ν_e appearance search

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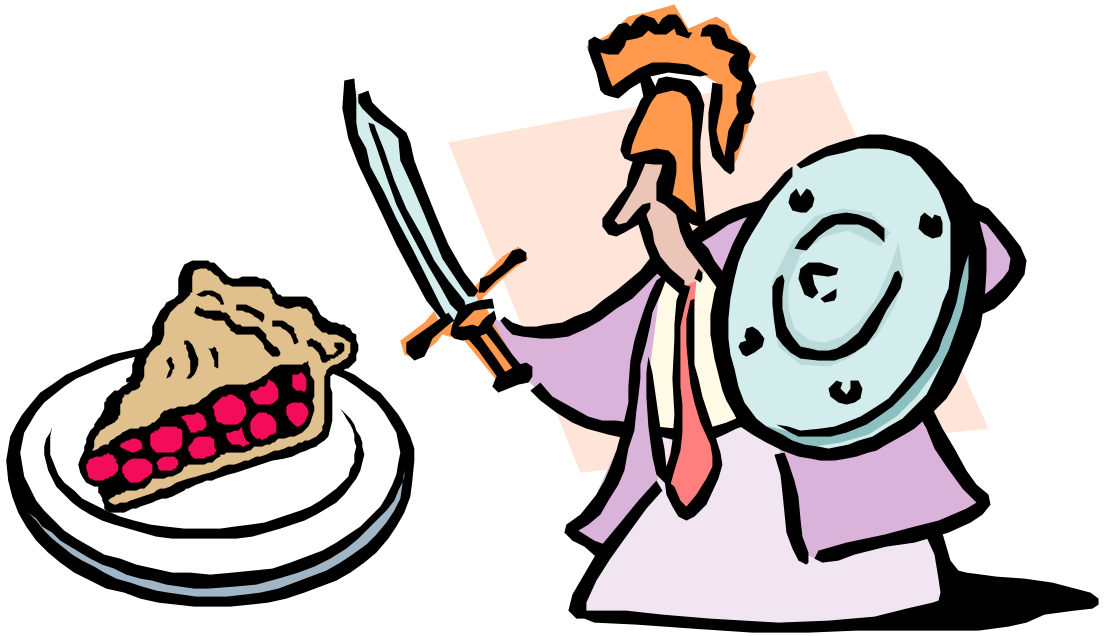


ν_μ to ν_e oscillation search

- **Three Active Neutrino & Mass Degeneration Scenario ($\Delta m^2_{12} << \Delta m^2_{13} \sim \Delta m^2_{23}$)**

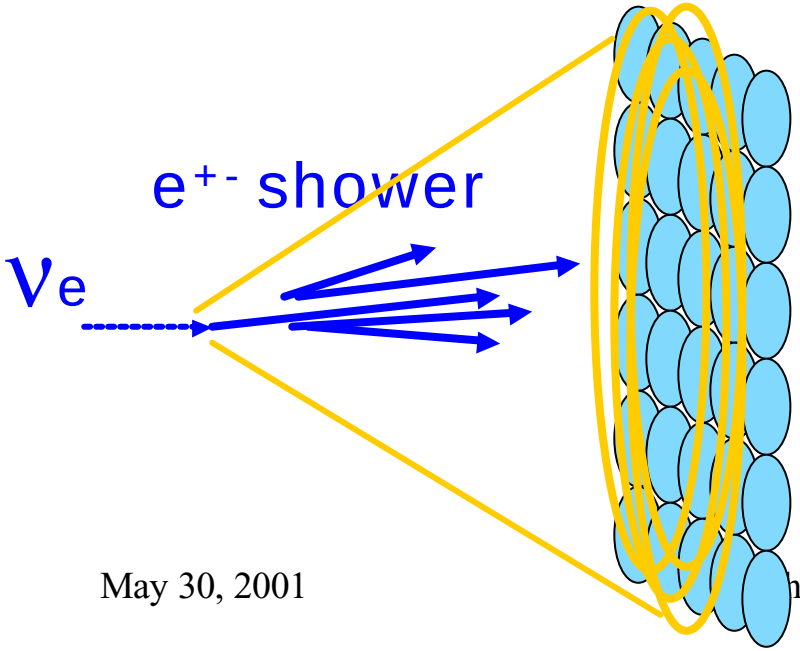
$$P(\nu_\mu \rightarrow \nu_e) = \sin^2(2\theta_{\mu e}) \cdot \sin^2\left(\frac{1.27 \cdot \Delta m^2 \cdot L}{E}\right)$$

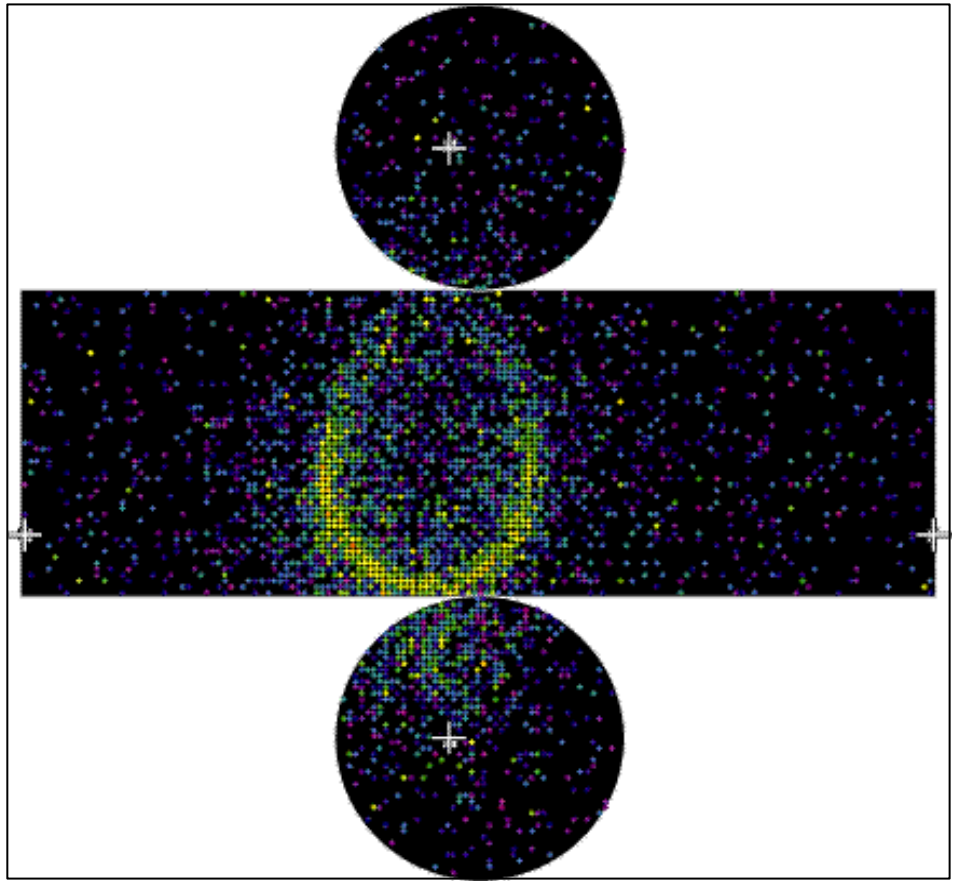
$$\sin^2 2\theta_{\mu e} \equiv 0.5 \cdot \sin^2 2\theta_{13}$$

- **Present Limit: $\sin^2 2\theta_{13} > 10^{-1}$ @ $\Delta m^2 \sim 3 \times 10^{-3}$ eV^2**
  - **Obtained by CHOOZ (PALO VERDE) experiment**
- **Neutrino Beam is Essentially Pure $\nu\mu$**
  - **(ν_μ : ν_e~100:0.2@peak)**
- **Optimum neutrino energy: below 1GeV**

Appearance Signal

- Q.E.ν_e C.C. interaction
  - No hadron
  - No recoiled proton ring
  - Single electron shower
    - Single Fussy Ring
    - Cherenkov Angle ~ 42°
  - Eν can be reconstructed

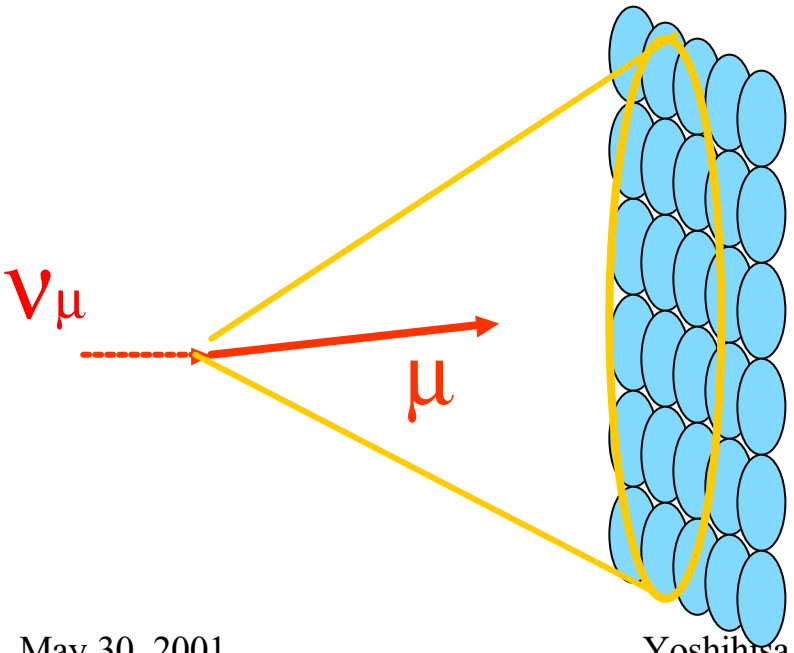


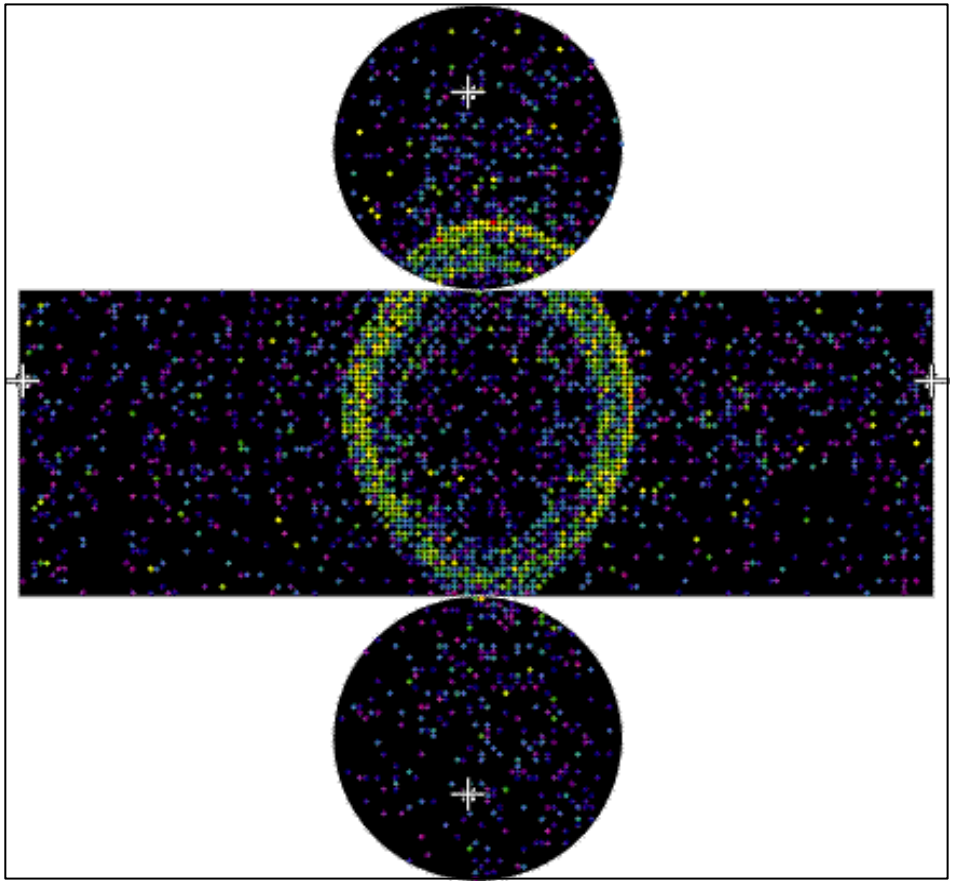


BG(1): ν_μ C.C. interaction

- Sharp Ring Edge
- Cherenkov Angle < 42°
- Good PID (atm. ν study)

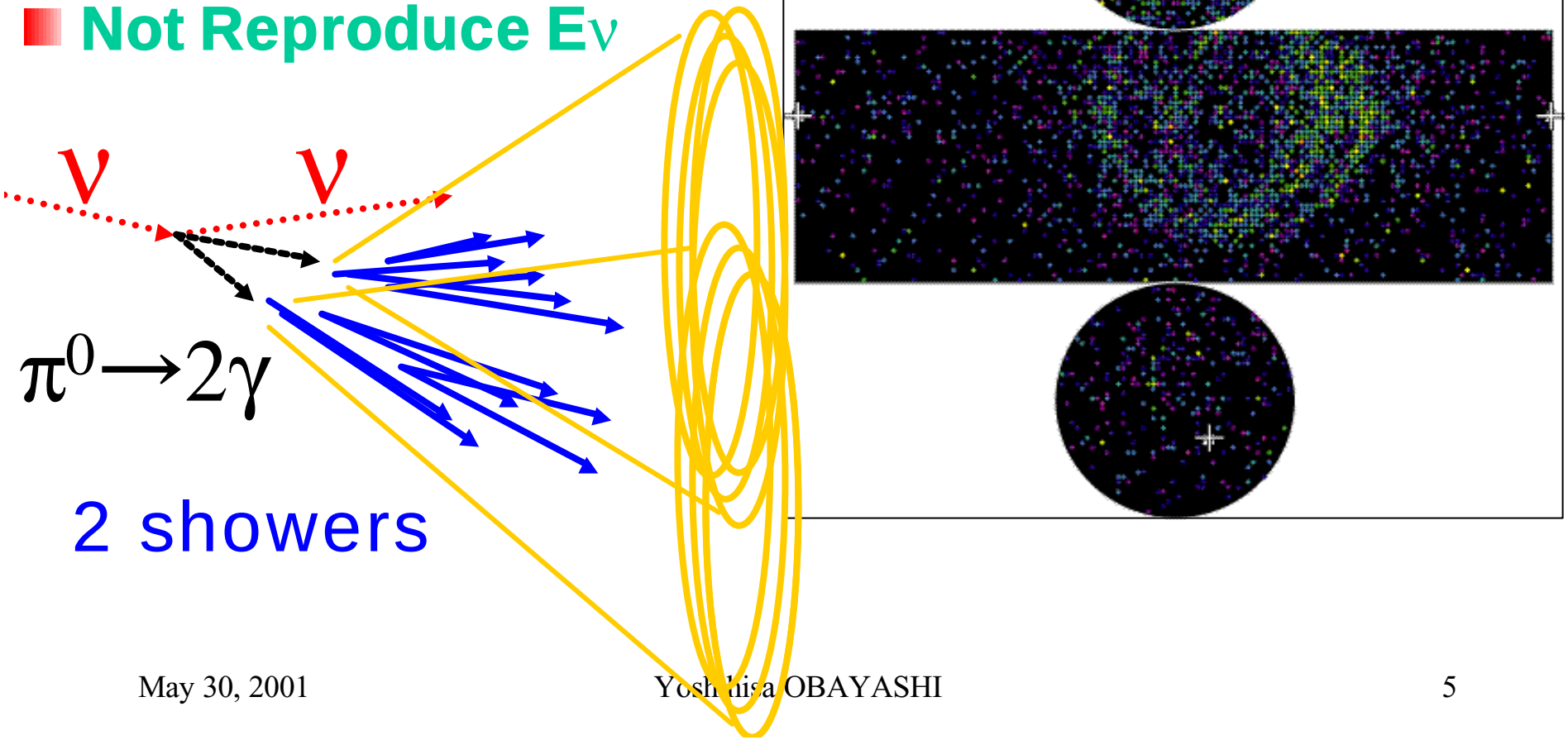
➔Easy to reject





BG(2): N.C. π^0 production

- $\pi^0 \rightarrow 2\gamma$
  - If 2 rings overlap or A ring is too weak
  - ➔single ring like
- Not Reproduce Eν



ν_e selection

- **SK Atmν official selection (single-ring e-like):**
  - Fully Contained (No Anti-counter Activity)
  - Only one ring is reconstructed
  - PID likelihood is e-like (Showering)
  - Evis > 100MeV
  - No Muon Decay Electron

$\Delta m^2=3\times10^{-3}eV^2$, $\sin^2 2\theta\mu e=0.05$

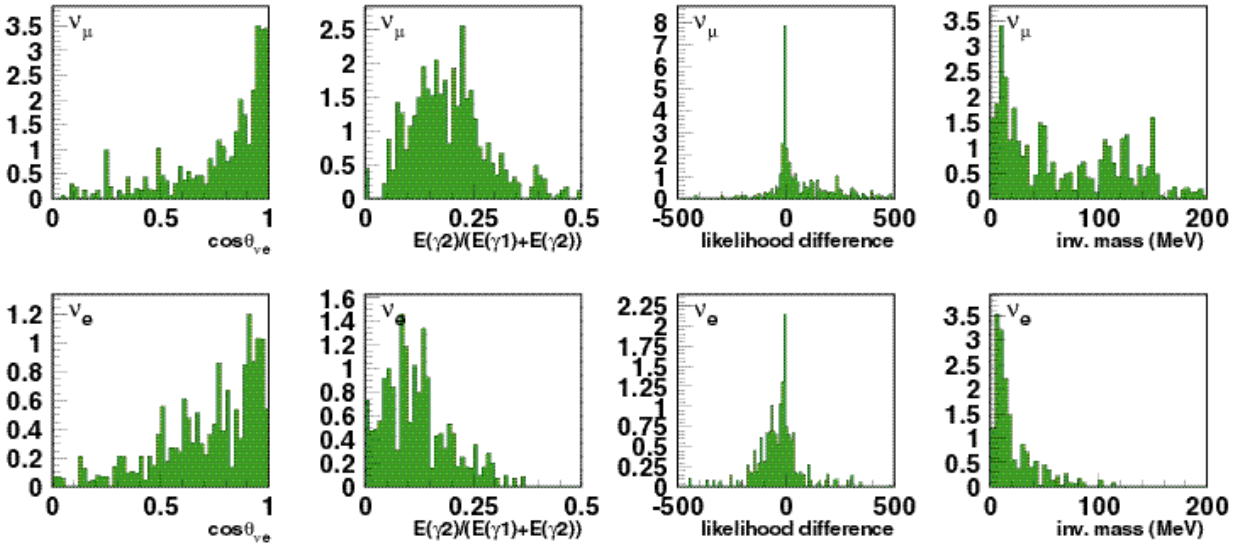
Number of events for JHF(0.77MW) 5yr exposure to Super-Kamiokande(22.5kt)

	$\nu\mu$C.C.	$\nu\mu$N.C.	Beam νe	Osc'd νe
Generated	10713.6	4080.3	292.1	301.6
1ring e-like	14.3	247.1	68.4	203.7
red. eff.	0.1%	6.1%	23.4%	67.5%

➔We need to reject more!

Tight e/π^0 separation

- **Shower direction w.r.t. beam**
  - **cosθ_{ve}: γ from π^0 tend to have a forward peak**
- **Force to find 2nd ring and…**
  - **E(γ_2)/E(γ_1+γ_2): Large for BG**
  - **Likelihood diff. between 1-ring and 2-rings**
  - **Invariant mass: Small for ν_e**



Expected Backgrounds & Signal

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$\sin^2 2\theta\mu e=0.05$

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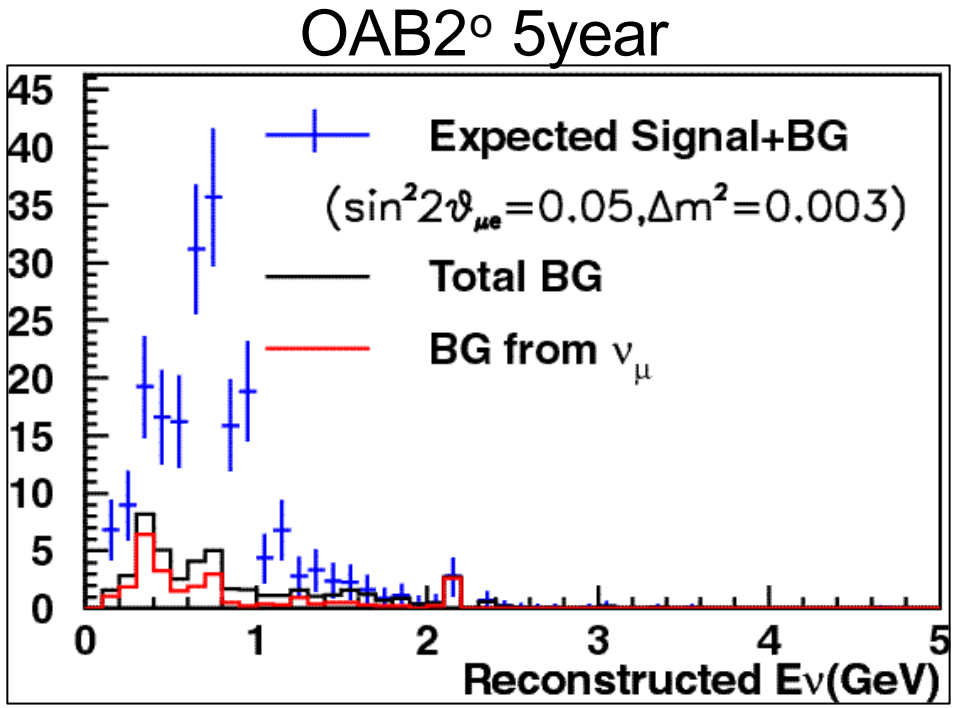
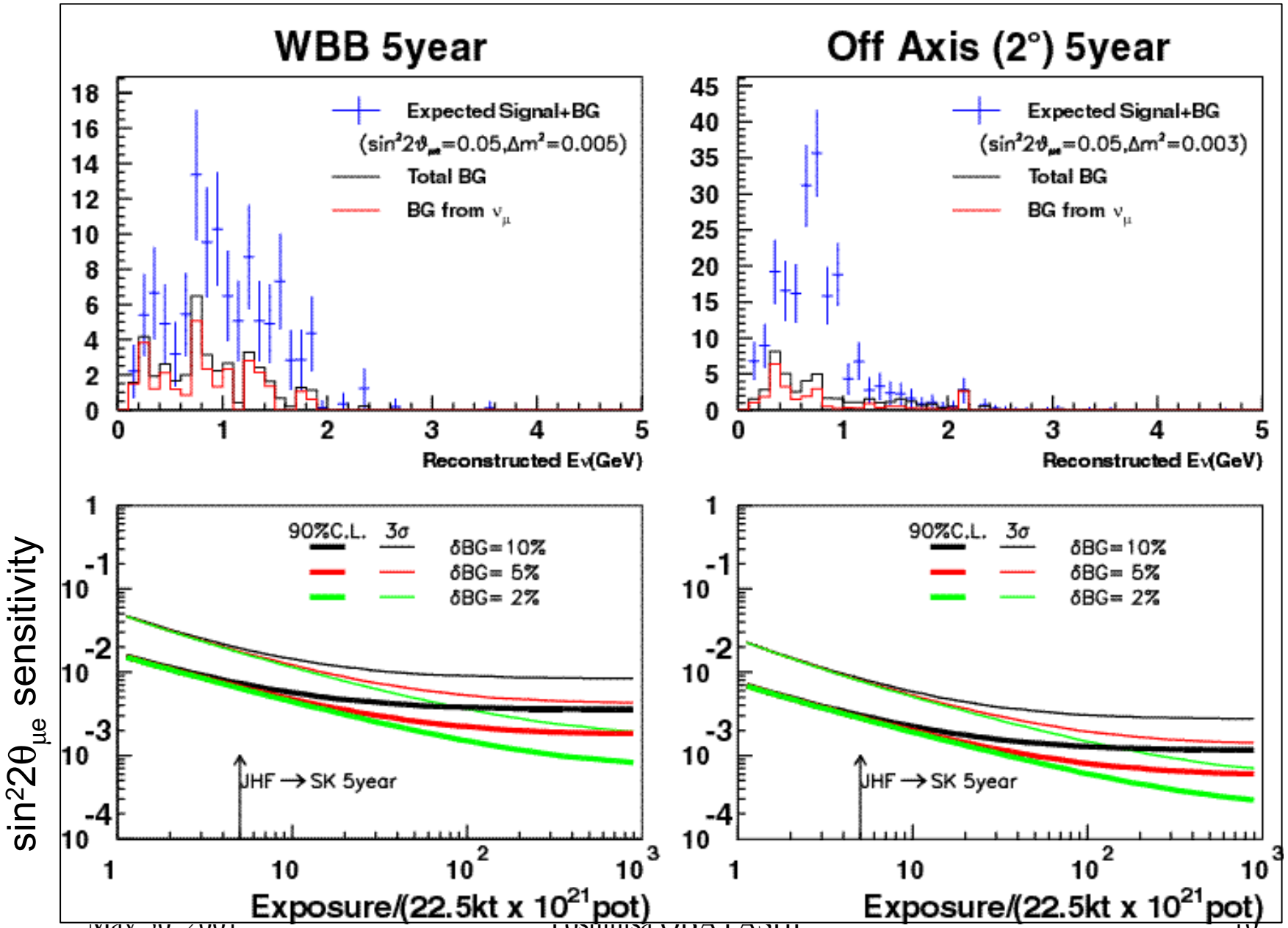
1ring e-like	14.3	247.1	68.4	203.7
red. eff.	0.1%	6.1%	23.4%	67.5%
e/π^0 sep.	3.5	23.0	21.9	152.2
red.eff.	0.03%	0.6%	7.5%	50.4%
.4<Eν<1.2	1.8	9.3	11.1	123.2
red.eff.	0.02%	0.2%	3.8%	40.8%

Expected Signal & BG distribution

- Reconstruct Eν as Quasi-Elastic interaction
- Apply Energy Cut
  - 0.4GeV< E <1.2GeV (OAB2^{o})

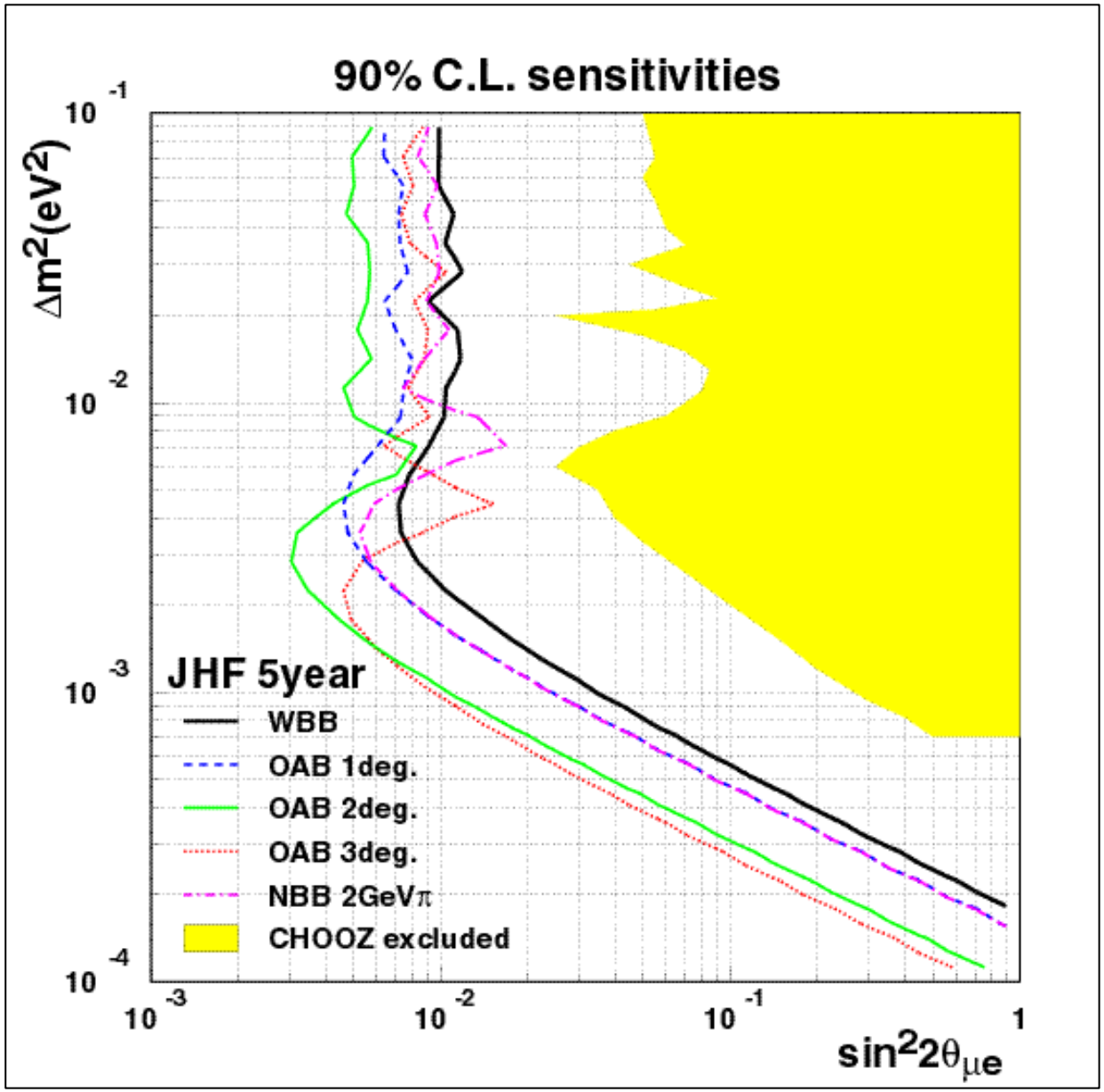


Sensitivity for Mixing Angle



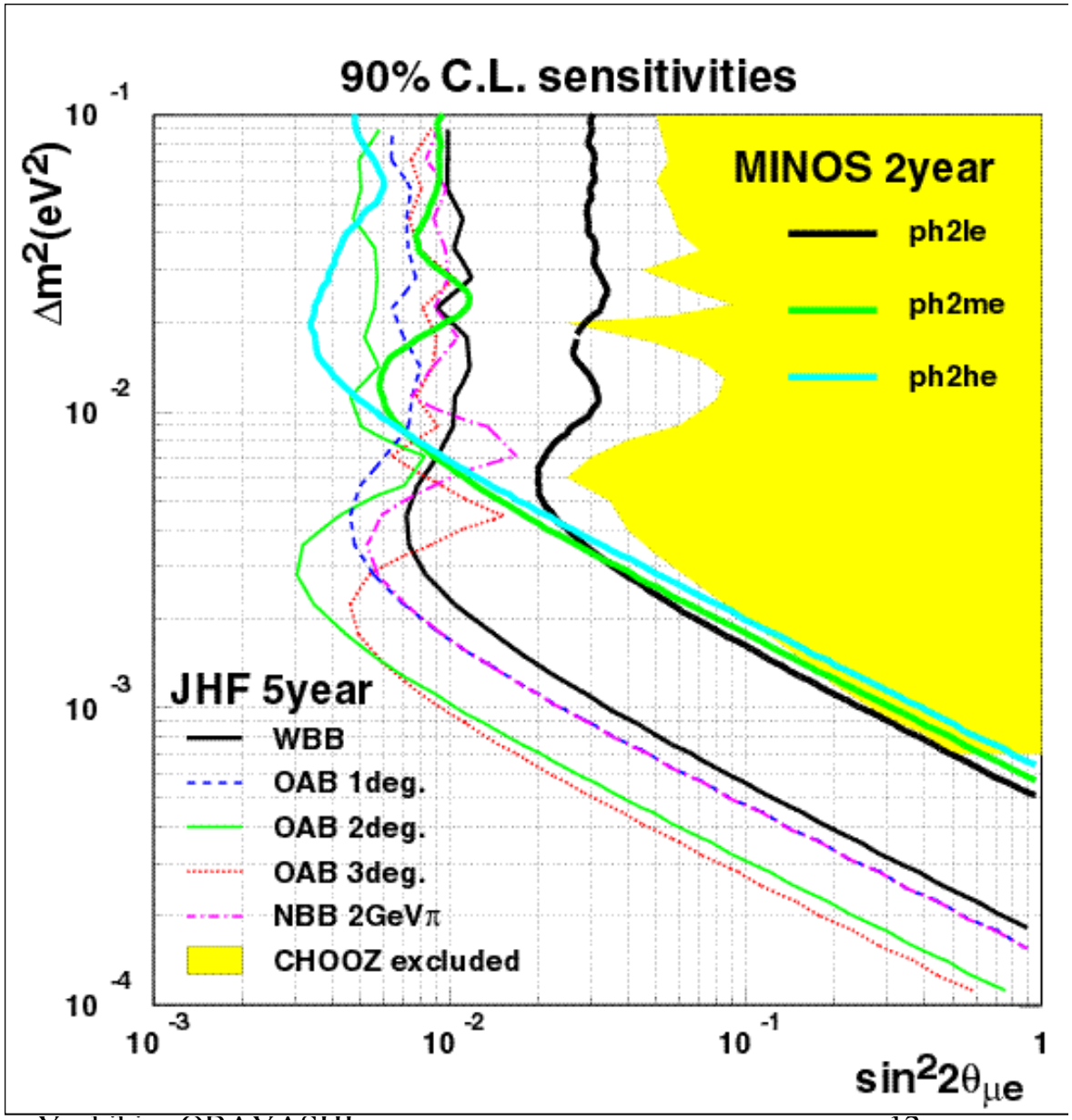
Sensitivities

- Sensitive down to $\sin^2 2\theta_{\mu e} \sim 3\times10^{-3}$ @$\Delta m^2 = 3\times10^{-3}\,eV^2$
- By tuning Eν, sensitive down to $\sin^2 2\theta_{\mu e} \sim 5\times10^{-3}$ in all allowed Δm^2_{atm}
- $\sin^2 2\theta_{13} \sim 1\times10^{-2}$ @90% C.L.



Comparison to Other Projects

- **MINOS:**
  - High Eν
  - $\nu_\tau CC \rightarrow \tau \rightarrow e$ may be a serious BG
- **OPERA(,ICARUS)**
  - Tuned to find ν_τ appearance
  - More high Eν
  - Small Far Detector
- **JHF neutrino has highest sensitivity in ν_e appearance search**



Summary

- ~1 GeV neutrino beam + SK(Water Cherenkov) is a good solution to search:

$$0.01 < \sin^2 2\theta_{13} < 0.1 \quad @ \ \Delta m^2_{atm.}$$

- Expected sensitivity:

$$\sin^2 2\theta_{13} \sim 0.01 \ @ \ 90\%\text{C.L.}$$

- ν_e appearance sensitivity of JHFnu+SK is higher than MINOS, OPERA.