

- **Detector location (cosmic-ray muon flux)**
 - Spallation
- **Photo coverage**
 - 40%: hep solar nu
- **Dark rate of photo sensors**
- **Radioactivity of photo sensors (& detector wall)**
 - ^{222}Rn : 2mBq/PMT/day @SK
 - U,Th-series,K: total ~???Bq/PMT cover (barrel&bottom) @SK-II,III,IV (we must reduce them)
- **Timing resolution of photo sensors**
- **# of compartments**
- **Calibration devices**

Remaining spallation events (Updated)

2nd HK open meeting

	spallation ×1	×2	×3	×5	×7	×10
Signal Efficiency	80%	79%	78%	78%	79%	77%
Remaining spallation rate	7%	7%	8%	9%	9%	10%

	spallation ×1	×2	×3	×4	×5	×7
Signal Efficiency	80%	81%	81%	80%	80%	81%
Remaining spallation rate	1.2%	2.1%	2.5%	3.0%	3.9%	4.6%

Current SK (solar) : 5~6%

Factor ×2.5 increase

- With **×4 spallation events**, the remaining spallation rate will be increased by a factor of **2.5**.
- Considering the cosmic muon rate of **×5**, the remaining spallation products in HK after relic spallation cut will be **15%**.
- With current SK and solar spallation cut, the remaining spallation products is **5~6%**.

Corresponding study (e.g. solar neutrino analysis) will be done.

Remaining spallation events (Updated)

- Solar neutrino BG increase factor **~3** (5~6% → 3.9% \times 4=16%)
 - This may be an optimistic case.
- Muon flux will be increased by 10~20%? (from I. Shimizu)
- Based on relic spa. cut in 17.5MeV- (below 17.5MeV ?)
 - This is not used in SK solar analysis yet.

	spallation $\times 1$	$\times 2$	$\times 3$	$\times 4$	$\times 5$	$\times 7$
Signal Efficiency	80%	81%	81%	80%	80%	81%
Remaining spallation rate	1.2%	2.1%	2.5%	3.0%	3.9%	4.6%

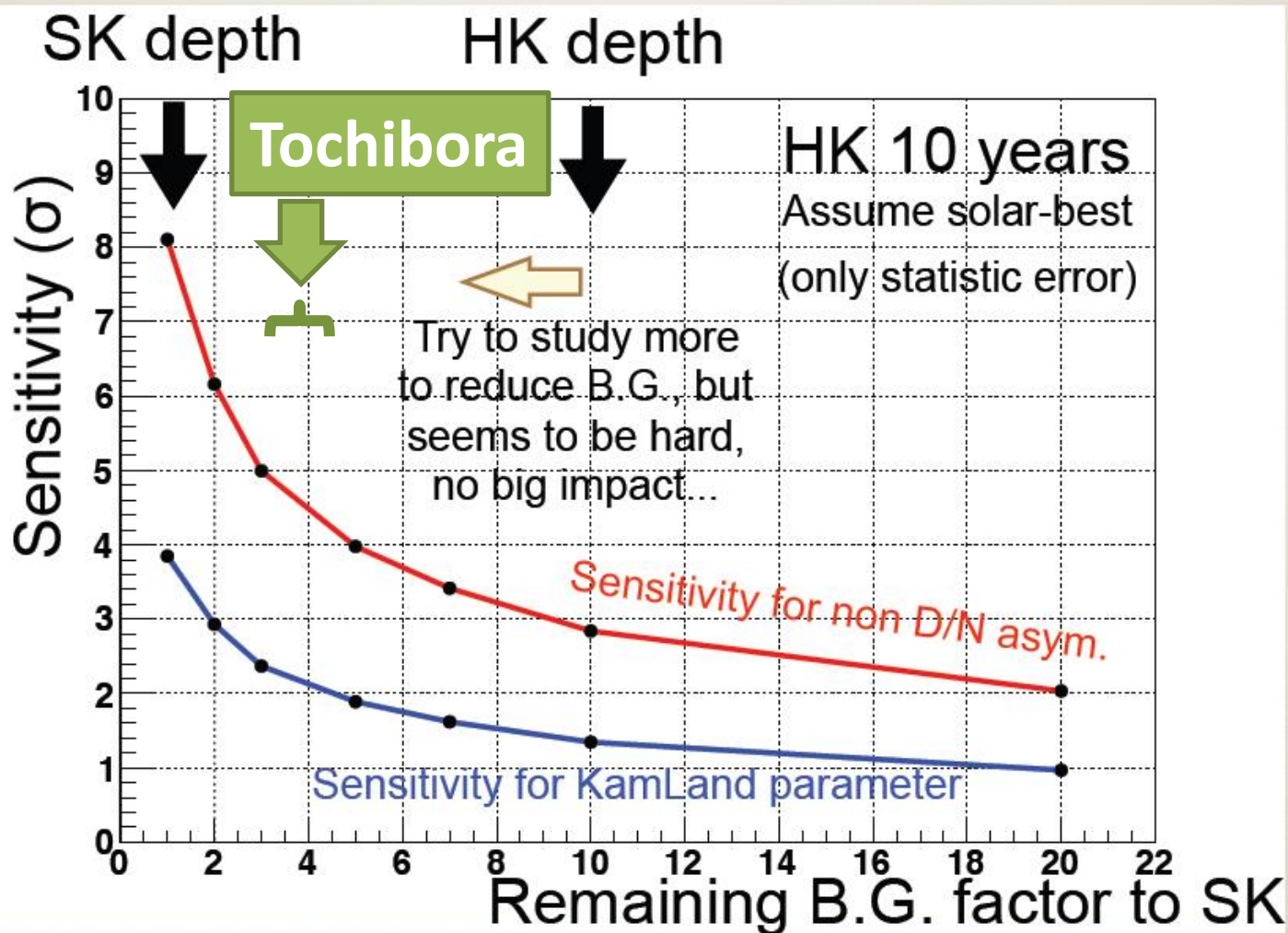
Current SK (solar) : 5~6%

Factor $\times 2.5$ increase

- With **$\times 4$ spallation events**, the remaining spallation rate will be increased by a factor of **2.5**.
- Considering the cosmic muon rate of $\times 5$, the remaining spallation products in HK after relic spallation cut will be **15%**.
- With current SK and solar spallation cut, the remaining spallation products is **5~6%**.

Corresponding study (e.g. solar neutrino analysis) will be done.

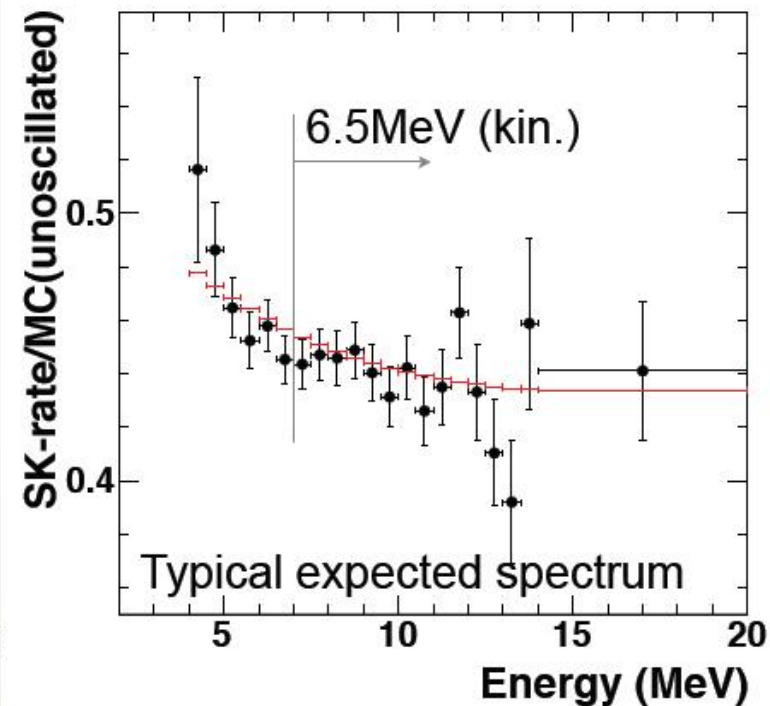
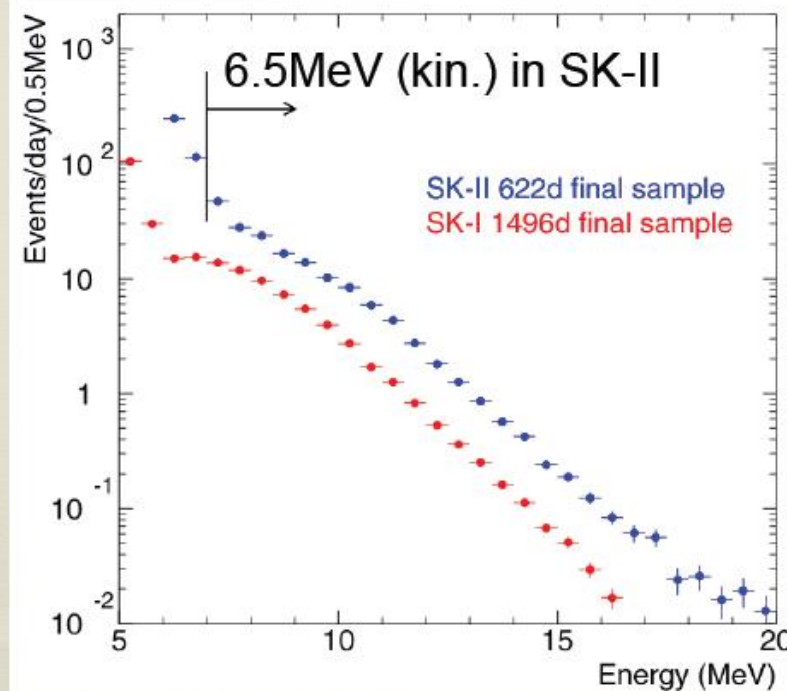
Sensitivity for D-N as a function of Remaining B.G.



Spectrum up-turn

Lowering energy threshold is crucial.

It strongly depends on the photo-coverage and Q.E.
(the current HK configuration is same as SK-II.)

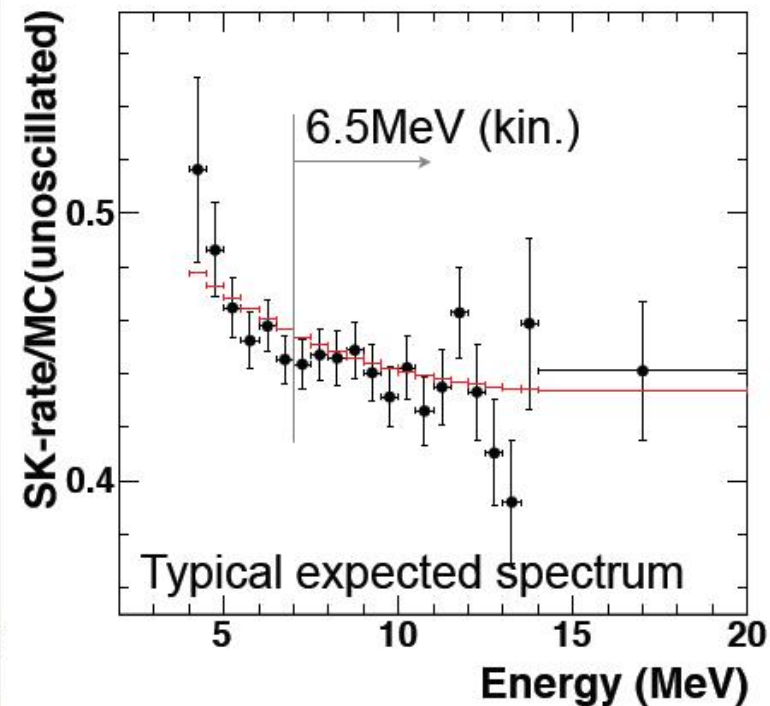
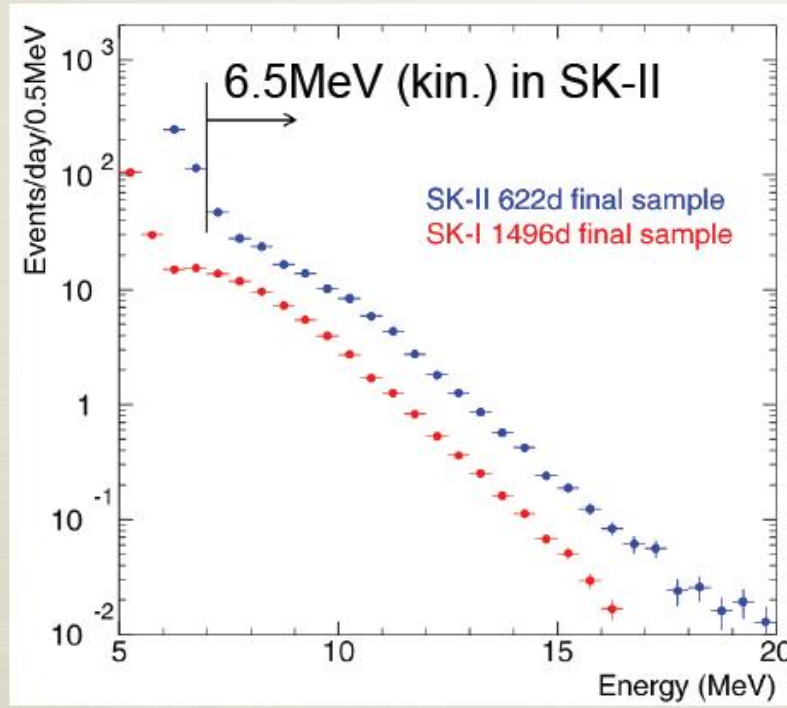


No chance to see the up-turn in the current configuration...

Spectrum up-turn

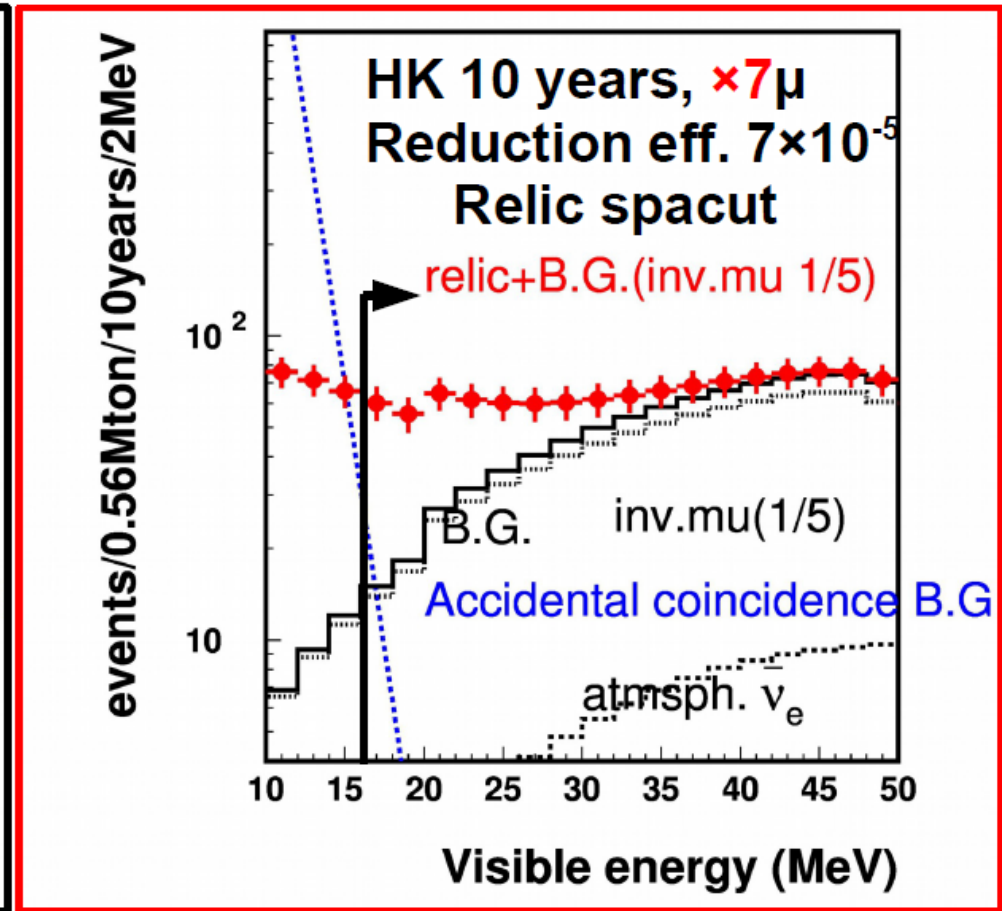
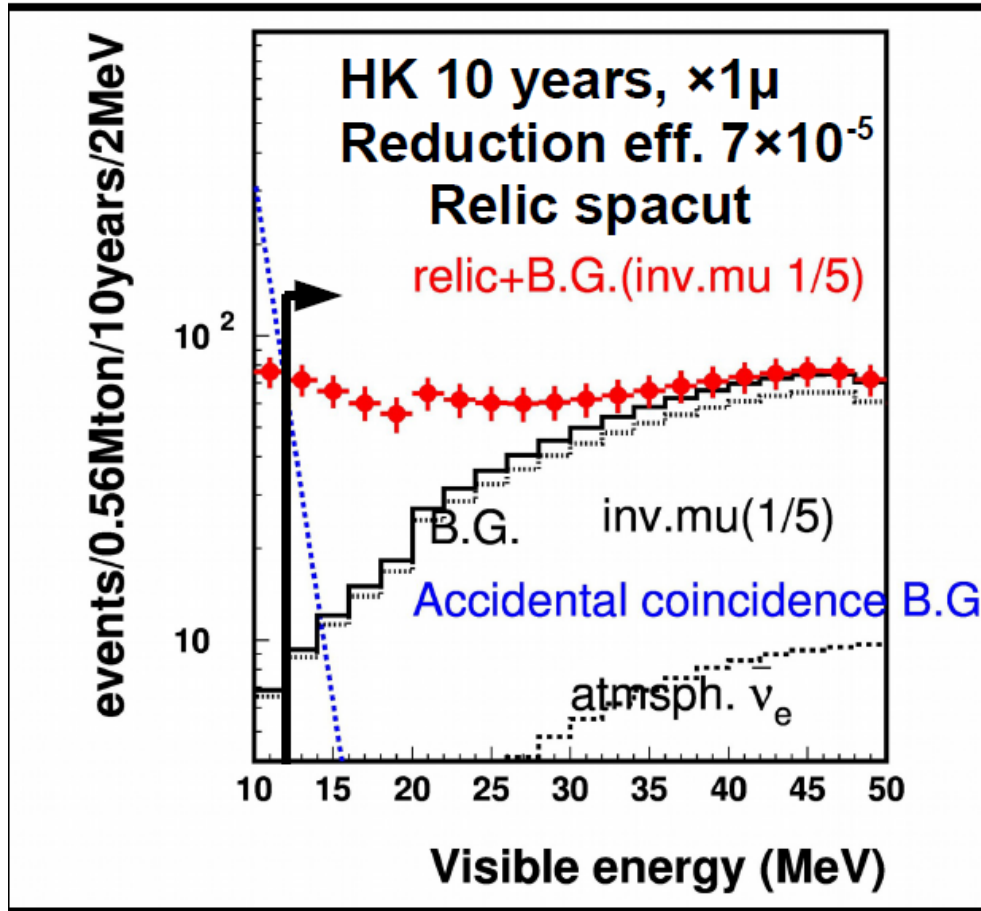
Lowering energy threshold
It strongly depends on
(the current configuration)

- Need Low-e threshold (low radioactivity)
- 40% coverage
- Electron LINAC



No chance to see the up-turn in the current configuration...

$\times 7 \mu$ for HK with Gadolinium



SRN (12-30MeV) = 325 ev.

total BG (12-30MeV)

(not including Accidental coincidence) = 599 ev.

SRN (16-30MeV) = 209 ev.

total BG (16-30MeV)

(not including Accidental coincidence) = 543 ev.

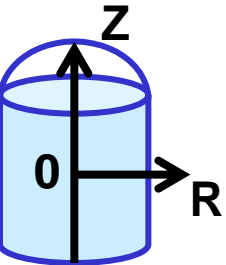
At HK+Gd, the SRN signal exceed the cosmic accidental BG at **>12 MeV ($\times 1 \mu$)** and at **>16 MeV ($\times 7 \mu$)**.

With SK-IV + Gd, we would see **> 10 MeV**.

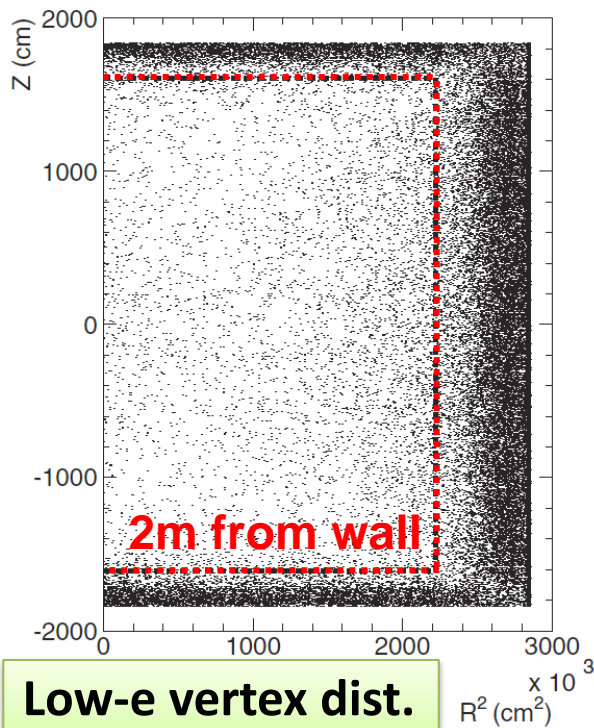


Spallation is dominant BG source in ~10-20MeV

- Misfit
- External gamma
- Radon, Misfit, External gamma, etc.
- Remaining spallation products (probably)

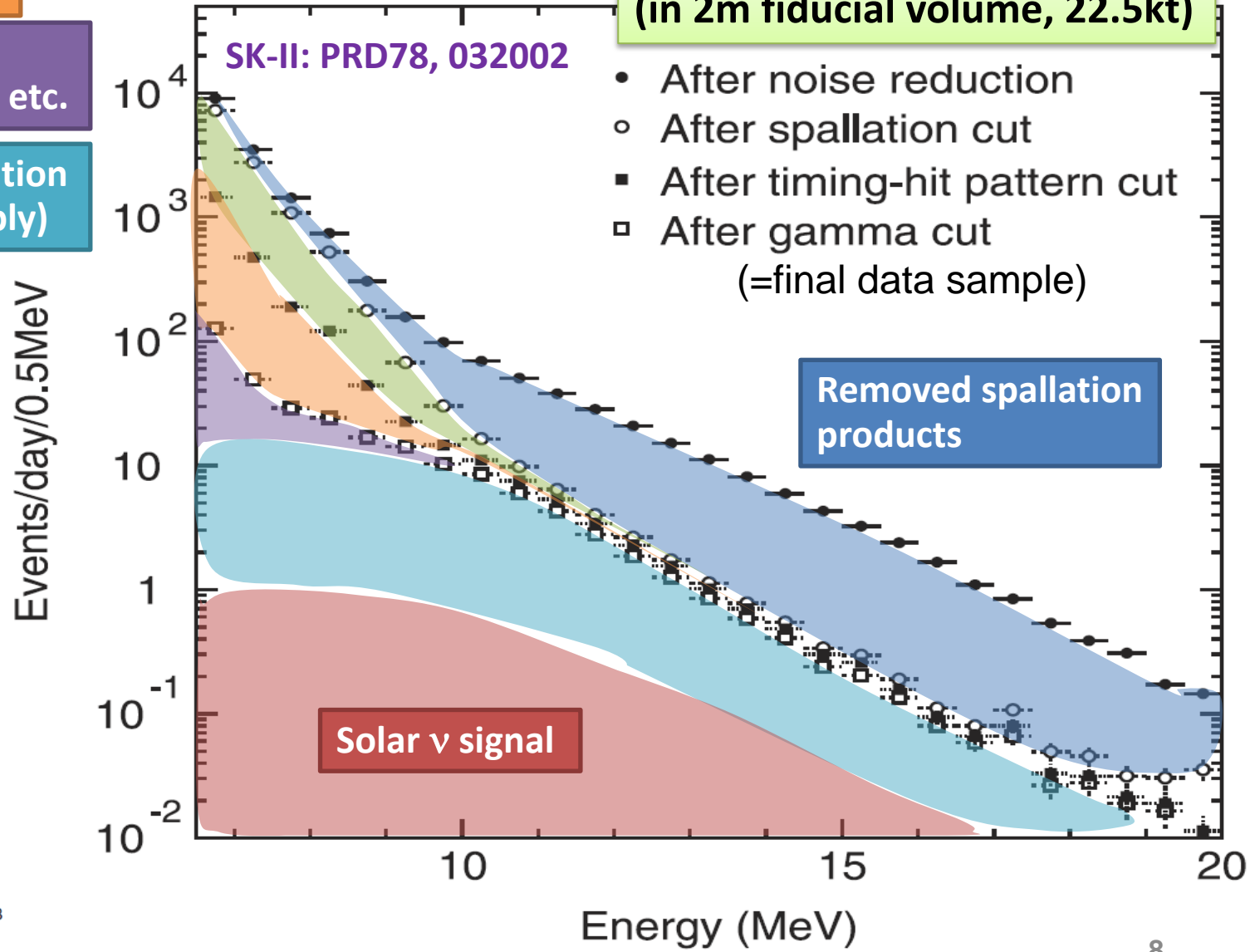


SK-I: PRD73, 112001



Solar ν data reduction
(in 2m fiducial volume, 22.5kt)

- After noise reduction
- After spallation cut
- After timing-hit pattern cut
- After gamma cut (=final data sample)



Event quality parameters in SK-II

SOLAR NEUTRINO MEASUREMENTS IN SUPER- ...

PHYSICAL REVIEW D 78, 032002 (2008)

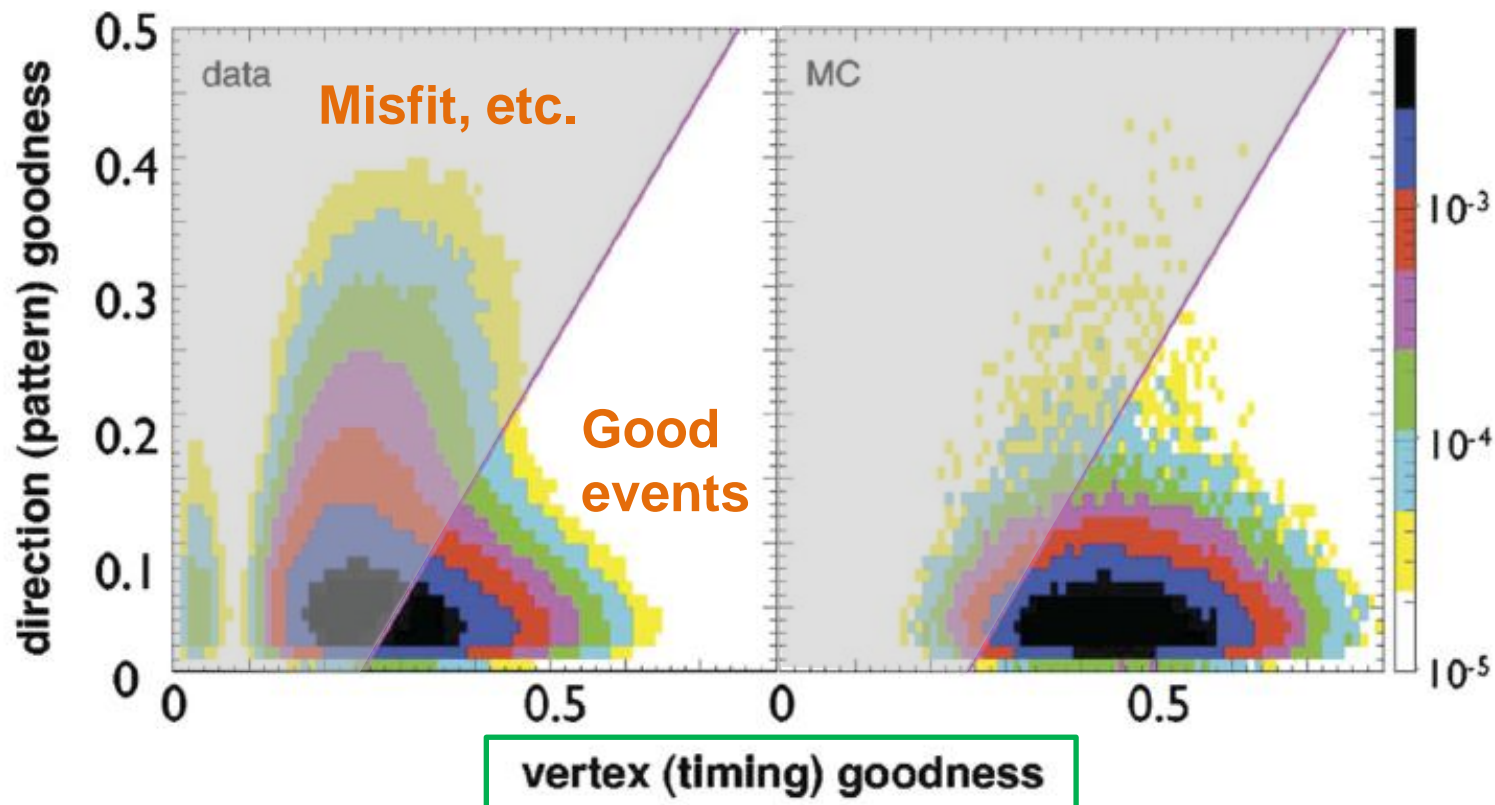
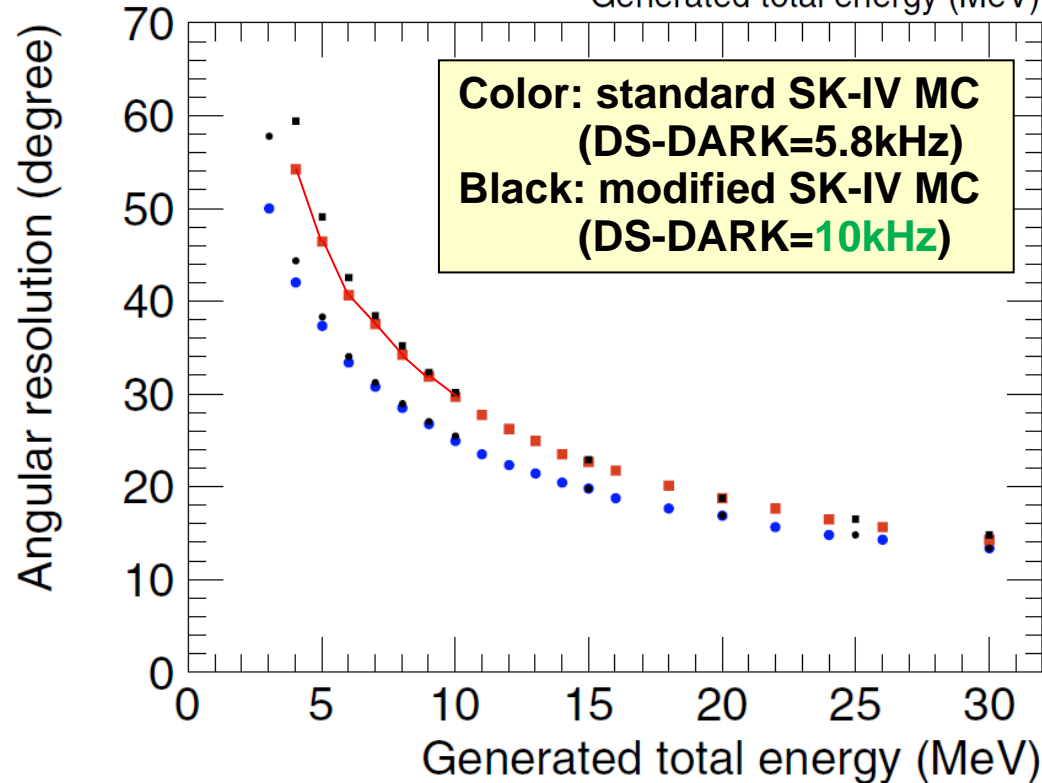
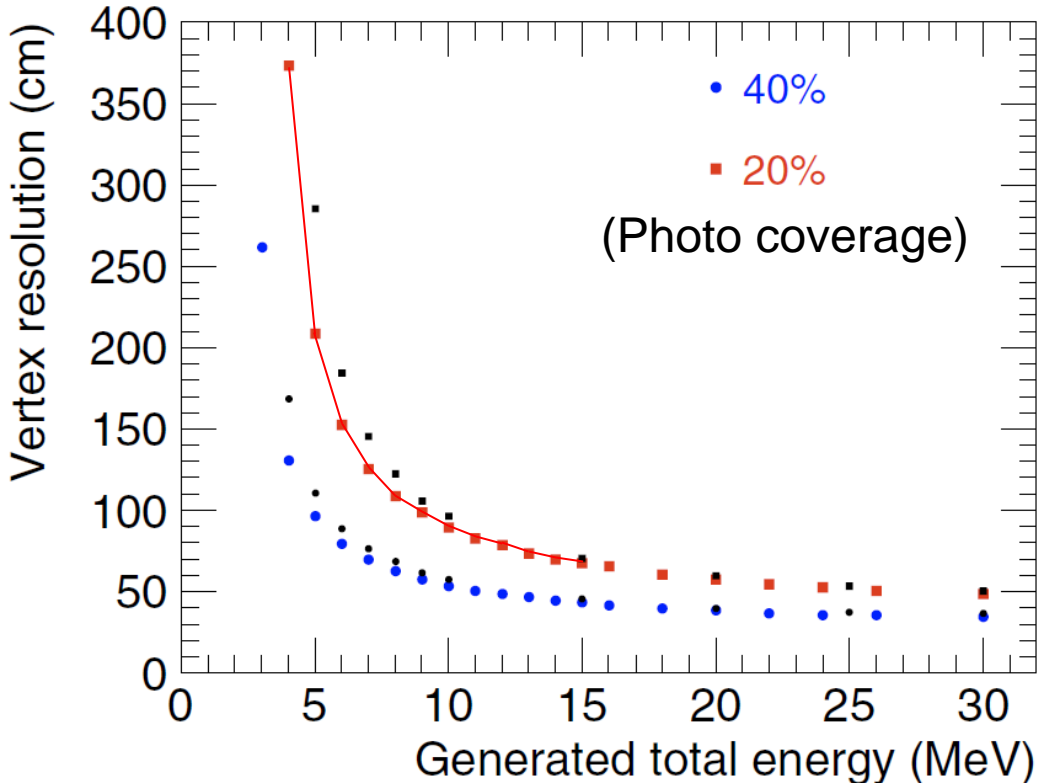
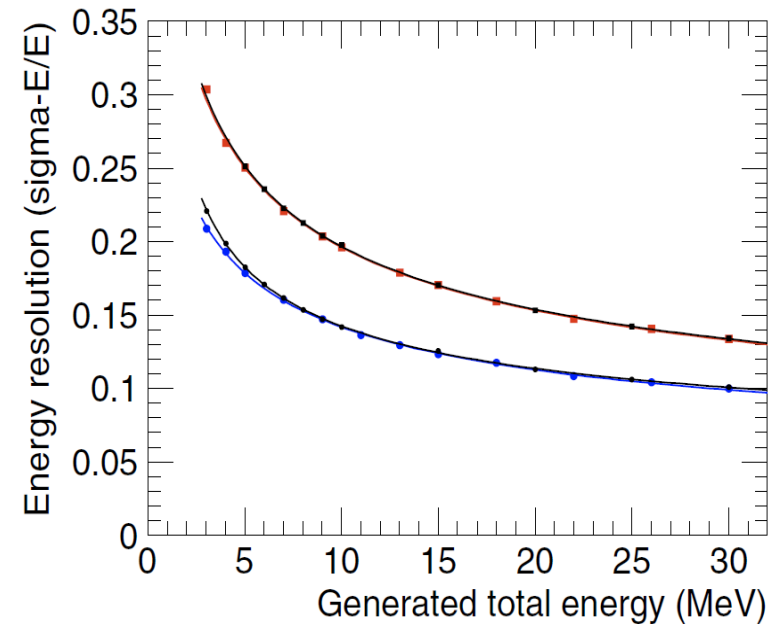


FIG. 9 (color). PMT timing and hit pattern cut. Data (left) show an excess of misreconstructed and non-Cherenkov events to the upper-left of the diagonal cut line. Approximately 78% (8%) of data (MC) events between 7.0–7.5 MeV are rejected by the cut. The color scale is to show the relative (normalized) number of events.

- High dark rate will increase low-e background events
 - Need to estimate

Expected resolutions for an electron

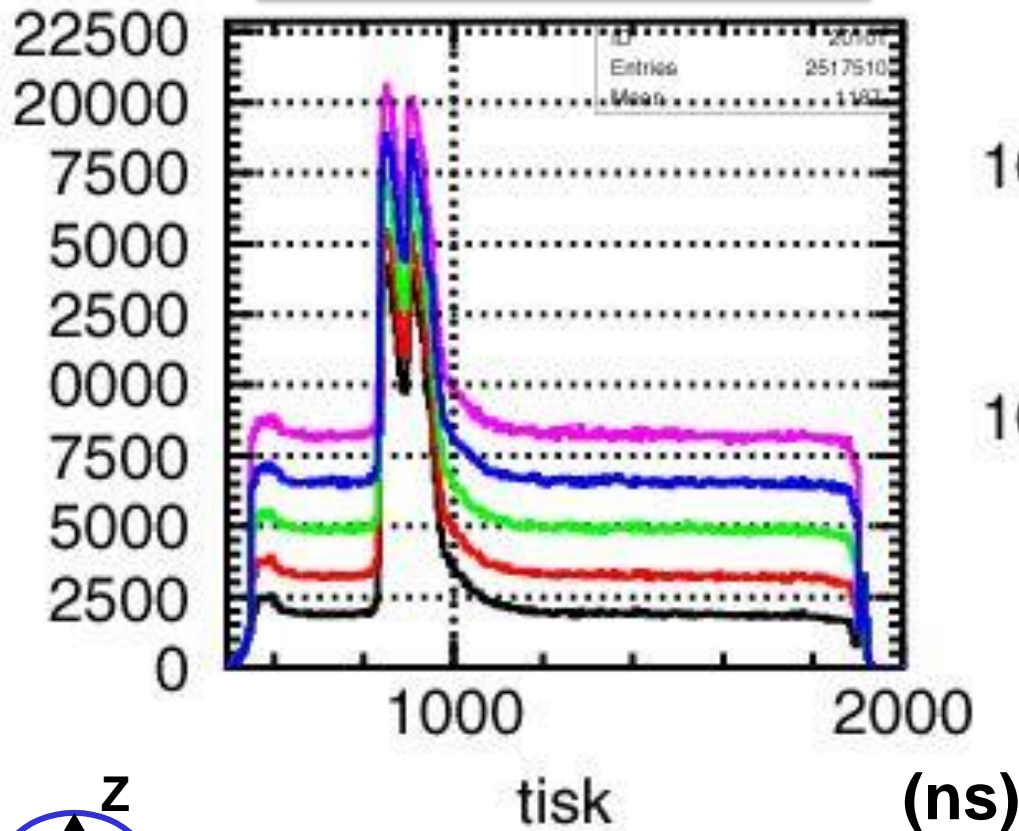
- Use SK-IV detector simulation
- Inside 2m fid. vol.
- Photo coverage was changed by masking about half PMTs in SK-IV
- **Vertex & angular resolutions will be affected by the high dark rate sensors.**



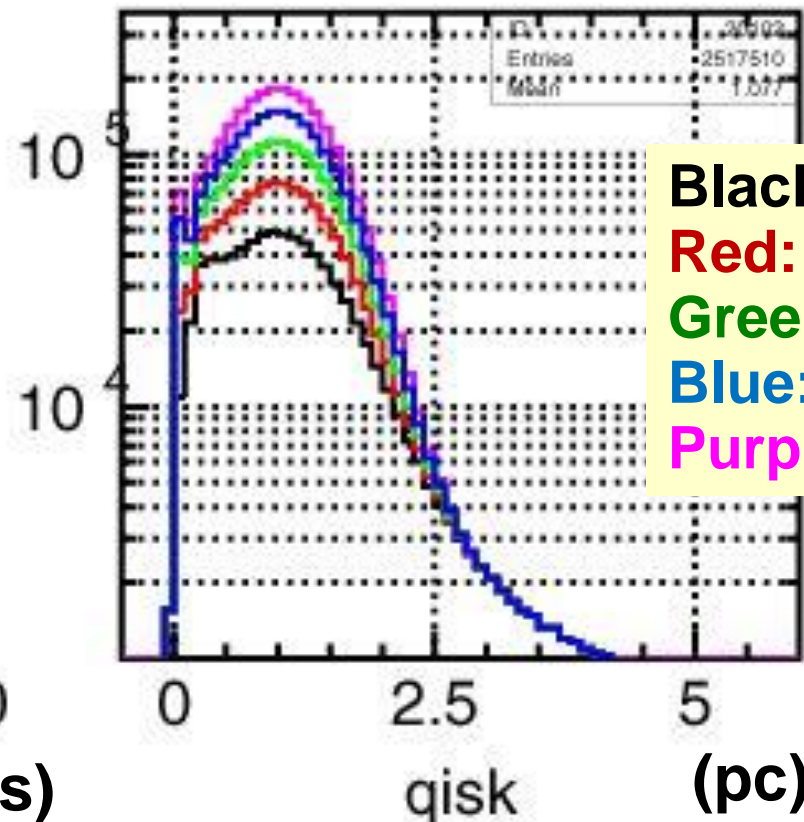
Effects on event reconstruction

- Dark rate hits in SK-I data are artificially increased.
 - SK-I observed dark rate: $\sim 3.4\text{kHz}$

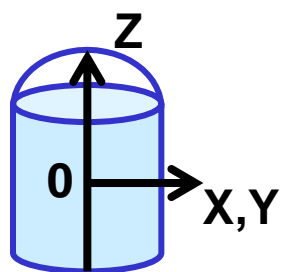
Time of each hit-PMT



Charge of each hit-PMT



Black: original
 Red: ~ 1.5
 Green: ~ 2.0
 Blue: ~ 2.5
 Purple: ~ 3.0



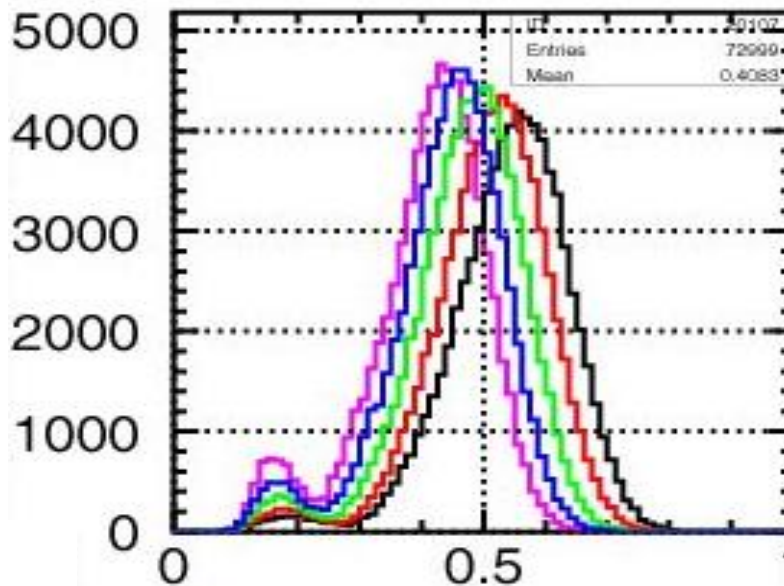
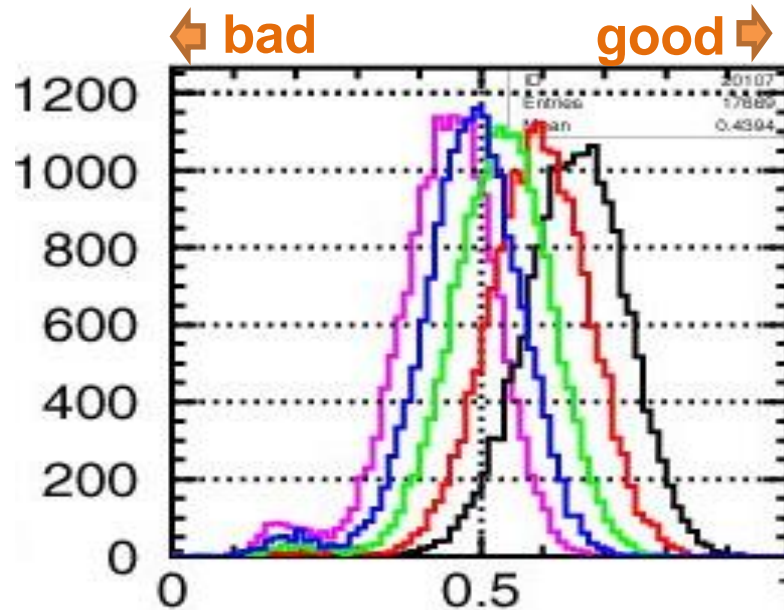
SK-I LINAC data (5 MeV, X=-12m Z=0m)

Vertex (timing) goodness

Signal:
SK-I LINAC
5MeV
X=-12m Z=0m

Background:
SK-I SLE
triggered
events

(without Intelligent
Trigger filtering)



Timing goodness (from Bonsai fit)

High dark rate study:3

