Solar Neutrino Measurement at SK-III

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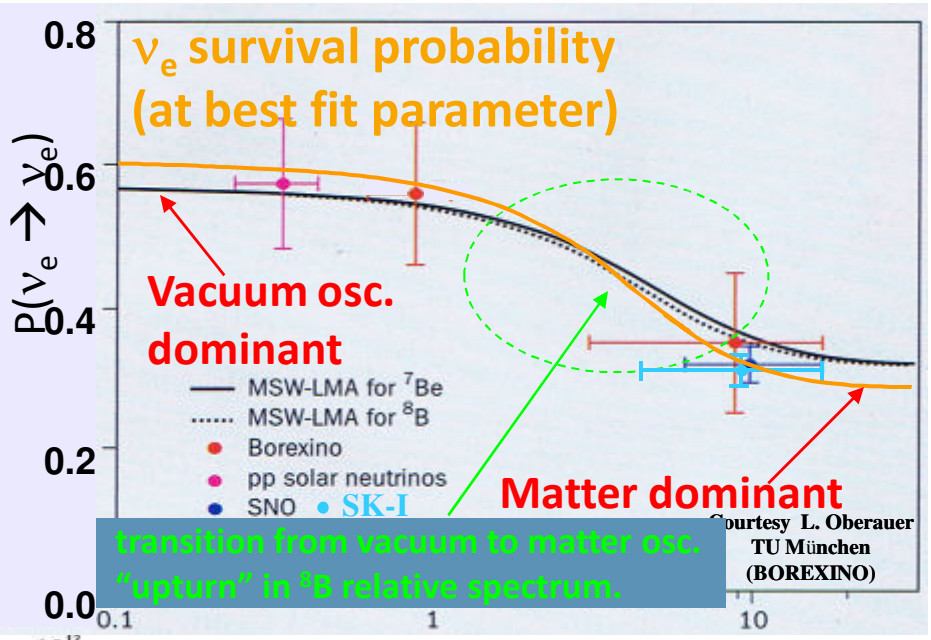
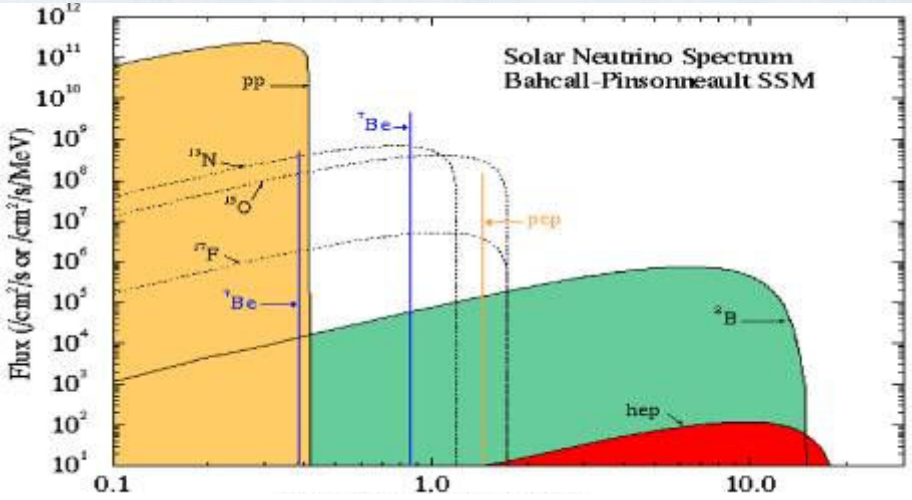
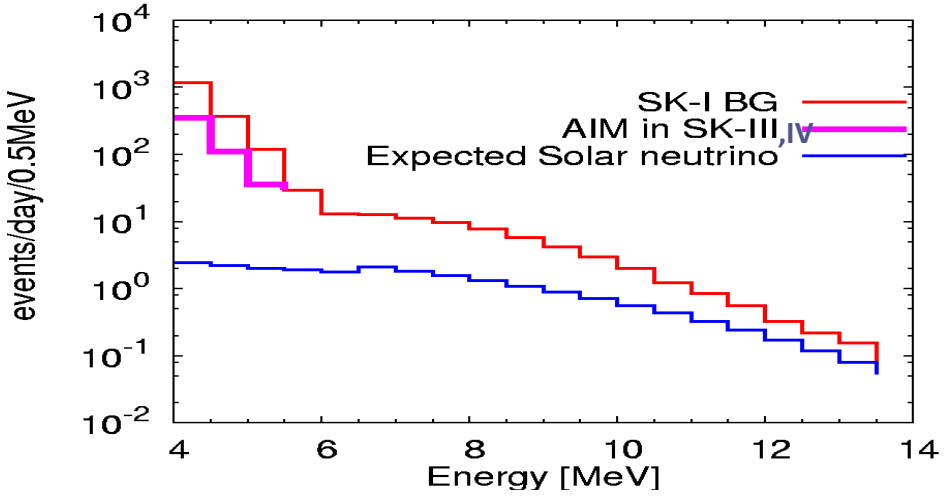
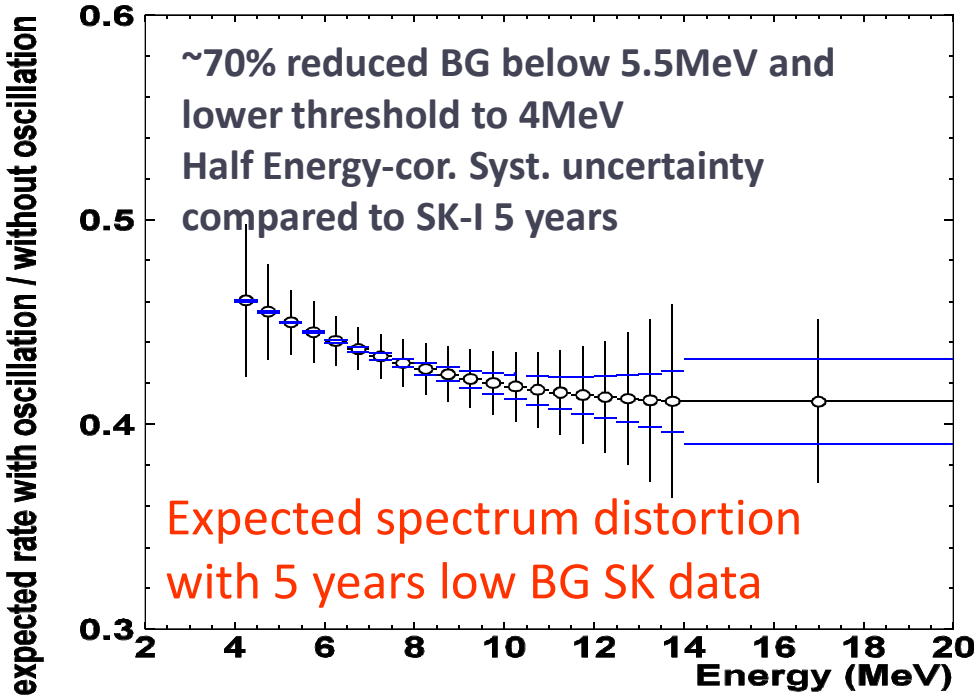
Solar Neutrino Future Prospects in SK





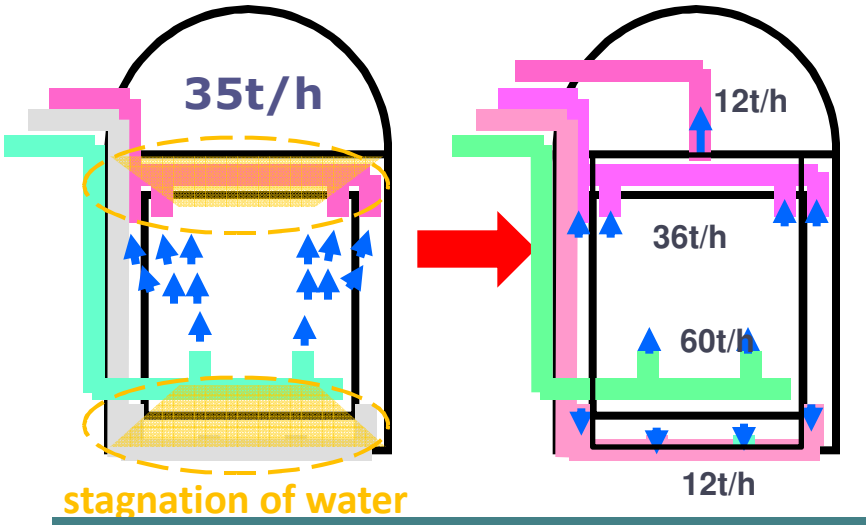


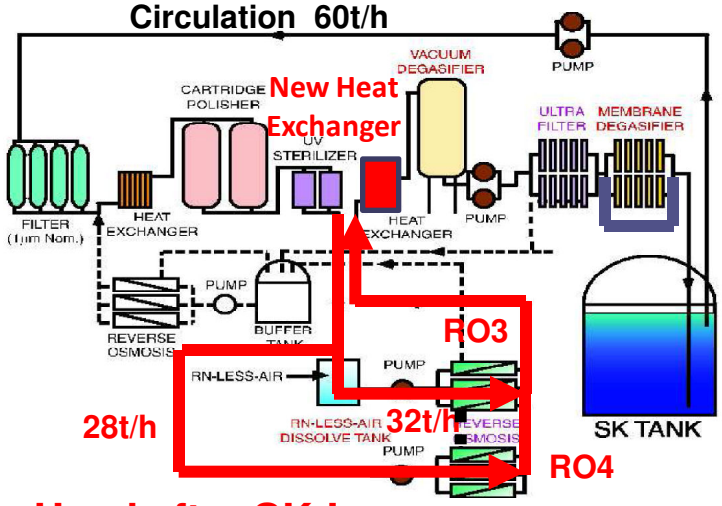


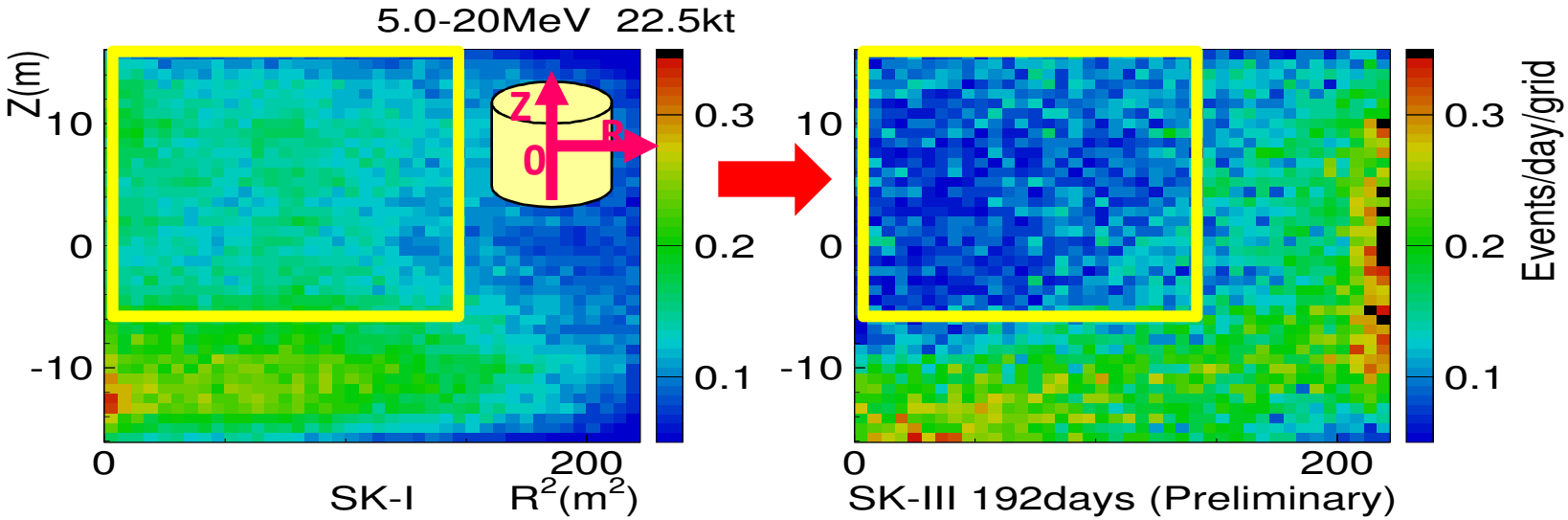
Current status

- To reduce BG and lower the energy threshold, improved the water system
- To reduce systematic errors
  - Found the reason of a large vertex shift(one source of the largest systematic error since SK-I) and shortened the shift
  - Installed the time and position dependency of the water quality into MC
  - Improved MC and a direction fitter and achieved ~10% better angular resolution
  - Most of the reconstruction tools & reduction criteria are retuned recently.
- Currently, estimation of the systematic errors are under way.
- The improved results will be summarized in this year.

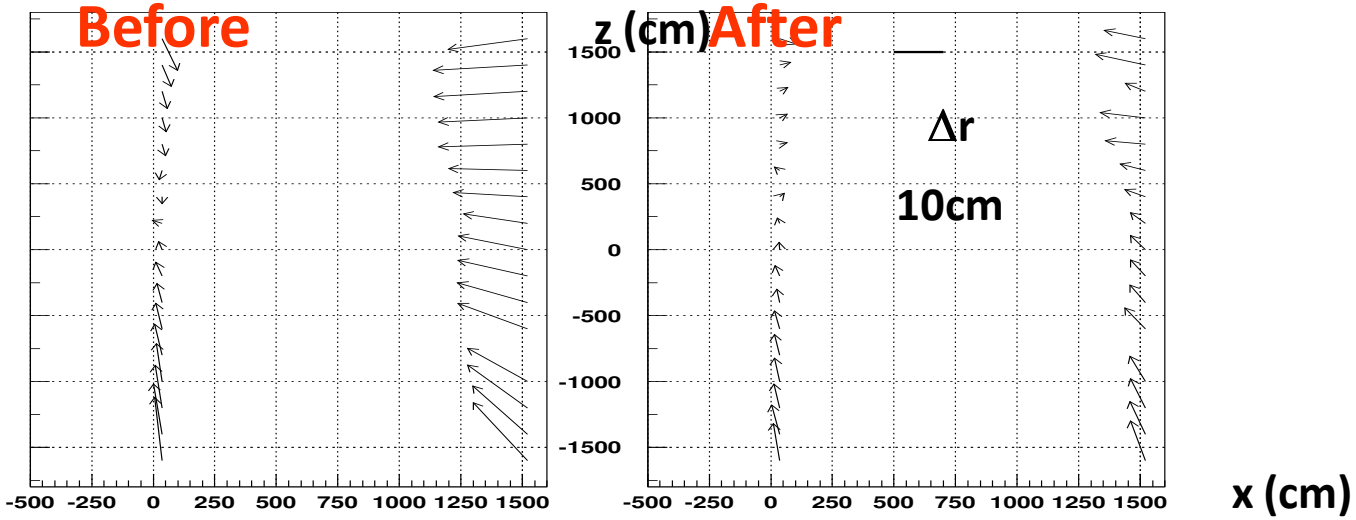
Improving the Water system



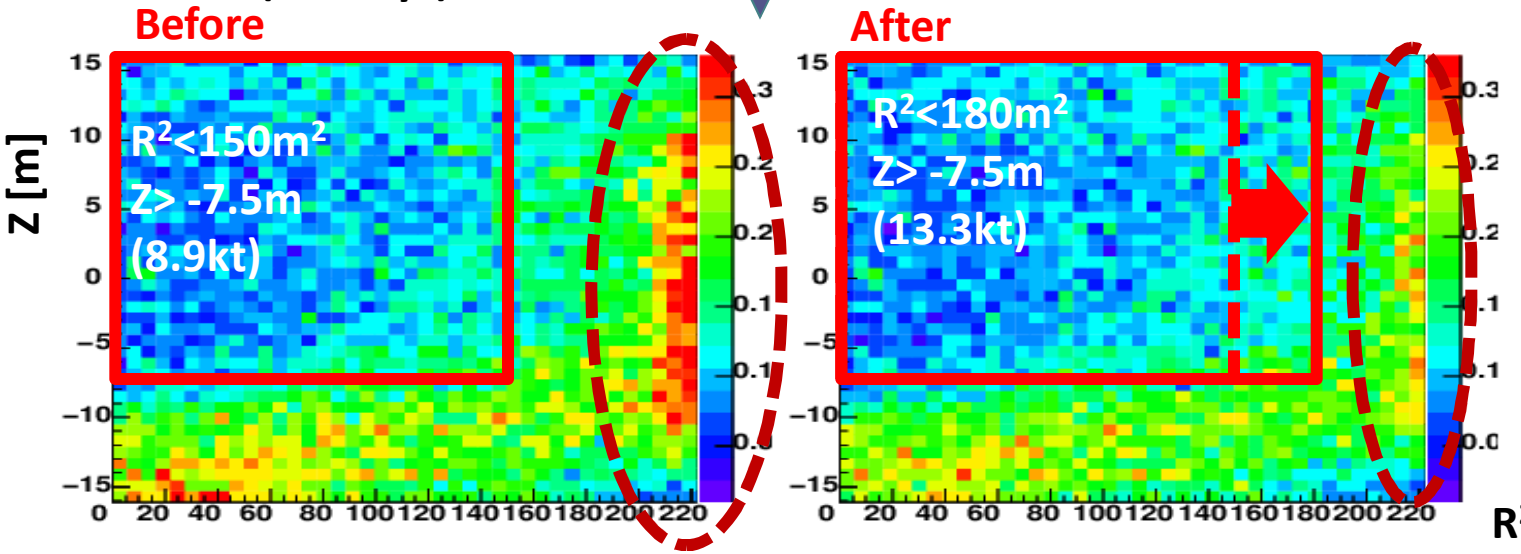




Shortening the Vertex shift

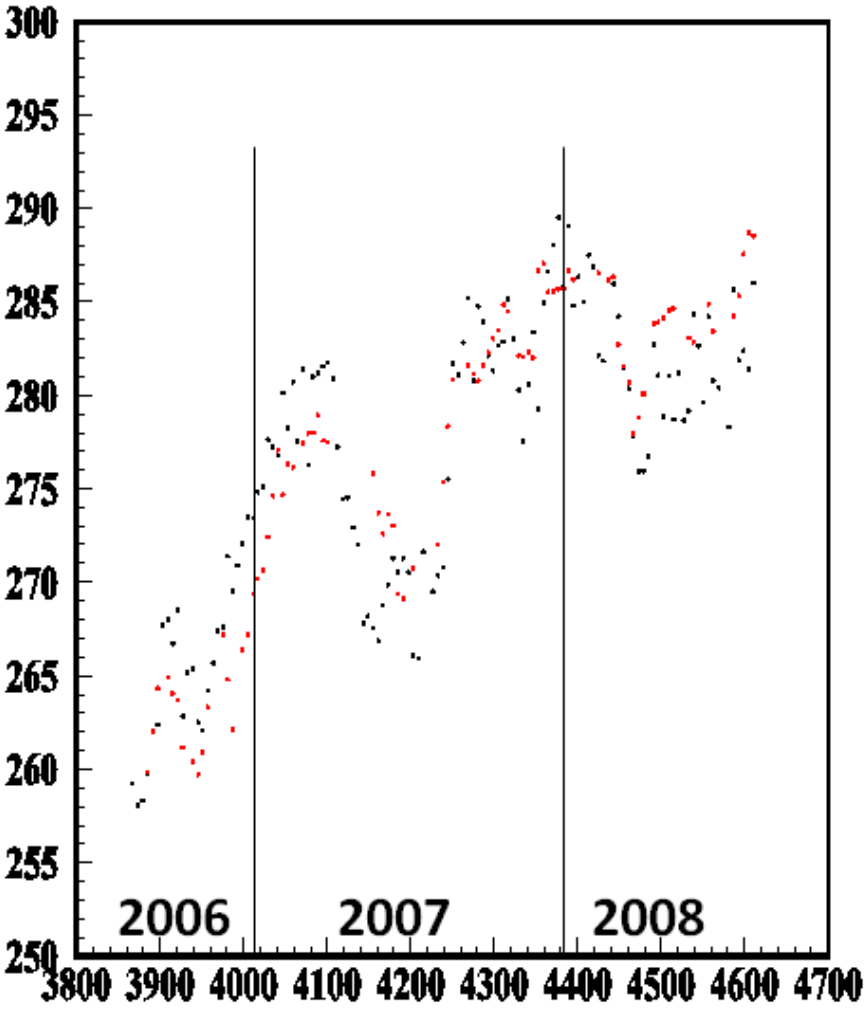


R31851-33899(192days) 5-20 MeV



Time & Position dependent MC

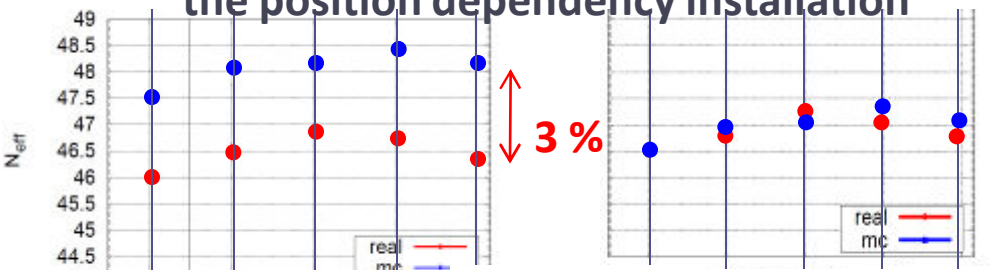
Decay-e **DATA** & **Time dependent MC**



N_{eff}(90m) VS Elapsed day

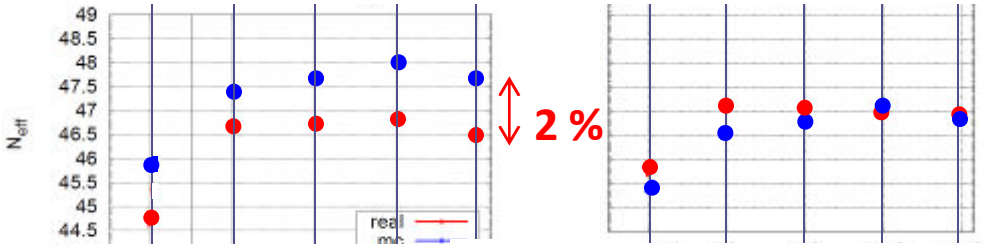
^{16}N calibration Before → After

the position dependency installation



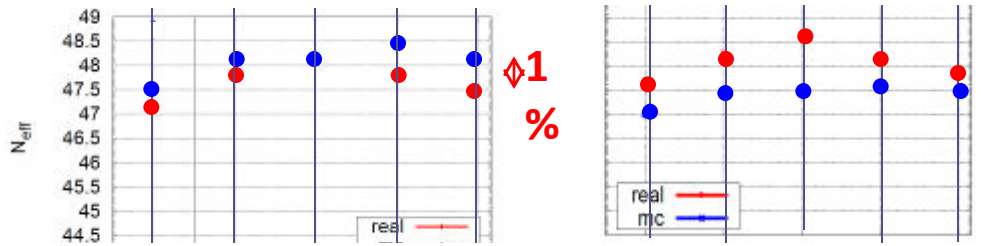
z=+12[m]

DATA MC



z=0[m]

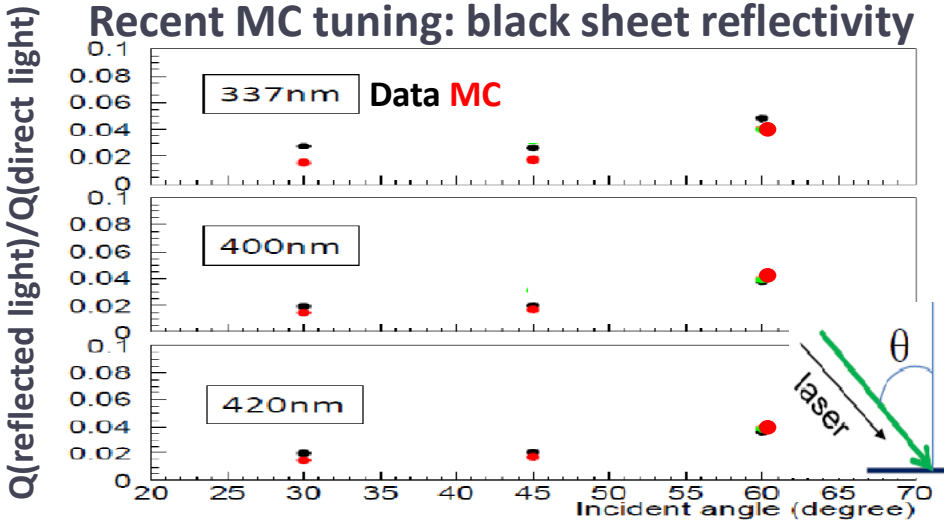
Center 0°90 °180 ° 270 °



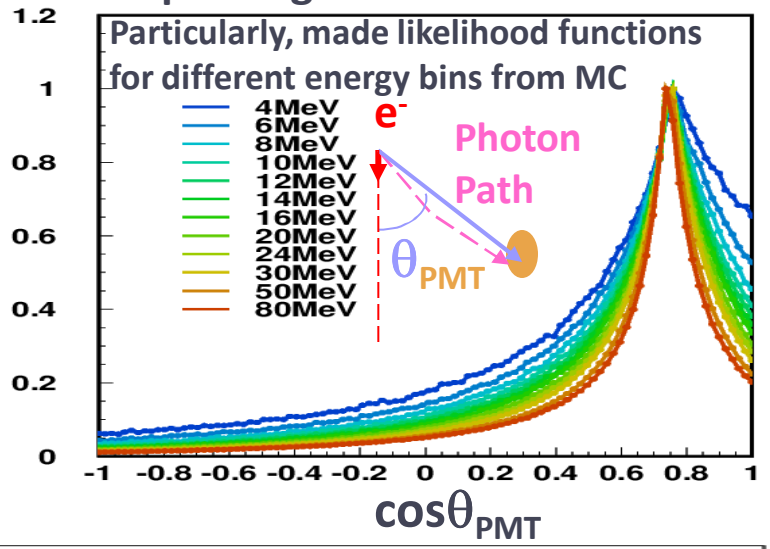
z=-12[m]

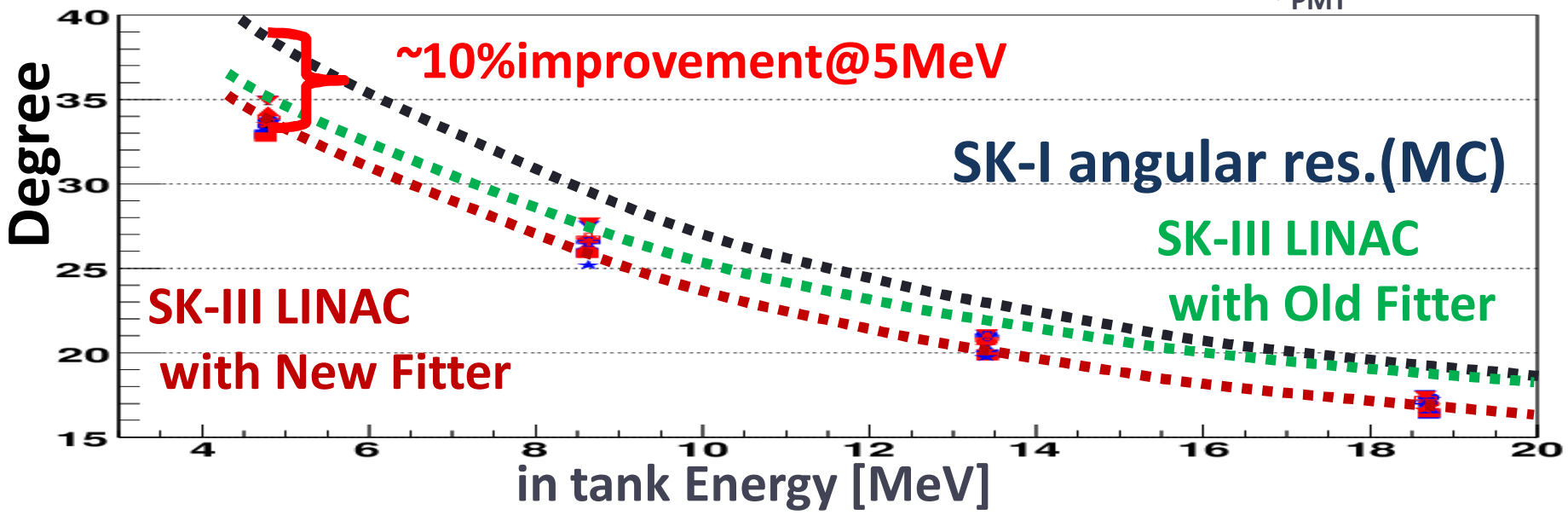
Reducing the angular resolution

Recent MC tuning: black sheet reflectivity



Improving direction fitter





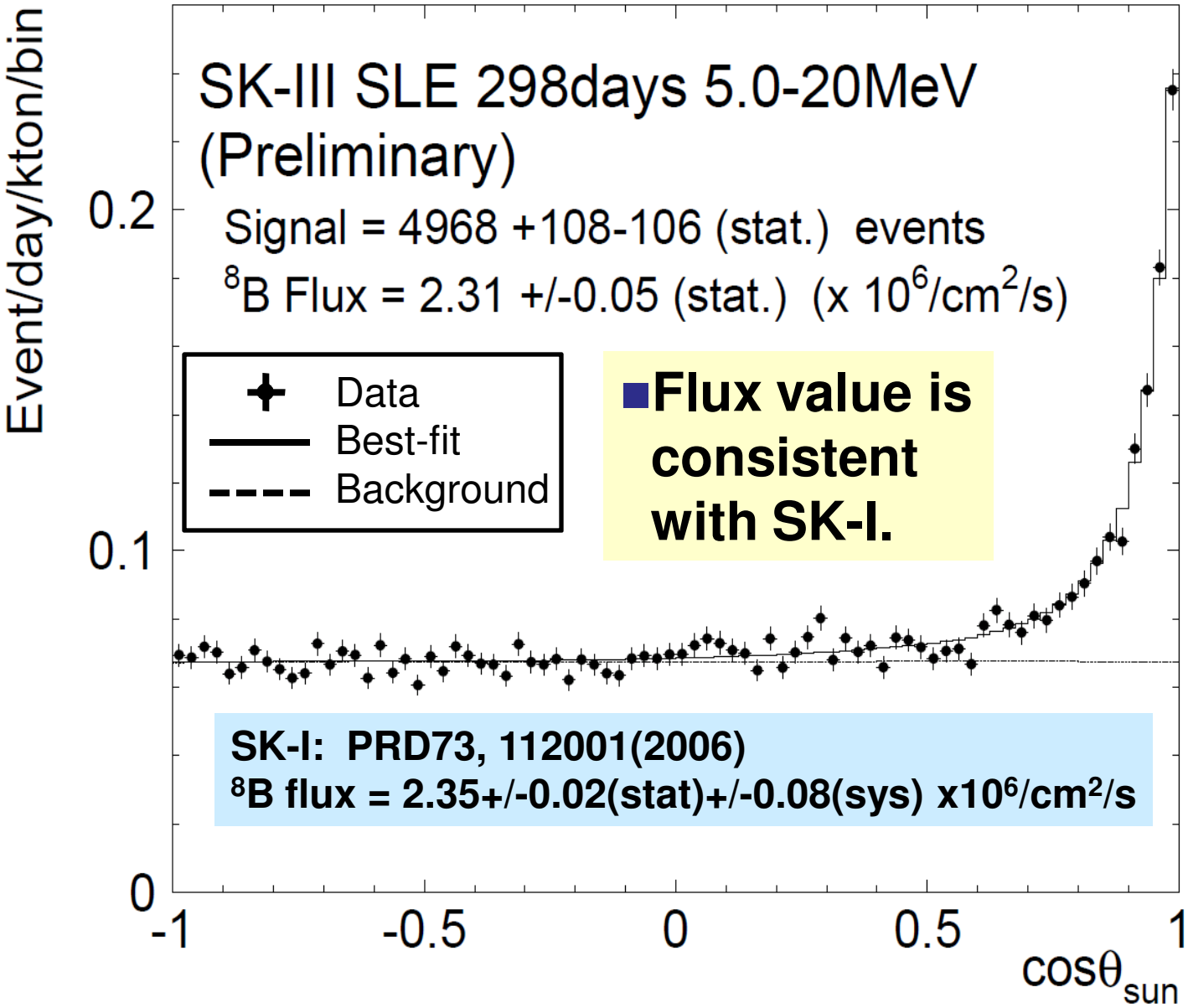
The estimation of the systematic errors

	SK-I Flux(%)	SK-III Flux(%)
Energy Scale	+/- 1.6	Still Under way Trying to reduce
Tirgger eff	+0.4 -0.3	
Spallation cut	+/- 0.2	
Reduction	+2.0 -1.6	
Gamma Cut	+/- 0.5	
Vertex shift	+/- 1.3	
Angular res.	+/- 1.2	
BG shape	+/- 0.1	
Livetime calc	+/- 0.1	
Total	+3.5 -3.2	

New Solar ν Results

- Observed ^{8}B ν flux in SK-III
- Angular distributions
- ^{8}B ν Flux Time Variation
- Recoil Electron Energy Spectrum
- Day/Night Asymmetry

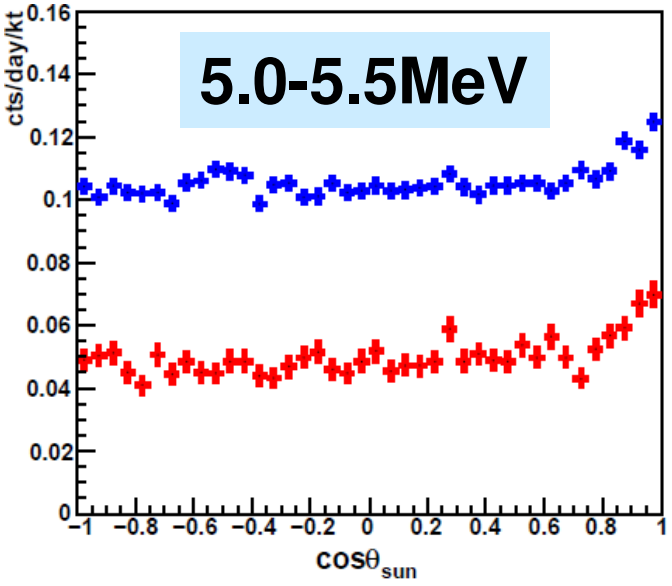
Observed ^{8}B flux in SK-III

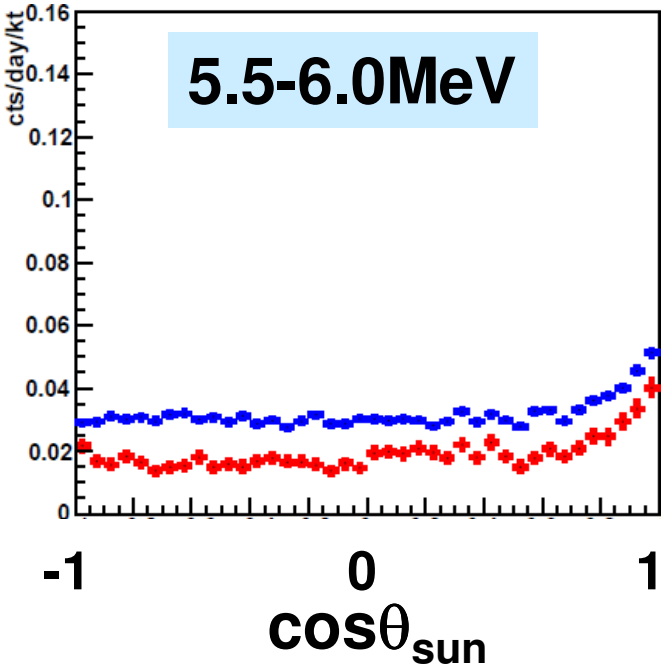


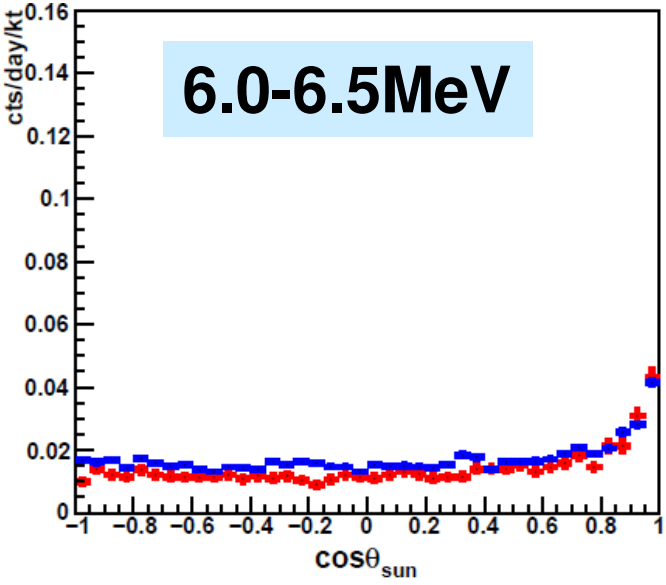
- **Flux value is consistent with SK-I.**

SK-I: PRD73, 112001(2006)
^{8}B flux = 2.35+/-0.02(stat)+/-0.08(sys) x10^{6}/cm^{2}/s

Angular distributions:1



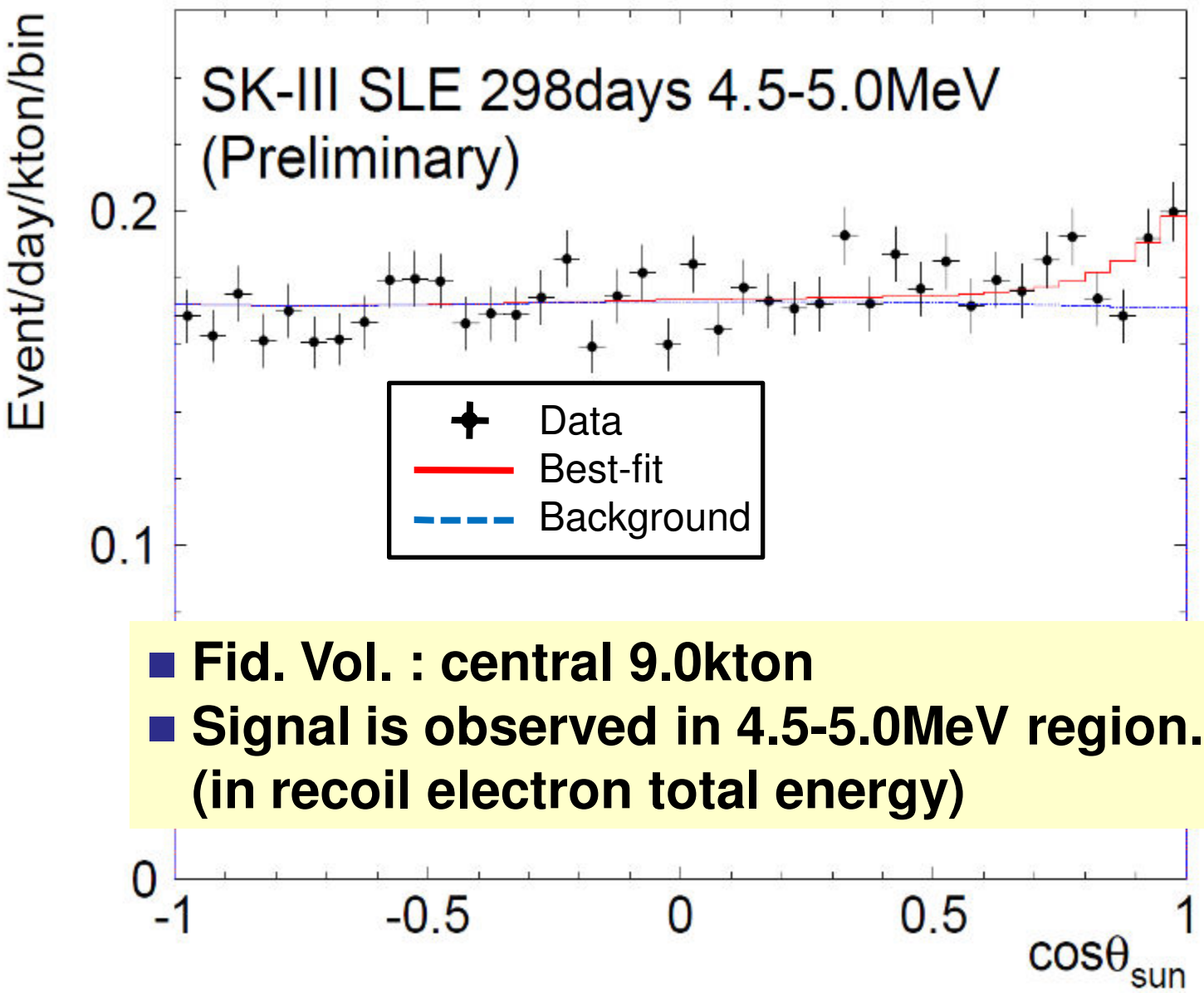




SK-I
SK-III

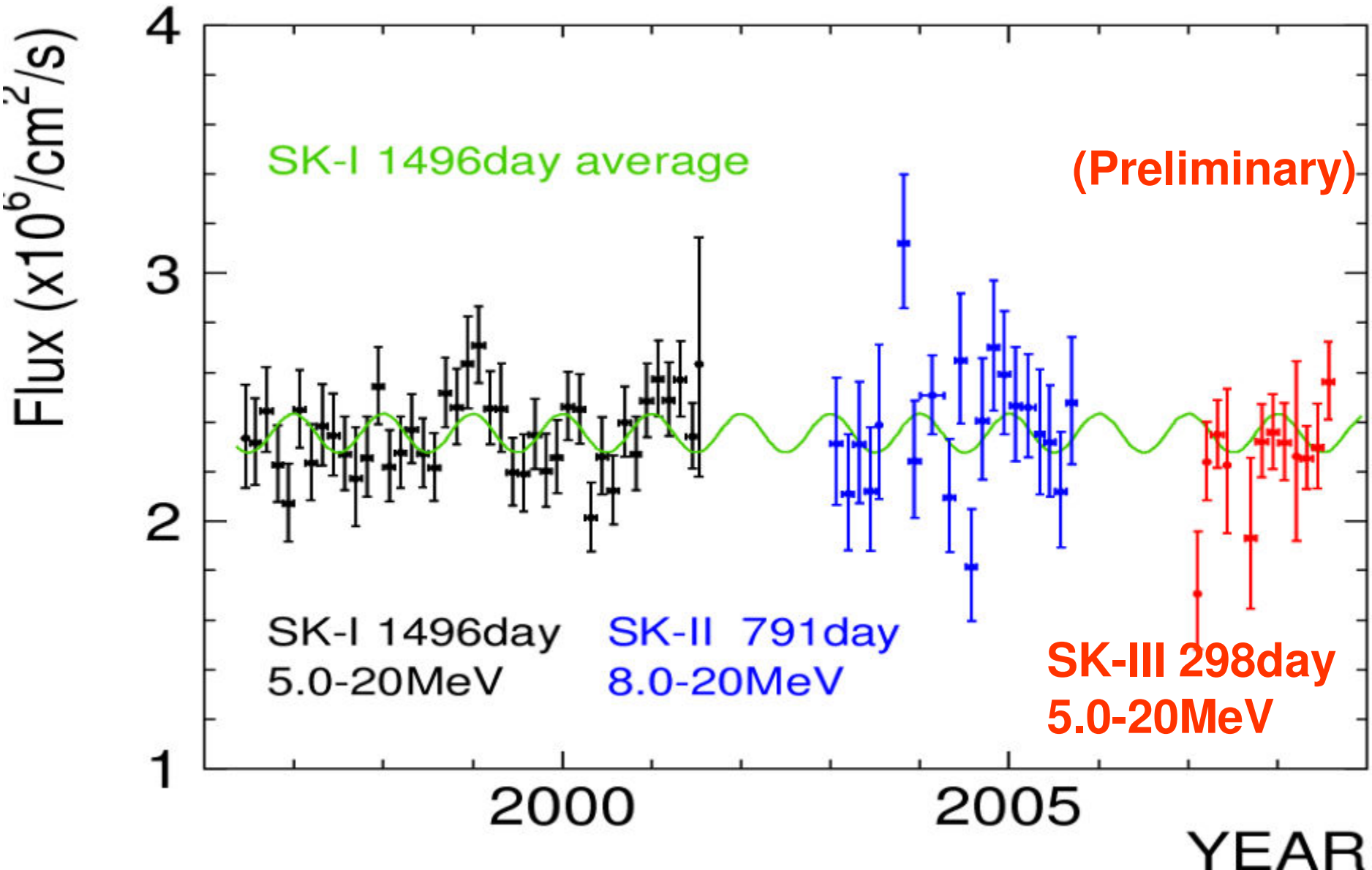
- Fid. Vol. : central 13.3kt
- Background : SK-I > SK-III
- Ang. Res. : SK-I > SK-III

Angular distributions:2

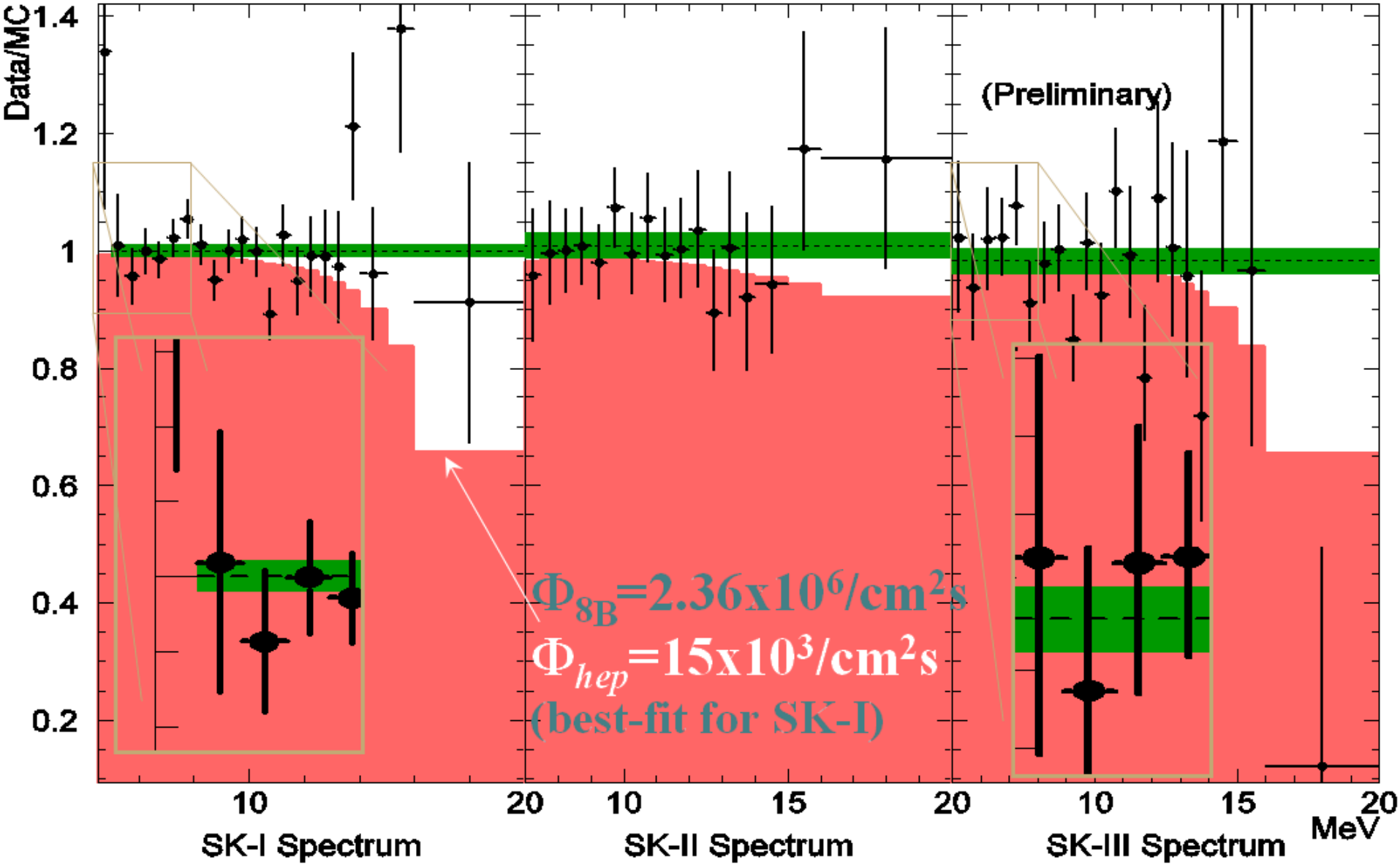


- **Fid. Vol. : central 9.0kton**
- **Signal is observed in 4.5-5.0MeV region. (in recoil electron total energy)**

^{8}B ν Flux Time variation



Recoil Electron Energy Spectrum



Day/Night Asymmetry

- only direct test of matter effects on solar neutrino oscillations
- SK-I measured $A_{DN}=2(D-N)/(D+N)$=-2.1±2.0%(stat)
- SK-I also fit LMA day/night variations; expressed as A_{DN} the result is A_{DN}=-1.8±1.6%(stat)
- SK-II measured A_{DN}=-6.3±4.2%(stat)
- SK-III can measure A_{DN} to ±4.3%(stat) with the shown 298 days of data; maybe to ±3.7%(stat) using the entire SK-III data set (including periods w/o SLE or high very low energy background runs)
- SK-I-III can determine A_{DN} to ±1.6%(stat)
- SK-I-III can fit LMA D/N variations to ±1.3%(stat)

Summary

- Achieved lower backgrounds <5.5 MeV in the center of SK
- Almost finished analyzing SK-III data
- Tried to reduce systematic errors compared to SK-I
- Estimation of the systematic errors are under way

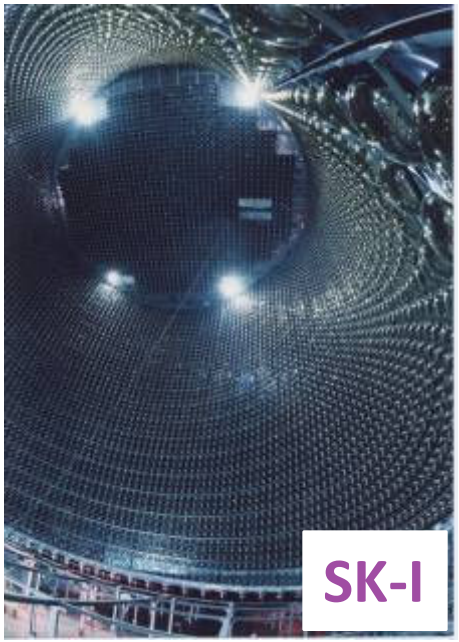
- Consistent with SK-I and SK-II results within statistical uncertainties
- At SK-III, SK solar analysis energy threshold was lowered to 4.5 MeV
- With existing data, SK is statistically sensitive down to LMA day/night asymmetries of 1.3%
- The improved results will be summarized in this year.

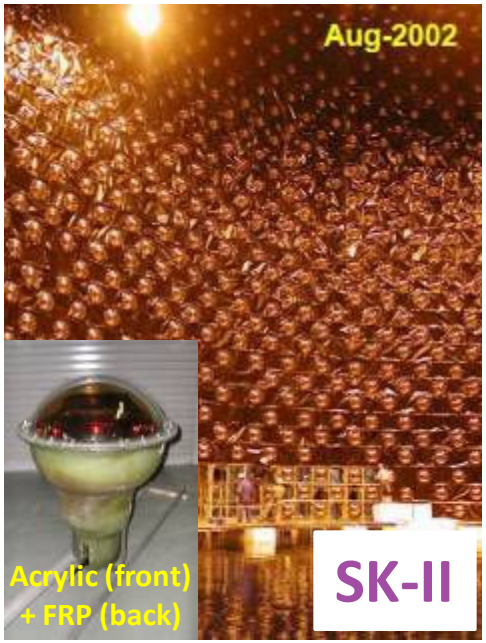
Backup

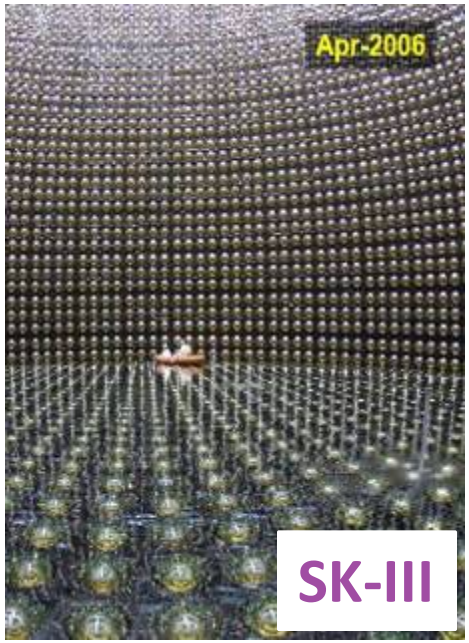
History of Super-Kamiokande detector

1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009

SK-I **SK-II** **SK-III** **SK-IV**

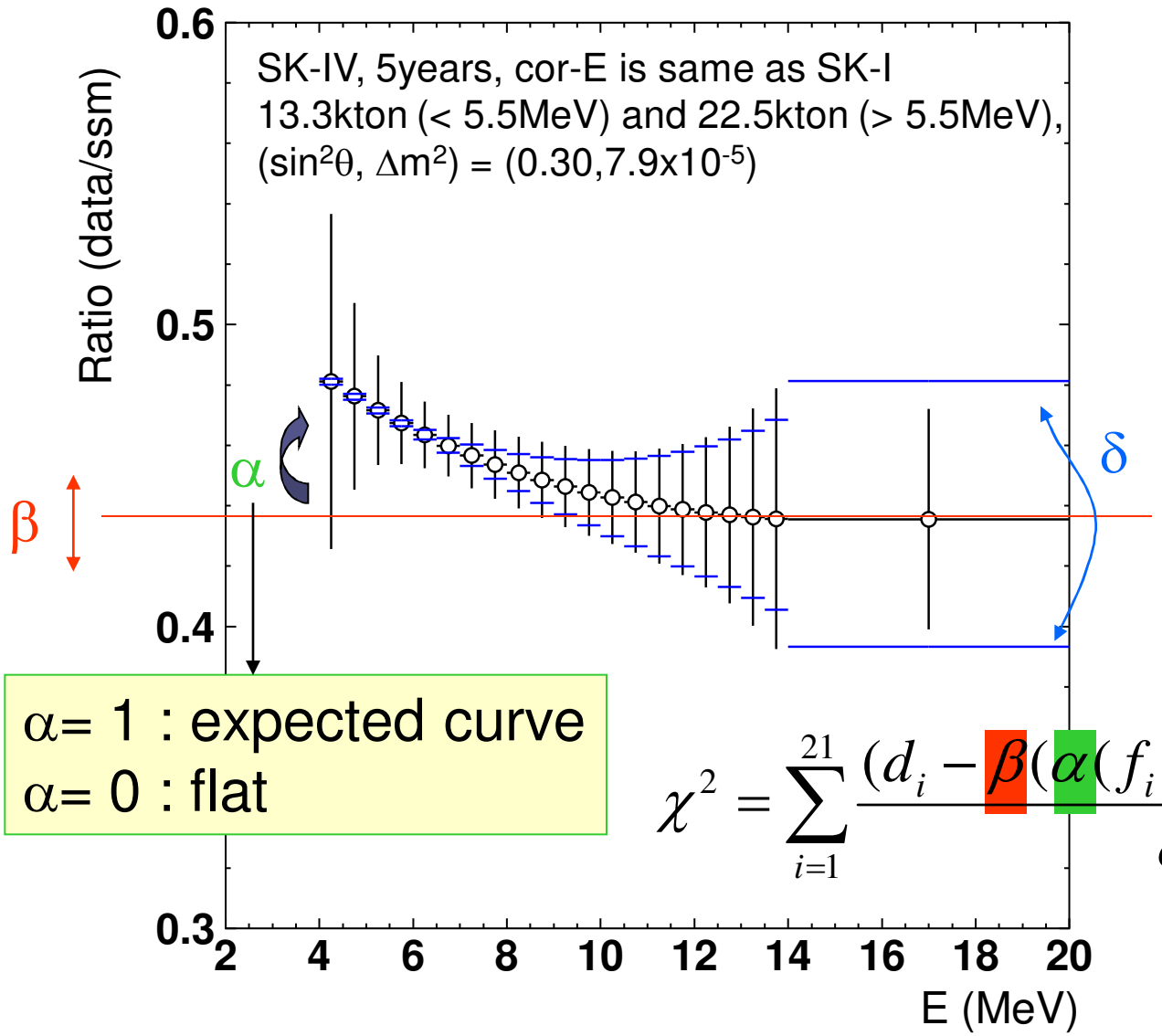






	SK-I	SK-II	SK-III	SK-IV
	11146 ID PMTs (40% coverage)	5182 ID PMTs (19% coverage)	11129 ID PMTs (40% coverage)	Electronics Upgrade
Energy Threshold (total electron energy)	**5.0 MeV**	**7.0 MeV**	**4.5 MeV** work in progress	**< 4.0 MeV** target

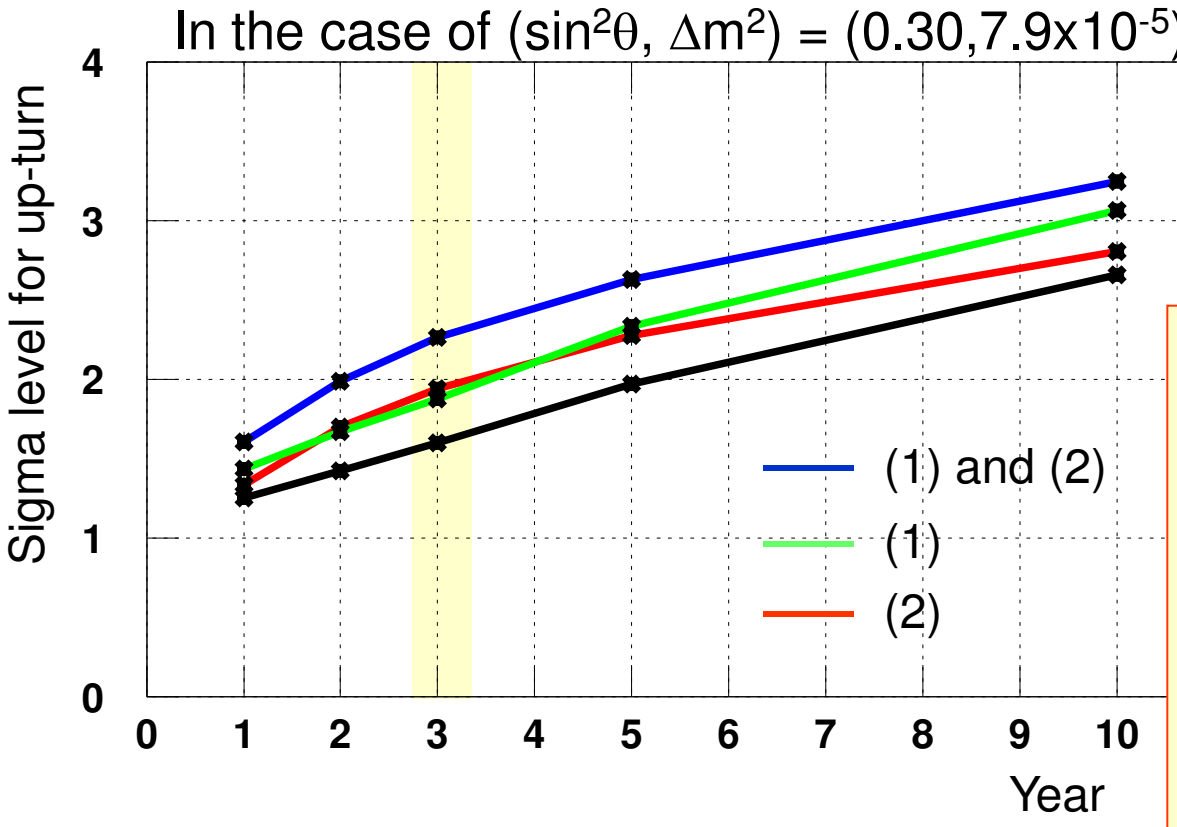
Upturn Sensitivity calculation



α= 1 : expected curve
α= 0 : flat

$$\chi^2 = \sum_{i=1}^{21} \frac{(d_i - \beta(\alpha(f_i(\delta) - C) + C))^2}{\sigma_i^2} + \frac{\delta^2}{\sigma_{cor}^2}$$

Sensitivity of the upturn measurement



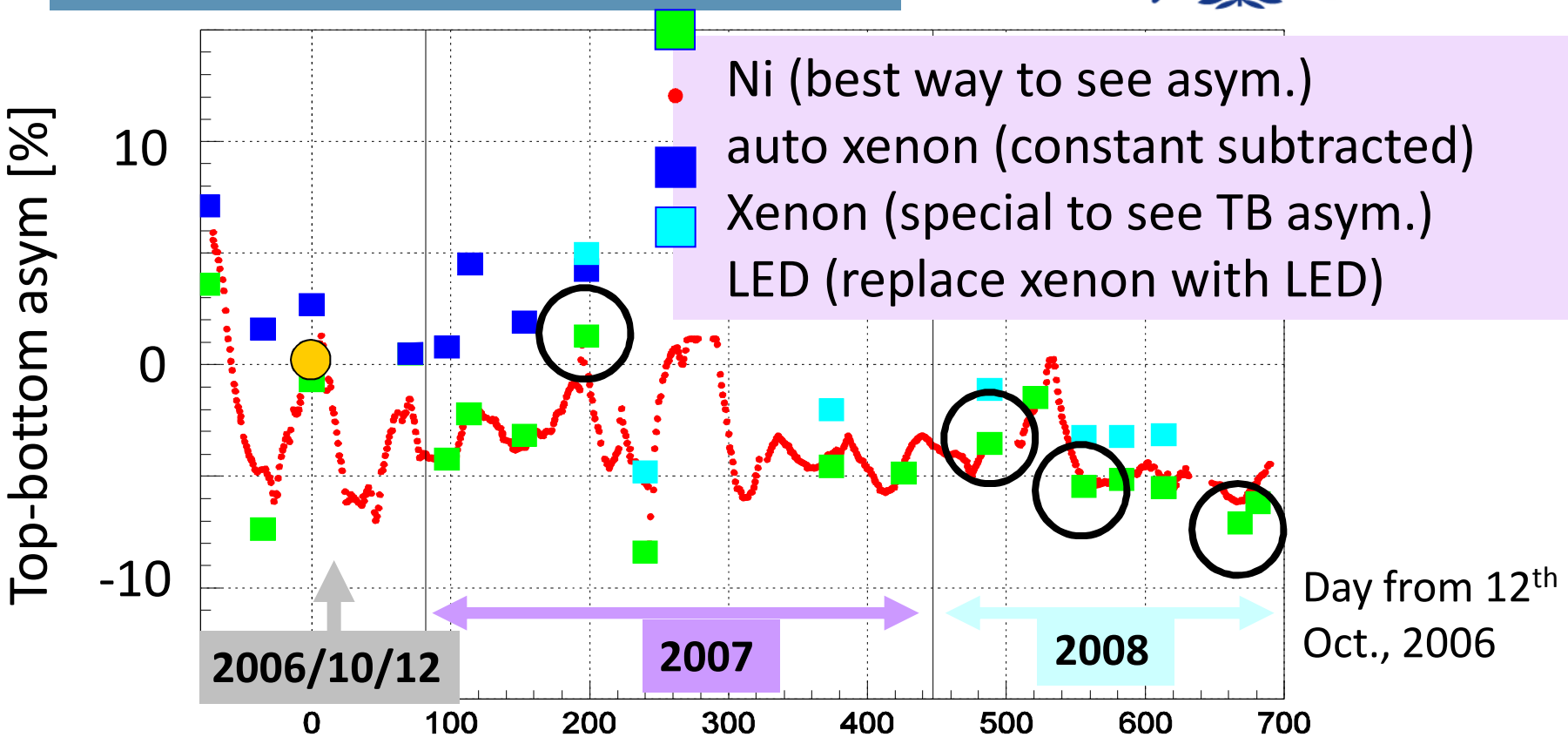
- First target : 2 sigma level up-tern discovery for 3 years observation. (or exclude the up-tern)
- Need to enlarge fiducial volume with low BG as large as possible
- Also the reduction of the energy correlated systematic error is important.

(1) Enlarge fiducial volume to 22.5kton with low B.G.
(2) Half energy correlated systematic error as SK-1.
The black line shows the 13.3kton (<5.5MeV), 22.5kton (>5.5MeV) fiducial volume with the same energy correlated error as SK-1

SK-IV status

- Running 100% trigger efficiency at 4.5MeV now.
- The trigger threshold will be lowered in future.

$$\text{Top-bottom asym.} = \frac{\text{TOP - BOTTOM}}{\text{BARREL}}$$



check the energy scale in 4 Ni data sets with 3 positions;
2007/04/27, 2008/02/12, 2008/04/19, 2008/08/09
z=-12m, 0m, 12m

How to install the WT function

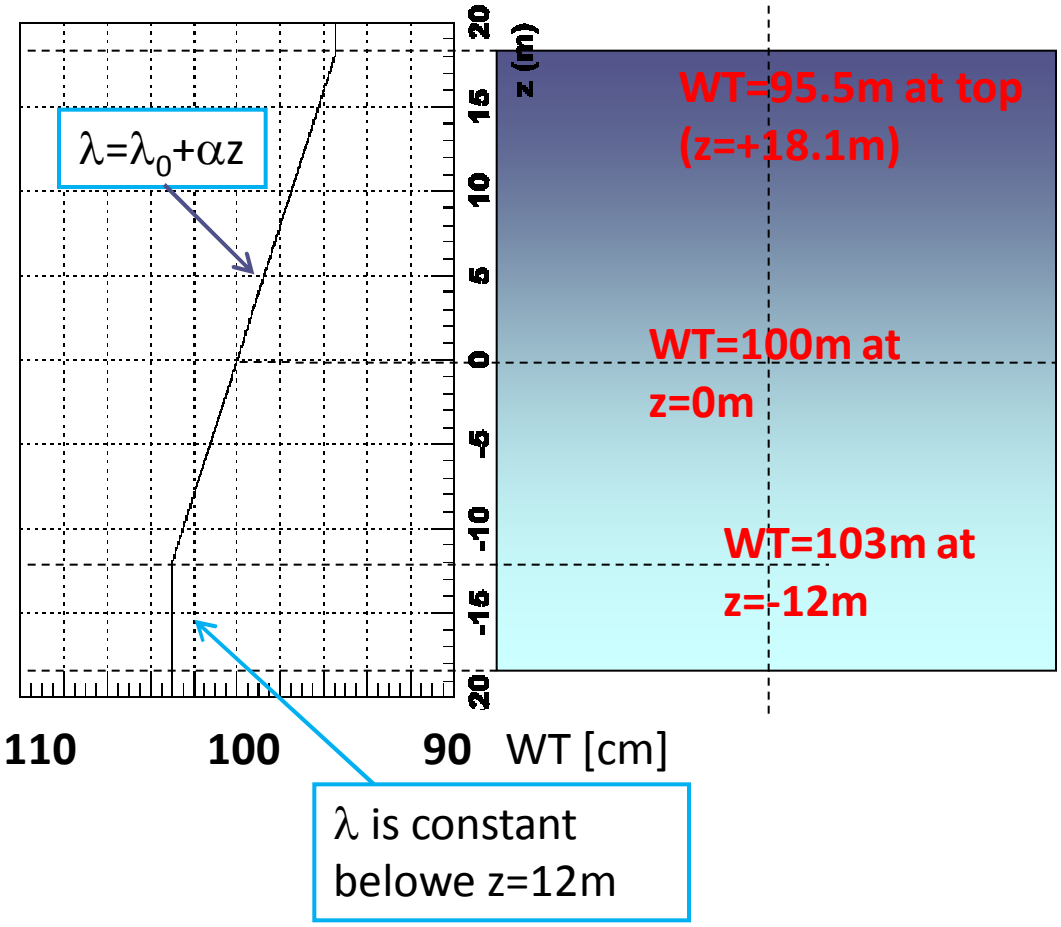
Right figure is example of WT function.

λ_0=100m, α= –0.25.

If λ_0 and α are calculated for all SK-III period, the time and position dependence of water quality can be installed into MC.

Time table of λ_0 is already calculated by Beongsu.

Try to make a relation between alpha and tba value.



^{16}N calibration