Radiation levels in the Hall D tagger area during the May 2014 beam delivery

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Abstract

We discuss the doses and dose rates seen in the Hall D tagger area during the May 2014 beam delivery. The averaged dose rate with the pulse beam tuned through the tagger was from 2 to 4 rem/h. For a 3 A continuous beam of similar quality (beam scrapping was evident on the tagger dump viewer during this period), this would represent from about 130 to 260 rem/h.

1 Goal

The goal of this work is to establish the level of radiation in the Hall D tagger area and approximately map it in order to know where to locate the tagger electronics and what would be its exposure. The beam delivery was not standard (pulse beam, scrapings, beam mis-steered) and so the doses and rates reported here may not be representative to those that will occur during future operations. However, they might indicate of the radiation distribution and magnitude expected during the next beam initial delivery (Fall 2014).

2 Set-up and integrated doses

To monitor the levels of radiation in the Hall D tagger area during the first test beam delivery, 10 OSL (personal dosimeters) and 4 SRPD were installed. Figure 1 indicates their location and integrated dose. We remark that the SRPD on the top left corner was slightly activated during the beam operations. The integrated doses are tabulated in Tables 1 and 2 (courtesy of B. Mosbrucker). The neutron radiations saturated OSL # 66058 (dose greater than 10 rem). The values of the SRPD disagree with the OSL ones. This is due to the use of pulse beam and beam mis-steering, which presumably caused large instantaneous dose rates that saturated the SRPD. The beam characteristics were 3μA current at 60 Hz (duty cycle of 1.524%, equivalent continuous current: 46 nA). We attempt to correct for the saturation in the next section.

3 Integrated Dose Time Evolutions

3.1 Data uncorrected for saturation

The time evolutions of the SRPD integrated doses, without any saturation correction, are shown in Fig. 2. If the origin of the radiation is always the same and if there is no saturation of the counters, all curves should scale. Fig. 3 shows all maximum doses normalized to SRPD 15027's maximum dose. The scaling is only very approximate. In particular SRPD 6233 scales badly.

3.2 Data corrected for saturation

The saturation may be corrected by making the following assumptions:

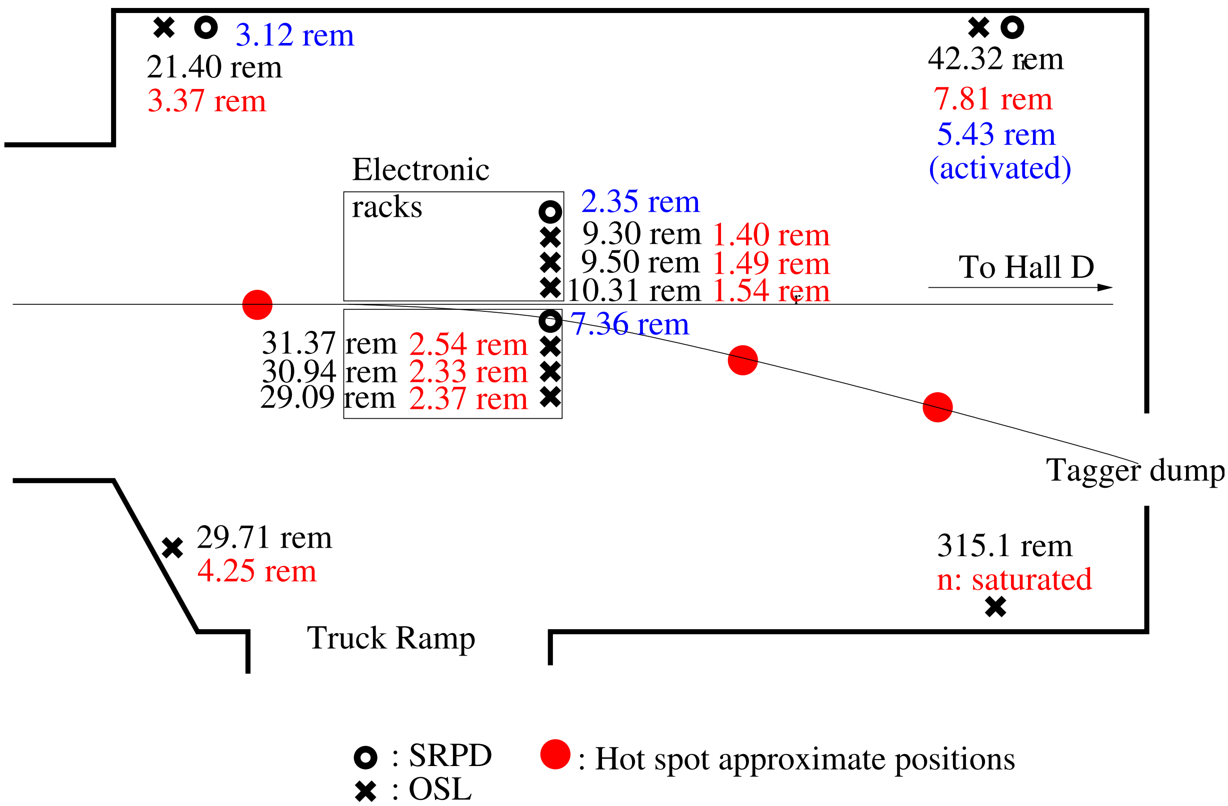

Figure 1:
Locations and integrated doses recorded by the SRPD (circle, dose in blue) and OSL (cross, deep dose in black, neutron dose in red) in the tagger area.

OSL#	Deep (rem)	Lense (rem)	Shallow (rem)	Neutron (rem)
66050	29.1	29.1	29.1	2.37
66051	31.4	31.4	31.4	2.54
66052	30.9	30.9	30.9	2.33
66053	9.5	9.5	9.5	1.49
66054	10.3	10.3	10.3	1.54
66055	9.3	9.3	9.3	1.40
66056	29.7	29.7	29.7	4.25
66057	21.4	23.5	25.6	3.37
66058	315.1	304.9	252.5	>10
66059	42.3	41.2	35.5	7.81

Table 1: Integrated deep, lense, shallow and neutron doses for the OSL. Their locations can be identified in Fig. 1 from their deep doses.

SRPD%	Dose (rem)	Location
C16233	2.35	In electronic rack under tagger, north of beam line
C12252	3.12	On north wall, upstream
C12253	5.43	On north wall, downstream
C15027	7.36	In electronic rack under tagger, south of beam line

Table 2: Doses for the SRPD. They are incorrect for saturation.

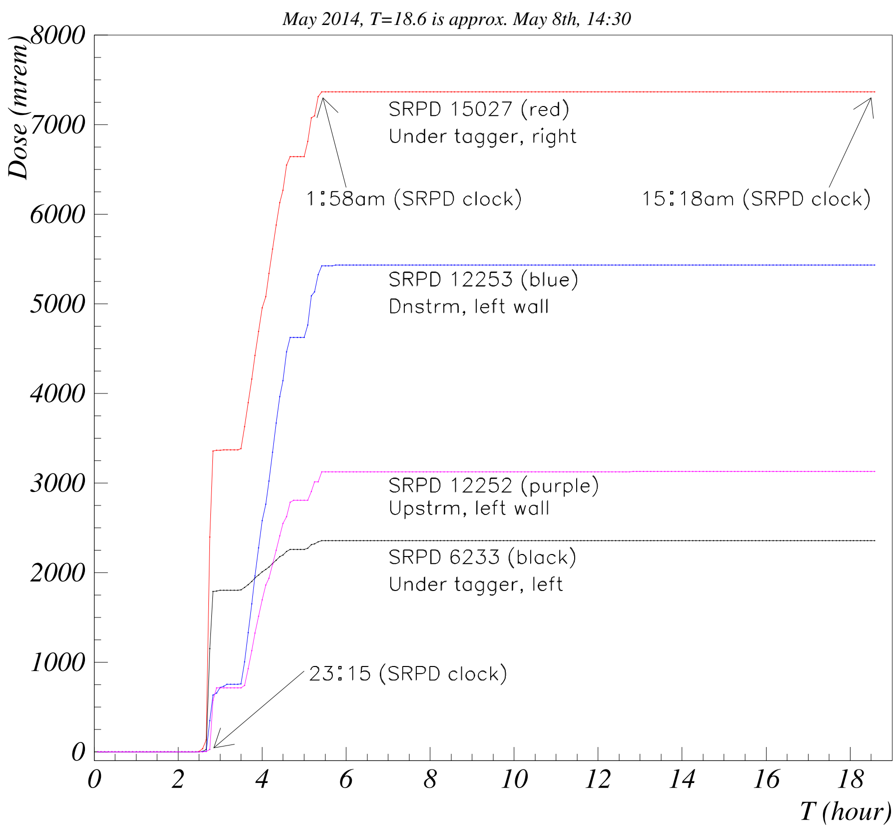

Figure 2:
Integrated time evolutions of the SRPD doses during the beam delivery, before correction for saturation.

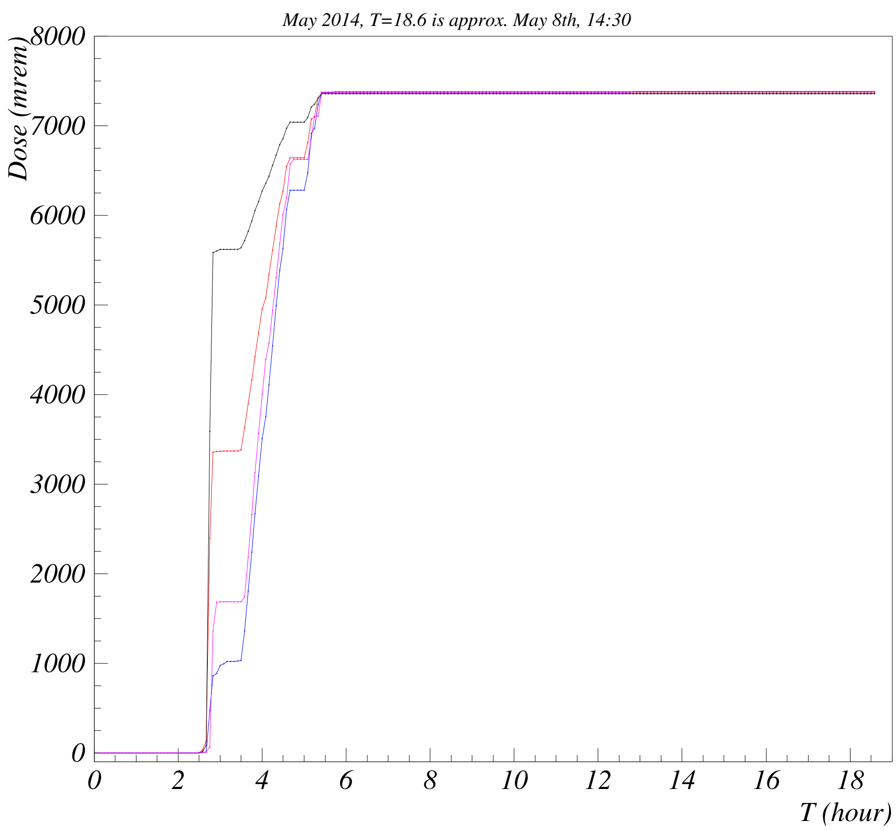

Figure 3:
Integrated time evolutions of the SRPD doses normalized to SRPD 15027's maximum dose, before correction for saturation.

1. The final integrated value of the SPRD is the same as the OSL situated nearby.
2. The saturation occurred during the first beam delivery (the "steering" period in Fig. 7).

Assumption #2 is plausible because dose rates are steepest during this beam delivery (for 2.6<T<3.0 on the horizontal scale of Fig. 2). It is also at that time that the tagger magnetic field was not correctly set. The BdL was 8.20×10^6 T.m instead of the nominal 8.39×10^6 T.m [1]. For the 6 m tagger and a nominal deflection of $13.4^{\rm O}$, it represents a difference in x-position of 3.2 cm at the tagger exit. The flanges, 3 m downstream the tagger end have a clearance of 2 cm, while difference in x-position was 4.8 cm. Consequently, the beam went through two stainless steel flanges (total thickness, 3.81 cm). This is presumably the origin of most of the radiation dose produced during the delivery. We can verify the consistency of the assumption by computing the dose rates and comparing them to the saturation rate of the SPRD (1 krem/h). We checked this for SRPD 15027: The uncorrected average dose rate during the "Steering" delivery (2.6<T<3.0) is 19 rem/h. Accounting for the pulse structure (1.524% duty factor), the uncorrected instantaneous dose rate is 1.3 krem/h, which is above the saturation rate. Accounting then for saturation, assuming it happened only during this period, the corrected instantaneous dose rate is 11 krem/h, well above the saturation rate. In contrast, during the second delivery period (for 3.5<T<4.7), the uncorrected average dose rate is only 2.81 rem/h. Accounting for the duty factor, the uncorrected instantaneous dose rate is 184 rem/h, still well below the saturation rate. Assuming that the whole saturation happened only during this second delivery period is not reasonable since the saturation would have been *a fortiori* higher during the first period given the dose rate in Fig. 2. However, this extreme assumption gives an indicative upper limit. The instantaneous dose rate in this limit would have been 1.6 krem/h. It is above the 1 krem/h saturation limit but since most of the radiations must have occurred during the first delivery, the actual instantaneous dose rate was most likely below the saturation rate.
Assumption #2 is further justified by the results in Fig. 5, as it will be discussed.

Under the two assumptions discussed above, we can approximately correct the data in Fig. 2 by offsetting the data after T=3h so that their final plateau matches their corresponding OSL value, and scaling the data during the "steering" delivery (2.6<T<3.0) so that we have continuity of the data at T=3h. The corrected data are shown in Fig. 4. The SRPD 12253 has now the larger integrated dose, which is consistent with the fact that it was the only one activated during the delivery period. We show in Fig. 5 how all curves scale. All maximum doses are now normalized to SRPD 12253's maximum dose. The scaling is now much better compared to the results shown in Fig. 3. We used the same vertical range as for Fig. 3 (8 rem) for easier comparison. The fact that SRPD 6233 does not scale well may be because the origin of the radiations changed. This would consistent with hypothesis #2: during the "Steering", a large amount of radiations came from the beam crossing the stainless steel flanges. SRPD 6233 was closest to this source of radiation (located approximately below it, see Fig. 1). It thus got a *relatively*[1] higher dose rate during this period. After the beam was better tuned, this radiation source disappeared and the relative dose rate of SRPD 6233 is smaller.

3.3 Dose rates

The dose rates corrected for saturation are shown on Fig. 6. We plotted only the relevant period, $2 < T < 6$h. The rates given are the average rates. The instantaneous rates would be a factor of 66 larger.

3.4 Consistency with accelerator beam delivery

Each dose increase should correspond to a beam delivery (neglecting the effect of activation compared to the prompt radiation). This is best seen on Fig. 7 which shows the dose rates overlaid on a slide indicating beam delivery in the tagger area [1]. During the first delivery ("Steering"), the beam missed the Tagger beam dump. Radiation rate was highest during this period. The tagger magnetic field was then adjusted ("Tagger magnet tuning") and subsequently, about 1 hour of beam was delivered to the beam dump. The beam profile in the beam dump still shows evidence of scrapping during this period [1].

[1] Relative, after normalizing to the maximum dose of SRPD 12253

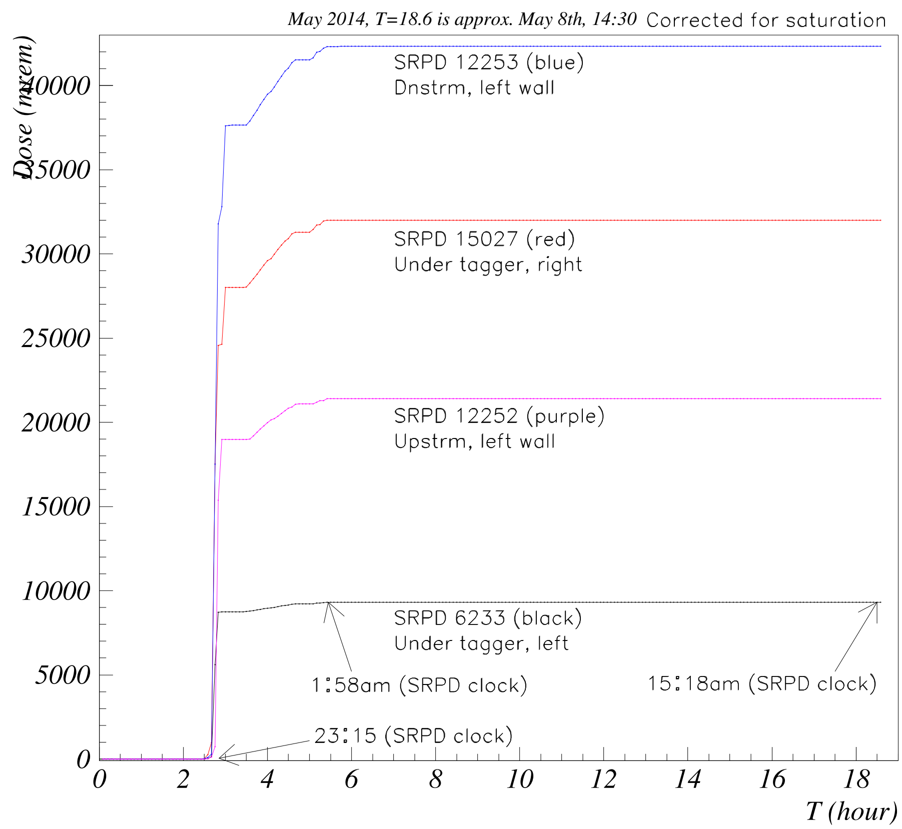

Figure 4:
Integrated time evolutions of the SRPD doses during the beam delivery, after correction for saturation.

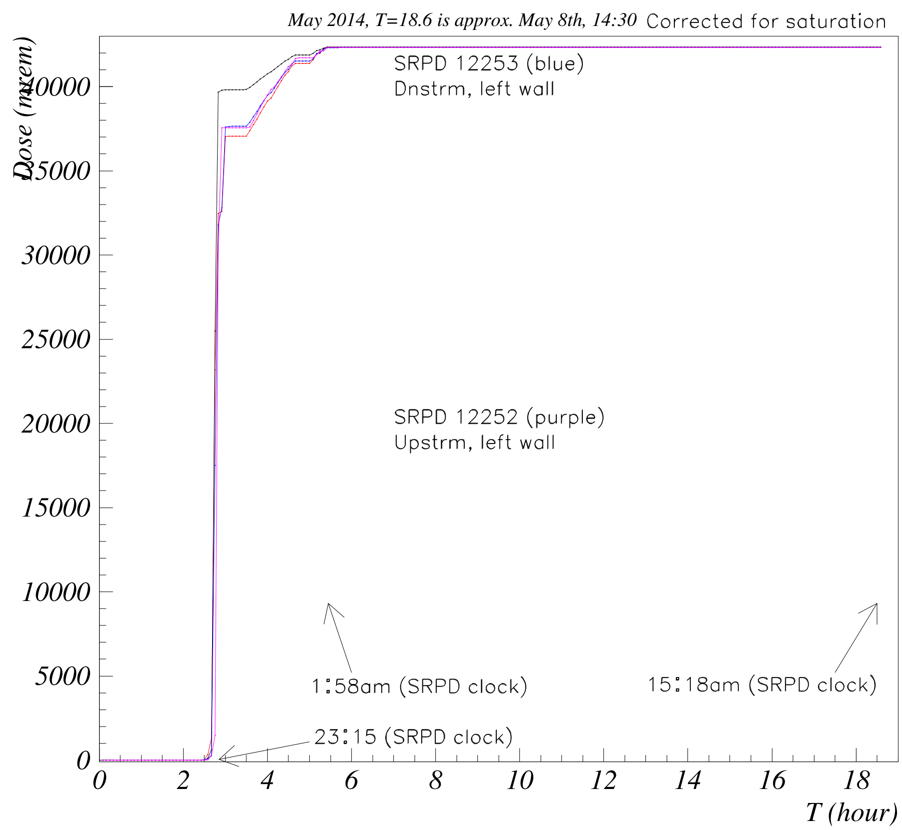

Figure 5:
Integrated time evolutions of the SRPD doses normalized to SRPD 12253 maximum dose, after correction of saturation.

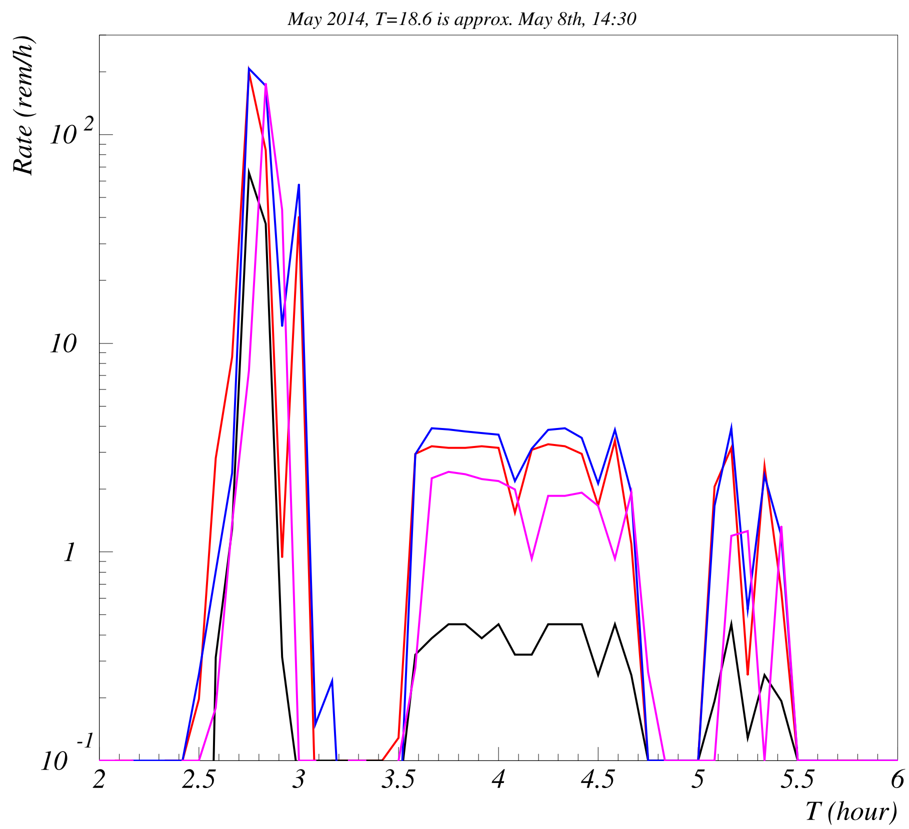

Figure 6:
Average doses rates, after correction for saturation.

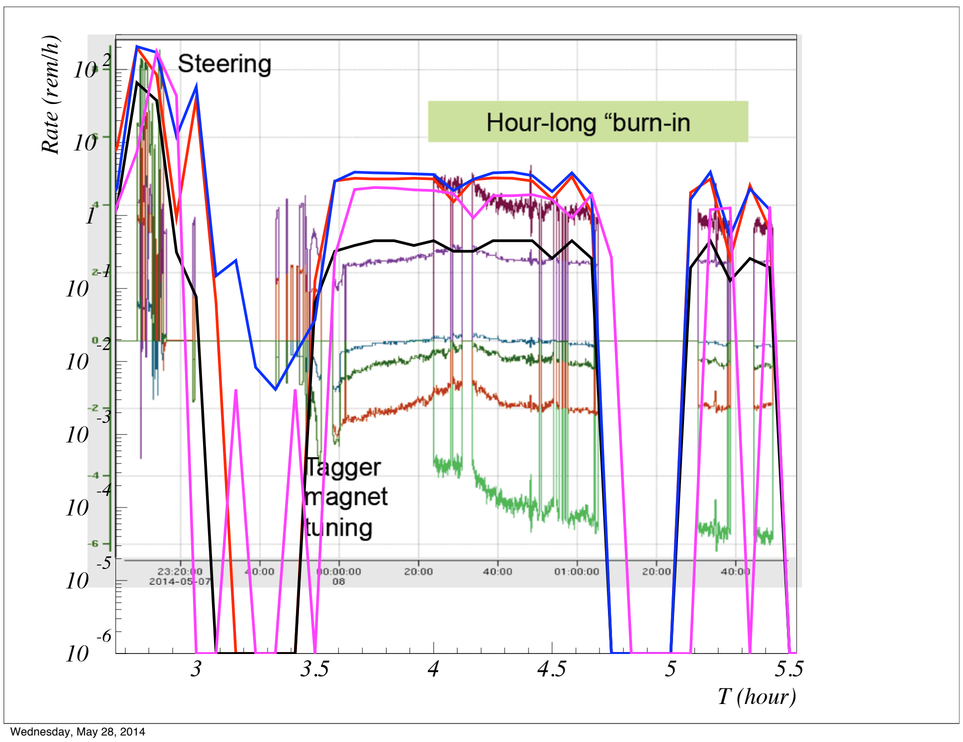

Figure 7: Dose rates overlaid on a slide indicating beam delivery in the tagger area. The horizontal scales are the same, corresponding to a total of 2.87 hours.

4 Conclusion

Radiations on the south wall (truck ramp side) of the tagger area were significantly higher. This is due to the direction toward which the electron beam is bent and the (related) beam dump position. This indicates that the best location for the electronics would be near the north wall side (left wall, facing downstream) and as upstream as possible. The averaged dose rate with the pulse beam tuned through the tagger was less than 4 rem/h (from SRPDs 15027, 12252 and 12253). For a 3 μA continuous beam of similar quality (beam scrapping was evident on the tagger dump viewer during this period), this would represent about 260 rem/h.

References

[1] T. Satogata. Presentation at the May 2014 GlueX collaboration meeting. http://www.toddsatogata.net/2014-05-12-HallDCollab-Satogata.pdf