PS Booster
Sensitivity studies of BLMs to beam losses

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LIU-PSB Meeting, CERN, March 1, 2012

Aim of the study

Based on beam optics studies, highest beam loss probabilities within a period expected at the

- vertical aperture limitation (exit face of the 1st BM)
- horizontal aperture limitations (center of the QFs)

Question:

Could a beam loss at the aperture limitations of one period be detected by additional beam loss monitors (BLMs) in the next period?

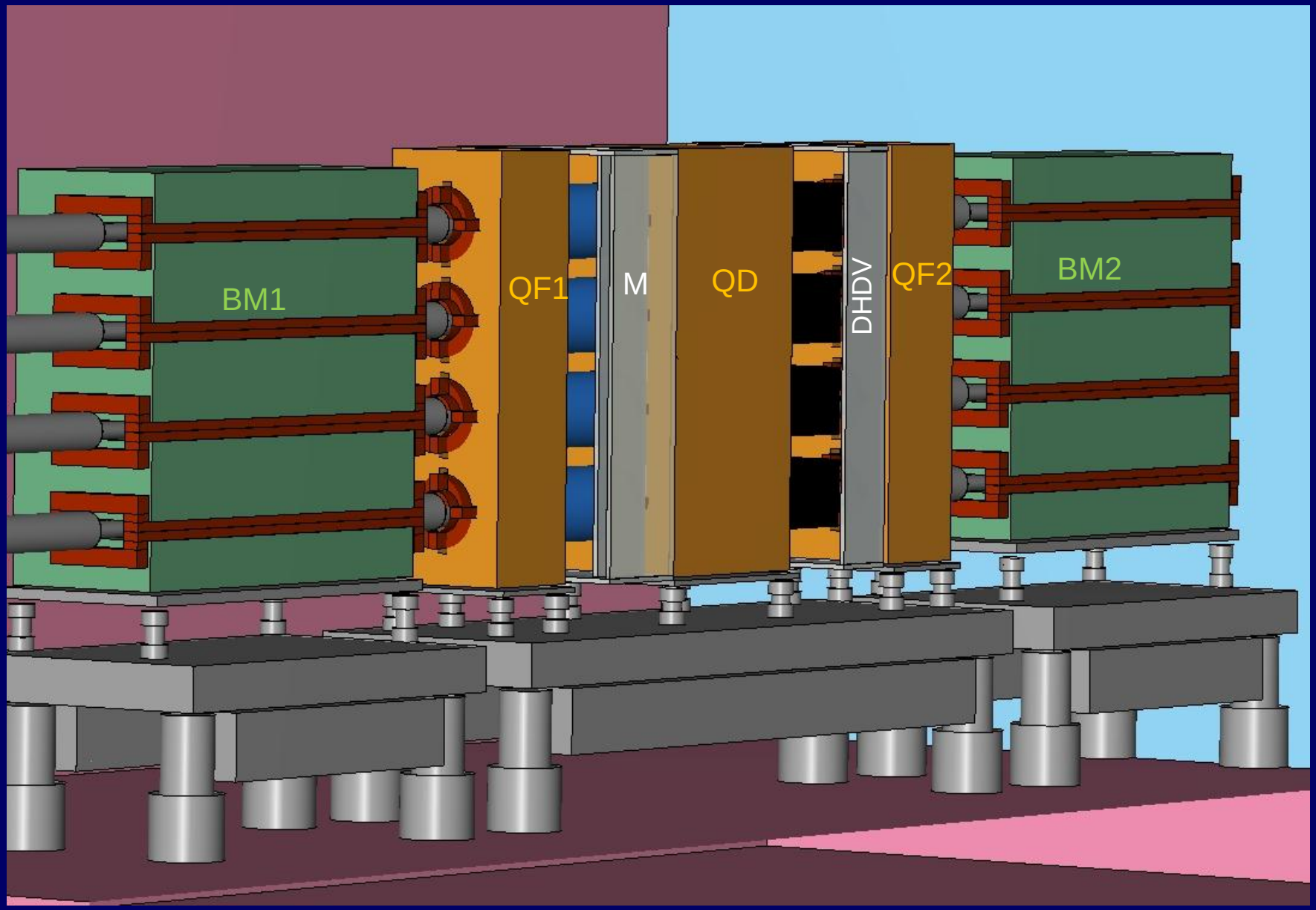
General Modelling of the Geometry

(probably useful also for other Booster studies)

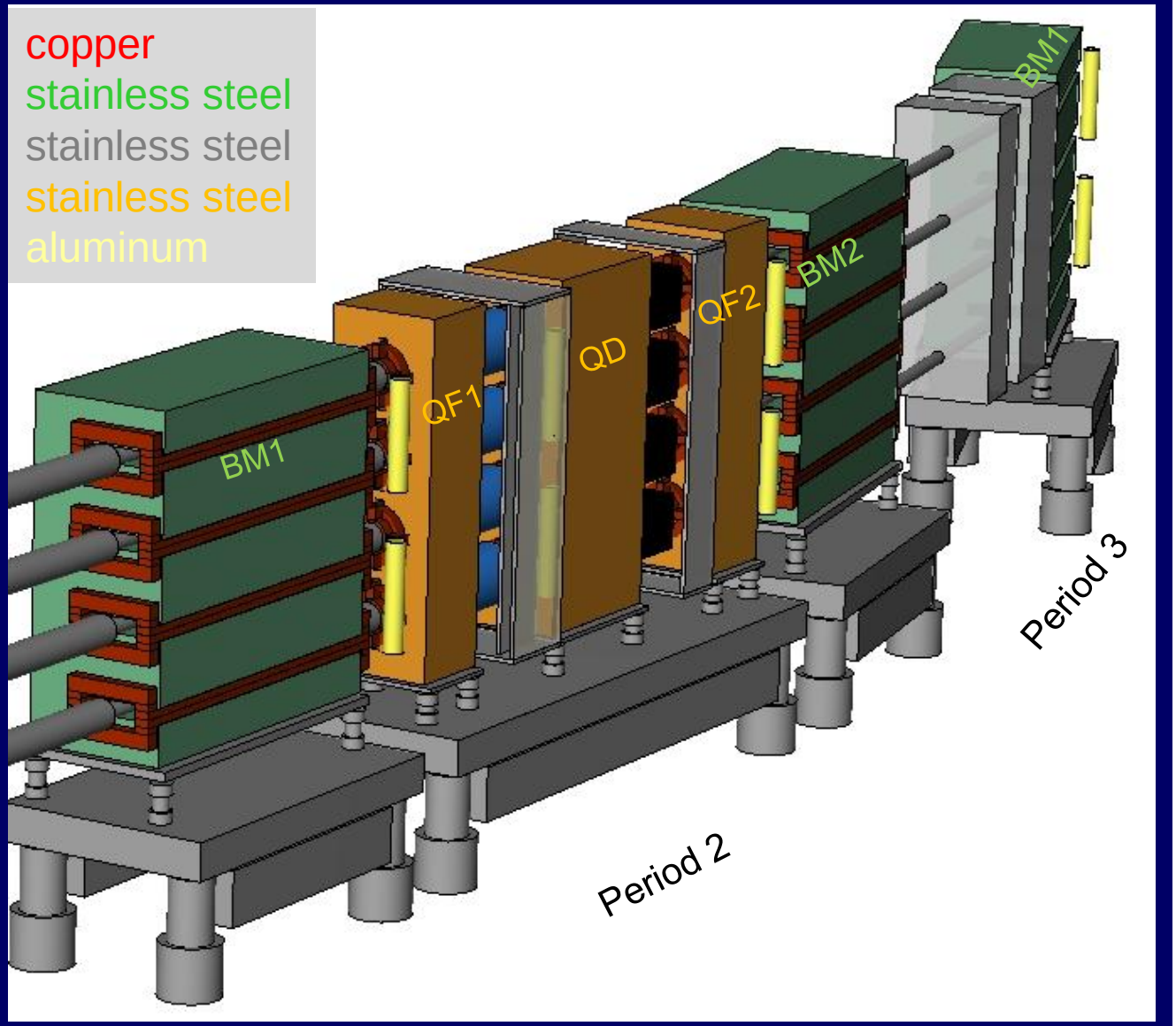
Basis

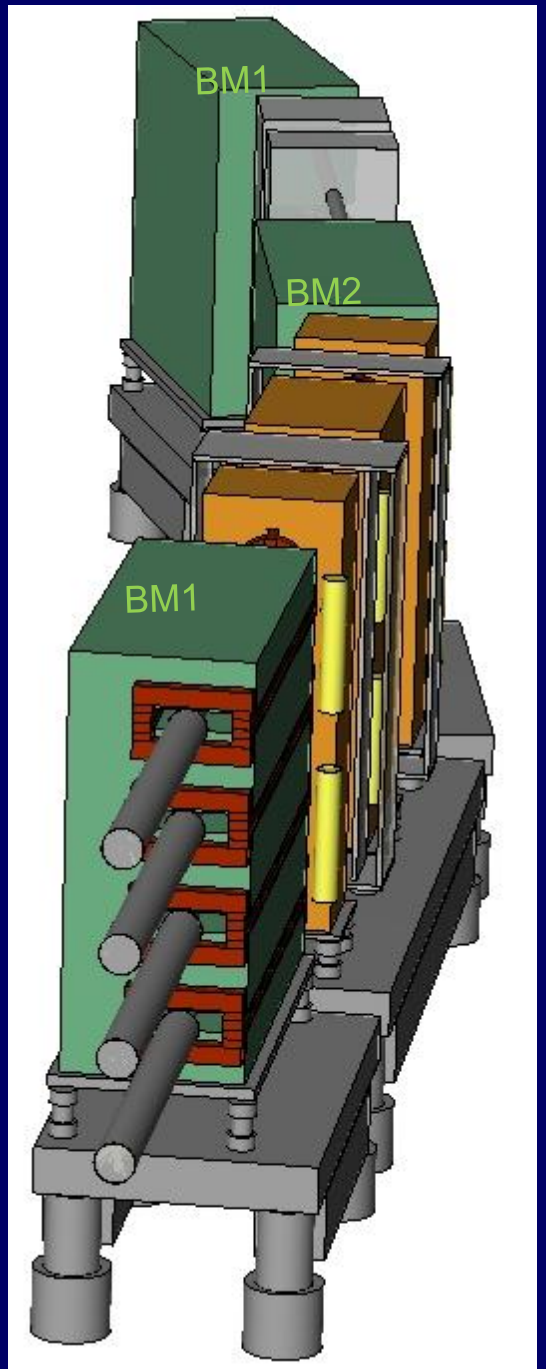
G:\Departments\TS\Services\Old Drawings\Complexe_PS\BOOSTER

Geometry of One PS Booster Period



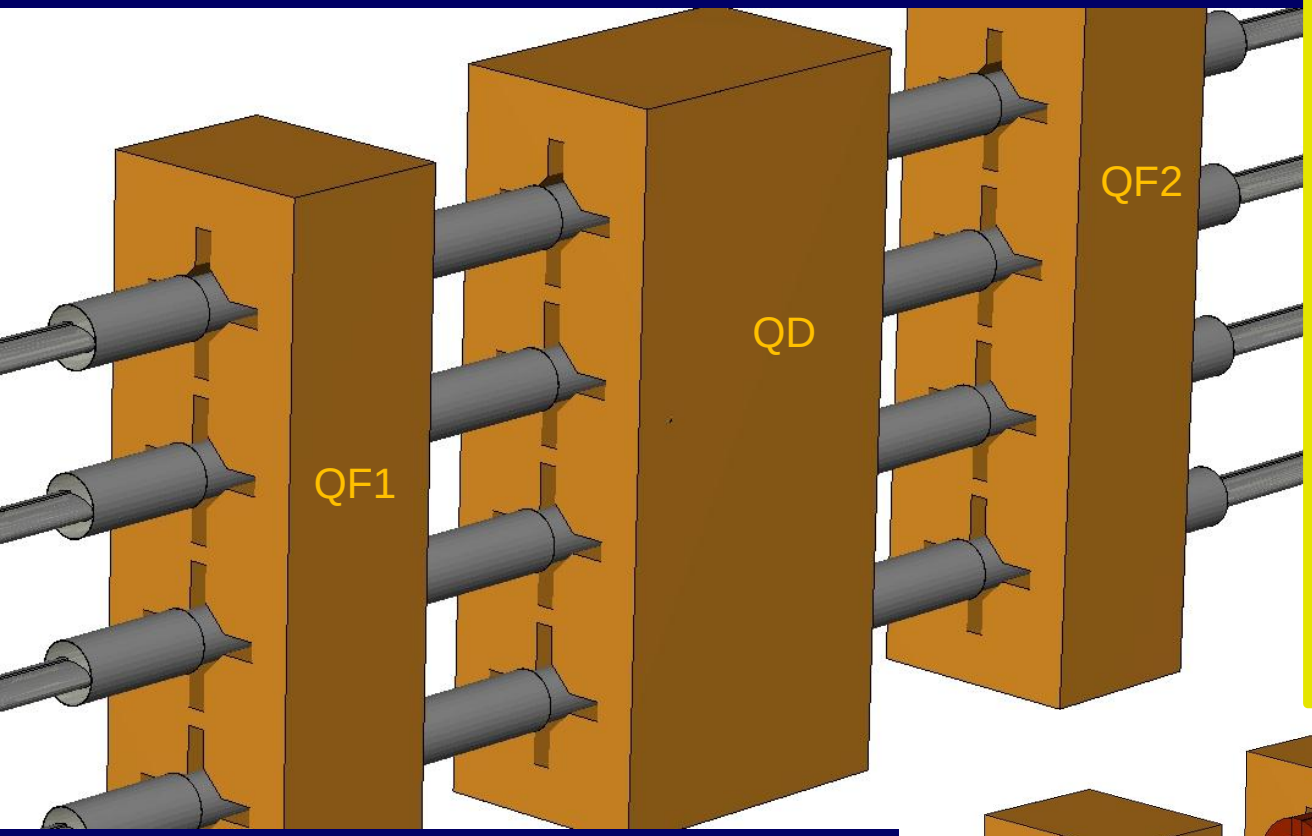
Extended Geometry

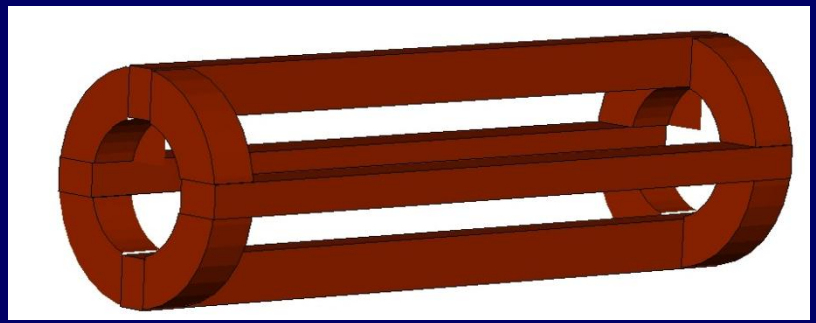


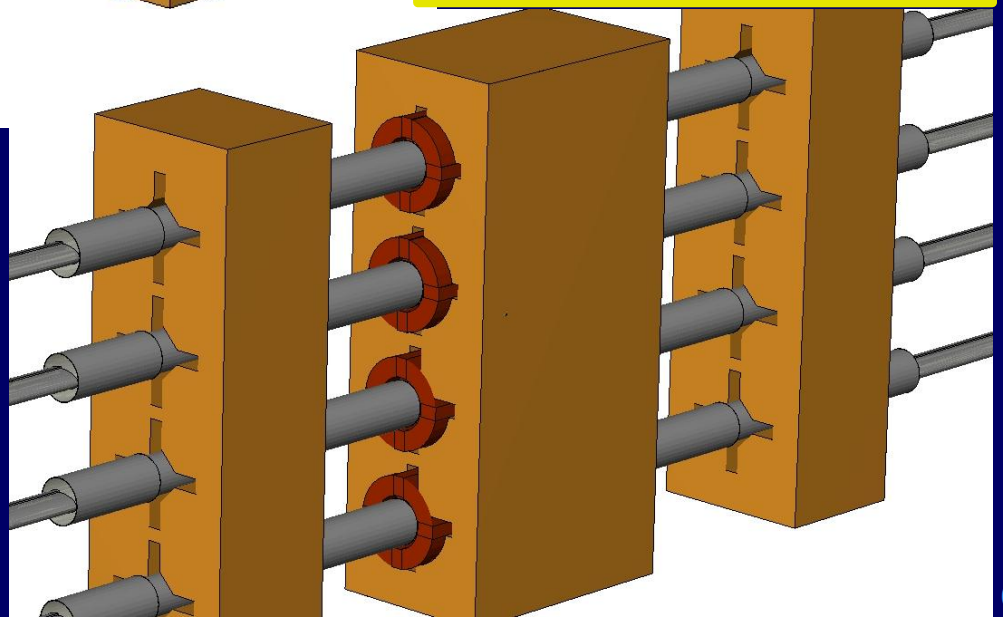


a straight section and the 1st bending magnet (BM) of the next Booster Period added

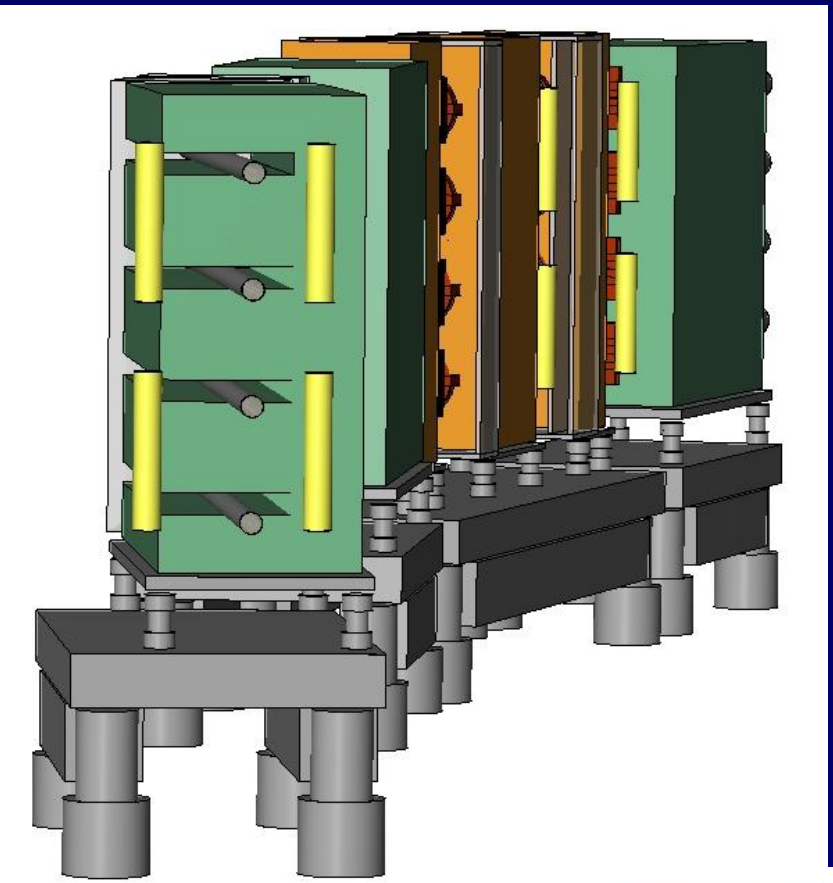
PS Booster - Quadrupoles: QF1, QD and QF2

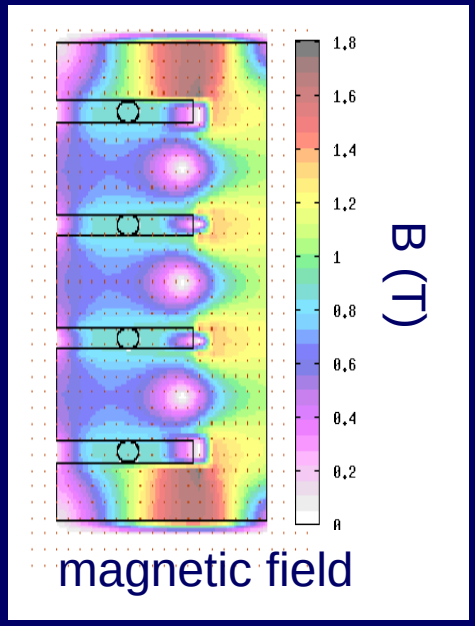


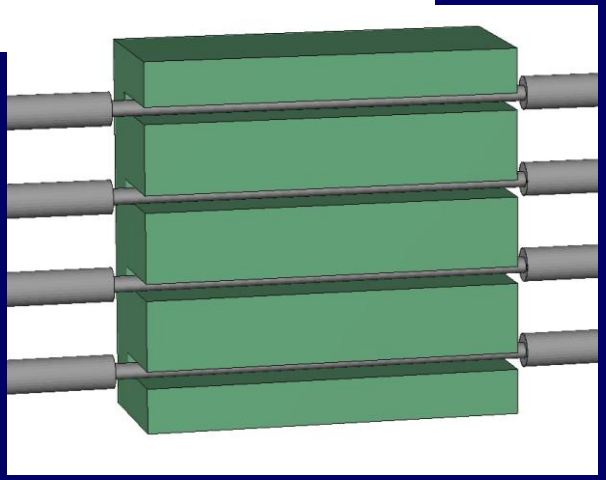


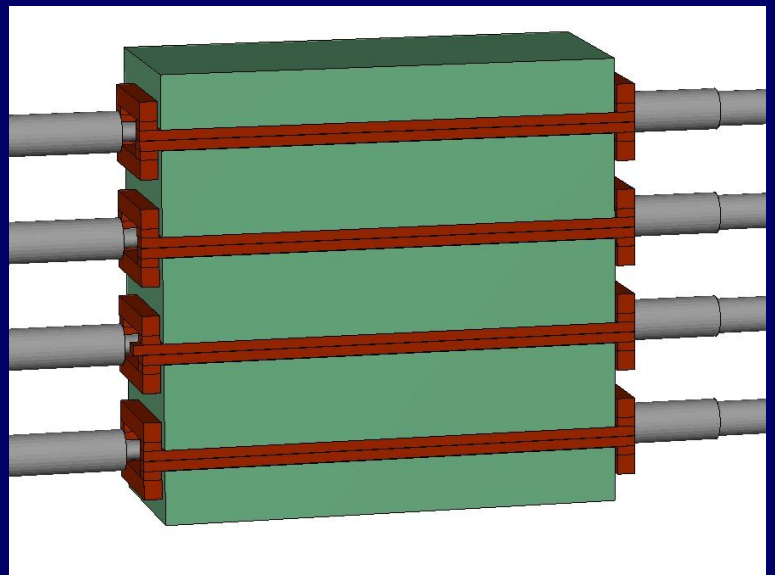


PS Booster - Bending Magnets

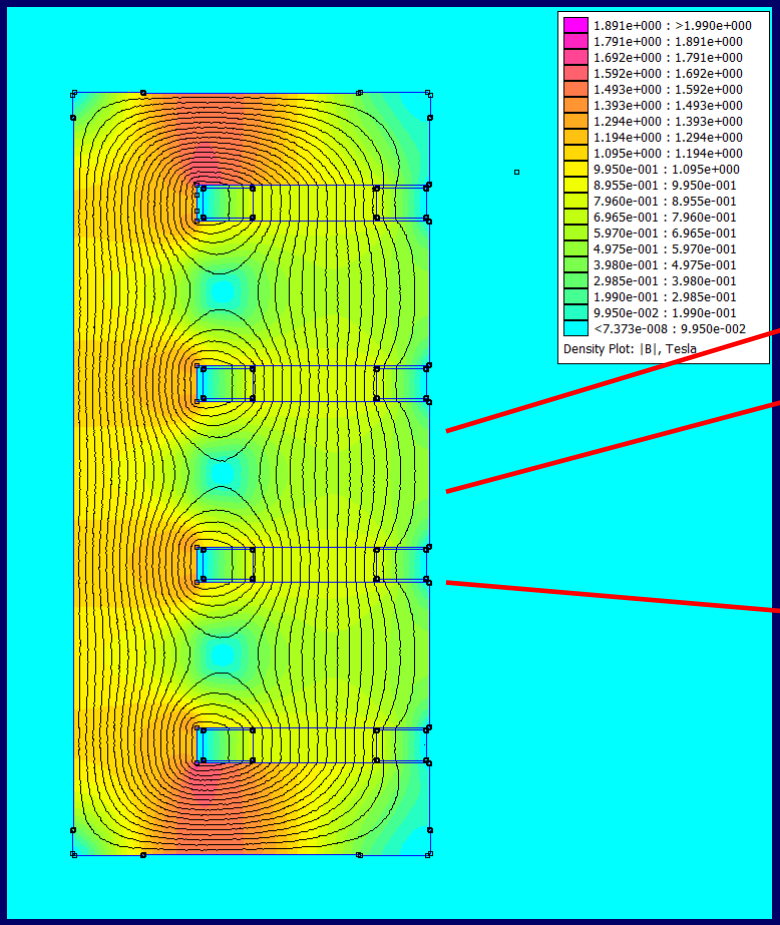


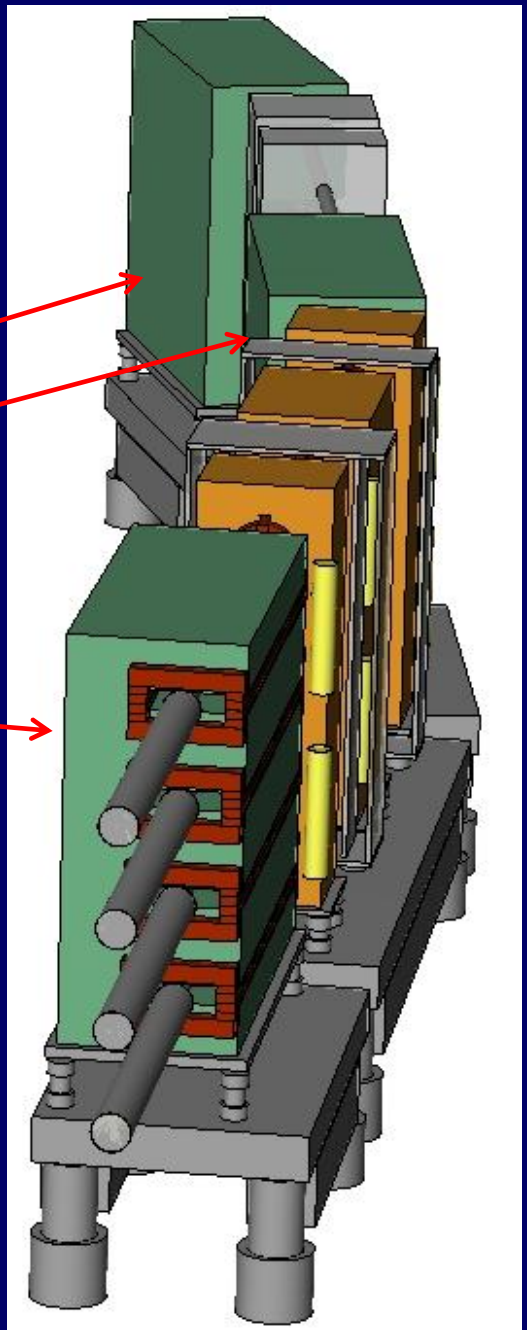






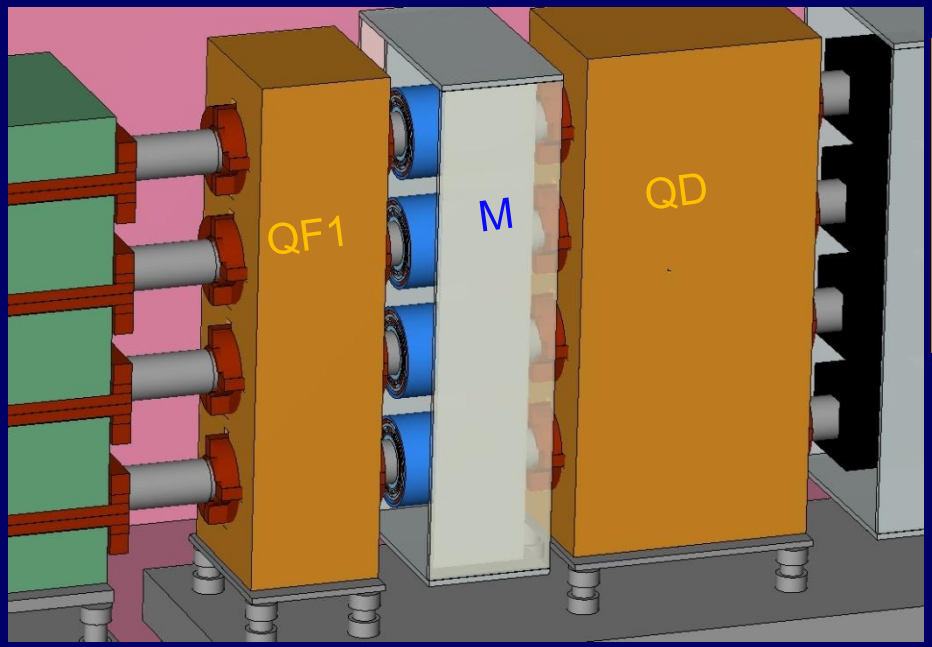
Magnetic field map added in each of the three dipoles

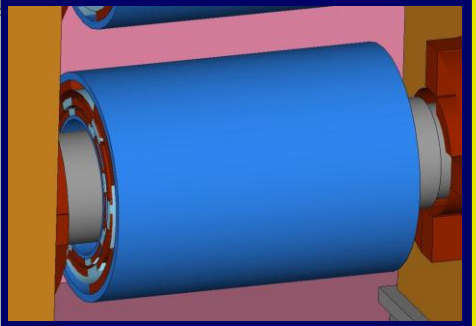




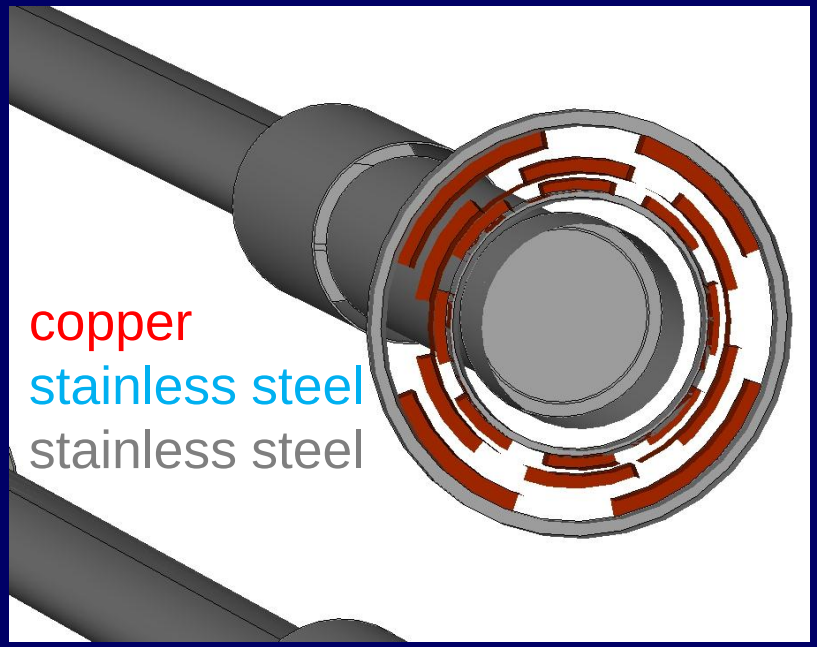
Field map from Antony Newborough and Marco Buzio

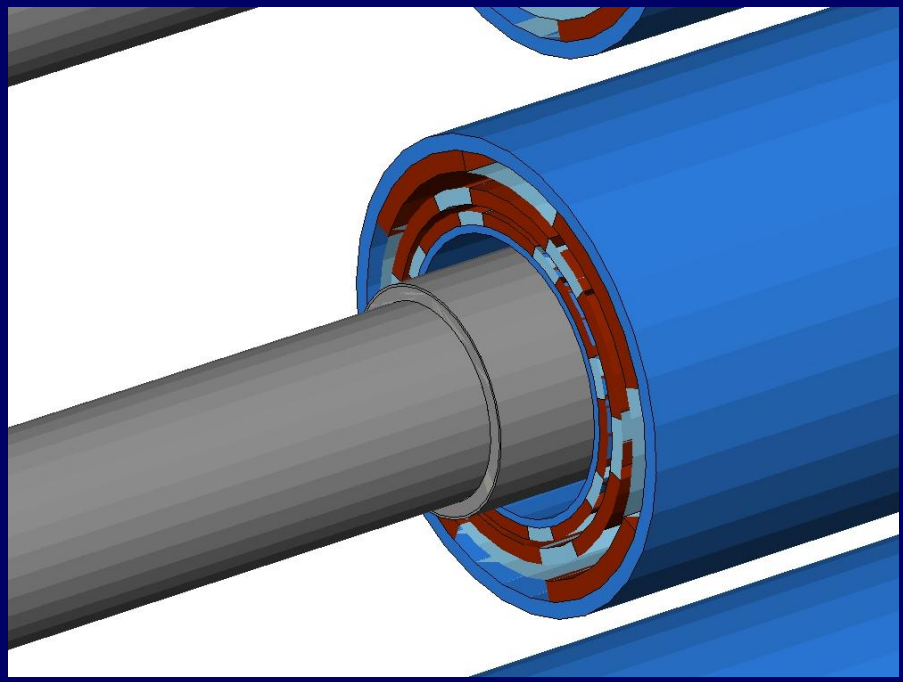
PS Booster - Multipole



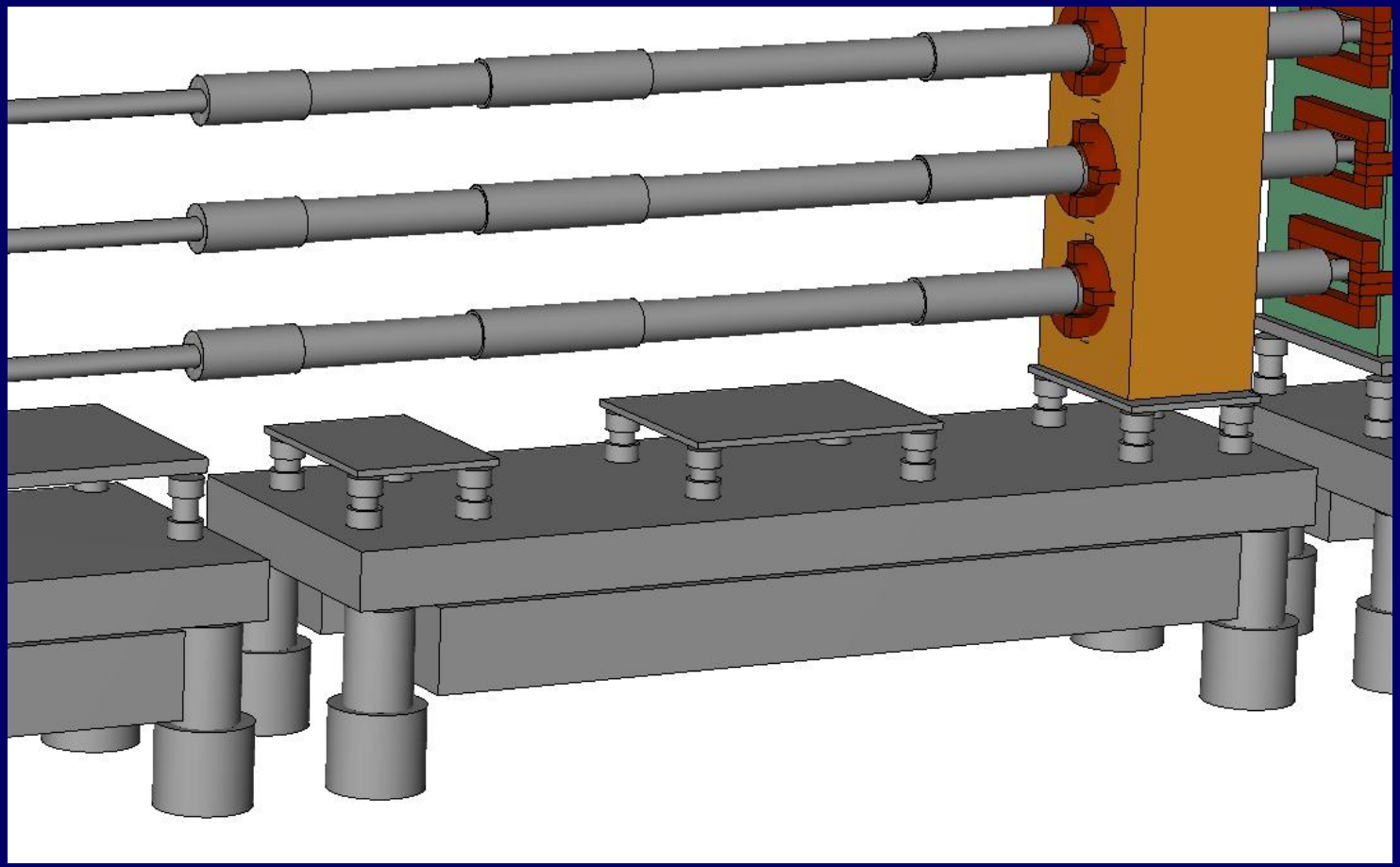


copper
stainless steel
stainless steel
stainless steel
glass fiber



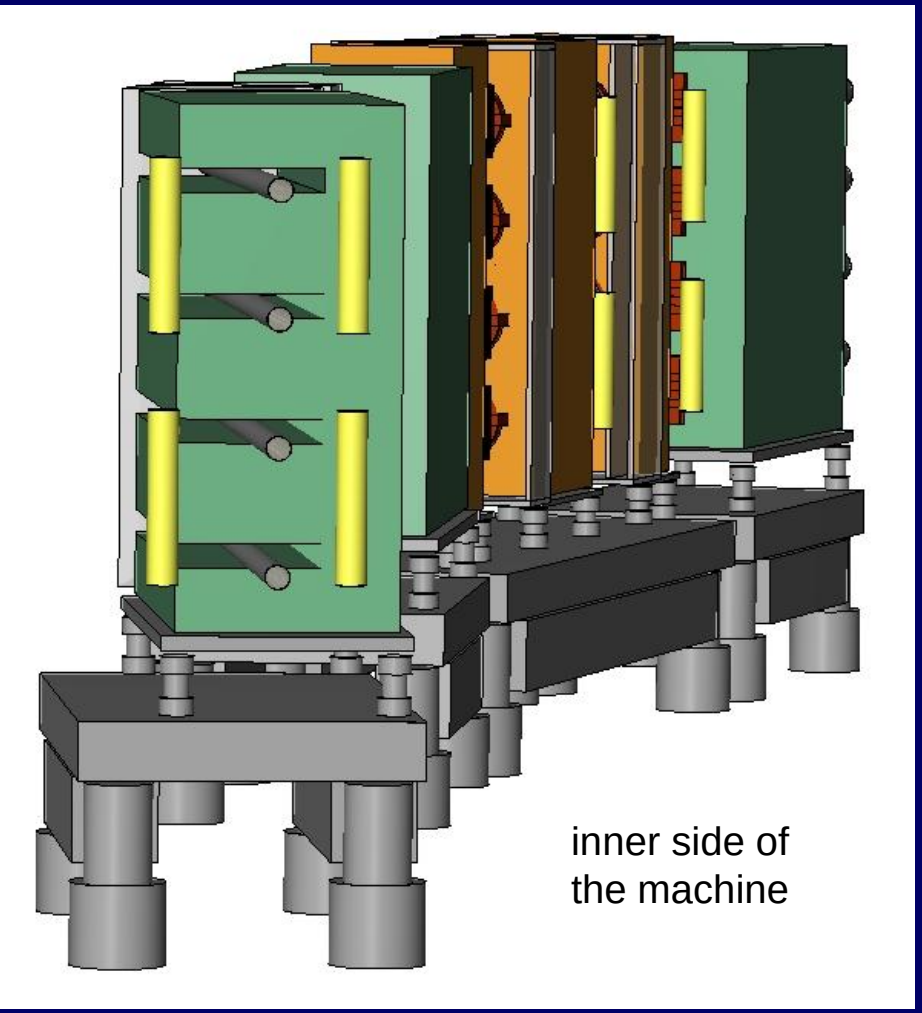


PS Booster: Beam Tubes and Pedestals



different beam tube shapes in different machine parts

IC-type Beam Loss Monitor (BLM)

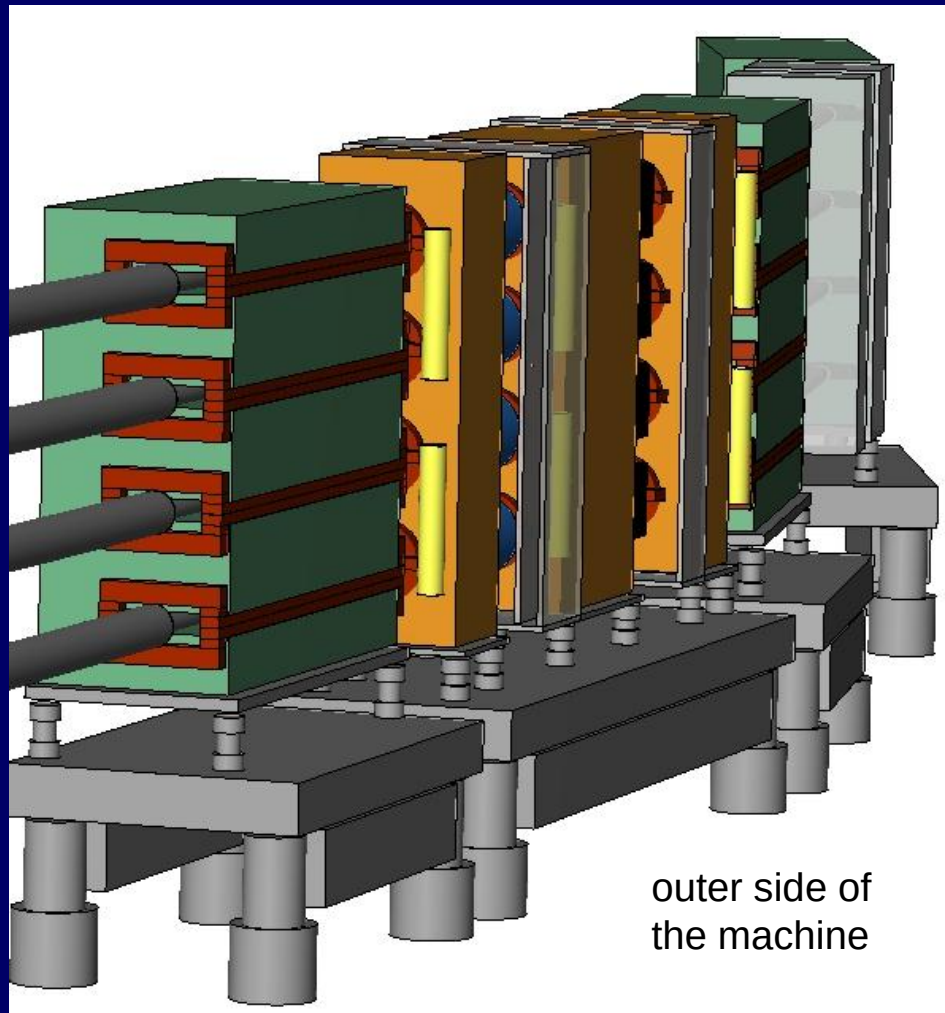


inner side of the machine

Beam Loss Monitors – LHC type

altogether 3×2 in the 2nd Booster Period and 1×2 in the 3th Booster Period (exit face of 1st BM),

on both sides of the beam



outer side of the machine

BLMs: cylindrical shape with 9 cm diameter and 50cm length, filled by nitrogen

placed 15 cm away from the beam tube

Assumptions for the simulations

- proton beam of E_k=160 MeV, 1.4 GeV and 2 GeV

- lost (ISOLDE-type) beam intensity: 8.3×10^{10} p/s
  (~1% of 1×10^{13} p/1.2s/ring)

- source I : at the vertical aperture limitation
  (exit face of the 1st BM)

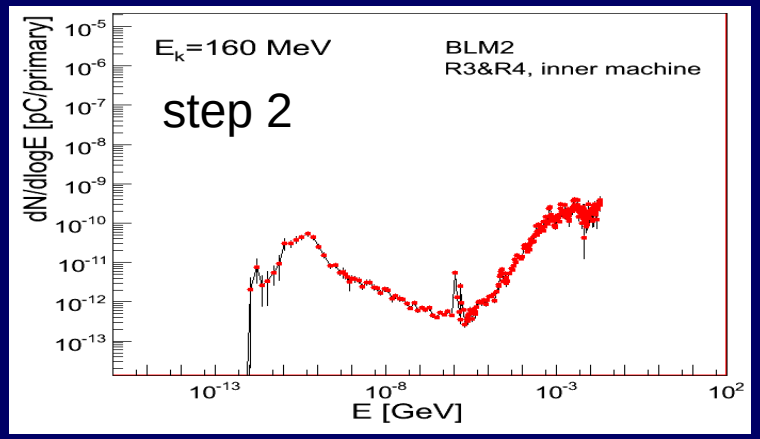
- source II: at the first horizontal aperture limitation
  (center of the 1st QF)

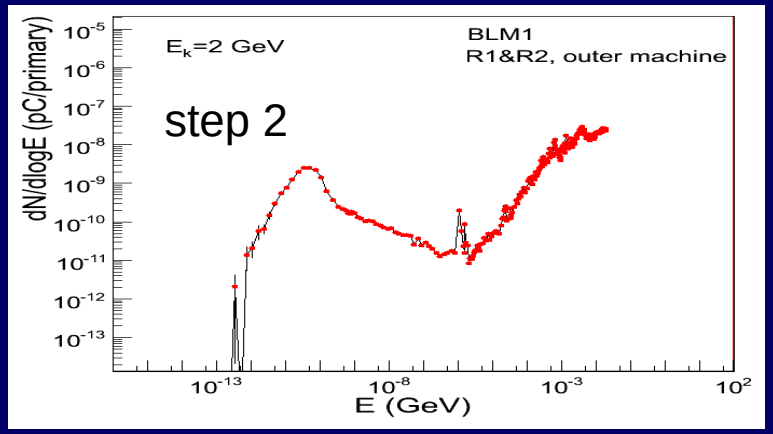
consider only 3rd ring for both sources

Analysis Procedure

- Simulate fluence spectra of all particles within the volume of the BLMs (1)

- Fold spectra with a specific response function (2) and integrate over energy (3) to get charge/primary; routine developed by M. Brugger and S. Roesler http://cernsearch.web.cern.ch/cernsearch/Default.aspx?query=CERN-EN-NOTE-2010-001

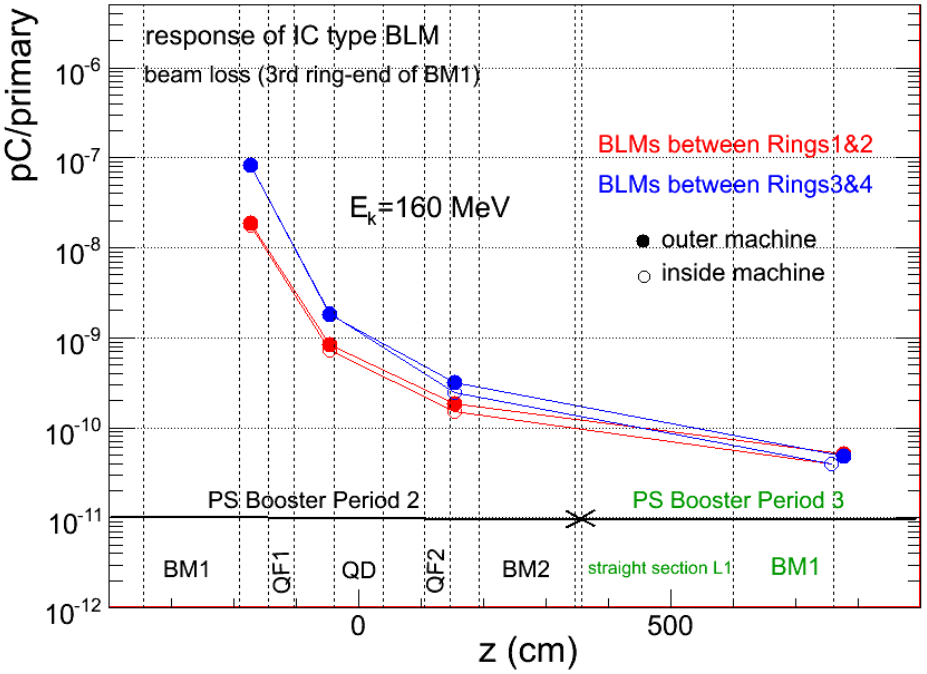




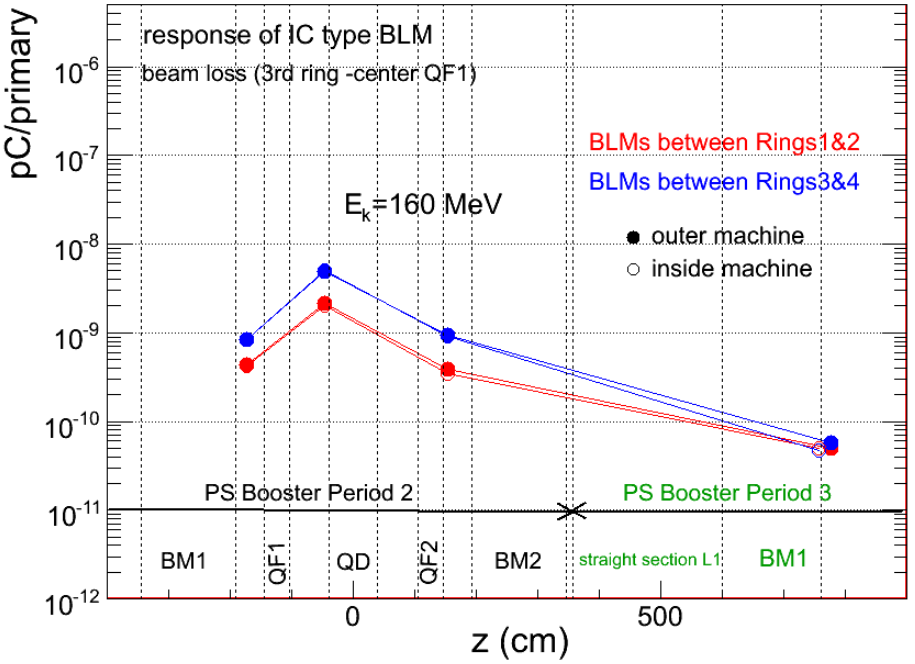
- Multiply with beam loss intensity to obtain current in the BLMs (4)

Response of the IC-type BLMs in pC/(lost primary) to beam losses inside the 3rd Ring for E_k=160 MeV

source I – vertical aperture limitation



source II – horizontal aperture limitation

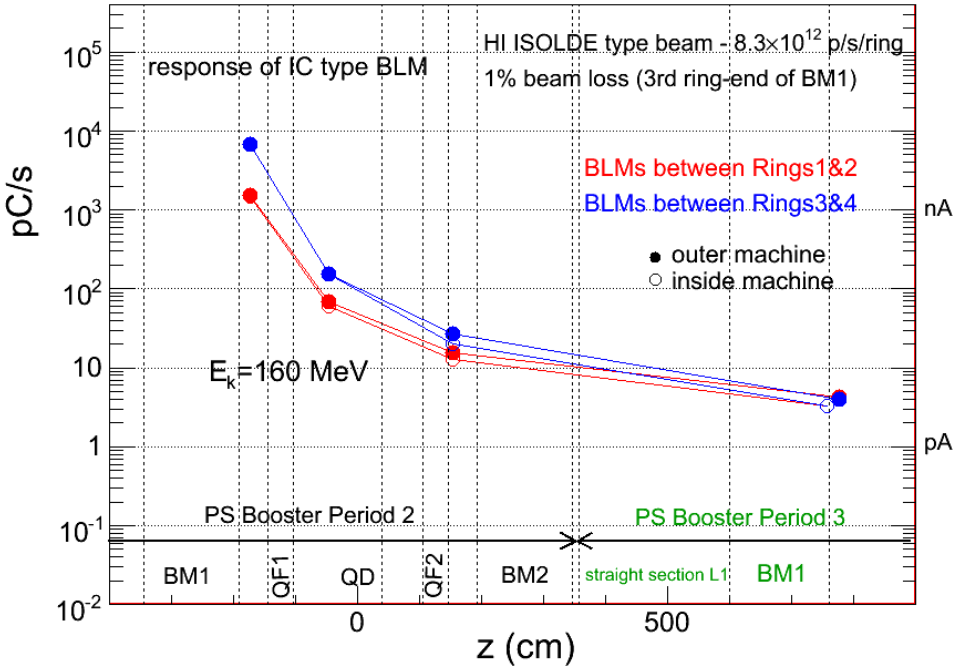


Values read by the BLMs in the next Booster Period smaller by 2-3 orders of magnitude compared to values close to the source

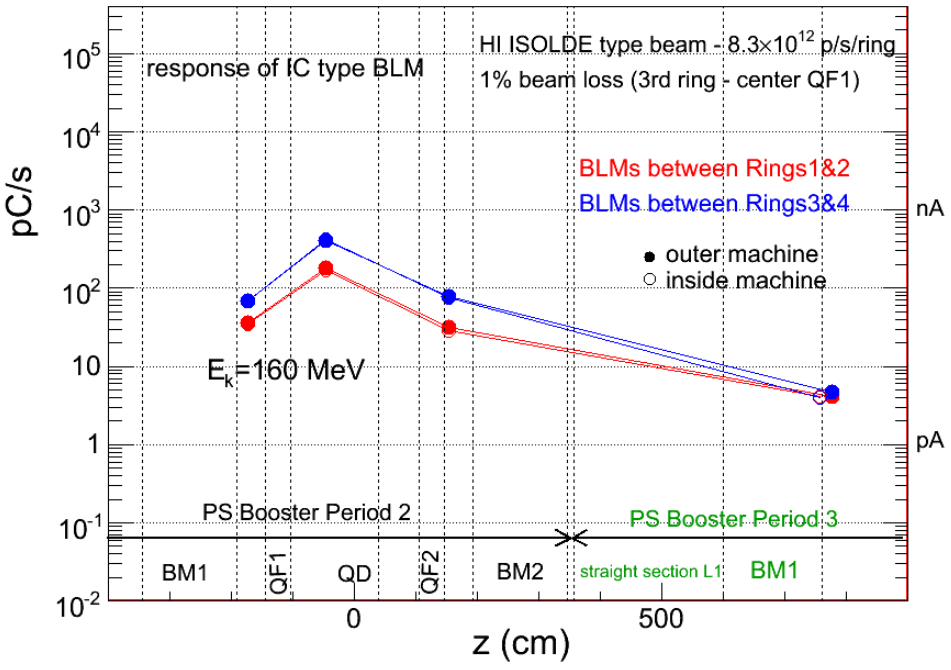
Differences in values read by the BLMs in the next PS Booster Period only up to a factor of 1.2 between source I and source II

Response of the IC-type BLMs in pC/s to 1% beam losses inside the 3rd Ring for E_k=160 MeV

source I – vertical aperture limitation



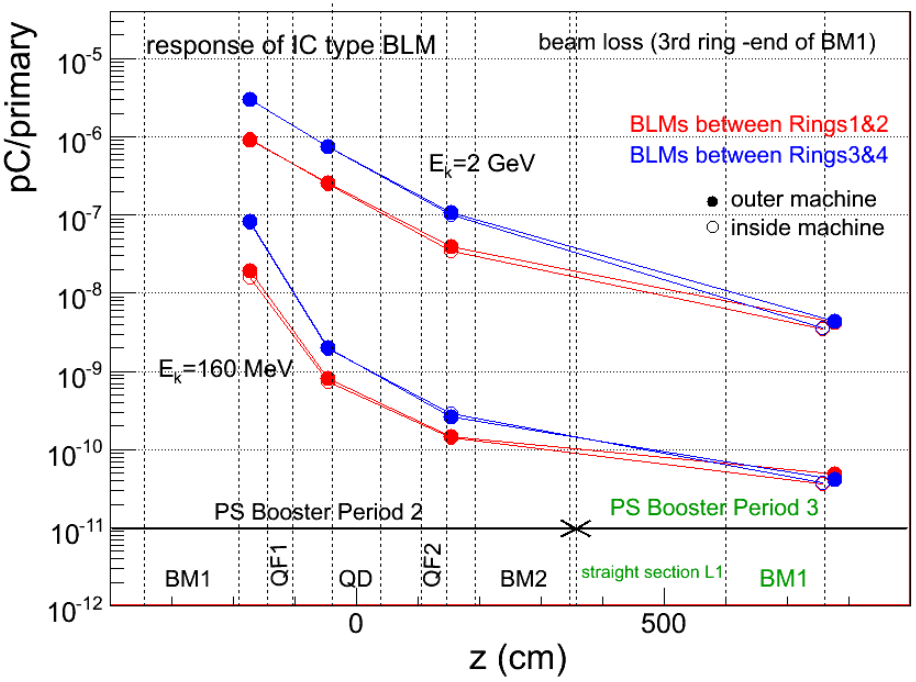
source II – horizontal aperture limitation



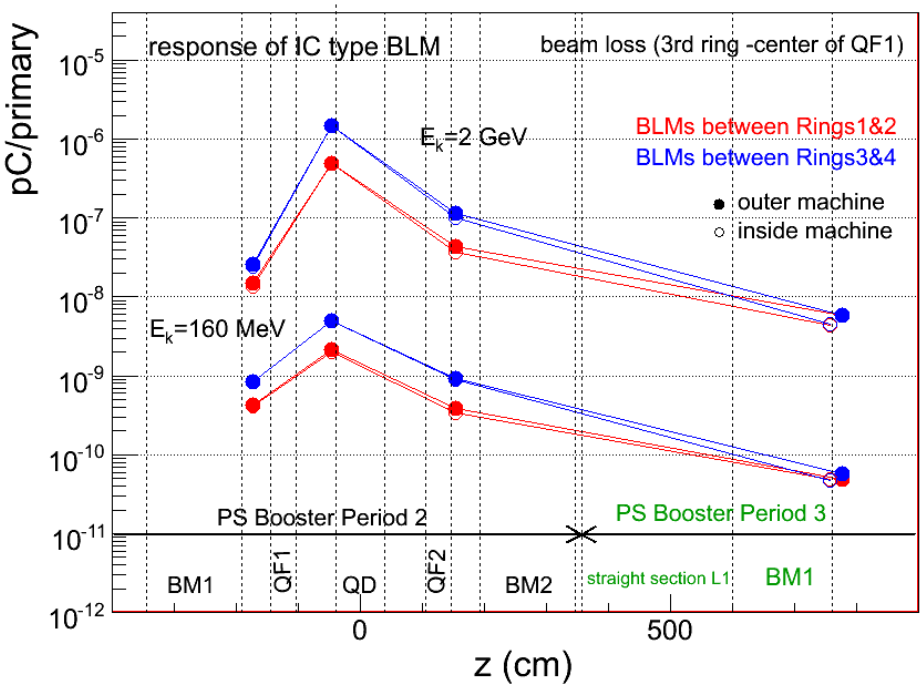
currents of ~4 pA for the source I and ~4.5 pA for the source II expected to be measured by the BLMs installed at the exit face of the 1st BM in the next Period

Response of the IC-type BLMs in pC/(lost primary) to beam losses inside the 3rd Ring for E_k=160 MeV and 2 GeV

source I – vertical aperture limitation



source II – horizontal aperture limitation

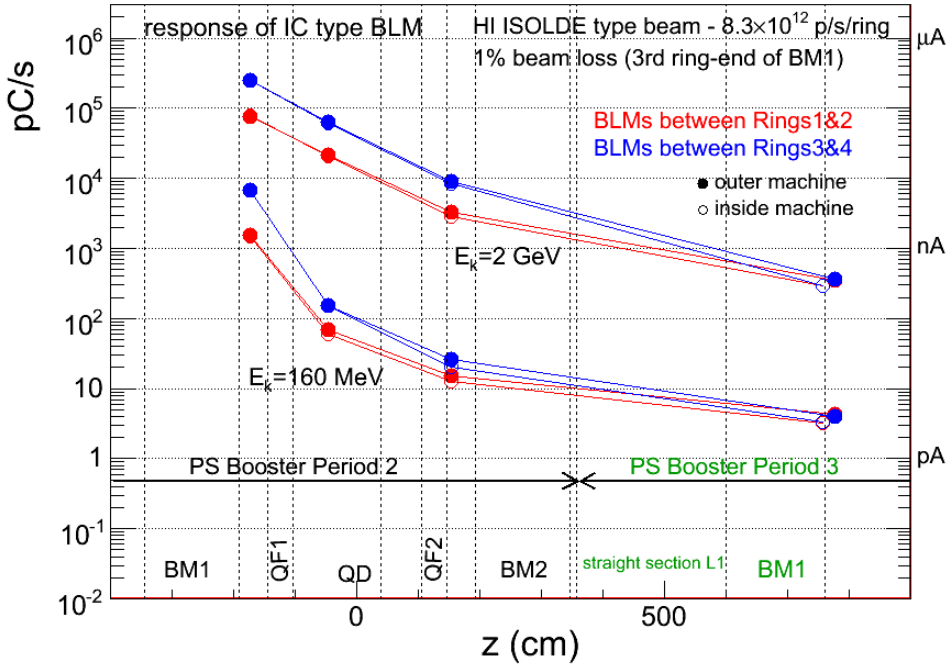


Values read by the BLMs in the next Booster Period smaller by 2-3 orders of magnitude compared to values close to the source for both energies.

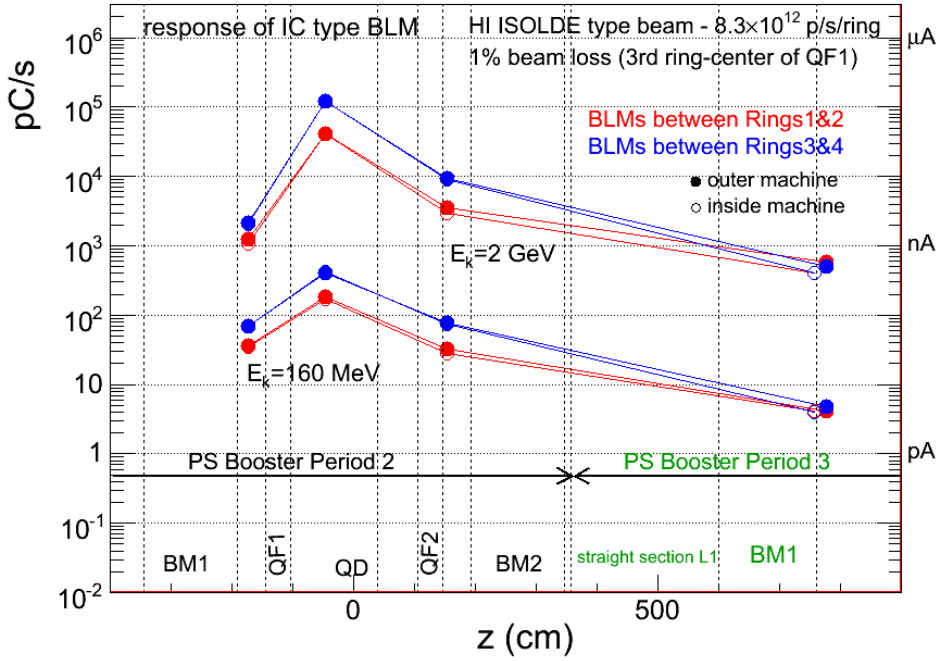
Values for E_k=160 MeV smaller by 2 orders of magnitude compared to E_k=2 GeV

Response of the IC-type BLMs in pC/s to 1% beam losses inside the 3rd Ring for E_k=160 MeV and 2 GeV

source I – vertical aperture limitation



source II – horizontal aperture limitation

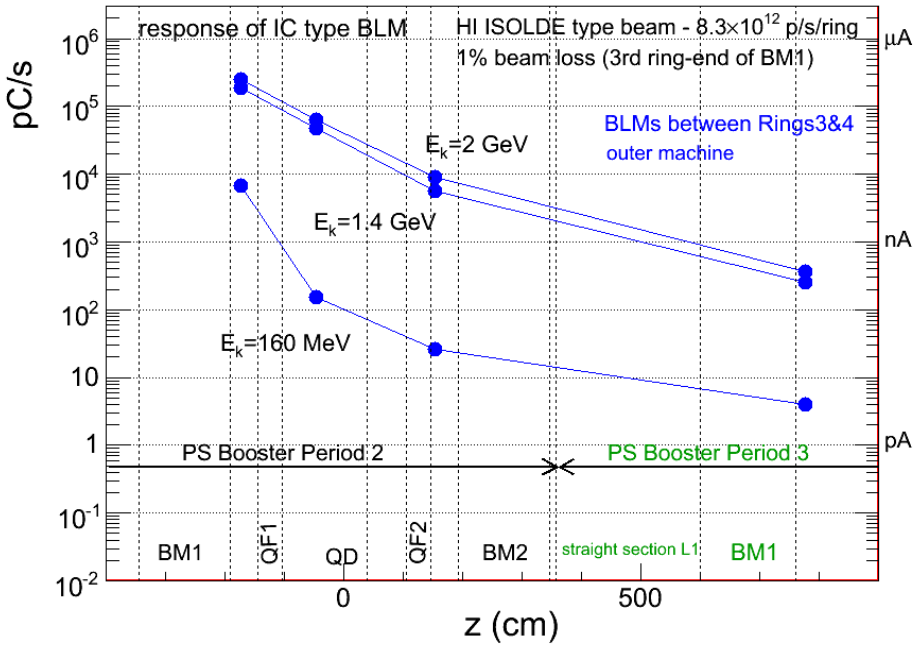


values for E_k=160 MeV smaller by 2 orders of magnitude compared to E_k=2 GeV

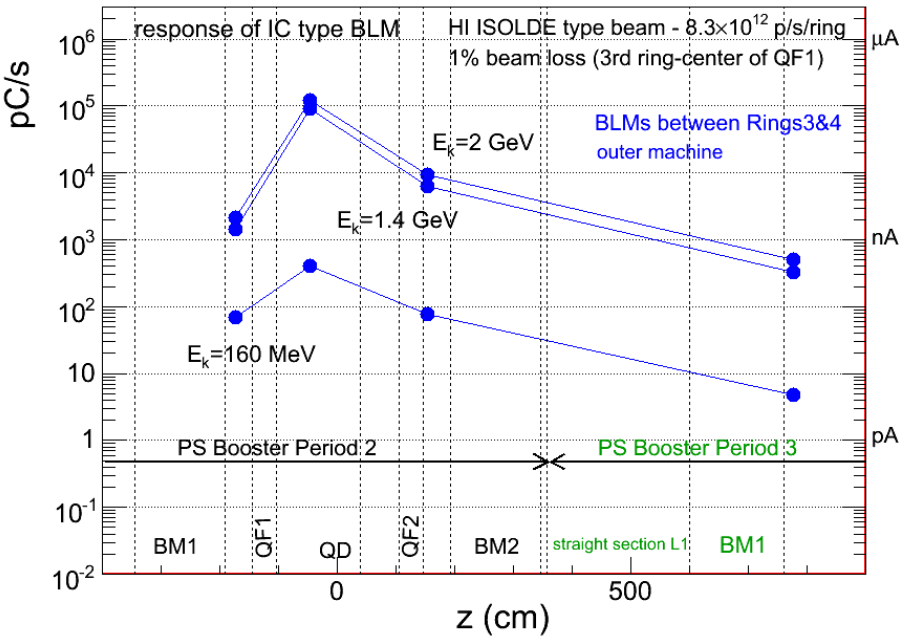
currents of ~4 pA (max 4.8) for E_k=160 MeV and ~400 pA (max 570) for E_k=2 GeV expected to be measured by the BLMs installed at the exit face of the 1st BM in the next Period

Response of the IC-type BLMs in pC/s to 1% beam losses inside the 3rd Ring for E_k=160 MeV, 1.4 GeV and 2 GeV

source I – vertical aperture limitation



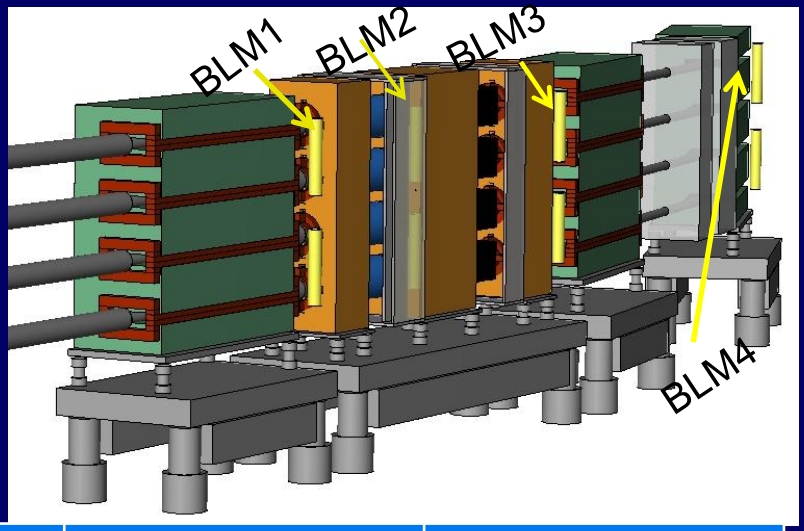
source II – horizontal aperture limitation



Values for E_k=1.4 GeV smaller by a factor of 1.5 compared to E_k=2 GeV (true also for the other 3 BLM positions: inner side, Rings1&2)

Response of the IC-type BLMs in nA to 1% beam losses (8.3×10^{10} lost p/s) inside the 3rd Ring

Example: BLMs along outer side of machine, between Rings3&4



160 MeV	BLM1 [nA]	BLM2 [nA]	BLM3 [nA]	BLM4 [nA]
Source I	6.9	0.15	0.026	0.004
Source II	0.07	0.4	0.08	0.0048

1.4 GeV	BLM1 [nA]	BLM2 [nA]	BLM3 [nA]	BLM4 [nA]
Source I	186	47	5.7	0.25
Source II	1.4	90	6.2	0.33

2.0 GeV	BLM1 [nA]	BLM2 [nA]	BLM3 [nA]	BLM4 [nA]
Source I	249	62	9	0.37
Source II	2	123	9.5	0.50