NDE Of Fuel Cells Via Neutron Imaging

Muhammad Arif (PI)
David Jacobson
Thomas Gentile
Alan Thompson

National Institute of Standards and Technology (NIST)
US Department of Commerce
Gaithersburg, Maryland

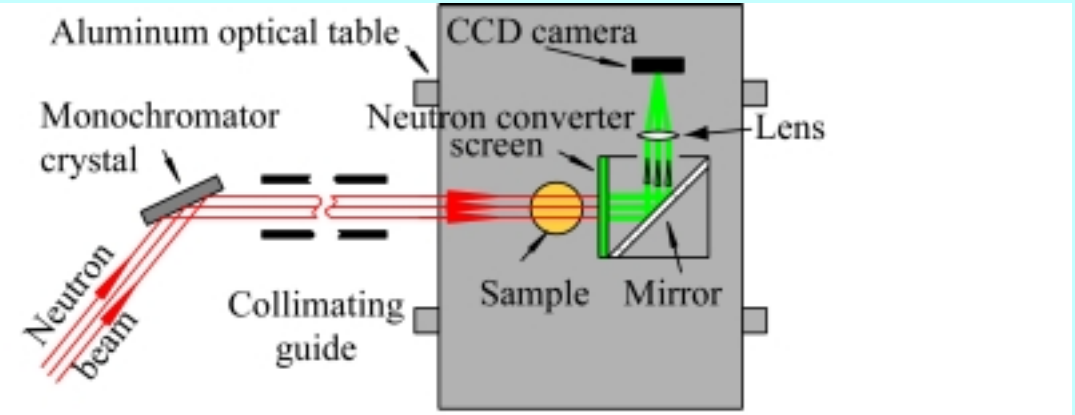
Supported by

Advanced Technology Program
Physics Laboratory
Materials Science and Engineering Laboratory

Technology

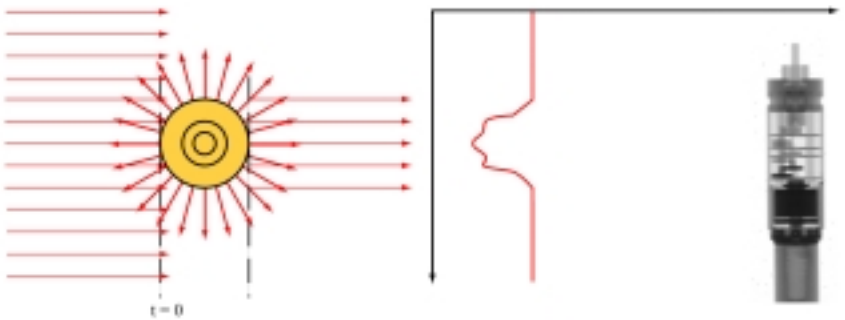
- **Uses *scattering, absorption and interferometric* properties of low energy neutrons to create 2-D and 3-D image of a sample.**
- **Extremely sensitive to the presence of hydrogenous material in the sample.**
- **Ideally suited to investigate water transport phenomena (among other things) inside a working fuel cell in a non-destructive and non-intrusive manner.**
- **NIST is the *only* facility developing this technology with *'cold neutrons'* to help the industry with fuel cell characterization.**
- **At the present, it is perhaps the *only* technology that can investigate an operating fuel cell.**

How An Image Is Taken

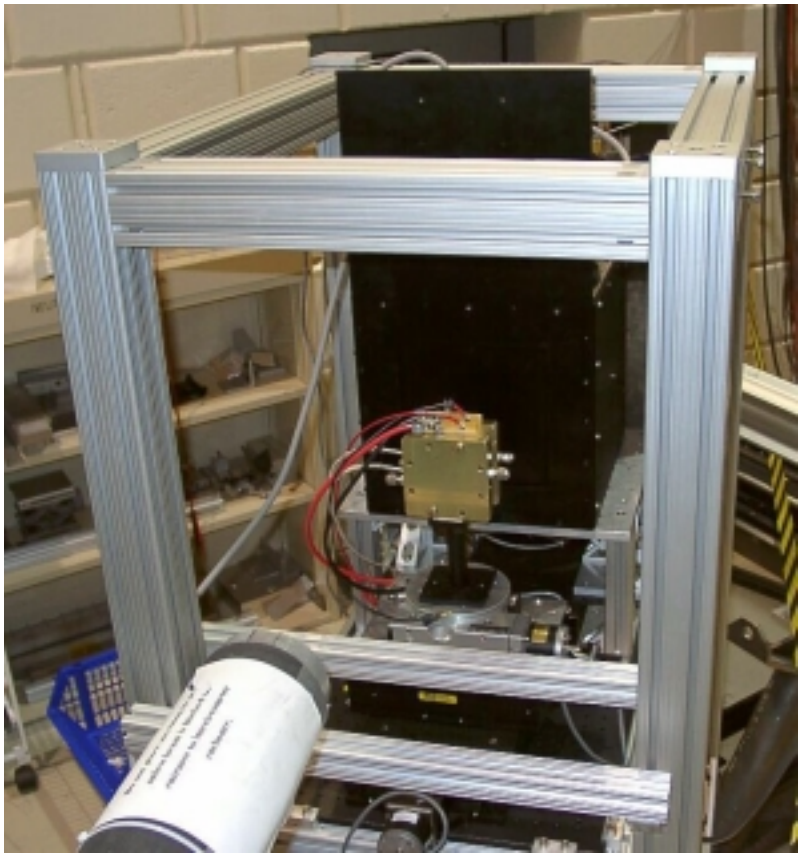


$$Transmission = I/I_0 = e^{\int_0^0 N(t)\,\sigma(t)\,dt}$$

N = Atom density
σ = total scattering cross section
t = Material thickness



Neutron Imaging Setup

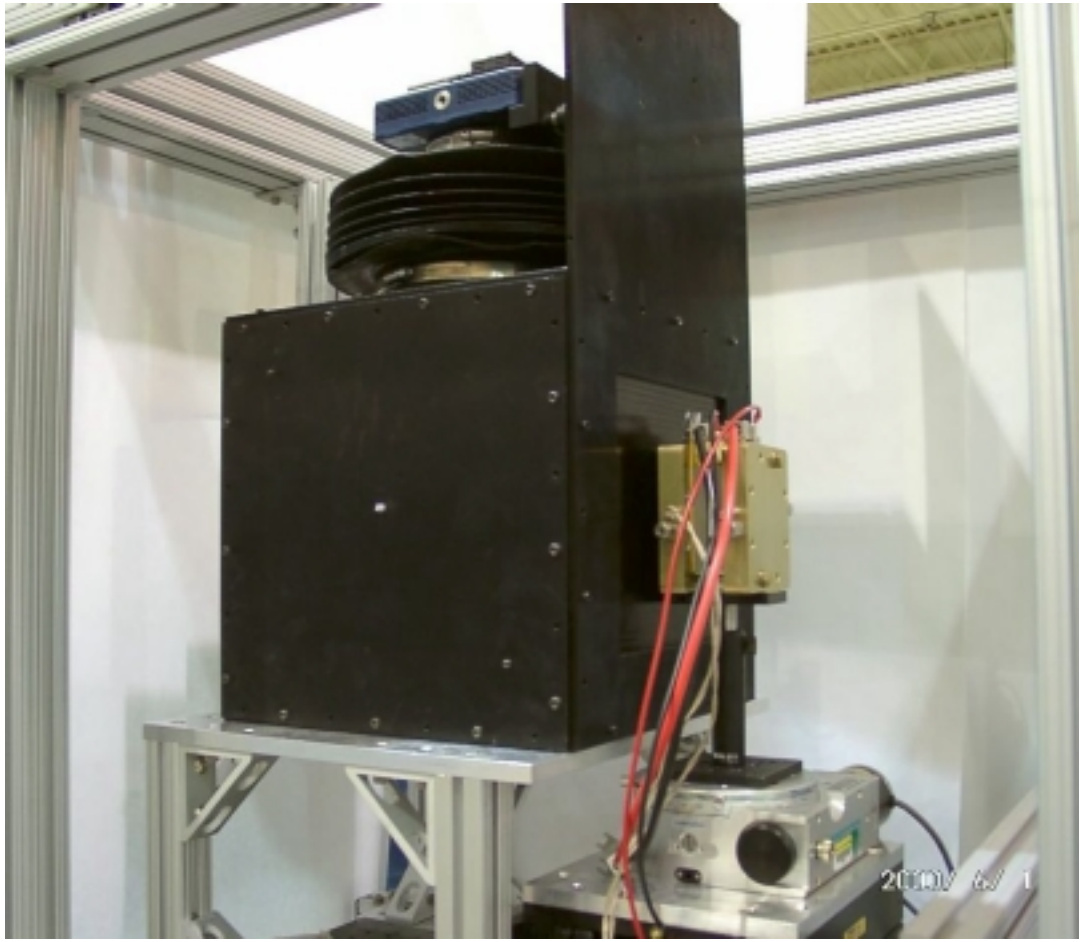


Can be placed in different beams - portable

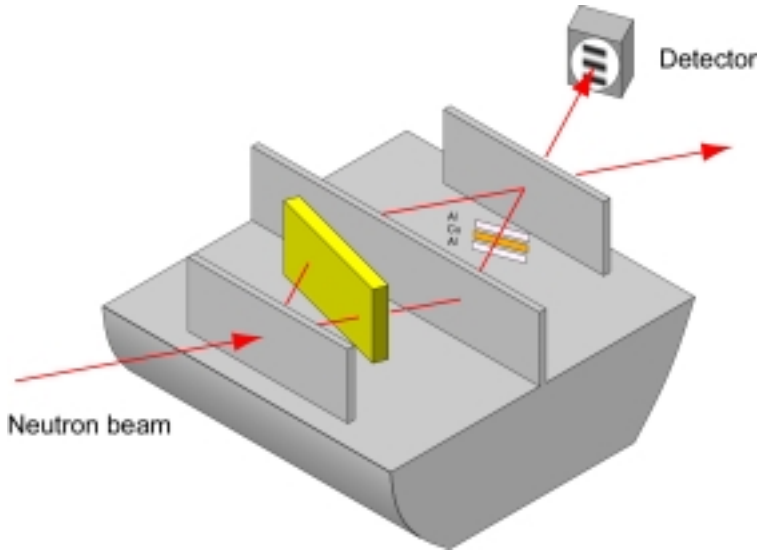
Can accept 20 cm x 20 cm sample

Can image larger sample by scanning

View Of The CCD Camera

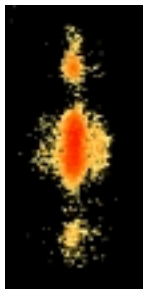


Phase Contrast Imaging



Phase contrast

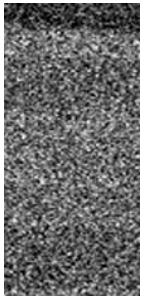
Radiograph



Al

CU

Al

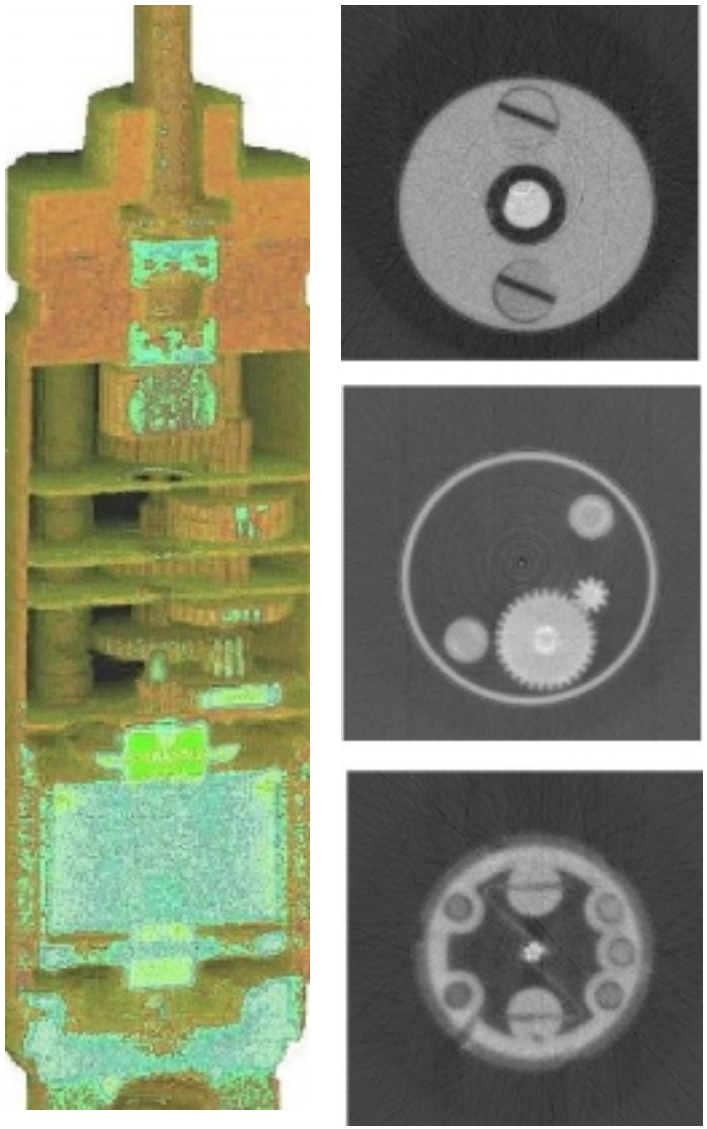


Sensitivity can be 1000 times greater than radiography.
Ideal for small thin samples

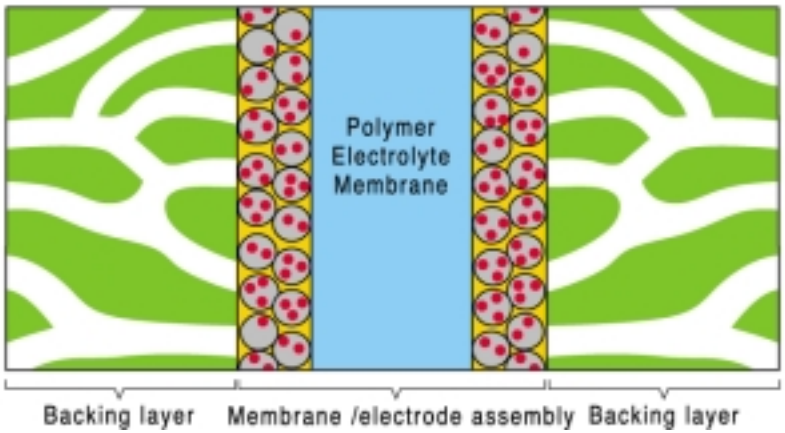
- **PEM hydration**
- **Thickness variation**
- **De-lamination**

Advantage of 3-D imaging

- Permits one to look at an individual component.
- Permits the study of any component from any direction.
- Example: Inside a fuel cell, it will allow one to study the water distribution in the flow channels independent of the water distribution in the membrane.



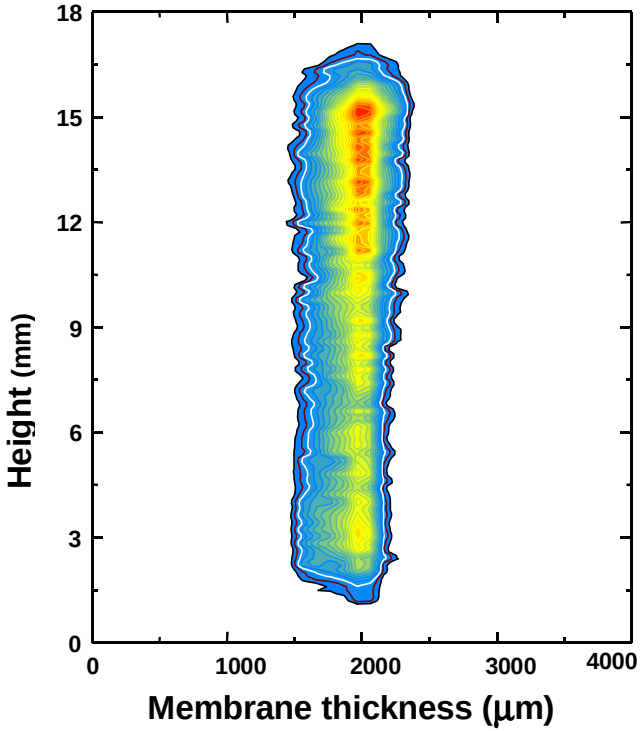
What We Can Do

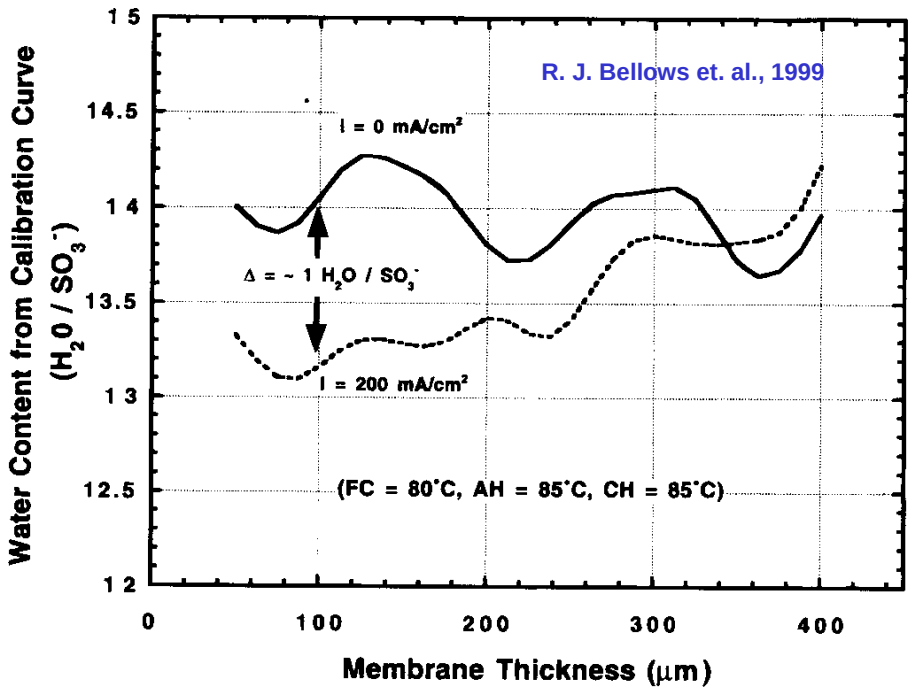


Source: http://education.lanl.gov/resources/fuelcells

- Investigation of fuel cell membrane water gradients under different humidification conditions.
- Investigation of the hydrophobic characteristics associated with a fuel cell gas diffusion layer (GDL).
- Study of two-phase flow mechanism in the fuel cell flow field and their impact on fuel cell vapor transport characteristics.
- Study of CO poisoning mechanism on Pt based catalyst.
- Fuel cell mechanical assembly.

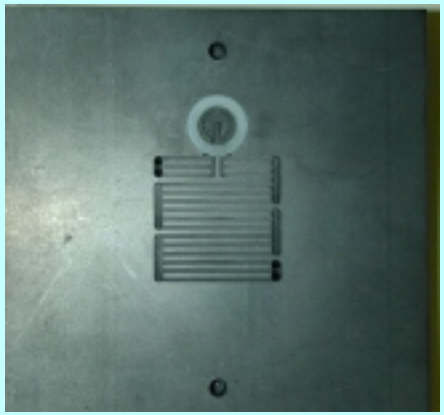
Neutron Image of a PEM inside a working fuel cell

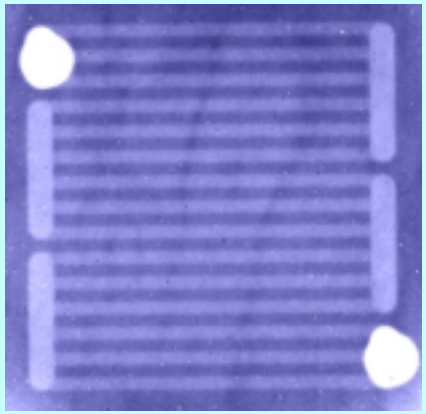




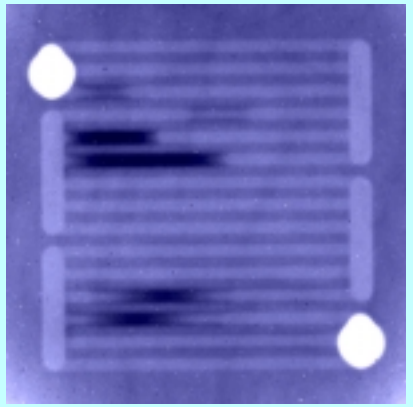
- There is a horizontal water gradient across thickness of PEM
- There is a much greater vertical water gradient due to *gravity*

Water In Flow Channels

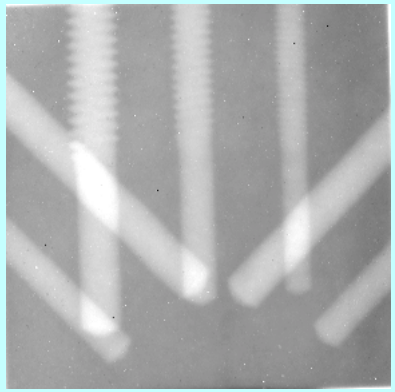


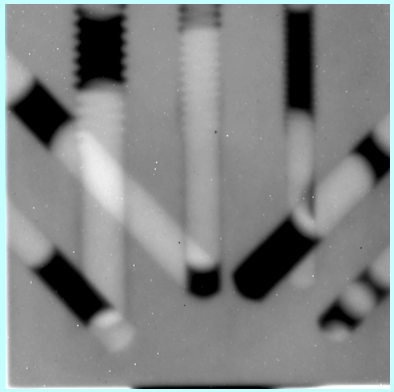


Dry



Wet





Contacts With Fuel Cell Related Companies

Plug Power

Exxon

International Fuel Cells

Electrochem

H-Power

Etek

W. L. Gore

Collaborations

McClellan AFB

Munich Technical University,Germany

Future Plans

- **Establish a dedicated fuel cell imaging station where fuel cell industry can bring their cells for characterization. A cold neutron beam position has already been dedicated for this purpose. We hope to establish a variably energy neutron beam line at this position in FY 2001.**
- **Provide standardized data acquisition and data analysis procedure for users.**
- **Establish regular interactions with industries and related government and academic institutions to better assess relevant fuel cell research needs.**
- **Enhance software and hardware for near 'real time' imaging capability to permit the study of chemical kinetics.**
- **Transfer the technology to DOE facilities (such as SNS and HFIR)**