Status of HRSMC: the Geant4 Simulation Program for G2P&GEP Experiments

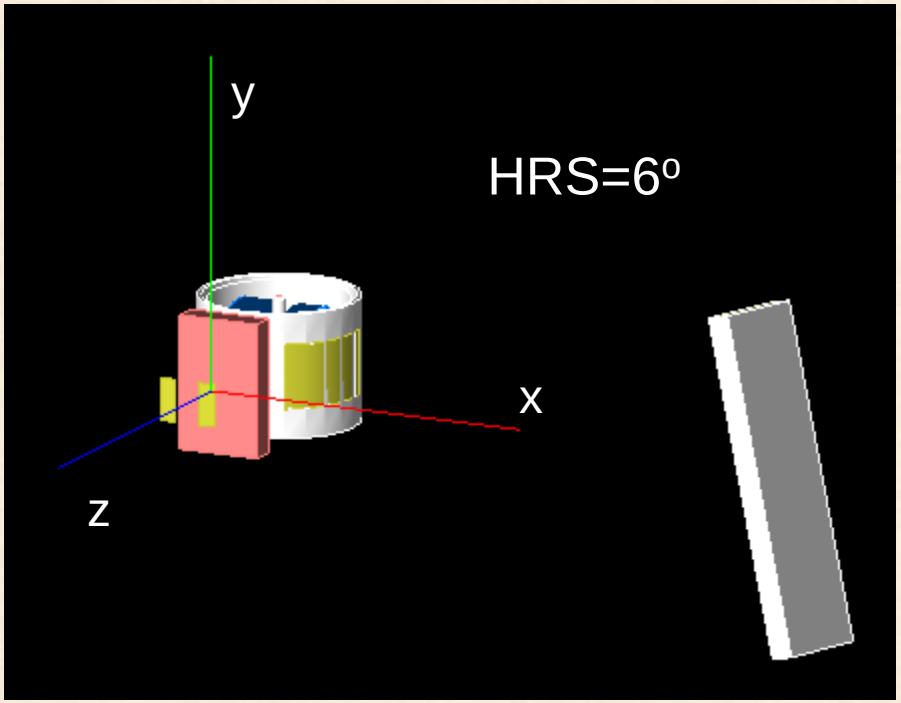
Jixie Zhang
Jefferson Lab

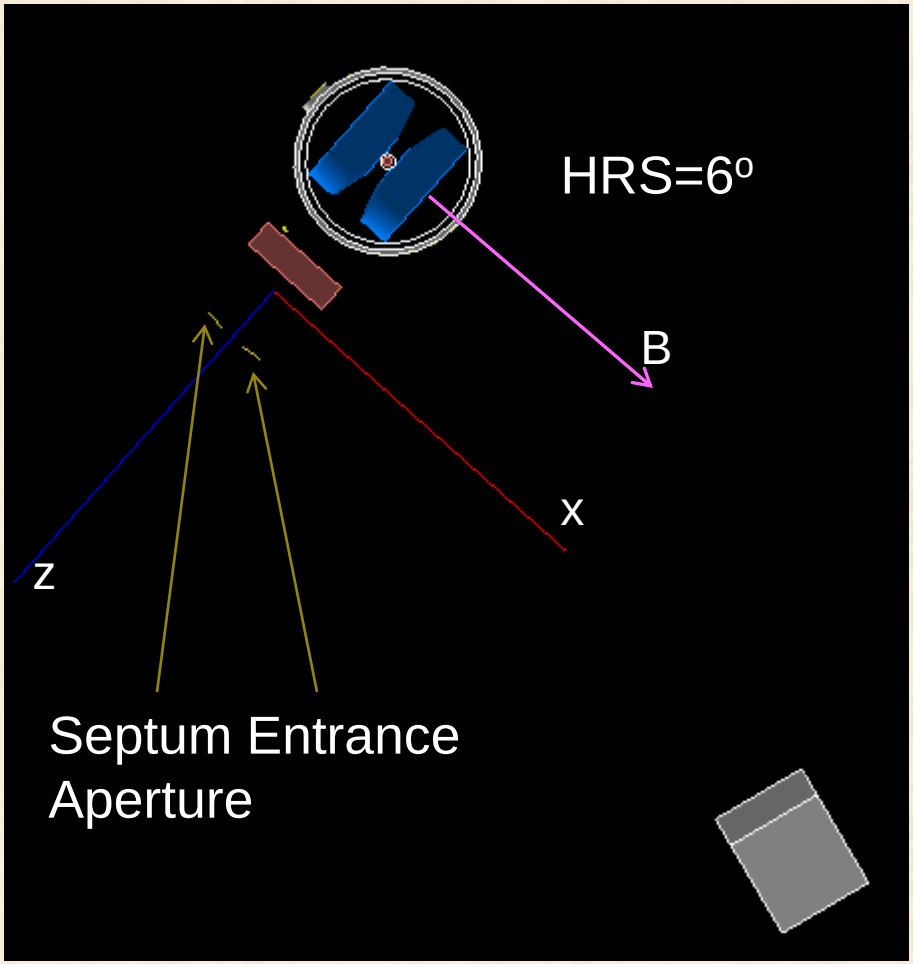
Apr 18th, 2011

Introuction

- Goals
  - Help to design detectors, such as the local beam dump, the seive slits, the 3rd arm...etc.
  - Study detector response
  - Study HRS optics and acceptance
  - interested physics process
- Strategy: Geant4 + Parameterized SNAKE Model
  - One single program linked against multi-language: Geant4 + Parameterized SNAKE model, support both Fortran and C++. Parameterized SNAKE model came from SANKE+MUDIFI (Check Min Huang's talk for details).
  - Use Geant4 to simulate the physics processes of the particle till it goes into a virtual boundary, which is the septum entrance aperture for 6 degrees setting or the Q1 entrance apertrue for the 12.5 degrees setting.
  - Then use the forword routines of the SNAKE model to propogate it to the focus plane. Cuts will be applied to ensure particle getting through all apertures along the HRS tunnel.
  - Reconstruct the particle from the focus pane back to the target plane using the inverse routines of the SNAKE model

Detector Geometries: 3 Settings



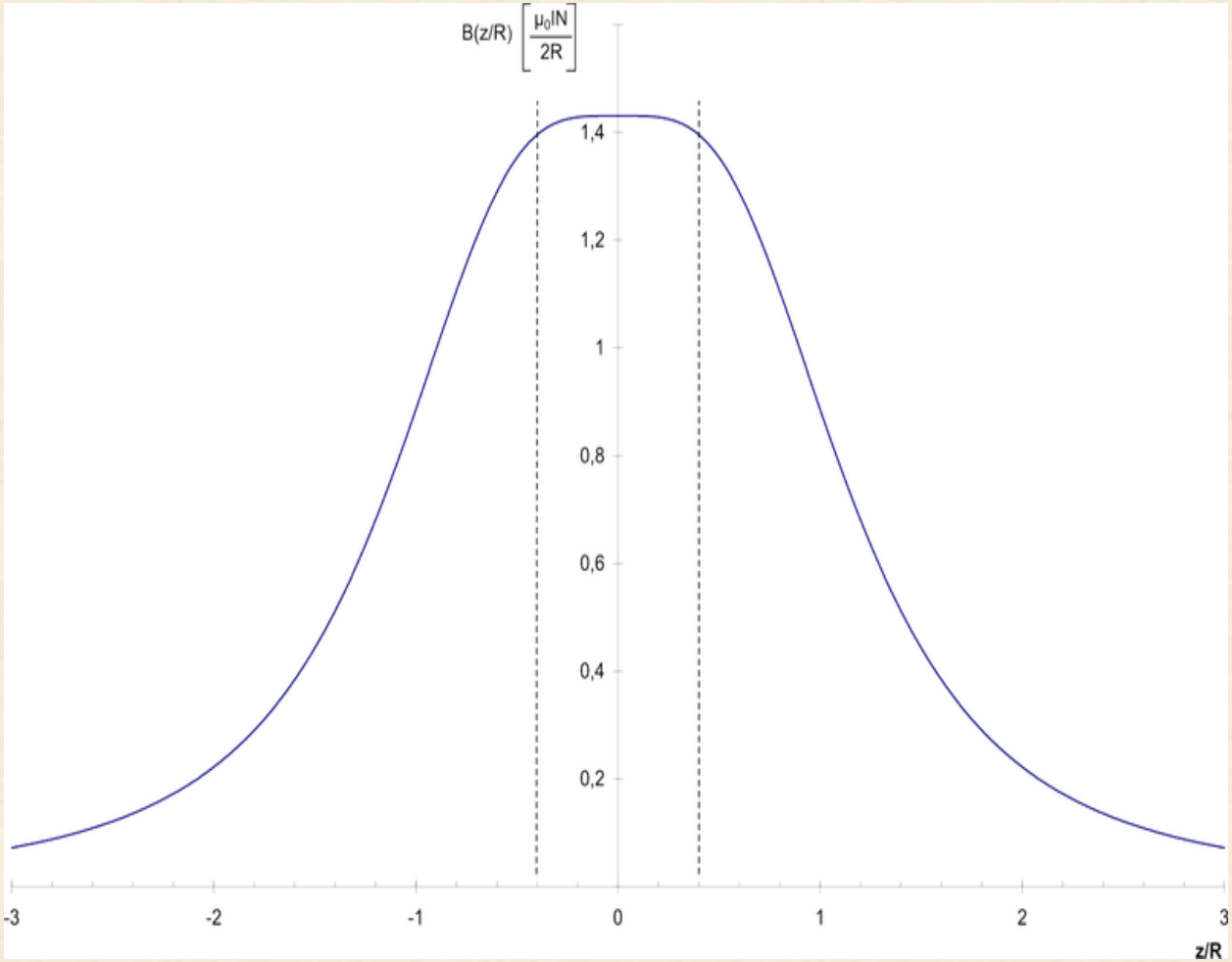


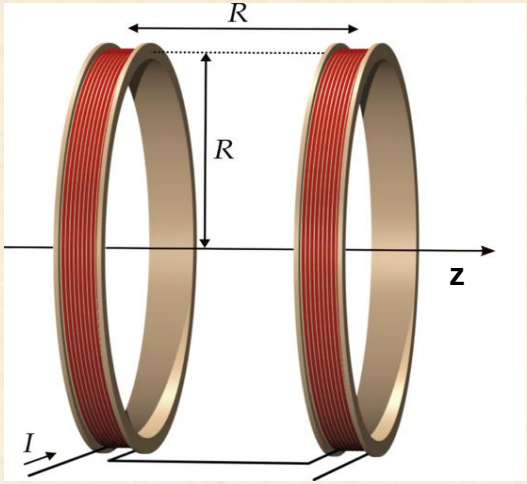
G2P Transverse: Target field goes along x

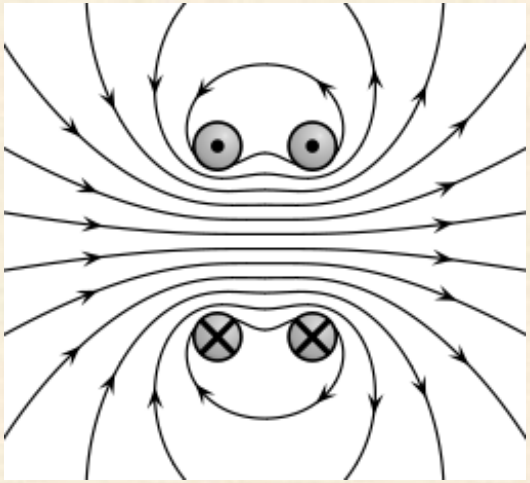
G2P Longitude: Target field goes along z

GEP:Target field goes along a line in x-z plane with θ=20º

The Field from the Helmholtz Coils

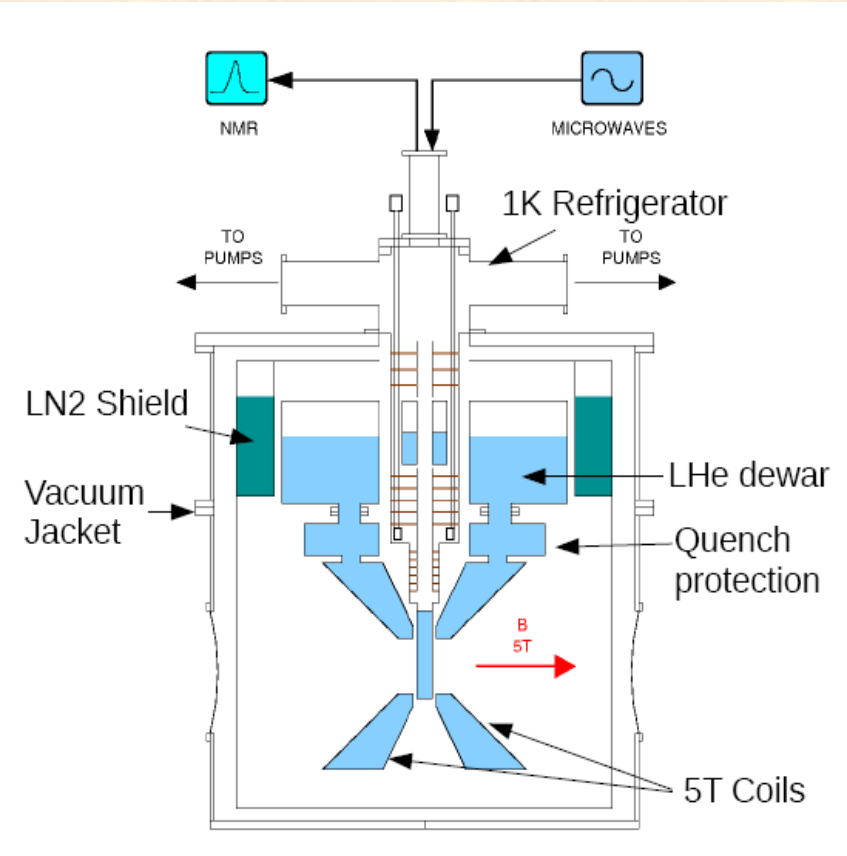




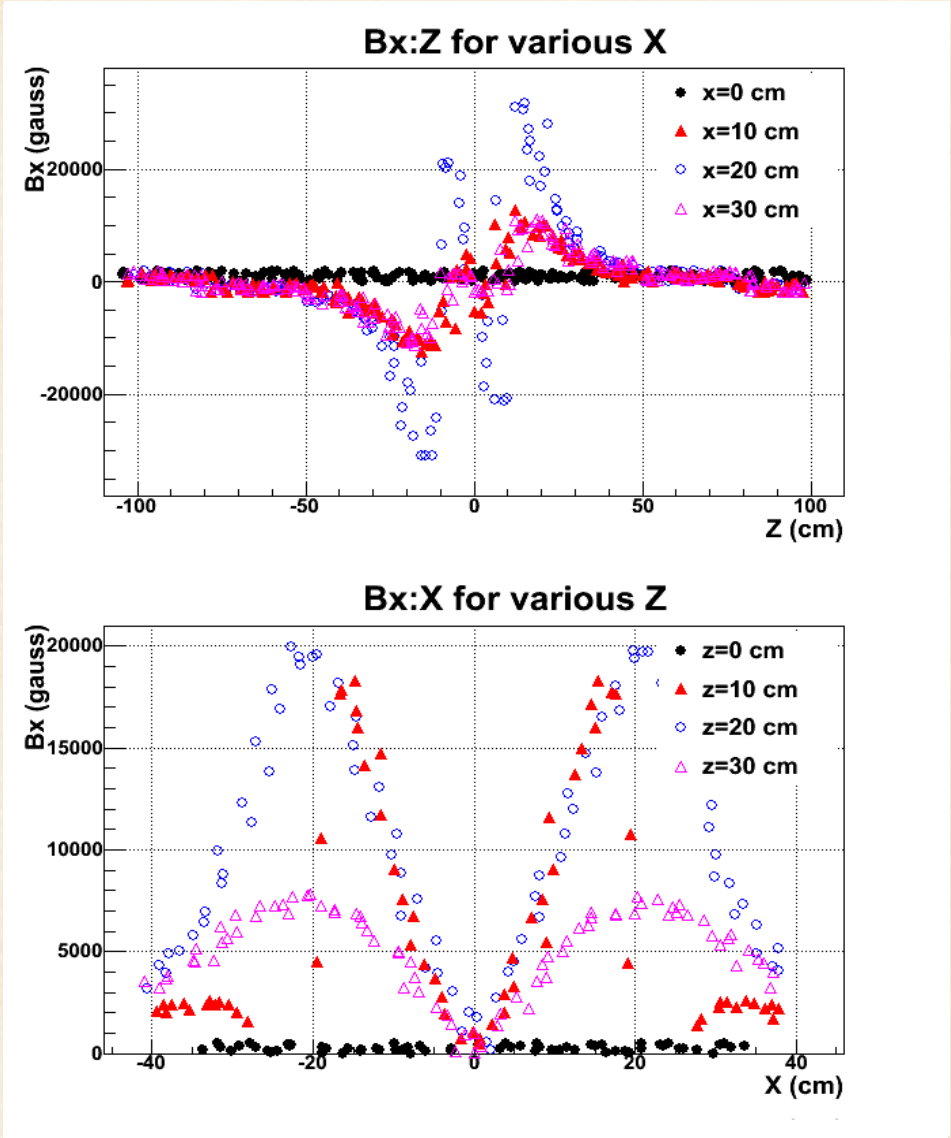


The uniform field regeon locates only at range of +/- 0.1 R

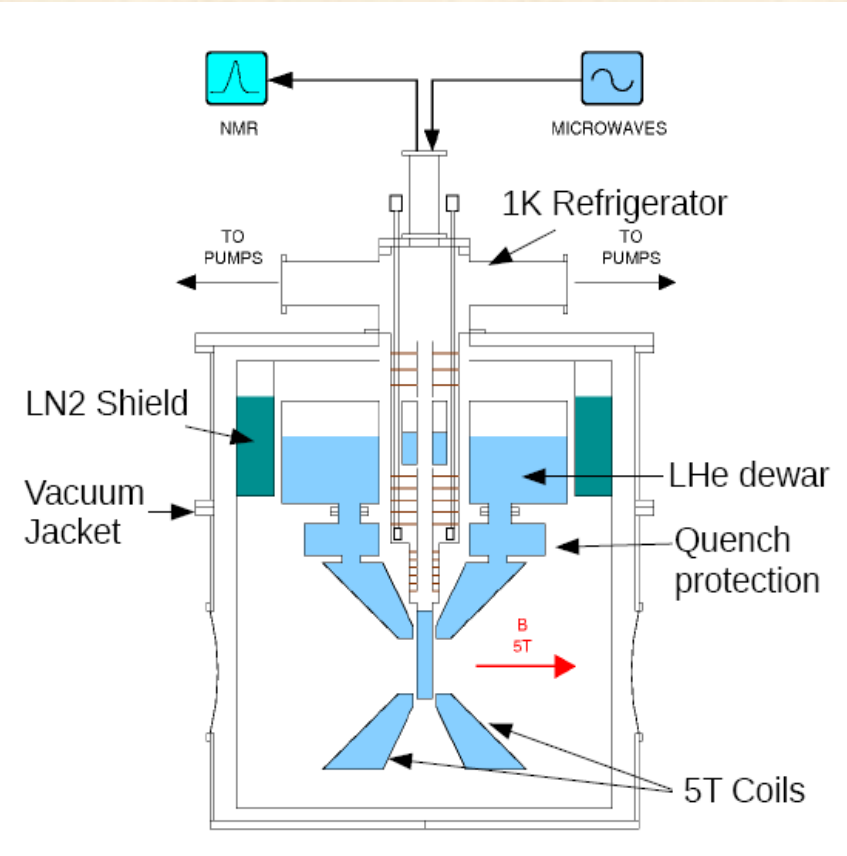
The G2P Helmholtz Coils

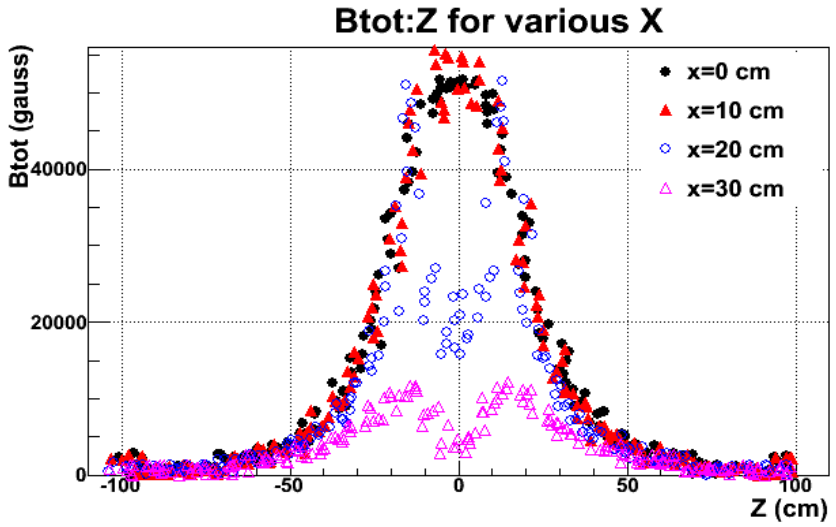


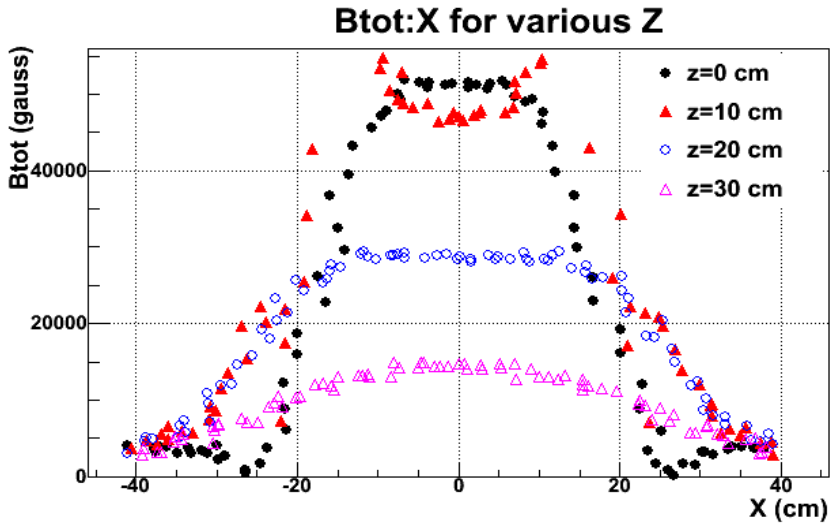
May also need to run at 50% of the total field



The G2P Helmholtz Coils

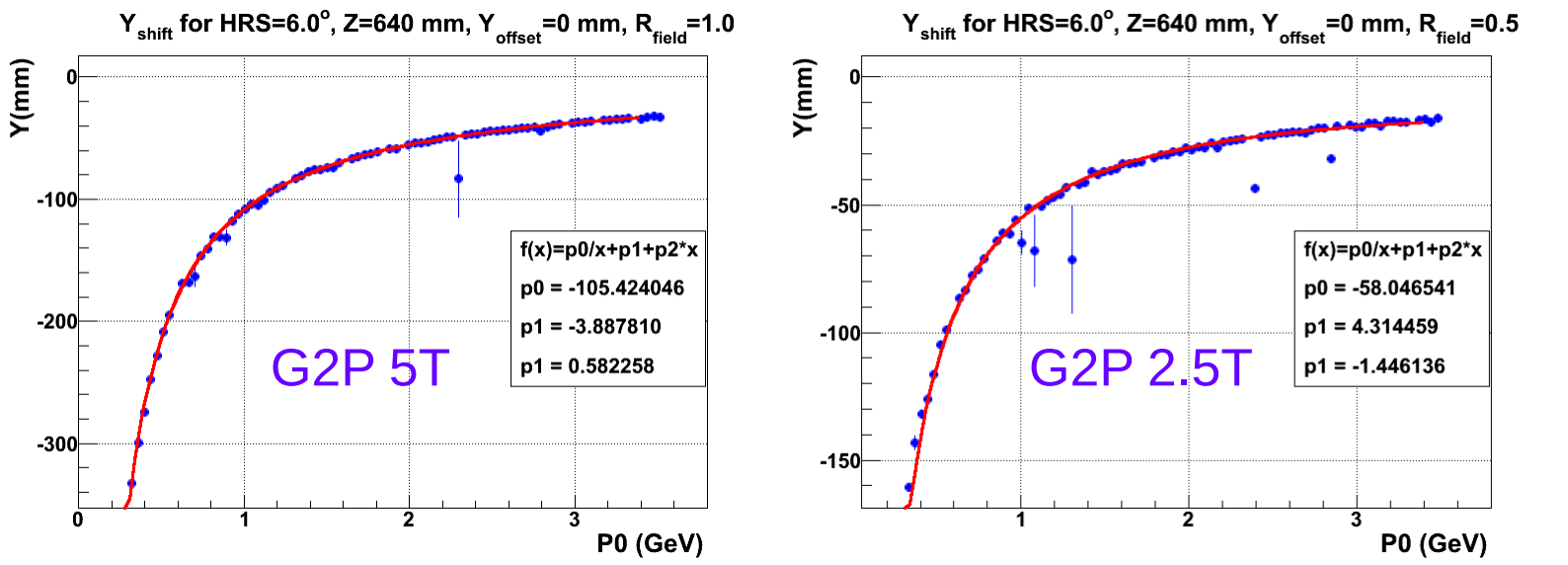






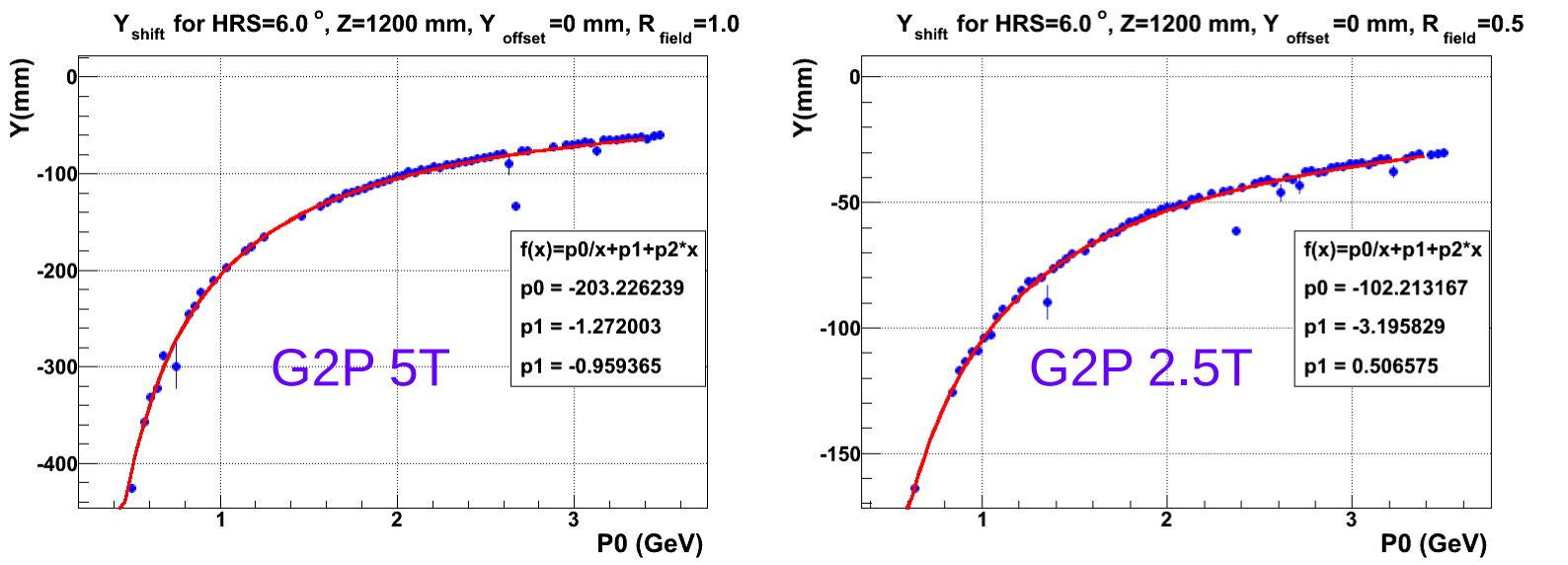
May also need to run at 50% of the total field

Beam Vertical Shift at the Beam Dump



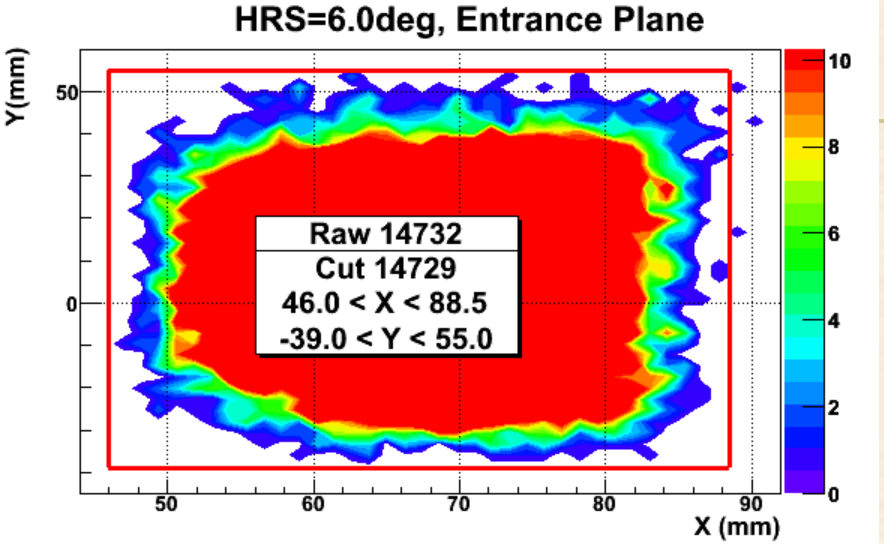
Electron beam always starts from the target origin and goes along z axis

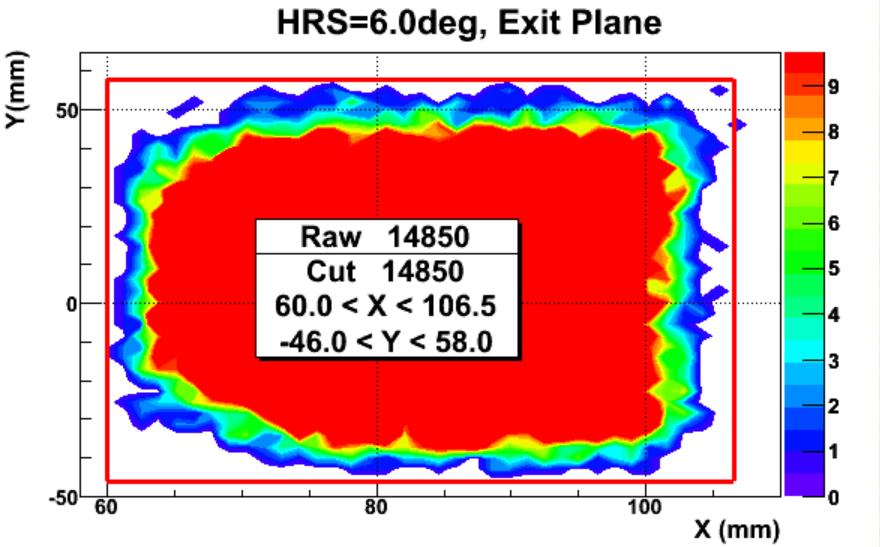
Vertical Shift at the Septum Entrance

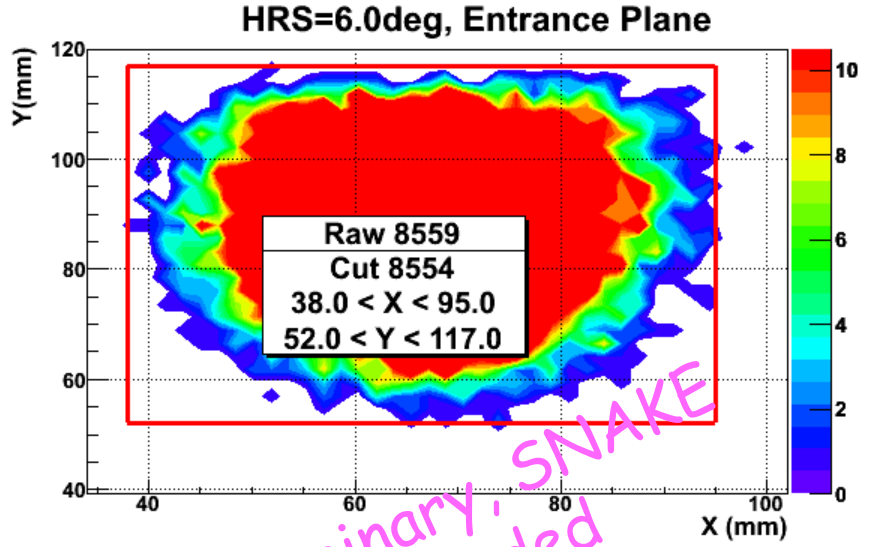


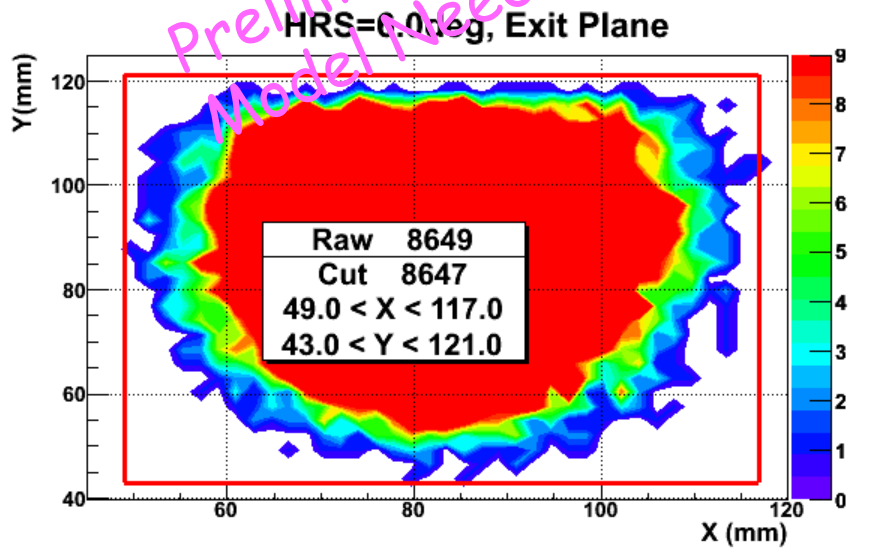
Electron starts from the target origin and goes horizontally along $\theta=6^{o}$

Local Beam Dump Openning







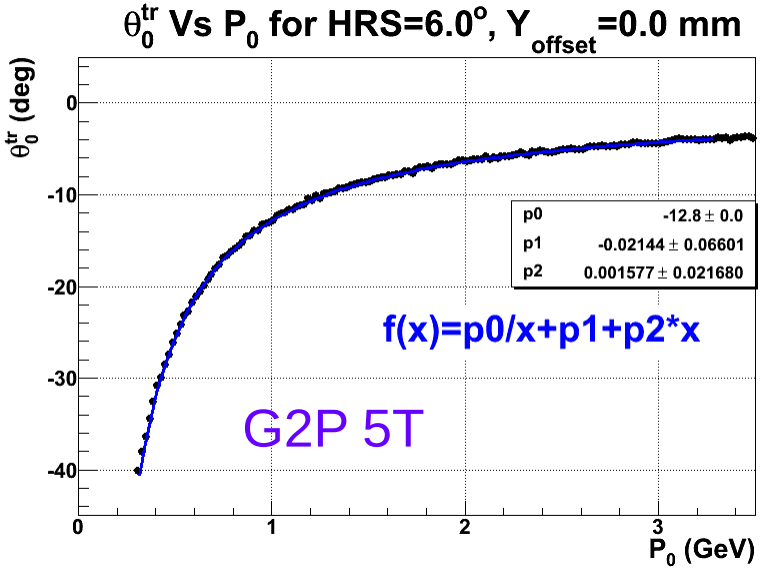


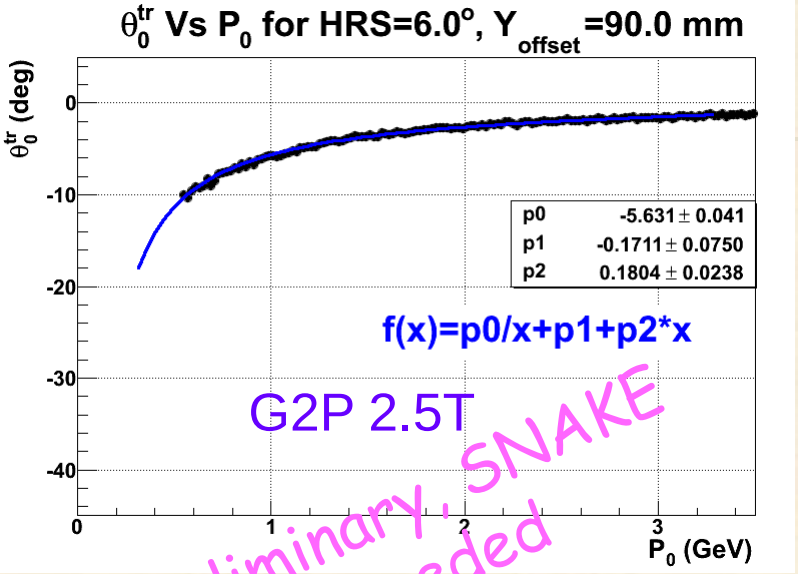
Preliminary, SNAKE Model Needed

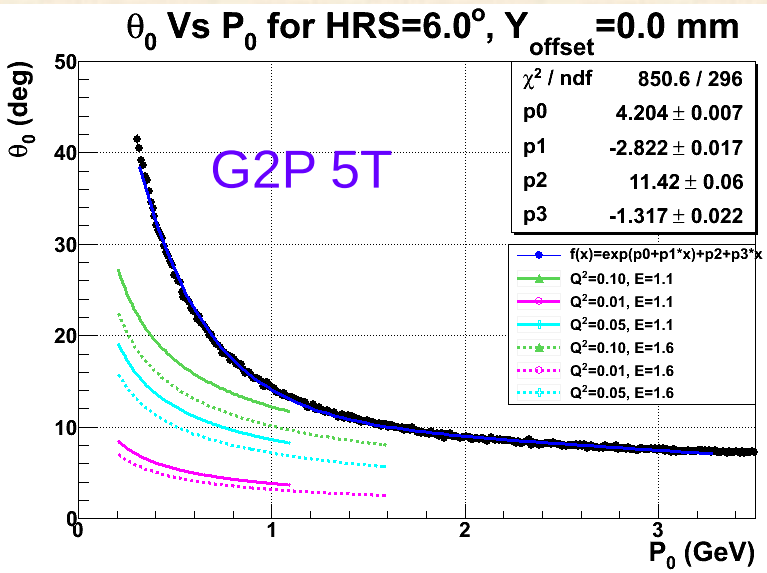
G2P 5T, Y_{offset}= 0 cm

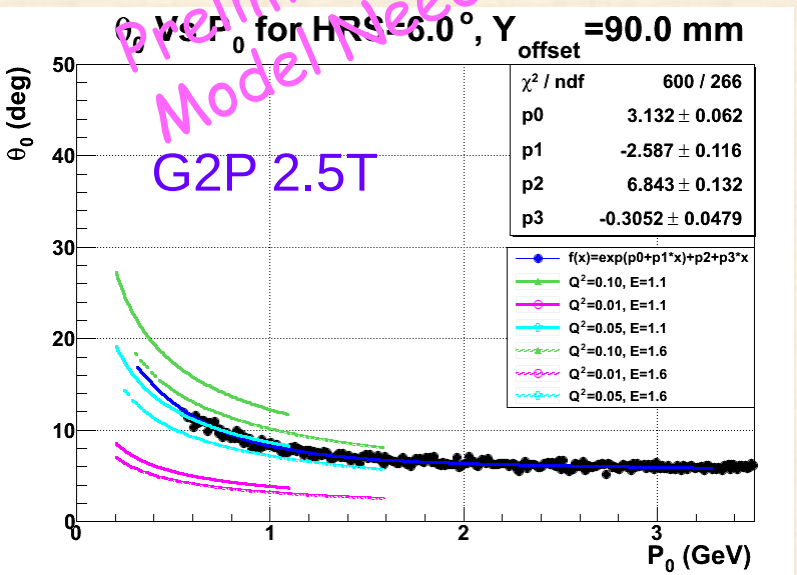
G2P 2.5T, Y_{offset} = 9 cm

Vertical Angle Shift

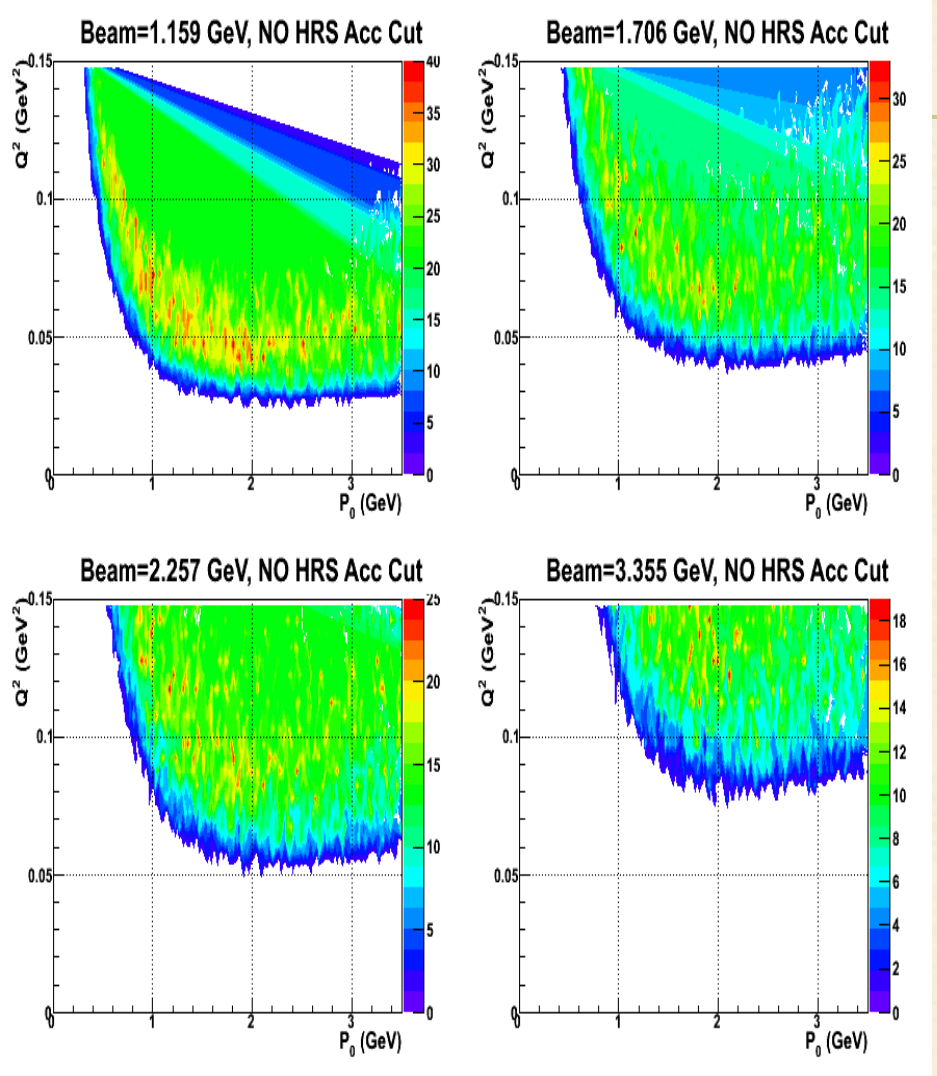




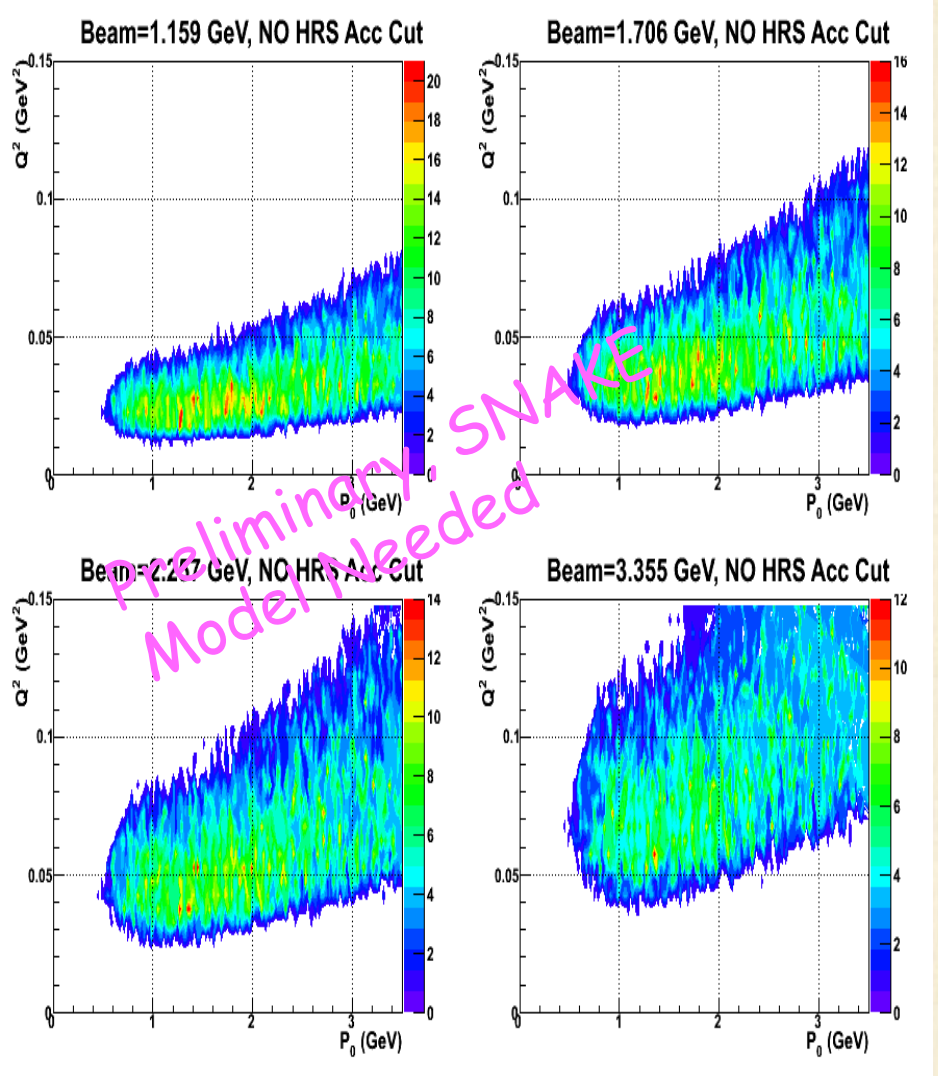




Q^2 Coverage



G2P 5T, Y_{offset}= 0 cm



G2P 2.5T, Y_{offset} = 9 cm

G2P Elastic Rates

20110405, HRSMC v0.93

Y=0cm B=5T

Tg	Beam	HRS	<Theta>	<E`>	<XS>(ub)	Lumi(10^33)	Acc(msr)	Rate(Hz)	Minute(100k)
C12	1.100	6.00	13.24	1.0971	54.84	18.02	3.0	2964.42	0.562
C12	1.600	6.00	10.13	1.5964	48.61	18.02	3.0	2627.96	0.634
C12	2.200	6.00	8.50	2.1952	18.18	18.02	3.0	982.86	1.696
C12	3.300	6.00	7.31	3.2919	0.62	18.02	3.0	33.68	49.483
H	1.100	6.00	13.59	1.0646	19.56	7.23	3.0	424.25	3.929
H	1.600	6.00	10.31	1.5563	28.22	7.23	3.0	612.07	2.723
H	2.200	6.00	8.58	2.1427	29.66	7.23	3.0	643.39	2.590
H	3.300	6.00	7.38	3.2048	19.63	7.23	3.0	425.88	3.913

Tg	Beam	HRS	<Theta>	<E`>	<XS>(ub)	Lumi(10^33)	Acc(msr)	Rate(Hz)	Minute(100k)
C12	1.100	12.50	16.96	1.0953	1.94	18.02	6.0	209.45	7.958
C12	1.600	12.50	14.86	1.5923	0.05	18.02	6.0	5.63	296.272
C12	2.200	12.50	13.87	2.1874	0.02	18.02	6.0	2.50	665.744
C12	3.300	12.50	13.22	3.2742	0.00	18.02	6.0	0.00	455388.393
H	1.100	12.50	17.48	1.0430	5.77	7.23	6.0	250.16	6.662
H	1.600	12.50	15.16	1.5098	3.89	7.23	6.0	168.83	9.872
H	2.200	12.50	14.08	2.0543	2.00	7.23	6.0	86.74	19.215
H	3.300	12.50	13.39	3.0109	0.54	7.23	6.0	23.39	71.267

Y=9cm B=2.5

Tg	Beam	HRS	<Theta>	<E`>	<XS>(ub)	Lumi(10^33)	Acc(msr)	Rate(Hz)	Minute(100k)
C12	1.100	6.00	9.85	1.0984	469.49	18.02	3.0	25380.66	0.066
C12	1.600	6.00	7.27	1.5982	662.81	18.02	3.0	35831.32	0.047
C12	2.200	6.00	6.54	2.1972	219.64	18.02	3.0	11873.91	0.140
C12	3.300	6.00	6.05	3.2945	10.51	18.02	3.0	568.21	2.933
H	1.100	6.00	9.80	1.0815	70.50	7.23	3.0	1529.24	1.090
H	1.600	6.00	7.34	1.5778	110.08	7.23	3.0	2387.54	0.698
H	2.200	6.00	6.52	2.1667	91.26	7.23	3.0	1979.41	0.842
H	3.300	6.00	6.16	3.2334	42.11	7.23	3.0	913.42	1.825

G2P 5T, Y_{offset}= 0 cm

G2P 2.5T, Y_{offset} = 9 cm

Preliminary, SNAKE Model Needed

GEP Elastic Rates

Target thickness = 100 mil
20110415 v0.94
Y=0cm B=5T GEP

Tg	Beam	HRS	<Theta>	<E`>	<XS>(ub)	Lumi(10^33)	Acc(msr)	Rate(Hz)	Minute(100k)
C12	1.100	6.00	9.96	1.0983	582.70	18.02	3.0	31500.49	0.053
C12	1.600	6.00	8.01	1.5977	426.02	18.02	3.0	23030.58	0.072
C12	2.200	6.00	7.25	2.1965	114.48	18.02	3.0	6188.96	0.269
C12	3.300	6.00	6.66	3.2933	3.24	18.02	3.0	175.10	9.518
H	1.100	6.00	10.13	1.0800	68.26	7.23	3.0	1480.64	1.126
H	1.600	6.00	8.06	1.5730	83.37	7.23	3.0	1808.24	0.922
H	2.200	6.00	7.27	2.1585	62.79	7.23	3.0	1361.85	1.224
H	3.300	6.00	6.68	3.2216	31.27	7.23	3.0	678.17	2.458

Y=9cm B=2.5T GEP

Tg	Beam	HRS	<Theta>	<E`>	<XS>(ub)	Lumi(10^33)	Acc(msr)	Rate(Hz)	Minute(100k)
C12	1.100	6.00	6.71	1.0993	6483.70	18.02	3.0	350508.58	0.005
C12	1.600	6.00	6.16	1.5987	2574.53	18.02	3.0	139179.21	0.012
C12	2.200	6.00	5.93	2.1976	612.33	18.02	3.0	33102.37	0.050
C12	3.300	6.00	5.81	3.2949	19.26	18.02	3.0	1041.14	1.601
H	1.100	6.00	6.73	1.0915	314.81	7.23	3.0	6828.28	0.244
H	1.600	6.00	6.17	1.5849	184.01	7.23	3.0	3991.22	0.418
H	2.200	6.00	5.94	2.1735	82.77	7.23	3.0	1795.26	0.928
H	3.300	6.00	5.82	3.2431	14.47	7.23	3.0	313.96	5.309

GEP 5T,
Y_{offset}= 0 cm

GEP 2.5T,
Y_{offset} = 9 cm

Preliminary, SNAKE Model Needed

Current Status

I. Version 0.94 released. A lot built-in event generator available. Source code and HOWTO document available through the svn:

   https://jlabsvn.jlab.org/svnroot/halla/groups/g2p/HRSMC

I. Target field and Septum field ready.

II. Scater Chamber Geometry ready, initial beam dump and the 3rd arm included. Keep updating with design.

III. Be able to run longitude, transverse and GEP setups according to input files.

IV. Still waiting for G2P and GEP SNAKE models. But the following SNAKE models included:

- Standard HRS transportation: good for HRS no smaller than 12.5^{o};
- E97110 SNAKE Model: good for 6^{o} HRS + Cold-Septum;
- PREx SNAKE Model: good for 5^{o} HRS + One-Coil-Septum;

V. Ready to study acceptance, elastic rates and optimize detectors. Can place a virtual detector anywhere according to the input files.

Outlooks

ToDo List:

- Background simulation, need inclusive cross section packages
- Event generator: QFS + EPC + P. Bosted's inclusive model
- Add G2P SNAKE Models, can add others per requested
- Add FAST option to speed up the program for the following cases:

  1) No secondary is required

  2) No big bite detector or no other detectors are placed farther than Q1

  3) Kill tracks if hit the coils or hit the scat chamber or the beam dump

  4) Place "black hole" (or dark matter) in places where there is no acceptance such that all tracks go into them will be killed

  5) Do not Setup some detectors if they are not needed for some specific cases

  6) Turn of the hit processing and the reconstruction if possible

- Design a Sensitive Detector template such that all hits will be written into the root ntuple automatically
- Add the real Bigbite detector, HAND and so on
- Add Q1, Q2, Dipole and Q3 fields. Need field maps and help (very low priority, still might happen if necessary)
- Reorganize the AnalysisManager
- Build a gui for visulization control

Student's Work

- Min Huang
  A. Working on SANKE+MUDIFI to get the HRS transportation package, later on will working on the Geant4 simulation
  B. Working on 3rd arm detector with Kalyan

- Peng-Jia Zhu
  A. Working on BCM|BPM and beam lines
  B. Working on target, would be one of the target experts
  C. Help a lot in prepare the experiment, will help in Geant4 simulation too if time alows

- Melissa
  Working on target and detectors
  .....