

Measurements from ${}^3\text{He}(e,e'n)$ Scattering at Jefferson Lab

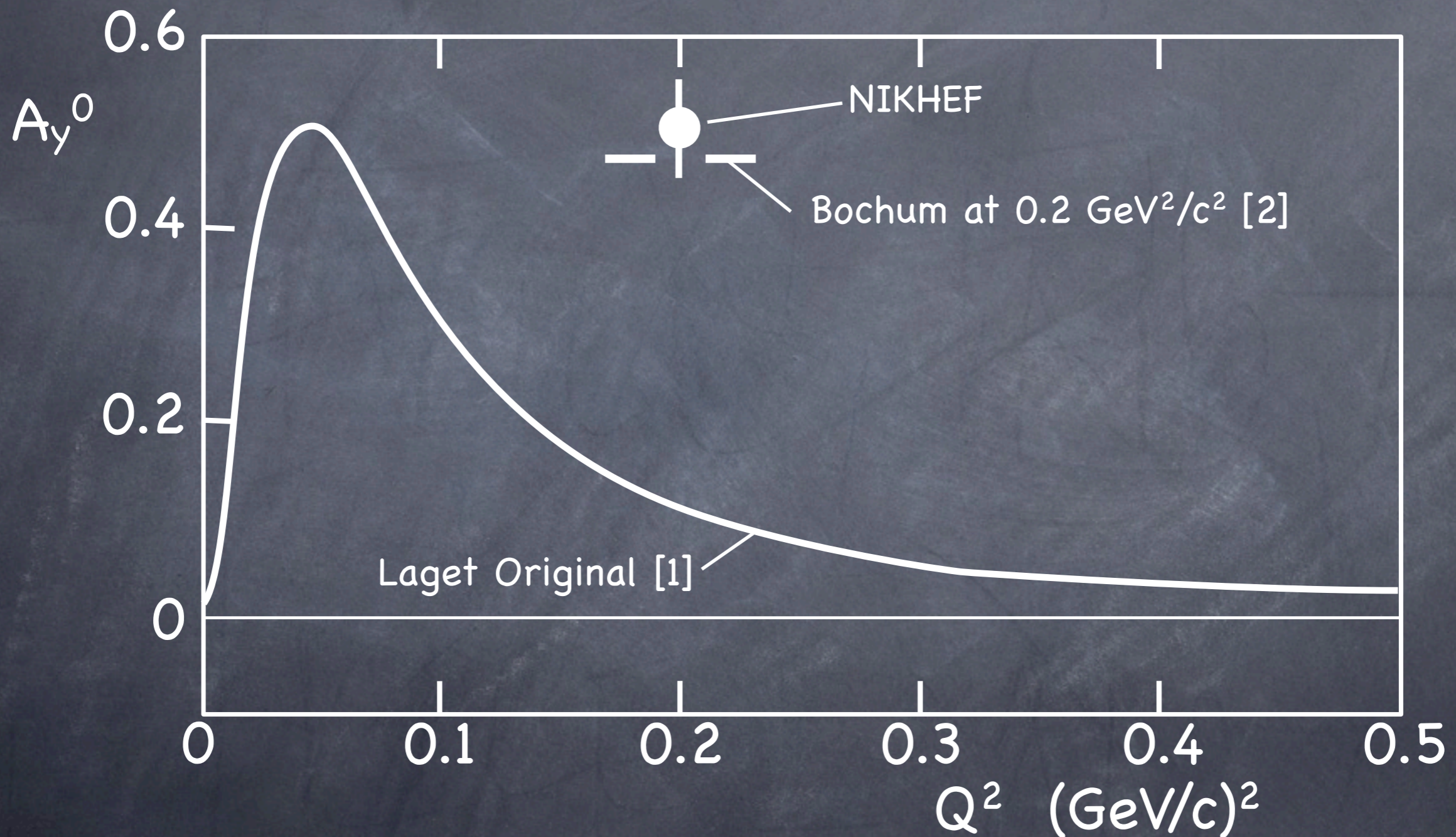
Elena Long
APS April Meeting
April 30th, 2011



What are we doing?

- In PWIA, A_y in Quasi-Elastic ${}^3\text{He}^\uparrow(e,e'n)$ is exactly zero
- Previous to this experiment, no measurements of A_y have been done at large Q^2
- We will analyze high precision data points taken at 0.1 $[\text{GeV}/c]^2$, 0.5 $[\text{GeV}/c]^2$, and 1.0 $[\text{GeV}/c]^2$
- Previous experiment at NIKHEF measured A_y at 0.2 $[\text{GeV}/c]^2$
- Faddeev calculations by Bochum group correctly predicted FSI result where other groups expected a much lower value

What are we doing?



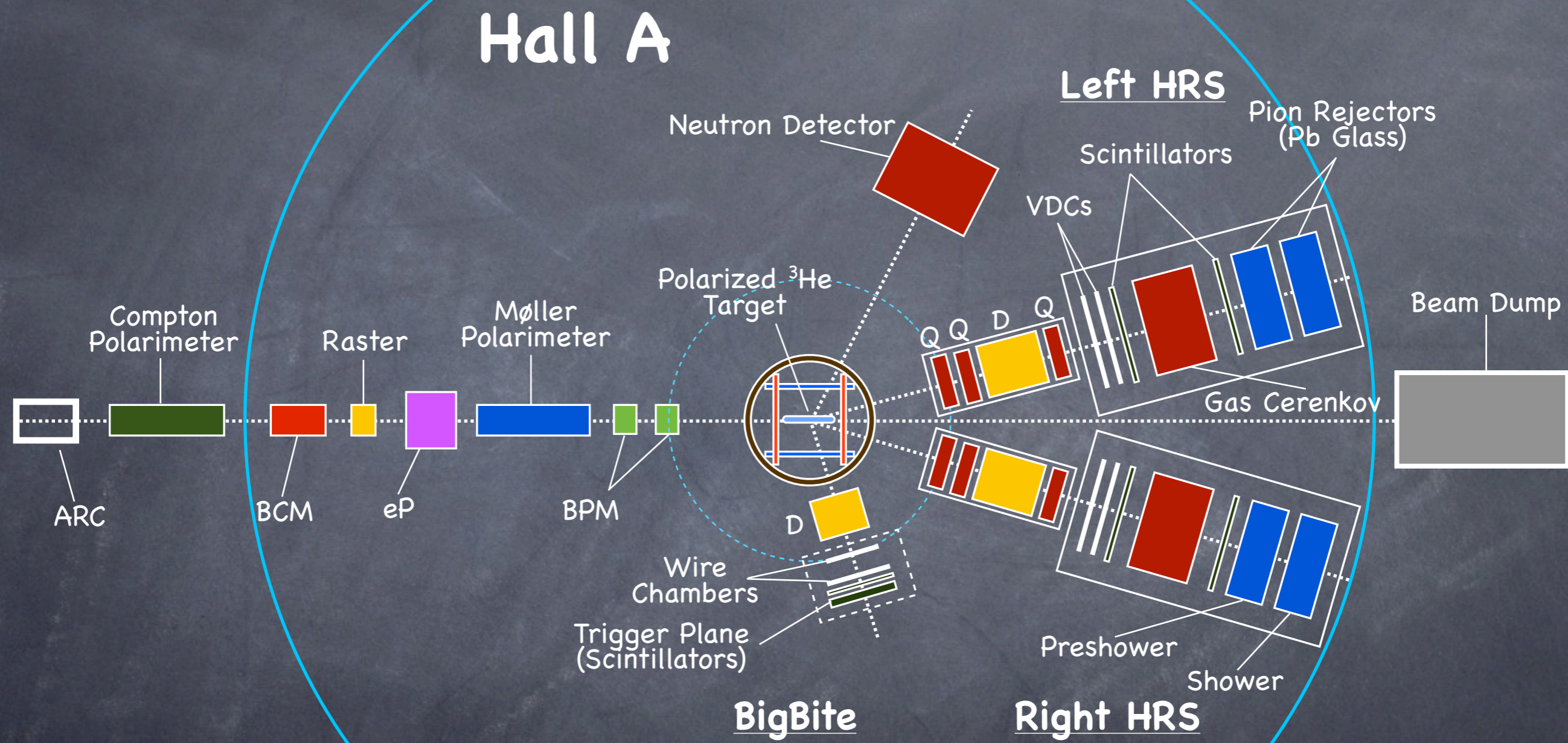
[1] J. M. Laget, Phys. Lett. B273, 367 (1991).

[2] W. Gloeckle, H. Witala, D. Huber, H. Kamada, and J. Golak, Phys. Rept. 274, 107 (1996).

What are we doing?

- Data will test state of the art calculations at high Q^2
 - Neutron form factor extractions must correctly predict this asymmetry
 - In calculating G_E^n from ${}^3\vec{\text{He}}(\vec{e}, e'n)$, A_y from ${}^3\text{He}^\uparrow(e, e'n)$ will also be calculated
- At high Q^2 , any non-zero result is indicative of effects beyond impulse approximation

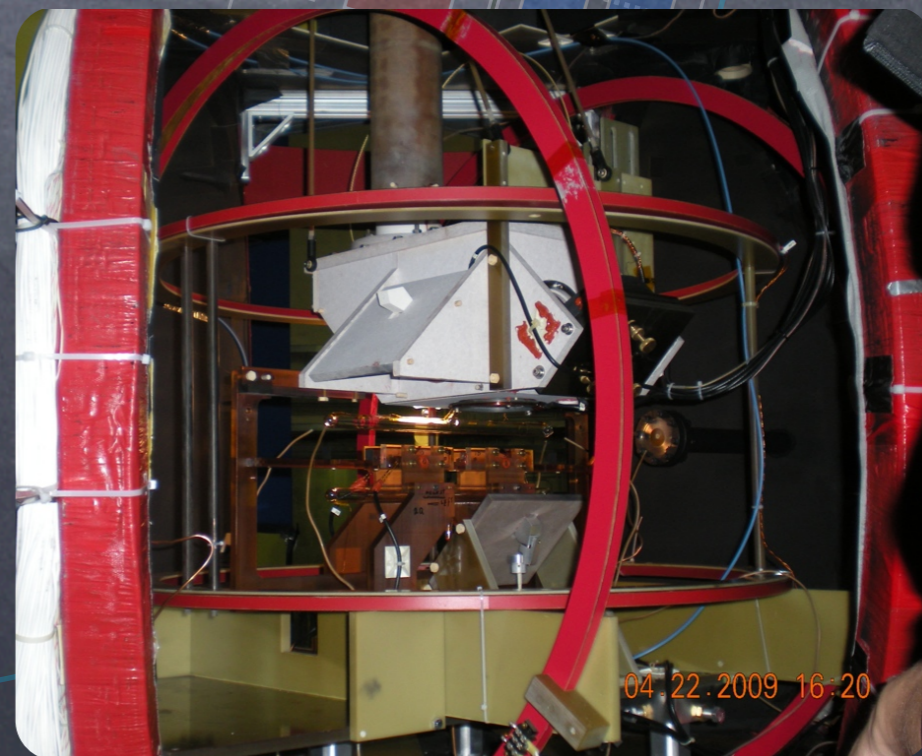
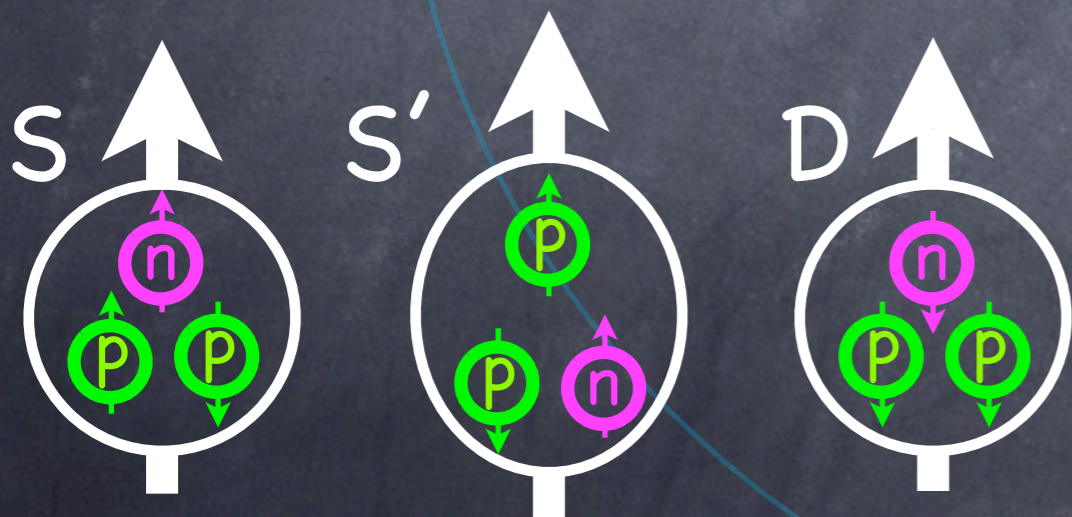
What's been done?



What's been done?

Polarized ^3He Target

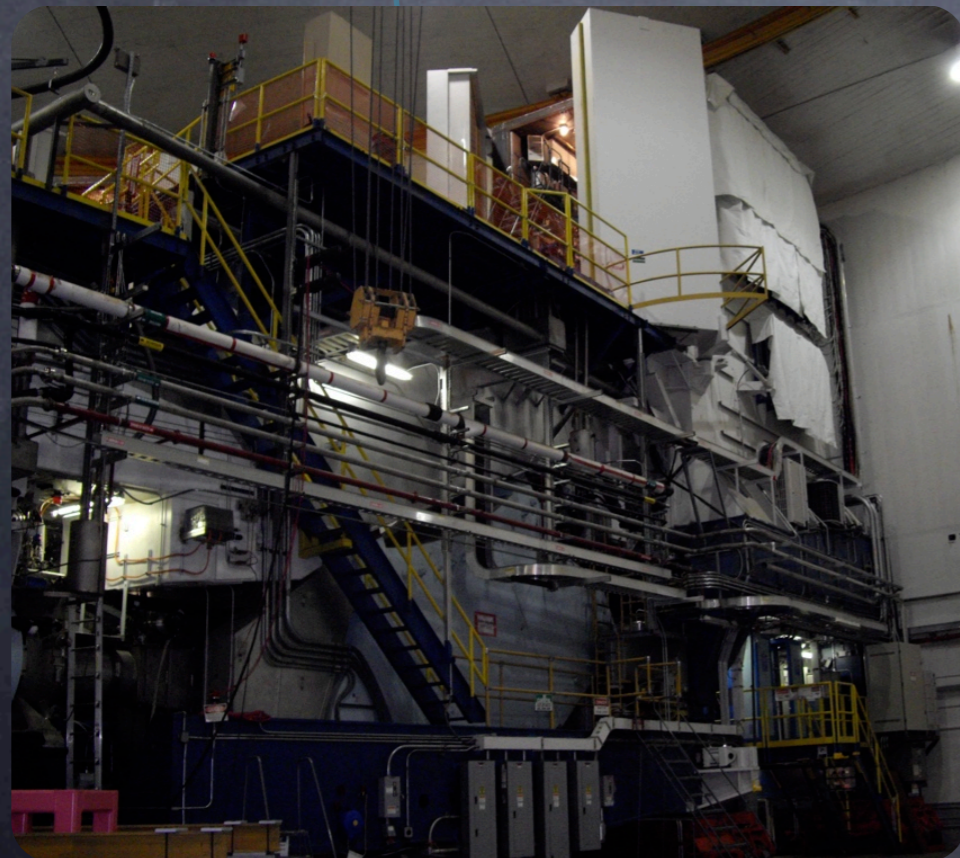
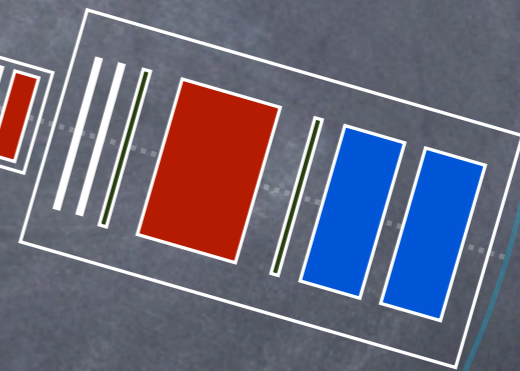
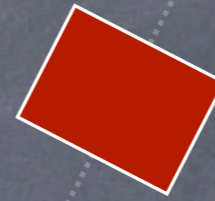
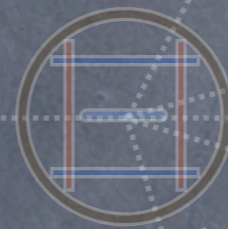
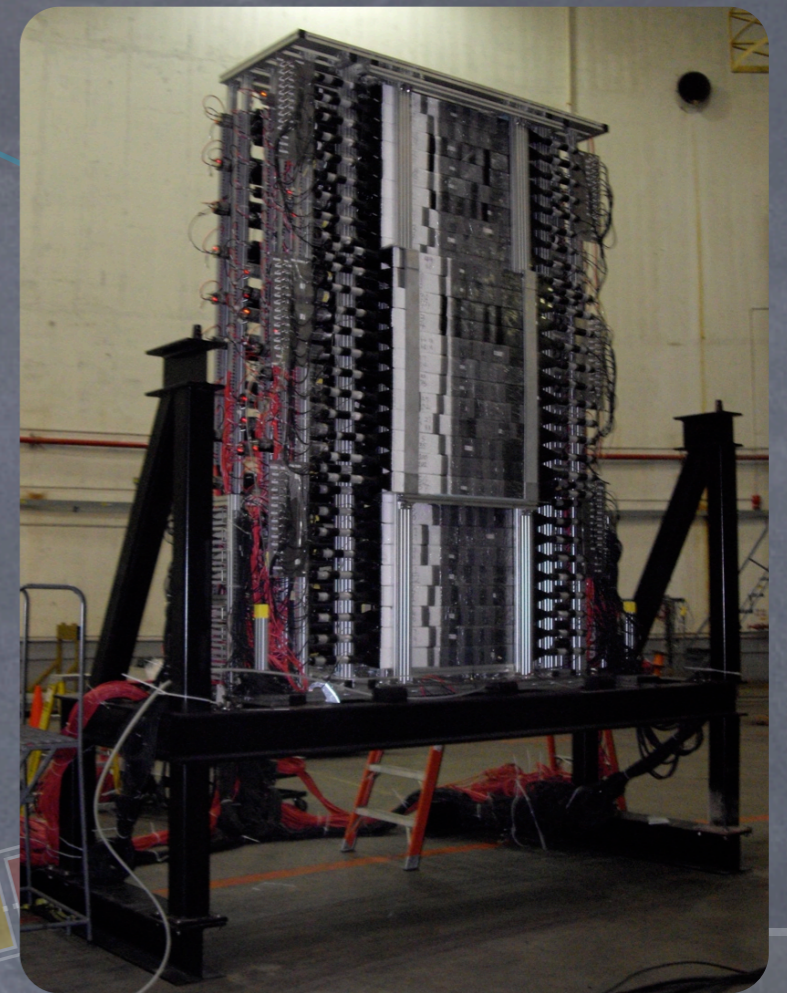
- Optically Pumped Rubidium Vapor used with Potassium to Polarize ^3He via Spin Exchange
- NMR and EPR Measure Polarization
- Polarization was in Vertical Direction
- Can Polarize up to 60%
- Luminosity $\sim 10^{36} \text{ cm}^{-2}\text{s}^{-1}$



What's been done?

Hall A Neutron Detector

- Detects neutrons from ${}^3\text{He}(e,e'n)$
- Along with RHRS allows G_E^n and A_y measurements to be made



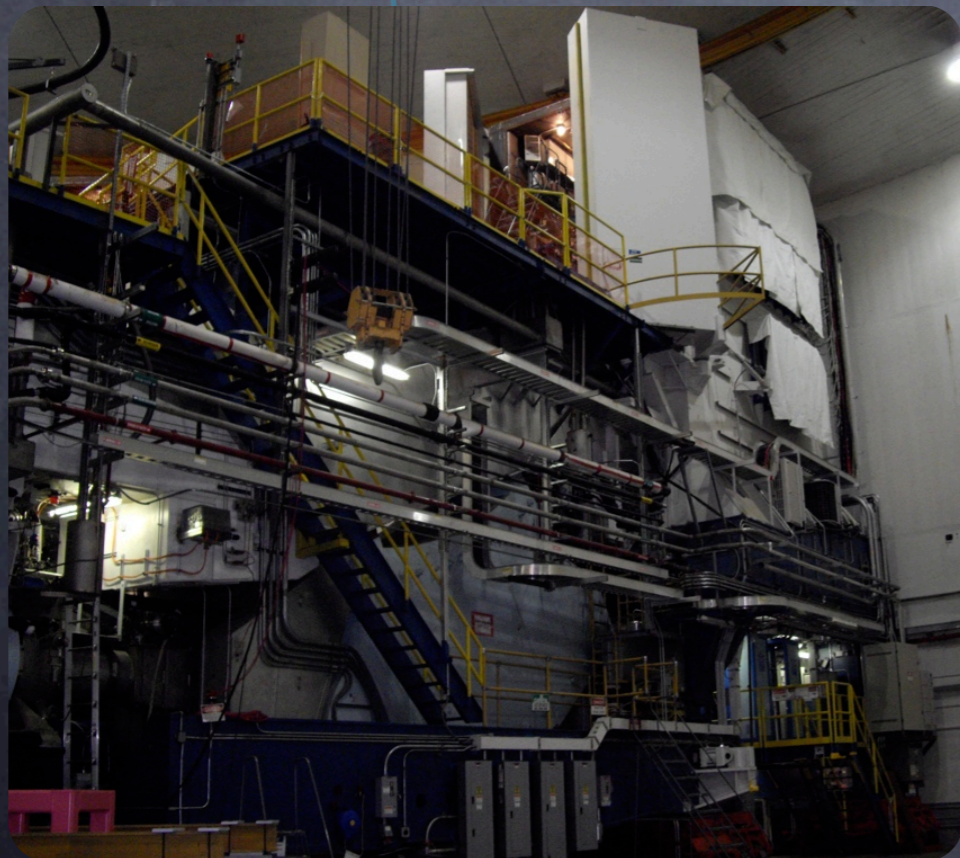
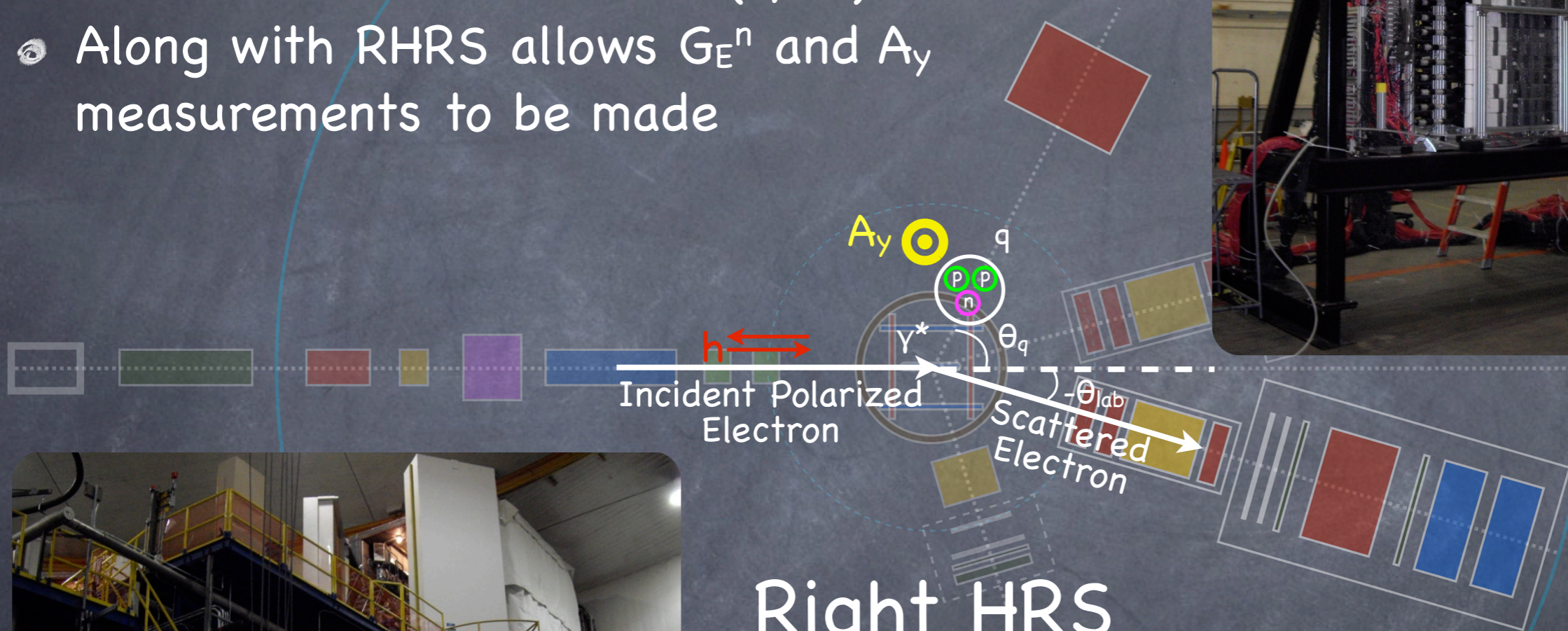
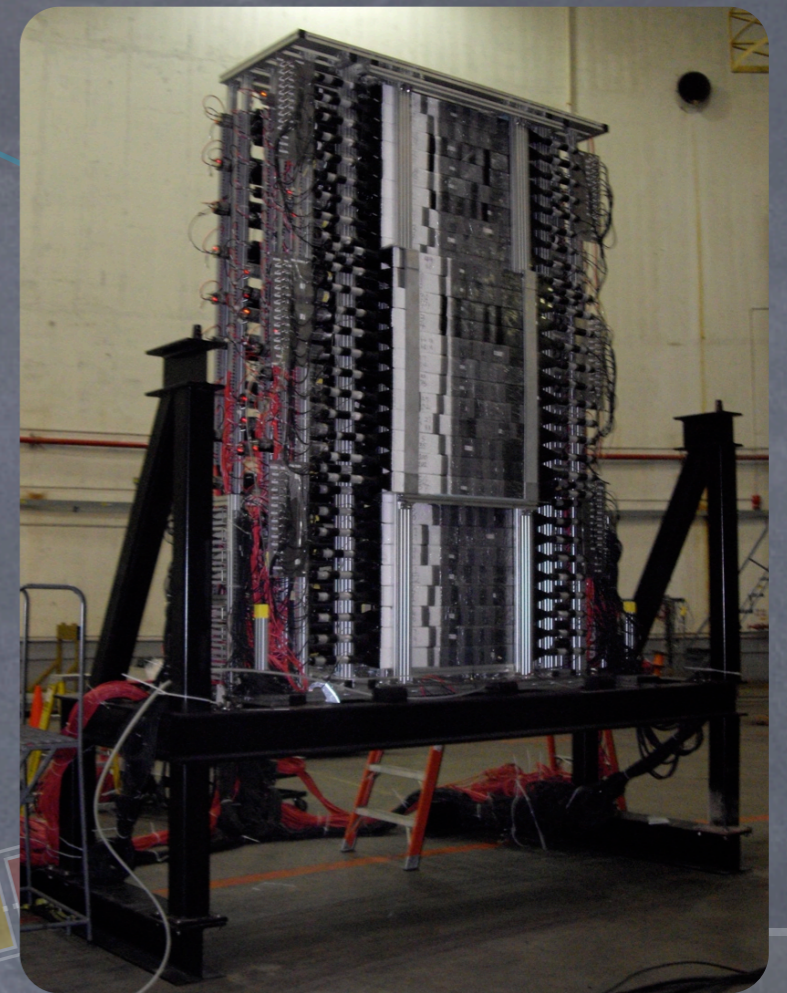
Right HRS

- Detects quasi-elastically scattered electrons from ${}^3\text{He}(e,e'n)$ and ${}^3\text{He}(e,e')$
- With q along beam polarization on ${}^3\text{He}(e,e')$, allows a G_M^n measurement to be made

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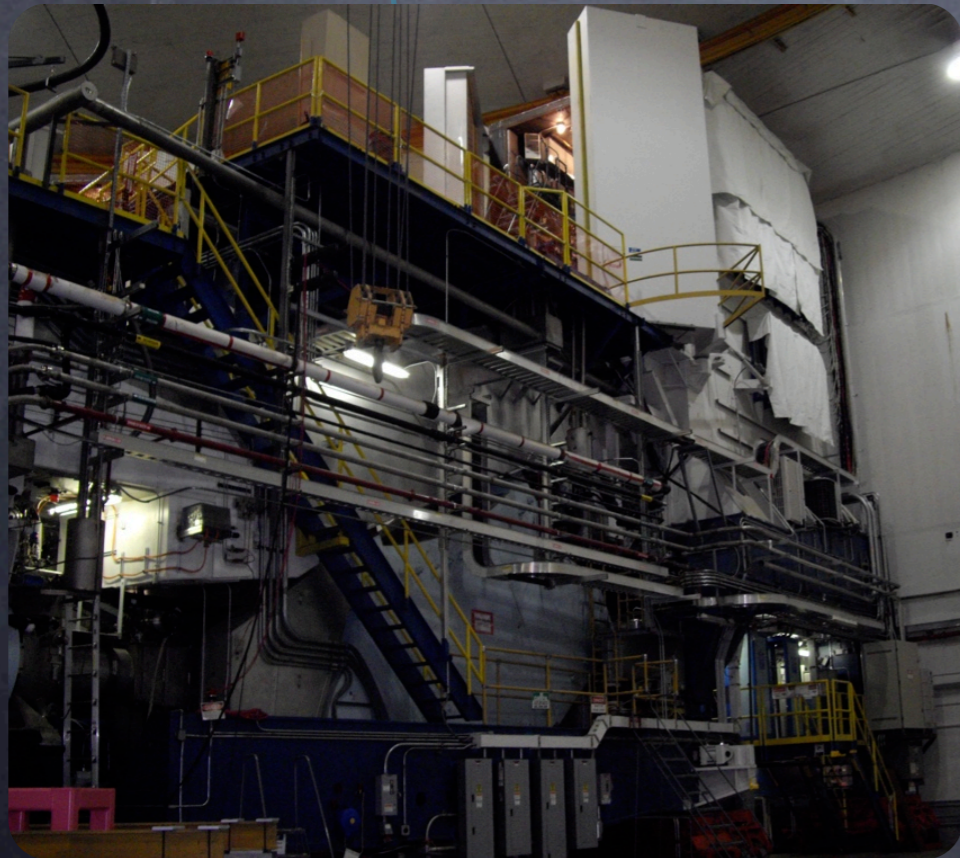
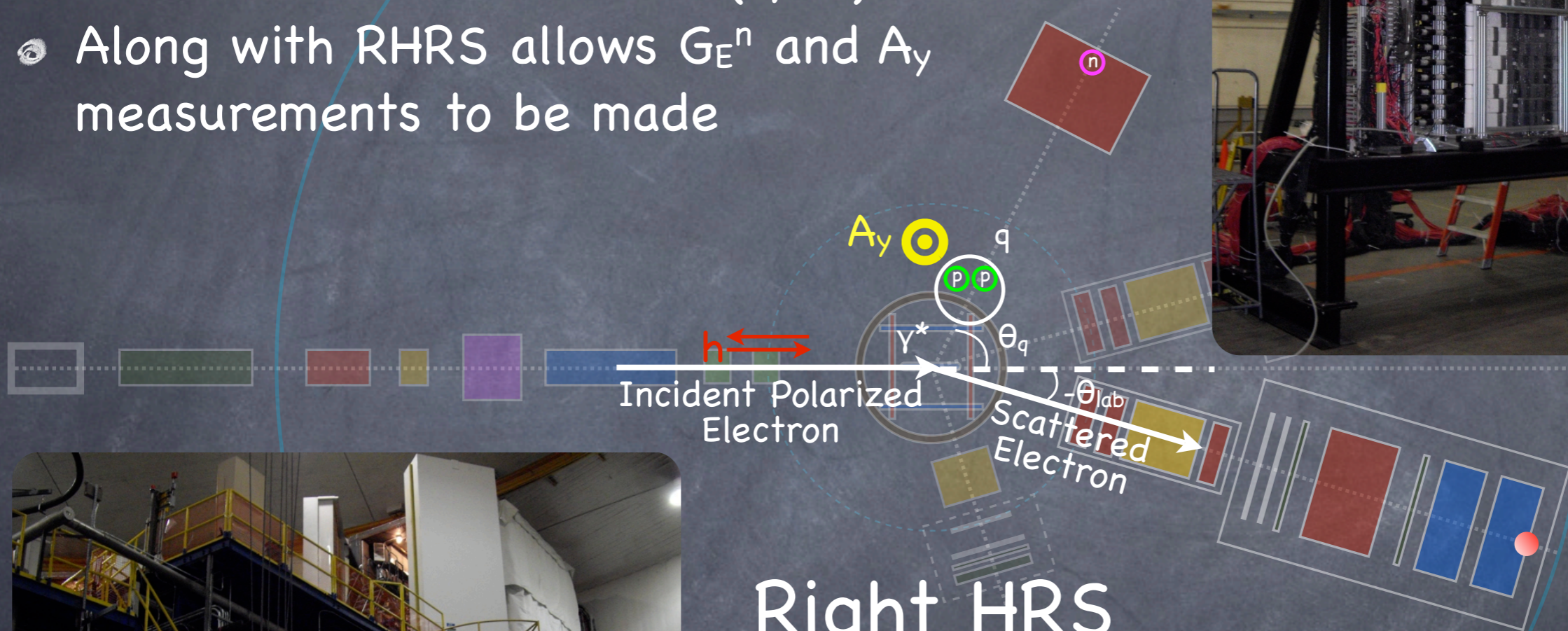
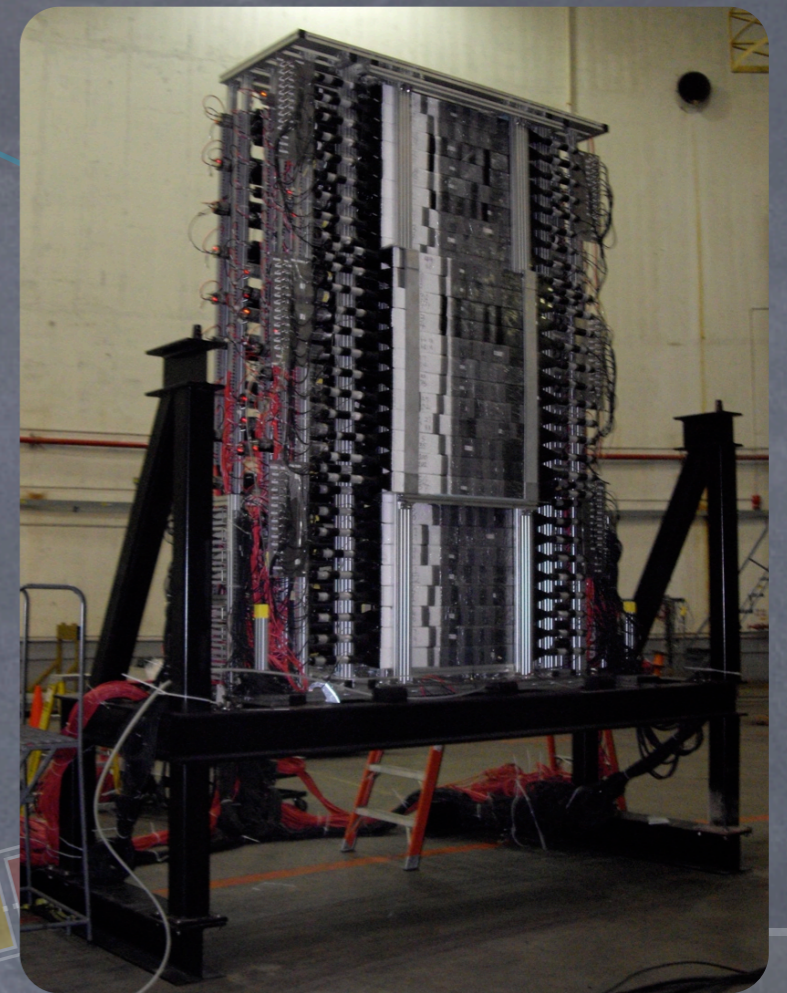
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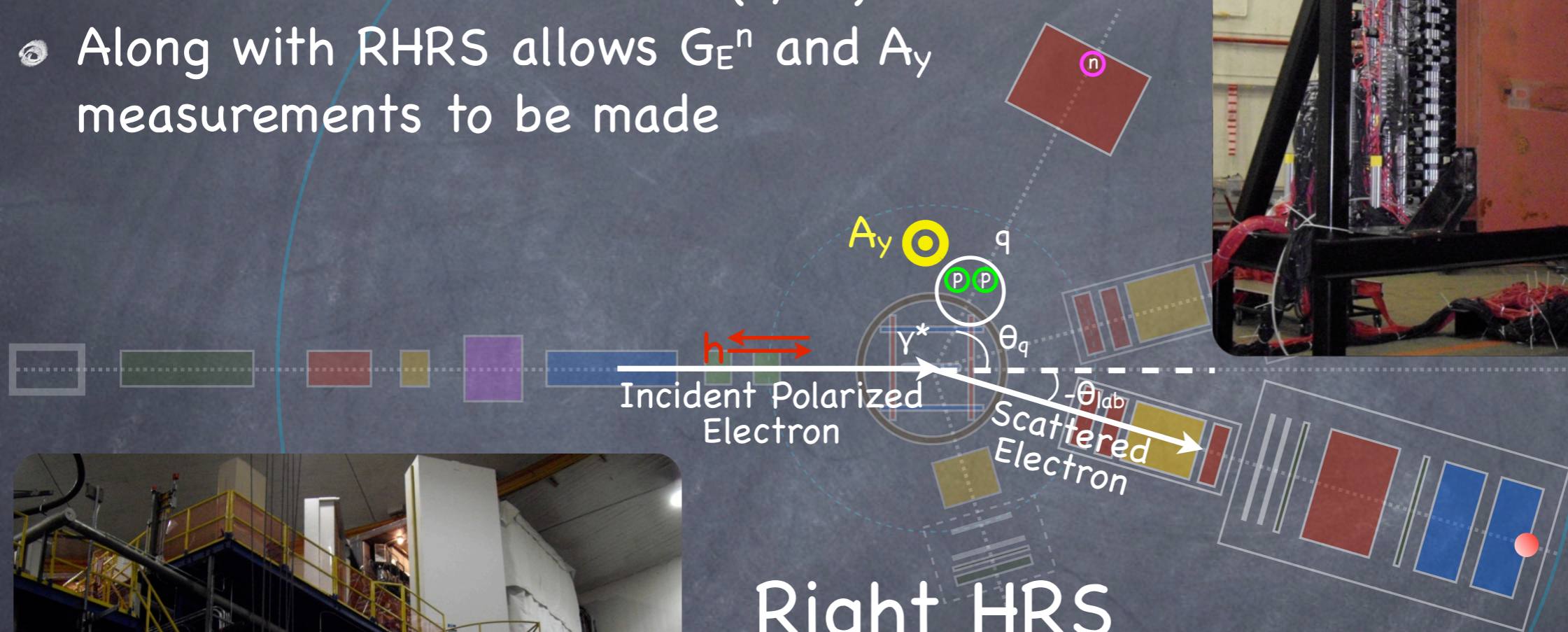
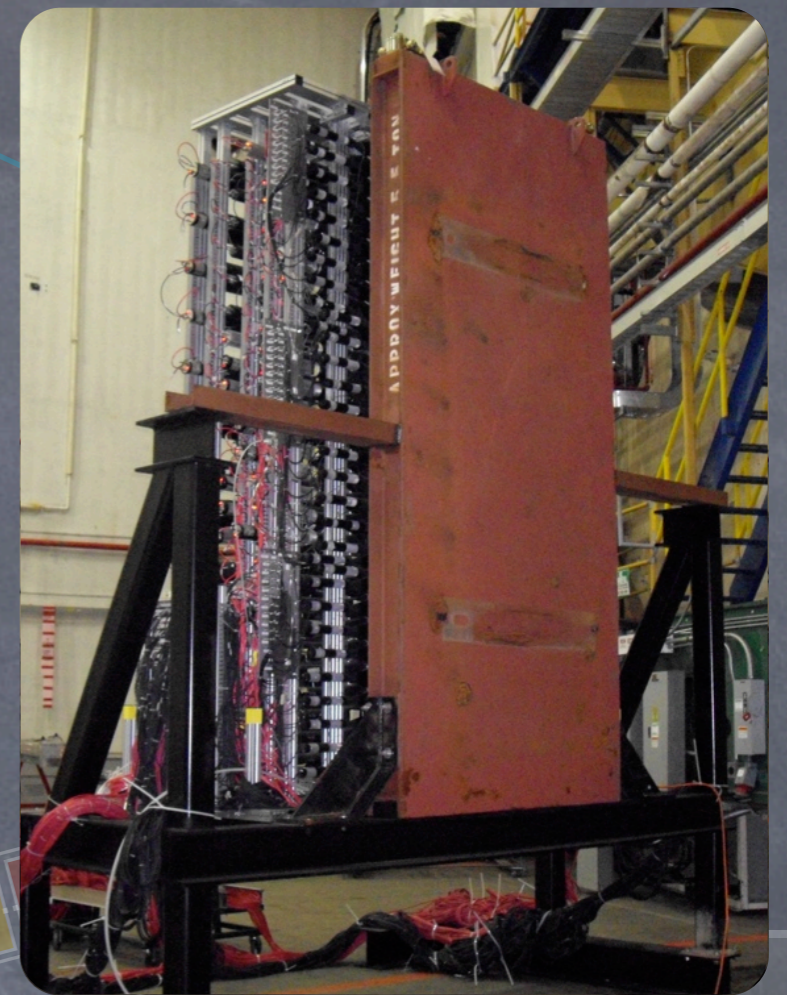
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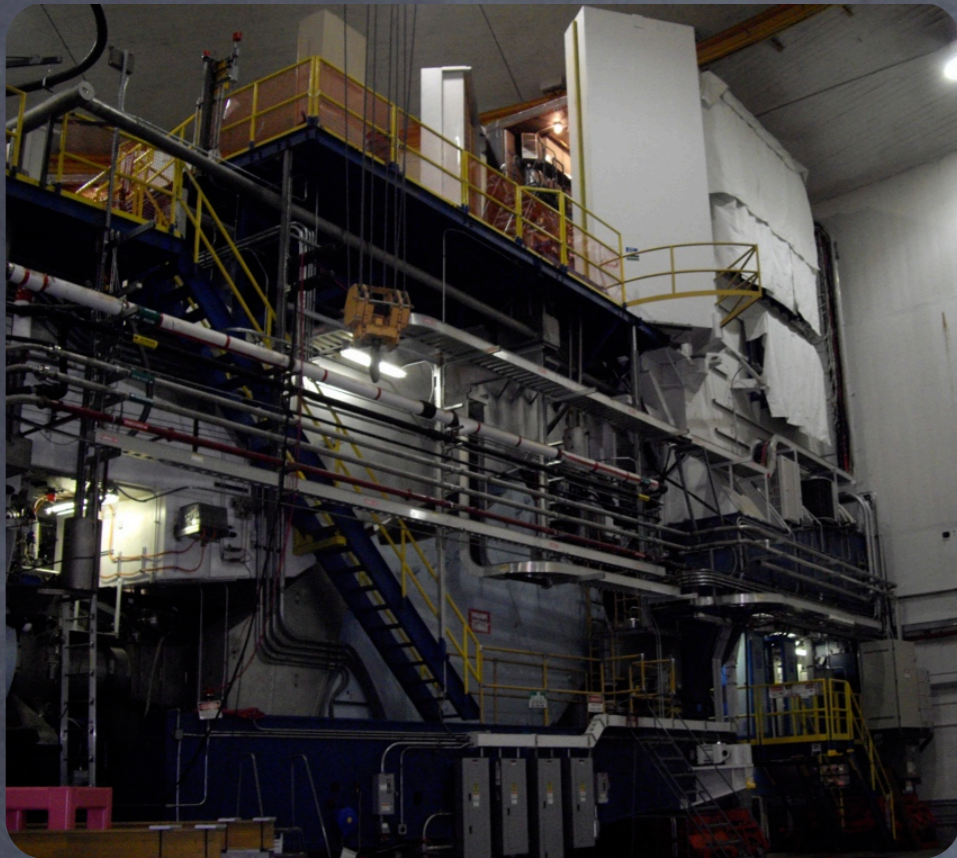
What's been done?

- This experiment, E08-005, ran from April 26th through May 10th in Jefferson Lab's Hall A
- The kinematics taken were:

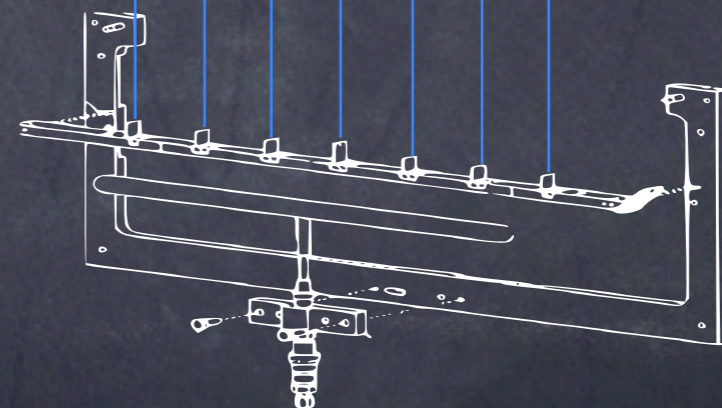
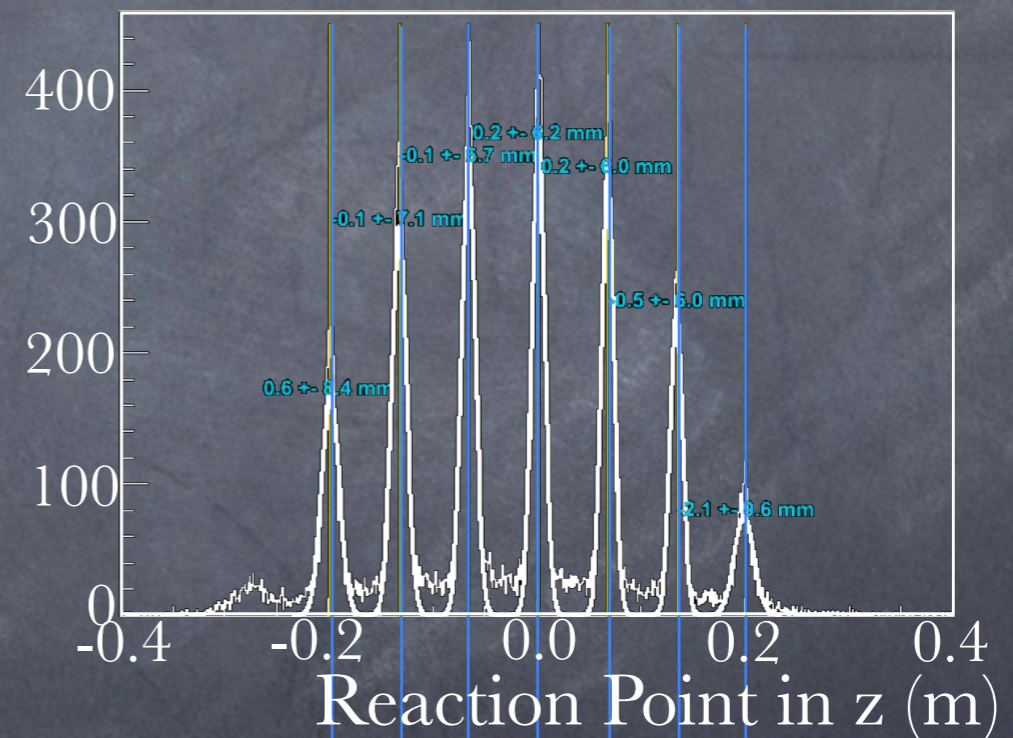
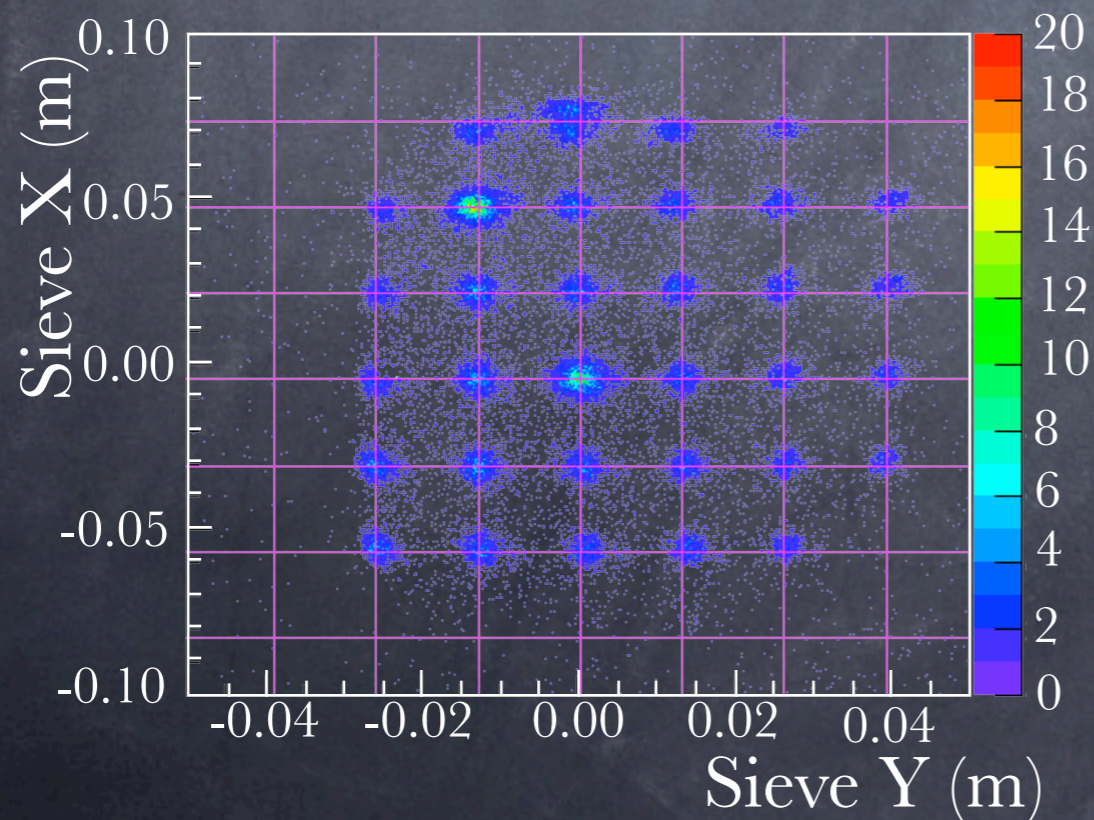
E_0 [GeV]	E' [GeV]	θ_{lab} [$^\circ$]	Q^2 [GeV/c] ²	$ q $ [GeV/c]	θ_q [$^\circ$]
1.25	1.22	17.0	0.13	0.359	71.0
2.43	2.18	17.0	0.46	0.681	62.5
3.61	3.09	17.0	0.98	0.988	54.0

Date	E_0 (GeV)	RHRS ($^\circ$)	RHRS P_0 (GeV)	LHRS ($^\circ$)	LHRS P_0 (GeV)	HAND ($^\circ$)	BigBite ($^\circ$)
4/26	1.245	-17	1.2205	17	1.2205	71	-74
4/27	1.245	-17	1.1759	17	1.1759	71	-74
4/29	3.605	-17	3.0855	17	3.0855	54	-74
5/6	3.605	-17	3.0855	17	3.0855	62.5	-74
5/8	2.425	-17	2.1813	17	2.1813	62.5	-74

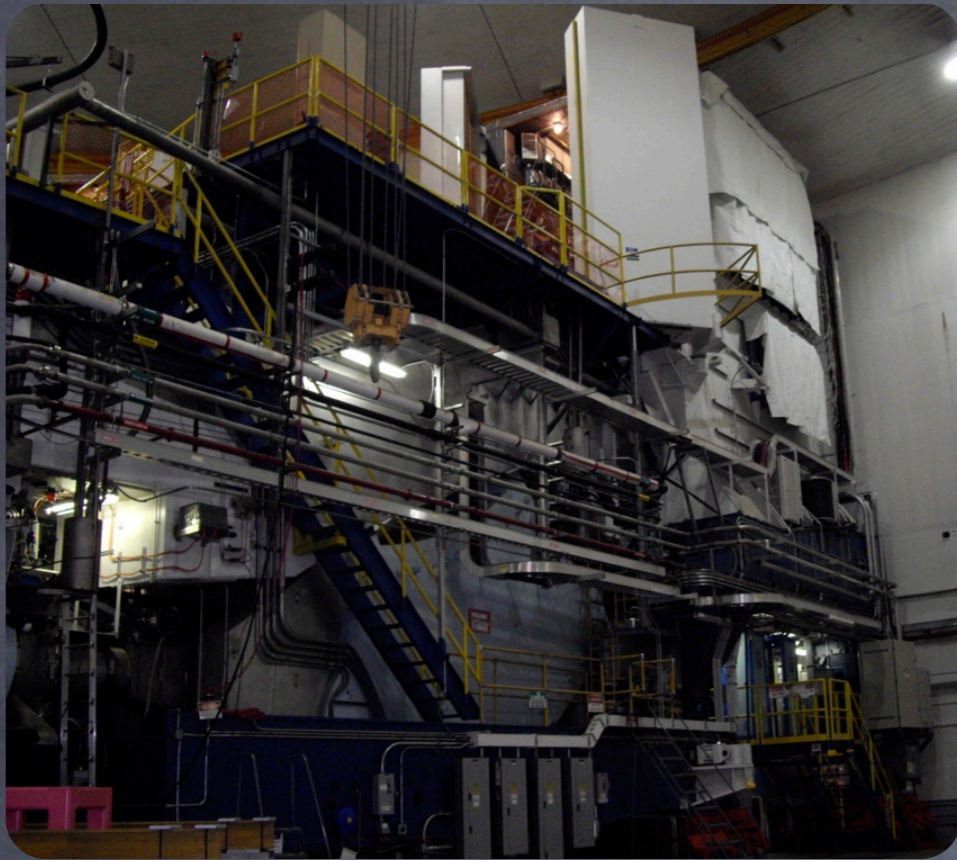
What's been done?



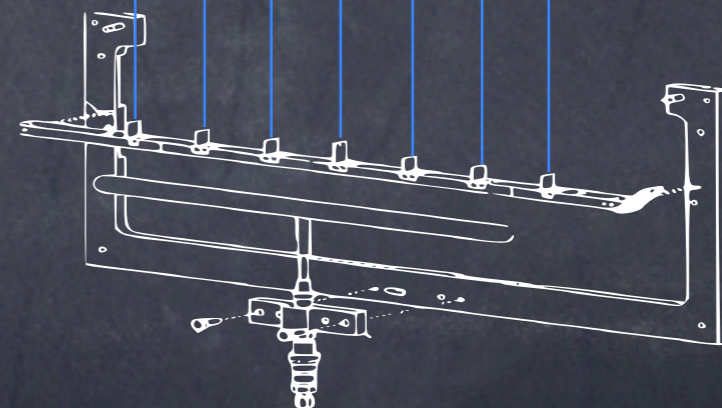
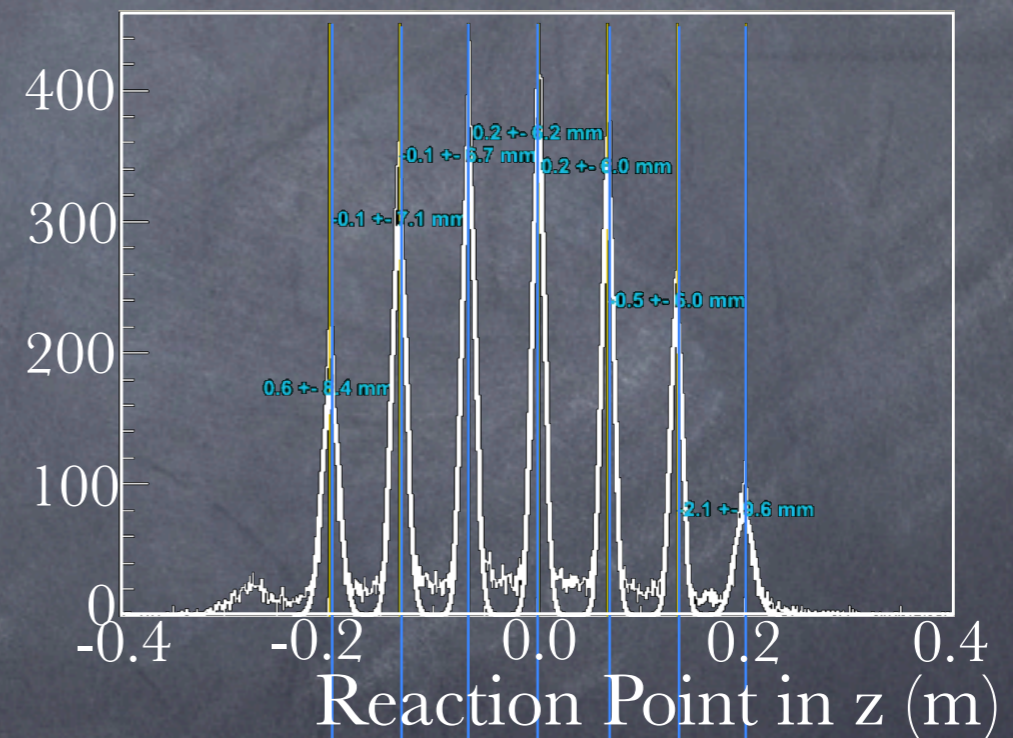
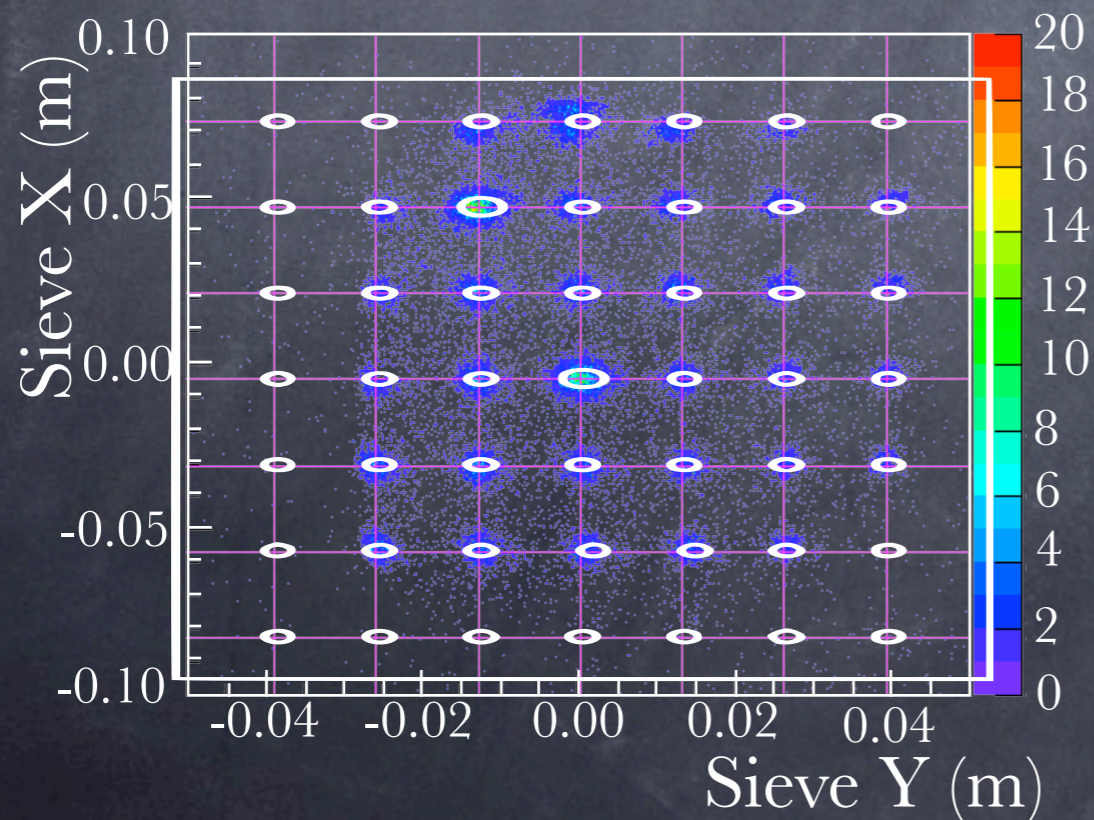
- RHRS optics calibration finished
- See Ge Jin's talk from the 2010 Summer Collaboration meeting (<http://bit.ly/faDudd>)



What's been done?

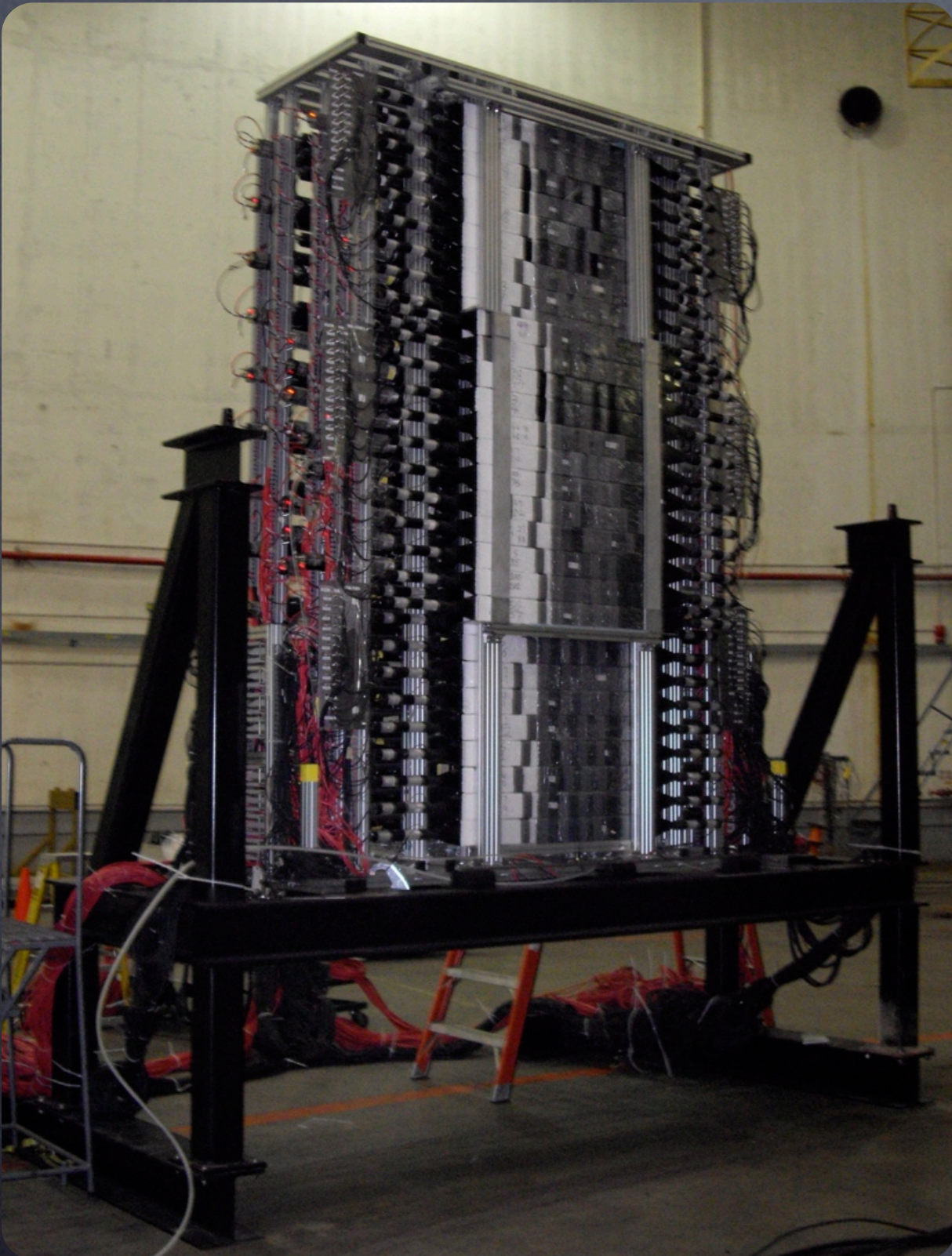


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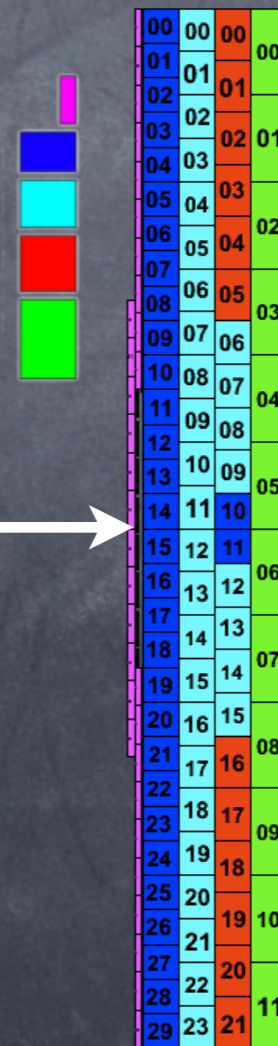


What's been done?

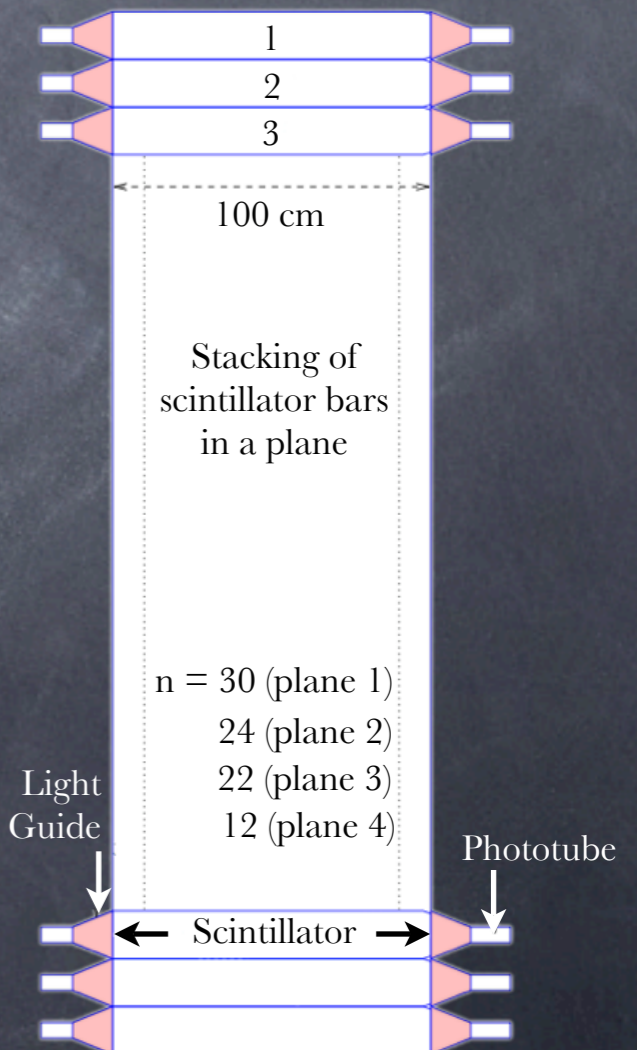
- Neutron calibration in progress
- 88 Scintillator + 64 Veto Bars
- ADC and TDC channels recorded for each of 240 PMTs



$2 \times 11 \times 70 \text{ cm}^3$
 $10 \times 10 \times 100 \text{ cm}^3$
 $10 \times 12.5 \times 100 \text{ cm}^3$
 $10 \times 15 \times 100 \text{ cm}^3$
 $10 \times 25 \times 100 \text{ cm}^3$



Side View



Front View

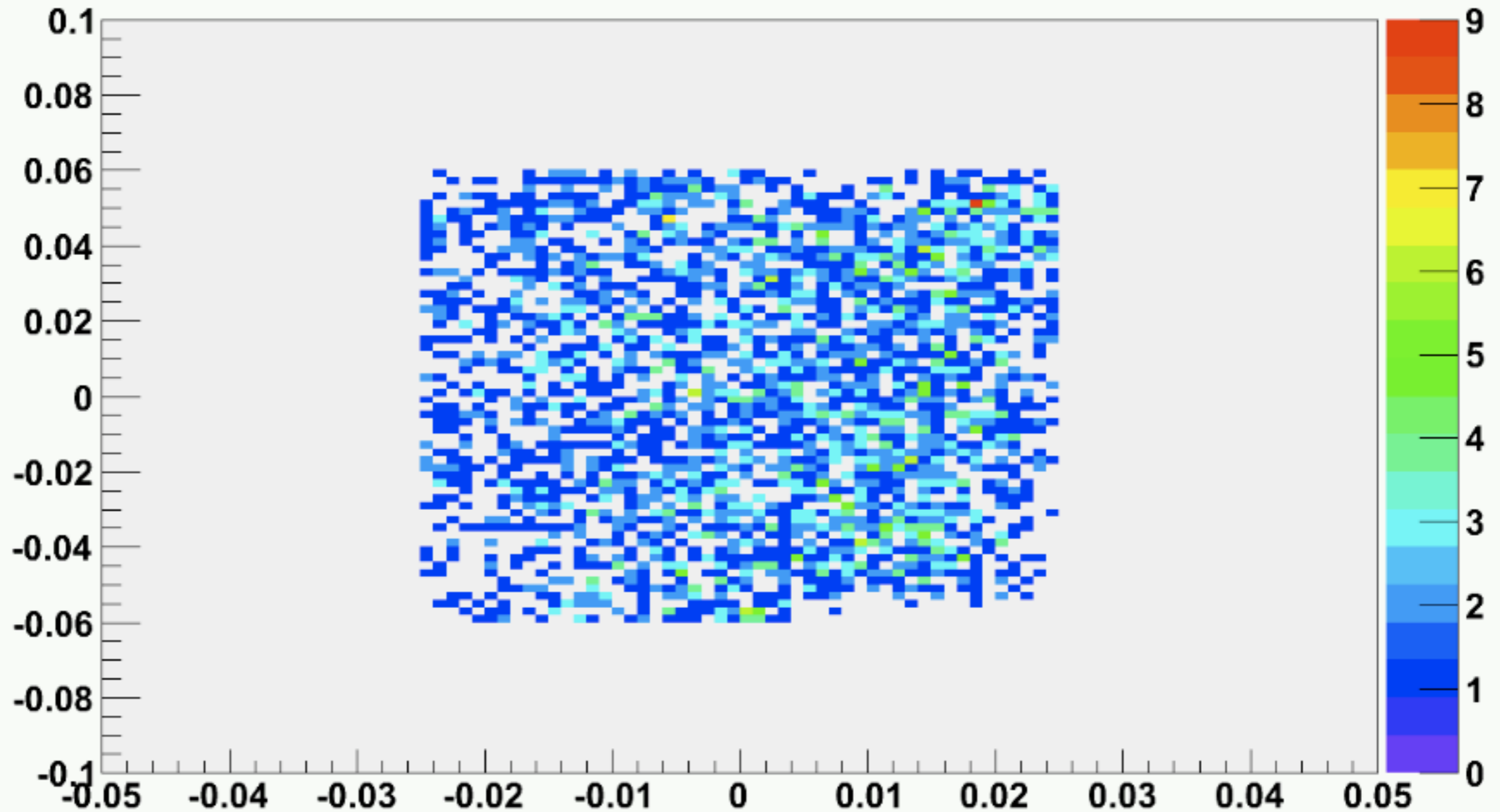
What's been done?

Theta Correlates to Bar

Run # 20791-20792

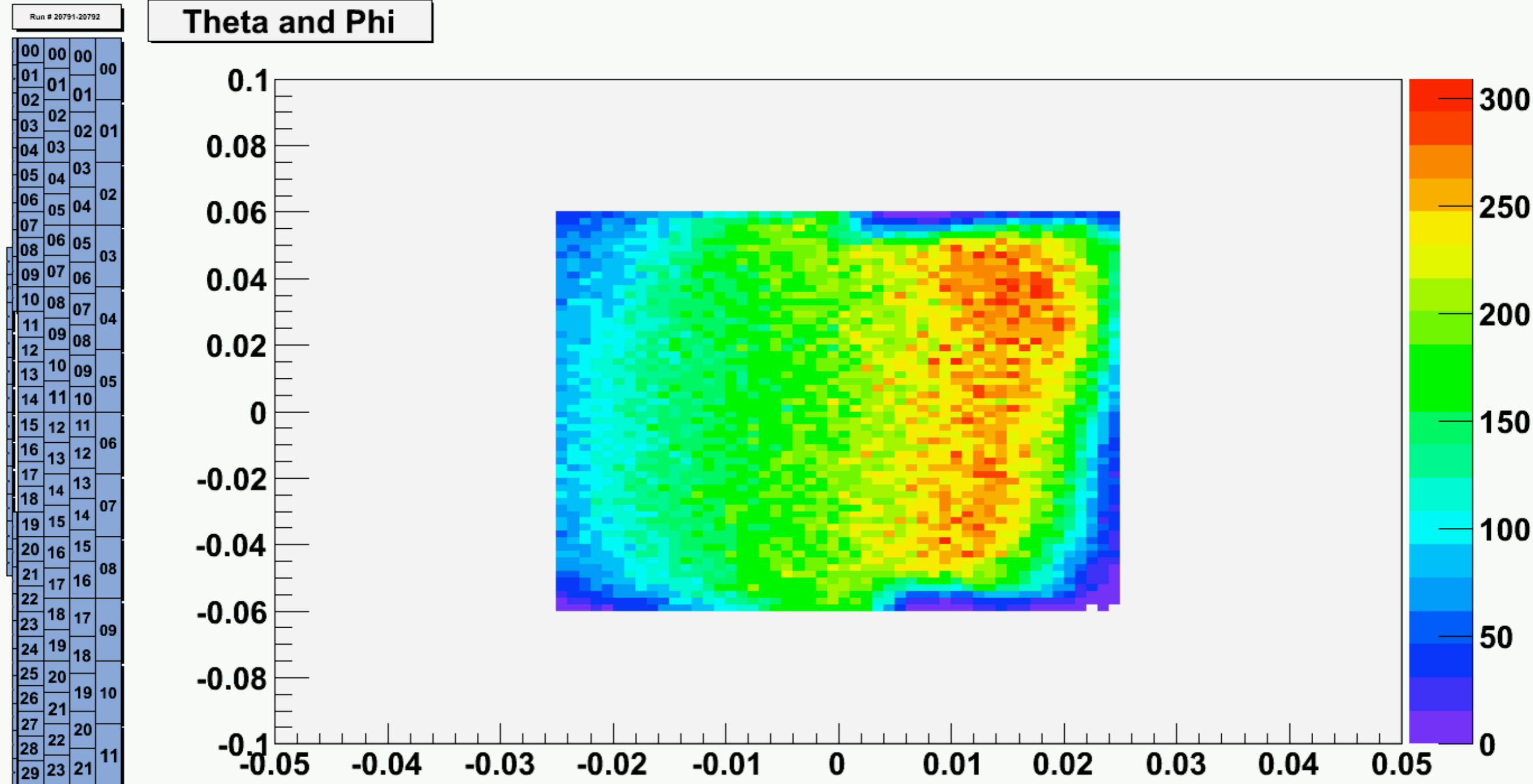
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01	01	00
02	01	
03	02	01
04	03	
05	04	
06	05	02
07	06	
08	05	03
09	07	06
10	08	07
11	09	08
12	10	09
13	11	10
14	12	11
15	13	12
16	14	13
17	15	14
18	16	15
19	17	16
20	18	17
21	19	18
22	20	19
23	21	20
24	22	21
25	23	22
26	24	23
27	25	24
28	26	25
29	27	26

Theta and Phi



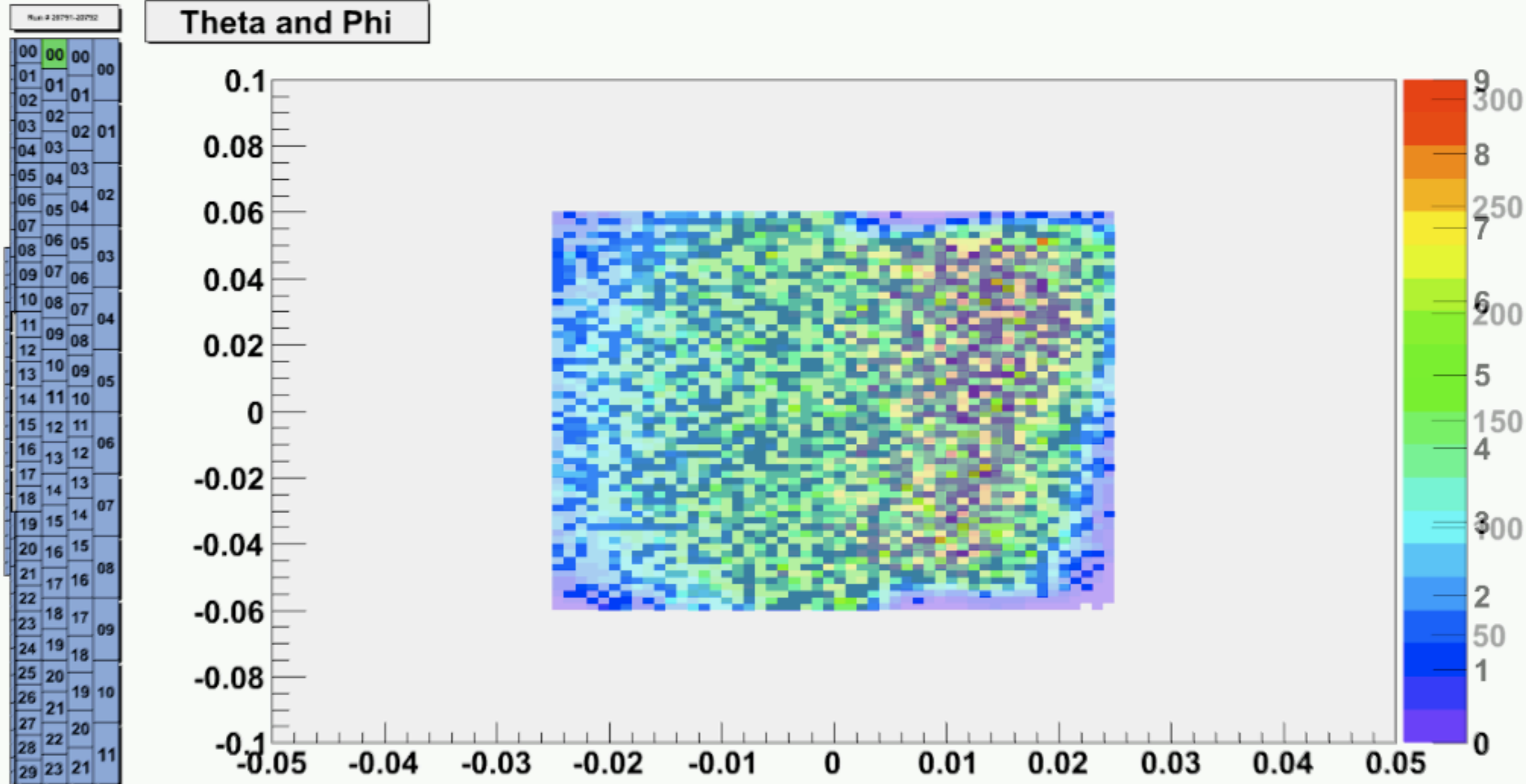
What's been done?

Theta Correlates to Bar



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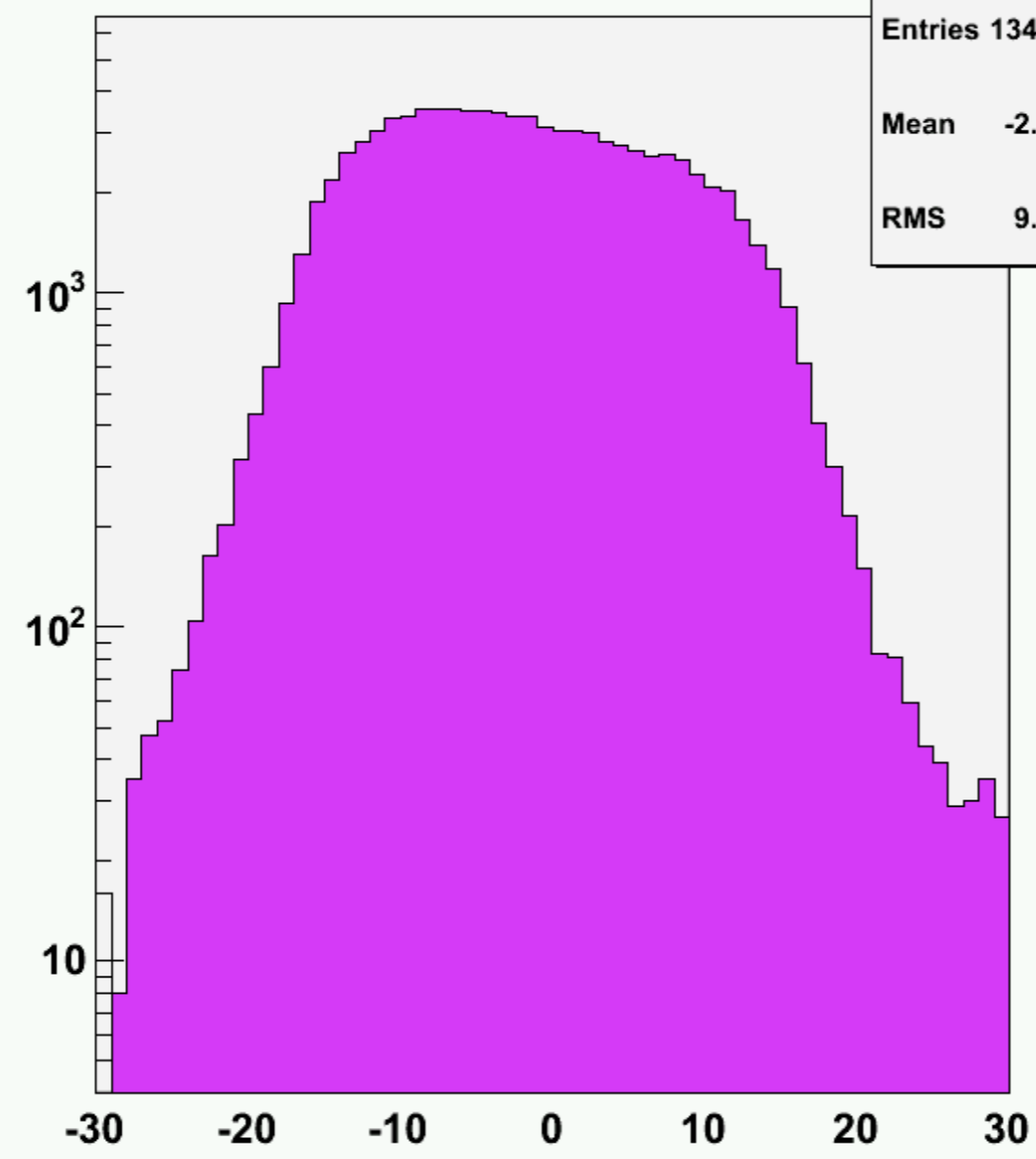
What's been done?

Phi Correlates to Left-Right Position

Run # 20791-20792

00	00	00	00
01	01	01	00
02	02	02	01
03	03	03	02
04	04	04	03
05	05	05	04
06	06	06	05
07	07	07	06
08	08	08	07
09	09	09	08
10	10	10	09
11	11	11	10
12	12	12	11
13	13	13	12
14	14	14	13
15	15	15	14
16	16	16	15
17	17	17	16
18	18	18	17
19	19	19	18
20	20	20	19
21	21	21	20
22	22	22	21
23	23	23	22
24	24	24	23
25	25	25	24
26	26	26	25
27	27	27	26
28	28	28	27
29	29	29	28

Left TDC - Right TDC for Plane #2, PMT # 10 without vetos



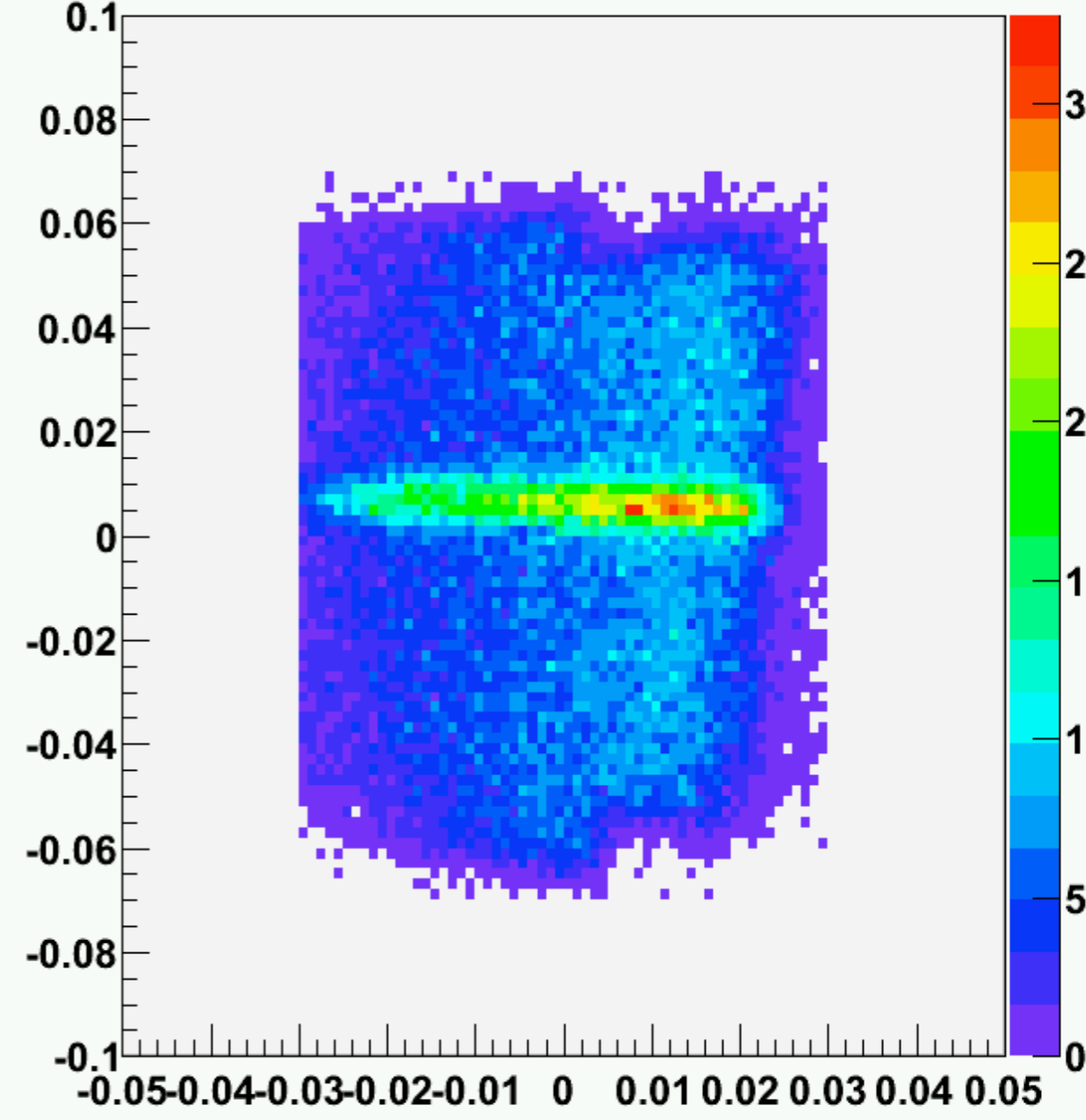
thph_p2_b10

Entries 134695

Mean -2.326

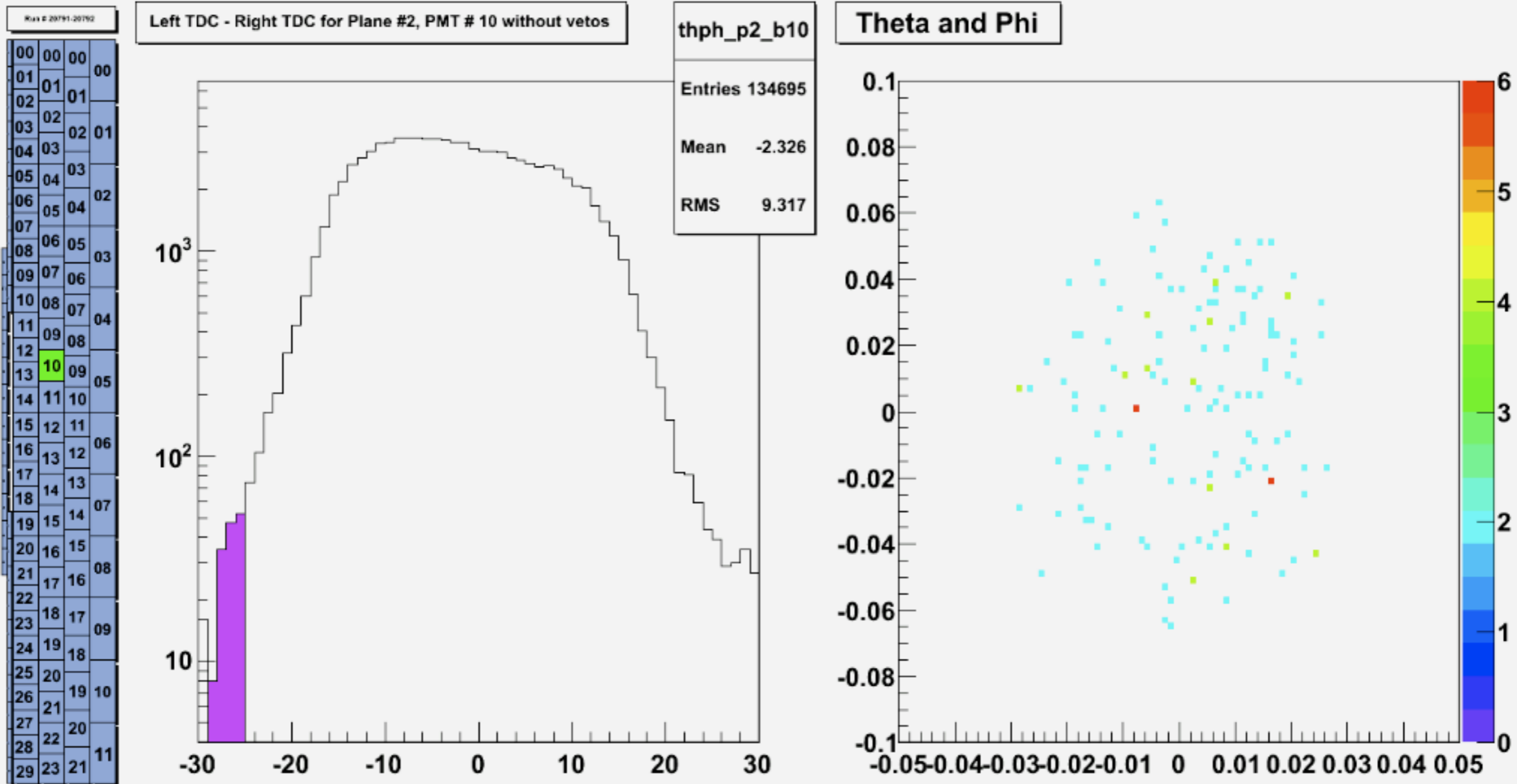
RMS 9.317

Theta and Phi



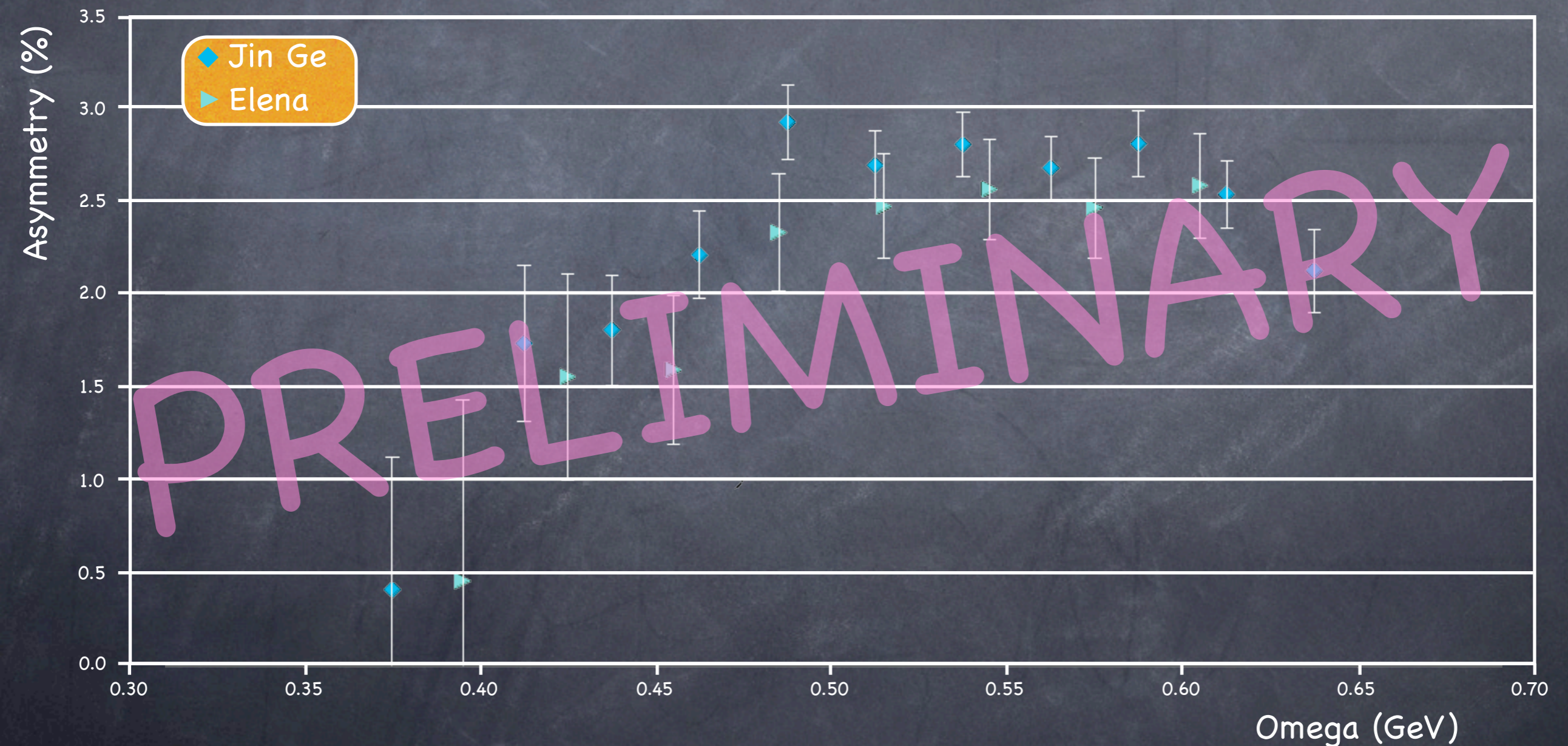
What's been done?

Phi Correlates to Left-Right Position



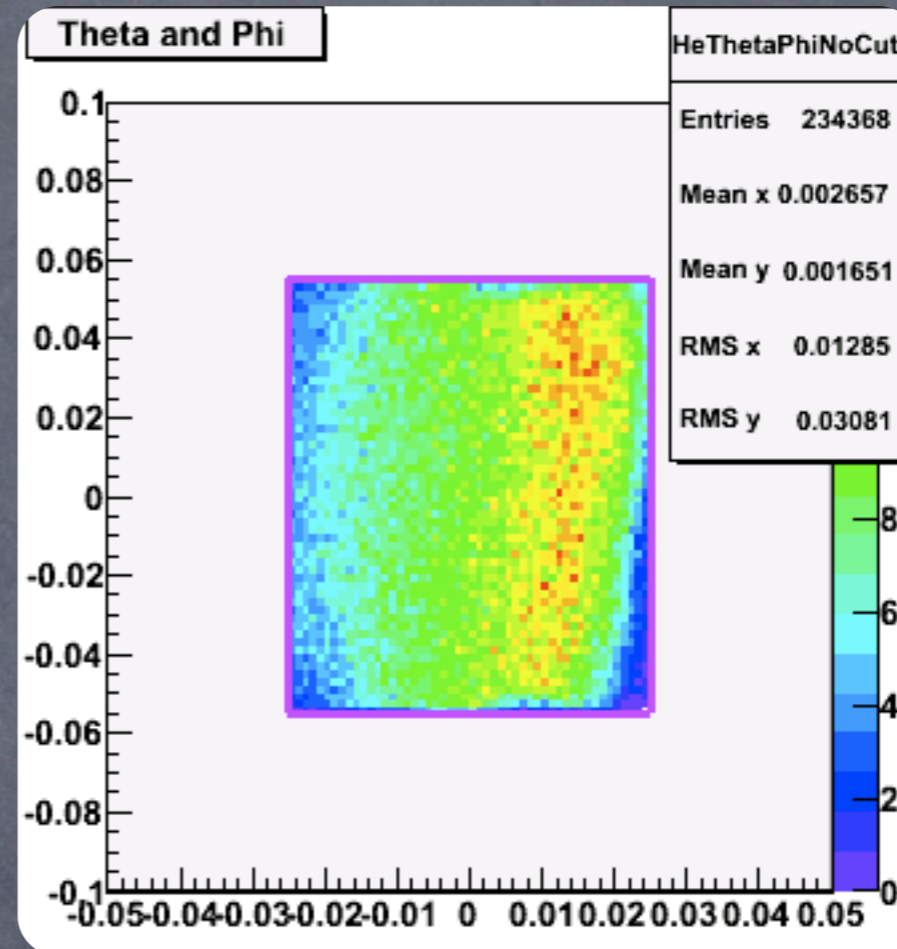
Where are we going?

- ${}^3\text{He}(e,e')$ Asymmetry for $Q^2=1$ with transversely polarized target is checked against Jin Ge's analysis



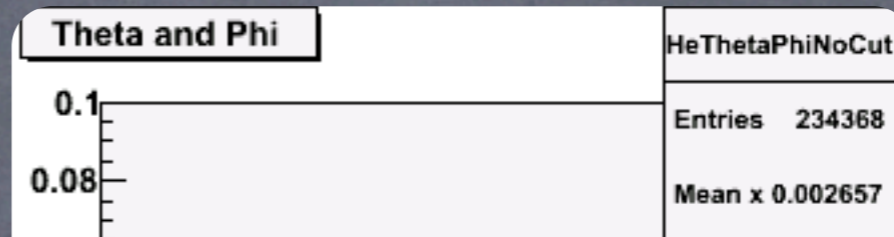
Where are we going?

- Ratio of protons that survive veto cuts



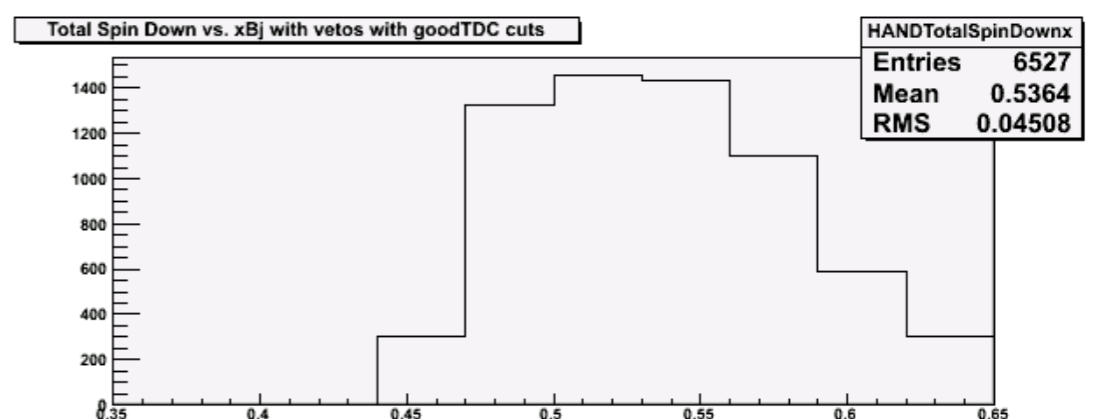
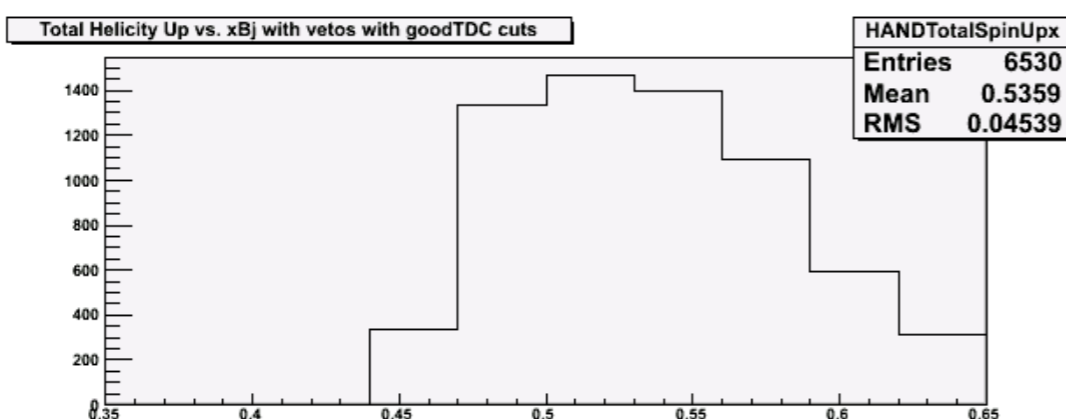
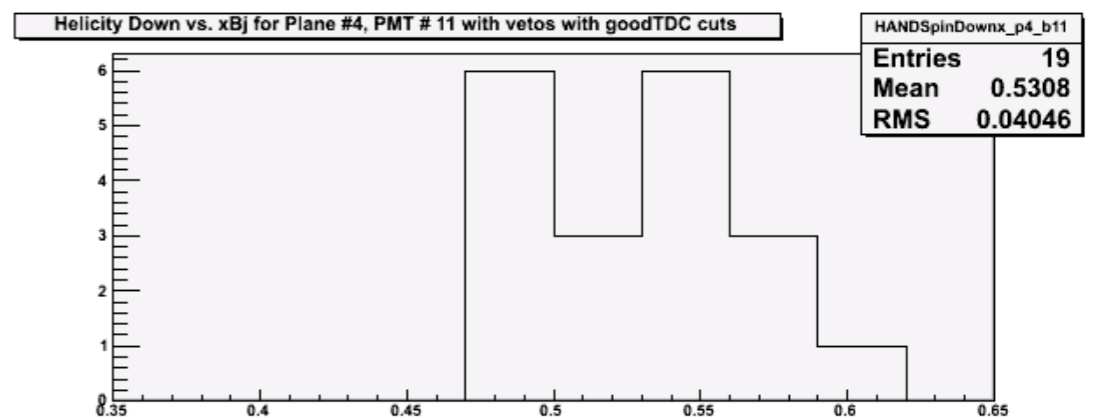
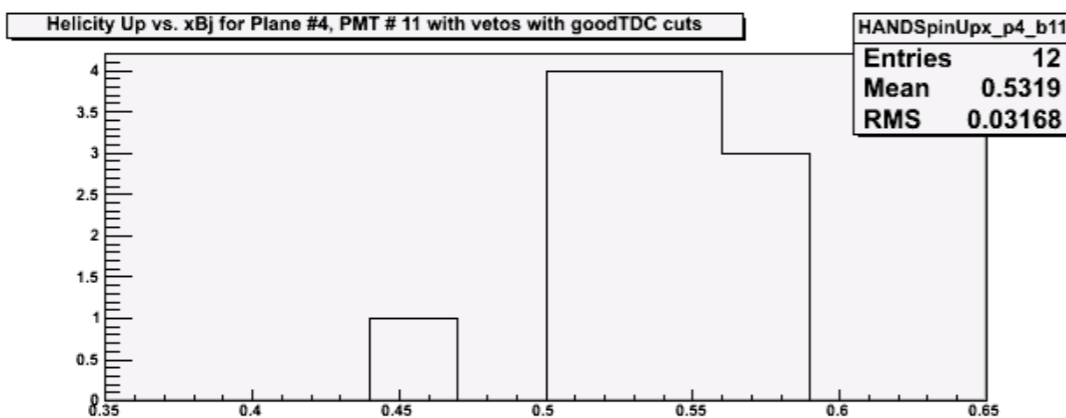
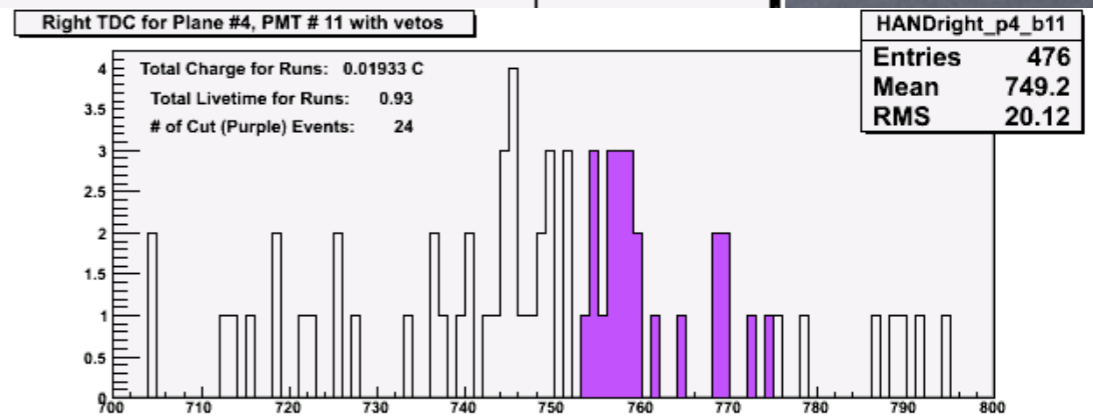
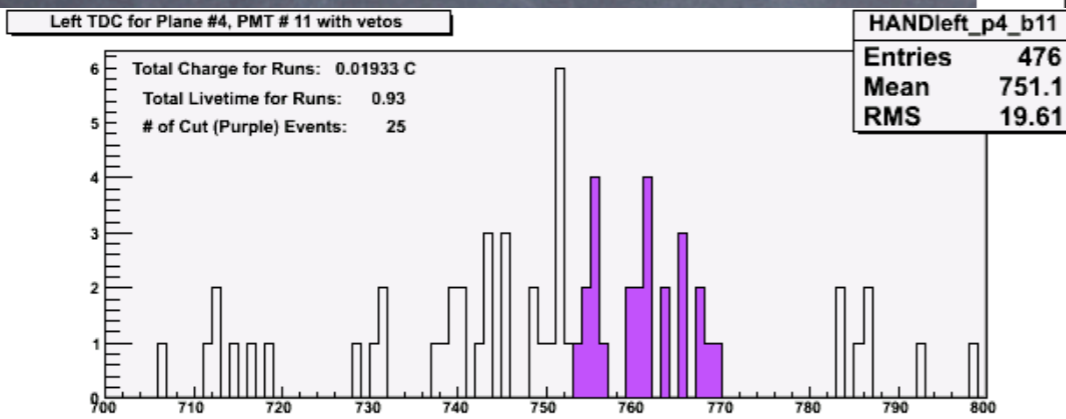
Where are we going?

- Ratio of protons that survive veto cuts



Run # 22441-22441

00	00	00	00
01	01	01	
02	02	01	
03	02	02	01
04	03		
05	04		
06	05	04	02
07	06		
08	06	05	03
09	07		
10	08	07	04
11	09		
12	10	09	05
13	11		
14	11	10	
15	12	11	06
16	13		
17	13	13	
18	14		07
19	15	14	
20	16	15	
21	17	16	08
22	18		
23	18	17	09
24	19		
25	20	18	
26	21	19	10
27	22		
28	22	20	
29	23	21	11



Where are we going?

- Finalize contribution of proton contamination to asymmetry
- Find semi-exclusive ${}^3\text{He}(e,e'n)$ asymmetry by applying neutron cuts on existing (e,e') asymmetry
- Finalize scaling factors and systematic errors of asymmetry

Thank to the Hall A Quasi-Elastic Family of Experiments

E05-015,
E08-005,
and E05-102

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S. Gilad, Massachusetts Institute of Technology (E05-102)
D. Higinbotham, Thomas Jefferson National Accelerator Facility (E05-102, E08-005)
X. Jiang, Rutgers University (E05-015)
W. Korsch, University of Kentucky (E05-102)
B. E. Norum, University of Virginia (E05-102)
S. Sirca, University of Ljubljana (E05-102)
V. Sulkosky, Thomas Jefferson National Accelerator Facility (E08-005)

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P. Bradshaw

M. Canan

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X. Deng

A. Deur

C. Dutta

L. El Fassi

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F. Garibaldi

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S. Golge

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R. Lindgren

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J. St. John

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G. M. Urciuoli

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B. Wojtsekhowski

Z. Ye

X. Zhan

X. Zheng

L. Zhu

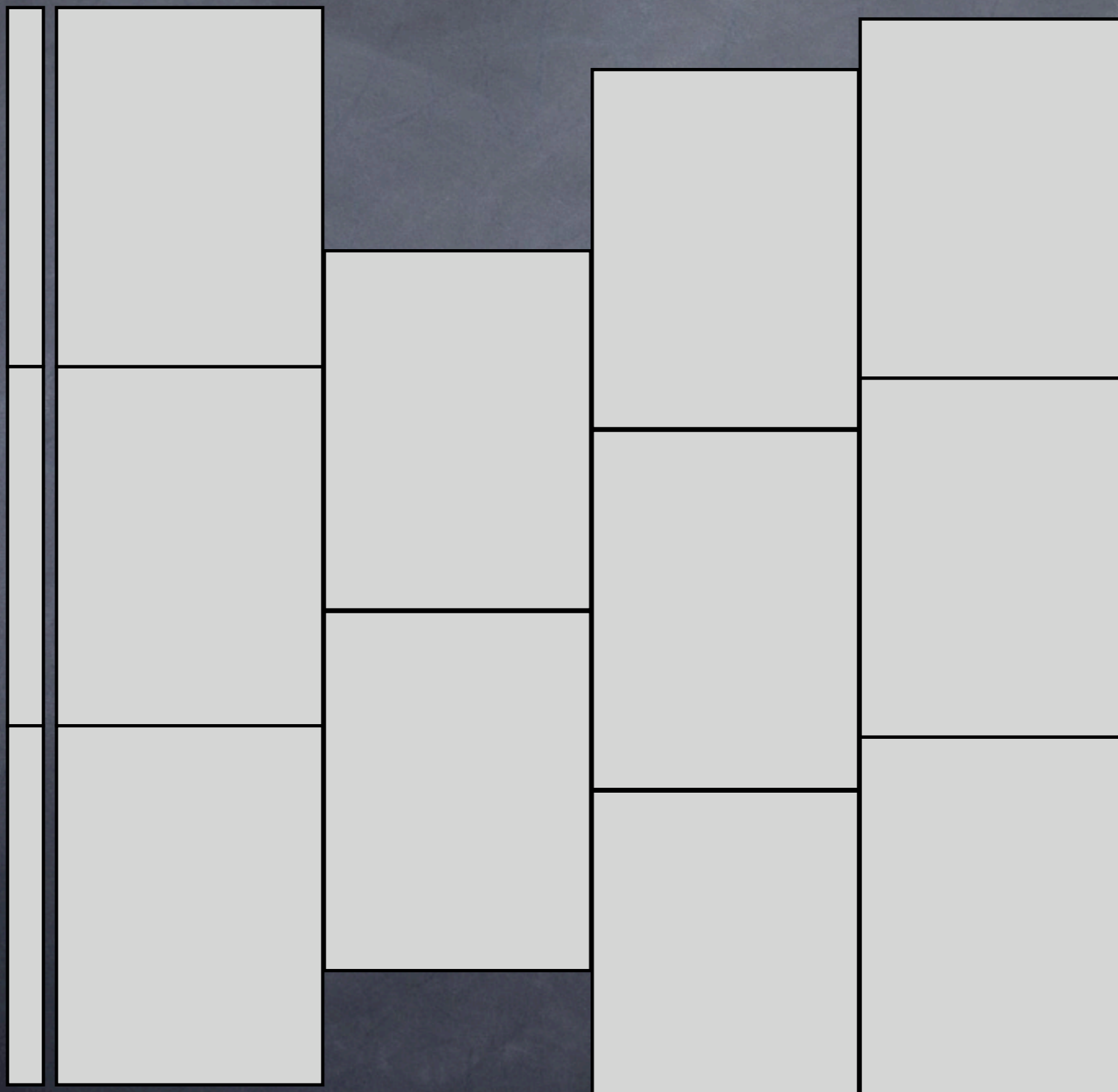
Extra Slides

Yields

$$\text{Yield} = \frac{N}{Q * LT * \rho * \Delta z} * \left(\frac{1}{\varepsilon_{det} * \Delta \Omega * \Delta E'} \right)$$

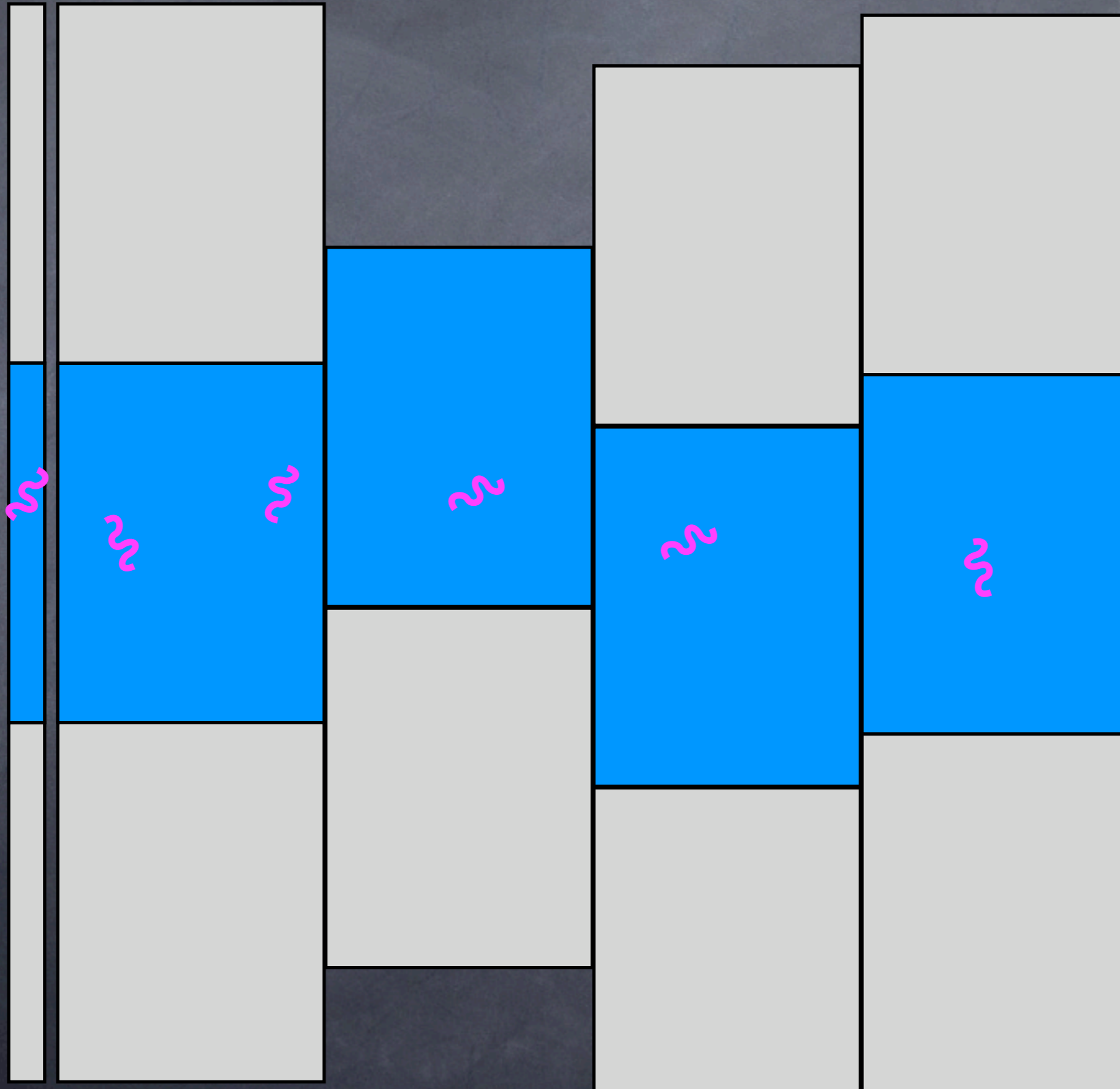
Ignore since
it will cancel

Neutron Detection

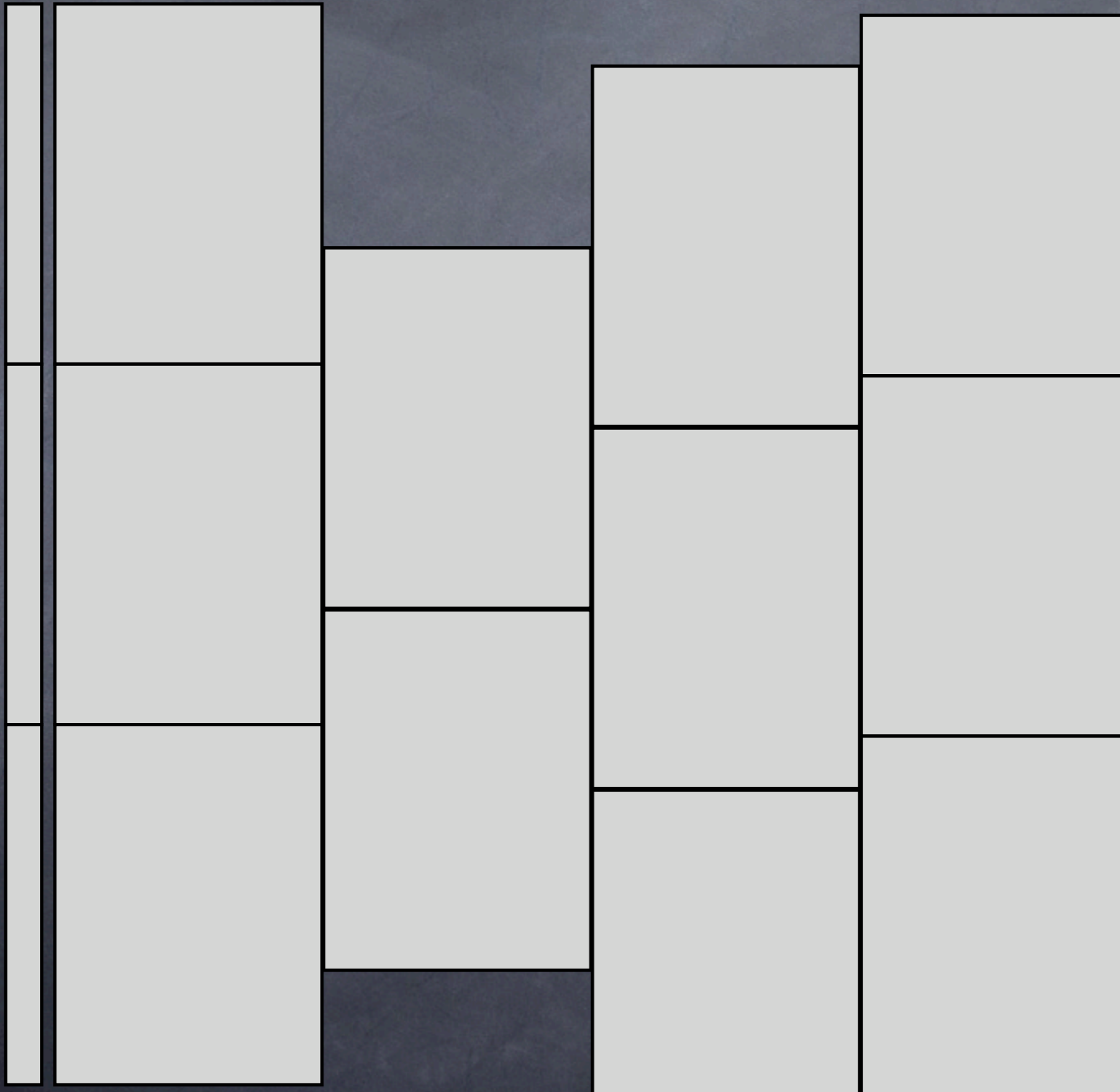


P

Neutron Detection

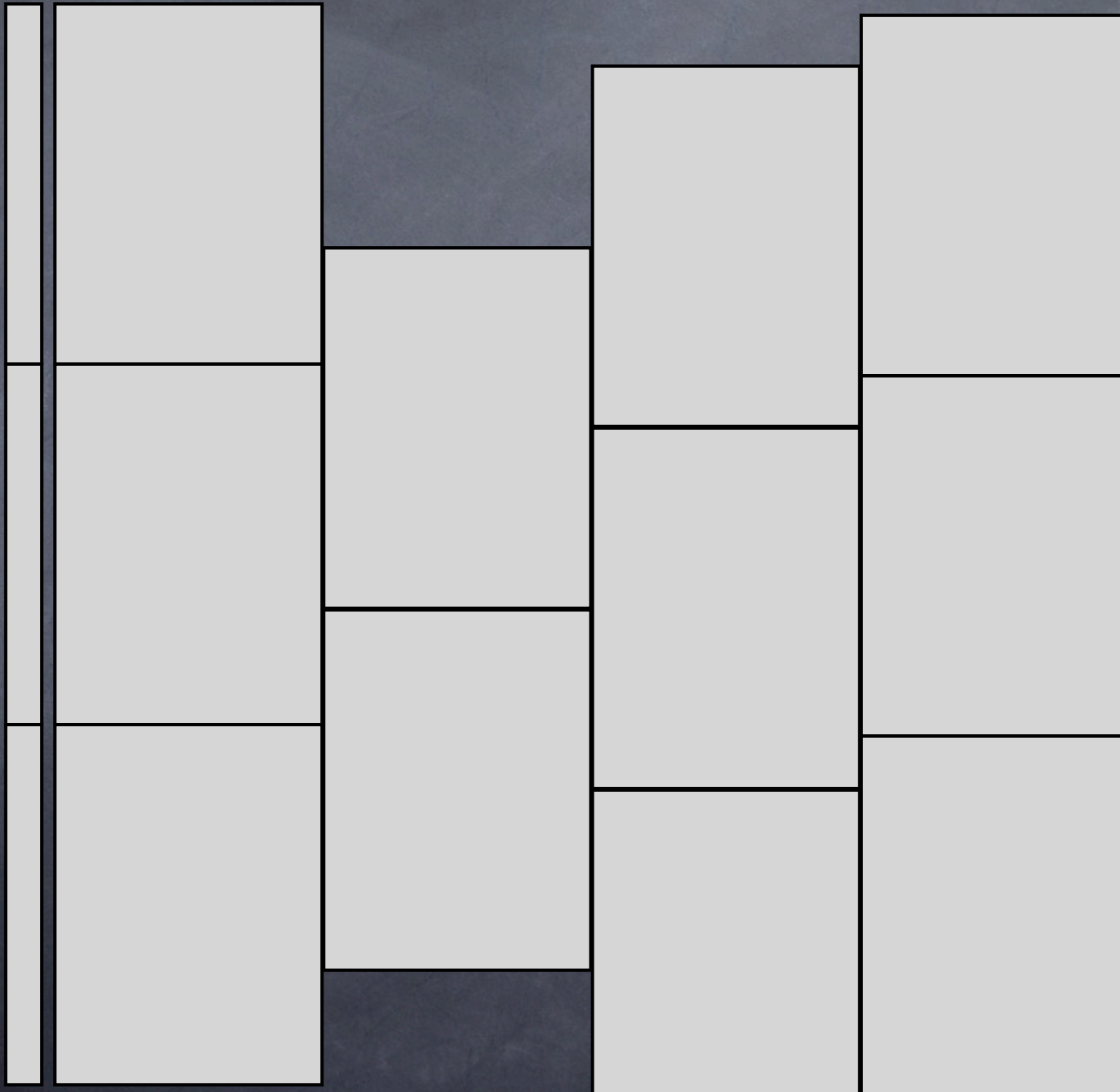


Neutron Detection

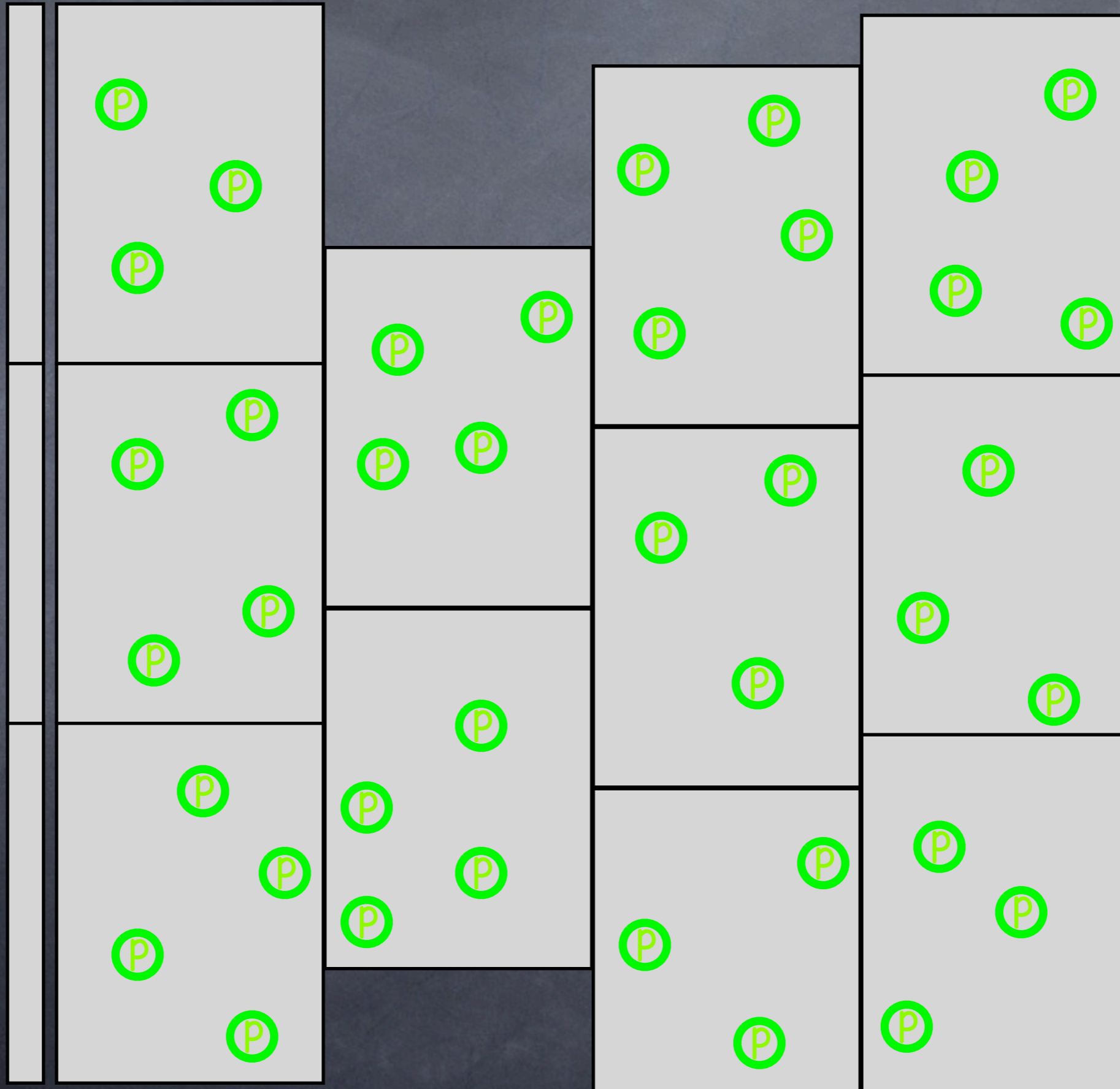


n

Neutron Detection



Neutron Detection



Neutron Detection

