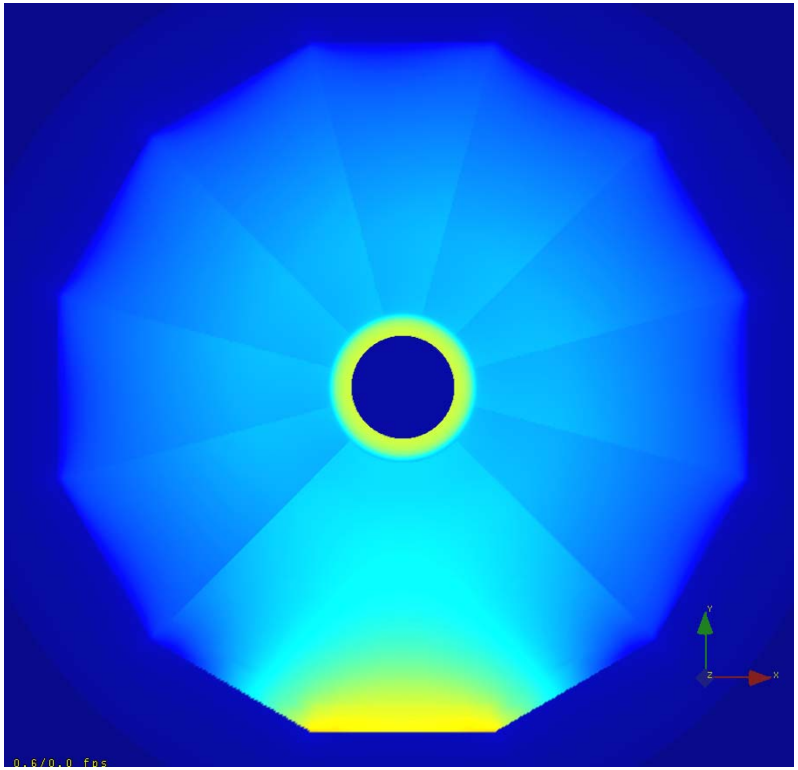
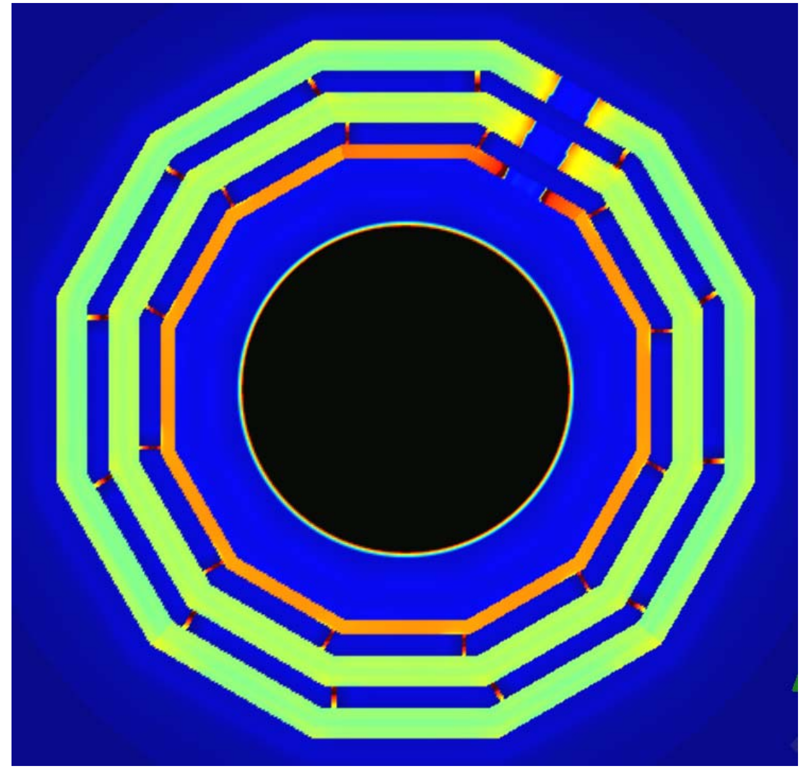
Magnetic Field Map in CMSSW 3.1.0





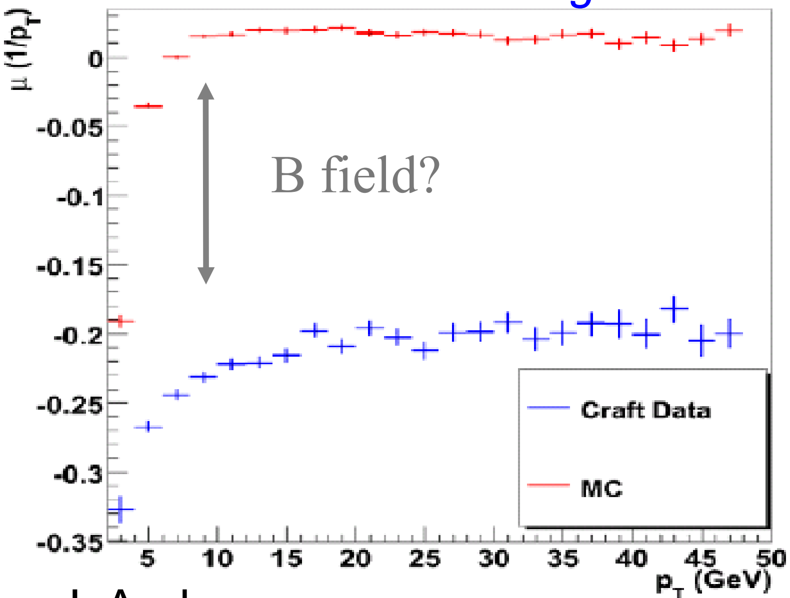
Summary of activity of MF WG and hn-cms-magnetic-field

N. Amapane, S. Bolognesi,

V. Klyukhin, M. Mulders

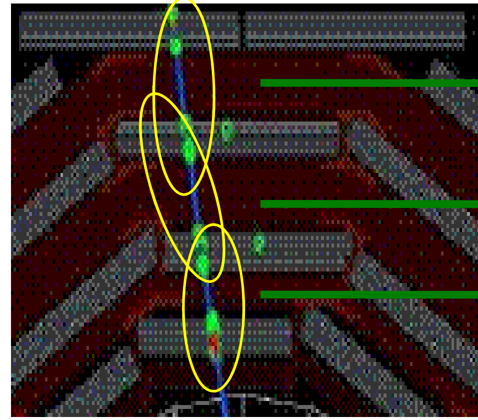
Starting point: CRAFT evidence

during CRAFT



J. Andrea

Dec CMS week

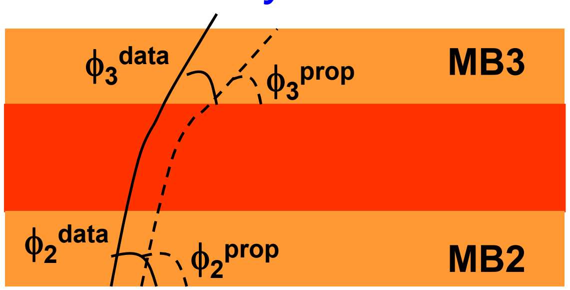


"Deficit" of B field in data:

- Layer3 ~ 30%
- Layer2 ~ 25%
- Layer1 ~ 5%

U.Gasparini, A. Calderon

Confirmed by measurement of "scaling factors":



real track (data) — solid line; **propagated track (B from map)** — dashed line

$$\frac{\left(\phi_3^{prop}-\phi_3^{data}\right)p_T^{MB3-2}-\left(\phi_2^{prop}-\phi_2^{data}\right)p_T^{MB2-1}}{\left(\phi_3^{prop}-\phi_2^{prop}\right)p_T^{MB3-2}} \propto \frac{B_{MB3-2}^{map}-B_{MB3-2}^{data}}{B_{MB3-2}^{map}}$$

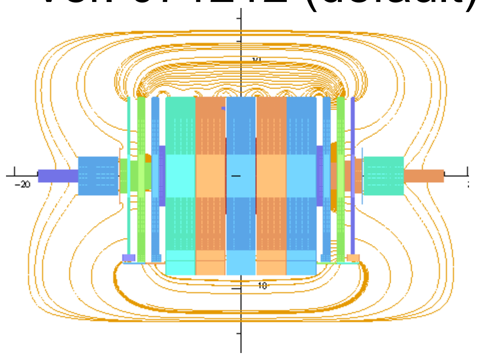
S. Bolognesi

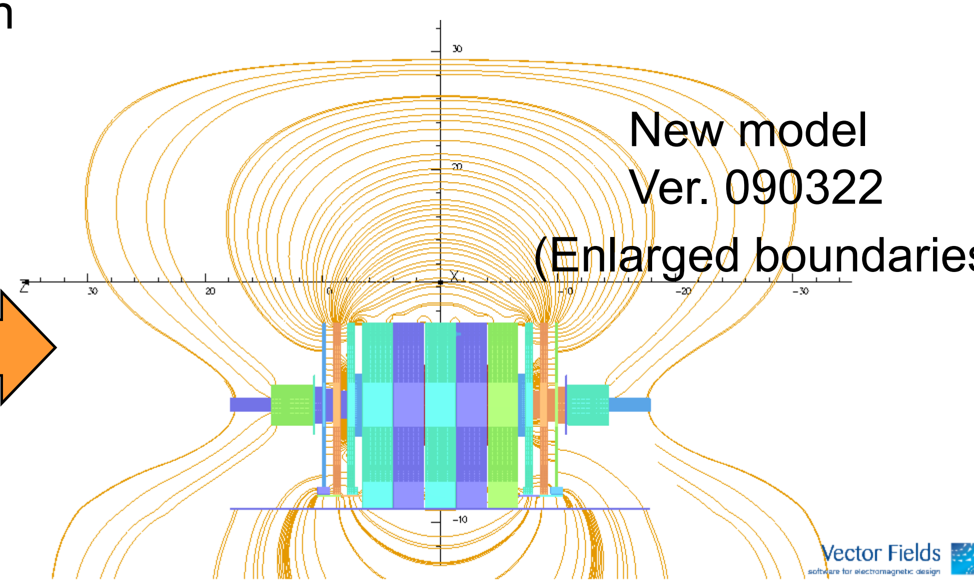
Other analyses by J. Pivarski; J. Ribnik; for the endcaps: D. Dobur, M. Schmitt

First improvement: "New" TOSCA model

Problem found: field lines "squeezed" in the yoke due to model boundaries

Ver. 071212 (default)





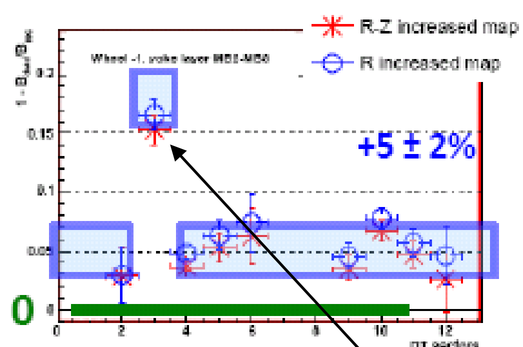
New model
Ver. 090322
(Enlarged boundaries)

Improves agreement with data:

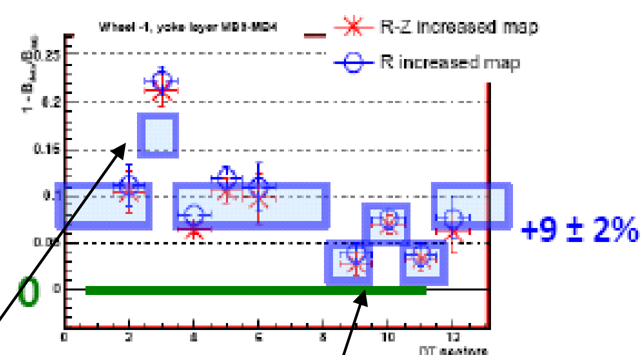
Overall scale difference:

- ~0% in layer 1 (was 10%)
- ~5% in layer 2 (was 25%)
- ~9% in layer 3 (was 30%)
- ~5-10% in EndCap

YB/-1/2 (layer 2)

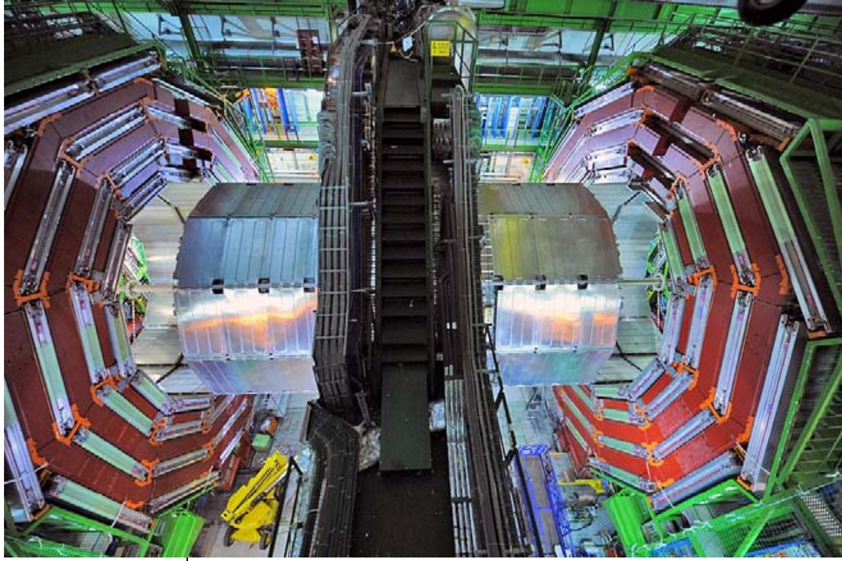


YB/-1/3 (layer 3)

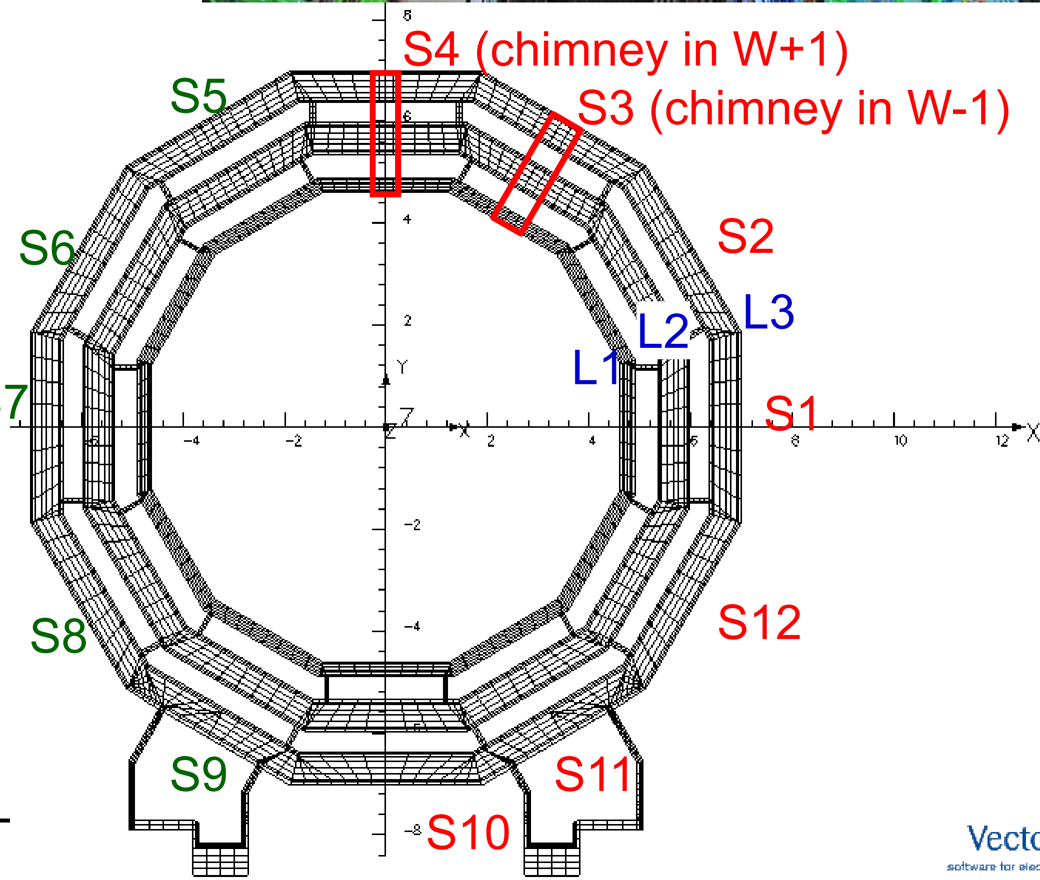


Phi-symmetry: good approximation, except for chimneys (S3, S4) and feet (S9-11)

Is CMS really ϕ-symmetric?

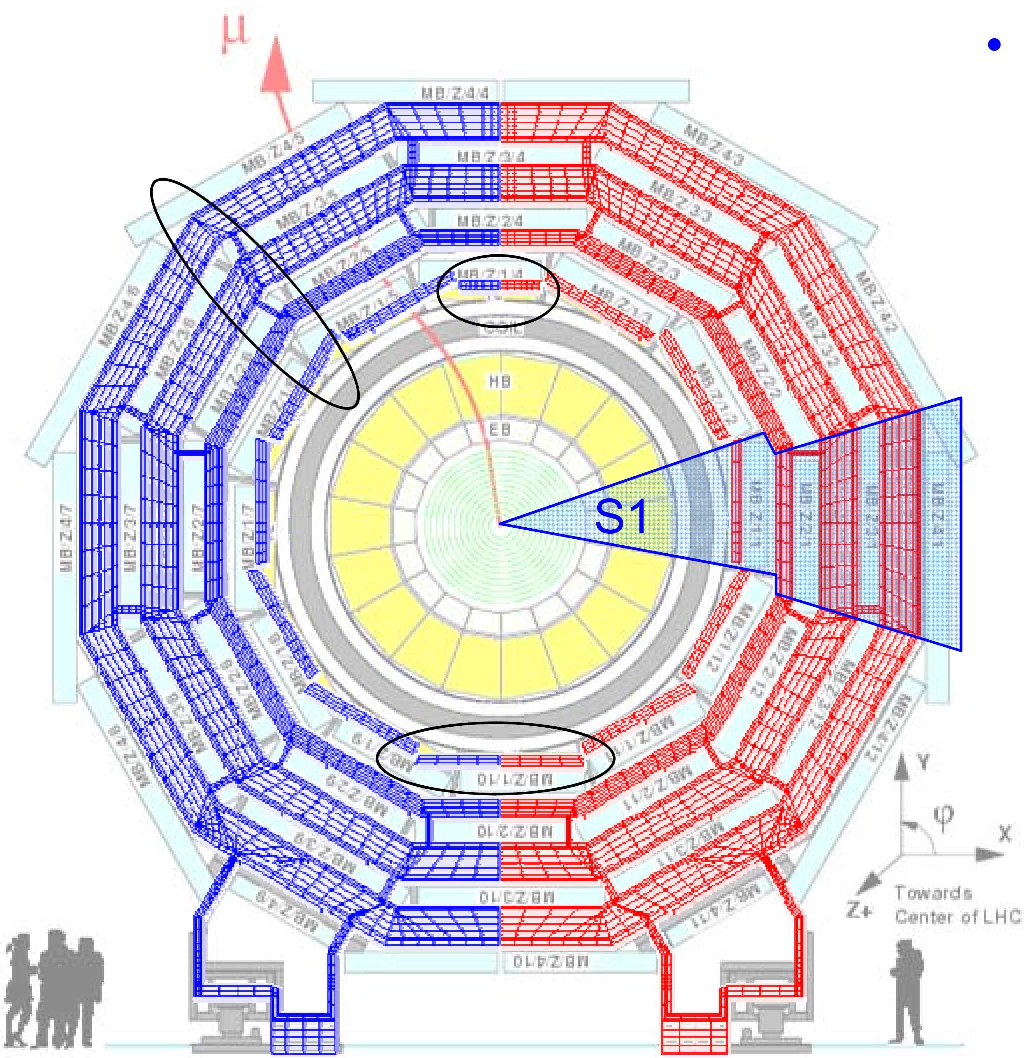


- Almost - except for few details
  - Electric chimney in S4 +W+1
  - Cryogenic chimney in S3 W-1
  - Feet in S9, S11 (also affect S10)
  - Thickness of S9-S11 in L3
    - Larger by +3.5 cm



- Thus, CMSSW map was designed ϕ-symmetric
  - TOSCA model for Sector 1 (312 volumes) replicated 12 times rotating it by (S-1)*30°

TOSCA Model and CMSSW Map



Mirrored

Described in TOSCA

- TOSCA model actually describes all the x>0 half of CMS
  - To allow comparison with measurements
  - Sectors other than 1 never [meant to be] used for the CMSSW map
  - Can they be?

- CMS is not x-symmetric

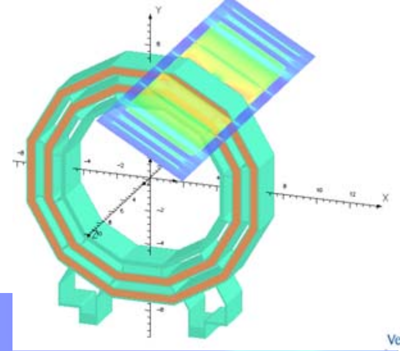
  ⇒ cannot simply mirror x>0 half to x<0!

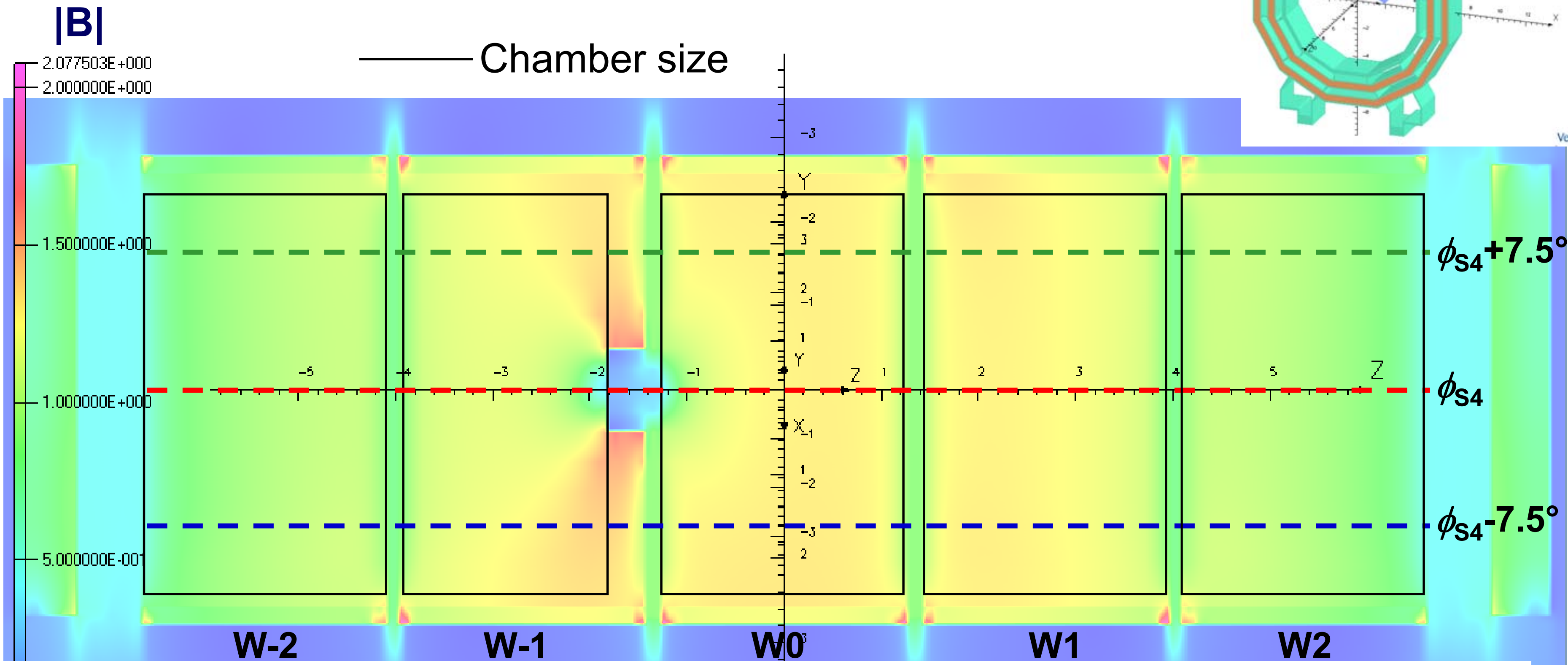
Predicted ϕ-asymmetry in TOSCA (recap)

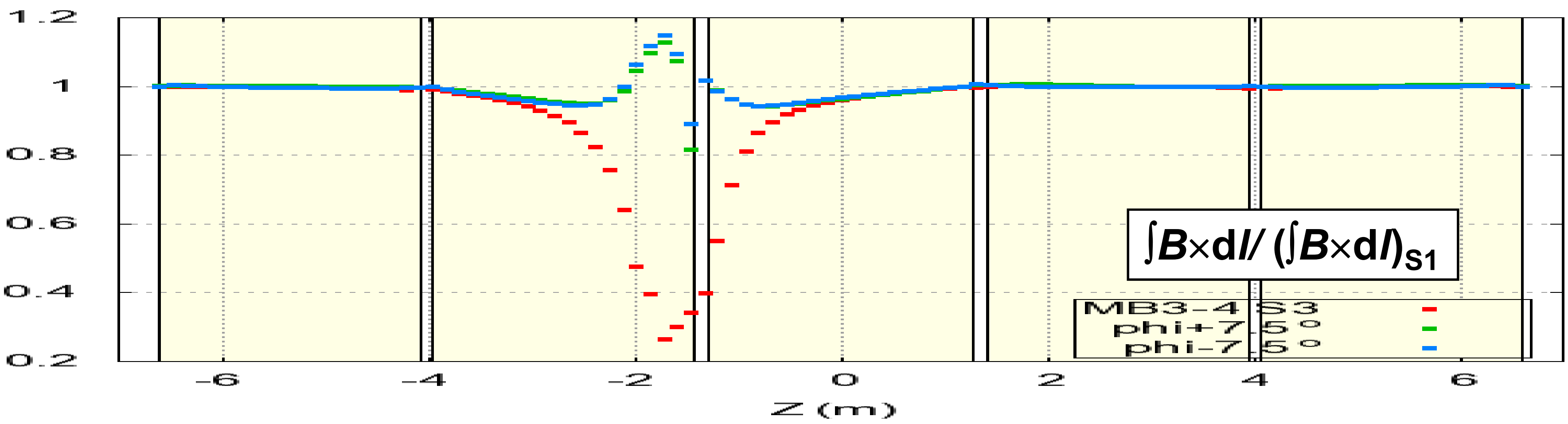
- Using the full X>0 part in TOSCA, we can:
  1. compare the ϕ-asymmetry of measured scaling factors with the model
  2. Study how good is the approximation of a 12-fold replicated sector-1 map

- Observable:
  - $\int B \times dl$ between MB1-MB2, MB2-MB3, MB3-MB4, computed in the TOSCA model 090322 for each sector, relative to sector 1
    - Full set of plots cf. backup slides; circulated/discussed on hn:
      https://hypernews.cern.ch/HyperNews/CMS/get/magnetic-field/36/2/1/1/1/4/1/1/2/1/2/1/1/1.html
    - Here just an example for S3, L3 (next slide)

S3, L3 (cryogenic chimney)







Predicted phi-asymmetry (summary)

1. "scaling factors" predicted from TOSCA match the asymmetry observed in data
   - Of course, apart for the overall scale
2. Differences w.r.t. sector 1 (used in the CMSSW map) are significant only where expected (chimney sectors and in S10-S11 of L3); small elsewhere (O(1%))
   - Scaling factors clearly not a good solution in these cases: large variation within the iron plate…

- This suggest that using the predicted shape of the field in these few sectors would be a significant improvement…

A ϕ-asymmetric map…

- Ideal solution: develop a complete 2π TOSCA map
  - Develop new TOSCA geometry
  - Develop new CMSSW geometry – lengthy to develop and integrate
  - (up to) 12 x more volumes and data tables
  - This is a long term project!!

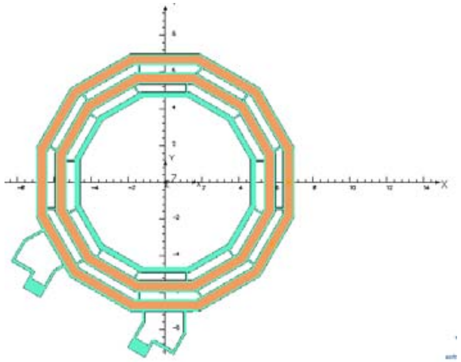
- In the meanwhile: can we exploit as much as possible the present TOSCA model, at least for sectors 3,4 (chimneys) and 9-11 (feets?)
  - Initially looked unrealistic:
    - **Problem 1**: Cannot afford a change of the CMSSW geometry $\Rightarrow$ Chimneys cannot be described explicitly
    - **Problem 2**: x<0 part mirrored from TOSCA x>0 model is not correct
    - **Problem 3**: work to adapt OPERA scripts to produce tables for sectors other than 1, adapt CMSSW to read them, and validate everything expected to be O(weeks)

Easier than expected…

- **Problem 1**: cannot change the CMSSW geometry ⇒ Chimneys cannot be described explicitly
  - **Solution**: use a very fine grid for the volumes with chimneys. Larger size in memory, but no need to tell CMSSW anything special

- **Problem 2**: mirrored part at x<0
  - Actually, the parts that are not x-symmetric are tail-catcher & iron brackets
  - the large iron plates *are* x-symmetric (except for indirect effect of the above)
  - Thus: the relevant effects of S9 and x<0 part of S4, S10 can be included using sector-specific tables for the large iron plates only

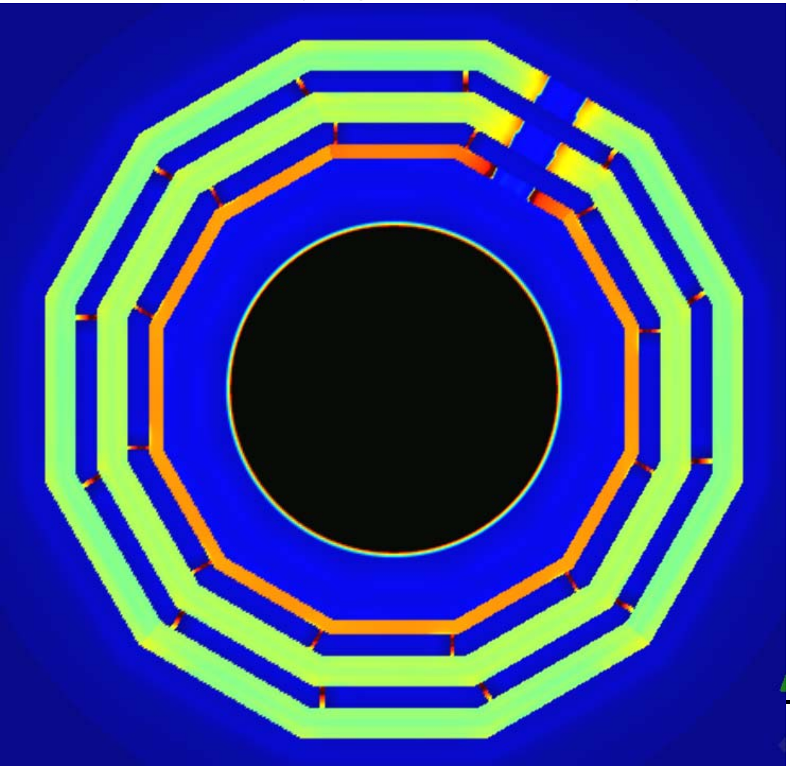
- **Problem 3**: lot of work to adapt OPERA scripts to produce tables for sectors other than 1, adapt CMSSW to read them, and validate it
  - Nice idea: rotate the local r.f. in TOSCA, keep the same OPERA scripts. Resulting tables are in local reference frame ⇒ no need to adapt CMSSW code



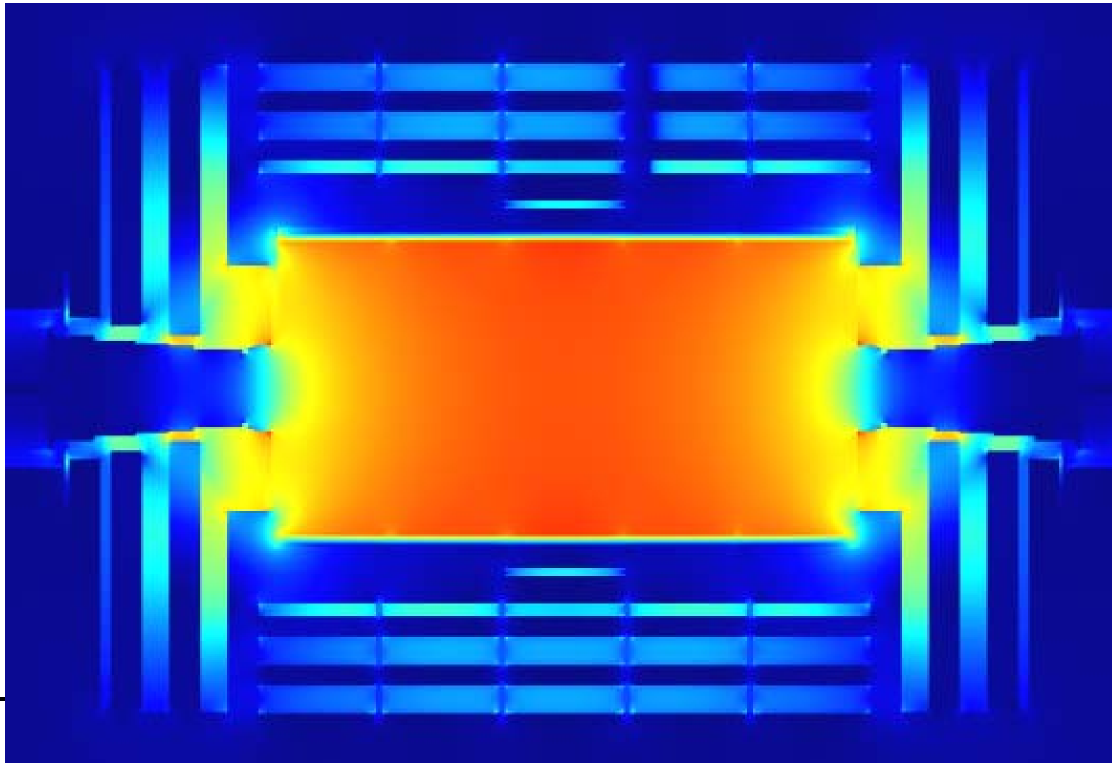
Barrel

- For S3 and S4, include specific tables for all volumes of L1, L2, L3
  - No TC and air surrounding it (wrong in x<0 part of S4)
  - No brackets and air between layers (wrong in x<0 part of S4)
- For S9,10,11 include only volumes of L3
  - Small difference elsewhere in the barrel

Cryogenic chimney

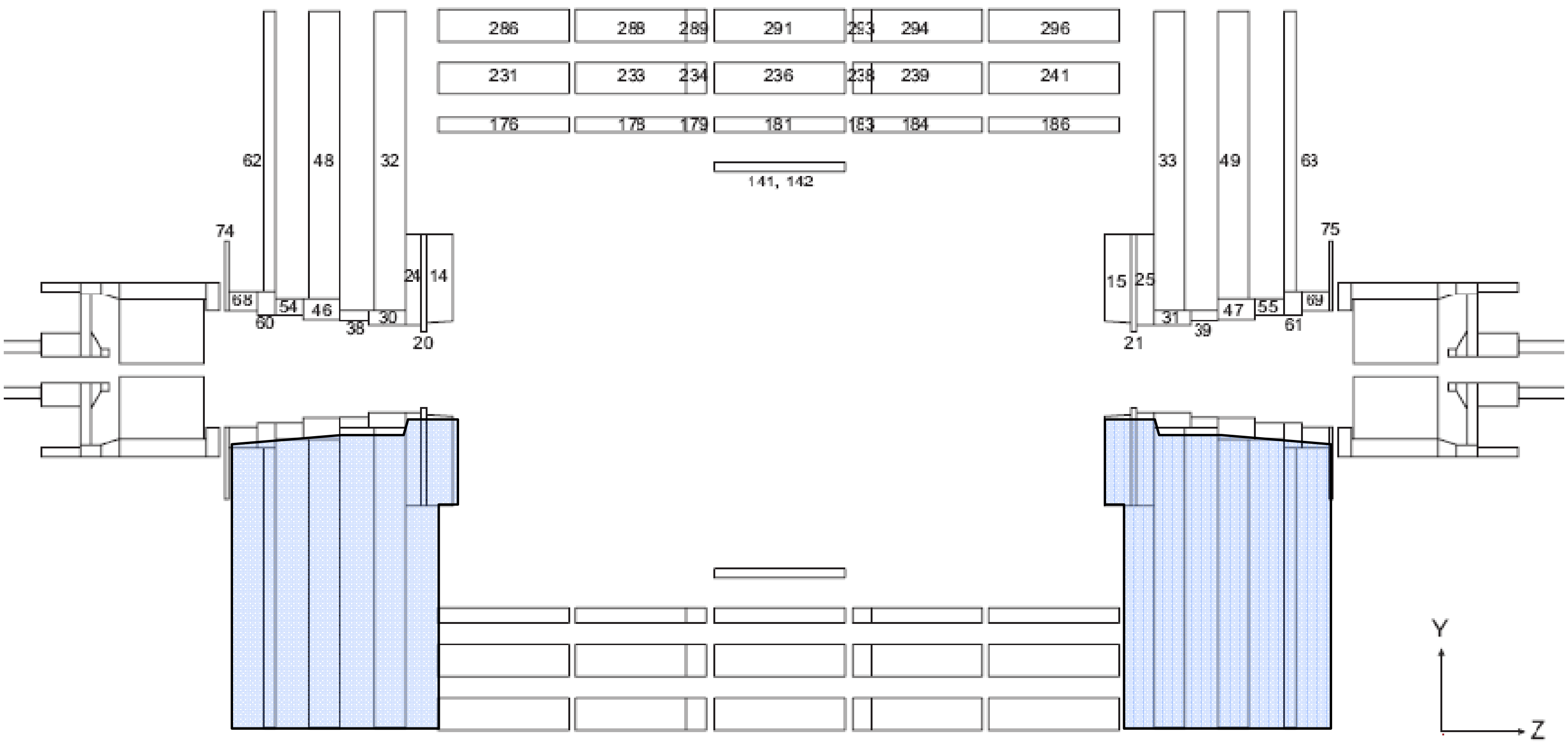


Electric chimney



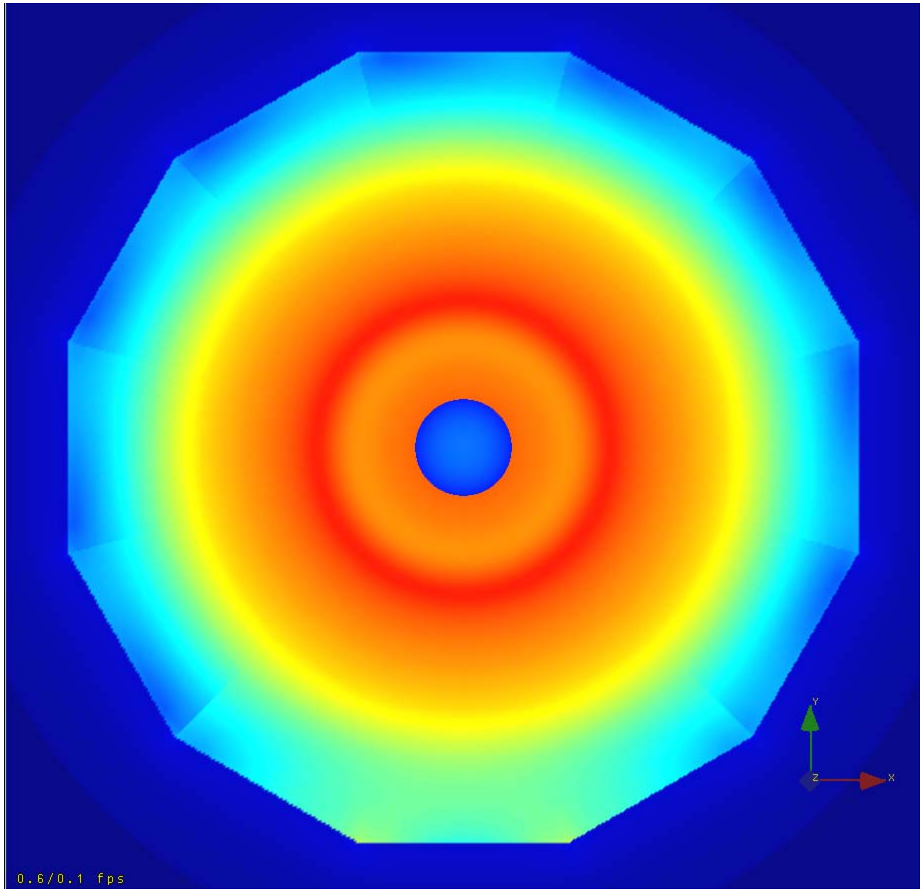
Endcaps

- for S9-11, include specific tables YE1, YE2, YE3 disks + YN + air between disks and between YE1 and barrel
  - No forward region and inner iron "collars"
  - Air is probably not really necessary, but is cheap

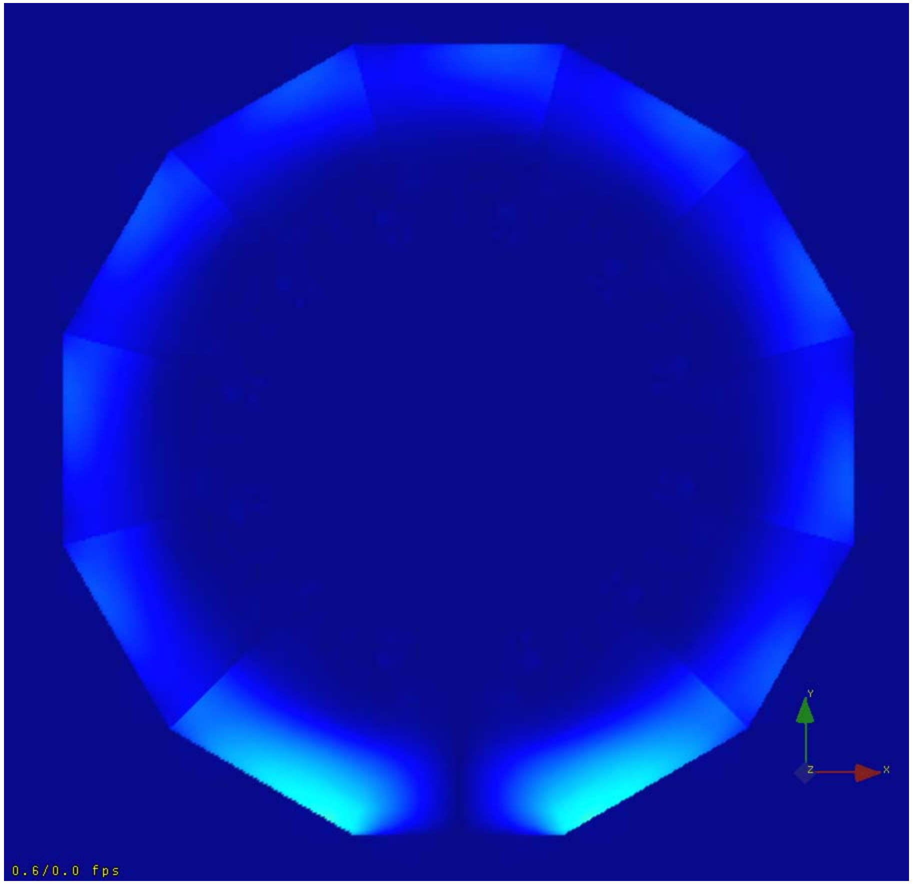


YE+1

|B|

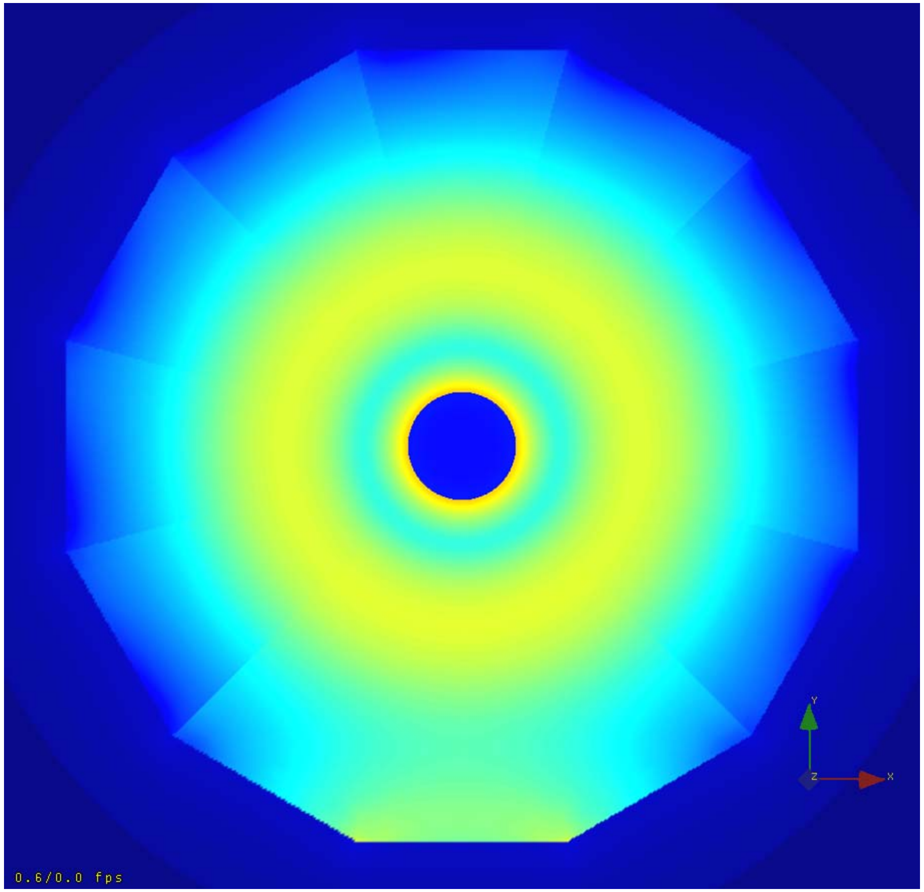


$|B_\phi|$

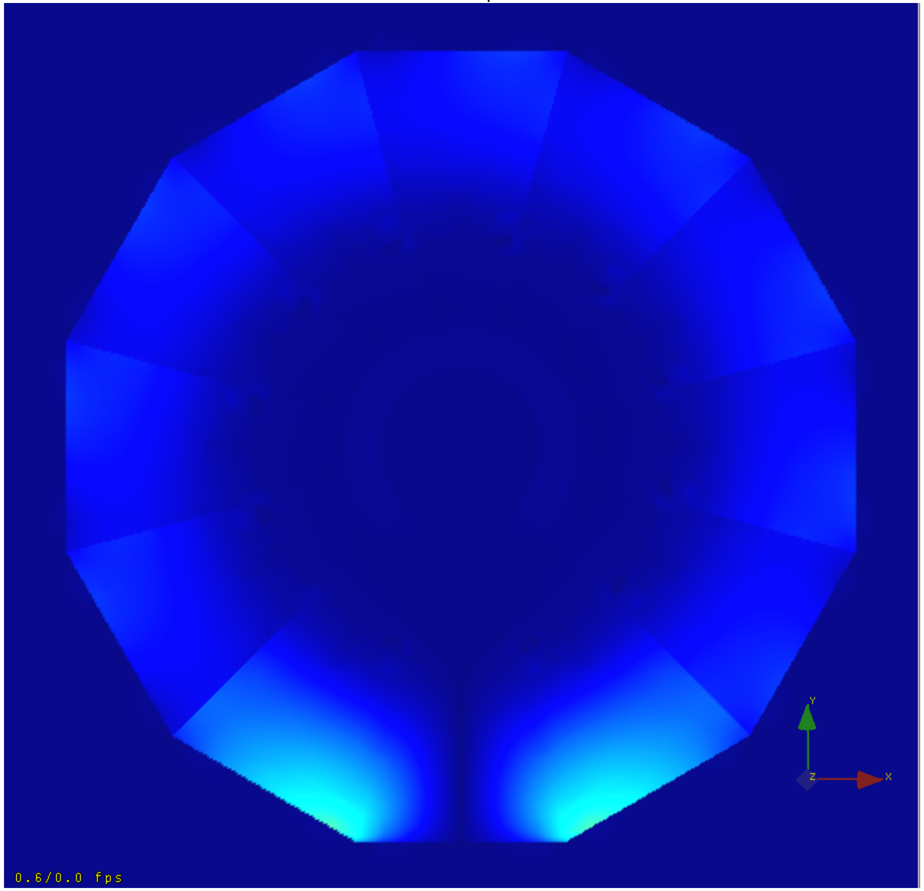


YE+2

|B|

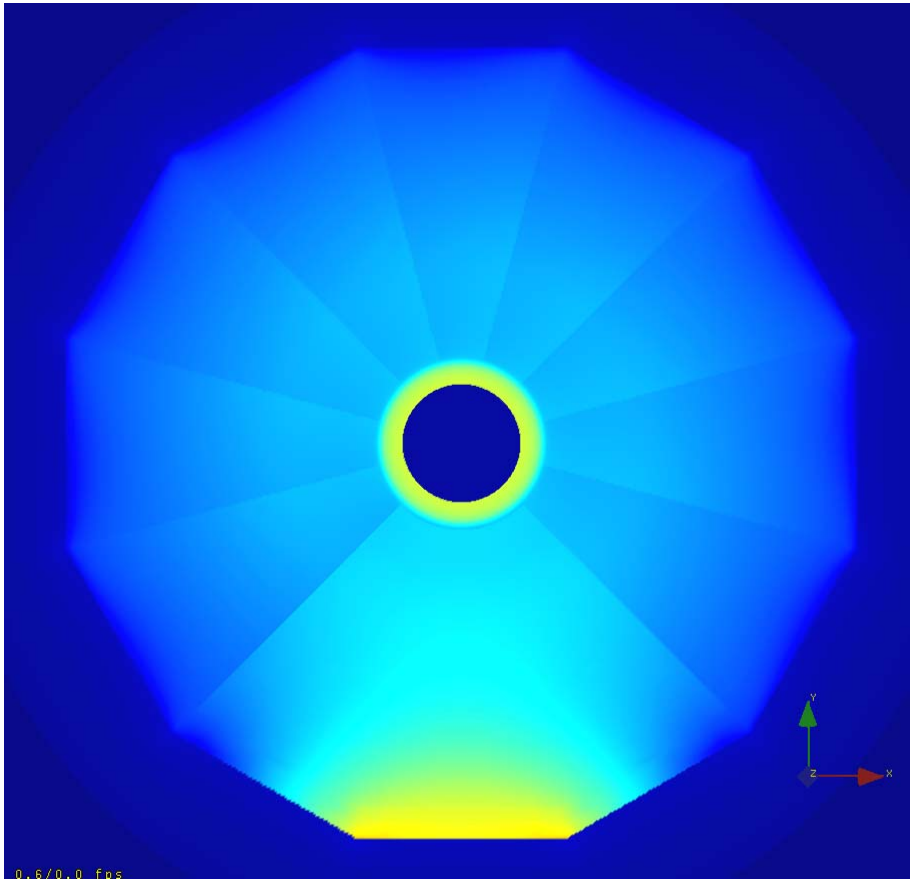


$|B_\phi|$

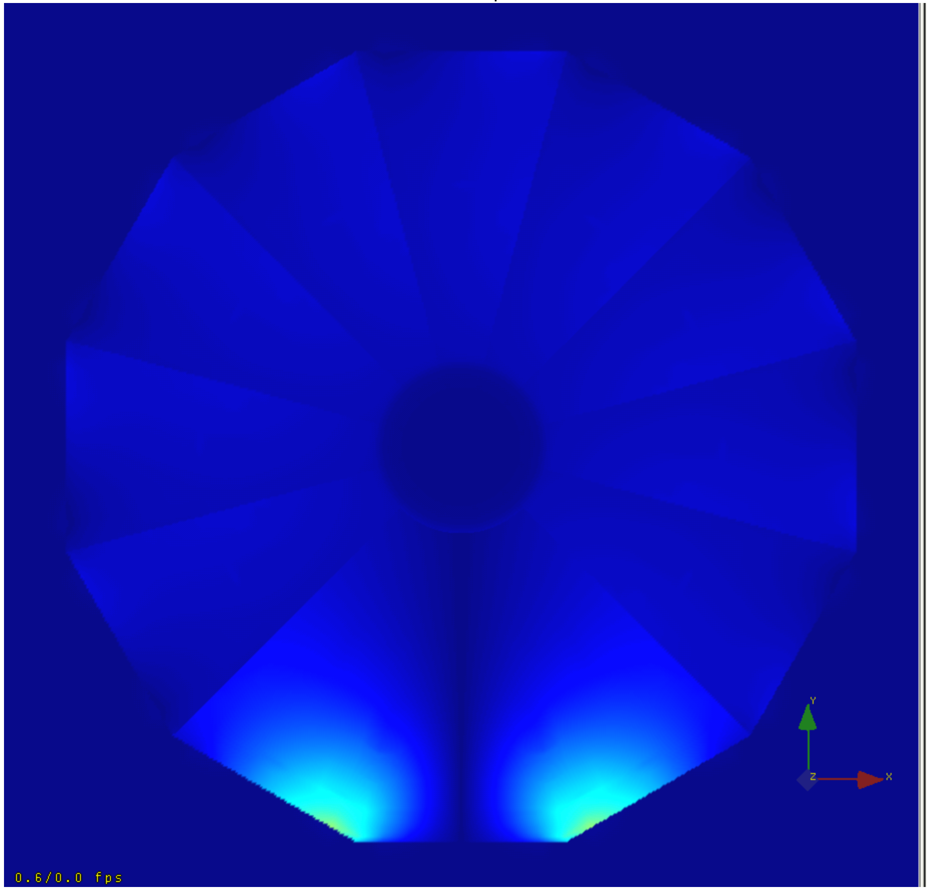


YE+3

|B|



$|B_\phi|$



Scaling factors

- S.F. recomputed on top of this phi-asymmetric map
  - With phi-asymmetric map, all sectors in a wheel can be fitted together (*)
  - Fit + and – wheels together

  - Scaling factors (*):

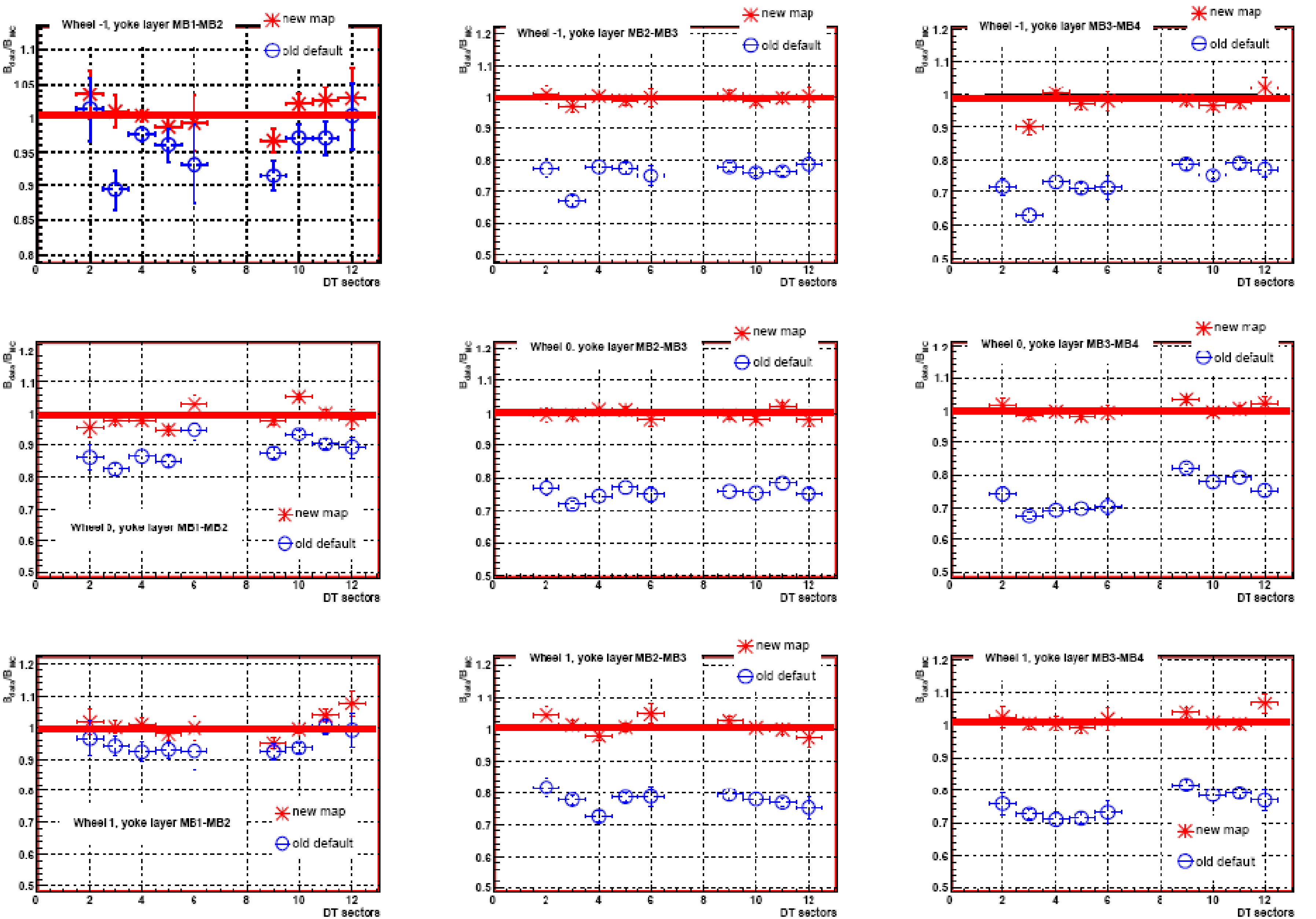
	W+-2	W+-1	W0
L1	0.994	1.004	1.005
L2	0.956	0.958	0.953
L3	0.918	0.924	0.906

** with additional factor for different thickness of S9-11*

- These factors are also included in the tag for CMSSW 3_1_0
  - Uncertainties can only be used to build distorted maps for systematic studies

- Endcaps: promising study on YE1 (D. Dobur, M. Schmitt)
  - To be updated on top of newest map…

Result: scaling factors with CMSSW 2.2.X vs. 3.1.0



Conclusions

- CMSSW 3_1_0 field map will include:
  - Specific tables for relevant volumes in S3, S4 (barrel) and S9-11 (barrel L3 and endcaps)
  - Scaling factors correcting for the overall scale of barrel layers

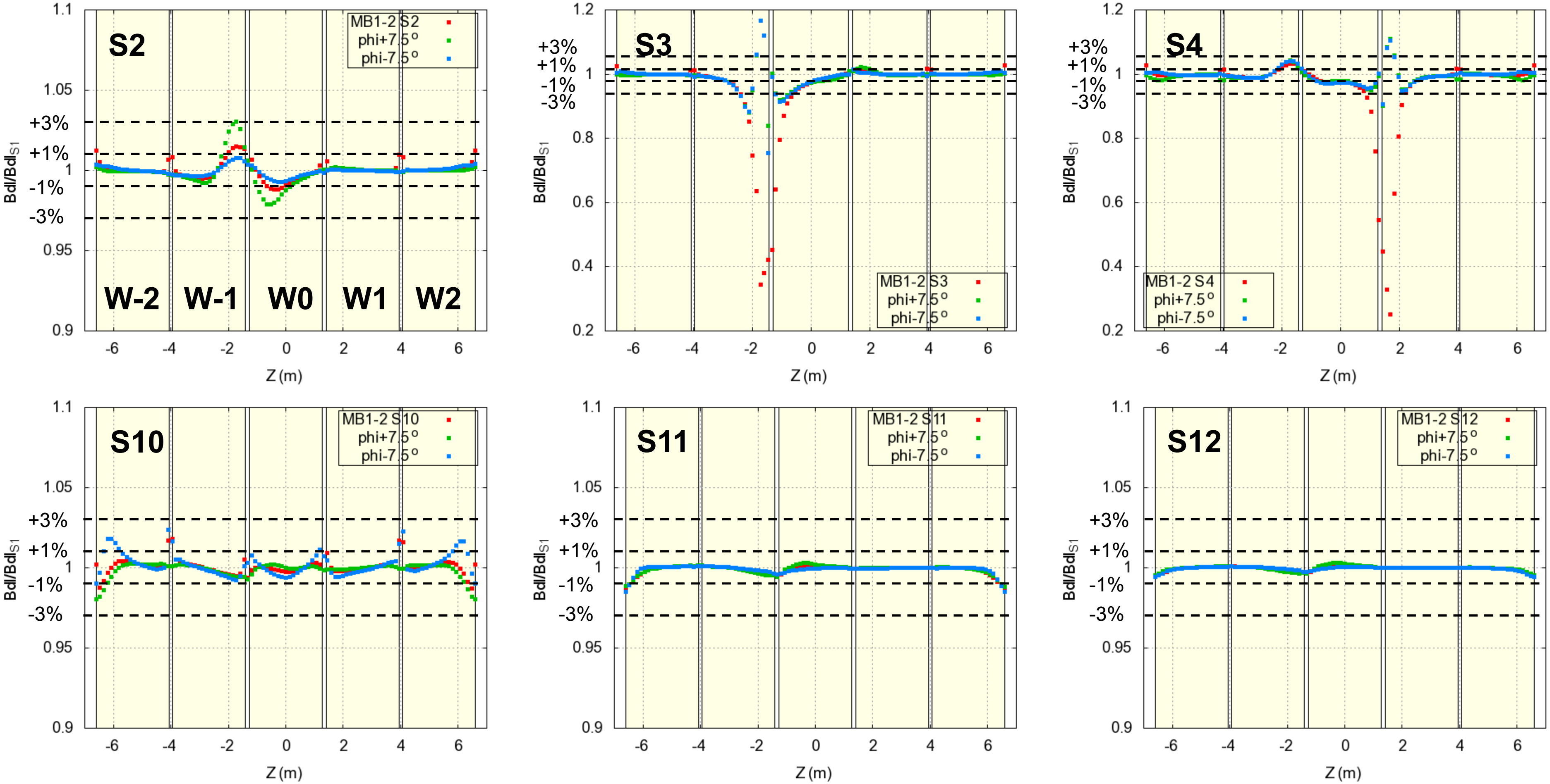
- Made good use of CRAFT data!

- CRAFT paper in preparation :CFT-09-015
  https://twiki.cern.ch/twiki/bin/view/CMS/MagneticFieldCRAFTPaper

BACKUPS

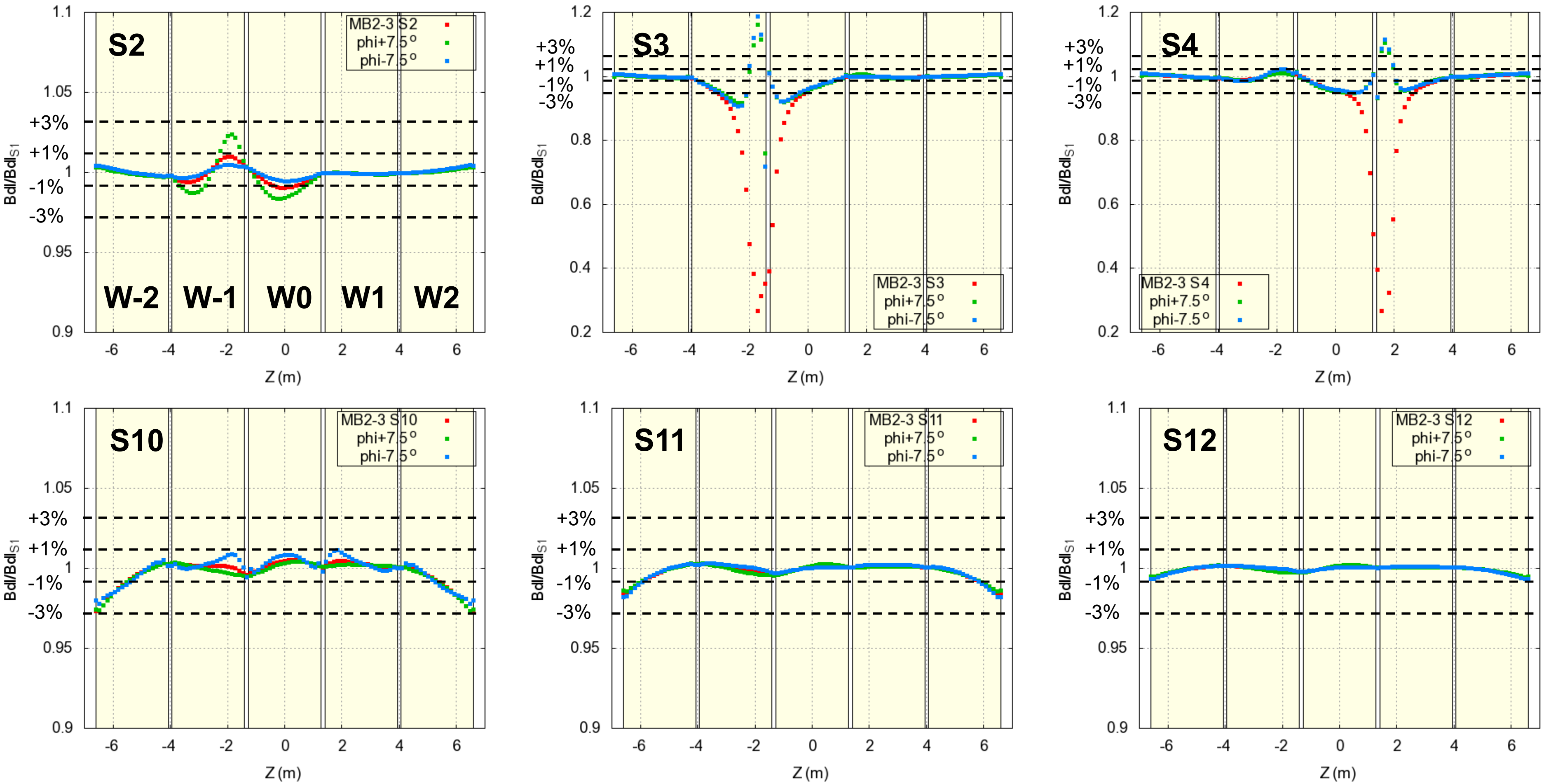
$\int B\times dl/ (\int B\times dl)_{S1}$ MB1-MB2

– Middle ϕ of sector
– Middle ϕ of sector +7.5°
– Middle ϕ of sector -7.5°



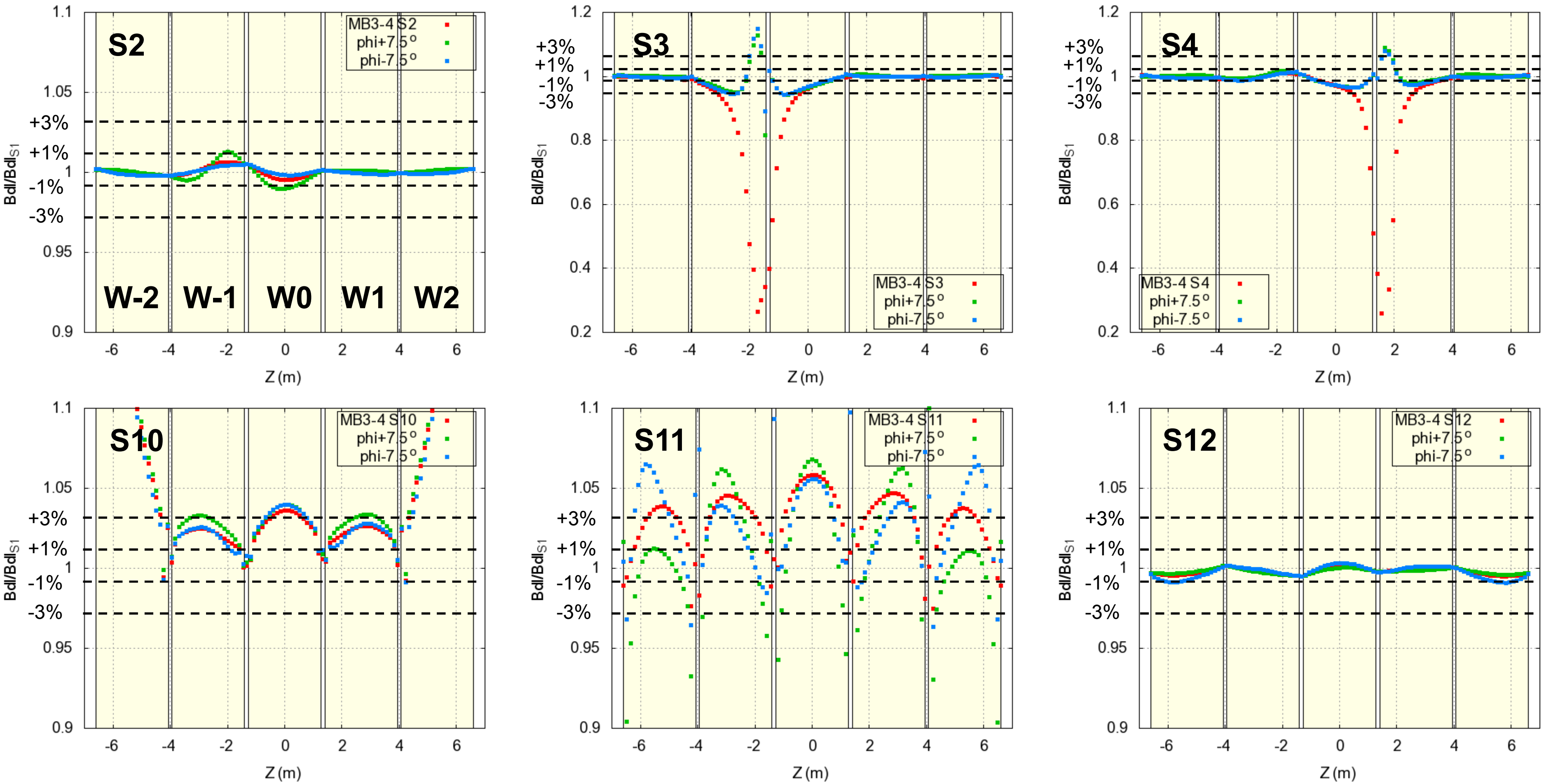
$\int B \times dl / (\int B \times dl)_{S1}$ MB2-MB3

– Middle ϕ of sector
– Middle ϕ of sector +7.5°
– Middle ϕ of sector -7.5°

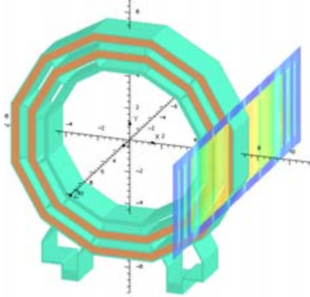


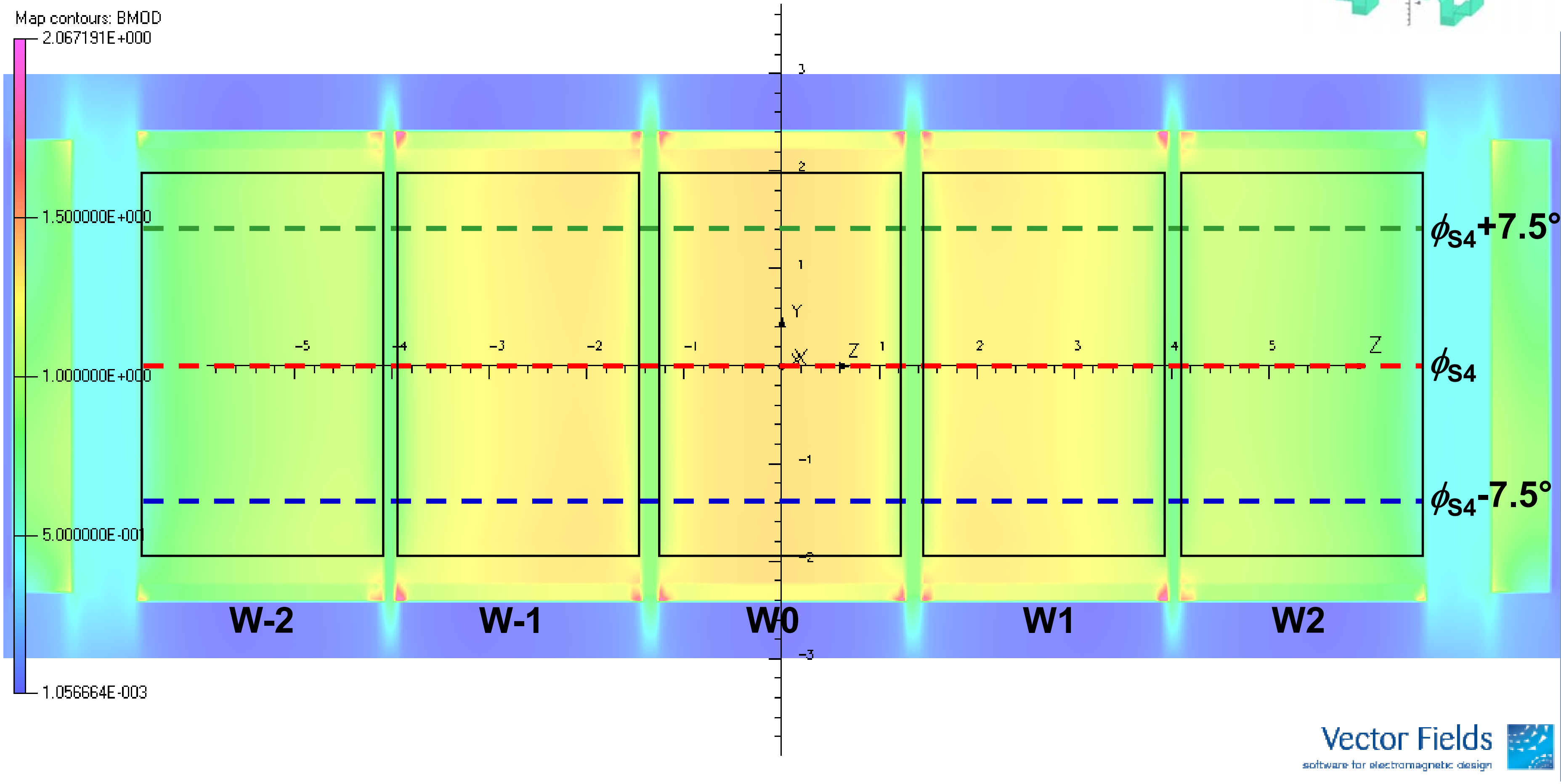
$\int B\times \mathrm{d}l / (\int B\times \mathrm{d}l)_{S1}$ MB3-MB4

– Middle ϕ of sector
– Middle ϕ of sector +7.5°
– Middle ϕ of sector -7.5°

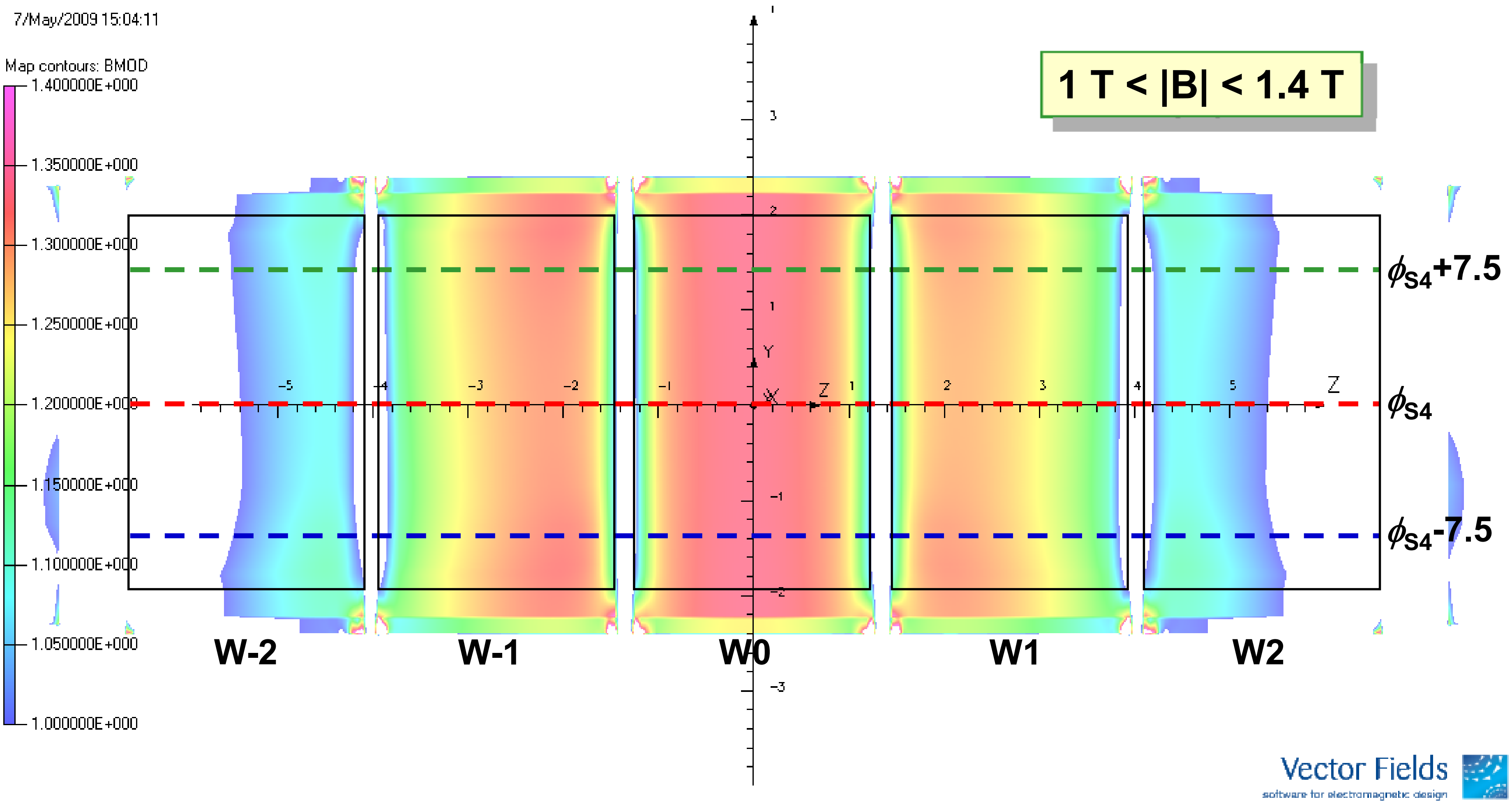


|B| in S1, L3 (normalization)

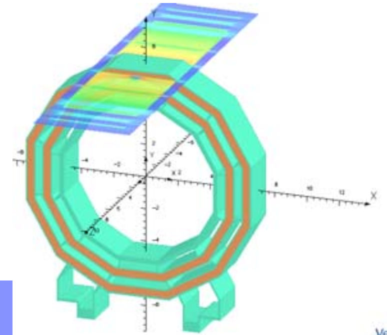


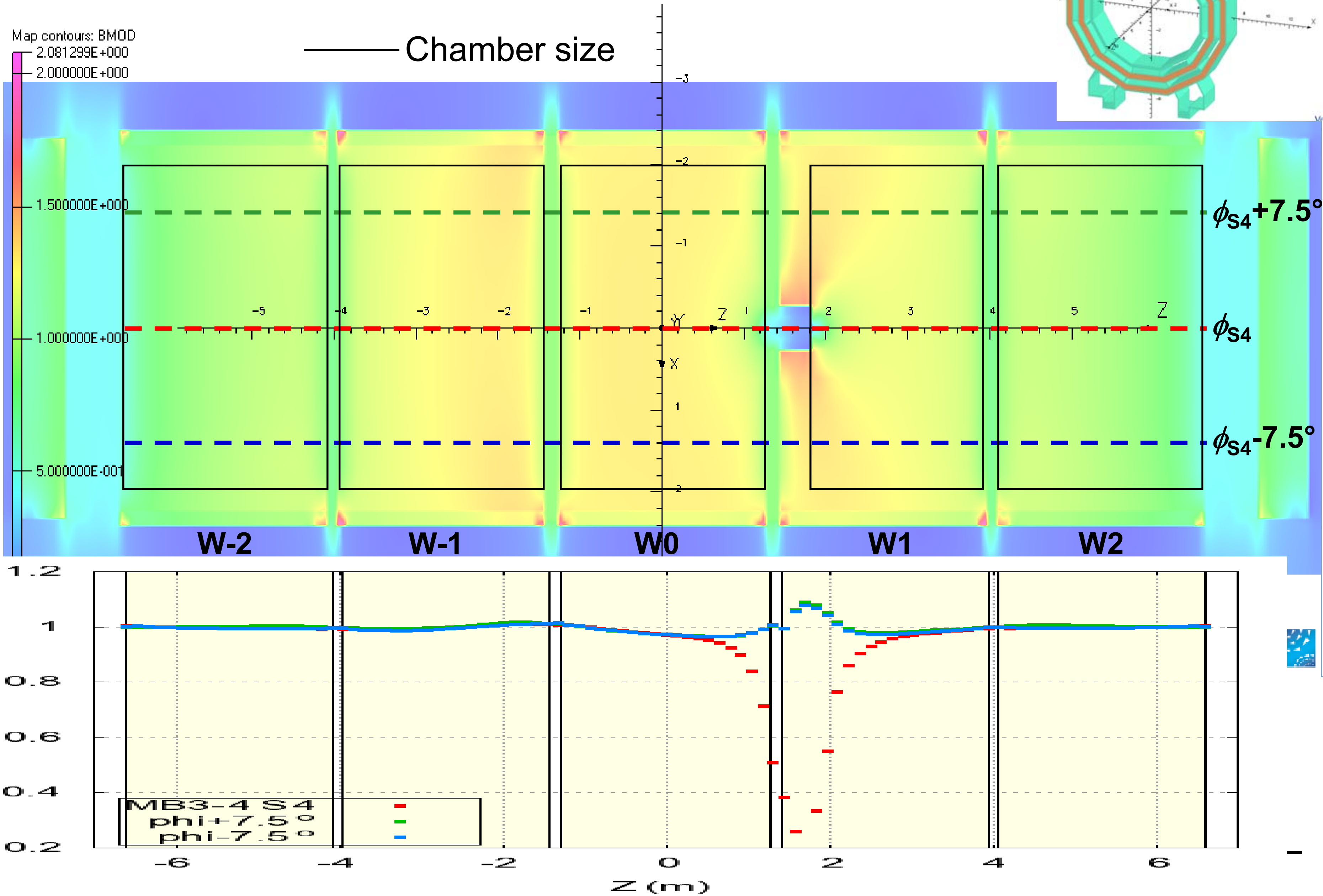


|B| in S1, L3 (normalization) - zoom

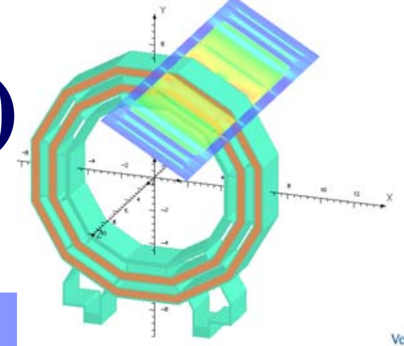


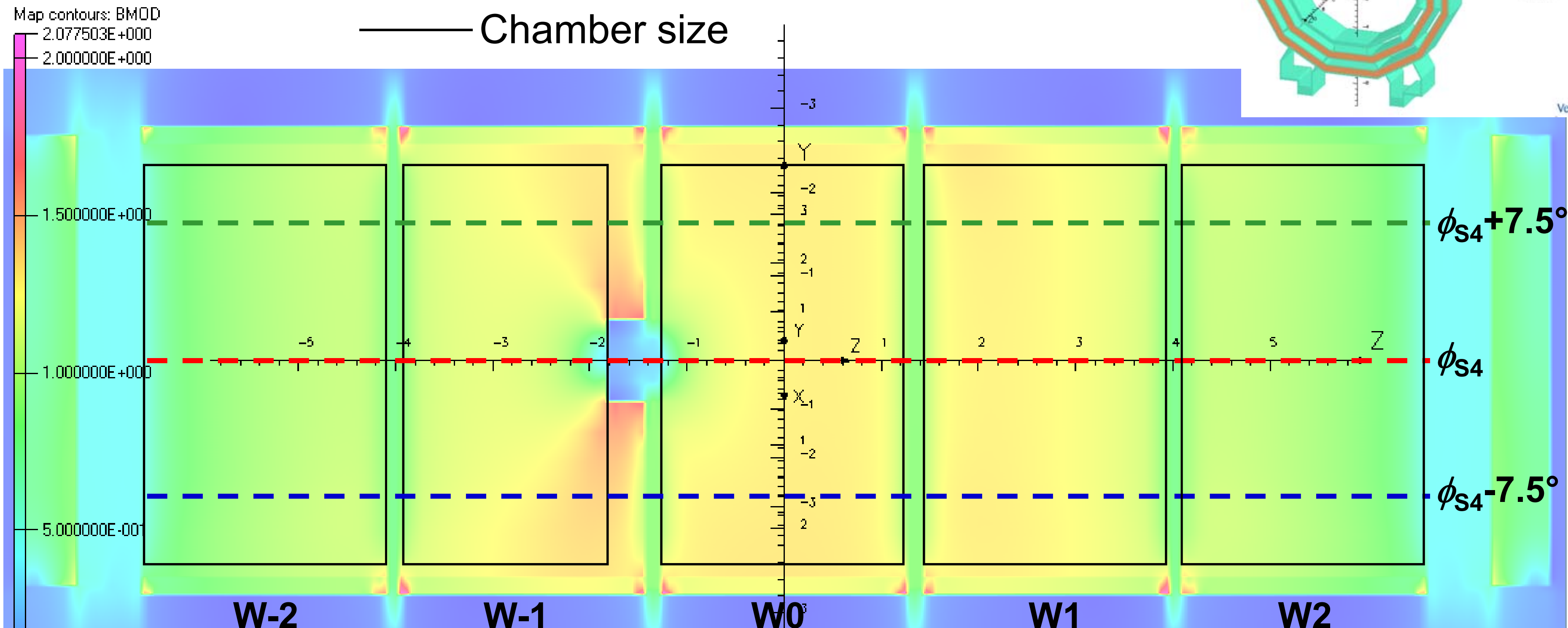
|B| in S4, L3 (electric chimney)

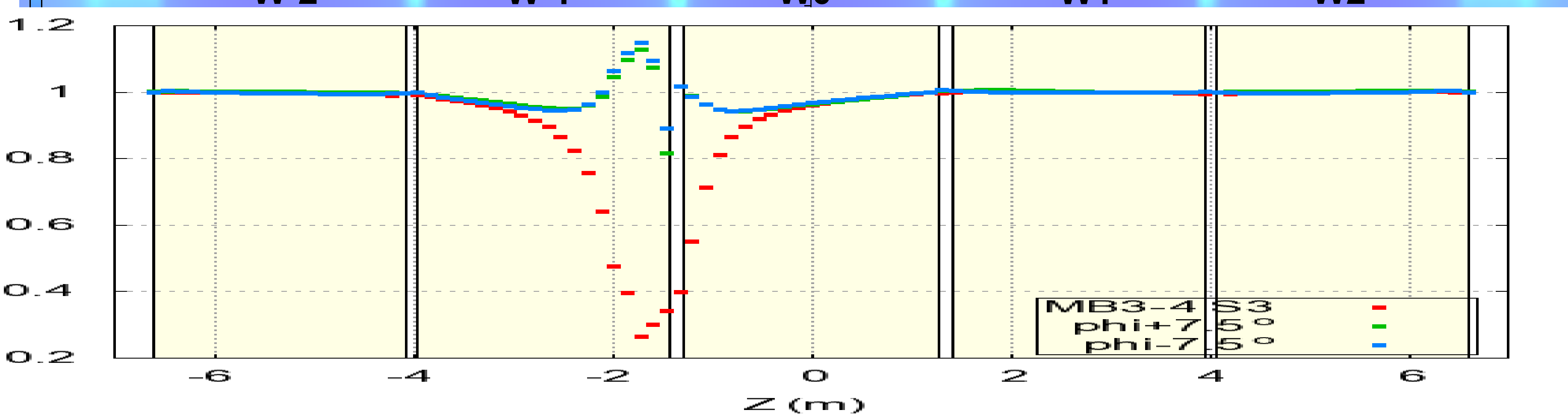




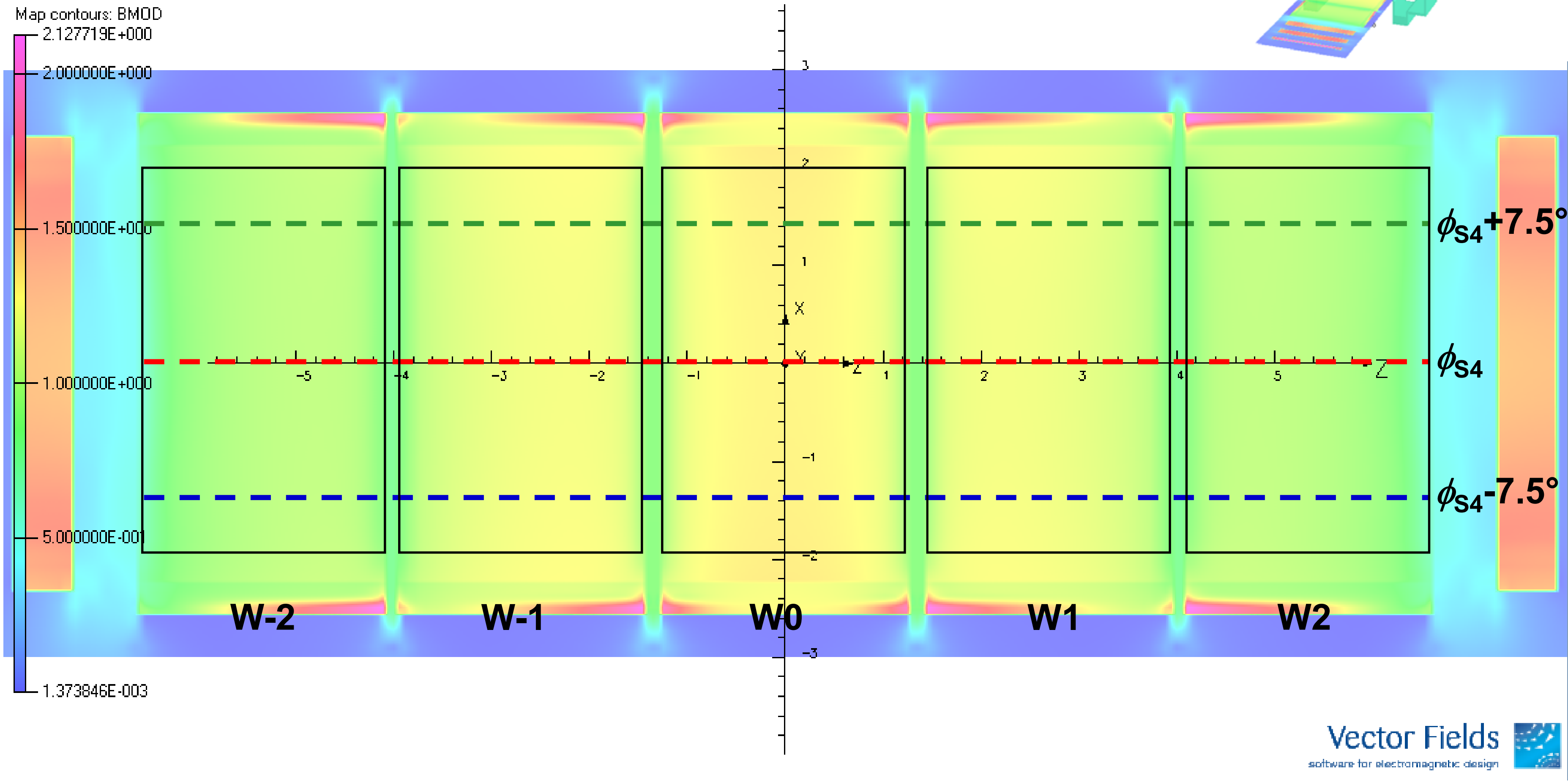
|B| in S3, L3 (cryogenic chimney)



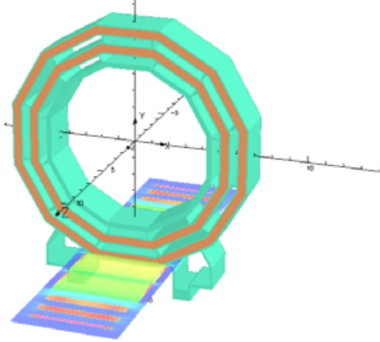




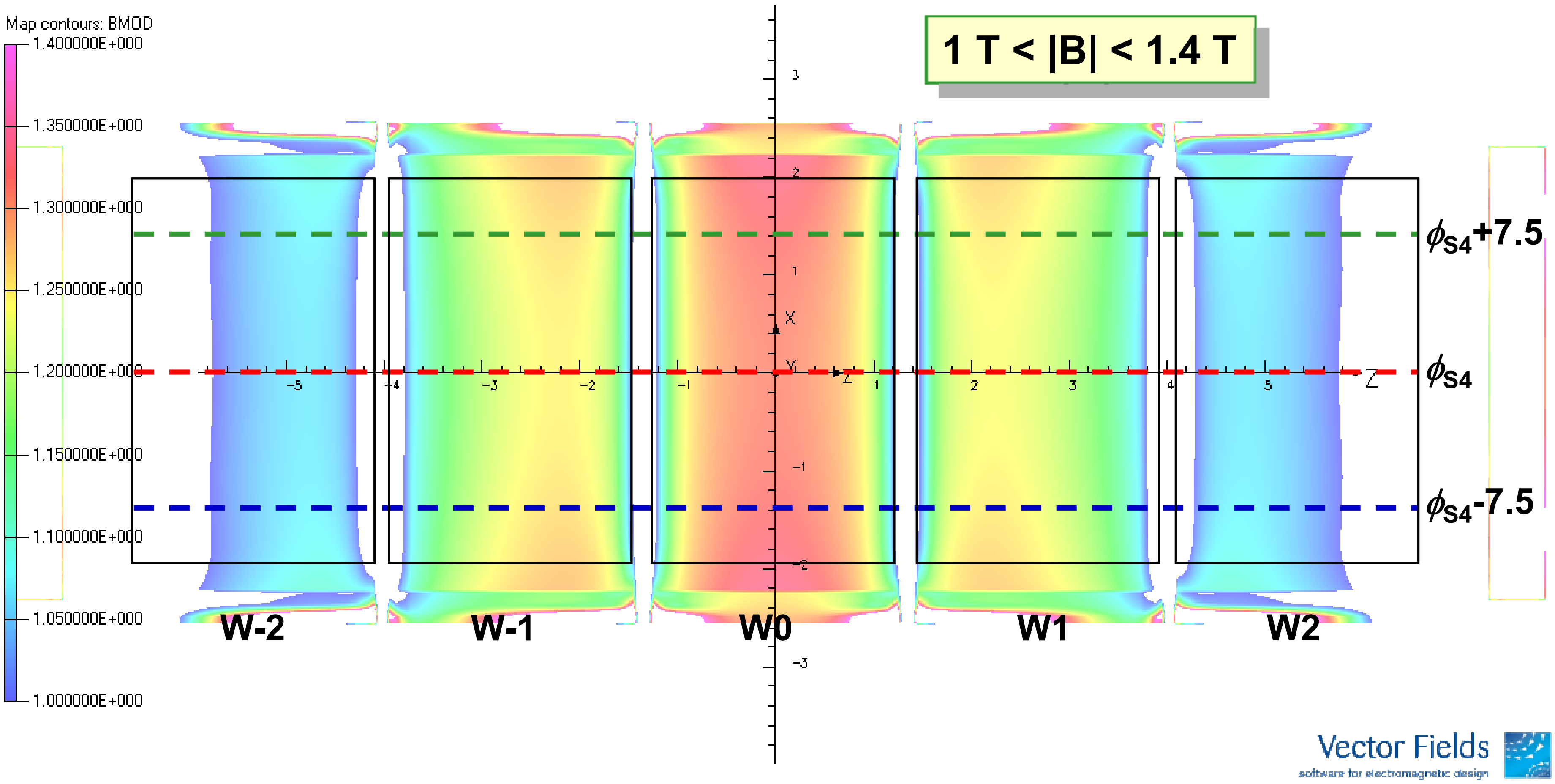
|B| in S10, L3



Map contours: BMOD
2.127719E+000
2.000000E+000
1.500000E+000
1.000000E+000
5.000000E-001
1.373846E-003
ϕ_{S4}+7.5°
ϕ_{S4}
ϕ_{S4}-7.5°
W-2
W-1
W0
W1
W2
Vector Fields
software for electromagnetic design



|B| in S10, L3 - zoom

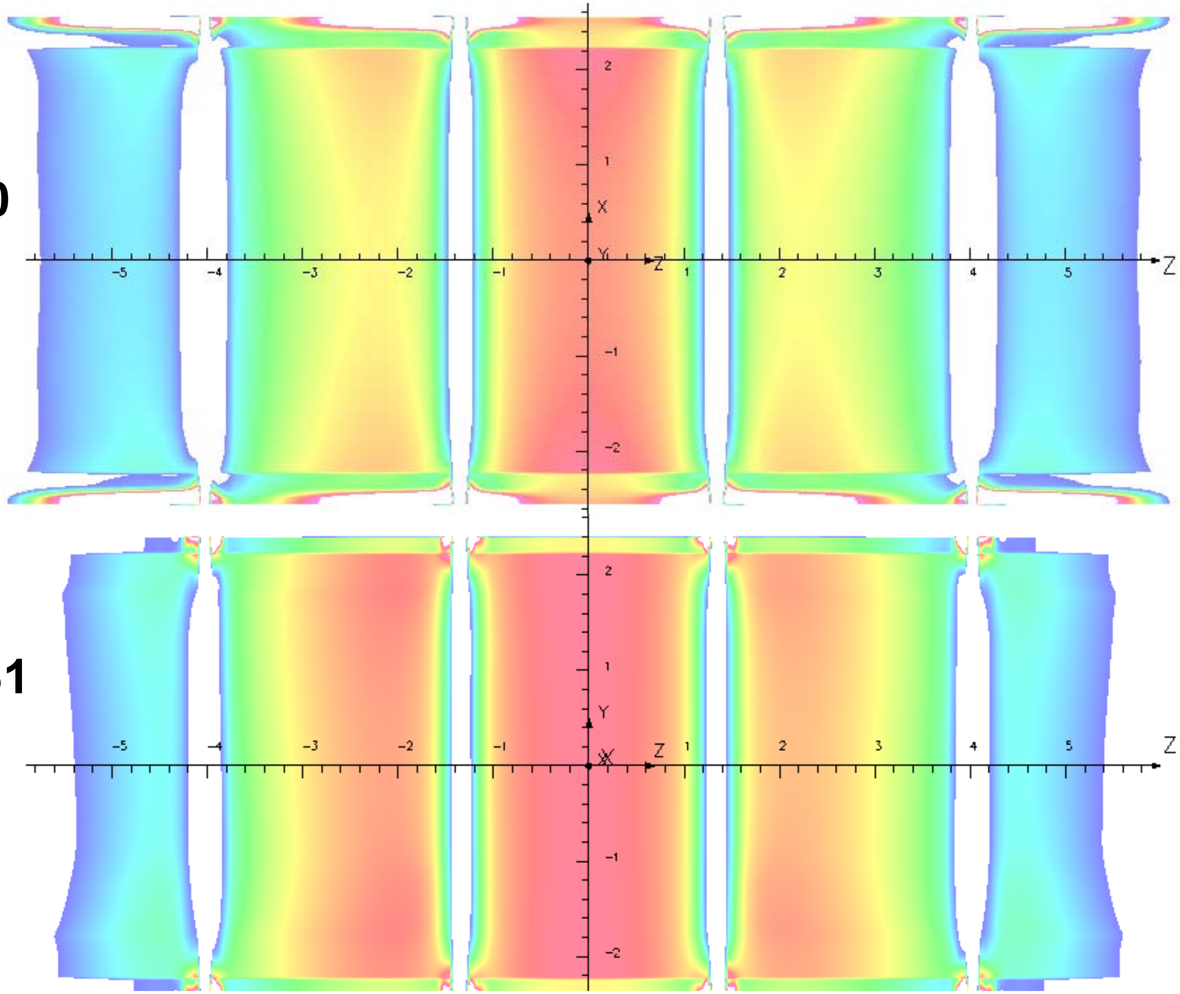


S10, L3

1 T < |B| < 1.4 T

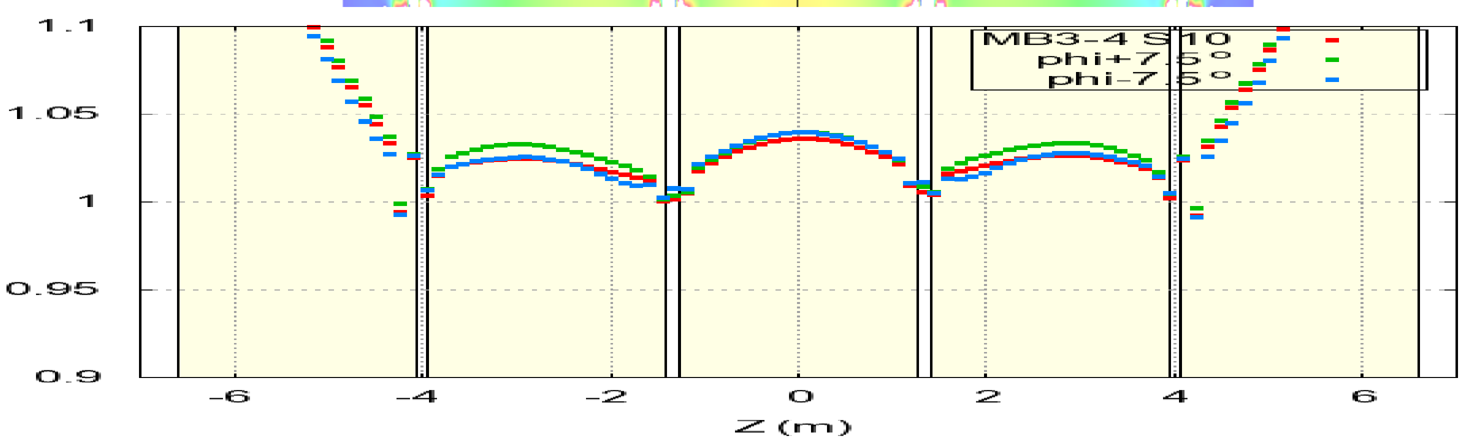
S10

S1

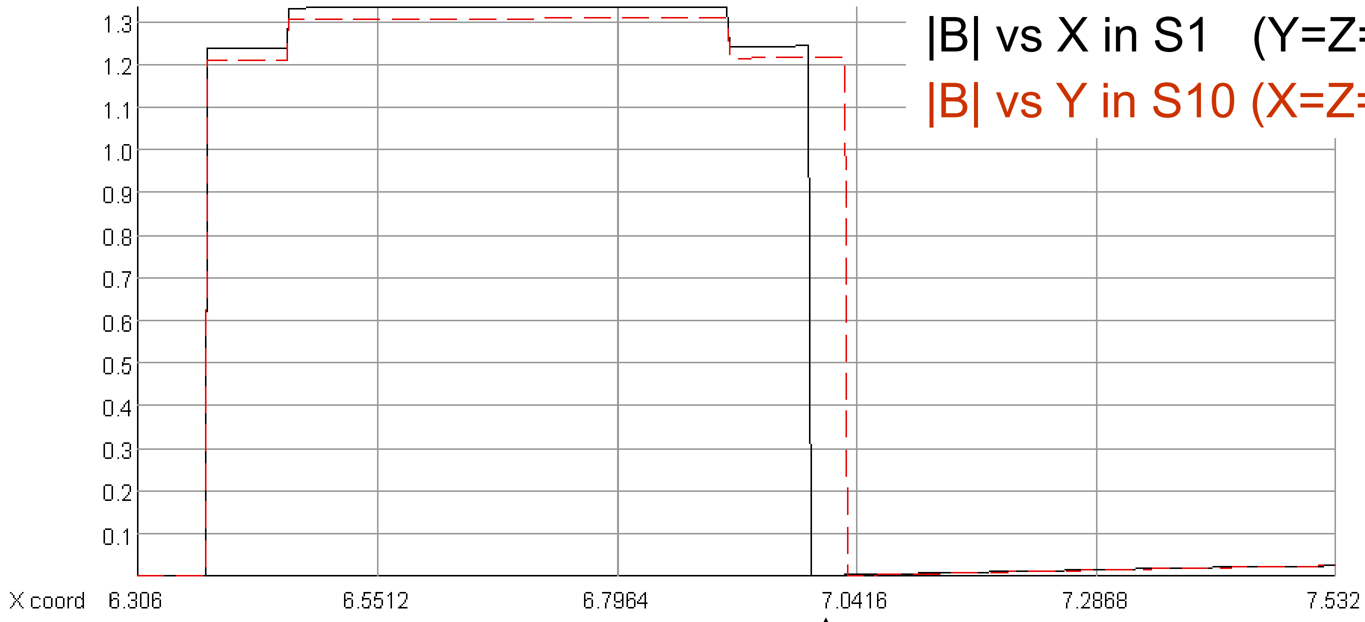


Note:
-Shape is different, consistently with $\int B \times dl / \int B \times dl|_{S1}$ plot

- |B| is generally larger in S1 but $\int B \times dl$ is larger in S10…

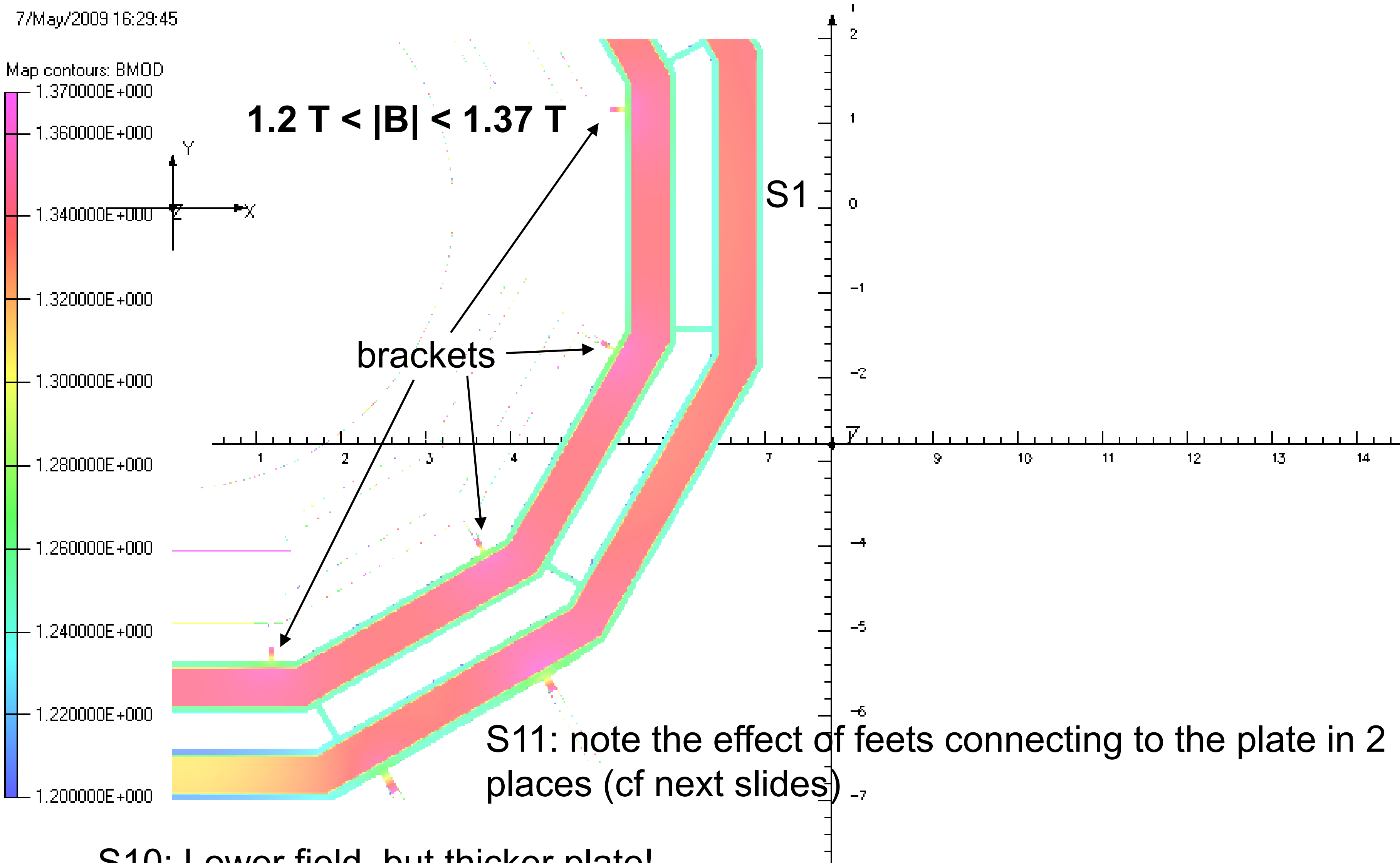


|B| is generally larger in S1 but $\int B \times dl$ is larger in S10: why?



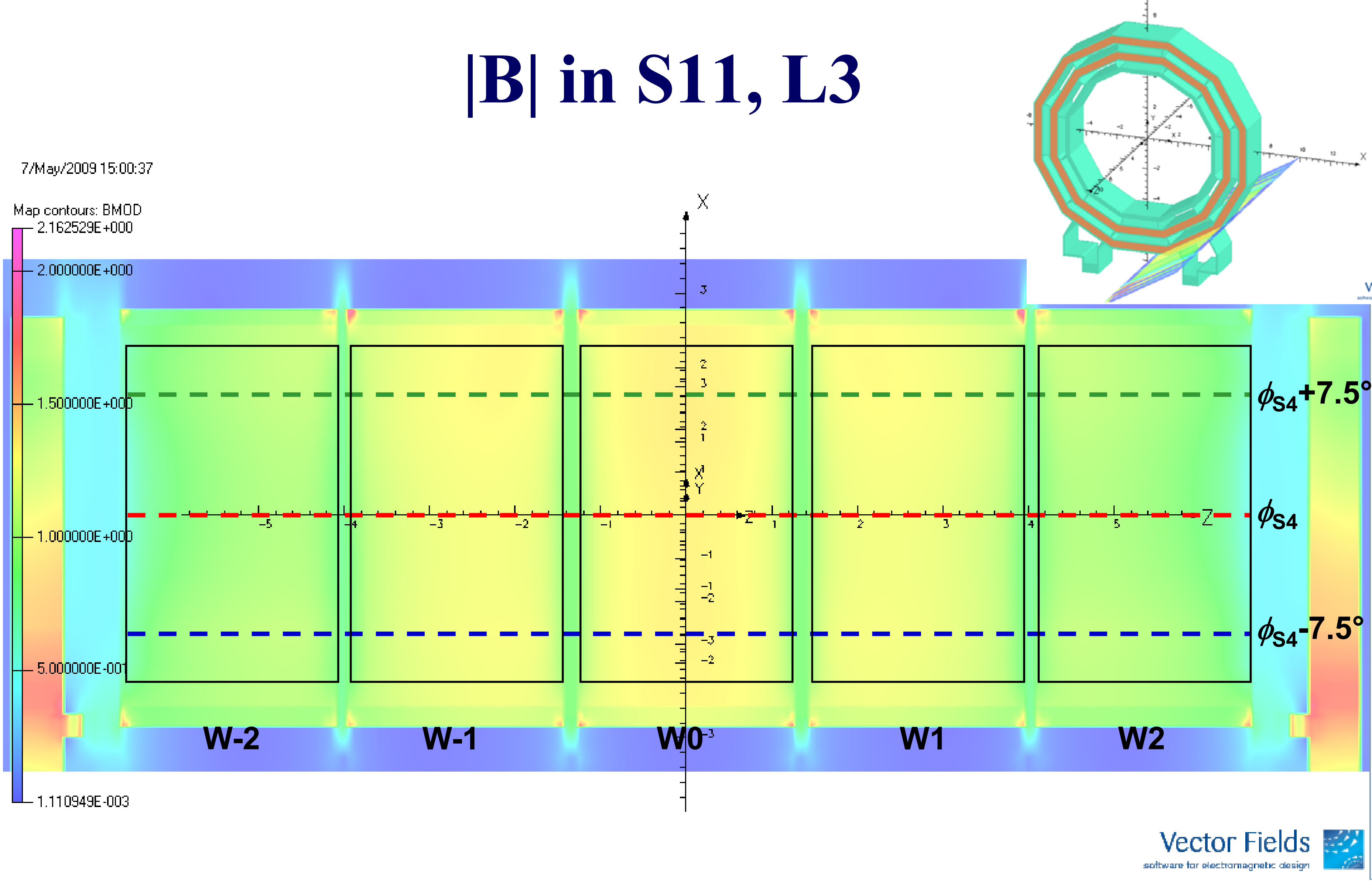
…S10 plate is thicker

Transverse section (Z=0)



S10: Lower field, but thicker plate!

|B| in S11, L3


7/May/2009 15:00:37
Map contours: BMOD
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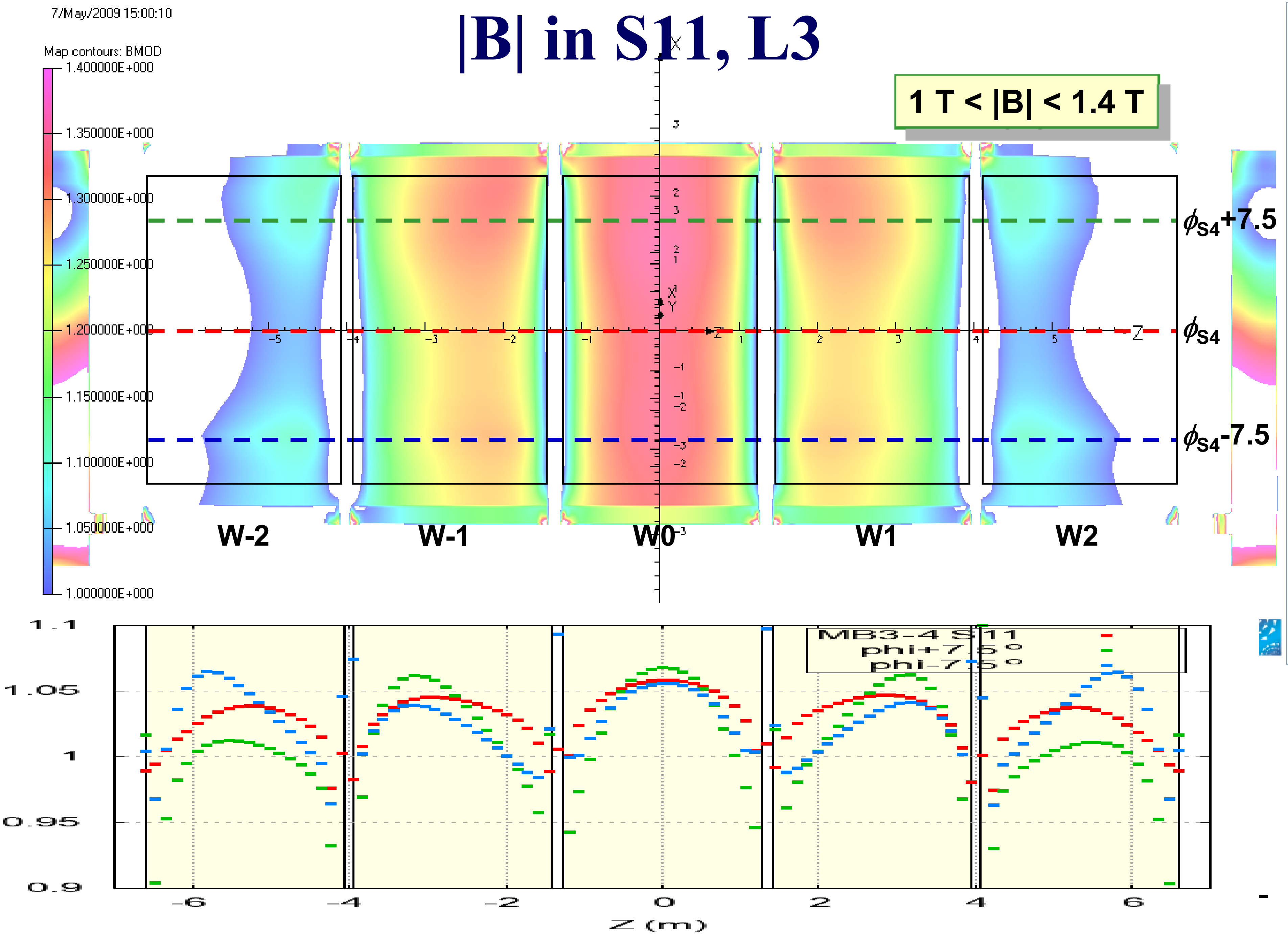
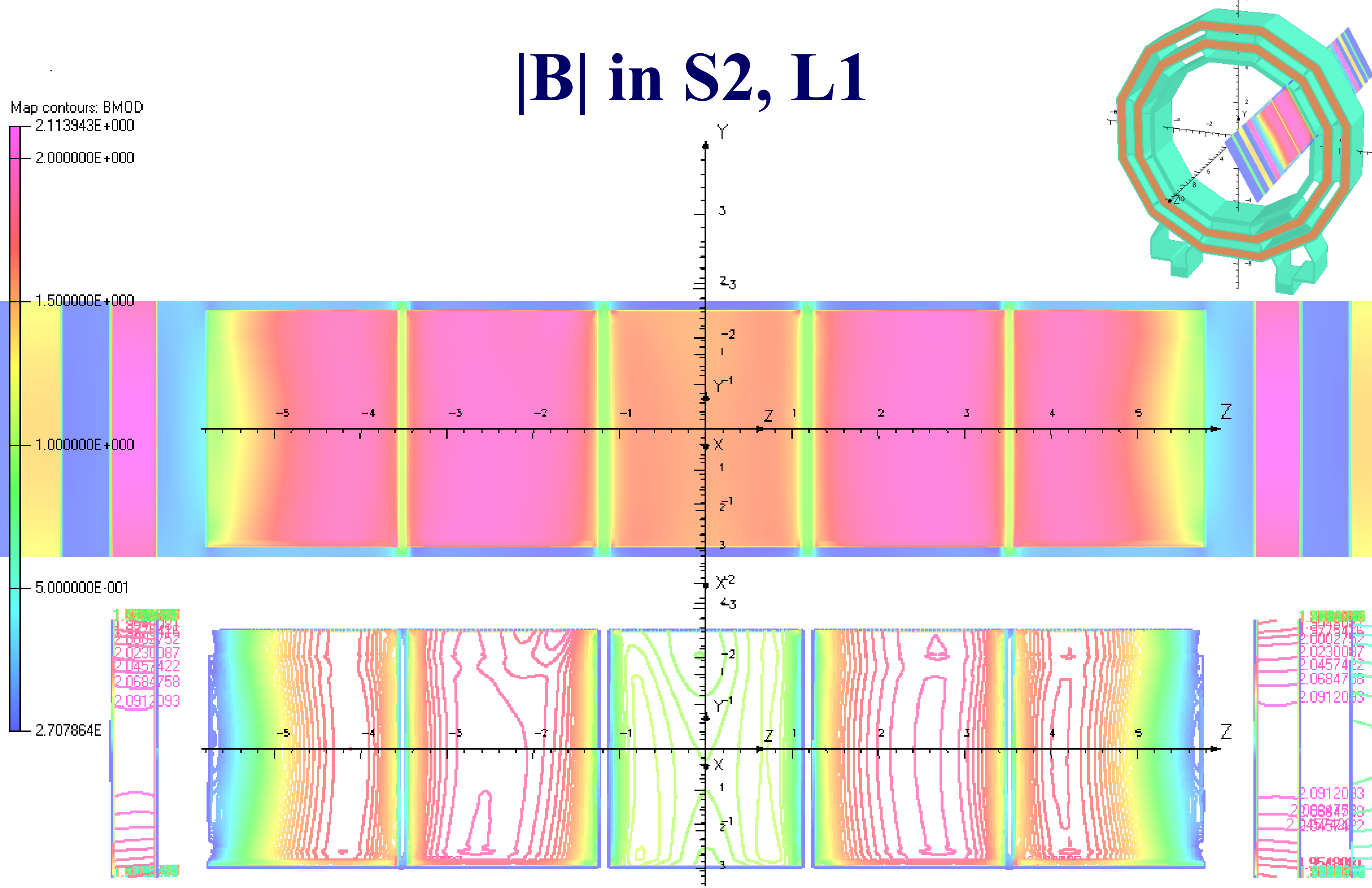
2.000000E+000
1.500000E+000
1.000000E+000
5.000000E-001
1.110949E-003
X
Z
ϕ_{S4}+7.5°
ϕ_{S4}
ϕ_{S4}-7.5°
W-2
W-1
W0
W1
W2
Vector Fields
software for electromagnetic design

|B| in S11, L3

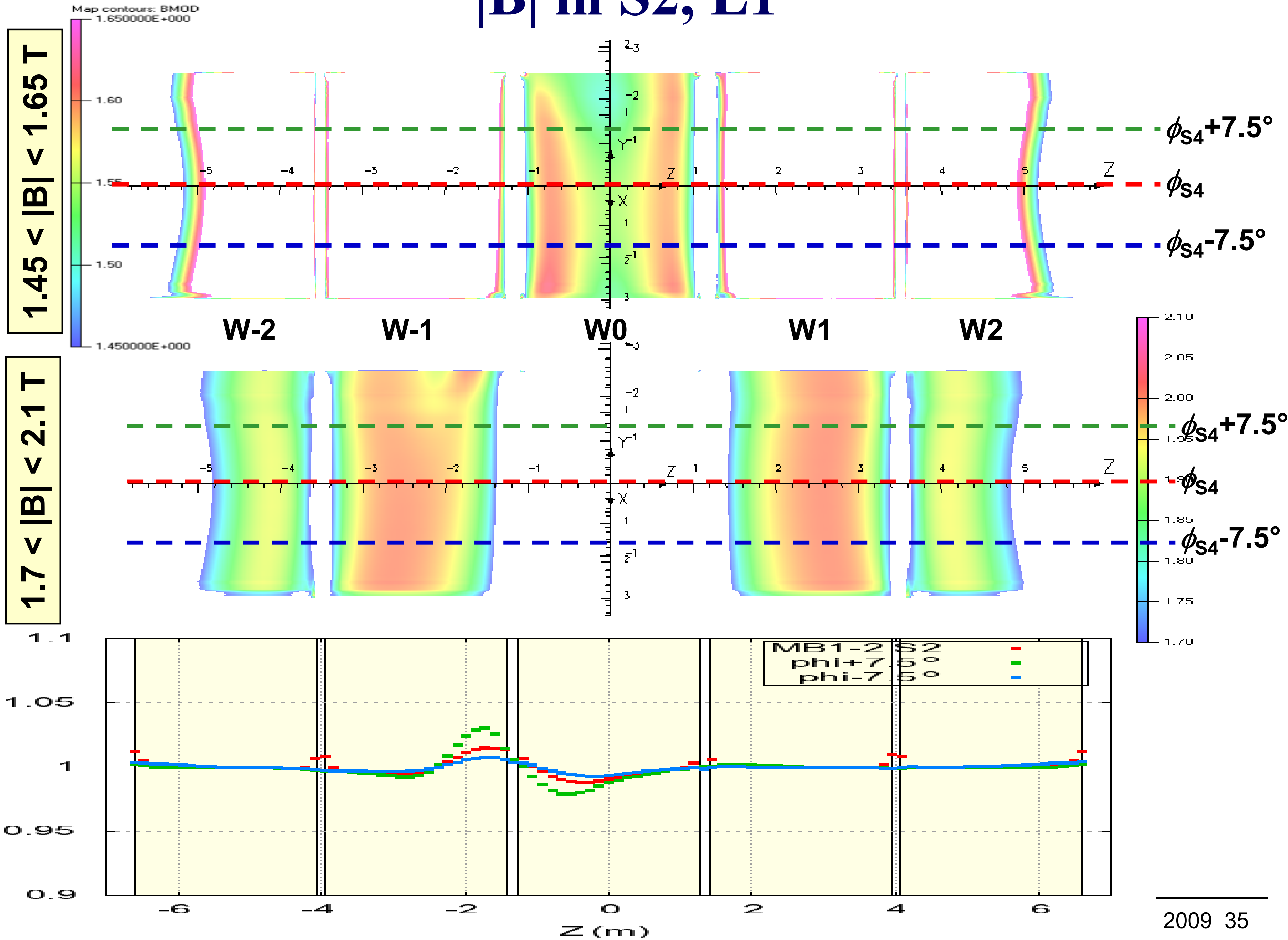

7/May/2009 15:00:10
Map contours: BMOD
1.400000E+000
1.350000E+000
1.300000E+000
1.250000E+000
1.200000E+000
1.150000E+000
1.100000E+000
1.050000E+000
1.000000E+000
1 T < |B| < 1.4 T
ϕ_{S4}+7.5
ϕ_{S4}
ϕ_{S4}-7.5
W-2
W-1
W0
W1
W2
MB3-4 S11
phi+7.5°
phi-7.5°
1.1
1.05
1
0.95
0.9
-6
-4
-2
0
2
4
6
Z (m)

|B| in S2, L1



- Difficult to see features in this scale ⇒ restrict |B| range

|B| in S2, L1



1.45 < |B| < 1.65 T
1.7 < |B| < 2.1 T
Map contours: BMOD
W-2
W-1
W0
W1
W2
ϕ_{S4}+7.5°
ϕ_{S4}
ϕ_{S4}-7.5°
MB1-2 S2
phi+7.5°
phi-7.5°
Z (m)

|B| along R in the endcaps