



UNIVERSITÉ DE NANTES



# A liquid xenon TPC for a medical imaging Compton telescope

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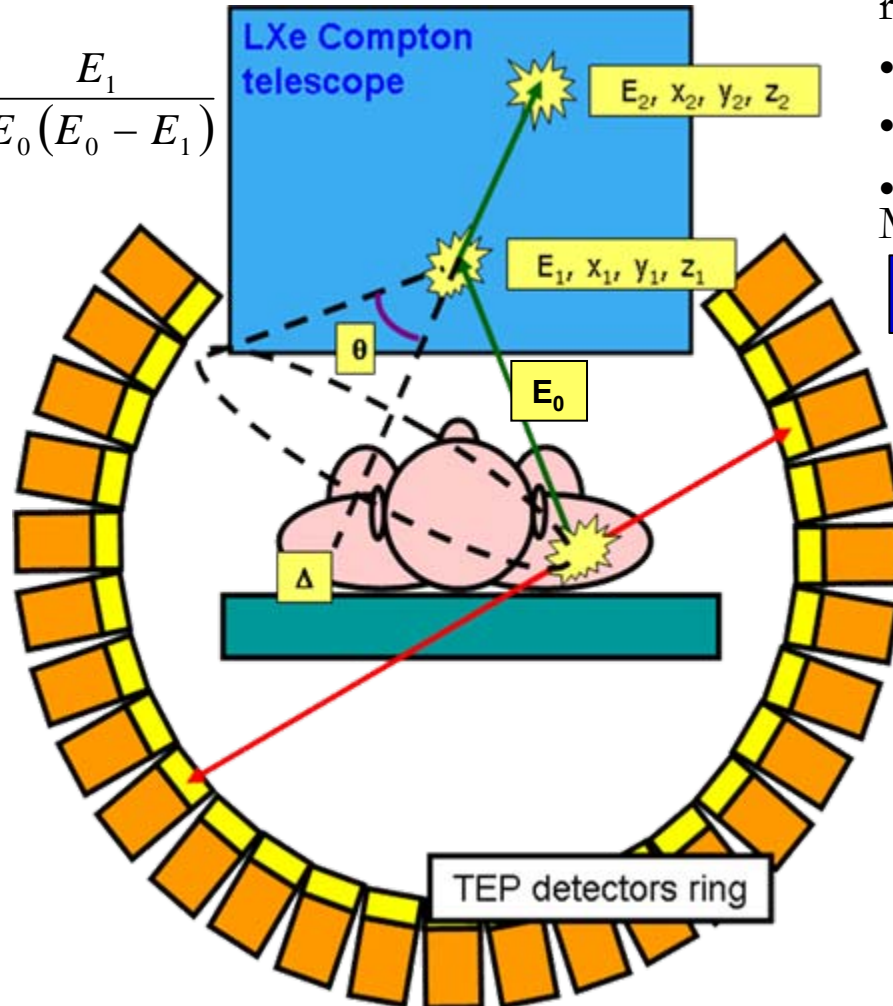


# Outline

- Context : the  $3\gamma$  imaging
- Apparatus
- Measurements
  - Procedure
  - Results

# The 3 $\gamma$ imaging

$$\cos \theta = 1 - m_e c^2 \frac{E_1}{E_0 (E_0 - E_1)}$$



Promising GEANT4 simulation results obtained with :

- 500  $\mu\text{m}$  spatial resolution
- low noise ( $\sim 200$  e-)
- 2.3% energy resolution at 1 MeV

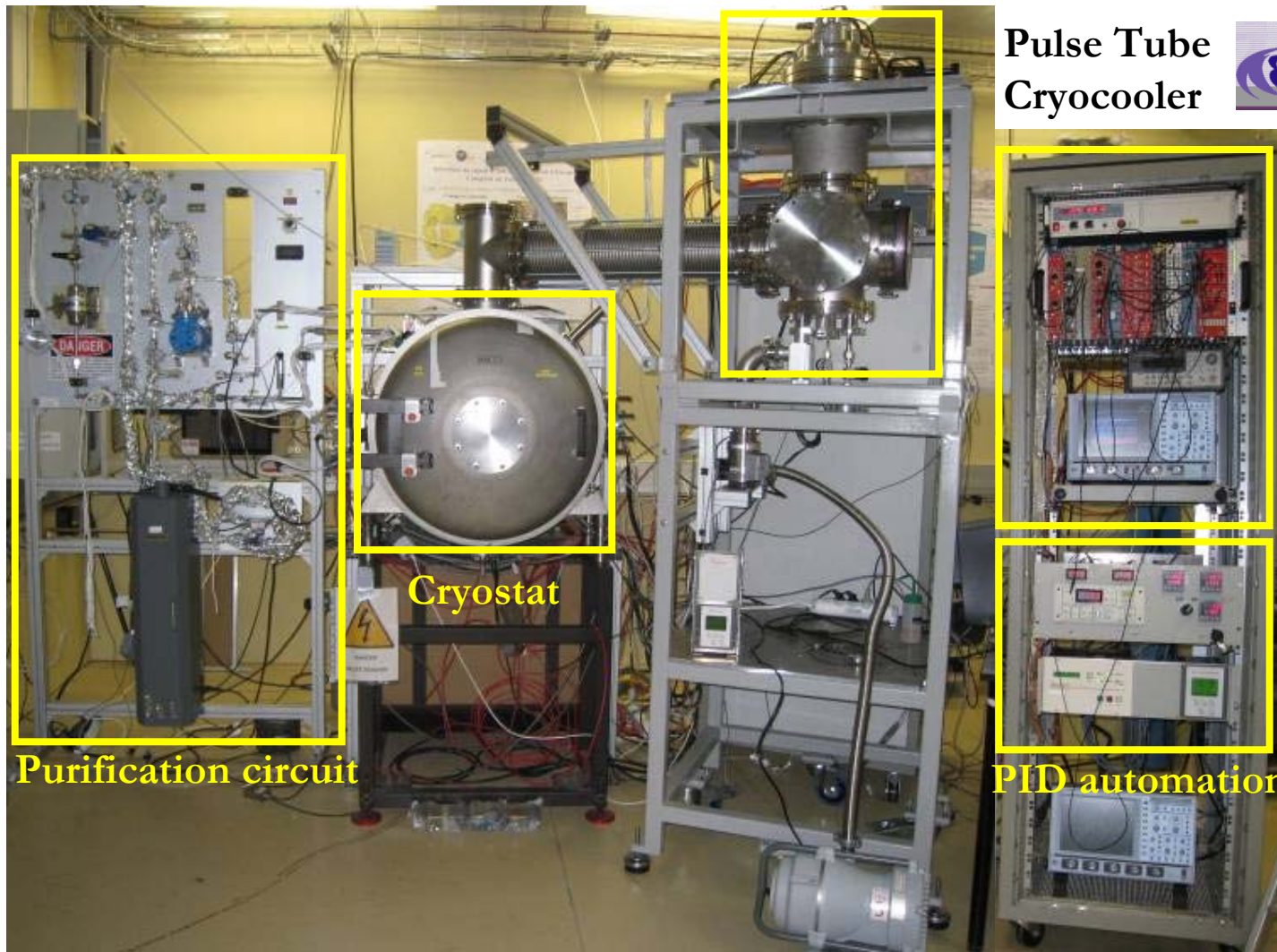
↳ Strong requirements on instruments

$\beta^+$ - $\gamma$  emitter :  $^{44}\text{Sc}$

Production research at



# The cryogenic prototype



Pulse Tube  
Cryocooler



DAQ system

Cryostat

Purification circuit

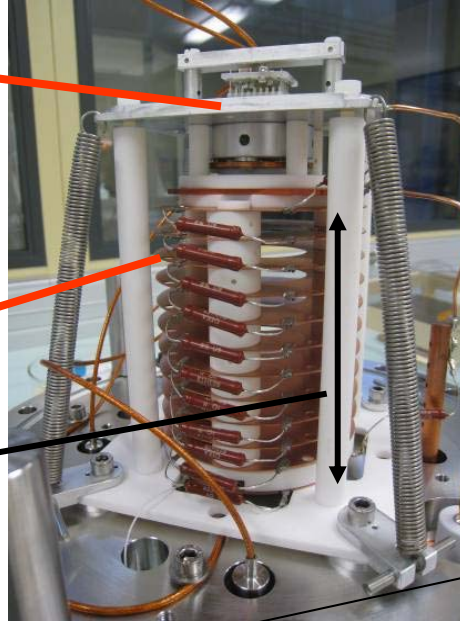
PID automation



# The Time Projection Chamber

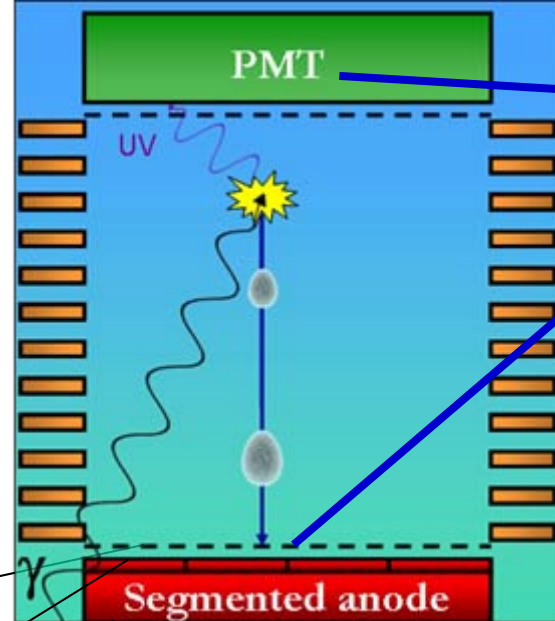


Hamamatsu PMT



Field rings

Height : 12 cm



Scintillation

$t_0$

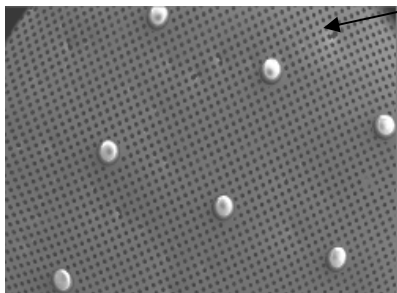
+ Ionisation

$t_1, E, x, y$

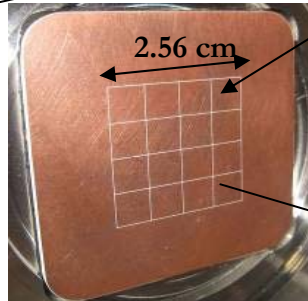
=

3D position :

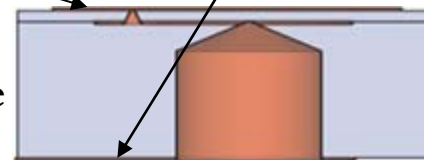
$x, y, z = v_{\text{drift}}(t_1 - t_0)$   
and energy  $E$



Micromegas grid

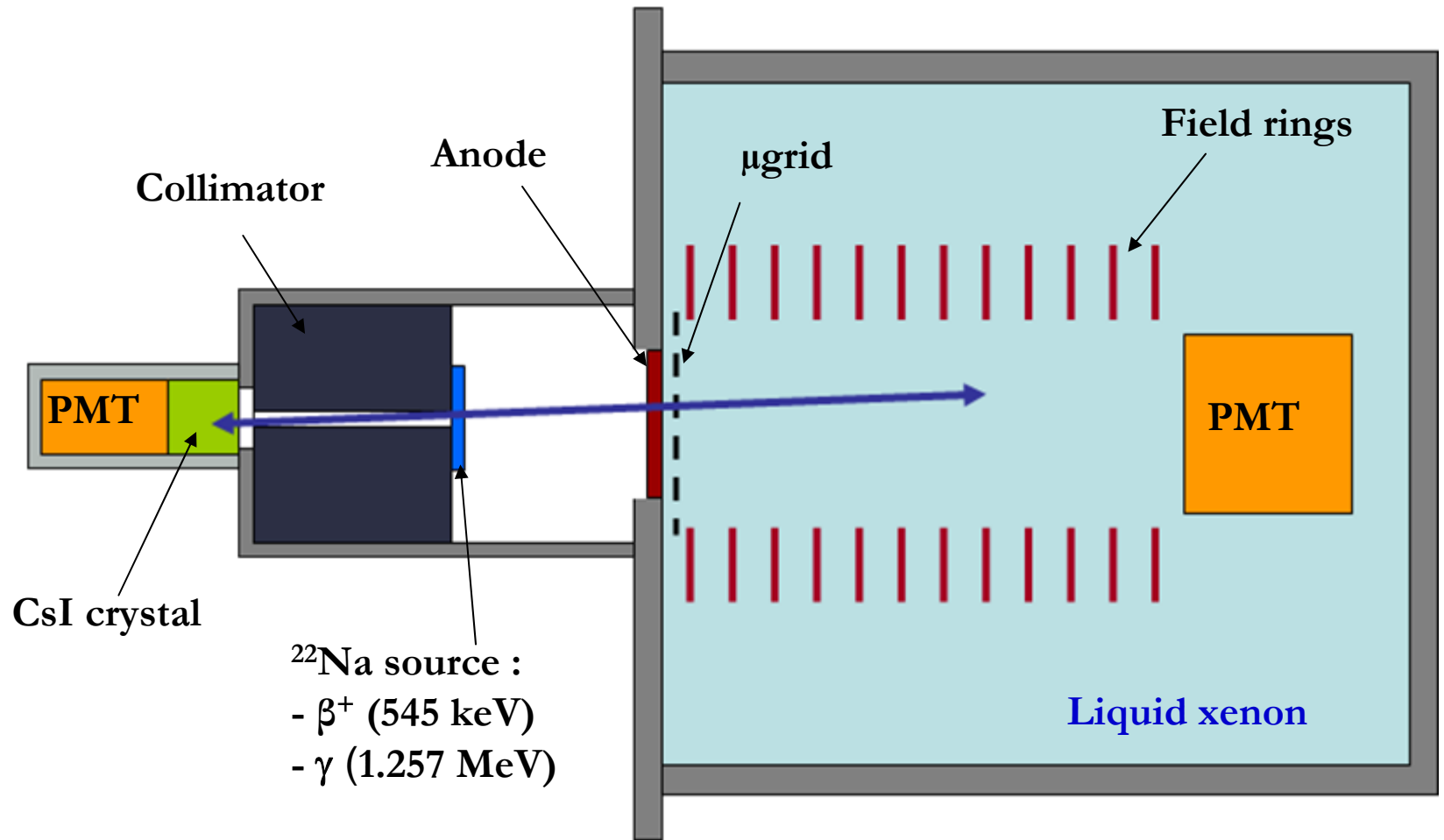


Segmented anode



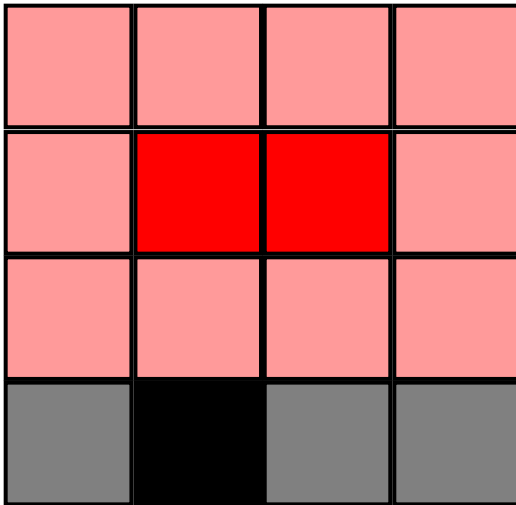
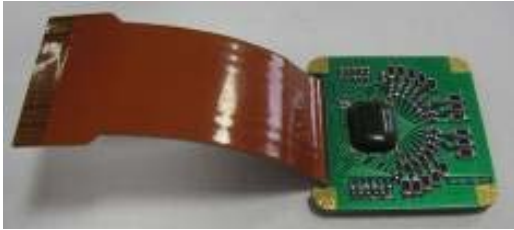
IDeF-X FEE

# 511 keV gammas acquisition

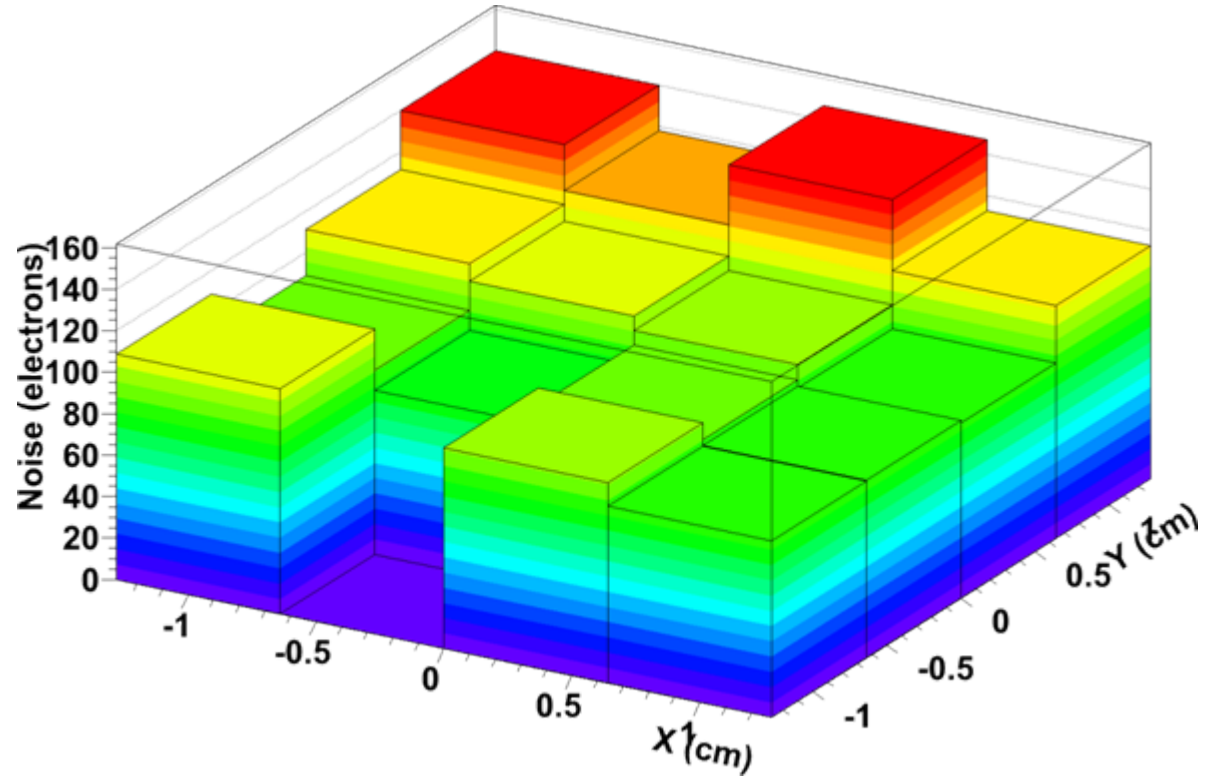


# FEE characterization

16 channels for 16 pads

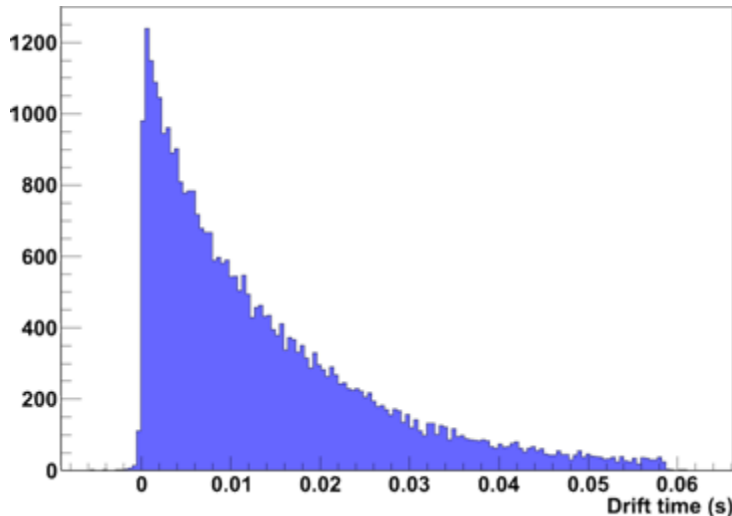


Only hits located in red region are used for the analysis.

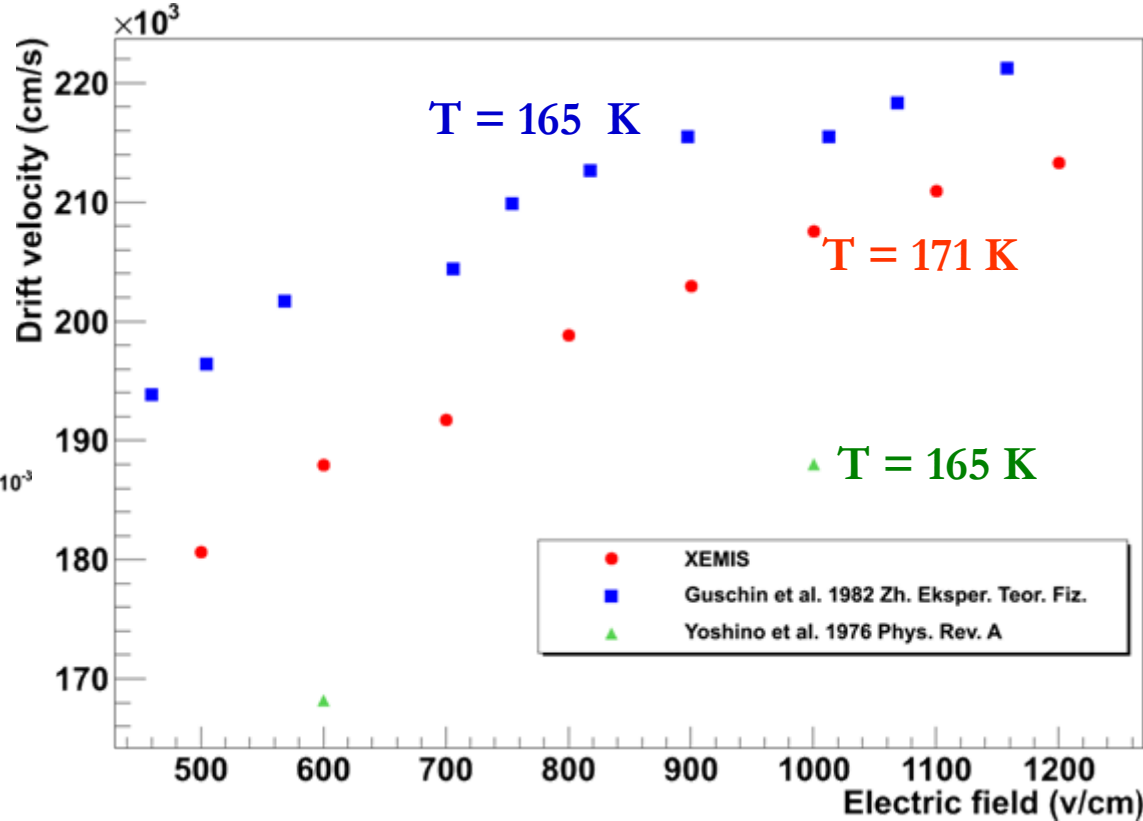
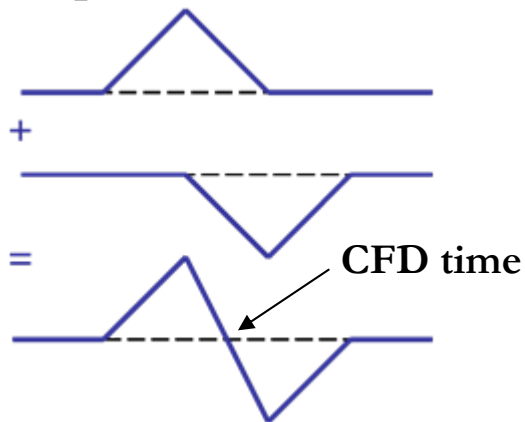


Noise on central pads  $\sim 100$  e- @171 K  
Best electronic noise measured in LXe

# Drift velocity measurement



Constant Fraction Discriminator principle:

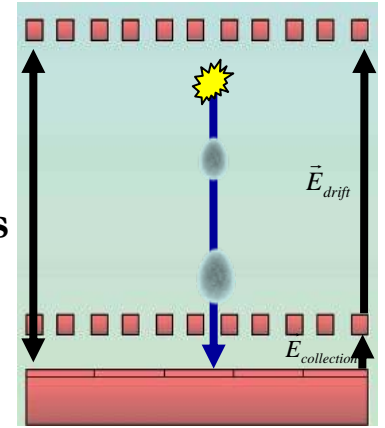


- Accurate drift time measurement:
- $\sigma \sim 165$  ns at the anode level
- $\sigma \sim 320$  ns at the cathode level



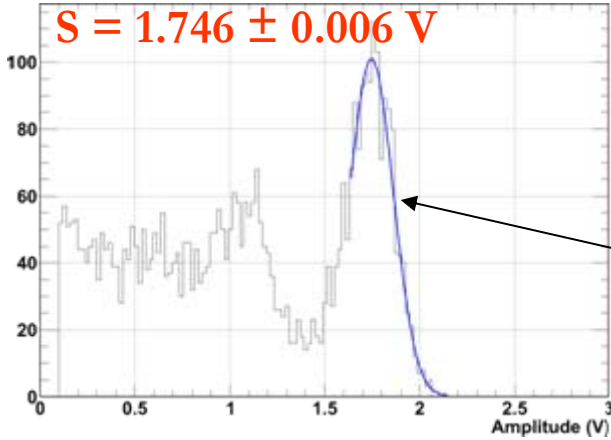
# Electron attenuation correction

Signal attenuation due to electronegative impurities:



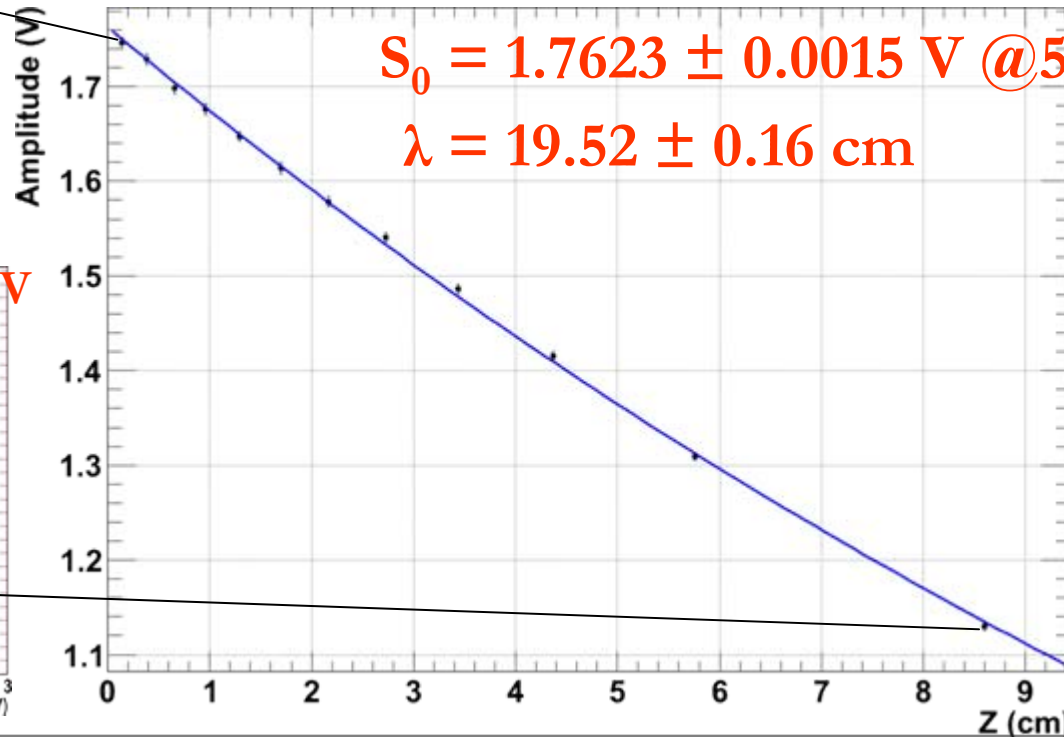
$$S(z) = S_0 e^{-\frac{z}{\lambda}}$$

$S = 1.746 \pm 0.006 \text{ V}$

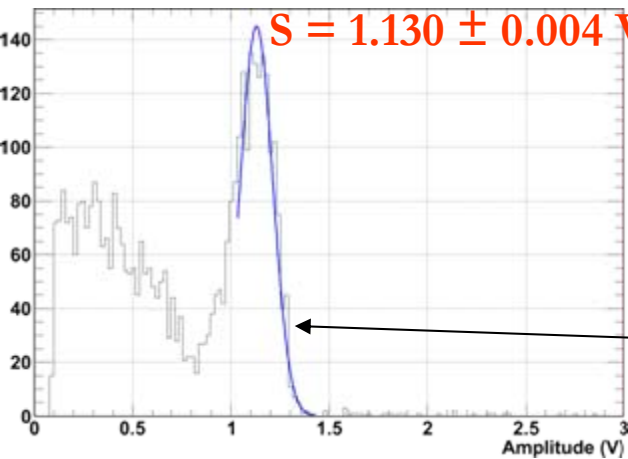


$S_0 = 1.7623 \pm 0.0015 \text{ V @511 keV}$

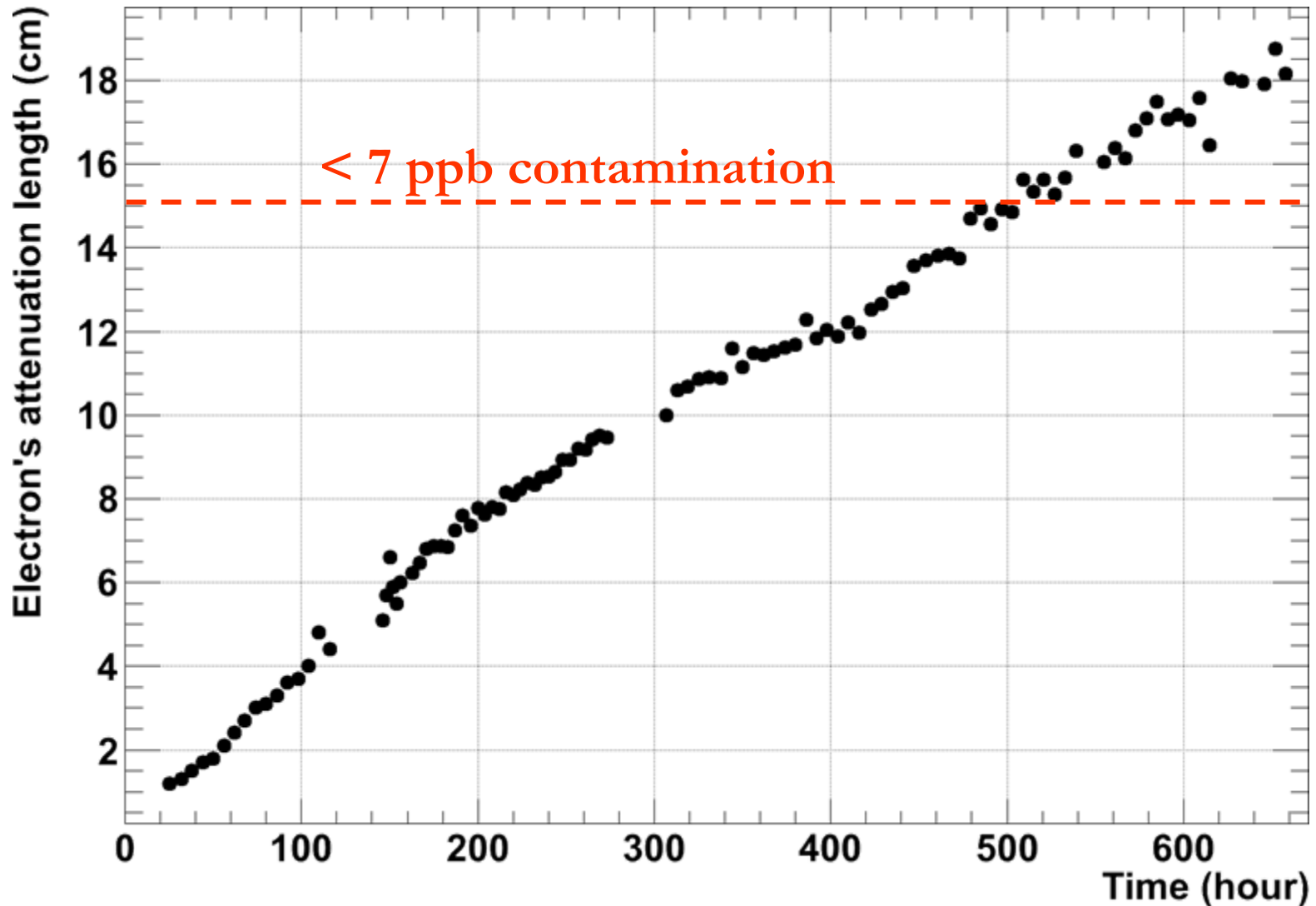
$\lambda = 19.52 \pm 0.16 \text{ cm}$



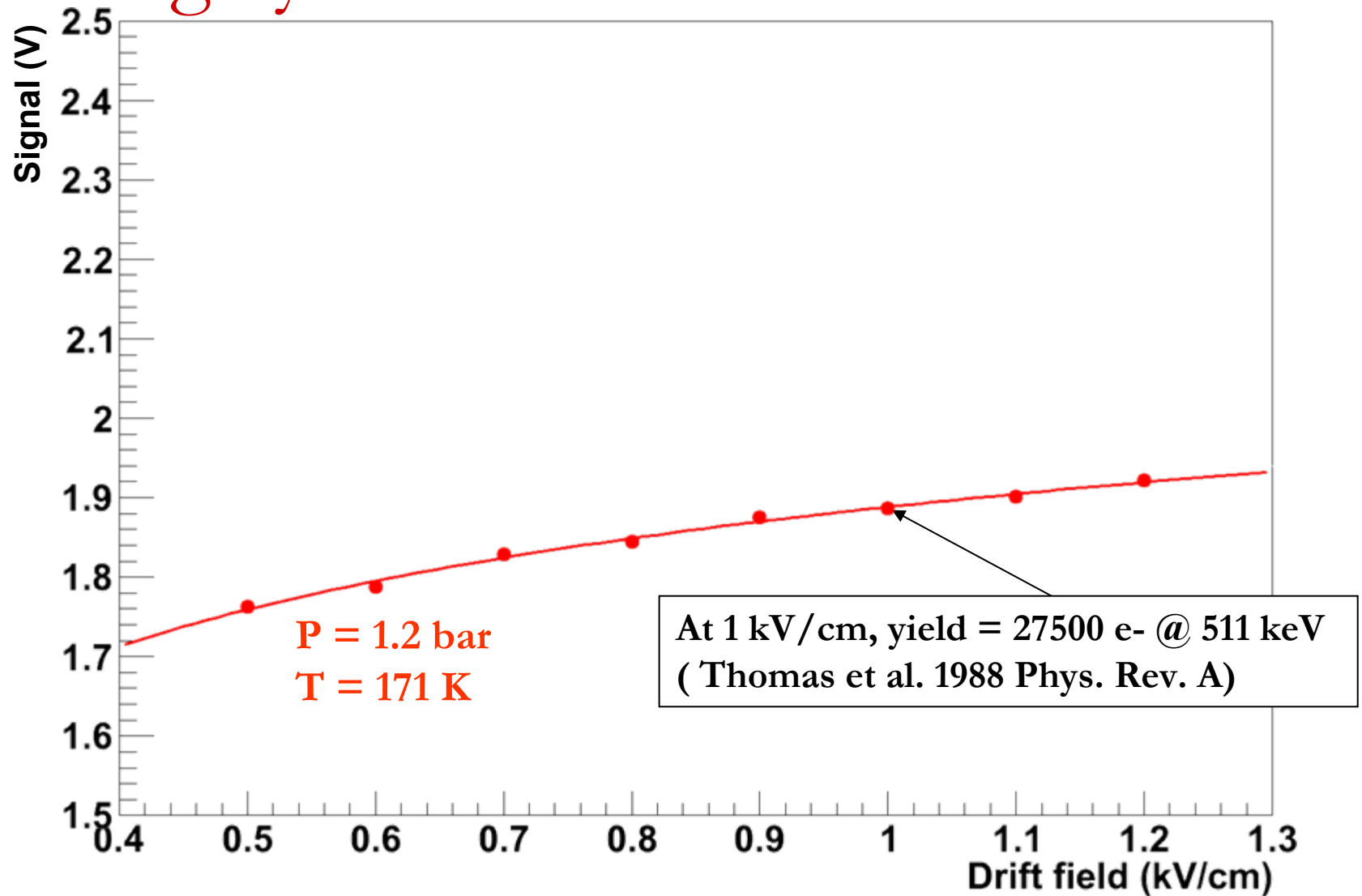
$S = 1.130 \pm 0.004 \text{ V}$



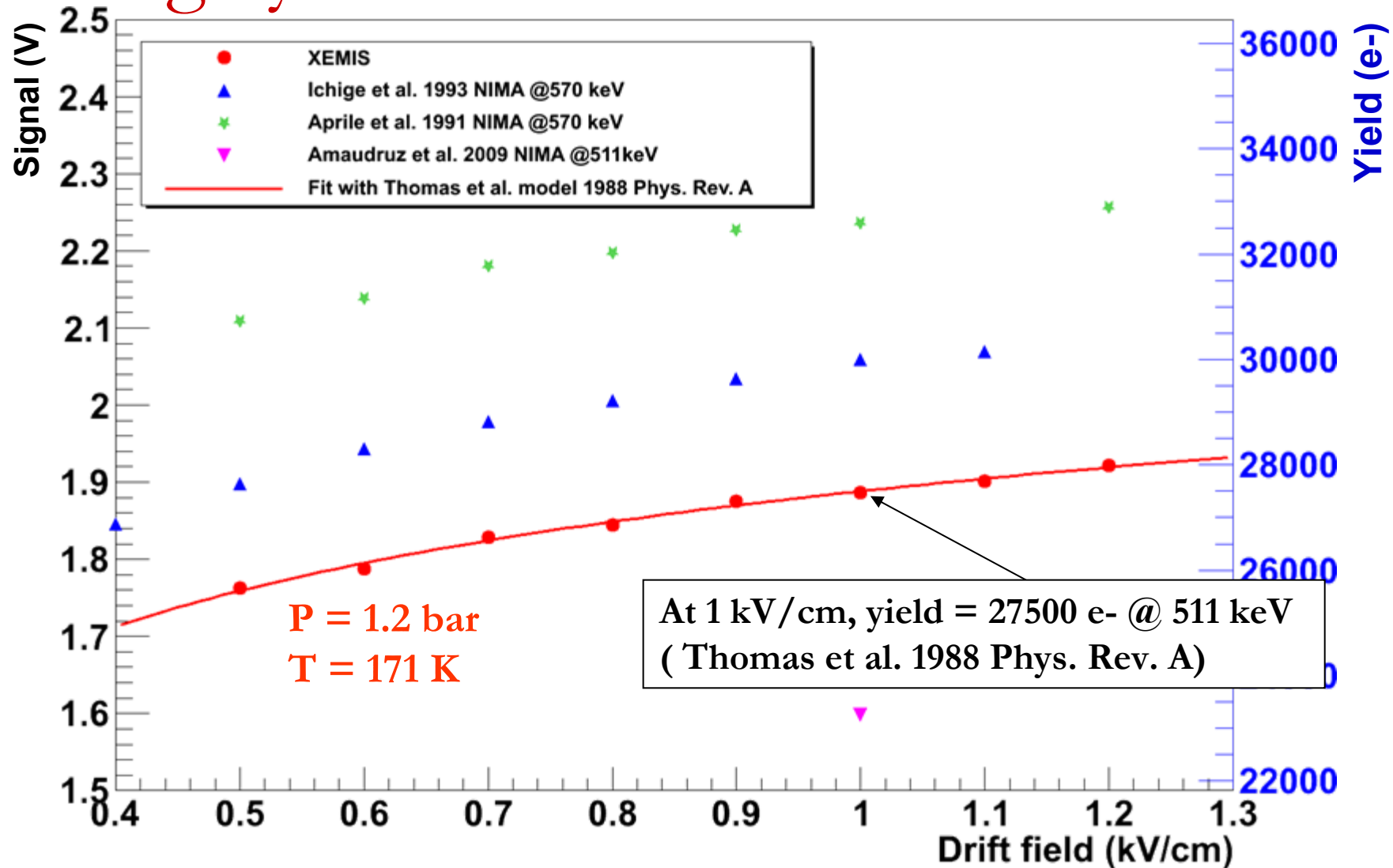
# Attenuation length evolution



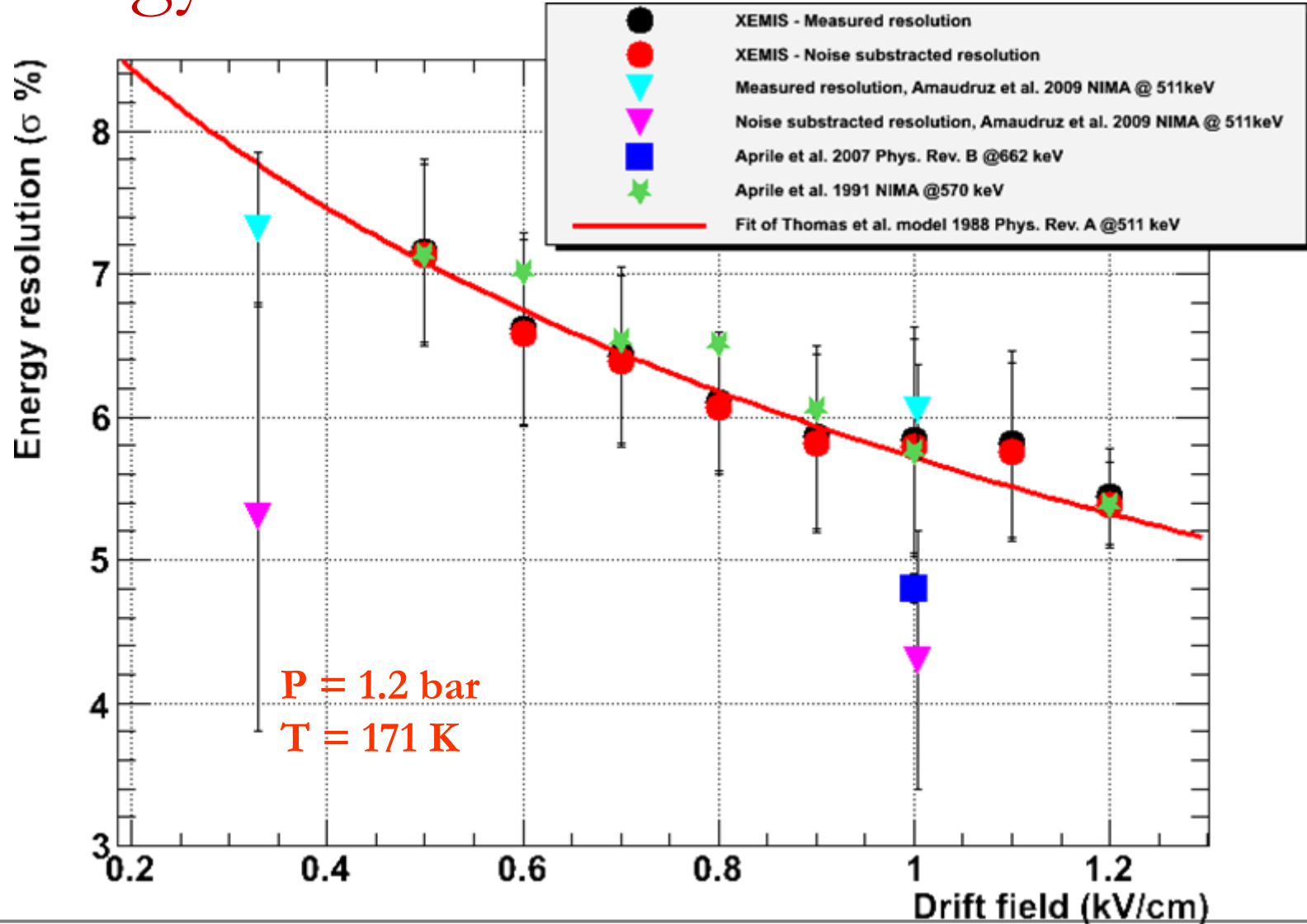
# Charge yield



# Charge yield



# Energy resolution





# Conclusion

- Low electronic noise ( $\sim 100 e^-$ )
- Good energy resolution
- Good Z-axis spatial resolution ( $< 500 \mu\text{m}$ )
- **Proof of concept is nearly done**  
 **$\sim 0.5 \text{ mm X and Y}$  resolution position has to be reached.**