



Analysis of Collimation Losses 2018

A. Mereghetti, on behalf of the LHC Collimation Team

Changes due to β -tron Cleaning

Approach

Collimation system designed to stand temporary drop downs in beam lifetime:

- 500kW beam losses in 1-10s, i.e. limit for jaw *plastic* deformation – **damage!**
- 100kW beam losses in steady state, i.e. limit for jaw *elastic* deformation - **loss of performance!**

Let's re-tune the BLM thresholds such that we don't **dump un-necessarily** beforehand:

- Cautious approach: **200kW / 40kW**, (1-10s / steady state) instead of **500kW / 100kW**, for the moment, using **MF=0.4** instead of MF=1;
- Use **qualification LMs** (RS09, all beams/planes) to spot all those BLMs that would trigger a premature beam dump → 3 configurations with **XRPs in** (N. Fuster Martinez, CWG, 2018-05-07):
 - $\beta^*=30\text{cm}, 160\mu\text{rad}$;
 - $\beta^*=30\text{cm}, 130\mu\text{rad}$; Most demanding in IR7 (still corrections are very close to previous one)
 - $\beta^*=25\text{cm}, 130\mu\text{rad}$; Most demanding at TCTs
- Change present **SSL corrections** on 'long' RSs (eg from RS08 onwards) according to scale factors identified with RS09;

Linear extrapolation of BLMs signals done as:

Loss map

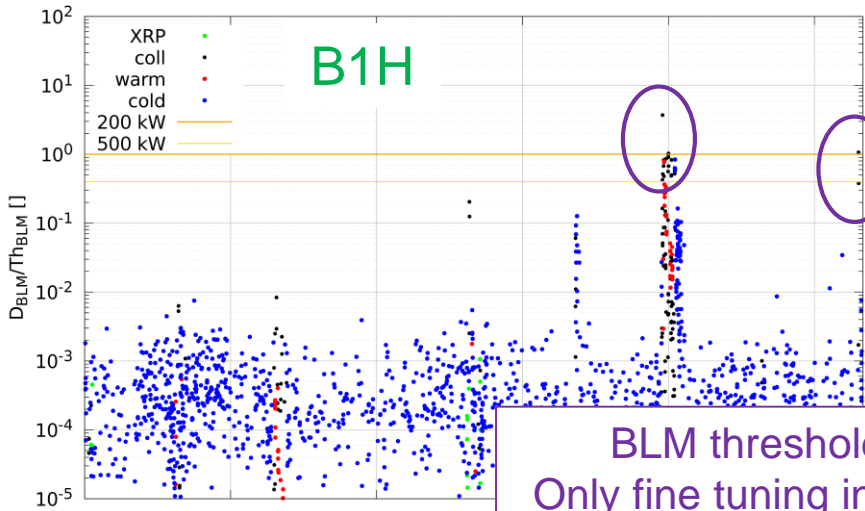
$$Th_{new} [Gy/s] = D_{LM} [Gy/s] \frac{200kW}{P_L [kW]} \rightarrow F = \frac{Th_{new} [Gy/s]}{Th_{old} [Gy/s]}$$

Extrapolation to target beam power loss

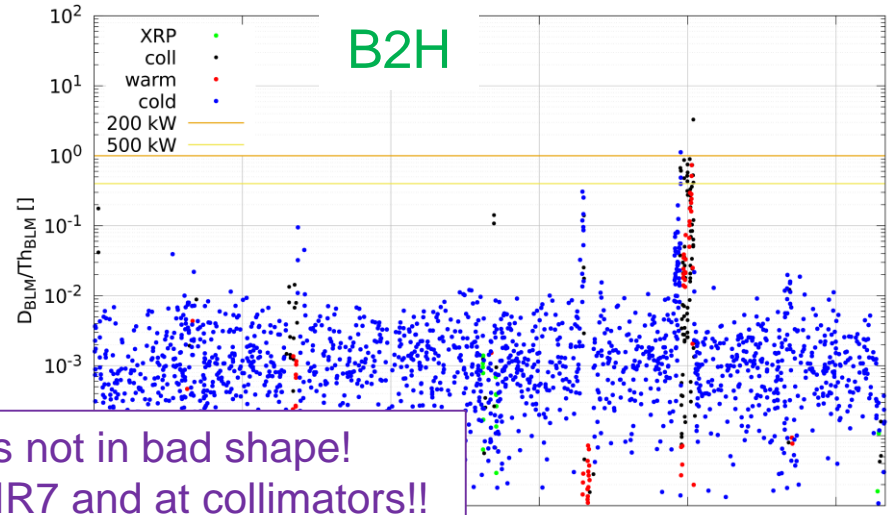
Correction factor to thresholds

$\beta^* = 30\text{cm}, 130 \mu\text{rad} - \text{LHC}$

Rescaled Loss Map normalised to thresholds - background subtracted
 B1H - 2018-04-16 03:30:01.038000

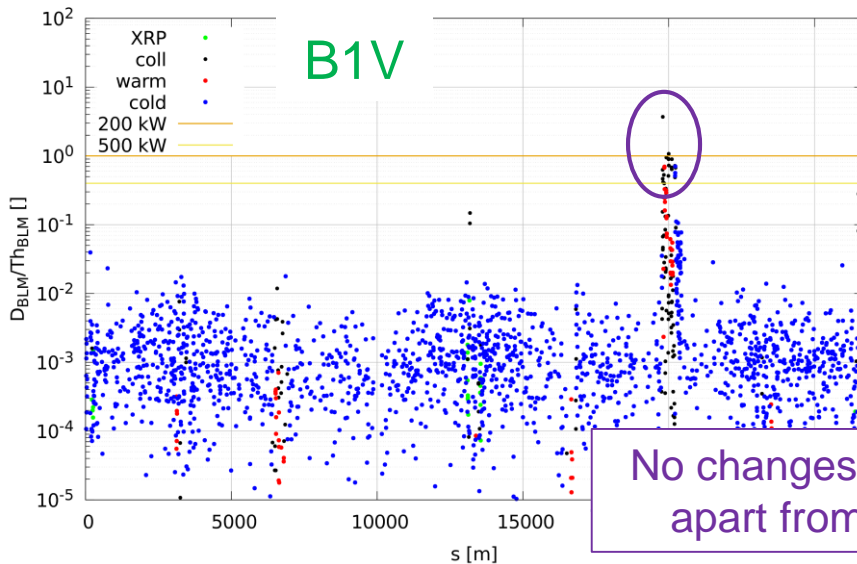


Rescaled Loss Map normalised to thresholds - background subtracted
 B2H - 2018-04-16 03:34:59.925000

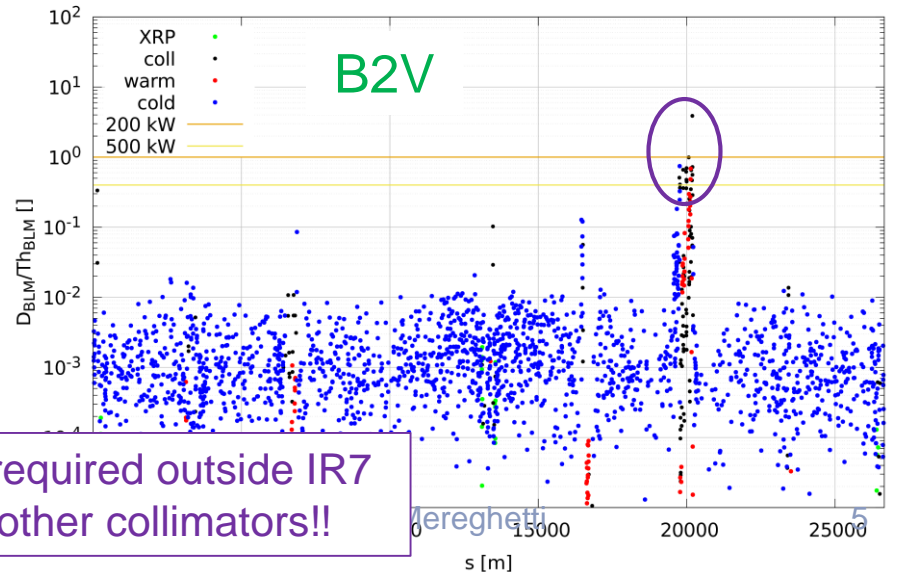


BLM thresholds not in bad shape!
 Only fine tuning in IR7 and at collimators!!

Rescaled Loss Map normalised to thresholds - background subtracted
 B1V - 2018-04-16 03:32:48.813000



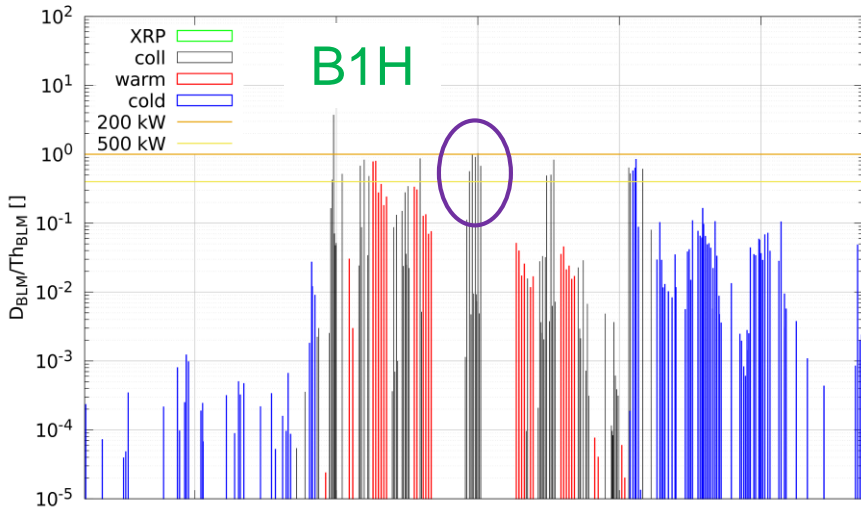
Rescaled Loss Map normalised to thresholds - background subtracted
 B2V - 2018-04-16 03:37:33.799000



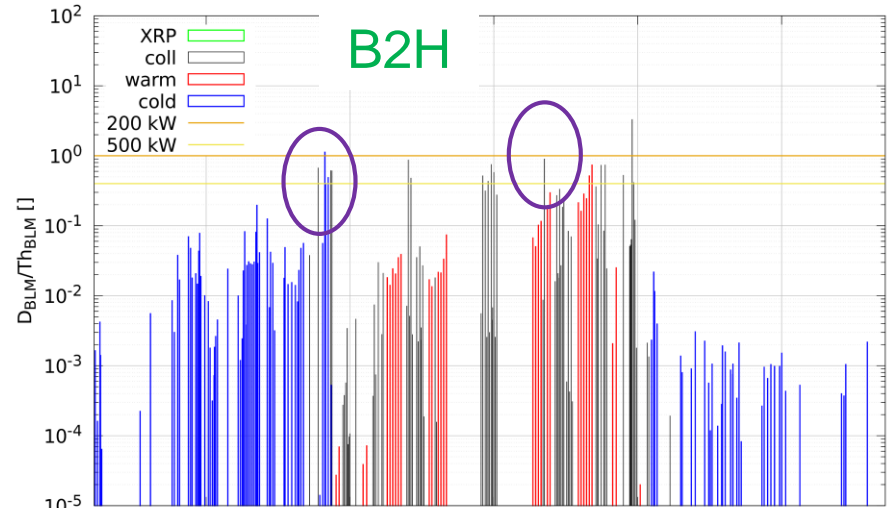
No changes required outside IR7
 apart from other collimators!!

$\beta^* = 30\text{cm}, 130 \mu\text{rad} - \text{IR7}$

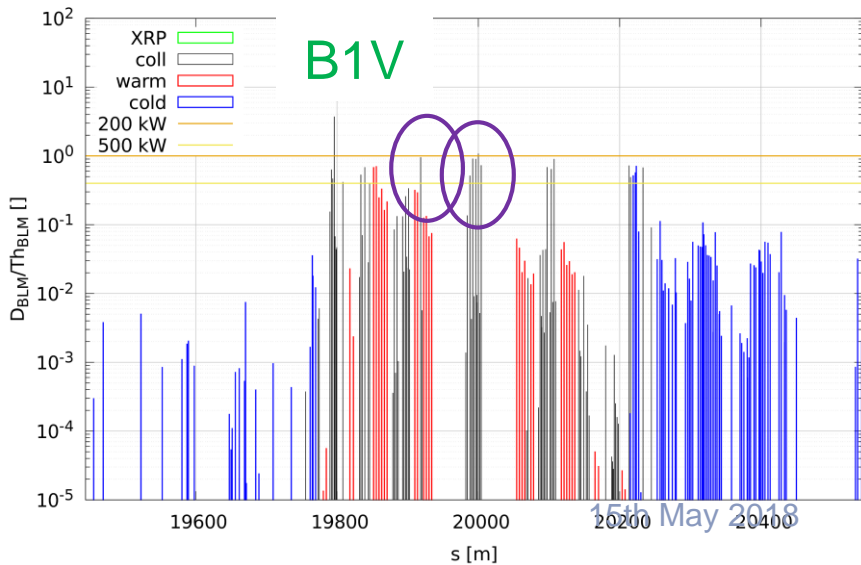
Rescaled Loss Map normalised to thresholds - background subtracted
B1H - 2018-04-16 03:30:01.038000



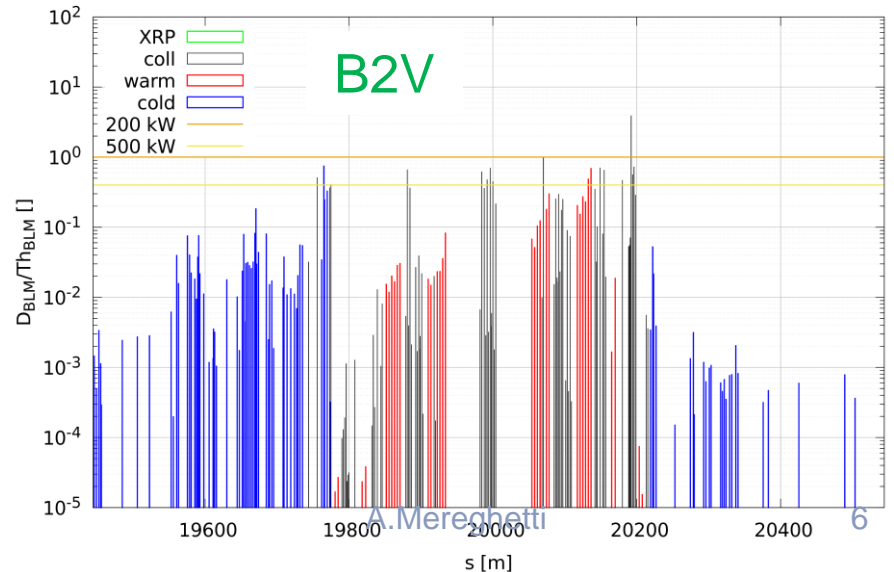
Rescaled Loss Map normalised to thresholds - background subtracted
B2H - 2018-04-16 03:34:59.925000



Rescaled Loss Map normalised to thresholds - background subtracted
B1V - 2018-04-16 03:32:48.813000

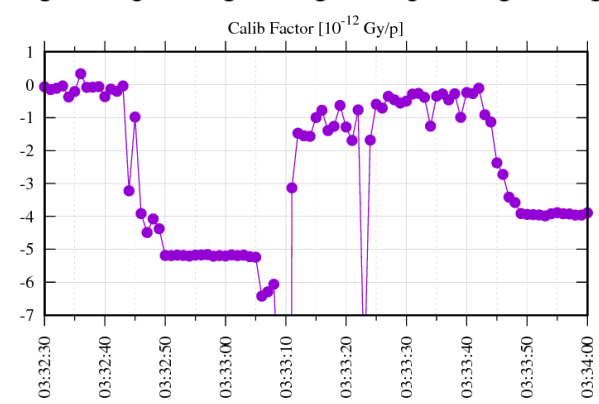
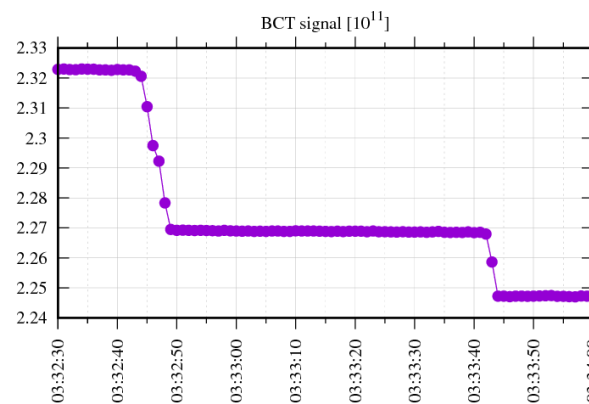
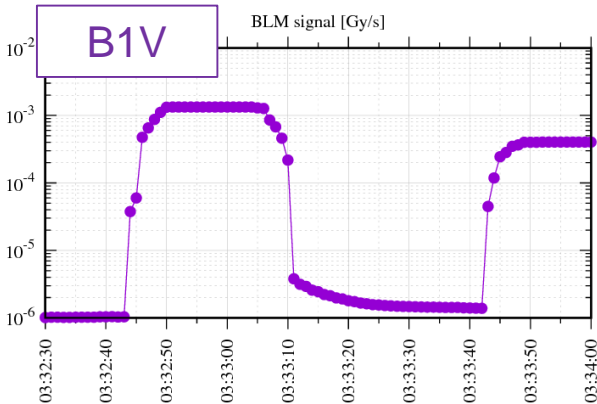
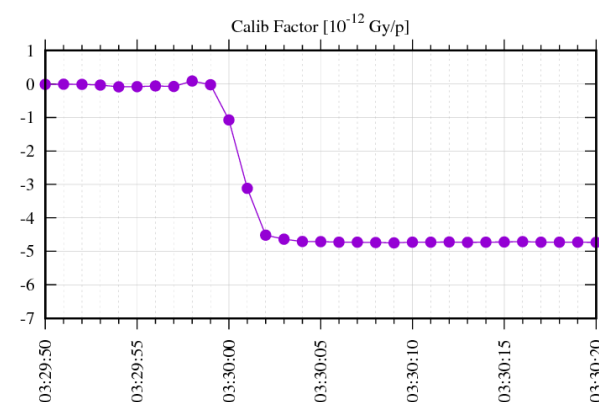
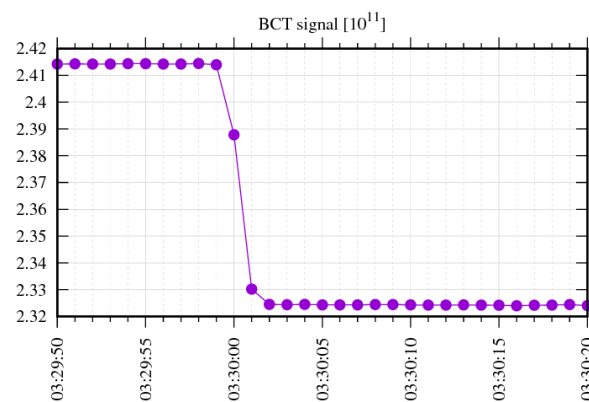
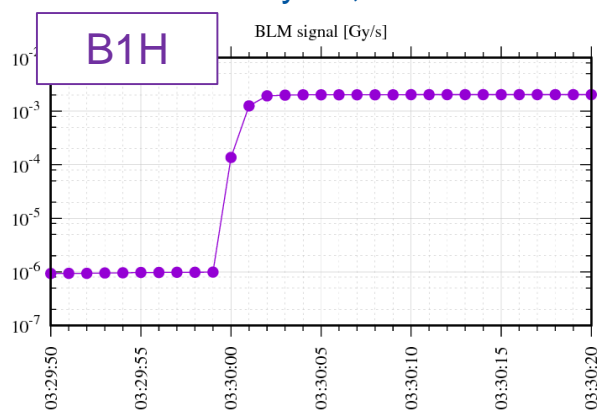


Rescaled Loss Map normalised to thresholds - background subtracted
B2V - 2018-04-16 03:37:33.799000



Estimating Beam Power Losses

- As done in 2017, BLM calibration factor estimated via long RSs:
 - Using not the **peak BLM signal in RS09 during LM** but **integrated BLM signal over entire excitation** via RS11 – RS12 not used due to cross-talks between LMs...
 - Using not the variation in beam current during the **peak of LM**, but the **overall loss of beam intensity for the entire excitation**;
- the **whole duration of the excitation** contribute to the estimation of the calibration factor, not only the **very short moment** of the LM!
- As last year, BLM at **skew collimator** used for estimating power loss during LM;



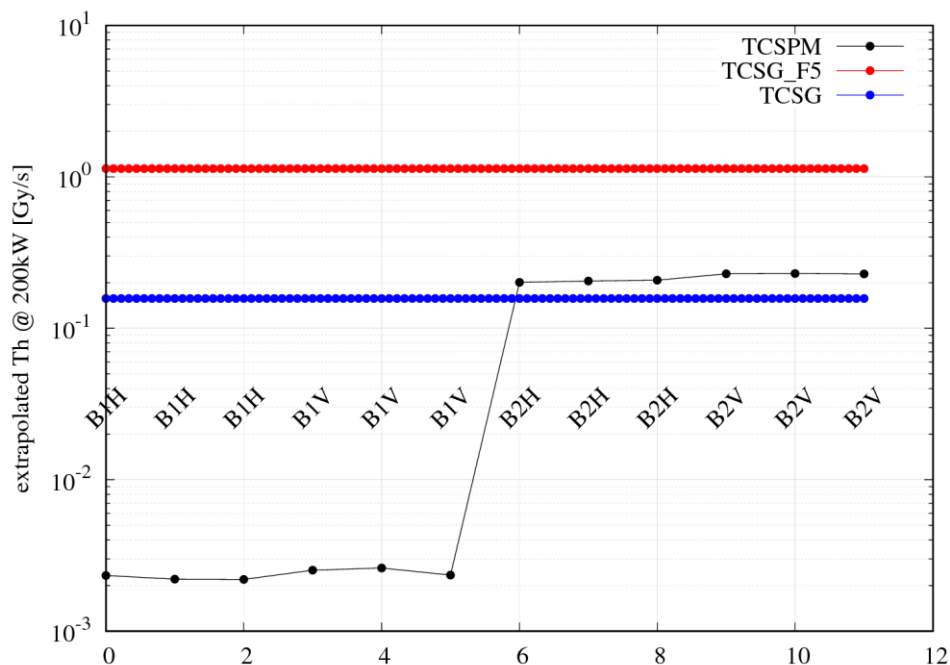
Changes due to β -tron Cleaning

- BLM thresholds at 200kW (1-10s) and 40 kW (steady state) have been extrapolated from 2018 qualification LMs (hence based on RS09) in collisions (XRP in), as done in the past;
- WRT last year, no relevant change is foreseen, in order to avoid premature beam dumps (i.e. <200kW);
- If we want to limit the power loss to 200kW, then some small adjustments in IR7 are needed;
- Reminder: present max power loss kept at 200kW instead of 500kW → to get to actual max, MF can be changed from 0.4 to 1 (fast change while more detailed updates via MT are prepared);
- Other configurations at FT energy do not imply any further change in IR7 BLM thresholds;

Family	BLM triggering the change	Factor	Factor (2017)
THRI_7_TCP	BLMTI.06R7.B2I10_TCP.C6R7.B2	7.23E-01	8.26E-01
THRI_7_TCSG	BLMTI.04R7.B2I10_TCSG.A4R7.B2	1.07E+00	1.19E+00
THRI_7_TCSG_F5	BLMTI.06R7.B2I10_TCSG.A6R7.B2	7.39E-01	7.64E-01
THRI.06_7_AB_TCLA	BLMTI.06L7.B2I10_TCLA.A6L7.B2	8.26E-01	7.87E-01
THRI.06_7_CD_TCLA	BLMTI.06R7.B1E10_TCLA.C6R7.B1	7.19E-01	6.73E-01
THRI.07_7_AB_TCLA	BLMTI.07L7.B2I10_TCLA.A7L7.B2	7.17E-01	8.14E-01
THRI_TCT	BLMTI.04L1.B1I10_TCTPH.4L1.B1	1.50E+00	
BLMQI.06R7.B1E10_MQTL	THRI_IP7_P1_MQTL_FT	5.83E-01	
BLMQI.06L7.B2I20_MQTL	THRI_IP7_P2_MQTL_FT	1.19E+00	
THRI_MQW_IP7	BLMQI.05L7.B1E10_MQWA.D5L7	7.88E-01	

TCSPM

- TCSPM:
 - Prototype IR7 secondary collimator for HiLumi;
 - Jaw in MoGr with three coating stripes (Mo, MoGr, TiN);
 - Used in 2017 only in MD (impedance characterization with beam of coating layer);
 - BLM thresholds set to max;
 - Operationally used in 2018!!
 - need for a family!



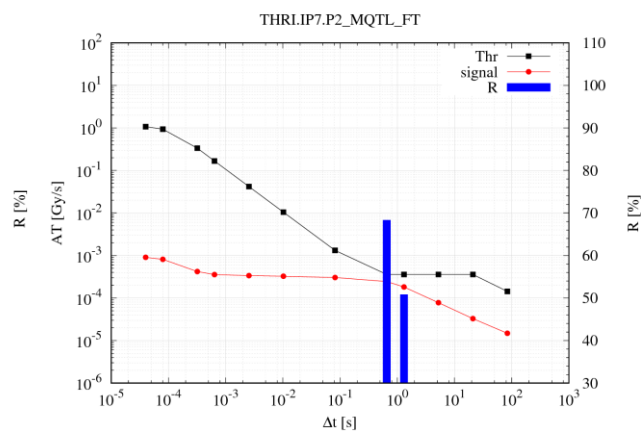
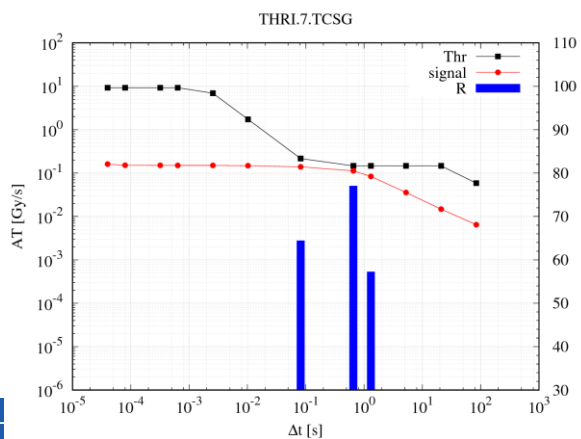
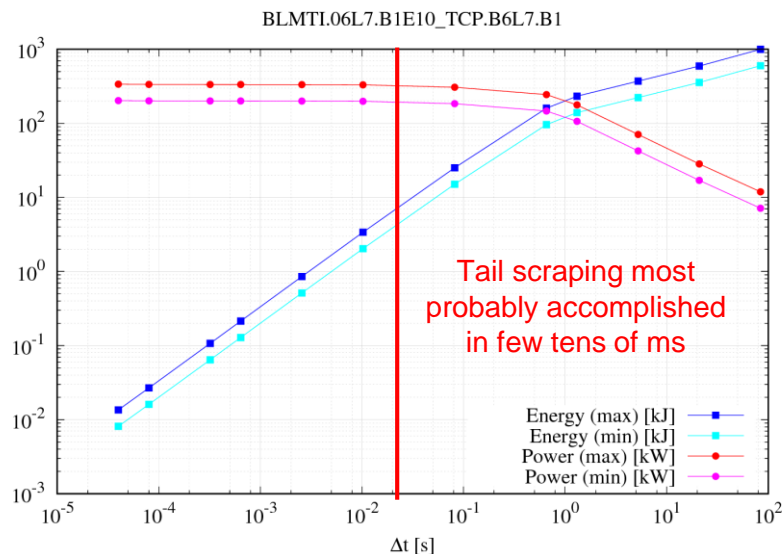
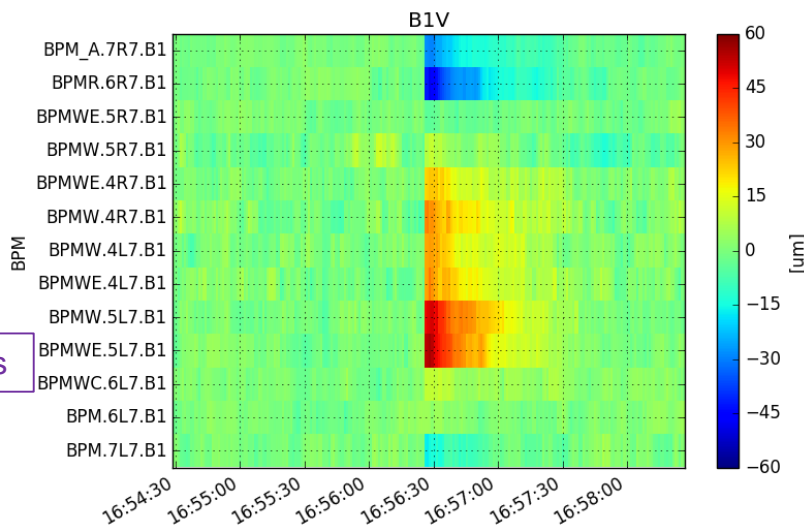
The regular THRI_7_TCSG family seems to be adequate – checked only against LM scaling;
 → SSL corrections for that family would be driven exactly by this collimator: +60% instead of +10%

Cross Checks

RQ6.A45B1 Trip

- Trip of RQ6.A45B1 (fill 6612, 2018-04-25, ~16:56, 603b):
 - V sudden orbit shift in IR7 (few tens of μm at TCPs) \rightarrow tail scraping \rightarrow losses;
 - RS07/RS08 concerned at few elements;

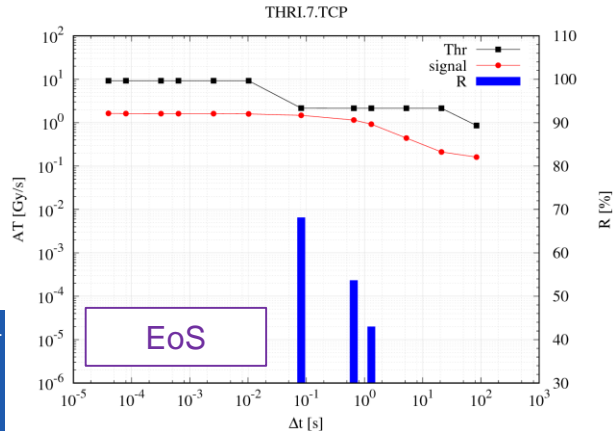
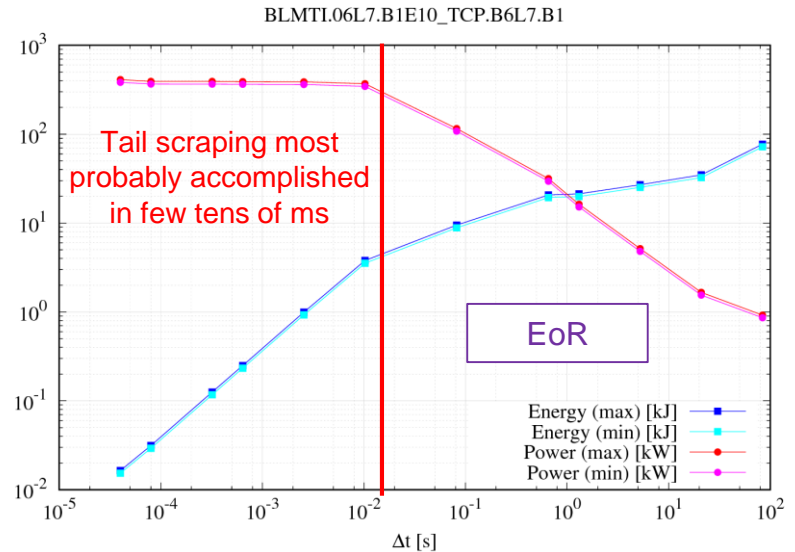
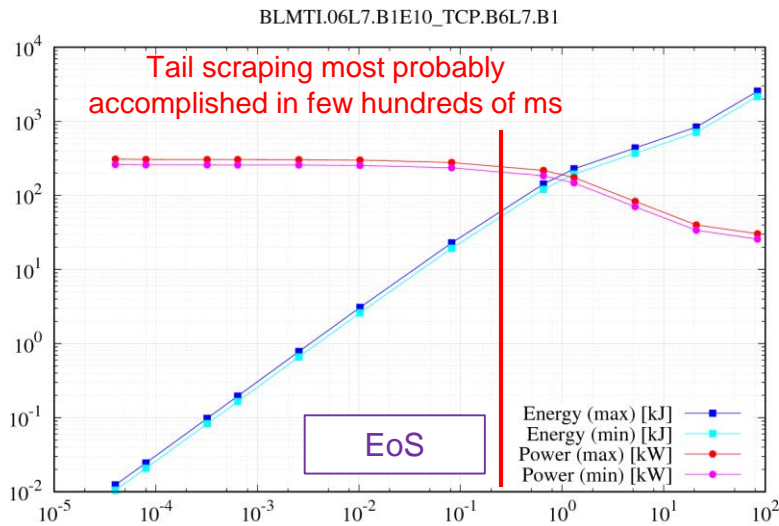
B1 TCPs



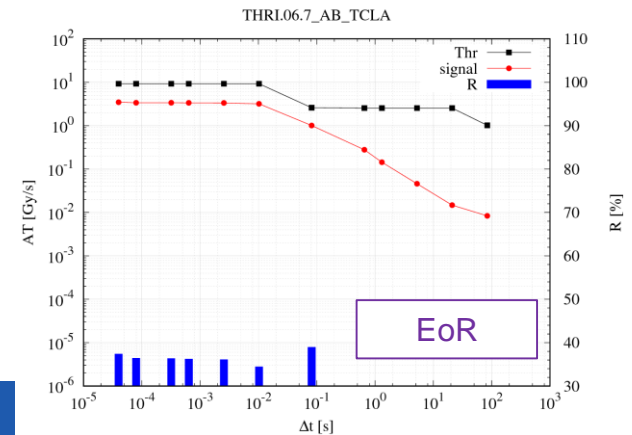
Some uncertainty on calibration factor taken from long RSs of BLM at skew TCP;
 \rightarrow Losses compatible with 100-200 kW seen by RS09, but shorter RSs mostly affected!

EoR (no MQTL) / EoS Losses

- EoR (no MQTL - fill 6611, 2018-04-24, ~22:14, 315b):
 - H orbit shift in IR7 (a few tens of μm at TCPs according to analysis by J.Wenninger) \rightarrow tail scraping \rightarrow losses;
 - RS07/RS08 concerned at few elements;
- EoS (fill 6638, 2018-05-02, ~23:22, 2175b):
 - No clear reason for losses (orbit, instability, ...)
 - RS07/RS08 concerned at few elements;



Shall we align BLM thresholds at RS07-RS08 to target losses scaled from LMs?



Changes due Collision Debris

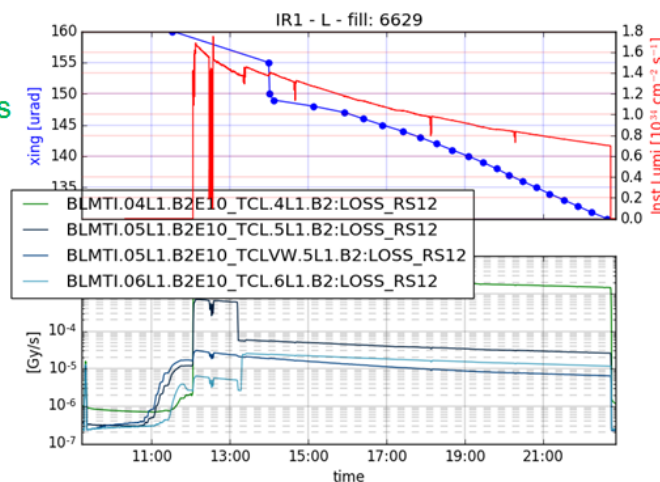
Approach and Caveats

Collision debris induced **spurious signals** in BLMs nearby interaction points:

- TCT / TCL collimators are involved → TCLs already presented at last BLMTWG meeting;
- Effect mostly visible on long RSs, since signal from debris has time to pile up;
- In comparison to 2017:
 - TCL.4s are slightly more opened – i.e. 16.43σ at $\beta^*=30\text{cm}$ instead of 15σ , actually reached at $\beta^*=25\text{cm}$;
 - Signals at TCL.5s are systematically lower than those at TCL.4s (as last year);
 - TCL.6s actually never inserted – BLM signals affected by upstream XRP;

- In 2018, quite a complex gymnastics at the high luminosity IPs:
 - crossing angle anti-levelling;
 - β^* levelling;
- Many configurations to check, as BLM response to pp-collision may not stay the same;

Detailed analysis focused only on few representative fills



Linear extrapolation of BLMs signals done as:

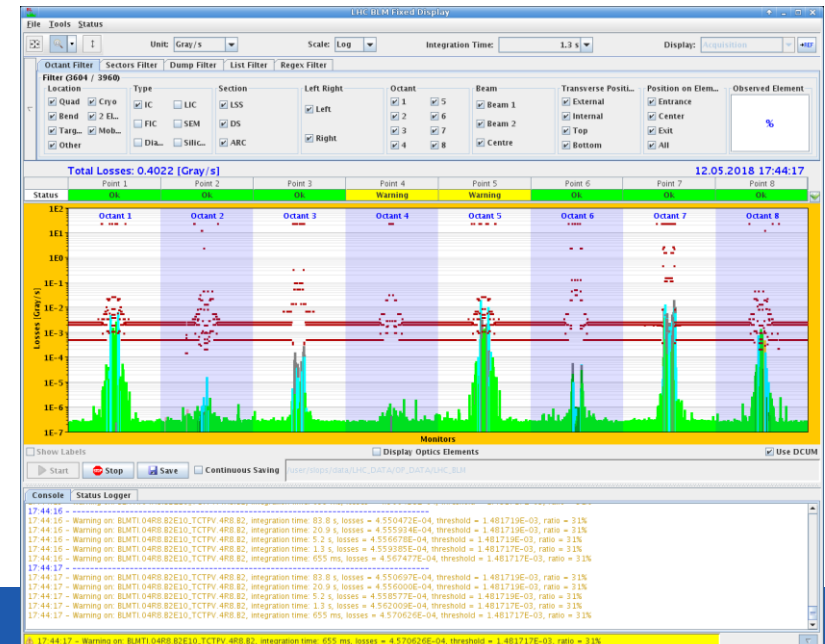
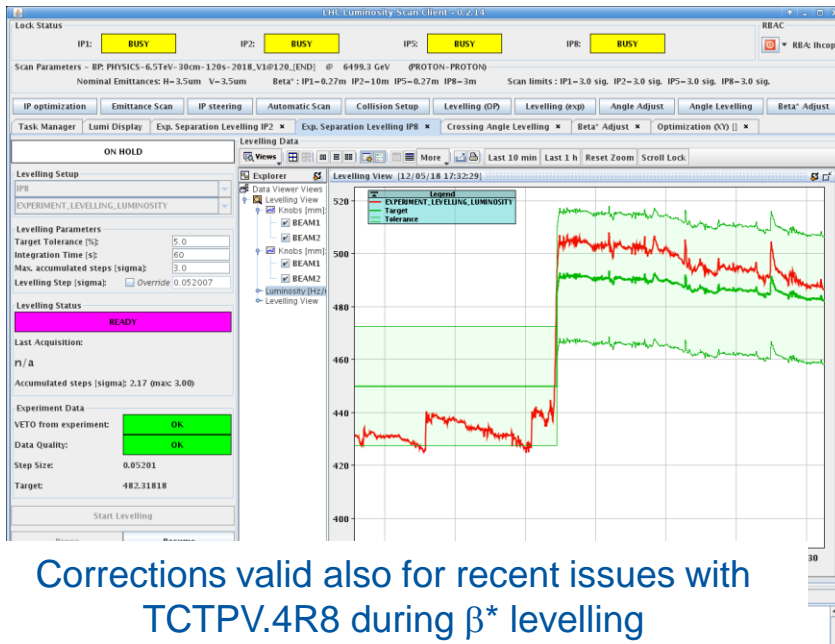
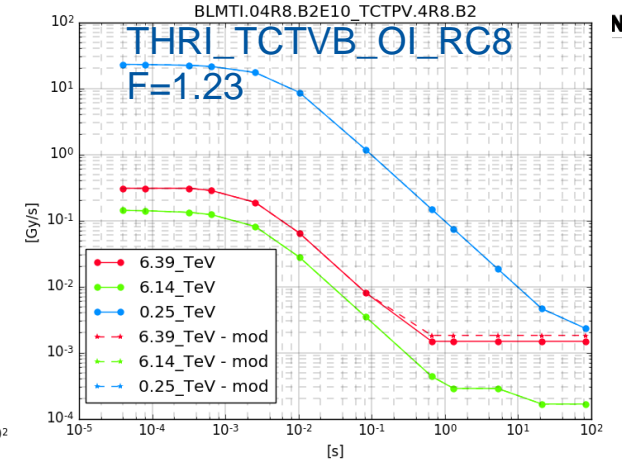
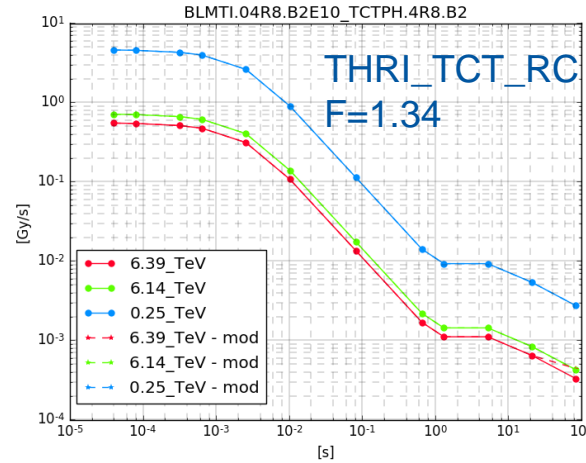
$$D_{th} = D_L \frac{TL}{L}$$

Results

Only IR8 needs corrections;

IP	Lumi [Hz μb^{-1}]
1/5	$2 \cdot 10^4$
8*	$6 \cdot 10^2$
2**	4

*above current lumi levelling;
 ** current lumi levelling;
 3x, to get to warning level;

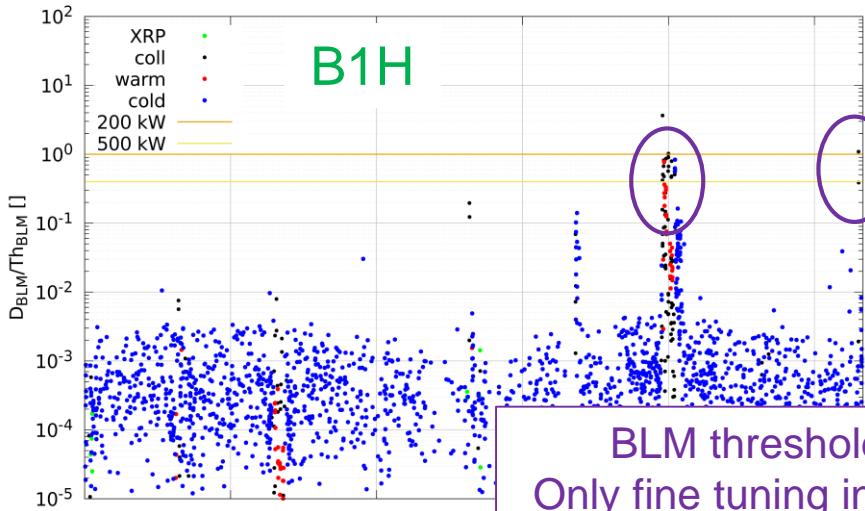


Corrections valid also for recent issues with TCTPV.4R8 during β^* levelling

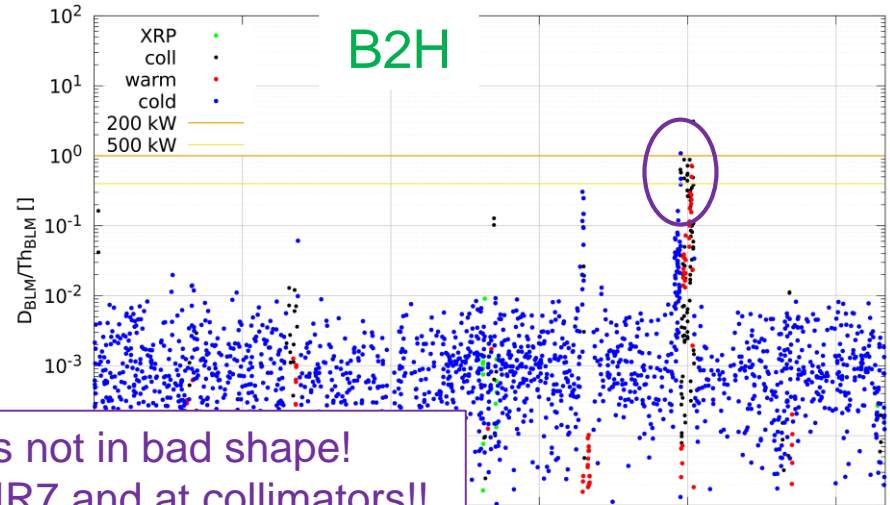
Reserve Slides

$\beta^* = 30\text{cm}, 160 \mu\text{rad} - \text{LHC}$

Rescaled Loss Map normalised to thresholds - background subtracted
B1H - 2018-04-15 20:54:45.807000

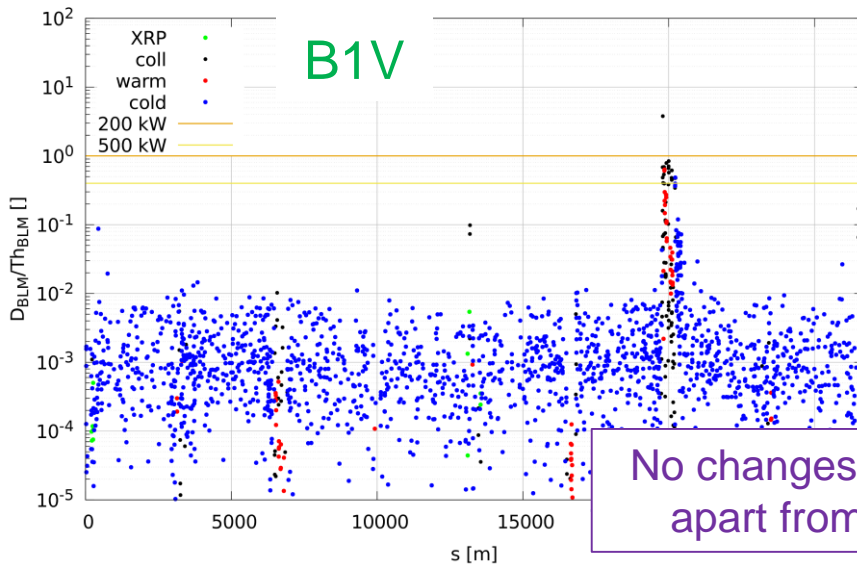


Rescaled Loss Map normalised to thresholds - background subtracted
B2H - 2018-04-15 20:57:02.770000

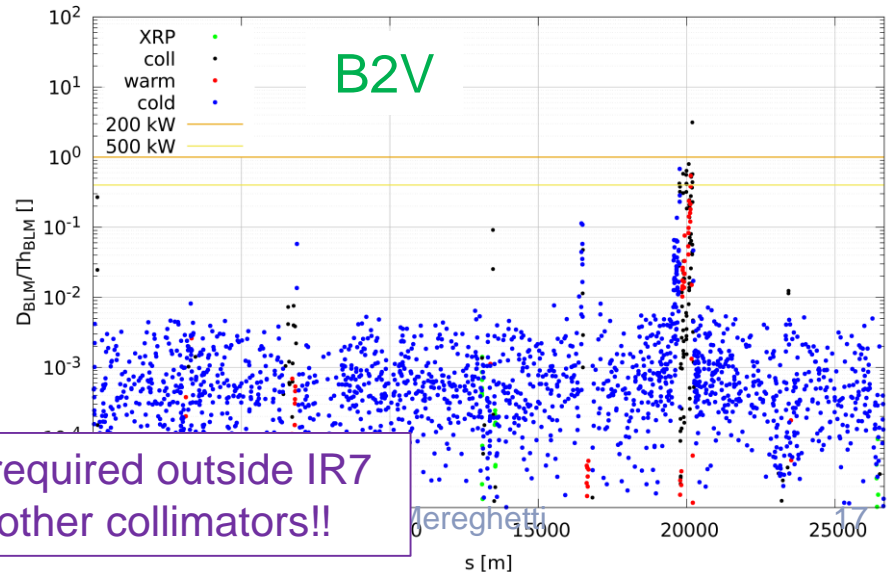


BLM thresholds not in bad shape!
Only fine tuning in IR7 and at collimators!!

Rescaled Loss Map normalised to thresholds - background subtracted
B1V - 2018-04-15 20:56:10.959000



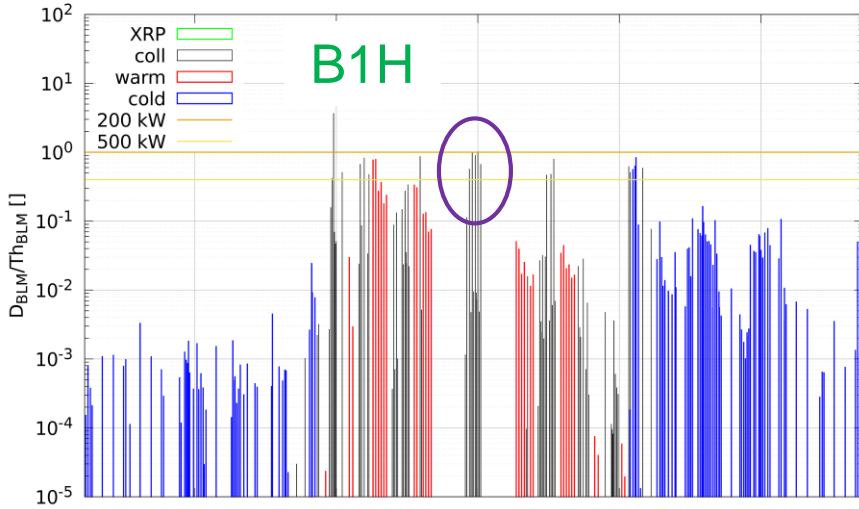
Rescaled Loss Map normalised to thresholds - background subtracted
B2V - 2018-04-15 20:57:42.778000



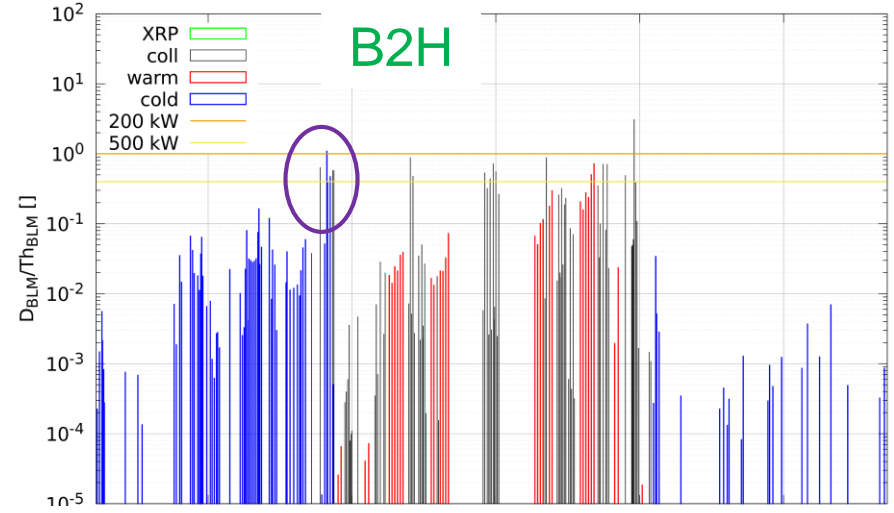
No changes required outside IR7
apart from other collimators!!

$\beta^* = 30\text{cm}, 160 \mu\text{rad} - \text{IR7}$

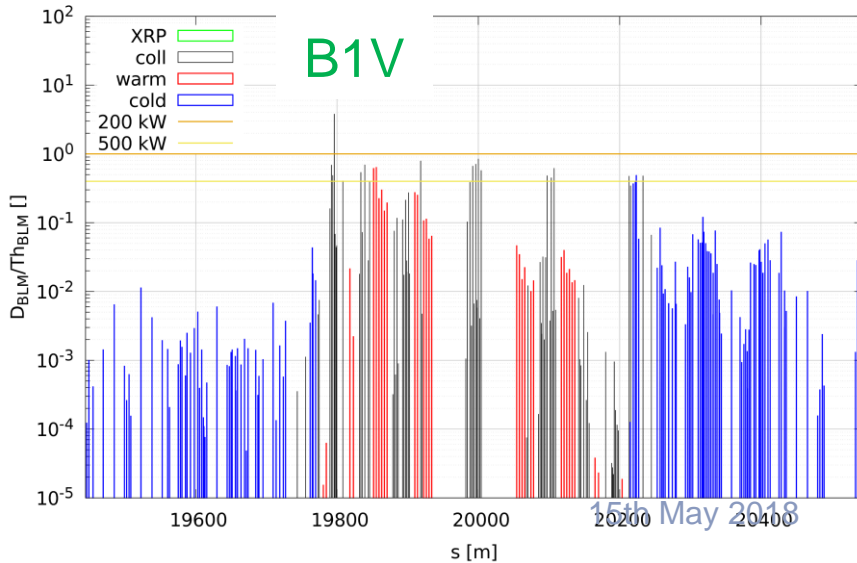
Rescaled Loss Map normalised to thresholds - background subtracted
B1H - 2018-04-15 20:54:45.807000



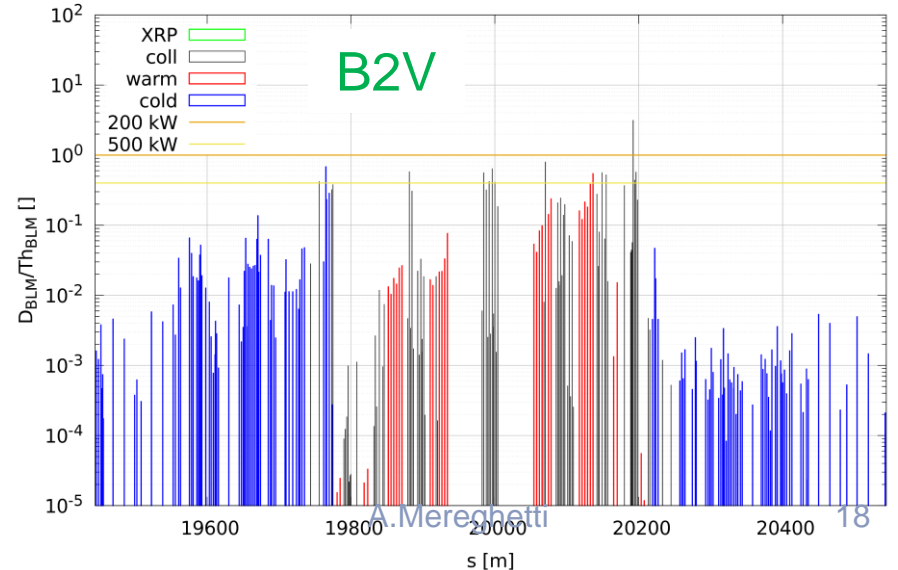
Rescaled Loss Map normalised to thresholds - background subtracted
B2H - 2018-04-15 20:57:02.770000



Rescaled Loss Map normalised to thresholds - background subtracted
B1V - 2018-04-15 20:56:10.959000

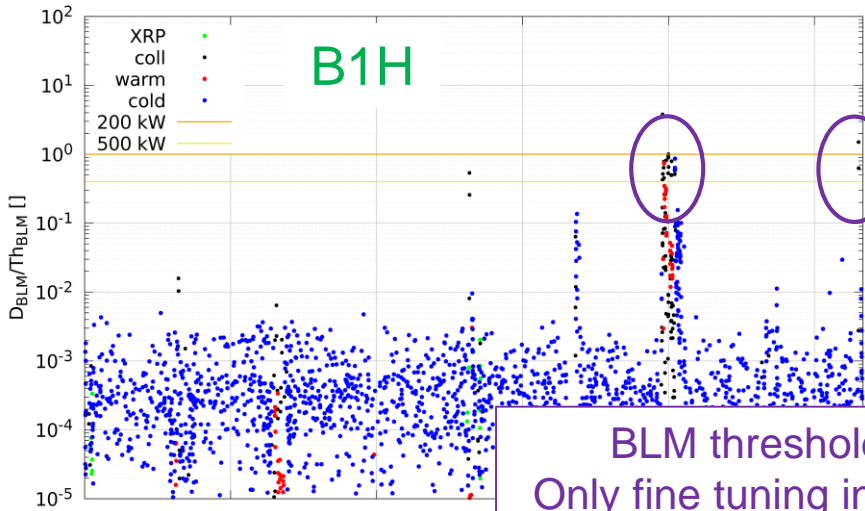


Rescaled Loss Map normalised to thresholds - background subtracted
B2V - 2018-04-15 20:57:42.778000

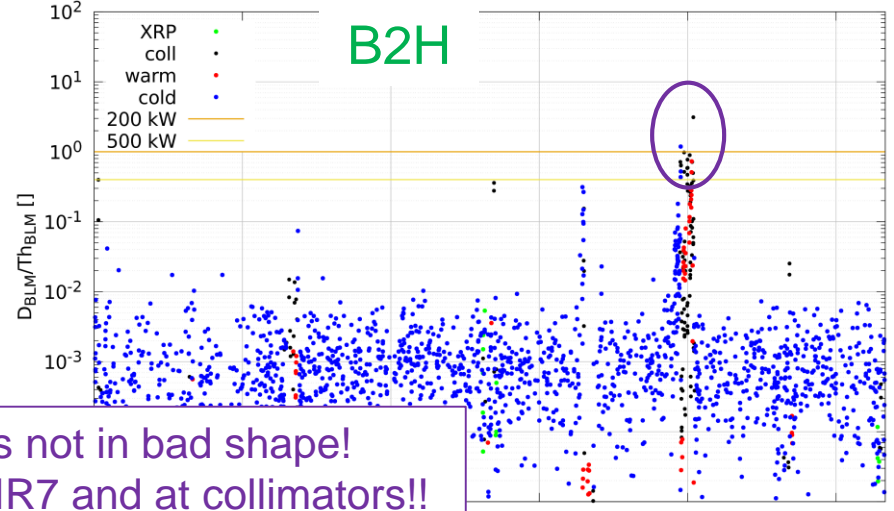


$\beta^* = 25\text{cm}$, $130\ \mu\text{rad}$ – LHC

Rescaled Loss Map normalised to thresholds - background subtracted
 B1H - 2018-04-16 04:14:51.807000

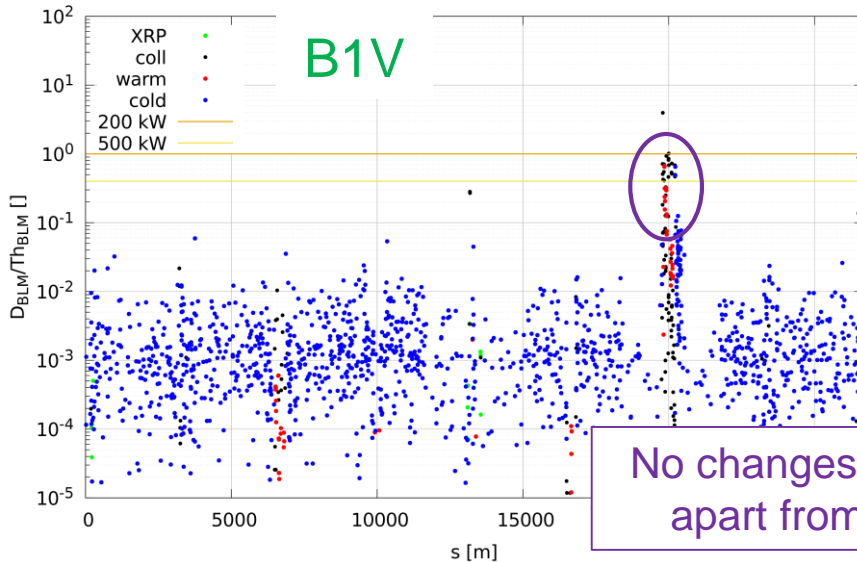


Rescaled Loss Map normalised to thresholds - background subtracted
 B2H - 2018-04-16 04:17:18.893000

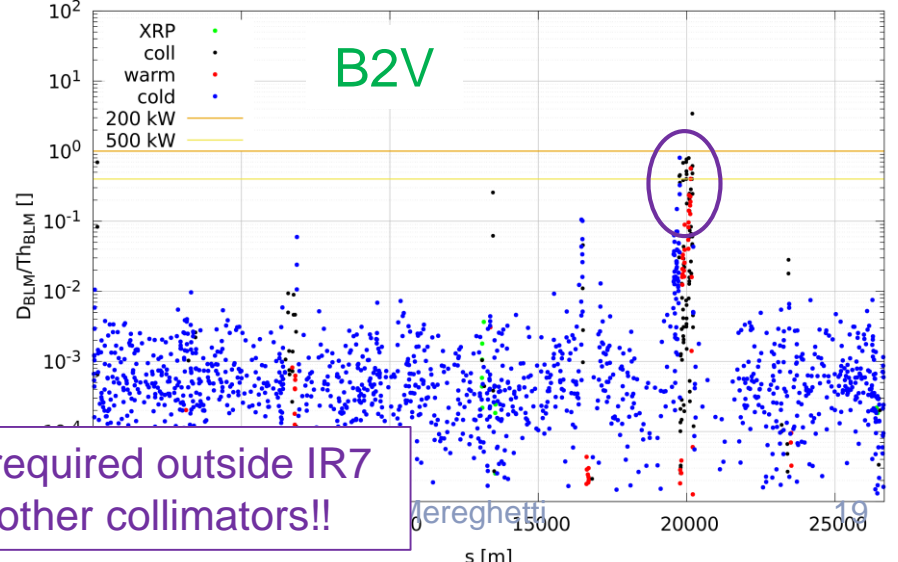


BLM thresholds not in bad shape!
 Only fine tuning in IR7 and at collimators!!

Rescaled Loss Map normalised to thresholds - background subtracted
 B1V - 2018-04-16 04:15:42.863000



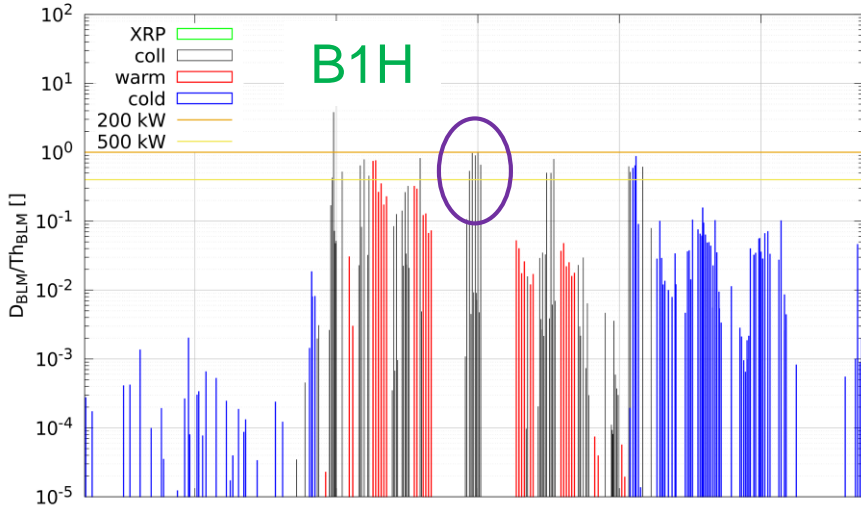
Rescaled Loss Map normalised to thresholds - background subtracted
 B2V - 2018-04-16 04:18:53.784000



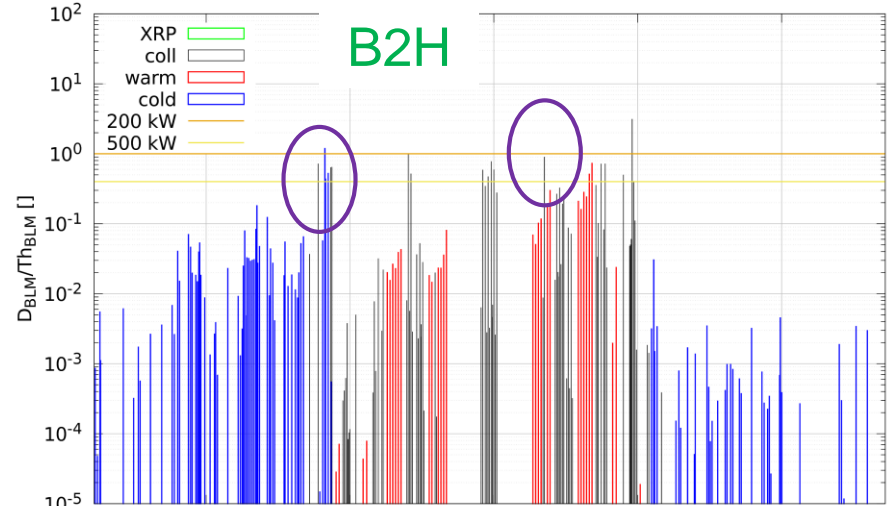
No changes required outside IR7
 apart from other collimators!!

$\beta^* = 25\text{cm}, 130 \mu\text{rad} - \text{IR7}$

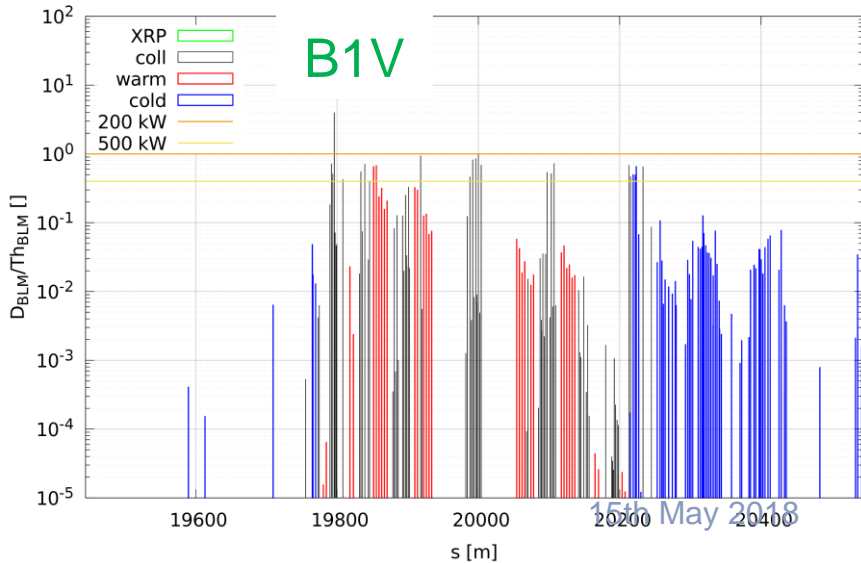
Rescaled Loss Map normalised to thresholds - background subtracted
B1H - 2018-04-16 04:14:51.807000



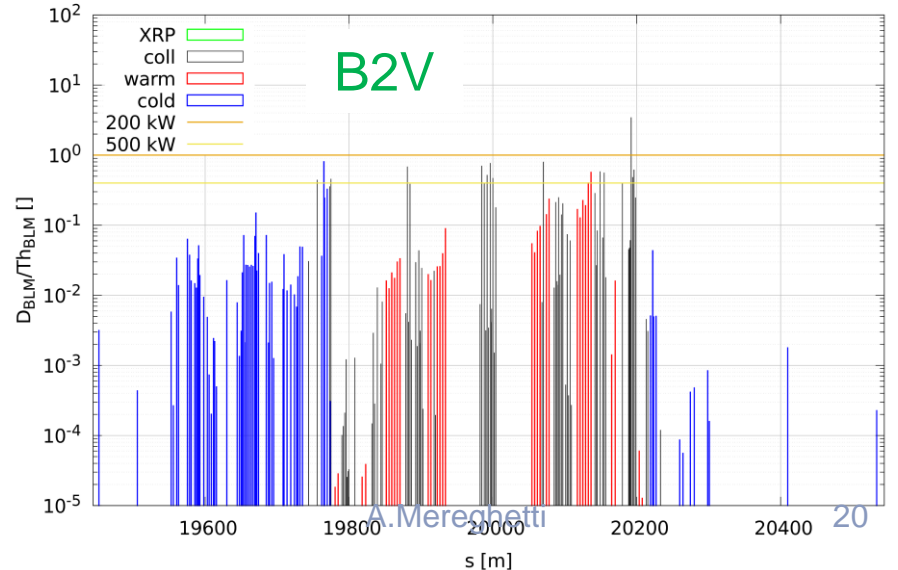
Rescaled Loss Map normalised to thresholds - background subtracted
B2H - 2018-04-16 04:17:18.893000



Rescaled Loss Map normalised to thresholds - background subtracted
B1V - 2018-04-16 04:15:42.863000



Rescaled Loss Map normalised to thresholds - background subtracted
B2V - 2018-04-16 04:18:53.784000



Lumi Losses – fill 6675

