

Liquid Scintillator Time Projection Chamber Concept

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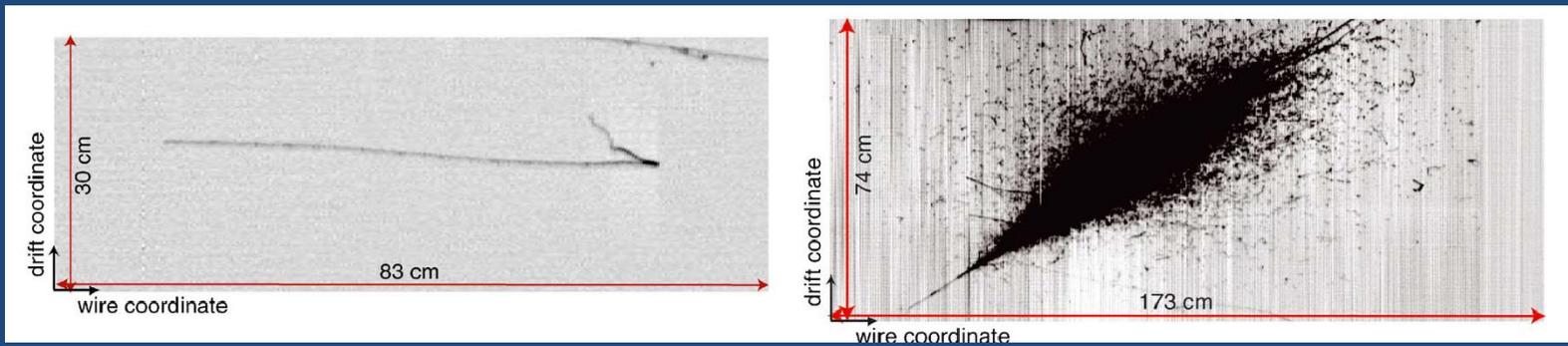
IoP Liverpool 2013

Contents

- Motivation – Neutrino physics
- Results
- Future measurement programme
- Conclusion

Motivation

- Future neutrino detectors:
 - Large volume / target mass
 - Good energy resolution
 - Tracking capability
- Liquid Argon time projection chamber (TPC) fits these criteria well.



S. Amerio et al. (2004)

A room temperature Liquid Scintillator TPC

History

- Free electrons in room temperature liquids first observed in late 60s
 - Neopentane, Tetramethylsilane
 - Chemicals toxic and dangerous to work with

J. Engler & H. Keim (1983)

I. Adamczewski & J. H. Calder (1976)

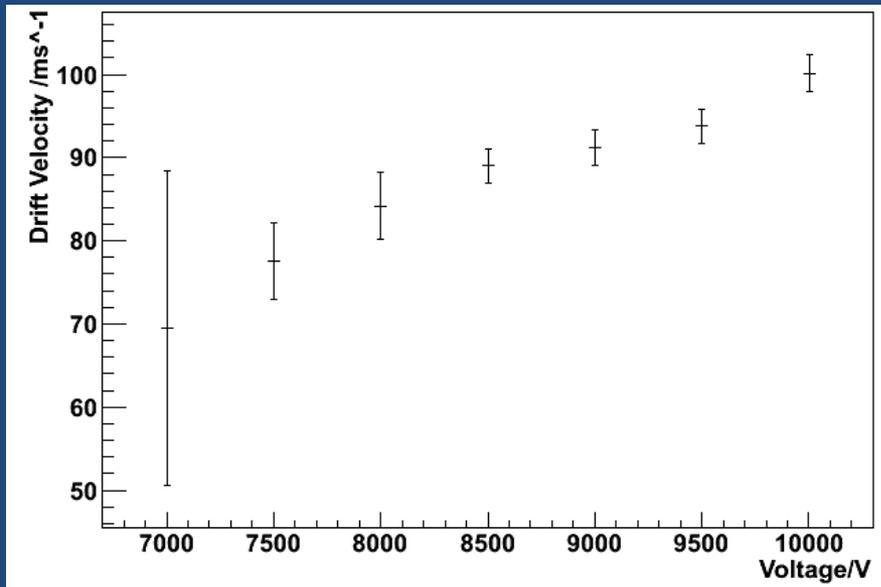
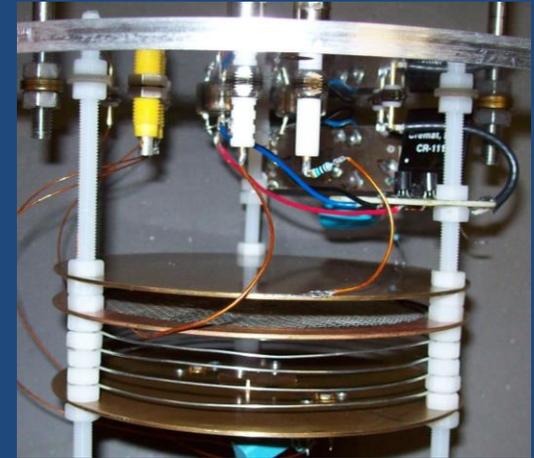
- Organic Liquid Scintillators
 - “Safe” solvents developed over past 20 years
 - Optical properties well known
 - Charge transport (until now) unknown

Benefits of a LScint TPC

- Fine grained tracking across whole volume
- Comparative simplicity of infrastructure to LAr
- Existing expertise in purification to high level
- Potential:
 - Large volume detectors for long baseline ν physics
 - Isotope loading for use in $\beta\beta$ experiments

Initial Results

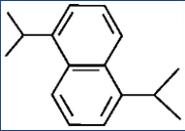
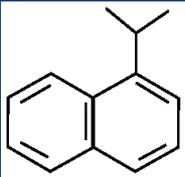
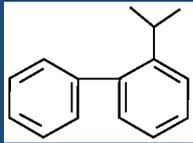
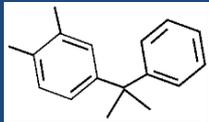
- 2.5 litre gridded ionisation chamber
- Am241 alpha source at cathode
- Drift distance of 22mm



- Initial drift speed measurements

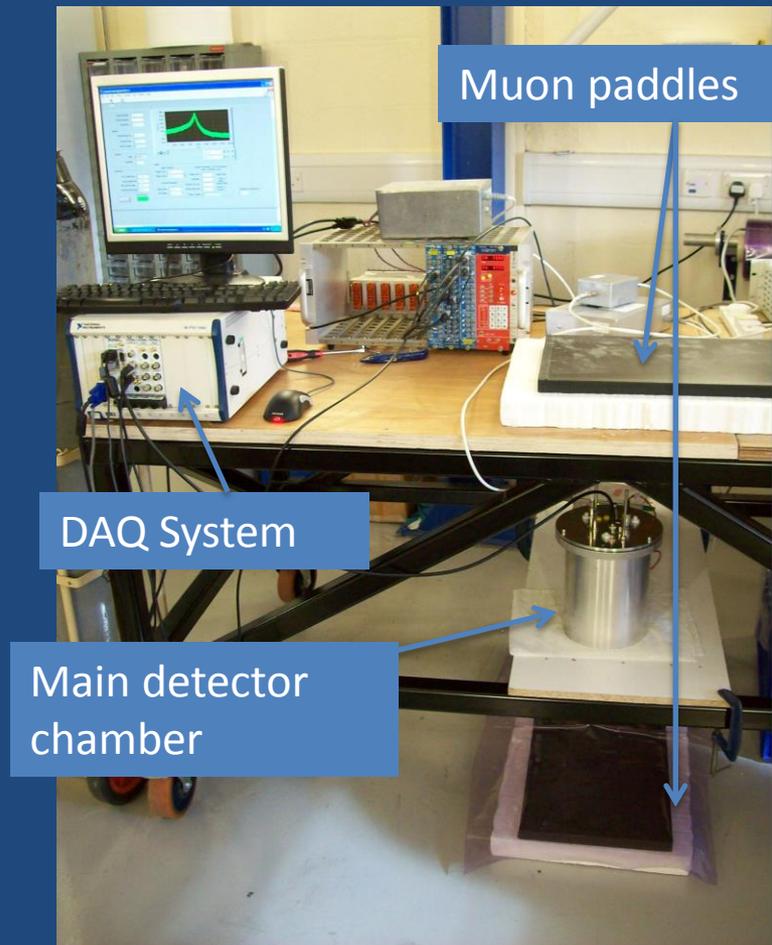
arXiv:1205.5695 [physics.ins-det]

Initial Results summary

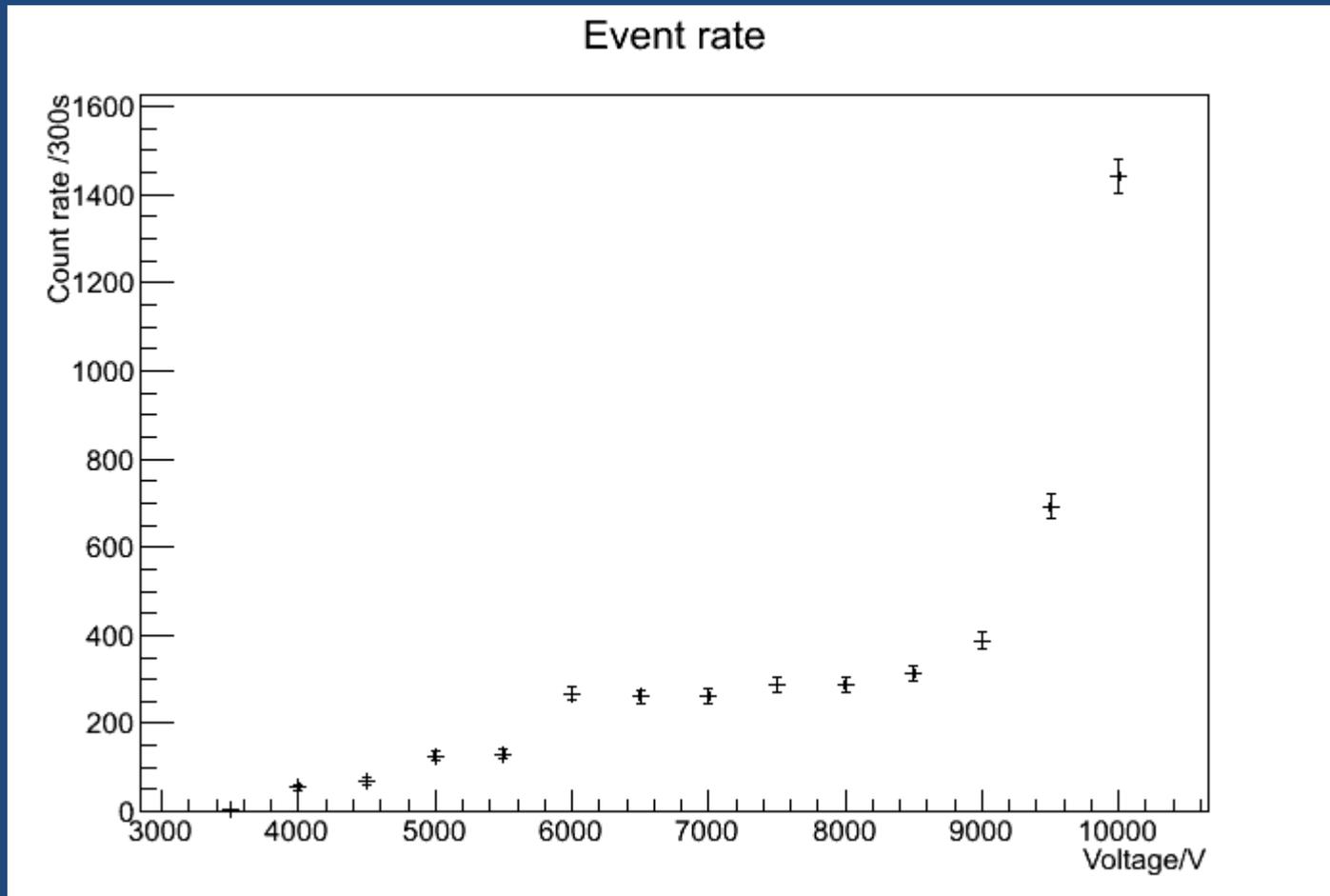
Chemical	Molecule Shape	Drift speed at 7kVcm ⁻¹
Di isopropyl naphthalene (DIN)		101±2ms ⁻¹
Mono isopropyl naphthalene (MIPN)		143±9ms ⁻¹
Mono isopropyl biphenyl (MIBP)		156±6ms ⁻¹
Phenyl xylyl ethane (PXE)		---
Linear alkyl benzene (LAB)		---

Detector Overview

- Multiwire proportional counter (MWPC)
 - Wire diameter: $50\mu\text{m}$
 - Wire pitch: 5mm
 - Distance to cathode: 10mm
 - All wires connected to single readout channel
- Bi210 beta source mounted above cathode



Latest Results – MWPC in DIN



Future Work

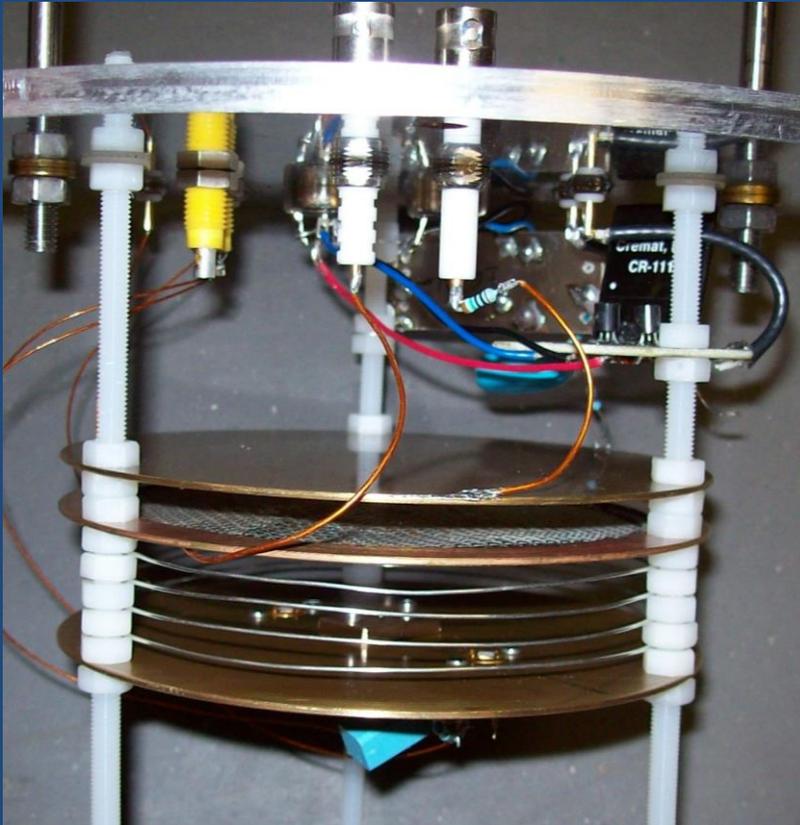
- Forthcoming results from current experimental setup:
 - Refined drift speed measurement
 - Energy spectrum
- Extension of MWPC to larger detector
 - Measurement of mean free path
- Alpha quenching factor
- Particle tracking:
 - Use as a Time Projection Chamber!

Conclusions

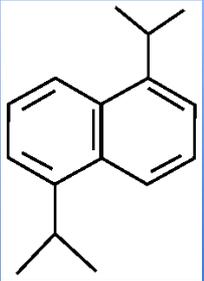
- Charge transport possible in room temperature liquid scintillators
- Further work to fully characterise transport properties
- Results will determine feasibility of a room temperature Liquid Scintillator TPC

Backup slides

Detector Overview



- 2.5 litre gridded ionisation chamber
- Am241 alpha source at cathode
- Drift distance currently 22mm

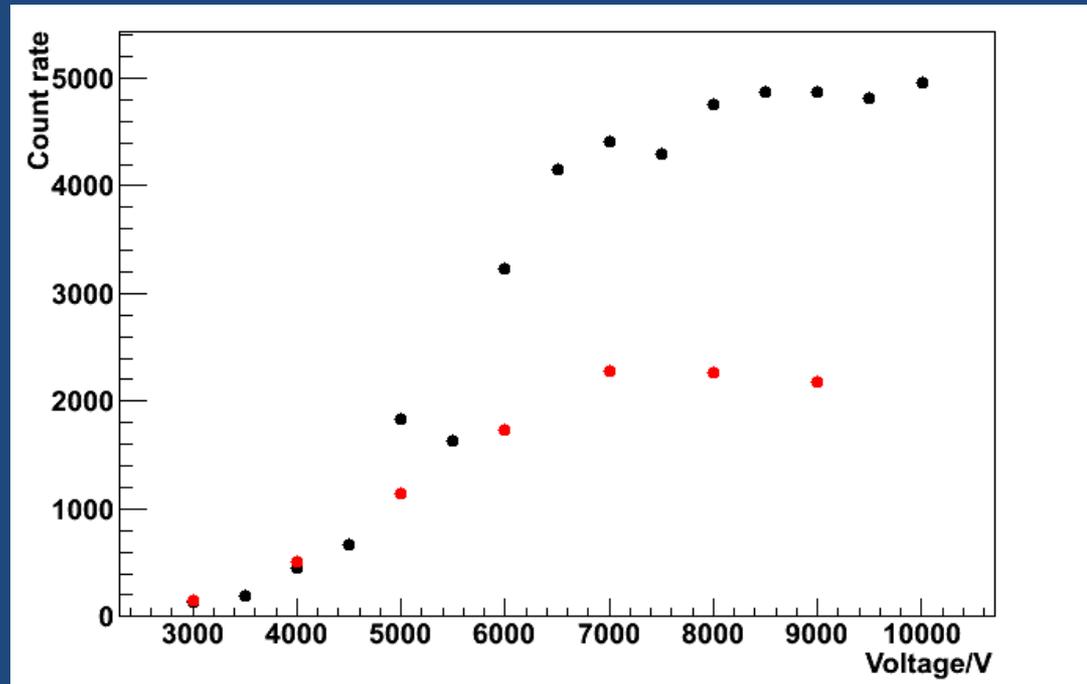


Di isopropyl naphthalene

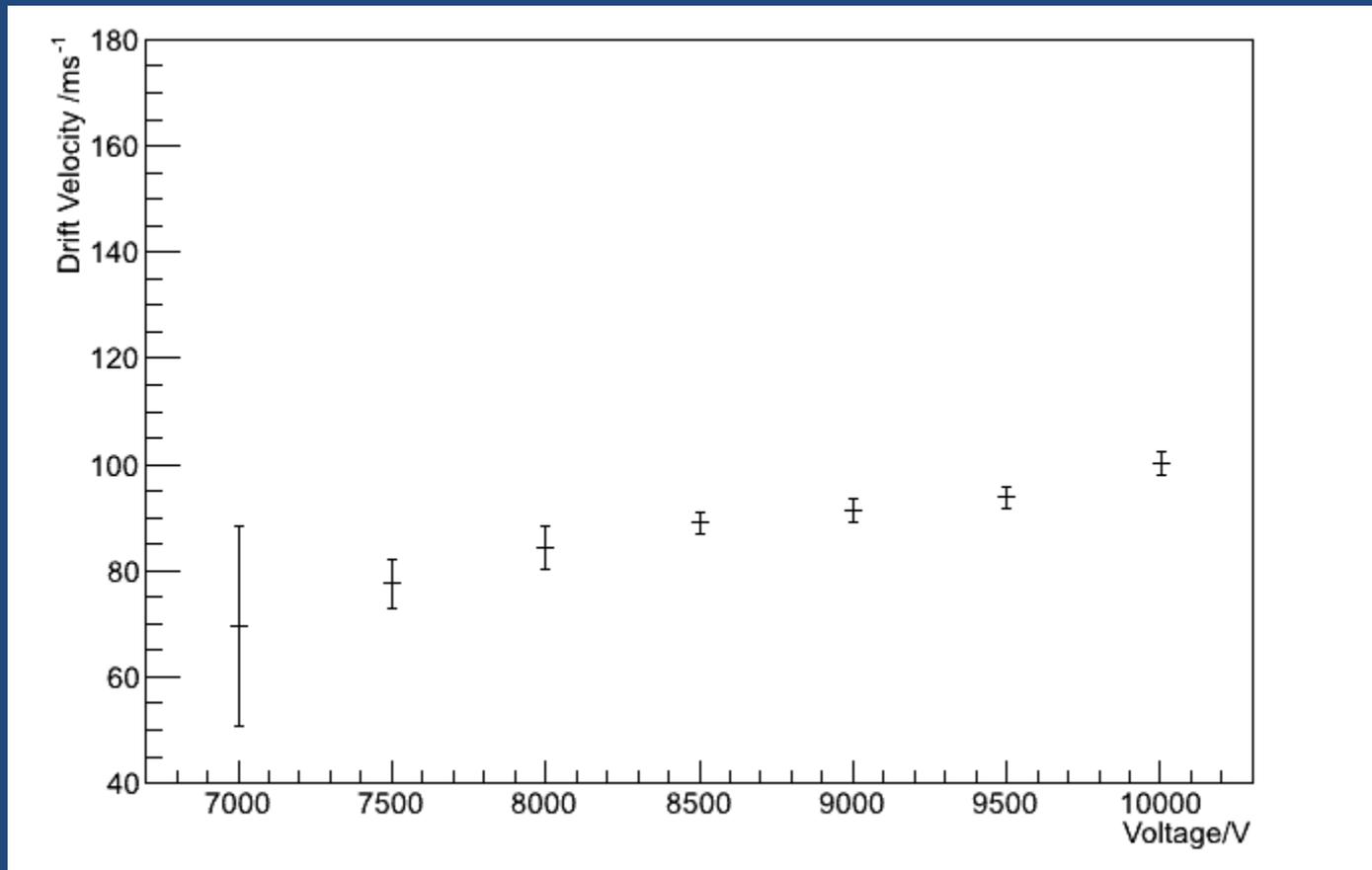
- Tested pure solvent and scintillation cocktail with fluors
- Observed event rate difference

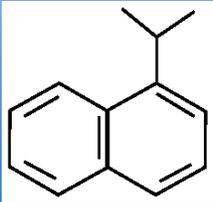
Pure solvent: Black points

Scintillation cocktail: Red points



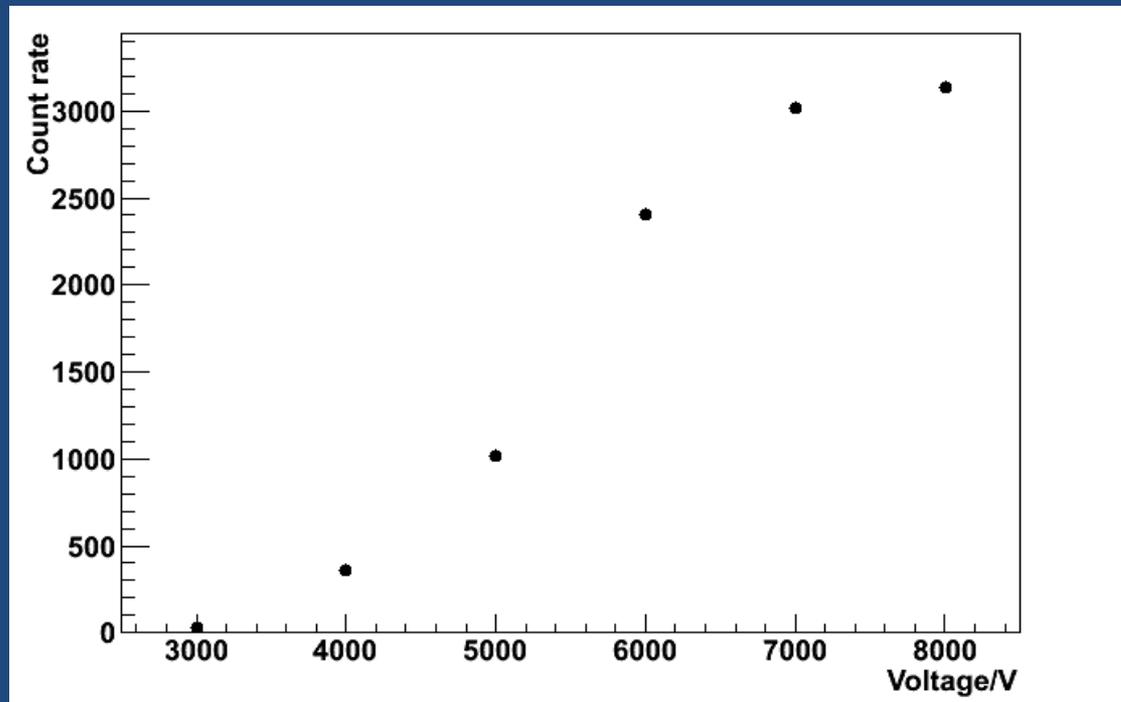
Di isopropyl naphthalene



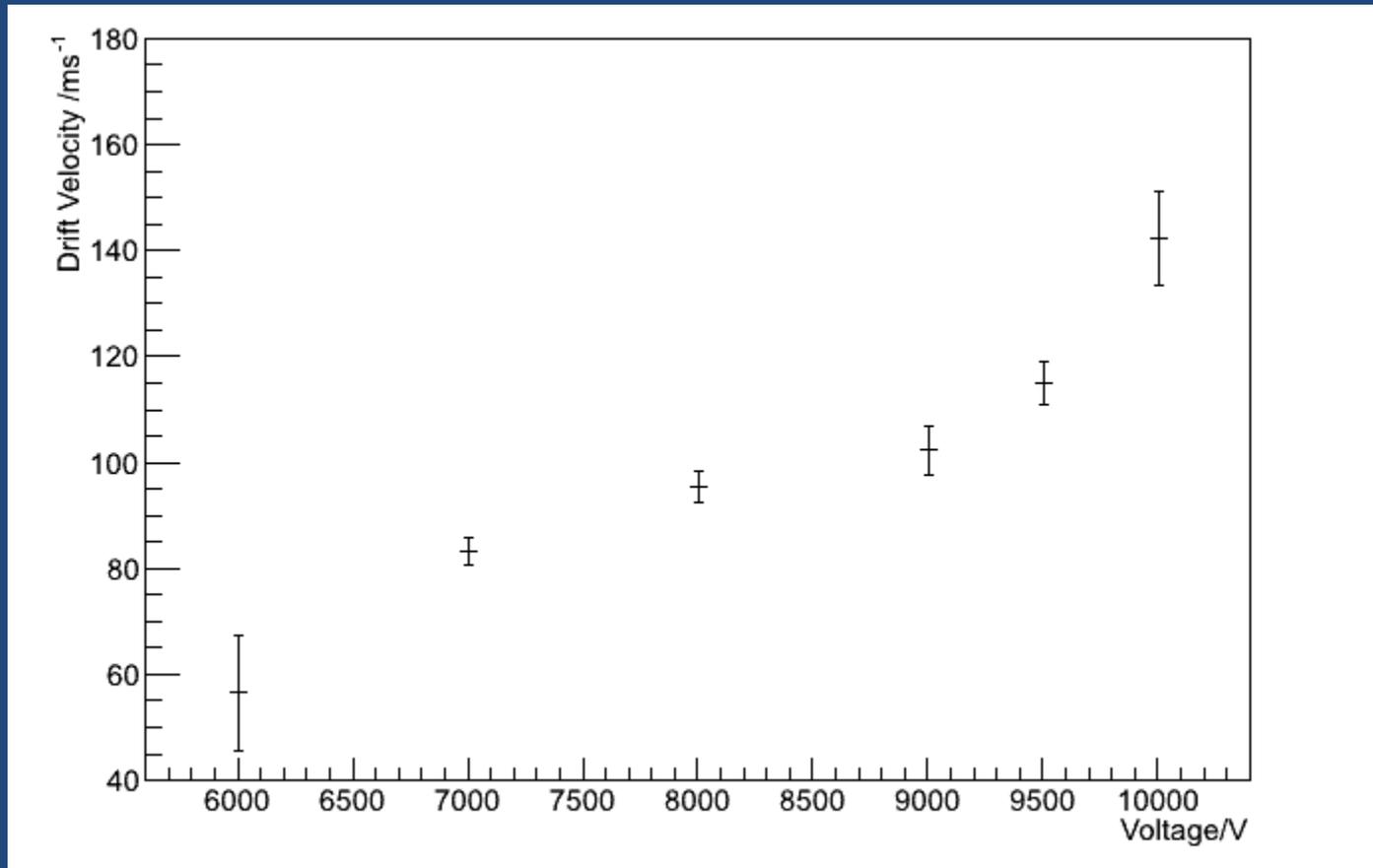


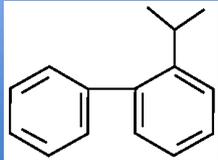
Mono isopropyl naphthalene

- Organic solvent similar chemically to DIN
- Not used for scintillation counting



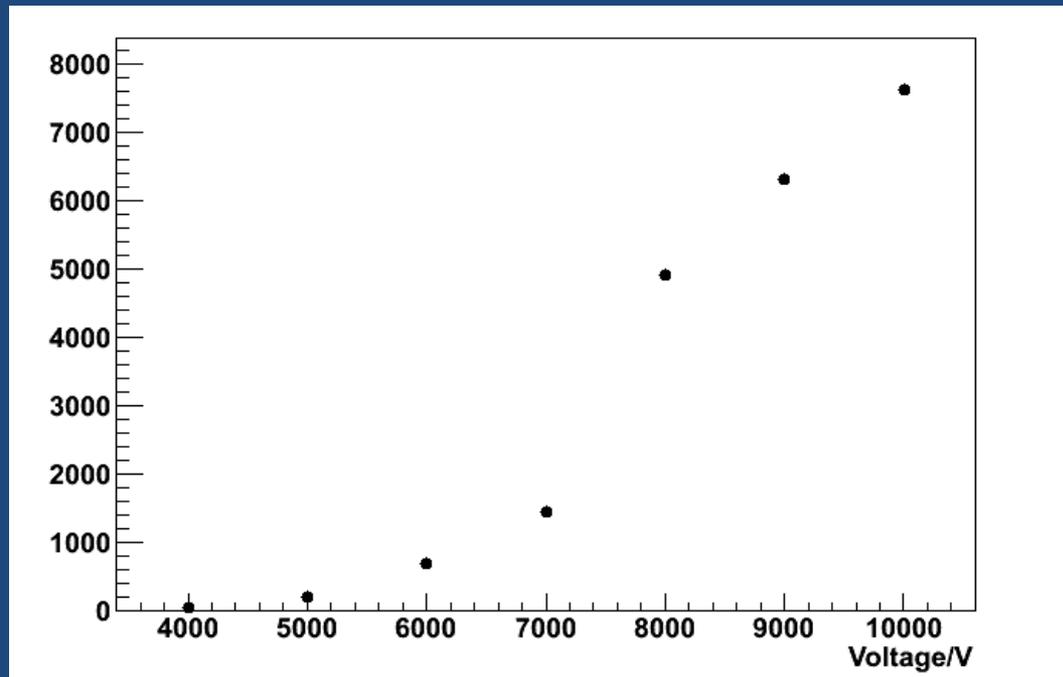
Mono isopropyl naphthalene



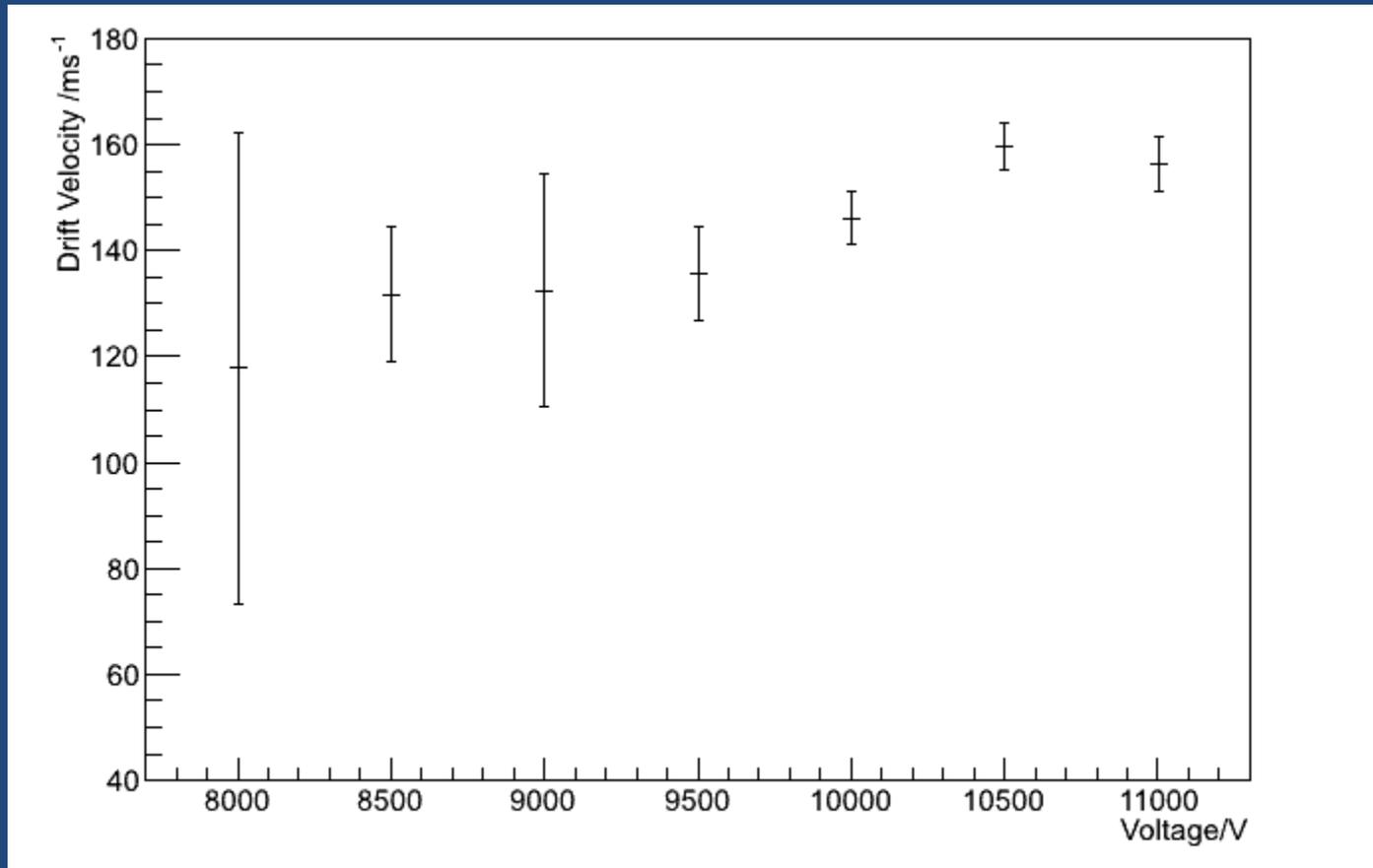


Mono isopropyl biphenyl

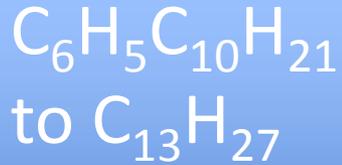
- Organic solvent similar chemically to DIN
- Not used for scintillation counting



Mono isopropyl biphenyl



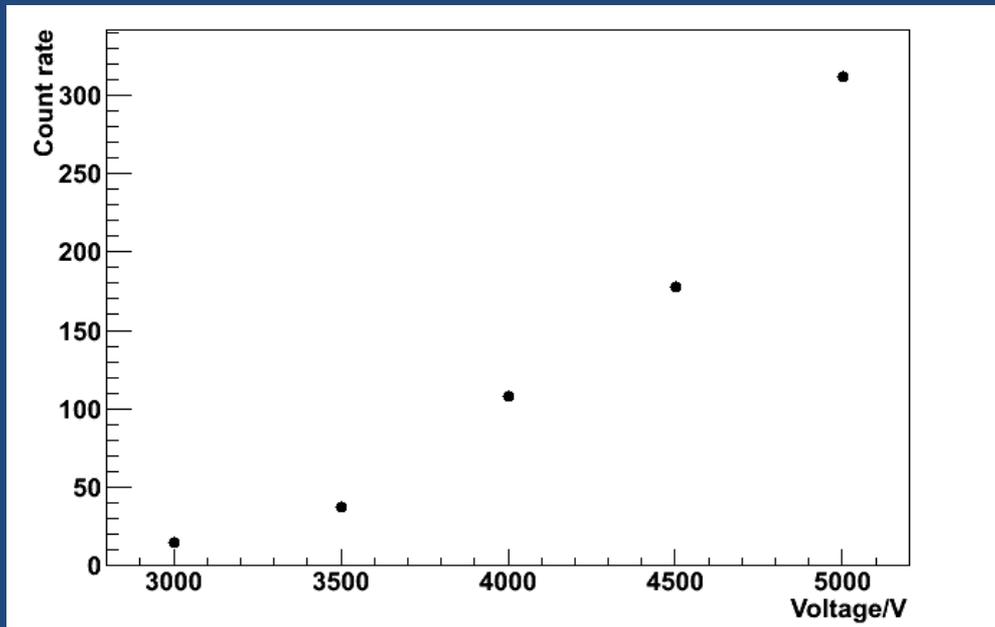
Linear Alkyl Benzene



- Scintillation cocktail, solvent with fluors

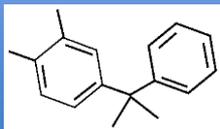
- Dielectric constant of LAB much lower than other solvents

- High electric fields not possible



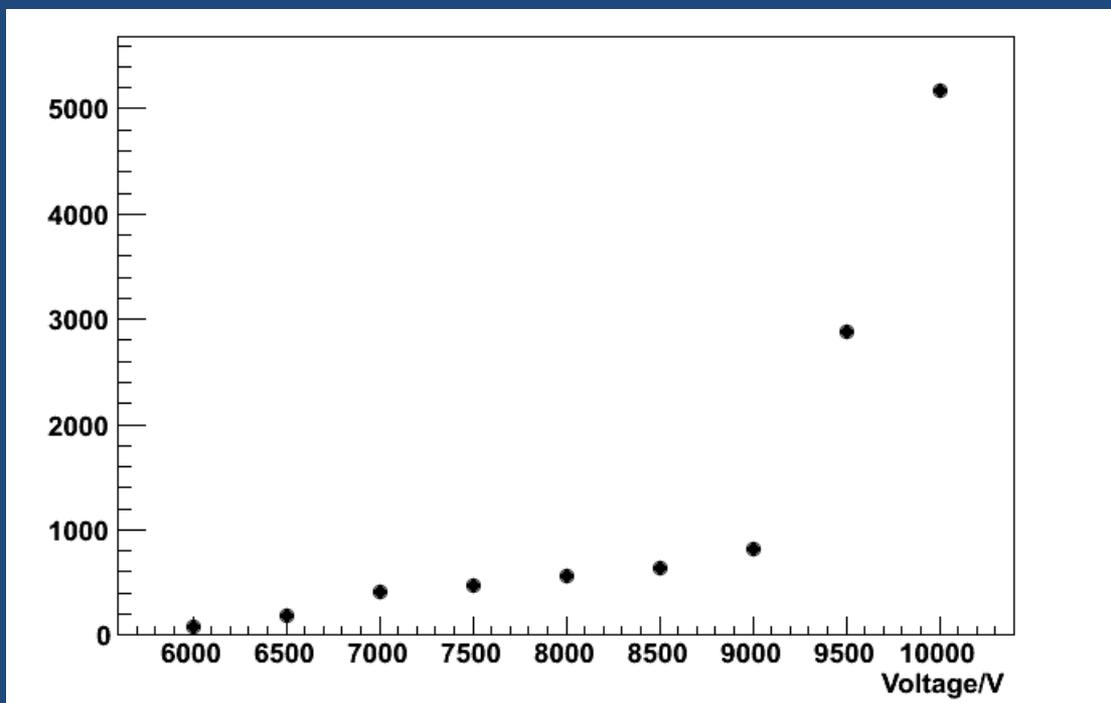
Linear alkyl benzene

- Does not transport charge at measurable speed
- Shape of LAB molecule non spherical
- Low mobility
- Low event rates not due to fluors



Phenyl xylyl ethane

- Scintillation cocktail, solvent with fluors



Phenyl xylyl ethane

- Liquid breaks down above 10kV
- Plateau in low event rate region
- Possible suppressed event rate due to fluors
- Source pure solvent for further tests