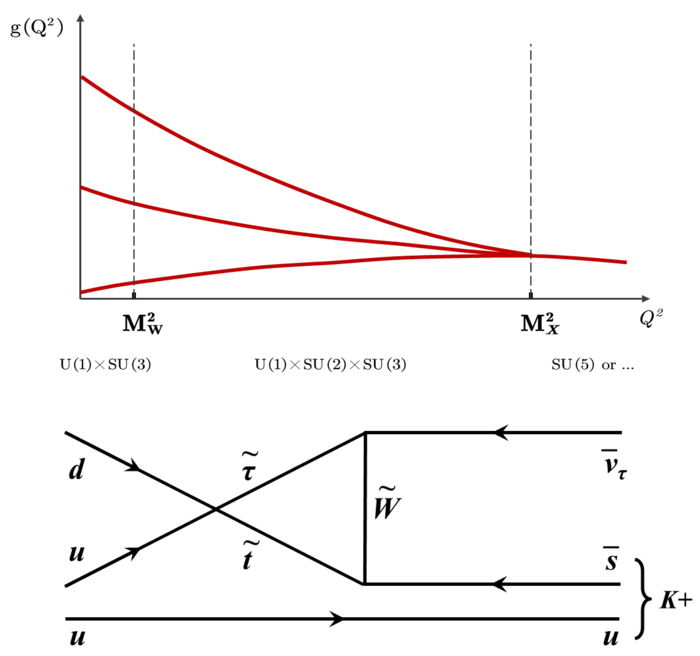
Prospects for the Nucleon Decay Search in JUNO

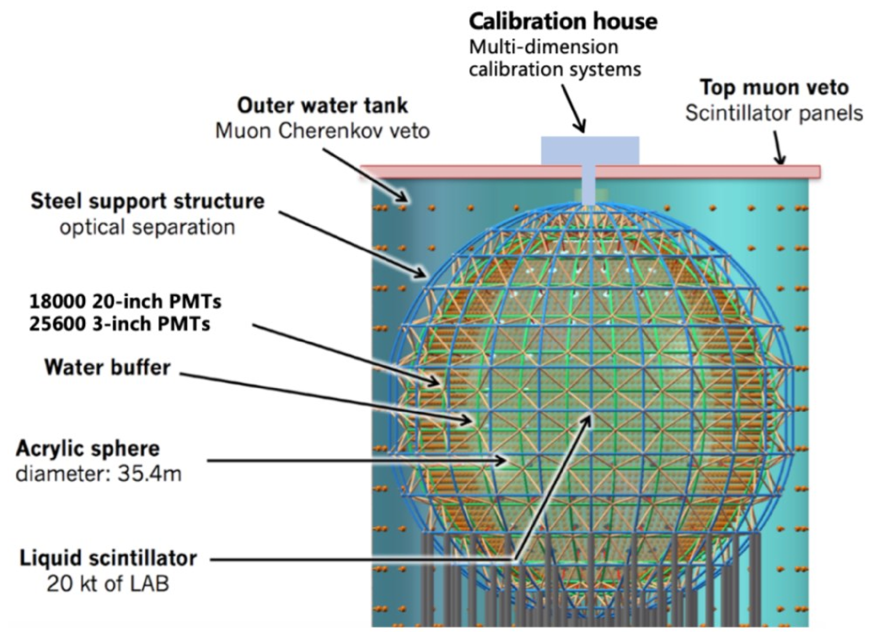
Yuhang Guo [1]* , Wanlei Guo[1] , Hang Hu[1] (On Behalf of JUNO Collaboration)

[1] Institute of High Energy Physics, Beijing, China

*guoyh@ihep.ac.cn

1. Introduction

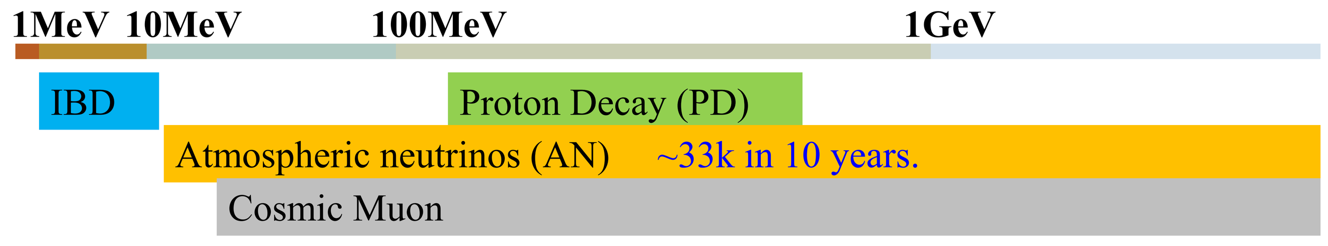




- Proton Decay (PD) is an apparent prediction of Grand Unification Theories (GUTs).
- So many predicted decay modes, among which $p \to \nu K^+$ has large branching ratio in Supersymmetric GUTs.
- The Jiangmen Underground Neutrino Observatory (JUNO) , which is a large Liquid Scintillator (LS) detector equipped with more than 43k PMTs.
- With 20 kton exposure mass, JUNO is expected to be sensitive to searching for $p \to \nu K^+$.

2. Simulation

- The dominant backgrounds are the Atmospheric neutrinos (AN) and Cosmic Muons.



	Kaon Production	Pion Production	Quasi-elastic Scattering	Nucleon Recoil	Total
Neutral current	0.30%	9.74%	---	20.23%	30.27%
Charge current	0.81%	23.75%	45.16%	---	69.73%

- A MC study has been done to analyze the JUNO's sensitivity to p2vK, with the tool simulation software SNIPER, a Geant4 based MC software developed by JUNO collaboration.

GENIE ⇨ SNIPER ⇨ MC truth

GENIE:
- Binding Effect
- Fermi Motion
- NN correlation
- Final State Interaction
- De-exciting

SNIPER:
- 10 k proton decay events
- 44 years AN exposure (160 k)
- 16 years cosmic muons exposure

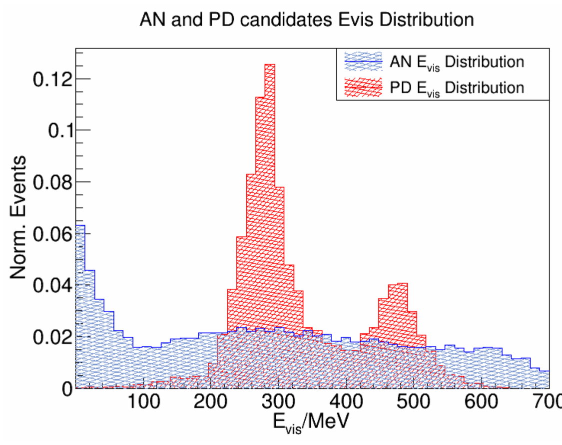
MC truth smearing:
- Energy
- Position
- Time

3. Analysis

■3 types of criteria proposed to find the rarely seen p2vK from the huge amount of BKG based on MC study.

1. Primary Selection

- Visible Energy Cut
- Volume Cut

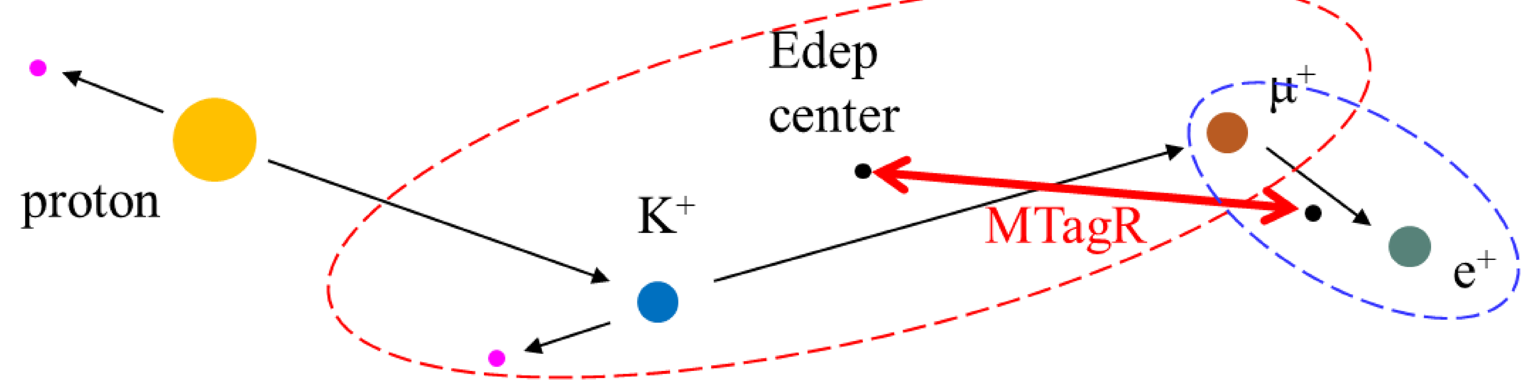


2. Delayed Signal Selection

Related criteria are set to tag a delayed signal:

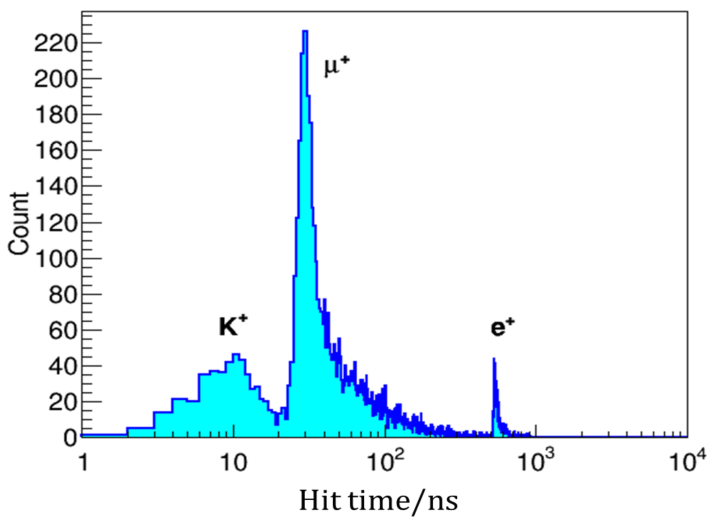
1. Correlated ΔT
2. Correlated E_{dep}
3. Correlated Position

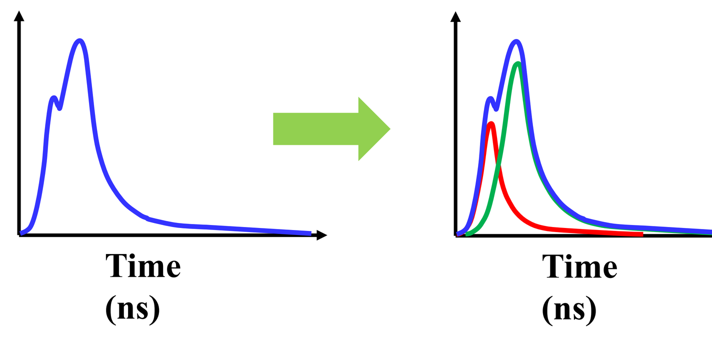
MTag – a Michel electron
CTag – a neutron capture



3. Time Character Selection

- Double pulse pile-up in Time spectrum is a feature of p2vK in LS.
- Reconstruction of the both signals can also help to distinguish.

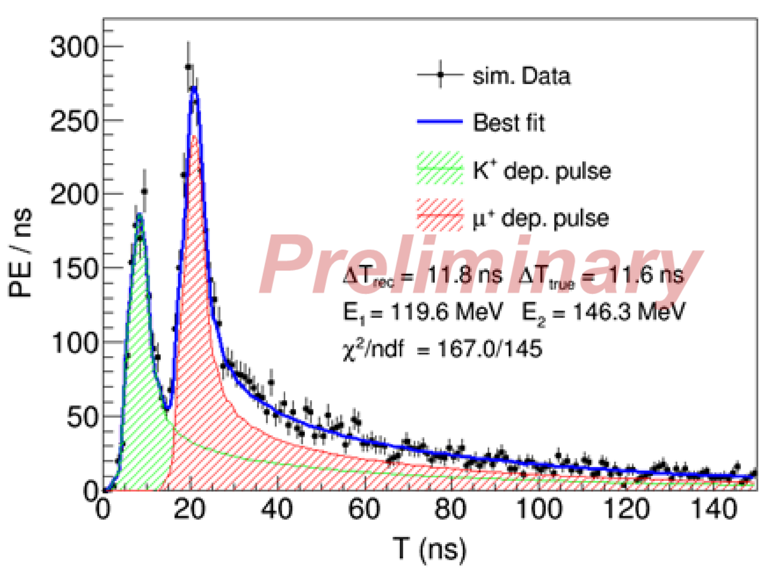




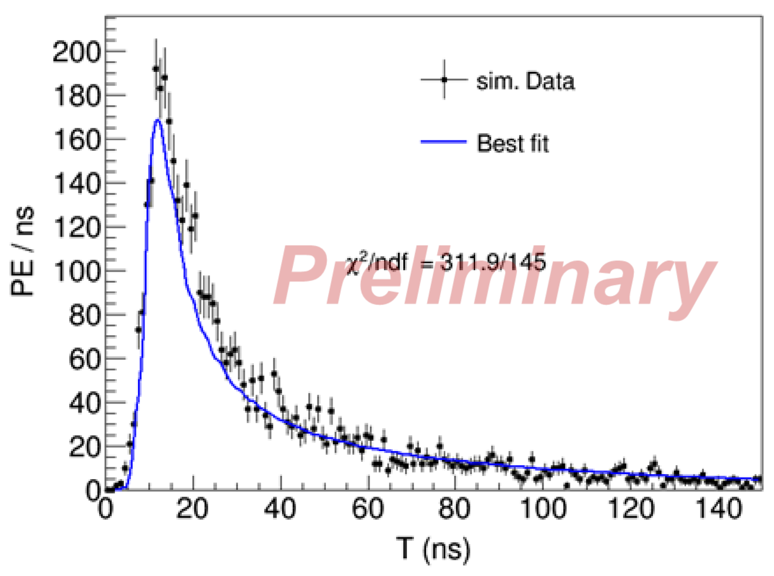
- **From BLUE to RED+GREEN**, we know:
  1. Tendency to be Double/Single pulse (χ^2 of fitting);
  2. Correlated ΔT (K+ lifetime);
  3. Correlated Edep (kinetic of K+ and μ+);

- The hit time spectrum will be fitted with :

$$\phi_Y(x) = \varepsilon_K \cdot f_K(x) + \varepsilon_Y \cdot f_Y(x - \Delta T_Y) \qquad \phi_B(x) = \varepsilon_B \cdot f_B(x)$$

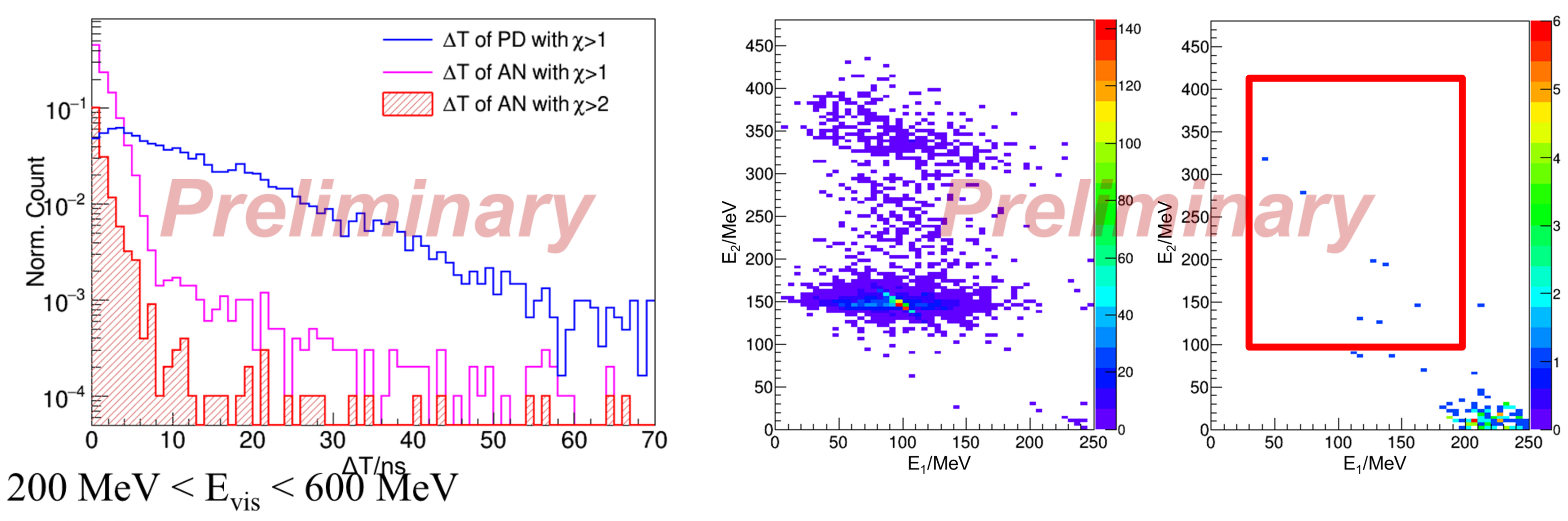


PD event
Distinguished as PD with fitting

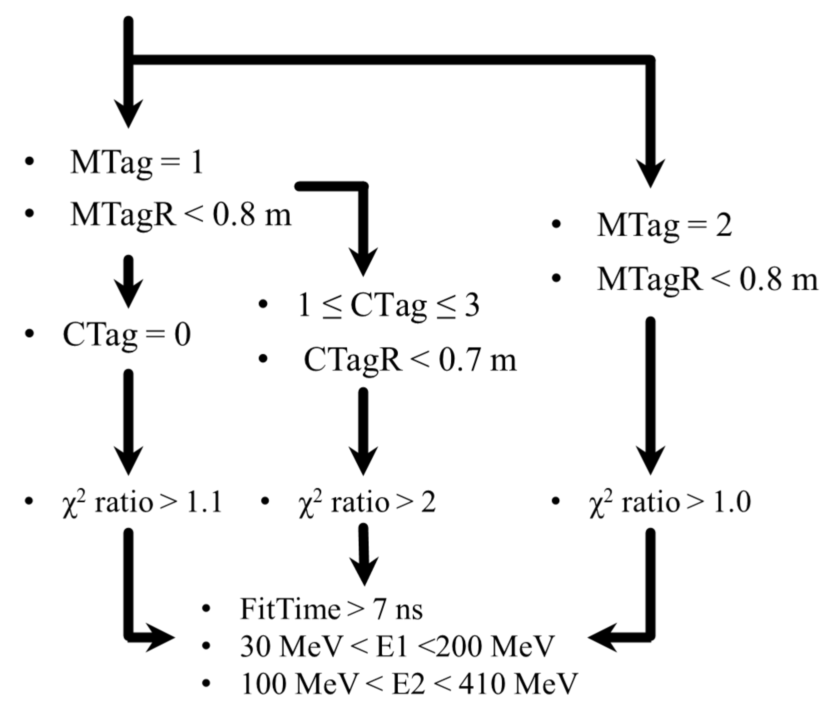


BKG event
Distinguished as BKG with fitting

The candidates will be selected roughly with the reconstructed information



- 200 MeV < E_{vis} < 600 MeV
- R<17.5m



- Better performance is achieved with finer criteria
- Efficiency > 30%.
- BKG level in 10 years is ~0.3
- Sensitivity ~ 9×10^{33} years with 10 years exposure.

4. Conclusion

- JUNO is expected to reach p2vK sensitivity of 8.34×10^{33} years with 10 years exposure (90% C.L.) DOI: 10.1016/j.ppnp.2021.103927
- The studies on signal selection and background estimation in this poster could lead to a better sensitivity and the analysis is to be finalized.

ICHEP 2022 BOLOGNA
ICHEP 2022 XLI International Conference on High Energy Physics Bologna (Italy)
6 13 07 2022