CPNR-OMEG Joint Workshop

Neutrino research in the JSNS2 and JSNS2-II experiment

2026/05/22

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Indication of a sterile neutrino ($\Delta m^2 \sim 1 eV^2$)

- Anomalies, which cannot be explained by standard neutrino oscillations for a few tens years are shown.

Experiments	Neutrino Source	Channel	Significance	E (MeV)	L (m)
LSND	μ Decay-At-Rest	$\overline{\nu_\mu} \rightarrow \overline{\nu_e}$	3.8σ	40	30
MiniBooNE	π Decay-In-Flight	$\nu_\mu \rightarrow \nu_e$	4.8σ	800	600
		$\overline{\nu_\mu} \rightarrow \overline{\nu_e}$			
BEST (Gallium)	e capture	$\nu_e \rightarrow \nu_X$	4.2σ	<3	10
Reactors	Beta decay	$\overline{\nu_e} \rightarrow \overline{\nu_X}$	3.0σ	3	10-100

- JSNS² uses the same neutrino source(μDAR), target(H) and the detection principle (IBD) as the LSND.

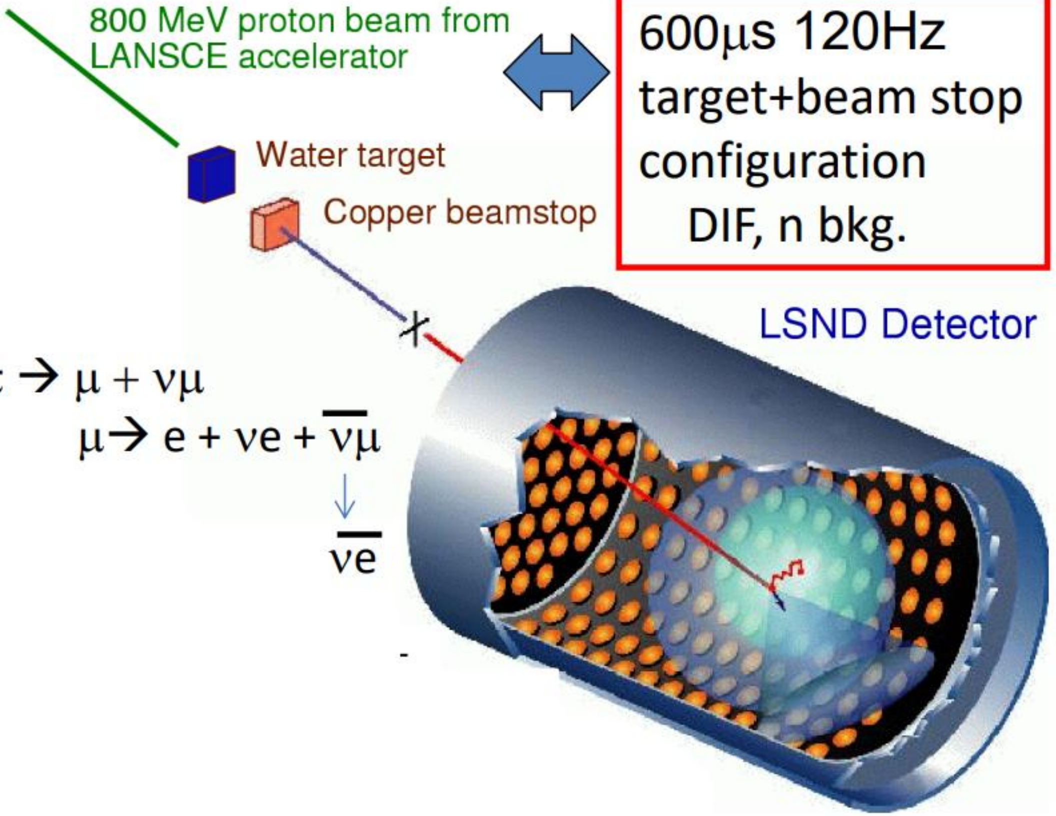
→ Even if the excess is not due to the oscillation, **we can prove this directly**.

LSND

LSND $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ Signal

1998 at LANL

600μs 120Hz
target+beam stop
configuration
DIF, n bkg.

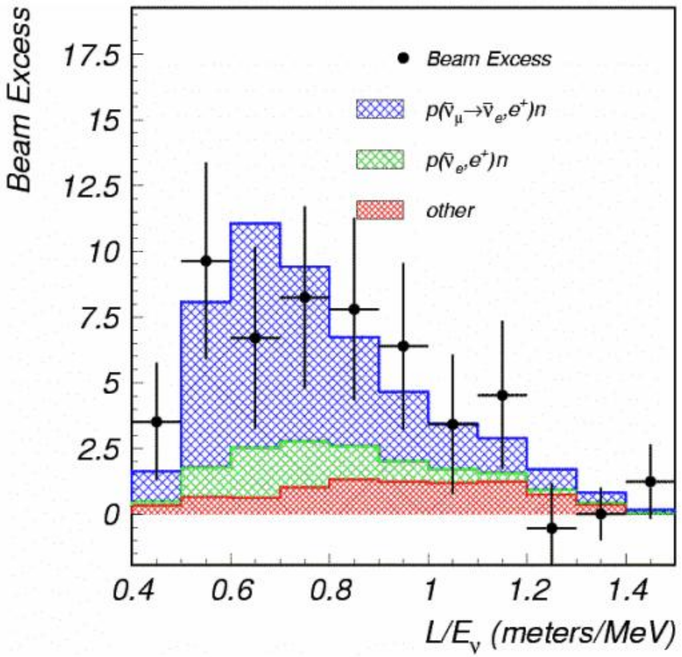


$\pi \rightarrow \mu + \nu\mu$

$\mu \rightarrow e + \nu e + \bar{\nu}\mu$

$\downarrow$

$\bar{\nu}e$



Saw an excess of:
87.9 ± 22.4 ± 6.0 events.

With an oscillation probability of (0.264 ± 0.067 ± 0.045)%.

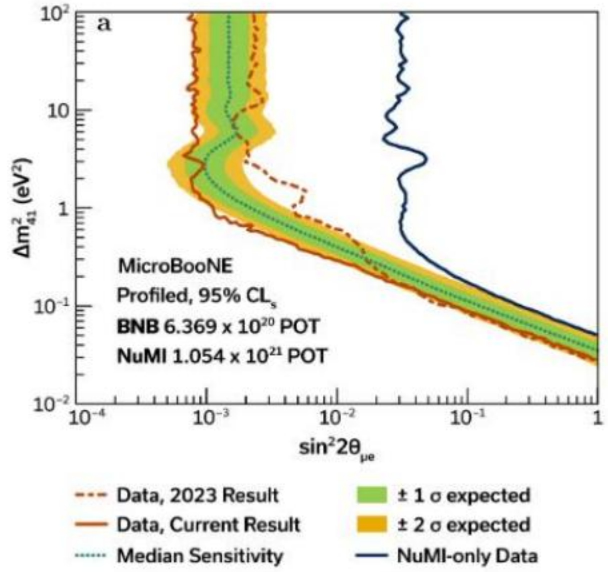
3.8 σ evidence for oscillation.

π^-, μ^- absorbed before decay into ν's
there should not be $\bar{\nu}e$ at the level of 7×10^{-4}

Signal : $\bar{\nu}e\ p \rightarrow e^+ n \quad np \rightarrow d\ \gamma(2.2\text{MeV})$

Recent MicroBooNE results (2025/Dec)

- Published as
  Nature volume 648, pages 64–69 (2025)
- Beautiful results with 2 different neutrino beams.
- 2 comments :
  - **<u>Their results do not explain the LSND anomaly</u>** (they say it could be difficult to explain it by 3+1 oscillation model)
  - Deficit of νe CC FC events (BNB beam) around 500-1000 MeV drives exclusion region to be ~2σ left side of their sensitivity.



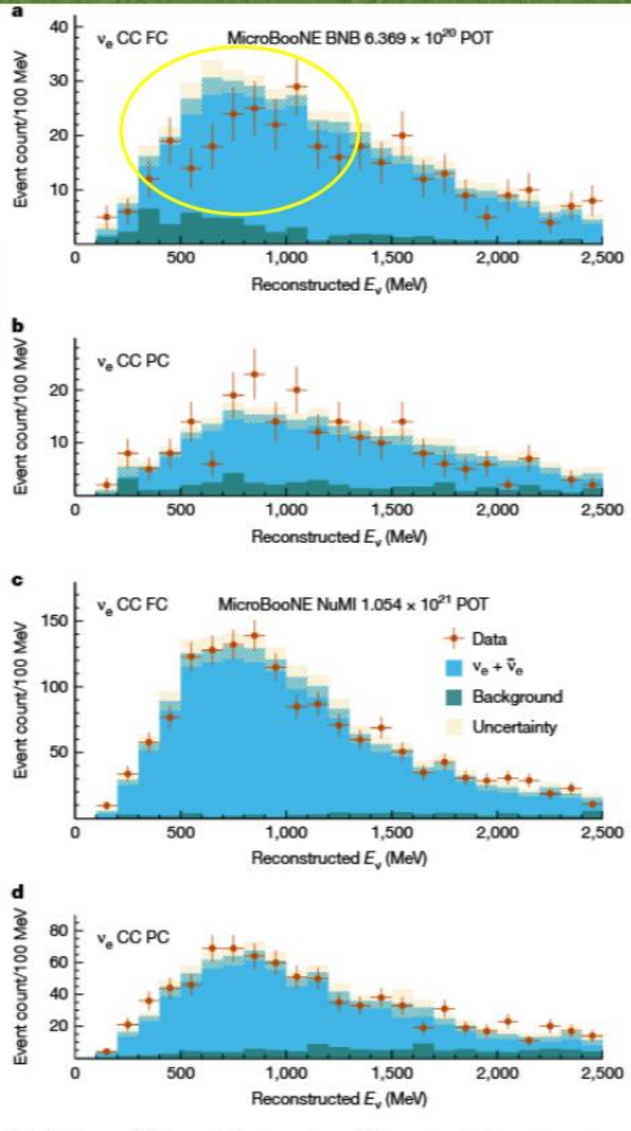


Fig. 2 | Observed CC ν_e candidate events. a–d, Reconstructed energy spectra of events selected as FC CC ν_e candidates in the BNB (**a**), PC CC ν_e candidates in the BNB (**b**), FC ν_e candidates in the NuMI beam (**c**) and PC ν_e candidates in the NuMI beam (**d**). The data points are shown with statistical error bars. The constrained predictions for each sample are shown for the 3ν hypothesis as the solid histograms, with the blue showing the true CC ν_e events and the green

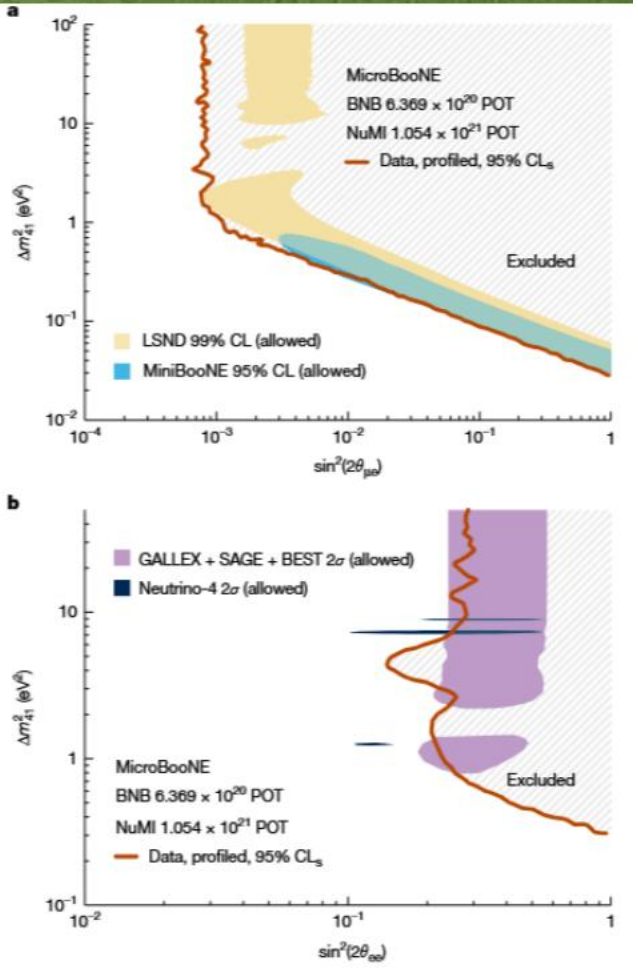
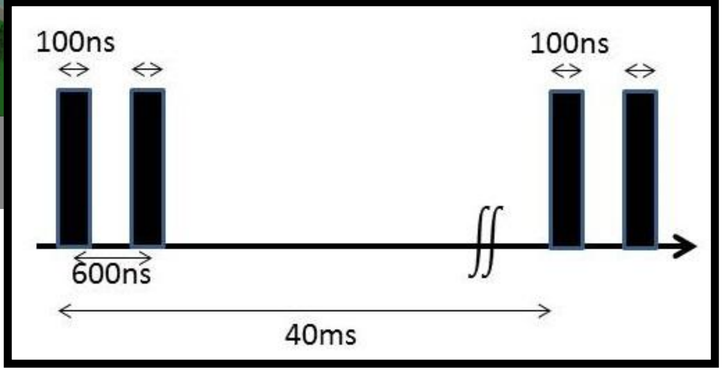


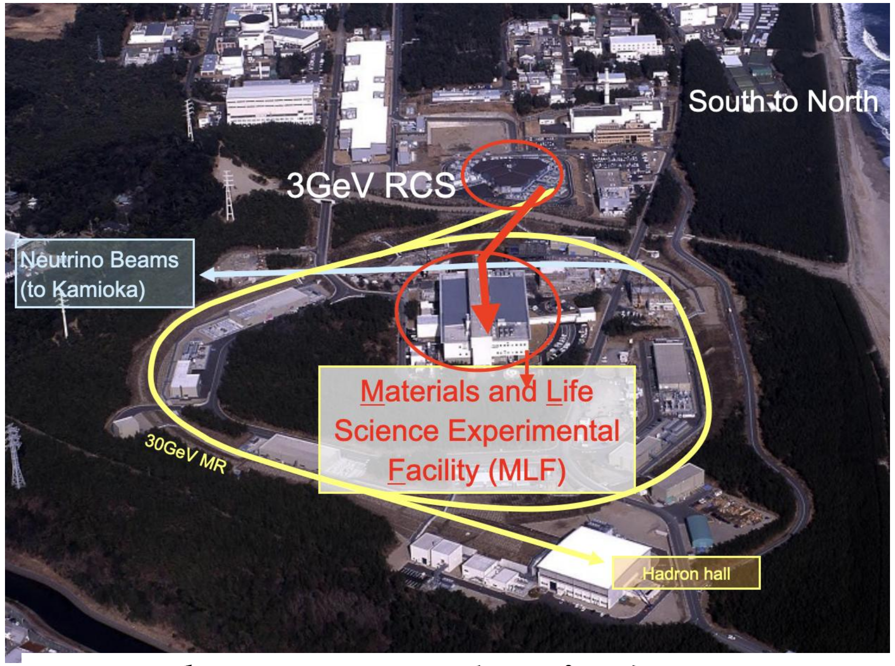
Fig. 3 | Constraints on parameters of the 4ν oscillation model. a,b, The red lines show exclusion limits at the 95% CL$_s$ level in the plane of Δm^2_{41} and $\sin^2(2\theta_{\mu e})$ (**a**) or $\sin^2(2\theta_{ee})$ (**b**). All the regions to the right of these lines are excluded by the MicroBooNE data. In **a**, the yellow shaded area is the LSND 99% CL allowed regions[3], which neglects the degeneracy between ν_e disappearance and appearance. The light blue area is the MiniBooNE 95% CL allowed region[58], considering both ν_e disappearance and appearance. In **b**, the purple shaded area is the 2σ allowed region of the gallium anomaly[59]. The dark blue shaded area is the 2σ allowed region from the Neutrino-4 experiment[9]. For context, note that the stronger-than-expected constraint on $\sin^2(2\theta_{\mu e})$, driven by the deficit observed in the BNB ν_e CC FC sample and the excess in the NuMI ν_μ CC sample, is discussed in detail in the Methods and Extended Data Fig. 2.

Same neutrino source (μDAR)

- As a LSND, neutrino beam from muon decay at rest is used.

: Proton Beam + Hg Target → Neutrino beam from muon decay at rest





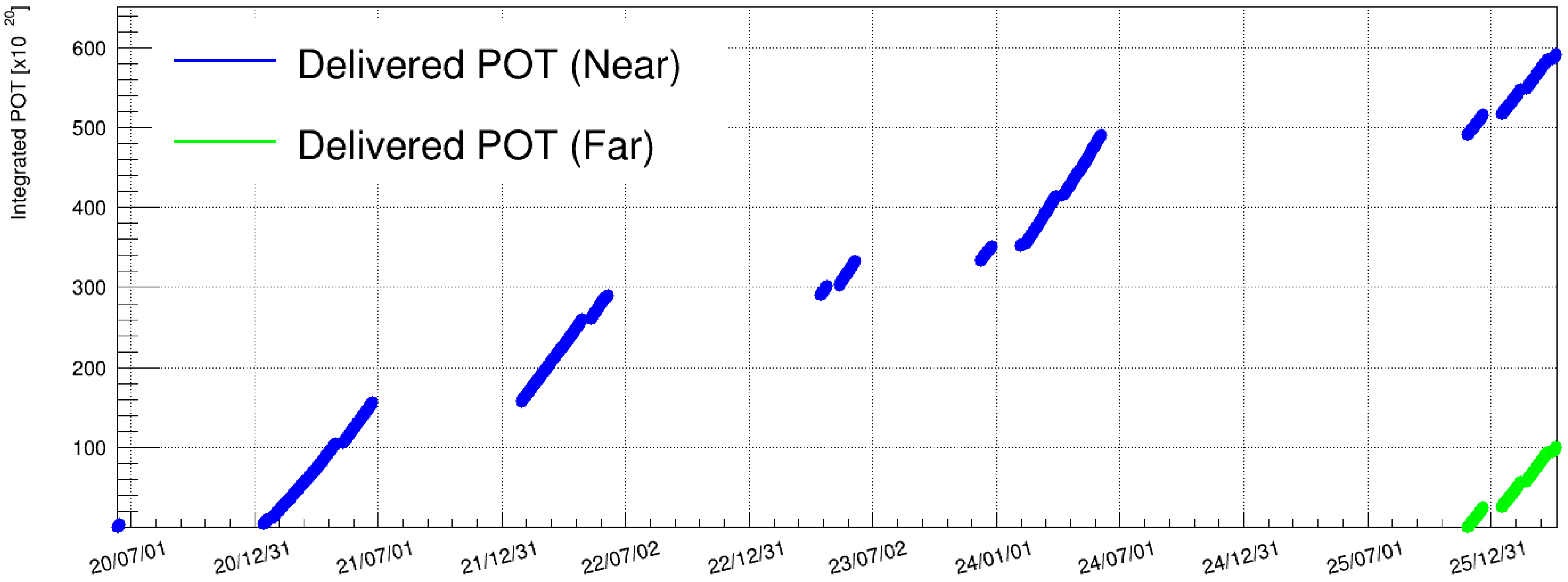
- **1MW beam power (Design)**

-> Achieve **1MW @ RCS extraction point** in 2024 (0.95MW @MLF)

- **Low duty factor beam**

(short pulse + small repetition rate) gives excellent S/N ratio.

Data taking (from 2021)



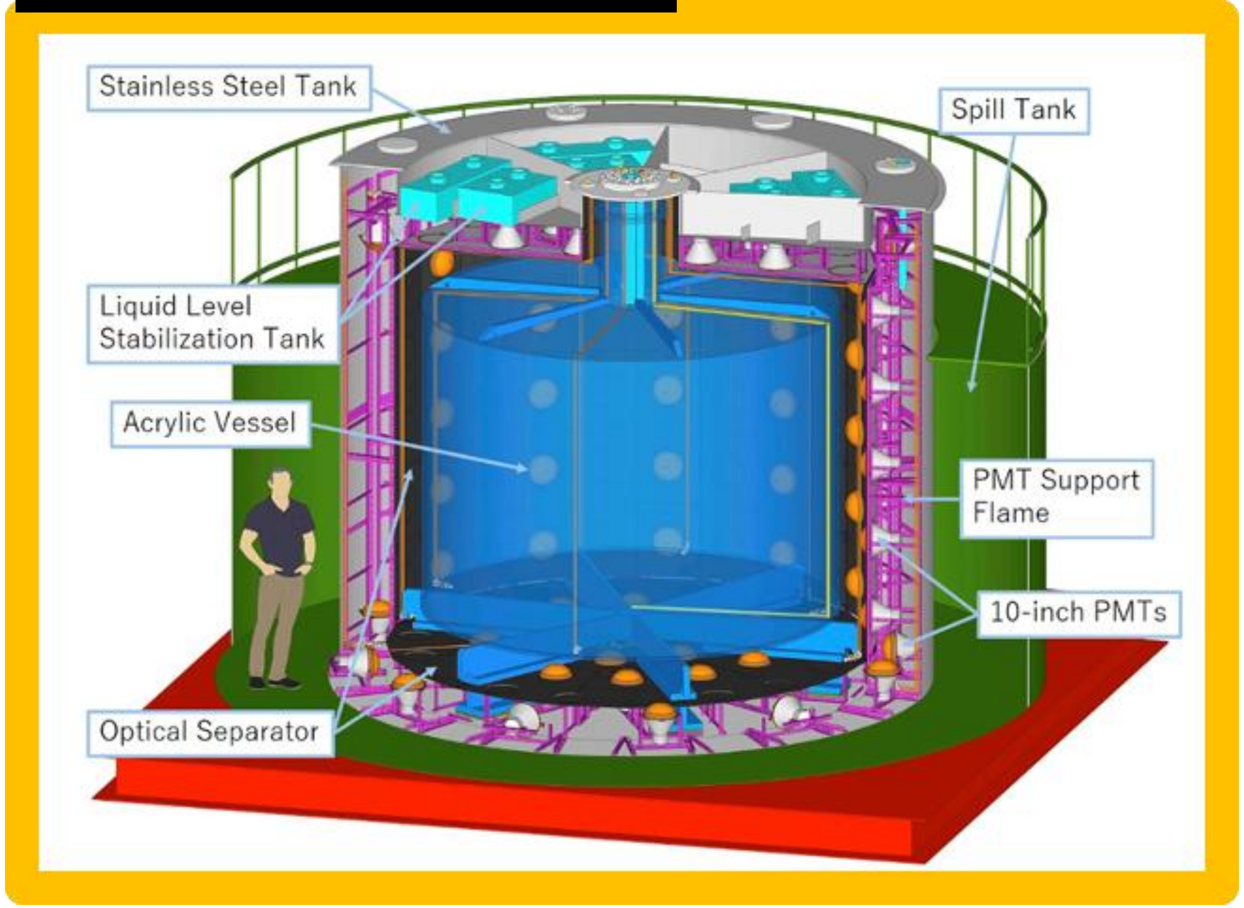
- Data taking
  - Commissioning (2020)
  - 4 long term physics runs (2021-2024)
  - **5th physics run NOW (2025 Nov ~)**

- **6.0x10^{22} POT so far**
  (~50% of approved POT)

Same neutrino target (H)

- As a LSND, JSNS2 used liquid scintillator-based detector.

Nucl. Instrum. Methods A 1014 165742 (2021)



JSNS² LS(Liquid Scintillator)

- Organic Solvent
  : LAB (Linear Alkyl Benzene, $C_nH_{2n+1} - C_6H_5$, $n = 10 \sim 13$)
- Primary Fluor
  : PPO (2,5-diphenyloxazole, $C_{15}H_{11}NO$), 3g/L
- Secondary Fluor
  : bis-MSB (1,4-bis(2-methylstyryl)benzene, $(CH_3C_6H_4CH = CH_2)_2C_6H_4$), 30mg/L

	Liquid	Volume (tons)
Target	Gd-LS + DIN (10%) *DIN (2,7-diisopropylnaphthalene)	17
Gamma-catcher and veto	Pure LS	31

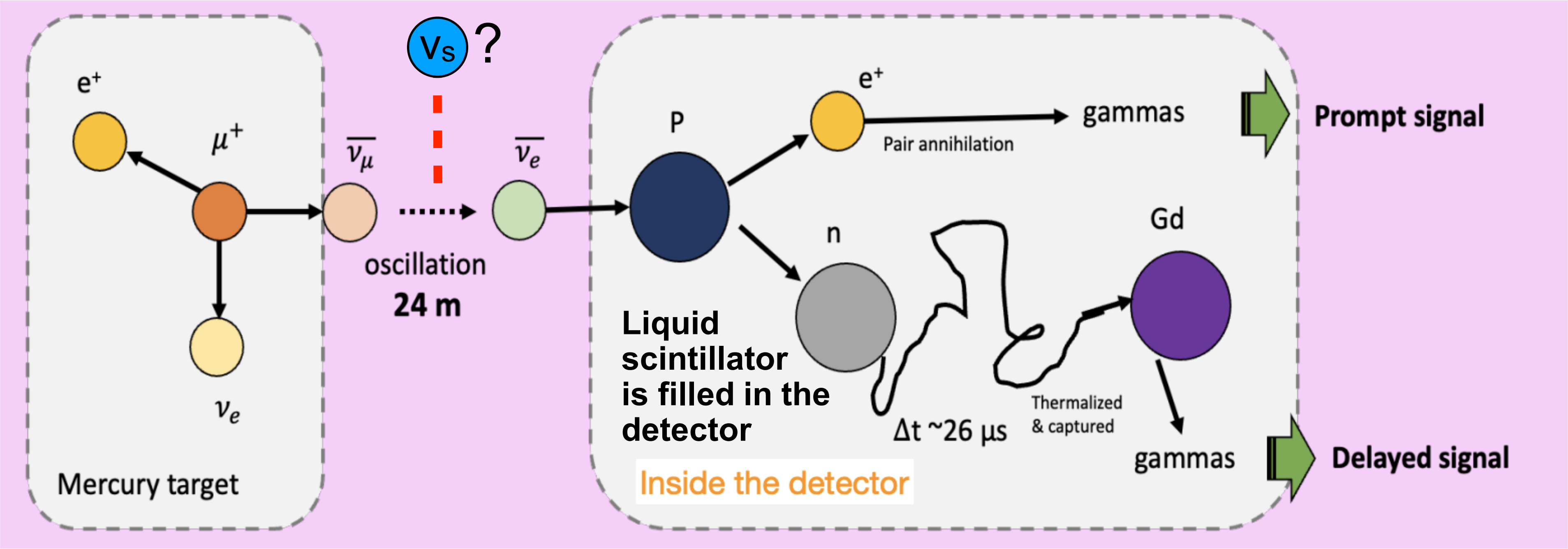
- 96 of 10-inch PMTs are installed on inner detector
- 24 of 10-inch PMTs are installed on veto

Same detection principle (IBD)

- **Detection by coincidence of IBD**

⇒ Prompt : e+ signal

⇒ Delayed : Neutron capture on gadolinium (Gd)



- **Selection cuts**

	Timing	Energy
Prompt	$2 < T_{beam} < 10\mu s$	20~60 MeV
Delayed	$\Delta T_{p\text{-}d} < 100\mu s$	7~12 MeV

+ Spatial correlation cut
$\Delta VTX_{p\text{-}d} < 60cm$

1. Side-band study before real search (2022)

1. Side-band analysis → **2. PSD (pulse shape discrimination)** → **3. LLK (loglikelihood method)**

blind analysis by using the energy side-bands.

Remove FN (fast neutron) background using PMT waveform

Using multiple variables, separate the signal, neutron, and accidental.

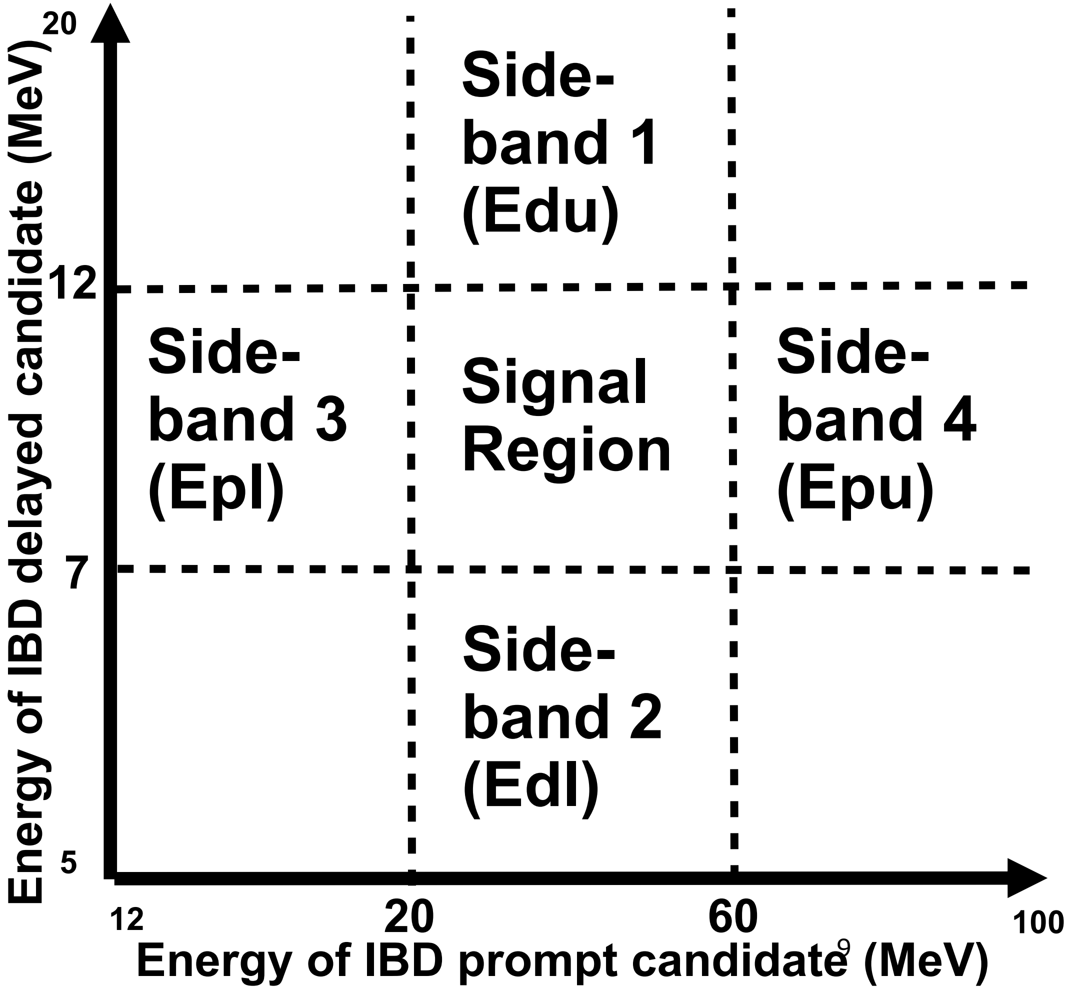
2022 Physics run (0.8x10^{22} POT)

Observation VS **Expectation**

Physics data with criteria :
□ < E_p < □ MeV
□ < E_d < □ MeV
$\Delta T_{p\text{-}d}$ <100μs
$\Delta VTX_{p\text{-}d}$ < 60cm

Purely **data-driven** control sample

- **Fast neutrons (Cosmogenic)**
-> obtained at T_{beam} > 1ms
- **Accidental background**
-> obtained with specific calibration runs



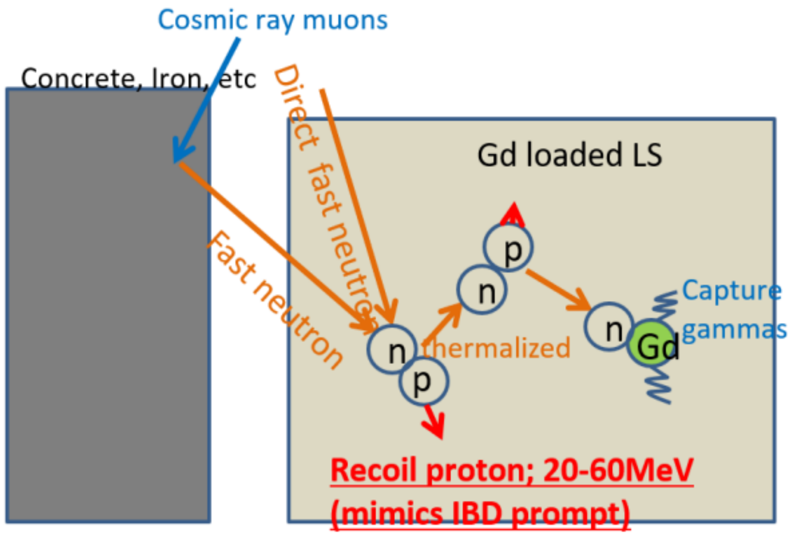
- Blind analysis is done with comparing the observation and expected background.
- The rates in the side-band regions will be predicted by the **control samples driven by data**

2. Pulse Shape Discrimination (PSD)

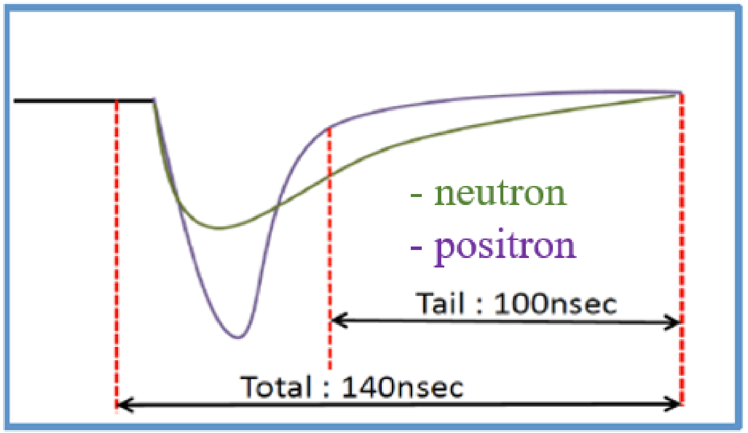
- **Fast neutrons** can mimic the IBD signals from electron anti-neutrino.

- **Pulse Shape Discrimination (PSD)** by using the difference of PMT waveforms between e-like and n-like.

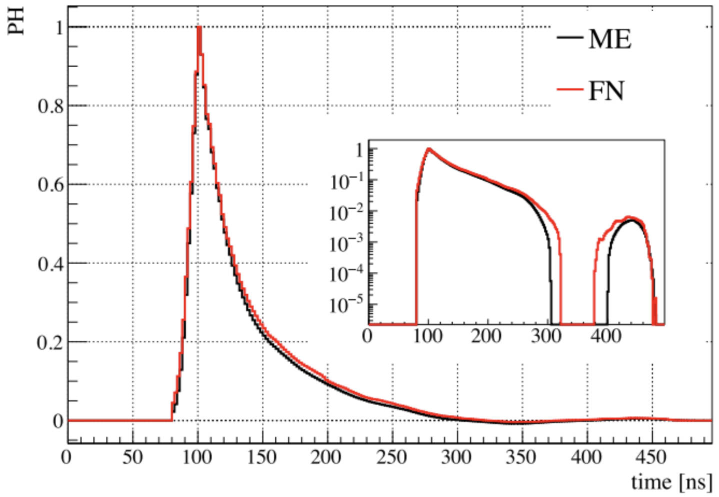
- **Data-driven likelihood method**
(Control sample :
Michel electron / Fast neutron)
=> Full information of waveform height are used.
=> Each PMT has its own separation power.



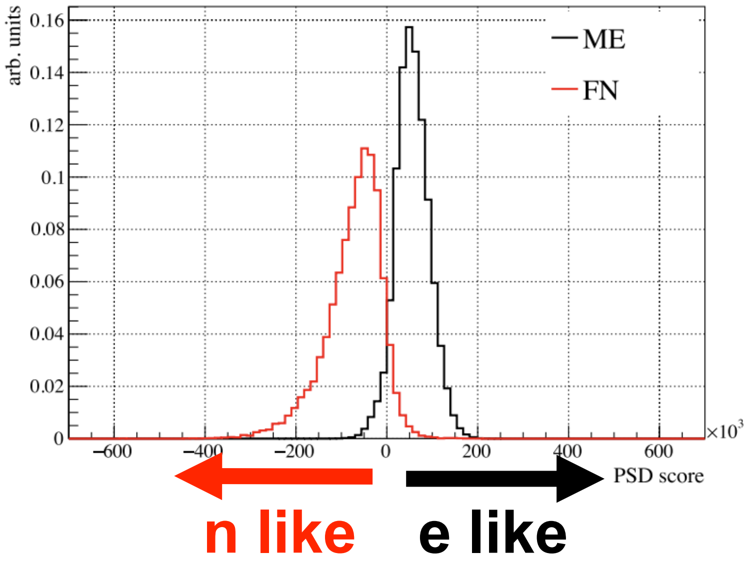
PMT waveform



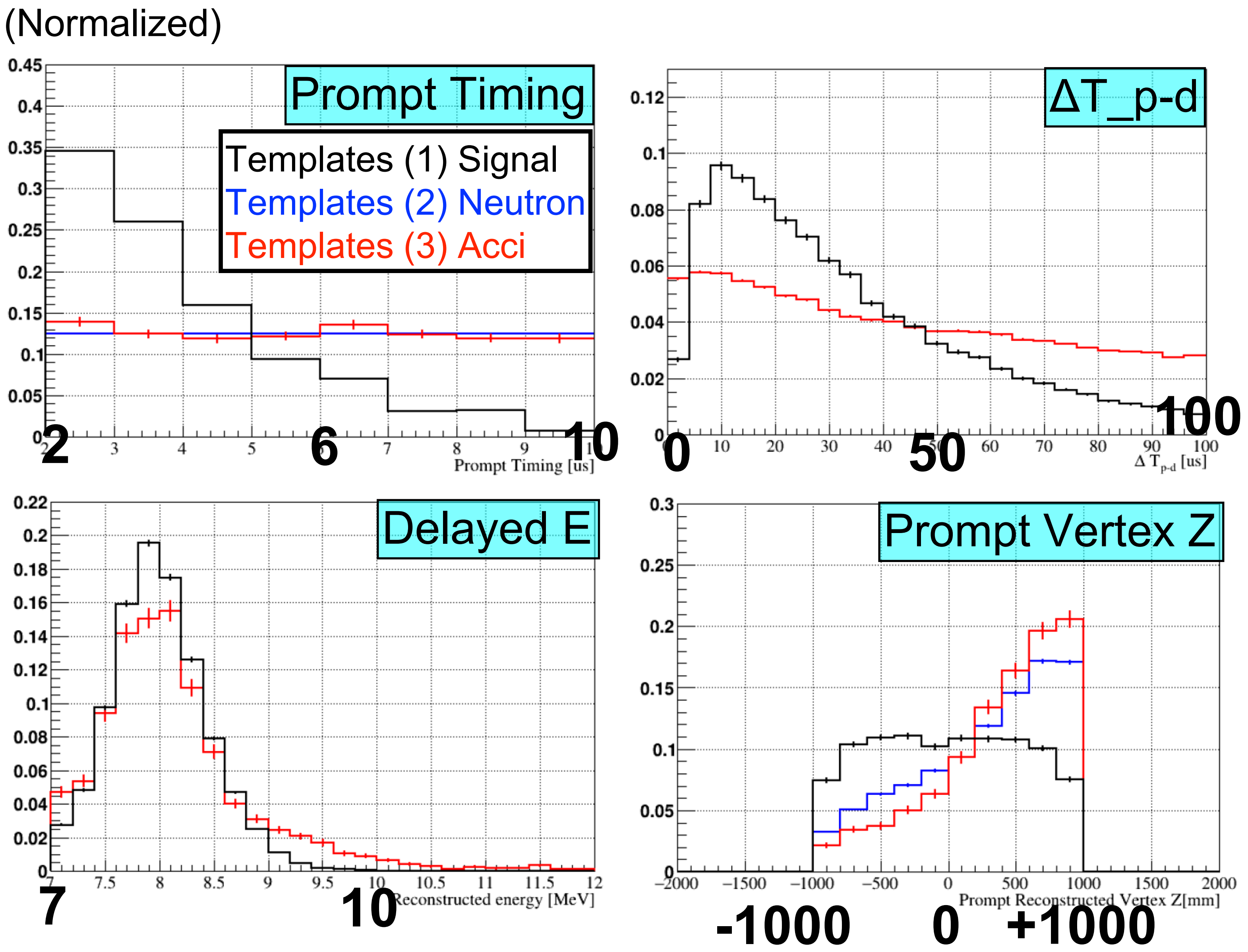
Waveforms (data)



PSD score



3. Backgrounds Control : Likelihood method



- IBD Signal vs Neutron vs Acci
=> Different shapes for each variable (Energy, Timing,)

- By using data-driven templates, calculate the binned Likelihood scores

$$Likelihood L_j = \prod_n prob_{j,n,i-th\ bin}$$

- j: three assumptions;
  IBD Signal / Neutron / Accidental
- n: type of the variables
  (Prompt Timing or …)

- By selecting **Signal-likely events**, most of neutrons / accidental bkg. are separated.

Results in signal region (w/ PSD)

- Observation vs prediction (Bkg. only) (signal region)

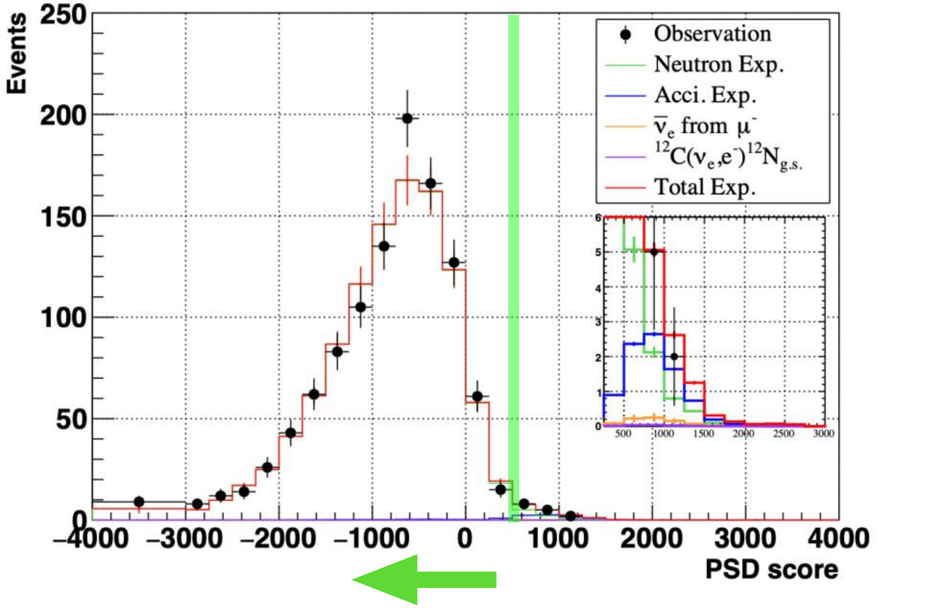
-> Good consistency for all cases

2022 Physics run (0.8×10^{22} POT)

CNgs 0.17 evt / nue bar from mu- 1.0 evt

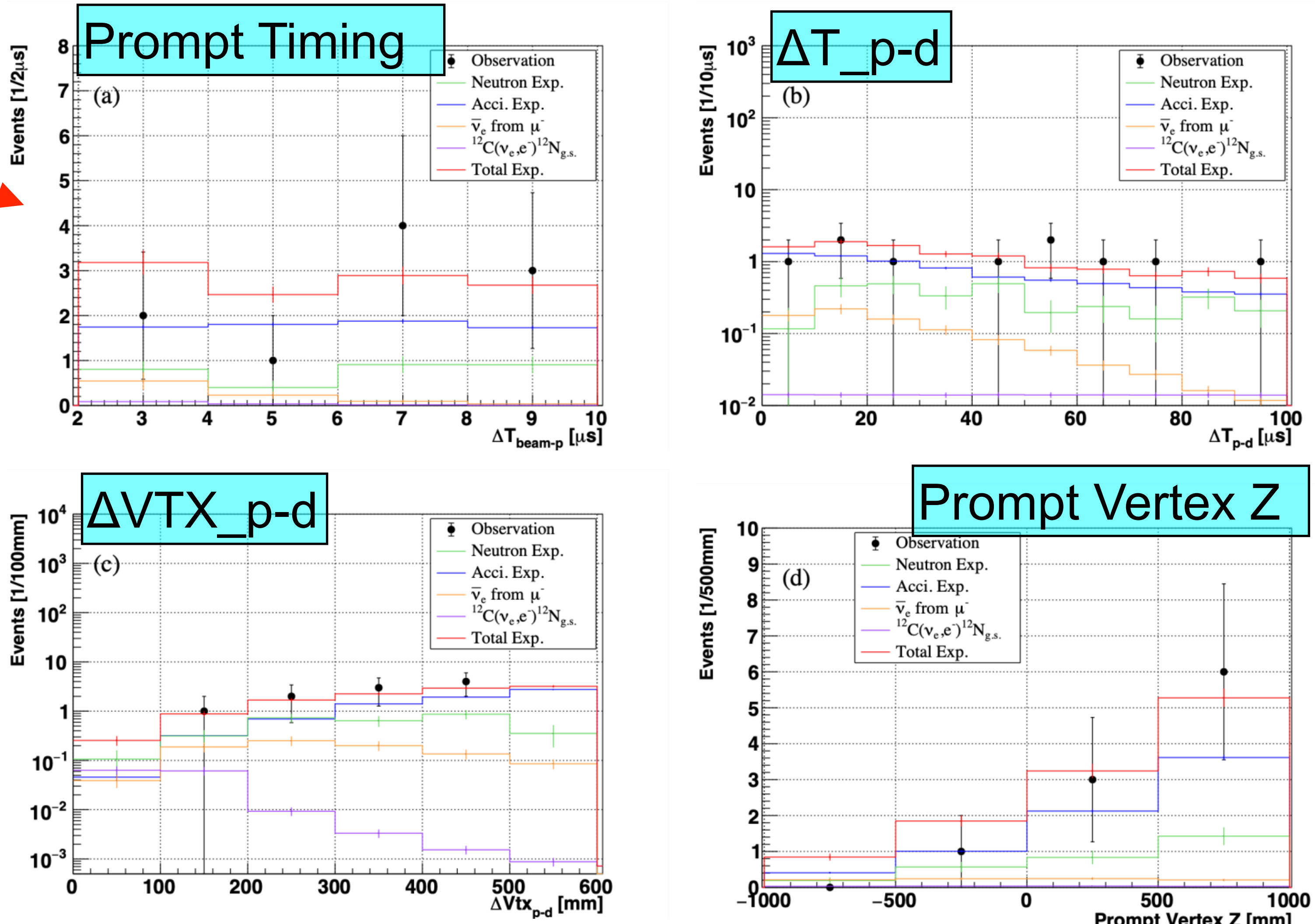
cases	observation	prediction
w/o PSD w/o LLK	1079	1063.0±25.7
w/o PSD w/ LLK	304	315.8±8.0
w/ PSD w/o LLK	10	11.2±0.7
w/ PSD w/ LLK	2	2.3±0.4

PSD application



Neutron >99% rejection

(Signal Eff. 87%)



Results in signal region (w/ PSD and LLK)

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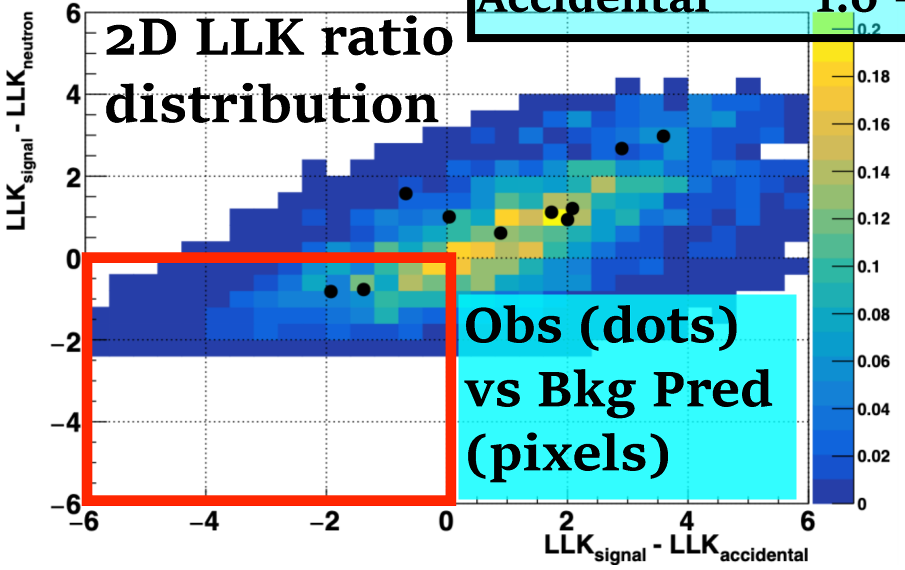
LSND $\overline{\nu_e}$ excess (scaled by POT, N_{target}, eff) = 1.1 +- 0.5 events

2022 Physics run (0.8x10²² POT)

Bkg. Components

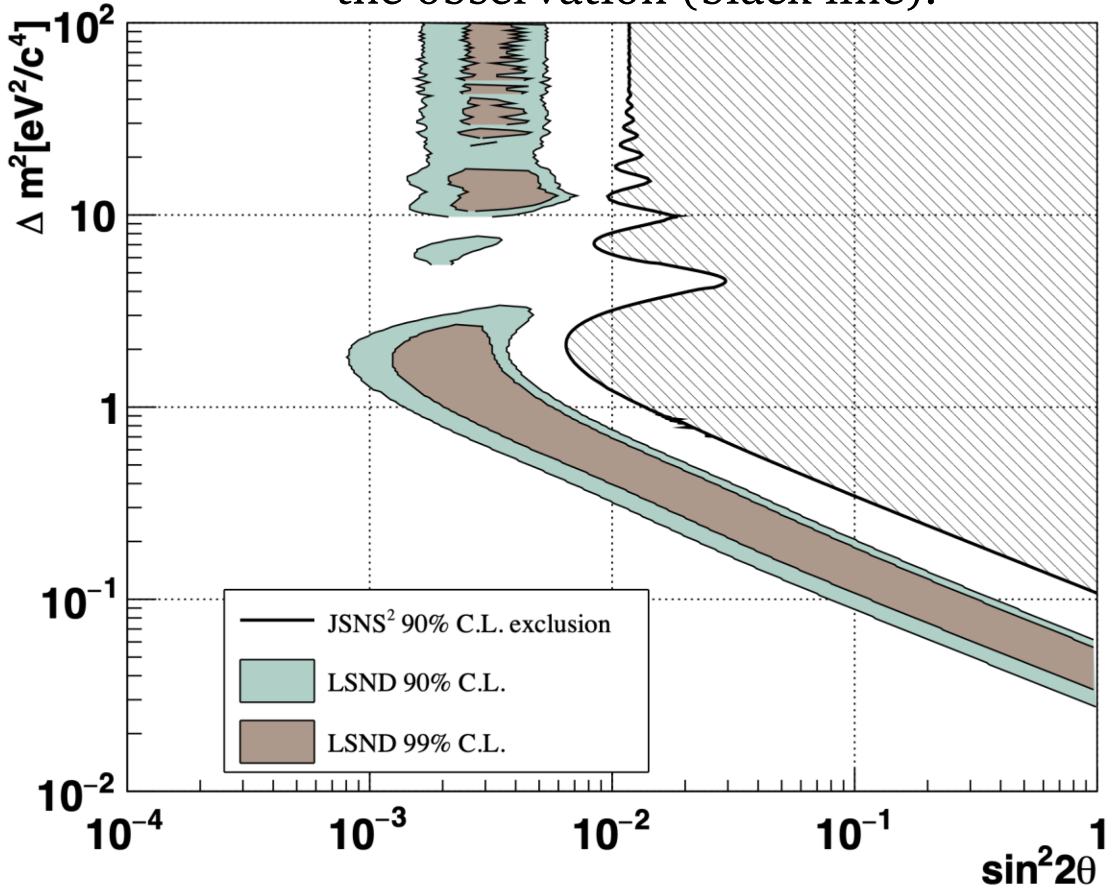
(Intrinsic)	$\overline{\nu_e}$ from μ^-	0.6 +- 0.3
	CNgs	0.08 +- 0.02
	Neutron	0.6 +- 0.2
	Accidental	1.0 +- 0.01

2D LLK ratio distribution

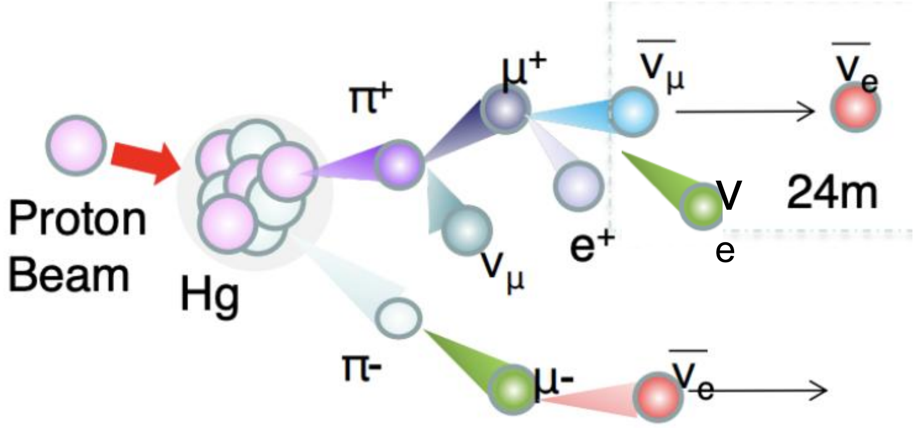


Obs (dots) vs Bkg Pred (pixels)

90% C.L. exclusion limit derived from the observation (black line).



Neutrinos in JSNS^2 experiment



Sterile neutrino search (IBD)

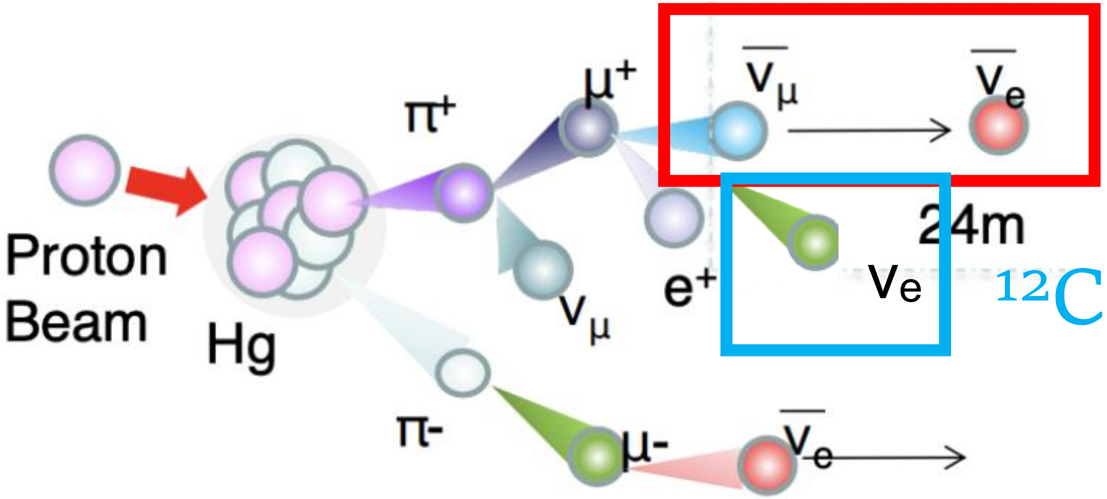
$^{12}C(\nu_e, e^-)^{12}N_{gs}$

- - - - (Signal)

$\overline{\nu_e}$ from μ^- - - - - (Intrinsic Bkg.)

Neutrino flux
- Due to no π production measurements with 3GeV p + Hg so far,
-> Flux of $\overline{\nu_\mu}$ from μ^+ , $\overline{\nu_e}$ from μ^- have **~a few tens % uncertainties** (at present)
(due to difference of a few MC models)

CNgs for the Neutrino Flux Measurement



Sterile neutrino search (IBD)

$^{12}C(\nu_e, e-)^{12}N_{gs}$

$^{12}C + \nu_e \rightarrow ^{12}N_{g.s.} + e^-$ prompt

$^{12}N_{g.s.} \rightarrow ^{12}C + \nu_e + e^+$ delayed

Total number of ν_e (=μ^+/p)

Observed Event rate

Cross Section

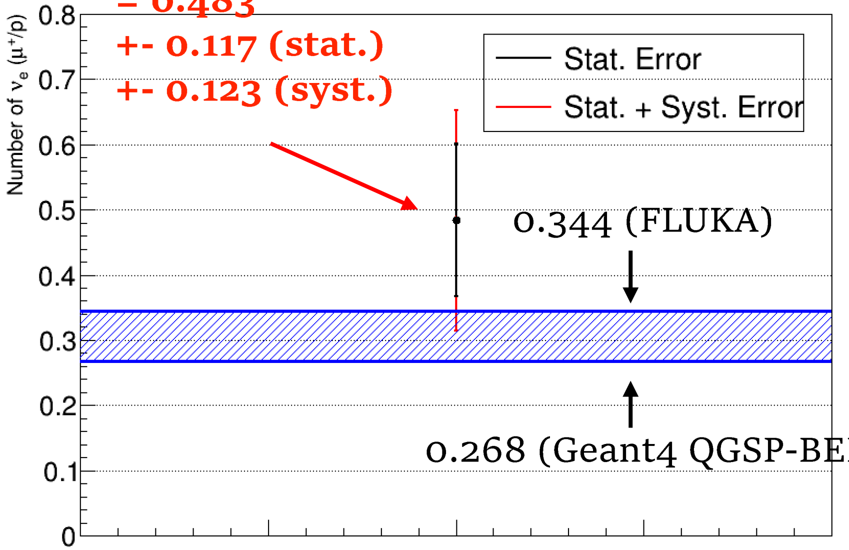
$$N_{CNg.s.} = \frac{\Phi_{\nu_e} POT}{4\pi r^2}\epsilon\sigma N_C$$

Selection Efficiency

Number of Carbons

- 2.2x10²² POT (2021+2022)
- ϵ = 5.88 +- 0.21 %
- Cross section (LSND+KARMEN) = (9.1 +- 0.7) x 10⁻⁴² cm²
- Number of C = (4.68 +- 0.94) x 10²⁹ (<- Fiducial error 20%)

Total number of ν_e (=μ^+/p)
= 0.483
+- 0.117 (stat.)
+- 0.123 (syst.)



Expected number of signal IBD events

- We can use in-situ CNgs observed number of events to predict the number of IBD signal with a following equation below.
- This gives ~760 IBD events (2022 only) with 100% transition from numubar to nuebar with eff. (syst. uncertainty is being estimated)
  - Eff_CNgs: 5.9+-0.2%, Eff_IBD: ~13.3% (PSD:~82.6%,LLK:~69.1%)
- Also, this method provides certain amount of cancelation for the systematic uncertainties for the prediction.
  - Current uncertainty is dominated from CNgs stat. error. ~30%.
  - Even nue (CNgs) is oscillated, this estimation gives the lowest limit of # of IBD. (also our CNgs measurement is good consistency with FLUKA model).

CNgs IBD/Sterile

$$\mu^+ \rightarrow e^+ + \boxed{\nu_e} + \boxed{\bar{\nu}_\mu}$$

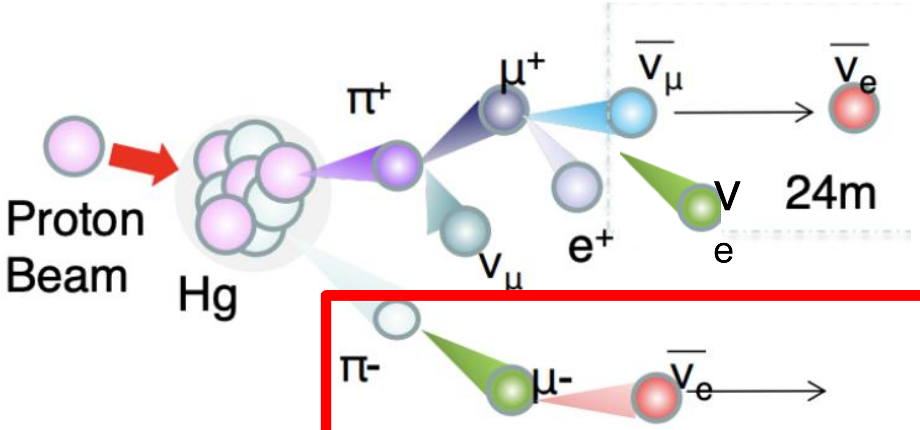
$$\frac{N_{IBD}}{N_{CNgs}} = \frac{\text{neutrino flux} \times \sigma_{IBD} \times \text{Number of Target (H)} \times \text{Eff}_{IBD}}{\text{neutrino flux} \times \sigma_{CNgs} \times \text{Number of Target (C)} \times \text{Eff}_{CNgs}}$$

(x (sterile)oscillation)

$$N_{IBD} = \frac{\cancel{\text{neutrino flux}} \times \sigma_{IBD} \times (\cancel{\text{Fiducial Volume} \times \text{density}} \times \text{H ratio}) \times \text{Eff}_{IBD}}{\cancel{\text{neutrino flux}} \times \sigma_{CNgs} \times (\cancel{\text{Fiducial Volume} \times \text{density}} \times \text{C ratio}) \times \text{Eff}_{CNgs}} \times N_{CNgs}$$

#Spill x beam power	POT	Signal(LSND best fit)	$\bar{\nu}_e$ from μ-	neutron	accidental
$1.3 \times 10^8 \times 0.75$MW	0.8×10^{22}	1.3 ± 0.4	0.7 ± 0.3	0.6 ± 0.2	0.9 ± 0.01

Neutrinos in JSNS^2 experiment - π^-, μ^- channel



Sterile neutrino search (IBD)

$^{12}C(\nu_e, e-)^{12}N_{gs}$

$\overline{\nu_e}$ from μ^-

17

3GeV proton beam hits mercury target

-> $\pi^- - \mu^-$ channel ; *(Due to High-Z material (Hg target))*

-> **Double Suppression** of $\pi^-/\pi^+, \mu^-/\mu^+$; **~10^-3** level. (Similar number of scale with expected $\overline{\nu_e}$)

-> Due to Insufficient information of the p + Hg -> π^-,
large uncertainty (~50%) makes the sensitivity worse.
-> (it directly affects to p-value-like estimation)

-> **Other ex-situ measurements** ; measure the rates of **p + Hg -> π**
-> aims to reduce **neutrino flux uncertainty to ~10%.**
-> significantly better sensitivity is assumed.

	Observed events	Expectation events
Total	2	2.3 +- 0.4
$\overline{\nu_e}$ from μ^-		0.6 +- 0.3
CNgs		0.08 +- 0.02
Neutrons		0.6 +- 0.2 (stat) +- 0.02 (syst)
Accidental		1.0 +- 0.01

Results in signal region (w/ PSD and LLK)

- Observation vs prediction (Bkg. only) (signal region)

-> Good consistency for all cases

cases	observation	prediction
w/o PSD w/o LLK	1079	1063.0±25.7
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LSND $\overline{\nu_e}$ excess
(scaled by POT, N_{target}, eff)
= 1.1 +- 0.5 events

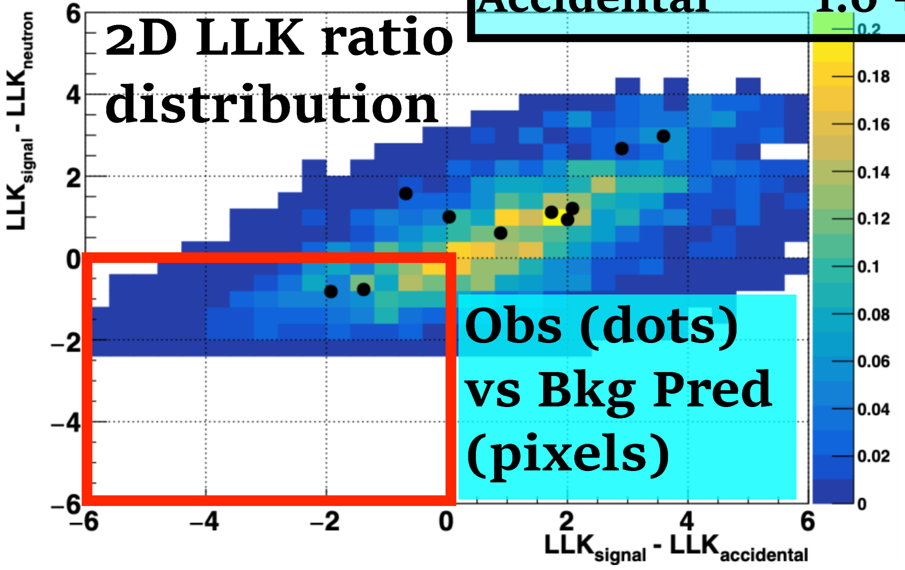
2022 Physics run
(0.8x10²² POT)

90% C.L. exclusion limit derived from the observation (black line).

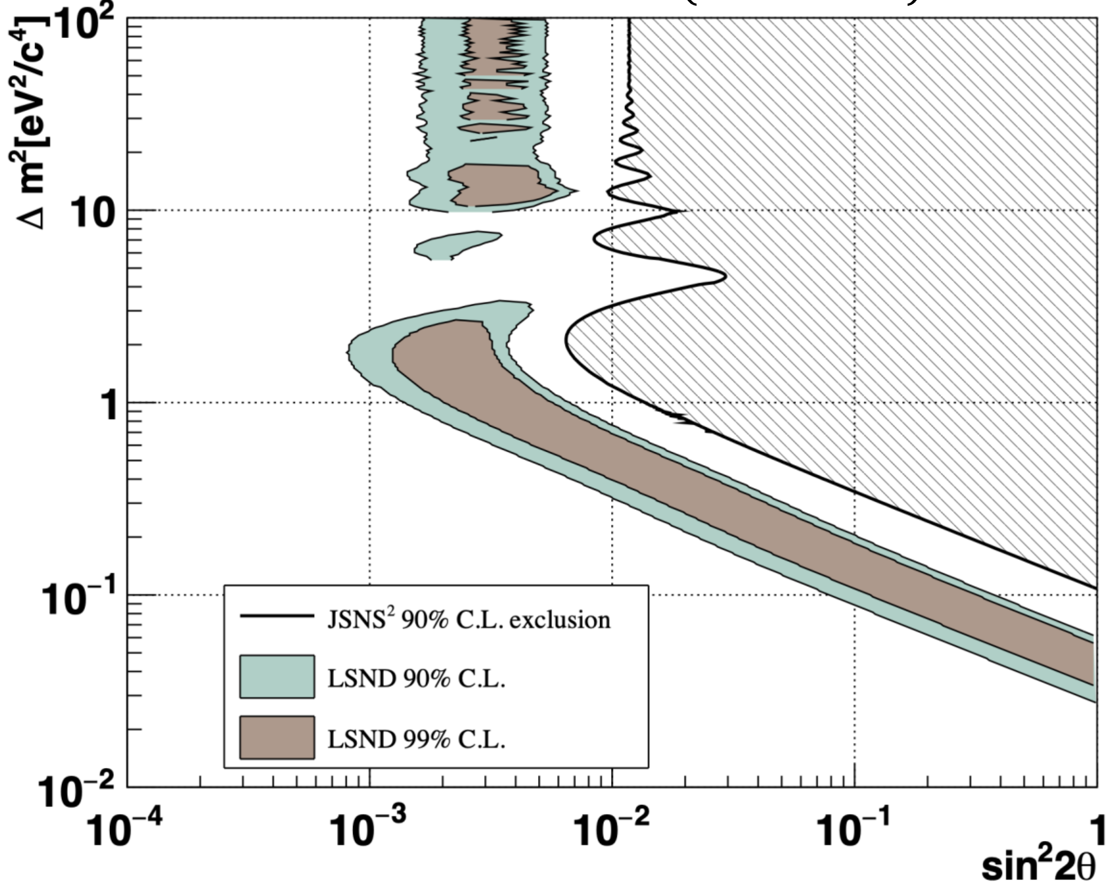
Bkg. Components

(Intrinsic)		
	$\overline{\nu_e}$ from μ^-	0.6 +- 0.3
	CNgs	0.08 +- 0.02
	Neutron	0.6 +- 0.2
	Accidental	1.0 +- 0.01

2D LLK ratio distribution



Obs (dots) vs Bkg Pred (pixels)



IBD selection criteria and the efficiencies/uncertainties

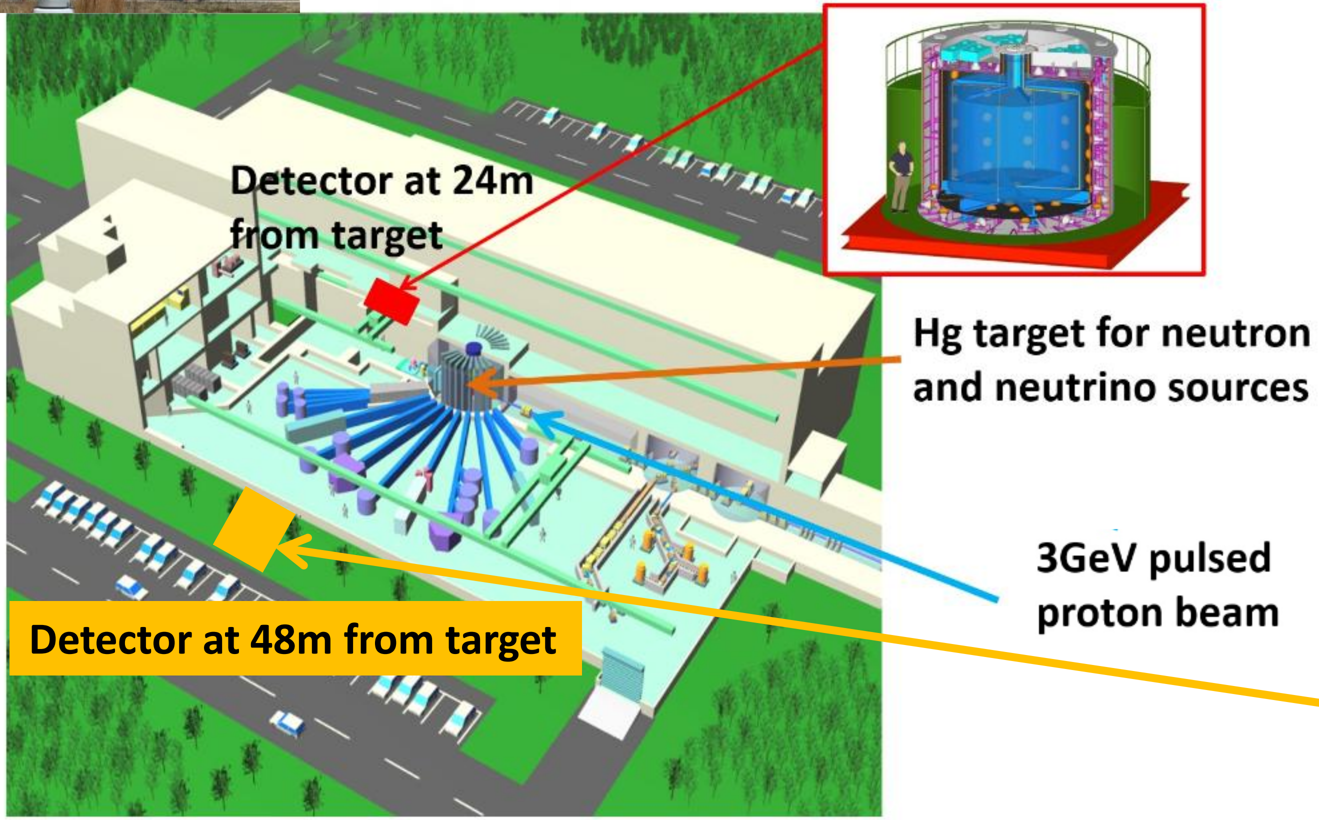
Requirement	Relative Efficiency (%)
–Prompt Candidate–	
$20 \leq E_{\mathrm{p}} \leq 60$ MeV	100.0
$2 \leq \Delta T_{beam-p} \leq 10$ μs	46.5±0.5
PSD	87.2±9.1
–Delayed Candidate–	
$7 \leq E_{\mathrm{d}} \leq 12$ MeV	75.3±0.9
Beam neutron rejection	94.1±0.1
–IBD paired Candidate–	
$\Delta T_{p-d} \leq 100$ μs	$96.6^{+3.4}_{-5.6}$
$\Delta \mathrm{VTX}_{p-d} \leq 60$ cm	83.4±10.0
Background rejection likelihood	70.5±1.5
–Muon and Michel electron rejections–	
Muon rejection	92.8±0.5
Michel electron rejections (veto layer)	97.0±0.03
Michel electron rejections (baseline)	86.1±1.4
Chimney passing muon rejections	98.7±0.1
Cumulative total efficiency	$12.4^{+2.1}_{-2.2}$

For 2022 physics run, these efficiencies are used

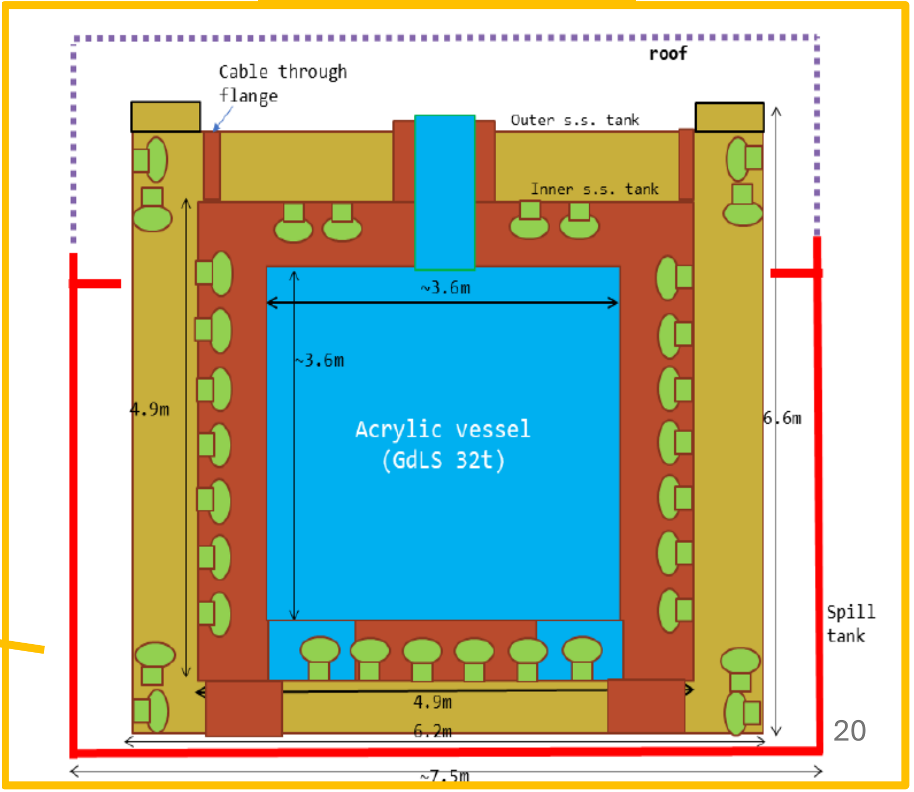
JSNS^2-II

Far detector

- The second phase of **JSNS^2**
(**J**-PARC **S**terile **N**eutrino **S**earch at **J**-PARC **S**pallation **N**eutron **S**ource)
: searching for neutrino oscillations ($\bar{\nu}_\mu \rightarrow \bar{\nu}_e$) with 24 m & 48 m baseline
- Far detector
  - 32 tonnes of Gd-loaded liquid scintillator (Gd-LS)
  - 131 tonnes of Gd-unloaded liquid scintillator (pure LS)
  - 172 PMTs in the gamma catcher region & 48 PMTs in the veto region



Detector design



Realistic scenario for Expected sensitivity of JSNS^2-II (Near+Far)

- Based on the results of 2022 Physics run (0.8×10^{22} POT, 12.3m^3 fiducial volume)

-> Keep the **same Bkg rates**

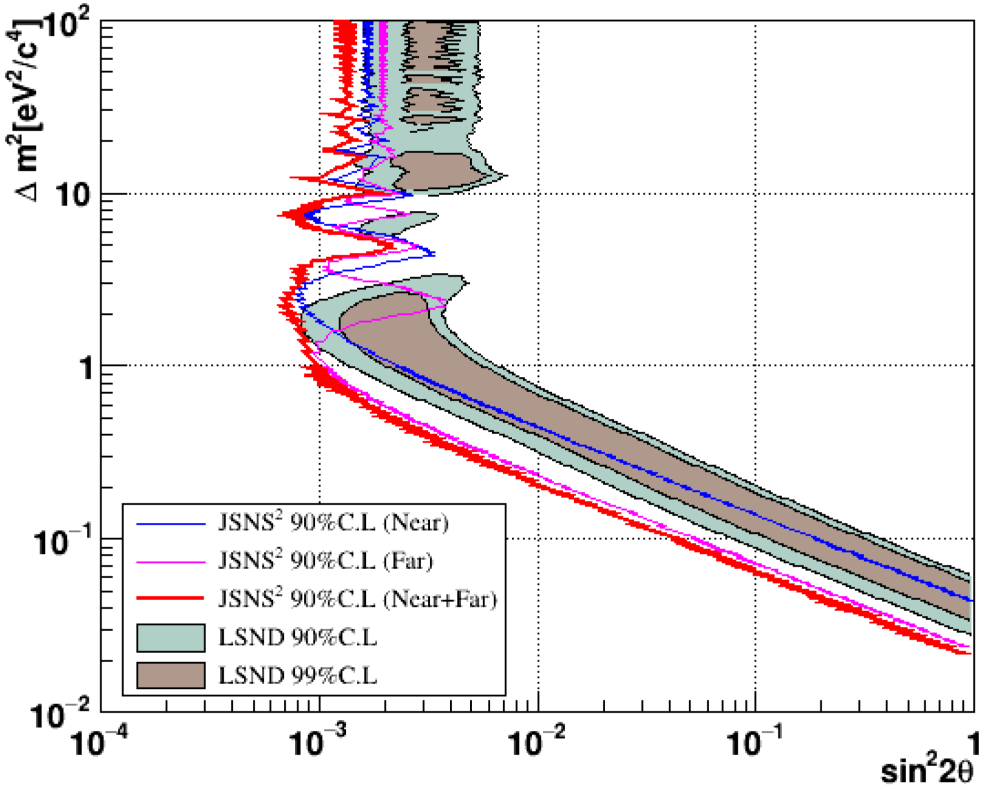
-> with possible updates :

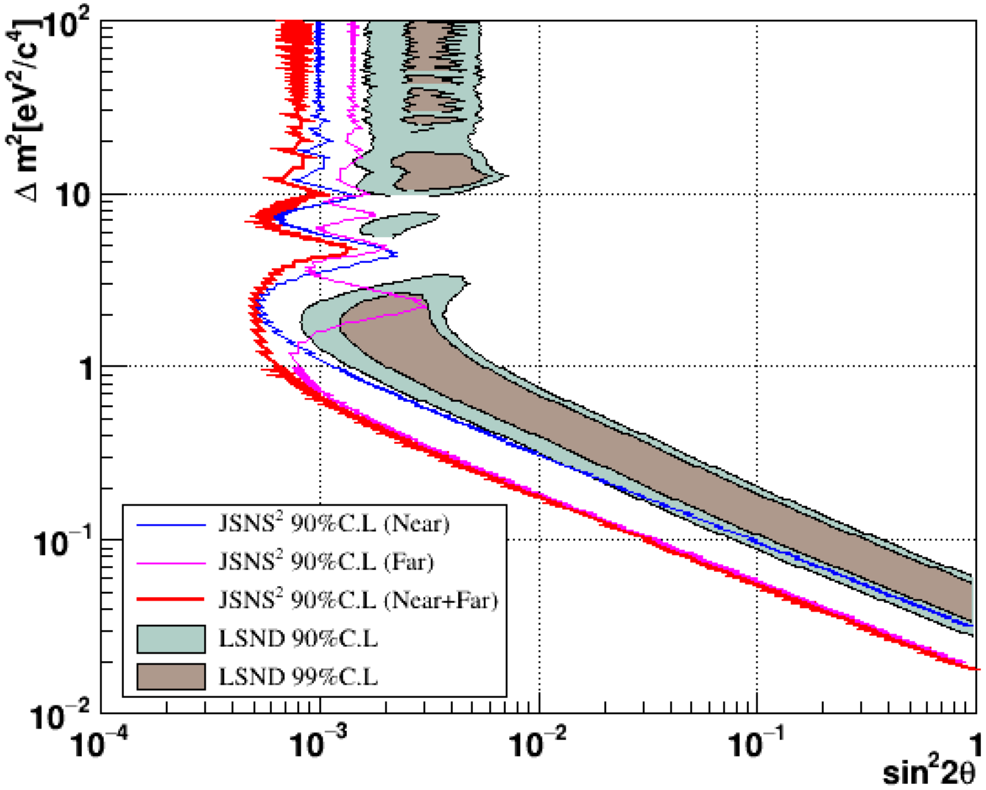
-> 1MW, **8 Years (3.04×10^{23} POT)** for JSNS^2-II (**Near only**)

-> **10%** uncertainty for $\overline{\nu_\mu}$ **from** μ^+ (from CNgs)

CNgs measurement will be improved with more statistics (14 times from the current result)

- Assumed uncertainty for $\overline{\nu_e}$ from μ^- : **50% (left) vs 10% (right)**

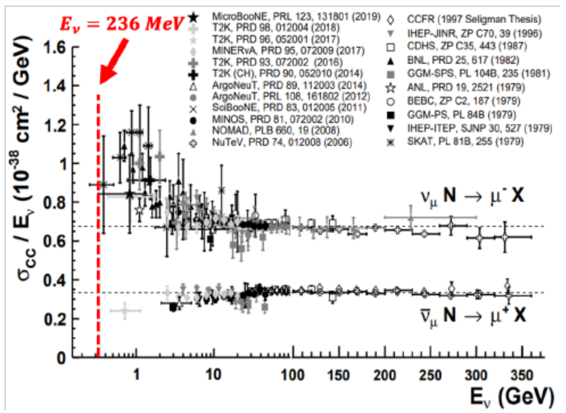


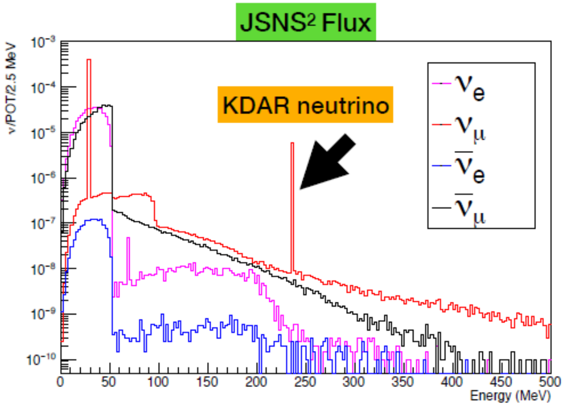


KDAR Neutrino

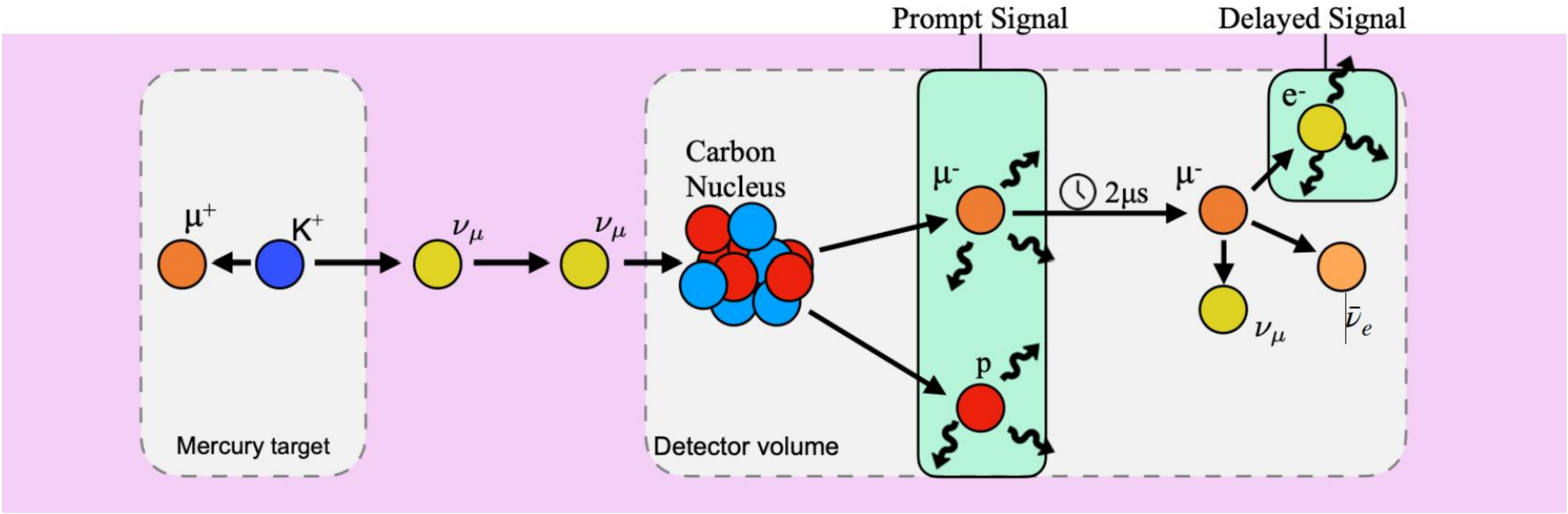
KDAR neutrino measurement

KDAR (Kaon Decay-At-Rest)





- KDAR neutrino has known mono-energy (235.5MeV)
- Few cross-section measurement below 1GeV so far.



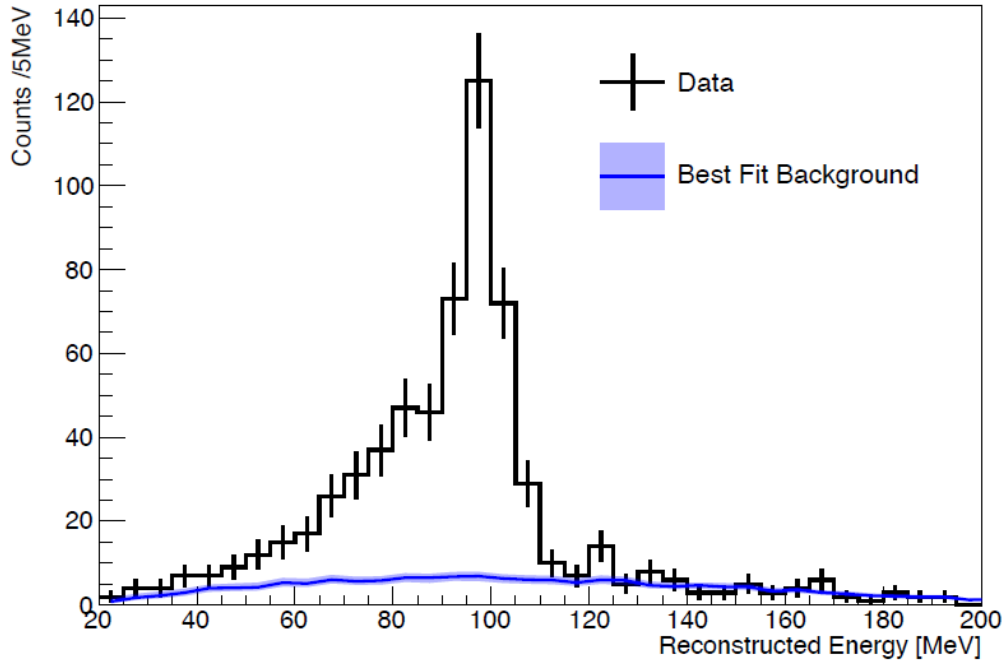
- Detection by double coincidence

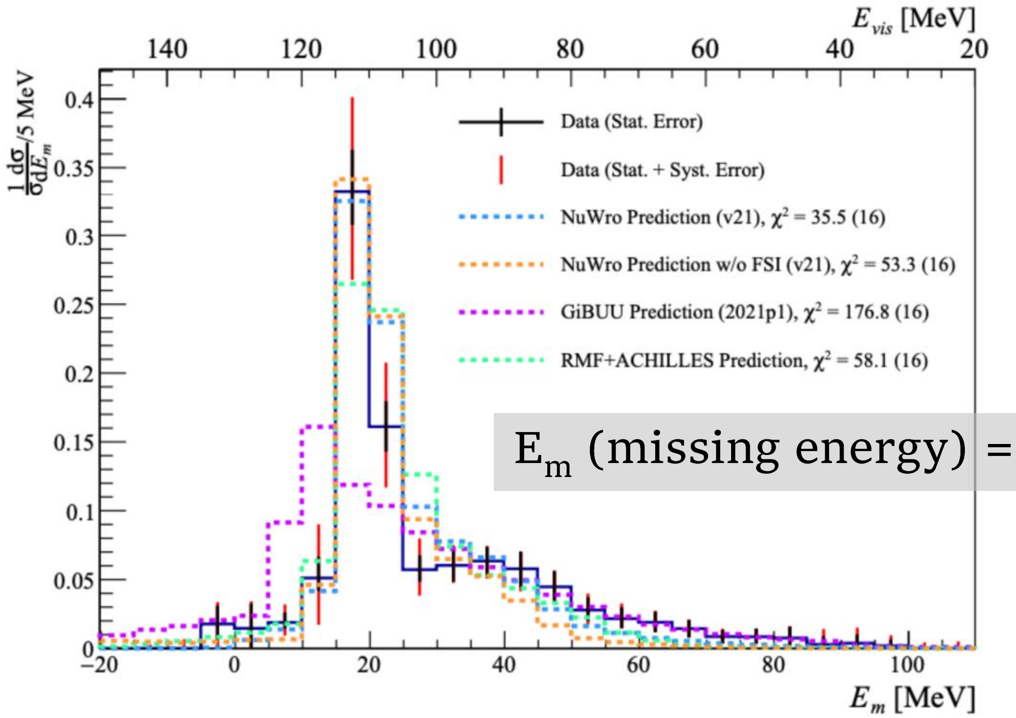
- Prompt : muon and proton
- Delayed : electron from muon decay

KDAR neutrino measurement

	Prompt	Delayed
Energy	20-150 MeV	20-60 MeV
Timing	2x150ns Beam centered windows	Δt < 10μs
Position	Fiducial Volume: R<1400mm -1000mm < z < 500mm	ΔVertex< 300mm

- KDAR candidates : 621 events
- Dominant background source is pion DIF neutrinos.
- True visible energy was estimated with Iterative Bayes (D’ Agostini) unfolding.
  → Provide better understanding of the lower energy interactio





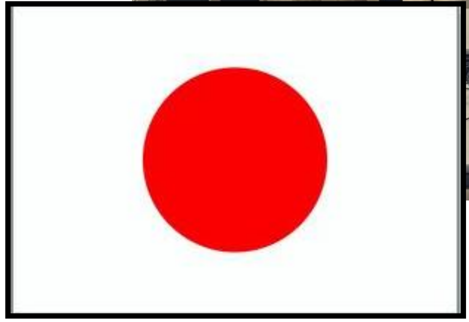
E_m (missing energy) = $E_\nu - m_\mu - E_{vis}$

BACKUP

JSNS² / JSNS²-II Collaboration

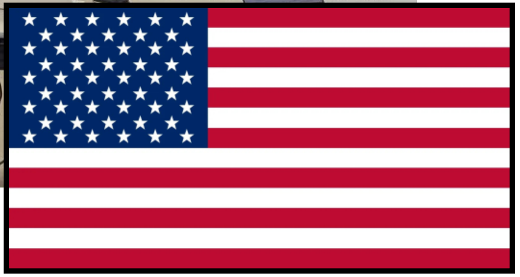
(J-PARC Sterile Neutrino Search at J-PARC Spallation Neutron Source)

JSNS² Collaboration meeting - Feb 2026

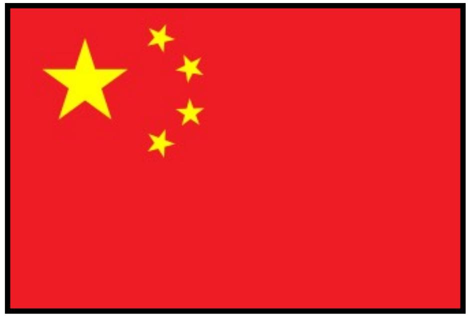


KEK
JAEA
J-PARC
Tsukuba University
Osaka University
Tohoku University
Kitasato University
Kyoto Sangyo University

Soongsil University
Dongshin University
Seoyeong University
KyungHee University
Gwangju Institute of Science and Technology
Seoul National University of Science and Technology
Sungkyunkwan University
Chonnam National University
Jeonbuk National University
Kyungpook National University

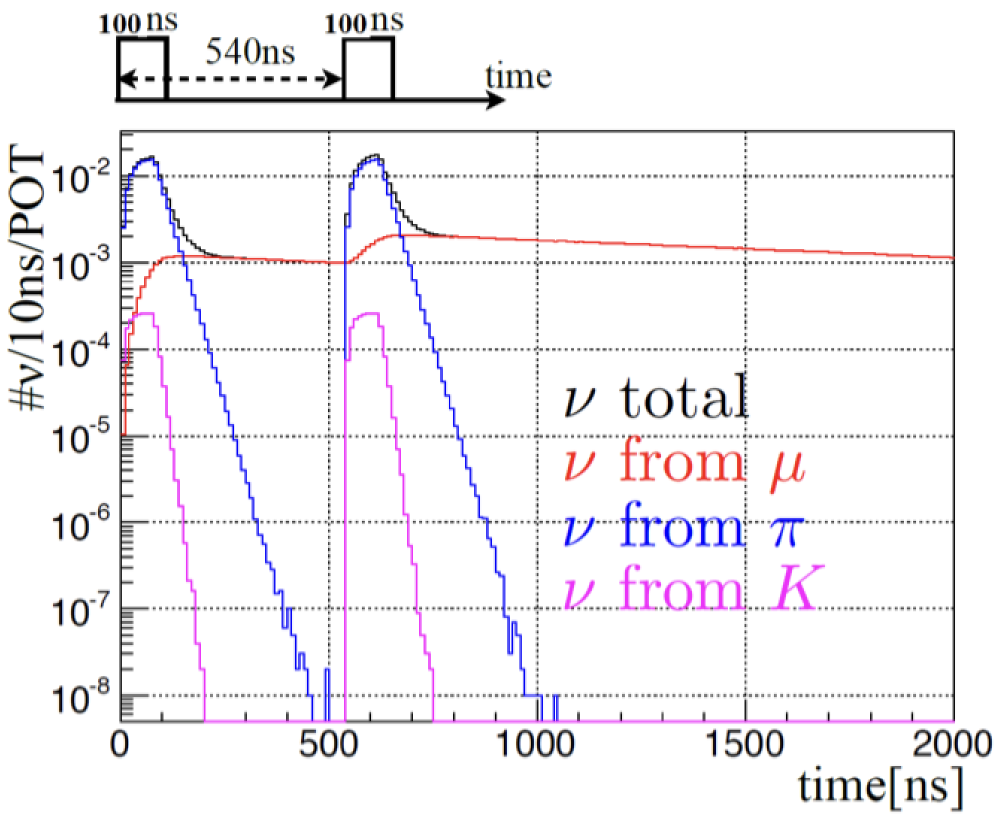


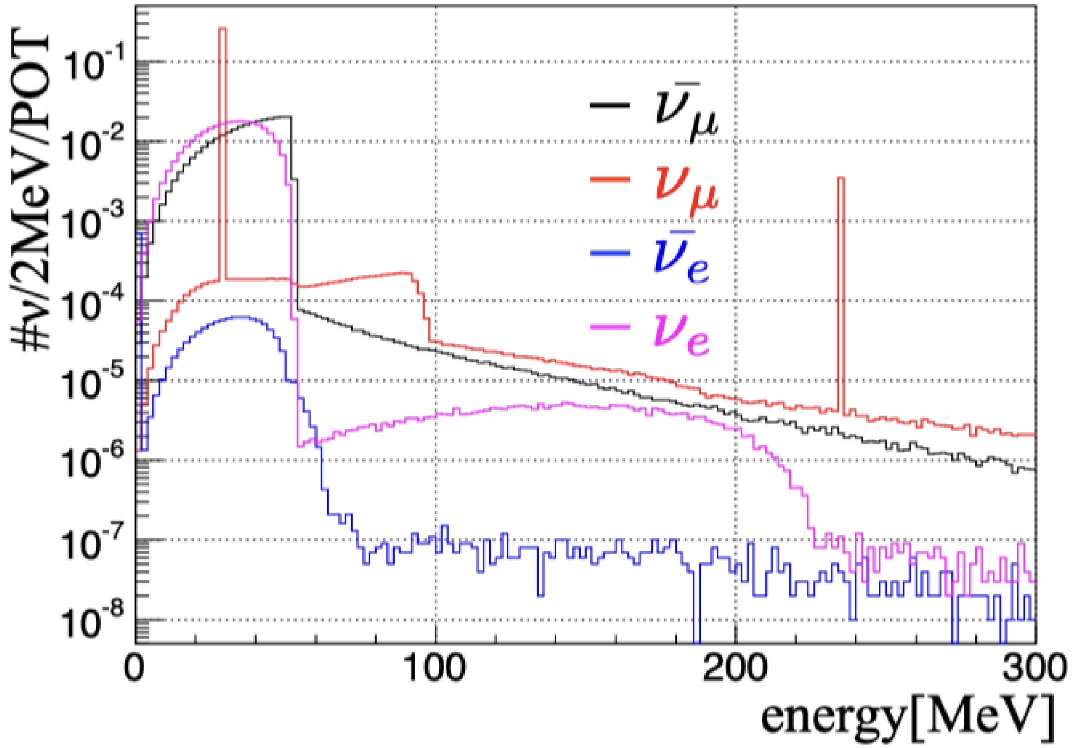
Brookhaven National Laboratory
University of Michigan
University of Utah



Sun Yat-sen University

4 countries
~60 collaborators


100 ns
540ns
100 ns
time
#ν/10ns/POT
ν total
ν from μ
ν from π
ν from K
time[ns]


#ν/2MeV/POT
$\bar{\nu}_\mu$
ν_μ
$\bar{\nu}_e$
ν_e
energy[MeV]

Comparison of MC models

"Neutrino Source for Sterile Neutrino Searches", T.Konno (Kitasato), NuFACT, Daegu, Korea, 2019-Aug

Various MCs are studied

- FLUKA (current default)
  - Target simulation only
  - => Applied G4 rate
- Geant4
  - v9.4p04 with QGSP_BERT
- PHITS
  - Most precise geometry
  - Different beam profile
  - => σx=18mm, σy=0.8mm

=> 1.3 ~ 1.7 times difference is obtained as MC uncertainty

FLUKA

	$\pi^+ \to \mu^+ \to \bar{\nu_\mu}$	$\pi^- \to \mu^- \to \bar{\nu_e}$
π/p	6.49×10^{-1}	4.02×10^{-1}
μ/p	3.44×10^{-1}	3.20×10^{-3}
ν/p	3.44×10^{-1}	7.66×10^{-4}
ν after $1\mu s$	2.52×10^{-1}	4.43×10^{-4}

Geant4

	$\pi^+ \to \mu^+ \to \bar{\nu_\mu}$	$\pi^- \to \mu^- \to \bar{\nu_e}$
π/p	5.41×10^{-1}	4.90×10^{-1}
μ/p	2.68×10^{-1}	3.90×10^{-3}
ν/p	2.68×10^{-1}	9.34×10^{-4}
ν after $1\mu s$	1.97×10^{-1}	5.41×10^{-4}

PHITS

	$\pi^+ \to \mu^+ \to \bar{\nu_\mu}$	$\pi^- \to \mu^- \to \bar{\nu_e}$
π/p	6.93×10^{-1}	8.02×10^{-1}
μ/p	4.46×10^{-1}	2.76×10^{-2}
ν/p	N/A	N/A
ν after $1\mu s$	N/A	N/A

CNgs Search

Motivation to measure $^{12}C(\nu_e,e^-)^{12}N_{g.s.}$

- The number of μ^+ can be estimated by CNgs

-> Normalization of IBD

Lifetime ~16ms
Max = 16.8MeV
Qval = 17.3MeV

CNgs IBD/sterile

$$\mu^+ \rightarrow e^+ + \nu_e + \overline{\nu_\mu}$$

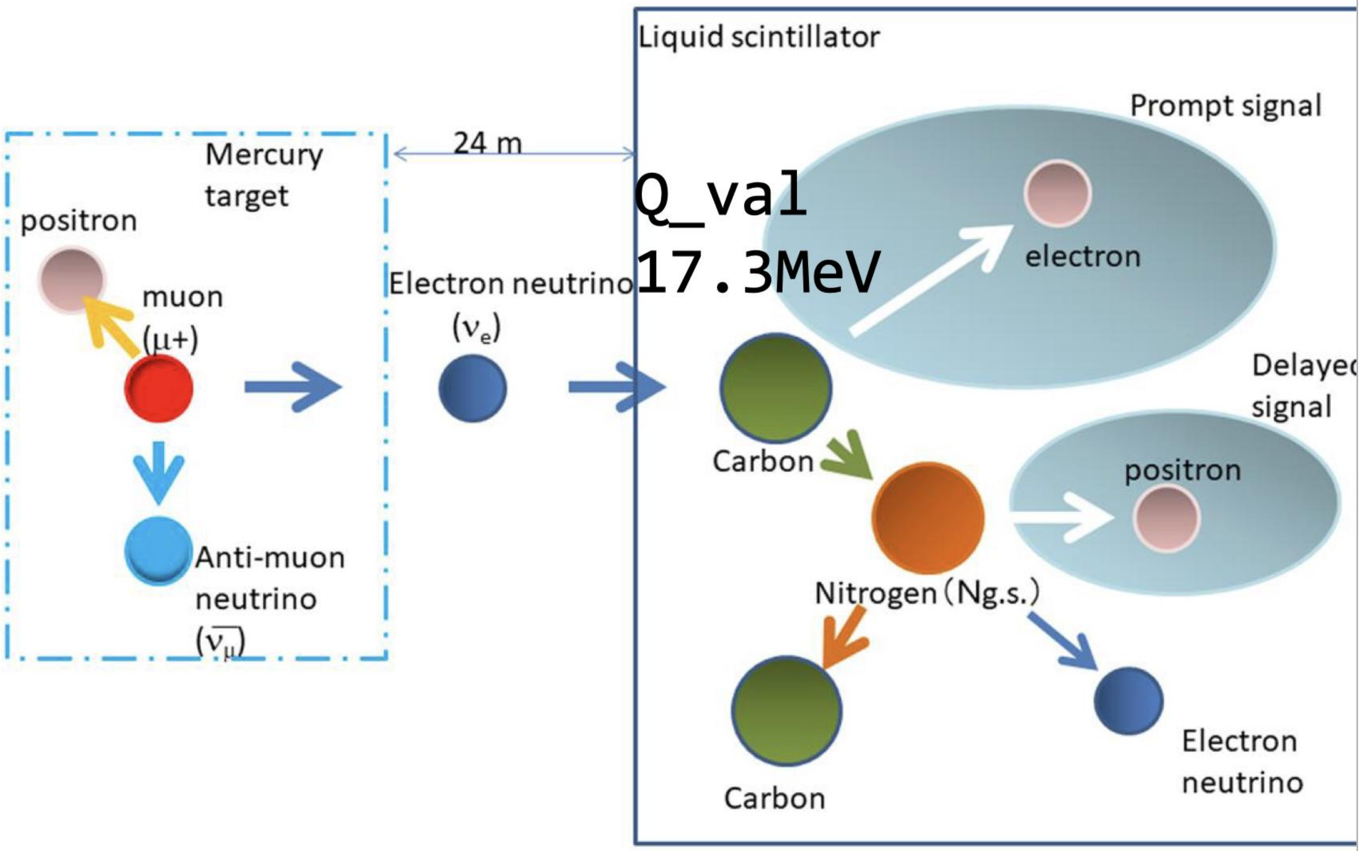
- $^{12}C(\nu_e,e^-)^{12}N_{g.s.}$

-> reaction of ν_e

$$^{12}C + \nu_e \rightarrow ^{12}N_{g.s.} + e^-$$ prompt

$$^{12}N_{g.s.} \rightarrow ^{12}C + \nu_e + e^+$$ delayed

-> CNgs is useful for understanding the Total number of ν_e (=μ^+/p)



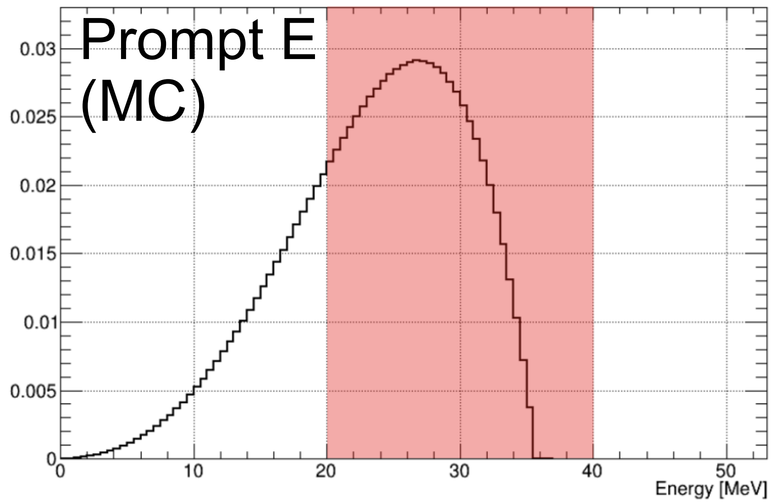
Selection criteria of $^{12}C(\nu_e,e^-)^{12}N_{g.s.}$

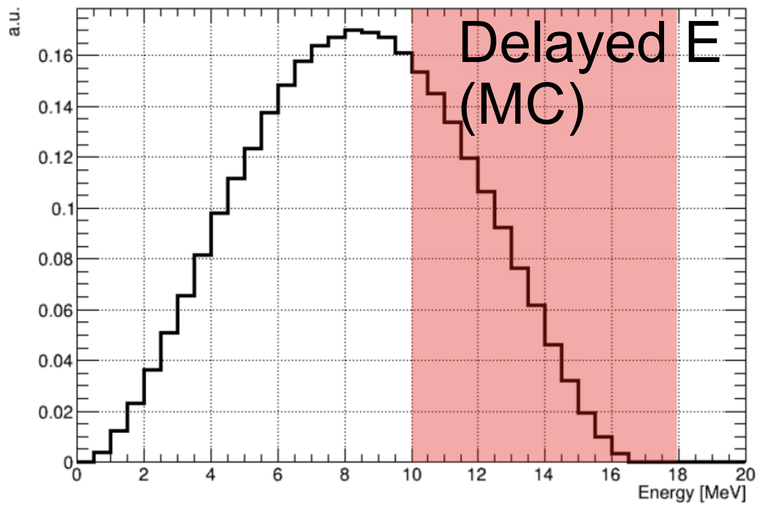
<Event Selection>
- Energy
Prompt : $20<E_p<40$MeV
Delayed : $10<E_d<18$MeV

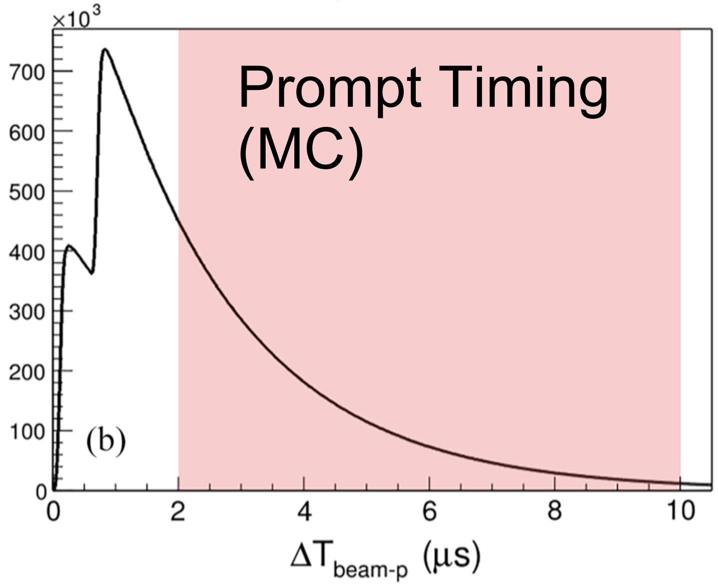
- Timing
Prompt : $2<T_{beam}<10\mu s$

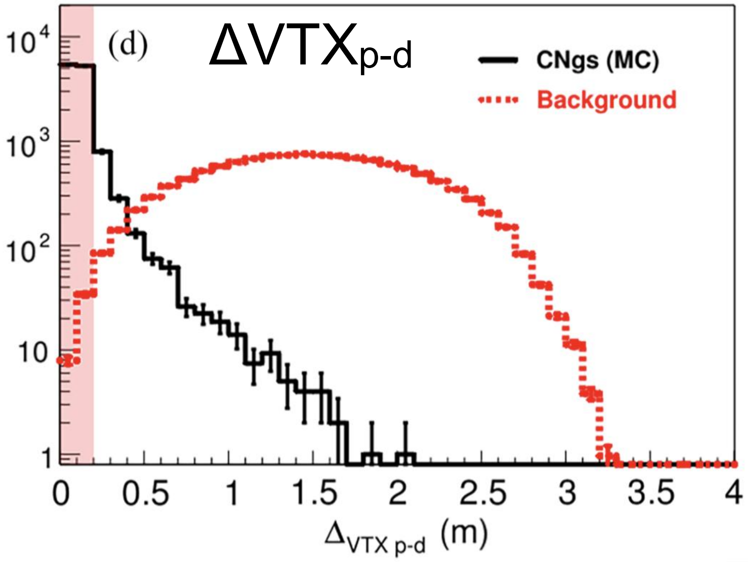
- Prompt vs Delayed 3
Timing : 1
$0.2<\Delta T_{p\text{-}d}<12$ms (2021)
<25ms (2022)
Spatial correlation :
$\Delta VTX_{p\text{-}d} < 20$cm

- Muon/Michel e veto
- Fiducial cut :
$R < 140$cm, $|Z| < 100$cm







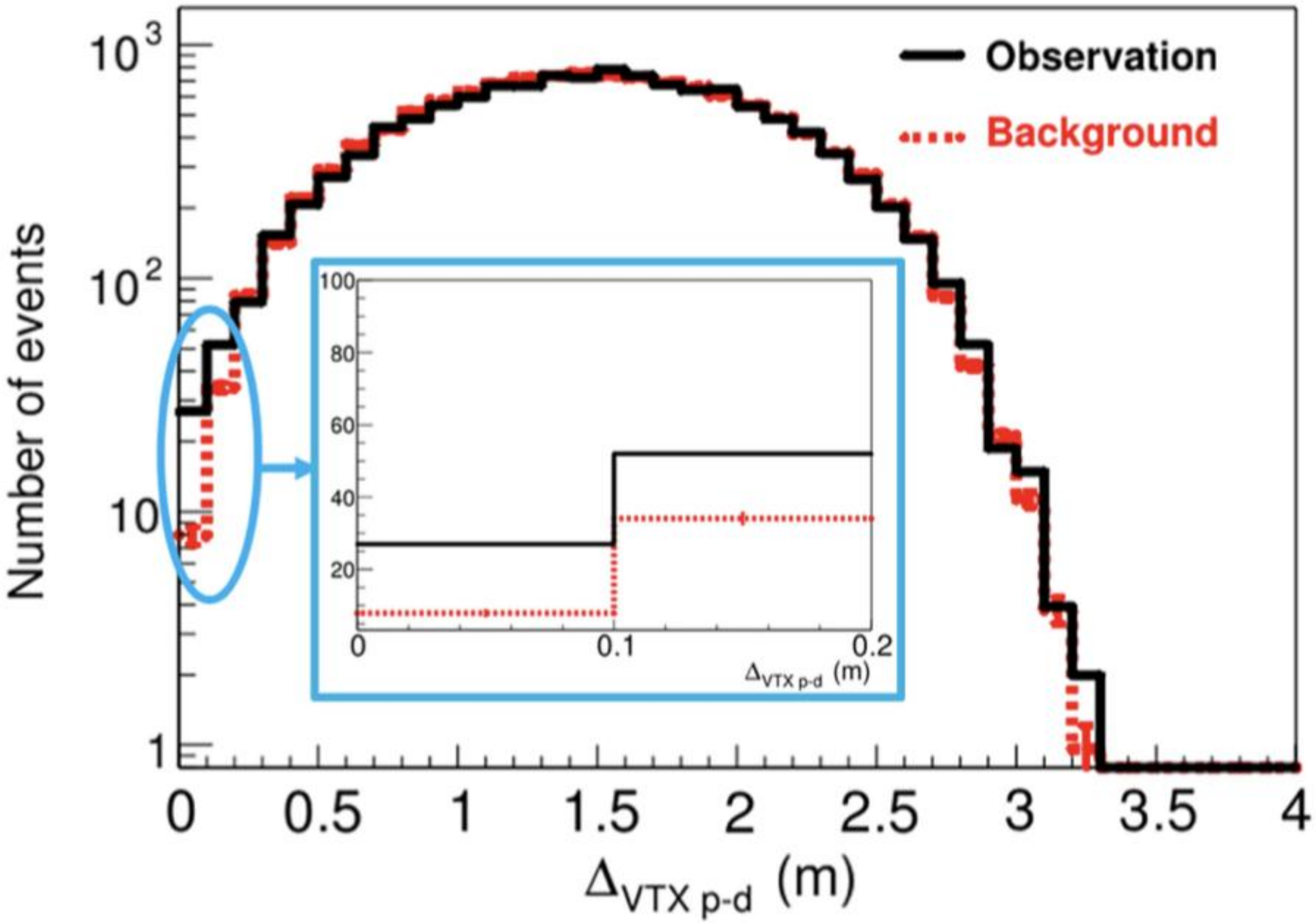


Observed events of $^{12}C(\nu_e,e^-)^{12}N_{g.s}$

- 2021 & 2022 physics data (2.2×10^{22} POT)

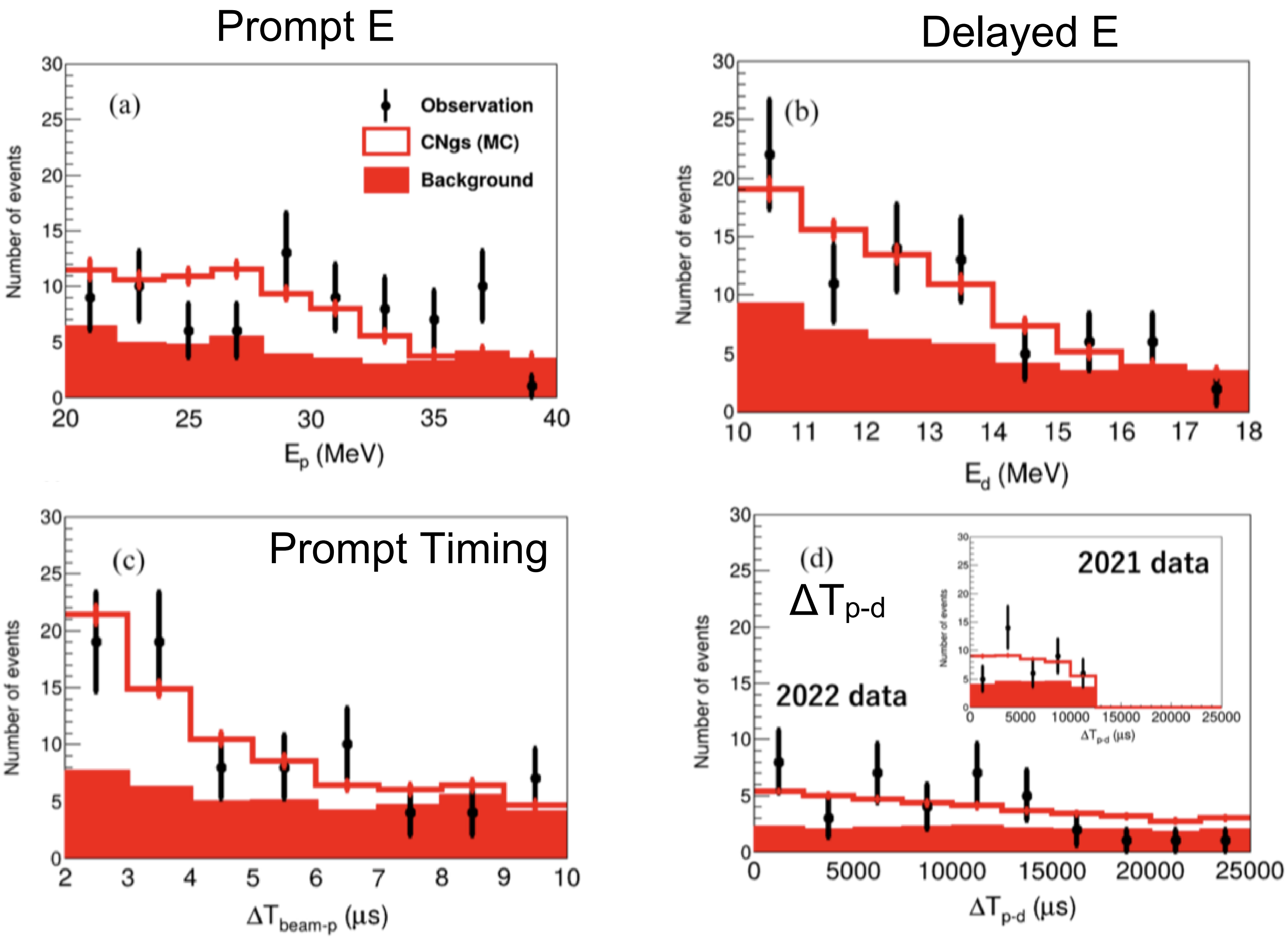
- Clear excess is seen in the signal region
  => Observed : 79 events
  => Bkg : 42.2 +- 4.8
  => CNgs signal :
  36.8 +- 8.9 (stat.) +- 4.8 (syst.)

- p-value : 2.9 x 10^-7



Variables of $^{12}C(\nu_e,e^-)^{12}N_{g.s.}$ Events

- All distributions for selected variables seem to be reasonable.



Interpretation to Number of ν_e

Total number of ν_e (=μ^+/p)

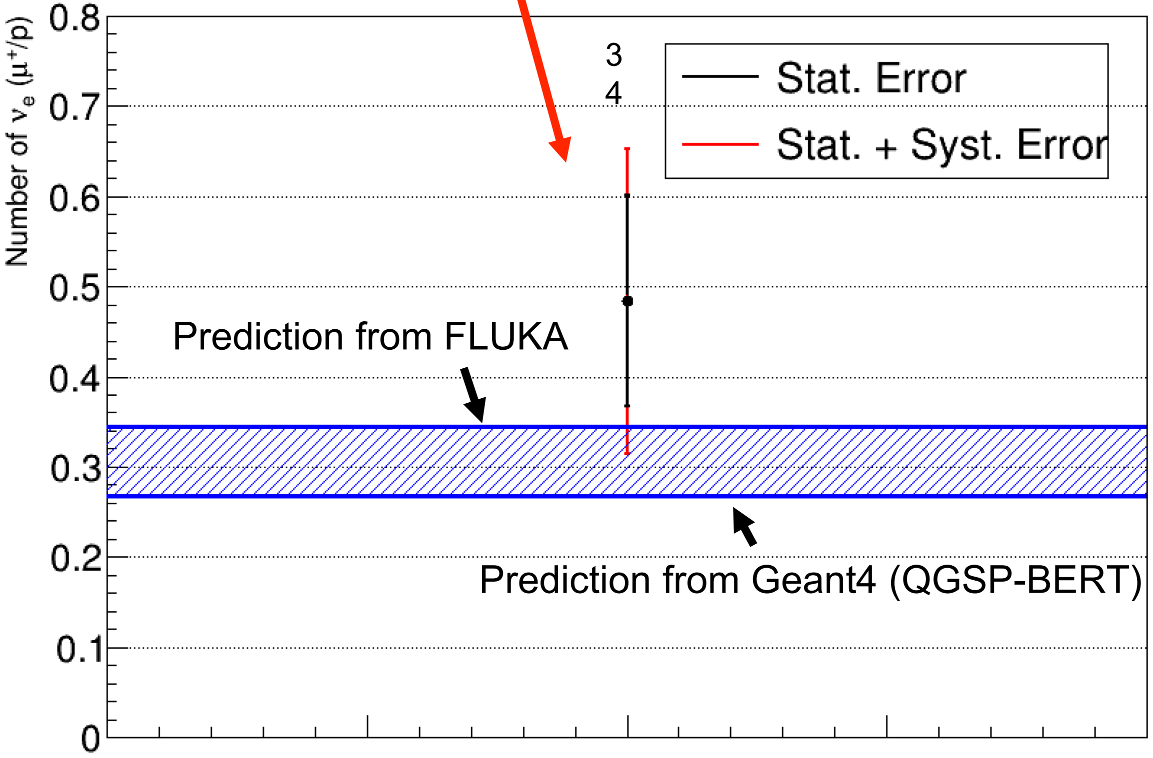
Observed Event rate

$$N_{CNg.s.} = \frac{\Phi_{\nu_e} POT}{4\pi r^2}\epsilon\sigma N_C$$

Cross Section

Selection Efficiency

Number of Carbons



- 2.2x10^{22} POT
- ϵ = 5.88 +- 0.21 %
- Cross section (LSND+KARMEN) = (9.1 +- 0.7) x 10^{-42} cm^2
- Number of C = (4.68 +- 0.94) x 10^{29} (<- Fiducial error 20%)

Total number of ν_e (=μ^+/p) =
0.483 +- 0.117 (stat.)+- 0.123 (syst.)

vs 0.344 (FLUKA), 0.268 (QGSP-BERT)

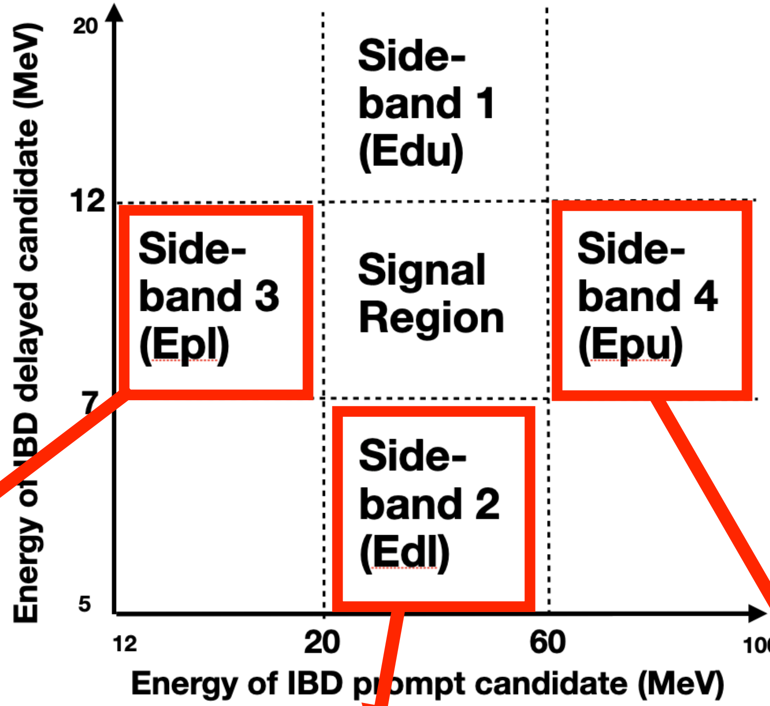
- This μ^+/p can be **directly** used for **Normalization of IBD signals.**
(already used in arXiv:2602.06274 [hep-ex])

- This measured μ^+/p from "CNgs measurement" is **40% larger** than FLUKA (assumed in TDR) (consistent within 1σ, though)
-> **Better results** compared to the previous sensitivities by using FLUKA.

* For cross section,
the combined value of LSND (Phys. Rev. C 64:065501 (2001))
+KARMEN (Prog. Part. Nucl. Phys. 40, 183 (1998)) is used.

PSD applications for side-bands

PSD Applications on
All side-bands
(except SB#1 due to a small statistics)
=> Agreements looks OK including tails.
=> OK for application to signal region

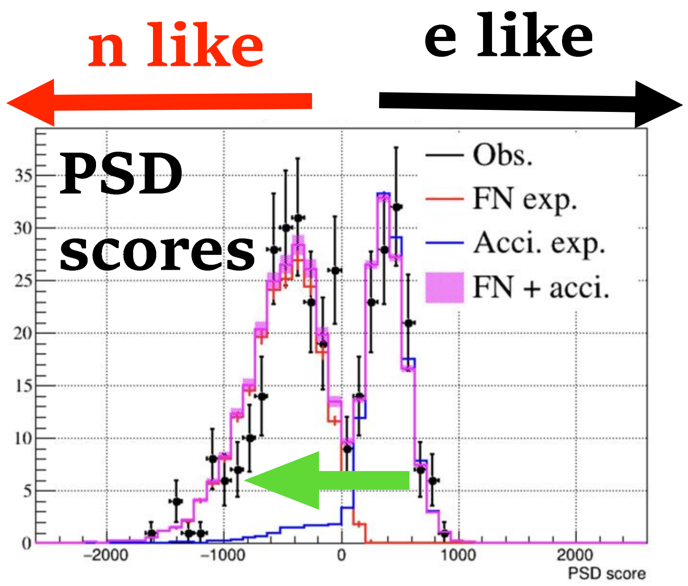


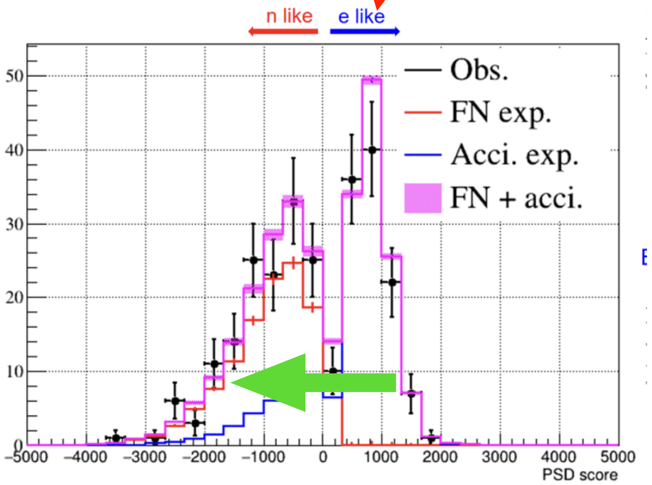
$\Delta VTX_{p\text{-}d} < 60cm$

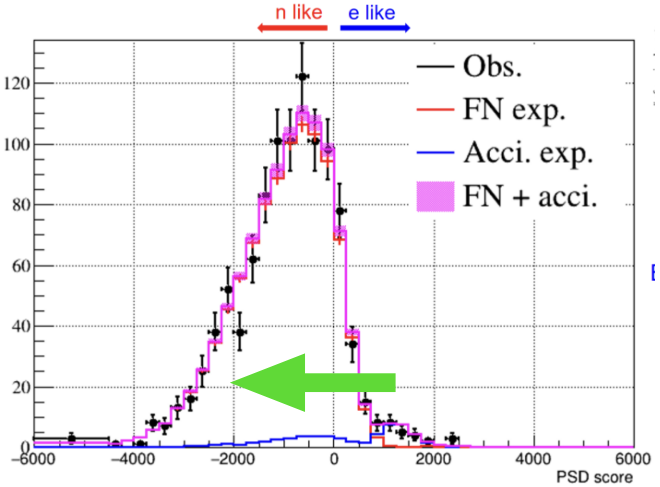
	Epl	Edl	Epu
w/o PSD	Obs 191 Exp 184.6±5.2	Obs 91 Exp 106.3±2.7	Obs 703 Exp 711.7±16
w/ PSD	Obs 6 Exp 3.3±0.2	Obs 2 Exp 5.1±0.3	Obs 5 Exp 5.4±0.3

(Remained bkg : accidental (gamma) dominant)

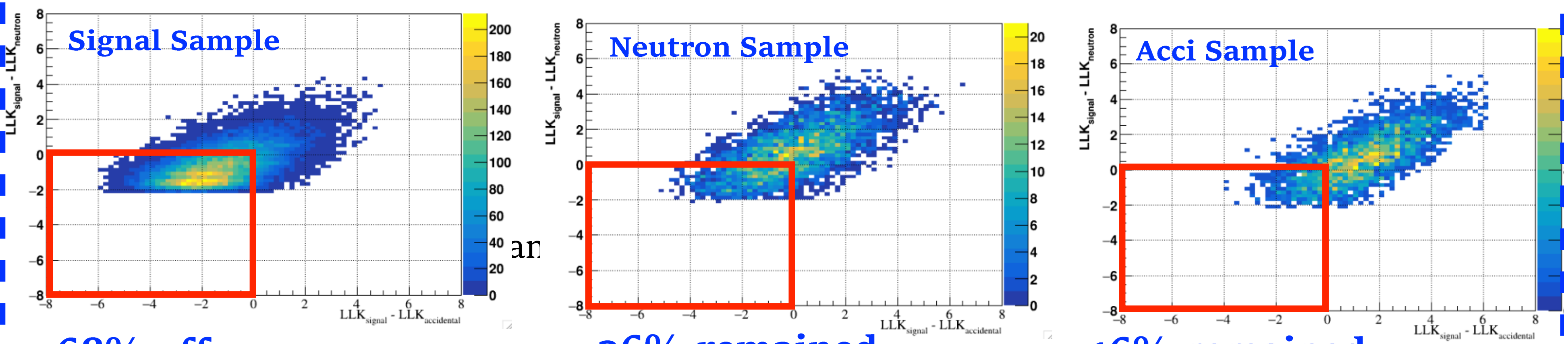
Neutron > 99% rejection



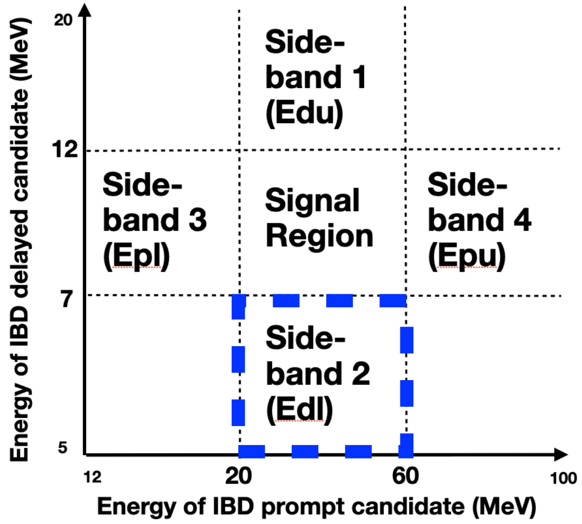




LLK applications for side-bands



68% eff. 26% remained 16% remained



$\Delta VTX_{p\text{-}d} < 60cm$

	Epl	**Edl**	**Epu**
w/o LLK	Obs 191 Exp 184.6±5.2	Obs 91 Exp 106.3±2.7	Obs 703 Exp 711.7±16
w/ LLK	Obs 49 Exp 50±1.5	Obs 25 Exp 27.4±0.8	Obs 240 Exp 214.6±4.8

- Observation vs Prediction(Bkg.) (side-band regions)
-> Good consistency for all cases