Beam Loss Monitors for TOTEM?

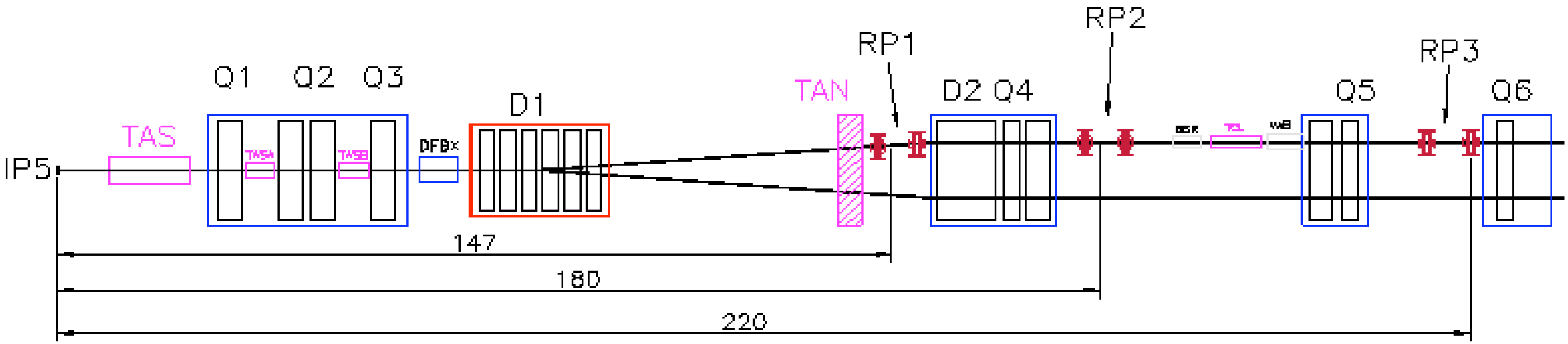
- Introduction and Motivation
- Optimal Positions of Monitors - Results of Simulation
  - 150m Station Results shown in MIB WG March '06
  - 220m Station Results new
- Summary and Outlook

Richard Hall-Wilton, Vadim Talanov,
Daniela Macina. TS/LEA

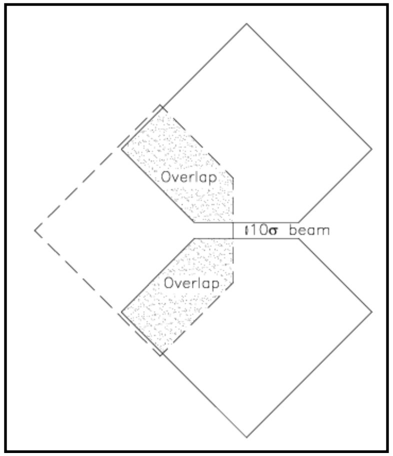
Motivation – Why BLMs are needed?

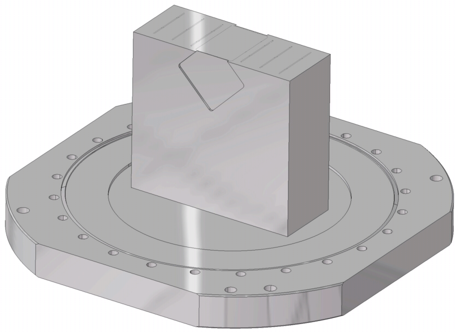
- TOTEM - Roman pots to be installed on either side of IP5
  - On the outgoing beams
  - Pots designed to go to 10 sigma from beam (1 mm)
  - Obvious potential danger to pot
  - From CDF experience also concern/potential for quenching or even damaging magnets
  - Can BLMs provide some degree of machine protection in catastrophic scenario of detector scraping?
  - Information should also be useful for monitoring

TOTEM



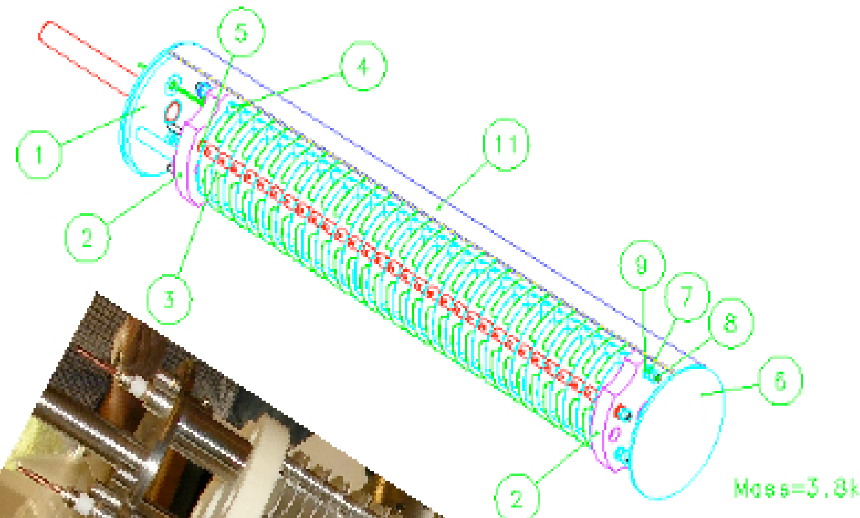
- Consider stations, RP1 – 150m and RP3 - 220m
- Nearest part of pot to beam 5 cm stainless steel

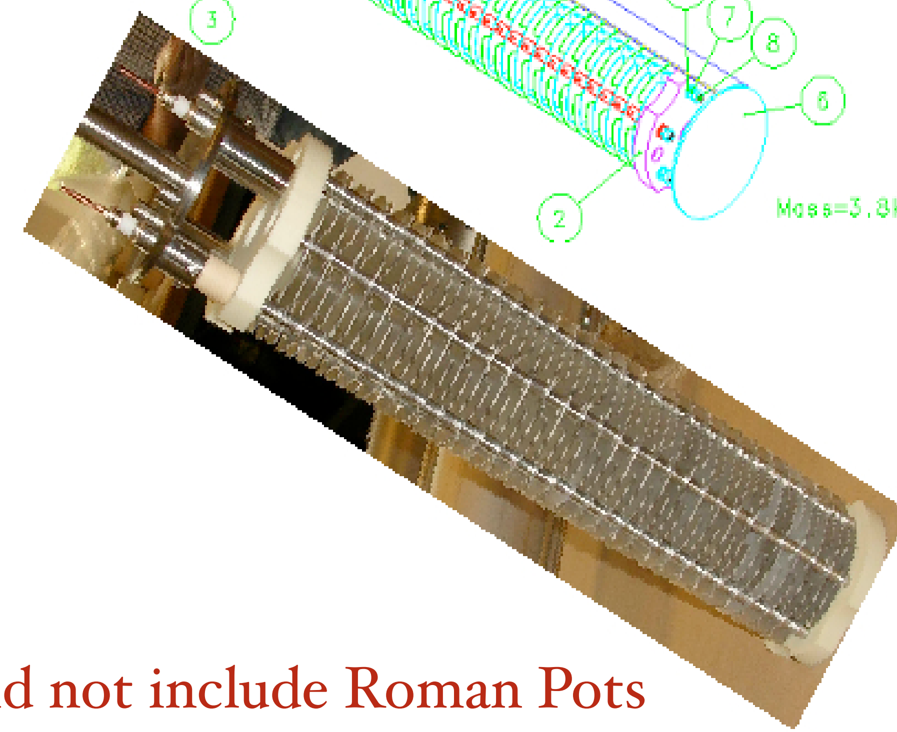




Beam Loss Monitors

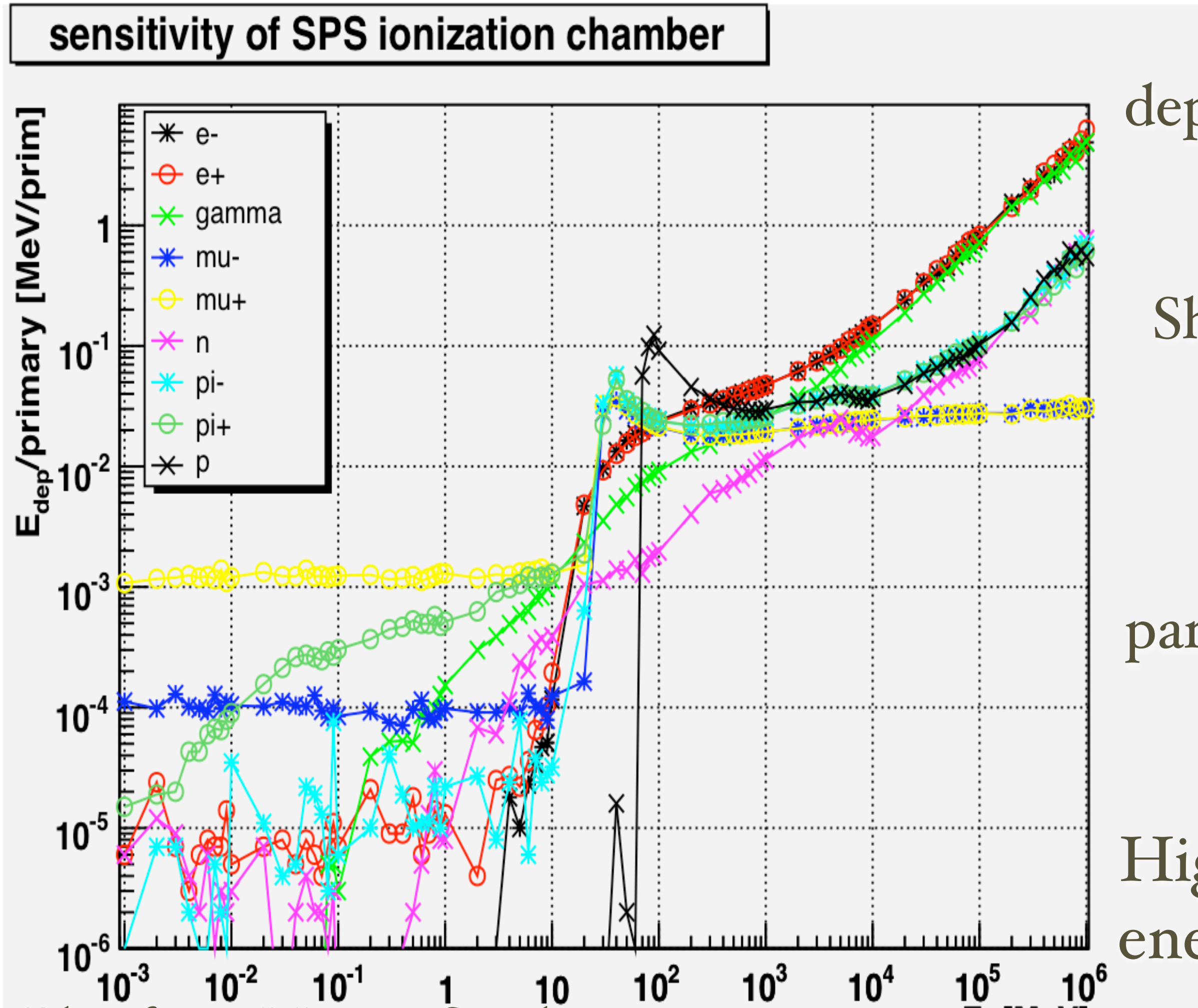
- Ionisation Chambers
- 60cm long, 9cm diameter
- 1100 around ring
- Main machine protection device - connected to beam dump system
- Quench prevention
- Beam Diagnostics
- Have been positioned at all major loss points, but …





… types of losses considered did not include Roman Pots
- different mechanism - need to evaluate losses

Beam Loss Monitors - Sensitivity



Plot from Marcus Stockner

Relative Signal depends upon particle type and energy

Shown here for SPS type chamber

Simulation assumes particles incident parallel to axis of detector

High energy and low energy response very different

Machine Protection BLMs nearby

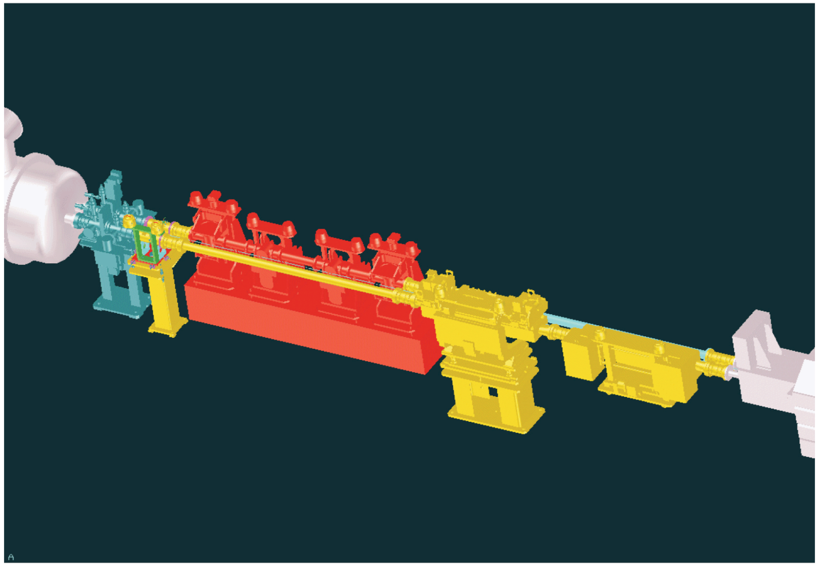
Machine protection BLMs also in Long straight sections

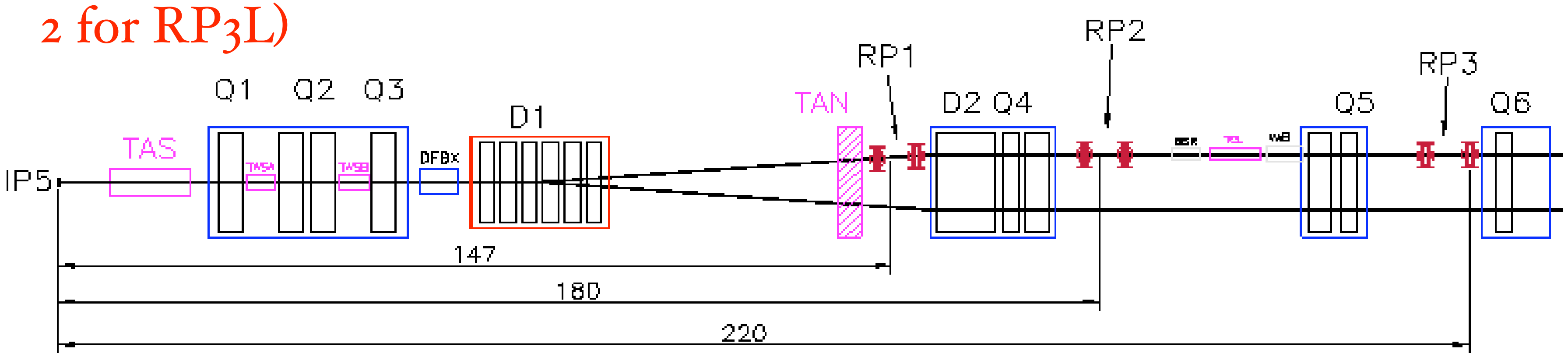
Nearby TOTEM:

Upstream - on TAN (2), Collimators TCTV/H (4)

Downstream - Q4 (6), Q5 (6), Q6 (6), TCL (185m - 2)

2 BLMs foreseen for every TOTEM RP station (i.e. 2 for RP1R, 2 for RP1L, 2 for RP3R, 2 for RP3L)





Simulation of Shower Topology

- Simulate shower from interactions in the pot (145m, 220m)
- 7 TeV proton collision with steel (point collision)
- Previous geometry - from TOTEM TDR. Updated geometry from post-EDR needs to be implemented
- Material implemented is magnet cores and yokes
- Trace where the flux of particles leaves the cryostat downstream (radius 33cm)
- What machine elements could be affected?
- What do showers look like downstream?

All plots shown are flux of particles per initial interaction

To get "real" fluxes/signals, need a normalisation, i.e. a beam halo distribution

Shower Profile on beamline (150m station)

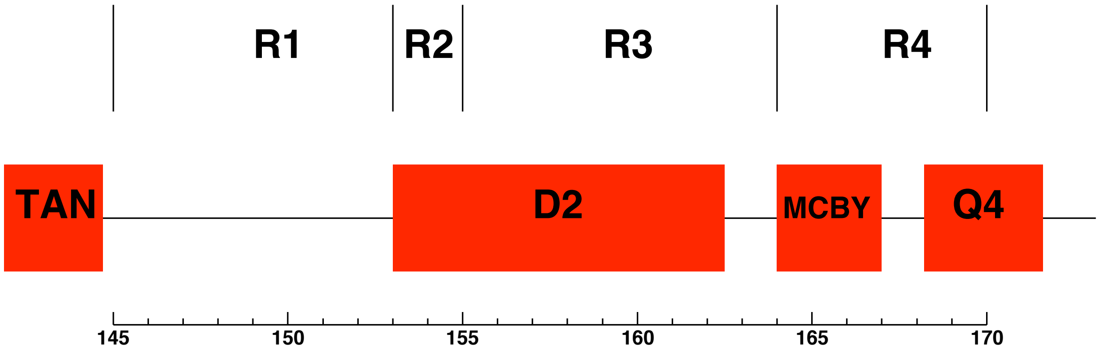
Cut of 100 MeV on particles

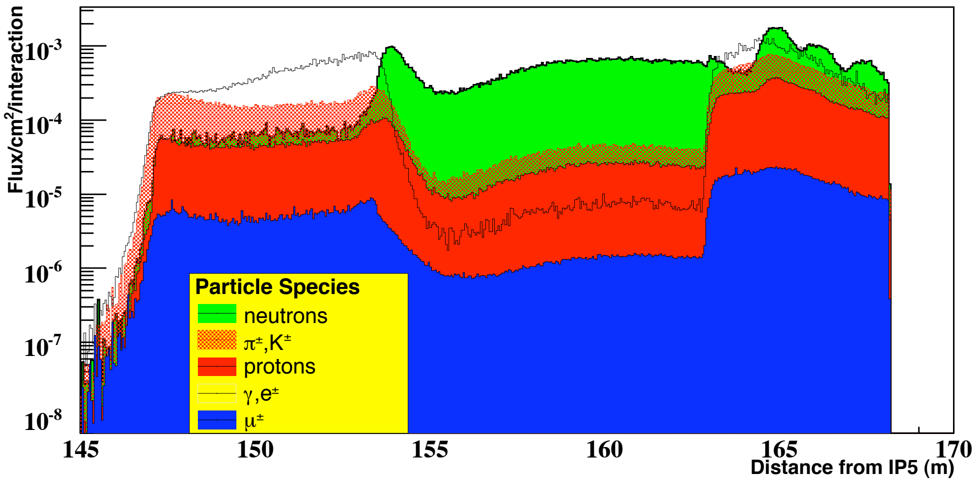
D2 core shields charged particles

Though neutron flux high, sensitivity lower - not large contribution to signal

Gamma flux high, but again sensitivity lower

Muon flux negligible

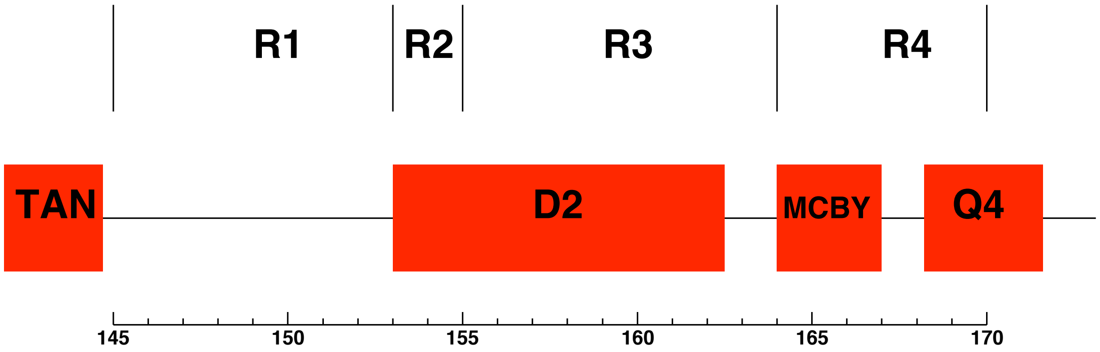




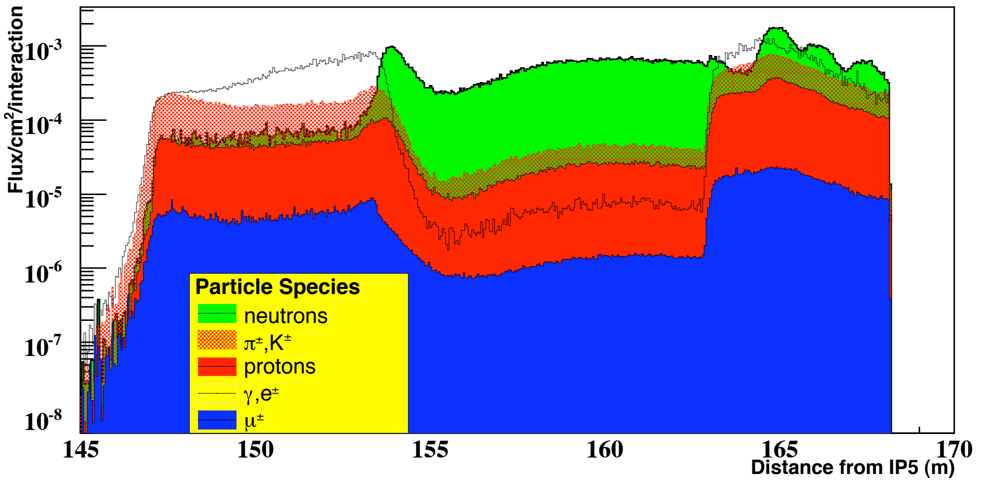
Shower Profile on beamline (150m station)

Distributions already show regions with differing behaviour

Divide into 4 regions of interest for further study:



R1: Up to start D2 cryostat (8 m)
R2: Start D2 cryostat (2 m)
R3: D2 (9 m)
R4: Correctors (6 m)



Multiplicities in each region (150m Station)

100 MeV cut - Realistic for particles exiting cryostat to be detected in BLMs

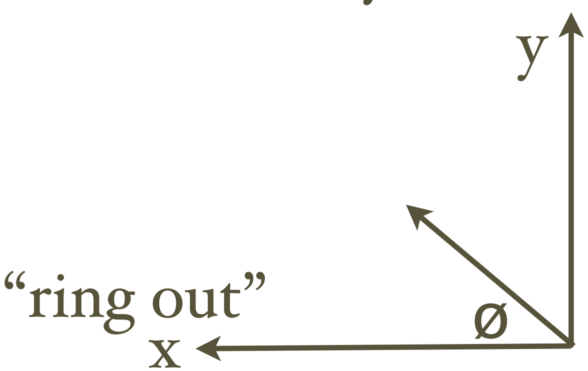
Indicative of flux that BLMs will see

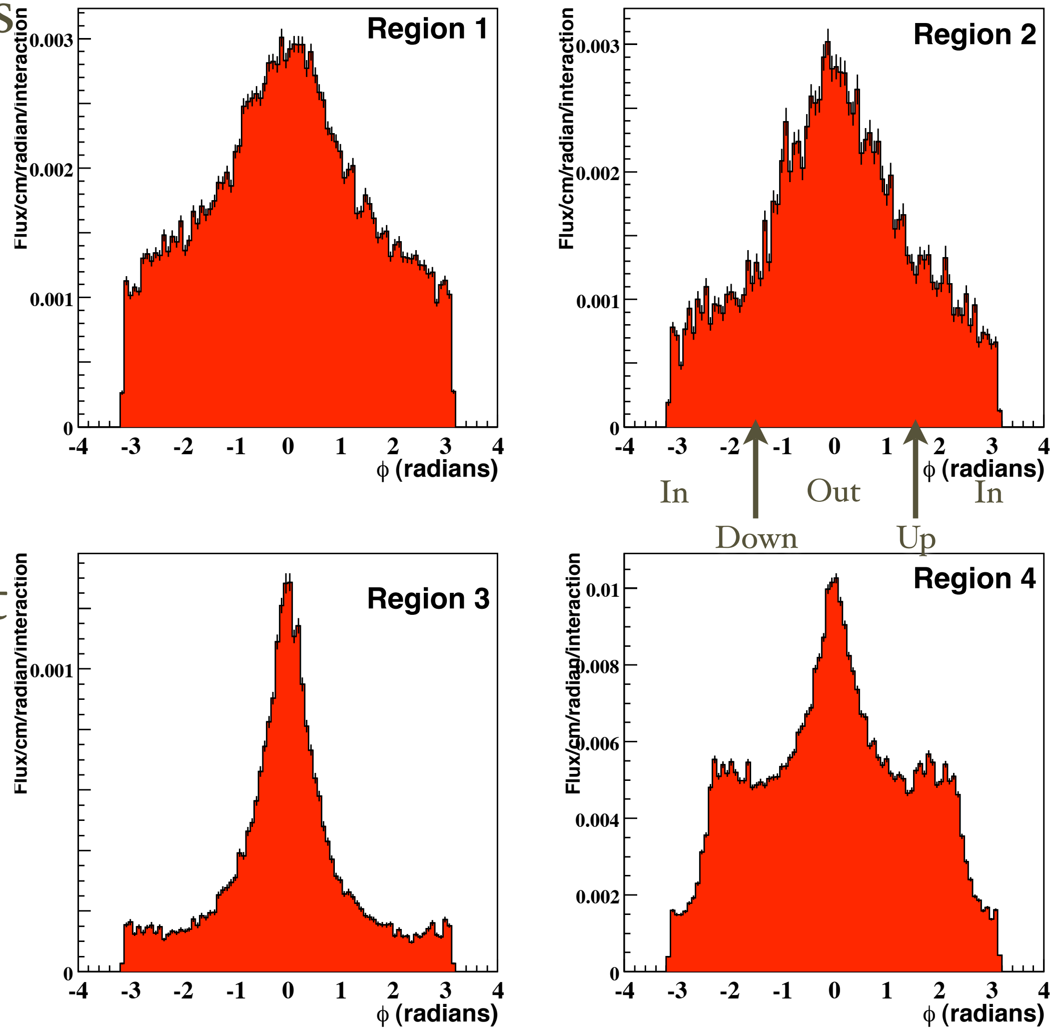
100 MeV Cut	R1	R2	R3	R4	Total
Pi,K	21.5	6.0	15.3	40.7	83.4
Gamma	50.3	12.3	15.4	55.4	133.3
Mu	0.7	0.2	0.6	1.4	2.8
Neutrons	7.8	20.7	97.4	75.6	201.5
Protons	5.9	2.6	7.7	19.3	35.5
Total:	86.1	41.7	136.3	192.4	456.5

Fluxes shown normalised per initial collision

Aximuthal Distributions (150m Station)

Angle at which particles leave cryostat

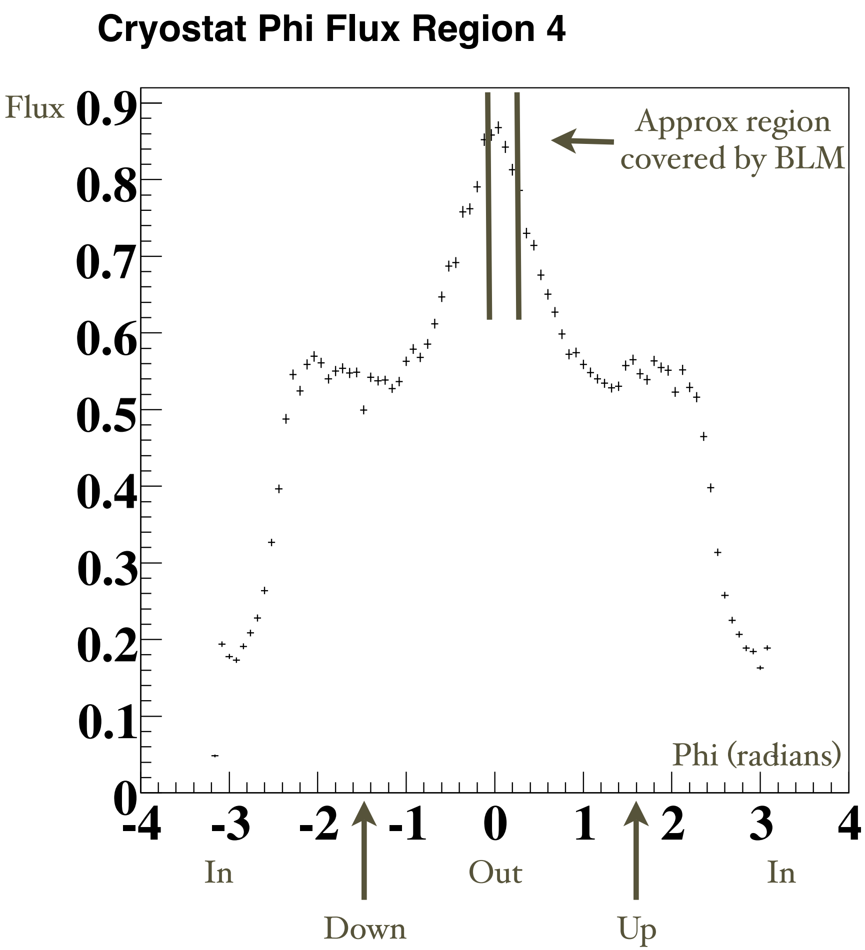


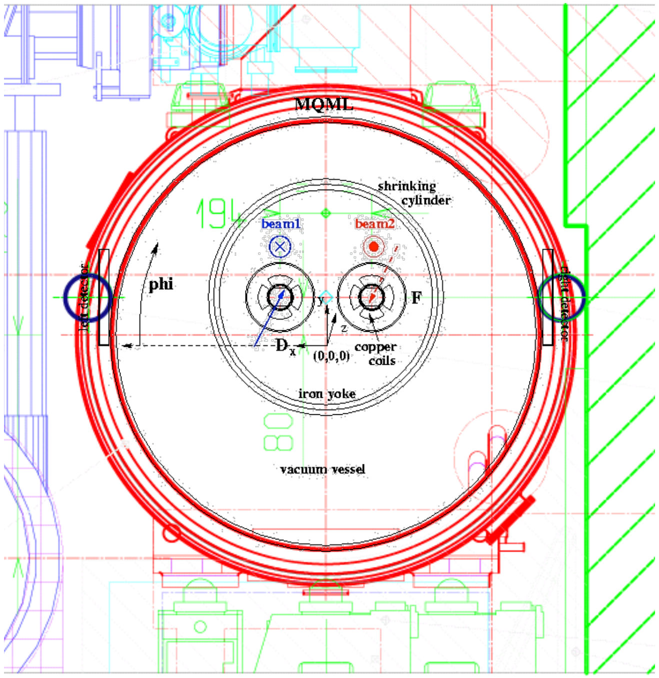


Signal predominantly at small positive phi

Only region 4 shows different behaviour

Phi Location of Machine BLMs





Similar to findings for machine BLMs

About 3-4% of angle covered by BLM

R2: 11% of flux
R4: 8% of flux

BLMs for RP losses should be at same angle on cryostat

Shower Profile on beamline (220m station)

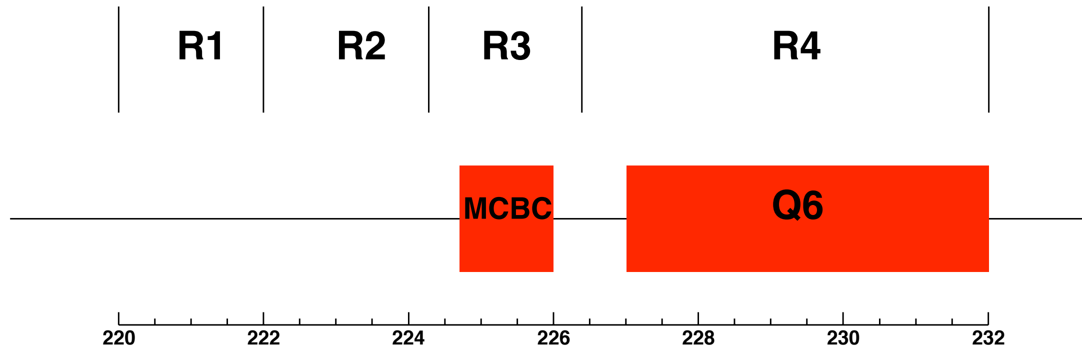
Cut of 100 MeV on particles

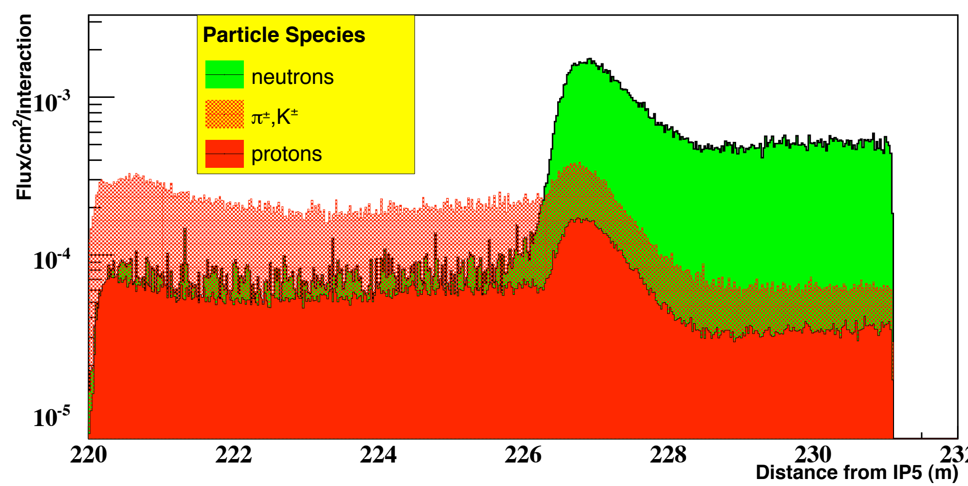
Q6 core shields charged particles

Though neutron flux high, sensitivity lower - not large contribution to signal

Large flux along bare beampipe

Large flux in corrector region

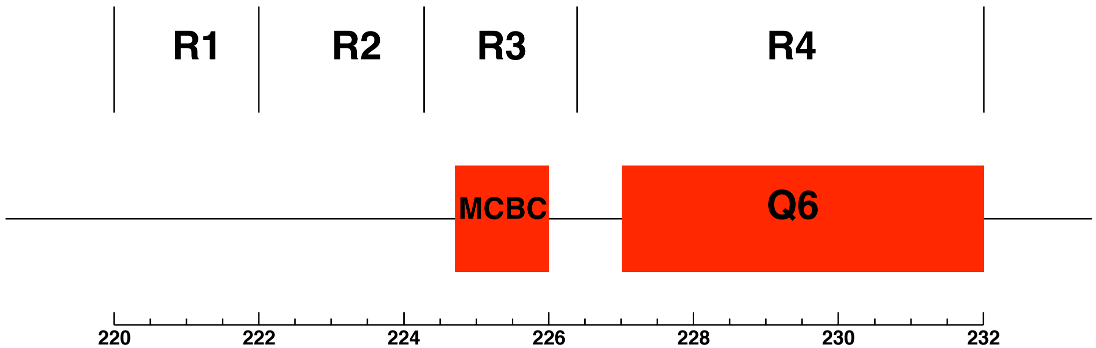


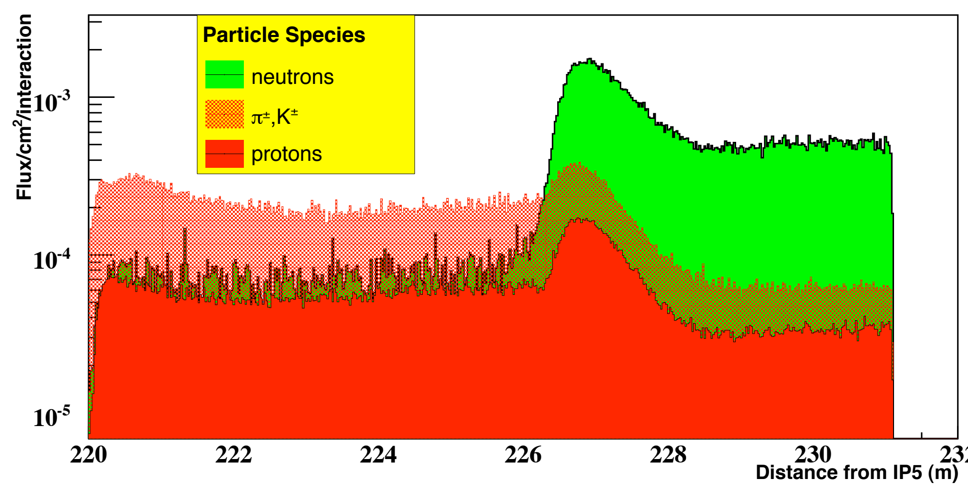


Shower Profile on beamline (220m station)

Distributions already show regions with differing behaviour

Divide into 4 regions of interest for further study:





R1: Immediately after interaction (2 m)
R2:Bare beampipe (2,3 m)
R3: Correctors (2.1 m)
R4: Q6 Core (4.8 m)

Multiplicities in each region (220m Station)

100 MeV cut - Realistic for particles exiting cryostat to be detected in BLMs

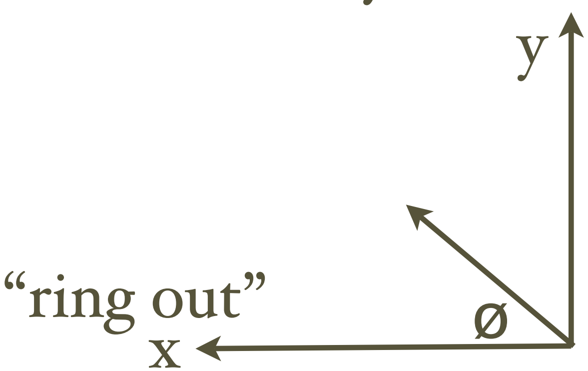
Indicative of flux seen by BLMs

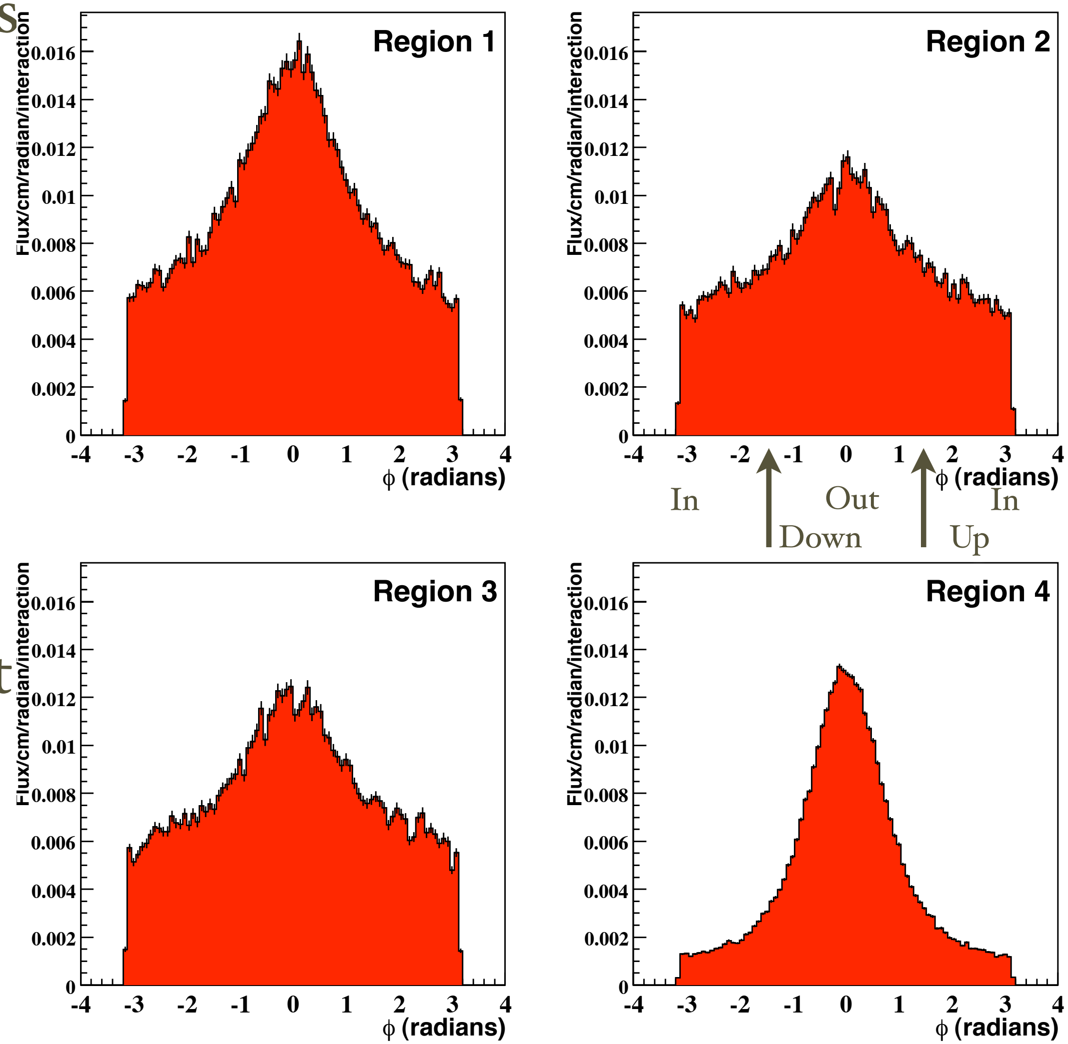
100 MeV Cut	R1	R2	R3	R4	Total
Pi,K	9.79	8.35	8.42	11.31	37.87
Neutrons	2.62	3.11	4.14	65.86	75.73
Protons	2.18	2.33	2.48	5.42	12.41
Total:	14.59	13.79	15.04	82.59	126.01

Fluxes shown normalised per initial collision

Aximuthal Distributions (220m Station)

Angle at which particles leave cryostat





Signal predominantly at small positive phi

Locations to Install BLMs given by Simulation

- 150m Station:
  - beginning of D2 cryostat, before D2 coils (s=153m)
  - Near the correctors on the D2-Q4 cryostat (s=164m)
- 220m Station:
  - As close as possible to last detector plane (s=221m)
  - Just before or at the start of Q6 magnetic length (s=226.5m)
- Phi - location ring out, just above horizontal preferred
  - As found for BLMs to protect against other loss types

Locations to Install BLMs: Note Available Soon

Preliminary draft 17:22 August 25, 2006

21 August 2006

Richard.Hall-Wilton@cern.ch

Recommended Locations of Beam Loss Monitors for the TOTEM Roman Pots

R.J.Hall-Wilton TS/LEA, D.Macina TS/LEA, V.Talanov TS/LEA,

Keywords: long straight sections, TOTEM, BLM, Monte-Carlo simulations

Summary

This note presents results from simulations of losses on the TOTEM Roman Pot stations located close to 150m and 220m from IP5. These results are used to evaluate suitable locations to position beam loss monitors to monitor these losses, and help to avoid quenches of the superconducting magnets downstream of the roman pots. The results presented in this note indicate the locations where the BLMs should be installed. A more detailed note on the topic will follow later.

Summary and Future Plans

- Aim of BLMs for TOTEM RPs:
  - Safety: Magnet quench protection and RP protection
  - Information and diagnostics on effect of RPs on machine
- Possible favourable locations have been identified
  - Integration to confirm there is room to install a BLM in these locations
- Plans:
  - Extend study beyond to Q4 and bare beampipe after
  - Beam halo shape needed to normalise results to "real" signal levels
  - What is the sensitivity to background from RPs compared to pp or p-beamgas? (compatibility of studies for simple comparison?)
  - How does BLM response to losses on roman pots relate to energy deposition and quench levels in magnets?