SIGMAPHI
RACCAM magnet design

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Part 1 – Magnet parameters overall view

Part 2 – Scaling ring magnet design

A. Radial field law generation

B. Azimutal field law (spiral shape)

C. First results from tracking

Part 3 – Vertical scaling achievement

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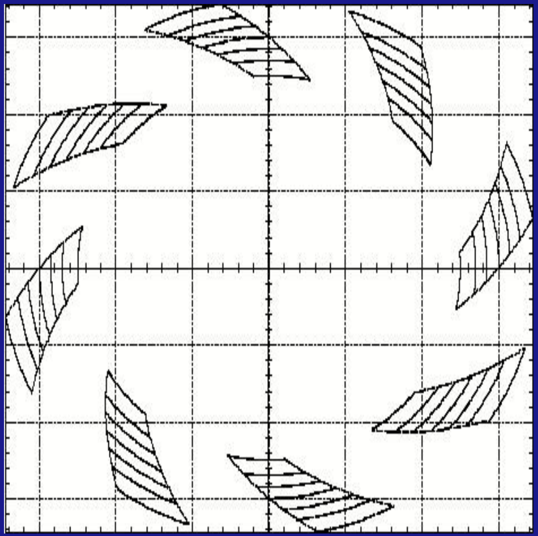
Part 1 – Magnet parameters



Spiral Scaling Proton FFAG ring

E injection	17	[MeV]
E extraction	180	[MeV]
Injection radius	2.8	[m]
Extraction radius	3.5	[m]
B field at extraction	1.5	[T]
Field index K	≈ 4.5	
Spiral Angle ζ	≈ 50	[°]

- Our challenge is to design a magnet which allows a perfectly scaling dynamics -

Part 2 – Scaling ring magnet design

A. Radial field law $(r/r_0)^K$

Two solutions are beeing studied

Constant gap with distributed curents on the pole

Studied by LPSC

(+) variable k
(+) better vertical dynamics (not proved)

(-) cost (large amout of power needed)

Gap shaping

Studied by SIGMAPHI

(+) the most economical solution

(-) k is not tunable
(-) vertical dynamics becomes tragic

Part 2 – Scaling ring magnet design A. Radial field law $(r/r_0)^K$

First step – Automated 2D(*) calculations

2D computation

Comparison Caculated B field – Theoretical B field

Generation of a new pole shape

Generation of the corresponding Opera 2D model

2D ITERATIVE PROCESS

(*)Every 2D and 3D calculations are realized with Opera Vector Fields

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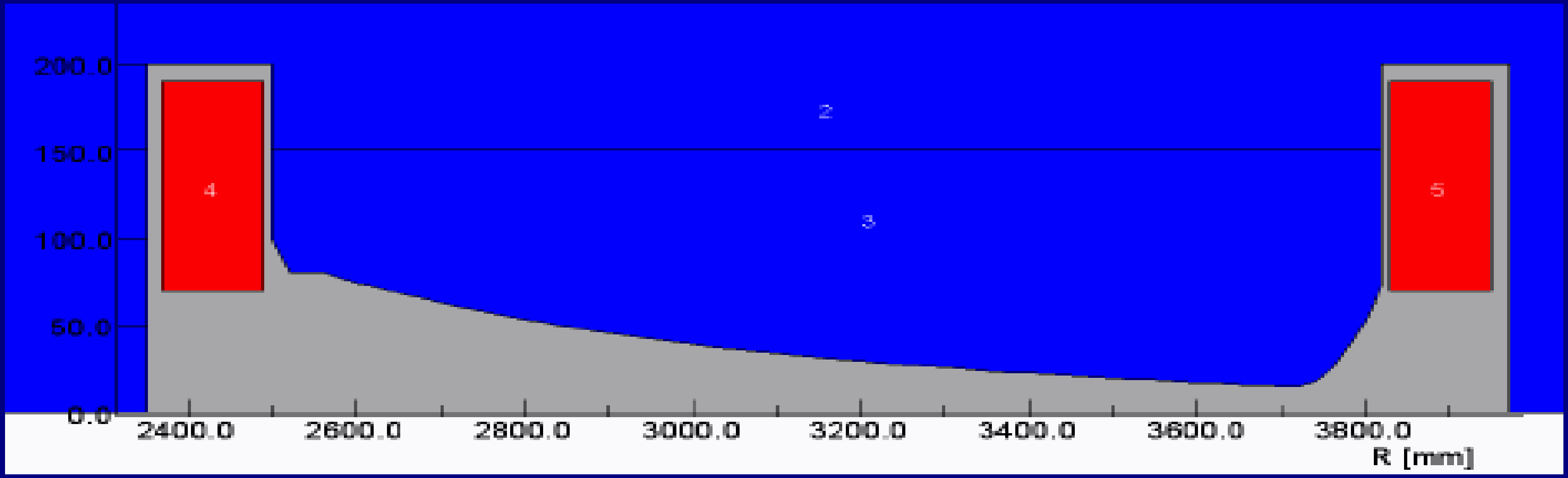
Part 2 – Scaling ring magnet design   A. Radial field law $(r/r_0)^K$

First step – Automated 2D calculations



→ It converges rapidely (about ten iterations) and gives a relative field homogeneity better than 10^{-4} in the good field region

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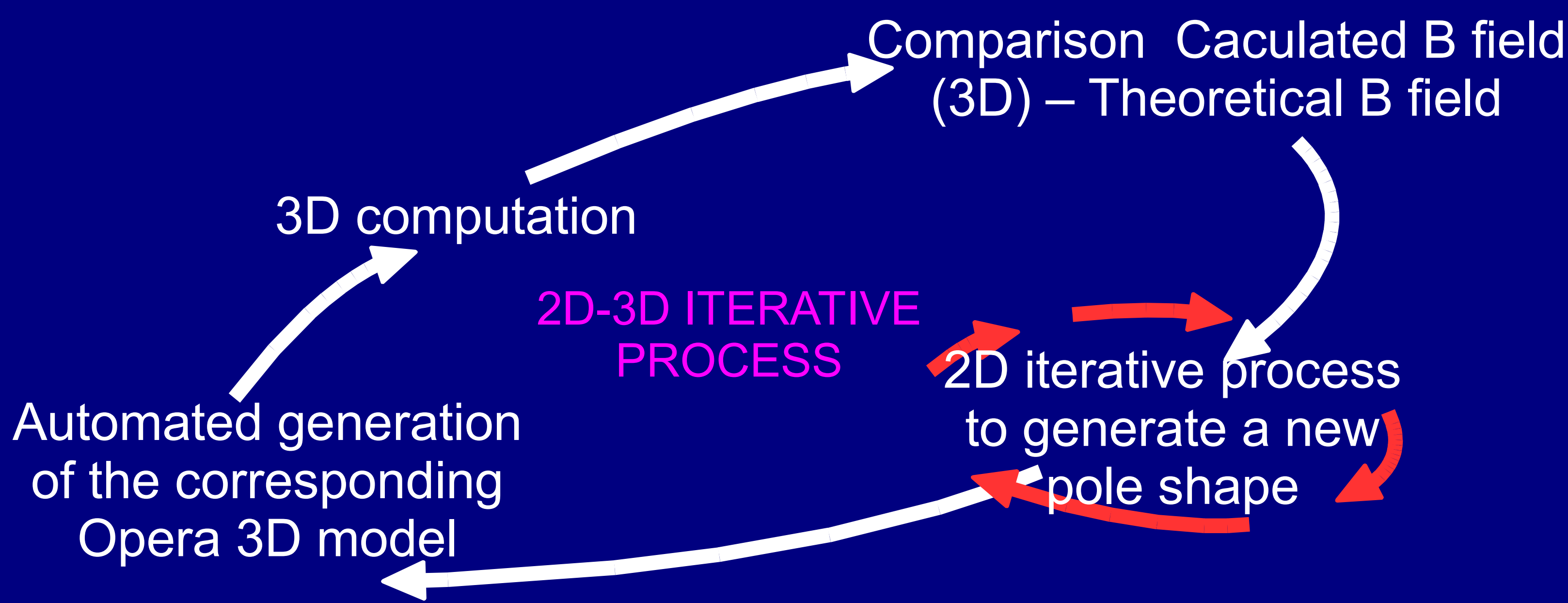
Part 2 – Scaling ring magnet design A. Radial field law $(r/r_0)^K$

Second step – Automated 3D(*) calculations



(*)Every 2D and 3D calculations are realized with Opera Vector Fields

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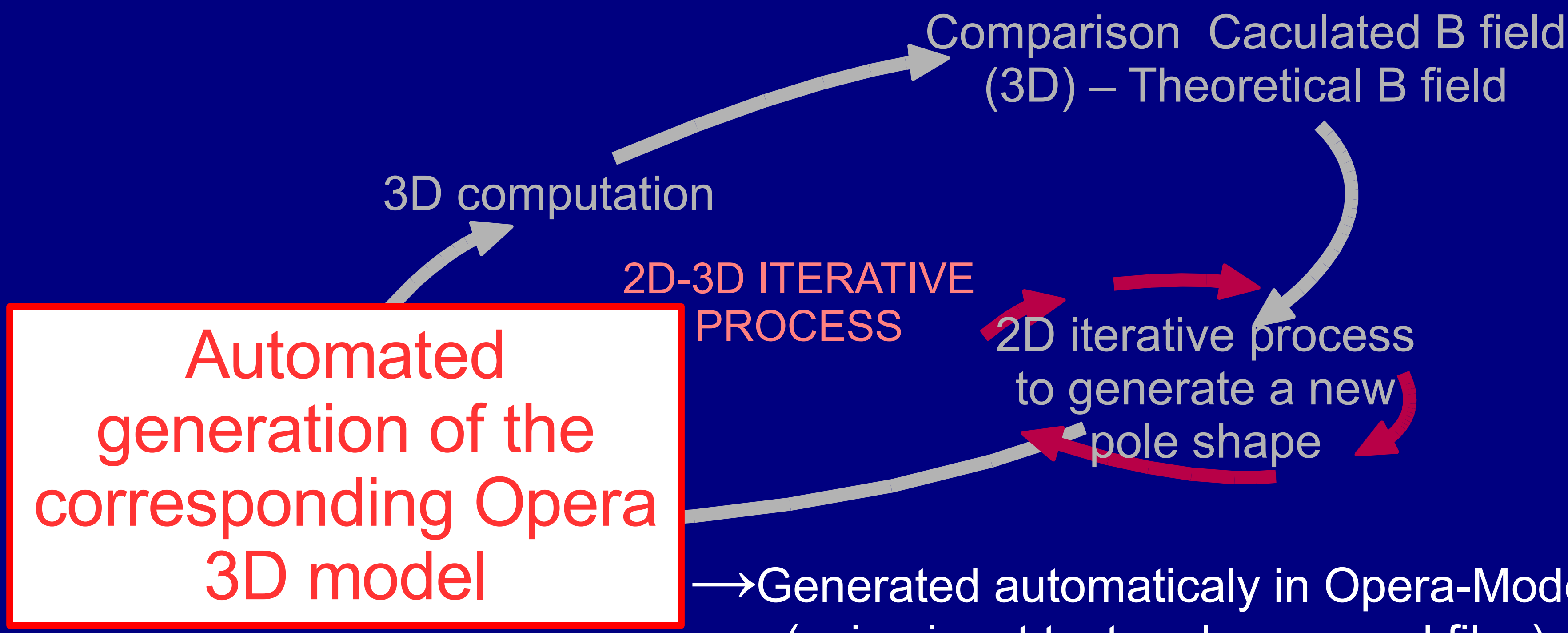
Part 2 – Scaling ring magnet design

A. Radial field law $(r/r_0)^K$

Second step – Automated 3D calculations



→Generated automaticaly in Opera-Modeller (using input text and command files)

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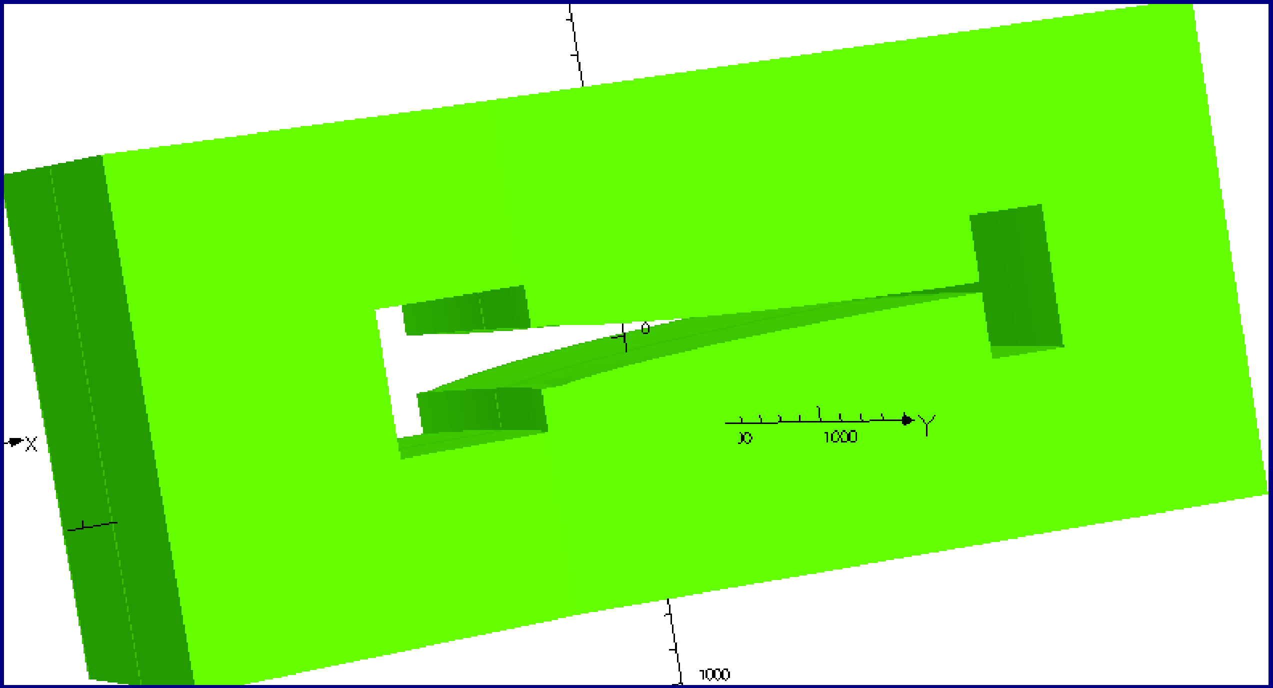
Part 2 – Scaling ring magnet design A. Radial field law $(r/r_0)^K$

Second step – Automated 3D calculations



→ **After several of these iterations (3 to 8) a 3D model with a relative field homogeneity <u>in its center</u> of few 10^{-4} is obtained**

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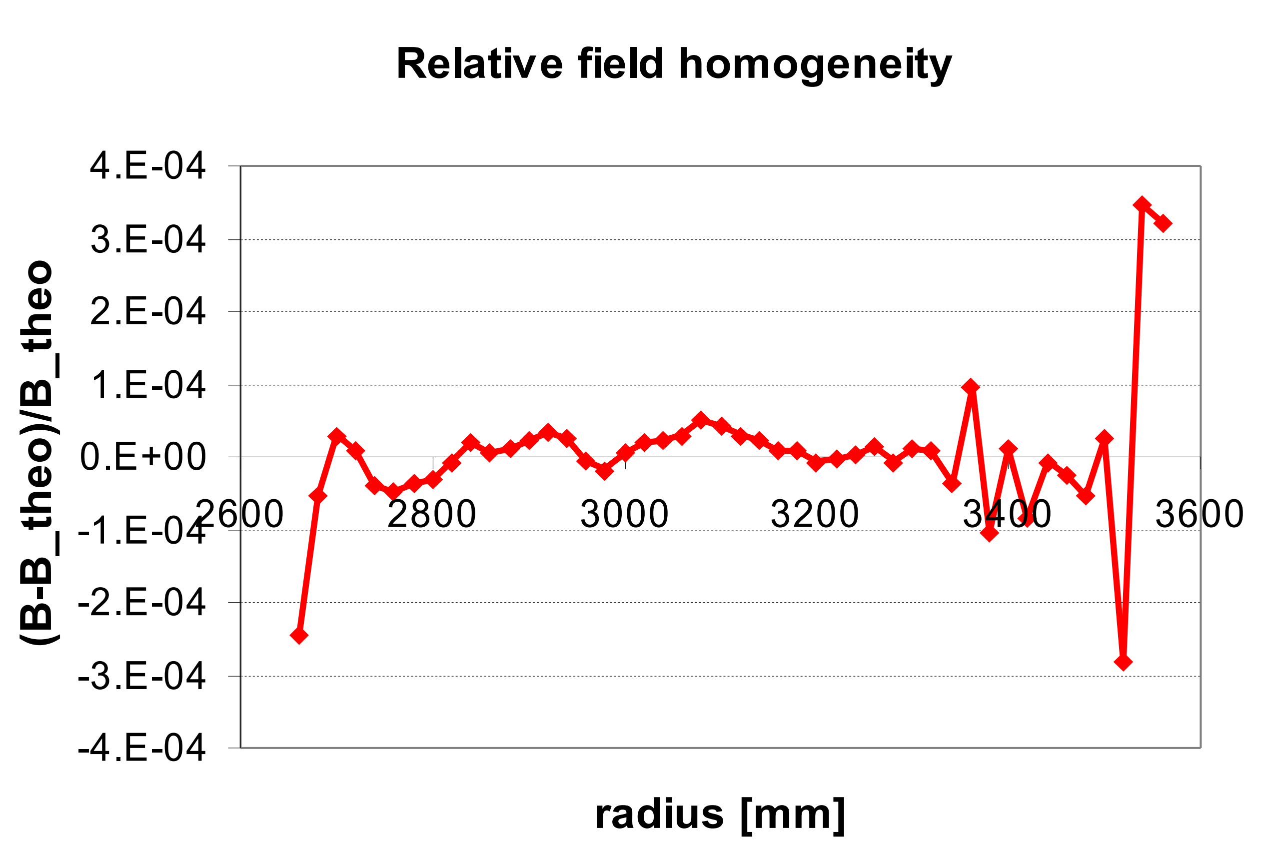
Part 2 – Scaling ring magnet design

A. Radial field law $(r/r_0)^K$

Second step – Automated 3D calculations



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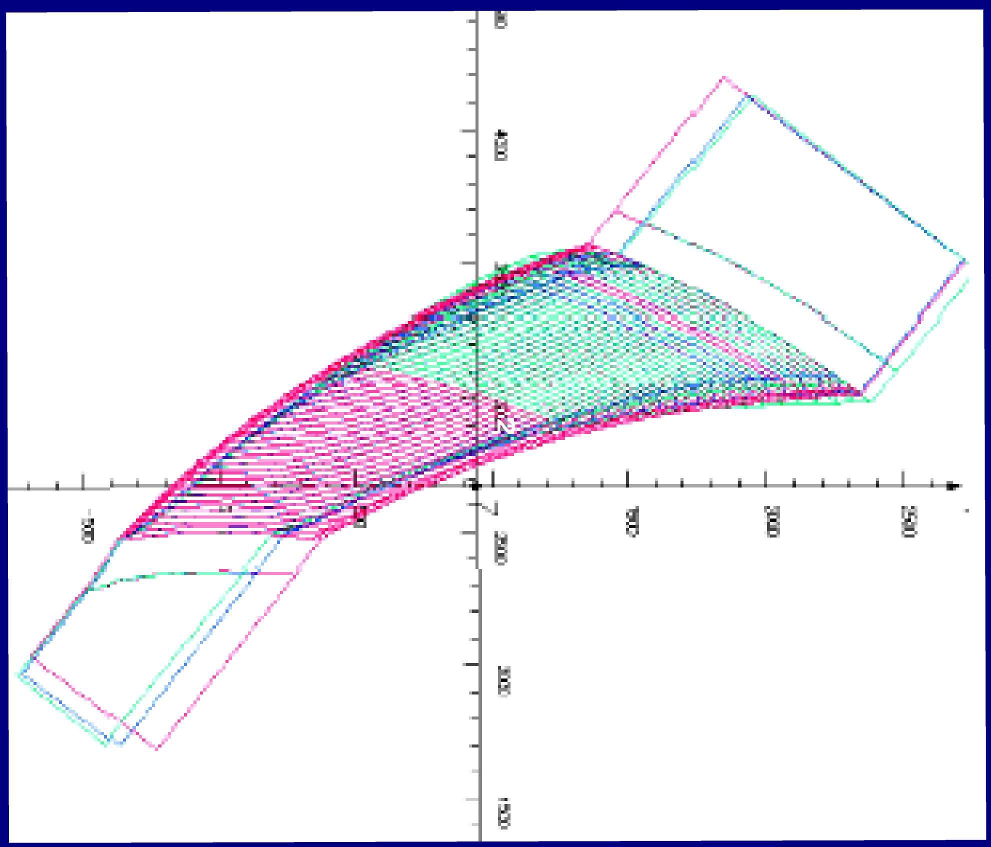
Part 2 – Scaling ring magnet design

B. Spiral magnet – Field azimuthal shape Tan(ς)*log(r/r_0)



Mechanical spiral must be tilted in order to obtained the right **magnetic spiral**

→Iterative process based on 3D calculations

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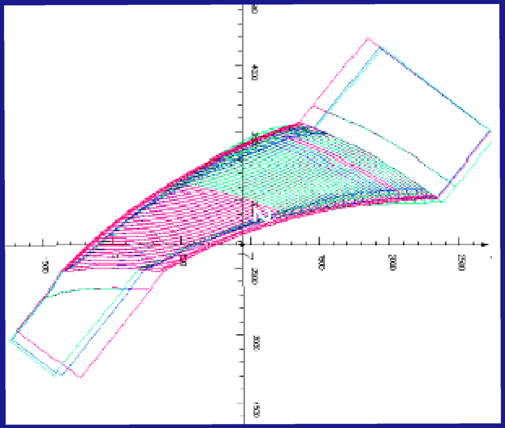
Part 2 – Scaling ring magnet design

B. Spiral magnet – Field azimuthal shape Tan(ς)*log(r/r_0)



- Magnetic center of the magnet is kept on the theoretical Tan(ς)*log(r/r_0) spiral shape
- Effective length is measured at different radius both sides of the magnet center
- Spiral shape is tilted so that the effective lenght corresponds to the theoretical calue at every radius
- An accuracy of 1 mm on effective lengths is reached after few iterations

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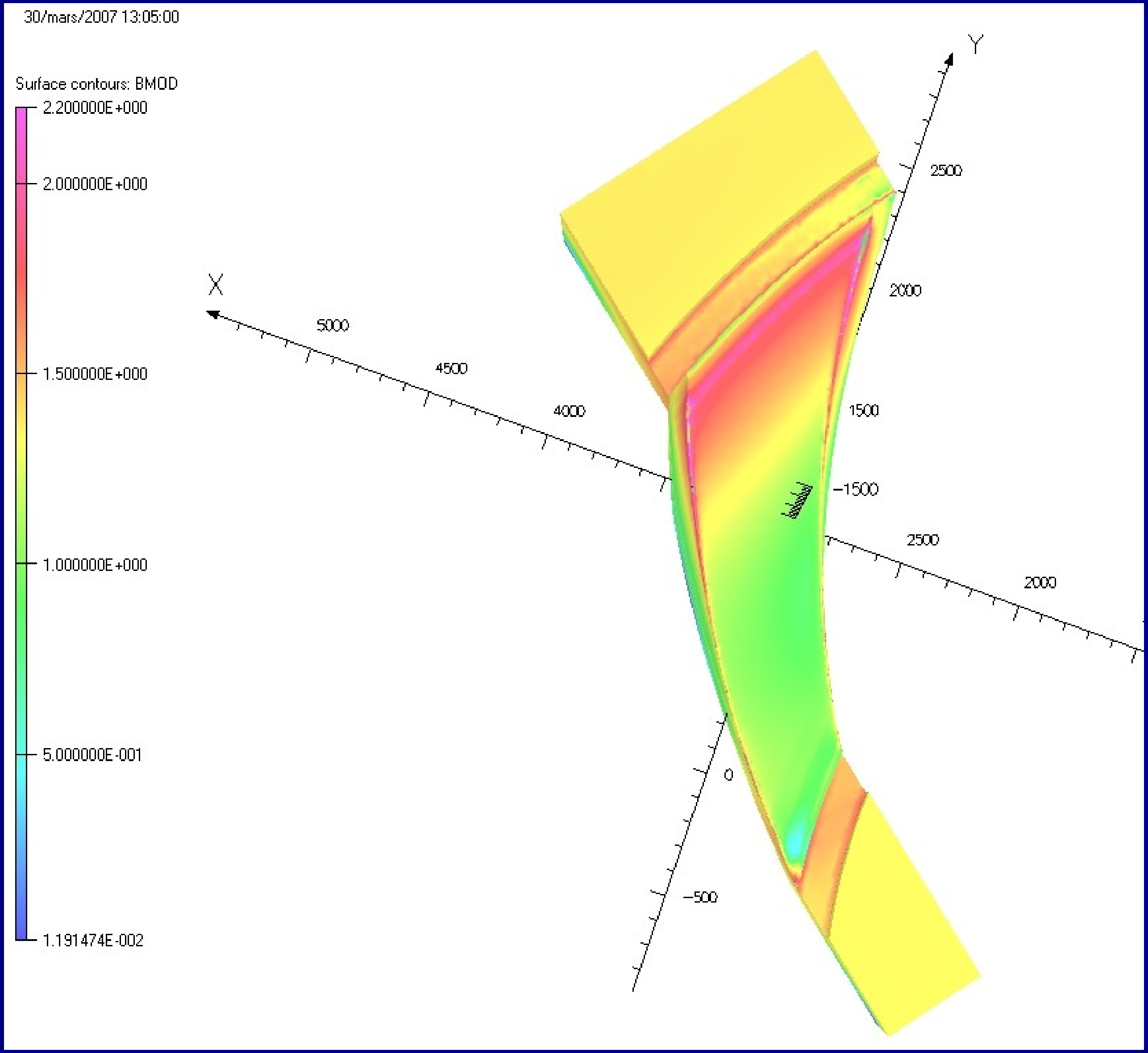

Per magnet

Iron ~ 25 t
Copper ~ 500 kg
Supply ~ 18 kW, 100A

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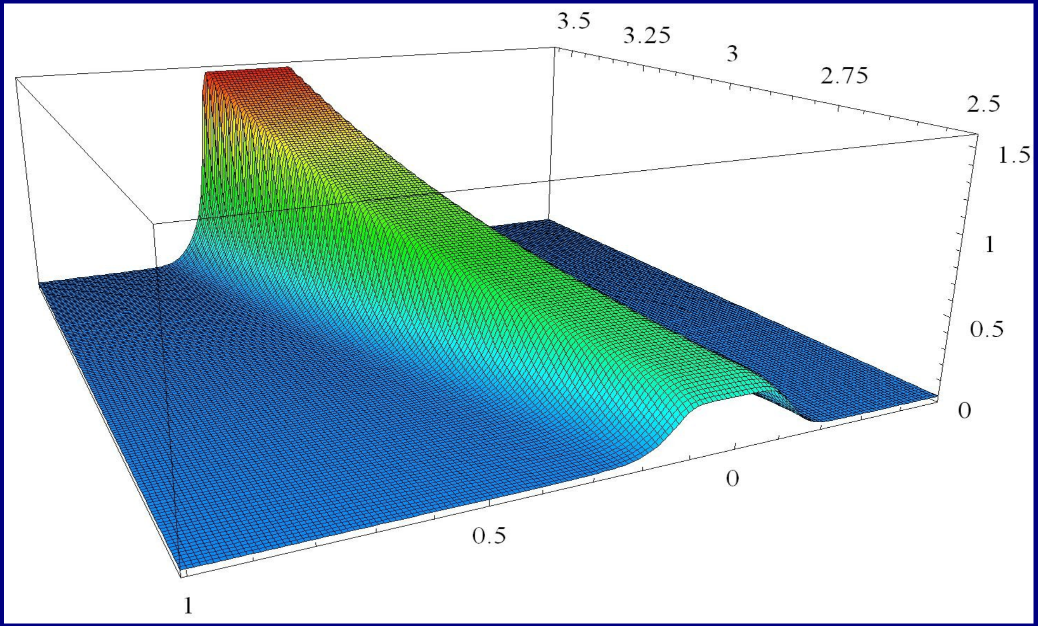
Part 2 – Scaling ring magnet design

C. First results from tracking

- Tracking is done at LPSC by Joris Fourrier using **Zgoubi**

- Field values in the middle plane are extracted from the 3D calculations



- Zgoubi extrapoles the field value in the upper planes

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C. First results from tracking

- The only results we have obtained yet are from 2D maps (middle plane of the magnet) extrapolated
- No result from real 3D map yet...

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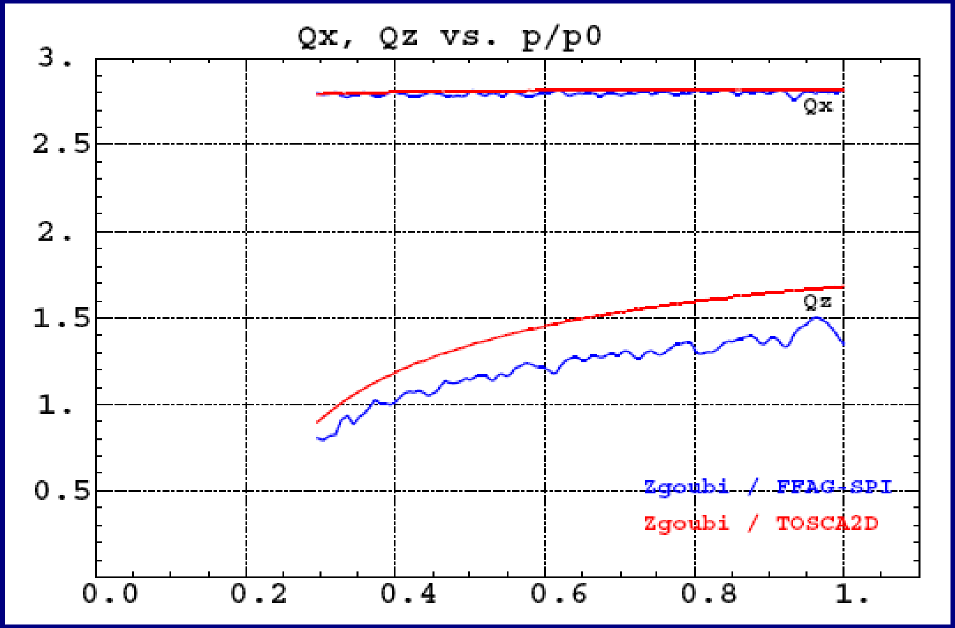
C. First results from tracking

Results of tracking in this extrapolated 2D maps are very close to what was expected with a gap shaped magnet



By Joris Fourrier

Horizontal motion is scaling, but vertical tune varies significantly

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Part 3 – Vertical scaling achievement

Issue

With gap shaped magnet fringe field length tends to decrease with radius ==> Vertical tune decreases

Two ways are curently explorered

- Chamfer height modification
- Spiral shape slight modification

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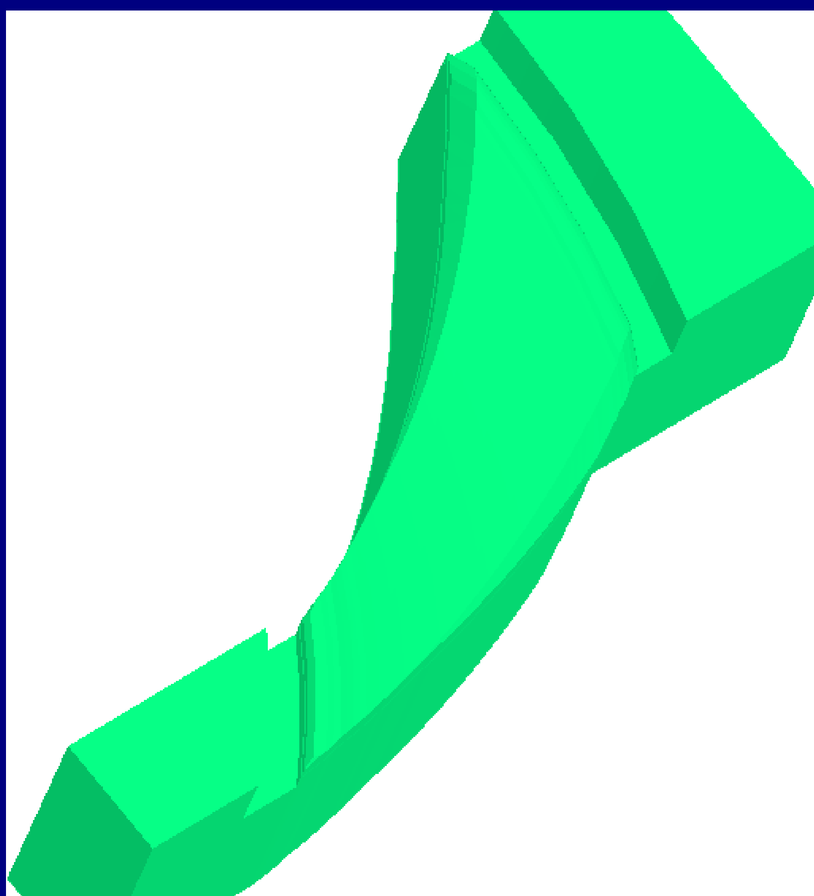
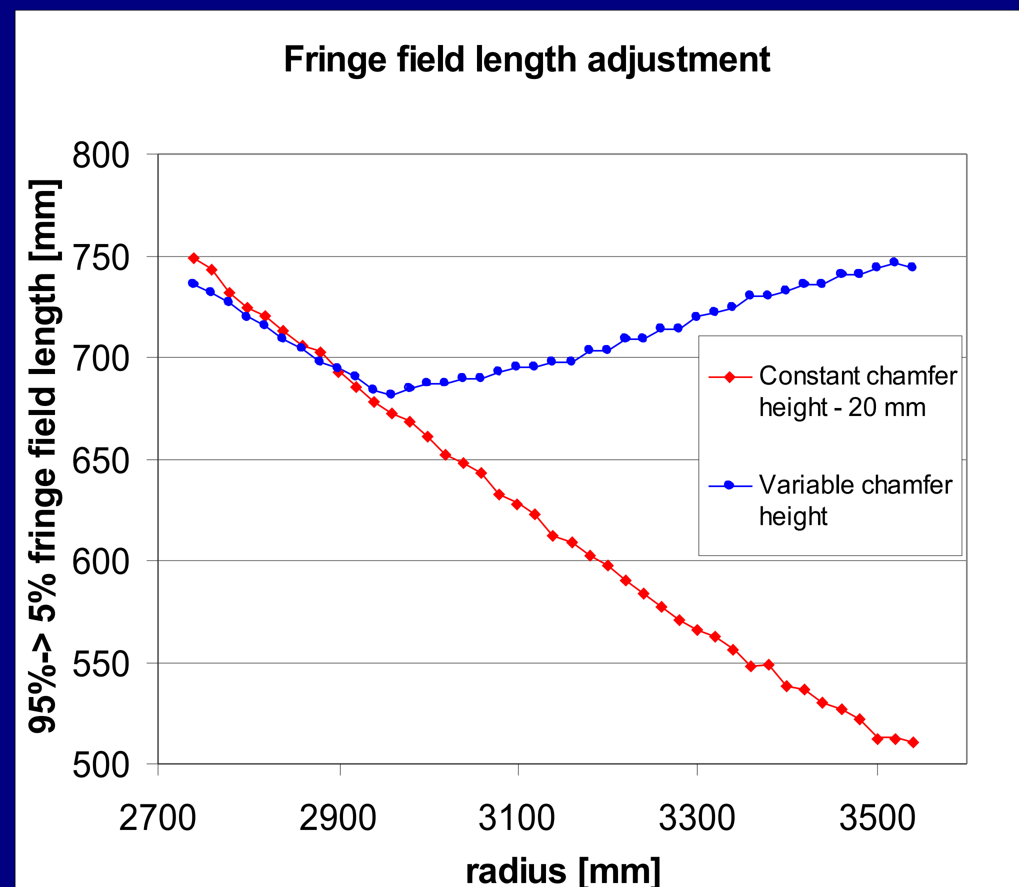
Part 3 – Vertical scaling achievement

Chamfer height modified with radius to increase fringe field length





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Part 3 – Vertical scaling achievement

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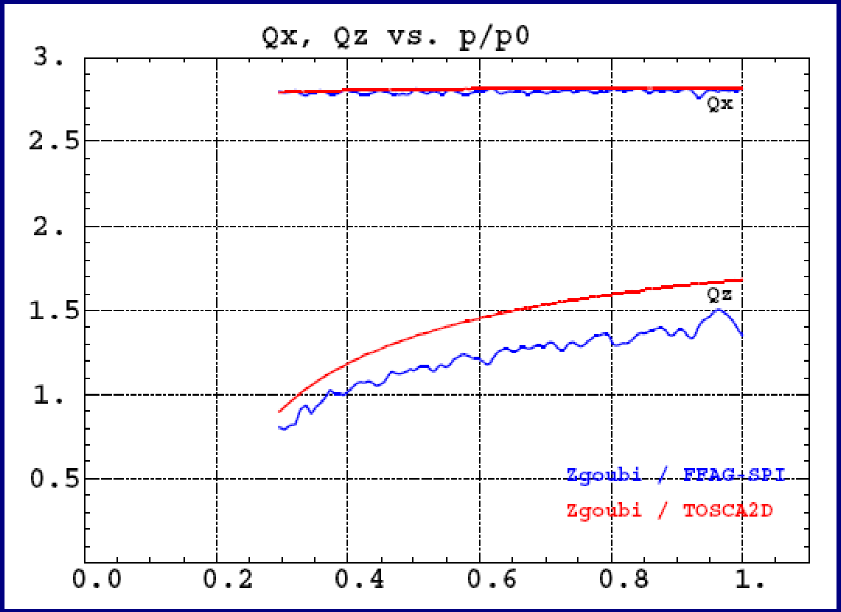
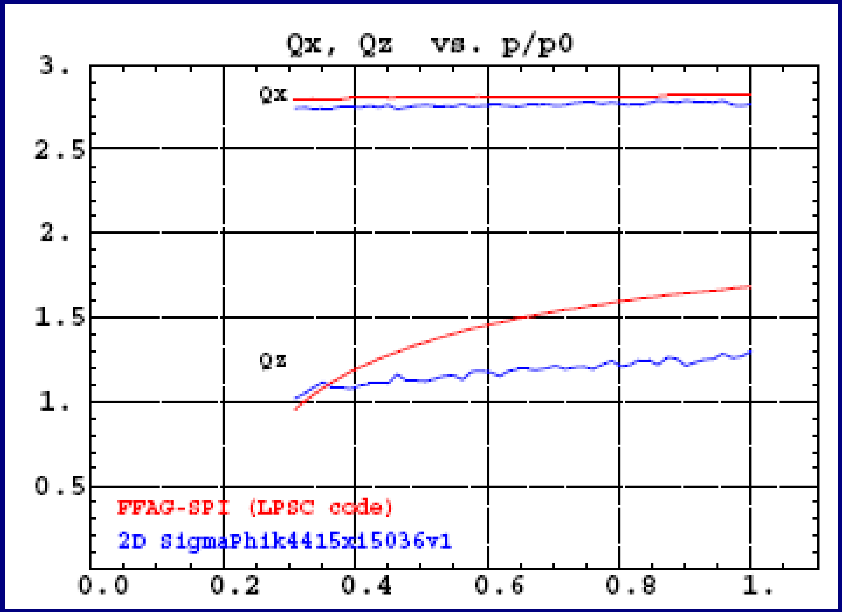


With constant chamfer



With variable chamfer

By Joris Fourrier

Part 3 – Vertical scaling achievement

Variation of spiral angle

UNDER STUDY...

Conclusion

- 3D calculation tools are ready: model conception process is almost entirely automated
- A large number of working points (K, ζ) and technical solutions (variable chamfer, variable K, ζ, use of field clamps...) will soon be tested by tracking...

Thank you for your attention