ν_e CCQE/CC1π^+ Selection Studies

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ν_e CCQE/CC1π^+ Meeting
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ν_e CC1π^+ Hybrid Sample

- <u>Step 1</u> (atm ν e-like extraction): – DONE
  - Generate list of 1-ring e-like events from atm data and from MC
  - Equalize MC to data
  - Extract e-like events from zbs files (data and MC)
- <u>Step 2</u> (T2K eπ^+ extraction): – DONE
  - Extract all eπ^+ events from T2K MC and save kinematics to text file
- <u>Step 3</u> (matching e's): – DONE
  - Match e from T2K MC eπ^+ events with single ring e-like events from atm data/MC
    - Rotates T2K MC eπ^+ events to line up the e with the e-like atm events
- <u>Step 4</u> (merge e and π^+): – DONE
  - Generate MC π^+ ring with same kinematics as π^+ from matched T2K events
  - Merge atm e (data/MC) with MC π^+ to create hybrid events
- <u>Step 5</u> (apfit, fiTQun):
  - Run apfit on hybrid .zbs files and run fillnt to get .hbk/.root files – DONE
  - Run fiTQun on hybrid .apfit.zbs files and run fillnt to get .hbk/.root files – DONE

> ν_e CC1π^+ sample construction is complete!
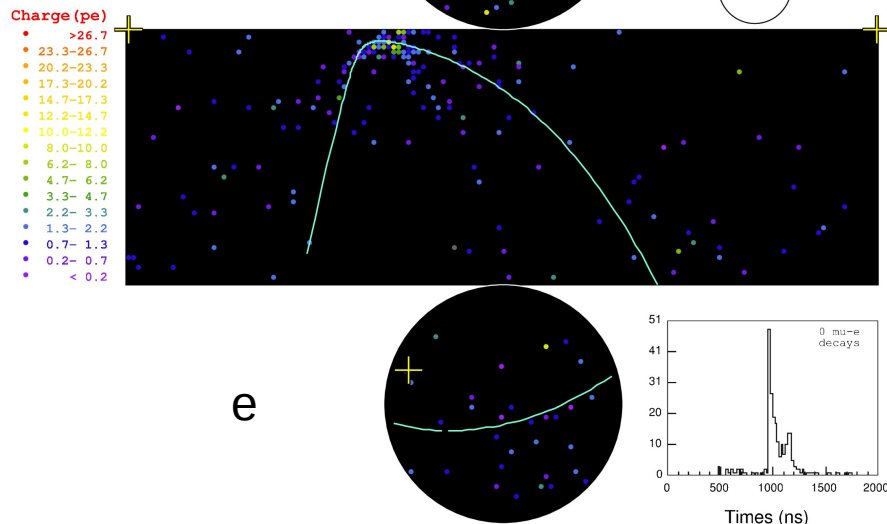
Validation: Event Displays

- Look at event displays of single e event, single π^+ event, and merged event

  - Do this for data and MC samples

  - Look at both charge and timing

    - Timing has yet to be studied

- <u>Question</u>: command line option to run superscan with timing instead of charge?
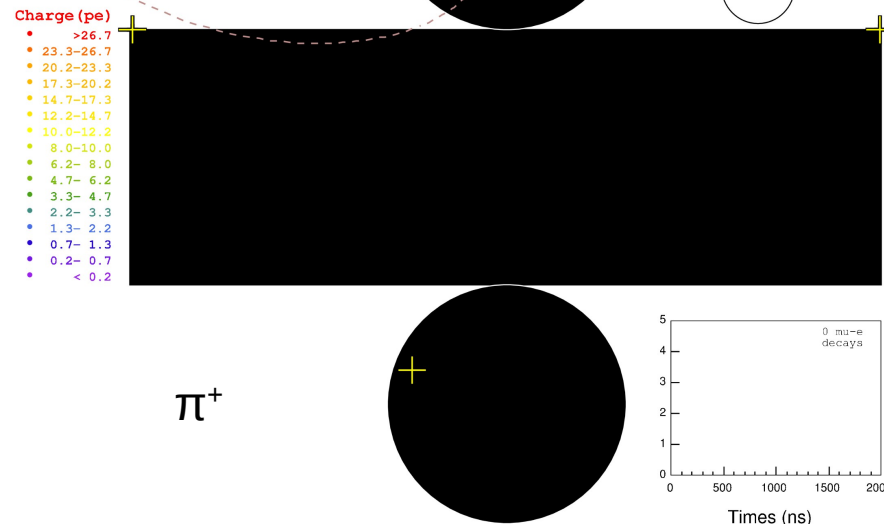
Data Sample

Super-Kamiokande IV
Run 61790 Sub 227 Event 49136464
08-10-20:22:24:32
Inner: 233 hits, 363 pe
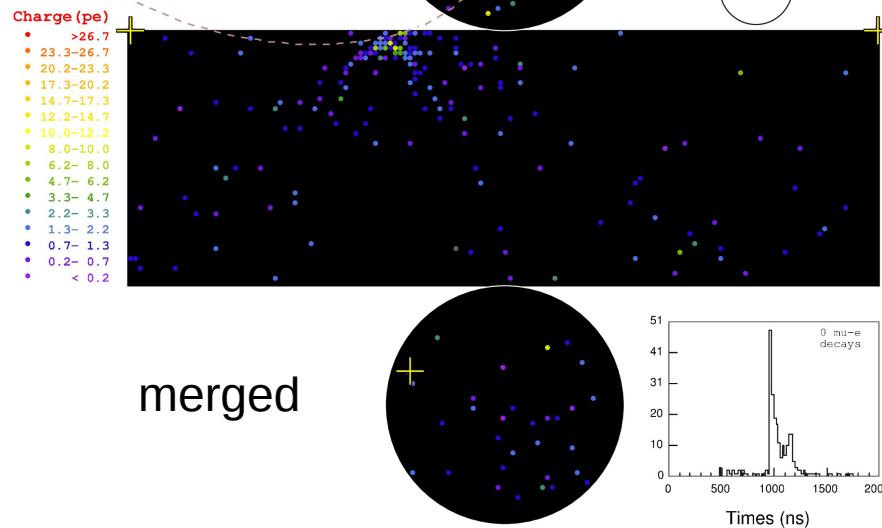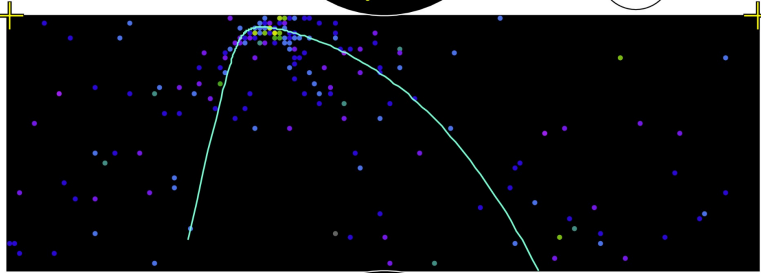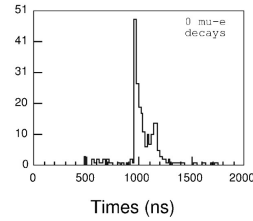Outer: 20 hits, 20 pe
Trigger: 0x1000000f
D_wall: 1.9 cm
Evis: 30.1 MeV
e-like, p = 30.1 MeV/c

Charge(pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
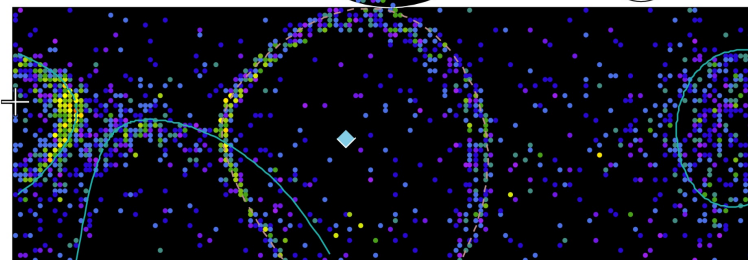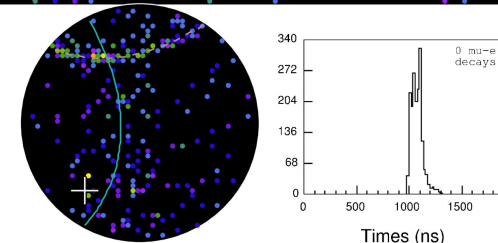4.7- 6.2
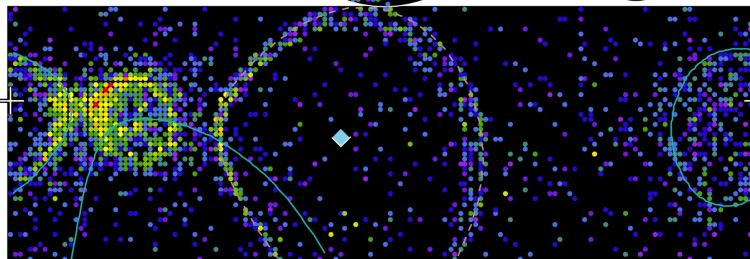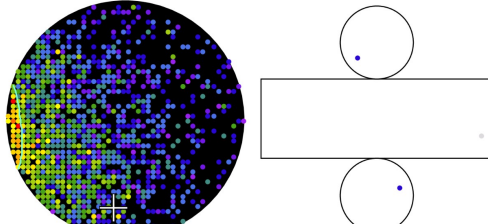3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

e

0 mu-e decays

Times (ns)

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:34
Inner: 0 hits, 0 pe
Outer: 0 hits, 0 pe
Trigger: 0x00
D_wall: 1.9 cm
Evis: 0.0 MeV

Charge(pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
4.7- 6.2
3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

π⁺

0 mu-e decays

Times (ns)
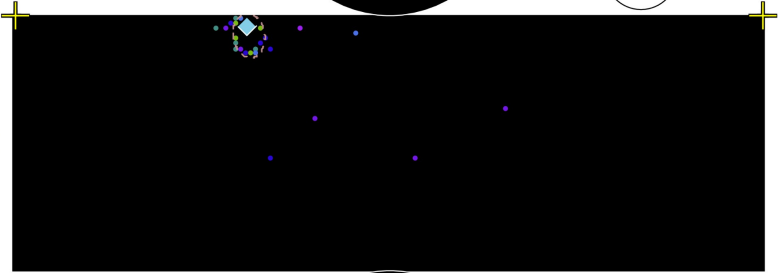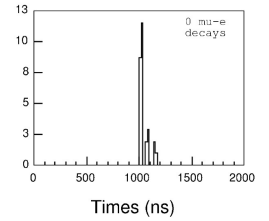
Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:34
Inner: 233 hits, 363 pe
Outer: 0 hits, 0 pe
Trigger: 0x00
D_wall: 1.9 cm
Evis: 0.0 MeV

Charge(pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
4.7- 6.2
3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

merged

0 mu-e decays

Times (ns)

Data Sample

Not sure where π^+ is...
Too close to wall?
p_π = 362.1 MeV/c

Data Sample

Data Sample

e

π⁺

merged

$\pi^+ \rightarrow \pi^0 \rightarrow \gamma\gamma$
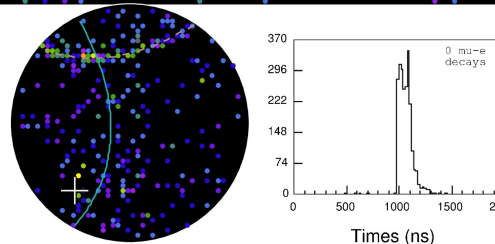
Data Sample

Super-Kamiokande IV
Run 66916 Sub 274 Event 65138042
10-06-07:17:39:52
Inner: 6045 hits, 32547 pe
Outer: 2 hits, 1 pe
Trigger: 0x10000007
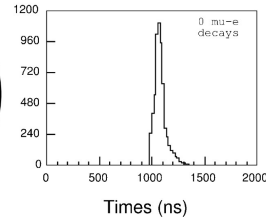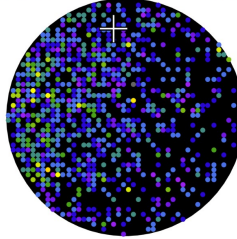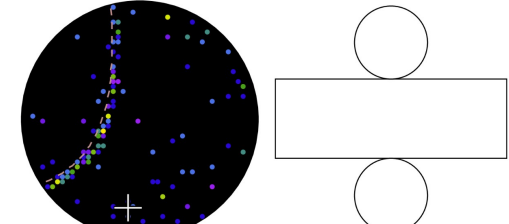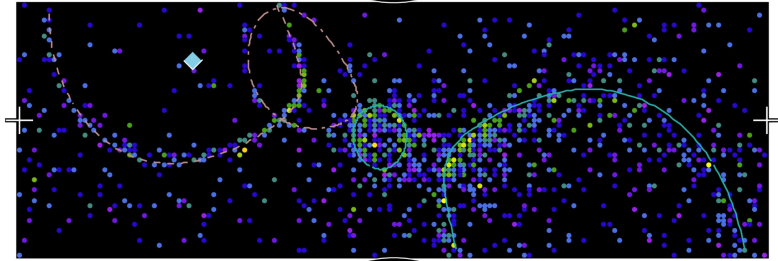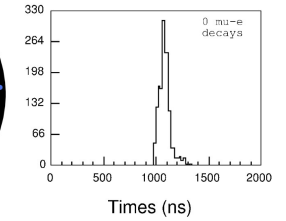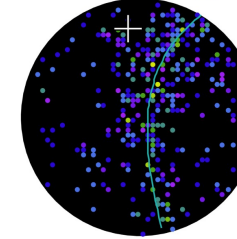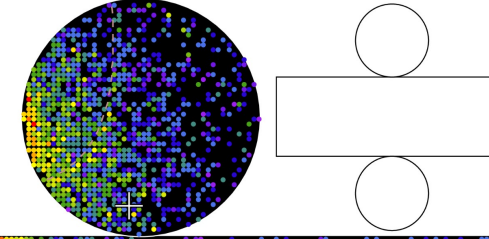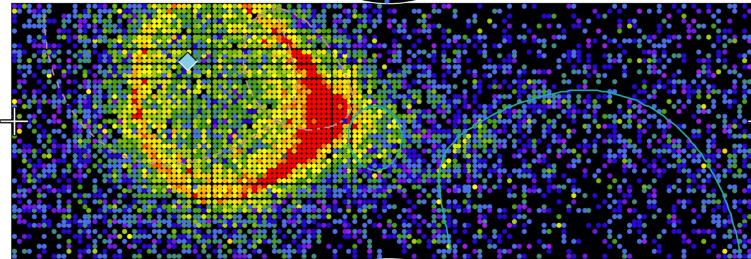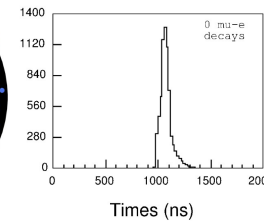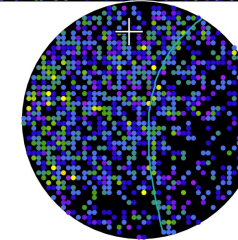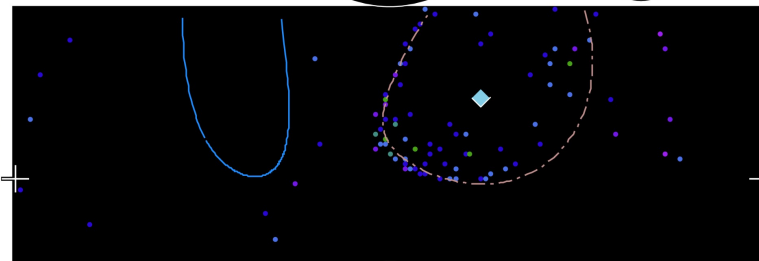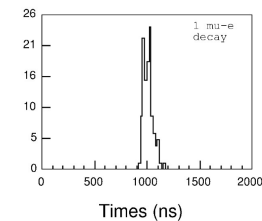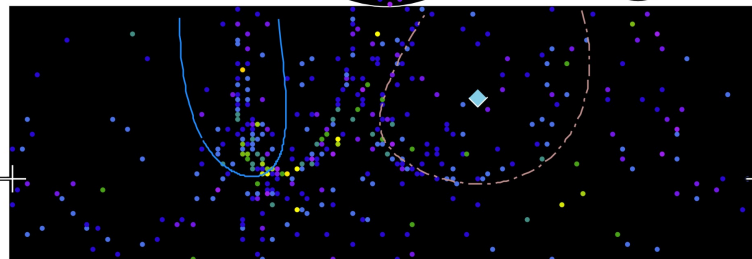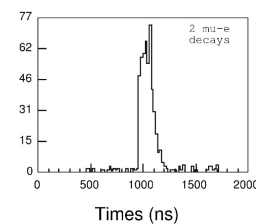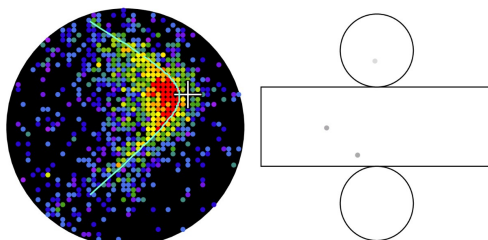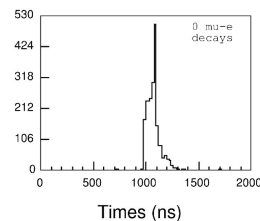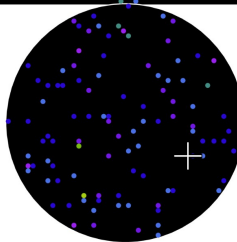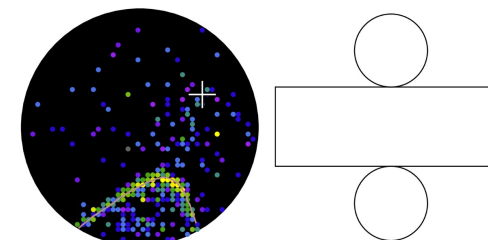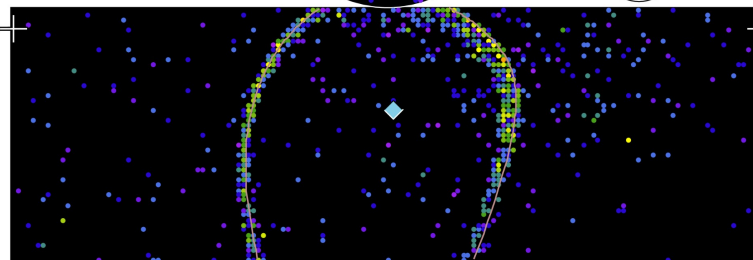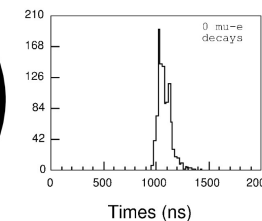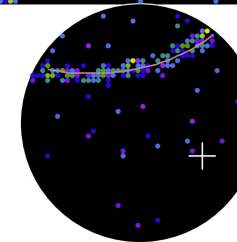D_wall: 422.8 cm
Evis: 3.4 GeV
e-like, p = 3418.5 MeV/c

Charge(pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
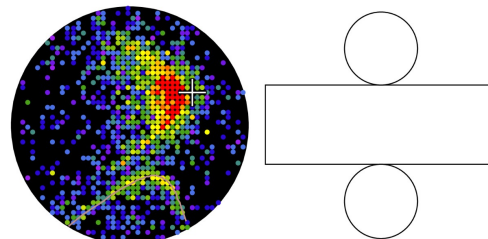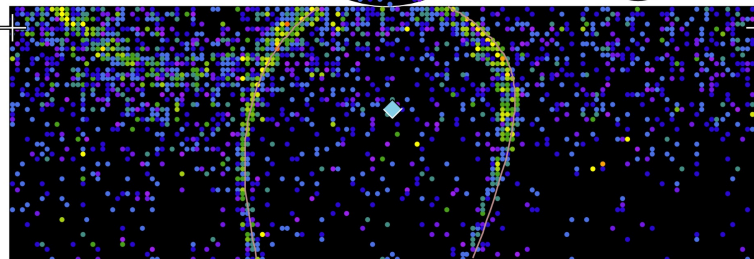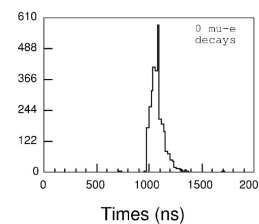4.7- 6.2
3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

e

0 mu-e decays

Times (ns)
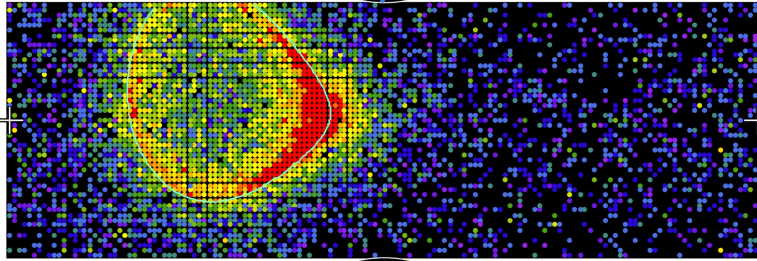
Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:34
Inner: 1570 hits, 2611 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_wall: 422.8 cm
Evis: 0.0 MeV

π^+

0 mu-e decays

Times (ns)

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:34
Inner: 6785 hits, 35153 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_wall: 422.8 cm
Evis: 0.0 MeV

merged

$\pi^+ \to \pi^+$
$\pi^0 \to \gamma\gamma$

0 mu-e decays

Times (ns)

Data
Sample

Super-Kamiokande IV
Run 68039 Sub 187 Event 44511673
11-01-13:16:02:58
Inner: 422 hits, 712 pe
Outer: 4 hits, 4 pe
Trigger: 0x10000007
D_wall: 390.9 cm
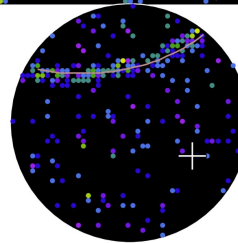Evis: 47.9 MeV
e-like, p = 47.9 MeV/c

Charge (pe)
- >26.7
- 23.3-26.7
- 20.2-23.3
- 17.3-20.2
- 14.7-17.3
- 12.2-14.7
- 10.0-12.2
- 8.0-10.0
- 6.2- 8.0
- 4.7- 6.2
- 3.3- 4.7
- 2.2- 3.3
- 1.3- 2.2
- 0.7- 1.3
- 0.2- 0.7
- < 0.2

e

0 mu-e decays
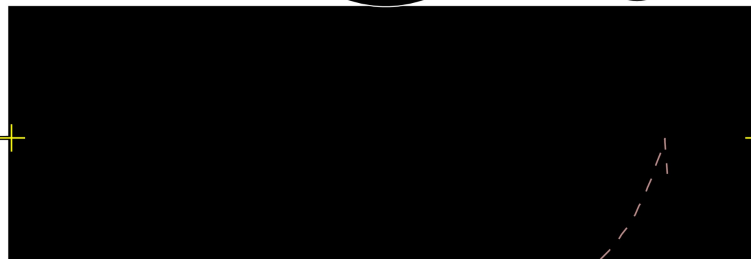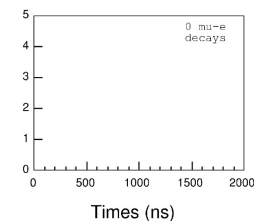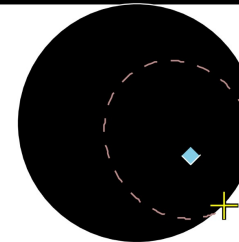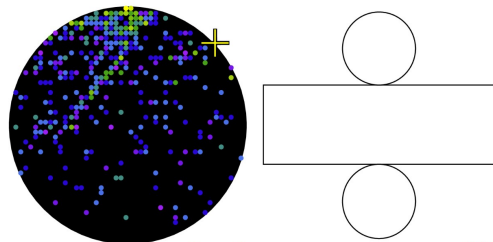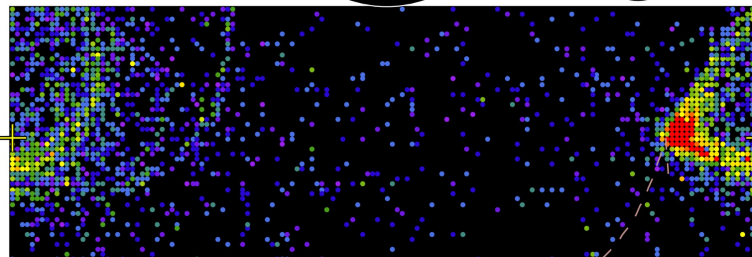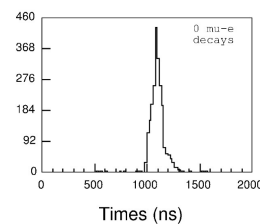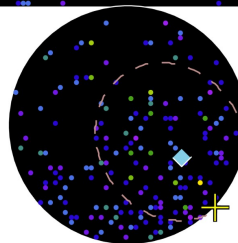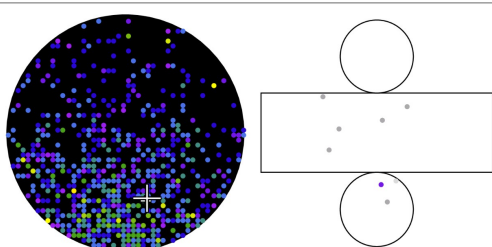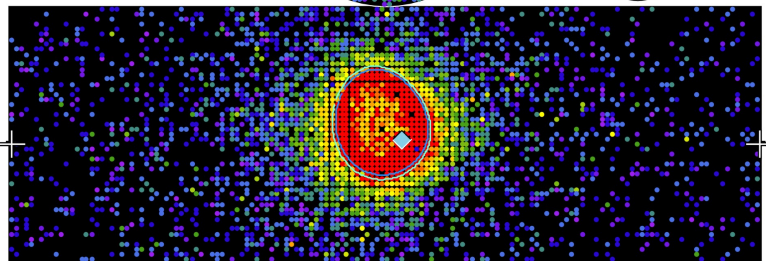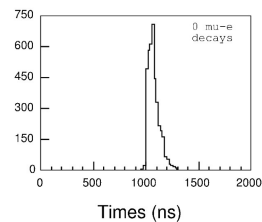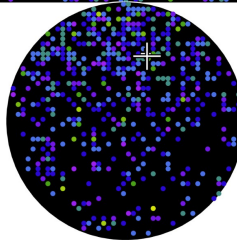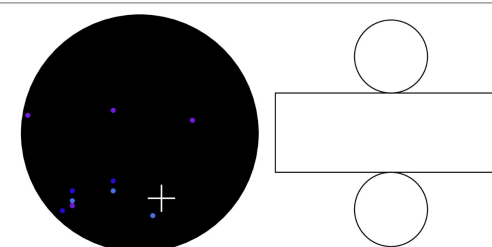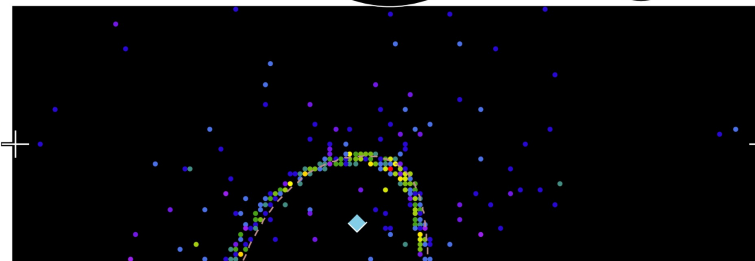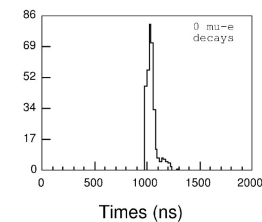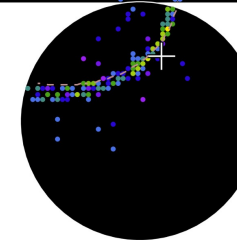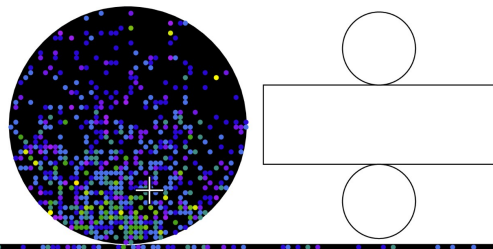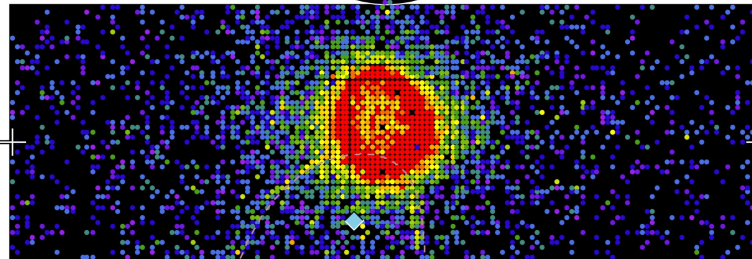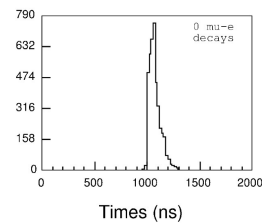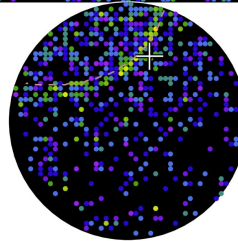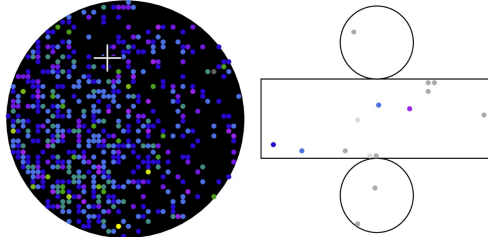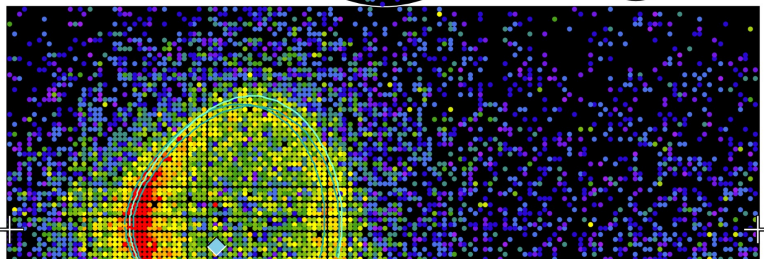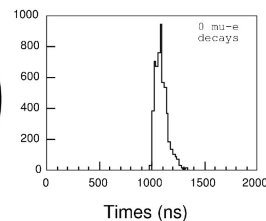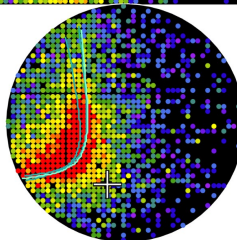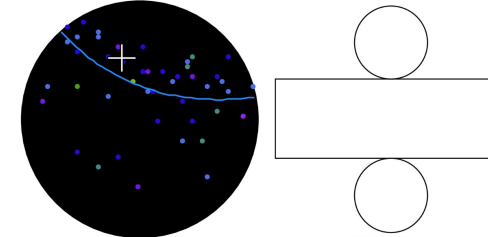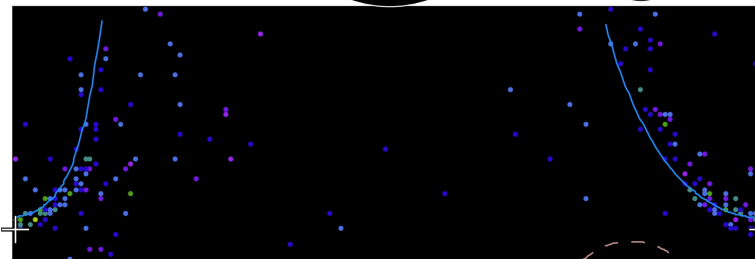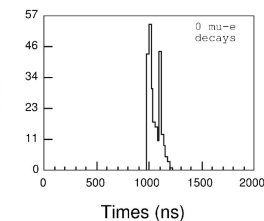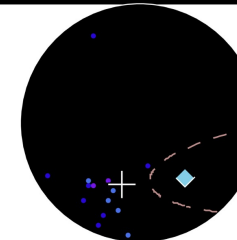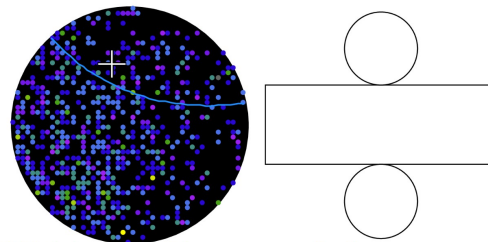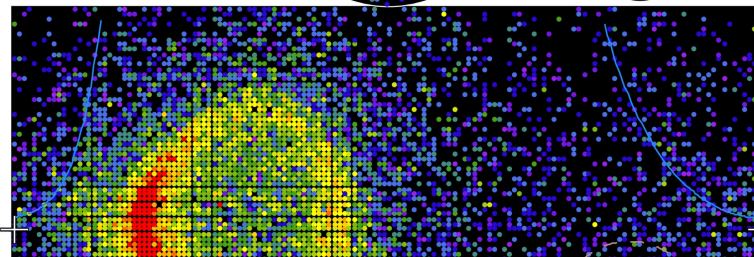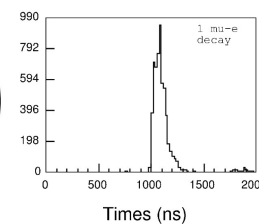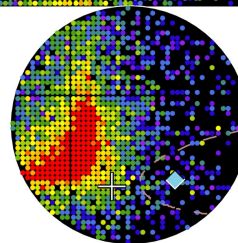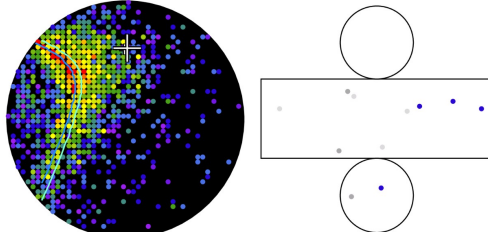
Times (ns)
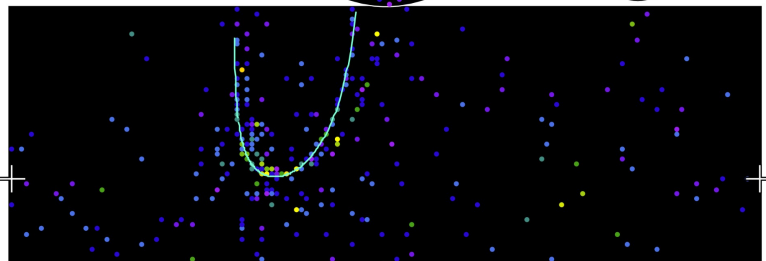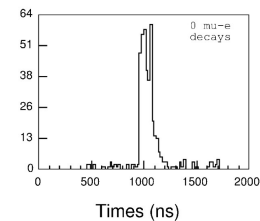
Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:35
Inner: 115 hits, 158 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_wall: 390.9 cm
Evis: 0.0 MeV

π^+

1 mu-e decay

Times (ns)

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:39:35
Inner: 533 hits, 871 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
D_wall: 390.9 cm
Evis: 0.0 MeV

merged

2 mu-e decays

Times (ns)
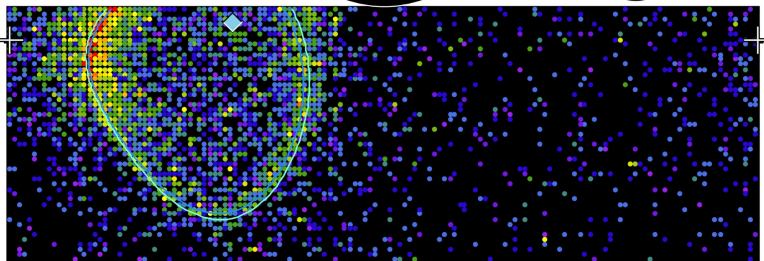
Data Sample

19-05-31

10

Data Sample

MC Sample

Super-Kamiokande IV
Run 999999 Sub 201 Event 8
16-03-10:19:06:31
Inner: 2329 hits, 9204 pe
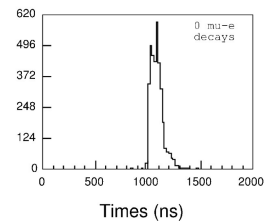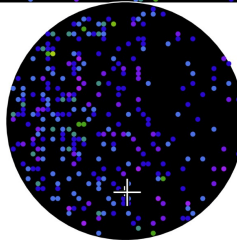Outer: 4 hits, 4 pe
Trigger: 0x07
D_wall: 0.3 cm
Evis: 589.8 MeV
e-like, p = 589.8 MeV/c
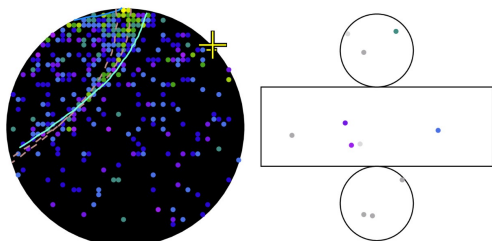
Charge(pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
4.7- 6.2
3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

e

Times (ns)
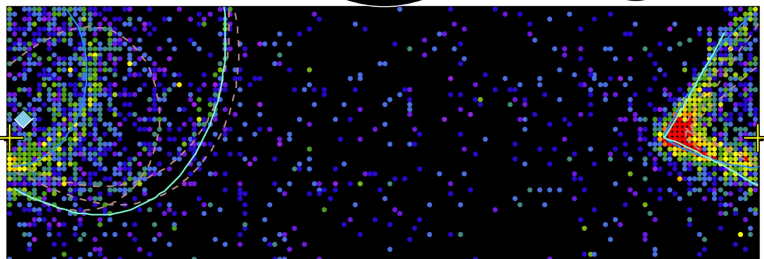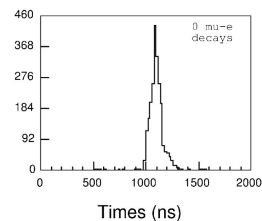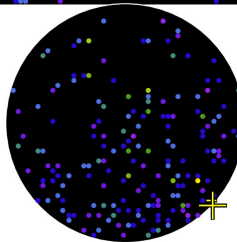
Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:41:19
Inner: 0 hits, 0 pe
Outer: 0 hits, 0 pe
Trigger: 0x00
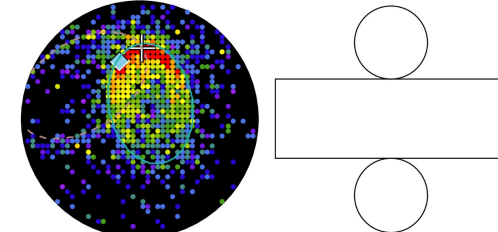D_wall: 0.3 cm
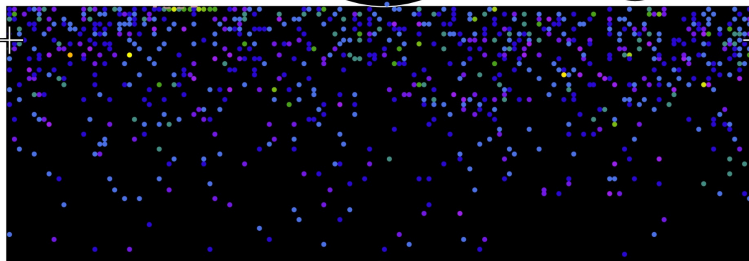Evis: 0.0 MeV
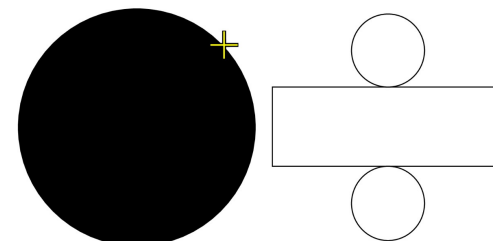
π⁺

Times (ns)

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:41:19
Inner: 2329 hits, 9204 pe
Outer: 0 hits, 0 pe
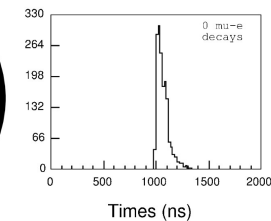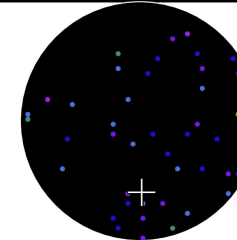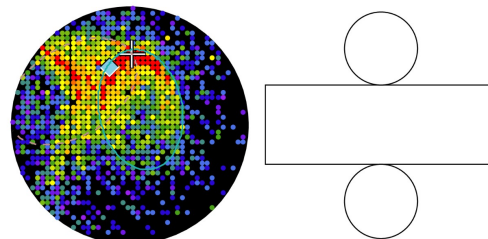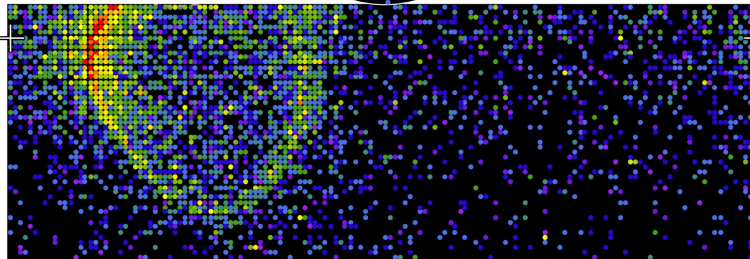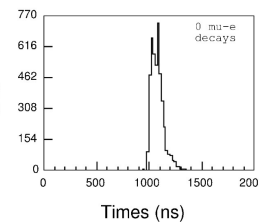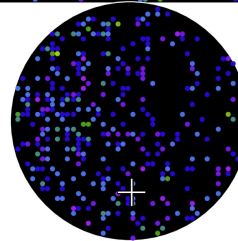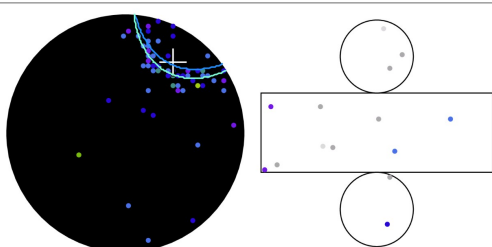Trigger: 0x00
D_wall: 0.3 cm
Evis: 0.0 MeV

merged

Times (ns)

MC
Sample

Not sure where π^+ is...
Too close to wall?
p_π = 217.7 MeV/c

MC
Sample

MC Sample

MC Sample
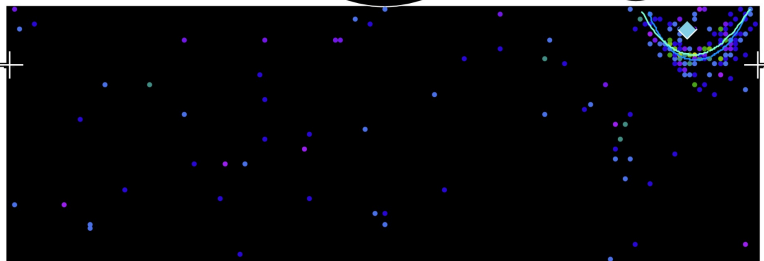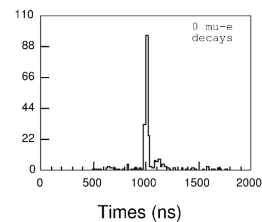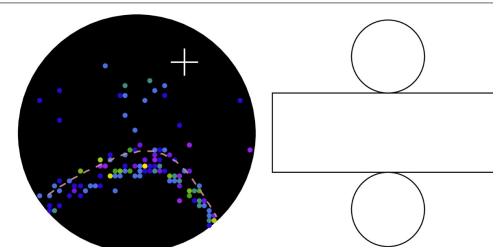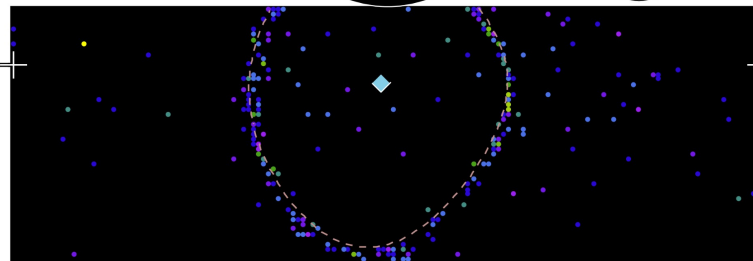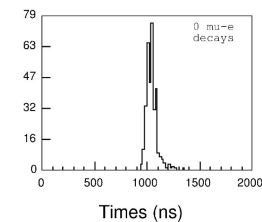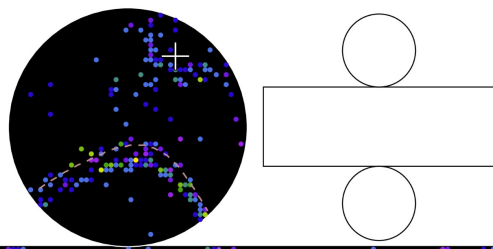
e

π⁺

merged

MC Sample

Super-Kamiokande IV
Run 999999 Sub 205 Event 2135
16-03-10:19:06:50
Inner: 1740 hits, 9140 pe
Outer: 5 hits, 5 pe
Trigger: 0x07
D_wall: 197.3 cm
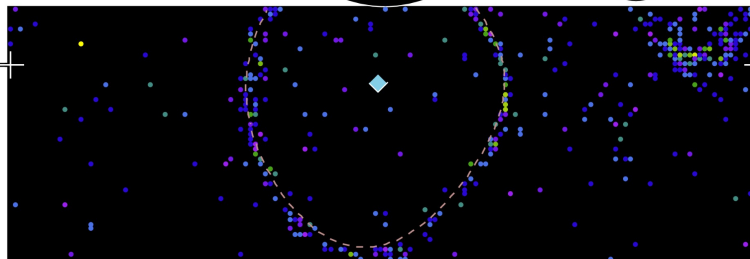Evis: 834.2 MeV
e-like, p = 834.2 MeV/c

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:41:20
Inner: 467 hits, 1758 pe
Outer: 0 hits, 0 pe
Trigger: 0x07
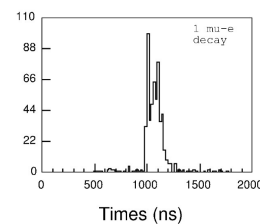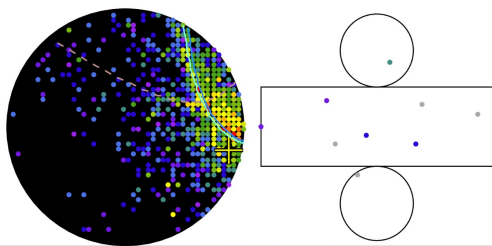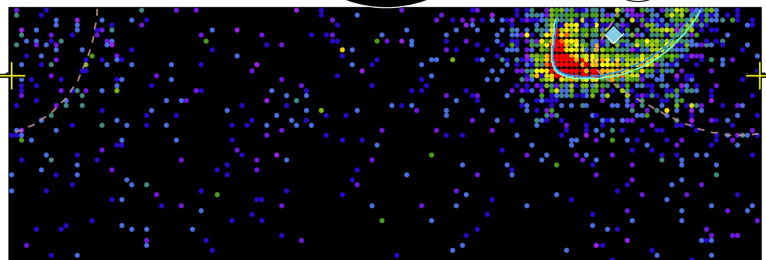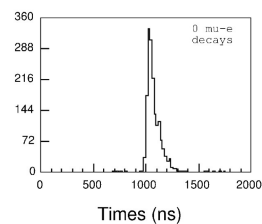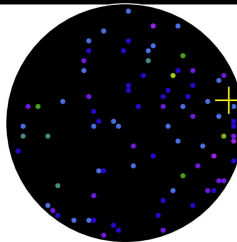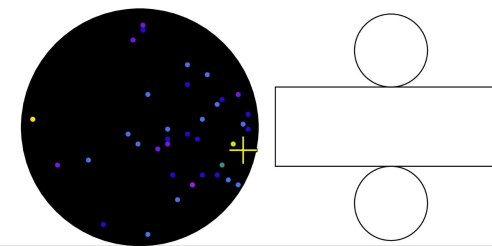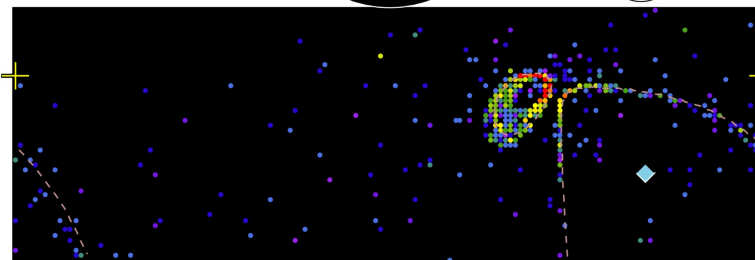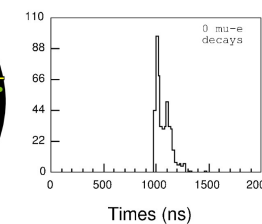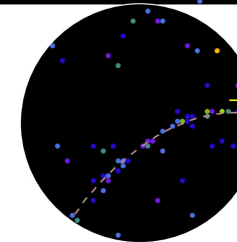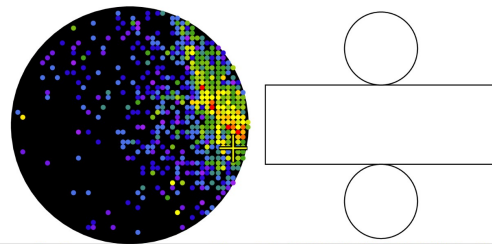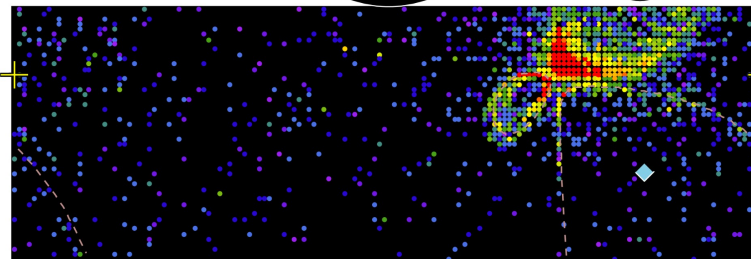D_wall: 197.3 cm
Evis: 0.0 MeV

Super-Kamiokande IV
Run 999999 Sub 0 Event 1
19-05-16:03:41:20
Inner: 2081 hits, 10925 pe
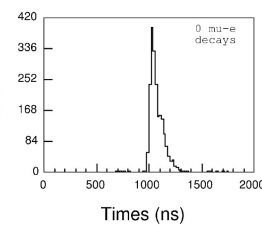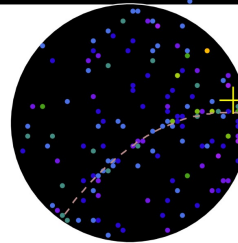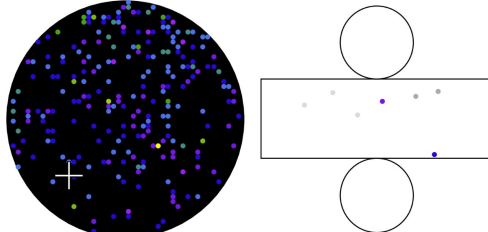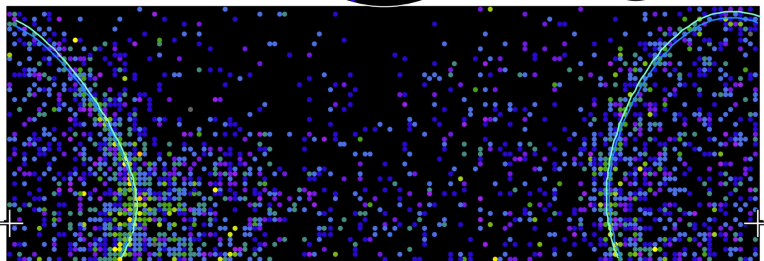Outer: 0 hits, 0 pe
Trigger: 0x07
D_wall: 197.3 cm
Evis: 0.0 MeV
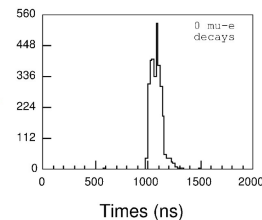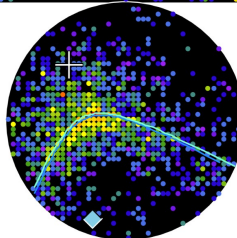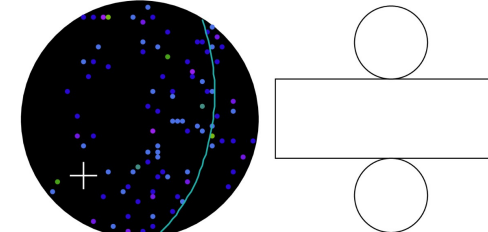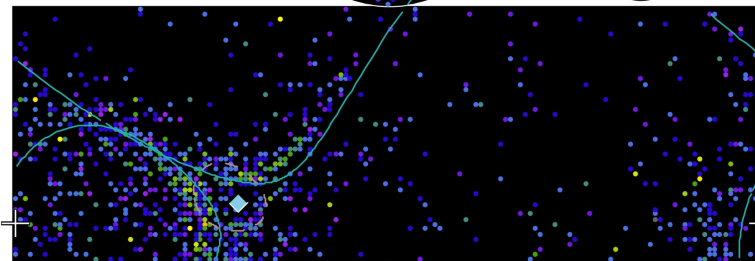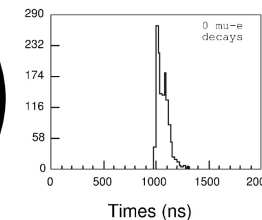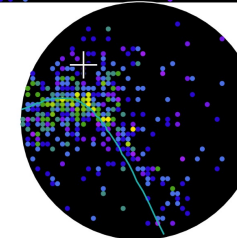
Charge (pe)
>26.7
23.3-26.7
20.2-23.3
17.3-20.2
14.7-17.3
12.2-14.7
10.0-12.2
8.0-10.0
6.2- 8.0
4.7- 6.2
3.3- 4.7
2.2- 3.3
1.3- 2.2
0.7- 1.3
0.2- 0.7
< 0.2

e

π⁺

merged

π⁺ → π⁺p

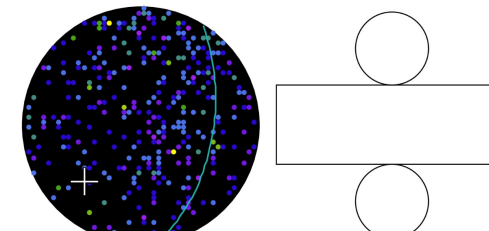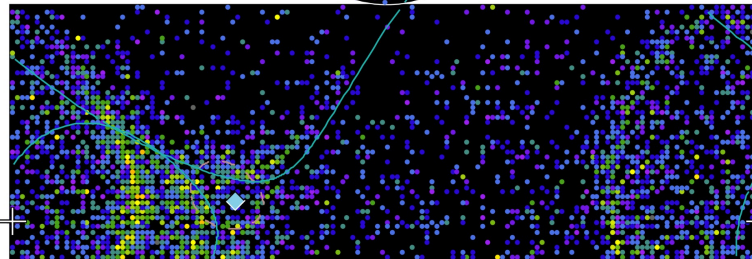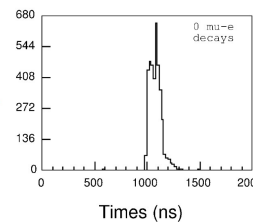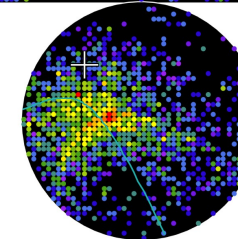MC Sample

MC Sample

$\pi^+ \to \pi^0 \to \gamma\gamma$

Future Work

- Event displays of timing

- Run BDT-based event selection on hybrid sample

Backup

nue CCQE/CC1pi Meeting
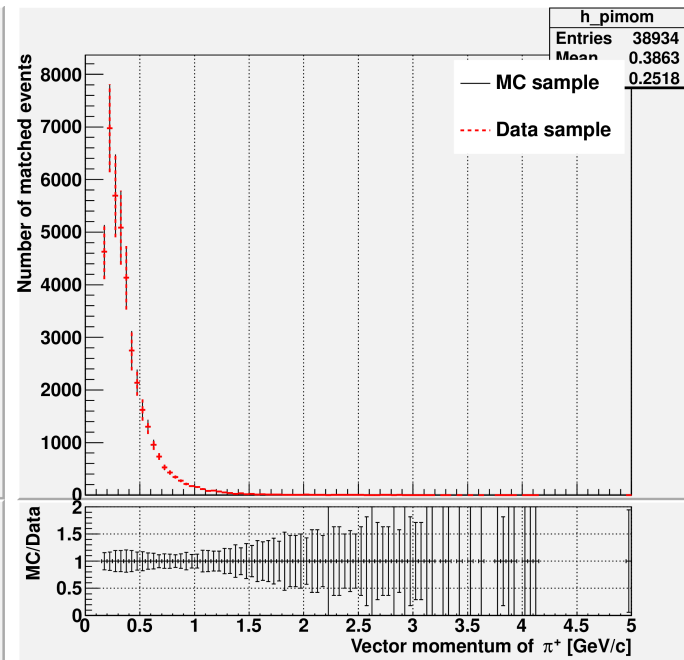
Kinematics of matched events

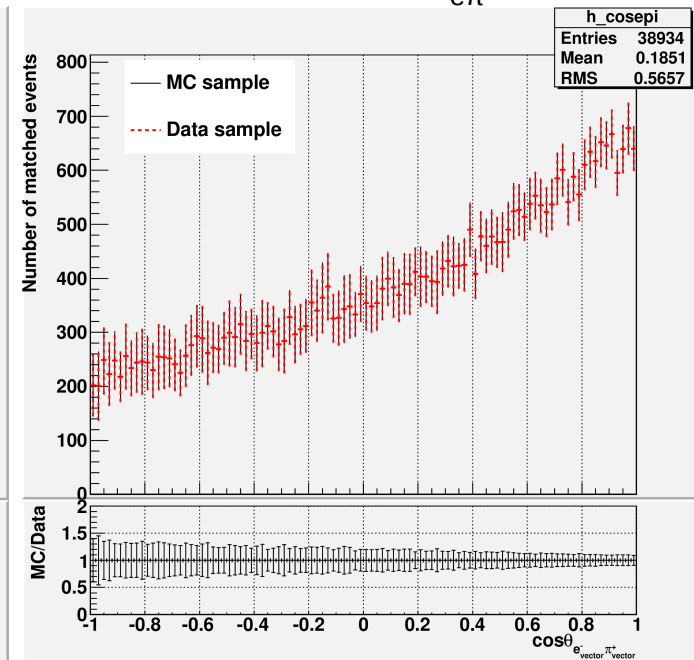

True e⁻ momentum
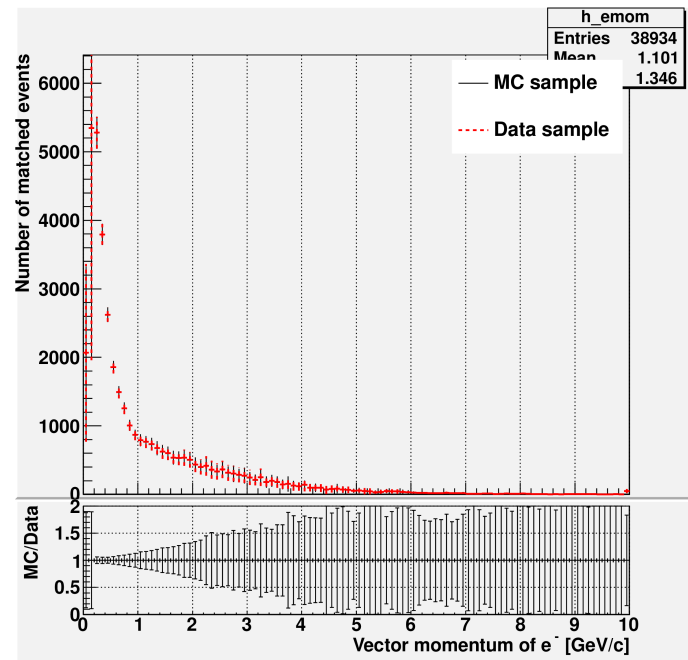
True π⁺ momentum

True cos($\theta_{e\pi}$)

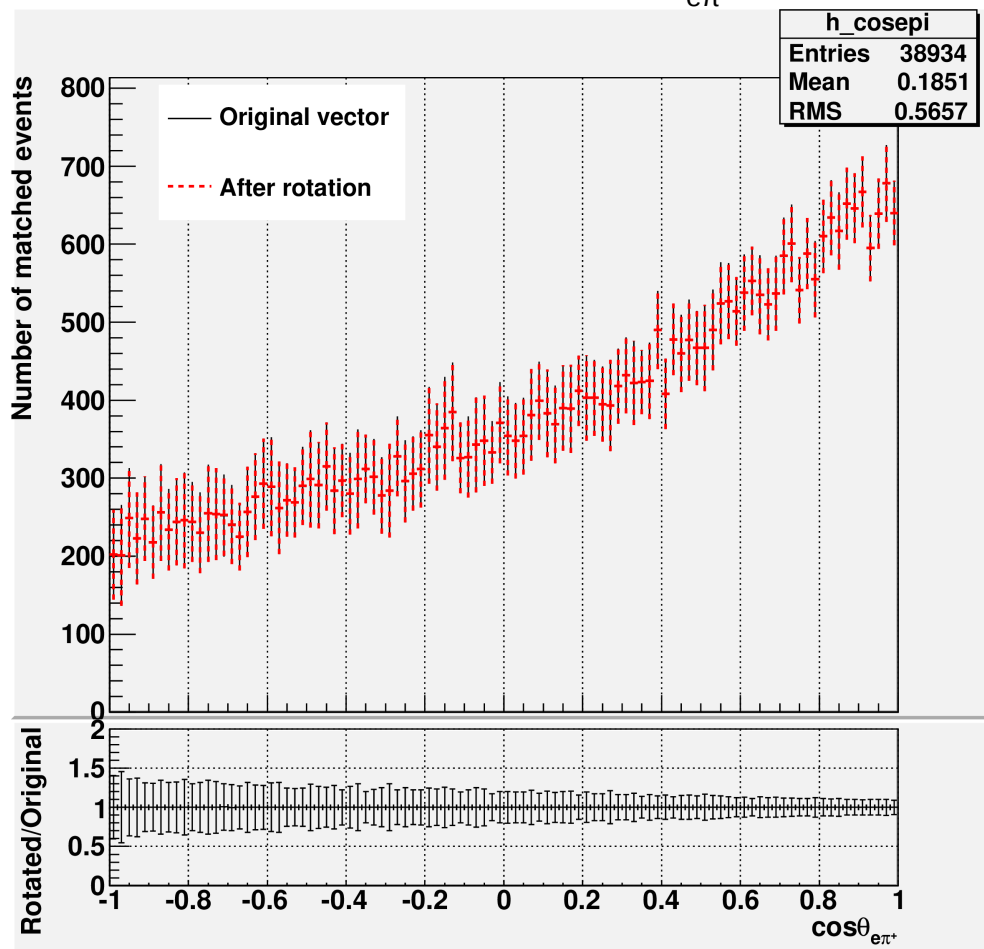MC/data should be perfectly matched (by construction)

Matched e Momentum Difference

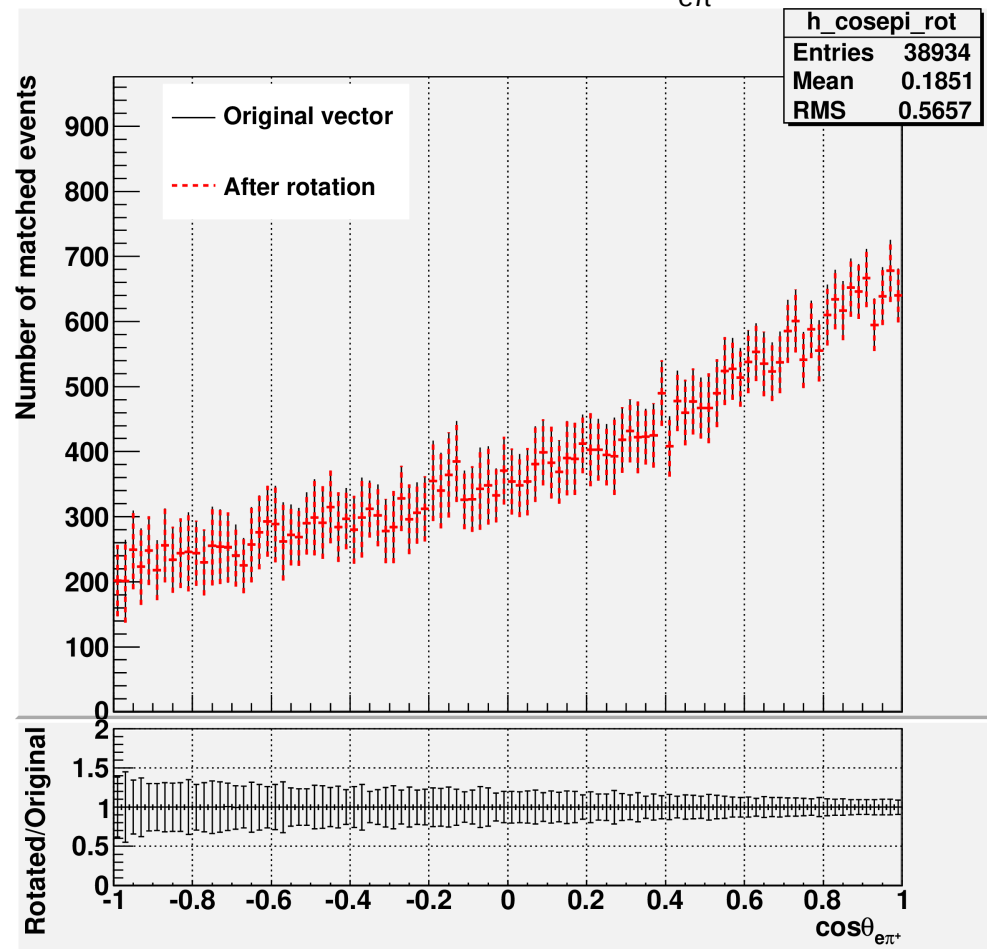$(p_{atm\ e} - p^{true}_{T2K\ MC\ e}) / p^{true}_{T2K\ MC\ e}$
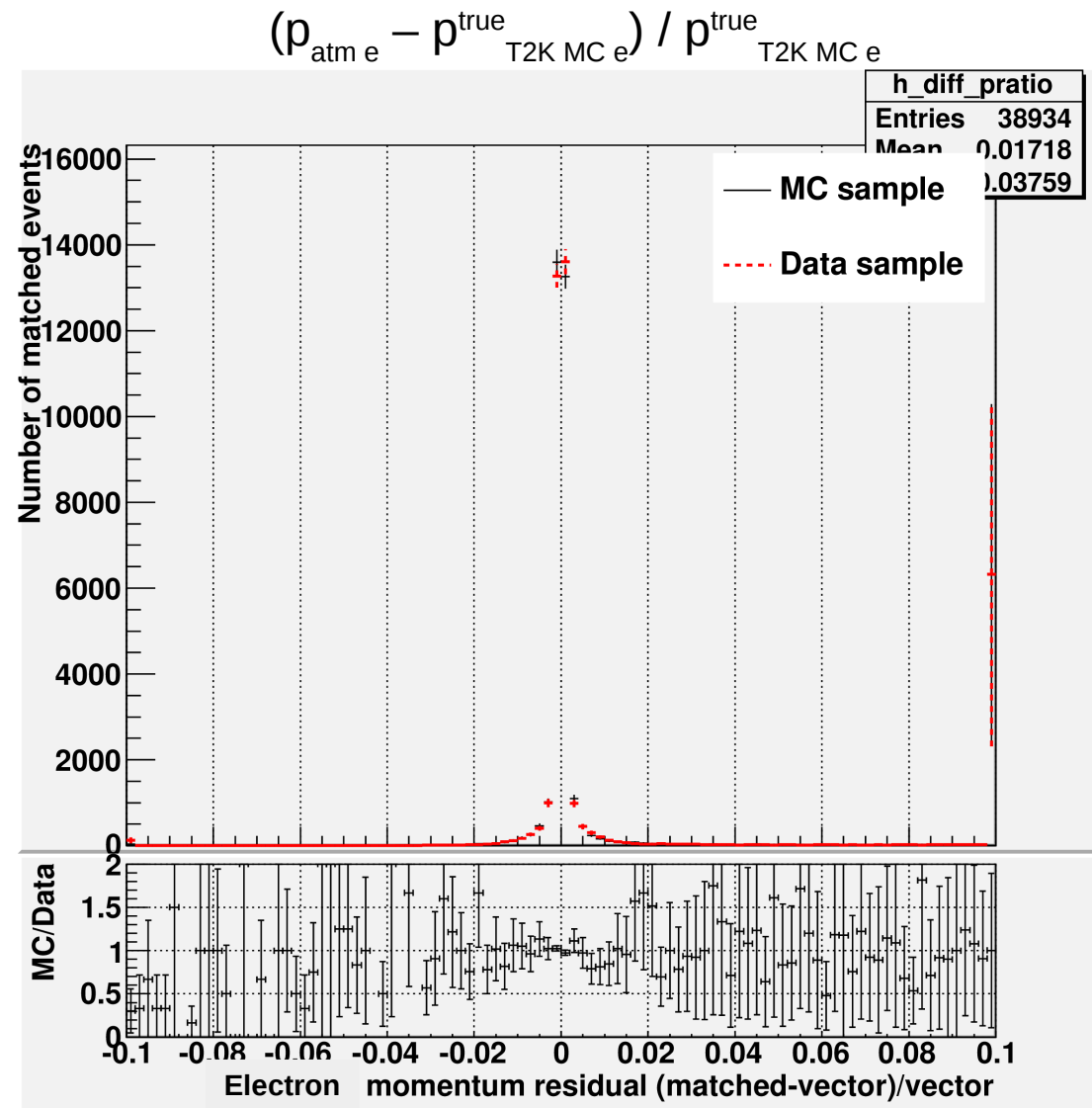
Rotation

Data Sample: $\cos(\theta_{e\pi})$

MC Sample: $\cos(\theta_{e\pi})$

Rotated/original should be perfectly matched (by construction)
Data sample and MC sample should have same distribution (by construction)