# Initial fast particle results from a candidate quasiaxisymmetric stellarator configuration

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# Thea Energy is a Private Stellarator Company Utilizing a Proprietary Magnet Scheme

- Thea's magnetic confinement scheme is based off the standard stellarator geometry
- Will avoid the complex 3D magnet coils common in traditional stellarators by employing a simplified system of planar coils (see right figure)
- Fast ion populations will include neutral beams and fusion products
- Initial design will act as a neutron source and contain a blanket for tritium production; later concepts will focus on fusion energy

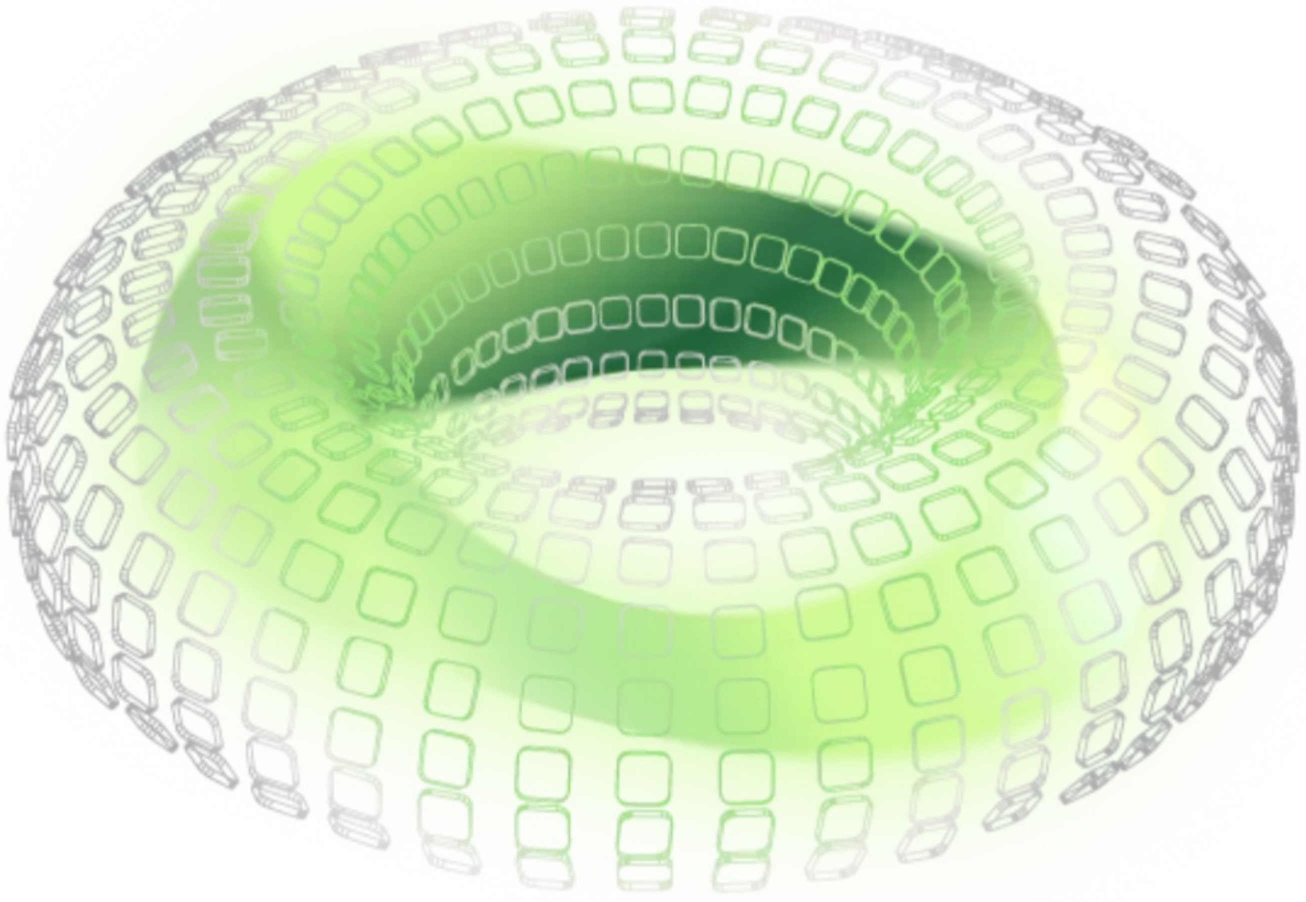


*Figure taken from thea.energy*

# Goal: Understand Fast Ion Confinement in Thea's Unique Stellarator Geometry

Problem: Stellarators traditionally suffer from strong neoclassical transport which leads to poor fast ion confinement. Numerical optimization techniques have been deployed to minimize this transport and enhance fast ion confinement.

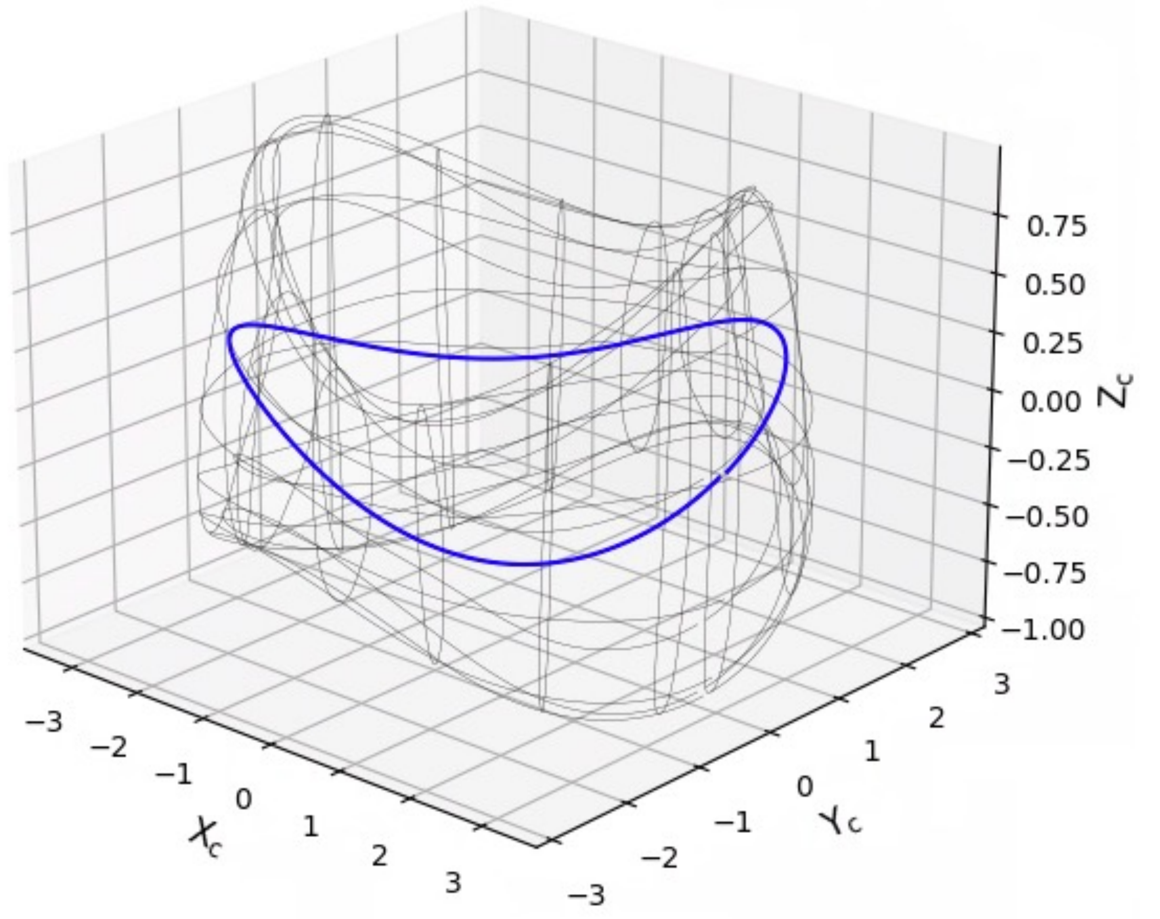
Project Goal: Thea will have optimized equilibria in which the fast ion confinement will need to be assesed

Project Steps

1. Obtain optimized stellarator equilibria from Thea's proprietary magnet system
2. Obtain realistic fast ion distributions – both neutral beam deposition and fusion profiles
3. Perform ASCOT5 simulations to numerically determine the nature of the fast ion confinement: loss time, loss location, phase-space dependence, etc.

# Step 1: Optimized Equilibria have been Created

- Optimized magnetic equilibria have been obtained with the VMEC[a] and DESC[b] codes
- Equilibria include both free and fixed boundaries
- First wall is currently a simple bounding box as engineering constraints determine the final geometry
- Equilibria are continually updated as machine design and optimization are edited and finalized



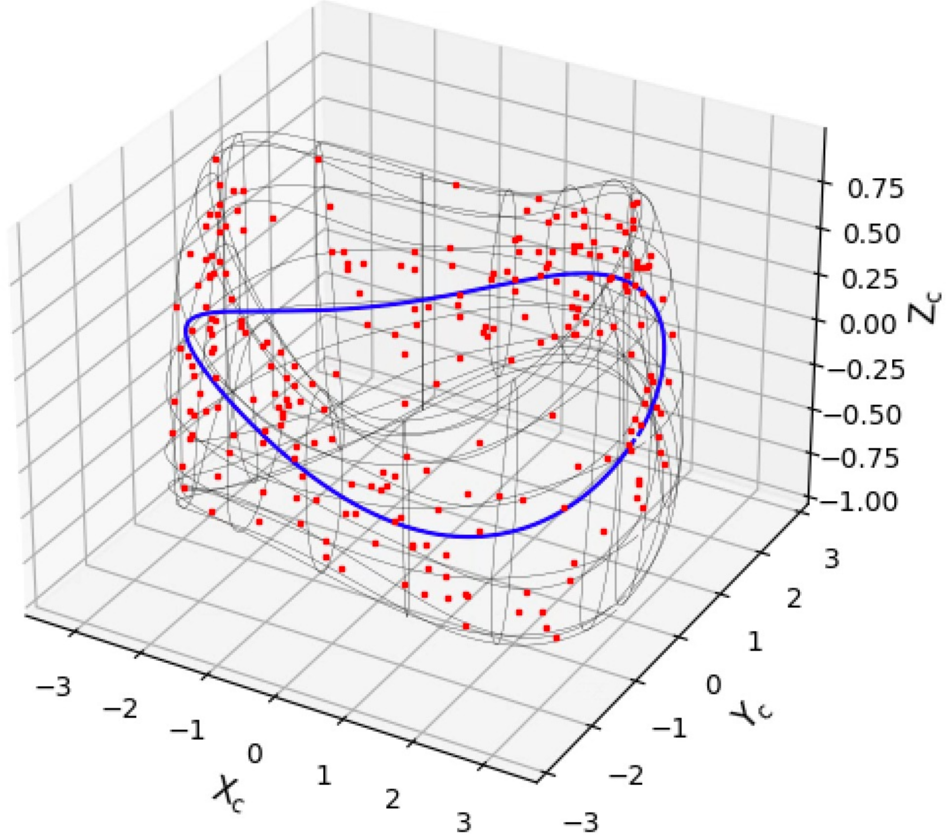

*Example equilibria from VMEC*
*Magnetic Axis*
*Last Closed Flux Surface*

[a]*S.P. Hirshman Comp. Phys. Comm. 1986*
[b]*D. Dudt J. Plasma Phys. 2023*

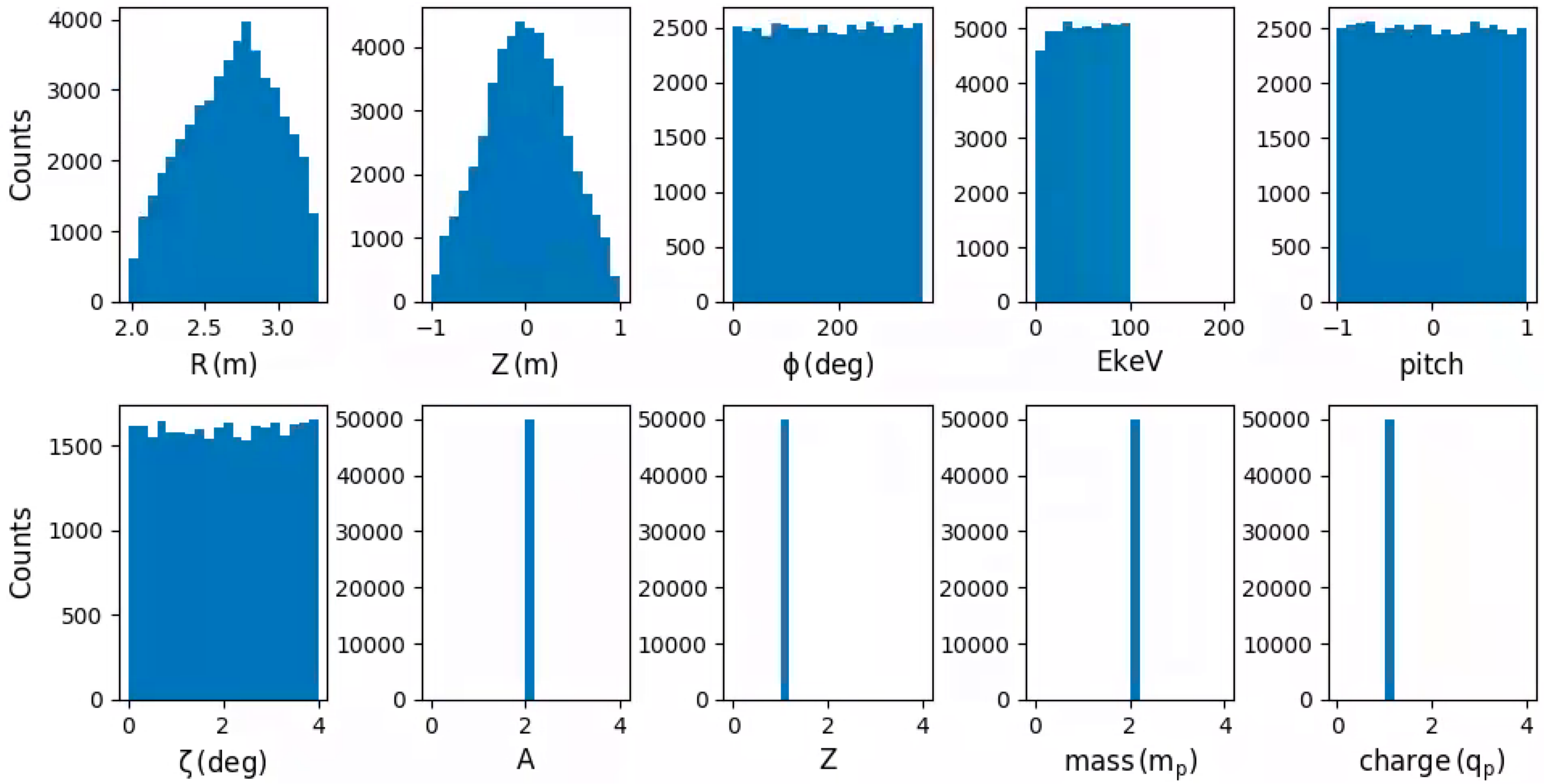
# Step 2: Uniform Distribution of Fast Ion Markers Provides an Initial Step

- Uniform sampling of fast ion markers is the easiest and quickest method for initial analysis
  - RZ bounds are kept within the last closed flux surface
- Can provide phase-space sensitivity as all regions of the distribution domain are sampled/covered

*Uniform Marker Positions*



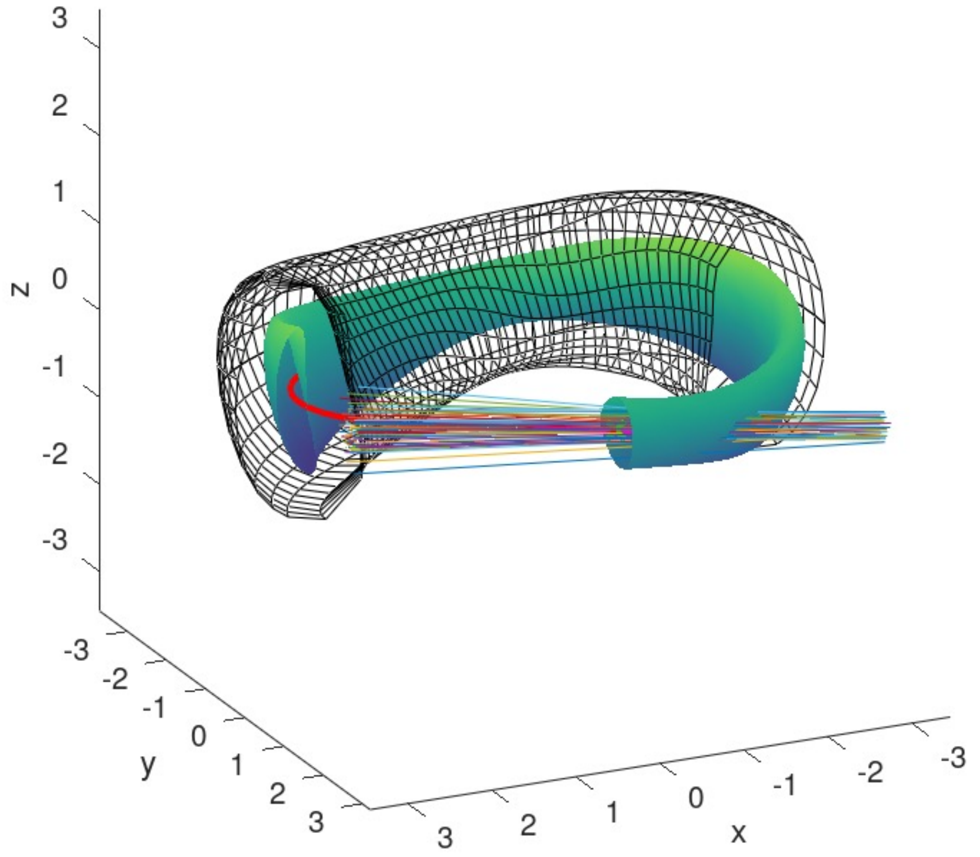

*Uniform Sampling Distribution*



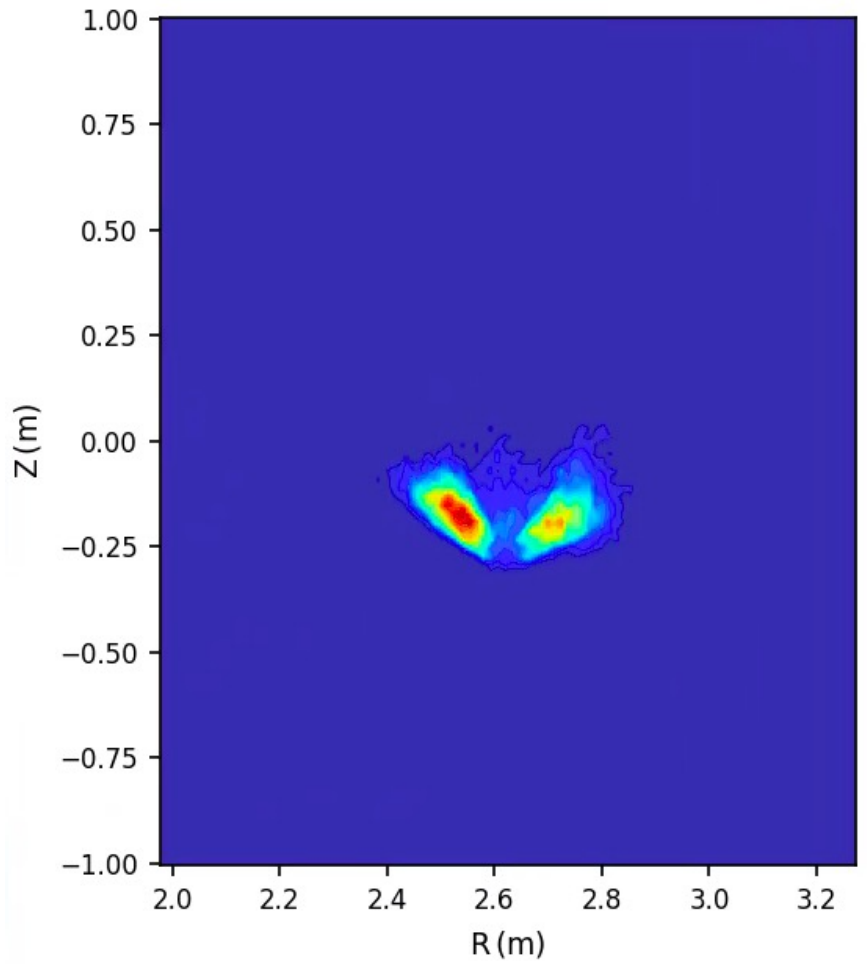
# Step 2: Theoretical NBI Beamlets Provide an Initial Estimate for Fast Ion Deposition

- Generalized NBI beamlets can find initial fast ion deposition as NBI geometry is finalized and charge-exchange interactions are numerically solved

*Initial NBI Beamlets*



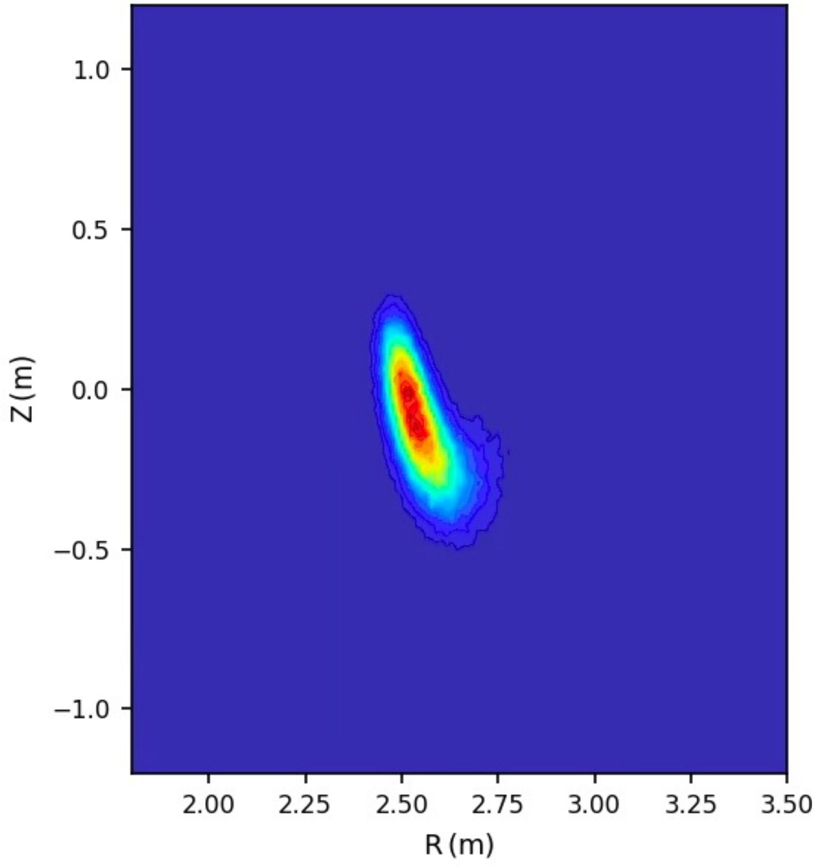

*Beamlet RZ-Deposition*



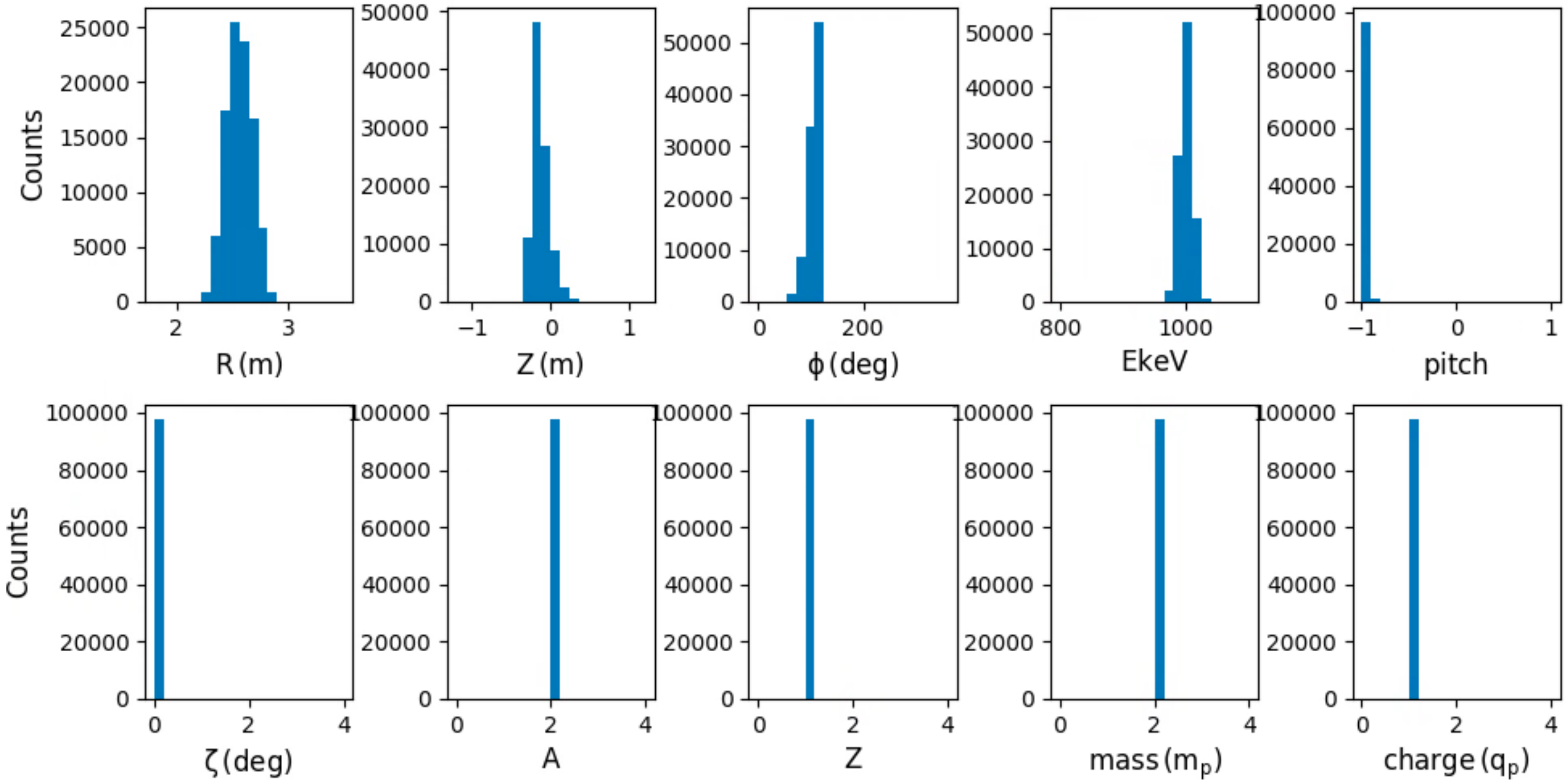
# Step 2: BEAMS3D NBI Distribution is Most Realistic

- BEAMS3D[a] provides a realistic NBI deposition in stellarator geometries
- 1 MeV, D-NBI gives deposition below for fast ion marker initialization in ASCOT5
  - Injection geometry gives core-localized, counter-passing, limited in $\phi$

*BEAMS3D RZ-Deposition*




*BEAMS3D NBI Distribution*




[a]*M. McMillan and S.A. Lazerson Plasma Phys. Control. Fusion 2014*

# Conclusions and Future Work

- Optimized equilibria have been obtained from Thea Energy with their unique magnet system
- Fast ion distributions have been created for orbit modeling from uniform phase-space sampling, theoretical NBI beamlets, and the BEAMS3D code
- ASCOT5 simulations are underway to assess the NBI fast ion confinement
  - Assessment of fusion product confinement will follow
- Iteration will occur as details on the equilibria and fast ion distributions are fine-tuned