Attempt to finalize the likelihood

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Outline

- Last week questions and some answers.
- Definition of Danka's variables
- Summary of methodoloy to use new var.
- Efficiency tables for Danka's variables
- Best configuration so far
- Possible improvement

Last week question and answer

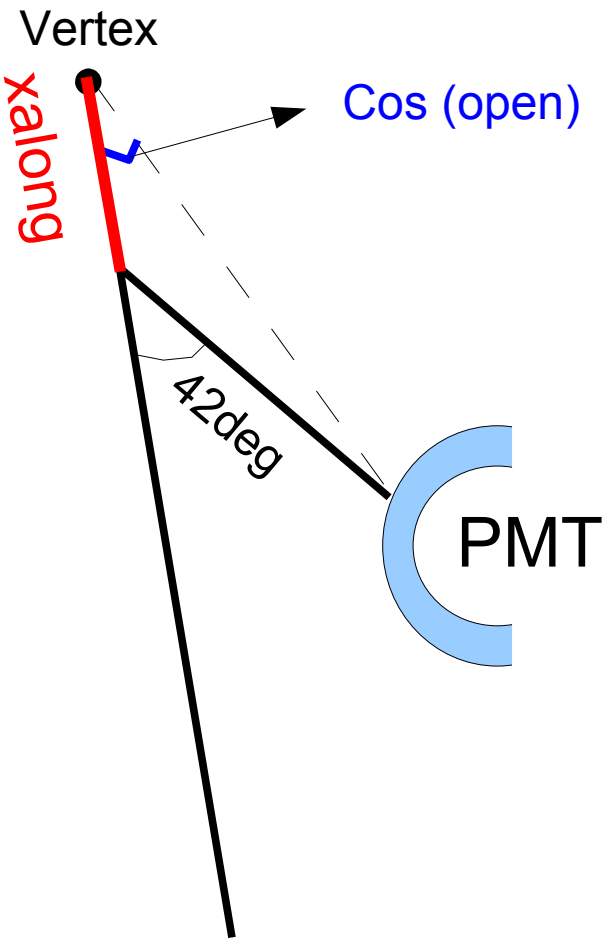
- What happens if I train my likelihood on ν_eCC vs. ν_eCCQE ?
  - background rejection improves
  - efficiency decreases

	5 variables only νe CCQE			5 variables on νe CC		
Erec(GeV)	Signal	Bckg(νμ CC)	Bckg(NC)	Signal	Bckg(νμ CC)	Bckg(NC)
0~0.35	91.9%	37.0%	14.1%	92.2%	38.2%	14.4%
0.35~0.85	83.6%	42.5%	25.7%	84.2%	43.1%	26.6%
0.85~1.5	78.3%	31.2%	27.3%	79.0%	31.6%	27.7%
1.5~	55.5%	16.2%	33.8%	64.4%	20.5%	38.0%

Definition of Danka's variables:

Xalong: Distance between vertex and emitting point of Cherenkov light.

Cos(open): Angle between vertex-pmt vector & direction of neutrino

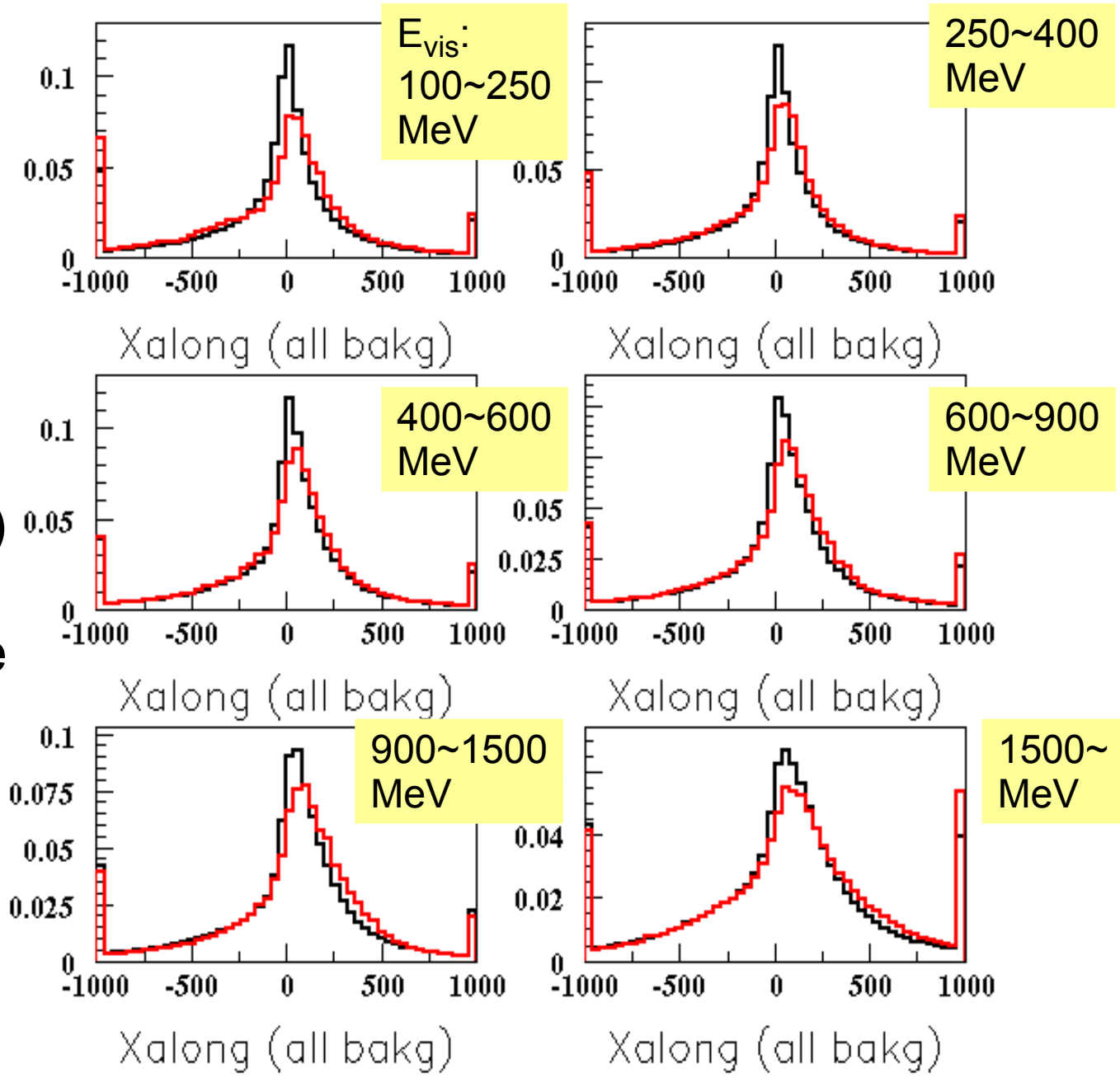


Xalong distribution

Distribution
for each hit pmt,
for each event,
for 20yr of MC.

Xalong weighted
by charge/
distance (vertex-pmt)

I didn't try to optimize
the weight:
→ work to be done.

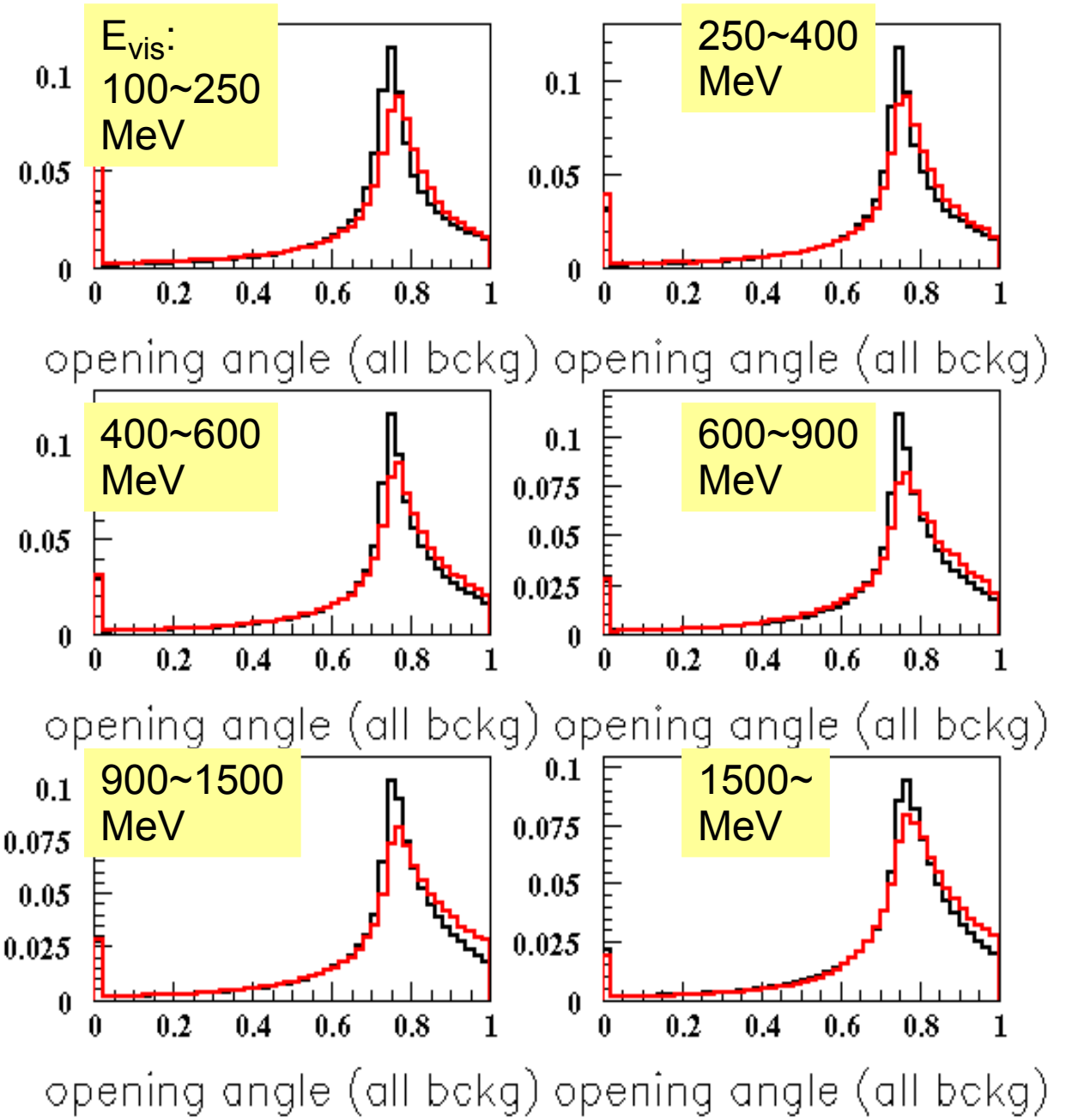


Cos(open) distribution

Distribution
for each hit pmt,
for each event,
for 20yr of MC.

Cos(open) weighted
by charge

I didn't try to optimize
the weight:
→ work to be done.



How to use those variables:

Using 20yr of MC:

Create template of Xalong and Cos(open) distributions.

On 100yr MC:

For each event compute χ^2 (signal) and χ^2 (bckg) using the templates.

$$\chi^2_{sig} = \sum_{bin} \left[\frac{(event(bin) - template_{sig}(bin))^2}{(event(bin))} \right]$$

Define new variables: var = χ^2 (bckg) - χ^2 (signal)

Create new bank containing those variables (EPI0SEP)

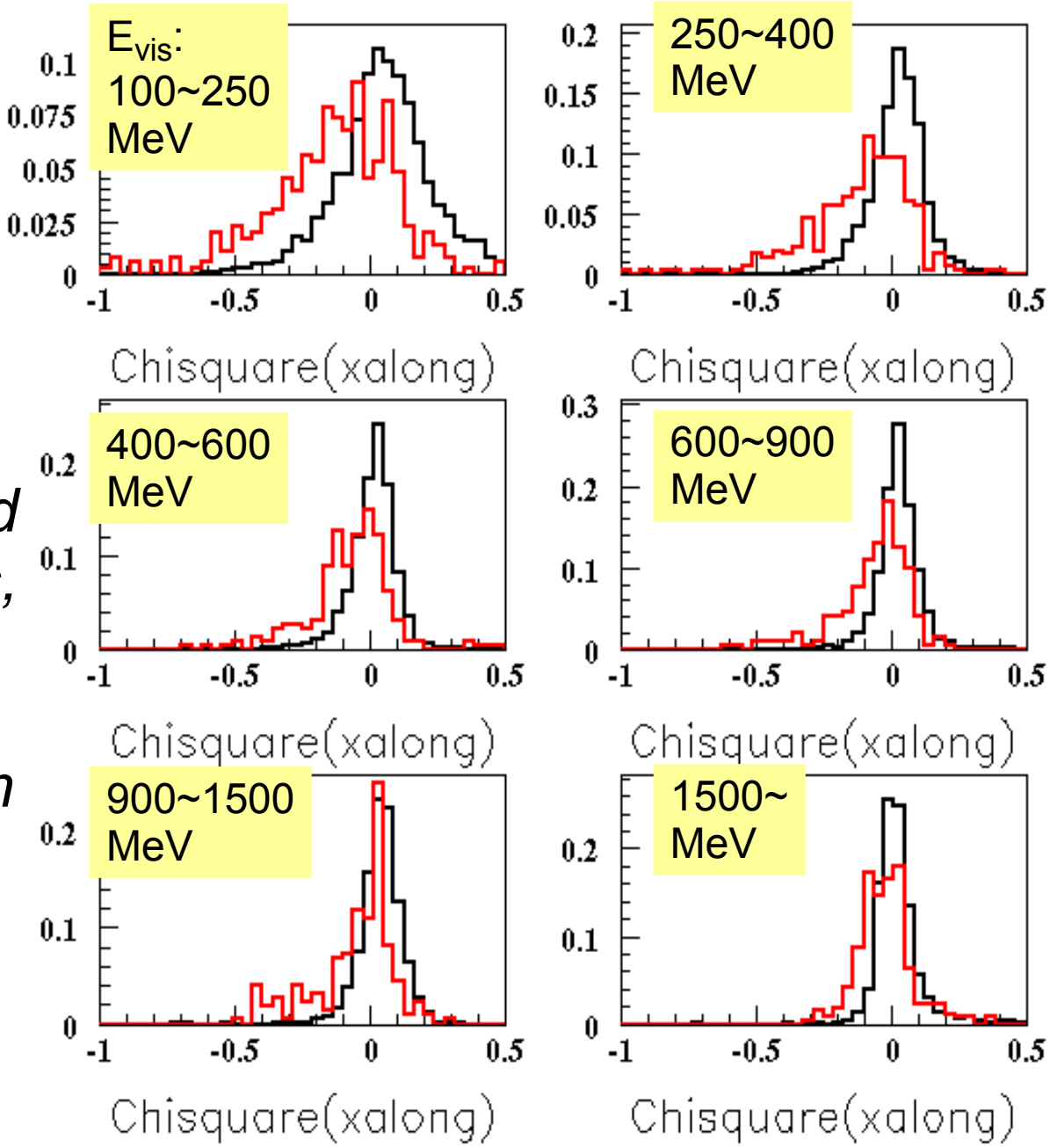
Create new zbs and hbk files containing this new bank

Use those 2 variables as I used every other one.

χ^2 Xalong distribution

Note:
I used all the background to make those templates, not only π^0 events

→ Give better separation



Efficiency tables: Xalong

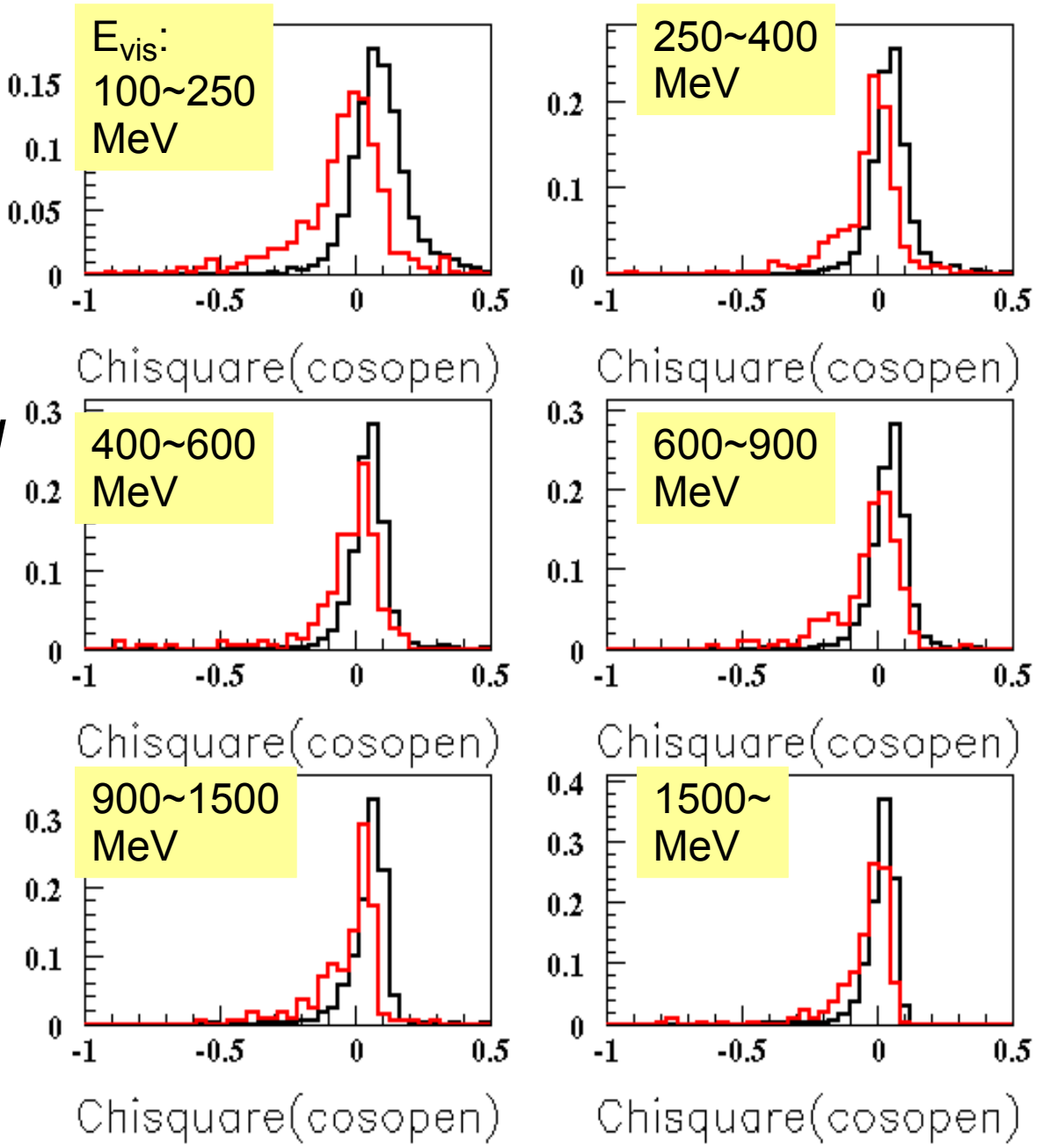
5 variables +xalong				5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	92.5%	23.6%	11.5%	92.2%	38.2%	14.4%
0.35~0.85	85.6%	32.2%	23.3%	84.2%	43.1%	26.6%
0.85~1.5	81.0%	12.4%	25.4%	79.0%	31.6%	27.7%
1.5~	76.0%	20.3%	42.0%	64.4%	20.5%	38.0%

At high energy: Good to keep signal
Bad to remove background

χ^2 Cos(open) distribution

Note:
I used all the background to make those templates, not only π^0 events

→ Give better separation



Efficiency tables: Cos(open)

5 variables +cos(open)				5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	91.4%	18.2%	11.5%	92.2%	38.2%	14.4%
0.35~0.85	82.6%	33.3%	23.0%	84.2%	43.1%	26.6%
0.85~1.5	76.5%	15.8%	23.8%	79.0%	31.6%	27.7%
1.5~	59.3%	8.8%	29.0%	64.4%	20.5%	38.0%

At high energy: Good to remove background
Bad to keep signal

Best configuration

- Depending on which variable I used, I can chose to:

  - Keep more signal
  - Remove more background

- The final set of variables to be used depends on what is more important according to the background spectrum of the beam.

- I also used the energy fraction variables defined last week:

  efrac = $E(\gamma_2)/(E(\gamma_1)+E(\gamma_2))$

Efficiency tables:Best config(1)

Keep a lot of signal, remove not much background

	5 variables +efrac + xalong			5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	91.2%	30.9%	11.3%	92.2%	38.2%	14.4%
0.35~0.85	84.6%	37.9%	22.6%	84.2%	43.1%	26.6%
0.85~1.5	81.5%	14.5%	26.0%	79.0%	31.6%	27.7%
1.5~	80.7%	20.3%	40.7%	64.4%	20.5%	38.0%

Efficiency tables:Best config(2)

Remove a lot of background, but keep little signal

	5 variables +efrac + cosopen			5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	90.0%	27.3%	11.5%	92.2%	38.2%	14.4%
0.35~0.85	81.8%	35.1%	22.6%	84.2%	43.1%	26.6%
0.85~1.5	78.1%	17.9%	25.5%	79.0%	31.6%	27.7%
1.5~	68.7%	11.7%	32.2%	64.4%	20.5%	38.0%

Efficiency tables:Best config(3)

Middle ground between config 1 & config 2

	5 variables +efrac + xalong + cosopen			5 variables		
Erec(GeV)	Signal	Bckg(νμ CC)	Bckg(NC)	Signal	Bckg(νμ CC)	Bckg(NC)
0~0.35	90.3%	16.4%	9.8%	92.2%	38.2%	14.4%
0.35~0.85	83.2%	31.6%	21.2%	84.2%	43.1%	26.6%
0.85~1.5	79.4%	12.0%	23.1%	79.0%	31.6%	27.7%
1.5~	76.0%	14.3%	34.5%	64.4%	20.5%	38.0%

Compare configuration

For bin evis >1.5 GeV

Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
Config(1) xalong	80.7%	20.3%	40.7%
Config(2) cos(open)	68.7%	11.7%	32.2%
Config(3) both	76.0%	14.3%	34.5%

Improvements & Known bugs

- No optimization was done on the weighting factors of Xalong and Cos(open):
  → We might be able to get better results

- Time cut on used hit should be applied.

- Didn't have time to implement totpe/evis on only 70% of hit.

- Worked really fast → careful check of my code should be done to look for hidden bugs.

- Right now, my ntuples don't have the EVIS block:
  problem when using fillnt (problem in the official fillnt?)
  doesn't matter for me since evis=amome(1)
  for 1ring, e-like
  →but needs to be fixed.

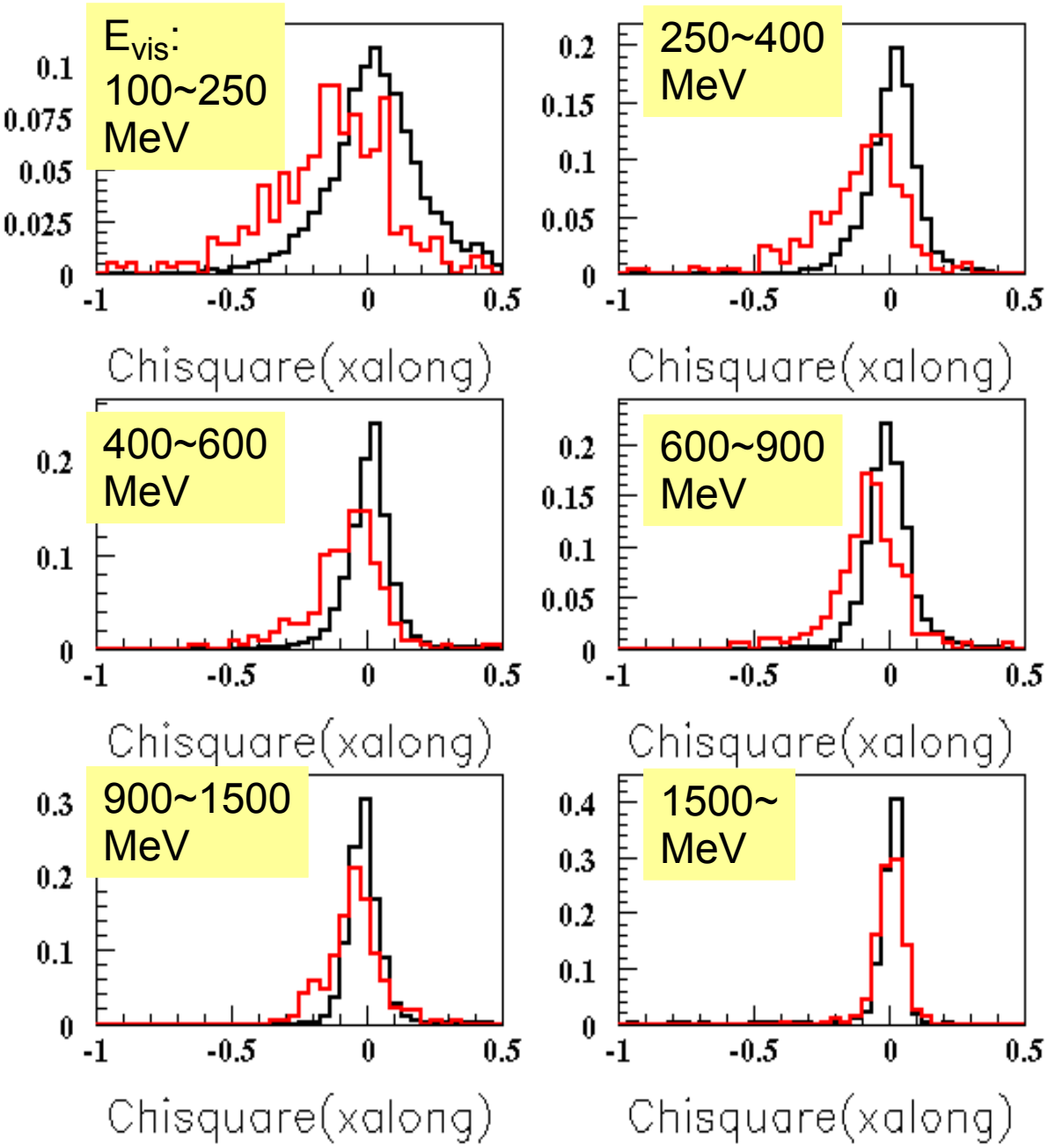
backups...

- How I trained the background/signal in main talk:
  - signal trained on ν_e CC
  - trained on all background for xalong & cos(open)
- Xalong and Cos(open with only π^0 background)
- Efficiency tables if train on ν_e CCQE
- Xalong and cos(open) distribution with split background

χ^2 Xalong distribution

Using only π^0 events for background

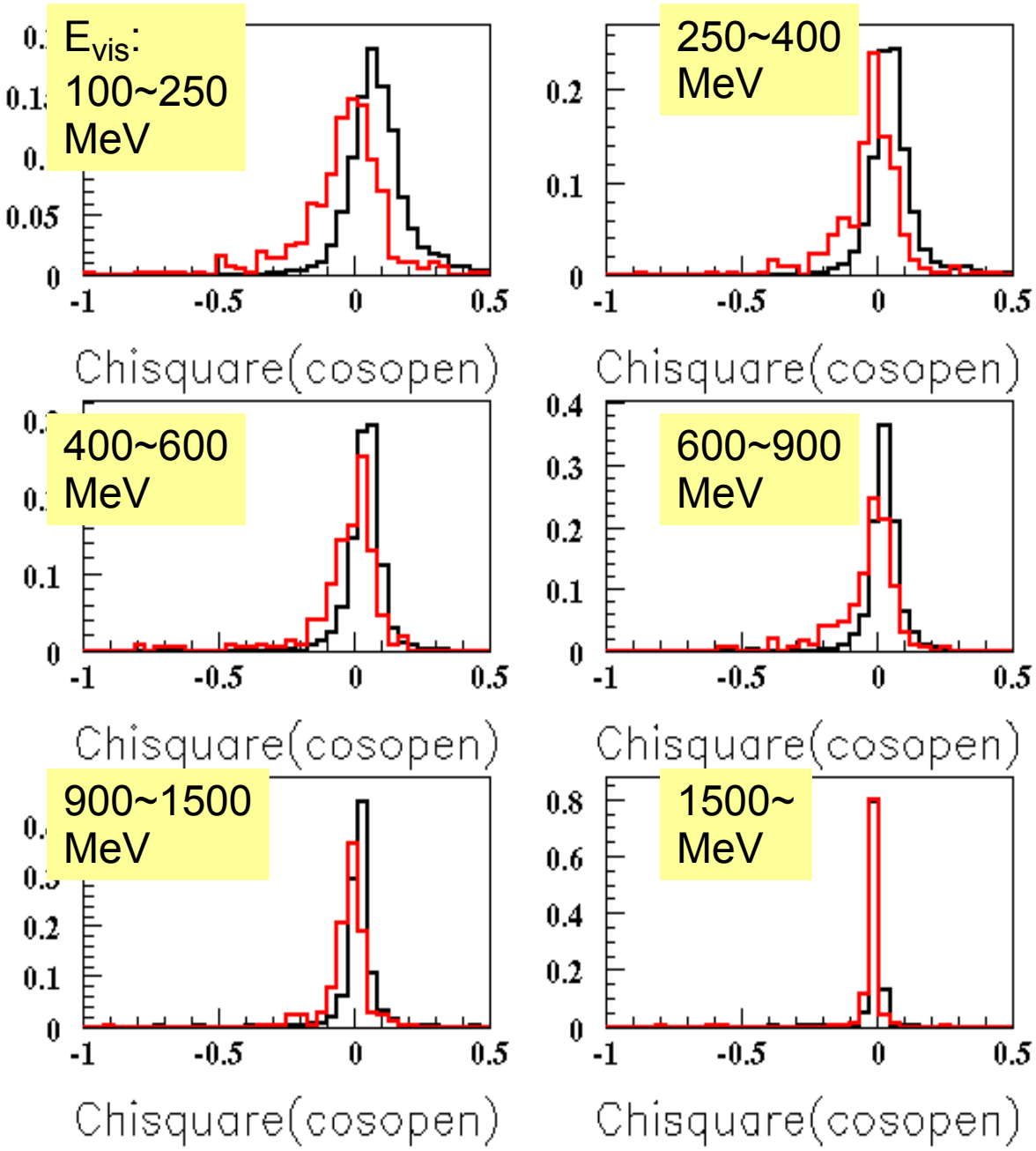
→ Give bad separation



χ^2 Cos(open) distribution

Using only π^0 events for background

→ Give bad separation



Efficiency (training on ν_e CCQE)

Next 3 slides are the 3 best configuration when
I train my likelihood only on the quasi-elastic charge-current

Efficiency tables:Best configuration

5 variables +efrac + xalong				5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	90.8%	29.1%	10.7%	91.9%	37.0%	14.1%
0.35~0.85	83.9%	36.8%	21.7%	83.6%	42.5%	25.7%
0.85~1.5	80.8%	14.1%	25.2%	78.3%	31.2%	27.3%
1.5~	67.1%	14.8%	33.7%	55.5%	16.2%	33.8%

Efficiency tables:Best config (2)

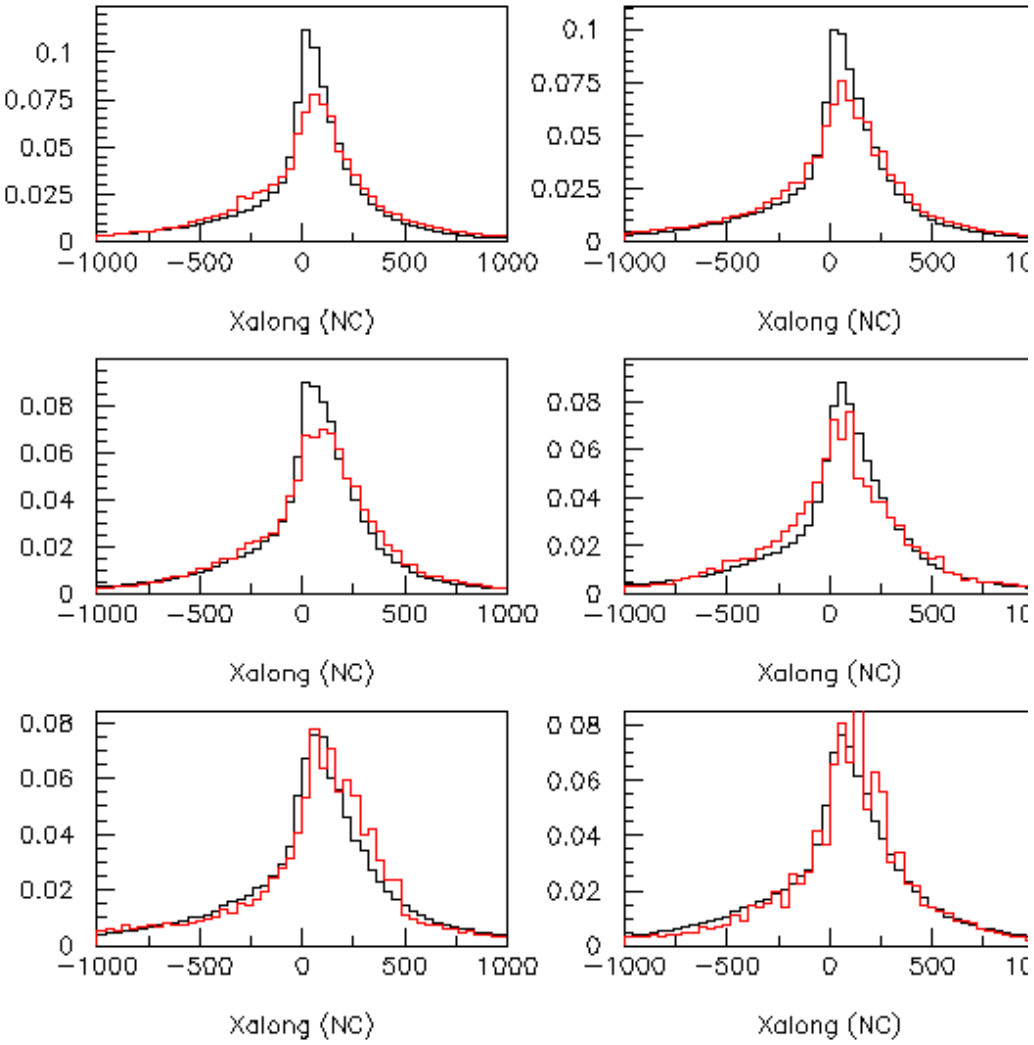
5 variables +efrac + cosopen				5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	89.4%	27.3%	10.7%	91.9%	37.0%	14.1%
0.35~0.85	81.1%	34.5%	21.7%	83.6%	42.5%	25.7%
0.85~1.5	77.4%	18.4%	24.8%	78.3%	31.2%	27.3%
1.5~	58.5%	10.4%	27.0%	55.5%	16.2%	33.8%

Efficiency tables:Best config(3)

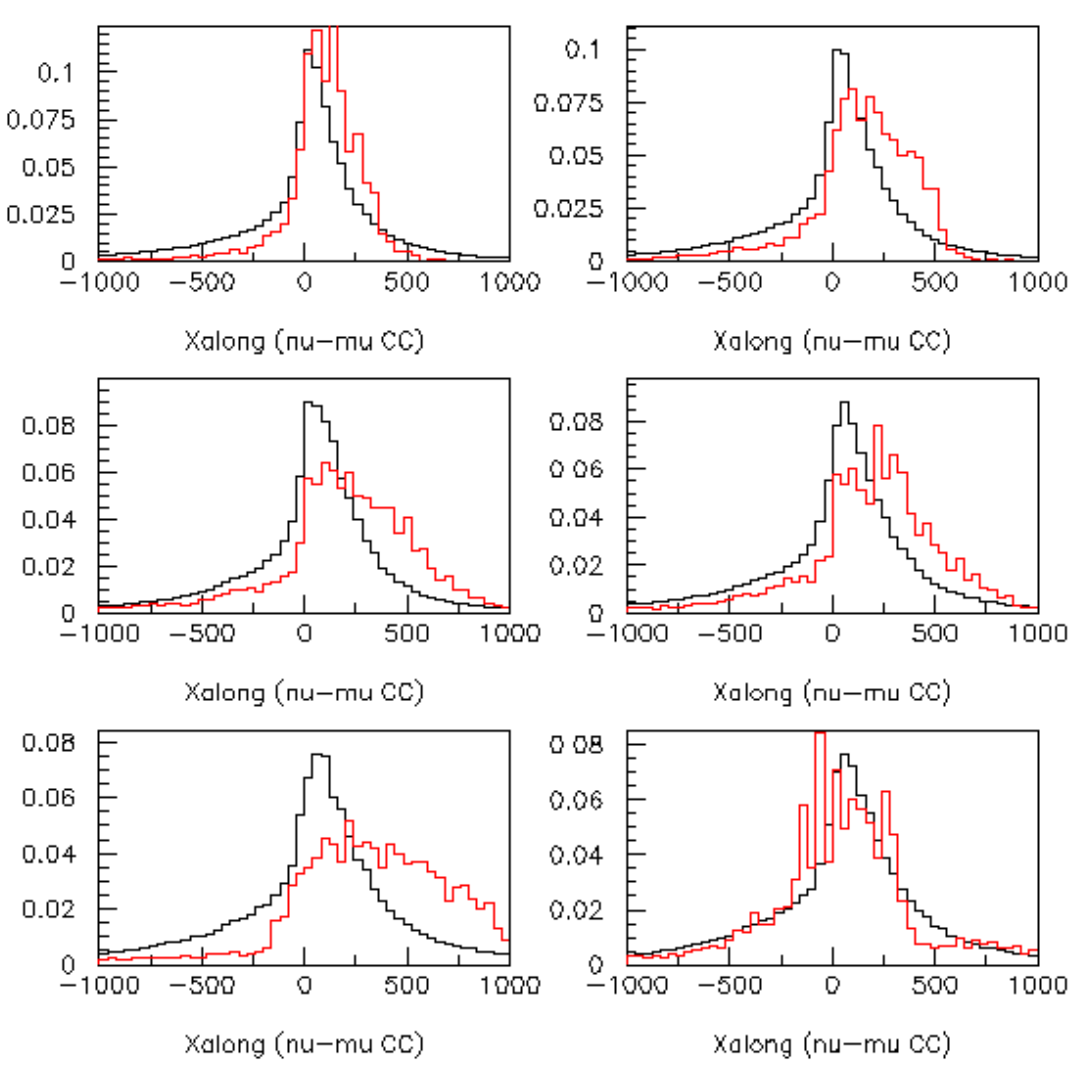
	5 variables +efrac + xalong + cosopen			5 variables		
Erec(GeV)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)	Signal	Bckg($\nu\mu$ CC)	Bckg(NC)
0~0.35	89.9%	16.4%	9.4%	91.9%	37.0%	14.1%
0.35~0.85	82.5%	30.5%	20.3%	83.6%	42.5%	25.7%
0.85~1.5	78.6%	12.4%	22.5%	78.3%	31.2%	27.3%
1.5~	63.6%	9.8%	28.7%	55.5%	16.2%	33.8%

Xalong distribution

Background:NC only



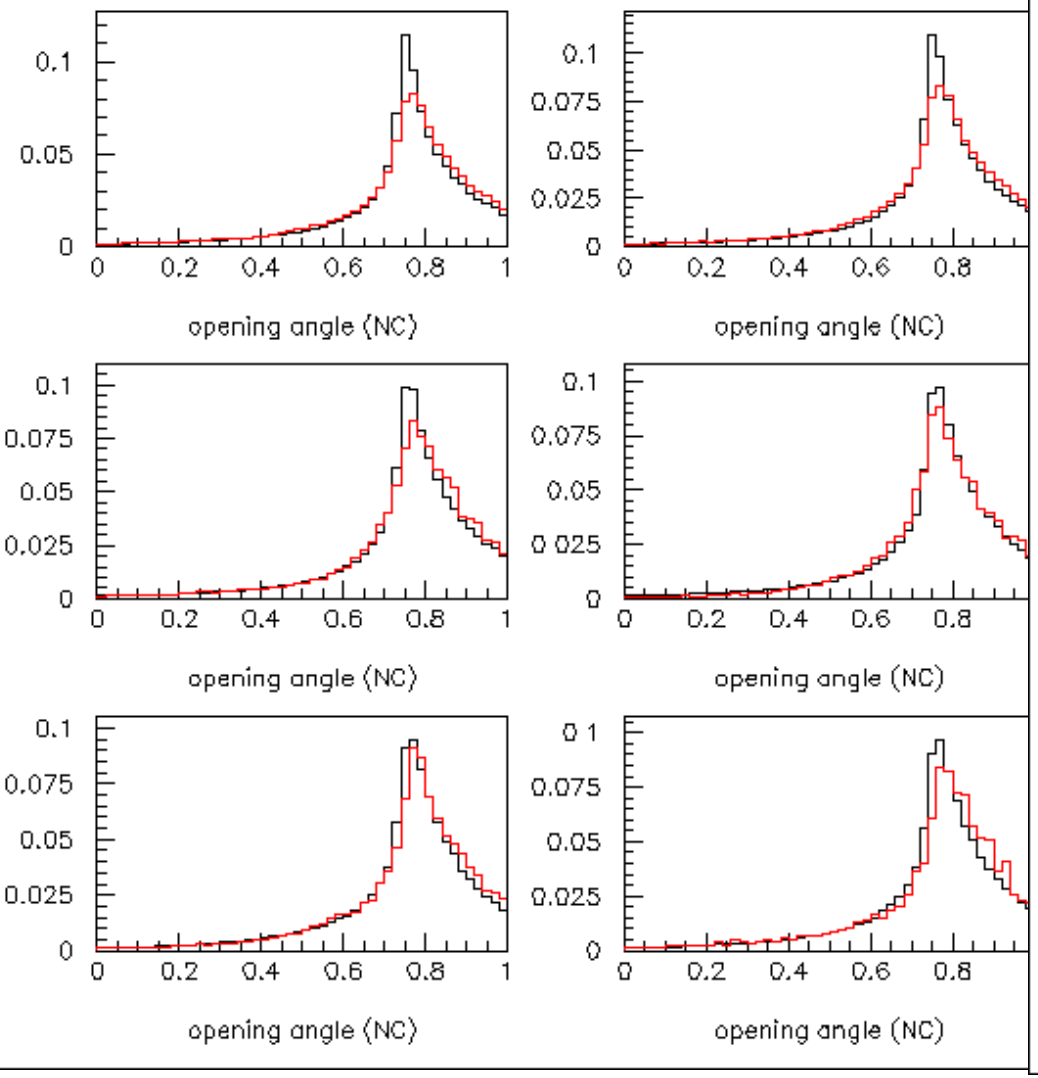
Background:ν_μ CC only



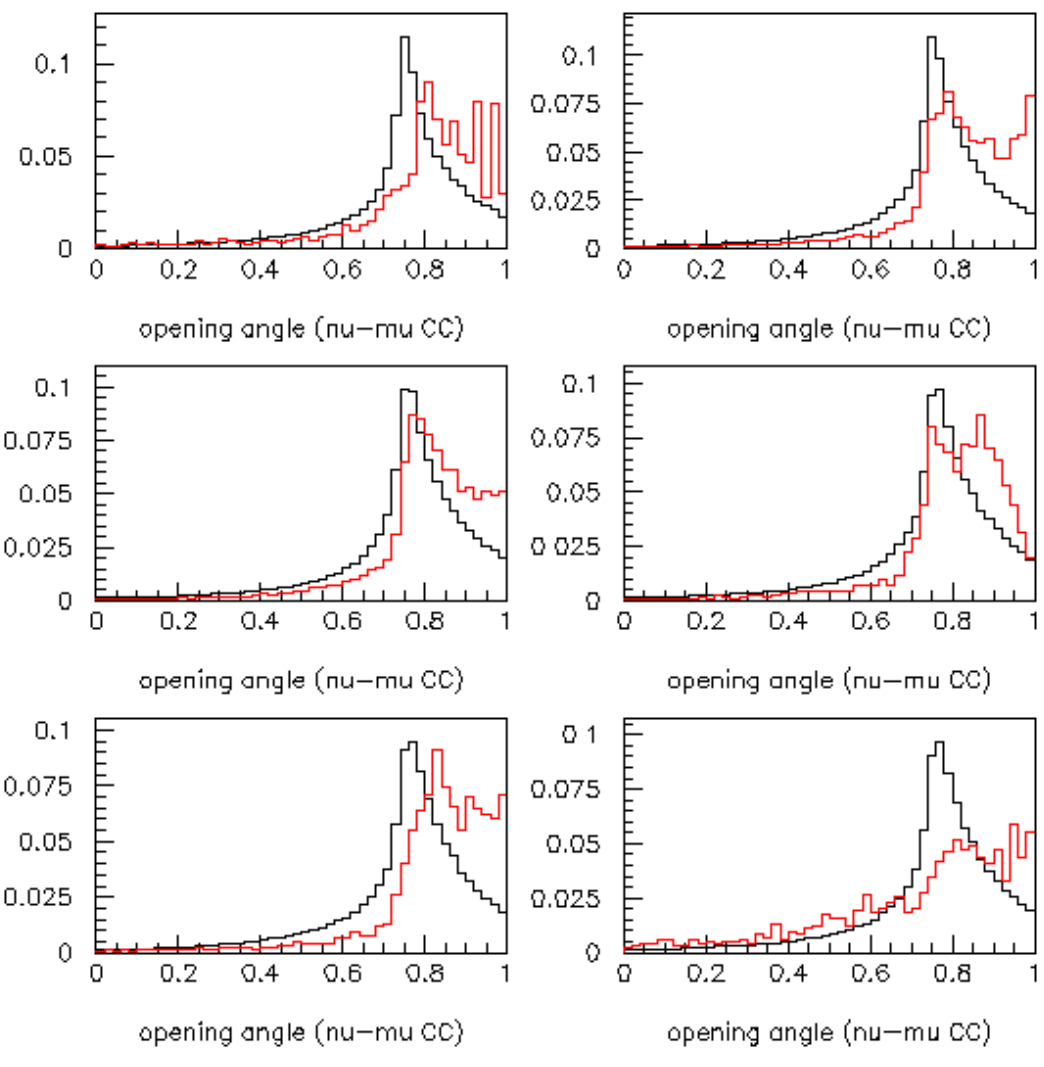
Run only on 4 yrs of MC → Just to give an idea

Cos(open) distribution

Background:NC only



Background:ν_μ CC only



Run only on 4 yrs of MC → Just to give an idea