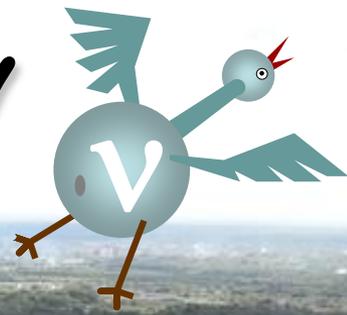


V. Egorov
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JINR (Dubna) + ITEP (Moscow)

DANS'S



1. Neutrino monitoring of an industrial reactor

- Power monitoring
- Fuel composition
- Tomography (?)...

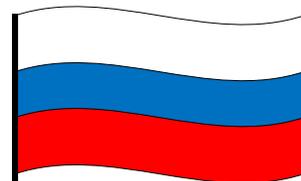
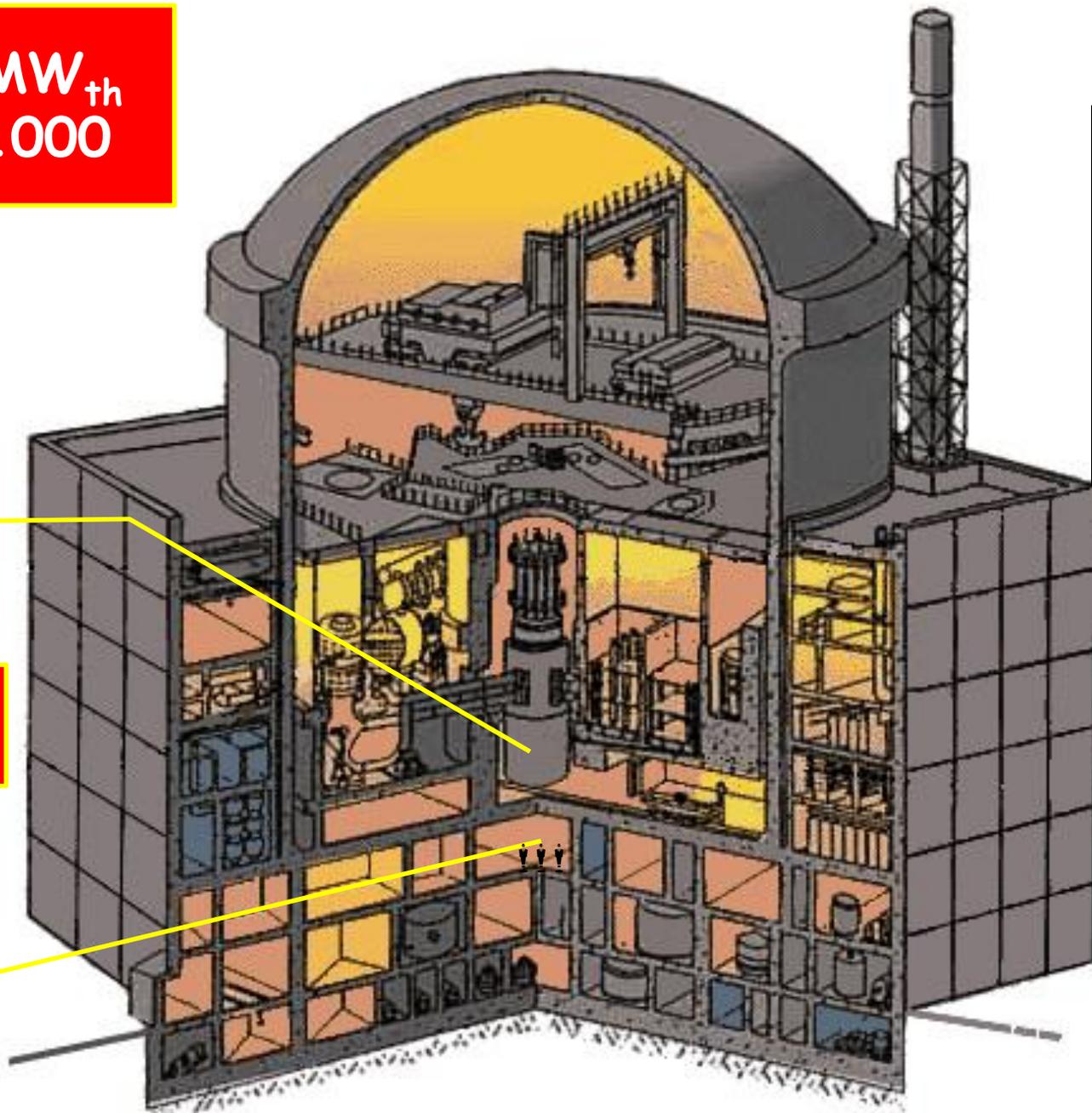
2. Search for short-range neutrino oscillations

Participants of the NANPino-2013 workshop (June 2013) visiting the DANSS site at KNPP



3 000 MW_{th}
ВВЭР-1000

Service
room

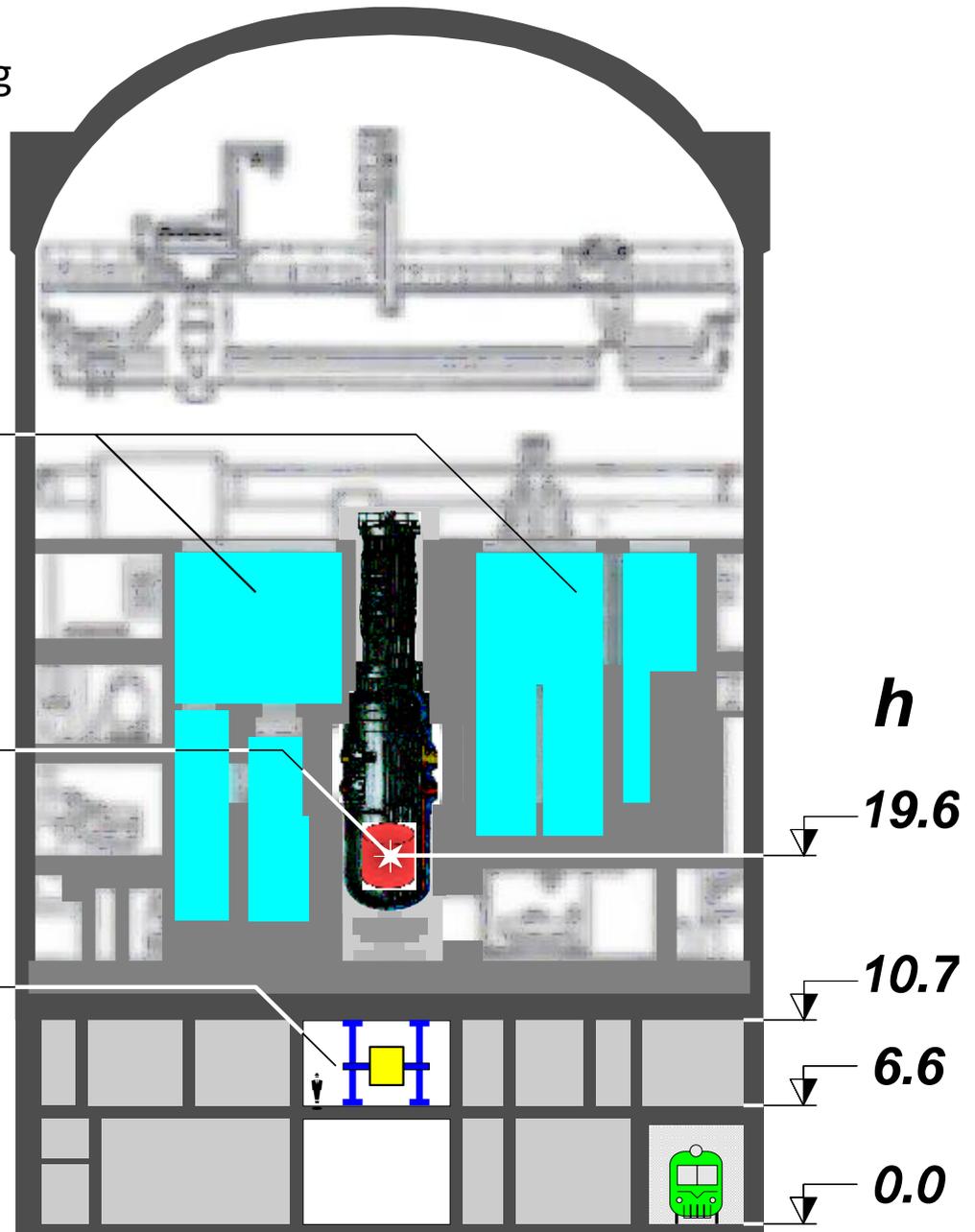


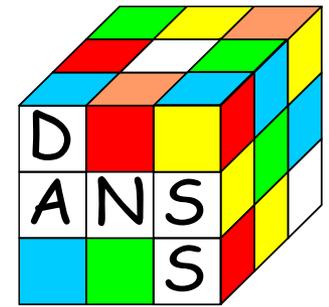
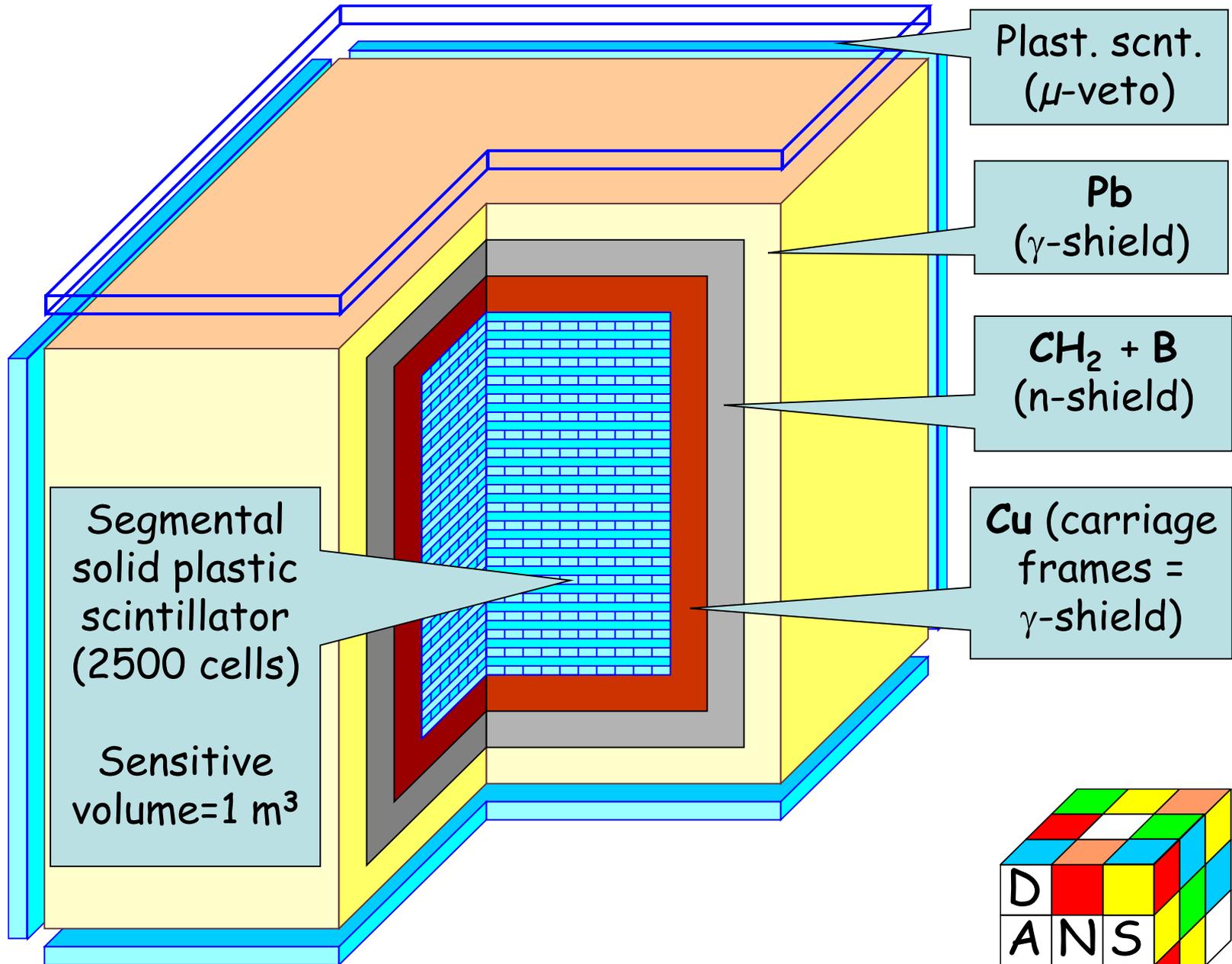
Typical reactor building
with **WWER-1000**

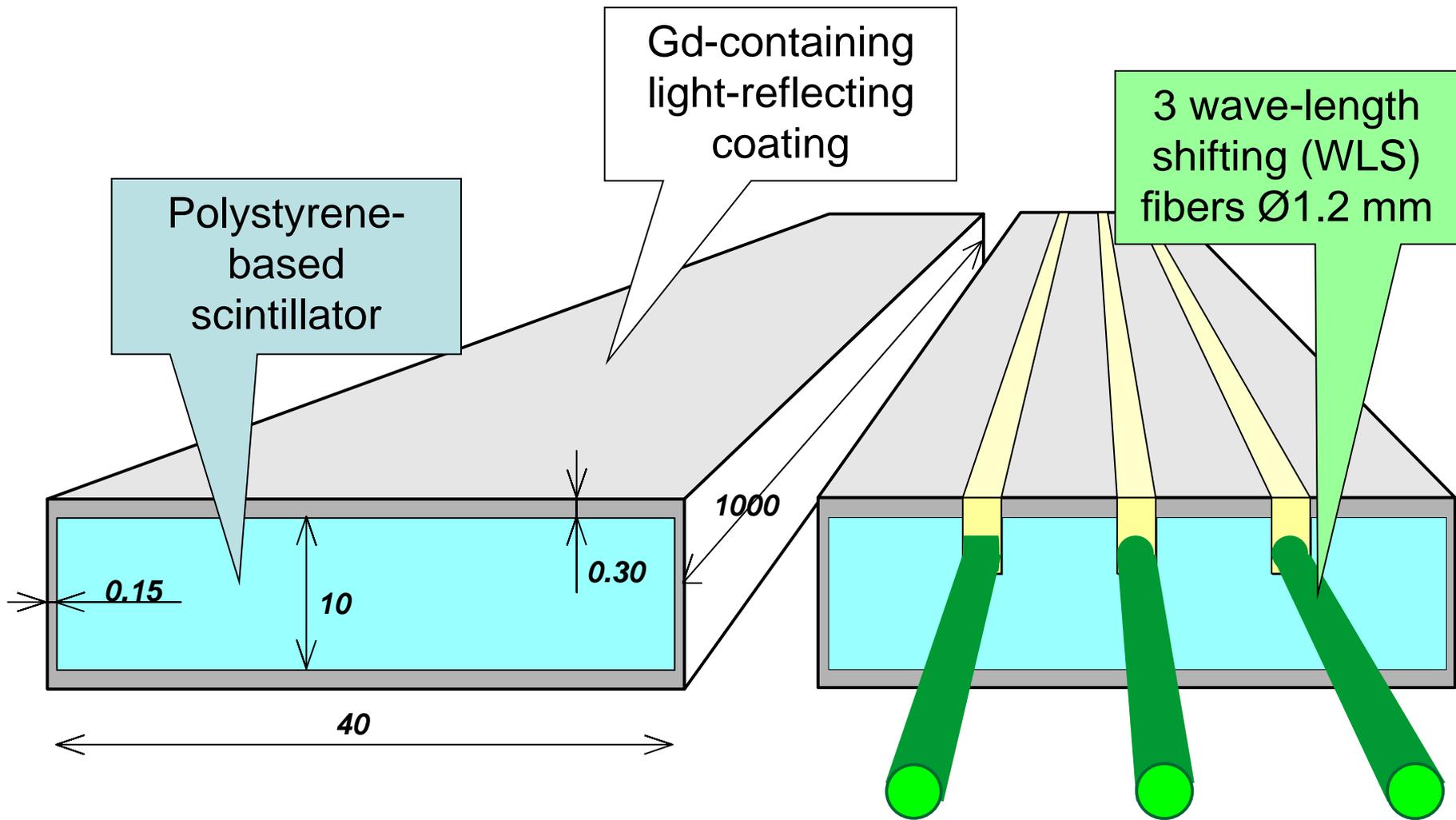
Reservoirs with
technological liquids
(cooling pond,
boric acid, etc.)

Core:
 $h = 3.50$ $\varnothing = 3.12$

DANSS on a movable
platform with a lifting gear.
 ν flux $\approx 5 \times 10^{13} \nu / \text{cm}^2 / \text{s}$
Overburden $\approx 50 \text{ m w. e.}$



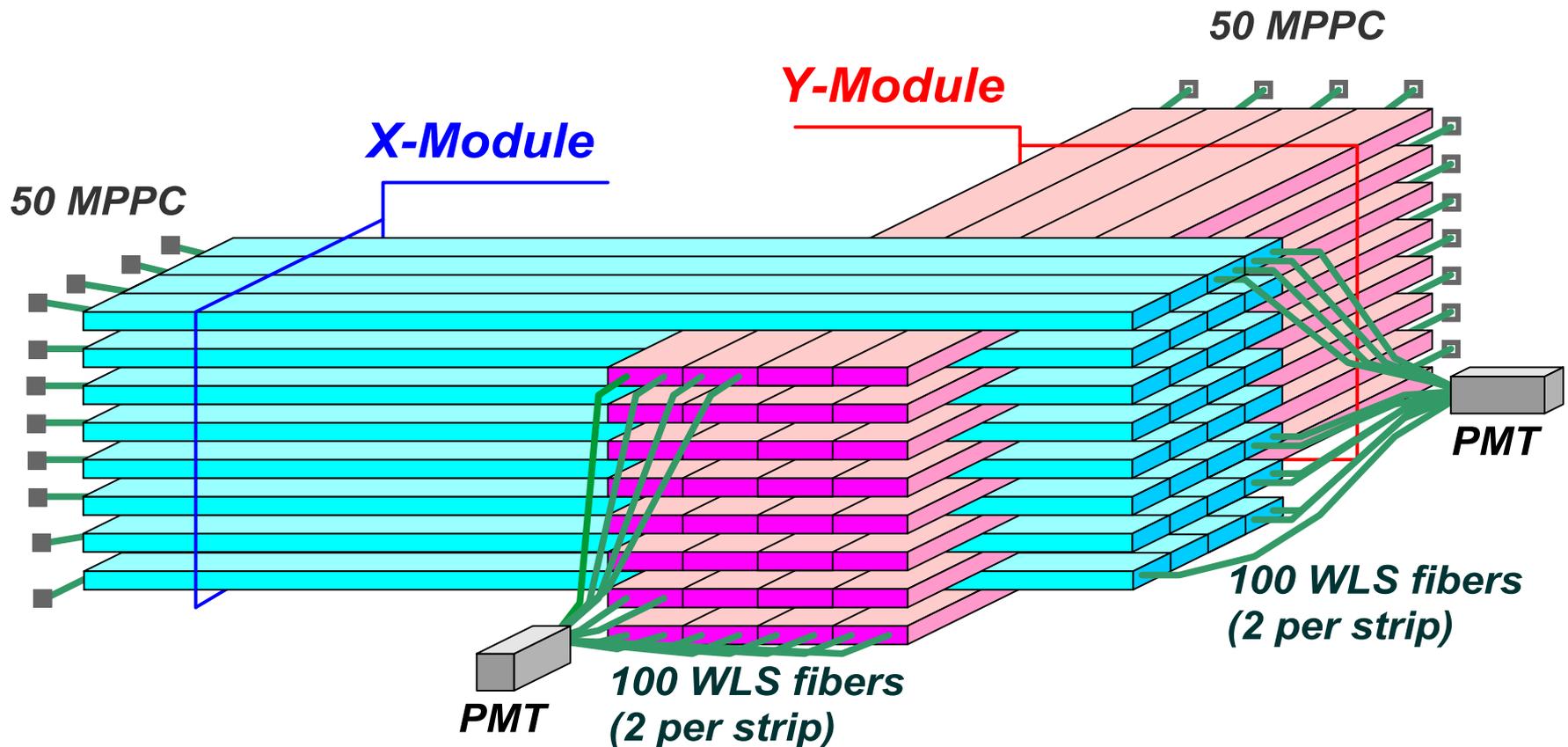




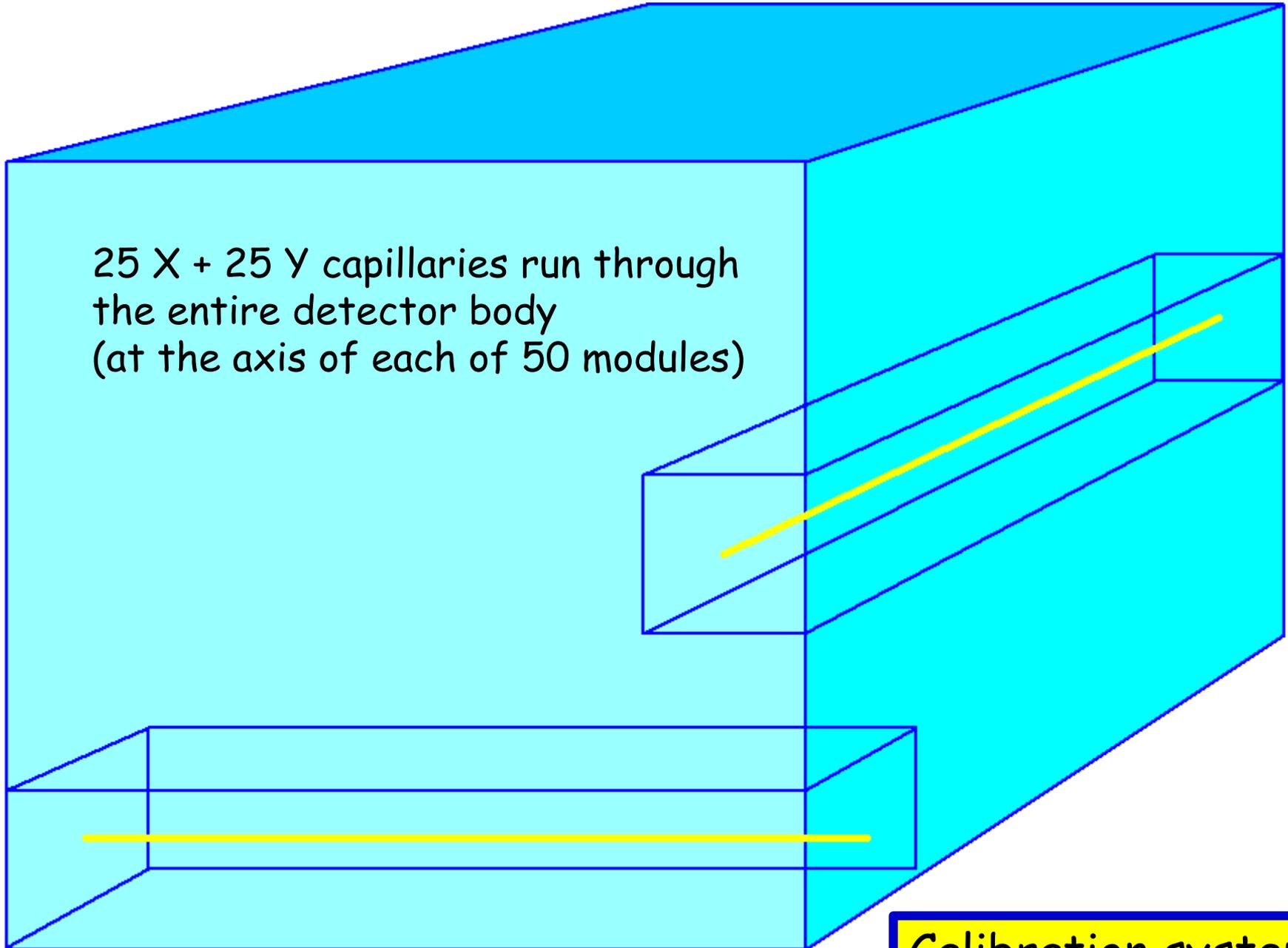
Basic element -
 - scintillator strip (1×4×100 cm)

Conception of the detector: modular structure

2500 strips are combined into intercrossing X- and Y-modules (20×20×100 cm), thus providing not only **energy information** but also **space pattern** of each event.



25 X + 25 Y capillaries run through
the entire detector body
(at the axis of each of 50 modules)



Calibration system

Teflon tube

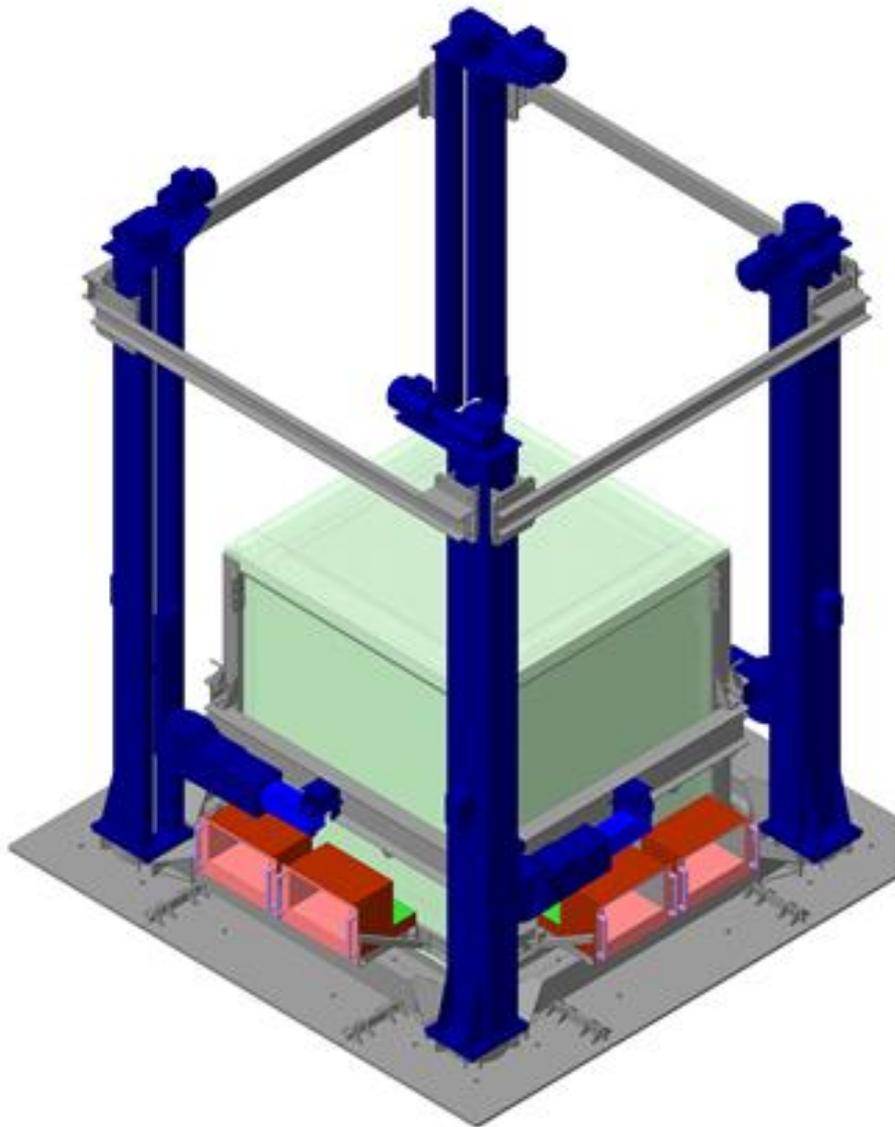
Radioactive source:
 ^{137}Cs (γ, e^-)
 ^{22}Na (γ, e^+)
 ^{60}Co (γ)
 ^{248}Cm ($\alpha, 3n, \gamma$)
etc.

0

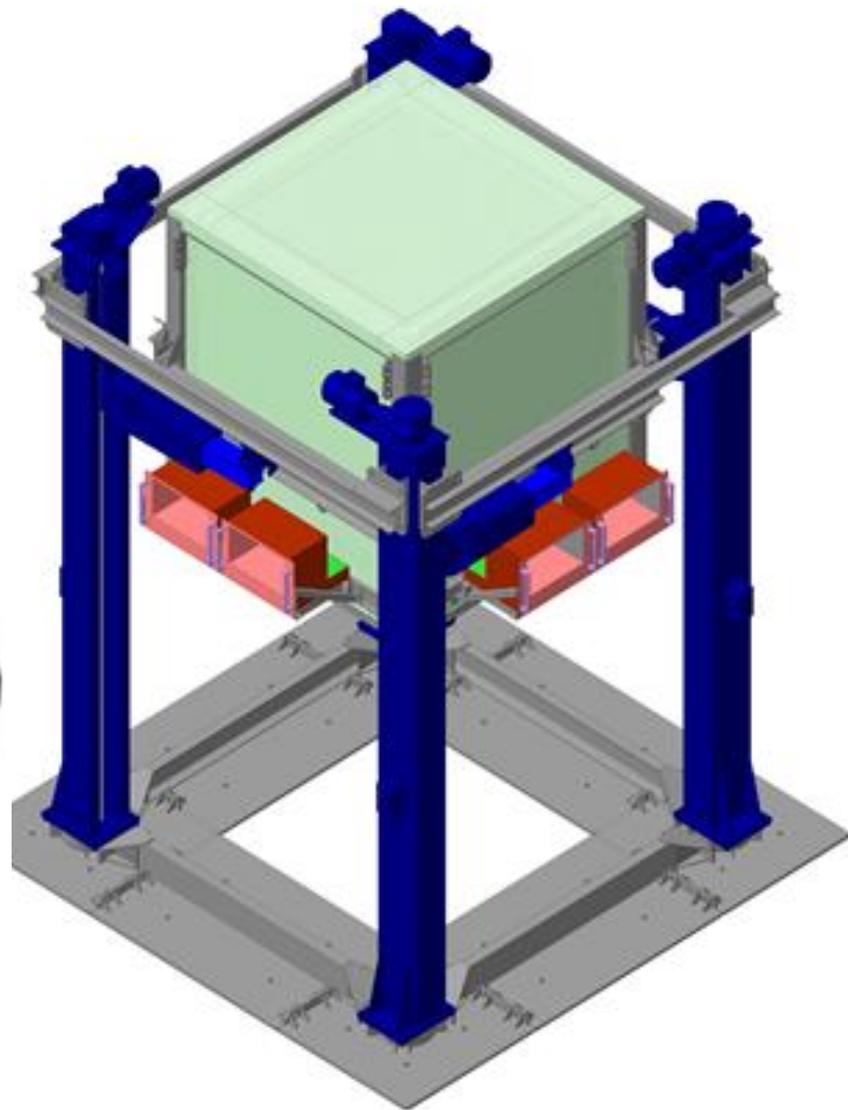
1

3

$L = 12.2 \text{ m}$

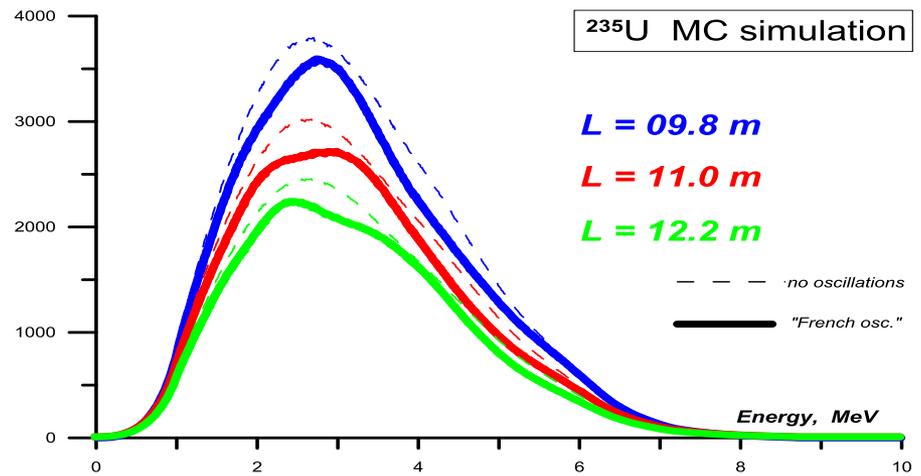
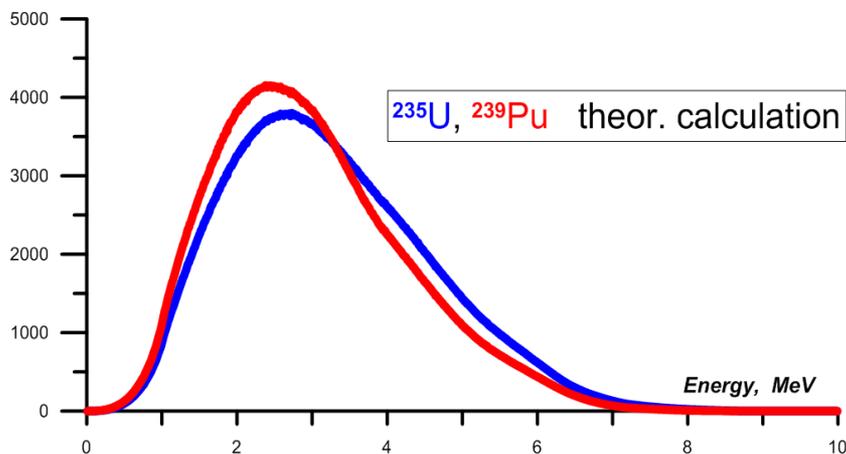


$L = 9.8 \text{ m}$



Expected parameters:

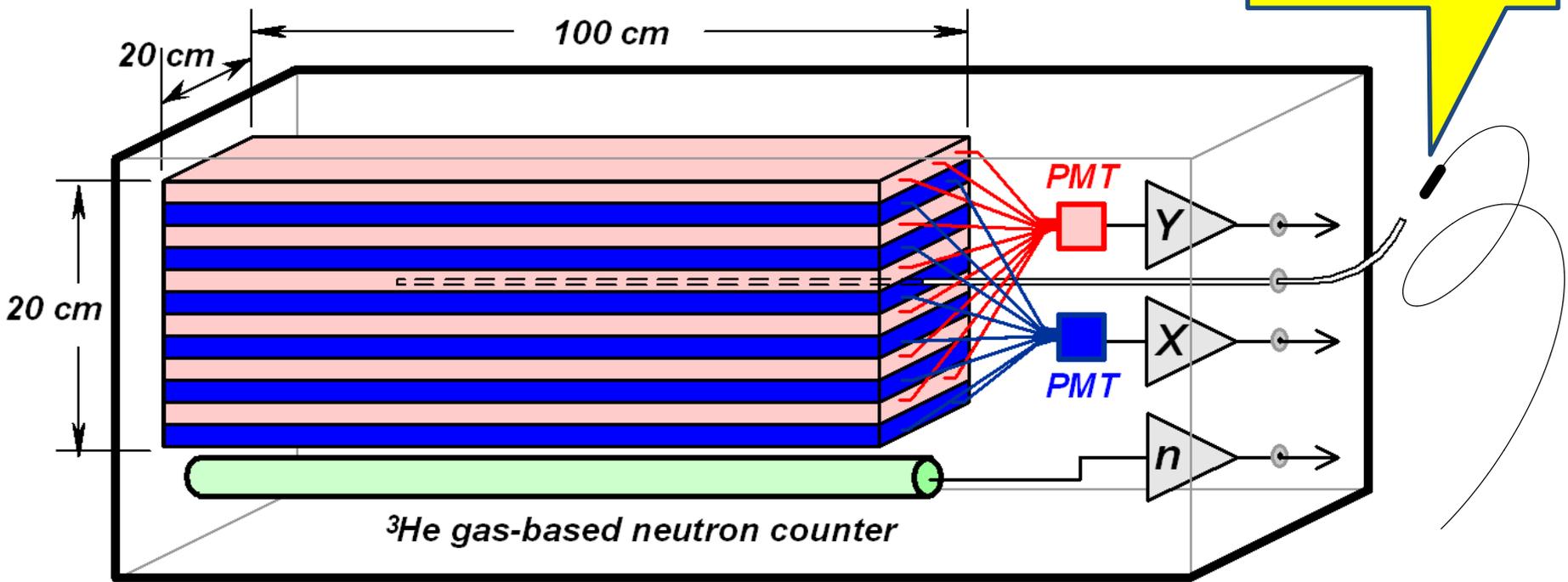
- Sensitive volume : $1 \text{ m}^3 = 100 \times 100 \times 100 \text{ cm}$
- Scintillator: Polystyrene based ($\sim 7.7 \%_{\text{wt}}$ of H)
- Structure: (25 X + 25 Y) intercrossing modules = 2500 strips
1 module $20 \times 20 \times 100 \text{ cm} = 50$ parallel strips
- Mass with (CHB+Cu+Pb)-shield: 16-18 tonnes
- Site: reactor unit#4 of Kalinin NPP (standard industrial WWER-1000, $\varnothing 3.12 \times h 3.50 \text{ m}$, $3000 \text{ MW}_{\text{th}}$)
- Reactor-Detector distance : **9.8-12.2 m** (*variable on-line*)
- Count rate: **(10 000 IBD + 50 BG)** /day @11 m
- Energy resolution @ $E_{\nu} = 4 \text{ MeV}$: 25% (FWHM)



- Unfortunately, design and creation of the lifting system took longer time than expected. (Nonstandard equipment: must be certified!...)
- Moreover, its mounting near the reactor could be done only during the fuel recharge period (when the reactor is OFF).
- 2-years delay... But we did not loose our time!

arXiv:1305.3350 [physics.ins-det]
arXiv:1304.3696 [physics.ins-det]

Calibration
r/a source:
 ^{60}Co
 ^{22}Na
 ^{137}Cs
 ^{248}Cm



Pilot version :

2 modules of 50

= 40 kg =

1/25th of DANSS

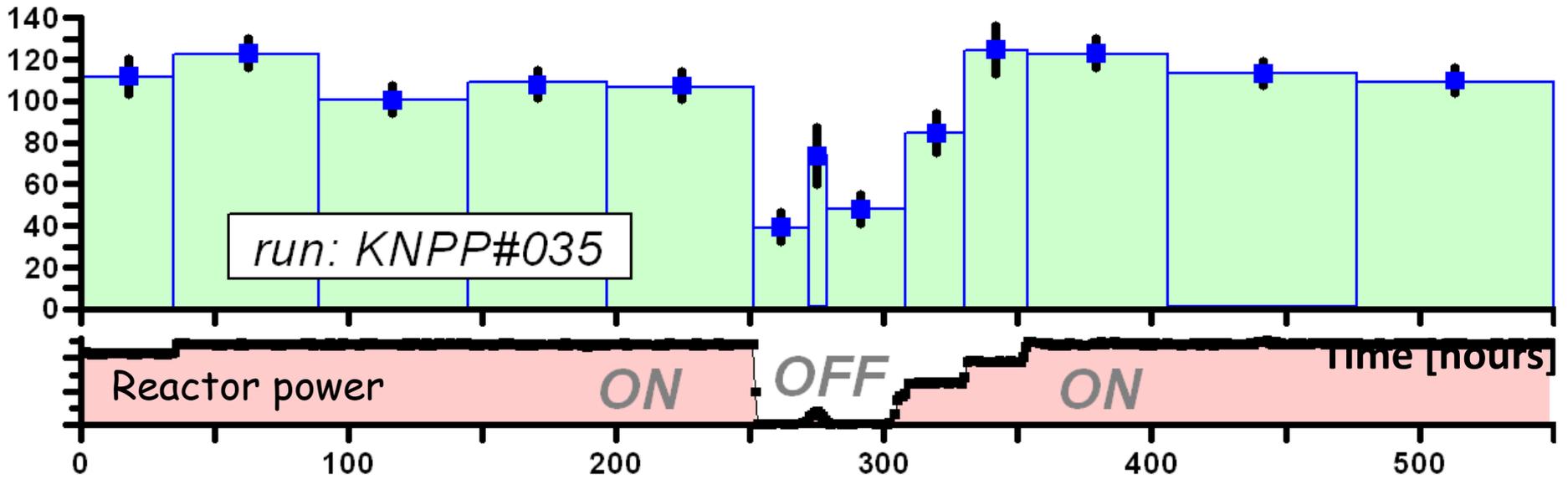
Simplified light collection
(2 PMT only, no MPPC)

Simplified electronics
(4 QDC and 1 TDC)

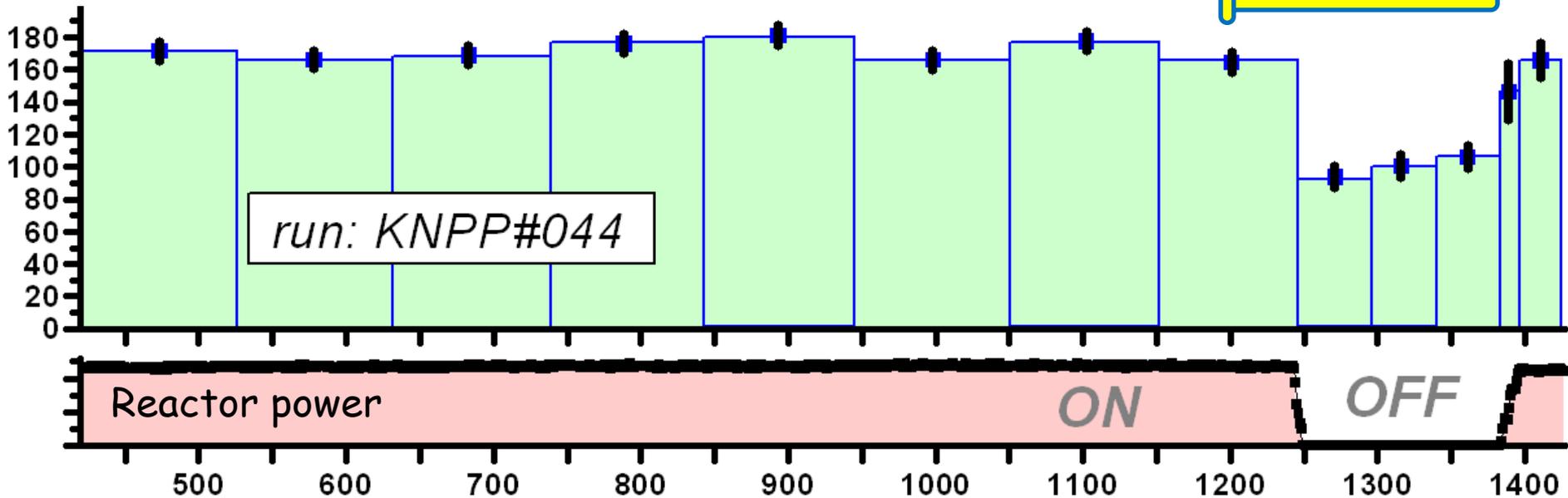
Simplified data selection



Rate of neutrino-like events detected per day



Rate of neutrino-like events detected per day



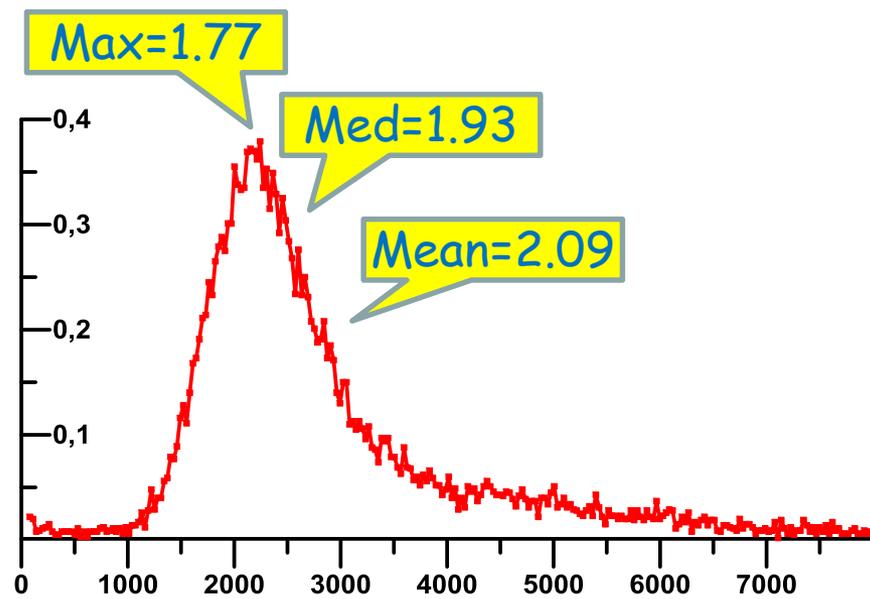
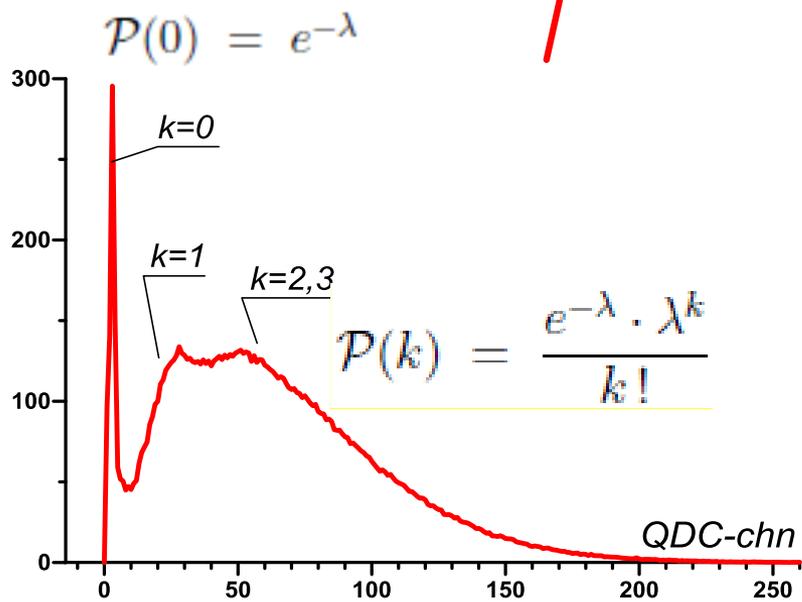
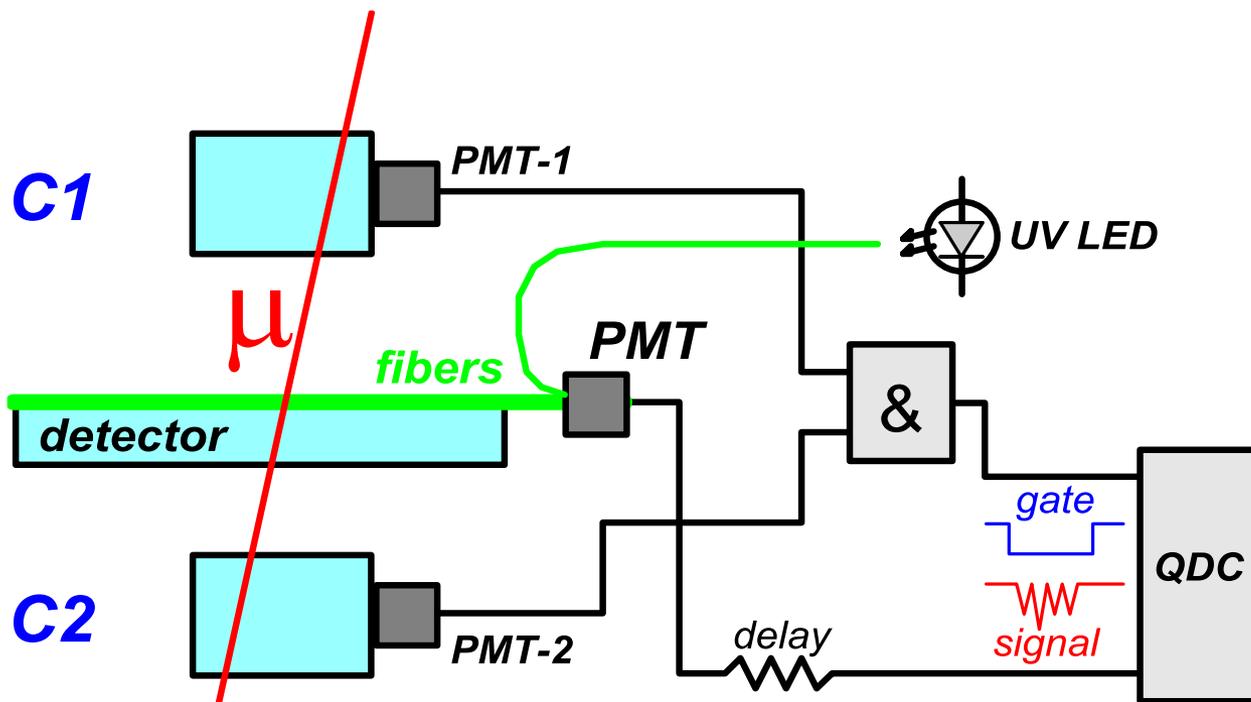


But Energy resolution was
poorer than expected:
we had only 10 pe/MeV... ☹️

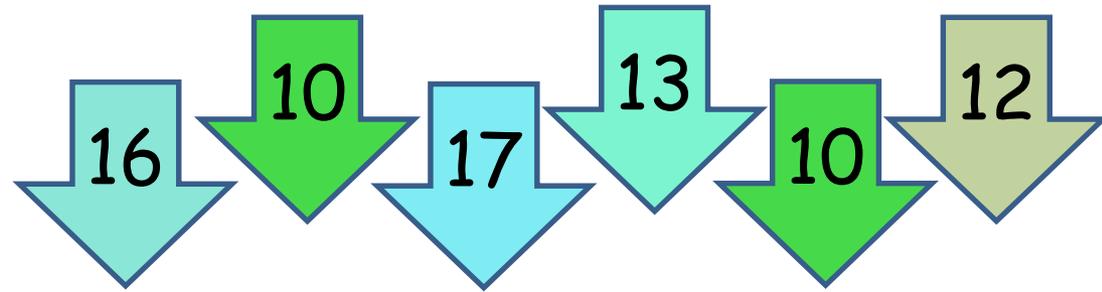
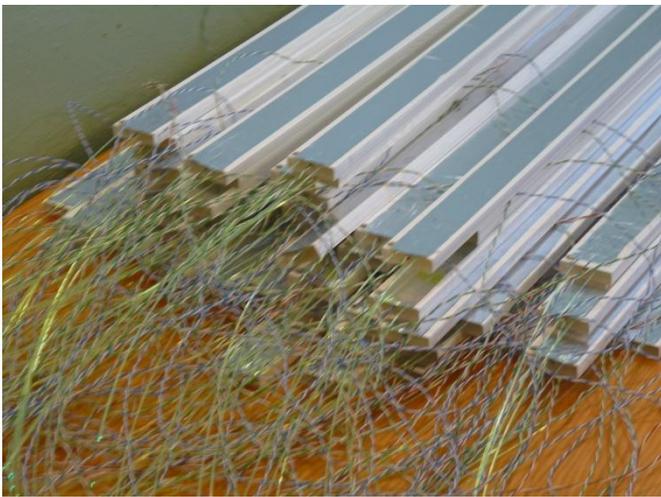
Kharkov (UA) production



(The after ends of strips
are UV-illuminated)



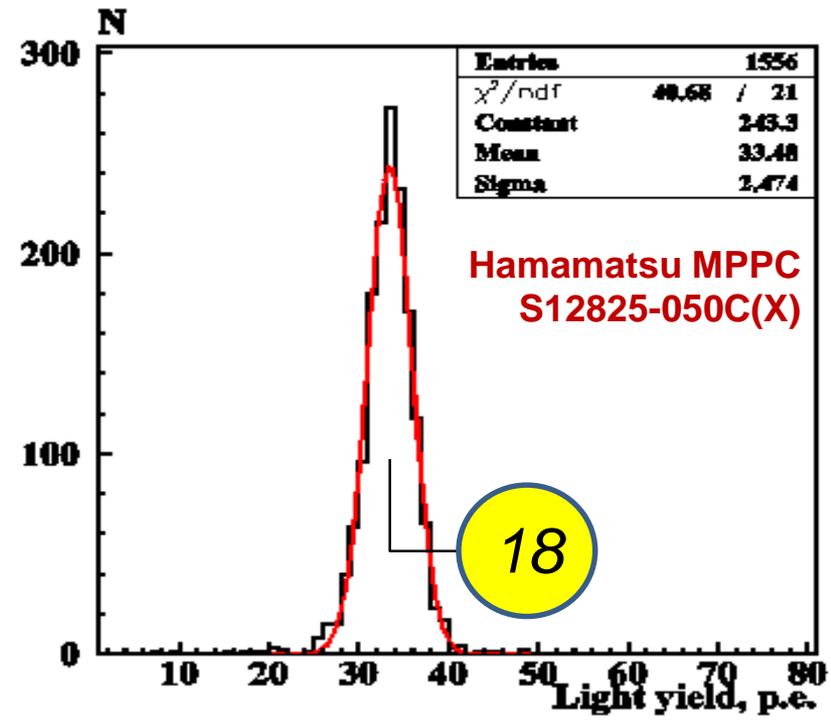
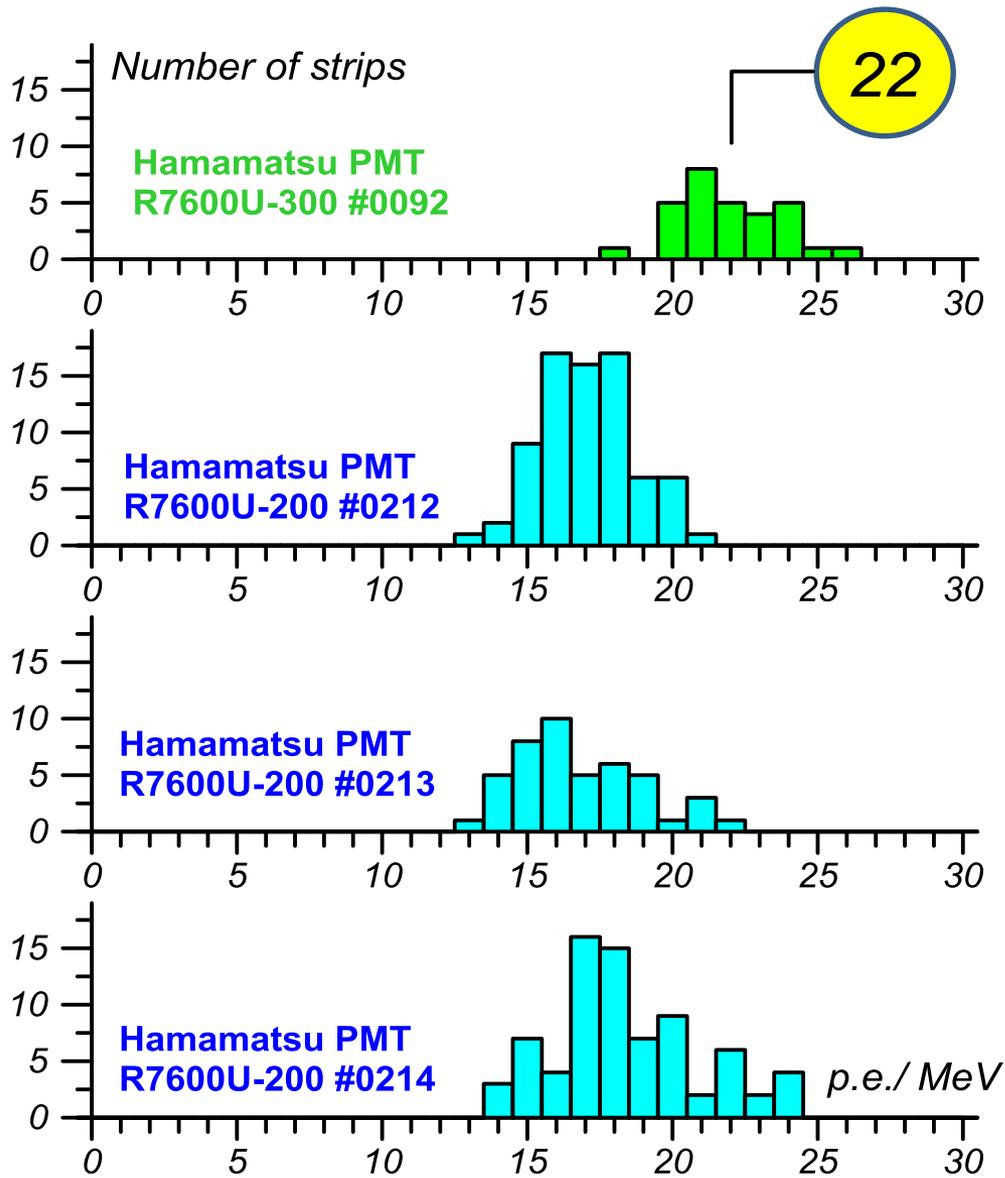
Quality dispersion of Kharkov (UA) production



(The after ends of strips are UV-illuminated)

Improvements undertaken:

- 2500 strips have been selected (by color) from 10000
- Ultra Bialkali PMT R7600U-200 replaced by Extended Green Bialkali ones R7600U-300
- Home-made MPPC replaced by Hamamatsu S12825-050C(X) - *new! with reduced noise*



$$18 + 22 = 40 \text{ p.e./MeV}$$

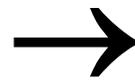
Resolution @ $E_\nu = 4 \text{ MeV}$:

$$N = (4.0 - 1.8) \times 40 = 88 \text{ p.e.}$$

$$\Delta E/E = \sqrt{N} / N = 11\% (\sigma)$$

$$= 25\% (\text{FWHM})$$

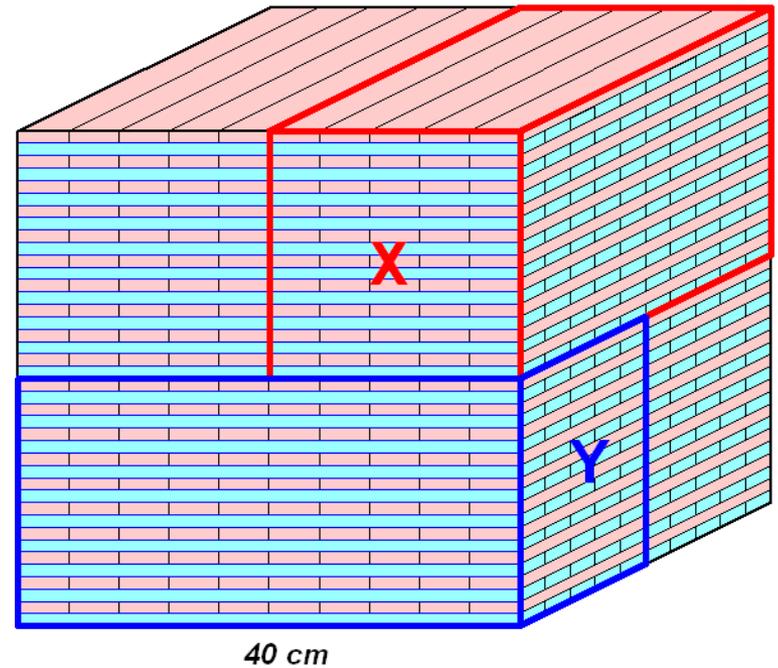
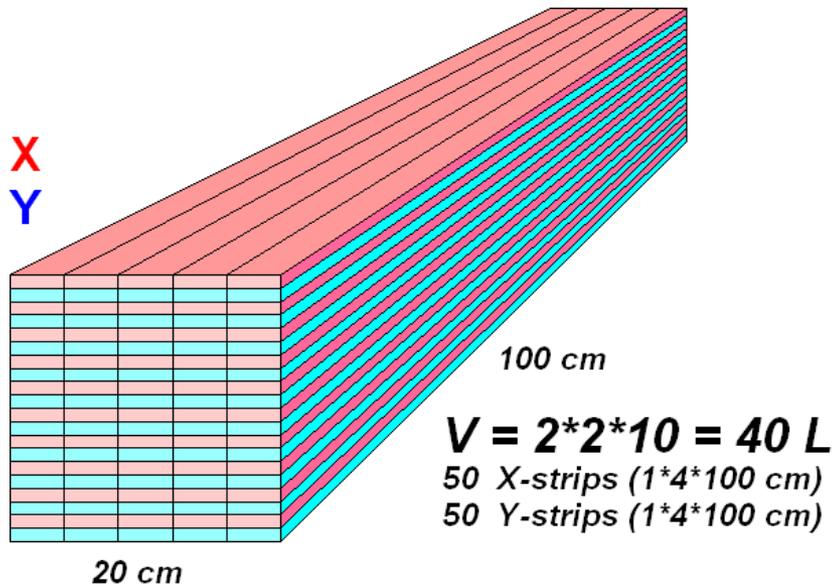
DANSSino



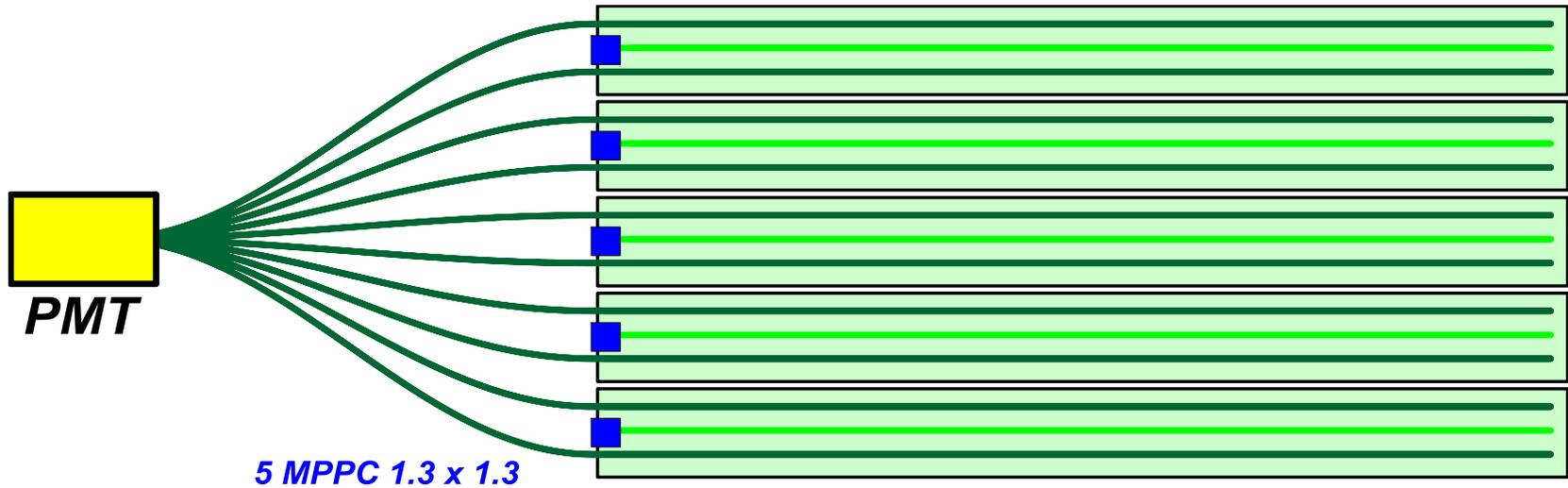
DANSSino2

Huge edge effects
↓
efficiency \approx 10-15%
(instead of 72)

\sim 400 IBD/day
($S/B \gg 1$)

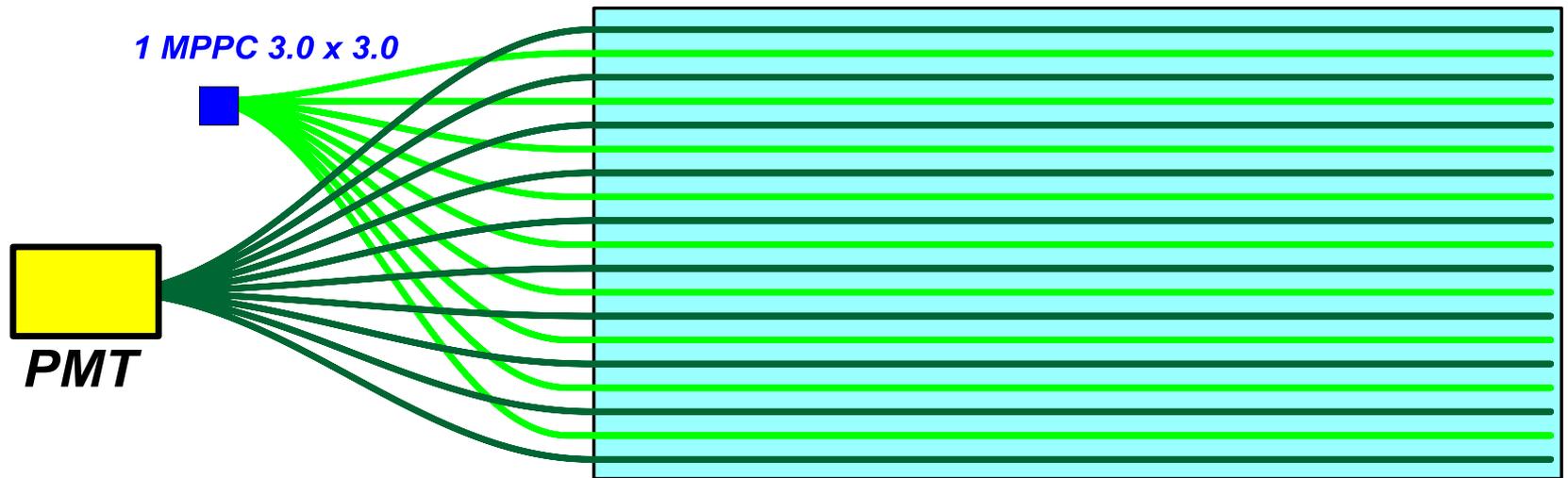


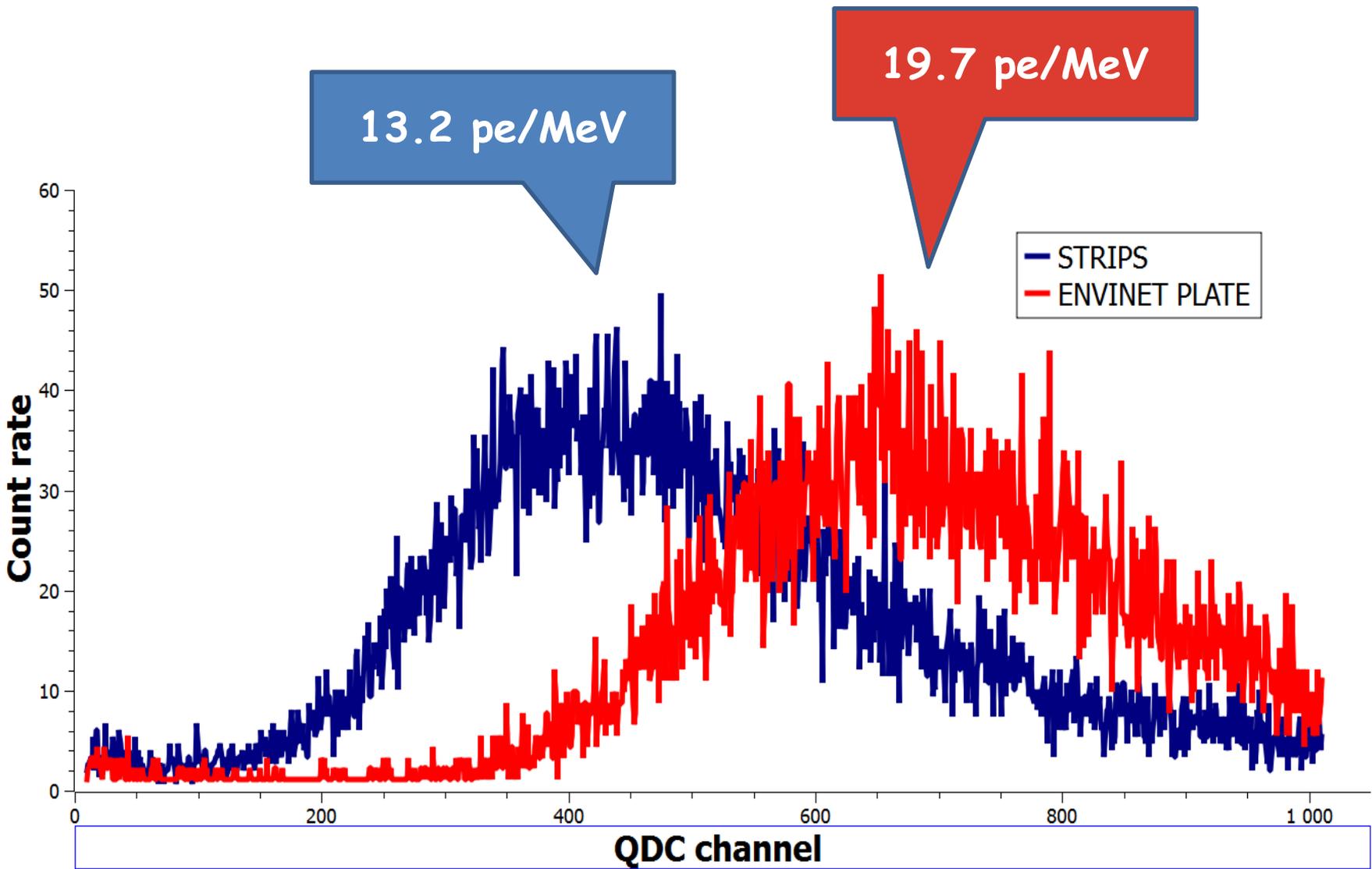
$V = 4 \cdot 4 \cdot 4 = 64 L$
 $4 \cdot 50 = 200$ X-strips ($1 \cdot 4 \cdot 40$ cm)
 $4 \cdot 50 = 200$ Y-strips ($1 \cdot 4 \cdot 40$ cm)



5 DANSS strips (shortcut)

1 ENVINET plate





Optimization of the basic scintillator element (ENVINET plate)

- WLS fibers:
Kuraray (JP) vs Bicron (S^t-Gobain)
○ vs □
- pTP concentration:
0.6 - 1.0 - 1.5 - 2.0 - 2.5 - 3.0 - 3.5 %
- POPOP concentration:
1/10 - 1/5 - 1/2 - 1/1 - 2/1 of standard
- Wrapping:
Mylar - Teflon - Tyvek - BC620 - ...
- MPPC:
Hamamatsu vs SensL

DANSSino2

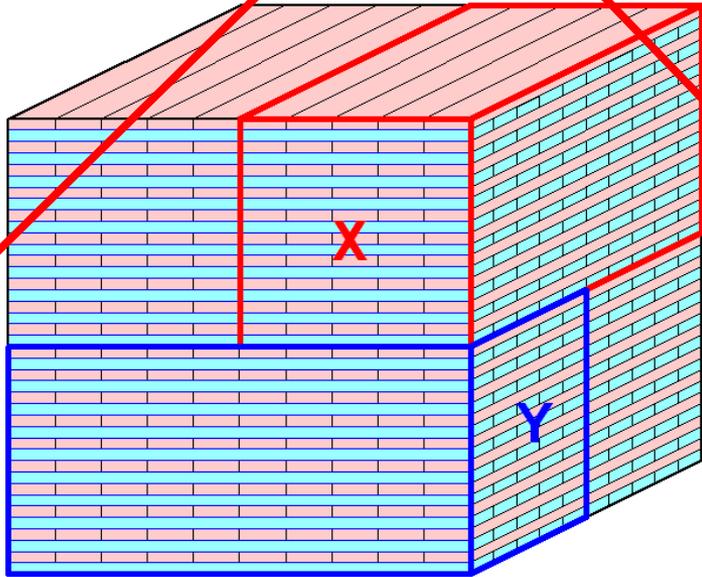


S³

40 p.e./MeV

70-80 p.e./MeV

~400 IBD/day
tomography?..



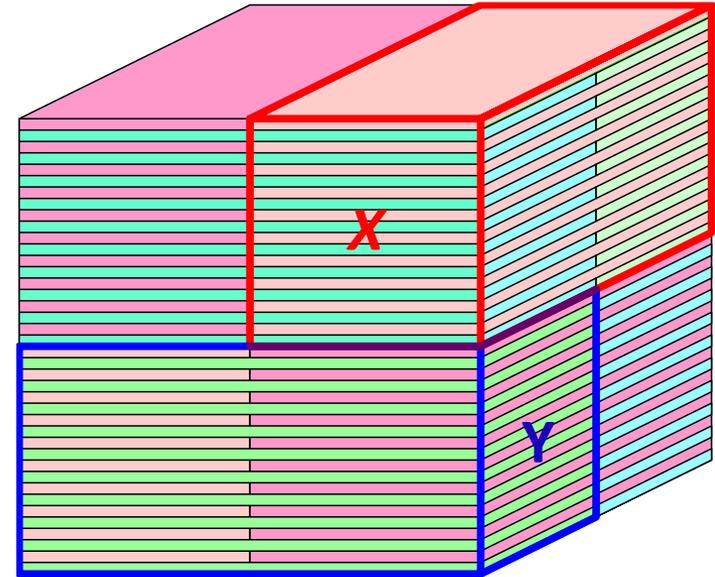
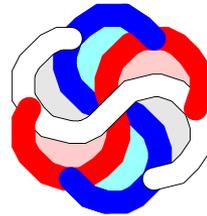
40 cm

$$V = 4 * 4 * 4 = 64 L$$

4 * 50 = 200 X-strips (1*4*40 cm)

4 * 50 = 200 Y-strips (1*4*40 cm)

8 PMT + 200 MPPC



$$V = 4 * 4 * 4 = 64 L$$

4 * 10 = 40 X-plates (1*20*40 cm)

4 * 10 = 40 Y-plates (1*20*40 cm)

8 PMT + 80 MPPC

Due date

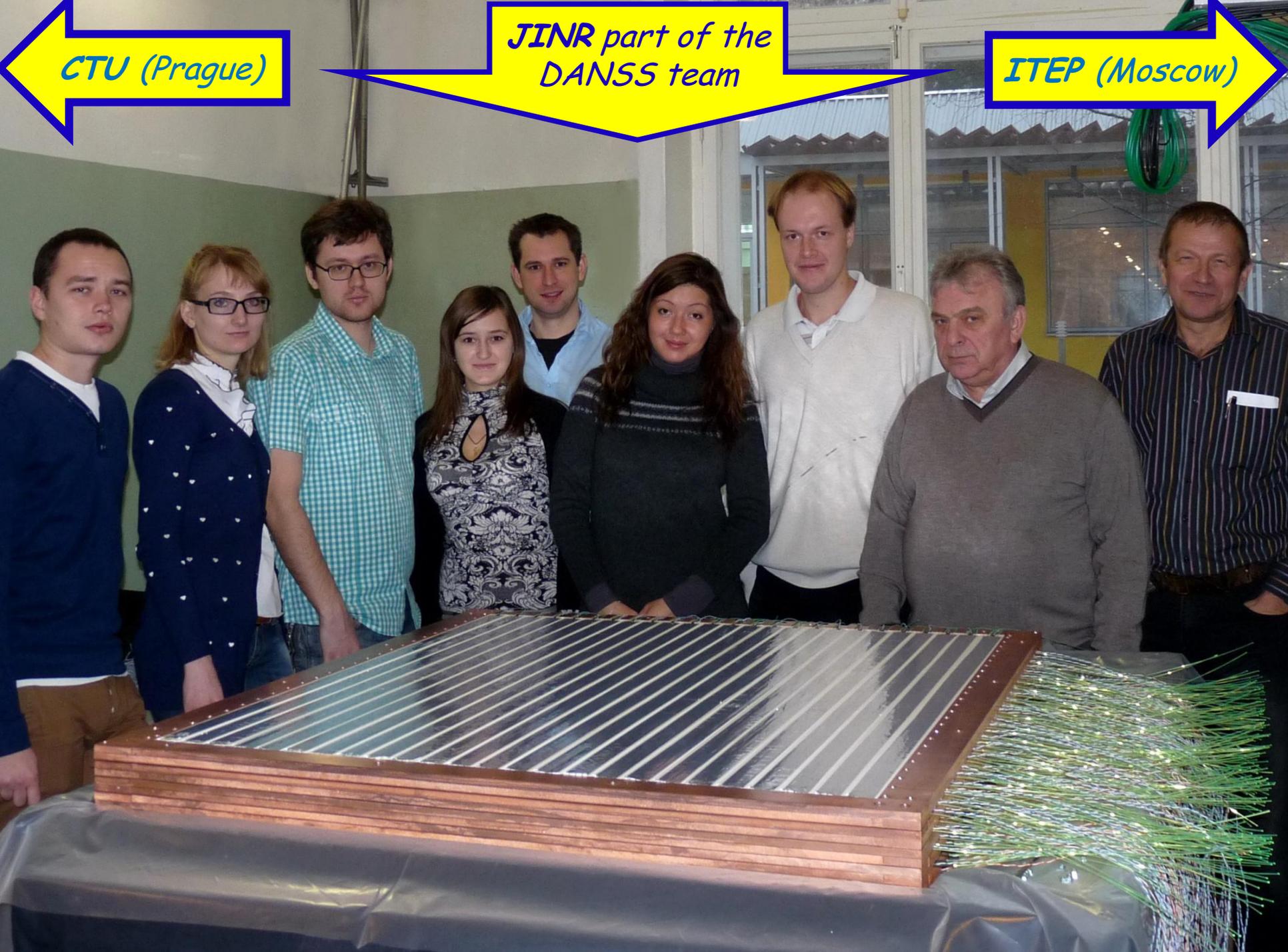
The main braking factor:
mnt. could be performed
only when the reactor is
stopped for recharge...

- Final mounting of the lifting system: Sep 2014
 - Mounting of the moveable platform: Oct 2014
 - Mounting of the bottom shielding: Nov 2014
 - Mounting of the DANSS detector: - Mar 2015
 - Mounting and tuning of the ACQ: - summer 2015
 - Mounting of the rest shielding: - summer 2015
 - Mounting of the Muon Veto: - summer 2015
 - Start of data taking: - summer 2015
 - Off-line and on-line tests with S^3 - summer 2015
- @(KNPP and Temelin NPP)

CTU (Prague)

*JINR part of the
DANSS team*

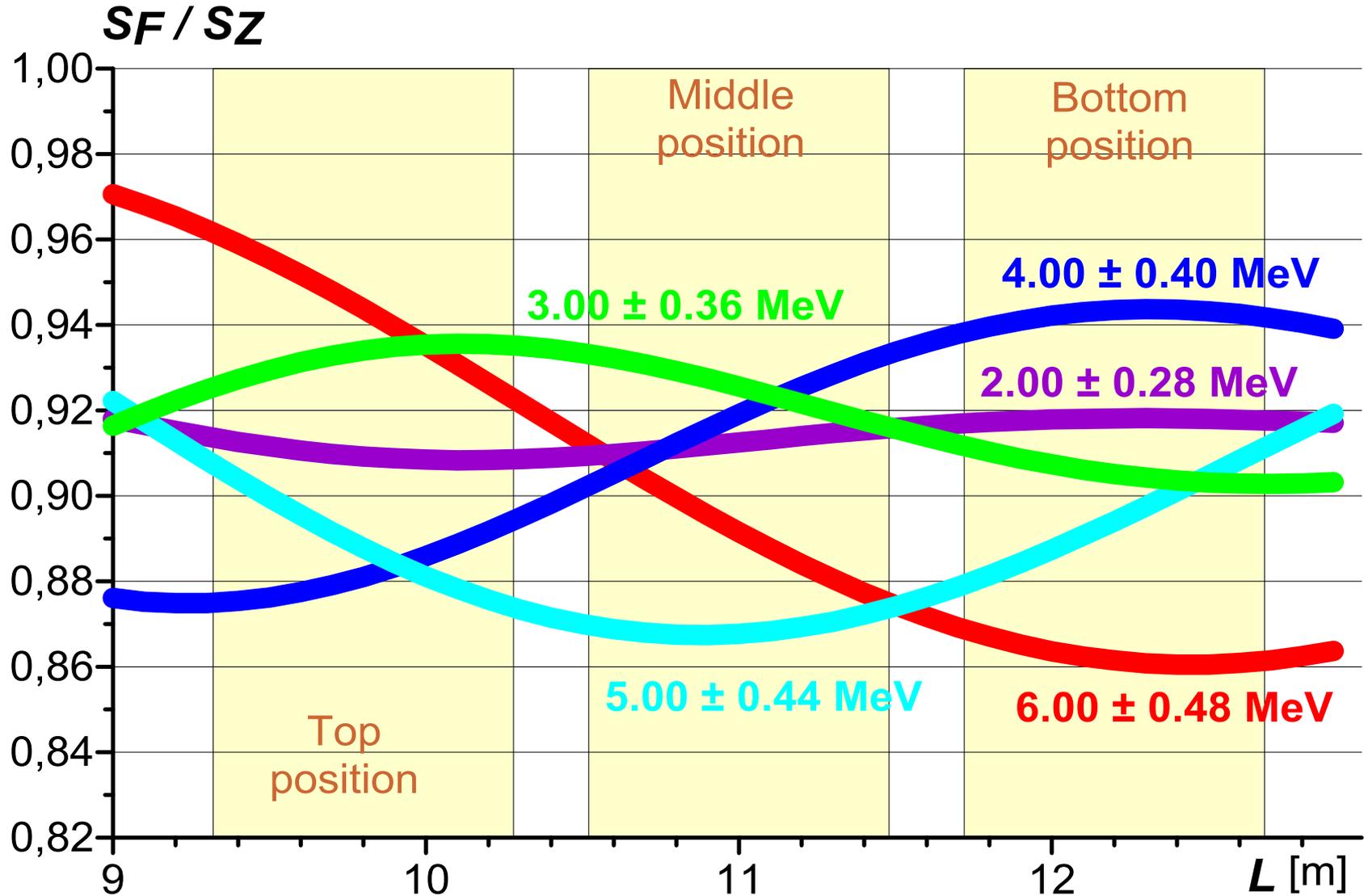
ITEP (Moscow)

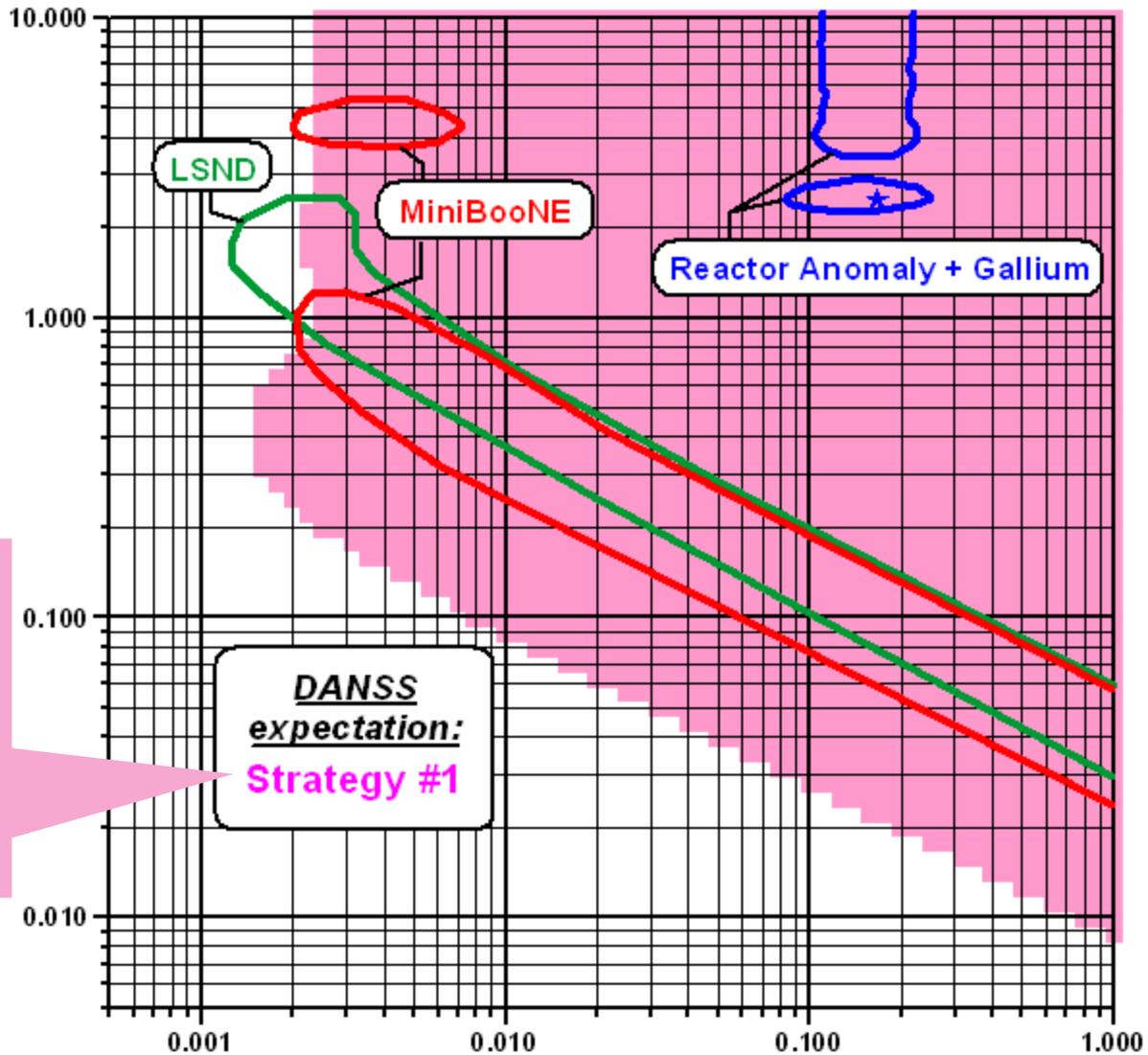


Few words about

"sterile sensitivity"
of DANSS 1y operation

Core dim. : D3.12 x H3.50 m
Burning prob. : $p \sim \cos(\pi \cdot h/H) \cdot \cos(\pi \cdot r/D)$
E resolution : 25 p.e./MeV

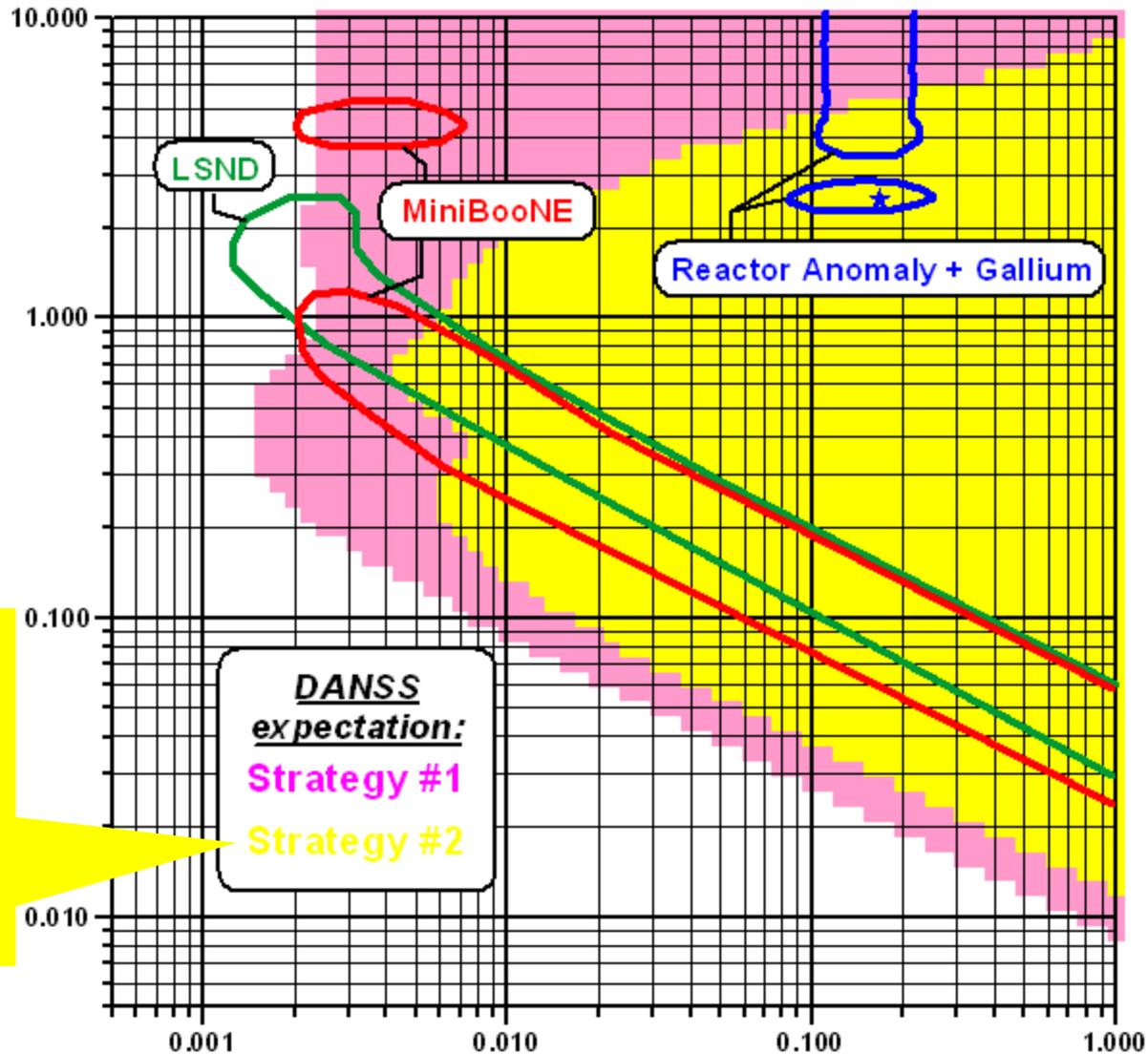




All parameters
of the reactor
and
the detector
are known
absolutely

Optimistic case

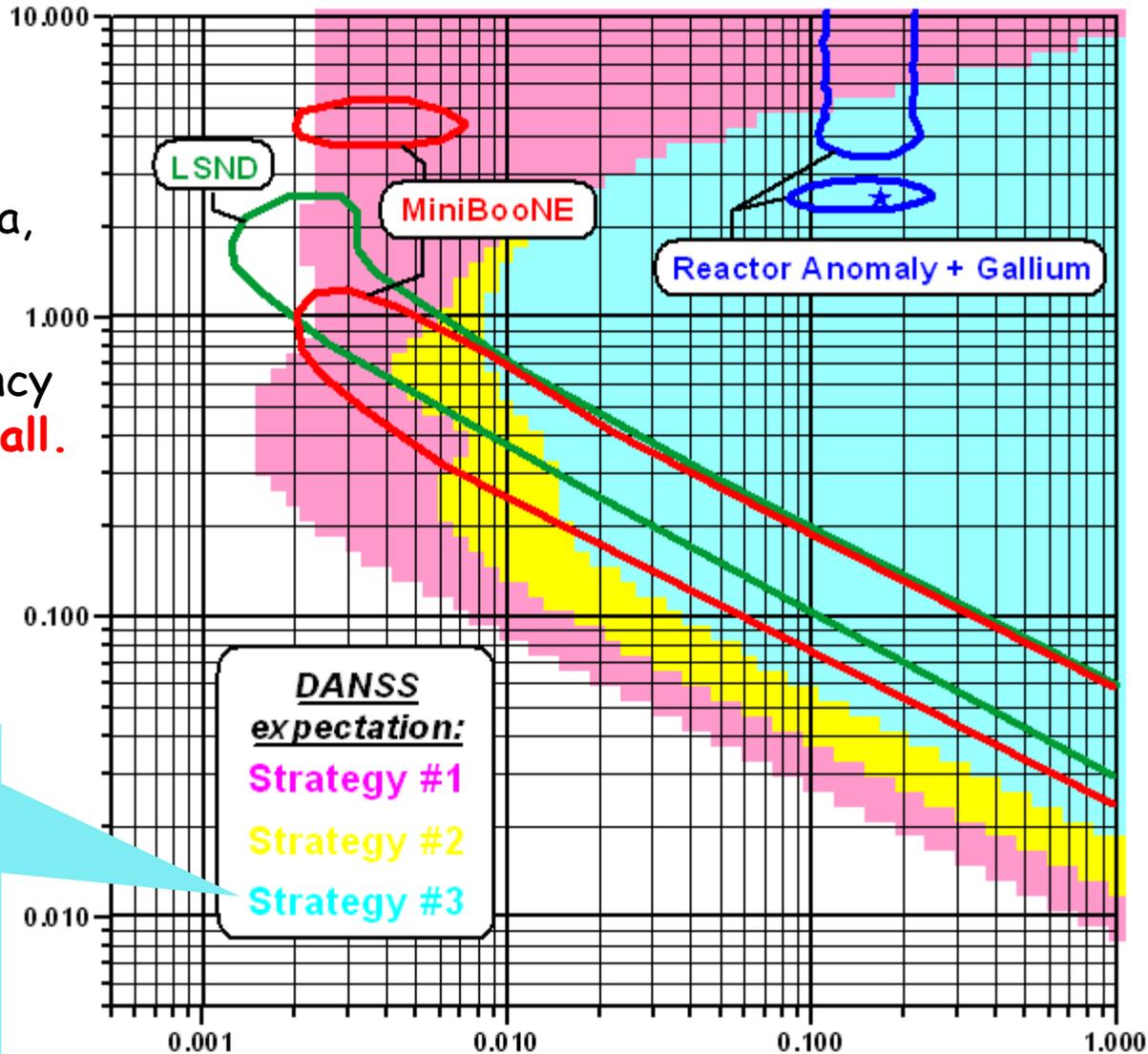
We compare (at 90%CL) absolute count rates
in 3 positions (100 days/pos) with
calculated ones - keV by keV



Realistic case

We compare (at 90%CL) shapes of energy spectra in 3 positions (100 days/pos) with calculated ones - keV by keV

Theor. $\bar{\nu}_e$ -spectra,
fuel composition,
power variations,
detector efficiency
are not used at all.

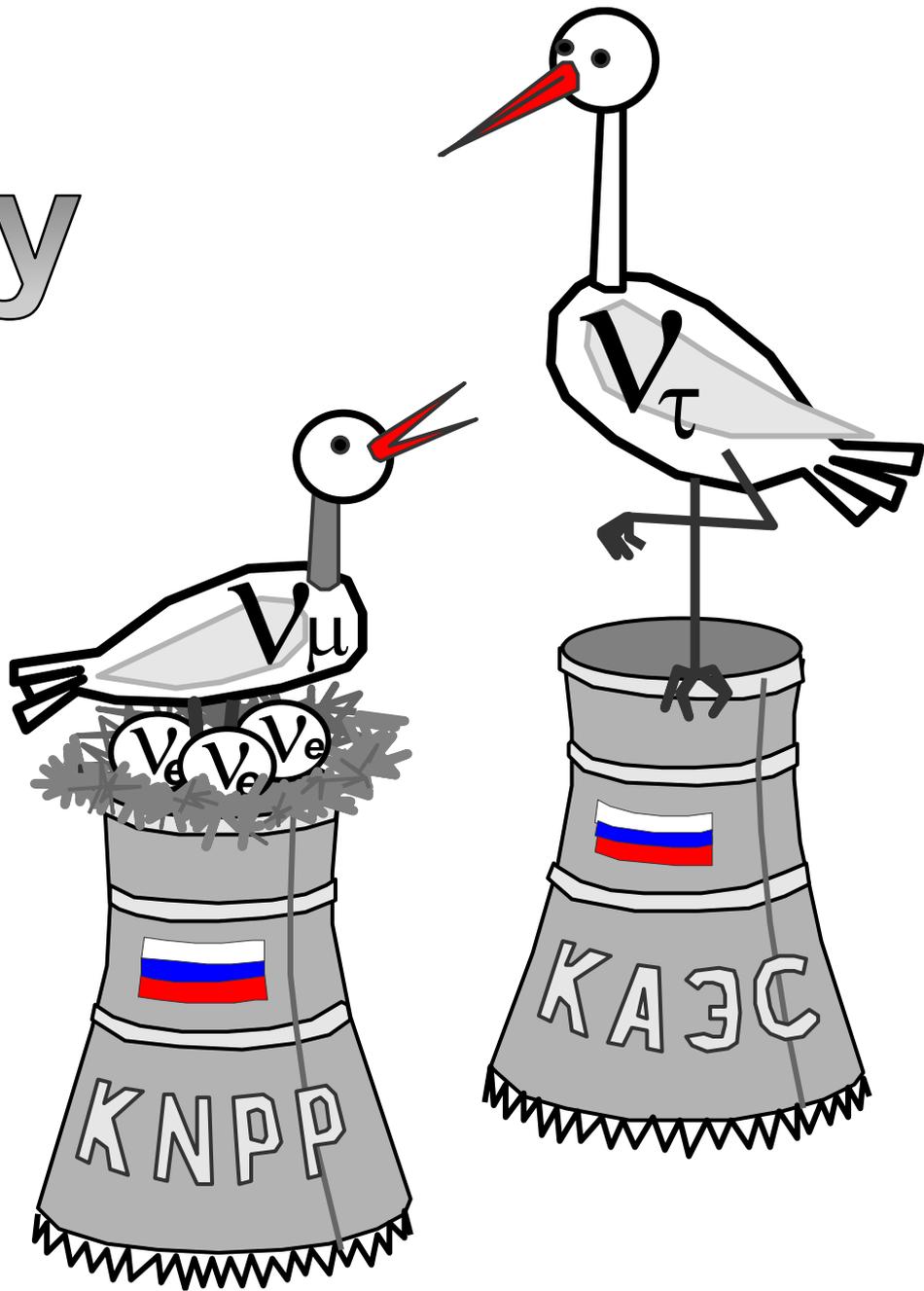


Only geometric parameters of the reactor and the detector are known

Pessimistic case

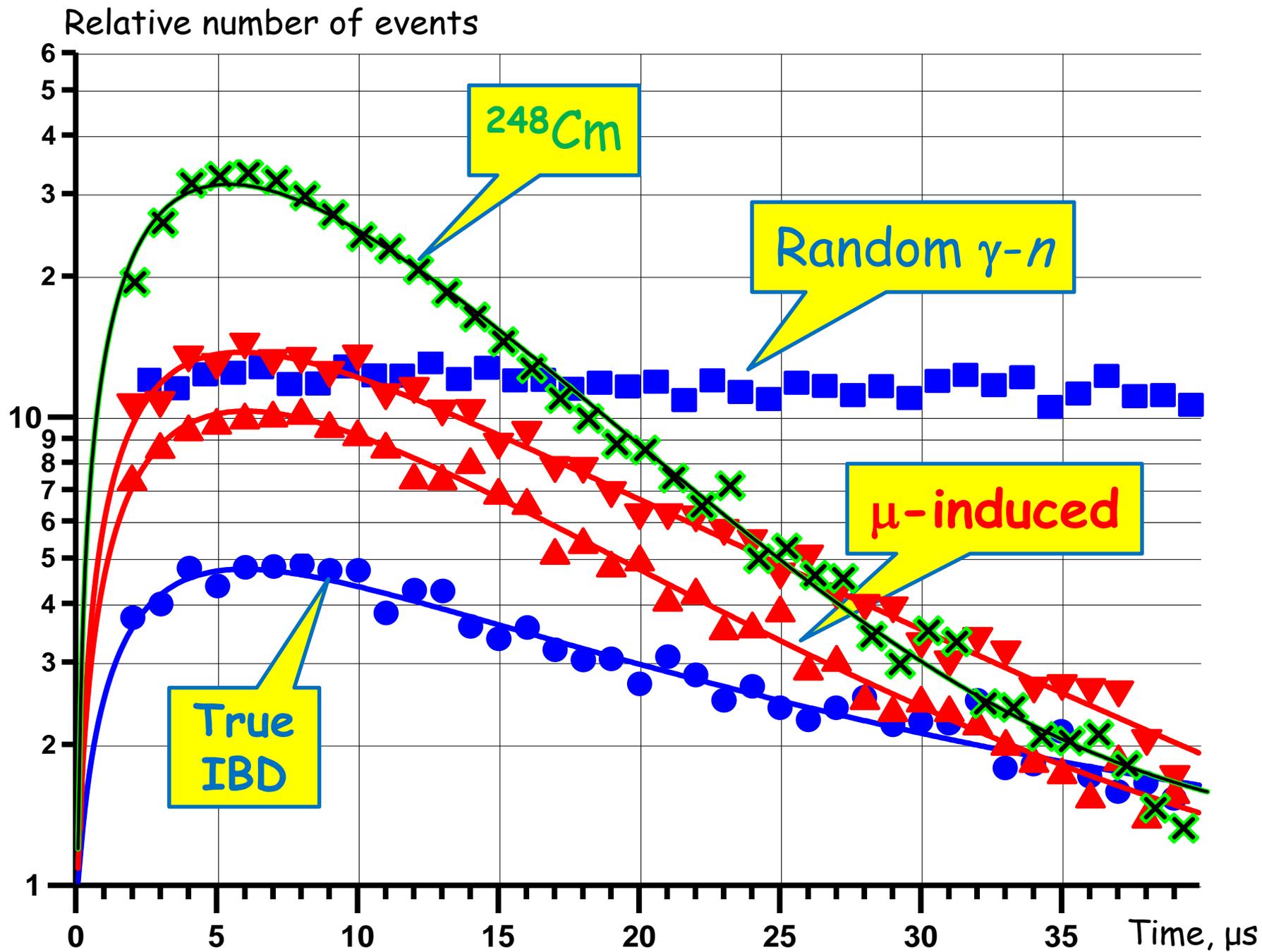
We compare (at 90%CL) evolution of each energy bin with distance (3 positions, 100 days/pos)

Happy
end



Spare slides:

Time and Energy spectra
of Neutrino-like events
detected by **DANSSino**



Rate of neutrino-like events / 0.5 MeV / day
(Differential spectrum = ON - OFF)

