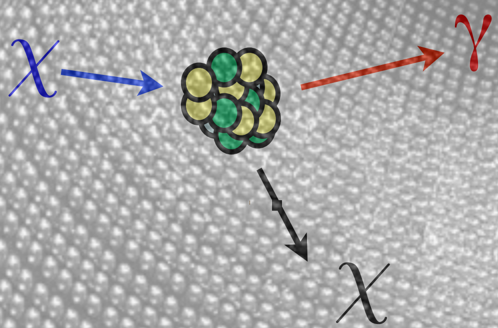
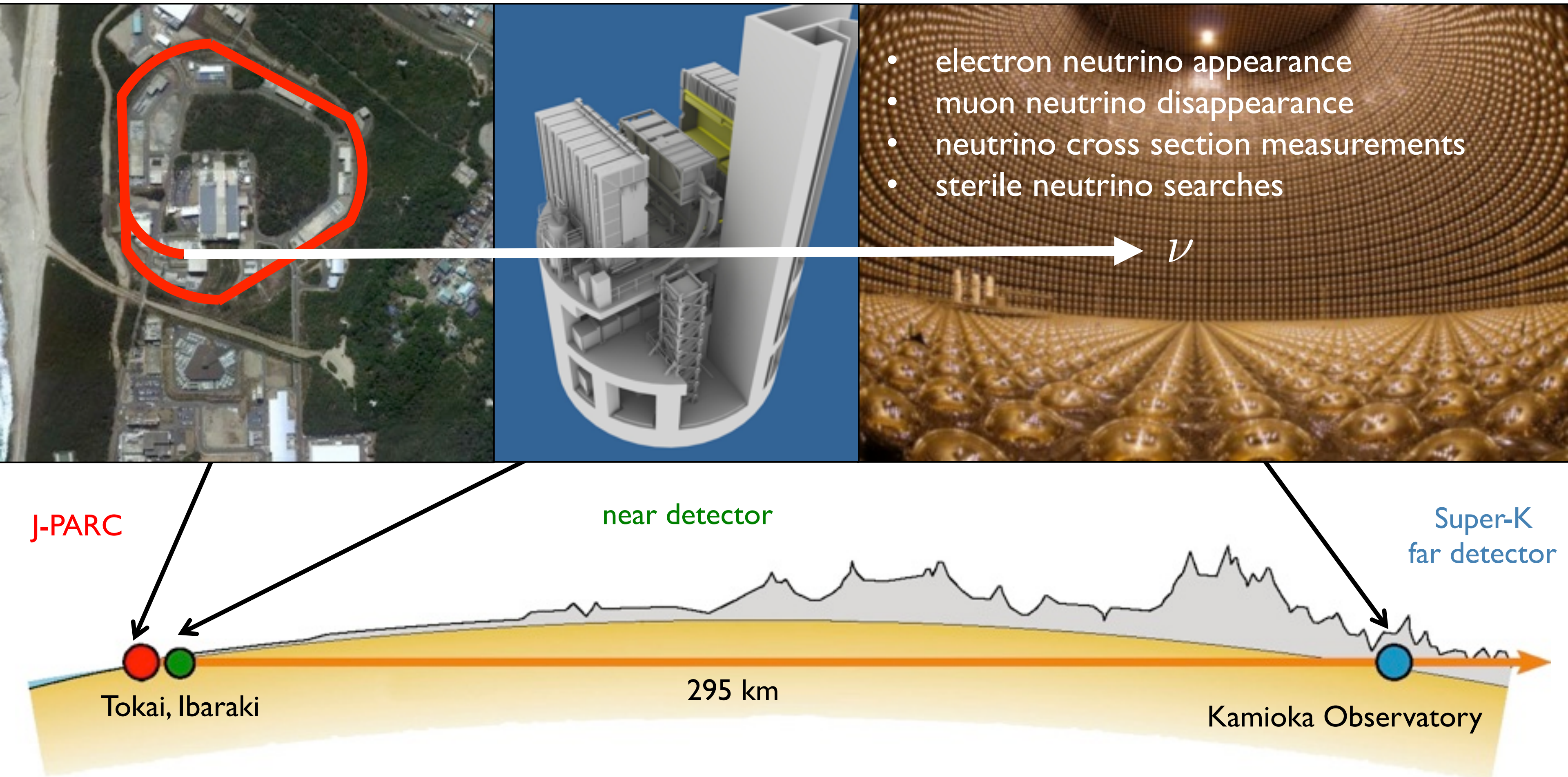
Corina Nantais
University of Toronto

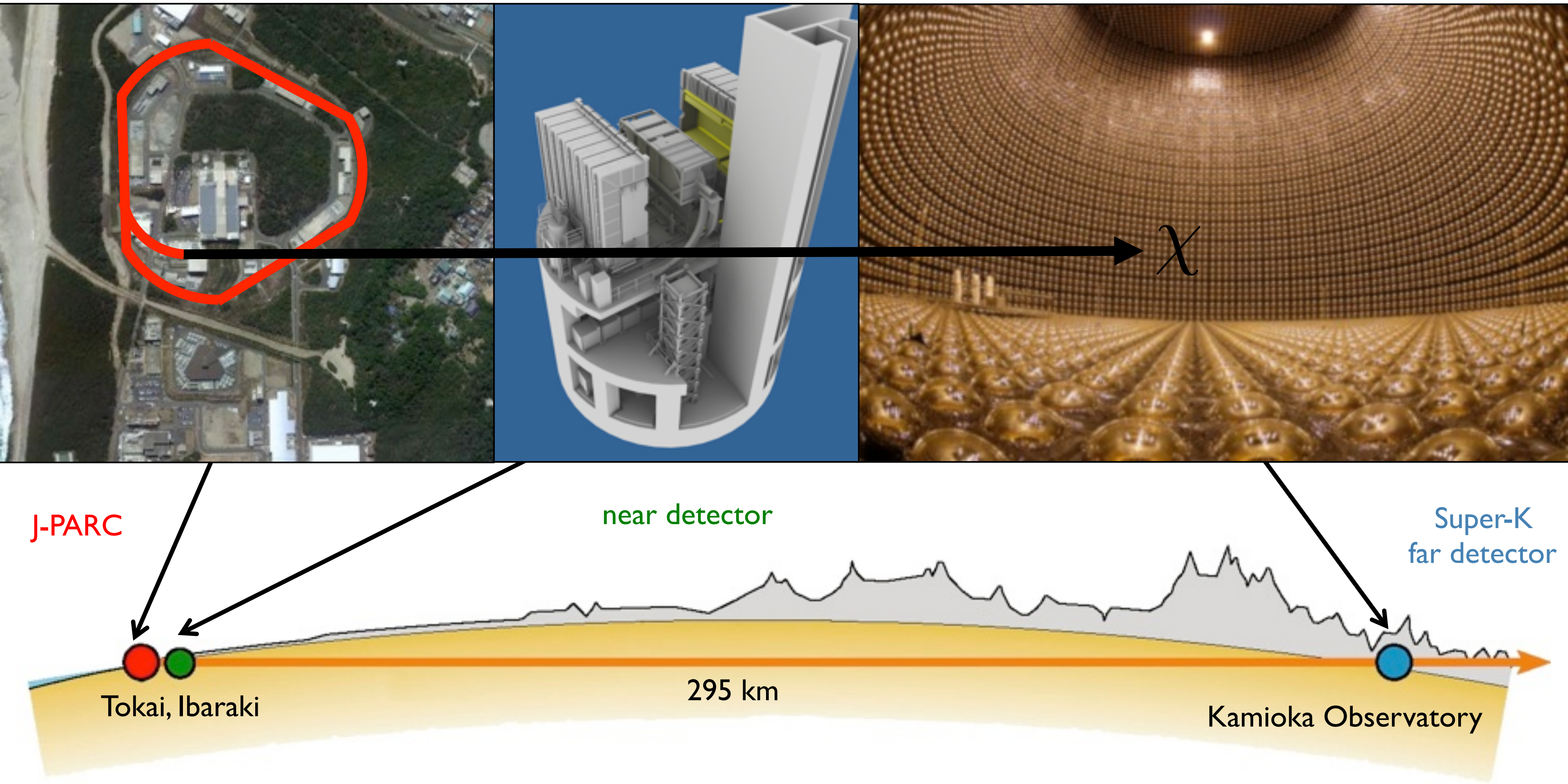


A search for low mass dark matter candidates produced in the T2K neutrino beam and detected by off-timing NCQE deexcitation gammas in Super-K

T2K is a long baseline neutrino oscillation experiment



T2K… can be used to produce and then detect DM



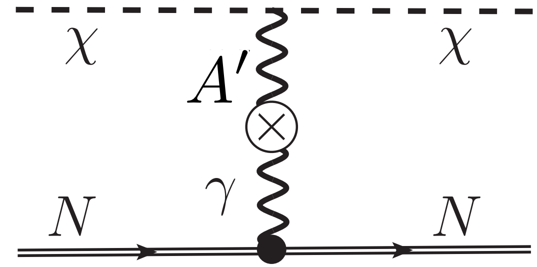
Technique proposed to detect accelerator-produced, relativistic DM in Super-K

Dark sector connected to Standard Model through vector portal

Kinetic mixing between Standard Model γ and vector mediator A'

$m_{A'} > 2\ m_\chi$

$A' \rightarrow \bar{\chi} + \chi$



direct production

$$p + p(n) \rightarrow A' \rightarrow \bar{\chi}\chi$$

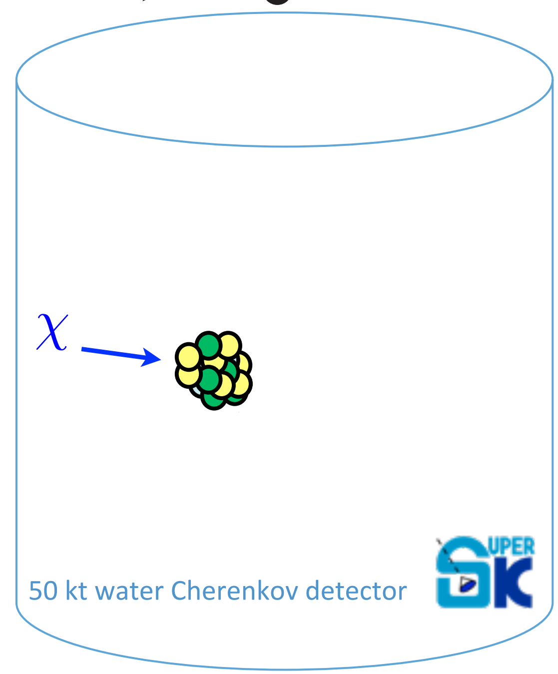
indirect production

$$p + p(n) \rightarrow \pi^0, \eta \rightarrow A'\gamma \rightarrow \bar{\chi}\chi\gamma$$

30 GeV protons

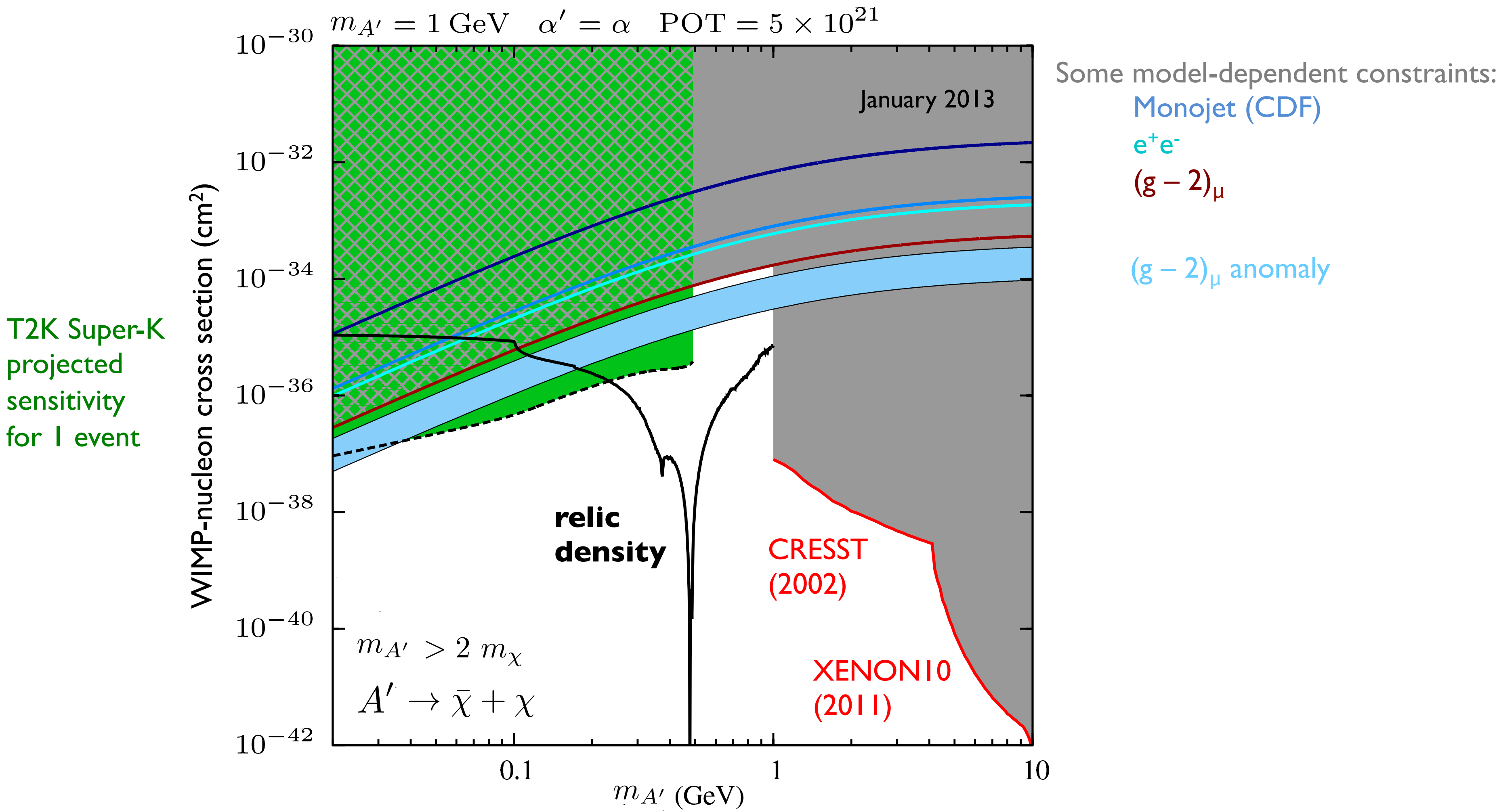
graphite target

295 km



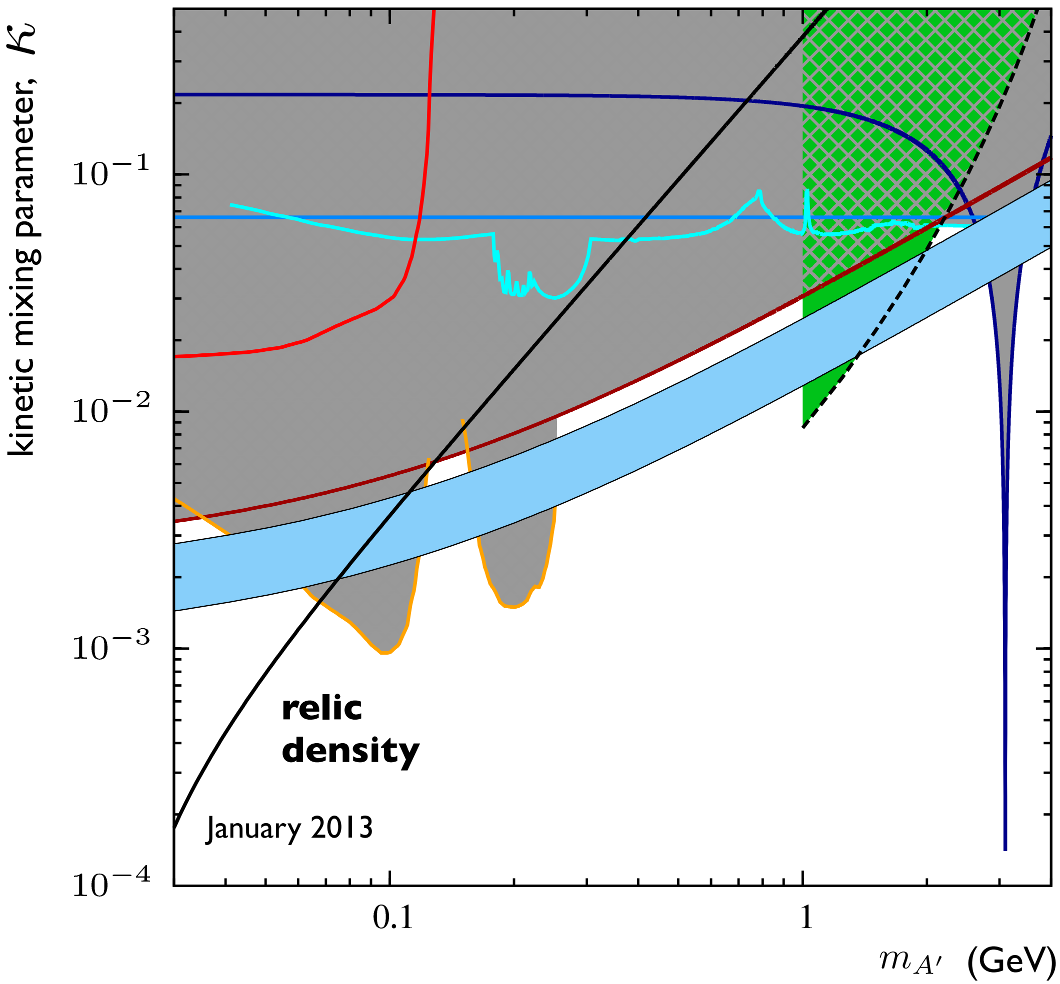
Theorist estimate of T2K Super-K sensitivity

A. Ritz and P. deNiverville, private communication.



The same sensitivity would also look like this:

T2K-SK projected sensitivity for 1 event



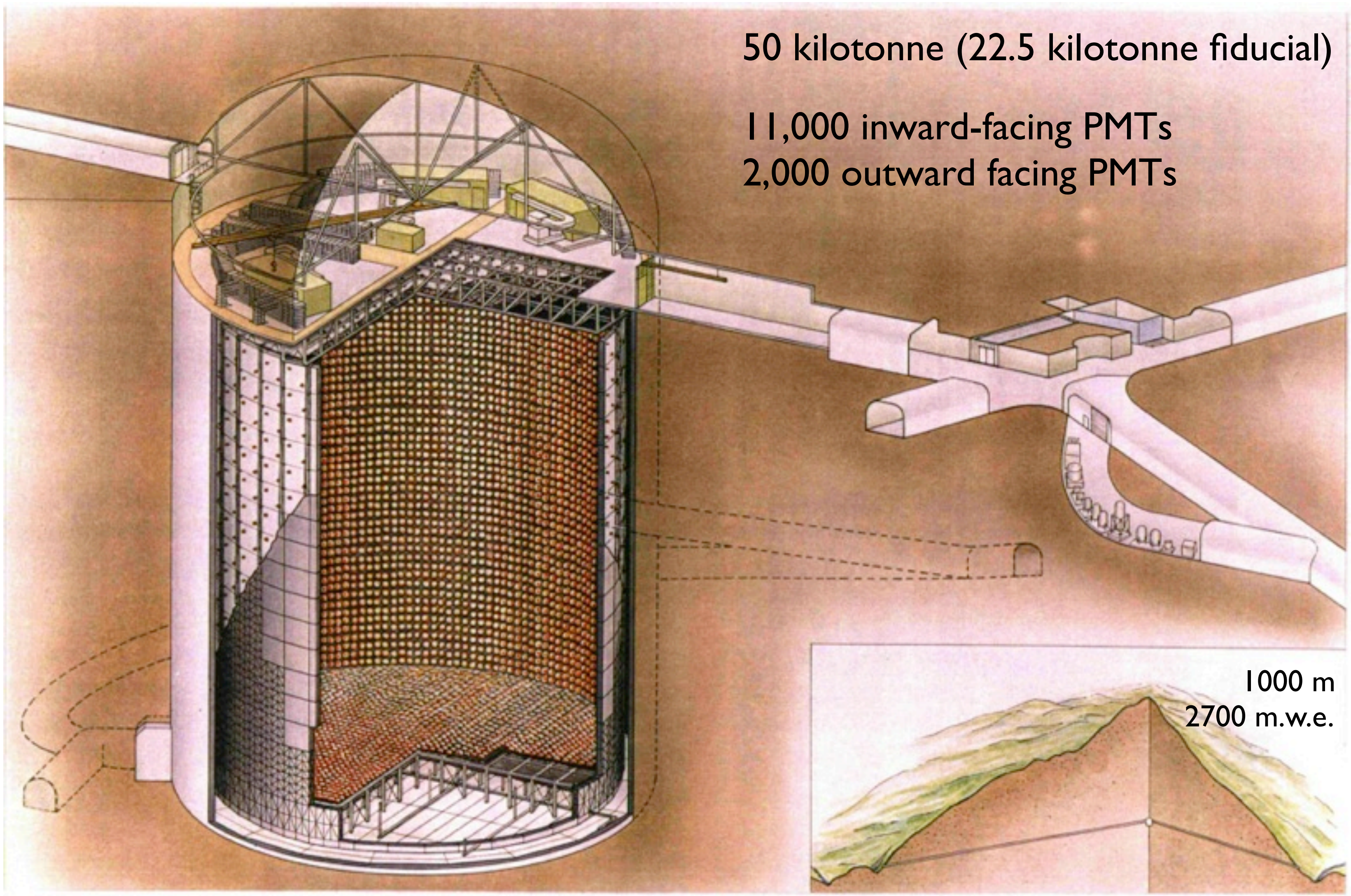
Some model-dependent constraints:

- $J/\psi \to$ invisible
- Monojet (CDF)
- e^+e^-
- $(g-2)_\mu$
- $\pi^0 \to \gamma$ + invisible
- $K^+ \to \pi^+$ + invisible

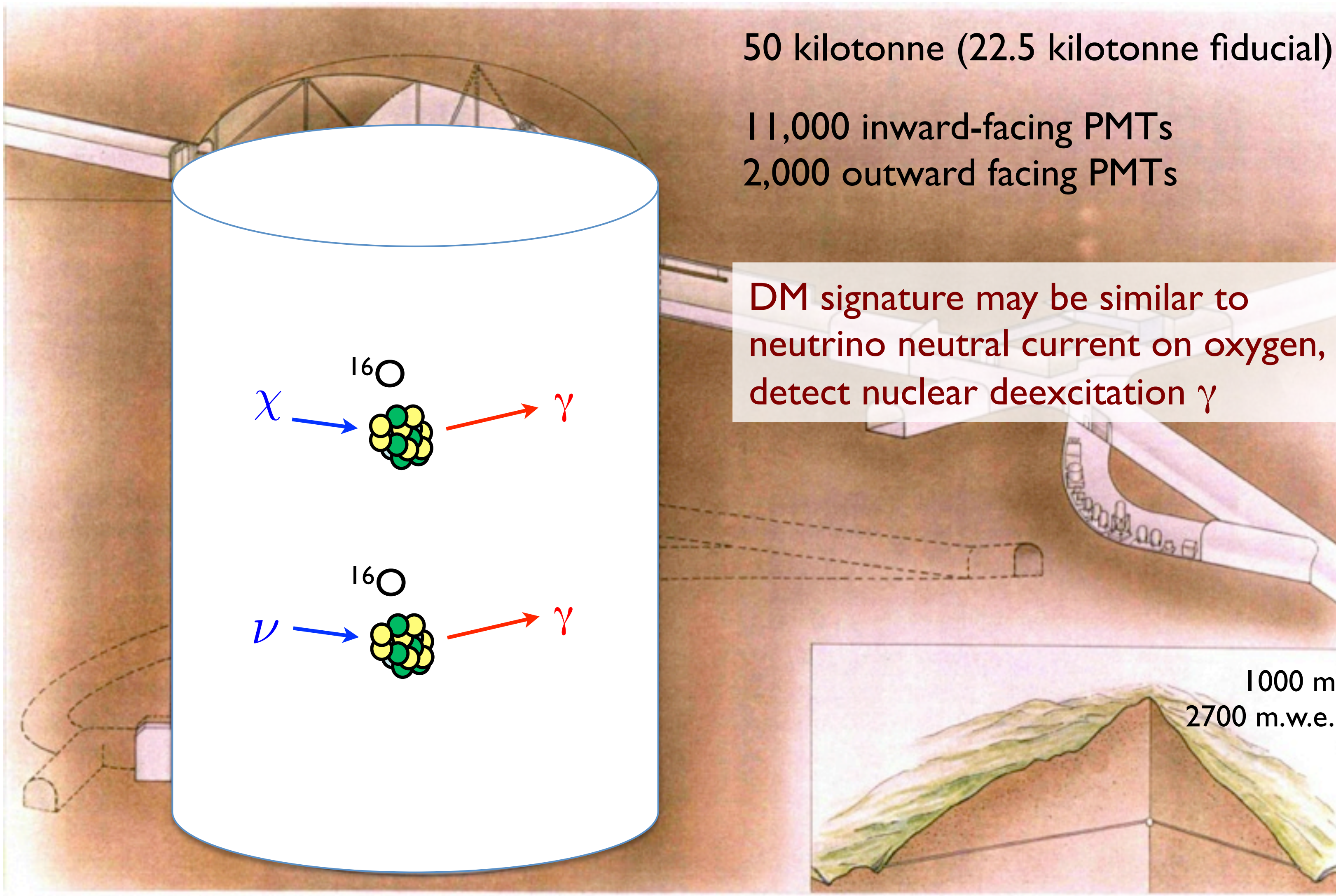
$(g-2)_\mu$ anomaly resolved

m_χ = 100 MeV
$\alpha' = \alpha$
5×10^{21} POT

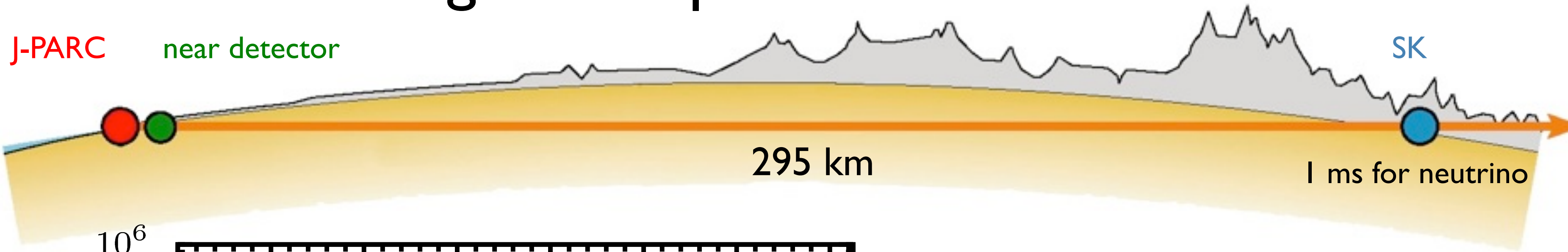
Super-K water Cherenkov detector is well understood

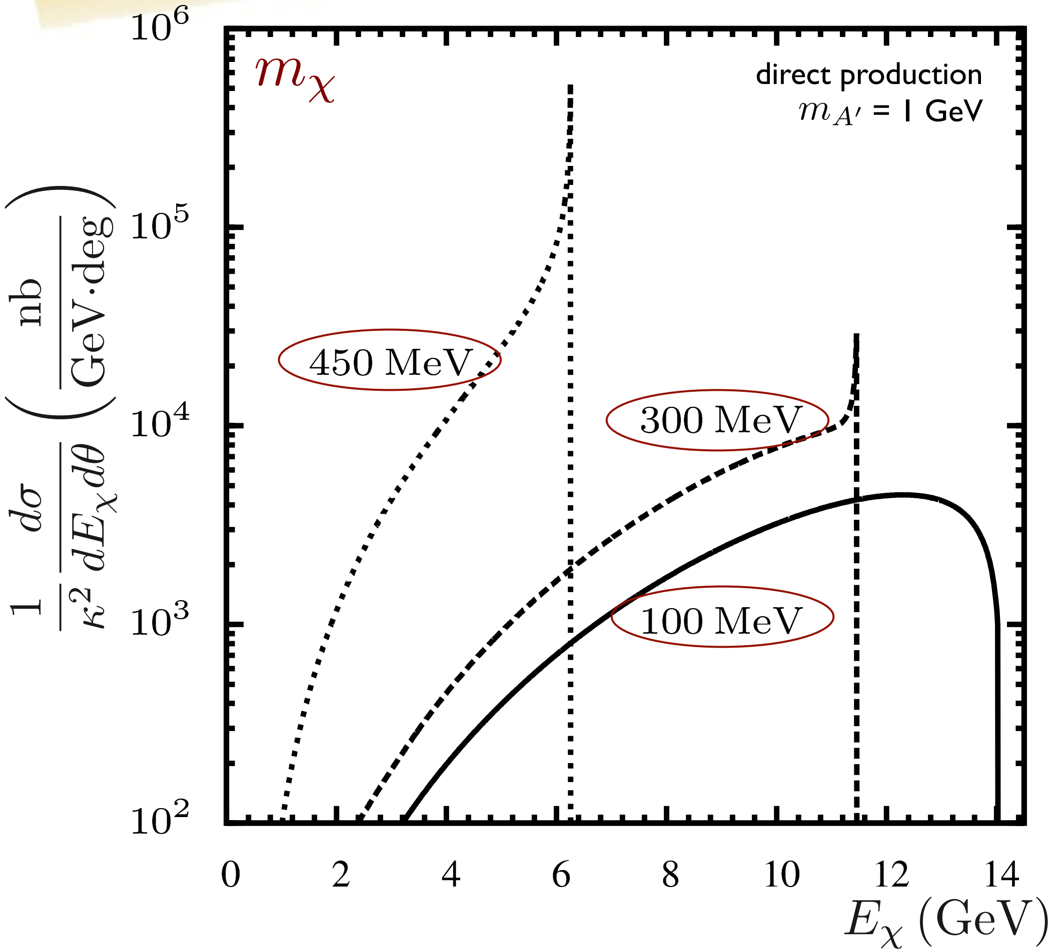


Super-K water Cherenkov detector is well understood



Time of flight to separate DM from neutrino

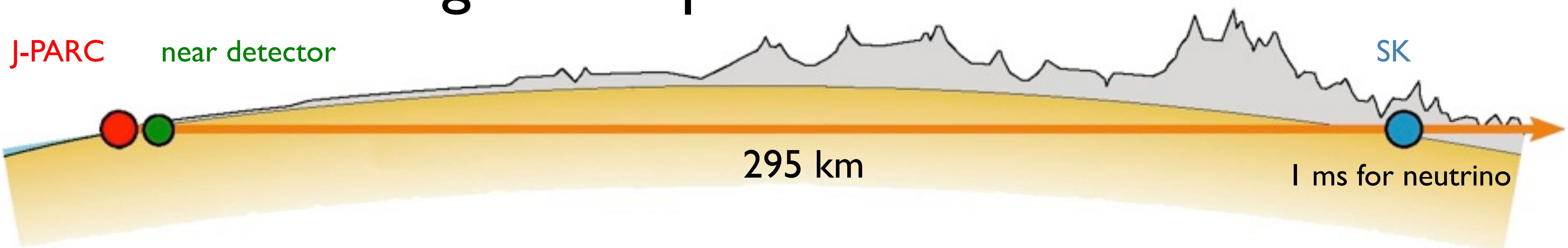


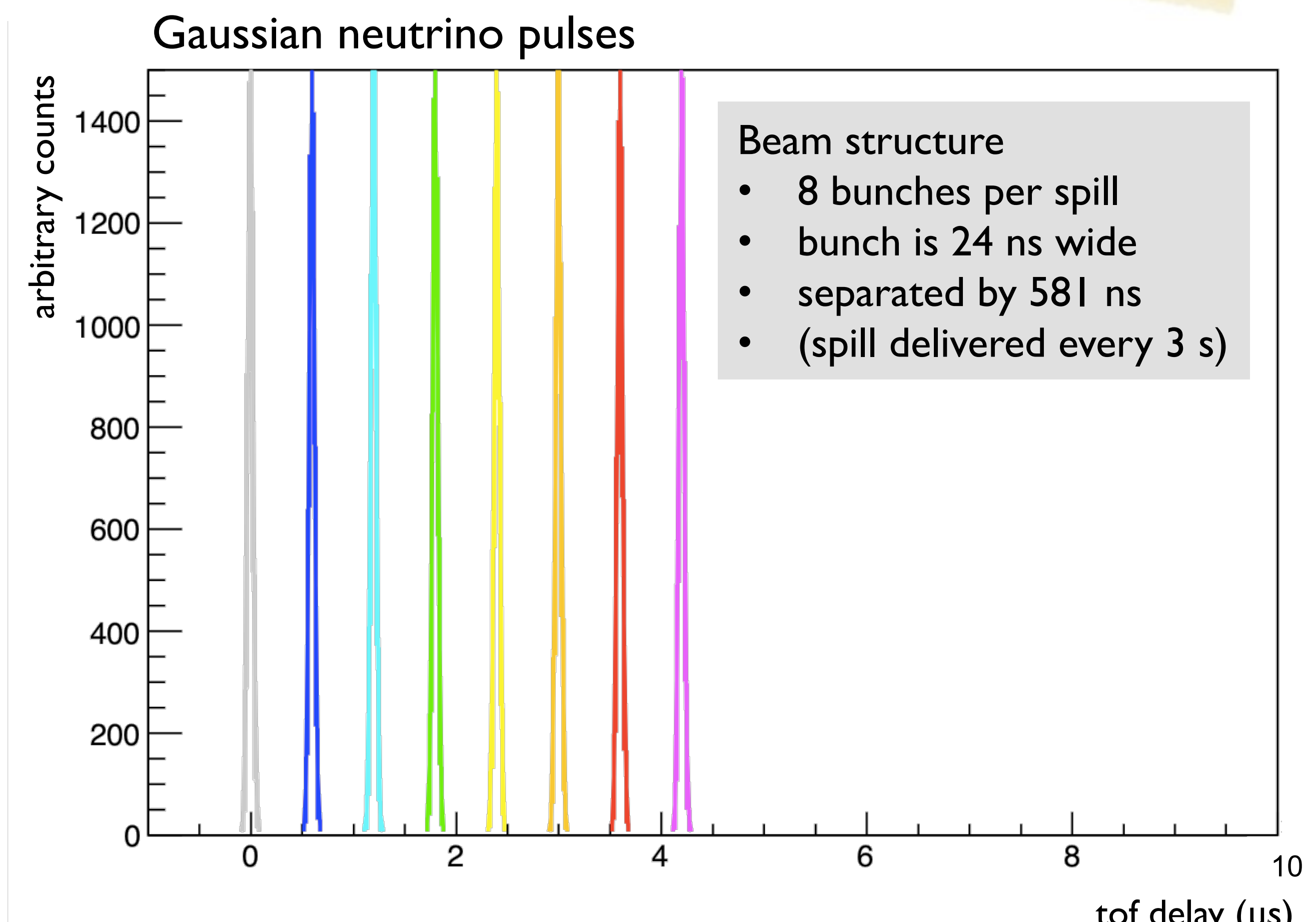


m_χ	TOF delay
450 MeV	3 µs
300 MeV	400 ns
100 MeV	30 ns

PRD **86** 035022 (2012), data from author

Time of flight to separate DM from neutrino





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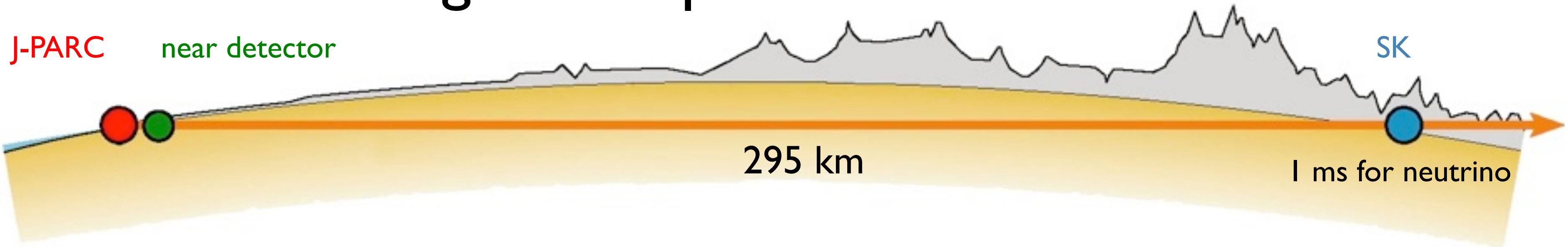
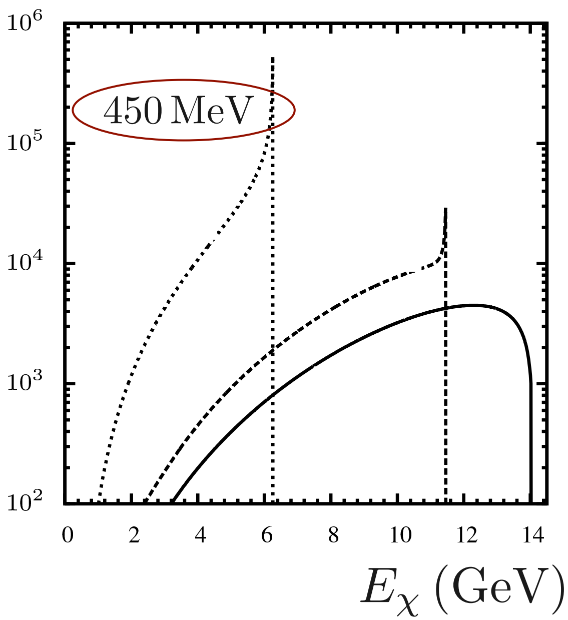
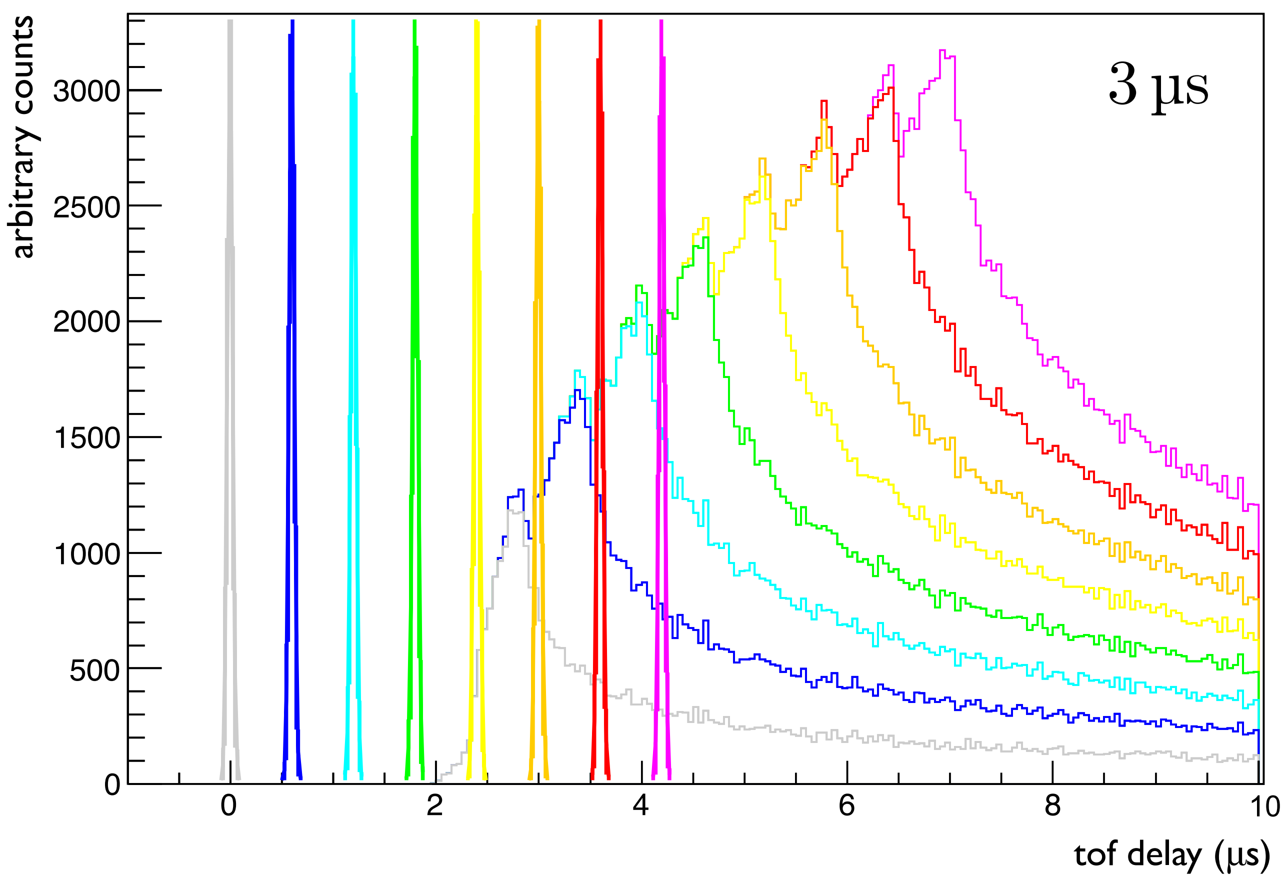




Gaussian neutrino pulses, followed by DM distributions



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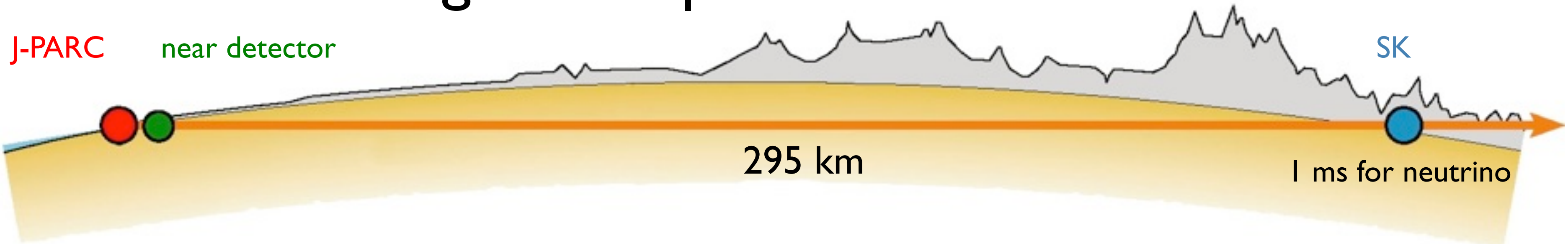

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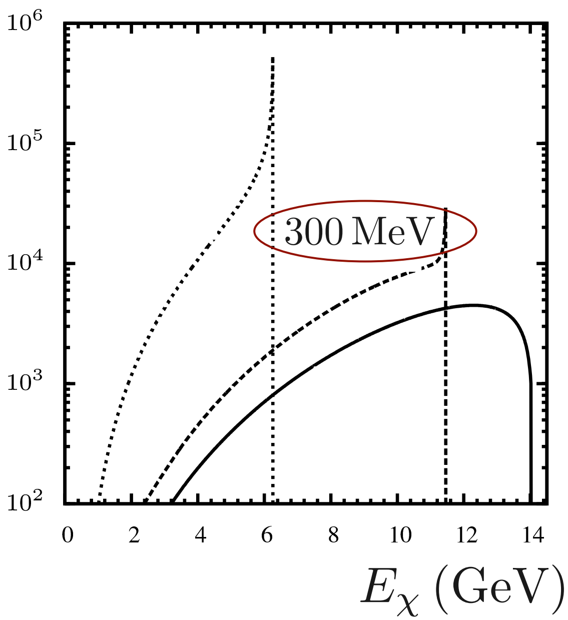
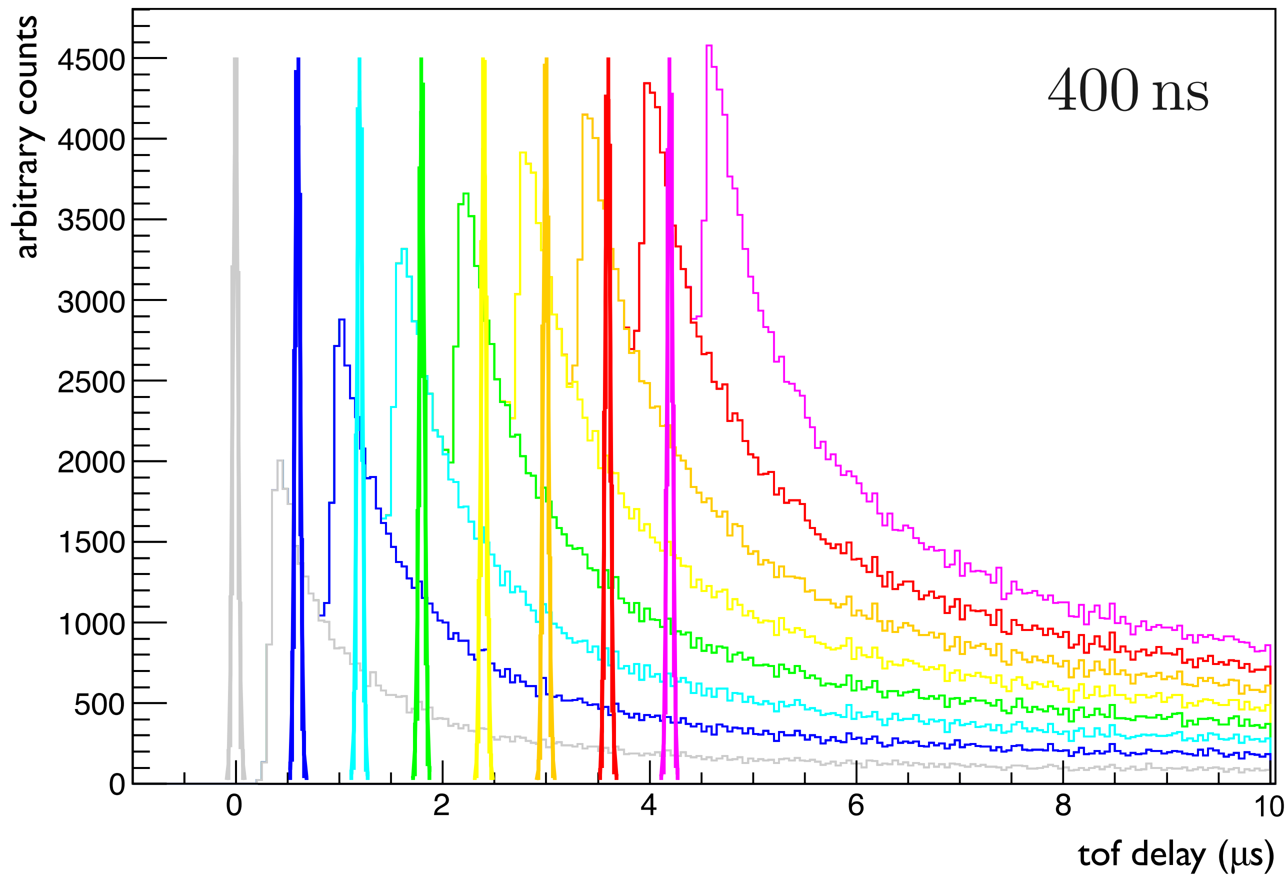
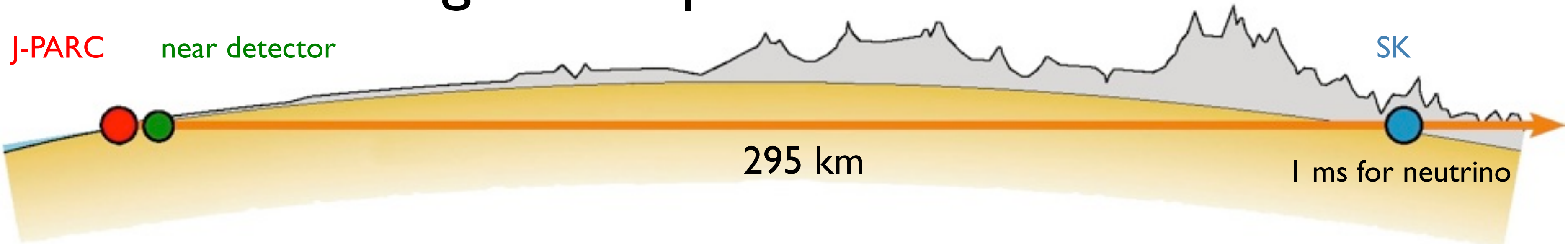
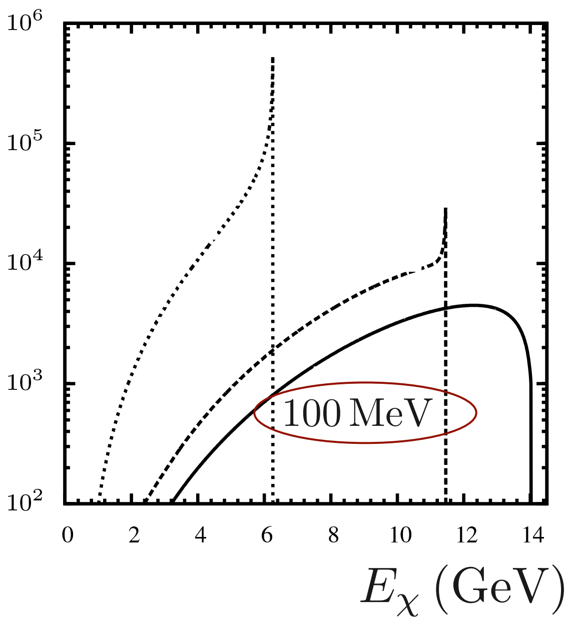




Time of flight to separate DM from neutrino





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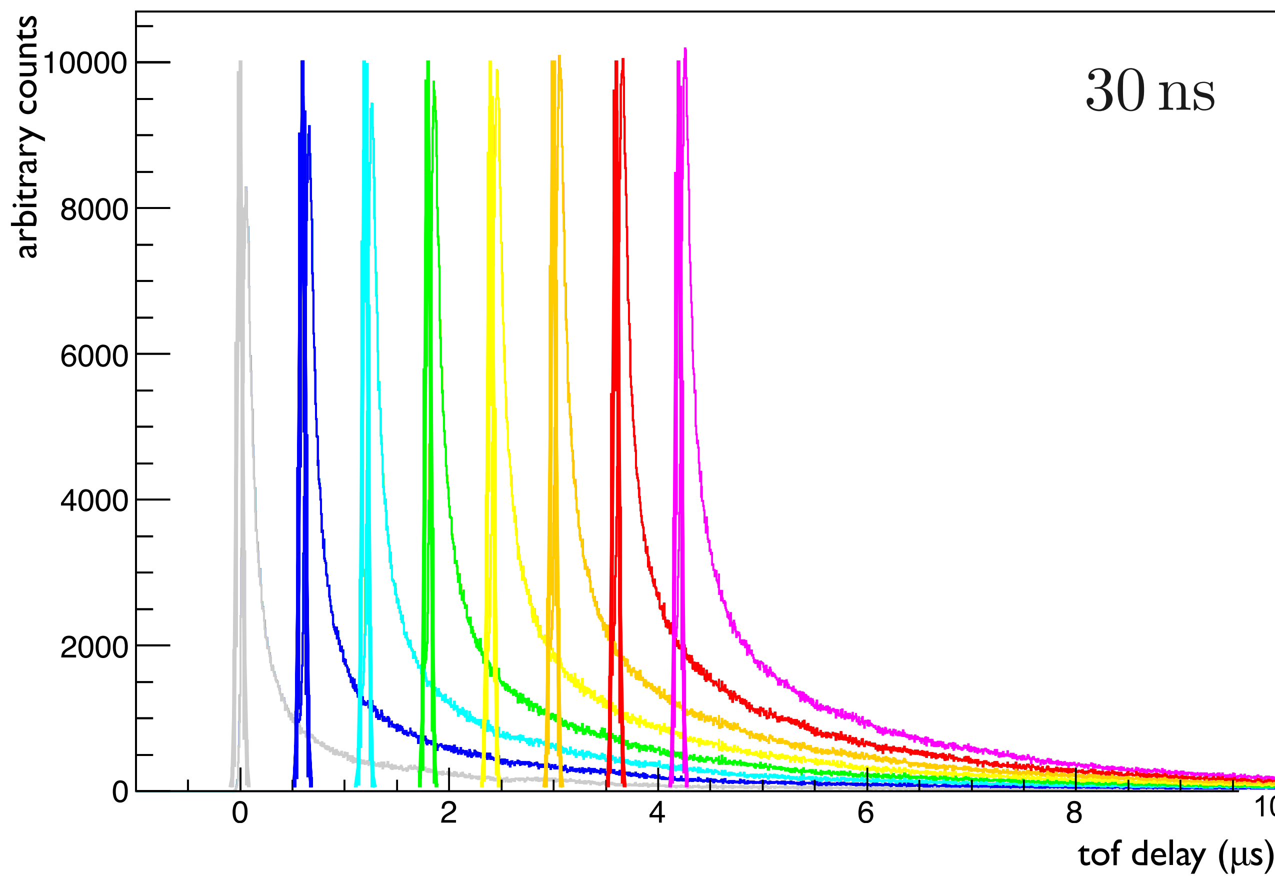
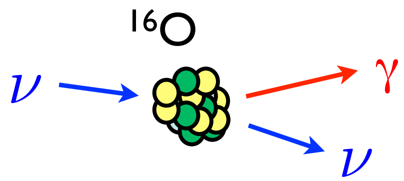


Nuclear deexcitation gammas after the neutrino-oxygen neutral-current quasielastic (NCQE) interaction

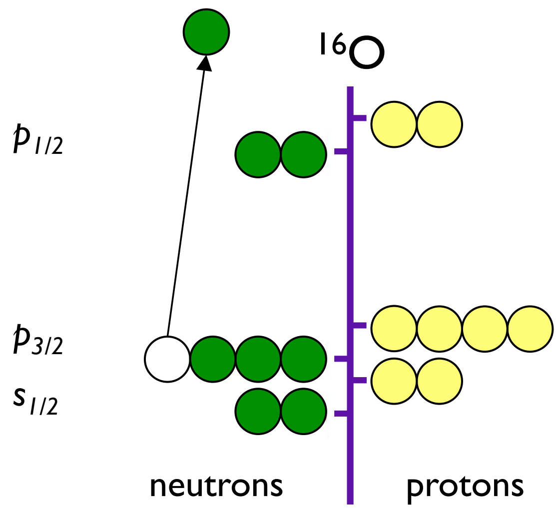


600 MeV, single nucleon emission is dominant mechanism

excited nucleus decays by emitting gammas

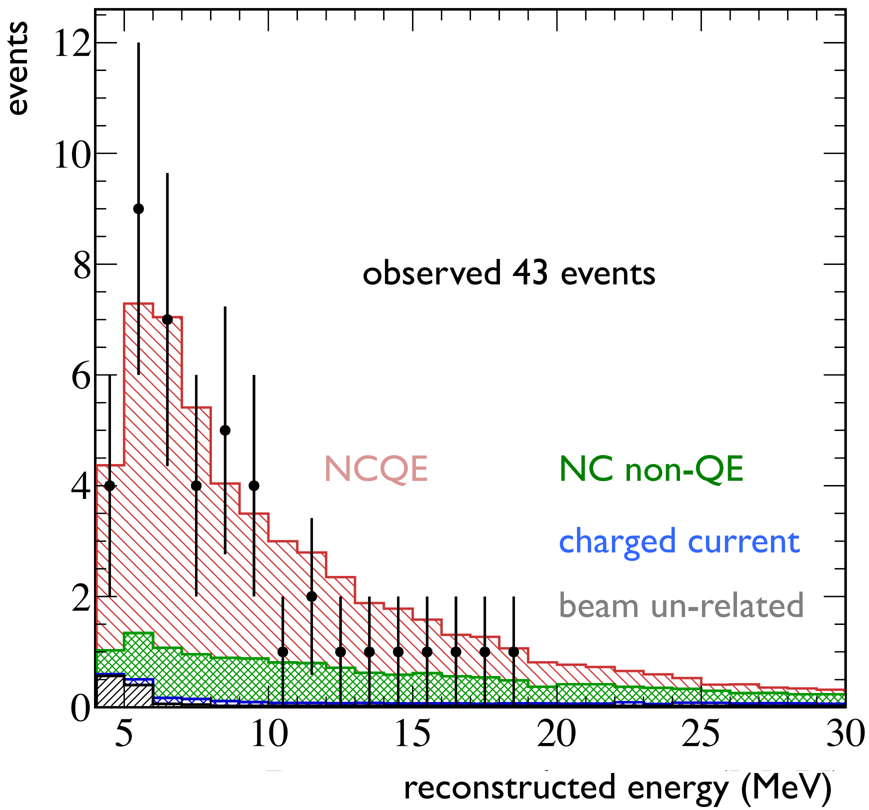
contribution of $p_{3/2}$ is overwhelming:
6.32 MeV from $(p_{3/2})_p$
6.18 MeV from $(p_{3/2})_n$

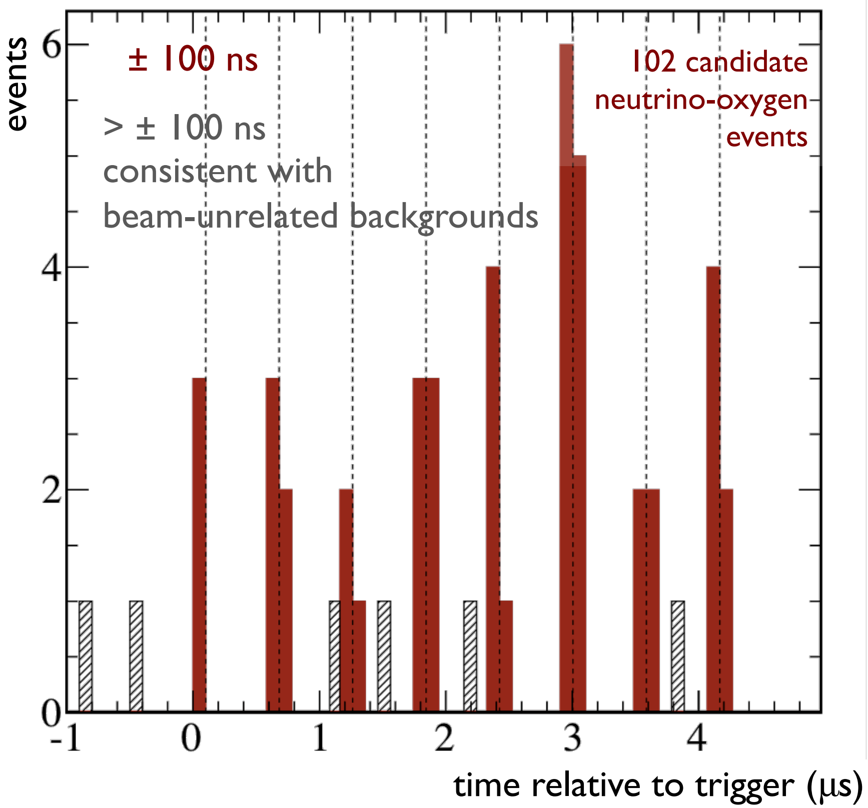
87% branching ratio for ~6 MeV from $p_{3/2}$



 PRL **108** 052502 (2012)

Analysis of neutrino-oxygen NCQE events in T2K Super-K





Selection cuts

- 4 – 30 MeV reconstructed energy
- > 34° Cherenkov angle to remove muons
- ±100 ns of beam timing
- fiducial volume
- reconstruction quality cuts

Conclusion

Search for low mass dark matter candidate produced in T2K neutrino beam

- understand detection of deexcitation gammas in Super-K after neutrino-oxygen NCQE
- plan to apply to DM search
- DM/neutrino discrimination using time of flight
- compare ratio of neutrino and DM for model-independent cross section