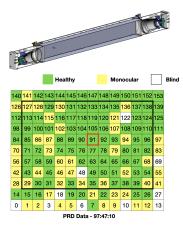# Improving PR⊙SPECT $\bar\nu$ oscillation and spectrum measurements with Single End Event Reconstruction

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presented by Michael P. Mendenhall (LLNL)

APS DNP 2020 (online) — October 30, 2020
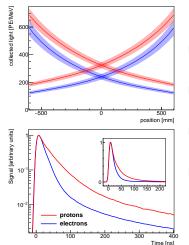Session EG: Reactor and Short Baseline Neutrino Experiments

PROSPECT AD1 dataset: still more to see

- Latest published results excluded 57 out of 154 scintillator segments.

- Leakage of corrosive scintillator into PMT housings damaged voltage dividers, requiring PMT shut-offs.

- 47 of the 57 excluded segments still had a functioning PMT on the other end.

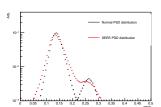- Using Single End Event Reconstruction (SEER) information can substantially improve analysis.

Healthy   Monocular   Blind

140	141	142	143	144	145	146	147	148	149	150	151	152	153
126	127	128	129	130	131	132	133	134	135	136	137	138	139
112	113	114	115	116	117	118	119	120	121	122	123	124	125
98	99	100	101	102	103	104	105	106	107	108	109	110	111
84	85	86	87	88	89	90	91	92	93	94	95	96	97
70	71	72	73	74	75	76	77	78	79	80	81	82	83
56	57	58	59	60	61	62	63	64	65	66	67	68	69
42	43	44	45	46	47	48	49	50	51	52	53	54	55
28	29	30	31	32	33	34	35	36	37	38	39	40	41
14	15	16	17	18	19	20	21	22	23	24	25	26	27
0	1	2	3	4	5	6	7	8	9	10	11	12	13

PRD Data - 97:47:10

Two-ended (normal) reconstruction

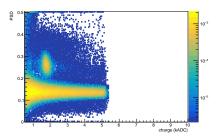(details in https://arxiv.org/abs/2006.11210)

- ▶ Normal event reconstruction uses a pair of waveforms.
- ▶ Relative pulse timing and amplitude indicates position along the cell.
- ▶ Energy is reconstructed from pulse areas corrected for position (light transport).
- ▶ Pulse shape discrimination (PSD) separates light (gamma, positron) from heavy (proton recoil, n+^{6}Li) charged particle interactions
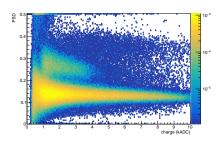
Particle ID with SEER

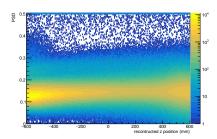PSD distributions for two-ended (black), single-ended (red) signals.

► Significant particle identification ability (neutron capture or proton recoil) still possible with SEER.

► SEER analysis can be tuned and validated by looking at single-PMT signal distributions in double-ended cell events.
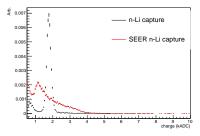

2-ended PSD vs signal

SEER ignoring one PMT

No z position or energy reconstruction

► Without 2-ended differential amplitude/timing data, there is minimal information for reconstructing event position.

► Energy reconstruction is highly position dependent for light collection by one PMT; too crude for useful IBD spectrum shape information.

Weak z-dependence of other observables such as PSD is insufficient for z reconstruction.
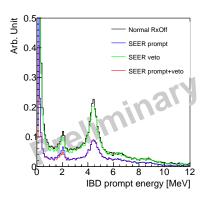

"Energy" reconstruction for a sharp feature in double-ended analysis is very broad in SEER data.

SEER useful for background rejection

IBD event selection cuts:

- Prompt/delayed time coincidence
- Exclude prompt events containing high-PSD cell hits
- Veto around muon (high energy) and neutron interaction (high PSD) events
- Prompt/delayed spacial proximity
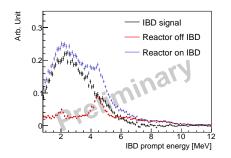- Event position fiducialization

Precise z, E reconstruction is not needed for prompt PSD requirements or neutron backgrounds veto.
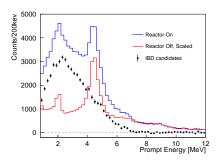

False IBD signal from reactor-off backgrounds. Small improvement from extra veto events; factor of two reduction from better identification of recoil-containing prompt signals.

PRELIMINARY background reduction with SEER

Latest published spectrum:

← with PRELIMINARY SEER analysis, signal to background (0.8–7.2 MeV) ratio improves from 1.4 to 3.3.

Conclusions

- Single-End Event Reconstruction is a highly promising method to improve the statistical reach of existing PROSPECT AD1 data.

- SEER produces a two-fold reduction in correlated background rates, primarily by improved rejection of fast neutron inelastic scatter prompt candidates.

- Use of nearby two-ended cell hits for z estimation in single-ended hits is a potential area for future development.

- Expect to see SEER incorporated into future AD1 re-analysis publications.

- … but do not expect SEER to be needed for future PROSPECT detectors!

Thank You from the PR😊SPECT collaboration.

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(now in appropriately segmented volumes)