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Investigation of the position resolution of the HOTWAXS Detector (Imaging at Higher X-ray Energies (10keV –30keV))

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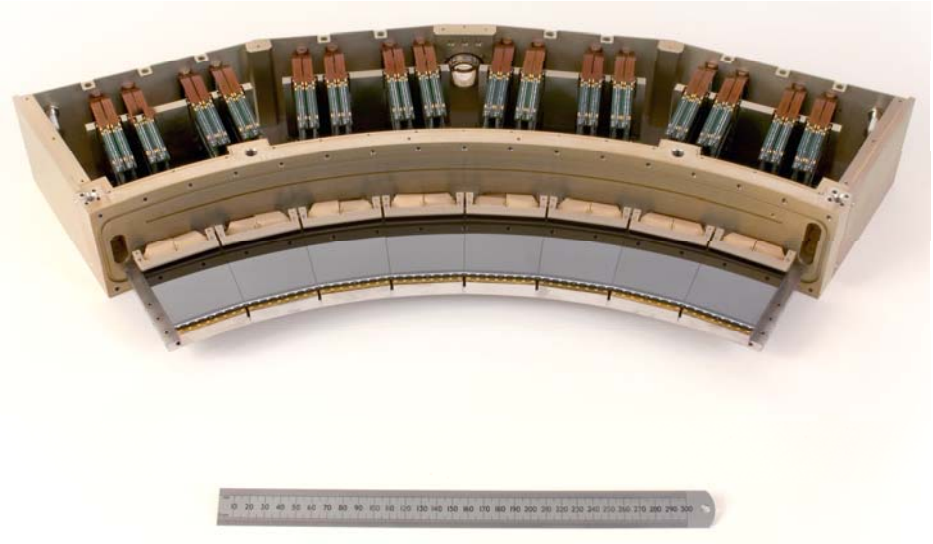
What is HOTWAXS?

- 512 independent channels of preamplifier, scaler and discriminator
- Channel count rate of 1 MHz, Global count rate 500 MHz
- 60º angular coverage, 400mm sample to detector distance
- 50mm active gas depth



see NIM A580 (2007) p1526

Imaging above 10keV

- For E_x<10keV resolution governed by convolution of electronic noise, secondary electron diffusion and primary photoelectron range - leads to quasi-normal charge footprint
- For E_x>10keV resolution photoelectron range dominates, varies as $E_{pe}^{1.7}$ So resolution rapid function of E_x
- HOTWAXS pixellated readout with LLD as only parameter, limits low energy resolution, but less severe increase in FWHM as E_x increases (at sacrifice of efficiency)

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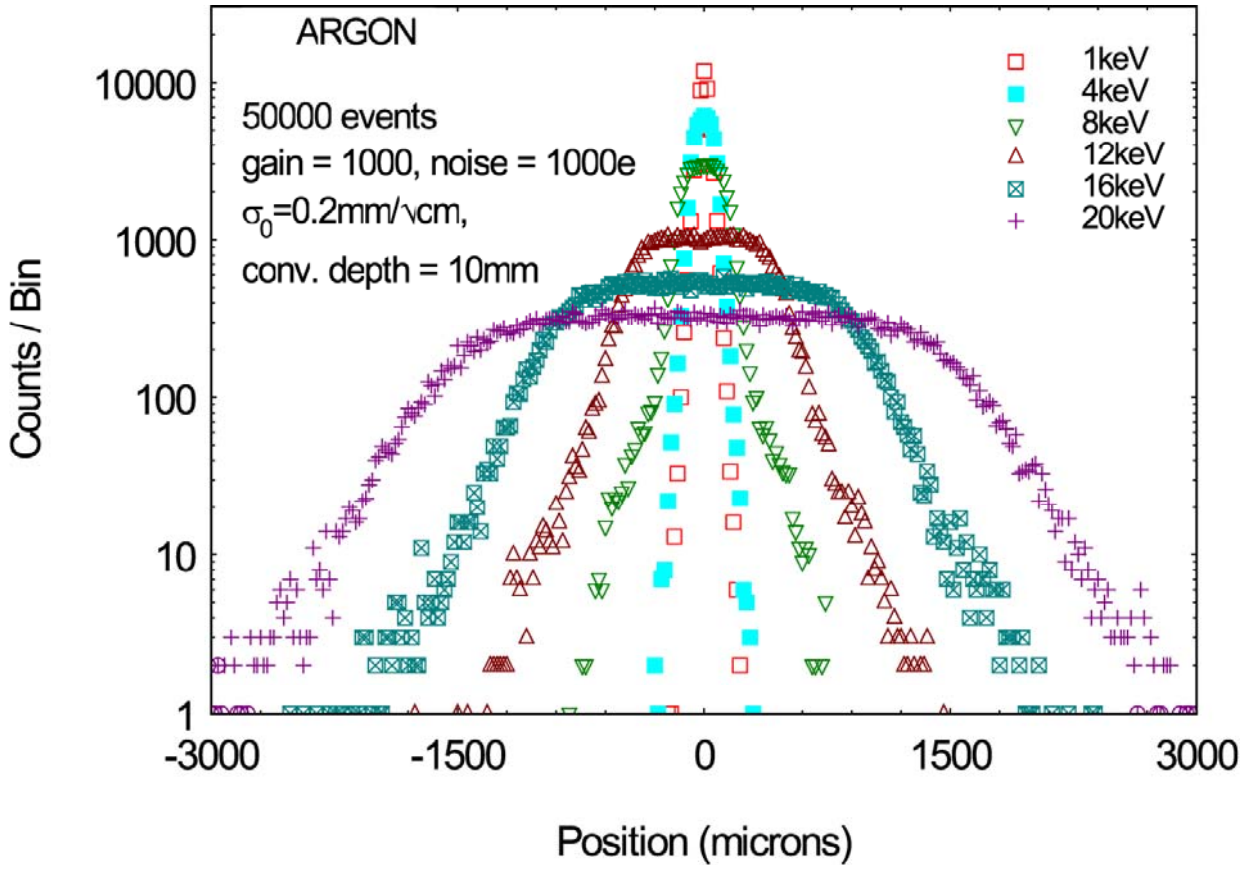
Charge footprint from simulation



In argon, K shell vacancy left with stored energy of 3.2keV which is dissipated locally in auger electrons (with max range of ~200μm)

In xenon, L shell vacancy, energy of 5.1keV, dissipated in ~100μm

Since these dimensions are small compared to HOTWAXS strip width, there is a punctual deposit at the X-ray interaction point of ~119 electrons for Ar, and ~189 electrons for Xe

As E_x increases, linear deposit of long range photoelectron energy in any strip decreases (as $E_x/E_x^{1.7}$) So that with a high LLD, the extra deposit in the 'correct' strip can be preferentially detected

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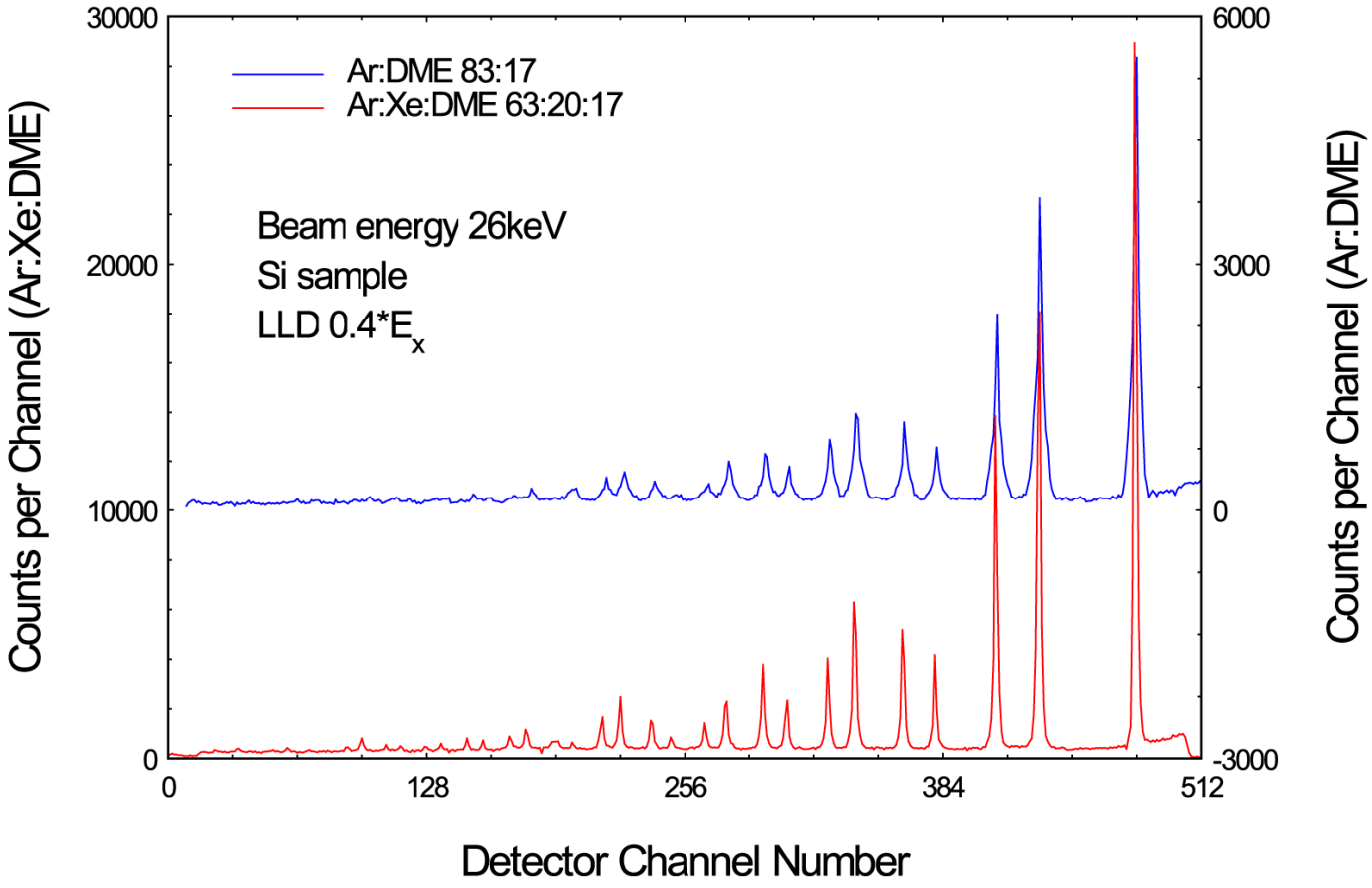
Si diffraction at 26keV



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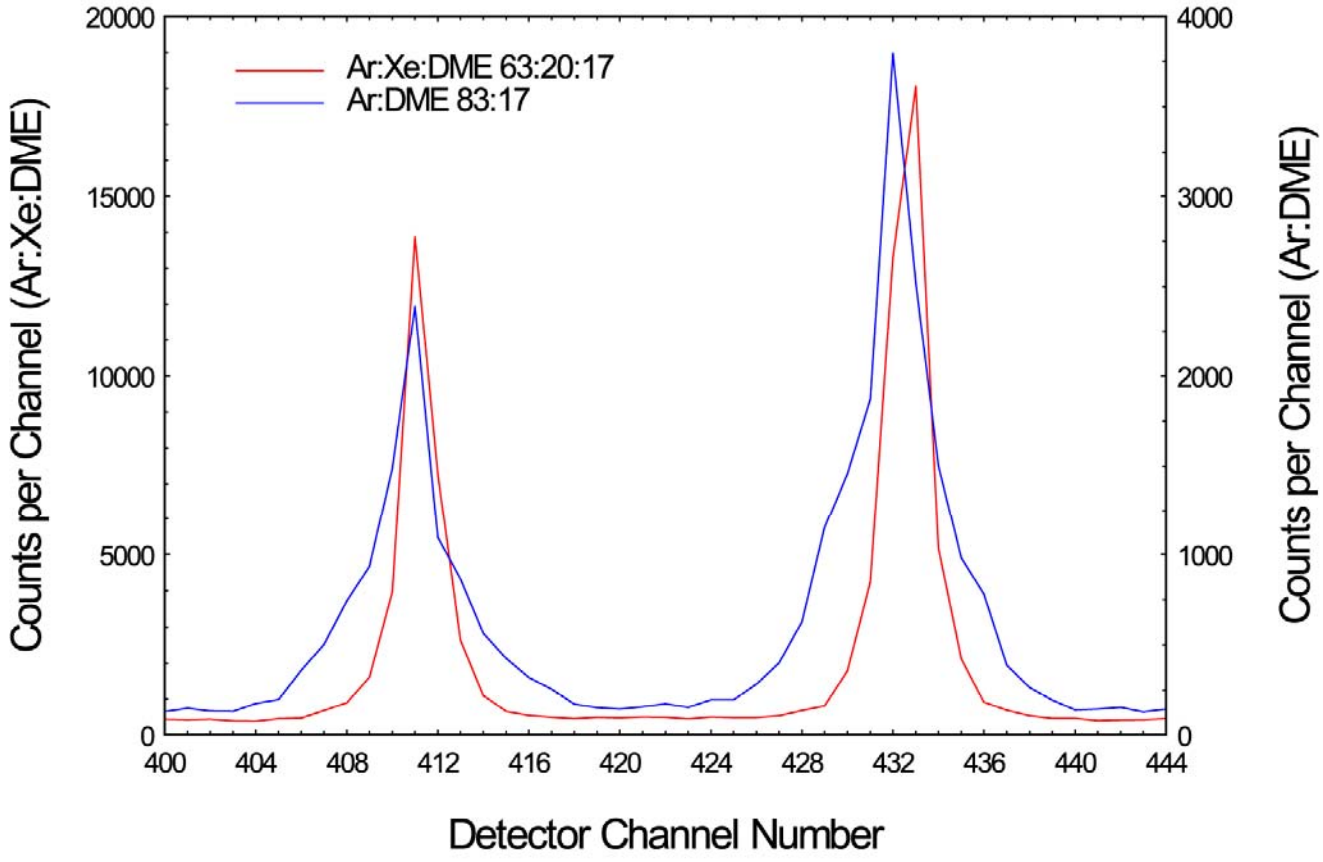
Si diffraction at 26keV



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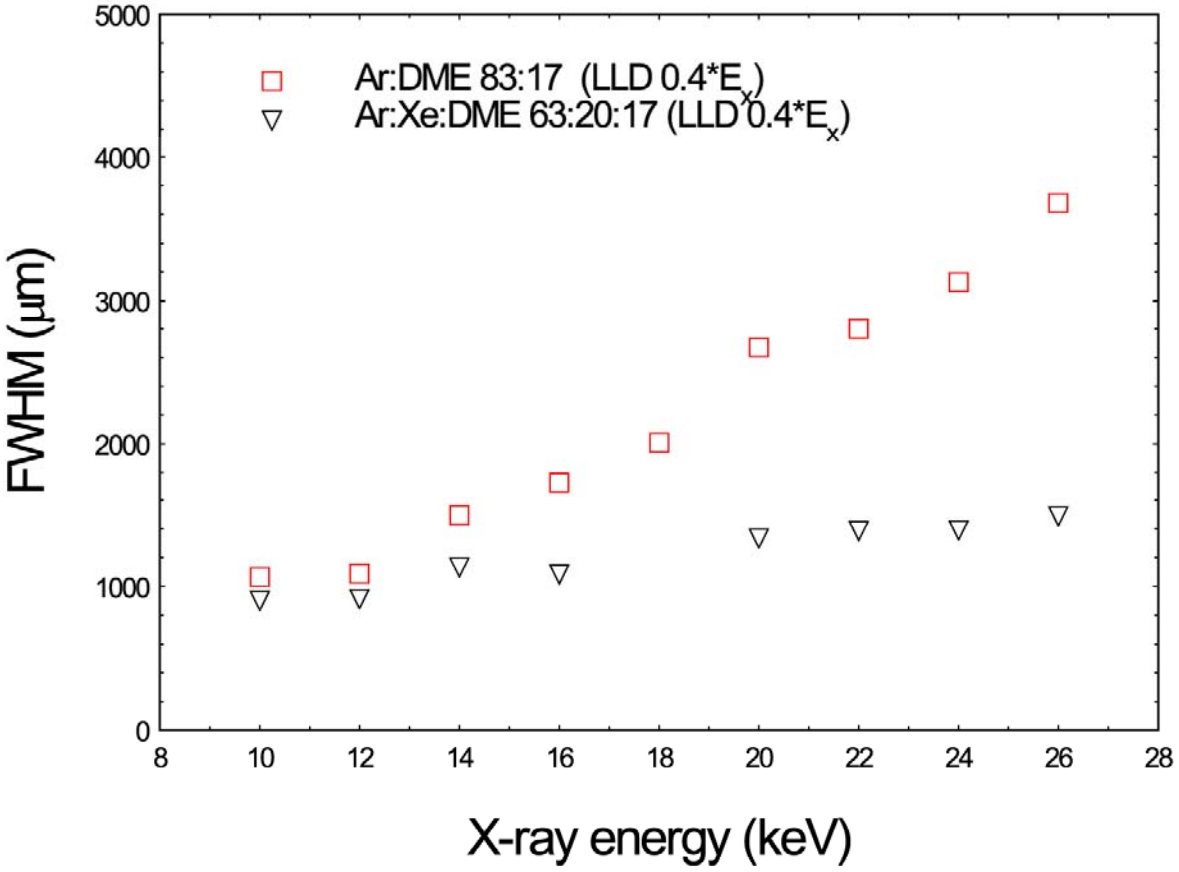
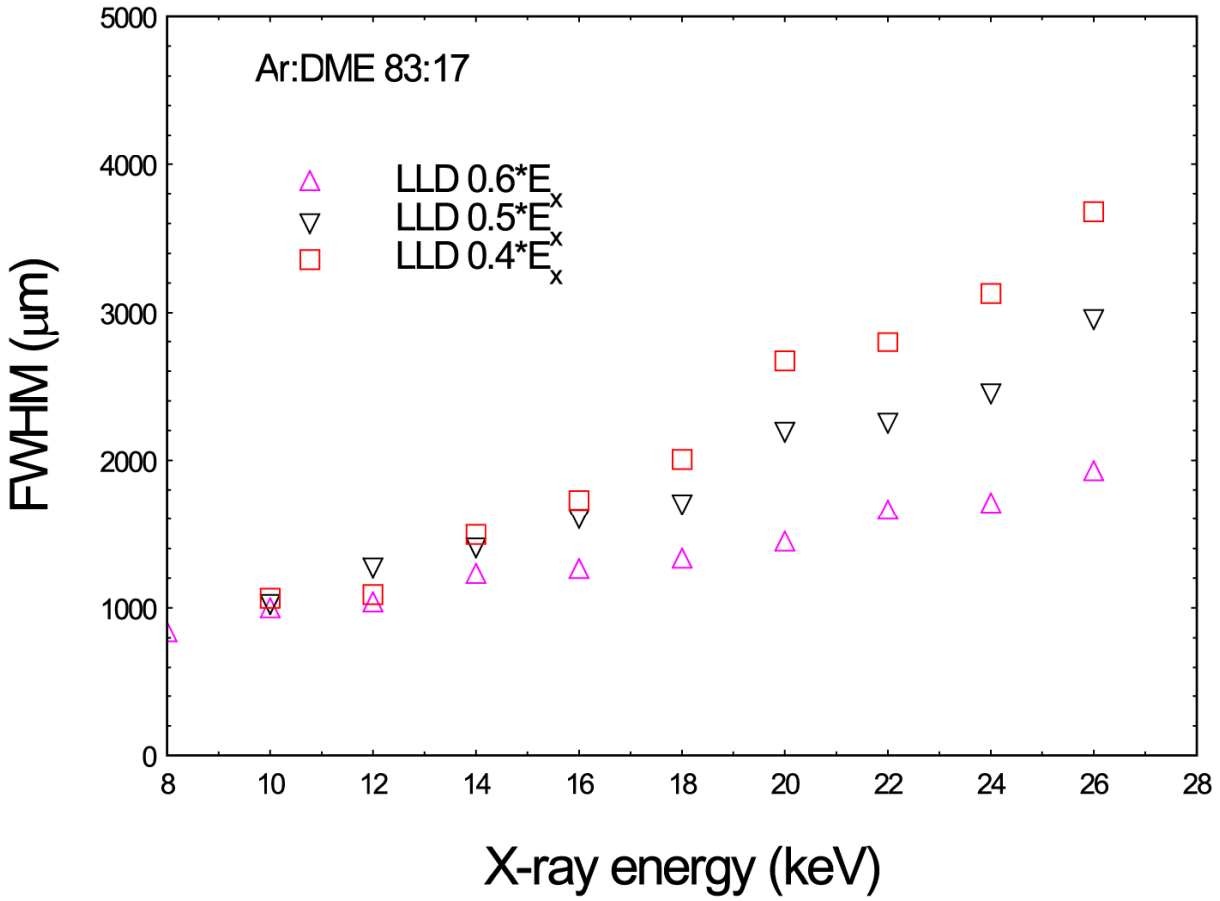
FWHM resolution variation with X-ray energy



FHWM resolution variation with LLD



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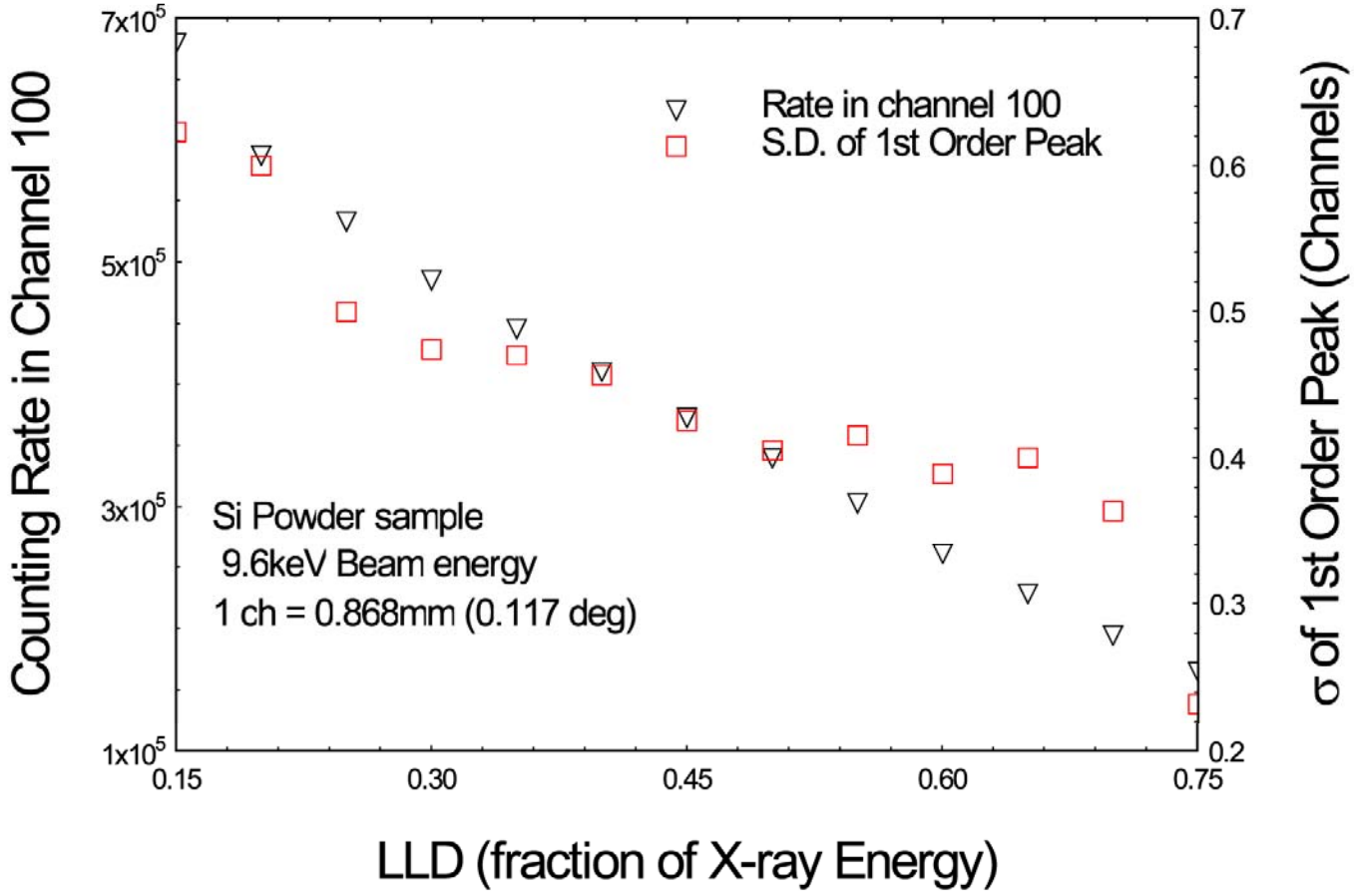
Resolution and count variation with LLD



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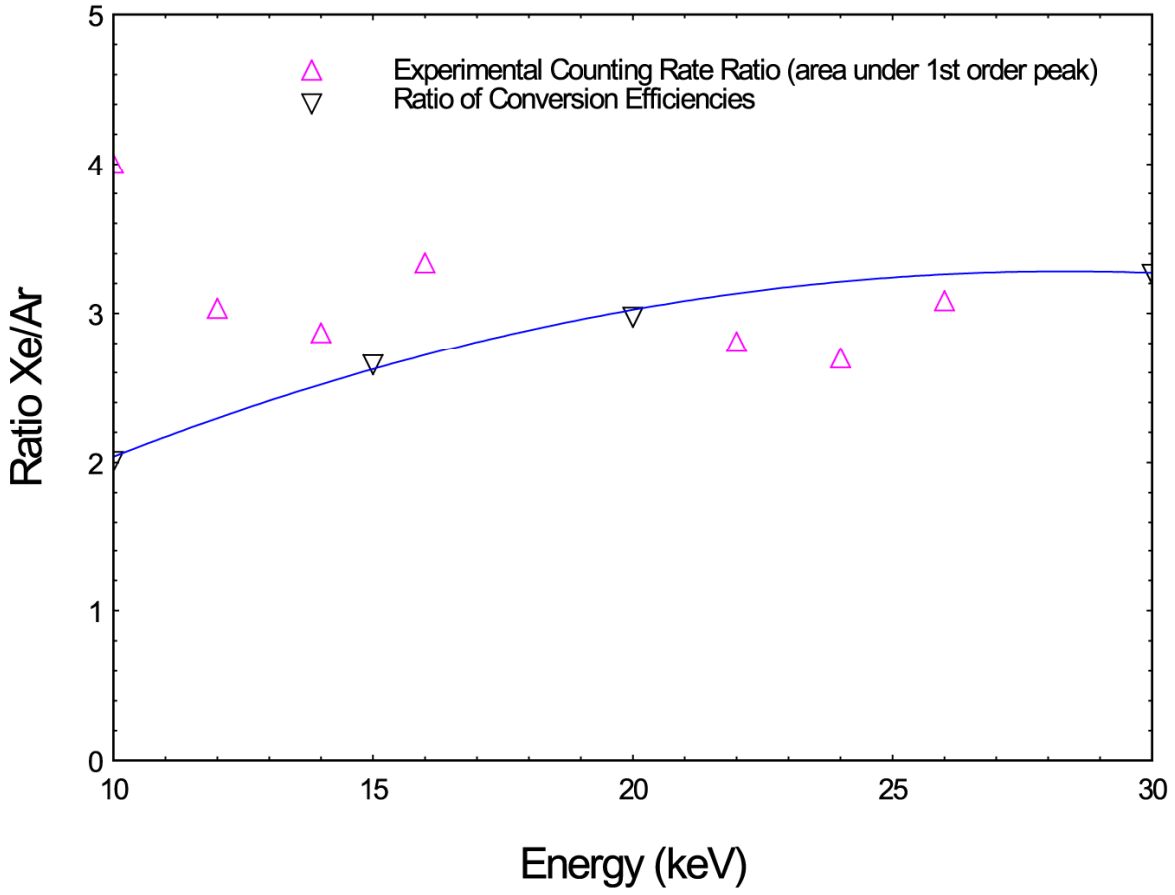
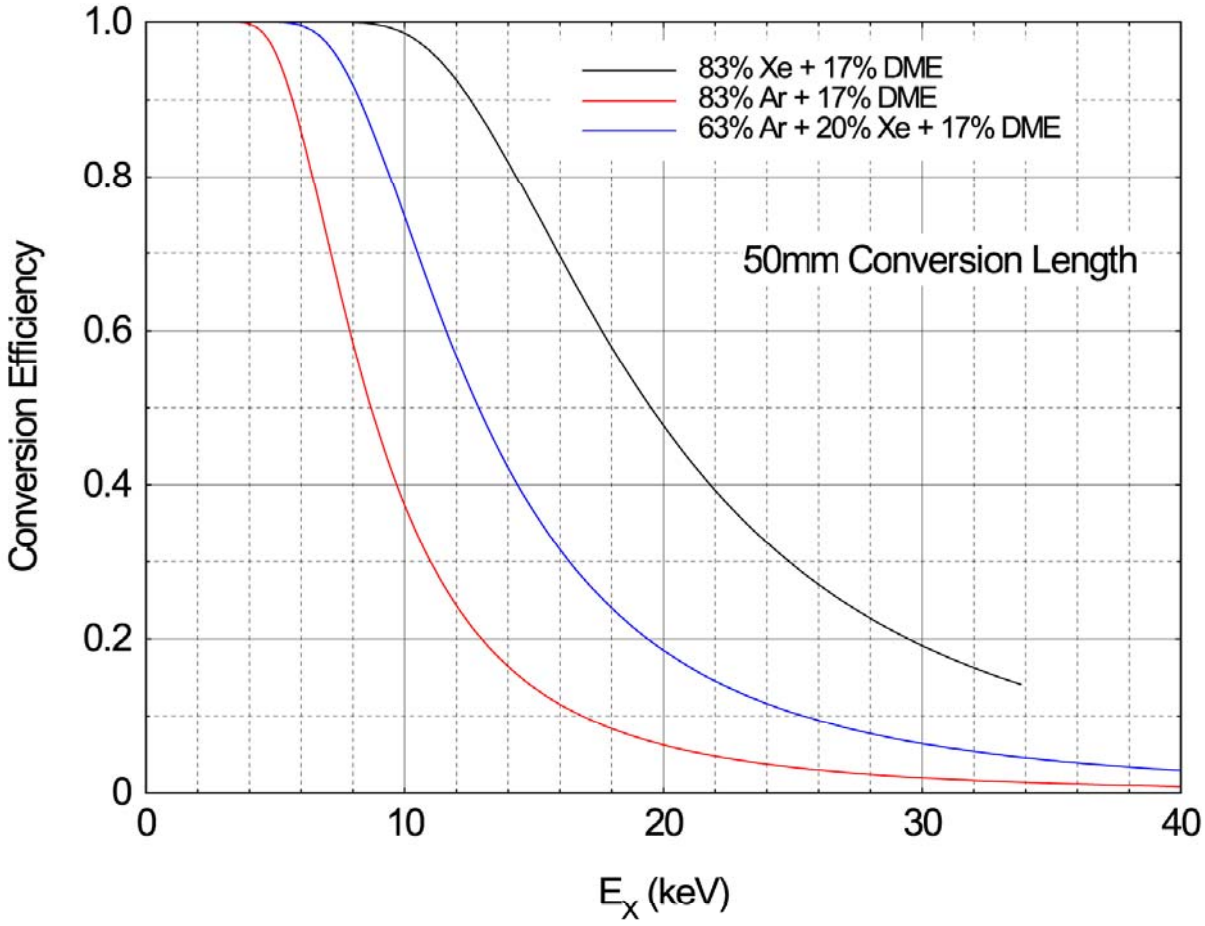
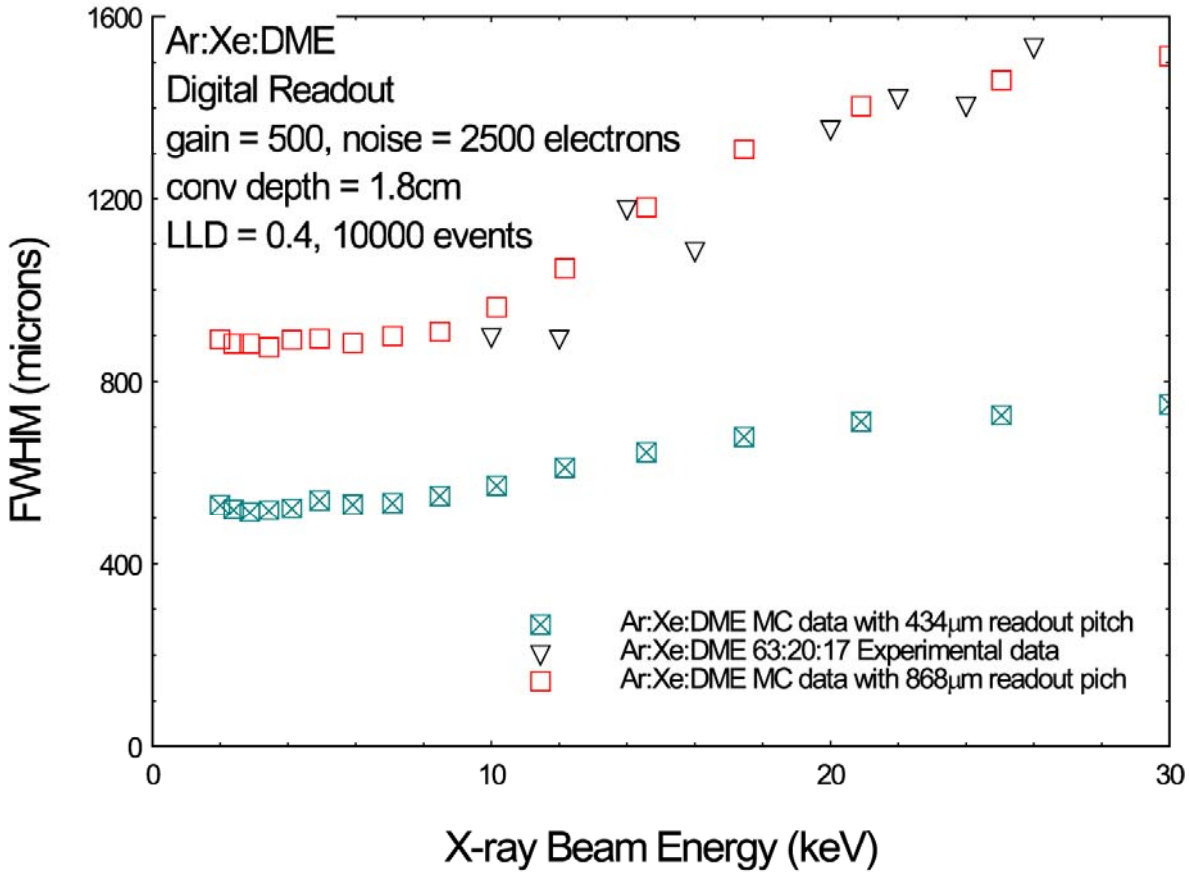
Experimental count ratio of 2 gas mixtures



Theoretical conversion efficiencies



Effect of reduced pitch (simulation)



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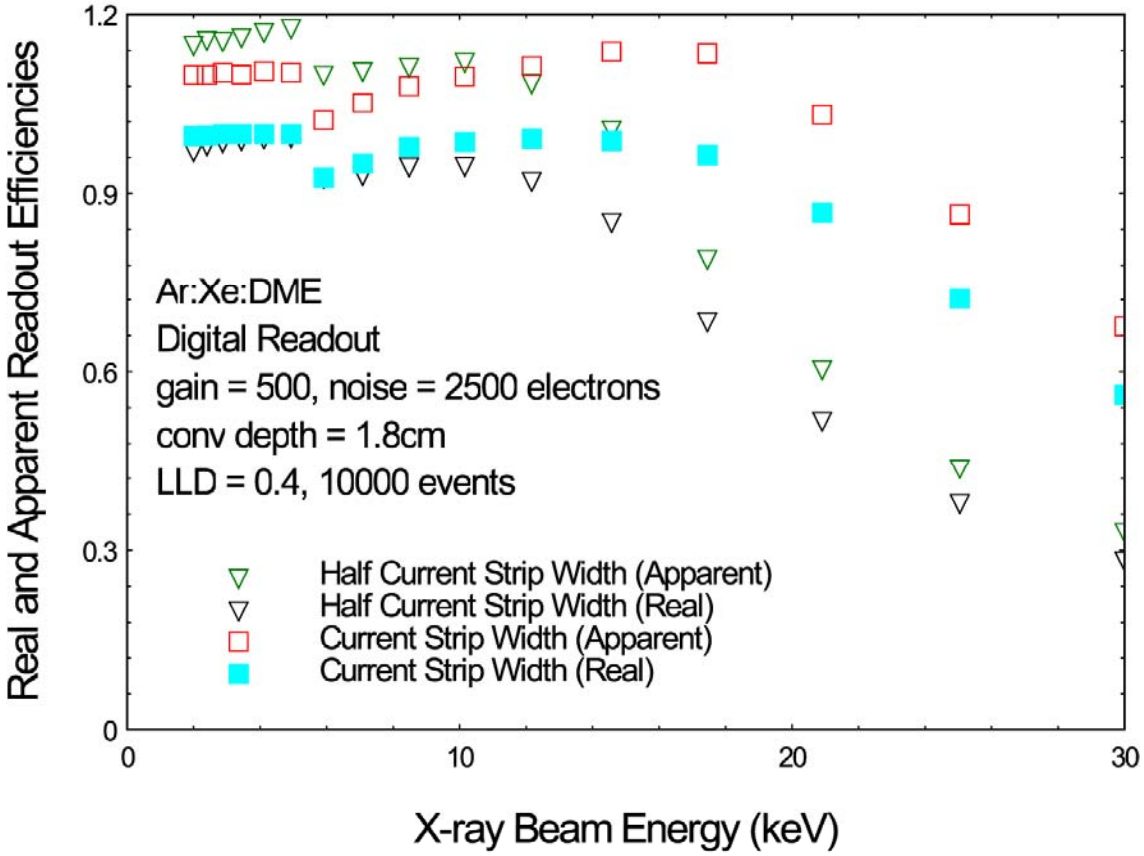
Efficiency comparison of two pitch geometries (simulation)



Conclusions and future work

Addition of 20% or more xenon to gas improves resolution drastically (and conversion efficiency)

Complete substitution of Ar for Xe offers much improved performance if able to recycle Xe

Instrumenting each channel offers possibility of sub mm resolution at 30keV (ASIC readout chip - FREDA)