Negative ionic drift

Update

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NIKHEF

Nikhef/Bonn LepCol meeting
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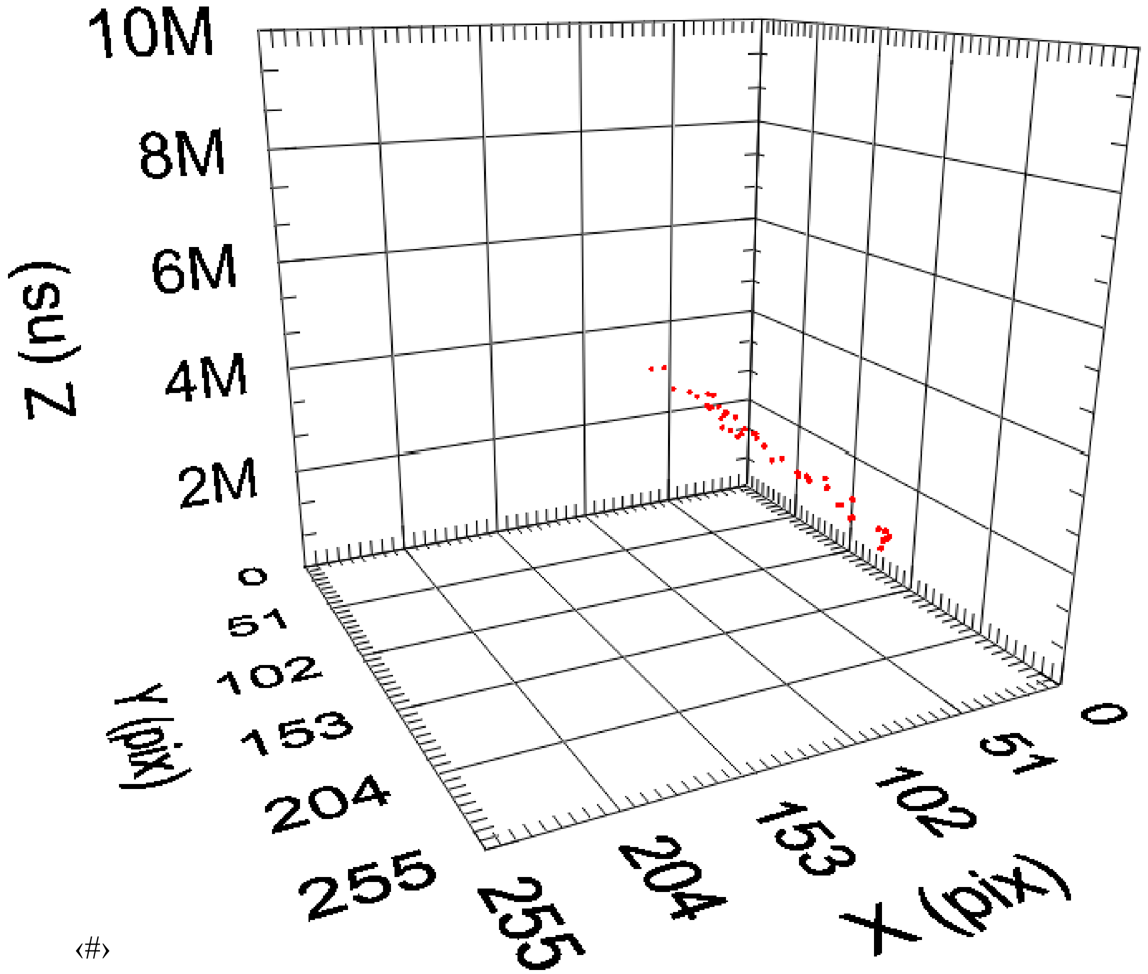
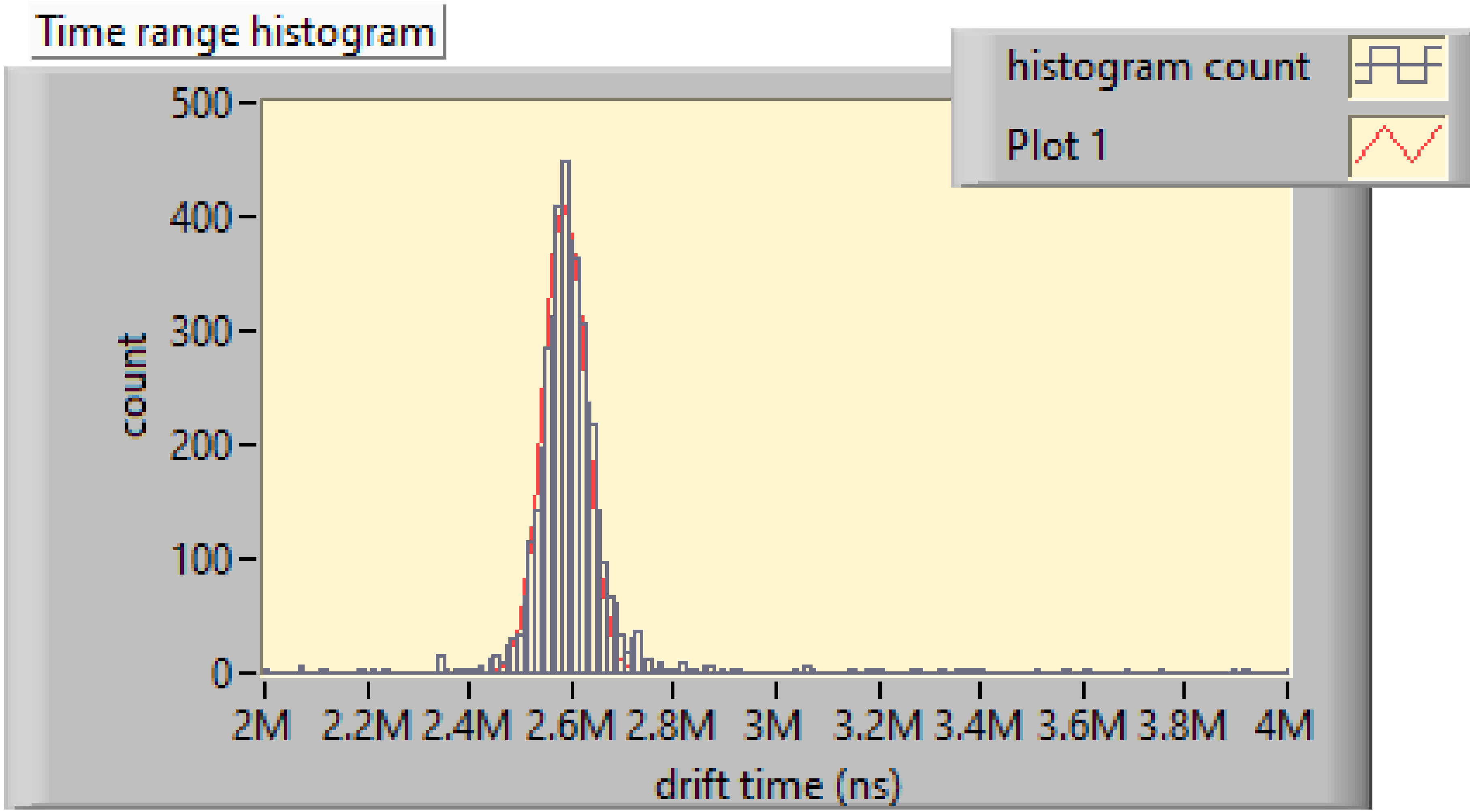


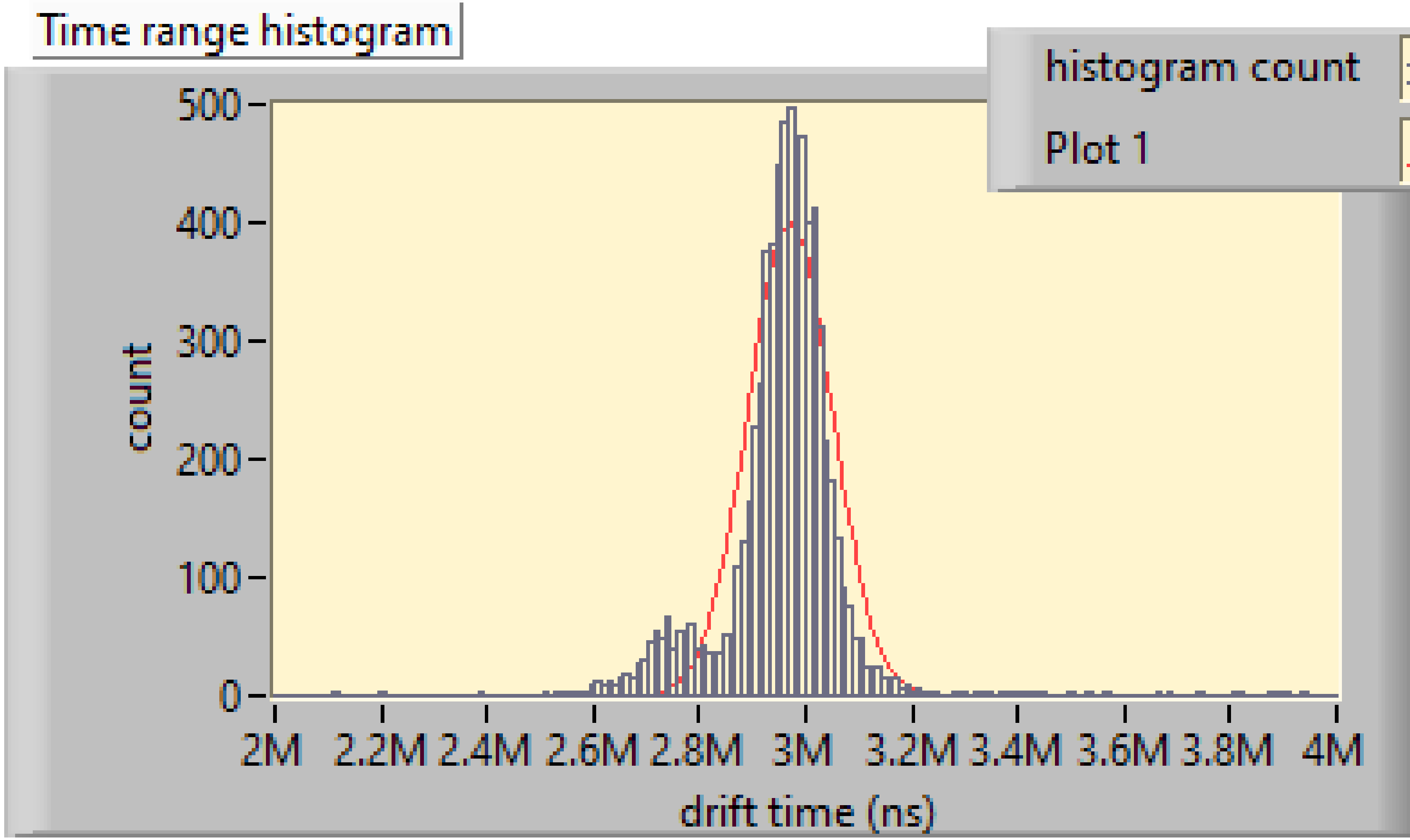
First result: pure Ar + 1.2% CS_2

- Drift time about 2.6 ms across 12 mm
- Rms = 0.0416M ns ≈ 180 μm
- Ar/CS_2 98.8/1.2
  - Run 1017V
- Grid -300 V
- E_d = 280 V/cm
- ToT 750 ns
- **Sparking at higher grid voltages**
- Measurement done in the 8-quad testbox



Now with quencher (isobutane)

- $Ar/iC_4H_{10}/CS_2$ 90/9/1 run 1025
- Vgrid = -430 V
- ToT 1750 ns
- Z = 12 mm
- Double peak (iC_4H_{10}?)
- But main peak still well symmetric



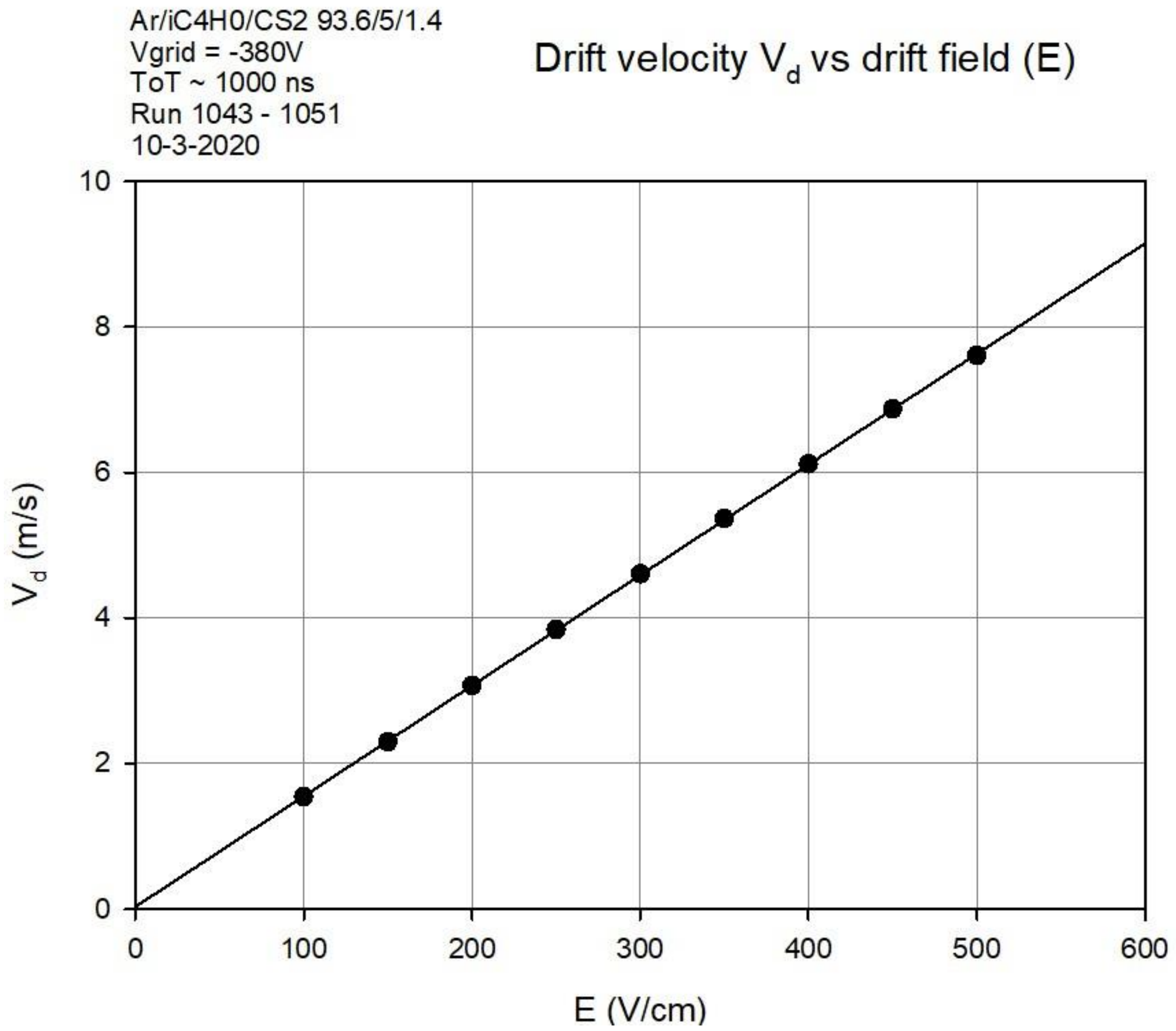
Dependencies on the drift field E measured (run 1043 – 1051)

- 9 different fields from 100 to 500 V/cm
- High CS_2 concentration
  - $Ar/iC_4H_{10}/CS_2$ 93.6/5/1.4
- Vgrid = -380 V => ToT ≈ 1000 ns
- Assumption: kinetic energy of the ions thermal, not depending on E_d
  - 3/2 kT
- => we expect several **first order dependencies**
- $V_d \propto E_d$ **Proven hereafter**
- Diffusion $\sigma^2 \propto^{-1} E_d$ **≈ proven hereafter for σ_L**
- Mean free path of electrons $\lambda \propto E_d$
  - The number of collisions per second does not depend on E_d
- $\lambda \propto^{-1} CS_2$ concentration **different relation seen**

Drift velocity $V_d \propto E_d$

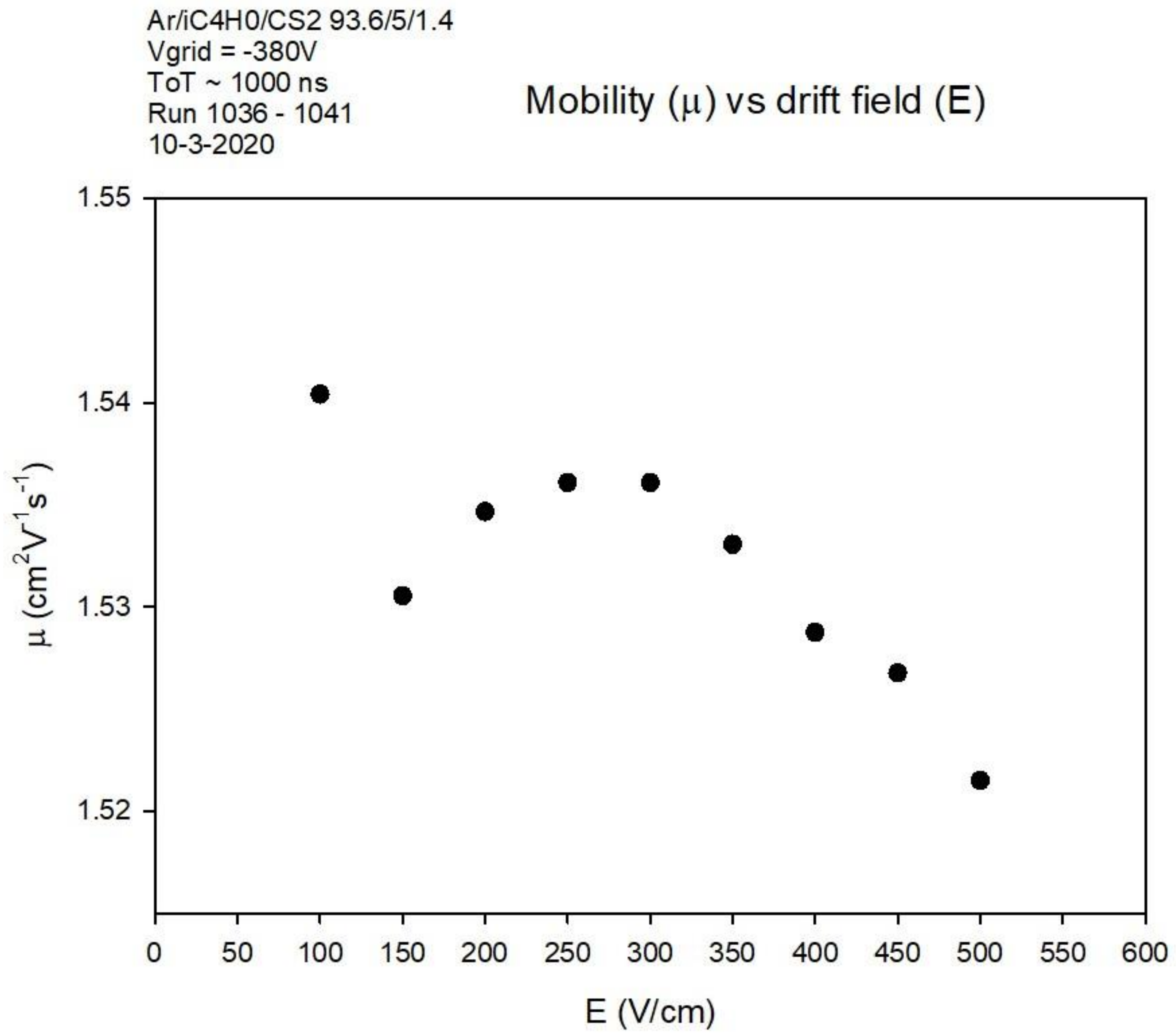
- $Ar/iC_4H_{10}/CS_2$ 93.6/5/1.4

- Excellent proportionality
  - Fit well passing the origin



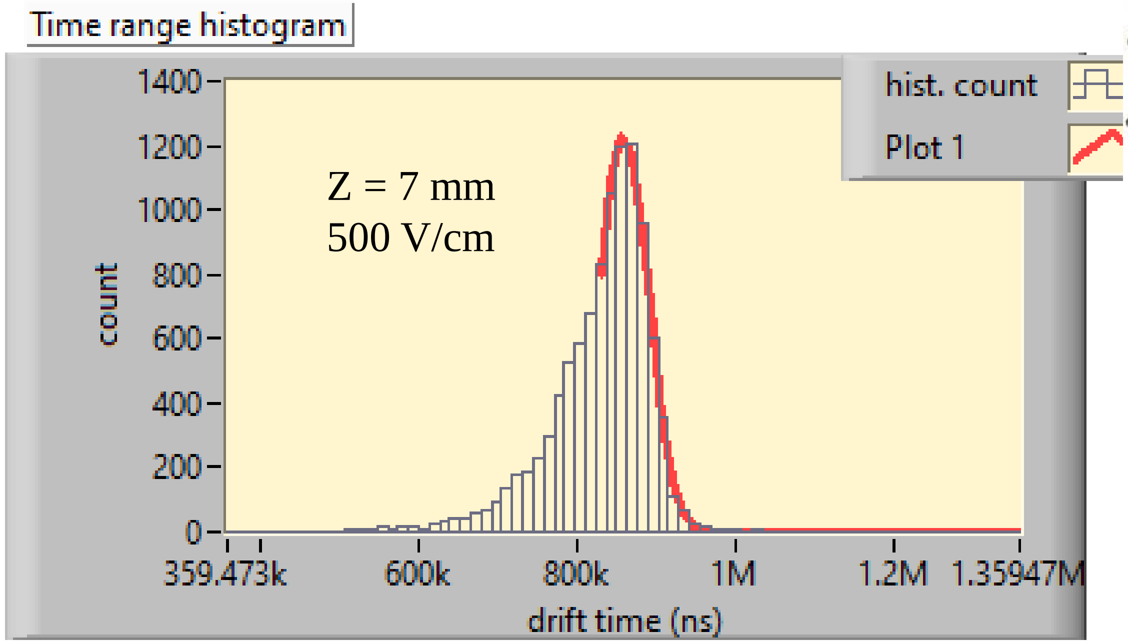
Mobility

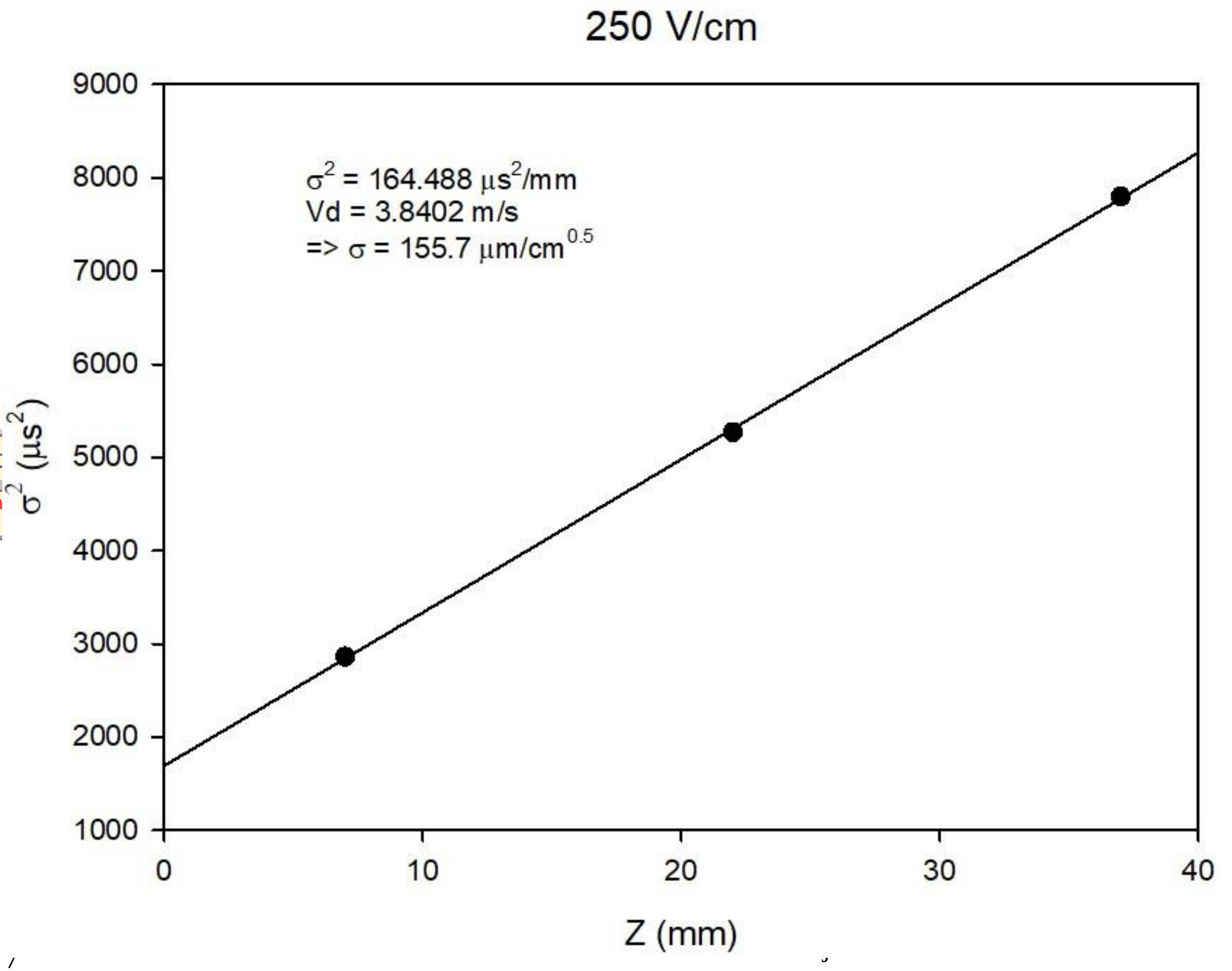
- $Ar/iC_4H_{10}/CS_2$ 93.6/5/1.4
- Mobility is constant at 1.53 $cm^2V^{-1}s^{-1}$
  - (+/- 0.5%)
- Point at 100 V/cm deviating



Diffusion measured by observing the width of the time peaks

- $Ar/iC_4H_{10}/CS_2$ 93.6/5/1.4
- From Gaussian fit through drift time peak
- Free path tail effect minimized by fitting mainly falling edge
- Diffusion from slope of linear fit
- => width of laser beam $\sigma \approx 40$ µm

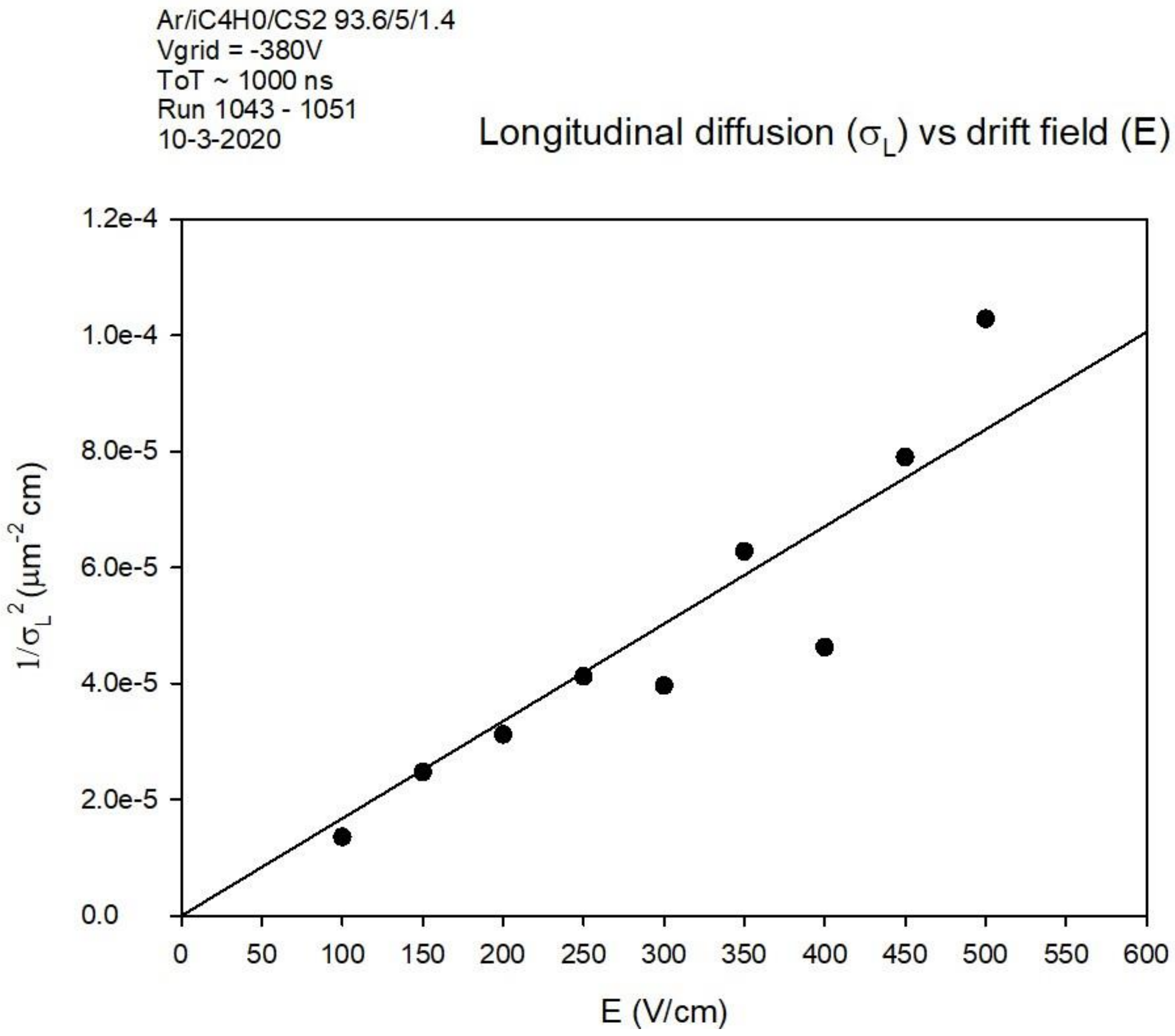




Longitudinal diffusion $\sigma^2 \propto^{-1} E_d$

- Linear fit forced to pass the origin

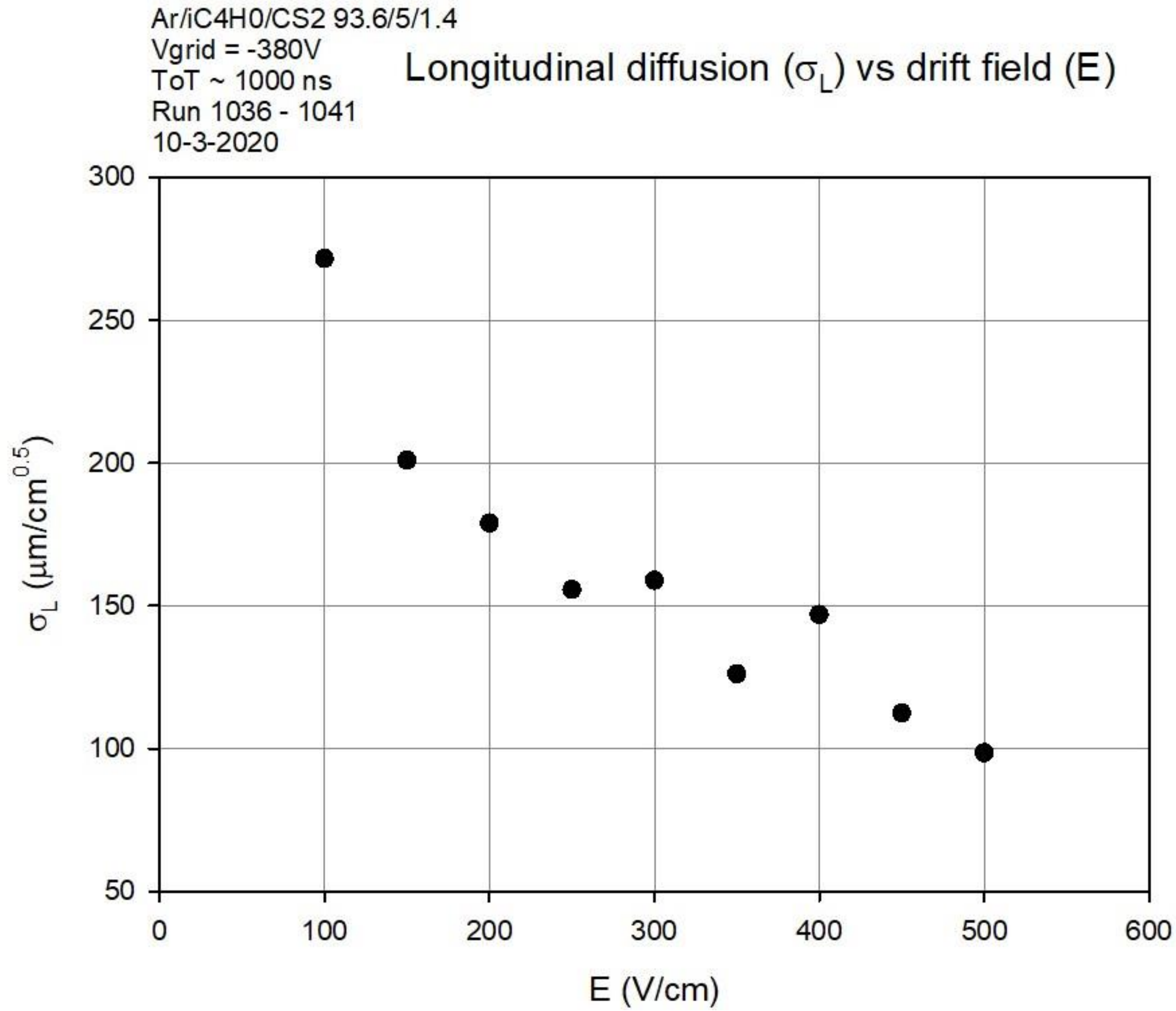
- Deviations at $E \geq 300$ V/cm
  - Effect from free path tail?



Longitudinal diffusion in µm/√cm

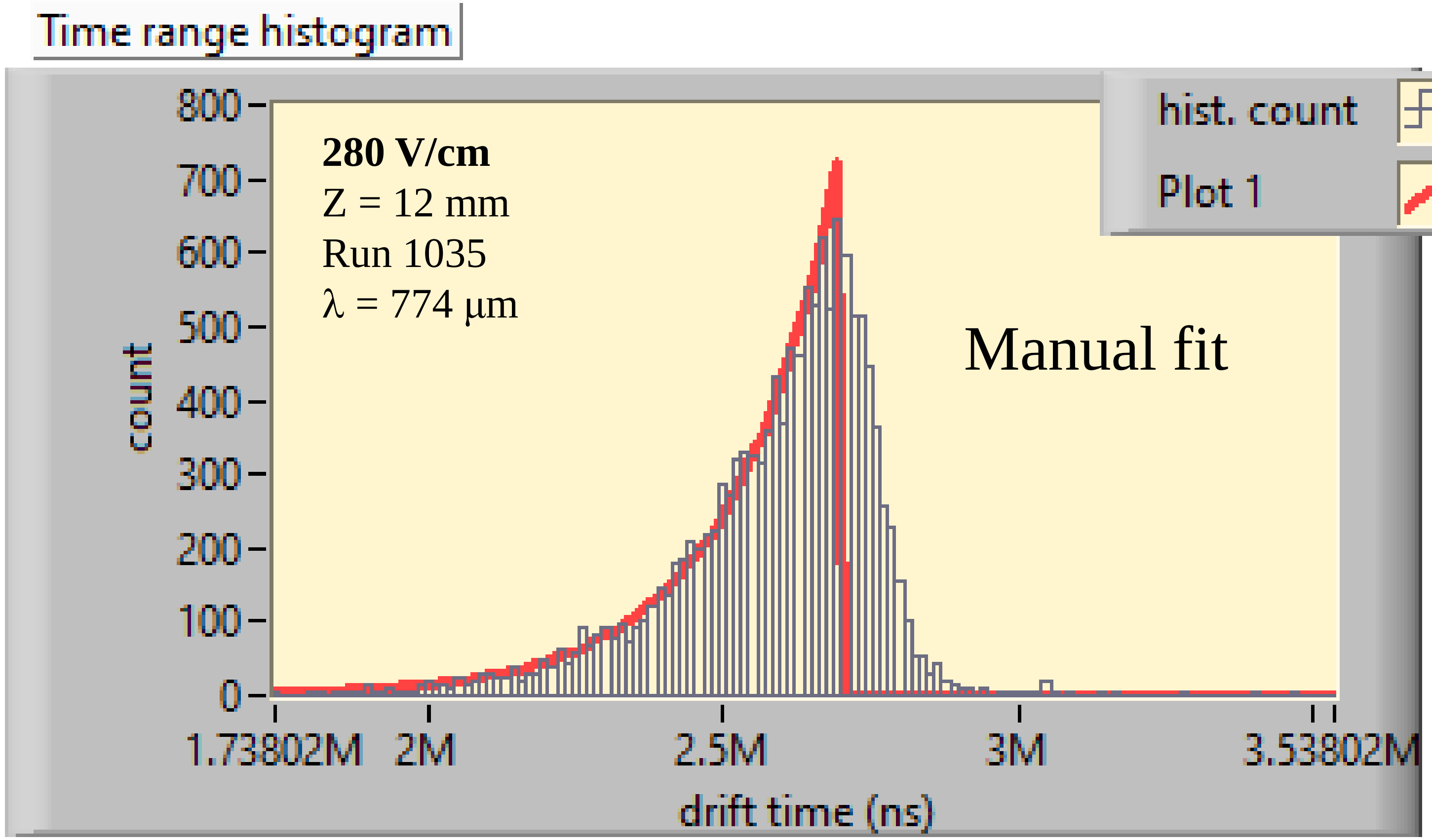
- $Ar/iC_4H_{10}/CS_2$ 95/4.5.0.5

- At 500 V/cm we pass the 100 µm/√cm line



Free path length measured at low CS_2 concentration

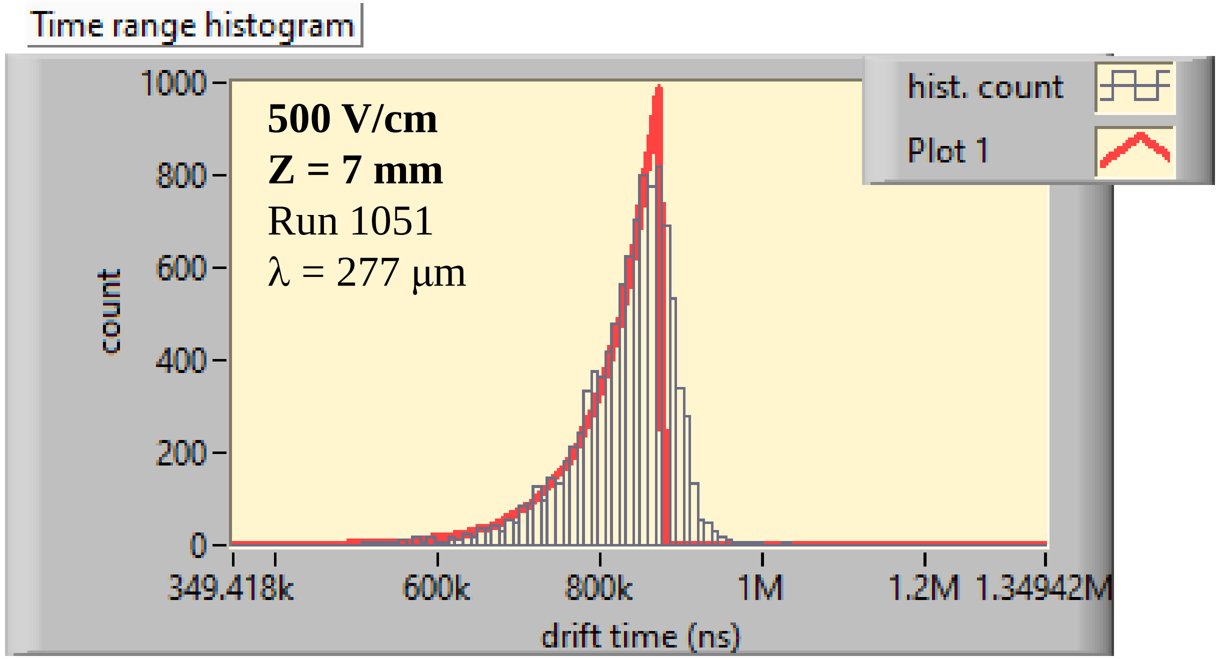
- **0.1% CS_2**
  - $Ar/iC_4H_{10}/CS_2$ 95/4.9/0.1, run 1035
- V_{grid} -380 V
- E = 280 V/cm
- ToT 1100 ns
- Z = 12 mm
- **Curve fitted with:**
  $\psi \propto \exp(-x/\lambda)$ †
- λ = 0.18 ms => 774**µm** for 0.1 % CS_2

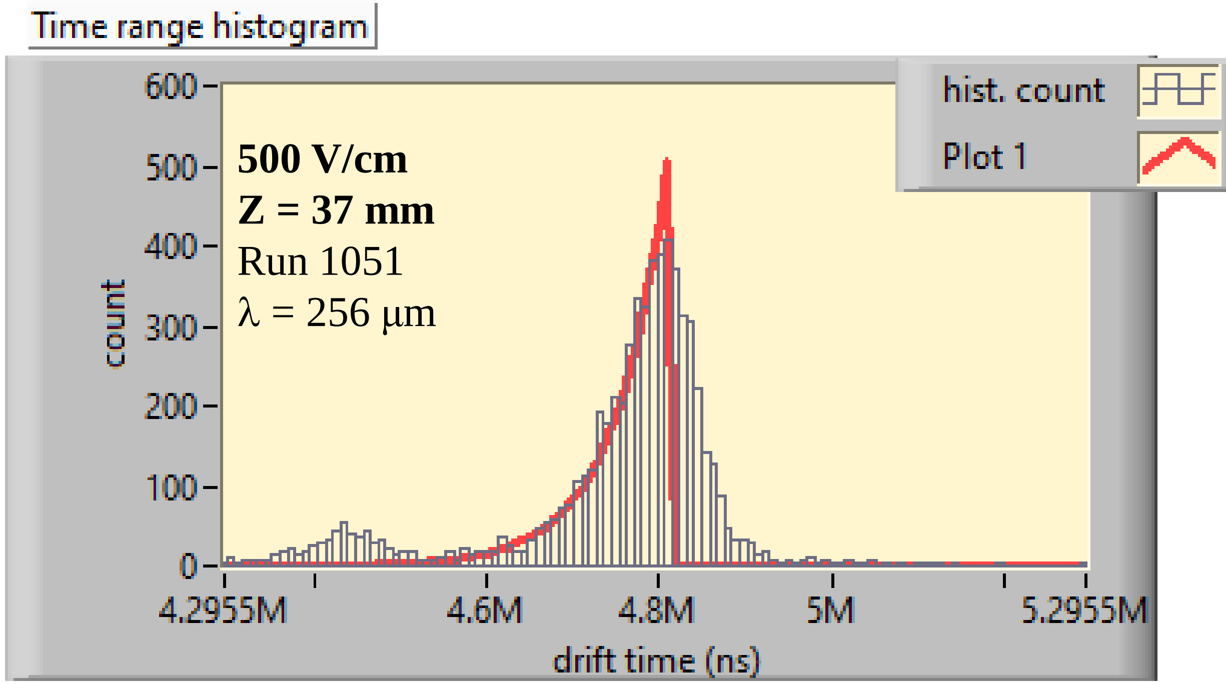


†*N. Dongari, Y. Zhang and J. Reese, Molecular free path distribution in rarefied gases Journal of Applied Physics, 44(12):125502 · March 2011*

Unexpected free path effect at 1.4% CS_2

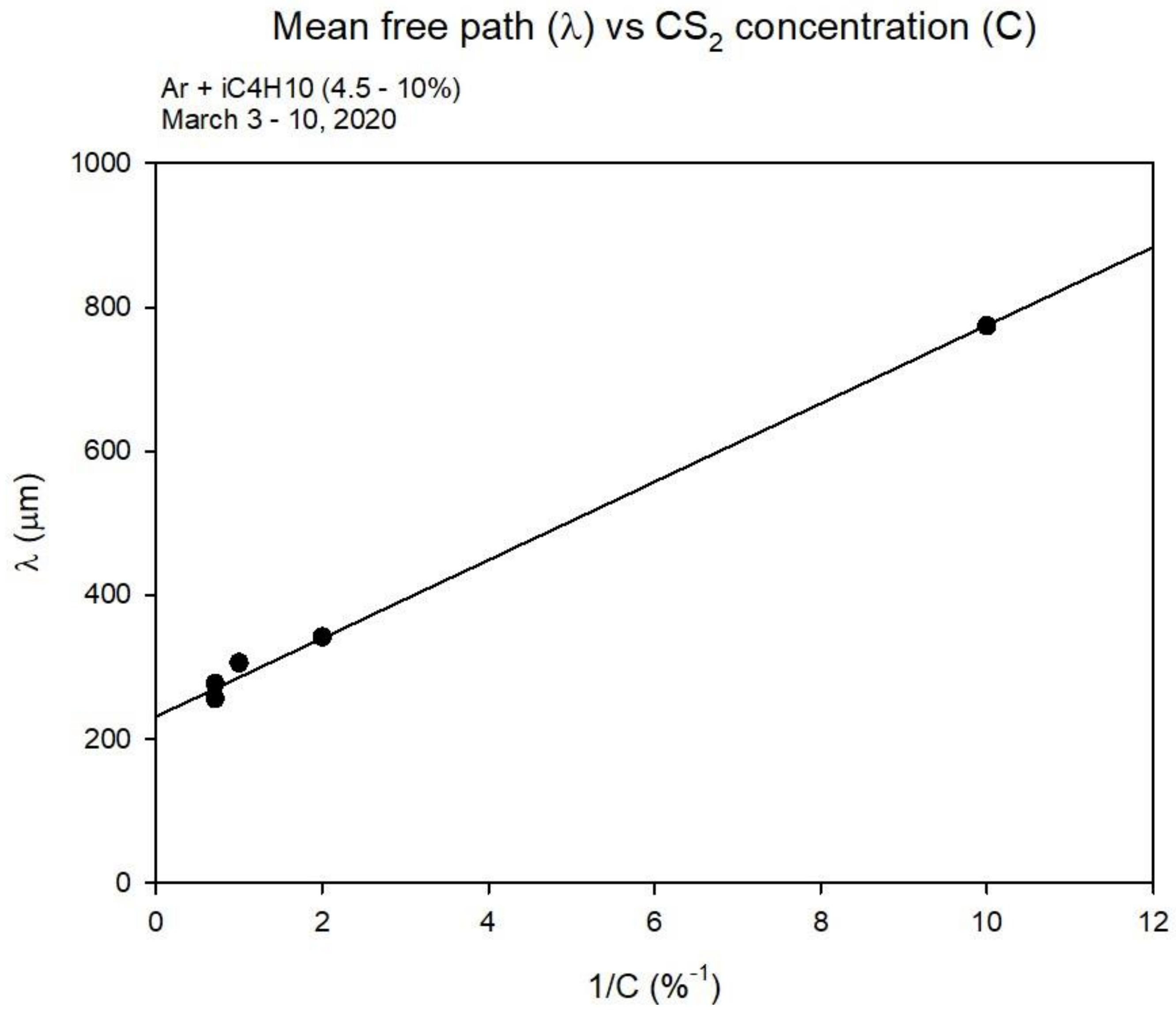
- Free path expected to be inversely proportional to the CS_2 concentration
- Electron attachment by CS_2 may be less efficient at higher field (500 V/cm) due to the higher electron energy?
- Needs more investigation
  - Measurements at different fields using the 0.1% CS_2 mixture





Mean free path vs CS2 concentration

- Various Ar/iC_4H_{10} mixtures
  - 4.5 – 10% iC_4H_{10}
- Data converted to E = 280 V/cm
  - Conversion $\lambda \propto E$ (assuming that the electrons still have the thermal energy
- More or less linear dependence
  - Non-linear behavior at high CS_2 concentrations??
  - Electron capture depending on the drift field??



Updated conclusions on negative ions

- Excellent proportionality of Vd vs E remains also for extended field range
  - Ions can be well described as being thermal
- Second peak remains unidentified

- σ_L behaves more or less as expected
  - $\sigma^2 \propto^{-1} E_d$
- At E = 500 V/cm we pass the 100 μm/√cm limit

- Mean free path of electrons does NOT show the expected dependence on the CS_2 concentration