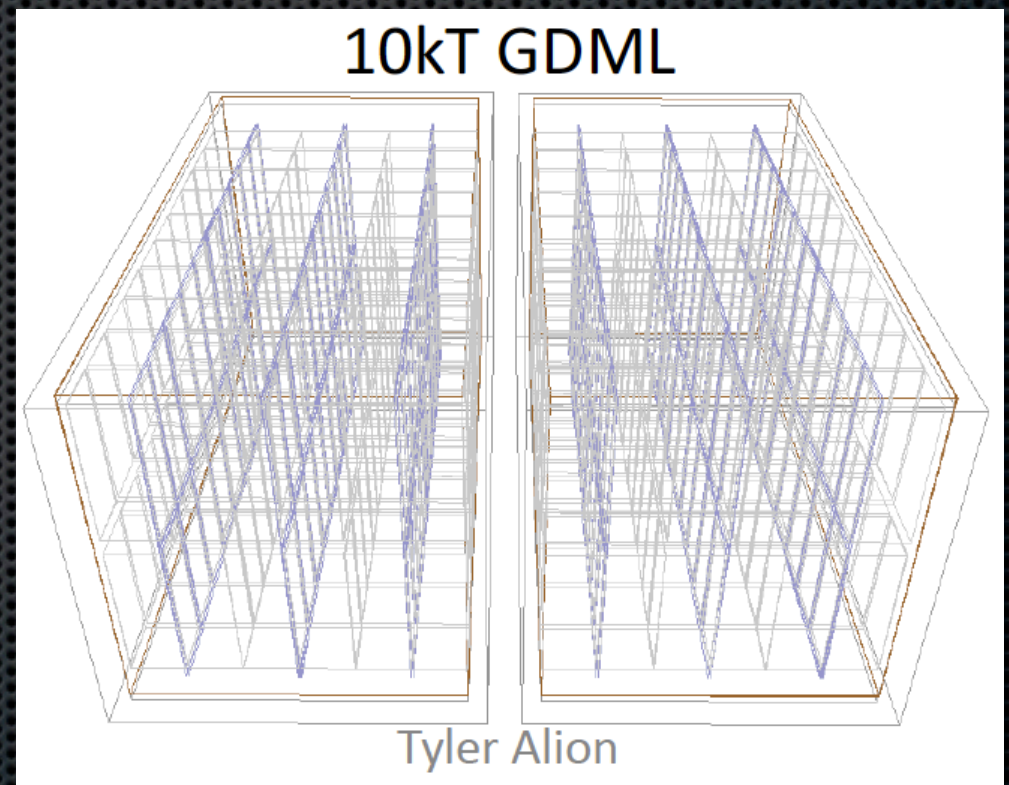# Effect of beamline angle on acceptance

Mike Kirby

Motivation

* how much does having a flat far detector affect acceptance

* seven different beam angles considered

    * 0° and 101 mRad yz

    * 10°, 20°, 30°, 40°, 50° in xz

* look at event containment of events

10kT GDML

Tyler Alion

starting samples

* taken from Dan Cherdack GENIE 4-vector generation

* /lbne/data/users/lblpwg_tools/FastMC_Data/data/nominal

* these are simply four-vector files

  * {nuflux,anuflux}, {nueflux, numuflux, nutauflux}, {nue, numu, nutau}

* take the files through a fortran program with either no rotation, 101 mRad rotation towards the sky, and then either 0°, 10°, 20°, 30°, 40°, or 50° in the xz-plane

kinematic distributions
ν_e flux - ν_e interactions
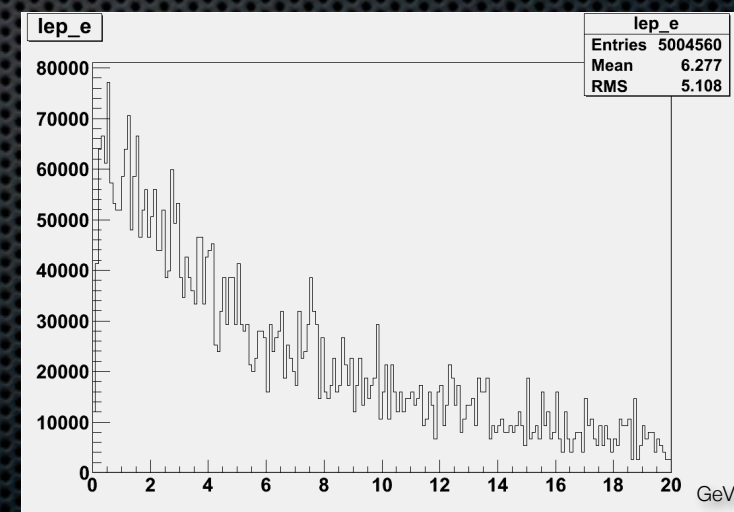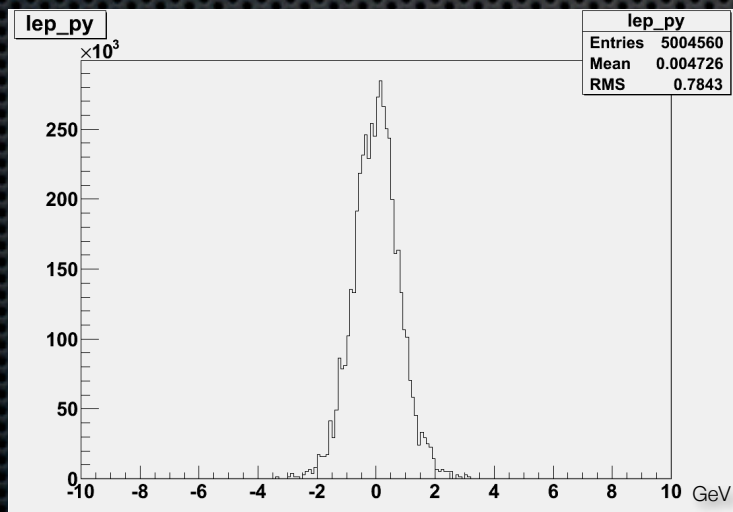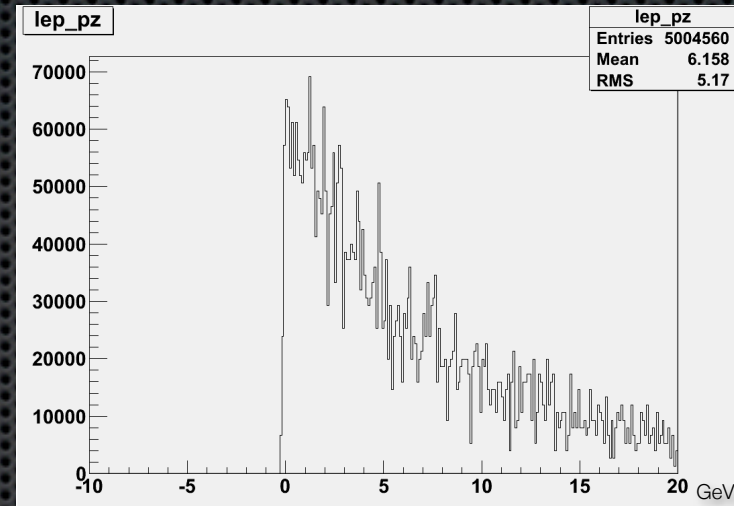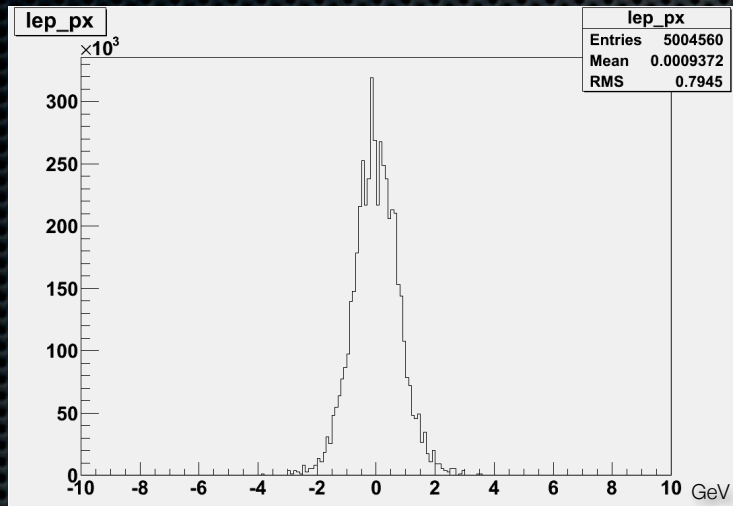
"propagating" charged lepton

* electrons - taken from a study by Andrzej Szelc

* lartpc-docdb, doc 799

* Moliere radius 22 cm for LAr

* start from the vertex, project the electron straight down the momentum vector

  * bug in the code had previously added the radiation length [14 + (....)]

  * instead of multiplying by this factor [14 * (....)]

* shower is a cylinder of radius 22cm

$$t_{max}[X_0] \simeq \ln(E/\varepsilon) - \alpha$$
$$(\alpha \simeq 1 \text{ for e's}, \simeq 0.5 \text{ for } \gamma\text{'s})$$

$$L_{0.95}[X_\bullet] = t_{max} + 0.08Z + 9.6$$

$$R \simeq 2\rho_M \simeq 14A/Z[\text{g cm}^{-2}]$$

"propagating" charged lepton
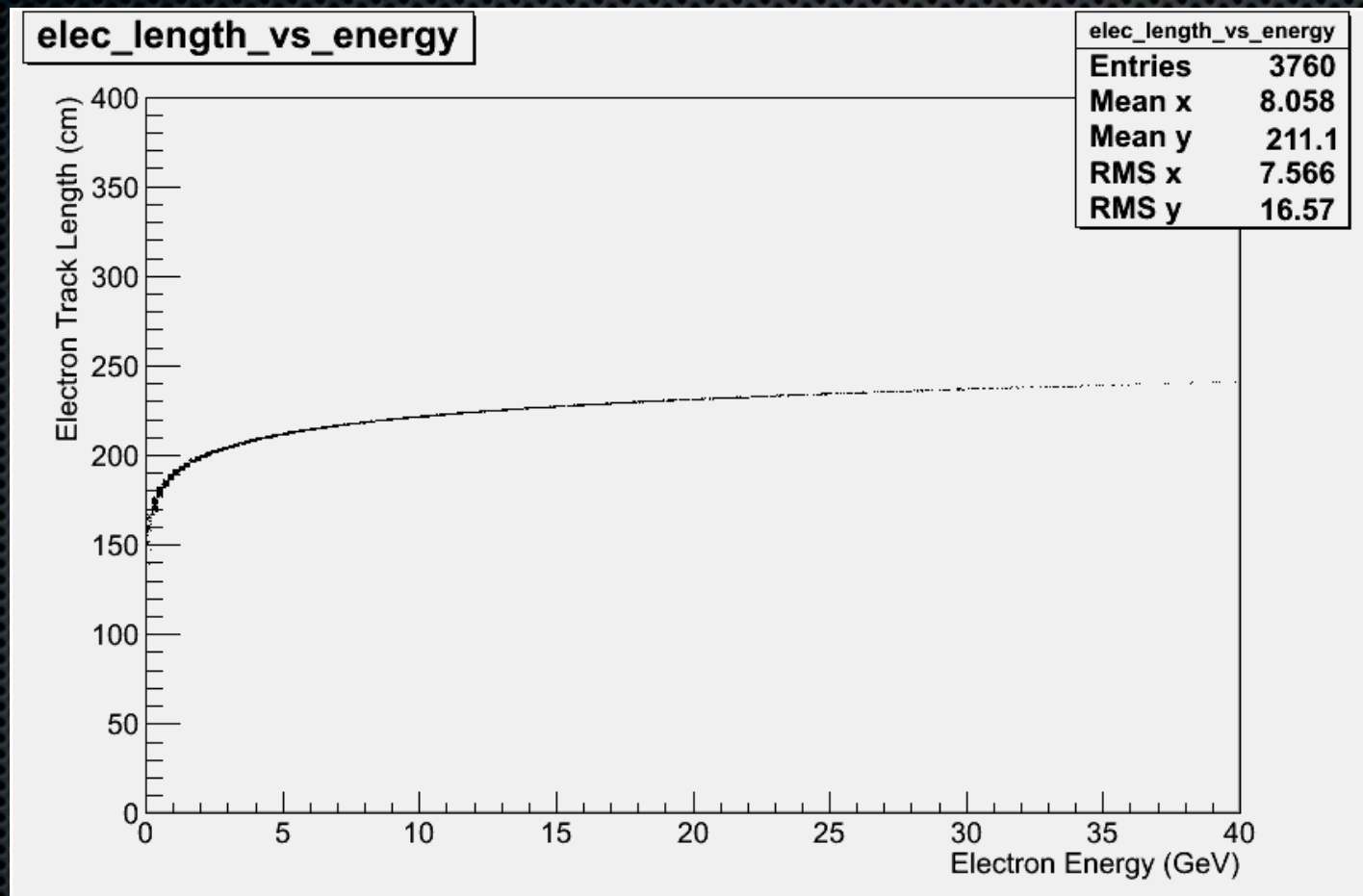
"propagating" charged lepton

* muons - taken from PDG

* http://pdg.lbl.gov/2012/AtomicNuclearProperties/MUON_ELOSS_TABLES/muonloss_289.dat

* treated as a lookup table

* 1 cm moliere radius but with no scattering

* start from the vertex, project the muon straight down the momentum vector

"propagating" charged lepton
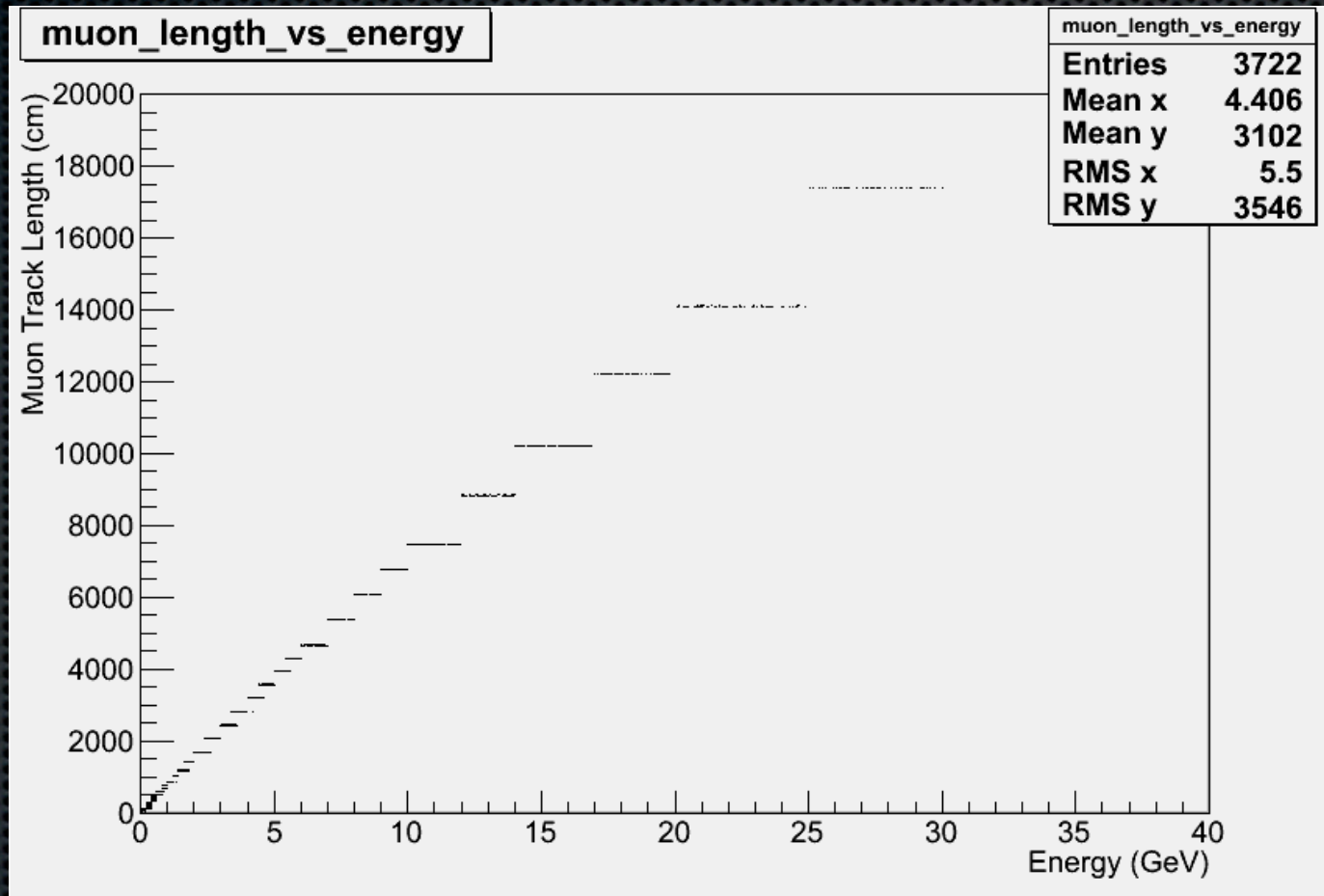
geometry of the detector

- active volume defined by (all units cm)

- X {-1633.1, -235}, {235, 1633.1}

- Y {-701.65, 701.65}

- Z {0.0, 2543.1}

- Taken from lbne-docdb 3383

- Each interaction is used 1331 times, offset in X, Y, & Z in 10 cm steps

Vertex dist - active volume
ν_e flux - ν_e interactions
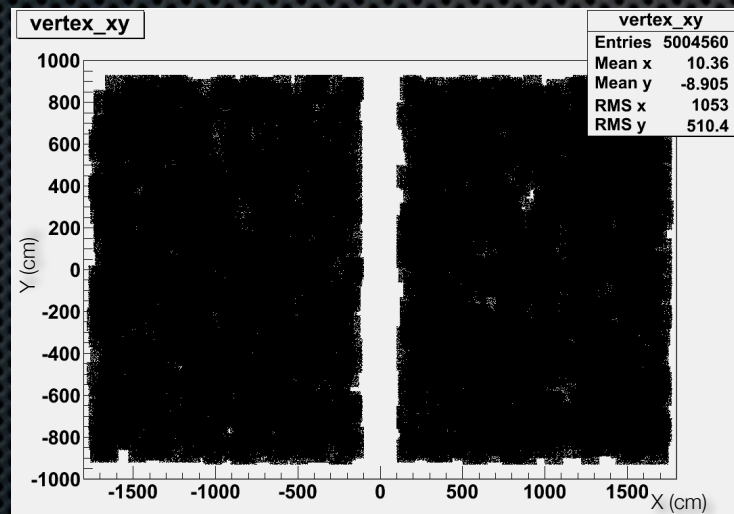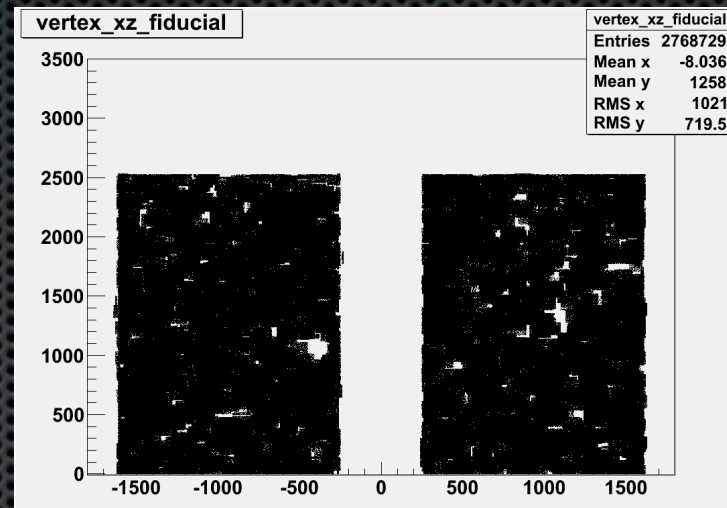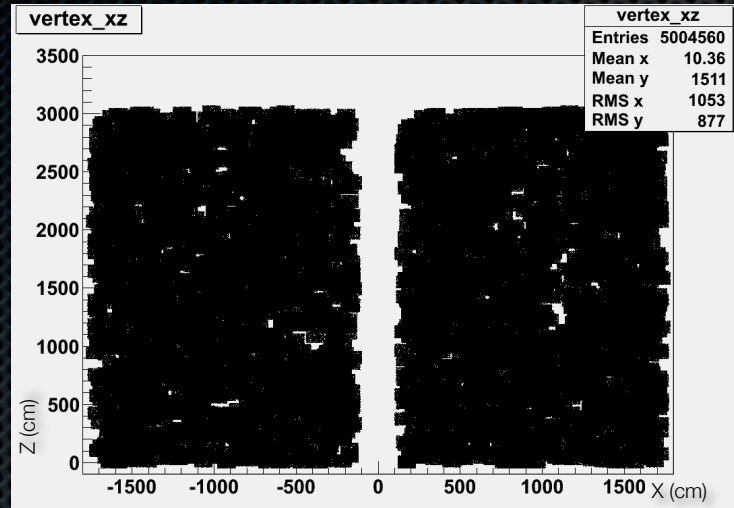
geometry of the detector

- fiducial volume defined by (all units cm)
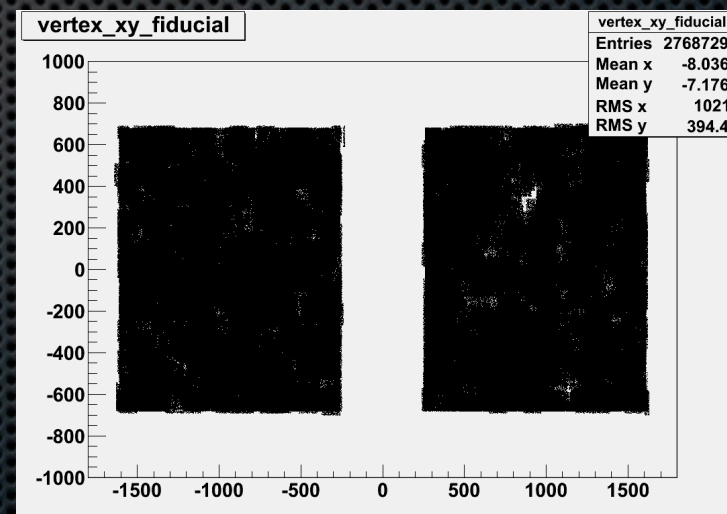
- X {-1603.1, -265}, {265, 1603.1} <- (offset by 30 cm)

- Y {-671.65, 671.65} <- (offset by 30 cm from active)

- Z {0.0, 2393.1} <- (only offset by 150 cm from downstream)

- added APA frames as simple boxes

  - 9 cm wide, full height and length of cryostat

geometry of the detector
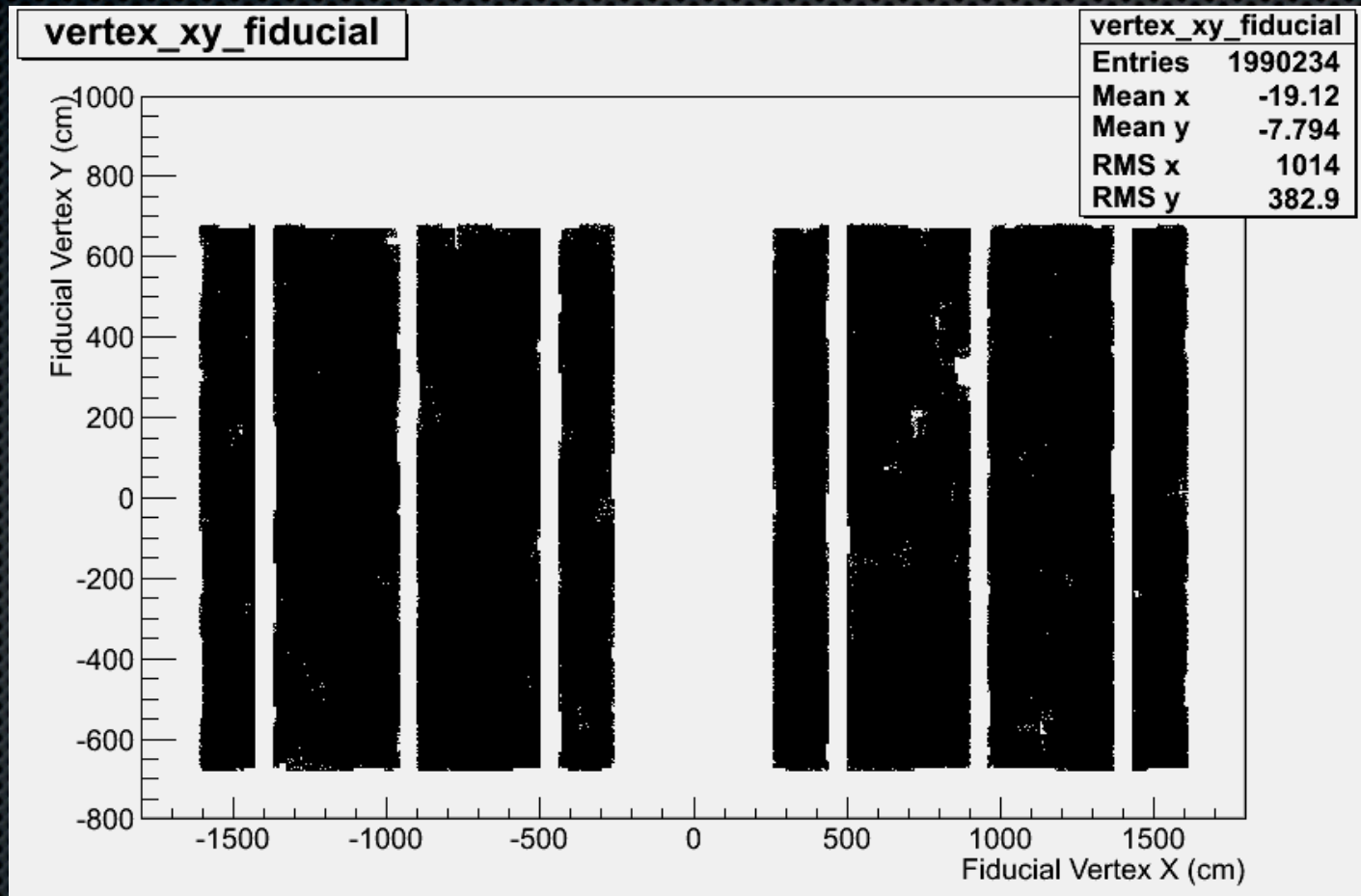
Single sample results - $\bar{\nu}$ horn current - $\bar{\nu}_e$ flux - $\bar{\nu}_e$ interactions

Events	6652338	1.000
CC Evt	4661162	0.7007
Vtx Active Vol	2752927	0.4138
Vtx Active no APA	2702881	0.4063
Vtx fiducial	2025548	0.3045
Endpoint Act	1953777	0.2937
Endpt Act no APA	1946712	0.2926
No APA crossed	1931884	0.2904
No CPA crossed	1881165	0.2828
Neither crossed	1866337	0.2806
Moliere Rad Act no APA	1889672	0.2841
Moliere Rad neither crossed	1813950	0.2727
Endpoint fiducial	1694088	0.2547
Endpoint fiducial neither crossed	1633260	0.2455
Moliere Rad fiducial	1457062	0.2190
Moliere Rad fiducial no cross	1399057	0.2103

acceptance results

Cut	$\bar{\nu}$ flux - $\bar{\nu}_e$ flux - $\bar{\nu}_e$ interaction						
Beam angle	0°	101 mRad	10°	20°	30°	40°	50°
CC event	0.7007	0.7007	0.7007	0.7007	0.7007	0.7007	0.7007
vertex fiducial	0.3045	0.3045	0.3045	0.3045	0.3045	0.3045	0.3045
end pt active vol	0.2940	0.2937	0.2913	0.2841	0.2761	0.2699	0.2648
end pt act no APA	0.2929	0.2926	0.2867	0.2772	0.2686	0.2626	0.2575
end pt act no APA crossed	0.2907	0.2904	0.2798	0.2478	0.2118	0.1810	0.1546
shower act no APA crossed	0.2835	0.2823	0.2651	0.2312	0.1968	0.1675	0.1427
end pt fiducial	0.2557	0.2547	0.2324	0.2051	0.1941	0.1901	0.1909
end pt fiducial no APA crossed	0.2551	0.2541	0.2311	0.1964	0.1643	0.1369	0.1169
end pt fiducial no APA or CPA X	0.2466	0.2455	0.2135	0.1635	0.1157	0.0732	0.0391

acceptance results

Cut	$\overline{\nu}$ flux - $\overline{\nu}_e$ flux - $\overline{\nu}_e$ interaction						
Beam angle	0°	101 mRad	10°	20°	30°	40°	50°
CC event	0.7007	0.7007	0.7007	0.7007	0.7007	0.7007	0.7007
vertex fiducial	0.3045	0.3045	0.3045	0.3045	0.3045	0.3045	0.3045
end pt active vol	0.2940	0.2937	0.2913	0.2841	0.2761	0.2699	0.2648
end pt act no APA	0.2929	0.2926	0.2867	0.2772	0.2686	0.2626	0.2575
end pt act no APA crossed	0.2907	0.2904	0.2798	0.2478	0.2118	0.1810	0.1546
shower act no APA crossed	0.2835	0.2823	0.2651	0.2312	0.1968	0.1675	0.1427
end pt fiducial	0.2557	0.2547	0.2324	0.2051	0.1941	0.1901	0.1909
end pt fiducial no APA crossed	0.2551	0.2541	0.2311	0.1964	0.1643	0.1369	0.1169
end pt fiducial no APA or CPA X	0.2466	0.2455	0.2135	0.1635	0.1157	0.0732	0.0391

acceptance results

Cut	ν flux - νₑ flux - νₑ interaction						
Beam angle	0°	101 mRad	10°	20°	30°	40°	50°
vertex fiducial	0.3291	0.3291	0.3291	0.3291	0.3291	0.3291	0.3291
end pt active vol	0.3133	0.3133	0.3113	0.3053	0.2993	0.2934	0.2880
end pt act no APA	0.3112	0.3112	0.3063	0.2980	0.2918	0.2857	0.2802
end pt act no APA crossed	0.3039	0.3038	0.2942	0.2663	0.2358	0.2049	0.1786
shower act no APA crossed	0.2932	0.2924	0.2790	0.2504	0.2199	0.1901	0.1652
end pt fiducial	0.2653	0.2615	0.2481	0.2268	0.2154	0.2085	0.2083
end pt fiducial no APA crossed	0.2622	0.2615	0.2443	0.2155	0.1856	0.1579	0.1370
end pt fiducial no APA or CPA X	0.2450	0.2443	0.2192	0.1778	0.1340	0.0920	0.0578

ν flux header uses subscript: ν flux - ν_e flux - ν_e interaction

acceptance results

Cut	$\bar{\nu}$ flux - $\bar{\nu}_\mu$ flux - $\bar{\nu}_\mu$ interaction						
Beam angle	0°	101 mRad	10°	20°	30°	40°	50°
vertex fiducial	0.3024	0.3024	0.3024	0.3024	0.3024	0.3024	0.3024
end pt active vol	0.0569	0.0565	0.0542	0.0494	0.0484	0.0489	0.0505
end pt act no APA	0.0559	0.0556	0.0530	0.0484	0.0474	0.0480	0.0494
end pt act no APA crossed	0.0308	0.0309	0.0290	0.0196	0.0133	0.0095	0.0077
end pt fiducial	0.0394	0.0390	0.0376	0.0335	0.0330	0.0350	0.0358
end pt fiducial no APA crossed	0.0228	0.0227	0.0214	0.0149	0.0102	0.0077	0.0059
end pt fiducial no APA or CPA X	0.0146	0.0145	0.0142	0.0082	0.0050	0.0042	0.0032

acceptance results

Cut	ν flux - ν$_\mu$ flux - ν$_\mu$ interaction						
Beam angle	0°	101 mRad	10°	20°	30°	40°	50°
vertex fiducial	0.3215	0.3215	0.3215	0.3215	0.3215	0.3215	0.3215
end pt active vol	0.0869	0.0870	0.0871	0.0873	0.0846	0.0841	0.0858
end pt act no APA	0.0852	0.0854	0.0854	0.0858	0.0827	0.0824	0.0841
end pt act no APA crossed	0.0448	0.0445	0.0438	0.0400	0.0341	0.0297	0.0259
end pt fiducial	0.0635	0.0638	0.0629	0.0644	0.0603	0.0616	0.0624
end pt fiducial no APA crossed	0.0343	0.0339	0.0332	0.0316	0.0267	0.0233	0.0208
end pt fiducial no APA or CPA X	0.0215	0.0212	0.0222	0.0224	0.0178	0.0153	0.0138

Conclusions

- updated geometry of the detector to account for APAs

- include the fiducial definitions along with active volume

- measure how often lepton crosses an APA or CPA

- fixed bug in the lepton length calculation for electrons

- the conclusion still seems to be similar, the effect on acceptance of a misalignment from an engineering aspect is small up to angles O(15º)

backup slides