Selection Efficiencies

and other
Systematic Effects in DONuT

Topics

1. Selection Efficiencies
    1. trigger
    2. strip
    3. visual scan
2. Event Timing (T1, T2, T3)
3. Non-prompt / summary of methods
4. Muon spectra
    1. μ^+ vs μ^-
    2. momentum resolution (MC study)
5. Single -Track Strip
    1. SFT / CS interactions
    2. di-lepton search
6. Electron energy estimates
    1. Event-specific analysis
7. Multiplicity One

Selection Efficiencies

- Trigger Efficiencies
- Strip Efficiency
- Visual Scan Efficiency - New Results

Trigger Efficiencies

- Results [Paolone/Aktagon] & Berghaus

type	from Berghaus	
	Per 1,2,3	Per 4
μCC	0.926	0.984
*e*CC	0.964	0.995
τCC	0.938	0.984
NC	0.826	0.885

More Trigger Efficiencies

- Electronic and Other Live Time

Period	Logic LT	Other LT	Self-Veto
1	0.92	0.89	0.96
2	0.91		
3	0.89		
4	0.87		
avg	0.89		

Strip Efficiency

- Reported May 2000 / MC study
  - μCC and eCC → 0.98
  - NC → 0.96

Visual Scan Efficiency -1

- Study 1 : Re-scan "nustrip" files
  - rescan 10% Period 4 files ➪ 0.83±0.06
  - reported May 2000
- Study 2 : Rienhard's muon analysis
  - Period 4 using MC & RS selection ➪ ~0.65

Visual Scan Efficiency - 2

- Study 3 : Single-track filter
  - Period 1,2 → 93 runs ⇨ $0.888 < \varepsilon < 0.931$
  - Period 3 → 35 runs ⇨ $0.870 < \varepsilon < 0.913$

Visual Scan Efficiency - 2+

- Filter requires:
  - at least one track reconstructed in DCs
  - projects to ±30cm @ z=0.
- Visual Scan :
  - throw out upstream interactions
  - throw out other pathologies (many types)

Visual Scan Efficiency - 3

- Combine Study 1 & 3 results
- Take mean for result
- Take total range as systematic error

$$\boxed{0.865 \pm 0.066}$$

Summary

Hardware / Scan Efficiencies

Product of "pre-emulsion analysis" efficiencies

	Period 1	Period 2	Period 3	Period 4
μCC	0.63	0.62	0.61	0.63
*e*CC	0.66	0.65	0.63	0.64
τCC	0.64	0.63	0.62	0.63
NC	0.56	0.56	0.54	0.57

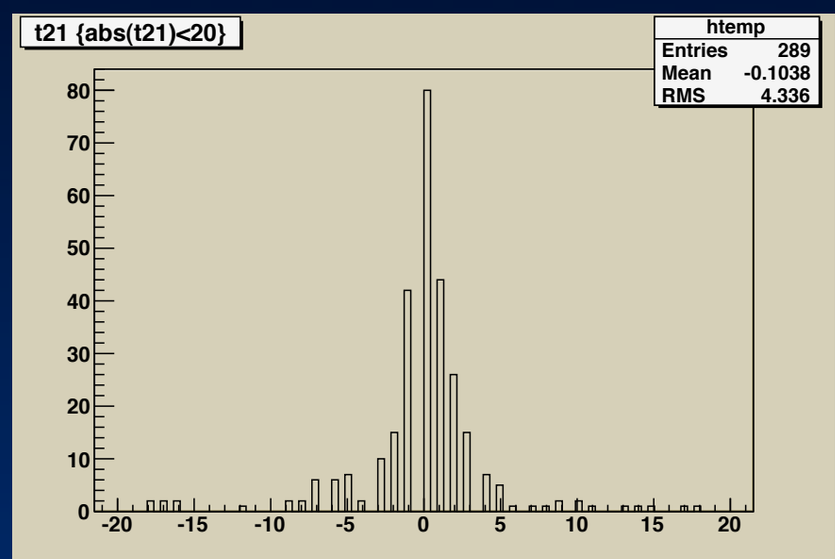
Timing

Located Event Trigger Counter Timing Distributions

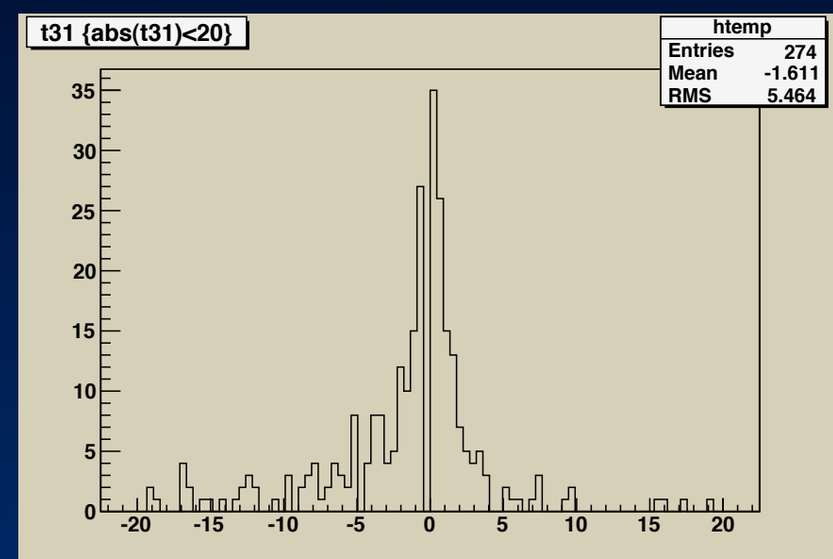
✳ TDCs on Trigger counters used for:

- Visual scan event elimination
- Validating interactions
- Time-of-flight
- Better timing on T3 possible using top and bottom independently
- Find out what happened to RF Sync TDC ?

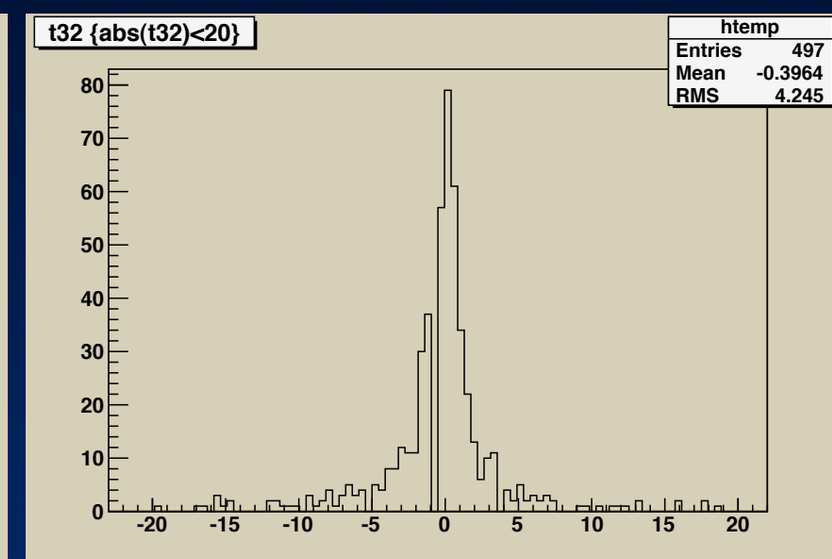
Timing - 1



T2-T1



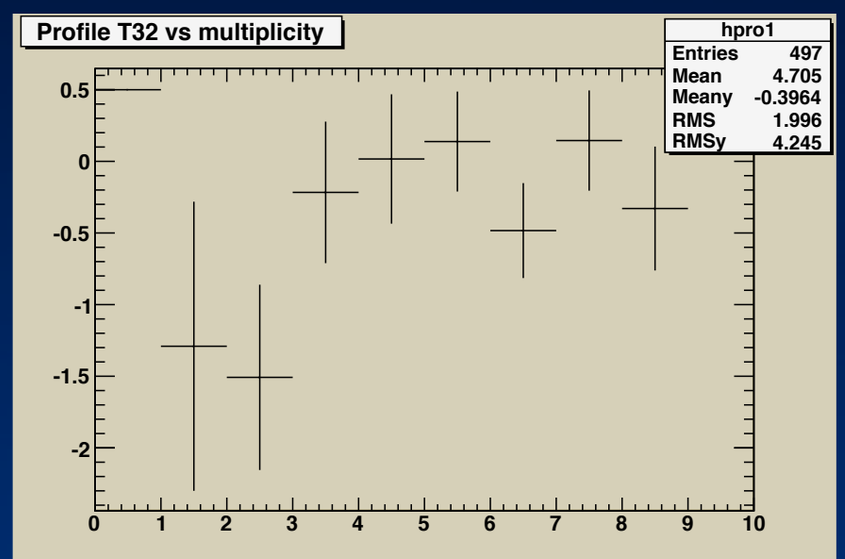
T3-T1

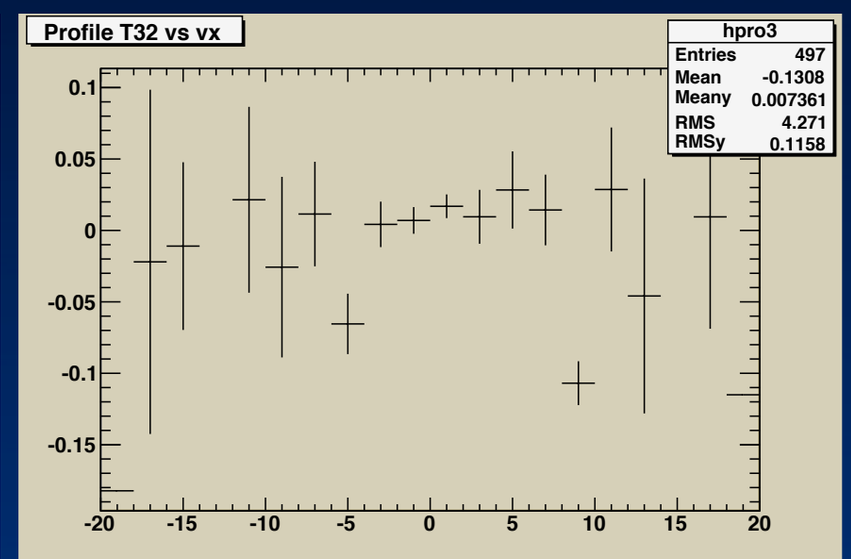


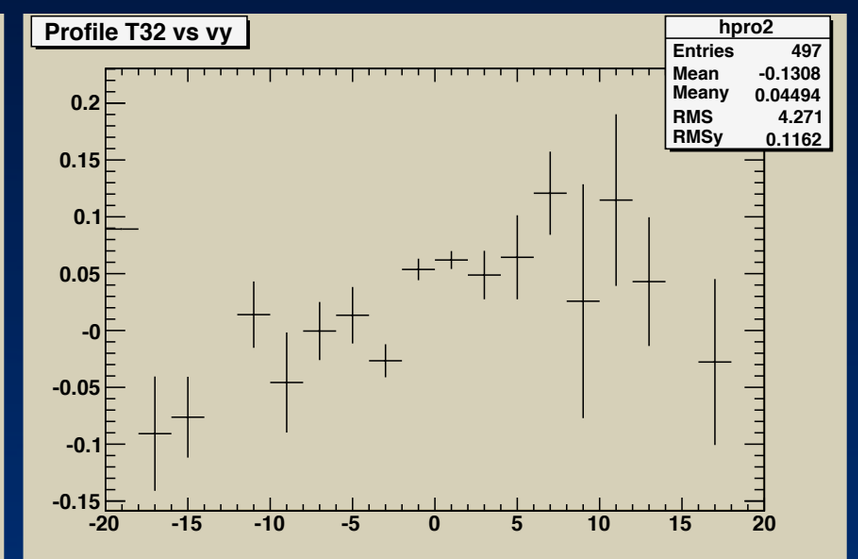
T3-T2

Timing - 2

Check for systematic effects







Multiplicity

x position

y position

Timing - 3

RF Synchronized TDC

$$m \simeq p\sqrt{\frac{2c\,\Delta t}{d}} = 0.13p \quad \text{for resolution of 1ns}$$

Not very impressive since p ~ 10 GeV/c

Timing - 4

- For multiplicity > 2 $\Rightarrow \Delta t$ < 2.0 ns
- Slewing effect in $y \Rightarrow \Delta t$ < 100 ps
- TOF limits : 3 τ (Per 4) ⇒ ~0.5 MeV

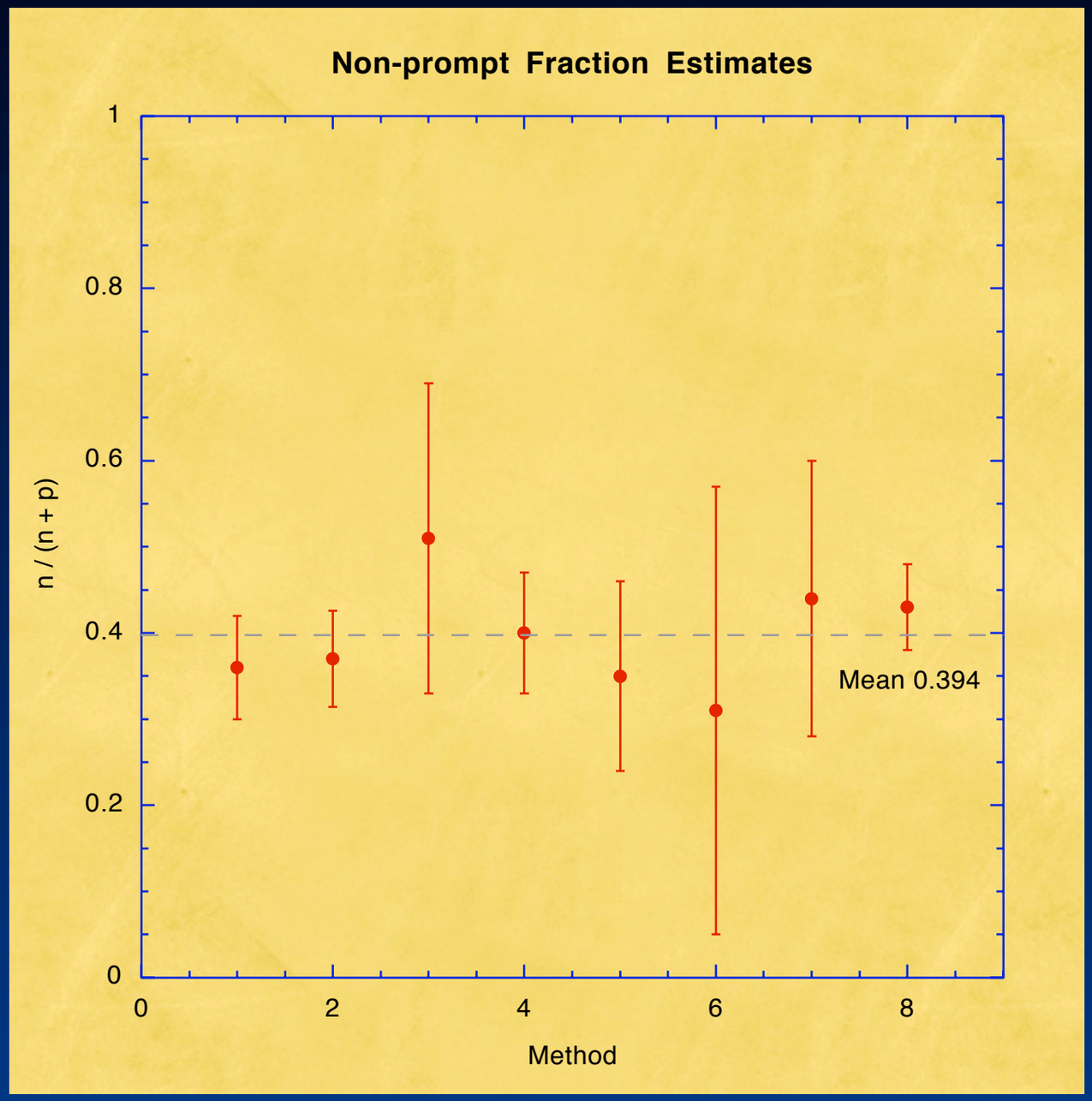
Timing for τ events (ns)

event	T2-T1	T3-T1	T3-T2
3039 01910	0.	-0.5	-0.4
3024 30175	-0.1	-0.05	-0.15
3263 25102	0.	-0.05	-0.05
3296 18816	-0.1	0.4	-0.1
3333 17665	0.	-0.4	0.
3334 19920	0.	-0.05	-0.15
3024 18706	-0.2	-0.05	0.1
3139 22722	*	*	-0.1
3356 17099	*	*	-0.3
3140 22143	*	*	0.05

Non-prompt Estimates

This topic has been studied with seven methods

Non-prompt Fraction



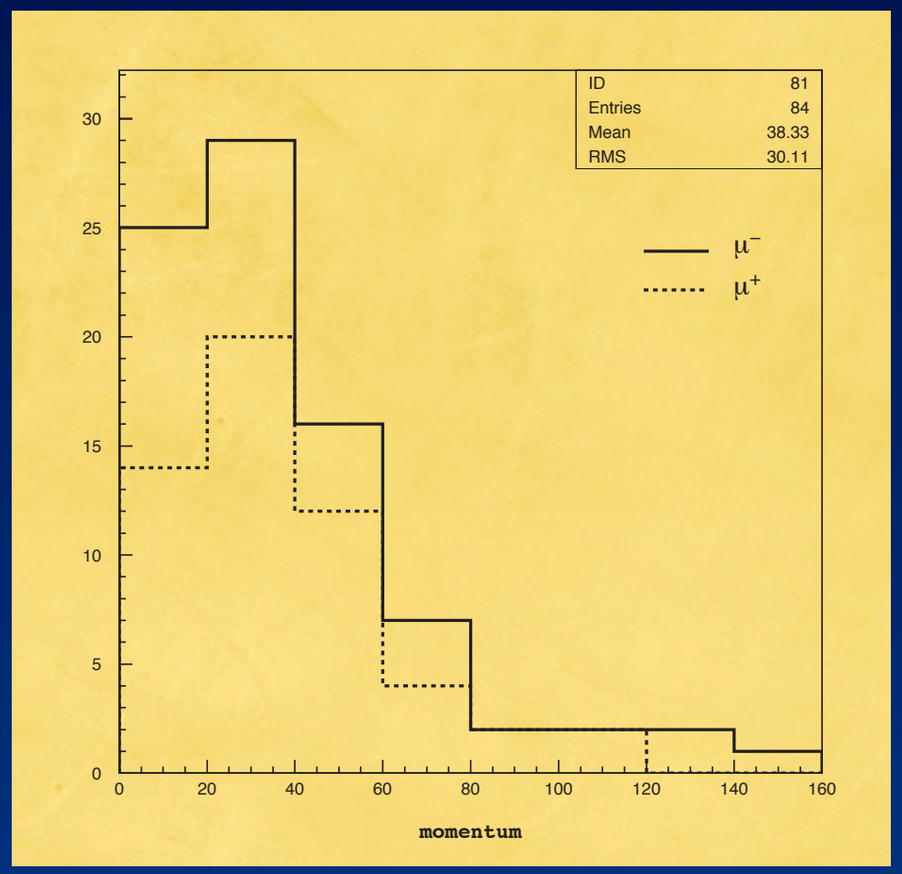
Methods:
1 - Geant / FLUKA (Berghaus)
2 - MARS
3 - Muon Spectrum
4 - Ecal Spectrum
5 - Ecal Spectrum (Per 3 + 4)
6 - Half-density Target
7 - Emulsion electron ID
8 - Fluka (Baller)

Muon Spectrum

It is expected that the mean momentum of the μ^+ from CC interactions is greater than μ^-

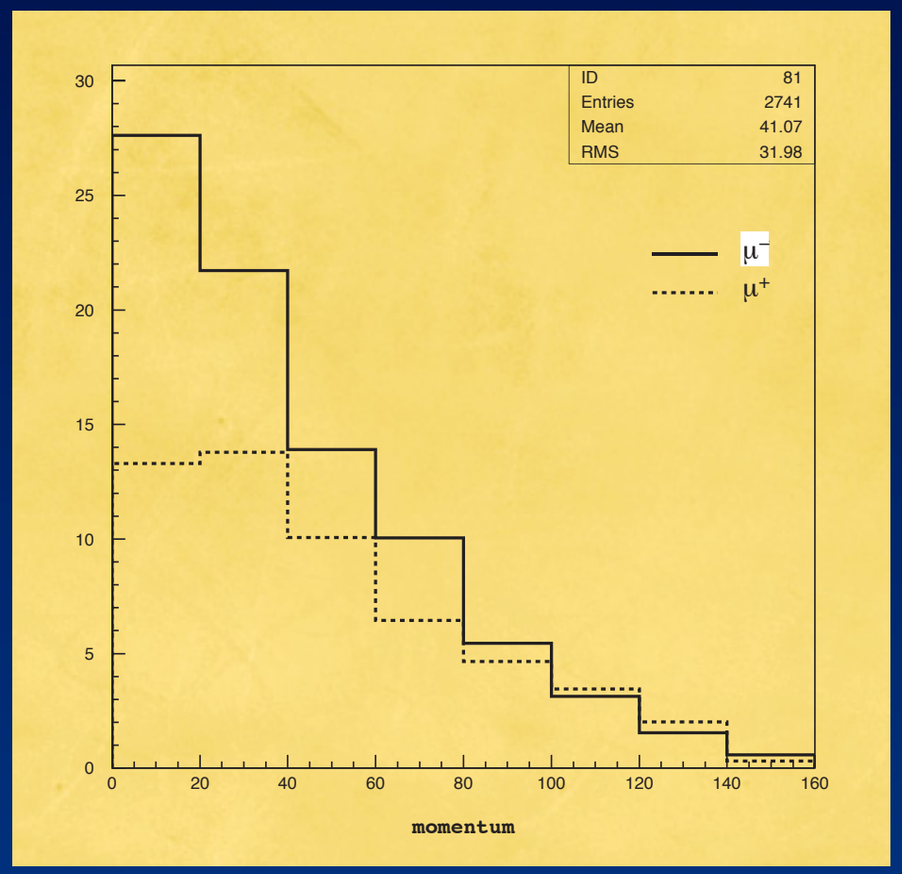
Muon Spectra

- The data show <$p(\mu^+)$> is less than <$p(\mu^-)$>



Data

<$p(\mu^+)$> = 37.4 ; <$p(\mu^-)$> = 38.3

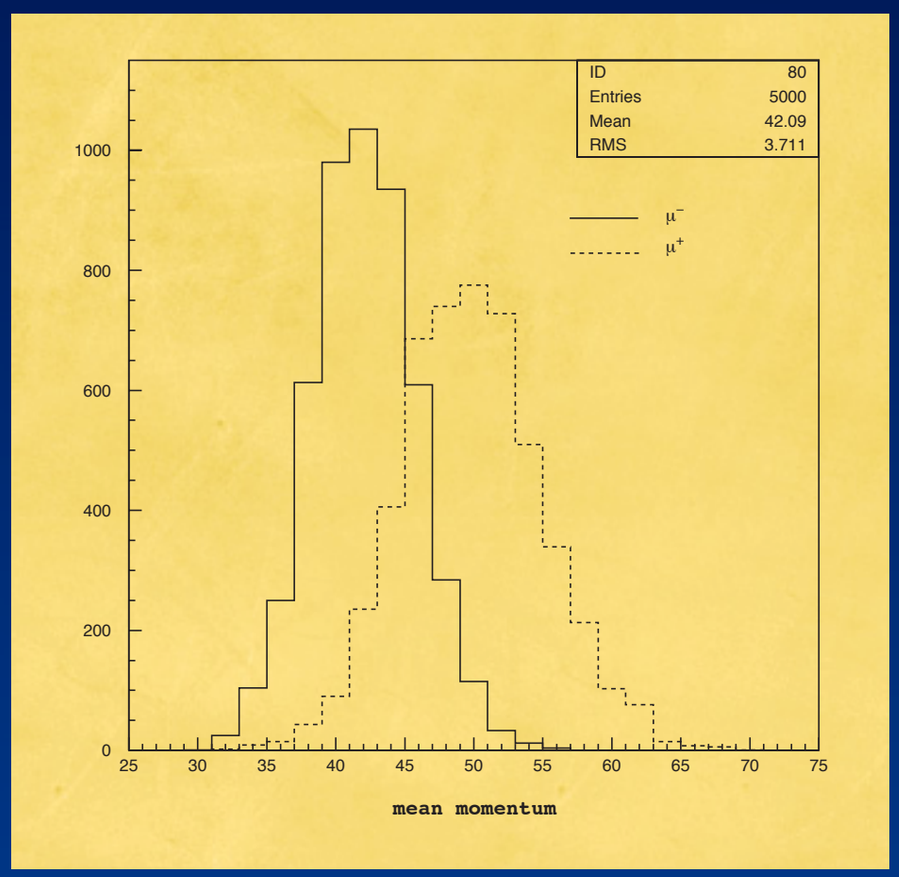


MC

<$p(\mu^+)$> = 49.5 ; <$p(\mu^-)$> = 41.1

Muon Spectra

What is the probability that the μ^+ sample will have smaller mean than the μ^- sample, given the same sample size as the data?



Calculate the mean of 5000 MC samples.
Each sample has the same number of events as the data, per sign.

The overlap is found to be 0.45

Thus the (one-sided) probability that $\langle p(\mu^+)\rangle$ is less than $\langle p(\mu^-)\rangle$ is 0.23

Track Momentum Resolution

MC Study with muons with fixed momenta.
SFT + DC data fit with MINUIT

p GeV/c	μ_p	σ_{dist}	χ^2	$\sigma(p^{-1})_{dist}$	$\delta(p^{-1})_{dist}$	$\delta(p^{-1})_{est}$	$\delta(p^{-1})_{MS}$	$\delta(p^{-1})_{TOT}$
5	5.08	0.69	1.09	0.028	0.0034	0.0040	0.028	0.028
10	10.11	1.13	0.69	0.018	0.0034	0.0040	0.014	0.015
10*	10.20	0.90	0.57	0.013	0.0034	0.0040	0.008	0.009
20	20.8	2.5	0.52	0.012	0.0034	0.0040	0.0069	0.0080
50	48.4	7.4	0.53	0.0035	0.0034	0.0040	0.0028	0.0049
100	103.	21.	0.49	0.0041	0.0034	0.0040	0.0014	0.0042
200	213.	75.**	0.51	0.0036	0.0034	0.0040	0.0007	0.0041

$$\Rightarrow \quad \delta\left(\frac{1}{p}\right) \cong \sqrt{\left(\frac{\delta\vartheta_{MS}}{p_T^{mag}\cdot p}\right)^2 + \left(\delta\vartheta_{meas}\right)^2} = \sqrt{\left(\frac{0.019}{p^2}\right) + 1.6\times 10^{-5}}$$

Details in memo Track_Mom_Err.pdf 26 Feb 2005

SpectrometerTrack Strip

Old "nustrip" files ➟ ≥1 DC/SFT track ➟ no vtx cuts

SpectrometerTrack Strip

- same strip as used in efficiency study
- use Period 4 data
- check interactions in SFT / CS
- look for di-lepton type events

SpectrometerTrack Strip

Statistics of Strip / Period 4

Files	105
Triggers	1402240
nustrip events	30030
strip events	905
visual scan	130
not located	56

Spectrometer Track Strip

- Interactions between emulsion modules

station	CS up	CS down	SFT
1	0	1	2
2	1	3	1
3	1	1	2
4	0	1	1
Σ	2	6	6

Estimate CS mass at
1270g x 8 = 10.2 kg
⇒ expect (10.2/262)x(109) = 4.2 events

compare 4.2 ↔ 8

Estimate SFT + T1 + T2 mass at
23.5 kg
⇒ expect (23.5/262)x(109) = 9.7 events

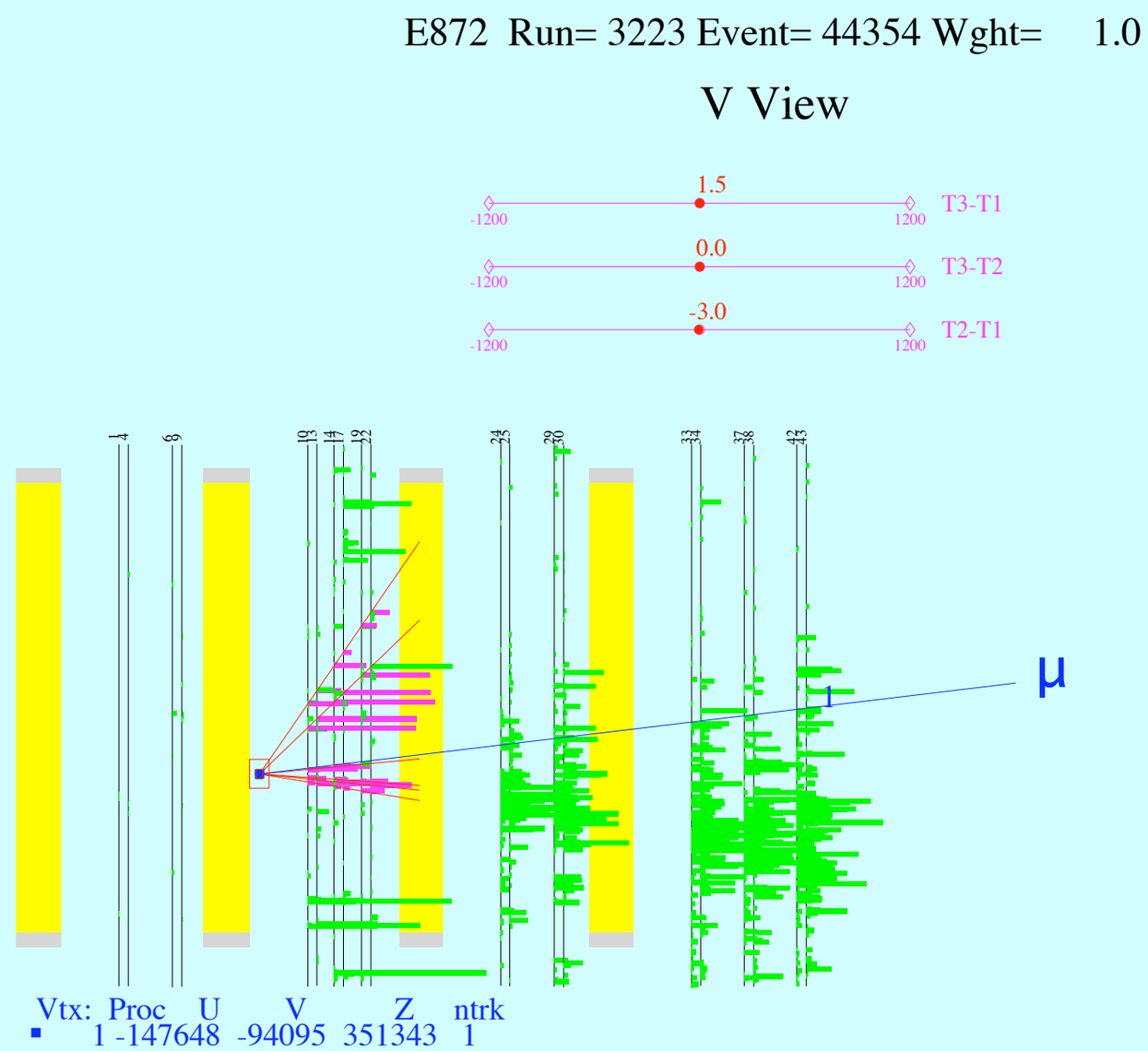
compare 9.7 ↔ 6

SpectrometerTrack Strip

- Search for "di-lepton" events
  - The filter is efficient for finding muons
  - require ≥ 1 muon
  - NOT (T0)
  - visual search for μμ and μ*e* vertices
  - set limits on di-lepton processes

SpectrometerTrack Strip
Di-Leptons

Example



SpectrometerTrack Strip
Di-Leptons

- scan Period 4 :
  - located (CCμ with one other emulsion track)
  - not located
  - in Spectrometer Track Strip
- Eliminate events with:
  - hadronic signatures (other tracks not in shower)

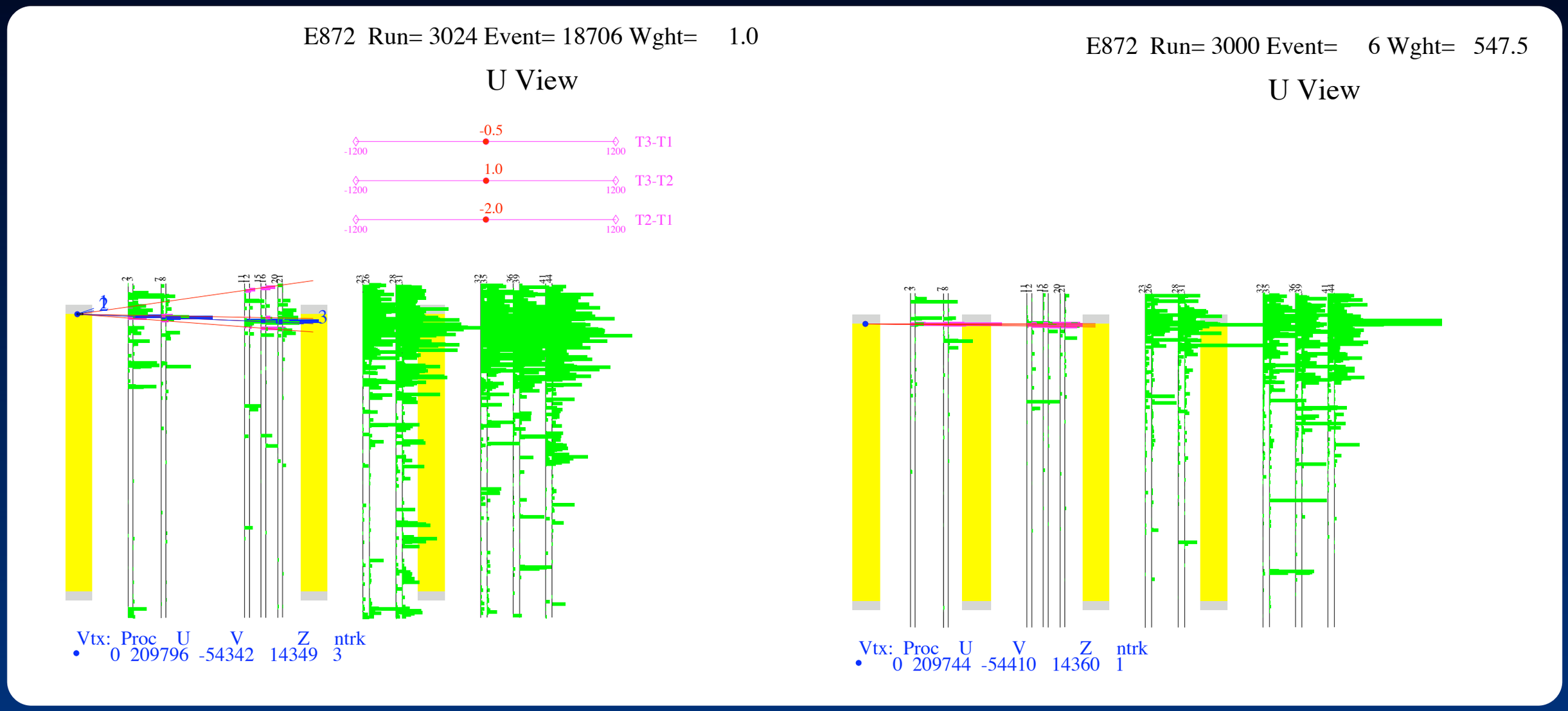
3024_18706

Electron Energy Estimate with Spectrometer

3024_18706

- *Event Specific* Analysis Energy
  - Monte Carlo Simulation of SFTs / calorimeter
    - MC Vertex *Set* at event vertex / track angle
    - 20, 30, 40 GeV e^+
- Use :
  - SFT pulse height
  - Calorimeter Energy

3024_18706



Data

MC (30 GeV)

3024_18706

PH Station 1 = 13

PH Station 2 = 13

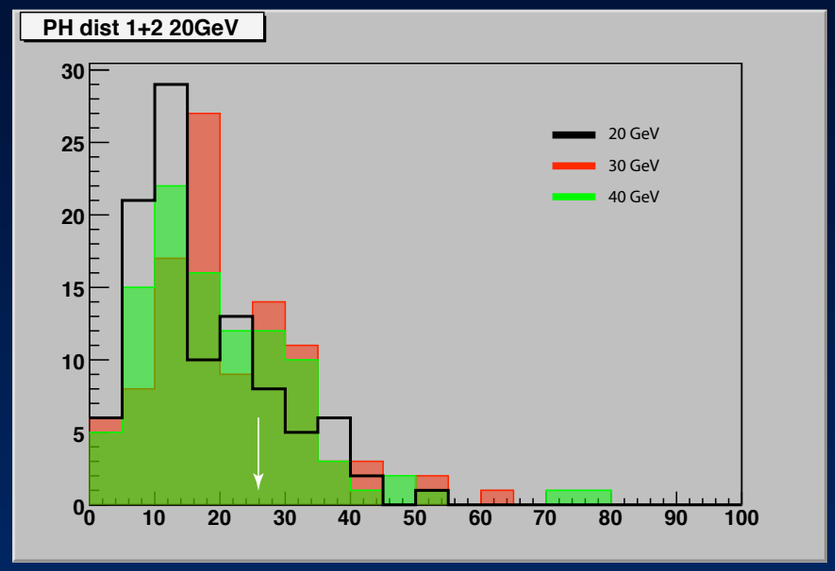
PH Station 3 = 138

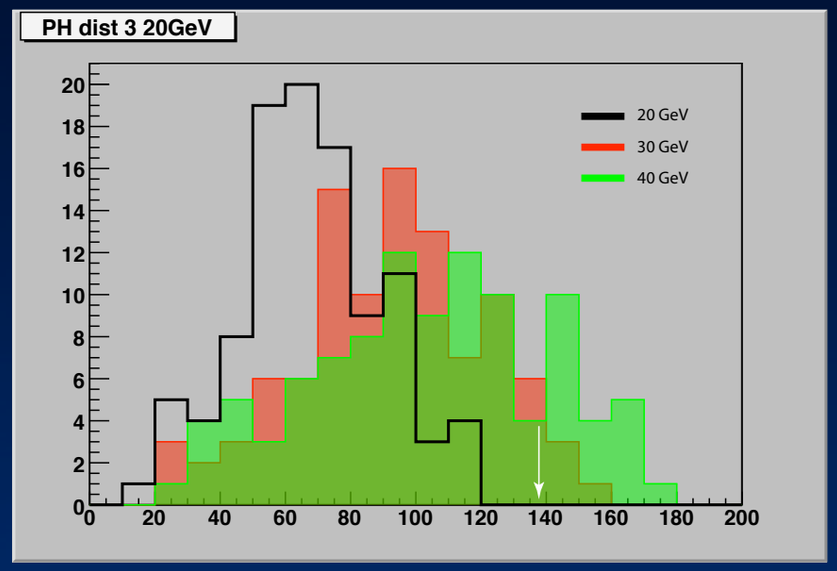
PH Station 4 = 184

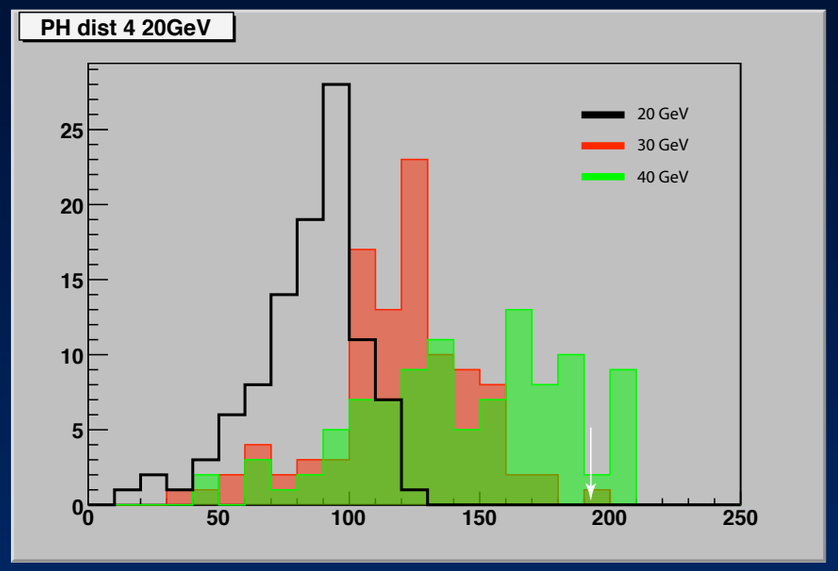
Calorimeter Energy 3.8 GeV

Vertex (u,v,z): (0.2097, -0.0543, 0.0144)

3024_18706

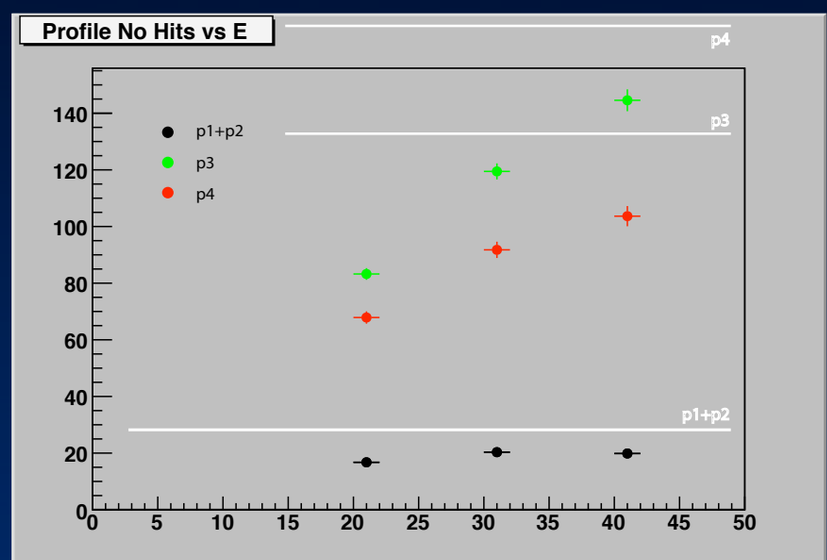


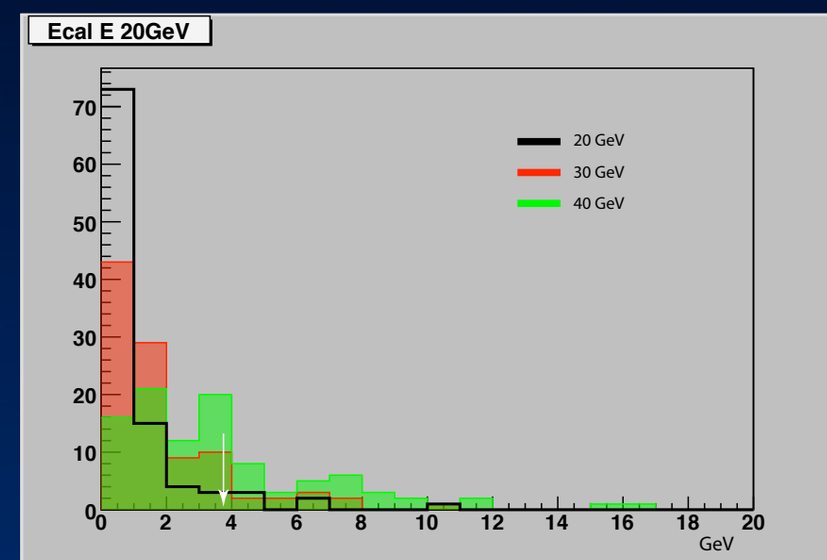


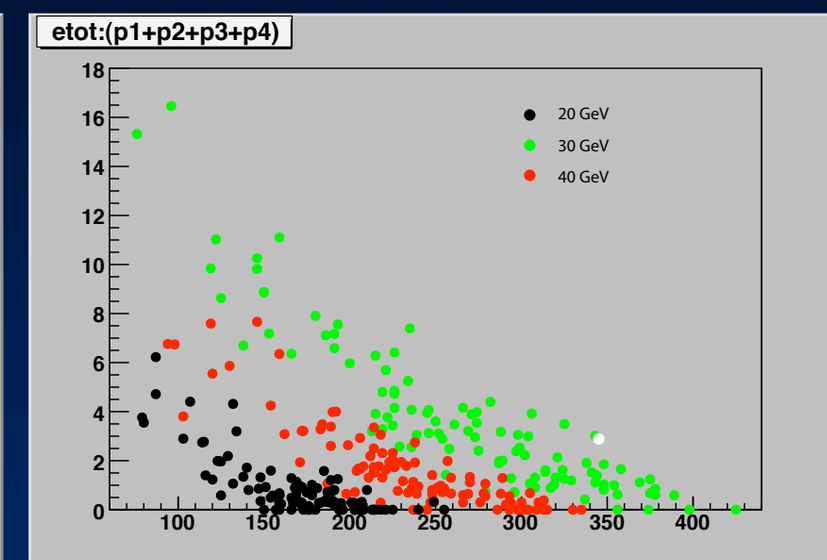


PH 1+2 PH 3 PH 4

3024_18706







Profile Plot

Calorimeter

E_{cal} vs ΣPH

Multiplicity One

Systematics of One-track Located Events

Multiplicity One

Period	!Loc	Loc	m=1		
			All	μ	!μ
1	41	69	6	2	4
2	27	57	2	1	1
3	116	158	15	7	8
4	160	248	33	18	15
Σ	344	532	56	28	28

} bias?