LHRS Analysis for d_2^n

Kinematics, BCM Zeroes, and Scintillator Checks

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OUTLINE

Proton Energy Loss (1)
Material Properties

General Properties					
Material	Z	A (g/mol)	Z/A	ρ (g/cm^3)	I (eV)
GE-180	19.56	40.51	0.4829	2.76	171.8
Polyvinyltoluene	3.37	6.22	0.5414	1.03	64.70
Mylar	6.46	12.41	0.5204	1.40	78.7
Teflon	8.28	17.25	0.4799	2.20	99.1
Titanium	22.0	47.87	0.4596	4.54	233.0

Density Effect Parameters			
Material	X_0	X_1	m
GE-180	0.2	3.0	3.0
Polyvinyltoluene	0.2	3.0	2.0
Mylar	0.2	3.0	2.0
Teflon	0.2	3.0	2.0
Titanium	0.096	3.039	3.302

Proton Energy Loss (2)

Energy Loss by Material

Yellow Cover Substitute: Polyvinyltoluene			
Material	x (g/cm^2)	dE/dx (MeV·cm^2/g)	dE (MeV)
^{2}H	8.975E-5	6.7480	0.0006
GE-180	0.6701	2.5830	1.7309
^{4}He	0.0131	3.1517	0.0413
Polyvinyltoluene	0.0916	3.2578	0.2983
Air	0.0617	2.9099	0.1795
Kapton	0.0361	3.0154	0.1088
Titanium	0.0461	2.3737	0.1095

Yellow Cover Substitute: Mylar			
Material	x (g/cm^2)	dE/dx (MeV·cm^2/g)	dE (MeV)
^{2}H	8.975E-5	6.7480	0.0006
GE-180	0.6701	2.5830	1.7309
^{4}He	0.0131	3.1517	0.0413
Mylar	0.1245	3.0624	0.3811
Air	0.0617	2.9102	0.1795
Kapton	0.0361	3.0158	0.1088
Titanium	0.0461	2.3740	0.1095

Proton Energy Loss (3)

Energy Loss by Material

Yellow Cover Substitute: Teflon			
Material	x (g/cm^2)	dE/dx (MeV·cm^2/g)	dE (MeV)
^{2}H	8.975E-5	6.7480	0.0006
GE-180	0.6701	2.5830	1.7309
^{4}He	0.0131	3.1517	0.0413
Teflon	0.1956	2.7503	0.5379
Air	0.0617	2.9109	0.1795
Kapton	0.0361	3.0165	0.1088
Titanium	0.0461	2.3746	0.1095

- Notes:
  - $\frac{dE}{dx} = \frac{dE}{dx}(Z, A, \rho, I, \beta, \delta(\beta\gamma))$
  - $\delta(\beta\gamma) = 0$ for all materials in this calculation
    - The lowest threshold is for Titanium, where one needs $\beta\gamma > 1.25$ to see the effect
    - For all materials: $\beta\gamma < 1$
  - Percent difference in dE between pyrex and GE-180: 7.68%

Proton Energy Loss (4)

Energy Loss for Different Yellow Cover Substitutes

- Utilizing $E_f = E_i - x\frac{dE}{dx}$; $E_i = 1281.0$ MeV
- Using polyvinyltoluene:

$$\begin{aligned} E_f &= 1278.53 \text{ MeV} \\ dE &= 2.47 \text{ MeV} \end{aligned}$$

- Using mylar:

$$\begin{aligned} E_f &= 1278.45 \text{ MeV} \\ dE &= 2.55 \text{ MeV} \end{aligned}$$

- Using teflon:

$$\begin{aligned} E_f &= 1278.29 \text{ MeV} \\ dE &= 2.71 \text{ MeV} \end{aligned}$$

THaPrimaryKine Class (1)

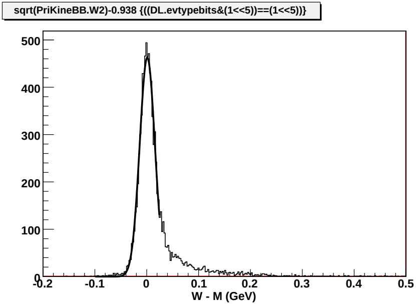
Invariant Mass: Elastic Run 1258

- Coincident mode
  - BigBite in negative polarity
  - LHRS in positive polarity
- Previous invesitgations of W were done with the wrong replay script
- The THaPrimaryKine class uses electron kinematics to calculate W
- Using the LHRS replay script (which only looks at proton data here) while trying to examine W doesn't make sense

THaPrimaryKine Class (2)

Invariant Mass: Elastic Run 1258

- Using the replay_phys_coin.C script:

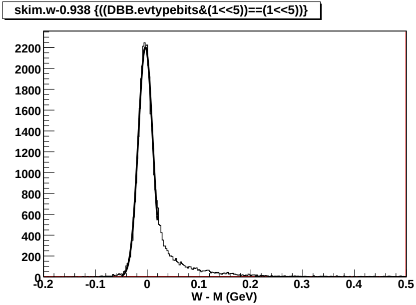


- $\mu = 1.1$ MeV
- $\sigma = 15$ MeV

THaPrimaryKine Class (3)

Invariant Mass: Elastic Run 1258

- Using Diana's skimmed ROOTfile:

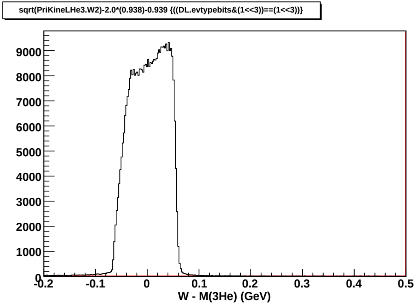


- $\mu =$ -3.51 MeV
- $\sigma = 13.8$ MeV

THaPrimaryKine Class (4)

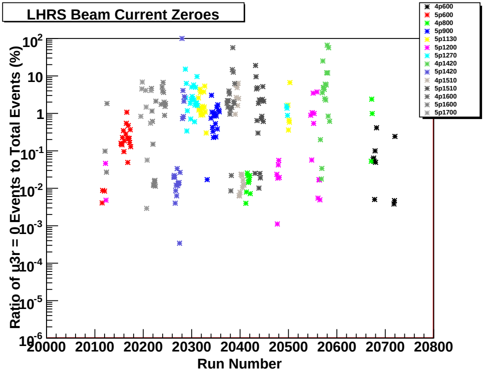
Invariant Mass: Elastic Run 1229

- Single arm, negative polarity mode
- Using the `replay_det_L.C` script:



$u3r = 0$ Study (1)

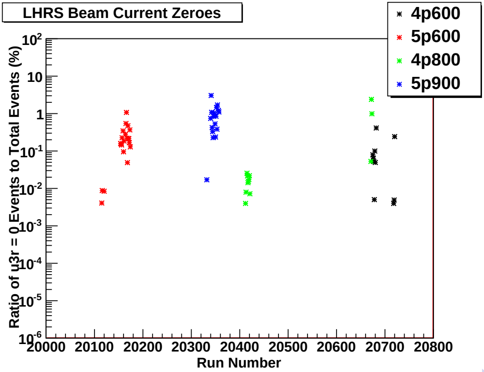
All Negative Polarity Production Data



- Most runs exhibit the effect to $\leq 20\%$ (!)
- Outliers: bad runs (e.g., lasted 2 minutes, no current, etc.)
- $I = 0$ should imply $u3r \sim 493$ (recall the equation for $I(u3r)$)

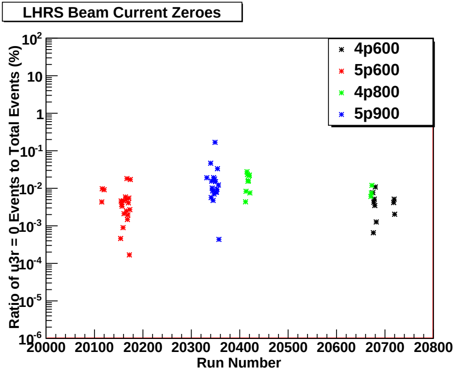
$u3r = 0$ Study (2)
Beam Trip Dependence

- Does this effect depend on beam trips?
- Look at the first four kinematics – skimmed runs (no beam cut):



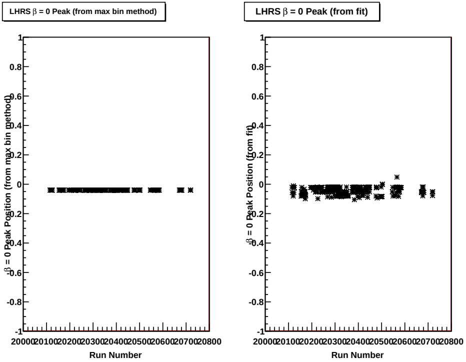
$u3r = 0$ Study (3)
Beam Trip Dependence

- With a beam cut:



Scintillators (1)
$\beta \sim 0$ Consistency

- To be sure of our cut on β, we examine the consistency of the $\beta \sim 0$ peak:

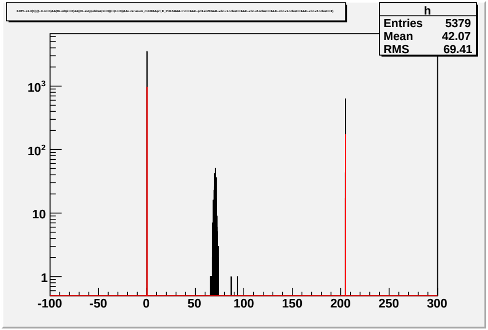


- $\beta =$ -0.04 (maximum bin method)
- $\beta \sim$ [-0.02,-0.1] (from gaussian fit)
- Proposed cut: $\beta >$ -0.15

Scintillators (2)

Multi-hit Effects

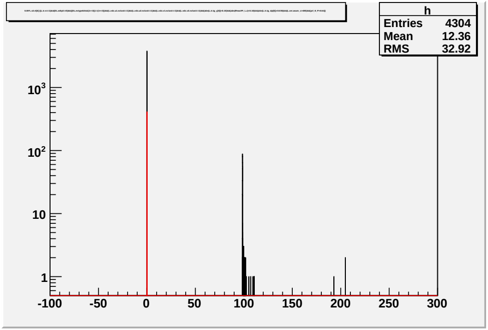
- Review: In a typical S1 or S2m TDC spectrum, there are large spikes at both TDC = 0 ns and TDC = 200 ns
  - Both of these spikes can be attributed to good hits in other paddles



- Plot of S1 TDC 2 (index 1)
- Black: good e^- cuts applied (T3, EDTM, VDC, GC, PR, target y, z, $\delta p/p$)
- Red: good e^- cuts + a cut on S1 TDC 5 (index 4) peak

Scintillators (3)
Multi-hit Effects

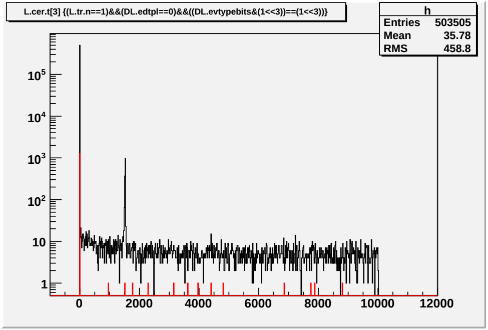
- In S2m, the spike at large TDC times is much more susceptible to GC and PR cuts:



- Plot of S2m TDC 7 (index 6)
- Black: good e^- cuts applied
- Red: good e^- cuts + a cut on S2m TDC 13 (index 12) peak

Scintillators (4)
Multi-hit Effects

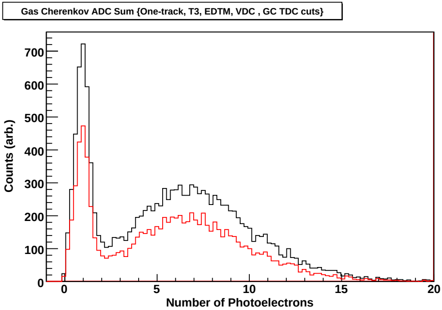
- A similar effect is seen in the gas Čerenkov TDCs:



- Plot of GC TDC 4 (index 3)
- Black: good events – T3, one-track, EDTM cuts
- Red: good events + a cut on GC TDC 8 (index 7) peak

Scintillators (5)
Multi-hit Effects: Discussion

- Is it possible that the reason why these multi-hit events are not removed with tight e^- cuts is due to their correlation to good hits in other TDCs, and hence they have a good gas Čerenkov spectrum?



- GC sum spectrum with the specified cuts + target y, z, $\delta p/p$
- Red: S1 TDC 2 (index 1) = 0 cut + good event cuts

Summary

- Proton Energy Loss:
  - $\Delta E \approx 2.5$–2.7 MeV with the inclusion of the yellow cover and the LHRS exit window
- THaPrimaryKine Class:
  - Behaves properly for elastic coincidence run 1258
  - Elastic single-arm run 1229 shows a considerable width in W about the ^{3}He mass
- Beam Data:
  - $u3r = 0$ events a significant percentage of each run
  - First few kinematics show a possible dependence on beam trips (need more skimmed runs)
- Scintillators:
  - Cut on β: $\beta >$ -0.15
  - Multi-hit effects: Bad hits in TDCs correlated to good hits in other TDCs don't clean up with agressive e^- cuts

What's Next?

- Beam Data:
  - Get to the bottom of the $u3r = 0$ issue
- Pion Rejector E/p:
  - Double-check pedestals for the PR ADCs
- Acceptance – compare data to SAMC
- Start writing code to extract preliminary cross sections
- Data quality (HALOG Perl scripts, cut performance, etc.) is ongoing in the background...