NEWS from SNO+

Sofia Andringa, for the SNO+ LIP group

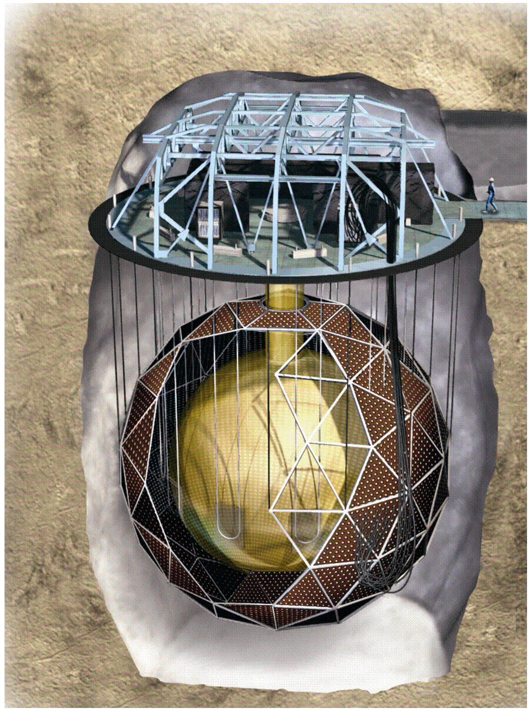
Jornadas do LIP 2014

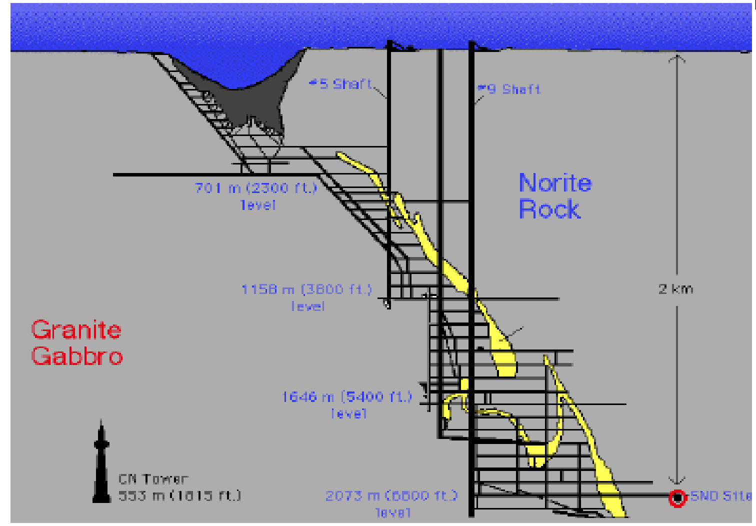
SNO+ and SNOLAB

780 tons
of liquid
scintillator
viewed by
9000 PMTs
(55% cover.)

for
low energy
ν physics:

- $0\nu\beta\beta$
- Oscillations
- SuperNovae
- Geo ν
- Solar ν
- ...

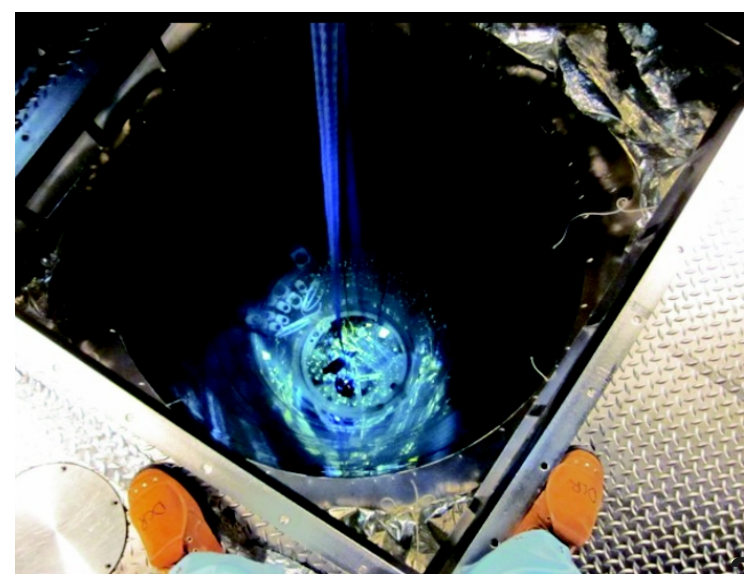




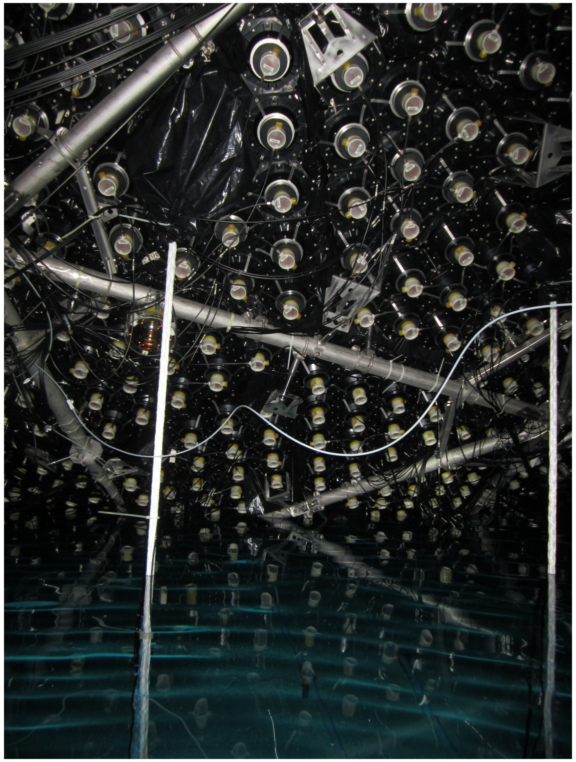
2000 m deep

Other ν/DM experiments:

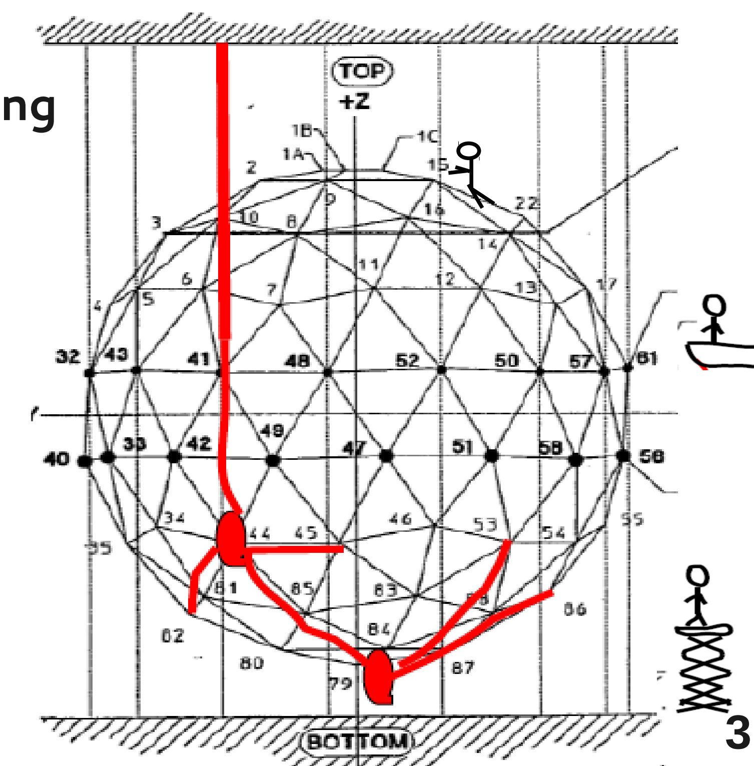
HALO
PICO
COUPP
DEAP-3600
MiniCLEAN
...



Fiber calibration system



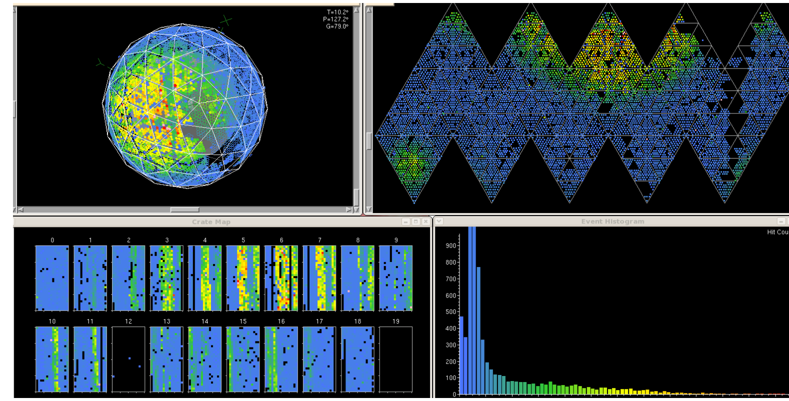
92 (+spares) mounting points:
36 installed from cavity floor,
others with boating and climbing

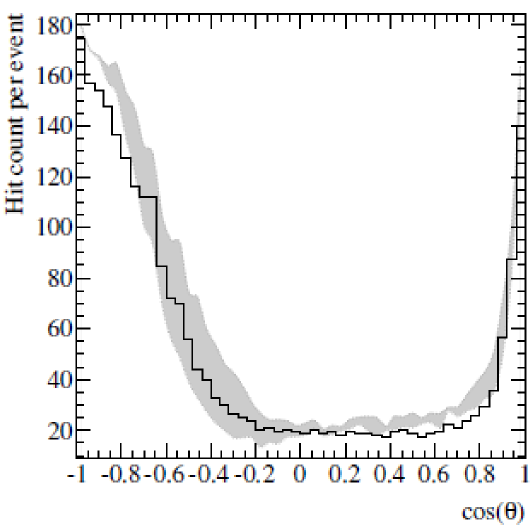


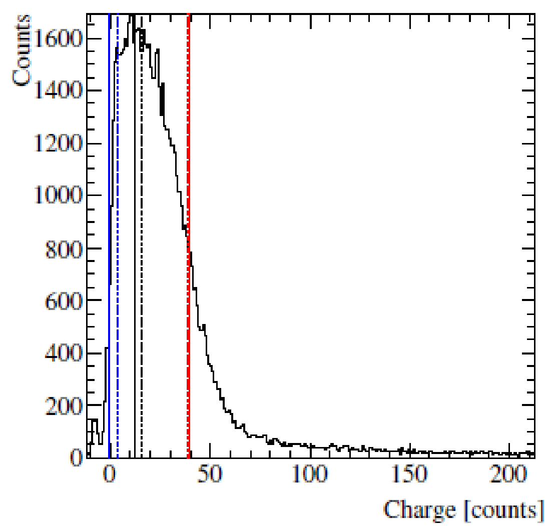
Commissioning Runs 2014

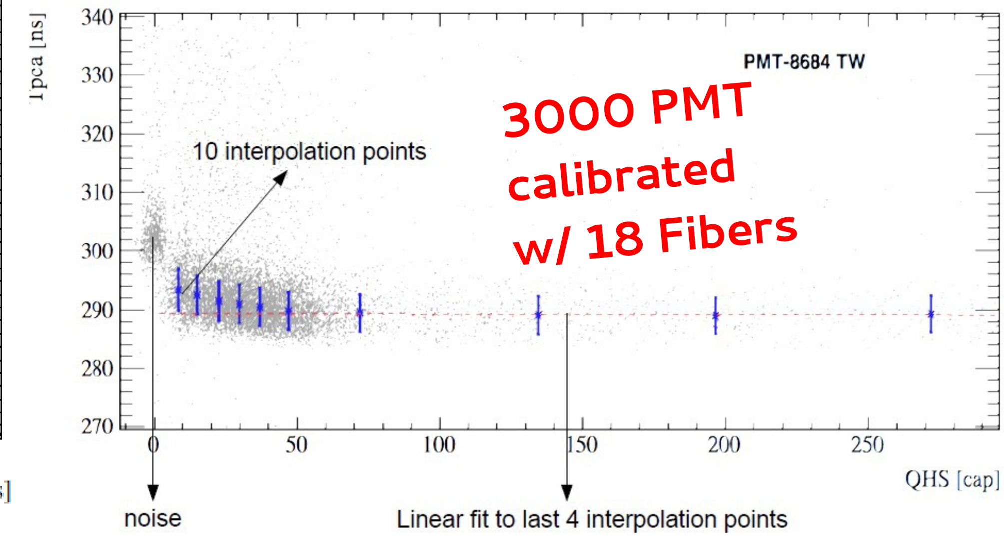
3 short Air Runs in 2013/2014:

- characterize LED/Fiber system
- first paper of SNO+ hardware
- first test of PMT calibrations









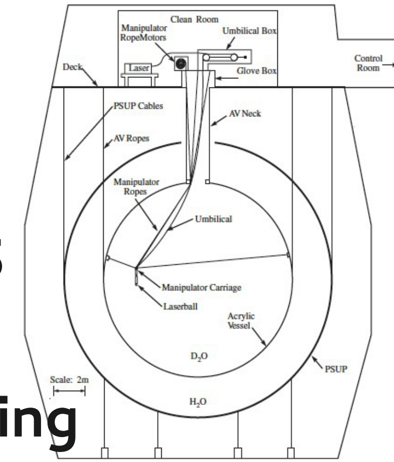
3000 PMT calibrated w/ 18 Fibers

Long Water Run in 2014:

- measure all PMT & optical properties
- cross-check with SNO last data
- test continuous running @ 10 Hz

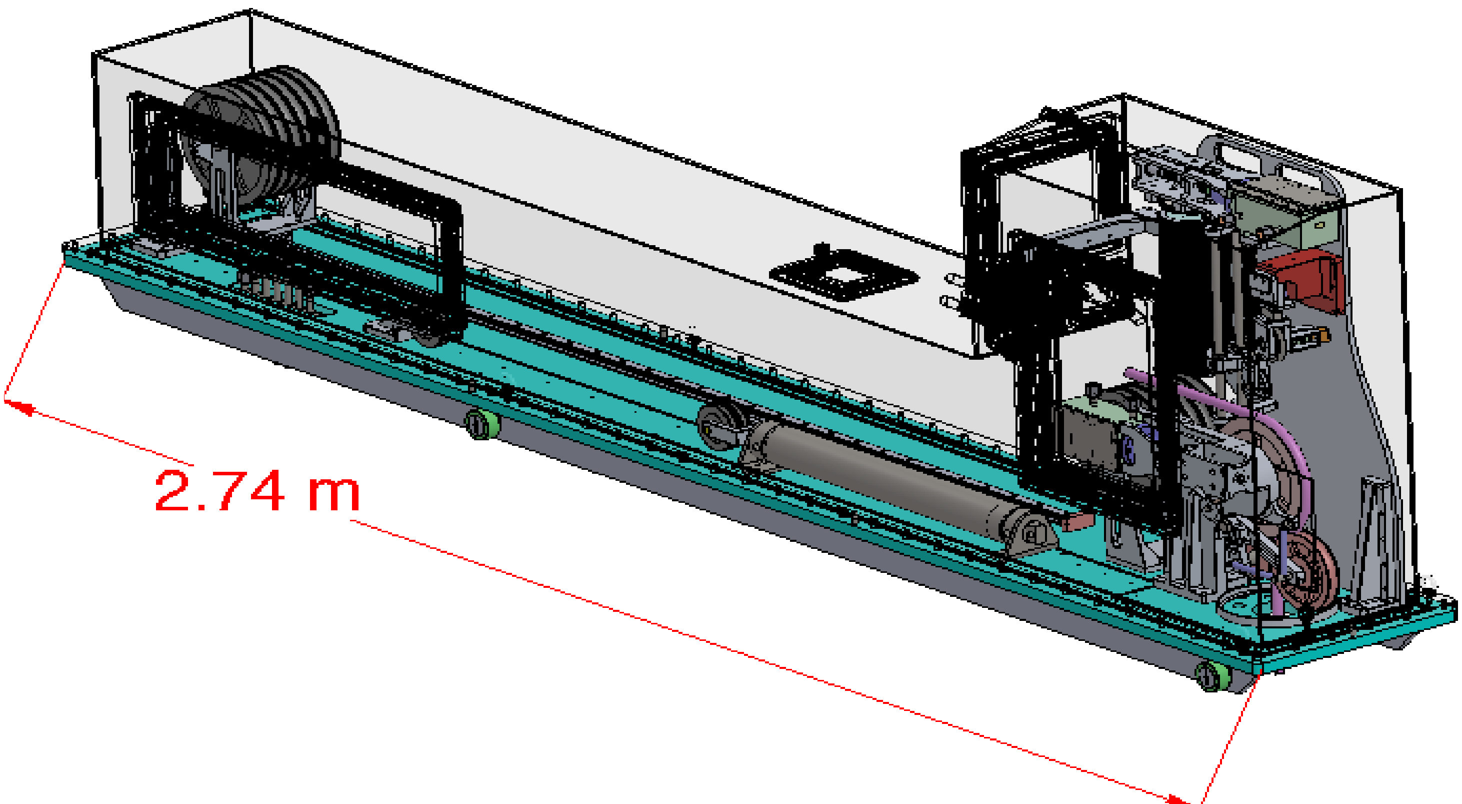
Water Run Physics
- nucleon decay
- solar/reactor ν

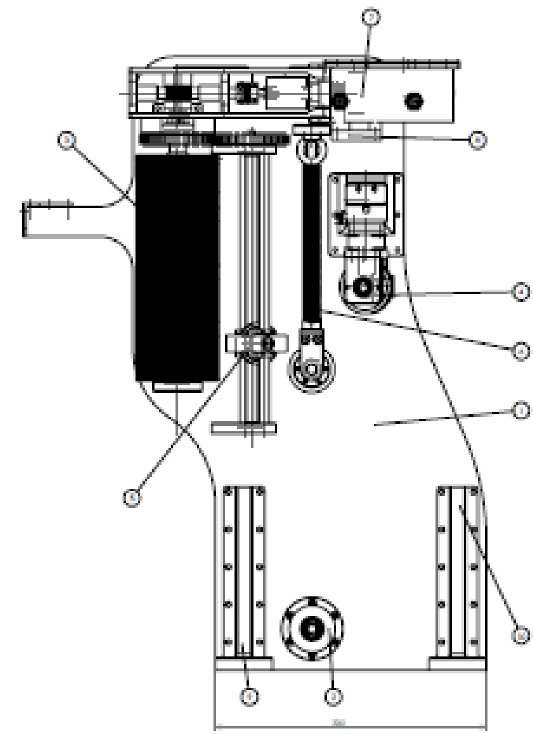
SNO+ last pieces...



Umbilical Retrieval Mechanism for Calibration Sources

- to insert / move radioactive sources inside the scintillator
- being made at LIP workshops; needed at SNOLAB in 2015
- general design approval from SNO+ & SNOLAB experts
- stringent requirements; material radio-purity tests on-going

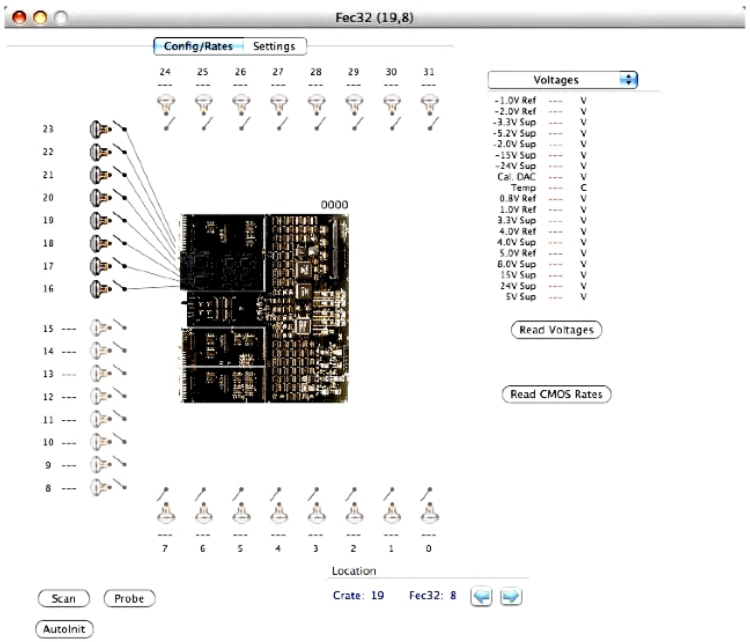




Scintillator Processing Systems also being done at SNOLAB

DAQ & Data Quality

DAQ based on ORCA (as in Majorana/Katrin)
- monitoring / slow control
- operator / level experts



Low level DQ tests
- check hardware vs run-log info
- data recording & building
- monitoring info – needing detector action
& logging info – set bit mask on run quality

Gersende Prior

Nasci em Paris e estudei física na Suiça, no EPFL. Durante a minha tese de diploma, trabalhei na experiência NOMAD no CERN. Descobri assim o mundo dos neutrinos. Isso convenceu-me a fazer o doutoramento na experiência HARP, que mediu secções eficazes hadrónicas importantes para as experiências dos neutrinos. Ajudei a construir a TPC, a renovar detetores de feixe e a instalar o DAQ.

Quando SNO publicou o artigo que contribuiu para provar as oscilações dos neutrinos, sonhei visitar um dia essa experiência. Aconteceu em 2005, quando fui para Berkeley para trabalhar em SNO. Era a ultima fase da experiência, em que uma rede de contadores proporcionais foi construída para melhorar as medidas. Trabalhei na calibração dos contadores e colaborei no R&D de um detetor de Germânio para a experiência MAJORANA.

Em 2009, voltei para o CERN e trabalhei no estudo do design de uma fábrica de neutrinos. Nos departamentos de aceleradores e engenharia, aprendi sobre a ótica dos feixes (radiofrequência, ímanes) e participei em simulações da performance da captura do feixe.

Foi com grande prazer que, no início deste ano, integrei o grupo do José Maneira para trabalhar na experiência SNO+, a sucessora de SNO. Apesar de esta mudança implicar que a nossa família tem agora que se distribuir entre França e Portugal, como o meu filho de dois anos diz, há coisas que vêm aos pares, como "pão beurre".

(Boletim do LIP – nb 7, Março 2014)

Optical Calibration

Group coordination at LIP (expertise since SNO)

Based on uniform Laser Ball with continuous monitoring by LED / Fiber

Light absorption,
re-emission and scattering
in Scintillator + Water (+ AV)
and PMT angular response

Processing, reconstruction
and selection of large sets
of calibration data:

- central LaserBall @ 6 wavelengths
- 30 x 6 positions & wavelengths
- Each LED / Fiber (1Hz + calib runs)

Large MC production in Pt GRID

$0\nu\beta\beta$

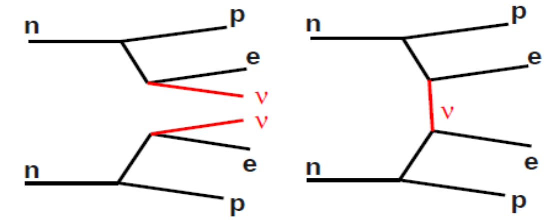
lower energy resolution than other $\beta\beta$ detectors

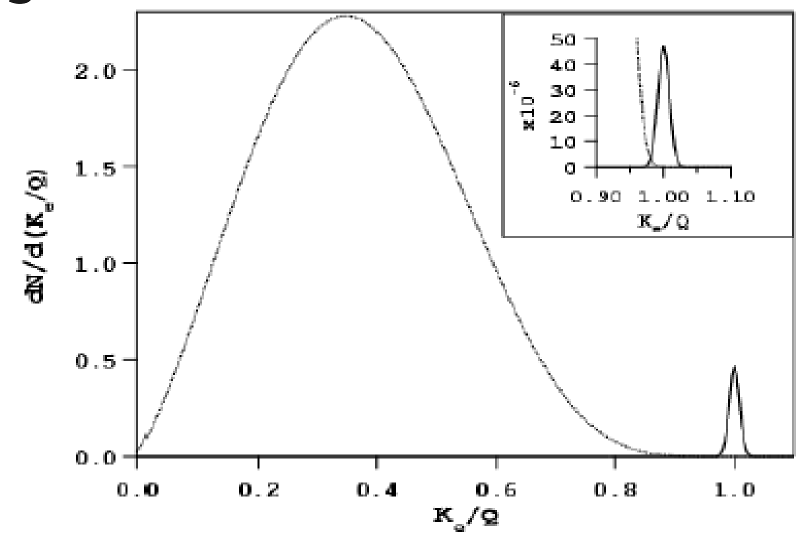
BUT very high quantity of the isotope dissolved in low background medium

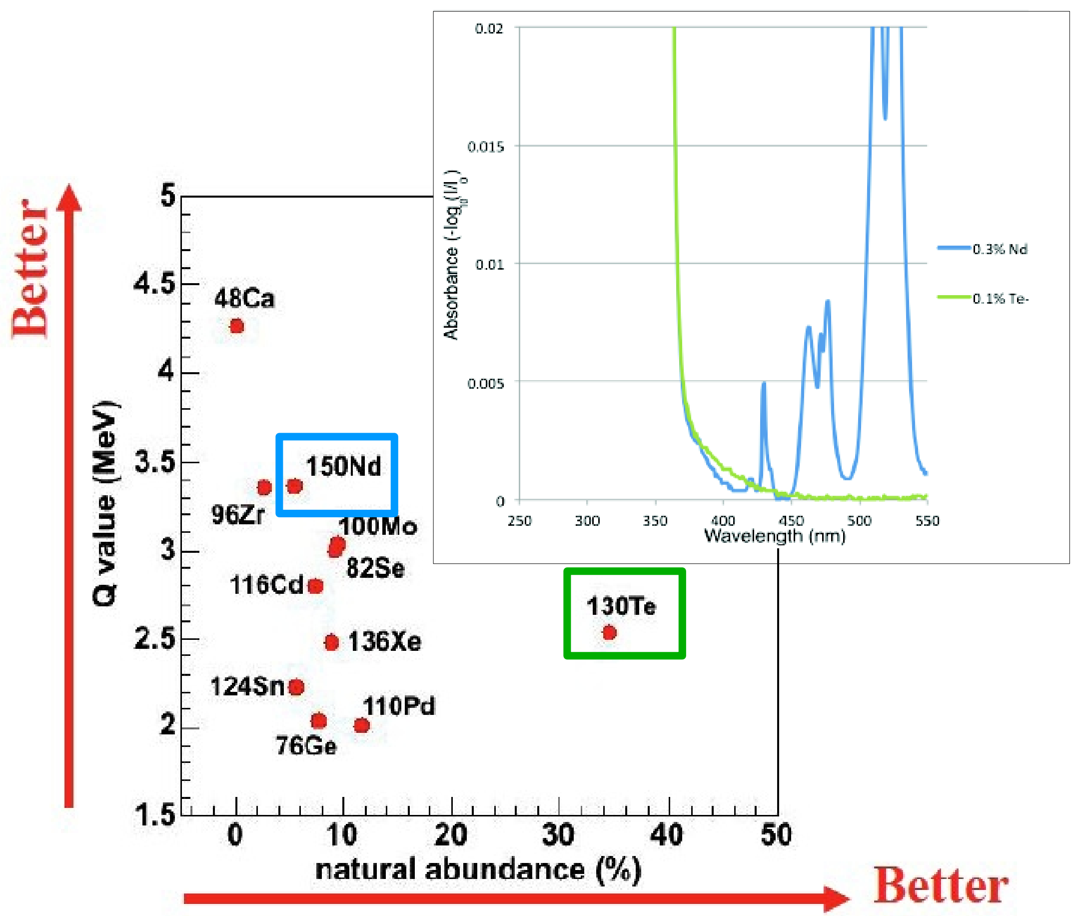
NEED not to degrade energy resolution

tested ^{150}Nd (high Q) and ^{130}Te (high NA)

(^{136}Xe tested and used in KamLAND-Zen)







$Q(2\nu) \sim \Delta M - E_e = 2M_\nu = 2\,\Sigma\, U_{ei}\, m_i$

$\Gamma(0\nu)\ \alpha\ |M_{\beta\beta}|^2 = |\,\Sigma\, (U_{ei})^2\, m_i\,|^2$

	$2\nu\beta\beta$ [years] **measured** by NEMO-3:	$0\nu\beta\beta$ [years] **calculated** by IBM-2:
Nd	9×10^{18} (g.s.) 1×10^{20} (e.s.)	3×10^{23} / $(M_{\beta\beta} / 1\ \text{eV})^2$
Te	7×10^{20} (g.s.)	4×10^{23} / $(M_{\beta\beta} / 1\ \text{eV})^2$

$0\nu\beta\beta$ with ^{130}Te

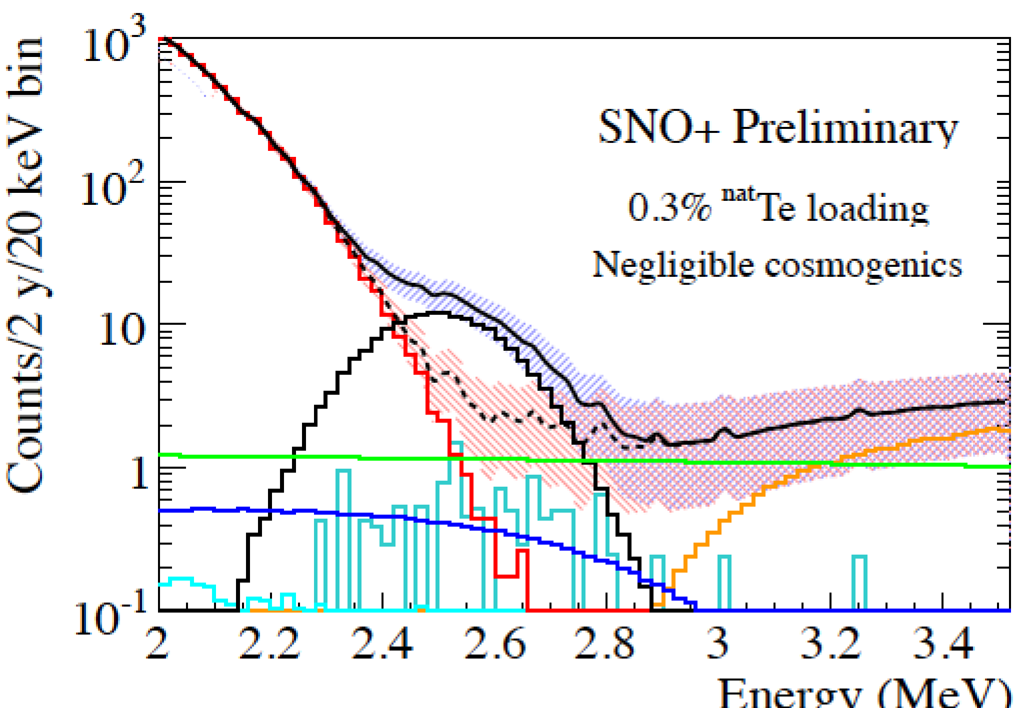
high natural abundance, expected high $0\nu\beta\beta$ / $2\nu\beta\beta$
can be loaded in scintillator (0.3% ok, tests up to 3%)

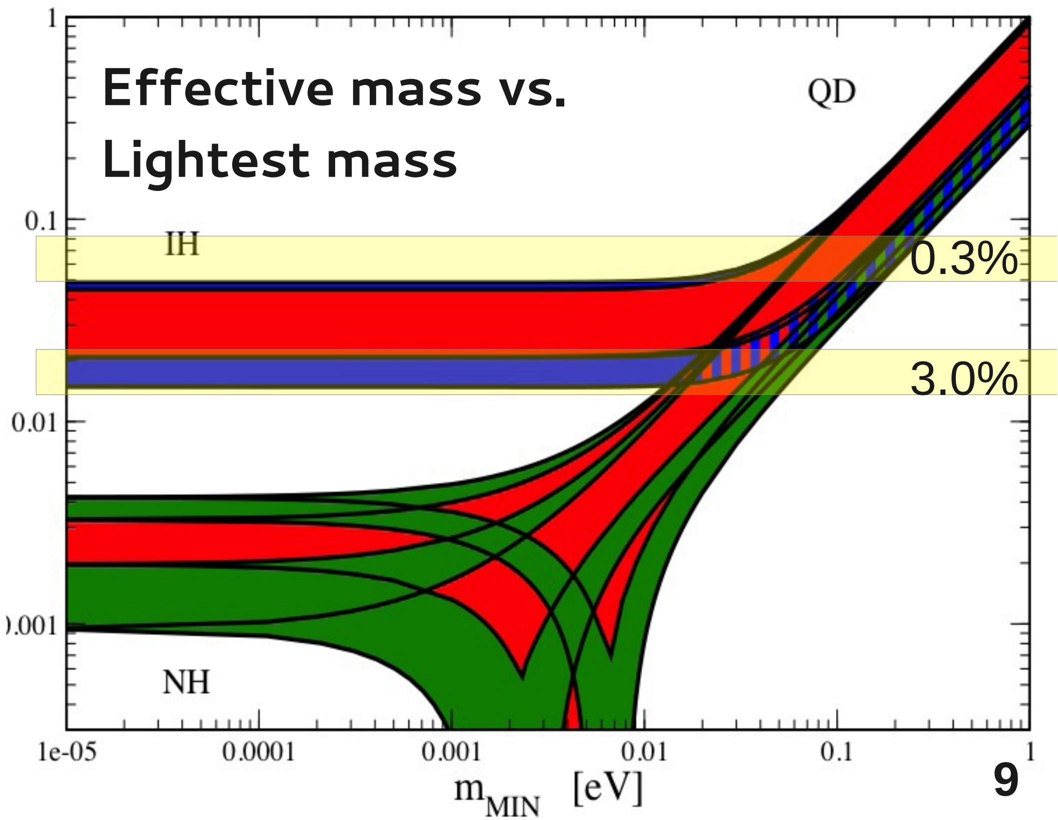
Te @ 0.3% (up to 3%?)

Expected sensitivity in 5 years
("simple" counting experiment):

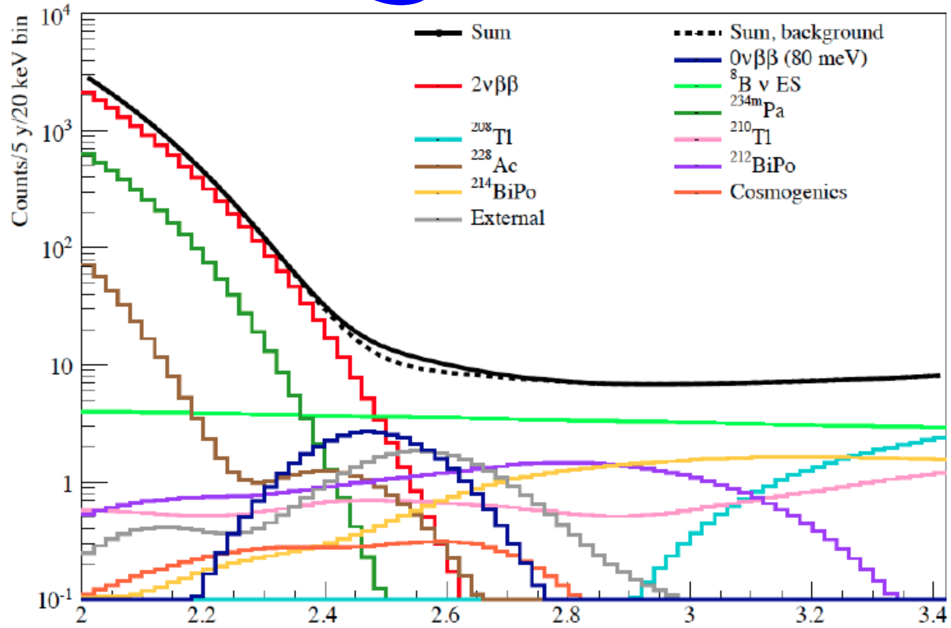
$T_{1/2} > 7.3 \times 10^{25}$ yr (90%CL)

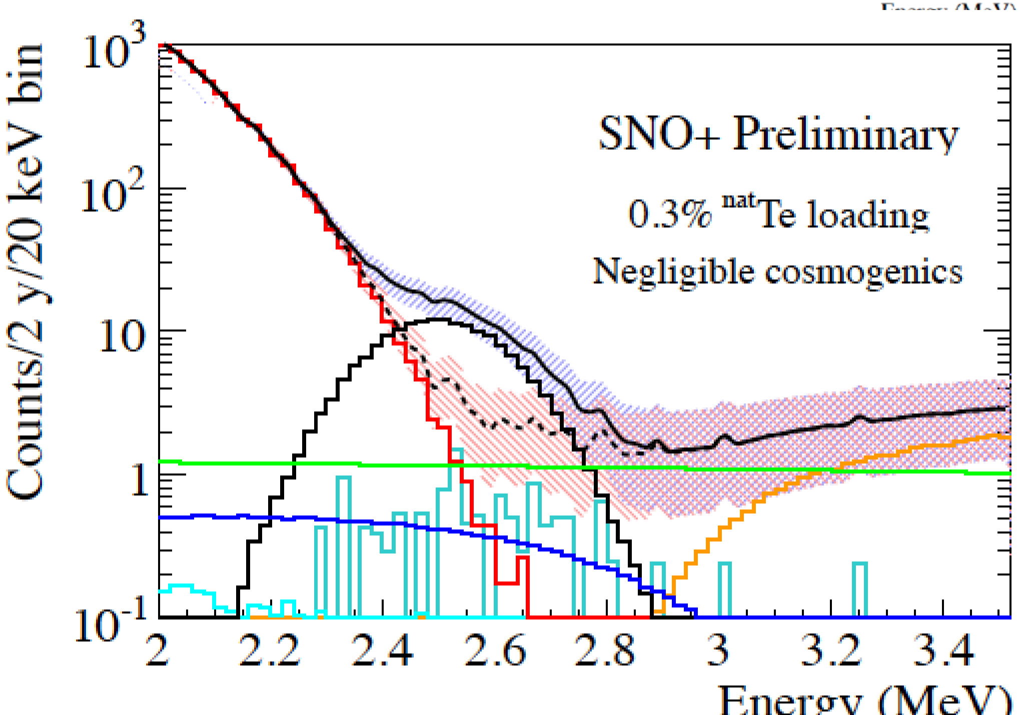
$T_{1/2} = 2.4 \times 10^{25}$ yr (5 σ)





Backgrounds & α/β tags





PMT/H_2O/AV backgrounds

reduced by Fiducial cuts

Loaded scintillator backgrounds

reduced by 2 stage purification

(can be tested in-situ with loading)

On-peak ^{214}Bi and ^{208}Tl

reduced by α–β coincidence tagging

(including pulse-shape discrimination)

Irreducible 2νββ

energy resolution (& pile-up rejection)

Solar ^{8}B neutrinos

irreducible but known and visible

Anti-neutrinos $\overline{\nu}_e + p \rightarrow e^+ + n$

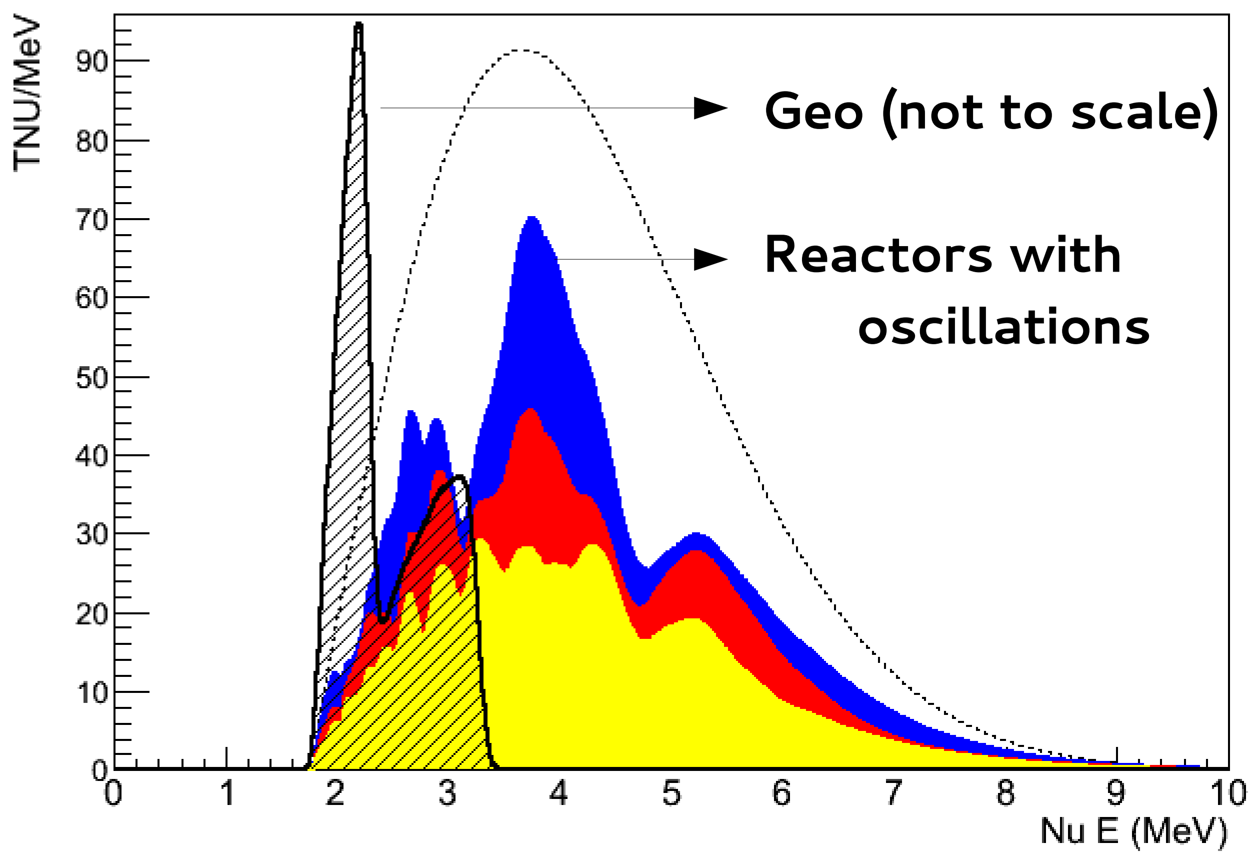
Group coordination at LIP (new 1-year "exploratory project")

Positron annihilation gives anti-neutrino energy and interaction point
Delayed neutron capture gives clear tagging and "smeared" direction

Almost background free
& very high efficiency

Contributions from:

- distant nuclear reactors
- 3 Canadian reactors
- geo-neutrinos from
  U/Th decay chains
  inside crust & mantle

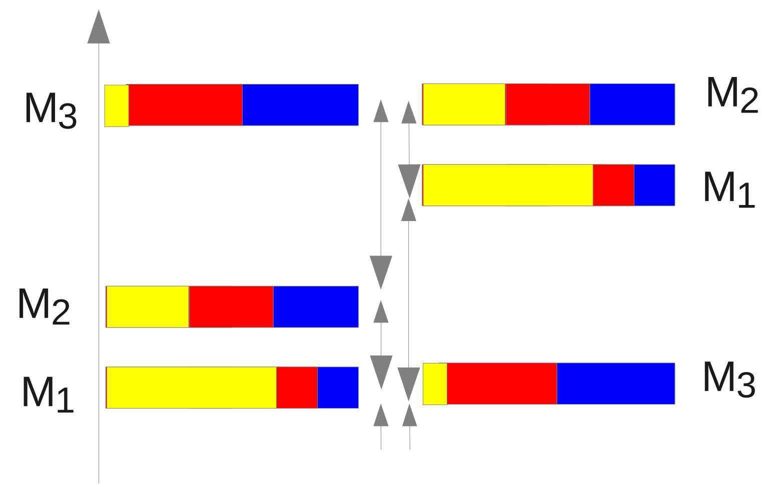


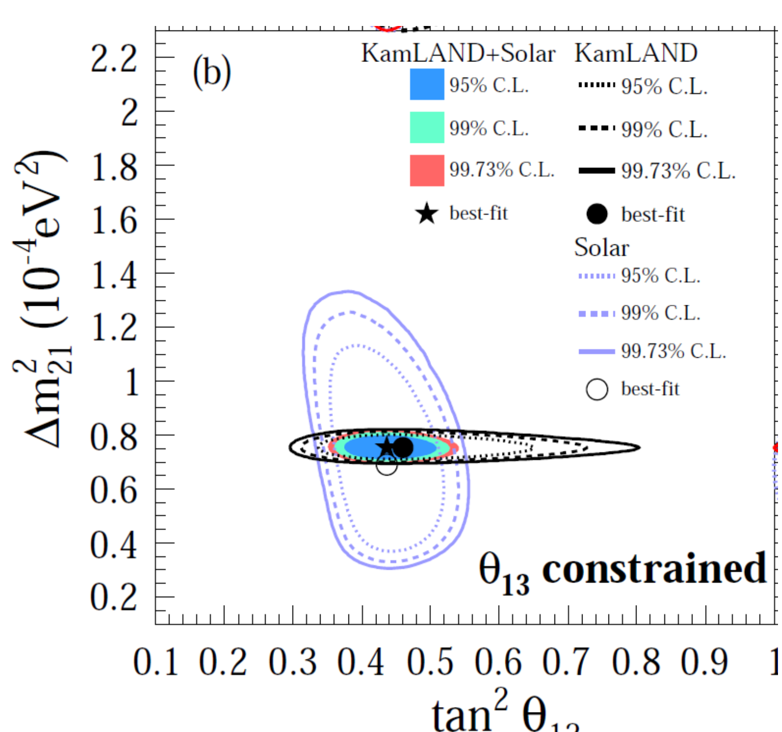
Mainly energy, but reactor variations and directions to be explored

Neutrino oscillations

In 2012 last mixing angle was measured with close-by reactors, from now on 3ν matrix must be used in analysis of all experiments

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} 0.82 & 0.55 & -0.15 \\ -0.35 & 0.70 & 0.61 \\ 0.44 & -0.45 & 0.77 \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$





SNO+ will see 12 oscillations

Solar ν for θ_{12} and θ_{13} and

Only LBL Reactor ν for ΔM_{12}^2

("directly" from L/E pattern)

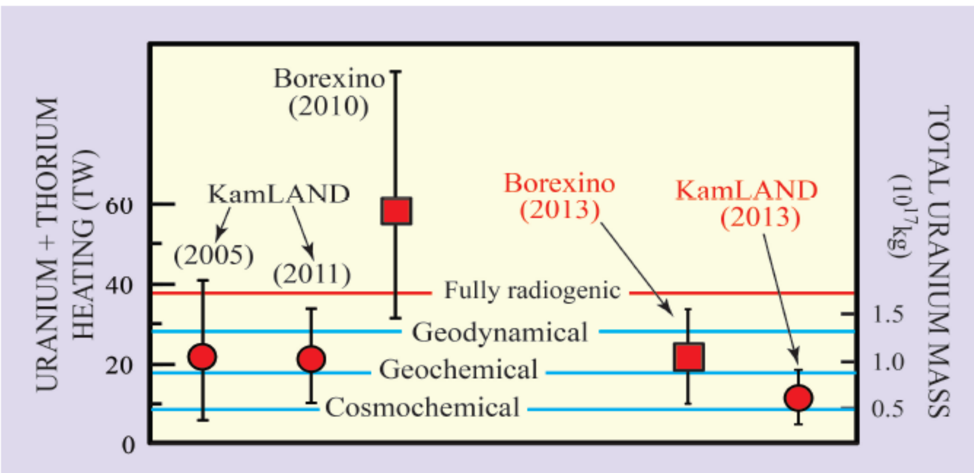
Same precision as KamLAND

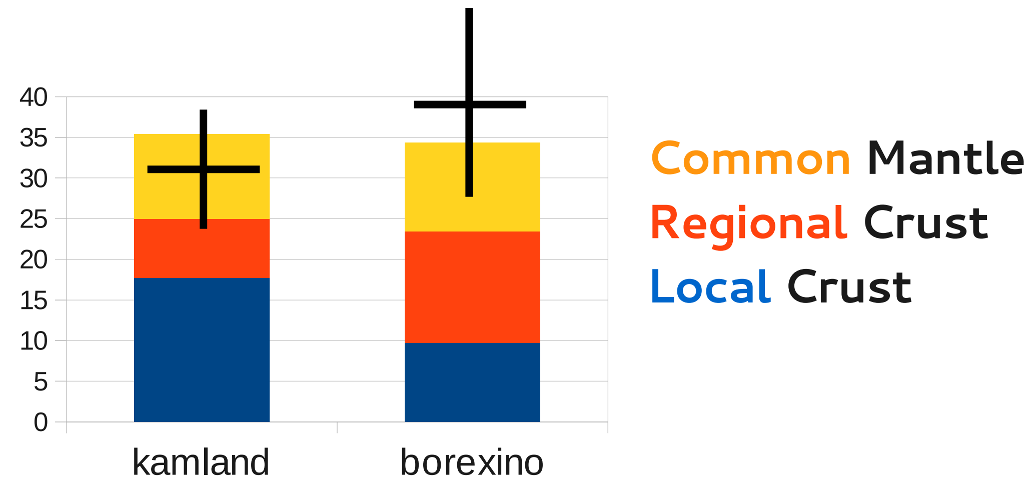
Geo-neutrinos

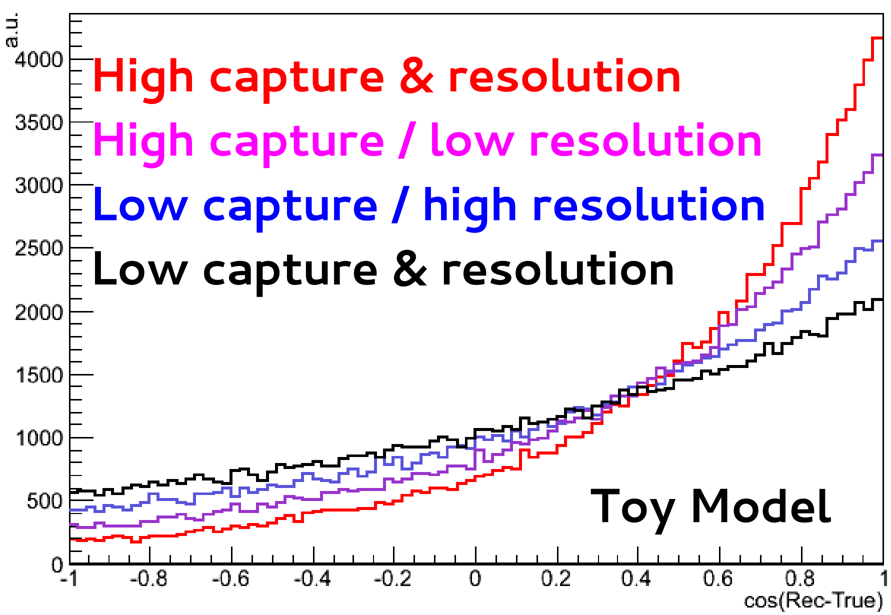
New field, measurements with impact on geo-physics!

Only two experiments up to now (KL – Japan, BX – Italy)

In SNO+, less background, larger area, well known crust fraction







We will try to use directionality (e^+ / n vector) to improve selection

– will be tested for SNO+ and future improved detectors with:
  – enhanced neutron capture
  – enhanced position resolution

Summary and outlook

SNO+ almost ready for (water) data in the end of 2014
- new PMT calibration system installation being finalized
- new URM being built at LIP workshops in Coimbra

LIP's group has grown in people and tasks
- DAQ & DQ
- Optical and PMT Calibration
- External Backgrounds
- α/β discrimination
- Reactor anti-neutrino Oscillations
- Geo-anti-neutrino Physics

Scintillator data now expected in 2015
- $0\nu\beta\beta$ in ^{130}Te (0.3% loading, can be later increased to 3%)
- Anti-neutrinos, SuperNovae, Solar Neutrinos, ...

Solar ν

B-8, measured at high energy
total rate measured by SNO!
CC / NC fixes oscillation

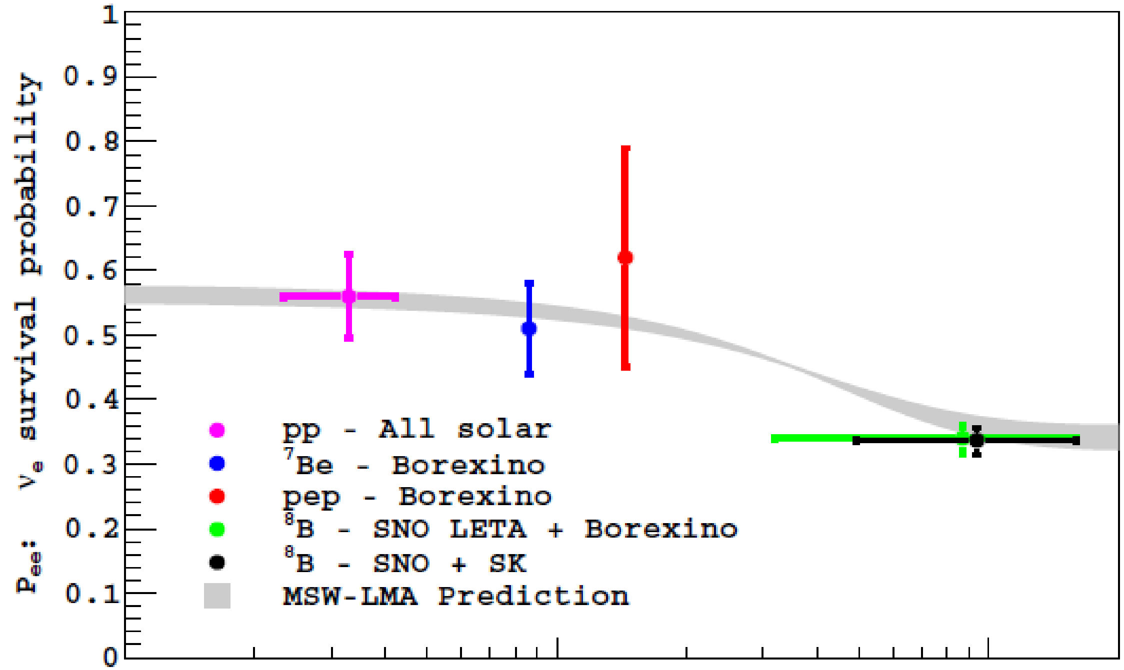
pep, measured @20%,
model prediction, @1%

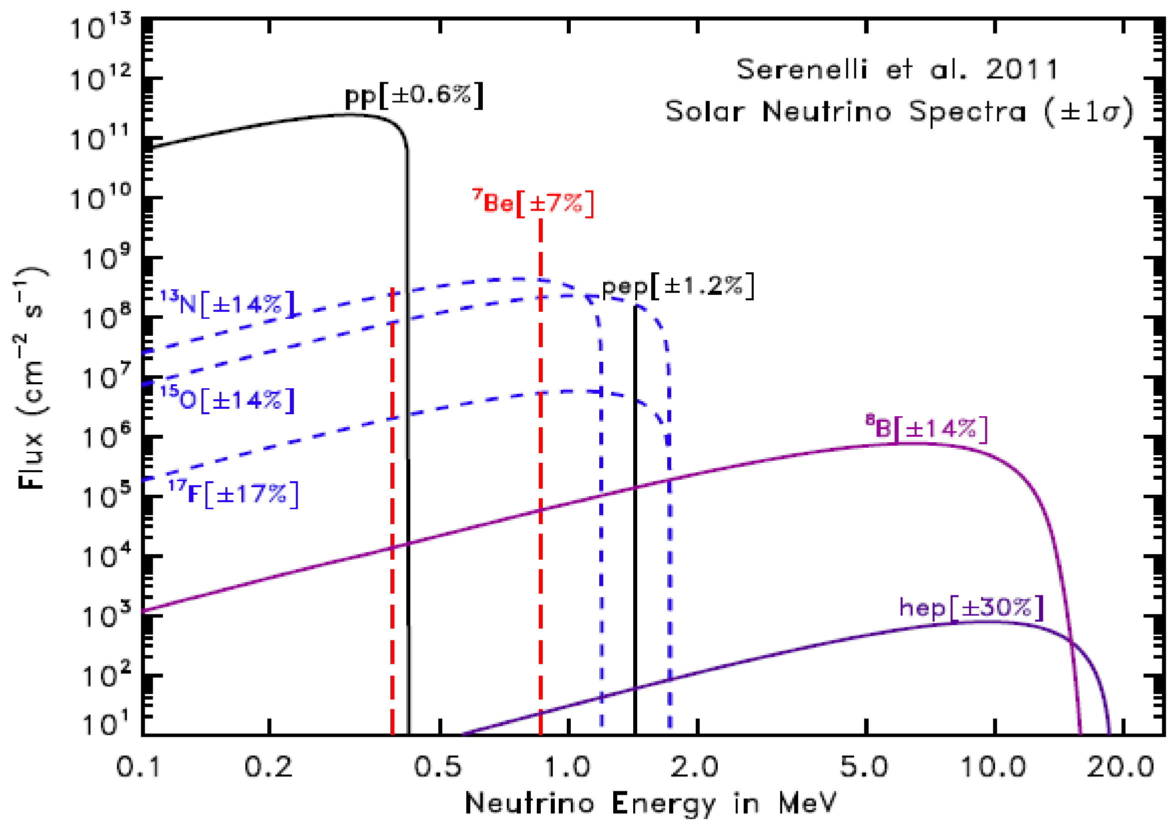
Be-7, 1st line @5%,
model prediction, @7%,
ratio of 2 lines fixed

CNO, upper limits only,
direct test of metalicity

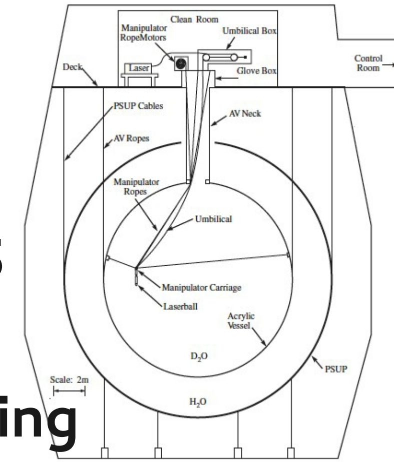
pp, only radio-chemical exps.
oscillation fit + luminosity

hep, unmeasured but small





SNO+ last pieces...



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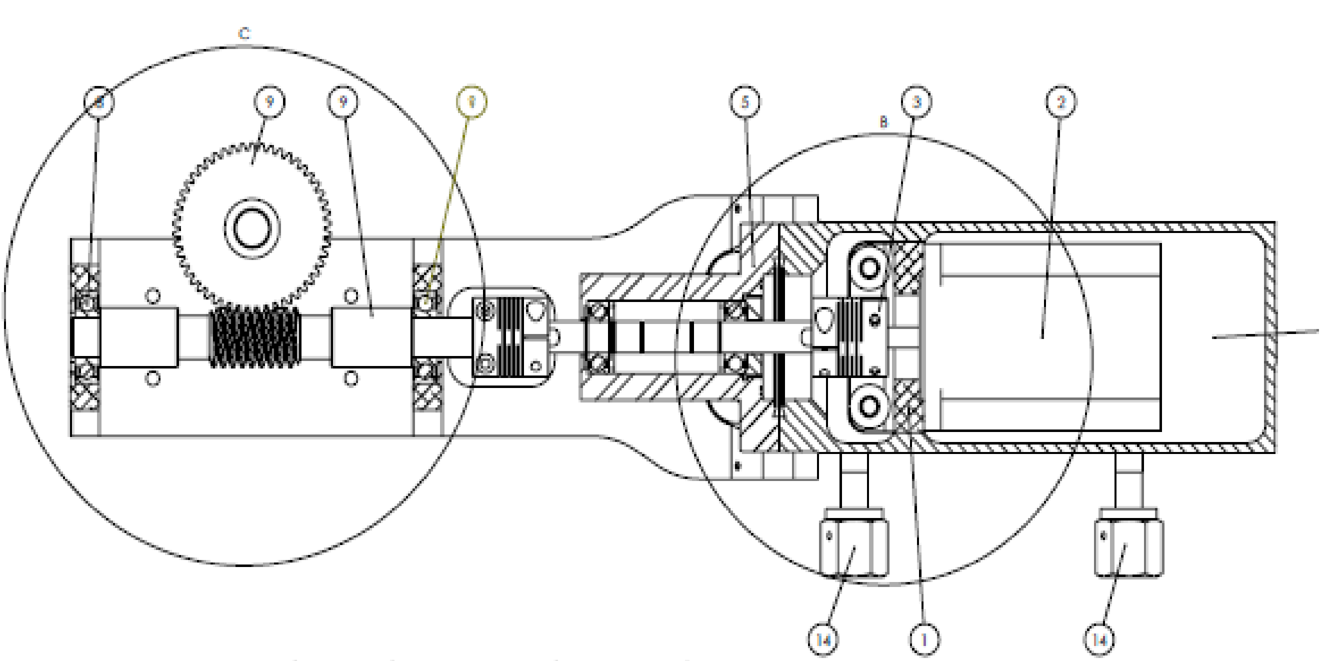
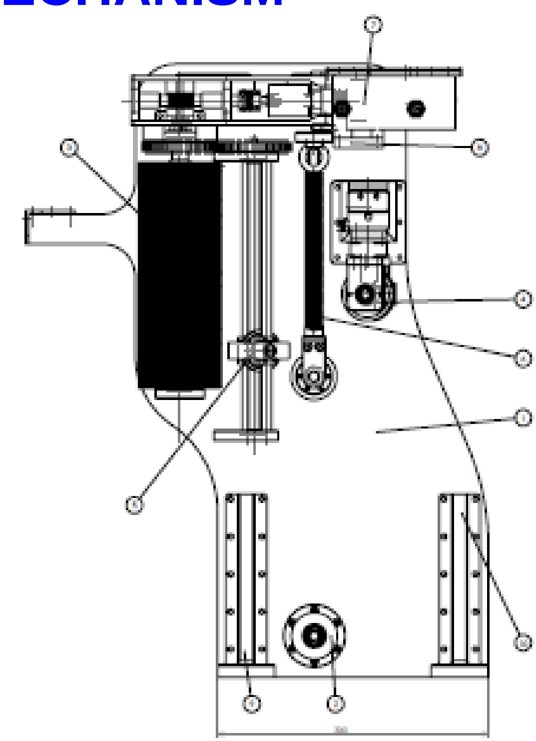
MOTOR BOX & ROPE MECHANISM





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