Imaging the Adsorption of Methane and Hydrogen in Corncob Carbon

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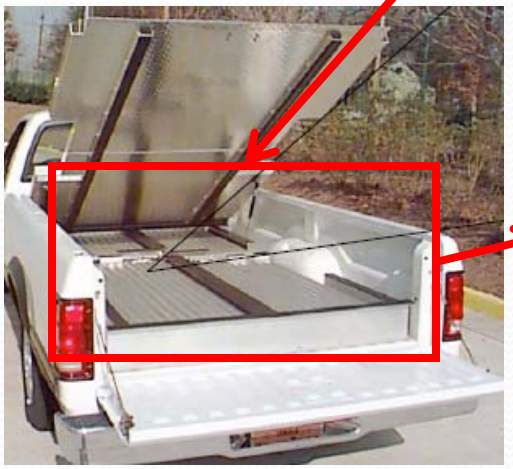
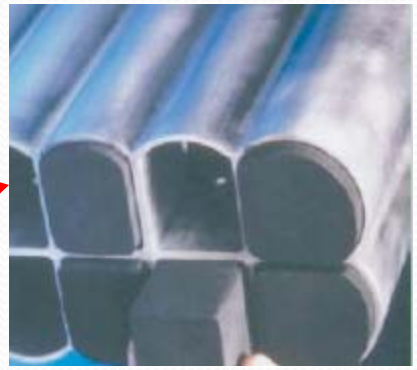
Driving Force: Why do we care?





- The need to find a practical method for low pressure – high capacity gas storage for CH_4 and H_2.
- Your next car might well run on clean natural gas and be ready for hydrogen when it comes along.

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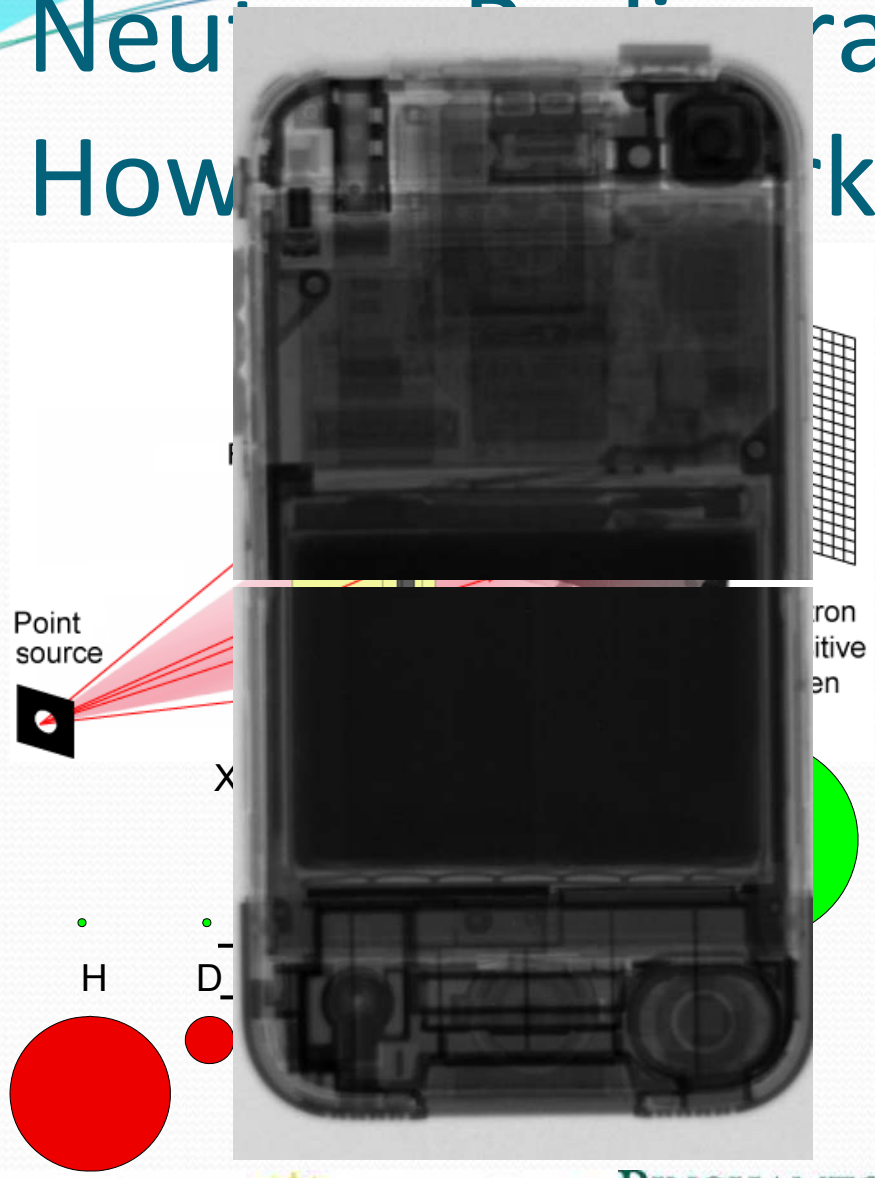
Neu raphy: How rk?



- Sample is placed in a neutron beam.
- Neutrons either pass through or are scattered/absorbed by a sample.
- Pixel intensity depends on the number of neutrons that pass through a sample point.
- 2-D grayscale images that are produced provide information about interior structure of a sample.

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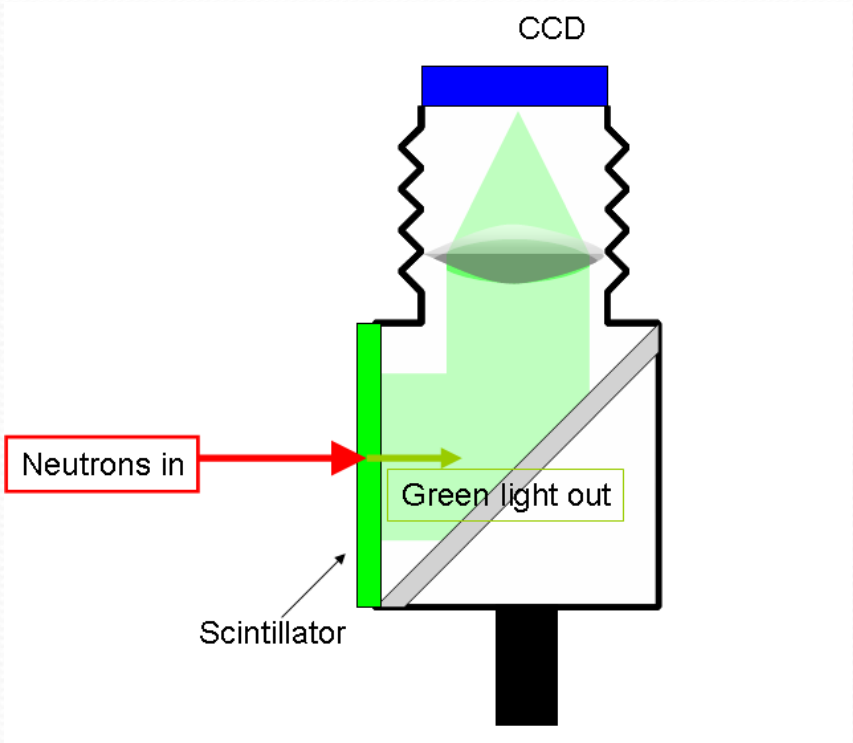
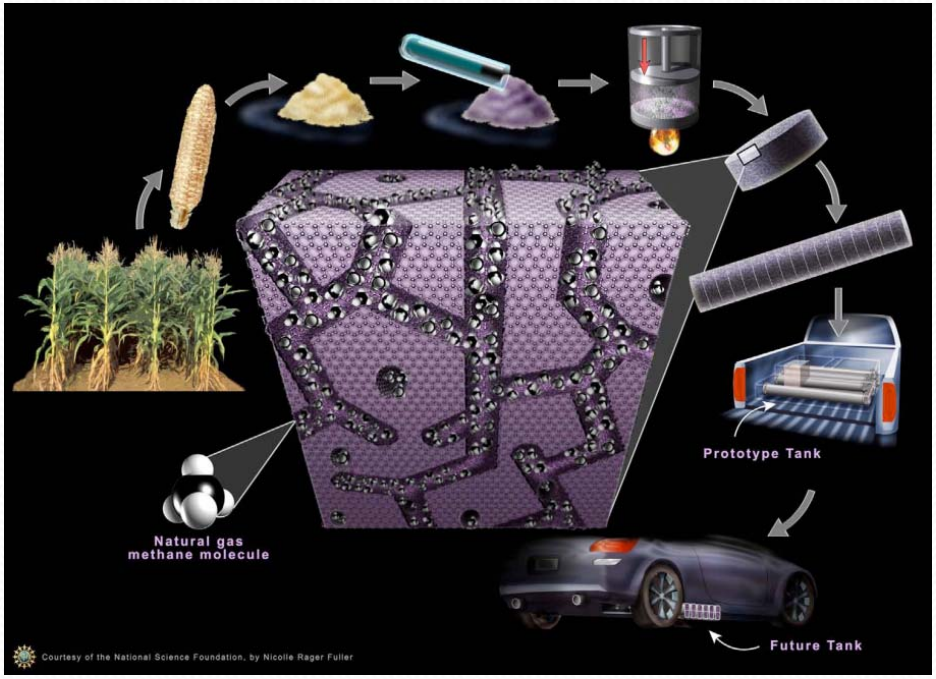
Neutron Radiography: Continued



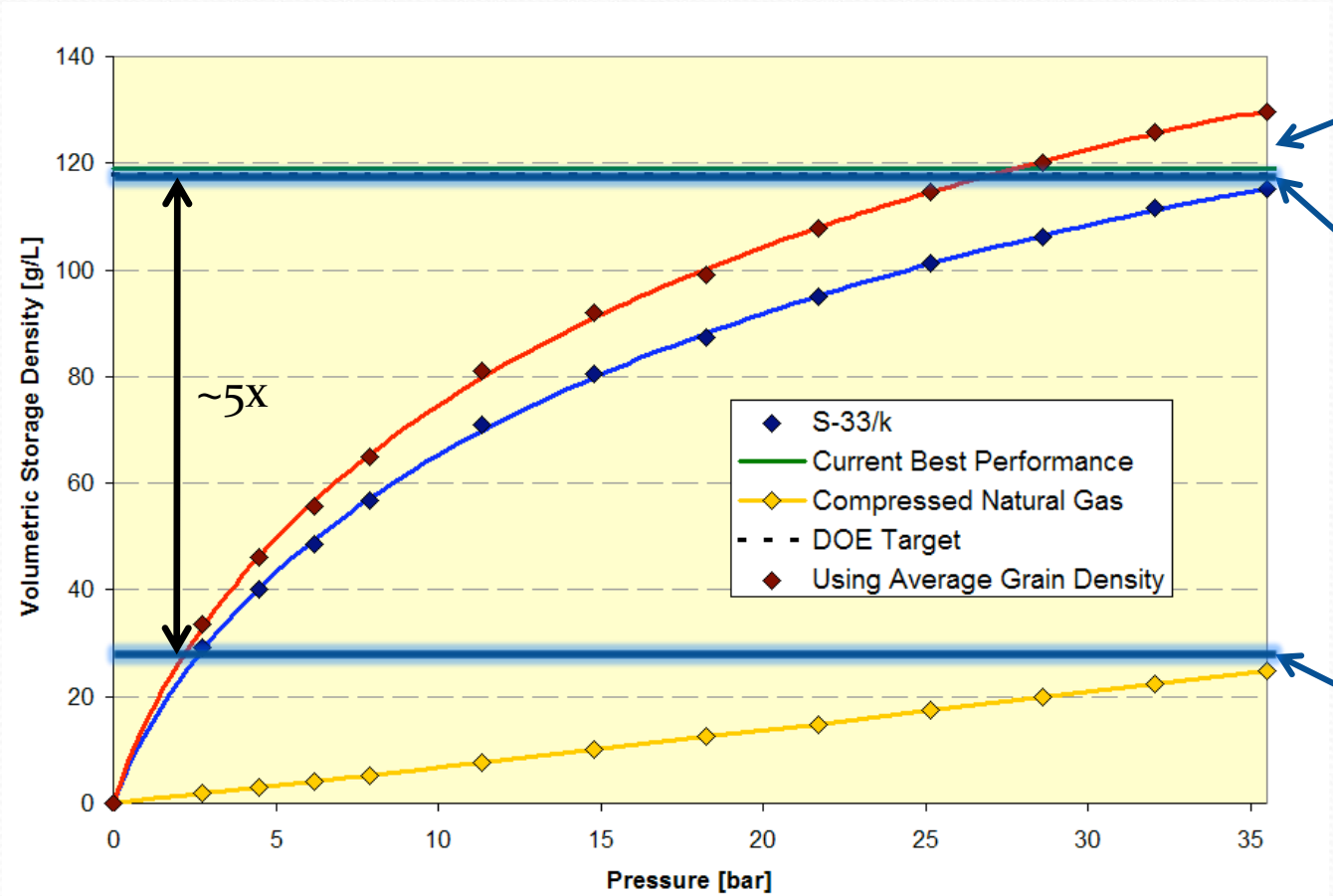
- Neutrons are converted to light by the scintillator (^{6}LiF/ZnS:Cu,Al,Au).
- Neutron to light conversion efficiency is 20%.
- The light is then captured by a CCD camera producing an image.
- CCD image acquisition rate is 0.2 Hz, pixel pitch of 57 μm

ALL-CRAFT:
The corncob carbon sample



- Developed by the University of Missouri
- Porous Carbon adsorbs gas.

ALL-CRAFT:
The corncob sample's performance



DOE Target:
118g/L

Adsorbed Natural Gas

Compressed Natural Gas

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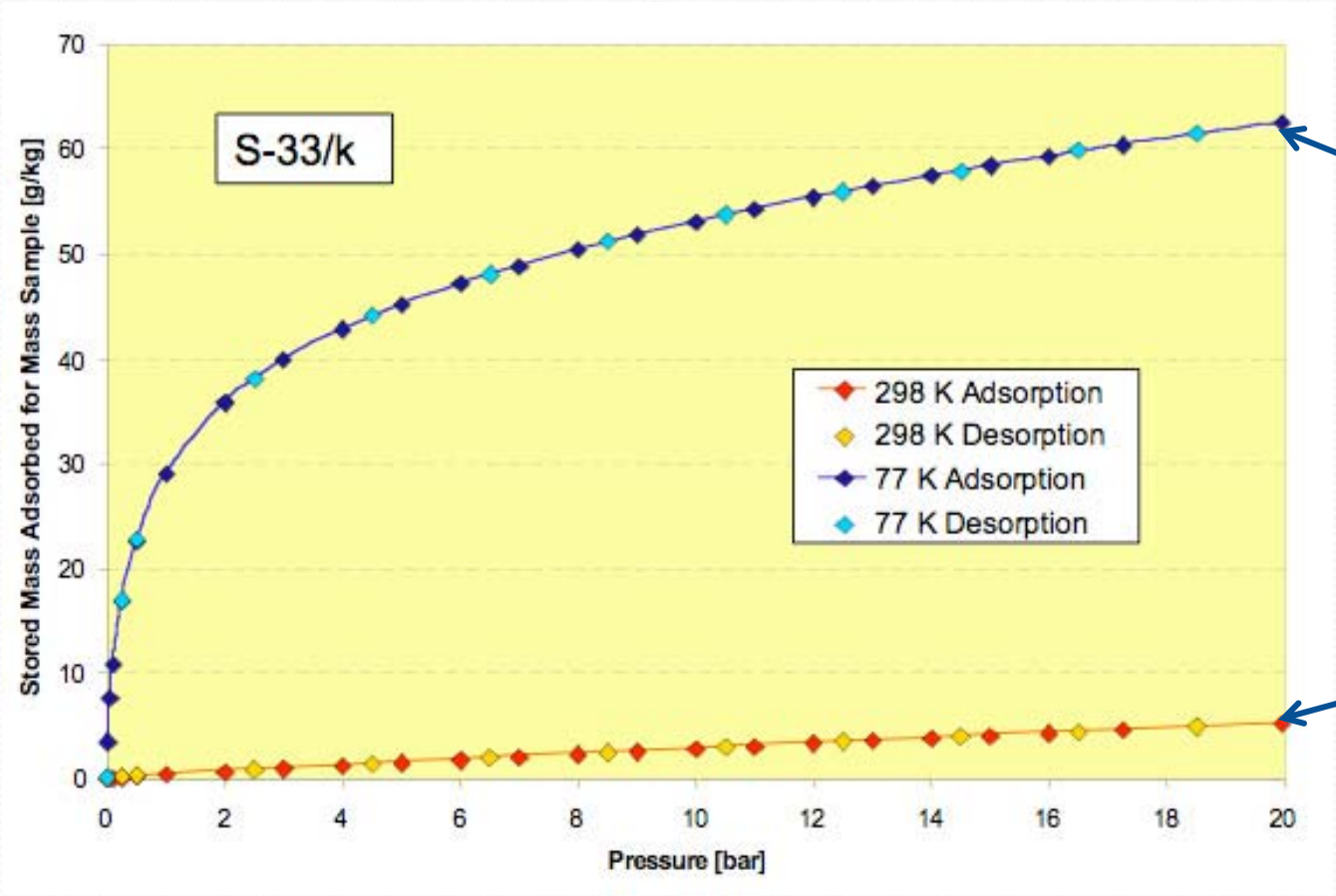
ALL-CRAFT:
The corncob sample's performance



Hydrogen
@ 77 K
6.2 mass%

Hydrogen
@ 298 K
0.5 mass%

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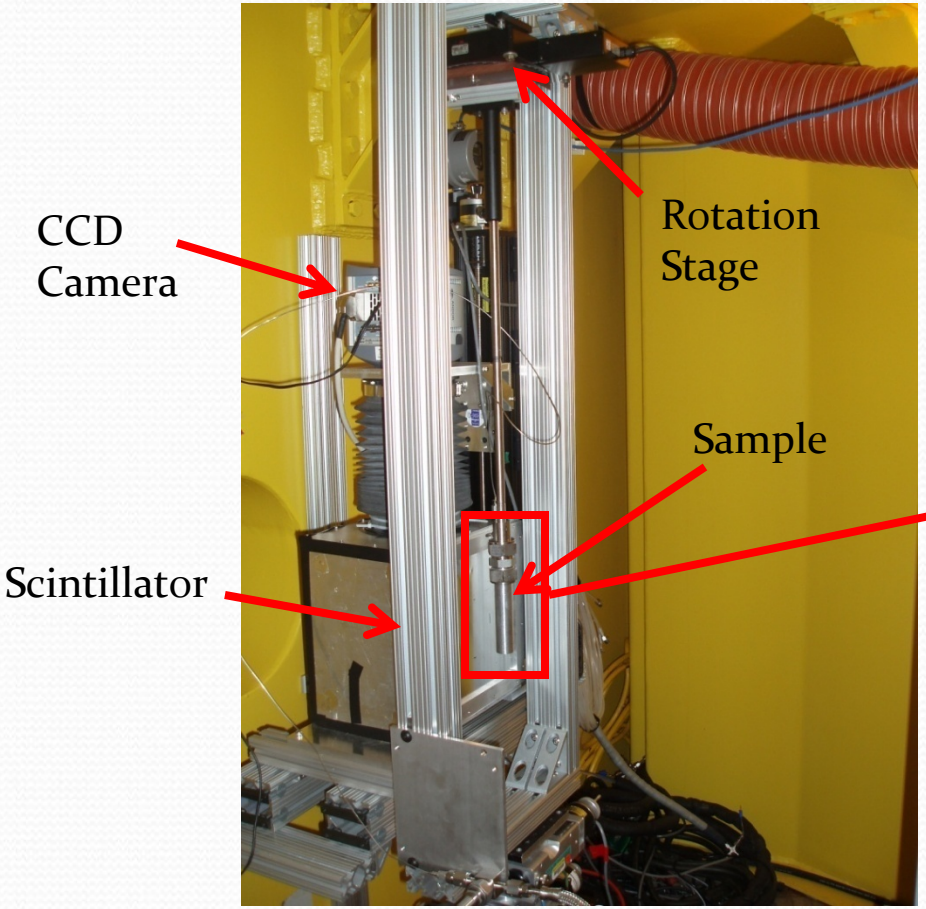
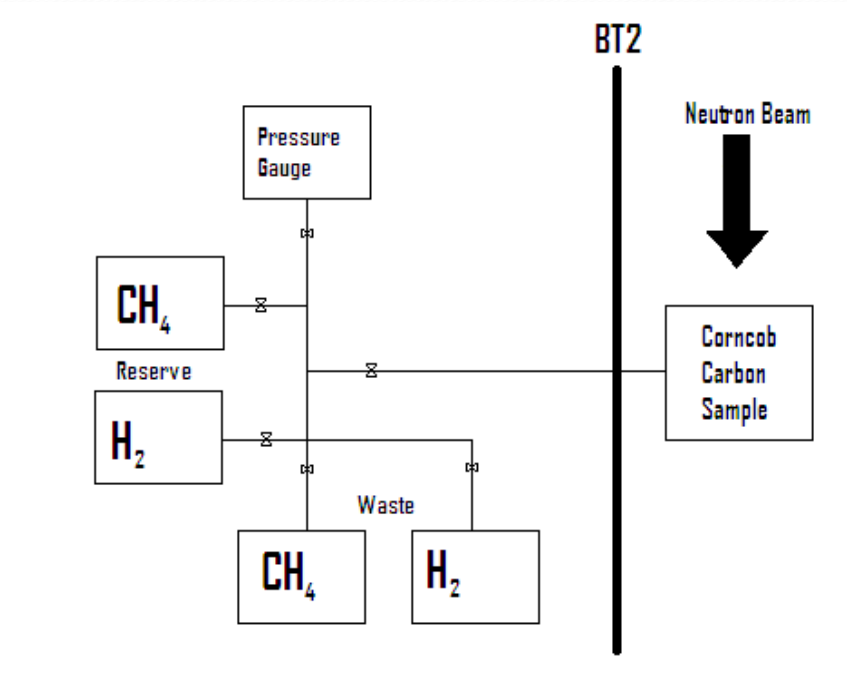
Experiment: Preparation



Experiment: Adsorption of CH_4 and H_2



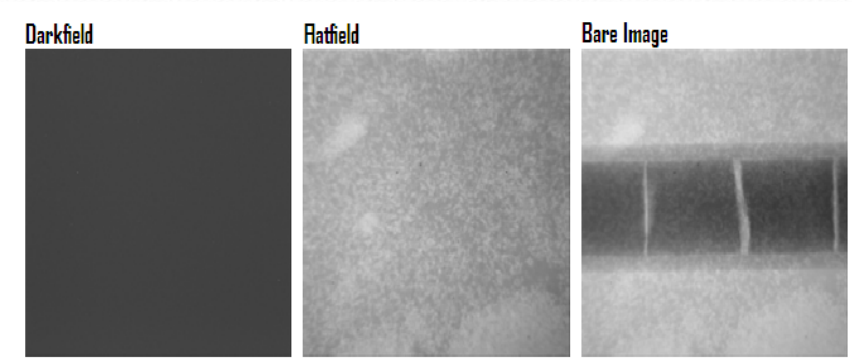
- Collected radiography and tomography data.
- Wanted to know how the gases distributed within the carbon with time.
- Varied pressure in between data collection.

Image Processing: How does it work?

Raw Data → Sum Images → Normalize → Colorize

Sum Images
- Average
- Sum
- Integrate

Normalize
- Darkfield
- Flatfield
- Bare Image



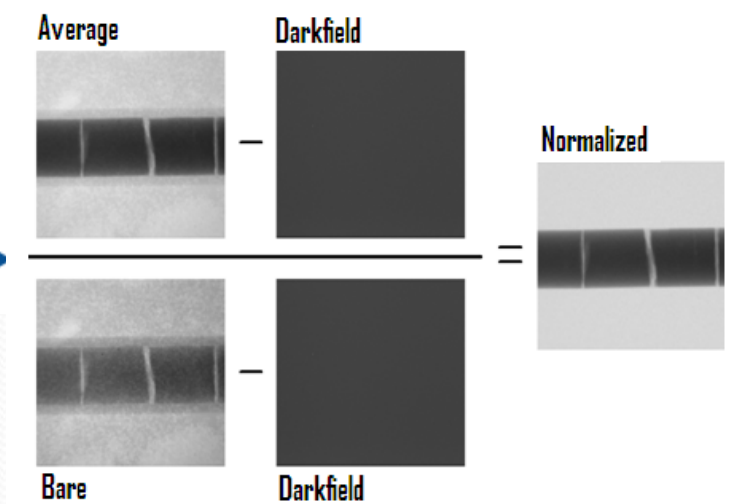


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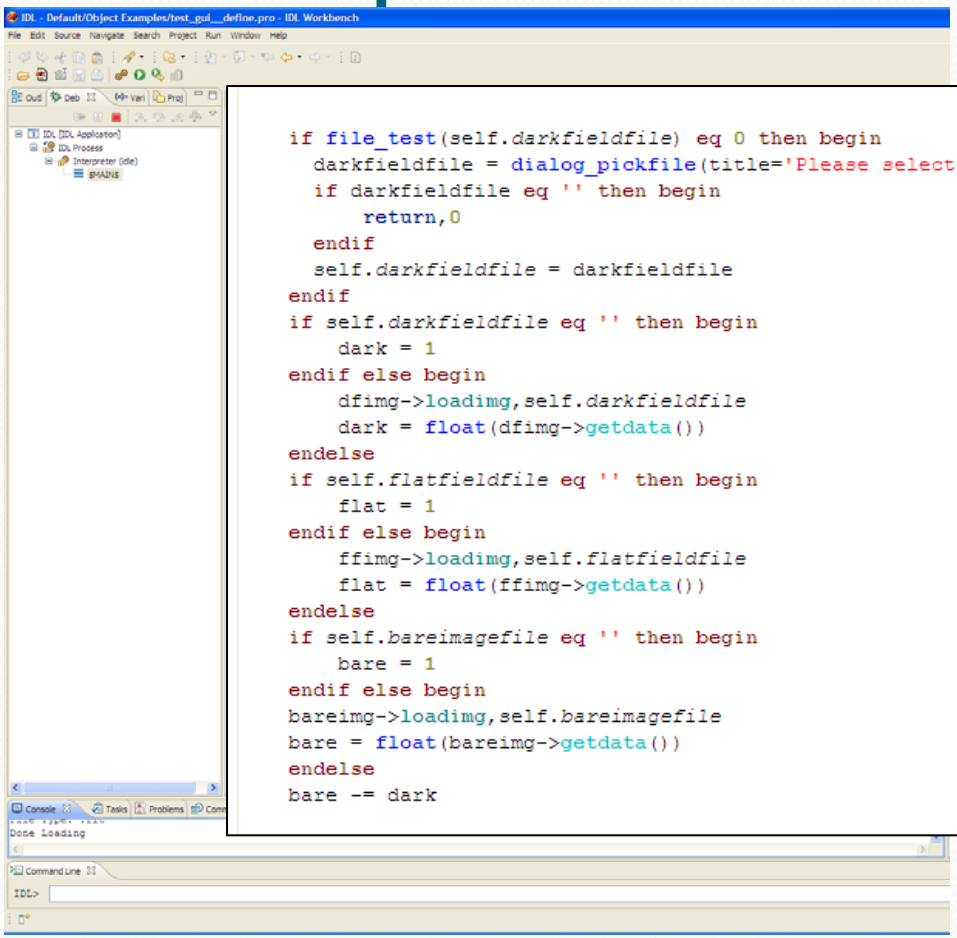
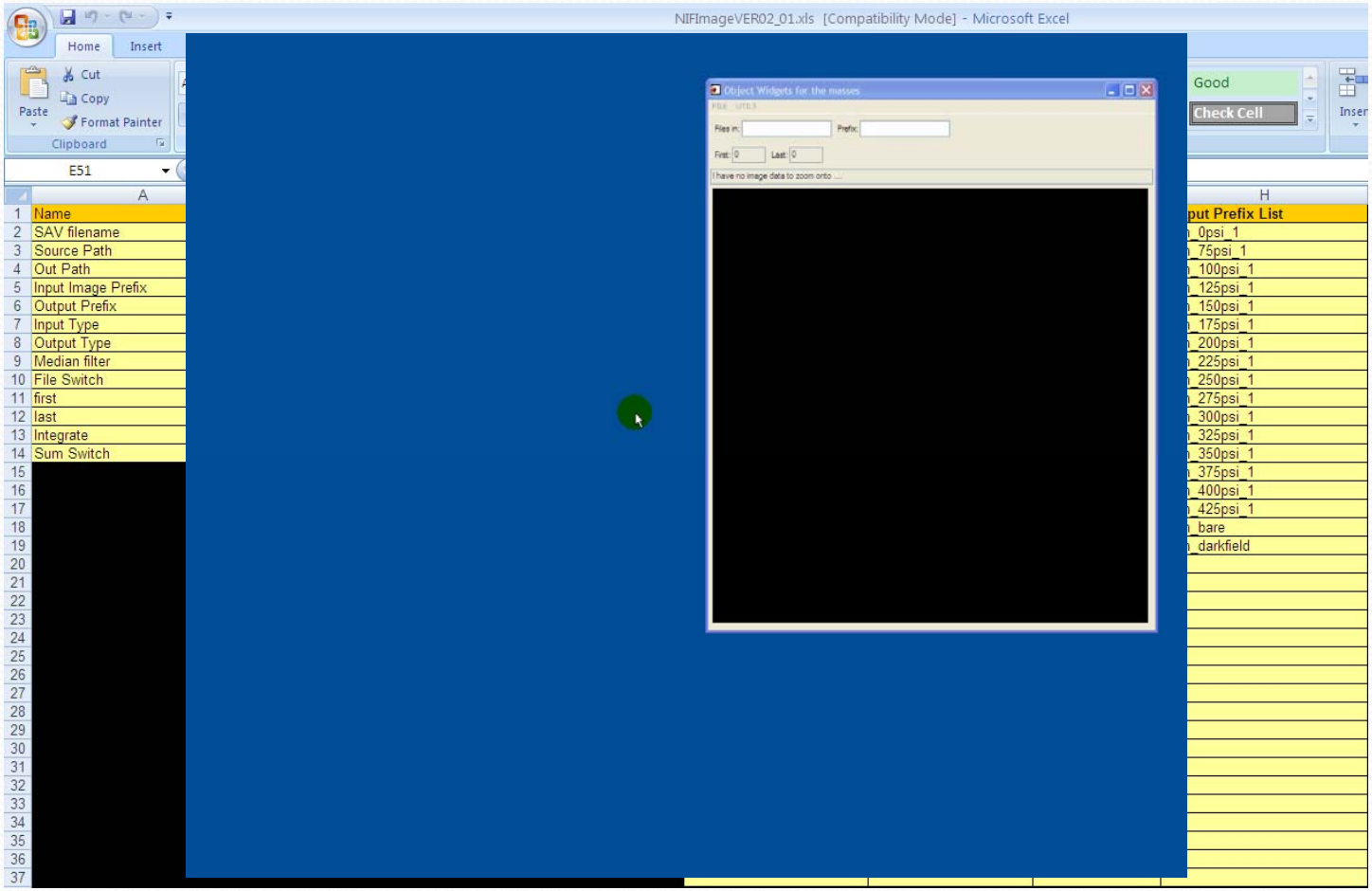
Image Processing: A new experience




```
if file_test(self.darkfieldfile) eq 0 then begin
  darkfieldfile = dialog_pickfile(title='Please select the DARK FIELD FILE:')
  if darkfieldfile eq '' then begin
      return,0
  endif
  self.darkfieldfile = darkfieldfile
endif
if self.darkfieldfile eq '' then begin
    dark = 1
endif else begin
    dfimg->loadimg,self.darkfieldfile
    dark = float(dfimg->getdata())
endelse
if self.flatfieldfile eq '' then begin
    flat = 1
endif else begin
    ffimg->loadimg,self.flatfieldfile
    flat = float(ffimg->getdata())
endelse
if self.bareimagefile eq '' then begin
    bare = 1
endif else begin
bareimg->loadimg,self.bareimagefile
bare = float(bareimg->getdata())
endelse
bare -= dark
```

Image Processing:
Faster than ever at the NCNR



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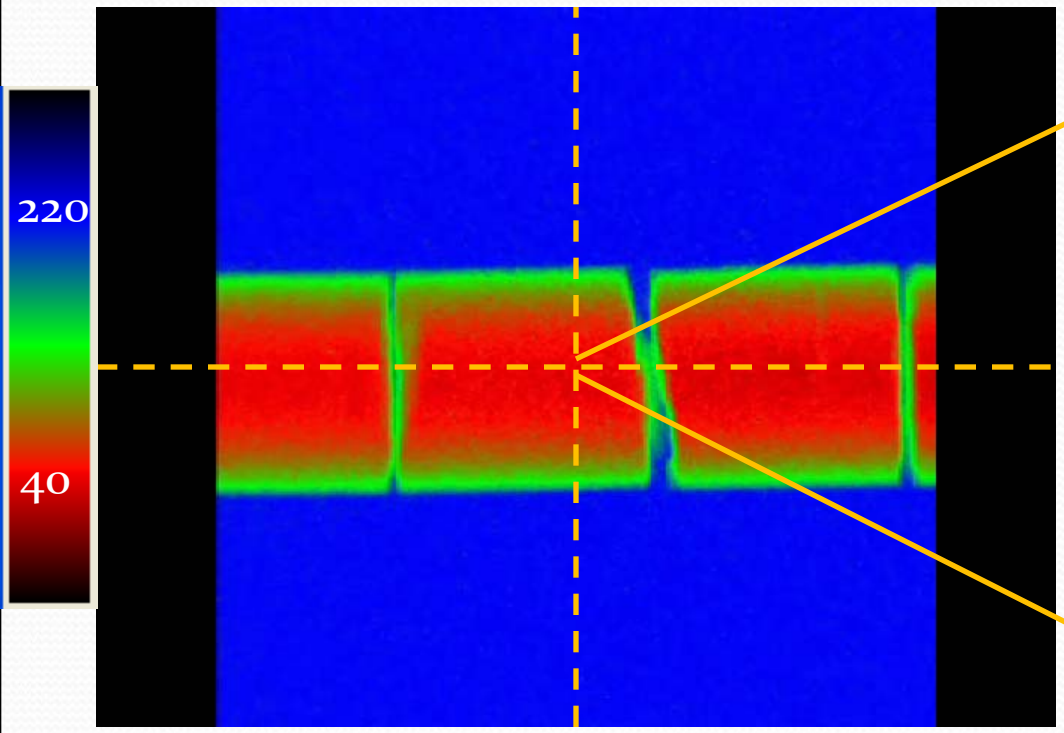
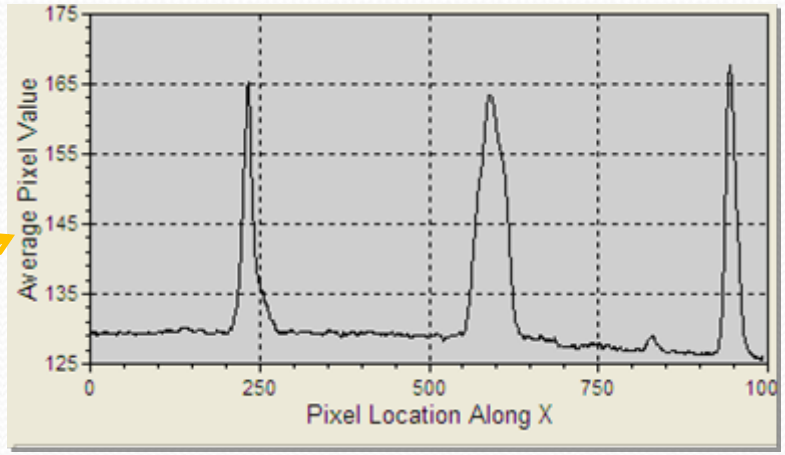
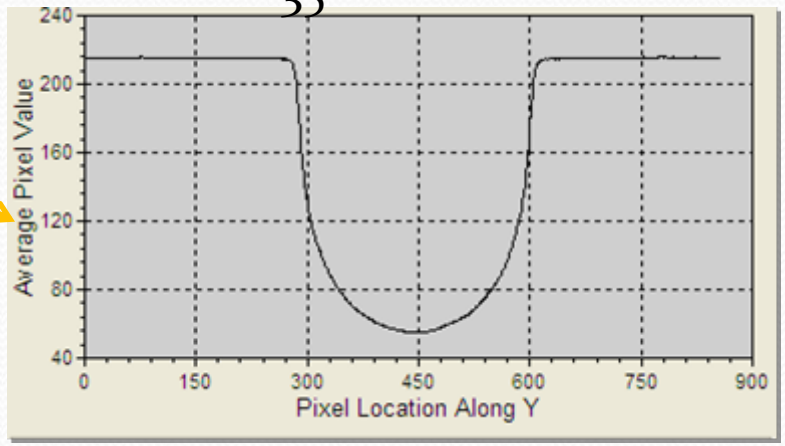
Results: Distribution of Methane at varying pressures



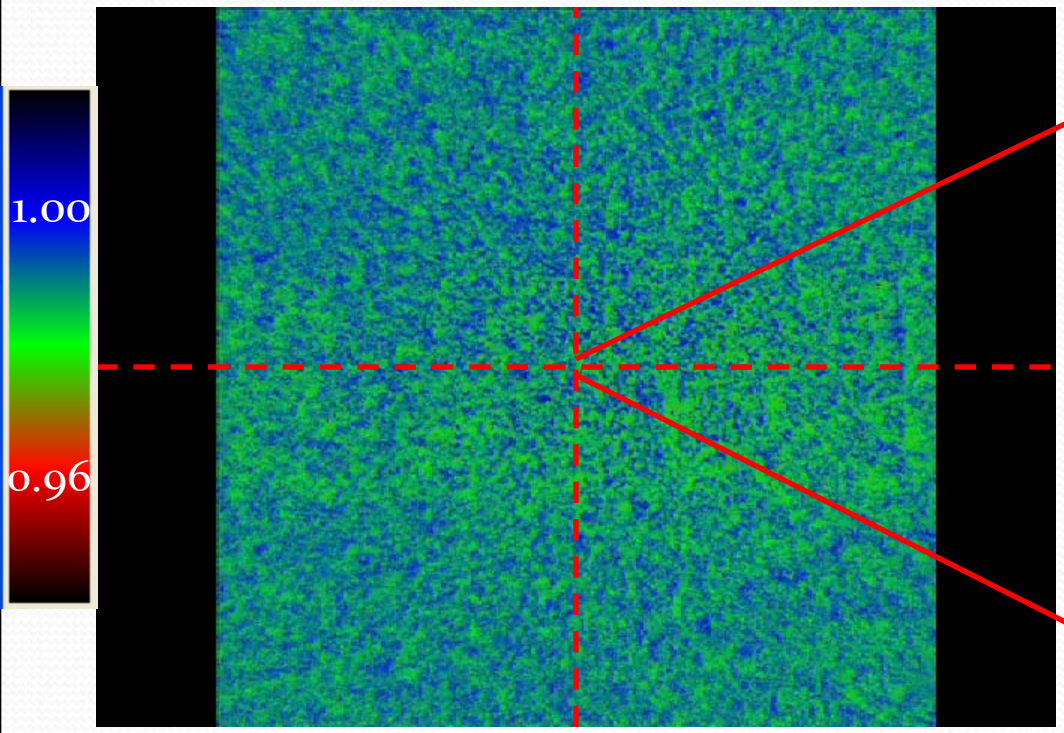


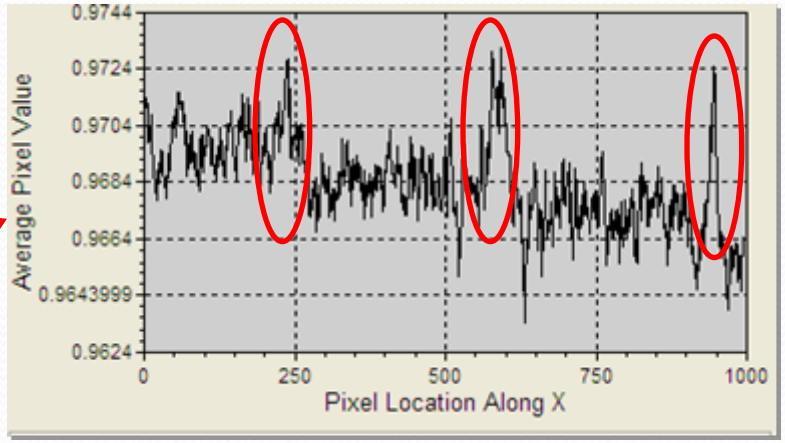
Δ Pixel Value: ~35



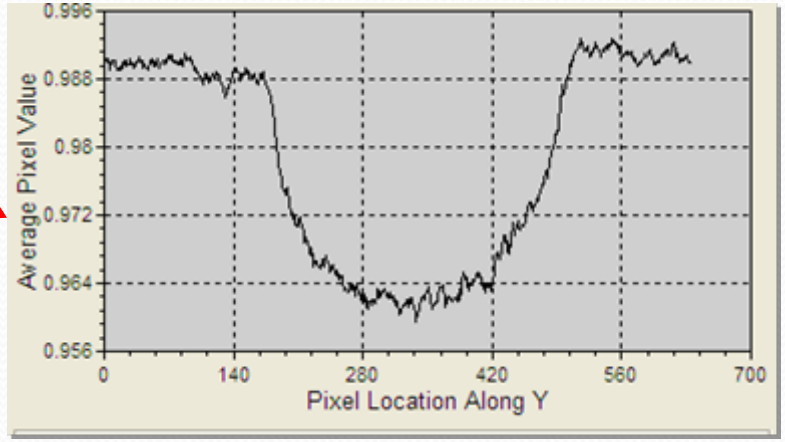
Δ Pixel Value: ~180

Results: Distribution of Hydrogen at varying pressures





Δ Pixel Value: ~0.004



Δ Pixel Value: ~0.024

The Future

- Process the tomography data.
- Collect radiography and tomography data
  - At cryogenic temperatures,
  - Time resolved.
- Expand the capabilities of the image processing program.
  - Quantitative analysis,
  - Write movie files,
  - Inclusion into the DAVE platform.

Acknowledgements

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