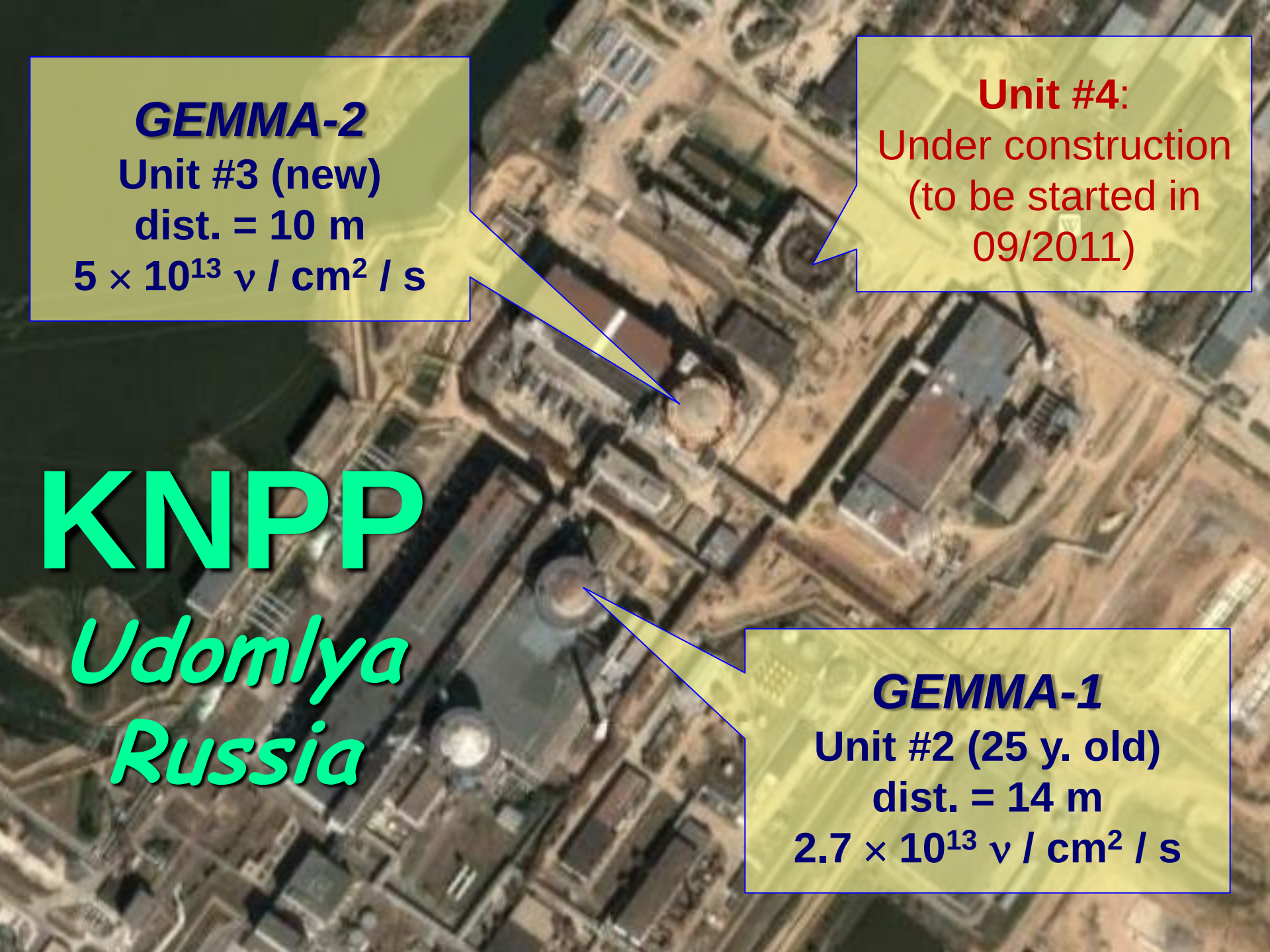
V.Egorov (JINR, Dubna) A.Starostin (ITEP, Moscow)

Solid Scintillator Detector of the Reactor Antineutrino

DANSS

status report


GEMMA-2
Unit #3 (new)
dist. = 10 m
5 × 10^13 ν / cm^2 / s
Unit #4:
Under construction
(to be started in
09/2011)
KNPP
Udomlya
Russia
GEMMA-1
Unit #2 (25 y. old)
dist. = 14 m
2.7 × 10^13 ν / cm^2 / s

for information:

- **The standard 3GW$_{th}$** ***ВВЭР-1000***
  Water-moderated Water-cooled Power Reactor
- Life-time ~ 320 days
- **1500 kg** of **^{235}U** is **burned out**
- and **311 kg** of **^{239}Pu** is **produced**
- which changes the **flux** and **energy spectrum** of the neutrino emitted
- ⇒ ***Would be nice to monitor it!...***

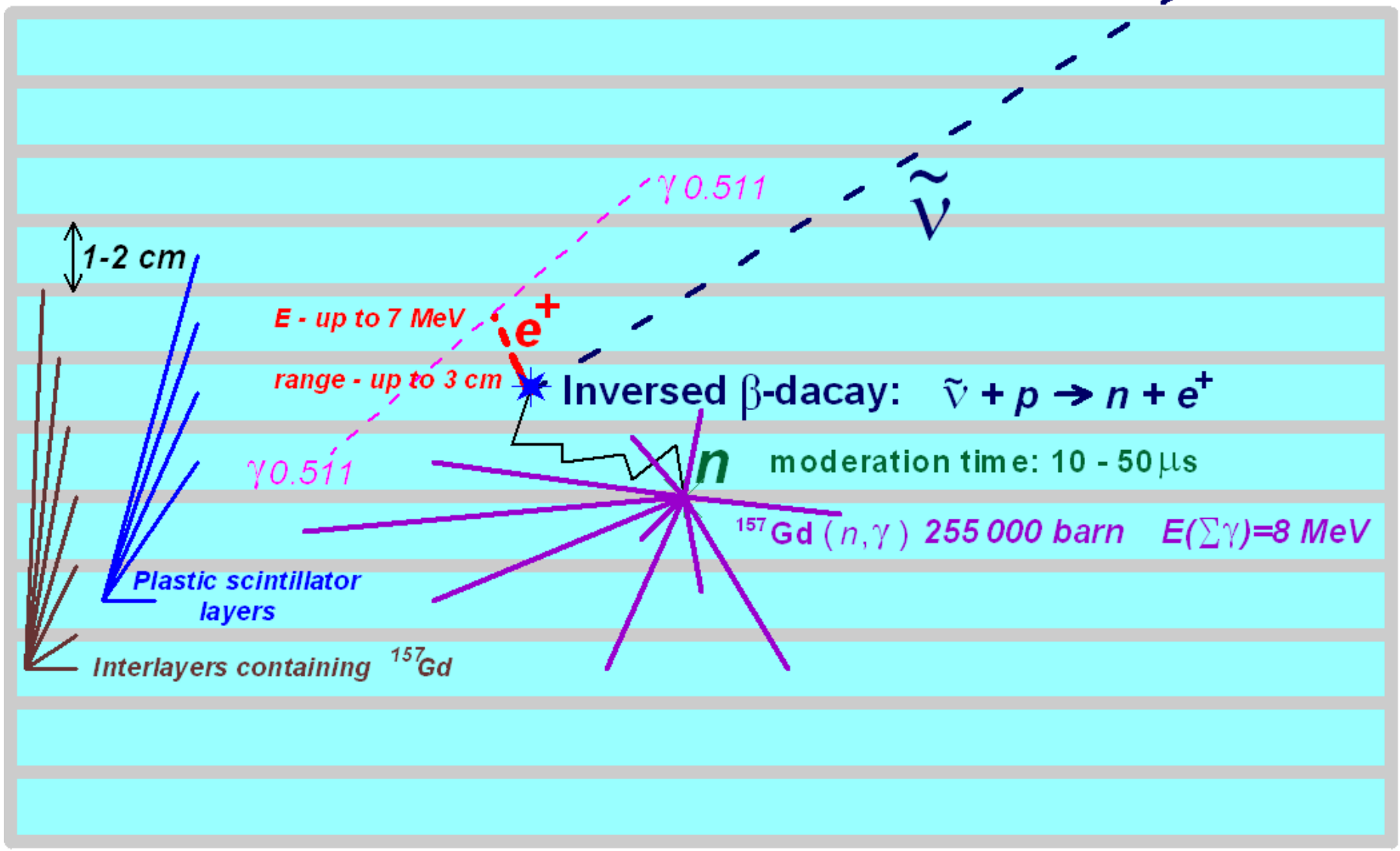
In addition, detection of the reactor neutrino would allow to solve some fundamental, applied and even political problems:

- **Precise Weak (ν-e) cross-section**
- **Measure the actual reactor power (N_ν)**
- **Deduce the actual fuel composition (E_ν)**
- **On-line reactor monitoring (tomography?)**

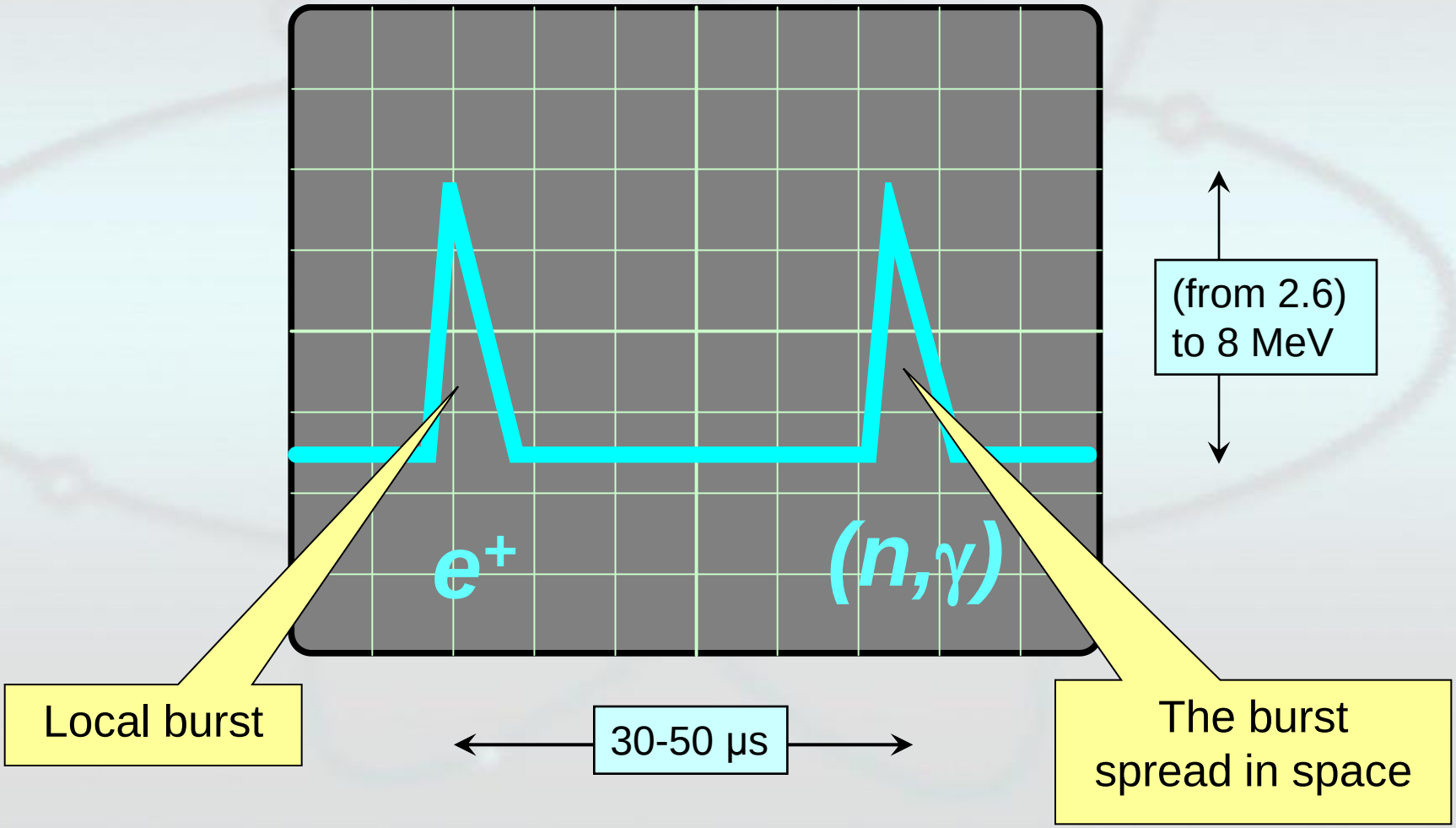
– especially important in view of the future FBR (with longer life-time and less studied)

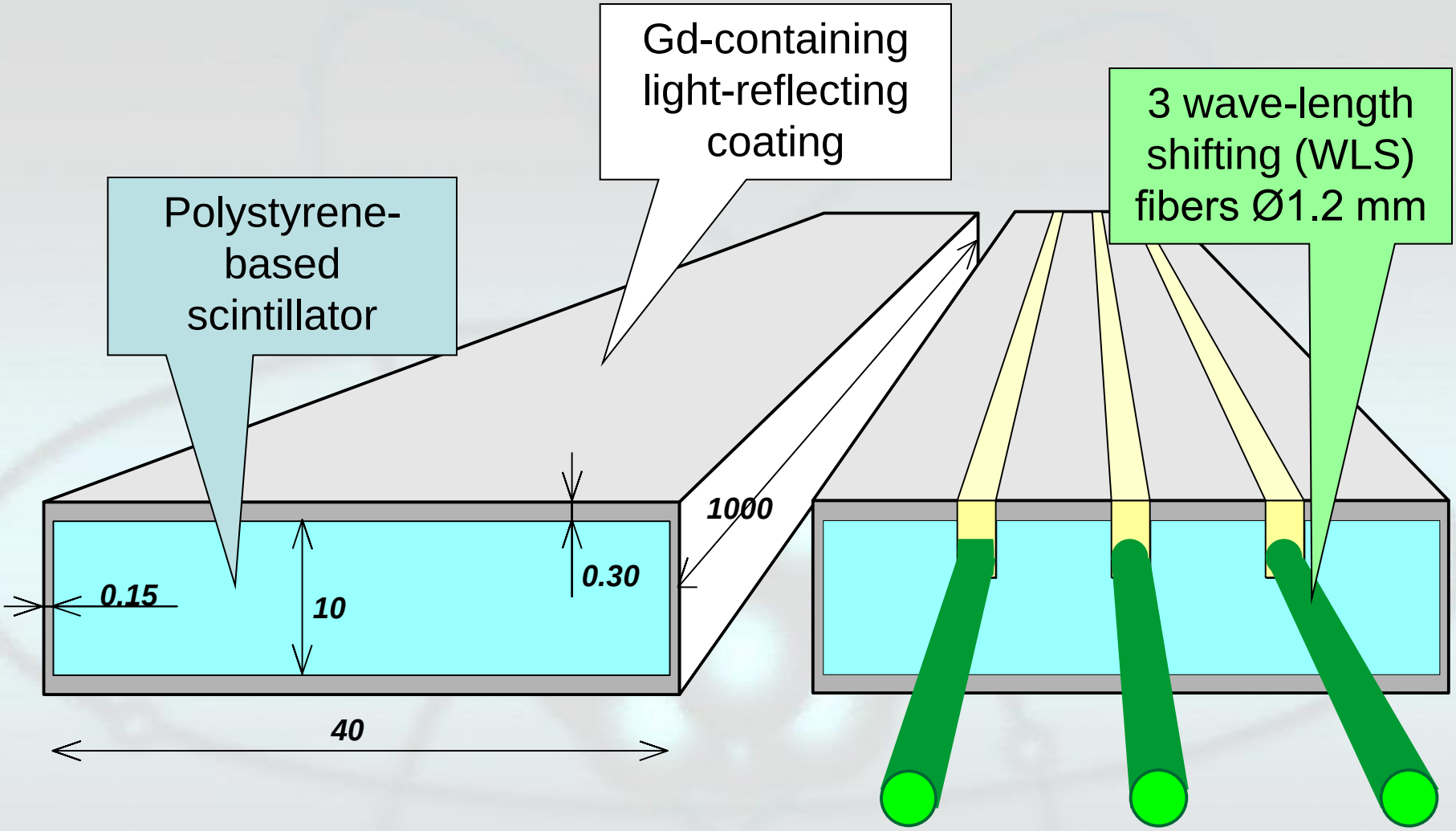
- **Non-proliferation** *(prevent unauthorized extraction of ^{239}Pu)*

Detection idea: Inversed Beta-Decay in plastic with Gd/Cd interlayers



Signature of the IBD registration

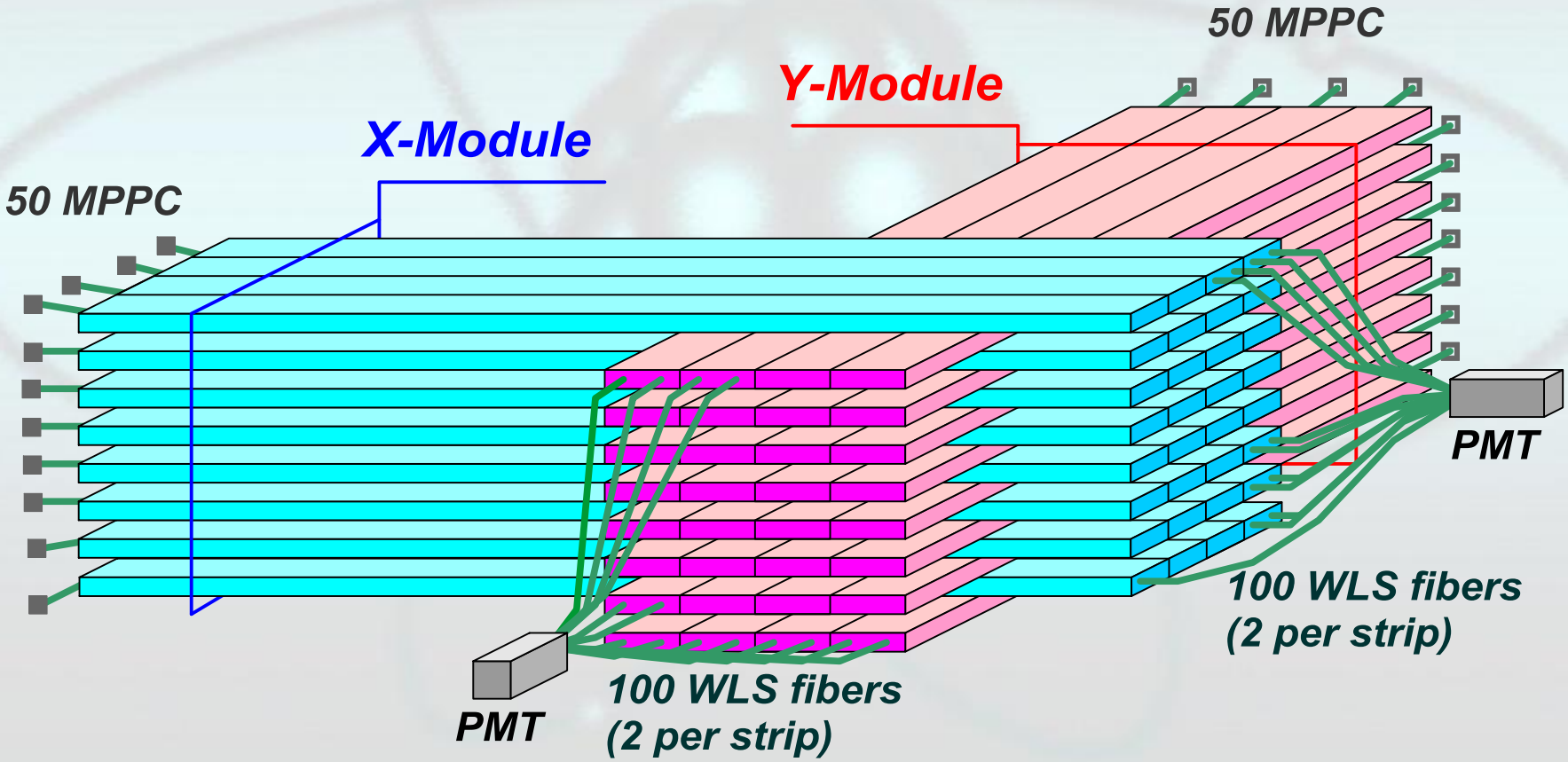


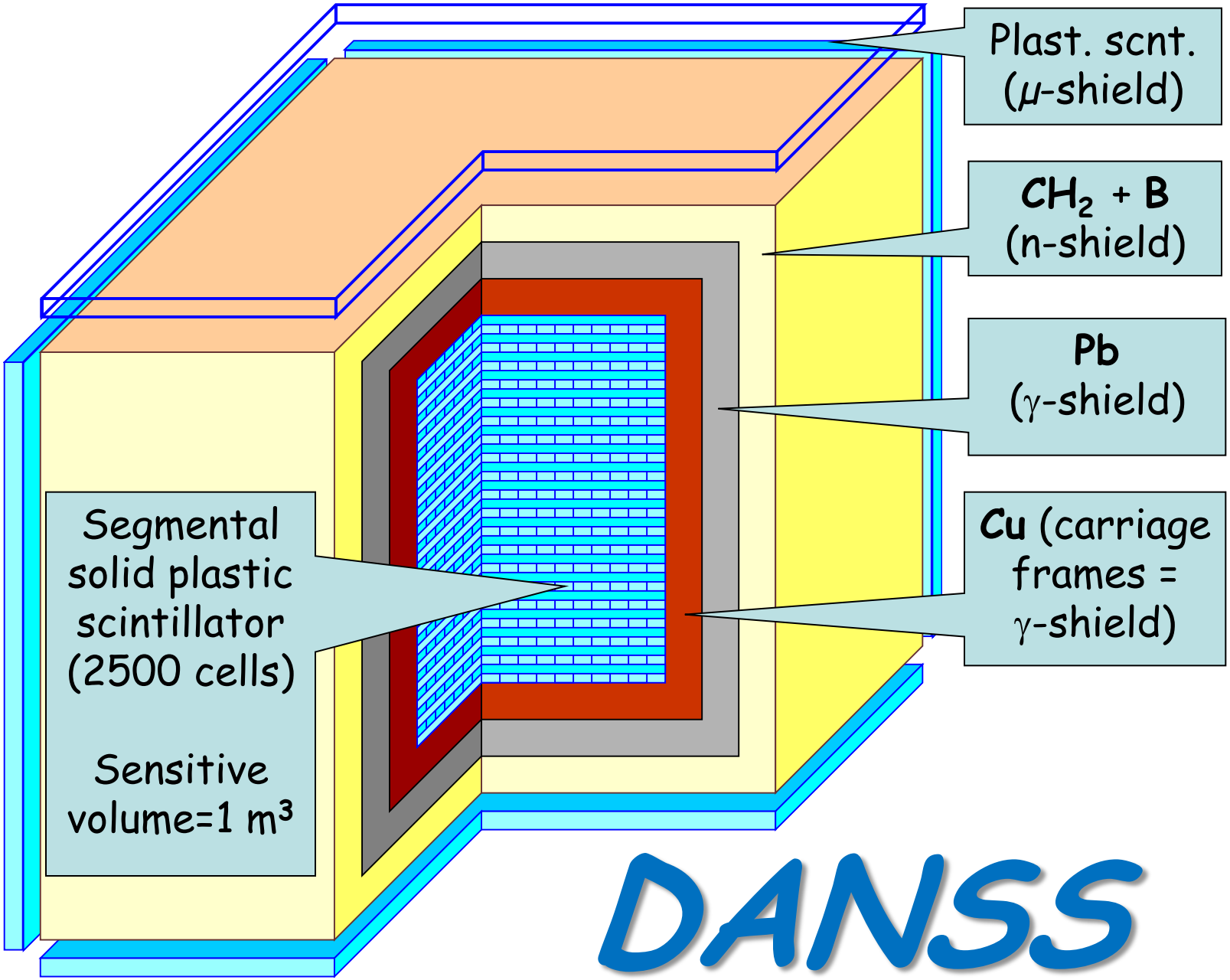


Basic element -
- scintillator cell ("*strip*")

Conception of the detector: Modular structure

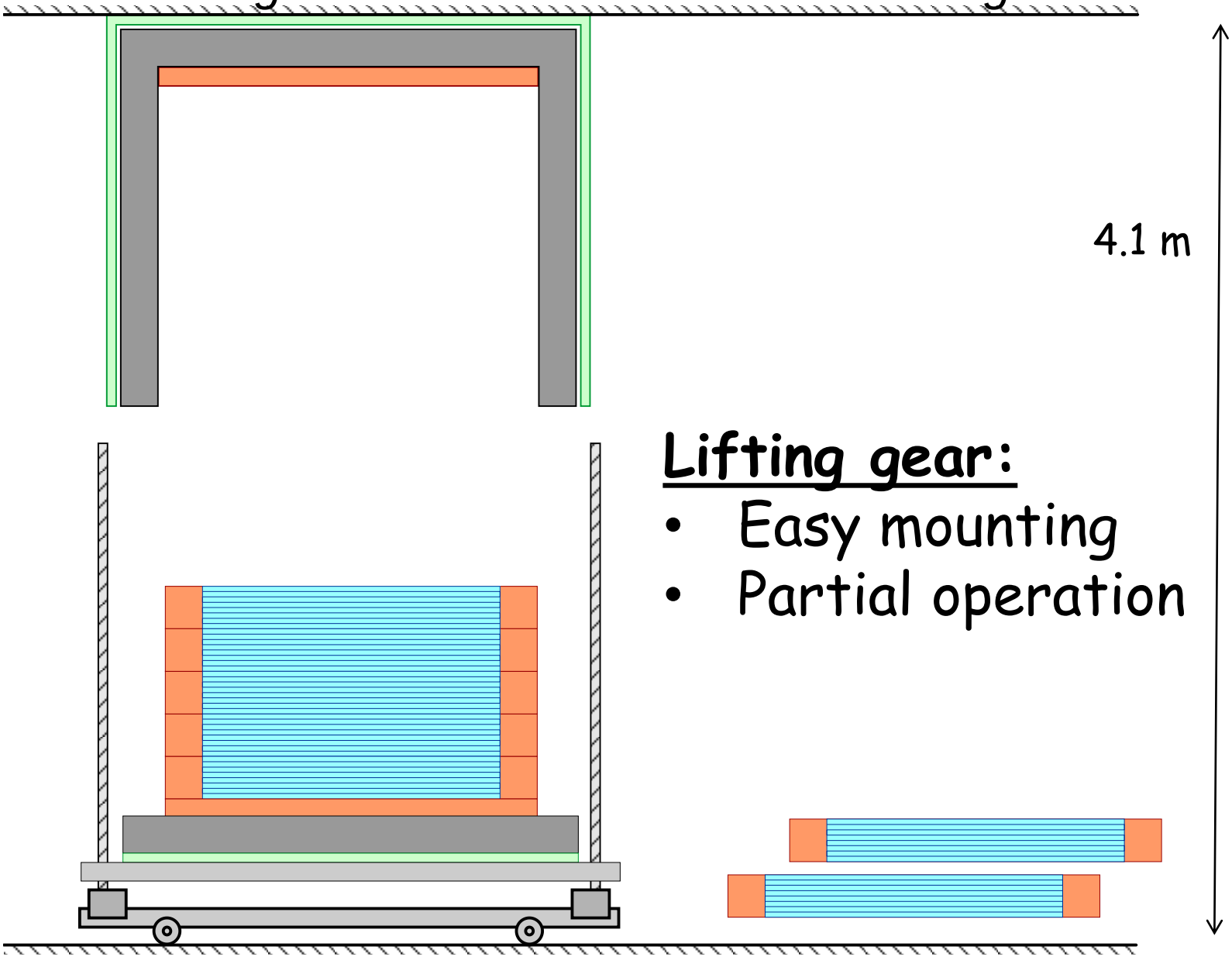
A number of strips are combined into intercrossing X- and Y-modules (20×20×100 cm)




Plast. scnt.
(μ-shield)
CH2 + B
(n-shield)
Pb
(γ-shield)
Cu (carriage
frames =
γ-shield)
Segmental
solid plastic
scintillator
(2500 cells)
Sensitive
volume=1 m³

DANSS

Ceiling = Bottom of the reactor shielding



Lifting gear:

- Easy mounting
- Partial operation


Jan. 2010. Mounting
of the trial section #0

Feb. 2010.
Trial section #0

Important features
(resp. to conventional liquid scint.)

•Handling is much safer *(not caustic, spontaneously igniting, volatile or solvent)* → no restrictions to move the detector very close to the reactor core → higher neutrino flux → **better sensitivity**.

•High segmentation (2500 cells) → space information → better IBD-signature → stronger **BCKG suppression**.

•PS is not doped with Gd, but interlayed with it → better **quality** and **stability** of the scintillator.

•WLS-fibers improve homogeneity of light-collection → better **energy resolution**.

•Each cell in a module is looked through with both individual MPPC *(high QE, but bad noise and range)* and common PMT *(lower QE, but better range and stability)* → coincidence mode and combination of **PMT and MPPC advantages**.

•Sectional structure → possibility of **"partial" operation**, **renewal** and **upgrade**.

•Use of lifting gear → measurements at **different distance** → more **reliable data interpretation**.

Expected parameters:

- Sensitive volume: 1 m^3
- Composition: 5 sections (1m 1m 0.2m)

  of (5**X** + 5**Y**) modules = 2500 scint. strips

  { 1 module = 5 10 = 50 strips }
- IBD detection efficiency: **~74%**
- Count rate: **9200 IBD-events per day**
- Background: 40-50 events per day
- Due date: section №0 – ***Feb 2010***

  sections №1-3 – ***2011*** №4-5 – ***2012***

The work was going on, but then priority changed

Sterile Neutrinos and Short-Baseline Oscillations

Carlo Giunti

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Neutrino Unbound: http://www.nu.to.infn.it

Workshop on Sterile Neutrinos and the Reactor Antineutrino Anomaly

T.U.M, Garching, 8 February 2011

Collaboration with Marco Laveder (Padova University)

The Reactor Antineutrino Anomaly

M. Fechner, G. Mention, T. Lasserre,
M. Cribier, Th. Mueller D. Lhuillier, A. Letourneau,
CEA / Irfu

arXiv:1101.2755 [hep-ex]

V. THE FOURTH NEUTRINO HYPOTHESIS

$$P_{ee} = 1 - \cos^4\theta_{\rm new}\sin^2(2\theta_{13})\sin^2\left(\frac{\Delta m^2_{31}L}{4E_{\bar{\nu}_e}}\right) - \sin^2(2\theta_{\rm new})\sin^2\left(\frac{\Delta m^2_{\rm new}L}{4E_{\bar{\nu}_e}}\right). \quad (13)$$

The conclusion of the Workshop was:

the 4th (sterile) neutrinos probably exist and cause short-range oscillations

but

<u>new experiments are needed</u>

Of-course, we trust our colleagues who claim they observe neutrino oscillations.

But how much stronger evidence of the neutrino oscillations would be direct observation of the oscillations with distance instead of just some deficit of events with respect to the expected number.

From this point-of-view, one needs to change the distance in the range of ~10 meters.

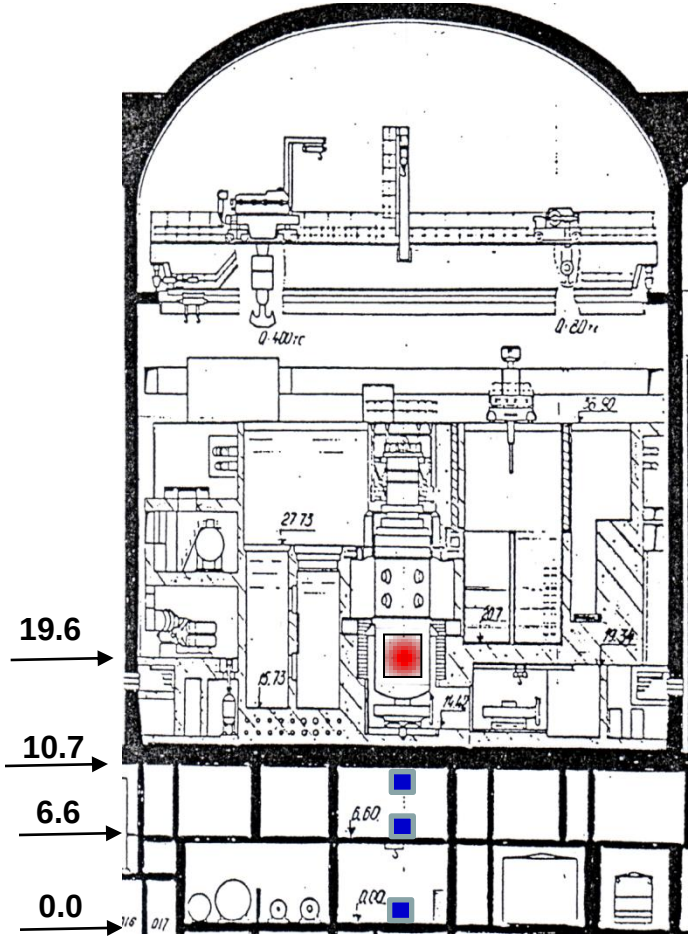
If made movable,

our **DANSS** of all detectors is probably the best suited

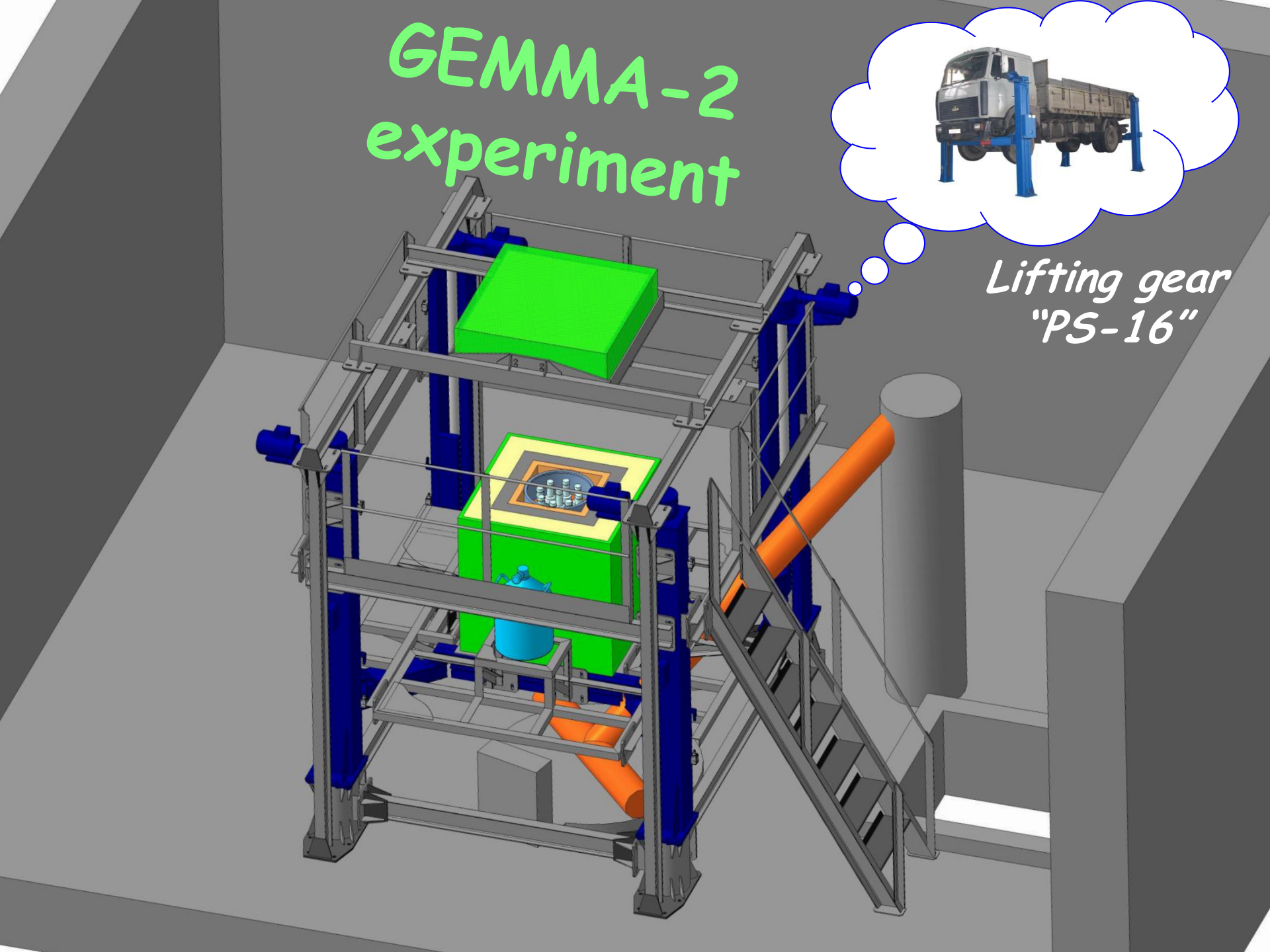
for the job

- In principle it is possible to move DANSS by ~2.5 m (from 9.7 to 12.2) doing it **<u>on-line.</u>**

- Or by longer distance (up to 18.8 m), but with <u>partial dismounting ☹</u> and moving to the ground floor.



GEMMA-2 experiment




Bottom part of the GEMMA-2 shield mounted on the movable platform

Use similar lifting gear with DANSS to move it as a whole

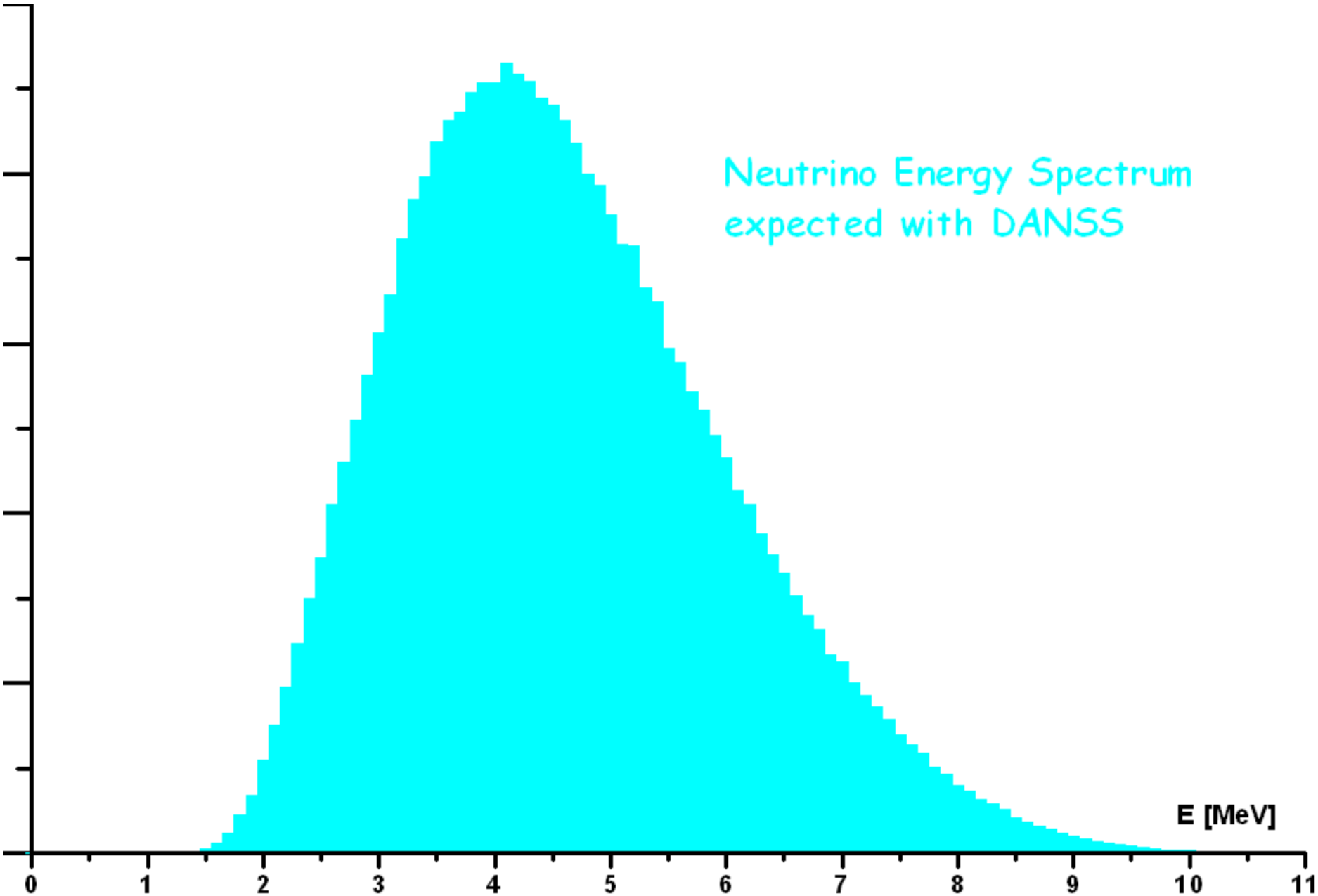
(not only internal part
as was planned initially)

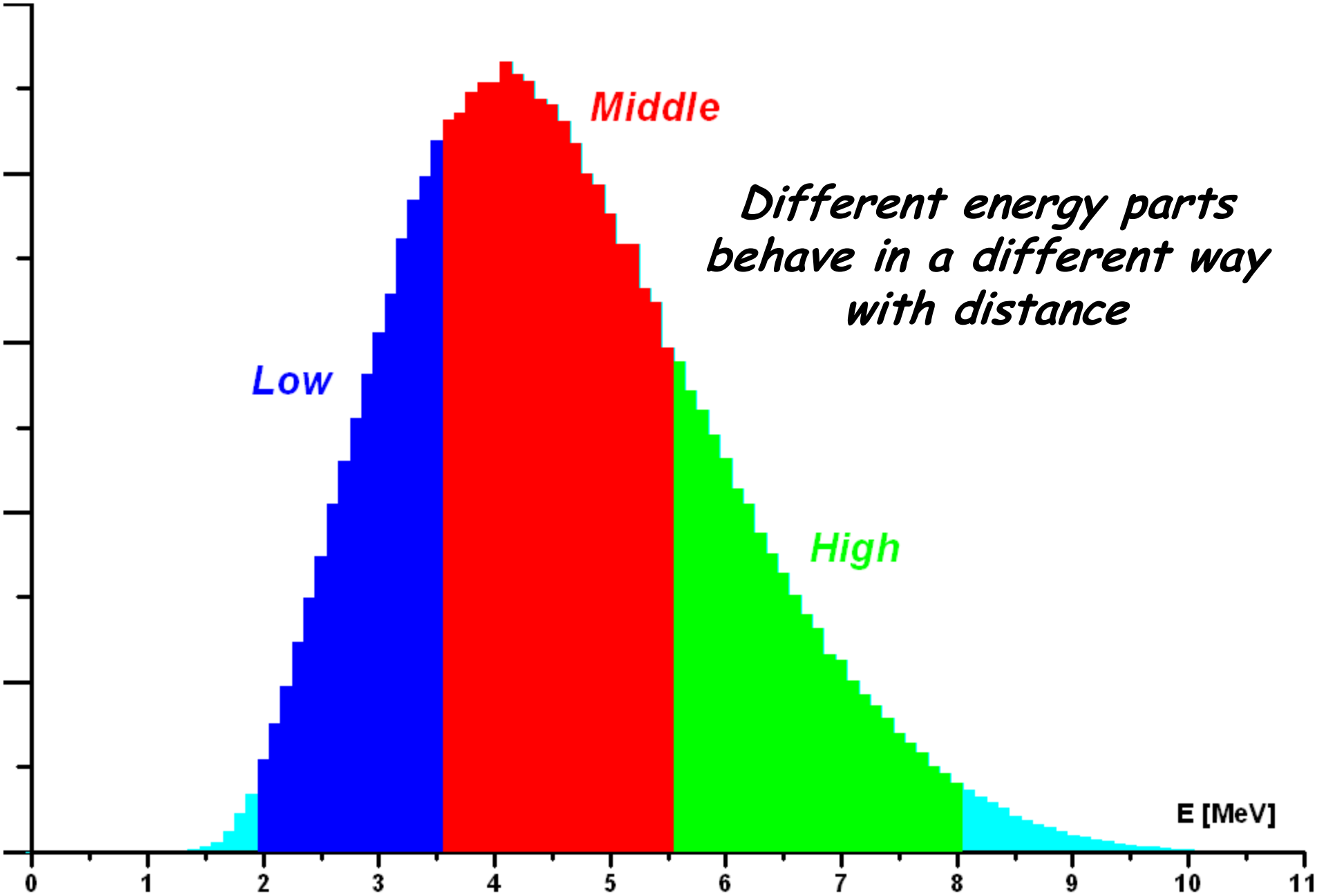
MC-simulation with realistic parameters

Reactor dimensions *(h=3.50, d=3.12, cos)*

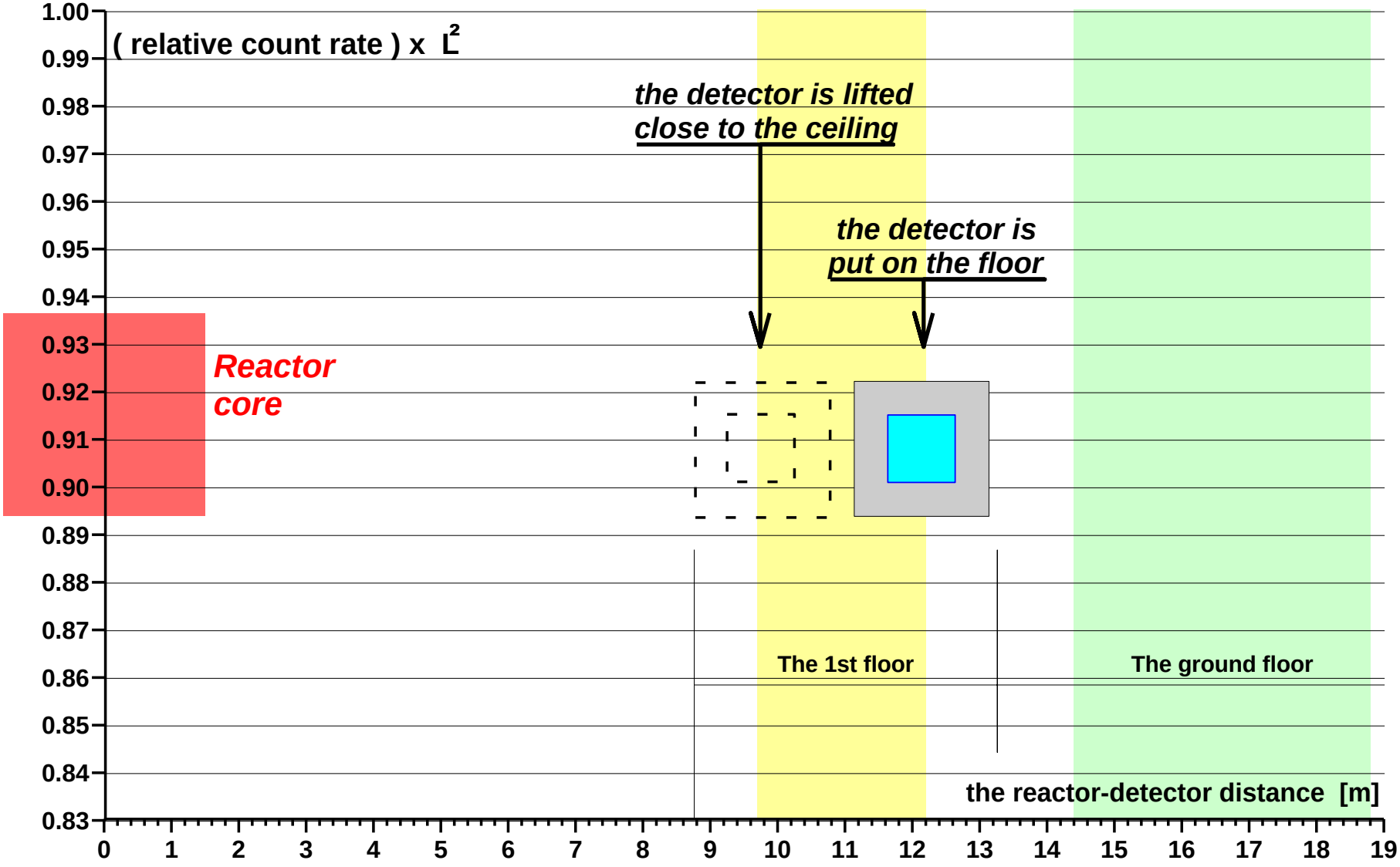
Typical neutrino spectrum *(arXiv:1101.2663)*

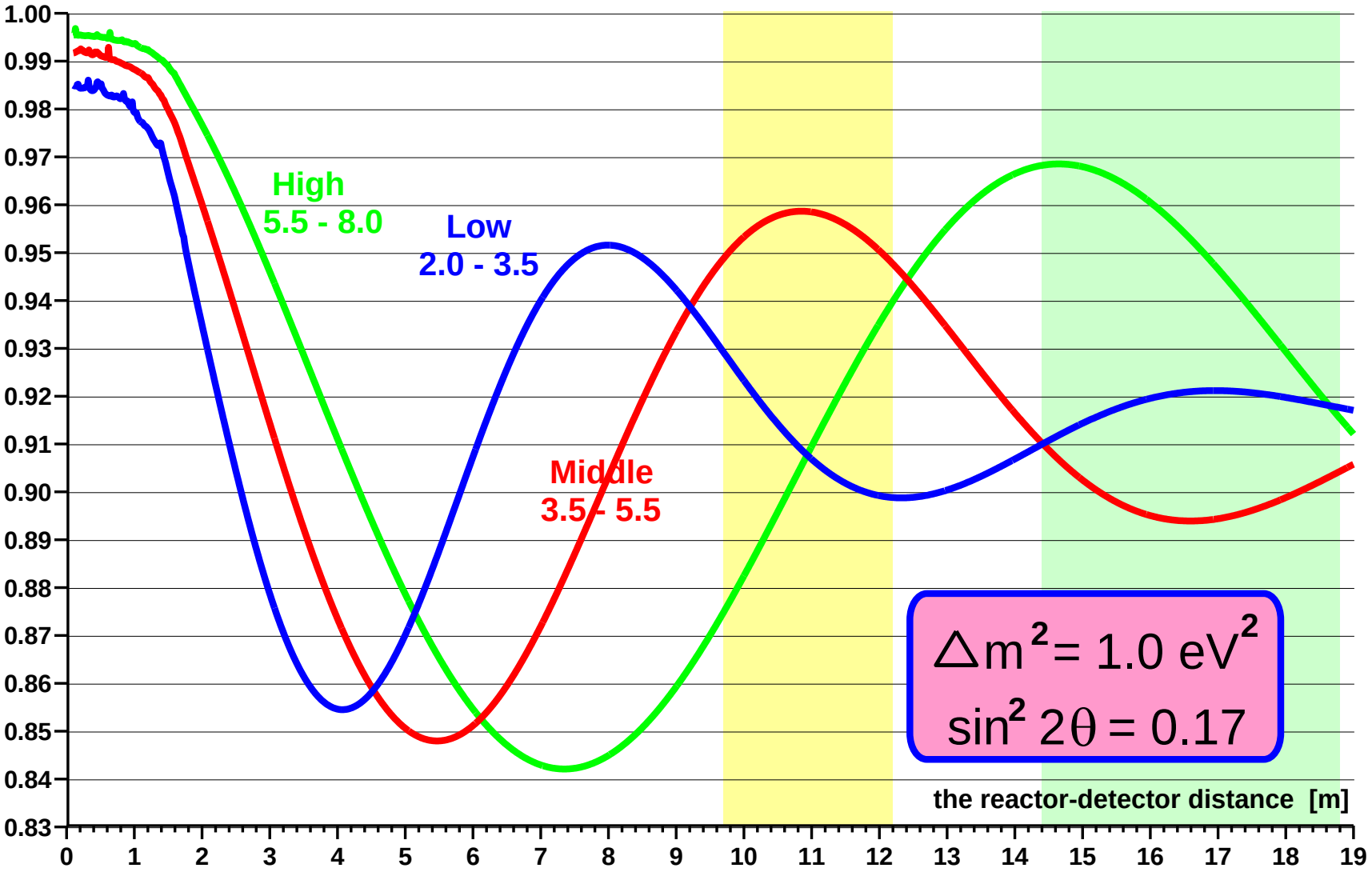
Detector finite resolution *(σ~30% @ E_ν=4 MeV)*


Neutrino Energy Spectrum
expected with DANSS
E [MeV]
0
1
2
3
4
5
6
7
8
9
10
11

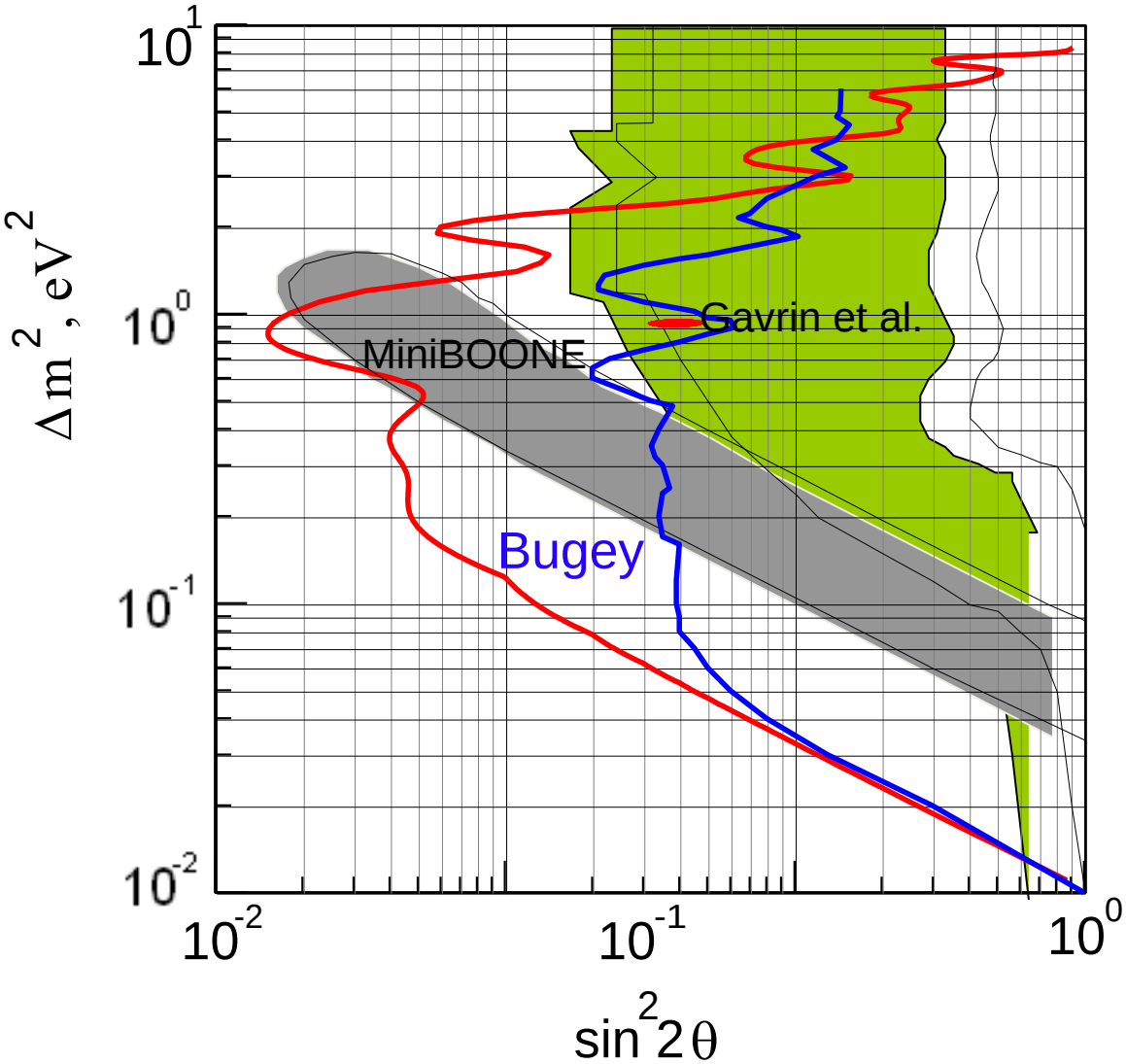


Different energy parts behave in a different way with distance

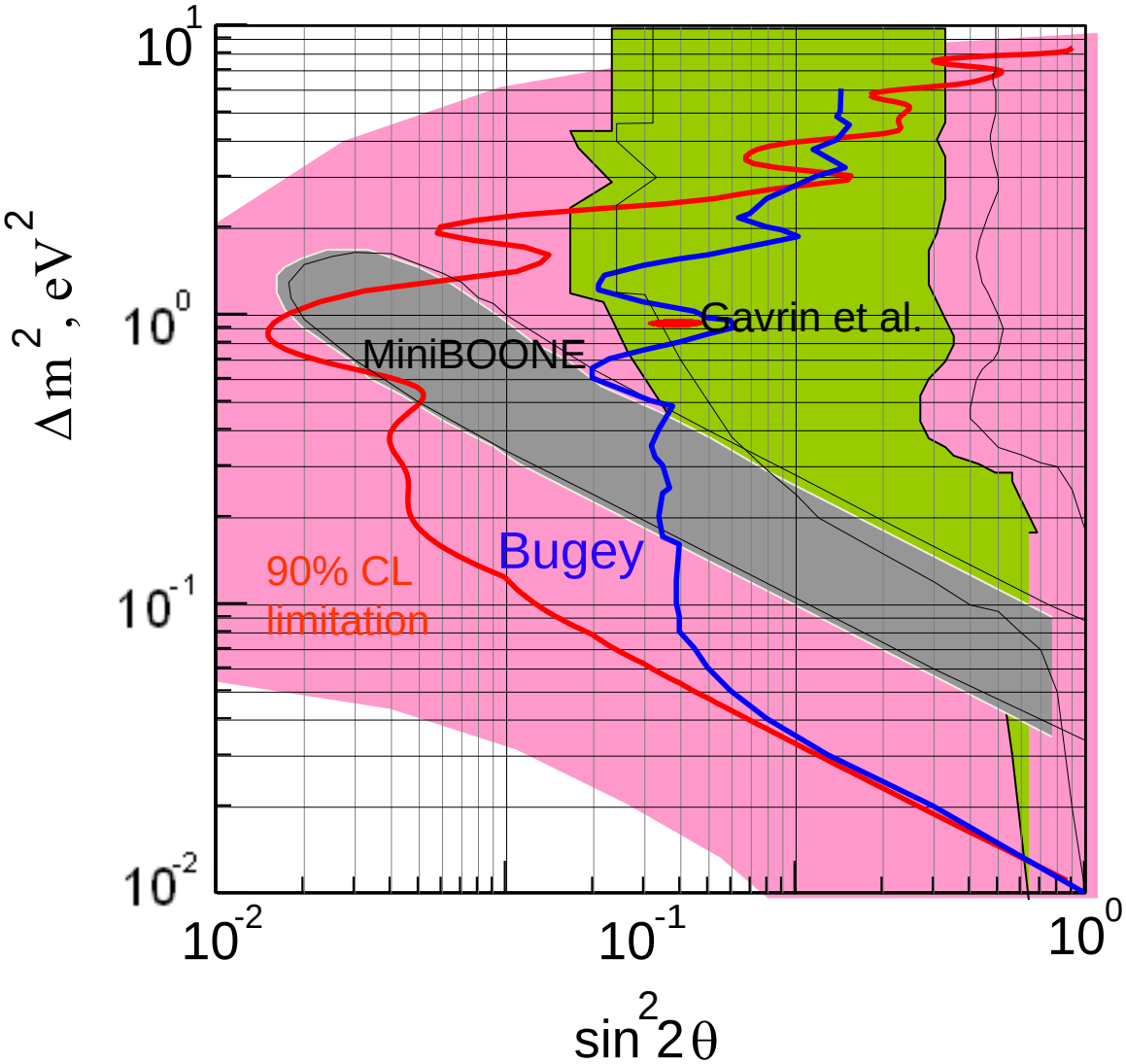

(relative count rate) x L²
the detector is lifted close to the ceiling
the detector is put on the floor
Reactor core
The 1st floor
The ground floor
the reactor-detector distance [m]
1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19


1.00
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
High
5.5 - 8.0
Low
2.0 - 3.5
Middle
3.5 - 5.5
$\Delta m^2 = 1.0\ eV^2$
$\sin^2 2\theta = 0.17$
the reactor-detector distance [m]

90%CL limitations on oscillation parameters estimated for 1-year measurements with DANSS at L=11 and 16 m



95%CL limitations on oscillation parameters estimated for 1-year measurements with DANSS at L=9.7, 11.0 and 12.2 m



Both estimations are very preliminary

and do not include systematics caused by the gain and background instability, etc.