

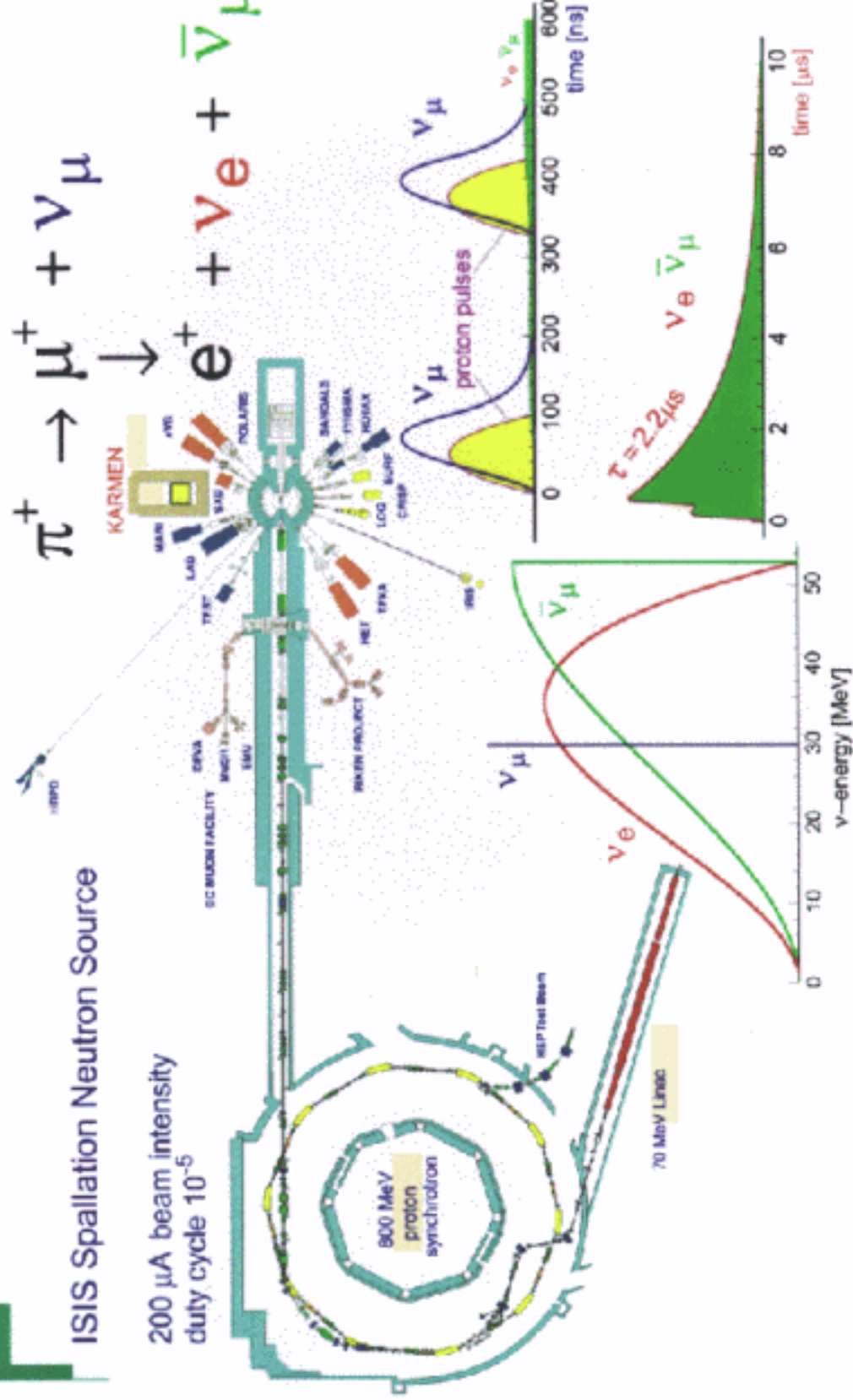
The KARMEN $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ Oscillation Search

- # Neutrinos from ISIS / KARMEN detector
- # $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ search: status 2000
- # discussion of results (history/present/future)
- # outlook
- # what next ?

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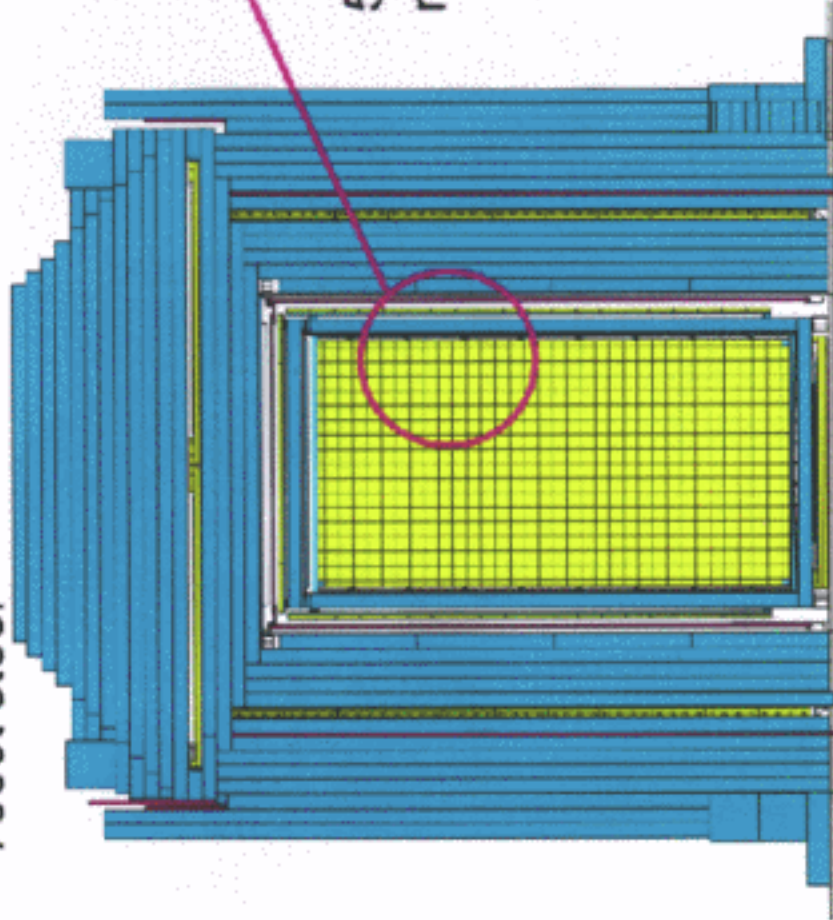
9th International Workshop on
"Neutrino Telescopes"
March 6-9, 2001
Venice, Italy

ν production at ISIS



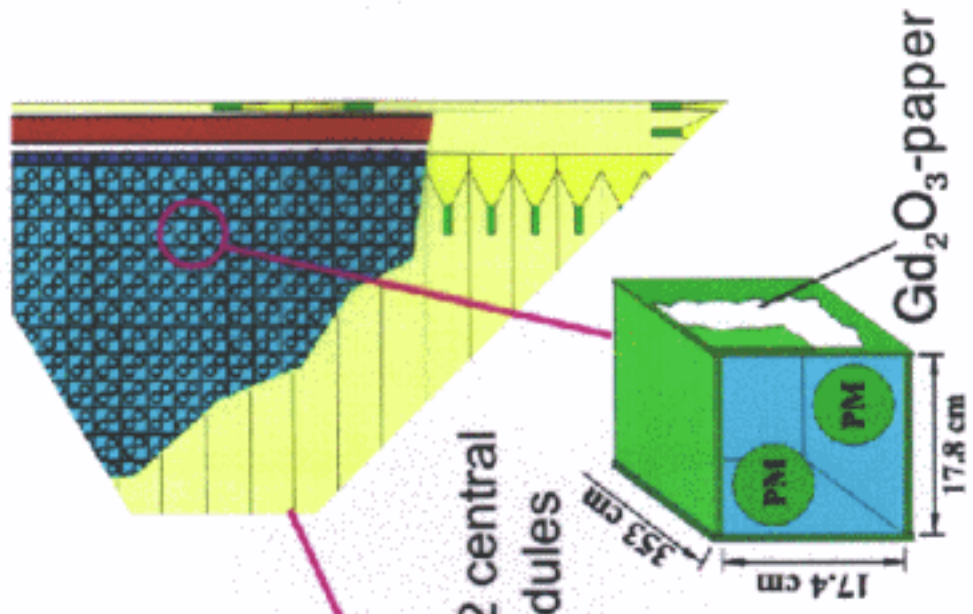
KARMEN2 detector system

7000t steel

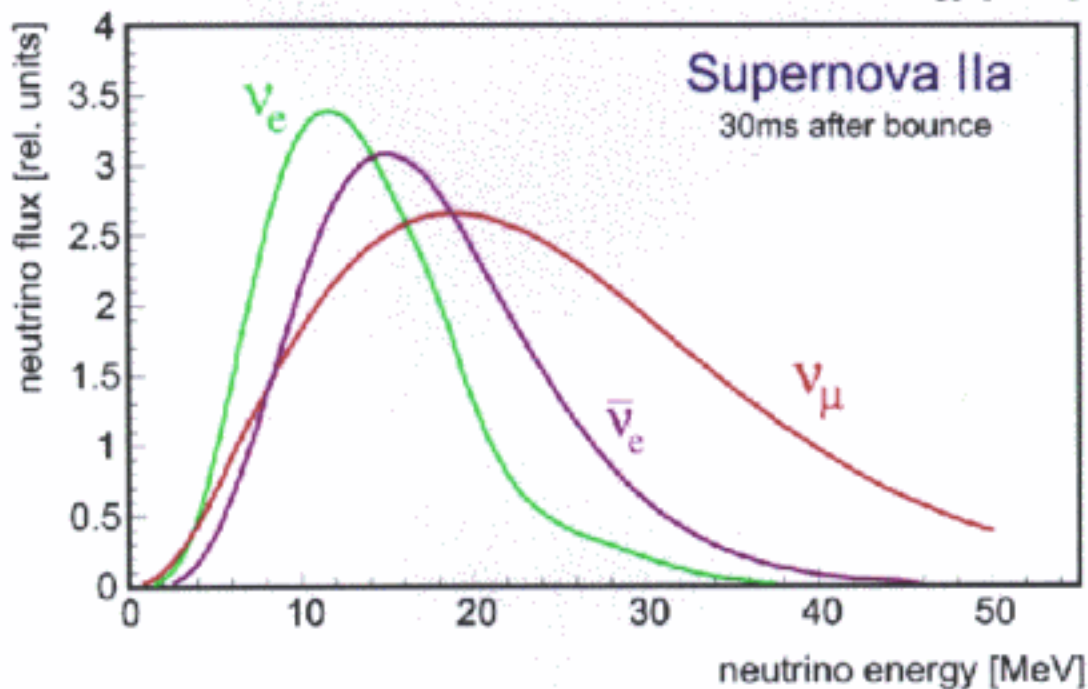
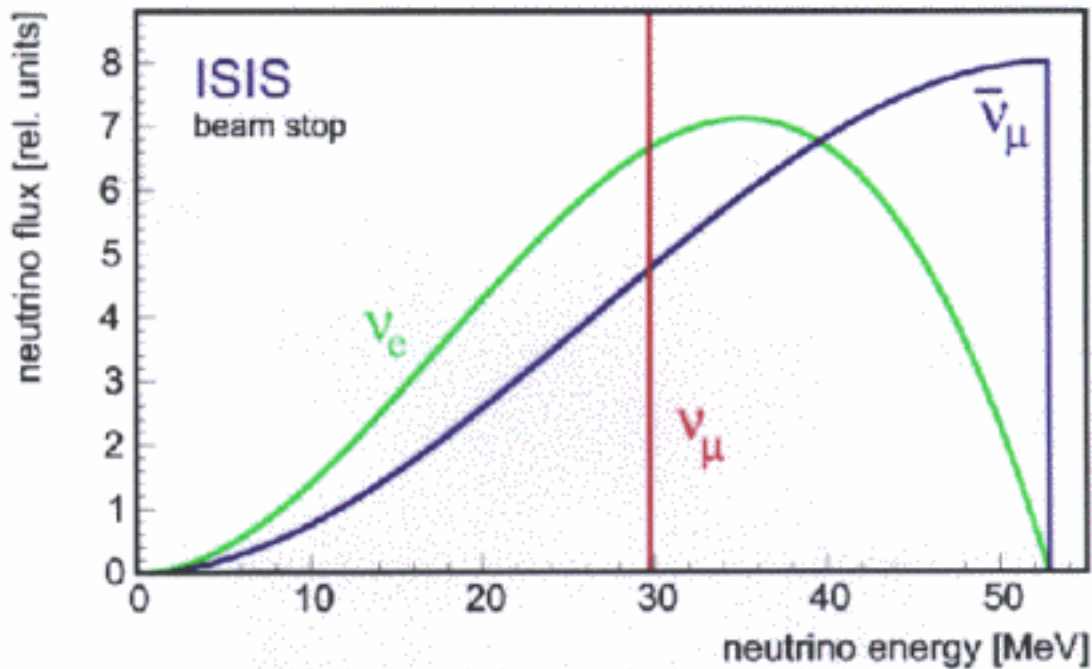


3 independent veto systems

512 central modules



Neutrino energy spectra from core-collapse **Supernovae** and **ISIS**

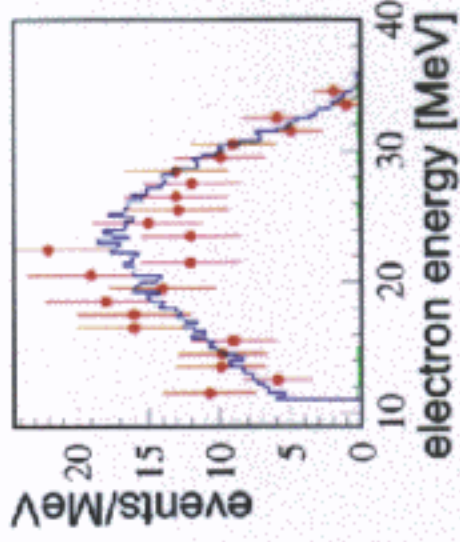
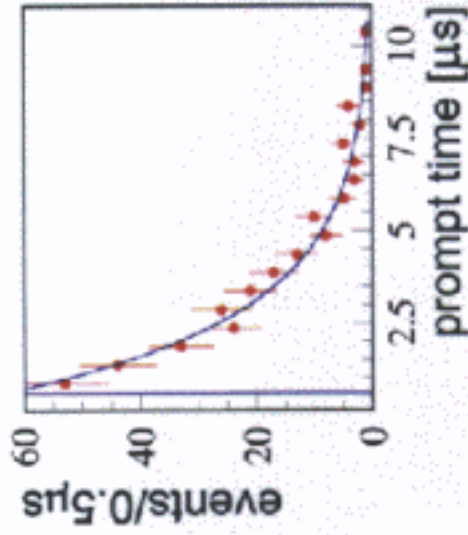


$$\langle E(\nu_e) \rangle = 10-12 \text{ MeV}$$

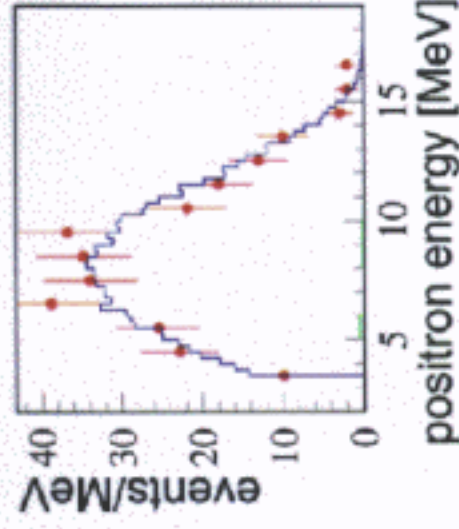
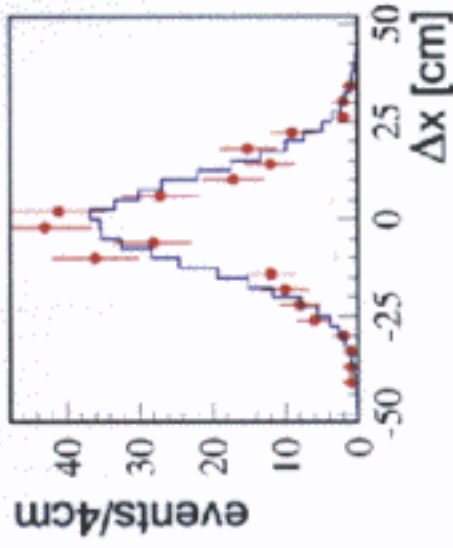
$$\langle E(\bar{\nu}_e) \rangle = 14-17 \text{ MeV}$$

$$\langle E(\nu_\mu) \rangle = 24-27 \text{ MeV}$$

$^{12}\text{C}(\nu_e, e^-)^{12}\text{N}_{\text{g.s.}}$ sequences KARMEN2



274 sequences,
1.3 cosmic bg



281 sequences
expected
from KARMEN1

KARMEN neutrino physics

CC



$$\langle \sigma \rangle = (9.4 \pm 0.4 \pm 0.8) \times 10^{-42} \text{ cm}^2$$

V-A of μ^+ -decay: $\omega_L < 0.113$

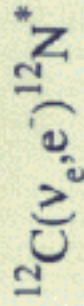
weak charge radius $R_A = (3.8_{-1.8}^{+1.4}) \text{ fm}$

Phys.Lett.B 280 (1992) 198

Phys.Lett.B 339 (1994) 215

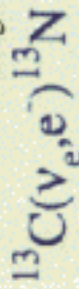
Phys.Rev.Lett. 81,3 (1998) 520

Phys.Rev. C 57 (1998) 3414



$$\langle \sigma \rangle = (5.1 \pm 0.6 \pm 0.5) \times 10^{-42} \text{ cm}^2$$

Prog.Part.Nucl.Phys. 40 (1998) 183

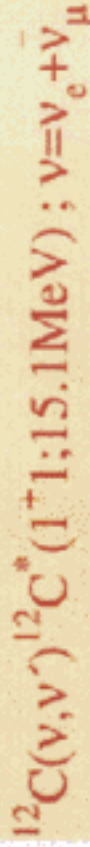


$$\langle \sigma \rangle = (0.5 \pm 0.37 \pm 0.1) \times 10^{-40} \text{ cm}^2$$



$$\langle \sigma \rangle = (2.51 \pm 0.83 \pm 0.42) \times 10^{-40} \text{ cm}^2$$

NC



$$\langle \sigma \rangle = (10.9 \pm 0.7 \pm 0.8) \times 10^{-42} \text{ cm}^2$$

flavor universality $R = 1.17 \pm 0.11 \pm 0.012$

Phys.Lett.B 332 (1994) 251

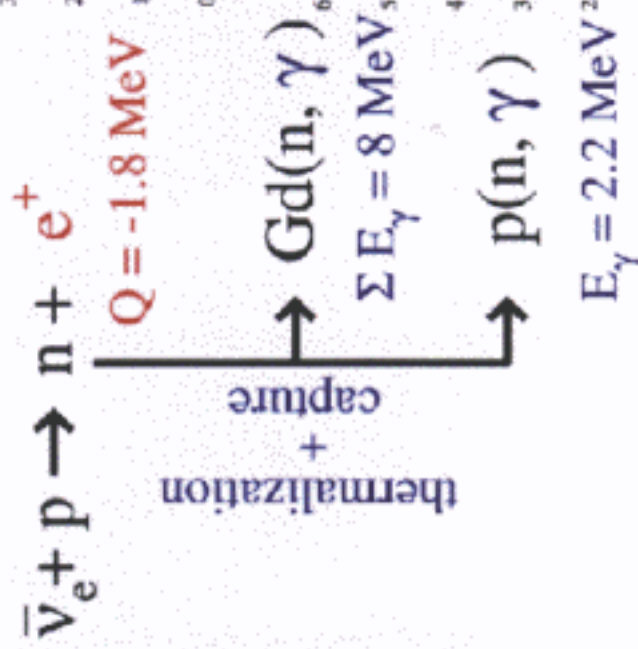
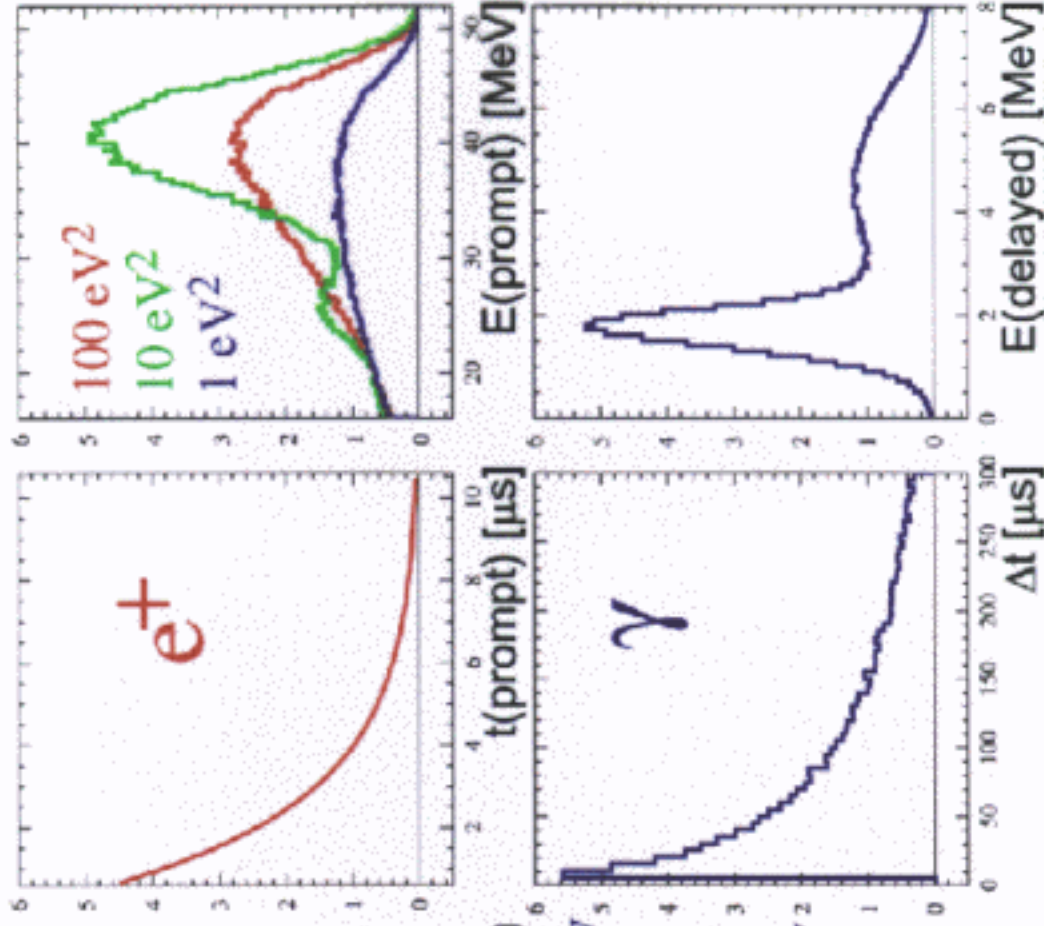


$$\langle \sigma \rangle = (3.1 \pm 0.8 \pm 0.5) \times 10^{-42} \text{ cm}^2$$

isovector-axial coupling $|\beta| = 1.08 \pm 0.18$

Phys.Lett.B 423 (1998) 15

$\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillation signature

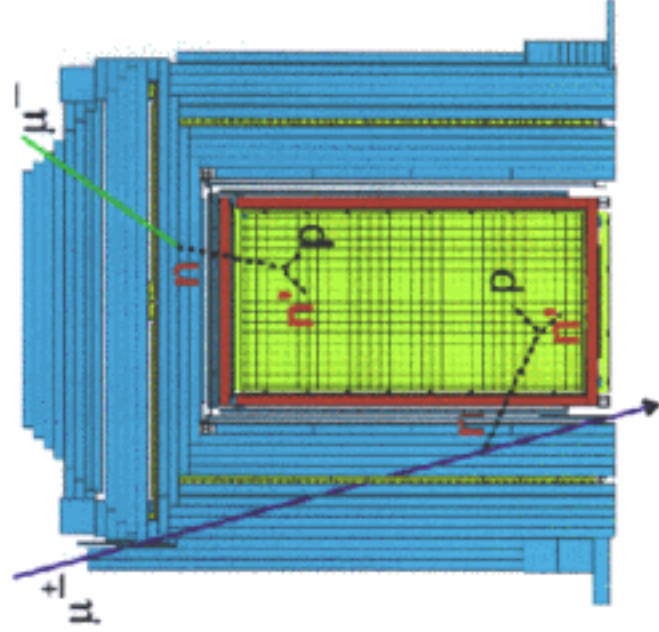


the KARMEN upgrade

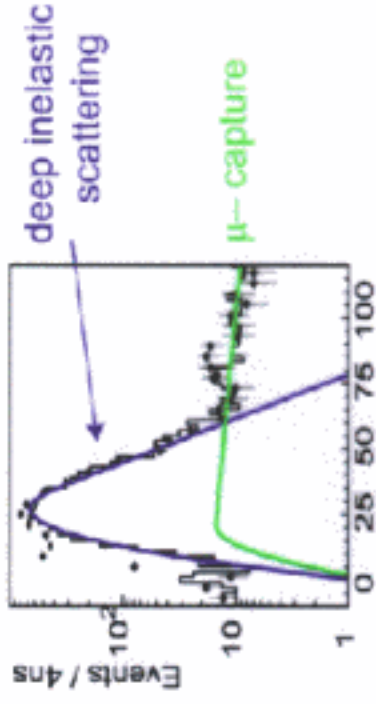
deep inelastic scattering



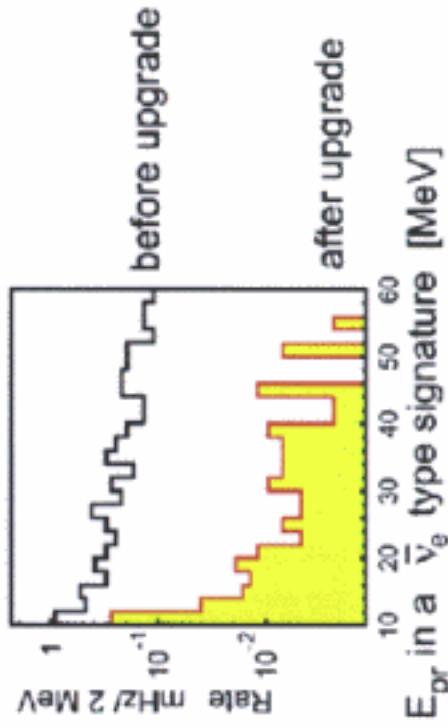
muon capture on iron



Muon induced sequences:



Δt (Veto-Hit - Central-Hit) [ns]



data set after final cuts

11 candidates

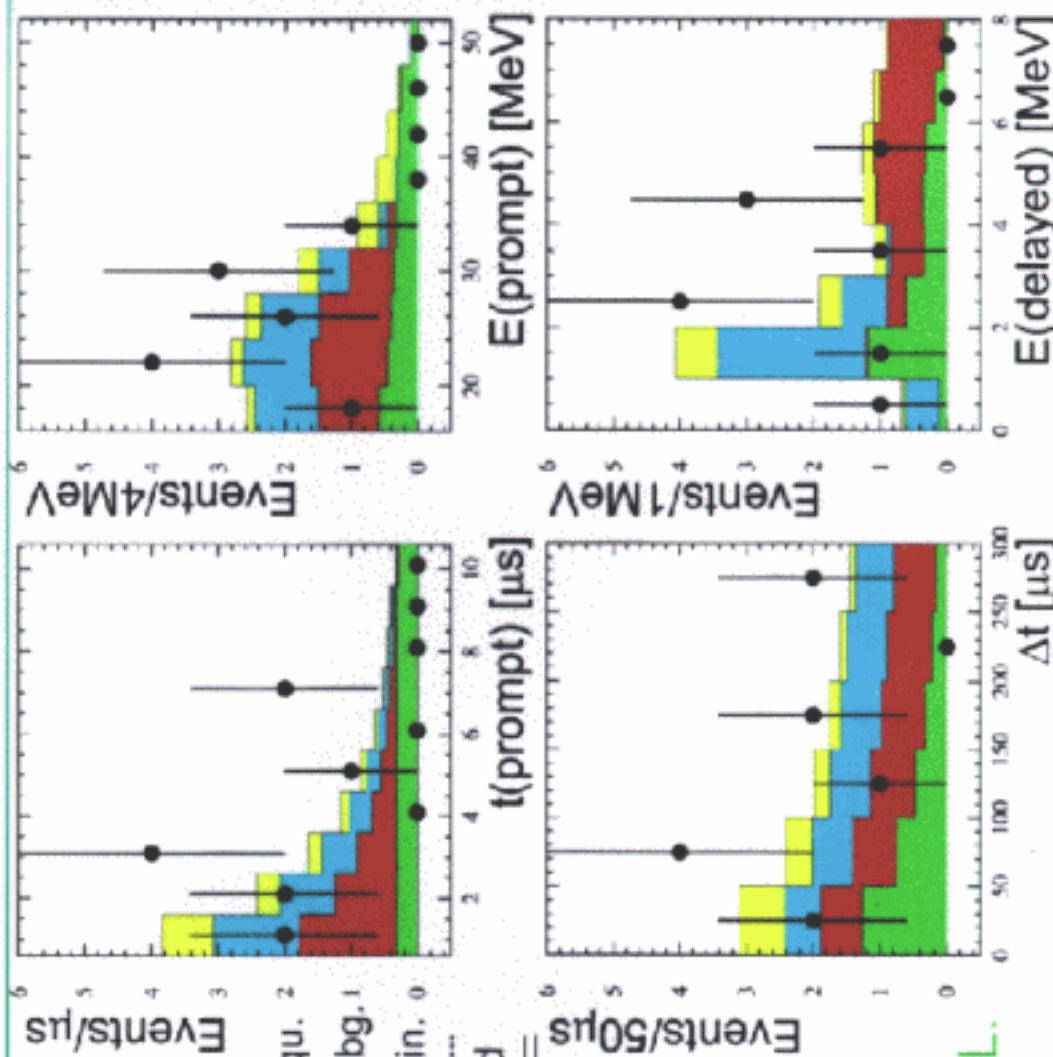
- 3.9 ± 0.5 ν_e -induced CC sequ.
- 3.5 ± 0.3 ν -induced random bg.
- 1.7 ± 0.2 $\bar{\nu}_e$ intrinsic contamin.

3.2 ± 0.2 cosmic background

12.3 ± 0.6 total background

no osci signal

Bayes:
 signal > 6.3 evts
 excluded @ 90% C.L.



the KARMEN2 likelihood function

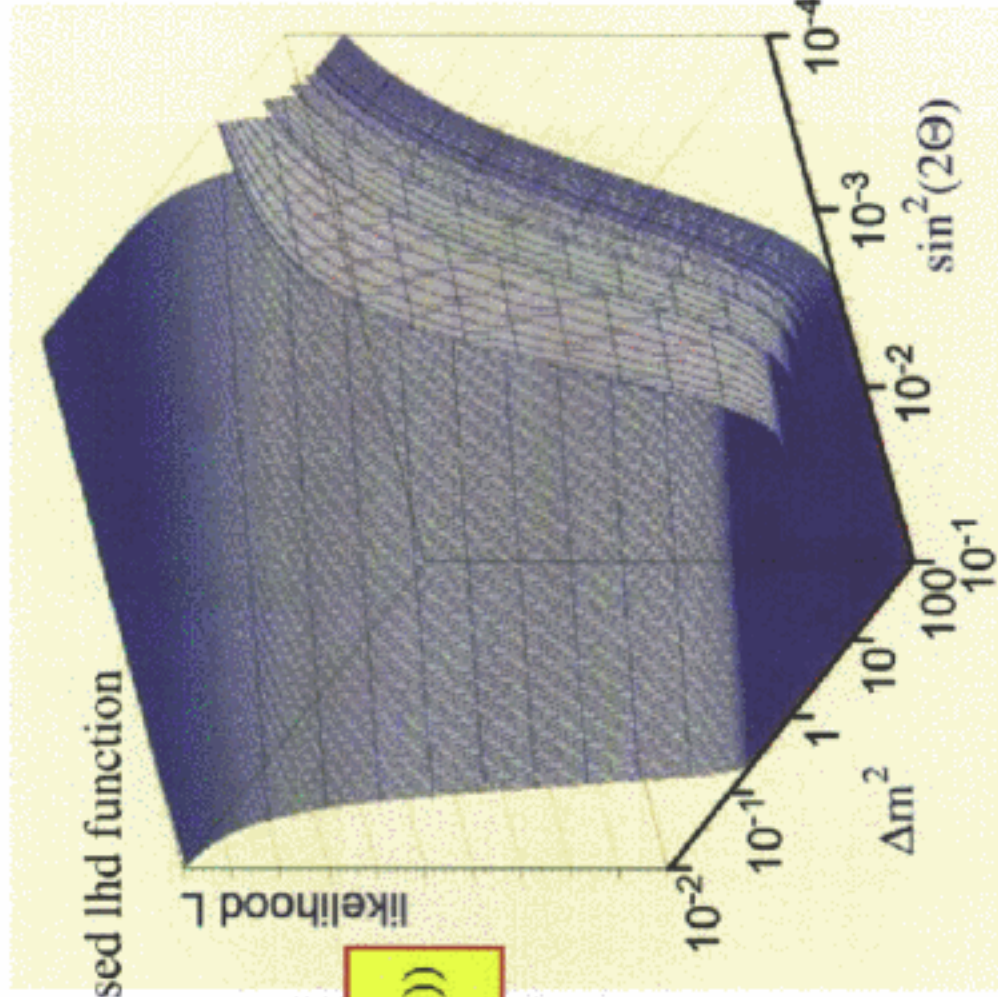
event-based lhd function

N events

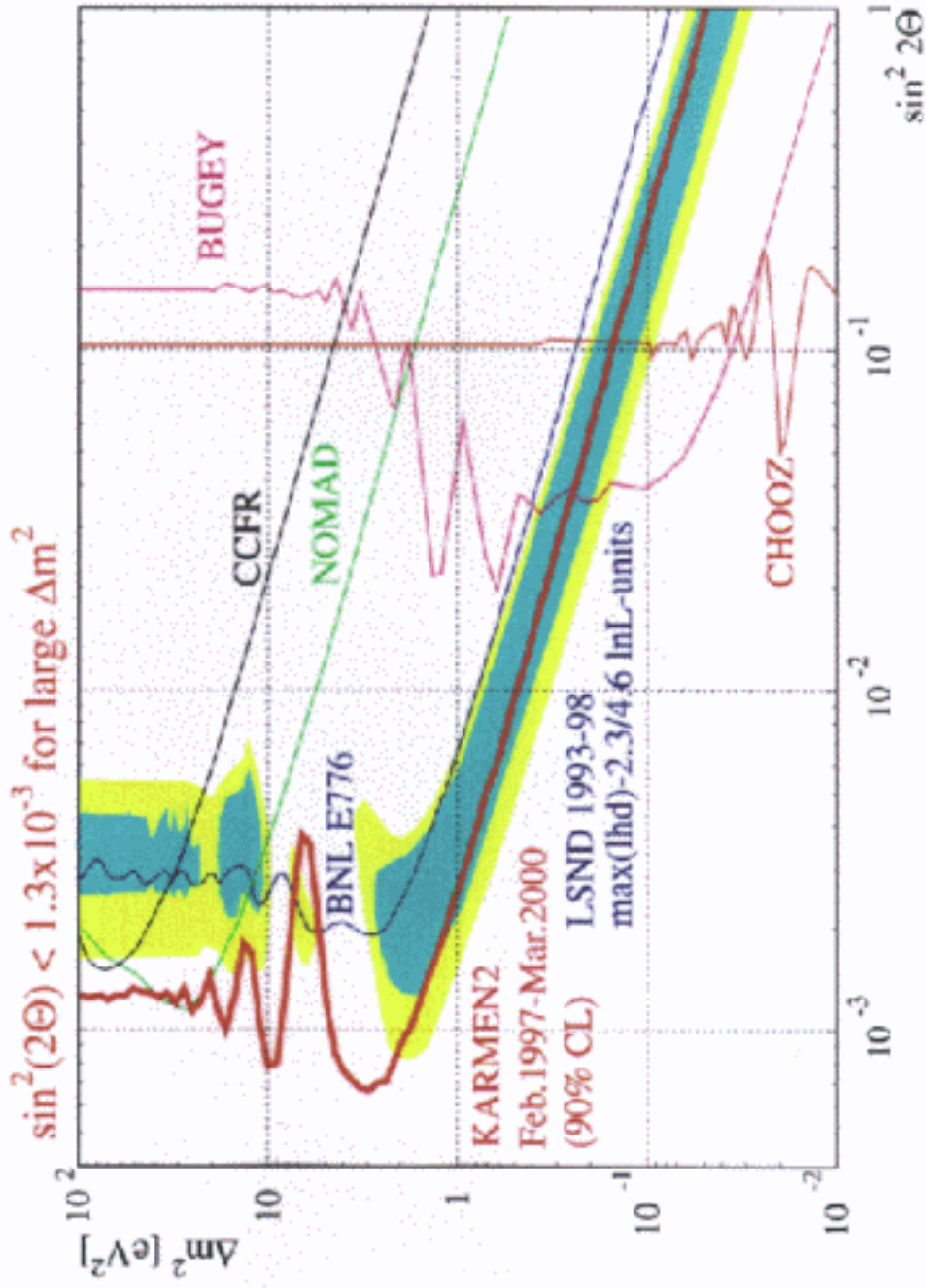
$$L = \prod_{i=1}^N f(\vec{x}_i, \Delta m^2, \sin^2(2\theta))$$

with

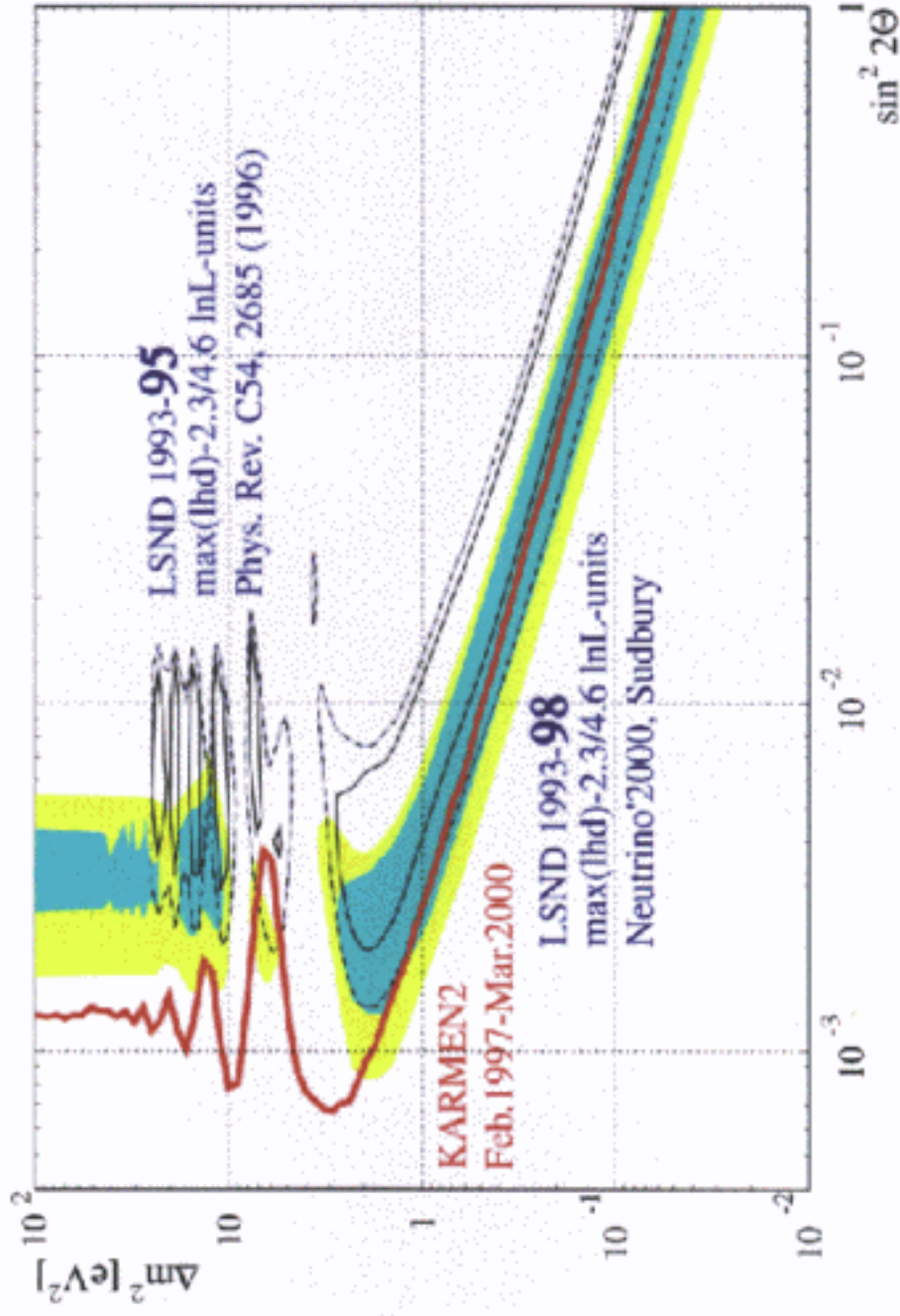
$$\vec{x} = (E_{pr}, E_{del}, t_{pr}, \Delta t, \Delta \vec{r})$$



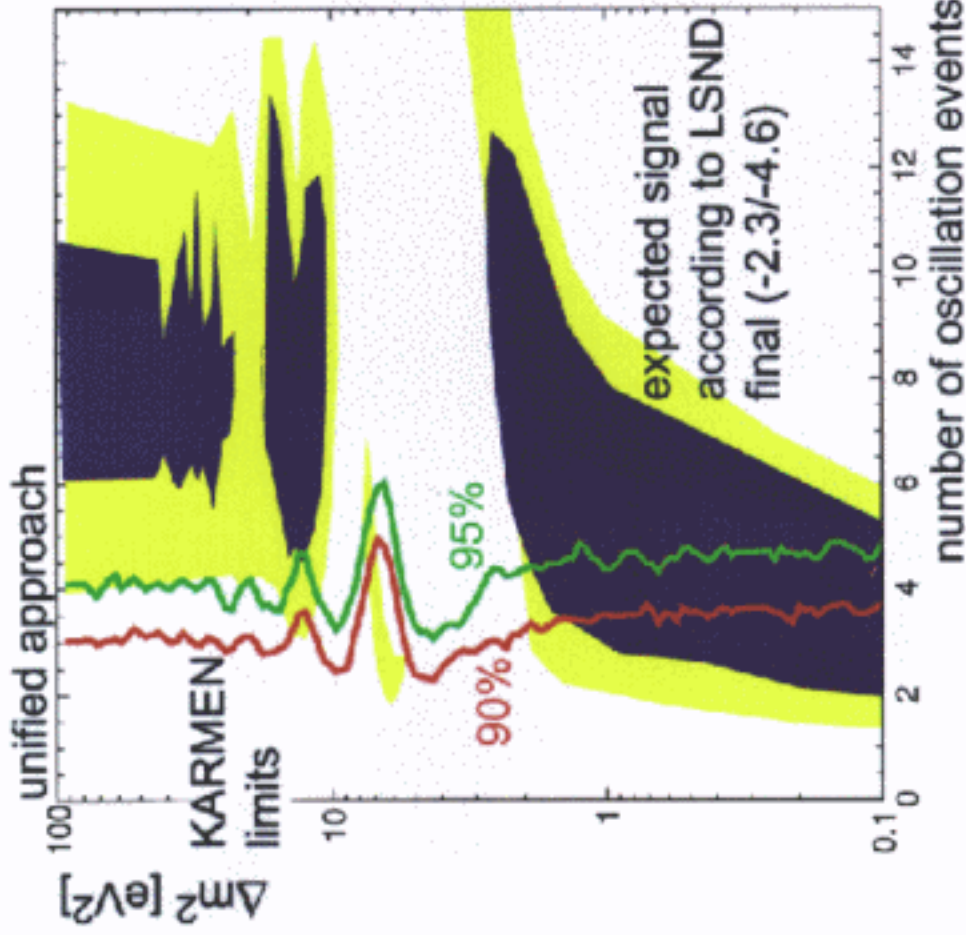
neutrino oscillation plot



LSND favored regions



excluded oscillation events by KARMEN



$N(\text{expected})=2442$ for $\sin^2(2\theta)=1$

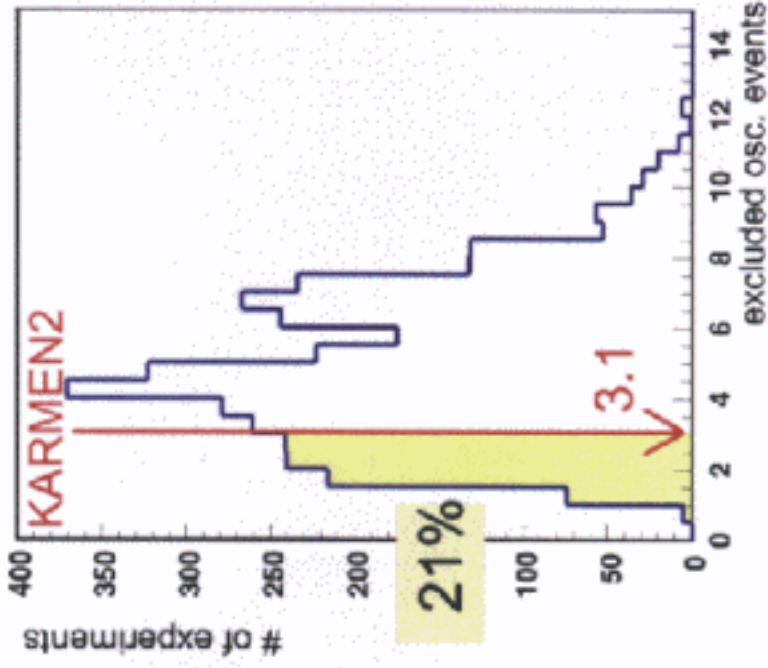
$N(\text{osc}) < 3.1$ (90% CL)
 $\Delta m^2 = 100 \text{eV}^2$

$N(\text{osc}) < 3.8$ (90% CL)
 $\Delta m^2 = 0.1 \text{eV}^2$

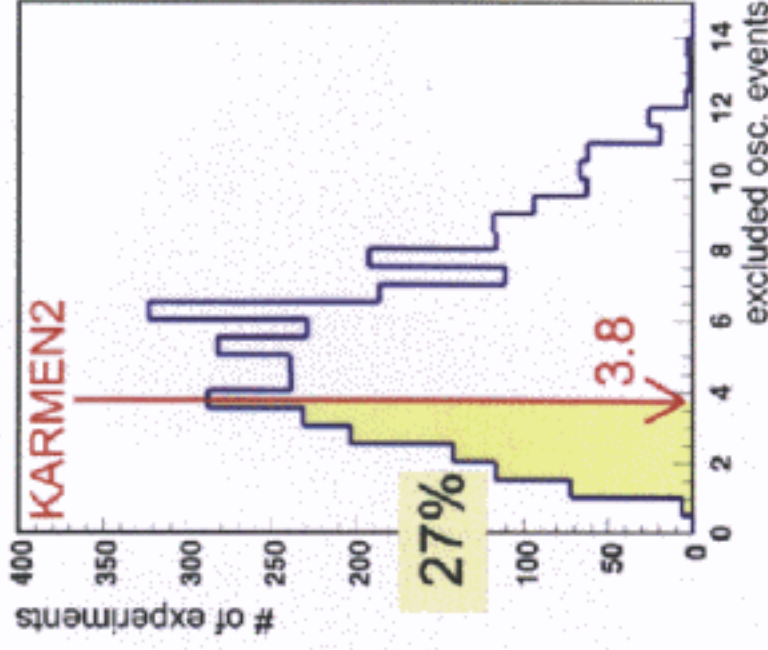
Status June 2000 !

KARMEN2 sensitivity in unified approach

$$\Delta m^2 = 100 \text{ eV}^2$$

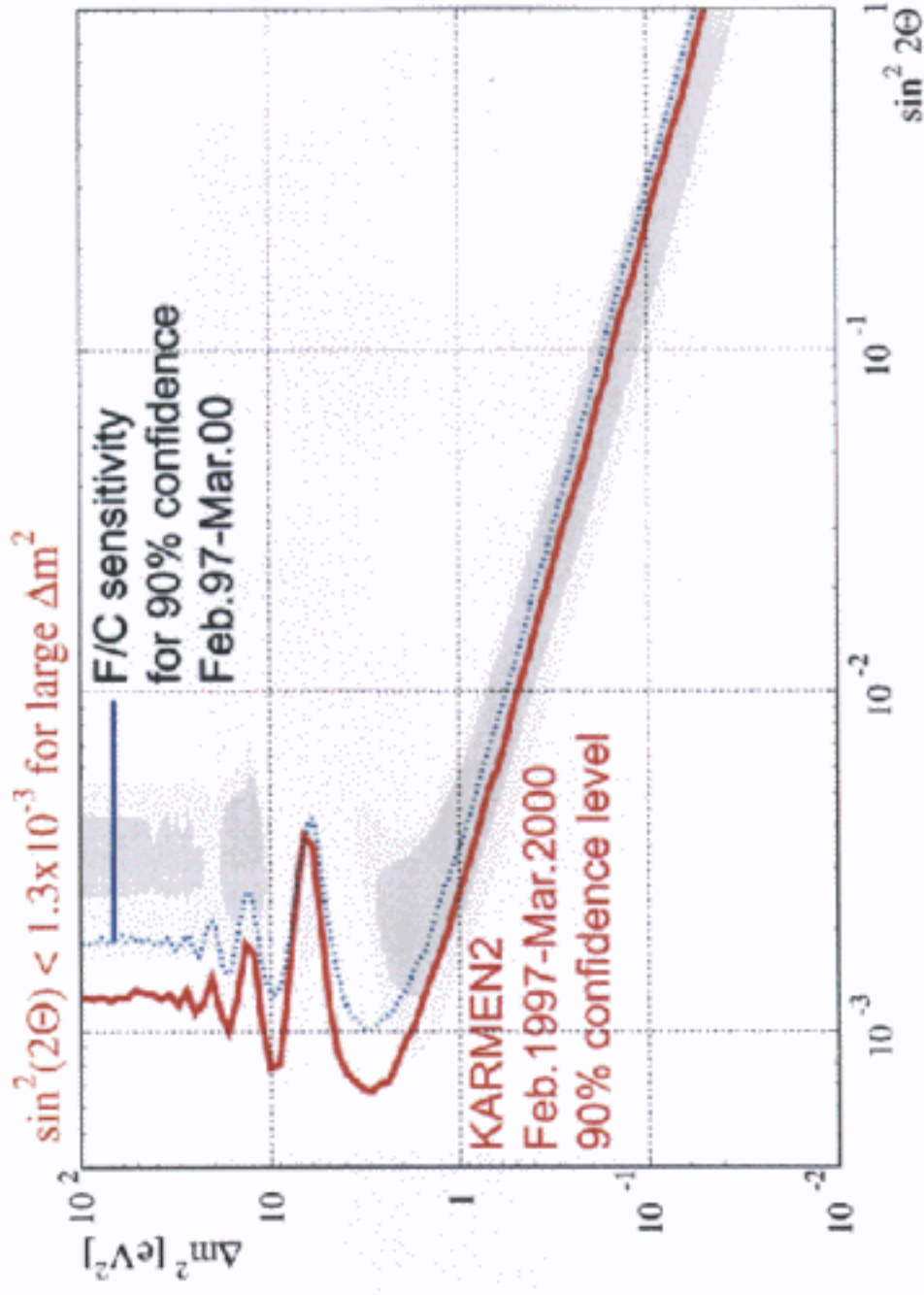


$$\Delta m^2 = 0.1 \text{ eV}^2$$



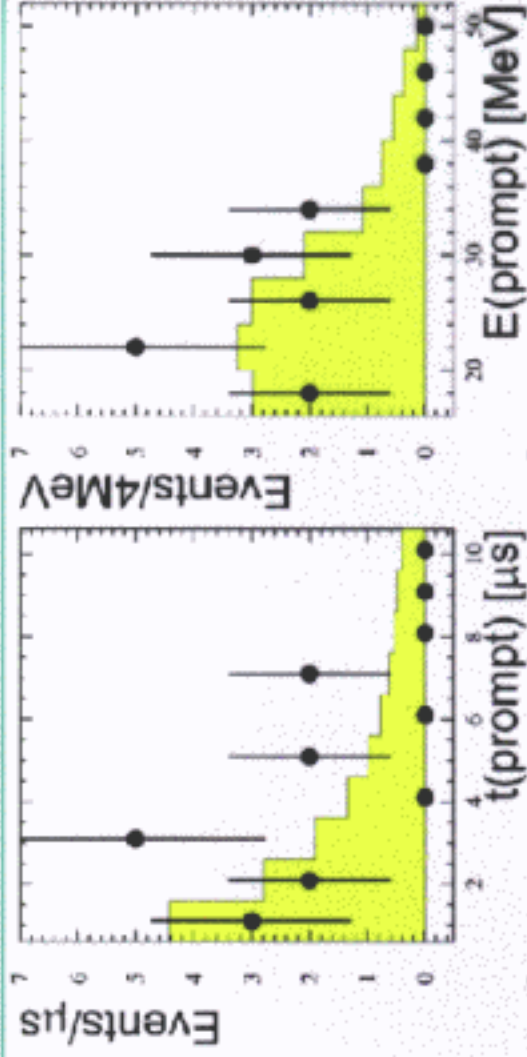
4000 K2 samples with $<12.3>$ background events, no signal
created by MC and analysed with max. lhd. analysis

KARMEN sensitivity plot

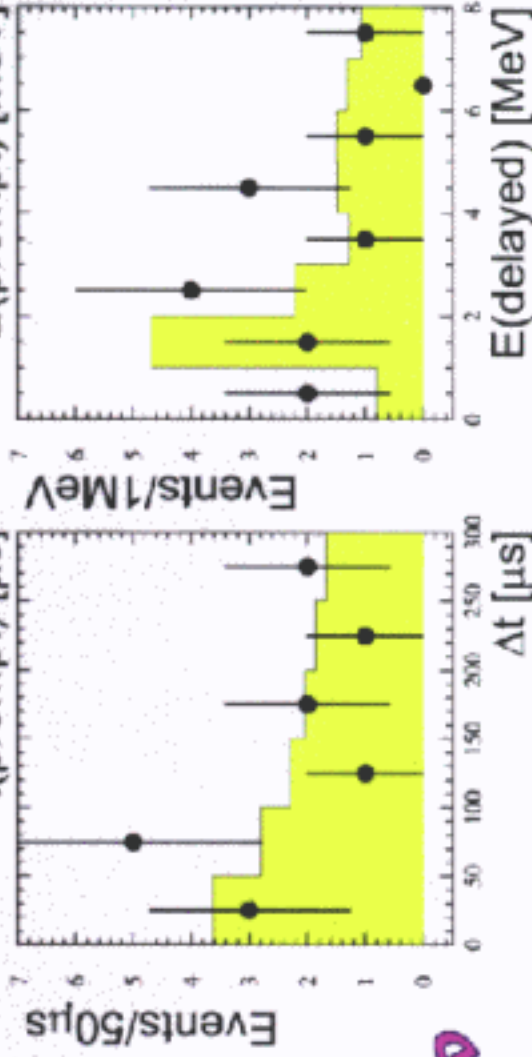


KARMEN Nov. 2000 status and NEAR future

data Feb. '97-March 2000
(7160C prot.-on-target):
11 candidates
12.3 bg events
sensitivity: $\sin^2 2\theta < 1.7 \times 10^{-3}$



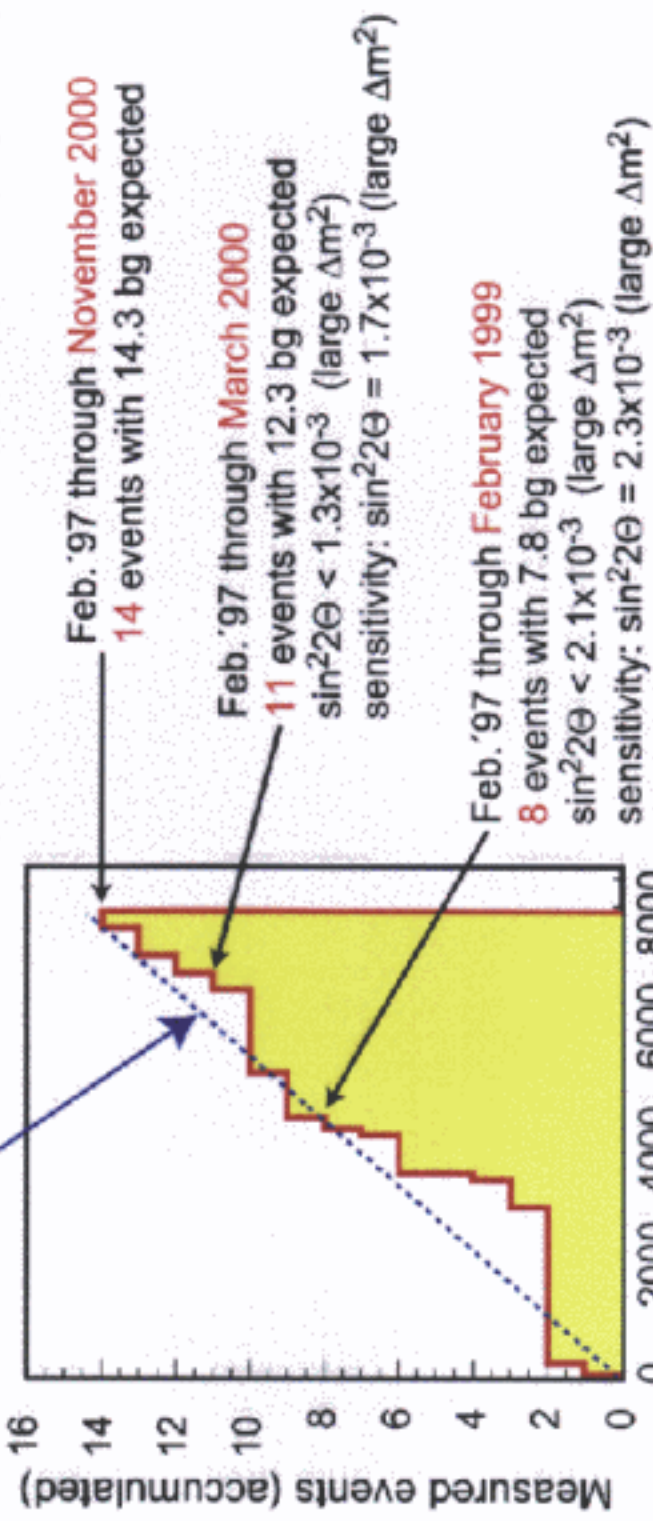
data Feb. '97-Nov. 2000
(8300C prot.-on-target):
14 candidates
14.3 bg events



data Feb. '97-March 2001
(9300C prot.-on-target)
THE END

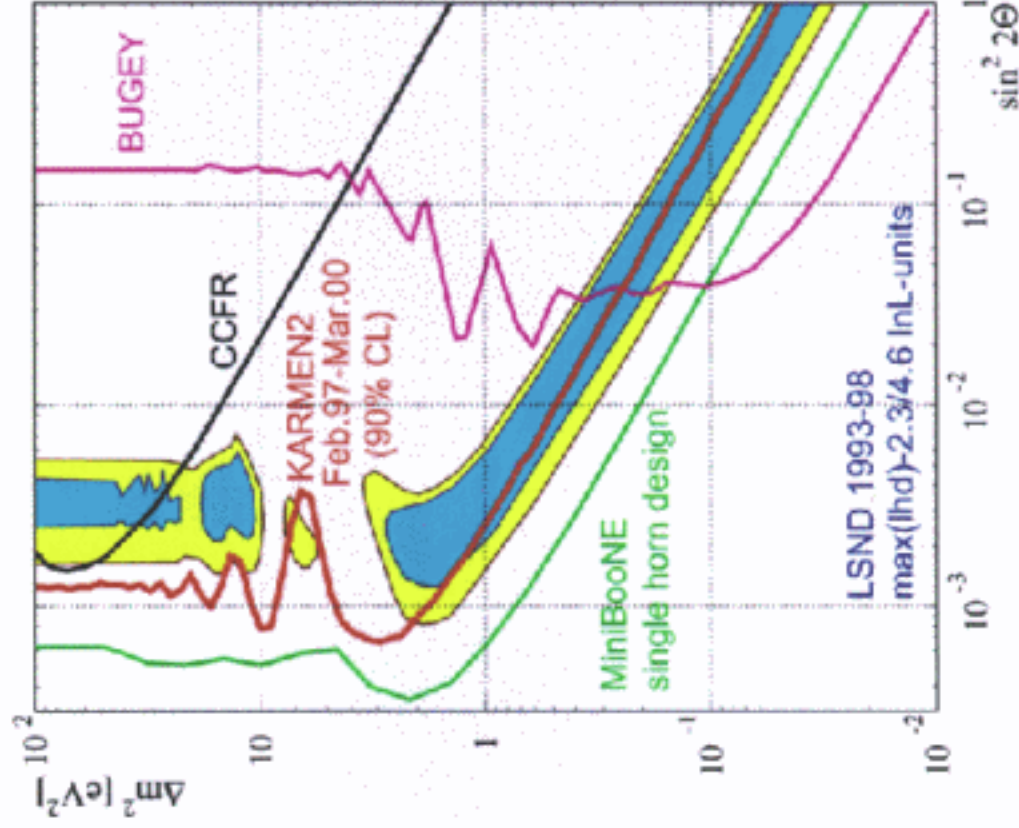
chronology of candidate events

Feb. '97 through **March 2001**
 expected sensitivity:
 $\sin^2 2\theta = 1.3 \times 10^{-3}$ (large Δm^2)



limits from likelihood analysis using spectral event information
 sensitivity based on unified frequentist approach

Summary and Outlook



KARMEN: no signal vs.

LSND: evidence

LSND final analysis:

only lhd-regions so far!

disagreement at ~70% level

KARMEN final data **today!**

MiniBooNE sensitivity

to test LSND interpretation
of excess events

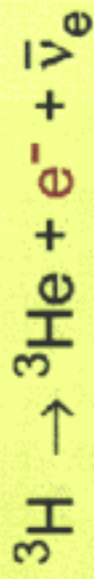
KARMEN:

$$\sin^2(2\Theta) < 1.3 \times 10^{-3} \text{ for large } \Delta m^2$$

MiniBooNE:

$$\sin^2(2\Theta) < 0.6 \times 10^{-3} \text{ for large } \Delta m^2$$

future

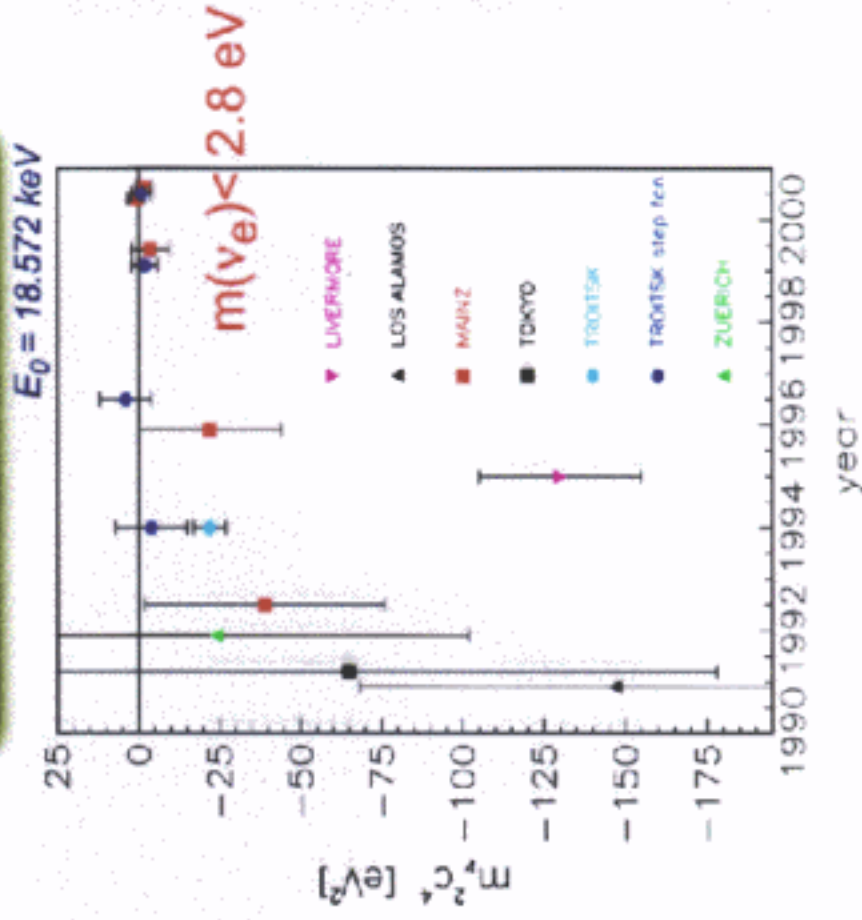


physics tasks:

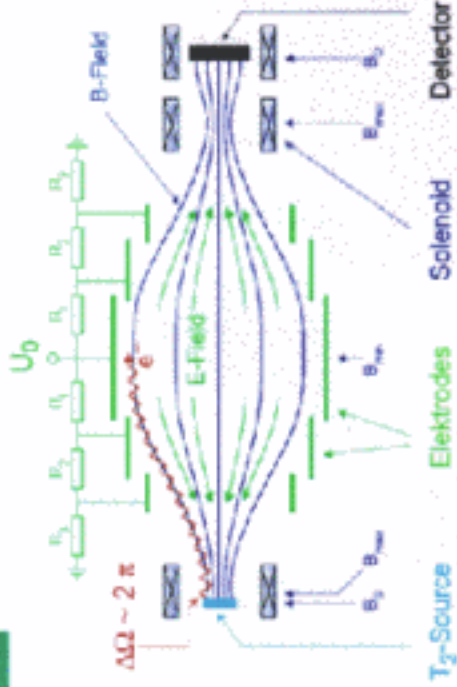
- # absolute ν mass scale
- # hierarchical/degenerate masses
- # ν 's as hot dark matter

strategies:

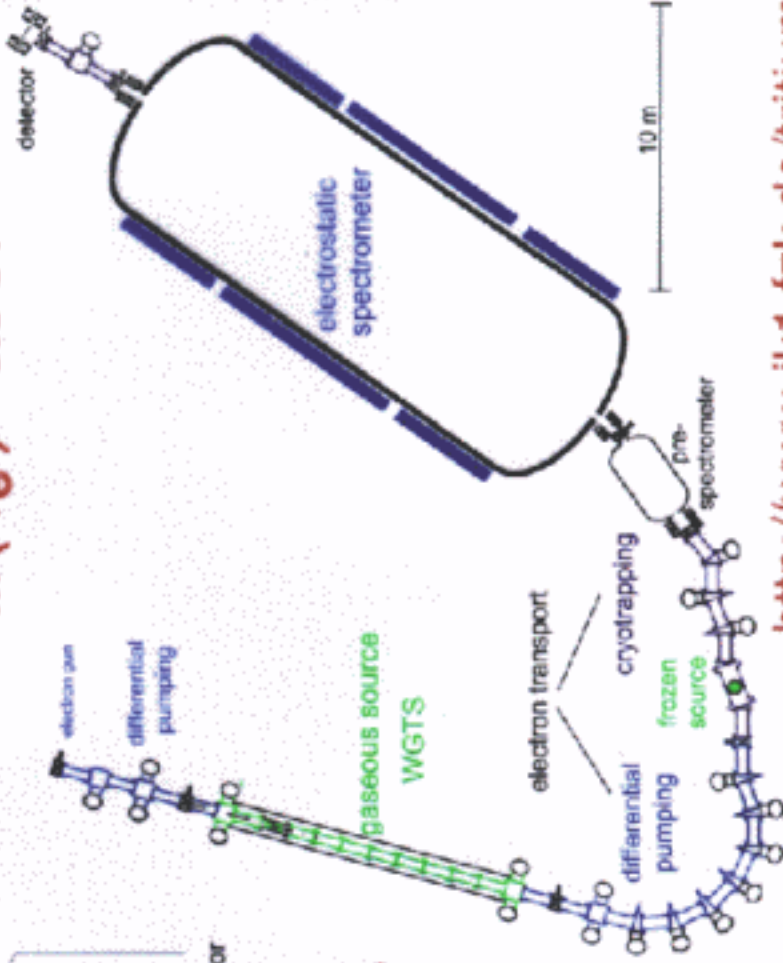
- # $0\nu\beta\beta$
- # CMB/large scale structures
- # direct mass measurements



a next generation tritium beta decay experiment



KATRIN sensitivity aim:
 $m(\nu_e) < 0.3 \text{ eV}$



electrostatic filter with $E \parallel B$



magnetic adiabatic transformation $E_{\perp} \rightarrow E_{\parallel}$

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 University of Mainz
 INR Troitsk
 University of Karlsruhe

<http://www-ik1.fzk.de/tritium>

Forschungszentrum Karlsruhe, Institut für Kernphysik