Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Tunability of Q2pF End Design

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Tunability for Peak Field and End Harmonics

Earlier Design

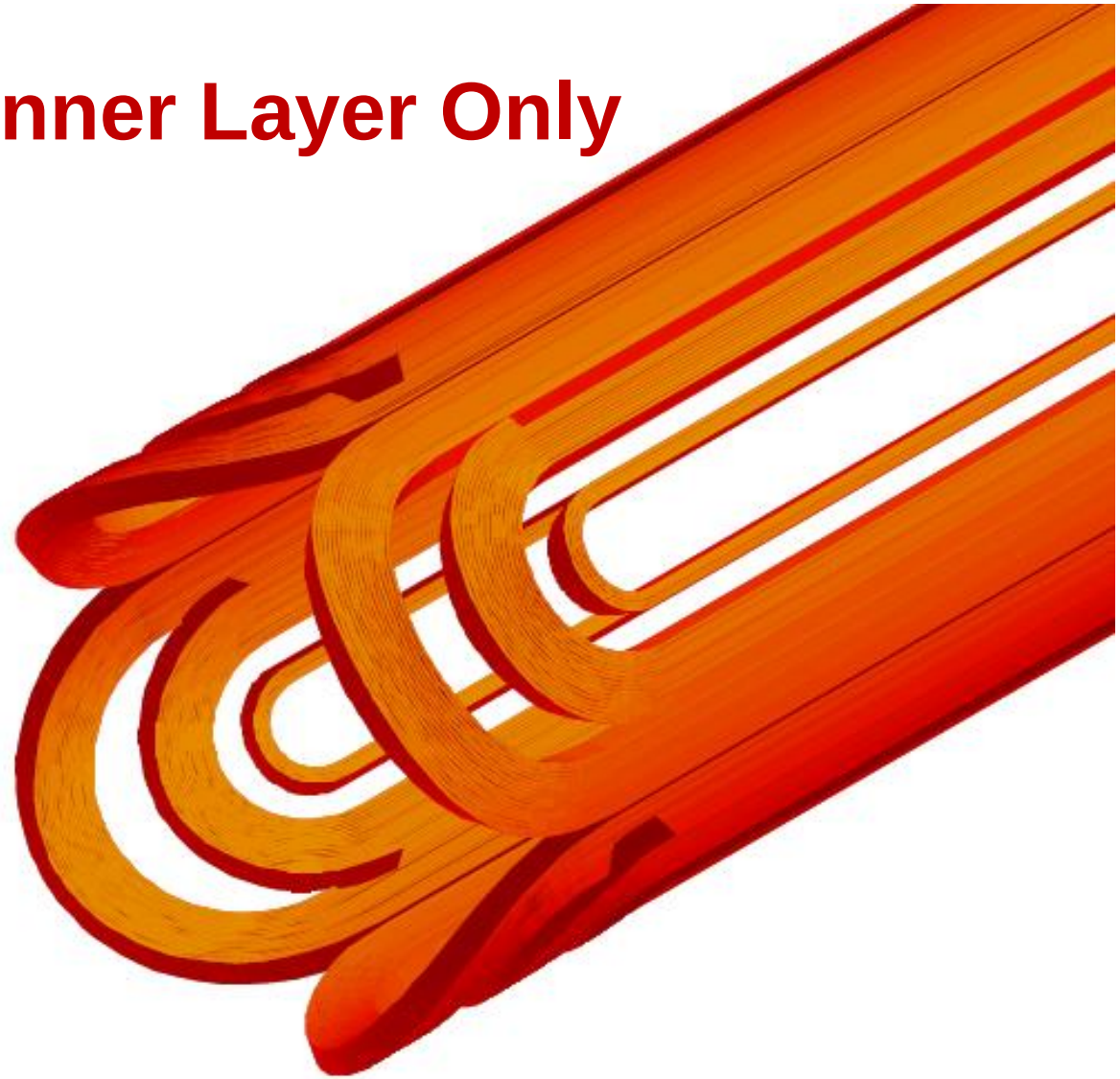
Iterated Design

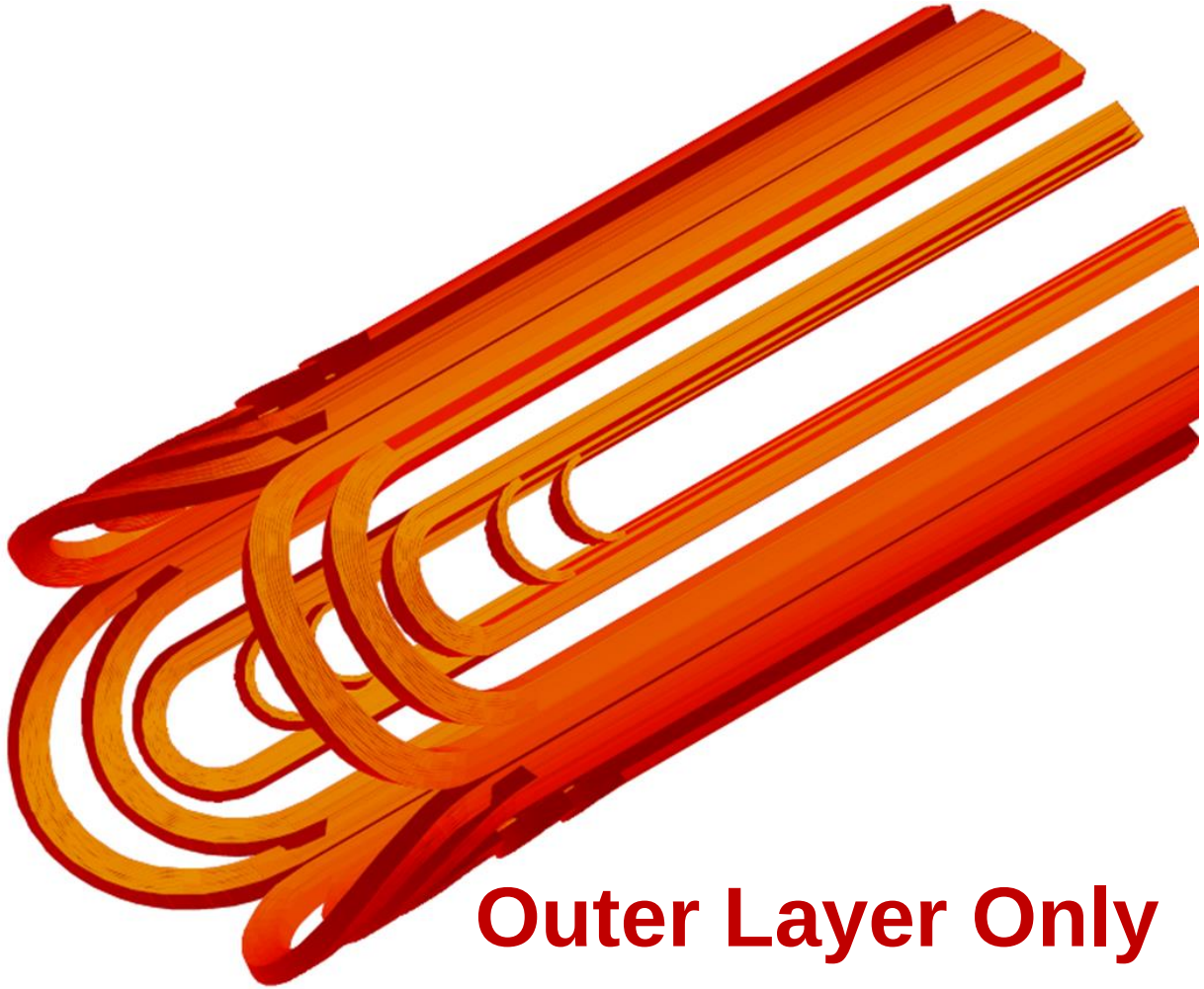
- Approach is that after the verification of the mechanical layout of the Ends from the single turn winding, tune the end design for end harmonics and peak fields without disturbing the mechanical layout of turns
- This is done by only changing the SS of various End blocks which changes harmonics, peak fields and to some extend distributions of the Lorentz forces.
- This doesn't change the internal distribution of turns within any end block.

Inner and Outer Layers

Change SS of individual block and thickness of the end spacers to tune end harmonics and peak field without changing the layout of the individual turns in the end.

Inner Layer Only





Outer Layer Only

An Example

- In previous design b10 got increased because of the ends
- Even though the integral value was less than 1 unit, we don't want to eat-up margin or make field quality unnecessary worse by design, unless there are good reasons.
- Iteration, showed in the last slide reduce this harmonic.

```
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
NUMBER OF ANALYSES ALONG Z ........................        100
LENGTH OF VIRTUAL COIL (mm) .......................     200.0000
REFERENCE POSITION NUMBER .........................         10
MEASUREMENT TYPE ..................... ALL FIELD CONTRIBUTIONS
ERROR OF HARMONIC ANALYSIS OF Br ..................  0.6826E-04
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))

3D REFERENCE MAIN FIELD (T) .......................      3.4386
REFERENCE MAGNET STRENGTH (T/(m^(n-1)) ............     41.4295
MAGNETIC LENGTH (mm) ..............................     200.0006

NORMAL 3D INTEGRAL RELATIVE MULTIPOLES (1.D-4):
b 1:      0.00000  b 2:  10000.00000  b 3:      0.00000
b 4:     -0.00000  b 5:      0.00000  b 6:      0.13027
b 7:     -0.00000  b 8:      0.00000  b 9:     -0.00000
b10:     -0.40171  b11:      0.00000  b12:      0.00000
b13:     -0.00000  b14:     -0.43070  b15:     -0.00000
b16:     -0.00000  b17:      0.00000  b18:      0.00484
```

Body (SS)

```
NUMBER OF ANALYSES ALONG Z ..........................        100
LENGTH OF VIRTUAL COIL (mm) .........................    2500.0000
REFERENCE POSITION NUMBER ...........................         10
MEASUREMENT TYPE ..................... ALL FIELD CONTRIBUTIONS
ERROR OF HARMONIC ANALYSIS OF Br ....................  0.5233E-04
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))

3D REFERENCE MAIN FIELD (T) .........................      3.4387
REFERENCE MAGNET STRENGTH (T/(m^(n-1)) ..............     41.4300
MAGNETIC LENGTH (mm) ................................   1726.1518

NORMAL 3D INTEGRAL RELATIVE MULTIPOLES (1.D-4):
b 1:     -0.00000  b 2:  10000.00000  b 3:     -0.00000
b 4:      0.00000  b 5:      0.00000  b 6:     -0.08770
b 7:     -0.00000  b 8:     -0.00000  b 9:     -0.00000
b10:     -0.63054  b11:      0.00000  b12:      0.00000
b13:      0.00000  b14:     -0.42979  b15:     -0.00000
b16:     -0.00000  b17:     -0.00000  b18:      0.00201
```

Integrated Harmonics (3-d)

An Example for B10

b 1:	0.00000	b 2:	10000.00000	b 3:	0.00000
b 4:	-0.00000	b 5:	0.00000	b 6:	0.13027
b 7:	-0.00000	b 8:	0.00000	b 9:	-0.00000
b10:	-0.40171	b11:	0.00000	b12:	0.00000
b13:	-0.00000	b14:	-0.43070	b15:	-0.00000

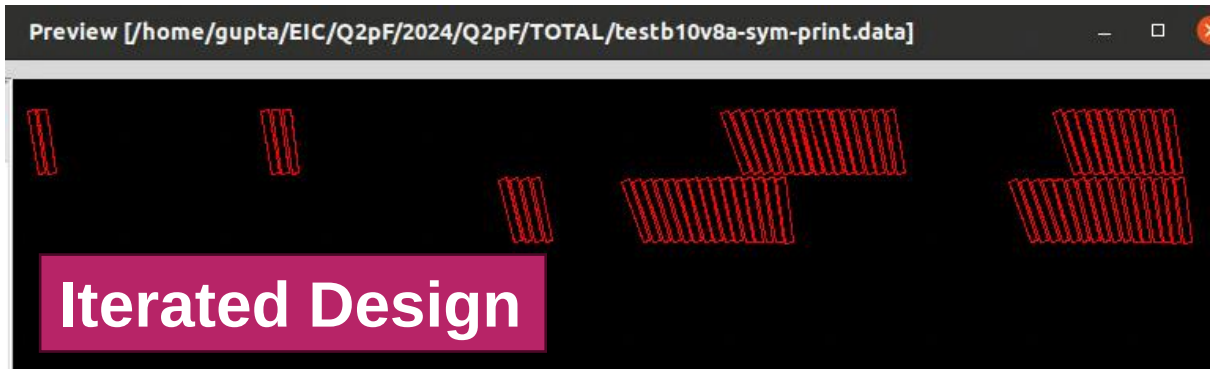
Body (SS)

Earlier Design


```
NUMBER OF ANALYSES ALONG Z ..........................          100
LENGTH OF VIRTUAL COIL (mm) .........................    2500.0000
REFERENCE POSITION NUMBER ...........................           10
MEASUREMENT TYPE ..................... ALL FIELD CONTRIBUTIONS
ERROR OF HARMONIC ANALYSIS OF Br ....................  0.5233E-04
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))

3D REFERENCE MAIN FIELD (T) .........................      3.4387
REFERENCE MAGNET STRENGTH (T/(m^(n-1)) ..............     41.4300
MAGNETIC LENGTH (mm) ................................  1726.1518

NORMAL 3D INTEGRAL RELATIVE MULTIPOLES (1.D-4):
b 1:     -0.00000  b 2:  10000.00000  b 3:     -0.00000
b 4:      0.00000  b 5:      0.00000  b 6:     -0.08770
b 7:     -0.00000  b 8:     -0.00000  b 9:     -0.00000
b10:     -0.63054  b11:      0.00000  b12:      0.00000
b13:      0.00000  b14:     -0.42979  b15:     -0.00000
b16:     -0.00000  b17:     -0.00000  b18:      0.00201
```

Integrated Harmonics

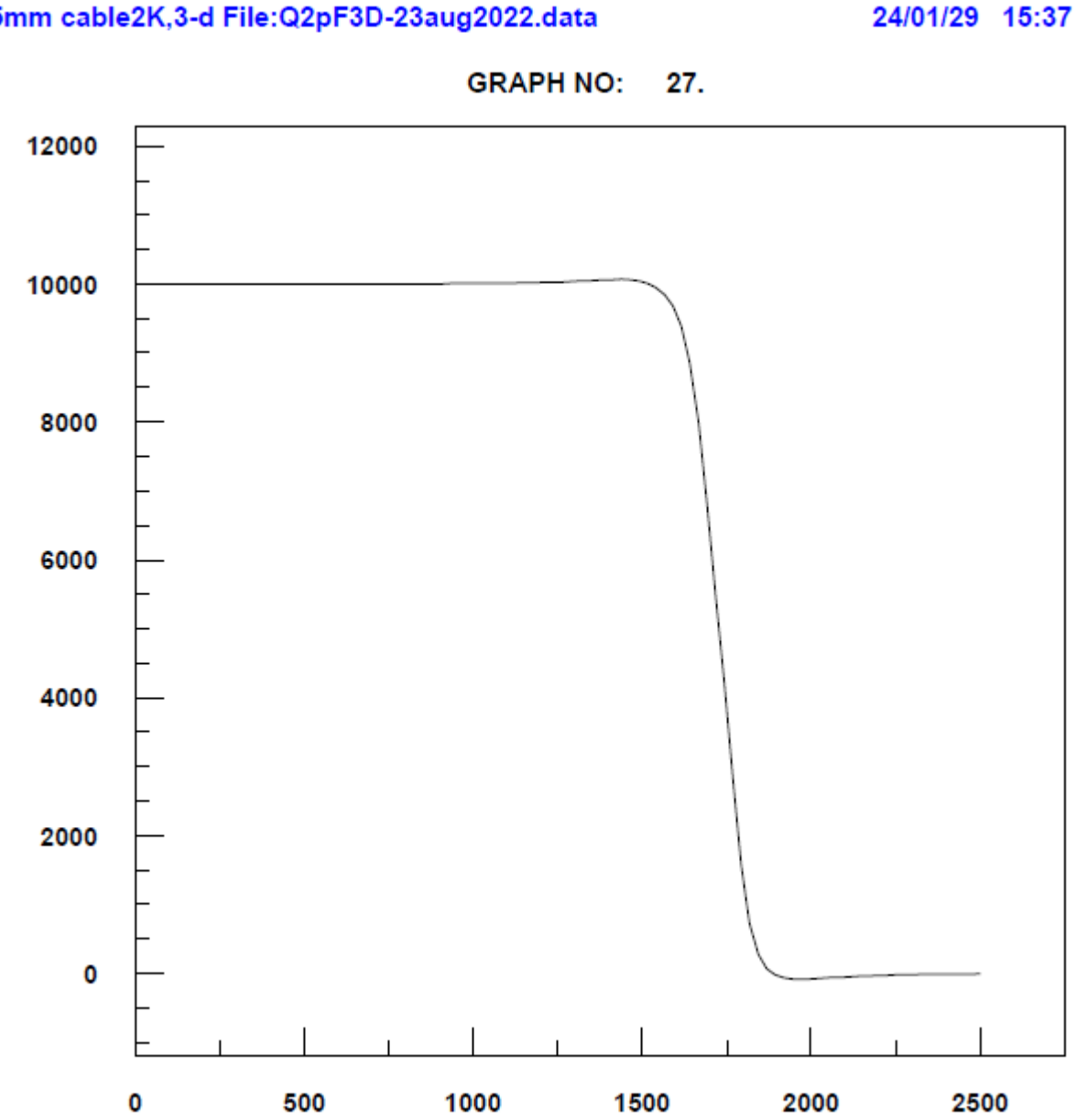
Iterated Design



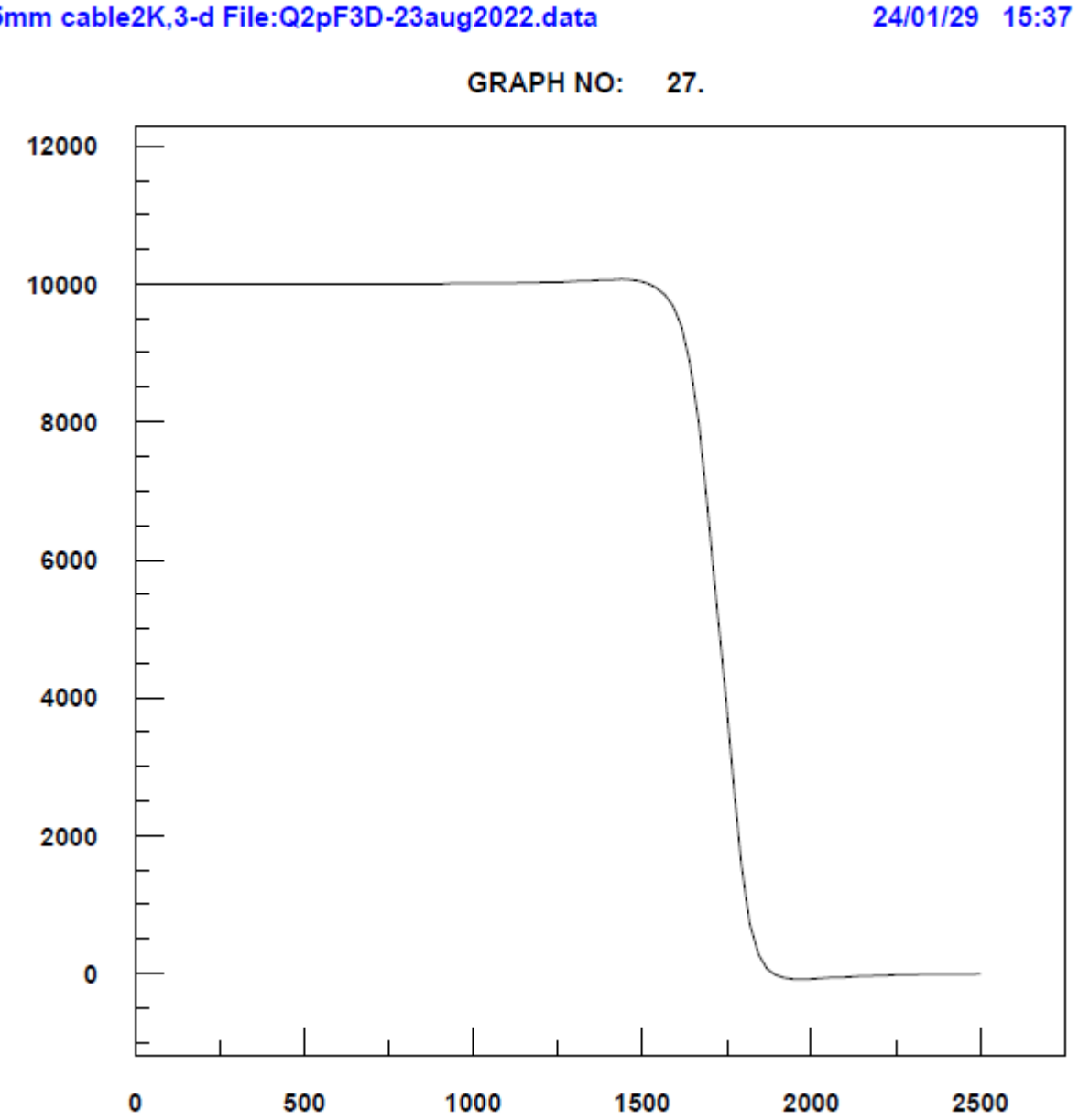
Integrated Harmonics

```
NUMBER OF ANALYSES ALONG Z ..........................          100
LENGTH OF VIRTUAL COIL (mm) .........................    2500.0000
REFERENCE POSITION NUMBER ...........................           10
MEASUREMENT TYPE ..................... ALL FIELD CONTRIBUTIONS
ERROR OF HARMONIC ANALYSIS OF Br ....................  0.5292E-04
SUM (Br(p) - SUM (An cos(np) + Bn sin(np))

3D REFERENCE MAIN FIELD (T) .........................      3.4389
REFERENCE MAGNET STRENGTH (T/(m^(n-1)) ..............     41.4325
MAGNETIC LENGTH (mm) ................................  1723.6657

NORMAL 3D INTEGRAL RELATIVE MULTIPOLES (1.D-4):
b 1:      0.00000  b 2:  10000.00000  b 3:     -0.00000
b 4:     -0.00000  b 5:      0.00000  b 6:      0.61375
b 7:     -0.00000  b 8:     -0.00000  b 9:      0.00000
b10:     -0.50762  b11:      0.00000  b12:      0.00000
b13:     -0.00000  b14:     -0.42946  b15:     -0.00000
b16:     -0.00000  b17:     -0.00000  b18:      0.00085
```

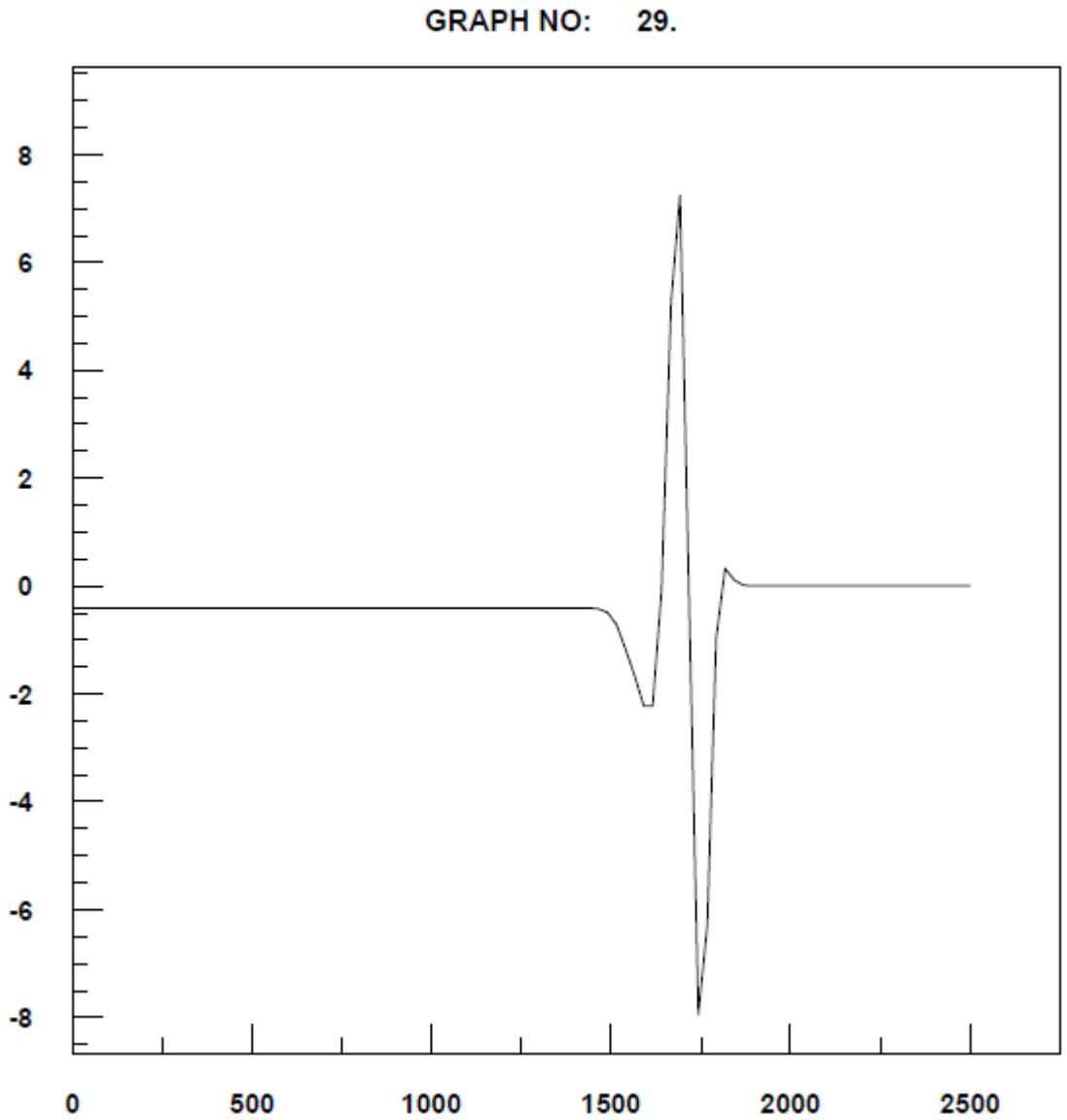
B2 along z-axis



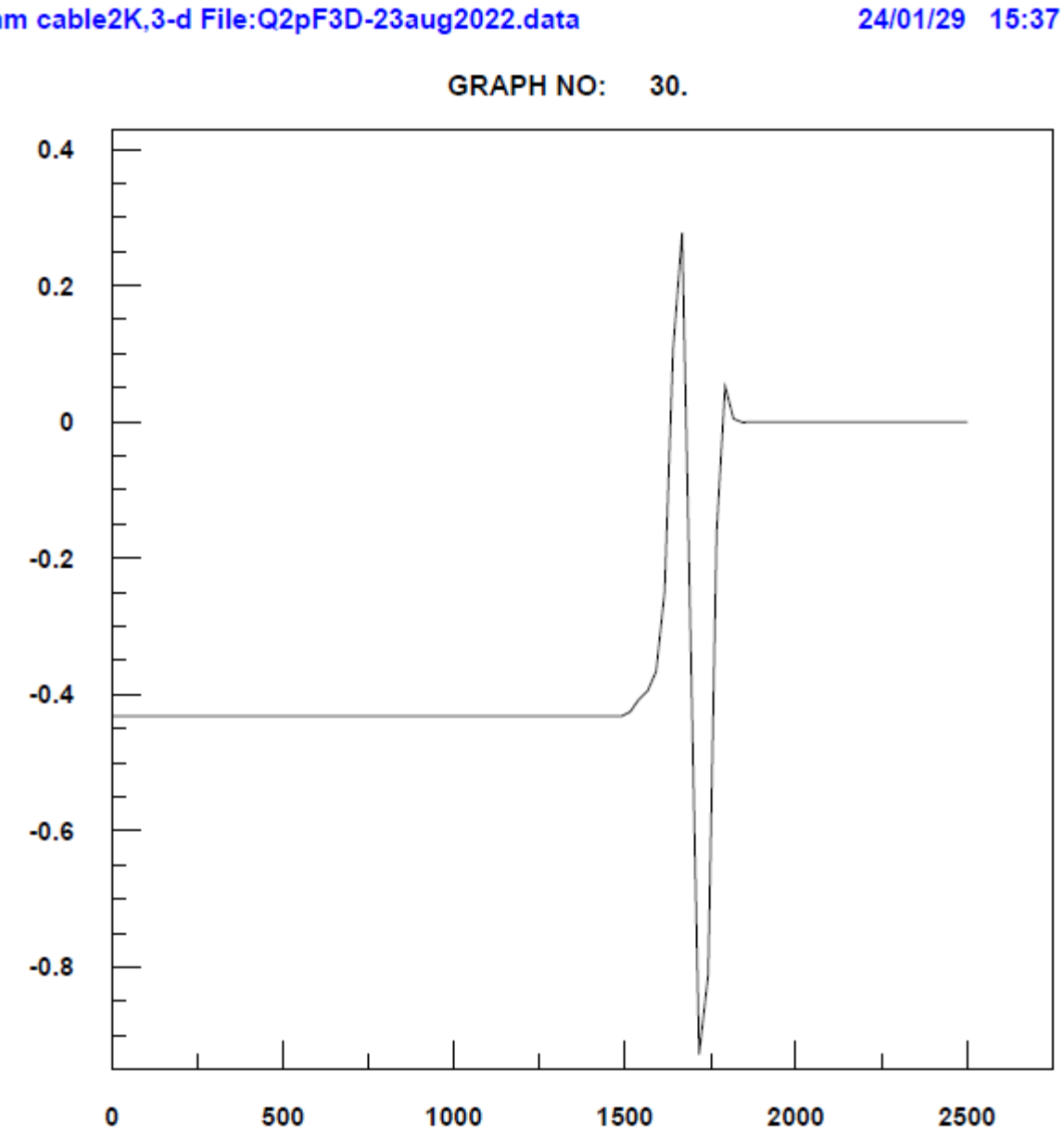
B6 along z-axis



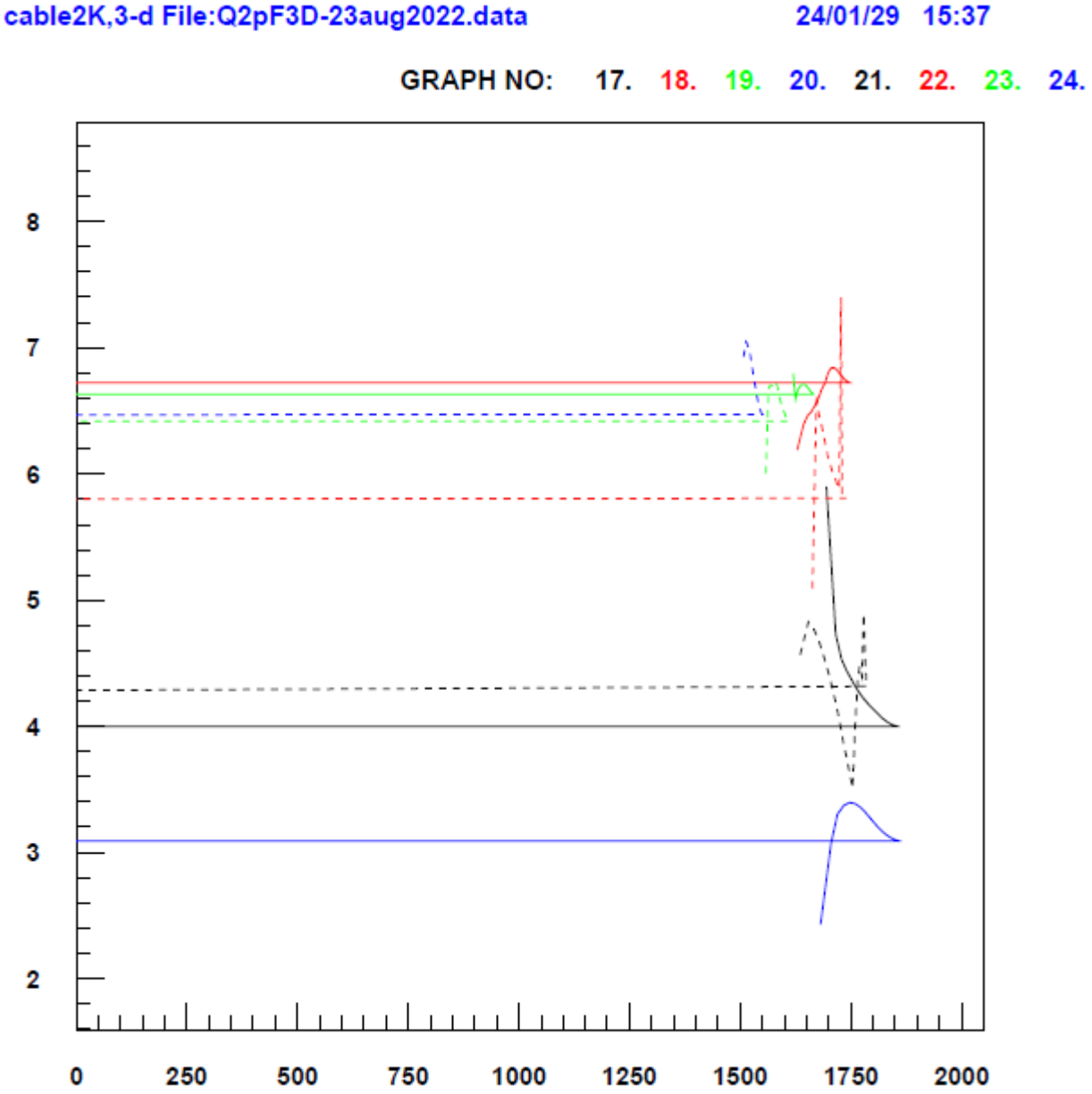
B10 along z-axis



B14 along z-axis



Peak fields in various blocks along z-axis (compare with OPERA3d)



Backup Slide

Xroxie [/home/gupta/EIC/Q2pF+/2024/Q2pF/TOTAL/testb10v8a-peak-symm.data]

File Edit Display Run

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ARCLS	0	0	BPEAK	2	0	14	Normal	
ARCLS	0	0	BPEAK	3	0	14	Normal	
ARCLS	0	0	BPEAK	4	0	14	Normal	
ARCLS	0	0	BPEAK	5	0	14	Normal	
ARCLS	0	0	BPEAK	6	0	14	Normal	
ARCLS	0	0	BPEAK	7	0	14	Normal	
ARCLS	0	0	BPEAK	8	0	14	Normal	
ARCL	1	0	|B|	1	0	15	Normal	
ARCL	2	0	|B|	2	0	16	Normal	
Z	1	0	B3D	2	0	17	Normal	
Z	1	0	B3D	6	0	18	Normal	
Z	1	0	B3D	10	0	19	Normal	
Z	1	0	B3D	14	0	20	Normal	