Multi-GeV Multi-Ring Systematics

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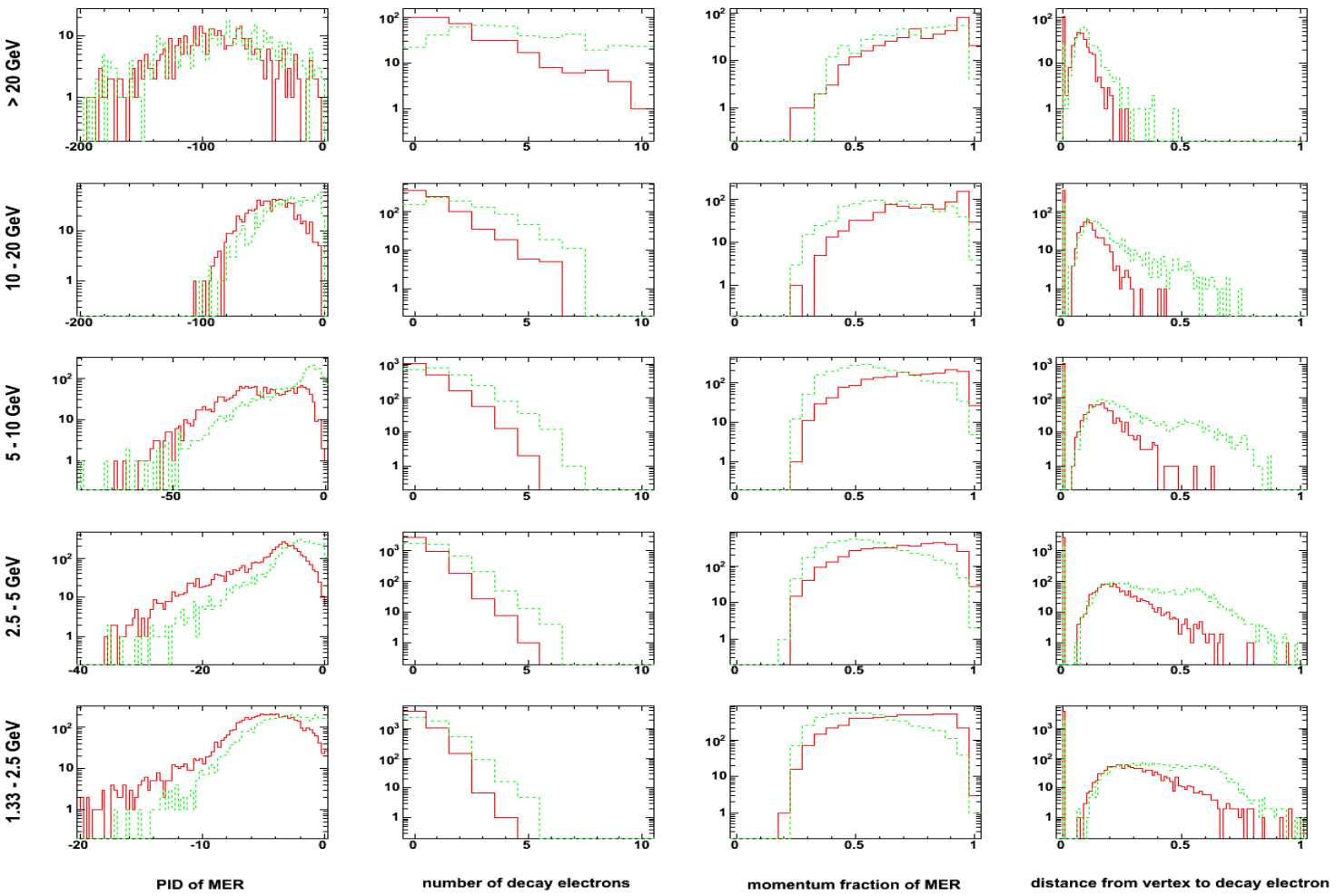
- **BG contamination, Likelihood systematic**

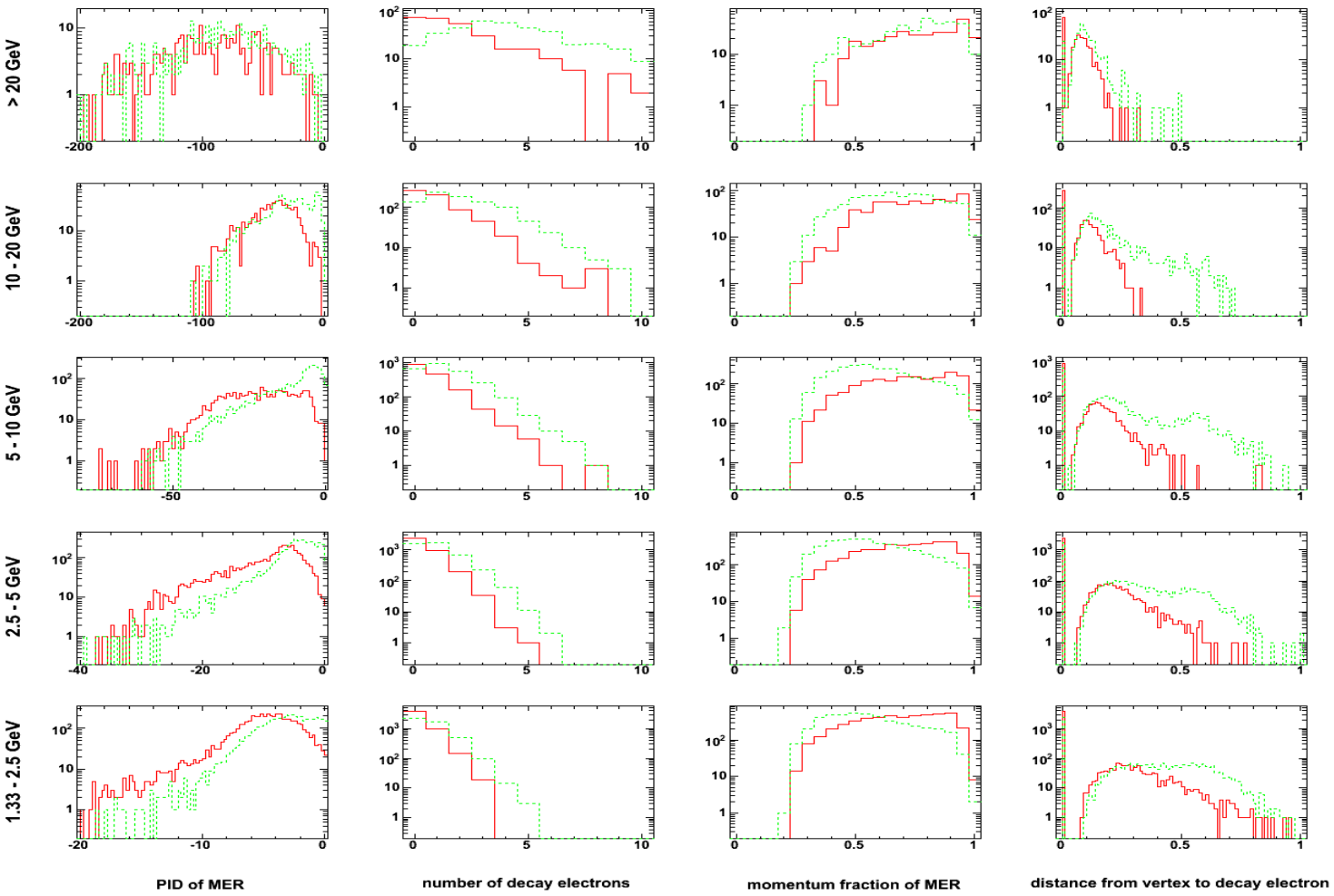
Multi-Ring Multi-GeV e-like likelihood: 100 yr SK-I



Signal (CC ν_e)

Background (CC ν_μ , NC)

Multi-Ring Multi-GeV e-like likelihood: 100 yr SK-III

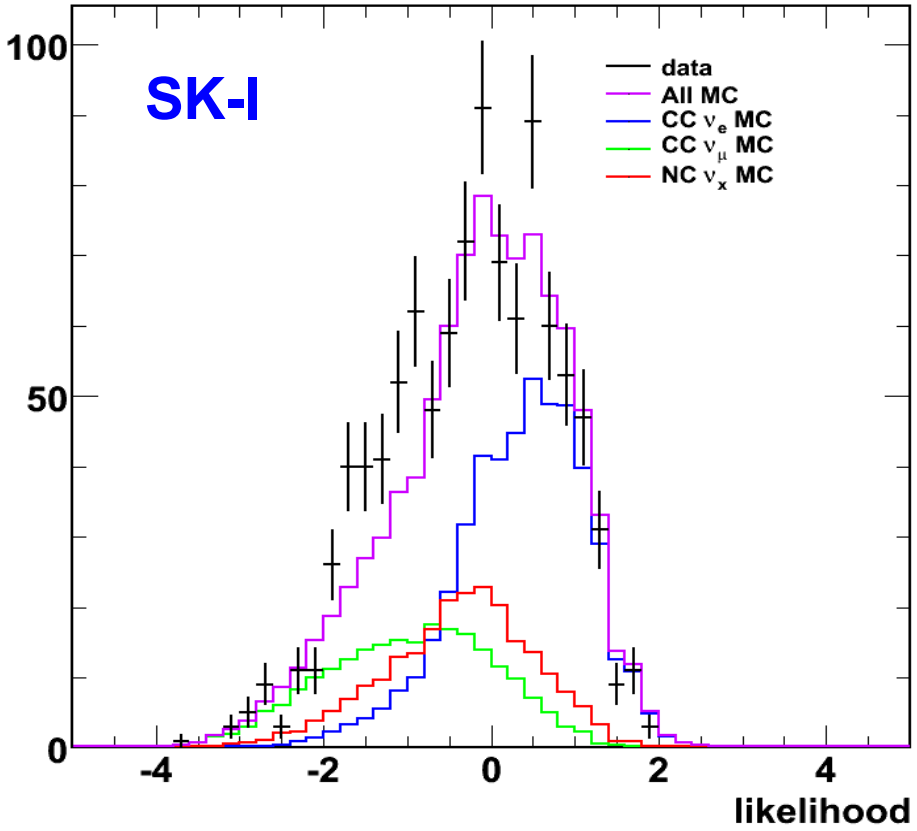


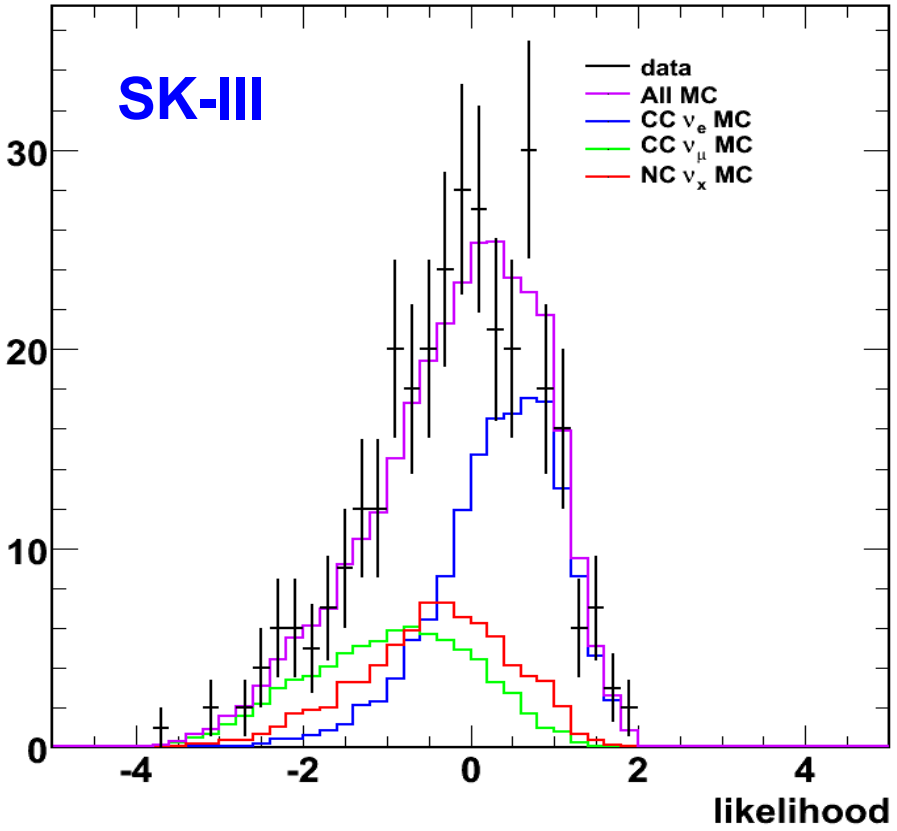
Signal (CC ν_e)

Background (CC ν_μ , NC)

- Shapes are consistent with SK-I (II)

Total Likelihood Distribution



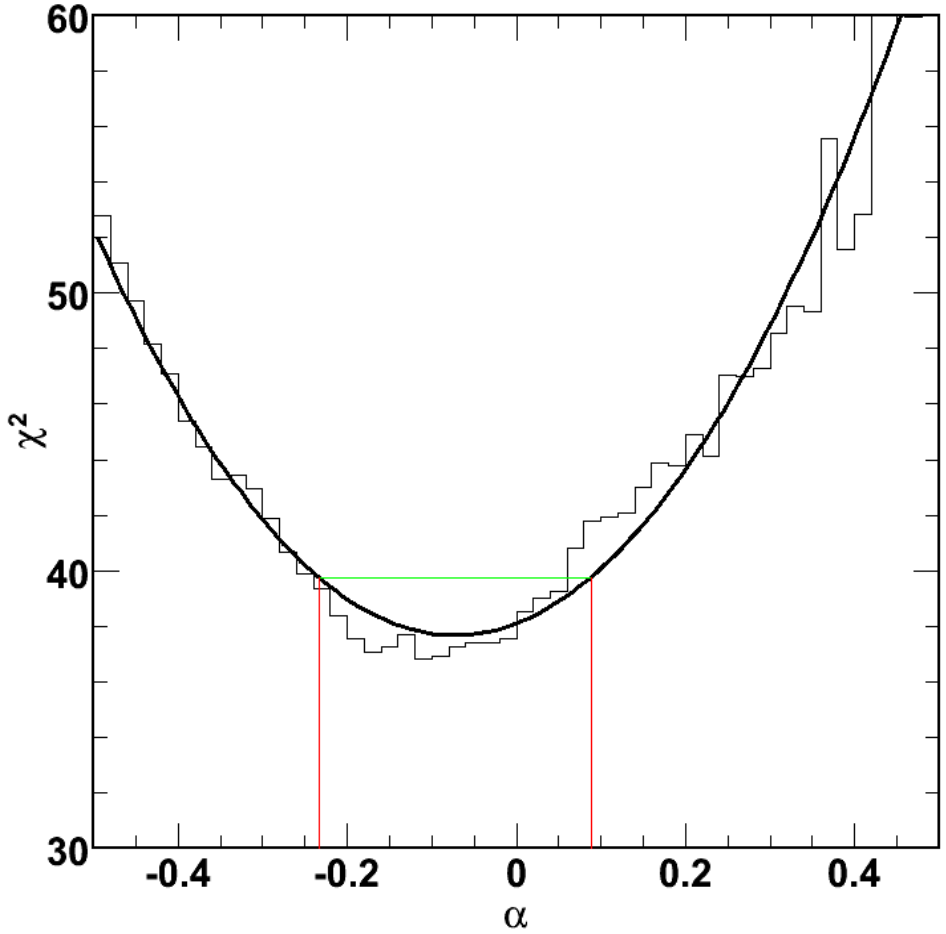


	CC ν_e	CC ν_μ	NC	Total
raw	46.4%	31.5%	22.0%	100%
Likelihood	71.3%	12.7%	16.0%	100%

SK-I CC ν_e : 74.4%

SK-II CC ν_e : 72.9%

Systematic Error Estimation



- **Fit likelihood distribution of the data for different shifts of the MC signal BG distribution**

fitting function:

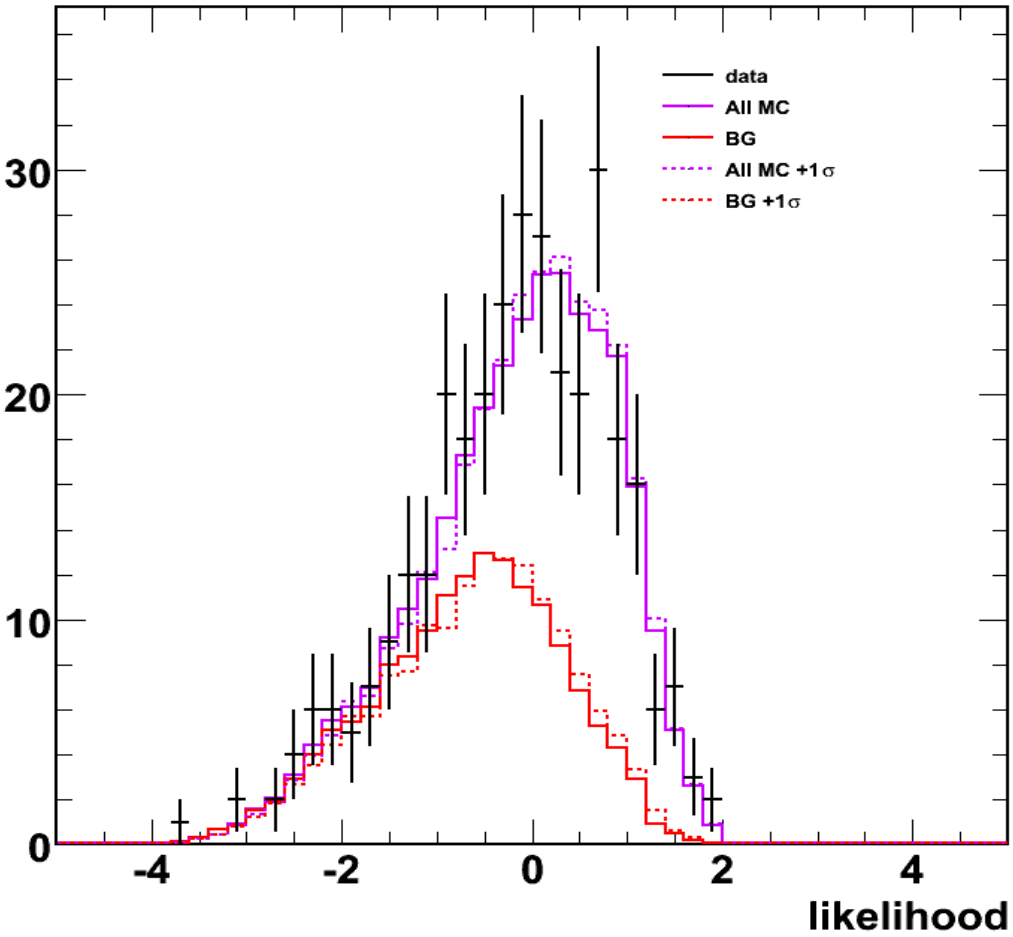
$f_{\nu_e CC}(x;\alpha) + f_{NC}(x,\beta) + f_{\nu\mu CC}(x,\beta)$

α, β : shift in Likelihood parameter

find best-fit by $\chi 2$ and derived α at 1σ upper limit.

- **Uncertainty becomes the percent change in amount of signal (background) background corresponding to the 1-σ shift in the parameter α (β)**

Non ν_e Background Systematic



SK-I :

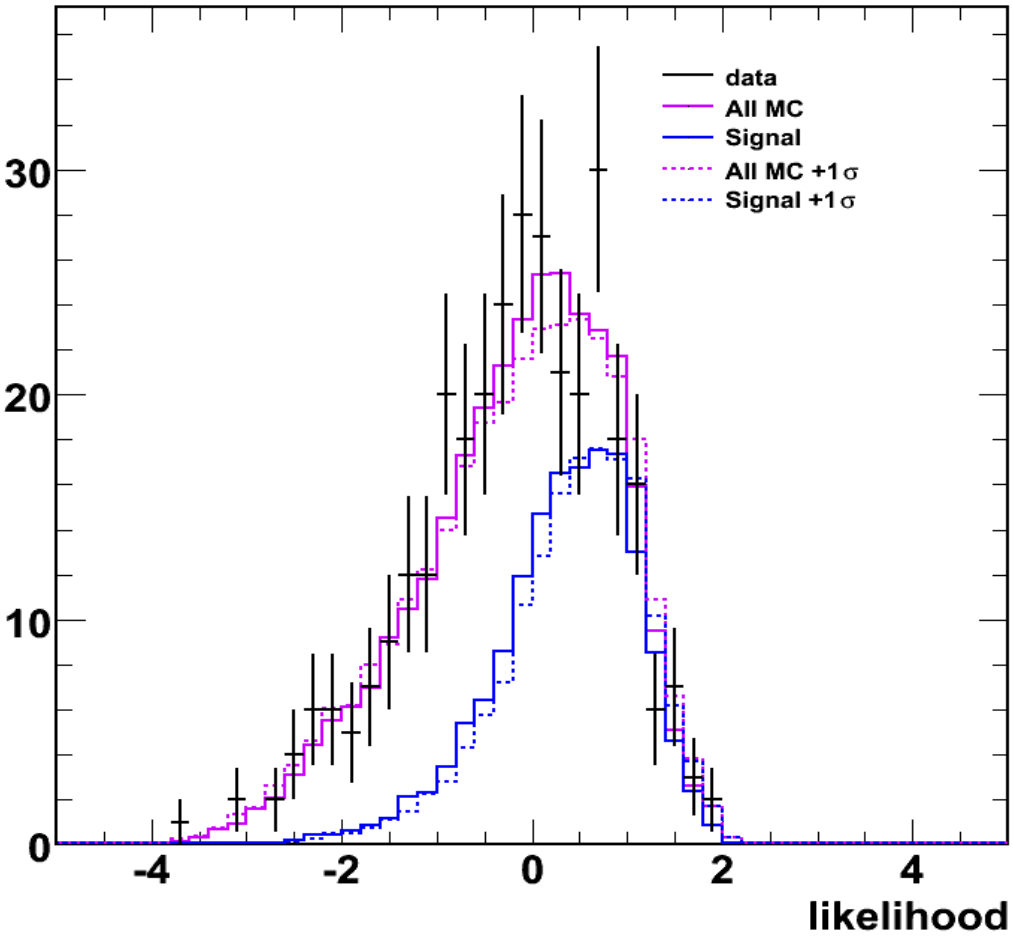
	All	BG	
standard	453.9	118.7	
Fitted	420.2	88.7	
+ 1σ	441.2	109.8	-7.5%
- 1σ	407.9	76.4	-35.6%

SK-III :

	All	BG	
Raw MC	152.9	40.6	
Fitted	147.2	33.3	
Fitted +1 s	154.0	44.7	+10.1%
Fitted -1 s	142.0	27.6	-32.0%

- Systematic error is taken to be the larger : 32.0%

Multi-Ring Multi-GeV Likelihood Systematic



SK-I :

	All	Signal	
standard	453.9	335.3	
Fitted	420.2	331.4	
+ 1s	423.1	334.3	-0.3%
- 1s	402.6	313.8	-6.4%

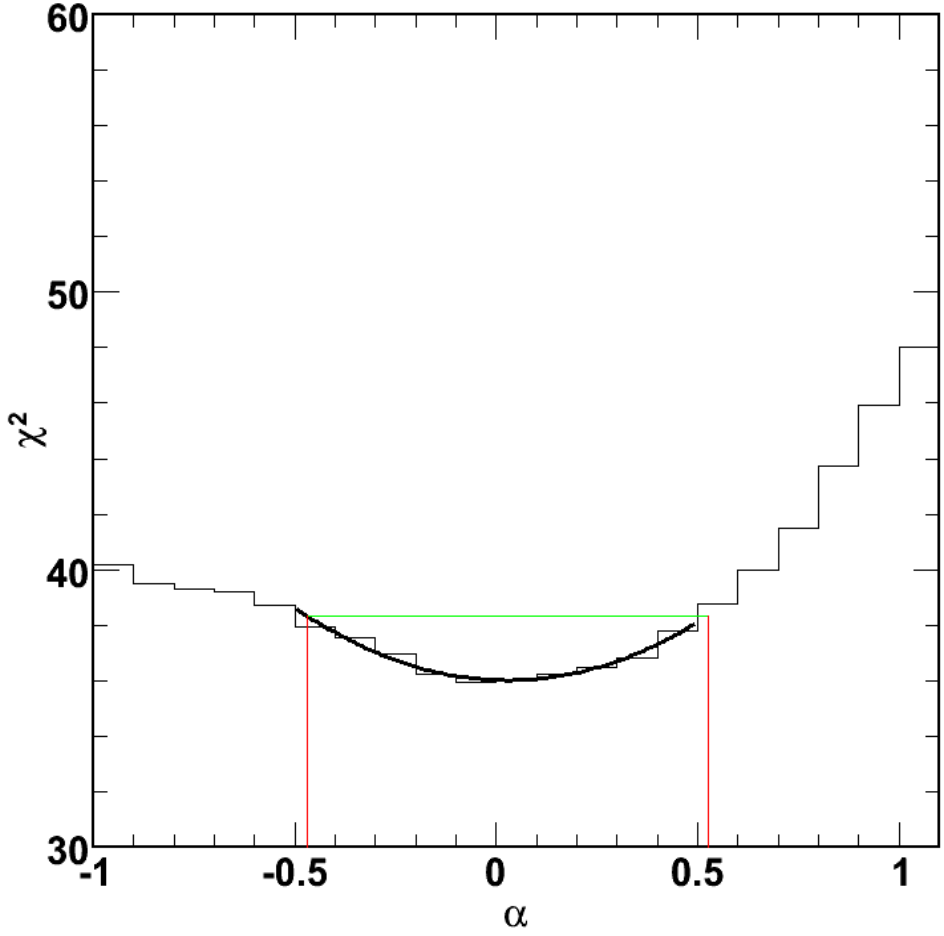
SK-III :

	All	Signal	
Raw MC	152.9	112.3	
Fitted	147.2	112.0	
Fitted +1 s	154.0	118.8	+5.7%
Fitted -1 s	142.0	106.8	-4.9%

- Systematic error is taken to be the larger : **5.7%**

Systematic Error Estimation: Single Ring e-like

Systematic Error Estimation : Singe-Ring e-like



- **Fit likelihood distribution of the data for different shifts of the MC signal BG distribution**

fitting function:

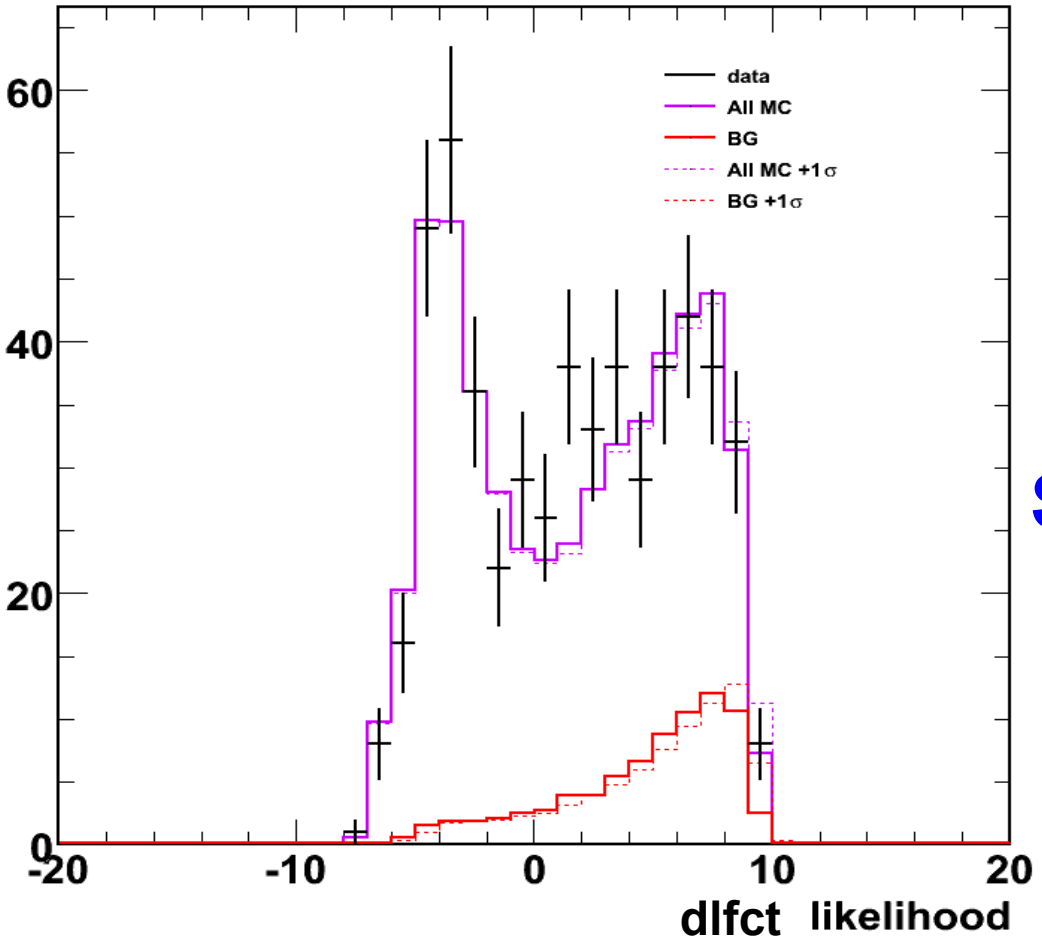
$$f_{\nu_e CC}(x;\alpha) + f_{NC}(x,\beta) + f_{\nu\mu CC}(x,\beta)$$

α, β : shift in Likelihood parameter

find best-fit by $\chi 2$ and derived α at 1σ upper limit.

- **Much more shallow for single-ring case**
  - **Non-χ^2 shape**

Non ν_e Background Systematic : Single ring e-like



SK-I :

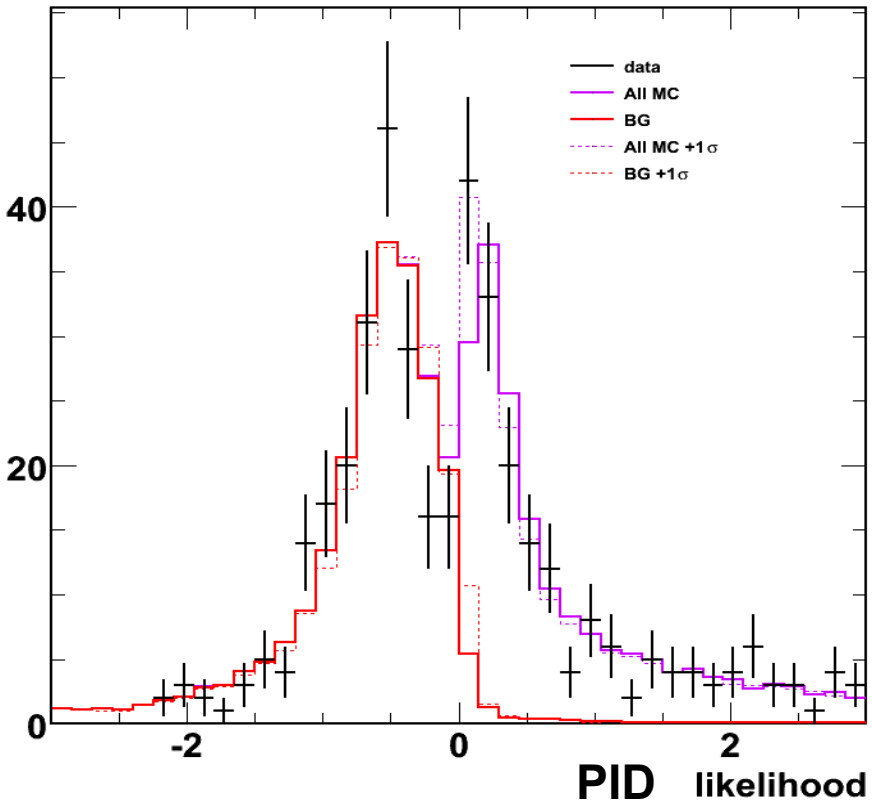
- 14.5%

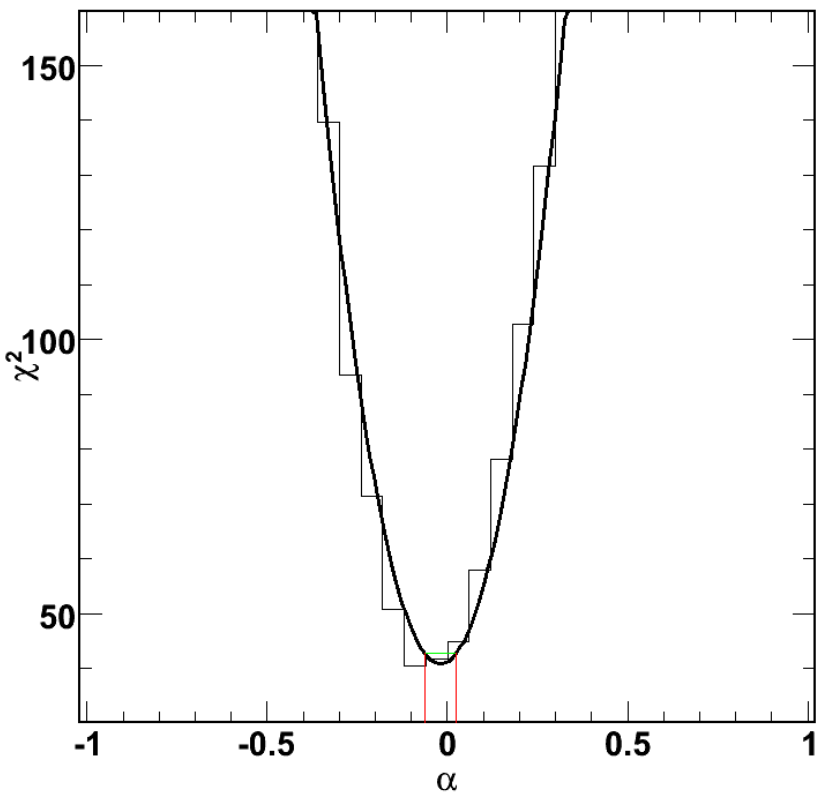
SK-III :

	All	BG	
Raw MC	2647	12.67	
Fitted	264.8	12.7	
Fitted +1 s	263.4	11.4	-10.55
Fitted -1 s	265.9	13.9	-9.3%

- Systematic error is taken to be the larger : 10.6%

Use PID instead ?





+ : 15.6 / 9.9 = 58.0%
- : 5.8 / 9.9 = -41.5%

- **Systematic error would be the larger : 58.0%**

Summary

- **Multi-ring Multi-GeV e-like Systematic Errors:**
  - **Non ν_e contamination - 32.0 %**
  - **Likelihood systematic - 5.7 %**
- **Single-ring Multi-GeV e-like Systematic Error:**
  - **Non ν_e contamination - 10.6 %**
  - **Requires more investigation**

```
            all    BG(muCC+NC)  eCC     BG/all
normal       : 152.912   40.5801   112.332   0.265382
fitted       : 145.273   33.2739   111.999   0.229044
fitted+1sig  : 156.692   44.6929   111.999   0.285228
fitted-1sig  : 139.973   27.5997   112.373   0.197179
bg systematic (fitted - normal/normal)  : 33.2739-40.5801 / 40.5801 = -0.180044
bg systematic (fit+1s - normal/normal)  : 44.6929-40.5801 / 40.5801 = 0.10135
bg systematic (fit-1s - normal/normal)  : 27.5997-40.5801 / 40.5801 = -0.319871
```

```
            all    BG(muCC+NC)  eCC     signal/all
  normal       : 152.894   40.5754   112.319   0.73462
  fitted       : 147.23   35.2448   111.986   0.760619
  fitted+1sig  : 153.998   35.2448   118.753   0.771133
  fitted-1sig  : 142.038   35.2448   106.793   0.751862
  sig systematic (fitted - normal/normal)  : 111.986-112.319 / 112.319 = -0.00296477
  sig systematic (fit+1s - normal/normal)  : 118.753-112.319 / 112.319 = 0.0572833
  sig systematic (fit-1s - normal/normal)  : 106.793-112.319 / 112.319 = -0.0491992
```

before likelihood cut (all energy)
nue CC, numu CC, NC, total = 11007 7474 5218 23699
46.445% 31.5372% 22.0178%

after likelihood cut (all energy)
nue CC, numu CC, NC, total = 7915 1407 1775 11097
71.3256% 12.6791% 15.9953%
efficiency= 71.9088%