MOLLER Spectrometer Update

October 2018 MOLLER Collaboration Meeting

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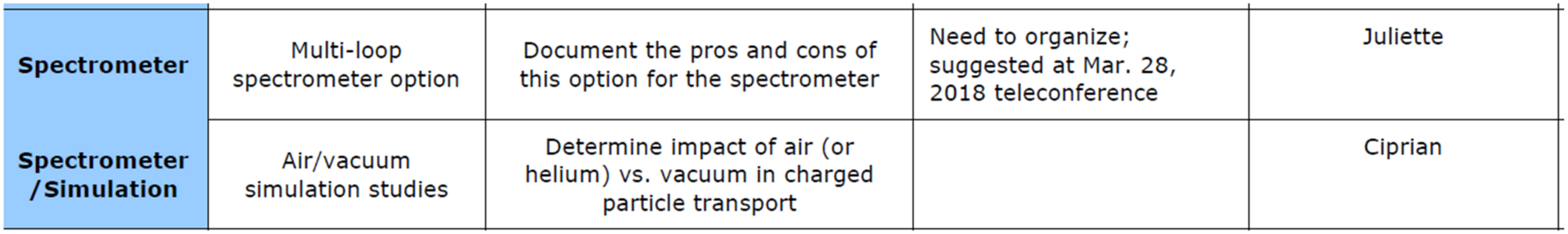
Moller Task Lists

Spectrometer-specific

Spectrometer /Simulation	Material Irradiation/Activation	Quantify radiation load and activation of primary components	Rakitha (LaTech) working on it, Juliette will tabulate materials,components and regions to be evaluated. Depends on complete FLUKA simulation to get this results. Simulation development on going, will take couple of months for first results. (Rakitha Priority 5)_	Juliette* ,Rakitha
Spectrometer /Simulation	Radiation load on hybrid toroid nose	More careful evaluation of local radiation load to determine survival of epoxy	Rakitha (LaTech) working on it. Feedback from Juliette and MIT engineers on epoxy specification. Analysis on going and expect results in one month. (Rakitha Priority 3)	Juliette*,Rakitha
Spectrometer	Tolerance analysis	Based on physics requirements to control systematics	Juliette working on it	Juliette
Spectrometer	Impact of environmental variations	Evaluate potential variation in performance and impact on physics requirements over time	Juliette and MIT to strategize and evaluate?	Juliette
General	Staged running plan	Strategy for multiple year runs with assembly/disassembly	KK, Mark and Kent will review plan	Mark, KK*
General/ Spectrometer	Fringe field impact	Evaluate possible background from fringe fields in the primary beam path	Juliette working on this, will involve Jay when appropriate	Juliette

Moller Task Lists

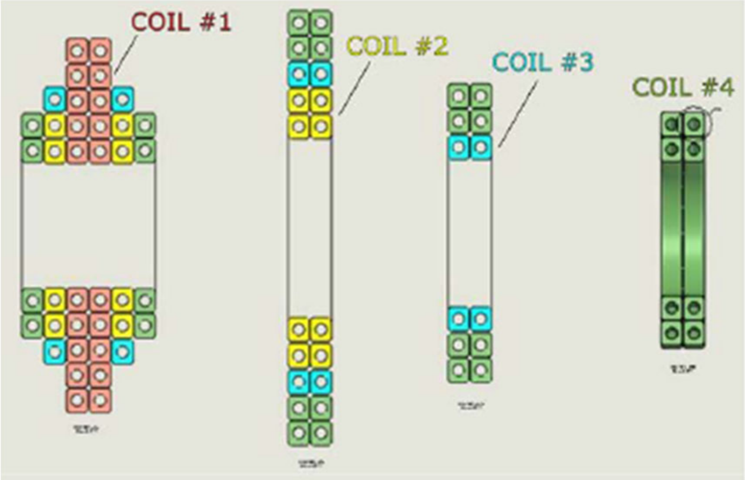
Spectrometer-specific



Spectrometer	Multi-loop spectrometer option	Document the pros and cons of this option for the spectrometer	Need to organize; suggested at Mar. 28, 2018 teleconference	Juliette
Spectrometer /Simulation	Air/vacuum simulation studies	Determine impact of air (or helium) vs. vacuum in charged particle transport		Ciprian

Prototype Coil Status

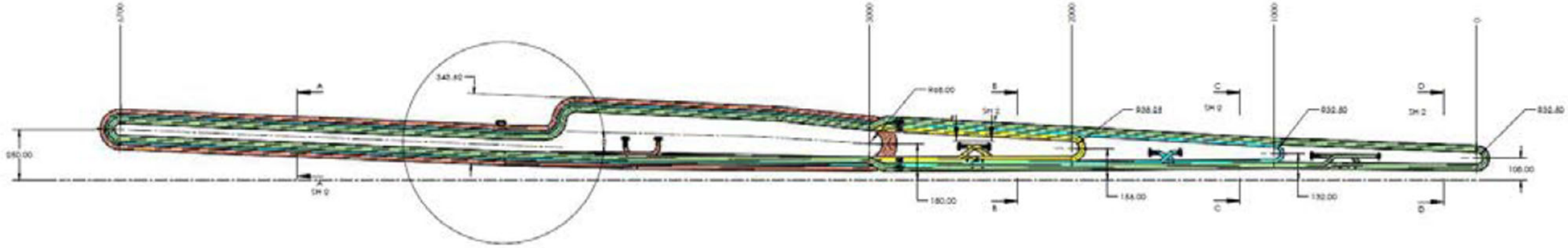
Luvata #8298
11.8x10.3 mm^2, 6 mm Ø



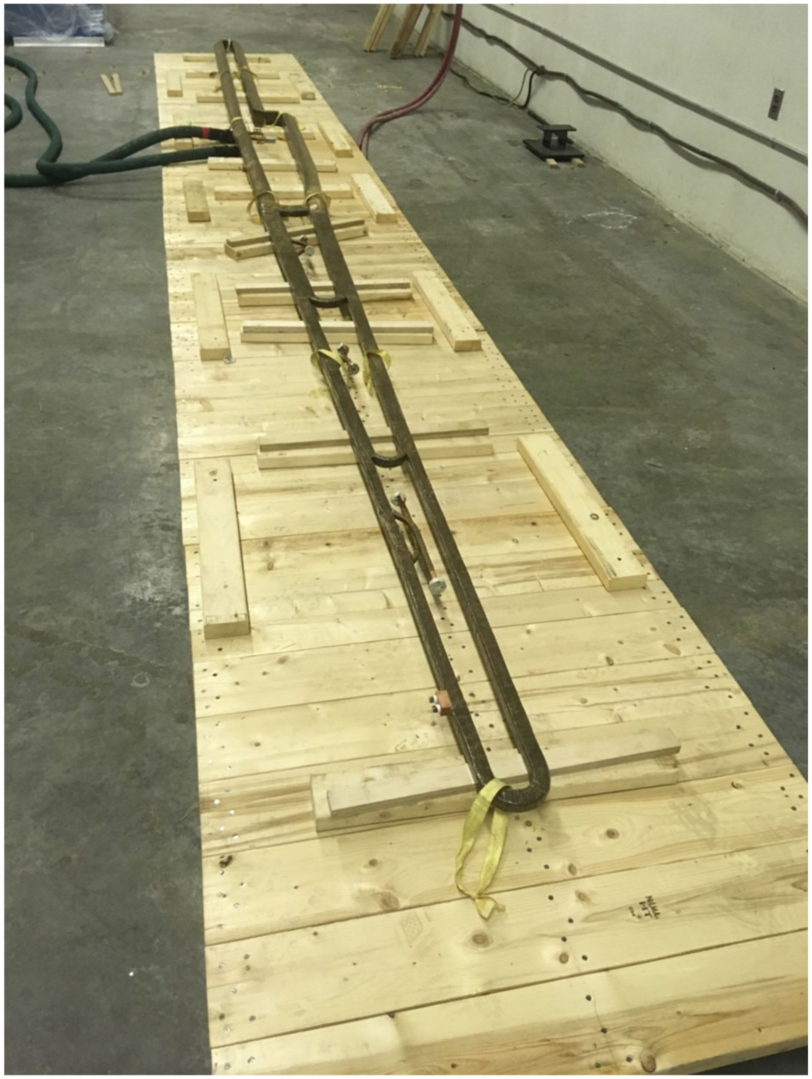
Manufactured at Everson-Tesla
Delivered to MIT-Bates

Coil	**I (A)**	**#**	**J (A/mm^2)**
1	1230	10	13.4
2	1565	4	17.0
3	1425	2	15.5
4	1938	4	21.1

NI (A)	29184	15360	10752	7680	*(nominal)*
	29160	16860	10600	7750	*(prototype)*



Prototype at MIT-Bates



Prototype Tests

- Characterize pressure drop vs water flow rates in all coils with zero current
- Power all coils simultaneously in SERIES and observe steady state temperature of entire coil assembly
- Determine flow rates to regulate coil temperature at various current values for cases where ONLY one coil is energized at any given time.
- Energize each coil to design NI value and higher subject to water flow pressure drop
- Measure temperature distribution of coil (Thermal imaging, RTD)
- Map magnetic field at specific locations

Working with JLAB magnet group

- Began talking to JLAB magnet group in June
  - One-on-one meetings in person and on the phone
  - Giving them CAD and TOSCA models
  - Describing the relevant optics
  - Getting together documentation
- Joint meetings with MIT engineers – end of August
  - Status of conceptual designs by MIT
  - Discussing priorities
  - Coordinating efforts between groups

JLab Magnet Group's involvement (at present) is three-fold:

Jefferson Lab
MAGNET GROUP

1. **Hybrid Torus Coil Design *(Lead: D. Kashy)***
   1. *Study coil design to:*
      - *Trade-off current density, temperature rise, no. of connections etc.*
      - *re-position conductor transitions to avoid clashes*
      - *Locate water/power in/out ports appropriately*
   2. *Produce initial 'coil-only' engineering winding design. Further iterations on mechanical and magnetic issues will be required*
2. **Vacuum vs Helium Environment *(Lead: S. Gopinath)***
   1. *Examine pros and cons of vacuum vs Helium environments from both the Physics and Engineering points of view*
   2. *Produce concept engineering solutions for environment transitions and windows*
3. **Upstream and/or Hybrid Torus design study *(Lead: P. Ghoshal*)**
   1. *to 'balance loading' between magnets to reduce risk on both designs*
   2. *to explore the possibility for installation in Hall C*

Large Phase Space for Design

I. Large phase space of possible changes
    A. Field (strength, coil position and profile)
    B. Collimator location, orientation, size
    C. Choice of Primary collimator
    D. Detector location, orientation, size

II. Large phase space of relevant properties
    A. Moller rate and asymmetry
    B. Elastic ep rate and asymmetry
    C. Inelastic rate and asymmetry
    D. Transverse asymmetry
    E. Neutral/other background rates/asymmetries
    F. Ability to measure backgrounds (the uncertainty is what's important)
        1. Separation between Moller and ep peaks
        2. Profile of inelastics in the various regions
        3. Degree of cancellation of transverse (F/B rate, detector symmetry)
        4. Time to measure asymmetry of backgrounds (not just rate)
    G. Beam Properties (location of primary collimator)

Large Phase Space for Design

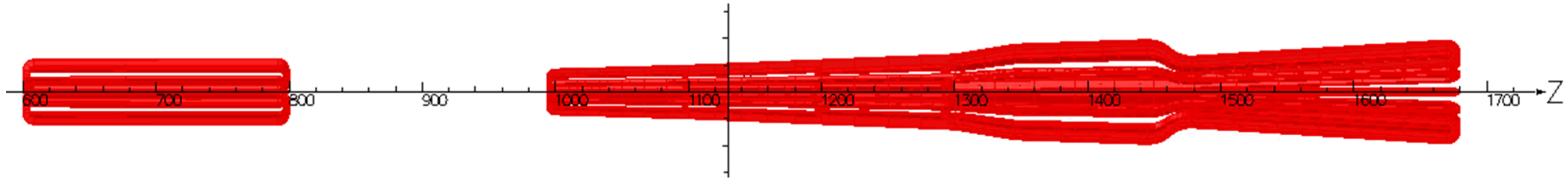
FOM: Moller (ee) and elastic ep (ep) rate and asymmetry
Neutral/other background rates/asymmetries
ee and ep focus and separation

Parameters:

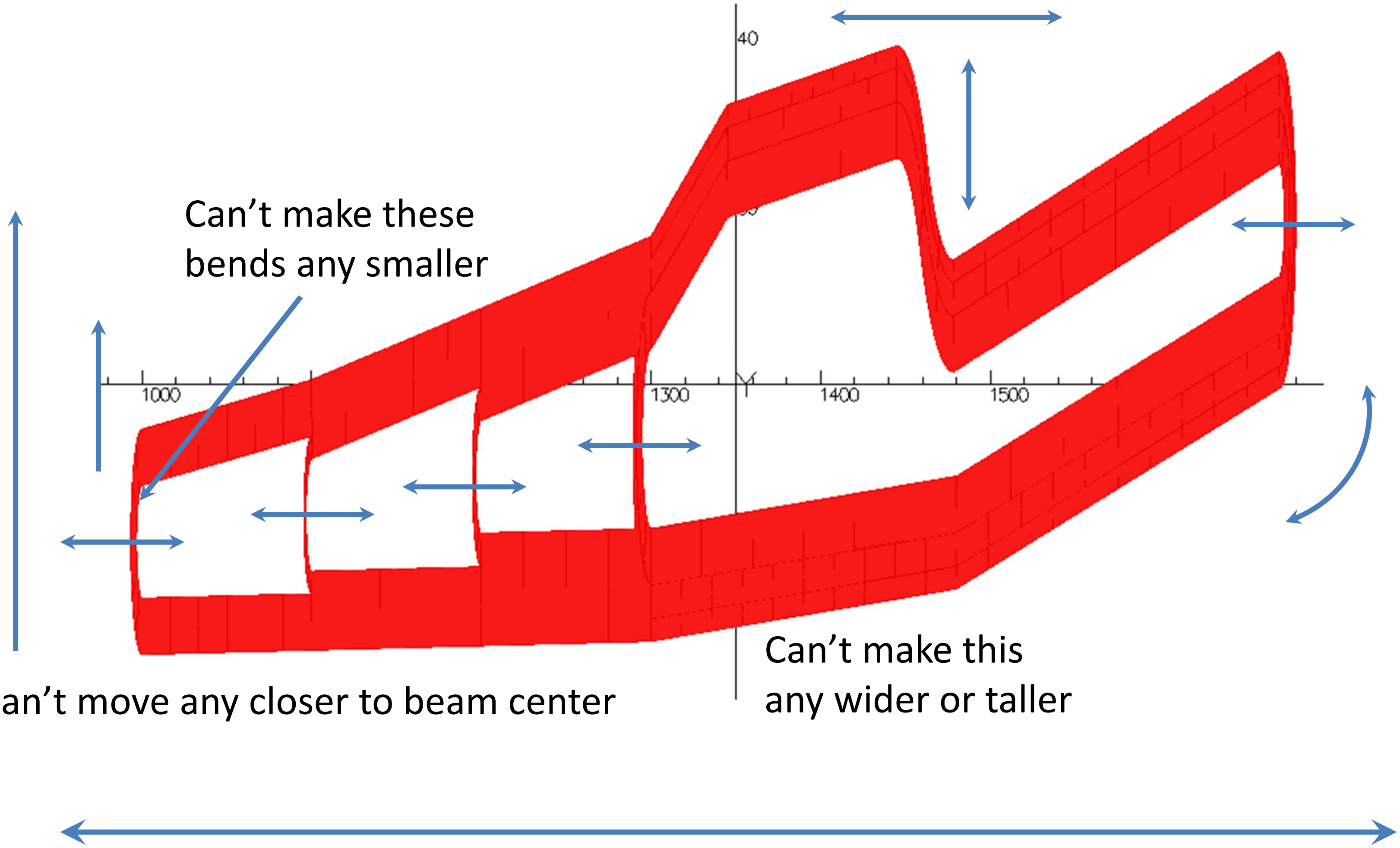
1. Strength of field integral
    a) Current density
    b) Length
2. Coil positions
    a) z
    b) radius

Constraints:

- Need to obey “keep-in” zones
    - Half azimuth between tracks
    - Full azimuth under tracks
    - no closer than 5x mult. scatt. radius
- Can’t have bends > 5 OD conductor
- Keep current density as low as possible



Constraints on the Current Distribution

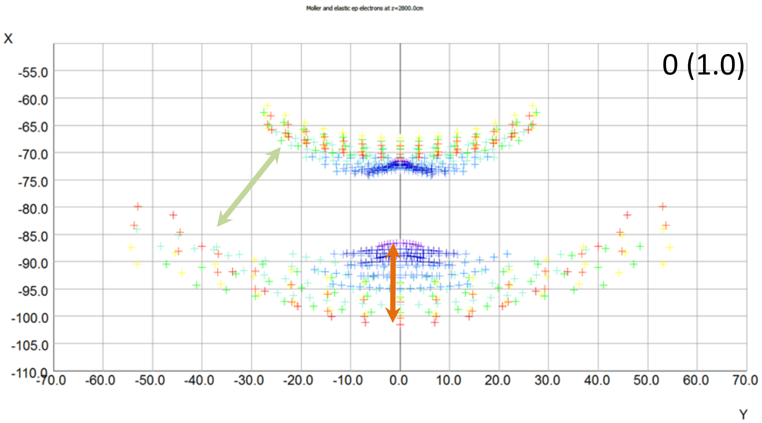


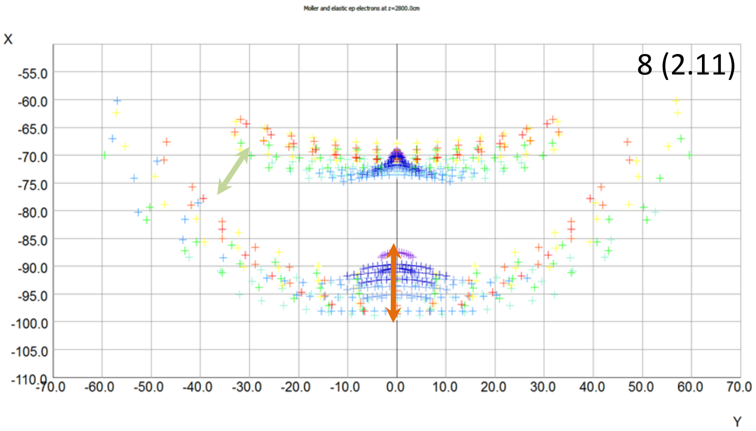
Can’t make these
bends any smaller

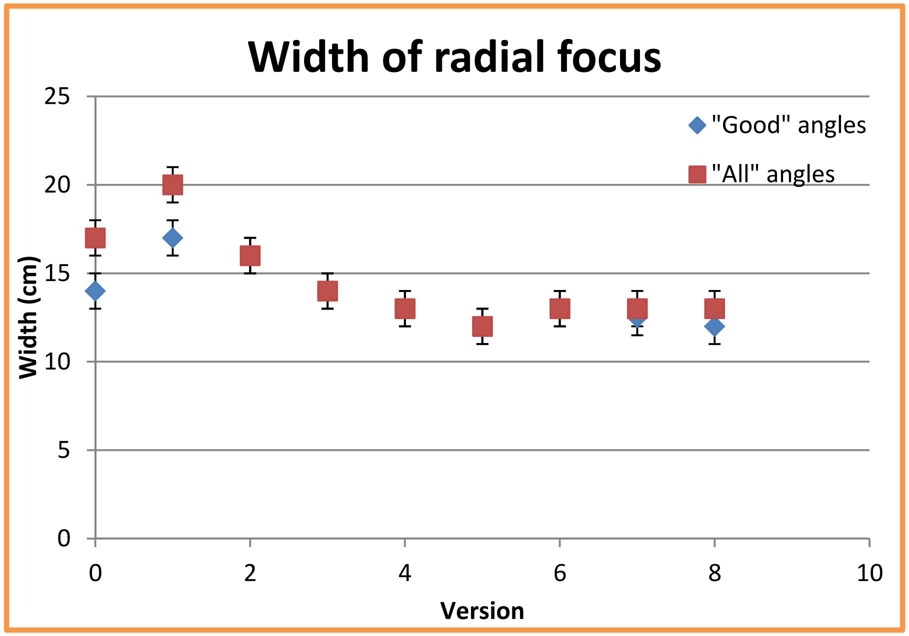
Can’t move any closer to beam center

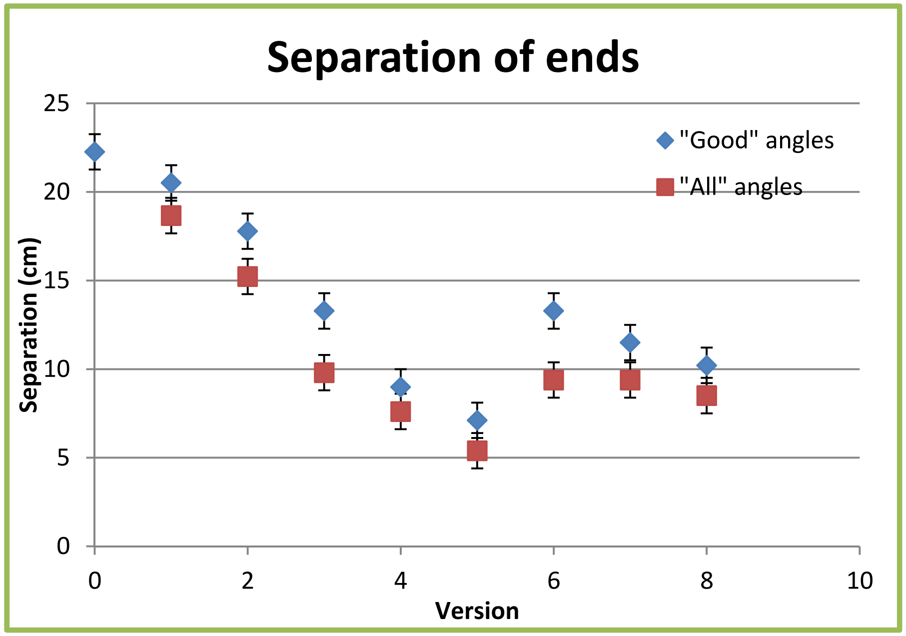
Can’t make this
any wider or taller

Preserving the optics

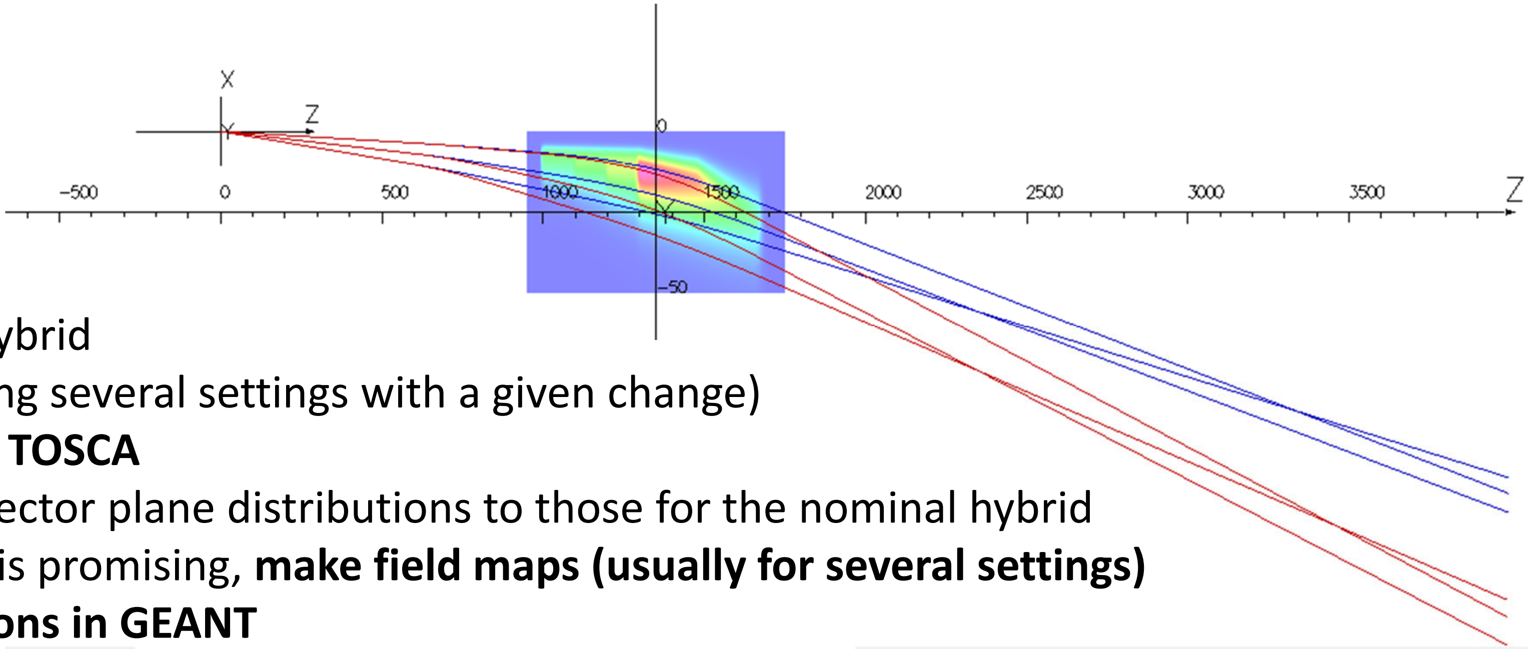






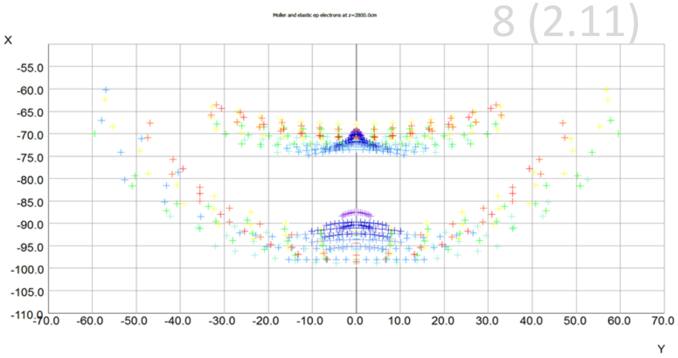


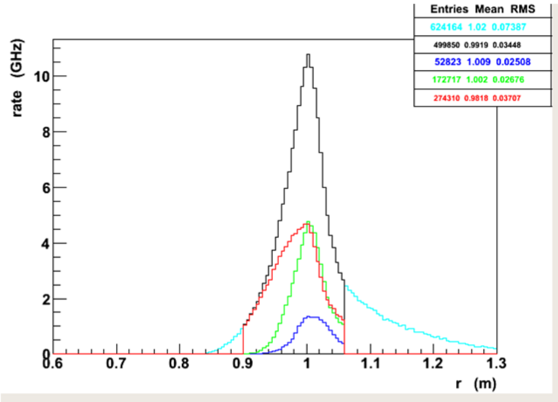
Exploring the parameter space



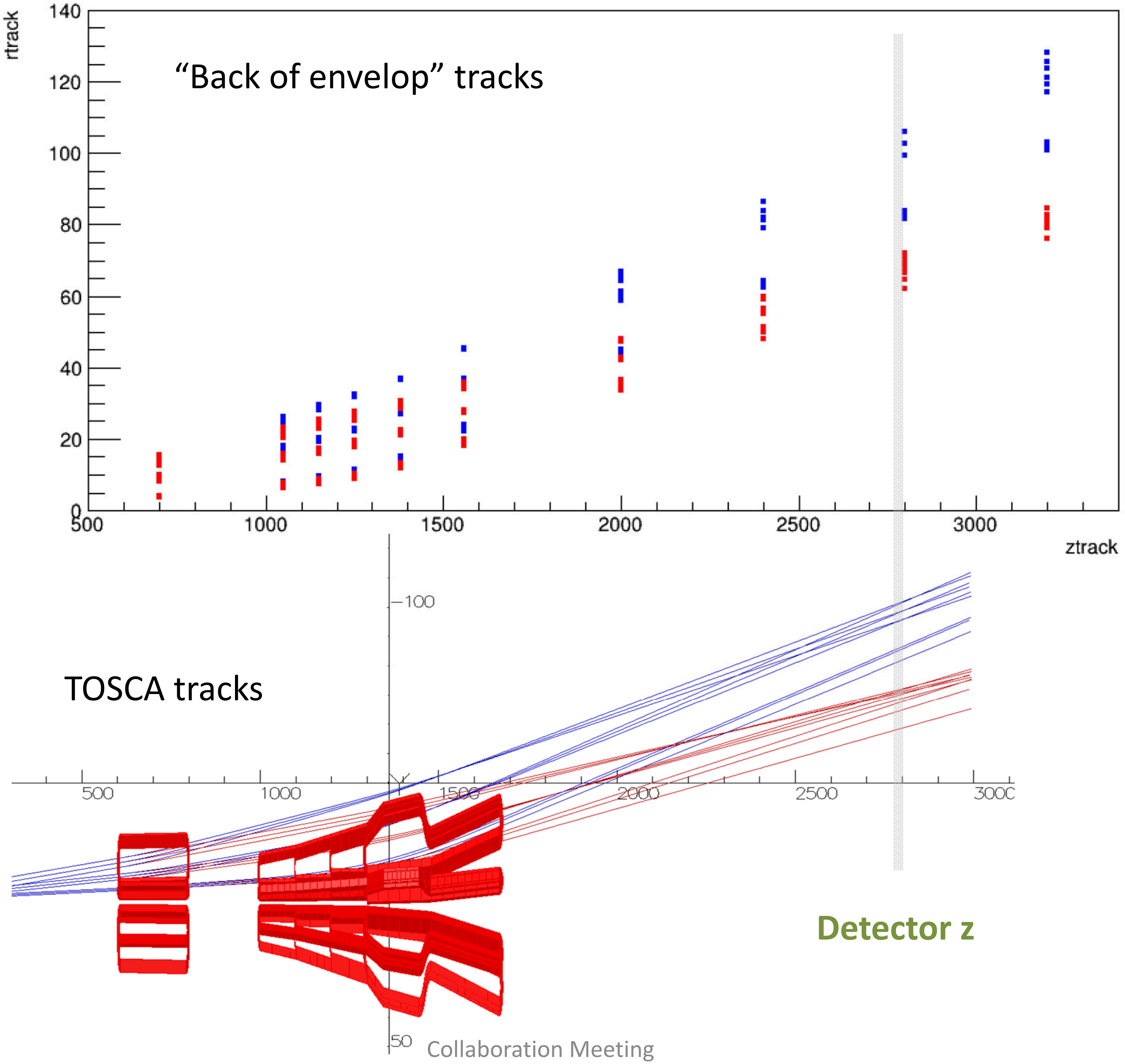
Steps:

1. Modify the hybrid
   (usually making several settings with a given change)
2. **Run tracks in TOSCA**
3. Compare detector plane distributions to those for the nominal hybrid
4. If something is promising, **make field maps (usually for several settings)**
5. **Run simulations in GEANT**
6. Look for Moller and elastic ep rates, asymmetries and background percentages





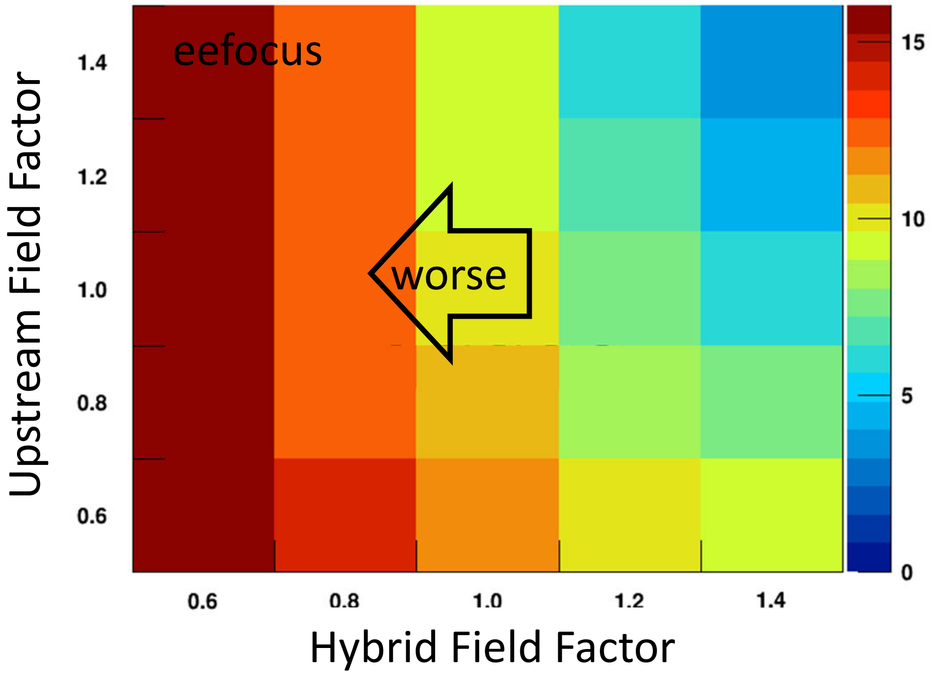
Entries	Mean	RMS
624164	1.02	0.07387
499850	0.9919	0.03448
52823	1.009	0.02508
172717	1.002	0.02676
274310	0.9818	0.03707

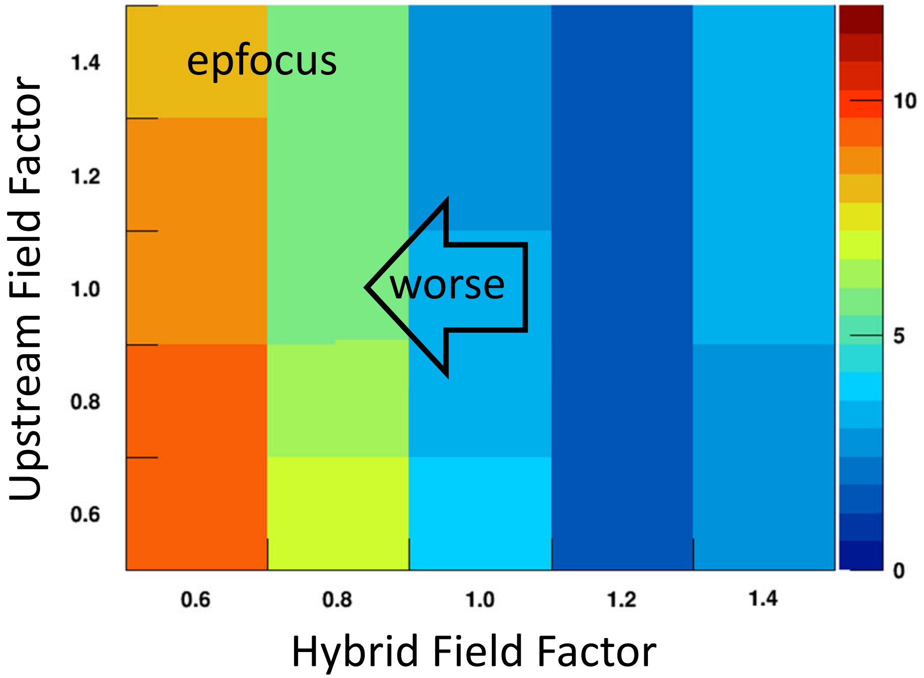


“Back of envelop” tracks

TOSCA tracks

Detector z



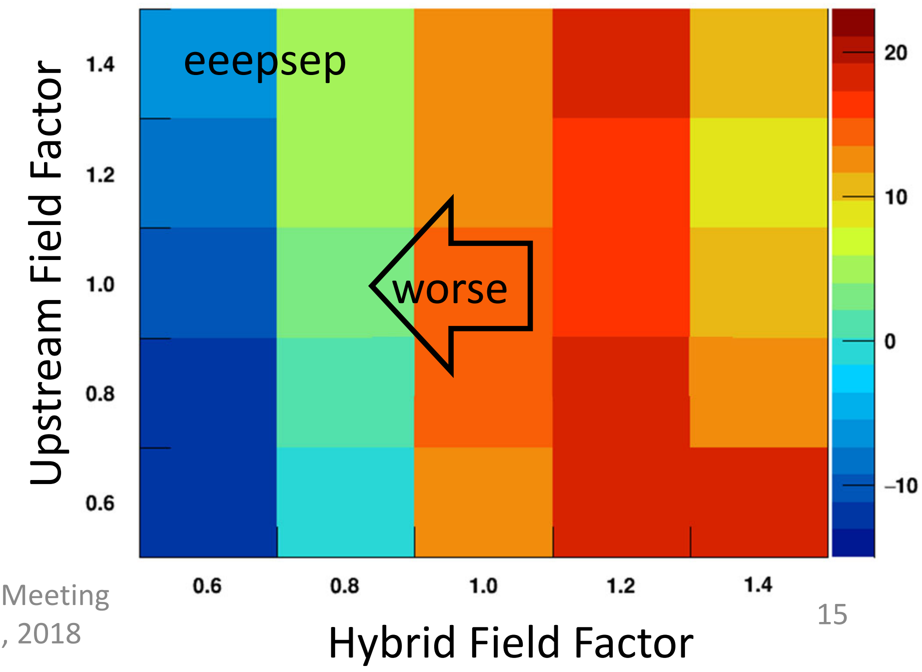


Plots of focus (top) and peak separation (bottom) in cm for different scale factors for the upstream vs. downstream field

eefocus - 0-16 cm,
epfocus - 0-12 cm, } red is worse

eeepsep - 15-23 cm red is better

Better focus and separation for higher current densities in hybrid torus



Back of the envelop calculations

Parameters:

1. Strength of field integral
    a) Current density
    b) Length
2. Coil positions
    a) z
    b) radius

Use iterative formula in C++ code for

low angle, mid-range and high angles

for

ee and ep events

from

upstream, middle and downstream parts of target

18 tracks

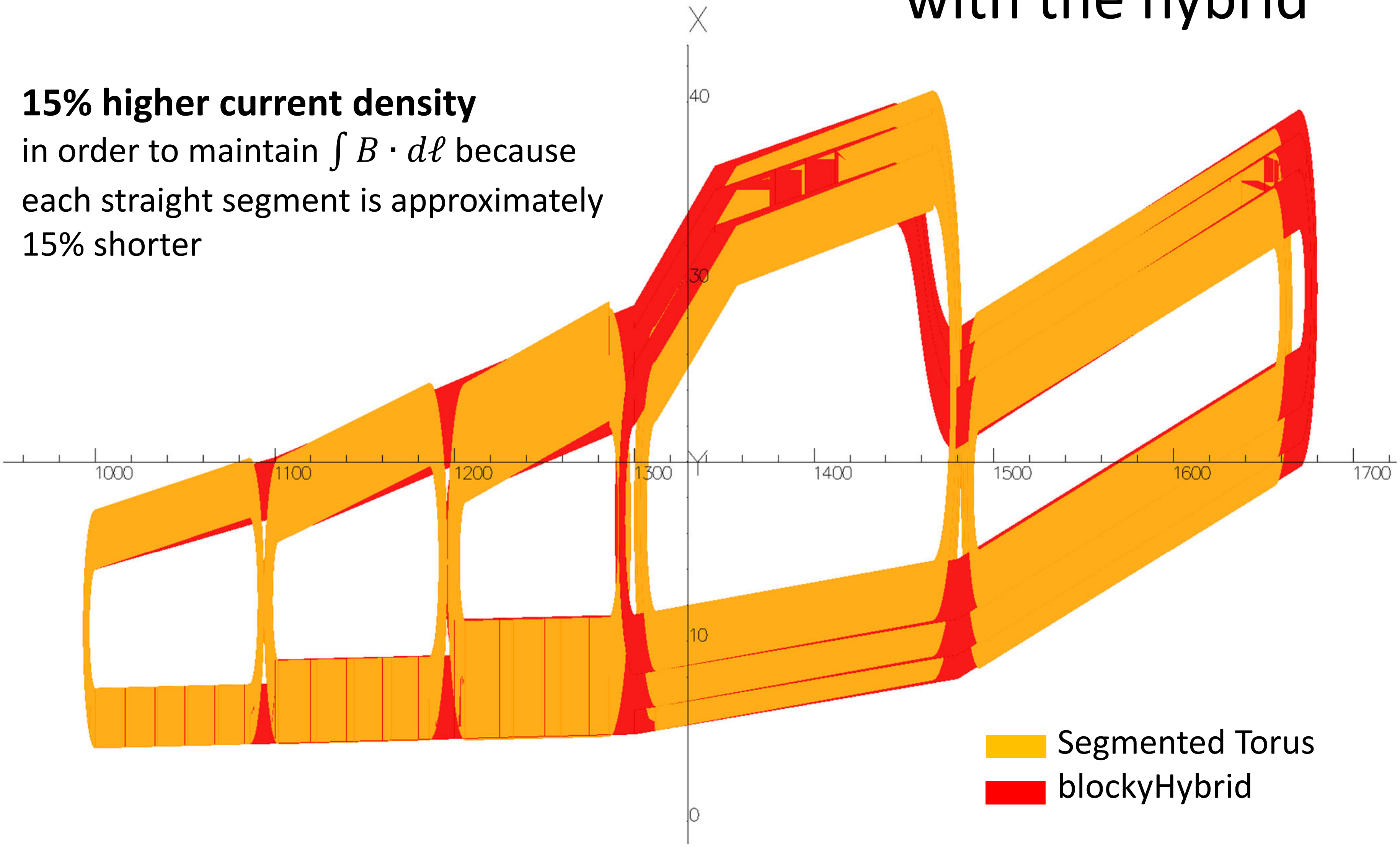
Look for all possible combinations of field strengths by applying a factor "B" to the field from TOSCA

Calculate the focus for each type of particle (stdev of radii at detector plane) and the separation of the envelopes at the ends (includes rough estimate of phi defocusing)

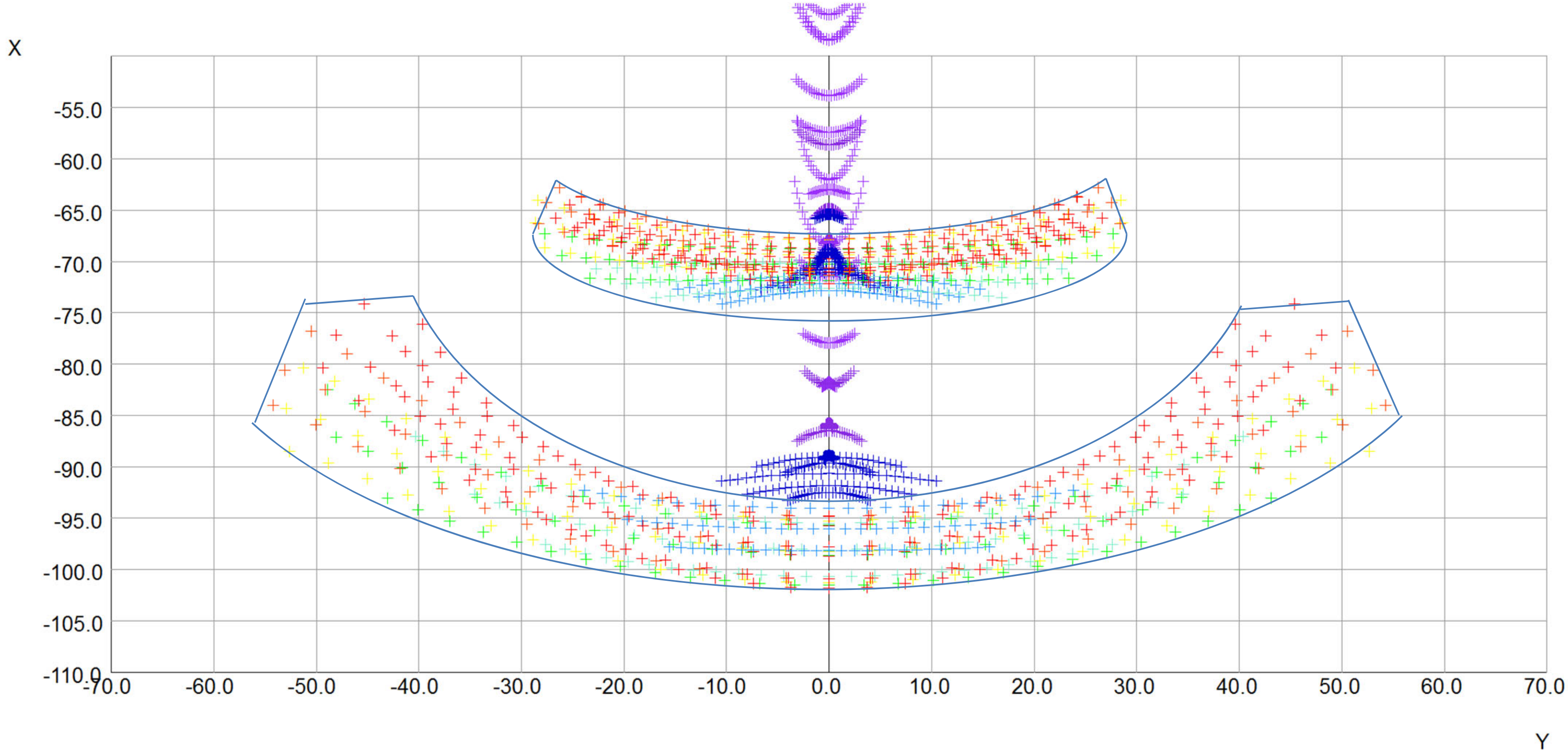
6 segments, try 5 settings of each – 5^6 = **15,625 combinations**

Exploring ideas in case there is a showstopper with the hybrid

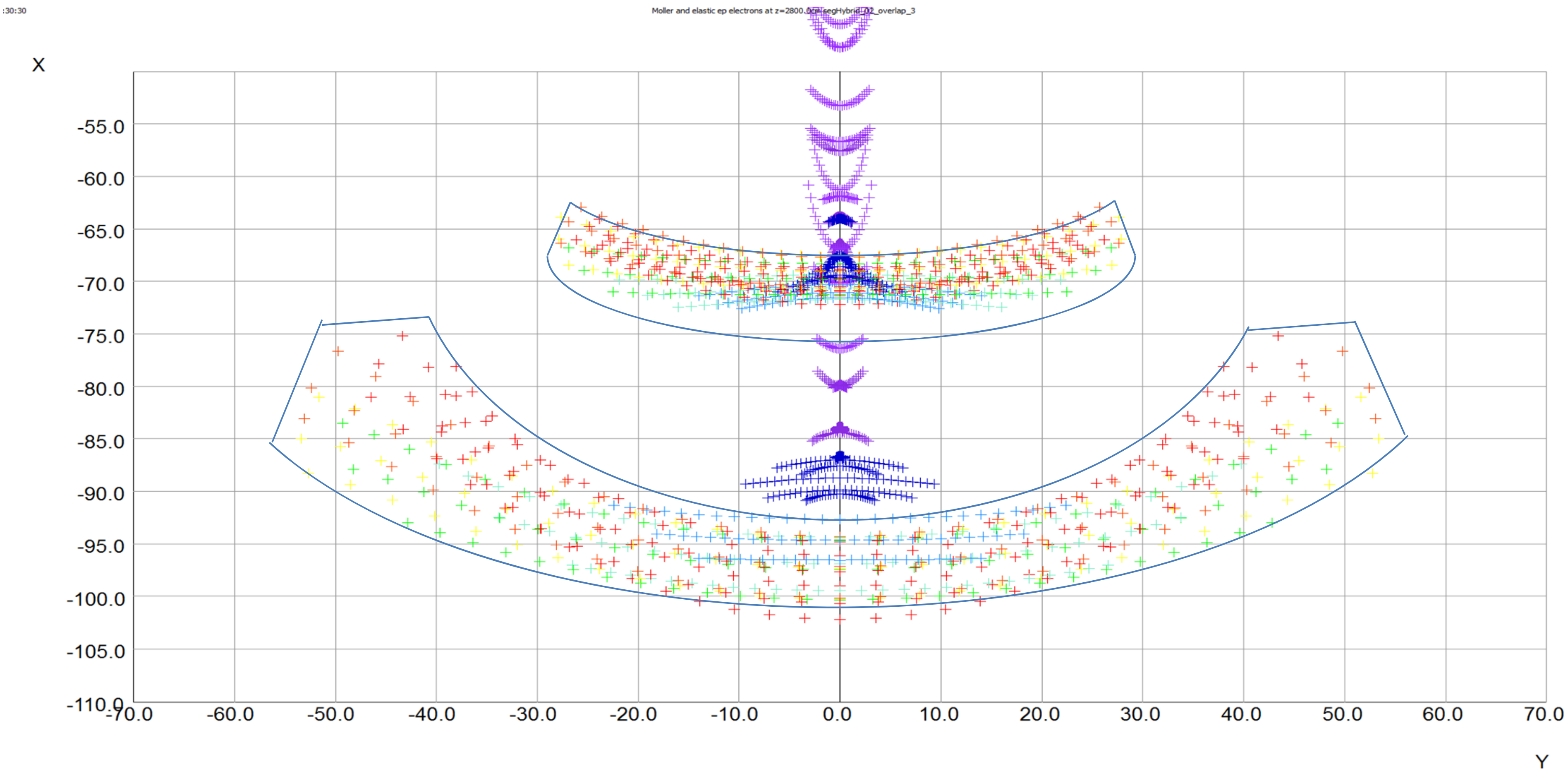
15% higher current density
in order to maintain $\int B \cdot d\ell$ because each straight segment is approximately 15% shorter



blockyHybrid



Segmented Torus
shortened straight sections, increased current density



Further Work

- Complete prototype tests
- Summarize cost/benefits of drift media
- Iterate with engineers on supports, water-cooling
- Continue with parameter space study
  - Cross-check sensitivities
  - Explore additional parameters (z, radius)
  - Need a phase space search algorithm

Show there is no solution with lower current densities that preserves the optics

- Have water-cooling calculations/conceptual comparisons of large conductor hybrid and segmented torus
- Prepare for a Magnet Advisory Group meeting