Advanced injector

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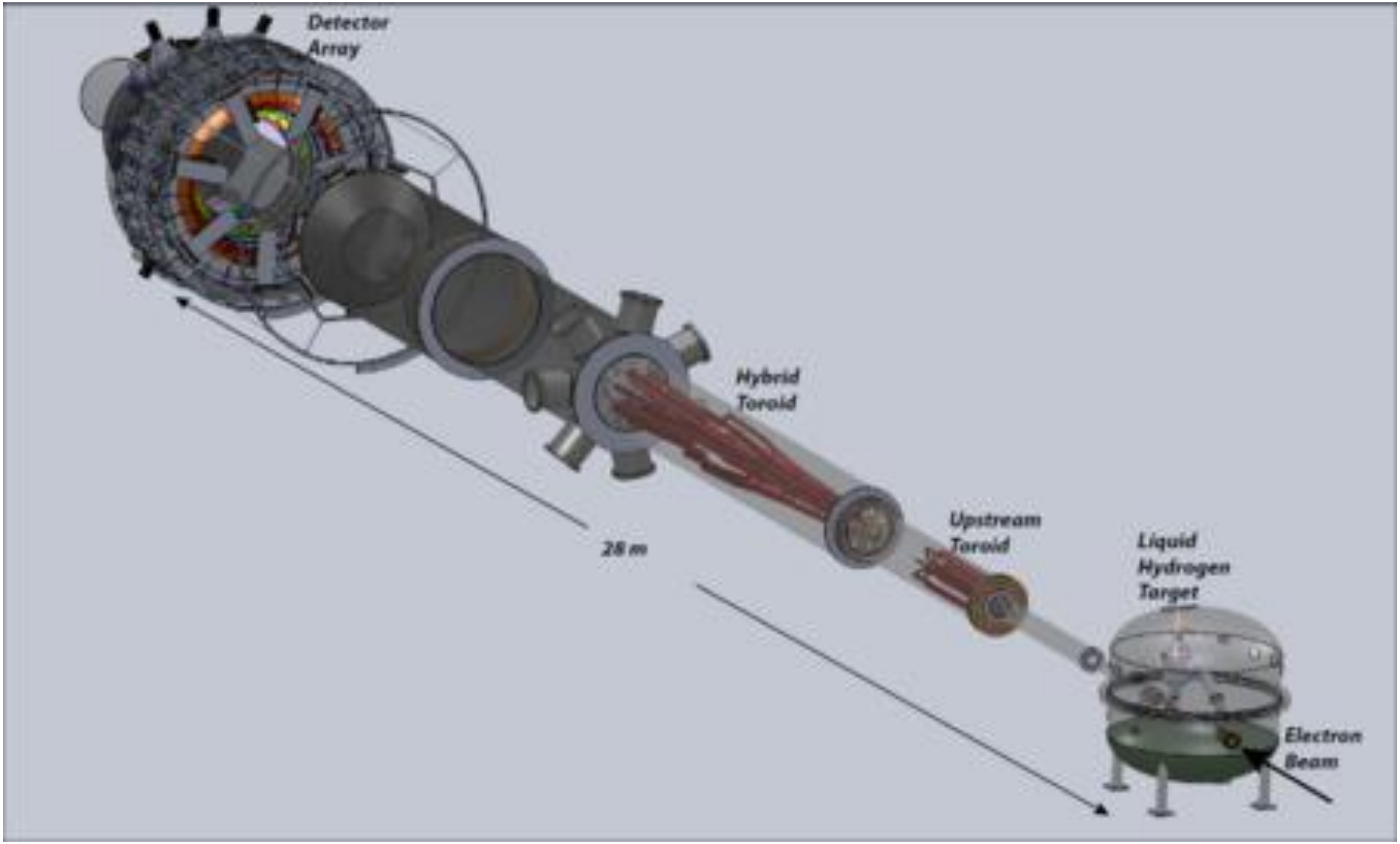
Physics requirements

- Parity violating electron scattering (PVES) experiments will be running the majority of the time in hall A
- The most stringent of these is MOLLER. For funding it needs to convince DOE/NSF/etc. that 1.1% systematic error on 28 ppb asymmetry is possible, aka 300 pp trillion. This is more than an order of magnitude tighter than Qweak beam achieved. It is known that helicity correlated (HC) beam property variation and halo with large HC asymmetry start in injector. *(MOLLER technical feasibility review ~May 2016)*
- The FY2016 injector experiment needs 0.1% energy accuracy. This will require a lot of work given environmental magnetic fields. Follow-on experiments with similar requirements are likely if this one provides valuable information.
- Four chopper slits would be nice.

MOLLER



https://hallaweb.jlab.org/wiki/index.php/MOLLER_at_11_GeV_E09-005

My druthers (1)

- Remove everything from the injector up to the gate.
- Redesign line for maximum aperture and minimum overall length before quarter cryomodule for required functionality.
- Put both Wien filters on same side of pre-buncher*
- Replace all eight low-P solenoids with one design with an order of magnitude better field homogeneity. (TNs 12-062, 14-022)
- Replace the “6 MeV” quads with a water-cooled variation on the low-P solenoids (same coils and steel tube OD) to reduce beam envelope a factor of two and lower lens steering (TN 15-029)

* *Prebuncher must remain on the beam line (off) and space must be left for the capture in the event of a failure of the new quarter which requires re-installation of the old quarter. Gun voltage would be turned down to 130 kV to match capture. Or design/build new capture with 200 keV KE input.*

My druthers (2)

- While injector is empty of all but utilities, cover floor, walls and ceiling with #12 or #14 steel sheet or ~0.2” of 50/50 steel_dust/epoxy mix to divert most transverse flux around beam line and convert what’s left to Bz (precession)
- Replace all the steel magnet stands with aluminum so induced multipoles don’t screw up beam as they do now.
- Make provisions on stands for adding 16” square or 24” square steel sheet symmetric around beam line if wall shielding proves inadequate. Lift-off top (inverted U) for access.

My druthers (3)

- Upgrade connectors on Wien filters to allow +-30 kV. Internal Macor should be fine. Magnet steel is fine but winding wire size must be increased. If you want 350 keV up-side, 40 kV connectors and must machine steel. (TN 15-032)
- Just one DP can after quarter, to free space for:
- Two stripline BPMs separated by about 70 cm (100 cm total) just before MDL with no magnetic elements between them so launch into MDL (and therefore energy) can be set precisely. Mott measurements would benefit from better knowledge of energy even if there are no future injector NP experiments.

My druthers (4)

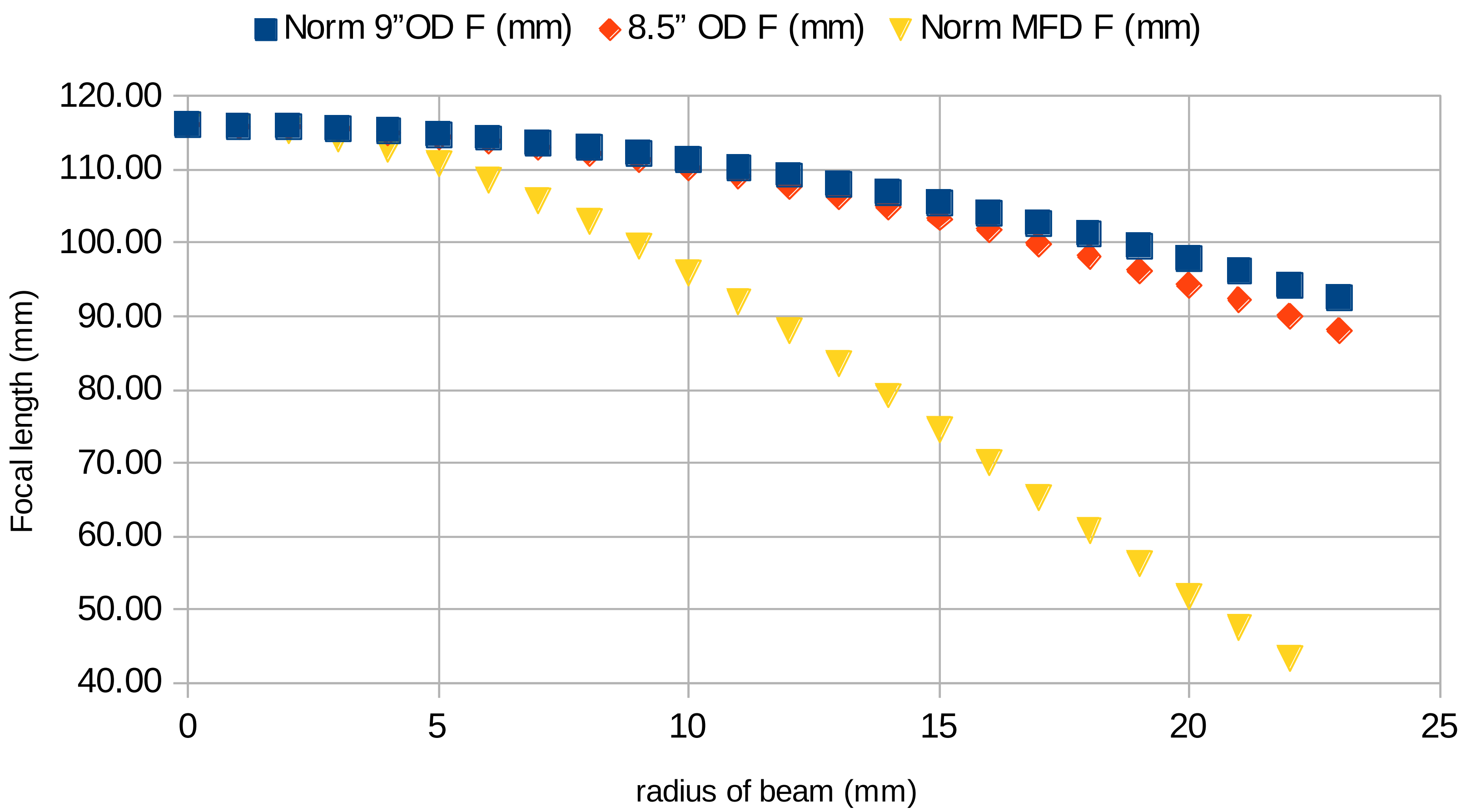
- Low-P solenoids use 10A trims instead of 1A now installed.
- High-P solenoid sets require one 20A/75V supply for 0L01 and 0L02, two for 0L03 Twiss measurements. For 10+ MeV capability, six 20A/75V. LCW under 1 GPM each.
- About 30 kg each so stands and alignment will be required. Designed to fit over 3.375" CF flanges so no welding on to beam line except at present chopper (4.625" CF).
- **Neither PSS nor MPS turns off gun HV. If three device, two technology ukase must be violated, so be it.**
- Determine what quad(s) are needed to deal with one-plane focusing from Wiens and 15^{o} degree bend. Air-core (QU, QW) or short Panofsky quads (TN13-002). Or Mainz triplet.

Why new solenoids?

radial loc mm	FA (typ count	FD (chopper)	FG (wien flip)	FL 500 keV c	4" cntrwnd	4" wired single
0	1		1	1	1	1
3	1.0365		1.0012	1.0447	1.0045	1.0009
5	1.1056		1.0033	1.1301	1.0125	1.0026
12		0.849			0.959	
15		1			1	
18		1.234			1.053	

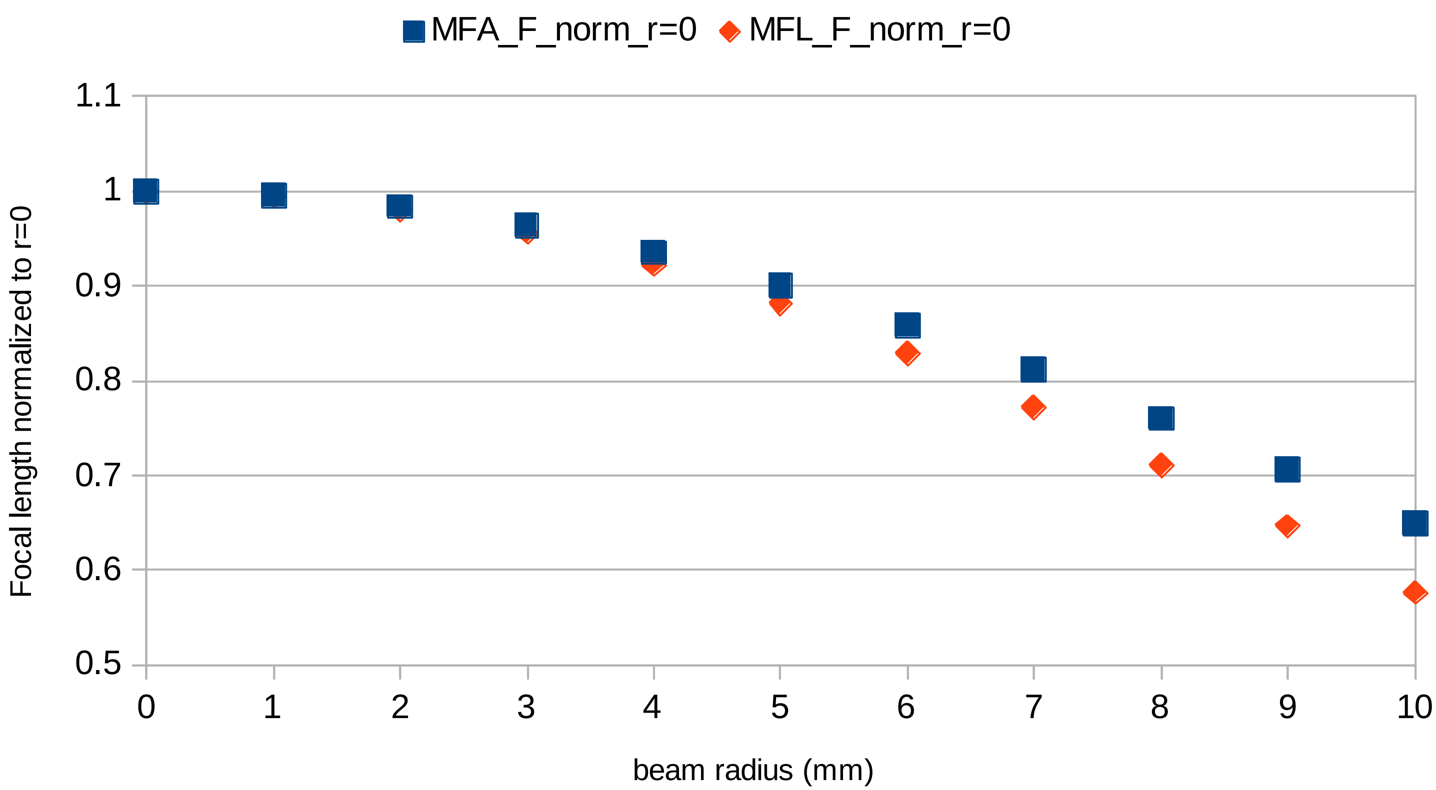
Order of magnitude improvement for on-axis performance.
Factor of four at chopper on 3 cm circle.
Design constraint: fit into 9" ID by 4.5" long chopper recess.

Chopper solenoid



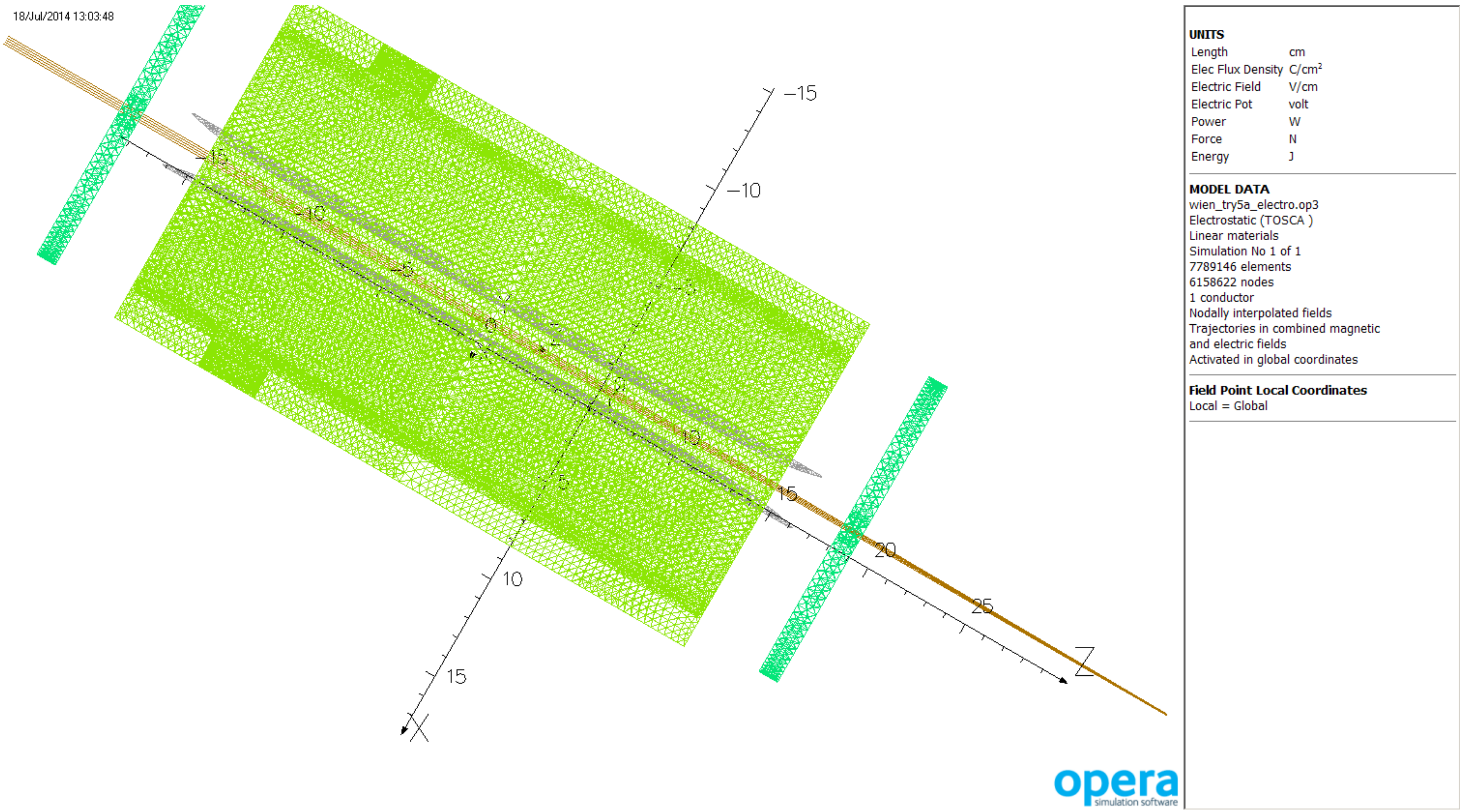
See also TN15-036

Other solenoids



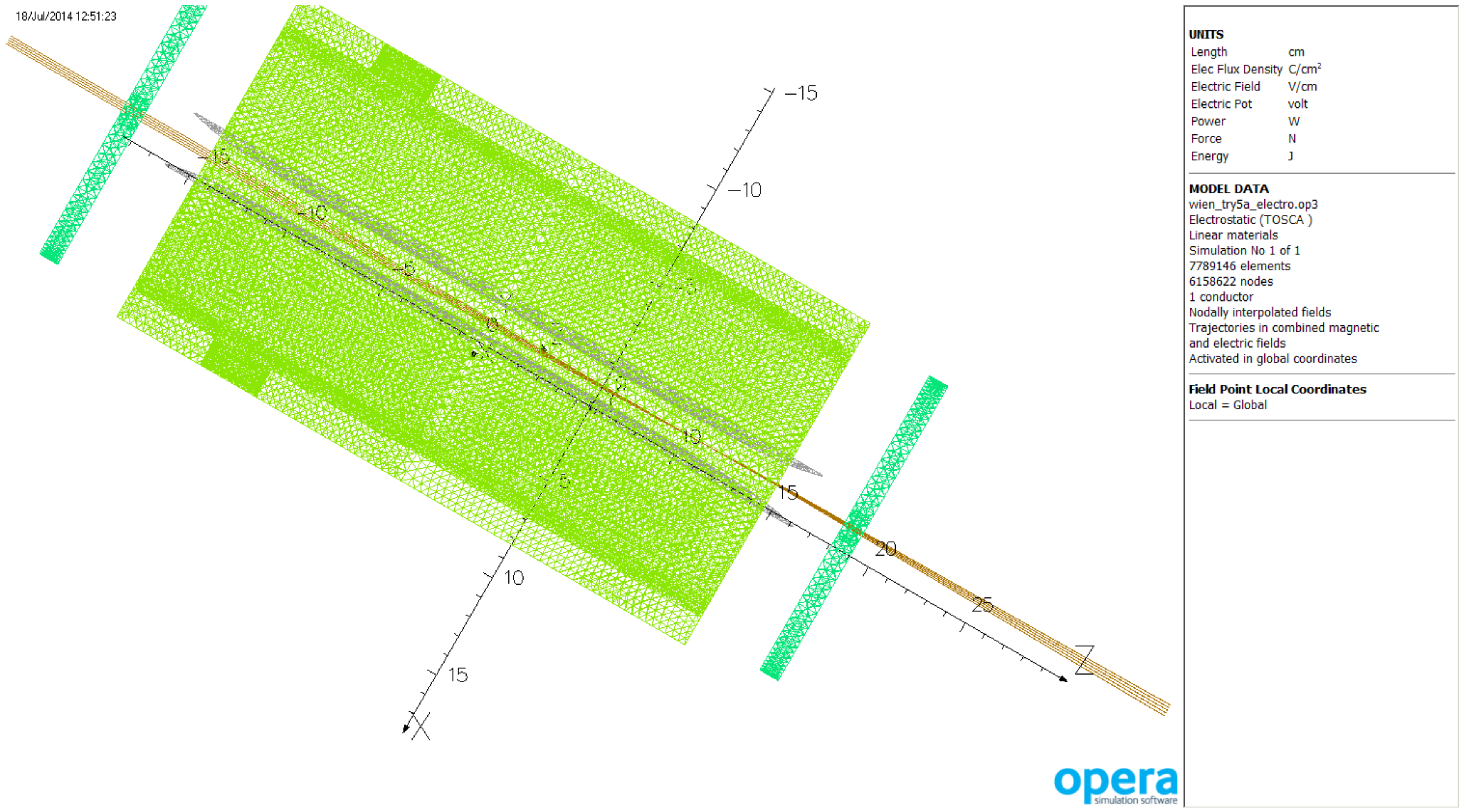
Focal lengths for solenoids with nominally centered beam, normalized at r=0

Wien focusing



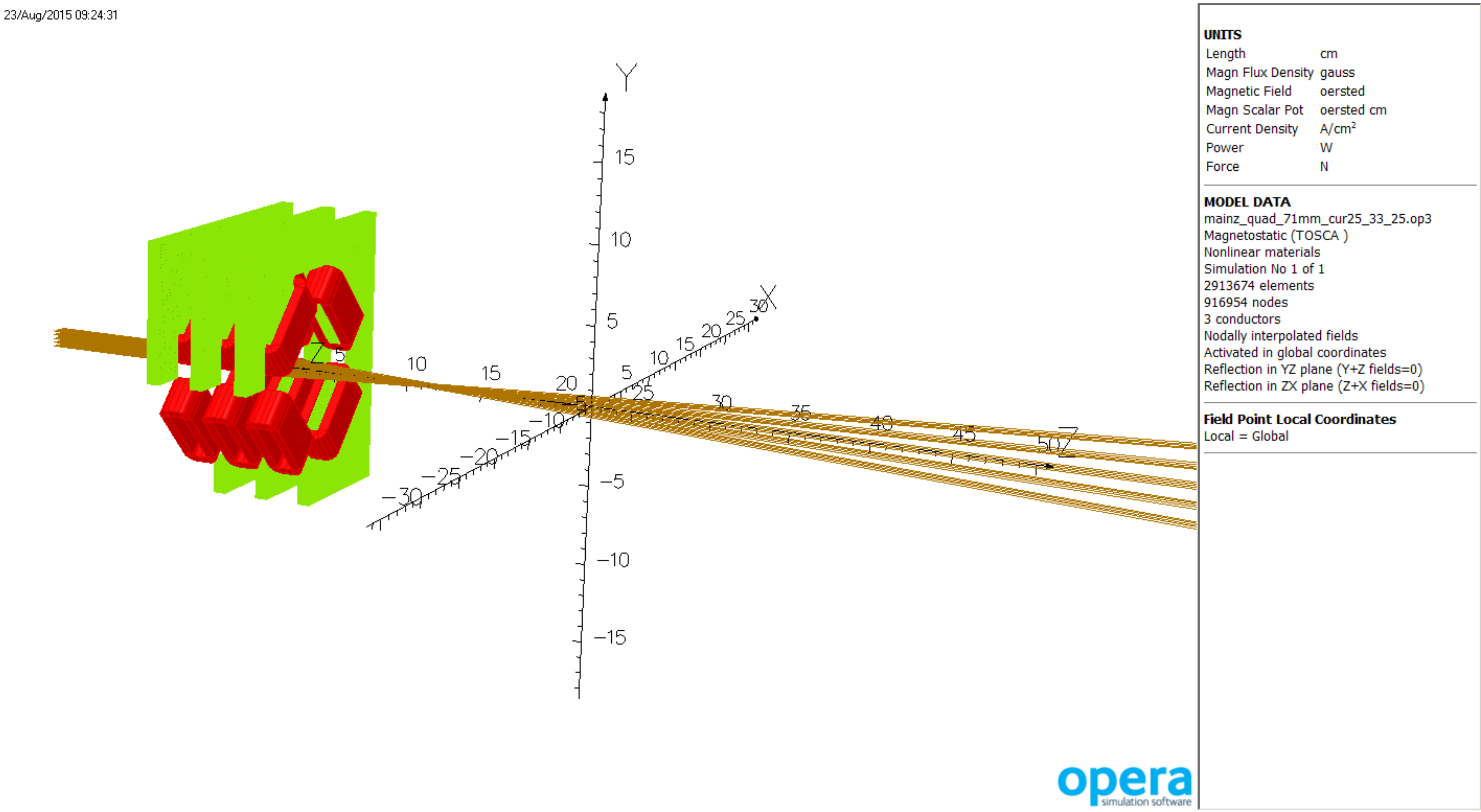
54 degrees precession

Wien focusing (2)



108 degrees precession

Mainz triplet



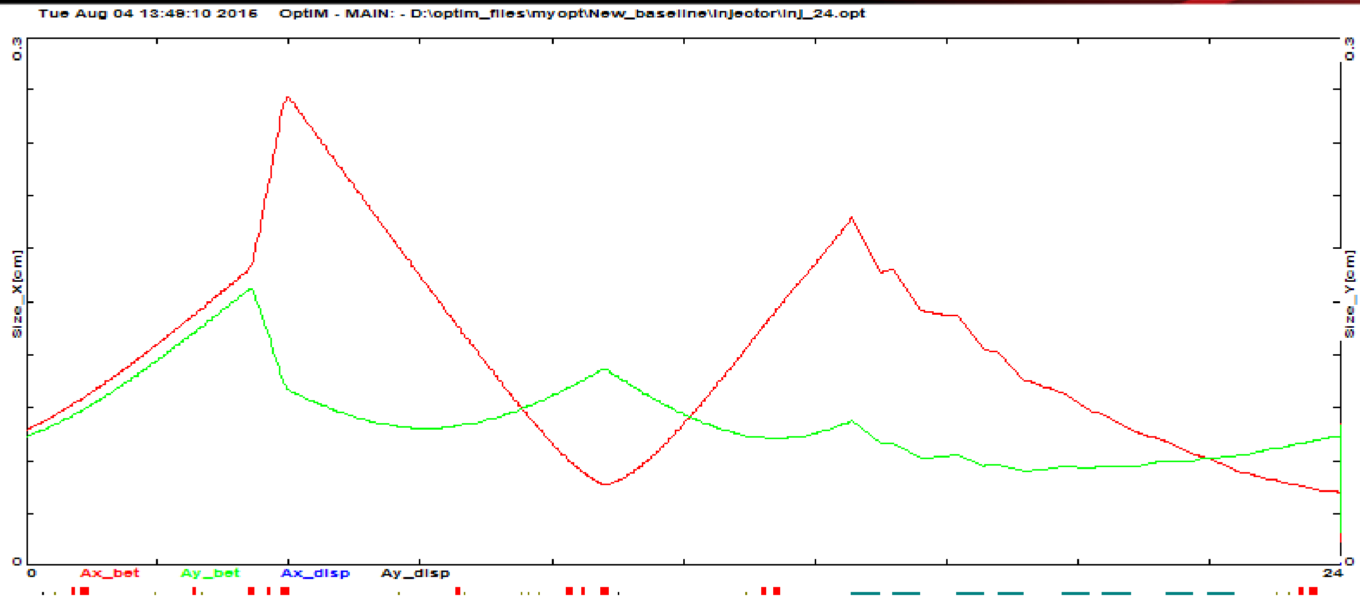
-375 AT, 990 AT, -375 AT, 200 keV beam, triplet 9 cm long overall

Wien focusing

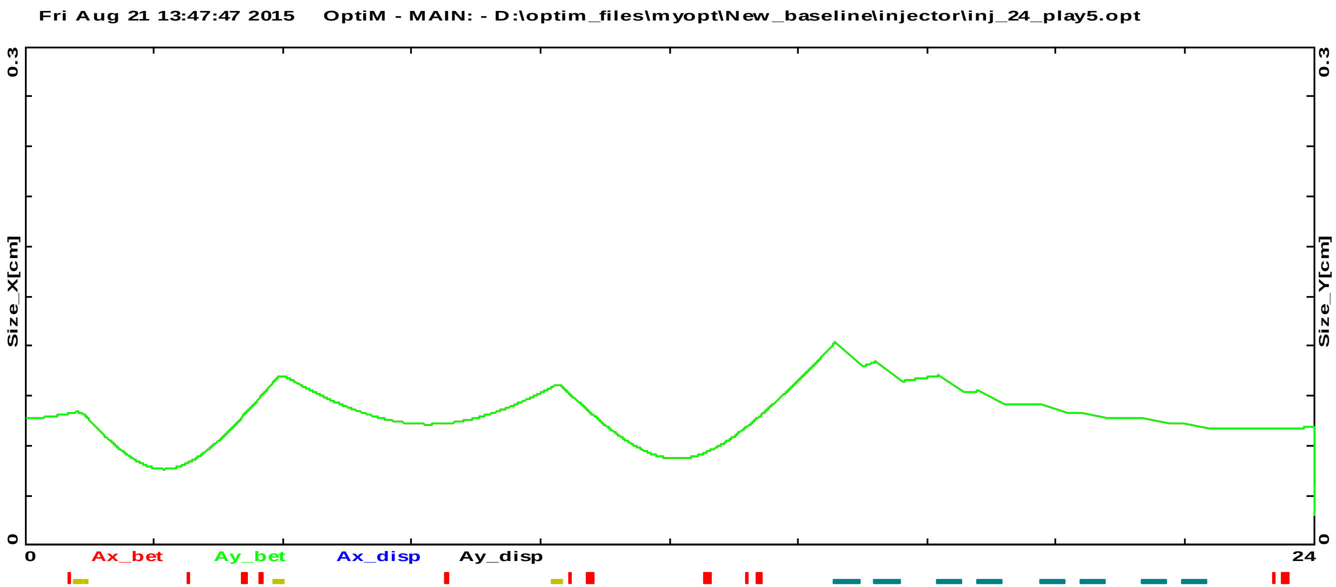
- Trajectories of 125 rays through Wien provided to T. Satogata 9/1 to determine first order transport.
- This should determine whether existing air core quads (QU, QW) will suffice or iron-core options are needed.

Why replace 6 MeV quads?

3mm vertical full scale



Present optics in 1.75cm radius tube. 6 sigma if beam centered, which it never is.



Solenoid focusing, ~15 sigma

Summary

- The injector was designed for a 100 keV thermionic source.
- It's been adapted to 100 keV and 130 keV polarized sources of three types over twenty years, including fallback to thermionic for the UIUC vertical gun.
- Let's start from a blank piece of paper and design an injector to do the best possible job for PVES experiments. These are the most demanding contemplated so if we can satisfy these, we satisfy all. We may not be able to satisfy MOLLER but we should at least simulate and build the best possible.