B-field Parameterization

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BIA Schedule

132 (wo)man-weeks (66 Univ. contrib.) $169, 646 Nov. 2008- May 2011

- Activity 5533010: MC Studies for Detector Optimization (OFFLINE COMP)

0% – Software optimization tools development

100% – CDC Optimization

100% – FDC Optimization

50% – Global tracking Optimization

50% – Start Time reconstruction sequencing

0% – ***Field Map Parameterization***

100% – XML geometry access

Chebyshev Polynomials

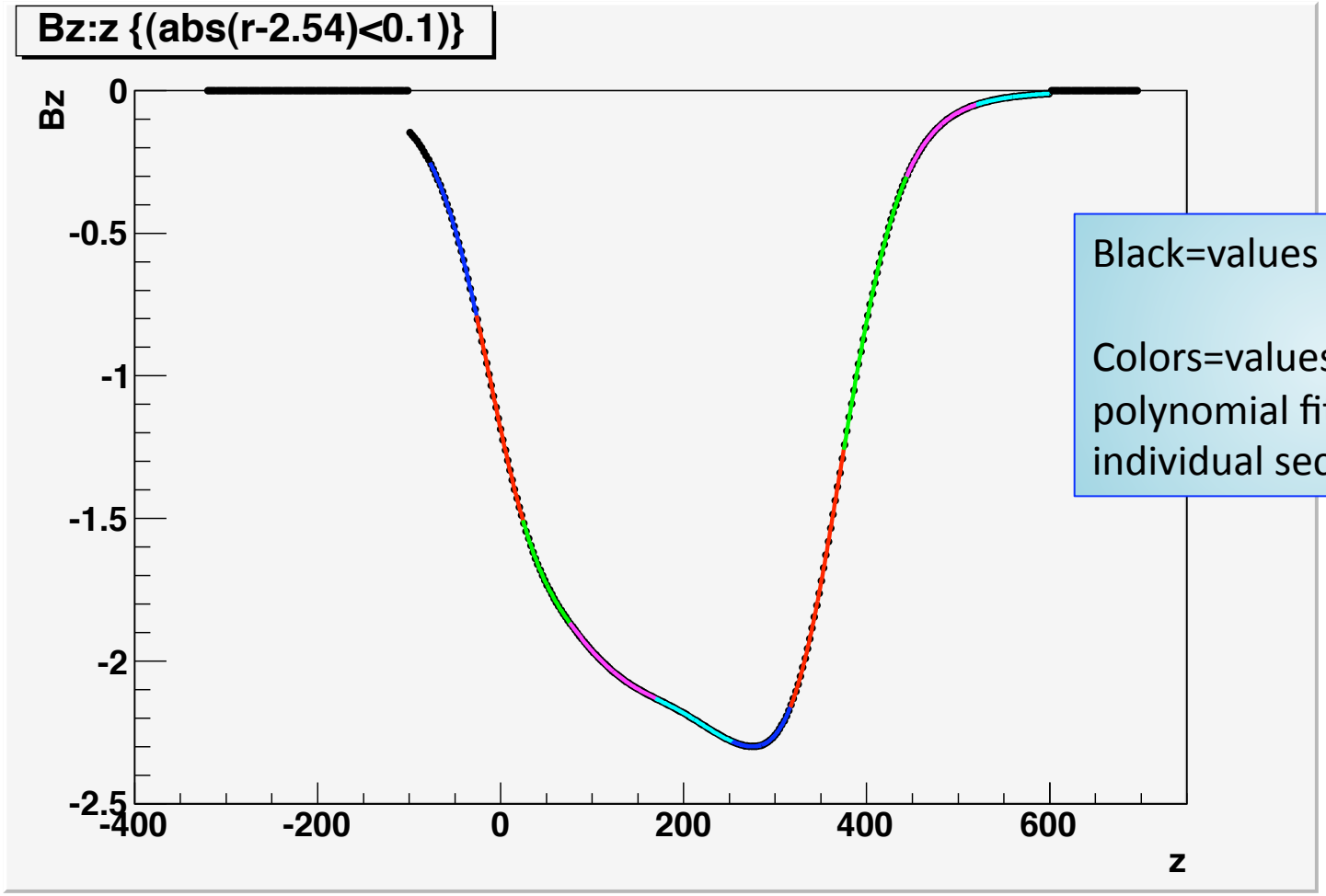
- Orthogonal set
- Simply defined
- Well documented

Fits were done to Bz and Bx using 9th order Chebyshev Polynomials as a function of z piece-wise for sections in z

Coordinate transformation of z to -1 to +1 range for each section

$$
\begin{aligned}
T_0(x) &= 1 \\
T_1(x) &= x \\
T_2(x) &= 2x^2 - 1 \\
T_3(x) &= 4x^3 - 3x \\
T_4(x) &= 8x^4 - 8x^2 + 1 \\
T_5(x) &= 16x^5 - 20x^3 + 5x \\
T_6(x) &= 32x^6 - 48x^4 + 18x^2 - 1 \\
T_7(x) &= 64x^7 - 112x^5 + 56x^3 - 7x \\
T_8(x) &= 128x^8 - 256x^6 + 160x^4 - 32x^2 + 1 \\
T_9(x) &= 256x^9 - 576x^7 + 432x^5 - 120x^3 + 9x.
\end{aligned}
$$

Example fit to Bz as a function of z



Black=values from map

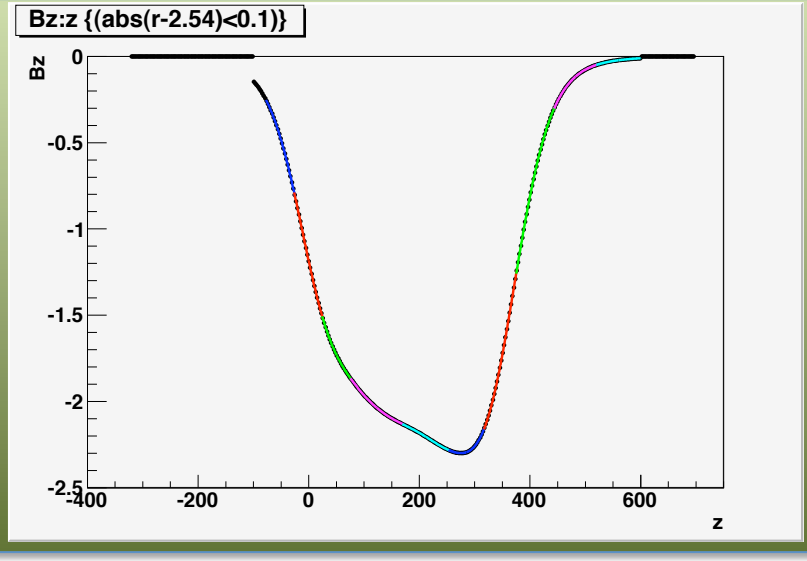
Colors=values from polynomial fits to individual sections in z

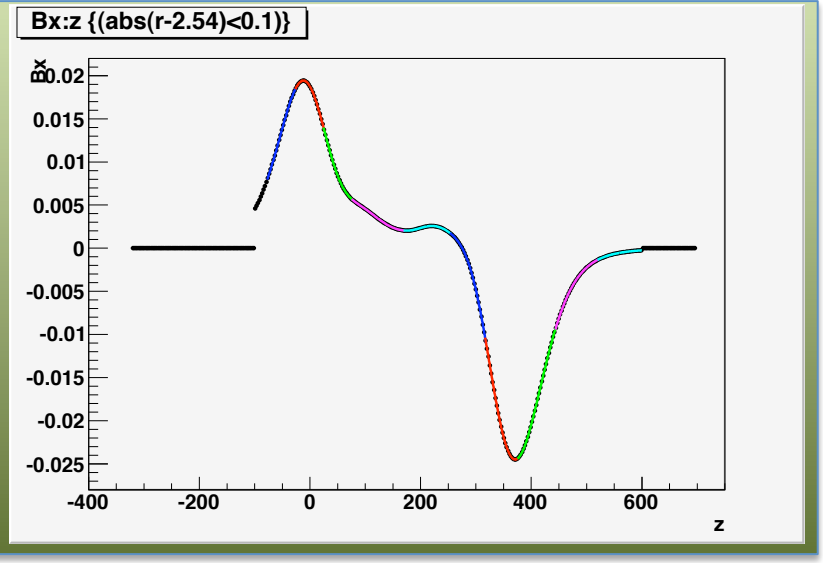
Fits to B_z and B_r

B_z

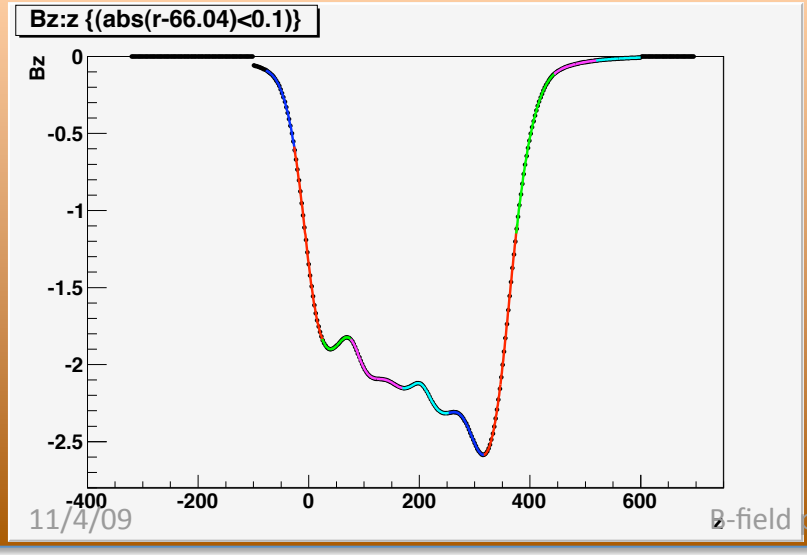
B_r

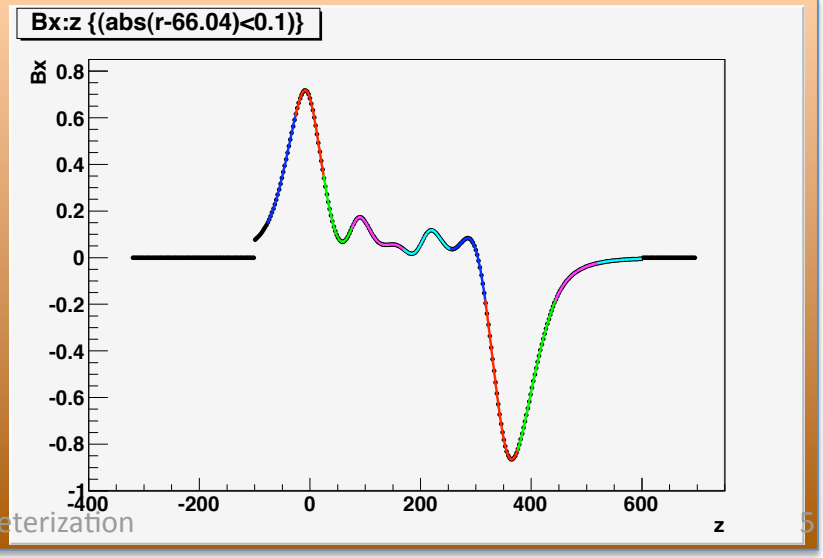
near beamline





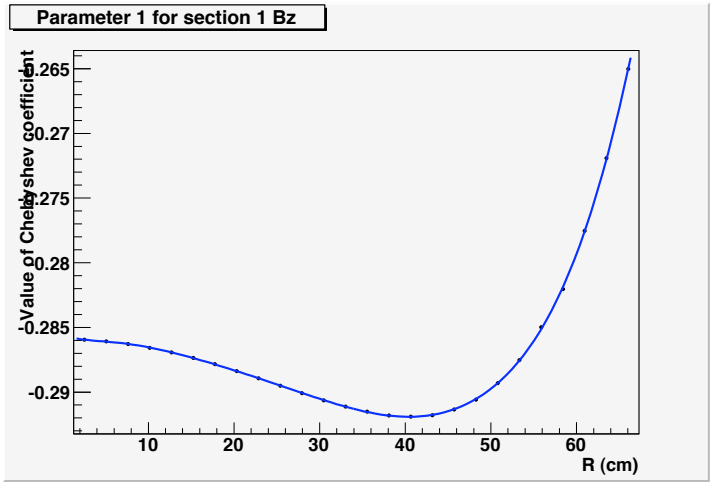
near BCAL

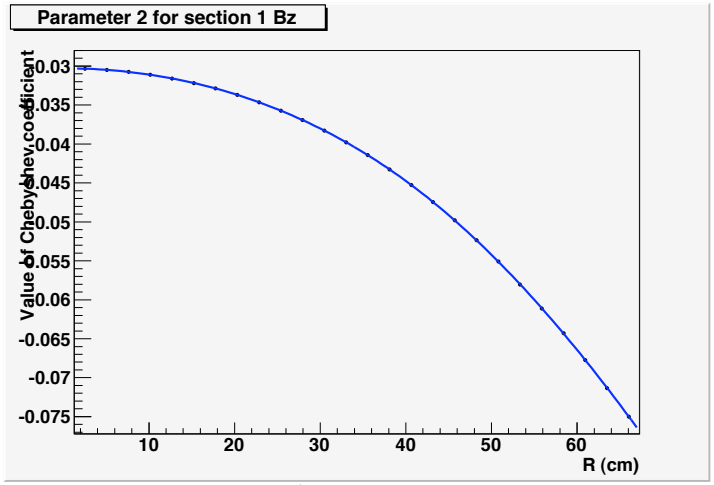


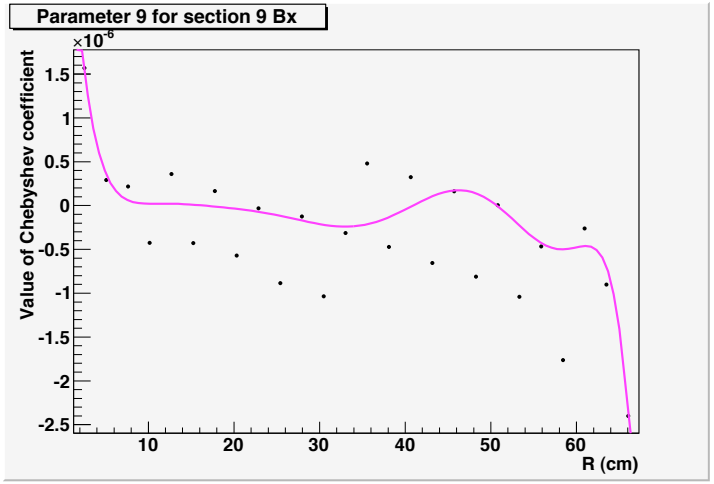


R- dependence

Coefficients from fits at various values of R were fit as a function of R, also with 9th order Chebyshev polynomials. Here are 3 examples.



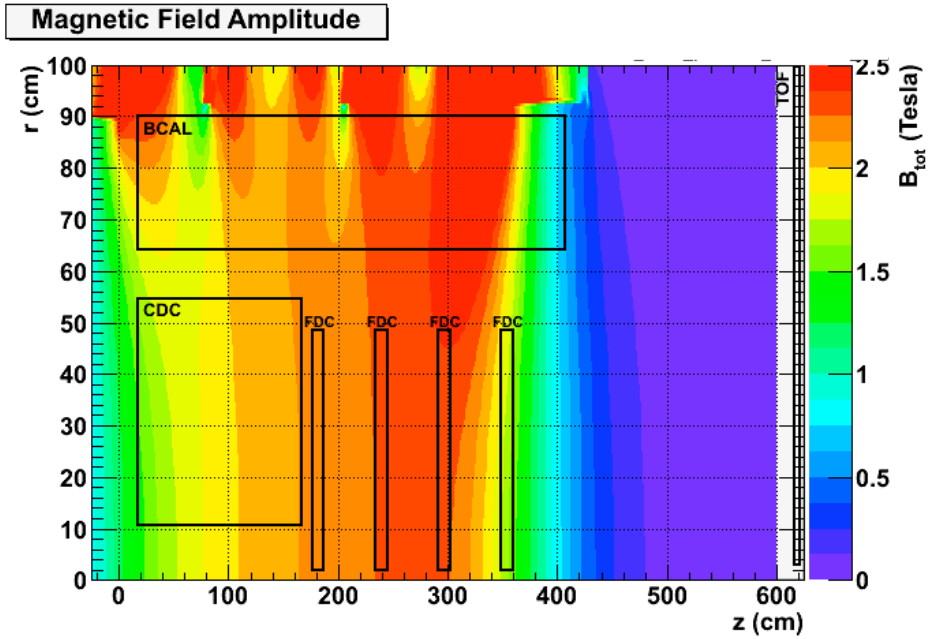




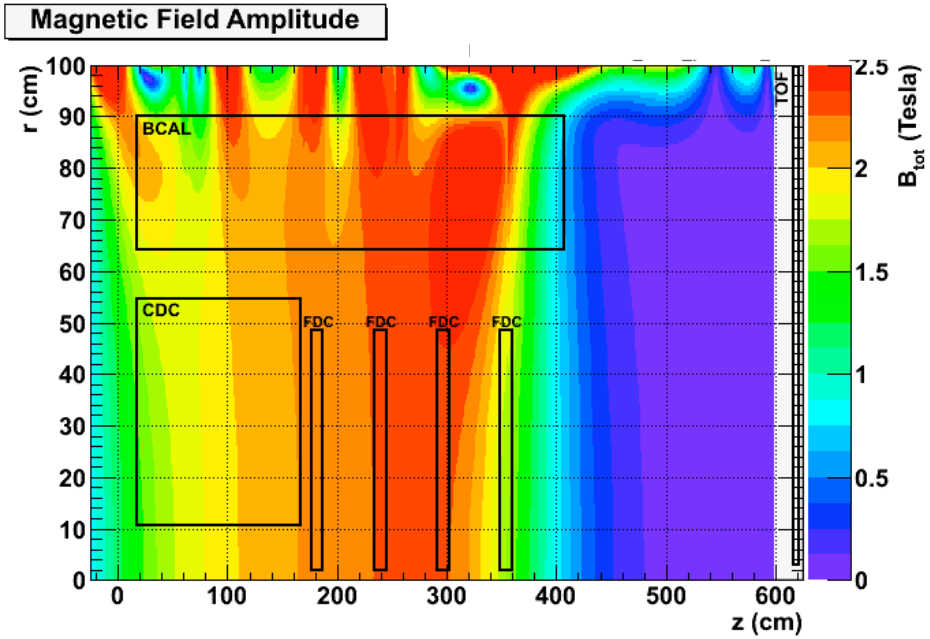
Some fits were not so good, but these tended to be for coefficients to higher order polynomials with small values.

Magnitude of B-field

Map

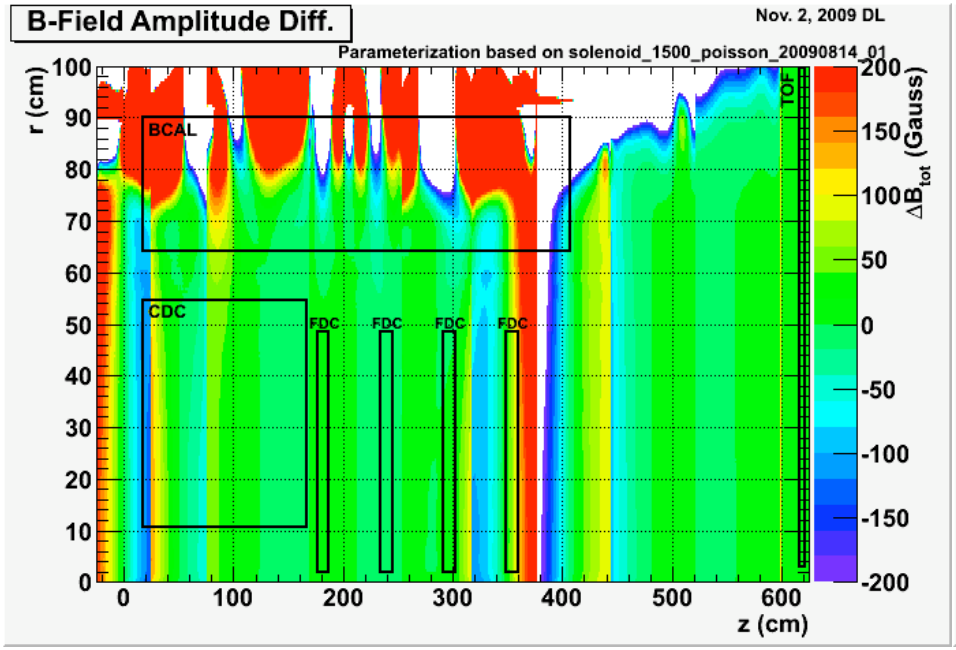


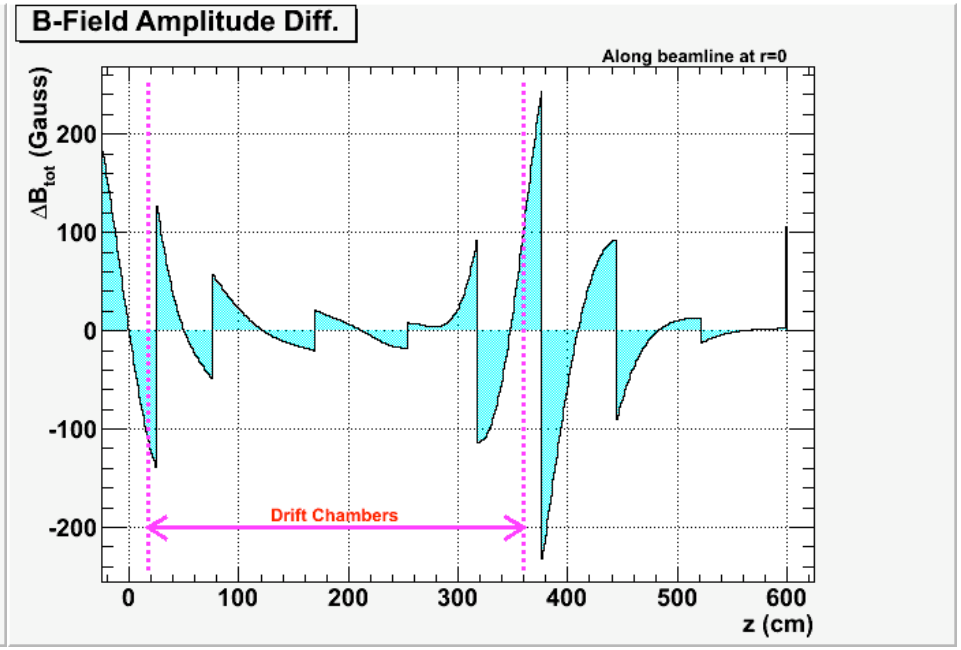
Parameters



General features in tracking area are well reproduced in active area of chambers.

Error in B-field magnitude





Throughout nearly the entire active area of the chambers the parameterized field is within 100 Gauss of the map.

However, there are no boundary conditions imposed on the sections so discontinuities exist.

Performance

	Instantiation	Instantiation +10M accesses	10M accesses	Total Memory
Map	10.6s	13.39s	2.79s	178M
Parameterized	0.57s	8.93s	8.36s	75M

Startup saves 10 seconds per invocation:

3people*5invocations/day * 5 days/week * 44 MW/yr * 5 yrs * 10 s/invocation = 45.8 mH

Or, approximately 1 manweek over next 5 years.

However, this is completely washed out by ***slower*** access time…

Each order N Chebyshev polynomial requires N operations
A sum of 9 of them requires 9+8+7… = 45 operations (+ 9 for coeff. mult.)

To evaluate second level (for r-dimension) is then
54*9 + 9 = 495 double precision, floating point operations

Summary

- The nominal 2-D GlueX solenoid B-field has been parameterized using Chebyshev polynomials.
- Parameters and source are all in repository
- Not ready for use since there is a significant performance hit when calculating field this way. (Also, gradient calculation not yet implemented).
- Perhaps NURBS? …