第一届中微子、原子核物理和新物理研讨会(vNN2025)

Neutrinoless Double beta decay with PandaX

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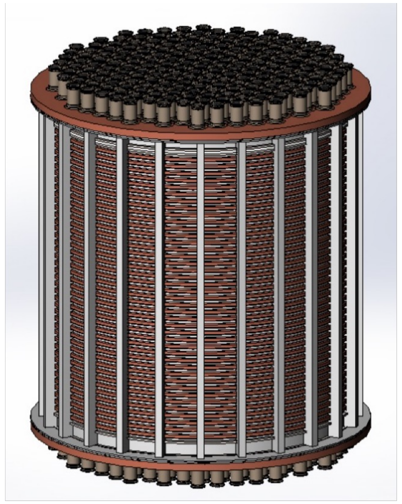
For the PandaX Collaboration

2025/7/23

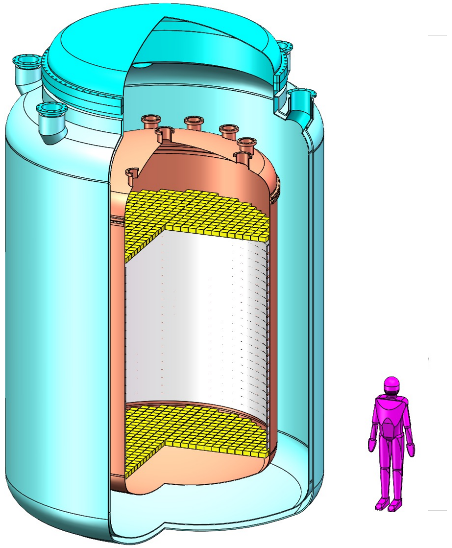
Outline

1. Introduction to PandaX and liquid xenon TPC
2. PandaX-4T
    1. ^{134}Xe 2νββ (0νββ) results
    2. ^{136}Xe 0νββ limits
    3. ^{136}Xe decay to excited states and ^{124}Xe double electron capture
3. Future: PandaX-xT

PandaX: Particle and astrophysical Xenon Experiment



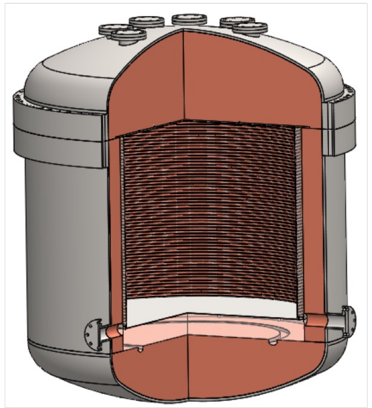
PandaX-4T LXe
(2020-)



PandaX-xT LXe
(future)

PandaX-I: 120kg
LXe (2009 – 2014)

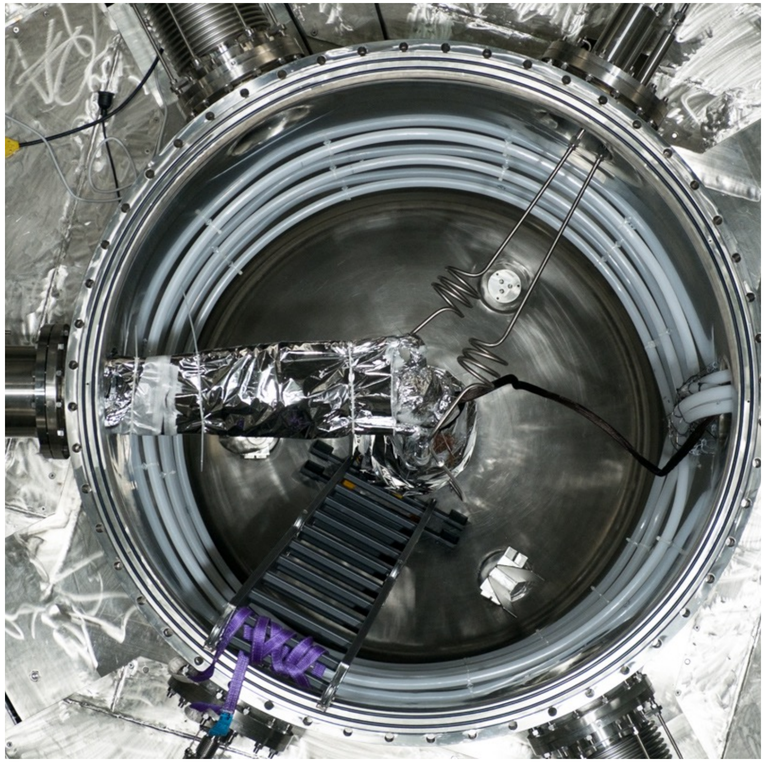
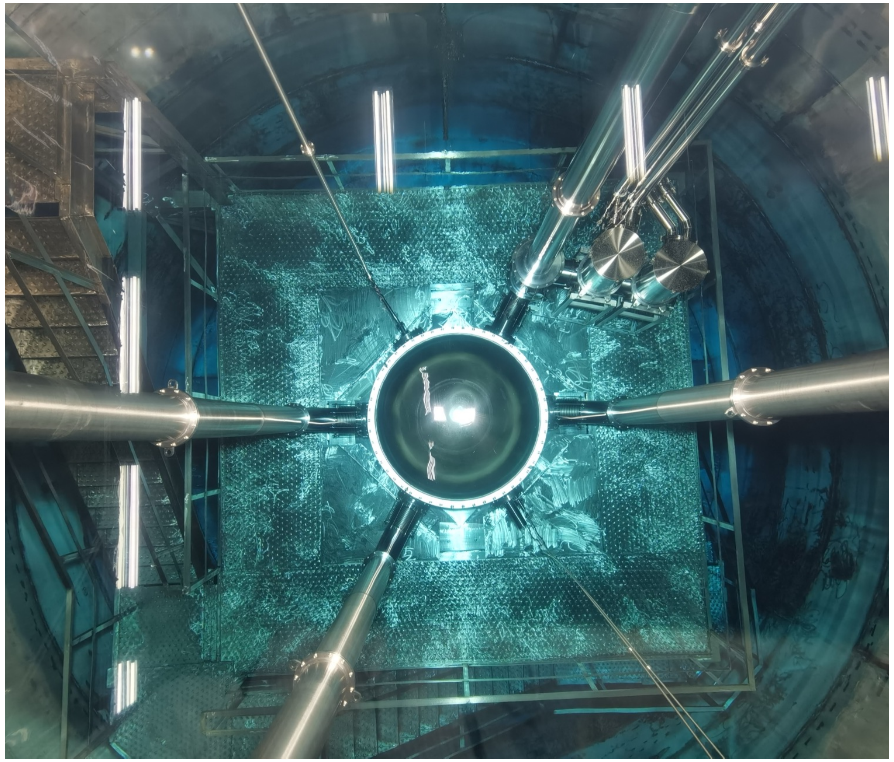
PandaX-II: 500kg
LXe (2014 – 2018)



PandaX-III: 100kg - 1 ton
HPXe for 0νββ (future)

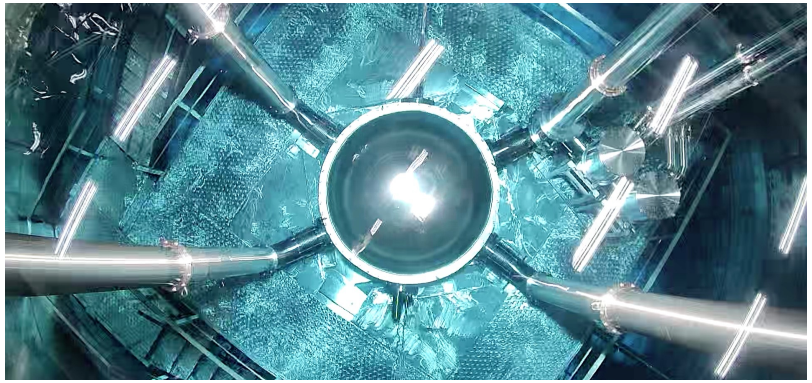
PandaX-4T

- A multi-ton dual-phase xenon TPC at B2 hall of China Jinping Underground Laboratory
- 1.2 m (D) ×1.2 m (H); Sensitive volume: 3.7-ton LXe; 3-inch PMTs: 169 top / 199 bottom
- Water shielding

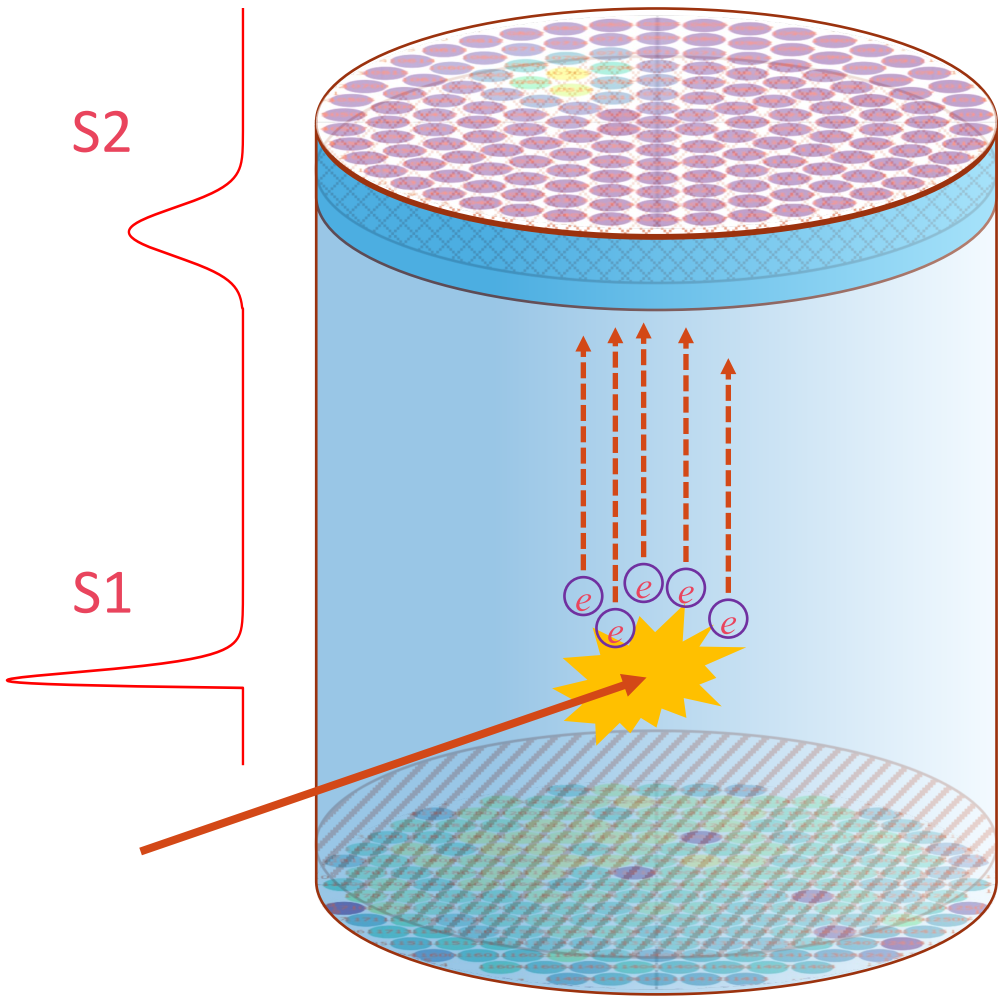
PandaX-4T timeline

2020/11 – 2021/04	**Commissioning (Run 0)** 95 days data
2021/07 – 2021/10	**Tritium removal** xenon distillation, gas flushing, etc.
2021/11 – 2022/05	**Physics run (Run 1)** 164 days data
2022/09 – 2023/12	**CJPL B2 hall construction** xenon recuperation, detector upgrade
Detector is taking Run 2 data	

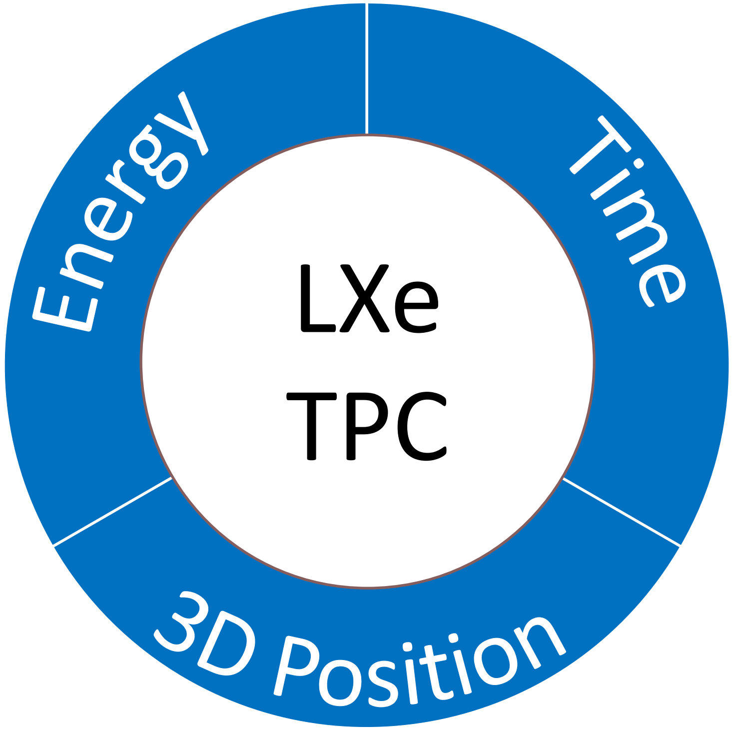


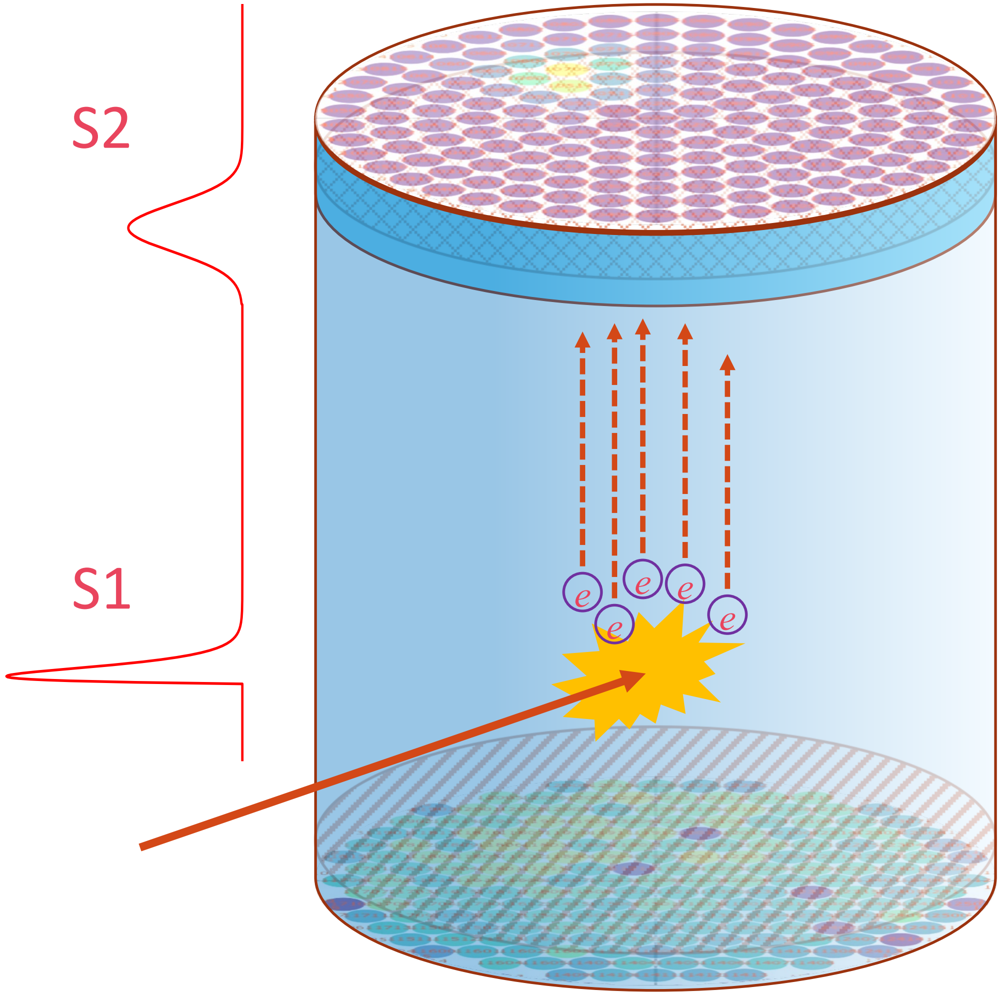
Liquid Xenon Time Projection Chamber (LXe TPC)

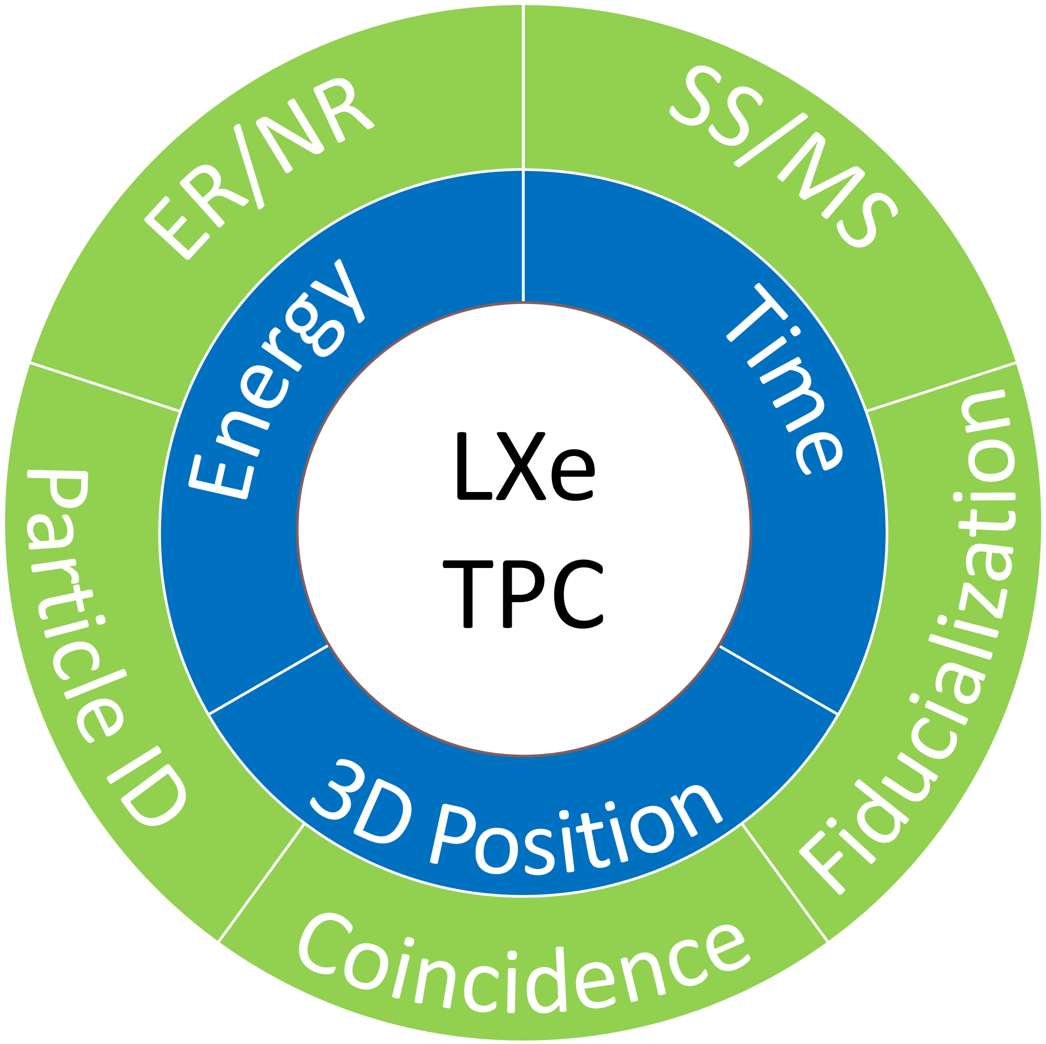
- Prompt scintillation signal (S1) followed by drift electron signal (S2)
- Measures the 3D position, energy, and time
- Nuclear Recoil (NR) and electron recoil (ER) discrimination
- Single-site (SS) and multi-site (MS) event discrimination
- Large monolithic target: High signal efficiency and effective self-shielding

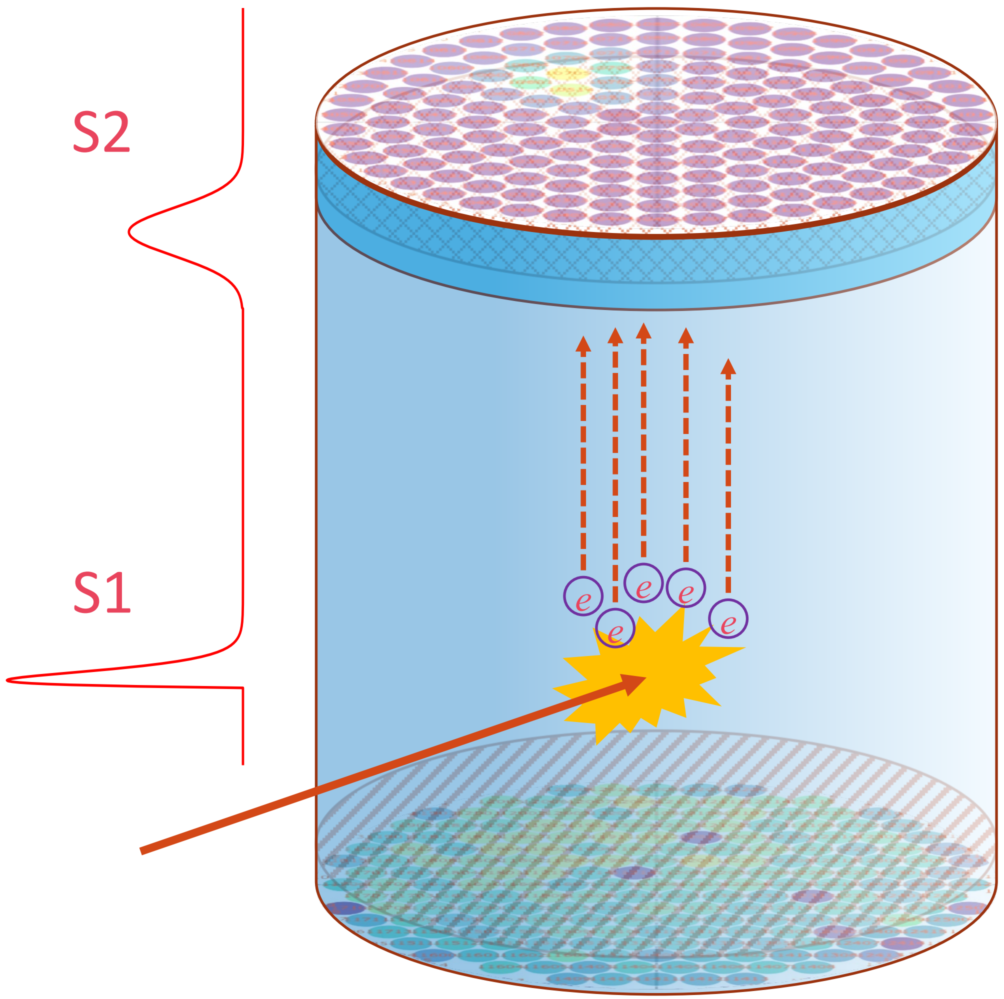


- LXe TPC as a Total-Absorption 5D Calorimeter

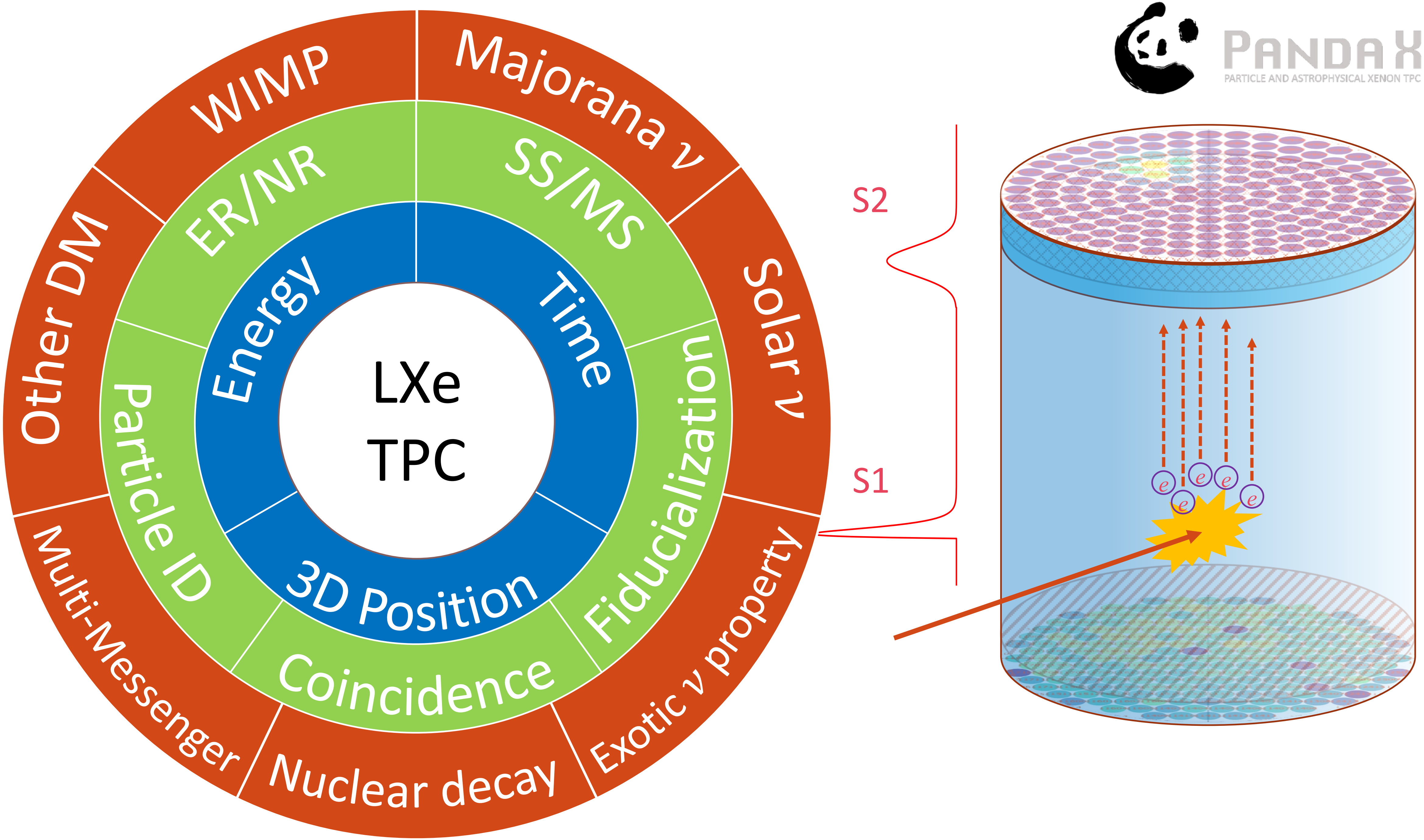

Energy
Time
3D Position
LXe
TPC

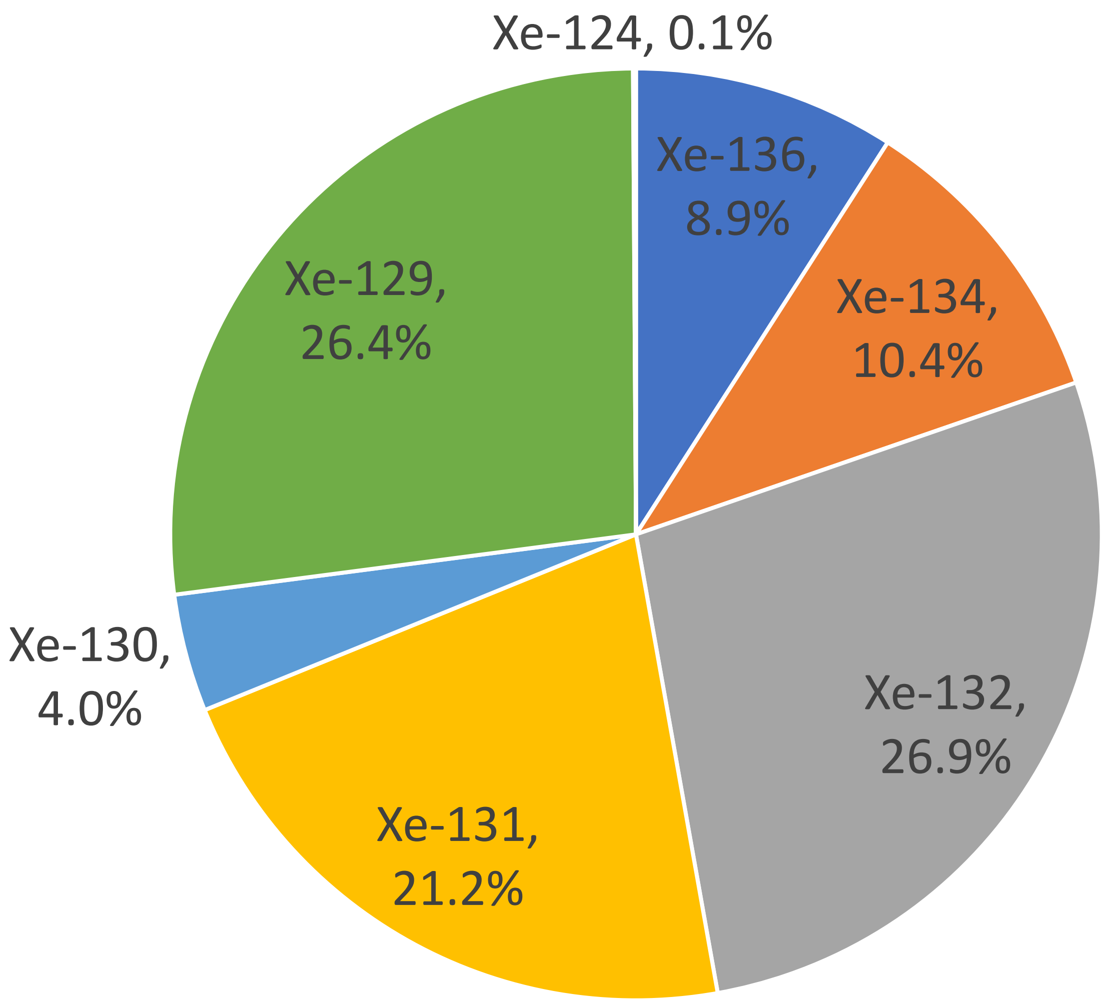

S2
S1

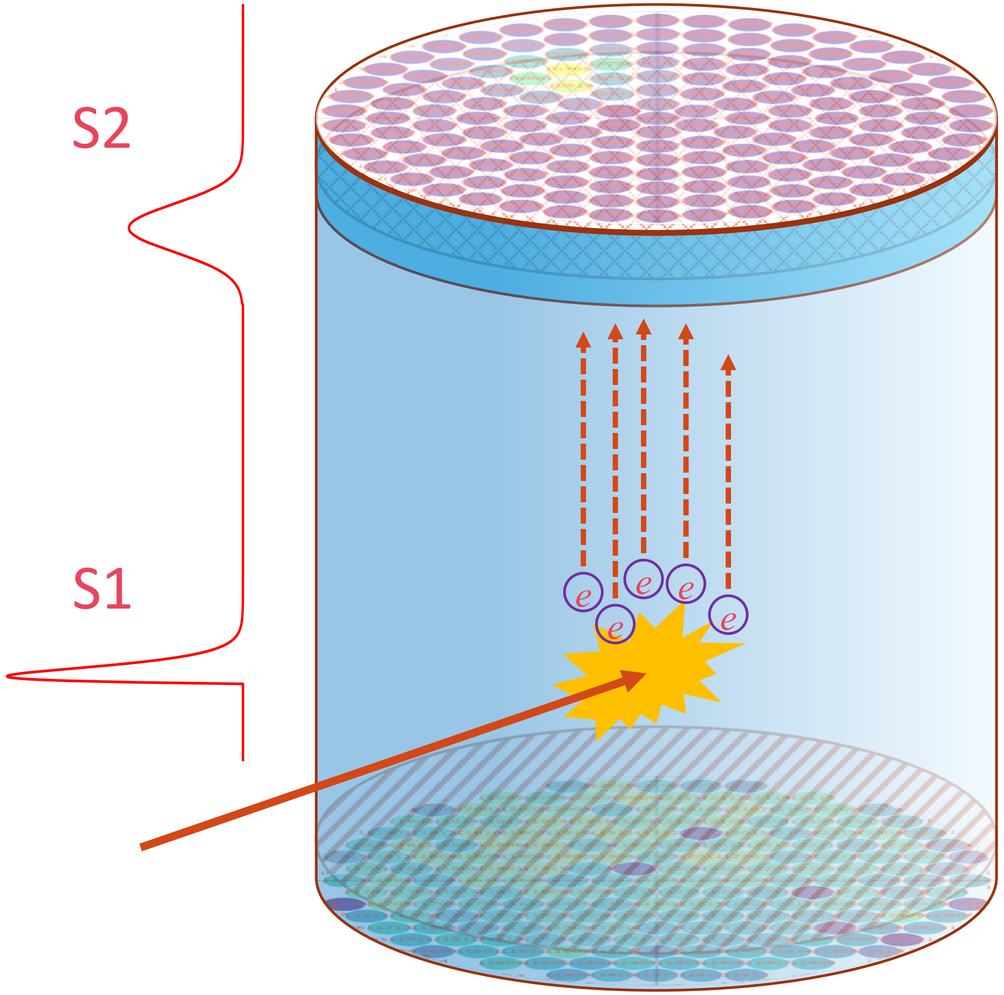

LXe
TPC
Energy
Time
3D Position
ER/NR
SS/MS
Fiducialization
Coincidence
Particle ID


S2
S1

PANDA X
PARTICLE AND ASTROPHYSICAL XENON TPC




Xe-124, 0.1%
Xe-136,
8.9%
Xe-134,
10.4%
Xe-132,
26.9%
Xe-131,
21.2%
Xe-130,
4.0%
Xe-129,
26.4%


S2
S1
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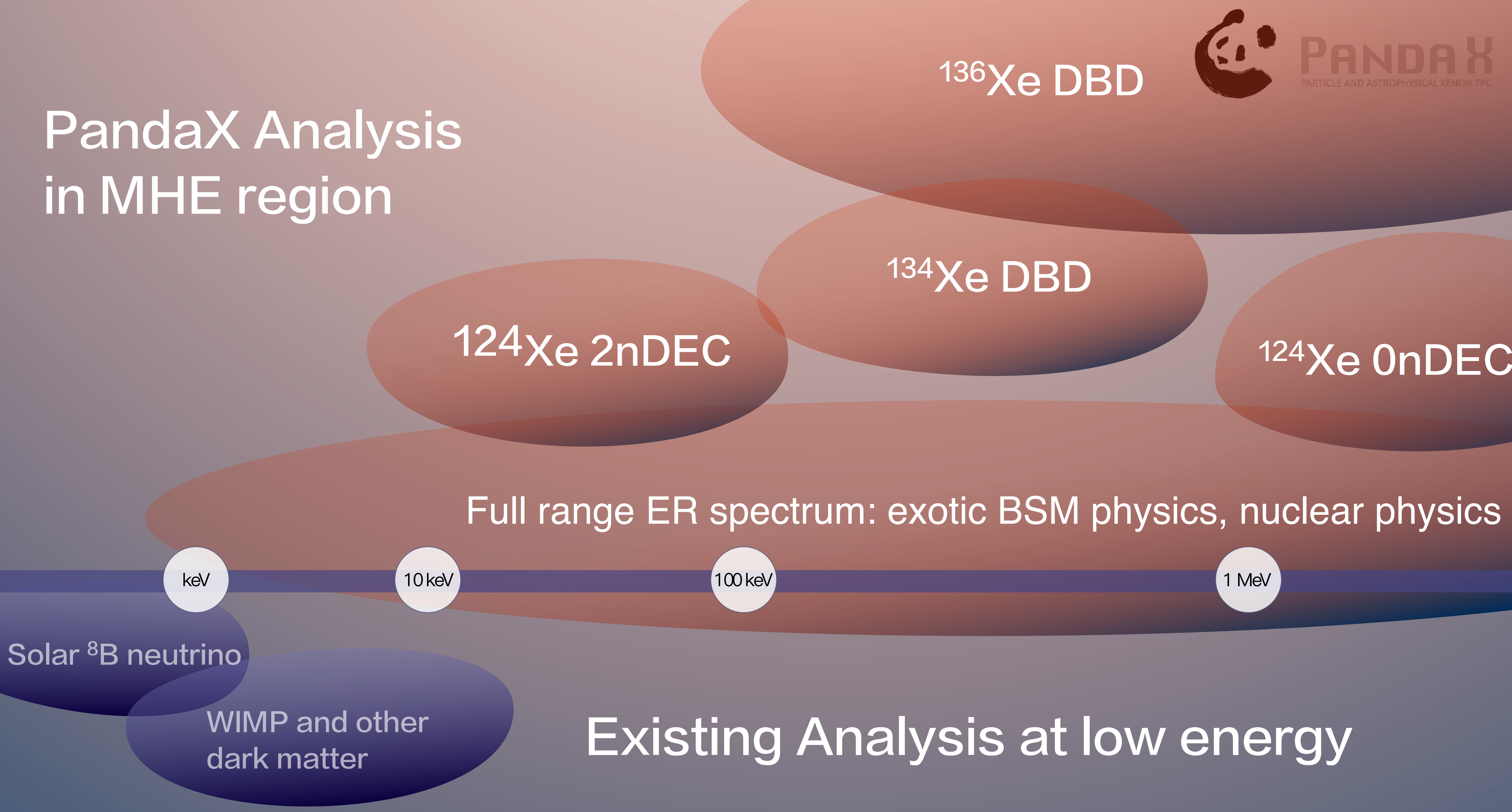
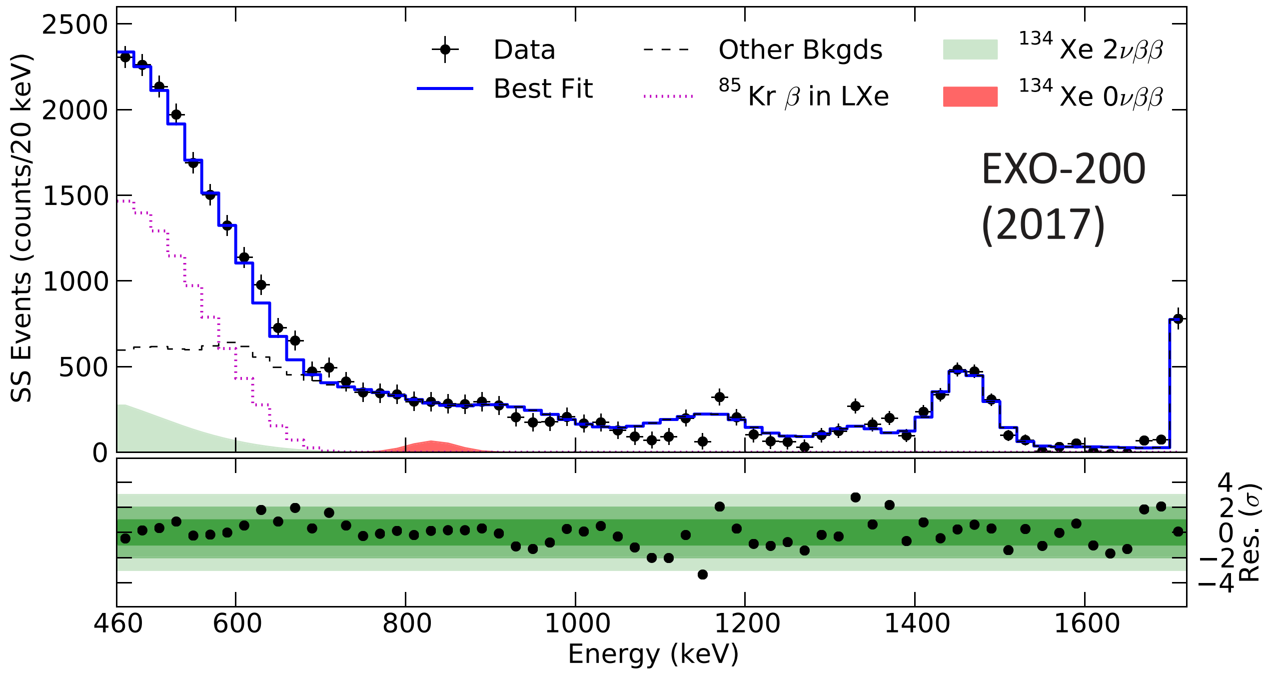
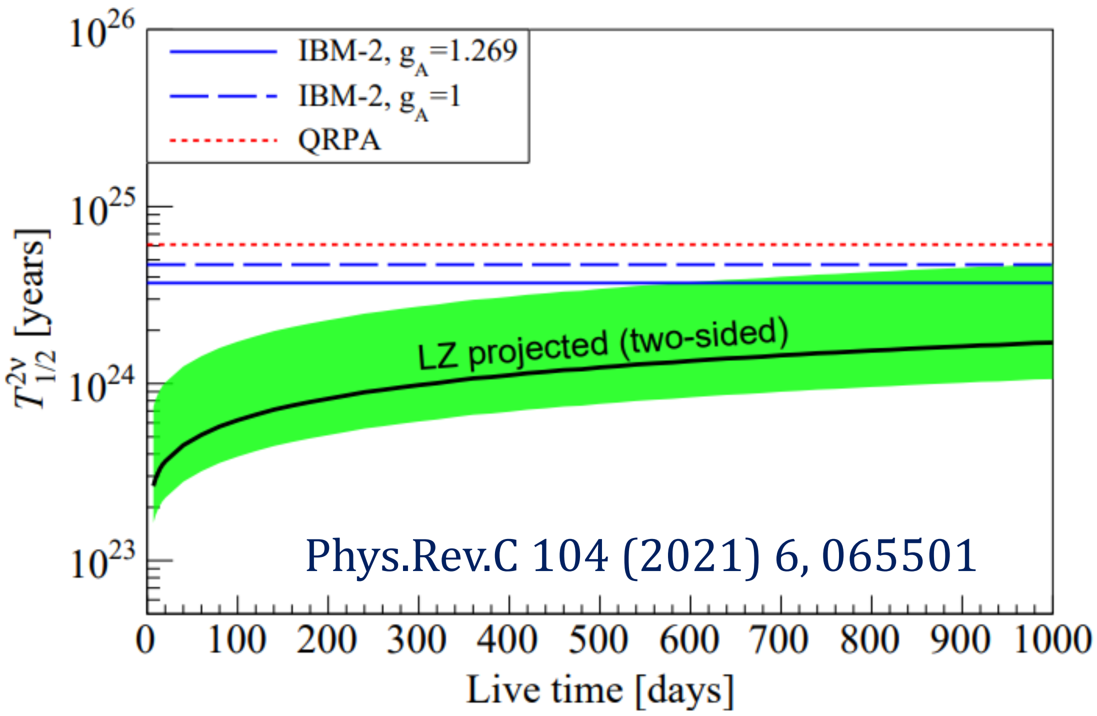
PandaX Analysis in MHE region



^{134}Xe 2νββ and 0νββ

- Q=826 keV; Half-life from theoretical predictions: 10^{24}-10^{25} yr; Never been observed
- Previous 2νββ (0νββ) half-life limit from EXO-200 : T >8.7x10^{20} yr (1.1x10^{23} yr) at 90% CL
- Discovery within reach with a natural Xe TPC

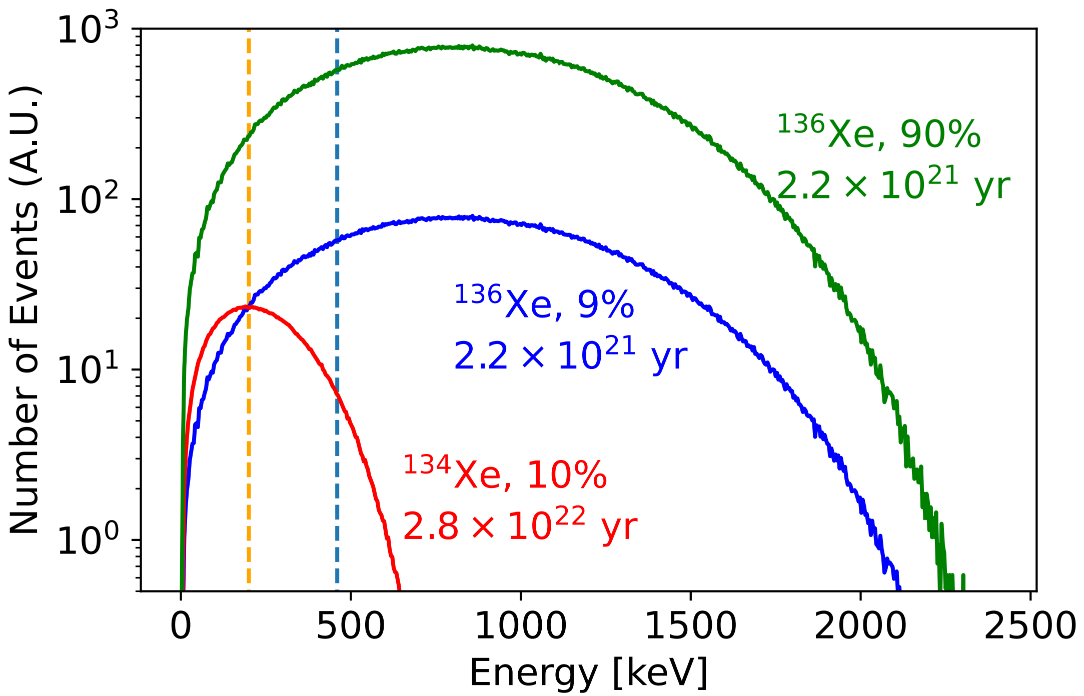




^{134}Xe (0)2νββ searches at PandaX-4T

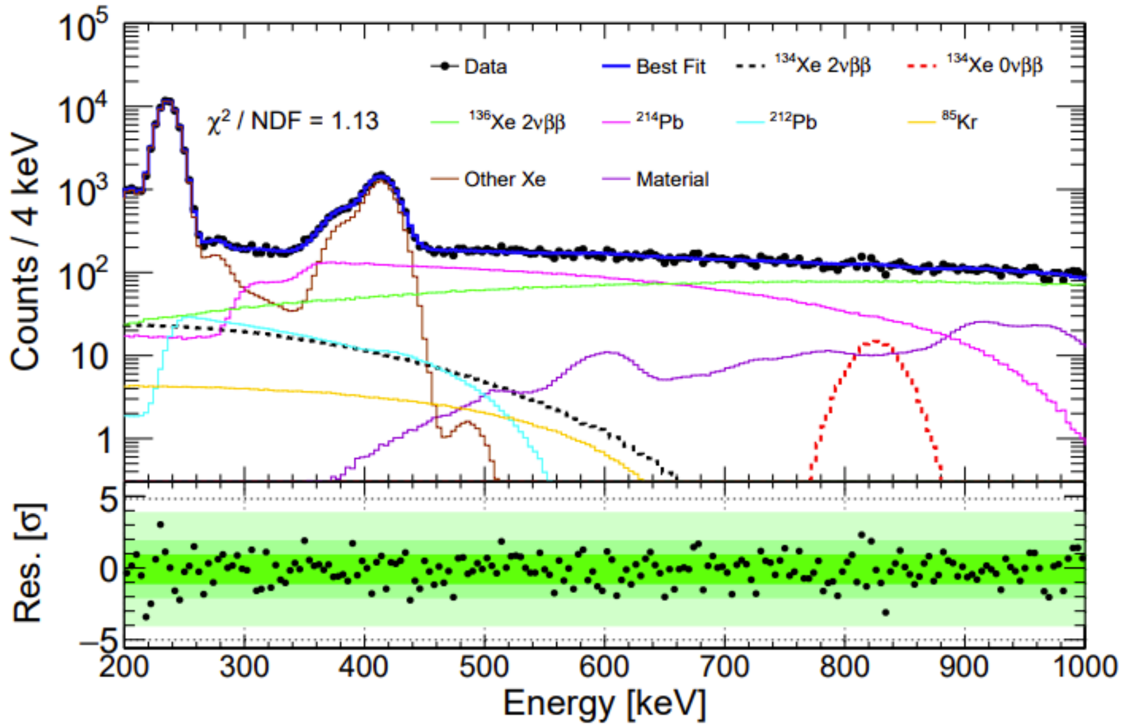
- Q=826 keV; Half-life from theoretical predictions: 10^{24}-10^{25} yr; Never been observed
- Previous 2νββ (0νββ) half-life limit from EXO-200 : T >8.7x10^{20} yr (1.1x10^{23} yr) at 90% CL
- PandaX-4T: more ^{134}Xe; much less ^{136}Xe; wider energy range; discovery possible

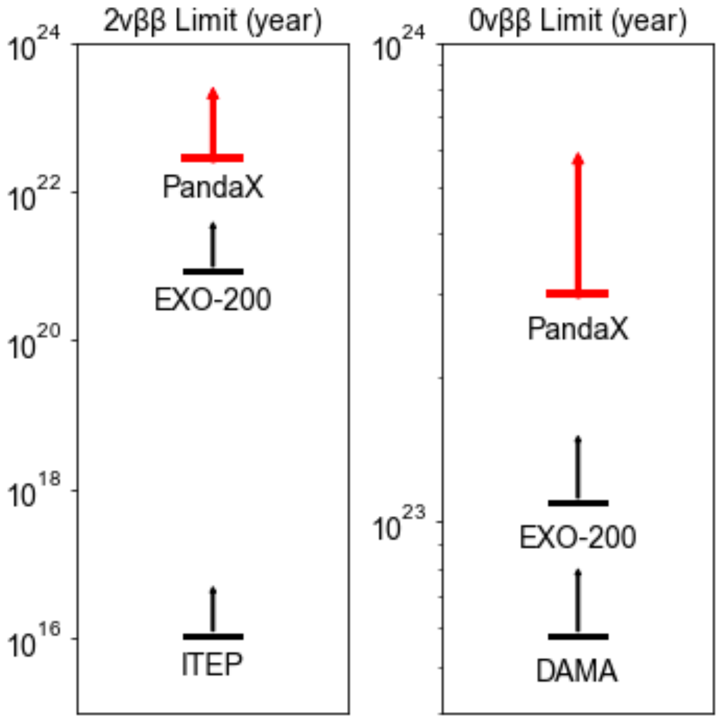
	PandaX-4T	EXO-200
^{134}Xe mass	68.7 kg	18.1 kg
^{136}Xe abundance	8.90%	81%
Analysis threshold	200 keV	460 keV
Live Time	94.9 days	600 days



^{134}Xe half-life limits @ PandaX-4T

- Simultaneous fit for ^{134}Xe $2\nu\beta\beta$ and $0\nu\beta\beta$
- Final counts of $2\nu\beta\beta$ and $0\nu\beta\beta$: 10±269(stat.)±680(syst.) and 105±48(stat.)±38(syst.)
- 90% CL lower limits on the half-life: $T_{1/2}^{2\nu\beta\beta} > 2.8 \cdot 10^{22}$ yr and $T_{1/2}^{0\nu\beta\beta} > 3.0 \cdot 10^{23}$ yr





PRL 132, 152502 (2024)

PandaX Analysis in MHE region

^{136}Xe DBD

^{134}Xe DBD

^{124}Xe 2nDEC

^{124}Xe 0nDEC

Full range ER spectrum: exotic BSM physics, nuclear physics

keV

10 keV

100 keV

1 MeV

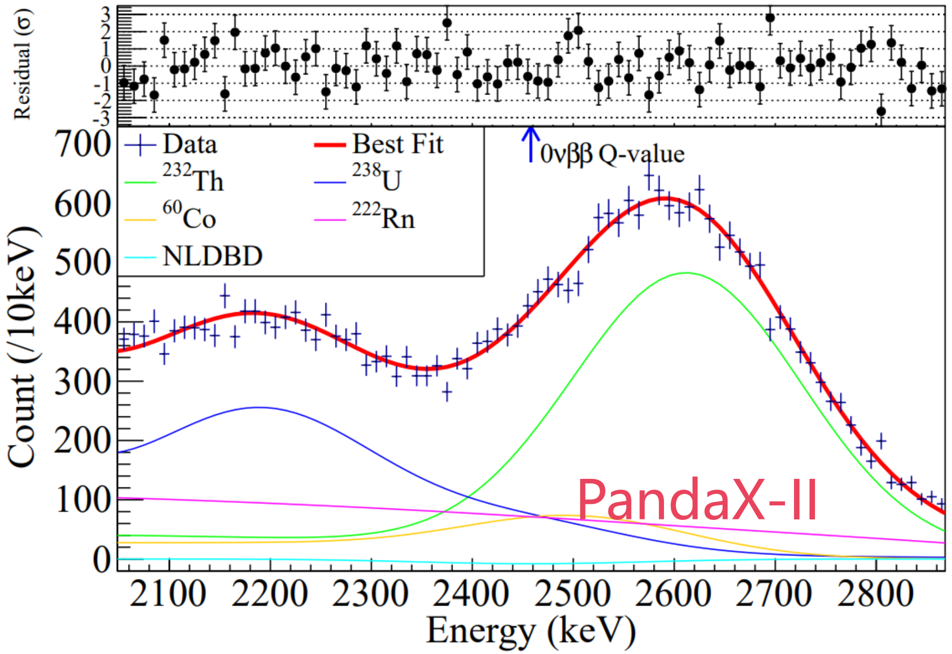
Solar ^{8}B neutrino

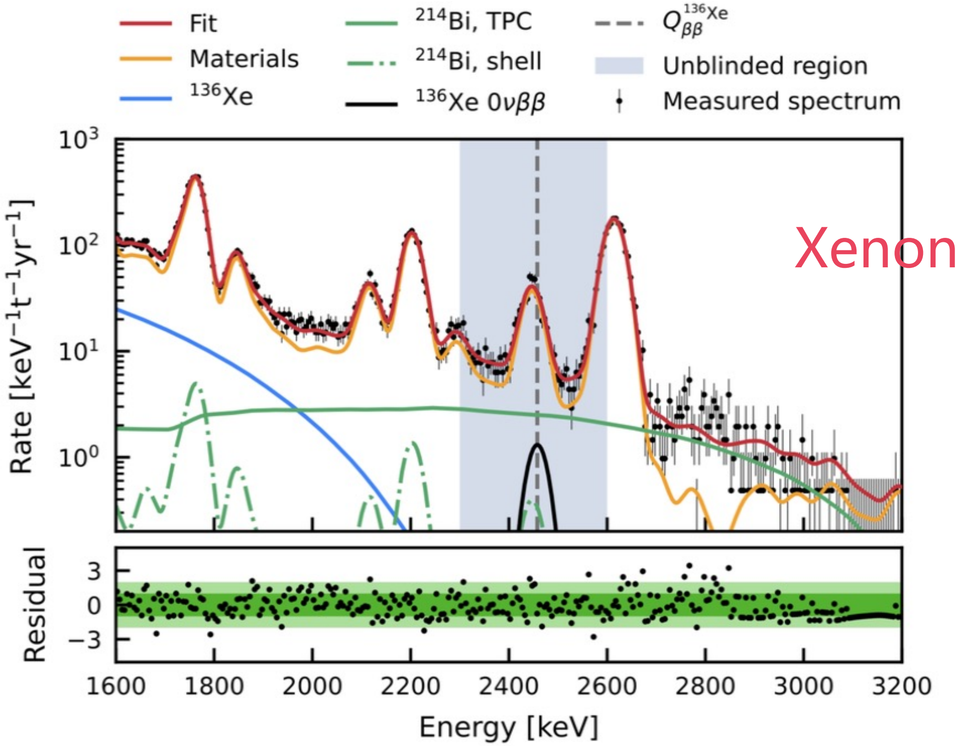
WIMP and other dark matter

Existing Analysis at low energy

Search for ^{136}Xe 0νββ with natural Xe TPC

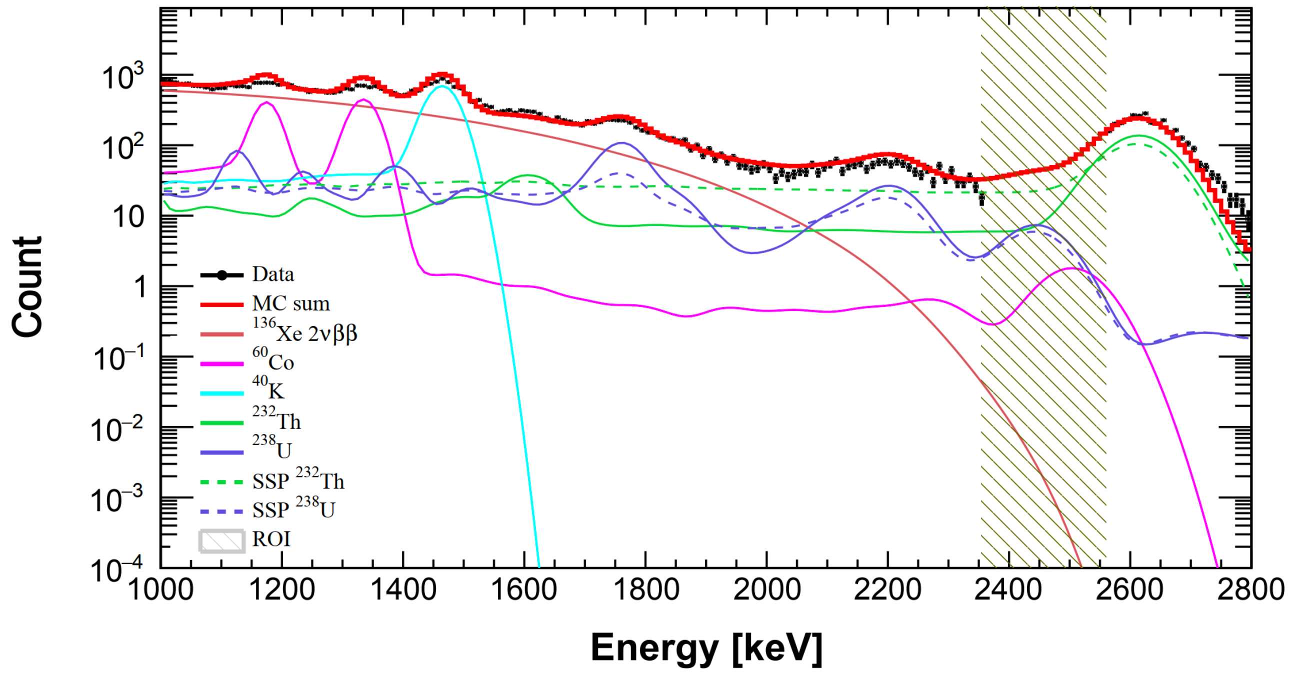
	Bkg rate (/keV/ton/y)	Energy resolution	FV mass (kg)	Live time	Sensitivity/Limit (90% CL, year)	Year
PandaX-II	~200	4.2%	219	403 days	2.4×10^{23}	2019
XENON1T	~20	0.8%	741	203 days	1.2×10^{24}	2022

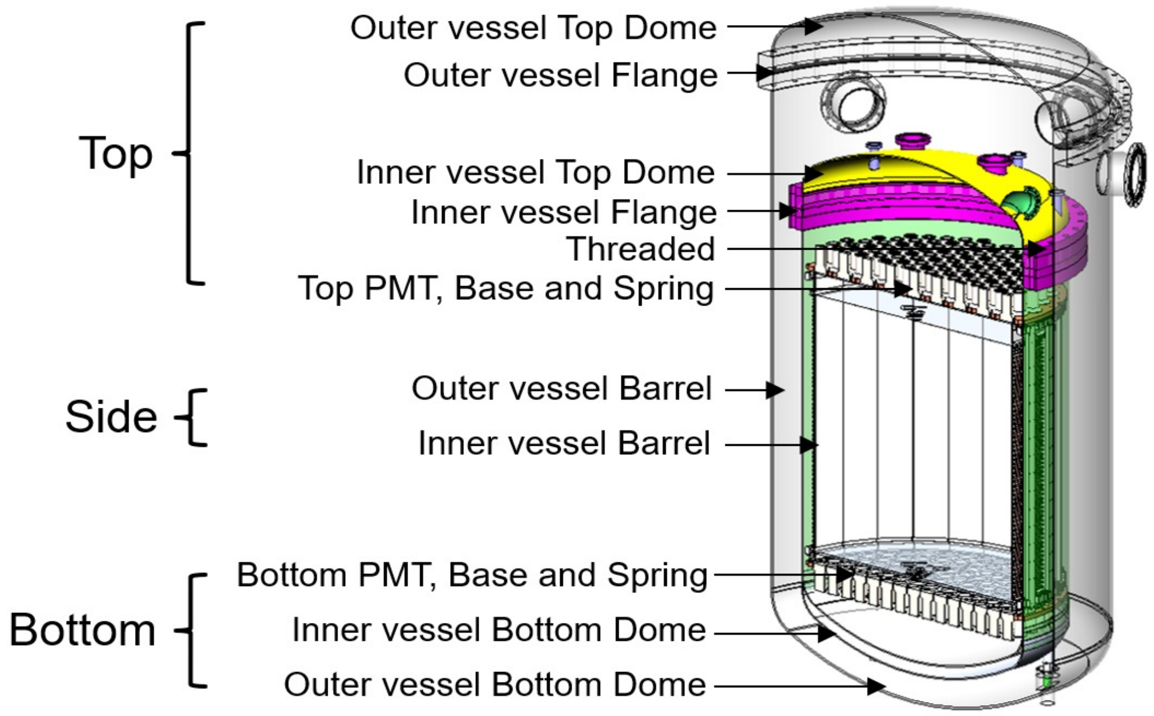




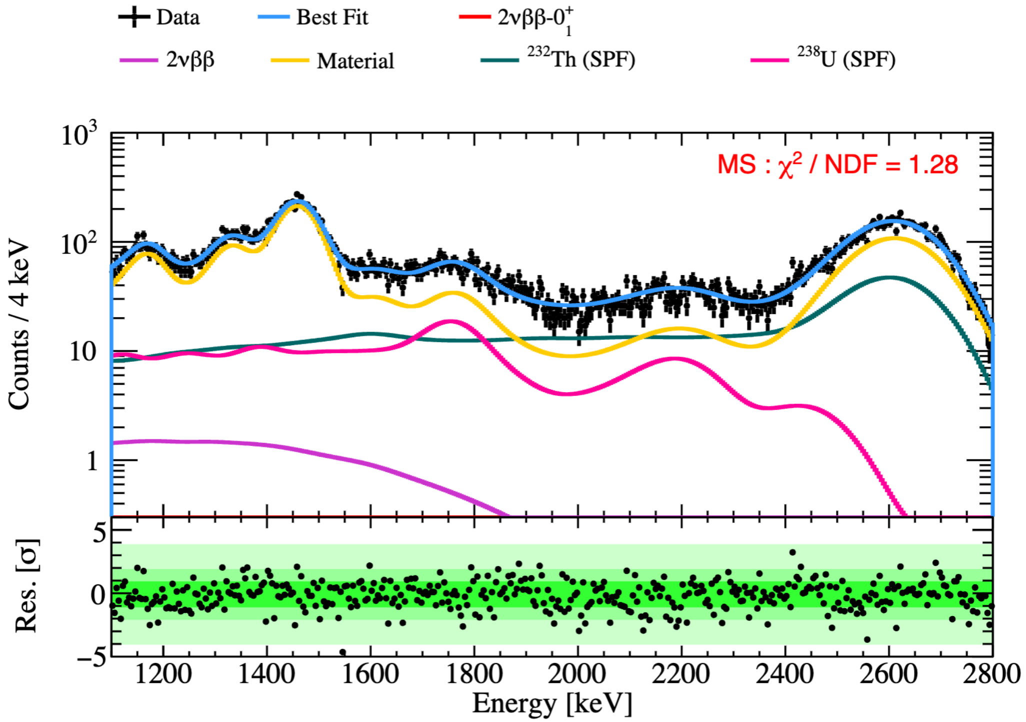
Background Model

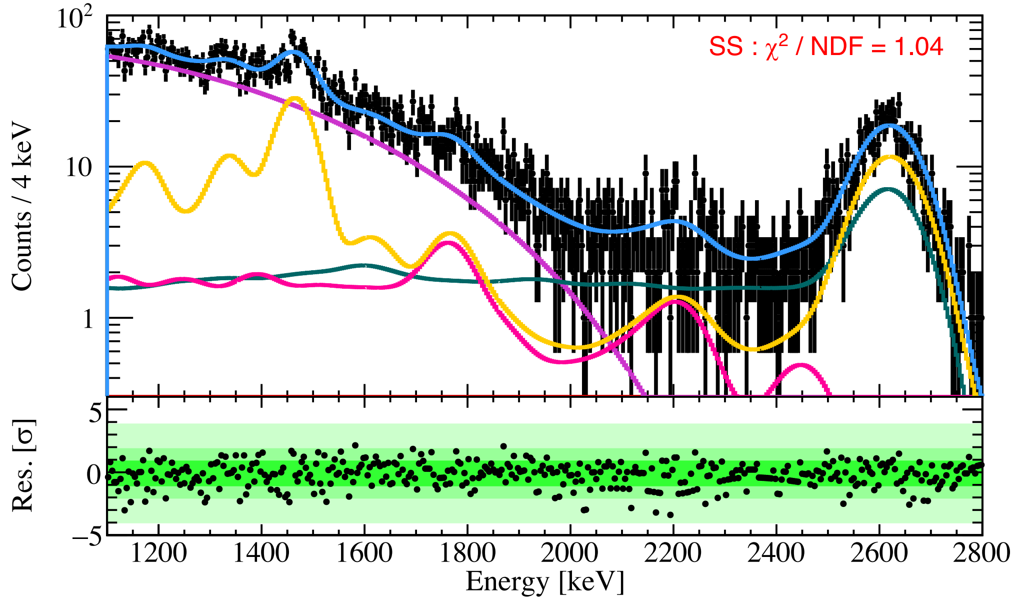
- ^{136}Xe $2\nu\beta\beta$ (from PandaX measured ^{136}Xe half-life)
- Detector material: ^{60}Co, ^{40}K, ^{232}Th, ^{238}U (from HPGe material assay), and grouped into top, side, and bottom parts
- Stainless steel platform (SSP): ^{232}Th, ^{238}U (from MS fitting)

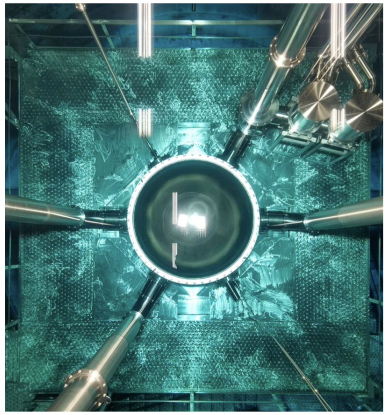


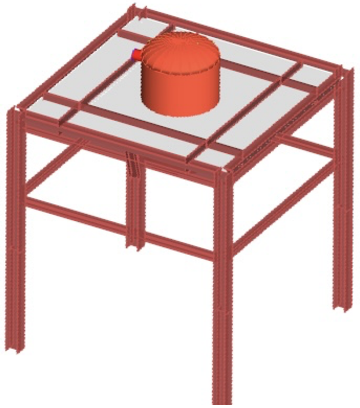


Stainless steel platform (SSP) contribution



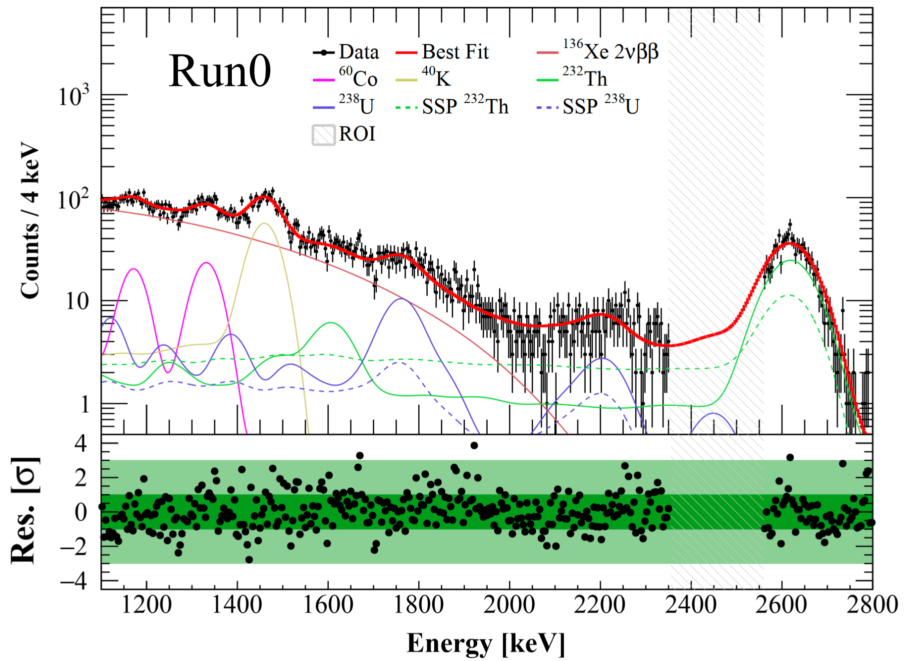


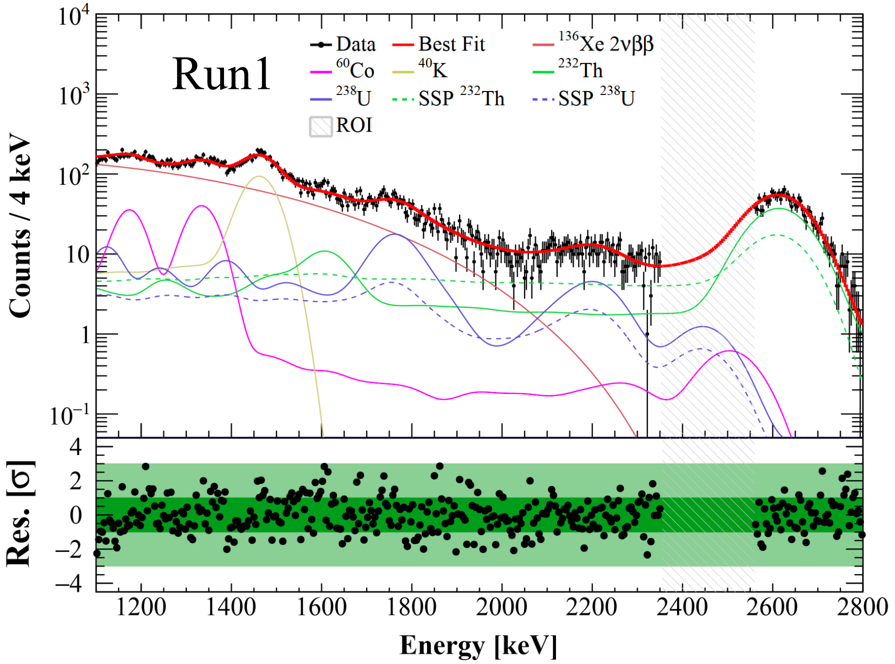




ArXiv:2502.03017;
JHEP

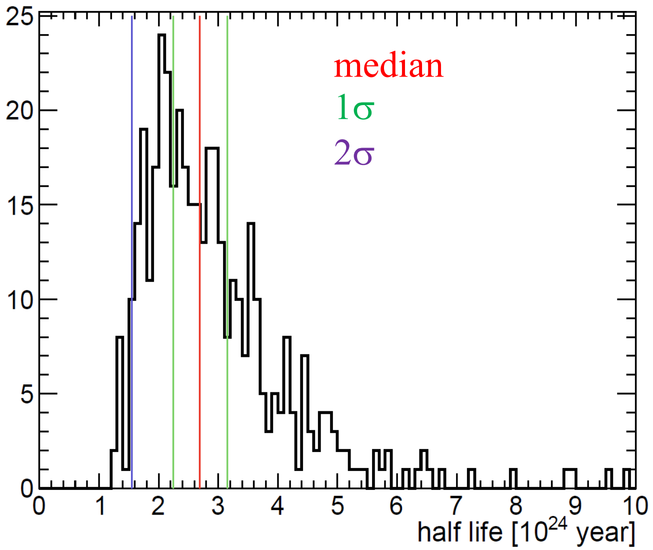
Blinded Fit and Sensitivity





Goodness-of-fit:

$\chi^2/NDF = 1.14$

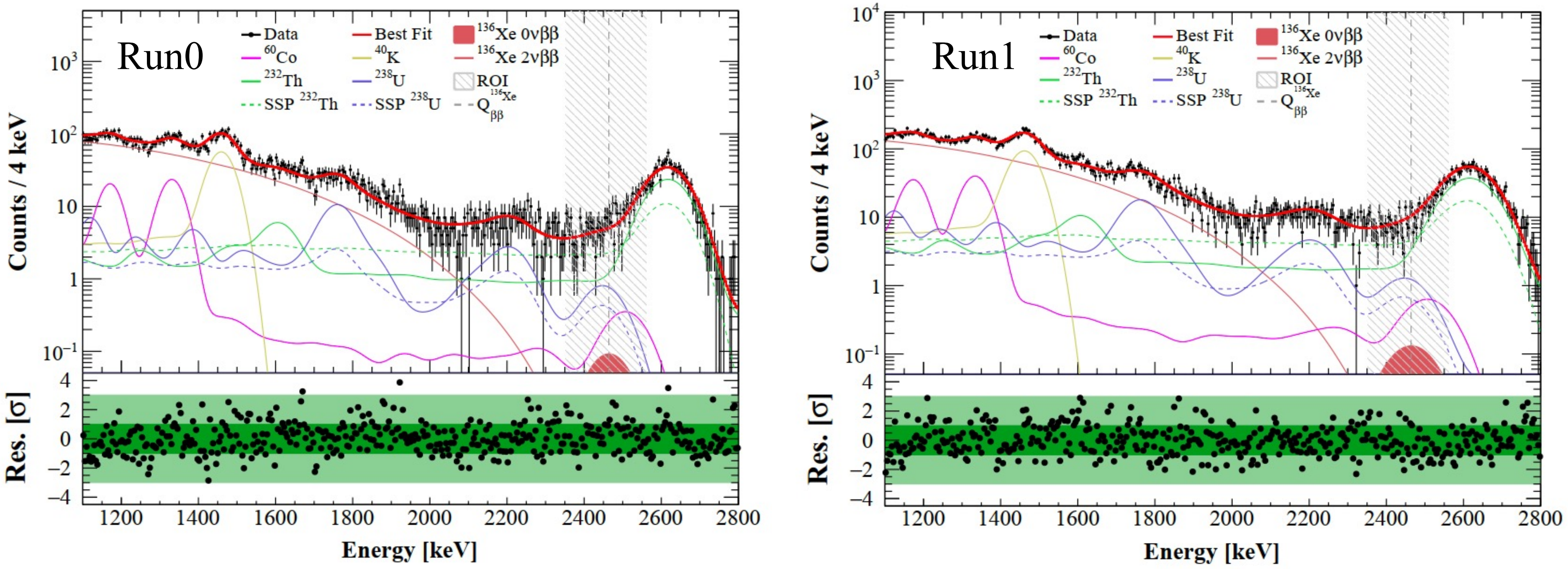


Median sensitivity is estimated by fits to toy-data, generated from background model.

$$T^{0\nu\beta\beta}_{1/2,\,sensitivity} > 2.7\times 10^{24}\ yr \text{ at 90\% C.L.}$$

Unblinded Fit and Results

PANDA X
PARTICLE AND ASTROPHYSICAL XENON TPC



- ^{136}Xe exposure: 44.6 kg-yr
- Energy resolution @ 2615 keV: 2.0% in Run0 and 2.3% in Run1
- ^{136}Xe $0\nu\beta\beta$ event rate: $14\pm55\ t^{-1}yr^{-1}$, <111 $t^{-1}yr^{-1}$ at 90% C.L.
- $T_{1/2}^{0\nu\beta\beta} > 2.1\times 10^{24}\ yr$ at 90% C.L. $\langle m_{\beta\beta}\rangle = (0.4 - 1.6)\ \mathrm{eV/c^2}$

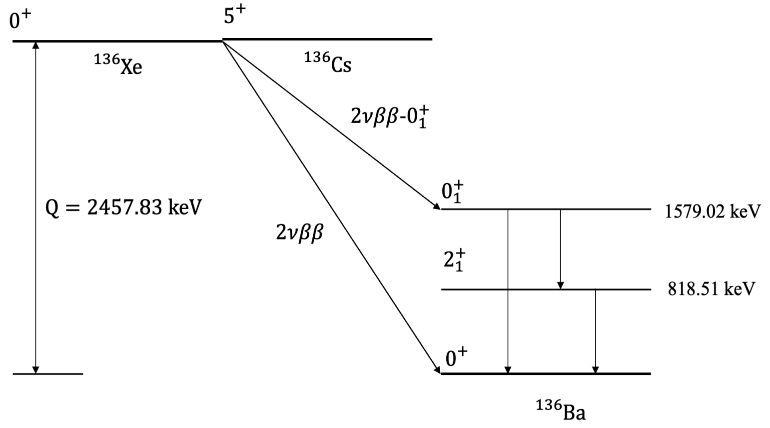
arXiv:2412.13979, Science Bulletin

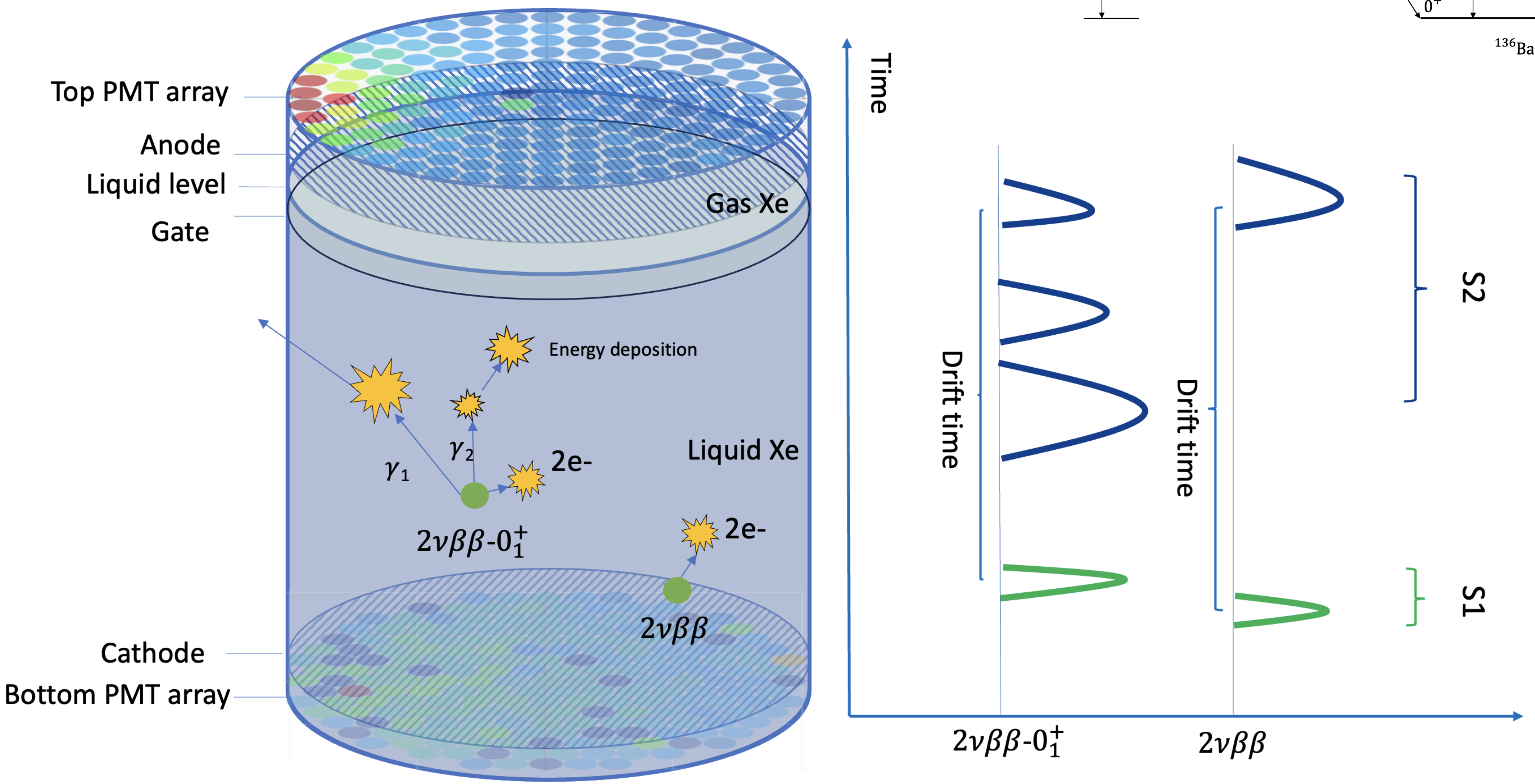
Search for ^{136}Xe 0νββ with natural Xe TPC

	Bkg rate (/keV/ton/y)	Energy resolution	FV mass (kg)	Live time	Sensitivity/Limit (90% CL, year)	Year
PandaX-II	~200	4.2%	219	403 days	2.4×10^{23}	2019
XENON1T	~20	0.8%	741	203 days	1.2×10^{24}	2022
PandaX-4T	~10	2.0-2.3%	735	258 days	2.1×10^{24}	2024

- The most stringent constraint from a natural xenon detector
- Improvement w.r.t PandaX-II by an order of magnitude and XENON1T by a factor of 1.8
- Demonstrating the potential of ^{136}Xe 0νββ search with next-generation multi-ten-tonne natural xenon detectors

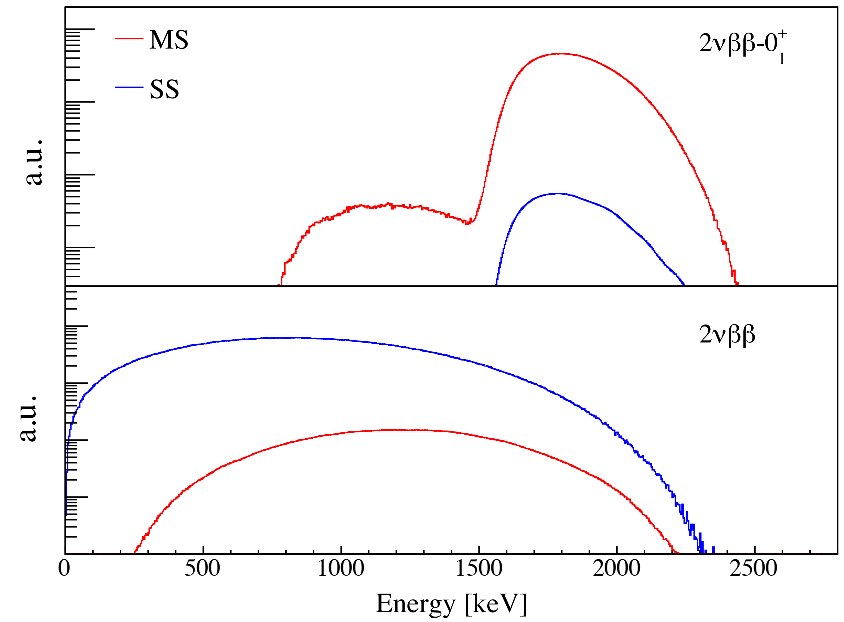
^{136}Xe Decay to excited states (ArXiv:2502.03017, JHEP)

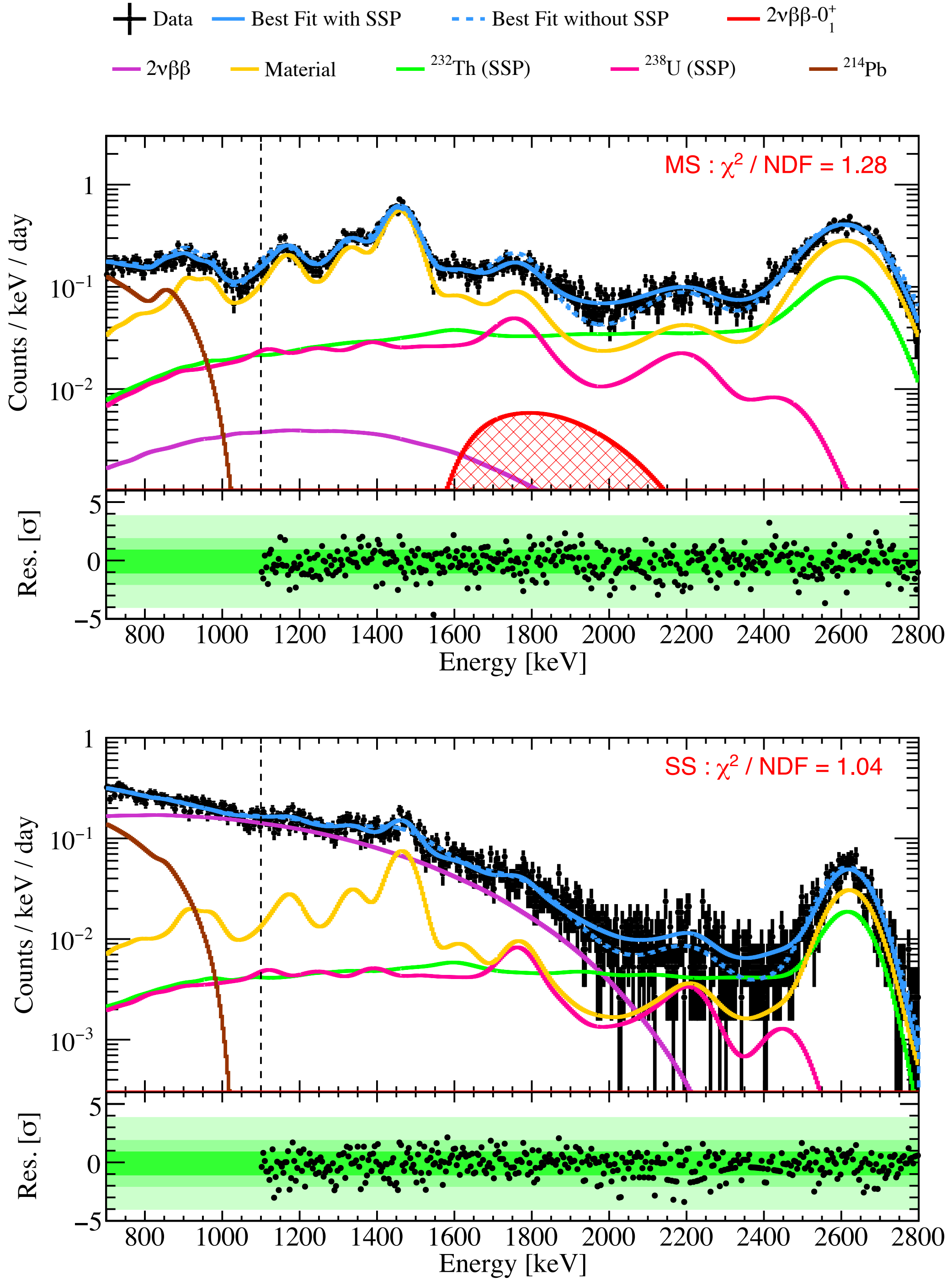




Results

- $T_{1/2}^{2\nu\beta\beta-0^+} > 7.5 \times 10^{22}$ yr at the 90% confidence level
- First such result from a natural xenon detector
- PandaX first MS analysis





PandaX Analysis in MHE region

^{136}Xe DBD

^{134}Xe DBD

^{124}Xe 2nDEC

^{124}Xe 0nDEC

Full range ER spectrum: exotic BSM physics, nuclear physics

keV

10 keV

100 keV

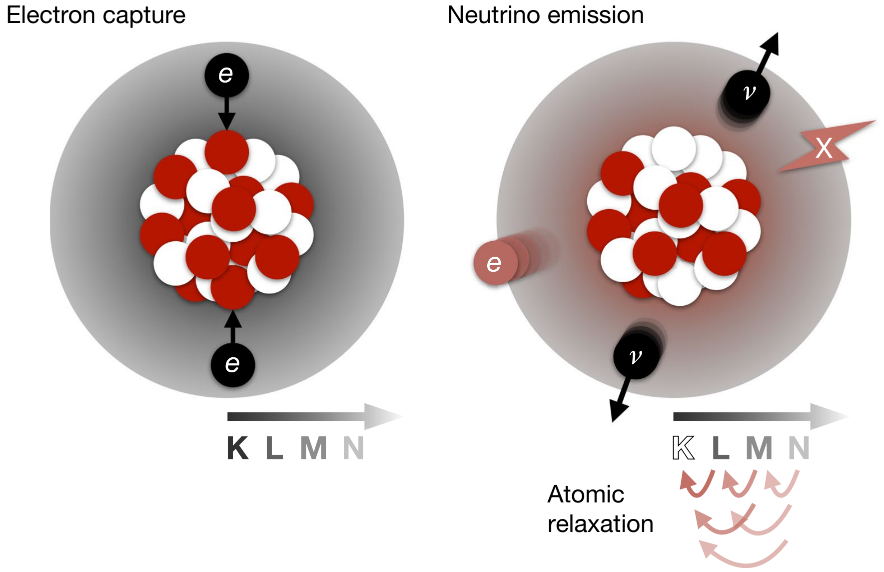
1 MeV

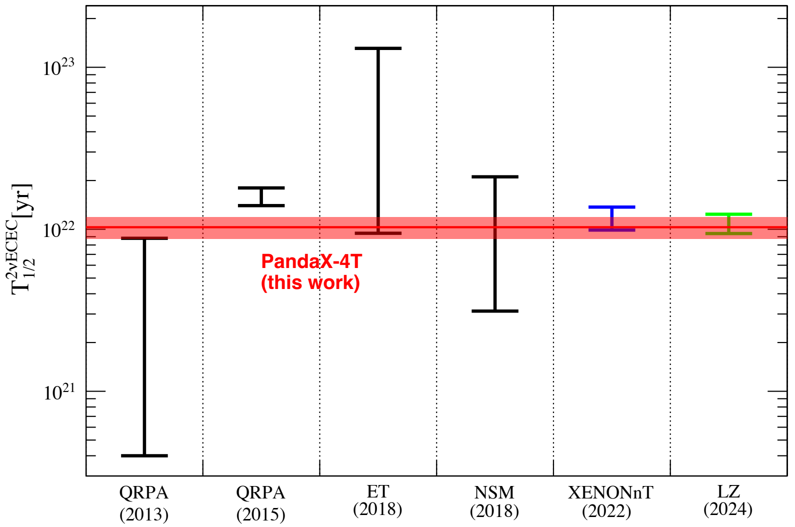
Solar ^{8}B neutrino

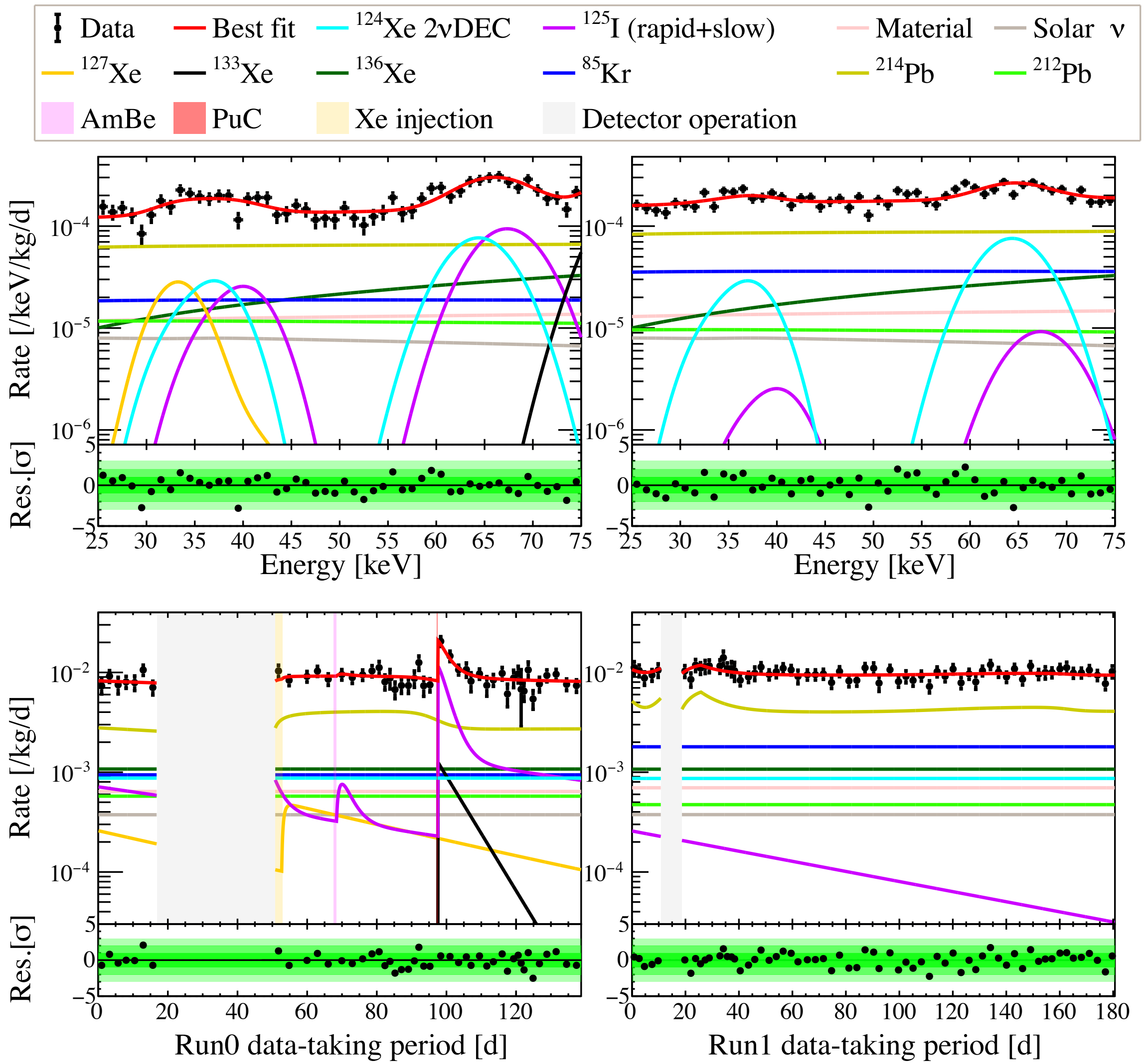
WIMP and other dark matter

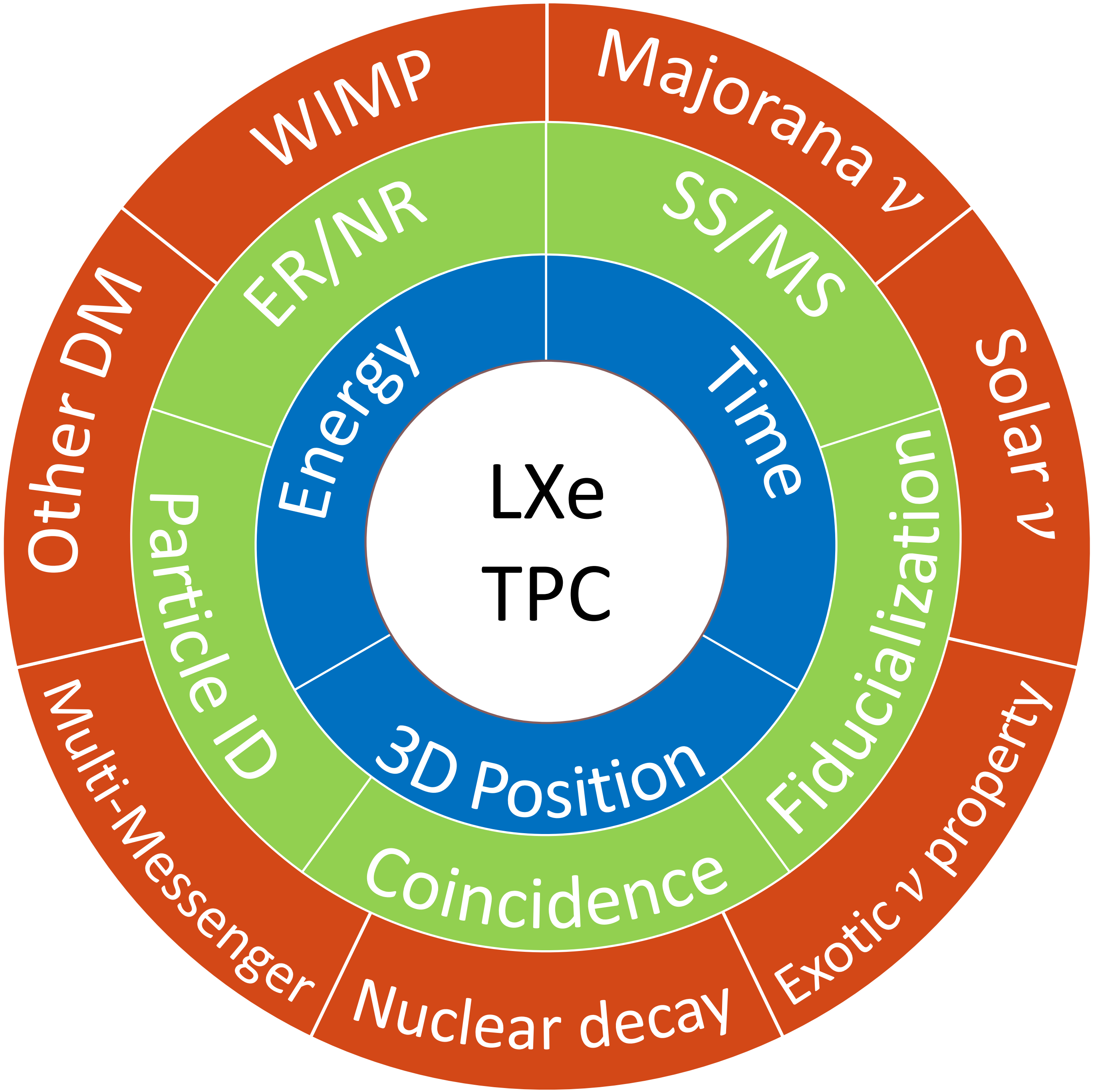
Existing Analysis at low energy

^{124}Xe double electron capture (arXiv:2411.14355, JHEP)





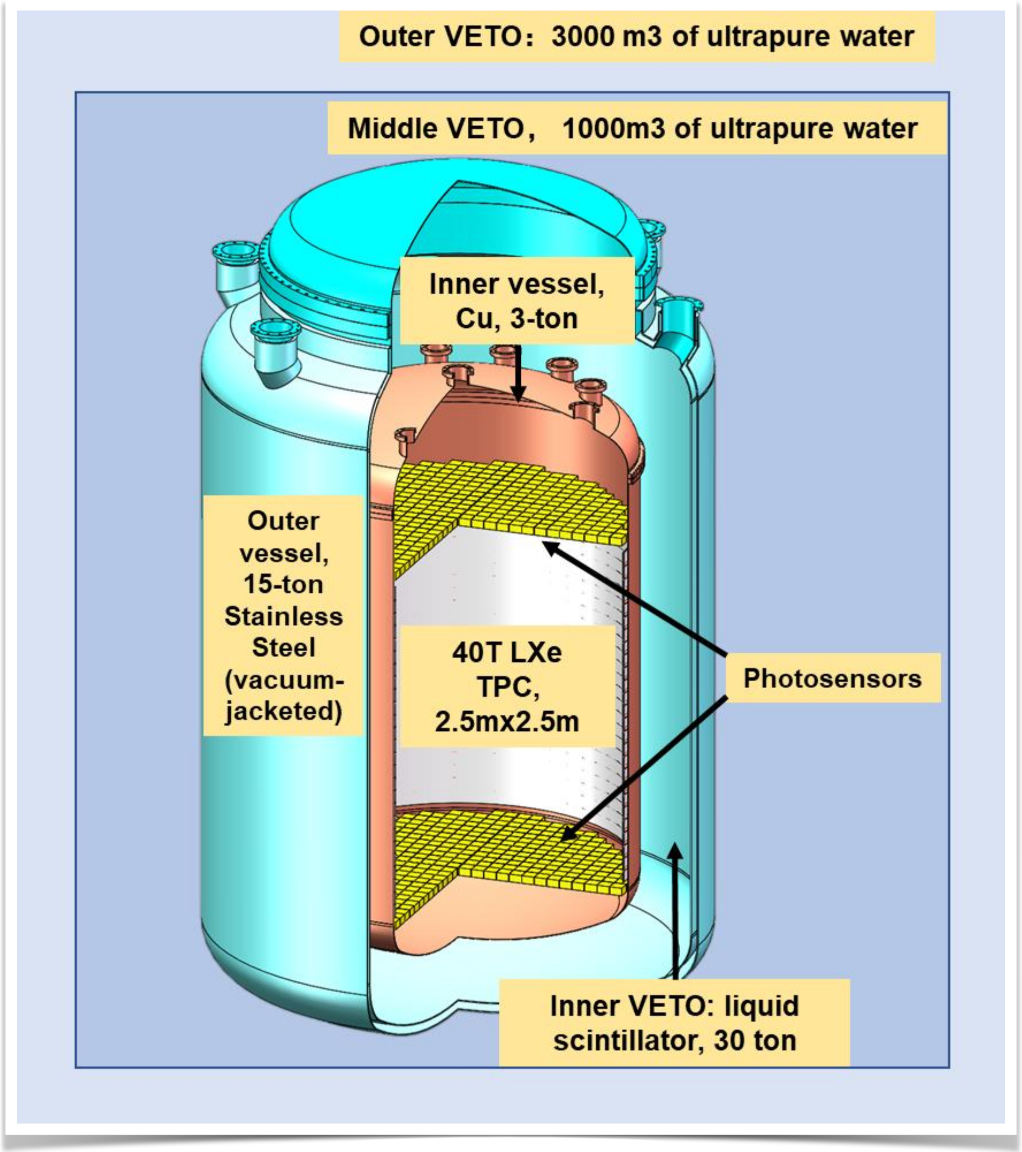




+ Larger Cleaner Detector

PandaX-xT: Multi-ten-tonne Liquid Xenon Observatory

- Active target: 43 tons of Xenon
  - Test the WIMP paradigm to the neutrino floor
  - Explore the Dirac/Majorana nature of neutrino
  - Search for astrophysical or terrestrial neutrinos and other ultra-rare interactions
- Notable detector improvements:
  - High-granularity, low-background 2-in PMT array
  - Cu/Ti vessel for improved radiopurity
  - Inner liquid scintillator veto



SCPMA 68, 221011 (2025)

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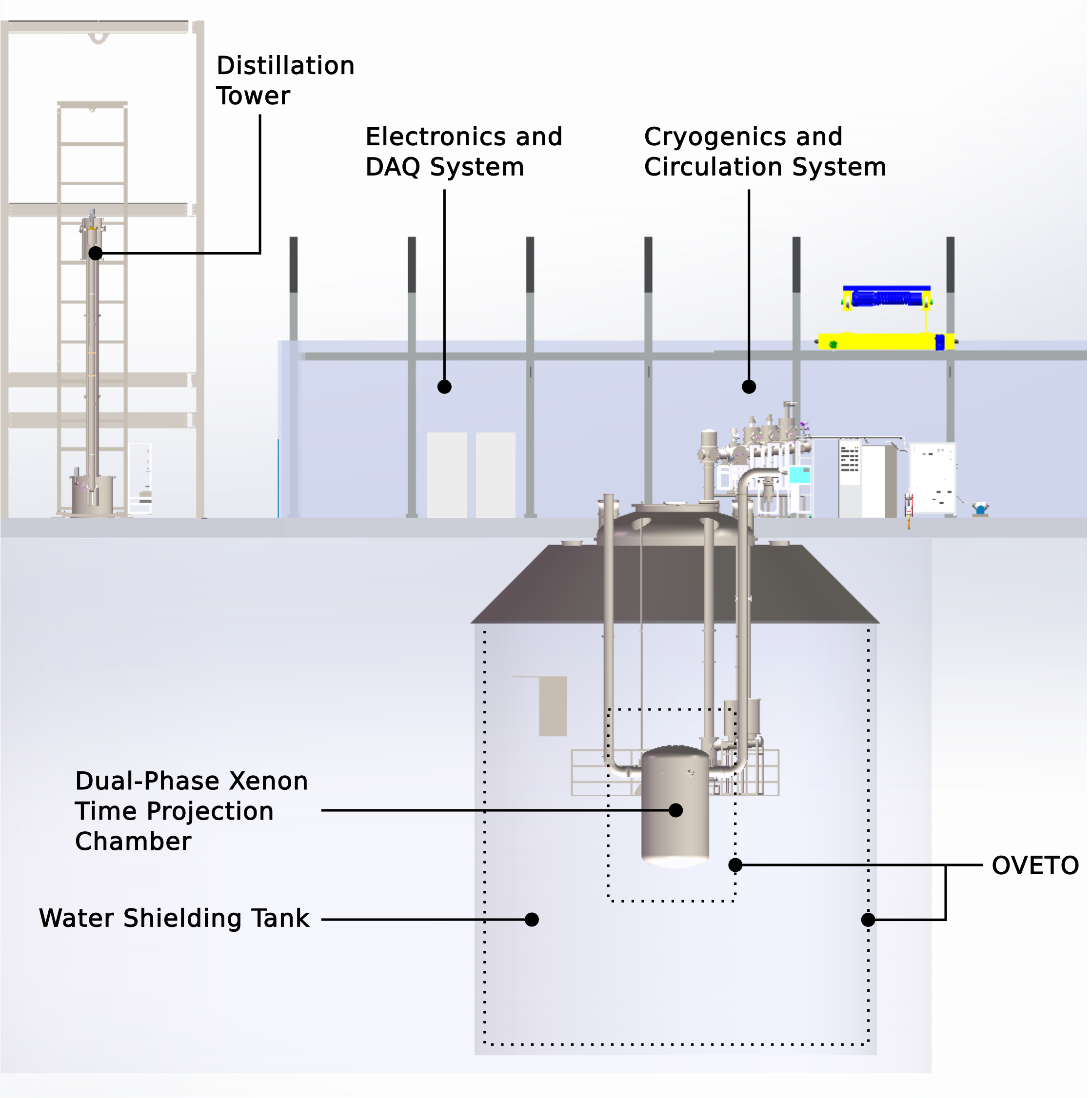
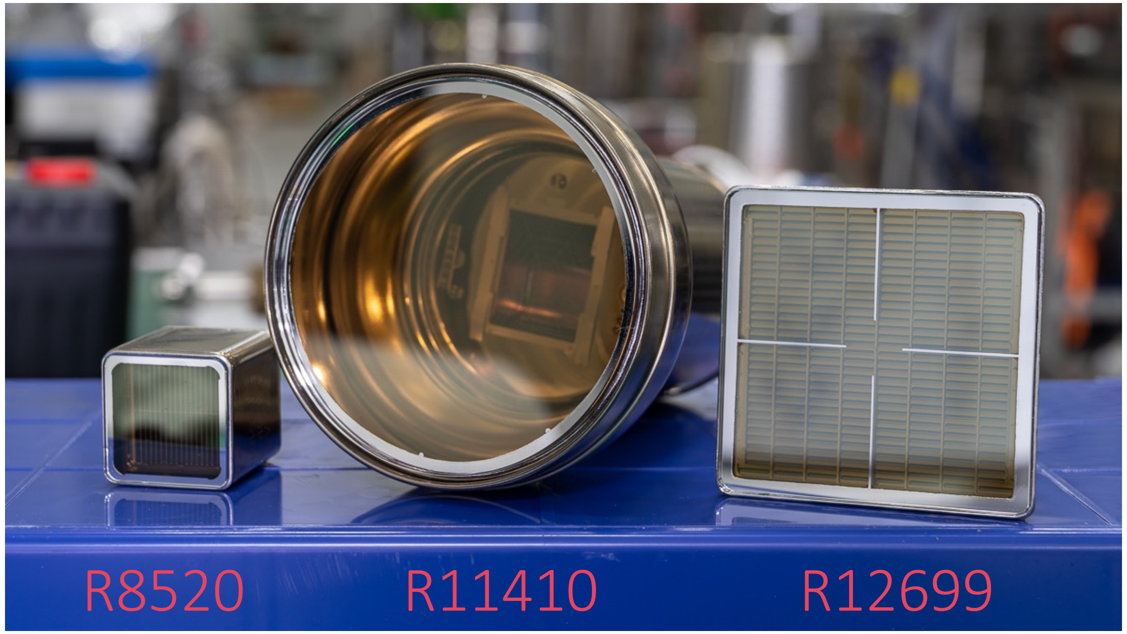
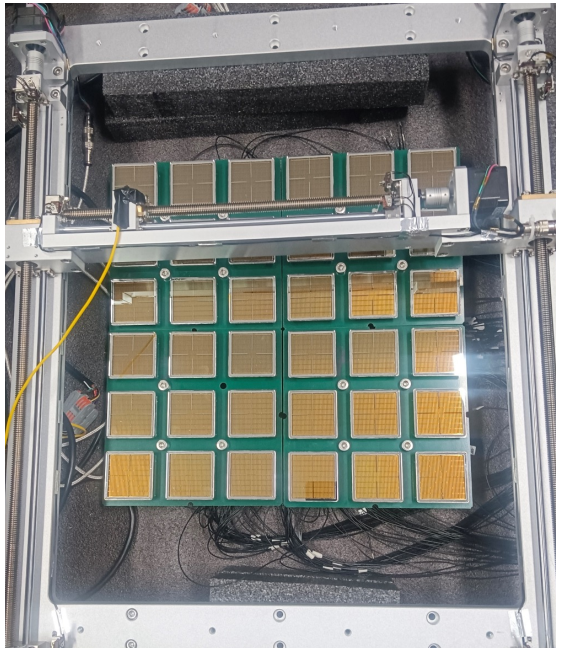
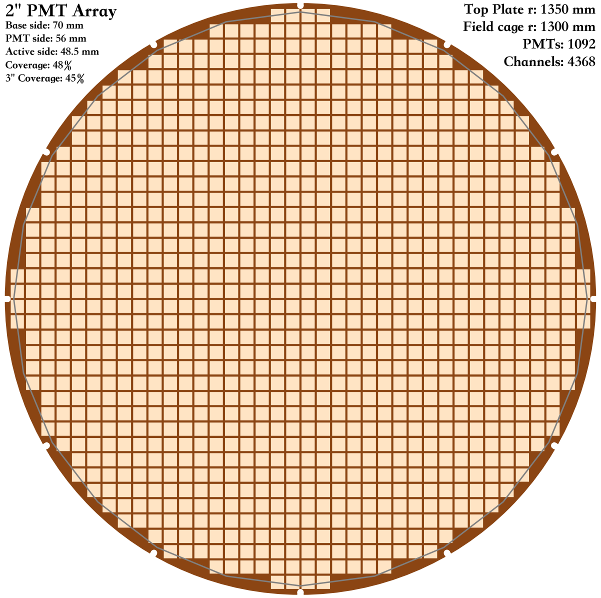


New 2” multi-anode R12699 PMT for LXe TPC

- Higher granularity while maintaining low dark noise: best of both large PMT and SiPM
  - Improved position reconstruction for better event topology
  - 2” array has an effectively wider dynamic range for DM and DBD simultaneously
  - Faster timing for possible pulse shape analysis or Cerenkov/Scintillation separation
- Collaboration between PandaX and Hamamatsu for a low-radioactivity version of R12699





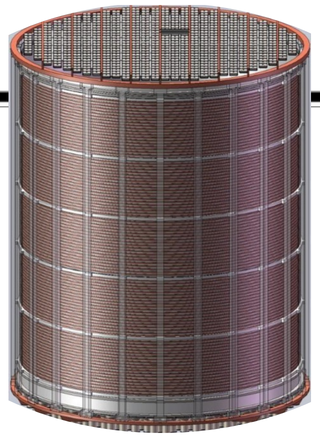


Conceptual array for a PandaX-xT

Timeline

PandaX Project Timeline	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Operation of PandaX-4T, and R&D for the upgrade																					
Project Phase-I：construct and operate PandaX-xT; procure xenon by stages and upgrade detector along the way while keeping high running-time; 20T => 43T																					
Project Phase-II: with isotopically separated xenon (versatile configurations)																					

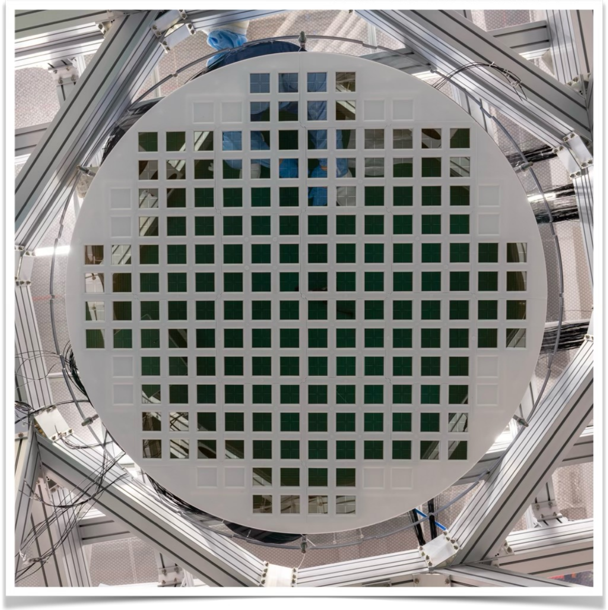
20T



43T

PandaX-xT 20T stage

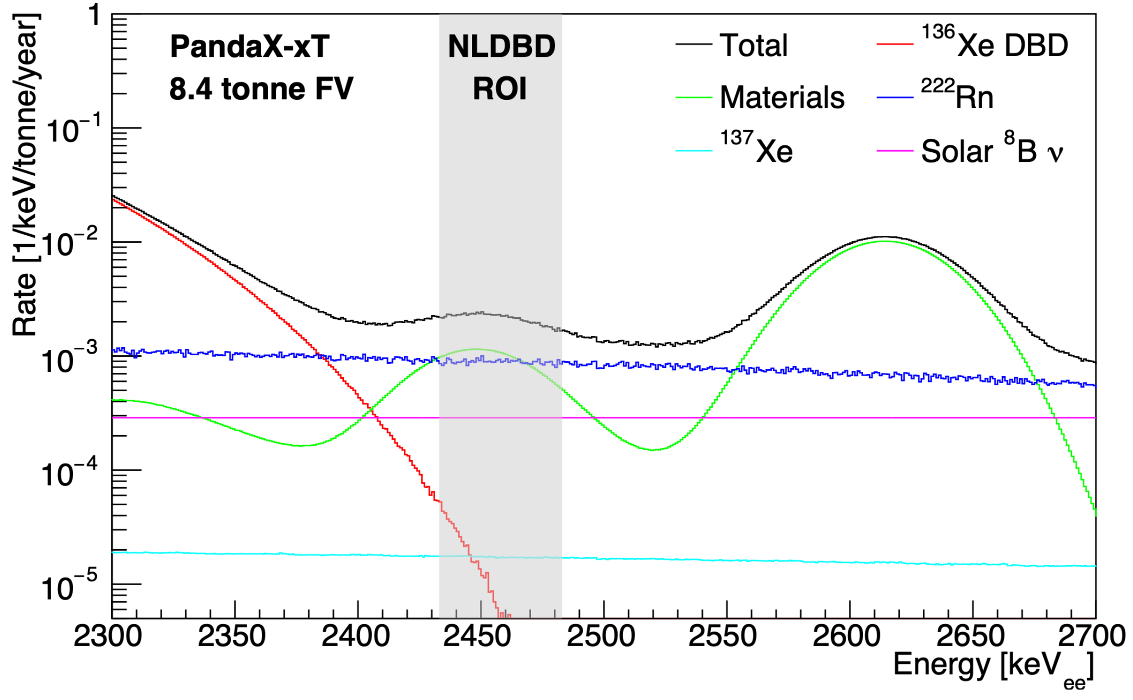
- Mostly funded
- Detector prototyping and construction in progress
- More at PandaX-xT Open Meeting: https://indico-tdli.sjtu.edu.cn/event/2934

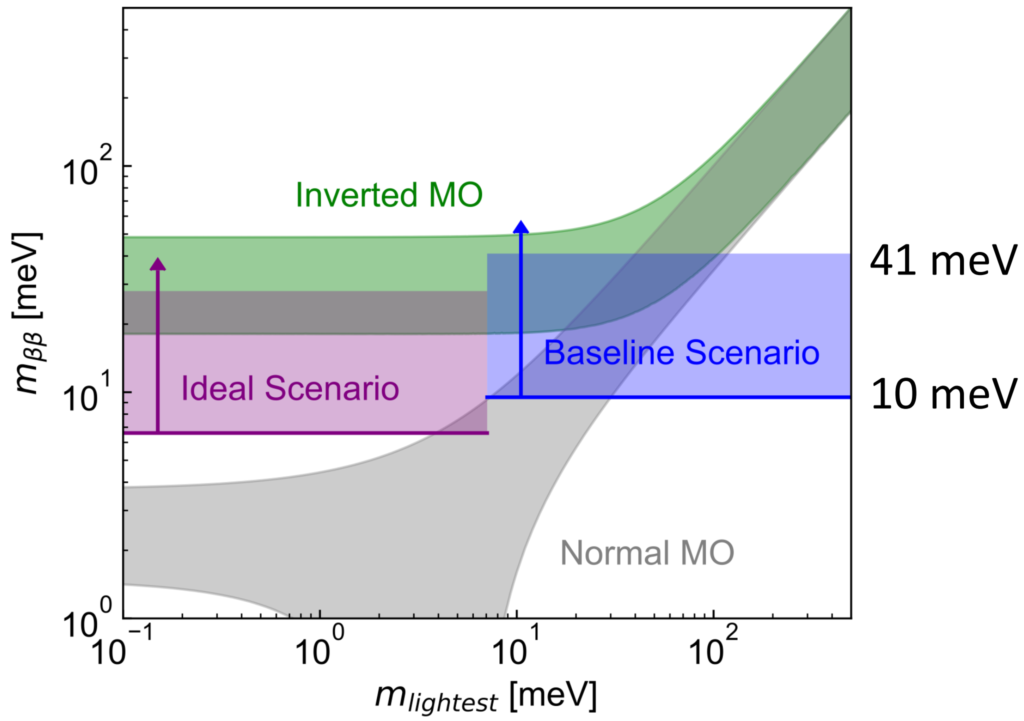


PandaX-xT for $0\nu\beta\beta$

- 4 ton of ^{136}Xe: one of the largest $0\nu\beta\beta$ experiments
- Effective self-shielding: Xenon-related background dominates in the 8.4-tonne center FV

	Baseline (1/tonne/year)	Ideal (1/tonne/year)
Photosensors	1.4×10^{-2}	2.8×10^{-3}
Copper vessel	3.2×10^{-2}	6.3×10^{-3}
^{222}Rn	4.5×10^{-2}	-
^{136}Xe DBD	5.2×10^{-4}	5.2×10^{-4}
^{137}Xe	8.7×10^{-4}	8.7×10^{-4}
Solar ^{8}B ν	1.4×10^{-2}	1.4×10^{-2}
Total	$\mathbf{1.1\times10^{-1}}$	$\mathbf{2.4\times10^{-2}}$





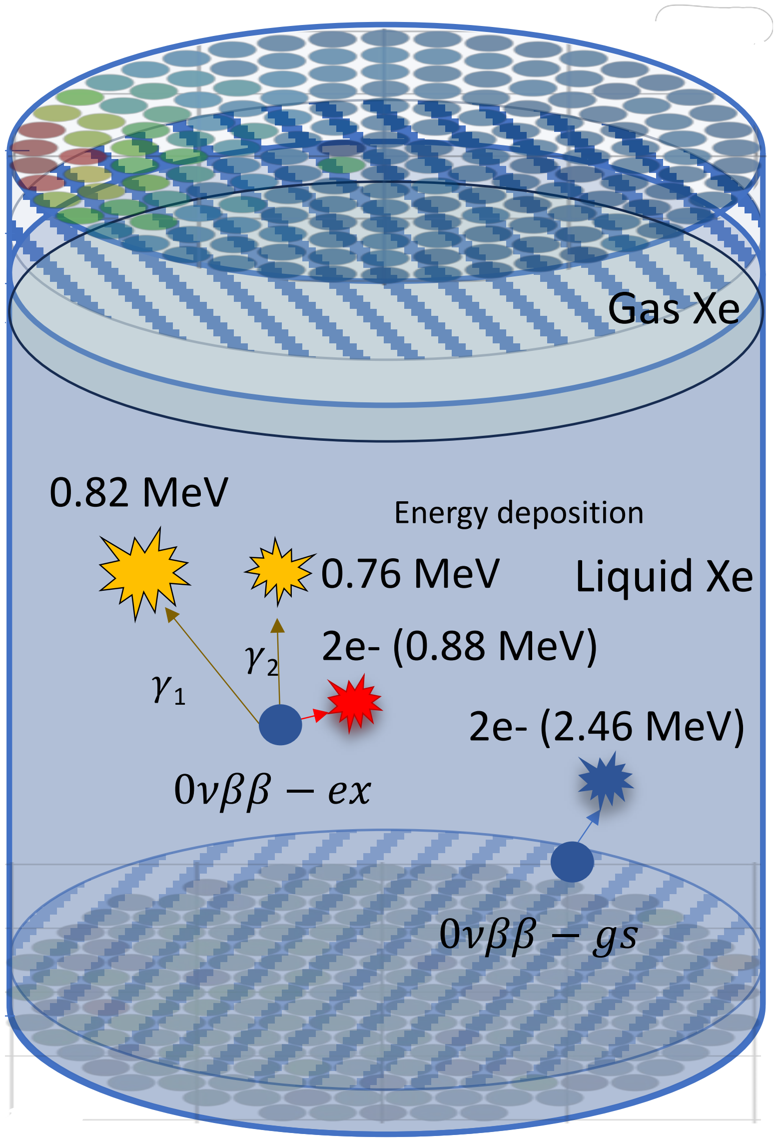
Head-to-head with other DM/0νββ experiments

	Bkg rate (/keV/ton/y)	Energy resolution	Mass (ton)	Run time	Sensitivity/Limit (90% CL, year)
PandaX-4T	6	1.9%	4	94.9 days	$> 10^{24}$
XENONnT	1	0.8%	6	1000 days (expected)	2×10^{25}
LZ	0.3	1%	7	1000 days (expected)	1×10^{26}
KamLAND-ZEN	0.002	5%	0.8 (^{136}Xe)	1.5 years	2.3×10^{26}
nEXO	0.006	1%	5 (^{136}Xe)	10 years	1.35×10^{28} **
DARWIN/XLZD	~ 0.004*/2E-4	0.8%/0.6%	40/80	10 years	$2 \times 10^{27}/1.35 \times 10^{28}$
PandaX-xT	0.002*	1%	43	10 years	3×10^{27}

* Major difference from cosmogenic ^{137}Xe; ** $\frac{S}{\sqrt{B}}$ sensitivity is 6×10^{27} yr, for detector performance comparison in the table.

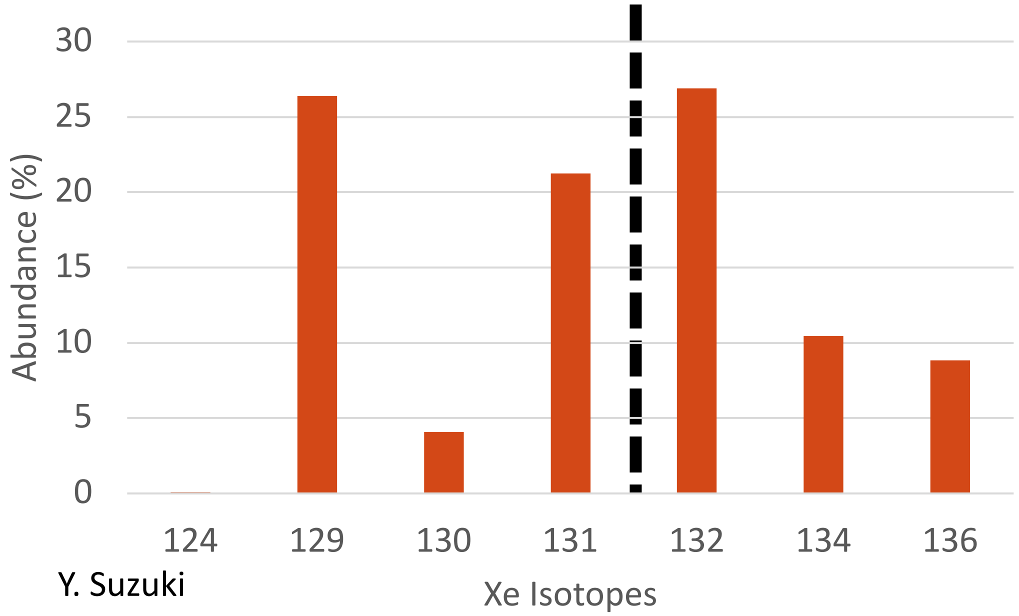
$0\nu\beta\beta$ + $0\nu\beta\beta$-ES

- Future $0\nu\beta\beta$ projects:
  - Modular solid-state detectors (LEGEND, CUPID, etc)
  - Liquid scintillator detectors (K2Z, JUNO)
  - Xenon TPC (PandaX, XLZD)
- Xenon TPC is the most effective technology to detect $0\nu\beta\beta$-ES
  - tag beta + gamma
  - Less background-prone
- A combined analysis of $0\nu\beta\beta$ + $0\nu\beta\beta$-ES helps improve the sensitivity to $m_{\beta\beta}$.
  - Chenrong Ding, KH, Shaobo Wang, Jiangming Yao

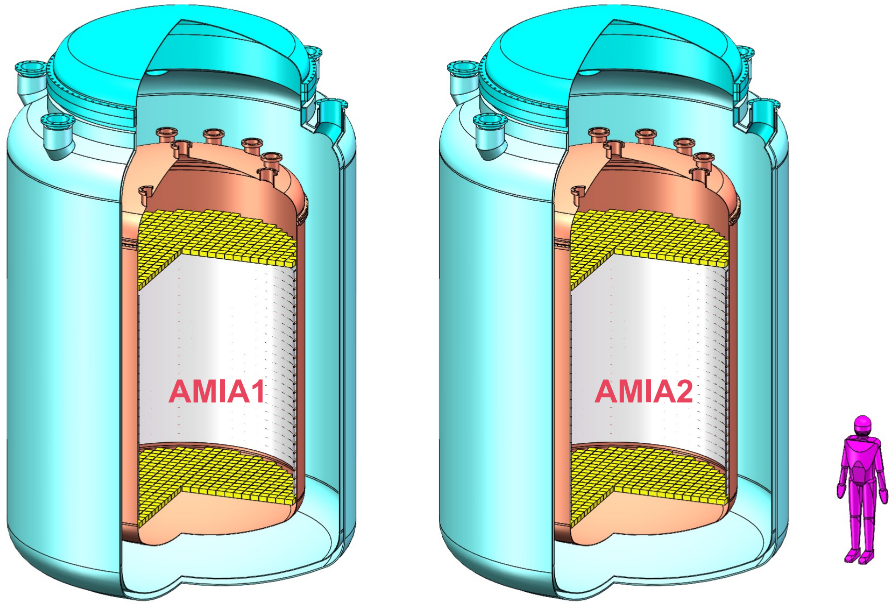


Possible isotope seperation/enrichment

- Xenon with artificially modified isotopic abundance (AMIA) for smoking gun discovery
  - A split of odd and even nuclei
  - Further enrichment of ^{136}Xe
  - to improve sensitivity to spin-dependence of DM-nucleon interactions and 0νββ

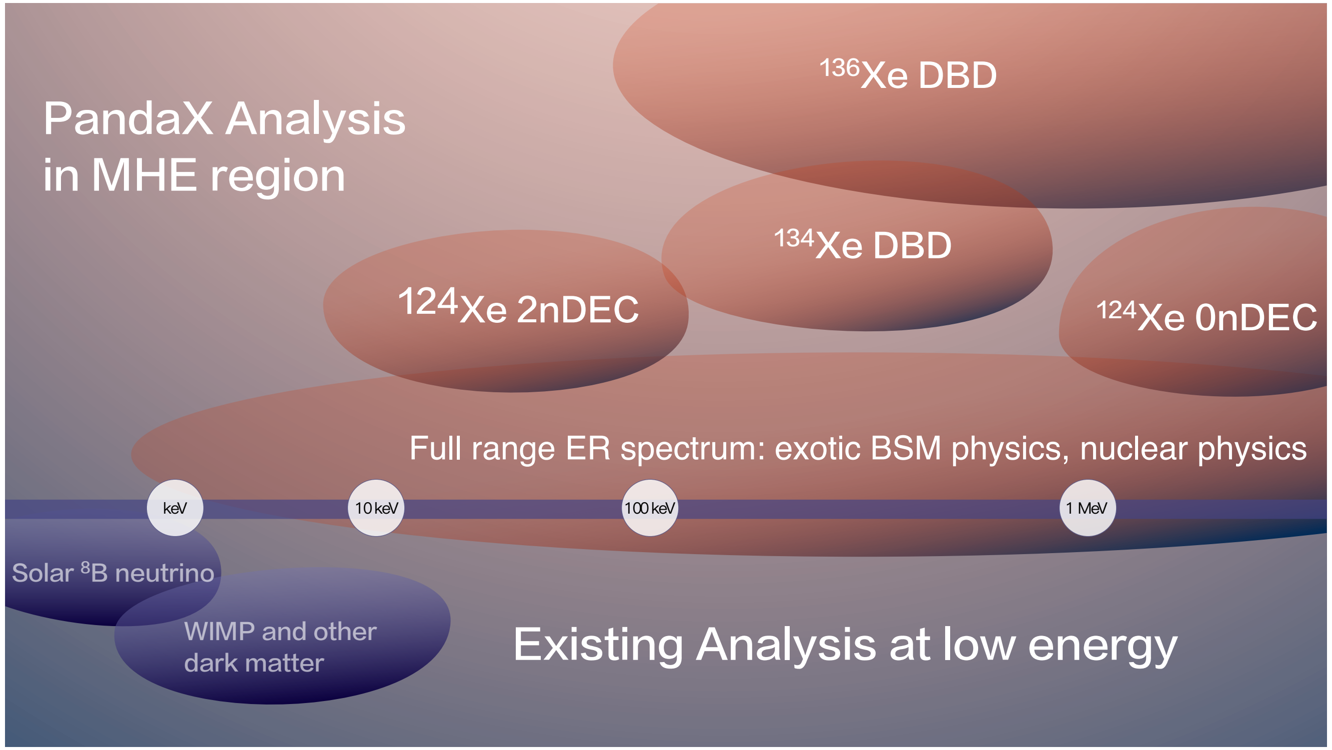


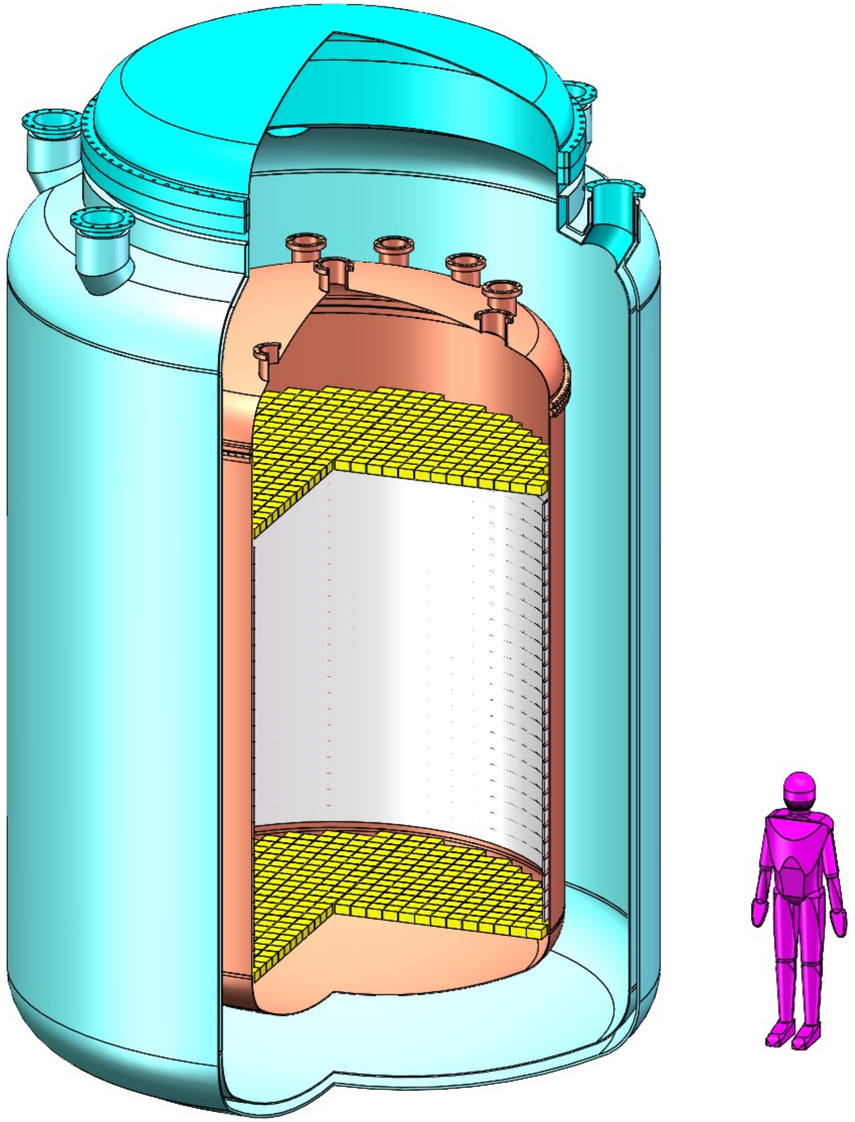
Y. Suzuki



Double beta decay with PandaX natural xenon TPC

- $0\nu\beta\beta$: important neutrino physics topic
- Competitive results from PandaX-4T
- Exciting future with PandaX-xT

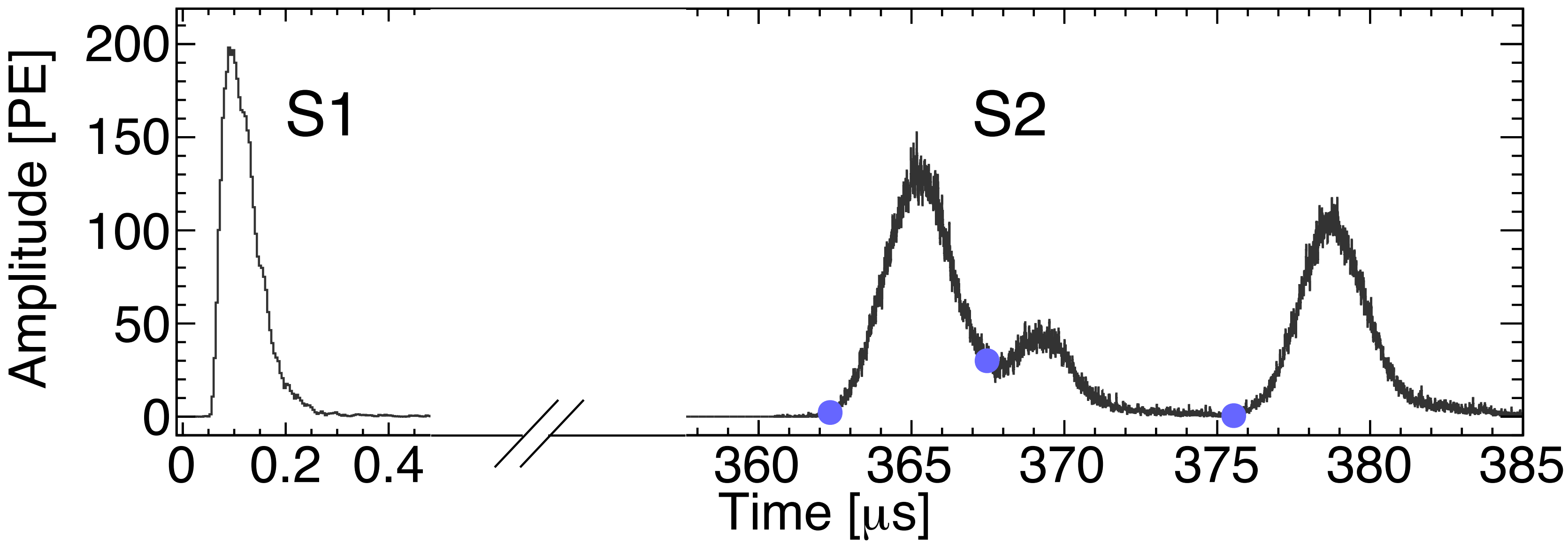


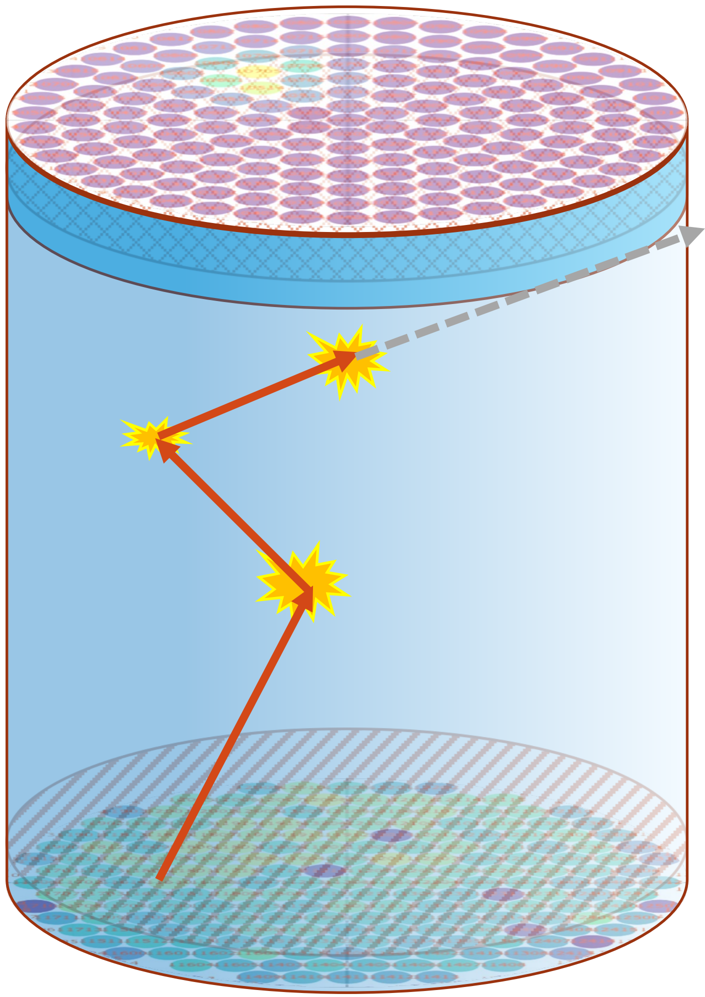



PANDA X
PARTICLE AND ASTROPHYSICAL XENON TPC
Thank you very much
We welcome new collaborators
at PandaX-xT

SS vs. MS

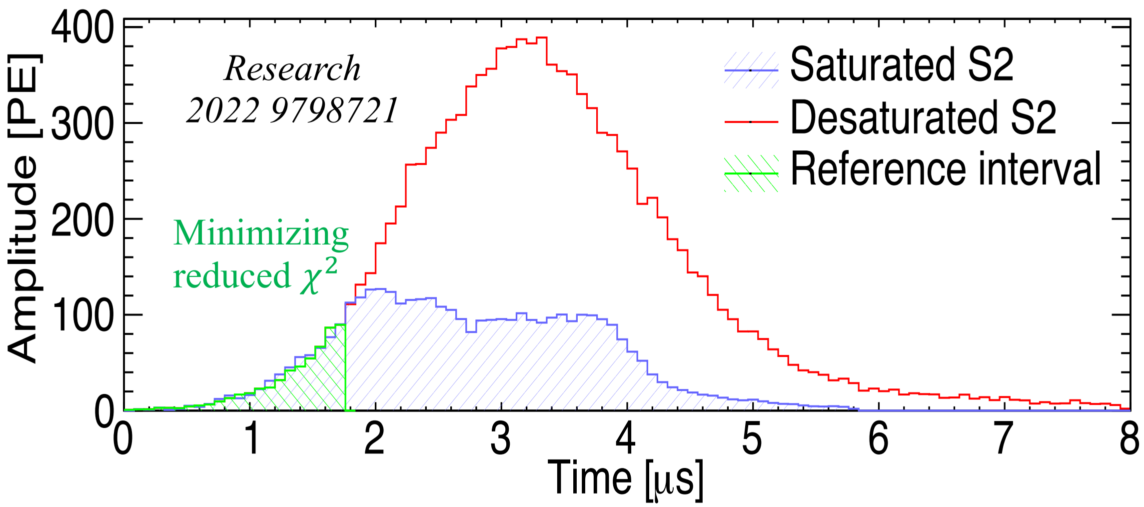
- MeV gamma events are mostly multiple-scattering events; while signals (DBD) are mostly single site (SS)
- Identifying Multi-Site (MS) events with PMT waveforms
- Width of waveforms dominated by Z (electron diffusion)

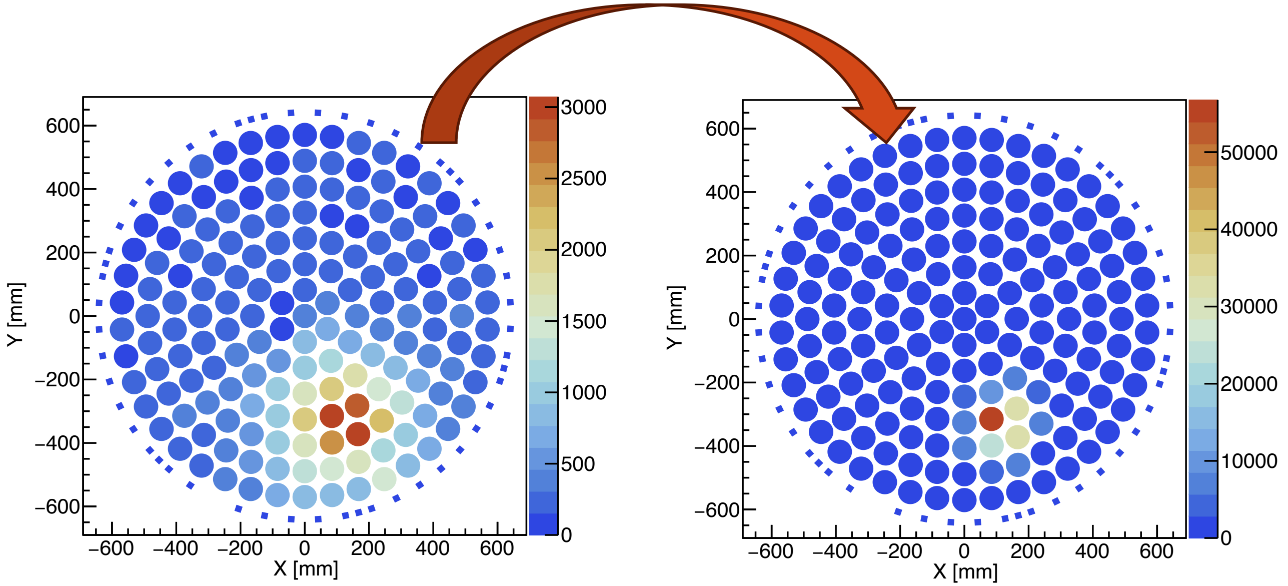


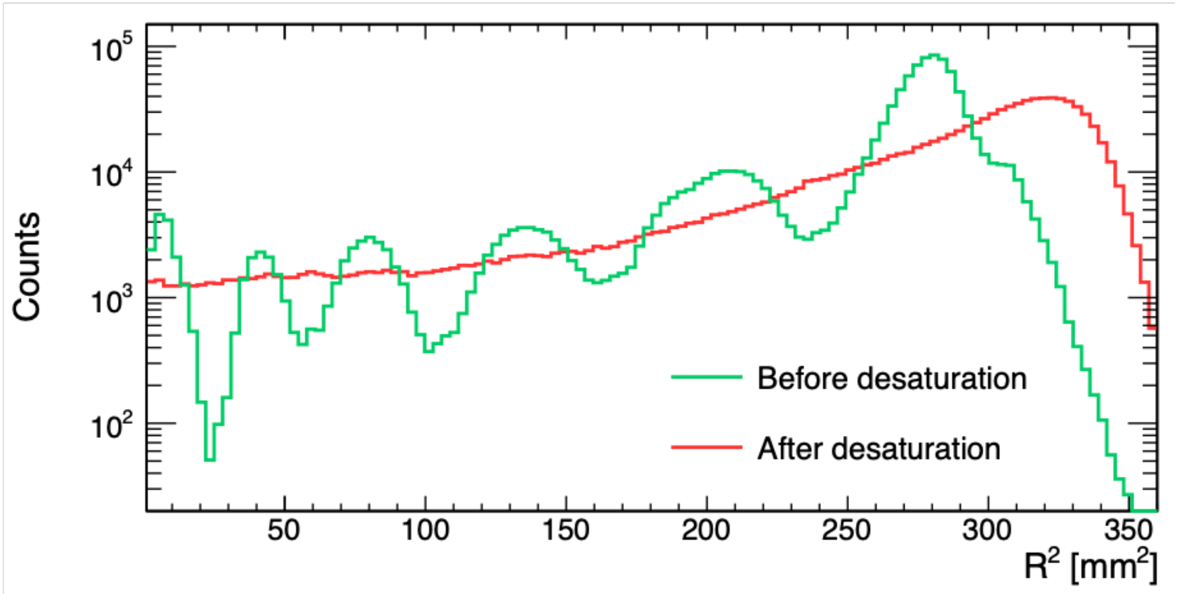


Extending energy from keV to O(100 keV) – O(MeV)

- PMT desaturation for large S2 signals
- Improvement of X-Y position reconstruction, energy linearity and energy resolution
- No longer an issue in Run 2

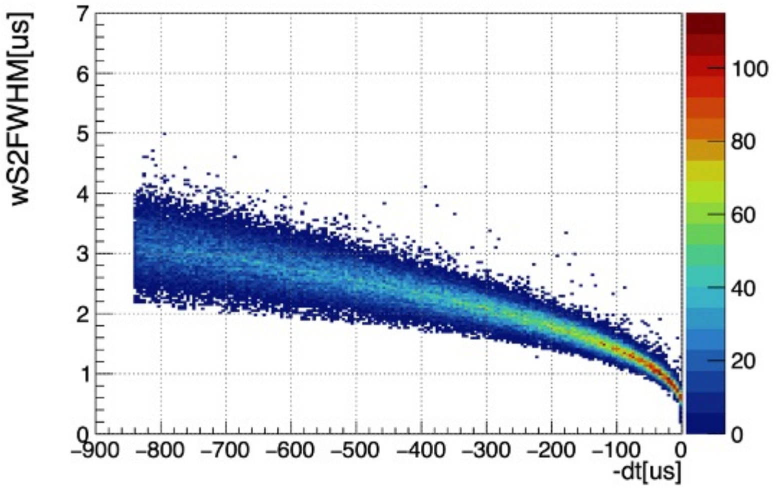


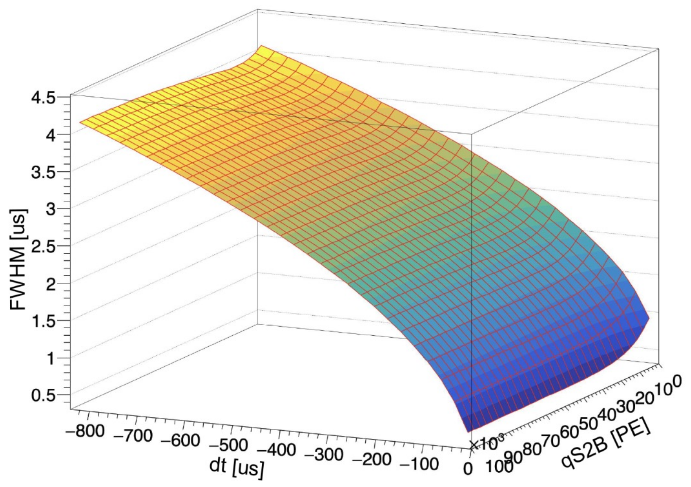


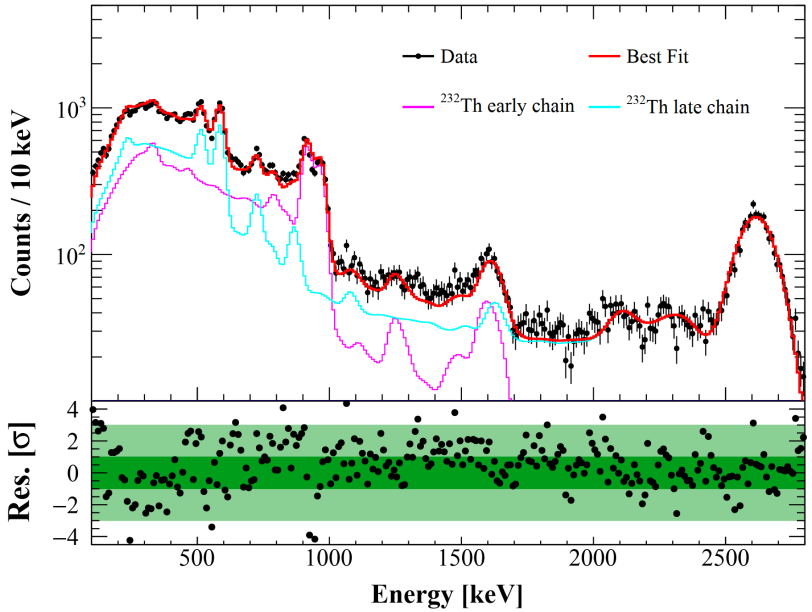


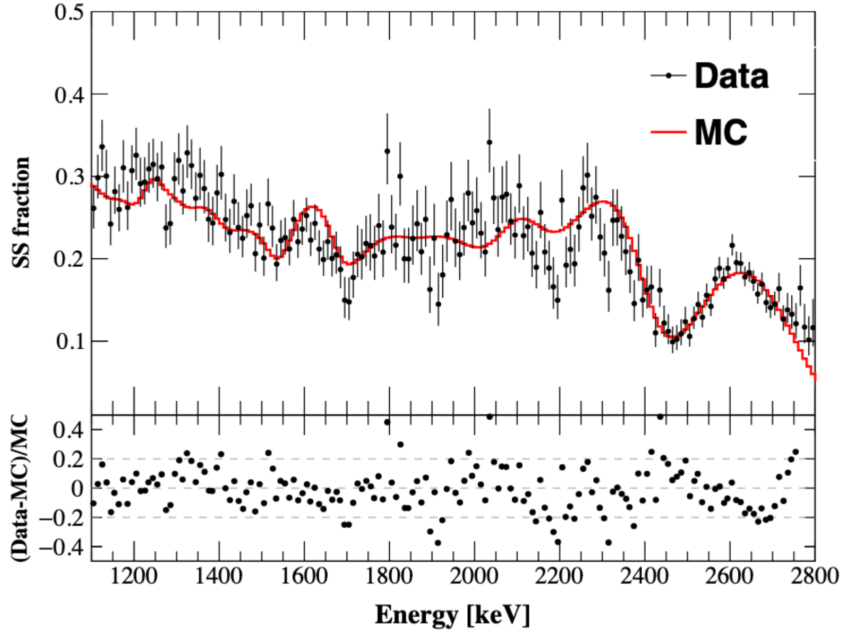
SS Fraction (SS/Total) determination

- Data-driven S2 waveform simulation + data processing
- SS fraction uncertainty is estimated by comparison MC/data of ^{232}Th calibration
- Spectrum average of the absolute bin-by-bin deviation between data and MC taken as SS fraction uncertainty









Likelihood and Systematics

- Binned Poisson likelihood with Gaussian penalty terms to constrain nuisance parameters
- Systematics include three categories: energy response, overall efficiency, ^{136}Xe mass
- ^{136}Xe mass uncertainties: abundance from RGA measurement; FV mass from the non-uniformity of ^{83m}Kr + LXe density fluctuation

$$L = \prod_{r}^{N_{run}} \prod_{i}^{N_{region}} \prod_{j}^{N_{bins}} \frac{(N_{rij})^{N_{rij}^{obs}}}{N_{rij}^{obs}!} e^{-N_{rij}}$$

$$\cdot \prod_{r}^{N_{run}} [\mathcal{G}(\mathcal{M}_r; \mathcal{M}_r^0, \Sigma_r^{\mathcal{M}}) \cdot \prod_{k}^{N_{eff}} G(\eta_r^k; 0, \sigma_r^k)]$$

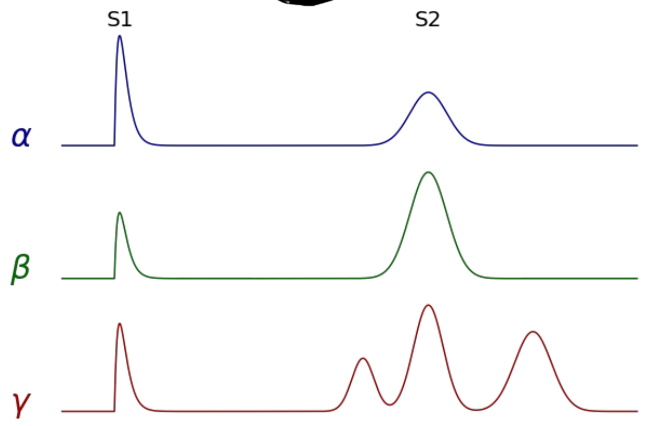
$$\cdot \prod_{b}^{N_{bkg}} G(\eta^b; 0, \sigma^b)$$

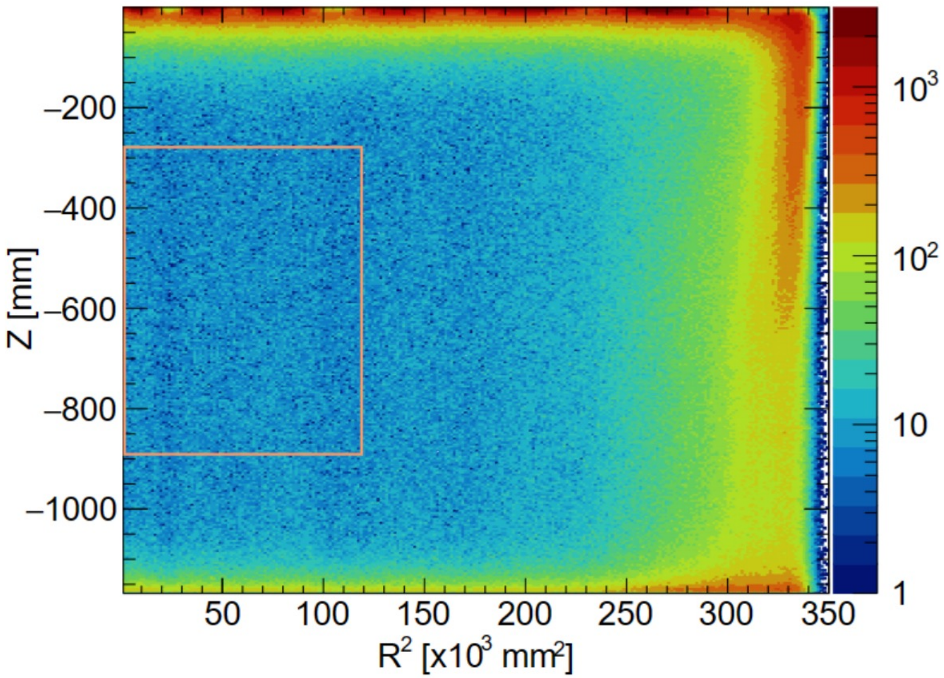
$$N_{rij} = (1 + \eta_r^o) \cdot [(1 + \eta_r^s) \cdot n_r^s \cdot S_{ijr} + \sum_{b}^{N_{bkg}} (1 + \eta^b) \cdot n_r^b \cdot B_{ijr}^b]$$

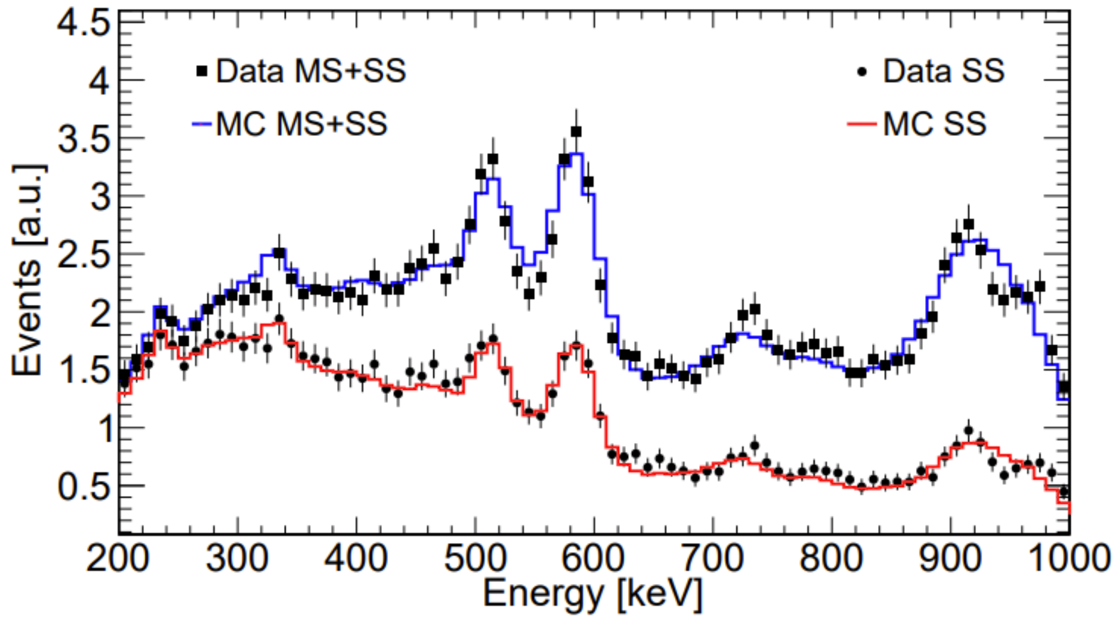
Sources		Values: Run0	Values: Run1
Energy response	a [keV^{-1}]	$(4.2 \pm 1.0) \times 10^{-6}$	$(1.1 \pm 1.4) \times 10^{-6}$
	b	0.992 ± 0.002	0.997 ± 0.004
	c [keV]	0.90 ± 0.32	1.4 ± 1.5
	d [$\sqrt{\text{keV}}$]	0.259 ± 0.046	0.46 ± 0.25
	e [keV^{-1}]	$(1.1 \pm 1.5) \times 10^{-6}$	$(8.8 \pm 22.2) \times 10^{-7}$
	f	$(9.7 \pm 3.5) \times 10^{-3}$	$(7.4 \pm 10.0) \times 10^{-3}$
Overall efficiency	^{136}Xe $0\nu\beta\beta$ SS fraction	$(87.1 \pm 11.3)\%$	$(87.3 \pm 7.0)\%$
	Quality cut	$(99.89 \pm 0.10)\%$	$(99.97 \pm 0.02)\%$
^{136}Xe mass	^{136}Xe abundance	$(8.58 \pm 0.11)\%$	
	FV mass [kg]	735 ± 3	735 ± 14
Background model		Table. 2	

Data selection

- An identical FV as in ^{136}Xe analysis, total isotopic exposure: 17.9 kg·yr
- Single site vs multi-site selection measured by ^{232}Th calibration data
  - Little impact to DBD signals (β SS events)





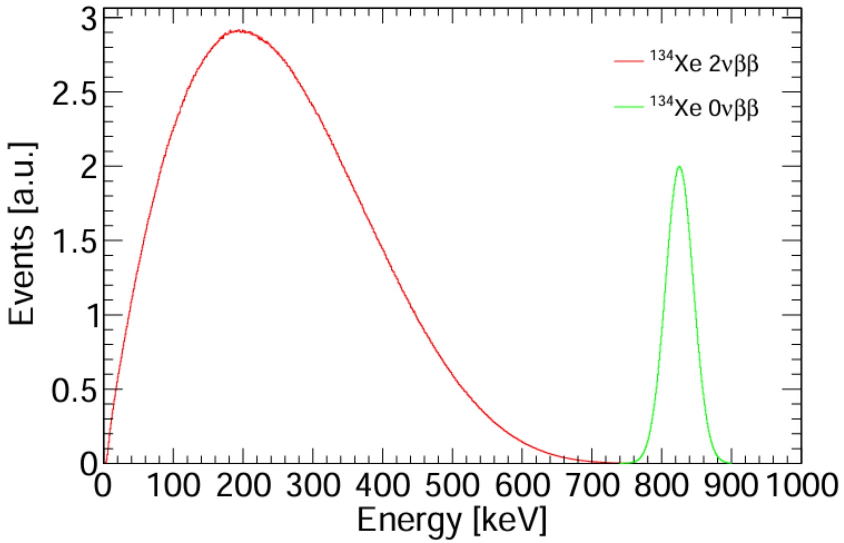


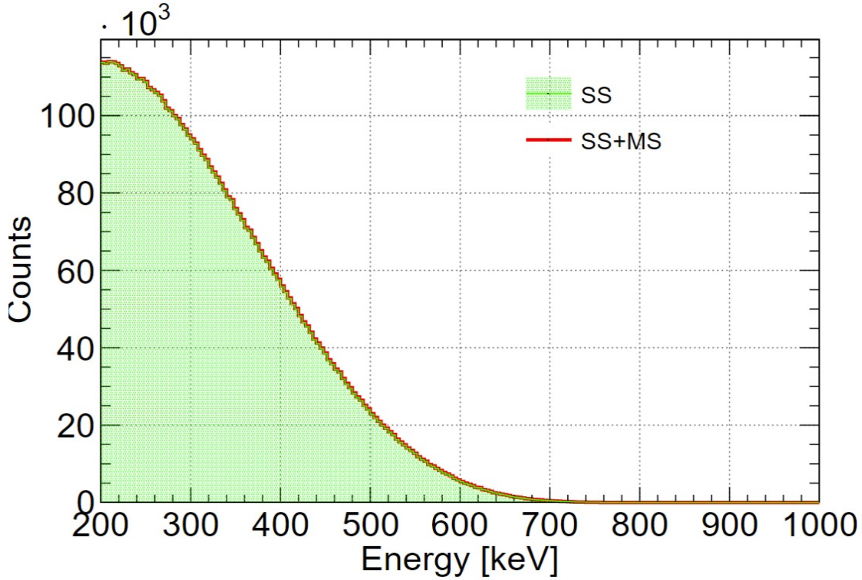
PandaX, Phys.Rev.Lett. 132 (2024) 15, 152502

Signal efficiencies

- ^{134}Xe $2\nu\beta\beta$ and $0\nu\beta\beta$ events generated with the theoretical calculation
- The signal events went through PandaX-4T simulation and data processing chain

- ROI [200,1000]keV cut:
  - $2\nu\beta\beta$: 60.56%
  - $0\nu\beta\beta$: 99.98%





- SS ratio in ROI:
  - $2\nu\beta\beta$: 99.89%
  - $0\nu\beta\beta$: 98.23%

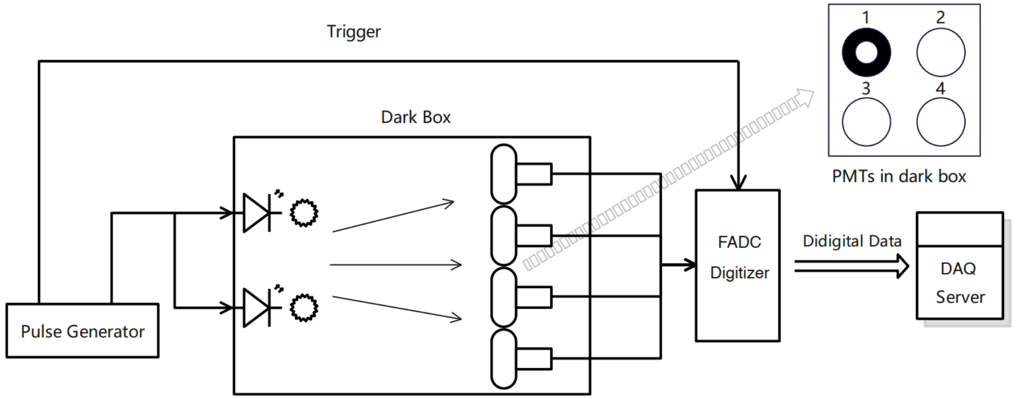
Physical Review C 85, 034316 (2012)

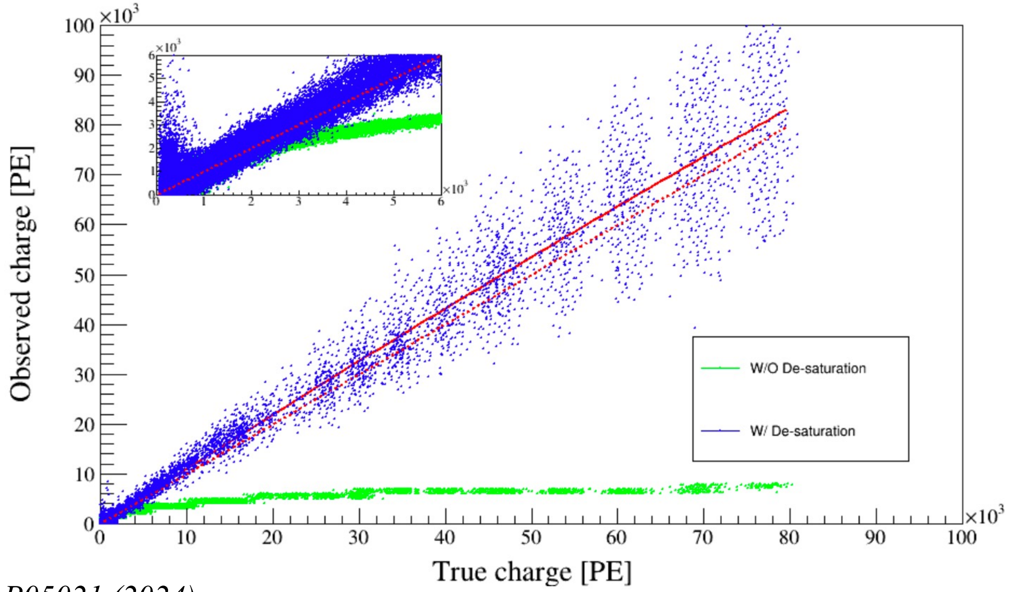
Background model

	Component	Input Counts	Constraint	
Materials	^{60}Co	130	13%	Measured in ^{136}Xe $2\nu\beta\beta$ analysis *Research* 2022 (2022) 9798721
	^{40}K	133	8%	
	^{232}Th	950	5%	
	^{238}U	274	8%	
LXe	^{136}Xe	12372	5%	
	^{212}Pb	1012	29%	Measured by its daughter ^{212}Po alpha decay
	^{85}Kr	296	52%	Determined by β−γ emission through the metastable state ^{85m}Rb
	^{133}Xe	3423	10%	Estimated the β+γ shoulder of ^{133}Xe between 90 and 120 keV
	^{214}Pb	19429	Free	Determined by ^{222}Rn
	^{125}Xe	-	Free	short-lived xenon isotopes induced by neutron calibration
	Other Xe	-	Free	^{127}Xe and ^{129m}Xe

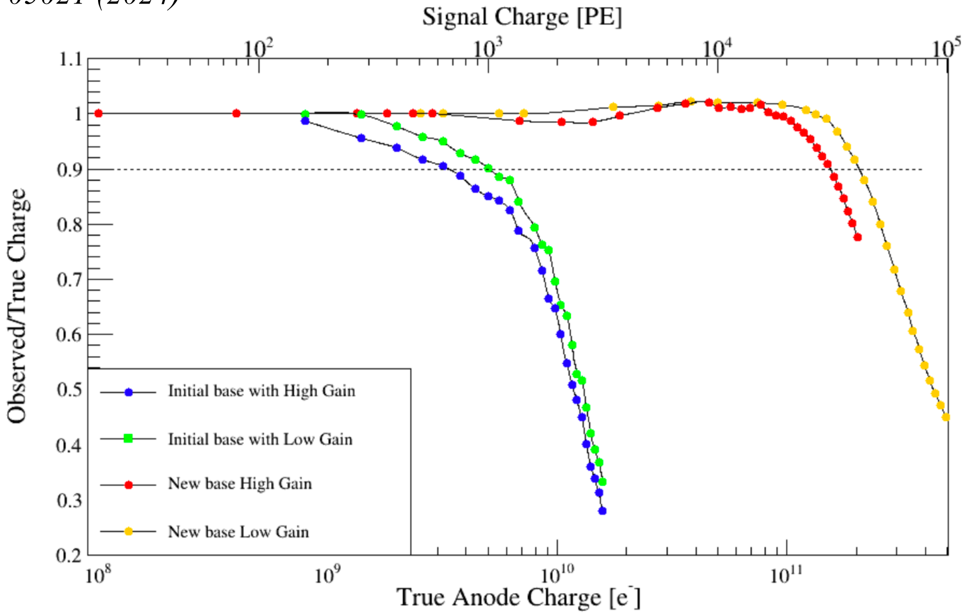
Bench test for saturation and new PMT base design

- PMT waveform saturation is studied by independent bench tests
- Desat

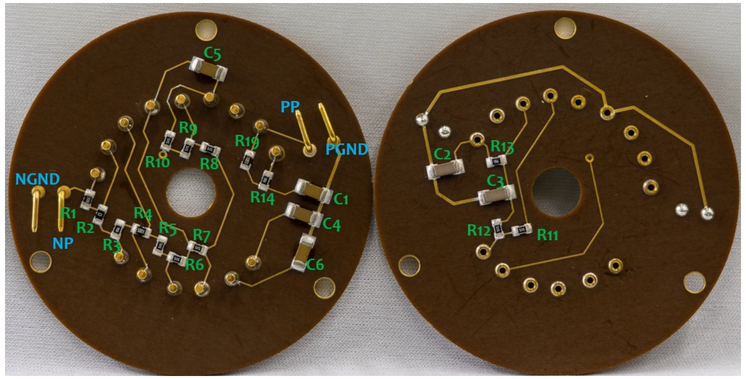




JINST 19 P05021 (2024)



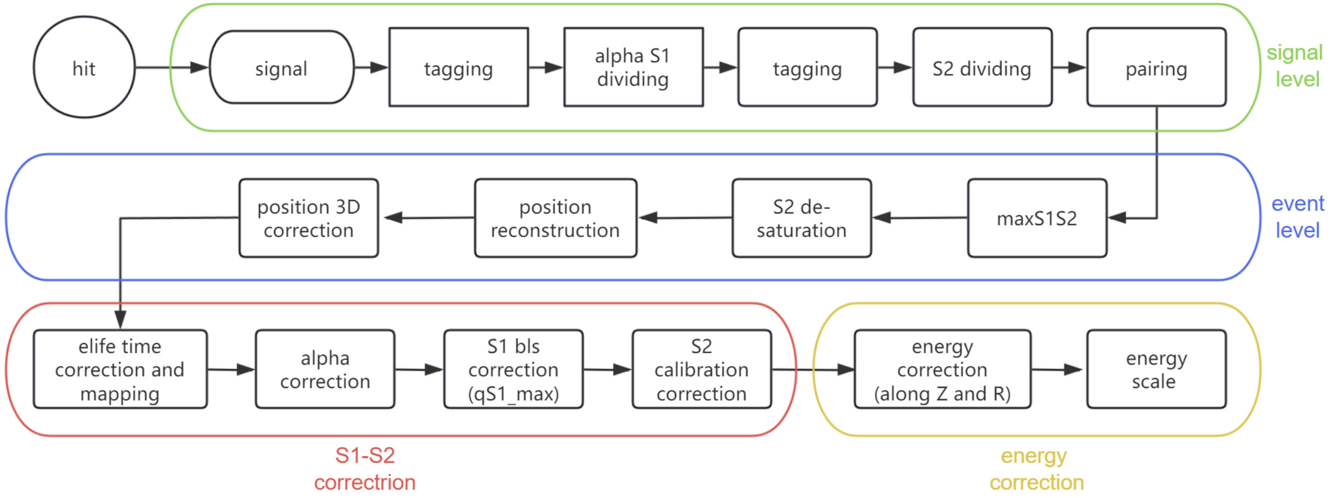
- New PMT base design to increase the dynamic range
- All PMT bases have been changed in Run2



Unified Data Reconstruction Pipeline

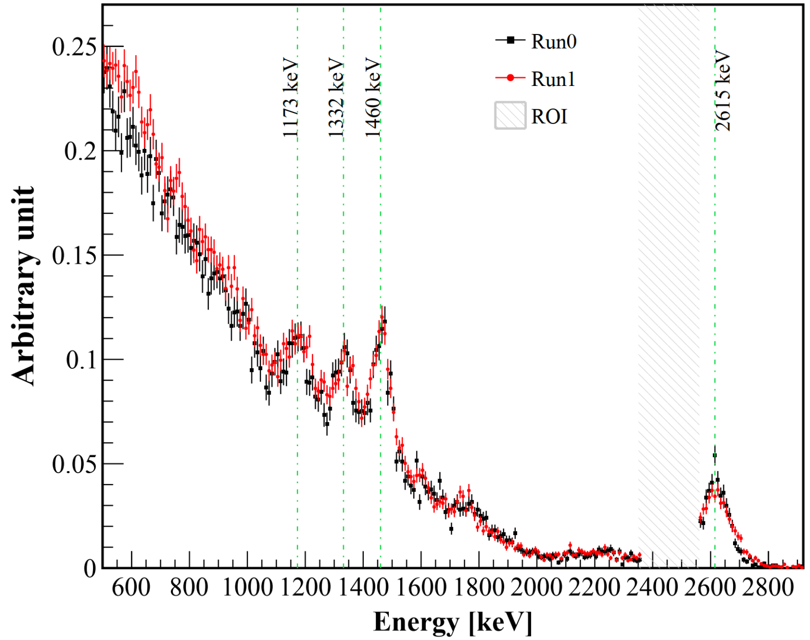
Optimizations in data processing:

- Recovered ~0.5% SS events by an improved time window cut
- S1 waveform slicing to improve alpha events reconstruction
- 3.5 ms dead-time cut before ^{214}Po events to remove isolated ^{214}Bi events: ~1% background reduction and negligible data loss
- And more…



Unified pipeline for Run0 and Run1

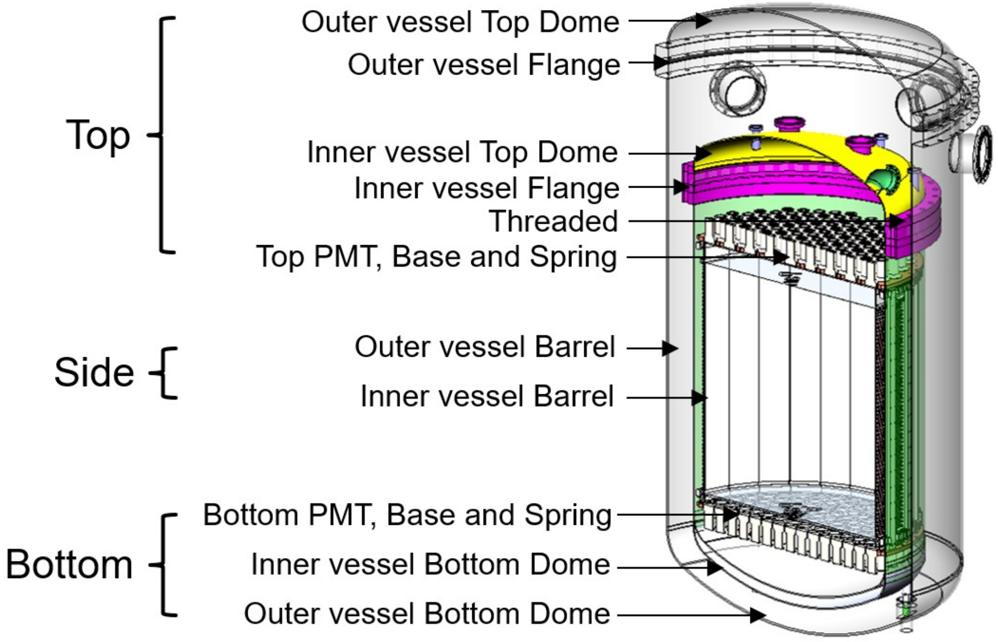
- Reconstructed spectra of Run0 and Run1 are consistent, considering the ^{222}Rn increase in Run1

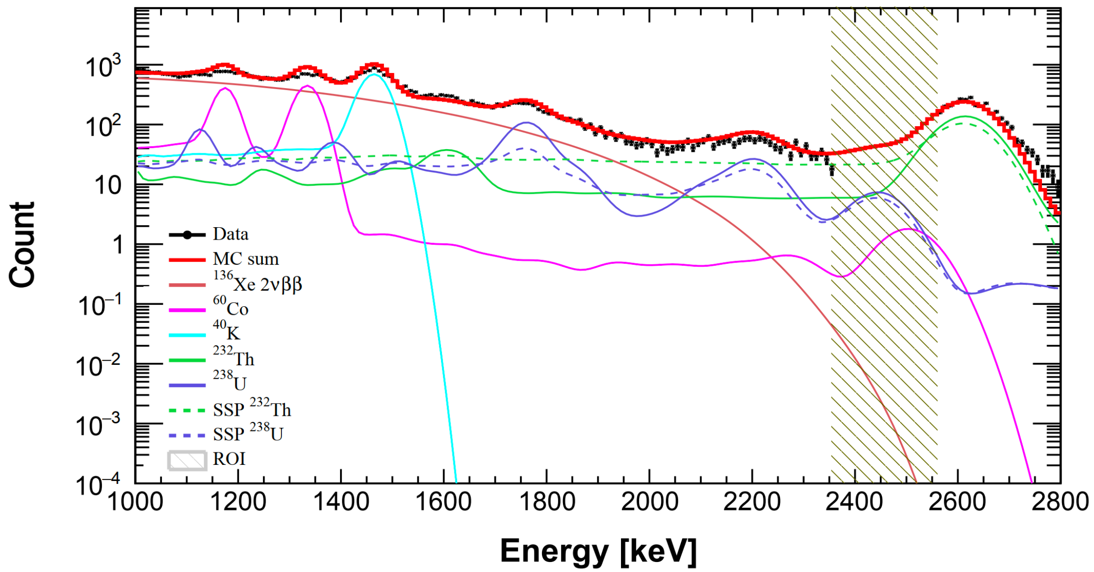


Blind analysis: ROI = [2356, 2560] keV, only SS events used

Background Model

- ^{136}Xe $2\nu\beta\beta$ (from PandaX measured ^{136}Xe half-life)
- Detector material: ^{60}Co, ^{40}K, ^{232}Th, ^{238}U (from HPGe material assay), and grouped into top, side, and bottom parts
- Stainless steel platform (SSP): ^{232}Th, ^{238}U (from MS fitting)





Other background components are checked:

- Residual ^{214}Bi in TPC -> negligible
- Gammas of ^{214}Bi from LXe skin region -> negligible
- 2.5 MeV peak from ^{60}Co cascade gammas -> well modelled

Likelihood and Systematics

- Binned Poisson likelihood with Gaussian penalty terms to constrain nuisance parameters
- Systematics include three categories: energy response, overall efficiency, ^{136}Xe mass
- Background model and systematics are included in likelihood fitting

$$L = \prod_{r}^{N_{run}} \prod_{i}^{N_{region}} \prod_{j}^{N_{bins}} \frac{(N_{rij})^{N_{rij}^{obs}}}{N_{rij}^{obs}!} e^{-N_{rij}}$$
$$\cdot \prod_{r}^{N_{run}} [\mathcal{G}(\mathcal{M}_r; \mathcal{M}_r^0, \Sigma_r^{\mathcal{M}}) \cdot \prod_{k}^{N_{eff}} G(\eta_r^k; 0, \sigma_r^k)]$$
$$\cdot \prod_{b}^{N_{bkg}} G(\eta^b; 0, \sigma^b)$$
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	Quality cut	$(99.89 \pm 0.10)\%$	$(99.97 \pm 0.02)\%$
^{136}Xe mass	^{136}Xe abundance	$(8.58 \pm 0.11)\%$	
	FV mass [kg]	735 ± 3	735 ± 14
Background model		Table. 2	

- ^{136}Xe abundance is measured by RGA with xenon samples from detector
- FV mass uncertainty is estimated from the non-uniformity of ^{83m}Kr calibration data distribution, plus the LXe density fluctuation (pressure fluctuation) during data-taking

Background counts and parameter pulls

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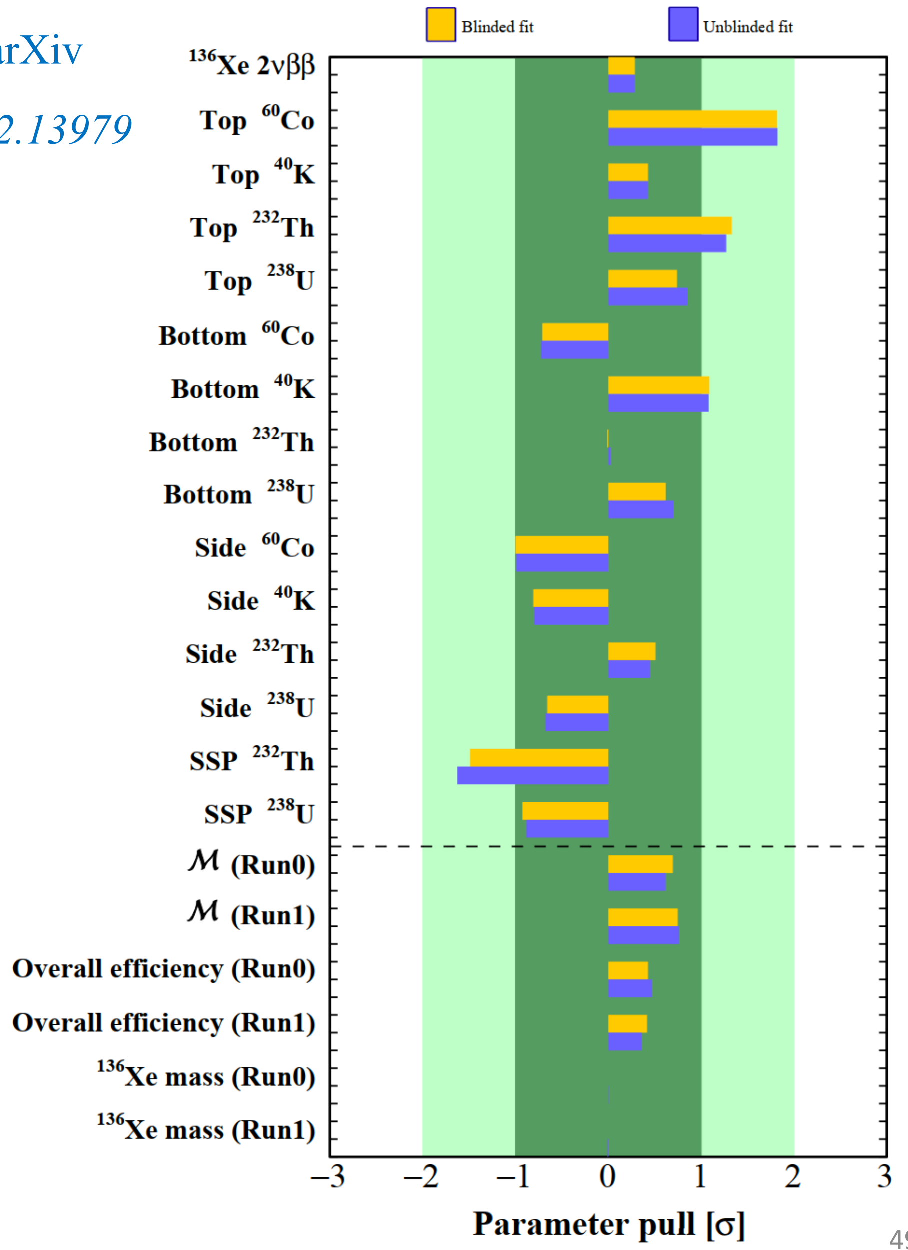
Background counts in the ROI

Background	Model expectation	Blinded fit	Unblinded fit
SSP ^{232}Th	527 ± 45	470 ± 34	458 ± 33
SSP ^{238}U	50 ± 15	38 ± 11	39 ± 11
^{232}Th	375 ± 224	510 ± 34	485 ± 31
^{238}U	78 ± 42	70 ± 9	72 ± 9
^{60}Co	18 ± 7	31 ± 3	31 ± 3
^{136}Xe	0.18 ± 0.01	0.19 ± 0.01	0.19 ± 0.01

paper on arXiv

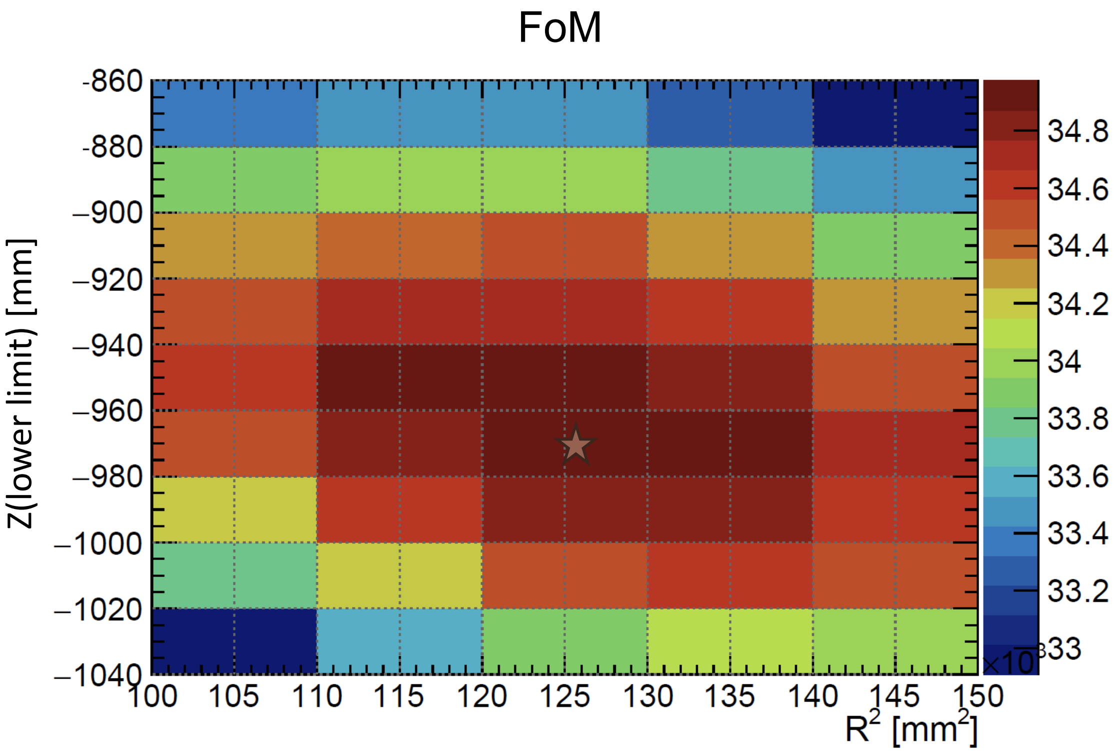
arxiv:2412.13979

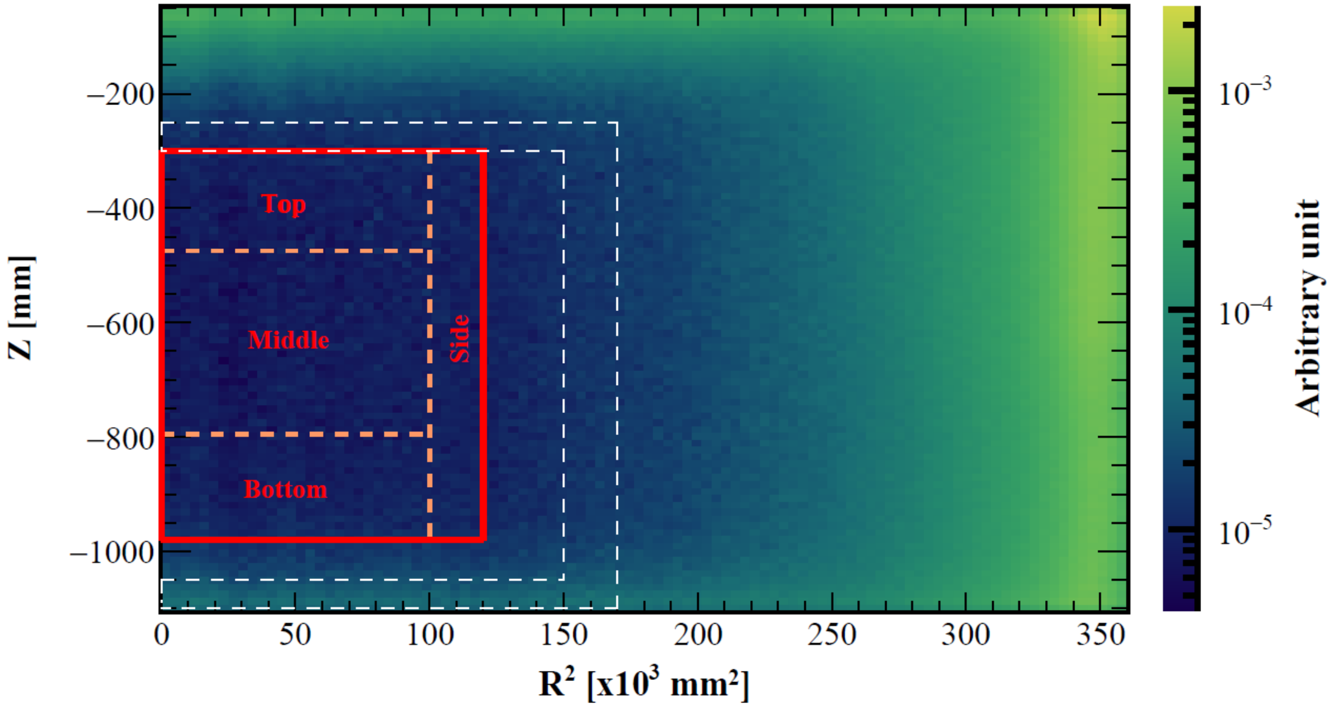


- All pulls of nuisance parameters fall within the ±2σ range
- All best-fit nuisance parameters are consistent between the blinded and unblinded fits
- Pull of top ^{60}Co reaches 1.8σ, indicating that the model expectation from the HPGe material assay might be slightly underestimated

Fiducial Volume (FV)

- FV is optimized by maximizing the FoM $FoM \propto \frac{m}{\sqrt{B}}$
- FV is further divided into four regions to better constrain detector material background from top, side, and bottom parts



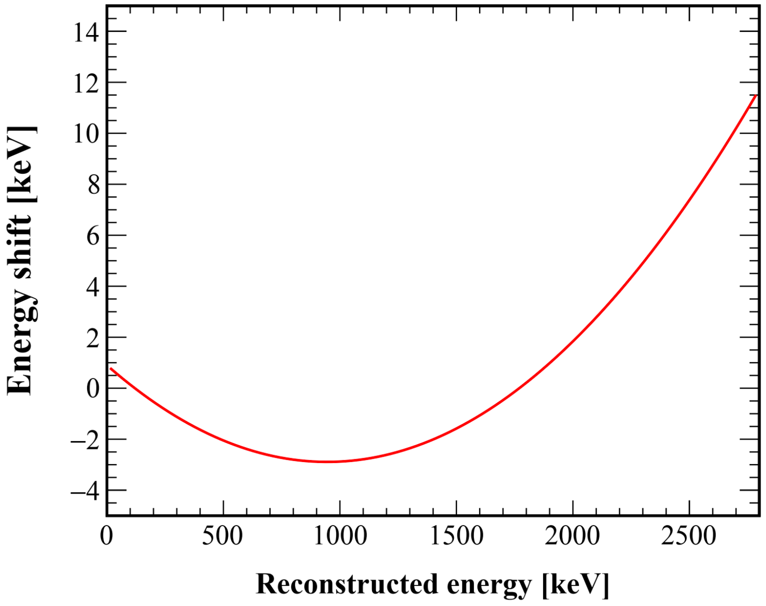


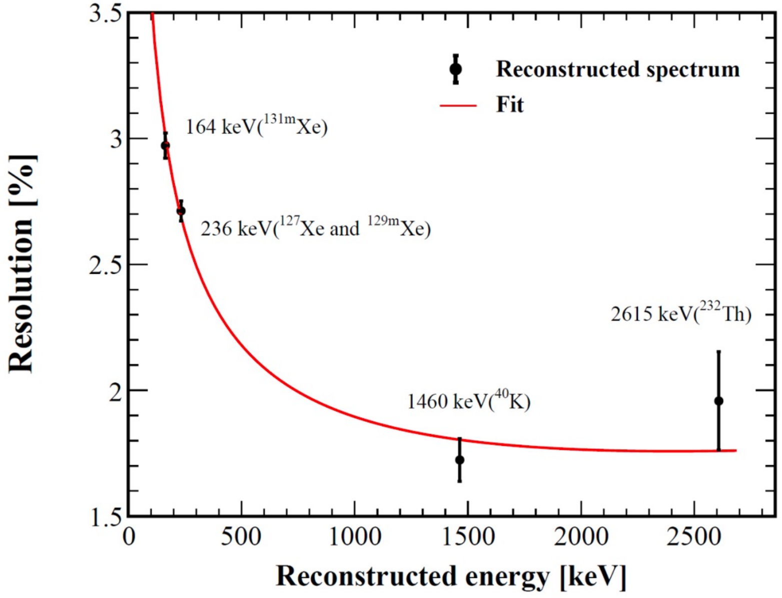
Energy Response Model

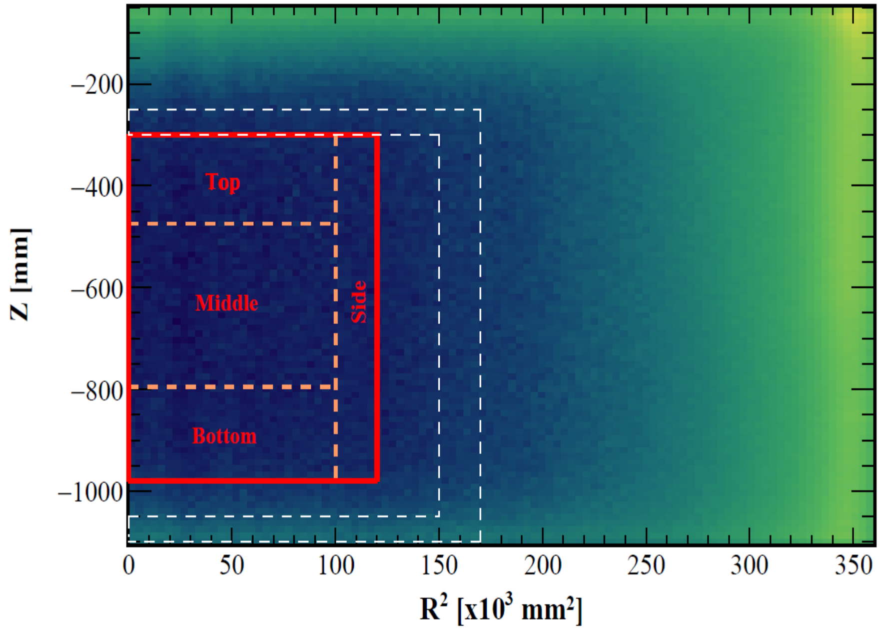
- Residual shift between simulated energy and reconstructed energy
- Energy resolution vs. reconstructed energy
- Response model from physics data in slim regions outside FV
- Model parameters naturally included in the likelihood fitting

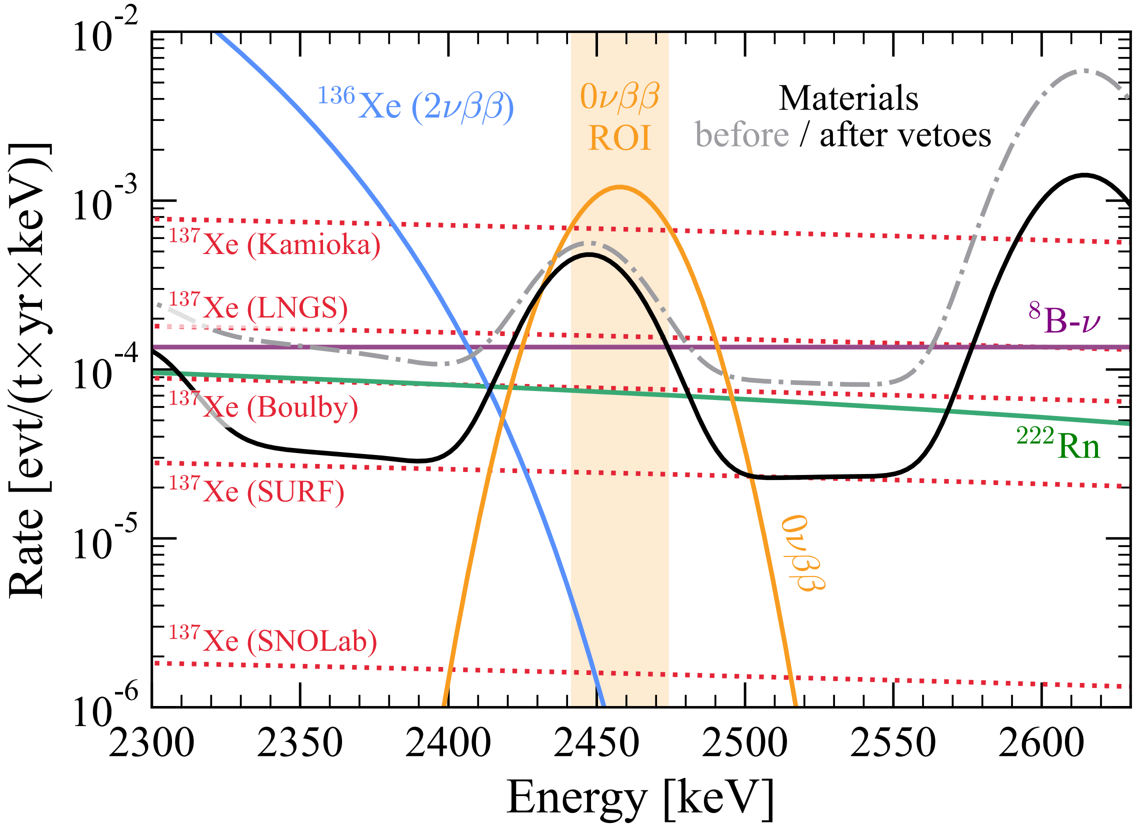
$$E = a \cdot \hat{E}^2 + b \cdot \hat{E} + c.$$

$$\frac{\sigma(E)}{E} = \frac{d}{\sqrt{E}} + e \cdot E + f.$$

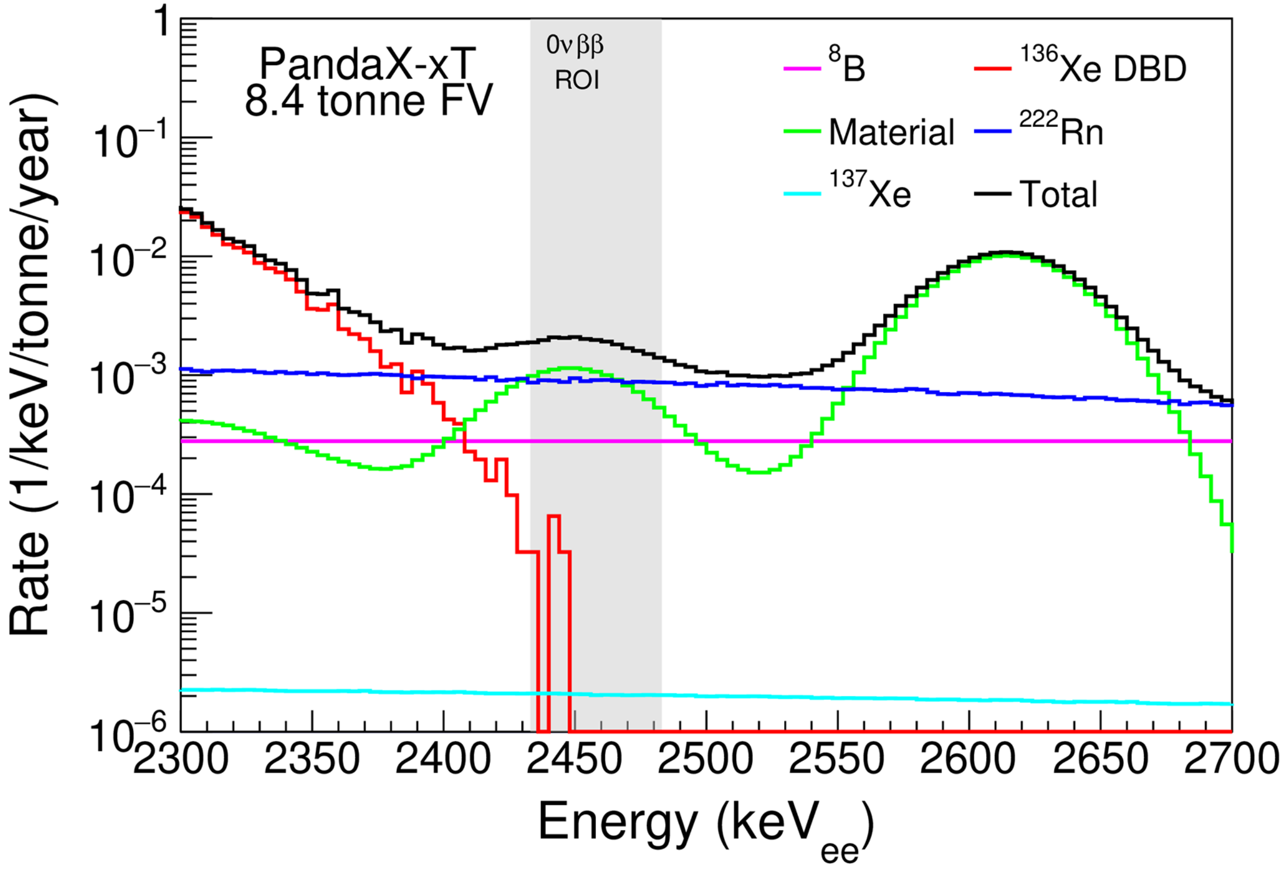








Rate [evt/(t×yr×keV)]
Energy [keV]
136Xe (2νββ)
0νββ
ROI
Materials
before / after vetoes
137Xe (Kamioka)
137Xe (LNGS)
137Xe (Boulby)
137Xe (SURF)
137Xe (SNOLab)
8B-ν
222Rn
0νββ
10-2
10-3
10-4
10-5
10-6
2300
2350
2400
2450
2500
2550
2600



PandaX-xT
8.4 tonne FV
0νββ
ROI
8B
136Xe DBD
Material
222Rn
137Xe
Total
Rate (1/keV/tonne/year)
Energy (keVee)
1
10−1
10−2
10−3
10−4
10−5
10−6
2300
2350
2400
2450
2500
2550
2600
2650
2700