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Building and Testing MARS PIP2 Model

Igor Tropin, Target Systems Department Topical Meeting

Outline

- Goal and method
- Tools
- Implementation of the MARS application
- Preliminary results
- Conclusion

Goal and Method, Tools

Goal : Produce data (multiple calculations) for shielding assessment for PIP-II Linac and Booster Transfer Line (BTL)

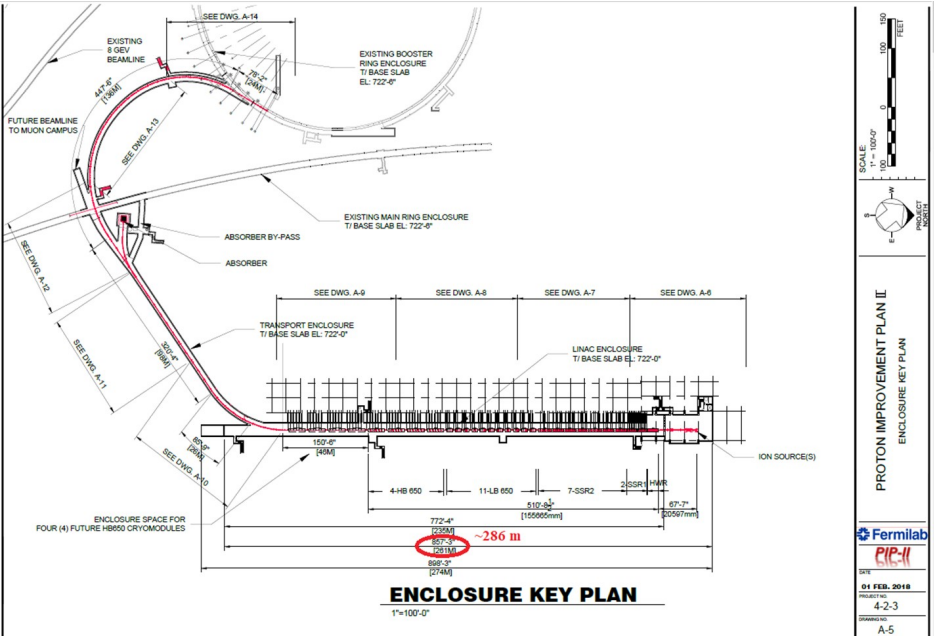
Method : MC simulation by means of the MARS15 code system.

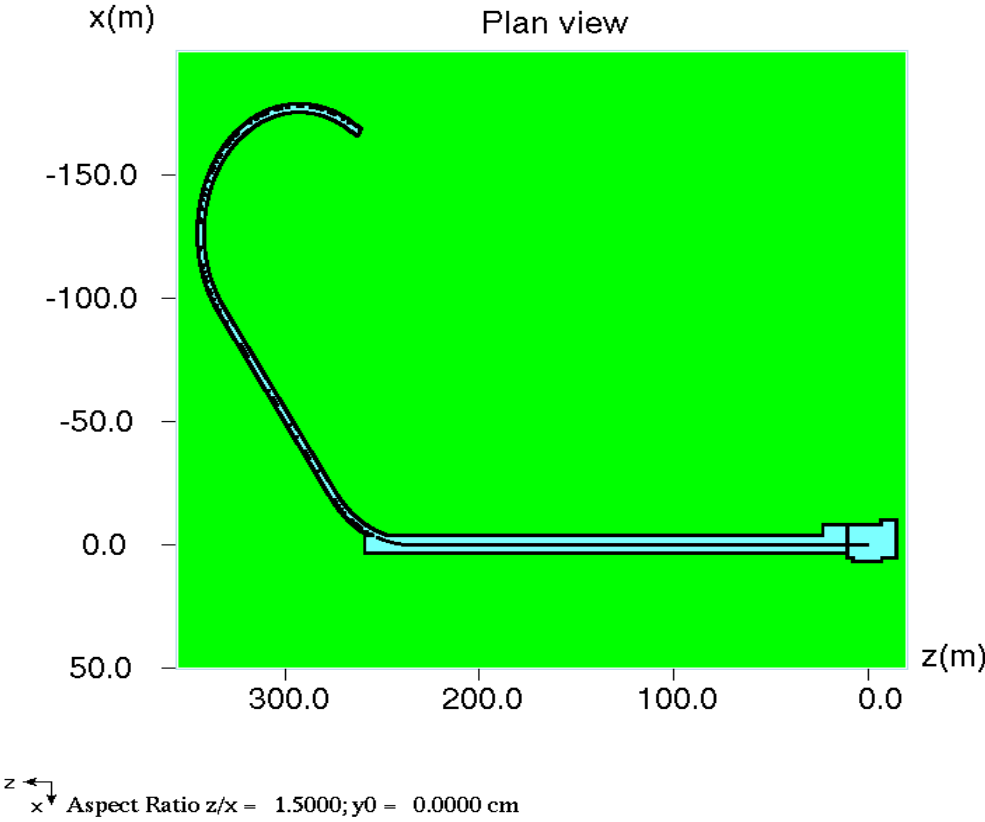
Task : Build and test the MARS application:

1. Gather and adapt input data for application from civil and mechanical engineers, accelerator physicists.
2. Define source, geometry, and estimators
3. Debug and test application code.

Tools : MARS15(2020), BOOST v.1.72.0, MAD-X v5.05.2, ROOT v.6.18.04

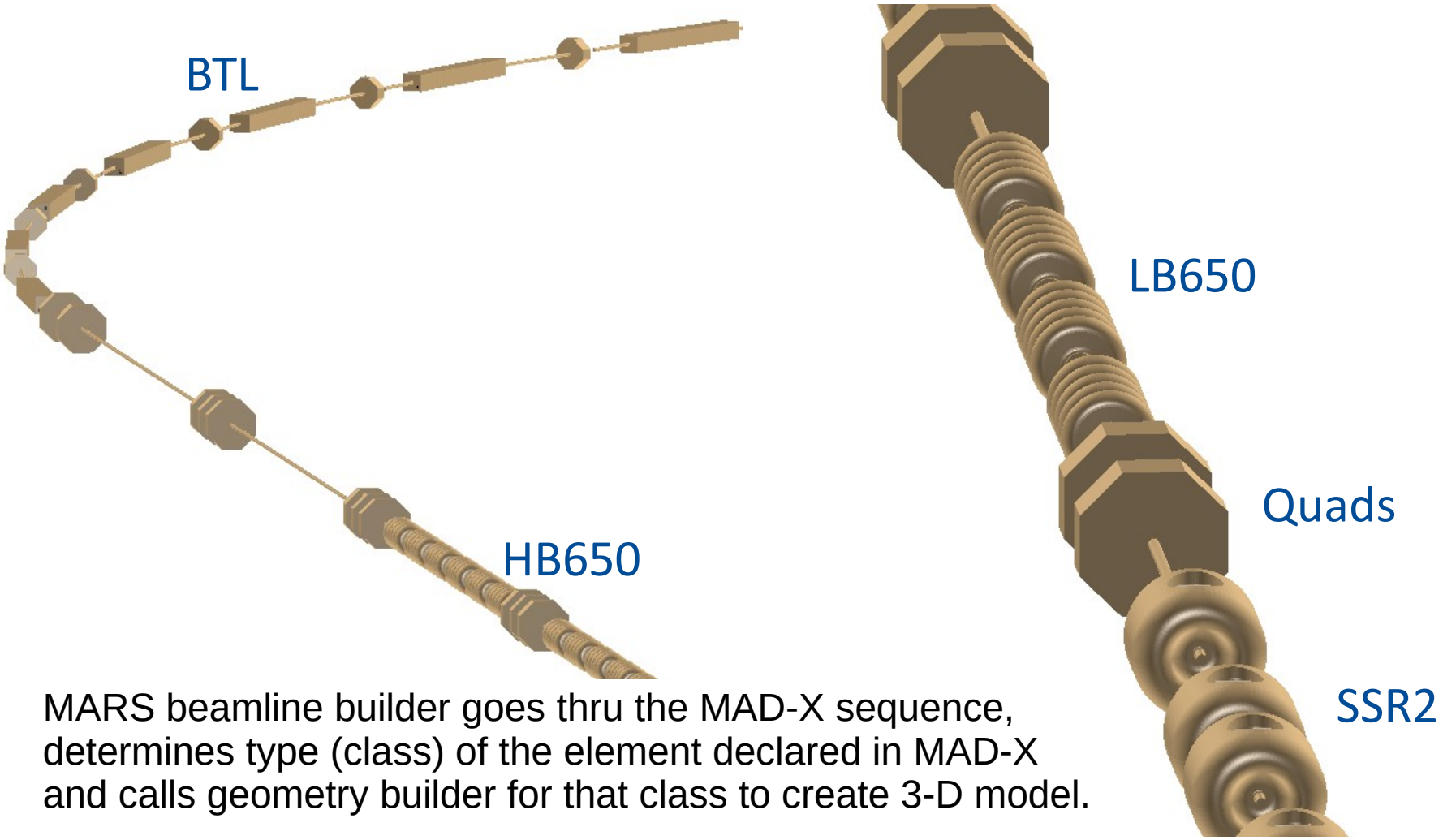
Geometry Model: General View





MAD-X survey table is used for positioning geometry elements in the MARS model.
BTL MAD-8 optics was provided by Meiqin Xiao, Linac optics – Arun Saini.

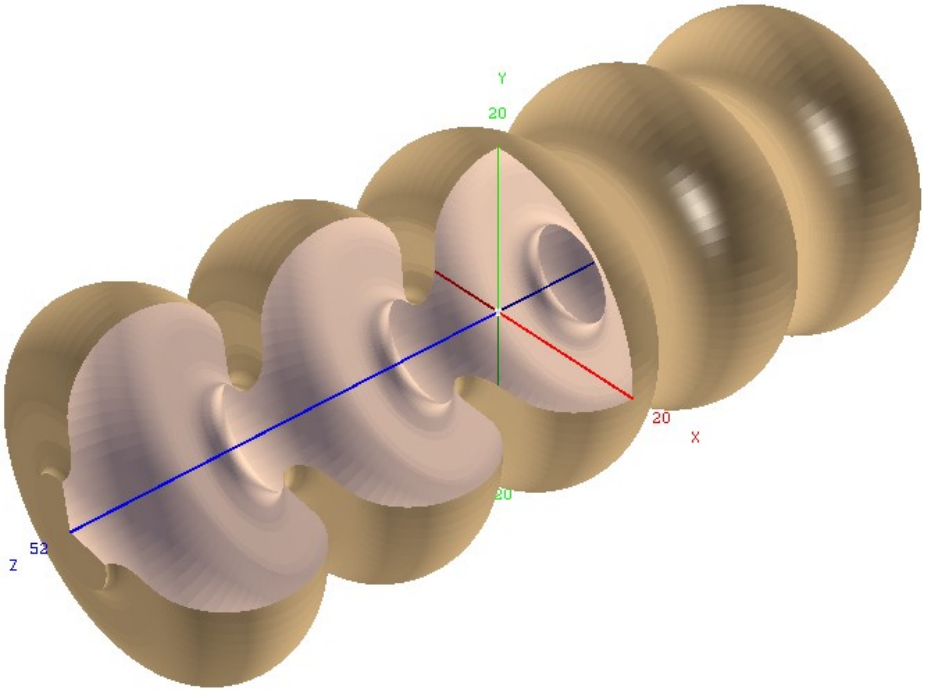
Fragments of the PIP-II Linac -- BTL Beam Line in MARS Model



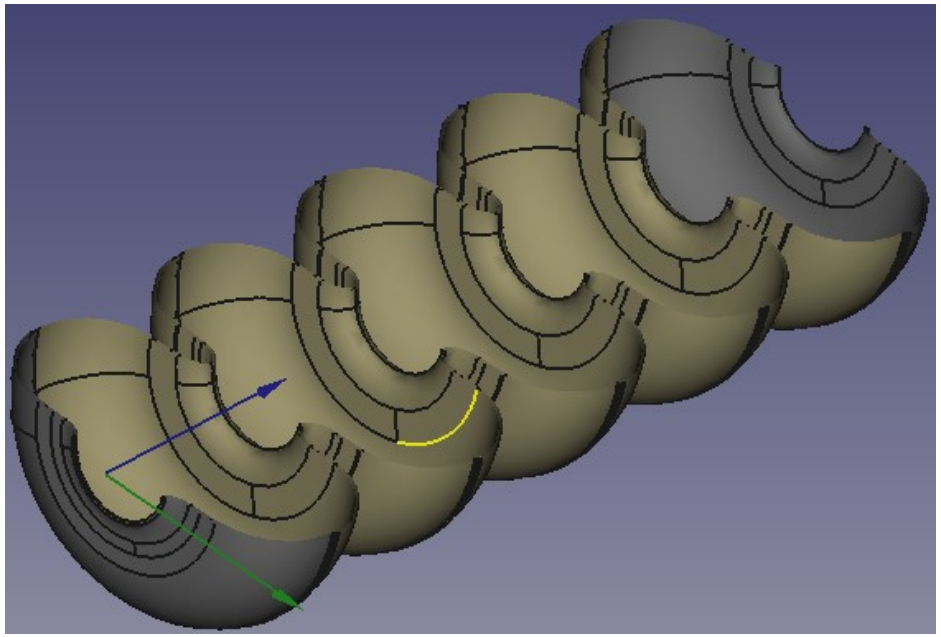
MARS beamline builder goes thru the MAD-X sequence, determines type (class) of the element declared in MAD-X and calls geometry builder for that class to create 3-D model.

Cavities in HB650 Section

MARS/ROOT model

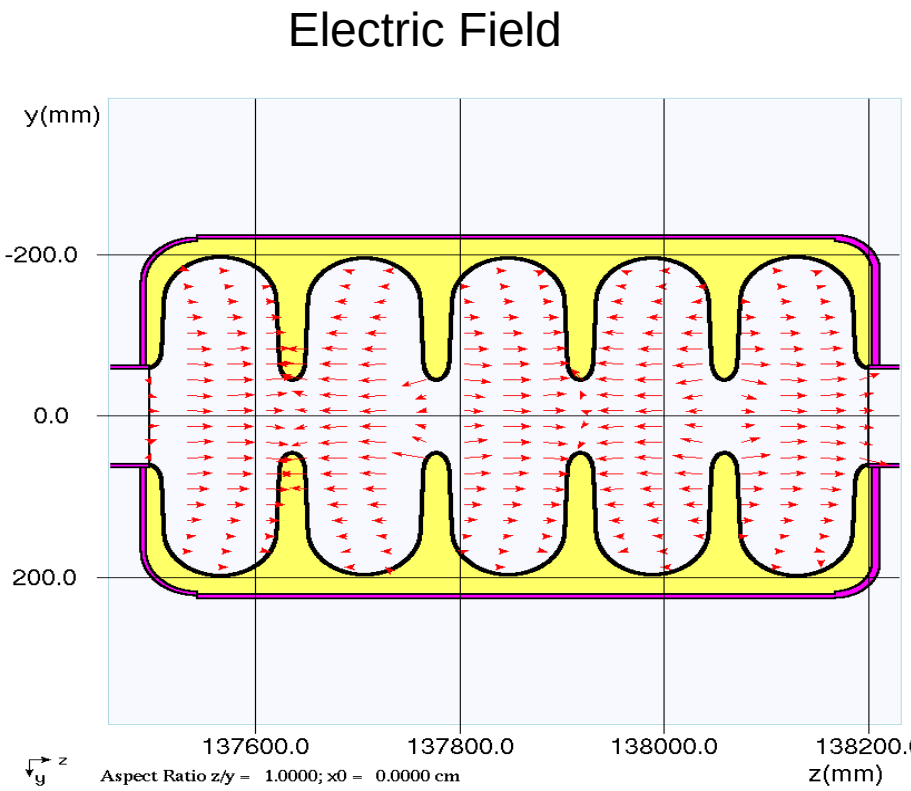


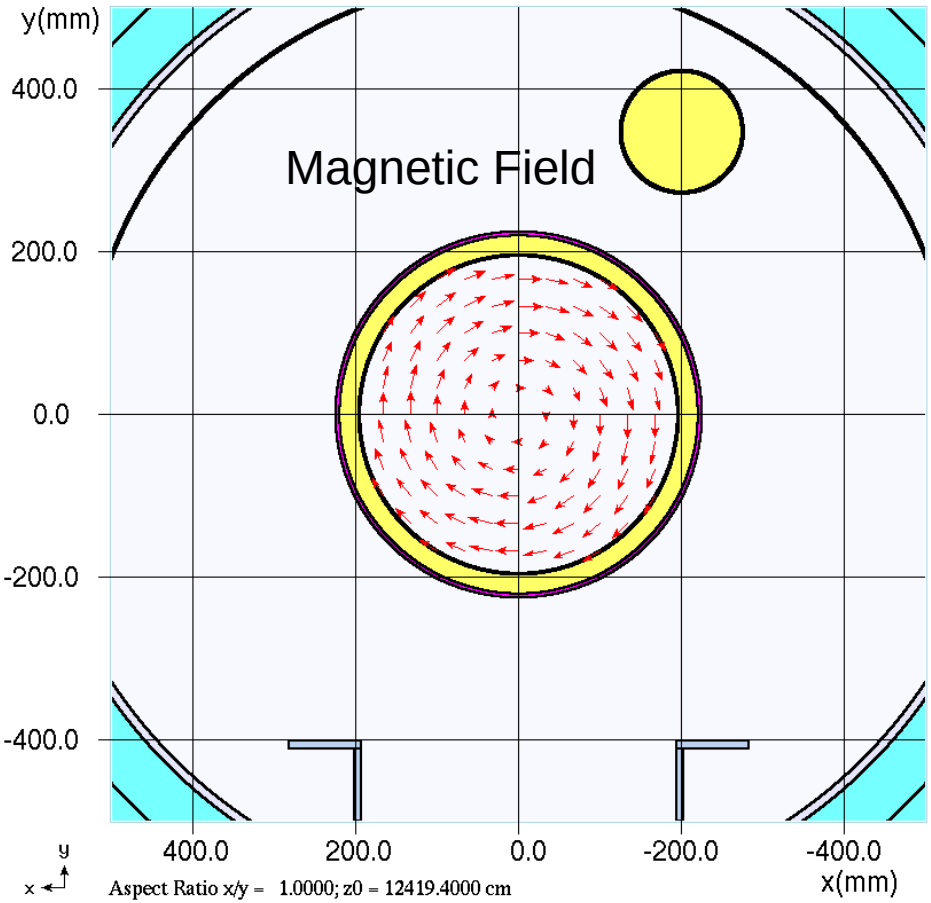
CAD model



CAD files for elliptical cavities as well as for SSR1,SSR2 are provided by I. Gonin

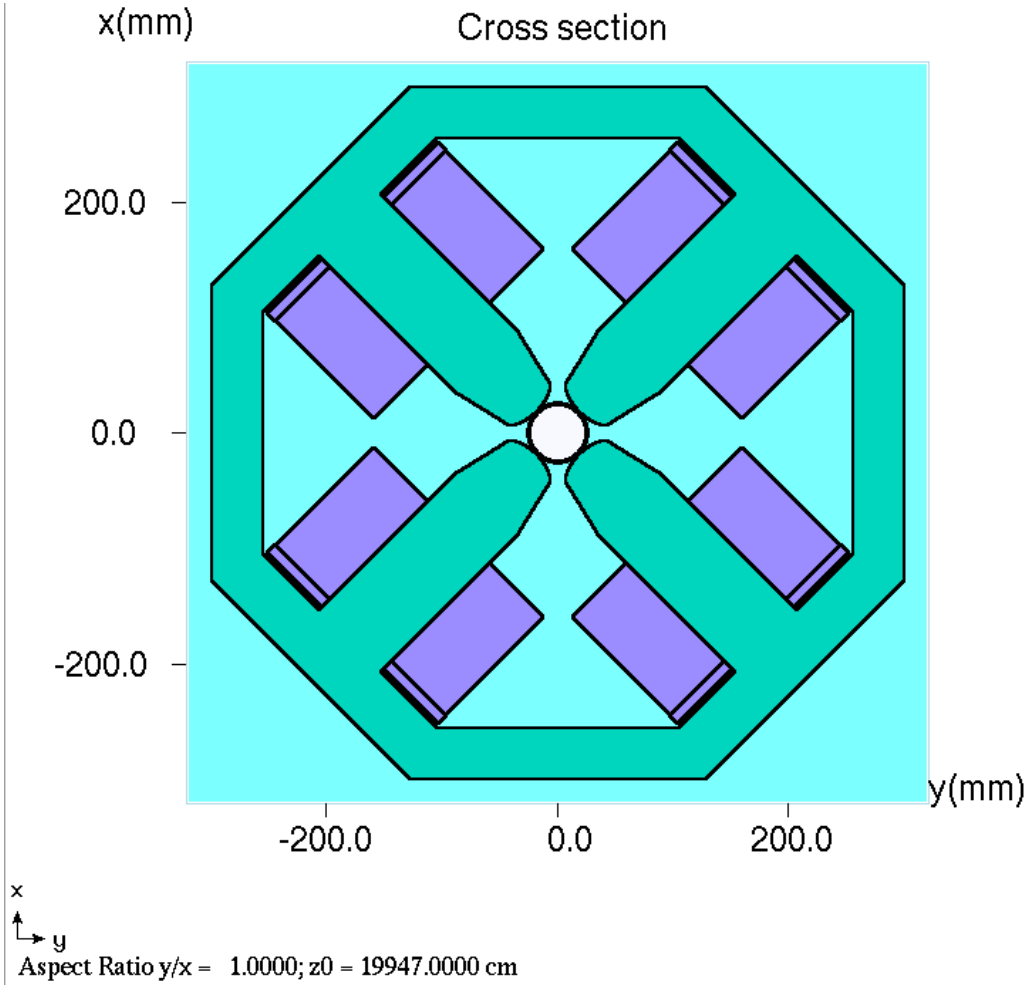
RF Field in Cavities





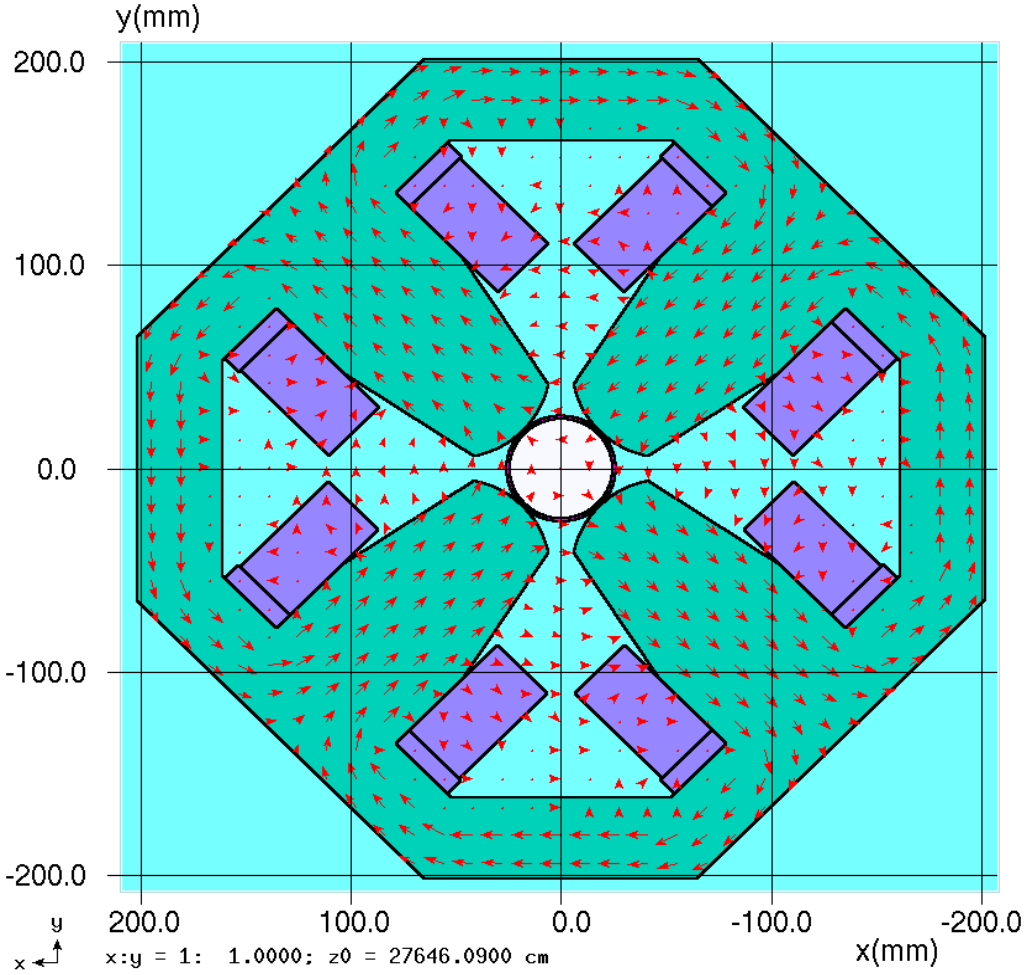
Field maps for elliptical cavities
Provided by A.Sukhanov

Quads in HB650 section

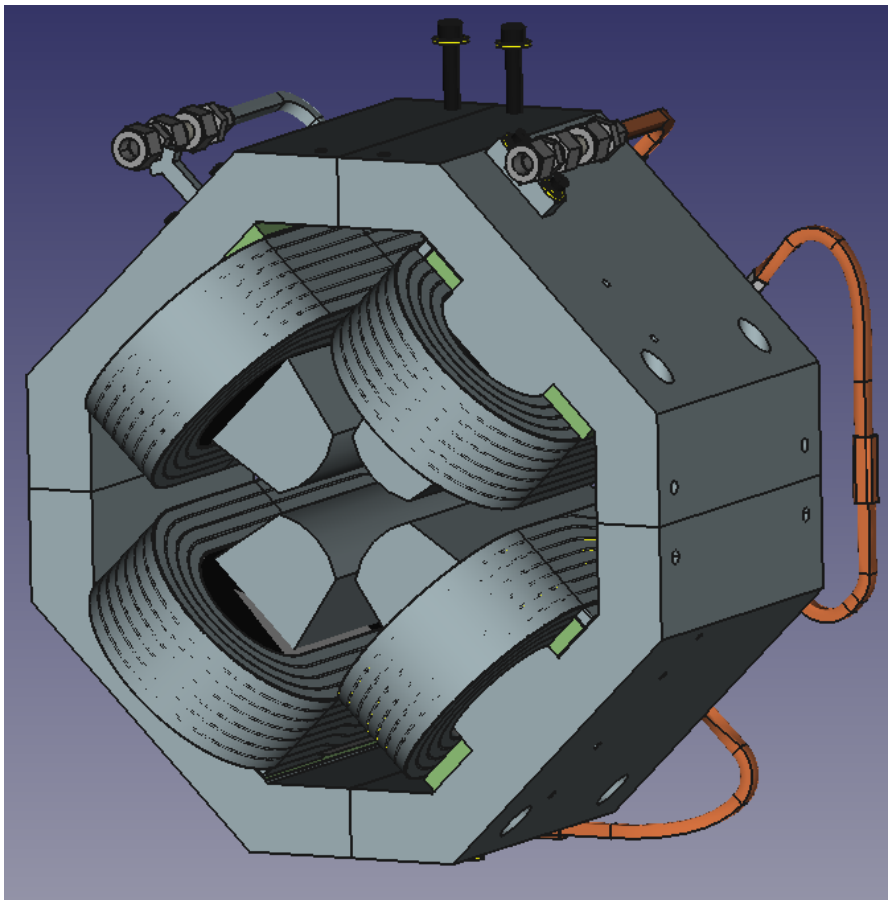


BTL Quadrupole Magnet

MARS model

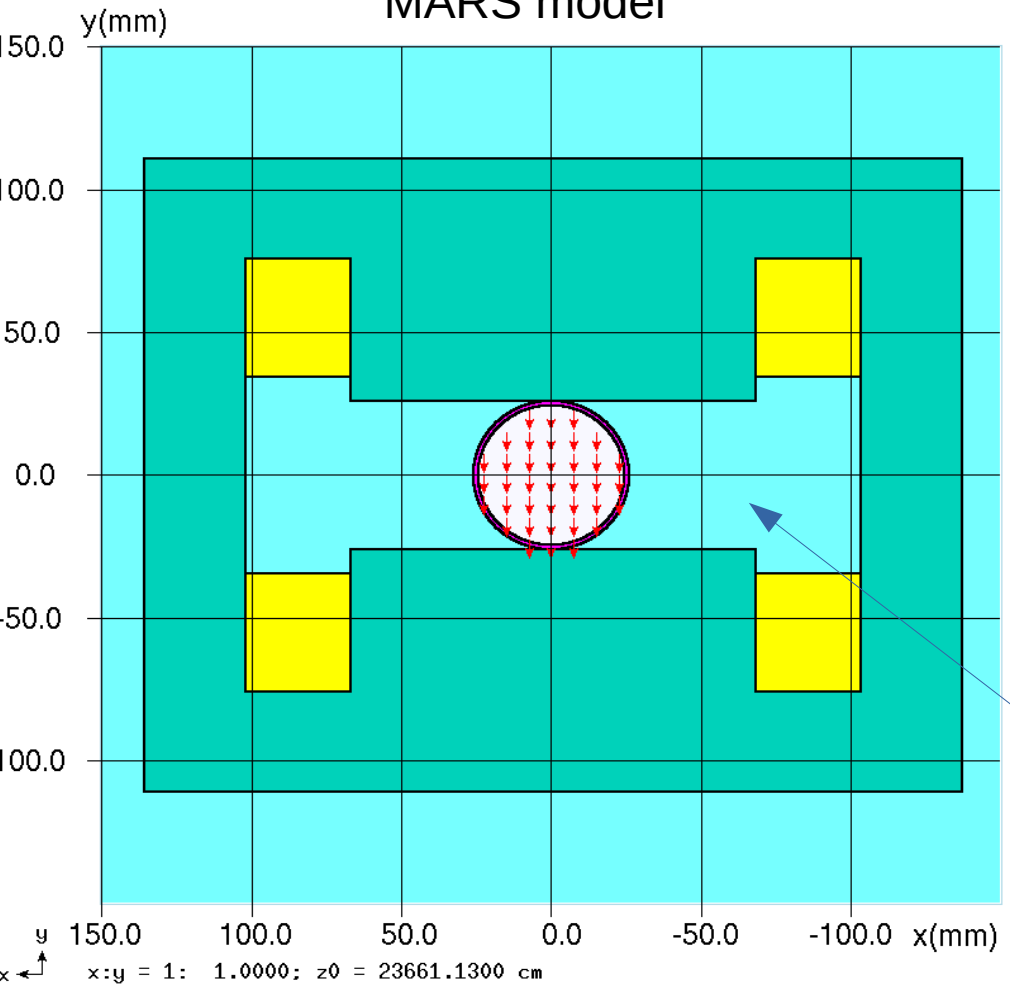


CAD model (V.Kashikhin)

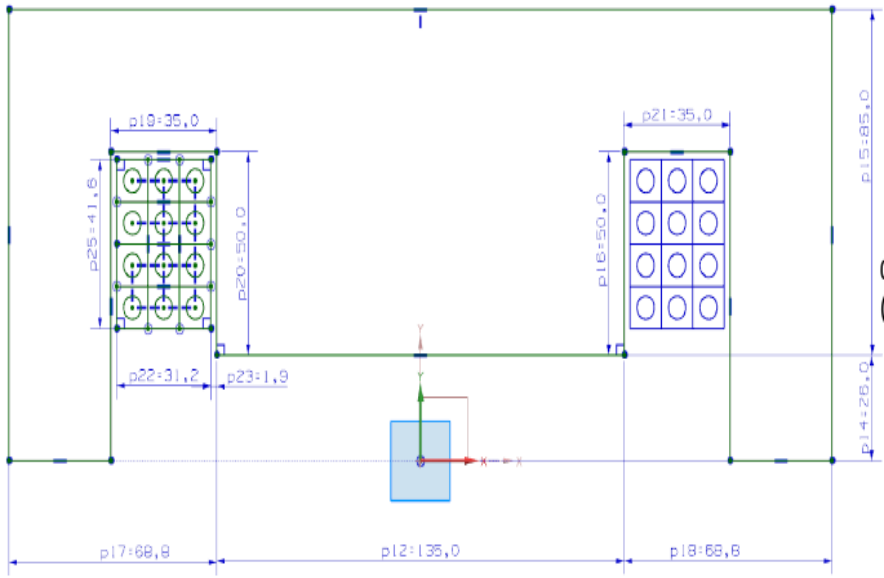


BTL Dipole Magnet

MARS model



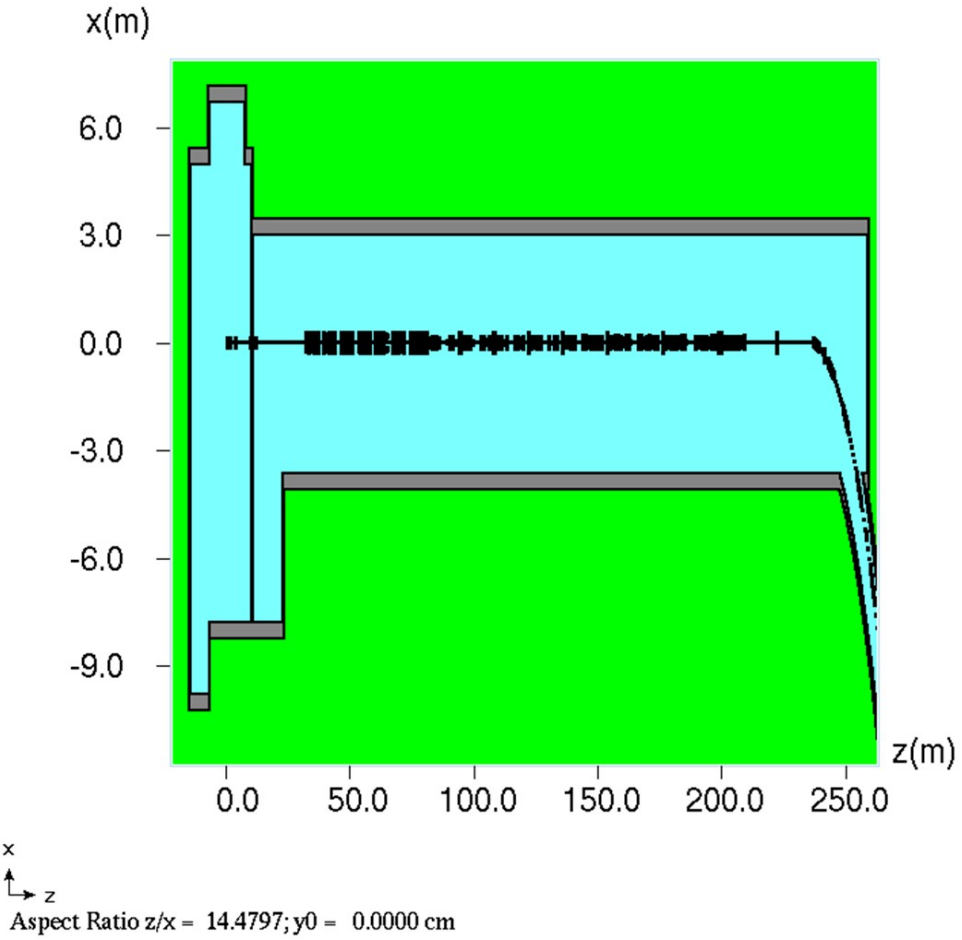
Design **(Miao Yu)**

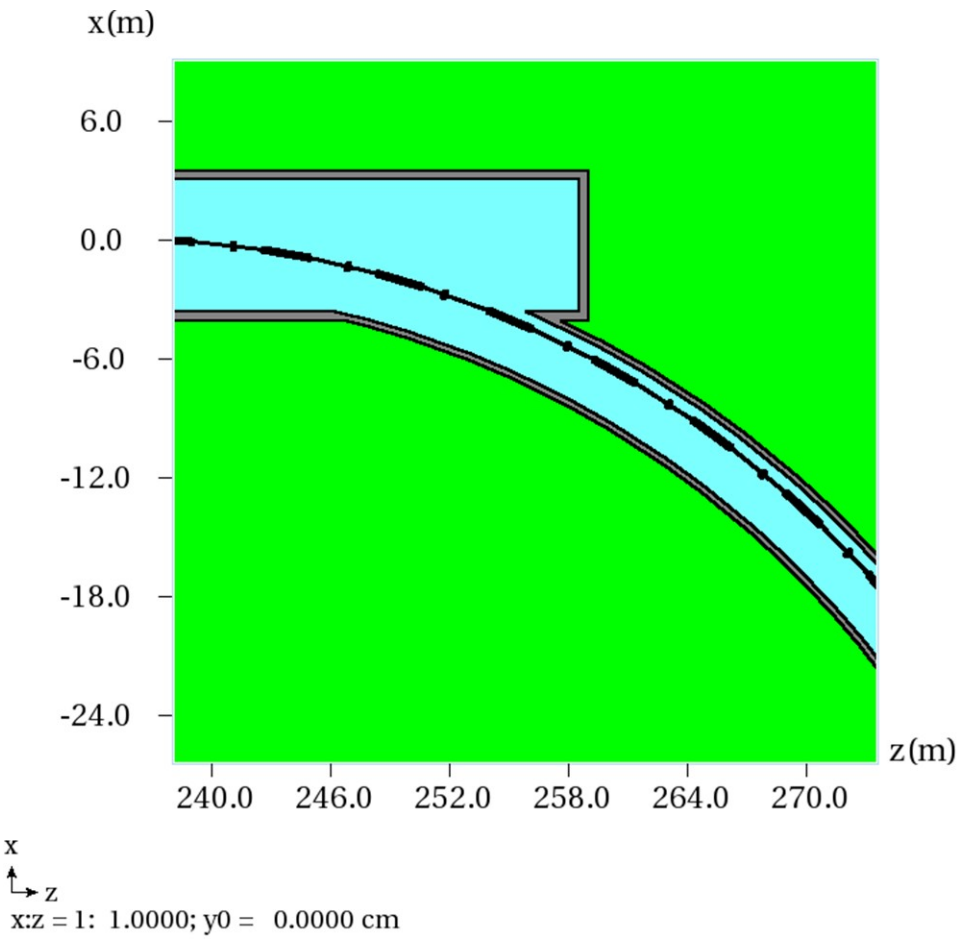


Width = 272.6 mm
Height = 111 mm (half), 222 mm (full)

Field to be added

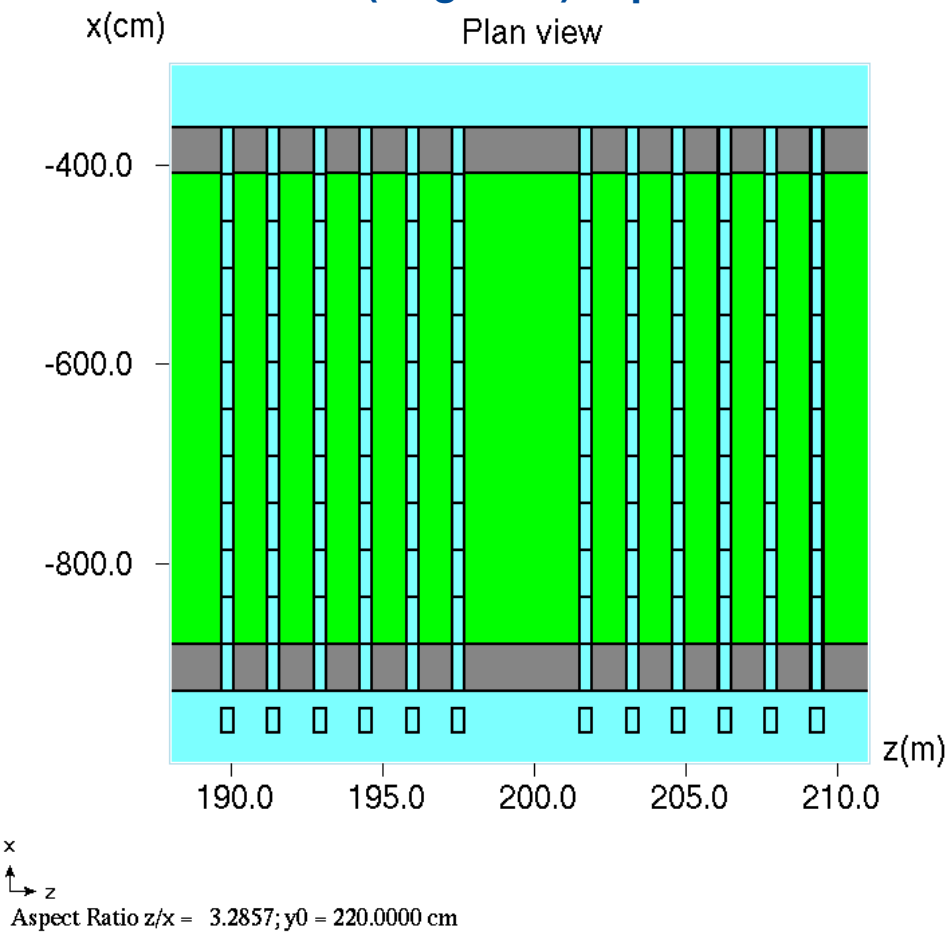
Linac and Transition to Booster Transfer Line (BTL)



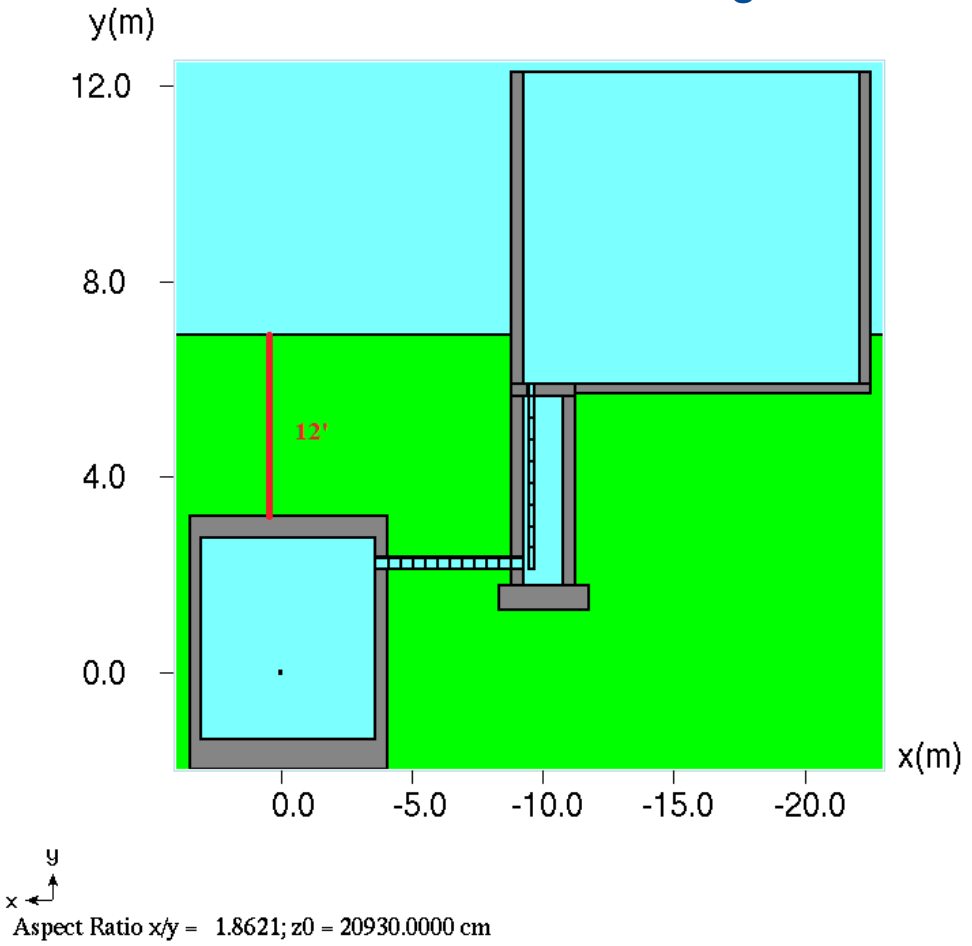


Linac Tunnel

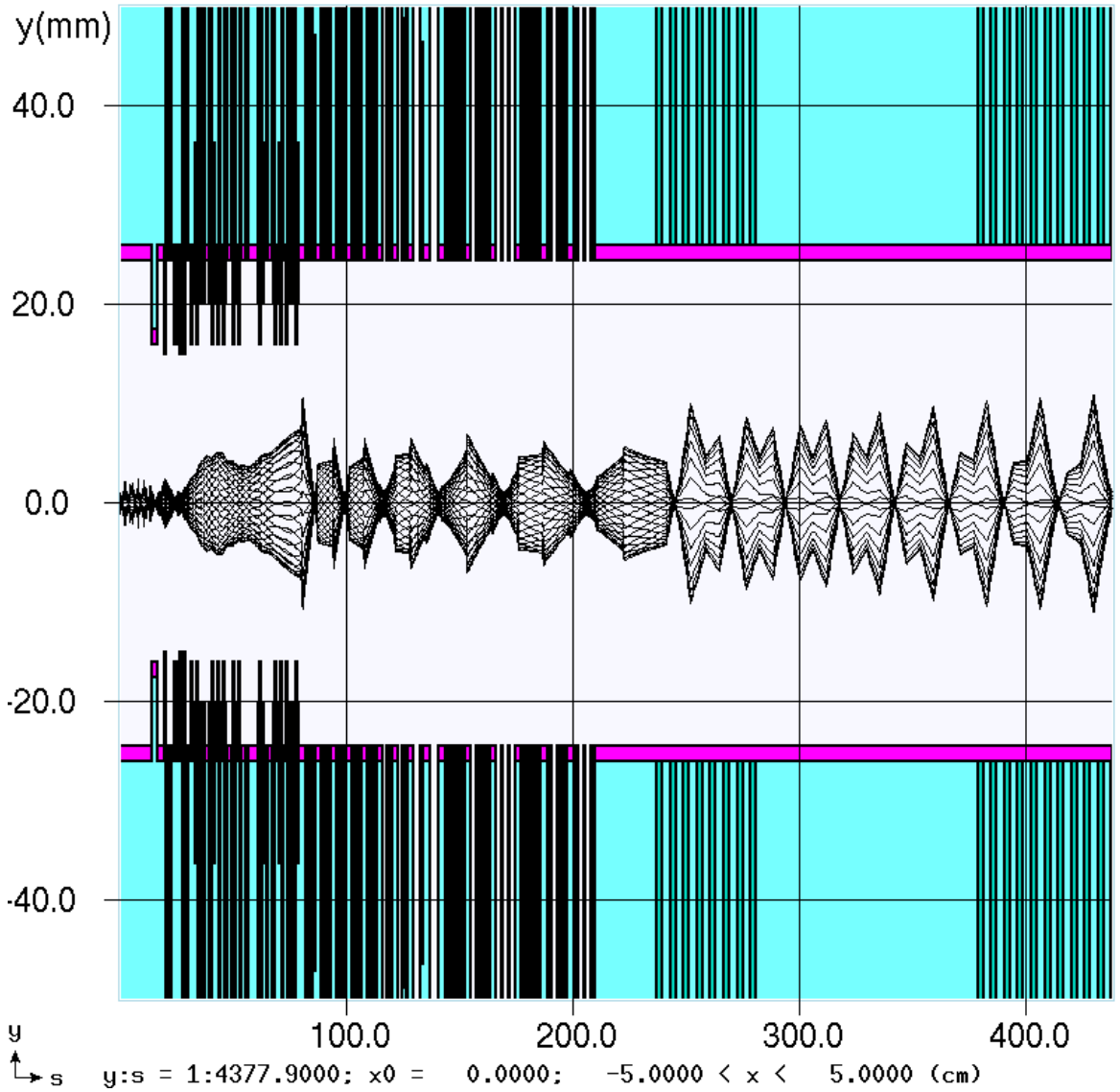
Plan View (fragment) w/penetrations



Cross section in HB650 region

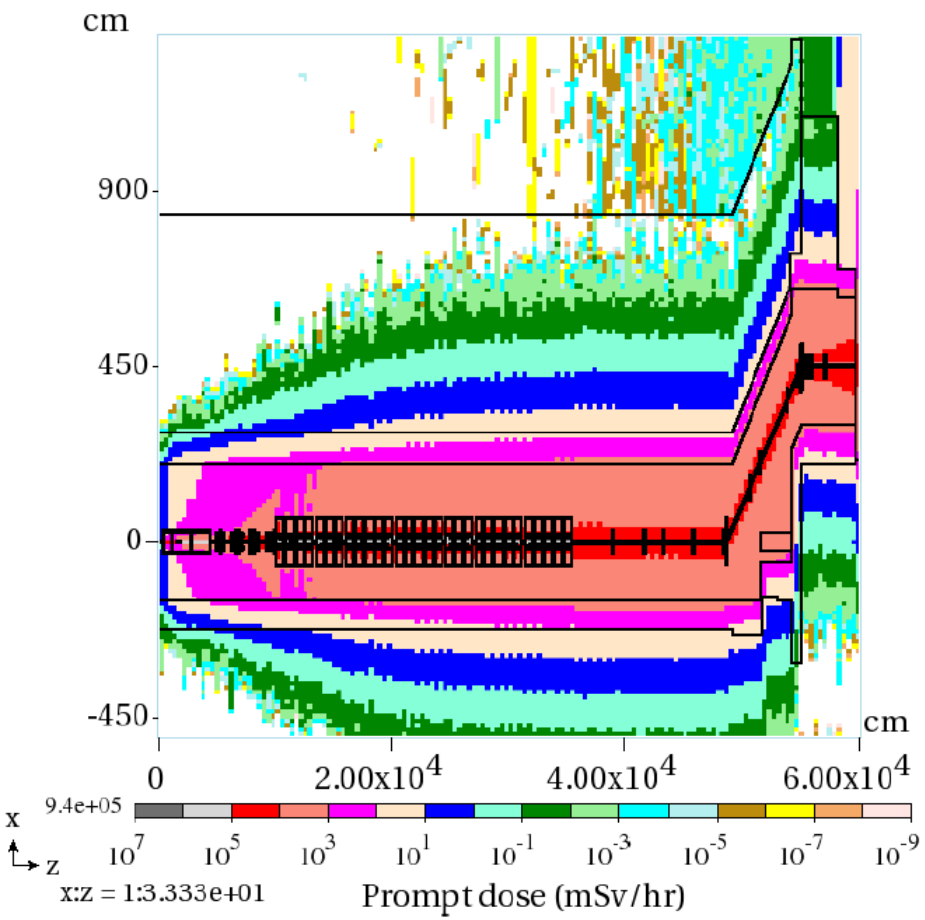


MARS 1σ Trajectories (Elevation View) From MEBT to End of BTL

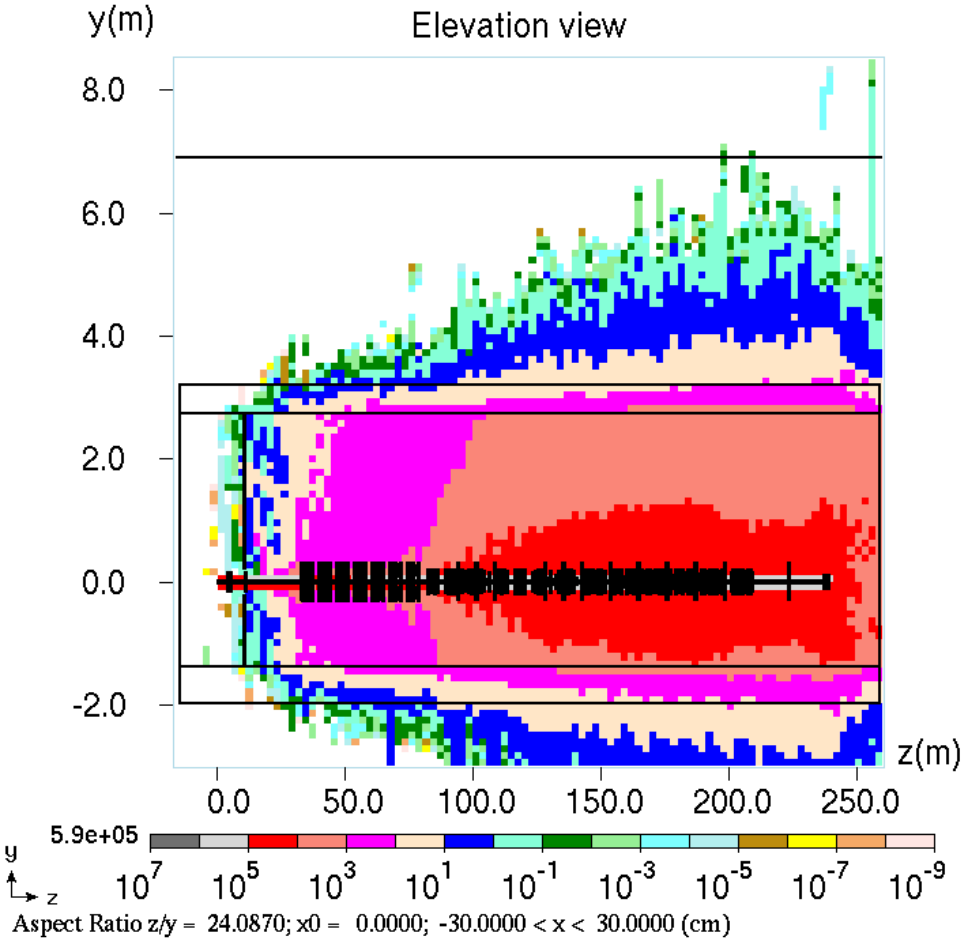


Prompt Dose (mSv/hr), Elevation View
1 W/m Beam Loss (Uniform in Azimuth)

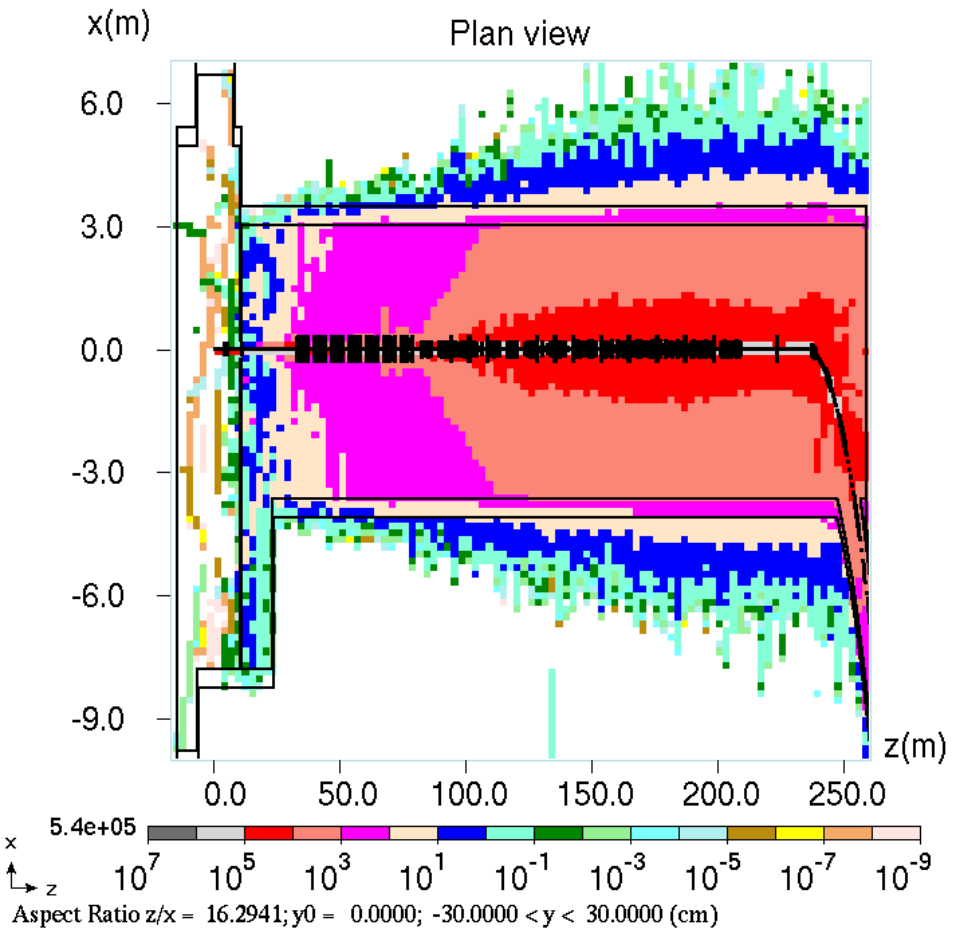
ESS Linac

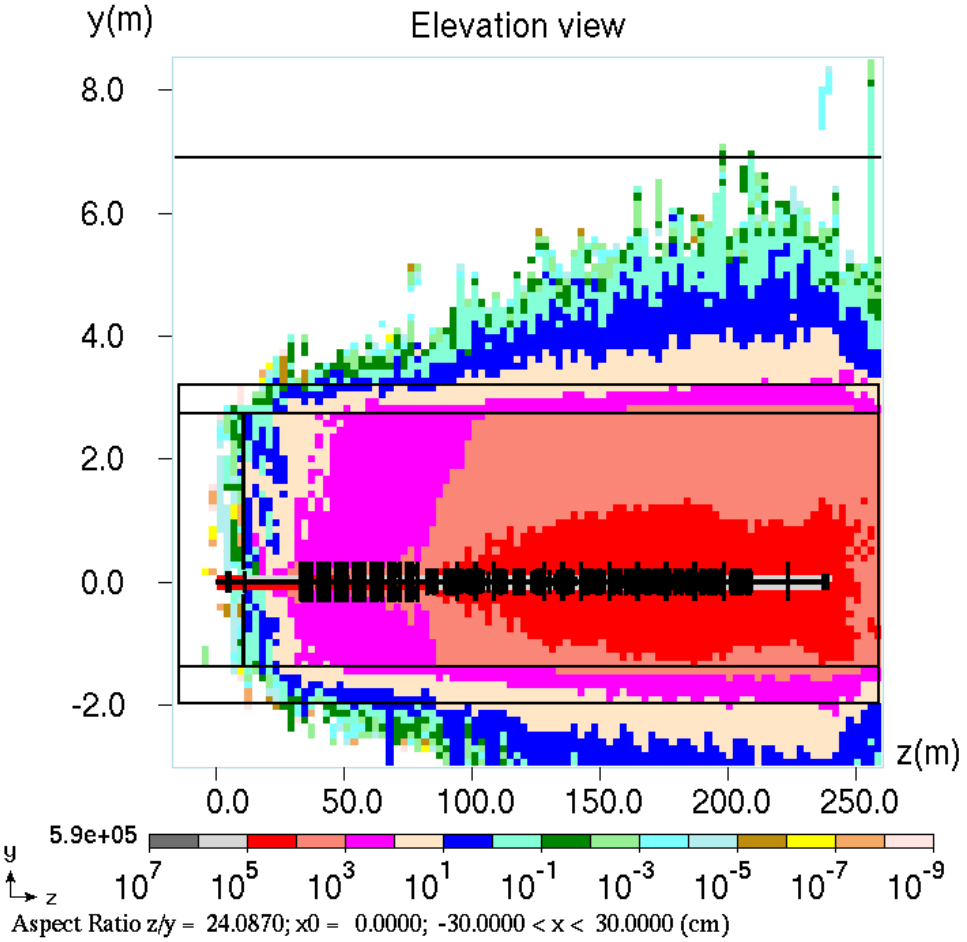


PIP-II Linac

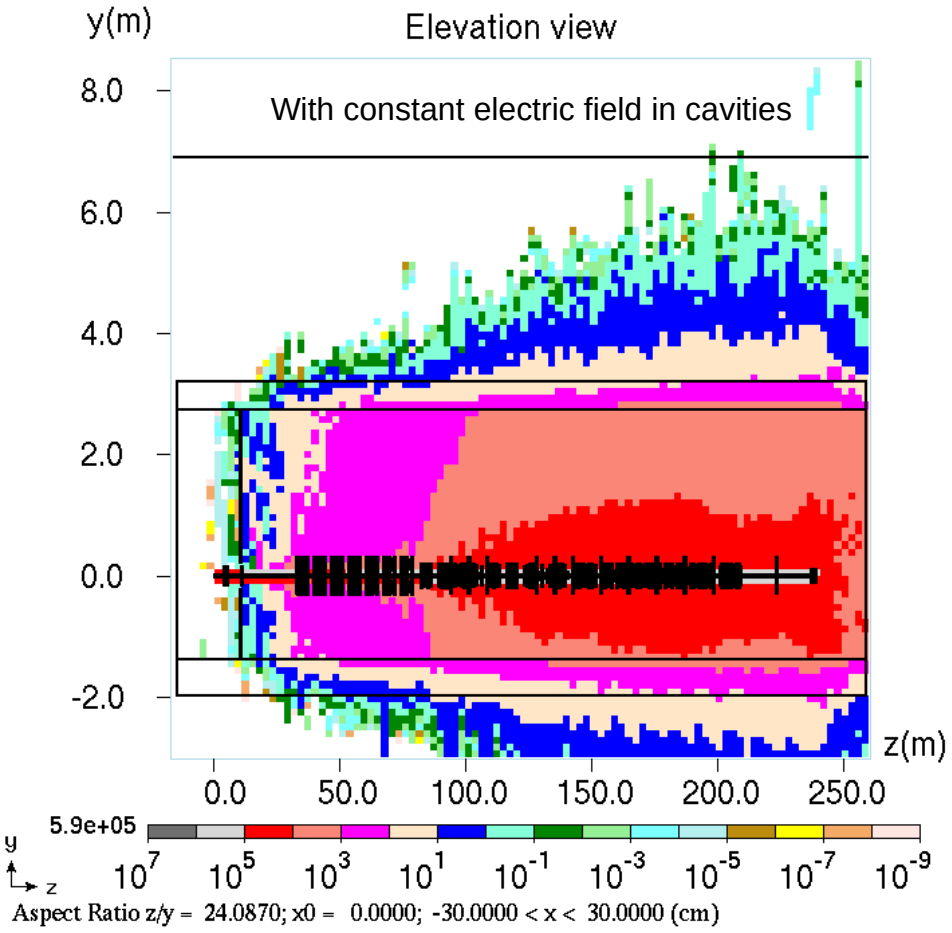


Prompt dose (mSv/hr) in PIP-II Linac
1 W/m beam loss (uniform in azimuth)

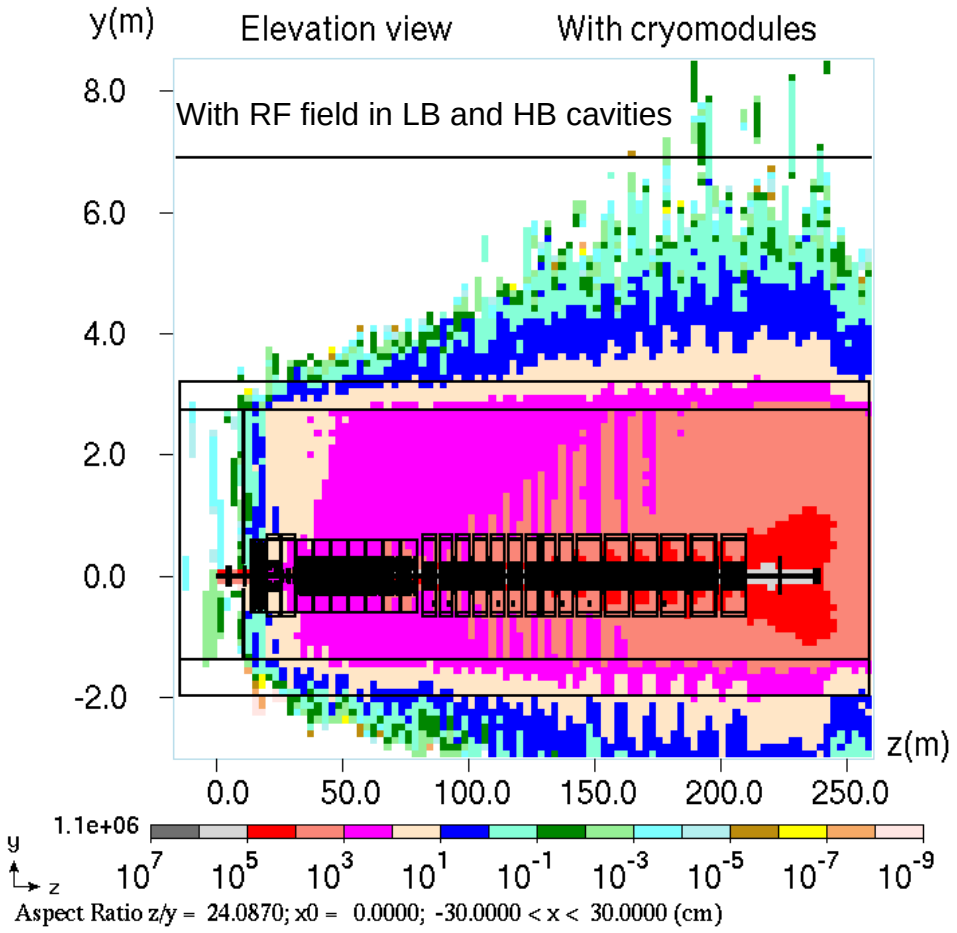




W/o cryomodules 1.108M
(beam loss along 500+ m)



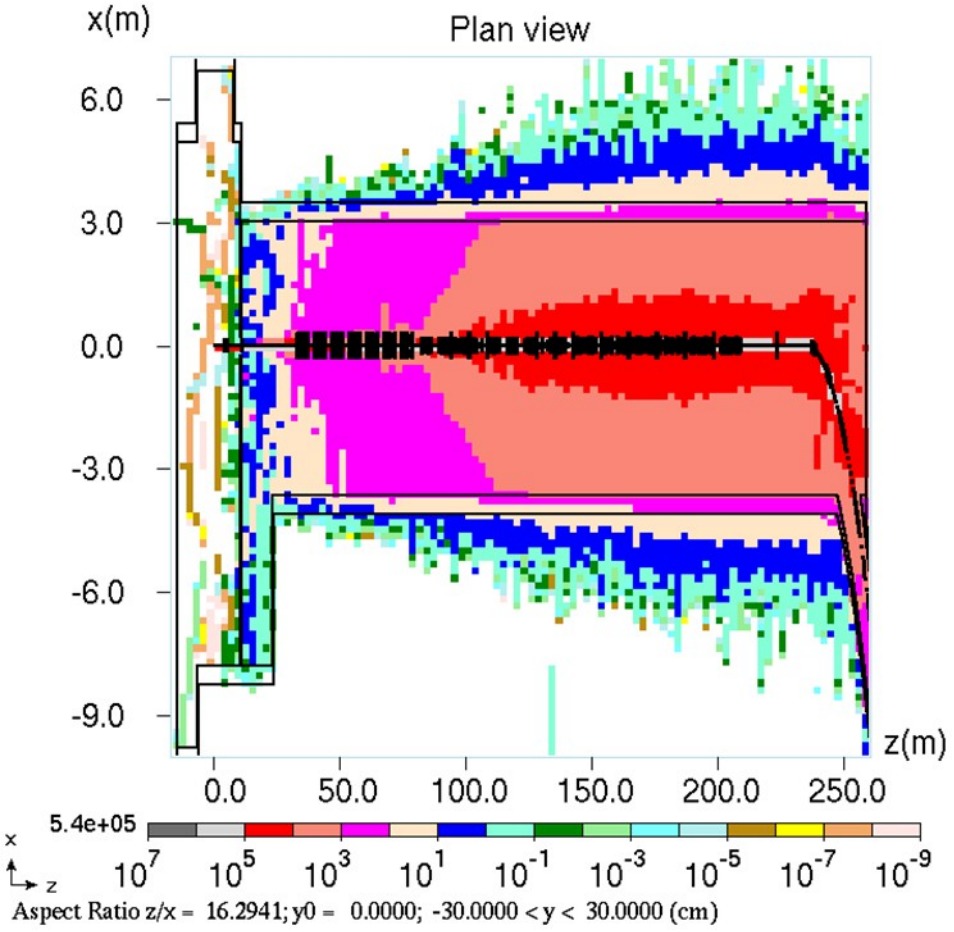
With cryomodules 1.408M
(beam loss along 236m)



Prompt Dose, mSv/hr

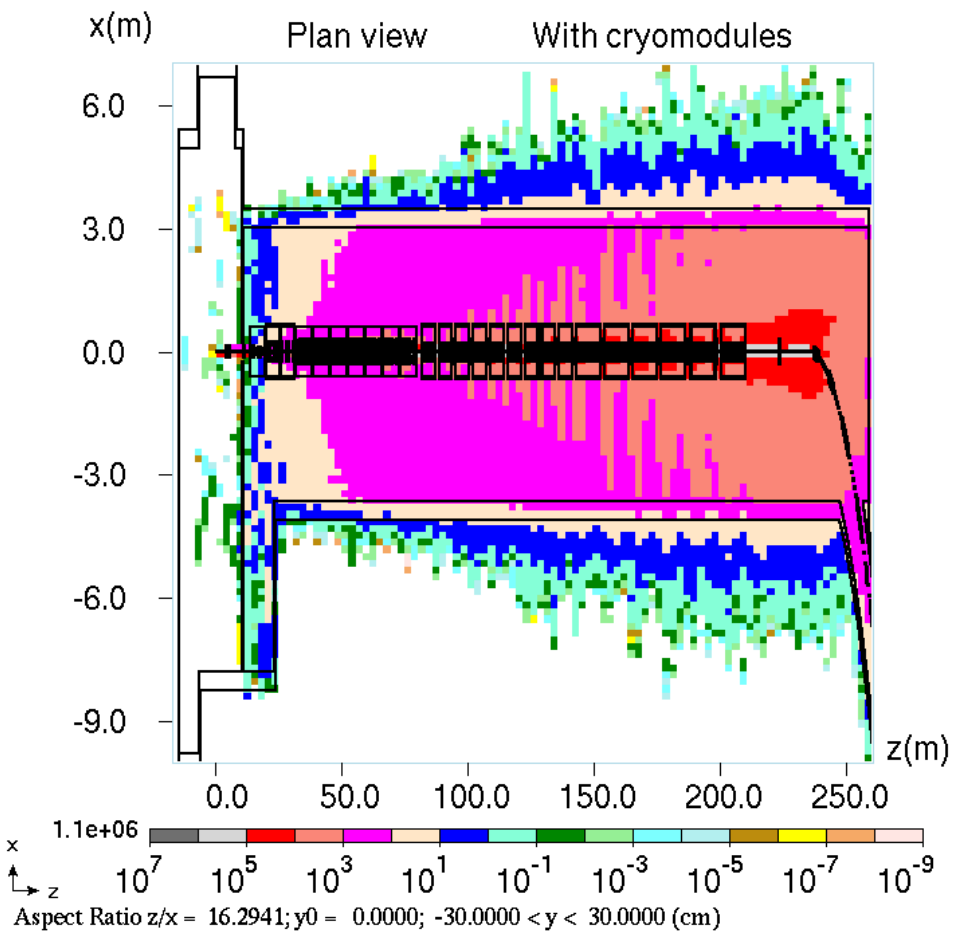
W/o cryomodules

1.108M
(beam loss along 500+ m)



With cryomodules

1.408M
(beam loss along 236m)



Prompt Dose Above the Linac Tunnel

- The prompt dose in soil above the tunnel is mostly due to (low energy) neutrons.
- The prompt dose attenuation in the soil above the tunnel ceiling follows the well-known rule of thumb: a soil layer as thick as 3′ provides approximately a 10-fold dose attenuation.
- The rule of thumb has been confirmed in many cases, most recently – in calculations performed for ESS linac.
- The estimated prompt dose atop the 12′ berm (in the hottest spot, that is above HB650 section) is approximately 0.01 mSv/hr = 1 mrem/hr **for the case of 1 W/m beam loss uniform in azimuth**.
- The hottest spot is expected to be qualified as a "**Controlled area of minimal occupancy**" with occupancy duration of less than 1 hr and corresponding signs.

Conclusion

To be done:

- Filling out cryomodules with internal parts (in progress)
- Incorporating the RF fields in SSR1,SSR2,HWR cavities, and magnetic field in solenoids.
- Implementing geometry of the first BTL dipole and solenoids in linac - magnets are not designed yet, beam dumps.
- Comparison between fields and trajectories in linac with those obtained using the TraceWin code (in progress).
- For discussion: publishing MARS applications in Git repository with the support subscription.