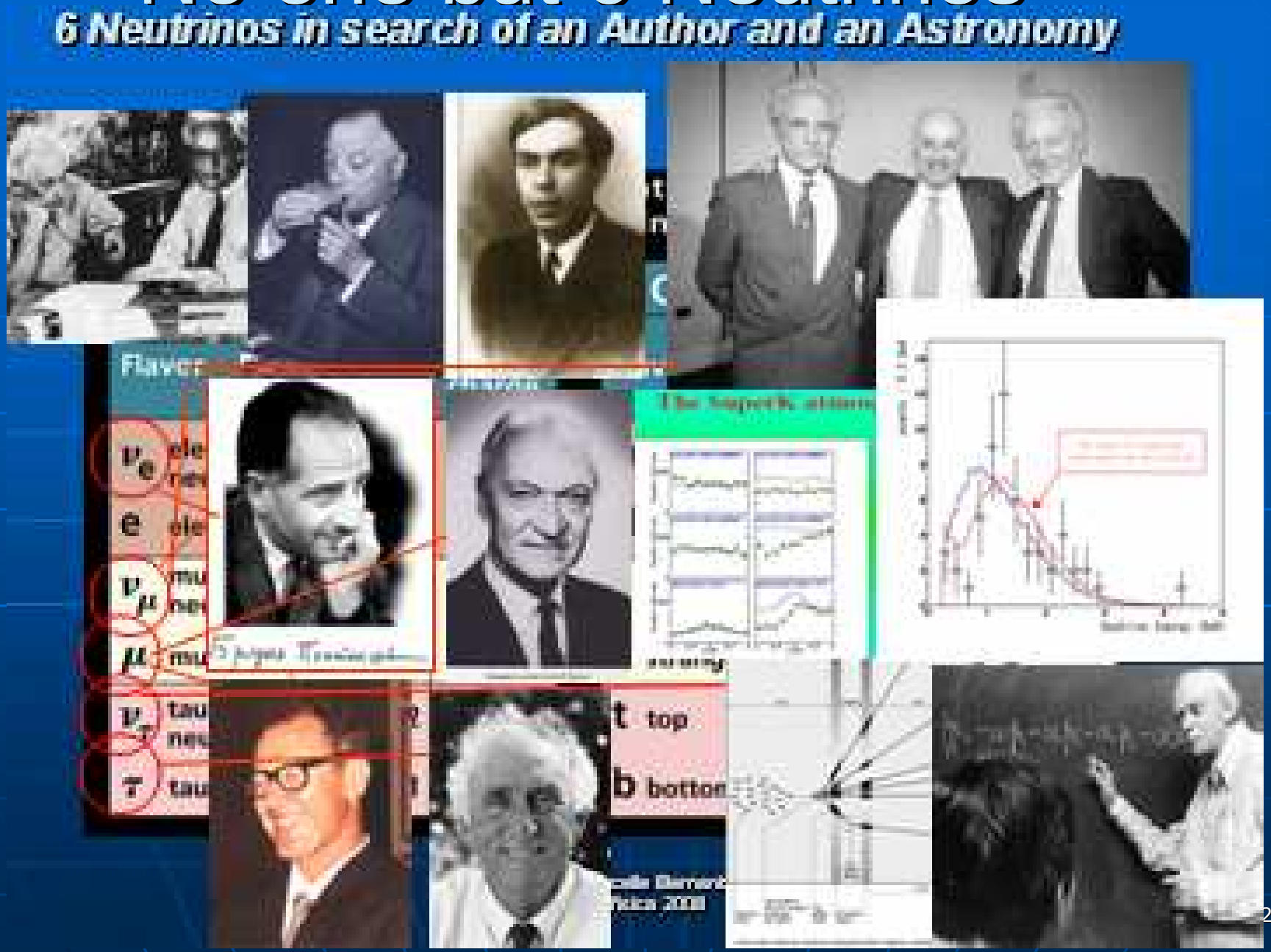
Underground megatons detectors :Solar ν Flares ***and Andromeda SN prompt ν -GW discover***

D.Fargion-Rome University1, INFN, Italy

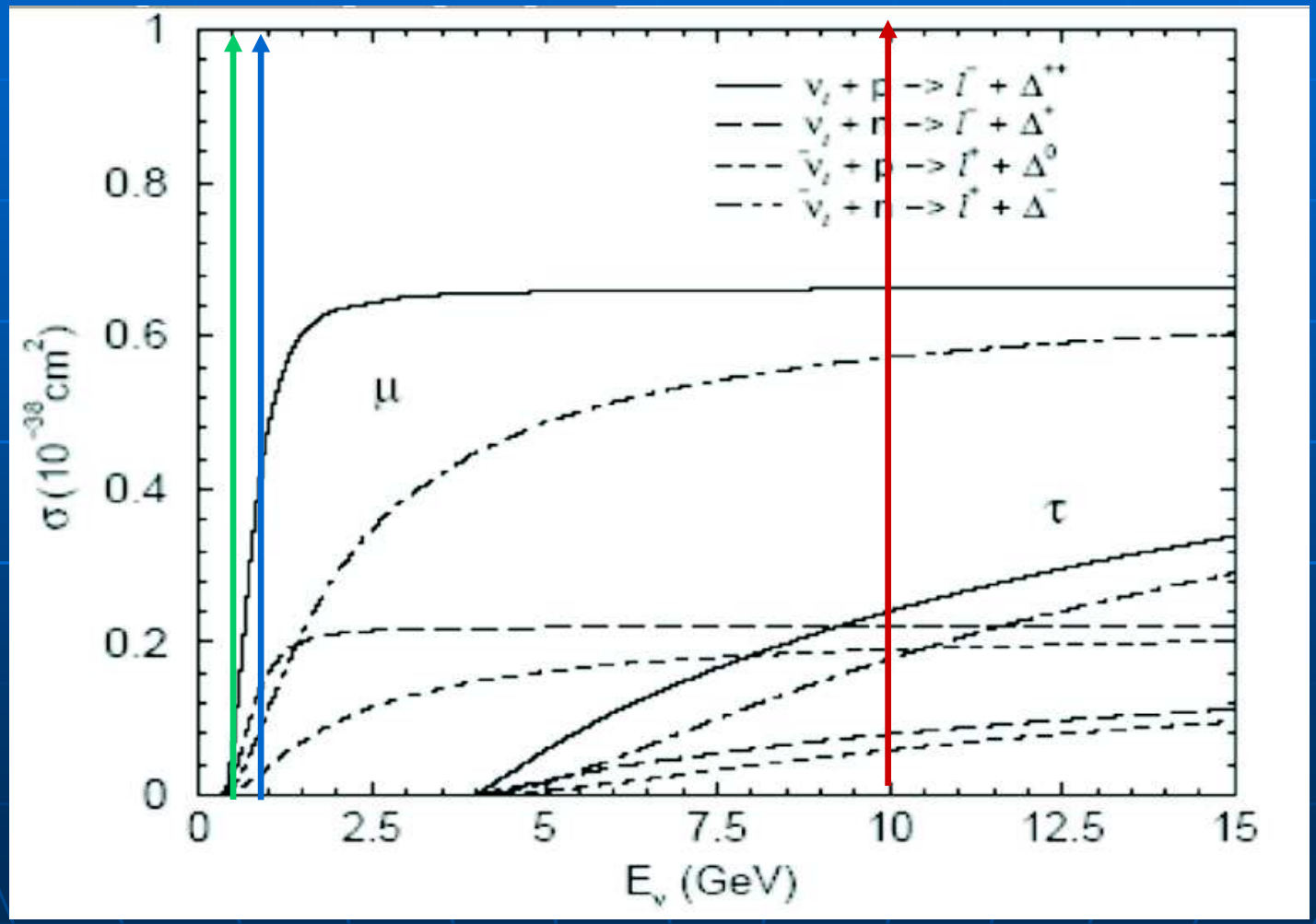
- ***A first , few MeVs Solar Neutrino Astronomy was opened by Davis, SK, Gallex, SNO last four decades.***
- ***Supernova neutrino 1987A Astronomy was oneshoot event two decades ago.***
- ***UHE GeVs- TeVs (Muon) Neutrino Astronomy are masked by abundant atmospheric neutrino noise..Maybe soon ICECUBE may rise clustering.***
- ***UHE Cosmogenic Tau Neutrino in EeV energy , via Tau Airshowers in AUGER is within horizons a few years from now.***
- ***Supernovae Relic background via Gadolinium at edge.***
- ***Solar tens MeVs Neutrino Flare is low energy <u>garanteed ,</u> but not too rare, <u>new</u> solar Astronomy testing in principle all Neutrino Flavours Astronomy, at SK or UNO detection mass thresholds* : for energetic events muons and taus might be born too.**

SN neutronization neutrinos versus GW detecting neutrino mass splitting

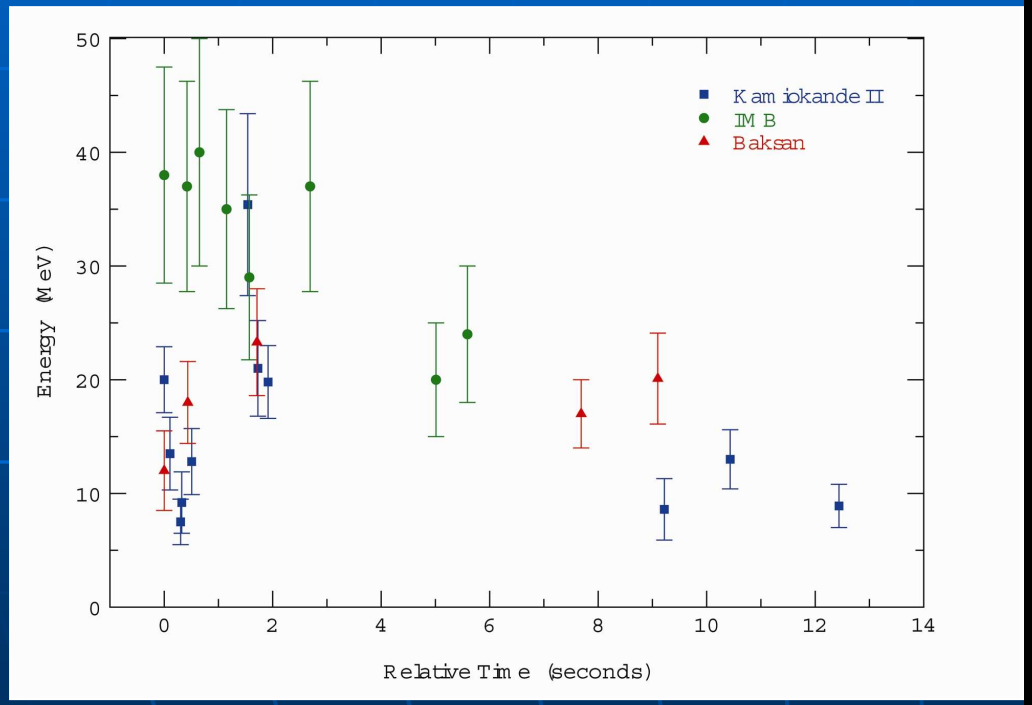
No one but 6 Neutrinos

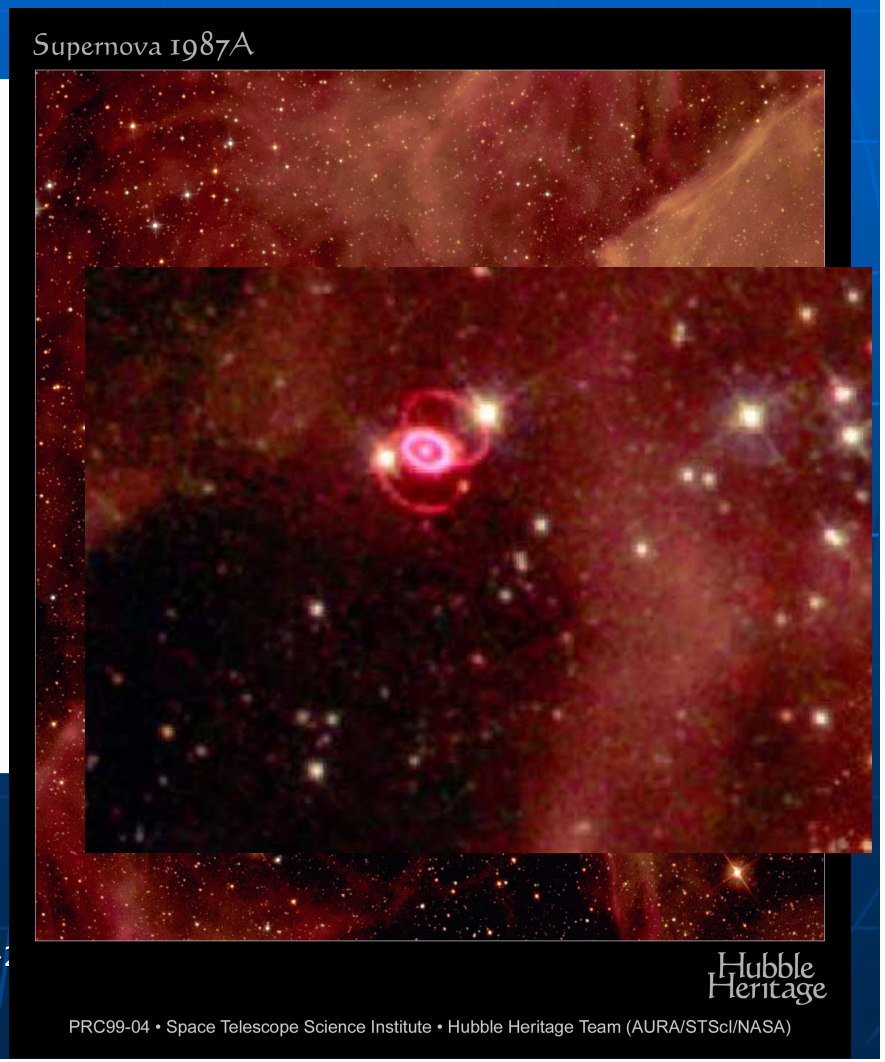


The lepton thresholds

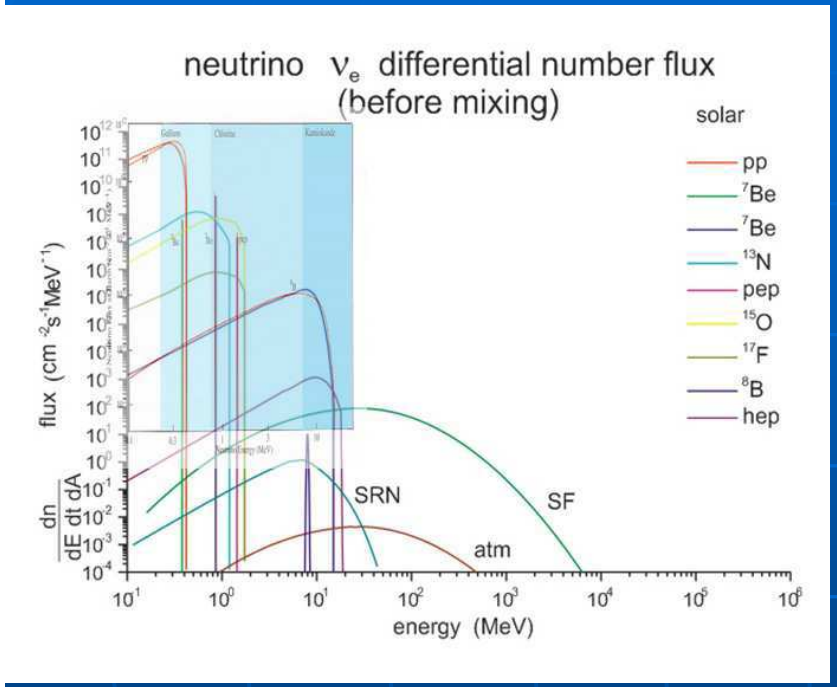


Neutrino events by SN 1987A in LMC in KII

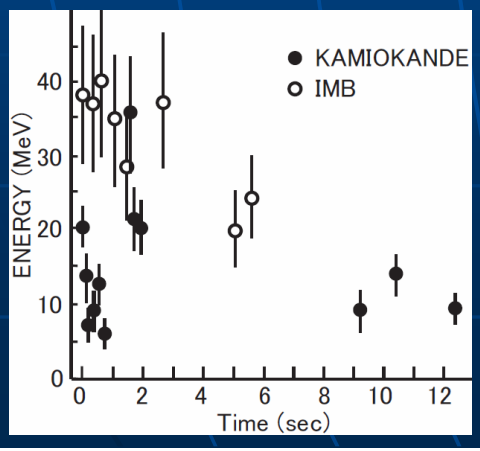




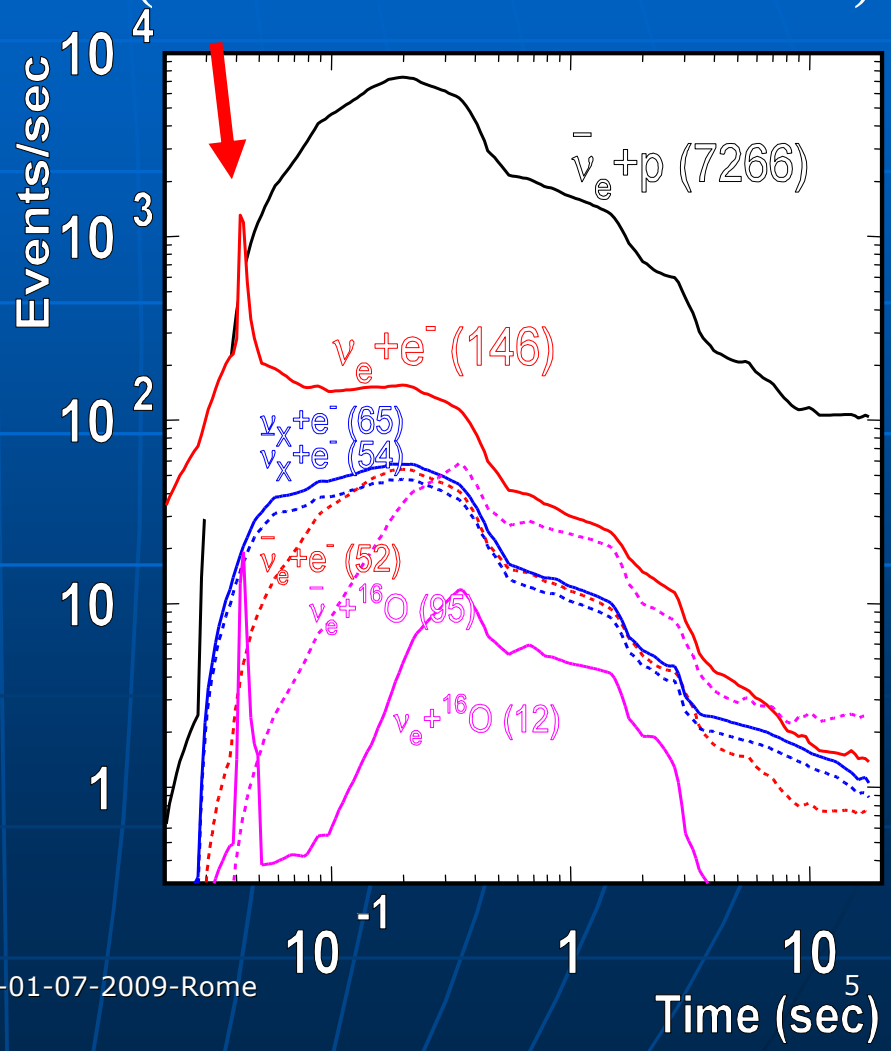
Supernova Neutrinos



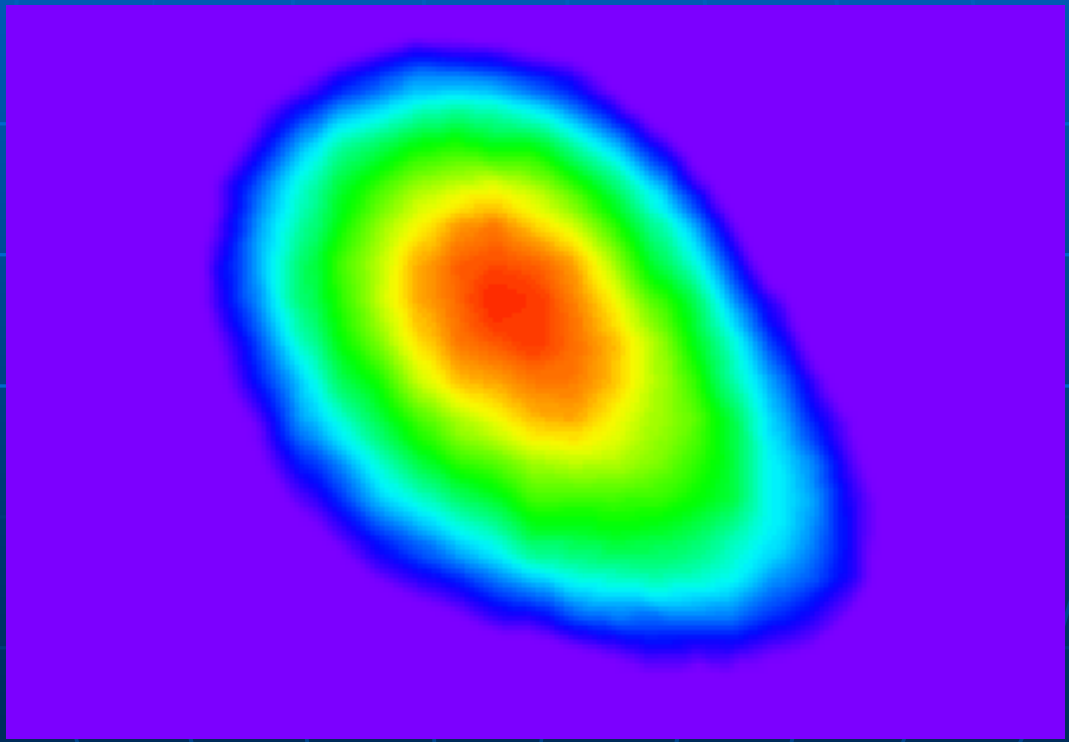
(1987)



Expected for
Super-KAMIOKANDE at 10kpc,
(ν-oscillation effects not included)



Additional Anti-Matter signals from Solar Flare: (as OSSE Neutrons June 1991) an earlier and rarest Anti-Neutron (above threshold 6.5 GeV) signal in GLAST followed by more abundant Neutrons and latest protons



From half century ago..1956
Neutron Solar Flare (J.Simpson)
:In one hour tenfold CR neutrons→ almost half a day CR→ 3-4 neutrino atmospheric expected → 3-4 from Solar Flare?

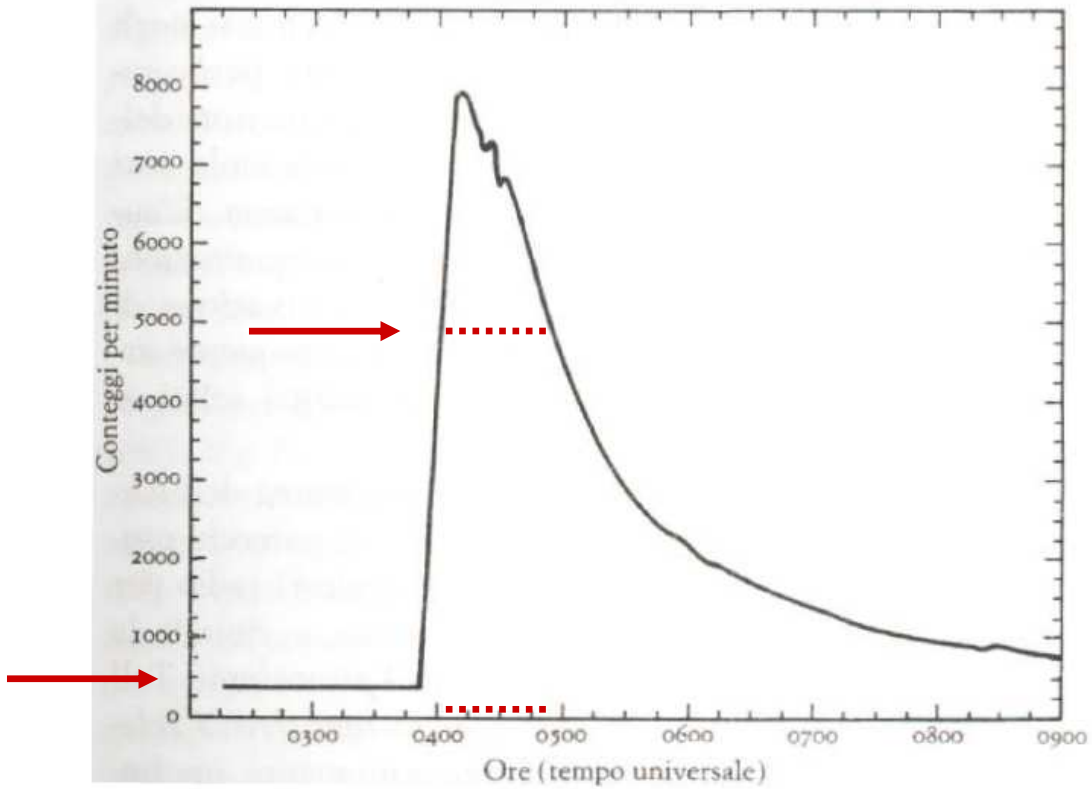


Figura 14.1: Aumento del numero di conteggi d'un contatore a neutroni a Chicago, dopo il brillamento solare del 26 febbraio 1956. (Da John Simpson, in «Proceedings of the National Academy of Sciences of the United States of America», vol. XLIII, 1957, p. 42)

Detecting Solar Neutrino Flare and Flavors
by *D.Fargion :*
JHEP 0406 (2004) 045
see also D.F. Phys.Scripta T127 (2006) 22-24
D.Fargion, P.Di Giacomo,astro-ph *0812.4592, Nucl. PhysB 2009*

D.Fargion,F.Moscato
" Muon and Tau Neutrinos Spectra from Solar Flares",
Chin. J.
Astron. Astrophys.Vol 3.Suppl.75-86. 2003.

Flare-Supernova 1987A energy Fluence Ratio

$$\frac{\Phi_{FL}}{\Phi_{SN}} \simeq \frac{E_{FL}}{E_{SN}}\left(\frac{d_{SN}}{d_{\odot}}\right)^2 \simeq \frac{1}{30}\left(\frac{E_{FL}}{10^{32}\ erg}\right)\left(\frac{E_{SN}}{3\cdot 10^{53}\ erg}\right)^{-1} \qquad (1.1)$$

$$10^{32}\ erg \sim\geq E_{FL} \geq 10^{31}\ erg \qquad (2.1)$$

$$\Phi_{FL} = 3.5\cdot\eta\cdot 10^{4}\ erg\ cm^{-2}\left(\frac{E_{FL}}{10^{32}\ erg}\right) \qquad (1.2)$$

Neutrino event expected in SK from SN 1987A versus SOLAR FLARE = 242 : 30 = 8

TABLE IV: Signal totals for various processes in representative supernova detectors at 10 Kpc [39]. ν_μ represents ν_μ, ν_τ, $\bar{\nu}_\mu$, $\bar{\nu}_\tau$.

Reaction	SNO	Superkamiokande	LVD
$\bar{\nu}_e$ p	331	5310	342
$\nu_e e^-$	12	77.6	8.04
$\bar{\nu}_e e^-$	6	16.9	1.49
$\nu_\mu e^-$	7	49.9	3.28
ν_eO (CC)	3	36.0	-
$\bar{\nu}_e$O (CC)	3	45.5	-
ν_xC	-	-	22
ν_ed (CC)	81.9	-	
$\bar{\nu}_e$d (CC)	66.7	-	
ν_ed (NC)	35.2	-	
$\bar{\nu}_e$d (NC)	37.2	-	
ν_μd (NC)	200	-	

Core-Collapse Astrophysics with a Five-Megaton Neutrino Detector

Matthew D. Kistler,[1,2] Hasan Yüksel,[1,2] Shin'ichiro Ando,[3] John F. Beacom,[1,2,4] and Yoichiro Suzuki[5,6]

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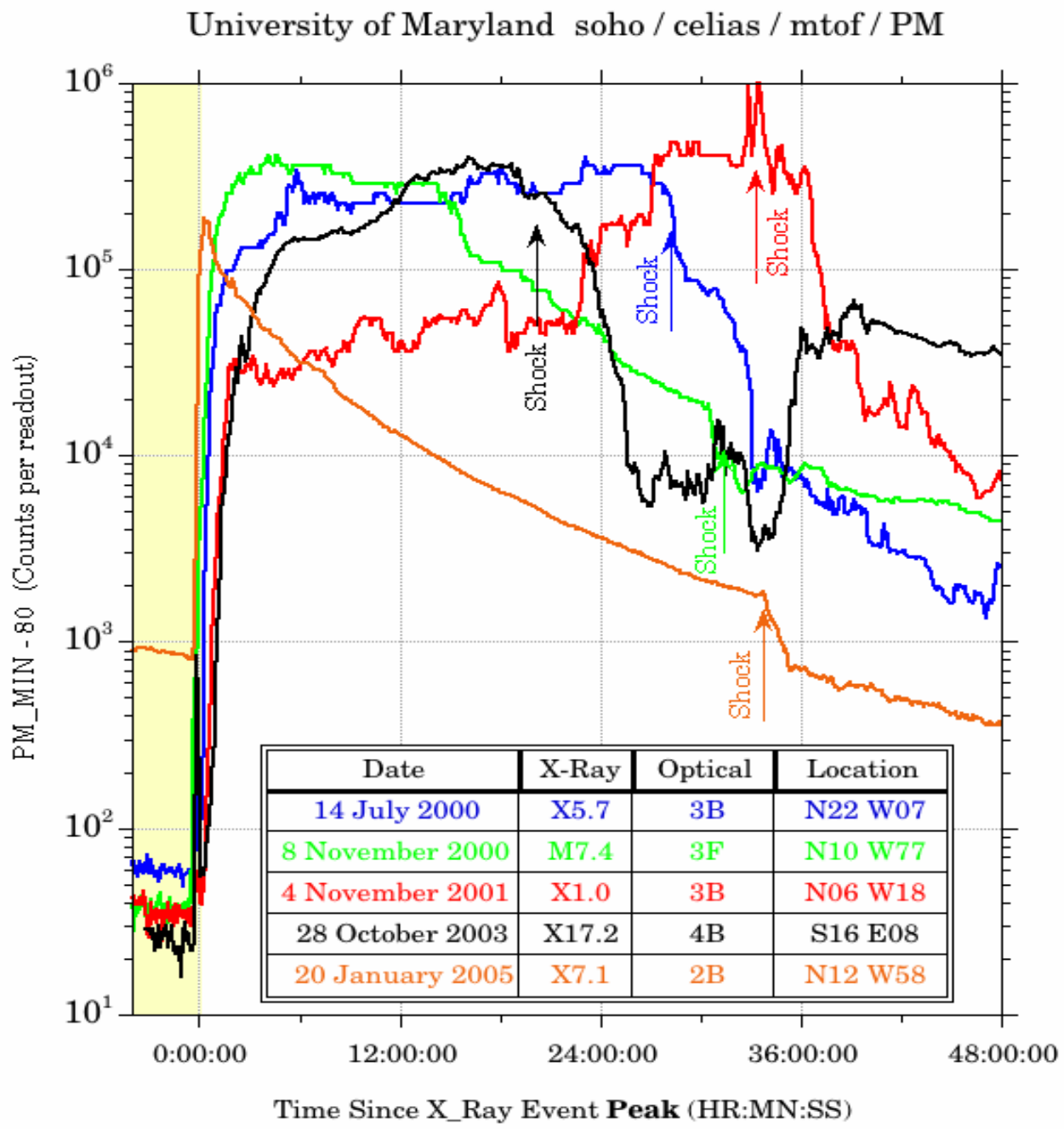
[2] *Center for Cosmology and Astro-Particle Physics, Ohio State University, Columbus, Ohio 43210, USA*
[3] *California Institute of Technology, Mail Code 130-33, Pasadena, California 91125, USA*
[4] *Department of Astronomy, Ohio State University, Columbus, Ohio 43210, USA*
[5] *Kamioka Observatory, Institute for Cosmic Ray Research, University of Tokyo, Hida, Gifu 506-1205, Japan*
[6] *Institute for the Physics and Mathematics of the Universe, University of Tokyo, Kashiwa, Chiba 277-8568, Japan*

(Dated: October 10, 2008)

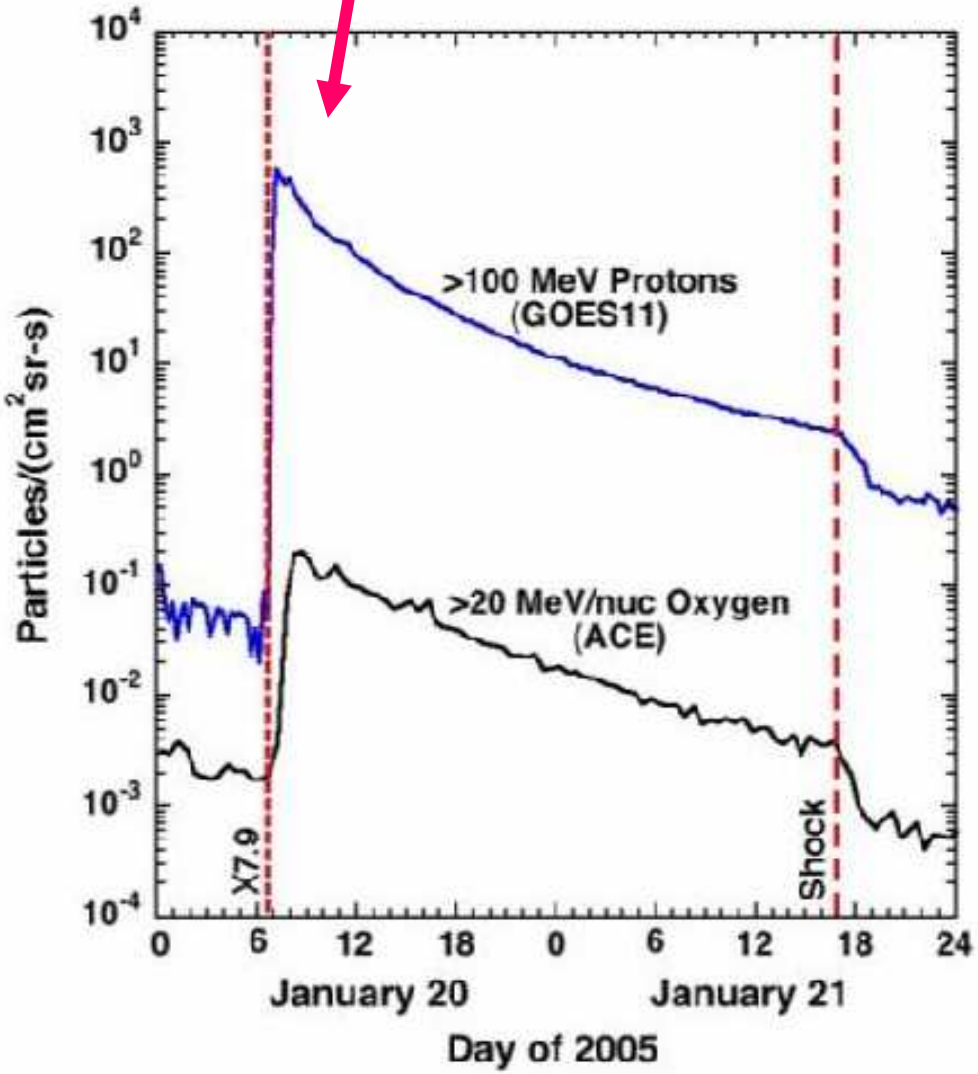
The legacy of solar neutrinos suggests that large neutrino detectors should be sited underground. However, to instead go underwater bypasses the need to move mountains, allowing much larger contained water Čerenkov detectors. Reaching a scale of ~ 5 Megatons, the size of the proposed Deep-TITAND, would permit observations of "mini-bursts" of neutrinos from supernovae in the nearby universe on a yearly basis. Importantly, these mini-bursts would be detected over backgrounds without the need for optical evidence of the supernova, guaranteeing the beginning of time-domain MeV neutrino astronomy. The ability to identify, to the second, every core collapse would allow a continuous "death watch" of all stars within ~ 5 Mpc, making previously-impossible tasks practical. These include the abilities to promptly detect otherwise-invisible prompt black hole formation, provide advance warning for supernova shock-breakout searches, define tight time windows for gravitational-wave searches, and identify "supernova impostors" by the non-detection of neutrinos.

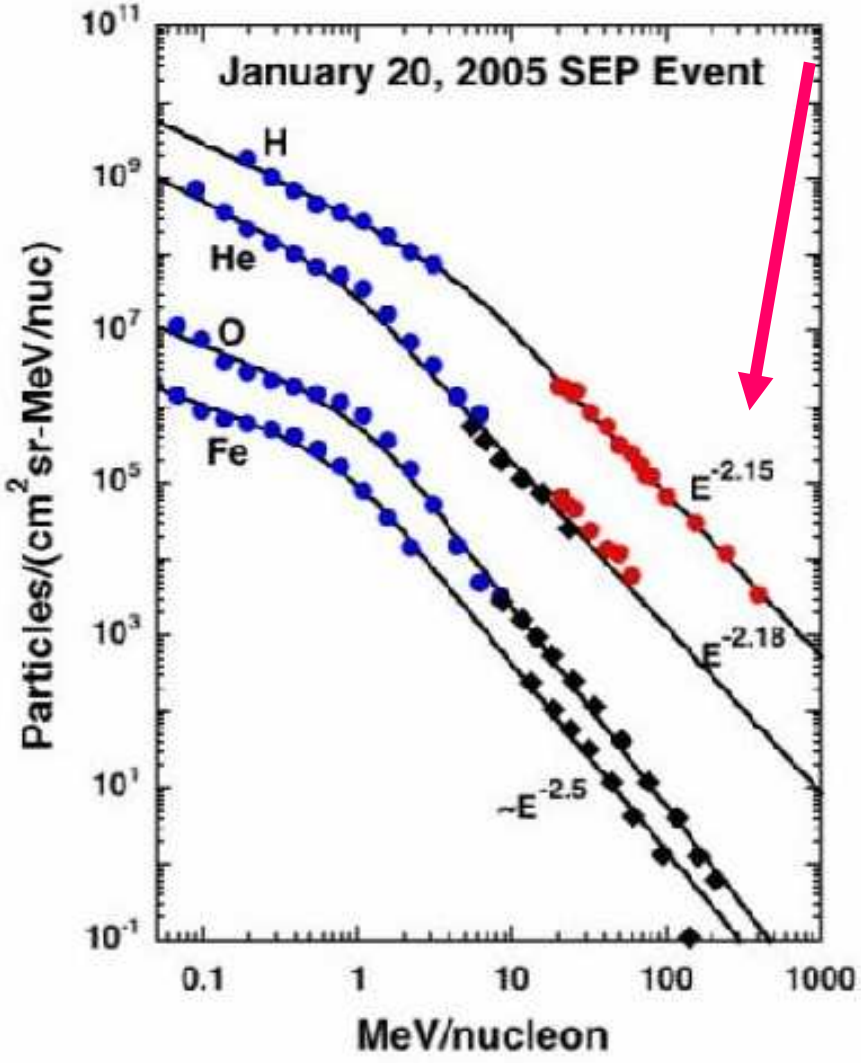
0 Oct 2008

		32 kton (SK)	0.5 Mton (HK)	5 Mton (Deep-TITAND)
10 kpc	(Milky Way)	10^4	10^5	10^6
1 Mpc	(M31, M33)	1	10	10^2
3 Mpc	(M81, M82)	10^{-1}	1	10


University of Maryland soho / celias / mtof / PM
PM_MIN - 80 (Counts per readout)
Time Since X_Ray Event Peak (HR:MN:SS)
0:00:00
12:00:00
24:00:00
36:00:00
48:00:00
Shock
Shock
Shock
Shock
Shock
Date | X-Ray | Optical | Location
14 July 2000 | X5.7 | 3B | N22 W07
8 November 2000 | M7.4 | 3F | N10 W77
4 November 2001 | X1.0 | 3B | N06 W18
28 October 2003 | X17.2 | 4B | S16 E08
20 January 2005 | X7.1 | 2B | N12 W58

Space Weather Aspects of the January 20, 2005 Solar Energetic Particle Event





GAMMA Spectra on 20 Jen. 2005

An Extreme Solar Event of 20 January 2005

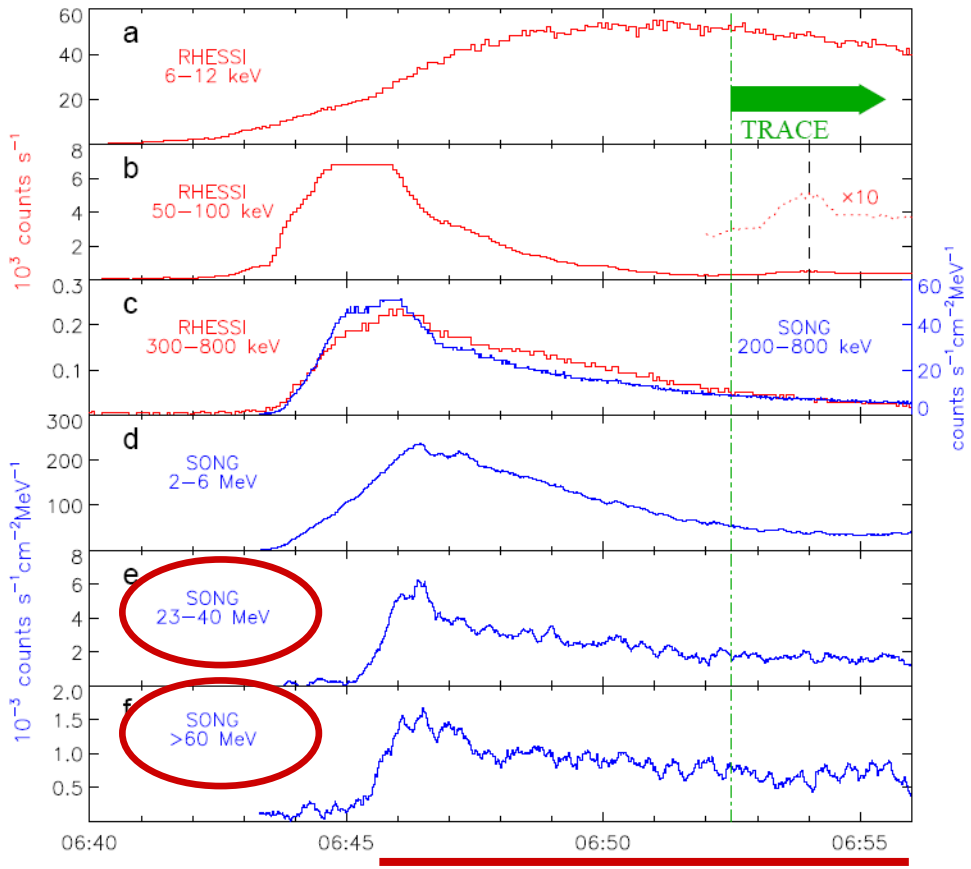


Figure 3. a – c: Some wide-band RHESSI time profiles (red). Green dash-dotted line shows start of TRACE observations. Black dashed line marks a weak enhancement of 25 – 300 keV emission. Red dotted line shows part of its time profile enlarged ten-times. c – f: Some SONG time profiles smoothed over 13 points (blue; the 200 – 800 keV channel has not been smoothed).

arXiv:0806.4424v2 [astro-ph] 30 Jun 2008

Solar Physics
DOI: 10.1007/•••••-•••-•••-••••-•

An Extreme Solar Event of 20 January 2005: Properties of the Flare and the Origin of Energetic Particles

V.V. Grechnev[1] · V.G. Kurt[2] · I.M. Chertok[3] · A.M. Uralov[1] · H. Nakajima[4] · A.T. Altyntsev[1] · A.V. Belov[3] · B.Yu. Yushkov[2] · S.N. Kuznetsov[2*] · L.K. Kashapova[1] · N.S. Meshalkina[1] · N.P. Prestage[5]

The neutral-pion signature: a clear trace of a LOWER BOUND of charged pions

An Extreme Solar Event of 20 January 2005

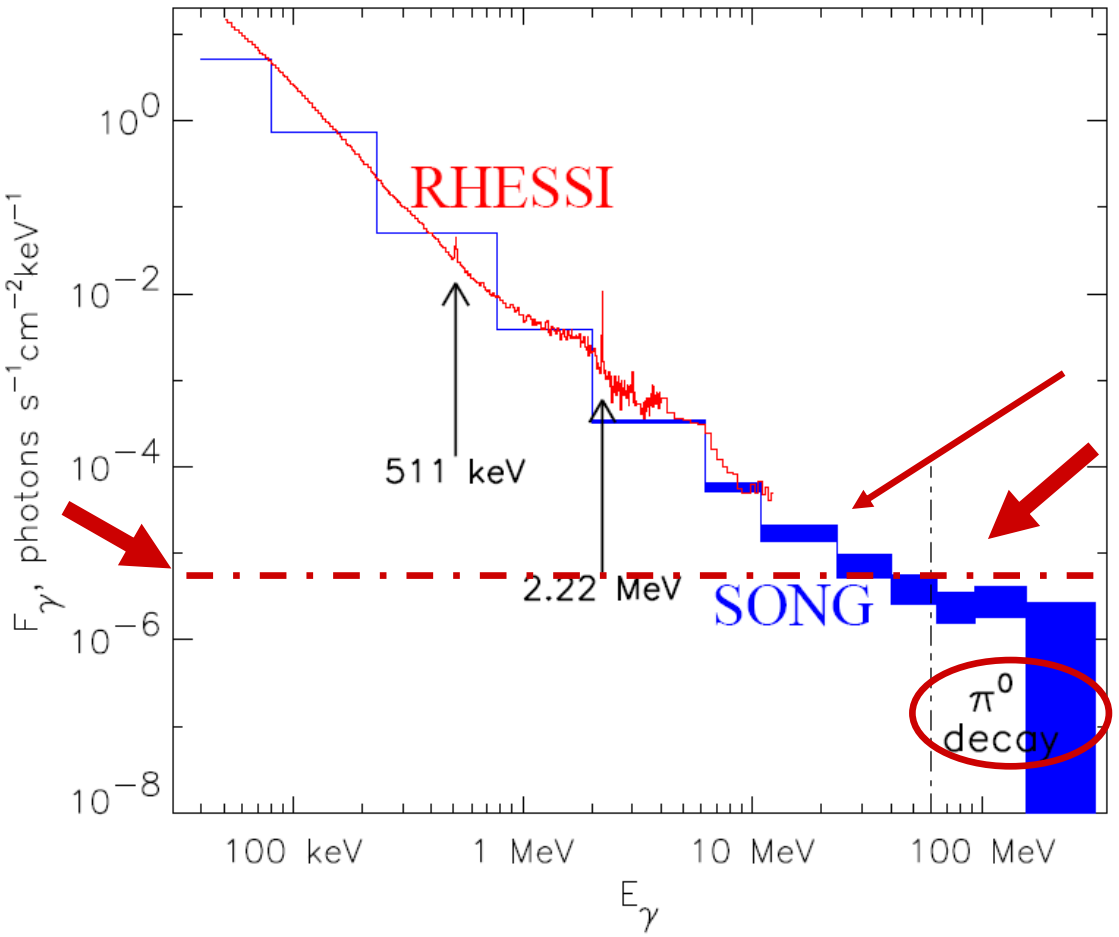
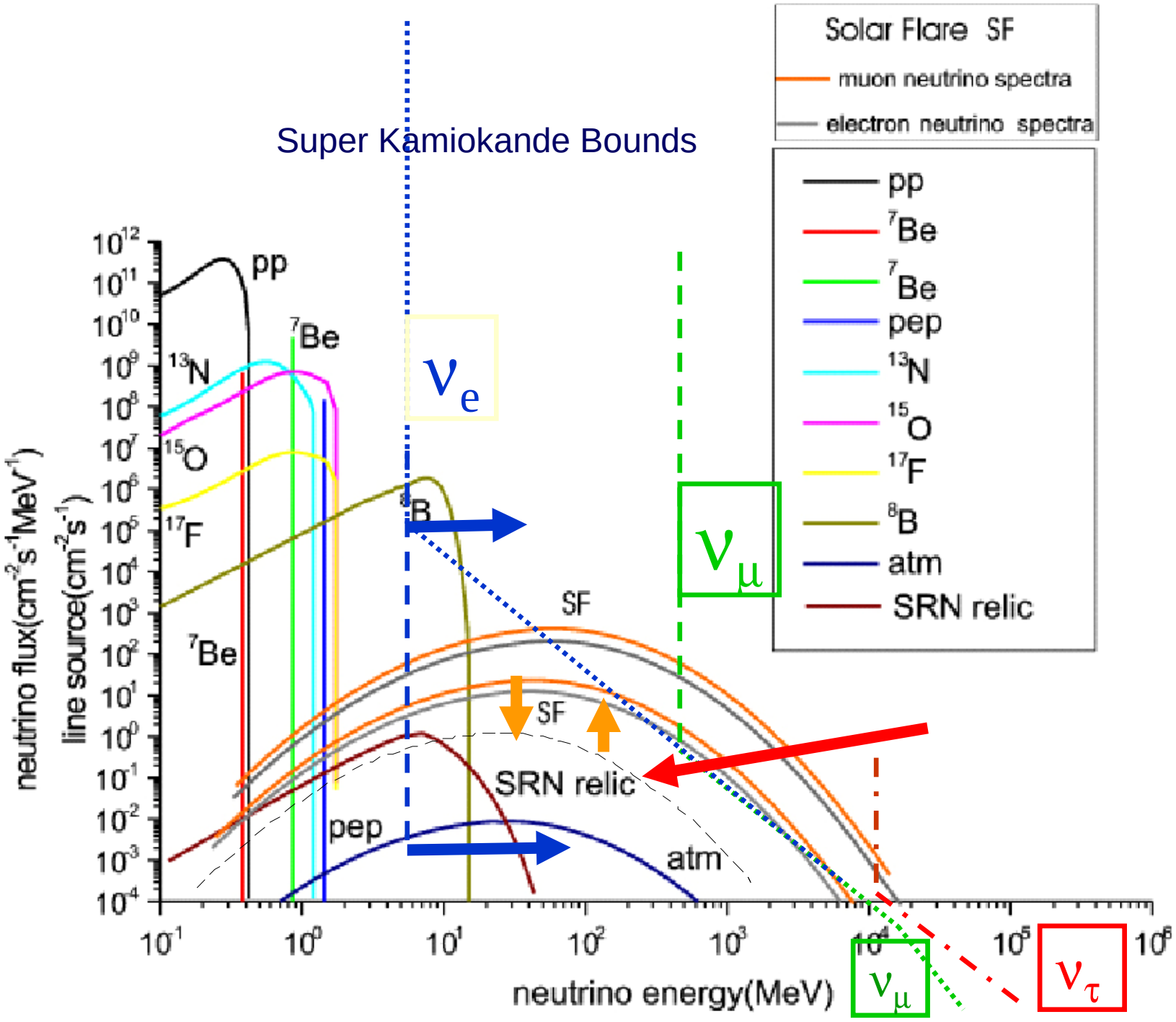
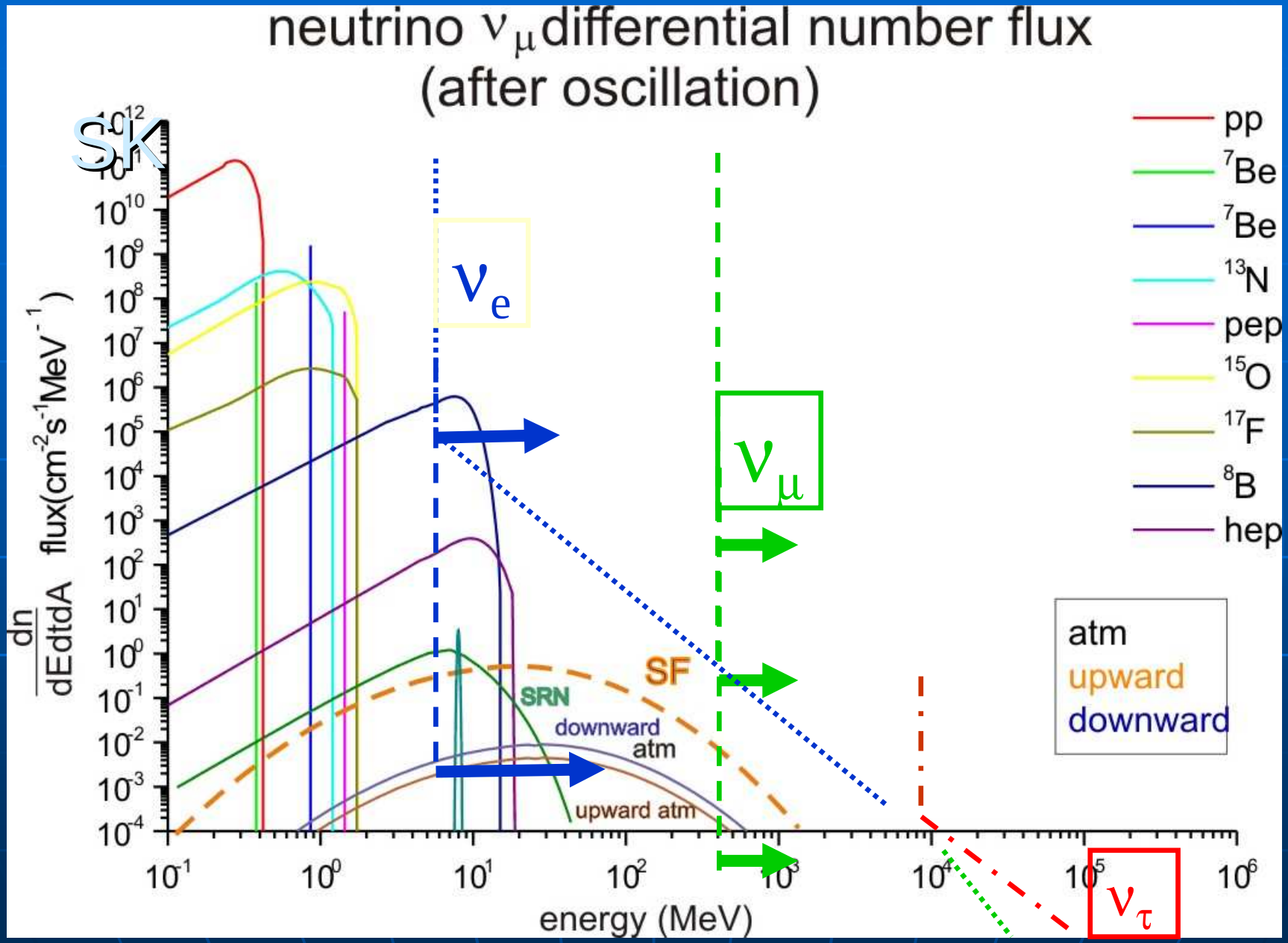
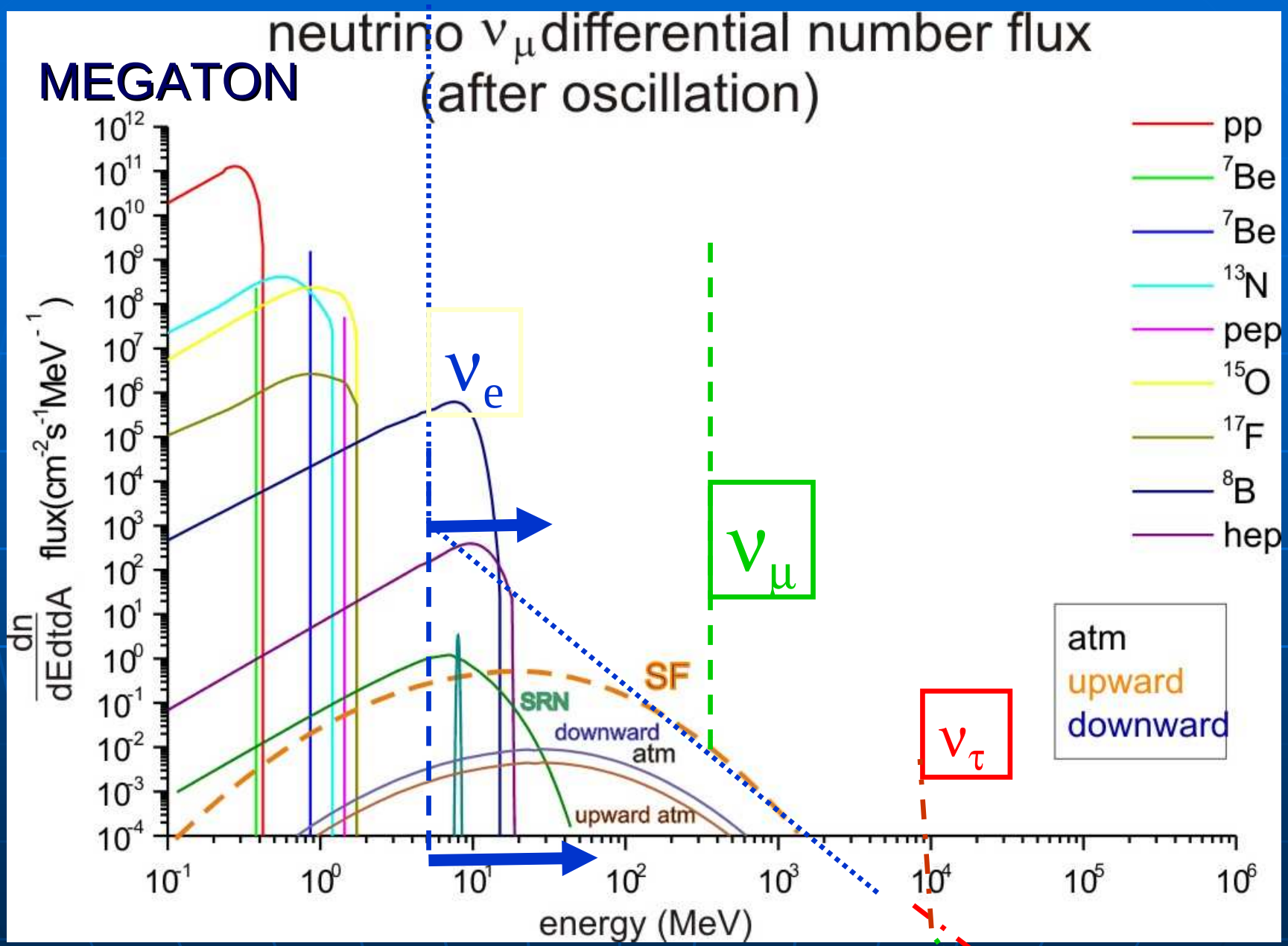


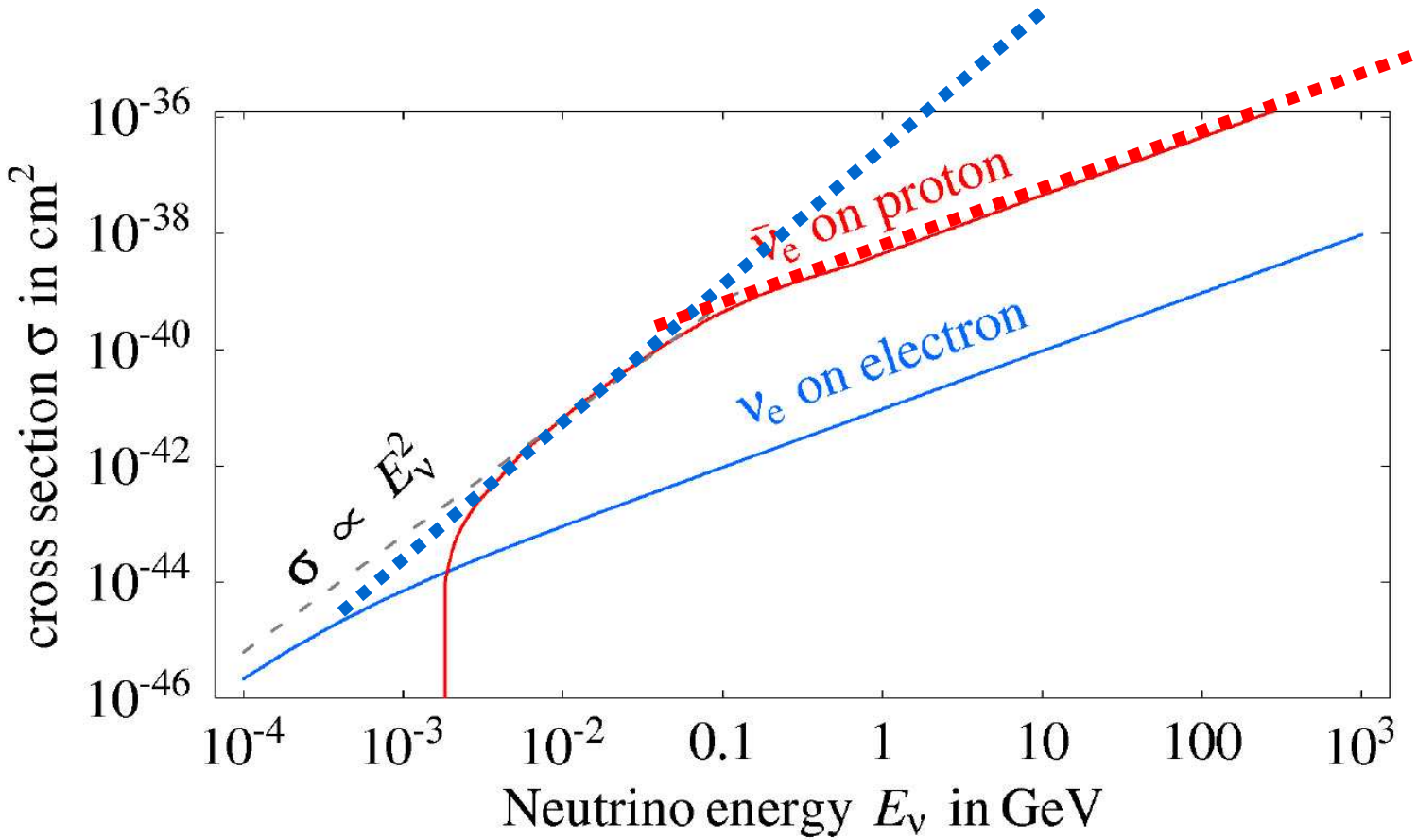
Figure 7. High-resolution RHESSI (red) and wide-range SONG (blue) spectra recorded during the hardest flare emission. Vertical dash-dotted line shows the high-energy part of the SONG spectrum where the π^0-decay emission dominates. Shading shows uncertainties.


Super Kamiokande Bounds
Solar Flare SF
muon neutrino spectra
electron neutrino spectra
pp
7Be
7Be
pep
13N
15O
17F
8B
atm
SRN relic
pp
7Be
13N
15O
17F
8B
7Be
SF
SF
SRN relic
pep
atm
νe
νμ
νμ
ντ
neutrino flux(cm-2s-1MeV-1)
line source(cm-2s-1)
neutrino energy(MeV)

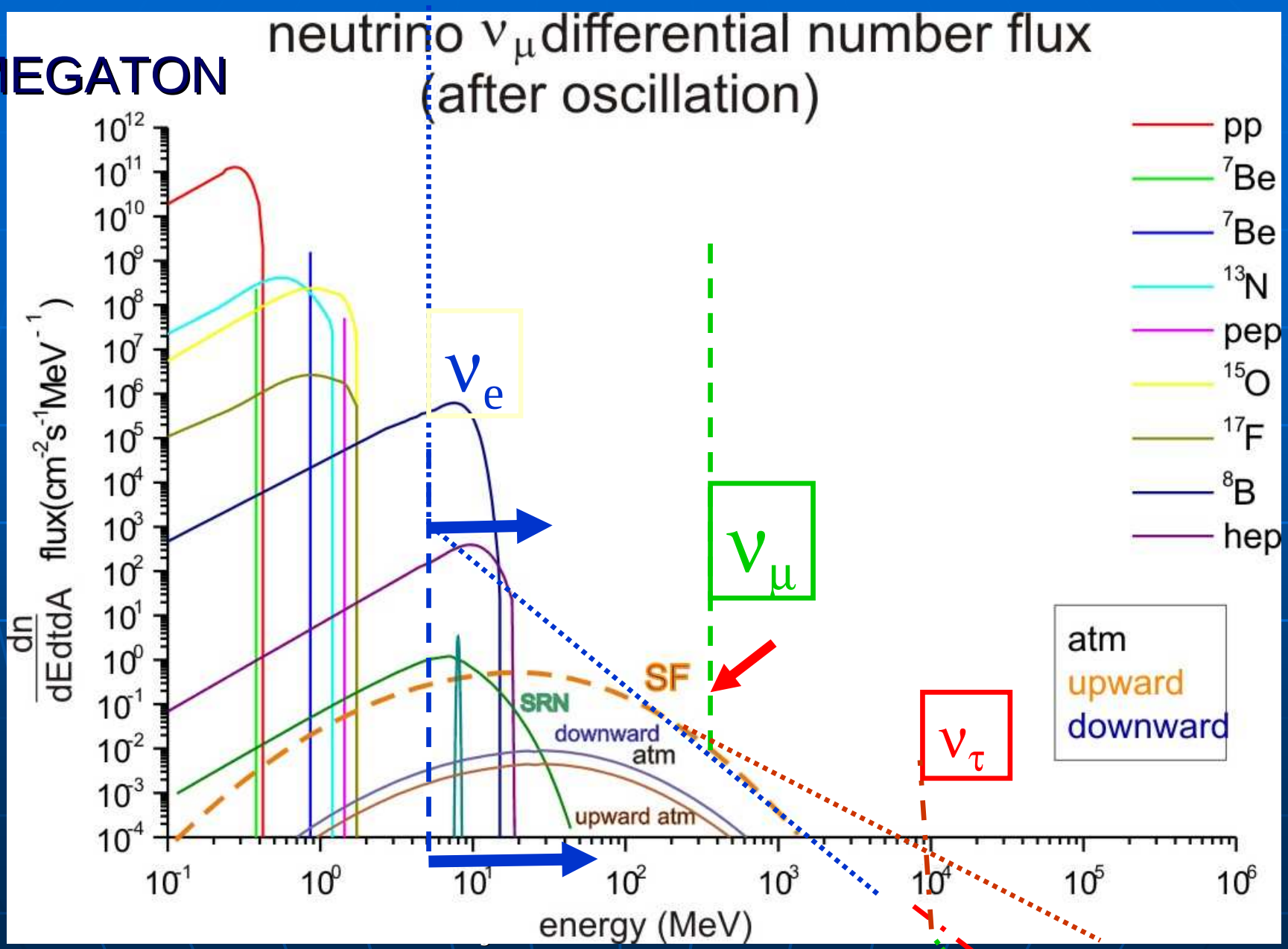

neutrino ν_μ differential number flux
(after oscillation)
SK
$\frac{dn}{dEdtdA}$ flux($cm^{-2}s^{-1}MeV^{-1}$)
energy (MeV)
ν_e
ν_μ
ν_τ
pp
^{7}Be
^{7}Be
^{13}N
pep
^{15}O
^{17}F
^{8}B
hep
atm
upward
downward
SF
SRN
downward atm
upward atm

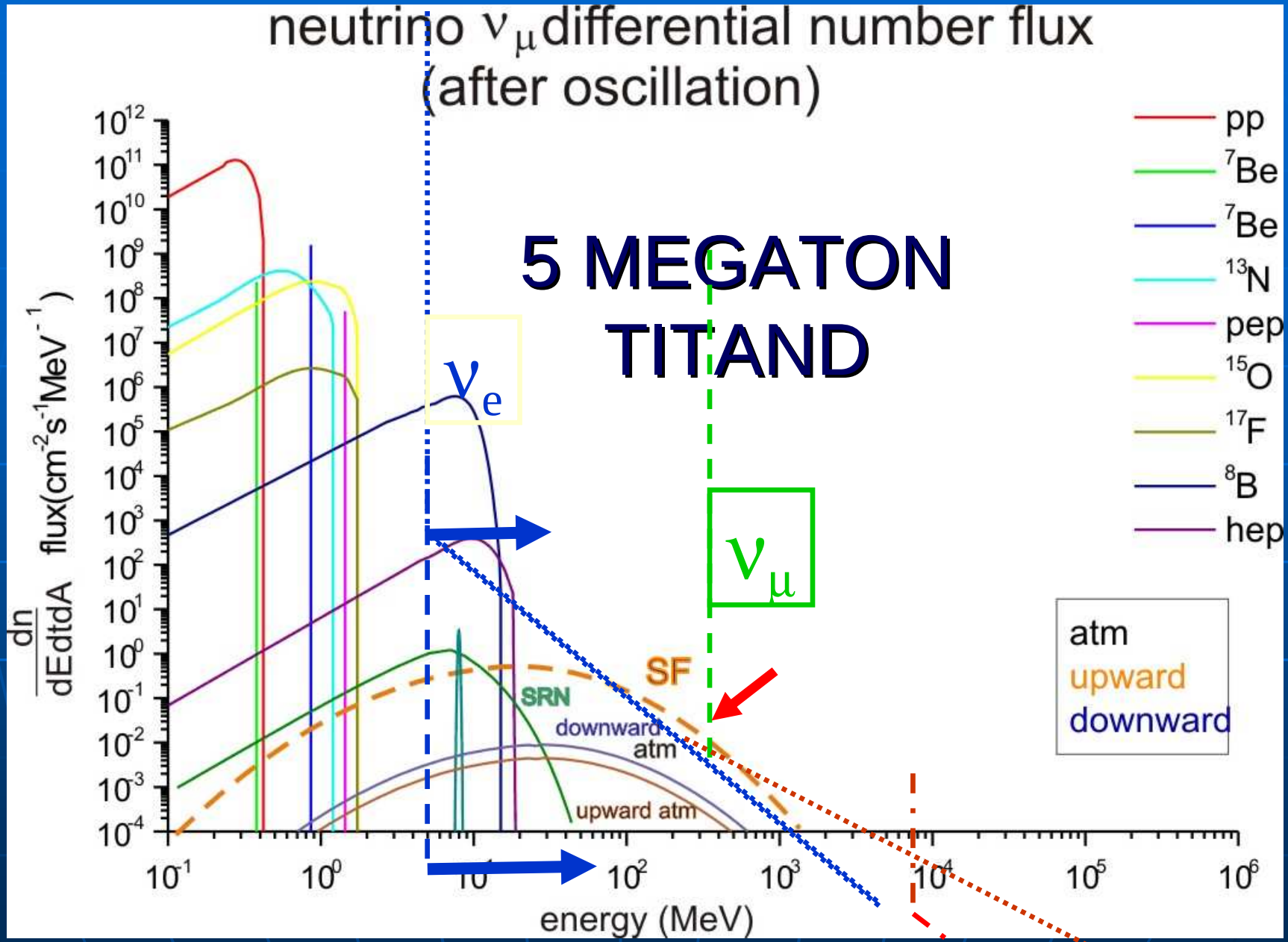

MEGATON
neutrino ν_μ differential number flux
(after oscillation)
$\frac{dn}{dEdtdA}$ flux($cm^{-2}s^{-1}MeV^{-1}$)
energy (MeV)
pp
^{7}Be
^{7}Be
^{13}N
pep
^{15}O
^{17}F
^{8}B
hep
ν_e
ν_μ
ν_τ
SF
SRN
downward atm
upward atm
atm
upward
downward

Correct cross section

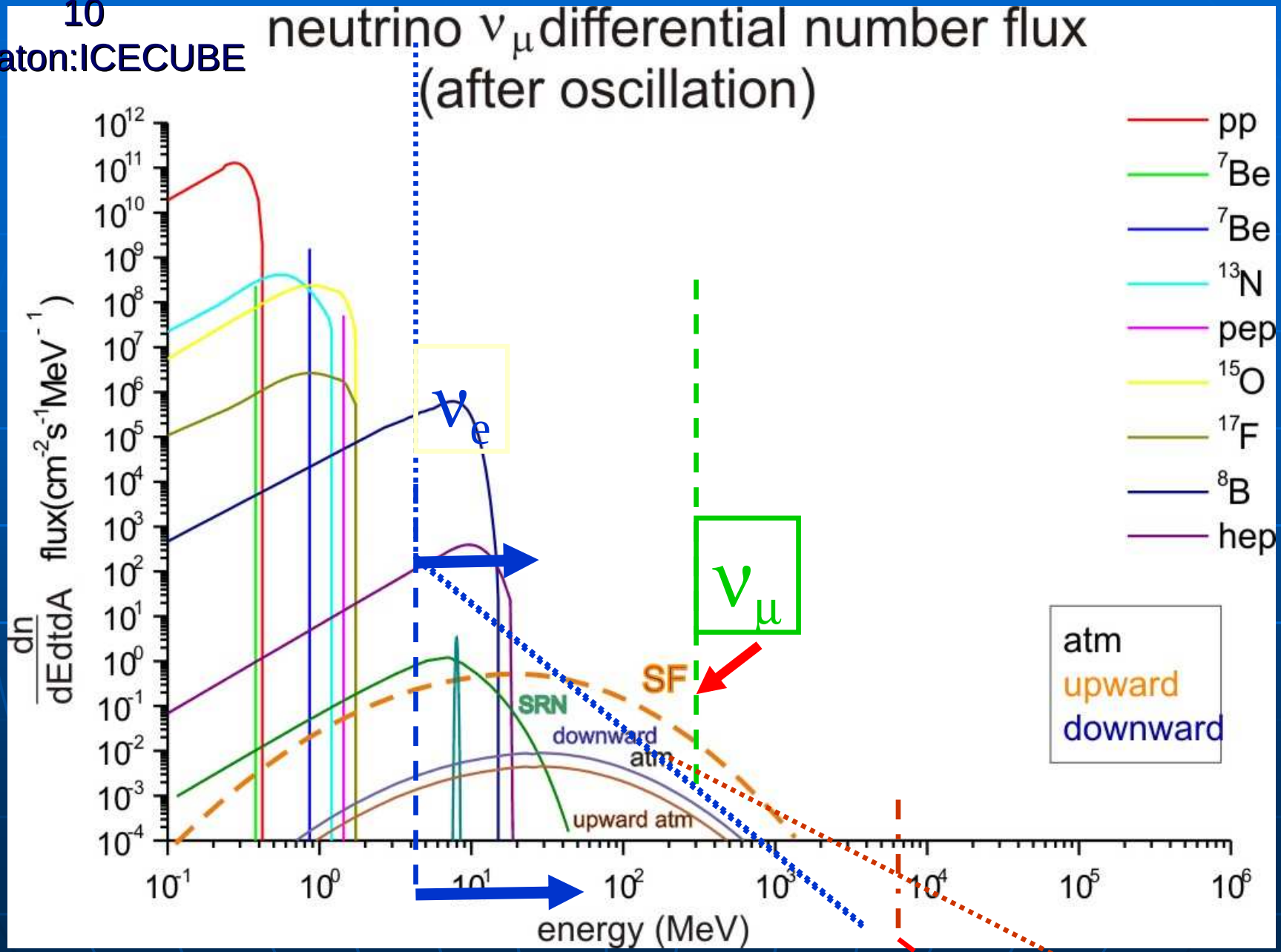


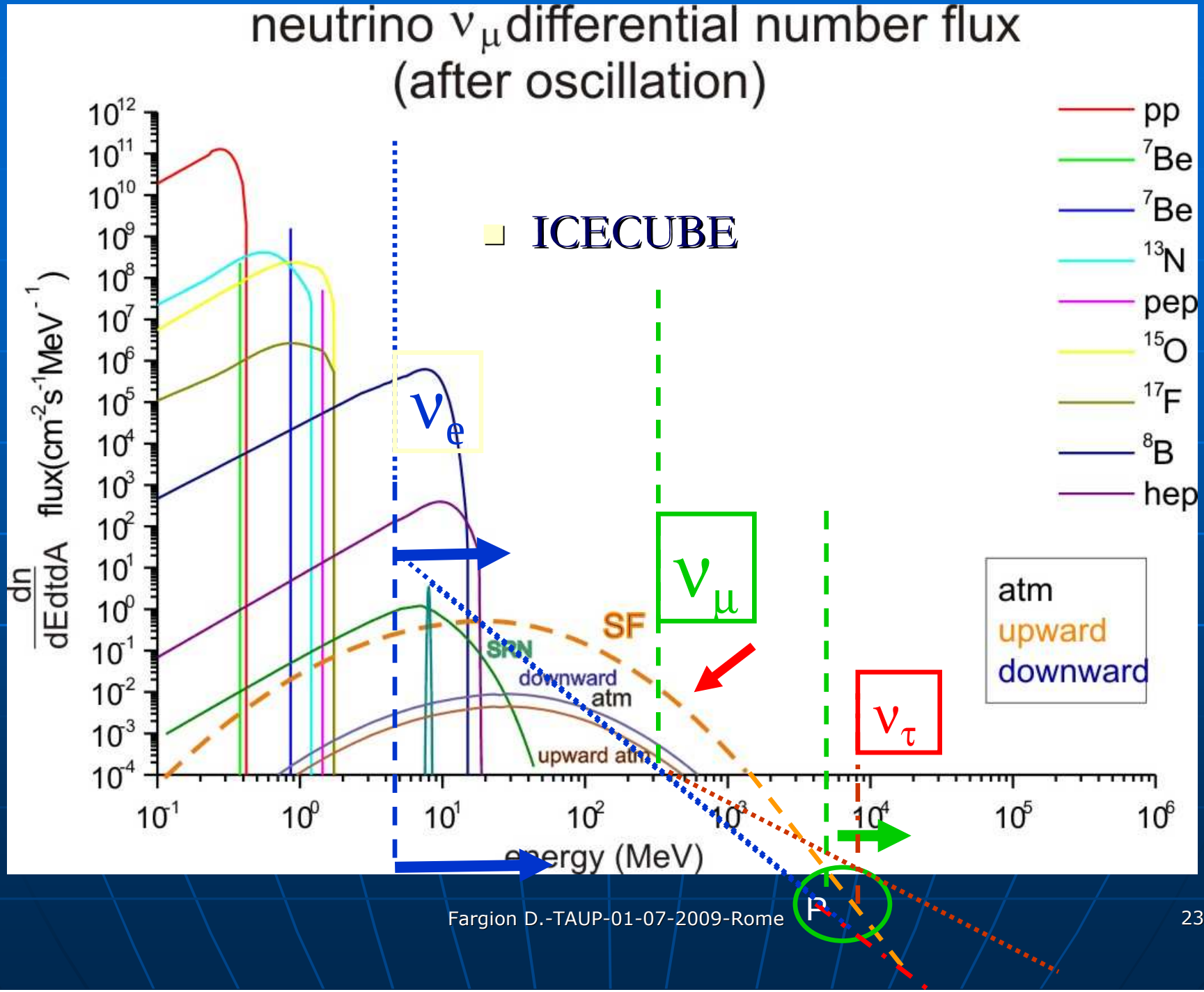
MEGATON


neutrino ν_μ differential number flux
(after oscillation)
$\frac{dn}{dEdtdA}$ flux($cm^{-2}s^{-1}MeV^{-1}$)
energy (MeV)
pp
^{7}Be
^{7}Be
^{13}N
pep
^{15}O
^{17}F
^{8}B
hep
ν_e
ν_μ
ν_τ
SF
SRN
downward atm
upward atm
atm
upward
downward

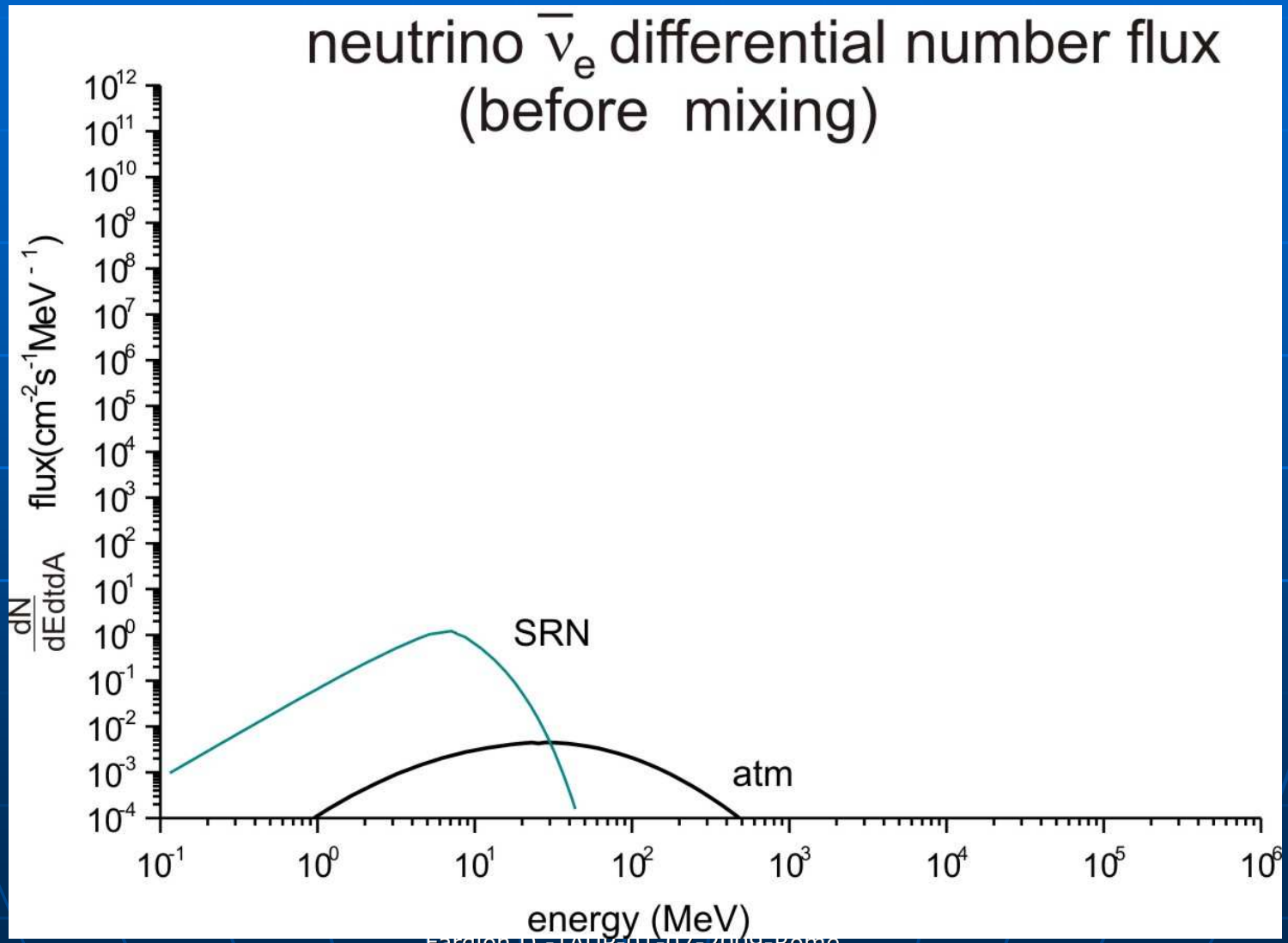

neutrino ν_μ differential number flux
(after oscillation)
5 MEGATON
TITAND
ν_e
ν_μ
ν_τ
pp
^{7}Be
^{7}Be
^{13}N
pep
^{15}O
^{17}F
^{8}B
hep
atm
upward
downward
SF
SRN
downward atm
upward atm
$\frac{dn}{dEdtdA}$ flux(cm^{-2}s^{-1}MeV^{-1})
energy (MeV)

10
Megaton:ICECUBE

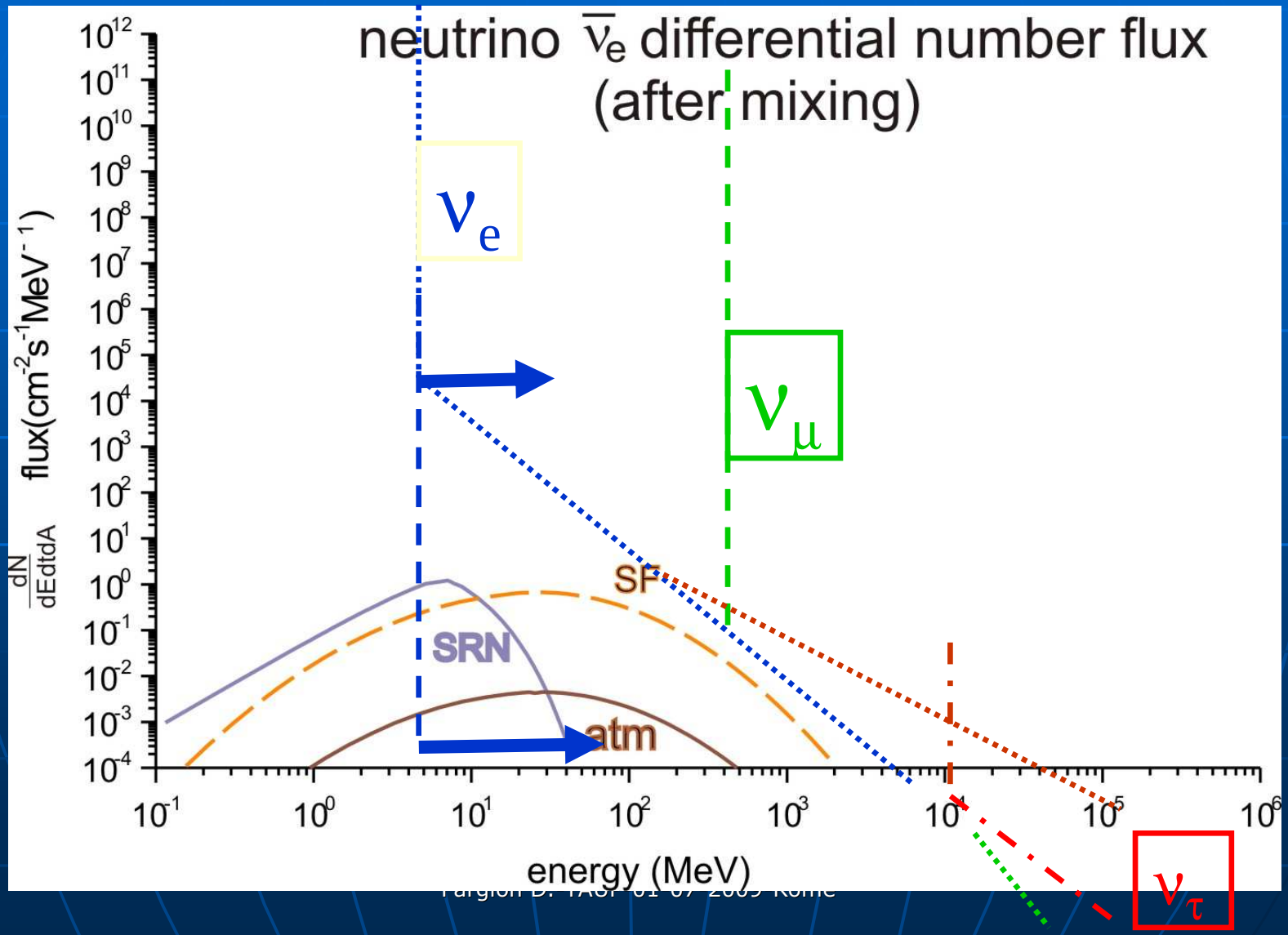



neutrino ν_μ differential number flux
(after oscillation)
ICECUBE
ν_e
ν_μ
ν_τ
SF
SRN
downward
atm
upward atm
pp
^{7}Be
^{7}Be
^{13}N
pep
^{15}O
^{17}F
^{8}B
hep
atm
upward
downward
$\frac{dn}{dEdtdA}$ flux(cm^{-2}s^{-1}MeV^{-1})
energy (MeV)

Best signals: by Anti Neutrino e before mixing



SK Anti ν e after in SK

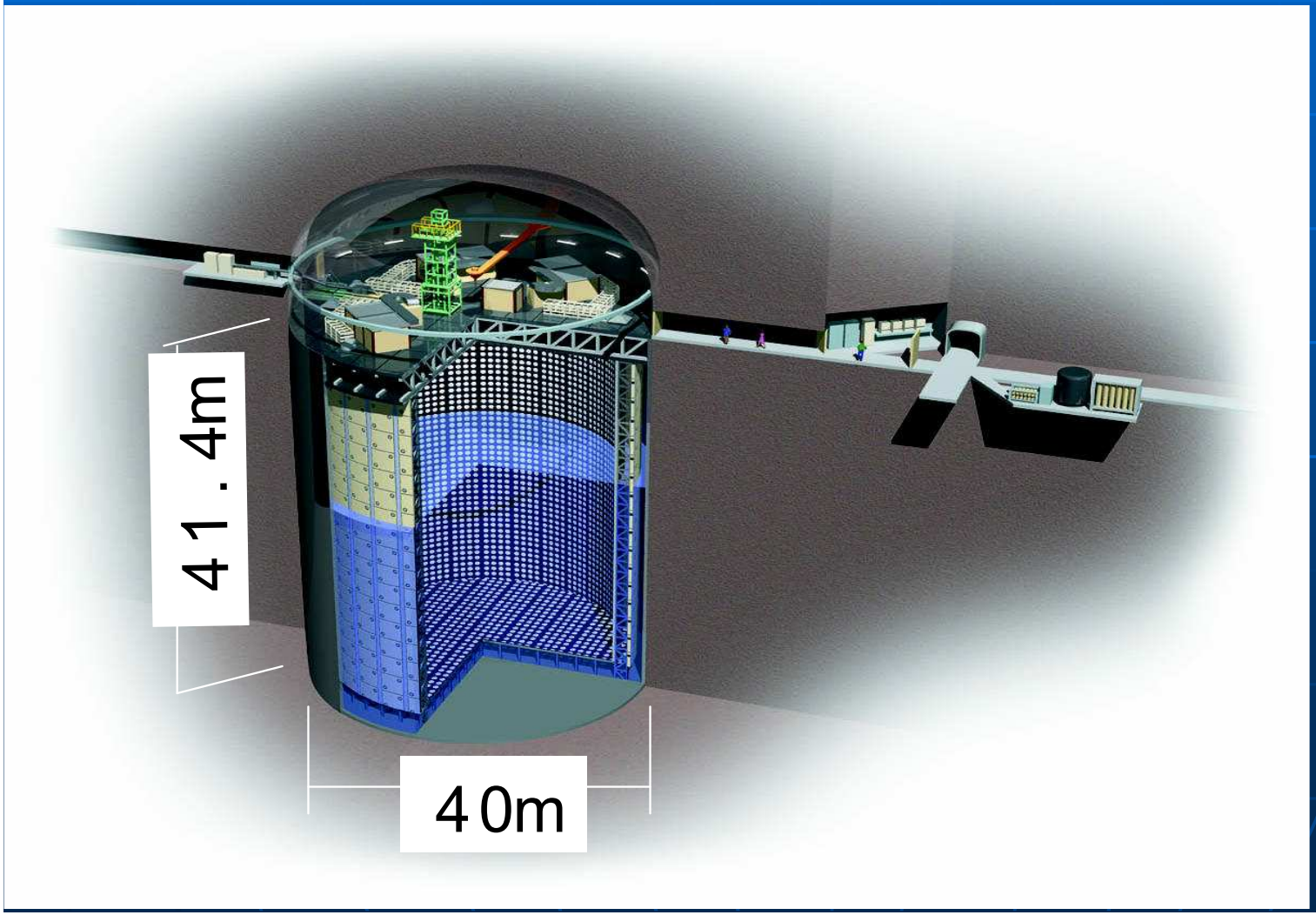


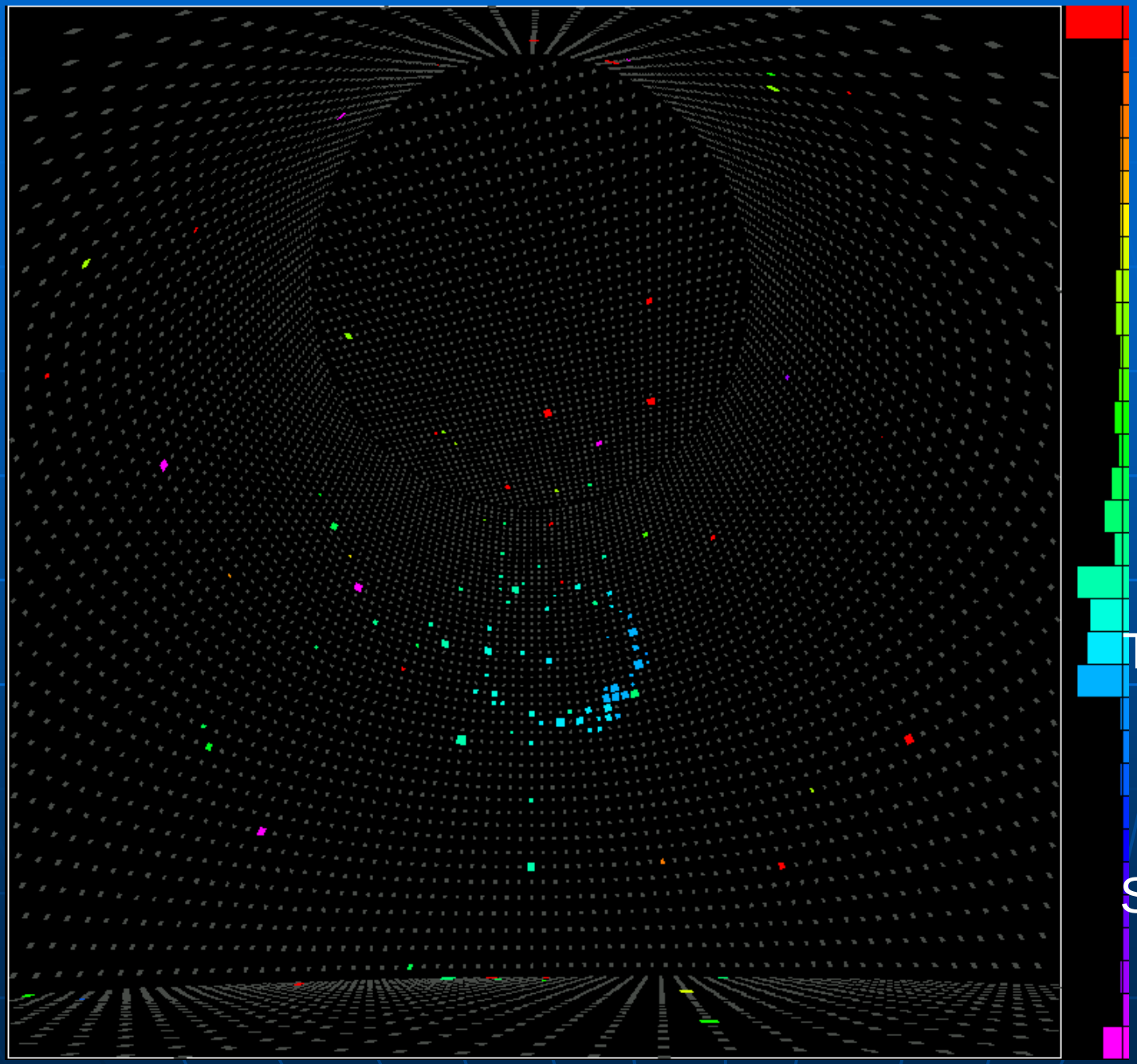
The SK Detector

50000 tons ultra-pure water

22500 tons fiducial volume

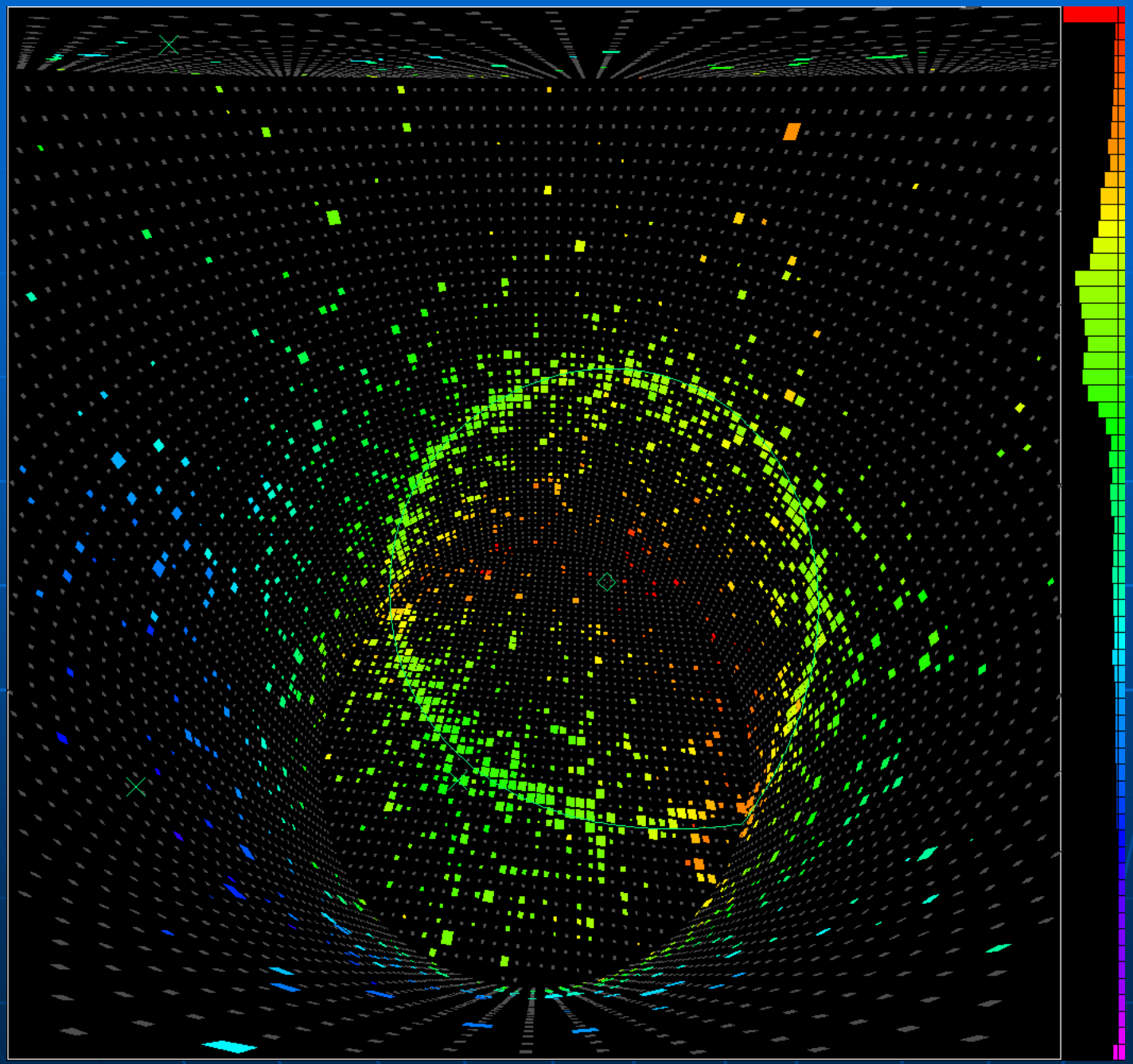
1 km overburden = 2700 m.w.e.





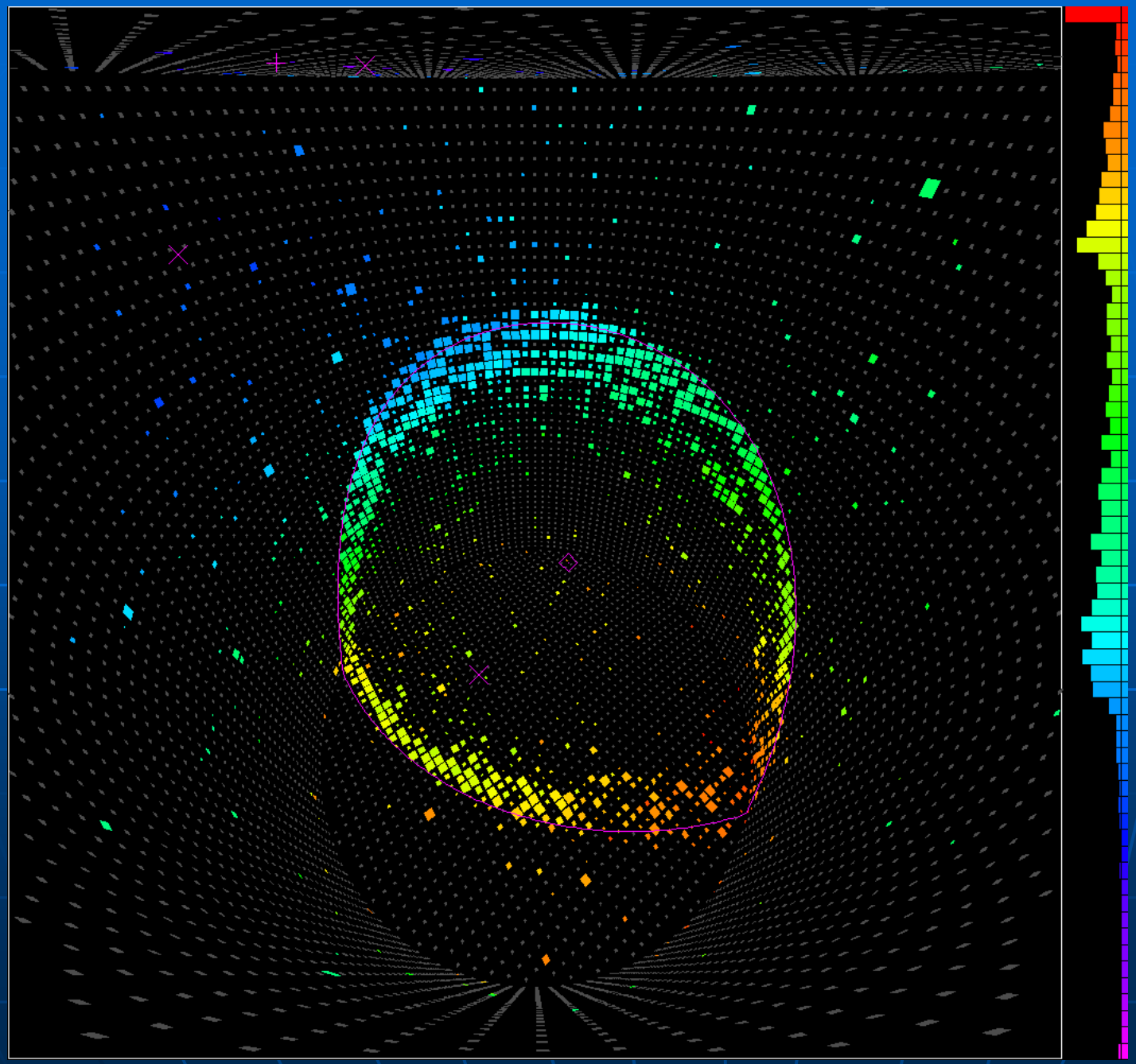
12 MeV solar ν

The low energy
ν-e
elastic
scattering
Still points back
To the Sun



492 MeV atmospheric <u>electron</u> ν

Note diffuse edge of ring from electron produced by ν_e-nucleon interaction



603 MeV atmospheric <u>muon</u> ν

Note sharp edge of ring from muon produced by ν_μ-nucleon interaction

Tau signal

$$E_{\nu_\mu} \geq \triangle M \cdot (1 + \frac{\triangle M}{2 \cdot m_p}) \simeq 3.46 \text{ GeV},$$

$$\text{where } (\triangle M = m_\tau + m_n - m_p)$$

Our first estimate on the neutrino number events detection at the Super-Kamiokande II Laboratory for horizontal or hidden flare is found to be: $N_{ev_{\bar{\nu}_e}} \simeq 0.63\eta_e(\frac{<E_\nu>}{35\ MeV})(\frac{<E_{FL}>}{10^{31}\ erg})$; and $N_{ev_{\bar{\nu}_\mu}} \simeq 3.58(\frac{<E_{\nu_\mu}>}{200\ MeV})(\frac{<E_{FL}>}{10^{31}\ erg})\eta_\mu$, where $\eta \simeq 1$, $E_{\nu_\mu} > 113$ MeV. Any large neutrino flare event record might also verify the expected neutrino flavour mixing leading to $\frac{\eta_\mu}{\eta_e} \simeq \frac{1}{2}$ and to $N_{ev_{\bar{\nu}_\mu}} \simeq N_{ev_{\bar{\nu}_e}} \simeq 2(\frac{<E_{\nu_\mu}>}{200\ MeV}(\frac{<E_{FL}>}{10^{31}\ erg})$; $N_{ev_{\nu_\mu}} \simeq N_{ev_{\nu_e}}$ as well as a comparable, ν_e, ν_μ, $\bar{\nu}_e$, $\bar{\nu}_\mu$ energy fluence and spectra. A surprising τ appearance may occur for a hard $(E_{\nu_\mu} \rightarrow E_{\nu_\tau} \simeq> 4GeV)$ flare spectra.

arXiv:hep-ph/0312011 v2 6 Dec 2003

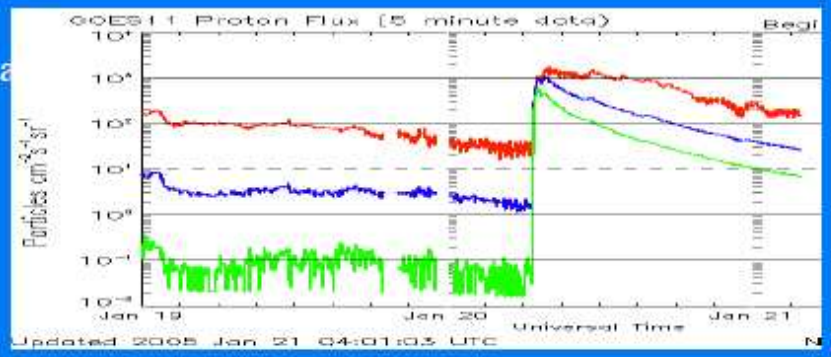
Highest energetic solar particles

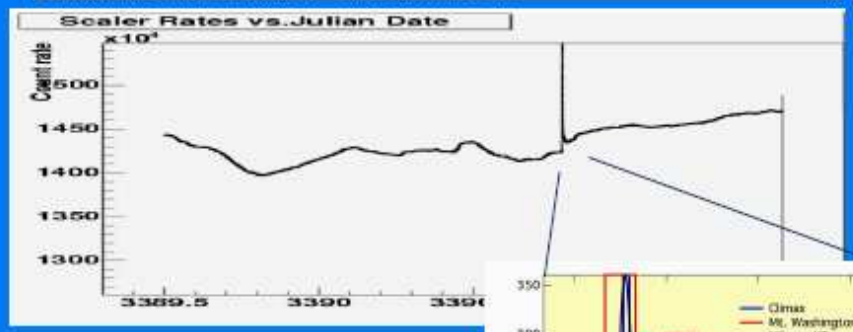
Milagro Observation of >10 GeV Particles from Sun on 20 Jan 2005

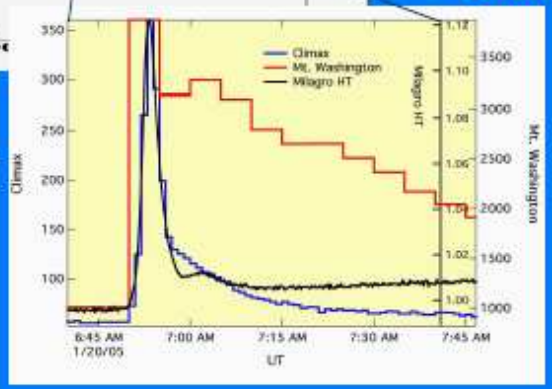
GOES proton da

>10 MeV

>100 MeV







Milagro scaler data

- > 10 GeV protons
- ~1 min rise-time
- ~5 min duration

Milagro Observed > 10 GeV from the Solar Energetic Particle events on

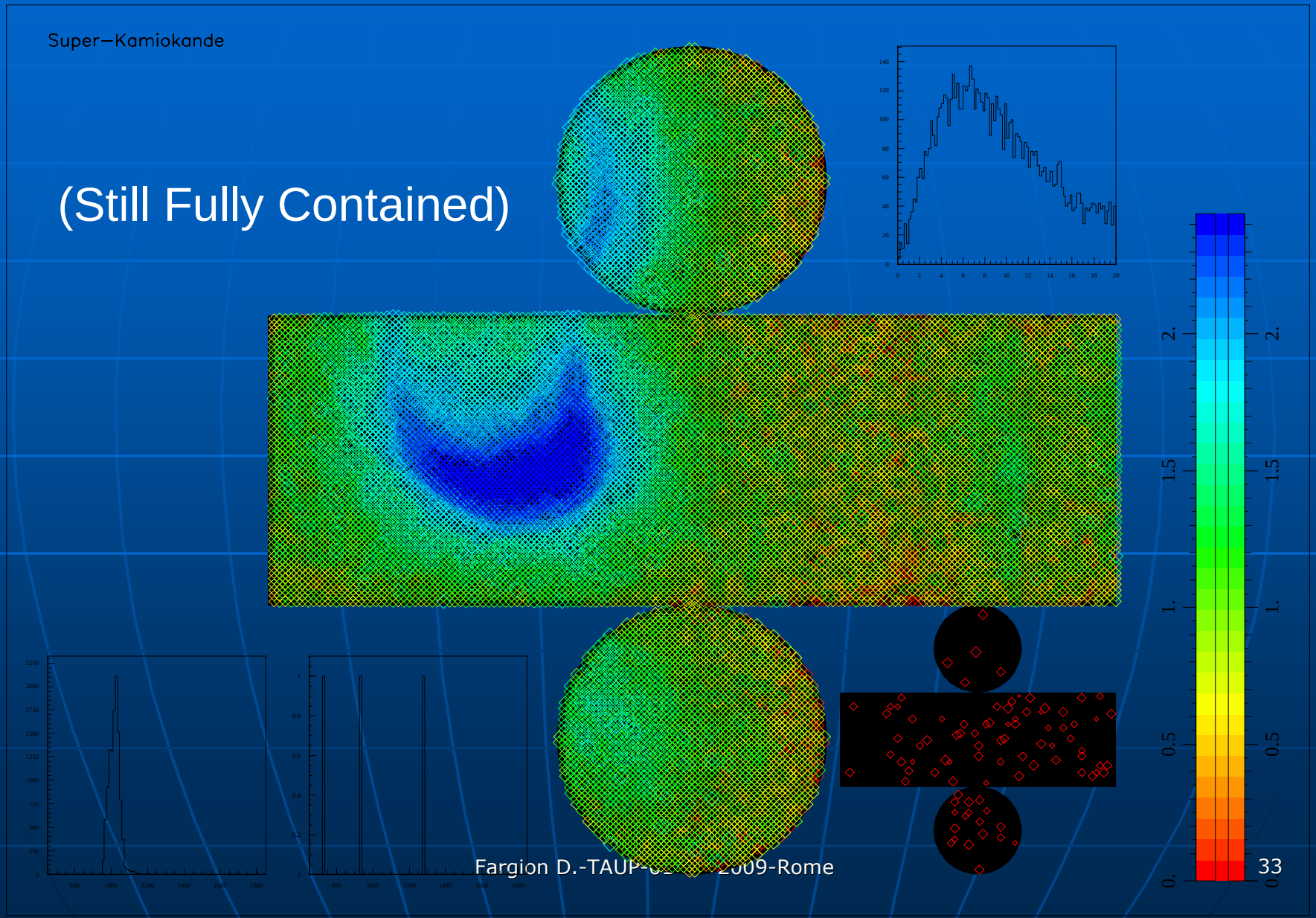
- 6 November 1997
- 14 July 2000
- 15 April 2001
- 20 January 2005

Flavor Neutrino Mixing by neutrino mass splitting : The rare Tau Appearence because of large Oscillation Lenghts versus Earth Diameter

$$L_{\nu_\mu-\nu_\tau} = 2.48 \cdot 10^9\, cm \left(\frac{E_\nu}{10^9\, eV}\right) \left(\frac{\Delta m^2_{ij}}{(10^{-2}\, eV)^2}\right)^{-1} \ll D_{\oplus\odot} = 1.5 \cdot 10^{13} cm$$

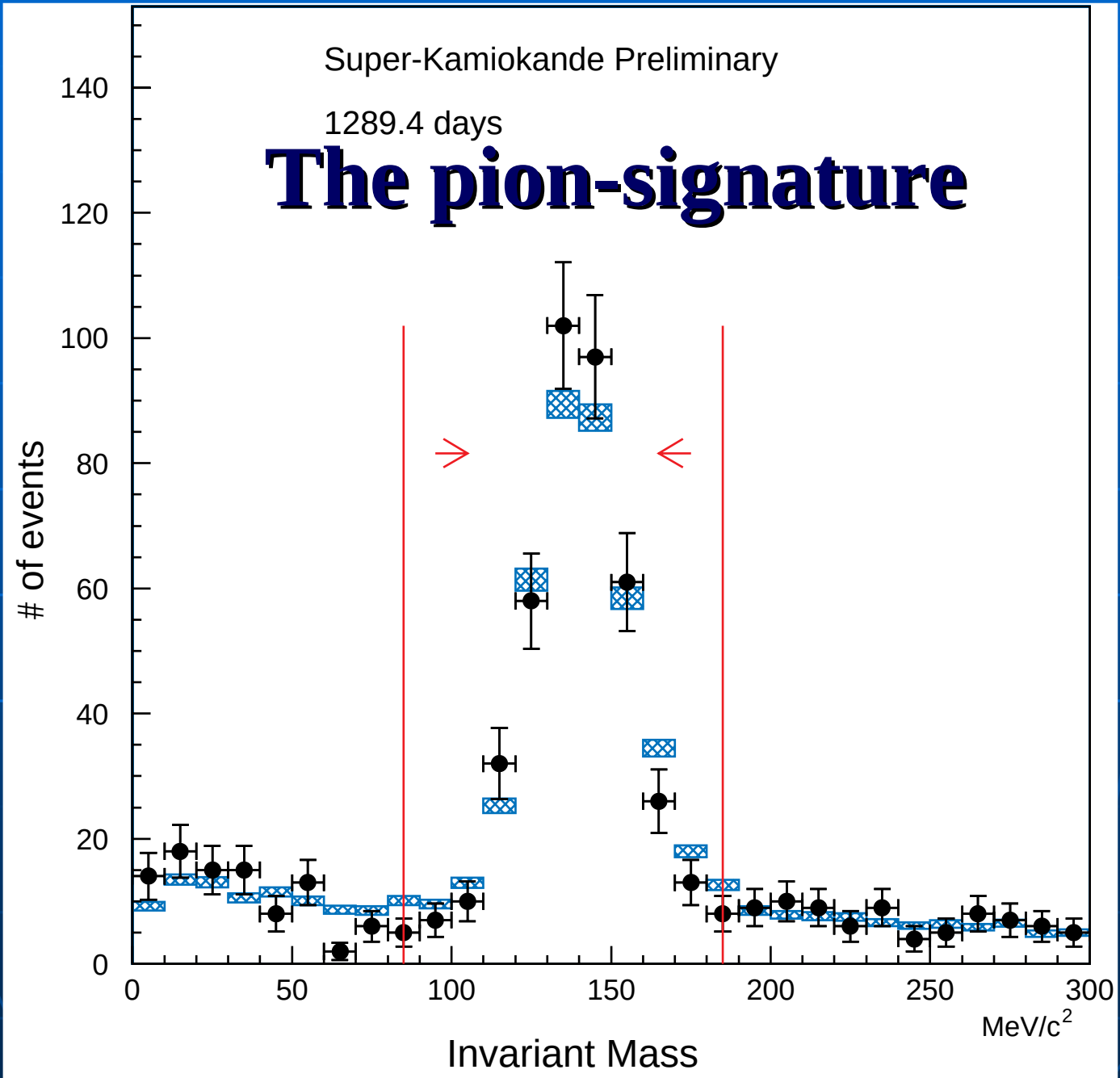
The allowable neutrino tau appearence from the Sun

A first SK Tau ν candidate event (~3 GeV)



(Still Fully Contained)

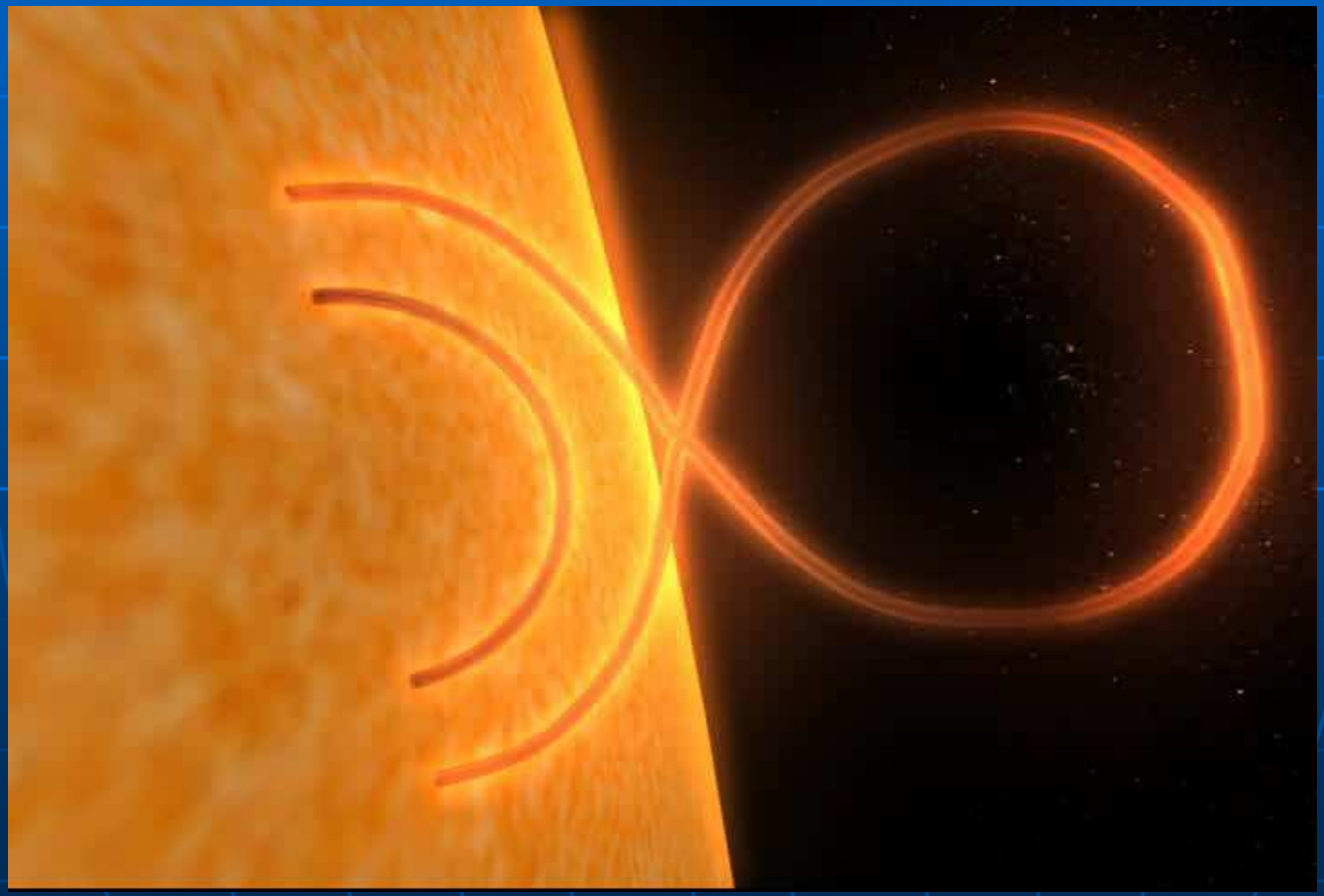
The pion-signature



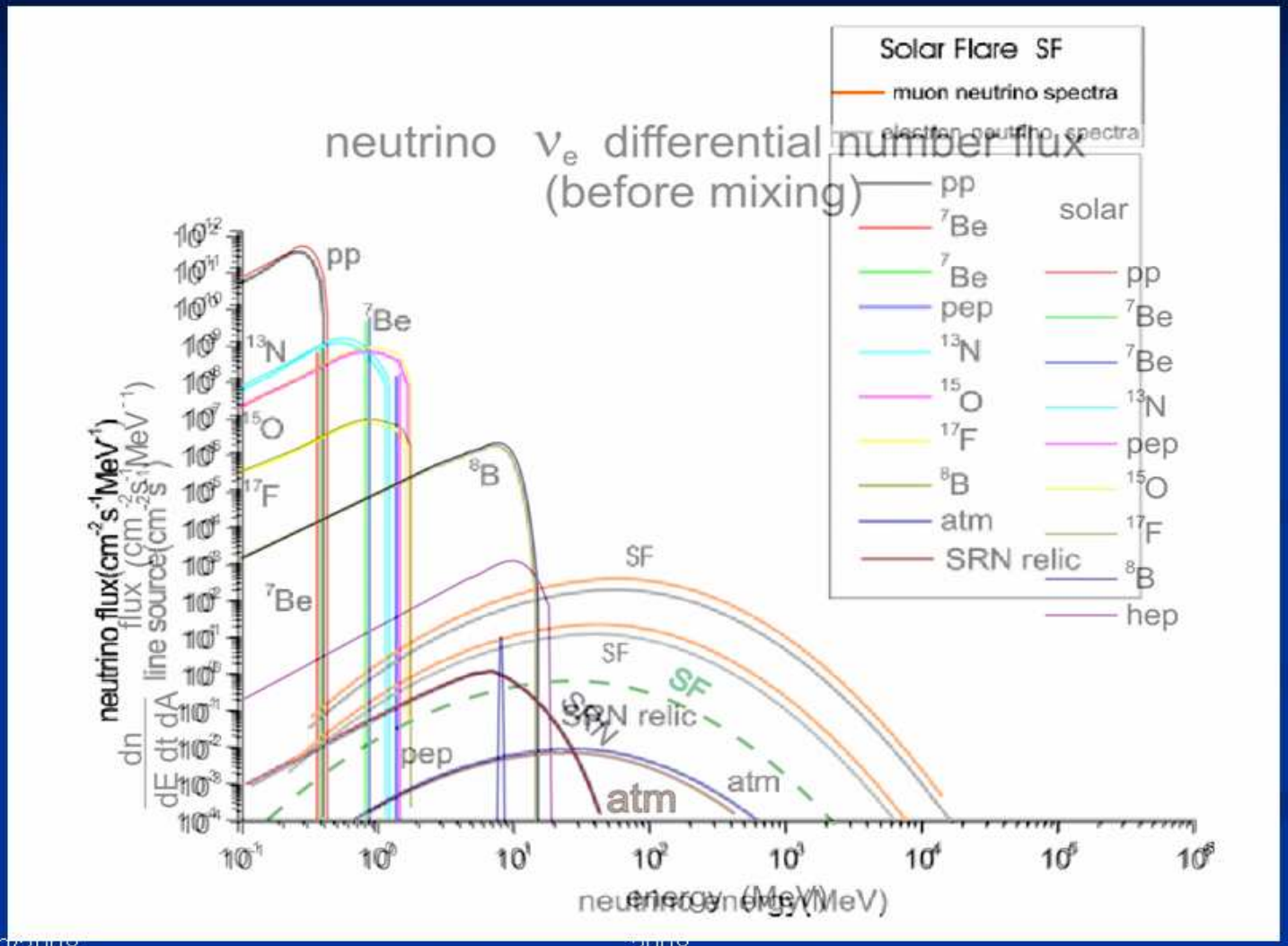
Probability Meaning

The recent solar flare on October-November 2003 as large as the one on Sept. $29th$, 1989 might be an exceptional source of cosmic, gamma, neutron rays and neutrinos as well. Their minimal event number at Super-Kamiokande $N_{ev_{\bar{\nu}_\mu}} \simeq N_{ev_{\bar{\nu}_e}} \simeq 2(\frac{<E_{\nu_\mu}>}{200\ MeV}(\frac{<E_{FL}>}{10^{31}\ erg})$; $N_{ev_{\nu_\mu}} \simeq N_{ev_{\nu_e}}$ is near or above unity. The noise signal of energetic atmospheric neutrinos at the Japanese detector is nearly 5.8 event a day time corresponding to a rate $\Gamma \simeq 6.710^{-5}s^{-1}$. The minimal and the largest predicted event number $(1 \div 5)\ \eta$, $(\eta \leq 1)$ within the narrow time gate defined by the sharp X burst onset $(100s)$, are above the noise. Indeed the probability to find by chance one neutrino event within a $1-2$ minute $\Delta t \simeq 10^2 s$ in that interval is $P \simeq \Gamma \cdot \Delta T \simeq 6.7 \cdot 10^{-3}$. For a Poisson distribution the probability to find $n = 1, 2, 3, 4, 5$ events in a narrow time window might reach extremely small values: $P_n \cong \frac{P^n}{n!} = (6.7 \cdot 10^{-3}, 2.25 \cdot 10^{-5}, 5 \cdot 10^{-8}, 8.3910^{-11}, 1.1 \cdot 10^{-13})$. Therefore the very possible presence of one or more high energetic (tens hundred MeVs) positron (or better positive muons) as well as any negative electron or muon, in Super-Kamiokande at X-flare onset time may be a well defined and most brilliant signature of the solar neutrino flare. A surprising discover by τ appearance of the complete mixing may occur by hard $(E_{\nu_\mu} \rightarrow E_{\nu_\tau} \simeq> 4GeV)$ flare spectra. Its most recognizable signature occurs by a rare π^o production , (by the common hadronic τ decay) , and its pion consequent decays into mono-cromatic γ whose relics are consequent e^+,e^- relativistic pairs production.

Why Solar Neutrino Flare have not been yet observed? Maybe because of low density acceleration target



Summary: Physica Scripta 2006 versus 2008



Conclusions:

1) Nearly equal electron-muon neutrino Flux Flare

2) A first ANTI-Neutrino signal in electron-positron tracks

3) A Hard electron neutrino spectra than SN ones

4) A first Muon appearence in harder spectra above 400 MeV

5) A rarest Tau appearence in harder spectra, 4 GeV,

6) Few events in future HK might occur in Oct –Nov 2003

A probable transient event on 20 January 2005

7) A Solar Neutrino and Anti Neutrino Flare Astronomy must be born almost garanteed in larger Gd-UNO (440 kton) and-or HSK and Deep TITAND.

8) More Solar Flare than SN at the edge.

9) The rare Andromeda SN neutronization neutrino delay versus GW may test neutrino mass splitting.

Thank You for the attention

Forbush after all…

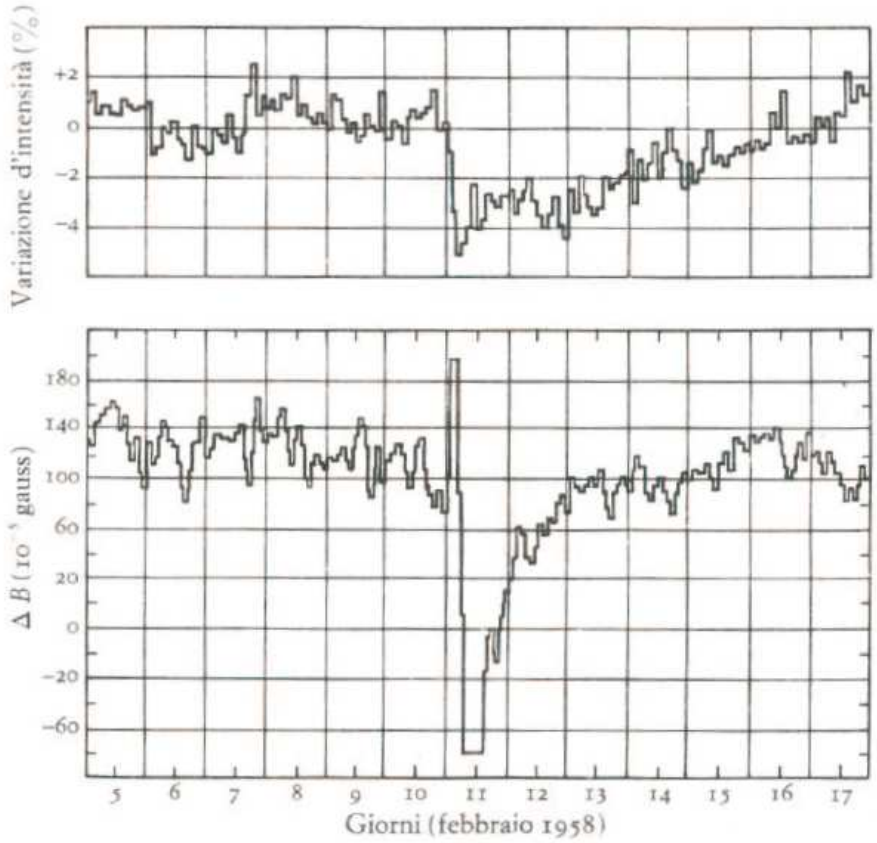


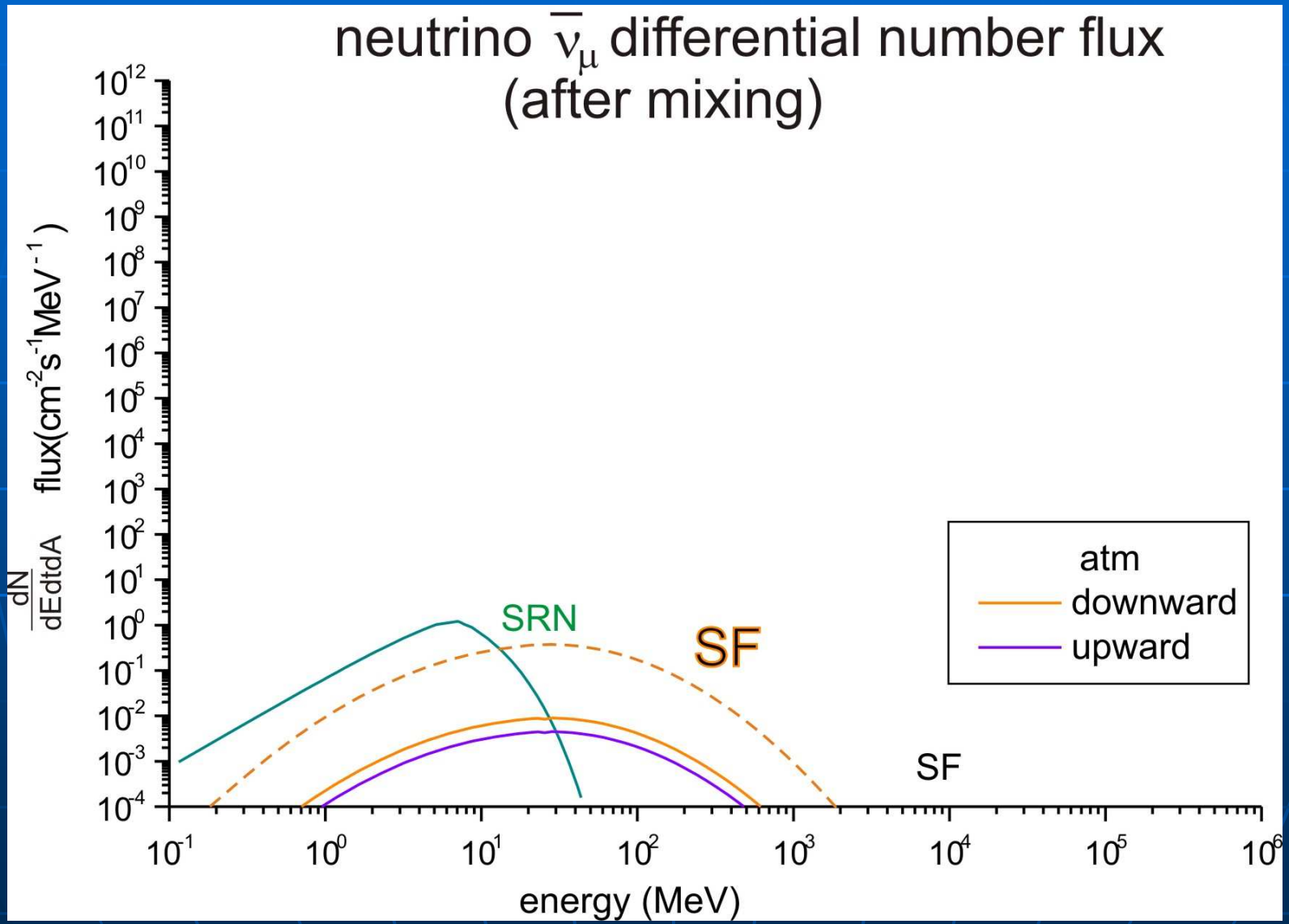
Figura 14.2: Tipiche diminuzioni di Forbush. La curva in basso rappresenta la componente

Present -Future Neutrino Detectors versus FLARE HK and UNO

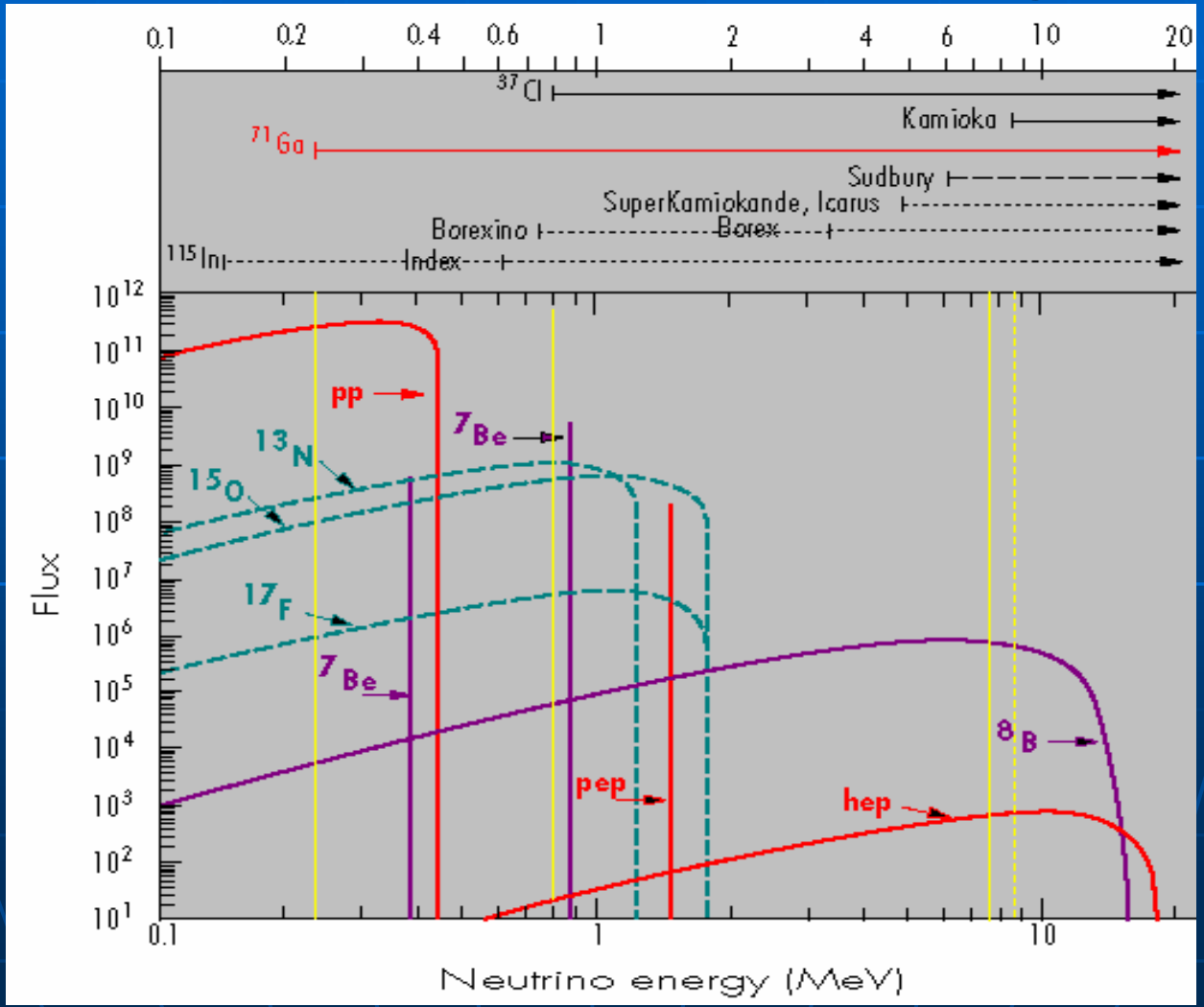
Detector		$E_{\rm th}$ (MeV)	(a_E, b_E)	Fiducial mass (kton)	$N^{\rm det}_{\overline{\nu}_e}$ ($D = 10$ kpc)
Čerenkov	SK[48, 49] (H_2O)	5	(0.47, 0)	32	5,900 - 9,990
	SNO[50, 51]	4	(0.35,0)		
	H_2O			1.4	260 - 440
	D_2O			1.0	80 - 160
Scintillator	KamLAND [52] (N12+PC+PPO)	2.6	(0,0.075)	1.0	240 - 400
Čerenkov	HK[33] (H_2O)	5	(0.5,0)	540	100,000 - 170,000
	UNO [55] (H_2O)	5	(0.5,0)	650	120,000 - 203,000
Scintillator	LENA [35] (PXE)	2.6	(0.1,0)	30	7,500 - 12,600

TABLE I: The relevant $\bar{\nu}_e$ detection parameters for some of the present and proposed detectors. In the last column we give the expected range for the number of charged current $\overline{\nu}_e$ events from a Galactic SN at 10 kpc, assuming the neutrino oscillation pattern discussed in sect 3B. The larger (smaller) numbers correspond to SN model 1 (model 2).

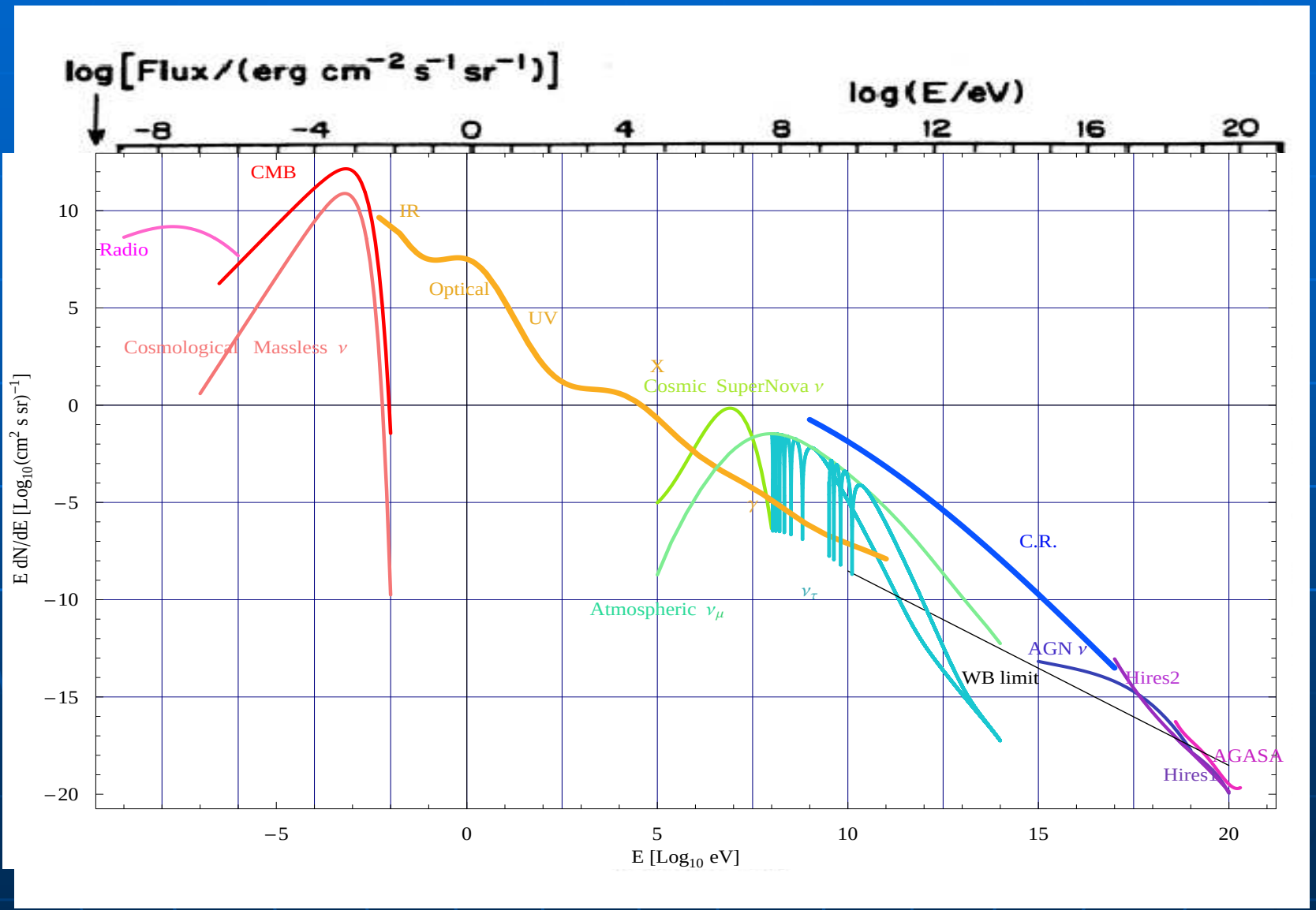
Anti mu after



Solar Standard Model: a noisy neutrino electron sky



Flux Number


log[Flux/(erg cm^{-2} s^{-1} sr^{-1})]
log(E/eV)
-8
-4
0
4
8
12
16
20
CMB
IR
Radio
Optical
UV
Cosmological Massless ν
X
Cosmic SuperNova ν
γ
C.R.
ν_τ
Atmospheric ν_μ
AGN ν
WB limit
Hires2
AGASA
Hires1
E dN/dE [Log$_{10}$(cm^2 s sr)$^{-1}$]
E [Log$_{10}$ eV]

Neutron and Gamma…and Neutrinos?

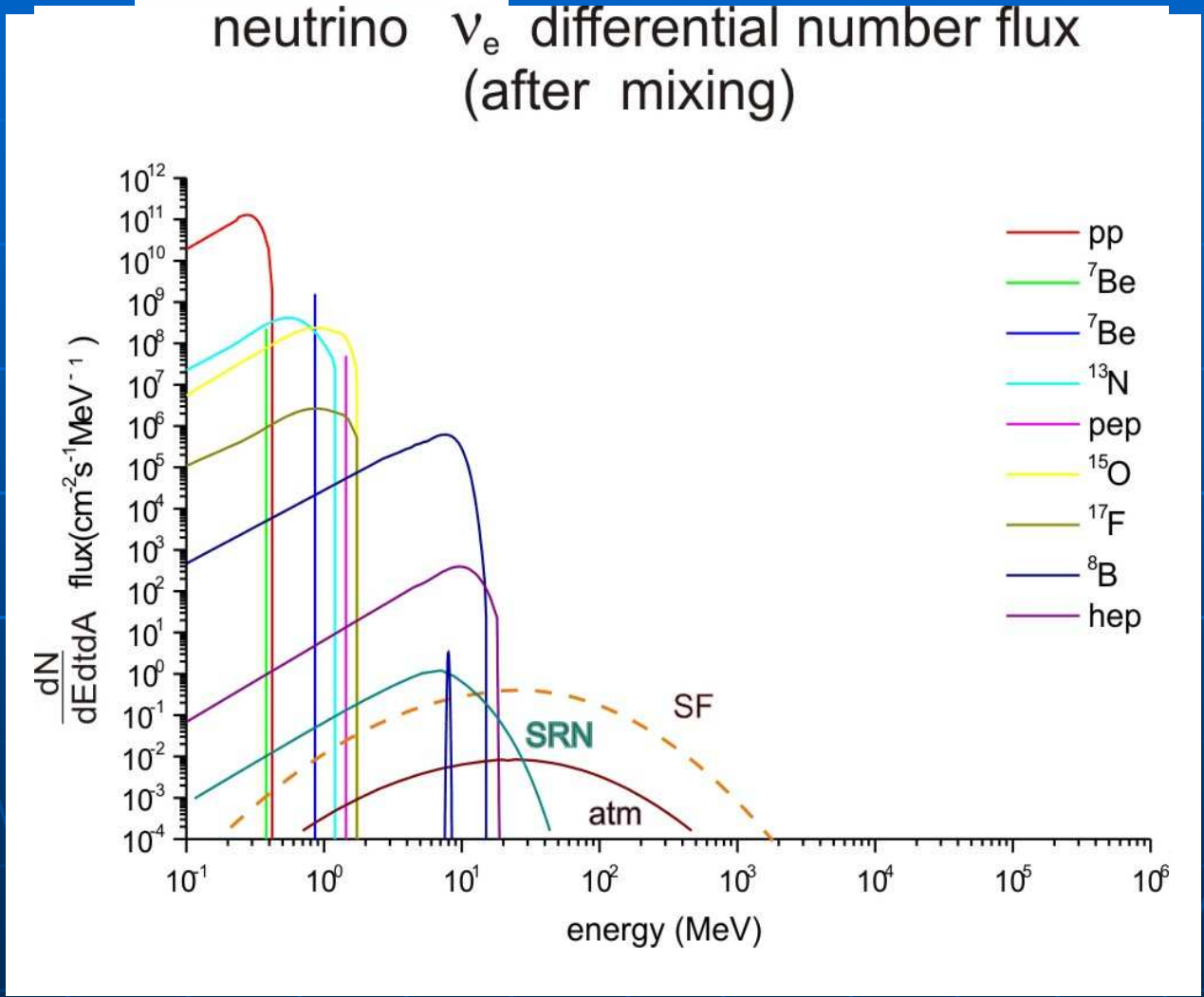
Solar Neutron Events of October-November 2003

K. Watanabe[1], M. Gros[2], P. H. Stoker[3], K. Kudela[4], C. Lopate[5], J. F. Valdés-Galicia[6], A. Hurtado[6], O. Musalem[6], R. Ogasawara[7], Y. Mizumoto[7], M. Nakagiri[7], A. Miyashita[7], Y. Matsubara[1], T. Sako[1], Y. Muraki[1], T. Sakai[8], and S. Shibata[9]

ABSTRACT

During the period when the Sun was intensely active on October-November 2003, two remarkable solar neutron events were observed by the ground-based neutron monitors. On October 28, 2003, in association with an X17.2 large flare, solar neutrons were detected with high statistical significance (6.4σ) by the neutron monitor at Tsumeb, Namibia. On November 4, 2003, in association with an X28 class flare, relativistic solar neutrons were observed by the neutron monitors at Haleakala in Hawaii and Mexico City, and by the solar neutron telescope at Mauna Kea in Hawaii simultaneously. Clear excesses were observed at the same time by these detectors, with the significance calculated as $7.5\,\sigma$ for

Earliest Estimate 2003-2006-versus 2008 gauged by gamma bound 2005



Neutrino muon before mixing