

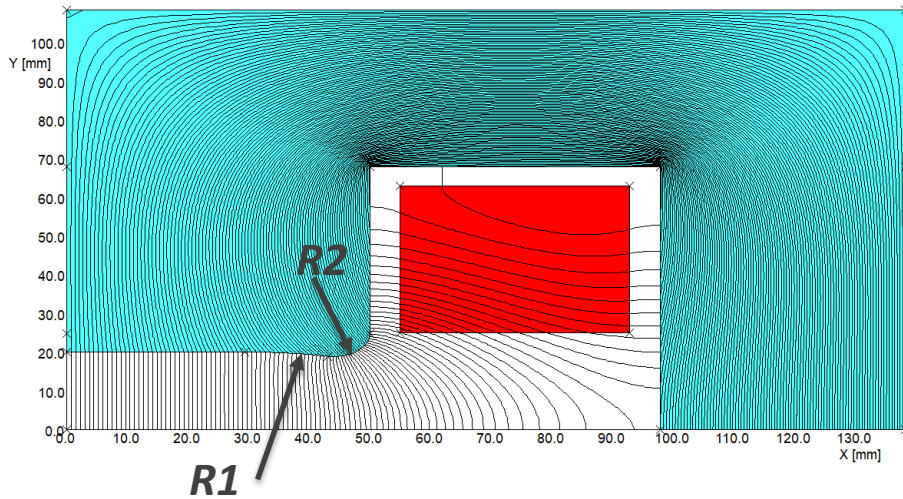


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EIC RCS Dipole Magnet

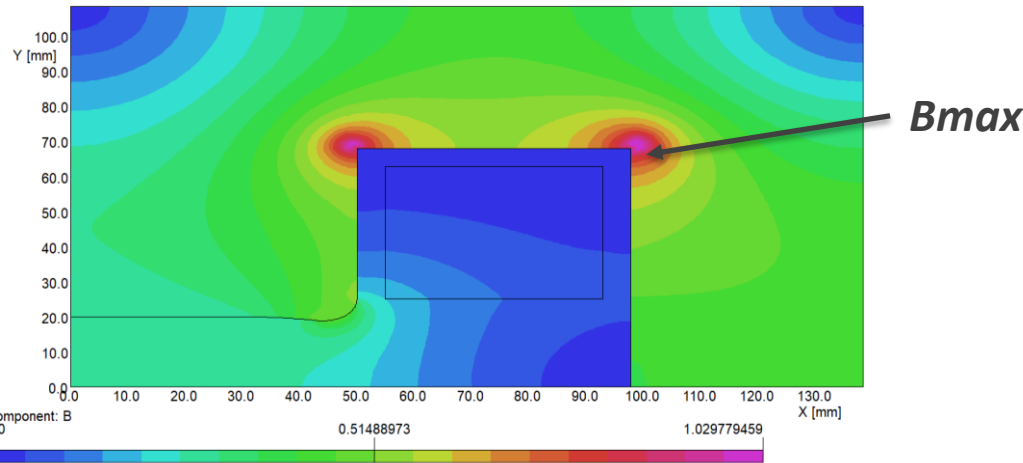
Vladimir Kashikhin
FNAL-JLAB Meeting
May 5, 2023

RCS Dipole 2D Simulation

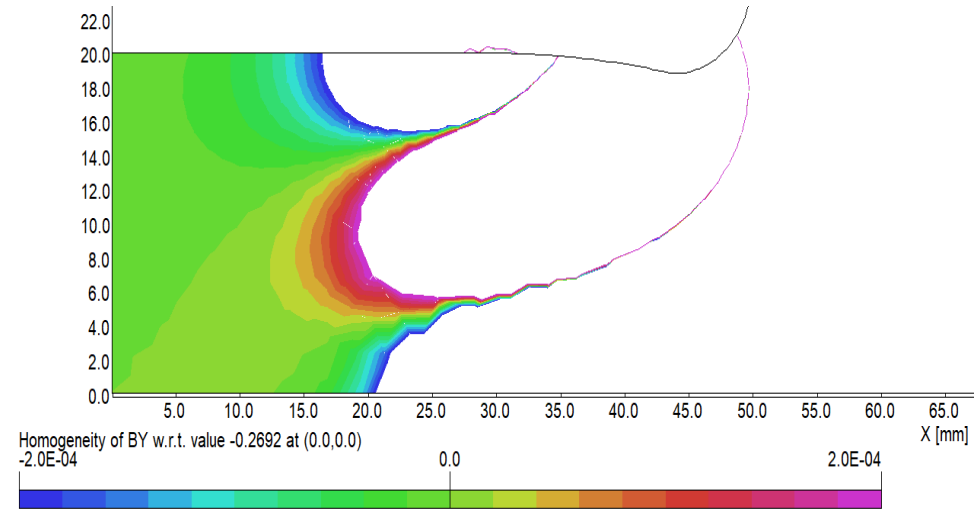
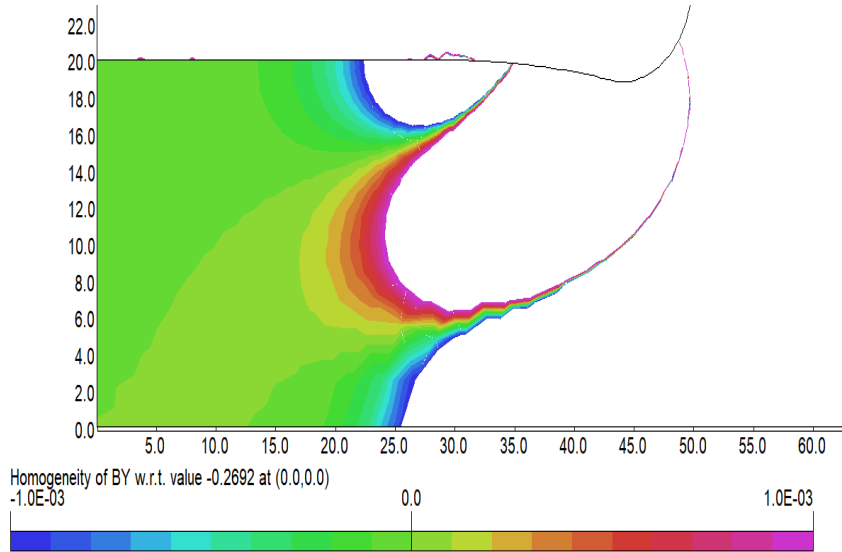


Coil ampere-turns 4100 A.
Center field 0.25523 T.
Iron peak field $B_{max}=1.03$ T.
Pole profile optimized to obtain the best field homogeneity in the magnet gap by variations:

- Pole width, pole shim height, and radiuses R1, R2.
- Besides the pole contour is smooth and has uninterrupted dy/dx derivative to eliminate high order harmonics.



RCS Dipole 2D Field Homogeneity



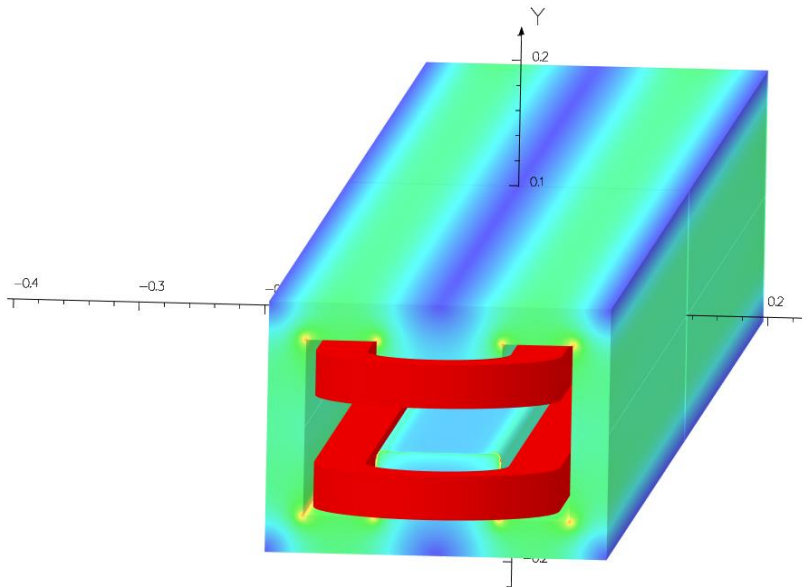
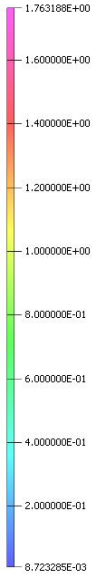
Field homogeneity area +/- 0.1%.

Field homogeneity area +/- 0.02%.

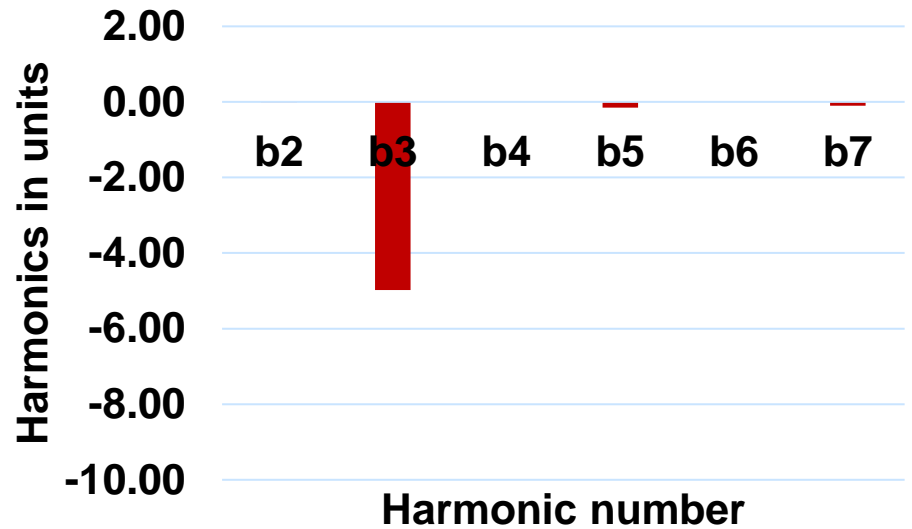
RCS Dipole 3D Field

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Surface contours: B



Iron core flux density.
 $B_{max}=1.4$ T (in corners).



Integrated field harmonics in
units (10^{-4}).
Integrated field 0.491 T-m.

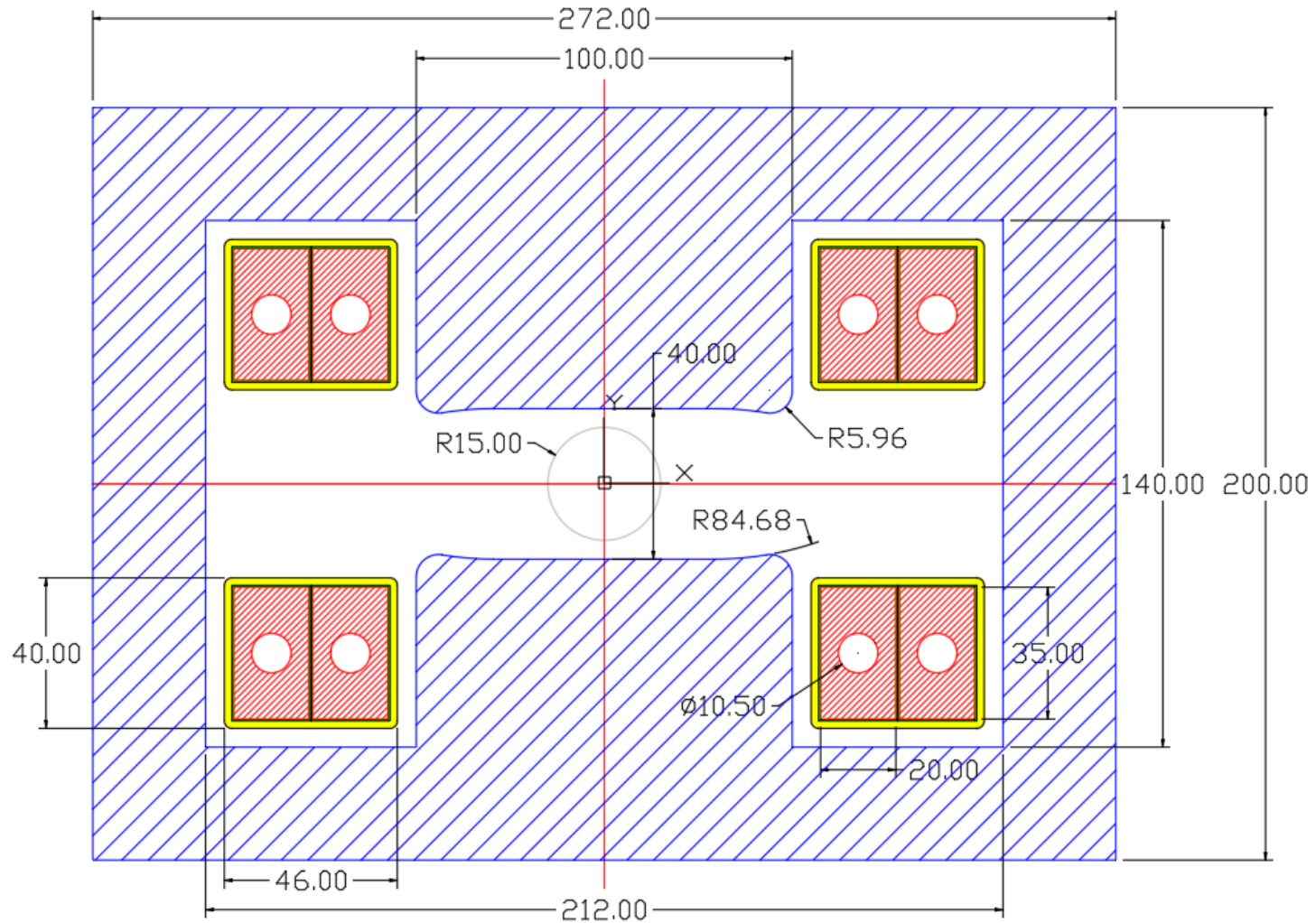
RCS Dipole Specification

Parameter	Unit	Value
Number of magnets		768
Magnetic length	m	1.923
Gap	mm	40
Gap minimum field	T	0.013
Gap maximum field	T	0.256
Field quality at Rref=15 mm	%	0.1
Current ramp time	s	0.1
Current pulses repetition rate	Hz	1.0
Field integrated strength	T-m	0.4923
Maximum water pressure drop	psi	80
LCW water inlet temperature (max)	C	30
LCW water rise temperature (max)	C	5.5

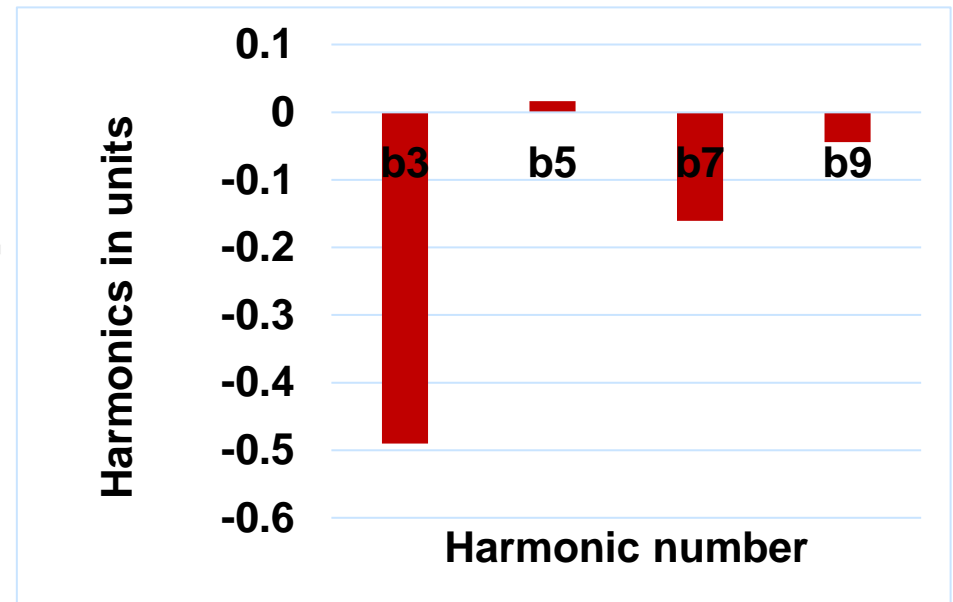
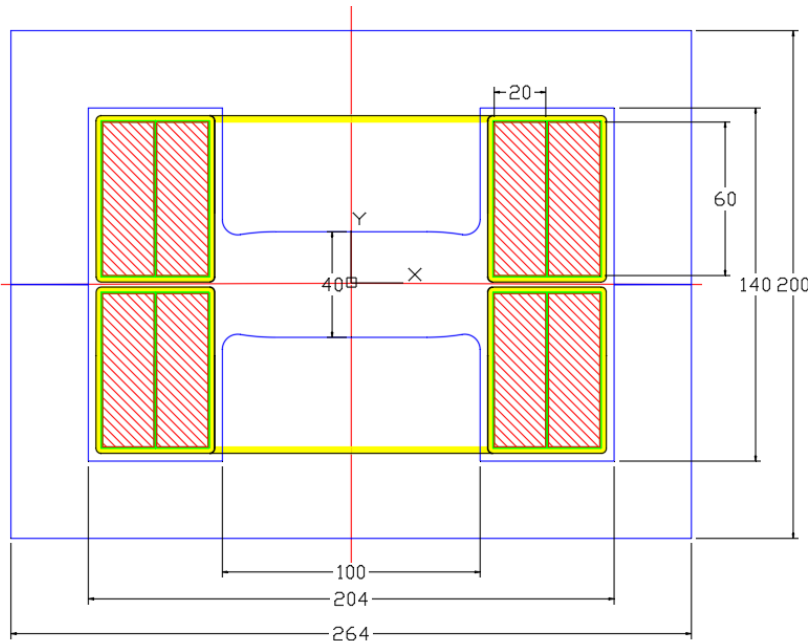
RCS Dipole Parameters

Parameter	Unit	Copper	Aluminum
Magnet integrated strength	T-m	0.4923	0.4923
Center field	T	0.24	0.24
Conductor	mm	20 x 35	20 x 60
Laminated core length	m	2.0	2.0
Cooling hole diameter	mm	10.5	No
Coil number of turns/pole		2	2
Number of racetrack coils		2	2
Magnet resistance	mΩ	0.57	0.43
Peak current	A	1915	1915
Peak voltage/magnet	V	5.0	4.5
Average power losses/magnet	W	180	138
Number water cooling circuits		1	N/A
Water pressure drop	psi	5.0	N/A
Water flow velocity	m/s	1.0	N/A
Total water flow	gpm	1.4	N/A
Water temperature rise	C	0.5	N/A

Water Cooled RCS Dipole with Copper Coil



Air Cooled RCS Dipole Field with Al Coil



2 m long magnet integrated field quality.

For air cooled magnets aluminum coils will cost much lower than copper coils because of 3.6 times difference in the raw material cost. Copper cost is 8500 \$/ton, aluminum 2350 \$/ton.

Summary

- **Air cooled magnet with the aluminum coil is a preferable cost efficient choice. Beside Al is better technological material than copper: easier bend, weld, machine.**
- **Larger Al resistance could be compensated by larger cross-section.**
- **Now most of electrical transmission lines, bus bars made from aluminum.**
- **CERN FCC Lepton Collider Magnets with close parameters are based on Al conductor.**
- **Major issue for RCS dipoles is a very low beam injection field only 130 Gauss. The next step in the design will be to improve the magnet performance for the low field area.**