



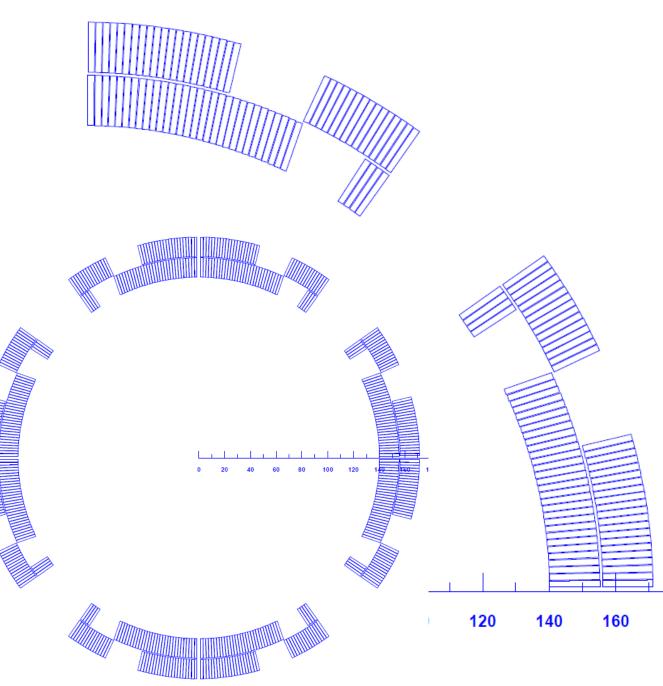
## Progress in Q2pF Design (Symmetric Wedges)

Ramesh Gupta June 20, 2023



## Review of the Current Design

- Field Quality Optimized
  Peak field Optimized
- Peak field Optimized
- One wedge per layer only
- Poles of Outer and Inner layers well aligned
- Collaring process will provide pre-stress
- However, the wedges are not exactly symmetric

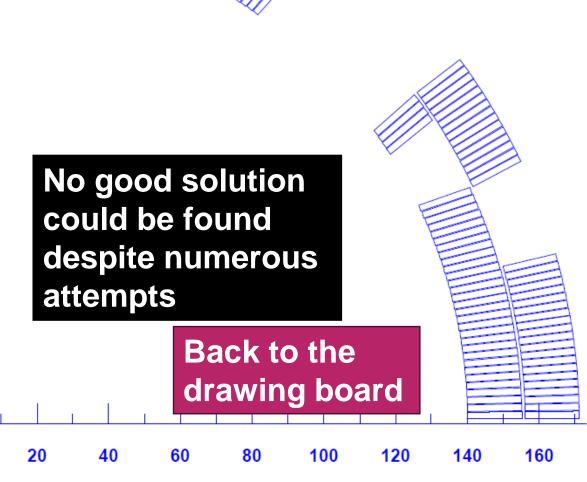




Ramesh Gupta

## Design with Wedges Forced Symmetric (using ROXIE feature)

- Field Quality Optimized
- Peak field Optimized
- Poles of Outer and Inner aligned and together
- wedges are now exactly symmetric
- However, collaring process will not provide good prestress (note: parallel poles)



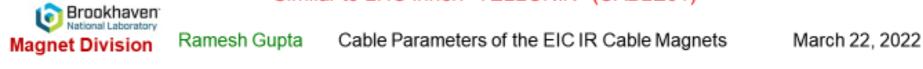


Ramesh Gupta

### LHC Style Cable used in Quad & Dipole (based on full keystone for Q2pF and B1ApF)

Ħ	Cable Geometry	4									
	No Naxe	height	width_s	i width_o	ns	transp.	degrd Connent	8			
	1 EICLHCB			5 1.984	28	115	5 LHC IN KEYSTOE FOR EIC DIPOLE	$\overline{\square}$			
	1 EICLHCQ	15.1	1.79	2.01	28	115	5 LHC IN KEYSTONE FOR EICIR QUAD	Keysto	one angle for cabl	e width << (	coil readius
	1 EICLHC01	15.1			28	115	5 LHC CABLE KEYSTOR FOR EIC 4,2K	Negoto	inc angue ron caus		
	2 EIC3642	19.4	1.773	3 2.027	36	115	3 EIC 36 STRAND 04.2K				B1ApF
	3 EIC3618	19.4	1,773	3 2,027	36	115	3 EIC 36 STRAND 01,8K	Cable h	neight	15.1	15.1
	4 EIC3642A	19.4	4 1.788	8 2.012	36	115	3 EIC 36 STRAND 04.2K 2 Layers	Cable r	mid-thickness	1.9	1.9
	5 CABLEO1	15.1	1.736	6 2.064	28	115	5 MB INNER LAYER, STR01				
	6 CABLEO2	15.1	1,362	2 1,598	36	100	5 MB OUTER LAYER,STR01	· ·			0.12
	7 SINGLE	0.94	0.94		1	0	O SINGLE STRAND	Coil i.r.		140	185
	8 GSI1CAB	9.74	4 1.061	1 1,271	30	74	0 GSI001 (RHIC) CABLE				
	9 GSI001	9,73	3 1.111		30	74	0 GSI001 following Wanderer				
	10 20MMCABLE	. 20	1.736	5 2.172	37	0	0 20mm cable	1			
	11 20MMCBNOK	. 20	13.8	8 13,8	290	0	0 7x20mm cable, no keystone	Avg Ra	d		192.55
	12 20MMCAB2	20	1.8	8 2	37	0	0 20 mm cable 2	dt		0.2190	0.1678
								Width	1	1.790	1.816
	Cable Definit;	lon						-			1.984
	No Naxe	Cable Geom.	Strand   Fi/	lament Insul	Trans	Quench Mat.	T_o Connent		~		
	1 EICLHCB2K	EICLHCB	STREIC1 NBT	II ALLPOLY	IL TRANS!	1 NONE	2 LHC INNER FOR EIC IR QUP	0.924	Note: Ke	vstone	s are
	2 EICLHCQ2K	EICLHCQ	STREIC1 NBT	/II ALLPOLY	IL TRANS!	1 NONE	2 LHC INNER FOR EIC IR DIP	OLE 6			
	3 LHCIN42K	EICLHC01	STREIC1 NBT	II ALLPOLY	IL TRANS!	1 NONE	4,2 LHC INNER FOR EIC 04,2K		reduce	ed for E	
Paar	YELLONIN	CABLE01	STR01 NBT	II ALLPOLY	IL TRANS!	1 NONE	1.9 W6-1 DESIGN DIPOLE INNER	t.			
	S YELLONOU	CABLE02	STR02 NBT	IO ALLPOLY	OL TRANS!	1 NONE	1.9 V6-1 DESIGN DIPOLE OUTER	2			
		No Name 1 EICLHCB 1 EICLHCB 1 EICLHCQ 1 EICLHCQ 1 EICLHCQ 1 EICLHCQ1 2 EIC3642 3 EIC3618 4 EIC3642A 5 CABLEO1 6 CABLEO2 7 SINGLE 8 GSI1CAB 9 GSIO01 10 20MMCABLE 11 20MMCBNCK 12 20MMCAB2  E Cable Definitis No Name 1 EICLHCB2K 2 EICLHC02K 3 LHCIN42K VELLONIN	1 EICLHCB 15.1 1 EICLHCQ 15.1 1 EICLHCQ 15.1 2 EIC3642 19.4 3 EIC3618 19.4 4 EIC36428 19.4 5 CABLE01 15.1 6 CABLE02 15.1 7 SINGLE 0.94 8 GSI1CAB 9.74 9 GSI001 9.73 10 20MMCABLE 20 11 20MMCBNDK 20 12 20MMCABLE 20 11 20MMCBNDK 20 12 20MMCAB2 20 ■ Cable Definition No Name Cable Geom. 1 EICLHCB2K EICLHCB 2 EICLHCD2K EICLHCB 2 EICLHCD2K EICLHCD 3 LHCIN42K EICLHC01 9 VELLONIN CABLE01	No         Name         Height         width_i           1         EICLHCB         15.1         1.816           1         EICLHCQ         15.1         1.79           1         EICLHCQ         15.1         1.796           2         EIC3642         19.4         1.773           3         EIC3618         19.4         1.773           4         EIC3642A         19.4         1.773           5         CABLEO1         15.1         1.736           6         CABLEO1         15.1         1.736           6         CABLEO2         15.1         1.736           6         CABLEO2         15.1         1.736           6         CABLEO2         15.1         1.736           7         SINGLE         0.94         0.94           8         GSI10AB         9.74         1.061           9         GSI001         9.73         1.111           10         20MMCABLE         20         1.736           11         20MMCAB2         20         1.8           12         20MMCAB2         20         1.8           12         20MMCAB2         20         1.8 <td>No         Name         height         width_i         width_o           1         EICLHCB         15.1         1.816         1.994           1         EICLHCQ         15.1         1.79         2.01           1         EICLHCQ         15.1         1.79         2.01           1         EICLHCQ         15.1         1.79         2.01           2         EIC3642         19.4         1.773         2.027           3         EIC3618         19.4         1.773         2.027           4         EIC3642A         19.4         1.778         2.012           5         CABLEO1         15.1         1.736         2.044           6         CABLEO2         15.1         1.362         1.598           7         SINGLE         0.94         0.94         0.94           8         GSI10AB         9.73         1.111         1.321           10         20MMCABLE         20</td> <td>No         Name         Height         width_i         width_o         ns           1         EICLHCB         15.1         1.816         1.984         28           1         EICLHCQ         15.1         1.79         2.01         28           1         EICLHCQ         15.1         1.79         2.01         28           2         EIC3642         19.4         1.773         2.027         36           3         EIC3618         19.4         1.773         2.027         36           4         EIC36429         19.4         1.773         2.027         36           5         CABLEO1         15.1         1.788         2.012         36           5         CABLEO1         15.1         1.736         2.064         28           6         CABLEO2         15.1         1.362         1.598         36           7         SINGLE         0.94         0.94         1.471         30           9         GSIO01         9.73         1.111         1.321         30           10         20MMCABLE         20         1.736         2.172         37           11         20MMCAB2         20</td> <td>No         Name         height         width_i         width_o         ns         transp.           1         EICLHCB         15.1         1.816         1.994         28         115           1         EICLHCQ         15.1         1.79         2.01         28         115           1         EICLHCQ         15.1         1.79         2.014         28         115           2         EIC3642         19.4         1.773         2.027         36         115           3         EIC3618         19.4         1.773         2.027         36         115           4         EIC3642A         19.4         1.778         2.012         36         115           5         CABLEO1         15.1         1.736         2.064         28         115           6         CABLEO2         15.1         1.362         1.598         36         100           7         SINGLE         0.94         0.94         0.94         1         0           8         GSI10AB         9.74         1.061         1.271         30         74           9         GSI001         9.73         1.111         1.321         32         7</td> <td>No         Name         height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.984         28         115         5         LHC IN KEYSTOE FOR EIC DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOE FOR EIC QUAD           1         EICLHCQ         15.1         1.776         2.027         36         115         3         EIC 36 STRAND 04.2K           2         EIC3642         19.4         1.773         2.027         36         115         3         EIC 36 STRAND 04.2K           4         EIC3642         19.4         1.773         2.027         36         115         3         EIC 36 STRAND 04.2K         2         Layers           5         DABLEO1         15.1         1.778         2.027         36         115         3         EIC 36 STRAND 04.2K         Layers           5         DABLEO1         15.1         1.773         2.064         28         115         5         MB DIMER LAYER,STRO1           6         CABLEO2         15.1         1.362         1.938         3<!--</td--><td>No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.984         28         115         5         LHC IN KEYSTOE FOR EIC DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOE FOR EIC ALX         Keysto           1         EICLHCQ         15.1         1.773         2.002         36         115         5         LHC CHBLE KEYSTOR FOR EIC 4.2K         Keysto           3         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Cable for           4         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Lagers         Cable for         Cabl</td><td>No         No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.994         28         115         5         LHC IN KEYSTOR FOR EICL DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOR FOR EICL QUAD           2         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Cable height         Cable height           4         EIC36429         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Lauers         Cable height         Cable MID4.2X         Lauers         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable iside         Cable         Cable         Sision (RHIC</td><td>No         Name         Height         Width_i         <thwidth_i< th=""> <thwidth_i< <="" td=""></thwidth_i<></thwidth_i<></td></td>	No         Name         height         width_i         width_o           1         EICLHCB         15.1         1.816         1.994           1         EICLHCQ         15.1         1.79         2.01           1         EICLHCQ         15.1         1.79         2.01           1         EICLHCQ         15.1         1.79         2.01           2         EIC3642         19.4         1.773         2.027           3         EIC3618         19.4         1.773         2.027           4         EIC3642A         19.4         1.778         2.012           5         CABLEO1         15.1         1.736         2.044           6         CABLEO2         15.1         1.362         1.598           7         SINGLE         0.94         0.94         0.94           8         GSI10AB         9.73         1.111         1.321           10         20MMCABLE         20	No         Name         Height         width_i         width_o         ns           1         EICLHCB         15.1         1.816         1.984         28           1         EICLHCQ         15.1         1.79         2.01         28           1         EICLHCQ         15.1         1.79         2.01         28           2         EIC3642         19.4         1.773         2.027         36           3         EIC3618         19.4         1.773         2.027         36           4         EIC36429         19.4         1.773         2.027         36           5         CABLEO1         15.1         1.788         2.012         36           5         CABLEO1         15.1         1.736         2.064         28           6         CABLEO2         15.1         1.362         1.598         36           7         SINGLE         0.94         0.94         1.471         30           9         GSIO01         9.73         1.111         1.321         30           10         20MMCABLE         20         1.736         2.172         37           11         20MMCAB2         20	No         Name         height         width_i         width_o         ns         transp.           1         EICLHCB         15.1         1.816         1.994         28         115           1         EICLHCQ         15.1         1.79         2.01         28         115           1         EICLHCQ         15.1         1.79         2.014         28         115           2         EIC3642         19.4         1.773         2.027         36         115           3         EIC3618         19.4         1.773         2.027         36         115           4         EIC3642A         19.4         1.778         2.012         36         115           5         CABLEO1         15.1         1.736         2.064         28         115           6         CABLEO2         15.1         1.362         1.598         36         100           7         SINGLE         0.94         0.94         0.94         1         0           8         GSI10AB         9.74         1.061         1.271         30         74           9         GSI001         9.73         1.111         1.321         32         7	No         Name         height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.984         28         115         5         LHC IN KEYSTOE FOR EIC DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOE FOR EIC QUAD           1         EICLHCQ         15.1         1.776         2.027         36         115         3         EIC 36 STRAND 04.2K           2         EIC3642         19.4         1.773         2.027         36         115         3         EIC 36 STRAND 04.2K           4         EIC3642         19.4         1.773         2.027         36         115         3         EIC 36 STRAND 04.2K         2         Layers           5         DABLEO1         15.1         1.778         2.027         36         115         3         EIC 36 STRAND 04.2K         Layers           5         DABLEO1         15.1         1.773         2.064         28         115         5         MB DIMER LAYER,STRO1           6         CABLEO2         15.1         1.362         1.938         3 </td <td>No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.984         28         115         5         LHC IN KEYSTOE FOR EIC DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOE FOR EIC ALX         Keysto           1         EICLHCQ         15.1         1.773         2.002         36         115         5         LHC CHBLE KEYSTOR FOR EIC 4.2K         Keysto           3         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Cable for           4         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Lagers         Cable for         Cabl</td> <td>No         No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.994         28         115         5         LHC IN KEYSTOR FOR EICL DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOR FOR EICL QUAD           2         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Cable height         Cable height           4         EIC36429         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Lauers         Cable height         Cable MID4.2X         Lauers         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable iside         Cable         Cable         Sision (RHIC</td> <td>No         Name         Height         Width_i         <thwidth_i< th=""> <thwidth_i< <="" td=""></thwidth_i<></thwidth_i<></td>	No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.984         28         115         5         LHC IN KEYSTOE FOR EIC DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOE FOR EIC ALX         Keysto           1         EICLHCQ         15.1         1.773         2.002         36         115         5         LHC CHBLE KEYSTOR FOR EIC 4.2K         Keysto           3         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Cable for           4         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRMD 04.2K         Lagers         Cable for         Cabl	No         No         Name         Height         width_i         width_o         ns         transp.         degrd         Comment           1         EICLHCB         15.1         1.816         1.994         28         115         5         LHC IN KEYSTOR FOR EICL DIPOLE           1         EICLHCQ         15.1         1.79         2.01         28         115         5         LHC IN KEYSTOR FOR EICL QUAD           2         EIC3642         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Cable height         Cable height           4         EIC36429         19.4         1.773         2.007         36         115         3         EIC 36         STRAND 04.2X         Lauers         Cable height         Cable MID4.2X         Lauers         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable mid-thickness         Insul (one side)         Cable iside         Cable iside         Cable iside         Cable         Cable         Sision (RHIC	No         Name         Height         Width_i         Width_i <thwidth_i< th=""> <thwidth_i< <="" td=""></thwidth_i<></thwidth_i<>

#### Cales considered for EIC: "EICLHCB2K" and "EICLHCQ2K" (EICLHCB and EICLHCQ) Similar to LHC inner: "YELLONIN" (CABLE01)





Ramesh Gupta

Progress in Q2pF Design

June 20, 2023

3

**Design with Wedges Forced Symmetric** (with EIC "Q" cable)

- Field Quality Optimized
- Peak field Optimized

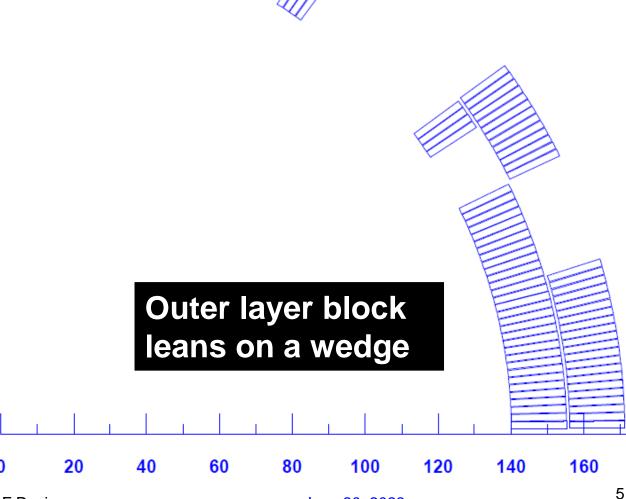
Brookhaven

Magnet Division

- Poles of Outer and Inner aligned and together
- > wedges made exactly symmetric with ROXIE feature
- Collaring process should provide a good pre-stress (note: wedge shape at poles)

Ramesh Gupta

Progress in Q2pF Design



June 20, 2023

#### Looks good mechanically

## **Comparison with the Previous Design**

#### Previous Design

I. T	NC-L	D			Comment   Califa mana	L KIA	NO 1					
lo Type	NCab	R	•	a	Current Cable name		N2 :	No	X1	Xu	Xs String	Act Bloc
1 Cos	▼ 30	140	0.5	0	-8500 EICLHCB2K 🔻	2	20 (	1	3	9	7,2697 PHIR	2 🔻 2
2 Cos	▼ 4	140	31,179	25,196	-8500 EICLHCB2K 🔻	2	20 (	2	25	33	32,8991 ALPHA	2 🔻 2
3 Cos	▼ 21	156	0.5	0	-8500 EICLHCB2K 🔻	2	20 (	3	6	10	8,6236 PHIR	2 🔻 4
4 Cos	▼ 15	156	17	30	-8500 EICLHCB2K 🔻	2	20 (	4	18	28	25,2508 ALPHA	2 🔻 4

#### **New Design**

Block Dat	a 2D										
No Type		NCab	R	+	a	Current	Cable name	N1	N2 I	No	X1
1 Cos	•	31	140	0.54	0	-8500	EICLHCQ2K 🔻	2	20 0	1	3
2 Cos	-	4	140	31,179	25,196	-8500	EICLHCQ2K 🔻	2	20 0	2	6
3 Cos	-	21	156	0.54	0	-8500	EICLHCQ2K 🔻	2	20 0	3	0
4 Cos	-	13	156	17	30	-8500	EICLHCQ2K 🔻	2	20 0	4	0

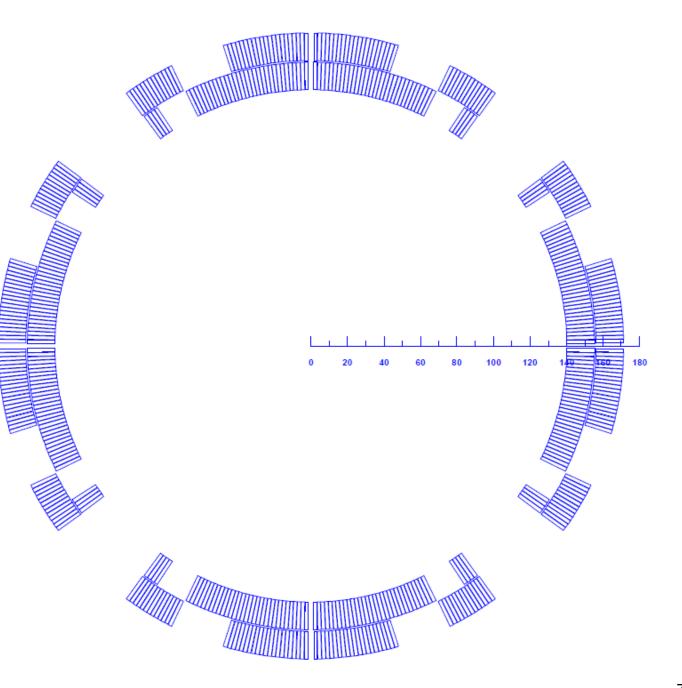
No	X1	Xu	Xs String	Act Block
1	3	9	6.44 PHIRS	2 🔻 2
2	6	12	10,34 PHIRS	2 🔻 4
3	0	0	0 ALPHRS	2 🔻 2
4	0	0	0 ALPHRS	2 🔻 4



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### One turn less in total (69 instead of 70) Inner layer has one more, outer two less

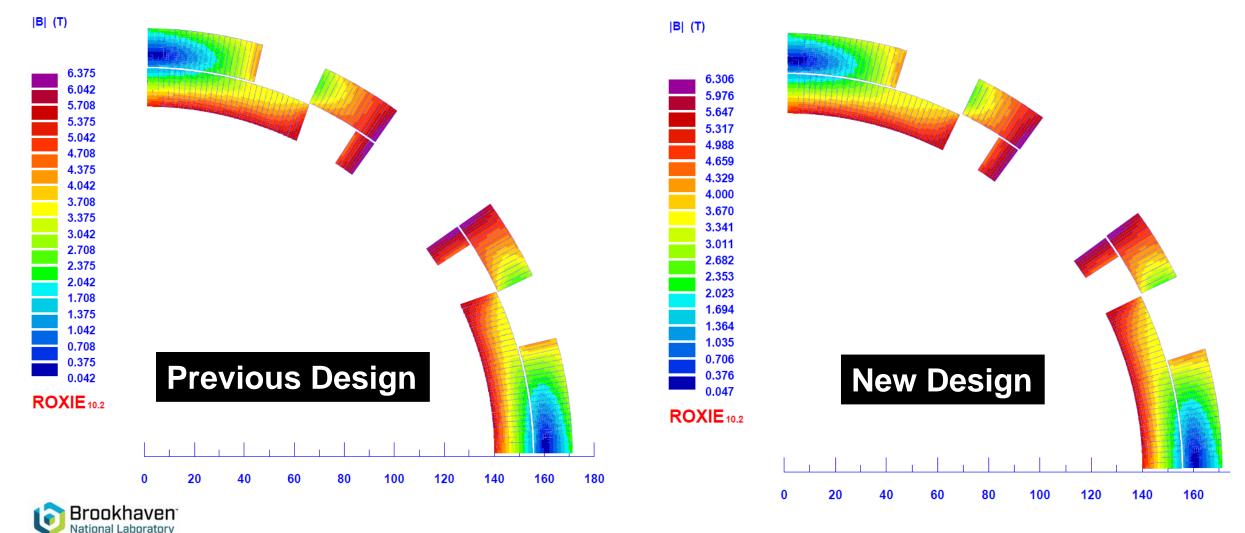
# Full View of the Coil Design





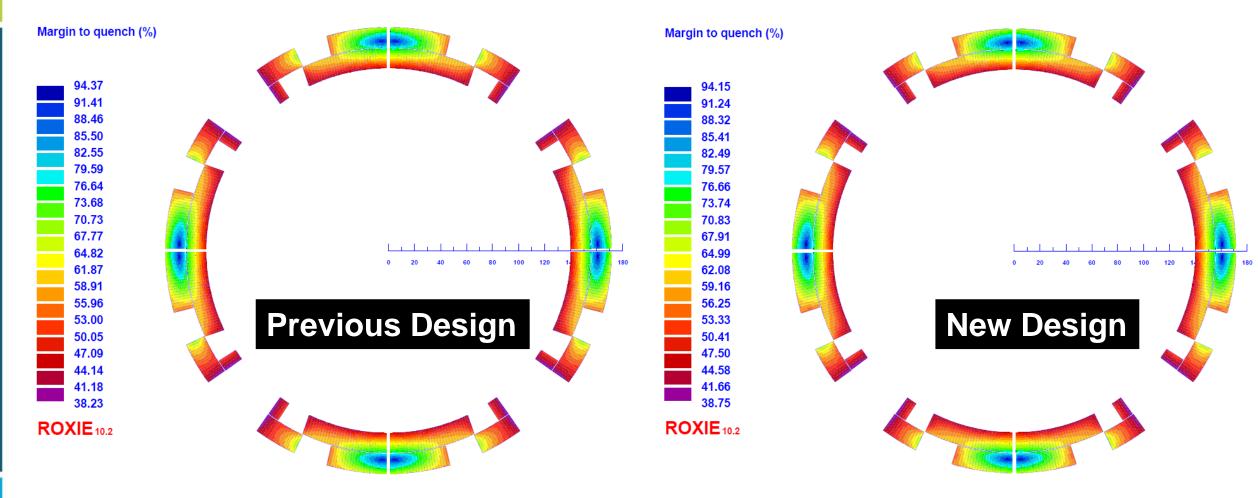
Ramesh Gupta

# Comparison with the Previous Design (Peak Fields)



Magnet Division Ramesh Gupta

# Comparison with the Previous Design (Quench Margin)





Ramesh Gupta

### **Comparison with the Previous Design** (Field Harmonics) New Design

#### **Previous Design**

	1
HARMONIC ANALYSIS NUMBER	T
MAIN HARMONIC	2
REFERENCE RADIUS (mm)	0
X-POSITION OF THE HARMONIC COIL (mm) 0.000	0
Y-POSITION OF THE HARMONIC COIL (mm) 0.000	0
MEASUREMENT TYPE ALL FIELD CONTRIBUTION	IS
ERROR OF HARMONIC ANALYSIS OF Br 0.8991E-0	4
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))	

MAIN FIELD (T) .		3.167908
MAGNET STRENGTH	(T/(m^(n-1))	38.1676

#### NORMAL RELATIVE MULTIPOLES (1.D-4):

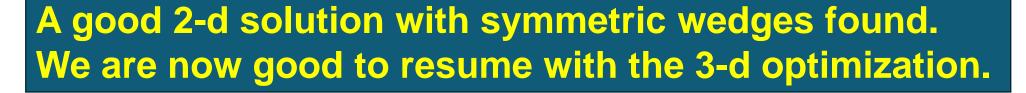
00620
26673
00075
00000
00000
01593

HARMONIC ANALYSIS NUMBER	1
MAIN HARMONIC	2
REFERENCE RADIUS (mm)	83.0000
X-POSITION OF THE HARMONIC COIL (mm)	0.0000
Y-POSITION OF THE HARMONIC COIL (mm)	0.0000
MEASUREMENT TYPE ALL FIELD CON	<b>TRIBUTIONS</b>
ERROR OF HARMONIC ANALYSIS OF Br	0.6776E-04
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))	

MAIN FIELD (T) .		3.147502
MAGNET STRENGTH	(T/(m^(n-1))	37.9217

#### NORMAL RELATIVE MULTIPOLES (1.D-4):

-0.14254	b 2:	10000.00000	b 3:	0.00250
-0.01577	b 5:	0.02641	b 6:	-0.10295
-0.00201	b 8:	-0.00094	b 9:	0.00065
-0.40774	b11:	-0.00011	b12:	0.00000
-0.00002	b14:	-0.46484	b15:	0.00000
-0.00000	b17:	-0.00000	b18:	0.00550
	-0.01577 -0.00201 -0.40774 -0.00002	-0.14254 b 2: -0.01577 b 5: -0.00201 b 8: -0.40774 b11: -0.00002 b14: -0.00000 b17:	-0.01577b 5:0.02641-0.00201b 8:-0.00094-0.40774b11:-0.00011-0.00002b14:-0.46484	-0.00201 b 8: -0.00094 b 9: -0.40774 b11: -0.00011 b12: -0.00002 b14: -0.46484 b15:





Ramesh Gupta