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NUMBERED PAGES
20# PREMIUM PAPER

152 PAGES
11.75" X 9.25"

LAB NOTEBOOK

Look at P10 in walls — April 7, 2010

Wall A = tube 18 could be improved. cutoff = 1.0411
0.985189

Wall B = tube 5

Veto coverage

Veto	Wall	tubes	X
0	A	~~0-11~~ 11-23	
1	A	11-23	
2	B	11-23 (maybe not 23)	
3	B	11-23 (" " ")	
4	B	11-23	
5	A	0-11 ~~-23~~	
6	A	0-11	
8	B	0-11	
9	B	0-11	
10	B	0-11	

I'm not convinced that pedestal events are almost all charged particles. However, there are still som C.P. contamination in the neutron detectors. will try to clean this up a bit more.

the shape matches proton events but why none in the veto?

pedestals don't seem to be a problem in wall B, but in wall A maybe.

- Still some proton contamination we must get rid of somehow.

Veto Coverage looking at

Veto	tubes	X
0		
1	13-23	180-283

Effective PID

GM-T >0
~~GA-T LWOS~~

=> Ok, I think I may revisit this later, but I think neutron PID is OK.

~~A~~ April 19 2010 = Neutrons More-or-less done
File for converting neutron Physics data:
Calibrate.C

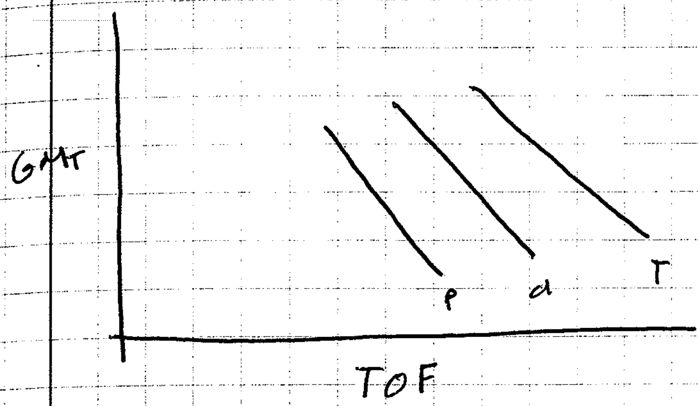
- Move on to LASSA particles

- For Neutrons we still need
  - geometric efficiency
  - Energy efficiency.

LASSA
- Si E calibration
- CsI E calibration
- Si Mapping
- E f vs E Back -> Pixelization
- First Convert Asic[*][*] to LASSA tree

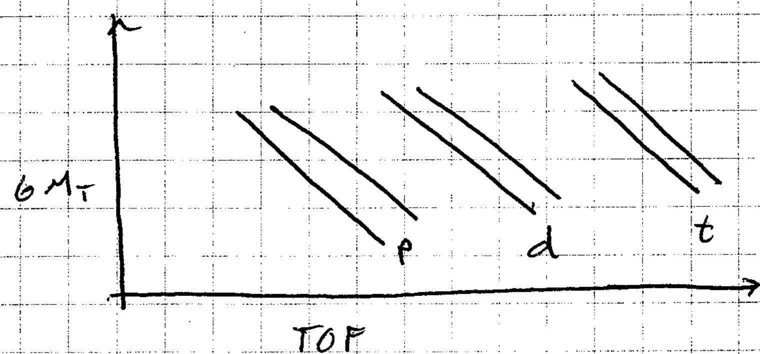
File to convert to Strip, Tel, etc.
LASSA_conv.C

PID Bands in neutron walls — June 26, 2010



Should look like this.

<u>However</u>, we're getting double bands:

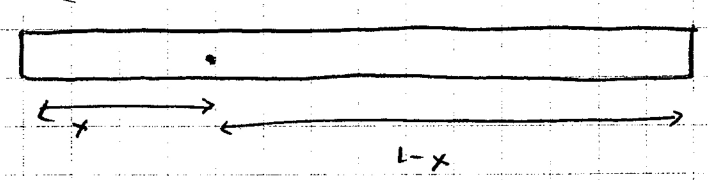


→ ~~It~~ only T_L or T_R must be shifted
⇒ or <u>both</u> shifted by the same amount (global offset)

We must have several events with some offset in TOF.
- Probably poorly calibrated as single tubes seem OK.
- However, the γ peak is so tiny, it's difficult to determine.

Try the following:
- Examine position ~~vs~~ ~~~~ using TOF vs. position using Q
- Finding Position using TOF

$\Delta T = T_L - T_R$



$T_L = \frac{x}{v_L}$ $T_R = \frac{L-x}{v_L}$ ⇒ $T_L - T_R = \frac{2x}{v_L} - \frac{L}{v_L}$

Position using Q_R/Q_L

$$Q_L = Q_0 e^{-x/\lambda} \qquad Q_R = Q_0 e^{-(L-x)/\lambda}$$

$$\frac{Q_R}{Q_L} = \frac{Q_0 e^{-(L-x)/\lambda}}{Q_0 e^{-x/\lambda}} = \frac{e^{-(L-x)/\lambda}}{e^{-x/\lambda}}$$

$$= e^{-(L-x)/\lambda + \frac{x}{\lambda}} = \exp\left[-\frac{L}{\lambda} + \frac{2x}{\lambda}\right]$$

$$x_Q = \ln\left[\frac{Q_R}{Q_L}\right] = \frac{2x}{\lambda} - \frac{L}{\lambda}$$

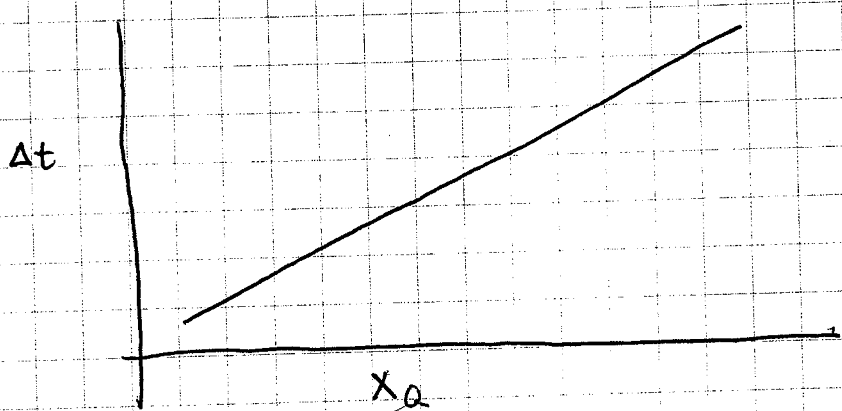
$\lambda \approx 1.2\,m$

when $x = 0$ $\quad X_Q = -1.67$

$x = 2$ $\quad x_Q = 1.67$

* plotting $X_{\Delta TOF}$ vs X_Q.

For No shift in ΔT



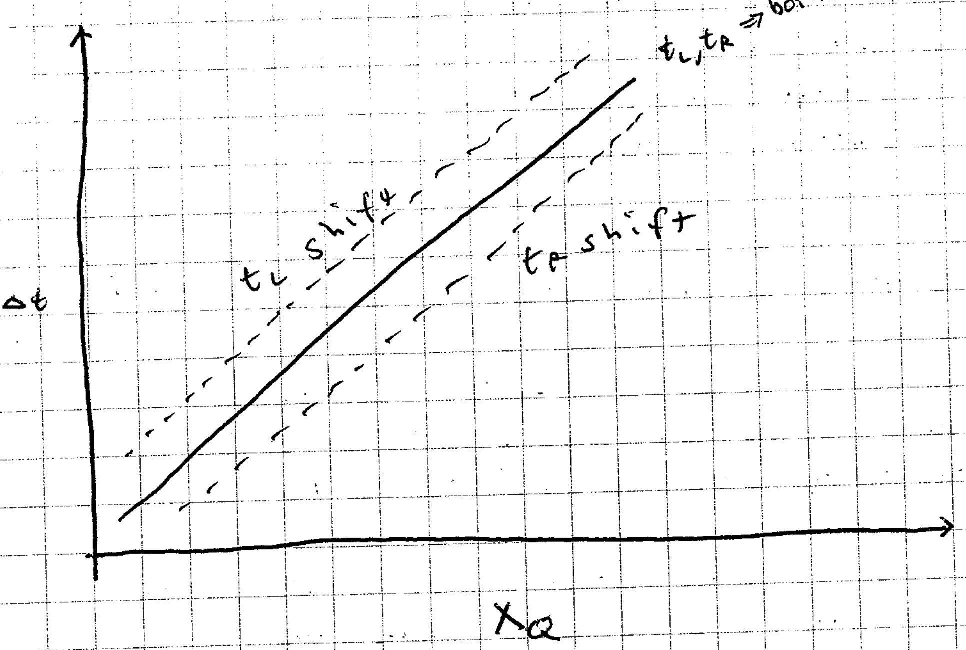
If shift in t

assume $\varepsilon > 0$ if $\varepsilon < 0$ then shift is opposite direction.

$t_L \to t_L + \varepsilon \Rightarrow$ increase in Δt

$t_R \to t_R + \varepsilon$ decrease in Δt

Both shift $\to$ no change in Δt



Solutions

{ Δt vs X_Q is a single line
$\Rightarrow$ both shifted by same amount (global offset)

{ Δt vs XQ is 2 lines
$\to$ only one shifted, (T_L or T_R) always but never other

{ Δt vs X_Q is 3 lines
$\to$ T_L or T_R one or the other ~~at~~ (or both)
$\Rightarrow$ we don't expect this solution!!

* Solution looks like a single line so very likely the global tdc offsets are wrong we can fix these!

Could it be that the QDG gains are that much different $\Rightarrow$ they haven't been calibrated

Recheck γ-peaks : ~~Run~~ Run 793-797

Aug. 20, 2010

Plans for n-p correlations proposal

- How many n-p pairs in wall A?
- what is p straggling
  - through Chamber 3/8" AL?
  - through 7m air?
  - through MoNA covering?
  - through N-wall tubes?

$^{48}Ca + ^{124}Sn$

How many n-p pairs in wall A. runs 792-797

Mult = 2 ⇒ 1.332×10^6 events
Overall w/ 1n+1p ⇒ 167,000 events
In wall A only: 65000 events

If we assume 10% are central collisions then estimate ~6500 for these runs.

This is for 5 hours of running.

- Scale for MoNA ε: ×7 ⇒ 45000 events
- If we want 10^6 events, then 110 hours ⇒ reasonable

Proton Straggling Energy + Angular

~~100~~ ~~50~~ MeV protons
10

Material	ΔE	Eout	σE	σθ mrad
3/8" AL chamber		21.25	0.687	32.56
1/8" plastic scint.		0	Stops	
7m Air				
~1mm plastic covering				

100 MeV protons

Mat	E_{out}	σ_E	σ_θ (mrad)
3/8" Al	83.8189	0.4484 MeV	17.147
1/8" plastic	77.6217	0.2244	7.5745
7 m air	70.3033	0.2125	10.167
1 mm plastic	68.5112	0.07768	4.3365

Total 0.6492 MeV 21.7616 mrad

$\downarrow$

velocity 10.9941 cm/ns σ_x = 15.23 cm !!

σ_{TOF} ~~800~~ 300 ps $\frac{\sigma_t}{t} \approx 0.0047$

$\Rightarrow \frac{\sigma_E}{E} = 2 \frac{\sigma_t}{t}$

$\frac{\sigma_E}{E} \approx 0.0094 \approx 1\% \Rightarrow \sigma_E \approx 0.7$ MeV

$\therefore$ σ_E from TOF $\approx$ 0.7 MeV $\sigma_{E\,tot}$ = 0.955 MeV $\approx 1\%$

σ_E from straggling $\approx$ 0.65 MeV

* Proton of about ~~55~~ 63.05 MeV will not penetrate to the Scintillator.

~~60~~ 65 MeV protons

Material	41.081	E_{lef}	σ_E	σ_θ (mrad)
3/8" Al	~~33.731~~	~~26.005~~	~~0.604~~ 0.566	~~28.044~~ 25.95
1/8" Platic	30.144	~~13.13~~	~~0.276~~ 0.246	~~18.369~~ 15.138
7m Air		11.305	0.352	25.579
1mm plastic		3.40	0.153	26.184

Total 0.726 MeV 47.355 mrad

⇓

σ_x : 33 cm

From TOF

$$\frac{\sigma_E}{E} = \frac{2\sigma_T}{T} : 0.0052 \quad \sigma_{E_{TOF}} : 0.339 \text{ MeV}$$

$\sigma_{E_{TOT}}$: 0.801 MeV => 1.2%

Sept. 21, 2010 Todo

Neutrons

~~correct for~~

- ~~σ_E~~ E correction
  - geometri
  - intrisic

(ASS)

- Position determination
- Energy calibration
-

→ Next thing to do is E calibration for each strip

α Source ^{228}Th calibration : Run 822-824

12-Oct-2010

Si ^{228}Th calibration

Use 4 largest ^{228}Th peaks

(NOTE: Check to see if SnPb foil was removed
I think it was!)
It must have been removed,

Energies of largest peaks

5.423
5.685 — 6.051 [~~6.05 + 6.09~~]
6.288
6.778
8.784 (probaby doesn't appear)

Fitting to peak   File: Back_Si_cal.dat   *

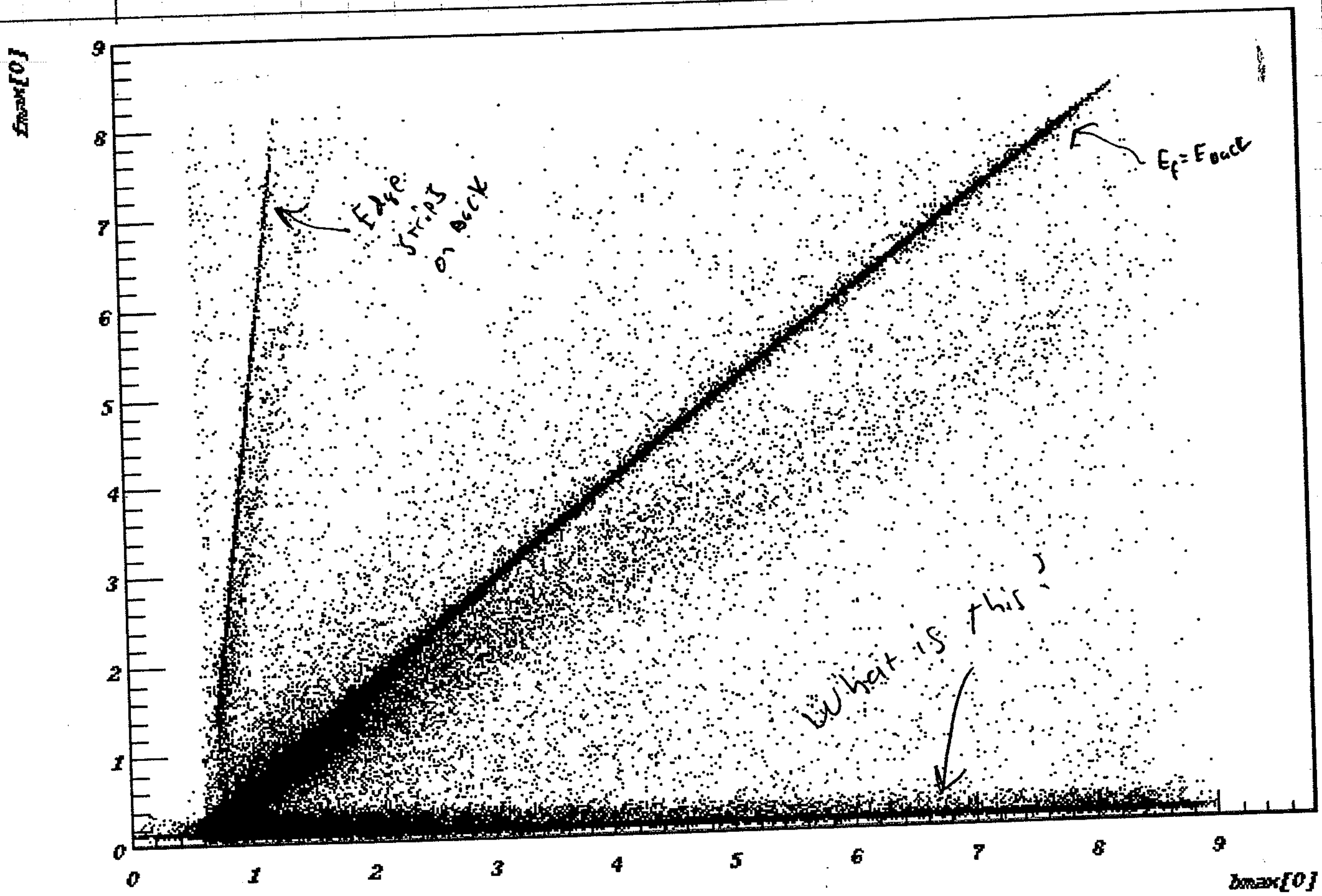
Strips to recheck

Back Tel	Strip	
0	5	(dead!)
	~~8~~	(only 3 pks)
1	~~1~~	
	~~8~~	
	~~10~~	
	~~11~~	
2	~~8~~	
	~~11~~	
	12	(dead!)
	13	(dead!)
	~~14~~	(dead!) → (Shouldn't be!)
3	0	(dead!)
4	0	(dead!)
	~~11~~	
5	~~8~~	
	~~10~~	
	~~11~~	
	13	(dead!)
	15	(dead!)

Front Tel	Strip	
0	[0]	
	14	(dead!)
	15	(dead!)
1	0	(dead!)
	[1]	(higher gain)
	~~6~~	
	~~4~~	should be OK
2	6	(dead!)
	~~15~~	Should be OK
3	~~8~~	High gain
	~~8~~	Should be OK
	[11]	(Should be OK)
	~~11~~	
4	~~12~~	
5	~~12~~	

Now SnPb is 14.82 mg/cm²
[illegible] (~ 1/10)

LASSA Calibration



Maximum Front vs. Maximum E on back

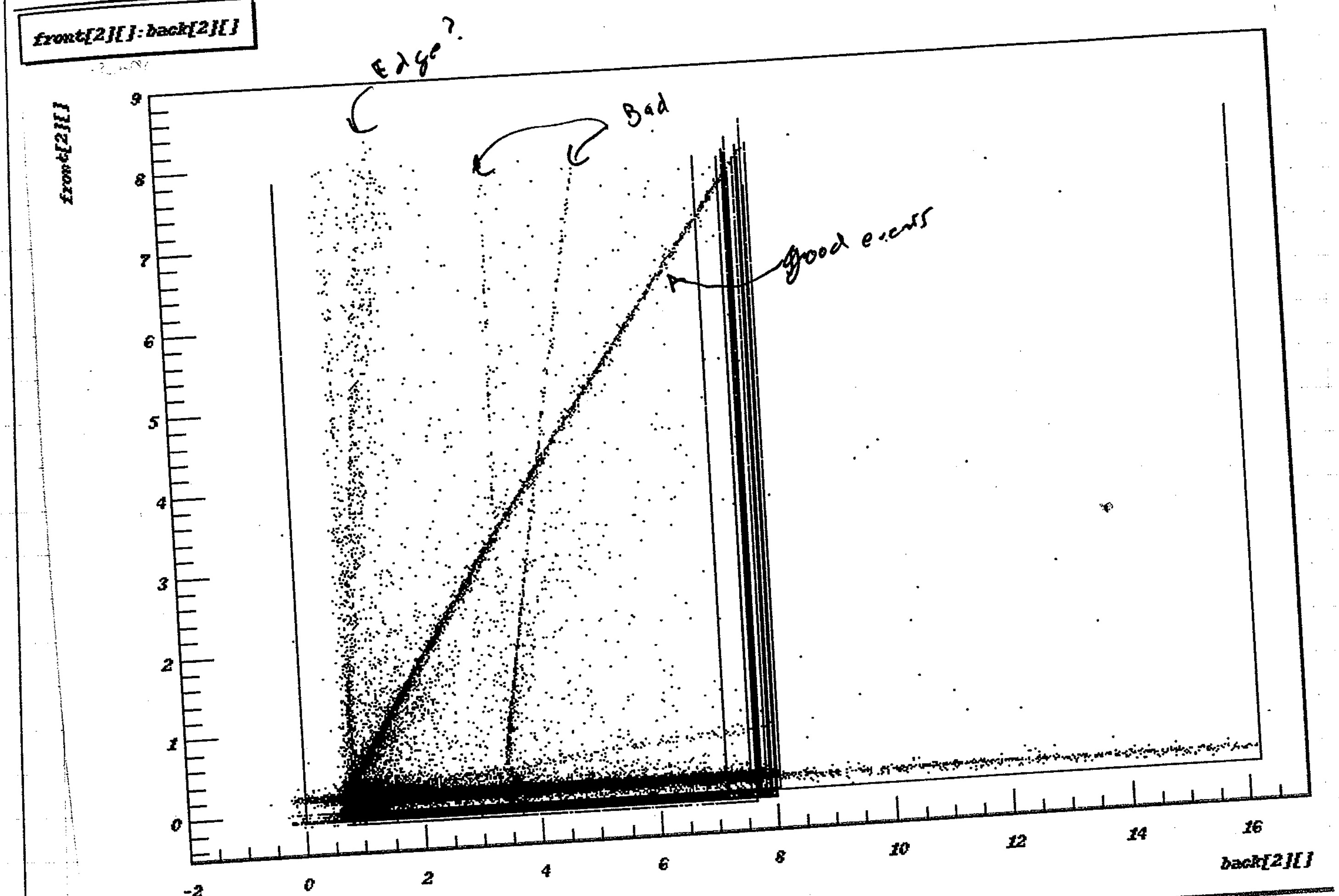
What is the Band where $E_f \approx 0$ and $E_{back} > 0$?
· Edge strips?

We don't have a corresponding Back band because that's at Max pedestal since the back is reverse energy and it gets cut out.

10-Dec-2010

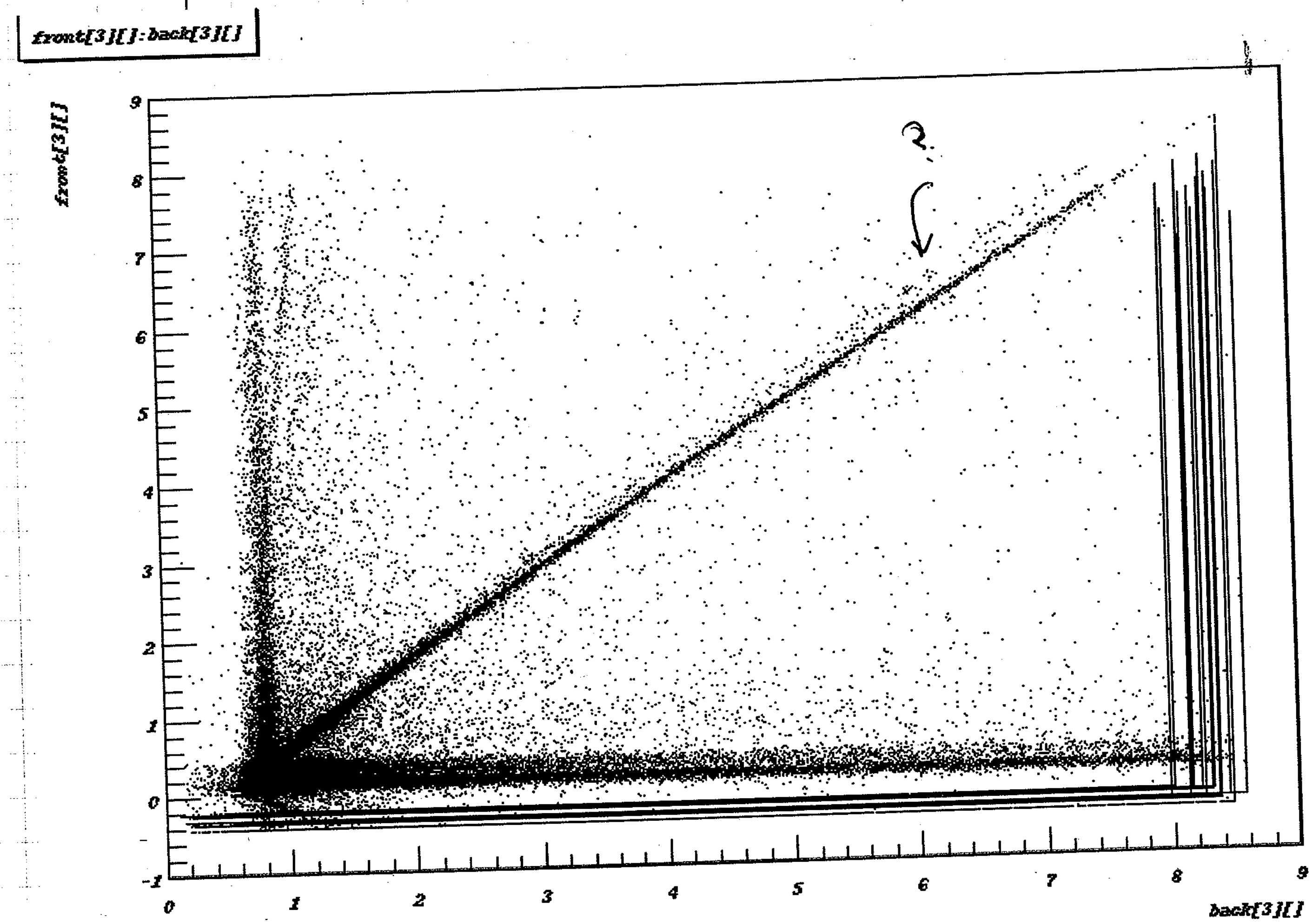
LASSA Si Detectors

Finishing pixelization routine



- All Front vs all back for Telescope 2
  Bad events look like a bad Calibration

Telescope 0,1,4,5 look ok (except correct for edge strips maybe)



Maybe a non-correlated line in Telescope 3

- It looks like we also have second order corrections in LASSA → Front maybe. we'll have to use pulser data to correct for this.
- Try the following
  - First linearize pulser data
  - Then calibrate & data

- Definitely appears non-linear on the back.

Linearize Si Using pulser data | 24-Dec-2010

· fit using 2nd order polynomial

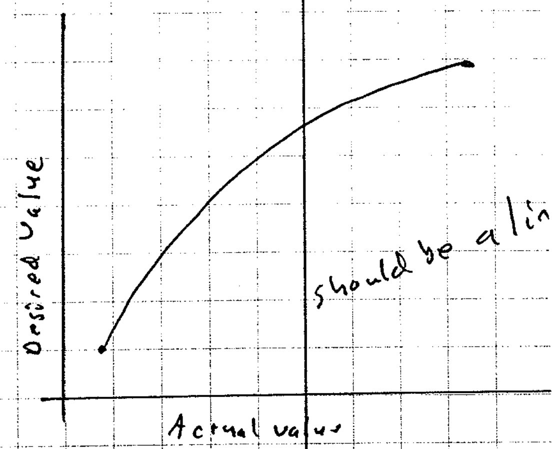
Strips to look at again

$E = A + Bx + Cx^2$

x = channel

E = pulser value → what it should be

A, B, C = fit values



Back

Tel	Strip	comment
0	3	too many pks ✓
	5	No peaks ✓
	7	Not enough pks ✓
	8	Too Many pks ✓
	9	Too Many pks ✓
1	1	Not enough pks ✓
3	0	No pks ✓
4	~~0~~	No pks ✓
	~~2~~	(Maybe (more)
	~~3~~	" "
	~~7~~	" "
	~~8~~	"
	~~9~~	"
	~~10~~	"
	~~12~~	"
	14	"
5	13	No pks ✓
	15	No pks ✓

Front

Tel	Strip	comment
0	0	No pks ✓
	7	too many
	11	too many → Bad fit
	12	too many
	14	No pks ✓
	15	No pks ✓
1	0	dead ✓
	5	too many
	6	too many
	7	too many
	↓	All bad
	15	
4	5	too many
	6	"
5	5	too many

Just tele 2 F left
~~Front~~ Back

- Don't seem to have pulser data for Fcn Tele 2b However, the front seem very linear, so we can match the back to the front on this.

To do

~~Front 2~~

- Back 2 (Missing)

✓ - Front 2 redo to be sure

- Back 3 ✓

- Front 3 ✓

3-Jan-2011

Telescope 2

~~Front~~ Strip	Front Comment	Back
0	~~too many~~ OK	↑ Missing file ↓
1	OK	
2	OK	
3	OK	
4	too many ✓	
5	OK	
6	missing	
7	OK	
8	OK	
9	too many ✓	
10	too many ✓	
11	too few	
12	ok	
13	ok	
14	ok	
15	ok	

Teloscopes

~~Front~~

Strip	Front	Back
0	✓	
1	OK	
2	Missing lower ✓	
3	OK	
4	OK	
5	OK	
6	Missing	
7	OK	
8	too many upper ✓	
9	" " ✓	
10	" ✓	Too few
11	"	
12	" ✓	
13	" ✓	
14	" ✓	
15	"	

3-Jan-2011

Class A is much better linearized

- Except for 2B !!

- To do:
  - Linearize 2B
  - Calibrate using γ.

To linearize 2B we need to compare to 2F.

linearizing 2B

Fit to 2F (same strips)

Strip	a	b	c
0	-1557.26	1.22361	-8.8952×10^{-6}
1	-1595.25	1.18401	-7.8271×10^{-6}
2	-1754.03	1.24867	-8.64927×10^{-6}
3	-1441.82	1.1756	-8.14514×10^{-6}
4	-1783.19	1.30784	-8.00794×10^{-6}
5	-1674.55	1.23353	-8.33602×10^{-6}
6	-1736.63	1.17398	-7.17533×10^{-6}
7	-1613.22	1.1937	-7.23005×10^{-6}
8	-1631.06	1.20469	-8.43384×10^{-6}
9	-1562.18	1.24722	-1.00795×10^{-5}
10	-1623.2	1.22976	-8.1418×10^{-6}
11	-1970.81	1.16877	~~-7.2517~~ -7.25317×10^{-6}
12	Dead channel		
13	-4478.93	2.75638	-3.66989×10^{-5}
14	-4338.68	2.56019	-2.5652×10^{-5}
15	-1525.16	1.17919	-8.02071×10^{-6}

Maybe look at again (Low Gain) — strips 13, 14

4-Jan-2011

* All Strips linearized

Next Steps

- Q calibration again
  - remake files w/ linearized strips
  - redo calibration
  - run 824

q-calibration

Back strips

Tel	Strip	comment
0	5	dead ✓
0	14	also 8.778 MeV
1	2	dead? (need to cut pedestal) ✓
	12	too many ✓
2	1	pedestal ✓
	3	" ✓
	4	Bad ✓
	6	~~Ped~~ Bad ✓
	7	" ✓
	8	" ✓
	11	~~s~~ Ped ~~✓~~
	15	" ✓
3	0	dead. ✓
	9	wrong PK ✓
4	0	dead ✓
	1	Ped ✓
5	3	May 8.778
	5	" ✓
	7	" ✓
	13	dead ✓

Strips w/ 8.778 M

T	S
0	6
	8
	14
5	7

9 - Calibration on Front

Tel	Strip	Comment
0	0	dead? ✓
	8	Bad ✓
	14	dead ✓
	15	dead ✓
1	0	dead ✓
	→ 1	dead
	6	Bad ✓
	7	Bad ✓
2	4	" ✓
	6	dead ✓
3	2	Bad ✓
	11	dead ✓
4	4	bad ✓
	6	bad ✓
	12	bad ✓
	13	bad ✓
	14	bad ✓
	15	bad ✓
1	14	bad ✓

5 Jan 2011

Have to reexamine the following:

✓ Back 0 ⇒ Shifted (All), otherwise good Cal.
Back 1 ⇒ Also shifted but some strips wrong.
Back 2 ⇒ all bad.
Back 3 ⇒ shifted.
Back 4 ⇒ wrong cal
Back 5 ⇒ shifted.

→ Wrong calibration file ⇒ Fixed!

LASSA position Calibrations

7-Jun-2011

Corner measurements using Romer arm data.

	LASSA0			LASSA1			LASSA2			LASSA3			LASSA4			LASSA5		
	x	y	z	x	y	z	x	y	z	x	y	z	x	y	z	x	y	z
TR	2481.438	84.046	52.085	2481.728	83.538	49.973	2481.716	83.551	47.792									
TL	2483.259	84.882	52.091	2483.546	84.359	49.985	2483.548	84.374	47.808	2485.164	85.999	51.086	2485.404	85.818	48.933	2486.548	87.696	49.927
BL	2483.494	84.364	50.169	2483.577	84.346	47.986	2483.346	84.878	45.880	2485.368	85.783	49.113	2485.231	86.026	46.949	2486.568	87.690	47.918
BR	2481.673	83.529	50.165	2481.757	83.525	47.973	2481.514	84.056	45.863									
TL-TR	2.004			1.995			2.009			2.013			2.004			2.003		
BL-BR	2.003			1.997			2.008			2.012			2.003			2.001		
TL-BL	2.004			1.999			2.002			1.995			2.002			2.009		
TR-BR	2.002			2.000			2.005			1.998			2.000			2.010		
estimated center	2482.466	84.205	51.128	2482.652	83.942	48.979	2482.531	84.215	46.836	2484.502	85.236	50.097	2484.554	85.274	47.941	2486.010	86.855	48.927

Preliminary Results

	Target x	y	z	
Post	2479.072	91.107	4.272	Take Z height as center of LASSA 5 +.098" from iges location guesses.
Post-mod	2479.012	91.107	49.025	Also, move x position back 0.060" to conform with igel file step side location in viewer position

	LASSA0	LASSA1	LASSA2	LASSA3	LASSA4	LASSA5	
T-Dist-Face (inch)	7.999	8.037	8.043	8.109	8.119	8.189	
T-Dist-Face (mm)	203.177	204.133	204.280	205.972	206.211	208.008	
Theta(deg)	64.418	63.069	64.051	47.389	46.952	31.289	To Center of Detector
Phi(deg)	16.944	-0.364	-17.620	10.348	-10.530	-1.320	To Center of Detector

Key

TR is Top Right, TL is Top Left, BR is Bottom Right and BL is Bottom Left
TL=TR is the 3d distance from top left to top right, qne similarly for the others
As an estimate of the coordinates of the center of the detector, I just took the average of the 4 corners for each dimension.
(black box) = GC added a plane not seen in iges file, always to right side (vault door side) displaced from existing iges plane. where it was most difficult to direct the probe so that the plane determined was on correct side of ball. Offset was always 0.1181", or 3.00 mm (diameter of ball on tip of probe.)

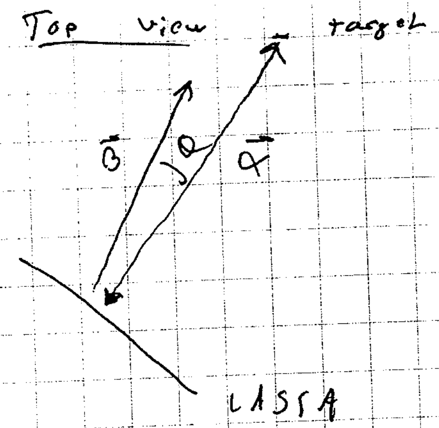
Determining angle between detector face normals and vector from nominal target position to face of detector

	LASSA0 x	LASSA0 y	LASSA0 z	LASSA1 x	LASSA1 y	LASSA1 z
LASSA Vector TR-BL	-2.056	-0.318	1.916	-1.849	-0.808	1.987
LASSA Vector TL-BR	1.586	1.353	1.926	1.789	0.834	2.012
LASSA Normal Vector	-3.205	6.999	-2.277	-3.283	7.275	-0.097
LASSA Normal Magnitude	8.027			7.982		
LASSA to Target Vector	-3.454	6.902	-2.103	-3.640	7.165	0.046
Lassa to Target Magnitude	7.999			8.037		
LASSA Normalized Normal	-0.399	0.872	-0.284	-0.411	0.911	-0.012
LASSA to Target Normalized V	-0.432	0.863	-0.263	-0.453	0.892	0.006
Angle Between vectors (deg)	2.275			2.833		
LASSA Angle to Lab System	66.470			65.714		

	LASSA2 x	LASSA2 y	LASSA2 z	LASSA3 x	LASSA3 y	LASSA3 z
LASSA Vector TR-BL	-1.630	-1.326	1.912	-1.733	-1.094	1.969
LASSA Vector TL-BR	2.034	0.319	1.945	1.323	1.526	1.980
LASSA Normal Vector	-3.189	7.060	2.179	-5.171	6.036	-1.197
LASSA Normal Magnitude	8.047			8.038		
LASSA to Target Vector	-3.519	6.892	2.189	-5.490	5.871	-1.072
Lassa to Target Magnitude	8.043			8.109		
LASSA Normalized Normal	-0.396	0.877	0.271	-0.643	0.751	-0.149
LASSA to Target Normalized V	-0.438	0.857	0.272	-0.677	0.724	-0.132
Angle Between vectors (deg)	2.637			2.654		
LASSA Angle to Lab System	66.653			49.961		

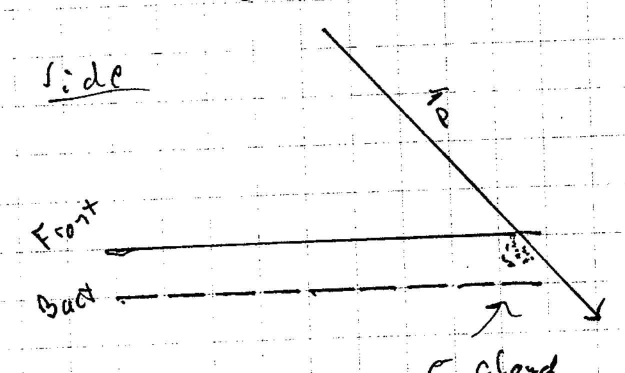
	LASSA4 x	LASSA4 y	LASSA4 z	LASSA5 x	LASSA5 y	LASSA5 z
LASSA Vector TR-BL	-1.355	-1.504	1.982	-1.116	-1.671	2.018
LASSA Vector TL-BR	1.700	1.088	1.984	1.075	1.681	2.001
LASSA Normal Vector	-5.140	6.058	1.083	-6.736	4.402	-0.080
LASSA Normal Magnitude	8.018			8.047		
LASSA to Target Vector	-5.542	5.833	1.084	-6.998	4.252	0.098
Lassa to Target Magnitude	8.119			8.189		
LASSA Normalized Normal	-0.641	0.755	0.135	-0.837	0.547	-0.010
LASSA to Target Normalized V	-0.683	0.718	0.134	-0.855	0.519	0.012
Angle Between vectors (deg)	3.189			2.264		
LASSA Angle to Lab System	50.127			33.172		

LASSA angle deviations.
That is, which way is LASSA *really* pointing compared to the LASSA - target vector



$\vec{\alpha}$ = vector from LASSA center to target
$\vec{B}$ = vector ⊥ to LASSA center

NOTE: Maybe we can use this to verify edge strip effects.
That is, a particle may enter a front but not entirely hit a back.

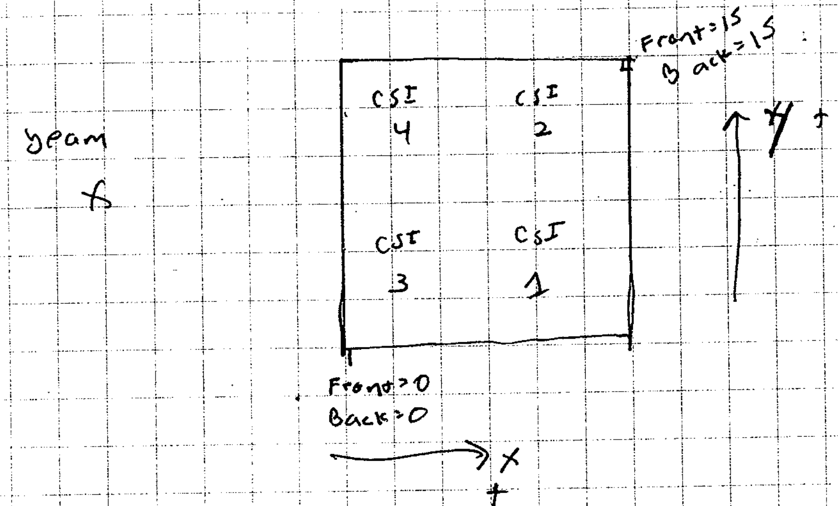


LASS A position

Miscellaneous Measurements

	x	y	z
Start Array Upstream Position	2286.275	n/a	n/a
Chamber Main Flange	n/a	n/a	44.116
GateValve US	2260.513	n/a	n/a
Ring 5 Base	n/a	n/a	28.997
Ring 5 Plane	2489.3	"+/-"	0.3

LASS A orientation - Beam view



* Double check CsI

0-Jan-2011

Verify L4SSA calibrations.

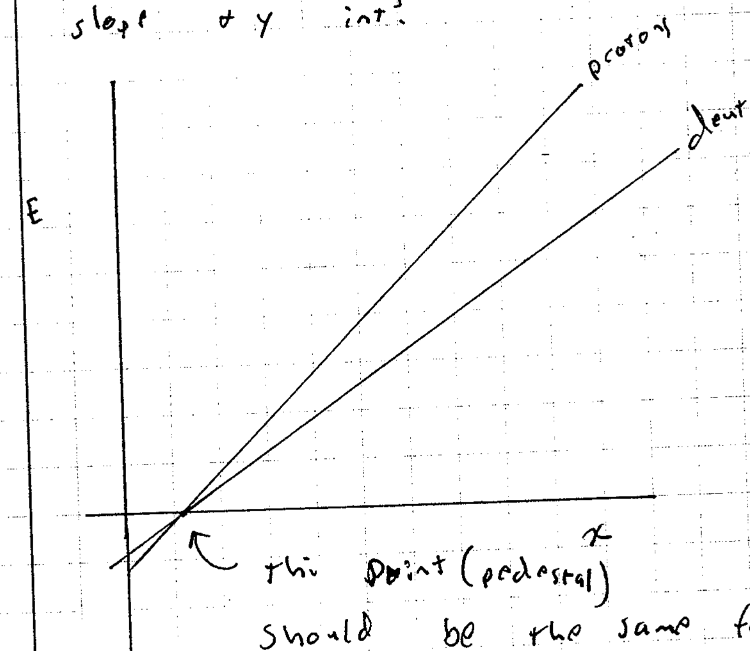
Punchthrough Energies in 6cm CsI (L4SS4)

Particle	E
p	146.84
d	193.852
t	~~612.714~~ 232.03
^3He	521.918
^4He	586.109

Need a separate Calibration for d, t.

$$E_p = m_p X_p + b_p$$
$$E_d = m_d X_d + b_d$$

Using proton calibration for deuterons, can we correct slope & y int?



Both have different slope and y-int

↖ this point (pedestal) should be the same for both.

try to use proton cal for deuterons, and find a relation to map to deuteron E

$$E_p' = m_p x_d + b_p$$ → deuteron energy using p calibration

$$x_d = \frac{E_d - b_d}{m_d}$$

$$E_p' = \frac{m_p}{m_d}(E_d - b_d) + b_p$$

$$E_p' = \frac{m_p}{m_d} E_d - \frac{m_p}{m_d} b_d + b_p$$

* we know two points

  - Deuteron punchthrough
  - $E_d = 0$

we also know m_p b_p

when $E_d = 0$, $E_p = 0$
- E_d = punch → E_p given.

For $E_d = 0$

$$0 = \frac{m_p}{m_d} \emptyset - \frac{m_p}{m_d} b_d + b_p \Rightarrow b_p = \frac{m_p}{m_d} b_d$$

at deuteron punchthrough:

$$E_p' = \frac{m_p}{m_d} E_d - \frac{m_p}{m_d} b_d + b_p = \frac{m_p}{m_d} E_d$$

$$E_p' = \frac{m_p}{m_d} E_d \Rightarrow m_d = m_p \frac{E_d}{E_p'}$$

$$b_p = \frac{m_p}{m_d} b_d$$

$$\Downarrow$$

$$b_d = \frac{m_d}{m_p} b_p = \frac{m_p E_d}{\frac{E_p'}{m_p}} b_p = \frac{E_d}{E_d'} b_p$$

- So, using the p calibration and measuring the d and t punchthrough, we can correct the d + t energies

E_p' = energy using p calibration
E_d = true deuteron energy (punchthrough)

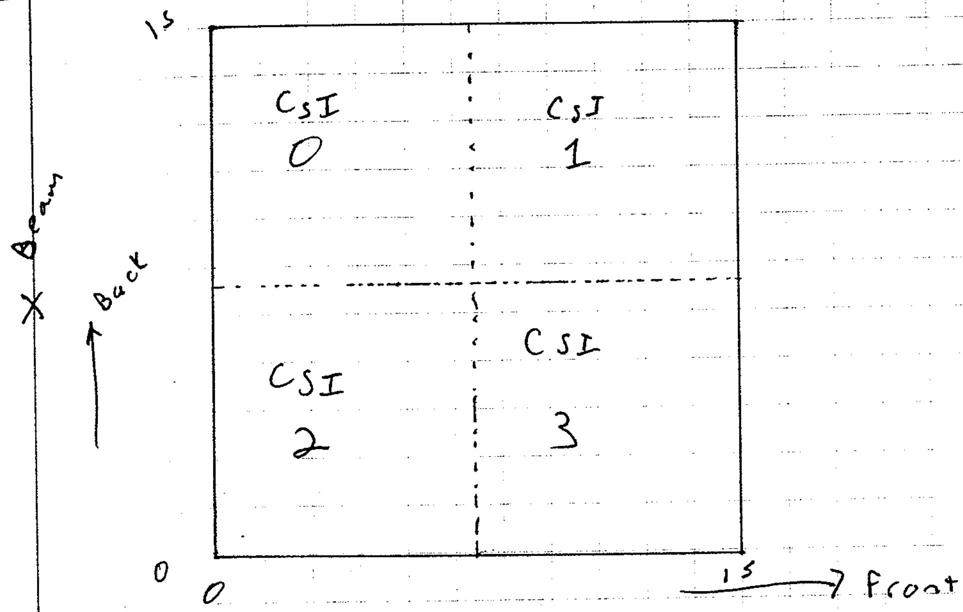
Deuteron punchthrough E_p'

Deuteron Punchthrouth	195.852									
Triton Punchthrough	232.03									
		Deuteron	Triton							
Telescope	CsI	E'_p	E'_p	m_p	b_p	m_d	b_d	m_t	b_t	Notes
0	0	199.068	247.838	0.108918	-27.7959	0.107158399	-27.34684935	0.101970818	-26.02297742	
	1	203.5	249.238	0.082421	-18.042	0.079323428	-17.36393997	0.076730453	-16.79633627	
	2			0.0544187	-11.0144	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	Spectrum cuts off
	3	207.685	241.755	0.103973	-18.3097	0.098049065	-17.26649187	0.099790512	-17.57316163	Difficult to see
1	0	204.418	240.355	0.0821718	-14.832	0.078728446	-14.21047493	0.079325676	-14.31827489	
	1	206.285	247.356	0.0781932	-14.9036	0.074238527	-14.14984060	0.073348406	-13.98018365	
	2	197.884	239.088	0.0699148	-13.8641	0.069196870	-13.72173452	0.067850879	-13.45482468	
	3	202.551	242.689	0.0814018	-14.3756	0.078709586	-13.90015360	0.077826600	-13.74421778	
2	0	200.217	244.089	0.11648	-26.639	0.113940579	-26.05823396	0.110725409	-25.32292389	the t channel is very difficult to see for many channels.
	1	202.084	242.689	0.0875843	-20.6611	0.084883317	-20.02393934	0.083737562	-19.75365605	
	2	205.351	247.356	0.110868	-22.9385	0.105739536	-21.87742500	0.103998698	-21.51724702	
	3	200.217	237.555	0.0778904	-16.9256	0.076192284	-16.55659915	0.076078843	-16.53194826	
3	0	204.885	244.089	0.155574	-16.0864	0.148715031	-15.37718043	0.147888005	-15.29166571	
	1	203.018	244.089	0.145275	-35.6649	0.140147176	-34.40602309	0.138097818	-33.90290733	
	2	204.418	246.422	0.135324	-31.9636	0.129653338	-30.62418665	0.127420554	-30.09680186	
	3	206.285	246.422	0.142207	-25.9812	0.135014787	-24.66718367	0.133901560	-24.46379721	
4	0	203.951	245.489	0.137608	-25.2097	0.132143515	-24.20860974	0.130063605	-23.82757146	
	1	199.284	240.355	0.104321	-36.5957	0.102524420	-35.96546153	0.100707710	-35.32816156	
	2	201.151	244.089	0.0976323	-17.2223	0.095060334	-16.76860617	0.092808863	-16.37144758	
	3	204.418	245.489	0.103944	-16.392	0.099588296	-15.70510417	0.098245242	-15.49330422	
5	0	199.751		0.0598768	-11.0952	0.058708047	-10.87862945	#DIV/0!	#DIV/0!	T cut off
	1	202.084	243.155	0.0722121	-12.0666	0.069985176	-11.69448221	0.068908201	-11.51452036	
	2	205.818	248.756	0.0895504	-9.91323	0.085214242	-9.433217318	0.083529158	-9.246678500	
	3	199.751		0.0626841	-10.7253	0.061460550	-10.51594964	#DIV/0!	#DIV/0!	T cut off

Fit Parameters for d, t.

<u>To do</u>

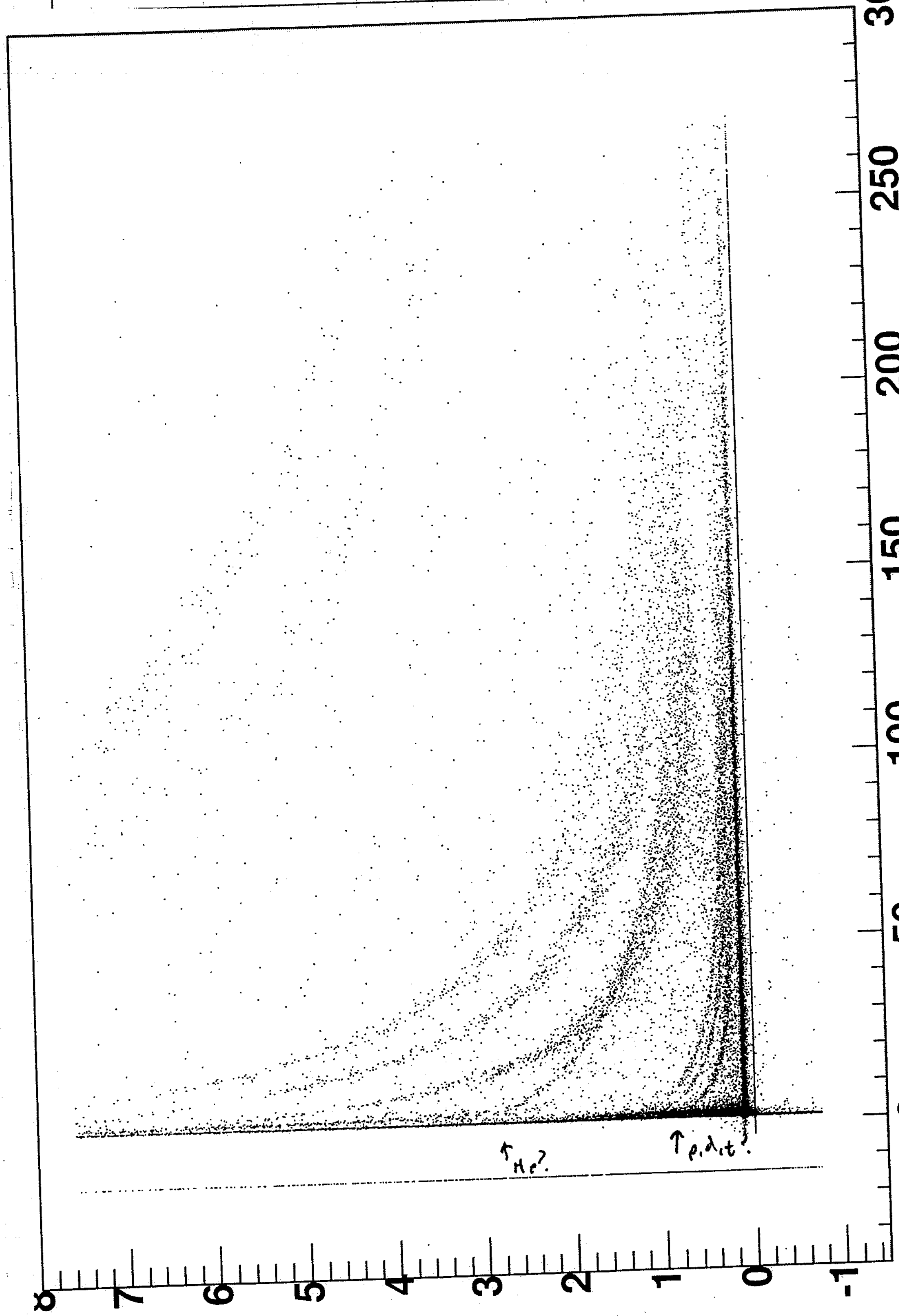
- Total E
- - Correct for foil e-loss
- PID
- Check CsI orientation
- Find optimum accuracy



11-Jan-2011

⇒ Si Front (1)(2) looks bad
- Some Strips shifted quite a bit
- But it looks like a discrete energy shift
- Maybe Ignore for now.

Front (1)(1) vs. CsI(1)(1)

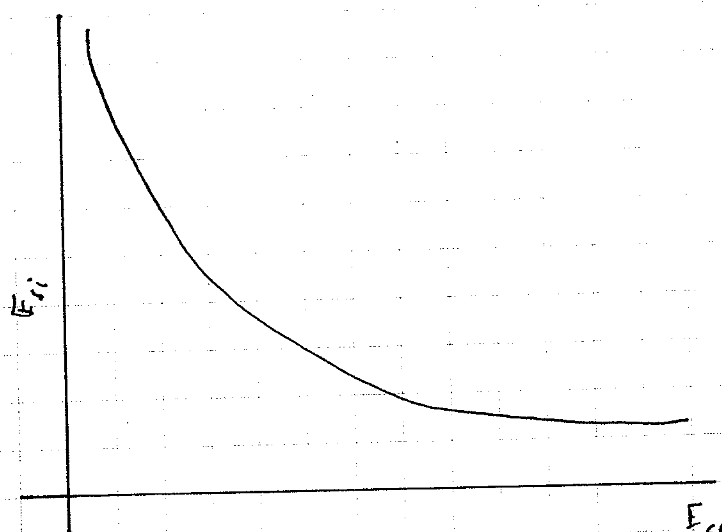


Seems to be some bad shifting in this one. Cause is unknown, but it's also verified in α calibrations.

- will ignore for now, but got to later

Next Step

- Evaluate PID function.
  - with only 5 telescopes, maybe we can do PID individually.
  - Alternatively try PID = $f(E_{CsI})$

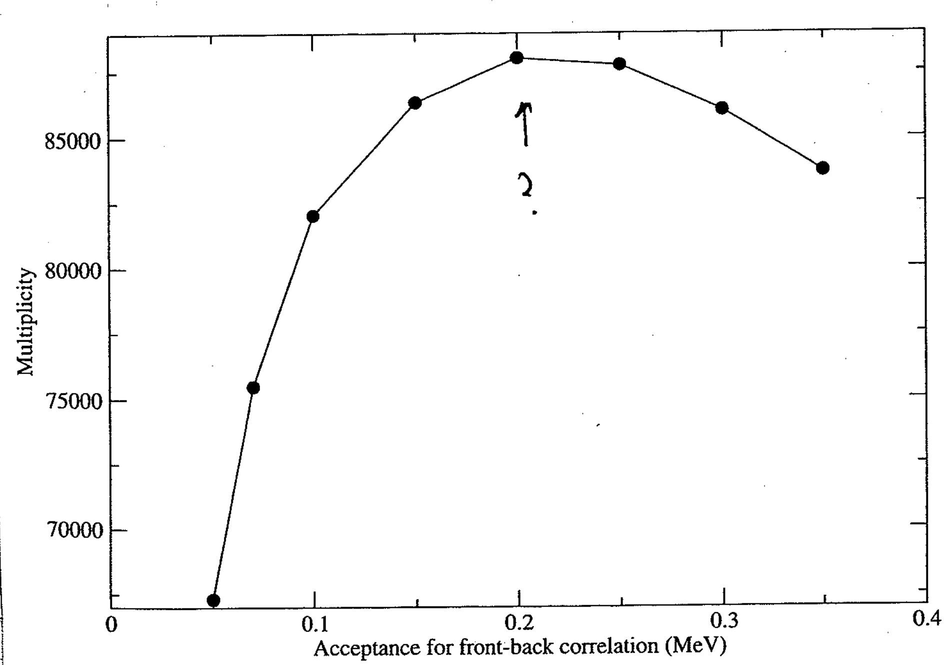


Find a functional fit to this.

- E.g. $E_{Si} = f(E_{CsI})$ then $PID = \frac{E_{Si}}{f(E_{CsI})}$

Find optimum accuracy

- Plot nevts vs accuracy (100000 total evts)



'cause we have more 1s = max

Number of valid events based on

|Front − Back| < ε

ε = accuracy

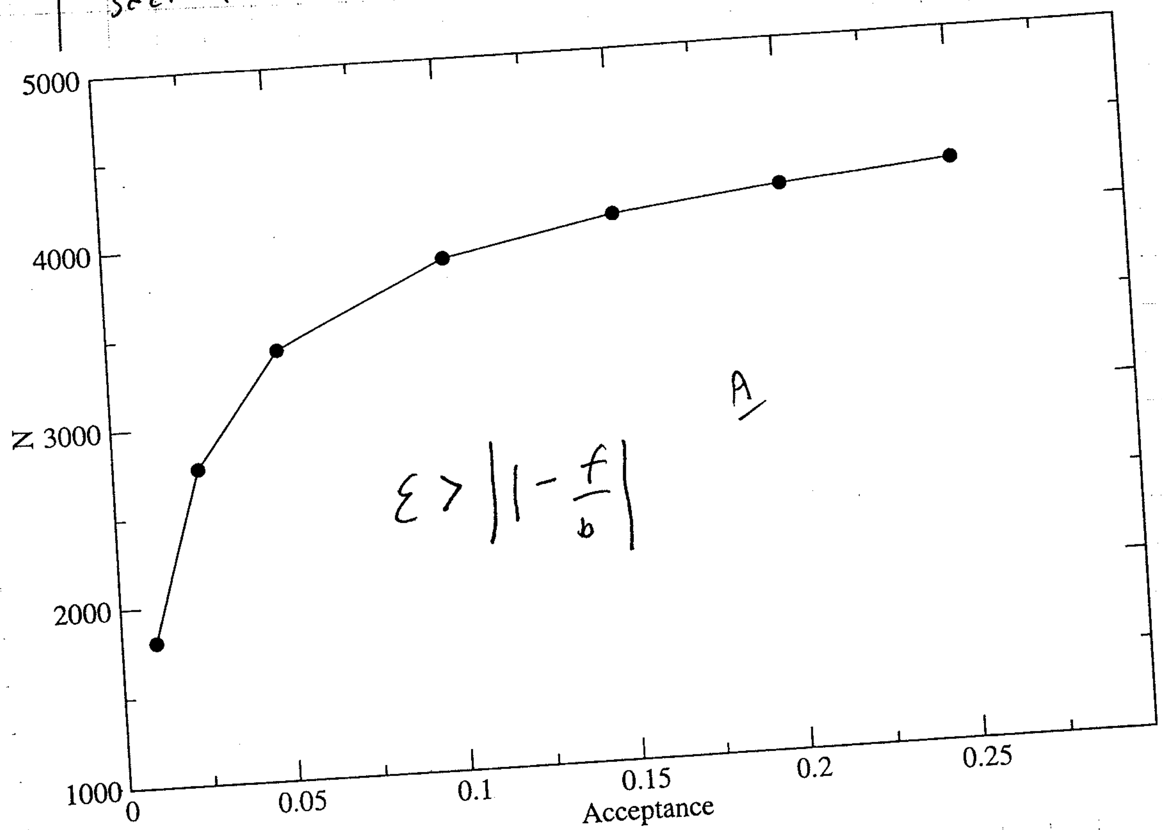
why does [illegible] decrease at ε = 0.[illegible] ?

Constrain Front > 50K0V and leave it.

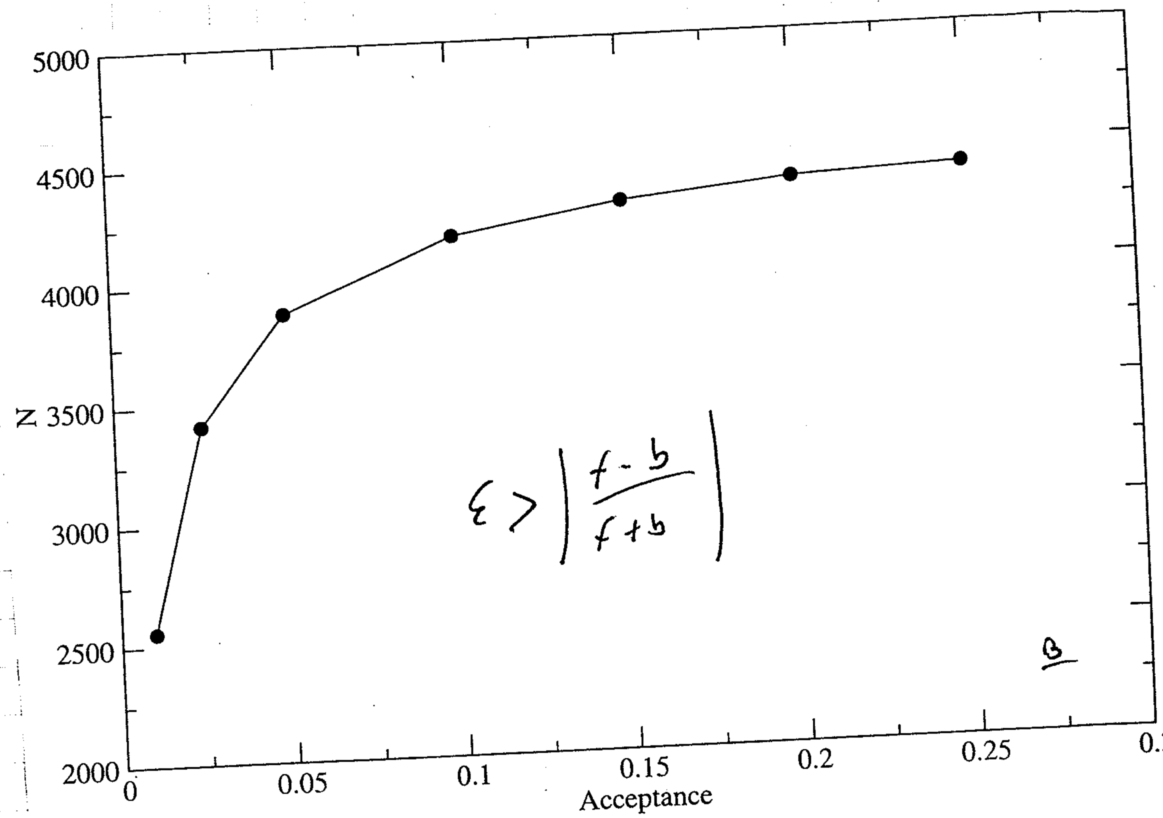
Also try using acceptance

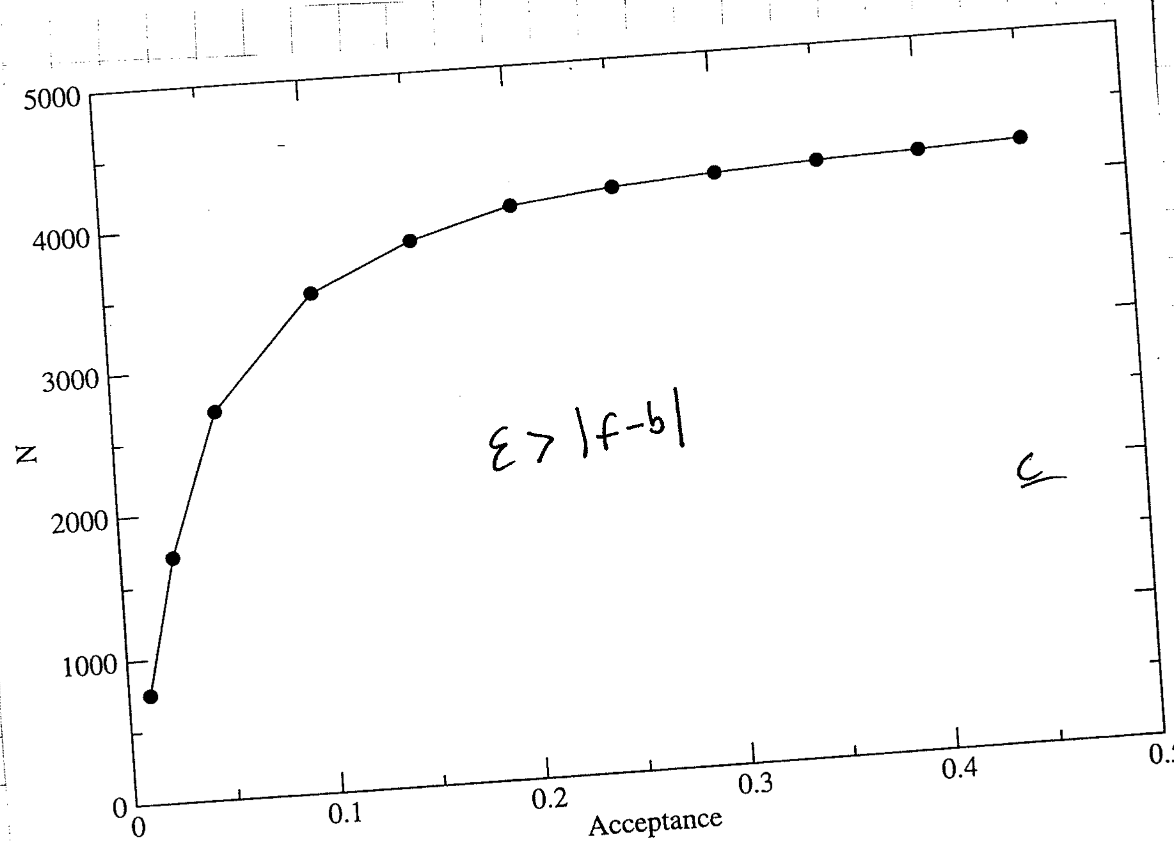
$$\left|1 - \frac{f}{b}\right| < \varepsilon$$

* Only look at E > 1 MeV to get a clean cross section.



Next, try $\varepsilon > \left|\frac{f-b}{f+b}\right|$



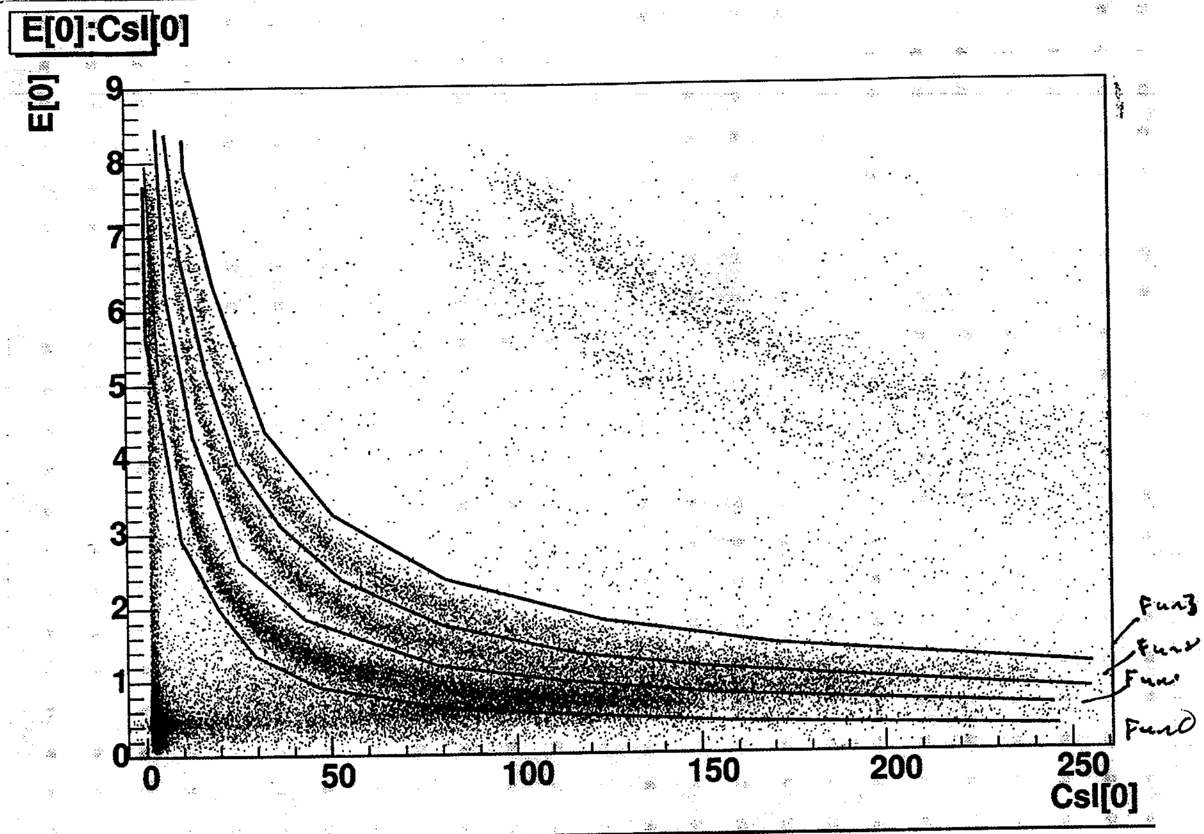


will use case C as the f vs. b plot generally has constant width.

ε is somewhere between 0.2 and 0.15

Set $\varepsilon = 0.2$

LASSA pid cuts



All Lassa CsI + Silicon detectors

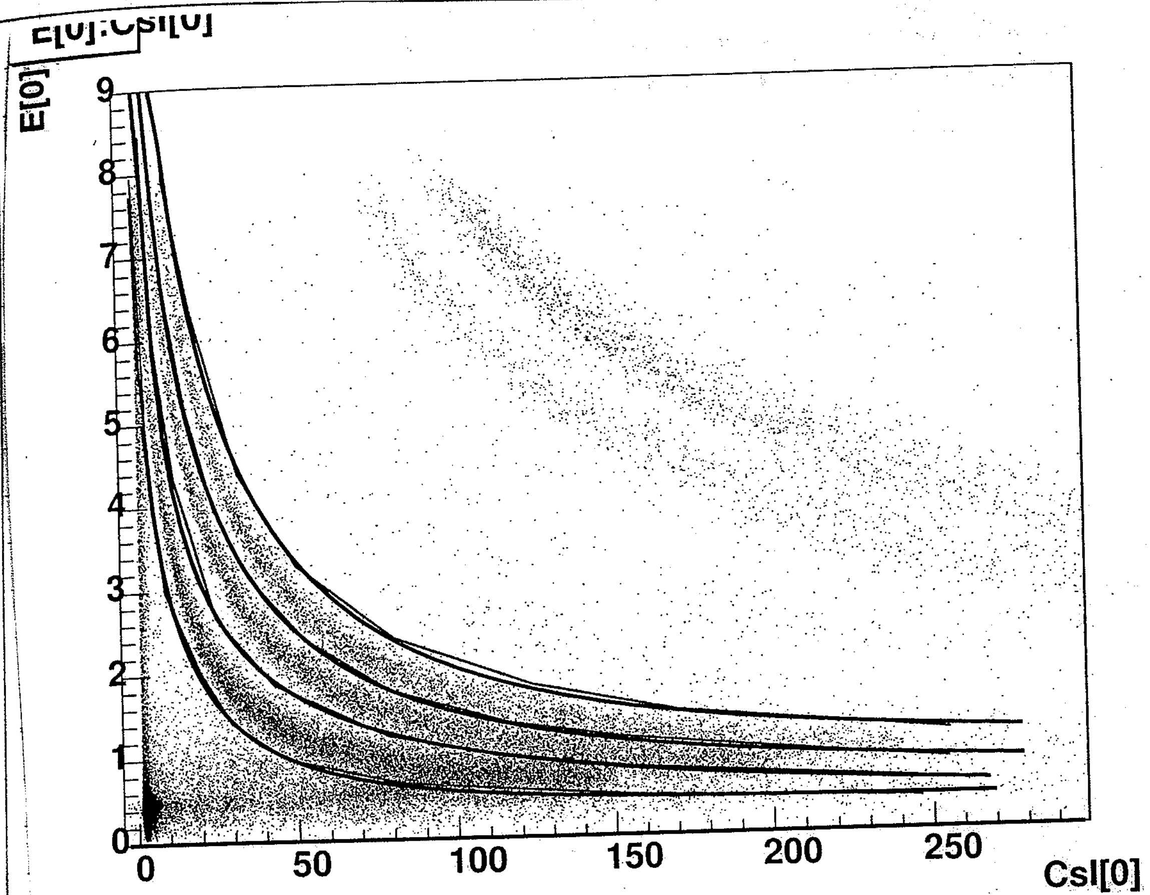
Fit cuts to the following

$$f(E_{CsI}) = a + b\,e^{c x^{d}}$$

If $E_{Si} > f(E)$ then it falls in a cut.

Function	a	b	c	d
3	1.03912	19.7041	-0.3374	0.476356
2	0.695983	21.2649	-0.503738	0.406708
1	0.259672	126.575	~~-0.22~~ -2.22169	0.178231
0	0.398878	9.83562	-0.422742	0.492693

Functional Fits to PID cuts.



Need to better evaluate N>1 events

- Sometimes we're doubly counting
- That is we might have e.g.

E_{f_0} E_{b_0} } double count
E_{f_1} E_{b_0}
E_{f_2} E_{b_1}

- One way to check
  - Different CsI can (greatly) reduce the problem
- This only occurs for Events w/ close Energy
- We can only have 1 Si per CsI for an effective evaluation
  - For this reason, we evaluate Si pairs based on CsI events
- We must also check to see that Si strips correspond to the proper CsI for all scopes. That is, does CsI 0 correspond to front 0-7 and back 8-15 e.g.
- Also check Si thresholds on all channels.

16-Jan-2011

Method to avoid double counting back events.

- Go through Si events for every CsI

```
If CsI(0) > thresh  ->  nevts ++
                        CsI(nevts) = CsI(0)
   For ~~front~~ i = 0 to ~~front~~ i < 8
       If front(i) > Si thresh
           fmult ++
   For i = 8 ; i < 16; i++
       If back(i) > Si thresh
           bmult ++  -> y
   If (bmult < fmult)
       for i = 8; i < 16; i++  -> ~~CFS=0~~  fmax = 0;
           If back(i) > Si thresh
               y = yref(i)
               nevts ++  -> ~~E(nevts) = back(i)~~ E(nevts) = back(i)
               for (j = 0 ; j < 8; j++)
                   If |front(j) - back(i)| < accuracy
                       ~~CFS=...~~
                       If (front(j) > fmax)
                           x(nevts - 1) = xref(j)
```

Same procedure for all other CsI.

- nevts should be based on CsI
- only 1 Si per CsI
- this should be based on Si max?

If we do this way, maybe check fmax & bmax
For all Si in every CsI event.
If CsI > thresh.
- Find fmax
- find bmax
- find |fmax - bmax|

} maybe this works.

when CsI + Si is at edge, we might have some problems — 17-Jan-2011

Ex. tel 3, Back 15 ⇒ partially collected

Special cases

Tel	CsI	Note

Things to check

- CsI crosstalk → Add Neighboring energies
- Si thresholds → Make sure they are OK.
- ~~CsI~~
- Check double count E ⇒ see how many events we lose from double counting

Todo

- E_{Tot} (after corrections) 3
- ✓ Correct CsI E for PID 1
- R, θ, φ. 4
- Pixel geometric E 5
- See about counting rate dependence. 6
- Si dead time? 7
- Correct for energy loss in Si. SnPbSb foil. 2
- Possible to extract d, p, t punchthroughs from p.

Redo parameters for PID function

For the correct pid, It looks like

$$\rightarrow \log(E_c) = m \log(E_{Si}) + b$$

$$\rightarrow \frac{\log(E_c) - b}{m} = \log E_{Si}$$

$$\Rightarrow \sout{\log E} \quad E_{Si} = \exp\left(\frac{1}{m}\ln(E_c) - \frac{b}{m}\right) = k \exp\left(\frac{1}{m}\ln(E_c)\right)$$

Line	k	1/m	revised k	1/m
0	16.9087	-0.674514	15.8868	-0.66496
1	25.0259	-0.657538	25.1284	-0.661372
2	33.9225	-0.648625	33.4058	-0.644406

~ PID Energy Corrections in CsI

* See pg 23-24

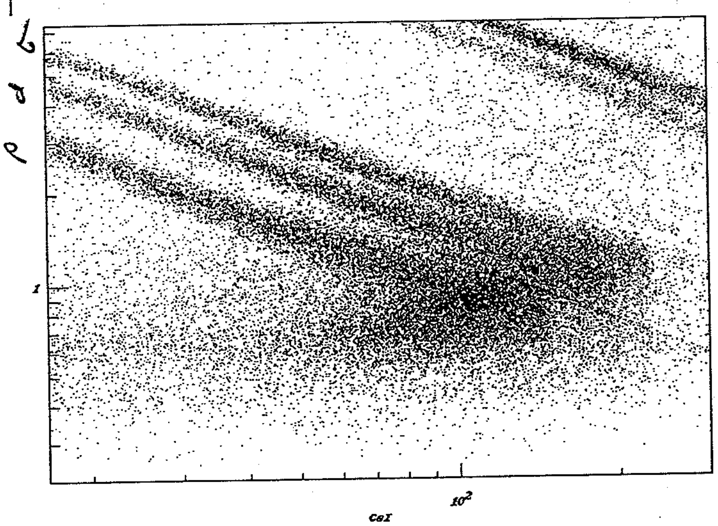
→ From pg 23 & 24, we must multiply E_{CsI} by a factor f

For deuterons $f = \frac{m_d}{m_p}$

For tritons $f = \frac{m_t}{m_p}$

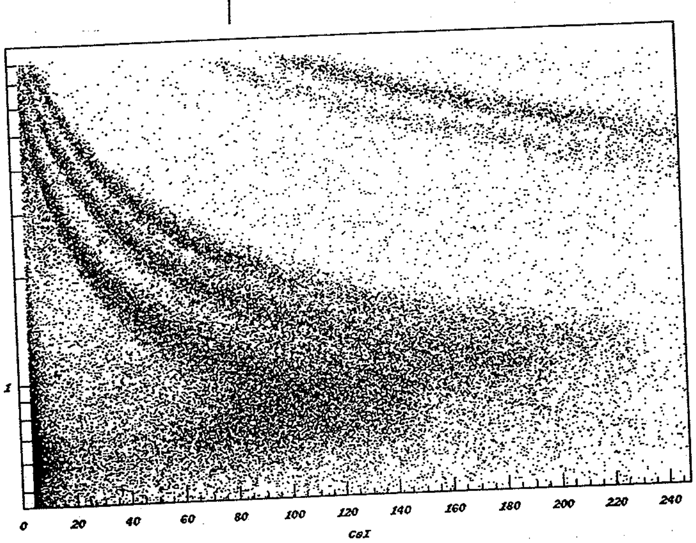
Recheck the following

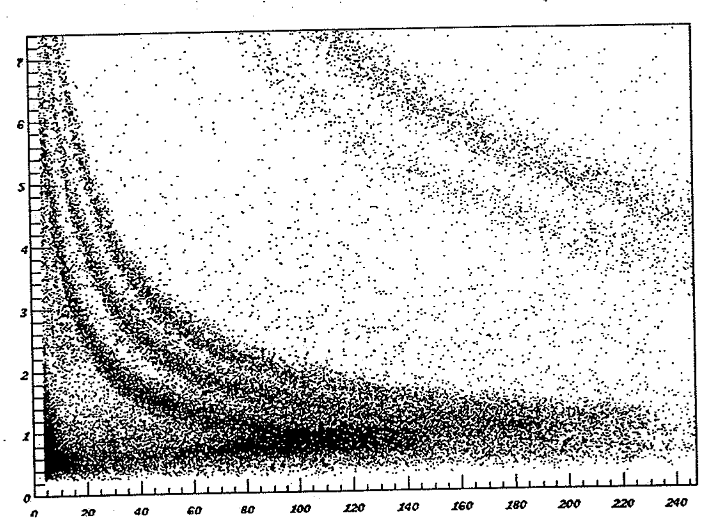
Tel	CsI	particle
0	2	d, t
5	0	t
5	3	t



PID plot after correcting for particle

→ This streak is an overlap of d+p after correcting because we shift the d's left a bit.





Correcting E in Lassa for SnPbSb foil 20-Jun-2011

- 14.82 mg/cm²

- Sn : Pb : Sb ⇒ 60:39:1

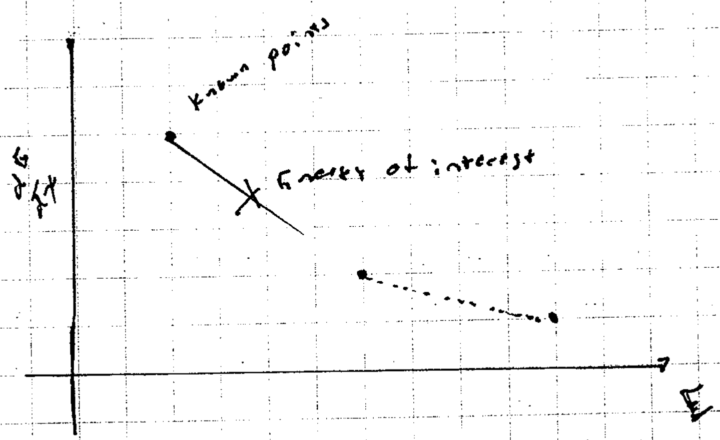
- Use Energy loss From Zeigler et. al.

$|\Delta E| = E_i - E_f$

we measure E_f

$E_i = E_f + \Delta E$

assume $\frac{dE}{dx}$ is constant accross target?



Also to do

- Si thresh for each strip
- ✓ CsI cross talk
- E-total
- R, θ, φ
- Pixel geometric correction
- Count rate dependence
- Si dead time?
- ✓ E-loss in SnSbPb
- Possible to separate p, d punchthroughs?
- recheck E_f vs. E_Δ

$\Delta E = \int \frac{dE}{dx} dx$

$\frac{dE}{dx}$ changes < 3 keV accross target.

- Need to do a better job on CsI cross talk. The current method isn't to good.

?. Jan-2011

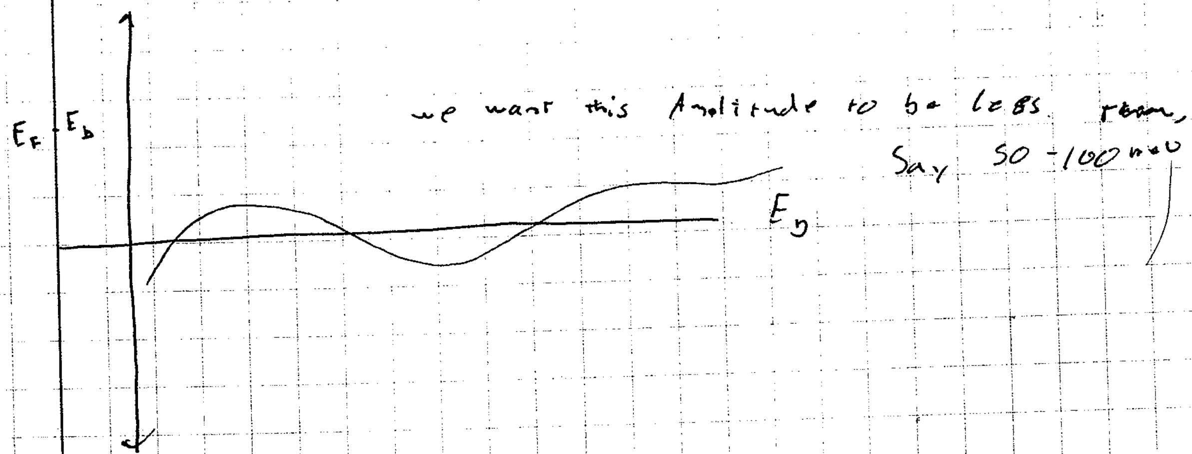
To do:

- pg 33-35 of this book
- Neutrons: pg 126 of book 2

2 Feb 2011

Recheck E_f vs E_b

- plot $\frac{E_f - E_b}{E_b}$ vs. E_b



- Si 2 looks good
- Si 1: Maybe offset overall by ~30 keV
- Si 0: Some non-linearity, can probably do better
- Si 3: Pretty good, but some non-linearity at low E_b.
- Si 4: Definitely non-linear. Should be corrected.
- Si 5: looks pretty good but maybe do a bit better.

- Front seems much better calibrated than back, so maybe better to match back to front strips

Plot $\frac{E_b - E_f}{E_f}$

Can we do an entire side? Looks like it.

$$\frac{E_b - E_f}{E_f} = F(E_f)$$

$$E_b = E_f F(E_f) + E_f$$

Probably better

$$\frac{E_b - E_f}{E_b} = F(E_b)$$

Try First a Multiplicative factor or Additive

$$\frac{E_F}{E_b} = F(E_b) \qquad E_f - E_b = f(E_b)$$

$$E_f = E_b f(E_b) \qquad E_f = f(E_b) + E_b$$

Use 3-D polynomial for additive

Tel	Polynomial $f(E_b)$
0	$-0.106359 + 0.0846416E - 0.0193891E^2 + 0.00137558E^3$
1	$-0.0768405 + 0.0604916E - 0.0154397E^2 + 0.00110831E^3$
2	$0.00162555 + 0.0239861E - 0.00890089 + 0.000775168E^3$
3	$-0.105799 + 0.0676683E - 0.0132667E^2 + 0.000787826E^3$
4	$0.180815 - 0.0407076E_b + 0.00859384E^2 + 0.000207652E$
5	$-0.0473468 + 0.0656783E - 0.0170015E^2 + 0.00130226E^3$

→ Need to redo #1 and #5

* Why do this since E_F looks good and we only base the E_T on the ~~back~~ ~~Front~~? Back?

Just take E from the Front!

- All non-linearities removed.

3-Feb-2011

Things to do next:

✓ - Si thresh: check to be sure all Si's are above ~0.5 MeV
✓ - CsI cross talk: correct for this
- R, θ, φ
- Geometric ε correction
- Count rate dependence?
- Possible to separate direct, punchthroughs?
- Double check PID

Recheck PID Fits

$$f = a E_{CsI}^{b}$$

Fit	a	b
0	19.3139	-0.734568
1	26.6362	-0.695891
2	35.2454	-0.679046
3	40.7353	-0.686256

4-Feb-2011

Recheck all Si thresholds.
- Be sure they are all above 0.5 MeV
- Double check spectra.

Front (0, 11) looks funny ⇒ really bad ⇒ should probably not use
Front (4, 11) looks funny ⇒ recheck : Close, but looks ok
Front (5, 13) looks funny ⇒ Also close, but OK

Back (2, 13) maybe bad OK
(2, 14) maybe bad Maybe a bit too high, probably OK
(2, 15) maybe bad Maybe a bit too high, probably OK
(4, 15) check looks ok, Calibration may be off

→ If we want to fix, we need an energy-dependent efficiency.
→ at low E, our efficiency down.

Examine CsI crosstalk

- Plot CsI_a vs CsI_b a & b are neighboring CsI's.

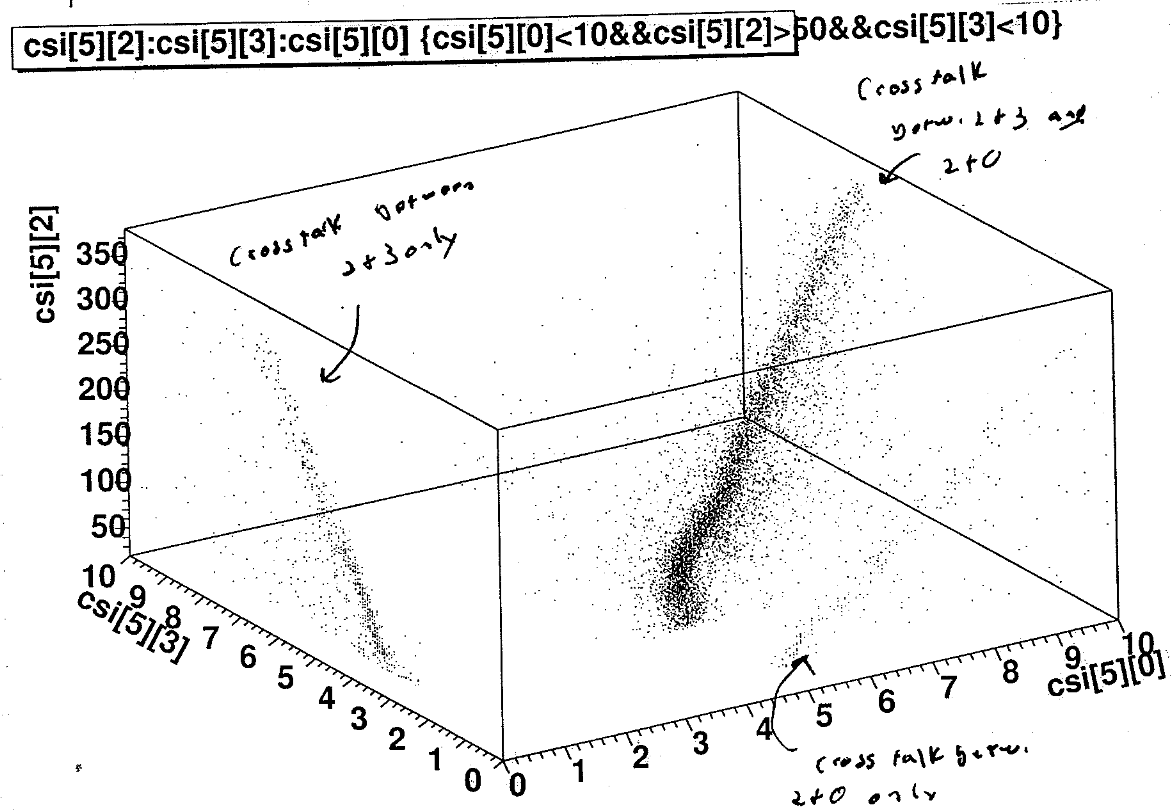
- Check the following.
  → Does Every event Have crosstalk?
  - If so maybe we don't have to worry about it since it's linear. Otherwise we need to do something tricky.

Note: Si Calibration is α's only. we need to adjust for Ionization density for p, d, t in Si!

7-Feb-2011

To do
✓ - Check charge Splitting in Si - Plot neighboring Strips - OK
✓ - Si edge effects
✓ - Ionization density correction. - Pulse height defect.
✓ - E, θ, φ
  · Geometric ε
  - Count rate dependence?
  - Separate d, t punchthroughs?
✓ - Double check PID.
  - CsI crosstalk?

* - Pulse height defect seems to be less than 1% above 20 MeV for protons and negligible for d, t.
  We can correct for this at any time.
  - Take care of double counting CsI for edge events
    - Actually can't be solved
      1. For most cases, coincident event fall off a PID line leaving either 1 valid only or both wrong
      2. For a very few cases (< 1%) it's ambiguous, so the best we can do is note we are double counting

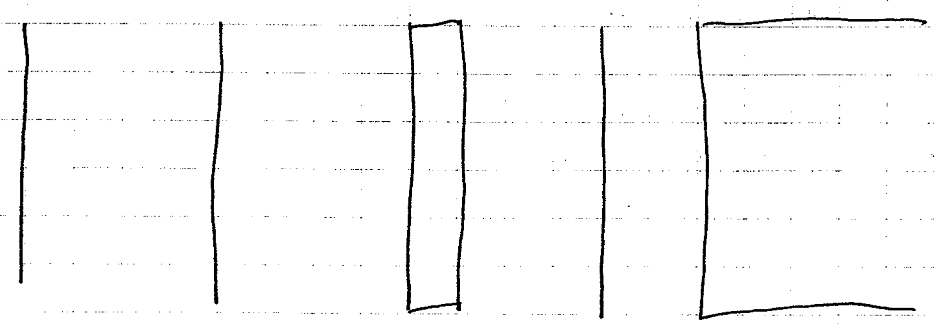


In this case at least *most* events have cross talk between 3 crystals

- Every event has cross talk and it's linear
Thus it should be calibrated out, so maybe it's OK.
- The real problem is for real events with cross talk from *another* crystal.
Not sure How to handle this

28-March-2014 Don't Forget
* E-loss in mylar wrapping CsI when calculating E-tot

Layers



SnSb Foil 14.82 mg/cm² — Sn: 60, Pb: 39, Sb: 1

Si dead layer ~1μm

Si 500μm — E_{Si}

Al mylar 12μm

CsI — E_{TOT}

⇒ Looks like the CsI elastic cal is wrong. But all the PID looks fine

CsI ~~(2)(6)~~ (3)(2) might have problems. Strange ⇒ cuts off at E=200 MeV 29-March-2011

Geometric ε 29-March-2011

For a given angle between θ_1 and θ_2

Things to revisit
- CsI calibration accuracy
- Count rate dependence
- Mylar energy loss
- deut punchthroughs
- CsI crosstalk

Pixel coverage = $\Delta\Omega_i$ for a pixel

~~Ang~~

Total angular coverage: $\Omega = \sum_i \Delta\Omega_i$

$$\varepsilon = \frac{\sum \Delta\Omega_i}{\int_{\theta_1}^{\theta_2} 2\pi \sin\theta \, d\theta} = \frac{\sum_i \Delta\Omega_i}{2\pi(\cos\theta_1 - \cos\theta_2)}$$

Correction for CsI ⇒ Multiply by $\frac{M}{\Delta\Omega_{CsI}}$ ↗ $dN/d\Omega$

Current plan

- Lassa $\varepsilon_{geo}(\theta)$
  - Multiplicity in μball
  - N-wall scattering / shadowbar measurements
    - N-wall geometric ε
    - N-wall energy efficiency
    - N-wall shadowbar correction
      - ε charms.

Si geometric ε

- Correct for $\varepsilon_{geo} = \frac{N(\theta)\Delta\Omega}{2\pi\sin\theta d\theta}$

- Correct for average multiplicity per CsI. M

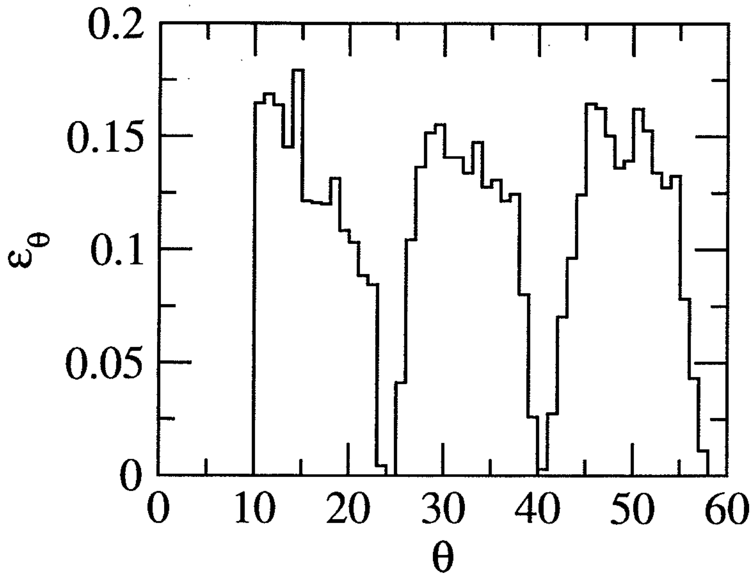
- To find $\frac{dN}{d\Omega}$ divide by $d\Omega$ of the CsI
  - ⇒ we don't need to do this for plotting <δ> vs y

- For each event, add ε_{geo} for every particle.
  - Maybe add M for every particle
  - Maybe add $d\Omega$ for every particle

* CsI detectors w/ problems

CsI (3)(2) ⇒ cutoff above 200 MeV
(2)(0) ⇒ double peaking?

Finding $\varepsilon(\theta)$ for lassa 31-March-2011



Geometric efficiency vs angle

- we need to correct for missing pixels, but that's easy, infact already built in.

50
55
60

Also average CsI multiplicity.
- How to determine?

Method

: Find real events in CsI (CsI > 4)

CsI multiplicity correction 1-April-2011

- Method: Find number of unique Front-back pairs on a given CsI region.

- That is check Front and back
If Front ≈ back and
~~Front/back~~
Front or back not equal to prior measurement a
Front, back coordinate corresponds to a CsI reg
then
it's unique and adds a correction to CsI

Multiplicity

How many CsI have multiple hits in Si in front.

Tel	CsI	⟨M⟩
0	0	1.012
	1	1.081
	2	~~1.067~~
	3	~~1.063~~ 1.063
1	0	1.072
	1	1.043
	2	~~1.104~~
	3	1.103
2	0	1.073
	1	1.054
	2	~~1.126~~ ??
	3	1.101
3	0	1.128
	1	1.095
	2	~~1.2~~ ?
	3	1.079
4	0	1.158
	1	~~1.085~~ 1.117
	2	
	3	~~1.079~~ 1.104
5	0	1.13
	1	1.119
	2	~~1.205~~ ??
	3	1.167

⟨M⟩ = average Multiplicity

$$\langle M \rangle : \cancel{\Sigma M_i} \quad \frac{\Sigma i\, M_i}{\Sigma M_i}$$

average number of hits (unique) / CsI

This seems wrong. should really check this.

Questions

- Should we bin ⟨M⟩ by particle?
- Should we bin by energy?

⇒ I think no because the total multiplicity is naturally ~~g~~ weighted by particle and E ~~for~~ from the physics.

More accurate way to get ⟨M⟩ more commensurate w/ method on ~~p~~ 43

Tel	CsI	⟨M⟩	
0	0	~~1.032~~	1.024
	1	~~1.054~~	1.025
	2	~~1.021~~	1.017
	3	~~1.025~~	1.021
1	0	~~1.072~~	1.037
	1	~~1.034~~ ~~1.052~~	1.048
	2	~~1.076~~ ~~1.017~~	1.036
	3	~~1.059~~	1.064
2	0	~~1.044~~	1.027
	1	~~1.036~~	1.021
	2	~~1.049~~	1.045
	3	~~1.028~~	1.04
3	0	~~1.132~~	1.125
	1	~~1.127~~	1.112
	2	~~1.106~~	1.102
	3	~~1.056~~	1.066
4	0	~~1.117~~	1.11
	1	~~1.105~~	1.101
	2	~~1.12~~	1.140
	3	~~1.118~~	1.114
5	0	~~1.10~~	1.104
	1	~~1.104~~	1.097
	2	~~1.161~~	1.183
	3	~~1.125~~	1.132

To do:

- Background / Punchthrough in LASS A

Punchthrough contribution

Total E (MeV)	CsI E (MeV)	E_tot	Hist value
81.9162	80.9976	81.9162	
50.771	49.4813	50.771	
184.34	89.3548	89.9983	
222.73	74.1027	74.6771	
297.75	59.594	60.073	
150		130.7899	
155		118.77	
160		111.1	
165		105.3	
170		100.6	
175		96.646	
180		93.1694	
185		90.229	
190		87.547	

* - Going to do tricky extracting punchthrough using data → having a hard time with it. May need a Geant Sim

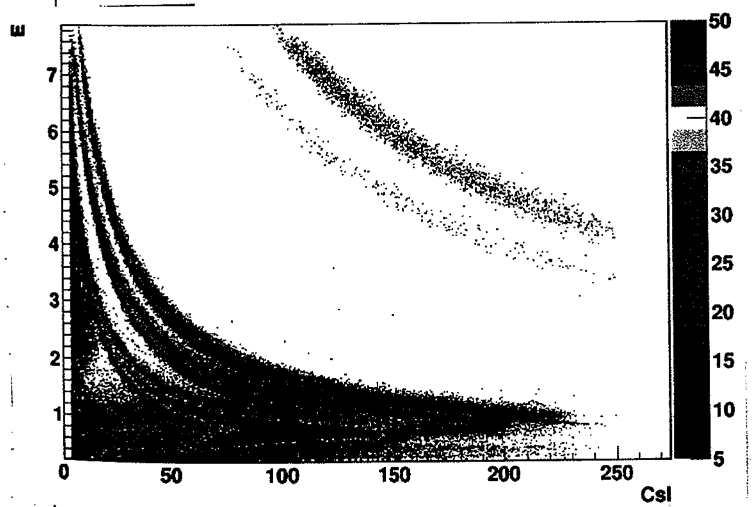
Things to do + Consider. 11-April-2011

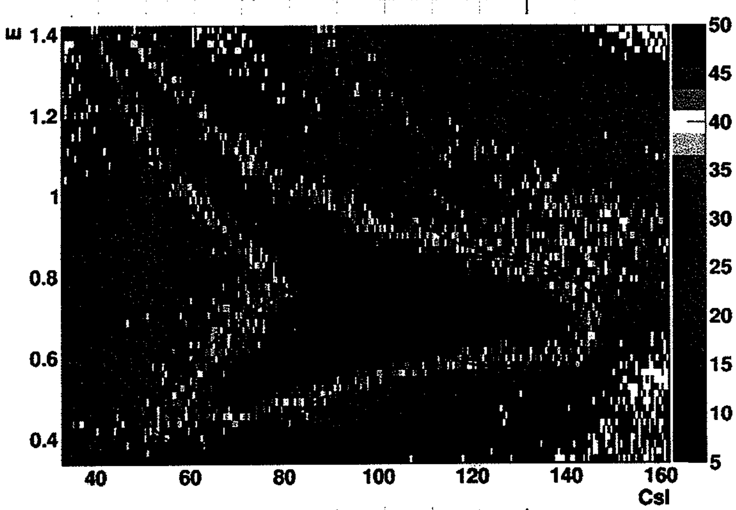
- GEANT Simulation for Punchthrough background in LASSA (maybe only CsI's)
- Incorporate Multiplicity correction In LASSA CsI (pg. 45) (easy!)
- Neutron wall shadow bar measurements (Fairly simple)
- Neutron wall geometric ε
- N-wall Energy efficiency (simulation)
- MBall multiplicity
- See if count rate dependence
- Examine LASSA 5 ⇒ Some low E CsI vs Si (crosstalk maybe?)
- Eliminate Front(1)(2) → shifting or something (pg 26)
  - need to redo E calibration.
- LASSA CsI tel 5 seems odd. gain shift at low E.
- Distinguish CsI and CsI corrected.

→ The problem with a GEANT Simulation for punchthrough is that I don't know the Spectra

- Maybe assume constant in the region of interest since it's a fairly narrow band.

- For a geant Sim, we need
  - Particle E
  - Energy deposited in Si
  - Energy deposit in CsI
  - Corrected CsI E
  - Corrected E_{tot}





Nice PID
- Bands (tiny) from shift correction in CsI

- Zoom in on proton punchthrough.
- How to correct?

G = proton gate
G' = punch through gate

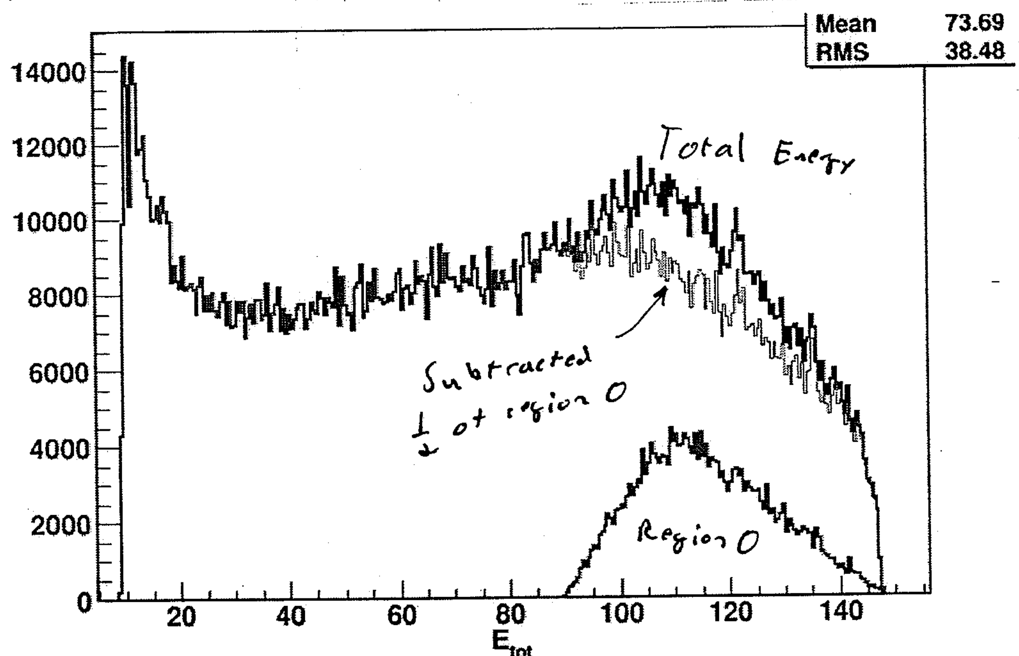
To correct for punchthrough

1. plot E_{TOT} for 6 : Spec A
2. plot E_{TOT} for 6' : Spec B
3. plot E_{TOT} For 6 and 6' : Spec C.

take ratio $\frac{\text{Spec A}}{\text{Spec C}}$ vs E_{TOT} ⇒ this is the correction factor?

In region O', the spectra have equal contributions?

we should do this individually for every CsI.



Question: Do we correct for efficiency before or after punchthrough correction?

I think after. Maybe doesn't matter but punchthrough is detector-specific. Also probably make it depend on system + CsI.

Find punch through Background for all CsI and all systems — 12-April-2011

System — Run

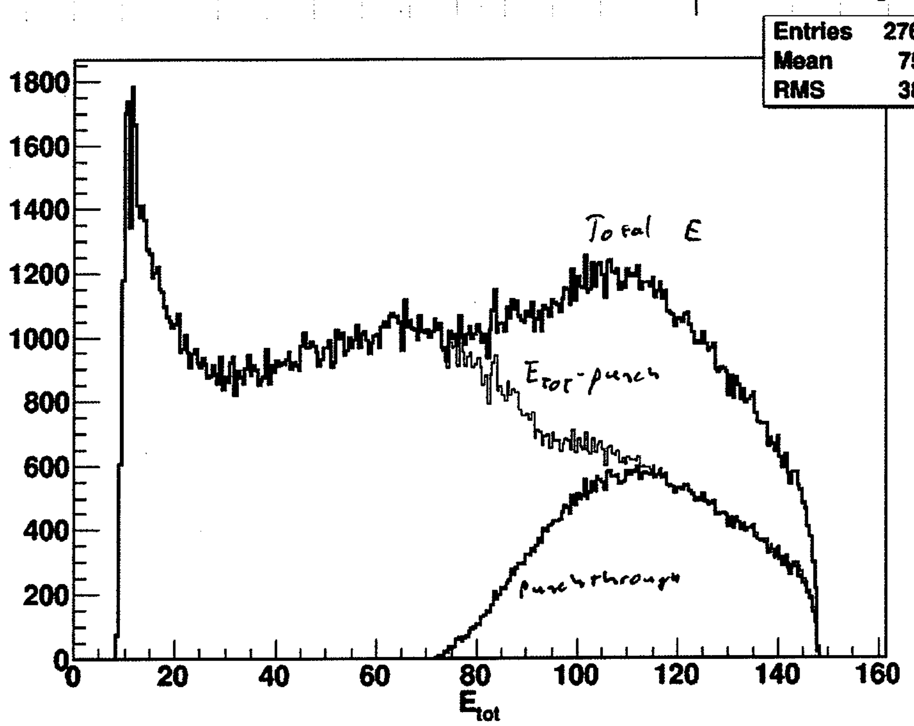
System	Run
$^{40}Ca + ^{112}Sn$	~~-719(?)~~ 607 - 612
$^{48}Ca + ^{112}Sn$	701 ~~720~~ - 767 (~~Not 714?~~) (Not 709-719)
$^{40}Ca + ^{124}Sn$	~~-769~~ 613 - 628
$^{48}Ca + ^{124}Sn$	~~Run 792~~ 768 - 809

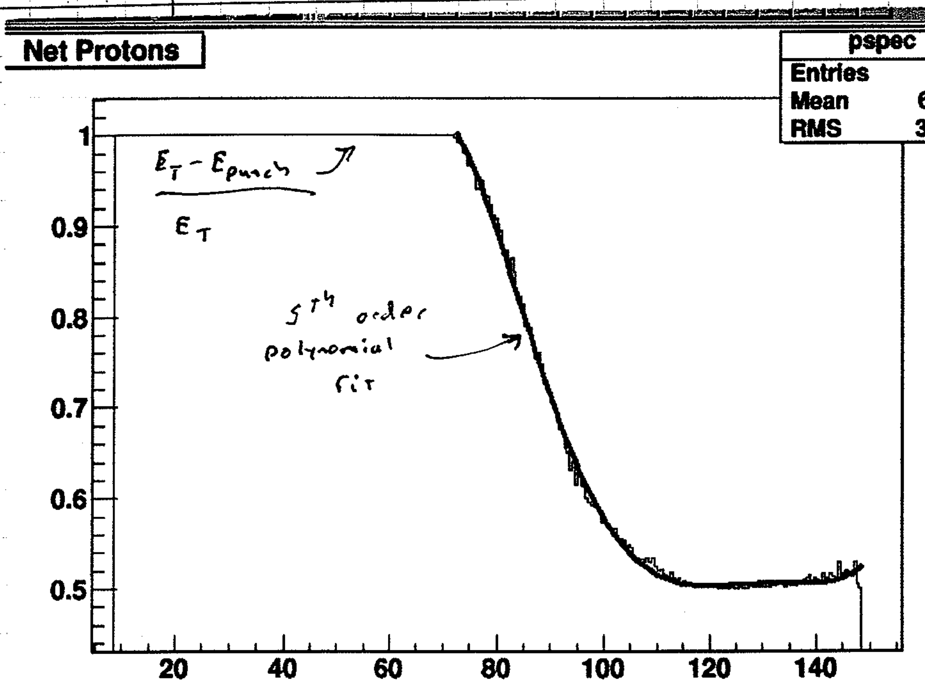
Sample runs for punchthrough calibration and data check.

System

System	Run
$^{48}Ca + ^{124}Sn$	792
$^{40}Ca + ^{124}Sn$	618
$^{48}Ca + ^{112}Sn$	767
$^{40}Ca + ^{112}Sn$	611, 610, 609

Proton Punch through Spectra
$^{48}Ca + ^{124}Sn$





$\frac{E_T - \text{Punch}}{E_T}$

used for correction

This correction is for all CsIs for this system, now we do it for individual CsI.

$^{48}Ca + ^{124}Sn$

<u>CsI</u> correction

$$P = \frac{\phi(E_{True})}{\phi(E_{TOT})}$$

$\phi(E)$ = Energy Spectrum

$\phi(E_{True})$: Actual Energy = $E_{TOT} - E_{punch}$

$\phi(E_{TOT})$: punchthrough

$$P = a_5 E^5 + a_4 E^4 + a_3 E^3 + a_2 E^2 + a_1 E + a_0$$

$^{48}Ca + ^{124}Sn$

Tel	CsI	a_0	a_1	a_2	a_3	a_4	a_5
Total		-38.7676	1.94963	-0.0368248	0.000336092	-1.49585×10^{-6}	$2.61237\times10^{-}$
5	0	-25.8509	1.33705	-0.0254148	0.00023159	-1.0245×10^{-6}	$1.77364\times10^{-}$[illegible]
	1						
	2						
	3						
4	0						
	1						
	2						
	3						
3	0						
	1						
	2						
	3						
2	0						
	1						
	2						
	3						
1	0						
	1						
	2						
	3						
0	0						
	1						
	2						
	3						

Maybe better to fit to a sigmoid function

$$P = \frac{0.5 + e^{-(x-E_0)/\tau}}{1 + e^{-(x-E_0)/\tau}} = 1 - \frac{0.5}{1+e^{-(x-E_0)/\tau}}$$

For total LASSA array

$E_0 = 88.4417$
$\tau = 6.12315$

Tel	CsI	E_0	τ
5	0		
	1	88.7920	5.81794
1	1	88.4723	6.29863
2	2	88.316	5.82852
3	3	90.0525	5.9878
0	0	83.6917	5.84226.

However, It looks like the punchthrough at larger angles is smaller. we can't really correct this way

* Set this aside and come back later.

Check punch through energies for the other systems for calibration purposes

Run 609 : Calibration looks the same ~~Same double banding~~
Run 618 : Some double-bands on proton line?
767 : Same
792 : Same

All seem to have same calibration, but 618 has weird double-banding

Run 618 : Looks like CsI tel 2 is miscalibrated.
- Maybe we used the low gain shaper file for this?

Run 616: Same problem

Run 609 and Run 792 look the Same.

Looks like CsI in tel 7 may be slightly undercalibrated
- Seems off by about 10%

To do

✓ - Re-examine Si & CsI cal.
- Punchthrough correction (GEANT? DATA?)
✓ - LASSA Multiplicity correction (pg. 45)
✓ - LASSA tel 5 has low E band?
✓ - Eliminate LASSA Si F(1)(2) → redo ~~anti~~ E correction (removal) entry in
- Check for count rate dependence
✓ - Neutron wall Shadow bar
- Neutron wall Energy E
✓ - Neutron wall geo E
- μ Ball multiplicity

Recheck Si calibration

Back (1)(0) ⇒ Maybe 35 keV low but probably don't have to worry

Silicon calibration is Fine!

Verify CsI calibration using Scattering data

Angle	E_{CsI}	E_{CsI} meas

(See spreadsheet)

One thing we can do:

- Fine tune LASSA ~~→~~ CsI punchthrough
  At CsI punch, the LASSA Si
  Energy should be about 0.51 MeV
  Not ~0.65, which it currently is.
  Low E LASSA Si have not been calibrated
  So the should be.

⇒ Si is only off by ≈ 100 keV at low E.

~~Mea~~ Measured	Actual
0.74	0.63
0.8227	0.7611

⇒ This may be what is making our total Energy off.
  ⇒ This will put the CsI line precisely where it needs to be!!
    ⇒ Then we can do CsI "pixelization" in which we match all CsI elements.

E_{Ca} = 36.911 MeV/u

B_ρ = 1.765 Tm

Examine E_{Si} vs θ for Elastic — 13-April-2011

- Since all Si are normalized in a telescope, do one at a time full telescope

Measured

Tel	Run		
0	662	E_{Si} = ~~0.388959 +0.0147589 θ~~ ~~0.323149 +0.0159691 θ~~ −0.581446 + 0.0329342 θ	
~~1~~	~~662~~	~~E_{Si} = −0.194847 +0.0274661 θ~~	~~40-60~~
2	662	E_{Si} = 0.100146 + 0.0227211 θ	40-60
3	663	E_{Si} = ~~1.31765 − 0.00636987 θ~~ 0.421815 +0.0130542 θ	25-40
4	663	E_{Si} = ~~0.494272 +0.0160991 θ~~ 0.716877 +0.00232482 θ	25-40
5			10-25
1	~~662~~ 661	E_{Si} = −0.2529 + 0.0274153 θ	
2	675	E_{Si} = −0.0688499 +0.0250643 θ	
3	675	E_{Si} = 0.334342 + 0.0142728 θ	
4	675	0.433695 +0.011674 θ	

But this still disagrees with E vs CsI. They seem to be all off by a constant.

Tel · 1 — too high by ~80 keV

· 0

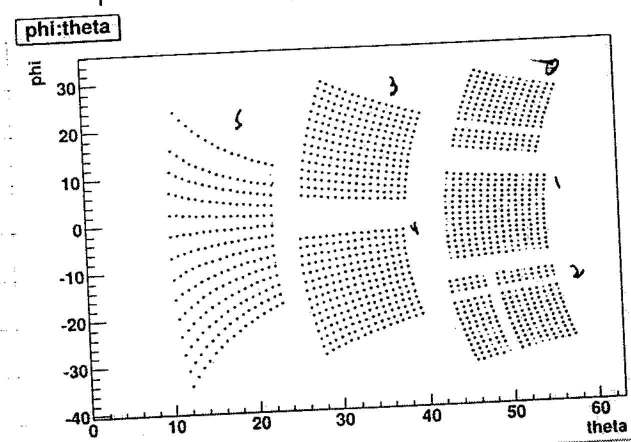
Energy Calibration

- Not off by more than a few percent.
- It really should be OK.
- We can probably tighten the Si Calibration for better pid, but the gates can easily be adjusted for each Si

Efficiency correction

1 - Must account for missing pixels
- Must account for CsI Mult.

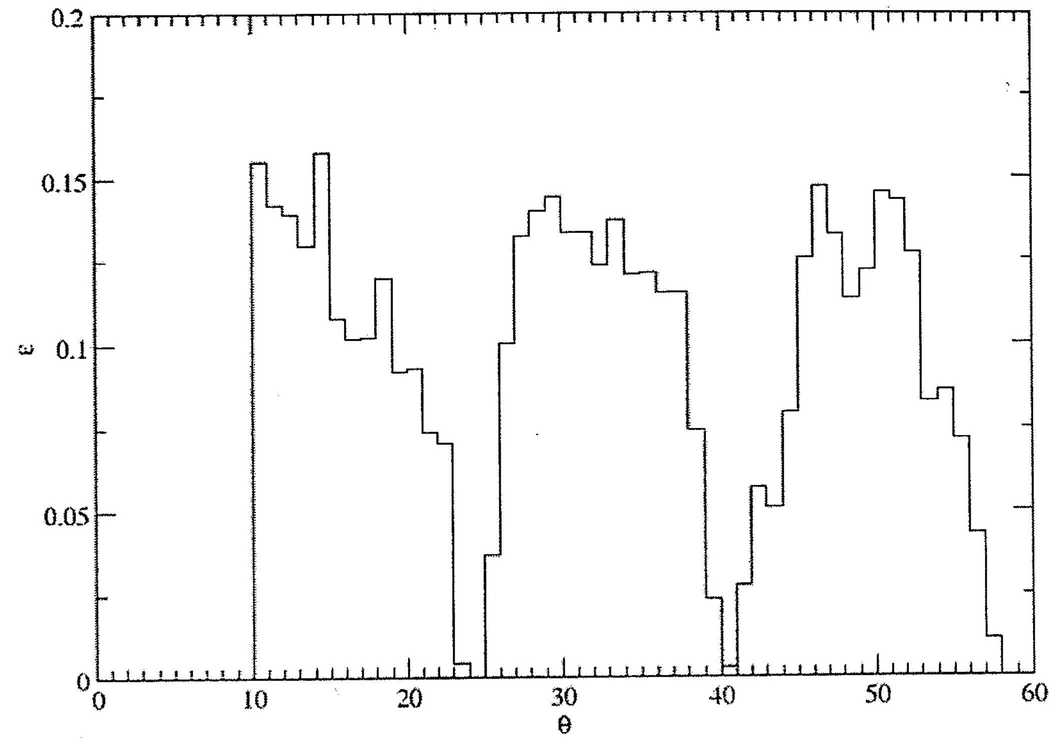
(1) Look for missing channels.



Missing Strips

Tel	Strip	
0	0F	5B
	14F	0B
	15F	
1	0F	
	1F	
	6F	12B
2		
3		0B
4		0B
5		13B
		15B

Angular efficiency corrected for missing pixels (compare to pg 43)



CsI multiplicity correction : must correct for system
- Do we need to correct for beam intensity? (in which case, we must have a correction for every run)
- Maybe just correct for overall multiplicity.
- actually no since it's multiplicity per event so there is no beam intensity factor.
- But we should correct for system

$^{48}Ca + ^{124}Sn$: Run 792 (pg 45) (already done)
$^{48}Ca + ^{112}Sn$: Run 767
$^{40}Ca + ^{112}Sn$: Run 609-611
$^{40}Ca + ^{124}Sn$: Run 618

14-April-2011

Average CsI Multiplicity

$^{48}Ca + ^{112}Sn$

Run 767

Tel	CsI	⟨M⟩	
0	0	~~1.034~~	1.021
	1	1.016	
	2	1.02	
	3	1.027	
1	0	~~1.046~~	1.038
	1	1.044	
	2	~~1.056~~ 1.04	
	3	1.039	
2	0	~~1.04~~	1.03
	1	1.031	
	2	1.056	
	3	1.046	
3	0	~~1.162~~	1.155
	1	1.107	
	2	1.096	
	3	1.068	
4	0	~~1.157~~	1.132
	1	1.099	
	2	~~1.156~~	1.148
	3	~~1.145~~	1.128
5	0	~~1.194~~	1.123
	1	~~1.107~~	1.10
	2	~~1.263~~	1.228
	3	~~1.183~~	1.143

40Ca + 124Sn Run 618

Tel	CsI	<M>	
0	0	1.006	
	1	1.000	
	2	1.000	
	3	1.000	
1	0	~~1.026~~	1.034
	1	1.045	
	2	1.041	
	3	1.022	
2	0	~~1.000~~	1.008
	1	1.015	
	2	1.009	
	3	1.000	
3	0	~~1.027~~	1.021
	1	1.011	
	2	1.014	
	3	1.000	
4	0	~~1.017~~	1.026
	1	1.024	
	2	1.022	
	3	1.017	
5	0	~~1.081~~	1.077
	1	1.077	
	2	1.128	
	3	1.11	

40Ca + 112Sn Run 610

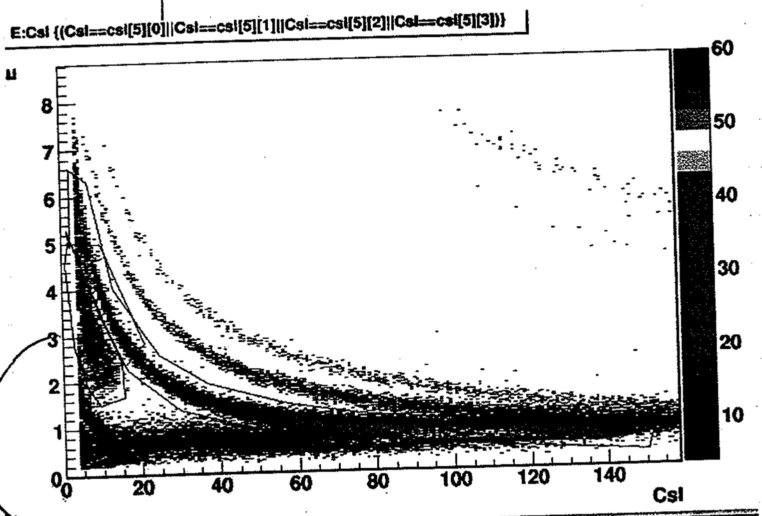
Tel	CsI	<M>	
0	0	1.000	~~1.000~~
	1	1.000	
	2	1.000	
	3	1.000	
1	0	~~1.012~~	1.015
	1	1.018	
	2	1.016	
	3	1.015	
2	0	~~1.038~~	1.008
	1	1.000	
	2	1.006	
	3	1.000	
~~3~~ 3	0	~~1.018~~	1.011
	1	1.017	
	2	1.015	
	3	1.019	
4	0	~~1.014~~	1.021
	1	1.012	
	2	~~1.015~~ 1.011	
	3	1.005	
5	0	~~1.052~~	1.048
	1	1.053	
	2	1.080	
	3	1.071	

Since we are correcting for multiplicity in CsI,
how do we want to handle multiple events in a CsI?

- First? => No
- Last? => No } these favor a specific silicon side
- Largest => OK?
- Random?

The largest will eliminate any possible crosstalk?

<u>CsI crosstalk in Tel #5</u>

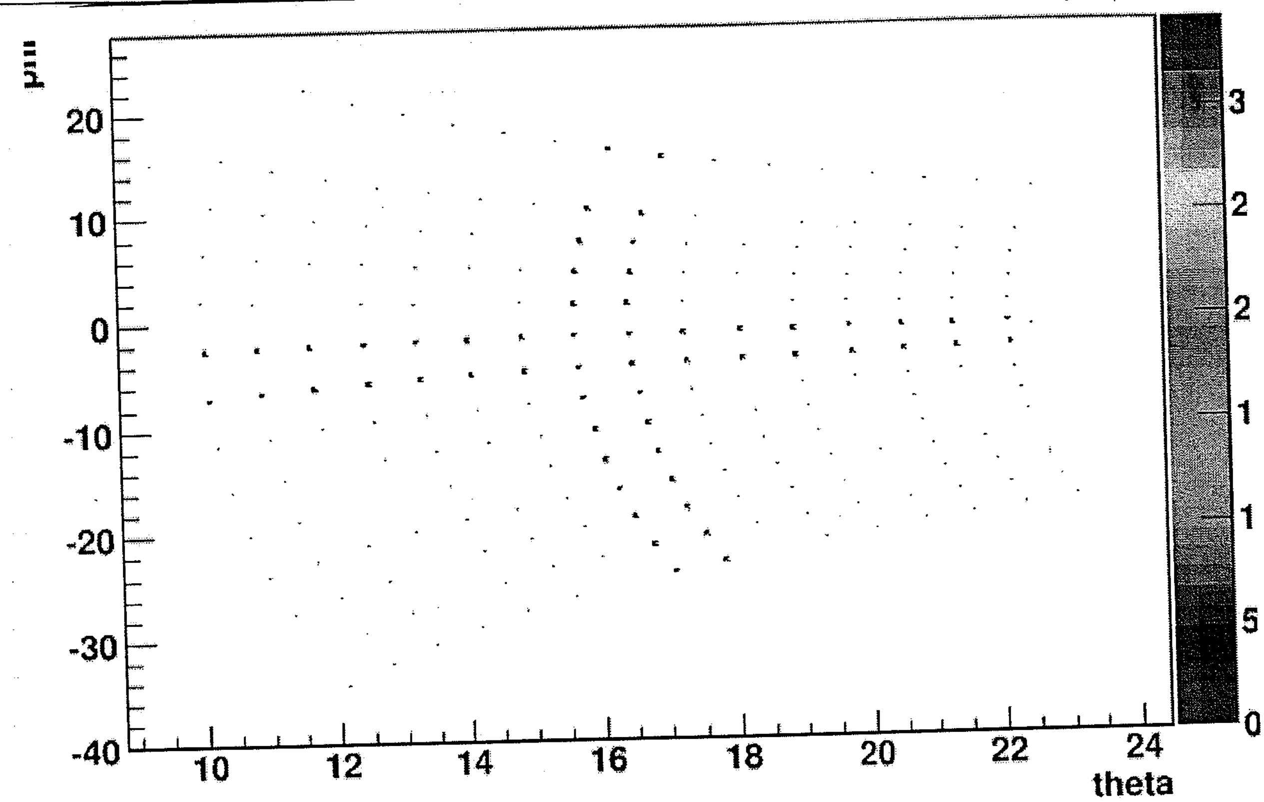


-> Crosstalk events
-> only in Tel #5

Do we worry about them?
- Doesn't seem to interfere with CsI events.
- Doesn't seem to ruin calibration of primary
- Only on edge strips

... hit
... attenuated
... in the
... transverse
... mass.
... looks like
... cross talk

Particles
losing some
energy in
neighboring
CsI



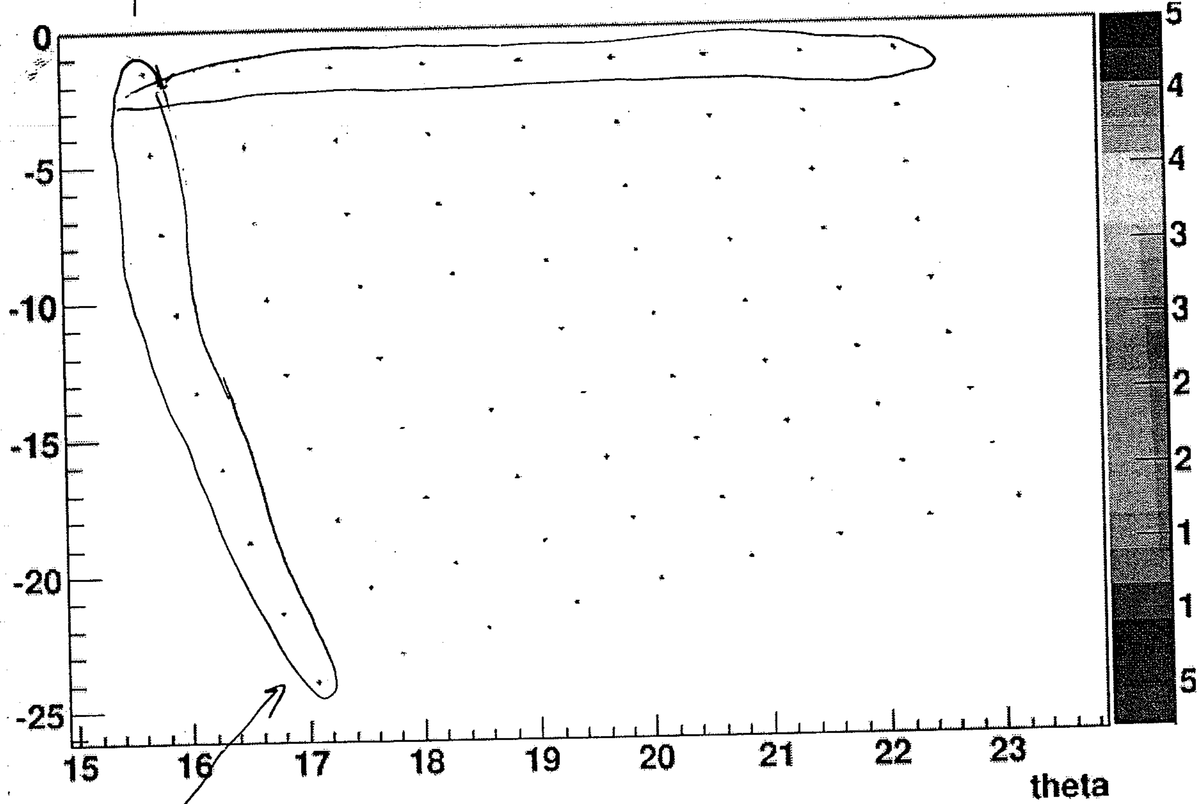
Optical crosstalk?

- Assuming that light leaving CsI is not re-absorbed, then it doesn't affect the CsI it is leaving.
- However, it might affect the Neighboring CsI if there is an event there.

Alternate

- Since we do some overlap in pixels, this could be due to Partial energy loss.

- Crosstalk events come from neighboring channels
  - Find E: csI(2) for events in 3...



Hit map in CsI 3 ~~E~~ gated only on cross talk events
Almost all events come from hits in neighboring strips

Now we must ~~d~~ try to plot Energy in neighboring CsI for Hits in CsI 3

→ Cross talk may only be due to really large $^{3,4}He$ in neighboring crystals → In that case we don't worry about it In fact may be just overflow!

* I think this band is due to cross talk for only the highest energy stuff ⇒ $^{3,4}He$ since the Si channel corresponds to overlap neighboring channels with cutoff where the He punchthroughs are.
In this case, we can ignore it!!!

Pulser ramps to examine rate dependence in Si

Runs

684- 695 ≈100 Hz (MB pulser)
810- 821 ≈100 Hz (MB pulser)
846-861 ≈ 1000Hz (?)

Run	live scaler	raw scaler
684		
685		
686		
687		
688		
689		
690		
691		
692		
693		
694		
695		
810		
811		
812		
813		
814		
815		
816		
817		
818		
819		
820		
821		

Count rate check

~~Run List Raw~~

For tests we examine tel 2F ≈ channel 8000

Run 686 : counts = 1276

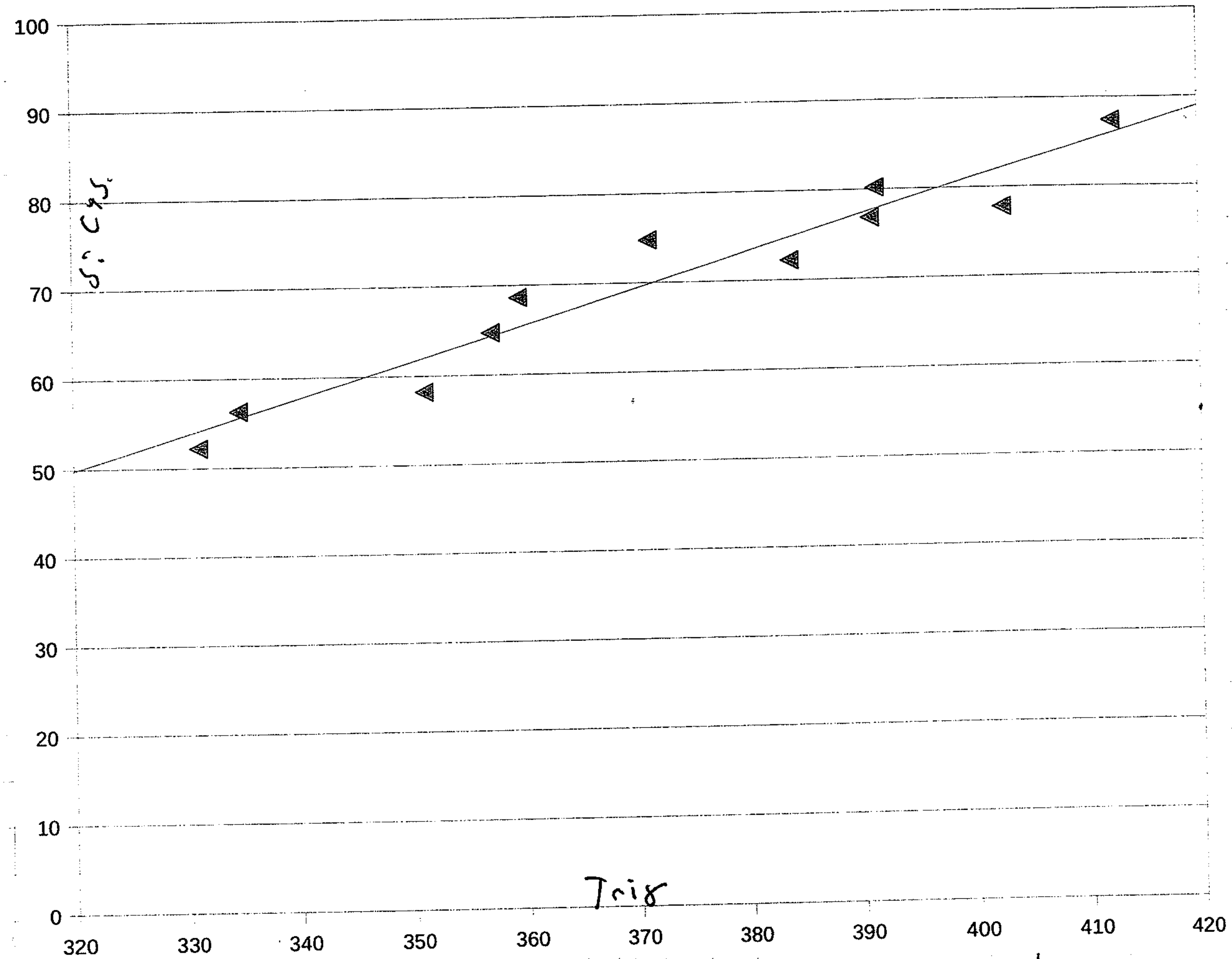
Possibility to examine Signals rate dependence.
- Count rates are uniform. ~330-400
- Check various rates vs run.

Run	Trigger rate	CsI Oe		
790	190.73	428.45		
789	344.07	~~339.22~~ 756.54		
788	351.06	772.22		
787	346.64	786.68		
786	359.46	~~1055.65~~	883.32	
785	371.11	~~1142.16~~	938.02	
784	420.05	~~1133.58~~	~~938.02~~	1616.01
783	391.13	~~1020.74~~	~~1616.01~~	1020.74
782	391.45	1017.76		
781	375.64	944.66		
780	425.11	1051.65		

Maybe try integrations over a specific region scaled for beam trt
Value (12)(7) ~~Value (3)(7)~~ : ch 4000-6000

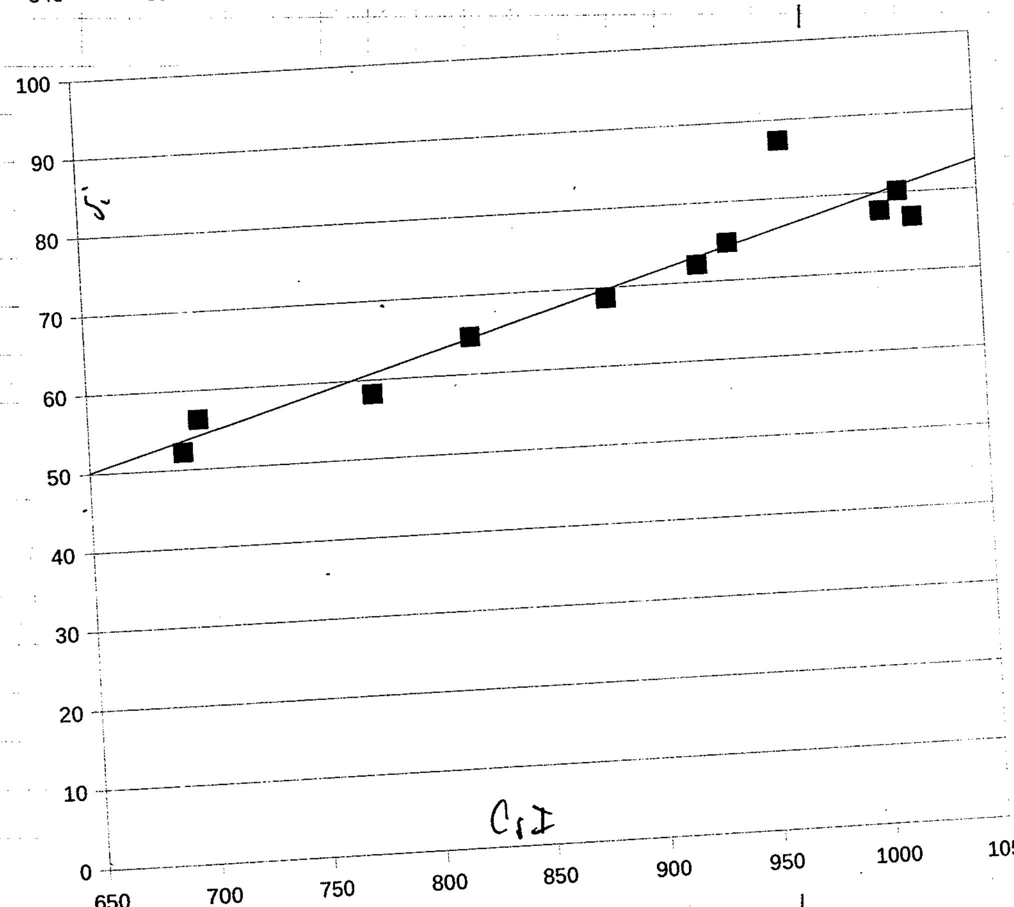
Run	Σ cts	Pulser	Pulser live	CsI	CsI live
783	994				
785	851				
788	1215				
790	916	→ Scaler problems?			
786	715				

Cts



Si Cts
vs CsI
cts.

Looks like no
count rate dependence
at least over
the range of interest.

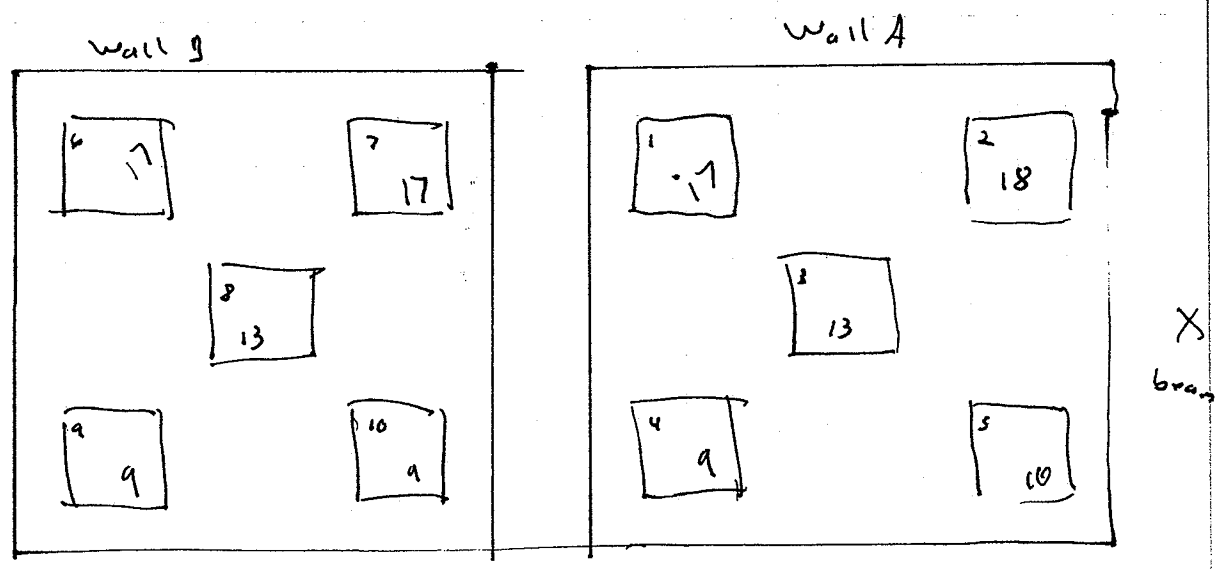


April-2011

Neutron shadow bar calibration

- Should calibrate by System and Configuration.
  - Thus we calibrate by system and angle.

Positions of tubes



System	Run	Positions
	618-623	3, 8
	624-625	Corners
	627-718	Opposite corners?
	719-727	Corners
	728-753	Center
	754-791	None (no mounts)
	792-797	Center
	798-802	2,4, 7,9
	803-804	"Smilie face"
	805-809	1, 5, 6, 10

Root chains

neut_84_C : runs 792-797 neutrons (^{48}Ca + ^{124}Sn center)

neut_84_2 runs 798-802 (^{48}Ca + ^{124}Sn 2,4,7,9)

neut_84_1 runs 805-809 (^{48}Ca + 124 1,5,6,10)

Some Final things to examine in 1ASSA

- Thresholds in all telescopes
- Calibration for all runs.

Center = tube 13

Position	tube
3, 8	13
2	18

See pg 65

Neutron Scattering

pid = 0

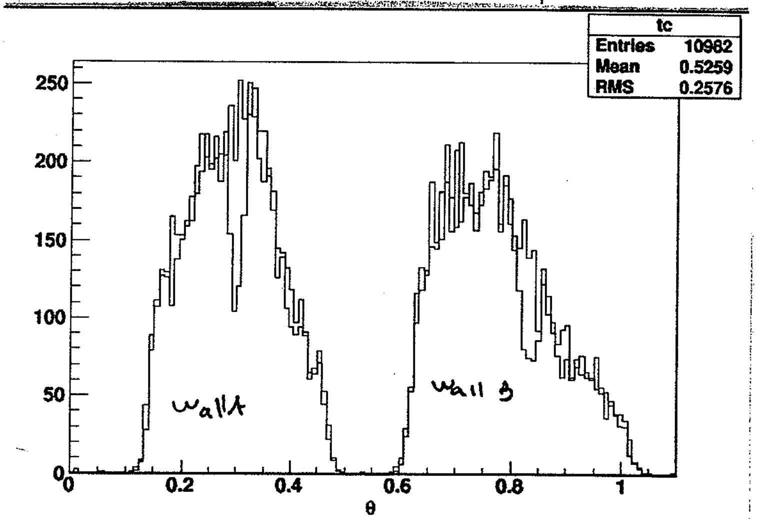
Try First runs 792-797

$^{48}Ca + ^{124}Sn$

Angular distribution with and without Shadowbars.

Black: without Shadowbar

Red: with Shadowbar

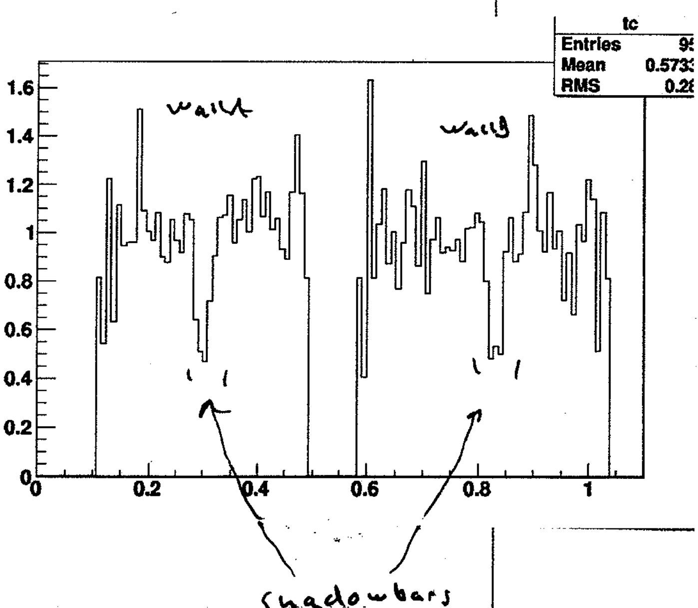


Reduction:

Scattered fraction vs angle

- Neutrons only

Angle:	f
0.302154	0.470194



$^{40}Ca + ^{124}Sn$

Run 617-628

Run	Position		
617-622	center		
~~623-625~~ 623-625	corners	2, 4, 7, 9	(Problem w/ run 624)
626-628	opposite corners	1, 5, 6, 10	

$^{48}Ca + ^{112}Sn$

Runs 701-767, but Not 709-719

712 - ~~718~~ ~~719~~ 717	~~2, 4, 7, 9~~	1, 5, 6, 10
719 - 725		2, 4, 7, 9
727 - 732		center

$^{40}Ca + ^{112}Sn$

Runs 607-612

No record

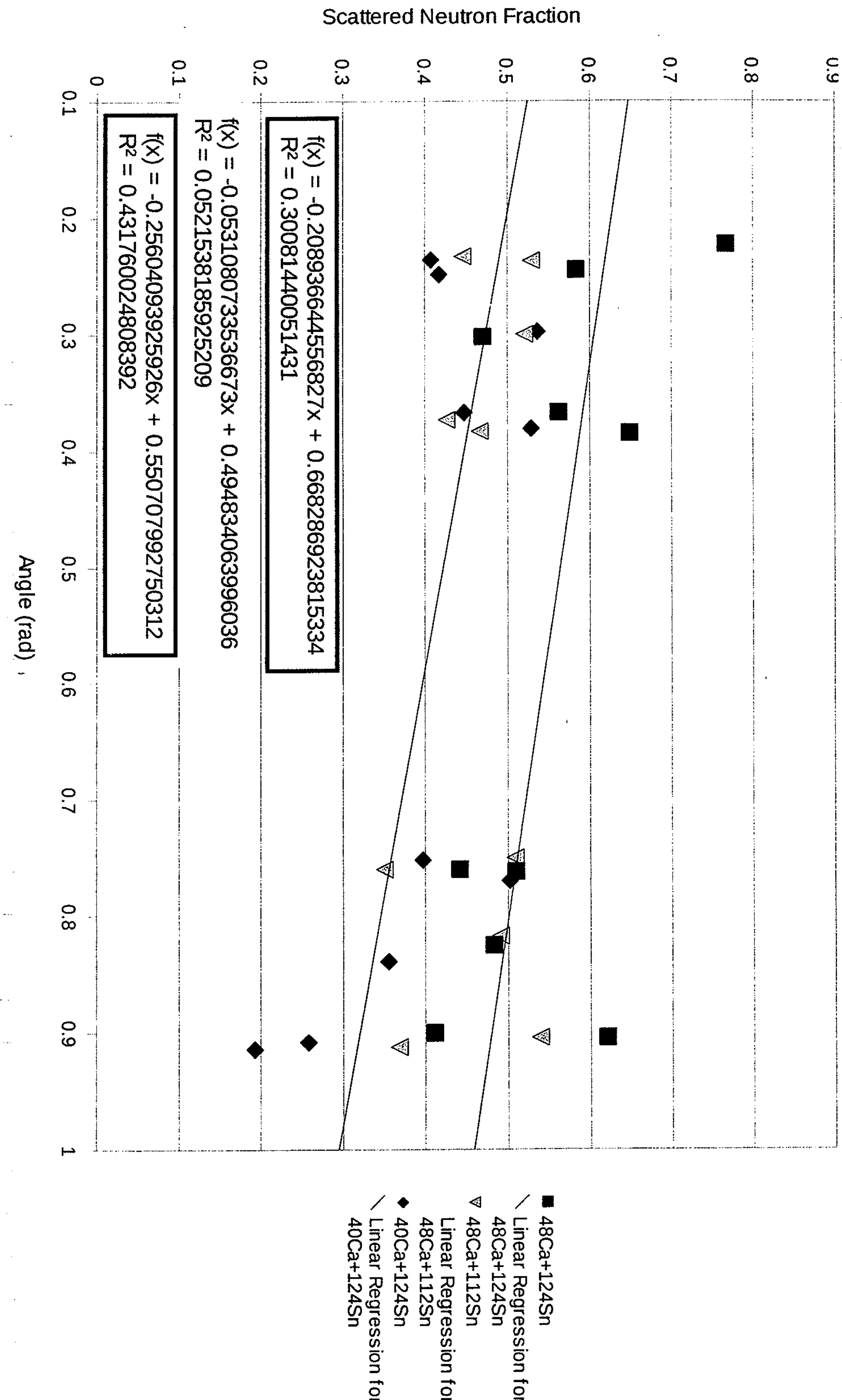
Note

* ~~For Some~~ → Can't seem to completely process runs 721 & 722

Neutron Wall
Fraction of neutrons which are due to Scattering

Notes:

$^{40}Ca + ^{112}Sn$ had very few events so not too much there



April 2011

Neutron wall Geometric efficiency

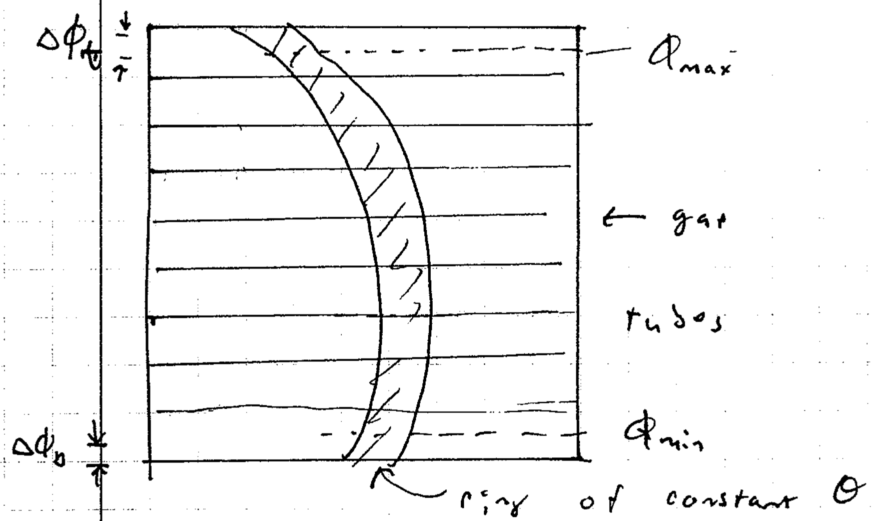
For a given angle.

Tube height $= h$
Gap between active area $= g$
Angular position $= \theta$
Azimuthal position $= \phi$

For a section of wall $\theta \to \theta + \Delta\theta$
assume constant height

The fraction of tubes that actually fill the space:
$n(\theta)$

For each angular region in the walls



The fractional area taken by the gaps is

$$f = \frac{A_g}{A_t} = \frac{23g}{24h}$$

23 → because there are 23 gaps, but since ϕ is measured at the tube mid point, we must also add on $\frac{1}{2}$ of a tube on each end (in terms of ϕ)

$\Delta\phi \approx \frac{h}{2R}$ R = distance at θ

For each tube

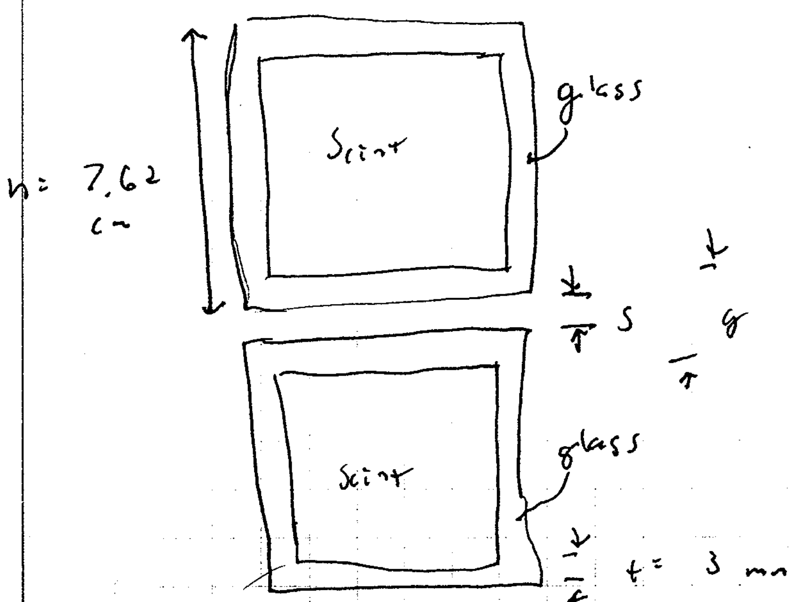
$$\mathcal{E}(\theta) \approx \left[\frac{\Phi_{max} - \Phi_{min} + 2\Delta\phi}{2\pi}\right] \frac{\ell}{\delta}(1-f)$$

$$= \left(\frac{\Phi_{max} - \Phi_{min} + \frac{h}{2R_t} + \frac{h}{2R_b}}{2\pi}\right)(1-f)$$

Not quite circ since we are at an angle and h ≠ tube height

$\frac{h}{2} = \frac{7.62}{2}$ cm = 3.81 cm

Cell Spacing



S = 3mm

g = 9mm

position wall

tube 23

tube 0

y = 90.38 cm

x = -10.61 cm

$f = \frac{23s}{24h} = 0.113188976$

$\frac{24g}{24h} = 0.118110236$

Probably the best way to determine $\varepsilon(\theta)$

$$\varepsilon(\theta) = \left(\frac{\phi_{max} - \phi_{min}}{2\pi}\right) \oint (1-f)$$

ϕ_{max} = top of tube 23 + ~~$\frac{1}{2}\phi$~~ $\frac{|\phi_{23} - \phi_{22}|}{2}$

ϕ_{min} = bottom of tube 0 + $\frac{|\phi_1 - \phi_0|}{2}$

↑ half distance between tubes.

Cont from pg 73

Angle	Tubes	ϕ
45	↓	
46	↓	
47	↓	
48	↓	
49	↓	
50	↓	
51	↓	
52	↓	
53	↓	
54	↓	
55	↓	
56	↓	
57	↓	
58	0-23	
59	0-3, ~~8,~~ 5,6, 10, 16-23	
60	0, 1, 23	
~~6~~		

Angles

Angle	Tubes	Φ_{min}	Φ_{max}
7	9-16, 18	$\phi_{80} =$ ~~0.52~~2 −0.2756 $\phi_9 = -0.3029$	$\phi_{16} =$ 0.4131 $\phi_{15} = 0.2868$ $\phi_{18} =$ ϕ
8	7-18		
9	5-20		
10	2-22		
11	1-23		
12	0-23		
13	↓		
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27	↓		
28	0-7, 9, 11, ~~13, 14~~ 12, 14-23		
29	1-3, 5, 23, 22, 20		
30	0		
31			
32			
33	0		
B 34	8-14, 16-18, 20, 21		
35	3-23		
36	0-23		
37			
38			
39			
40			
41			
42			
43			
44			

Geometric ε

Spreadsheet

May-2011

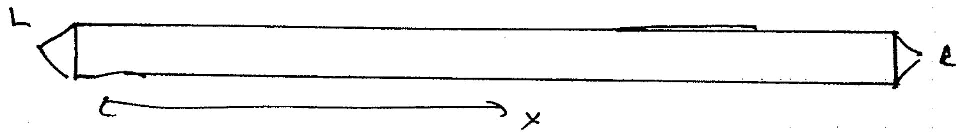
Now to Neutron energy efficiency

Depends on
- threshold left
- threshold right
- Position
- Energy

Pg 53 !!!

Also
- incorporate scattering correction into wall
- incorporate geo E into wall

Consider a single tube and single E at position x



Thresh = T_L Thresh: T_R

If $E_L = E e^{-x/\lambda} < T_L$ then no event
$E_R = E e^{-(L-x)/\lambda} < T_r$ no event

so x must be constrained by

$$E e^{-x/\lambda} > T_L$$

$$-\frac{x}{\lambda} > \ln\left(\frac{T_L}{E}\right)$$

$$x < \lambda \ln\left(E/T_L\right)$$

$$E e^{-(L-x)/\lambda} > T_r$$

$$\ln\left(\frac{T_R}{E}\right) < \frac{-(L-x)}{\lambda}$$

$$L - x < \lambda \ln\left(\frac{T_R}{E}\right)$$

$$-x < \lambda \ln\left(\frac{E}{T_R}\right) - L$$

$$\boxed{\lambda \ln\left(\frac{E}{T_L}\right) > x > L - \lambda \ln\left(\frac{E}{T_R}\right)}$$

$c = 2$

$\lambda = 160$ cm $= 1.6$ m

Assume $T_L = T_R = 1$ MeV

E

For thresholds of about 1 MeV, the effect is low for neutron energies above 4 MeV, so maybe not a big deal

To do
- Find relation between energy & channel
- then find thresholds for each side.
  - Two types of ε for this
    - interaction ε
    - detection ε by PMT
      - but this is more of a geometric ε

Looks like most thresholds set to 110.

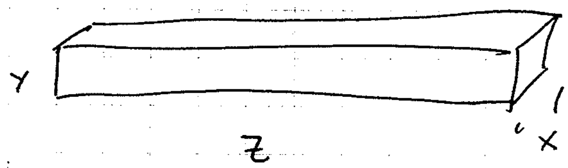
Very rough calibration. ^{60}Co compton edge is near channel 400
pedestals at ~ ~~300~~ ~250

Threshold of 110 ~ channel 450
very approximate ≈ 1.5 MeV thresh.

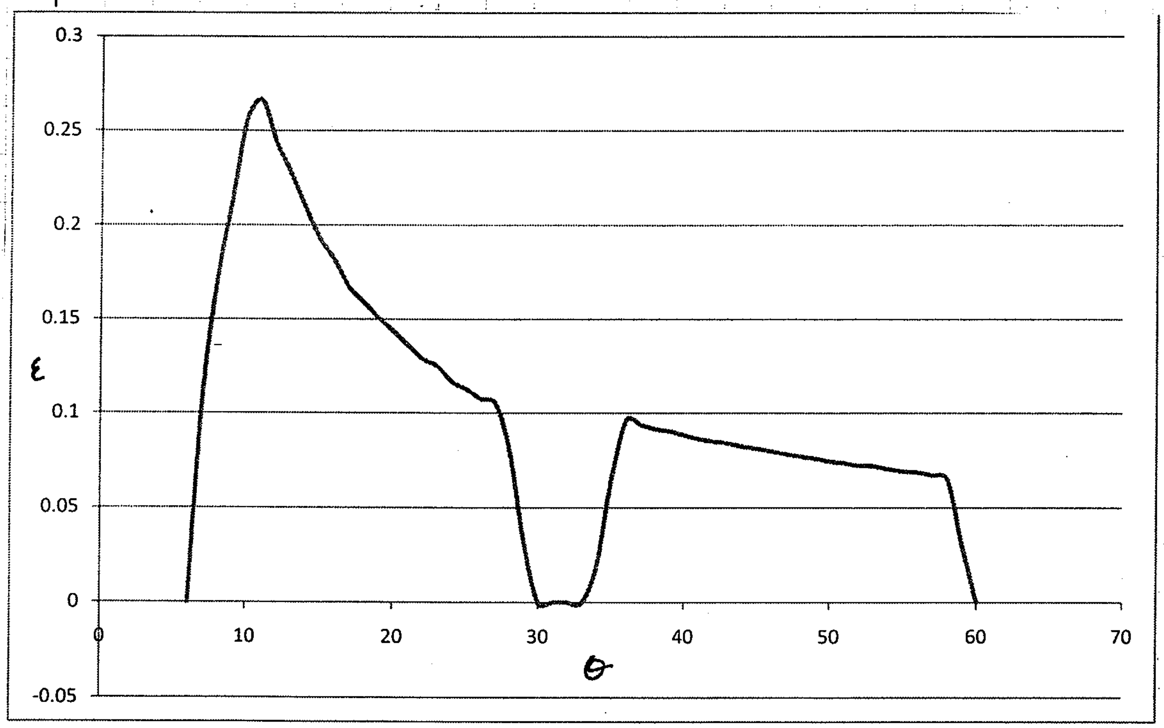
See eXcel file Neutron-thresh analysis.

$$\varepsilon = \varepsilon(T_L, T_R, x, E)$$

GEANT Sim



NE 213	Quartz
z = 2.00 m	z = 2.006 m
y = 7.62 cm	y = 7.626 cm
x = ~~6.35 cm~~ 6.35 cm	z = 6.766 cm
~~Zcm 6.76cm~~ (?)	



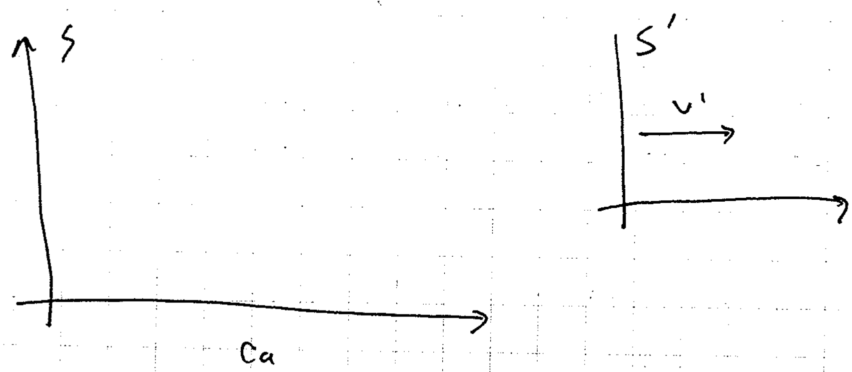
Neutron wall geometric ε

Todo
- Adjust geo eff for Shadow bars
- Relook at 40Ca +112 files + calibrations
- E eff for neutrons

Preliminary look at $^{40}Ca + ^{124}Sn$ — 14-May-2011

$E_{Ca} = 140$ MeV/A $E_{cm} = 104.332$ MeV/A

$y_{lab} = 0.541865921$ $y'_{b,cm} = 0.469202593$



S: lab frame

S' = CM frame

Velocity of CM Frame

$y'_{b,cm} = y_{lab} - y'$

$y' = 0.072663328$

$y_{cm} = y_{lab} - y'$

To find $y_{cm} \Rightarrow y_{cm} = y_{lab} - y'$

<u>Figures</u>

- δ vs $(Y/Y_b)_{cms}$ for $\hat{b} \lesssim 0.2$ • | free + <u>all</u> nucleons
- $\frac{dN}{dy}$ vs $(Y/Y_b)_{cm}$ for $\hat{b} \lesssim 0.2$
- $(n/p)_{free}$ vs $\cos(\theta)_{lab}$ for $\hat{b} \lesssim 0.2$
- $(\frac{n}{p})_{free}$ vs T_{lab} for $\hat{b} \lesssim 0.2$ for very forward $(\cos\theta \gtrsim 0.75)$ and very backward $(\cos\theta \lesssim -0.5)$
- Also do for $^{48}Ca + ^{124}Sn$
  $^{48}Ca + ^{112}Sn$

-May-2011 Runs evaluated (exp49)

$^{40}Ca + ^{124}Sn$	$^{40}Ca + ^{112}Sn$	$^{48}Ca + ^{124}Sn$	$^{48}Ca + ^{112}Sn$
~~767~~	611 ✓	792	767
	610 ✓	793	732
	609 ✓	794 n	731 *

For $^{40}Ca + ^{124}Sn$ we use different files for n + p
so we have to scale n's by 0.3643

- 7-June-2011 Target thickness: Verify this!!

^{124}Sn 5.3 mg/cm²
^{112}Sn : 5.57 mg/cm²

Scripts and Analysis code

neutron [run] [buffers) : converts raw data to ROOT Files

Calibrate. C : Generates calibrated neutron data from ROOT files

~~Mini~~.

MINIBALL_conv.C : Generated uncalibrate Miniball dat files from ROOT files

LASSA_raw.C : Generates uncalibrated LASSA files from ROOT files.

LASSA-conv.C : Generates calibrated LASSA data files from ROOT files

si-cal. C : Silicon calibration routine for LASSA ROOT files