NSLS2 Dipole with Electromagnetic (EM) Tooth

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EM Dipole Tooth Studies

Active tooth (coil around small pole) with various **axial pole width** for 35 mm pole gap

- ↓ **100 mm** : Starting point - Too large deflection ~10 mrad (initially desired ~2 mrad) - ***OUT***
- → **50 mm** : Seems to work (but with larger than initially desired deflection)
- ↘ **20 mm** : Seems to be too small - ***Almost OUT (will not be discussed today)***
- ↗ **35 mm** : Why not examine this as a possible solution - **looks promising …**

Passive tooth – Adjust pole gaps to generate 1 T field step in a nominal 0.4 T dipole.

For this meeting, rather than field quality, we would examine field profile (field, peak field, half width, etc.). First work on the basic design, then on harmonics.

Also a brief comparison of EM and PM tooth options.

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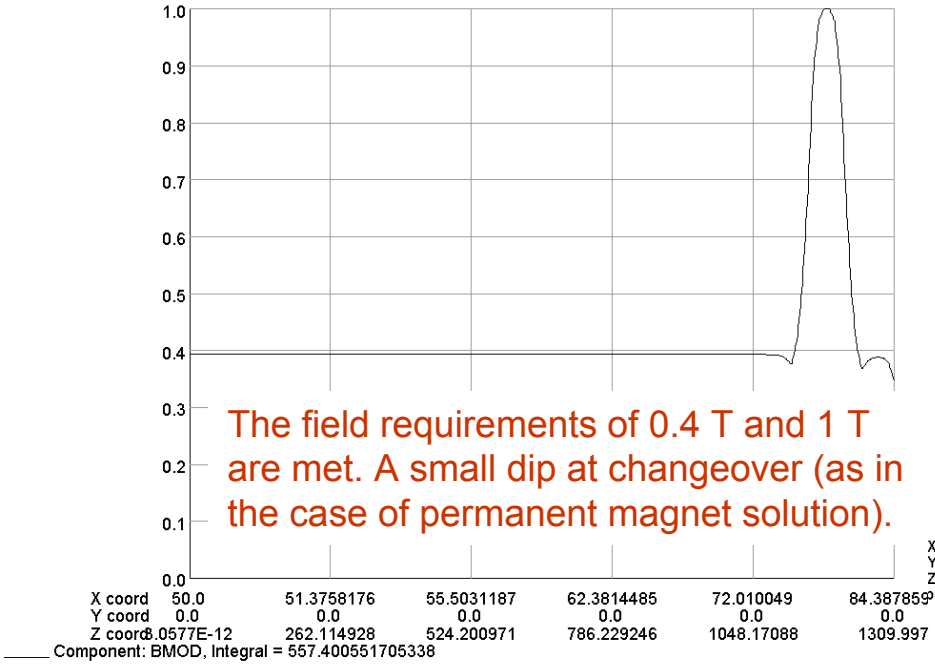
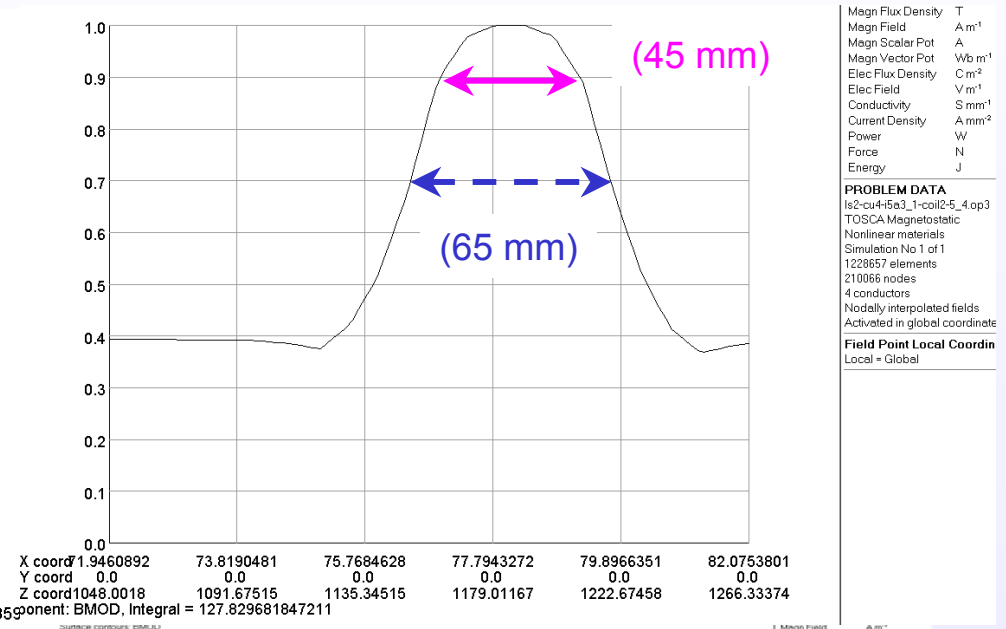
50 mm Wide Pole
(plus 50 mm space either side for coil)



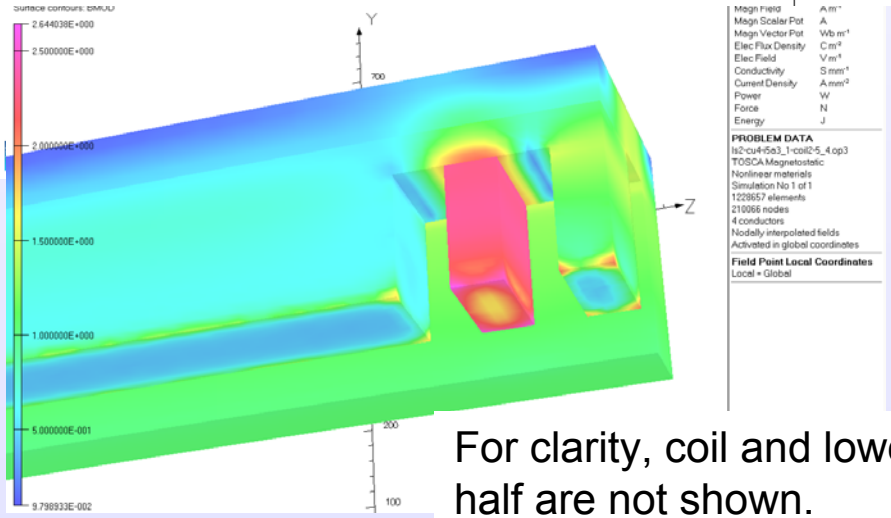
The field requirements of 0.4 T and 1 T are met. A small dip at changeover (as in the case of permanent magnet solution).



Deflections:

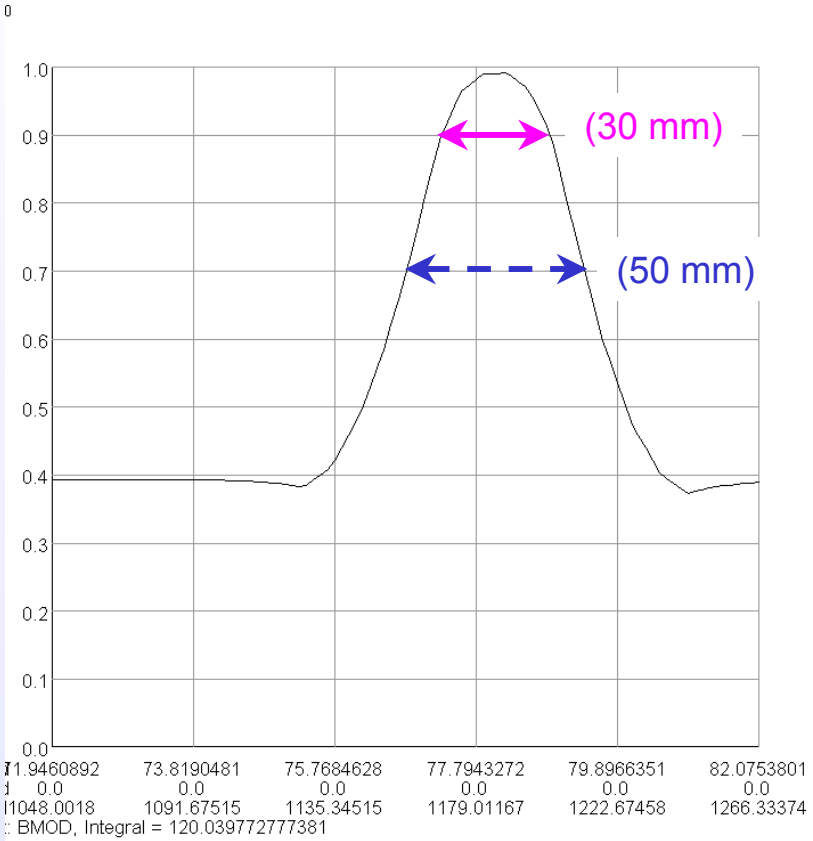
- ~4.3 mrad in 0.9 T – 1 T region (~45 mm).
- ~4.7 mrad additional deflection from the entire tooth region (~130 mm).

What is the relevant parameter of merit? Above or any other?



For clarity, coil and lower half are not shown.

35 mm Wide Pole
(plus 50 mm space either side for coil)



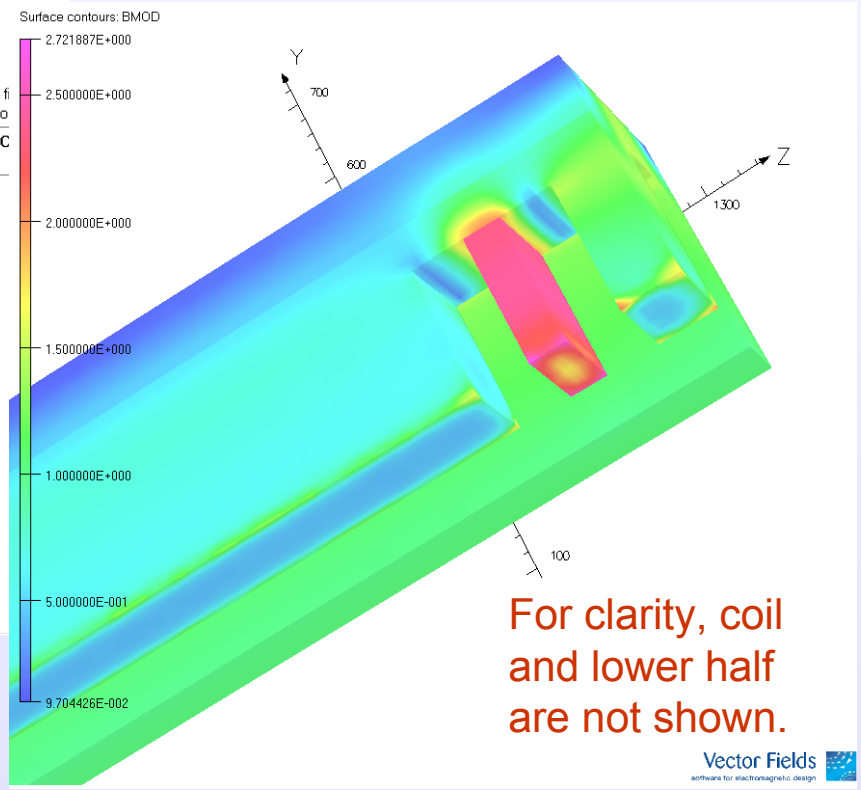
UNITS	
Length	mm
Magn Flux Density	T
Magn Field	A m^{-1}
Magn Scalar Pot	A
Magn Vector Pot	Wb m^{-1}
Elec Flux Density	C m^{-2}
Elec Field	V m^{-1}
Conductivity	S mm^{-1}
Current Density	A mm^{-2}
Power	W
Force	N
Energy	J

PROBLEM DATA
ls2-cu4-35mm-coil2-7_0.op3
TOSCA Magnetostatic
Nonlinear materials
Simulation No 1 of 1
1245825 elements
213015 nodes
4 conductors
Nodally interpolated fi
Activated in global co

Field Point Local C
Local = Global

Deflections:

- ~3 mrad in 0.9 – 1 T region (~30 mm).
- ~3.3 mrad additional deflection from the entire tooth region (~100 mm).

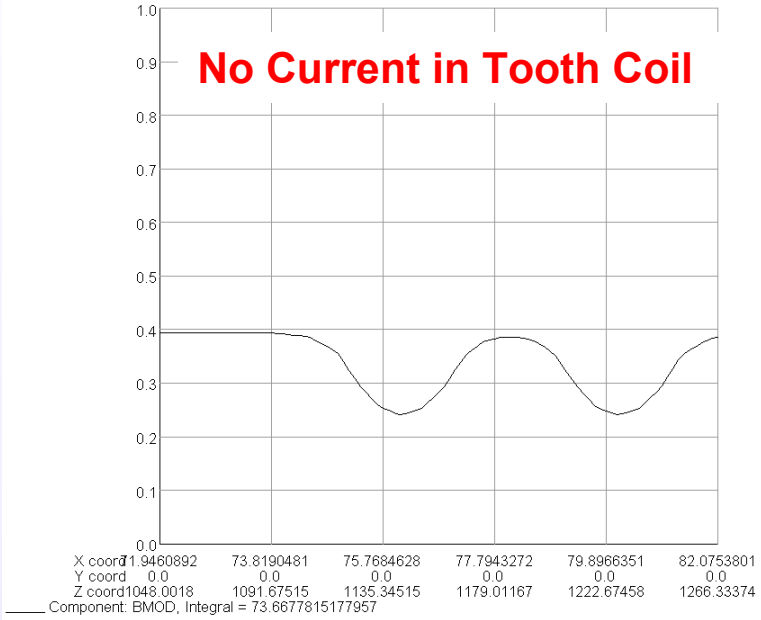


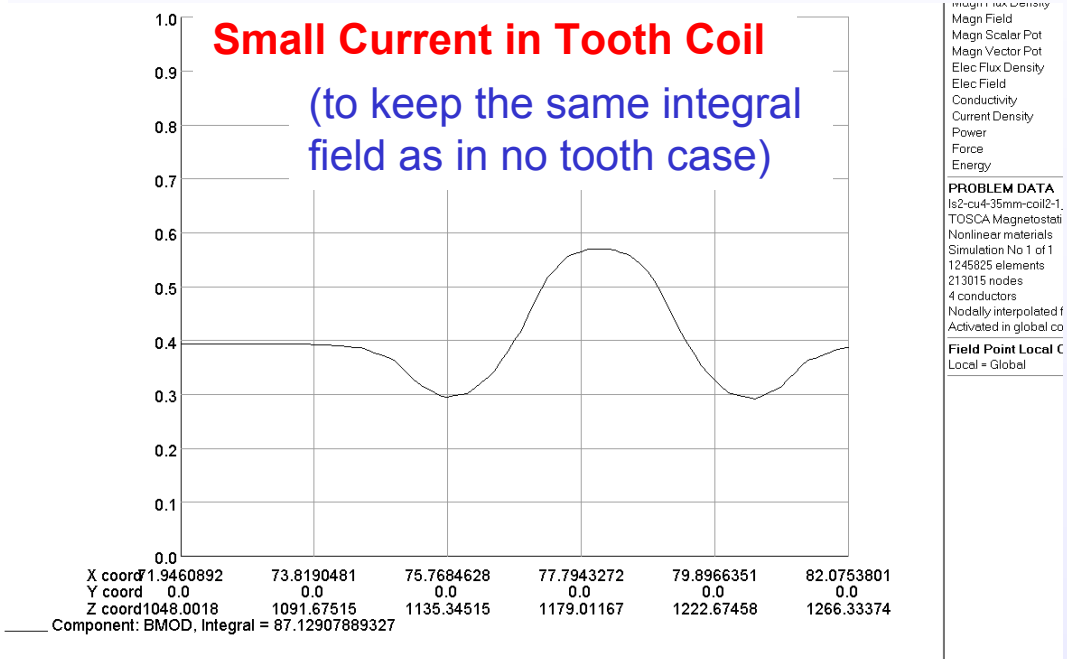
For clarity, coil and lower half are not shown.

Remember now we have:

35 mm long powered tooth, 35 mm pole gap and 100 mm pole width.

Turning off (sort off) EM Tooth





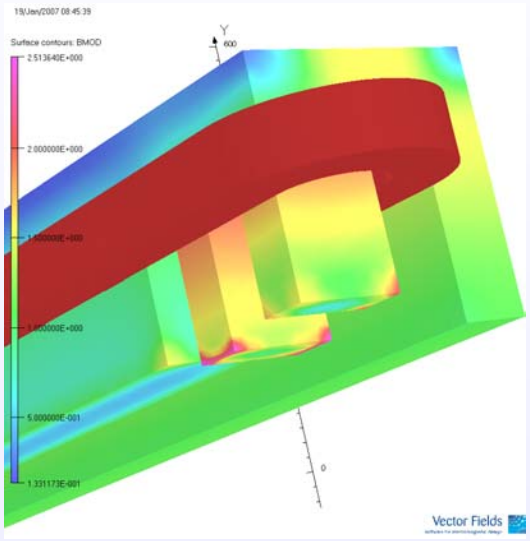
To obtain the same integral field as in no tooth case, one can

(a) either switch off the tooth coil and adjust the current in main coil

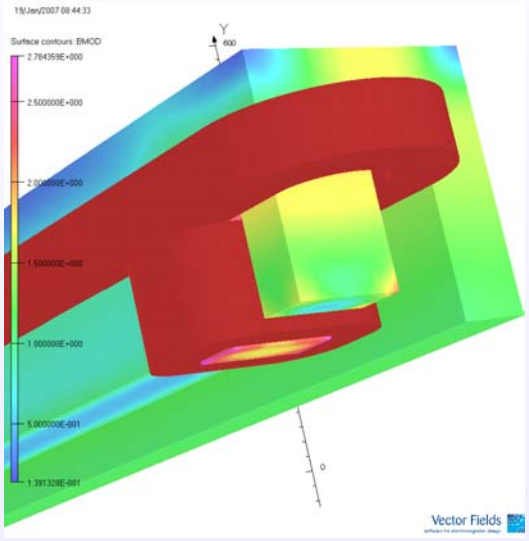
or (b) can adjust the current in tooth coil.

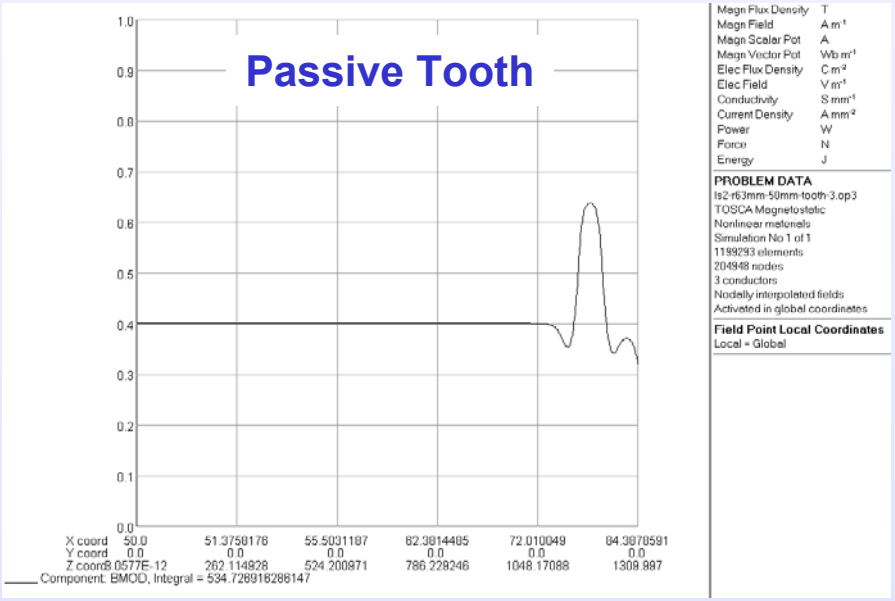
- Small iron "cap" can be inserted under coil to homogenize the field, if wiggle is not desired (such mechanical operations are easy in non-magnetized EM tooth)
- Can small adjustment in tooth coil may be used to serve as corrector dipole?

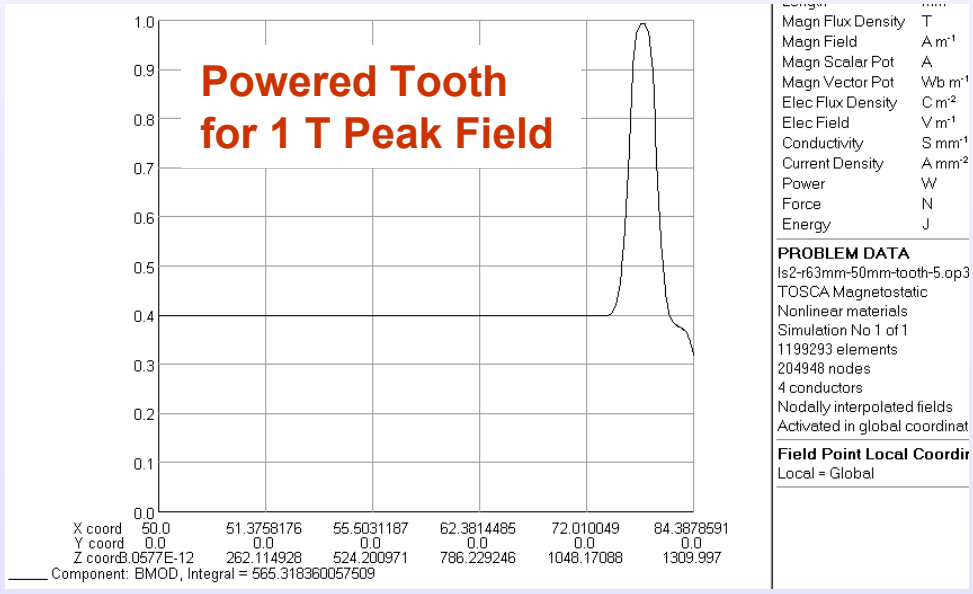
Passive Tooth (sort off) (35 mm tooth and in nominal 63 mm gap)



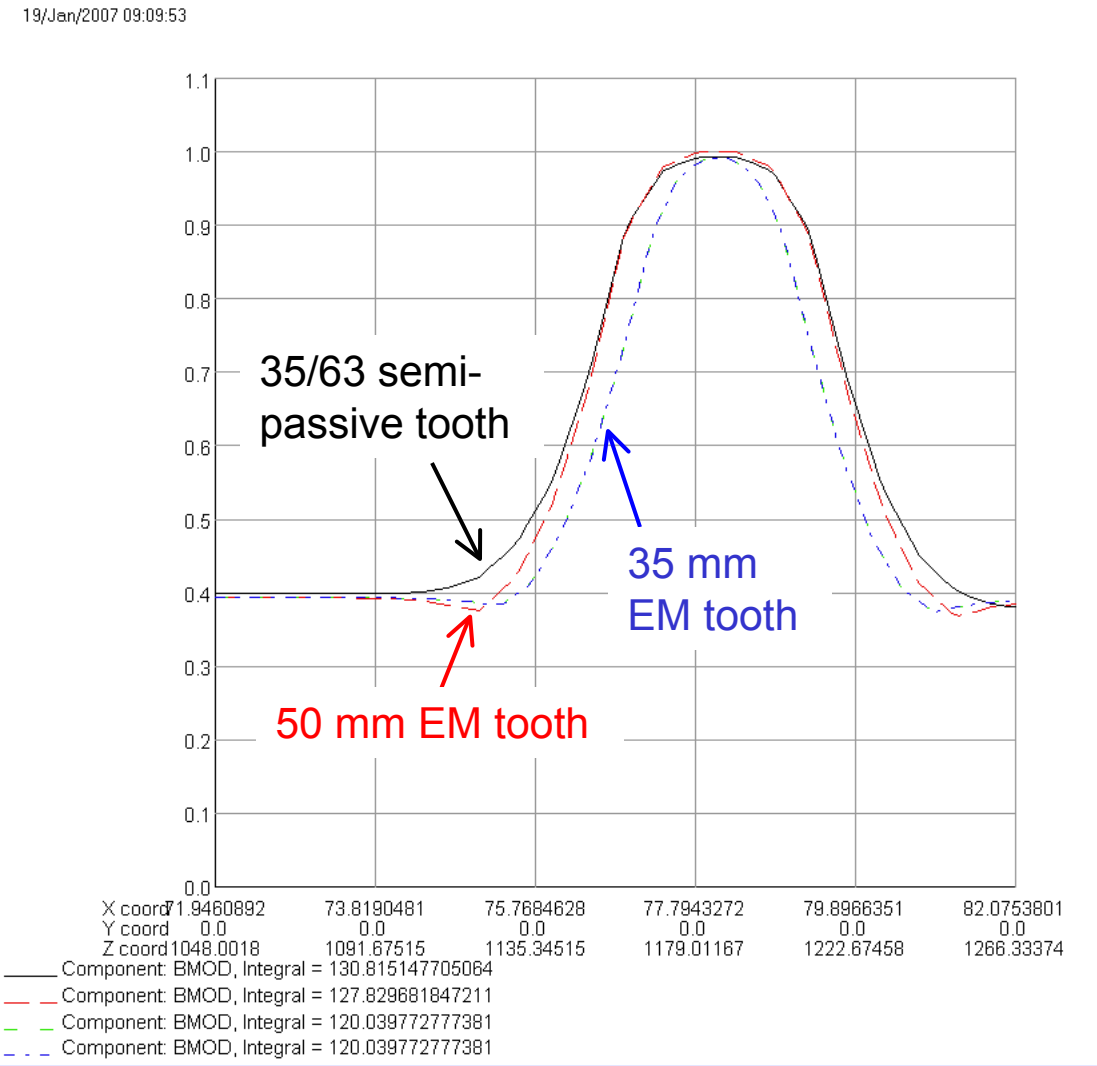
- For a passive tooth with a pole gap of 35 mm in a dipole with a nominal gap of 63 mm, the gap ratio is not right for 1 T and 0.4 T respective fields.
- Additional coil is used to obtain the desired 1 T to 0.4 T ratio. Thus, it is not a fully "Passive Tooth" any more.







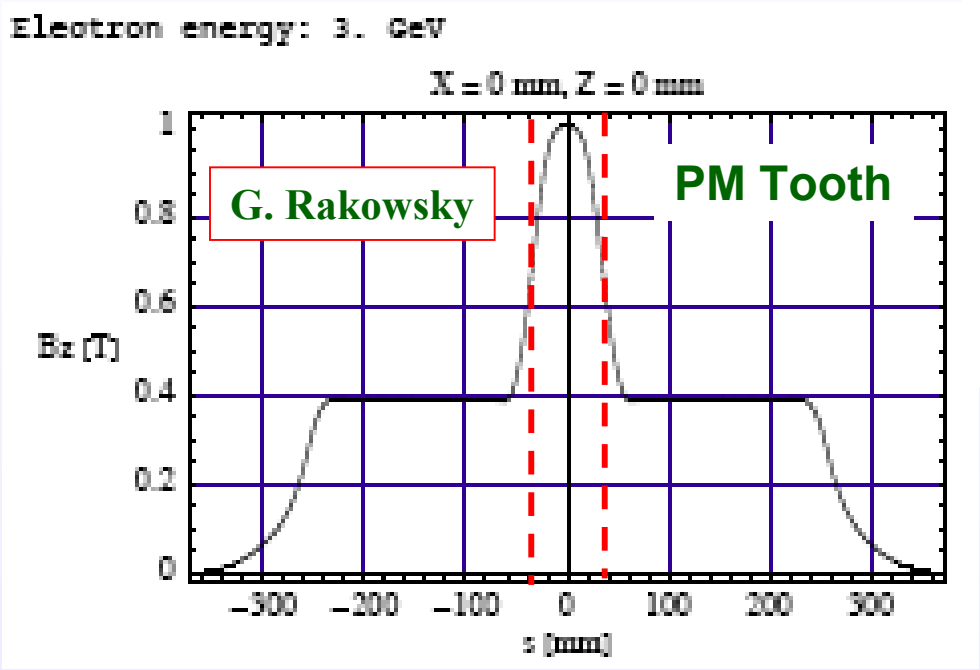
Comparison of Field Profiles in Various Solutions



35 mm EM powered tooth seems to be promising in keeping width and hence deflection small

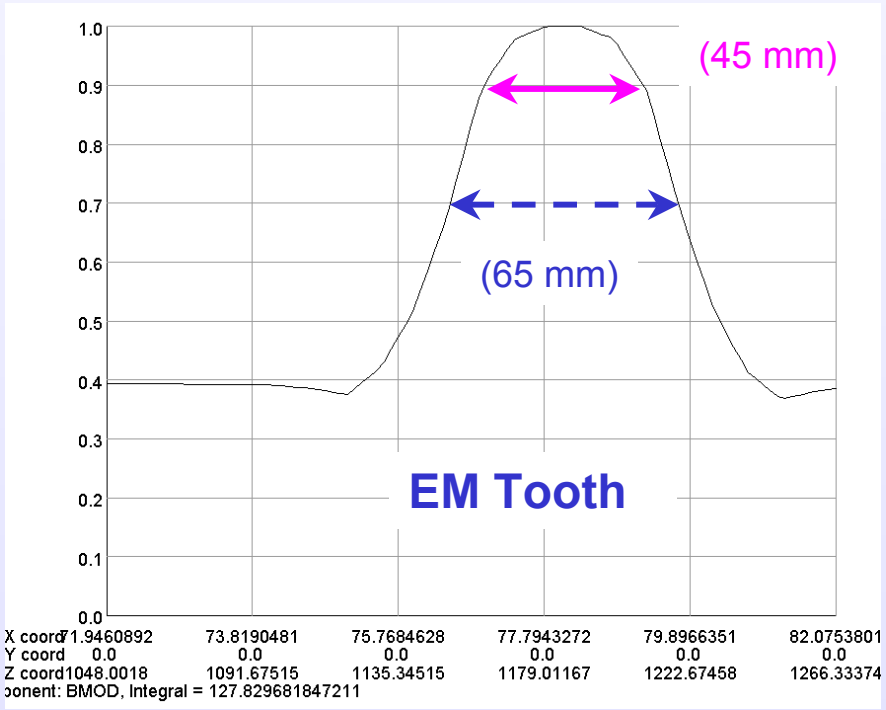
(3 mrad?)

Comparison of PM and EM Solutions for 50 mm Pole



~75 mm

- Both Permanent magnet and electromagnet tooth generate similar axial field profile (electromagnet tooth may be a little better).
- PM does not need additional power supply.
- The electromagnet tooth can be adjusted electrically – I.e. turn it off (almost), tune it (for axial wiggle profile) or mechanically cap it.



Question

Which one offers a better technical and operational solution?

Conclusions

- Pole length to pole gap ratio is an important design consideration. Pointed pole create high field locally but not high field in the gap.
- 35 mm long electromagnetic tooth with ~3mrad(?) deflection may turn out to be a working solution.
- If acceptable, the next step would be to work on specifying and optimizing field quality (field harmonics).
- At this stage, one should also briefly look at some creative variations to the design to explore if even a better solution exist.
- However, soon we should soon be able to make an informed decision on the fate of the "Tooth Option".