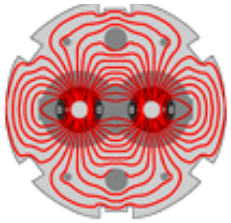


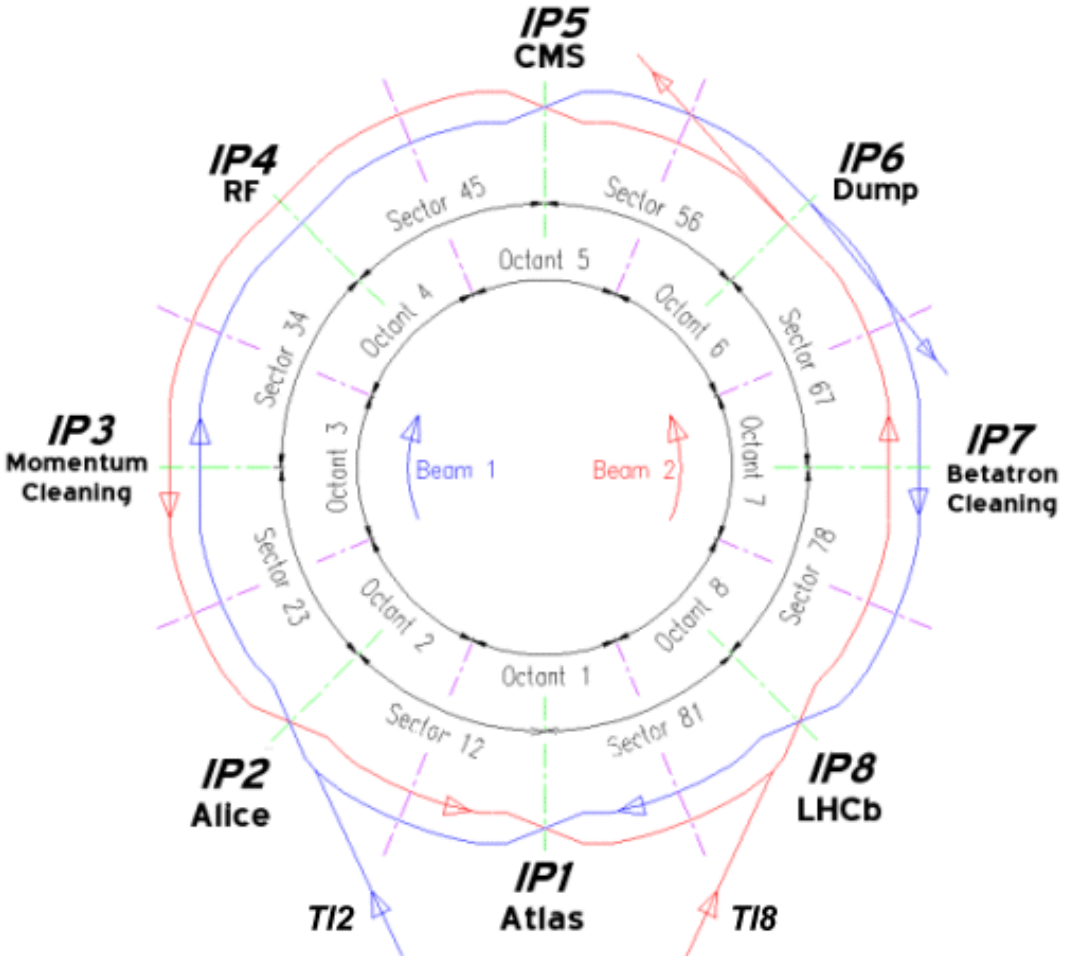
RADIATION ASPECTS OF LHC

04 December 2002

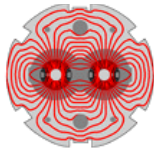
SIMULATION OF A SIGNAL IN THE BEAM LOSS MONITORS FOR THE MOMENTUM CLEANING INSERTION

Igor A. Kourotchkine
IHEP, Protvino, Russia

Summary of the presentation



- Introduction
- The momentum cleaning insertion model
- Simulation strategy
- Results and discussion
- Conclusion



Introduction: Beam Loss Monitor

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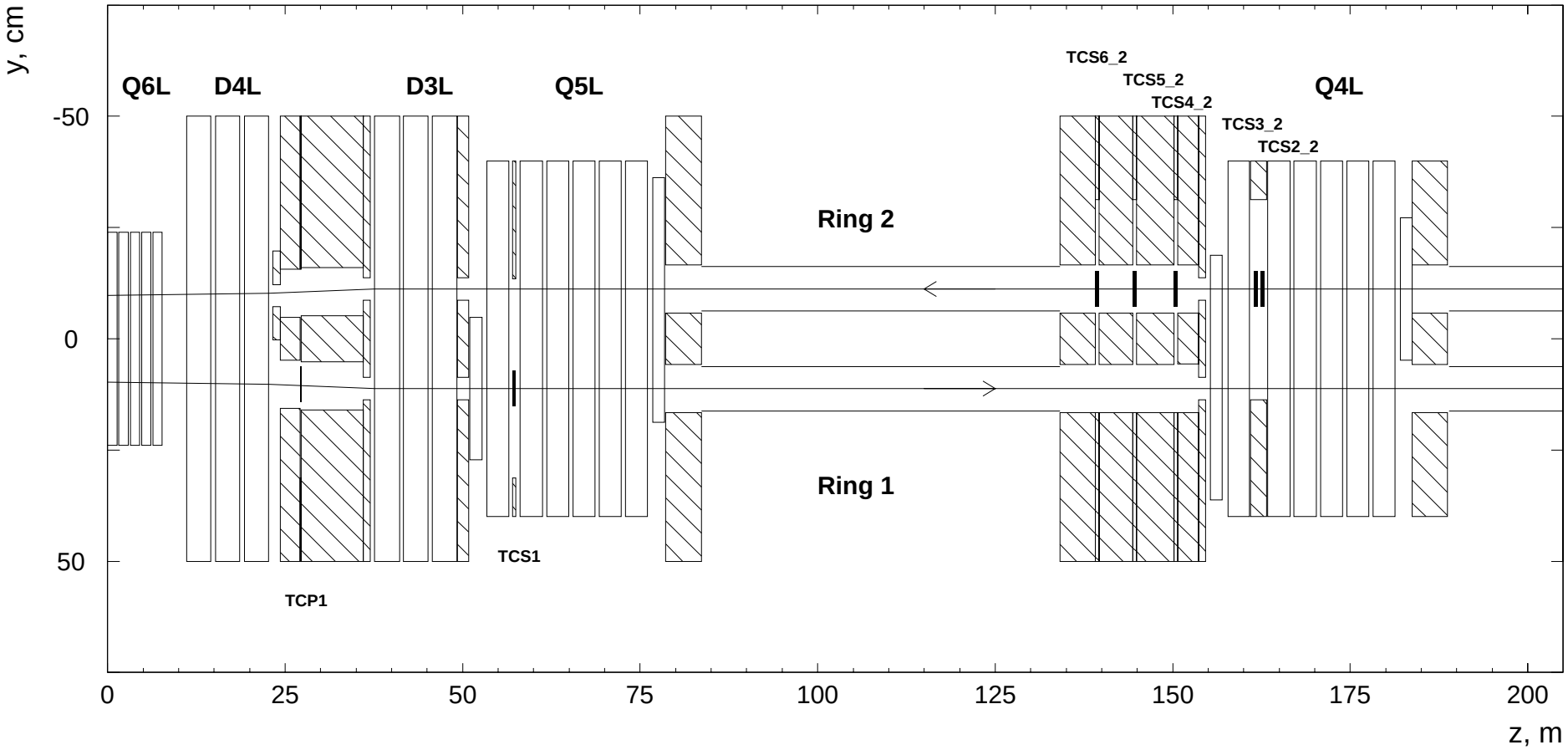
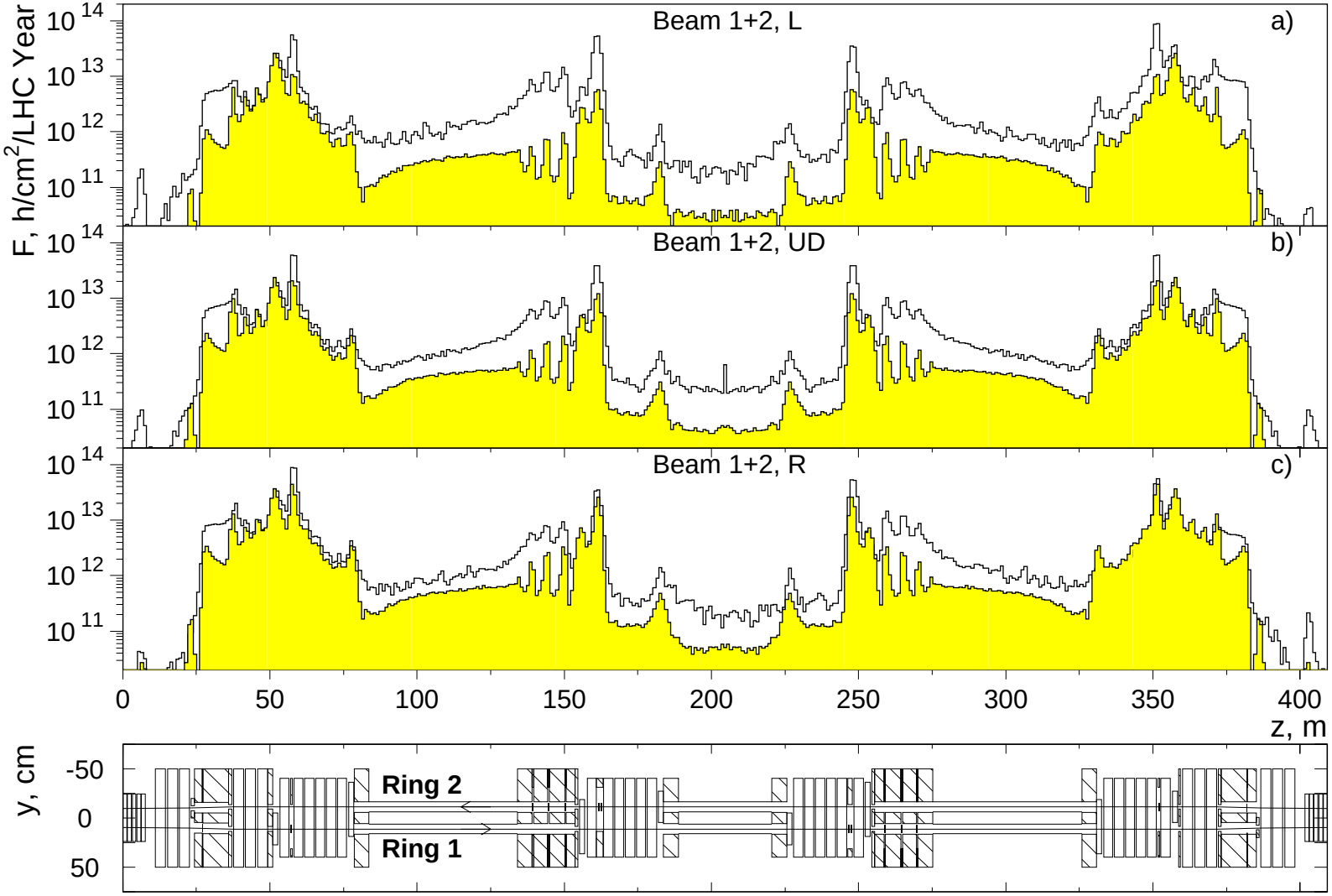
- Beam losses must be monitored carefully during the LHC operation period to avoid a quench (losses less than 10^7 p $\cdot$ s $^{-1}$ can induce a quench)
- Two insertions IR3 and IR7 will be performed the cleaning of the beam halo using with collimators system
- The beam loss monitors will be located close to all collimators
- Calculations (I.Baichev) of the BLM responses for the TCP and the TCS collimators (simplified model: source - detector) allowed to determine the optimum position of the BLM and to estimate a value of the signal level.
- Problems: multiparameter task (many sources - many detectors), an signal interpretation depends on many factors (relation of background/signal, beam losses/signal, individual parameters of each collimator).
- What do we want? Ideally, a measured signal is proportional to local beam losses ???
- A goal - to simulate a signal induced in the beam loss monitors located in the momentum cleaning insertion IR3 and to estimate a partial contribution to total signal from each collimators

The insertion model: shielding design

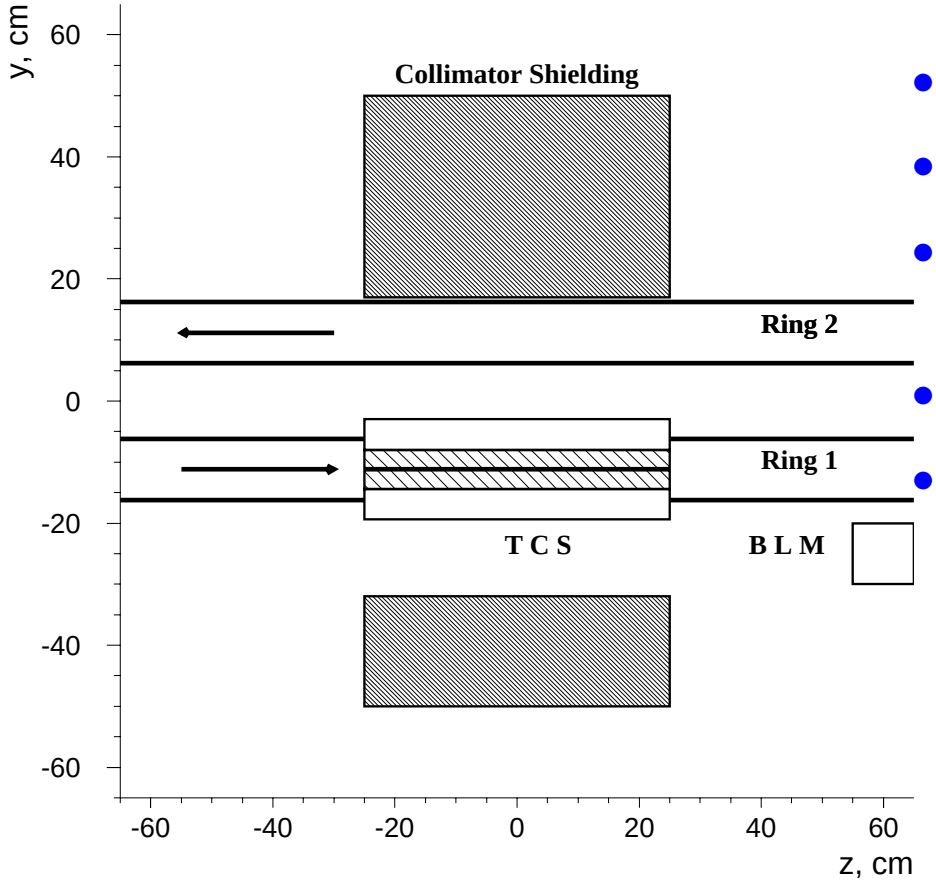
Layout of one half of the momentum cleaning section



The insertion model: hadron fluence



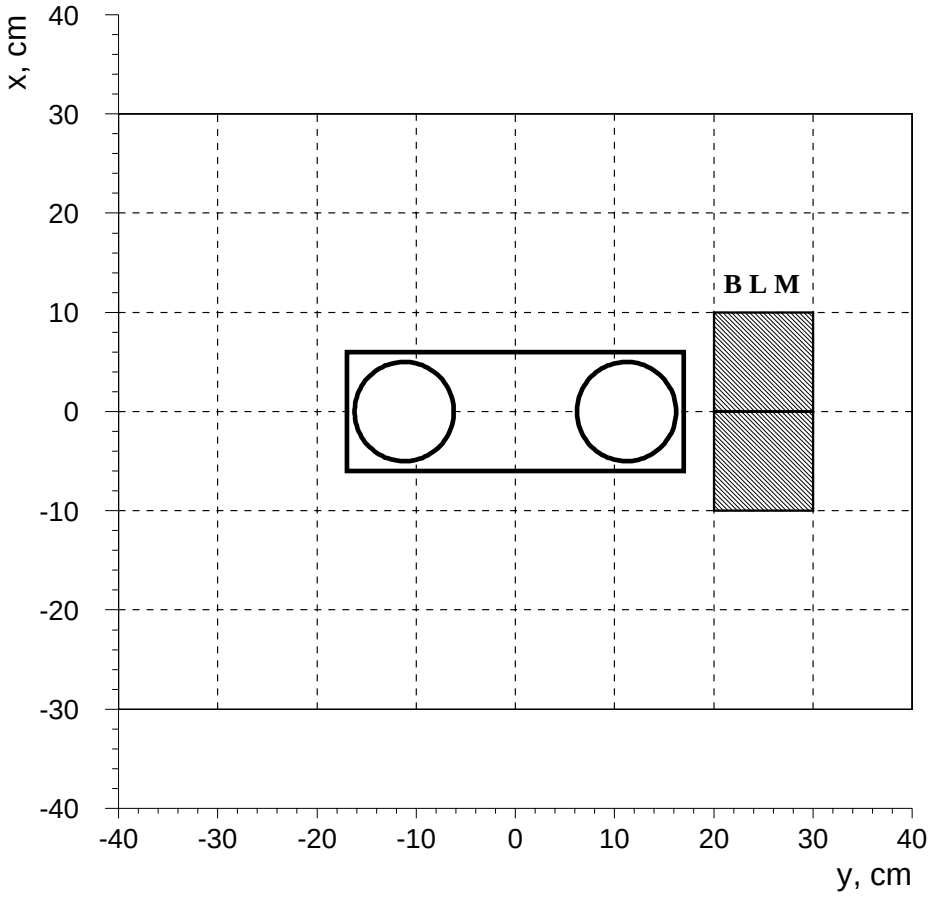
The insertion model: details



- Specific features of optics version V6.2 for the momentum cleaning (LHC Project Note 263)
- Reduced shielding design (Project Note 297)
- Position of the BLM – 30 cm downstream of TC
- The primary losses are shared between 1 primary and 6 secondary collimators for each ring.
- TCP – 20 cm (Al), TCS – 50 cm (Cu)
- The relative rates of inelastic interactions in the collimator jaws (LHC Project Note 263).

Collimator	Injection	Collision
TCP1	0.431	0.760
TCS1	0.211	0.059
TCS2	0.183	0.078
TCS3	0.104	0.054
TCS4	0.034	0.022
TCS5	0.030	0.022
TCS6	0.007	0.005

Simulation strategy



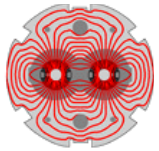
- The K2 code – a map of primary inelastic interac tions
- BLM - an air ionisation chamber (10x10x10 cm^3)
- Simulation approaches

$$S = R \cdot F \quad (1$$

$$r_{ij} = \sum_{k=1} \int_{E_{th}}^{E_{max}} \varepsilon_k(E)\varphi_k(E,i,j)dE \quad (2$$

$$r_{ij} = \sum_{k=1} \Phi_k(i,j) \quad (3$$

- The MARS code – the fluence and energy deposition simulation
- Energy thresholds - 10 MeV for charged hadrons, MeV for electrons
- An individual cascade from inelastic interactions in side the jaws of each collimator (j) impacting on BLM (i) is simulated separately ($\sim 10^7$ pr.in.int./run)



Results: the response of the BLM

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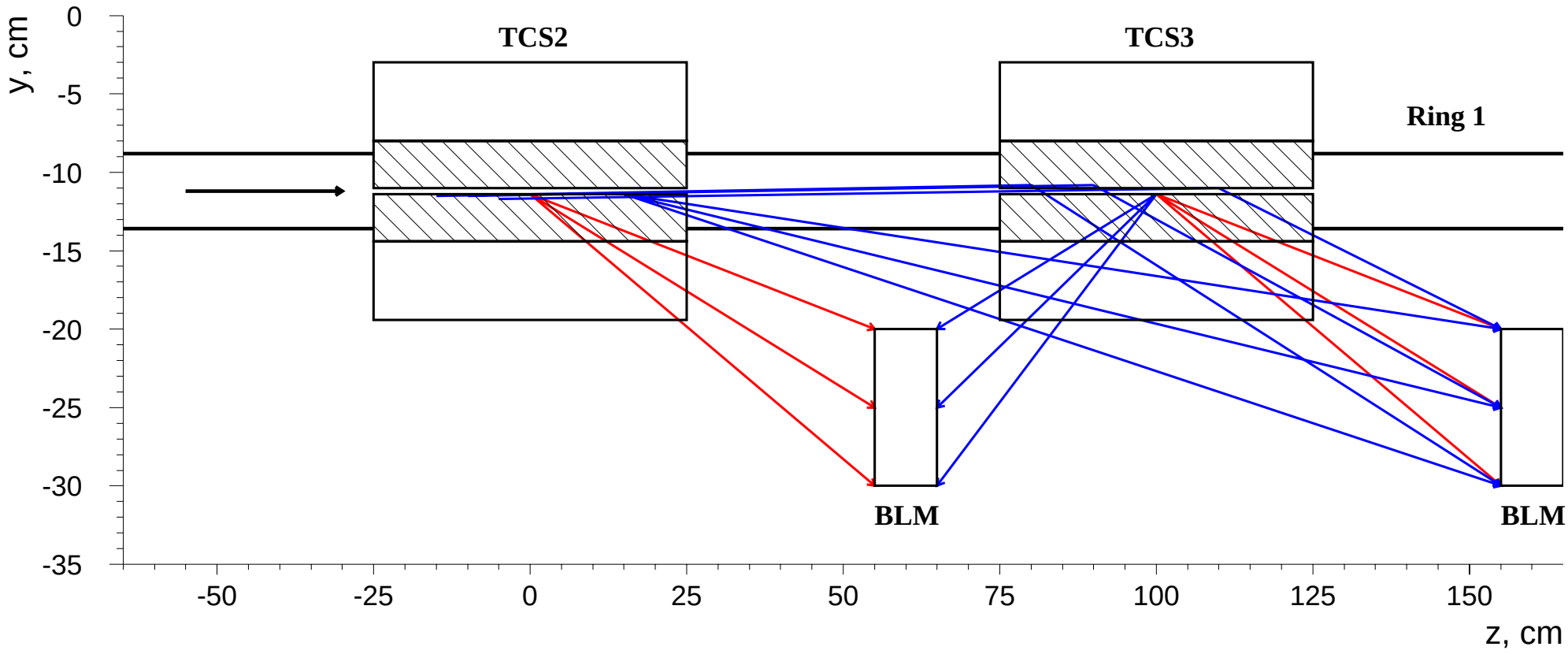
The responses of the beam loss monitors per one lost inelastic proton on each collimator a top energy

$$r_{ij} = \sum_{k=1} \Phi_k(i,j)$$

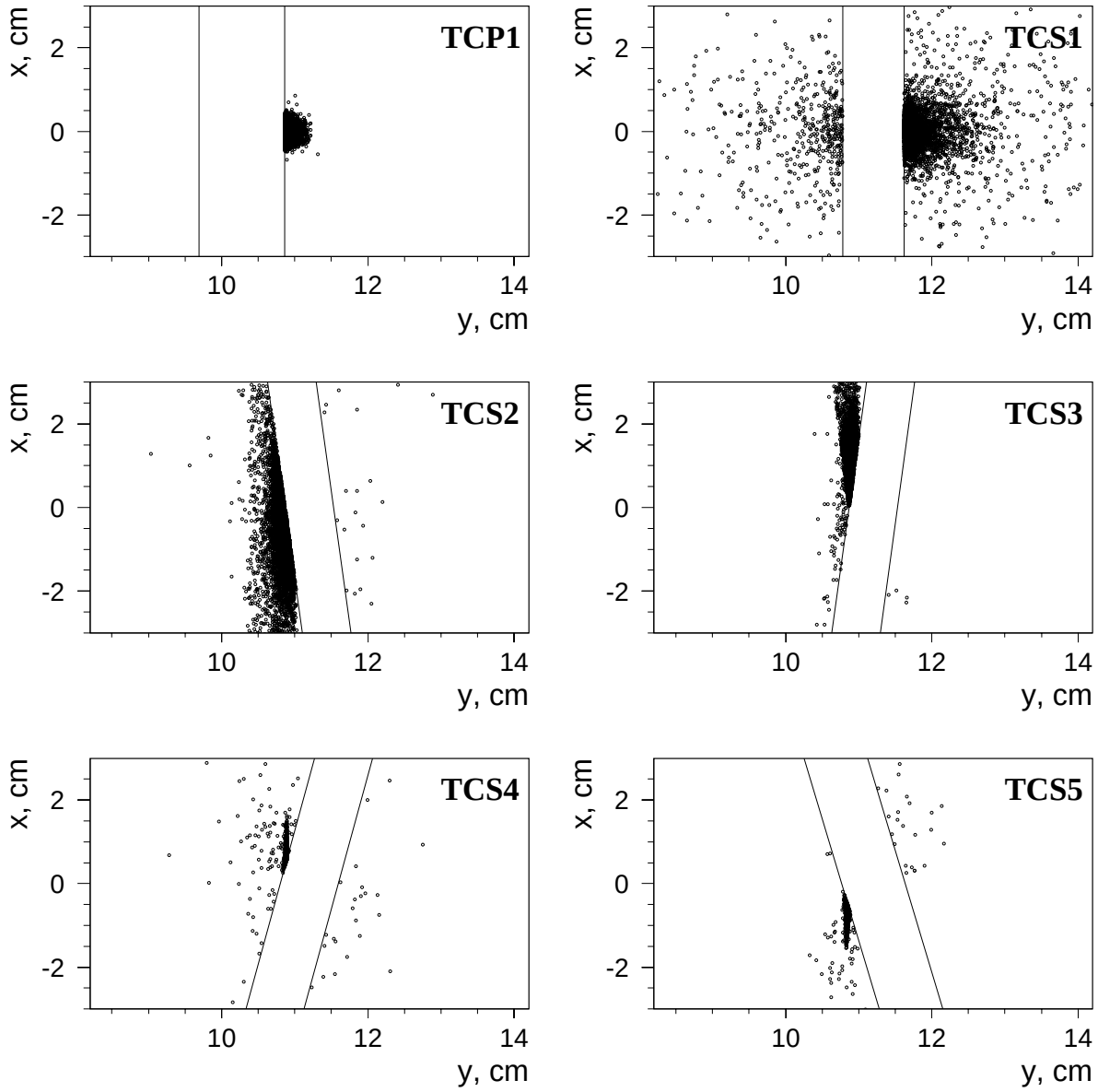
Collimator (j)	Beam loss monitor (i)						
	1	2	3	4	5	6	7
TCP1	0.0178	0.4662	0.02684	0.04321	0.0079	0.00361	0.00123
TCS1	0.0	1.19	0.02911	0.03889	0.00361	0.00177	0.00069
TCS2	0.0	0.0	1.081	1.085	0.138	0.03858	0.00992
TCS3	0.0	0.0	0.00039	1.044	0.3245	0.1187	0.03493
TCS4	0.0	0.0	0.0	0.0	0.9891	0.513	0.16417
TCS5	0.0	0.0	0.0	0.0	0.0	0.9848	0.5093
TCS6	0.0	0.0	0.0	0.0	0.0	0.0	0.9445

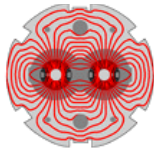
Results: “good” signal ...

Formation of a “good” signal and “background” signal in the BLMs



Results: spatial distribution for injection





Results: the partial signal at top energy

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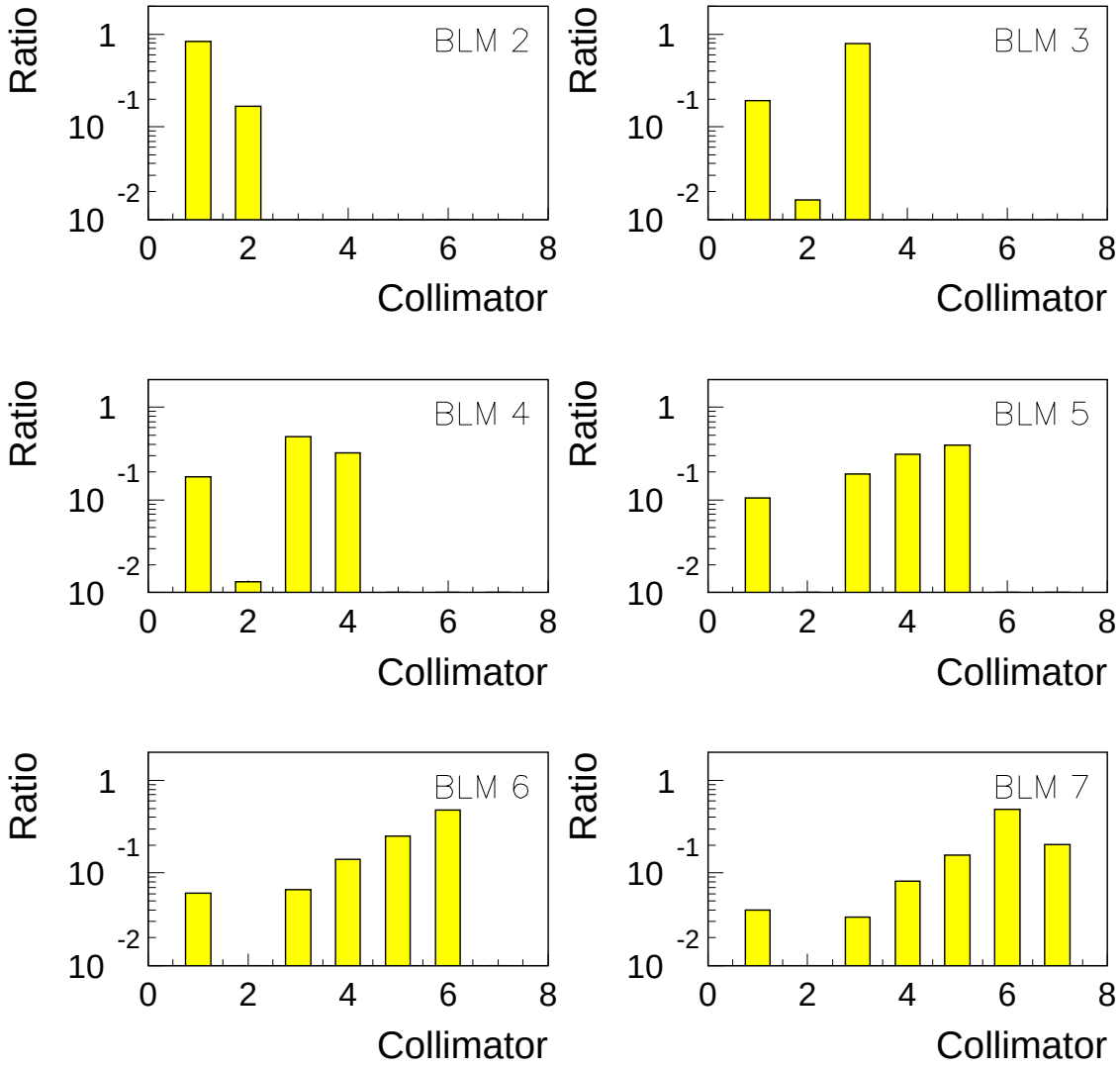
The partial signals at top energy

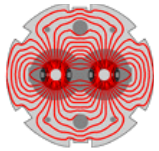
$$p_{ij} = r_{ij} \cdot f_j$$

Collimator (j)	Beam loss monitor (i)						
	1	2	3	4	5	6	7
TCP1	0.01352	0.3543	0.0204	0.03284	0.00593	0.00274	0.00093
TCS1	0.0	0.07021	0.00172	0.00230	0.00021	0.00010	0.00004
TCS2	0.0	0.0	0.08432	0.08463	0.01077	0.00301	0.00077
TCS3	0.0	0.0	0.00002	0.05638	0.01752	0.00641	0.00189
TCS4	0.0	0.0	0.0	0.0	0.02176	0.01129	0.00364
TCS5	0.0	0.0	0.0	0.0	0.0	0.02167	0.01121
TCS6	0.0	0.0	0.0	0.0	0.0	0.0	0.00472
Total s_i	0.01352	0.42451	0.10646	0.17614	0.05619	0.04521	0.002318

Results: ratio at top energy

$$Ratio = p_{ij}/s_i$$





Results: ratio at top energy

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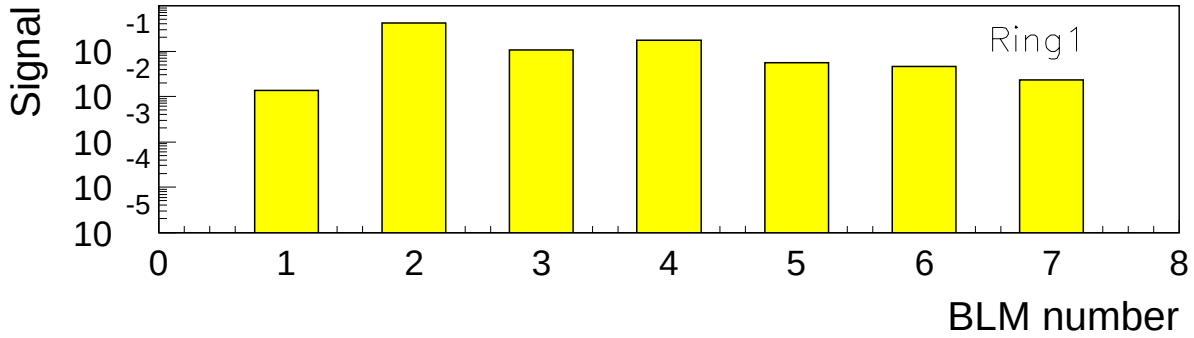
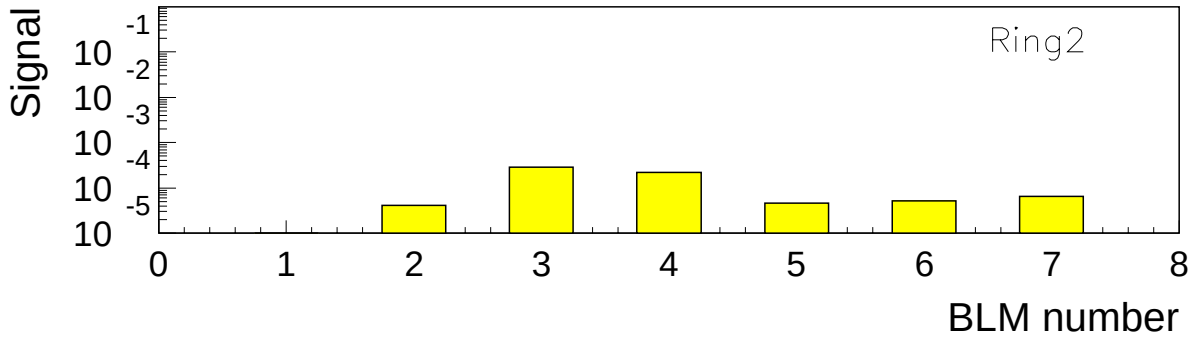
A relative partial contribution to total signal in the beam loss monitor. A sum over all relative contributions for each monitor is equal to 1.

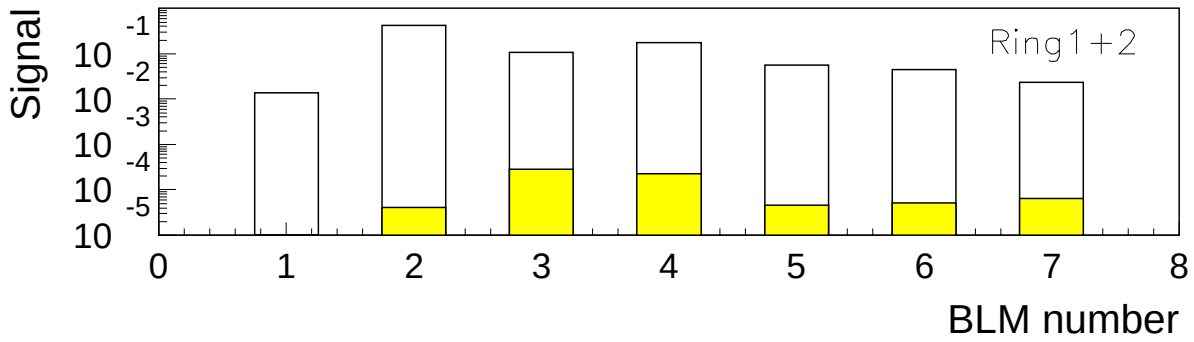
$$Ratio = p_{ij}/s_i$$

Collimator (j)	Beam loss monitor (i)						
	1	2	3	4	5	6	7
TCP1	1.0	0.847	0.232	0.164	0.120	0.066	0.031
TCS1	0.0	0.153	0.024	0.012	0.005	0.003	0.003
TCS2	0.0	0.0	0.742	0.440	0.199	0.068	0.032
TCS3	0.0	0.0	0.0002	0.380	0.309	0.136	0.091
TCS4	0.0	0.0	0.0	0.0	0.368	0.254	0.118
TCS5	0.0	0.0	0.0	0.0	0.0	0.474	0.529
TCS6	0.0	0.0	0.0	0.0	0.0	0.0	0.195

Results: total signal at top energy

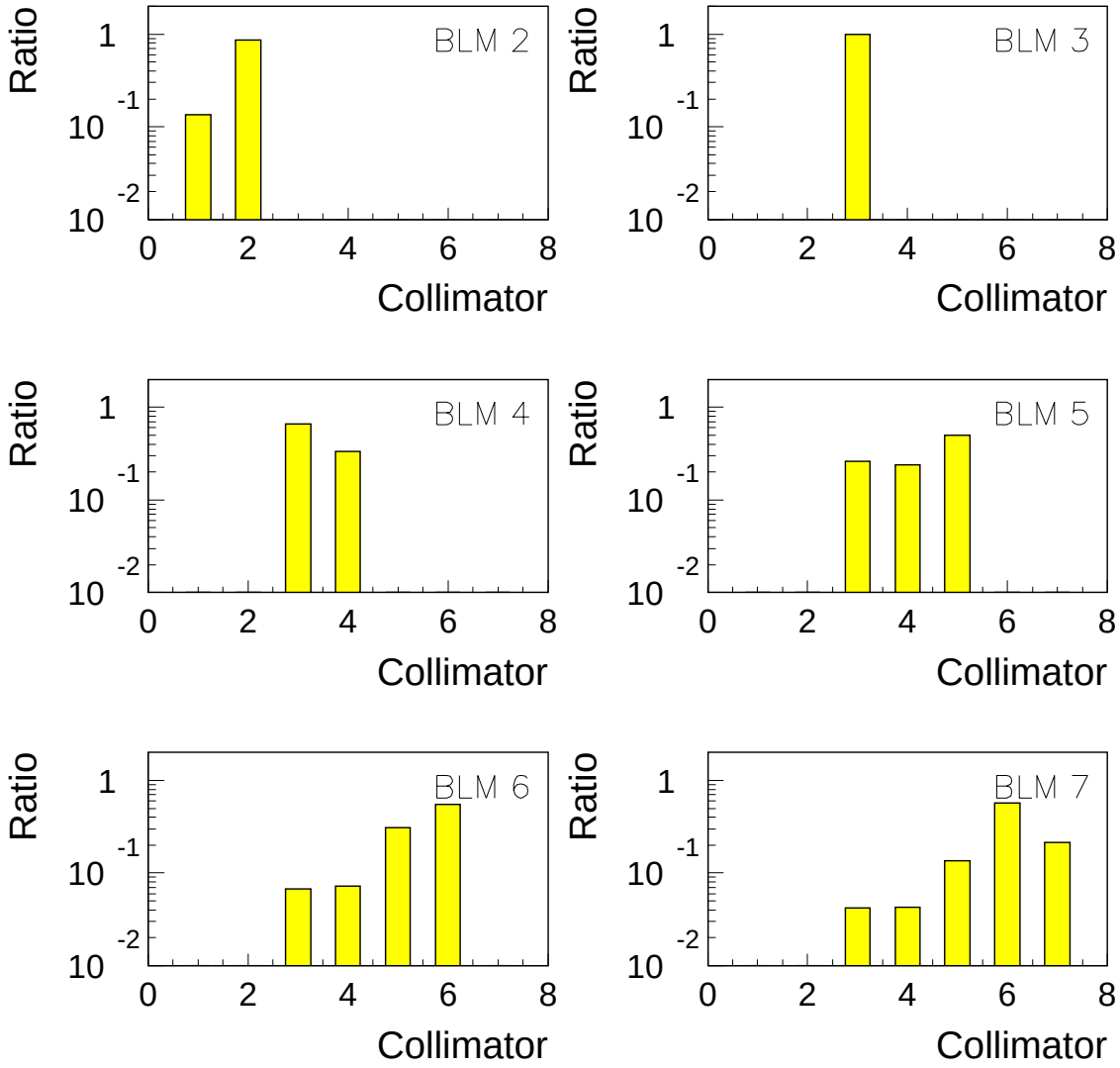


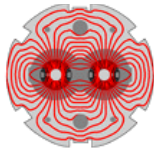




Results: ratio for injection

$$Ratio = p_{ij}/s_i$$





Results: ratio for injection

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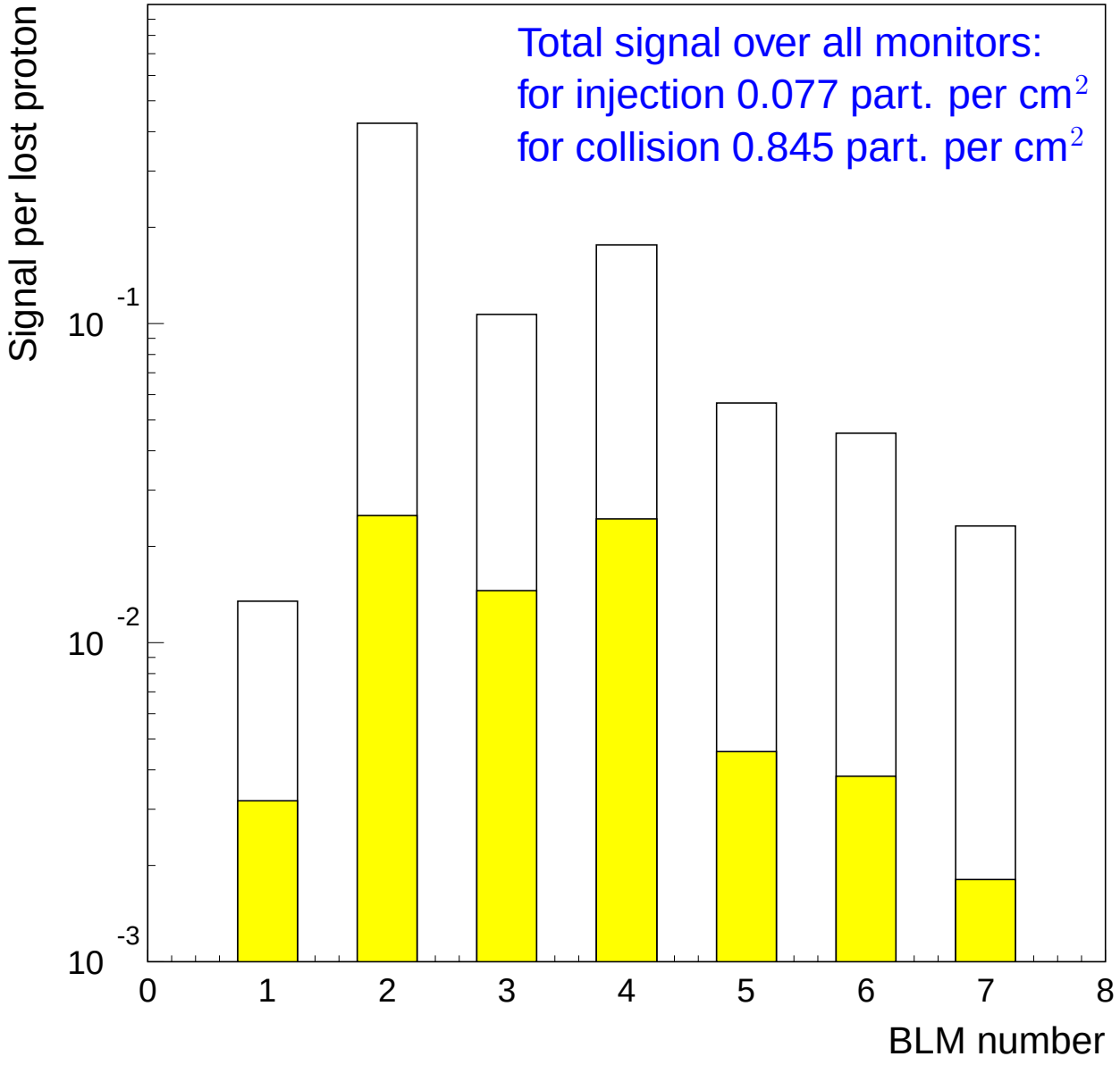
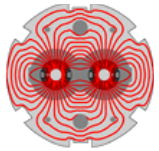
A relative partial contribution to total signal in the beam loss monitor. A sum over all relative contributions for each monitor is equal to 1.

$$Ratio = p_{ij}/s_i$$

Collimator (j)	Beam loss monitor (i)						
	1	2	3	4	5	6	7
TCP1	1.0	0.1341	0.0029	0.0017	0.0011	0.0009	0.0007
TCS1	0.0	0.8659	0.0006	0.0003	0.0001	0.0002	0.0001
TCS2	0.0	0.0	0.9957	0.6654	0.2592	0.0676	0.0421
TCS3	0.0	0.0	0.0007	0.3325	0.2386	0.0725	0.0428
TCS4	0.0	0.0	0.0	0.0	0.5010	0.3097	0.1357
TCS5	0.0	0.0	0.0	0.0	0.0	0.5492	0.5657
TCS6	0.0	0.0	0.0	0.0	0.0	0.0	0.2130

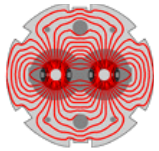
Results: total signal in the BLM





Conclusions

- The results of our simulation unique to the momentum cleaning section model and the optics version V6.2.
- The response matrix has a triangular form. A value of response of the beam loss monitor close to the TCP1 collimator is 65 times less than a response from the secondary ones. The value of the signal in the BLM comes to only 4.0% and 1.6% of the total for cases of injection and collision, respectively.
- At injection the beam loss monitors close to the TCP1, TCS1 and TCS2 collimators have the “good” spatial resolution. Ratio of ”good” signal to the total is about of 85%.
- At top energy only two beam loss monitors close to the TCP1 and TCS2 collimators have the “good” spatial resolution (about of 75%).
- For cases of injection and collision, signals in the beam loss monitors 2-5 give a contribution about 90% to the total, the signal in the beam loss monitors close to the TCS1 and the TCS4 collimators constitute of 64% from the total signal.



Conclusions

- The total signal in the beam loss monitors of the momentum cleaning system has a value of 0.077 and 0.845 part. per cm^2 for injection and collision, respectively.
- The contribution from the Ring 2 to the total signal of the beam loss monitors of the Ring 1 does not exceed 0.3%.
- The optics modification, the use of new materials for the collimator jaws and new design of the collimator tanks require more detail studies of the formation of the signal in the beam loss monitors for the cleaning systems.
- The betatron cleaning must be studied in detail.