Scoping studies for the divertor design in optimized stellarators

H. Frerichs[1], J. Schmitt[3], A. Bader[1], M. Cianciosa[2], T. Kruger[1], O. Schmitz[1]

[1]Department of Engineering Physics, University of Wisconsin – Madison, WI, USA
[2]Oak Ridge National Laboratory, Oak Ridge, TN, USA
[3]Auburn University, Auburn, AL, USA

Introduction

- Control of particle and energy exhaust is essential for successful operation of next step magnetic confinement devices
- Presently, however, even a post-processing approach is not well established in stellarator optimization
- Development of reliable tool chain for assessment of divertor performance is ongoing

Plasma boundary modeling requires magnetic field information beyond the last closed flux surface (VMEC boundary), but also needs to take into account finite β effects

→ **combine information inside and outside LCFS**

Scoping study based on field line diffusion

- Offset surfaces from VMEC boundary

Targets for equilibrium optimization (ROSE) → Poster by A. Bader

- Quasi symmetry (at s = 0.6)
- Energetic particle confinement (γ_c at s = 0.2, 0.4, 0.6)
- Presence of magnetic well
- Constraint $\varepsilon_{eff} < 0.01$

VMEC equilibrium

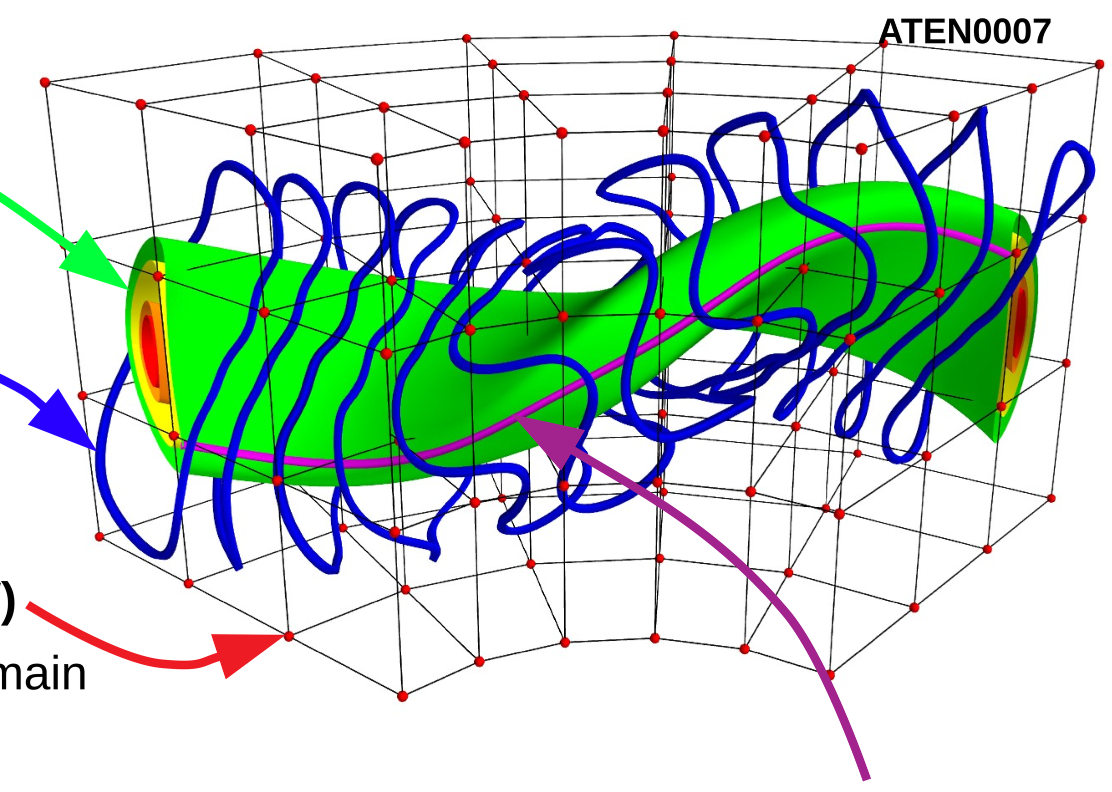
- 121 surfaces

Coil implementation (FOCUS) initialized from REGCOIL with offset 22 cm

- Minimum coil to plasma (VMEC) boundary separation: 19 cm

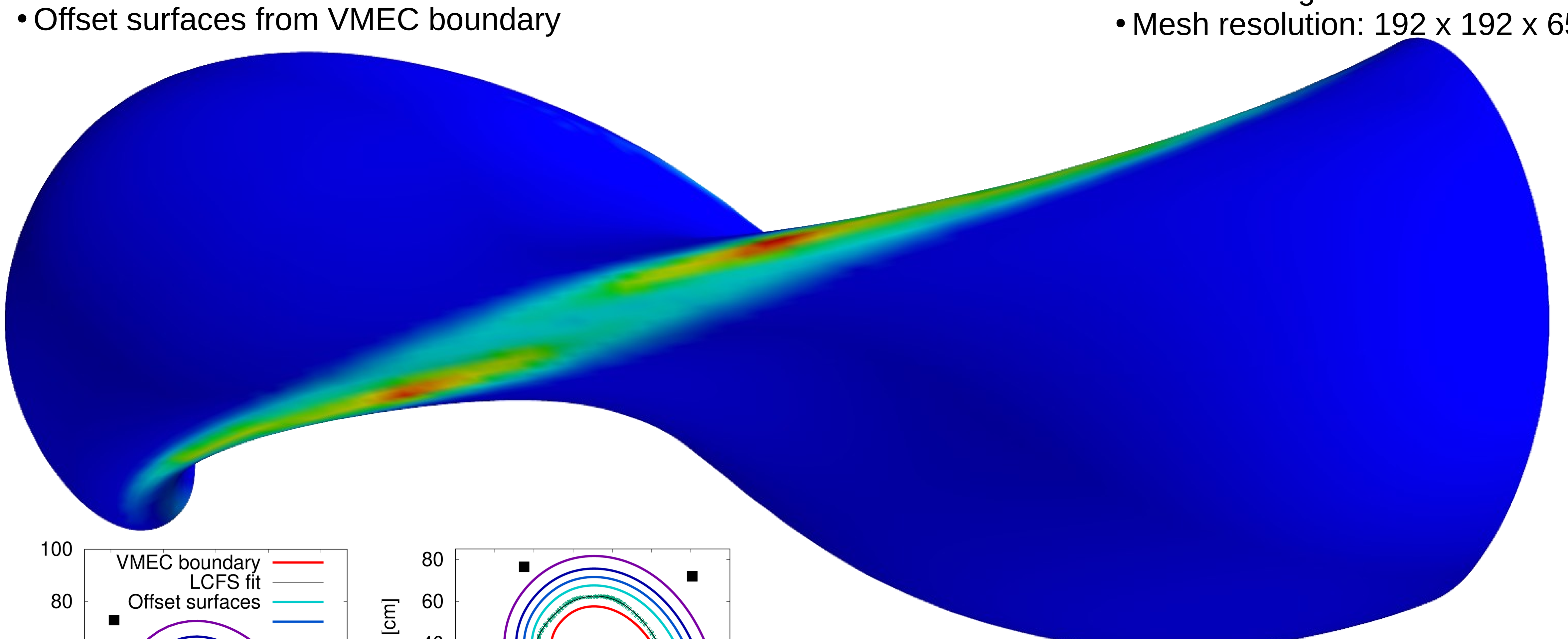
Vector potential on cylindrical grid (BMW)

- Volume integral over currents in VMEC domain
- Mesh resolution: 192 x 192 x 65



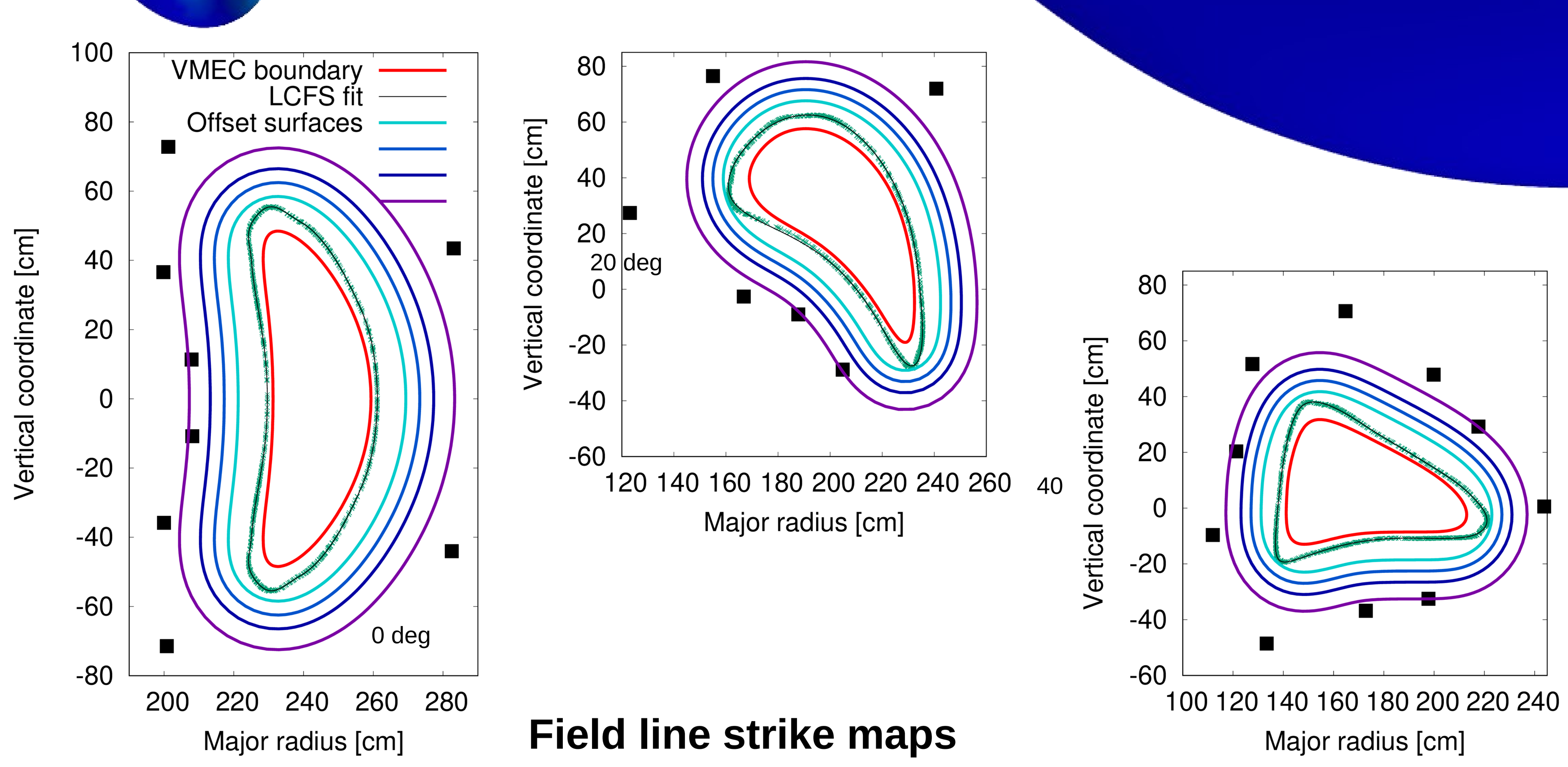
Field Line Analysis and Reconstruction Engine (FLARE)

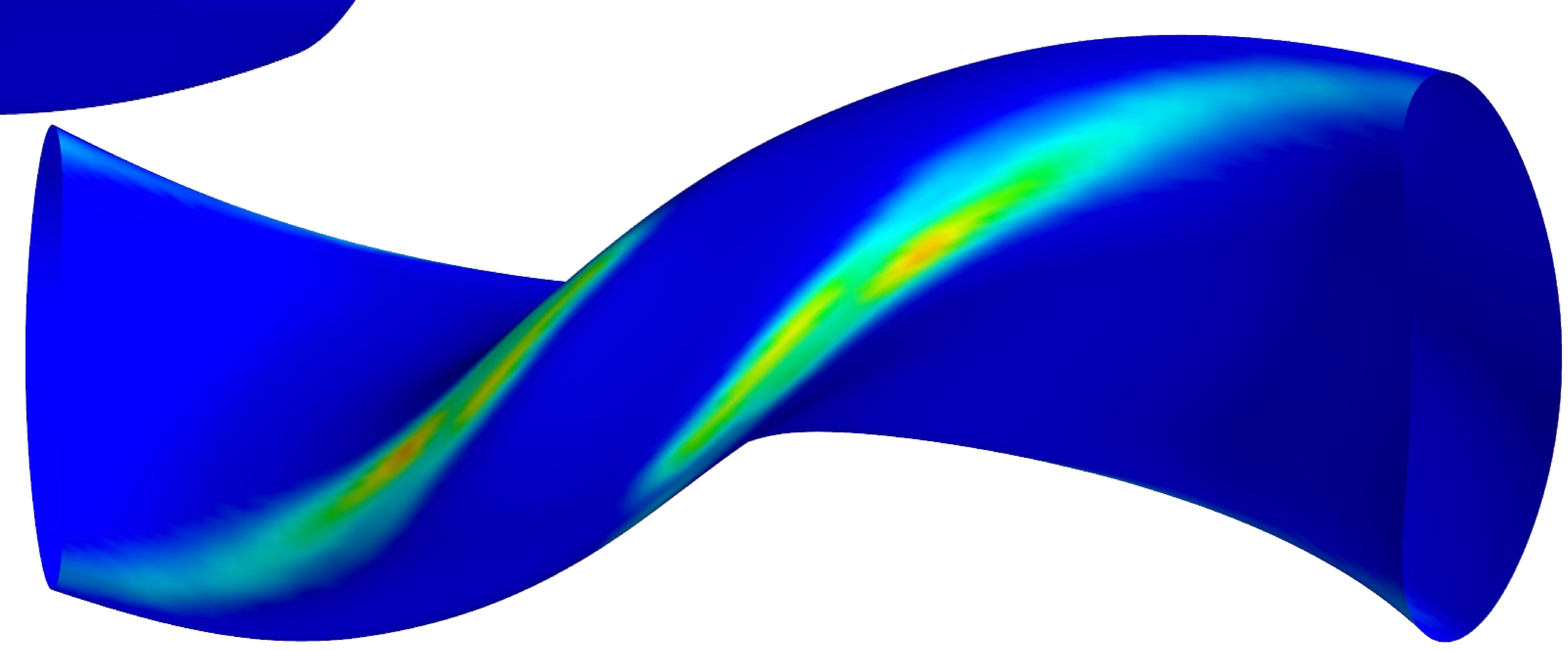
- 3D B-Spline based interpolation of vector potential
- Field line tracing $\frac{dR}{d\varphi} = R\frac{B_R}{B_\varphi}$ $\frac{dZ}{d\varphi} = R\frac{B_Z}{B_\varphi}$



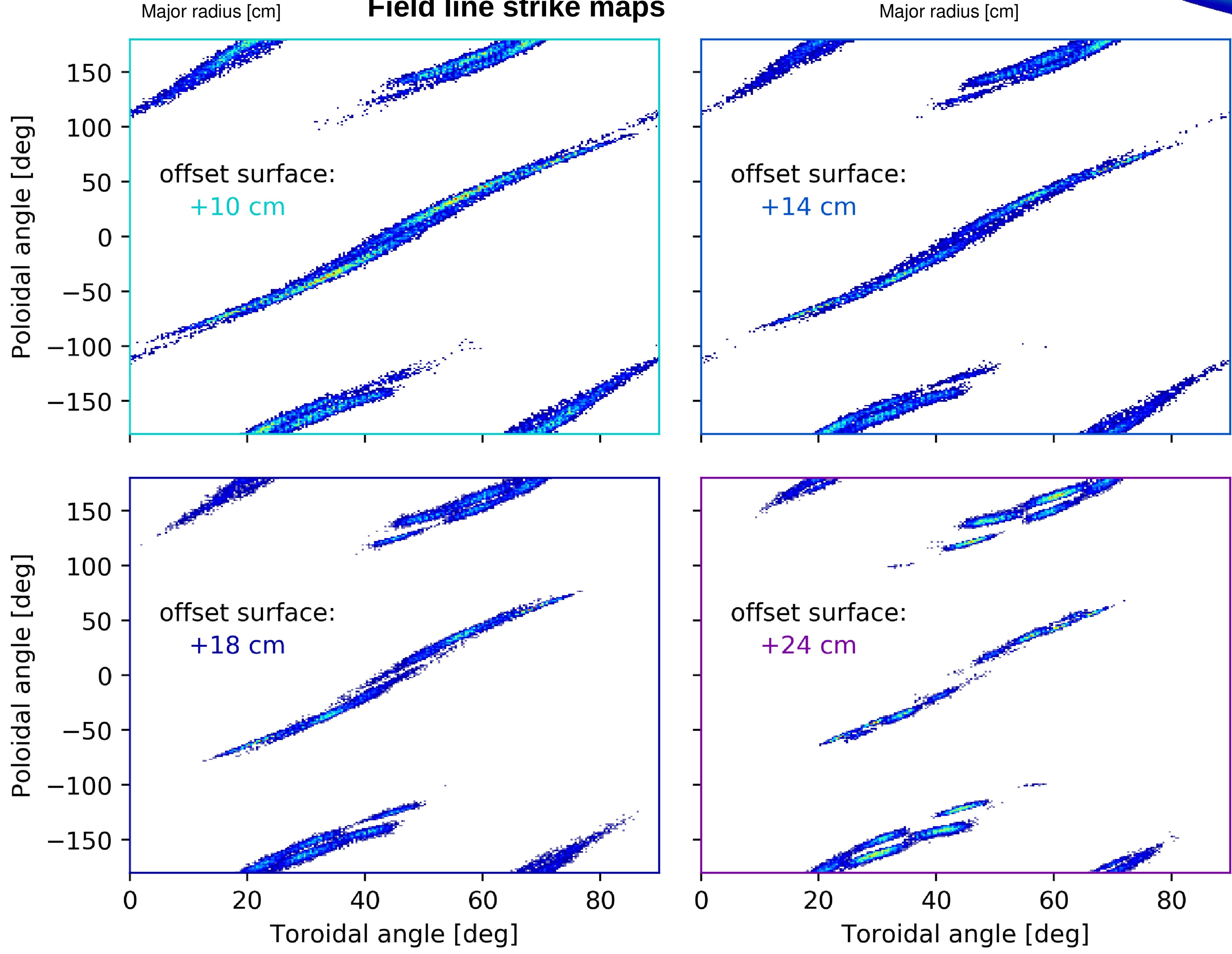
Outlook

- Optimize divertor plate geometry for minimal particle and heat loads (trade-off between flexibility in magnetic configuration for research stellarators and performance for reactor type stellarators)
- Baffles for neutral gas compression important for particle exhaust (pumping) and core contamination → EMC3-EIRENE



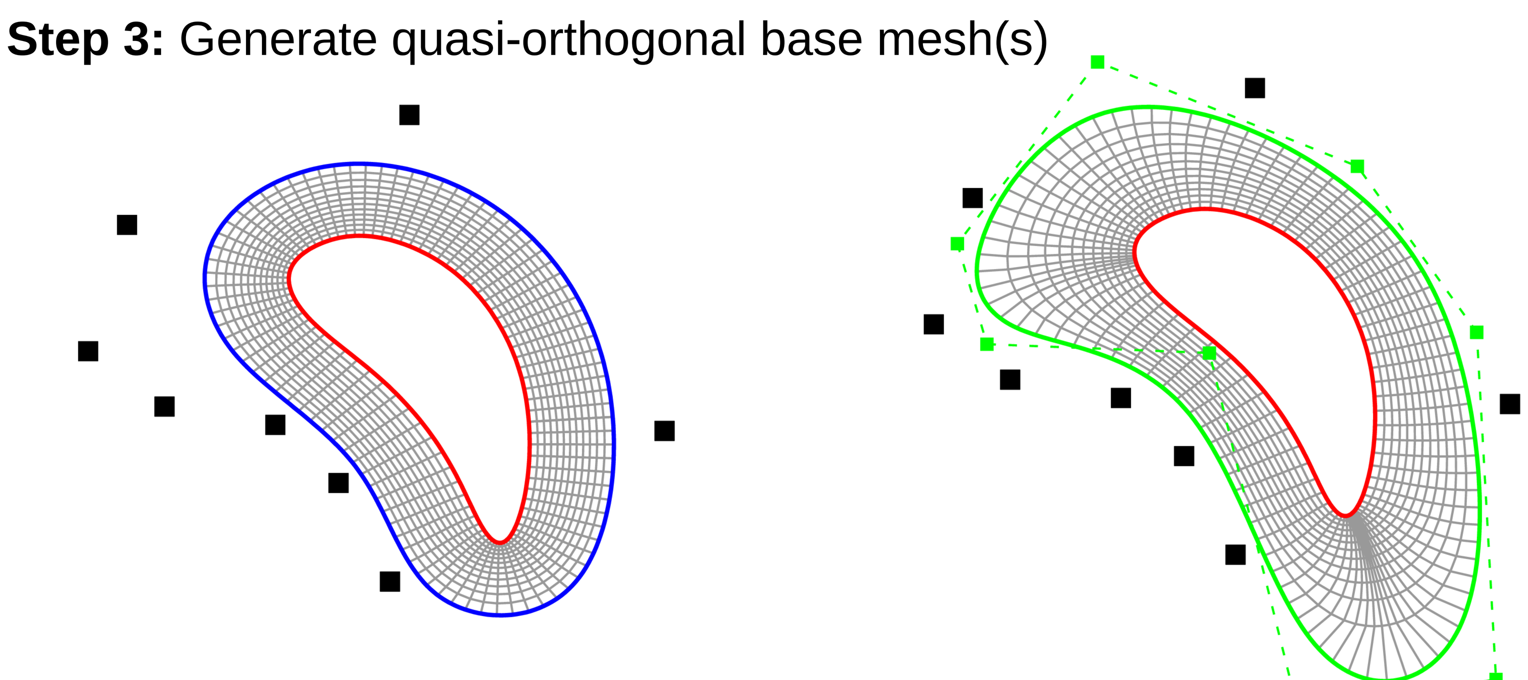


Field line strike maps

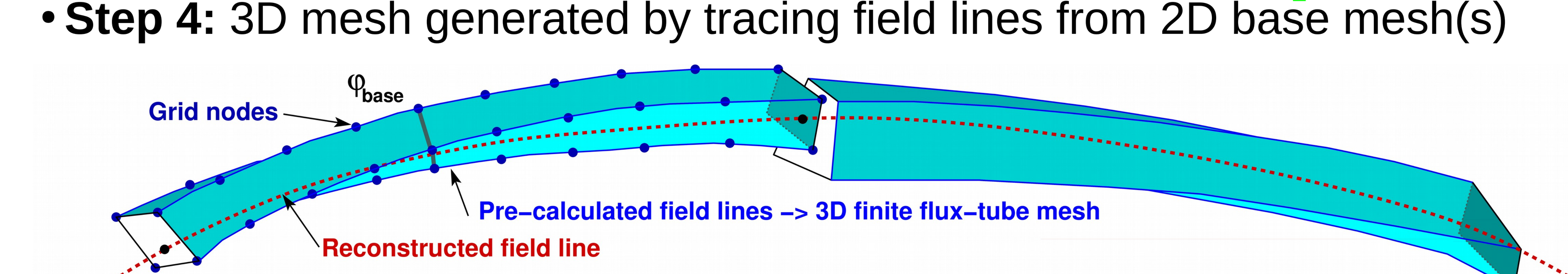


Divertor load modeling (EMC3-EIRENE) requires 3D finite flux-tube mesh

- **Step 1:** Identify inner simulation boundary from Poincaré plot
  - Smooth representation from B-Spline fit
- **Step 2:** Define outer simulation boundary
  - Offset surface (automatic), or manually adjusted surface (B-Spline)
- **Step 3:** Generate quasi-orthogonal base mesh(s)



- **Step 4:** 3D mesh generated by tracing field lines from 2D base mesh(s)



→ Reconstruction of field lines from interpolation within finite flux tube

Contact:
hfrerichs@wisc.edu
3dpsi.engr.wisc.edu

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College of Engineering
UNIVERSITY OF WISCONSIN–MADISON