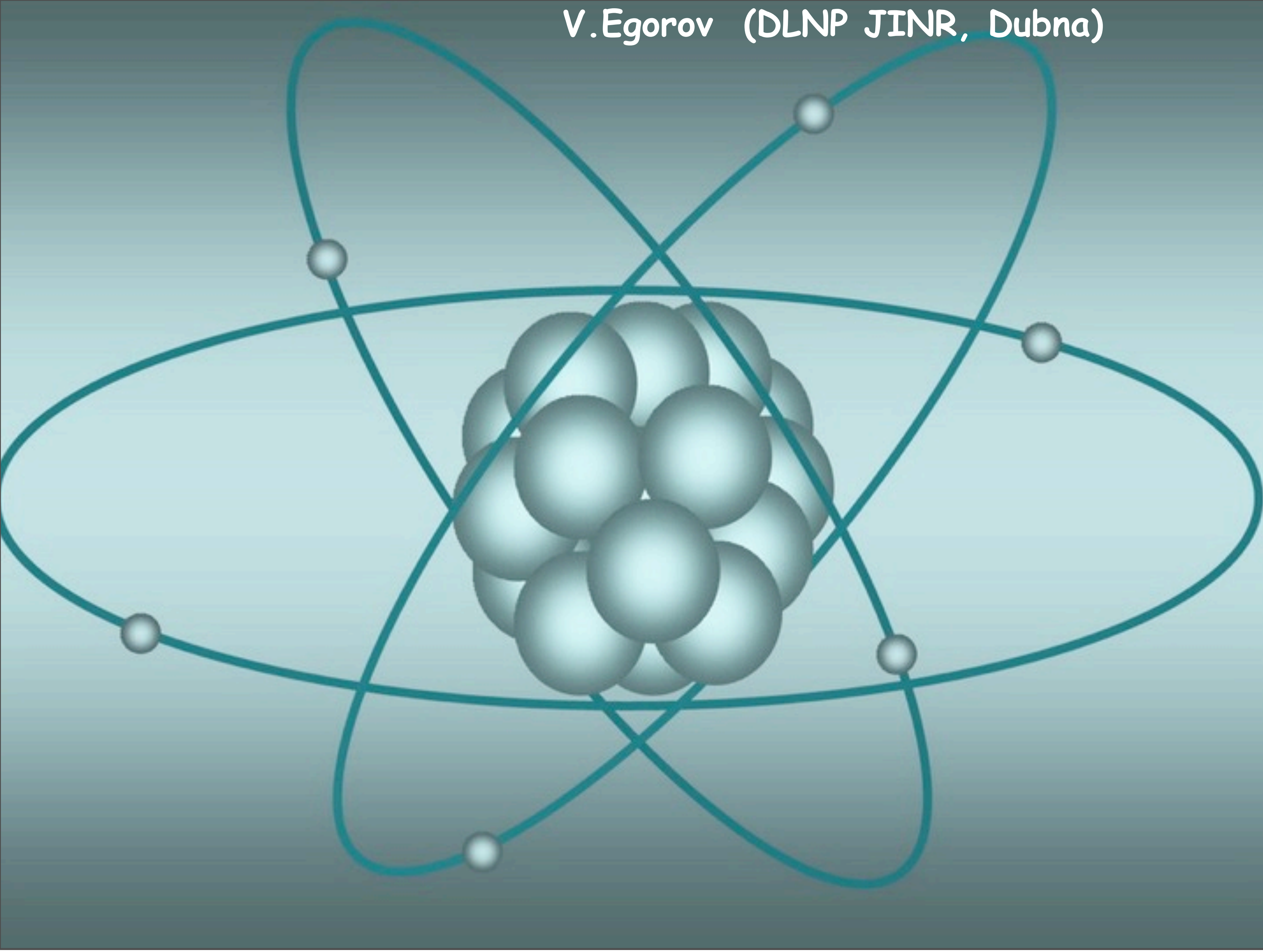
V.Egorov (DLNP JINR, Dubna)



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DANSS - detector of the reactor antineutrino

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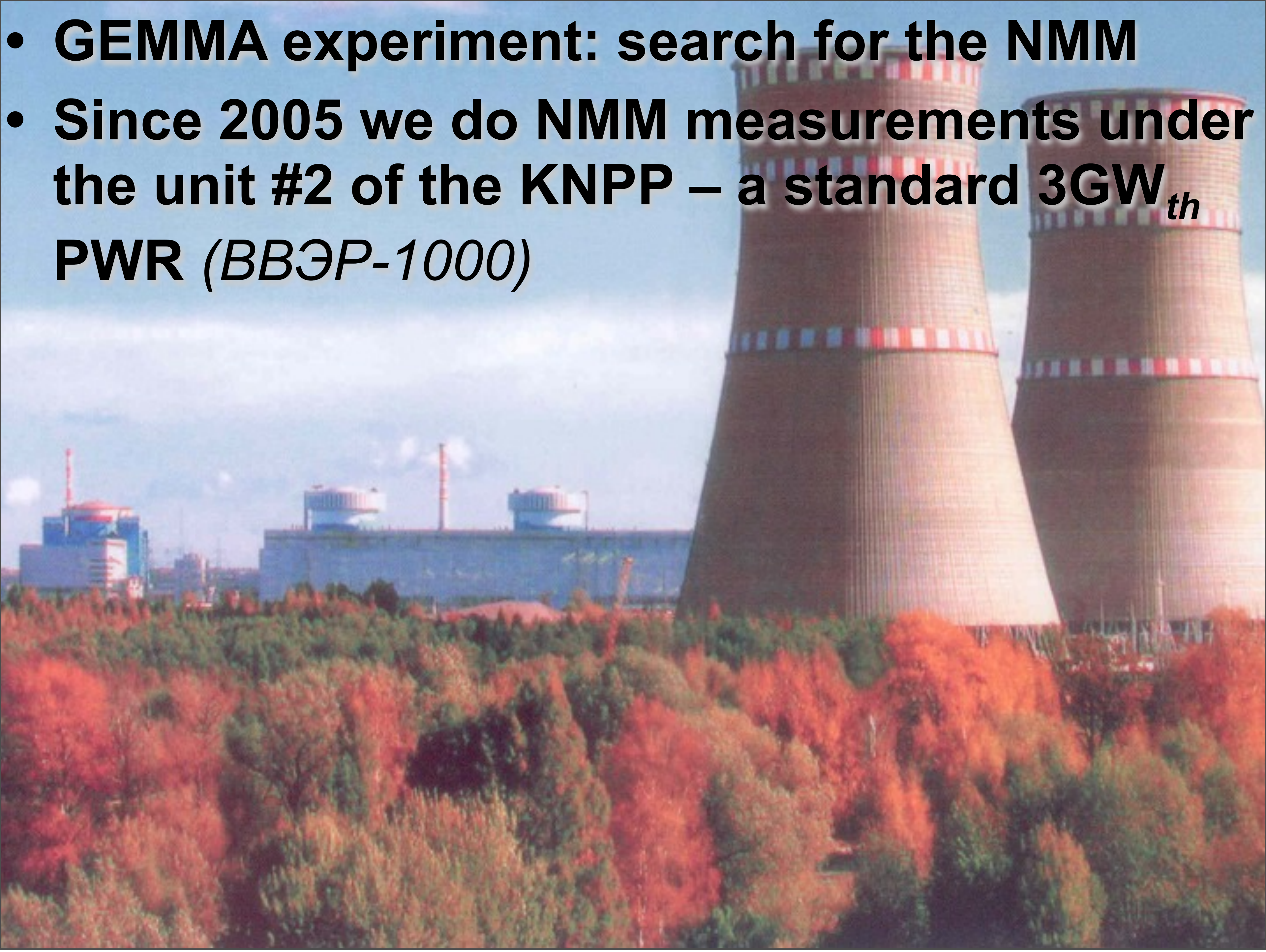

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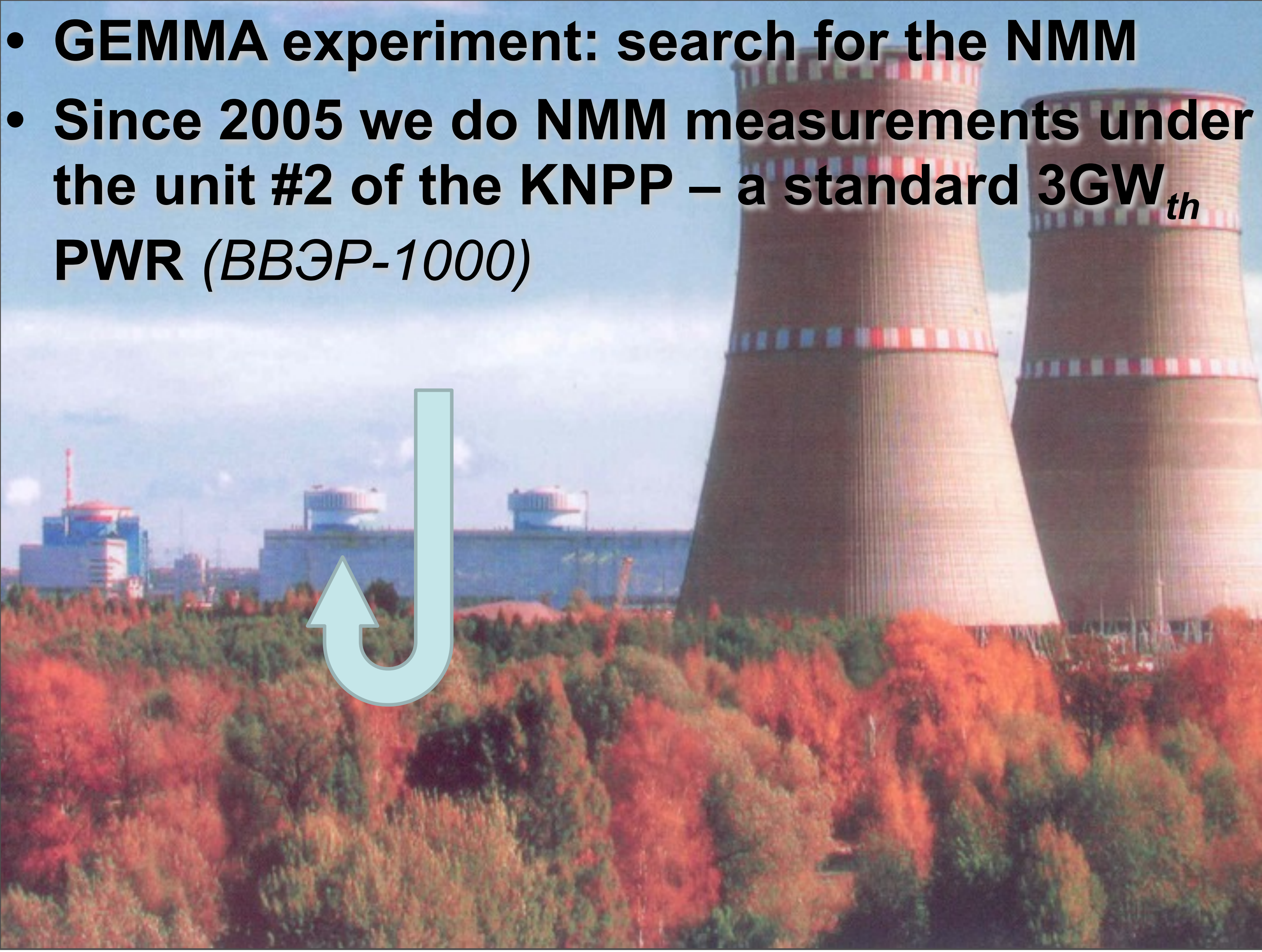

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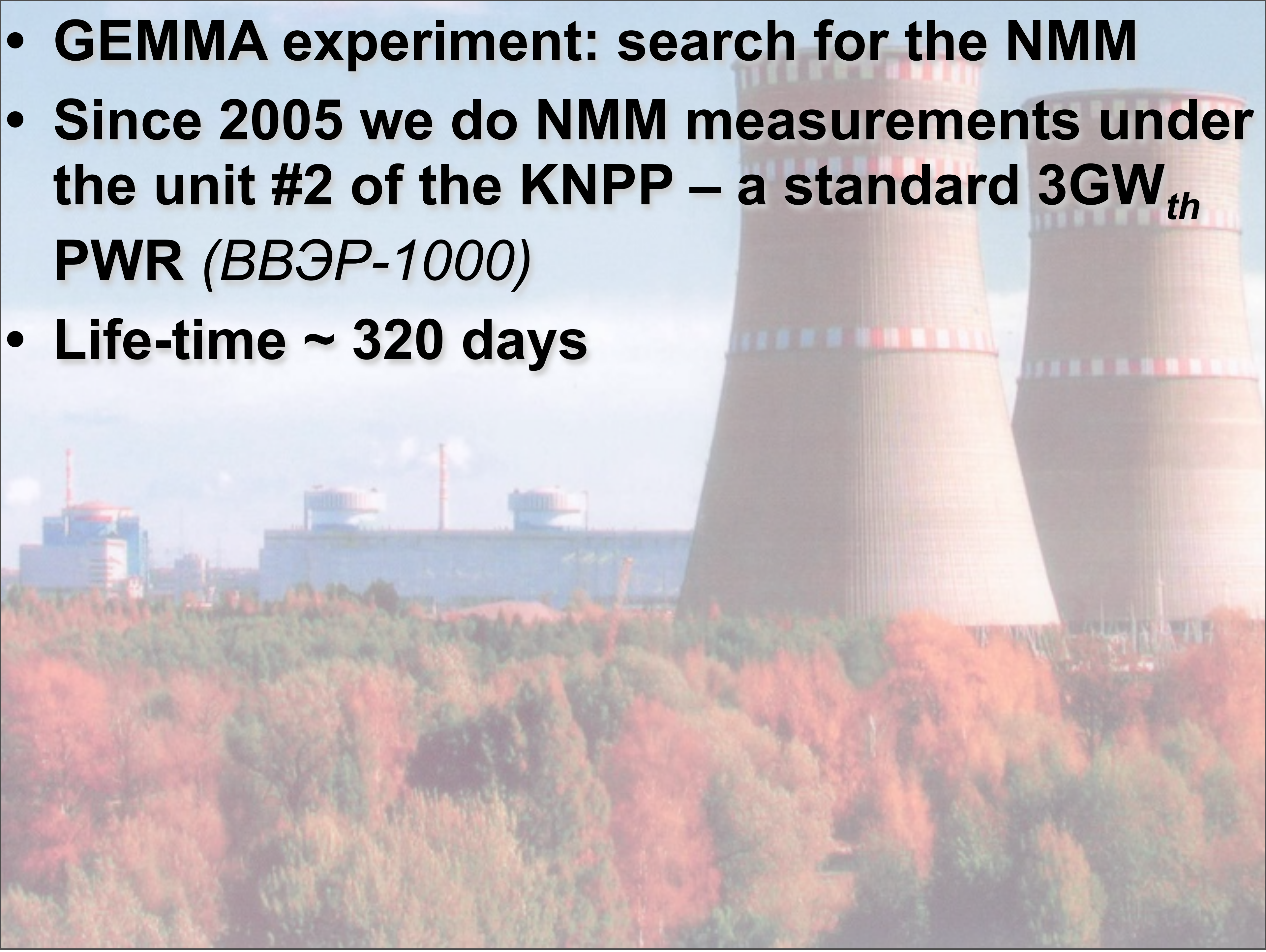

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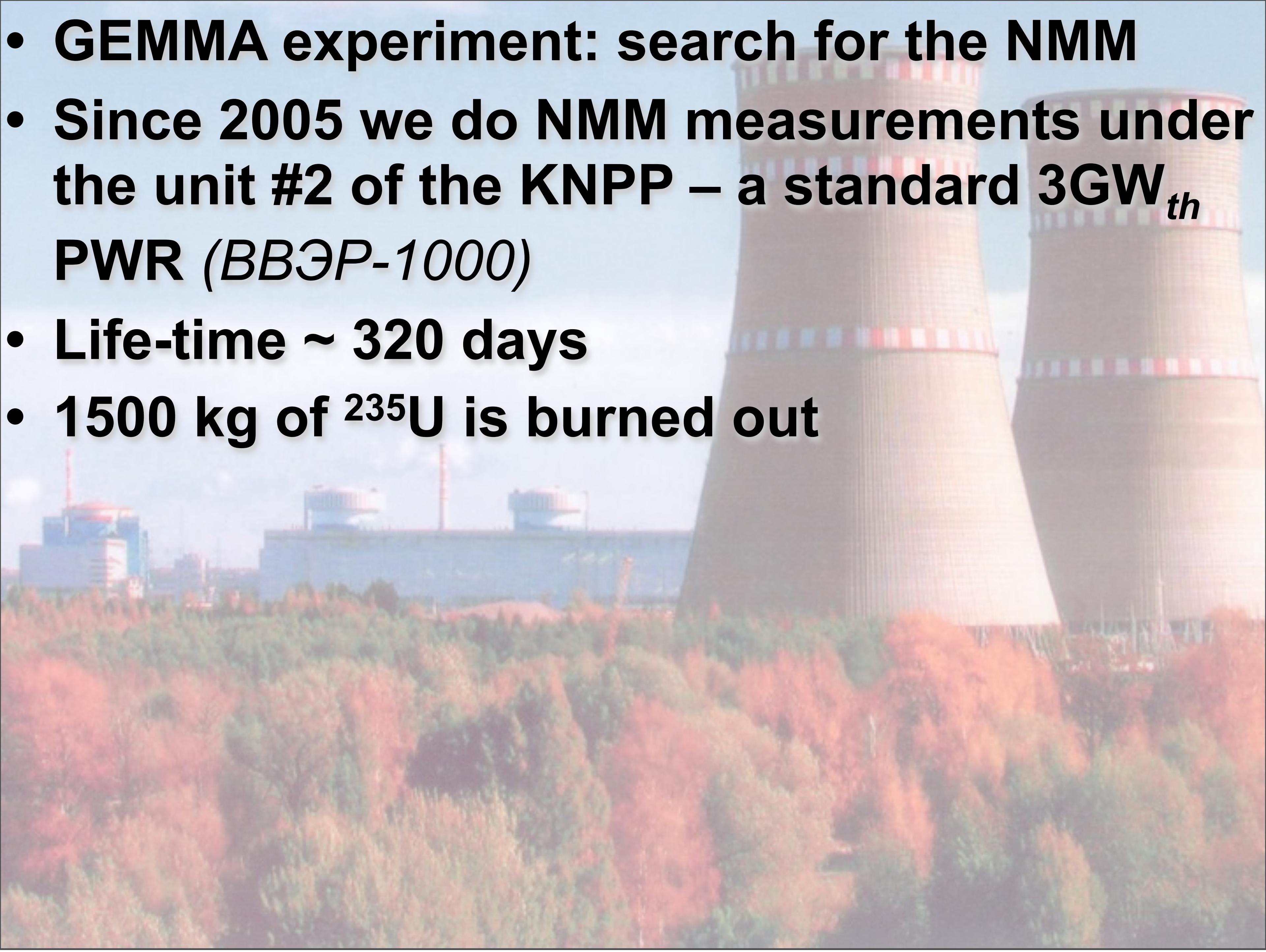

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- **Would like to monitor the neutrino spectrum and flux ($2.7 \cdot 10^{13}$ $\nu/cm^2/s$)**

For the monitoring we needed anything **simple** and **reliable**

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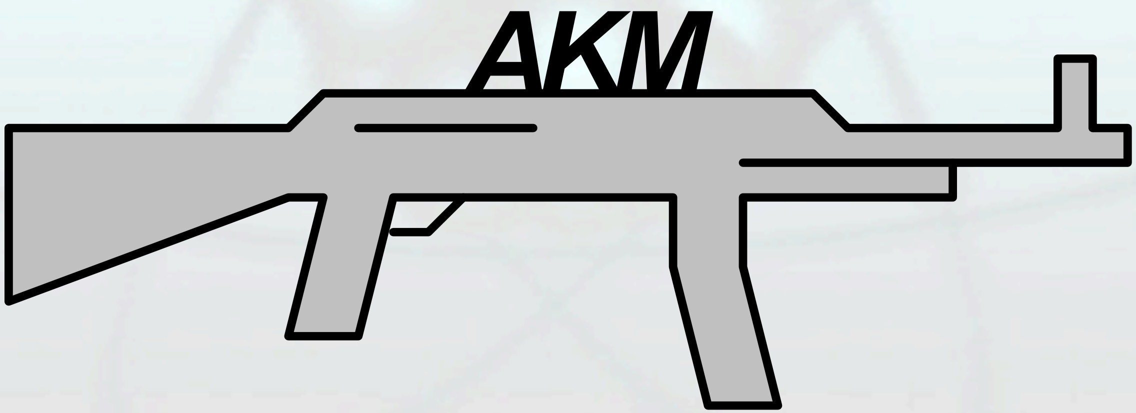
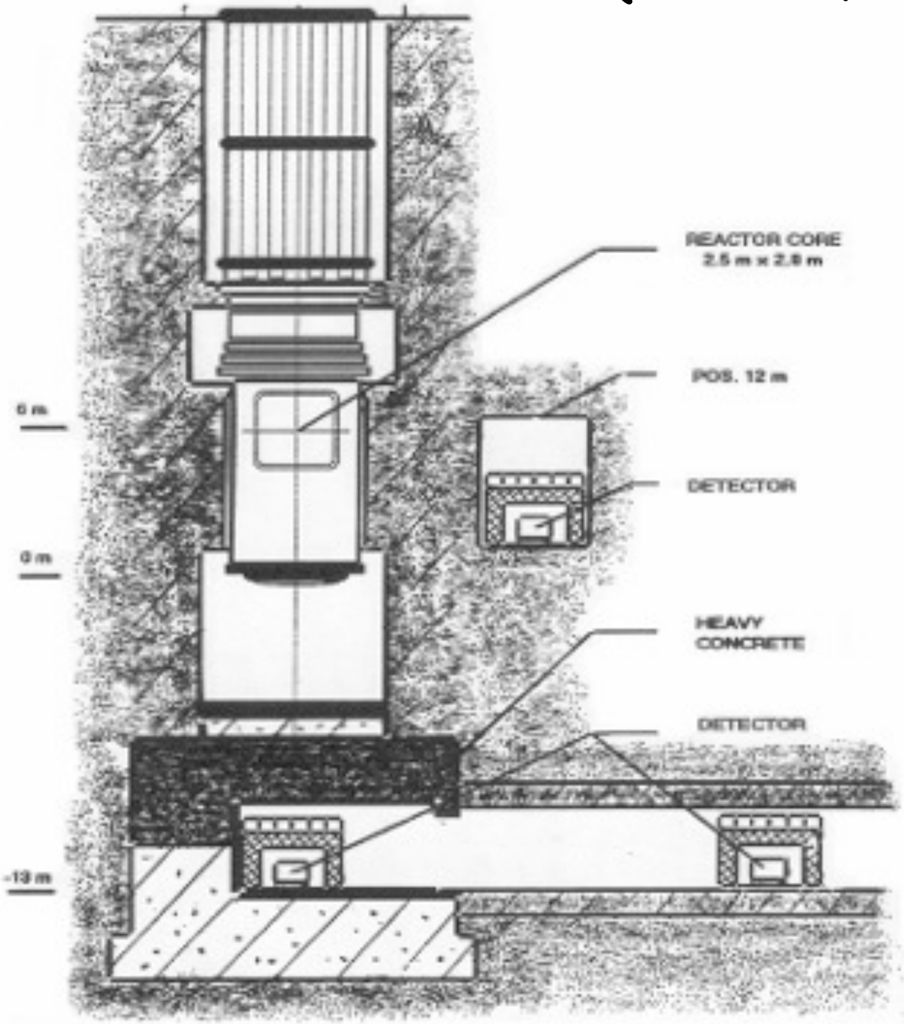
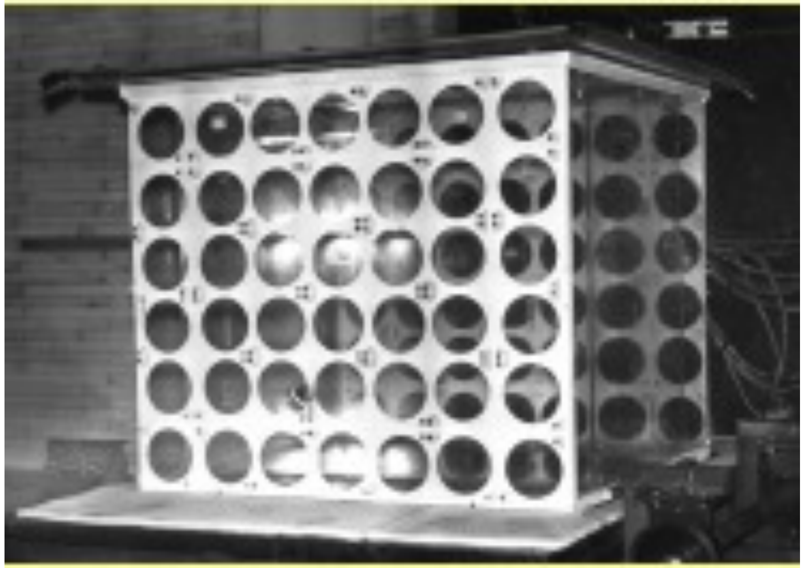
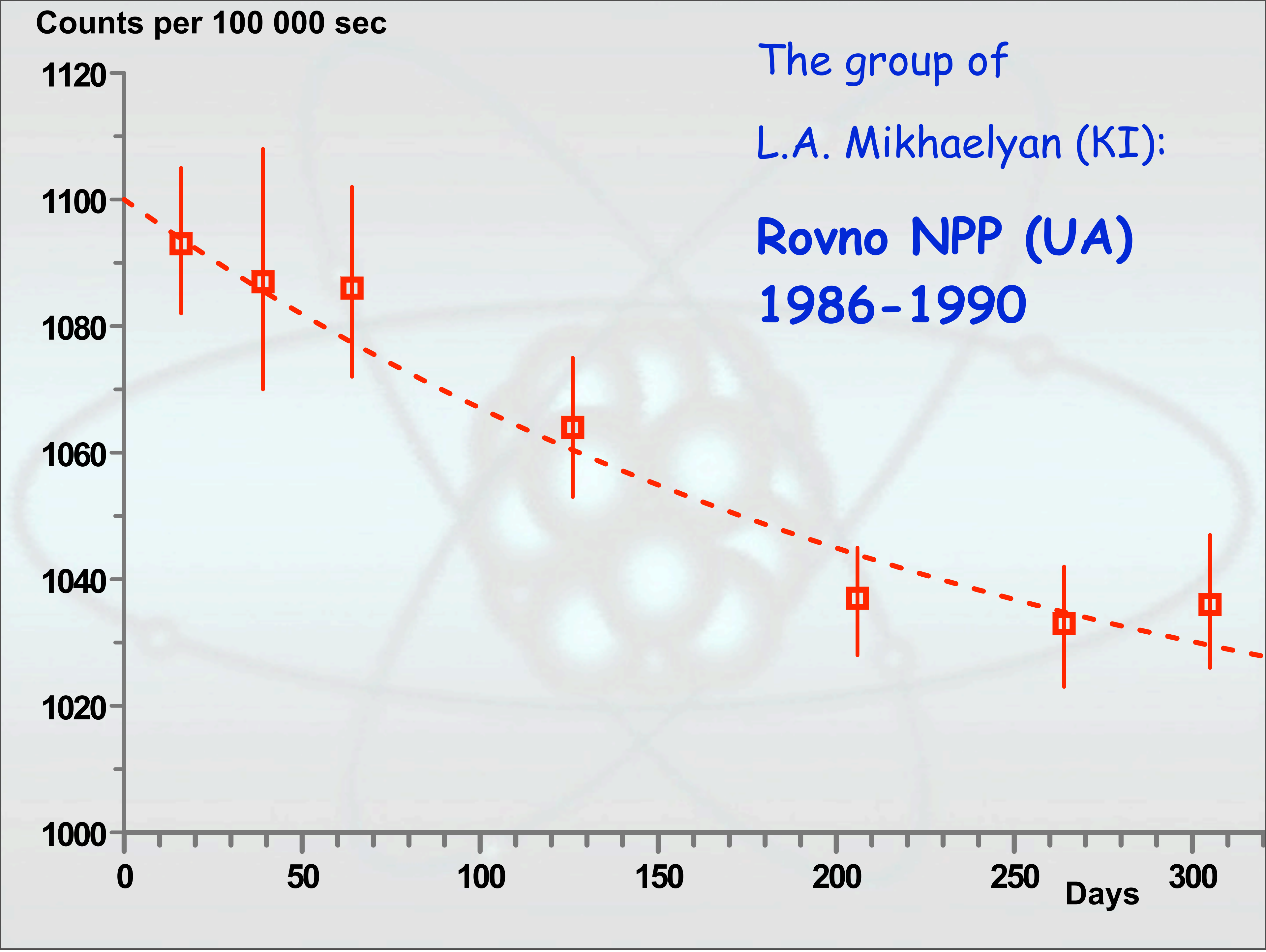


20 years ago our colleagues from KI were the first who tried to perform the neutrino monitoring RONS (Rovno, UA) 1986-1990





Liquid scintillator (~1 m^3) in a special laboratory


Counts per 100 000 sec
1120
1100
1080
1060
1040
1020
1000
0
50
100
150
200
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Days
The group of
L.A. Mikhaelyan (KI):
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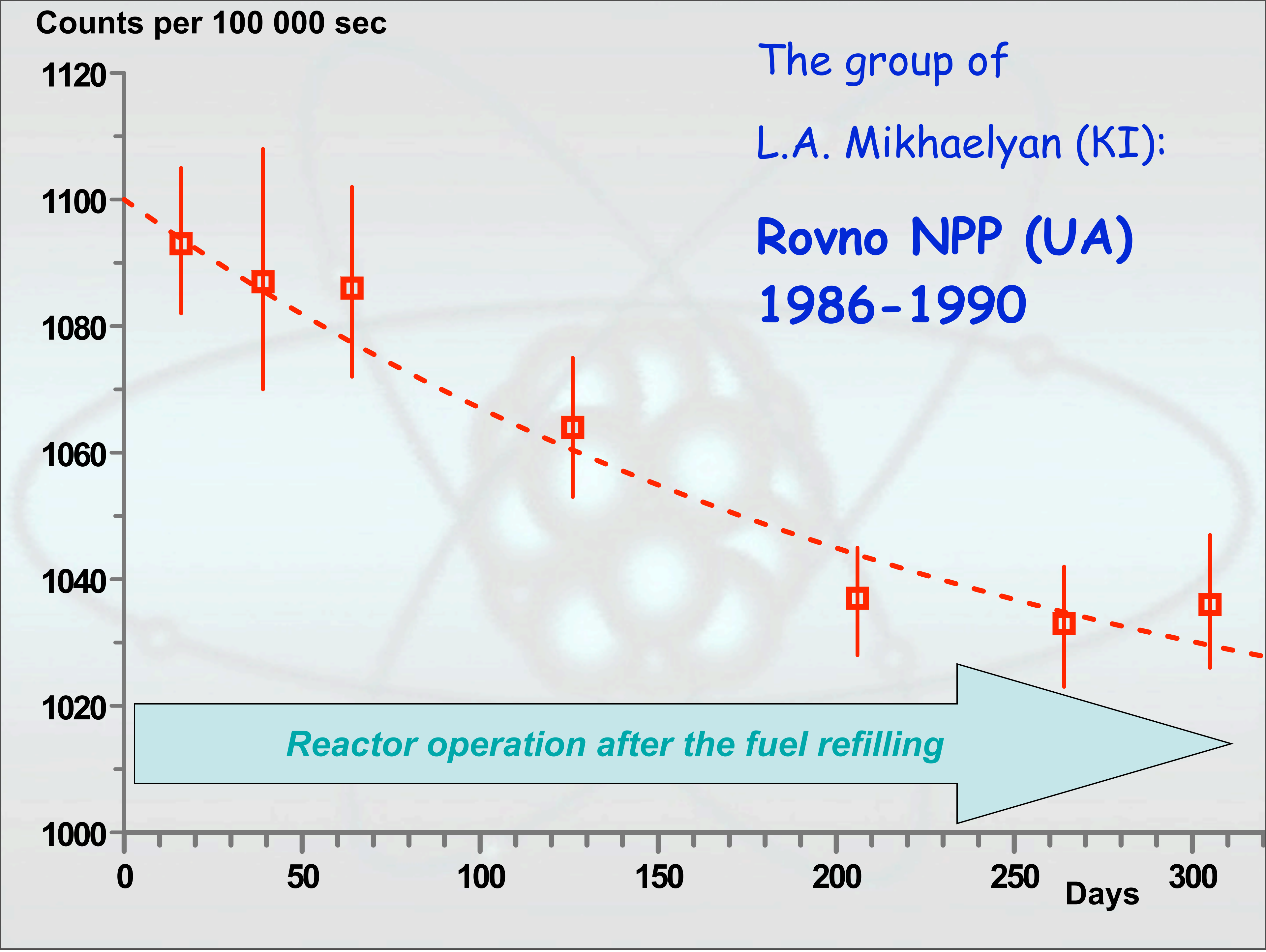

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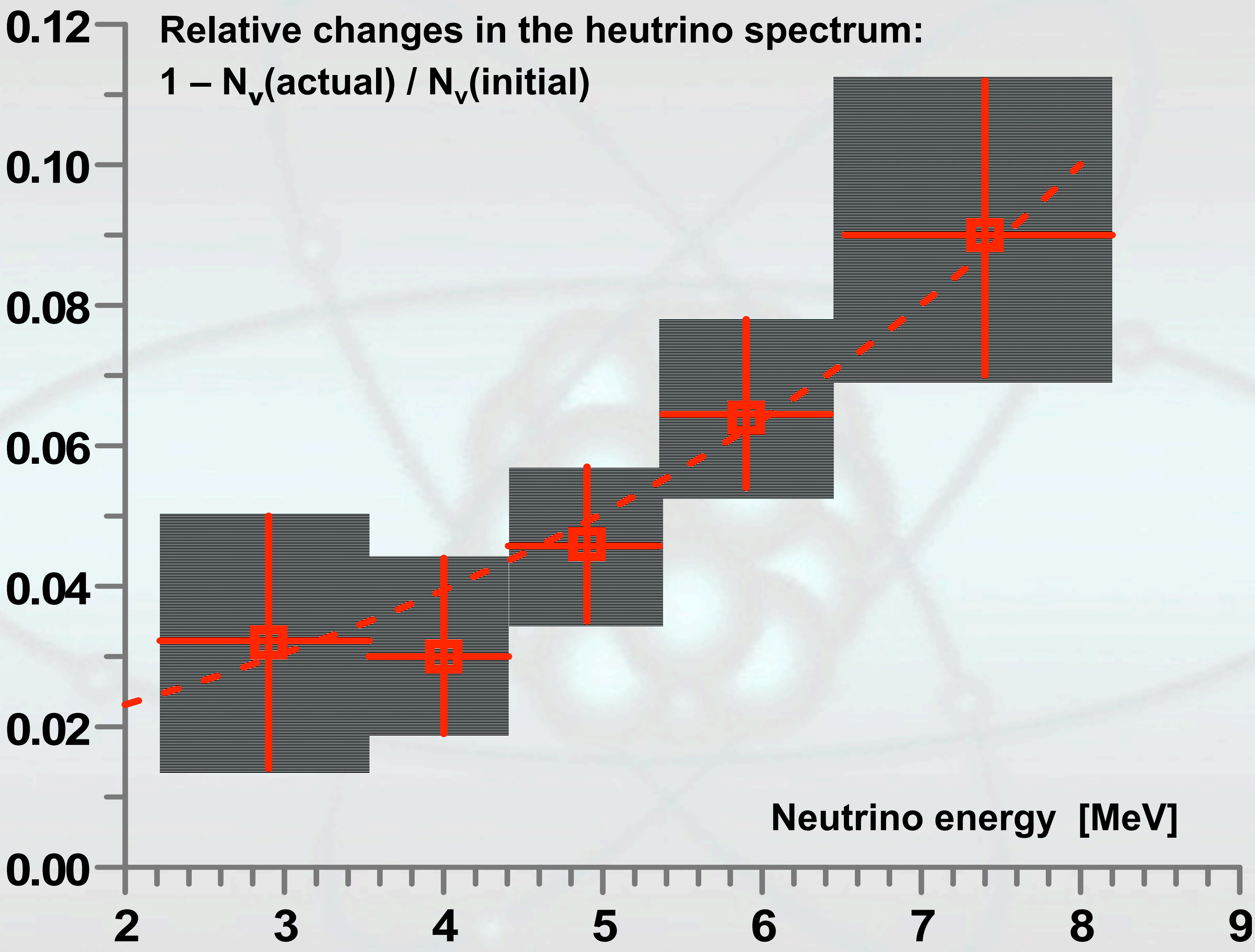
Reactor operation after the fuel refilling



Relative changes in the heutrino spectrum:
1 – N_v(actual) / N_v(initial)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Neutrino energy [MeV]
2
3
4
5
6
7
8
9

We want

such

We want such

«We» - means JINR (Dubna)

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+

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ITEP (Moscow)

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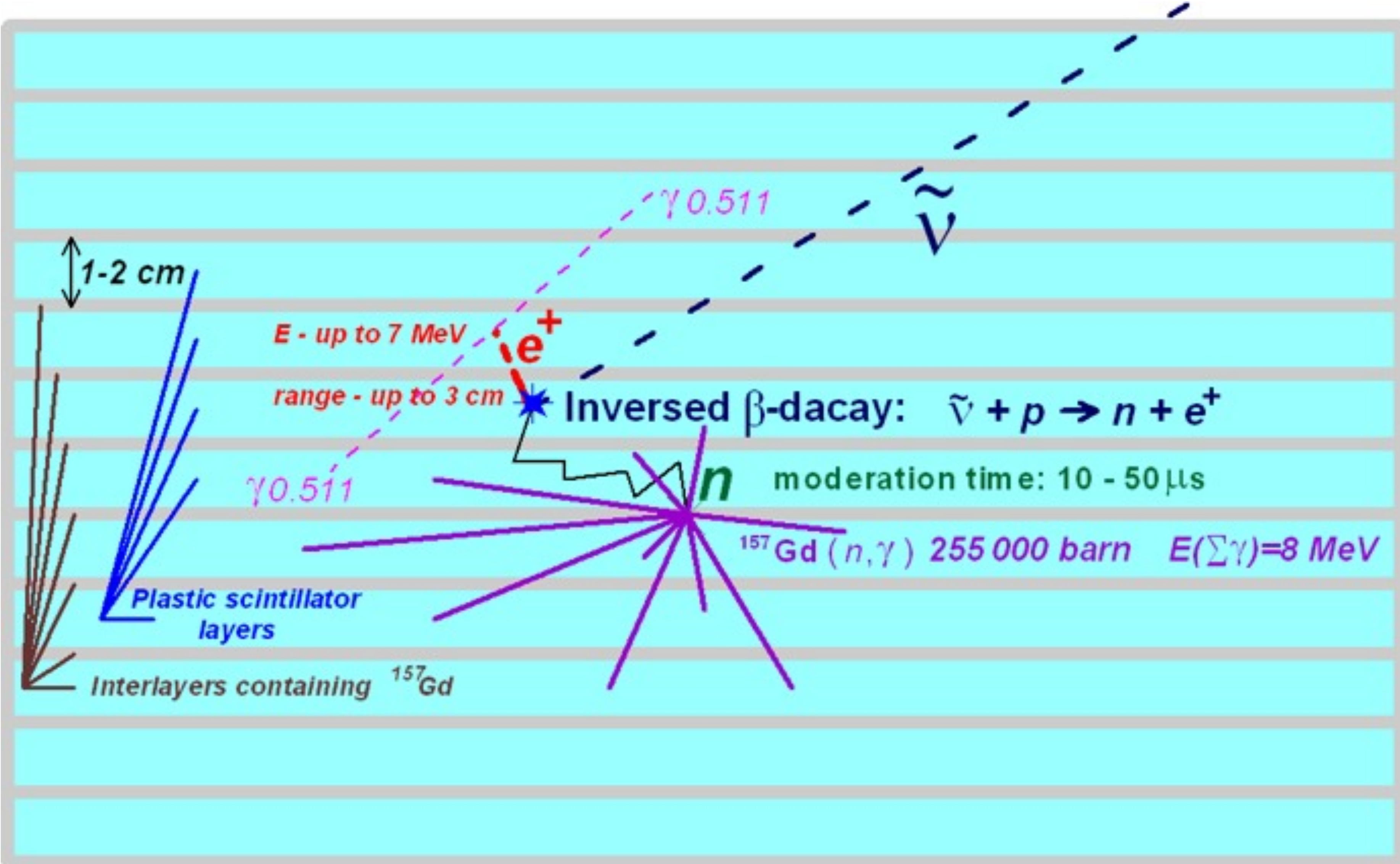
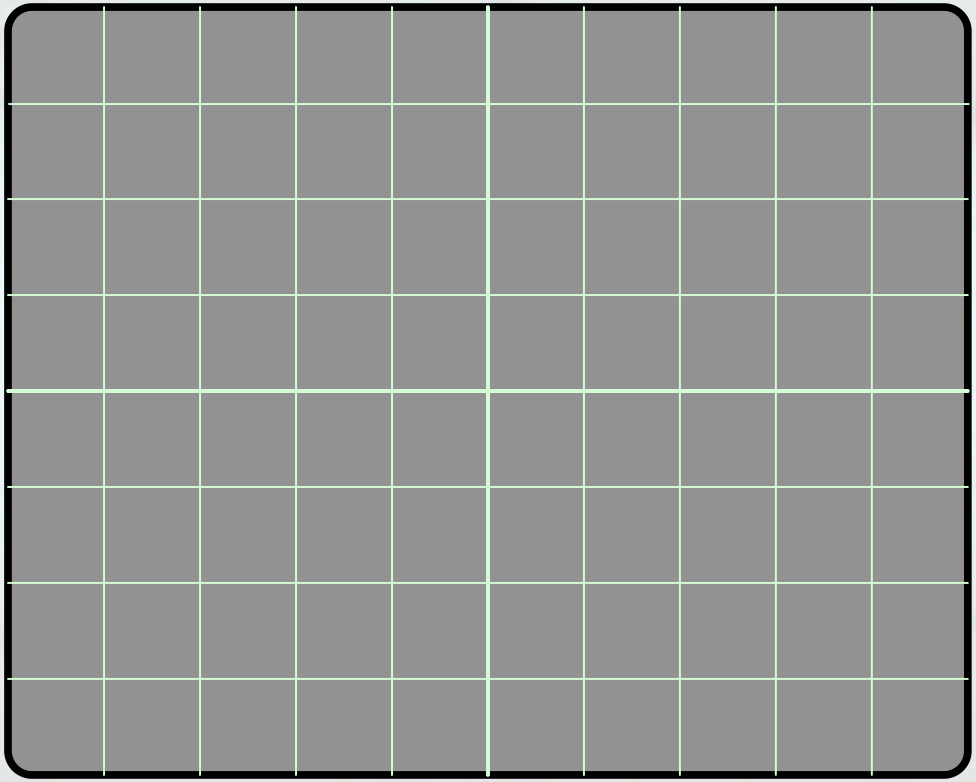
- ☺ How much better is plastic

Detection idea: Inversed Beta-Decay



Signature of the IBD registration



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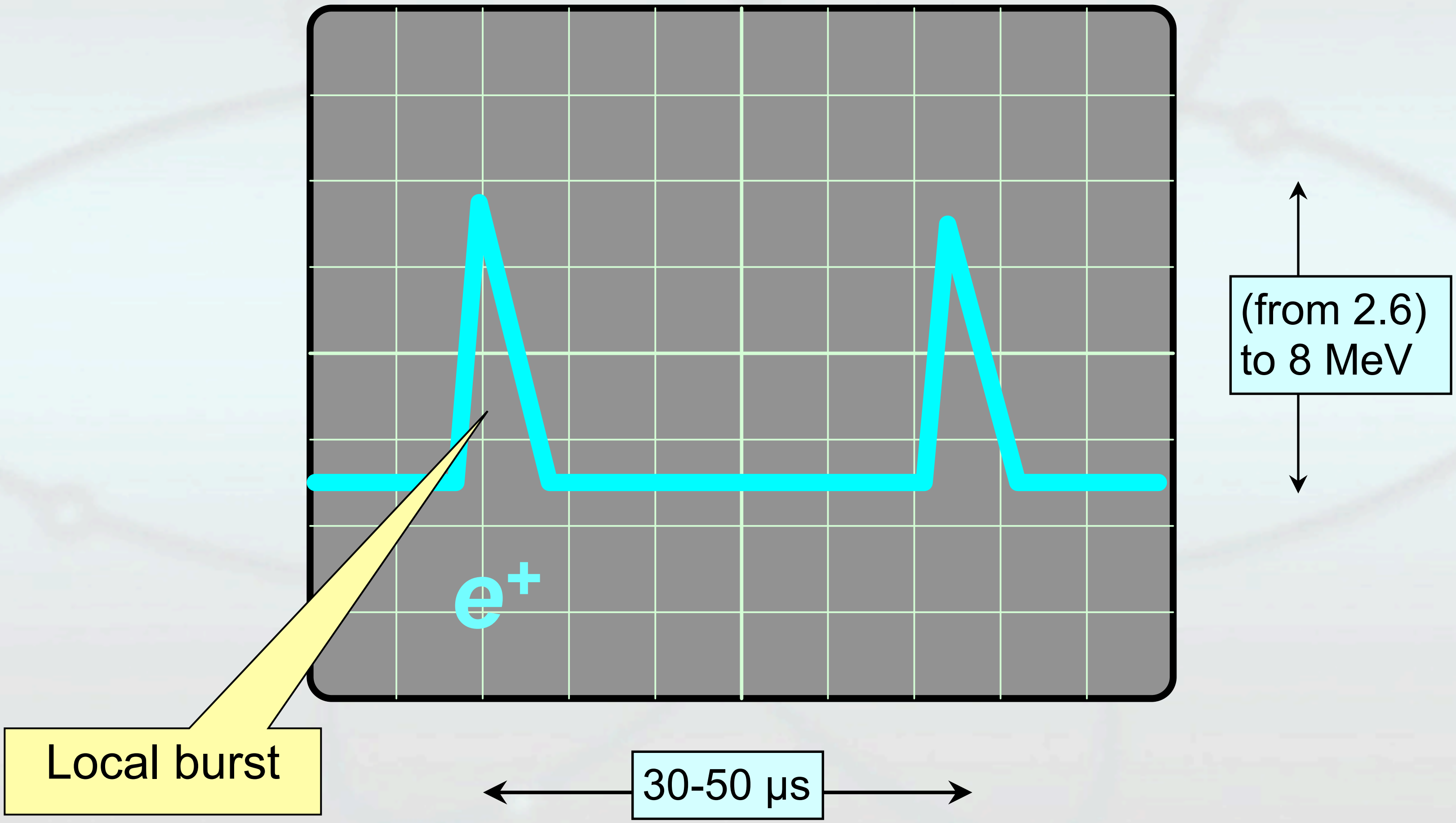

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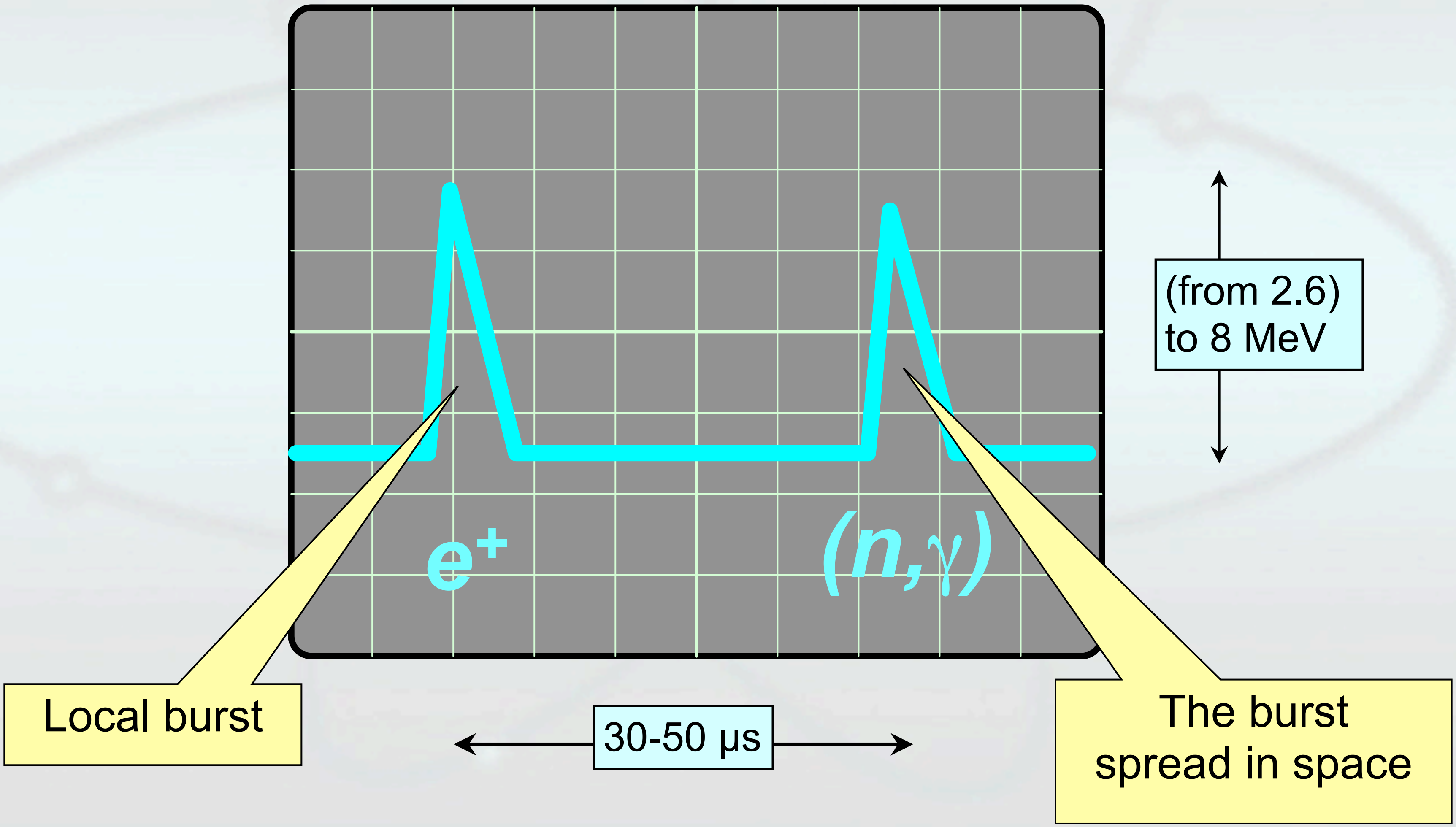

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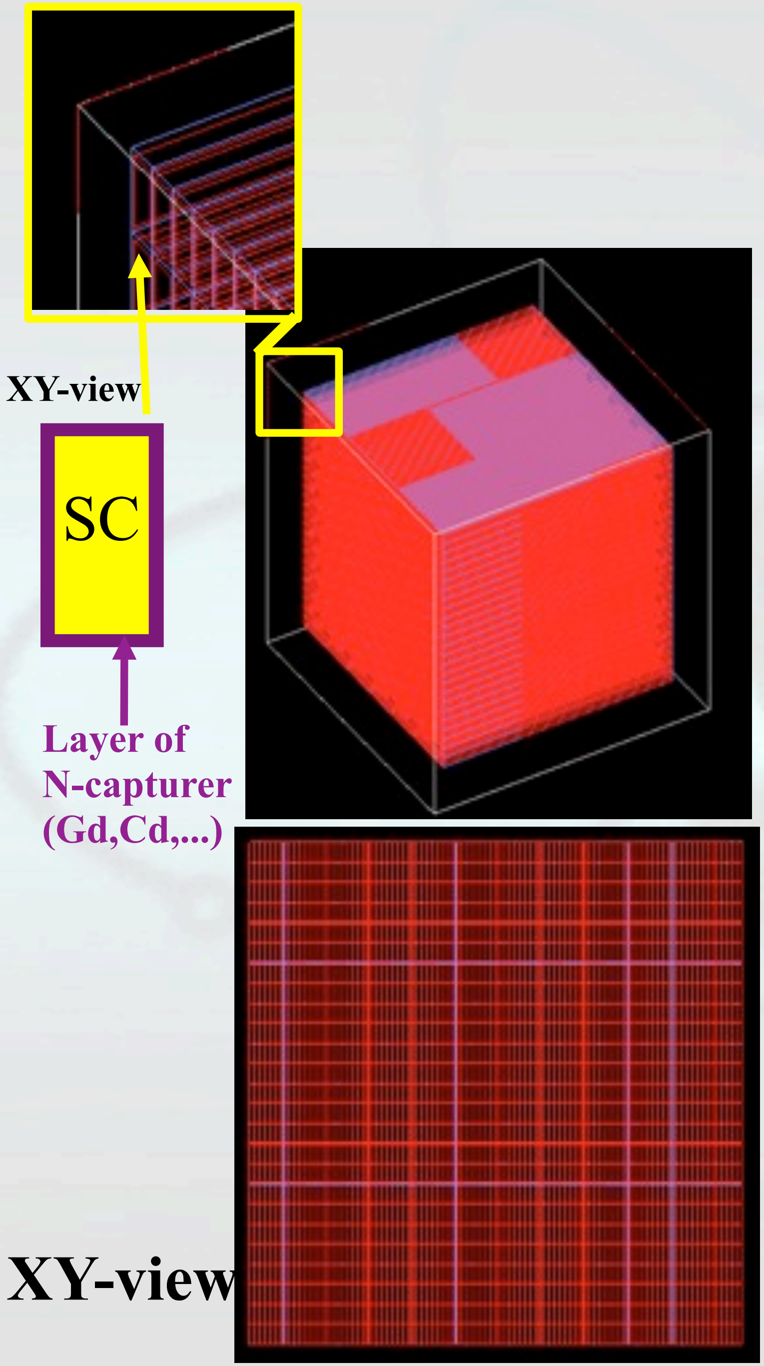
- Weak (ν-e) cross-section
- On-line reactor monitoring (tomography?) - especially important in view of the future FBR (with



geometry of neutrino detector

SCINTILLATOR BLOCKS
in X axis
bottom-scinblock.number-of-columns=100
in Y axis
bottom-scinblock.number-of-rows=25
in X axis
bottom-scinblock.width=1 cm
in Y axis
bottom-scinblock.length=4 cm
in Z axis
bottom-scinblock.thickness=1 m
material of capturer layer on the scintillator surface
available materials: Gadolimium Cadmium
bottom-scinblock.n-capt.material=Cadmium
thickness of capturer layer on the X surface
bottom-scinblock.n-capt.x-thickness = 150 micrometer
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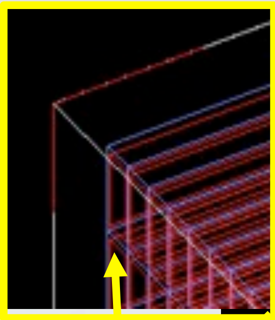
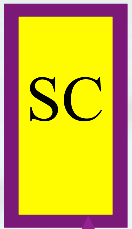
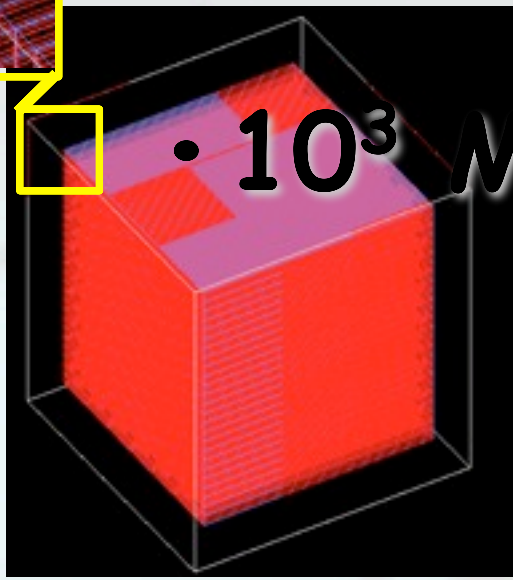


XY-view



Layer of N-capturer (Gd,Cd,...)



• 10^3 MC-simulations

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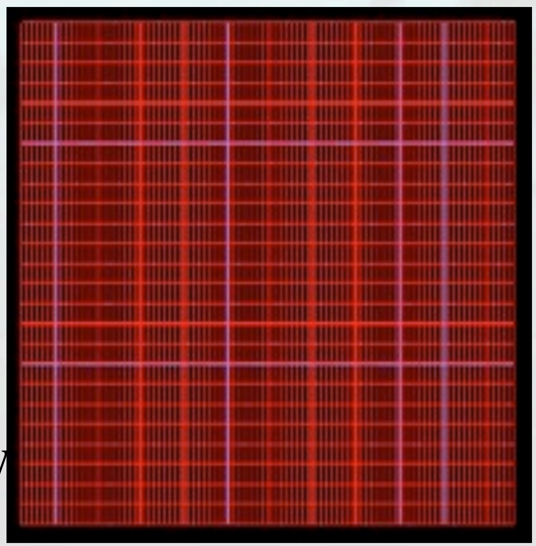

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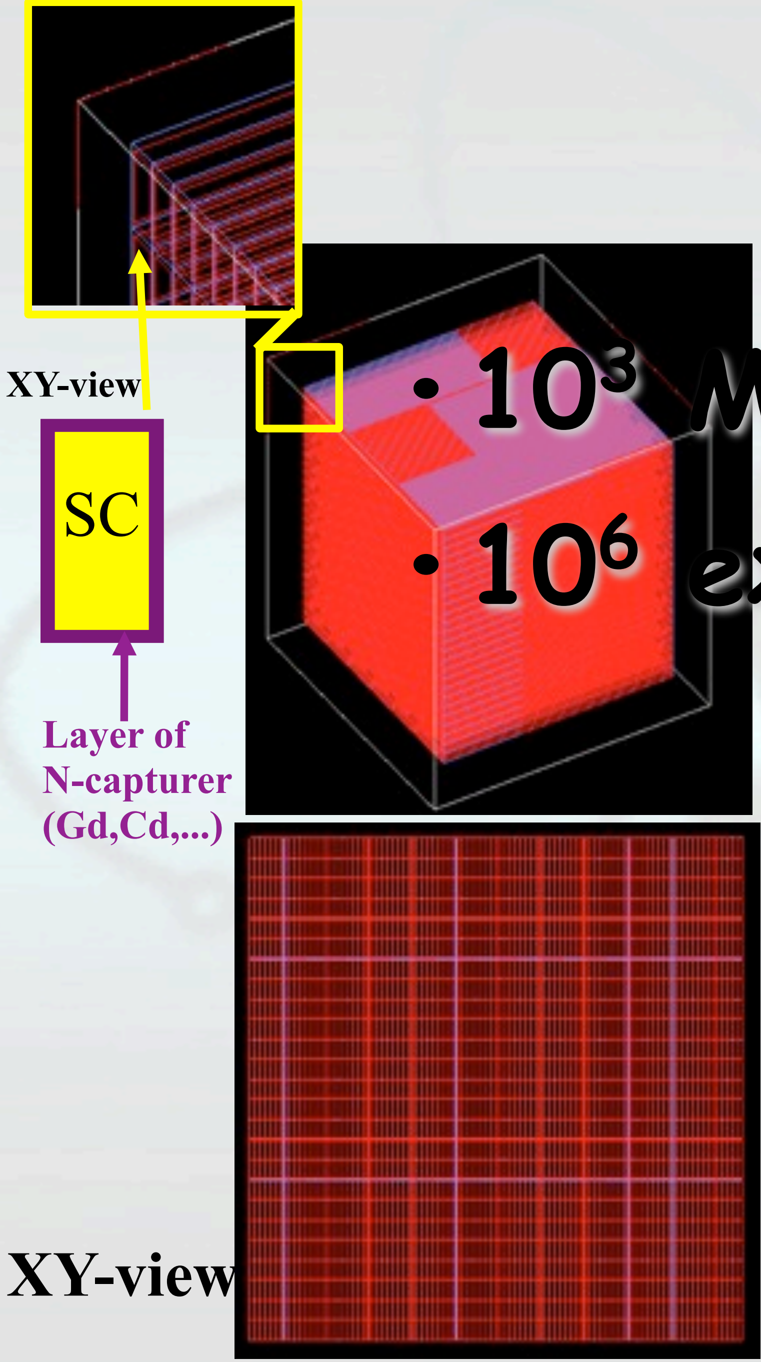

- 10^3 MC-simulations
- 10^6 experimental tests

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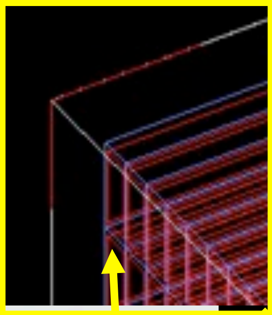

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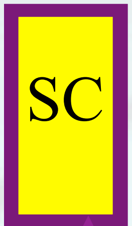

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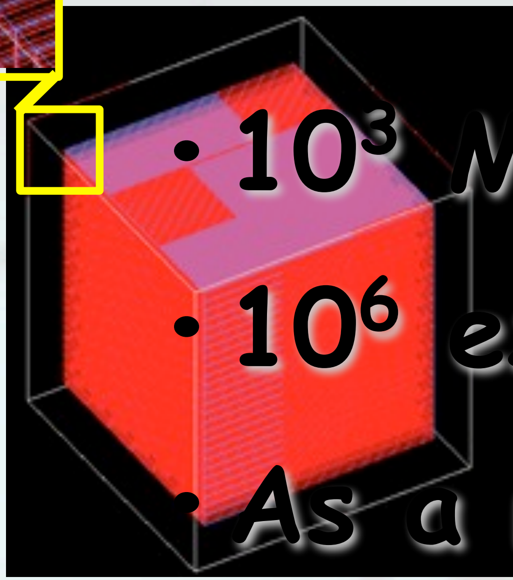

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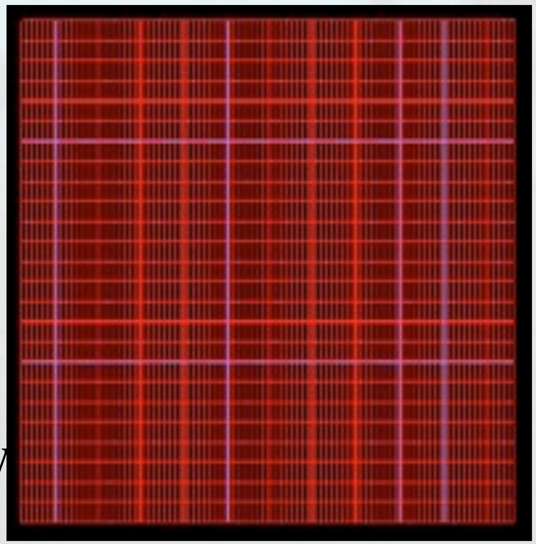

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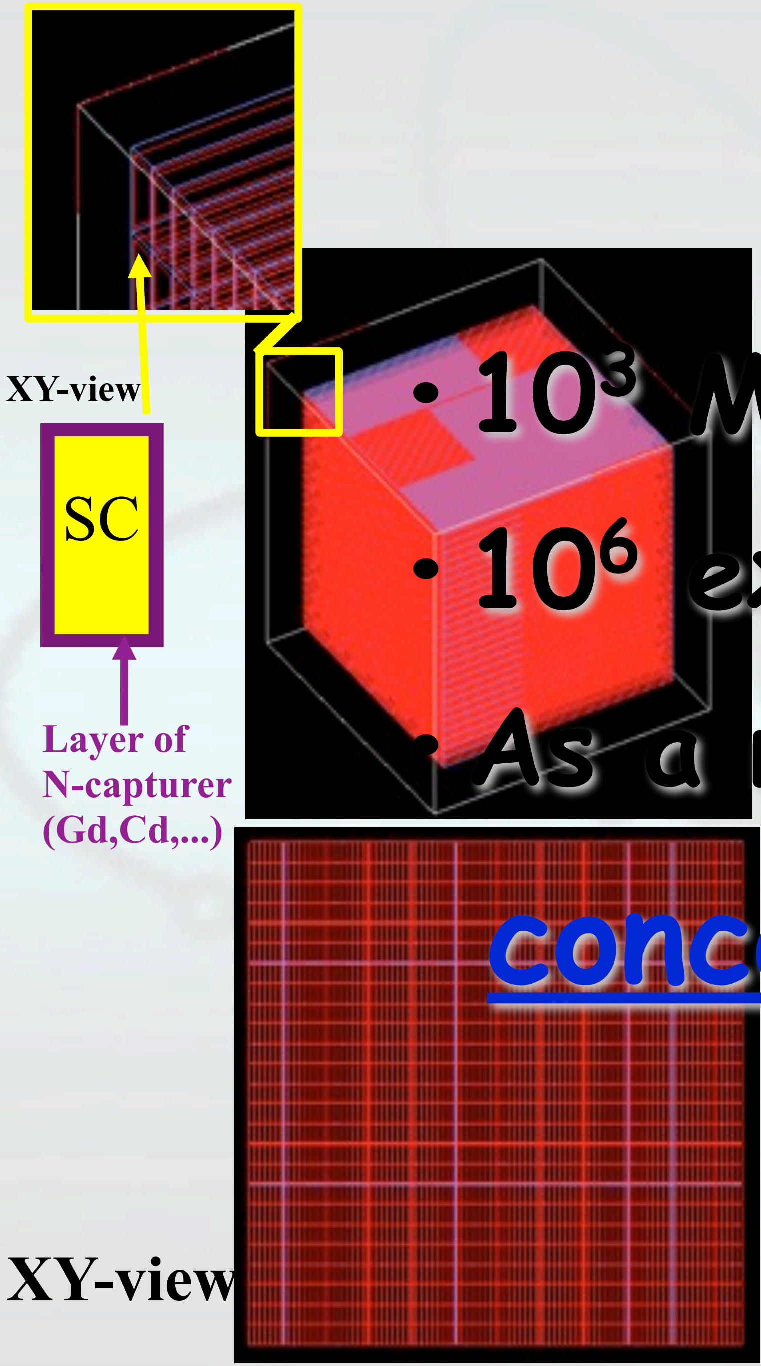

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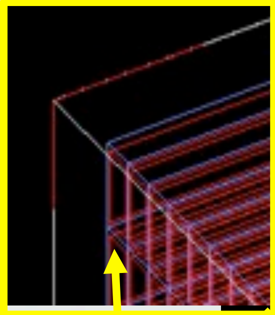

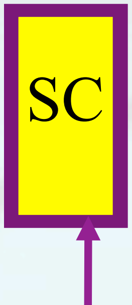

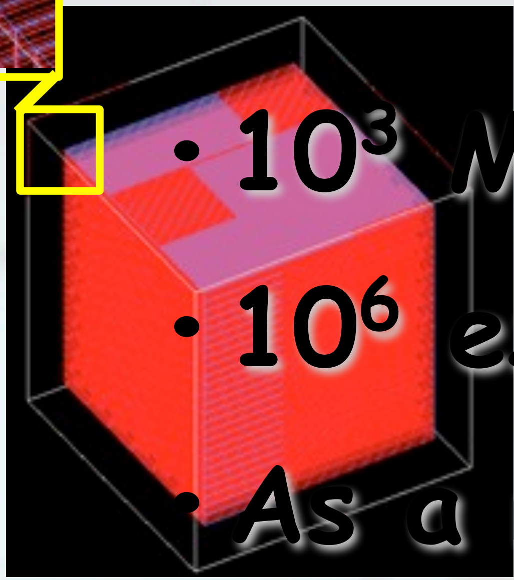

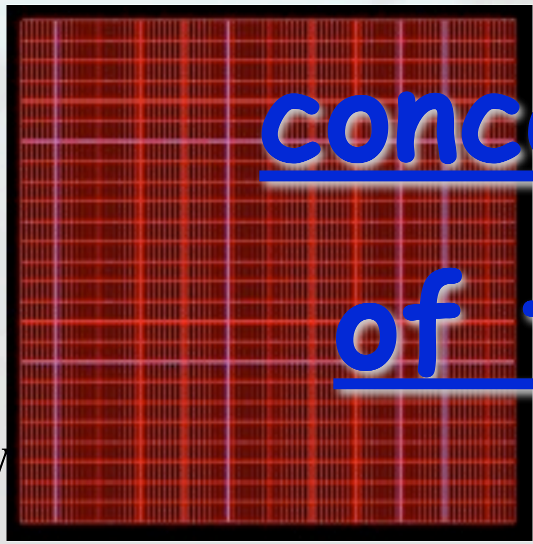

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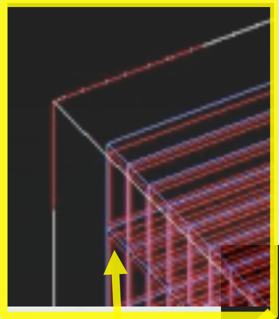
conception of the spectrometer



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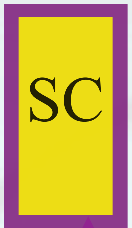

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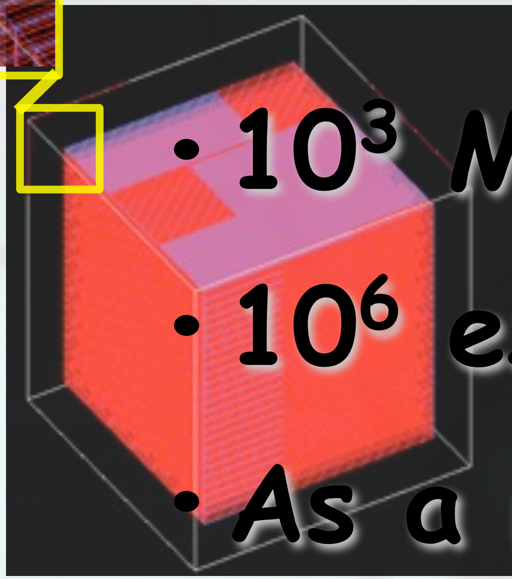

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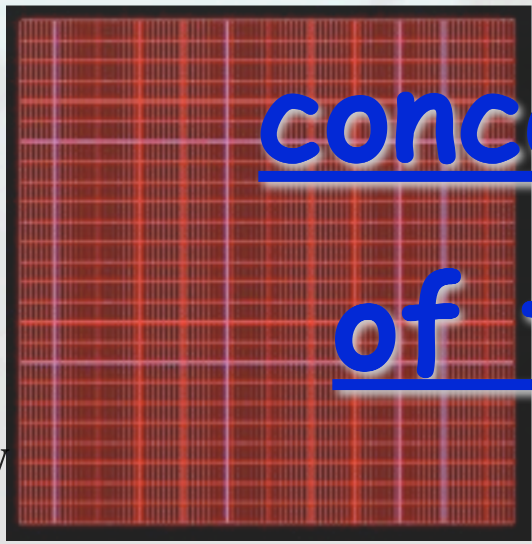

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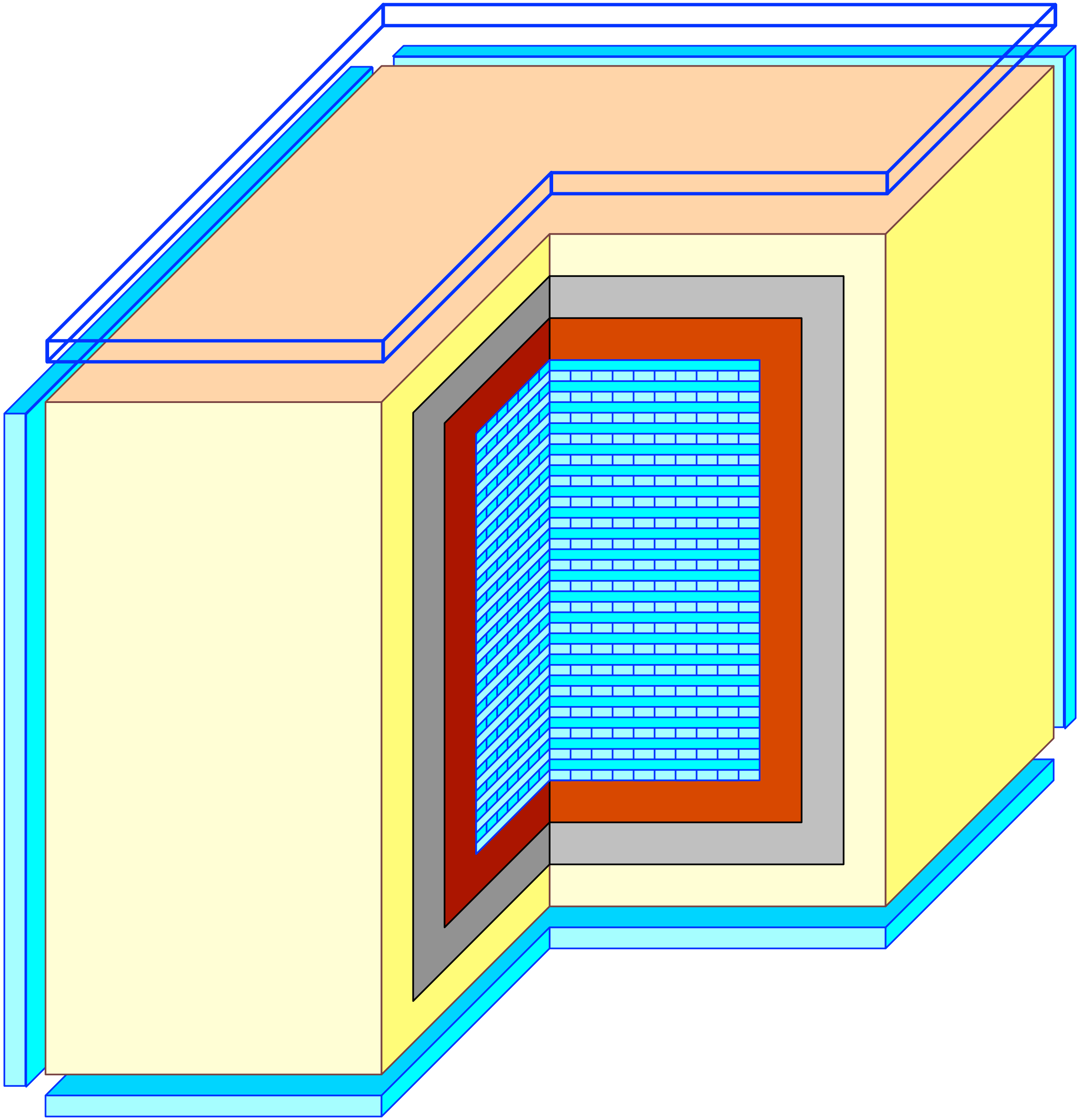
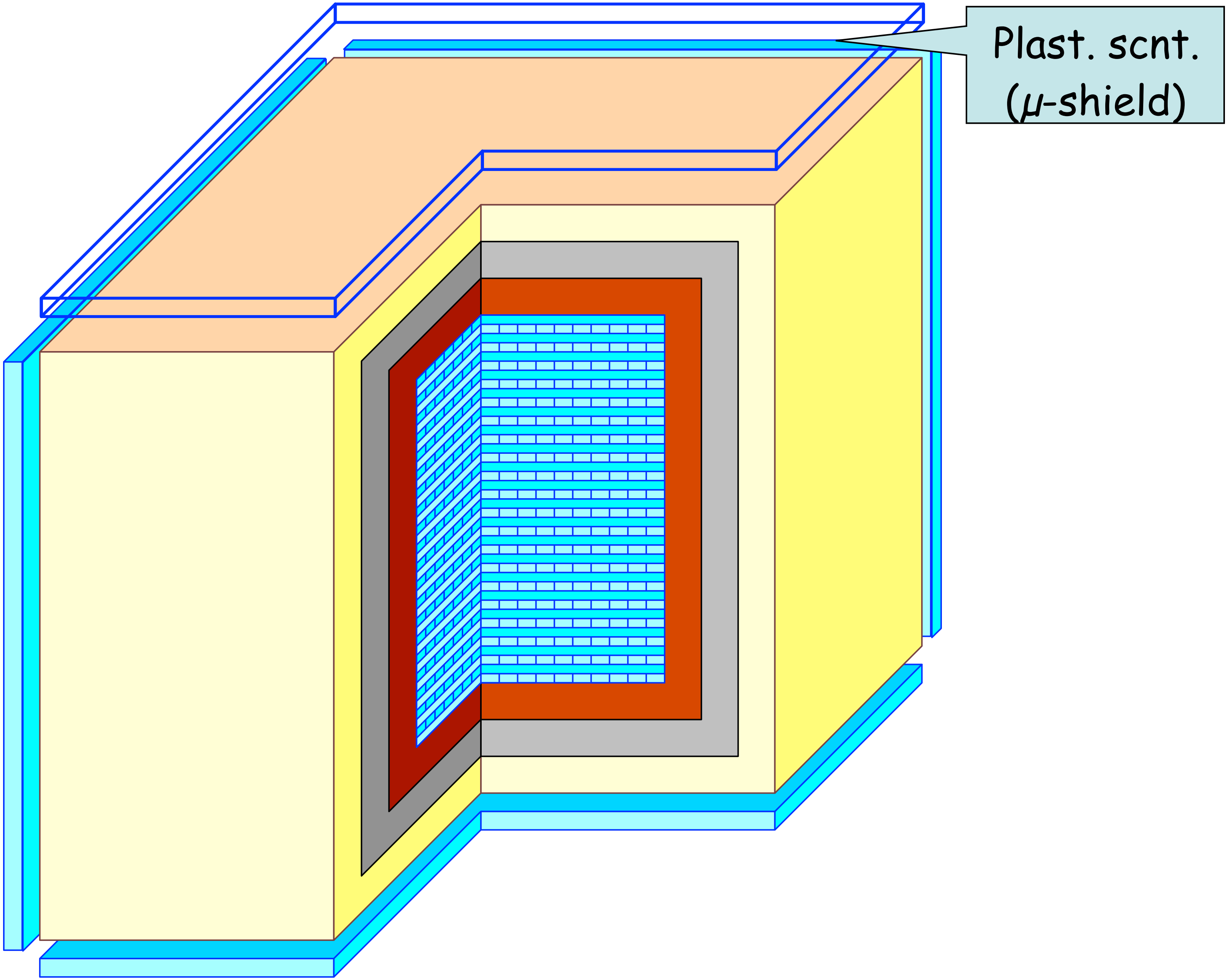
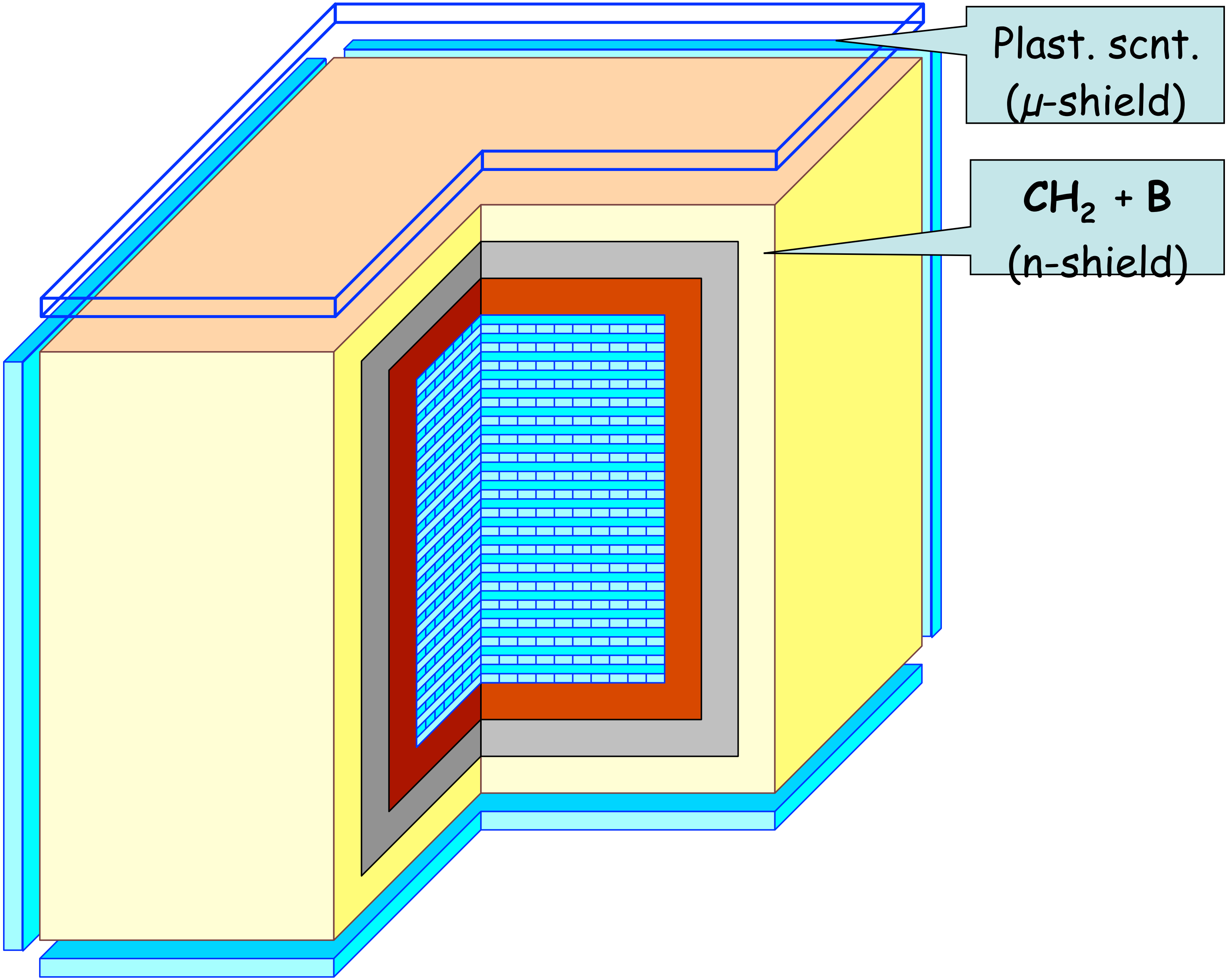
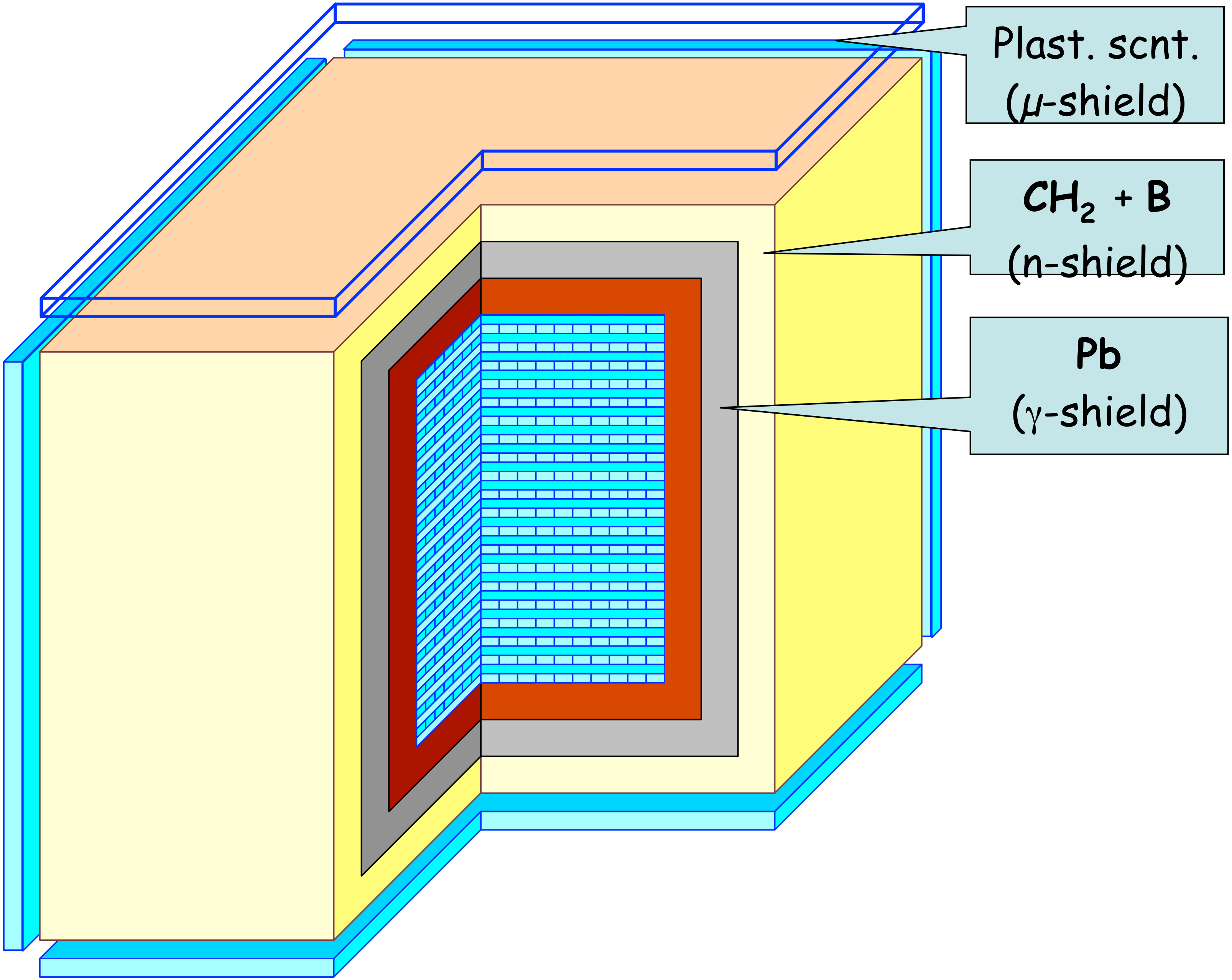
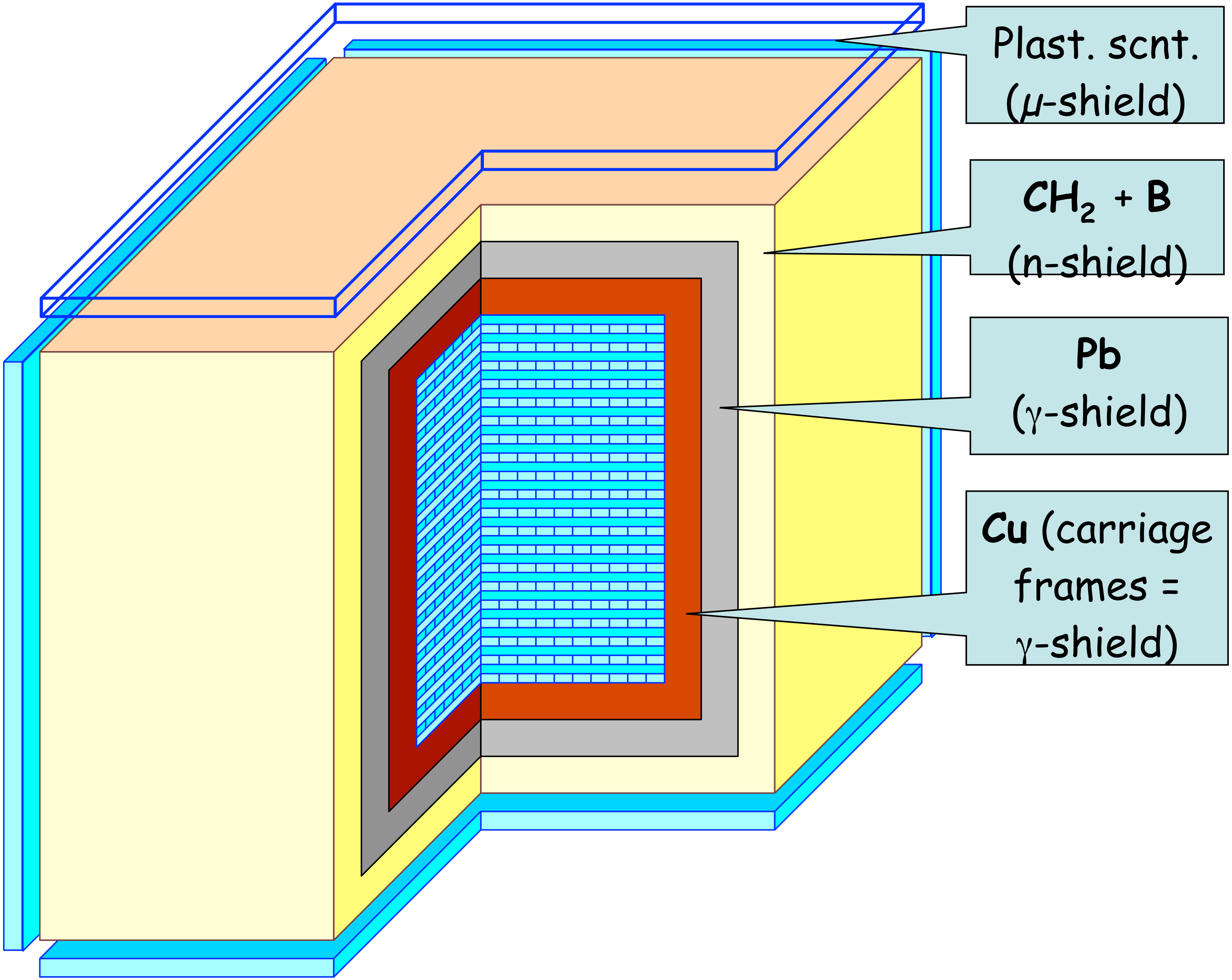


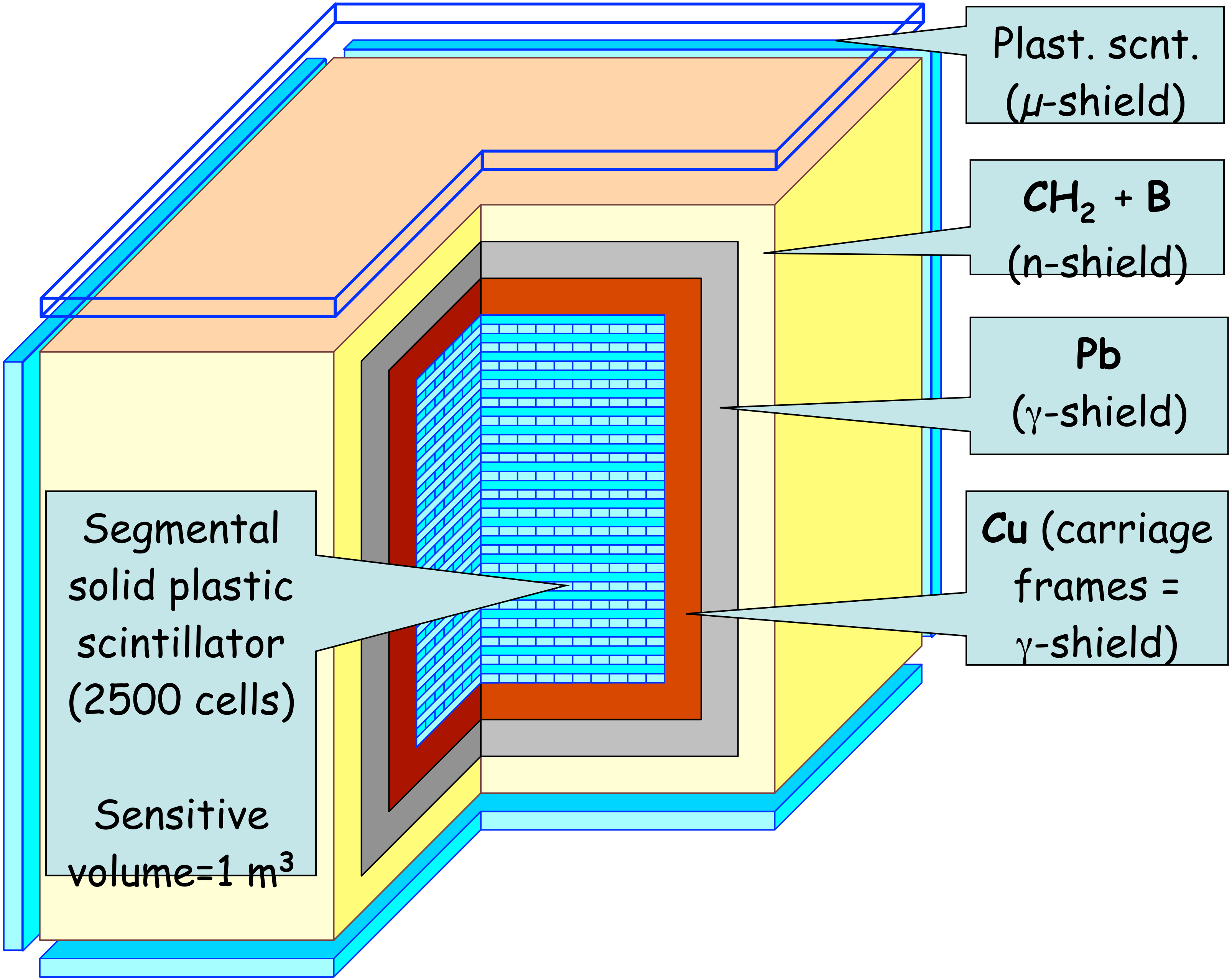

Plast. scnt.
(μ-shield)

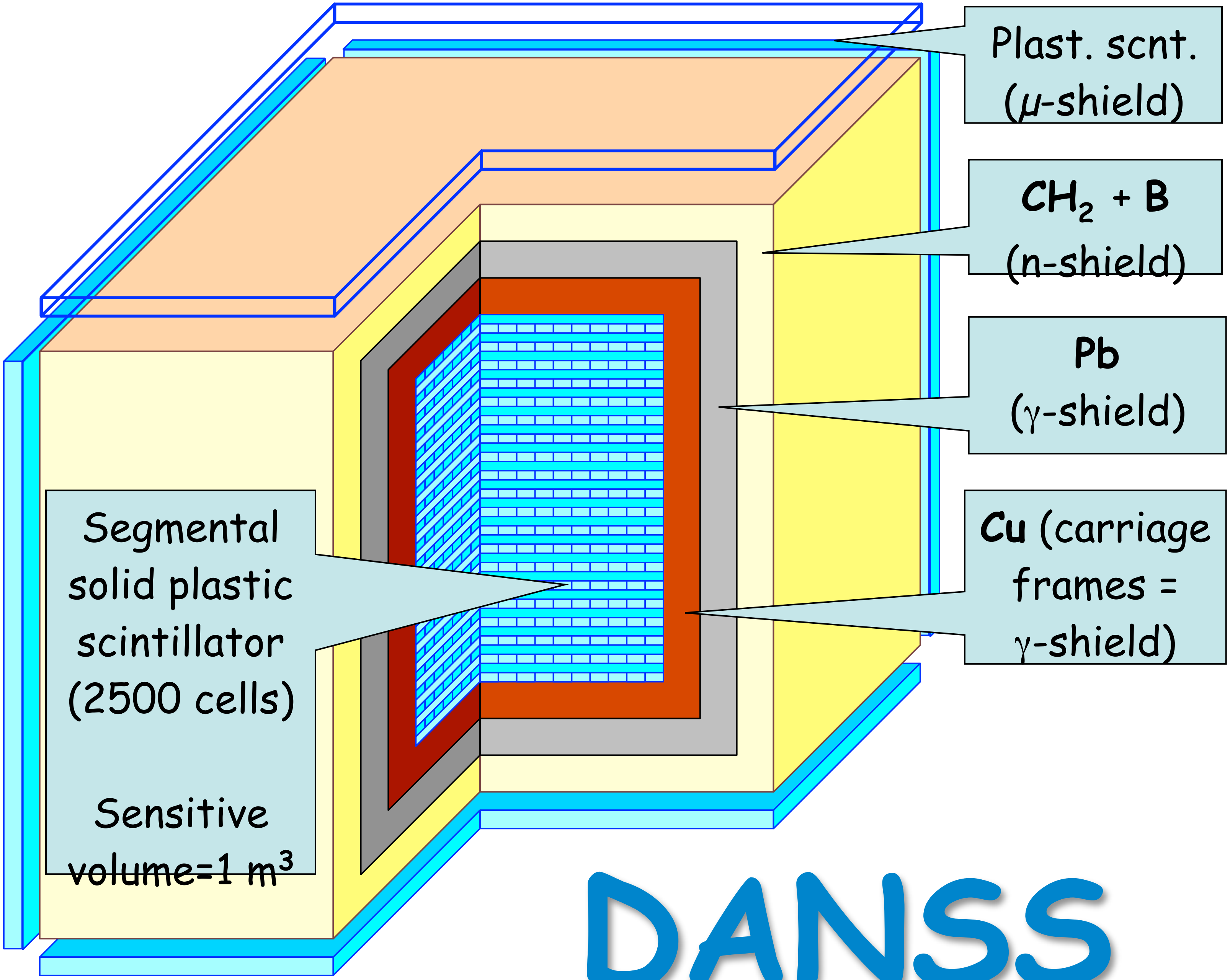

Plast. scnt.
(μ-shield)
CH_2 + B
(n-shield)


Plast. scnt.
(μ-shield)
CH2 + B
(n-shield)
Pb
(γ-shield)



Plast. scnt.
(μ-shield)
CH_2 + B
(n-shield)
Pb
(γ-shield)
Cu (carriage
frames =
γ-shield)


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



Plast. scnt.
(μ-shield)
CH2 + B
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(γ-shield)
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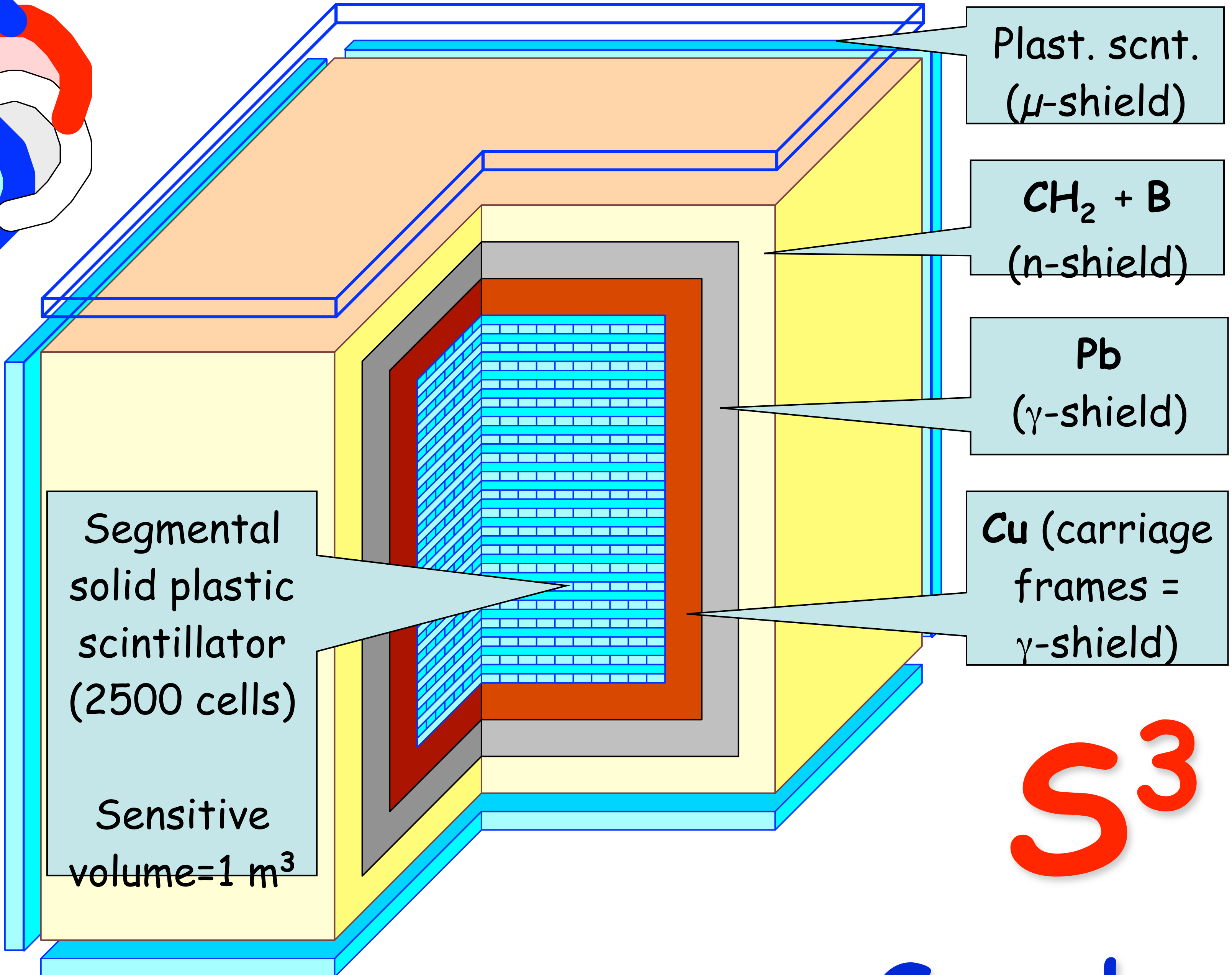
γ-shield)
Segmental
solid plastic
scintillator
(2500 cells)
Sensitive
volume=1 m3
DANSS


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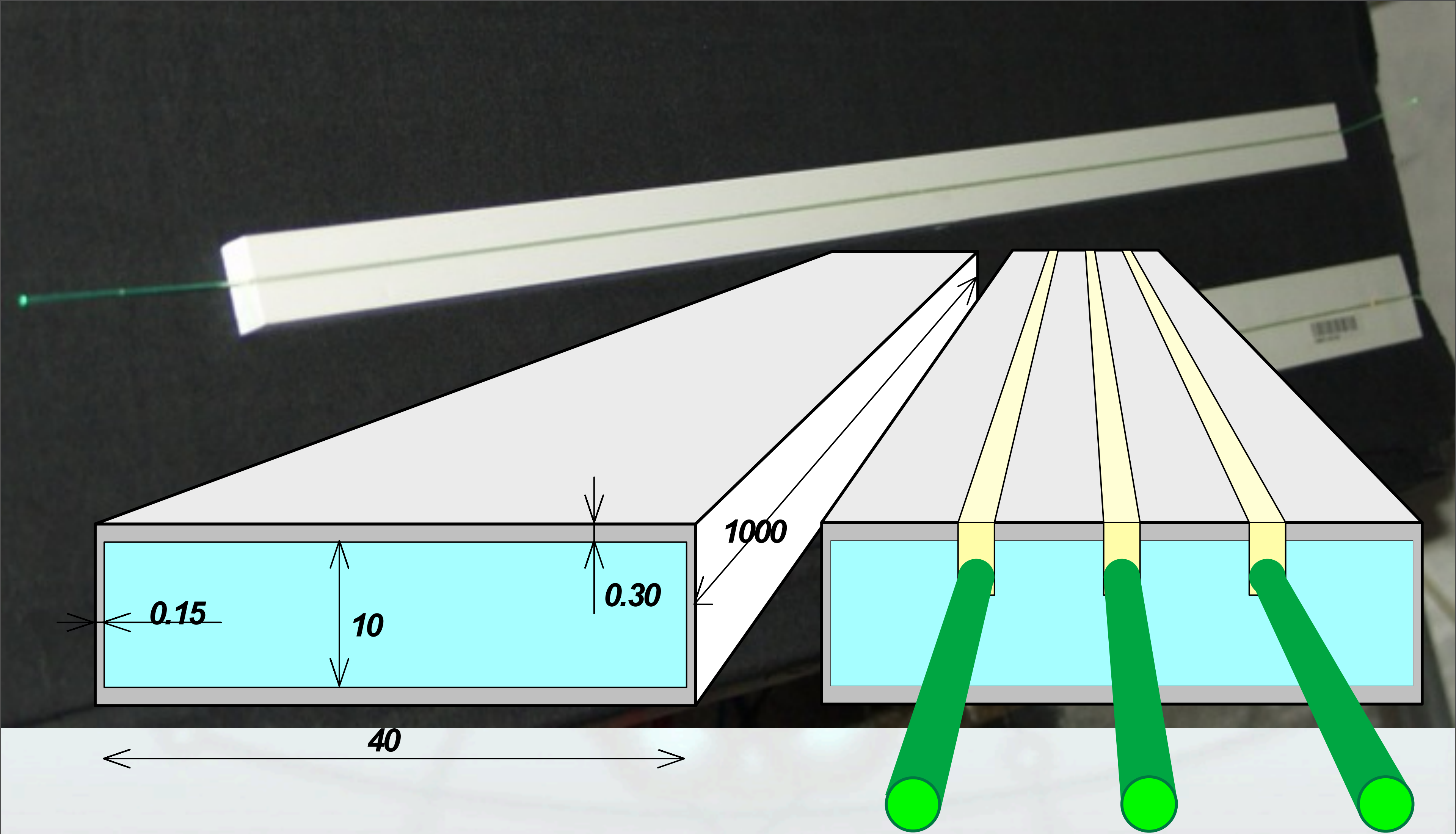
Cu (carriage
frames =
γ-shield)
Segmental
solid plastic
scintillator
(2500 cells)
Sensitive
volume=1 m3

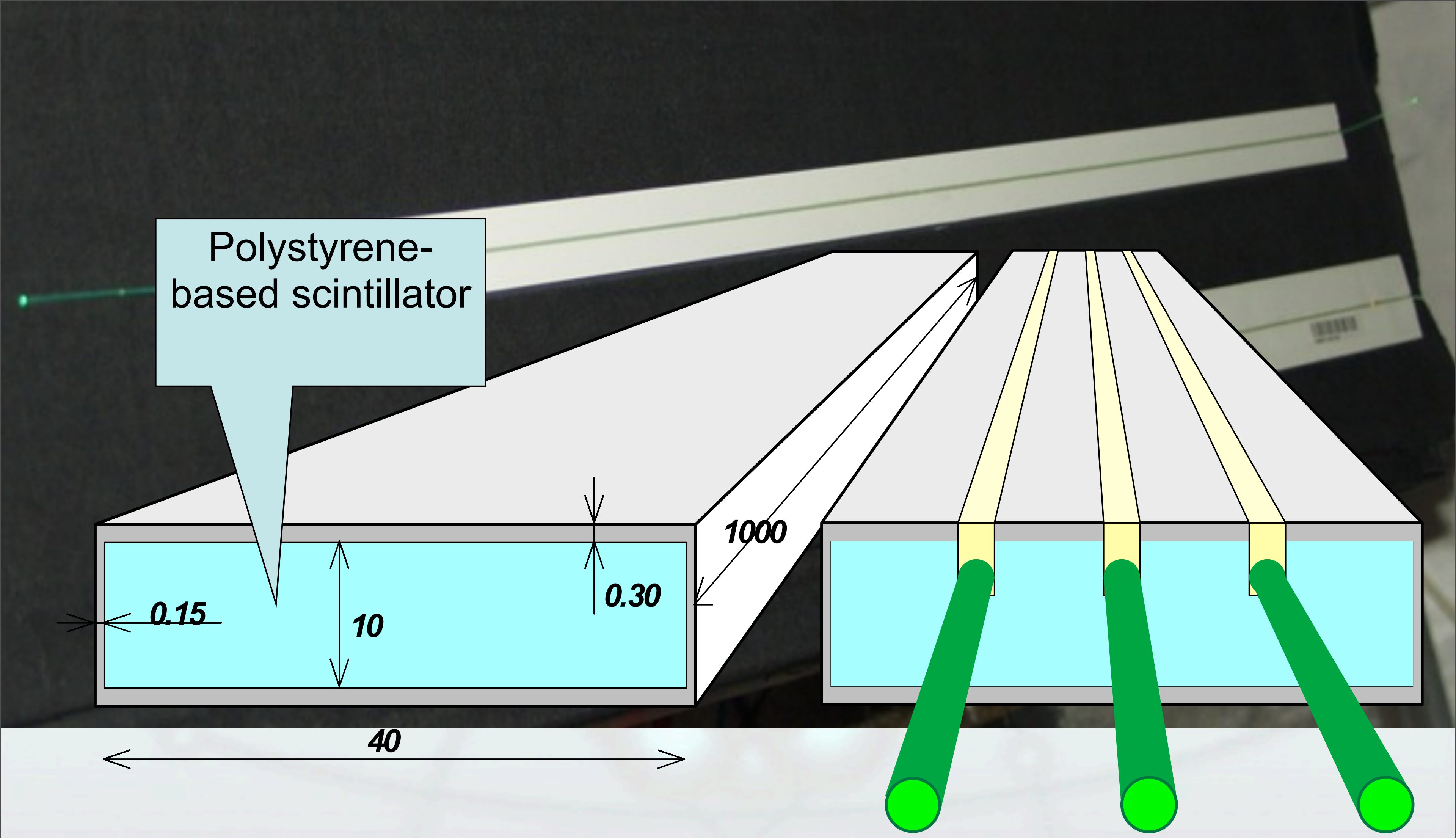
S^3

S-cube

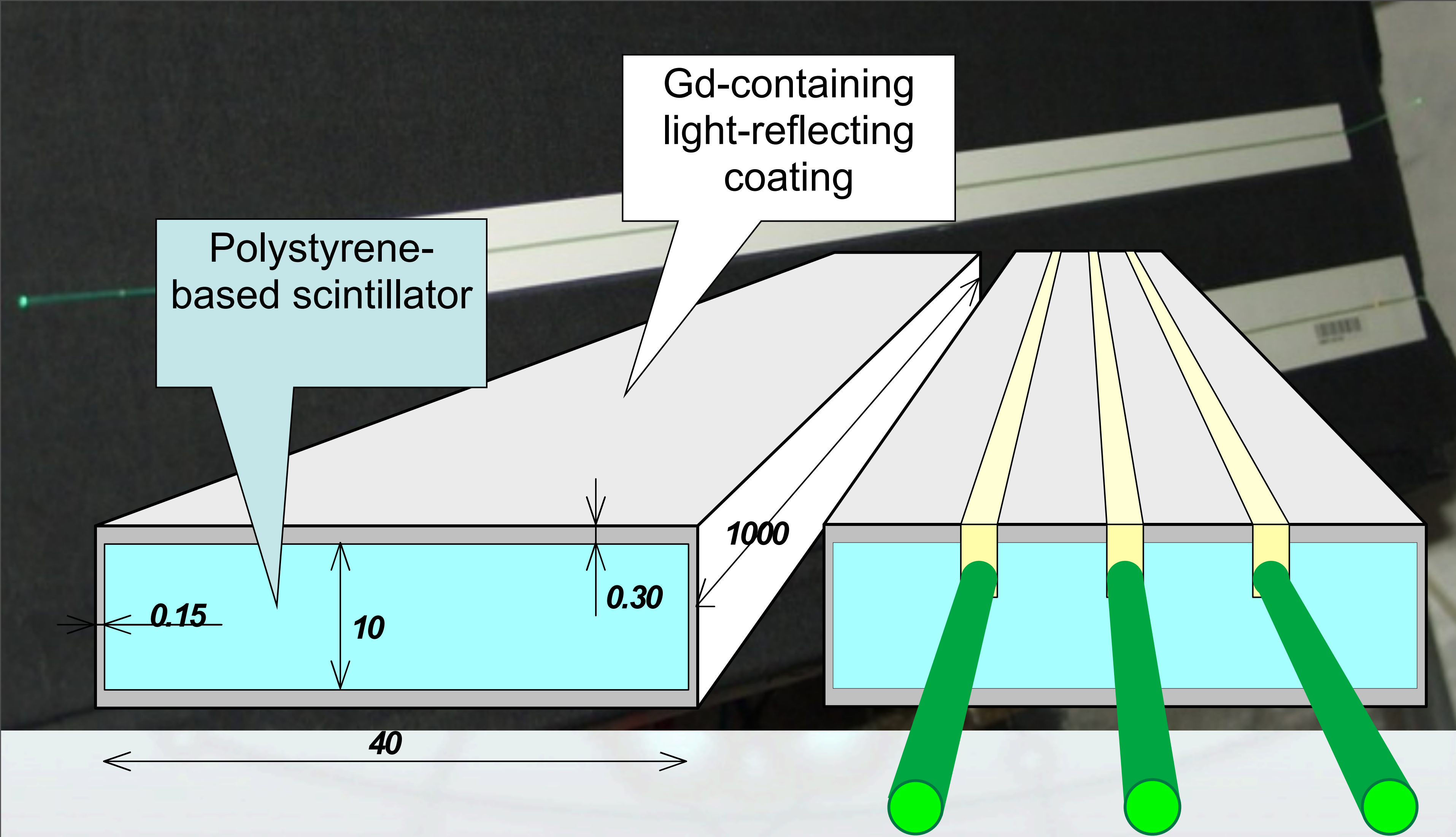
Basic element -



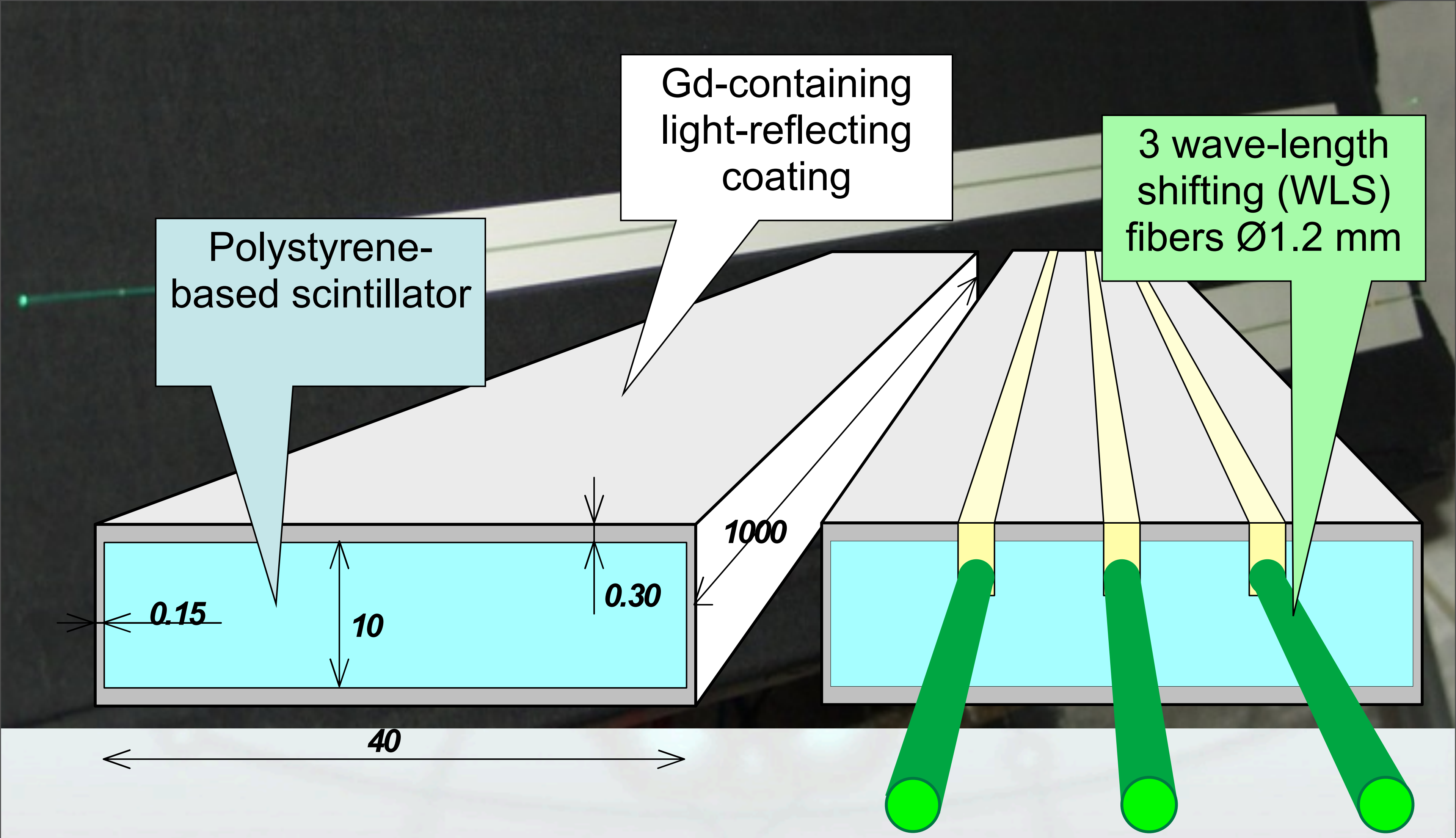
Basic element -



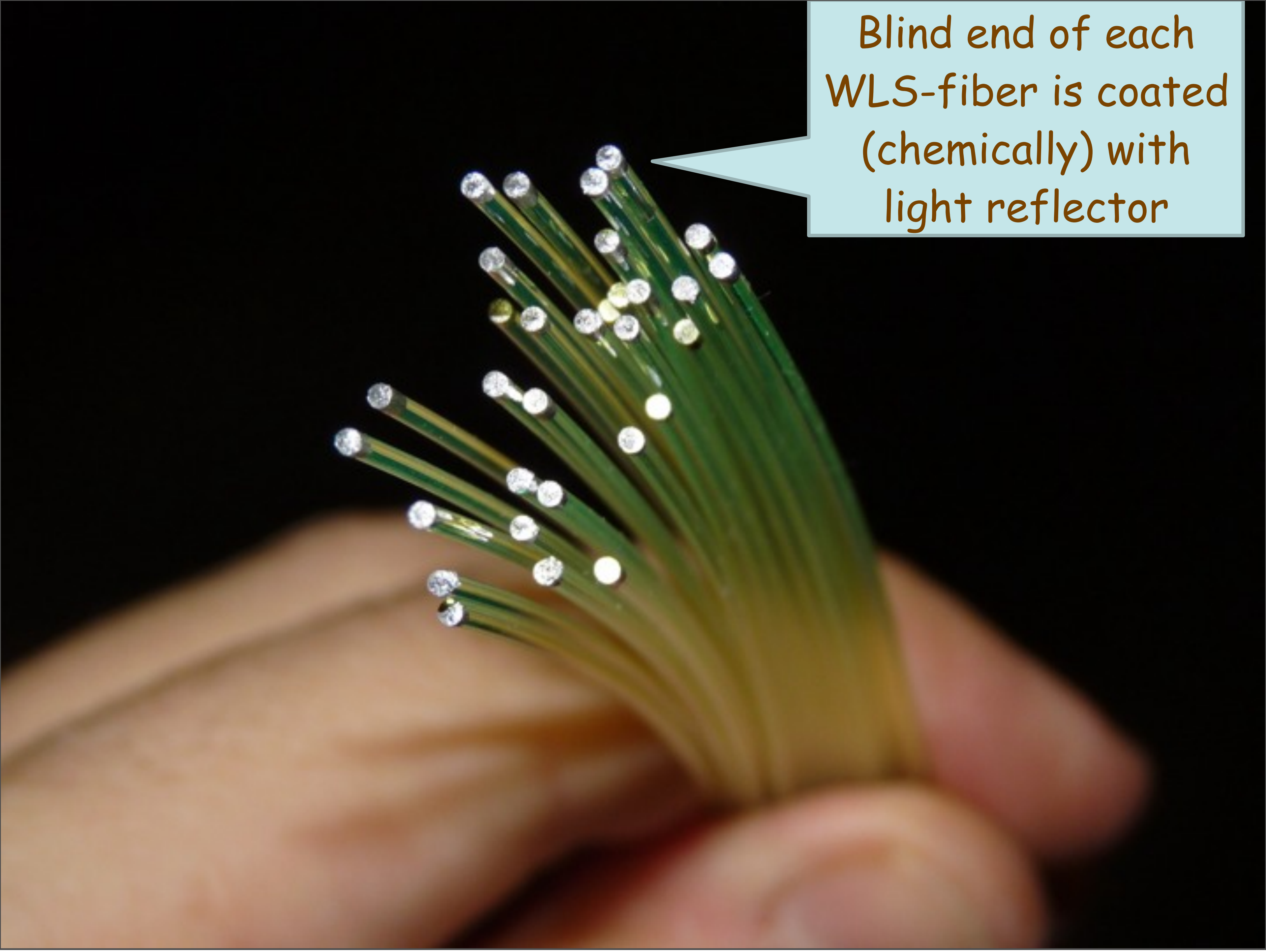
Basic element -



Basic element -

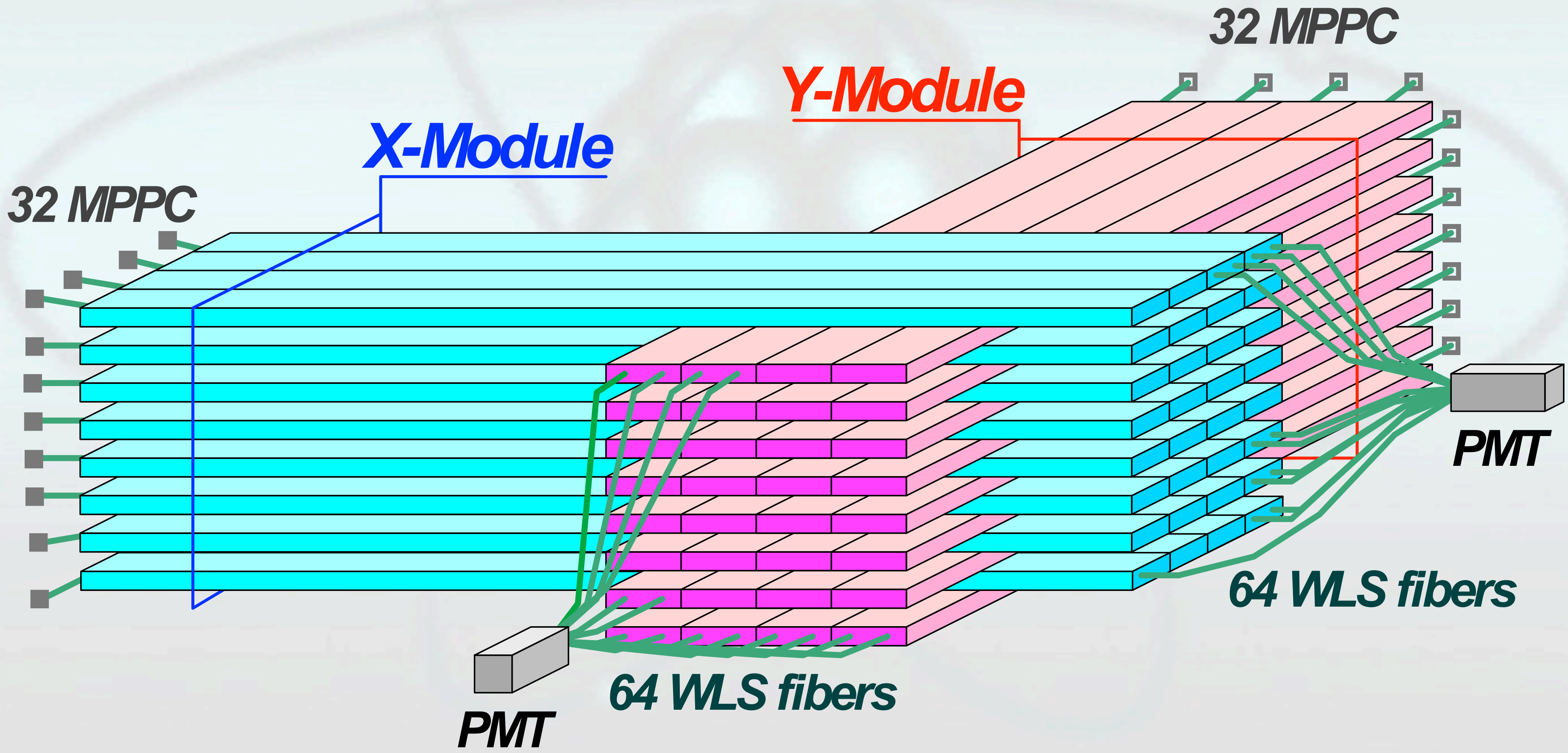


Basic element -


Blind end of each WLS-fiber is coated (chemically) with light reflector

Modular structure of the detector

A number of strips are combined into intercrossing X- and Y-modules.



Prototype: 2 parallel modules (no Gd-coating)

Light collection

Light collection

- **One PMT per Module (25-50 strips):**

Light collection

- **One PMT per Module (25-50 strips):**

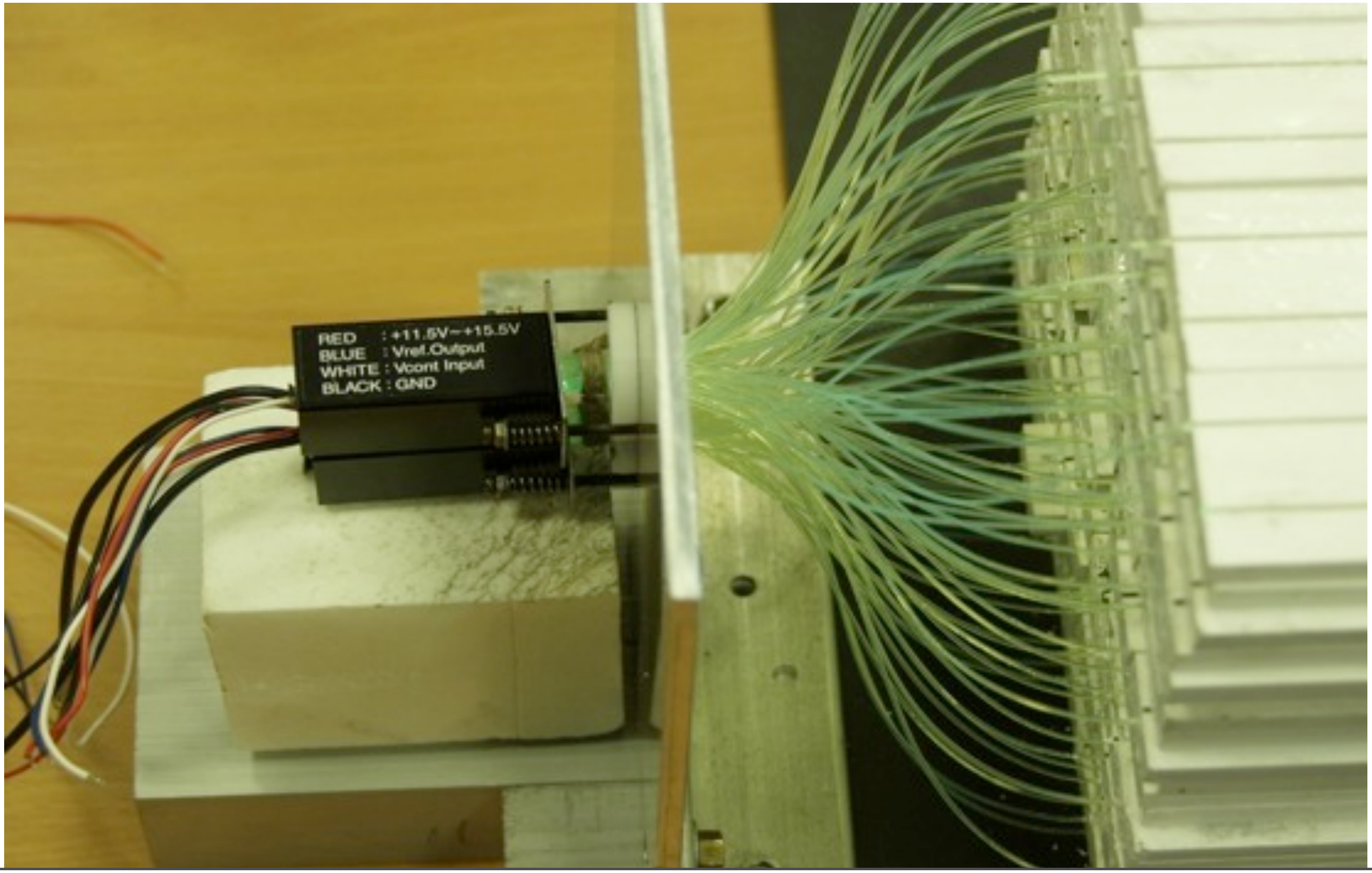
  *measure **total energy** of the photon burst*

Light collection

- **One PMT per Module (25-50 strips):**

  *measure **total energy** of the photon burst*

  *produce "**hard trigger**"*



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  ***space** distribution of the photon burst*

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  measure ***total energy*** *of the photon burst*

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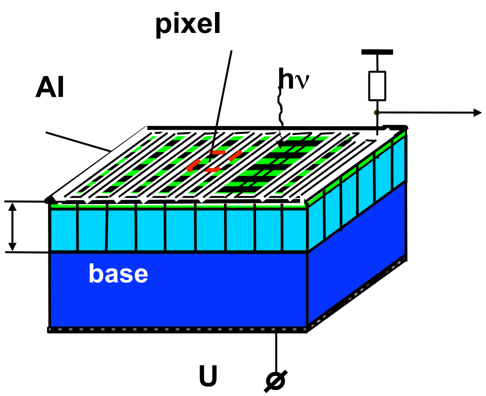
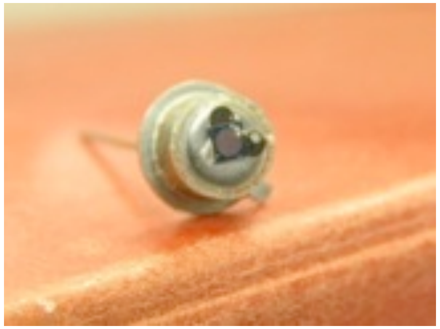
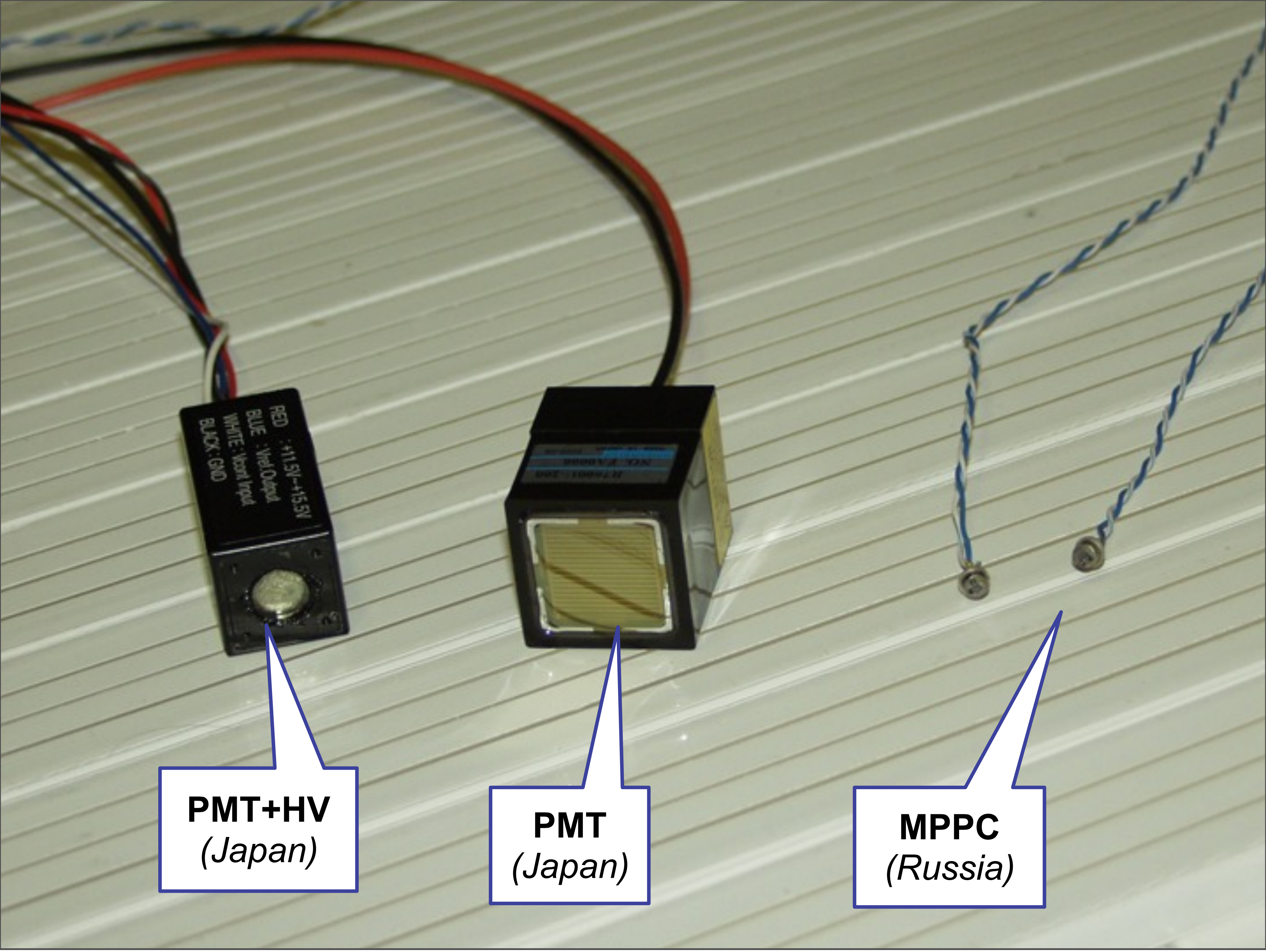
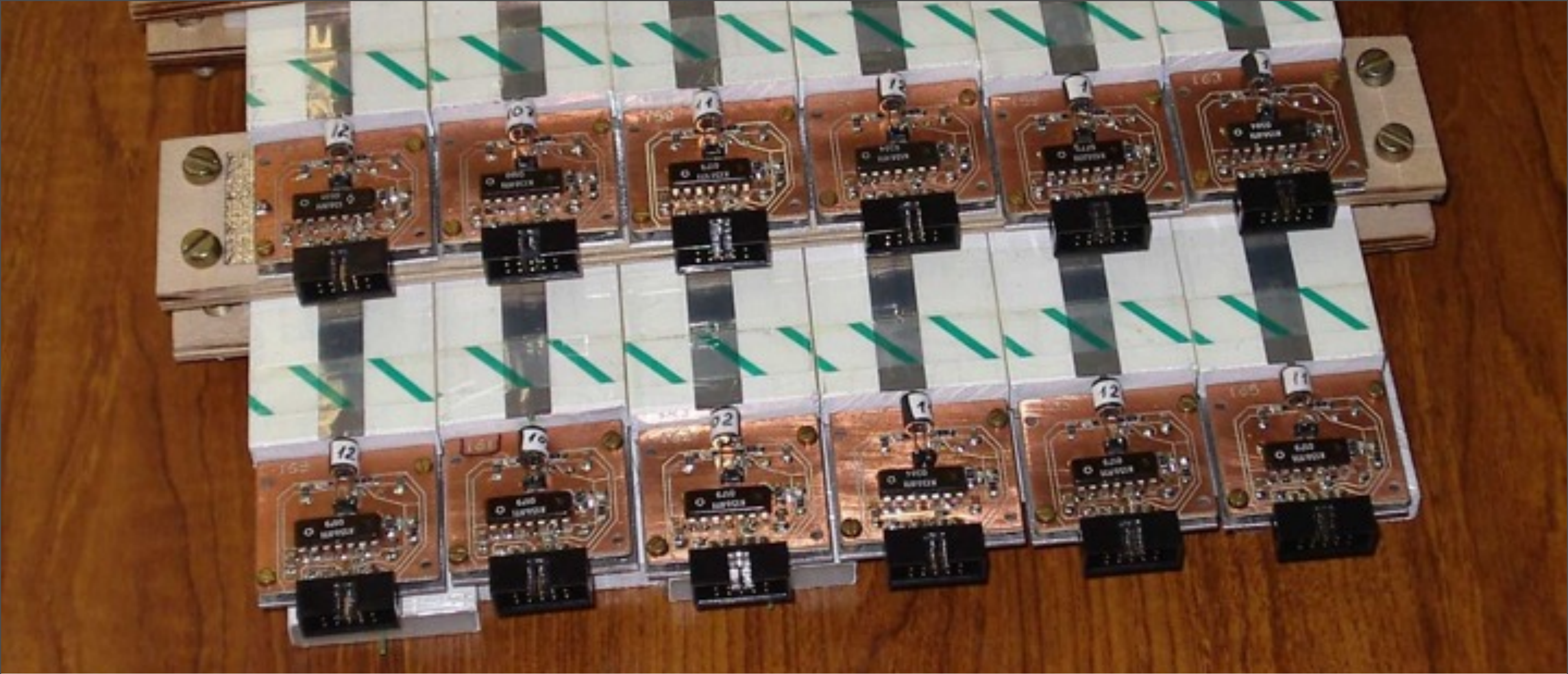
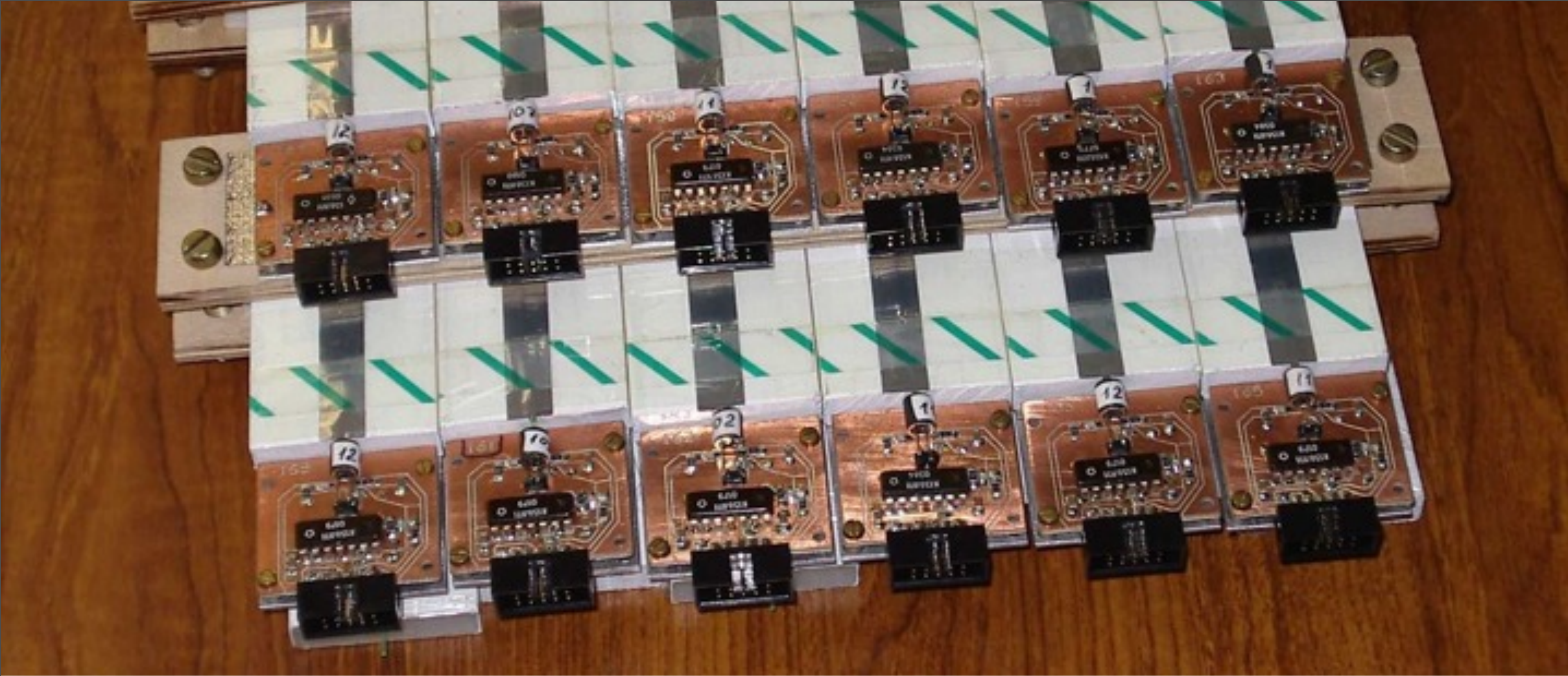




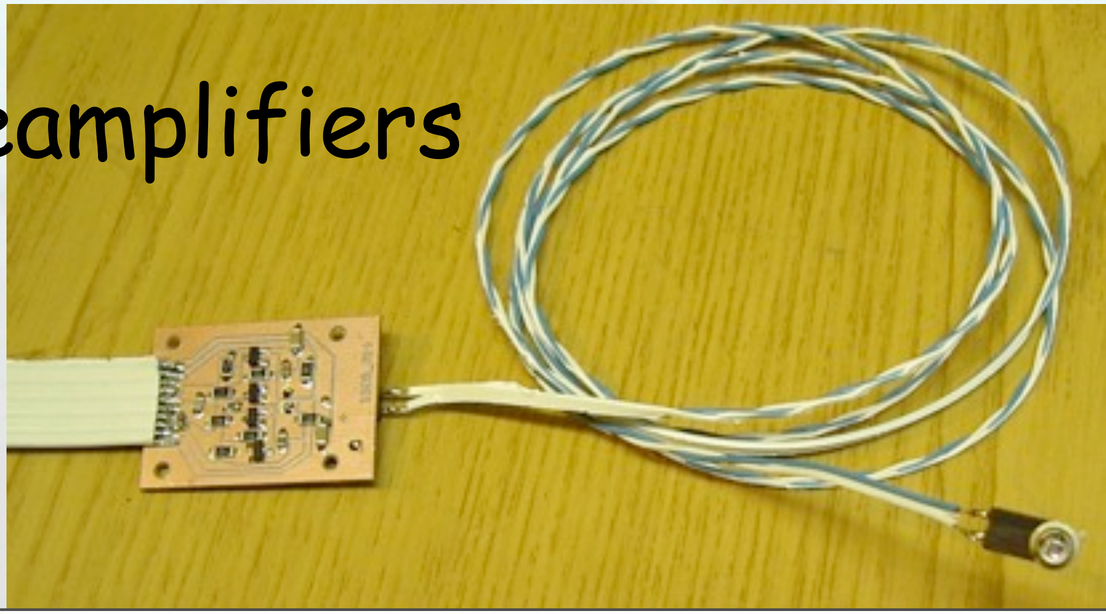

RED : +11.5V~+15.5V
BLUE : Vref. Output
WHITE : Vcont Input
BLACK : GND
PMT+HV
(Japan)
PMT
(Japan)
MPPC
(Russia)

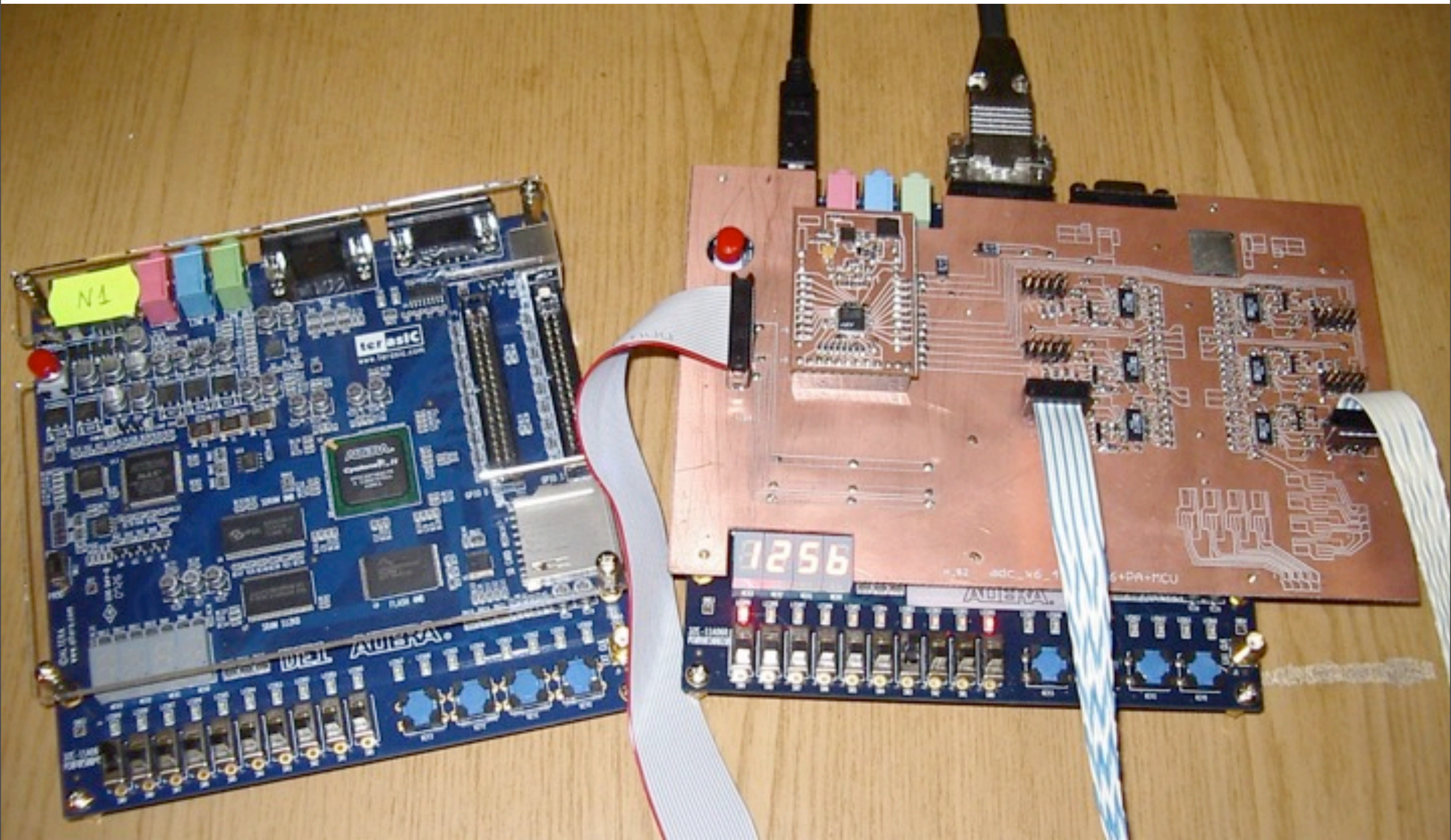


MPPC preamplifiers

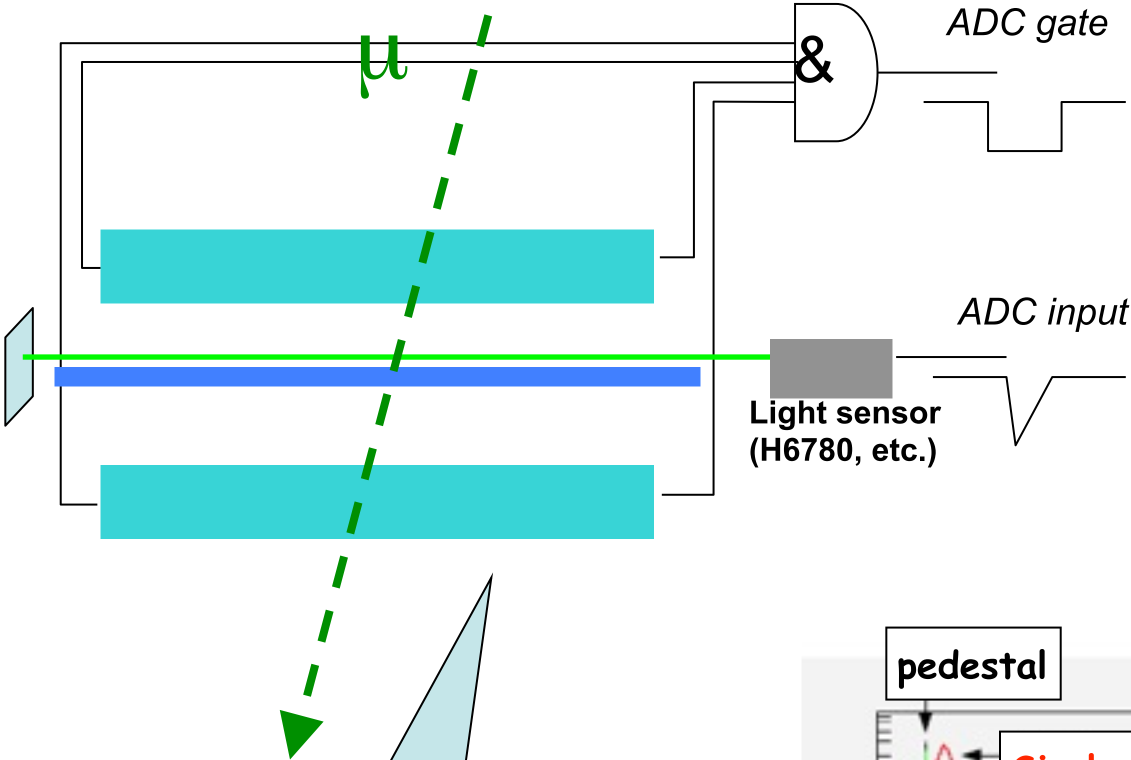


MPPC preamplifiers



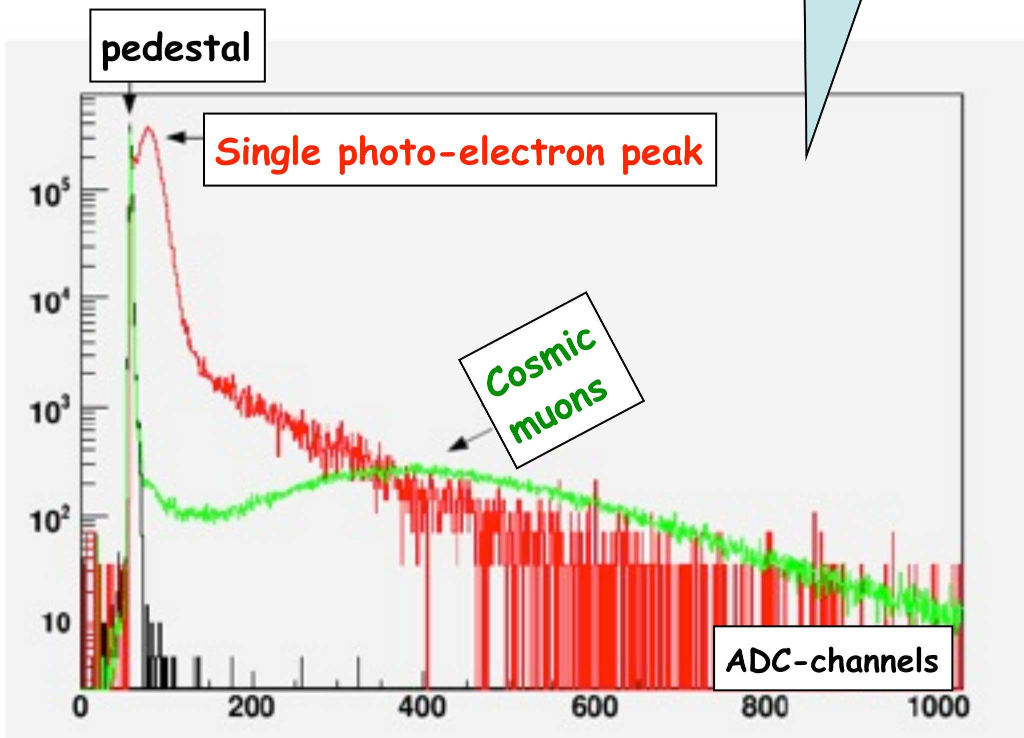


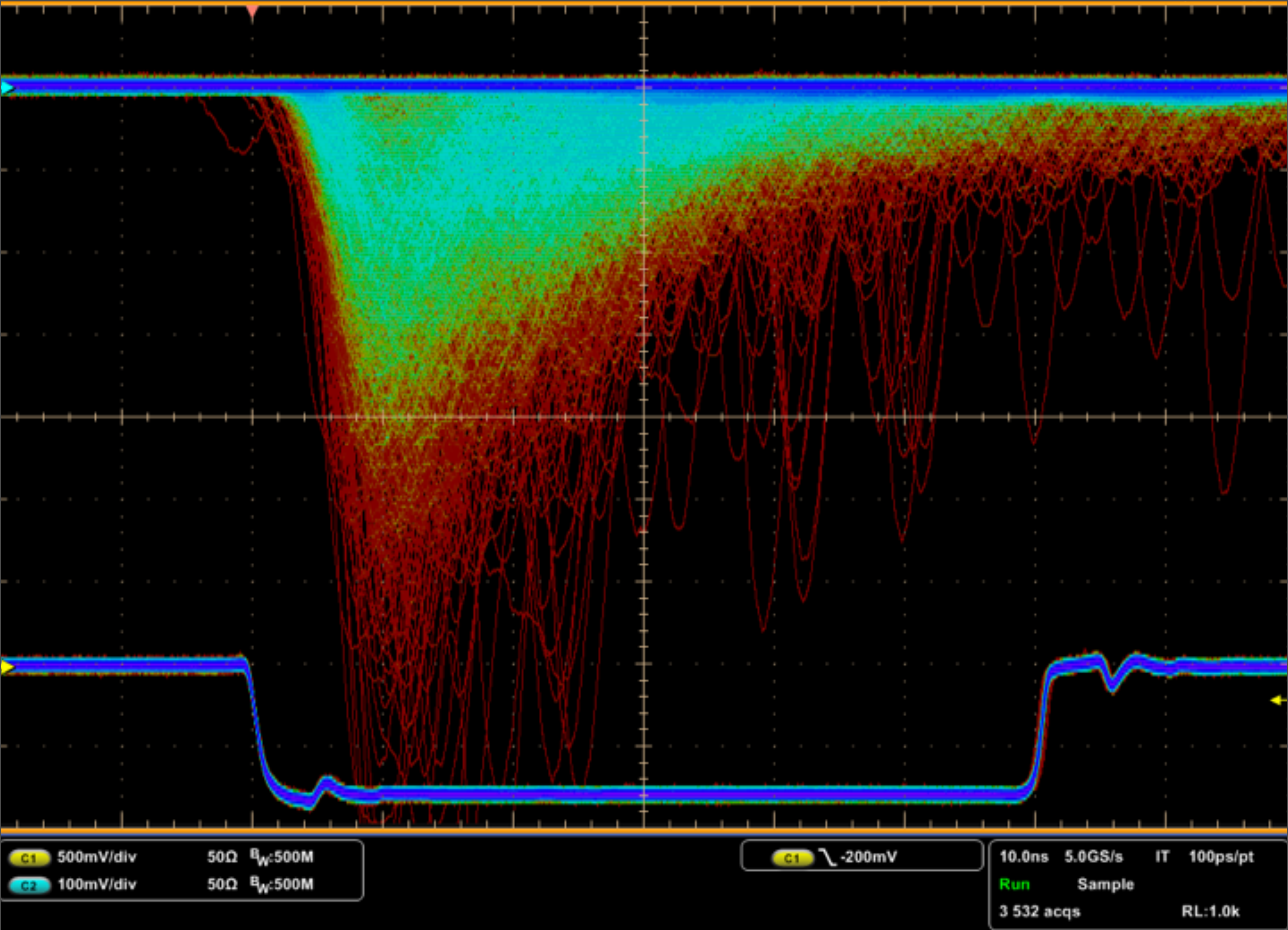
Flash ADC etc.



Test bench for strips, WLS-fibers and photo sensors

Typical energy spectrum



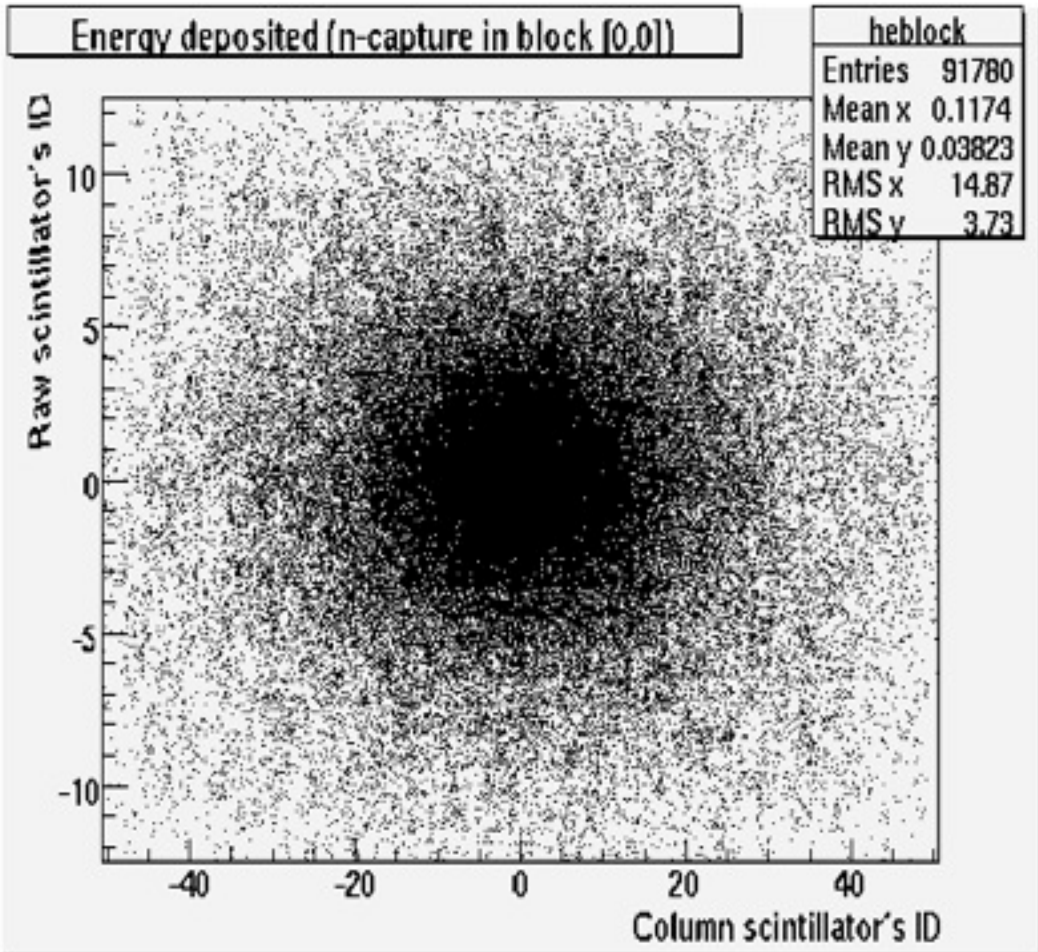


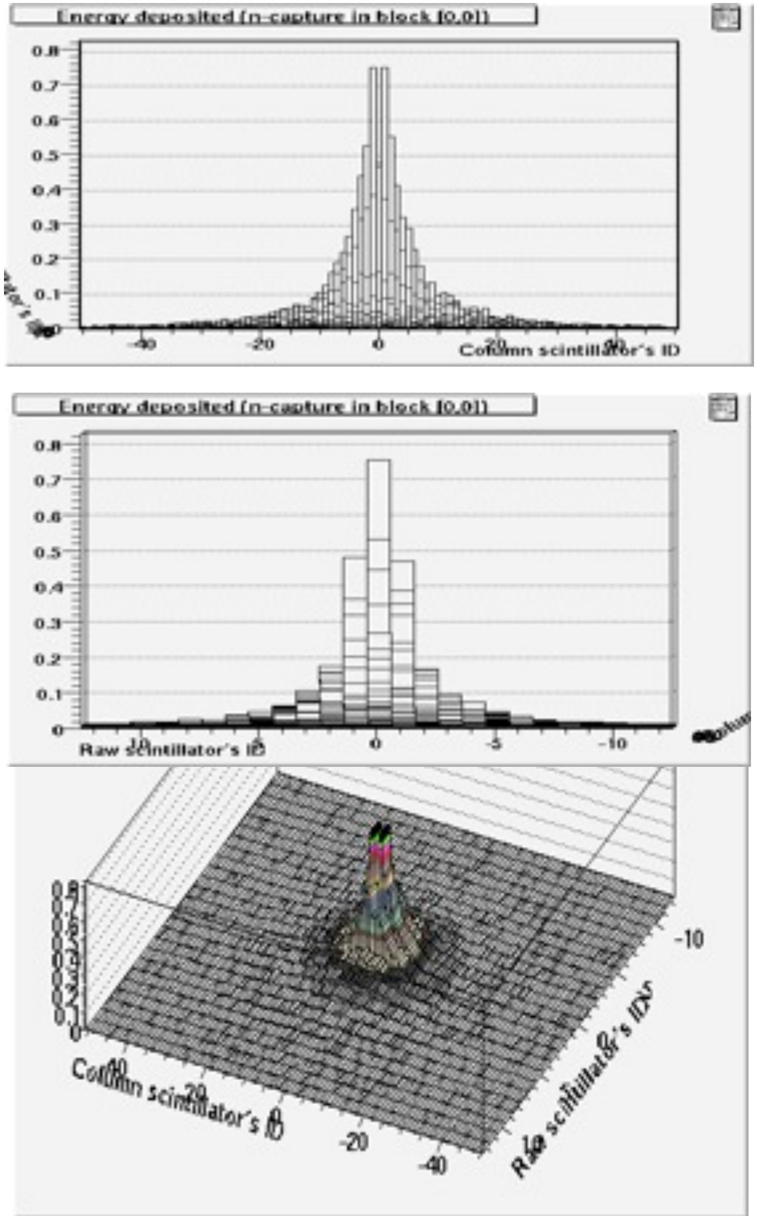
C1 500mV/div 50Ω BW:500M
C2 100mV/div 50Ω BW:500M
C1 -200mV
10.0ns 5.0GS/s IT 100ps/pt
Run Sample
3 532 acqs RL:1.0k

Monte Carlo simulations

Example:

Space distribution of the energy deposit after the ^{157}Gd(n,γ) reaction





End of 2009:

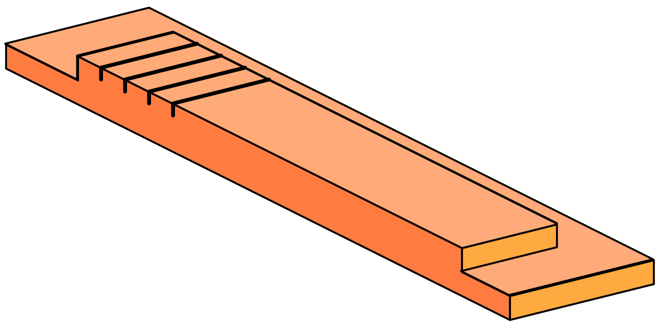
Start

the real

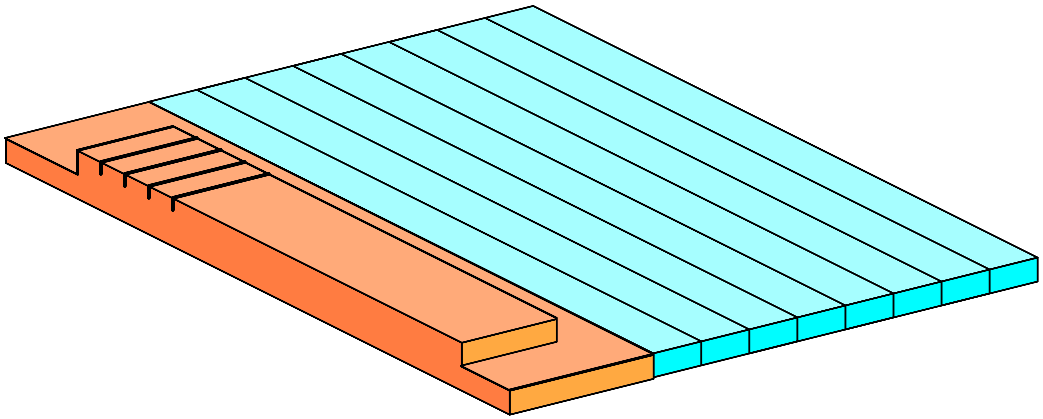
creation!

Carriage frames

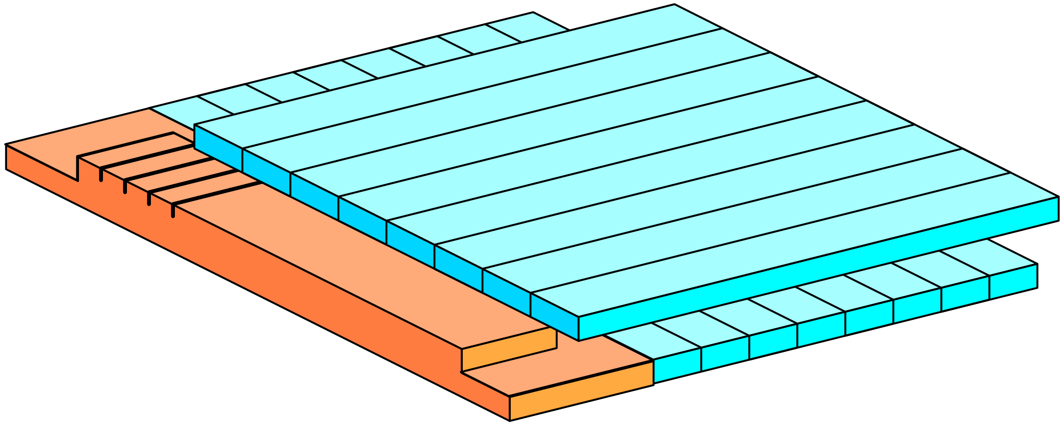
Carriage frames



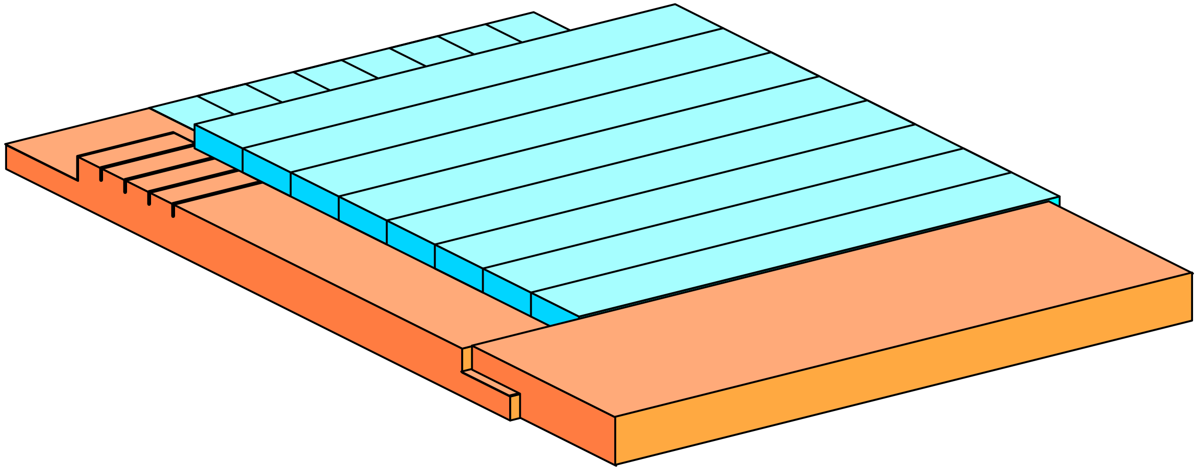
Carriage frames

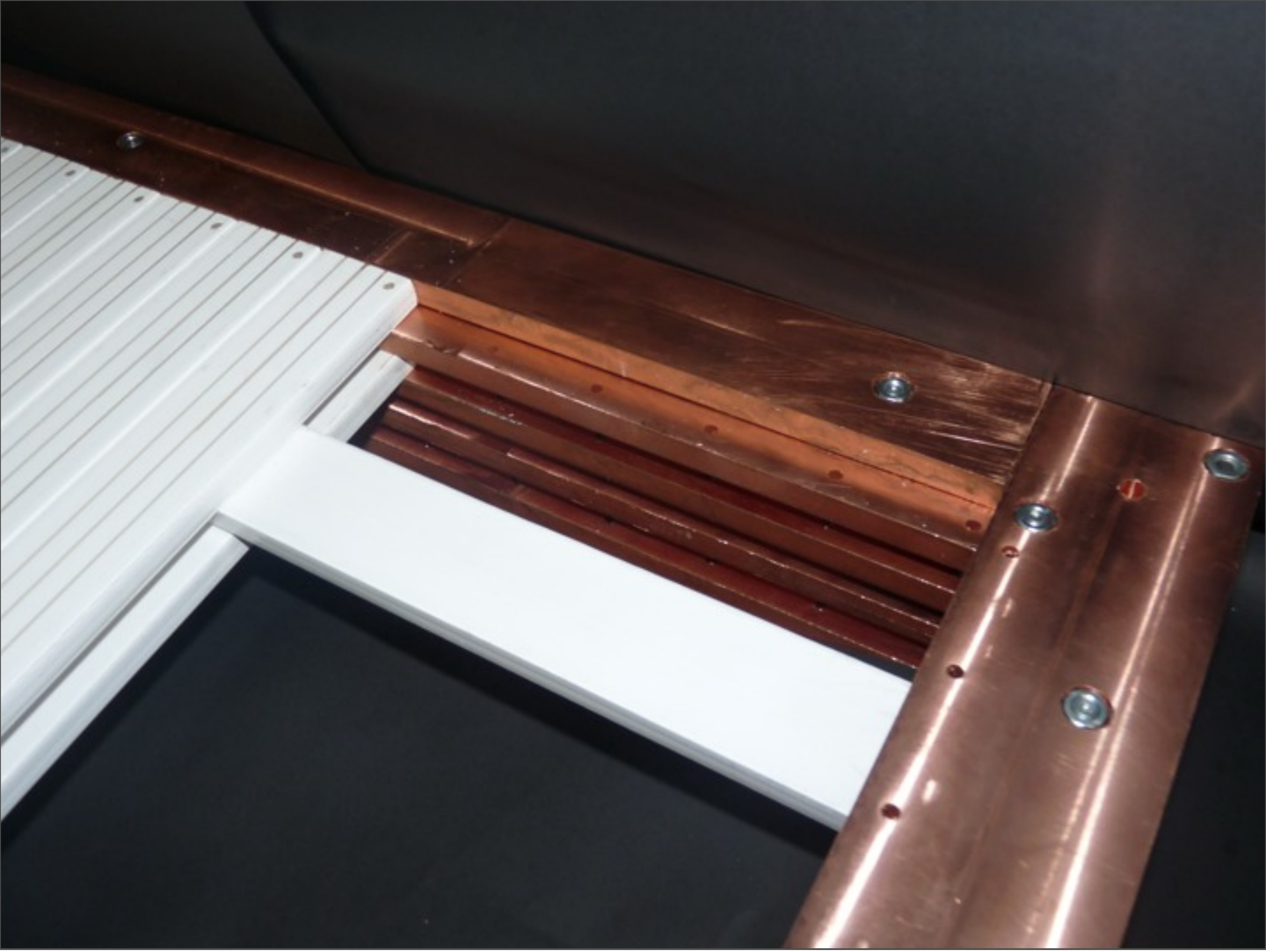


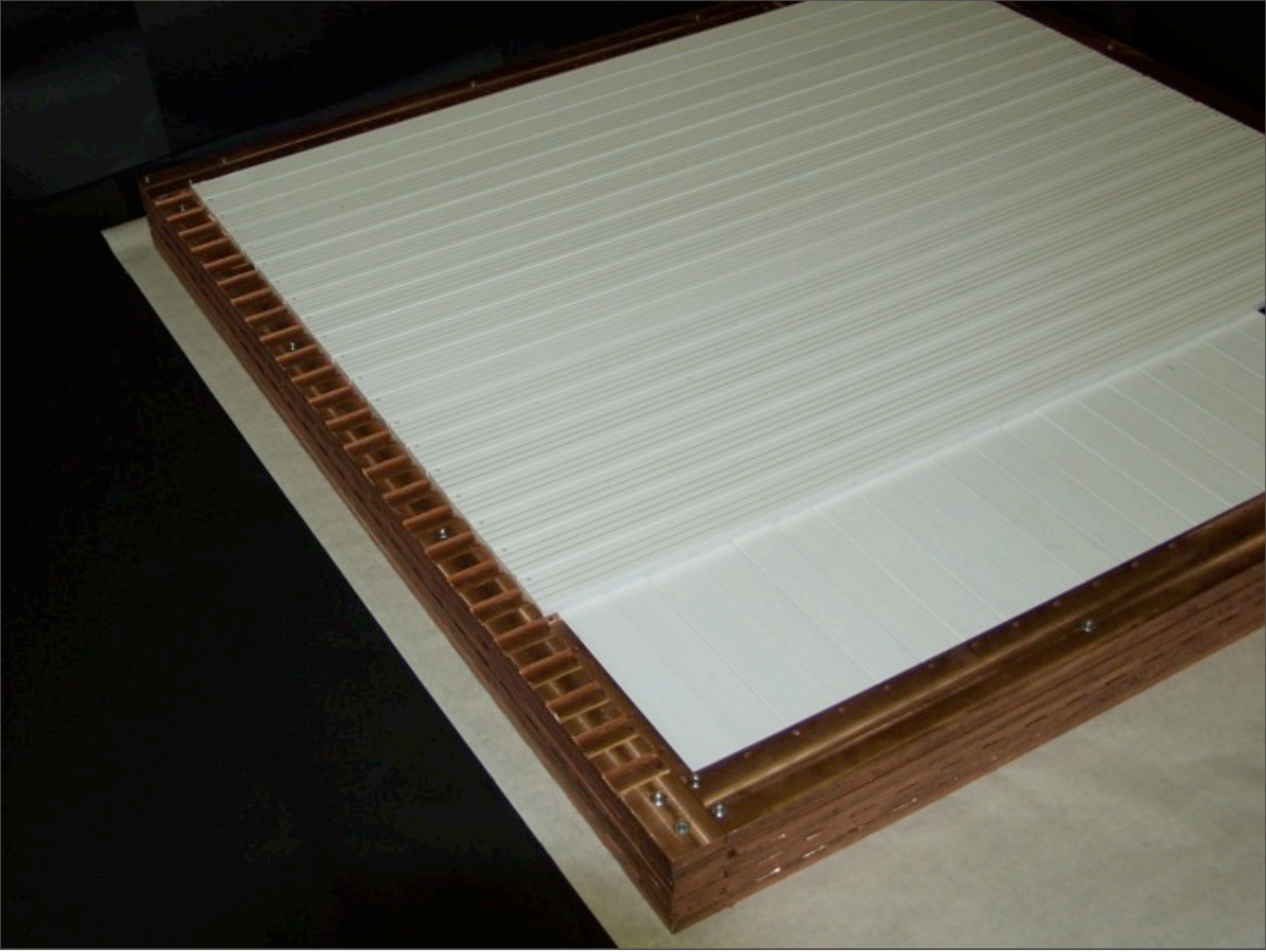
Carriage frames

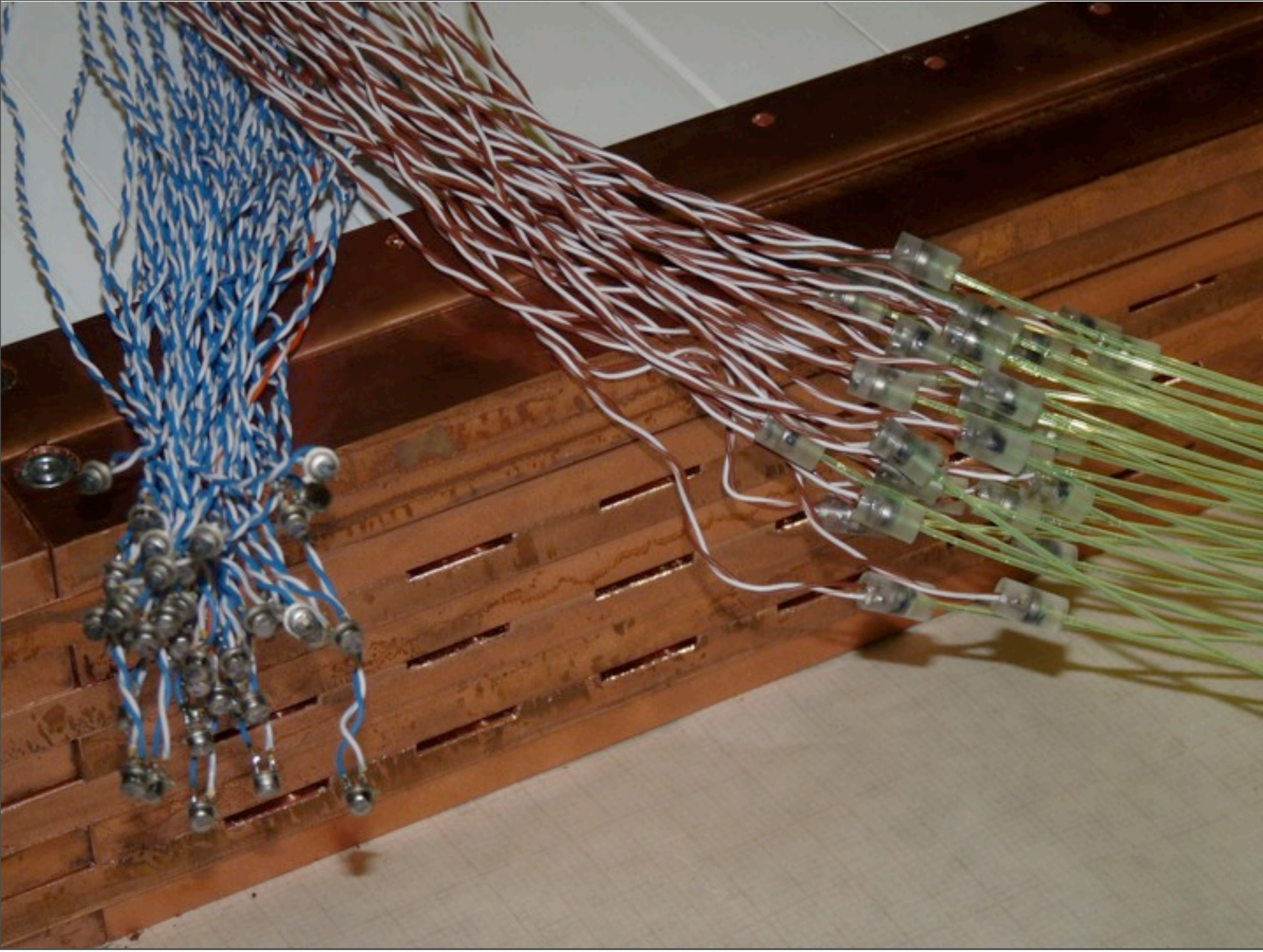


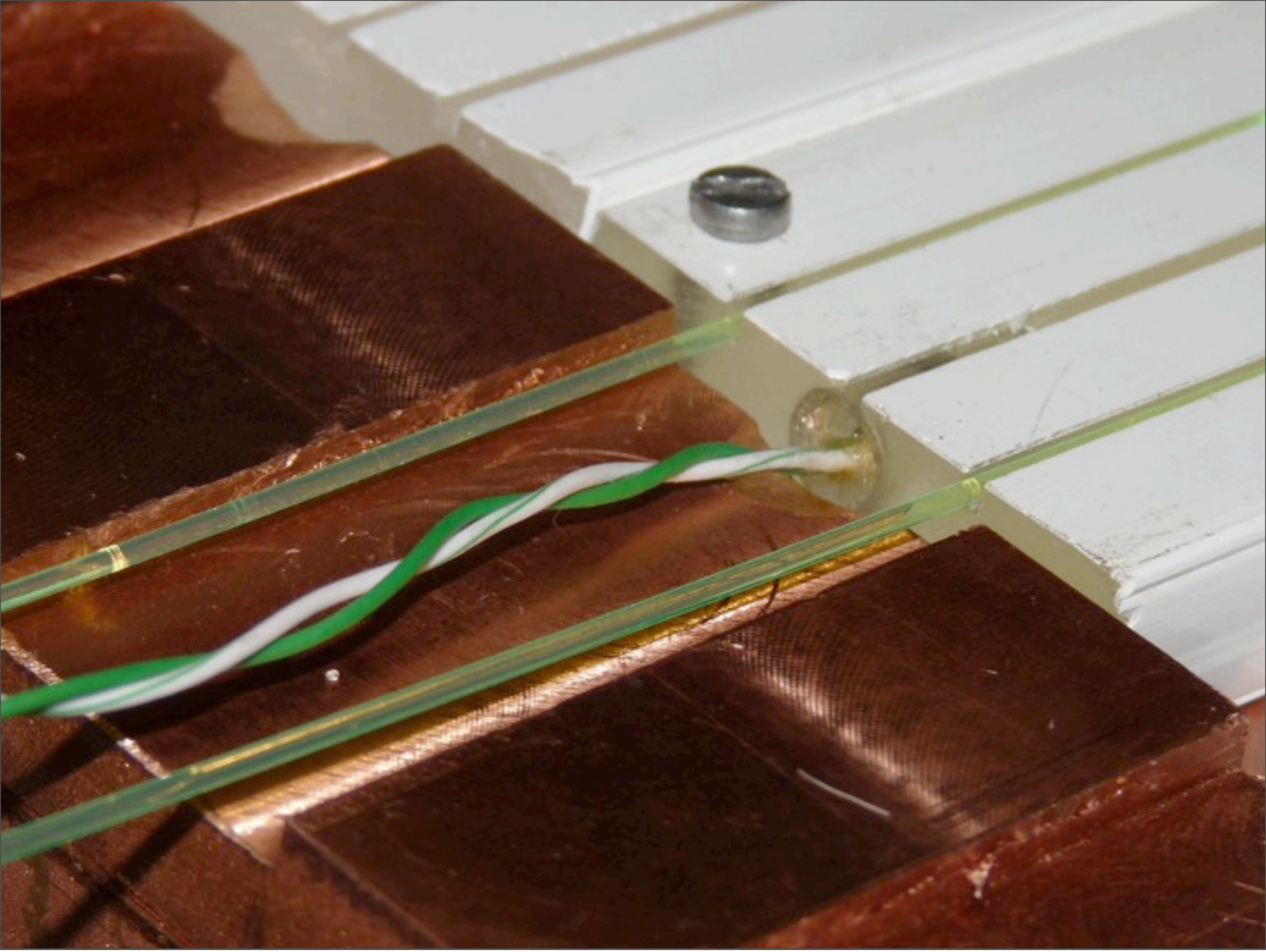
Carriage frames

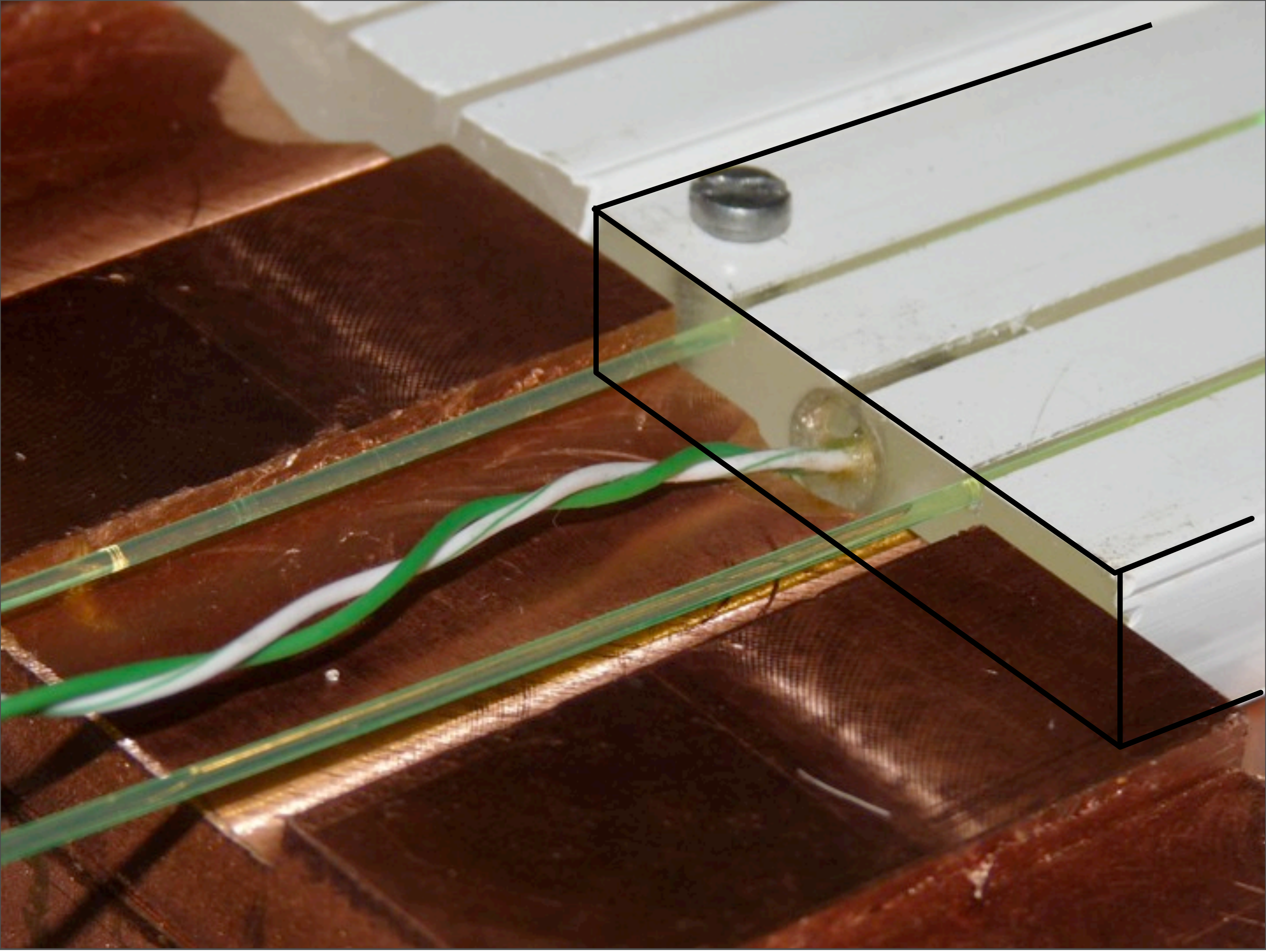


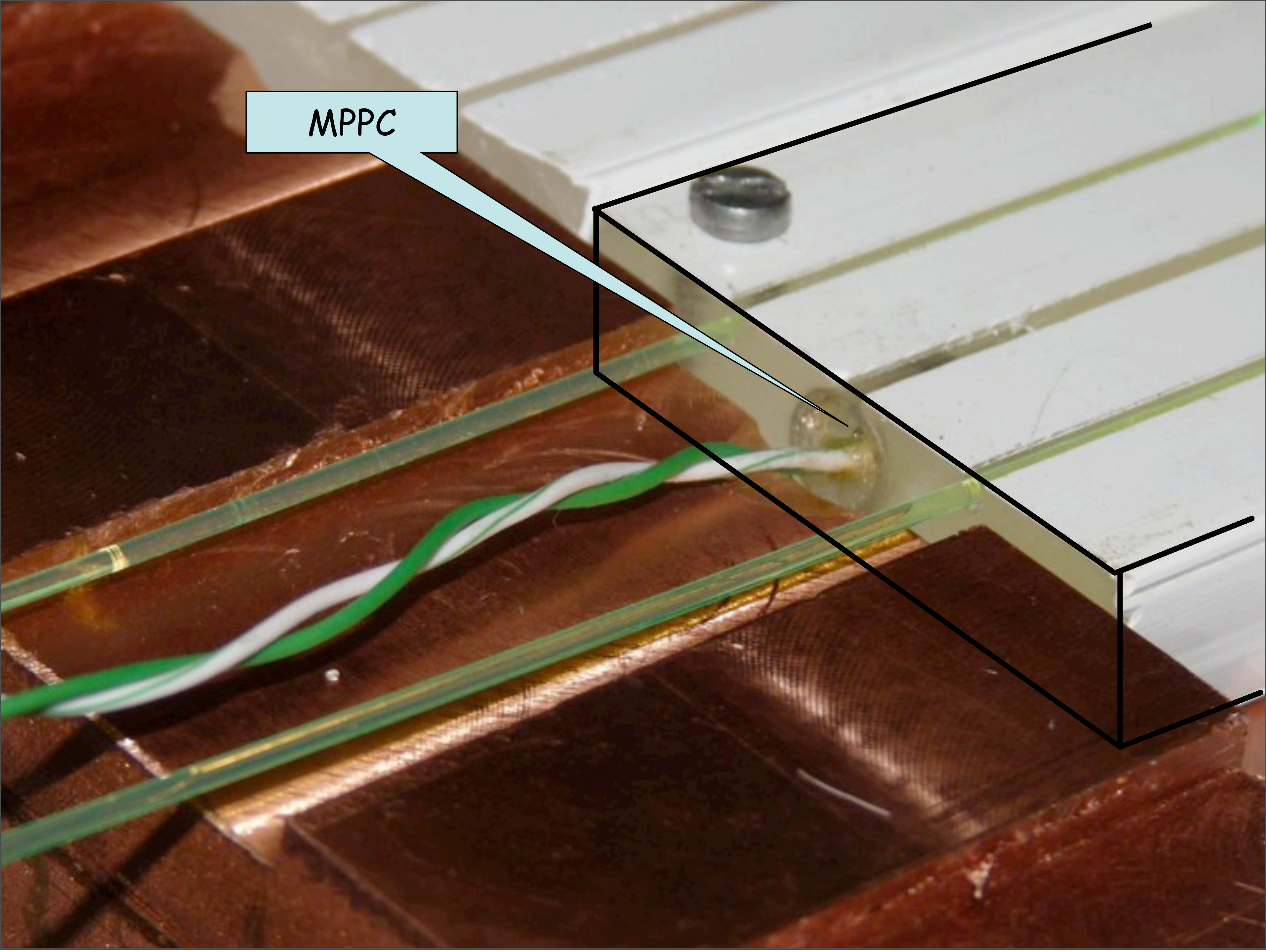


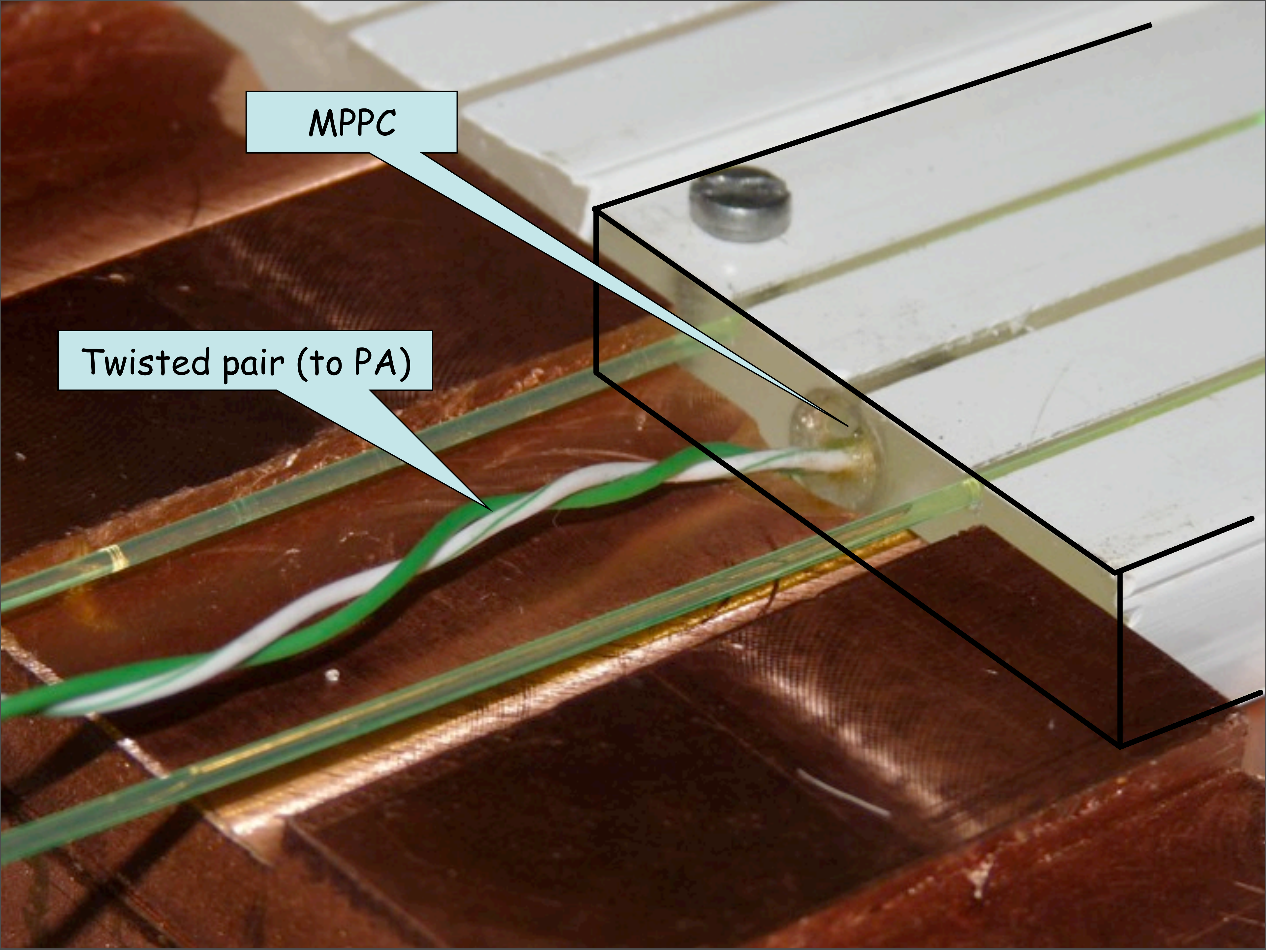


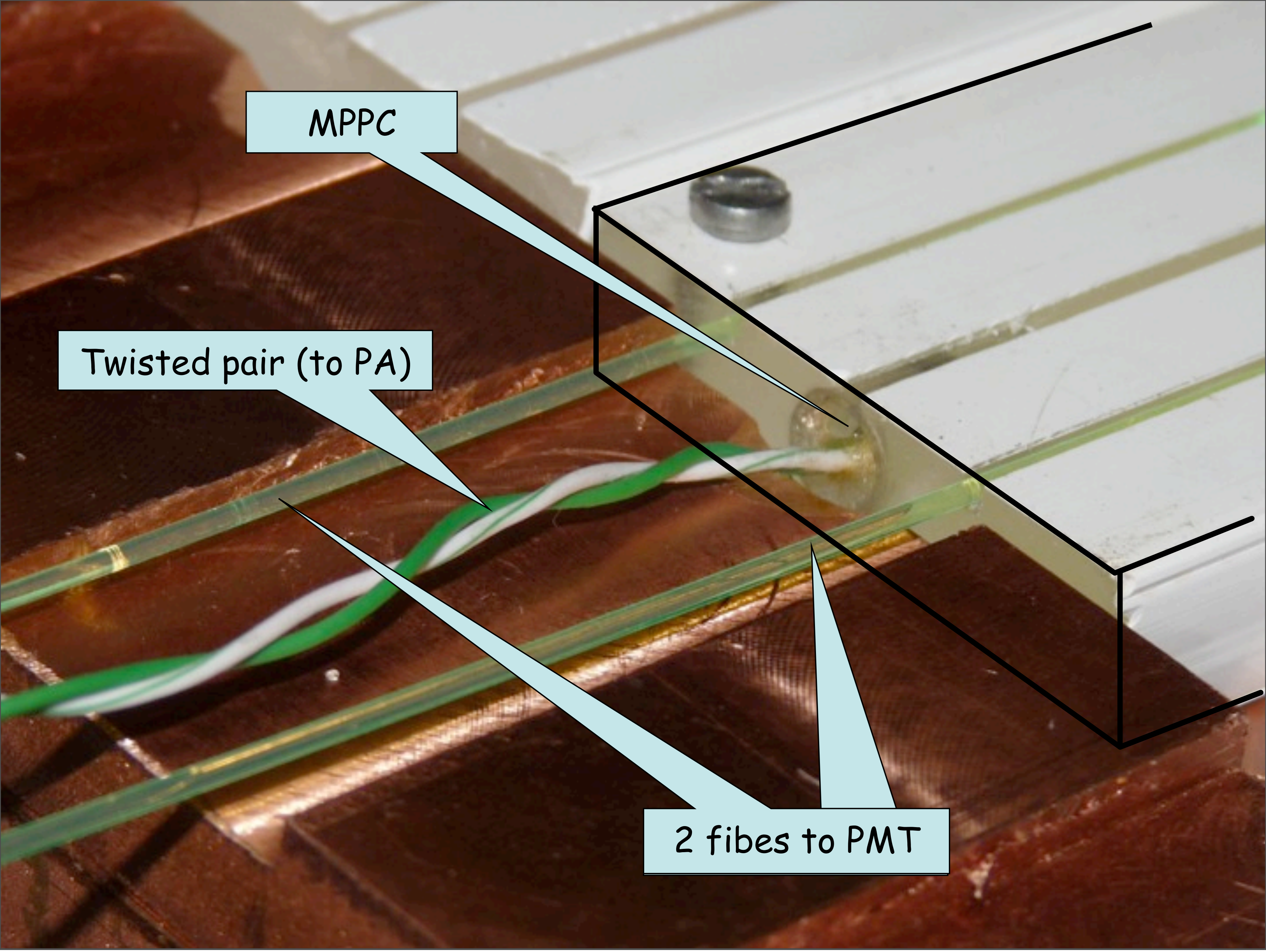






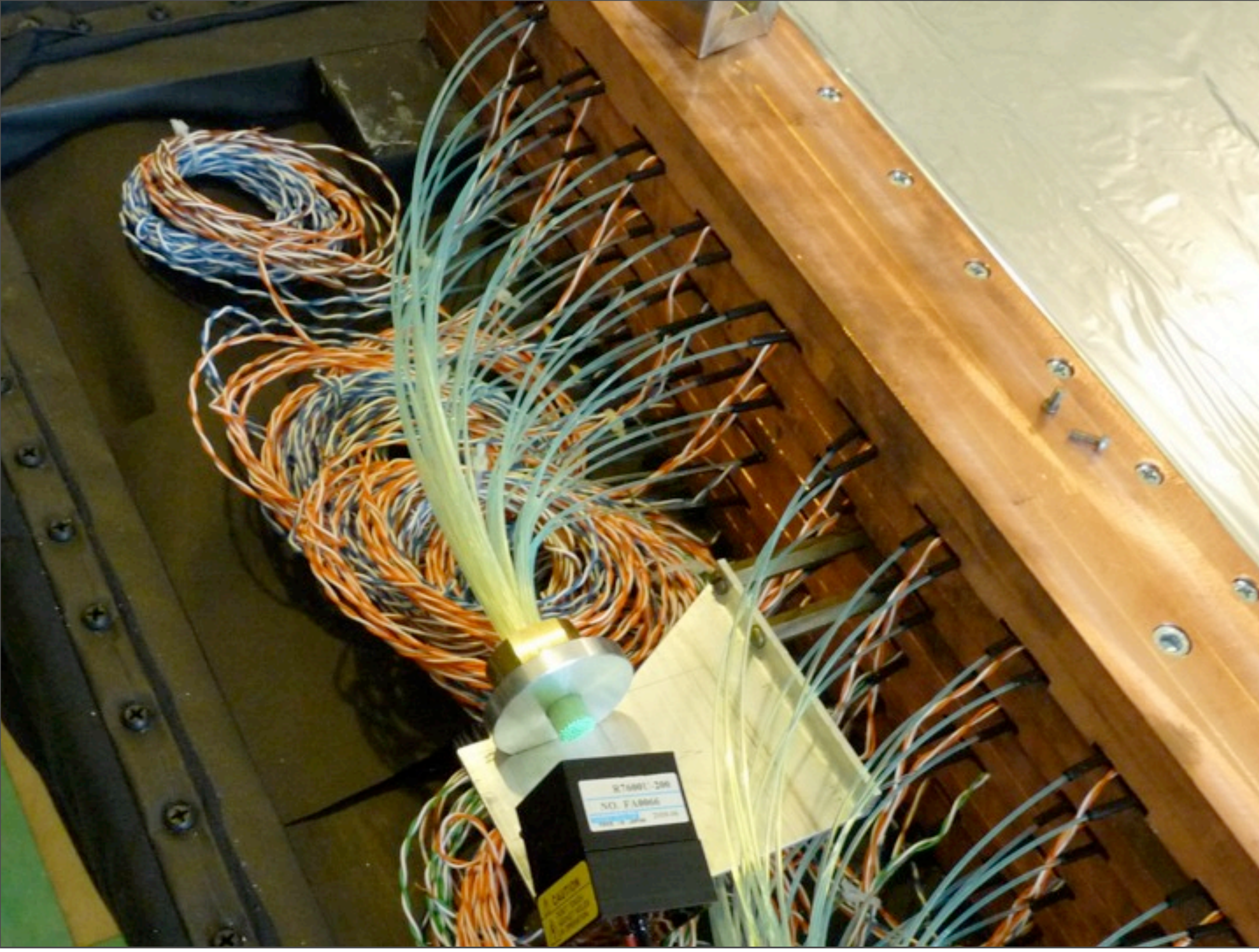

MPPC


MPPC
Twisted pair (to PA)


MPPC
Twisted pair (to PA)
2 fibes to PMT

Mounting table
(with Cu bottom shielding)

Mounting of the first section




LOMOND


LOMOND

The section #0 was dismounted and sent to Moscow (our ITEP-members of the team are playing with it now).

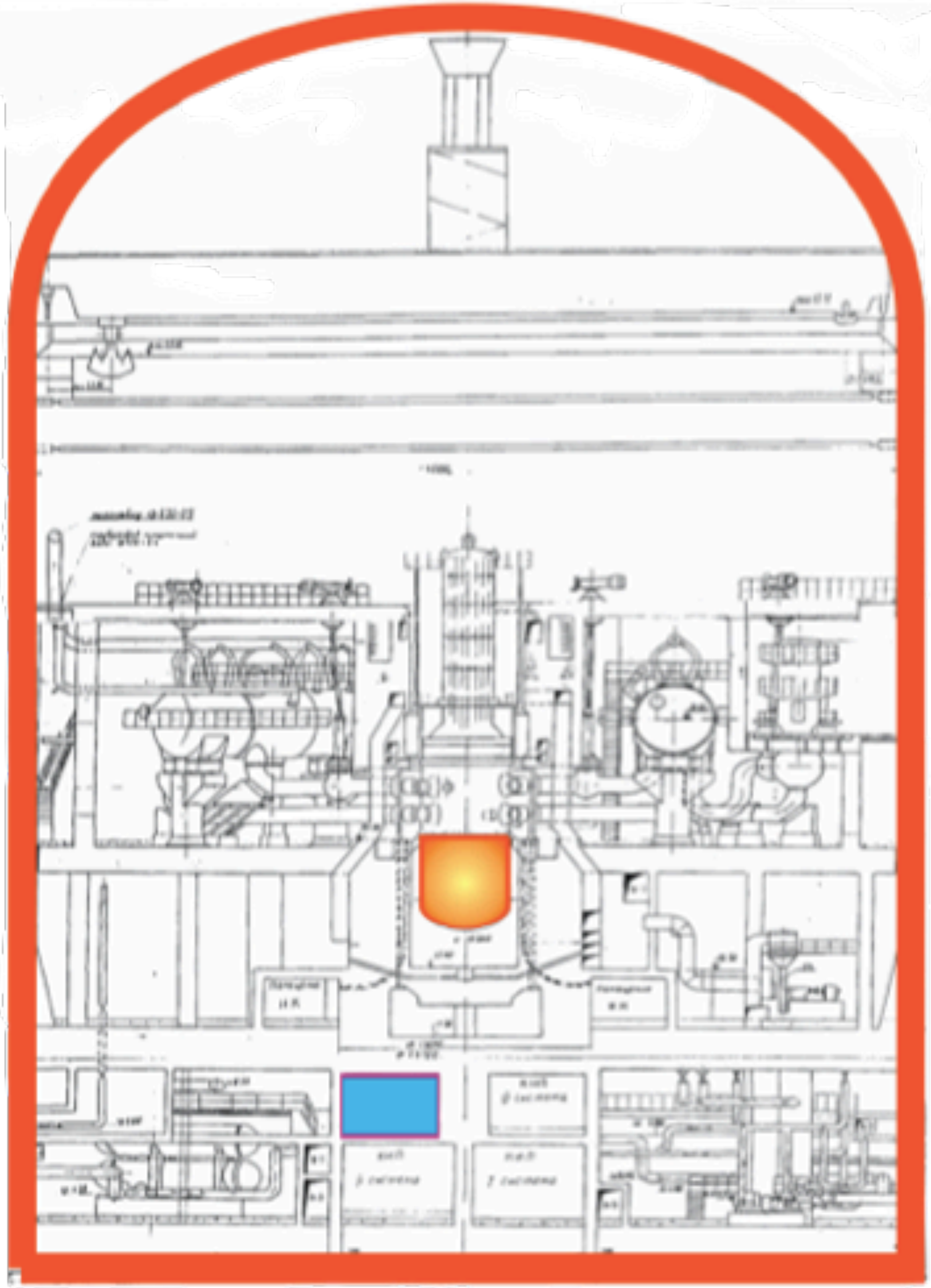
After some corrections we have started production of the sections #1, #2, etc.

The GEMMA-1 site:

Reactor unit #2 of the

“Kalinin” Nuclear Power Pla

(400 km North from Mosco



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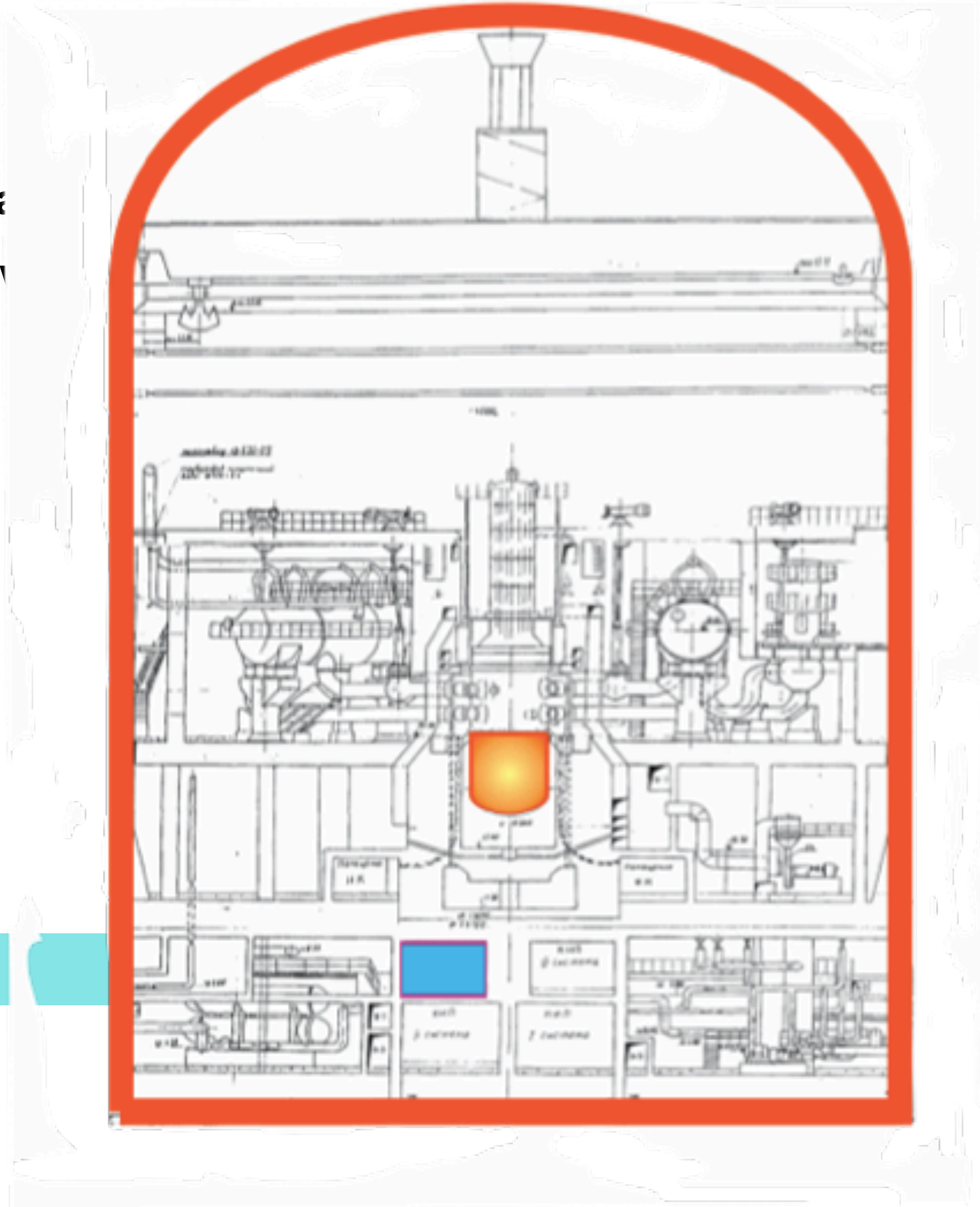


Technological room
just under reactor
14 m only!
$2.7 \times 10^{13}\ \nu/cm^2/s$

The GEMMA-1 site:

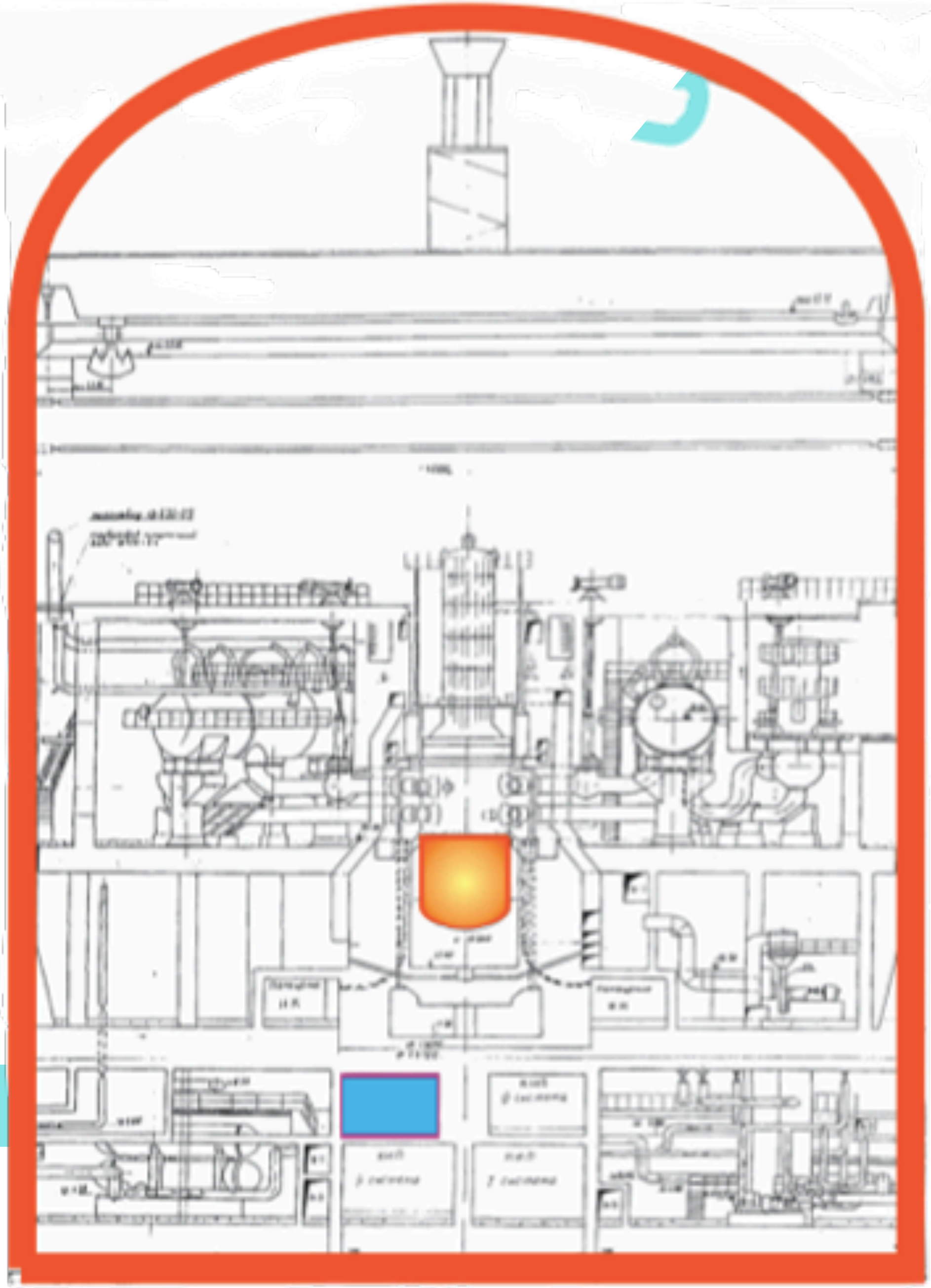
Reactor unit #2 of the

"Kalinin" Nuclear Power Pla

(400 km North from Mosco

Overburden
(reactor, building, shielding, et :
~70 m of W.E.

Technological room
just under reactor
14 m only!
$2.7\times10^{13}\ \nu/cm^2/s$



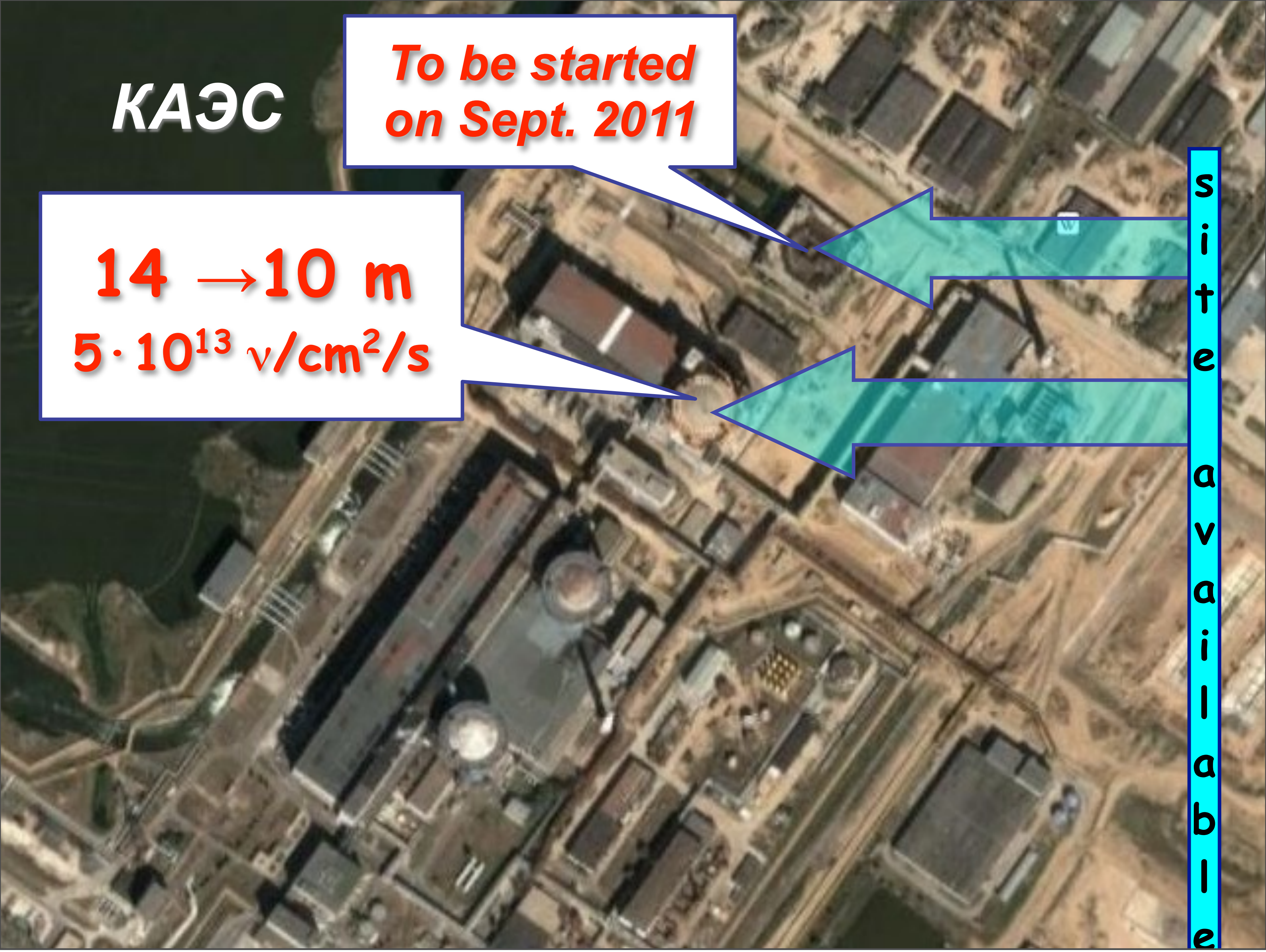
GEMMA background conditions

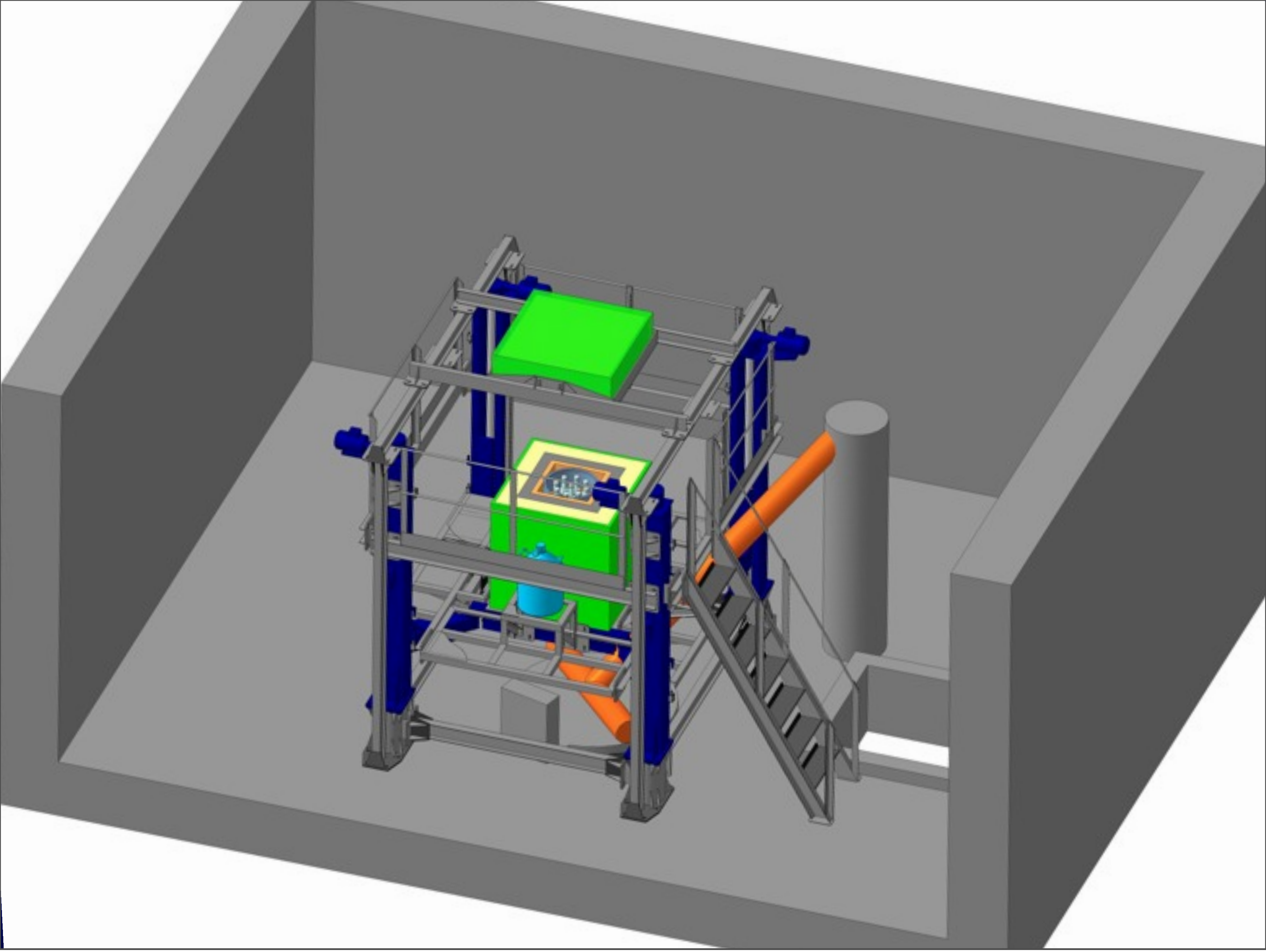
- **γ-rays** were measured with Ge detector. The main sources are: **^{137}Cs , ^{60}Co, ^{134}Cs.**
- **Neutron** background was measured with ^{3}He counters, i.e., thermal neutrons were counted. Their flux at the facility site turned out to be **30 times lower** than in the outside laboratory room.
- **Charged** component of the cosmic radiation (**muons**) was measured to be **5 times lower** than outside.


КАЭС

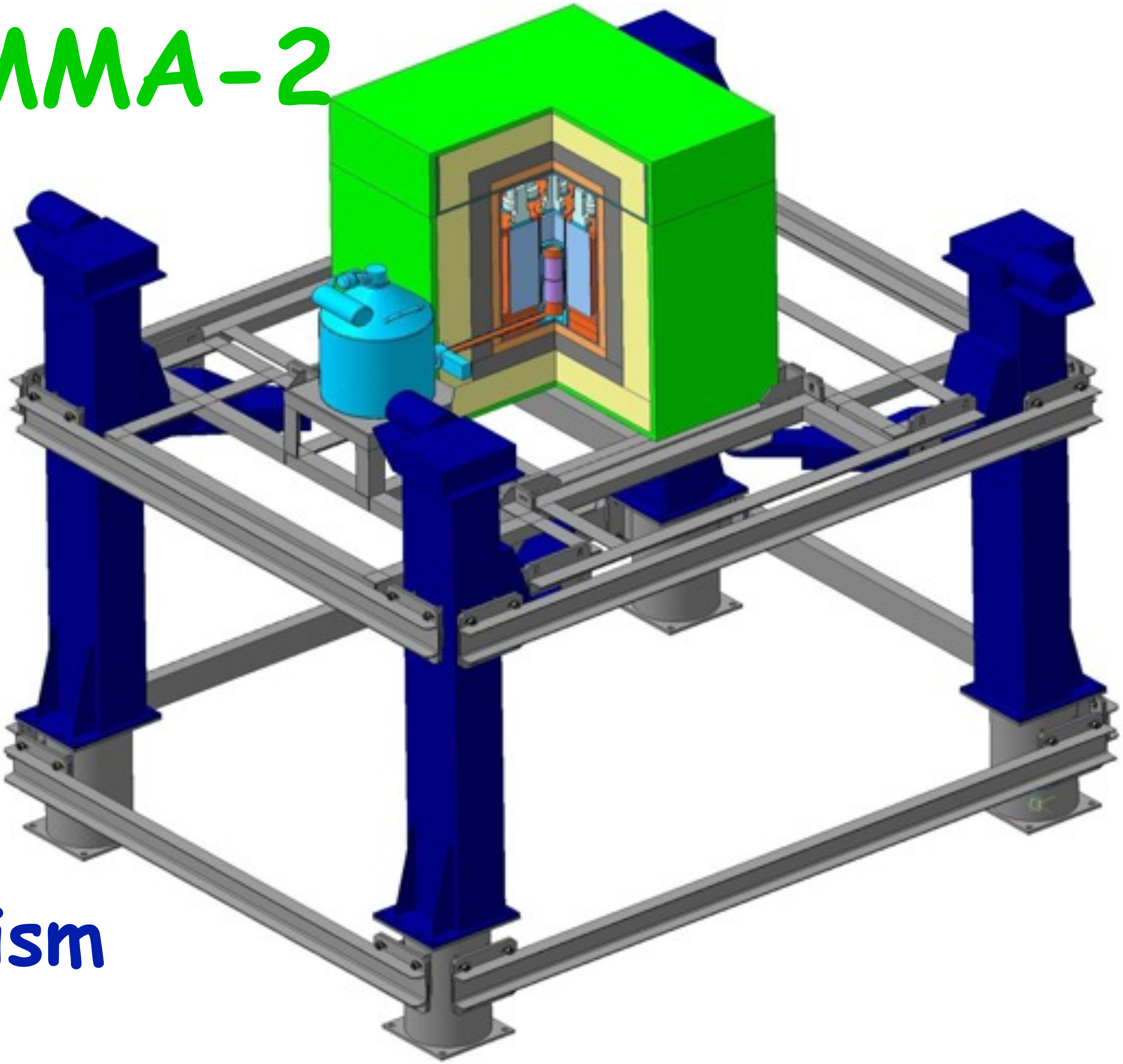

КАЭС
site available


КАЭС
To be started
on Sept. 2011
site available

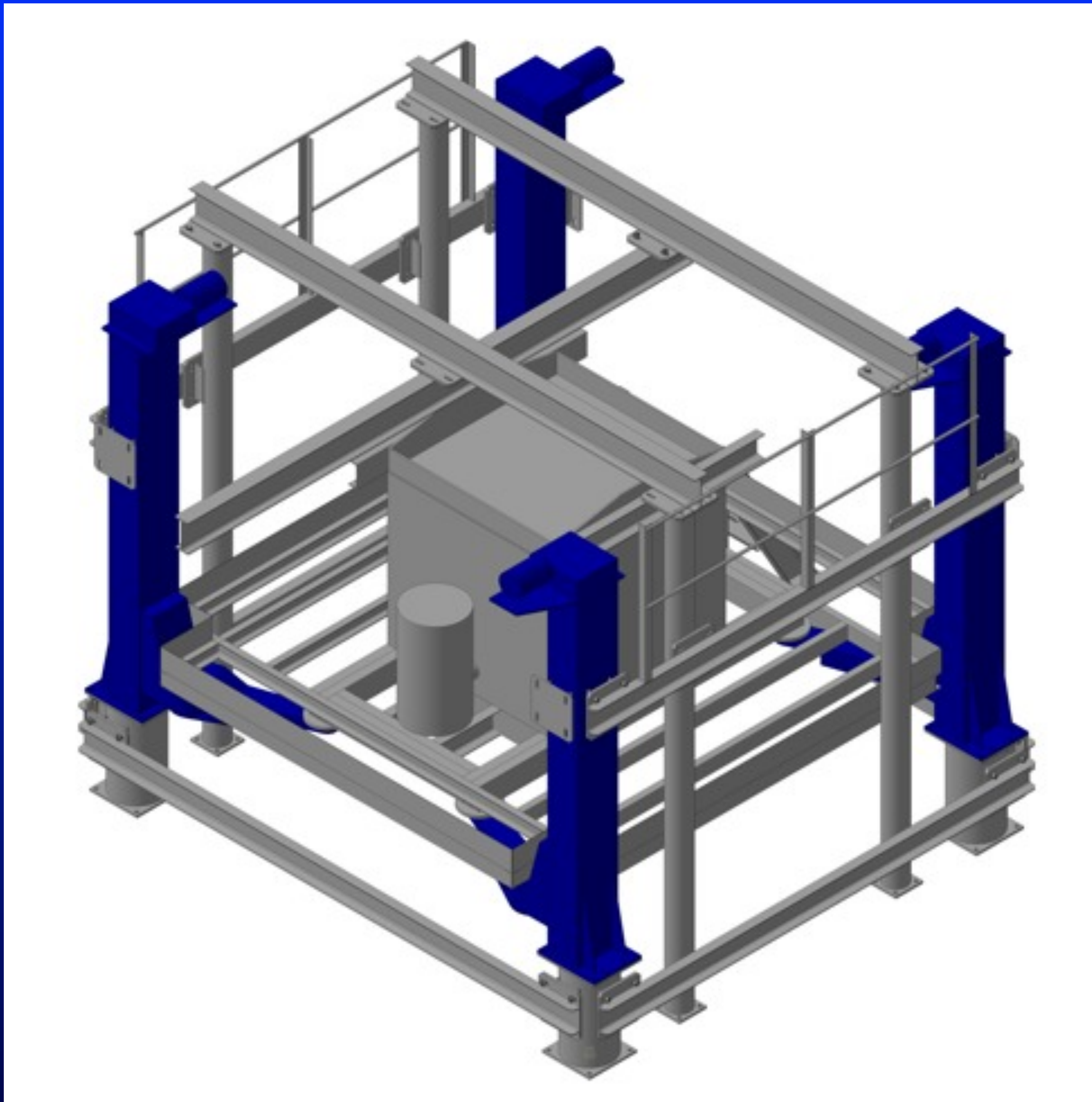

КАЭС
To be started on Sept. 2011
14 →10 m
$5 \cdot 10^{13}$ ν/cm²/s
site available

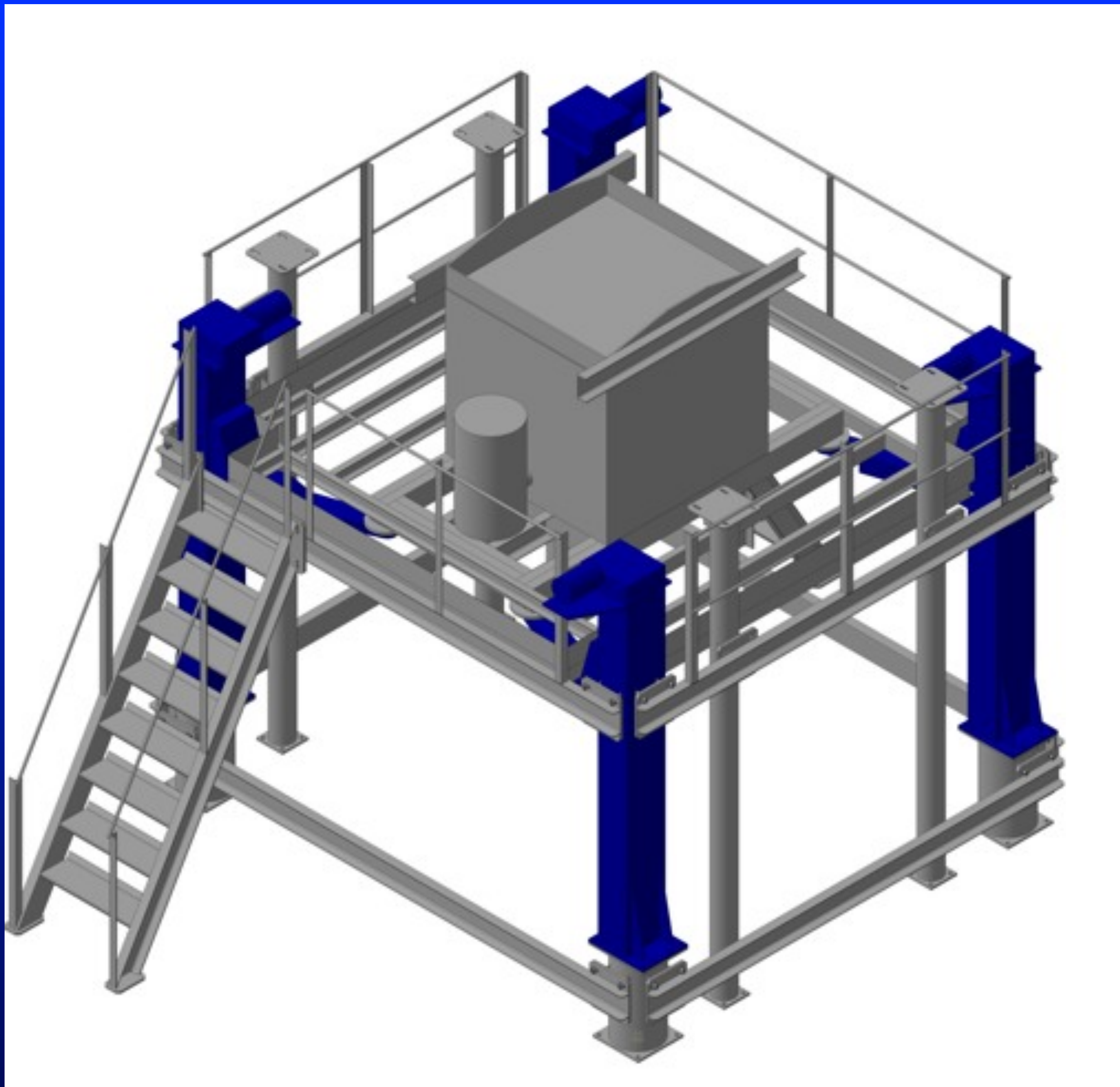


GEMMA-2

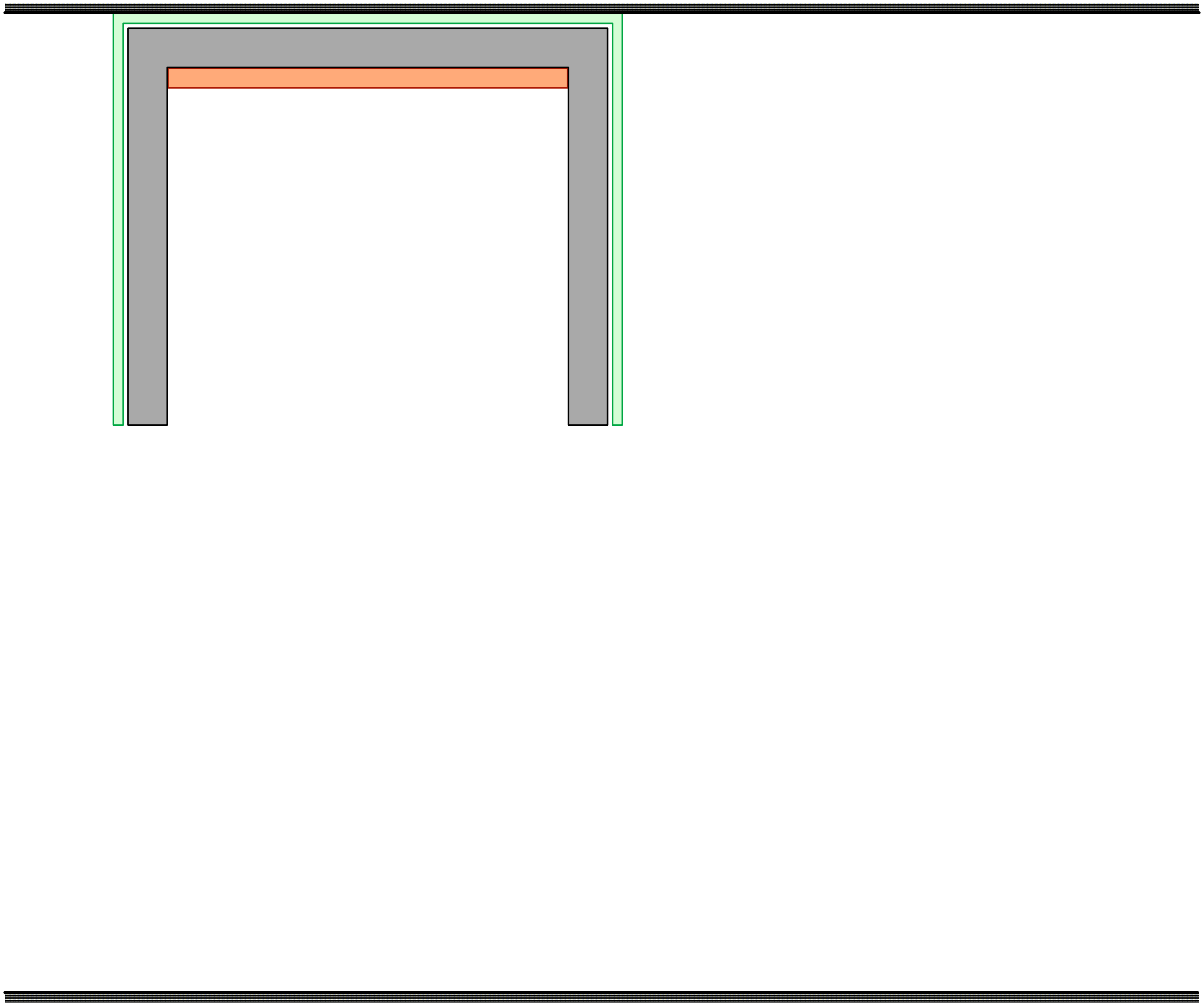


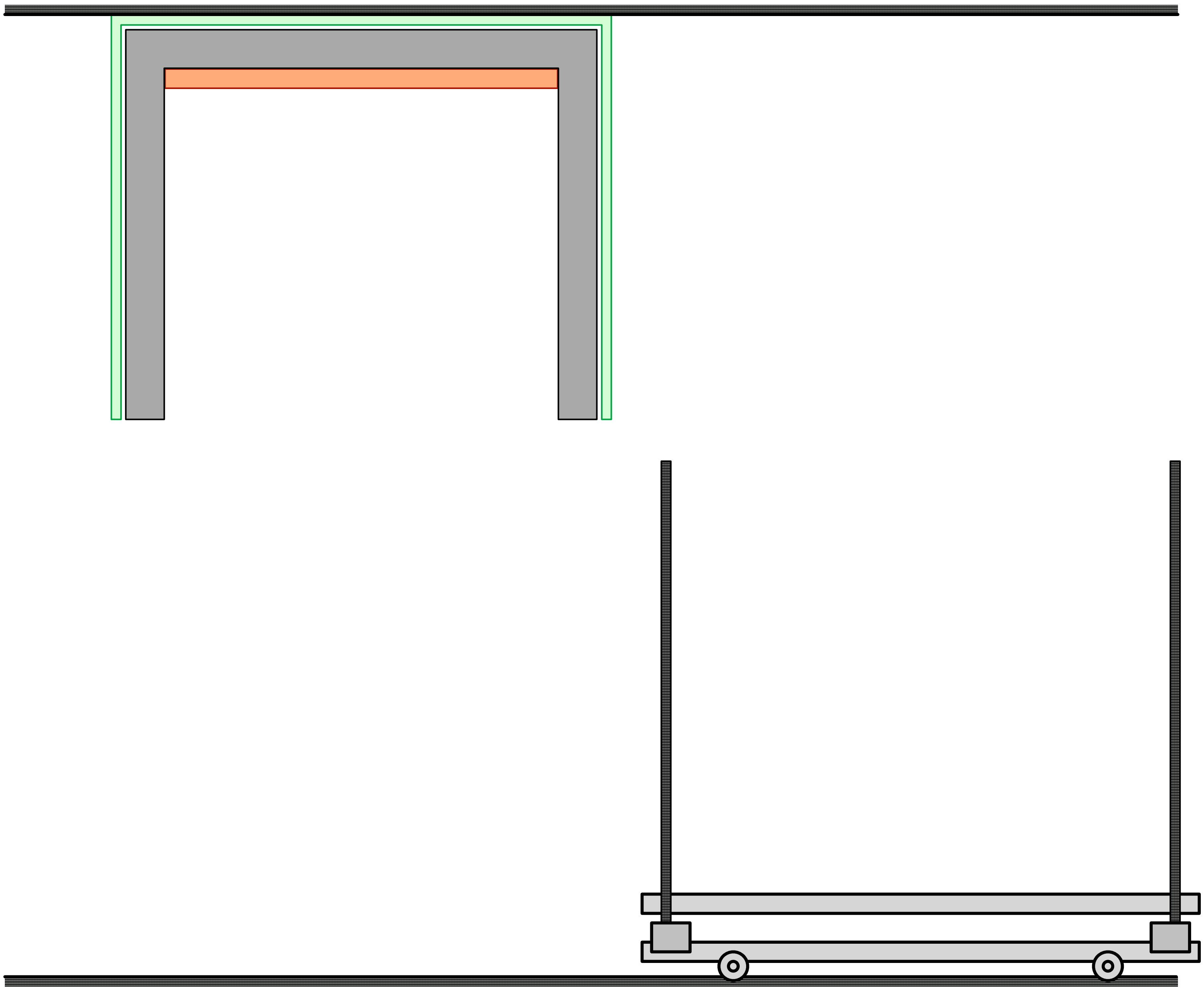
Lifting mechanism

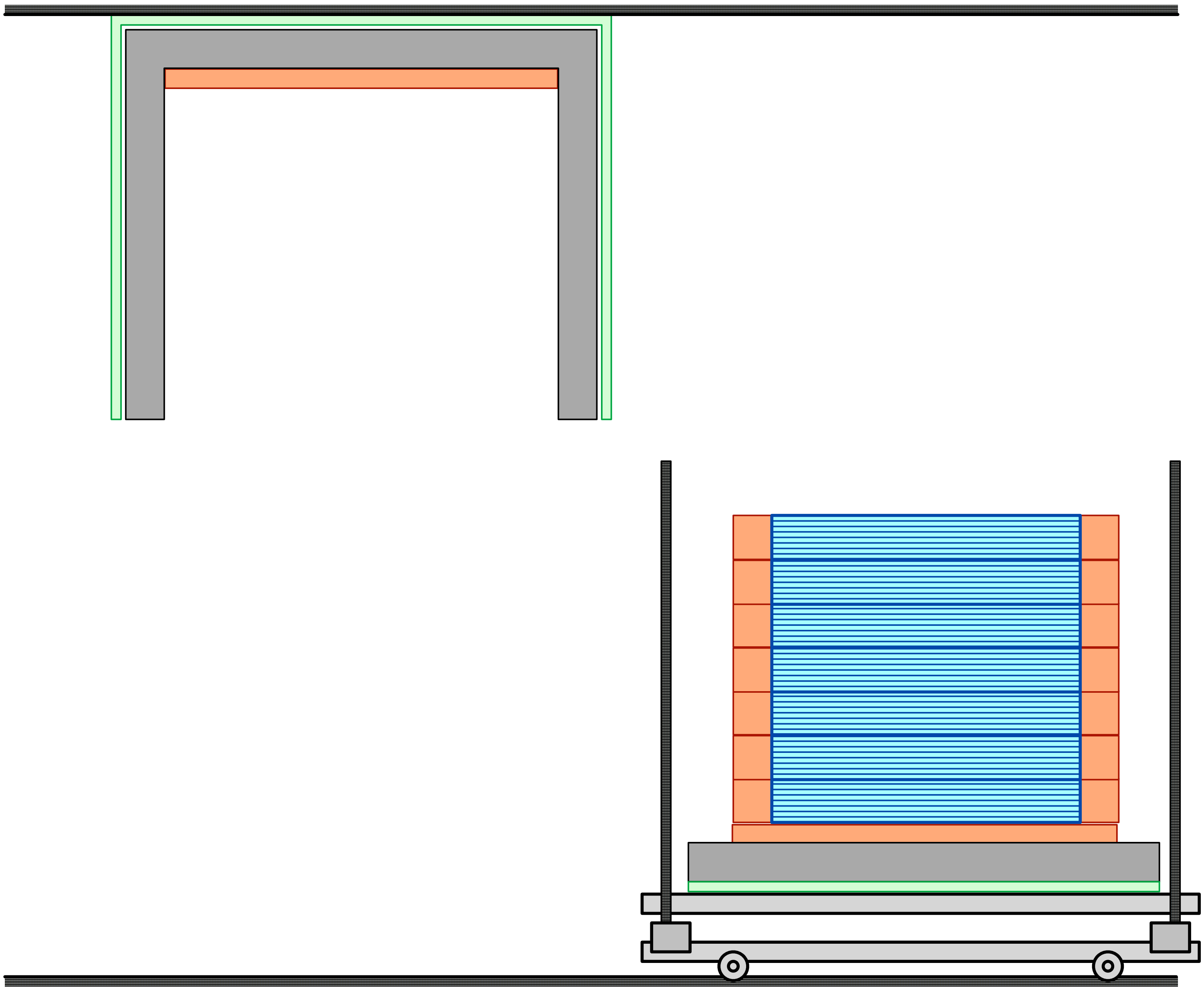


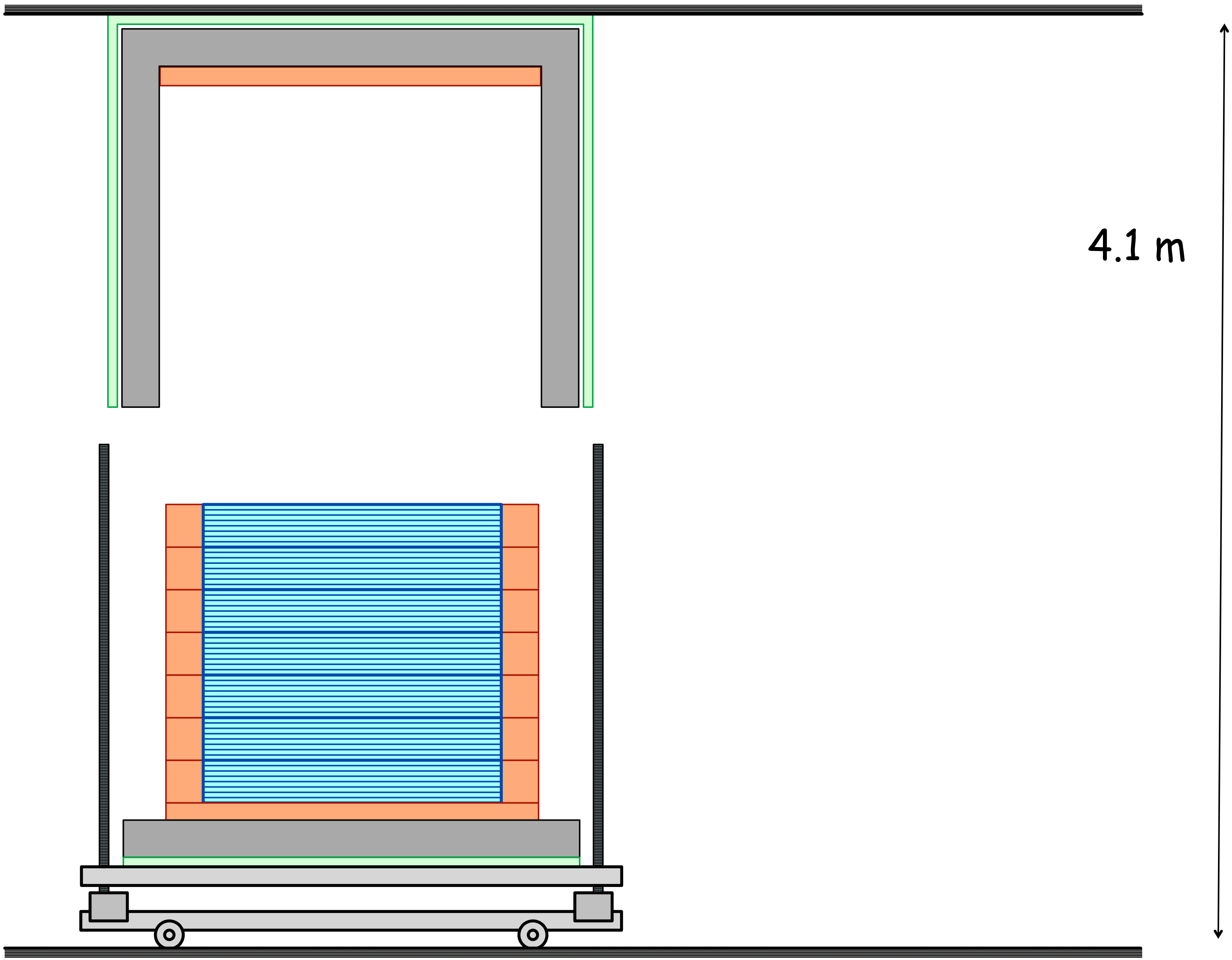


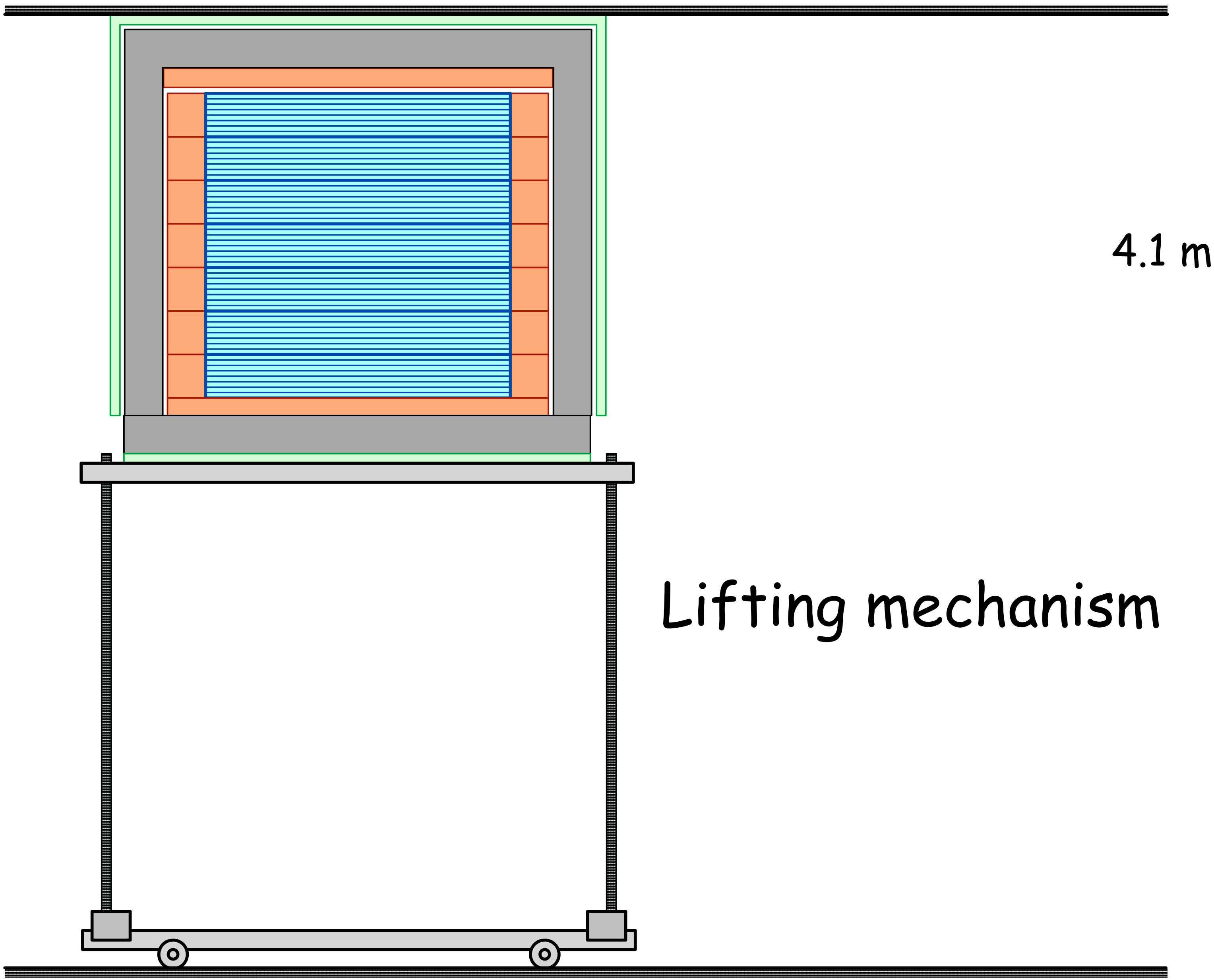

Could we make
the same
for the
DANSS








4.1 m


4.1 m
Lifting mechanism

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 mechanism → measurements at **different distance** → more **reliable data interpretation**.

Expected parameters:

Expected parameters:

- Sensitive volume: 1 m^3

Expected parameters:

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

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  or 10 sections (1m × 1m × 0.1m)

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  { 1 module = 5 × 10 = 50 strips }

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- IBD detection efficiency: **74%**

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- Count rate: **9200 IBD-events per day**

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  or 10 sections (1m × 1m × 0.1m)

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  { 1 module = 5 × 10 = 50 strips }
- IBD detection efficiency: **74%**
- Count rate: **9200 IBD-events per day**
- Background: 40-50 events per day

Expected parameters:

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

  or 10 sections (1m × 1m × 0.1m)

  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***

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- Background: 40-50 events per day
- Due date: section №0 – ***Feb 2010***

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