LHC ARC radiation levels with a focus on the peaks and their evolution

30-01-2018, 31st MCWG

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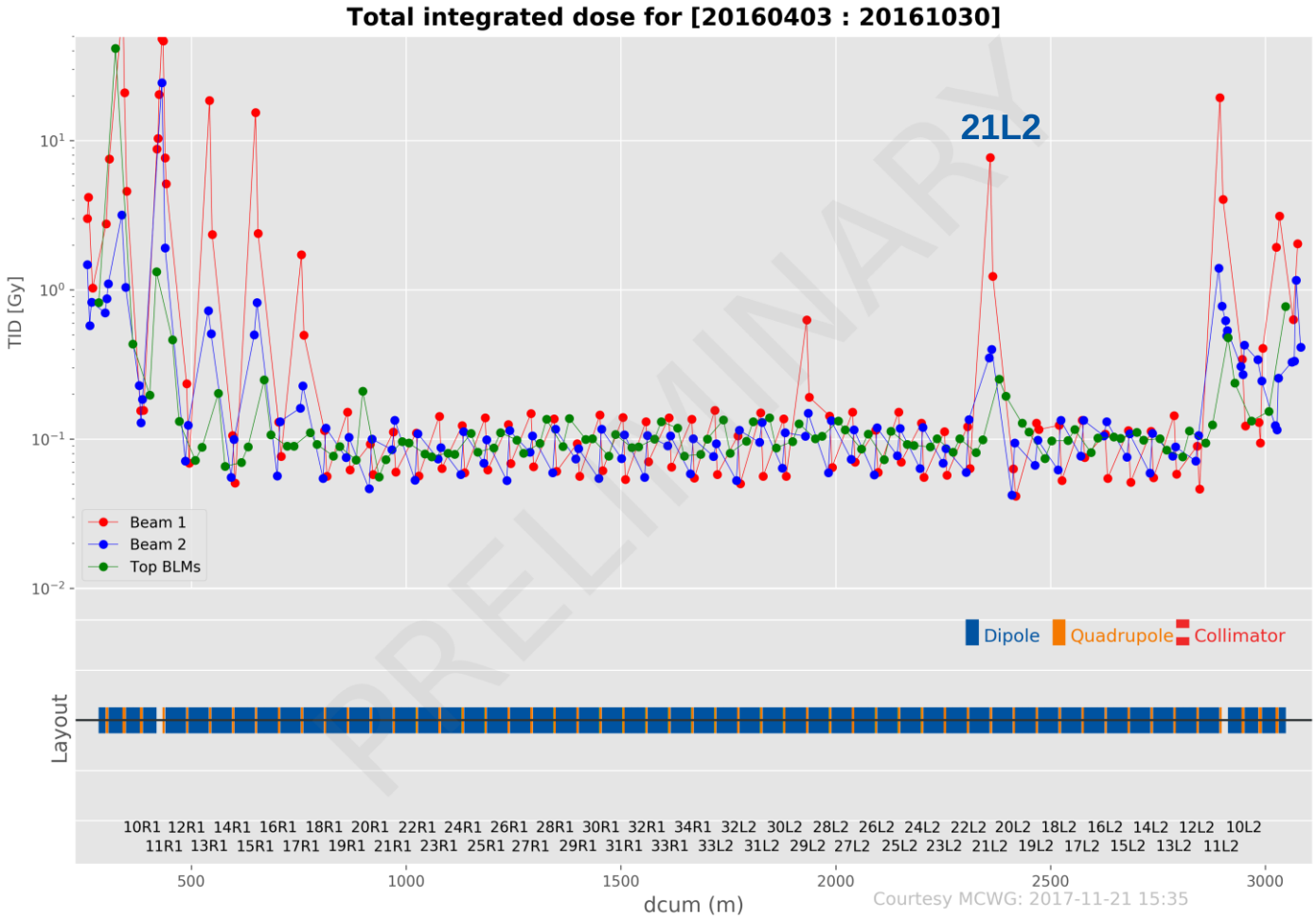
Cell	Points
12	L1
13	R1, L5, R5, R7, L1
14	L8
15	R1, ***R8***, L1, L5
16	L2, ***R2, L8***, L1, R8
17	R1, L2, L1
18	***R7***
19	***L2, R4, R8***
21	L2
22	***L3***
23	R4
32	L7

- *Baseline ARC BLM annual values of ~100 mGy*
- *Peak condition: >1 Gy/year*
- *All peaks (except 2017 17L2) appear in MQ BLMs*

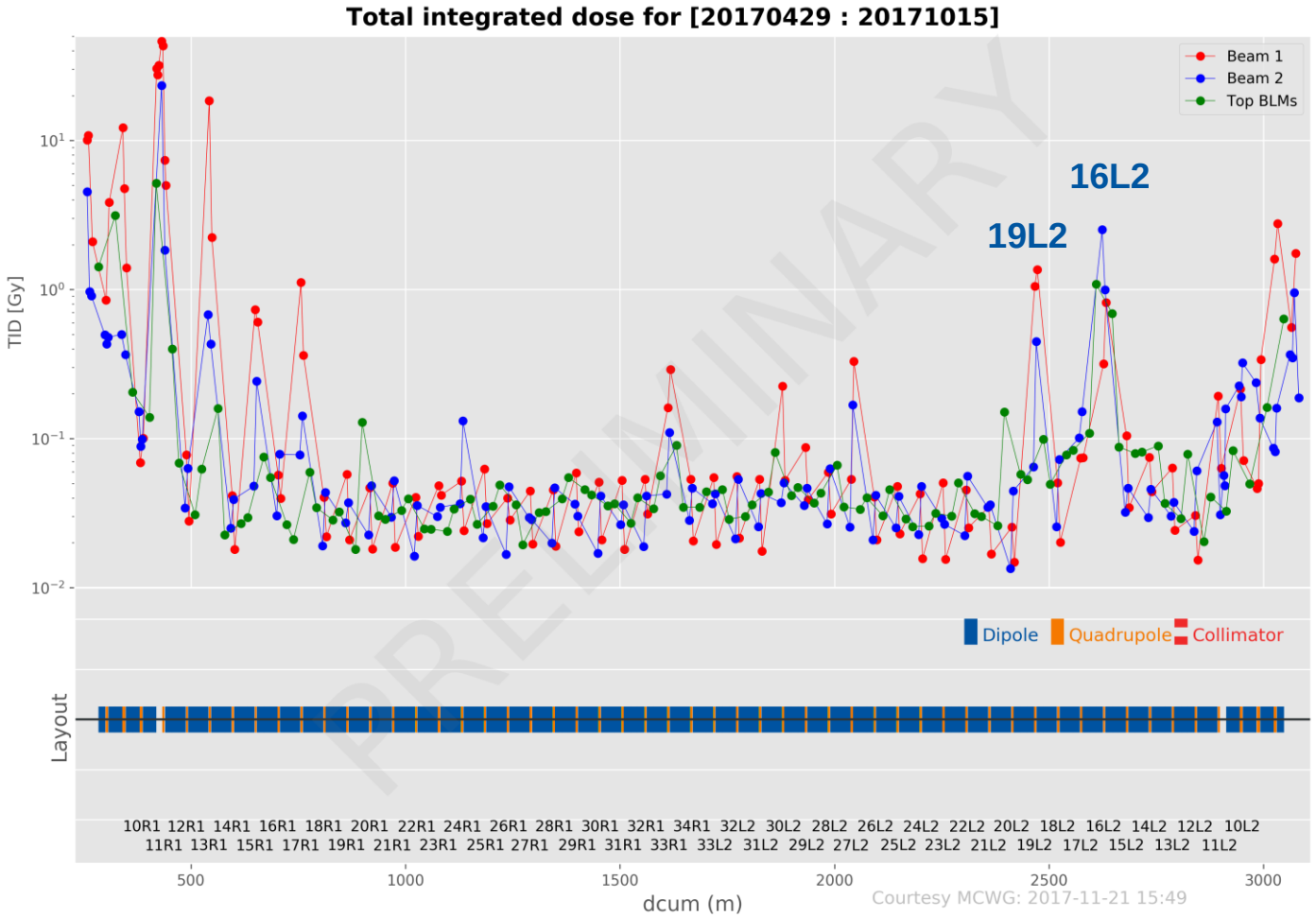
Only in 2016
Only in 2017
Both 2016 and 2017

DS-like peaks mainly around IP1 and IP5 - we will focus on most of "the rest" (marked in italic)

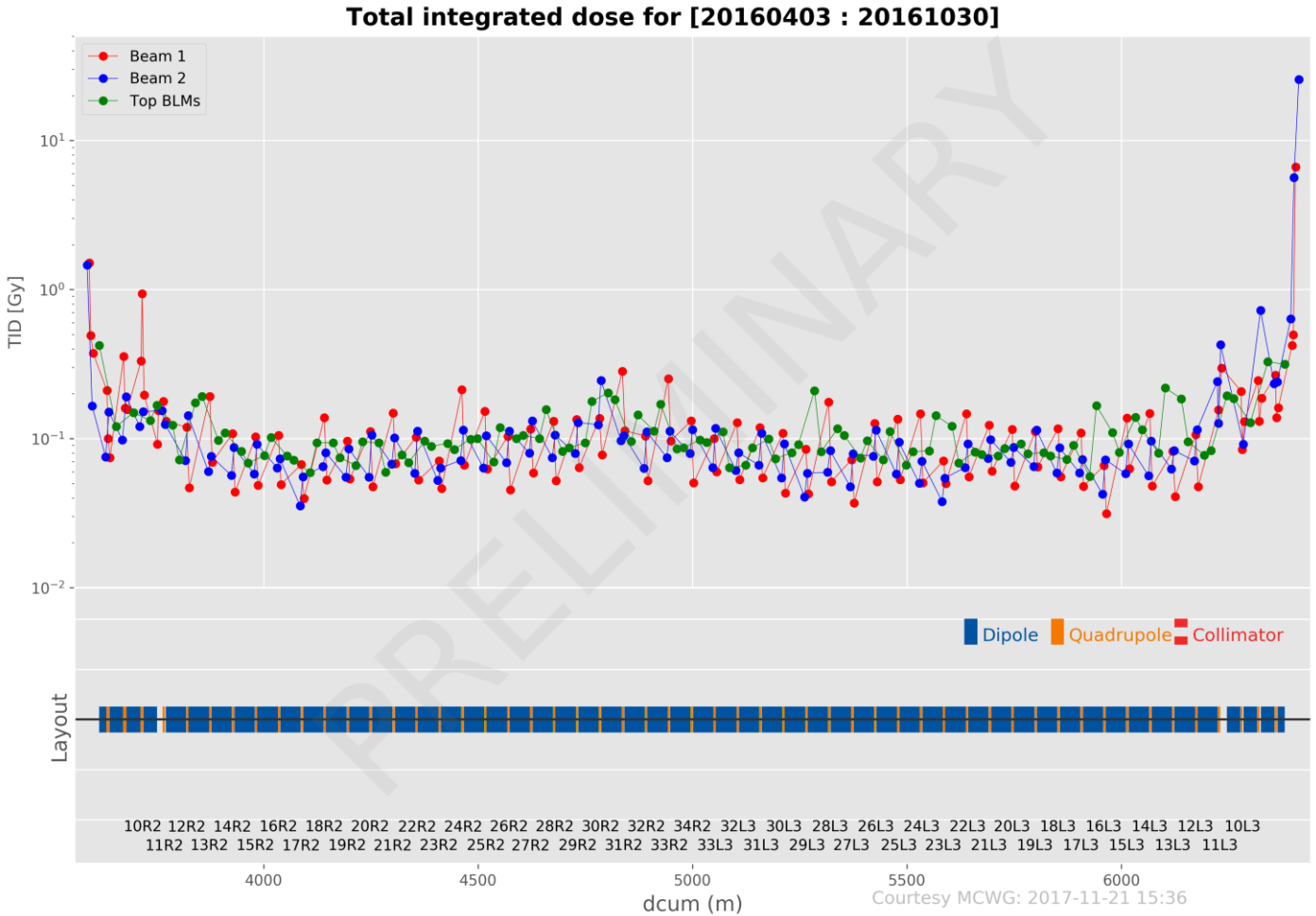
1-2, 2016


Total integrated dose for [20160403 : 20161030]
21L2
PRELIMINARY
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
Beam 1
Beam 2
Top BLMs
Dipole
Quadrupole
Collimator
Layout
10R1 12R1 14R1 16R1 18R1 20R1 22R1 24R1 26R1 28R1 30R1 32R1 34R1 32L2 30L2 28L2 26L2 24L2 22L2 20L2 18L2 16L2 14L2 12L2 10L2
11R1 13R1 15R1 17R1 19R1 21R1 23R1 25R1 27R1 29R1 31R1 33R1 33L2 31L2 29L2 27L2 25L2 23L2 21L2 19L2 17L2 15L2 13L2 11L2
500
1000
1500
2000
2500
3000
dcum (m)
Courtesy MCWG: 2017-11-21 15:35

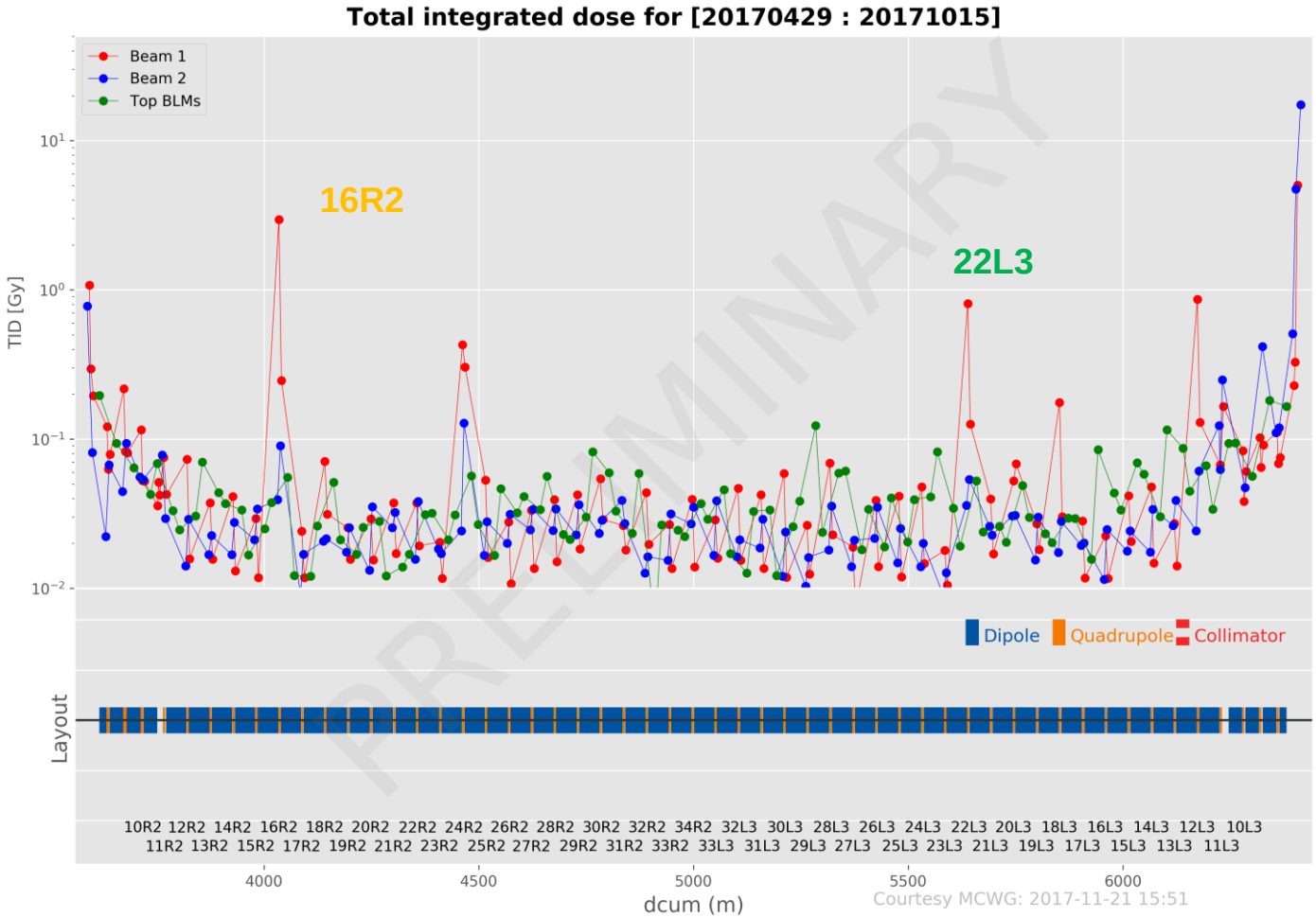
1-2, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
16L2
19L2
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R1 12R1 14R1 16R1 18R1 20R1 22R1 24R1 26R1 28R1 30R1 32R1 34R1 32L2 30L2 28L2 26L2 24L2 22L2 20L2 18L2 16L2 14L2 12L2 10L2
11R1 13R1 15R1 17R1 19R1 21R1 23R1 25R1 27R1 29R1 31R1 33R1 33L2 31L2 29L2 27L2 25L2 23L2 21L2 19L2 17L2 15L2 13L2 11L2
dcum (m)
Courtesy MCWG: 2017-11-21 15:49
PRELIMINARY

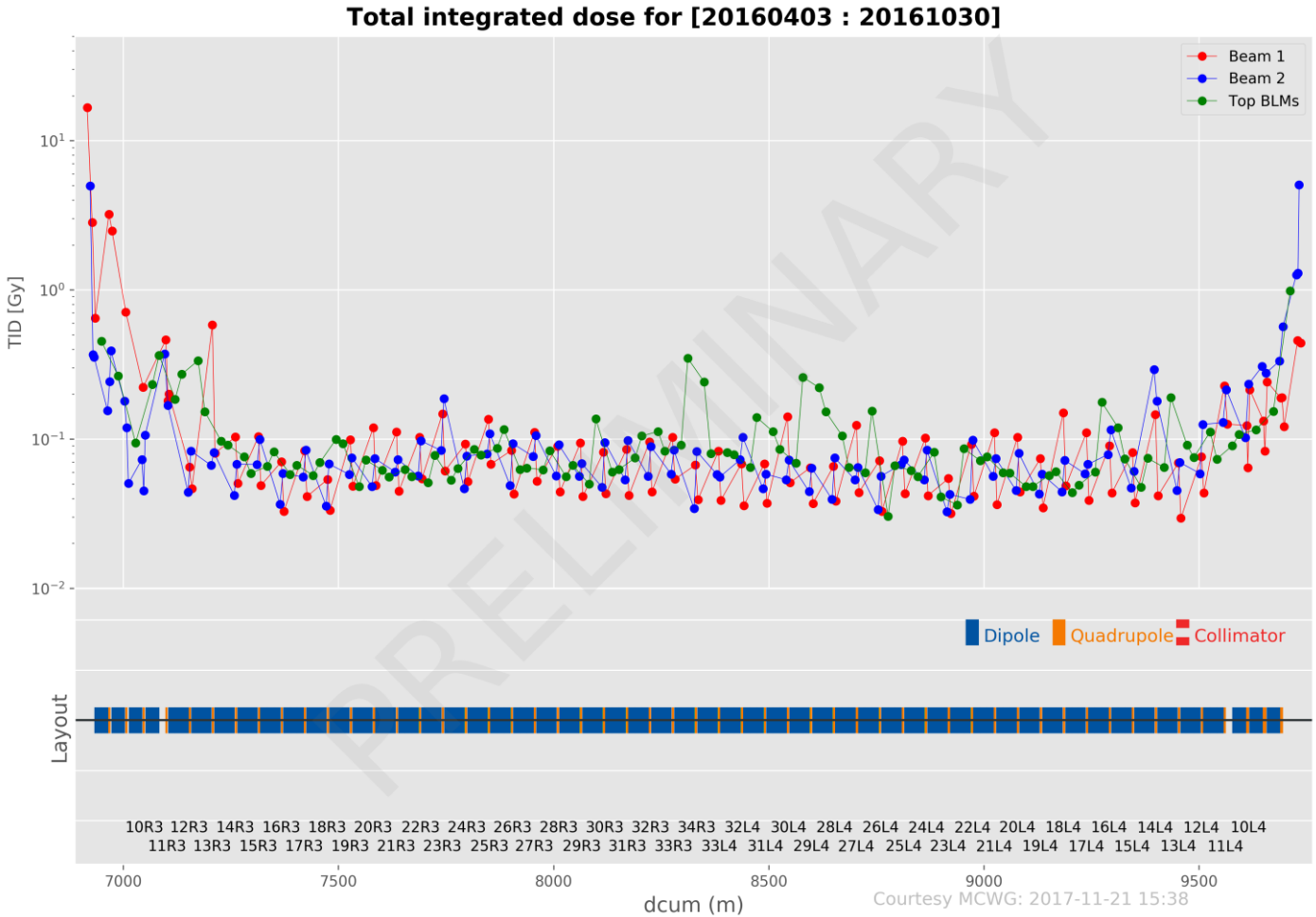
2-3, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
PRELIMINARY
Dipole
Quadrupole
Collimator
Layout
10R2 12R2 14R2 16R2 18R2 20R2 22R2 24R2 26R2 28R2 30R2 32R2 34R2 32L3 30L3 28L3 26L3 24L3 22L3 20L3 18L3 16L3 14L3 12L3 10L3
11R2 13R2 15R2 17R2 19R2 21R2 23R2 25R2 27R2 29R2 31R2 33R2 33L3 31L3 29L3 27L3 25L3 23L3 21L3 19L3 17L3 15L3 13L3 11L3
4000
4500
5000
5500
6000
dcum (m)
Courtesy MCWG: 2017-11-21 15:36

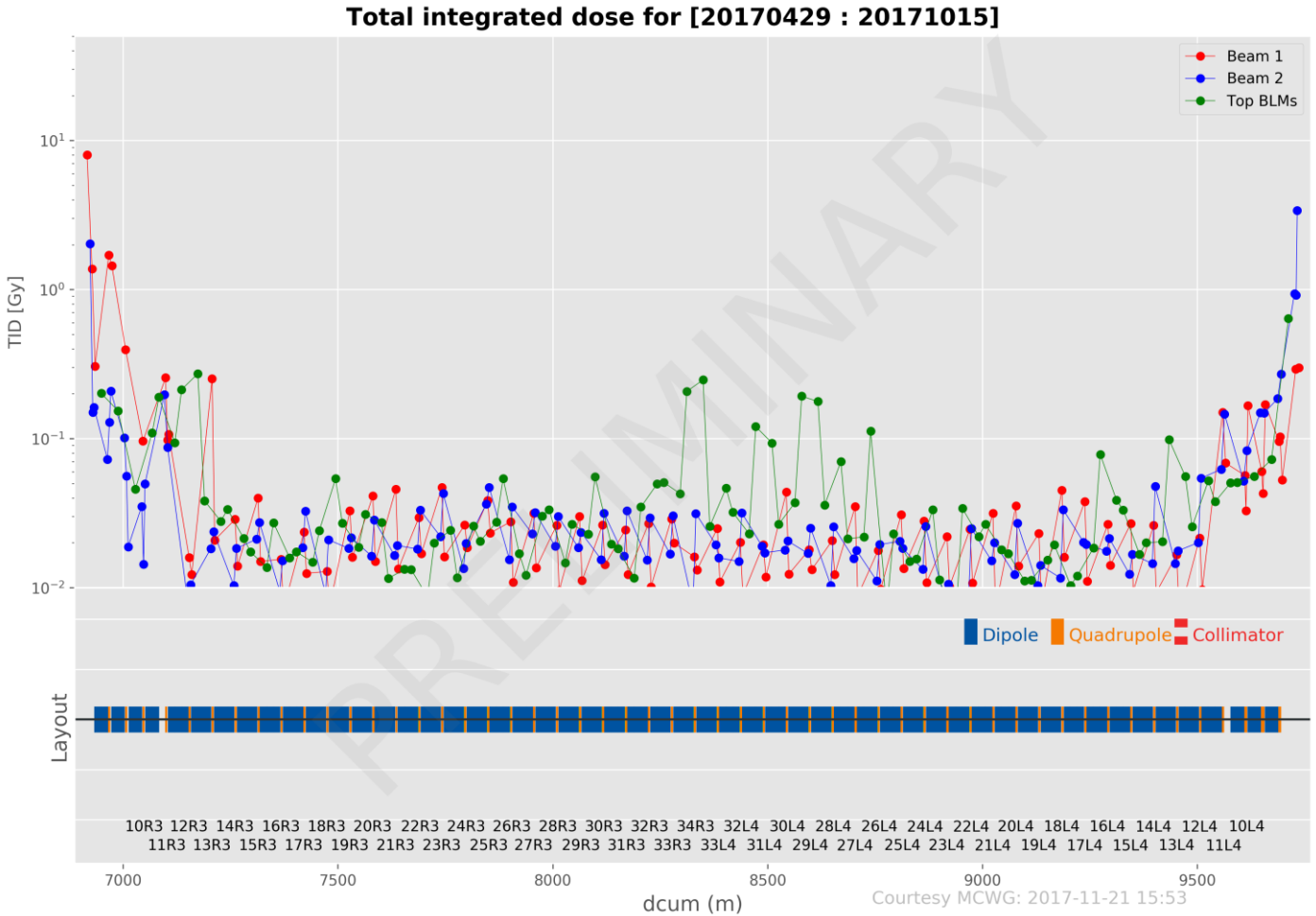
2-3, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
16R2
22L3
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R2 12R2 14R2 16R2 18R2 20R2 22R2 24R2 26R2 28R2 30R2 32R2 34R2 32L3 30L3 28L3 26L3 24L3 22L3 20L3 18L3 16L3 14L3 12L3 10L3
11R2 13R2 15R2 17R2 19R2 21R2 23R2 25R2 27R2 29R2 31R2 33R2 33L3 31L3 29L3 27L3 25L3 23L3 21L3 19L3 17L3 15L3 13L3 11L3
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:51

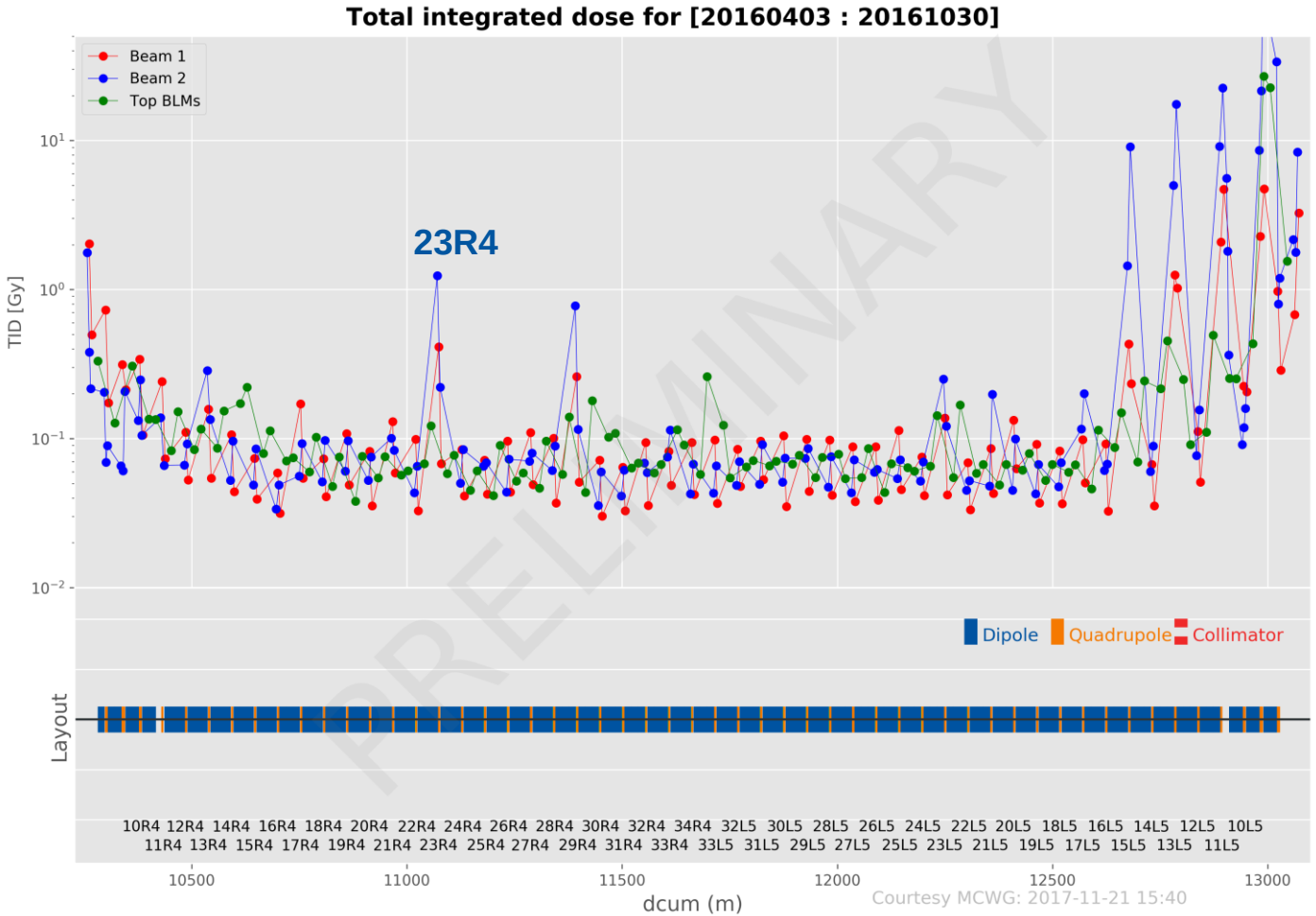
3-4, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
Dipole
Quadrupole
Collimator
Layout
10R3 12R3 14R3 16R3 18R3 20R3 22R3 24R3 26R3 28R3 30R3 32R3 34R3 32L4 30L4 28L4 26L4 24L4 22L4 20L4 18L4 16L4 14L4 12L4 10L4
11R3 13R3 15R3 17R3 19R3 21R3 23R3 25R3 27R3 29R3 31R3 33R3 33L4 31L4 29L4 27L4 25L4 23L4 21L4 19L4 17L4 15L4 13L4 11L4
7000
7500
8000
8500
9000
9500
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:38

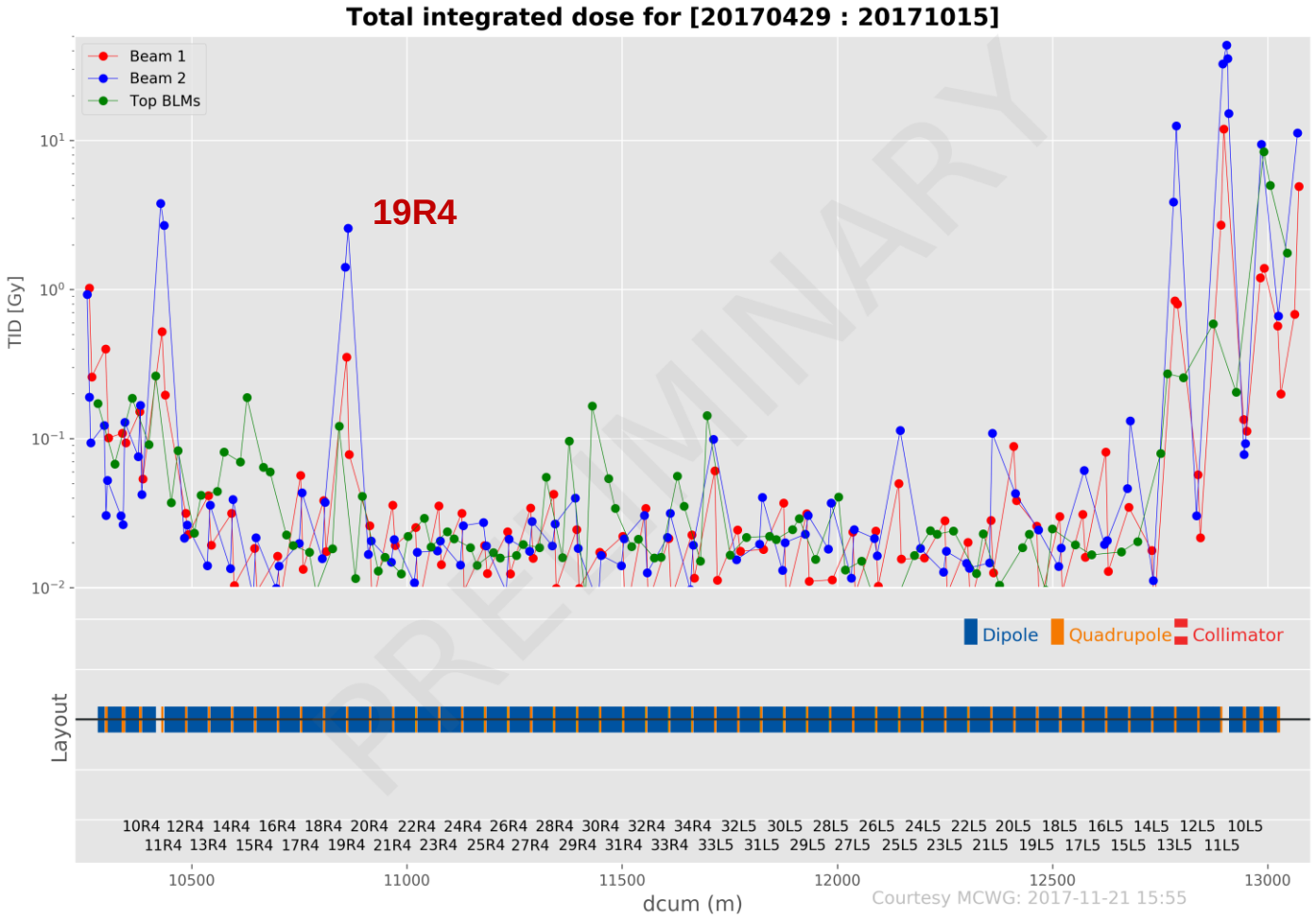
3-4, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
PRELIMINARY
Dipole
Quadrupole
Collimator
Layout
10R3 12R3 14R3 16R3 18R3 20R3 22R3 24R3 26R3 28R3 30R3 32R3 34R3 32L4 30L4 28L4 26L4 24L4 22L4 20L4 18L4 16L4 14L4 12L4 10L4
11R3 13R3 15R3 17R3 19R3 21R3 23R3 25R3 27R3 29R3 31R3 33R3 33L4 31L4 29L4 27L4 25L4 23L4 21L4 19L4 17L4 15L4 13L4 11L4
7000
7500
8000
8500
9000
9500
dcum (m)
Courtesy MCWG: 2017-11-21 15:53

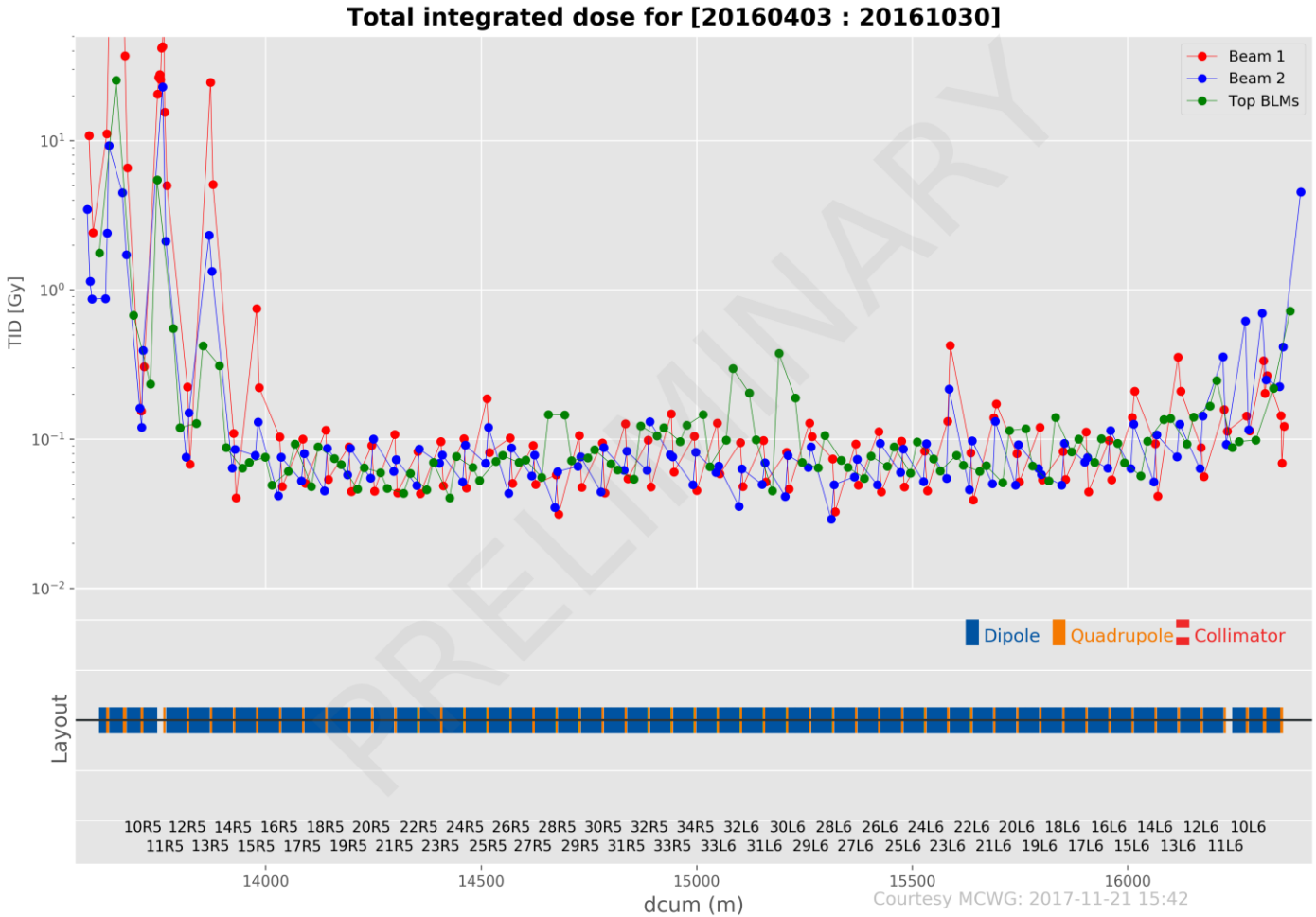
4-5, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
23R4
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R4 12R4 14R4 16R4 18R4 20R4 22R4 24R4 26R4 28R4 30R4 32R4 34R4 32L5 30L5 28L5 26L5 24L5 22L5 20L5 18L5 16L5 14L5 12L5 10L5
11R4 13R4 15R4 17R4 19R4 21R4 23R4 25R4 27R4 29R4 31R4 33R4 33L5 31L5 29L5 27L5 25L5 23L5 21L5 19L5 17L5 15L5 13L5 11L5
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:40

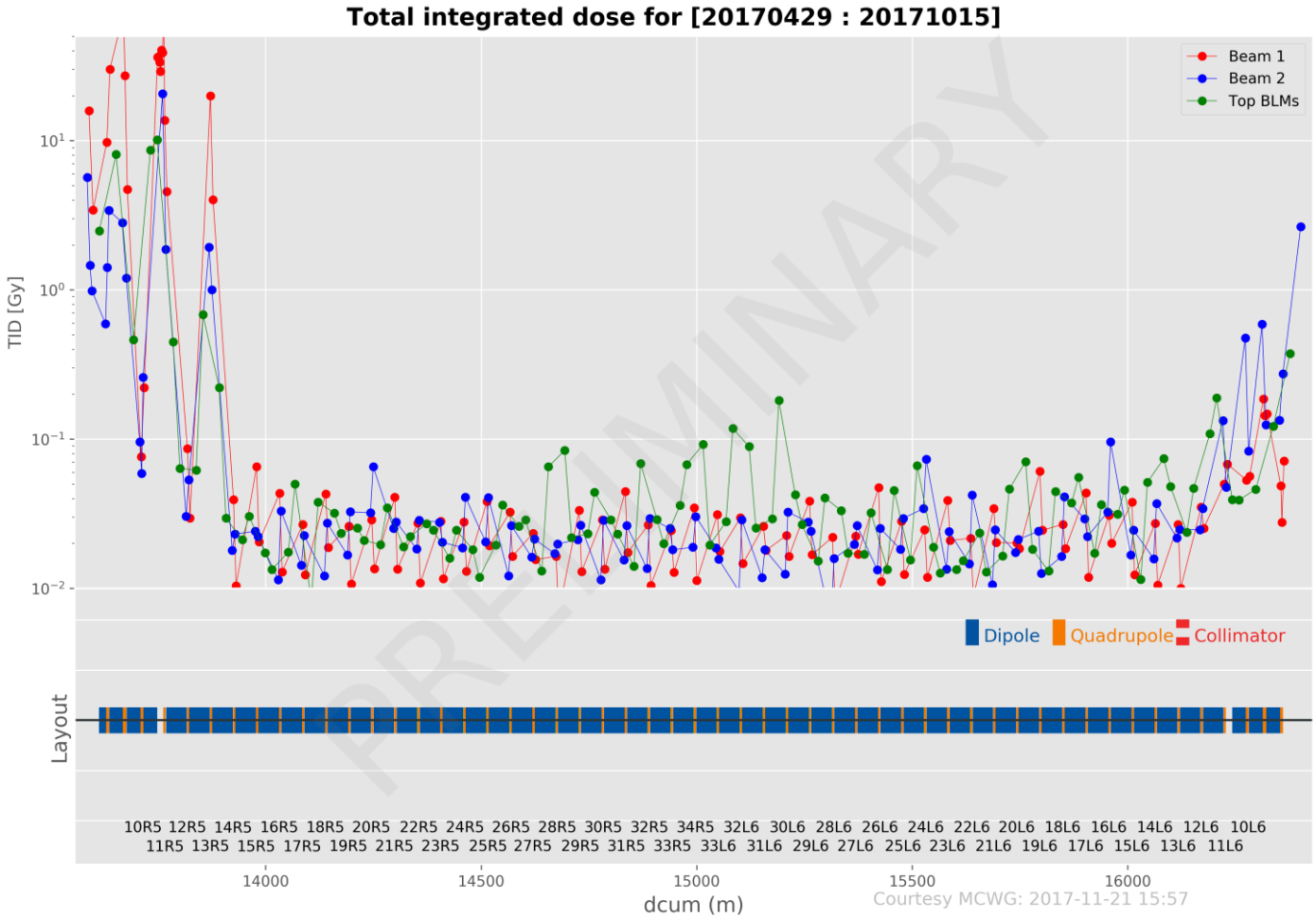
4-5, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
19R4
PRELIMINARY
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R4 12R4 14R4 16R4 18R4 20R4 22R4 24R4 26R4 28R4 30R4 32R4 34R4 32L5 30L5 28L5 26L5 24L5 22L5 20L5 18L5 16L5 14L5 12L5 10L5
11R4 13R4 15R4 17R4 19R4 21R4 23R4 25R4 27R4 29R4 31R4 33R4 33L5 31L5 29L5 27L5 25L5 23L5 21L5 19L5 17L5 15L5 13L5 11L5
dcum (m)
Courtesy MCWG: 2017-11-21 15:55

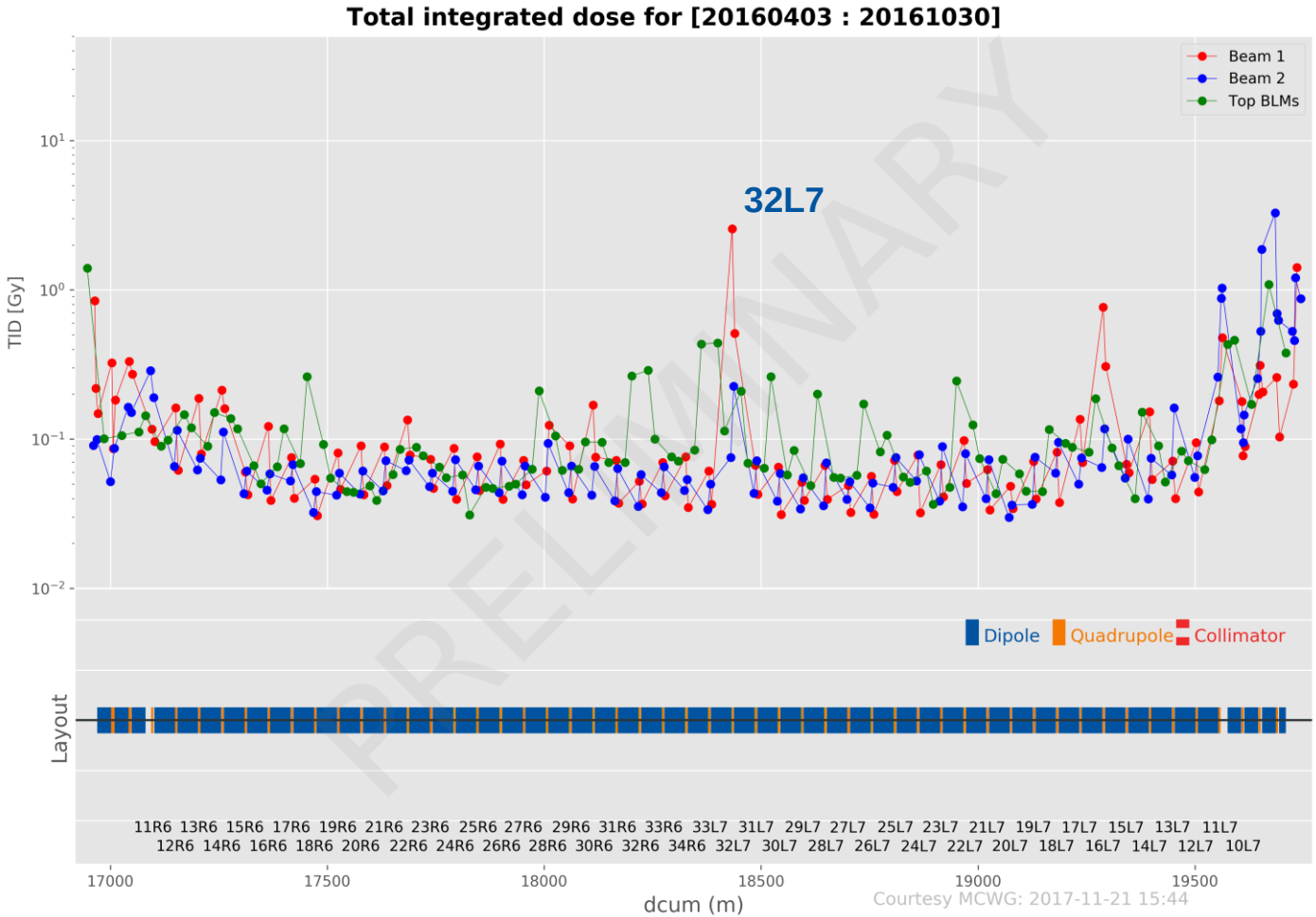
5-6, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
Dipole
Quadrupole
Collimator
Layout
10R5 12R5 14R5 16R5 18R5 20R5 22R5 24R5 26R5 28R5 30R5 32R5 34R5 32L6 30L6 28L6 26L6 24L6 22L6 20L6 18L6 16L6 14L6 12L6 10L6
11R5 13R5 15R5 17R5 19R5 21R5 23R5 25R5 27R5 29R5 31R5 33R5 33L6 31L6 29L6 27L6 25L6 23L6 21L6 19L6 17L6 15L6 13L6 11L6
14000
14500
15000
15500
16000
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:42

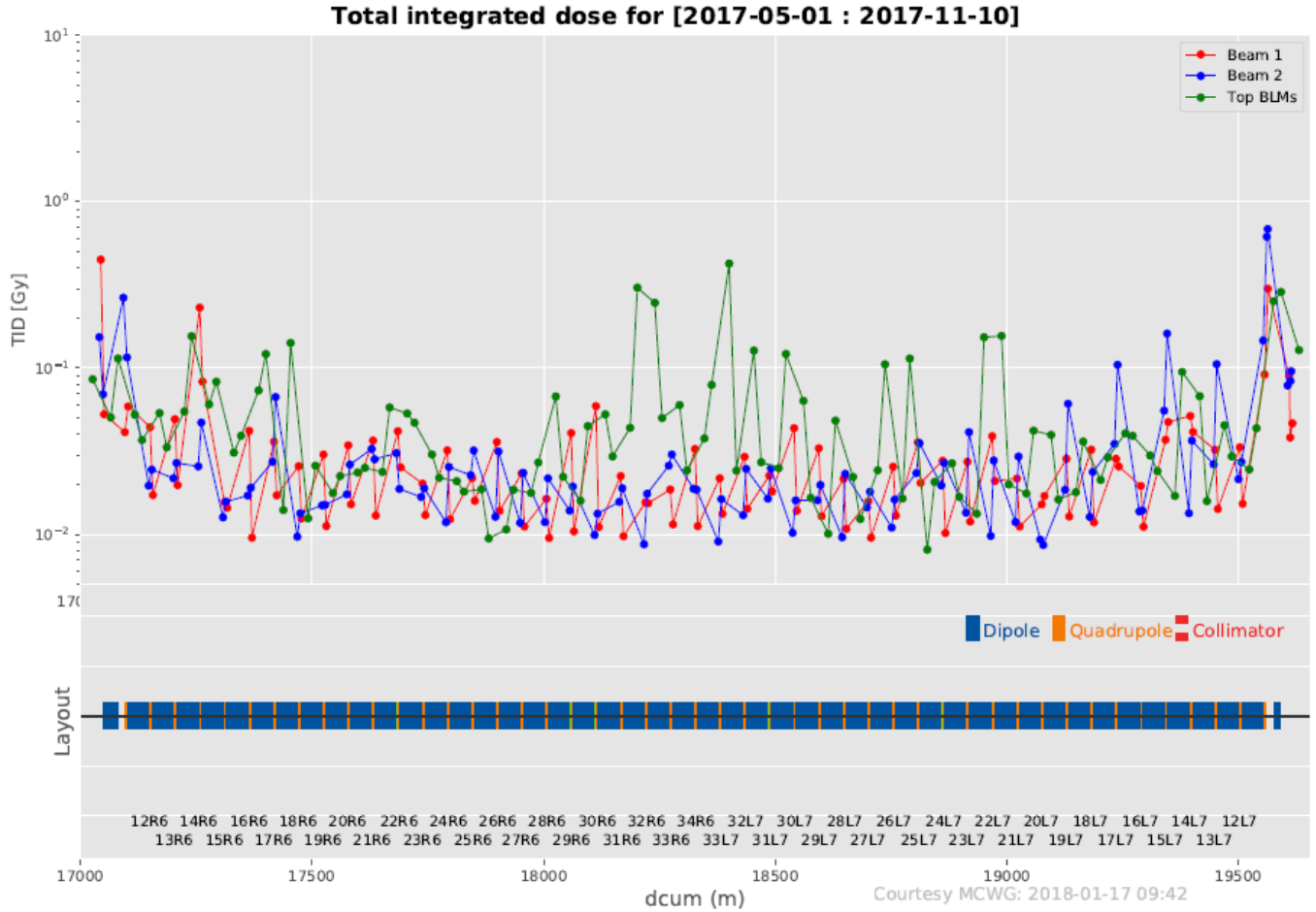
5-6, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
PRELIMINARY
Dipole
Quadrupole
Collimator
Layout
10R5 12R5 14R5 16R5 18R5 20R5 22R5 24R5 26R5 28R5 30R5 32R5 34R5 32L6 30L6 28L6 26L6 24L6 22L6 20L6 18L6 16L6 14L6 12L6 10L6
11R5 13R5 15R5 17R5 19R5 21R5 23R5 25R5 27R5 29R5 31R5 33R5 33L6 31L6 29L6 27L6 25L6 23L6 21L6 19L6 17L6 15L6 13L6 11L6
14000
14500
15000
15500
16000
dcum (m)
Courtesy MCWG: 2017-11-21 15:57

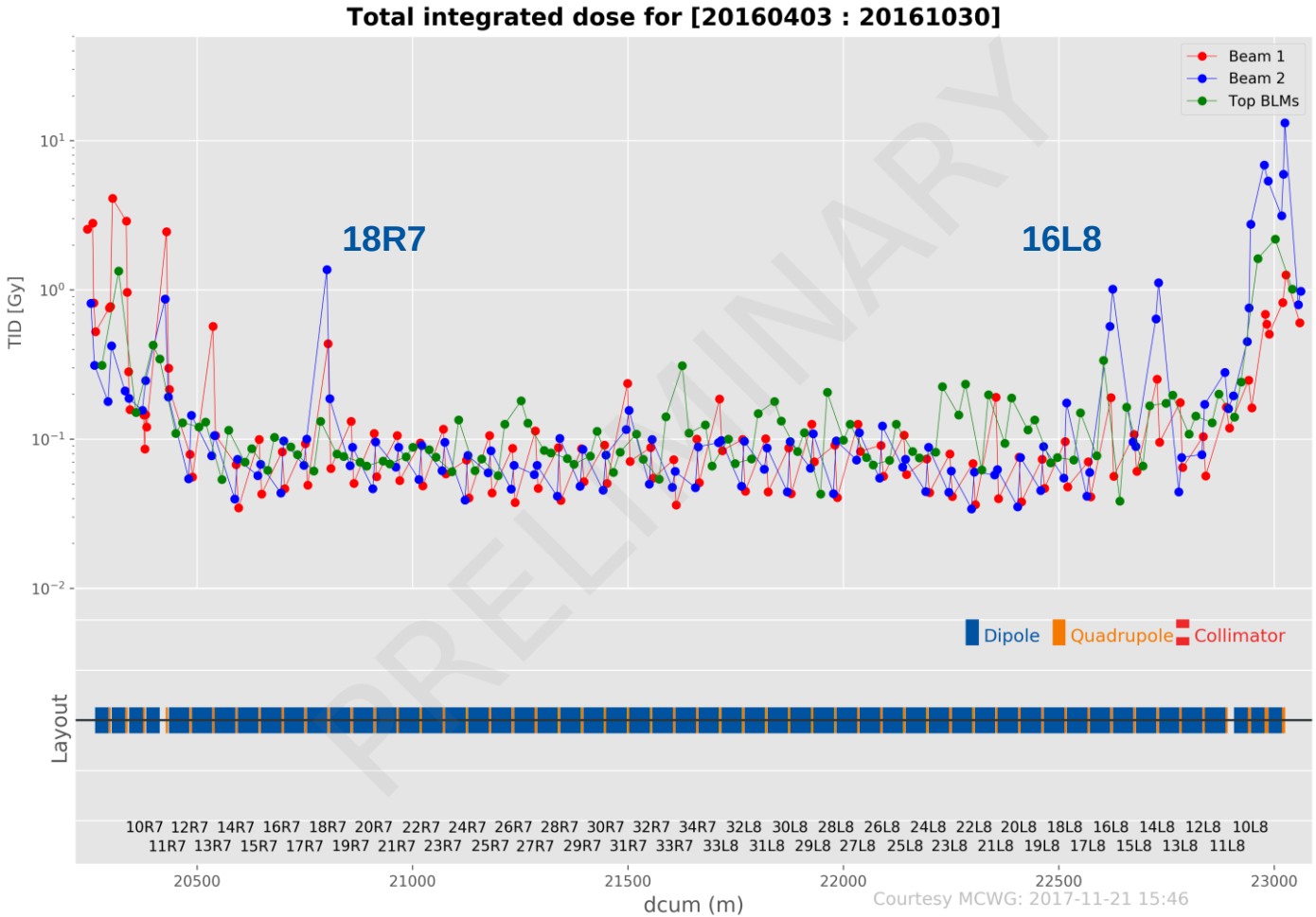
6-7, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
32L7
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
Dipole
Quadrupole
Collimator
Layout
11R6 13R6 15R6 17R6 19R6 21R6 23R6 25R6 27R6 29R6 31R6 33R6 33L7 31L7 29L7 27L7 25L7 23L7 21L7 19L7 17L7 15L7 13L7 11L7
12R6 14R6 16R6 18R6 20R6 22R6 24R6 26R6 28R6 30R6 32R6 34R6 32L7 30L7 28L7 26L7 24L7 22L7 20L7 18L7 16L7 14L7 12L7 10L7
17000
17500
18000
18500
19000
19500
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:44

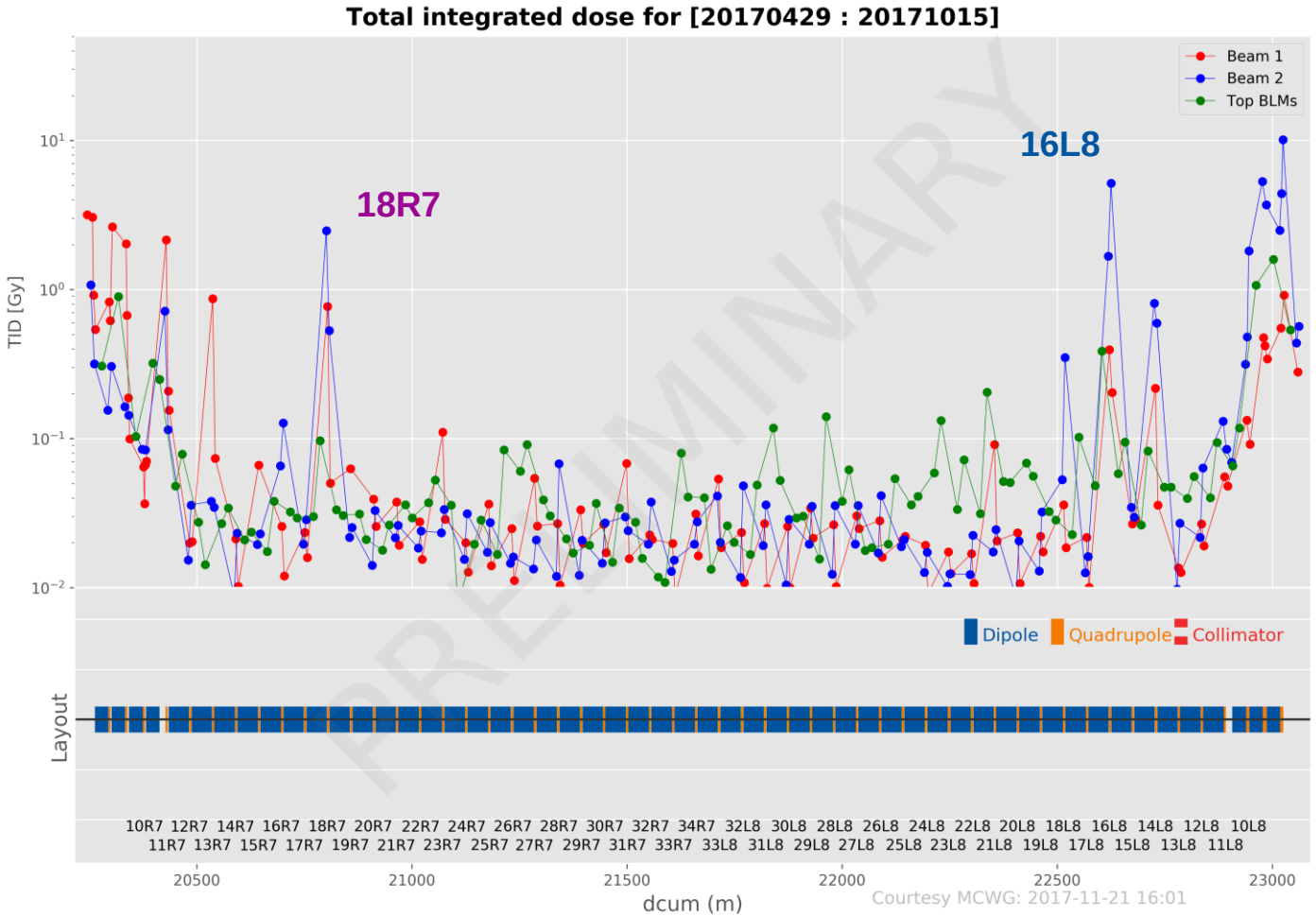
6-7, 2017


Total integrated dose for [2017-05-01 : 2017-11-10]
Beam 1
Beam 2
Top BLMs
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
12R6 14R6 16R6 18R6 20R6 22R6 24R6 26R6 28R6 30R6 32R6 34R6 32L7 30L7 28L7 26L7 24L7 22L7 20L7 18L7 16L7 14L7 12L7
13R6 15R6 17R6 19R6 21R6 23R6 25R6 27R6 29R6 31R6 33R6 33L7 31L7 29L7 27L7 25L7 23L7 21L7 19L7 17L7 15L7 13L7
17000
17500
18000
18500
19000
19500
dcum (m)
Courtesy MCWG: 2018-01-17 09:42

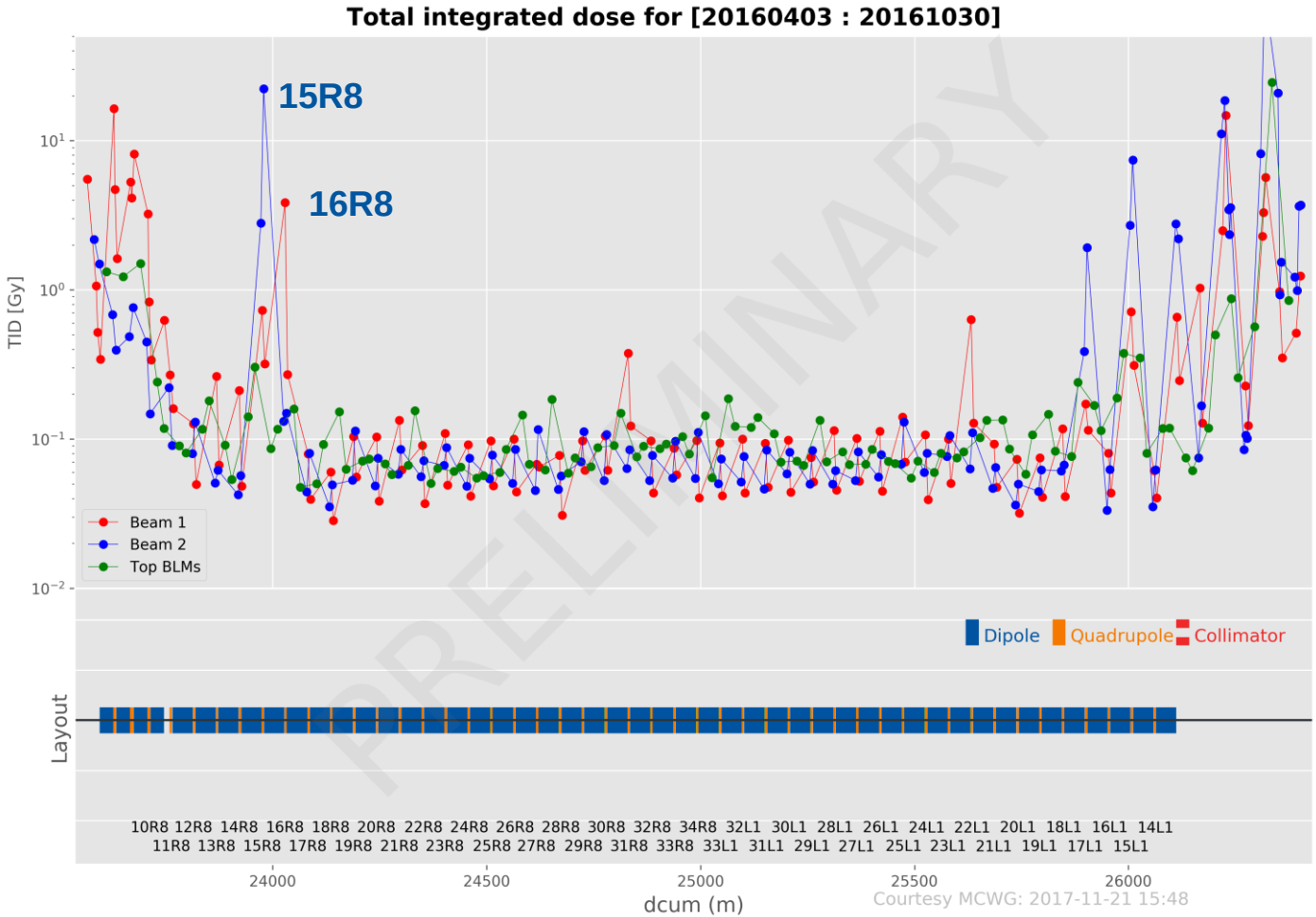
7-8, 2016


Total integrated dose for [20160403 : 20161030]
Beam 1
Beam 2
Top BLMs
18R7
16L8
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R7 12R7 14R7 16R7 18R7 20R7 22R7 24R7 26R7 28R7 30R7 32R7 34R7 32L8 30L8 28L8 26L8 24L8 22L8 20L8 18L8 16L8 14L8 12L8 10L8
11R7 13R7 15R7 17R7 19R7 21R7 23R7 25R7 27R7 29R7 31R7 33R7 33L8 31L8 29L8 27L8 25L8 23L8 21L8 19L8 17L8 15L8 13L8 11L8
dcum (m)
Courtesy MCWG: 2017-11-21 15:46

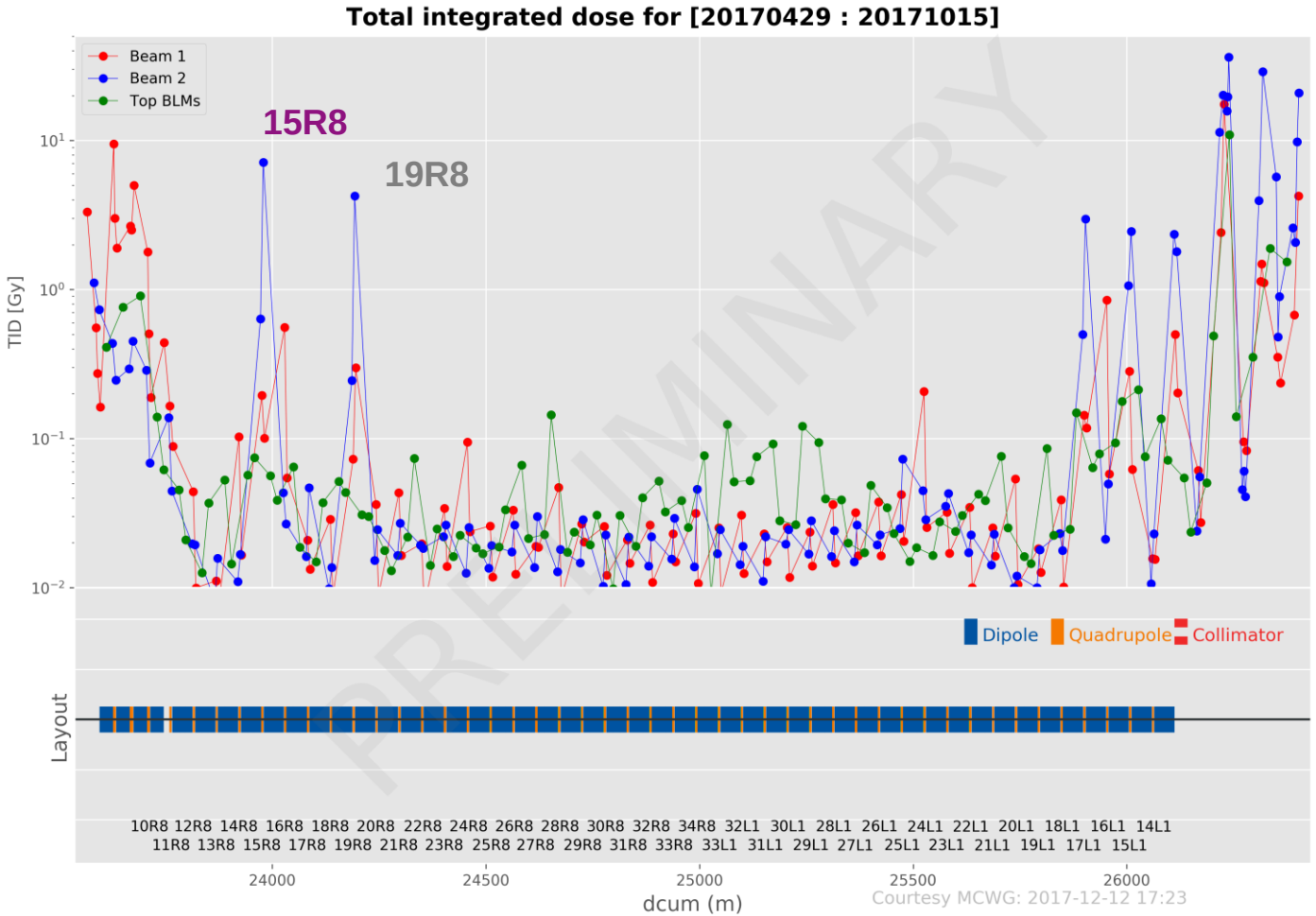
7-8, 2017

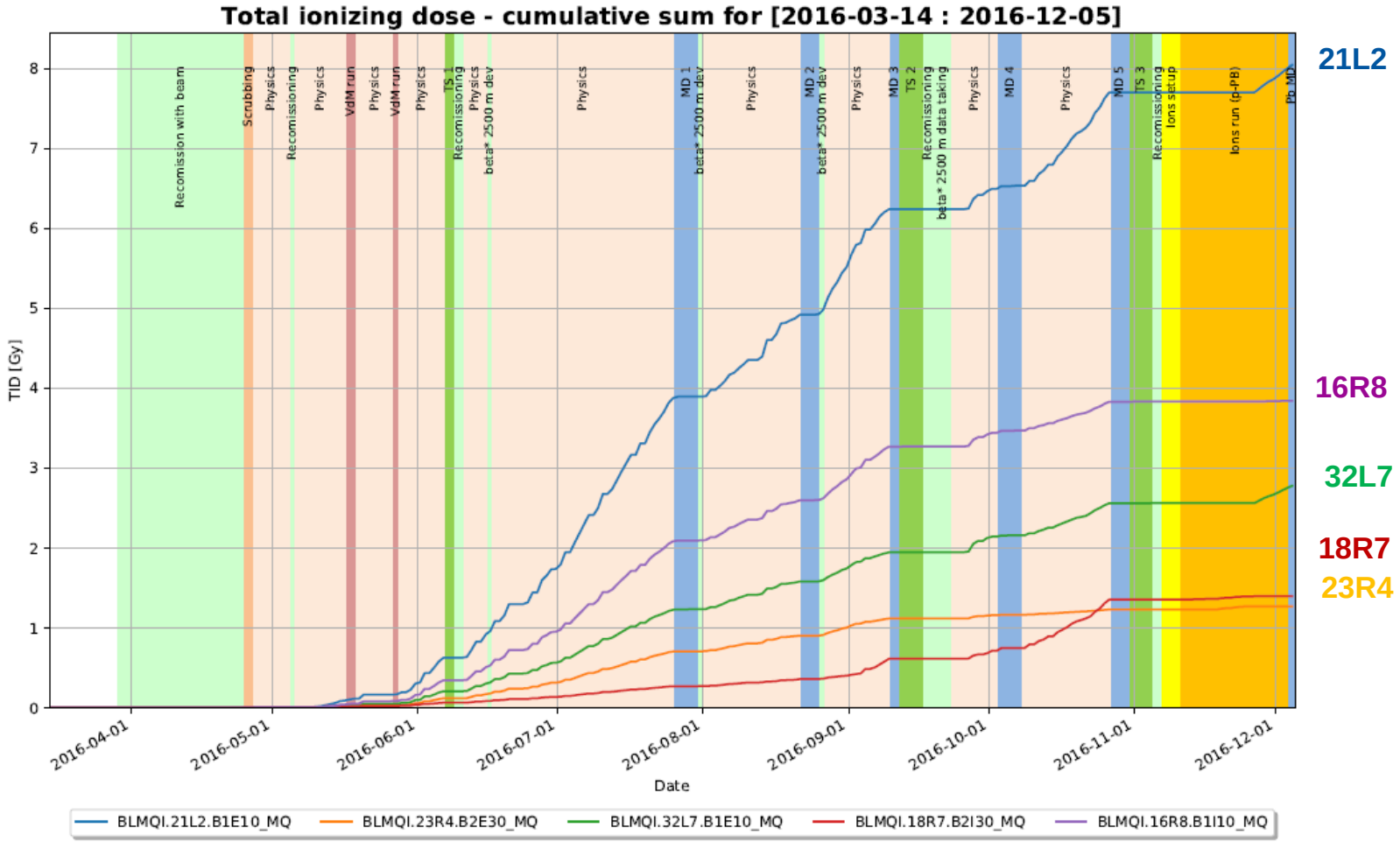

Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
18R7
16L8
TID [Gy]
Dipole
Quadrupole
Collimator
Layout
10R7 12R7 14R7 16R7 18R7 20R7 22R7 24R7 26R7 28R7 30R7 32R7 34R7 32L8 30L8 28L8 26L8 24L8 22L8 20L8 18L8 16L8 14L8 12L8 10L8
11R7 13R7 15R7 17R7 19R7 21R7 23R7 25R7 27R7 29R7 31R7 33R7 33L8 31L8 29L8 27L8 25L8 23L8 21L8 19L8 17L8 15L8 13L8 11L8
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 16:01

8-1, 2016


Total integrated dose for [20160403 : 20161030]
15R8
16R8
TID [Gy]
Beam 1
Beam 2
Top BLMs
Dipole
Quadrupole
Collimator
Layout
10R8 12R8 14R8 16R8 18R8 20R8 22R8 24R8 26R8 28R8 30R8 32R8 34R8 32L1 30L1 28L1 26L1 24L1 22L1 20L1 18L1 16L1 14L1
11R8 13R8 15R8 17R8 19R8 21R8 23R8 25R8 27R8 29R8 31R8 33R8 33L1 31L1 29L1 27L1 25L1 23L1 21L1 19L1 17L1 15L1
24000
24500
25000
25500
26000
dcum (m)
PRELIMINARY
Courtesy MCWG: 2017-11-21 15:48

8-1, 2017


Total integrated dose for [20170429 : 20171015]
Beam 1
Beam 2
Top BLMs
15R8
19R8
TID [Gy]
10^{1}
10^{0}
10^{-1}
10^{-2}
PRELIMINARY
Dipole
Quadrupole
Collimator
Layout
10R8 12R8 14R8 16R8 18R8 20R8 22R8 24R8 26R8 28R8 30R8 32R8 34R8 32L1 30L1 28L1 26L1 24L1 22L1 20L1 18L1 16L1 14L1
11R8 13R8 15R8 17R8 19R8 21R8 23R8 25R8 27R8 29R8 31R8 33R8 33L1 31L1 29L1 27L1 25L1 23L1 21L1 19L1 17L1 15L1
24000
24500
25000
25500
26000
dcum (m)
Courtesy MCWG: 2017-12-12 17:23



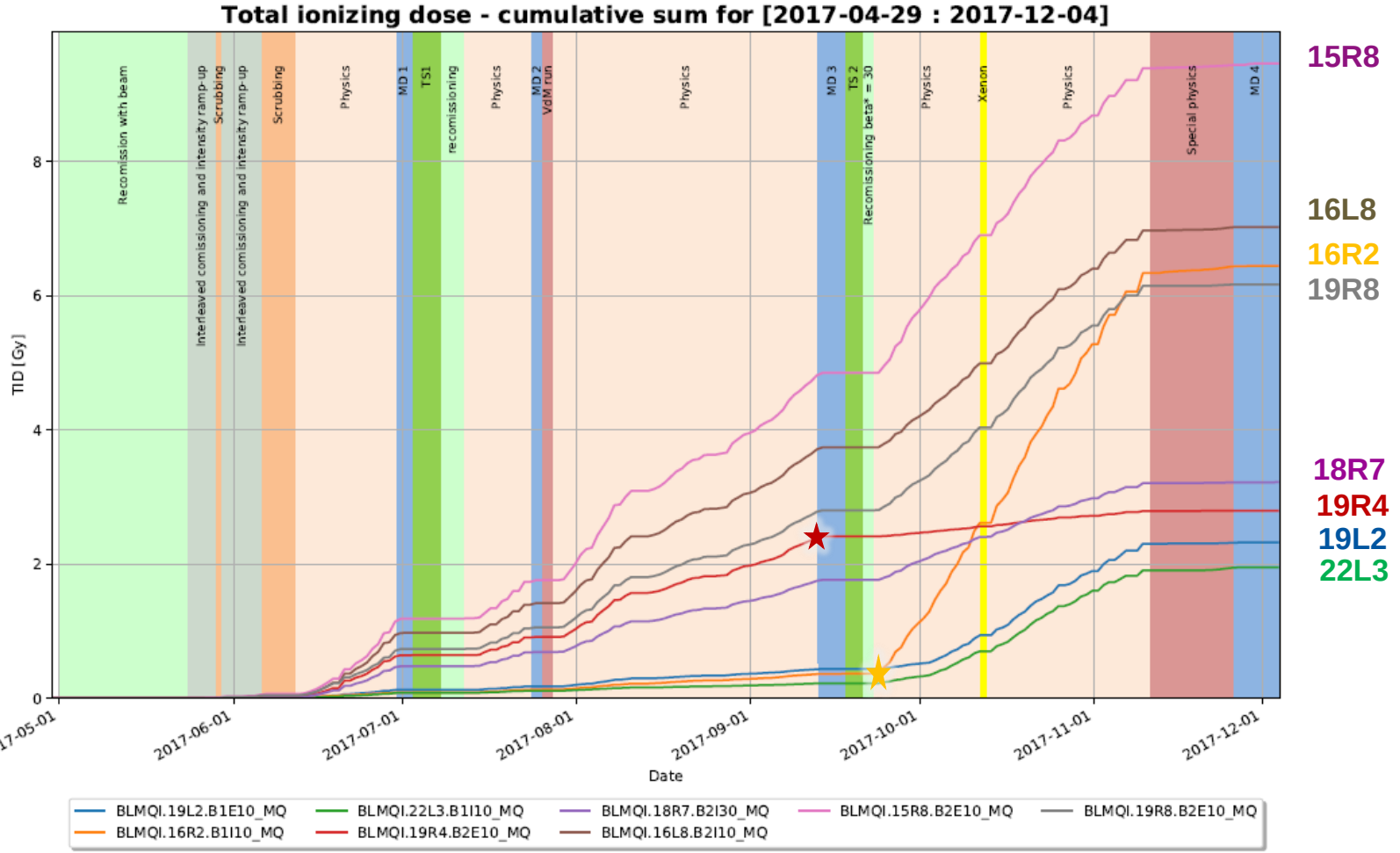
21L2

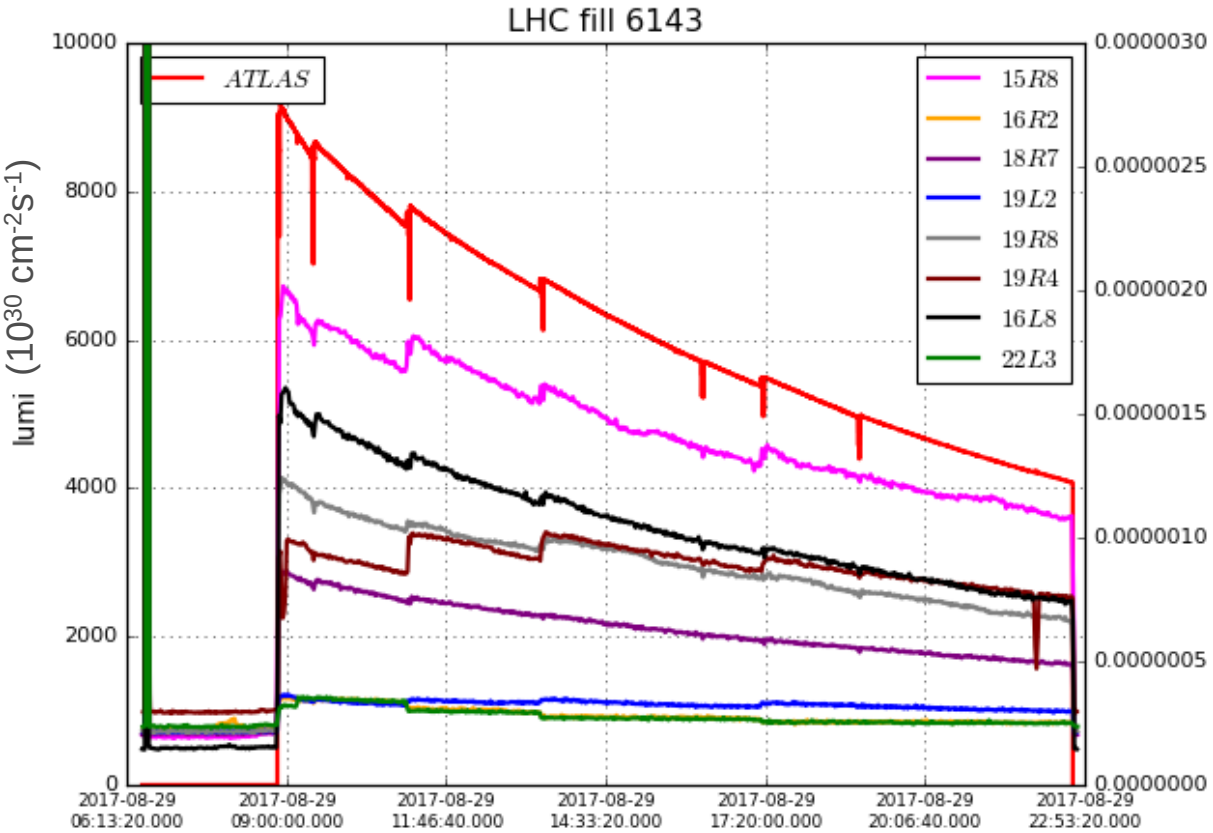
16R8

32L7

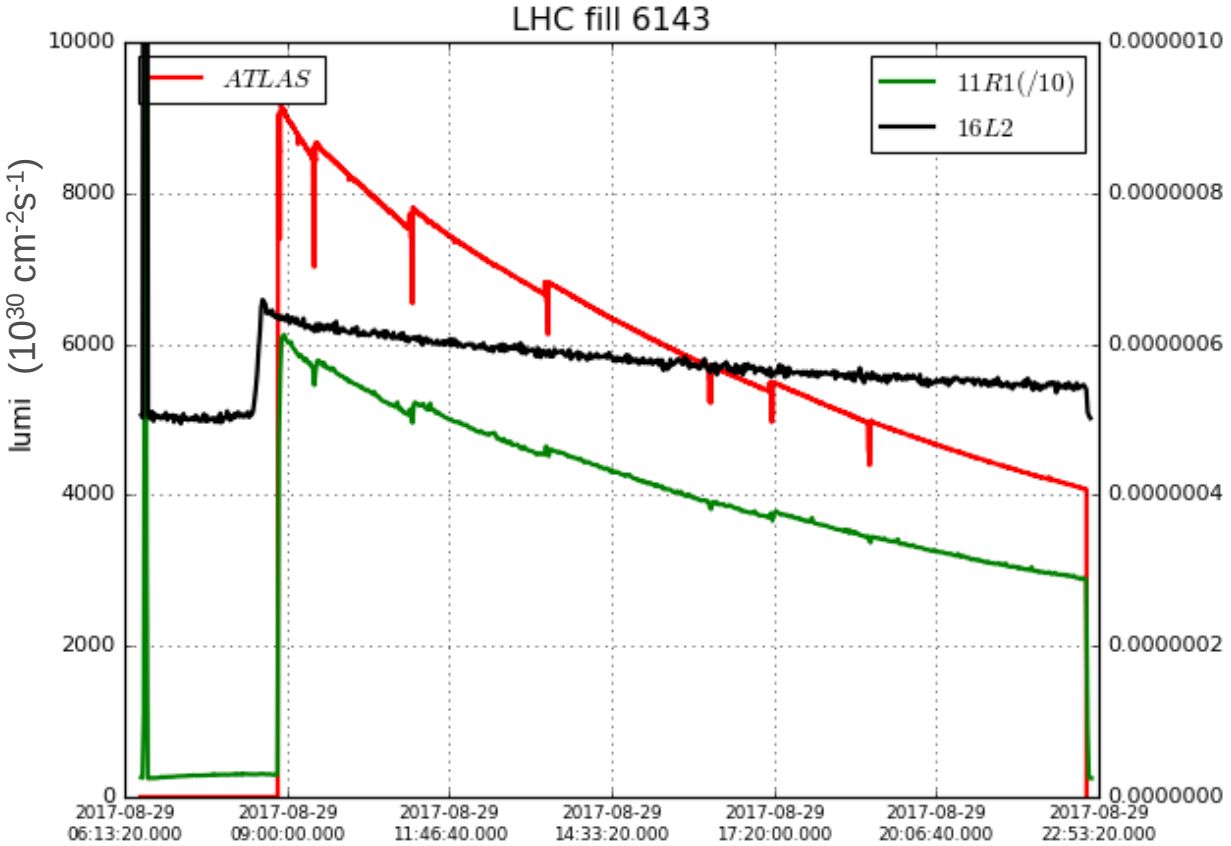
18R7

23R4


Total ionizing dose - cumulative sum for [2017-04-29 : 2017-12-04]
TID [Gy]
Date
Recomission with beam
Interleaved comissioning and intensity ramp-up
Scrubbing
Interleaved comissioning and intensity ramp-up
Scrubbing
Physics
MD 1
TS1
recomissioning
Physics
MD 2
VdM run
Physics
MD 3
TS 2
Recomissioning beta* = 30
Physics
Xenon
Physics
Special physics
MD 4
15R8
16L8
16R2
19R8
18R7
19R4
19L2
22L3
BLMQI.19L2.B1E10_MQ
BLMQI.16R2.B1I10_MQ
BLMQI.22L3.B1I10_MQ
BLMQI.19R4.B2E10_MQ
BLMQI.18R7.B2I30_MQ
BLMQI.16L8.B2I10_MQ
BLMQI.15R8.B2E10_MQ
BLMQI.19R8.B2E10_MQ

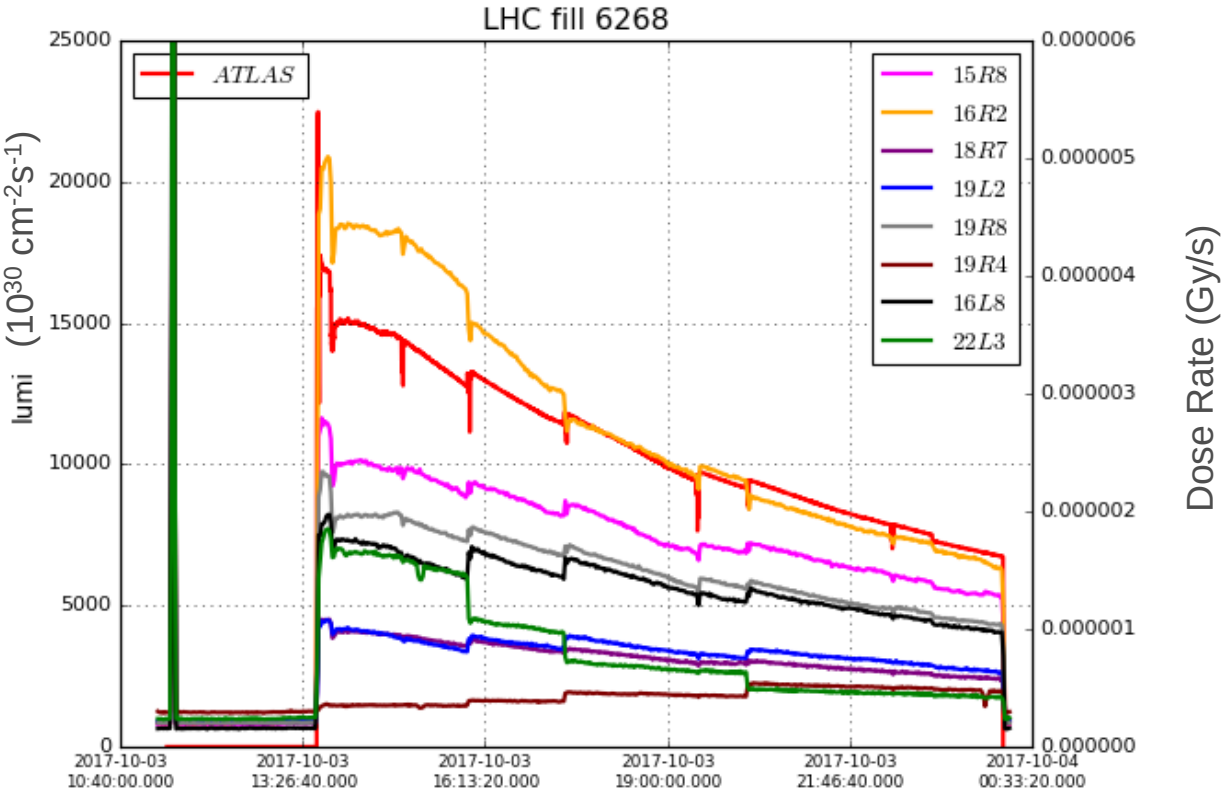


Aug 29
n_b = 1550
t = 13.6h
L_{peak}=9206·10^{30} $cm^{-2}s^{-1}$

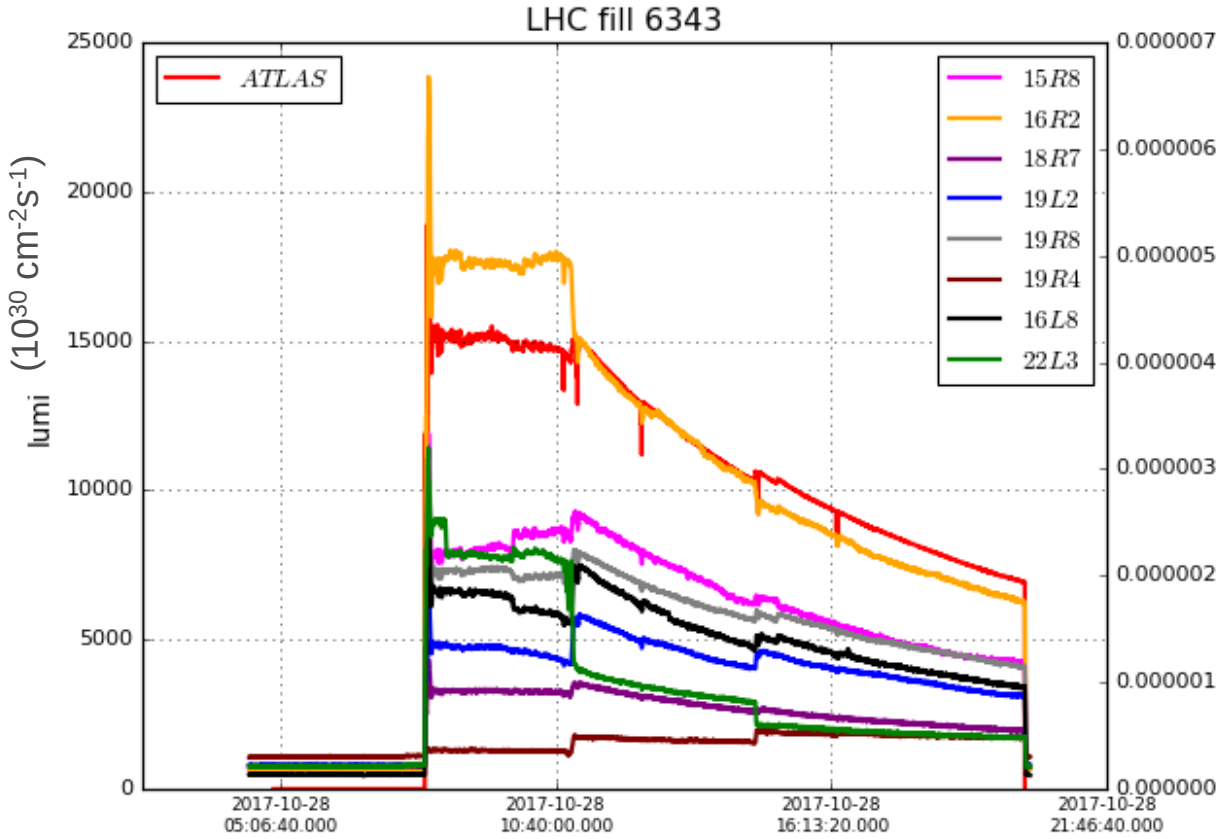


Another two examples for same fill:

- *11R1, showing purely luminosity-dominated BLM levels (i.e. smooth evolution)*
- *16L2, starting before collisions*

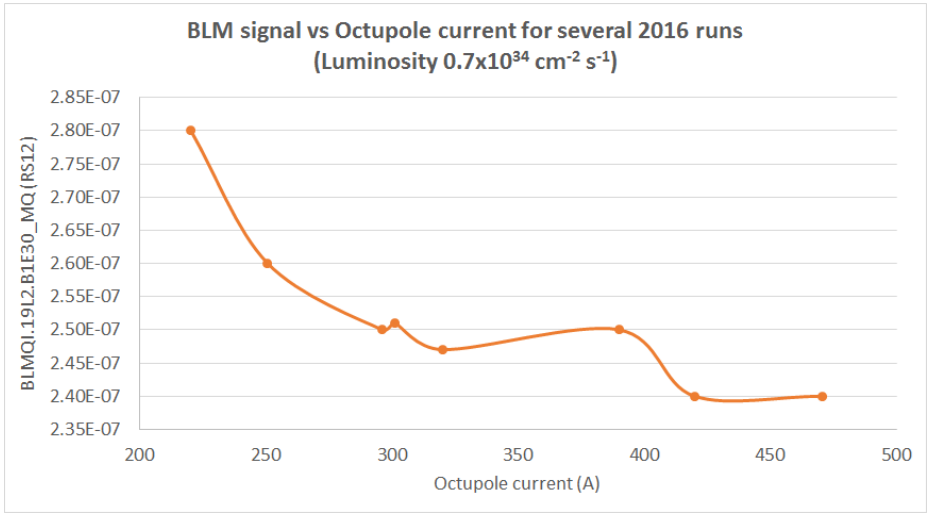


Oct 3
n_b = 1836
t = 10.6h
L_{peak}=16878·10^{30} $cm^{-2}s^{-1}$



Oct 28
n_b = 1868
t = 11.9h
L_{peak}=15543·10^{30} $cm^{-2}s^{-1}$

Correlation with octupole current

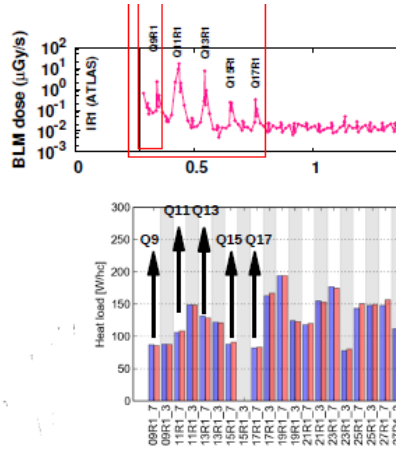


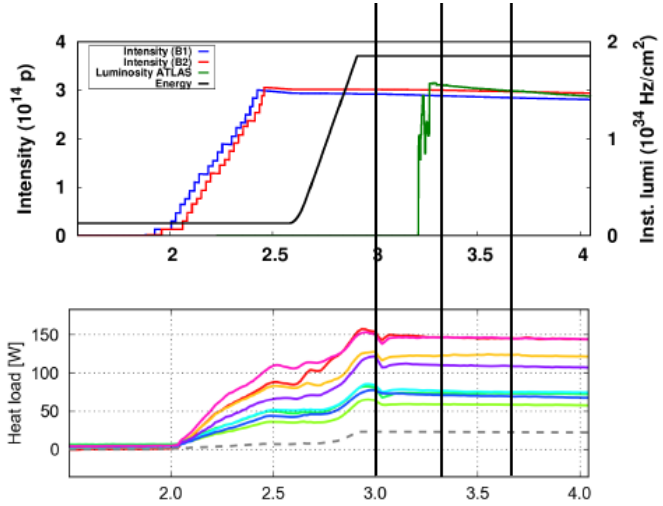
(Input from Cristina)

- BLM levels without background subtraction
- Very strong impact of octupole current on BLMs losses
- Explanation of why losses appear in 19L2 around September 2016, following octupole current decrease
- Different trend observed in 2017 in terms of 19L2 dependence on octupole current
- No obvious correlation between losses and aperture restrictions
- Ongoing analysis in the scope of evaluating possible associated FLUKA study

Possible beam-gas radiation level correlation with heat load

- Input from Anton, *Heat Load Task Force, 18/12/2017*
- Sector 12 analysis
- Heat load clearly not driven by beam losses:
  - Beam losses increase significantly when going into collisions, but heat load does not
  - Beam losses concentrated in DS, but not heat load distribution



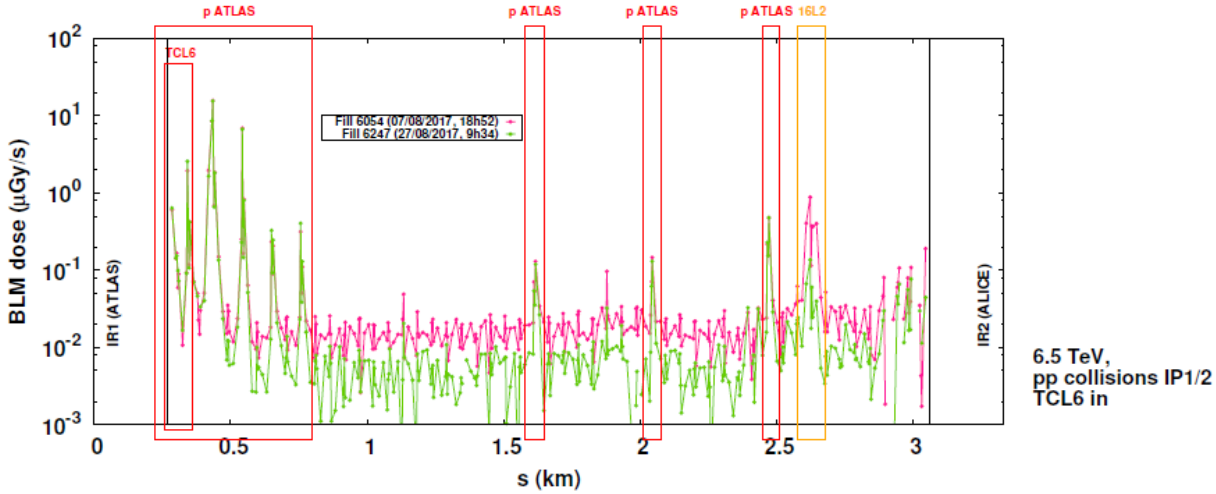


Possible beam-gas radiation level correlation with heat load

- Input from Anton, *Heat Load Task Force, 18/12/2017*
- However, beam-gas losses for same luminosity visibly lower in 8b4e (i.e. lower heat load)

Example: Fill 6054 (07/08/2017, 25 ns BCMS) vs Fill 6247 (27/09/2017, 25 ns 8b4e)

→ look at times where the lumi was the same (1.35× 10^{34} cm-2s-1)



Conclusions and Outlook

- Baseline arc BLM annual radiation level decreases from ~100 mGy to ~30 mGy from 2016 to 2017
  - interesting to look into 2015 (and 2012, but different BLM configuration)
  - important to correlate BLM and RadMON measurements with radiation levels at equipment location
  - possible correlation with heat load (BCMS → 8b4e change) to be further investigated
- Losses in 15R8 and 16R8 are due to known Unidentified Lying Objects (ULOs) and can therefore be expected to disappear after LS2
- Possible correlation of luminosity-driven arc losses with crossing angle, β^* and octupole current
  - The appearance of the 16R2, 19L2 and 22L3 losses in 2017 after TS2 could be related to the change in β^* from 0.4m to 0.3m