IEAP CTU activities related to the SuperNEMO, next generation ββ decay, experiment

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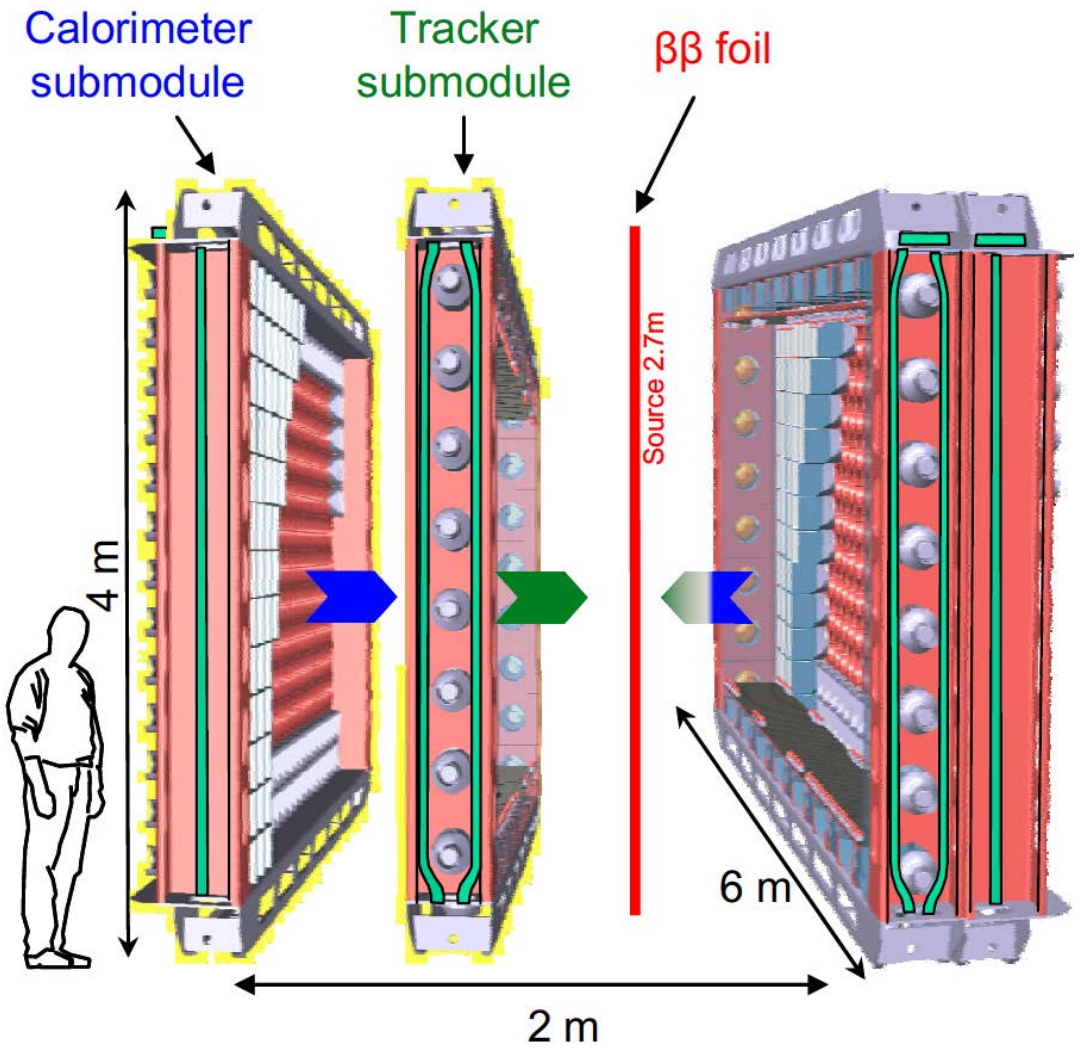
SuperNEMO experiment



First “demonstrator” module → in mid 2016

IEAP CTU group take care of:

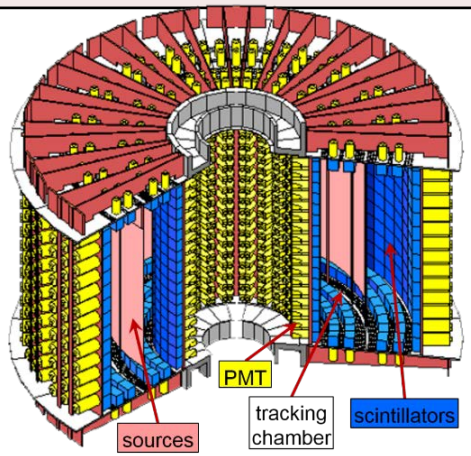
- **Theory** → Calculations of NME of $0\upsilon\beta\beta$ (A.S.)
- **SN calorimeter** → $\Delta E/E$ of scintillating detectors
- **Construction of SN frame**
- **Selection of proper radiopure materials** → OBELIX detector (E.R.)
- **Radon programme** → removal of Rn from air (K.S.)
  → diffusion, emanation, ultra-low activities (F.M.)

- **In the near future** → Installation of calorimeter part at LSM underground lab
  → Data analysis

NEMO3		SuperNEMO
^{100}Mo	isotope mass	^{82}Se (^{150}Nd or ^{48}Ca)
7 kg		100 - 200 kg
18 %	signal efficiency	> 30 %
^{208}Tl ~ 20 μBq/kg ^{214}Bi < 300 μBq/kg Rn ~ 5 mBq/kg	contaminations in the source foil Rn in the tracker	^{208}Tl ~ 2 μBq/kg ^{214}Bi < 10 μBq/kg Rn ≤ 0.2 mBq/kg
~ 15 % @ 1 MeV	Calorimeter FWHM	~ 8 % @ 1 MeV
$T_{1/2}(0\nu\beta\beta) > 2 \times 10^{24}$ y $\langle m_\nu \rangle < (0.3 - 0.9)$ eV	half-life sensitivity effective neutrino mass	$T_{1/2}(0\nu\beta\beta) > 1 \times 10^{26}$ y $\langle m_\nu \rangle < (0.04 - 0.11)$ eV

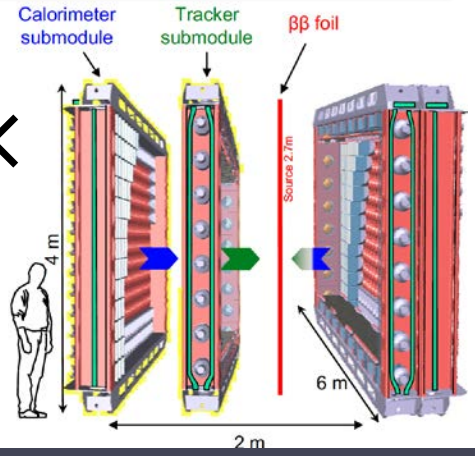
Since 2006

R&D



$$T^{0\nu}_{1/2} > \sqrt{\frac{1}{\Delta E}}$$

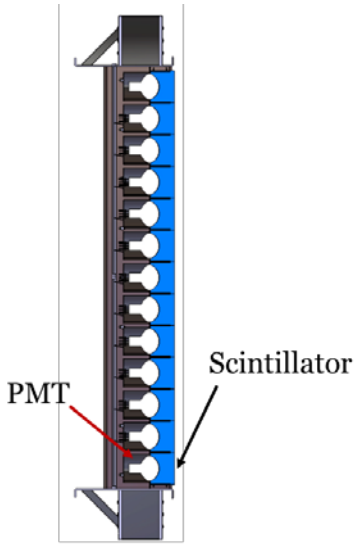
20×



Within this experimental work, IEAP CTU group closely cooperates with the Czech company, **ENVINET a.s. - NUVIA group**, which is a producer of the plastic scintillators based on polystyrene.

- Cca 400 pieces of scintillators for SN main wall (250 ready), cca 180 pieces for SN x-wall (ready)
- 200 000 € (SN collaboration)

The aim → optimization of concentration of **pTP** and **POPOP fluorescent additives** in the scintillating detector in order to improve the energy resolution.



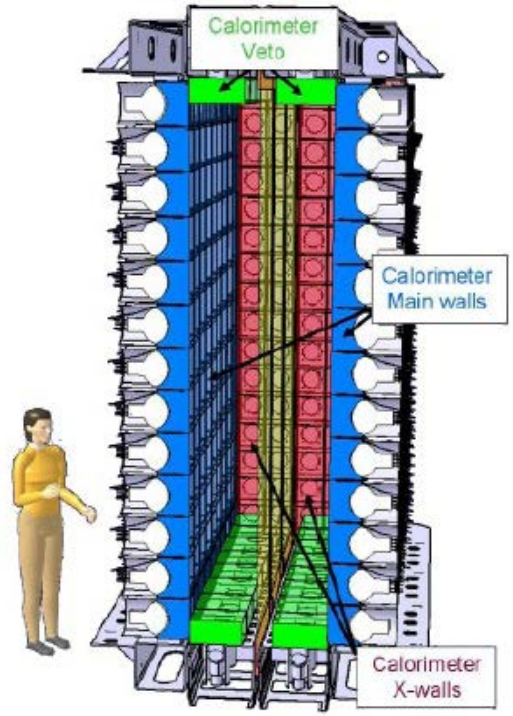
Main wall of the SN detector

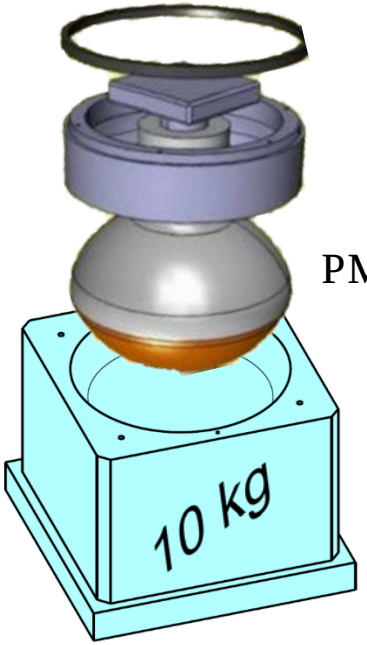
For the comparative measurement:

- 13 scintillating block with different pTP and POPOP concentrations

pTP [%] \ POPOP [%]	0,05	0,025	0,0125		
0,6					
1					
1,5	0,05	0,025	0,01	0,005	0,0025
2					
2,5					
3					
3,5					

SuperNEMO scintillating module



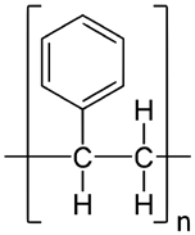


PMT

scintillator

23.6×23.6×19.4 cm^3

Plastic base → solvent



Polystyrene

$(C_8H_8)_n$

+

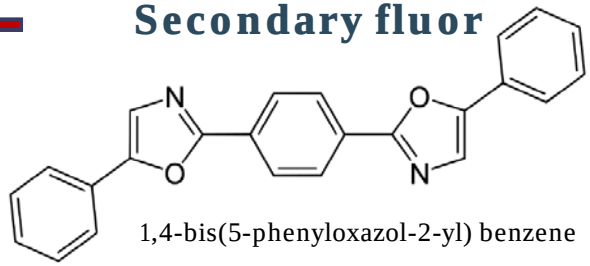
Primary fluorescent emitter → fluor

pTP → para- Terphenyl

$(C_{18}H_{14})$

+

Secondary fluor

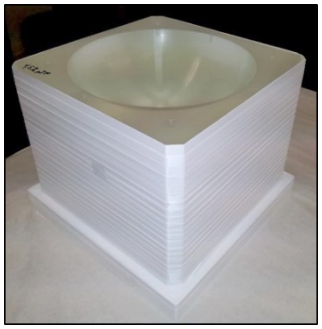


1,4-bis(5-phenyloxazol-2-yl) benzene

POPOP

$(C_{24}H_{16}N_2O_2)$

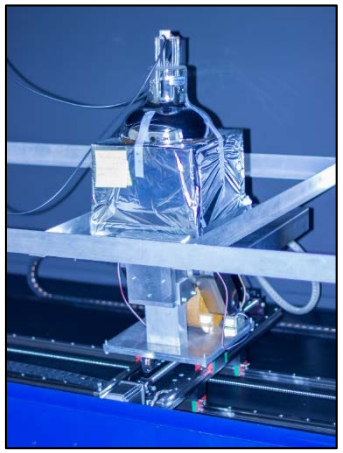
Wrapping (to ensure reflexivity)



Teflon tape
3×200 μm

Mylar foil
15 μm

8” Hamamatsu
R5912 PMT

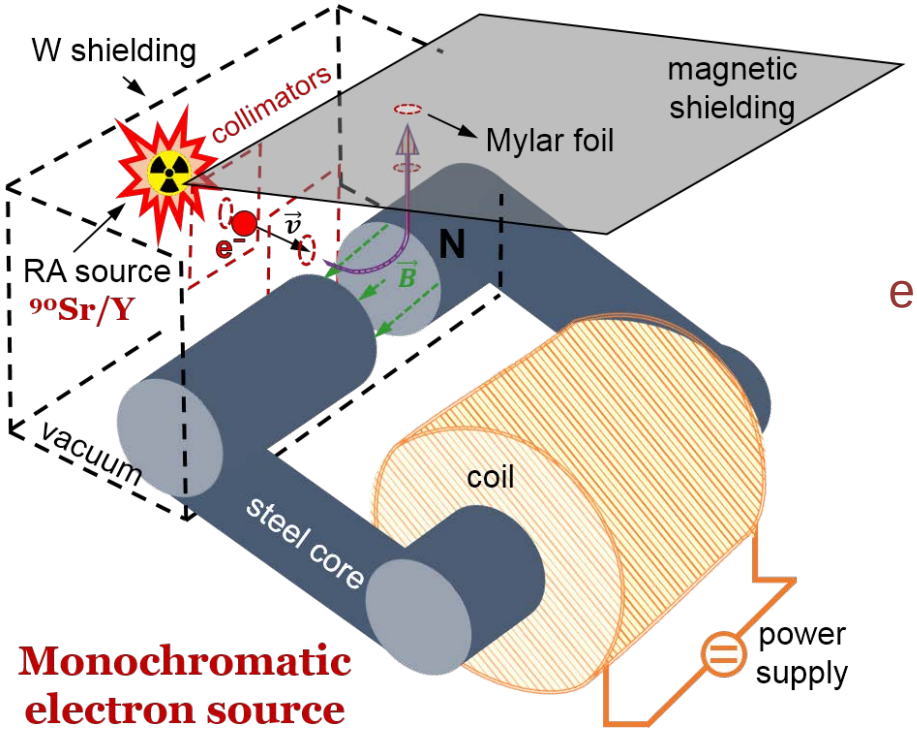


Connected to
e^- source

Lightproof box

Experimental setup

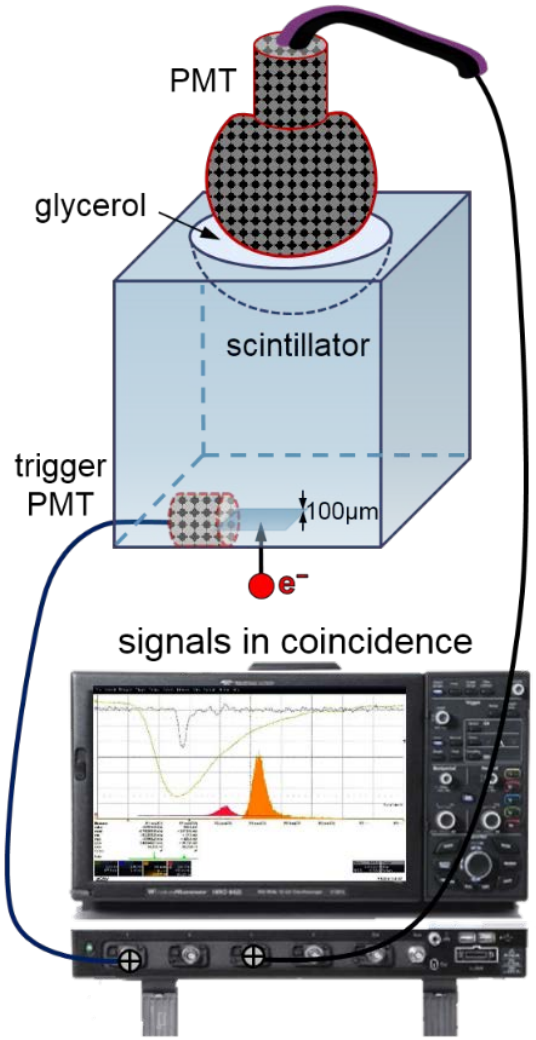
Experimental procedure



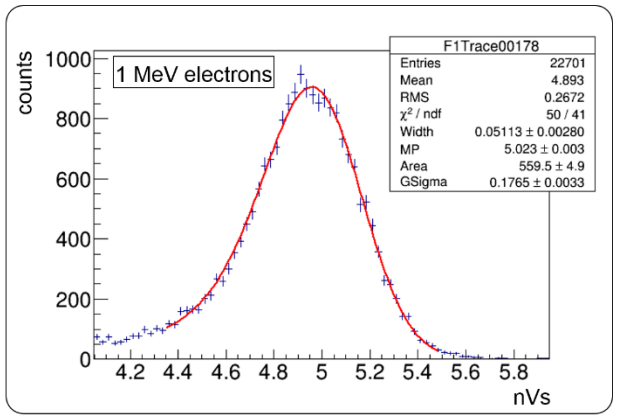
Monochromatic electron source

Electron energy range (0.4 – 1.6) MeV

@ 1500 V



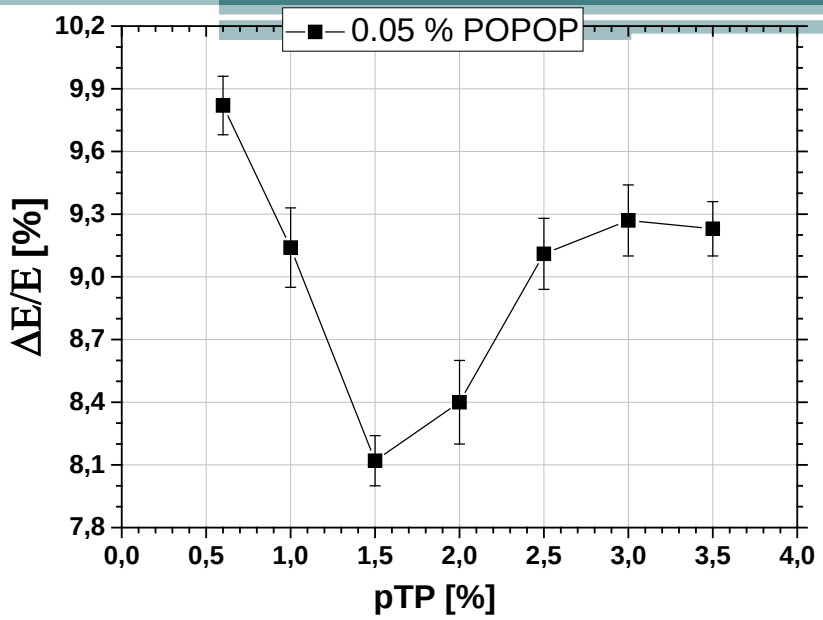
LeCroy Wave Runner 610Zi



Data analysis

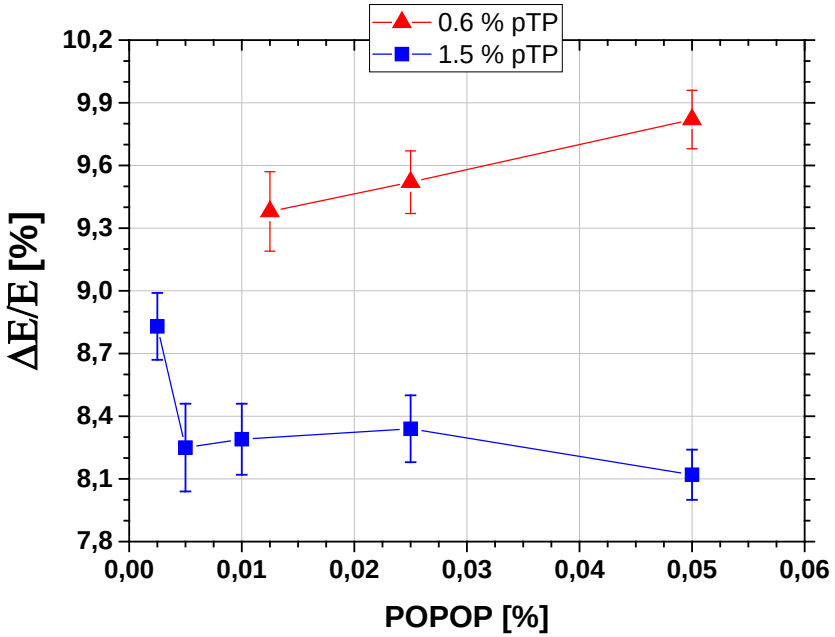
1 MeV electron spectrum fitted by Landau function convoluted by Gauss distribution

The influence of the **pTP** amount on the **ΔE/E**
@ **0.05 % POPOP**



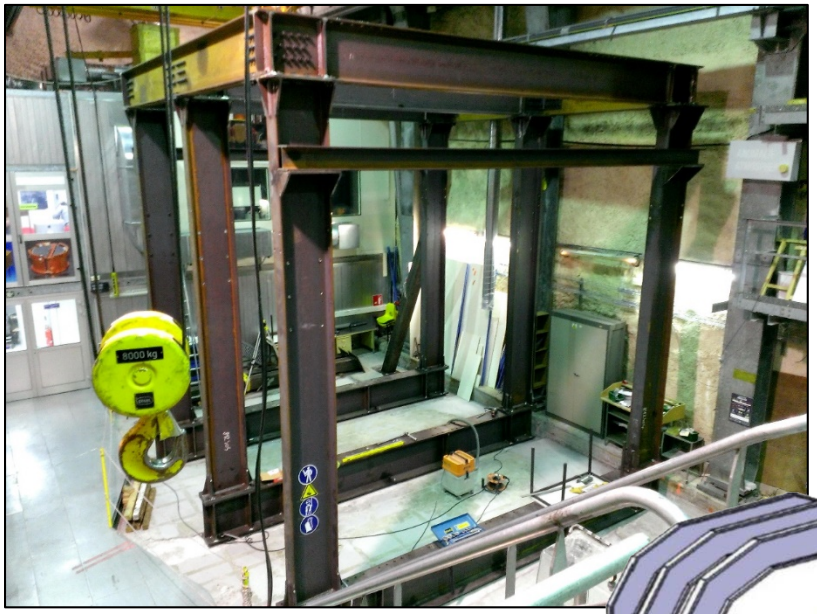
Tested with 1 MeV electrons

The influence of the **POPOP** amount on the **ΔE/E**
@ **0.6 % pTP**
@ **1.5 % pTP**

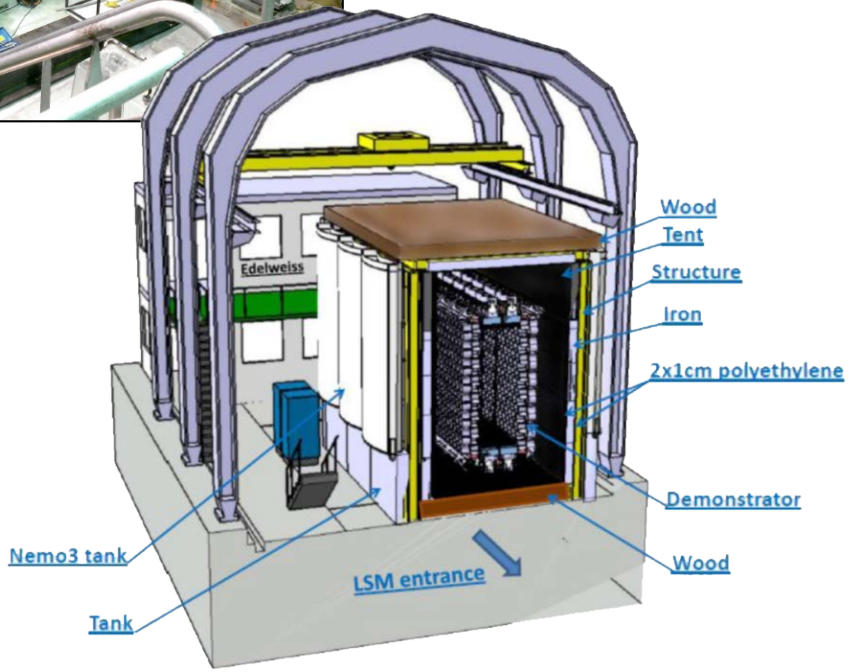


Frame for the first SN module

May 2013



February 2015

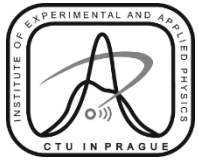


Produced by:

- Transporta Czech Republic a.s. (Chrudim)
- 35 000 € (IEAP)

Calorimeter Summary

- Improved ΔE/E for blocks for SuperNEMO experiment @ 1.5 % pTP and 0.05 % - 0.005 % POPOP.
- Results comparable with PVT based scintillators (~ 4x more expensive).
- Verification of Prague results at CENBG Bordeaux successful. Good agreement of Prague/Bordeaux results.
- Submitted as a patent application.



- Ivan Štekl, Petr Přidal, Karel Smolek, L. Fajt, M. Špavorová, E. Rukhadze, P. Kouba, M. Bukový, F. Mamedov, A. Smetana, F. Šimkovic

- Fabrice Piquemal, Cédric Cerna, Jean Jouve, Christine Marquet

Thank you for your attention

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Homogeneity measurement

@ 2 % pTP & 0.05 % POPOP