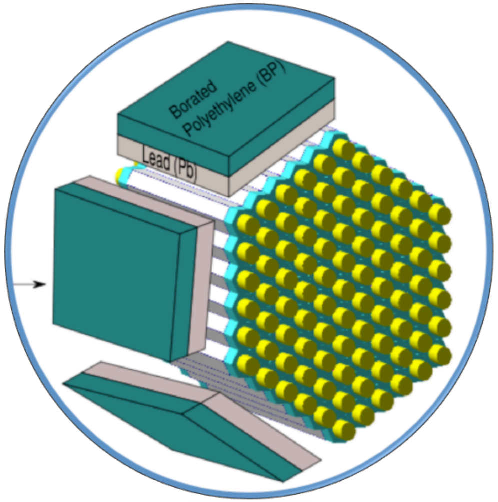

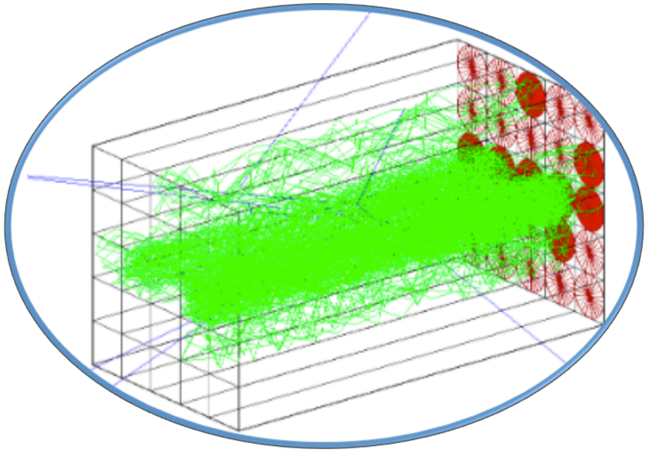

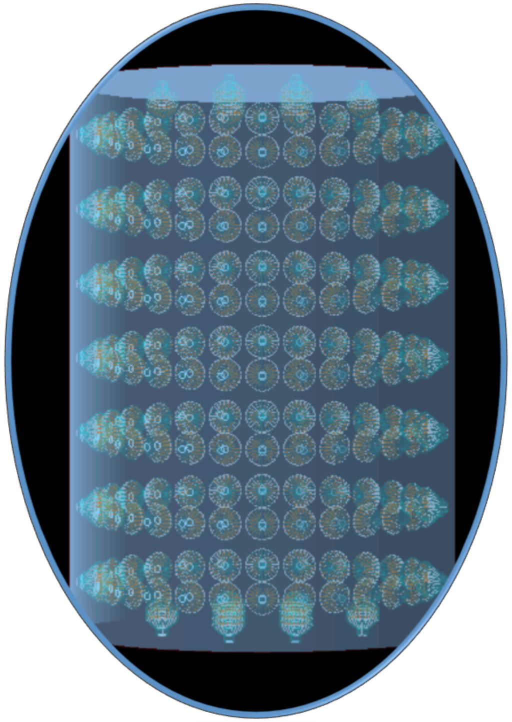

Reactor Neutrino Studies in Turkey

Emrah Tiras*[1], Sertac Ozturk[2] & Mustafa Kandemir[3]

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[1] Iowa State University (at Fermilab) & Erciyes University
[2] Tokat GOP University & The University of Iowa
[3] Recep Tayyip Erdogan University

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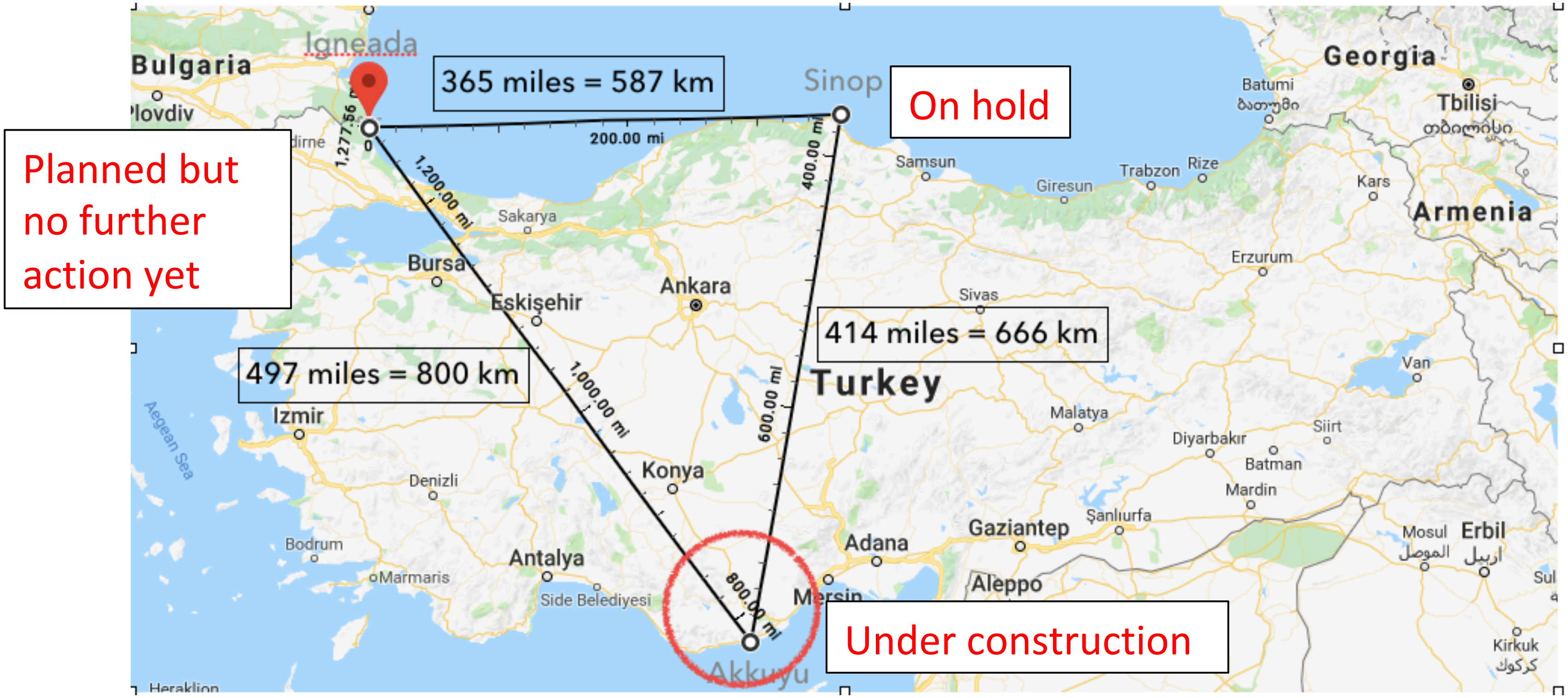
NuTools Mini-Workshop
July 22-24, 2020

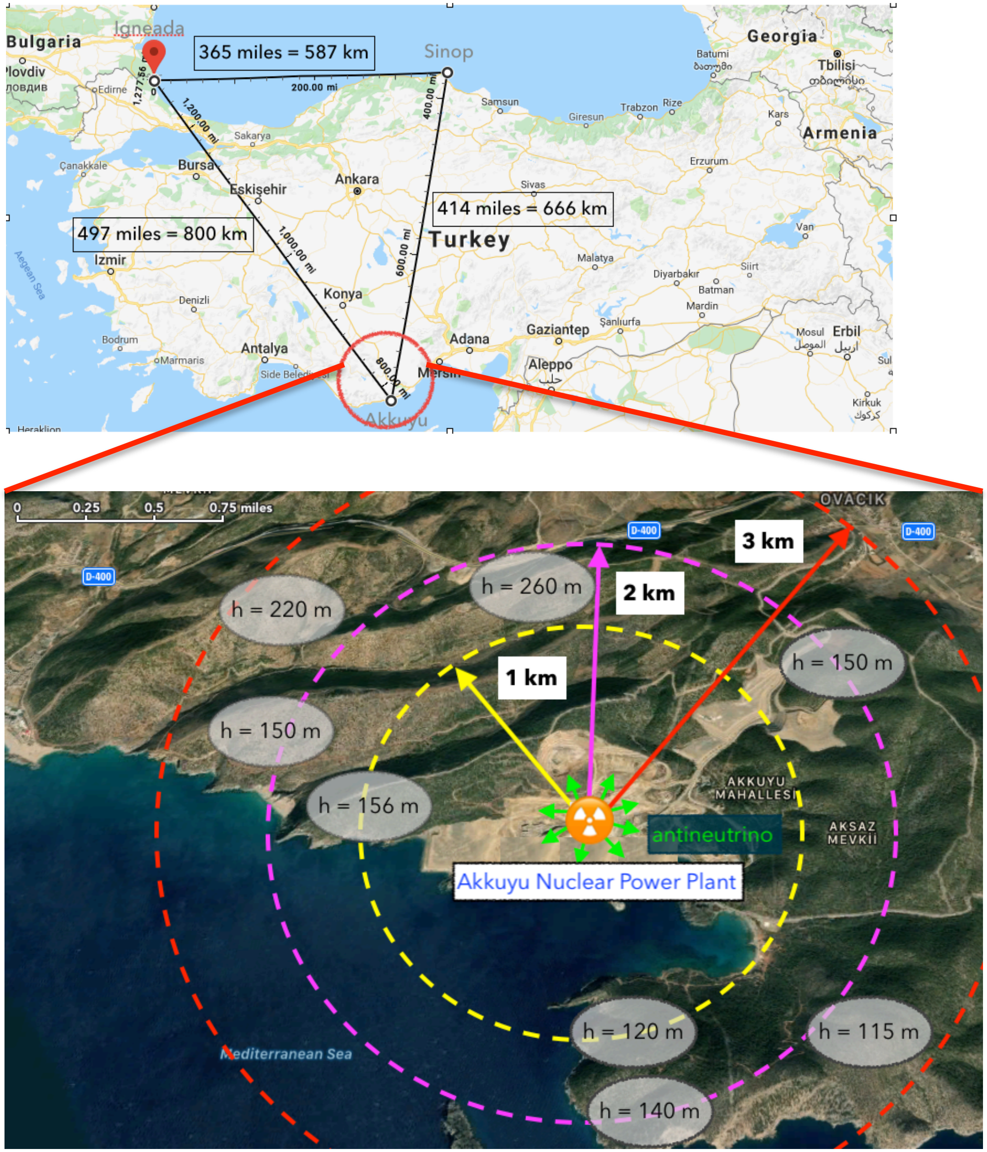
Planned Nuclear Power Plants in TURKEY



❑ Great opportunity for building the country's very first neutrino detector and fuelling the expanding field of neutrino science in Turkey. Our goals are:

- Monitoring the Akkuyu NPP
- Deploying & testing new technologies and techniques (Gd-loaded WbLS, LAPPDs etc.)
- Recruiting and training the next generation of detector experts and neutrino physicists in Turkey.

Akkuyu NPP is under construction…

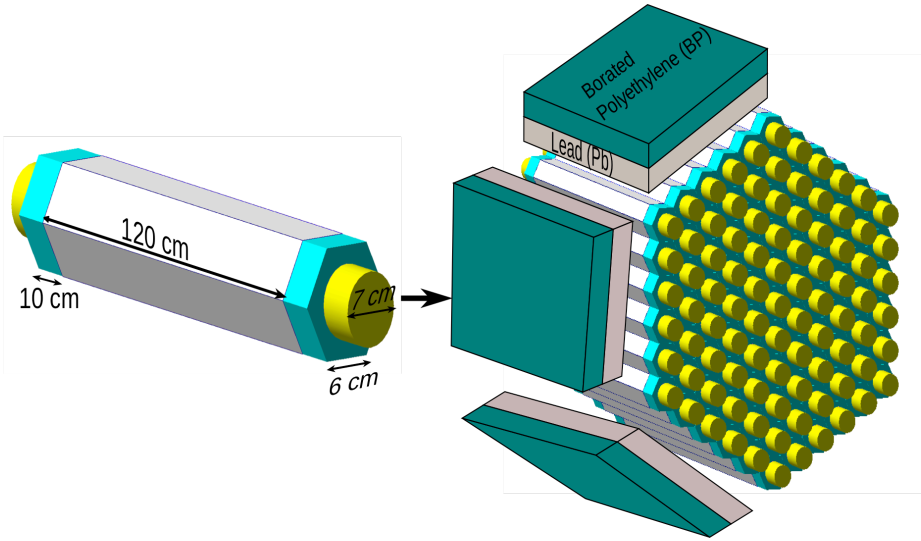


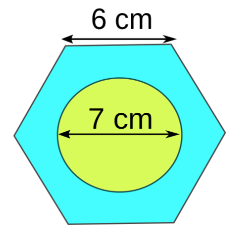
- It is being built by a Cooperation of Governments of the Russian Federation and the Republic of Turkey.
- Under a long term contract ($20B), Akkuyu Nuclear Joint-Stock Company is responsible for the design, construction, maintenance, operation and decommissioning under the guidance and recommendations of International Atomic Energy Agency (IAEA), Turkish Atomic Energy Authority (TAEK) and Turkish Ministry of Energy.
- 4 power units with VVER-1200 reactors with a total capacity of 4800 MWe.
- The first reactor core is planned to be active in 2023 with a ~3.2 GWt.

http://www.akkuyu.com

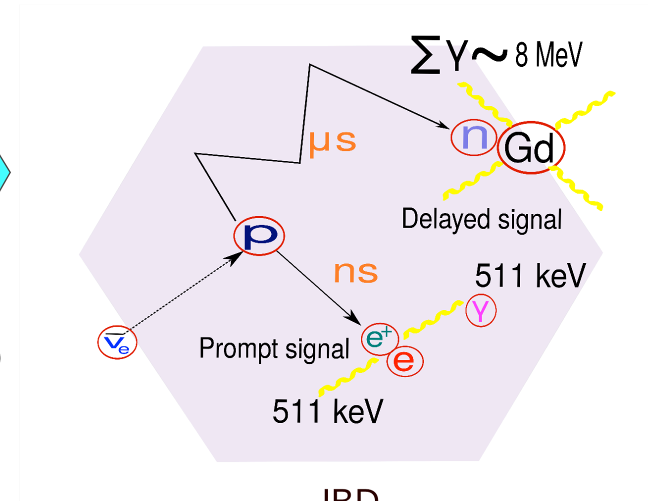
Near-field (<100 m) detector proposal

Dr. Mustafa Kandemir





Coverage area of PMT: 41 %



$$\bar{\nu}_e + p \xrightarrow{IBD} e^+ + n$$

Detector properties

Mass (kg):	1045
Volume (m^3):	1.02
Module number:	91
Proton number per cm^3 ($\times 10^{22}$):	5.26
Gd conc. (%, w/w) :	0.18
Energy resolution (%):	$9 / \sqrt{E(\mathrm{MeV})}$

Why hexagons?

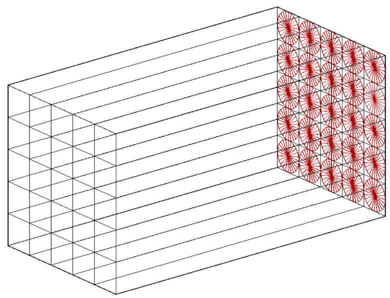
- The answer is the same with the question "Why Honey bees use hexagon ?"
- There are three possible module shapes that can be put together without leaving gaps: square, triangular and hexagonal prism. Hexagonal prisms provide a minimum surface area to enclose the same detector volume.
- With this approach, the required number of PMTs to readout a given detector volume is reduced.
- The tighest possible arrangments of PMTs.

Nucl.Instrum.Meth.A 953 (2020) 163251

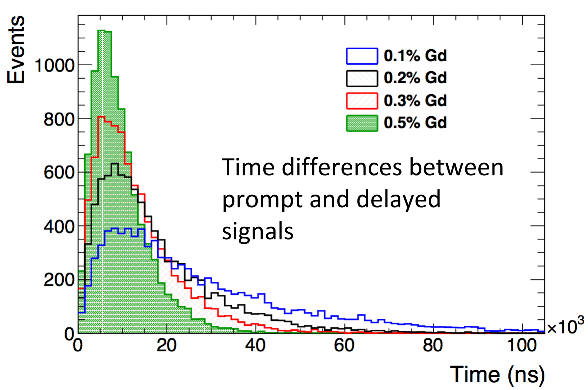
Nuclear reactor monitoring with gadolinium-loaded plastic scintillator modules (<100 m)

Prof. Sertac Ozturk

Detector Design

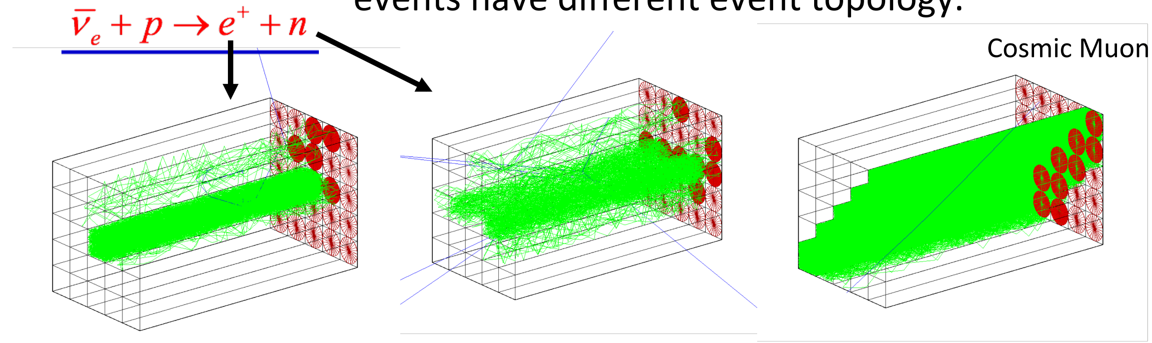


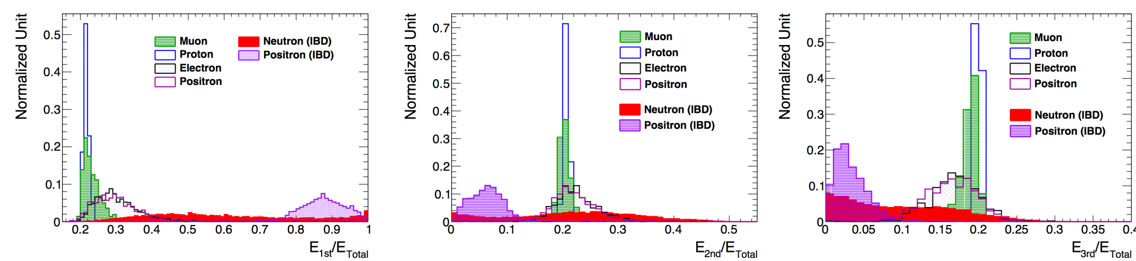
- Segmented detector structure with Gd loaded plastic scintillator. 25 identical 10 × 10 × 100 cm sized modules.
- Optimum Gd concentration in plastic scintillator is about 0.2%-0.3%.
- The weight of the designed detector is about 250 kg and about 1185 antineutrino events can be observed per a day when it is placed 50 m away from the 3.2 GWt reactor core.



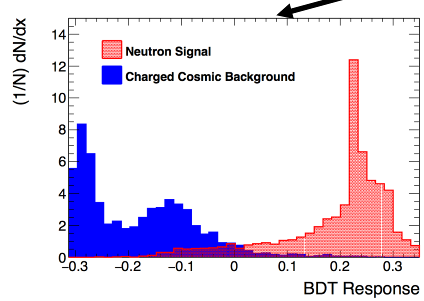
Background Suppression with Multivariate Analysis

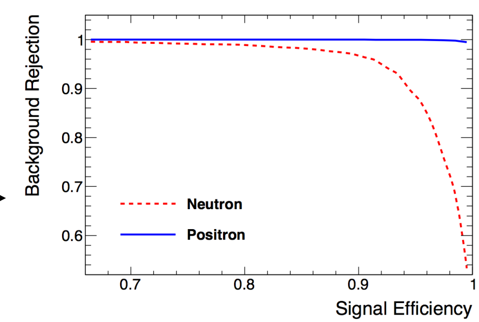
- The antineutrino events and cosmic ray events have different event topology.





TMVA



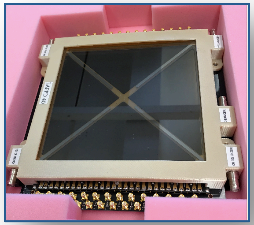


NIM A, Volume 955,163314, DOI: 10.1016/j.nima.2019.163314

Water-based Liquid Scintillator R&D Detector

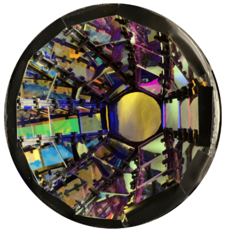
Dr. Fischer and Dr. Tiras

- 30 ton WbLS detector at a distance of 1 km from the core.
- 10% scintillator loading with 0.1% Gd doping.
- Portable design as a testbed detector for new technologies:

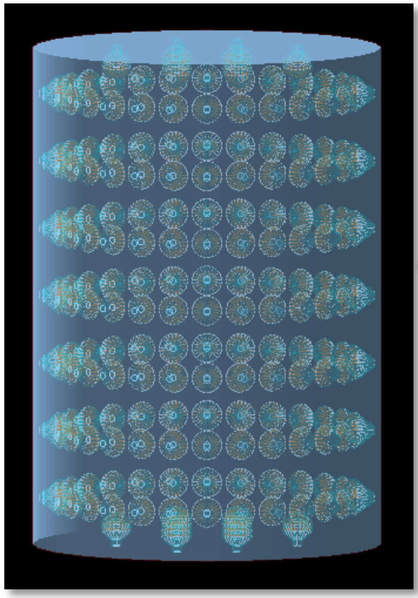


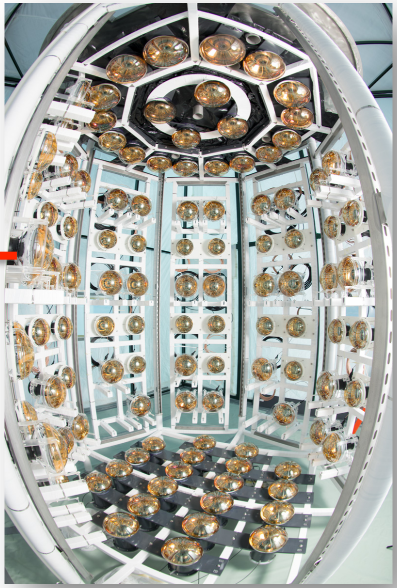
LAPPDs

WbLS

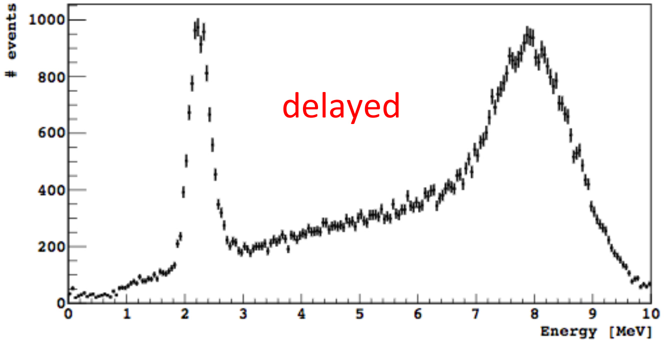


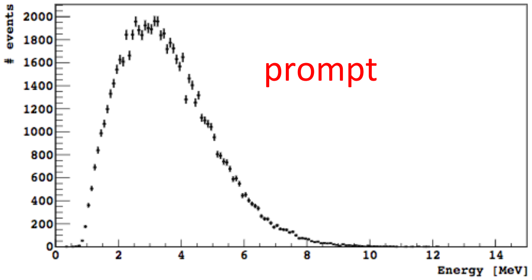
Dichroicon





ANNIE-like PMT structure





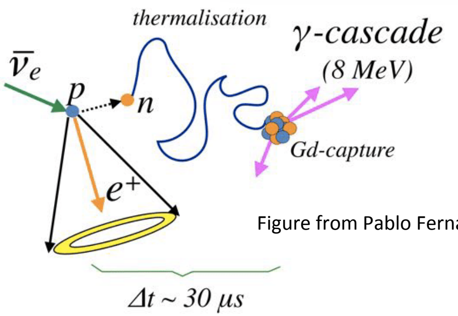


Figure from Pablo Fernandez

- We expect 200 neutrinos per day.
- After signal selection and background rejection cuts we reconstruct 50 neutrinos per day at 1 km.

Nucl.Instrum.Meth.A 969 (2020) 163931

Dr. Ozturk et al. also proposed a small Gd-doped WCh detector at <100 m and submitted a proposal: Turk.J.Phys. 41 (2017) 1, 41-46

SUMMARY

- Akkuyu NPP is under construction and the first reactor core is aimed to start working in 2023.
- It's a great opportunity for both monitoring purposes and neutrino physics studies in Turkey.
- The reactor neutrino studies would be the first step towards development of a future reactor neutrino oscillation experiment in Turkey.
- All of the studies we have done so far are simulation studies and related proposals for detector R&D.
- We haven't approached to any policy makers or regulators yet but we are planning to do so in the near future.