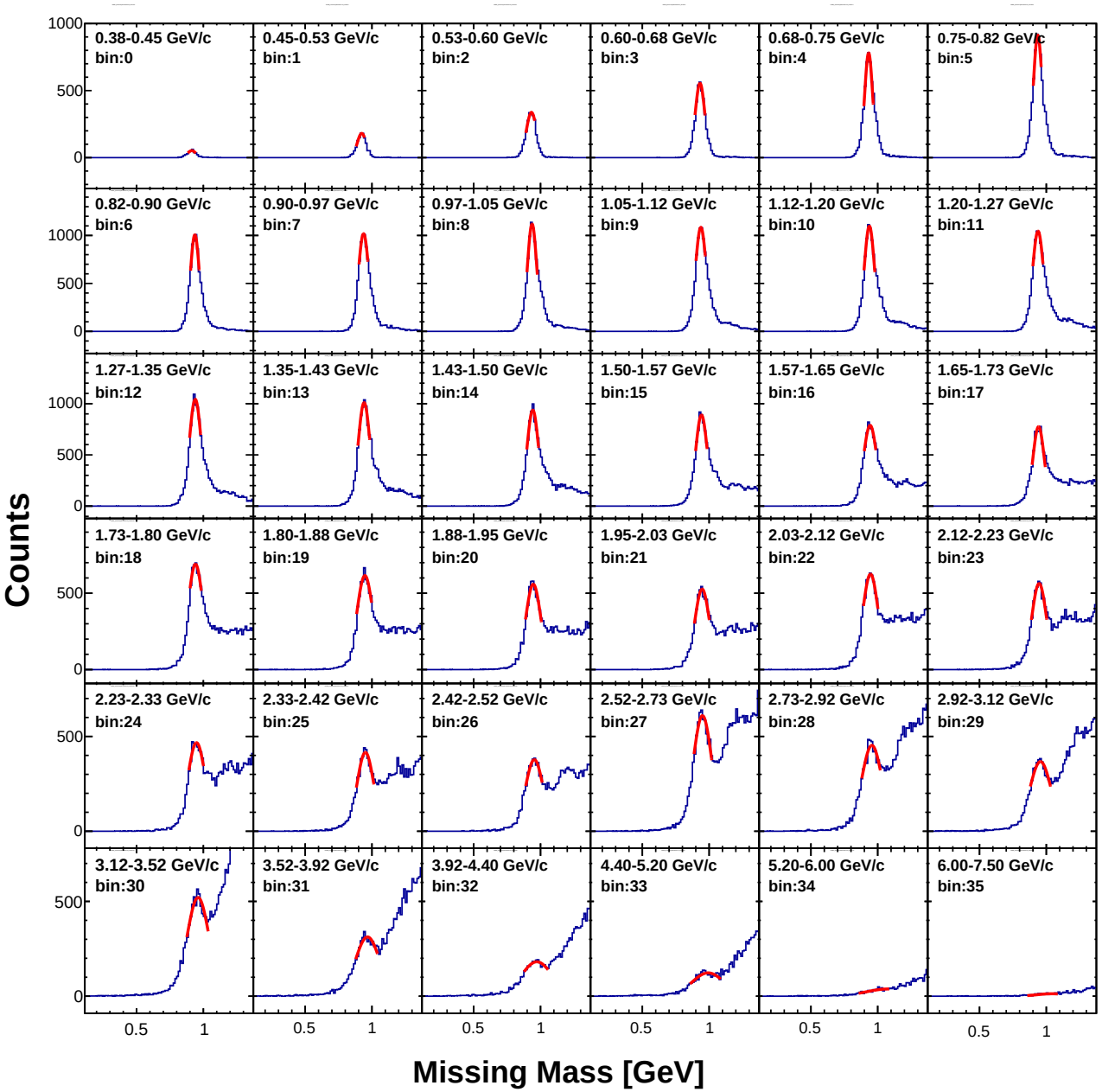
Measuring the Neutron Detection Efficiency (NDE) 1

1. Use the $^1\mathrm{H}(e, e'\pi^+)X_n$ reaction as a source of tagged neutrons.
2. Assume X_n is a neutron and swim the track to the calorimeters. If it strikes the fiducial region of the detector, then the event counts as 'expected'. If it misses the detector, drop the event.
3. In the region near the intersection of the neutral track with the calorimeter search for a neutral particle. If a neutral particle is found this is a tagged neutron candidate and the event is 'detected'.
4. Apply additional cuts to identify neutrons and seperate them from background.
5. The ratio of detected/expected neutrons is the NDE.

Fit the 'Cores' (Detected neutrons)



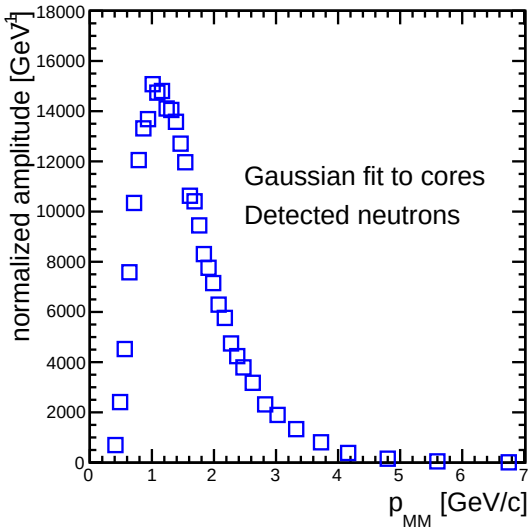
Data file:
data10p6nosidiscutv4.root

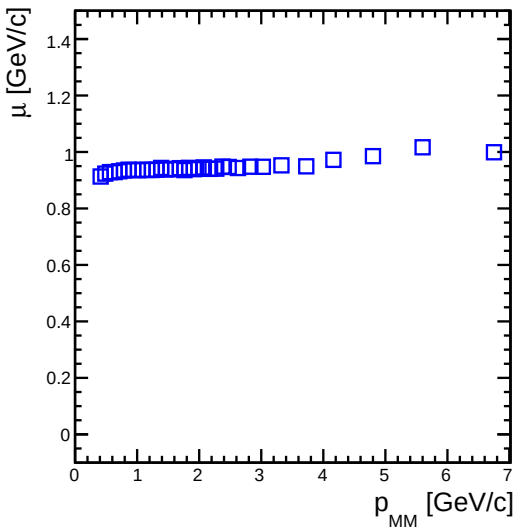
Histograms:
detMM_passdcxdcyMass2Rmincut_Pmmbin

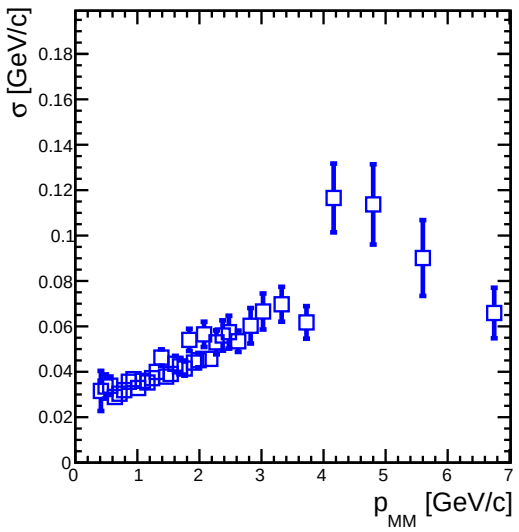
Start each fit at previous p_{mm} solution.

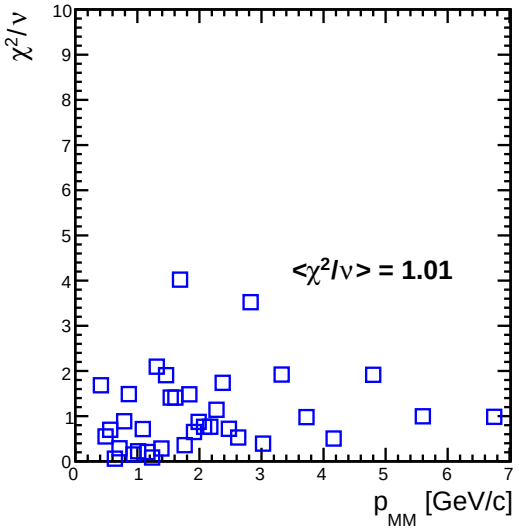
Fit the missing mass range $\mu \pm \sigma$ with a Gaussian.

Core Fit Results (Detected neutrons)

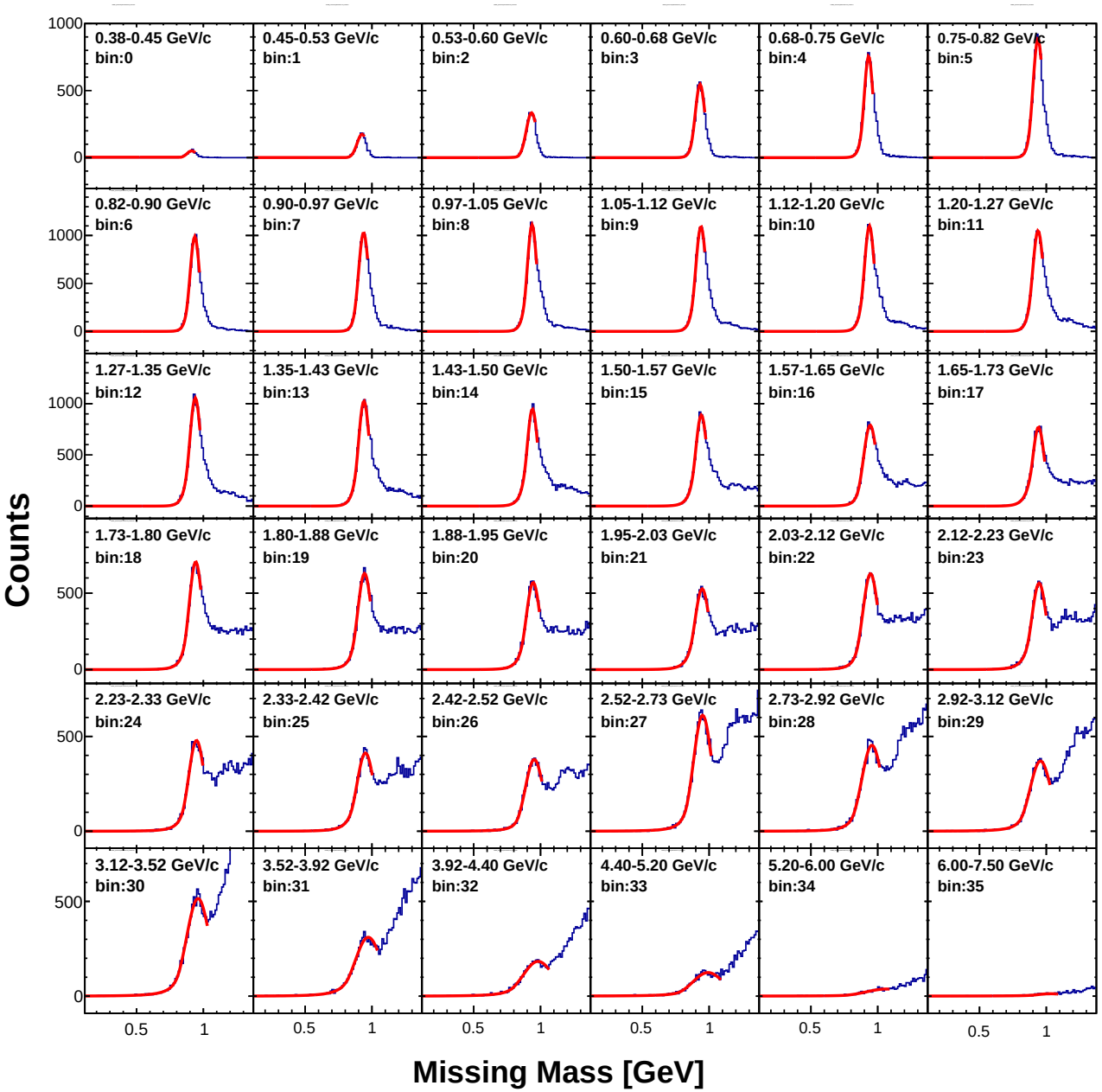








Fit Crystal Ball Function (Detected neutrons)



Data file:
data10p6nosidiscutv4.root

Histograms:
detMM_passdcxdcyMass2Rmincut_Pmmbin

Start each fit at previous p_{mm} solution.

Fit missing mass over $0 \rightarrow \mu + \sigma$ with the Crystal Ball function.

The Crystal Ball function is given by

$$f(x;\alpha,n,\overline{x},\sigma) = N\exp\left(-\frac{(x-\overline{x})^2}{2\sigma^2}\right), \qquad \text{for}\,\frac{x-\overline{x}}{\sigma} > -\alpha$$

$$= N\cdot A\cdot\left(B-\frac{x-\overline{x}}{\sigma}\right)^{-n}, \qquad \text{for}\,\frac{x-\overline{x}}{\sigma} < -\alpha$$

where

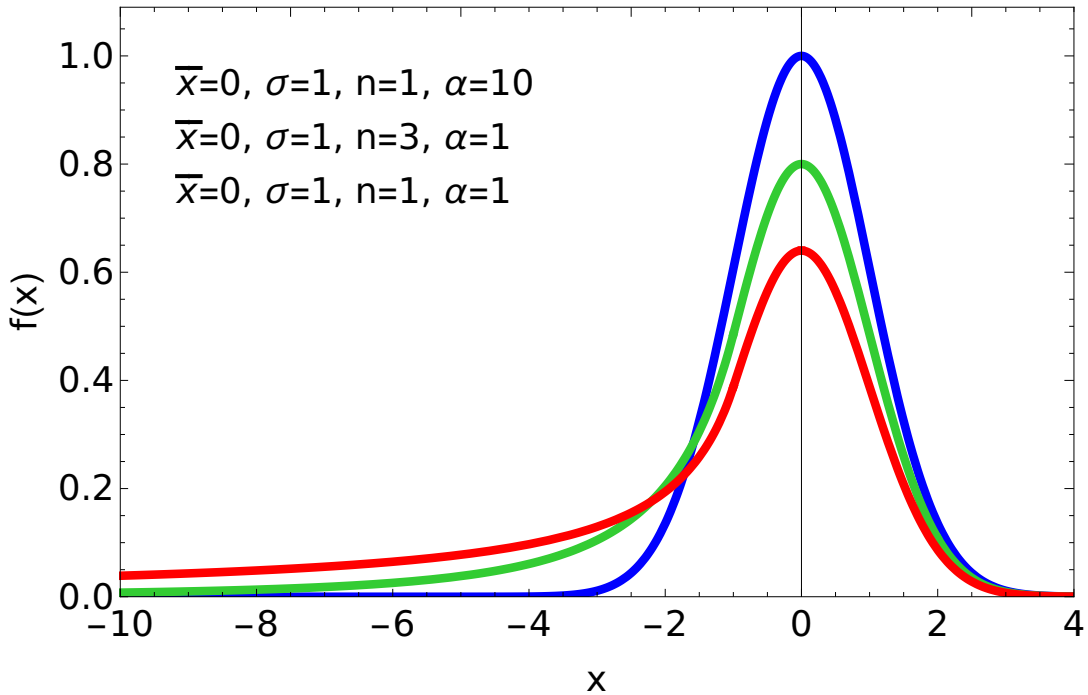
$$A = \left(\frac{n}{|\alpha|}\right)^n\cdot\exp\left(-\frac{|\alpha|^2}{2}\right),$$

$$B = \frac{n}{|\alpha|}-|\alpha|,$$

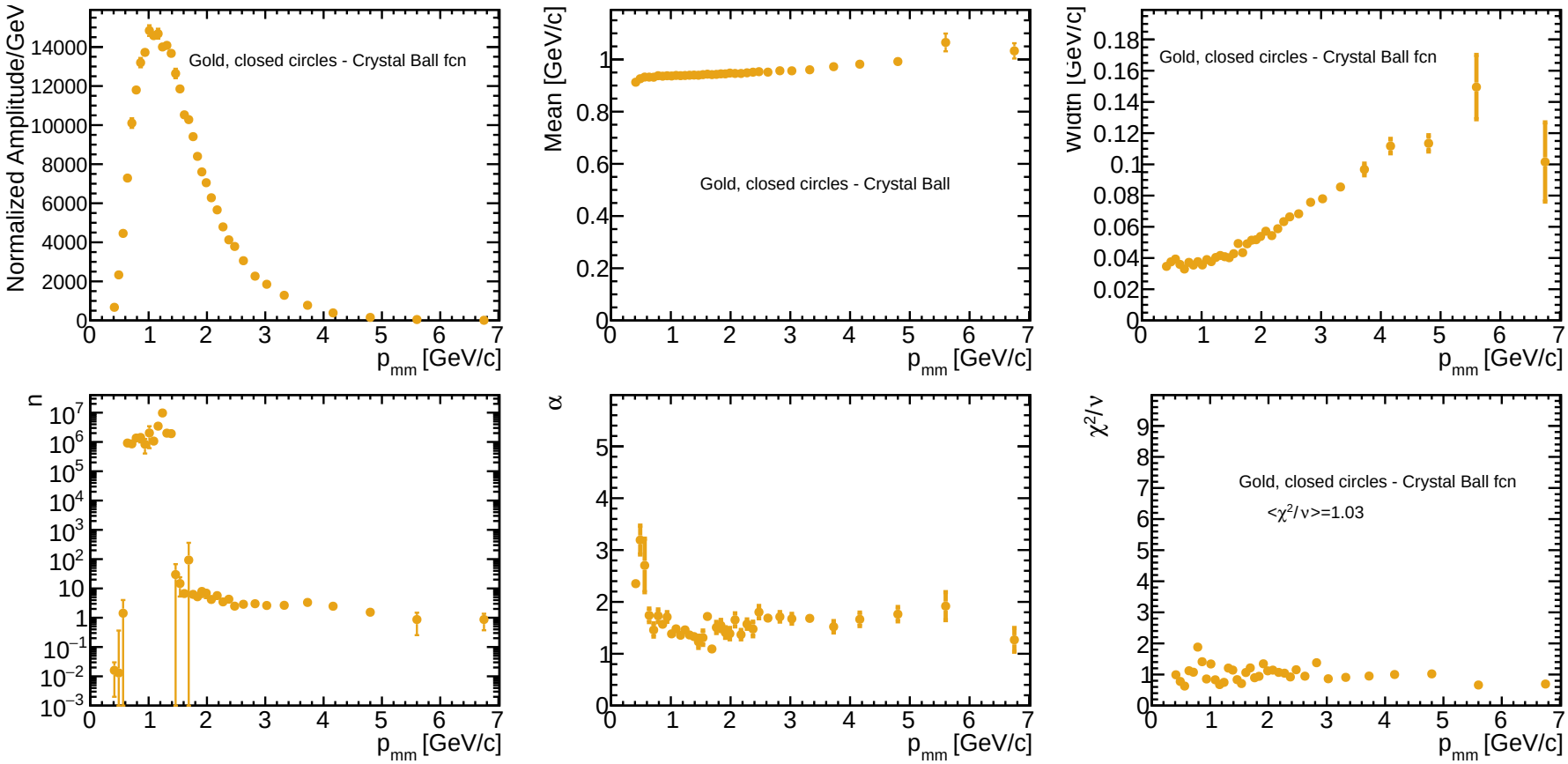
$$N = \frac{1}{\sigma(C+D)},$$

$$C = \frac{n}{|\alpha|}\cdot\frac{1}{n-1}\cdot\exp\left(-\frac{|\alpha|^2}{2}\right),$$

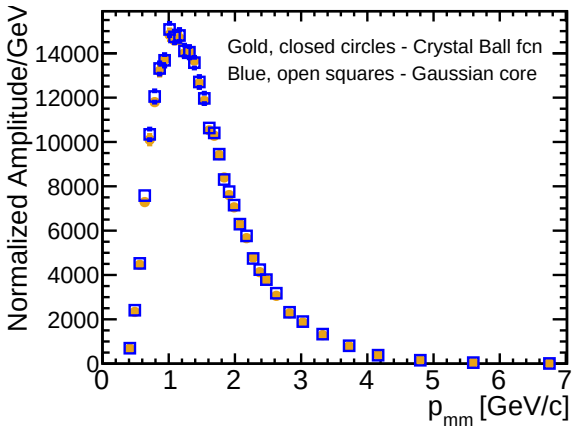
$$D = \sqrt{\frac{\pi}{2}}\left(1+\text{erf}\left(\frac{|\alpha|^2}{2}\right)\right)$$

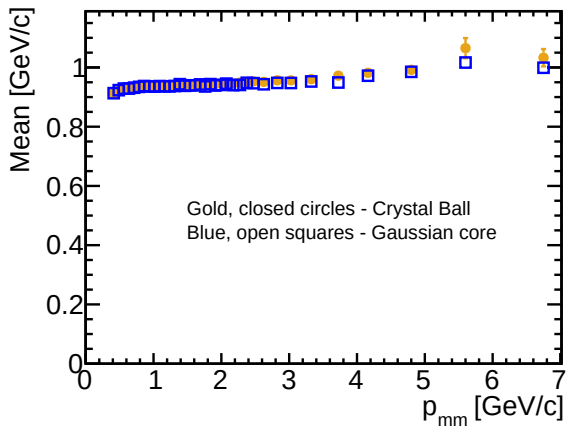


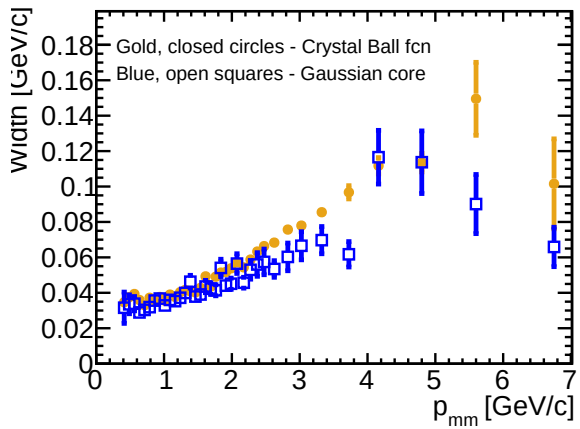
Crystal Ball Fit Parameters (Detected neutrons)

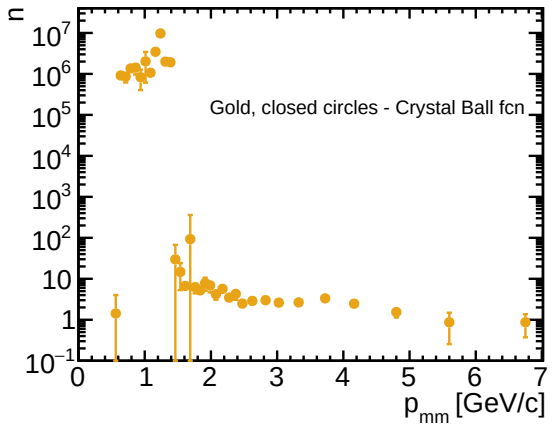


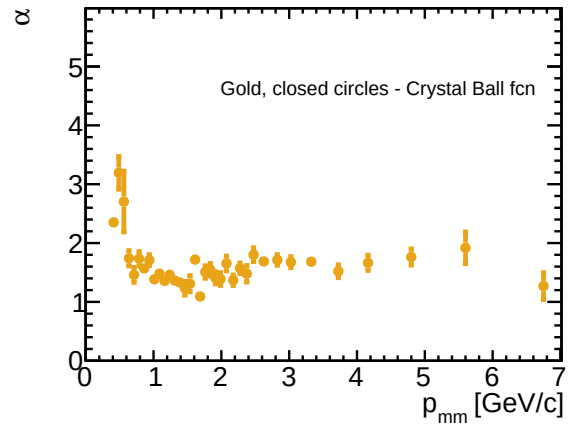
Compare LE+Core fit with Core only (Detected neutrons)7

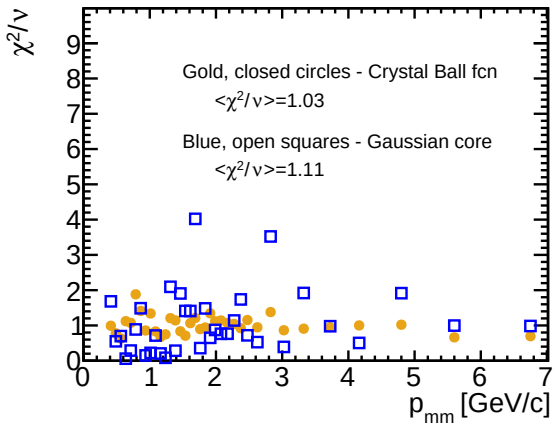












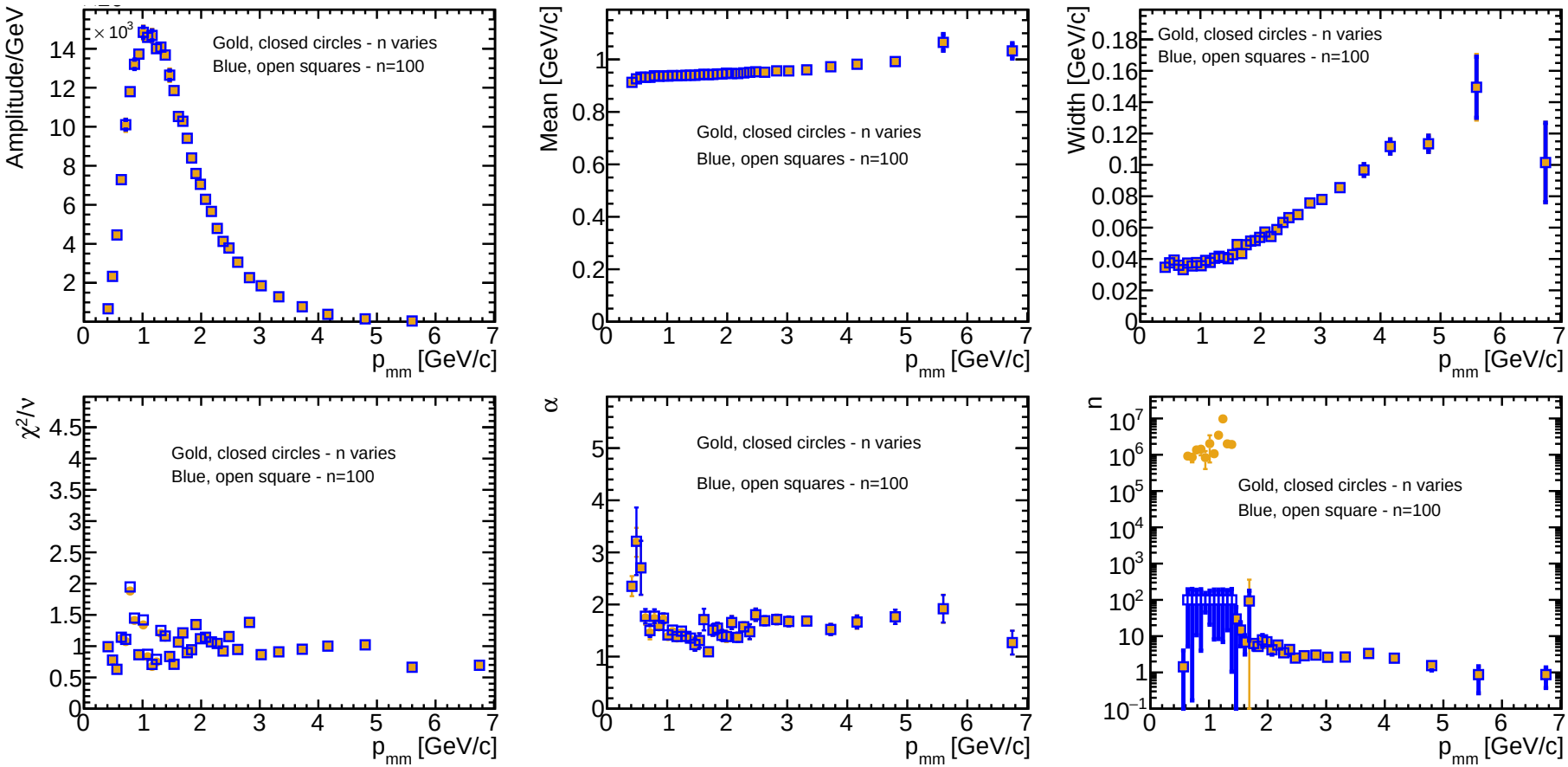
Weak Parameters in the Crystal Ball (Detected neutrons) 8

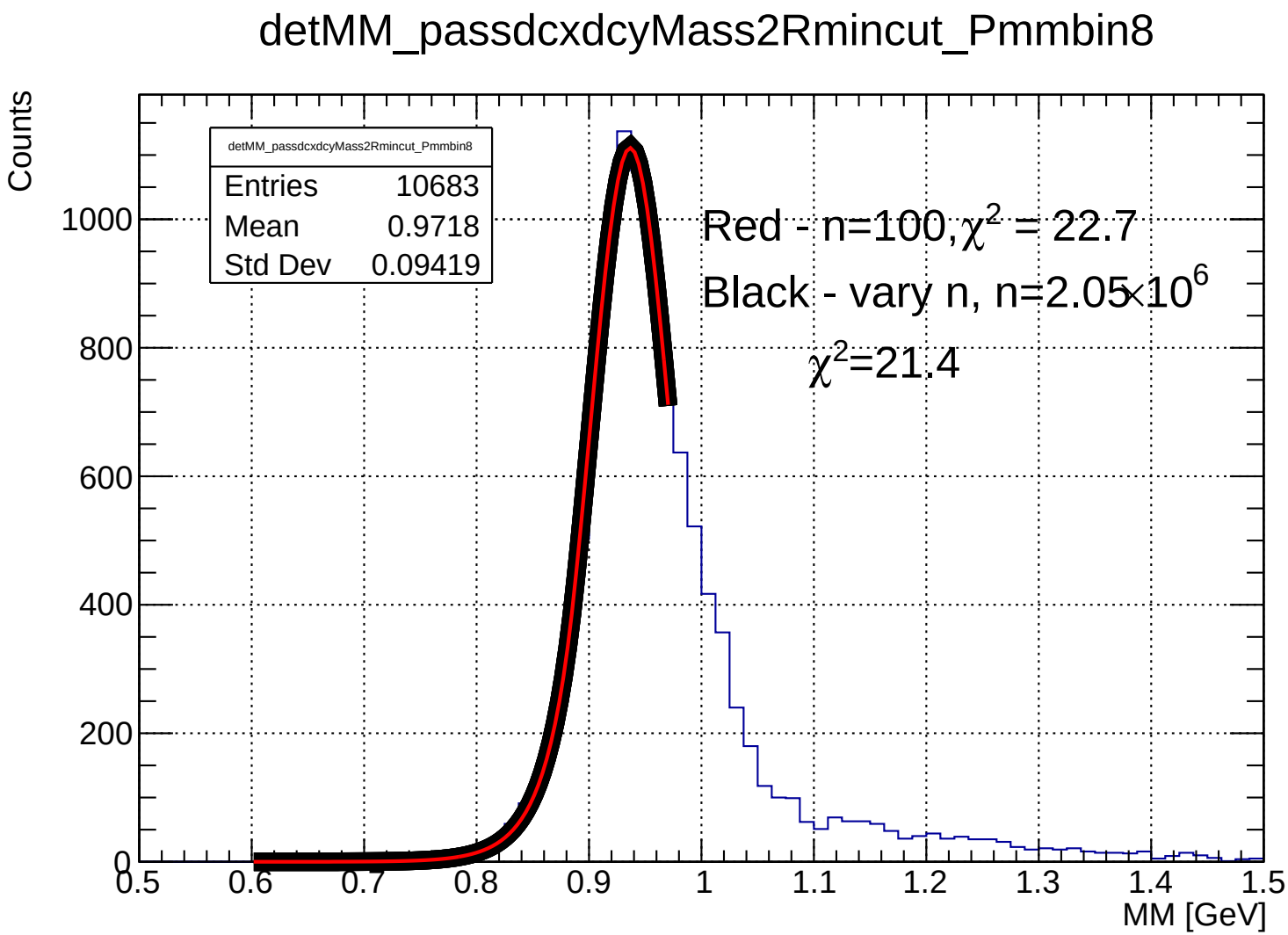
1. Table shows results of two CB-fit passes through the detected neutrons.
2. Right - all parameters free to vary. Left - constrain n.
3. Changes in reduced χ^2 are small.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	mylog14c	NDF	FCN	N		FCN/NDF		mylog14b	NDF	FCN	N		FCN/NDF
2		6	5.94902	5.50E-11		0.992			6	5.9498	3.64E-05		0.992
3		8	6.22077	8.22E-03		0.778			8	6.22077	1.30E-02		0.778
4		12	7.55283	1.43E+00		0.629			12	7.55283	1.43E+00		0.629
5		13	14.8548	1.00E+02		1.143			13	14.578	9.17E+05		1.121
6		11	12.1959	1.00E+02		1.109			11	11.8137	8.60E+05		1.074
7		13	25.3118	1.00E+02		1.947			13	24.4635	1.36E+06		1.882
8		16	23.1791	1.00E+02		1.449			16	22.5901	1.42E+06		1.412
9		17	14.6719	1.00E+02		0.863			17	14.5723	8.33E+05		0.857
10		16	22.7083	1.00E+02		1.419			16	21.4336	2.03E+06		1.340
11		18	15.6494	1.00E+02		0.869			18	14.9514	1.07E+06		0.831
12		22	15.5754	1.00E+02		0.708			22	14.873	3.47E+06		0.676
13		16	12.6243	1.00E+02		0.789			16	11.9618	9.75E+06		0.748
14		21	26.2613	1.00E+02		1.251			21	25.3512	2.00E+06		1.207
15		21	24.3957	1.00E+02		1.162			21	24.0063	1.92E+06		1.143
16		24	20.0389	2.98E+01		0.835			24	20.0389	2.98E+01		0.835
17		24	17.0437	1.47E+01		0.710			24	17.0437	1.47E+01		0.710
18		35	37.2838	6.86E+00		1.065			35	37.2858	6.69E+00		1.065
19		29	35.168	9.31E+01		1.213			29	35.168	9.30E+01		1.213
20		28	25.0977	6.27E+00		0.896			28	25.0977	6.27E+00		0.896
21		36	33.9184	5.21E+00		0.942			36	33.9184	5.21E+00		0.942
22		33	44.385	7.89E+00		1.345			33	44.385	7.89E+00		1.345
23		33	36.9161	6.91E+00		1.119			33	36.9161	6.91E+00		1.119
24		40	45.6839	4.20E+00		1.142			40	45.6839	4.20E+00		1.142
25		41	43.8068	5.69E+00		1.068			41	43.8068	5.69E+00		1.068
26		40	41.7199	3.48E+00		1.043			40	41.7199	3.48E+00		1.043
27		43	39.6484	4.28E+00		0.922			43	39.6484	4.28E+00		0.922
28		38	43.8506	2.49E+00		1.154			38	43.8506	2.49E+00		1.154
29		48	45.4617	2.88E+00		0.947			48	45.4617	2.88E+00		0.947
30		53	73.1246	3.01E+00		1.380			53	73.1246	3.01E+00		1.380
31		55	47.524	2.62E+00		0.864			55	47.524	2.62E+00		0.864
32		64	58.1676	2.65E+00		0.909			64	58.1676	2.65E+00		0.909
33		63	59.8998	3.33E+00		0.951			63	59.8998	3.33E+00		0.951
34		62	62.0625	2.47E+00		1.001			62	62.0625	2.47E+00		1.001
35		63	64.3042	1.54E+00		1.021			63	64.3042	1.54E+00		1.021
36		52	34.4725	8.69E-01		0.663			52	34.4725	8.69E-01		0.663
37		41	28.4802	8.71E-01		0.695			41	28.4802	8.71E-01		0.695
38													
39					AVE	1.028						AVE	1.016
40													
41					AVE2	1.155						AVE2	1.117

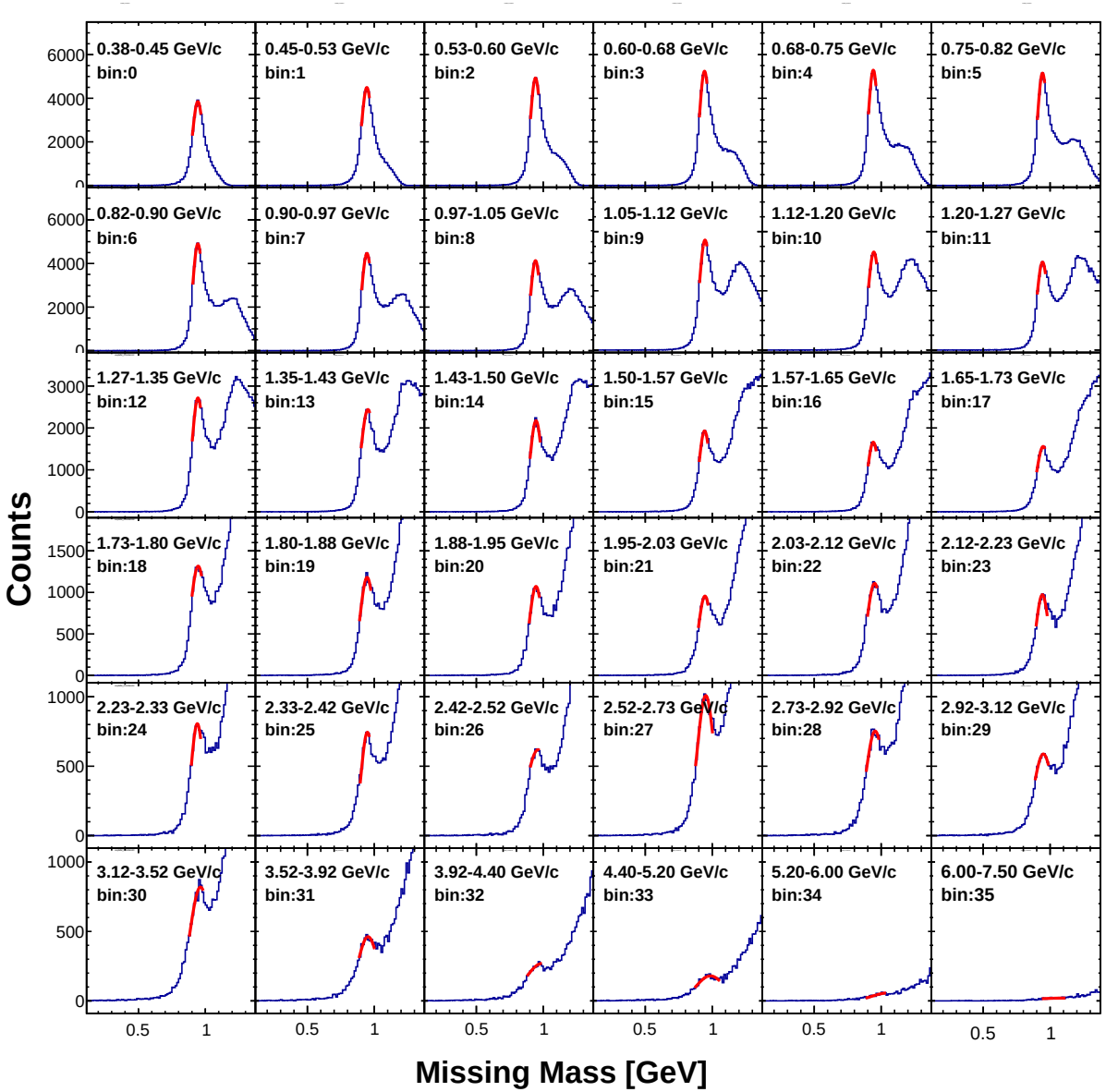
Weak Parameters in the Crystal Ball (Detected neutrons) 9

Compare n varies with $n = 100$




detMM_passdcxdcyMass2Rmincut_Pmmbin8
Counts
detMM_passdcxdcyMass2Rmincut_Pmmbin8
Entries 10683
Mean 0.9718
Std Dev 0.09419
Red - n=100, χ^2 = 22.7
Black - vary n, n=2.05×10^6
χ^2=21.4
0
200
400
600
800
1000
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
MM [GeV]

Fit the 'Cores' (Expected neutrons)



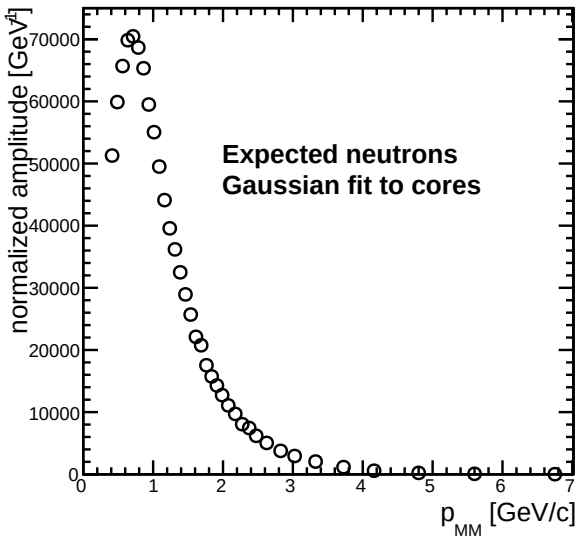
Data file:
data10p6nosidiscutv4.root

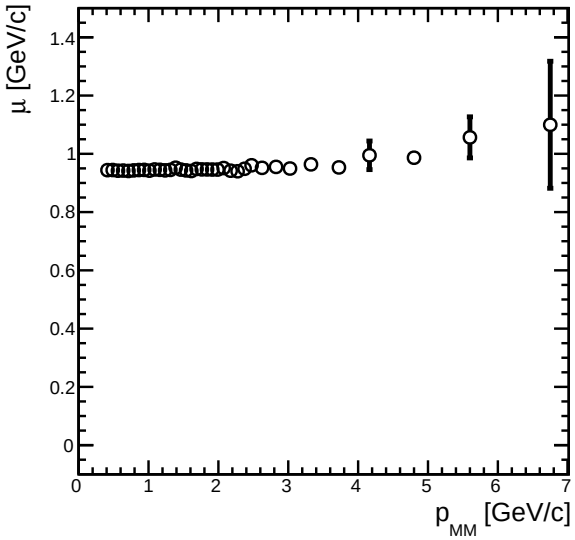
Histograms:
expMM_Pmmbin

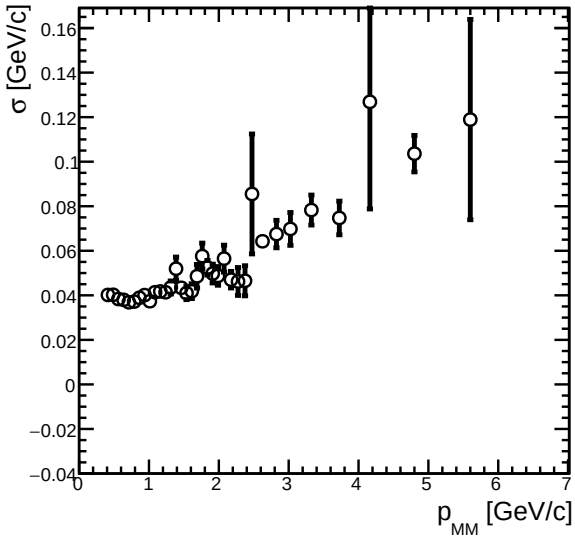
Start each fit at previous p_{mm} solution.

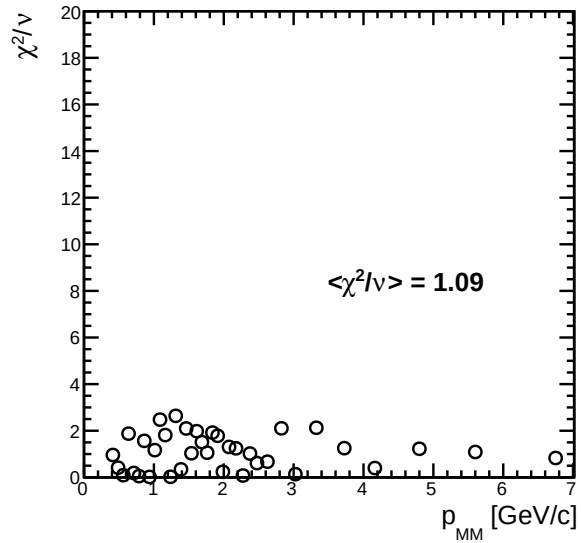
Fit the missing mass range
$\mu - \sigma \rightarrow \mu + \sigma/2$ with a Gaussian.

Fit the 'Cores' (Expected neutrons)

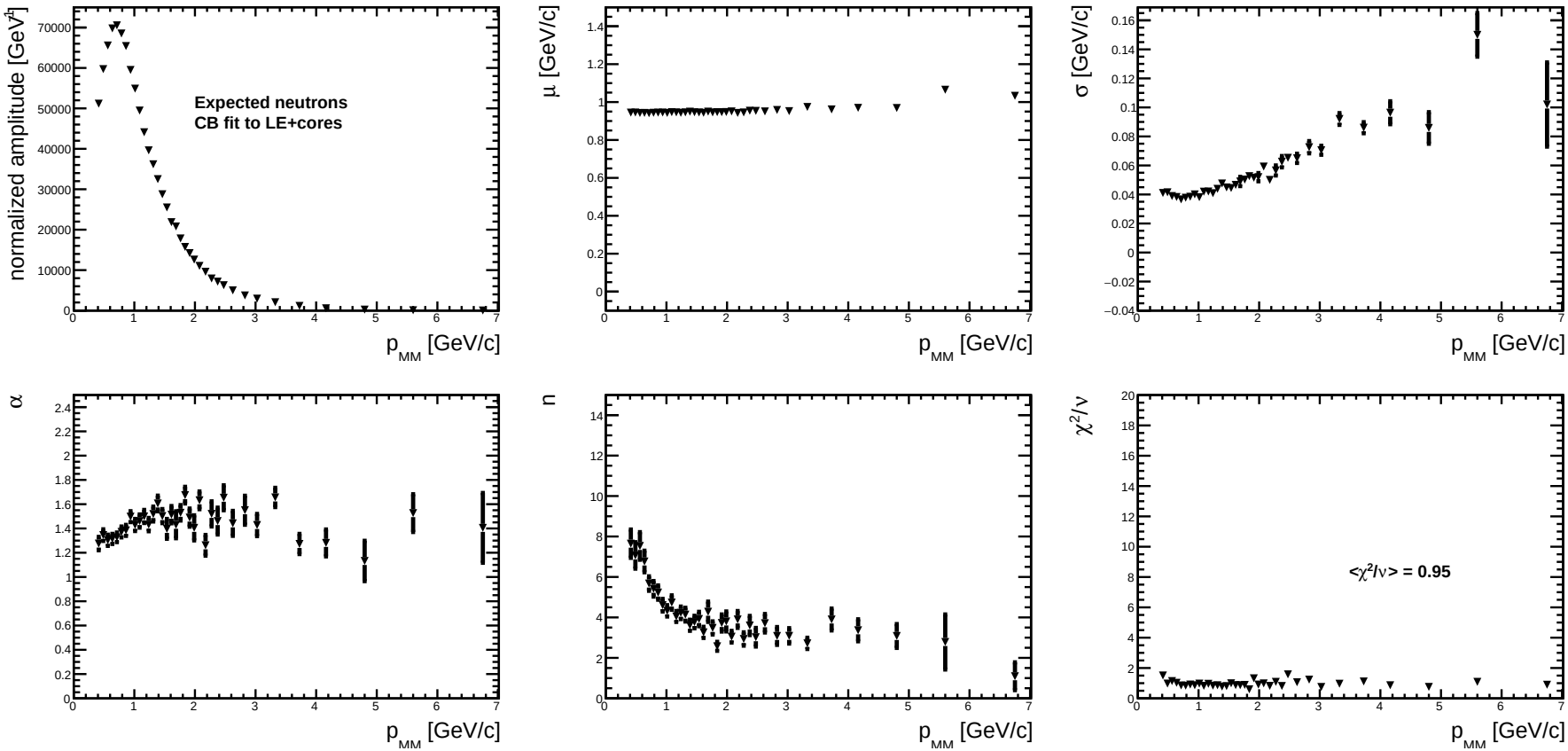




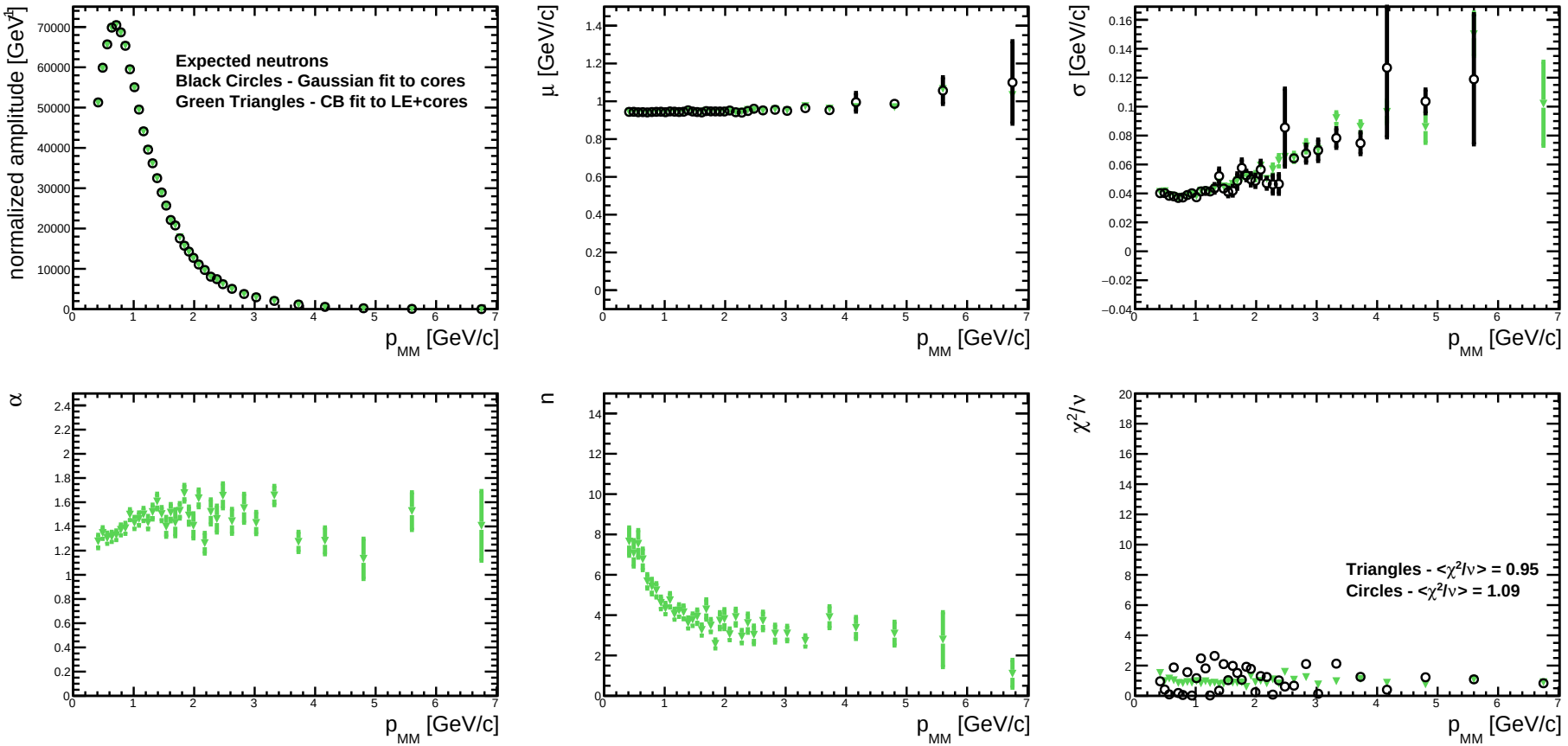


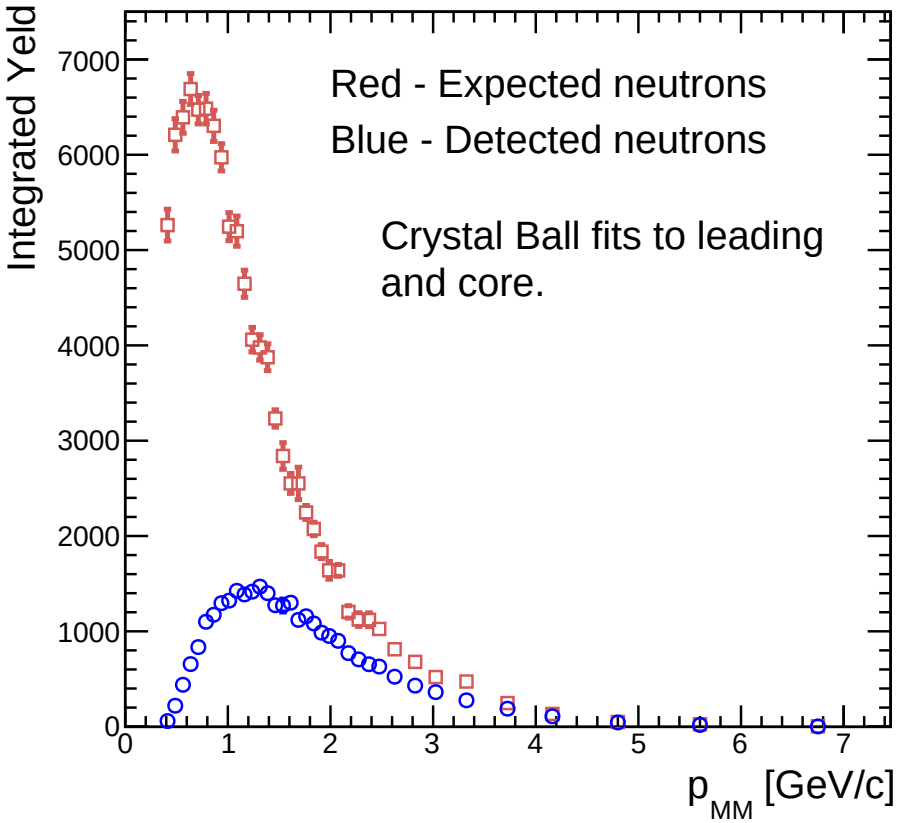


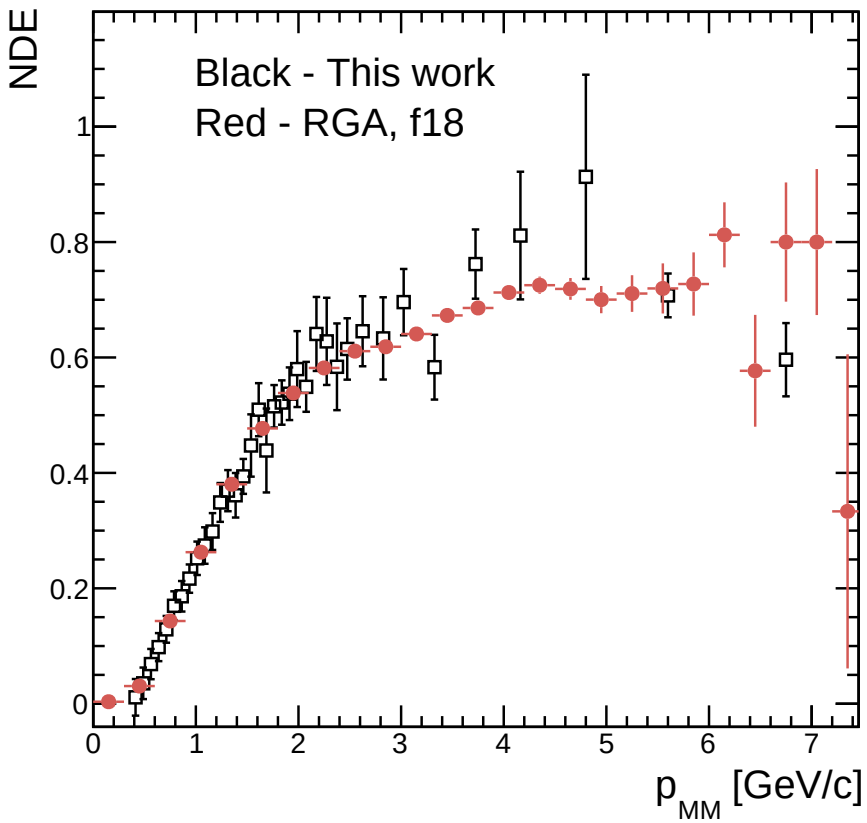
Crystal Ball Fit Parameters (Expected neutrons)



Compare LE+Core fit with Core (Expected neutrons) 14




Integrated Yeld
Red - Expected neutrons
Blue - Detected neutrons
Crystal Ball fits to leading and core.
p_MM [GeV/c]


NDE
Black - This work
Red - RGA, f18
p_MM [GeV/c]