



The Ionization-signal-only Analysis and Results in PandaX-4T Experiment

Shuaijie Li Yalong Hydro (CJPL) / SJTU On behalf of the PandaX Collaboration

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Dark matter detection



> The two directions in the next step for LXe experiments are to possible weaker interaction and to light DM



PandaX-4T Time Project Chamber



- Physical events produce S1 (scintillation) and delayed S2 (ionization) signals.
- > TPC uses S1-S2 paired information to reconstruct events.



Detection efficiency of S1 << S2



W. Ma et al. PhysRevLett.130.021802

Best constraint: 3-10 GeV (DM-n)



Shuaijie Li. et al. PhysRevLett.130.261001

Best constraint: 0.04–10 GeV F_{DM}=1 (DM-e)

DM–nucleon Interactions with Migdal effect



Di Huang et al. PhysRevLett.131.191002

Best constraint: 0.03–1 GeV (DM-n)

1.10

РалдаХ

Backgrounds limit the sensitivity





Cathode events features

- > Paired cathode events can be easily selected by S2 quality cuts
- The features of cathode events and cathode S2 from waveform simulation are similar.



contribute to S2-only data when cathode S1 is small

TPMT

Anode

Cathode

Bttm Screer BPMT Edrift

Gate

46mm

10mm 🚽

-5 k\

1185mm

100mm

Paired cathode events



> compare the cathode S2 spectrum with different S1 to predict the S2-only cathode spectrum



The spectrum are flat and stable with different S1

Cathode events estimation by sideband



> simple hypothesis

- sideband S2 only events are only from cathode and physical backgrounds
 - ✓ gate electrode or above gate events can easily be removed

vbelow cathode events have no S2



Propose micro-discharge background



> In run0 data, set3 is a typical MD dataset

> The detector was in unstable state after set3



Unphysical high rate after set3 is the MD backgrounds we proposed

MD events features

- > Usually, the deadtime cut is used to remove the time windows that have an abnormally high event rate caused by large S2. Livetime is the opposite.
- > compare the S2-only signal features of high SE rate runs between deadtime and livetime, they seem similar.



We can use events in deadtime sample the MD backgrounds

Yalong Hydro / Shanghai Jiao Tong University



time to largeS2 [ms]

 10^{5}

 10^{4}

deadtime

100

MD estimation by sideband



May be from the pileup of single electrons
select sideband which S2 is smaller than ROI





 We divided the S2 charge and width into different sideband regions to test the systematic error

Estimation	run0	run1
Result	25.2±3.1	20.5 ± 3.7
Systematic error	10.6%	16.9%

S2-only data fit results

more details see Qing Lin's talk on Monday



- S2only background-only hypothesis p-value = 0.003 (~2.6 σ);
- best-fit B8 neutrino flux of 1.8+-0.8 theoretical prediction.

Summary



- > With low-energy detection mode, the best constraints of light DM interactions were built. (run0 data)
 - DM-n: 0.03–1 GeV (with Migdal effect)
 - DM-n: 3-10 GeV
 - DM-e: 0.04–10 GeV F_{DM}=1; 0.1 to 10 GeV/c² F_{DM}=1/q²
- > Use sideband methods to estimate the contributions of cathode and micro-discharge backgrounds in run0 and run1.
- The relevant physical analysis in low-energy region including DM and boron-8 neutrino is ongoing...

