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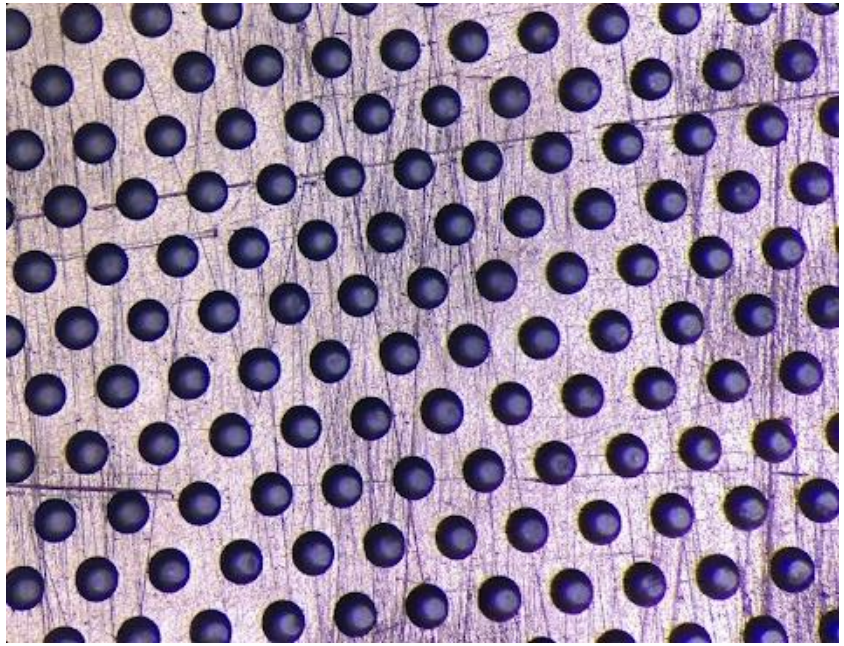
ISIS Neutron and Muon Source

μRWELL operation in $^3He/CF_4$ gas mixtures



Raheema Hafeji
Davide Raspino
Erik Schooneveld
Nigel Rhodes

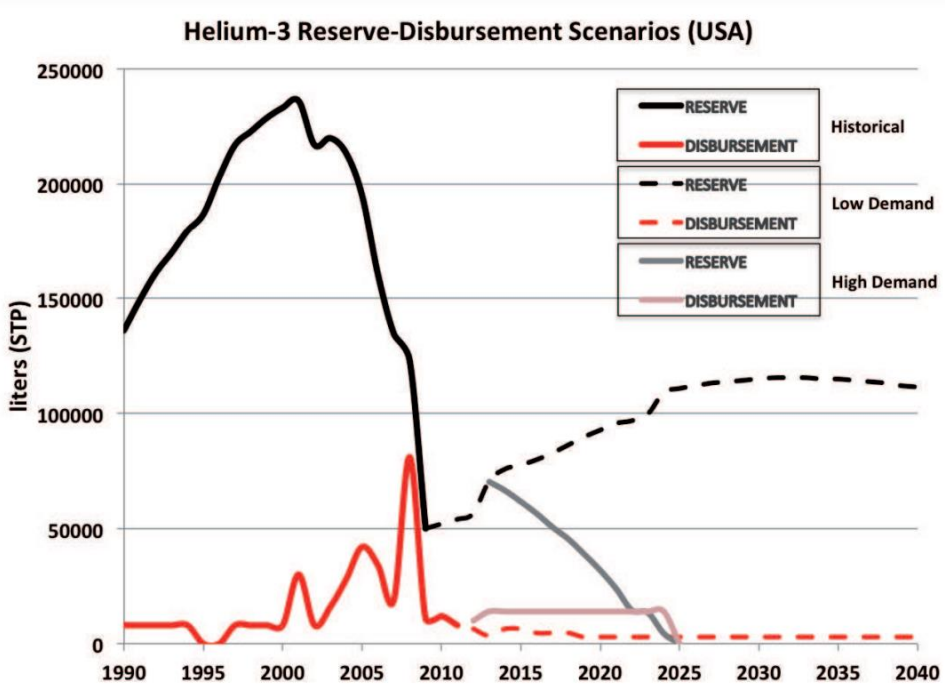
Outline

- Why are we still developing ^{3}He based neutron detectors?
- Why do we need CF_4?
- Gain Measurement of μRWELL in ^{3}He and CF_4
- Impact of these results
- Future measurements

New ^{3}He detectors for neutron scattering

- 2009 increase cost of ^{3}He
- Very low availability
- Situation improving
- Budget and technical challenge for large area neutron detectors

- Small area (200 x 200 mm^2)
- High efficiency (> 70% at 25 meV)
- High rate (>1 MHz/full detector area)
- High spatial resolution (<1 mm FWHM)



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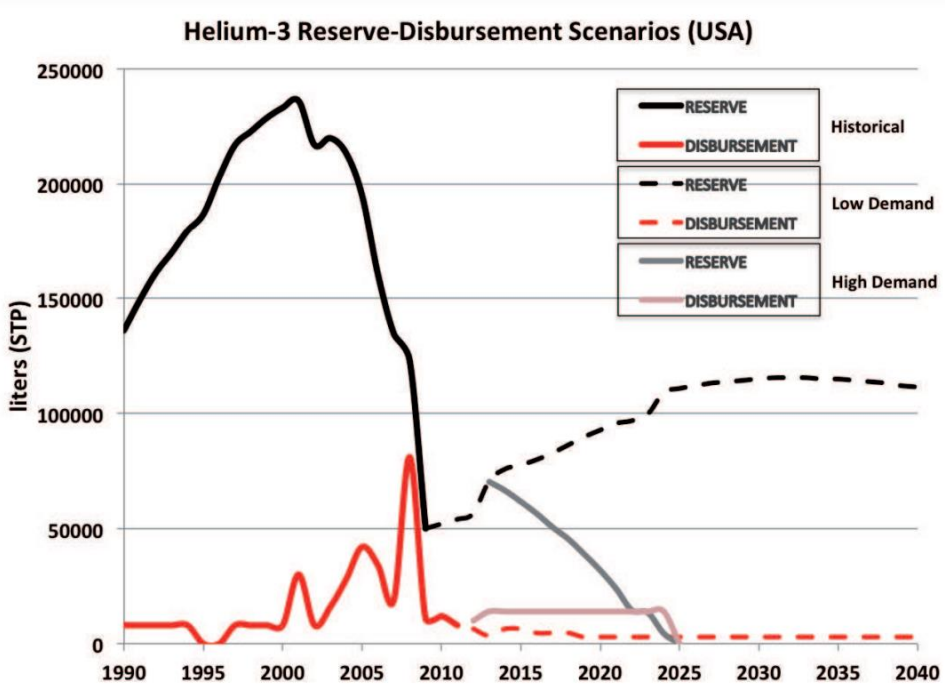
- MPGD ideal solution



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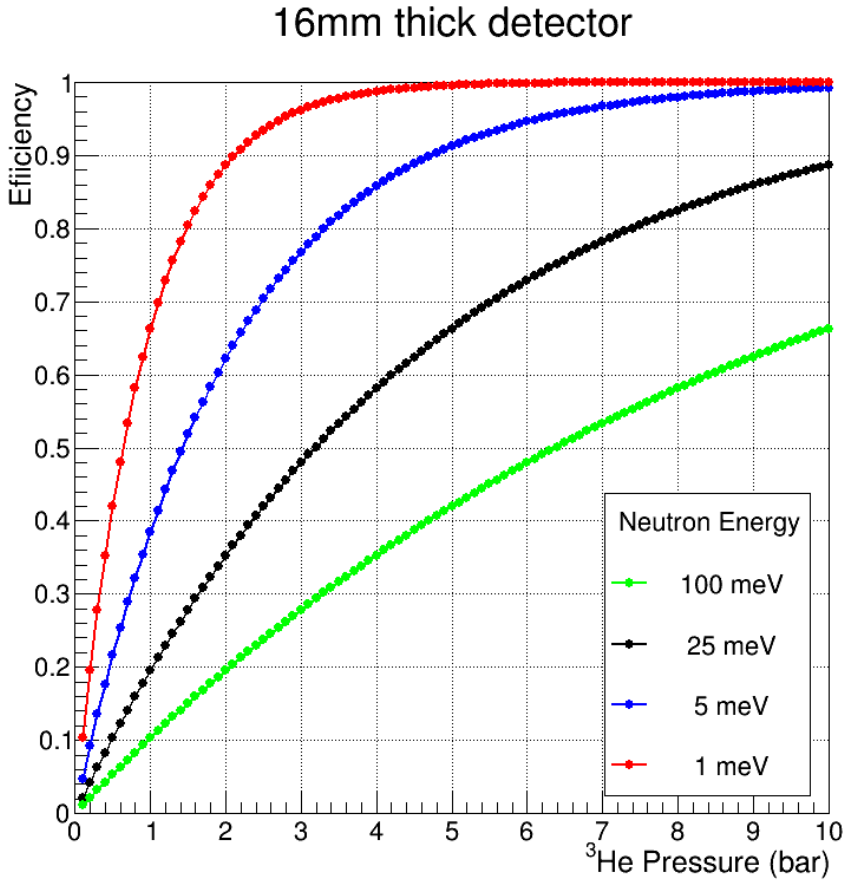
$^3He/CF_4$ gas mixtures

$$n + {}^3He \rightarrow {}^3H + {}^1H + 764\ keV$$

$$Efficiency = 1. - \exp(- n \cdot P \cdot \sigma \cdot d)$$

n = number density = 2.7 x 10^{19} /cm^3-bar
P = gas pressure [bar]
$\sigma(\lambda)$ = cross section [cm^2] (function of λ)
d = gas depth [cm]



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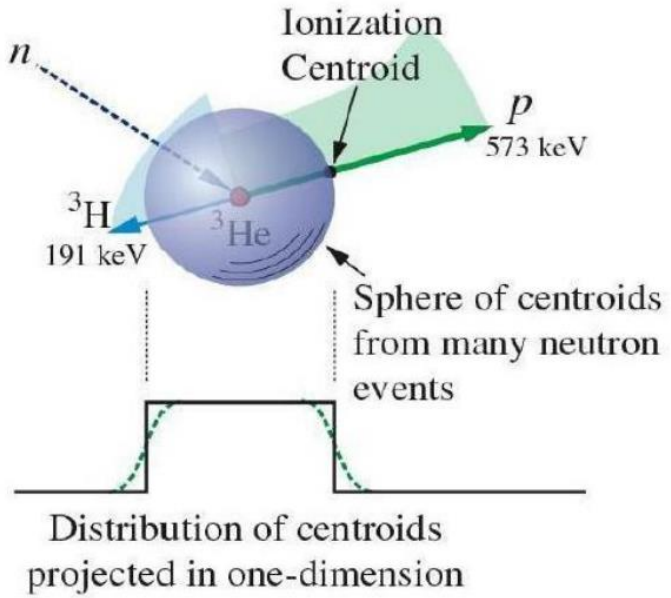

FWHM ~ 0.8 x proton range

V. Radeka, DOE BES Neutron&Photon Detector Workshop, Aug 1-3, 2012

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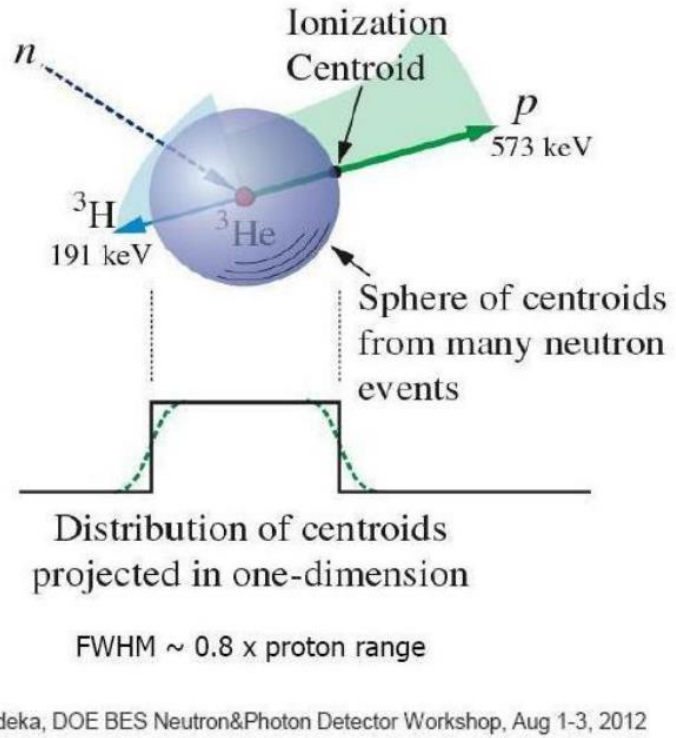

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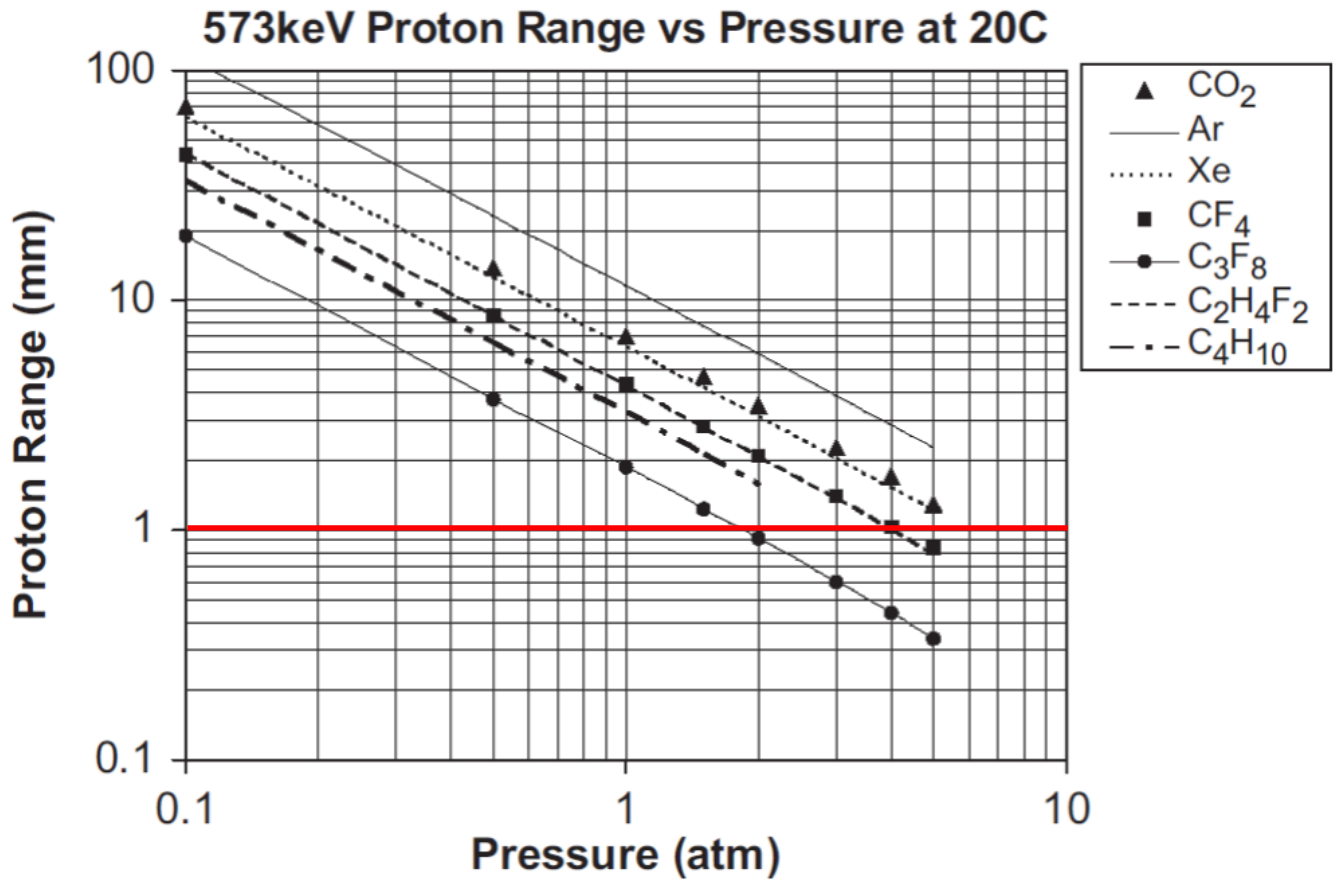

G.C. Smith et al.
doi:10.1016/j.nima.2012.01.035

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μRWELL setup at ISIS

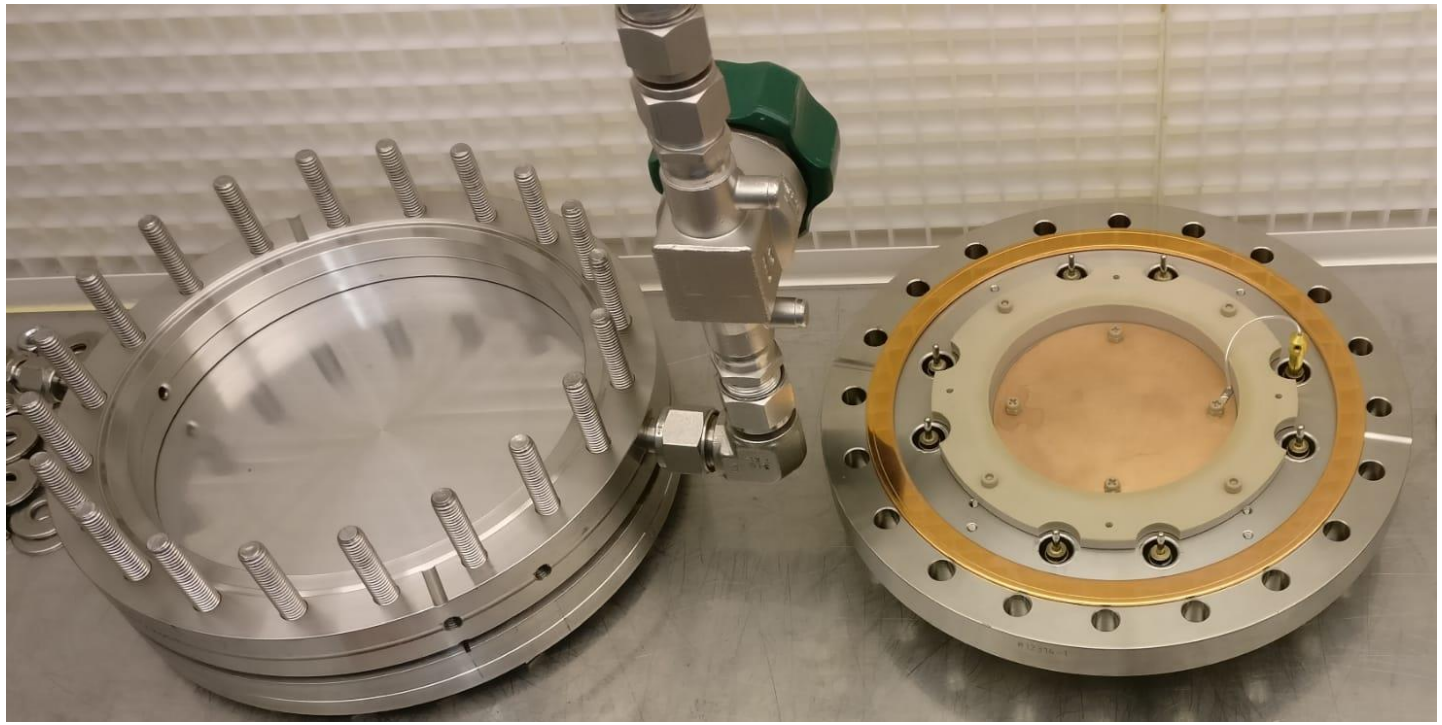
- Sealed vessel
- Certified up to 7bar

- 1bar ^{3}He
- 1 to 6 bar of CF_4 in step of 0.5 bar

- Active area 50x50mm^2
- DLC 80MΩ/□
- Anode segmented in four strips
- Joined together for this test

- Drift volume 16mm thick

- Bipolar preamp



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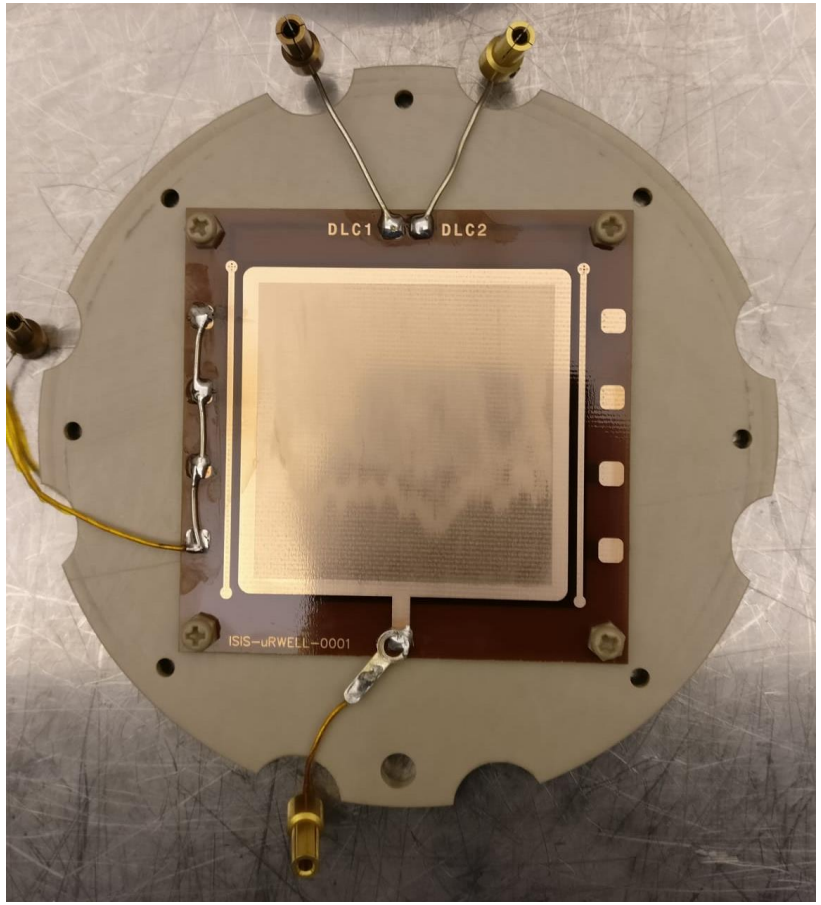

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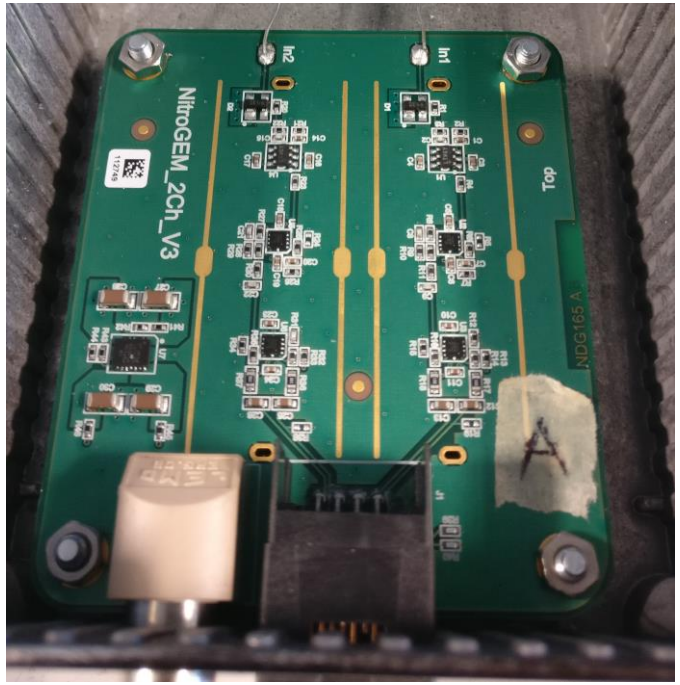
- Bipolar preamp based on LTC6226



PH spectrum

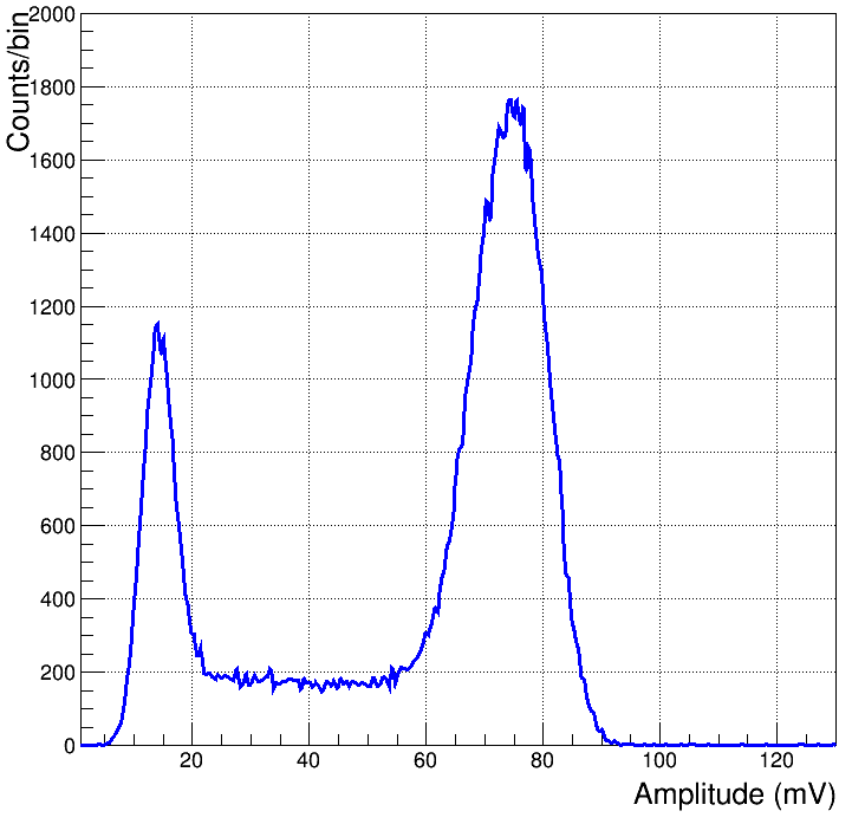
E_d = 1.875 kV/cm

1 bar of ^{3}He and 1 bar of CF_4

$V_{\mu RWELL}$= 480 V

Primary Charge 2.26 fC

Gain ~10



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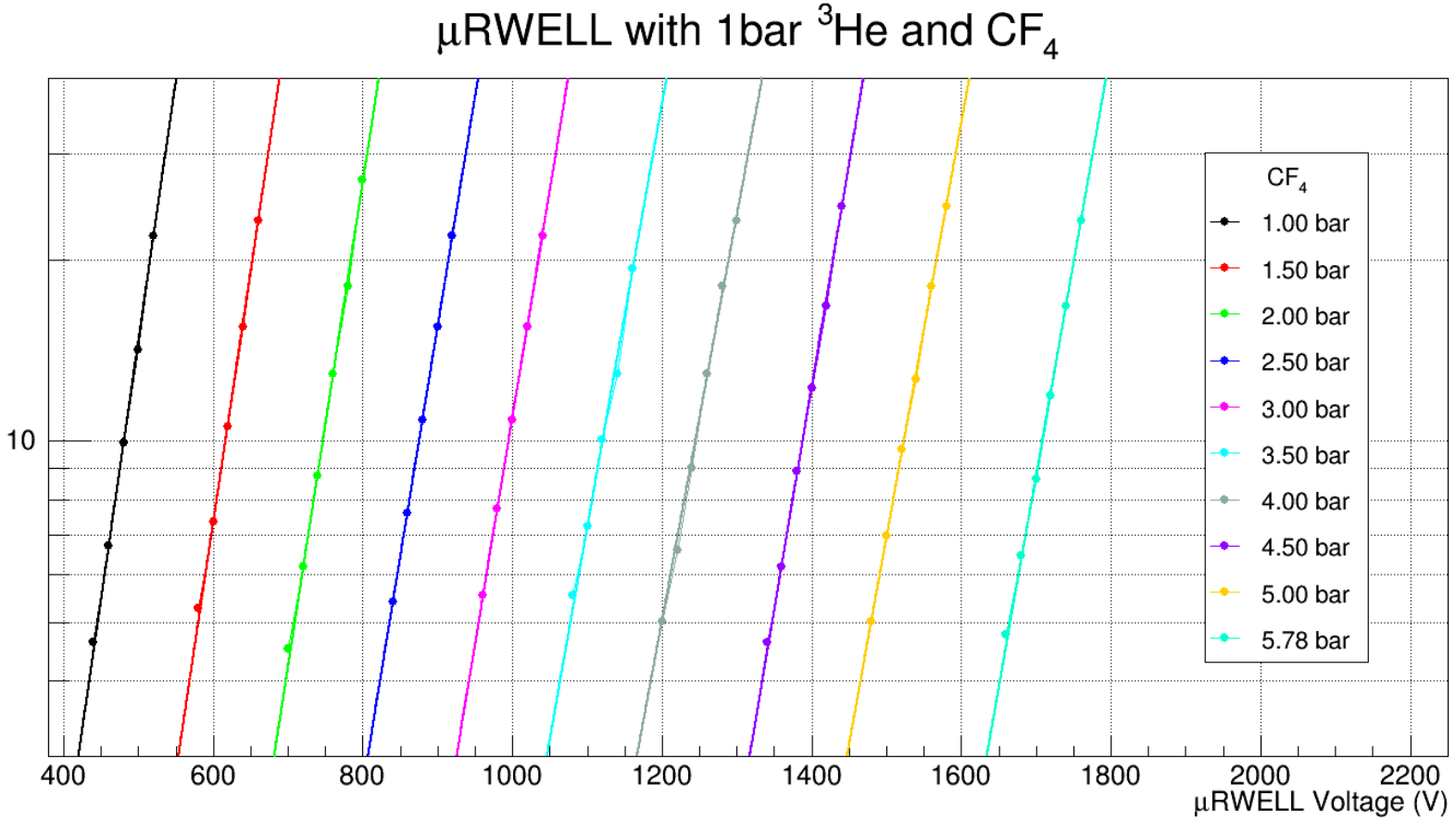
Gain Measurements

E_d=1.875 kV/cm

~280V/bar of CF_4



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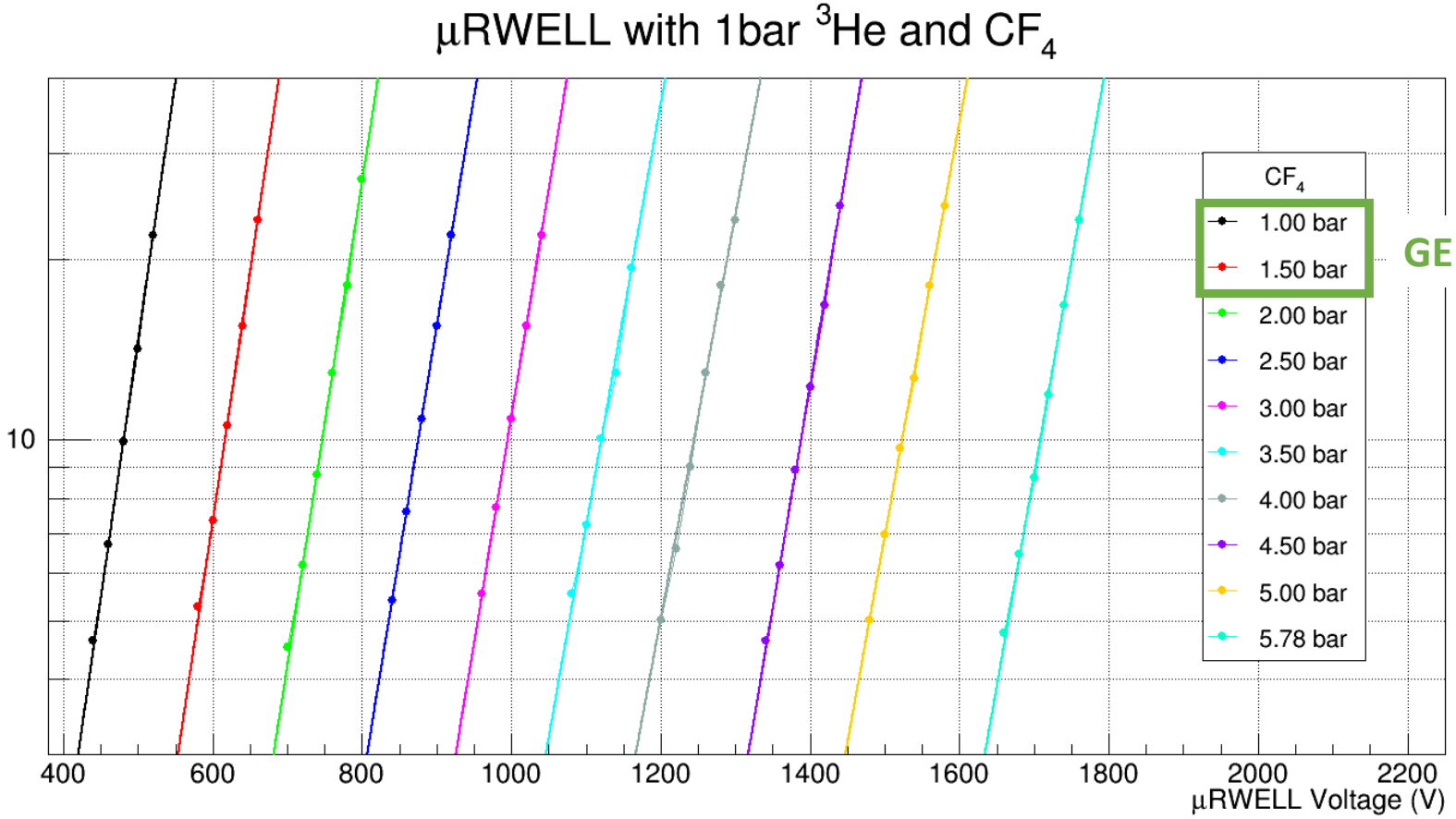

GEMs

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Gain Measurements

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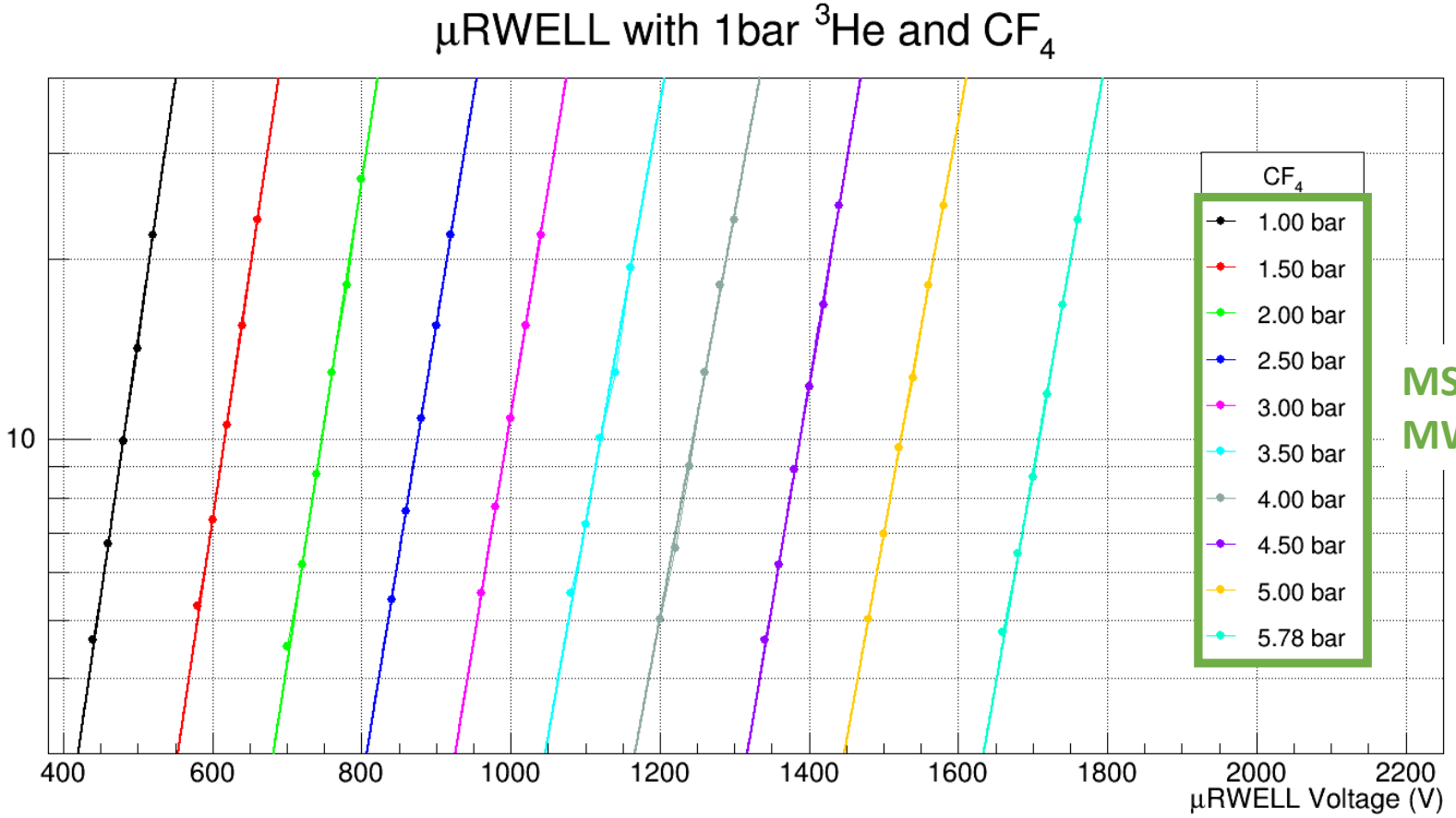

MSGCs
MWPC

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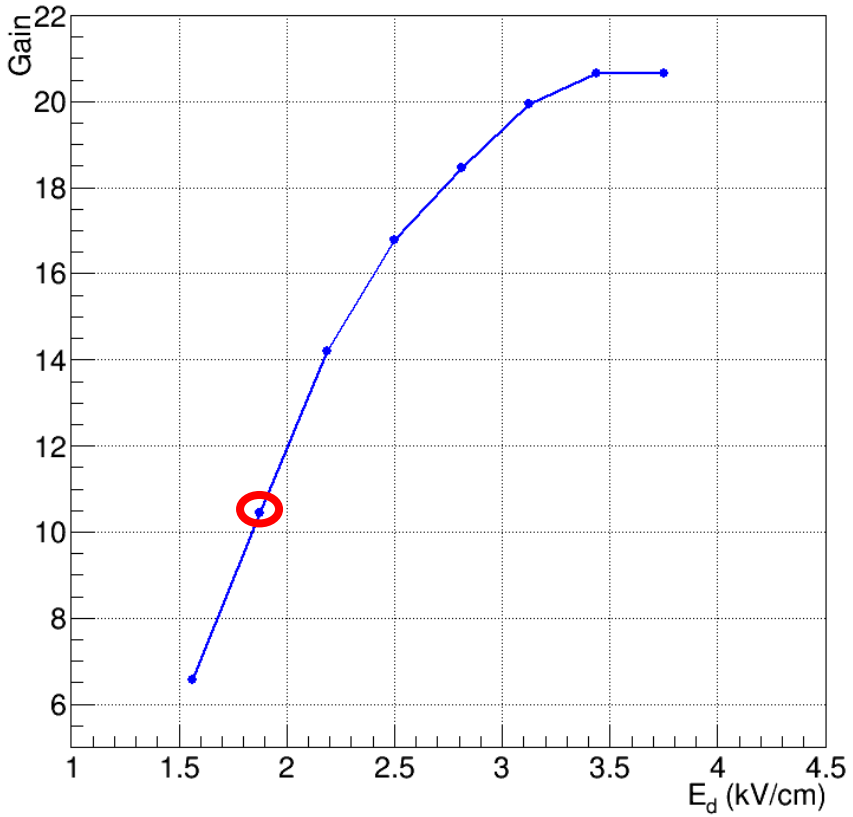
Scan in drift field

1bar ^{3}He +5.78bar of CF_4

$V_{\mu RWELL}$=1720 V

Primary charge collection increases by a factor two passing from 1.8 to 3.5 kV/cm



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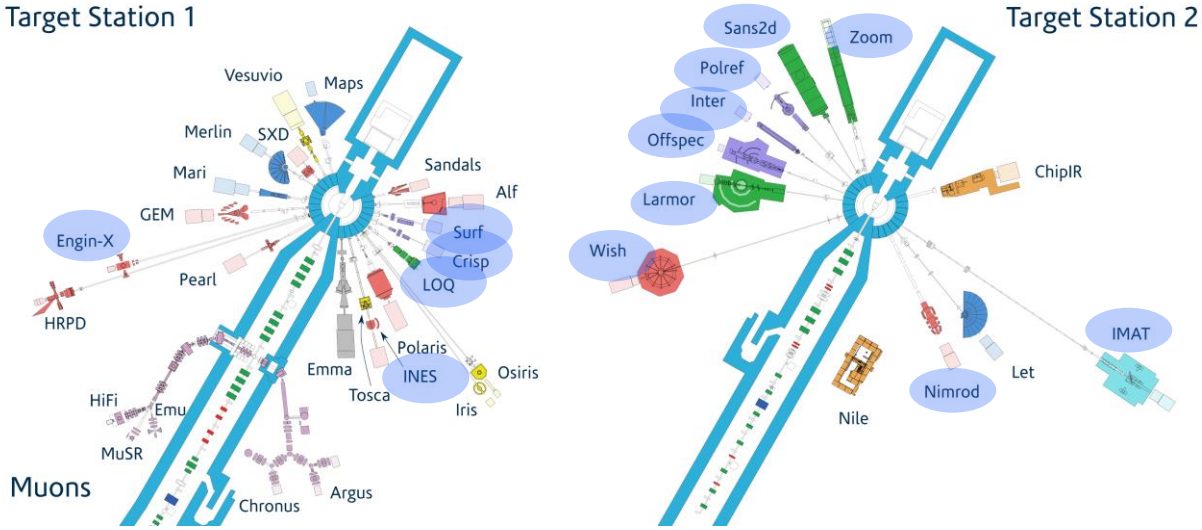
Results Summary

- We measured a gain between 20 and 40 with the μRWELL operating in ^3He and CF_4 up to 5.78 bar.
- Such gas mixture is a key component for a neutron detector with sub-millimetric position resolution (FWHM).
- MSGC – GEM – MWPC
- Potential application in neutron instruments:
  - SANS
  - Reflectometry
  - Imaging
- 14/30 instruments at ISIS



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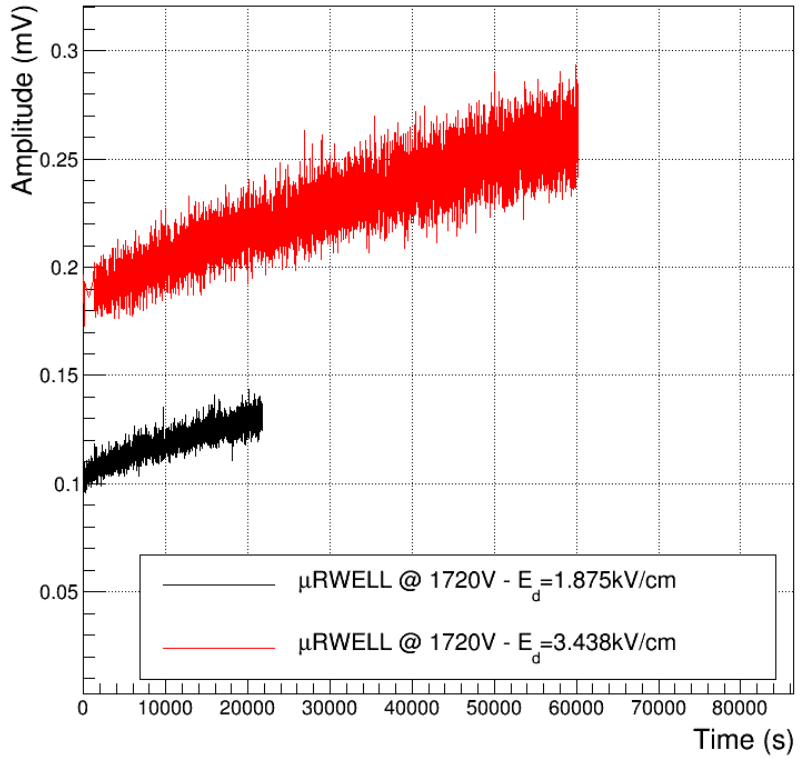
Next steps (without neutron beam)

- Better understanding and control of charging up
- Gain increase up to a factor 40% in 17h:
  - Neutrons from AmBe source
  - Detected rate ~200Hz
  - Gain ~20
- The charge up does not disappear after:
  - Switching of the detector for up to 72h
  - Inverting the polarity of the electrodes
- Next things to try:
  - Different connection to ground of the DLC layer
  - Cylindrical holes in the Kapton rather than conical
- Ideas for the future:
  - Is Kapton's resistance too high?
  - Is there any other suitable material (with lower resistance) to build a µRWELL?



Next steps (with neutron beam)

- Beam available at ISIS in autumn
  - At the end of Target Station 1 long shutdown
- Measure the rate capability
  - Once we have the charging up under control
- Measure the position resolution
  - Already designing μRWELL with X-Y readout
  - Modifying the current vessel
  - Exploring several electronics options for the readout