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Liquid Scintillator Time Projection Chamber Concept

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- Measurement Programme
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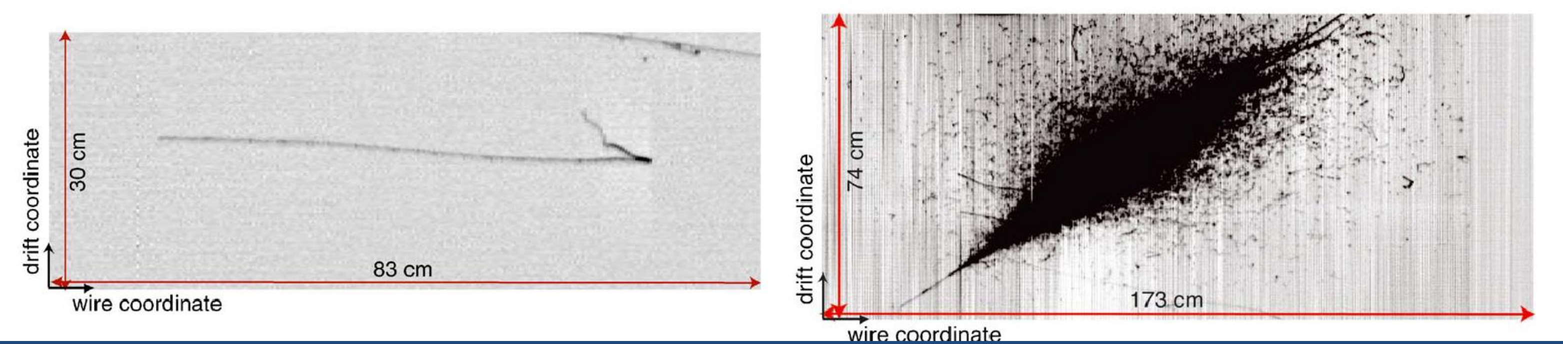
Motivation

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



S. Amerio el al. (2004)

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A room temperature Liquid Scintillator TPC

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Past work

- Free electrons in room temperature liquids first observed in late 60s
  - Neopentane
  - Tetramethysilane (TMS)
- TMS ionisation chamber built in early 80s
- Chosen for spherical shape of molecules

J. Engler & H. Keim (1983)
I. Adamczewski & J. H. Calder (1976)

Organic Liquid Scintillators

- “Safe” solvents developed over past 20 years
- Widely used in particle physics
  - *(SNO+, RENO, Daya Bay, LENA)*
- Optical properties well known
- Charge transport (until now) unknown

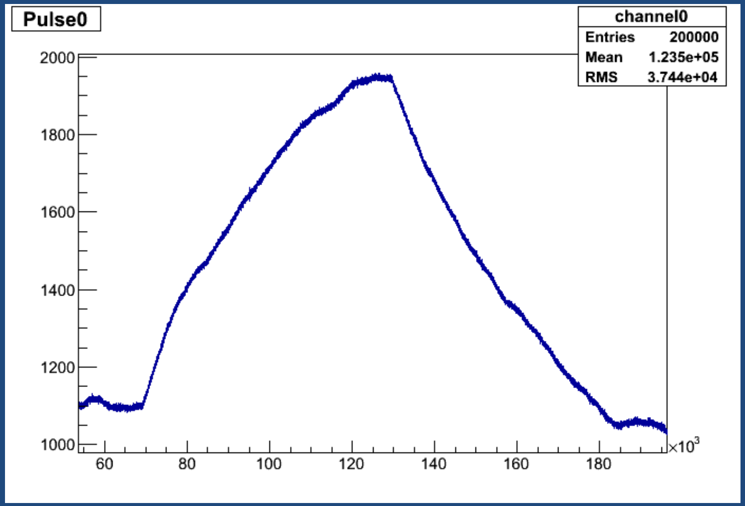
Benefits of a LScint TPC

- 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 ββ experiments

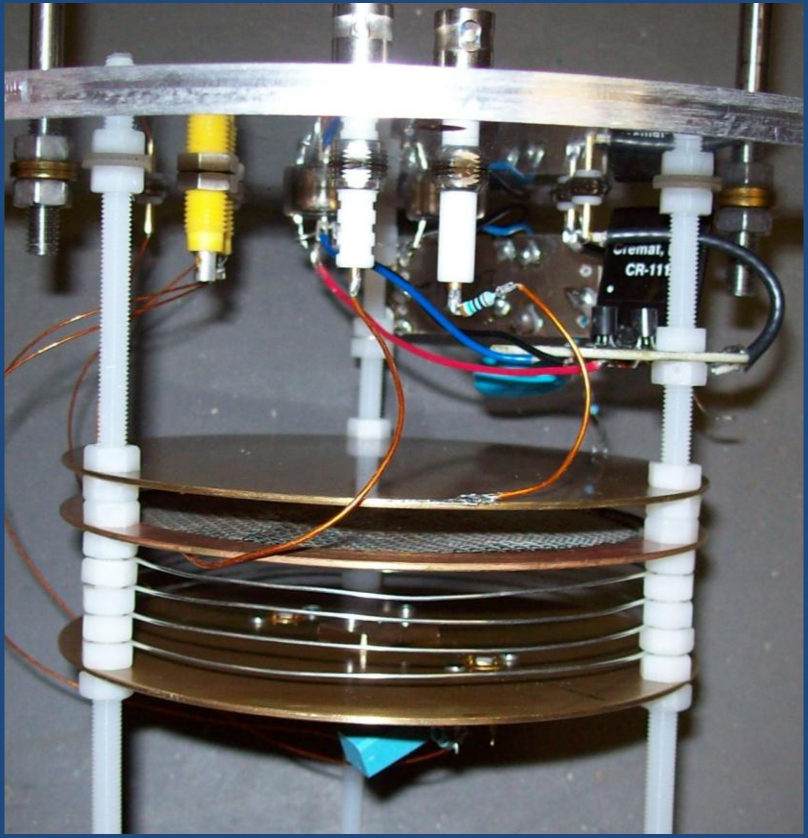
Measurement Programme

- Investigate charge transport properties of organic liquid scintillators and solvents.

- Drift Speed: First results are presented here.



Detector Overview

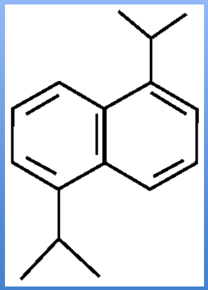


- 2.5 litre gridded ionisation chamber
- Am241 alpha source at cathode
- Drift distance currently 22mm

Results

- Liquid Scintillators and solvents tested:
  - Di isopropyl naphthalene (DIN) cocktail
  - Di isopropyl naphthalene (DIN) solvent
  - Mono isopropyl naphthalene (MIPN) solvent
  - Mono isopropyl biphenyl (MIBP) solvent
  - Linear Alkyl Benzene (LAB) cocktail
  - Phenyl Xylyl Ethane (PXE) cocktail

$C_{16}H_{20}$

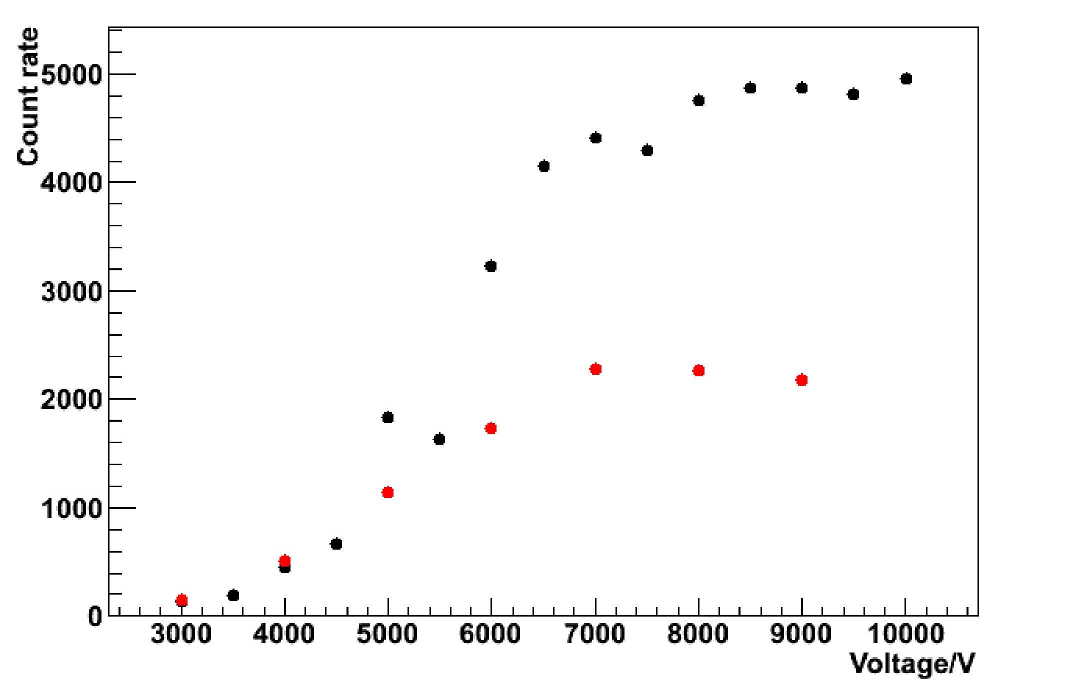


Di isopropyl naphthalene

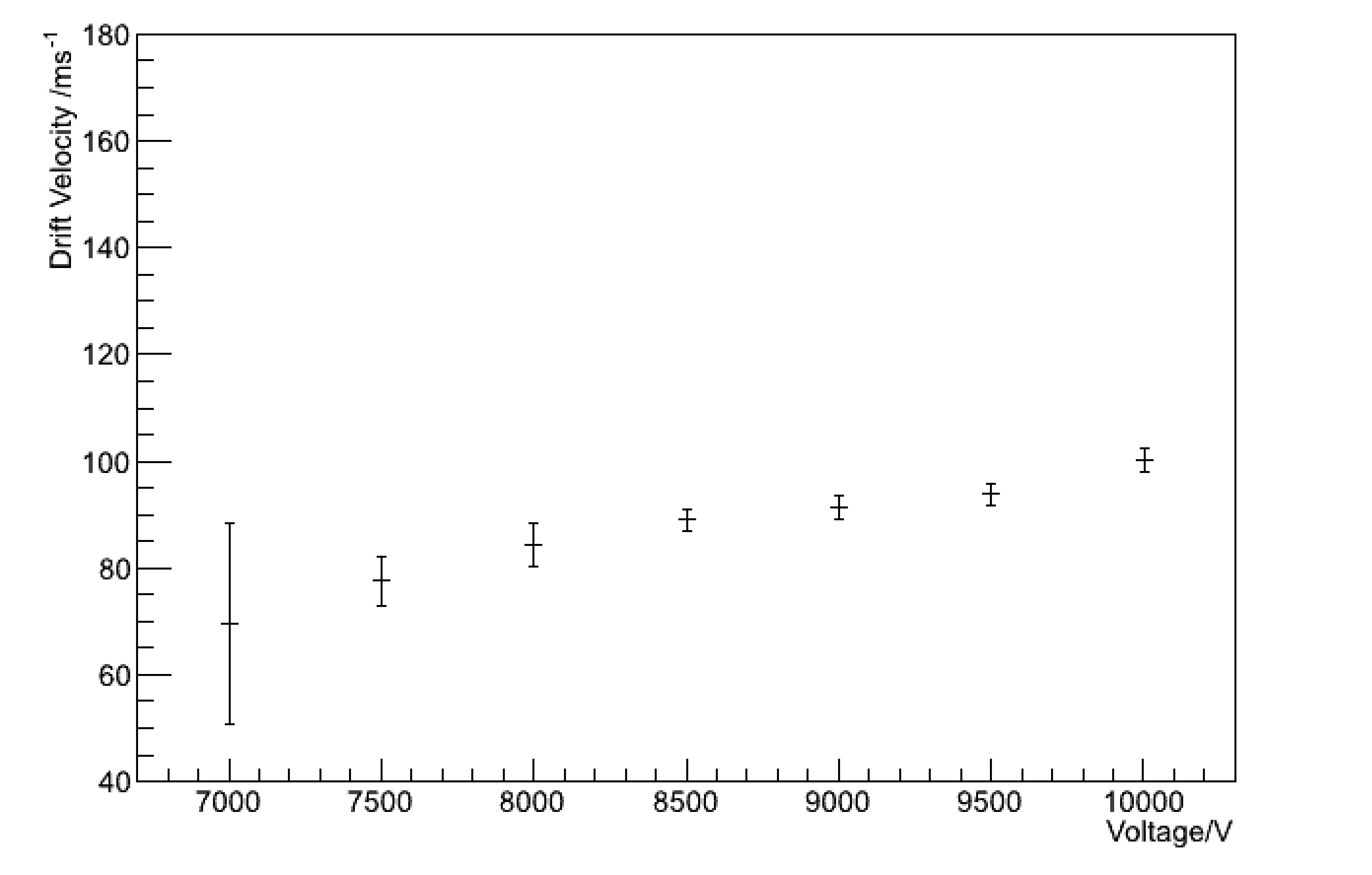
- Tested pure solvent and scintillation cocktail with fluors
- Observed event rate difference

Pure solvent: Black points

Scintillation cocktail: Red points

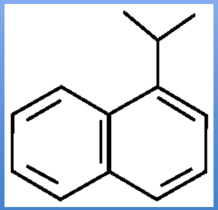


Di isopropyl naphthalene

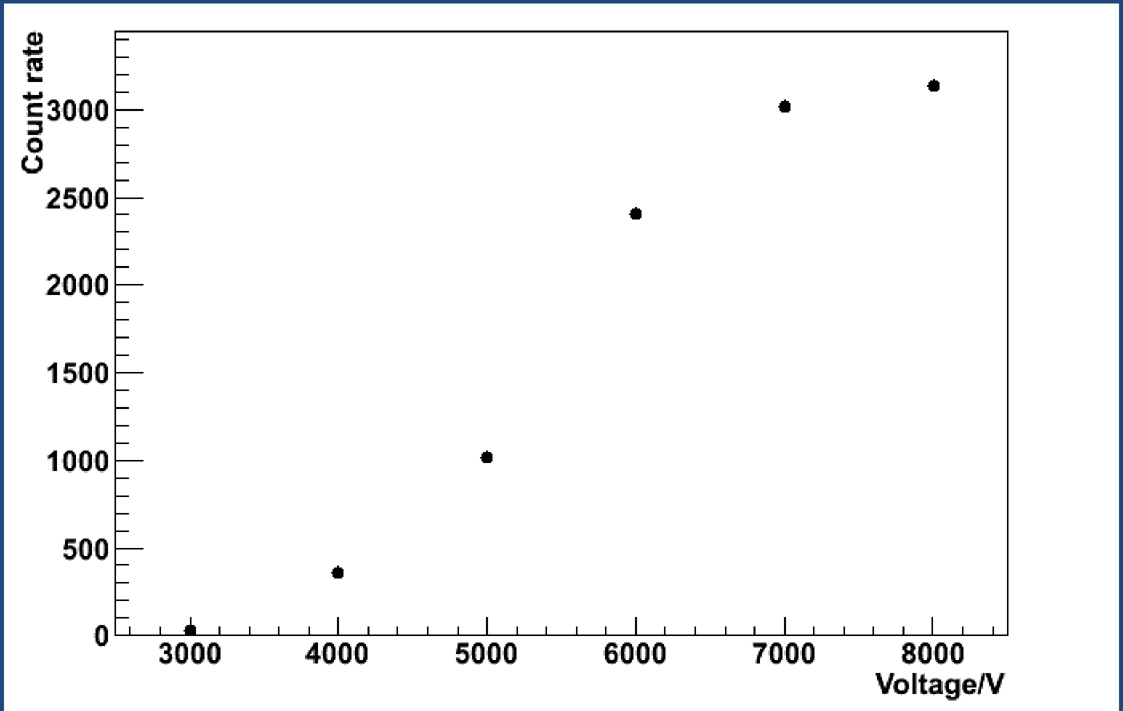


Mono isopropyl naphthalene

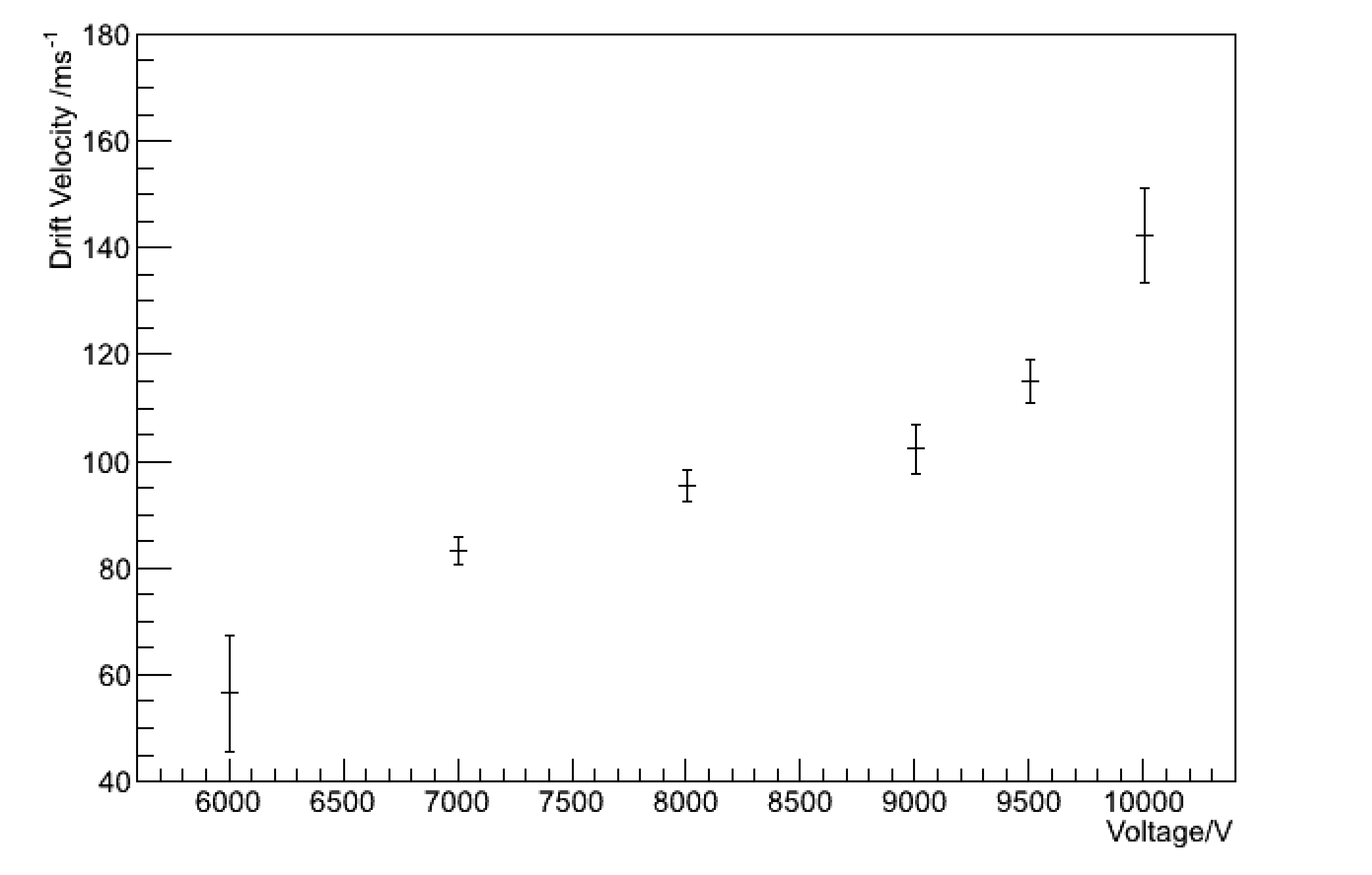
$C_{16}H_{14}$



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



Mono isopropyl naphthalene



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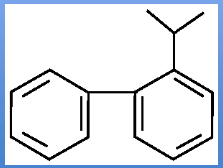
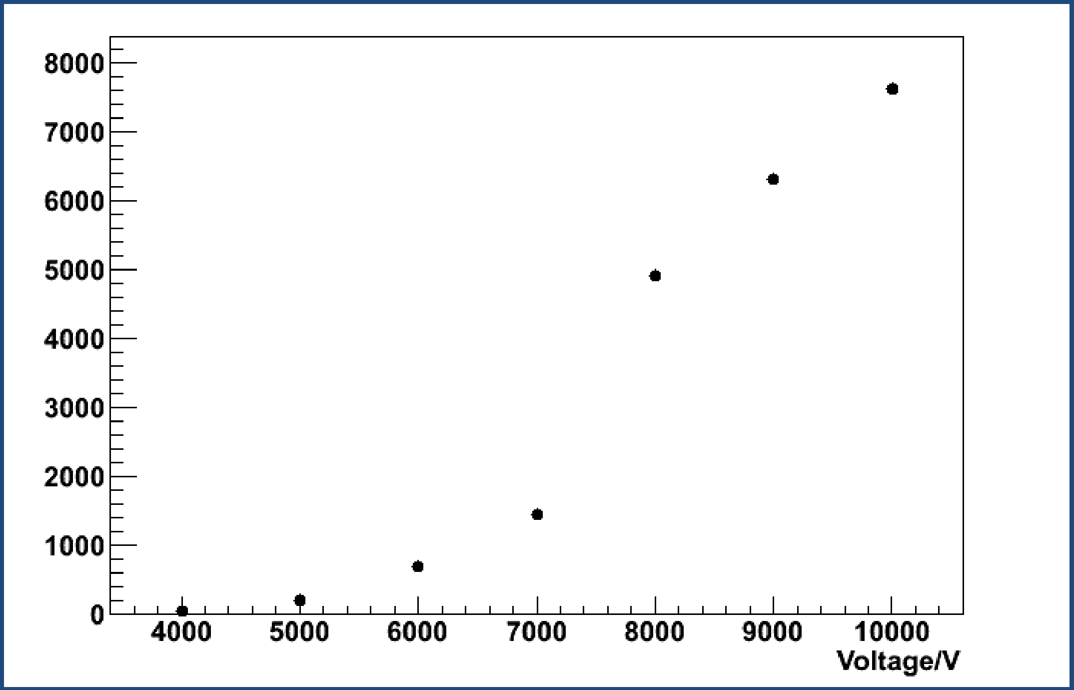
$C_{15}H_{16}$

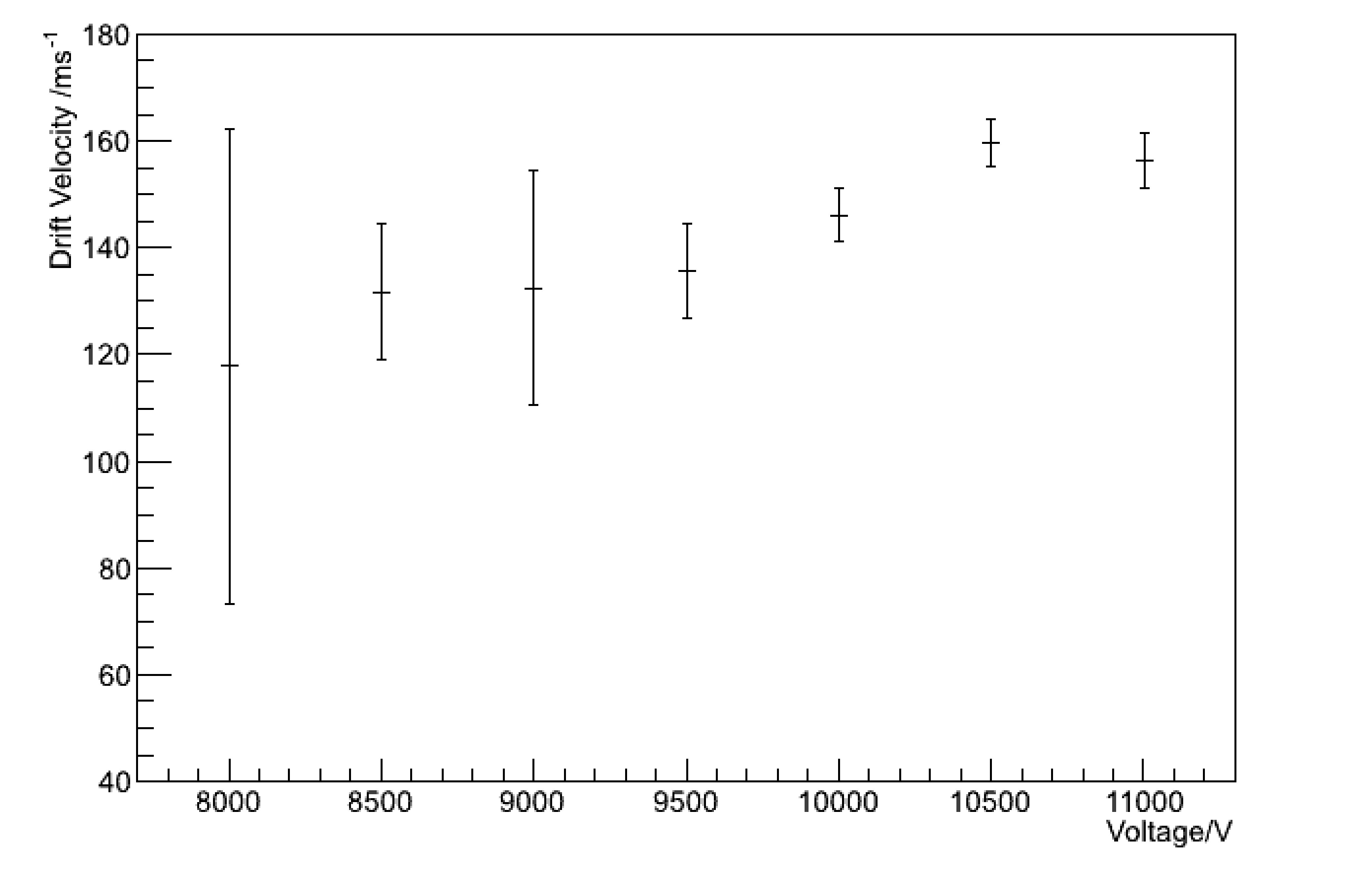


Mono isopropyl biphenyl

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



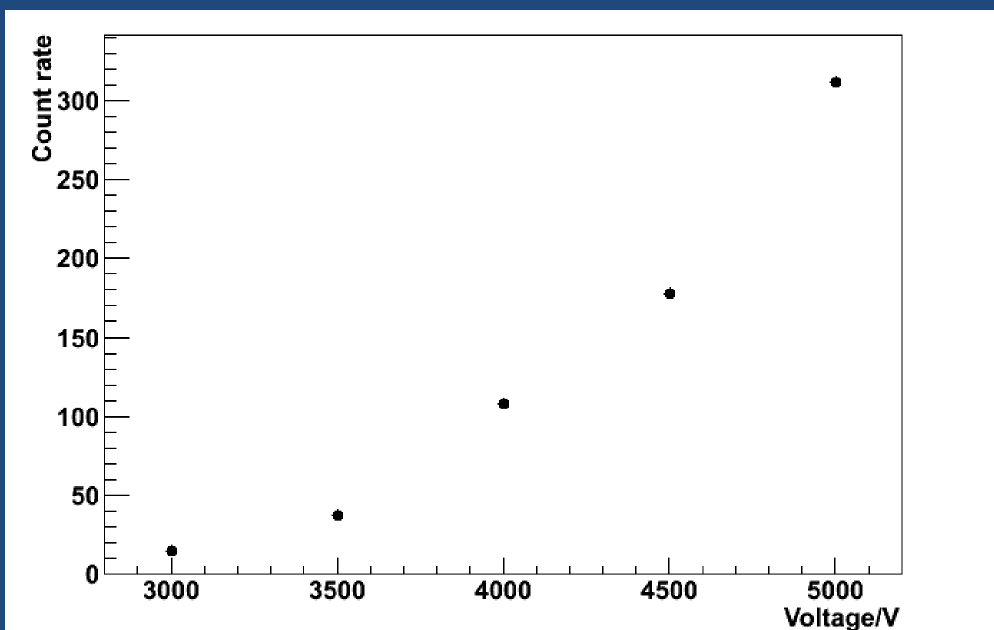
Mono isopropyl biphenyl



Linear Alkyl Benzene

$C_6H_5C_{10}H_{21}$ to $C_{13}H_{27}$

- Scintillation cocktail, solvent with fluors
- Dielectric constant of LAB much lower than other solvents



- High electric fields not possible

Linear alkyl benzene

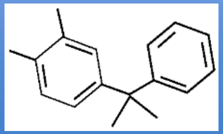
- Does not transport charge at measurable speed

- Shape of LAB molecule non spherical
- Low mobility

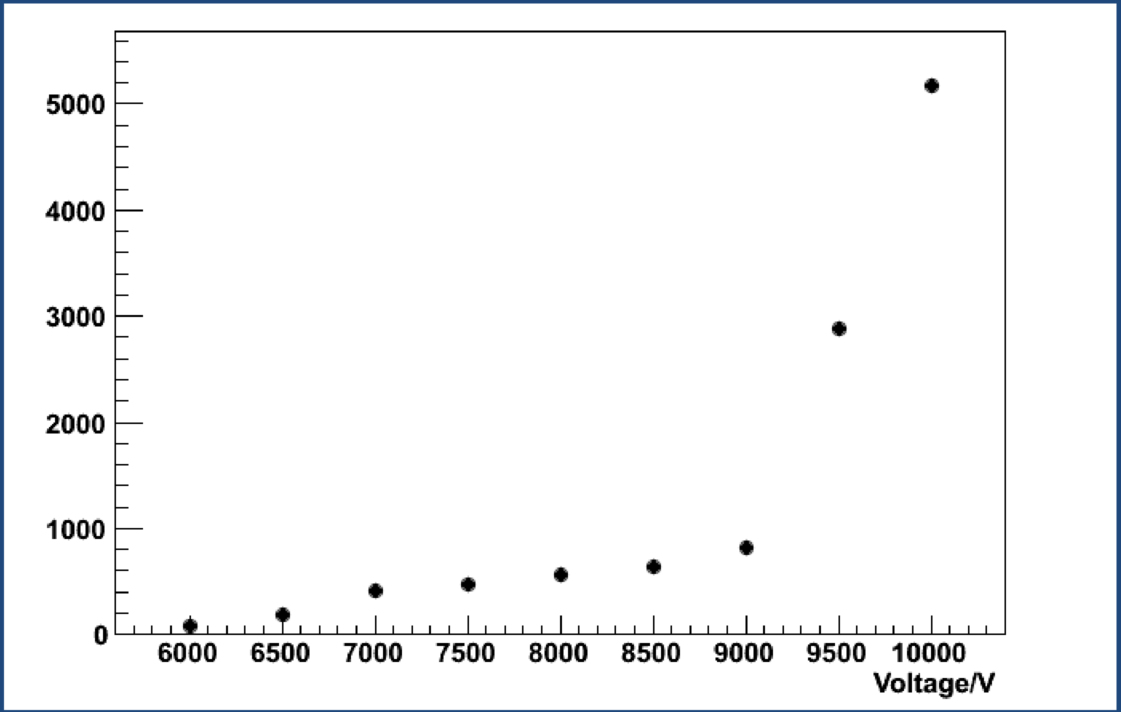
- Low event rates not due to fluors

Phenyl xylyl ethane

$C_{16}H_{18}$



- 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

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Conclusions

- Charge transport possible in:
  - DIN, MIPN, MIBP, PXE
- Charge transport not possible in:
  - LAB
- Successful first step
- Further work to fully characterise transport properties

Future work

- With photoconversion pulsed source:
  - Refine preliminary drift velocities
  - Mean free path
  - Diffusion

- UV Optical Spectroscopy:
  - Characterise scintillation properties of all solvents

Future Work

- Charge transport is possible in room temperature organic liquid scintillators

- Results will determine feasibility of a room temperature Liquid Scintillator TPC.