Drift Field Effects on Prompt Scintillation in the DarkSide-10 Liquid Argon TPC

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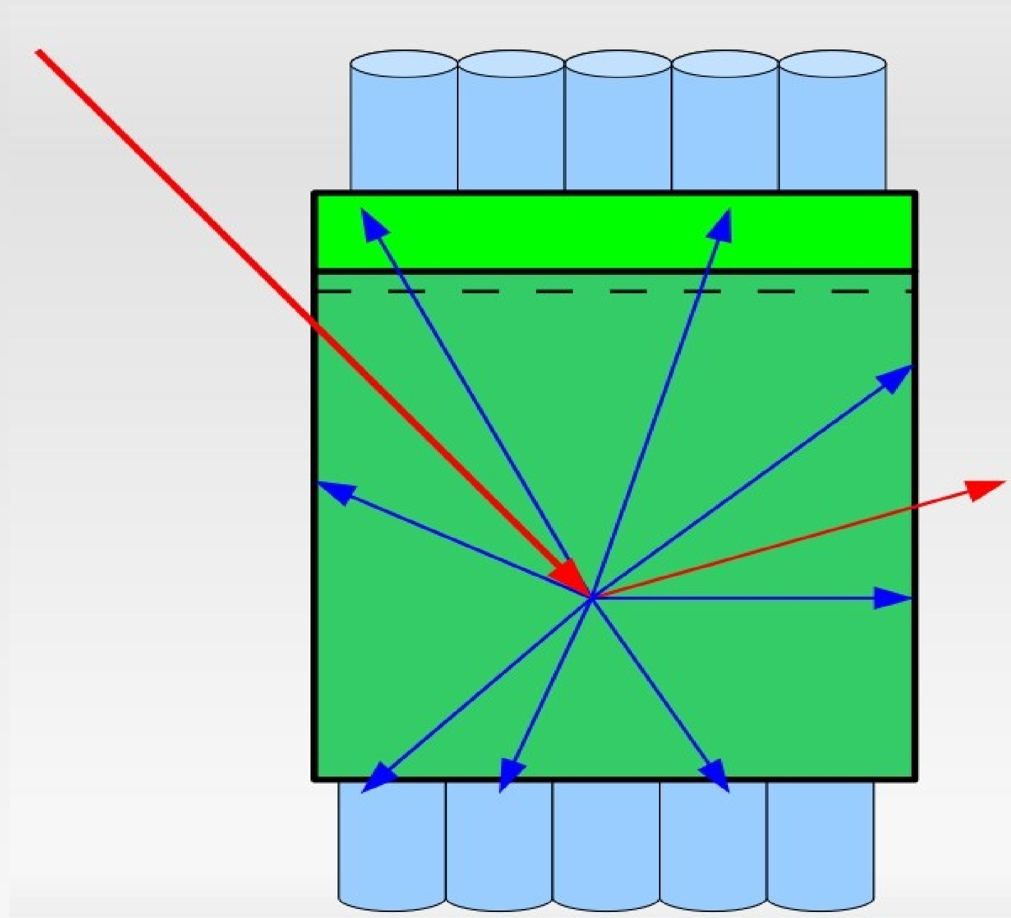
LAr Scintillation

- Incident particles scatter off Argon atom
- Interactions can either form an excited Ar atom, or ionize the Ar atom
- For ionization:

$$Ar^+ + Ar \rightarrow Ar_2^+ r$$
$$e^-_{hot} + collisions \rightarrow e^-_{th}$$
$$Ar_2^+ + e^-_{th} \rightarrow Ar^{**} + Ar$$
$$Ar^{**} \rightarrow Ar^* + heat\ (non\ radiative\ transition)$$
$$Ar^* + Ar \rightarrow Ar_2^*$$
$$Ar_2^* \rightarrow Ar + Ar + h\nu\ (UV)$$

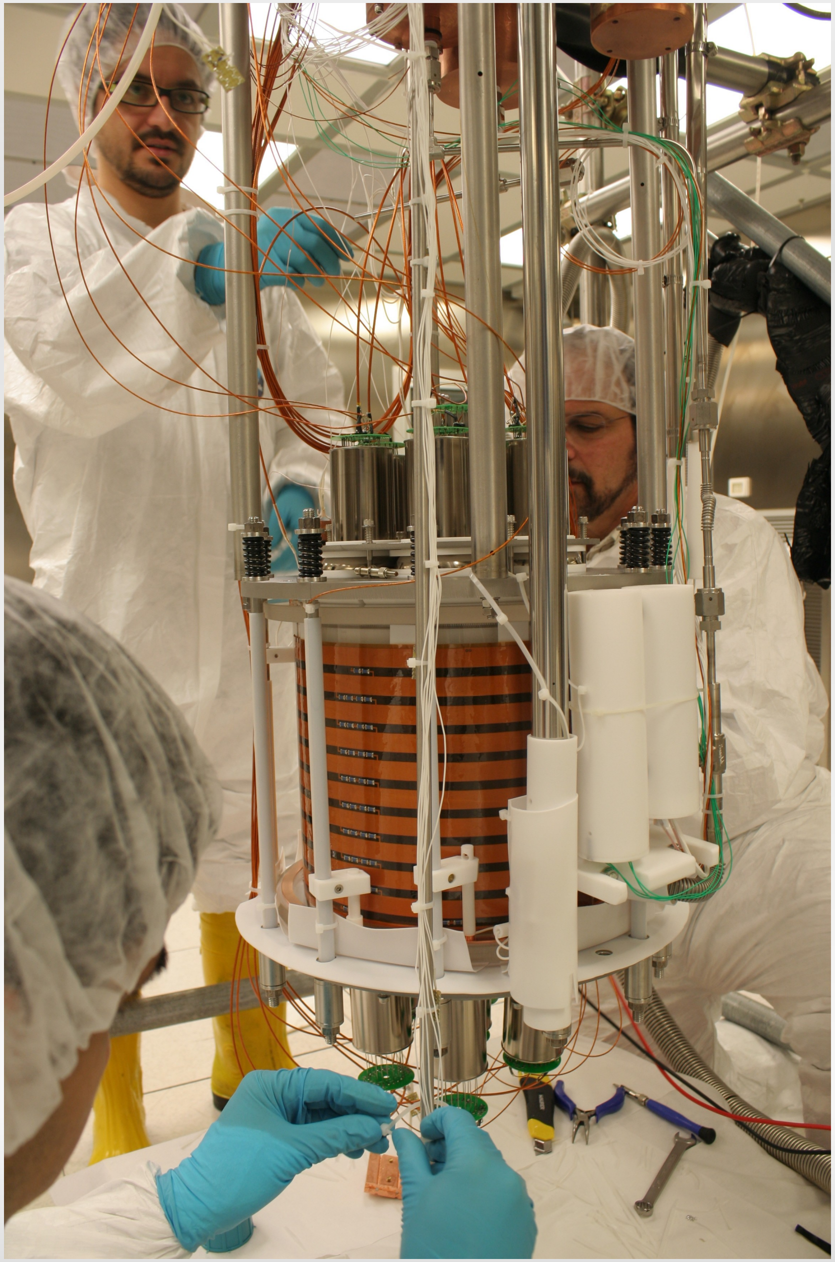
- For excitation:

$$Ar^* + Ar \rightarrow Ar_2^*$$
$$Ar_2^* \rightarrow Ar + Ar + h\nu\ (UV)$$



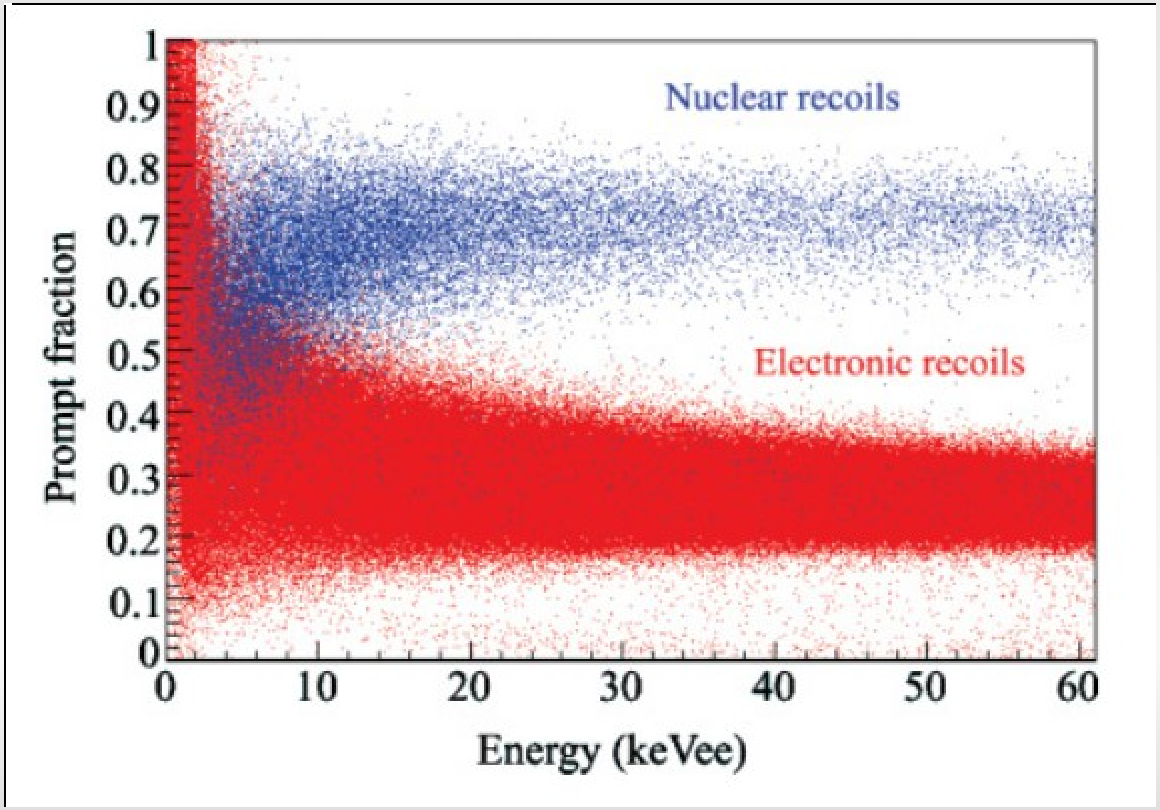
DARKSIDE-10 Run 3

- July 2011 – November 2011
- DARKSIDE-10
  - 10 kg active Lar volume
  - Depleted LAr
- Calibrated with 22Na, 57Co, and 137Cs sources
- Runs analyzed in this talk were background runs with applied drift field
- Limited to drift fields of 500 V/cm and lower
- Run underground at Gran Sasso National Laboratory
- Water shield enclosed the detector, so the primary source of backgound events are beta decay of the 39Ar
- Presented runs were run without a gas pocket or extraction field, so no S2 signals were measured

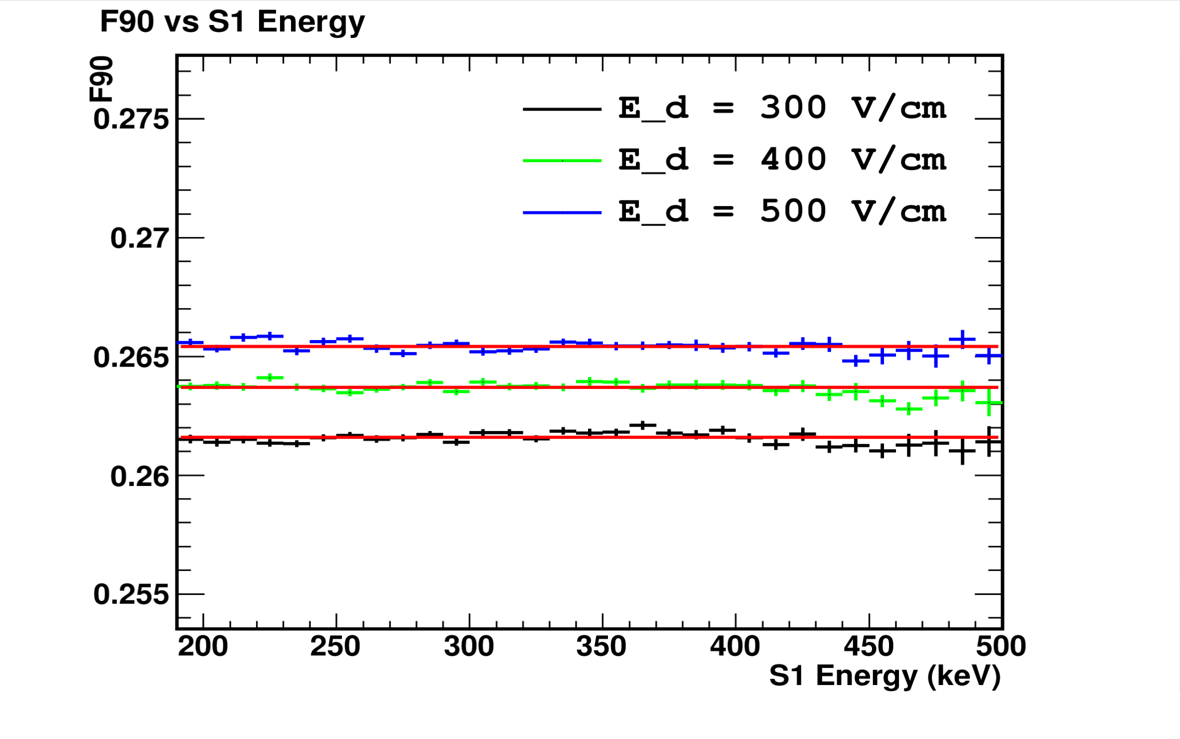


Discrimination

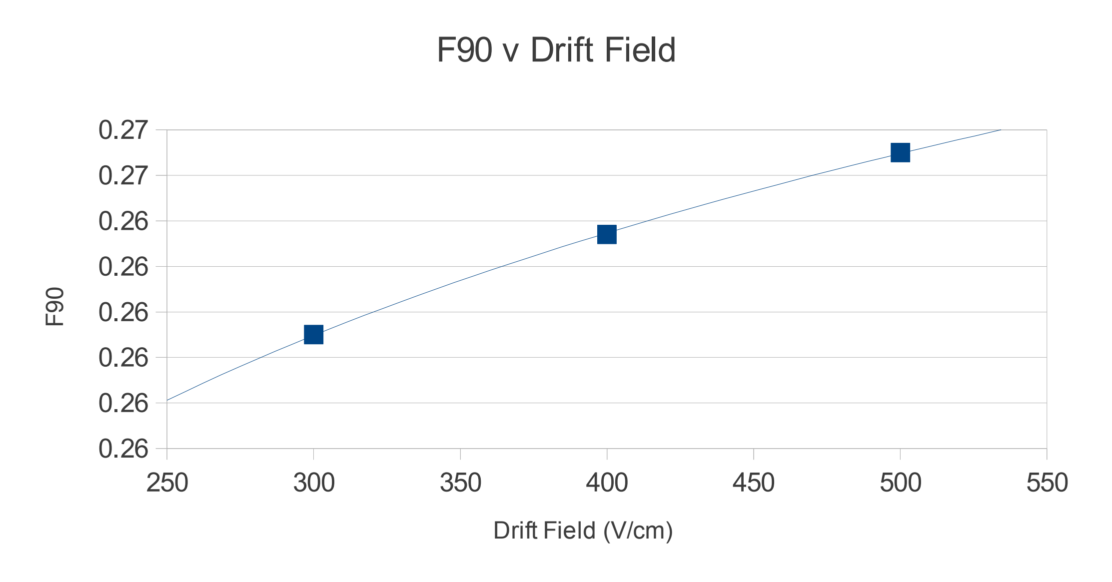
- The Ar can be excited into into either the first singlet molecular state 1 Σ+ or the triplet state 3 Σ+. Both release scintillation when decaying to the ground state
- The singlet state has a lifetime ~7 ns, while the triplet state has a lifetime ~1.5 μs
- While the lifetime of the excited states are not dependent on the LET of the incident particle, the measured scintillation intensities are
- This allows us to define a useful discrimination parameter, F90
- F90 is the fraction of light that arrives in the first 90 ns of the pulse



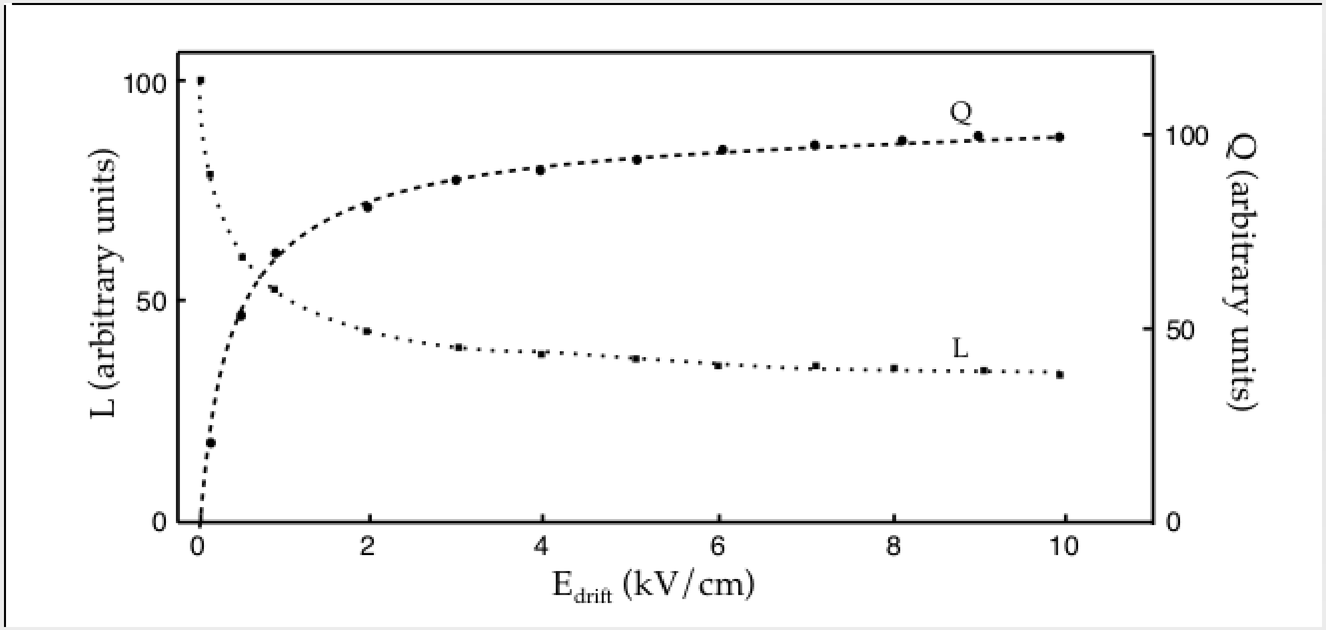
Results



E_d (V/cm)	F90
300	.2616
400	.2637
500	.2655



Results



- One factor in the change in F90 comes from the effect of the drift field on the ionized electrons
- As the field increases, more electrons are drifted towards the anode and escape recombination, reducing the total scintillation
- If one assumes only the ionization scintillation is affected by the field, this effect alone is not enough to account for the change in F90
- Other possibilities: reduced quenching of the singlet state as field increases, change in singlet and triplet state yields as the field increases

Conclusions

- F90 can be used as a discrimination parameter in liquid Ar TPCs
- Currently capable of producing field up to 1 kV/cm
- Extraction field available to measure electrons escaping recombination
- Similar studies on neutron and alpha source runs