# Studies of the NeuRad detector properties of the EXPERT project

**Muzalevsky Ivan**

Dubna 2017

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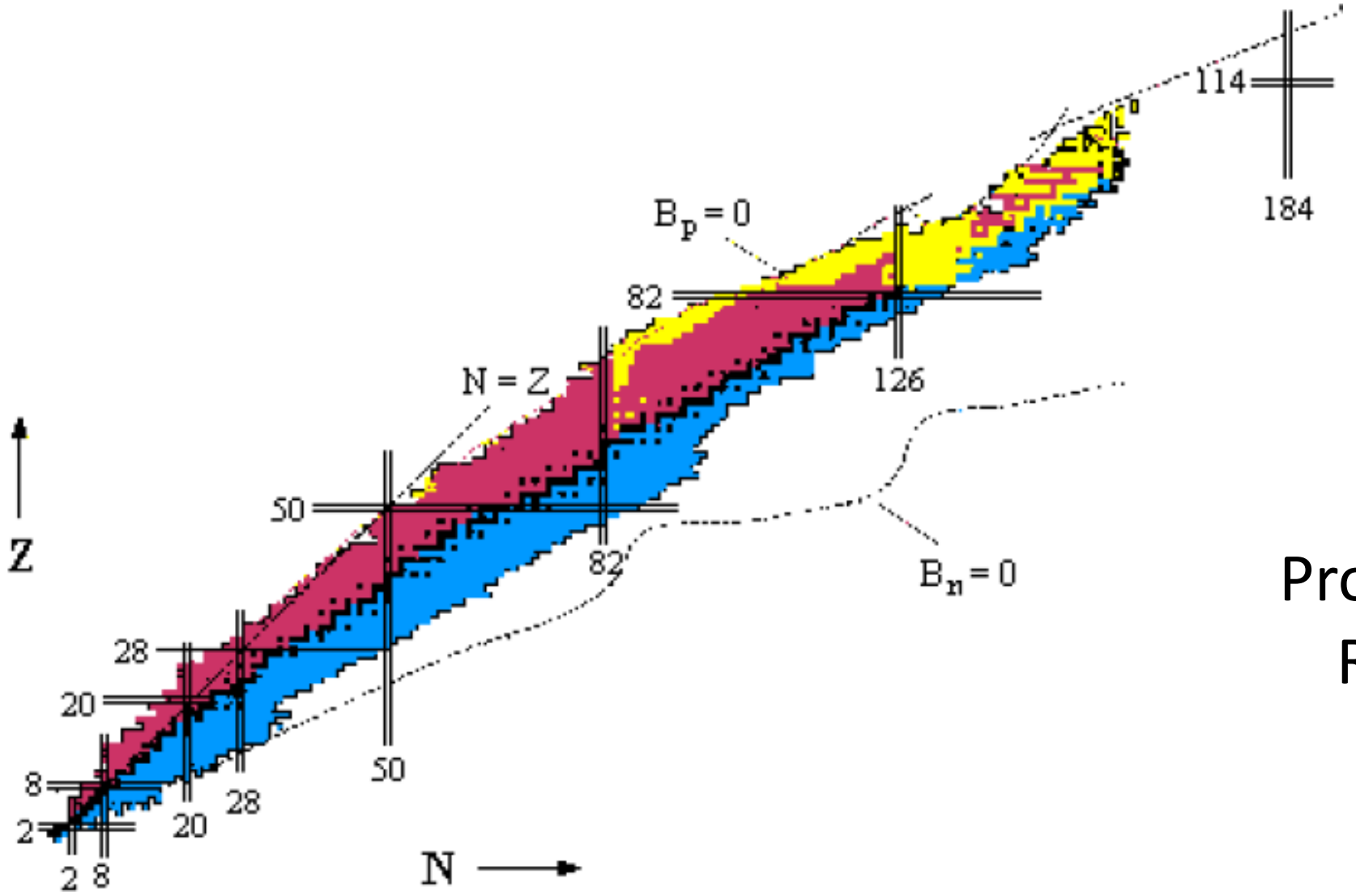


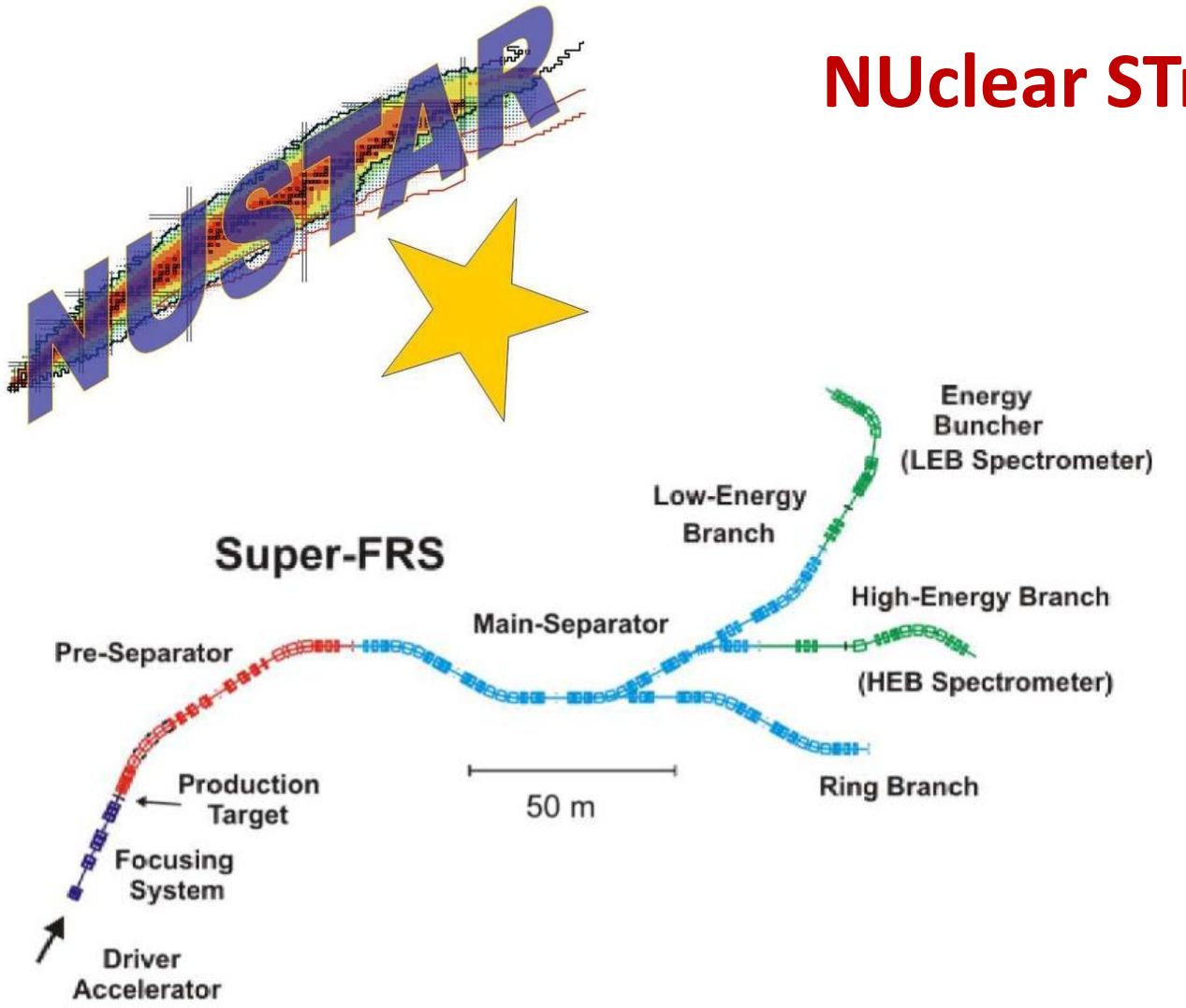

Nuclear map.
Driplines – are borders between bound and unbound nuclei

Exotic nuclei phenomena:

- Neutron halo
- Soft mode of dipole excitation

Producing exotic nuclei.
Radioactive beams!

# NUclear STructure Astrophysics and Reactions



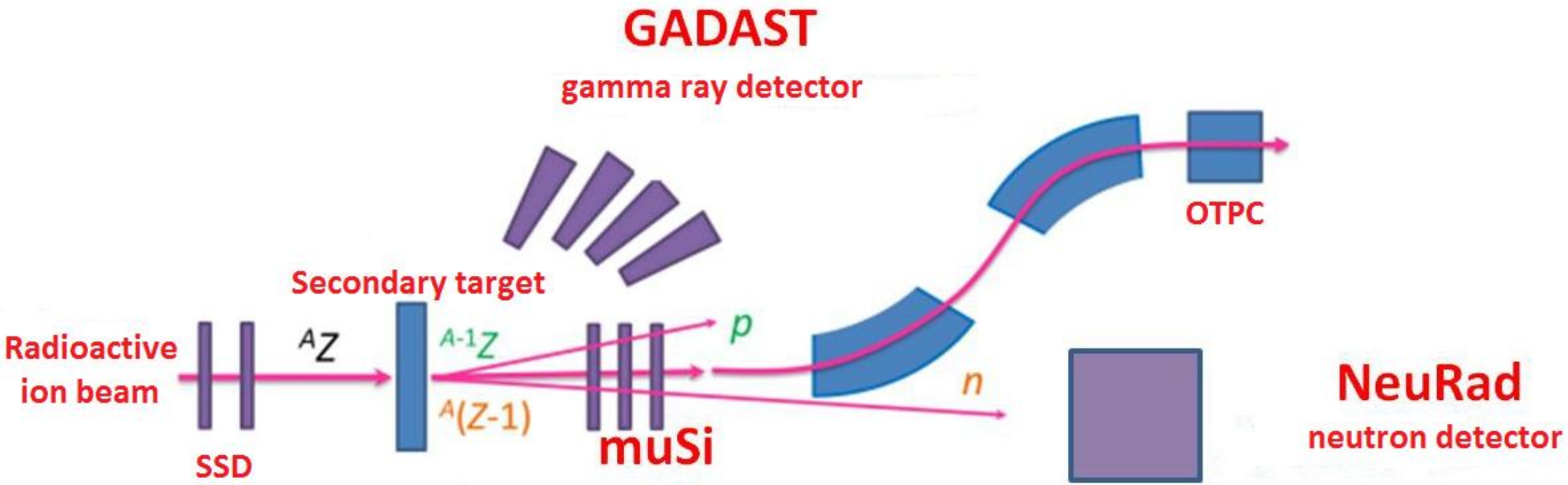

## Super-FRS Experiment Collaboration

## EXPERT (EXotic Particle Emission and Radioactivity by Tracking)

# EXPERT project

- nuclear states beyond driplines
- new types of radioactivity
- exotic decays

# Components of the EXPERT setup



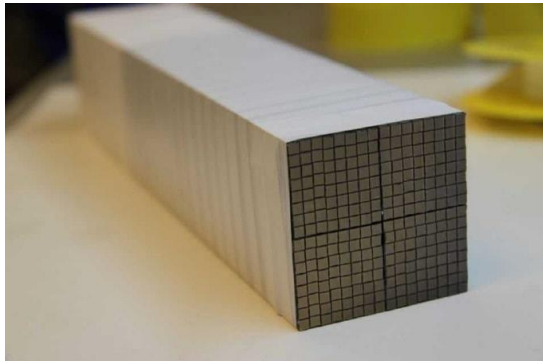
# NeuRad

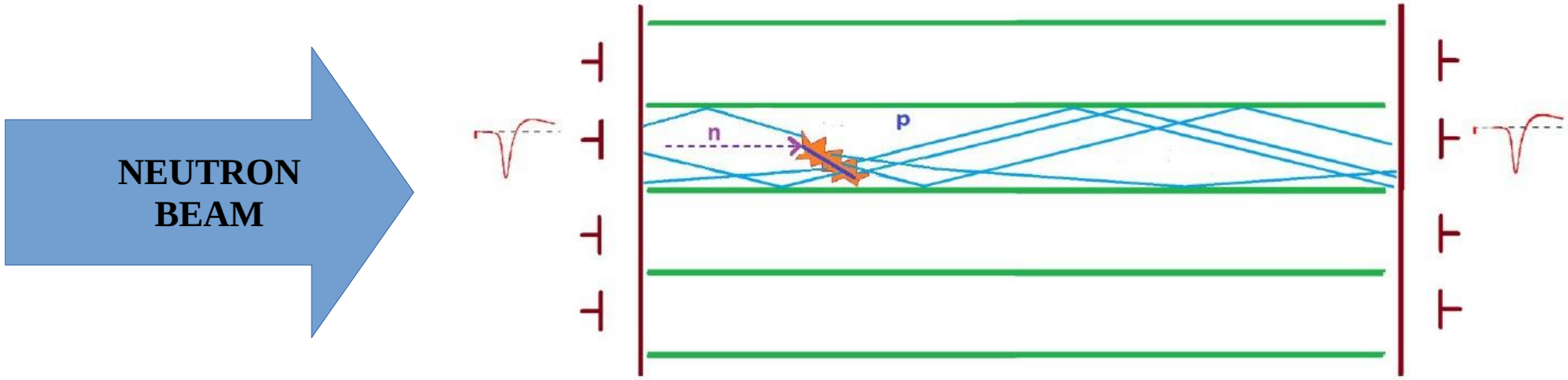
## Neutron Radioactivity detector

More than **10000 fibers** in module structure.

**Bundle:**

- 256 fibers 3x3x1000 mm
- MAPMT from each side






## Neutron emission angle

- **Longitudinal coordinate** of the interaction along the fiber
- **Determination the very first hit**
- Avoid **neutron cross-talk**

# EXPERT software

**EXPERTroot** - framework for Monte-Carlo simulations detector responses signals, reconstruction of events and analysis data of the EXPERT experiment.

- **Simulating of experiment**
  - Detector geometry
  - Digitizing methods
- **Data analysis:** implementing analyzing methods in EXPERTroot interface
  - Constant Fraction Discriminator
  - Leading Edge Discriminator
  - Time-Over-Threshold

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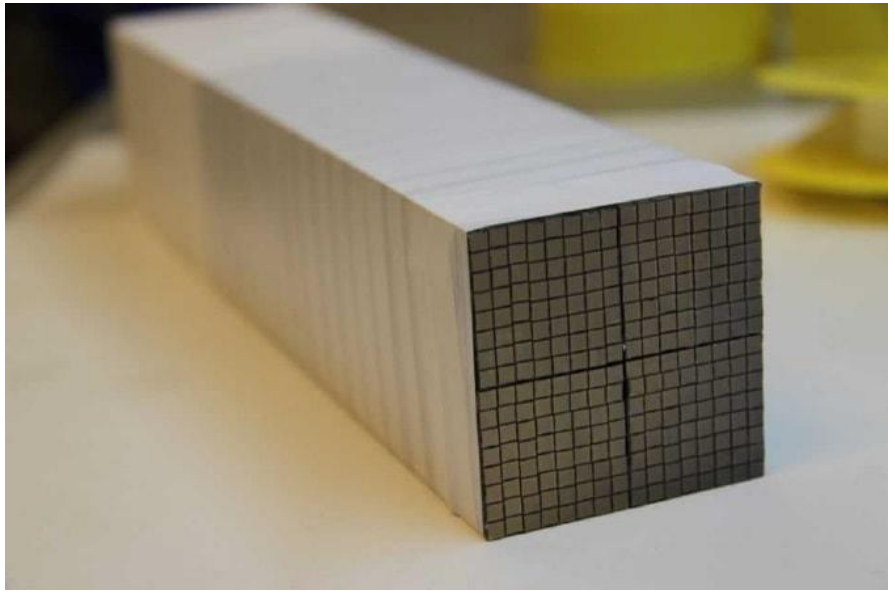
# Simulating experiments

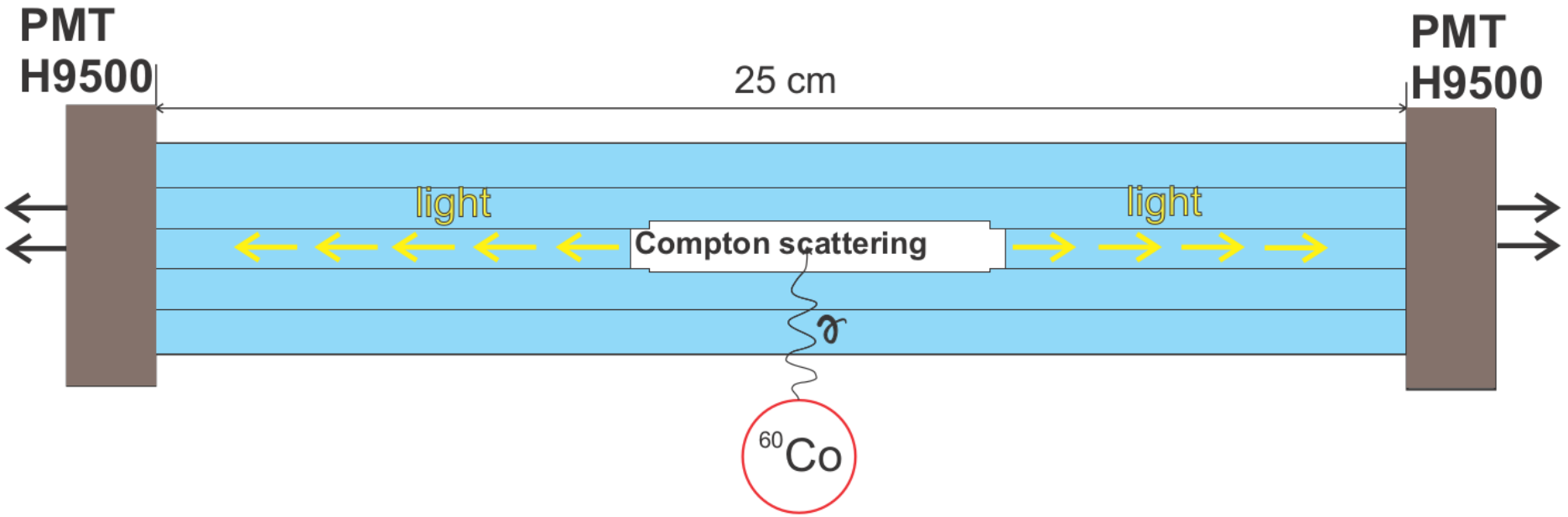
- **Create detector geometry**
- GEANT4 for particle transport
- **Develop digitizing methods for detector responses**

selection of physical parameters

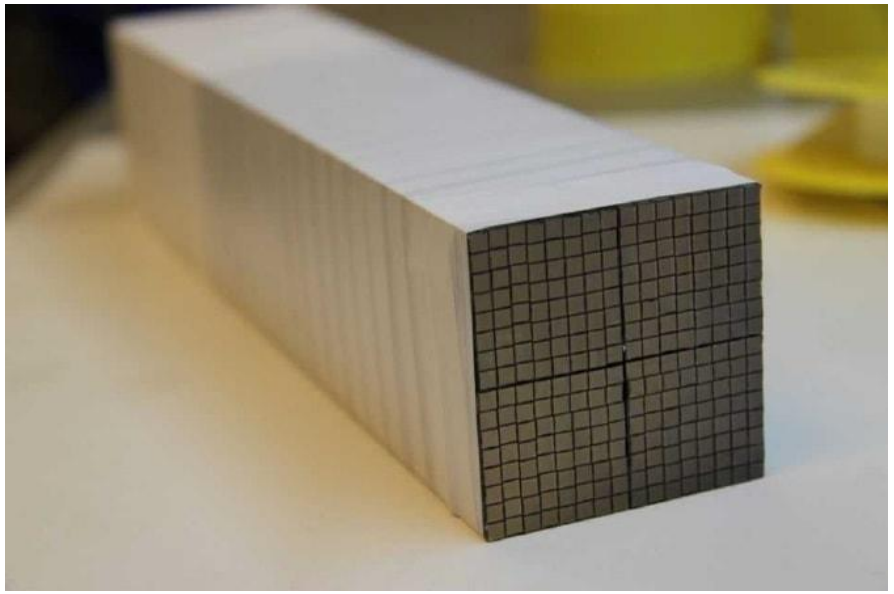
# NeuRad prototype

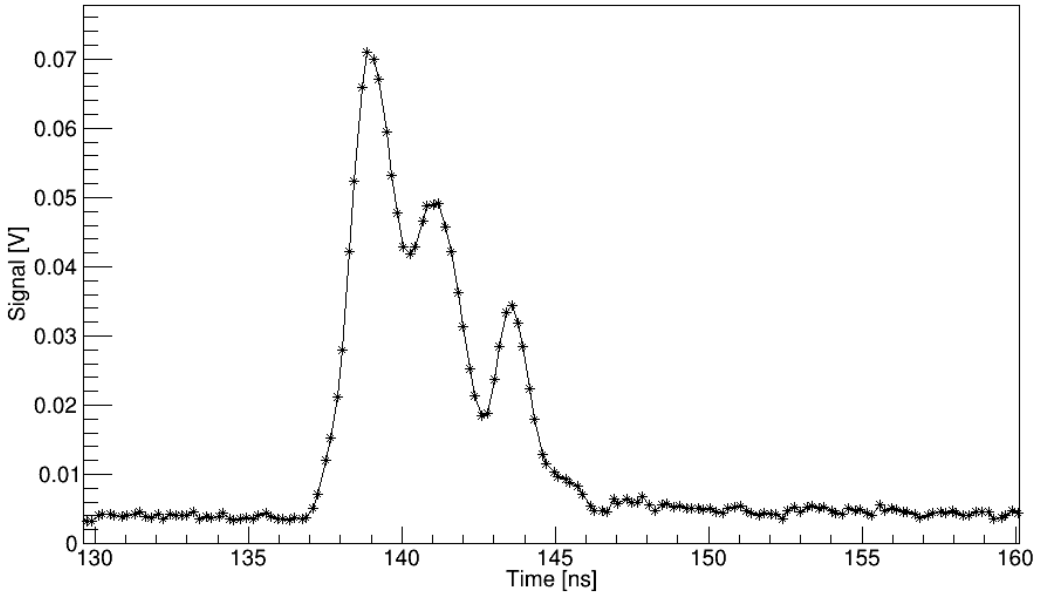
- 256 scintillation fibers 3 x 3 x 250 mm
- MAPMT HAMAMATSU9500
- Source – **60Co**, collimated

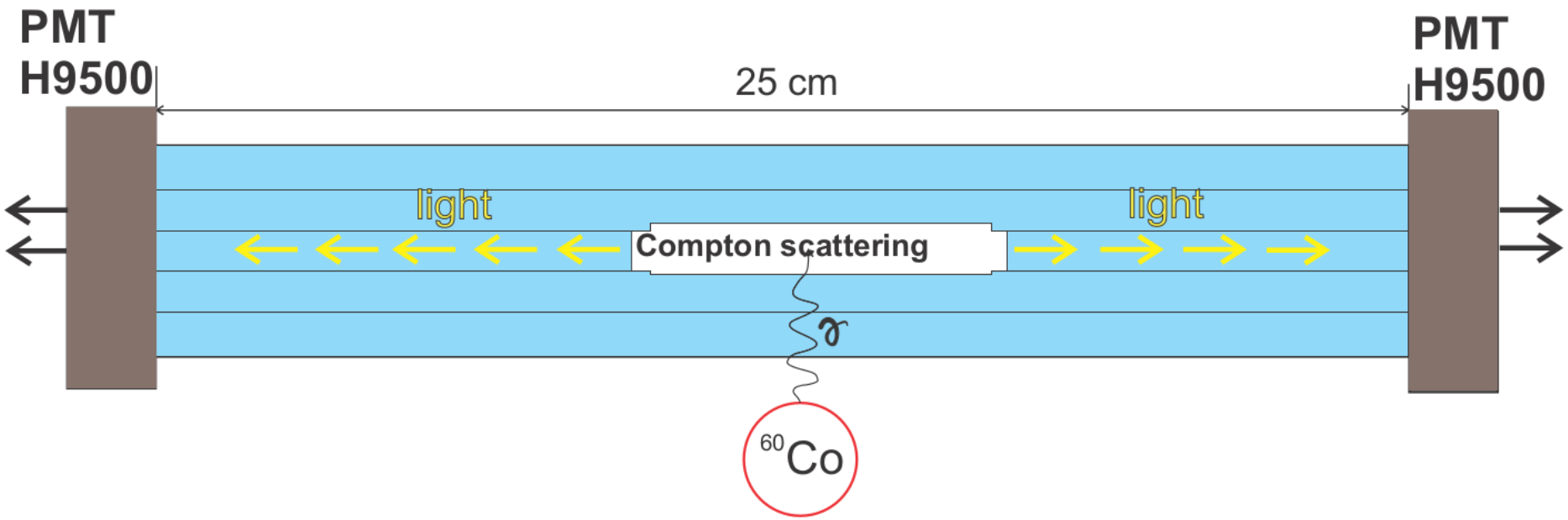





$E_{gamma}$=1173 keV, 1333 keV



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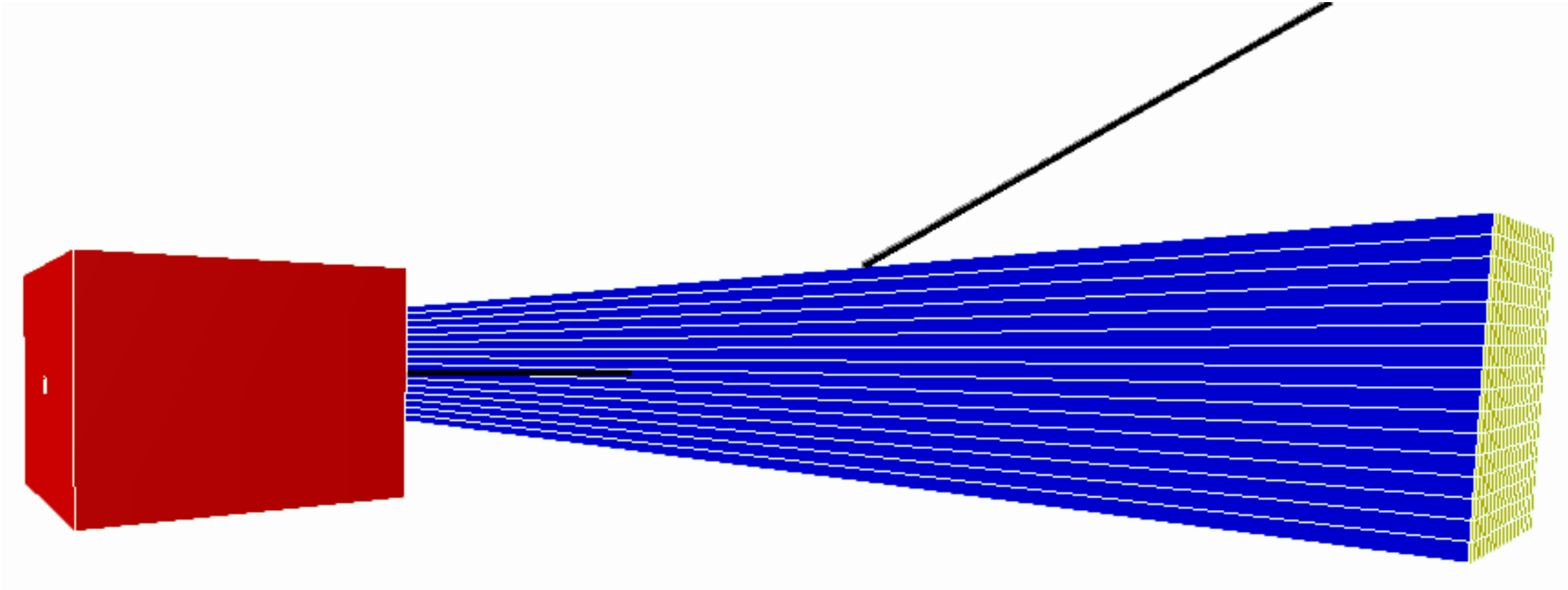
# NeuRad geometry



- Birk's law

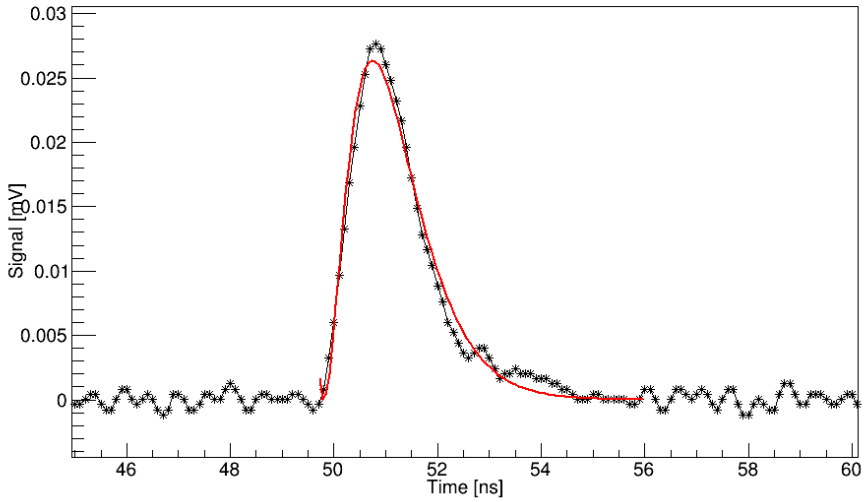
$$Q_i = \frac{A}{1 + B\frac{dE_i}{dx_i} + C\left(\frac{dE_i}{dx_i}\right)^2}$$

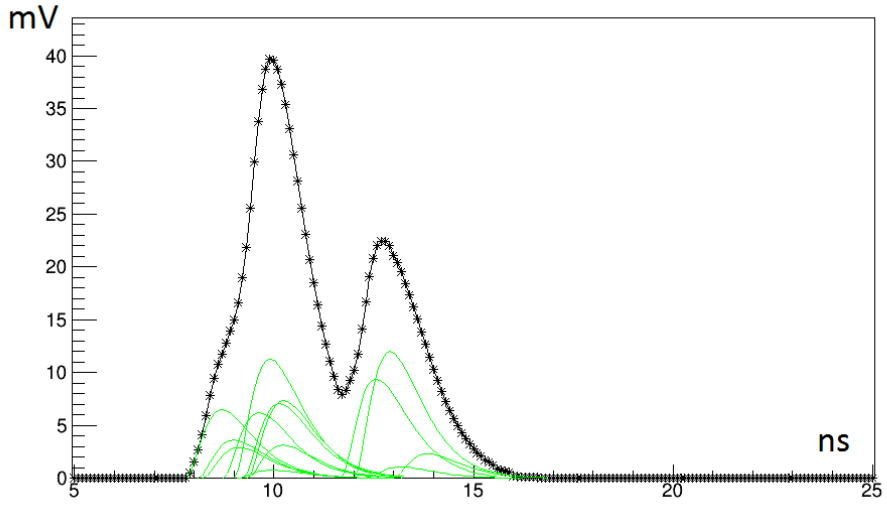
- Single electron shape

$$U(t) = a\,A_{pe}\,(t - T_{pe})^2 \exp\left(-\frac{t - T_{pe}}{b}\right)$$

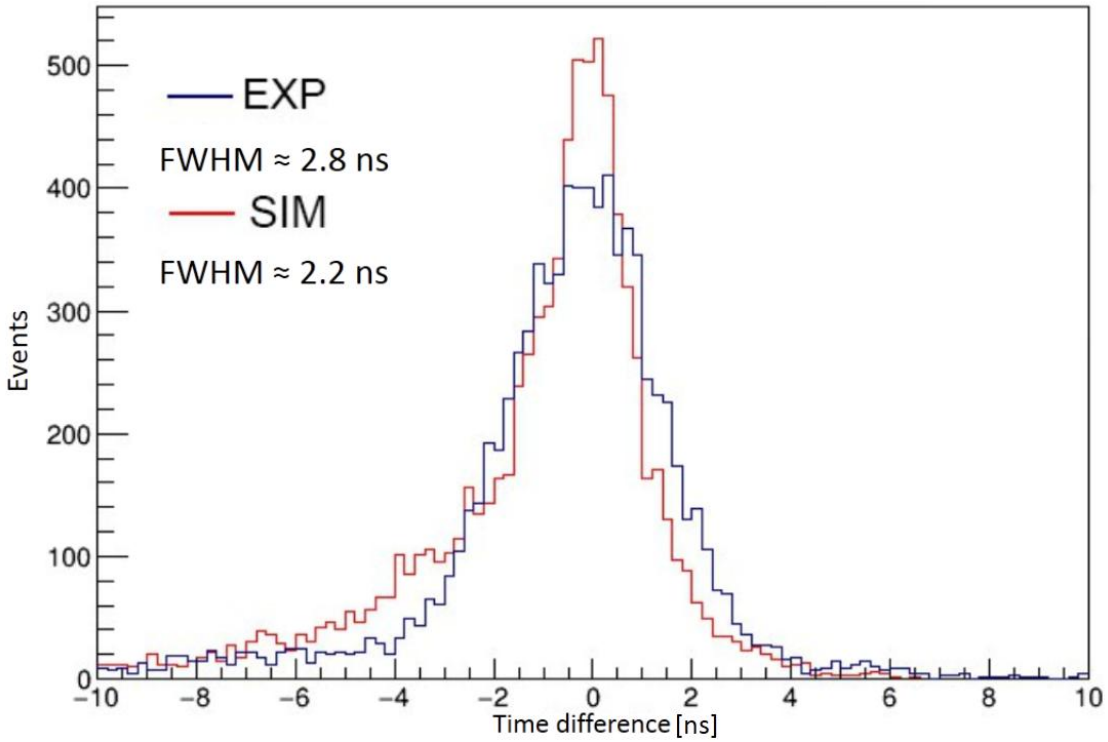
- PMT parameters

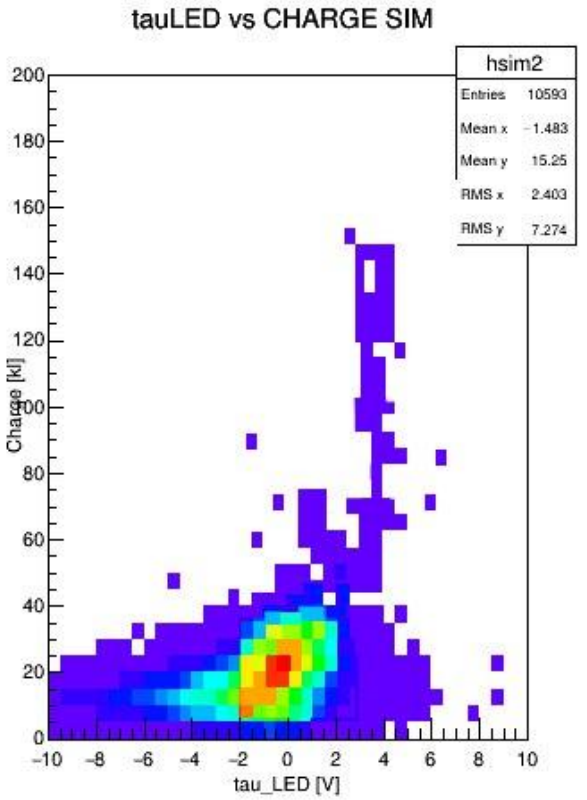
$$T_{pe} = T_k + N(D_{\mathrm{PMT}}, J_{\mathrm{PMT}}),$$

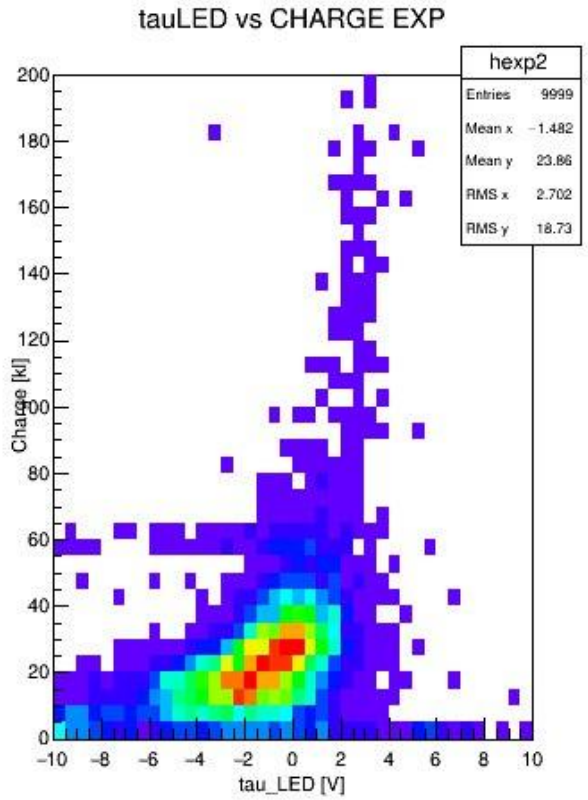


# Compare



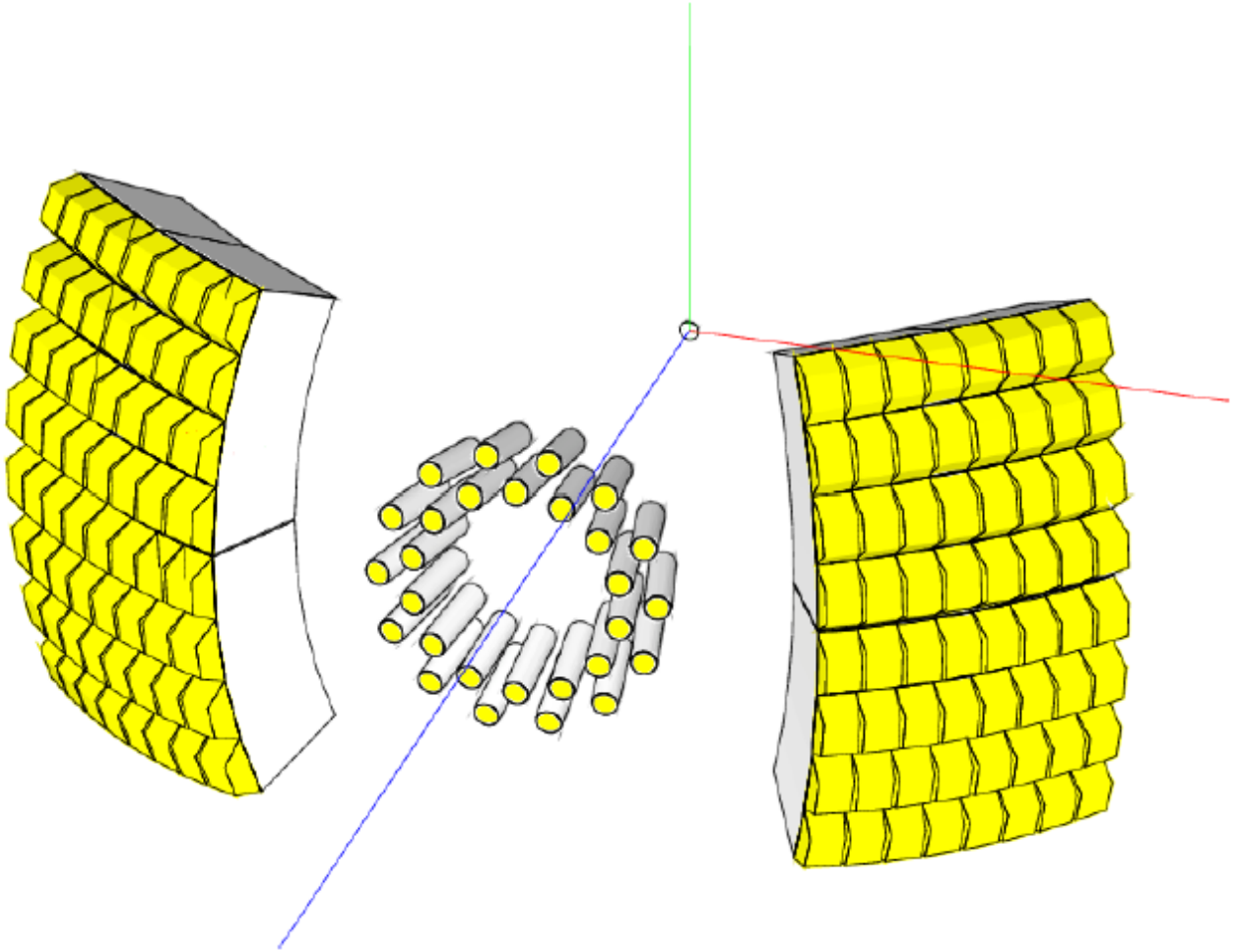




- Photocathode quantum efficiency
- Birk's constants

- Scintillation light yield
- Scintillator decay time

- PMT time jitter
- Birk's constants

# GADAST



- Gamma ray and light particle detector
- 128 CsI and 32 LaBr3 crystals

- Measuring light yield heterogeneity

**Geometry and digitizing methods already created!**

# Outlook

- Simulating EXPERT experiments
- Measurements of the fine structure of the GADAST crystals
- Measurements of the time and energy properties using multi-channel electronics PETsys
- Developing software could be used for other experiment simulations

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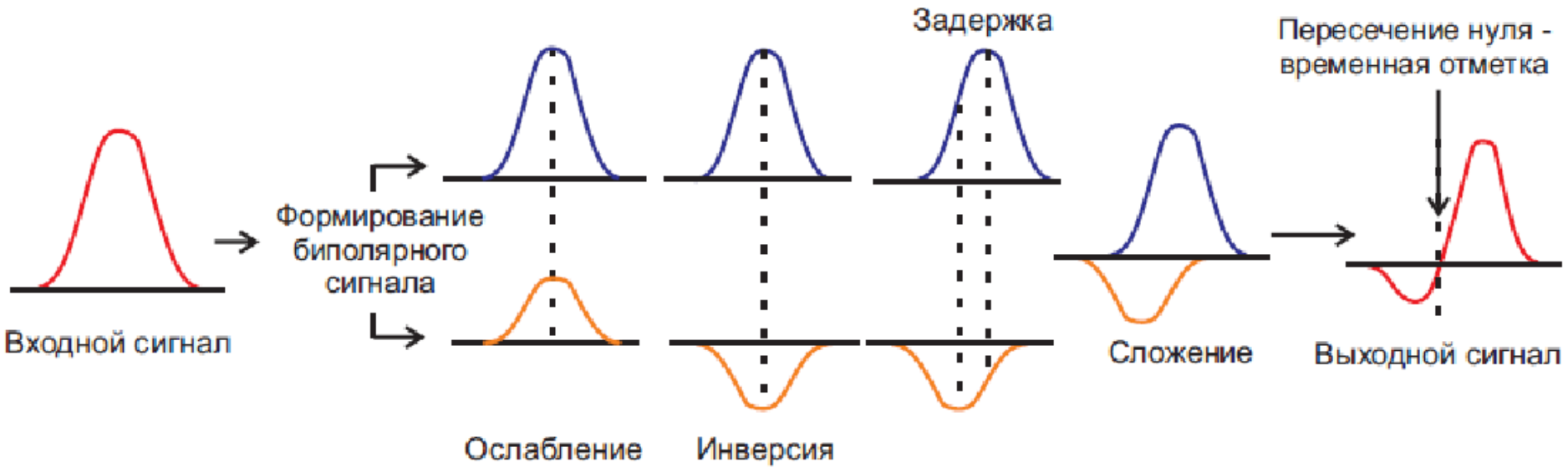
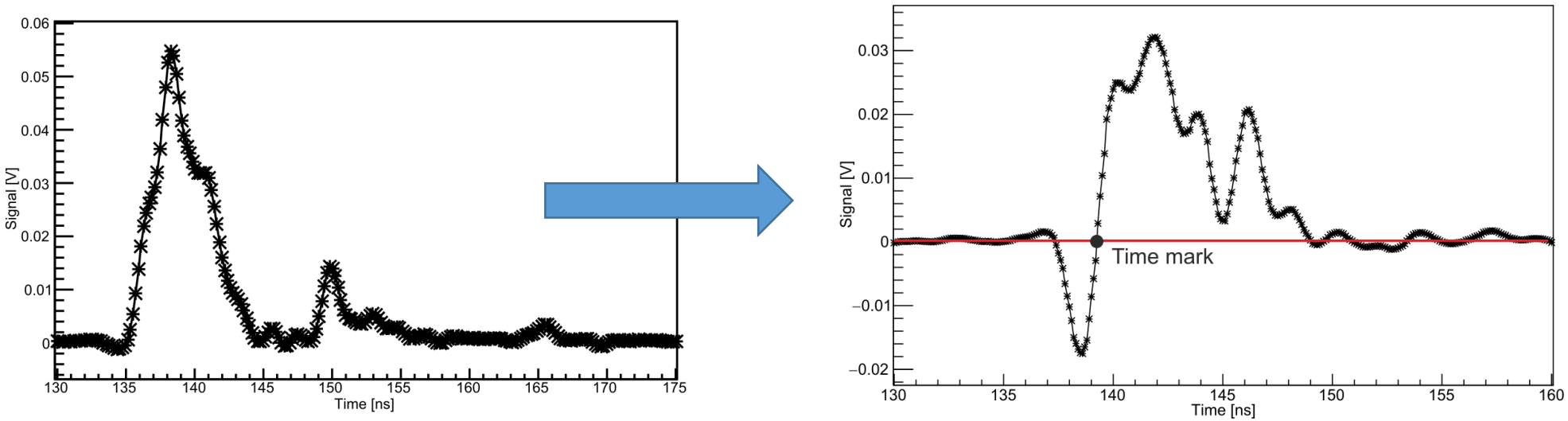
**Thanks for attention**

# **Methods:** Constant Fraction Discriminator



# **Methods:** Leading Edge Discriminator Time-over-Threshold