at collimators: missing ingredients and work in progress;
- Conclusions;

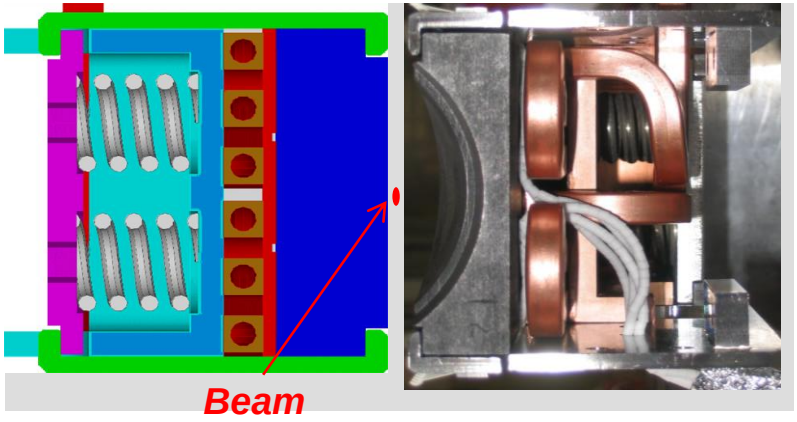
Introduction

Collimators are amongst the most robust LHC components

- Ok for injection failure of 288x1.15x10^{11}p at 450 GeV: tested in TT40 (2004/2006);
- Ok for up to 8 nominal bunches at 7 TeV (simulations for pessimistic conditions);
- Designed to handle 500kW beam losses in IR7 over 1-10s - achieved 1 MW in 2012!



TCP jaws that have intercepted 1MW losses during the 4 TeV quench test



Need for BLM thresholds at collimators because:

- Collimators are very high precision devices. Their functionality can be jeopardized even in absence of apparent jaw material damage;
- ”Operational thresholds” at collimators: large losses there can be exploited to detect earlier undesired loss conditions;
- Some LHC metallic collimators are less robust and can be damaged.

Setting BLM Thresholds at Collimators – Basics

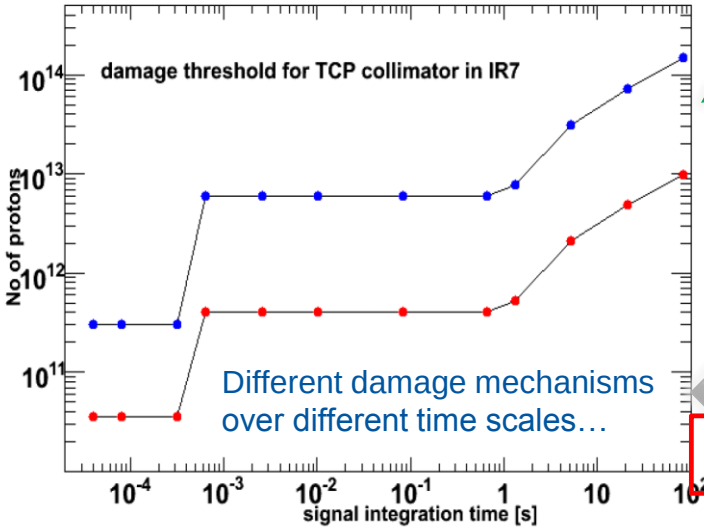
EDMS 995569 (2008)

TCP collimators

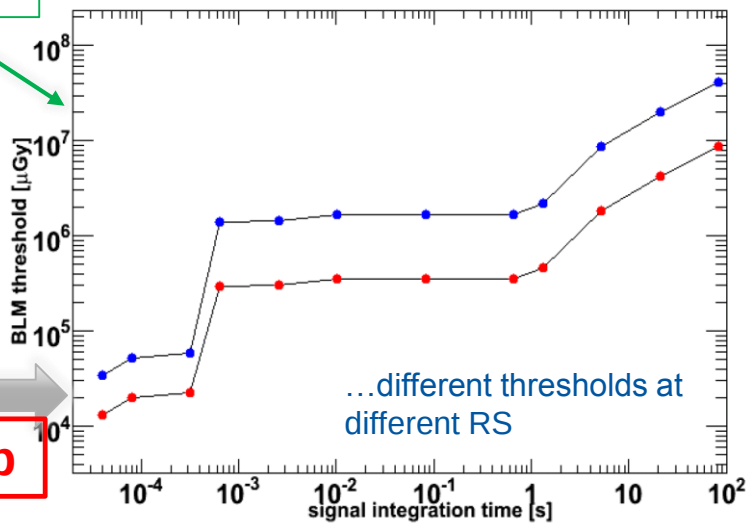
From ``damage'' limits…

450 GeV
7 TeV

… to BLM thresholds



Gy per p

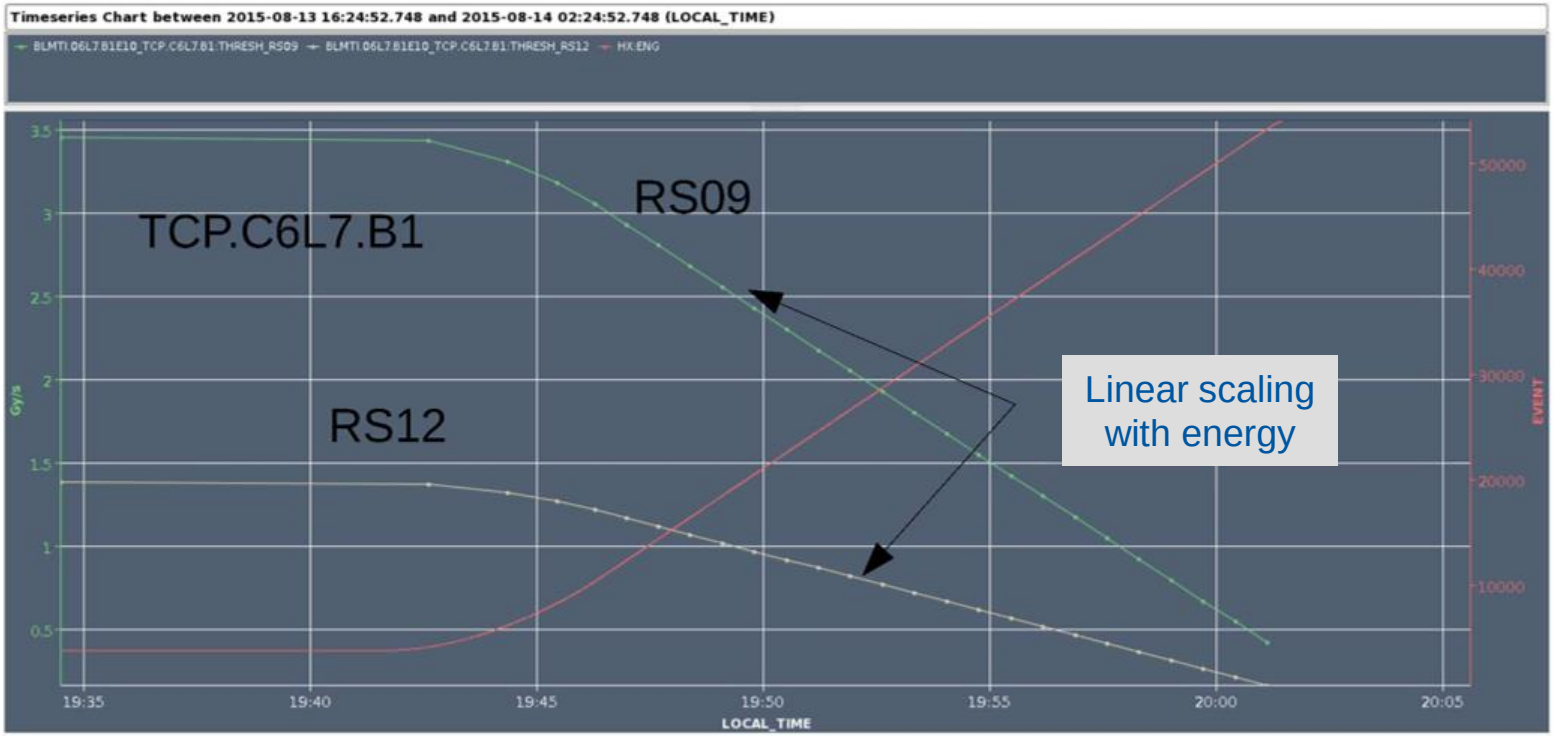


Other collimators: ``material'' factors (lower limits), to take into account different material properties and impact of secondary particle showers;

2015 – Experience so Far

2015 Start-up

BLM thresholds as at the end of Run I have been scaled by energy (from 4 TeV to 6.5 TeV) following present energy dependence

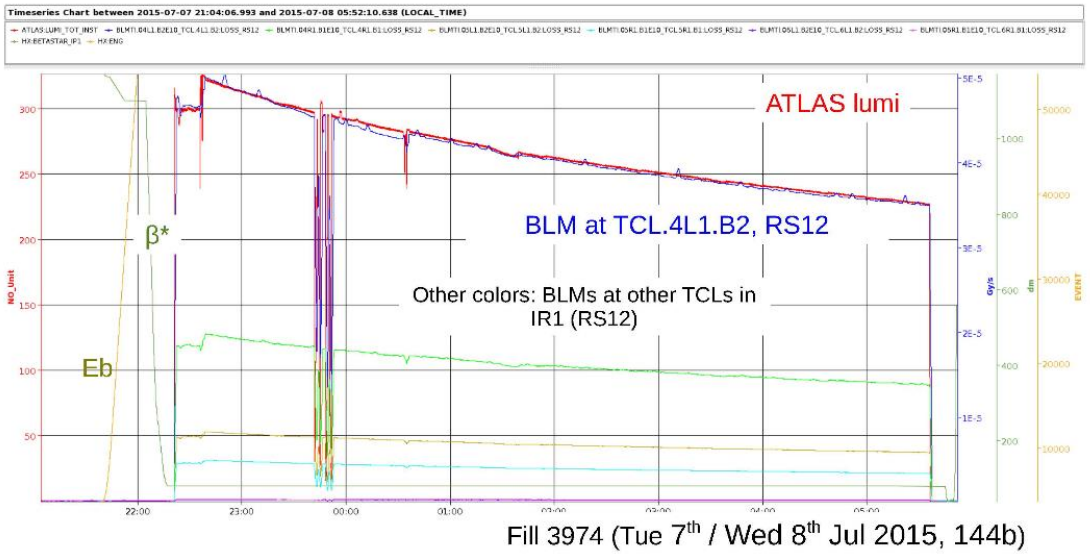


Collision Debris

Collision products from **experimental IP**s:

- secondary particles from pp collisions scatter and reach BLMs;
- Long RSs mostly affected: debris signal has time to pile up;
- Affected collimators: **TCT**s and **TCL**s (W/Cu);

July 2015



The time evolution of RS12 faithfully reproduces the one of the luminosity

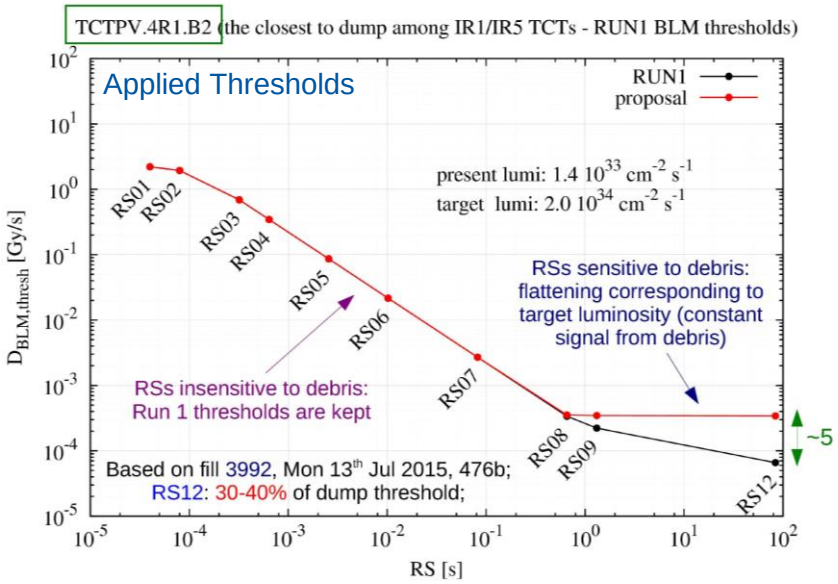
IP	Target Lumi [cm^{-2} s^{-1}]
IP1 & IP5	10^{34}
IP2	$9x10^{30}$
IP8	$6x10^{32}$

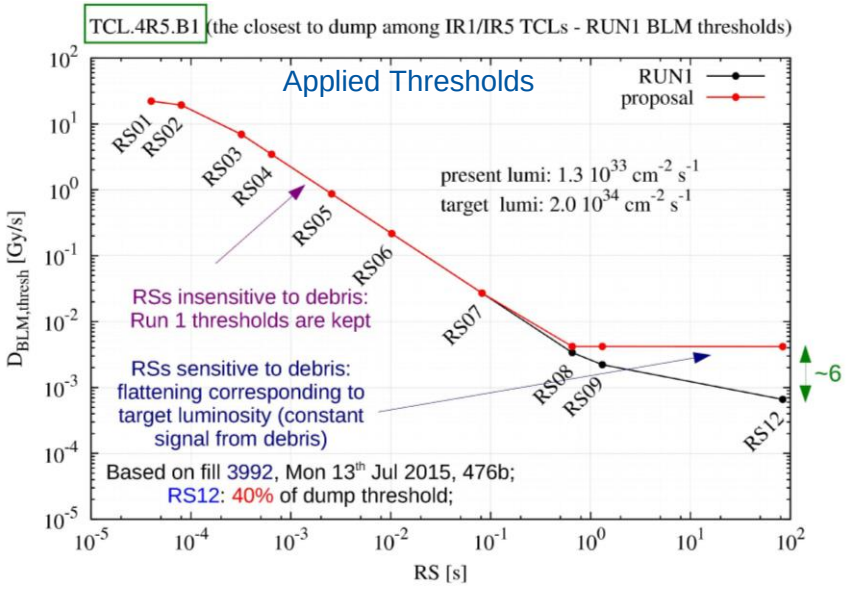
margin: factor x2 (on top)

The cure:
To scale BLM readouts at luminosities present in machine to target ones, thus extrapolating the new thresholds;

Collision Debris (II)

Extrapolation of new thresholds: FT correction + flattening out long RSs





Changes documented in BLM **ECR 0036**

Operational Scaling

Design limits of the **IR7** collimation system:

- steady state: **100 kW** max beam losses;
- Δt ~1-10s: **500 kW** max beam losses;
- Δt <1s: energy deposition (different regimes) limited to avoid plastic deformation (permanent effects);

2012: BLM thresholds at collimators set on the basis of loss maps ("operational scaling");

- to avoid useless dumps, i.e. in presence of losses that the collimation system could actually stand;
- to protect collimation system;
- a factual way of dealing with dependence of BLM signals on:
  - Collimator settings / jaw material;
  - Cross-talk from collimators close-by;

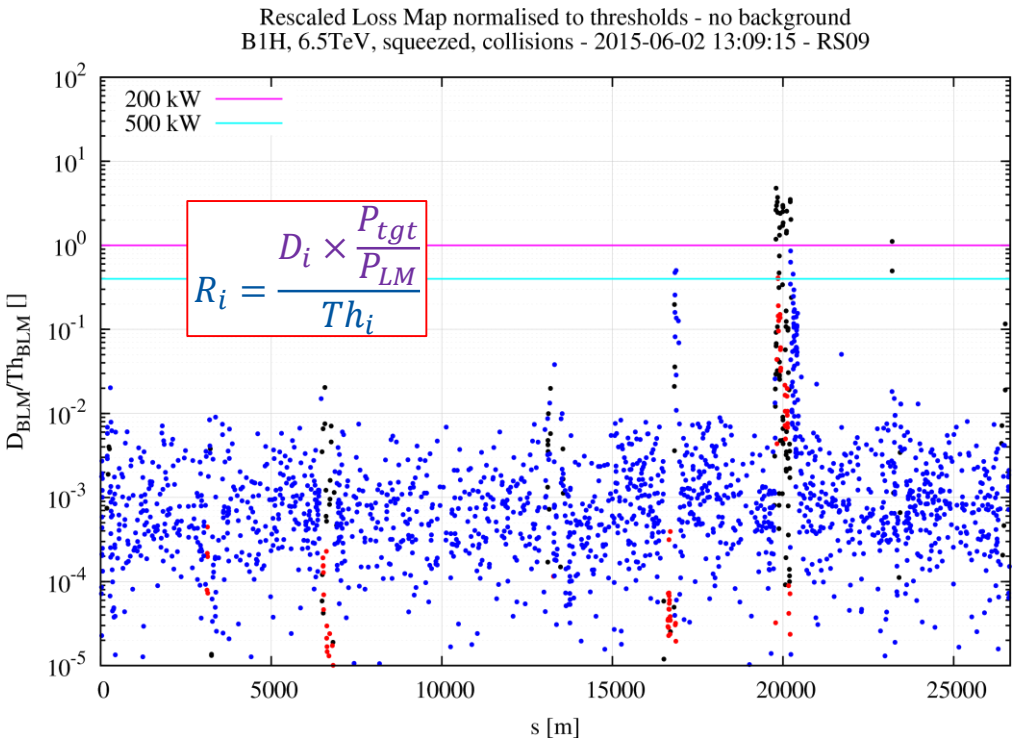
2015: new beam energy (higher than RunI);

Operational scaling has been repeated to update thresholds (Aug 2015);

Operational Scaling (II)

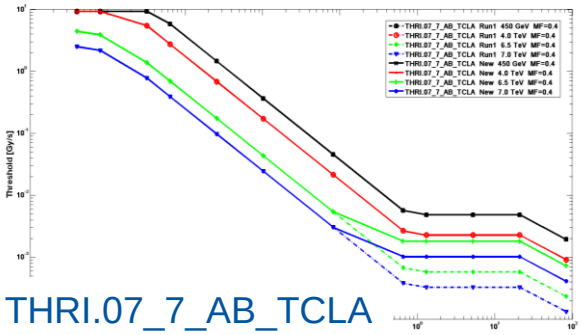
Characteristics:

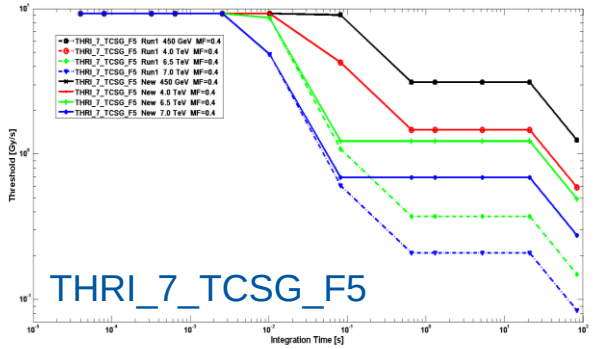
- *Extrapolate* from qualification LMs BLM signals at maximum allowed power loss;
- FT corrections + flattening out of long RSs (RS09-RS11) – i.e. let's keep changes at minimum;
- MF=0.4 – i.e. let's allow 40% of the system limit;
- BLMs at elements other than collimators had thresholds changed: MQY (IR6), MQTL/MQWA/MQ (IR7);

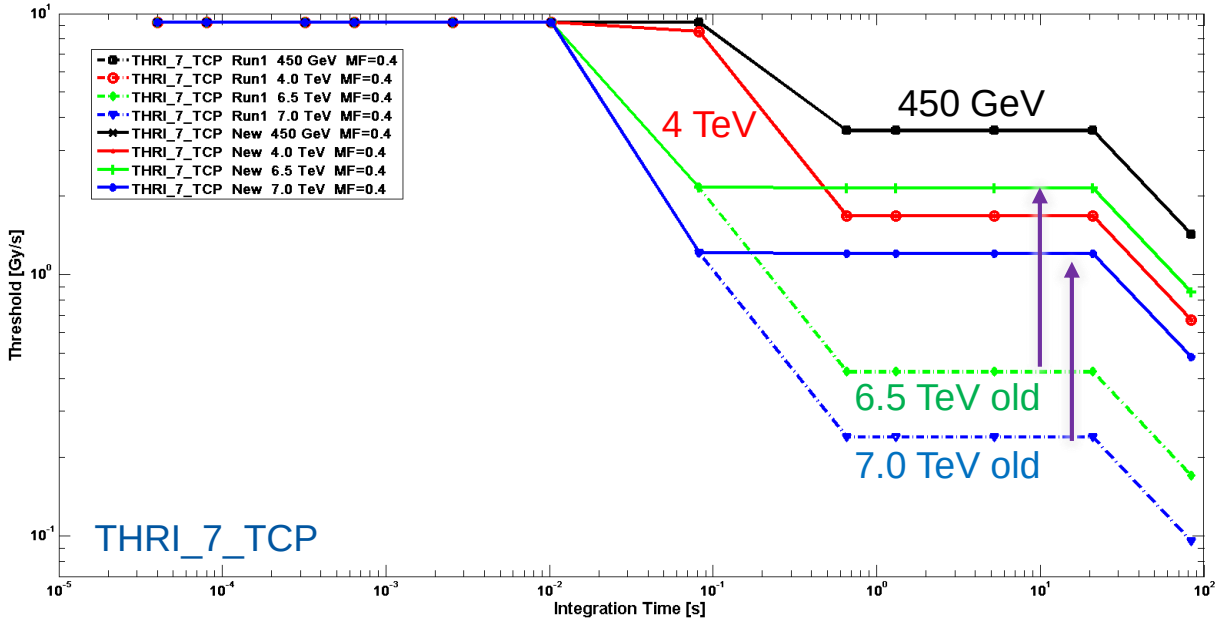


Operational Scaling (III)

FT correction + flattening out long RSs







Affected collimators: all IR7 ones
Changes documented in BLM **ECR 0038**

UFOs in LSSs

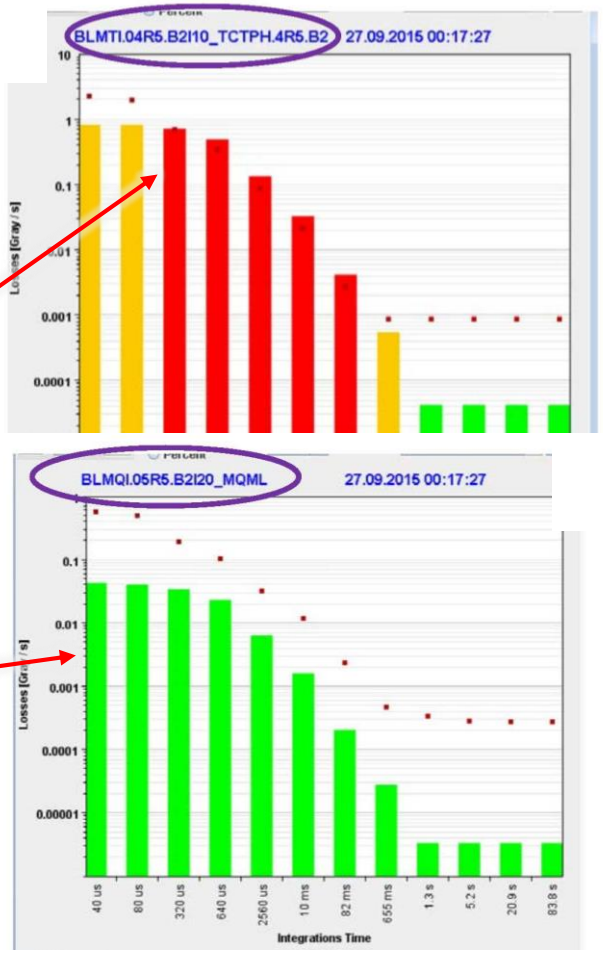
Oct 2015

Two **UFO** beam **dump**s triggered by BLMs at **TCT**s:

- Fill 4423, 26th Sep 2015, 12:31, L1;
  → RS06/RS07 @ 110% of thresholds;
- Fill 4426, 27th Sep 2015, 00:17, R5 – actual case used for setting new thresholds;

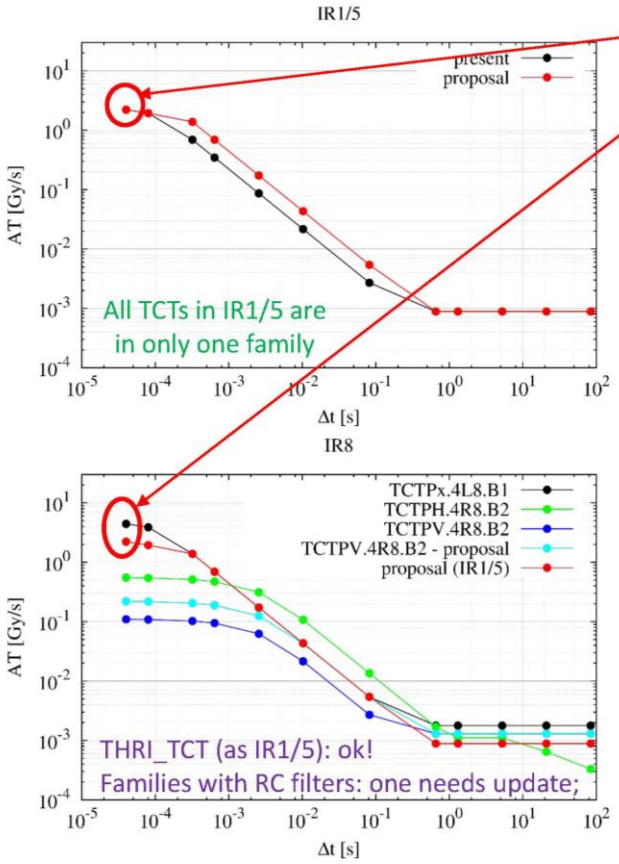
- Cure: factor x2 increase in thresholds on RS03 – RS07;

- UFO actually happening at the upstream MQM, but no warning level was reached there;

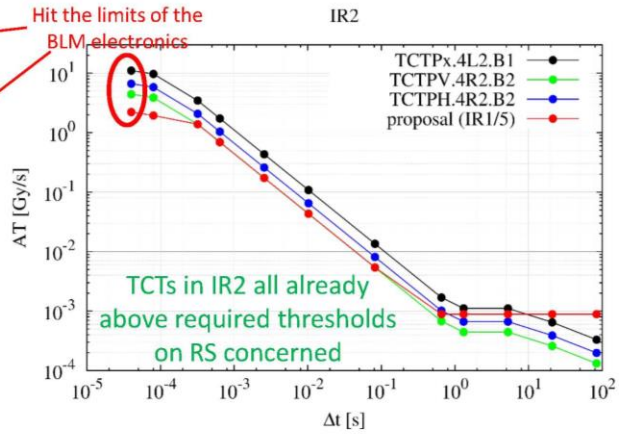


UFOs in LSSs (II)

Oct 2015



Hit the limits of the BLM electronics



UFO events: dump triggered by TCT BLMs;

- Mainly RS03-RS07;
- At FT;

Proposal:

- Increase BLM thresholds at TCTs at RSs concerned (RS03-RS07);
- Only at FT – TCTs are the most delicate of all collimators;

Changes documented in BLM **ECR 0040**

BLM Family	Collimators
THRI_TCT	All TCTs in IR1/5 and L8
THRI_TCTVB_OI_RC08	TCTPV.4R8.B2

Bits (Here and There)

- MF doubled at TCL.6 in IR5 (0.1 → 0.2);
  - Updated TCL configuration in IR5 for Totem XRPs (protons): TCL.5 moved out (35σ) and TCL.6 moved in (20σ);
  - Debris signal on TCL.6 BLMs getting too close to dump threshold;
  - Required change of BLM thresholds → strategy: change of MF;
- MF doubled at TCTPH.4L2.B1 (0.5 → 1.0);
  - High ion losses in IR2 (^{207}Pb from left jaw of IR7 TCP.H);

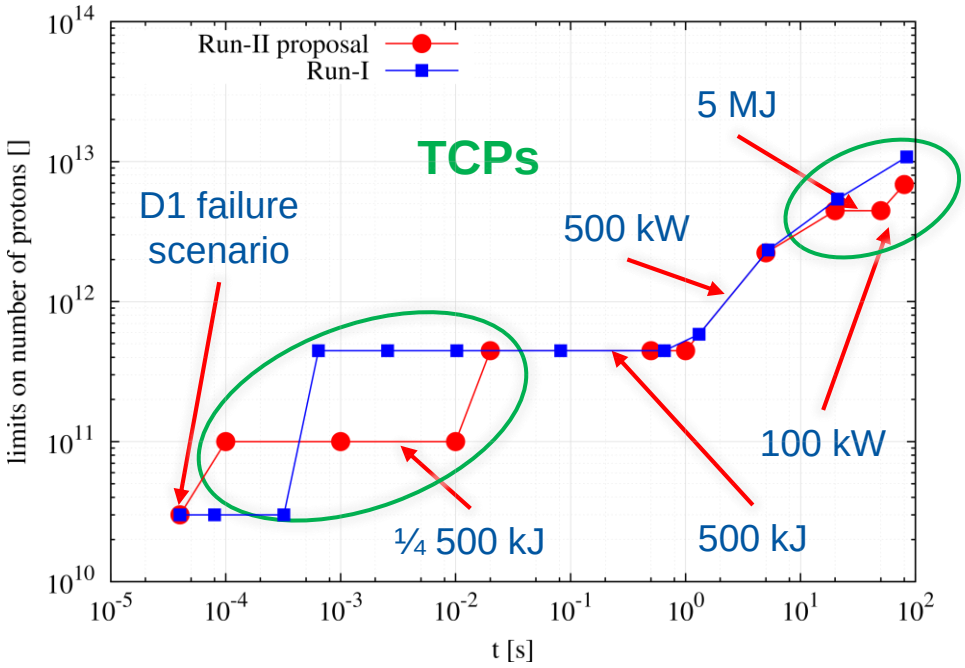
2016 – Proposals

Start-Up in 2016

- Default plan: let's deploy the thresholds of BLMs at collimators as at the end of the 2015 proton run – optimization based on operational experience;
- Actual plan: during YETS 2015-2016, review of thresholds at all collimators:
  - More accurate curve of limit number of protons allowed to impact collimator jaws:
    - energy deposition and thermo-mechanical analyses;
    - limits of protons on jaws;
  - More accurate evaluation of BLM signal per proton:
    - Metallic collimators;
    - A bit of sensitivity on beam energy;
  - (ions);

Start-Up in 2016 – Proton Limits

Curve of proton limits on TCPs already available!



BLM families at non-TCP collimators

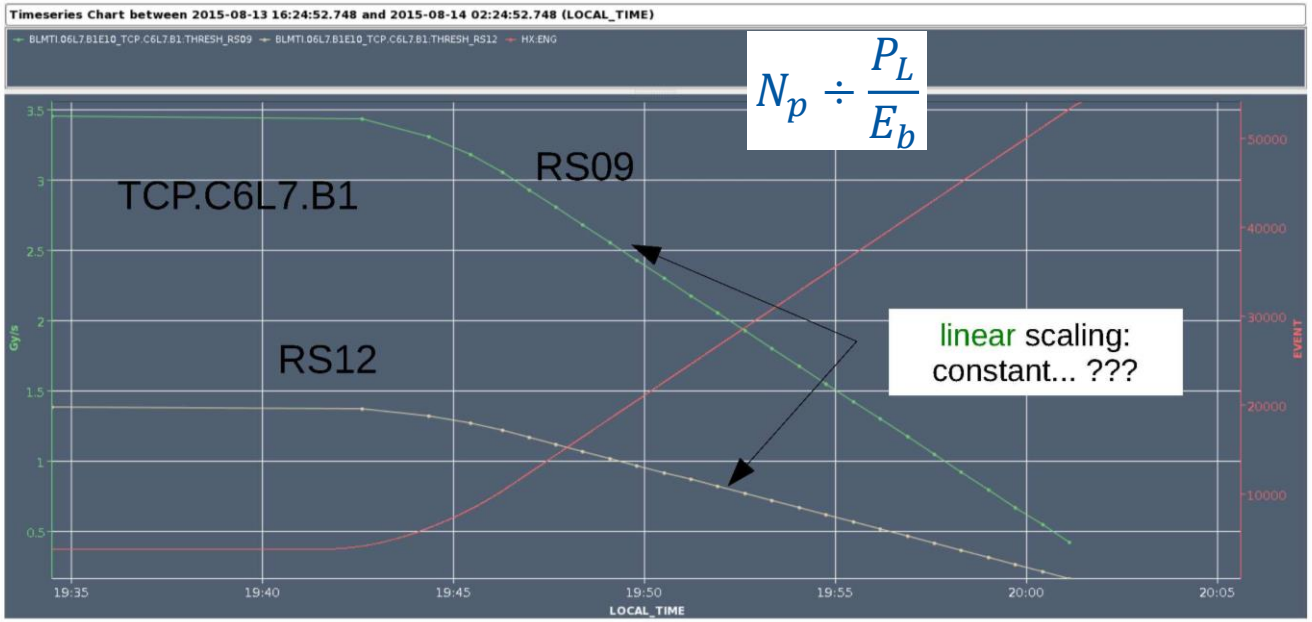
Other Families	Scal. Fact. Run 1	Scal. Fact. Run 2
TCSGs	10	10
Cu jaws	200	1500
W jaws	2000	2500

→ missing ingredient: more refined evaluations of signal-per-proton;

BIQ 2014 & 8th BLMTWG

Start-Up in 2016 - Miscellanea

Re-evaluation of BLM signal per proton includes sensitivity on beam energy;



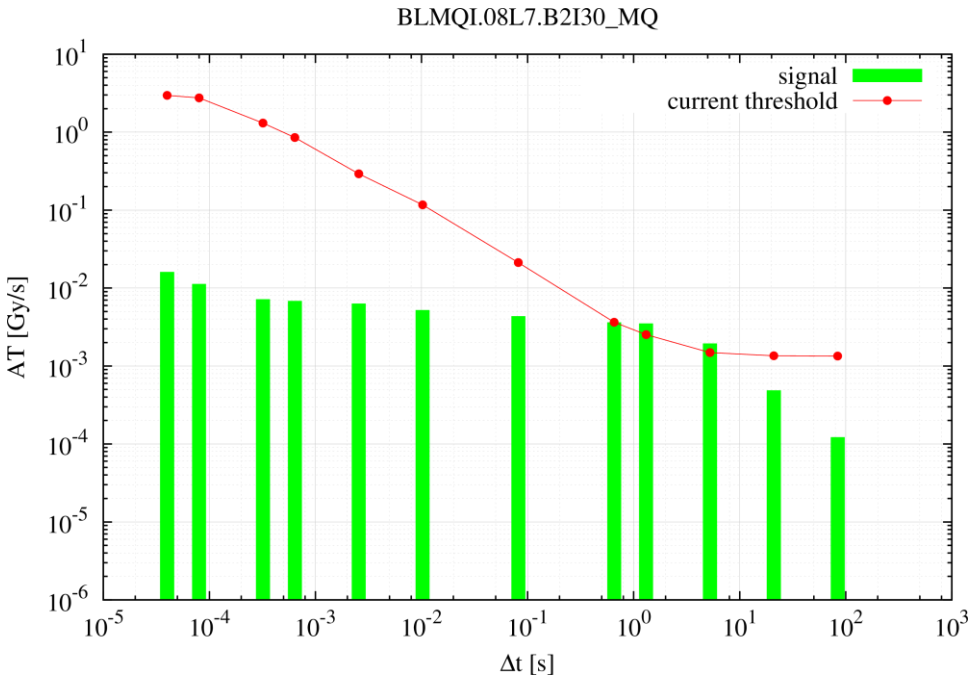
Furthermore:

- ABD scenario does not drive present work: too specific scenario!
  - New TCT materials → HL-LHC framework;
  - 5th axis → not in YETS 2015-2016!
- Better MKD-TCT phase advance; → see R. Bruce talk (Thu Morning);

Quench Tests

- Results might be of help in tuning BLM thresholds in IR7 DS;
- We know that:
  - no quench of IR7 DS cold magnets with ~600kW proton beam losses;
  - quench of IR7 DS cold magnets with ~14kW ion beam losses (on-going analysis);
- Leakage from IR7 is a scenario different than UFOs & dynamic orbit bump;

→ Maybe it could say something on other time-scales…



BLM signals and operational thresholds at BLMQI.08L7.B2I30_MQ at dump (collimation proton quench test)

Conclusions

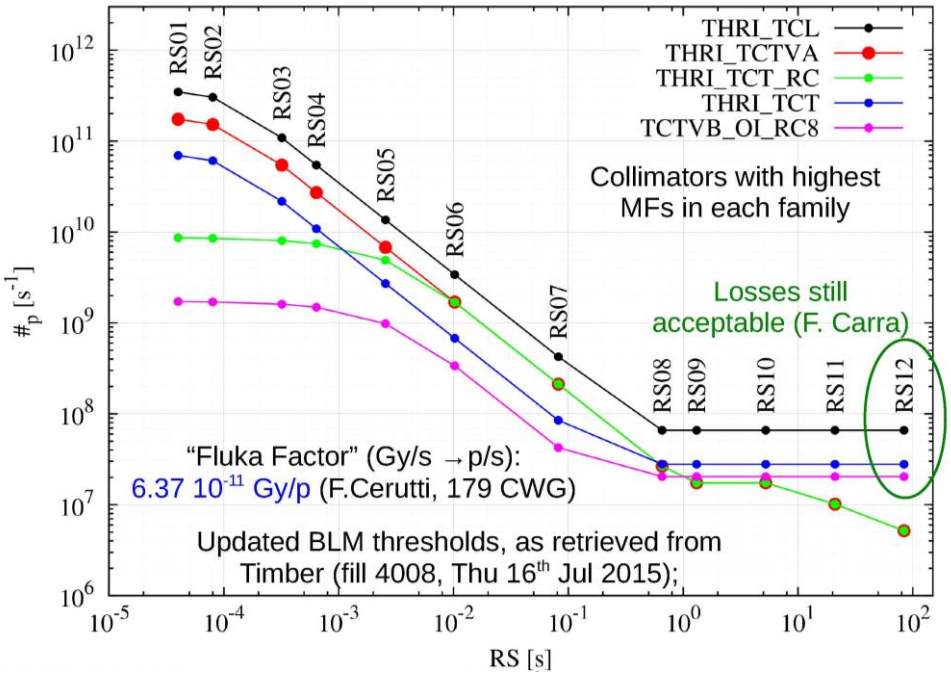
- Overview of BLM thresholds deployed in 2015, and their updates (debris / operational scaling in IR7 / UFO events in experimental IRs);
- 2016: review of BLM thresholds at collimators:
  - New curve of proton limits at TCPs and scaling factors for non-TCP collimators (already available);
  - Analysis campaign for proton-to-signal conversion factors – focus on metallic collimators and energy dependence (and ions);
  - Lessons learnt from 2015 will be taken into account;

Thanks for your attention!

Any questions?

Back-up Slides

Collision Debris (III)



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