Search for neutrinos from SGR1806-20

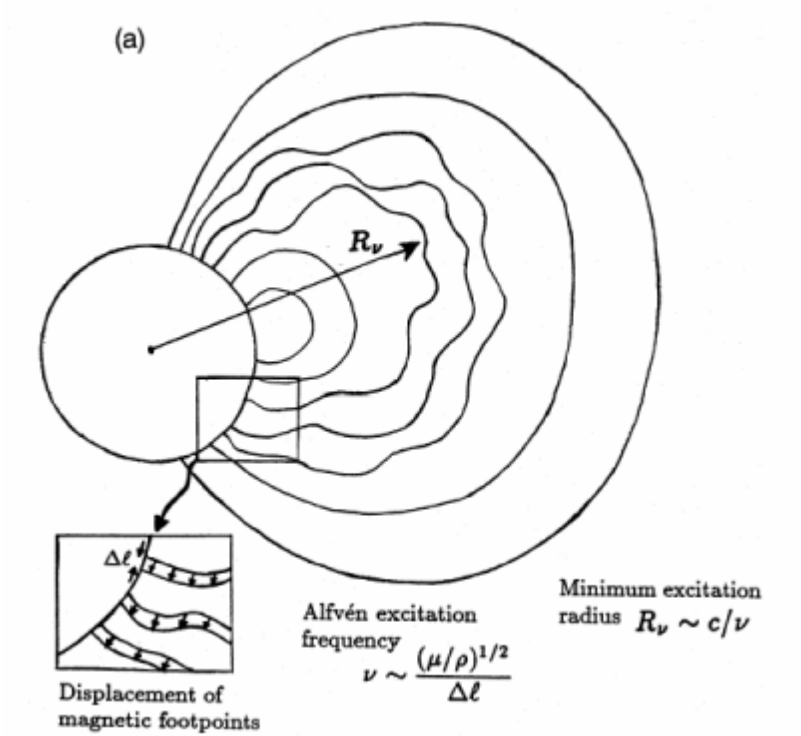
Y.Itow
Solar-Terrestrial Environment Laboratory
Nagoya University

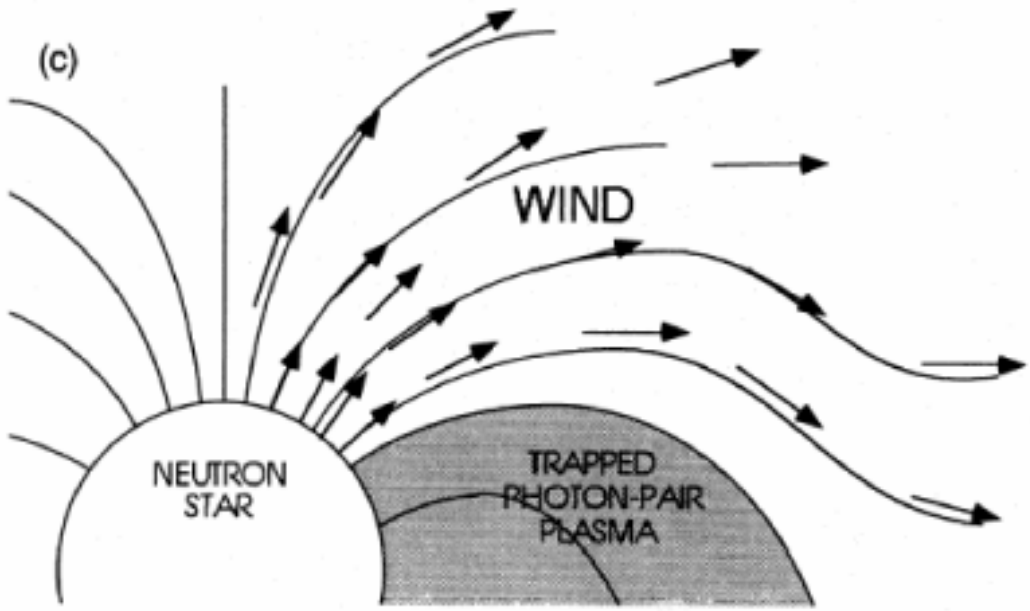
Menu

- Introduction
  - Possible neutrino emission from SGR
  - Neutrino detection
- Super-Kamiokande detector (SK)
- Past GRB ν search in SK
- Rate estimation at SK from SGR1806-20

Introduction

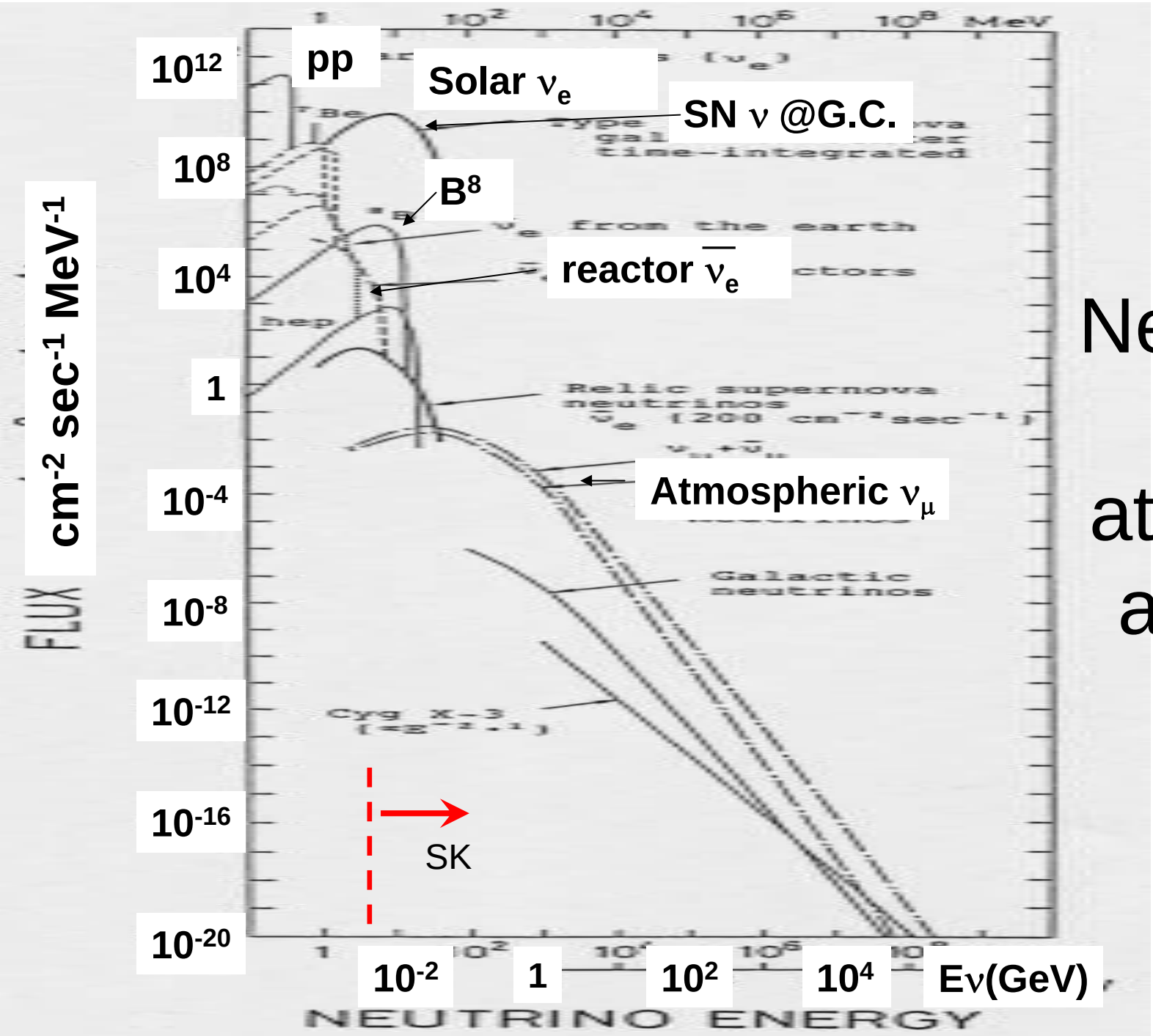
Soft Gamma-ray Repeater (SGR)





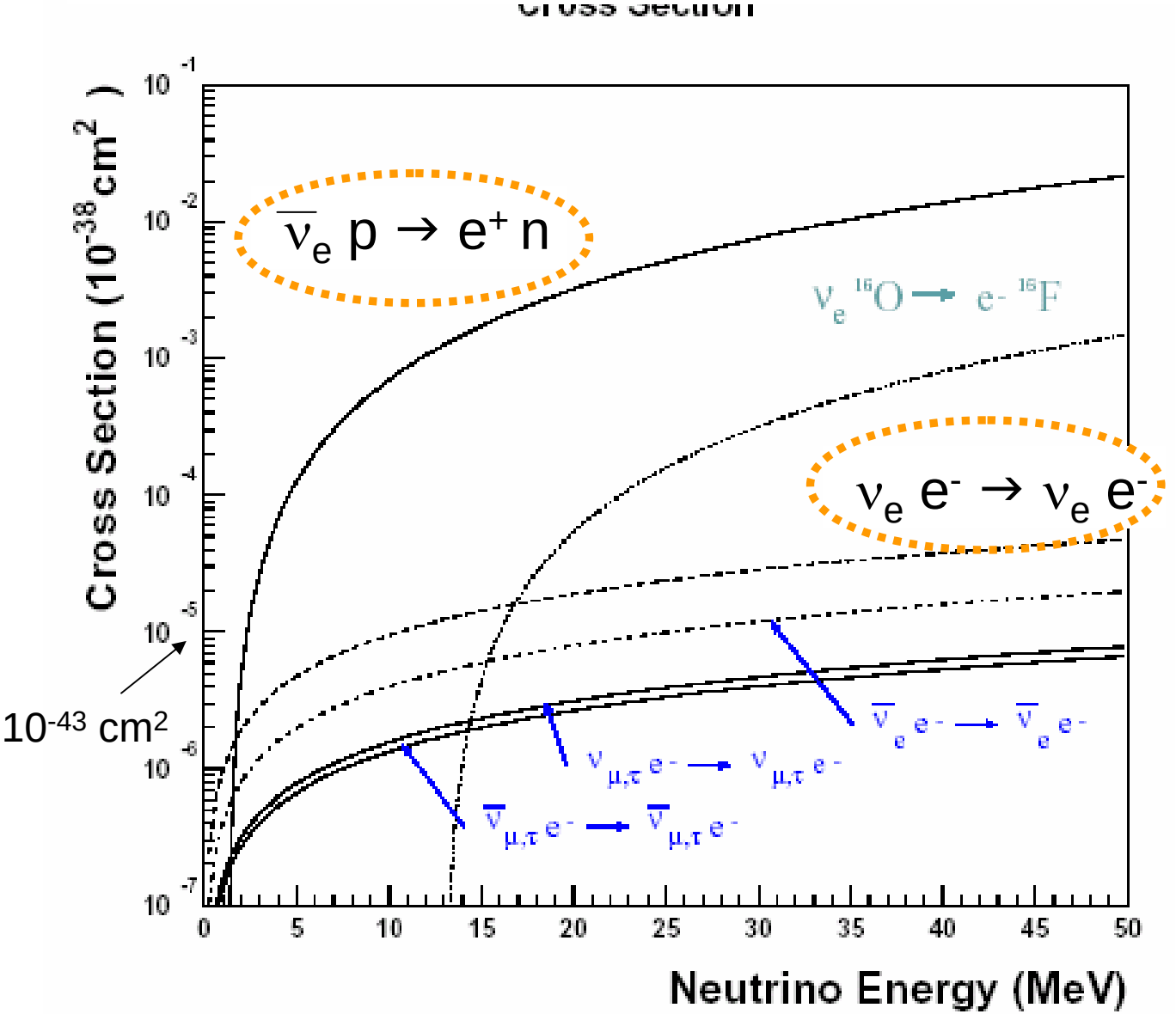
[Thompson and Duncan, MNRAS, 1995]

- Large flare of magnetic filed of neutron star
- Possible source of proton acceleration
  - p +A → N+X+ π+-, $\pi \rightarrow \mu\nu$

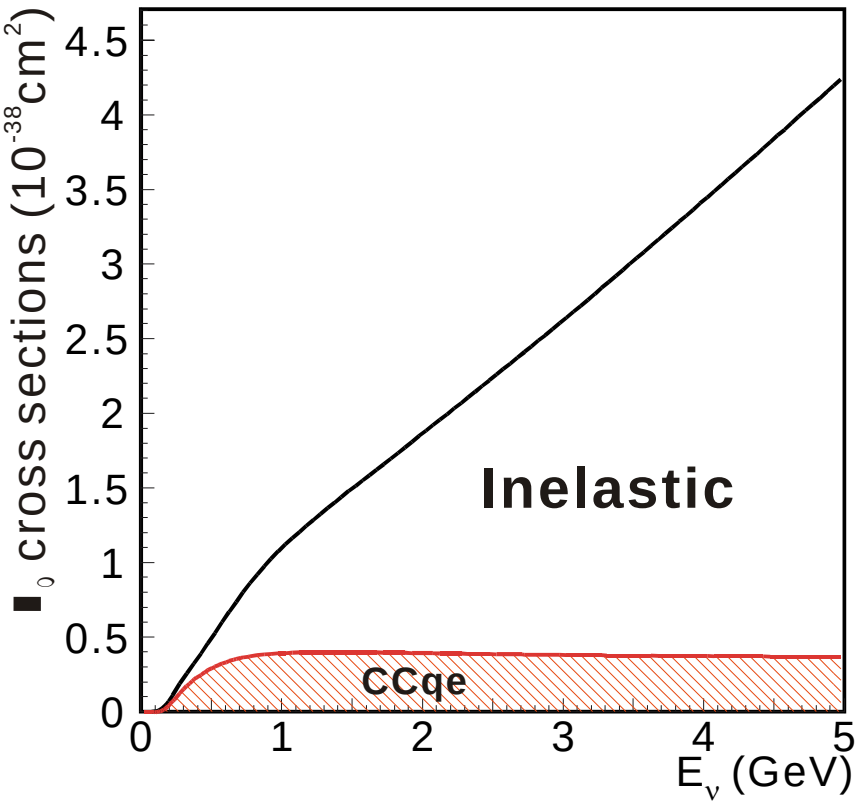


Neutrino flux at Earth as BG

ν interaction @ ~10MeV



ν interaction @ ~GeV



$$\sigma_{CC} \approx 0.5 \times 10^{-38}\,\mathrm{cm}^2 \times E_\nu \text{ (@ 1GeV)}$$

$$\frac{1\,\nu}{\mathrm{cm}^2\,\mathrm{s}} \times \frac{0.5 \times 10^{-38}\,\mathrm{cm}^2}{\mathrm{N}} \times \frac{6 \times 10^{32}\,\mathrm{N}}{\mathrm{kT}} \times \frac{3.15 \times 10^{7}\,\mathrm{s}}{\mathrm{yr}} \sim \frac{100\ \text{int.}}{\mathrm{kt\ yr}}$$

Current neutrino experiment

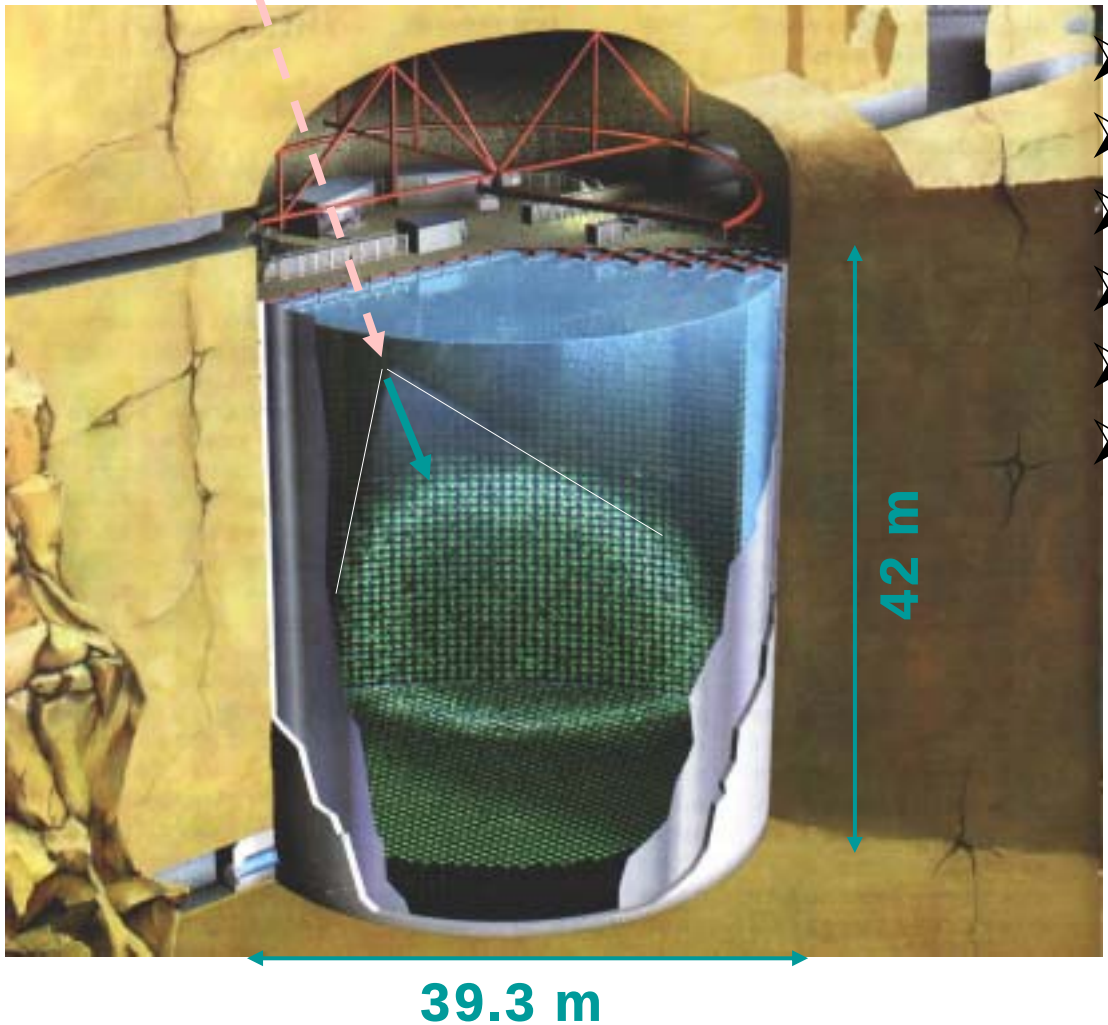
- Solar ν
  - νe scattering (Super-K, SNO…)
  - Radio-chemical (ν_eCl → eAr) (Davis, Gallex …)
- Reactor ν
  - inverse β ($\overline{\nu_e}$ p → e^+n) (KamLAND, …)
- O(~GeV) Atmospheric / accelerator ν
  - ν_x A →ℓX (Super-K, MINOS….)
- O(>100GeV) high energy neutrinos
  - upward going μ (ν int. w/ rock or ice)(AMANDA…)

3 issues for detection method

- Event Yield
  - vertex-contained: target size is detector, but all direction
  - upgoing μ : larger target size than detector. Down-going μ is suffered by cosmic μ.
- Time correlation
  - Radiochemical method has several days for time accuracy
- Directional correlation
  - ~20deg $\nu e \rightarrow \nu e$(@10MeV)
  - ~20deg $\nu A \rightarrow lX$ (@1GeV)
  - ~1deg $\nu A \rightarrow lX$ (@ 100GeV, upgoing μ)
  - no correlation for inverse β, radiochemical

Super-Kamiokande

Super-Kamiokande detector



- 50kt water Cherenkov
- 1000m underground
- ID viewd by 11176 PMT
- 2m thick OD for veto
- Fiducial mass 22.5kt
- E_{th}~5 MeV (~7MeV for SKII)

’96~’01 SK-I
’02~’05 SK-II
(w/ half PMTs)
’06~ SK-III
(restore full PMTs)

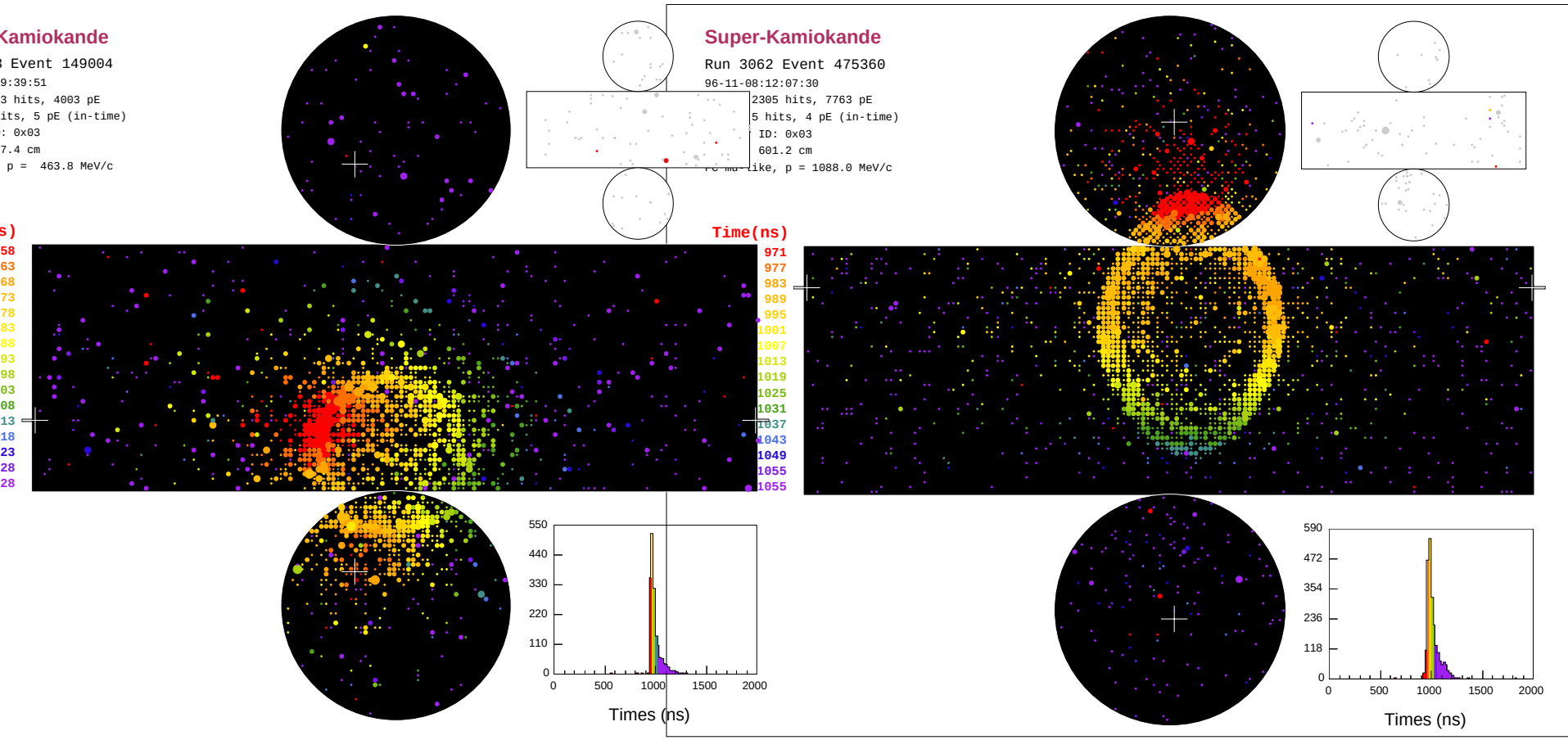
Ring imaging Cherenkov

- **ν + e → ν + e**

ν

Electron

Particle ID for single ring ν event

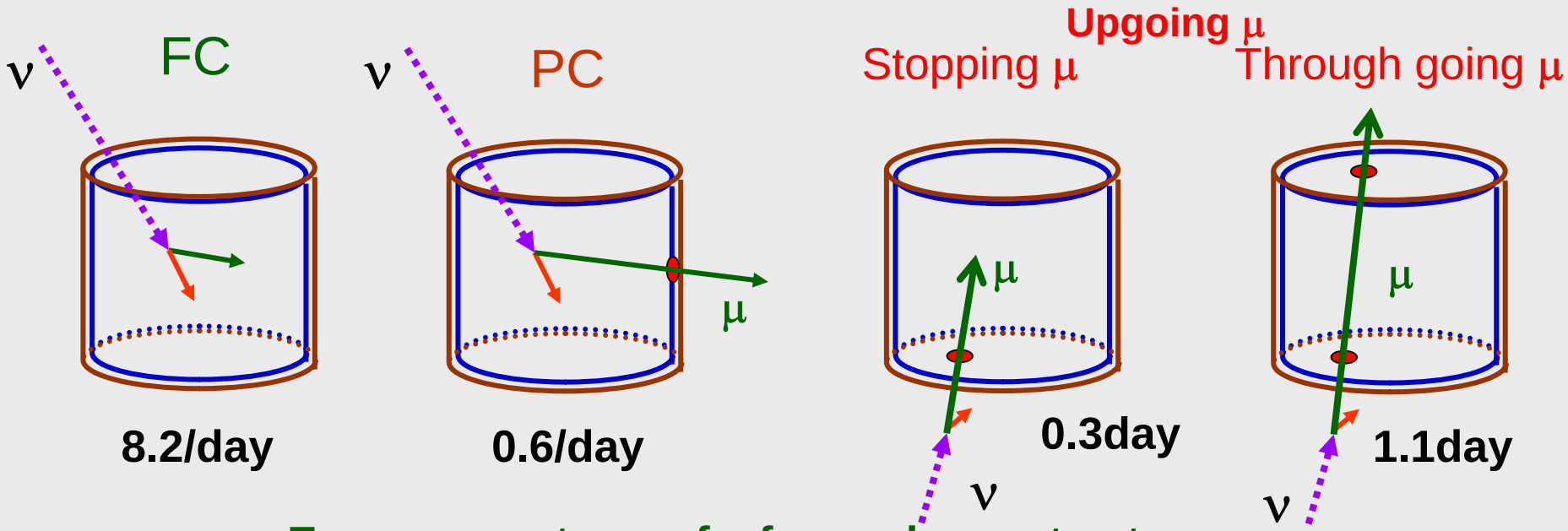


e-like event (mostly CCν_e)

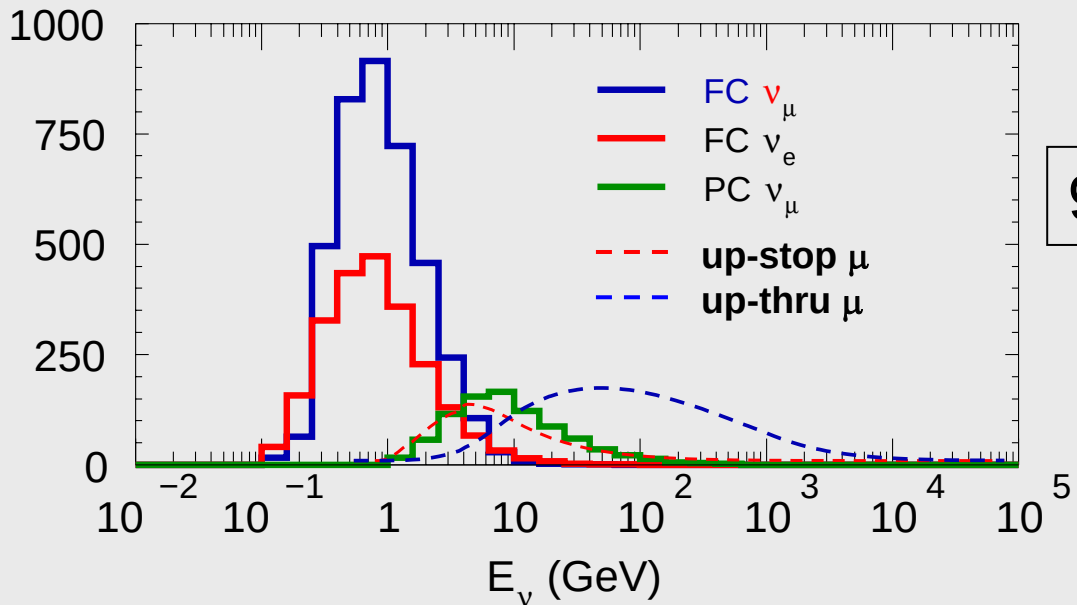
μ-like event (mostly CCν_μ)

CC ν_τ (E_ν>3.5GeV) looks multi ring

Atmospheric ν categories at SK

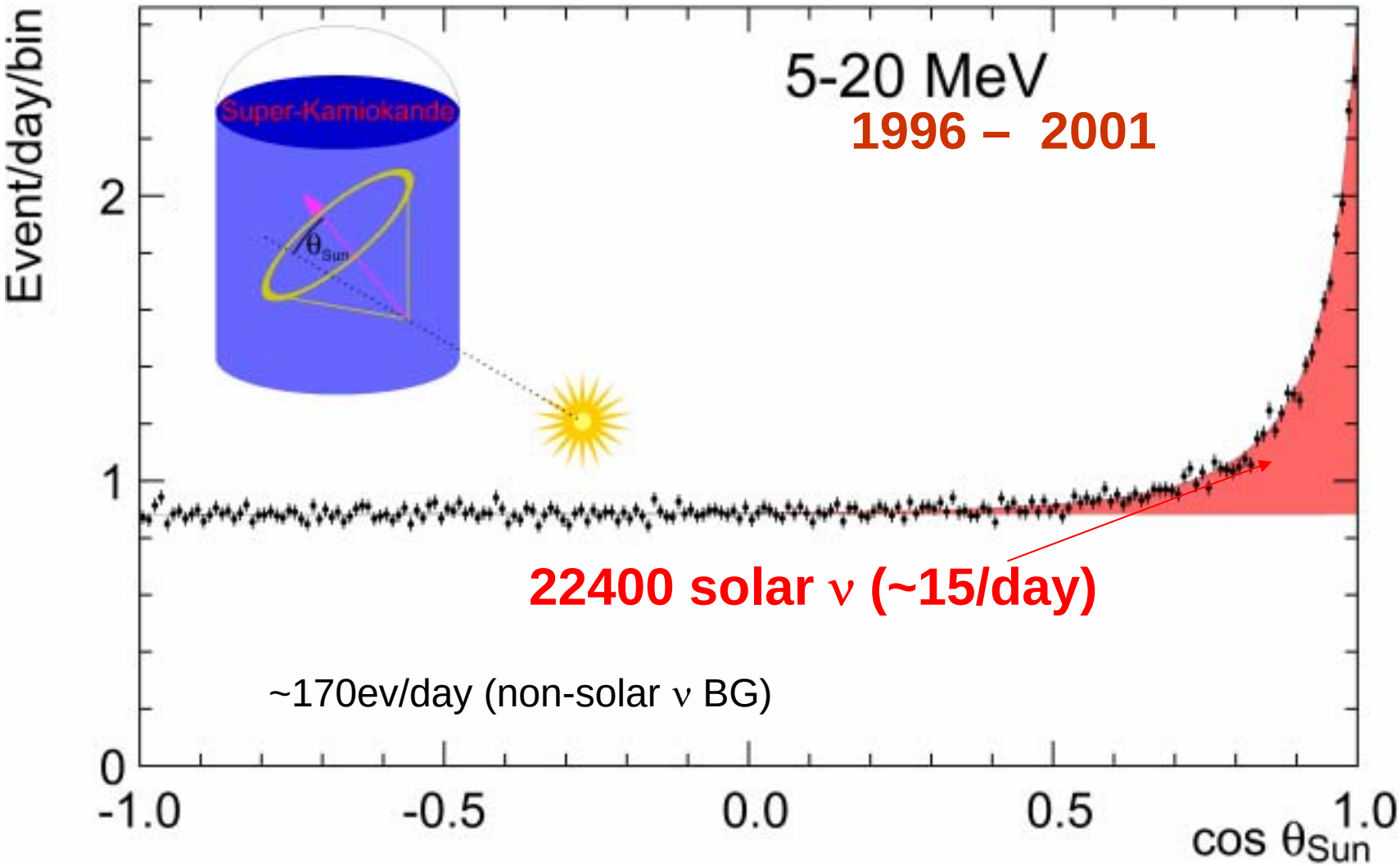


Energy spectrum of ν for each event category



9.9×10^{-5} BGν/sec

cos θ_{sun} Solar ν in Super-Kamiokande



79.8x10^{-5} BGν/sec (E_ν>7MeV)

Current GRBν search at Super-K

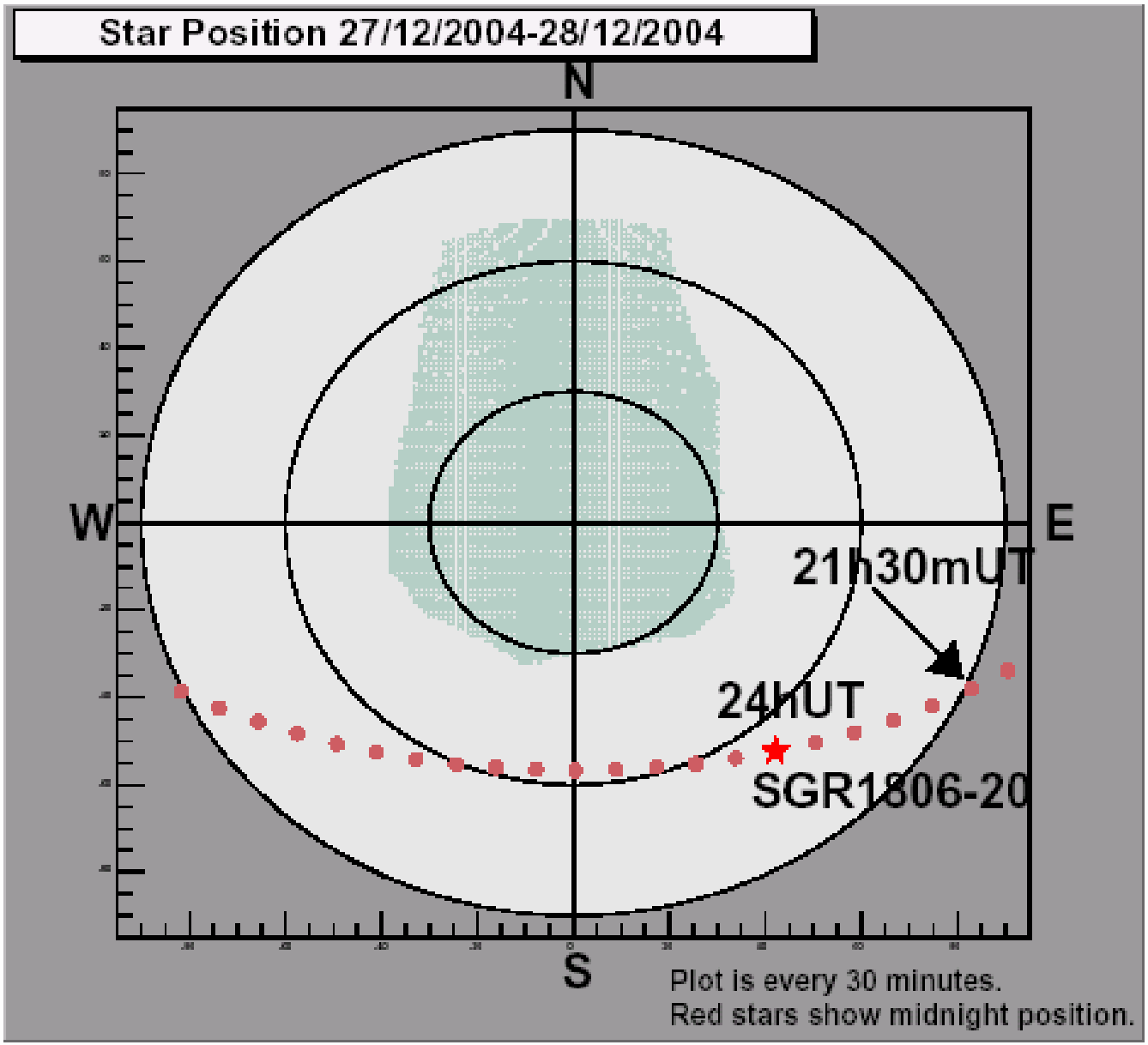
Astrophys.J.578:317-324,2002

- Time correlation with GRBs taken from BATSE catalog
- event rate in +-10sec, +-100sec, +-1000sec, 1hour window
- No significant excess → **Fluence (w/ E^{-2} spectrum assumption)<2.64E6/cm²**

Window	Sample	GRBs	Bgd.[a]	Sig.[b]	Number of GRBs with Max. Sig.[c]	Prob.[d]
±10 s	(LE)	1086	0.0160	1	(11 GRBs)	0.96
	(HE)	1115	0.00198	1	(3 GRBs)	0.38
±100 s	(LE)	1081	0.160	4	GRB 970605	0.026
	(HE)	1111	0.0198	1	(26 GRBs)	0.21
±1000 s	(LE)	1027	1.60	7	GRB 991004D, NTB 961019.51	0.40
	(HE)	1056	0.198	2	(19 GRBs)	0.45
SN-like: (−8 hr, −7 hr)	(LE)	1018	2.87	11	GRB 980601	0.99
	(HE)	1037	0.357	5	GRB 990202B	0.59
AG: (+4 hr, +5 hr)	(LE)	990	2.87	9	NTB 970525.36	∼1.00
	(HE)	1011	0.357	5	GRB 990202A	0.58
±1000 sec; ≤15°	(upmu)	1454	0.00096	1	GRB 991004D	0.75

Possible ν rate estimation from SGR1806-20

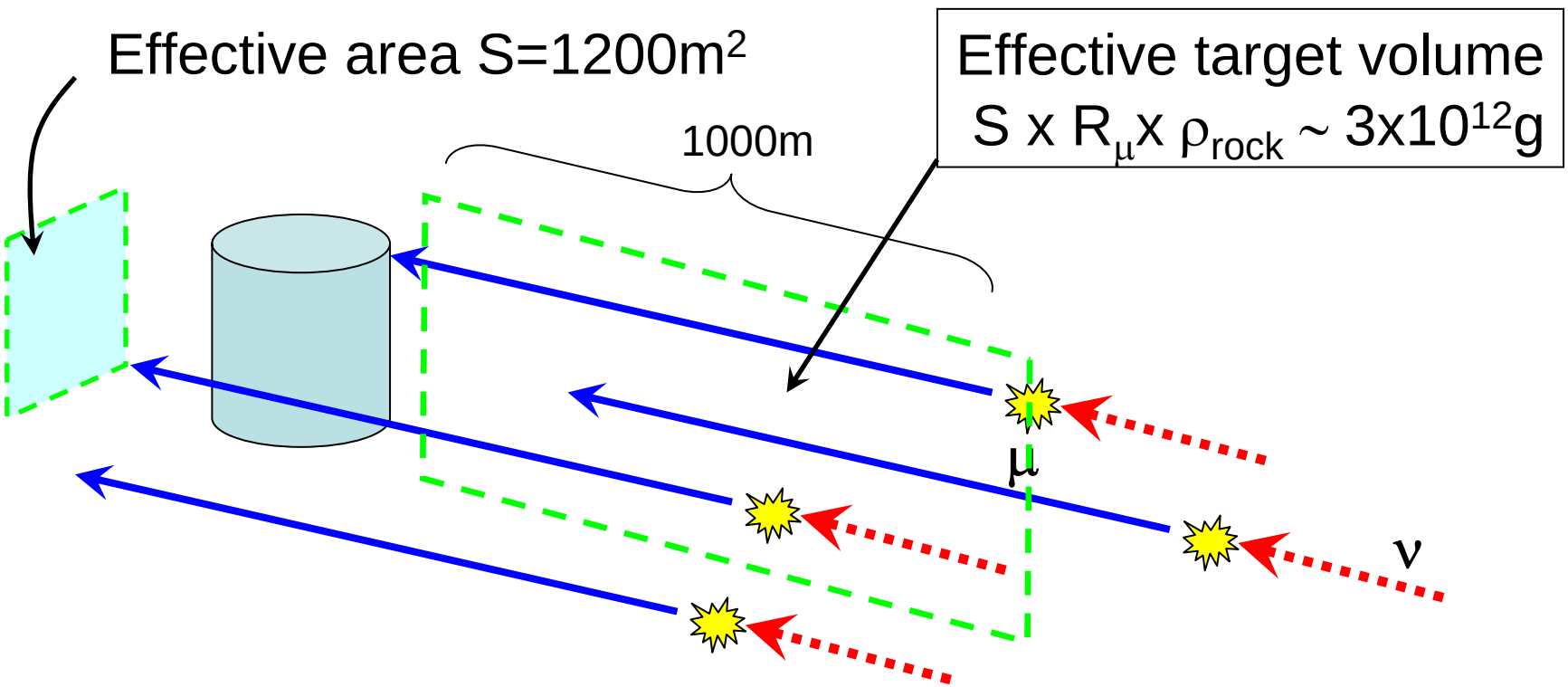
SGR1806-20 direction at Kamioka



Just below horizon

Easy event rate estimation at SK

- 1 TeV ν produces up-going through μ at SK
- Assuming E_μ ~1TeV, R_μ~1000m



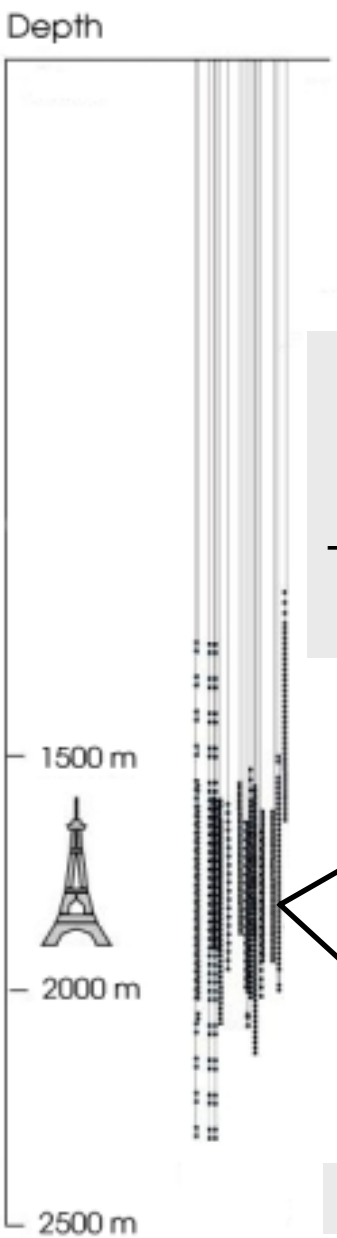
Order estimation of Up-going through μ at SK

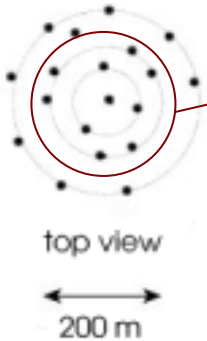
- I use $\Phi_\nu = 10^{-7}\ \nu$ /cm^2/s @Earth w/ typical E_ν=1TeV here (from private communication with Prof Nagataki, YITP Kyoto-U)
- $\sigma \sim 10^{-38} \times E_\nu$ (GeV) cm^2 $\rightarrow 10^{-35}$ cm^2 @ TeV
- Nevt = $\Phi_\nu\ \sigma\ N_t$
  $= 10^{-35}\ (\mathrm{cm}^2) \times 10^{-7}\ (\nu/\mathrm{cm}^2/\mathrm{s}) \times 10^{36}$ (proton)
  ~10^{-6} events/s

Note that PC events is even smaller by 100

Neutrino flux Φ is estimated as $\Phi \sim L_\nu \div E_\nu$(typical) here. Since $\sigma(E_\nu) \propto E_\nu$, this results might not depends on typical E_ν assumed here

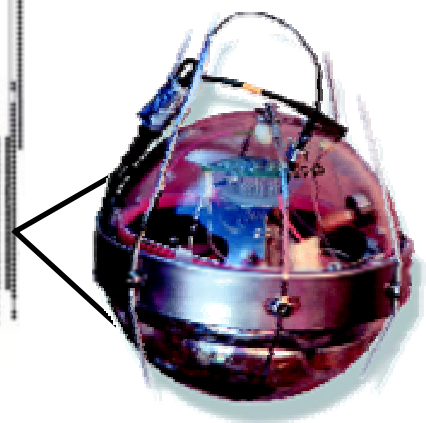
The Antarctic Muon and Neutrino Detector Array



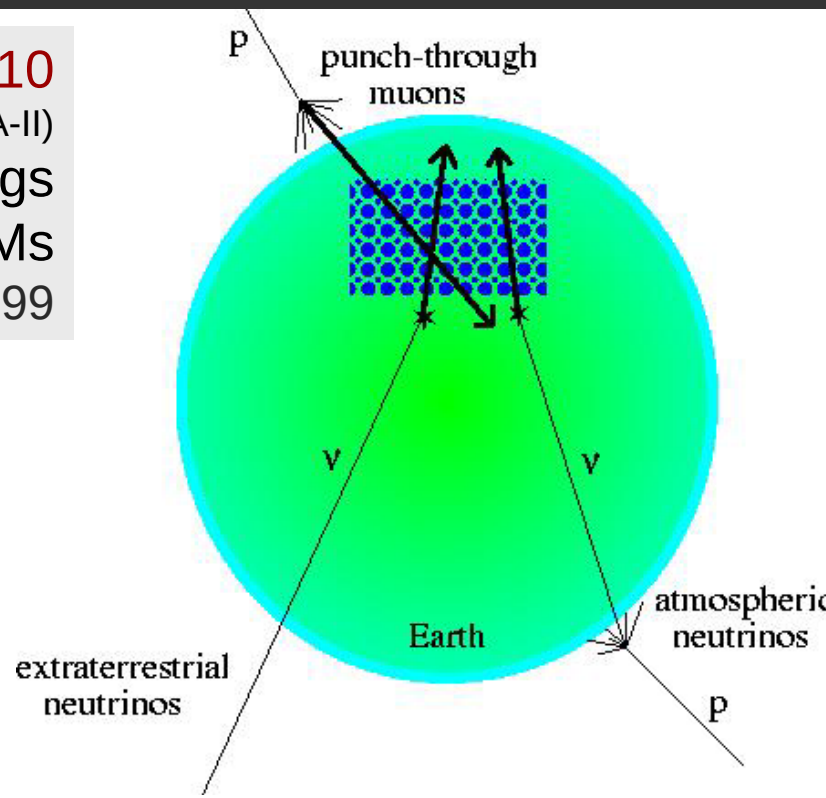


AMANDA-B10
(inner core of AMANDA-II)
10 strings
302 OMs
Data years: 1997-99

AMANDA-II
19 strings
677 OMs
Trigger rate: 80 Hz
Data years: 2000-

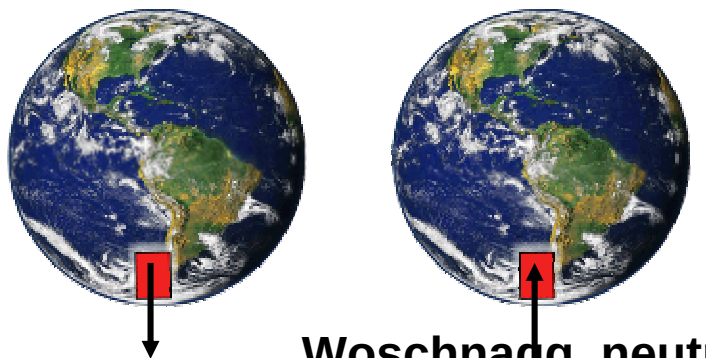


Optical Module
PMT noise: ~1 kHz



"Up-going"
(from Northern sky)

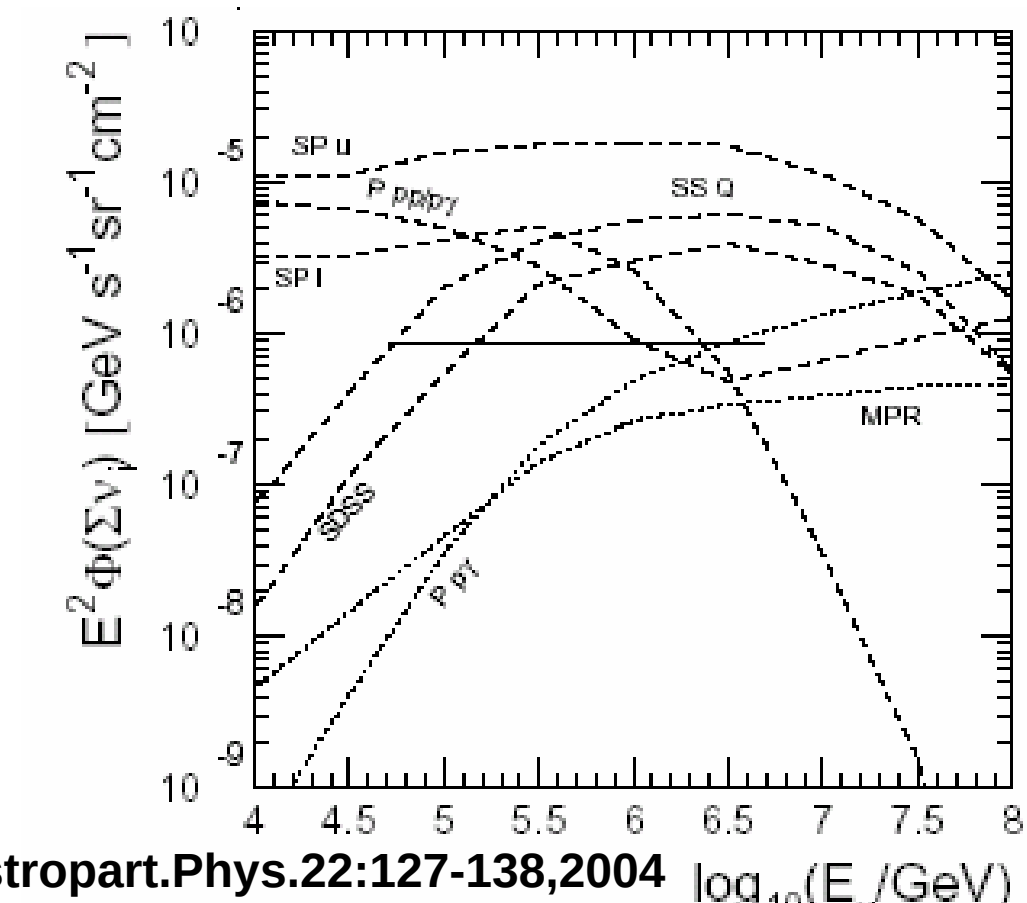
"Down-going"
(from Southern sky)



Woschnagg, neutrino2004

Can AMANDA detect ?

- AMANDA up-going μ is only sensitive to northern hemisphere.
- Possible sample is “cascade sample “
  - Flux limit $E^2\Phi$<8.6E-7 GeV/s /sr /cm^2
  - But E_ν>50TeV



Astropart.Phys.22:127-138,2004

Summary

- SGR1806-20 may possibly emit neutrinos via π decay from pp collision
- Super-K, at Northern hemisphere, can be the most sensitive to it (c.f. AMANDA)
- Very rough estimation of flux based on pulser wind picture gives ~10^{-7} /cm^2 sec (c.f. Prof. Nagataki), which gives negligible event rate, ~10^{-6} ν events, @Super-K
- But a model is a mode. Experiments must keep searching.