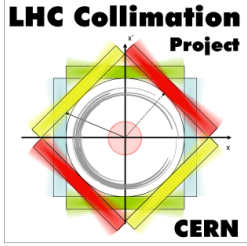

CERN

Regular Updates of Collimation BLM Thresholds for 2017

A. Mereghetti, on behalf of the LHC Collimation Team

Changes due to β-tron Cleaning

Approach and Caveats



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

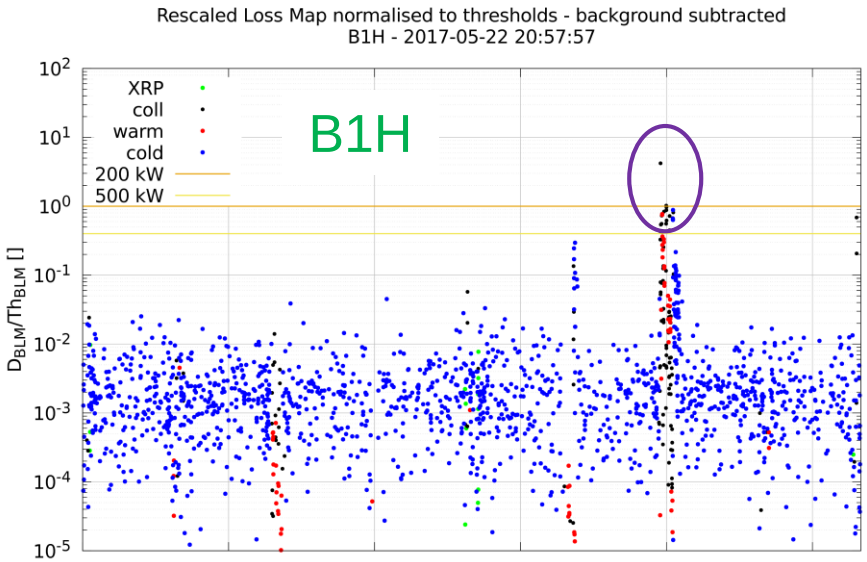
- 500kW beam losses in 1-10s, i.e. limit for jaw *plastic* deformation – damage!
- 100kW beam losses in steady state, i.e. limit for jaw *elastic* deformation - loss of performance!

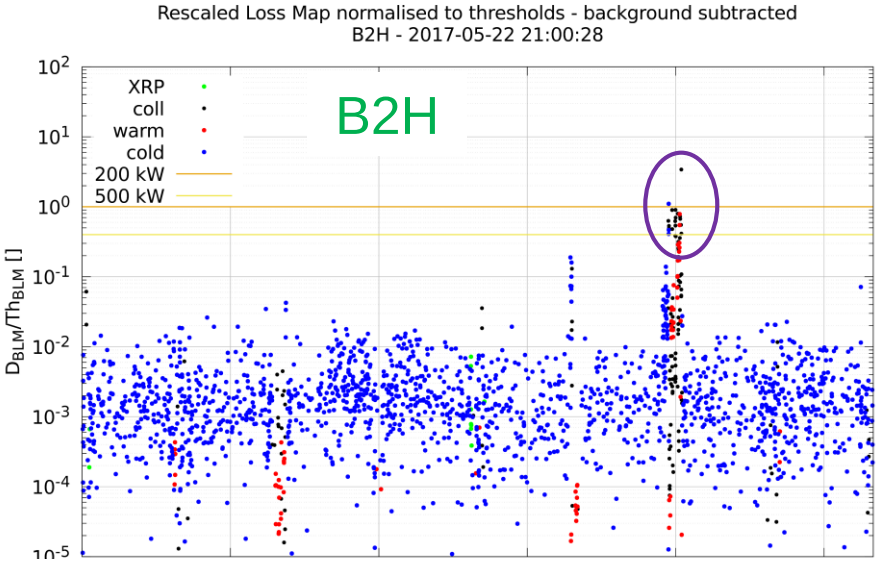
Let's re-tune the BLM thresholds such that we don't dump un-necessarily beforehand:

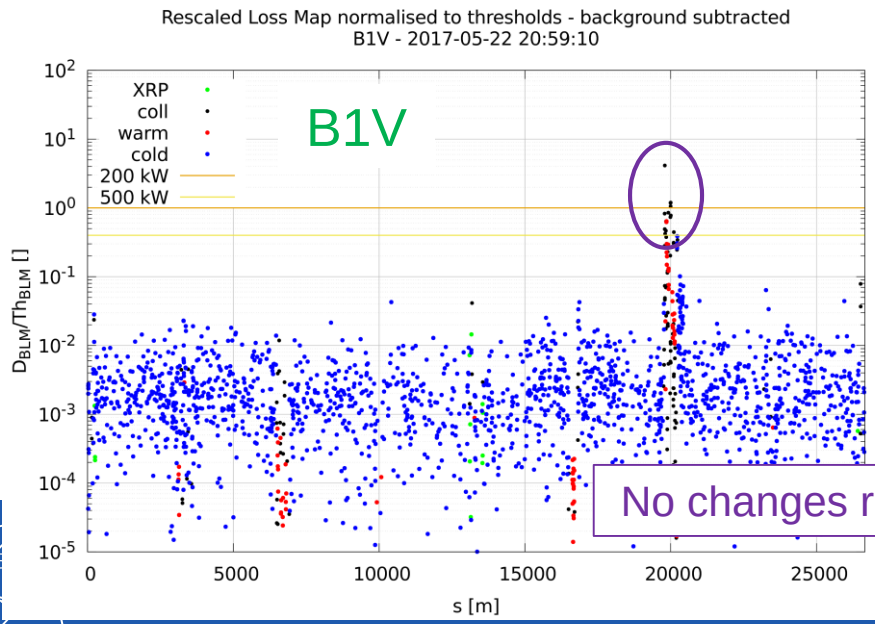
- Cautious approach: 200kW / 40kW (1-10s / steady state) for the moment;
- Use qualification LMs (RS09, all beams/planes) to spot all those BLMs that would trigger a premature beam dump → configuration with XRPs in (D.Mirarchi, CWG, 2017-05-29);
- Change present FT corrections on 'long' RSs (eg from RS08 onwards) according to scale factors identified with RS09;

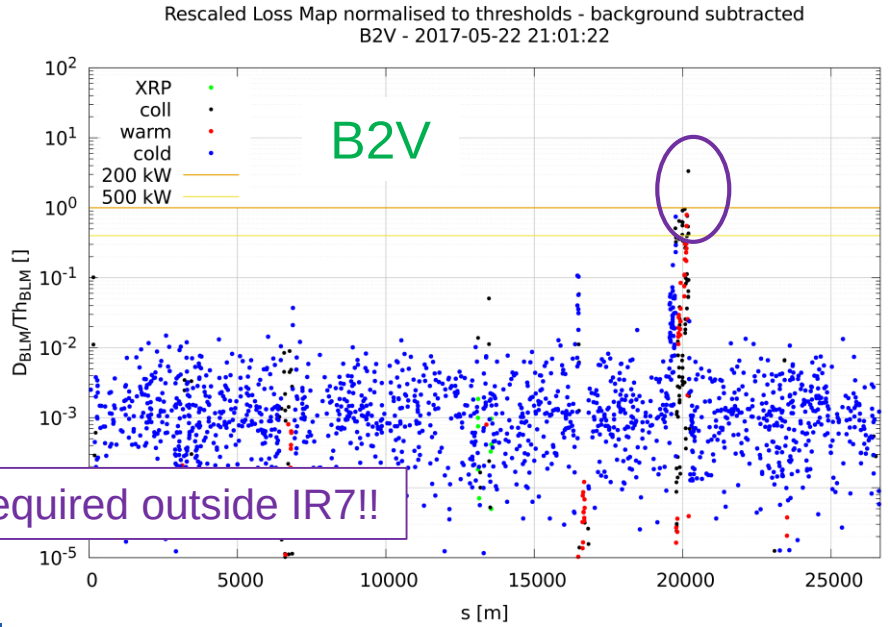
Linear extrapolation of BLMs signals done as: $D_{th} = D_{PL} \frac{200kW}{PL}$

Overview on LHC



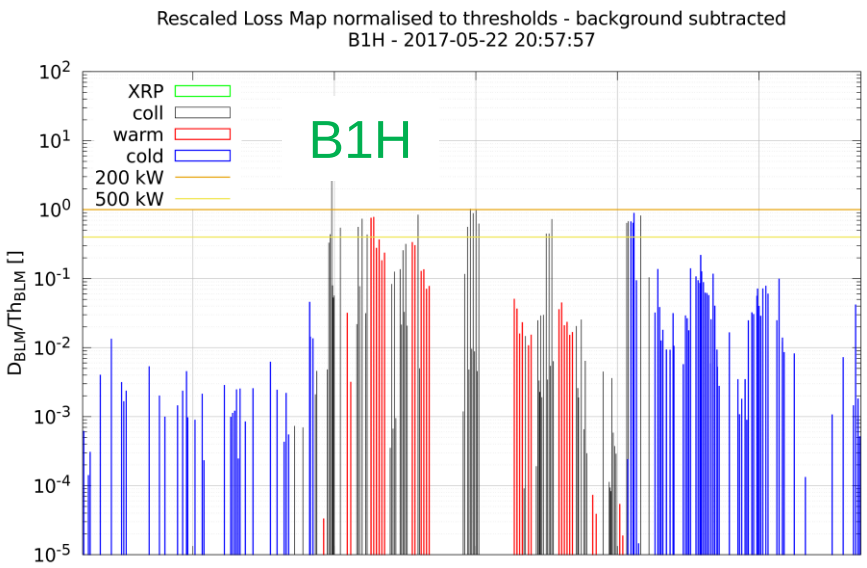


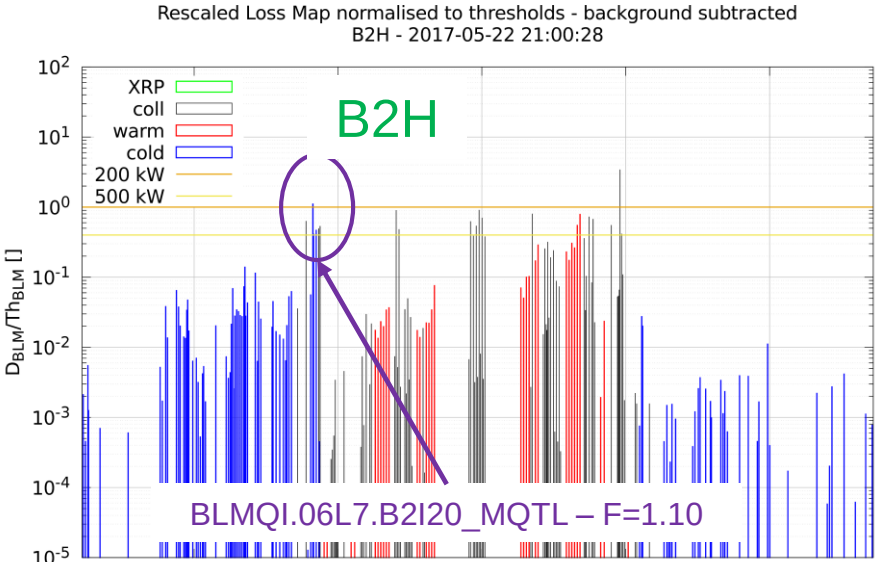


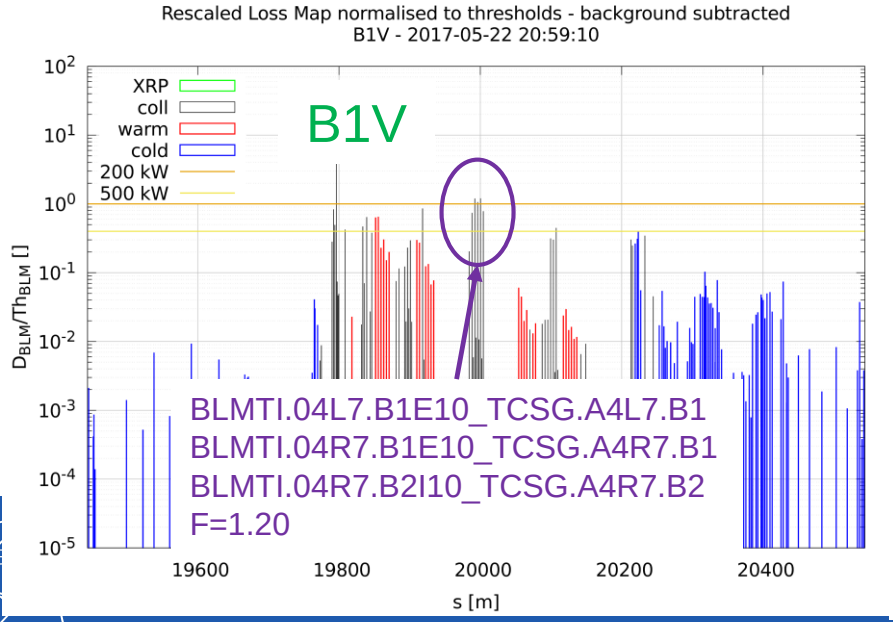


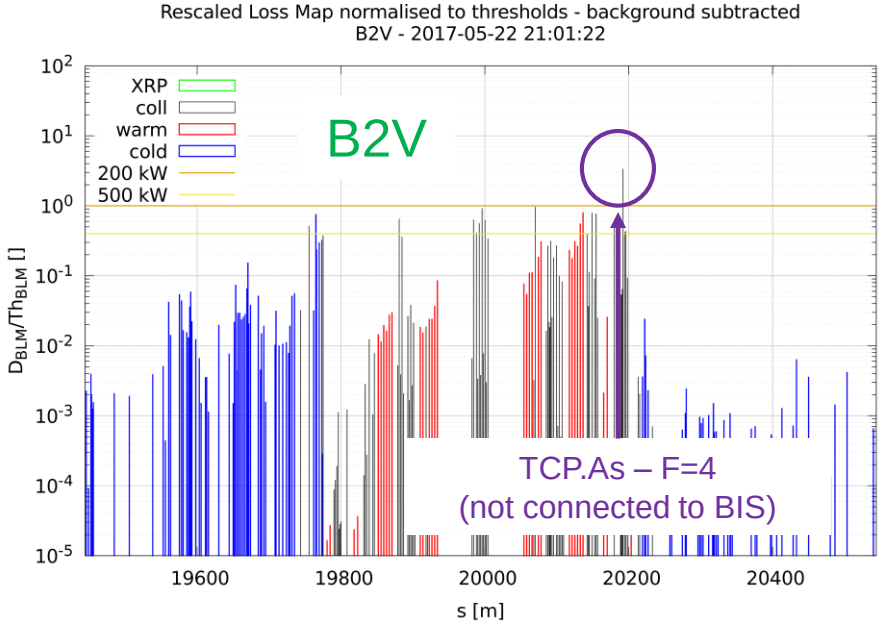
No changes required outside IR7!!

Zoom on IR7

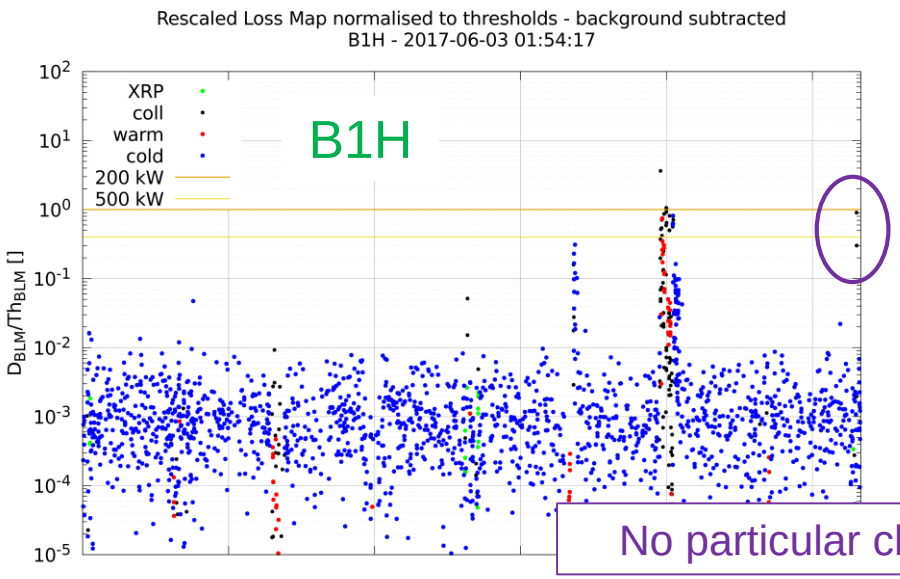

Rescaled Loss Map normalised to thresholds - background subtracted
B1H - 2017-05-22 20:57:57
XRP
coll
warm
cold
200 kW
500 kW
B1H
D_{BLM}/Th_{BLM} []

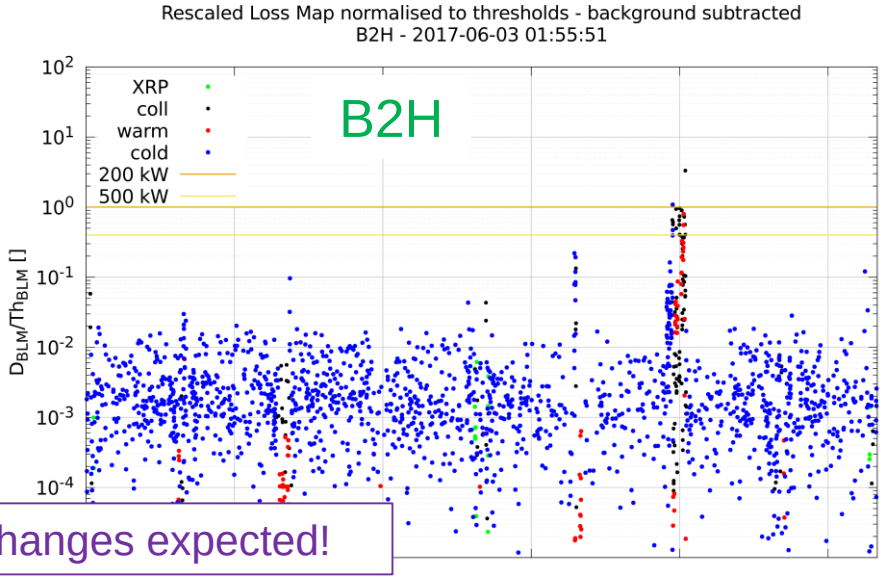

Rescaled Loss Map normalised to thresholds - background subtracted
B2H - 2017-05-22 21:00:28
XRP
coll
warm
cold
200 kW
500 kW
B2H
BLMQI.06L7.B2I20_MQTL – F=1.10
D_{BLM}/Th_{BLM} []


Rescaled Loss Map normalised to thresholds - background subtracted
B1V - 2017-05-22 20:59:10
XRP
coll
warm
cold
200 kW
500 kW
B1V
BLMTI.04L7.B1E10_TCSG.A4L7.B1
BLMTI.04R7.B1E10_TCSG.A4R7.B1
BLMTI.04R7.B2I10_TCSG.A4R7.B2
F=1.20
D_{BLM}/Th_{BLM} []
19600
19800
20000
20200
20400
s [m]

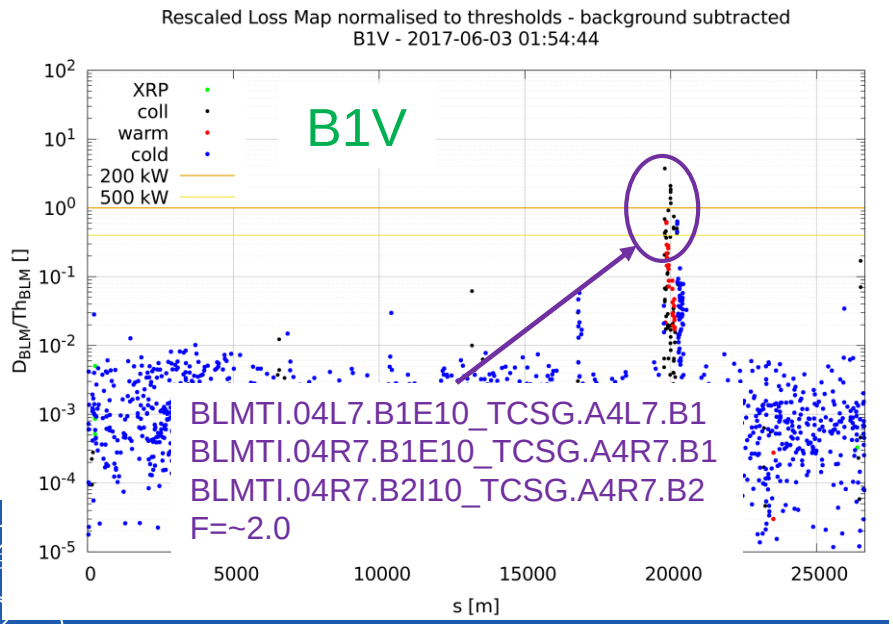

Rescaled Loss Map normalised to thresholds - background subtracted
B2V - 2017-05-22 21:01:22
XRP
coll
warm
cold
200 kW
500 kW
B2V
TCP.As – F=4
(not connected to BIS)
D_{BLM}/Th_{BLM} []
19600
19800
20000
20200
20400
s [m]

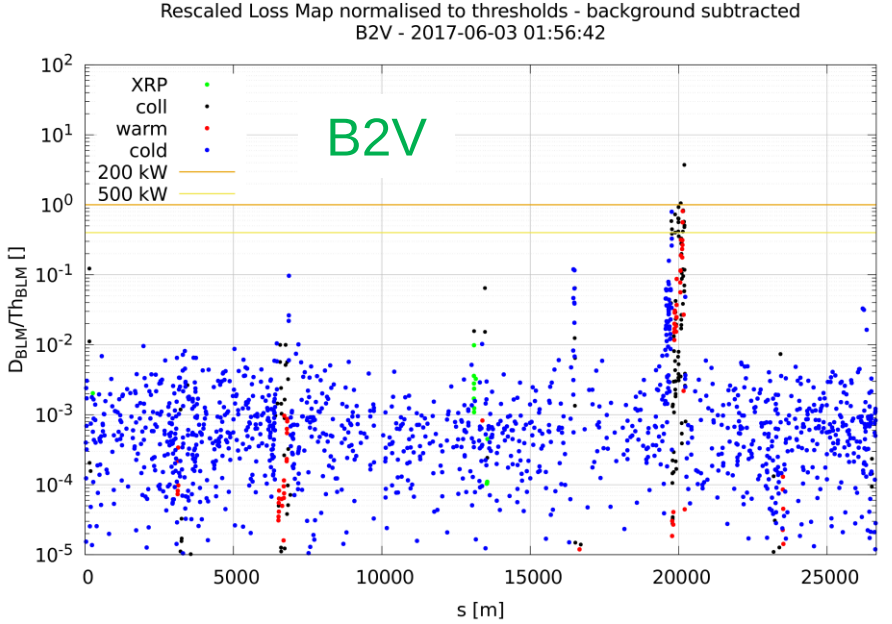
Levelling at 120 μrad - Overview on LHC





No particular changes expected!





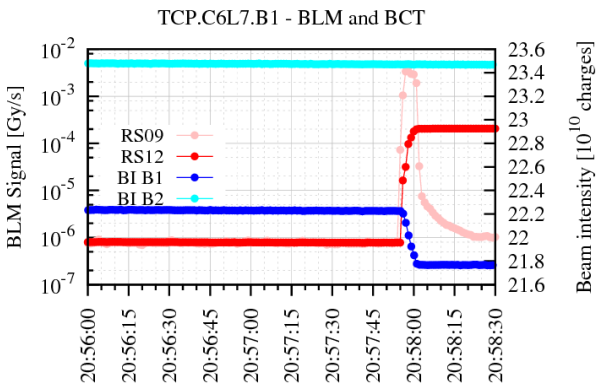
Estimating Beam Power Losses - 2017

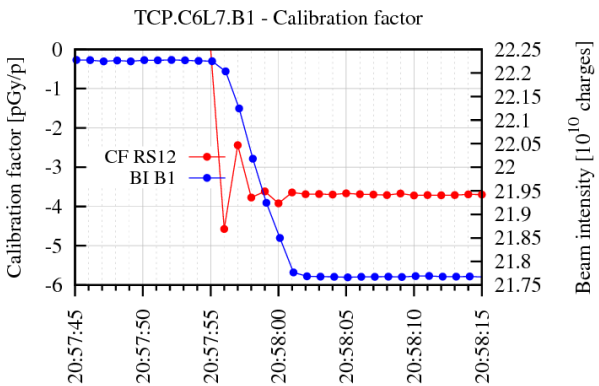
- BLM calibration factor estimated via long RSs:
  - Using not the peak BLM signal in RS09 during LM but integrated BLM signal over entire excitation via RS12;
  - Using not the variation in beam current during the peak of LM, but the overall loss of beam intensity for the entire excitation;

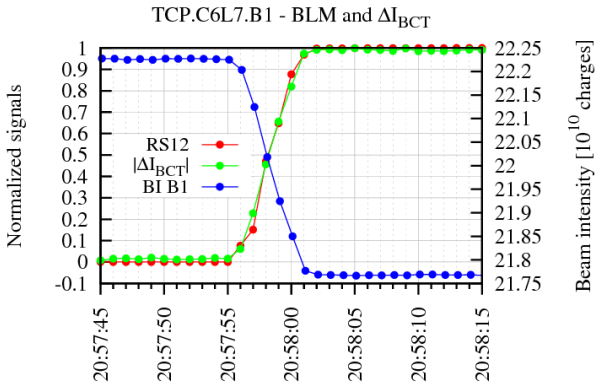
→ the whole duration of the excitation contribute to the estimation of the calibration factor, not only the very short moment of the LM!

- Careful monitoring by M. D'Andrea of calibration factors at all TCPs whenever relevant (controlled) losses occurred during commissioning:
  - Qualification LMs in collisions;
  - Killing of nominal bunches before performing measurements;

  → BLM at skew collimator has most stable readout → used for estimating power loss during LM;







PL [kW]	B1H	B1V	B2H	B2V
150 μrad	0.9524	0.9726	1.081	1.462
120 μrad	3.27	2.532	1.002	2.621

Courtesy M.D'Andrea

Conclusions - Changes due to β-tron Cleaning

- BLM thresholds at 200kW (1-10s) and 40 kW (steady state) have been extrapolated from 2017 qualification LMs (hence based on RS09) in collisions (XRPs in), as done in the past;
- WRT last year, no relevant change is foreseen, in order to avoid premature beam dumps (i.e. before 200kW are reached); the only required change would be (FT correction, flattening out):
  - an increase by 10% of BLMQI.06L7.B2I20_MQTL (THRI.IP7.P2_MQTL_FT);
  - An increase by 20% of the THRI_7_TCSG family;
- If we want to limit the power loss to 200kW, then some small adjustments in IR7 would be needed (see table below);
- 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);
- Running at 120 μrad instead of 150 μrad does not imply any relevant change in IR7 BLM thresholds;

Family	BLM triggering the change	Factor
THRI.06_7_AB_TCLA	BLMTI.06R7.B1E10_TCLA.A6R7.B1	7.87E-01
THRI.06_7_CD_TCLA	BLMTI.06R7.B1E10_TCLA.D6R7.B1	6.73E-01
THRI.07_7_AB_TCLA	BLMTI.07R7.B1E10_TCLA.A7R7.B1	8.14E-01
THRI_7_TCP	BLMTI.06L7.B1E10_TCP.C6L7.B1	8.26E-01
THRI_7_TCSG	BLMTI.04R7.B2I10_TCSG.A4R7.B2	1.19E+00
THRI_7_TCSG_F5	BLMTI.06R7.B2I10_TCSG.A6R7.B2	7.64E-01

Changes due Collision Debris

Approach and Caveats

Collision debris induced spurious signals in BLMs nearby interaction points:

- TCT / TCL collimators are involved;
- Effect mostly visible on long RSs, since signal from debris has time to pile up;
- Not the first time that this correction is required:
  - LHC-BLM-ECR-0036 (2015) – for each BLM family concerned, peak values from a single fill have been extrapolated to target Lumis;
  - LHC-BLM-ECR-0049 (2016) – for each BLM family concerned, the peak BLM signal and lumi recorded during intensity ramp up have been correlated, to build a calibration curve;
- 2017:
  - intensity ramp up started when still in commissioning phase – many fills had tests of lumi levelling / collimator scans;
  - Fill by fill follow up, where for every BLM the correlation curves were built on available data (stable crossing conditions);

Linear extrapolation of BLMs signals done as: $D_{th} = D_L \frac{TL}{L}$

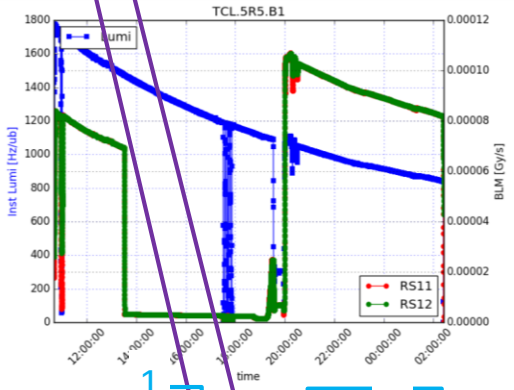
Example – fill 5730

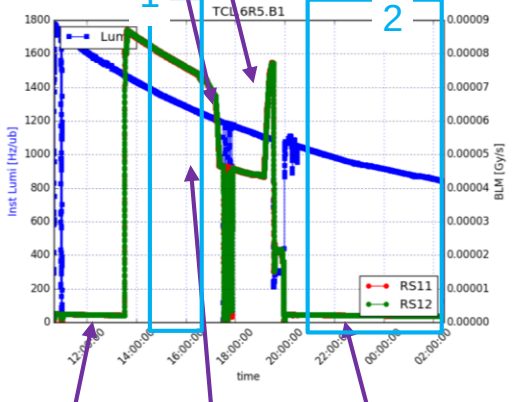
TCL6/5/4 scans

RS12 vs <L>

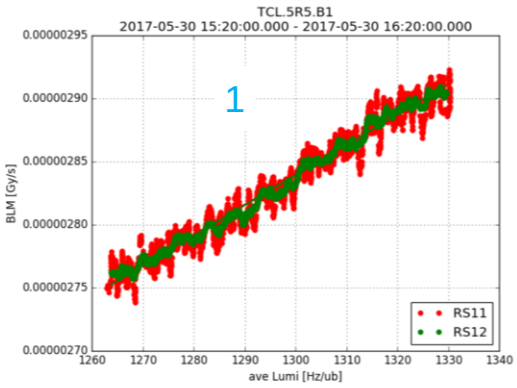
TCL.5R5

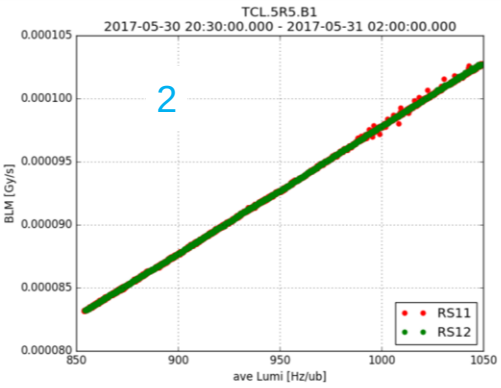
TCL.6R5

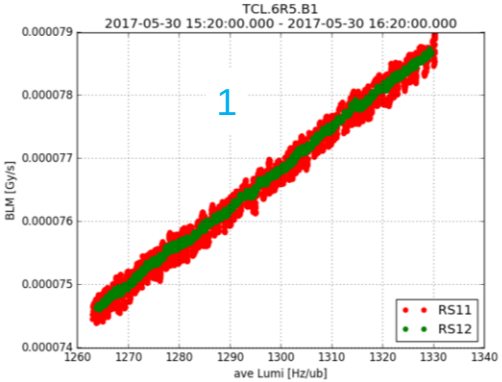


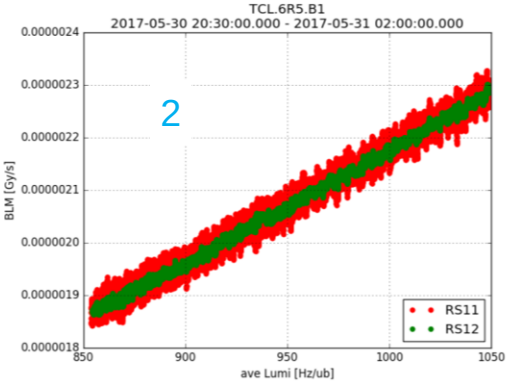


XRPs: OUT IN OUT





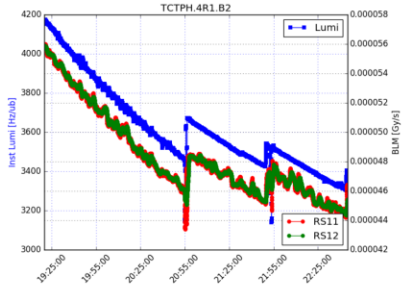


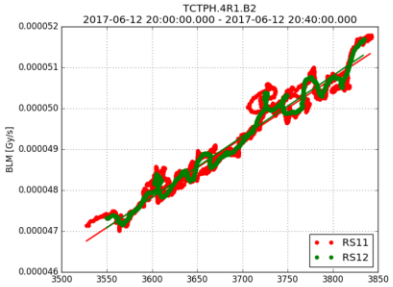


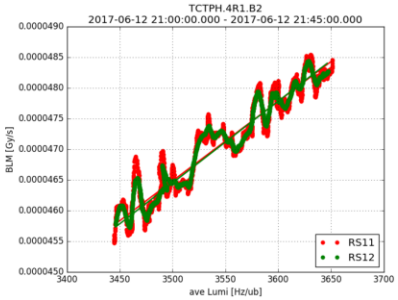
Example – fill 5748

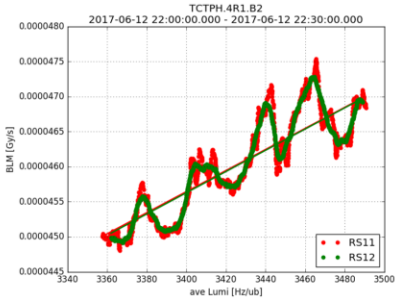
IP1, right side

TCTPH.4R1.B2

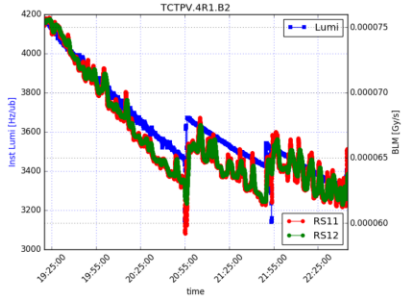


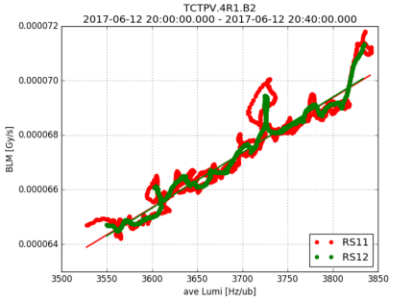


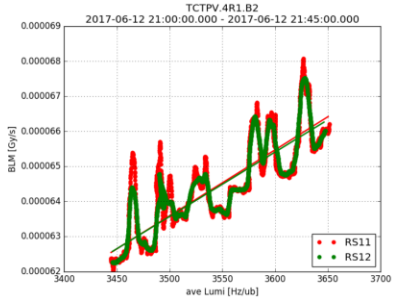


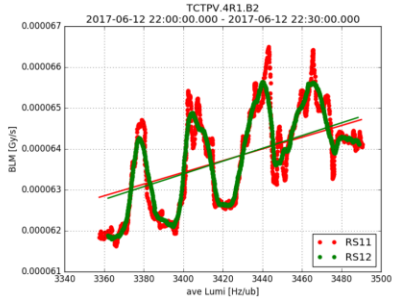


TCTPV.4R1.B2

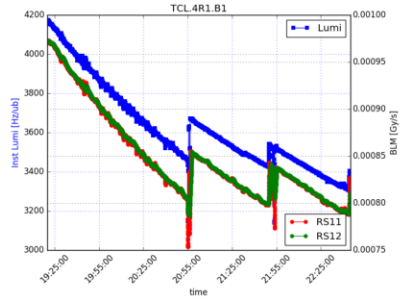


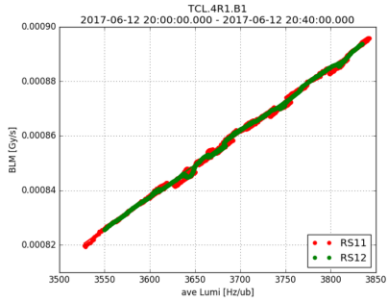


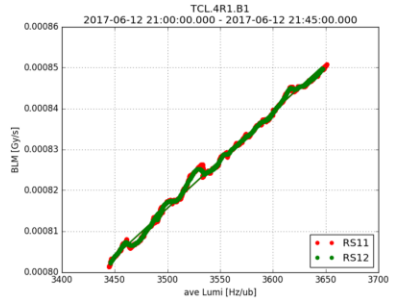


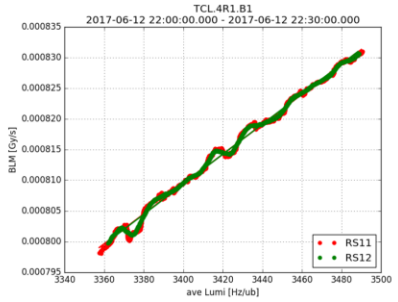


TCL.4R1









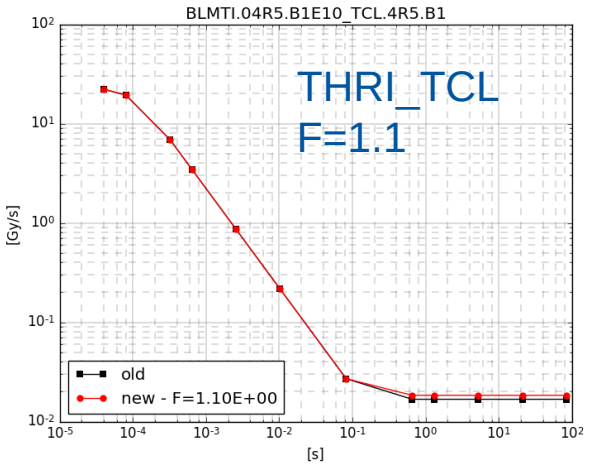
Results

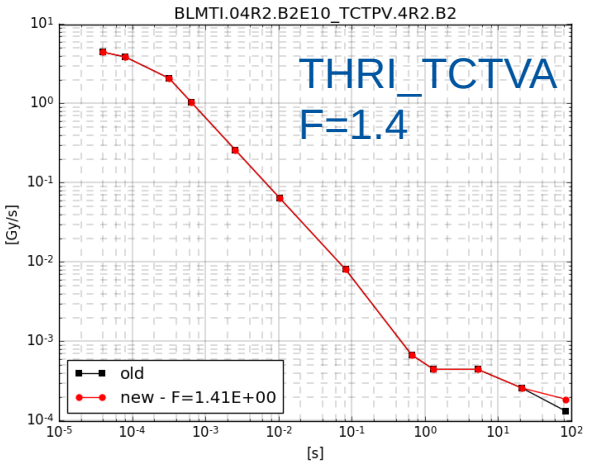
IP	Lumi [Hz μb^{-1}]
1/5	3x 1.75 10^4
8*	3x 5 10^2
2**	3x 9

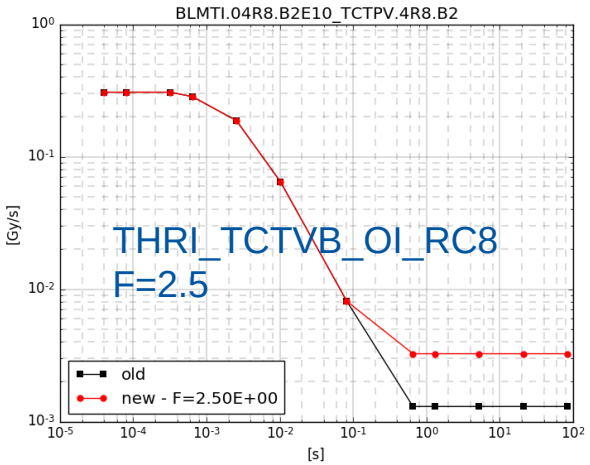
*J.Boyd, Chamonix 2017;
** same as 2016;
3x, to get to warning level;

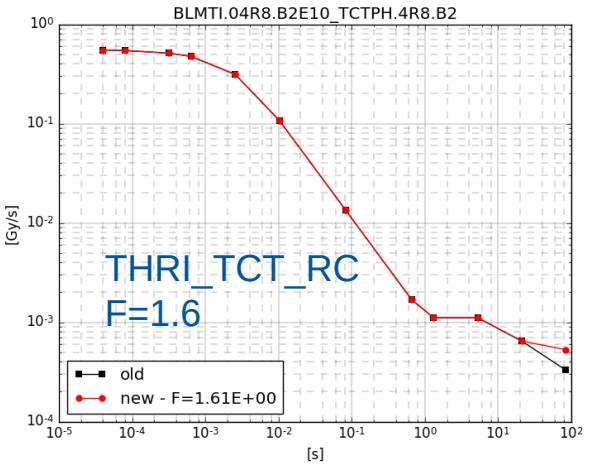
Major TCT family (i.e. IR1 / 5) stays untouched;

Conside red fills	XRPs out	XRPs delayed	XPRs in
75x75	5717	5718	5719
300x300	5722	5730	5737
600x600	5746	5750	5824







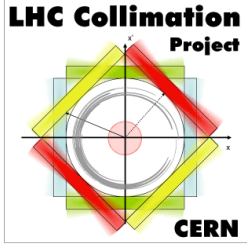


Conclusions - Changes due Collision Debris

- BLM thresholds at target luminosities at TCT/TCL collimators in all interaction regions have been estimated, based on intensity ramp up accomplished so far;
- WRT last year, no relevant change is foreseen to the main TCT family dumps; the only required change (FT correction, flattening out) would be:

Family	BLM triggering the change	Factor
THRI.TCTVA	BLMTI.04R2.B2E10_TCTPV.4R2.B2	1.41
THRI.TCT_RC	BLMTI.04R8.B2E10_TCTPH.4R8.B2	1.61
THRI.TCTVB_OI_RC8	BLMTI.04R8.B2E10_TCTPV.4R8.B2	2.50
THRI_TCL	BLMTI.04R5.B1E10_TCL.4R5.B1	1.10

- Target lumis considered in the study take into account x3 for warning levels



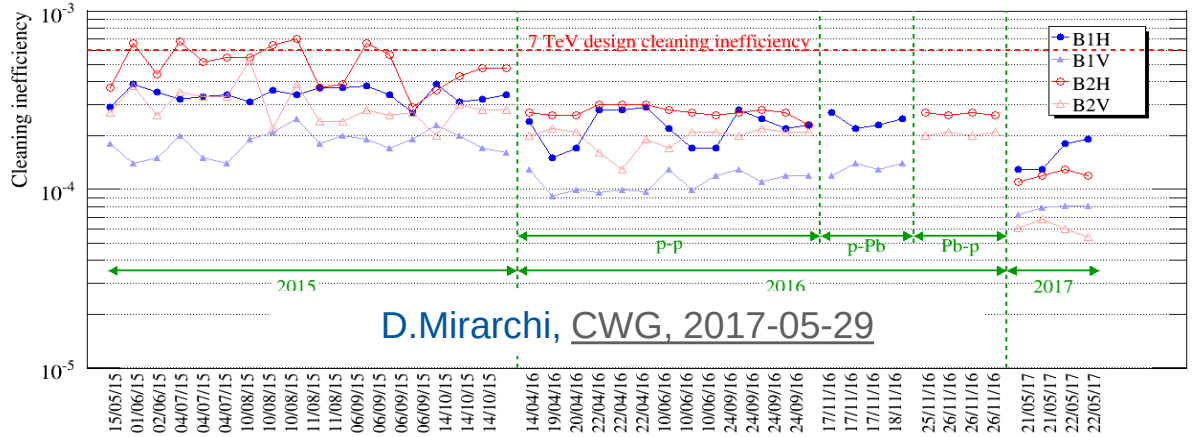
Reserve Slides

Improving the Collimation Performance

- Collimation settings have changed over the past years to improve the performance, safely allowing the β* reach;
- Changes in collimation settings imply changes in loss patterns → BLM thresholds must follow accordingly, to dump at the desired loss rates!
- Adjustments suggested by LMs, which show the BLM response at each LHC location for a given loss rate;

Tighter settings

	2015	2016	2017
IR7 TCP / TCSG / TCLA	5.5 / 8 / 14	5.5 / 7.5 / 11	5 / 6.5 / 10
IR3 TCP / TCSG / TCLA	15 / 18 / 20	15 / 18 / 20	15 / 18 / 20
IR6 TCSP / TCDQ	9.1 / 9.1	8.3 / 8.3	7.3 / 7.3
IR1 / IR2 / IR5 / IR8	13.7 / 37 / 13.7 / 15	9 / 37 / 9 / 15	9 / 37 / 9 / 15



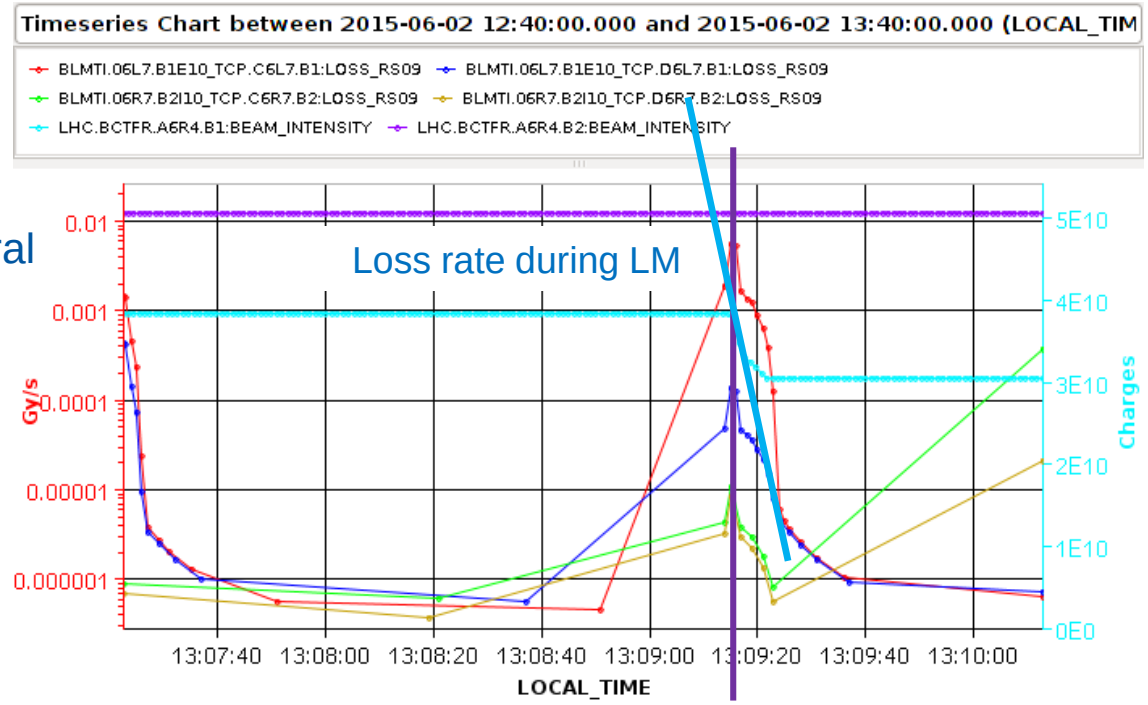
Estimating Beam Power Losses

- The correct estimation of the beam power loss is crucial for adjusting BLM thresholds!
  - scaling BLM thresholds based on LMs is actually a linear extrapolation of signals recorded at 1-2 kW to 200-500kW beam losses!
- **2015** (LHC-BLM-ECR-0038 and MPP, 14th Aug 2015):
  - Beam power loss estimated via 1Hz logging of BCT signal;
  - Decrease in beam intensity during LM;

"The devil is in the detail":

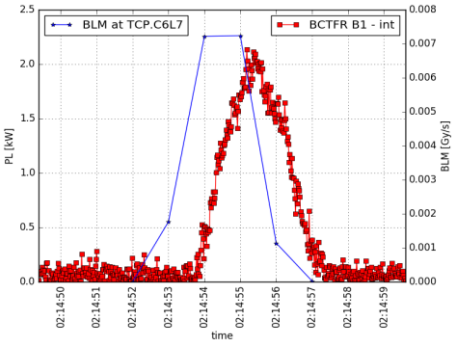
- BCT: logged every 1.02s + average of the last 1s;
- BLMs: logged every s + integral over ~1.3s + last value computed (refresh: 82ms);

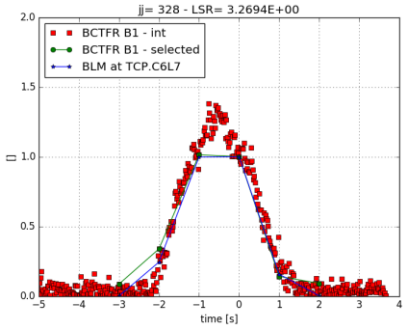
→ premature beam dump during proton collimation quench test at ~600kW instead of 1MW;

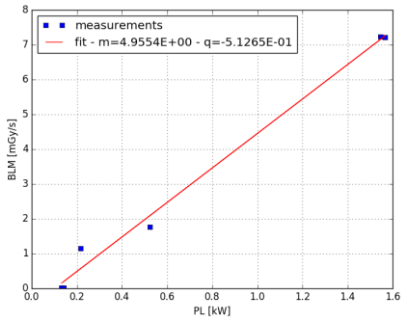


Estimating Beam Power Losses - 2016

- Beam power loss estimated via 50Hz logging of BCT signal (coll team, thanks to G. Valentino);
- Complicated procedure (LHC-BLM-ECR-0049 and BLMTWG, 7th June 2016), based on a pattern-recognition mechanism:
  - ΔI_{BCT} over 1.3s computed from 50Hz BCT logging;
  - Matching time profile of ΔI_{BCT} and BLM signal, to get signals synchronized;
  - Use every point in BLM vs ΔI_{BCT} (i.e. kW) to get calibration curves;







Cross-check using long RSs:

- No dependence on details of logging!
- way simpler and not necessarily less accurate!
- Good agreement → promising approach;

Estimating Beam Power Losses – 2017 (II)

Power losses reconstructed from different LM campaigns

B1H	TCP.D	TCP.C	TCP.B	*AVE*	*STD*
0	8.41E-01	9.44E-01	9.52E-01	9.12E-01	6.20E-02
1	1.32E+00	1.60E+00	1.11E+00	1.34E+00	2.43E-01
2	1.25E+00	1.59E+00	1.10E+00	1.31E+00	2.49E-01
3	1.26E+00	1.61E+00	1.13E+00	1.33E+00	2.49E-01
AVE	1.05E+00	1.27E+00	1.03E+00		
STD	2.90E-01	4.56E-01	1.06E-01		
B1V	**TCP.D**	**TCP.C**	**TCP.B**	*AVE*	*STD*
0	1.01E+00	1.01E+00	9.73E-01	9.97E-01	2.18E-02
1	1.29E+00	1.16E+00	1.10E+00	1.18E+00	9.79E-02
2	1.29E+00	1.09E+00	1.04E+00	1.14E+00	1.31E-01
3	1.31E+00	1.08E+00	1.04E+00	1.14E+00	1.42E-01
AVE	1.15E+00	1.05E+00	1.01E+00		
STD	1.94E-01	5.87E-02	4.91E-02		
B2H	**TCP.D**	**TCP.C**	**TCP.B**	*AVE*	*STD*
0	8.15E-01	1.07E+00	1.08E+00	9.89E-01	1.51E-01
1	8.35E-01	1.11E+00	1.11E+00	1.02E+00	1.59E-01
2	7.39E-01	1.07E+00	1.08E+00	9.65E-01	1.95E-01
3	8.22E-01	1.14E+00	1.12E+00	1.03E+00	1.80E-01
AVE	7.77E-01	1.07E+00	1.08E+00		
STD	5.37E-02	0.00E+00	1.41E-03		
B2V	**TCP.D**	**TCP.C**	**TCP.B**	*AVE*	*STD*
0	1.51E+00	1.48E+00	1.46E+00	1.49E+00	2.52E-02
1	1.08E+00	1.21E+00	1.28E+00	1.19E+00	1.05E-01
2	1.03E+00	1.17E+00	1.26E+00	1.15E+00	1.14E-01
3	1.07E+00	8.49E-01	2.08E+00	1.33E+00	6.57E-01
AVE	1.27E+00	1.33E+00	1.36E+00		
STD	3.39E-01	2.19E-01	1.45E-01		

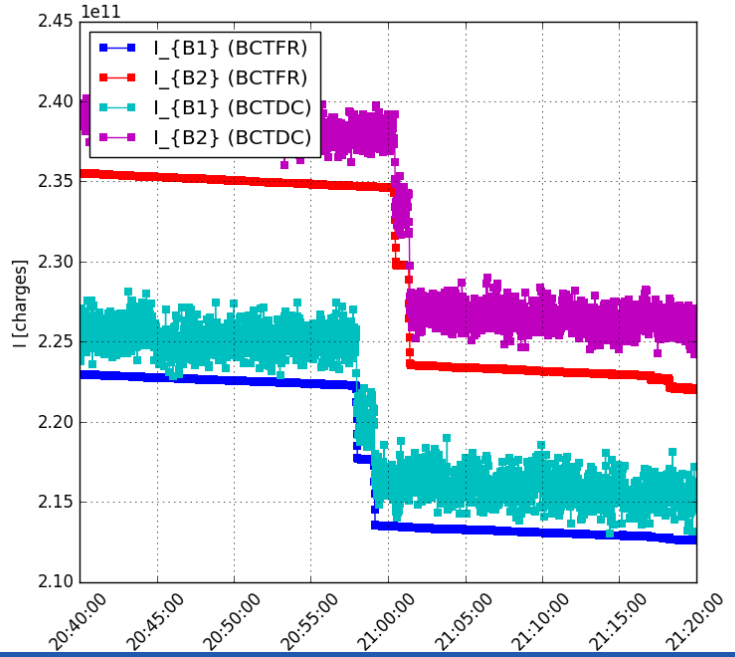
Data sets:

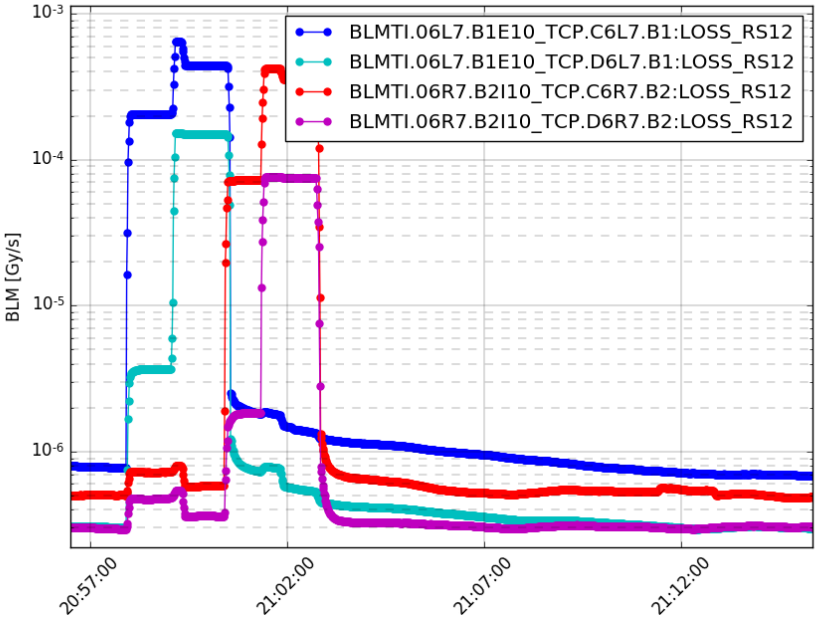
- 0: qualification LM, coll, XRPs in (2017-05-22)
- 1: LM at 120 μrad;
- 2: LM at 150 μrad (lumi optimised);
- 3: LM at 150 μrad (lumi non optmised);

Estimating Beam Power Losses – 2017 (III)

Comparison of calibration factors estimated graphically

		Calib Fact [pGy/p]			
		2015	2016	2017	2017 (MDA)
B1H	TCP.C6L7	2.34	4.70	3.93	3.70
B1V	TCP.D6L7	3.03	2.26	3.38	3.00
B2H	TCP.C6R7	2.42	1.38	1.52	1.22
B2V	TCP.D6R7	1.43	0.07	1.02	1.00

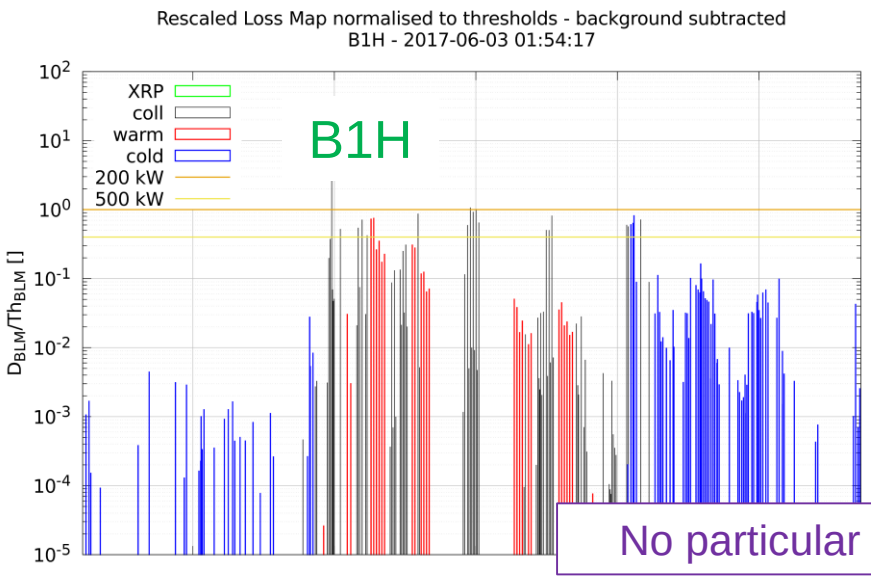


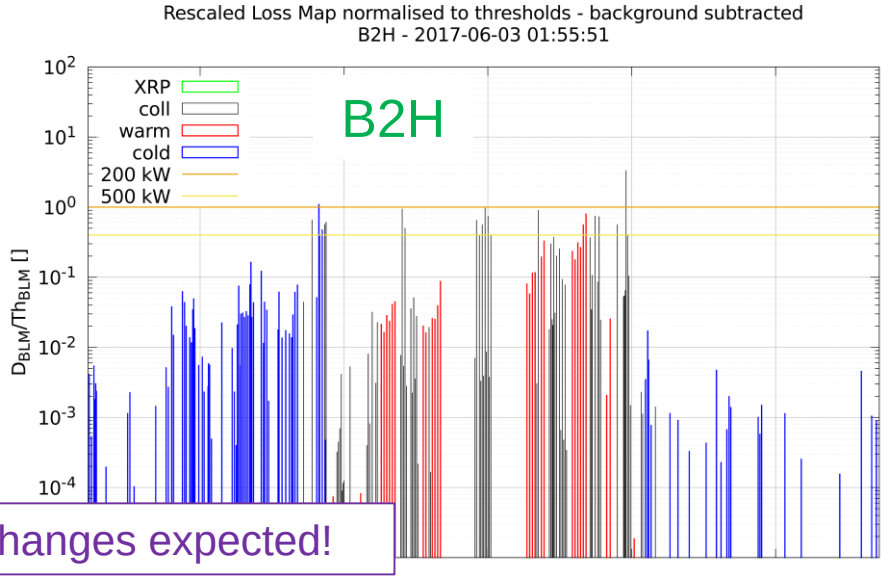


Graphical estimation via:

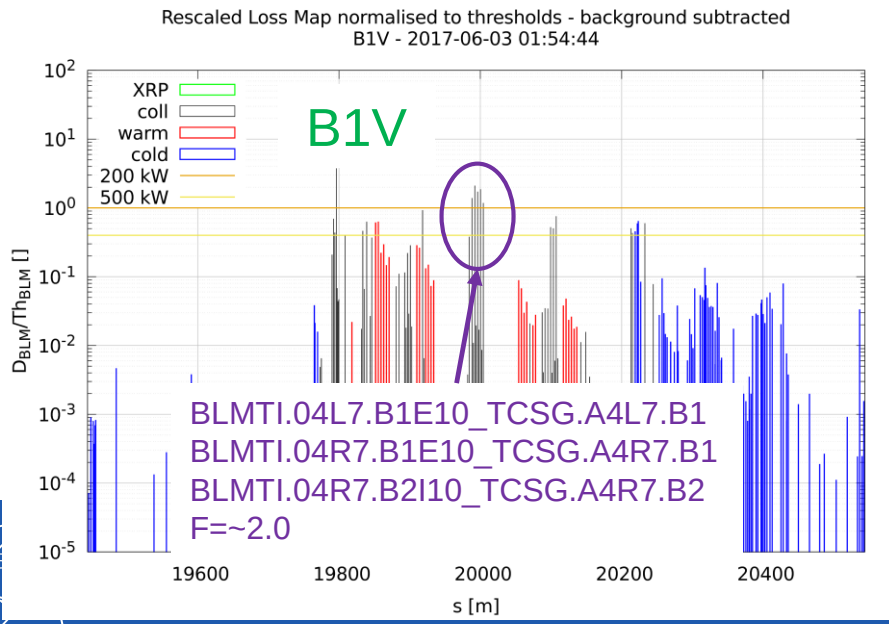
$$F = \frac{D_{BLM} \times \Delta T_{RS12}}{\Delta I_{BCT}}$$

Levelling at 120 μrad - Zoom on IR7





No particular changes expected!



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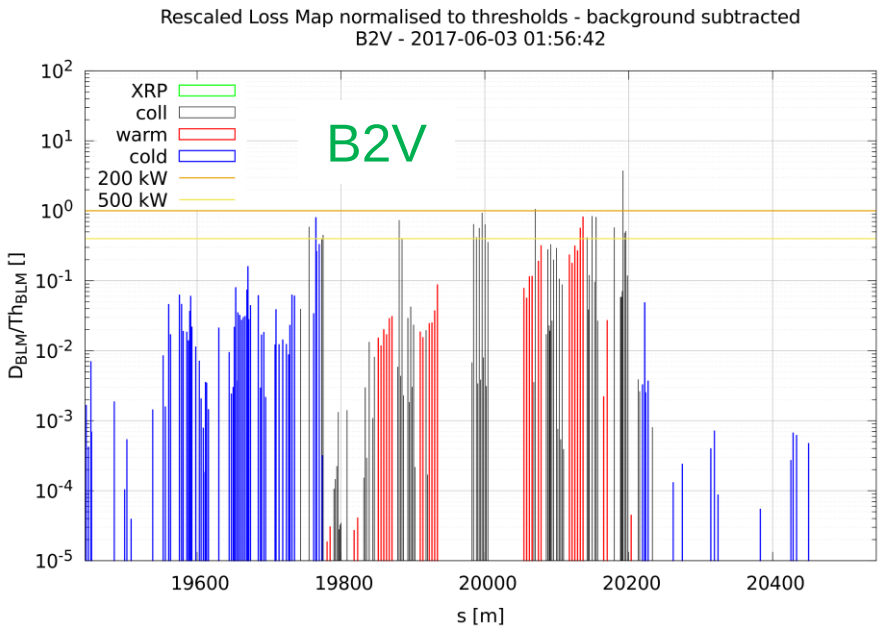
BLMTI.04R7.B1E10_TCSG.A4R7.B1
BLMTI.04R7.B2I10_TCSG.A4R7.B2
F=~2.0



Changes due Collision Debris – Other BLMs