Chicane shielding and energy deposition (IPAC'13 follow-up)

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IDS-NF phone meeting

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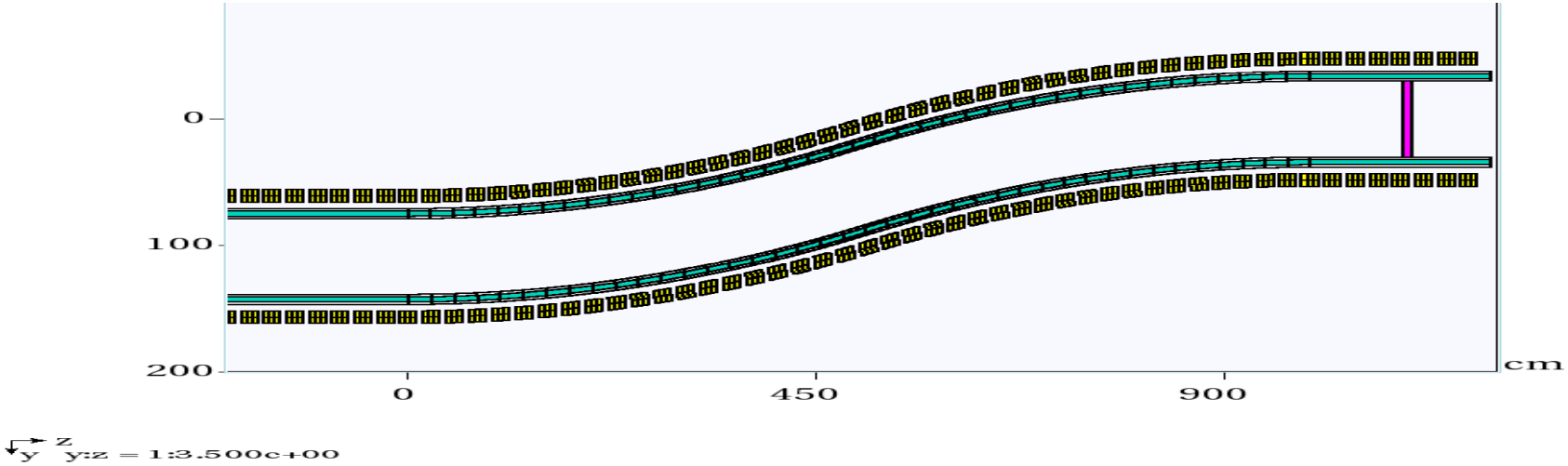
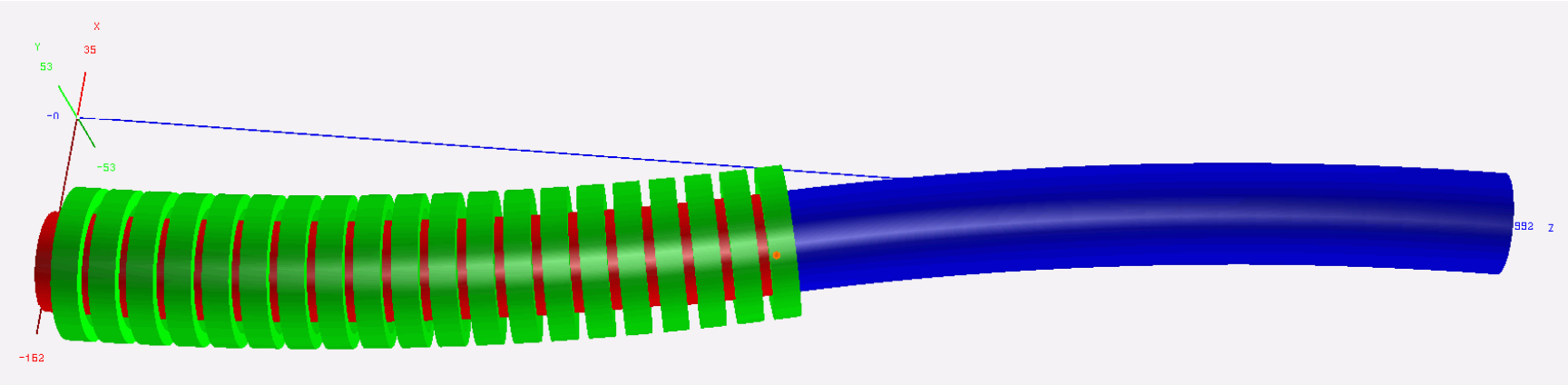
Updates to the chicane



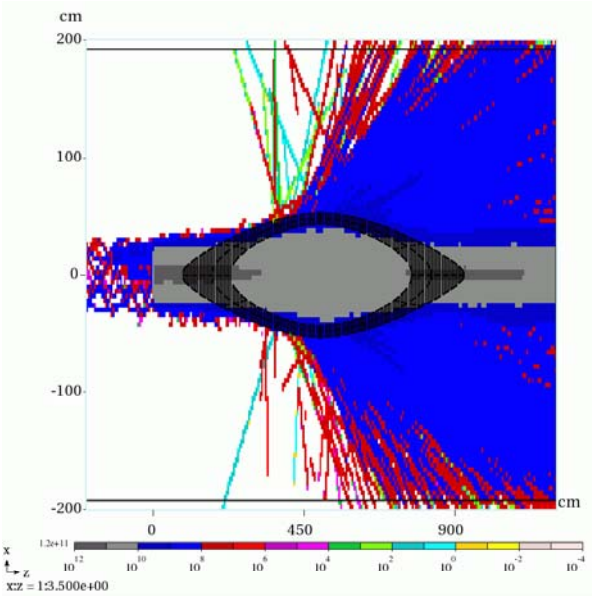
- Yellow: coils, subdivided into smaller segments (3 longitudinal, 2 radial, 12 azimuthal) for more precise energy deposition study. Radius = 43-53 cm, length of 18 cm, on-axis field 1.5 T throughout the channel.
- Cyan: W shielding (pure W, need to change the density to 60%), 4 cm thickness @ 32-36 cm radii.
- Gray around cyan: inner and outer SS pipe, 2 cm thick each @ 30-32 & 36-38 cm radii to enclose W, yet stay 5 cm clear of the coils.
- Magenta: proton absorber, 10 cm of Be, outer radius = 30 cm.
- Z=0 corresponds to 30 m downstream of the target.

ROOT-based geometry

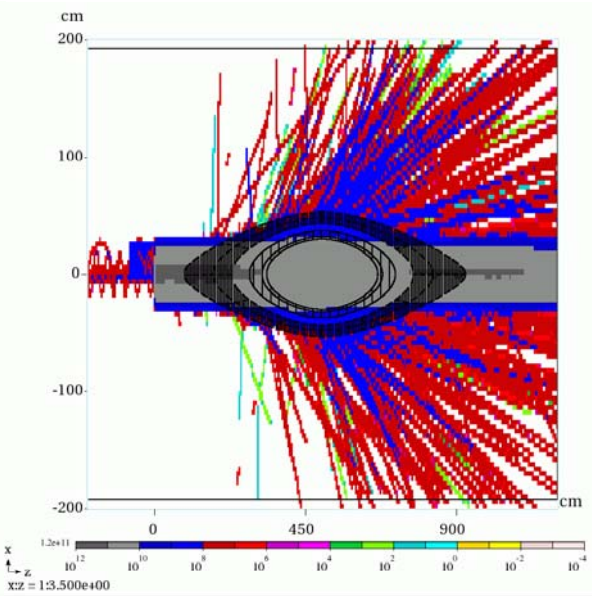


- For irradiation study the chicane is simulated in MARS15. Field maps for MARS simulations are generated by G4beamline.
- Complicated geometry of the chicane, => adding shielding is not possible using only MARS extended geometry.
- ROOT-based geometry framework for MARS is used with a wide variety of basic volumes provided by the ROOT TGeo module.
- The volume of each shielding or coil segment can be calculated precisely in ROOT; removes the uncertainty intrinsic to MARS Monte-Carlo based volume calculation.
- Easy to visualize your geometry for debugging (3D visual above is produced by ROOT).
- Geometry is straightforward to read/comprehend/modify as needed
- Most important for seamless shielding is the TGeoCtub elementary volume (cut tubes with arbitrary entrance/exit angles).

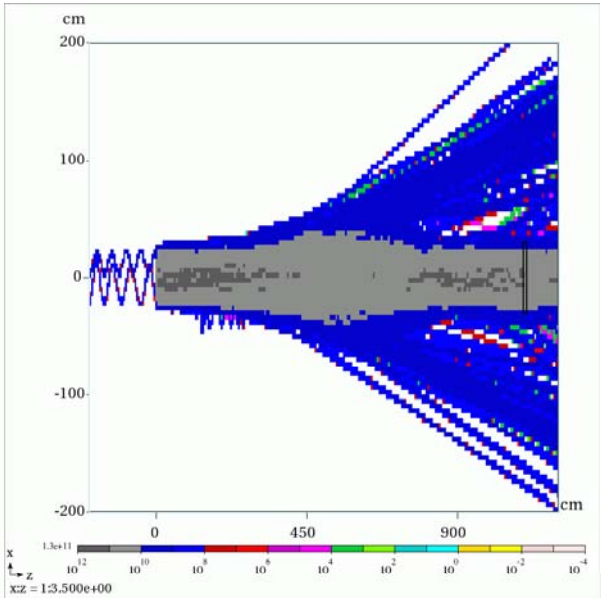
(Vertical) beam size considerations



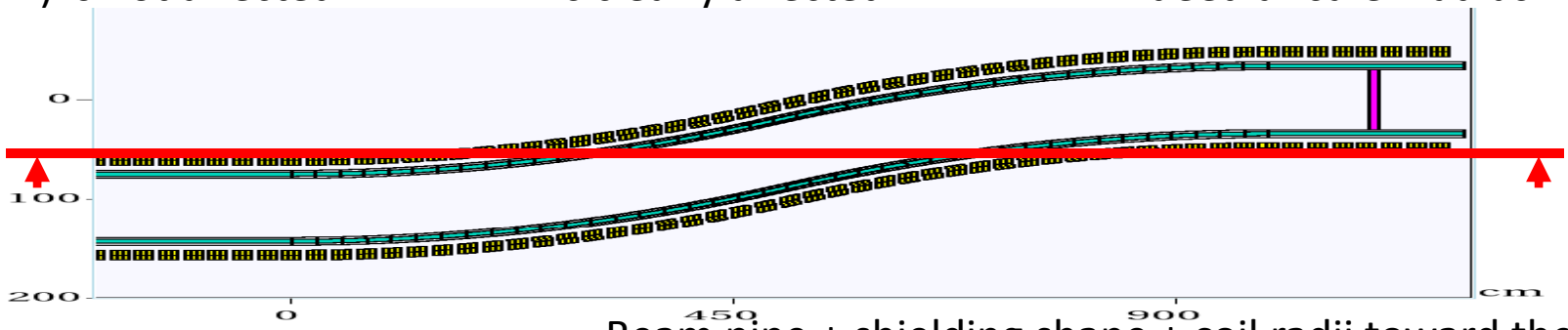
No shielding, coil inner R = 43 cm, muon flux (main) is not affected

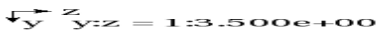


With shielding starting at R = 30 cm, muon flux is clearly affected



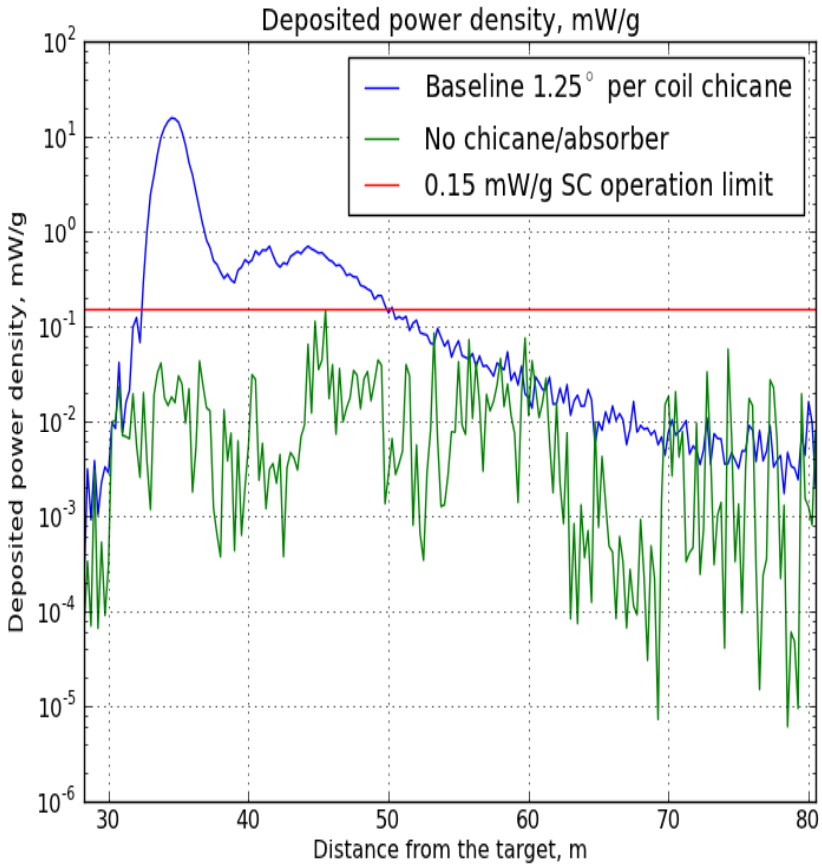
No coils, smaller statistics, test that R = 43 cm is indeed a “safe” radius





Beam pipe + shielding shape + coil radii toward the center of the chicane need further modifications.

Reference case: no shielding



- Average deposited power density (DPD) per coil is shown
- The limit of 0.15 mW/g is exceeded in a number of coils; however, it could be reduced to within the limits by providing extra shielding in about half of the coils.
- DPD peaks at 15.8 mW/g, that translates into 42.6 kW/m for Cu coils or 33.3 kW/m for SC coils.
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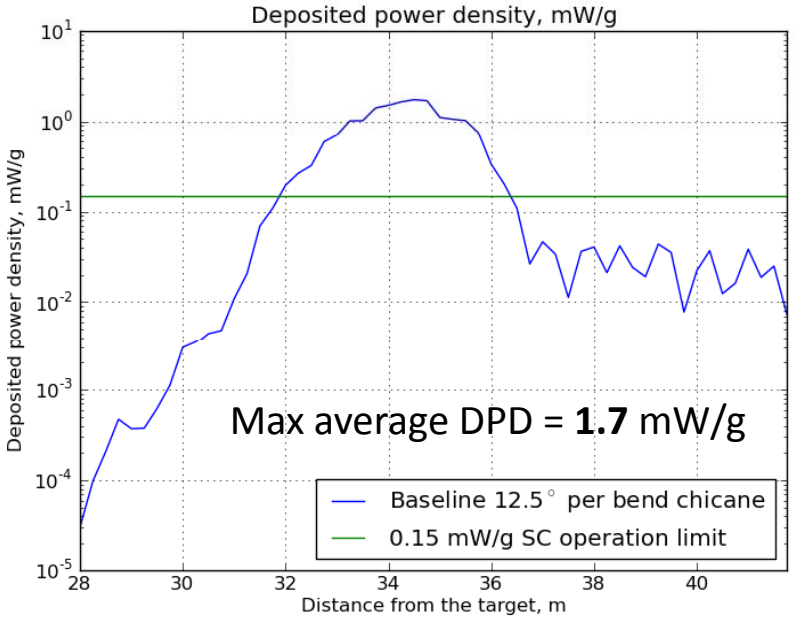
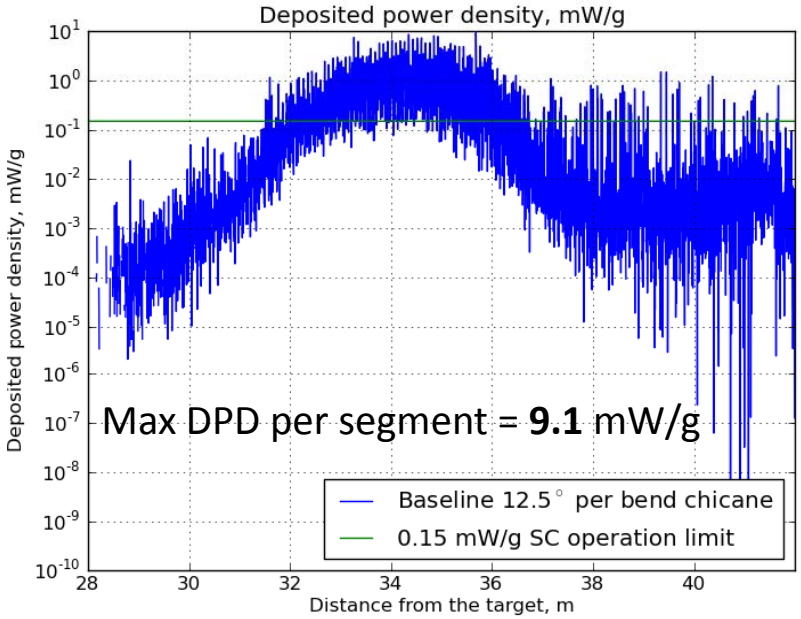
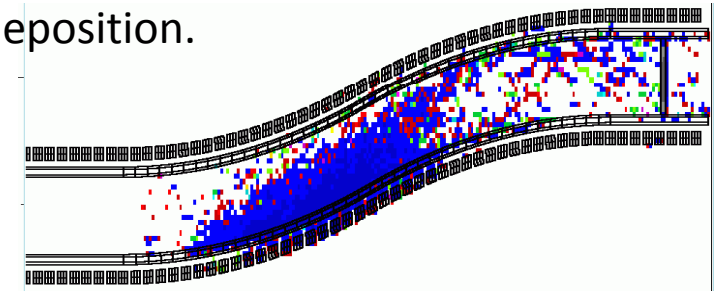
First attempt @ shielding, 4 cm of W





- Average deposited power density in the coils is at maximum 1.7 mW/g.
- On average: the limit of 0.15 mW/g is exceeded in a smaller number of coils, only those between 32 and 36 m downstream of the target.
- Need to change W density to 60%.

- At the same time, certain coil segments can get up to 9.1 mW/g (3 longitudinal, 2 radial, 12 azimuthal segments per coil) due to the non-uniformity of energy deposition.



Summary

- ROOT-based geometry allows to simulate the complex shape of the chicane + shielding.
- Current simulations are based on pure W, should be redone with 60% density (which increases the amount of material considerably, hence, the radius of the coils as well).
- Coil and shielding shape need modifications compatible with the beam width at the center of the chicane.
- Average DPD with 4 cm of W drops almost an order in magnitude: 15.8 => 1.7 mW/g, although still an order of magnitude larger than the required 0.15 mW/g (even worse if a conservative limit of 0.1 mW/g is used as suggested by Kirk McDonald).
- As expected, segmentation of the coils reveals that energy deposition is not uniform, max = 9.1 mW/g.
- I would like to continue energy deposition studies, but I will need some help from the Targetry group with their expertise.