FFA Magnet design

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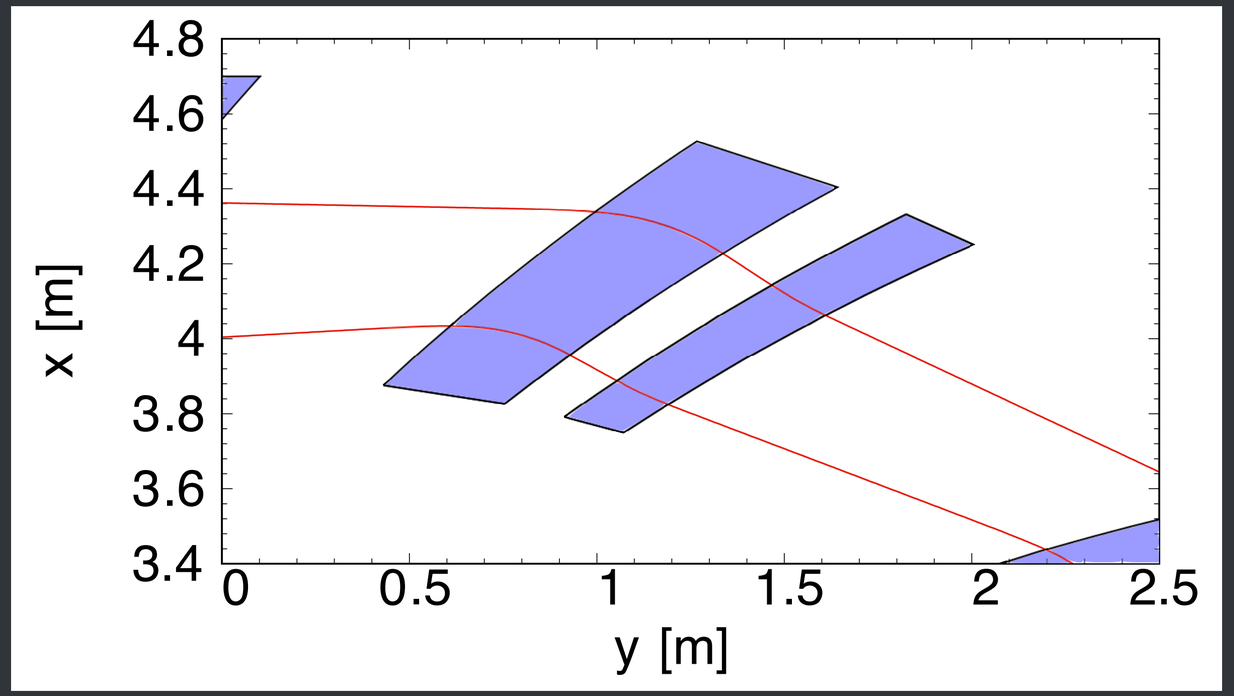
FFA for ISIS-II

- FETS-FFA ring: proof of principle for high power pulsed operation

  → zero-chromatic operation (tune constant during acceleration)

  → adjustable tune as a function of intensity (FD structure with adjustable *k*-value)

  → Large gap with large dynamic aperture to accommodate beam without uncontrolled losses



Scaling FFA field law:

$$B = B_0 \left(\frac{r}{r_0}\right)^k \mathcal{F}\left(\theta - \tan\xi \ln\left(\frac{r}{r_0}\right)\right)$$

with $B_0=B(r_0)$, k: geom. field index, ξ: spiral angle

Magnet prototype scope

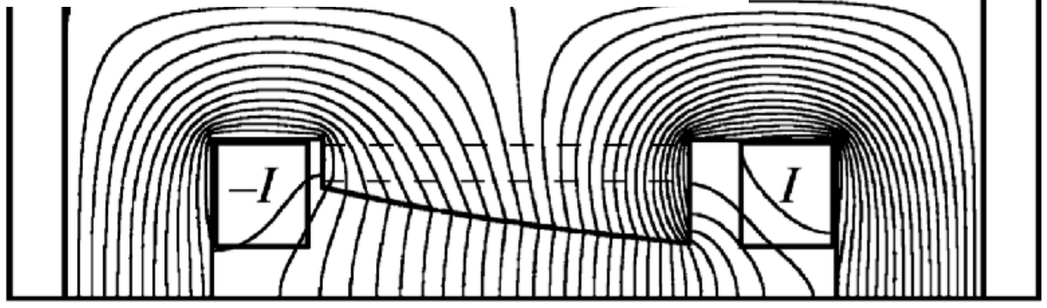
- Develop skills internally to design and build FFA magnet
- Design and build spiral hFFA magnet suitable for high intensity operation
- Investigate SC to improve sustainability for ISIS-II

Project tasks

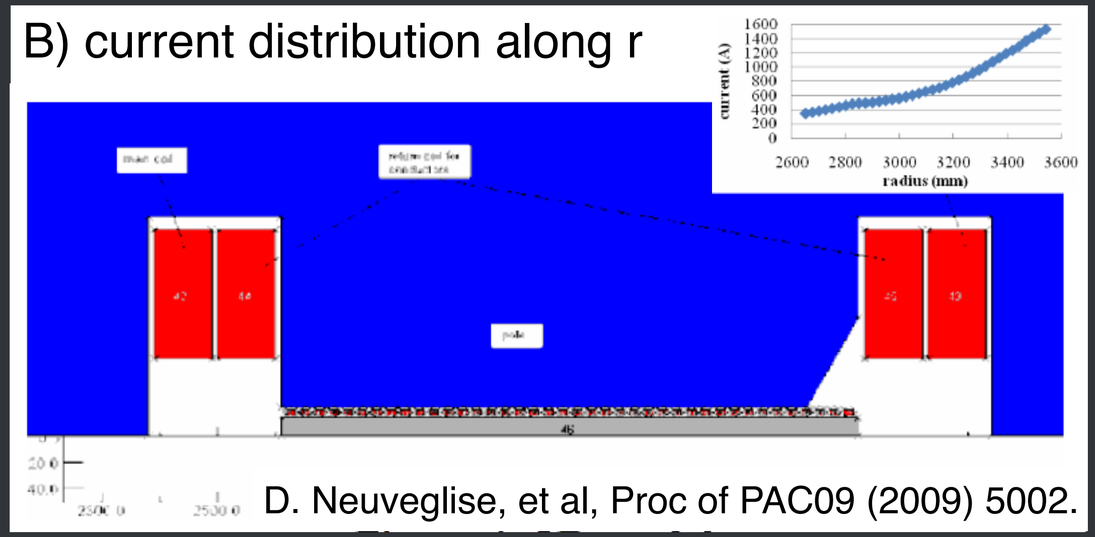
1. Manufacturing options: 2D study ✓✓
2. Fringe field requirements: preliminary 3D model ✓✓
3. Manufacturing contracts options
4. Magnetic modelling of chosen design ✓
5. SC coil investigation
6. Mechanical design
7. Prototype manufacture
8. Magnetic measurements of prototype
9. Analysis of measurements and publication

Manufacturing options

A) change gap height along radius

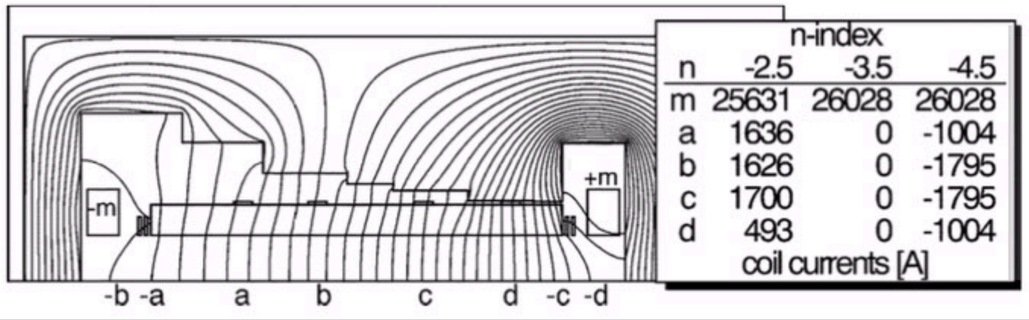


B) current distribution along r



D. Neuveglise, et al, Proc of PAC09 (2009) 5002.

C) Anisotropic iron



n-index			
n	-2.5	-3.5	-4.5
m	25631	26028	26028
a	1636	0	-1004
b	1626	0	-1795
c	1700	0	-1795
d	493	0	-1004

coil currents [A]

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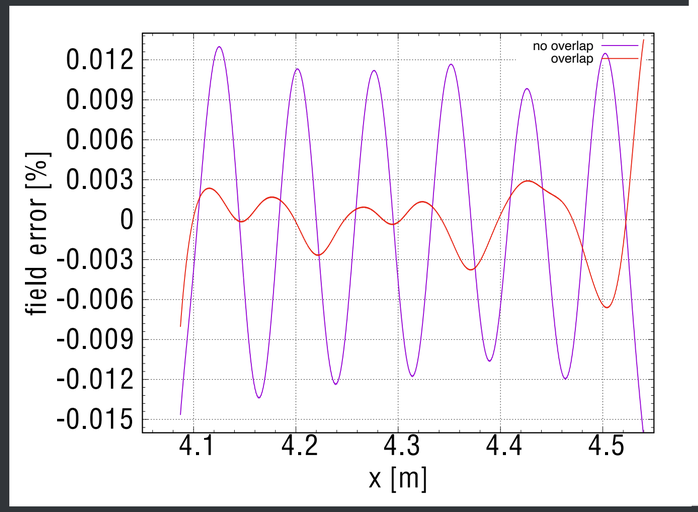
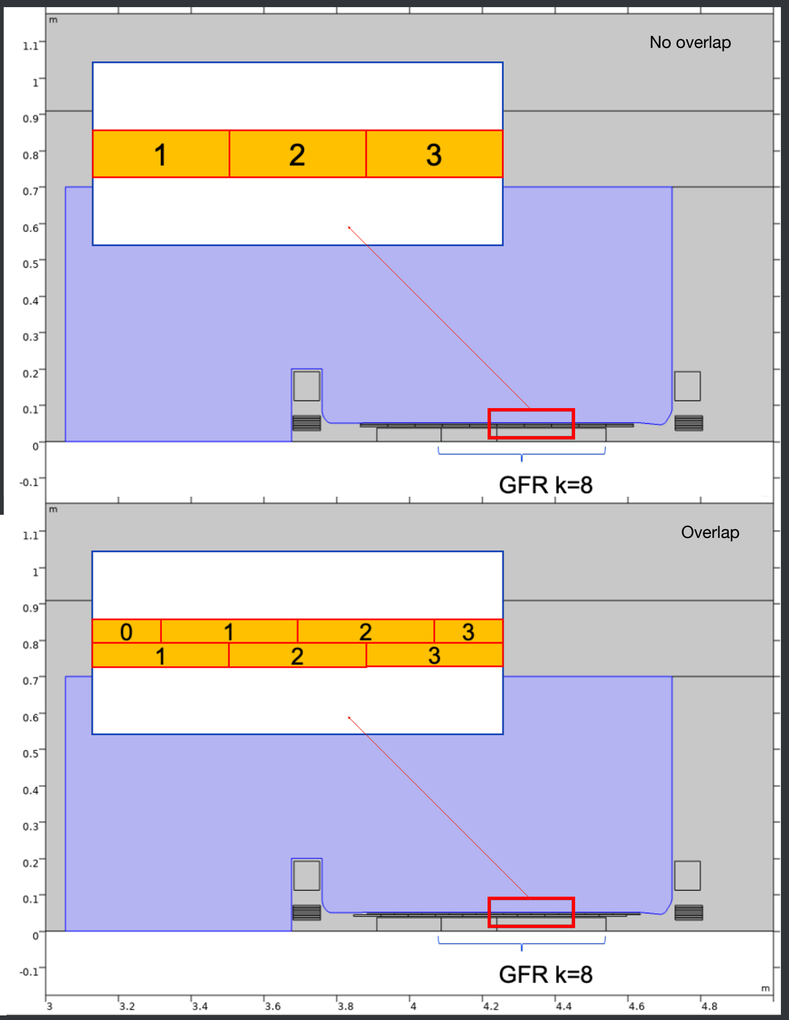
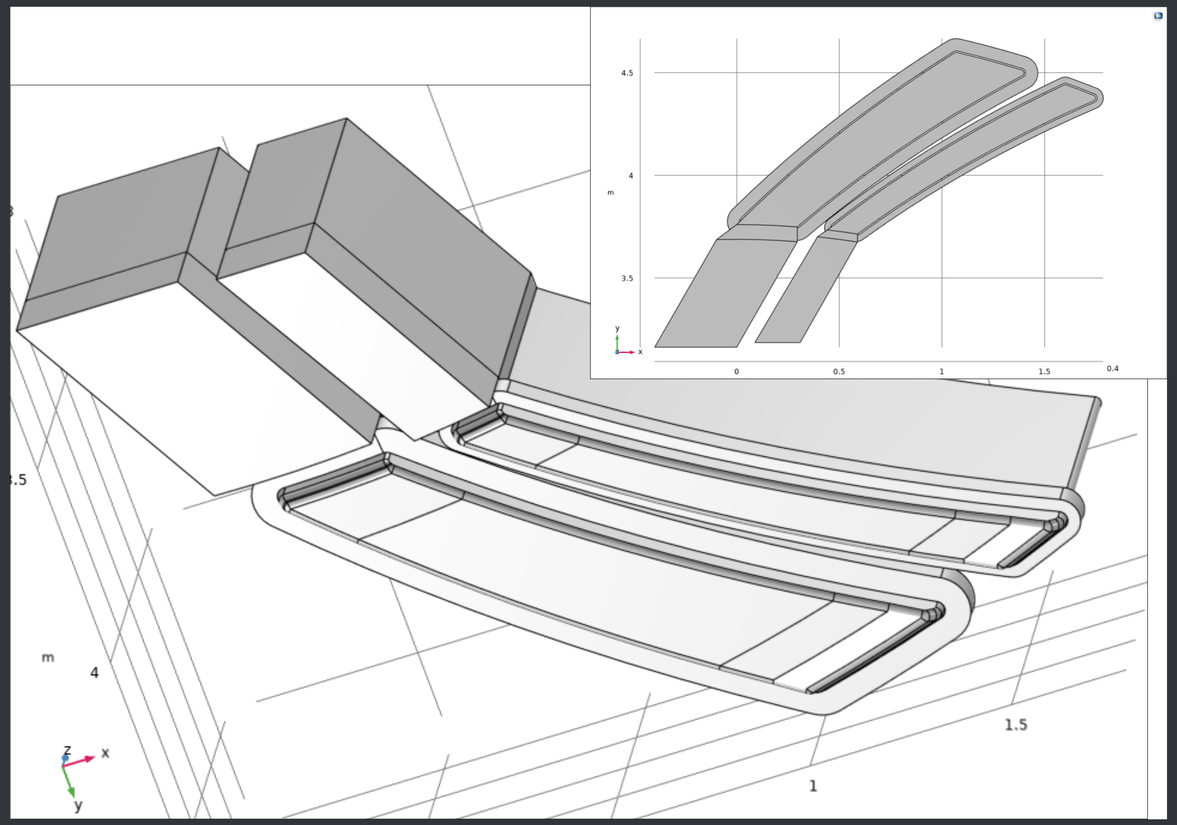
Chosen manufacturing option

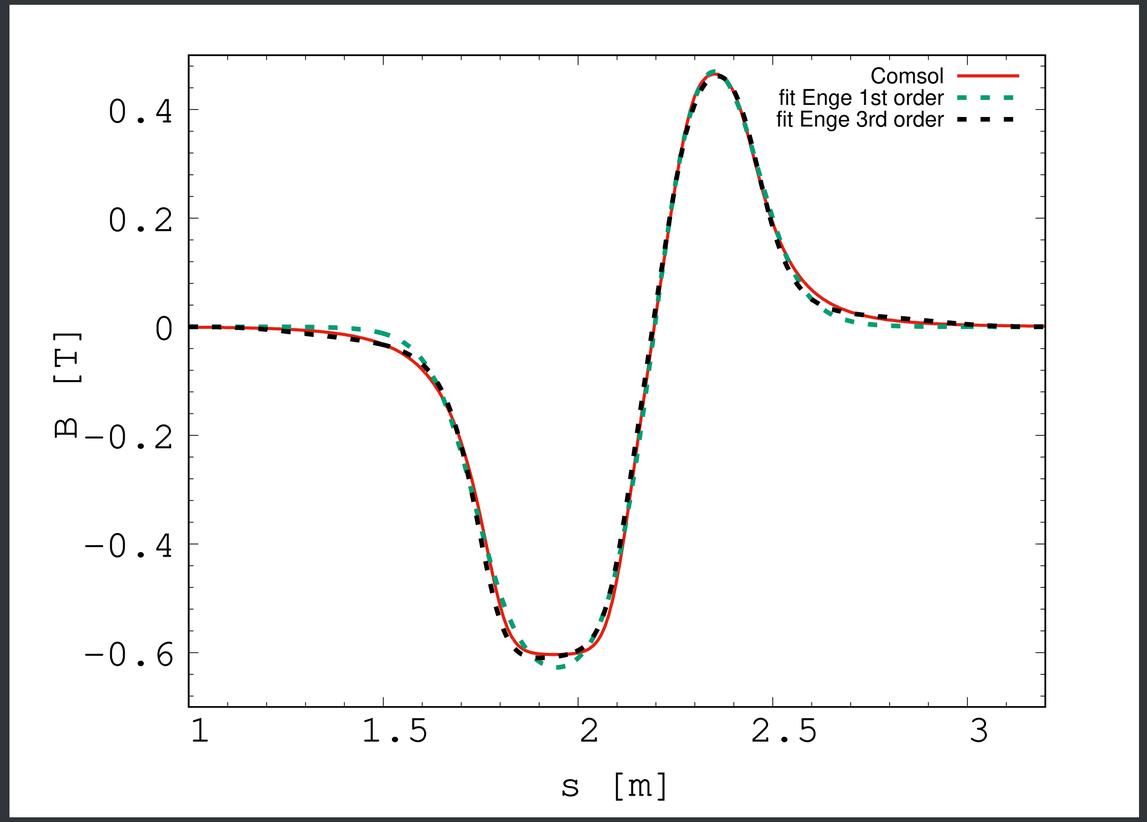
- C-type magnet to fit in R9 at RAL
- Flat pole with overlapped trim coils
  - Total power consumption comparable with shaped pole option for small k-value (k≈8)
  - Trim coils necessary to vary gradient
  - Overlapped trim coils reduce error due to discrete coils





3D preliminary model in COMSOL





Fringe field model investigation in lattice design code

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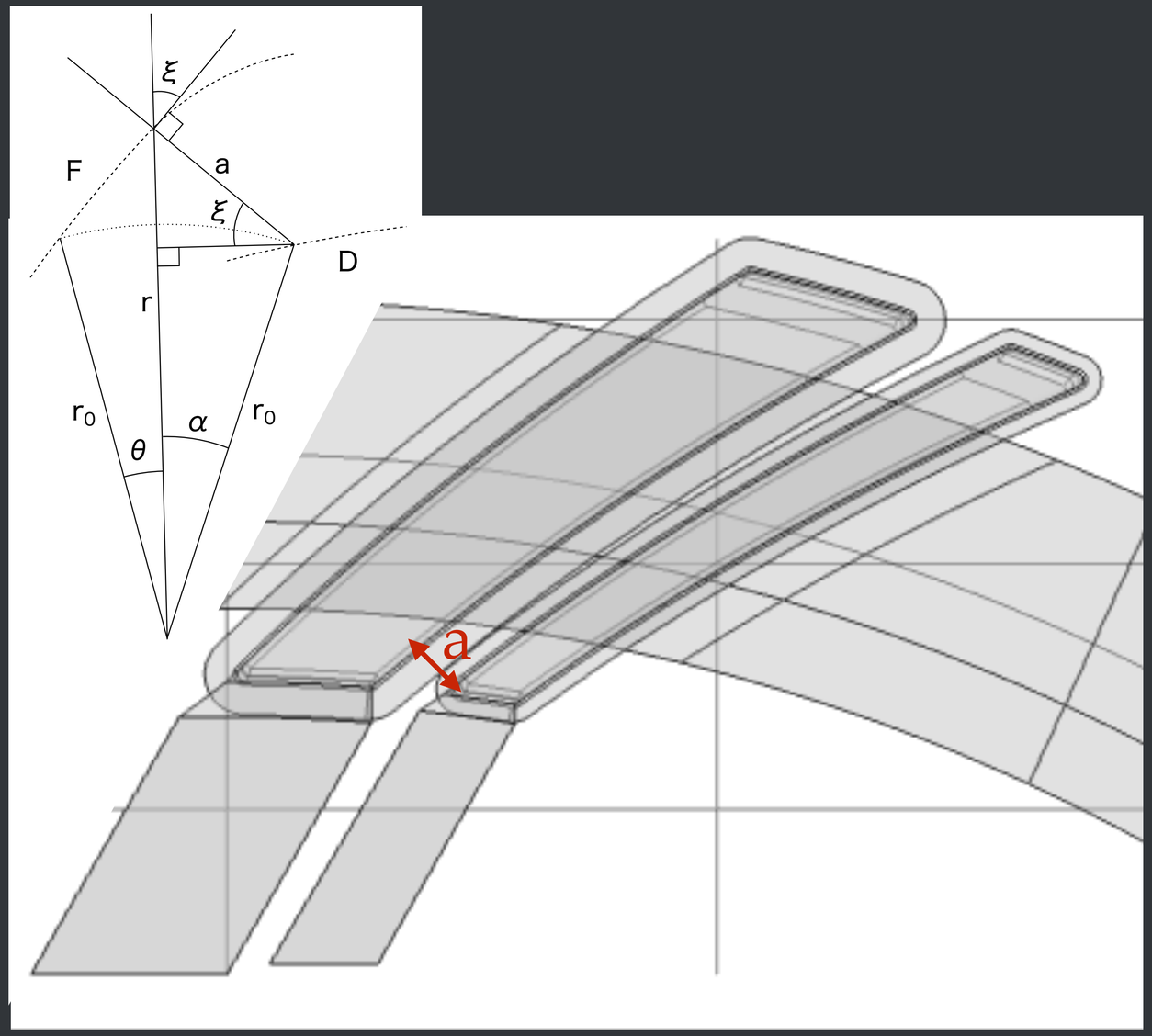
Distance F/D

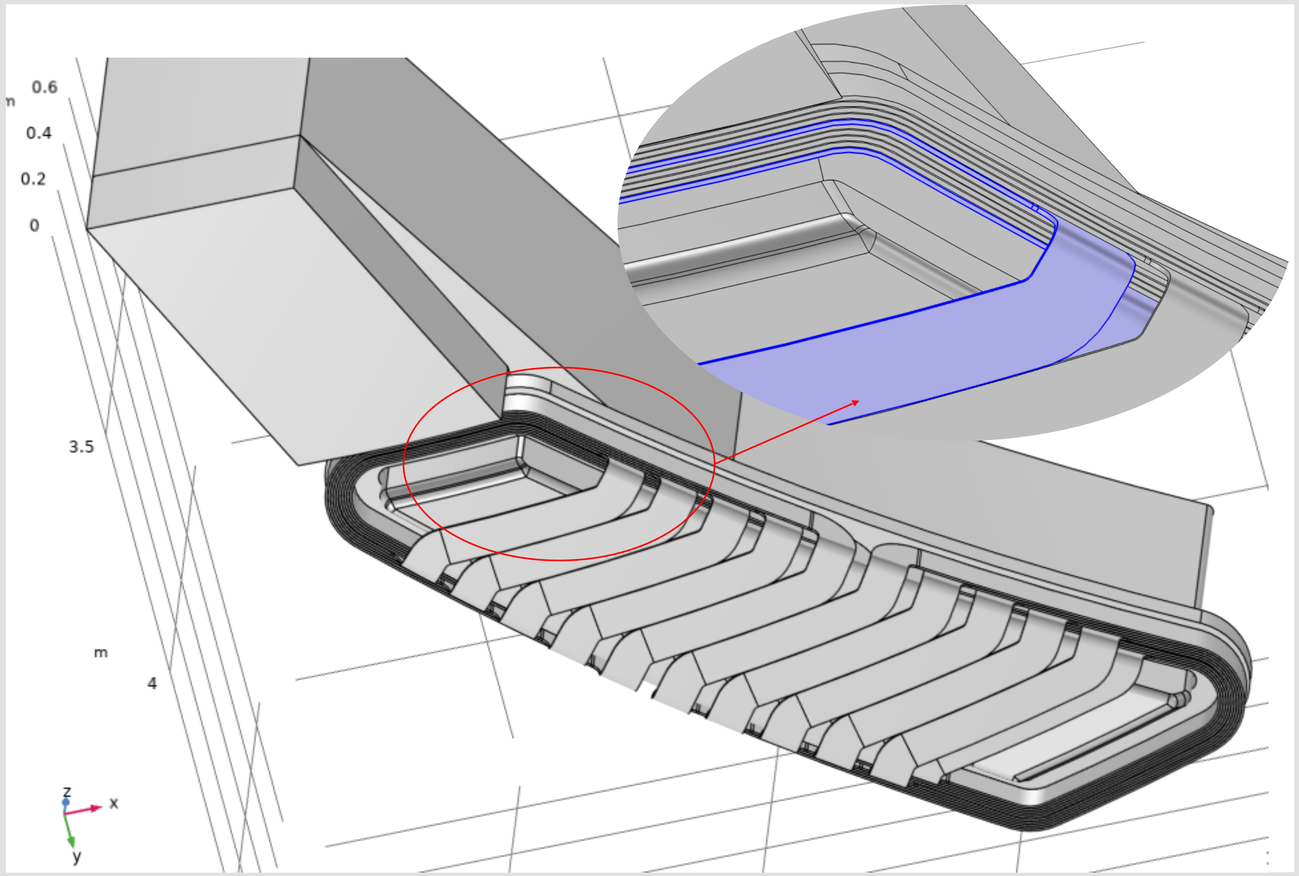


$$r = r_0 \exp\left(\frac{\theta}{\tan\xi}\right)$$

$$\theta + \alpha = \tan\xi \ln\left(\frac{a}{r_0}\sin\xi + \sqrt{1 - \frac{a^2}{r_0^2}\cos^2\xi}\right) + \arcsin\left(\frac{a\cos\xi}{r_0}\right)$$

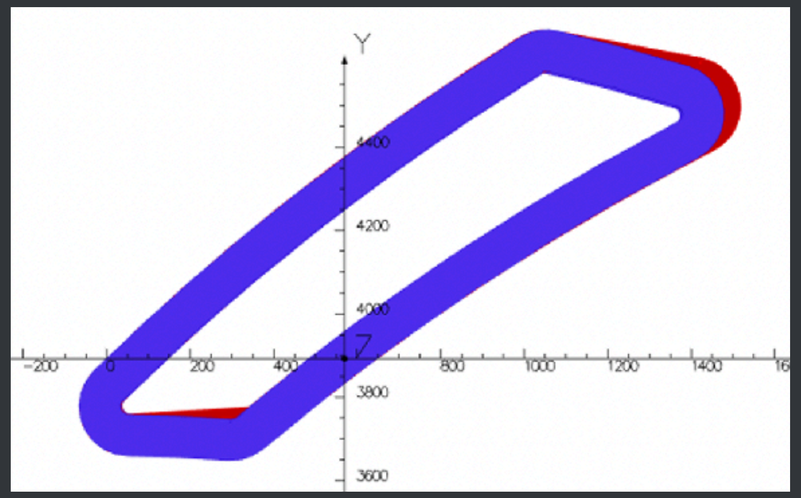
- 10 trim coils (10 mm thick) return on the inner side → 200 mm between F and D.
- 4-fold sym. (r=3.54 m , ξ=30°) F / D=3.69° (+64%)

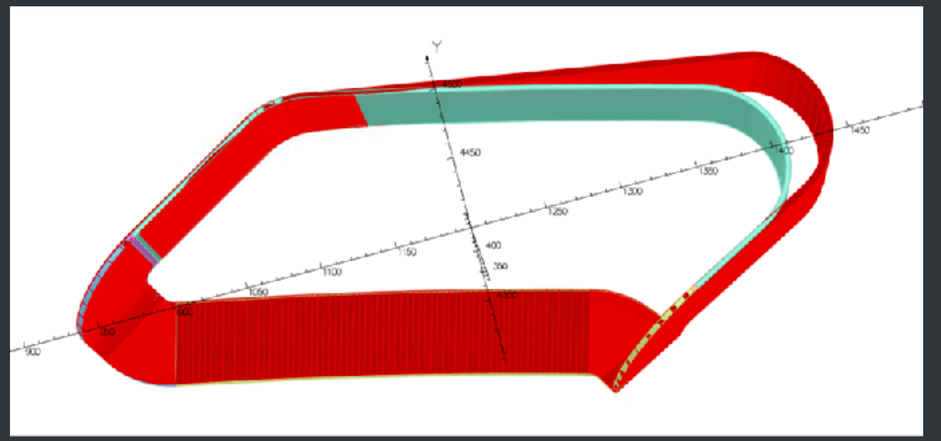
3D preliminary model in COMSOL

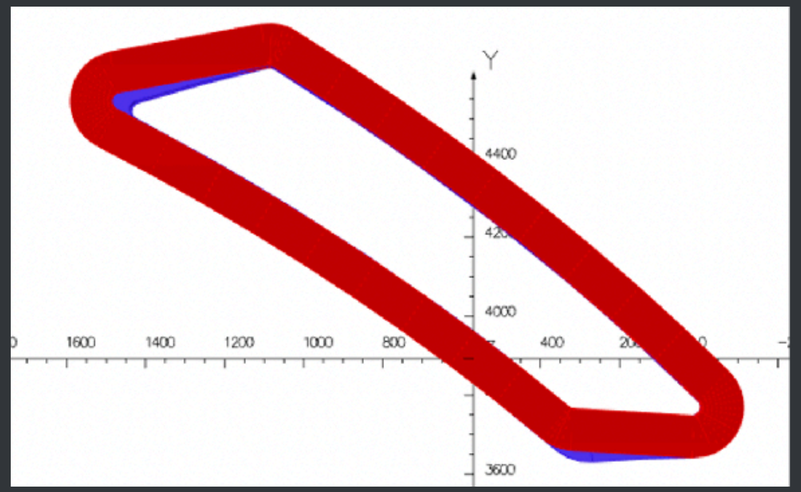


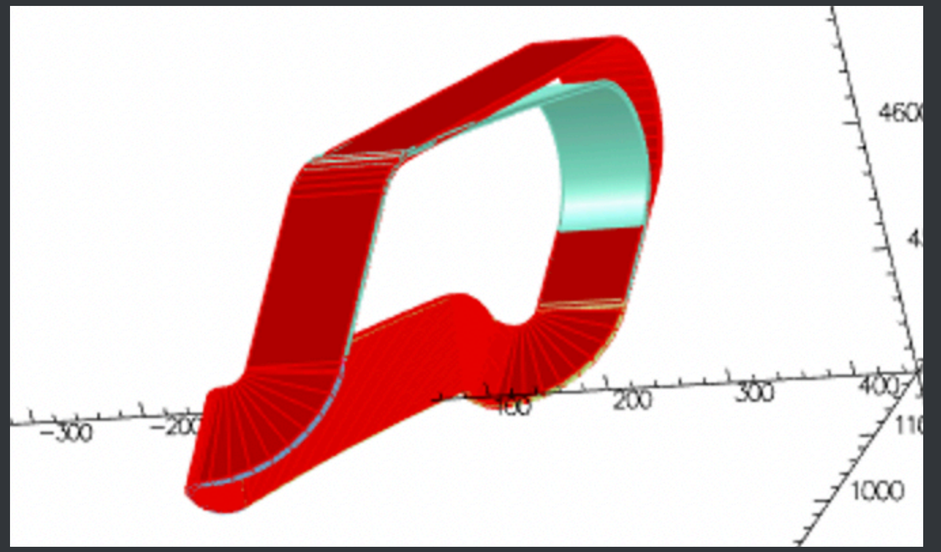
- Doublet (with 40 trim coils) may be impossible to solve with 128 GB RAM in Comsol.
- Implementation of model in Opera 3D with field clamps in progress.
- Aim to have reasonably optimised model for central scenario by end of September 2023.

Migration to OPERA









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Conclusion

- Strong synergy for building expertise and tools between FETS-FFA and LhARA
- Timeline aligns well between both projects
- Magnet prototype parameters based on FETS-FFA, usable for LhARA?