Chiral Belle: SuperKEKB e- Polarization Upgrade

Monday Feb 2, 2026, 3:00 PM → 5:15 PM Asia/Tokyo

Meeting room 1st floor (3-go-kan)

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Spin Rotator design at BNL: status

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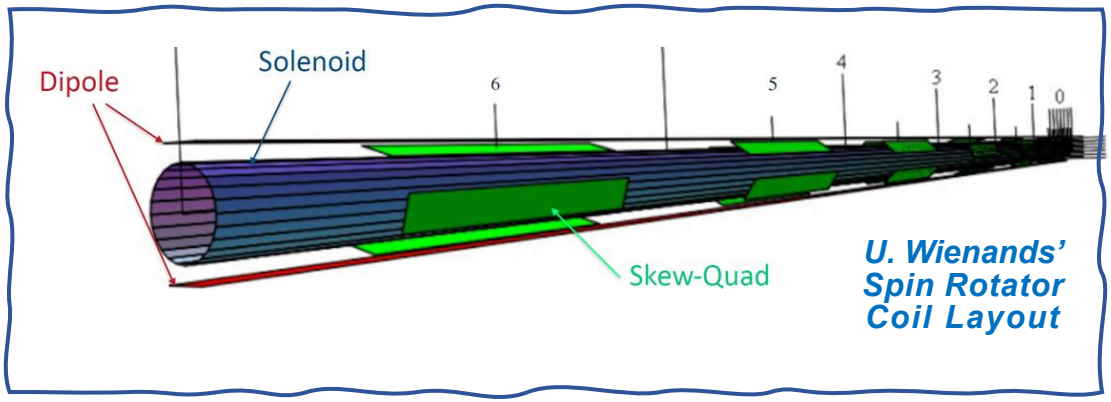
The Compact Multifunction Concept for SuperKEKB HER



HER Warm Dipoles in Tunnel at KEK.

- Dipole coil matches the HER ring dipole bending,
- Along with solenoid to change the spin direction,
- Skew-quads make optics and coupling corrections.
- **Turning solenoid and skew-quads off restores HER!**

Each spin rotator module is a drop-in replacement for an existing HER warm dipole that leaves the overall SuperKEKB ring geometry unchanged.*

Opera EM analysis of HER dipole

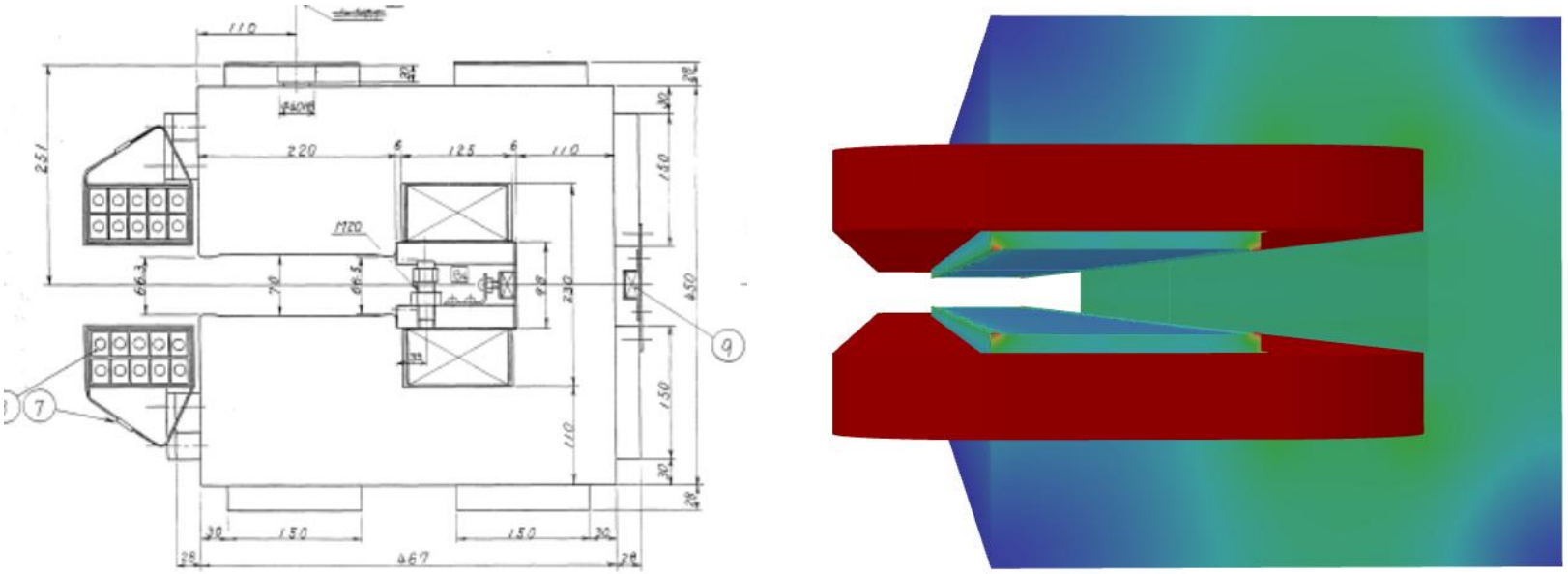


Figure 1. Left: Cross section of the dipole magnet from original CAD diagram, Right: Opera 3D model.

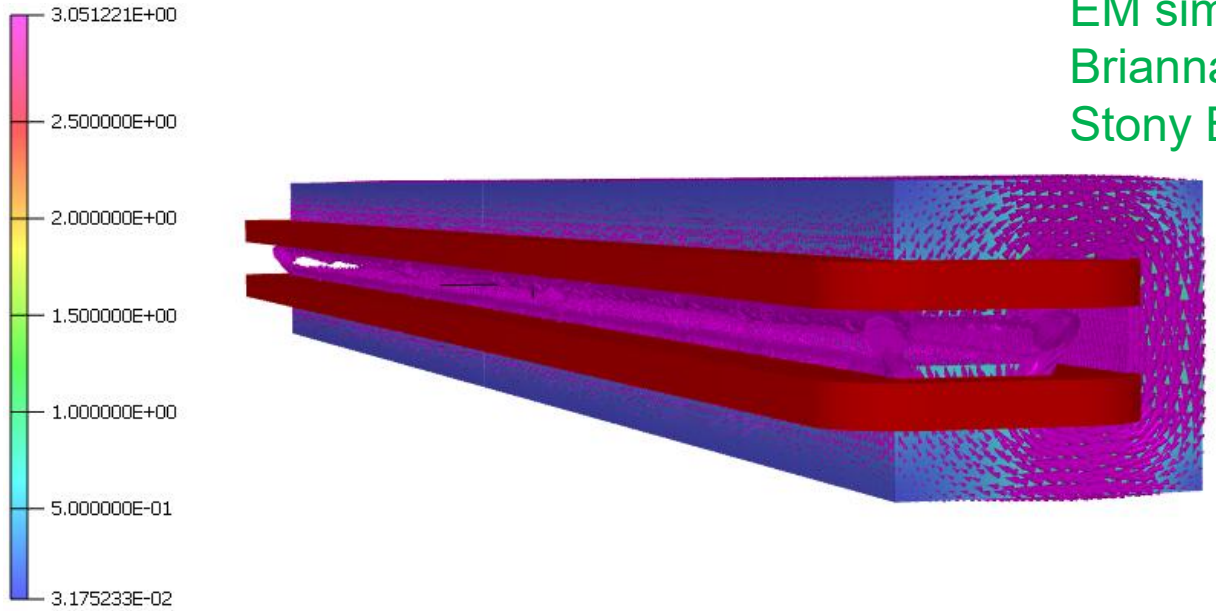
Iron Yoke		Racetrack Coils	
Yoke length	$5804\ mm$	Coil Radius	$13.38\ mm$
Aperture width	$220\ mm$	Coil thickness	$65\ mm$
Aperture height	$70\ mm$	Current density	$1.086\ A/mm^2$

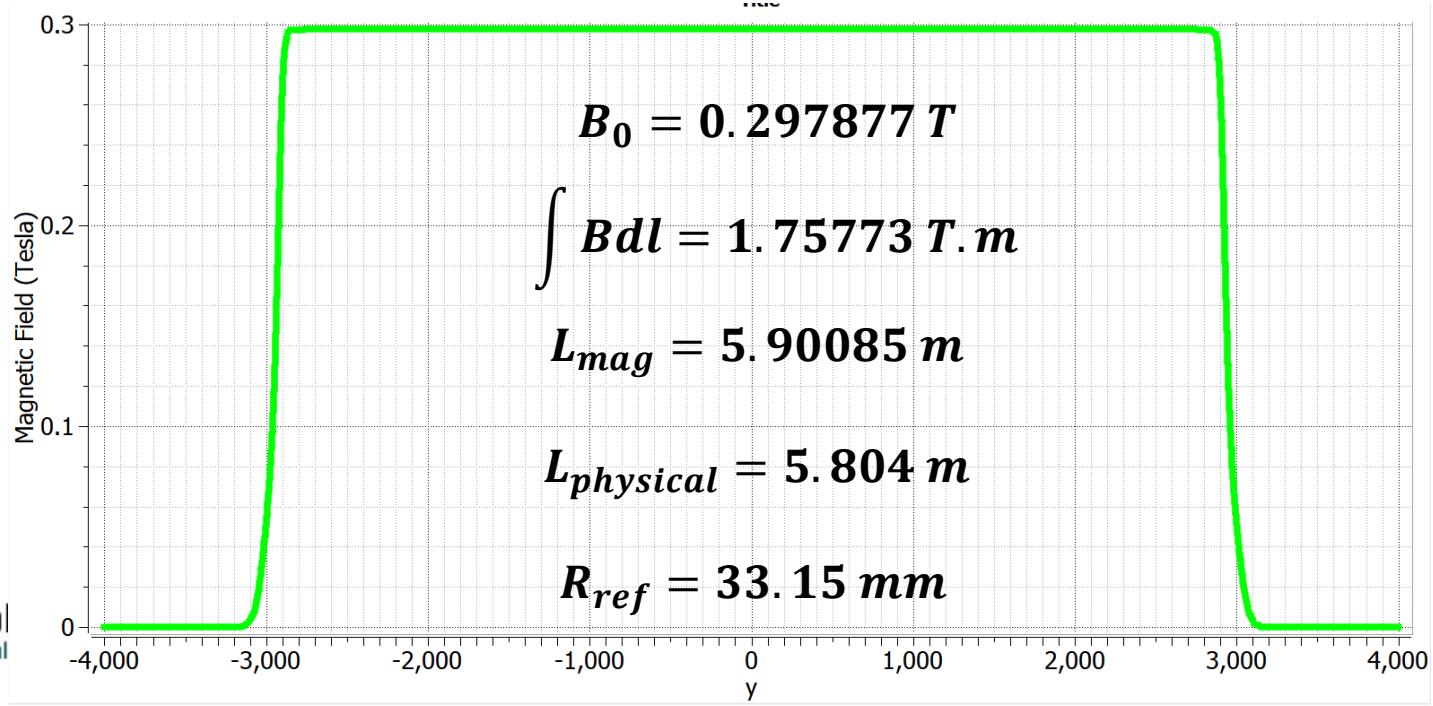
Table 1. Geometry parameters for iron yoke and racetrack coil parameters

Brianna Romasky
Stony Brook University , New York

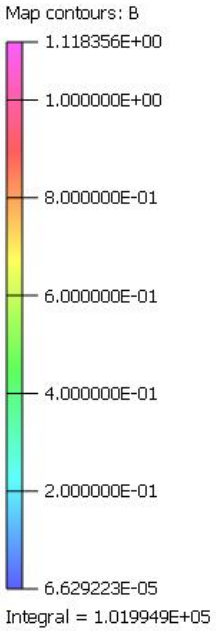
HER dipole magnet EM simulations

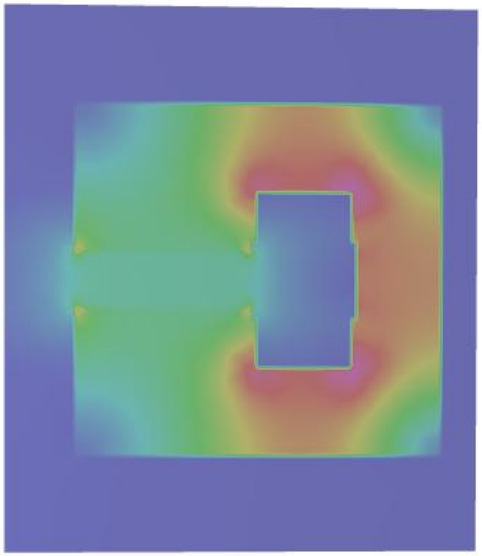
EM simulations by
Brianna Romasky,
Stony Brook University

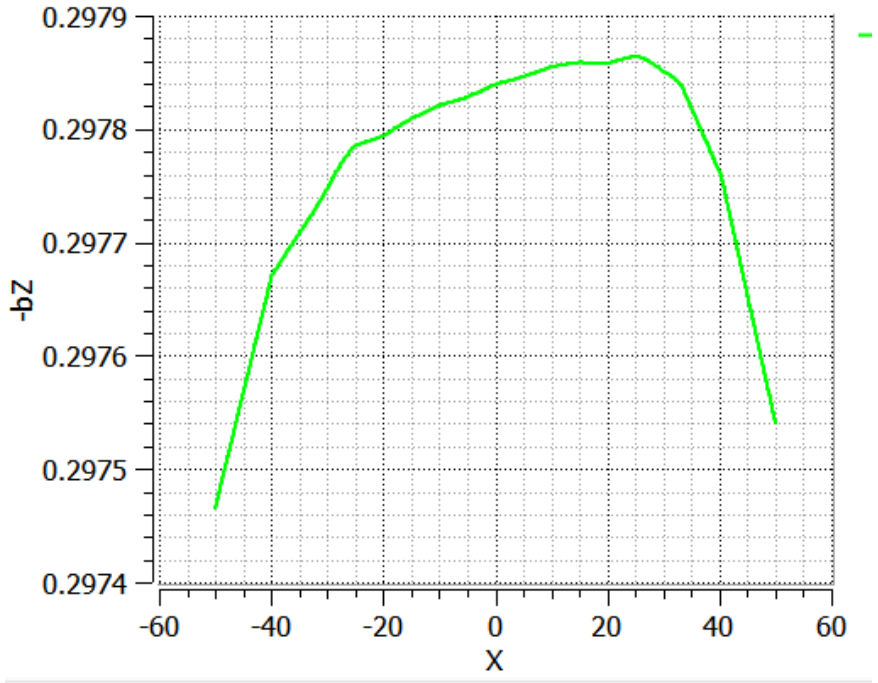


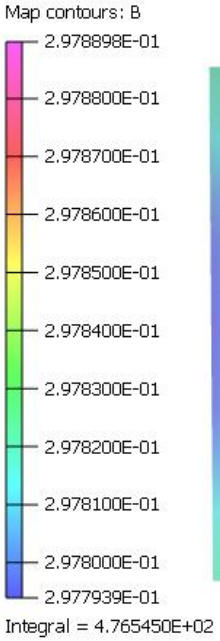


2D map at median plane of existing HER magnet









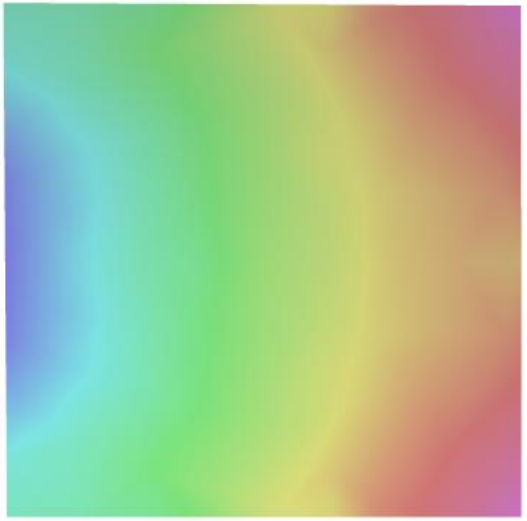
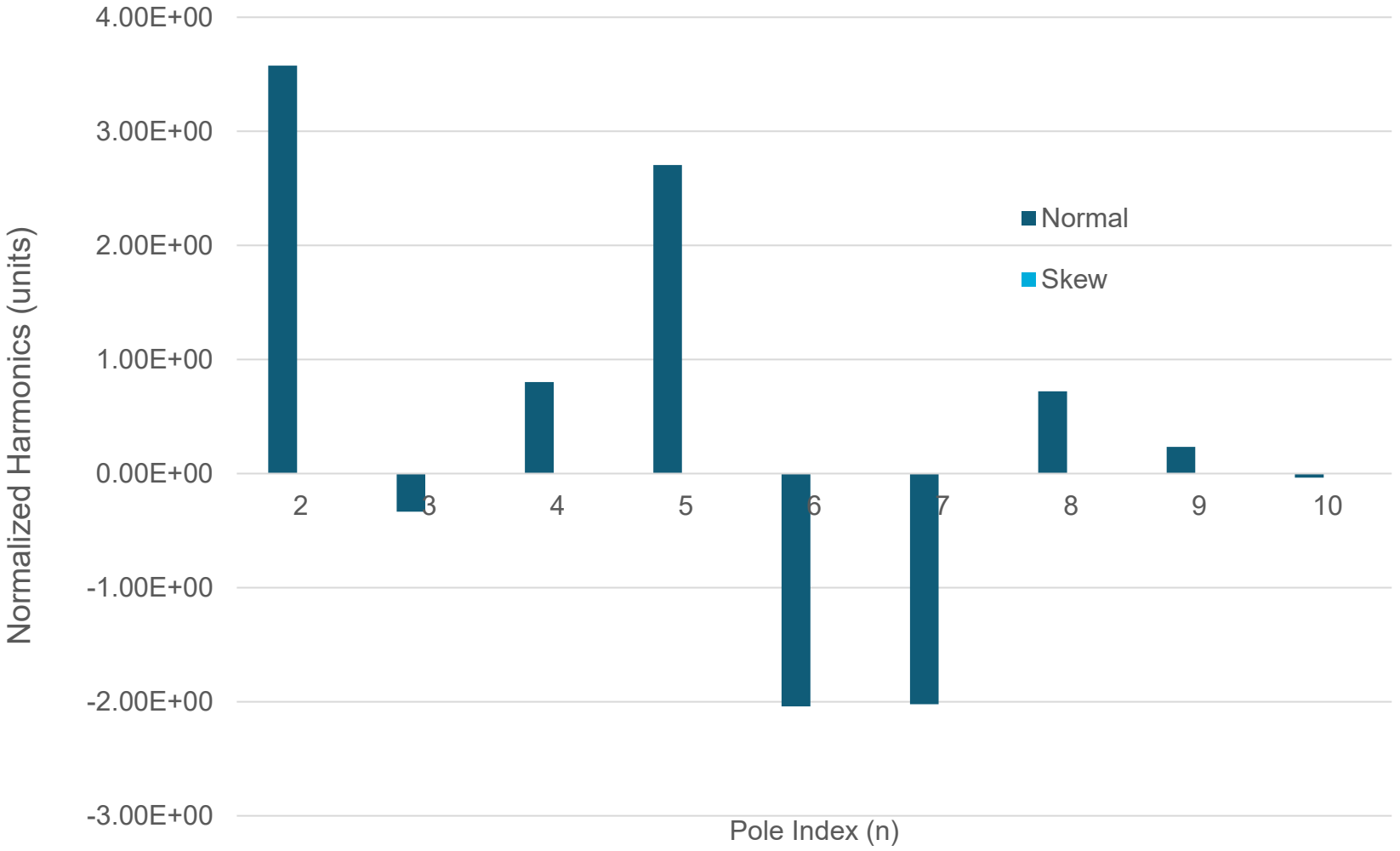


Table 8
Magnetic field measuring results for the dipole and wiggler magnets

	Type of magnets	B_{design} (T)	I_{max} (A)	L_{lam} (m)	L_{eff} (m)	B_{meas} (T)	$\Delta BL/\langle BL\rangle \times 10^{-4}$
LER	B	0.848	1250×32	0.76	0.8876	0.83616	4.724
	Blc	0.52	1000×24	2.1	2.2273	0.52697	3.514
	BV	0.20	500×18	1.2	1.3561	0.20523	
	BS	0.21	500×20	0.3	0.4085	0.21994	
HER	B	0.30	840×10	5.804	5.9006	0.29974	3.234
	BS1	0.048	10×150	2.8			
	BsFL	0.214	500×12	1.14	1.2393	0.21473	
	BsFR	0.339	500×32	0.76	0.8935	0.35205	
LER	Wig	0.77	944.4×36	0.75	0.6939 (3.34 × 10^{-4} Tm)	0.77056	11.68 (6.395)

In the row for the wiggler magnets, values in parenthesis are BL, integrated B all through the magnetic gap of the wiggler magnets. Values not in parenthesis are $|B|L$, the sum of absolute integrated B for each pole.

Harmonics at 33.15 mm ref radius



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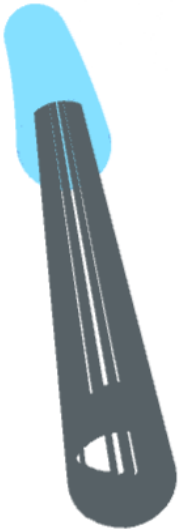
Spin Rotator Magnet lay-out

Solenoid Magnet					
Skew Quad-A	Skew Quad-B	Skew Quad-C	Skew Quad-D	Skew Quad-E	Skew Quad-F
Dipole Magnet					

Aperture



2D design of the Dipole Magnet

```
! Chiral Belle Dipole
 Fundamental(dipole=1)  1,  2 Layers, C-to-C space =
Rref=   34.000 mm  Offset = 0.00 mm Span   0.45 to  7
 Layer   Block  Radius   Spacer(deg) Turns   c2c(mm)
    1       1   112.000      0.000     28.00   1.780
    1       2   112.000      2.000     17.00   1.780
    1       3   112.000      4.000     12.00   1.780
    1       4   112.000     10.000      7.00   1.780
    2       1   113.800      0.000     28.00   1.780
    2       2   113.800      0.722     17.00   1.780
    2       3   113.800      6.000     12.00   1.780
    2       4   113.800     10.000      7.00   1.780
 Transfer Function =     0.71818E-03 T,m  chisq =
   M      bm      bmdesign    weight   bnOFFSET
   1 10000.000 10000.000      0.000      0.000
   2     0.000      0.000      0.000      0.000
   3    -0.002      0.000     50.000      0.000
   4     0.000      0.000      0.000      0.000
   5    -0.072      0.000     30.000      0.000
   6     0.000      0.000      0.000      0.000
   7    -0.089      0.000     20.000      0.000
   8     0.000      0.000      0.000      0.000
   9     0.003      0.000     25.000      0.000
  10     0.000      0.000      0.000      0.000
  11     0.000      0.000     10.000      0.000
  12     0.000      0.000      0.000      0.000
  13     0.000      0.000      5.000      0.000
  14     0.000      0.000      0.000      0.000
  15     0.000      0.000      5.000      0.000
  16     0.000      0.000      0.000      0.000
  17     0.000      0.000      5.000      0.000
  18     0.000      0.000      0.000      0.000
  19     0.000      0.000      5.000      0.000
  20     0.000      0.000      0.000      0.000
  21     0.000      0.000      5.000      0.000
 ENTER MINUIT COMMAND:
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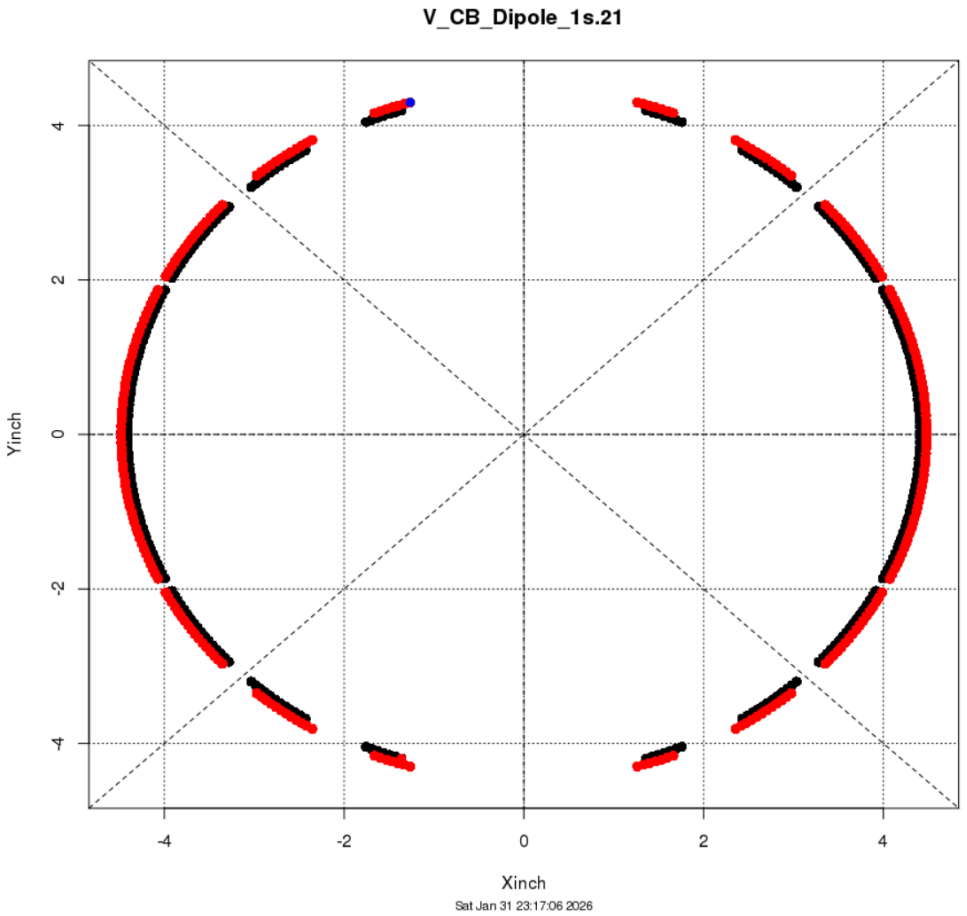
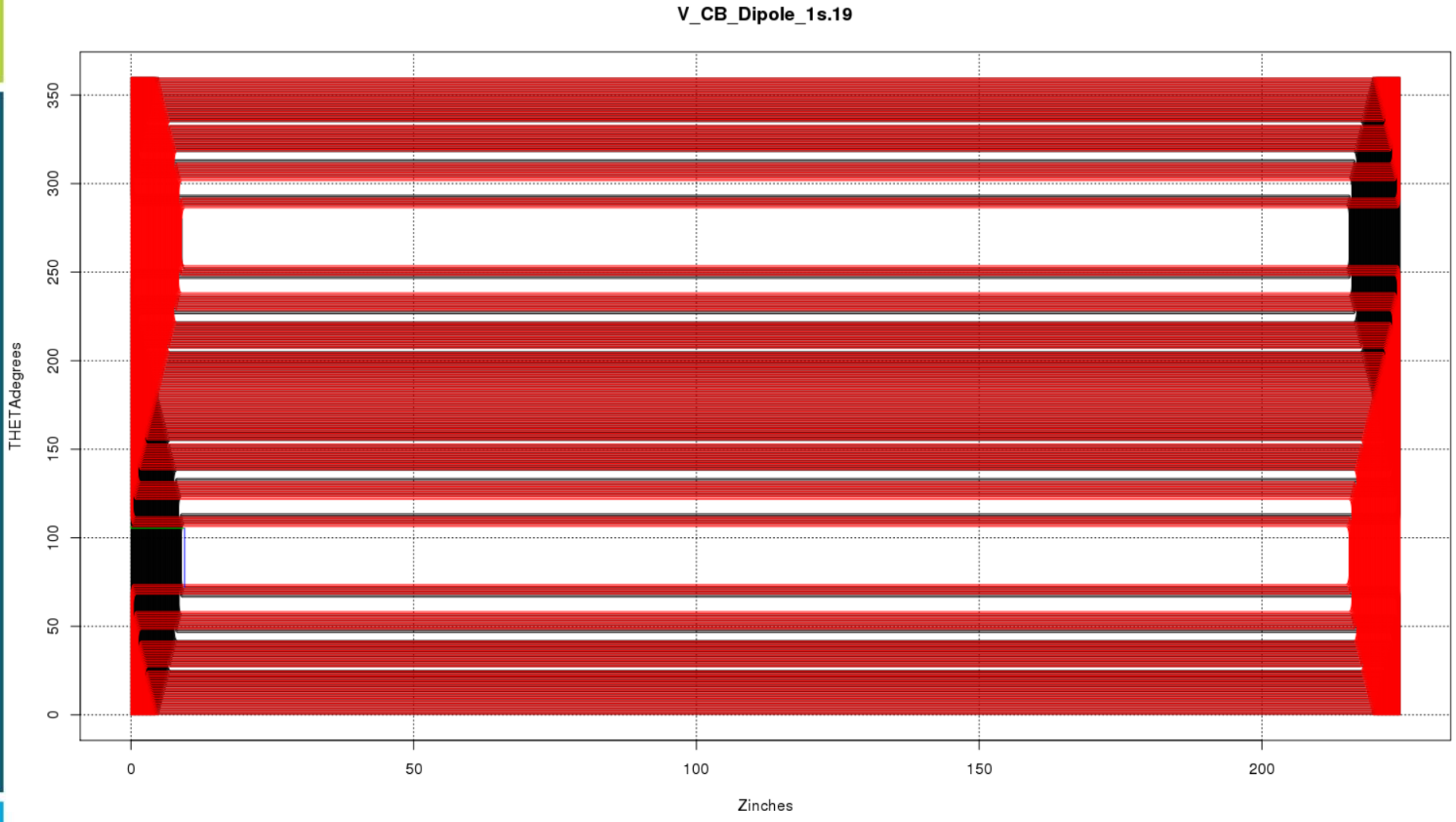


3D Coil layout



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Harmonics

Harmonics Table | Main Harmonics | Skew harmonics | Axial Field

harmonics given at a reference radius of: 34.000 [mm]

Order	An [T.m]	an	Normalized Shape	Order	Bn [T.m]	bn	Normalized Shape
A1	3.58e-07	0.00		B1	1.75e+00	10000.00	
A2	7.32e-06	0.04		B2	1.28e-04	0.73	
A3	1.33e-06	0.01		B3	-8.32e-04	-4.76	
A4	5.01e-06	0.03		B4	-4.64e-06	-0.03	
A5	-3.52e-07	-0.00		B5	-8.44e-05	-0.48	
A6	5.14e-06	0.03		B6	-1.35e-07	-0.00	
A7	4.95e-08	0.00		B7	2.54e-05	0.14	
A8	5.19e-06	0.03		B8	7.16e-08	0.00	
A9	6.29e-09	0.00		B9	2.70e-05	0.15	
A10	5.17e-06	0.03		B10	5.53e-09	0.00	

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Summary

- For ensuring the dipole field of the proposed spin rotator with the existing HER dipole, Electromagnetic analysis of the existing magnet is being carried out using OPERA.
- Thanks to Mika san for providing Drawings and measured parameters of the HER dipole.
- The magnetic field strength along the beamline at a radius of $50mm$ was found to have a magnitude of 0.2978 T, reproducing the nominal field value of the original HER dipole magnet, which was measured at 0.2997 T [2]. The difference in the magnetic properties of the yoke material can be one of the source for the difference.
- Further work is under way to understand the longitudinal variation of the magnetic field profile
- This will follow with EM design of the Skew Quadrupole and Solenoid.
- Yoke optimization
- BMAD simulations shall commence capturing the field maps from the design.

Thanks for your kind attention!