Xenon Doping in LAr

High-E WG meeting

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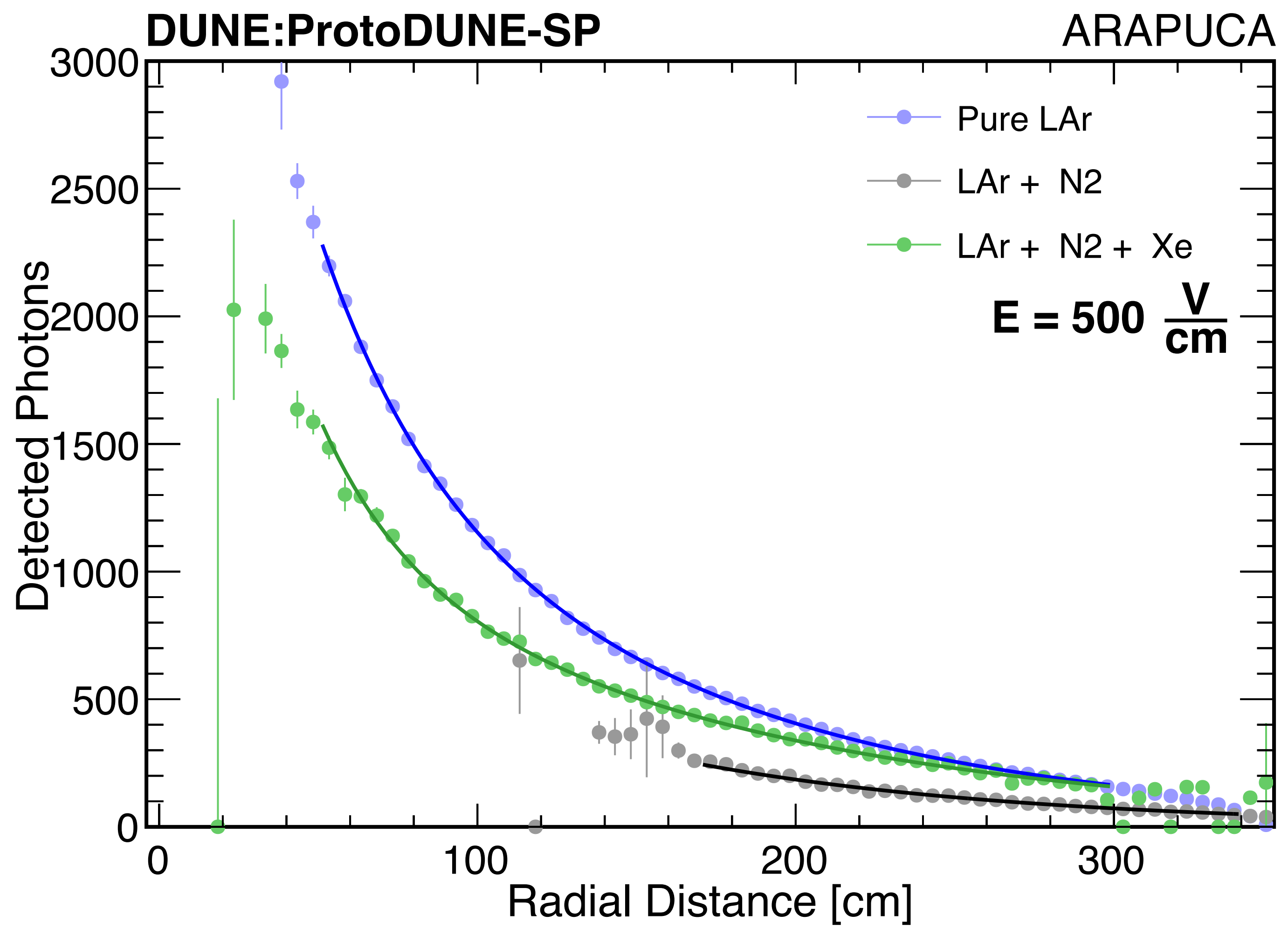
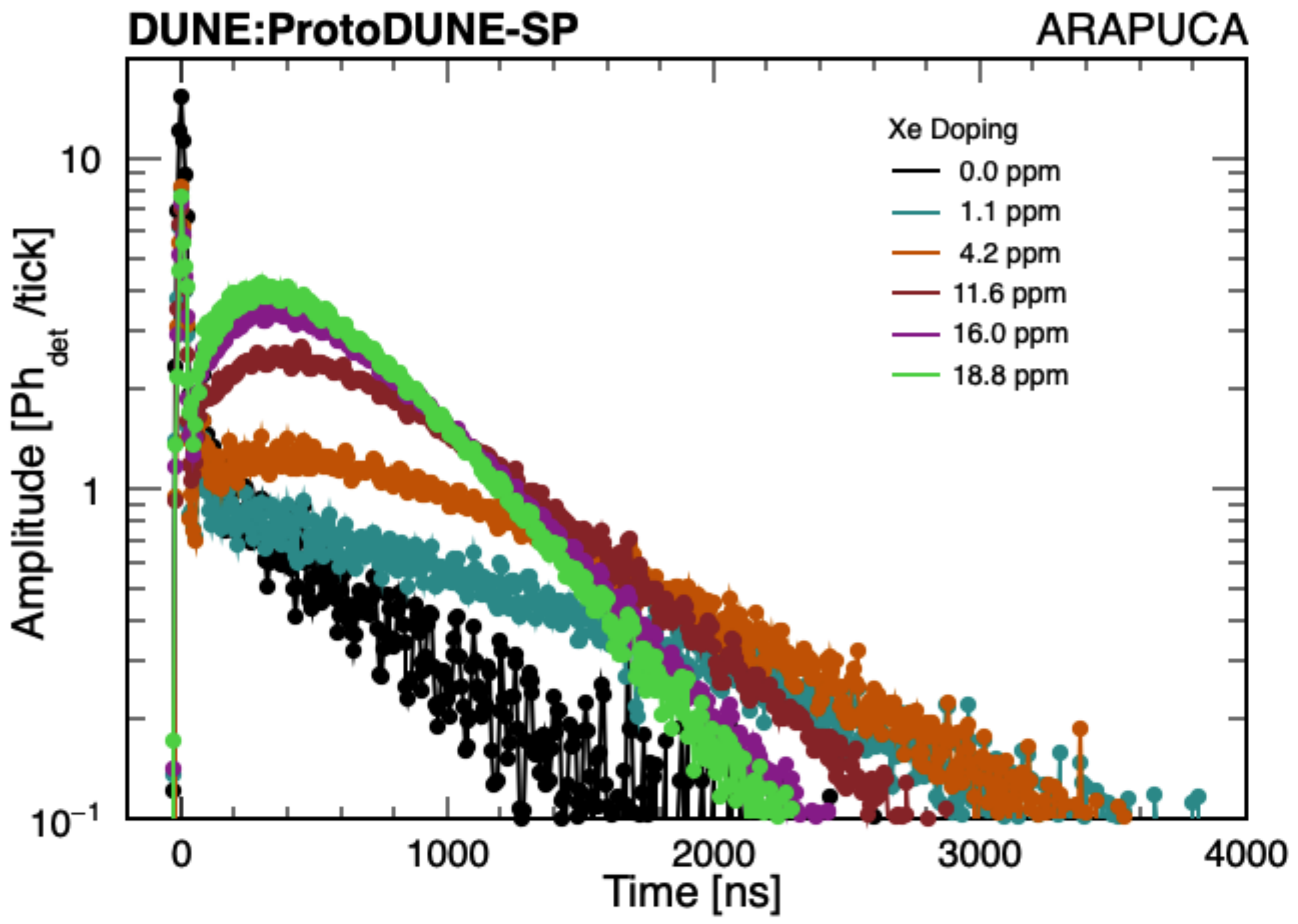
Summary

- Xenon doping in LArTPCs has been a known idea for some time
- It provides a number of positive effects that make it an attractive option
  - Altered time structure
  - Decreased Rayleigh scattering producing more uniform light signals
  - Shift from 128 nm to 175 nm scintillation wavelength - moderate collection improvement
  - Alleviation of contaminants

Summary

- Xenon doping has occurred in ProtoDUNE-SP
  - Studies are underway
    - Light yield and collection
    - Light yield recovery from Nitrogen contamination
    - Rayleigh Scattering length measurement
    - Effects on TPC performance
  - Preliminary results show promise in all of these fields
  - See this talk from the collaboration meeting





The idea

- From DUNE TDR:
  - “For nucleon decays into charged kaons, the possibility of using the time difference between the kaon scintillation signal and the scintillation signal from the muon from the kaon decay has been investigated. In the Super–Kamiokande analysis of p → K+ν, the corresponding timing difference (between the de-excitation photons from the oxygen nucleus and the muon from kaon decay) was found to be an effective way to reduce backgrounds [4]. **Studies indicate that measuring time differences on the scale of the kaon lifetime (12ns) is difficult in DUNE, independent of photon detector acceptance and timing resolution, due to both the scintillation process in argon – consisting of fast (ns-scale) and slow (μs-scale) components – and Rayleigh scattering over long distances.**”
- We do not expect the timing change to be fast enough to resolve the kaon decay
- Might be hardware limited. Current design has PDS readout at “<16ns”/tick.

The idea

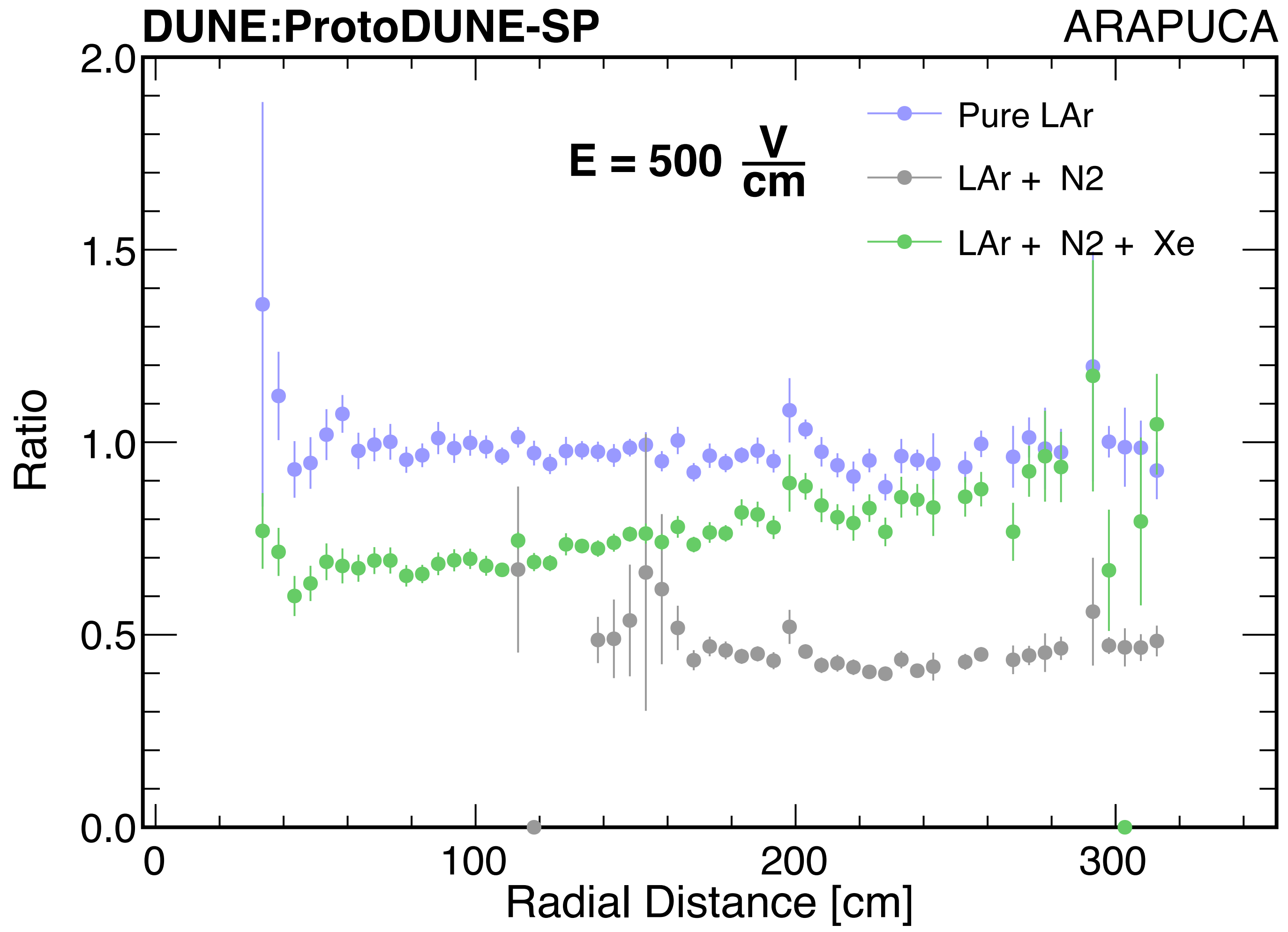
- The increase in light detection efficiency and uniformity should also increase PDS calorimetry abilities.
  - With this, we expect t0 resolution to be improved throughout the detector particularly near the cathode, possibly contributing to looser fiducial cuts
  - Might improve energy resolution for events near the cathode
- Xenon-doping may be desirable or necessary for other reasons
  - Can this have a negative impact on the PDK analysis?
  - Even “No major impact” is a valuable result

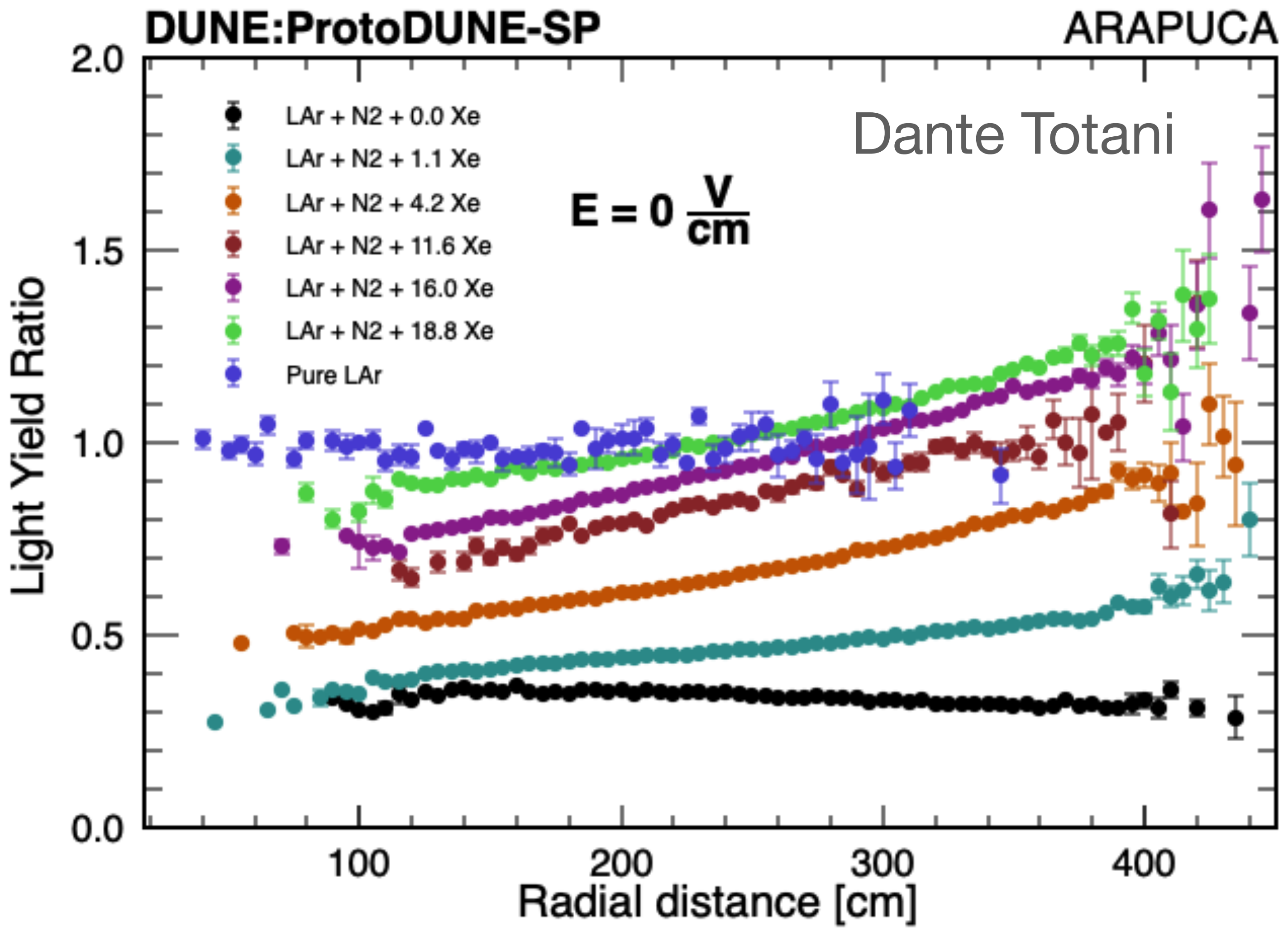
The questions

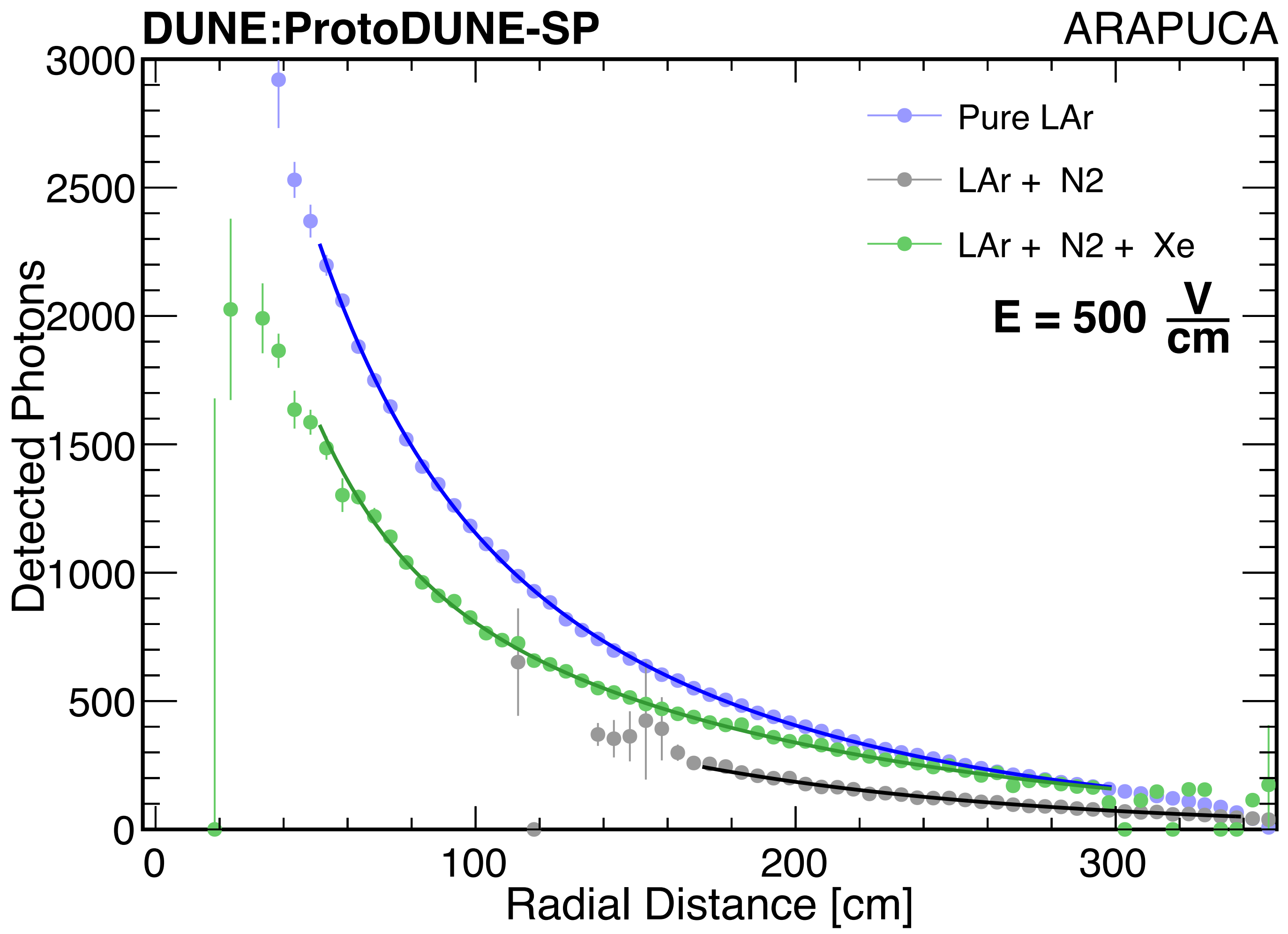
- What impact does the addition of xenon have on signal selection and background rejection cuts in the p->K nu analysis?
- Where do we start?
    - How can we explore fiducial volume cuts?
    - How can we explore event selection cuts?
    - What are the impacts on efficiency and purity?

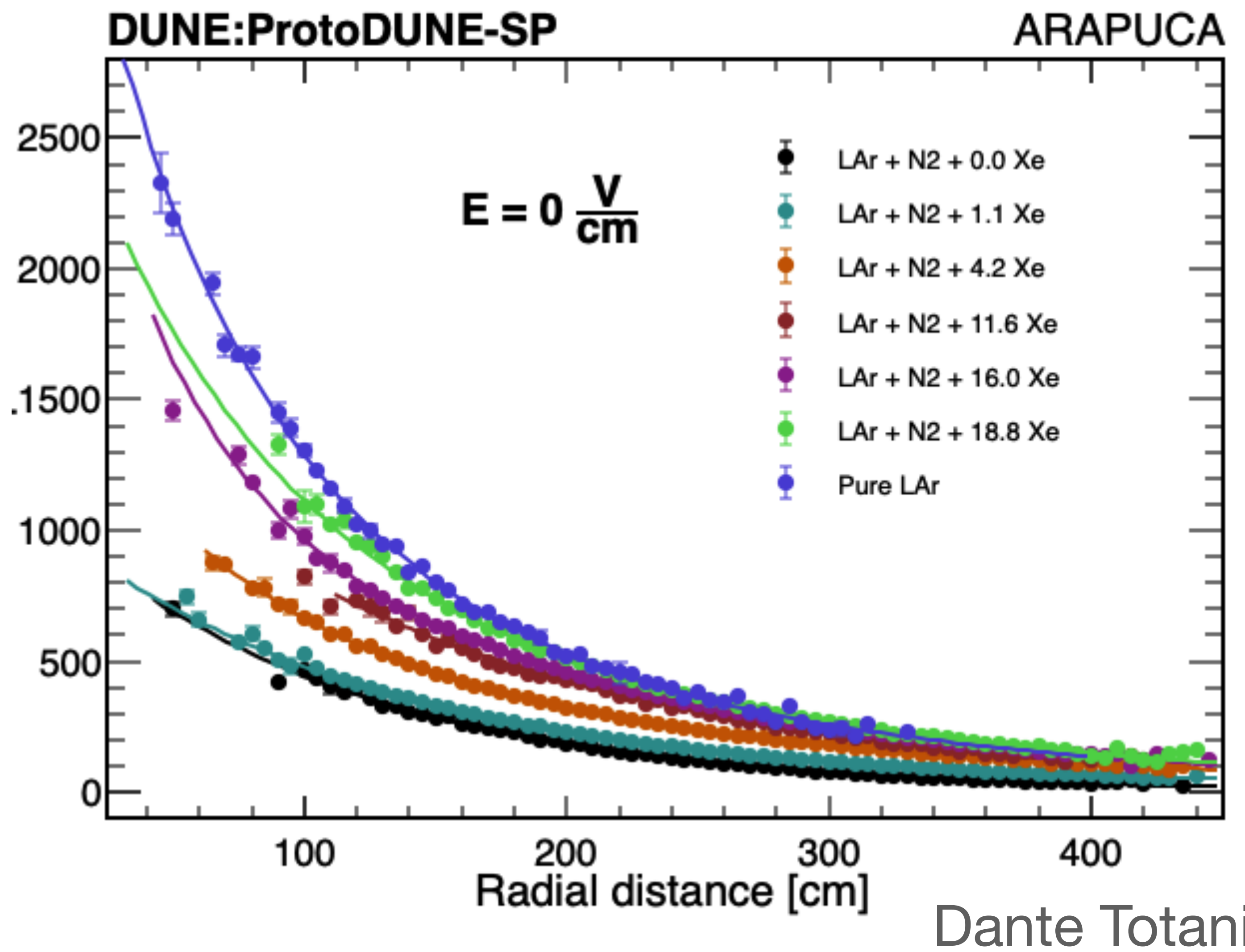
Major results

- Light yield increases with Xenon concentration with and without the field on
- Evidence of increased yield at long distances also seen
- In line with expectations form simulation/theory









Dante Totani

Major results

- Also of interest is the scintillation time structure, which is being studied
- Some studies exist here