Fluka & E872 MC

Bruce Baller

November 15, 2005

Outline

- Fluka simulation of E872 dump
- Neutrino production: Fluka vs E872
- Monte Carlo corrections
- Fluka Generator
- CCmu data/Fluka/E872 comparison
- Conclusions

Motivation – Why Fluka?

- Independent check of
  - ν production
  - Energy spectrum
- Patrick's analysis used Geant/Fluka
  - Fluka code in Geant is ancient
- Using Fluka 2005
  - SPY results (p-Be 400 GeV)
  - Charm & Tau decays
    - Problem with Tau decays…
  - Fluka is a "Black Box"

Fluka geometry

- 10cm x 10cm x 102 cm HeavyMet tgt
- HeavyMet = 90% W, 10% Ni *Also Fe, Cu*
  - Density =18.2 g/cm^3 (measured)
- 3650 cm of Fe shielding
- 35cm x 35cm detector
  - All particles in detector written to text file
  - Particle code, parent code, energy, direction cosines, position, weight (=1)

HeavyMet density reference

- Measured sample of target material in my office
  - 10.78 cm x 5.03 cm x 24.90 cm
- Weighed the sample at Lab 5
  - 2.45 kg
  - Checked calibration of scale w 50# weight
- Estimated accuracy ~1%

Fluka Runs

- Charm transport & decay ON
- Electron & photon transport OFF
- Tau decays ON (doesn't work yet)
- Ignore electrons, γ's, μ's, π^0's
- Minimum 5 GeV tracking threshold
- Ran 8 – 1M Fluka jobs
  - 2373 ν's (1405 ν's in 25cmx25cm target)

Fluka ν Parents & Fractions

Parent	Daughter	% of Tot	<E>
Kl	anue	0	17.5
Kl	num	0	17.5
pi+	num	17.5	12.5
pi-	anum	14	13.5
K+	nue	1	22.3
K+	num	14.6	25.2
K-	anue	0.5	20.7
K-	anum	10.8	22.8
K0	nue	0.8	20.5
K0	anue	0.8	14.9
K0	num	0.3	10.6
K0	anum	0.4	21.4
AK0	nue	0.4	24.7
AK0	anue	0.6	15.2
AK0	num	0.2	14.5
AK0	anum	0.3	14.4

Ignore the muons

Parent	Daughter	% of Tot	<E>
D+	nue	2.5	51.6
D+	num	3.1	47.4
D-	anue	4.5	45.2
D-	anum	4.8	44.9
D0	nue	3.7	55.7
D0	num	2.8	54.2
AD0	anue	6.5	50.7
AD0	anum	5.8	48.2
DS+	nue	0.1	80
DS+	num	0.1	45.8
DS+	nut	0.5	27
DS+	anut	0.6	76.8
DS-	anue	0.1	99.2
DS-	anum	0.1	42.5
DS-	nut	0.7	50.9
DS-	anut	0.2	23.5
LamC	nue	0.8	77.5
LamC	num	0.3	68.9
ALamC	anue	0.2	46.5
ALamC	anum	0	27.5

Generated Ratios vs E872 Std

Fluka					
	nue	**anue**	**num**	**anum**	**num+anum**
P	115	170	87	137	224
NP	38	26	467	365	832
P/(P+NP)	75%	87%	16%	27%	21%

E872					
	nue	**anue**	**num**	**anum**	**num+anum**
P	81	78.4	80.7	78.3	159
NP	0	0	176.5	195.4	371.9
P/(P+NP)	100%	100%	31%	29%	30%

E872 events scaled by Genbod weight only
Fluka weights = 1
Applied target cut

Fluka $\nu_\mu/\overline{\nu}_\mu = 1.1$

E872 $\nu_\mu/\overline{\nu}_\mu = 0.9$

Production Rates

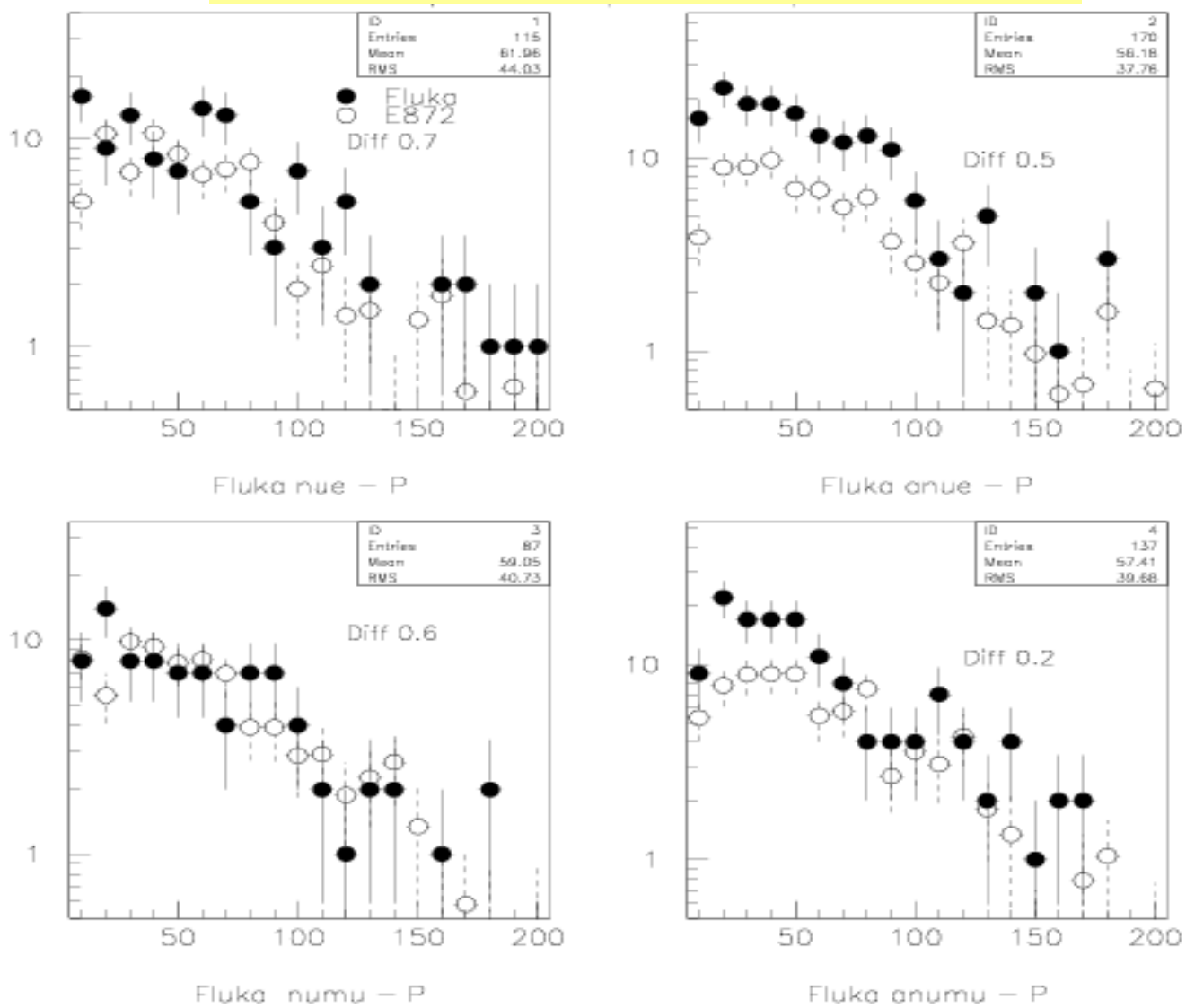
	Fluka	Rate (E-5 /PoT)	Patrick Rate	Reinhard Rate
P (nue+a)	285	3.6		3.1
P (num+a)	224	2.8	3.4	3.0
NP (nue+a)	64	0.8		
NP (num+a)	832	10.4	9.5	

"+a" → + anti-neutrino
"Patrick" & "Reinhard" rates from their theses
Fluka 5 GeV Energy cut…

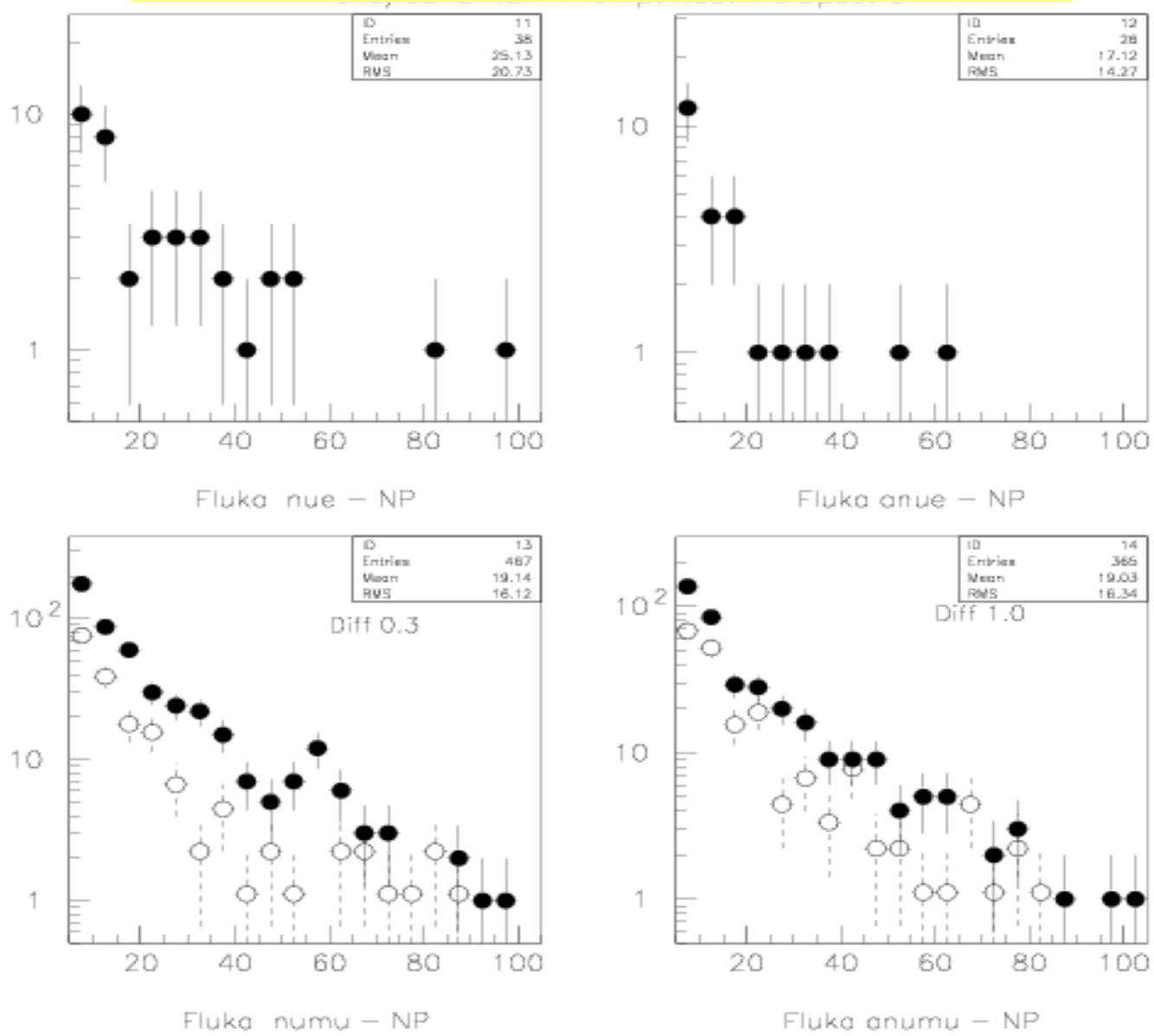
Prompt Neutrino Energy (un-interacted)

Diff = Kolmogorov test confidence level

Normalization not included in test



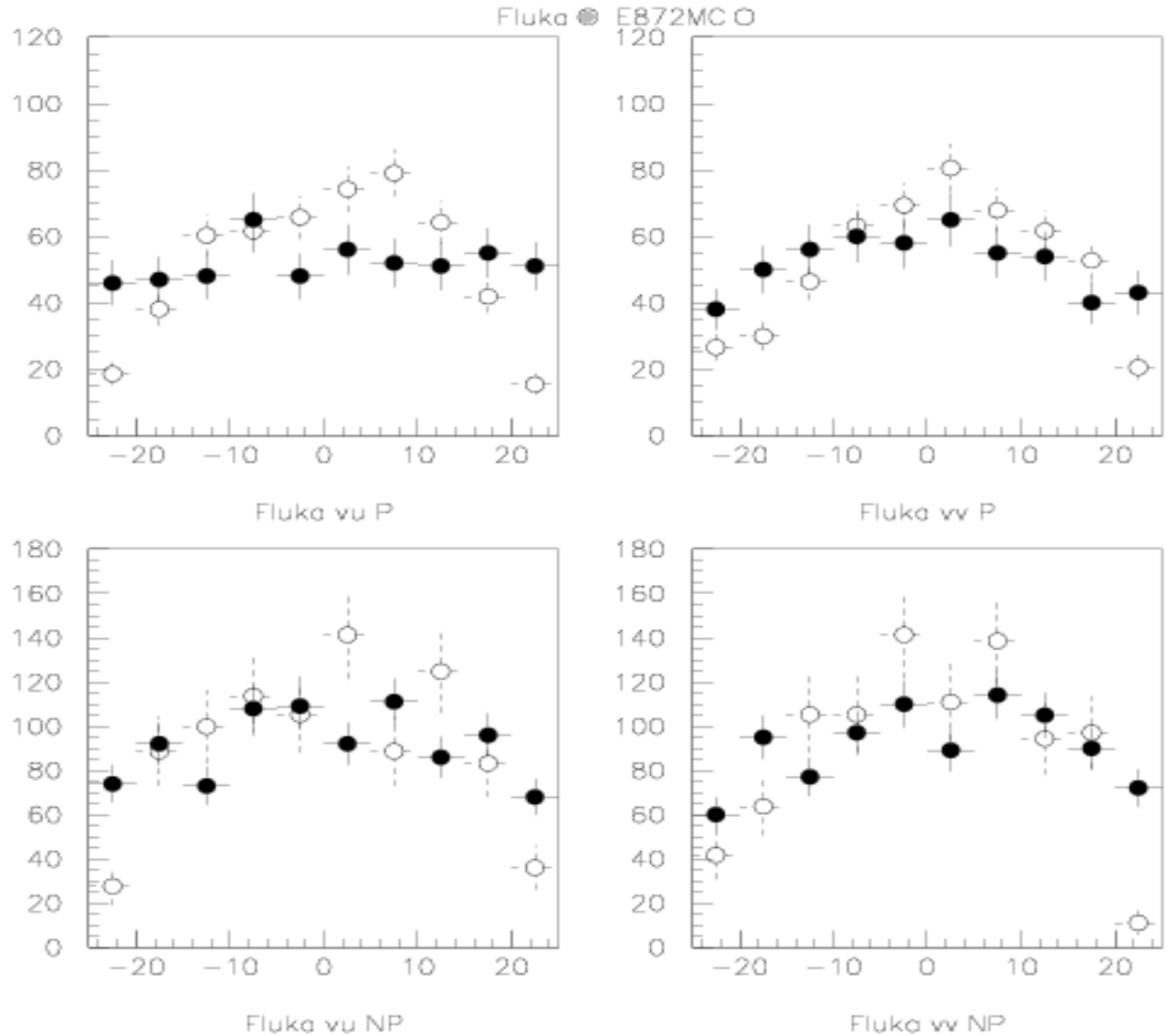
Non-Prompt Neutrino Energy (un-interacted)



Neutrino U,V positions @ tgt (Prompt/Non-Prompt)

Prompt: Fluka is flatter than E872 MC

Non-Prompt: OK



Summary

- Generated P/NP ratios are different
- ~20% of ν_e's are non-prompt
- Energy spectra similar
  - E_ν Prompt ~ 60 GeV
  - E_ν Non-Prompt ~ 20 GeV
- Fluka has broader angular distribution

Monte Carlo Corrections

- MID panel positions were not corrected in the MC geometry file as reported in October
- Developed code to compare MC geometry and offline alignment constants
  - Code runs at the start of every MC job

Alignment Check (checkmcalign.sf)

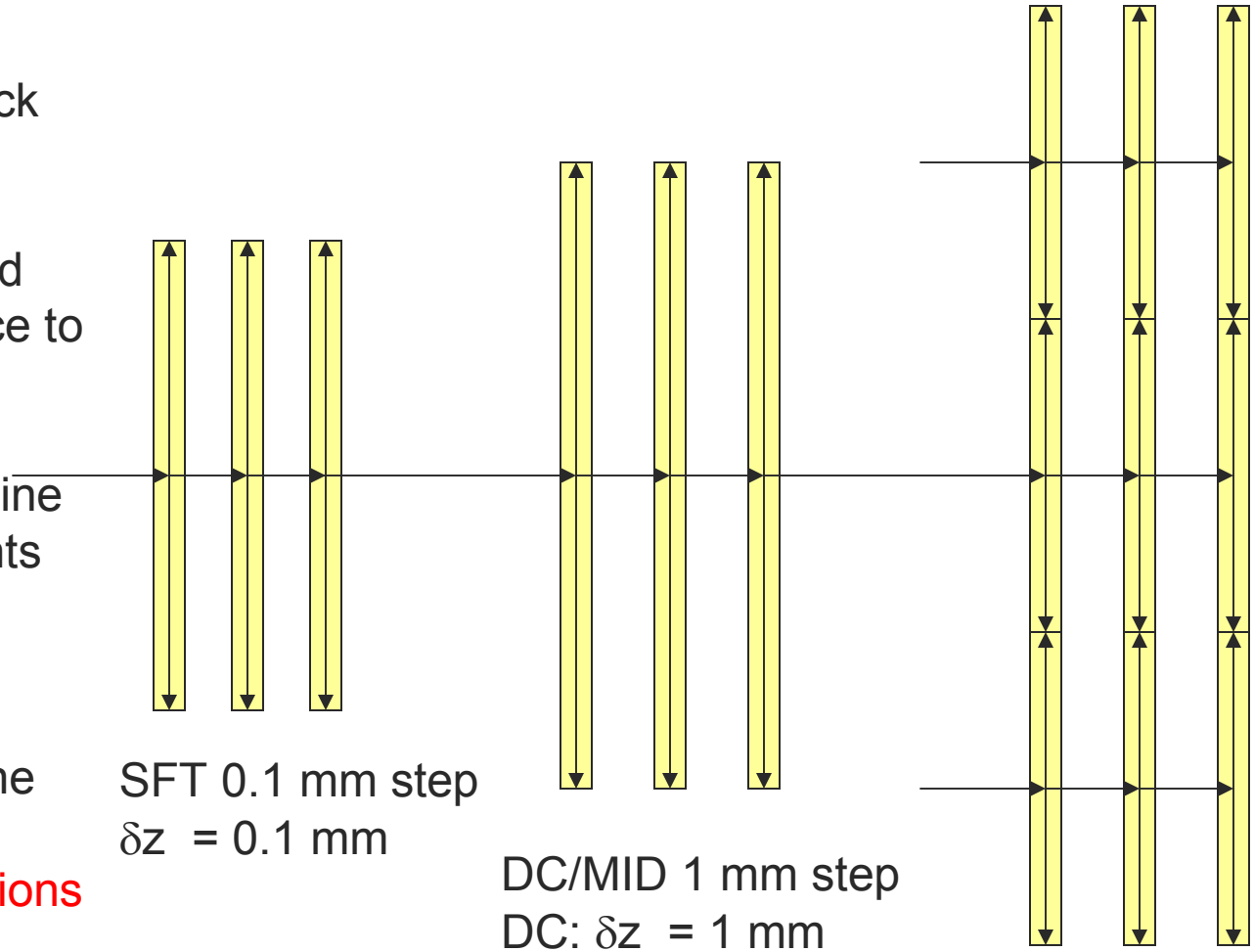
Step in Z and check media type

Use GNEXT to find transverse distance to edges

Compare with Offline alignment constants

Ensure that MC sensitive plane boundaries > offline

Non-readout positions NOT checked for SFT/DC



SFT 0.1 mm step
δz = 0.1 mm

DC/MID 1 mm step
DC: δz = 1 mm
MID: δz = 1 cm

MC Geometry changes

- SFT Z plane moves <~ 1 mm
- SFT sensitive plane box size 28 cm → 32 cm + X,Y offsets ~1 mm
- Increase several DC sensitive plane box sizes by 3 cm
- 30 cm X offsets in DC U,V planes
- Several cm offsets in MID panels

Fluka “Generator”

- Created a direct access file of the 2373 ν’s
- Modified code to switch between random ν selection in Fluka file (gensource=1) or standard E872 generator (gensource=0)
- Fluka ν’s are randomly rotated around the Z axis
- Target cut applied
- Fluka events written to myfluk_perN.mc
- No mechanism in place to select prompt fraction, neutrino ratios, ν/νbar, etc

An Aside: T1·T3 Muon generator

- Can now generate random muons in station 1 with gensource=2
  - Calls mugen_T1T3.sf
  - Don’t need to edit gukine anymore
- T1.T3 trigger requirement applied in mctrigger.sf
- Output file = muons_T1T3.mc

MC Runs

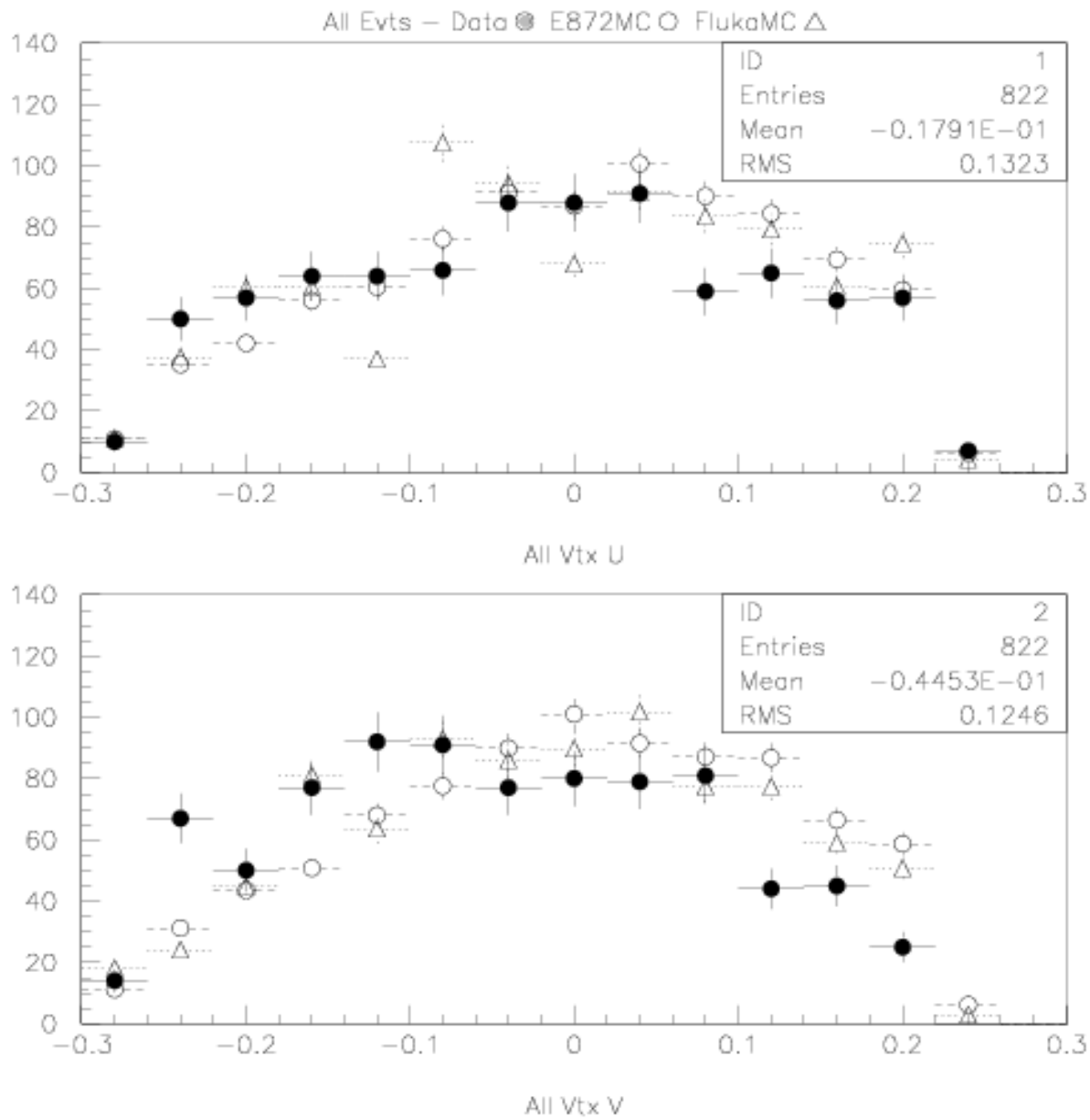
- Generated 10k MC runs in all periods
  - Fluka & Standard E872
  - Alignment corrections in place

Data Ave (cm):
δx = -1.9 +/- 0.4
δy = 4.5 +/- 0.4

E872 MC Ave
$\delta x = \delta y = 0$

Fluka Ave
δx = -0.5 +/- 0.4
δy = 1.3 +/- 0.4

Forgot to lower the dump by 4.5 cm

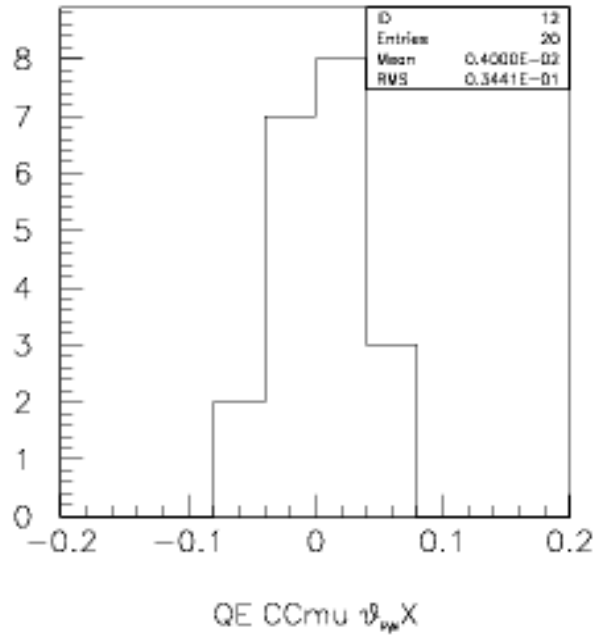


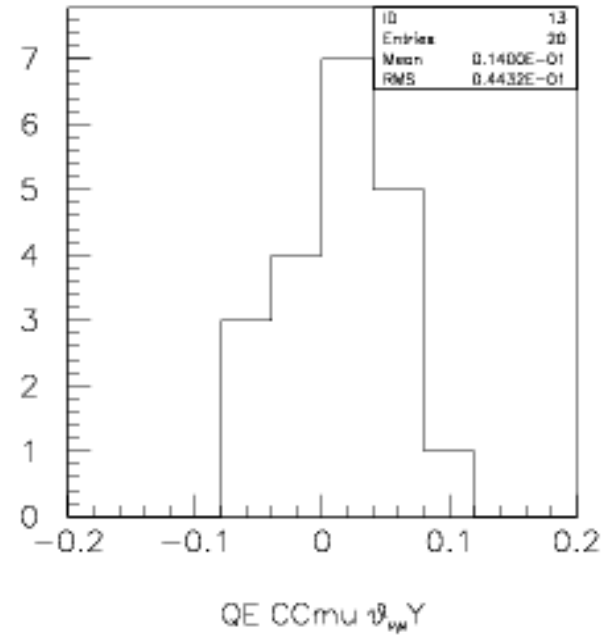
Is the dump really low?

- Use QE events to confirm the average neutrino Y slope is 4.5/3650 = 1.2 mrad
- Select CCmu events with only 1 long emulsion track
  - Extra 1 segment tracks OK
  - Visual scan
    - Reject if EMCal energy > few GeV
    - Reject if SFT shower or other long SFT tracks
  - Find 20 events
- QE CCMu/Total = 20/212 = 9% (a bit high)

Data: $<\theta\nu-\theta\mu>Y$ = 0.014 +/- 0.010

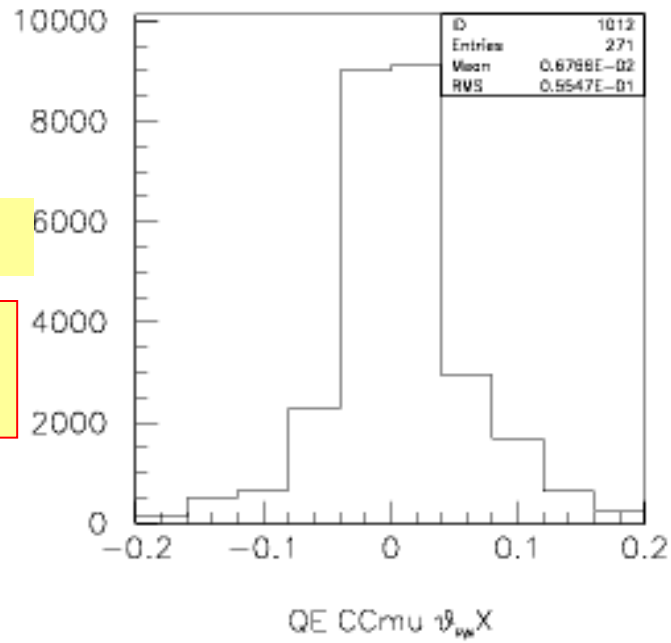
The right slope but not significant

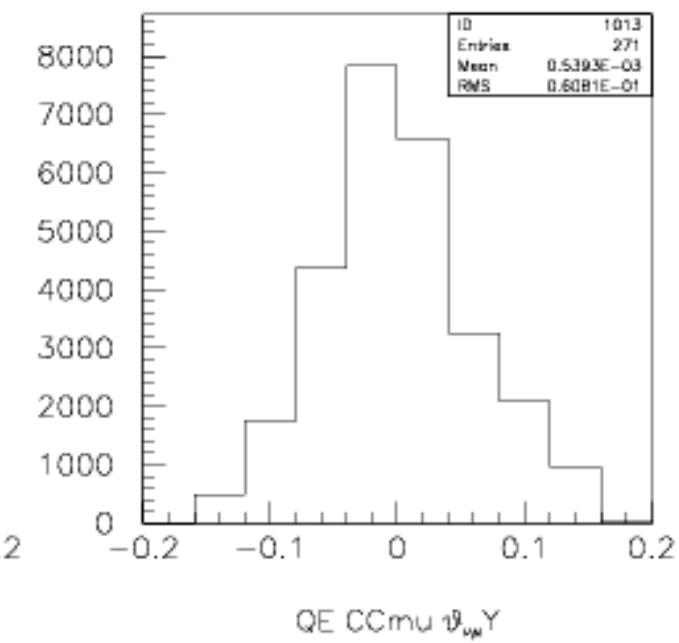




MC: $<\theta\nu-\theta\mu>$ ~0

MC not visually scanned…





CCmu Comparison

- See ccmu.ps
- Both MC'c match the data well (shape-wise) except for
  - $\theta_{\nu\mu}$: No QE in MC's
  - μ+: $\theta_{\mu+h}$ & N emulsion trks
    - Jetset?
  - DC tracking is better in the MC

Data/Fluka/E872 Comparison

	Nmu+/Nmu-	P/(P+NP)
Data	67% +/- 8%	
E872	52%	72%
Fluka	63%	57%

- Good μ+/μ- agreement between Fluka & Data
- 60% Prompt ratio favored by other analyses

Conclusions & Plans

- Good agreement between Fluka & Data
- More Fluka events
  - Lower the dump tgt by 4.5 cm
  - Generate >5k Fluka ν's
  - Check ν_τ production rate if problem fixed
- Use Fluka for NP & E872 MC for P