Study of neutrino background to proton decay search using K2K 1kt detector data

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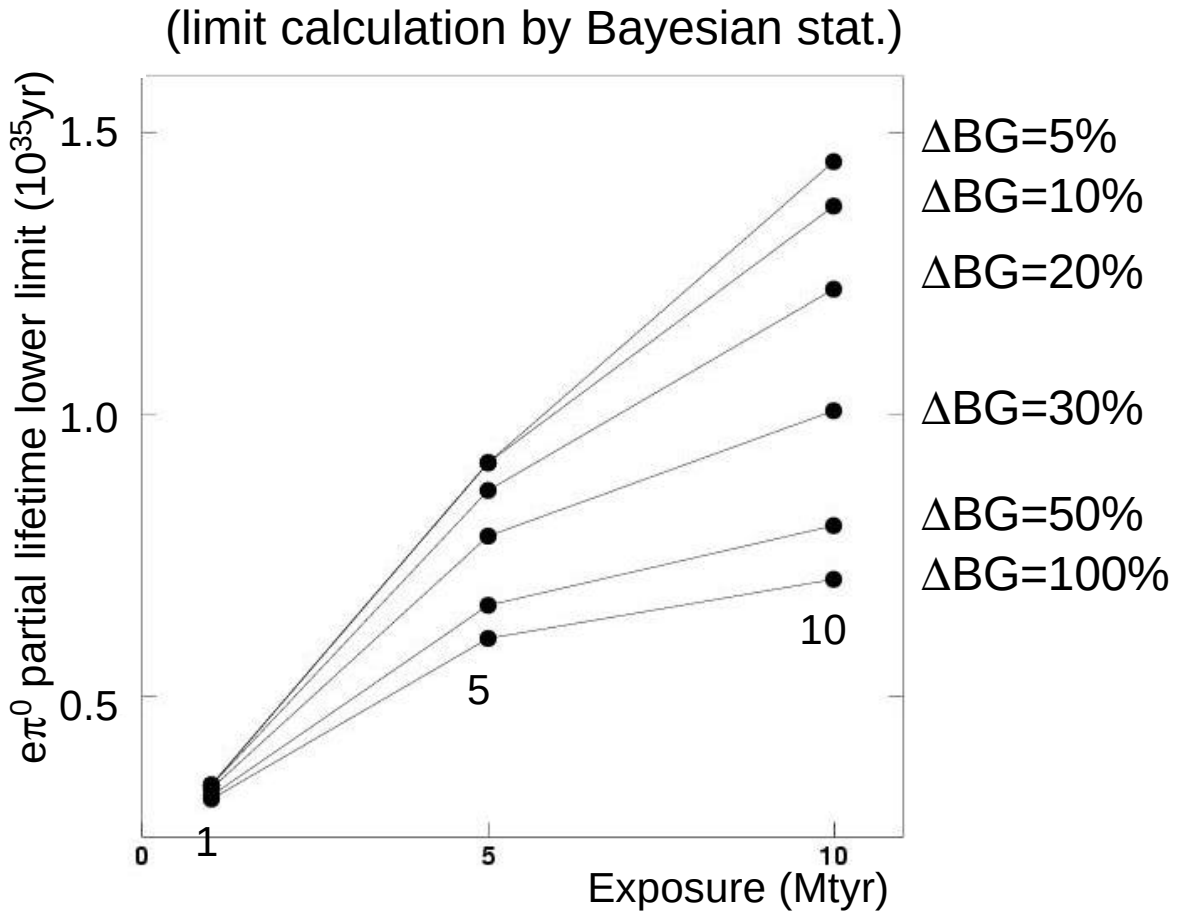
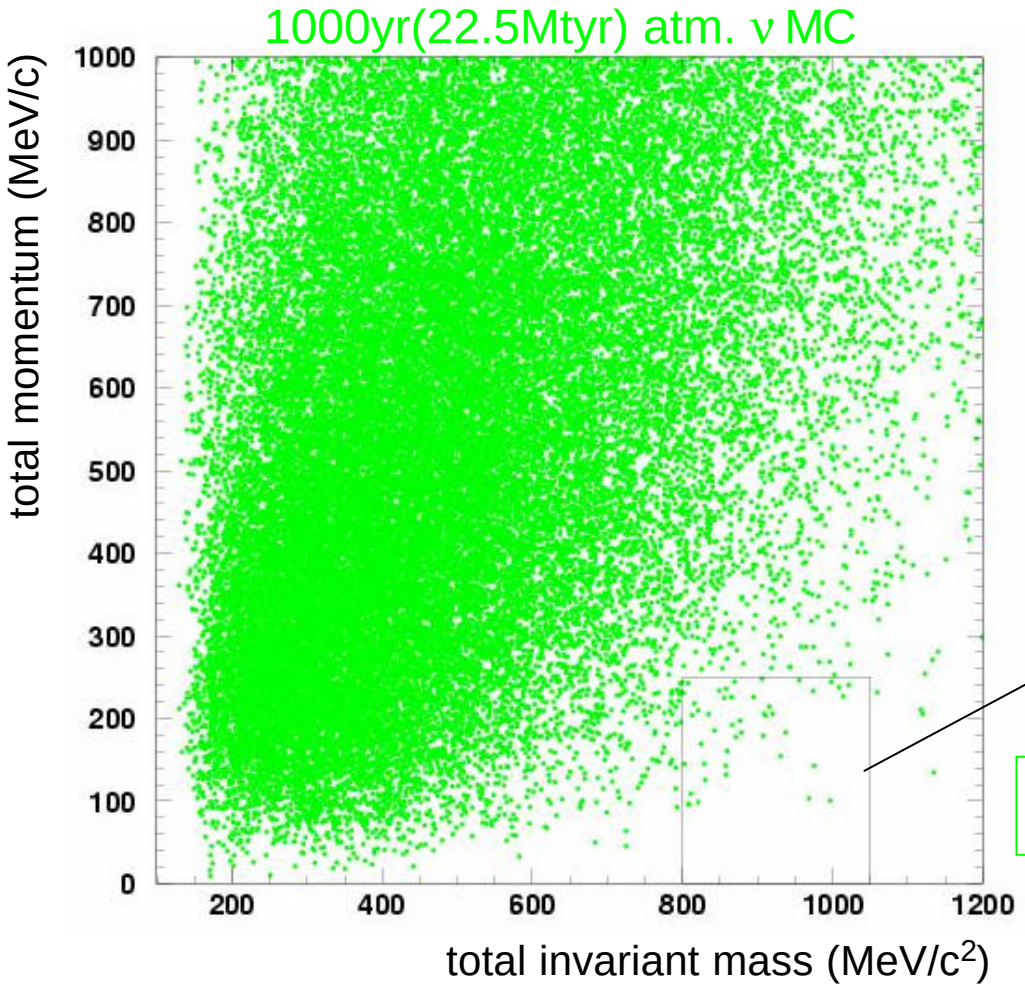
1. Background @ SK
2. 1KT data analysis
3. Summary

1. Background @ SK

PDK sensitivity & background



MC sample of $e\pi^0$ background



- pre-selections:
  - only ν_e int.
  - no QE & NC
  - $1\pi^0$ in final
- true vector info.

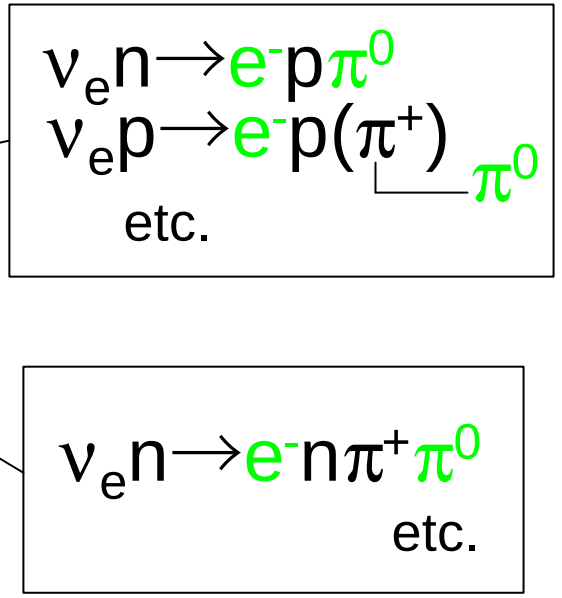
46evts / 22.5Mtyr

⇩

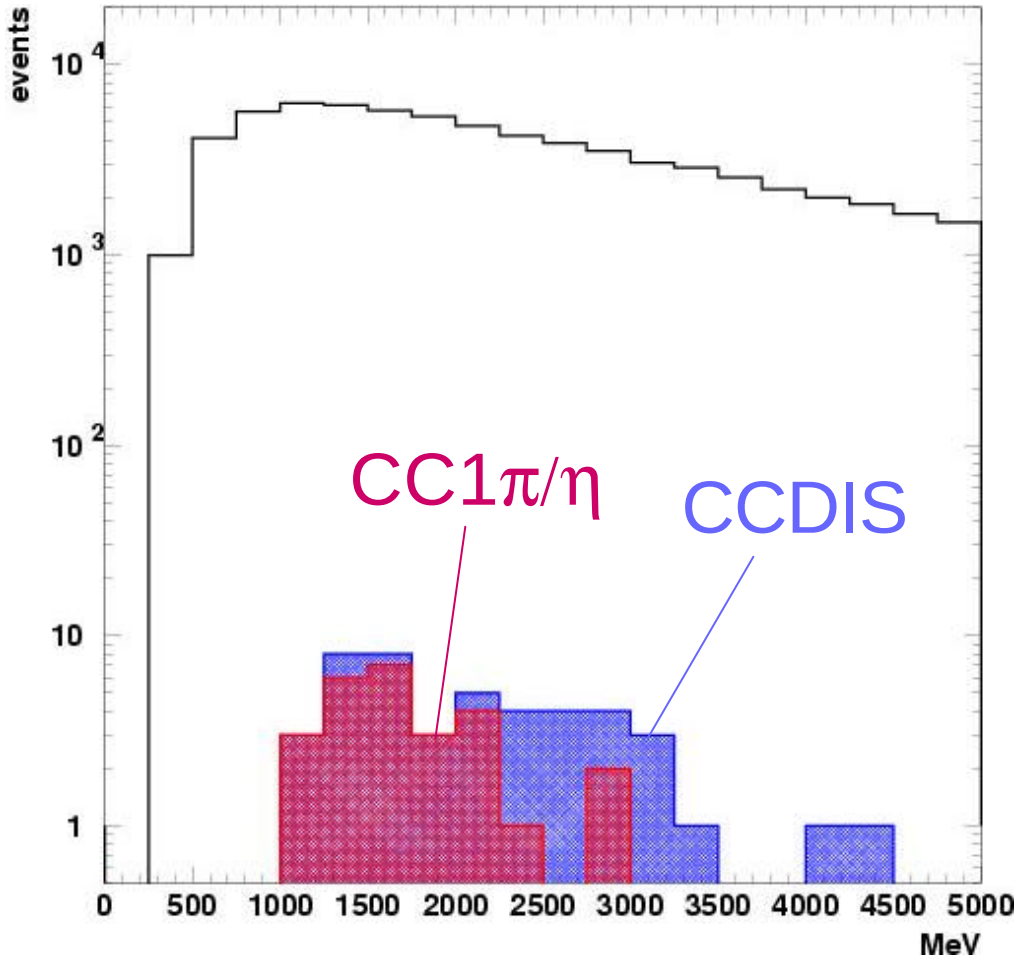
~2 evts / Mtyr

ν int. of $e\pi^0$ background

CCQE	———
CC1π(res.)	26
CC1η	2
CCDIS	18
NC	———
total	46



ν energy of $e\pi^0$ background



$\bar{\nu}K^+$ background

PDK: $^{16}O \rightarrow \nu K^+ \, ^{15}N \gamma$

$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \llcorner \mu^+ \nu$

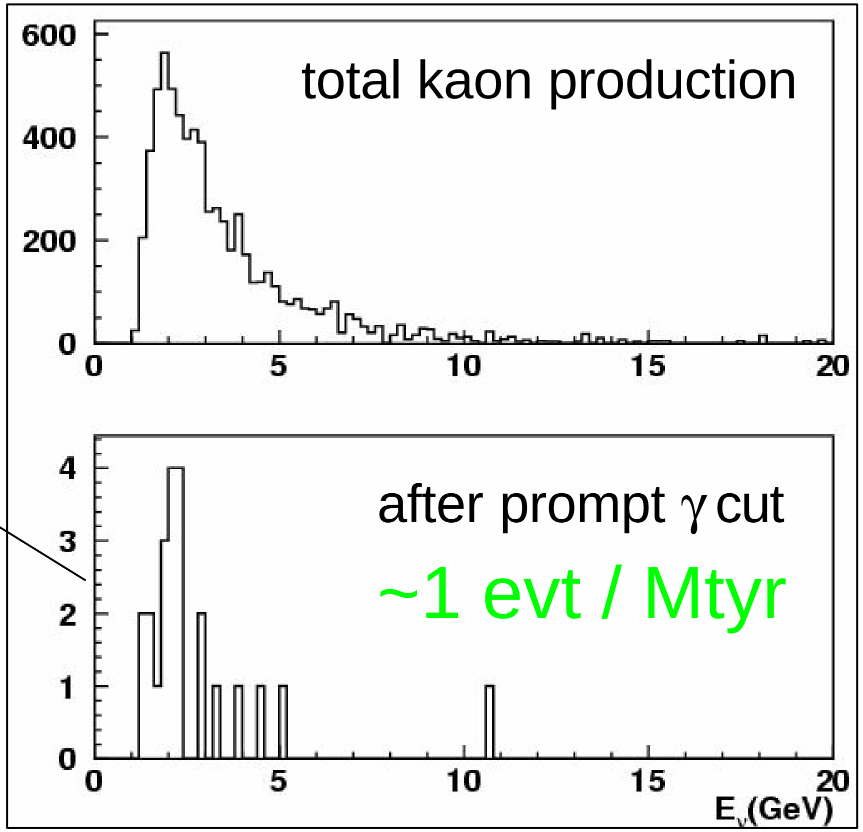
atm. ν BG:

$\nu ^{16}O \rightarrow \nu \Lambda^0 K^+ \, ^{15}N \gamma$

$\quad\quad\quad\quad\quad\quad\quad\quad\quad\quad \llcorner \mu^+ \nu$

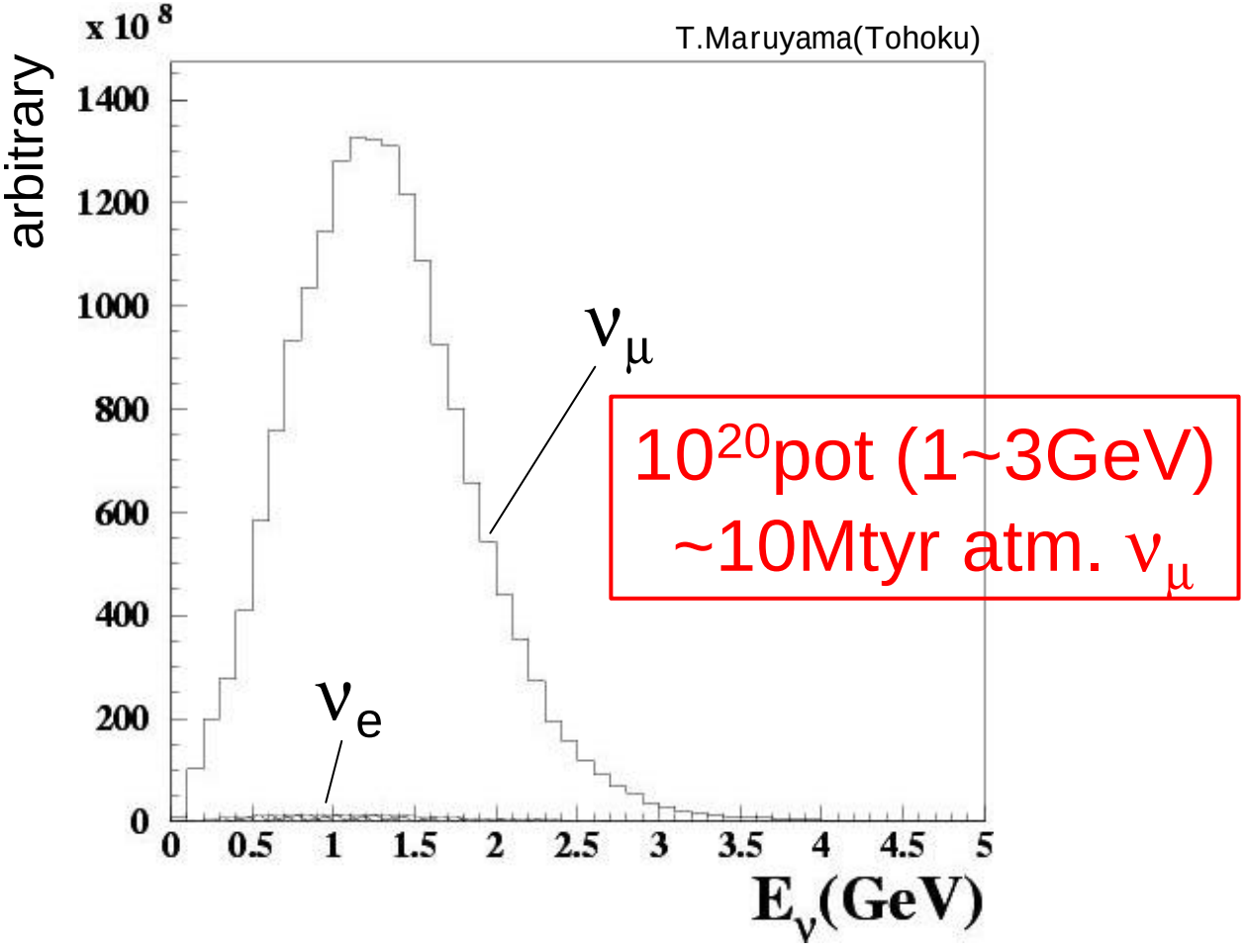
($\Lambda^0 \rightarrow N\pi$ invisible)

K.Kobayashi(SUNY)/UNO02

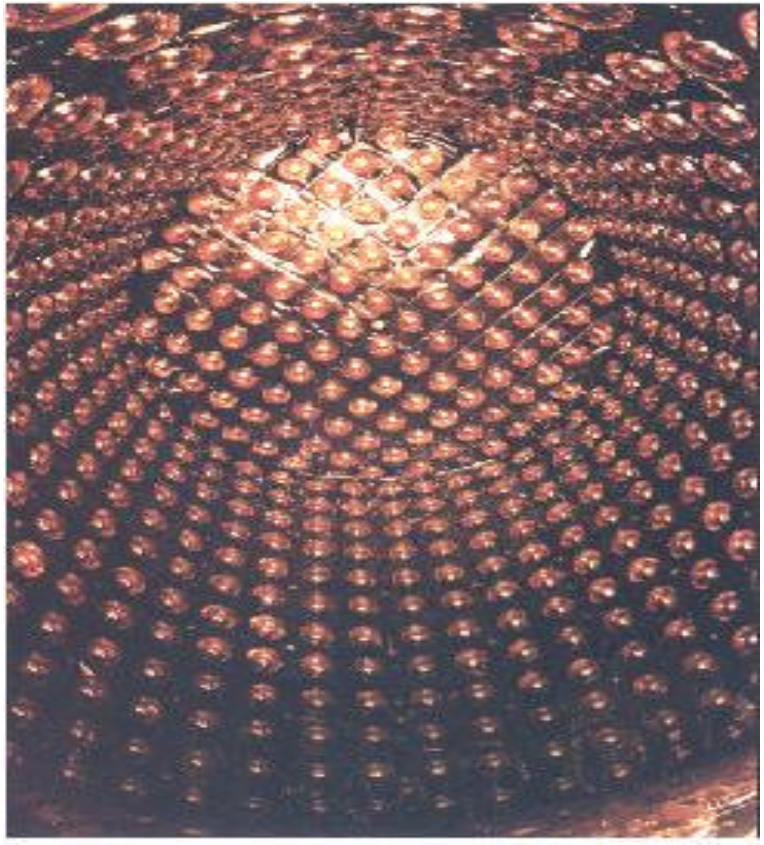


2. 1KT data analysis

K2K neutrino beam



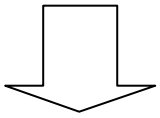
1kt water Cherenkov detector



- Miniature of SK:
  ~10×10m^2 cylinder
  50t fiducial volume
  (r=2m cylindrical vol. along beam)
- 680 20” PMTs with 70cm spacing (same as SK-I)
- Same readout modules

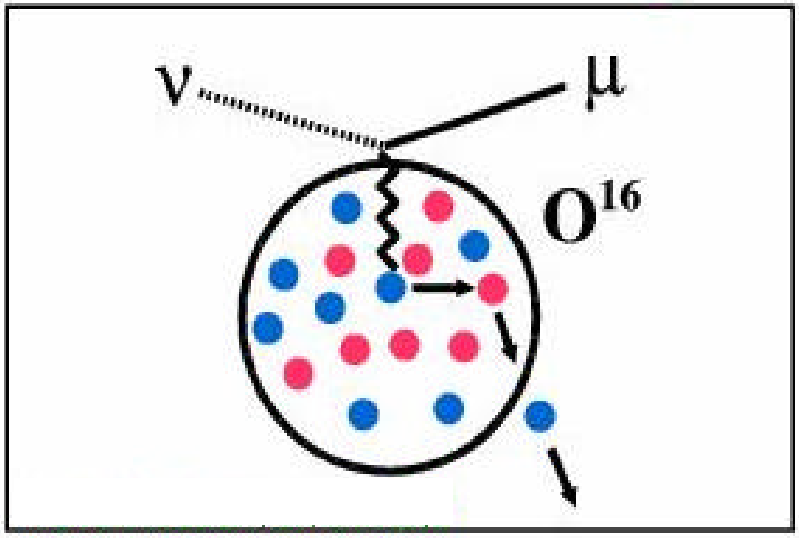
Validity check of ν MC

Dominant ΔBG @ SK:
uncertainty of σ_ν in hadron sector & secondary π int. in oxygen nucleus



Atm. ν BG for $p \rightarrow e\pi^0$ can be checked by $\nu_\mu N \rightarrow \mu\pi^0 X$ int. produced in K2K ν_μ beam

C.Walter(BU)



Event selection criteria

50t fiducial

A. fully contained

B. 2 or 3 rings

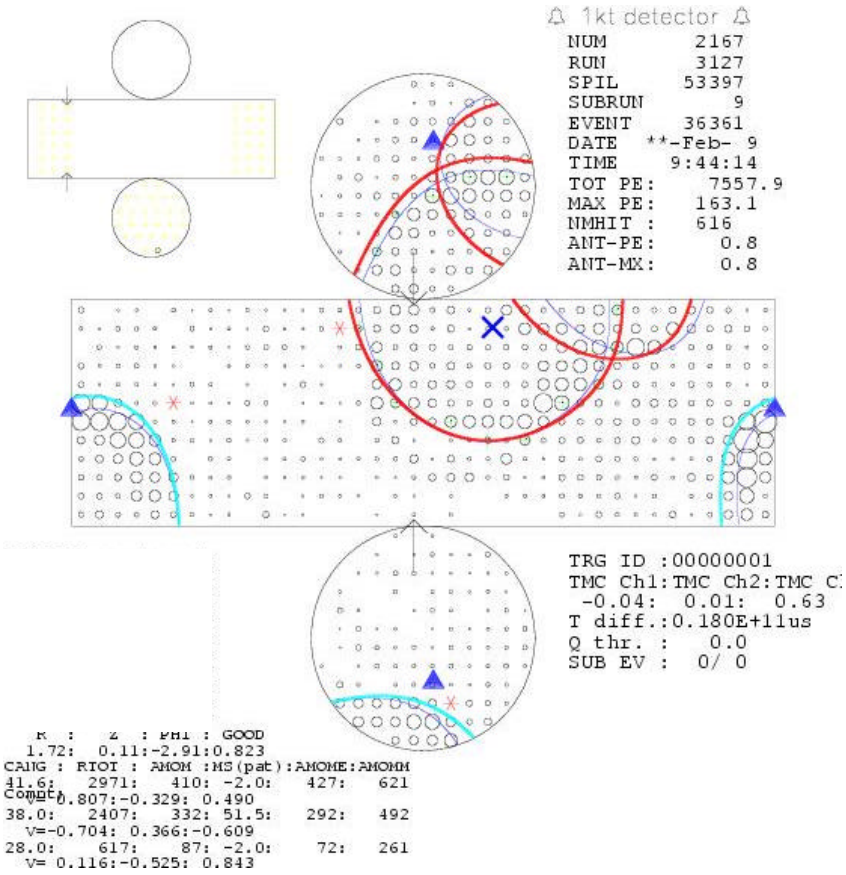
C. 1μ-like,other(s) e-like(s)

D. $85<M\pi^0<215 MeV/c^2$

(3 ring event)

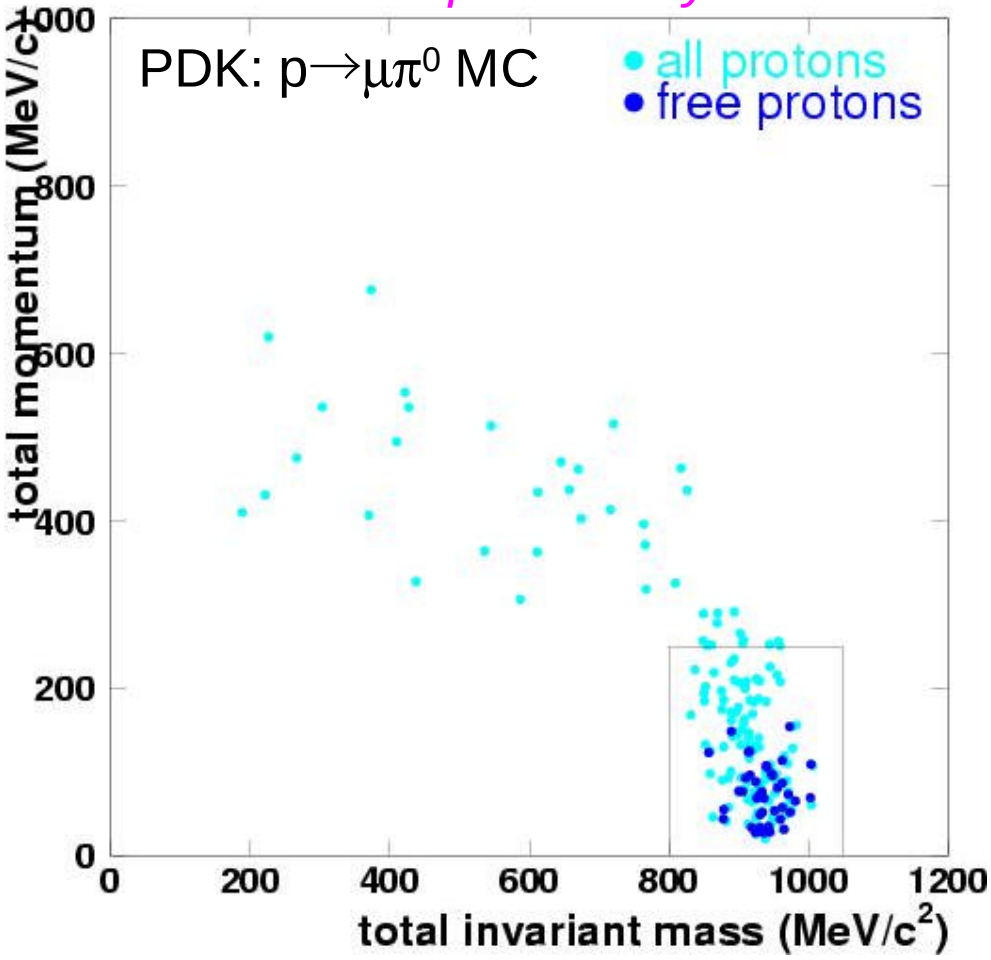
E. $800<M_{tot}<1050 MeV/c^2$,

$P_{tot}<250 MeV/c$



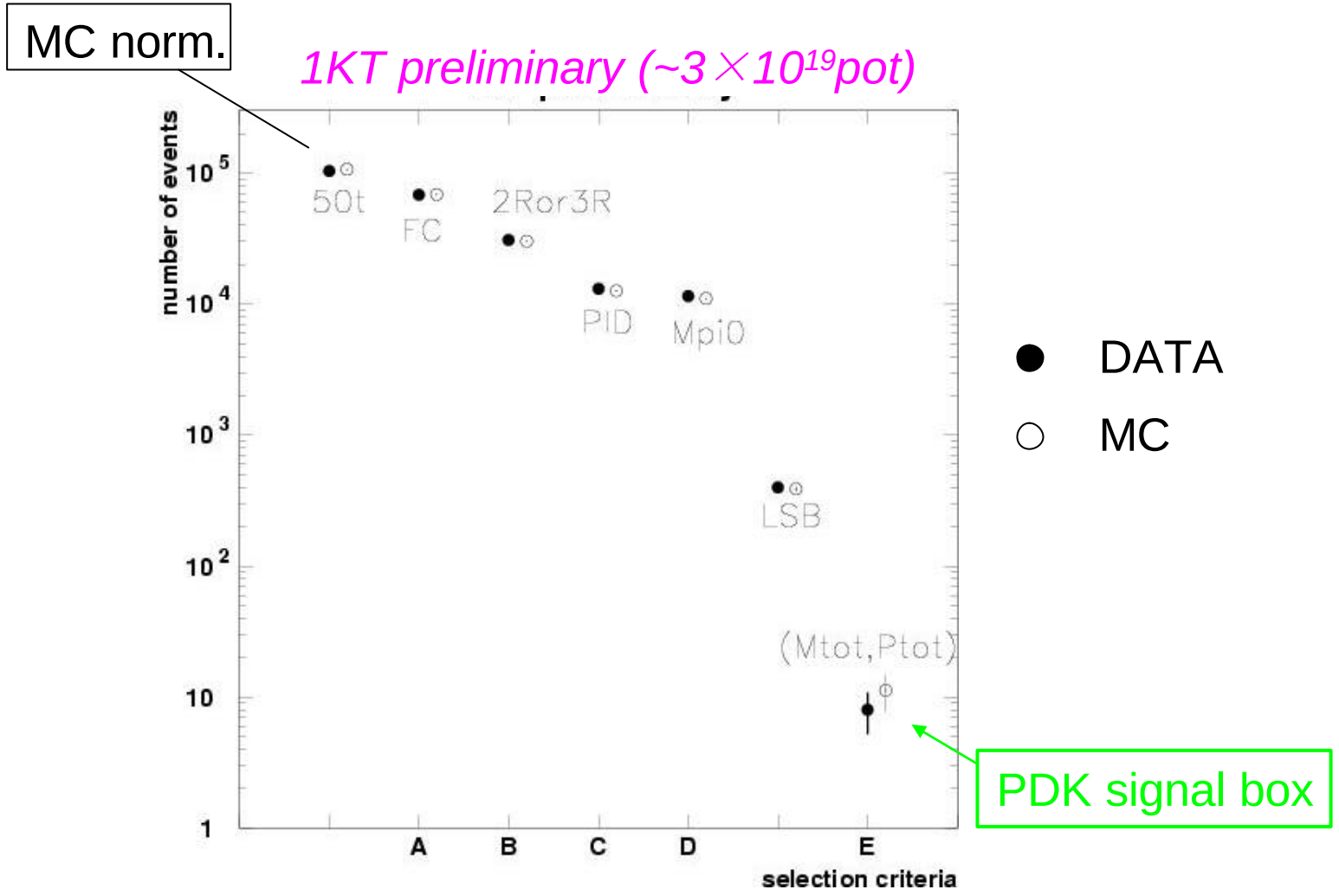
Detection efficiency

1KT preliminary



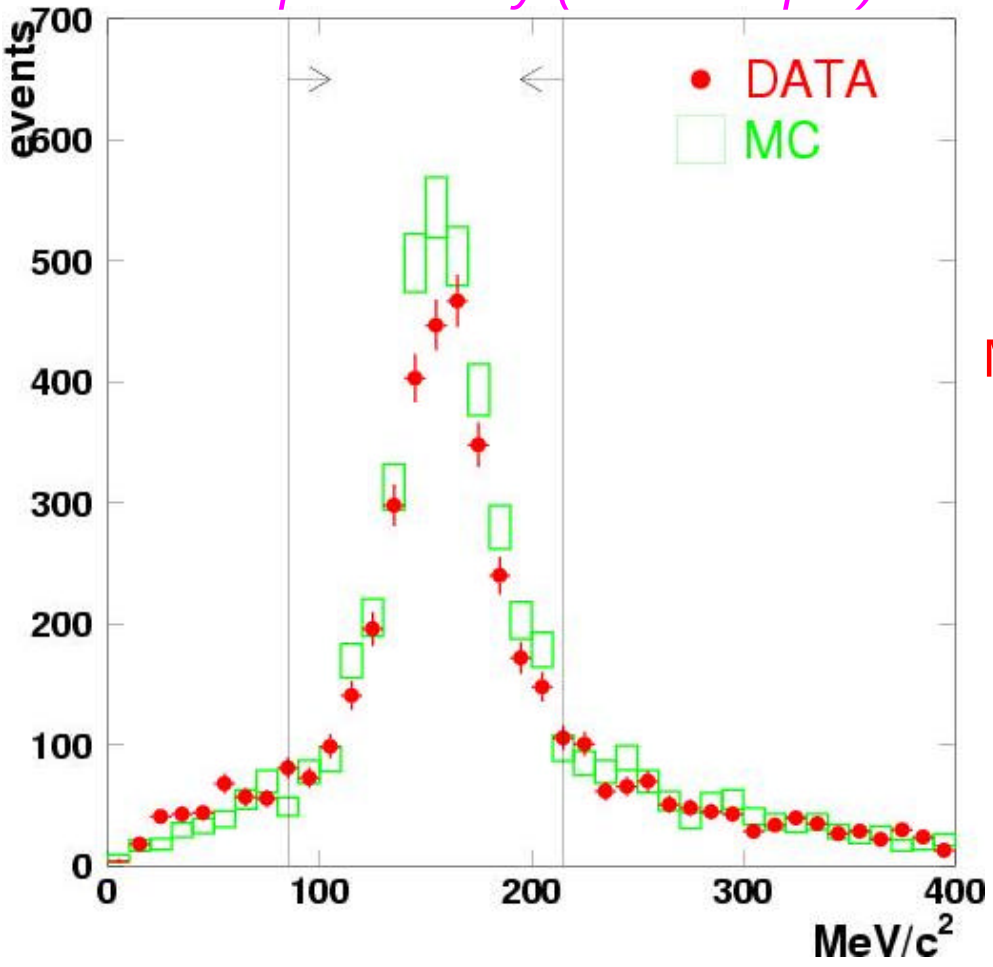
ε~34%

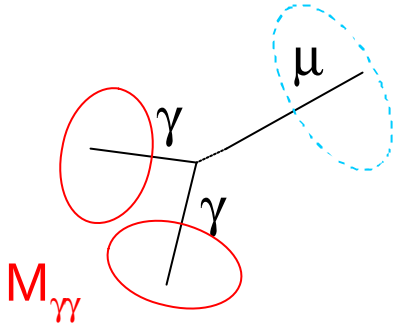
Event rate after each selection



π^0 mass

1KT preliminary (~3×10^{19}pot)



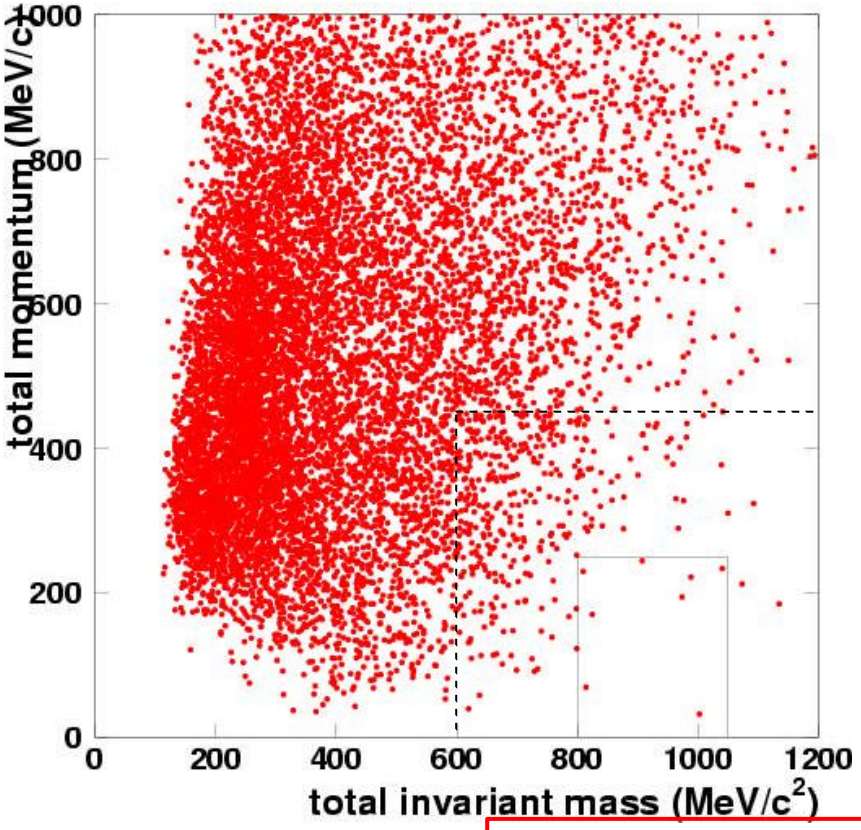


γ

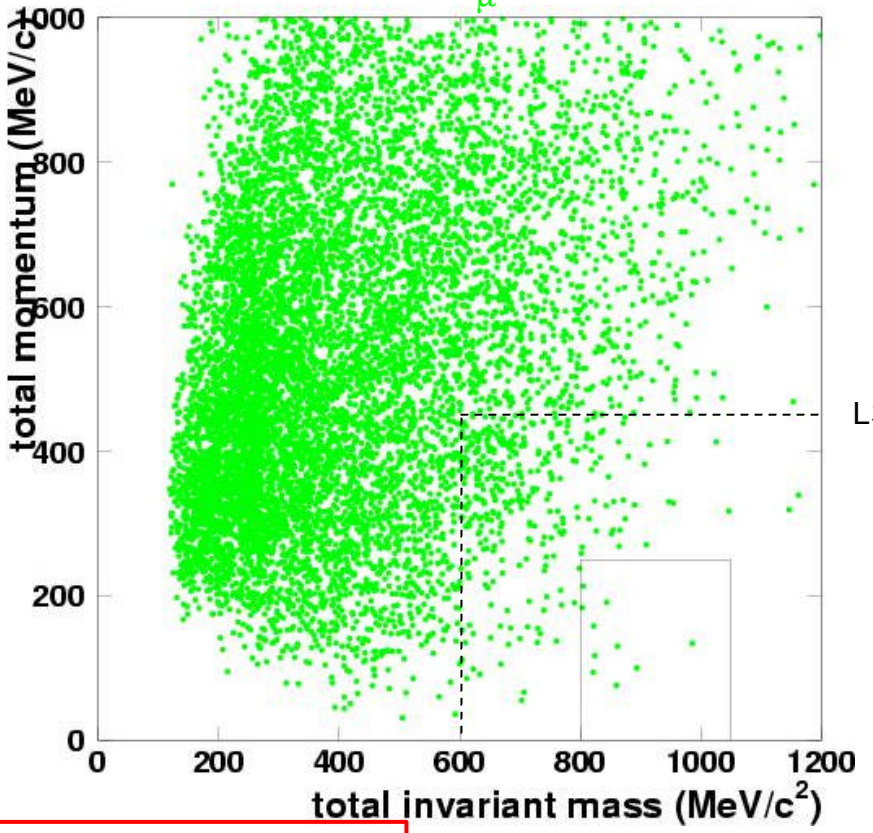
Total momentum vs. invariant mass

1KT preliminary (~3×10^{19}pot)

1KT DATA



K2K ν_μ MC

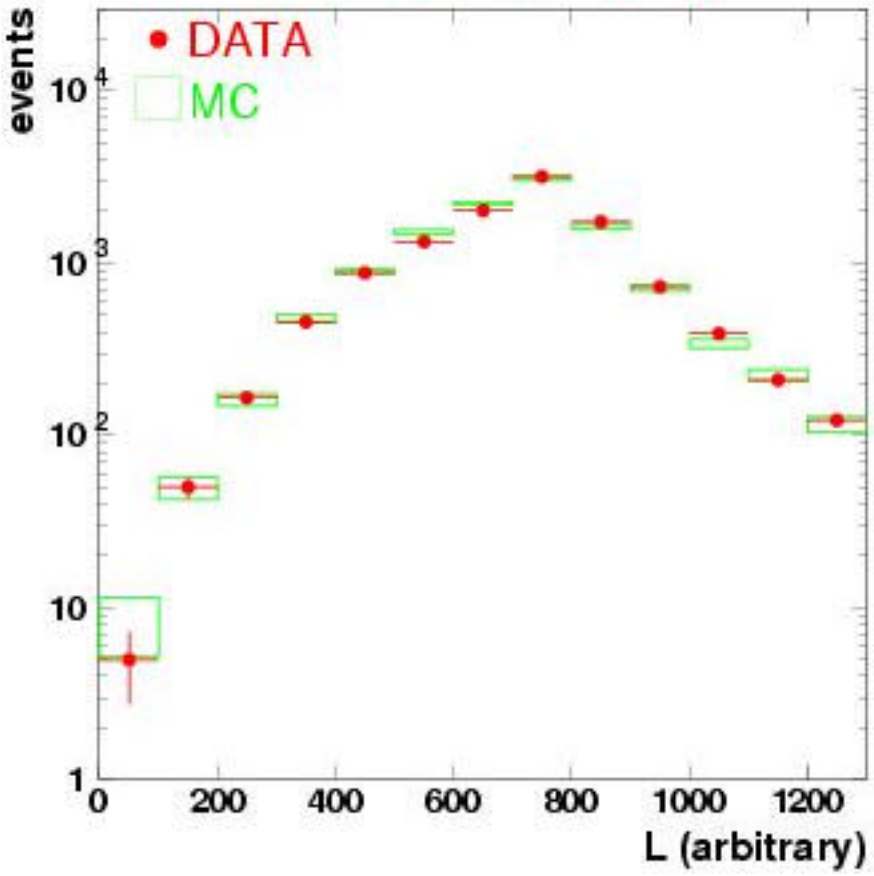


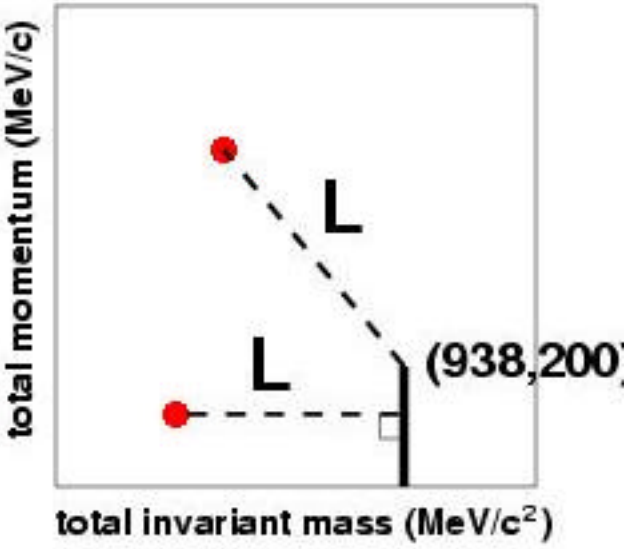
LSB

exposure ~ 3Mtyr atm. ν_μ equiv.

Distance “L” in P_{tot} vs. M_{tot} plot

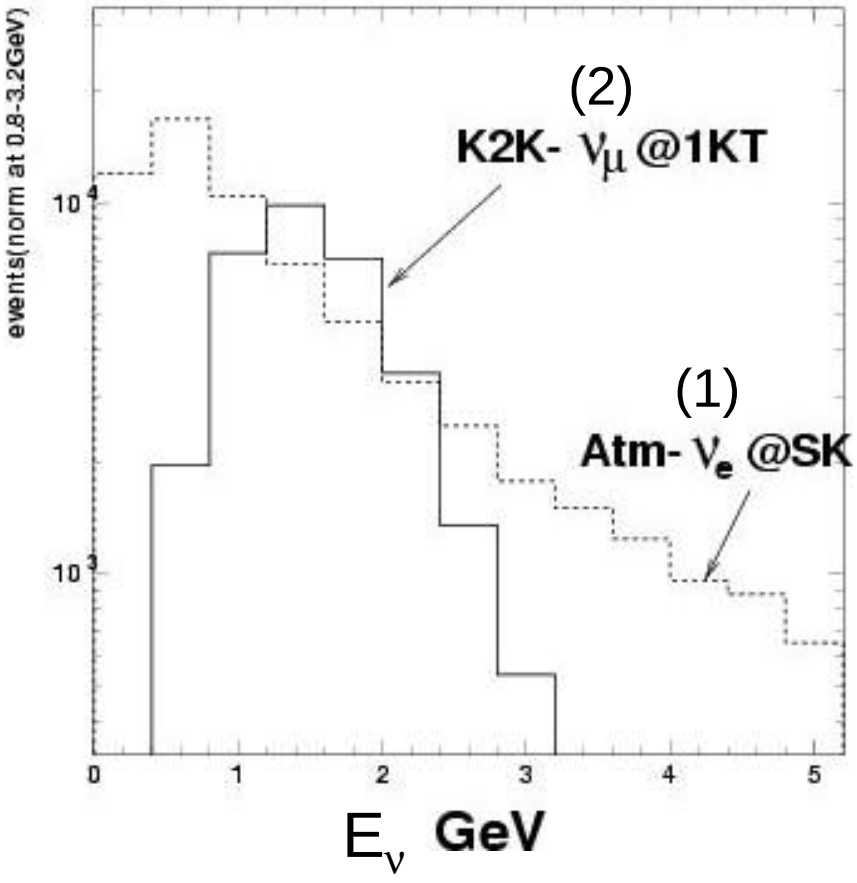
1KT preliminary (~3×10^19pot)





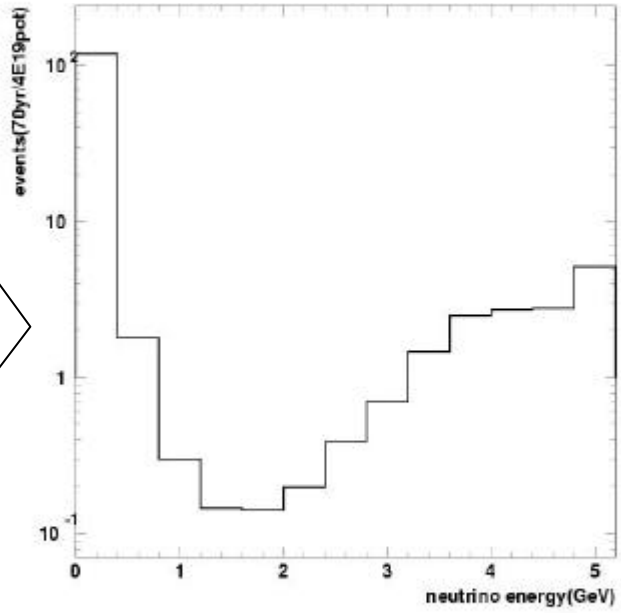
Order check of $e\pi^0$ background in current SK data

Comparison of ν flux · σ



(1)/(2)

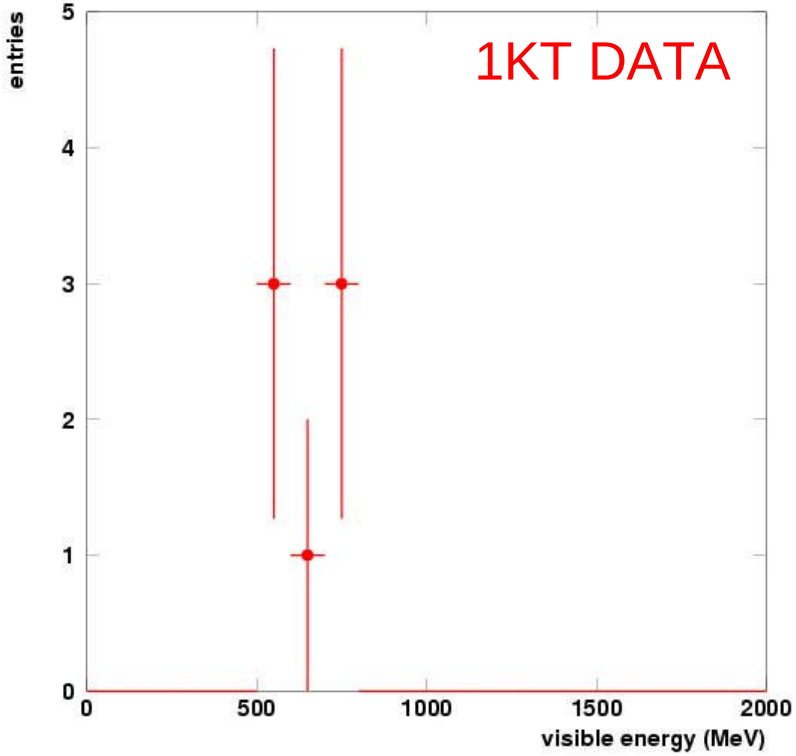
weight dist.



W(i)

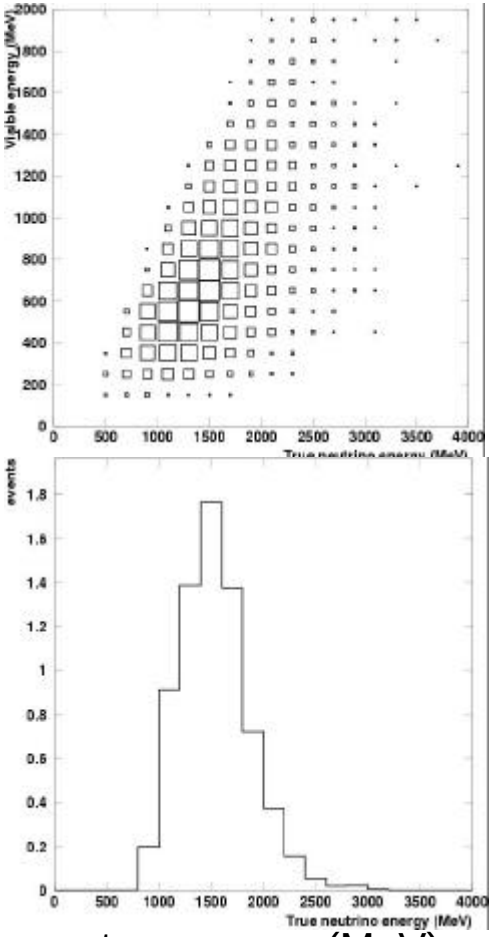
Visible to true ν energy

1KT preliminary (~3×10^{19}pot)



visible energy (MeV)

S(j)



P(j,i)

true energy (MeV)

(i)

Systematic errors on S(j)

ring counting	29%
PID	21%
energy scale	4%
ν flux shape	1%
others	6%
total	37%

Very preliminary

(Cancellation between SK & 1KT has not been fully considered yet)

Crude prediction of $e\pi^0$ background

$$\Sigma_i \Sigma_j \, S(j) \, P(j,i) \, W(i) \, \varepsilon_{SK} / \varepsilon_{1KT}$$

i : true neutrino energy bin
j : visible energy bin
S : 1KT DATA in signal box
P : probability (visible to true energy)
W : weight dist.
ε : detection efficiency

$= 0.12 \pm 0.05(stat) \pm 0.05(syst)$ evts / 1489days

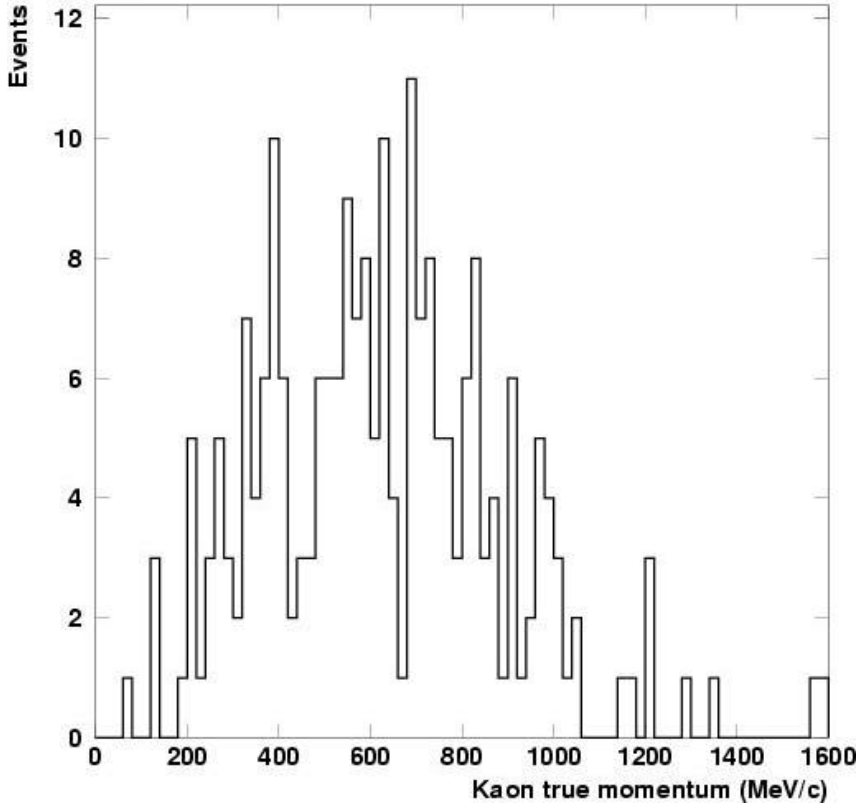
cf) ~0.2 exp'd from atm. ν MC @ SK

Very preliminary

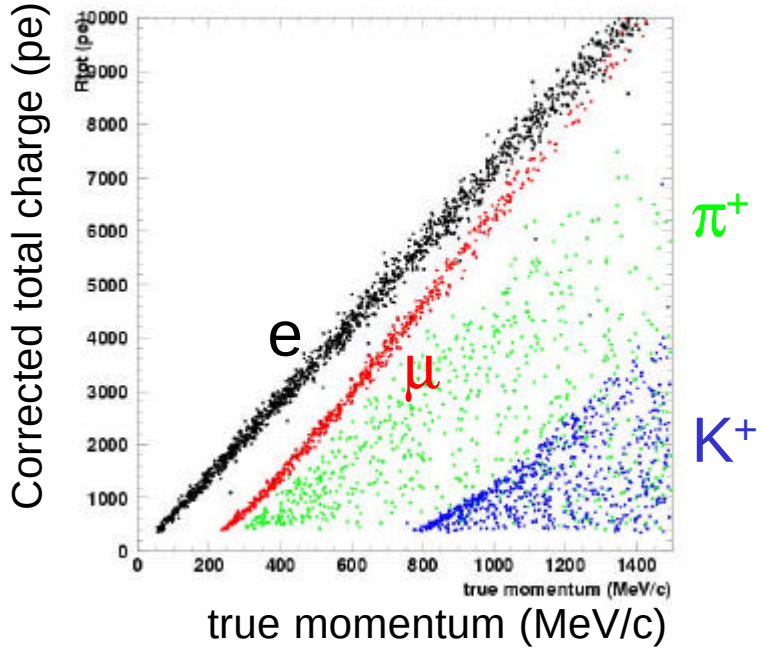
K^+ production from resonance:

$$\nu n \rightarrow \mu^- \Lambda^o K^+$$
$$\hookrightarrow \mu^+ \nu$$

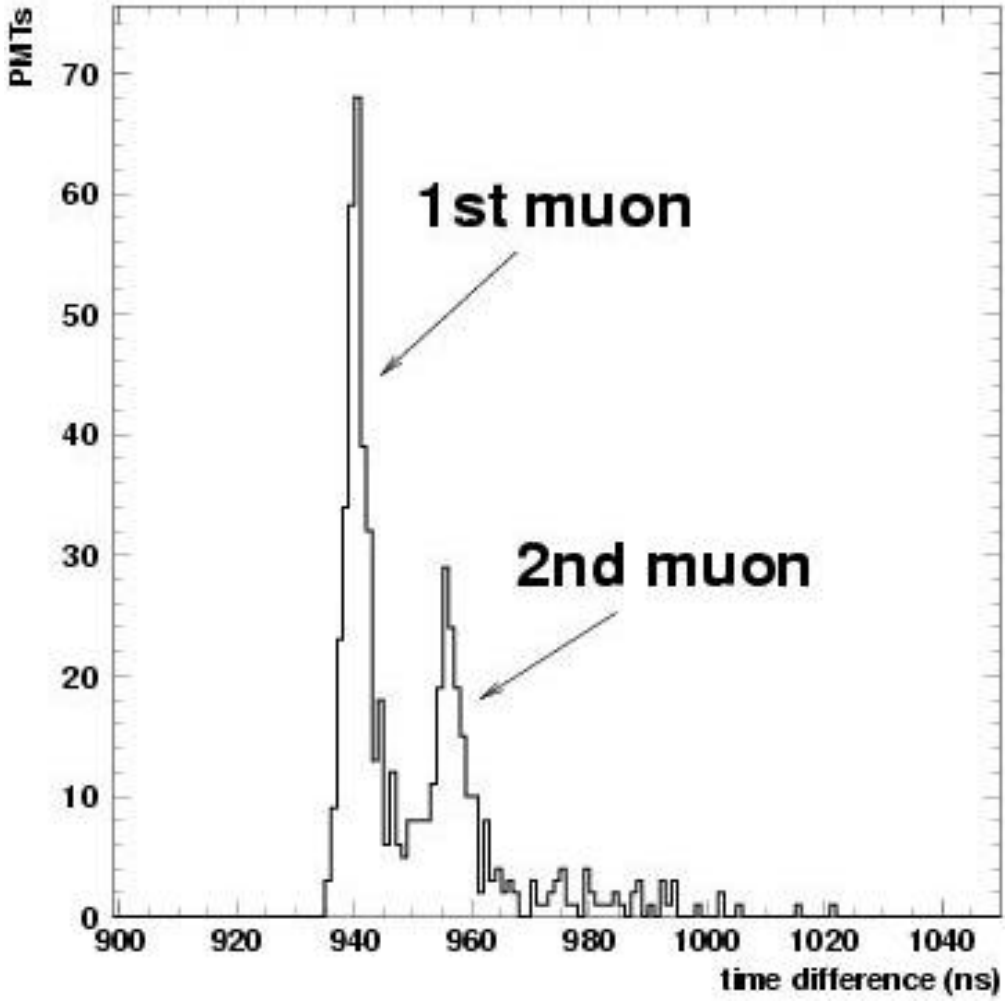
K^+ momentum



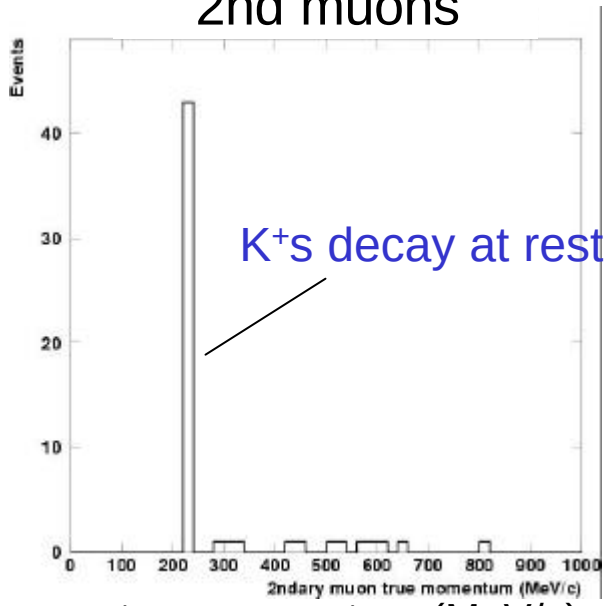
visible



Typical time distribution



2nd muons

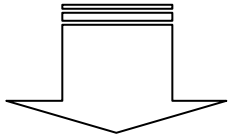


true momentum (MeV/c)

ν int. of clear “two muons”

1KT preliminary

K^+ invisible	~60%
$K^+ \rightarrow \mu^+ \nu$	~63%
K^+ decays at rest	~86%
$\Lambda^0 \rightarrow N\pi$ invisible	~66%
total	~21%



~ several 10’s for 10^{20}pot

3. Summary

- It is crucial to understand ν background for future PDK searches
- Our ability to model atmospheric ν background for $p \rightarrow e\pi^0$ at SK is well supported by K2K 1KT data
- Atmospheric ν background for current $p \rightarrow e\pi^0$ at SK is negligible
- Kaon production measurement has just been started at 1KT