TERTIARY COLLIMATORS IN LHC IP1/IP5

Nikolai Mokhov

LARP Collaboration Meeting

Port Jefferson, NY

April 6-8, 2005

OUTLINE

- Introduction
- MARS15 TCT and Beam Loss Models
- TCT-TAN Region
- Energy Deposition in Inner Triplet
- Backgrounds at CMS/ATLAS

INTRODUCTION

Particle leak from secondary collimators and beam-gas scattering upstream of the LHC interaction points would create a “tertiary halo”. Possible errors and inefficiency of the IP6 machine protection system at an unsynchronized beam abort (TCDQ etc) would result in a misbehaved beam. In both cases, corresponding beam losses would take place in the inner triplets. It is proposed to put tertiary collimators (TCT’s) around the interaction points in order to protect the superconducting triplets and collider detectors against these beam losses.

LHC apertures in beam σ: primary collimators - 6, secondary collimators - 7, inner triplet - 8.4, arcs $\geq$ 30. Triplets potentially absorb tertiary beam halo from 8.4σ to 30σ.

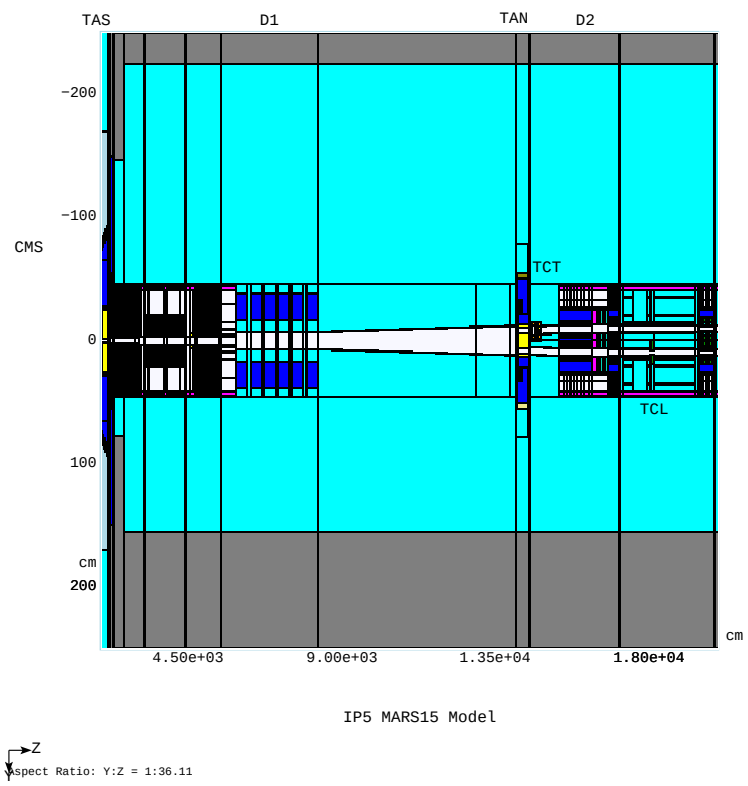
Let tertiary collimators do this job!

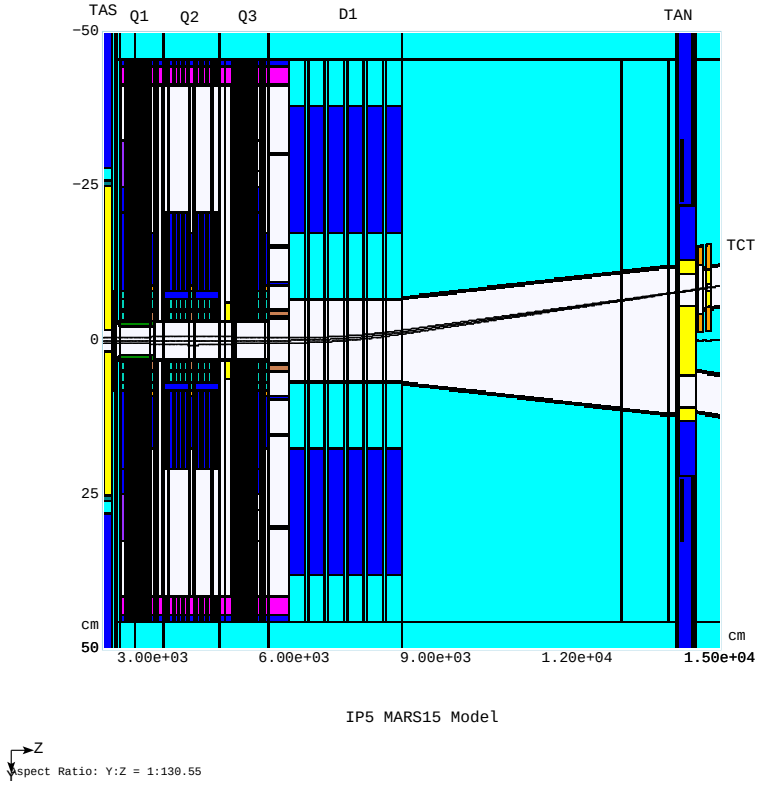
Tevatron experience: tertiary collimators are absolutely essential!

TERTIARY COLLIMATOR CONSTRAINTS

1. Minimal phase advance between the TCTs and the inner triplets, in order to produce an optimal shadow.
2. Place horizontal TCT's at a location of sufficient beam-beam separation, such that two opposite jaws can be placed for the incoming beam.
3. Put TCT's farther away from IP1/IP5, such that showers originating from the TCT's are for diluted at the collider detectors.
4. Accumulated and residual doses at the TCT's do not create extra problems in that region at normal operational conditions.
5. Accept that the TCT's can be destroyed at the full beam loss.
6. TCT-induced peak energy deposition in the triplets below the quench limit (1.6 mW/g) with a safety margin of 3.
7. TCT-induced backgrounds in the collider detectors to not exceed the accelerator-related ones.

IP5 MARS15 MODEL

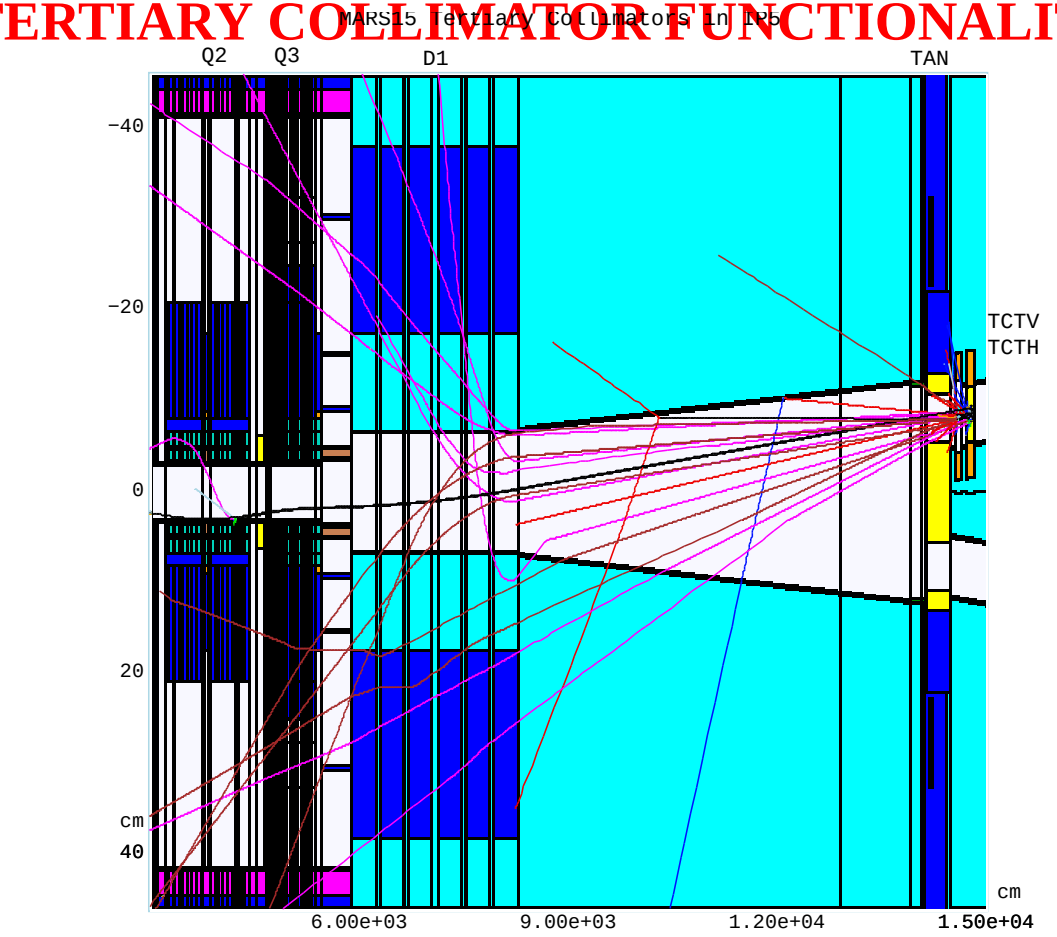




TERTIARY COLLIMATORS IN MARS15 MODEL

- TCT's are added to the MARS15 IP1/IP5 model ranging $\pm$ 215 m from IP, in front of the D2 separation dipole.
- No TCLP collimator at 149.23 m (reserved for later stage).
- One-meter long jaw straight sections start at 145.34 m (TCTV) and 147.34 m (TCTH) from IP, tank length 1.48 m.
- Copper jaws, 8-cm wide and 2.5-cm thick, opened to 8.4σ: $\pm$ 0.78 cm (TCTV) and $\pm$ 0.54 cm (TCTH).
- Operational tertiary beam halo outside 8.4σ is $1/r$.
- Operational beam loss rate on TCTH/TCTV couple at 7 TeV is 10^6 p/s (justified later).

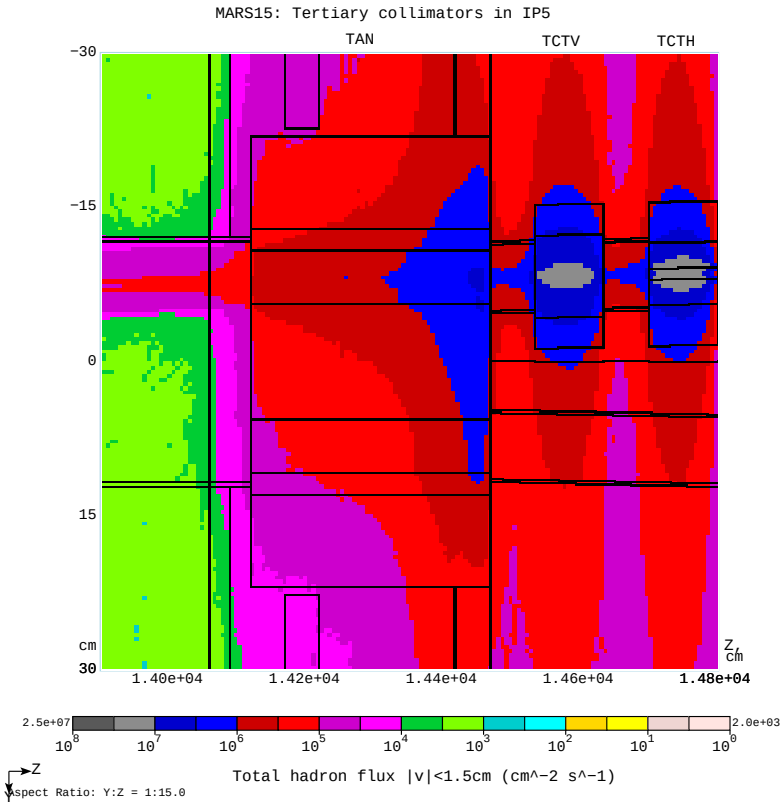
TERTIARY COLLIMATOR FUNCTIONALITY

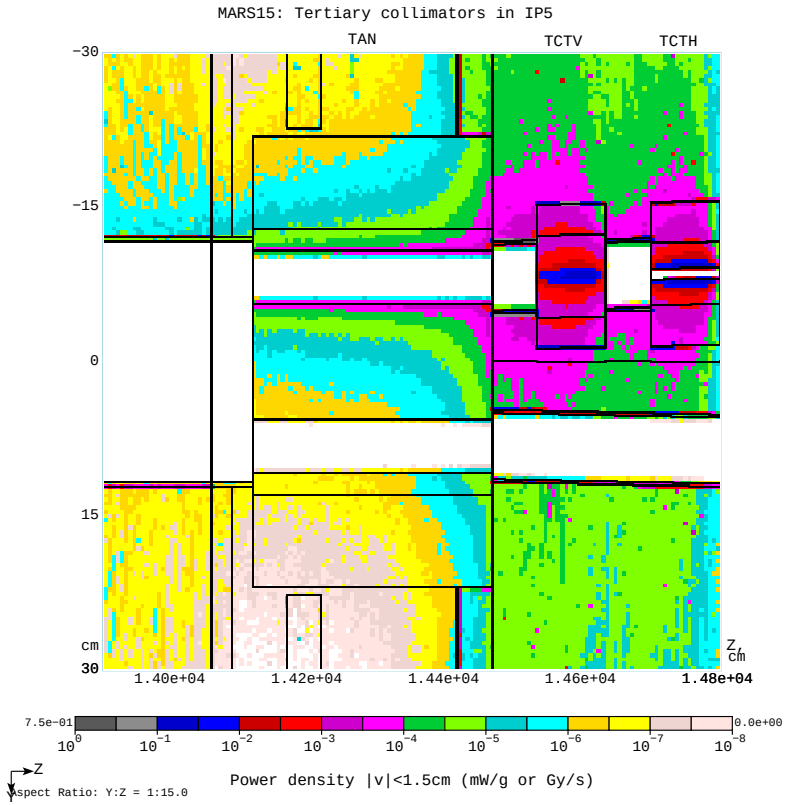


Particle tracks E>10 GeV for a few 7−TeV protons on TCTs

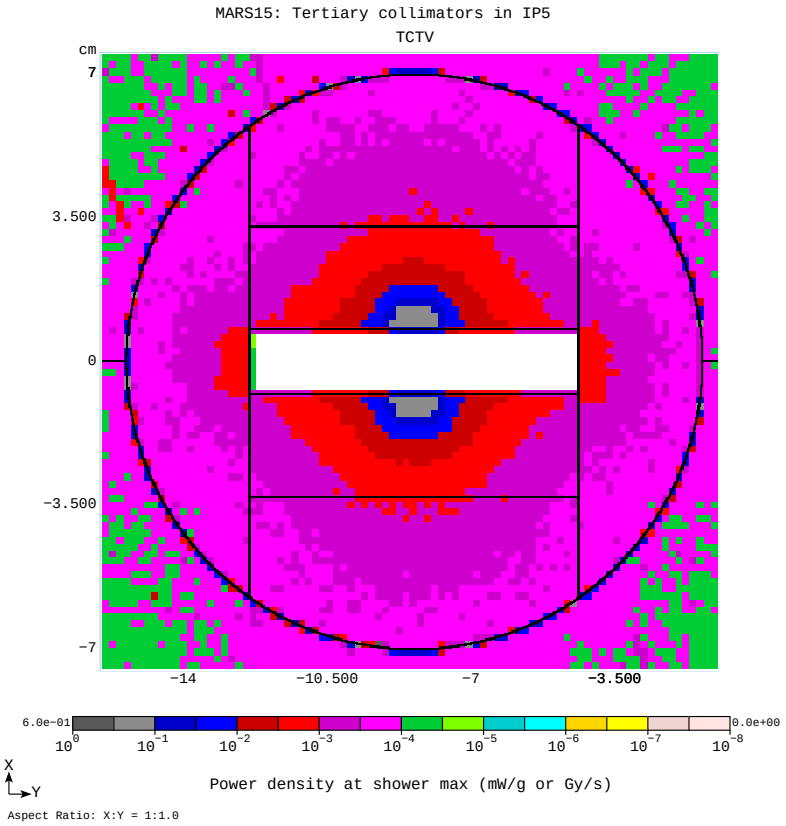
Z
Y
Aspect Ratio: Y:Z = 1:130.434

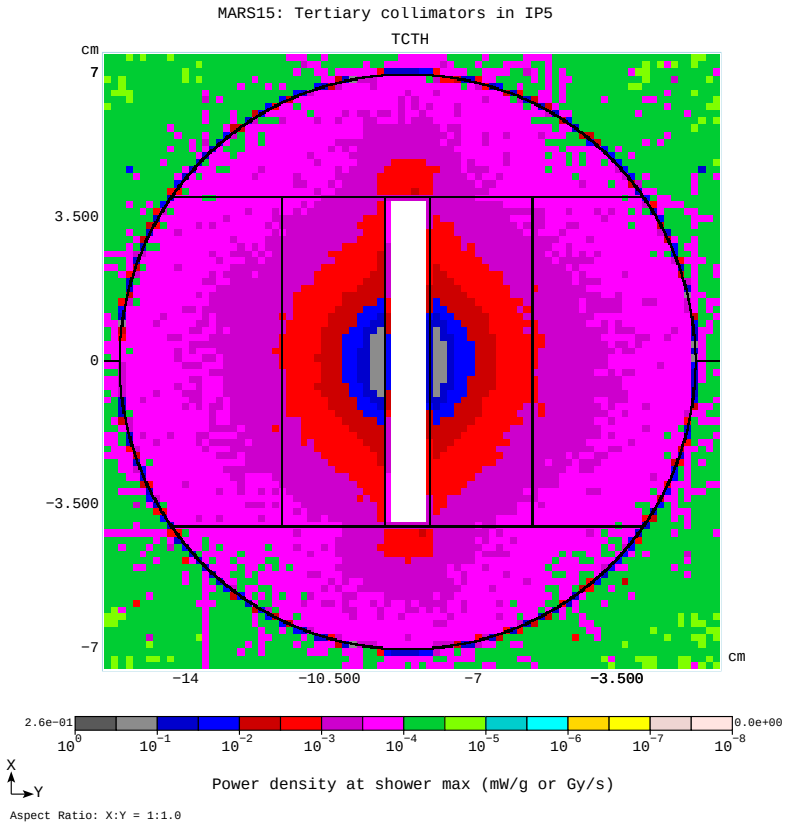
HADRON FLUX AND POWER DENSITY IN TCT-TAN REGION



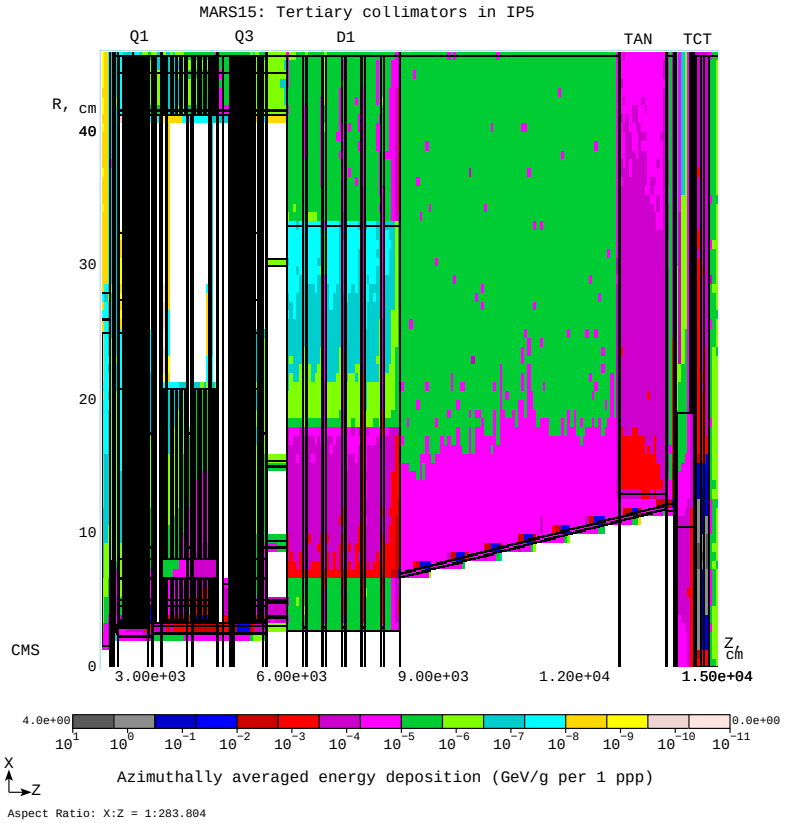


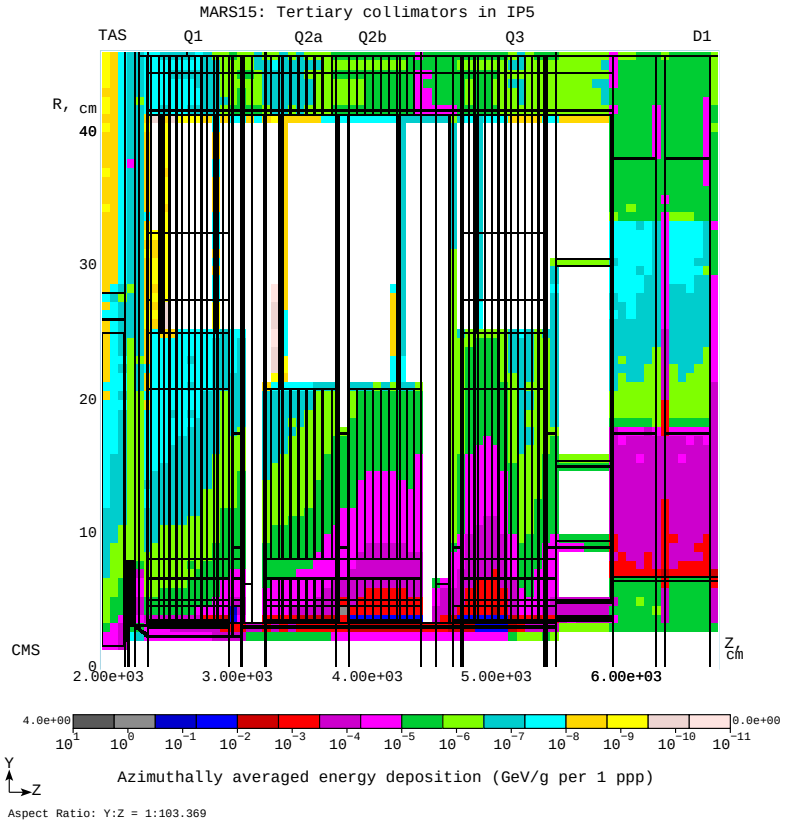
POWER DENSITY IN TCTV AND TCTH



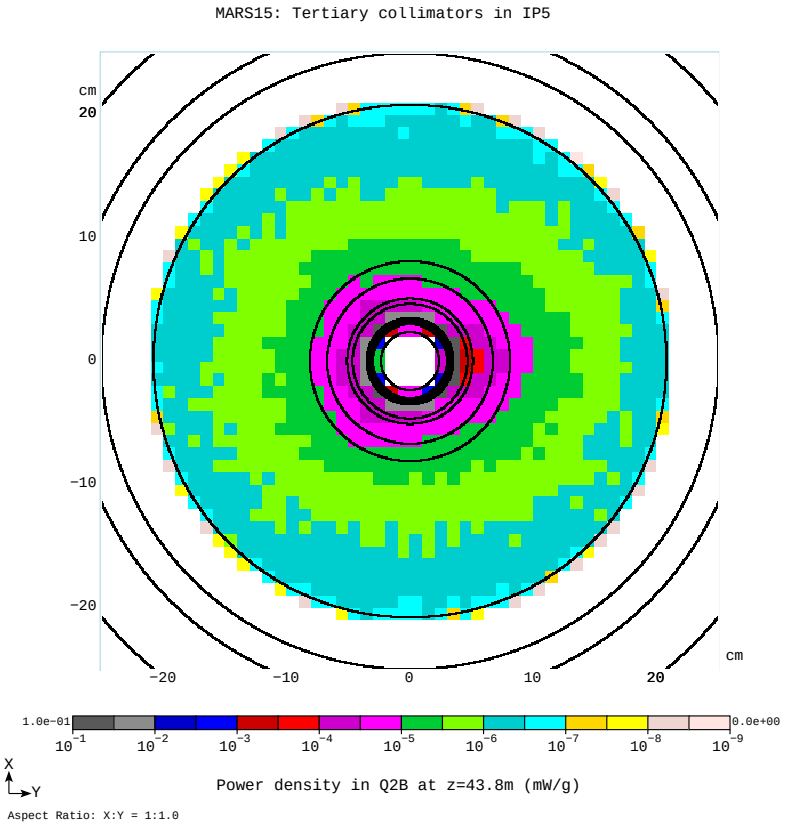


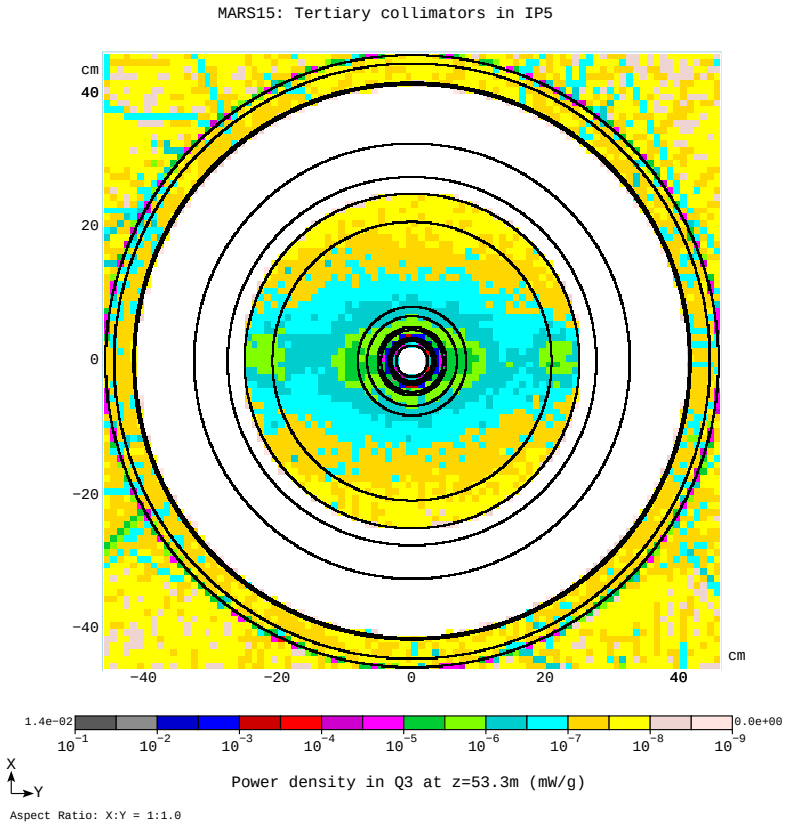
TCT-INDUCED ENERGY DEPOSITION IN IP5 (RZ)





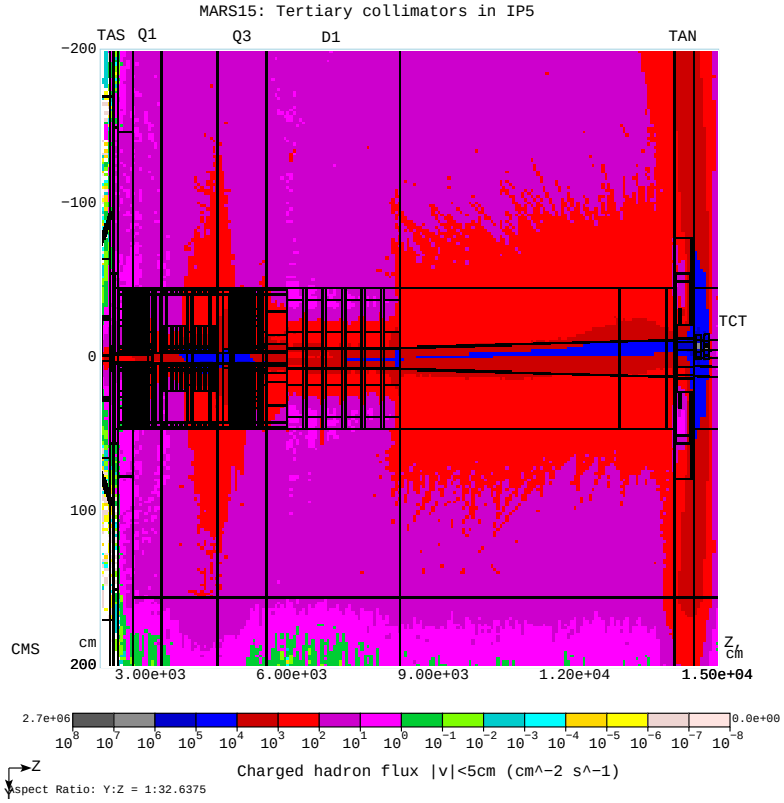
POWER DENSITY IN TRIPLET QUADS

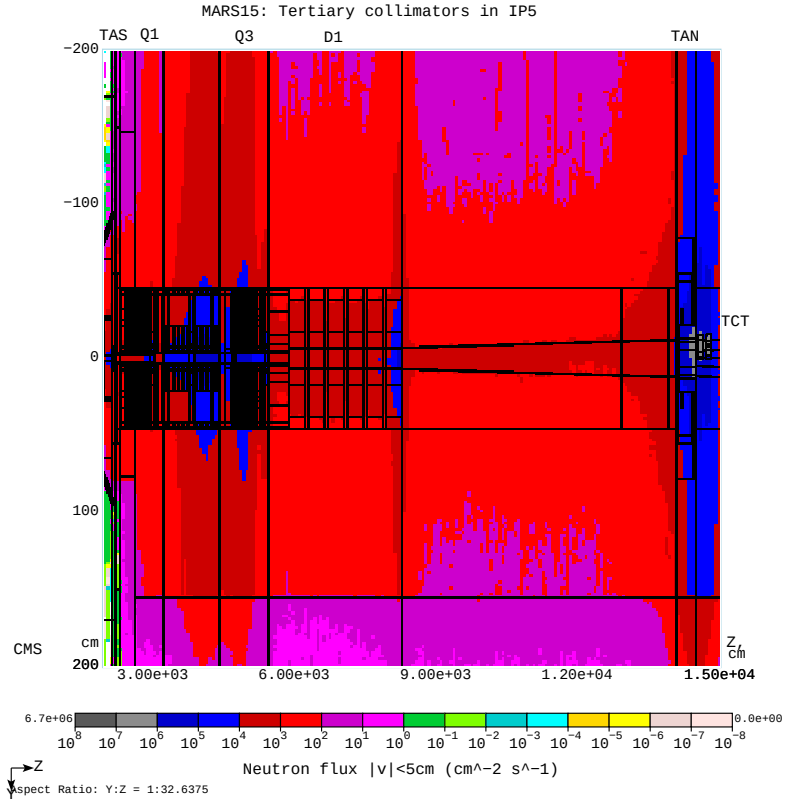




Peak power density of 0.35 mW/g occurs in the Q3 superconducting coils at z = 50 m (β_{max}). Therefore, the maximum "scraping rate" on the TCTV/TCTH couple is about 2×10^6 p/s.

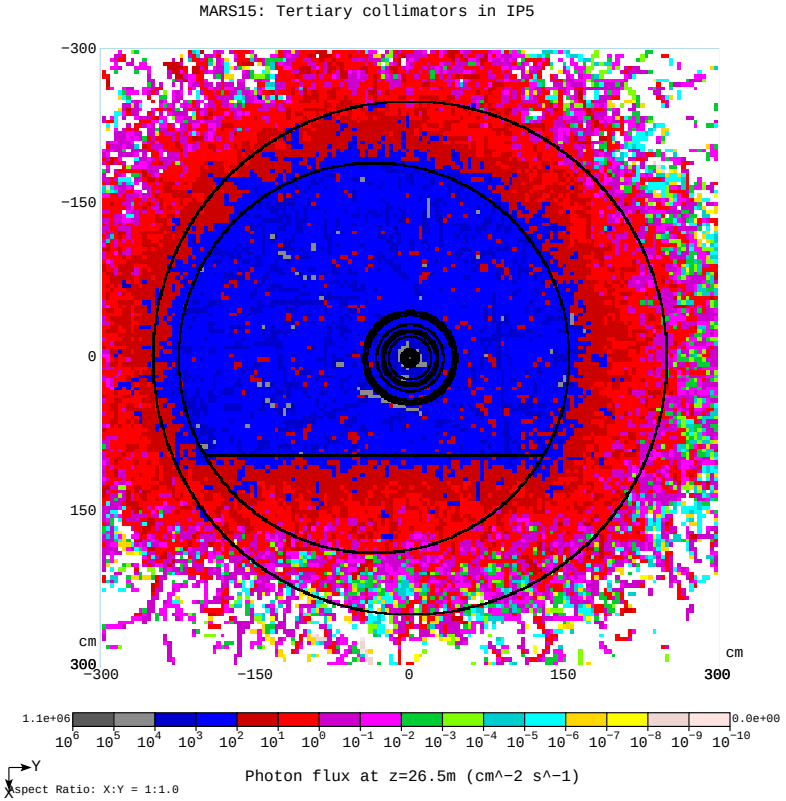
TCT-INDUCED PARTICLE FLUXES IN IP5

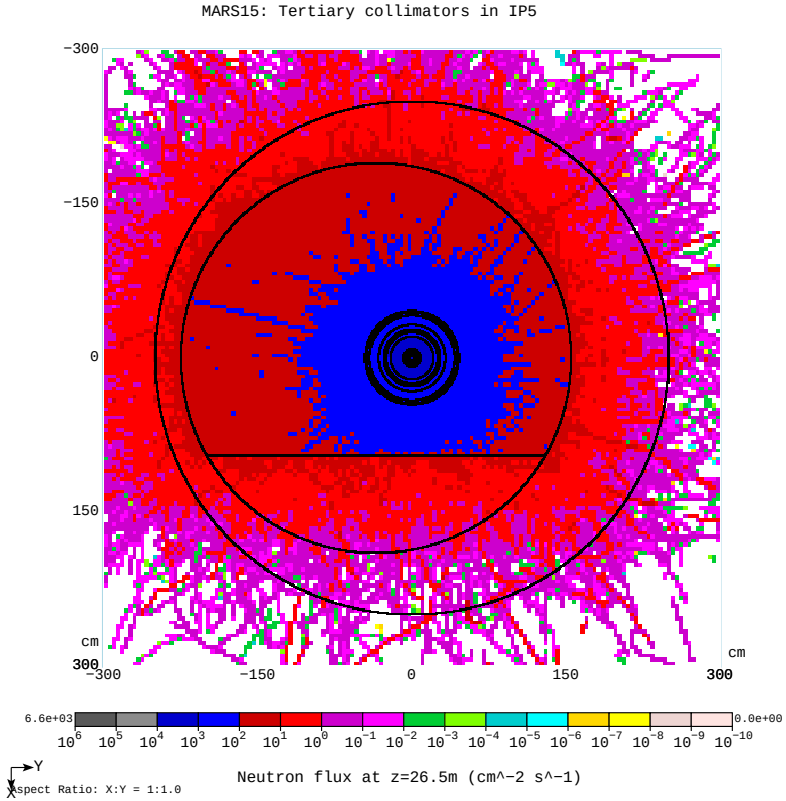




Plan view in a slice ±5 cm thick (vertically).

TCT-INDUCED PHOTON AND NEUTRON FLUXES ENTERING EXPERIMENT (z=26.5 m)





Rather similar to “accelerator-related” backgrounds. Therefore, keep TCT scraping rates $\leq 2\times10^{6}$ p/s.

SUMMARY

- Tertiary collimators have been implemented into MARS15 IP1/IP5 model.
- Modeling shows that two 1-m long two-jaw copper TCT's perform their job appropriately.
- There is no outstanding problems with TCT's themselves.
- Maximum scraping rate on the TCT set should not exceed 2×10^6 p/s, both from peak power density in the triplet and detector background standpoints.
- More work to do with operational tertiary beam halo and miskicked beam (both for triplet and detector), and engineering constraints.