Facilities, Capabilities and Uses of NAA at the Breazeale Nuclear Reactor

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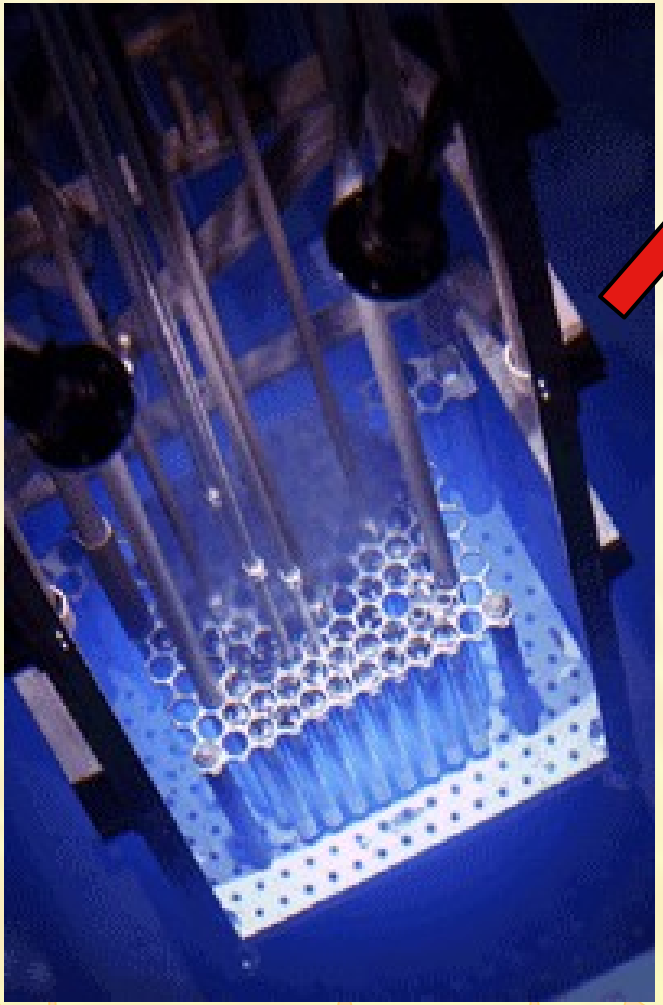
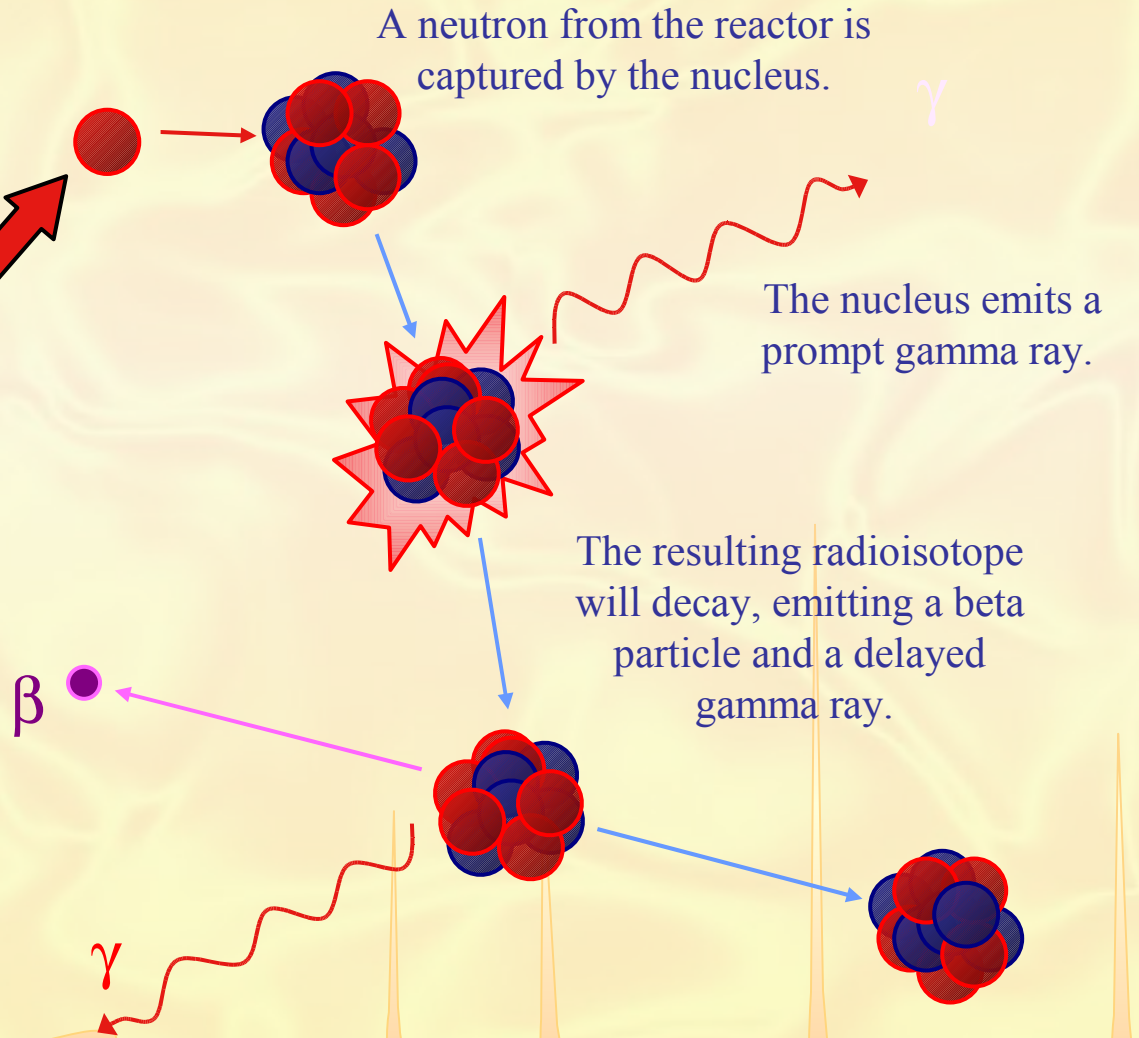
Neutron Activation Analysis

Neutron Activation Analysis is a compositional analysis technique with parts-per-billion sensitivity. Advantages of NAA include the simultaneous identification of multiple elements. It is also non-destructive, allowing for subsequent irradiations and analysis.

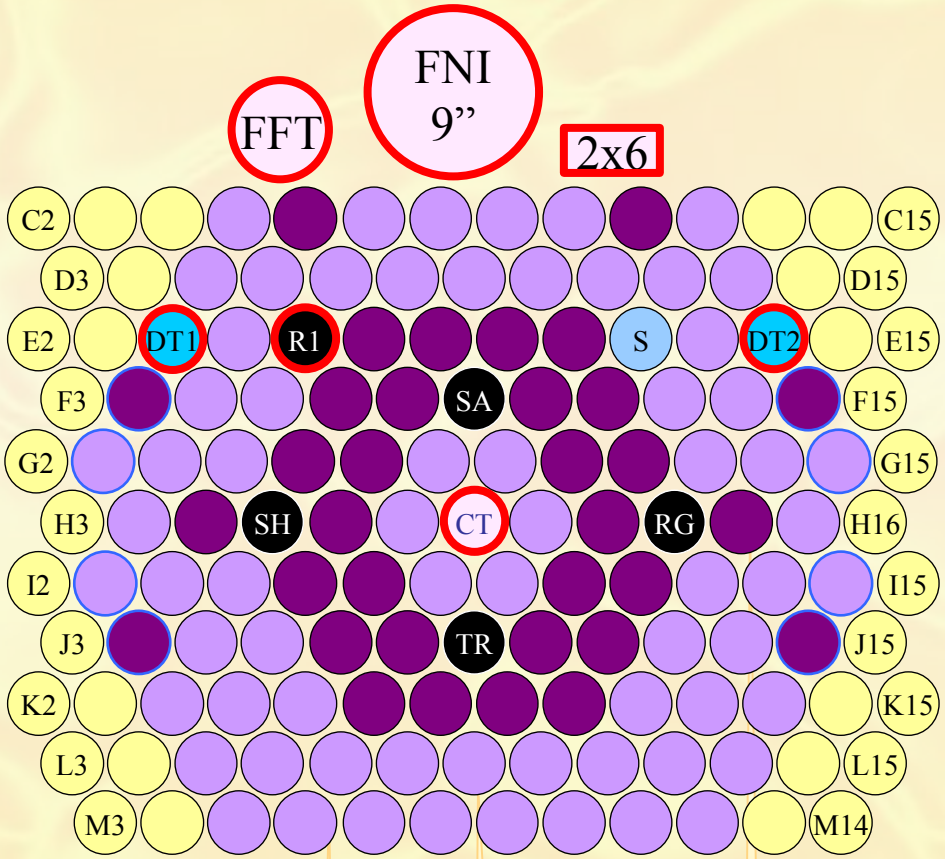




Irradiation Facilities

- Dry Irradiation Tubes
- Central Thimble
- Pneumatic Transfer System
- Fast Neutron Irradiator
- Fast Flux Tube
- “2 x 6” Tube

Core Locations



Irradiation Facilities

Dry Irradiation Tubes (DIT)

Neutron Flux

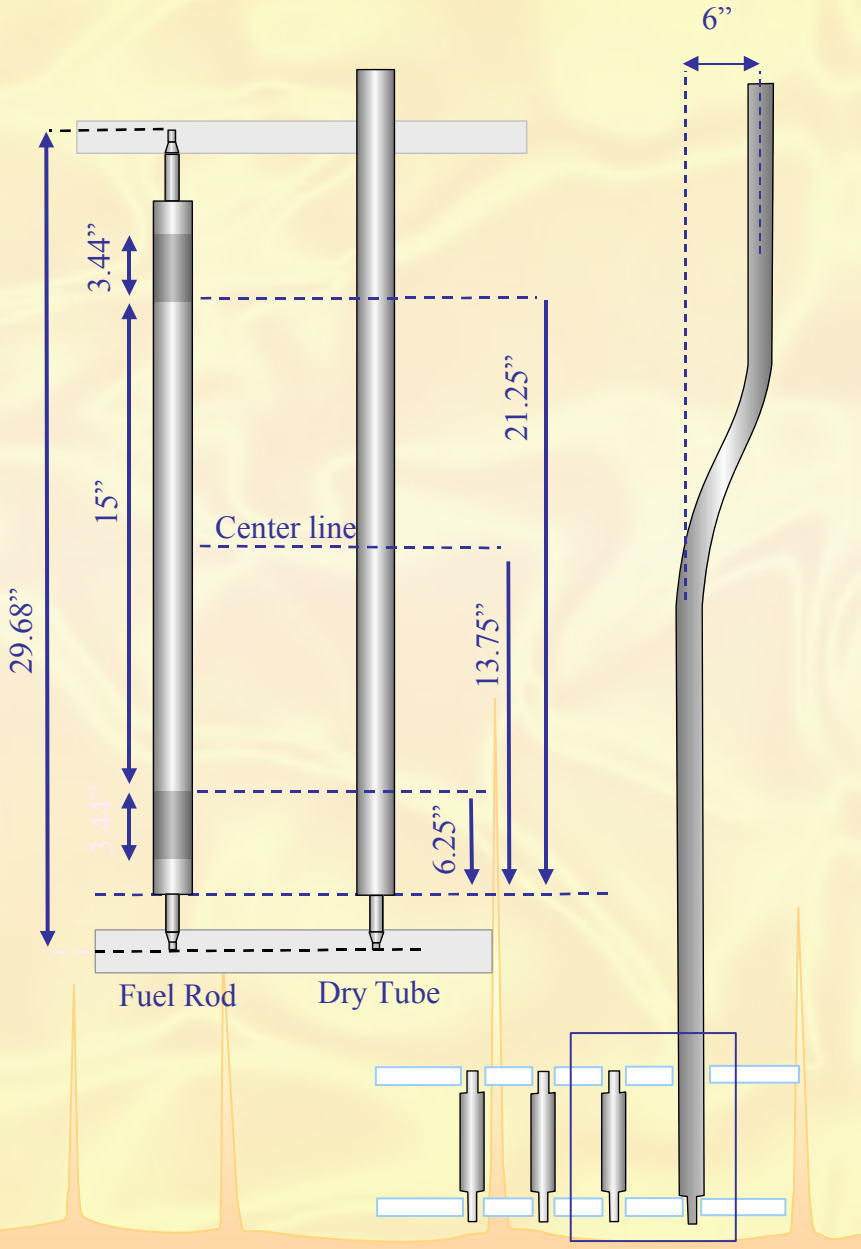
1.8×10^{13} n/cm^2/s thermal
8.1×10^{11} n/cm^2/s epi-thermal
6×10^{12} n/cm^2/s fast

Position

E-3, E-14 Grid plate locations in the outermost core ring

Advantages

The DITs were designed and implemented specifically for the dendrochronolgy project, but are available for general use. The well-documented flux profile (determined from Au-Al wire) makes them ideal for INAA.



Irradiation Facilities

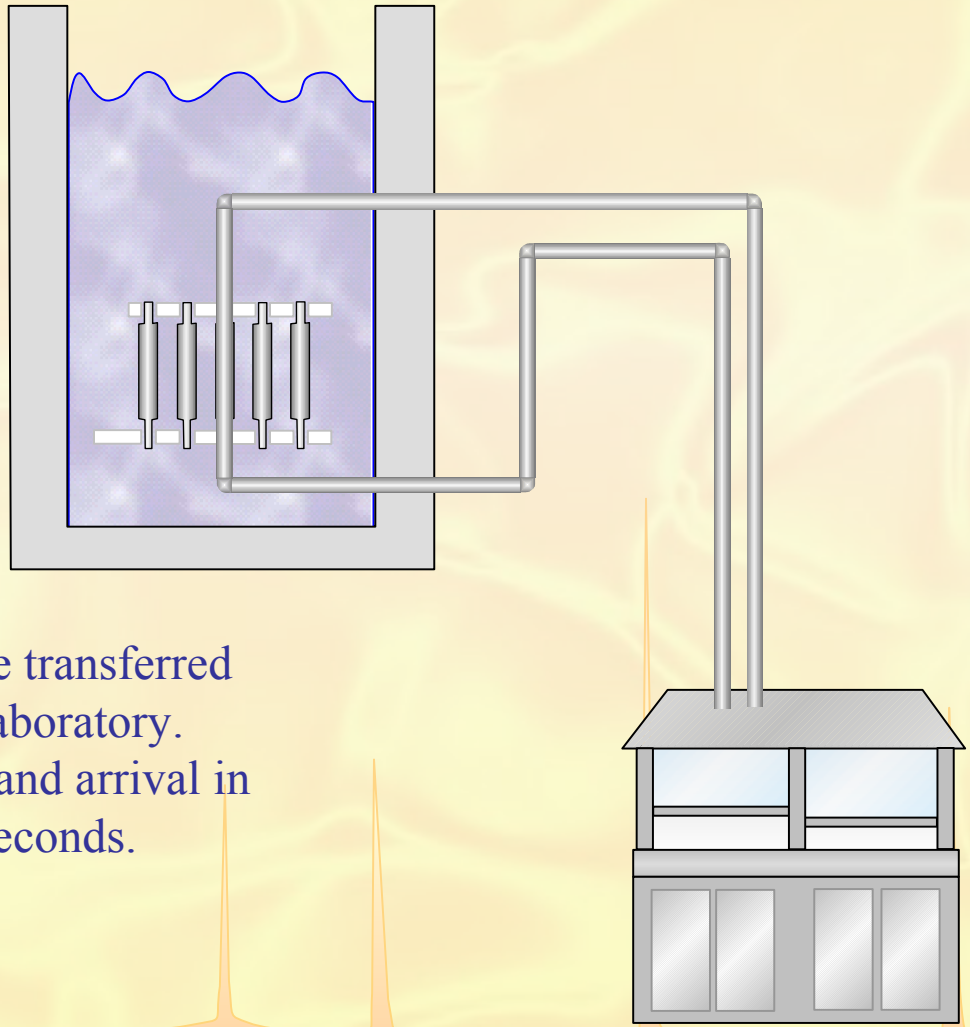
Pneumatic Transfer System

- **Neutron Flux**
  - 1.7×10^{13} n/cm^2/s thermal
  - 9×10^{11} n/cm^2/s epi-thermal
  - 6×10^{12} n/cm^2/s fast

- **Position**

  Grid plate location E-6.

- **Advantages**



The “rabbit” allows for samples to be transferred into the reactor core from a remote laboratory. The time between release of sample and arrival in the reactor core is approximately 5 seconds.

Irradiation Facilities

Central Thimble

- **Neutron Flux**

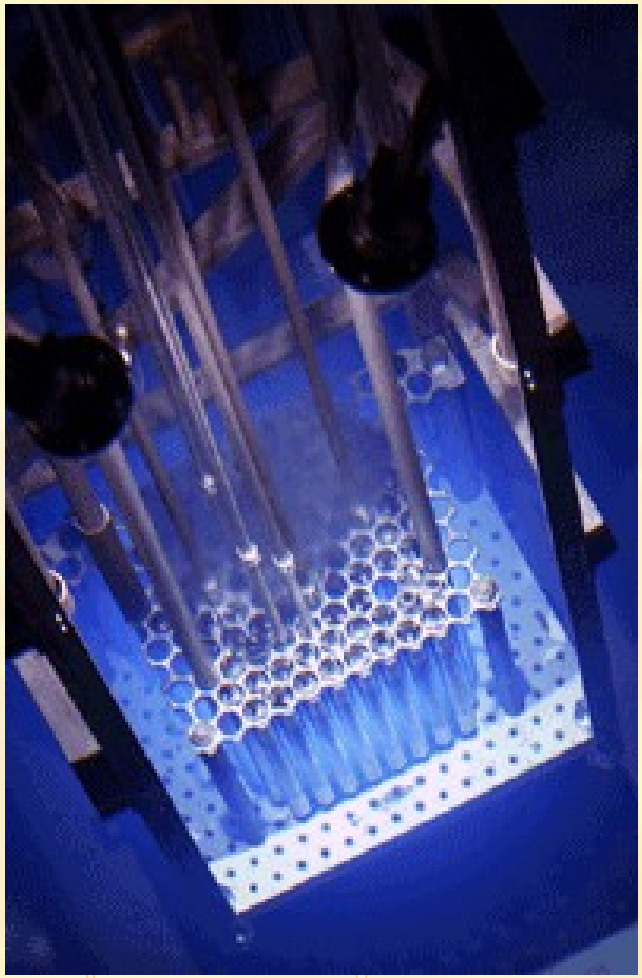
  3.3×10^{13} n/cm^2/s thermal
  3×10^{12} n/cm^2/s epi-thermal
  6×10^{11} n/cm^2/s fast

- **Position**

  Grid plate location H-9.

- **Advantages**

  The Central Thimble features the highest thermal fluxes for irradiation facilities at Penn States core.



Irradiation Facilities

Fast Flux Tube

- **Neutron Flux**

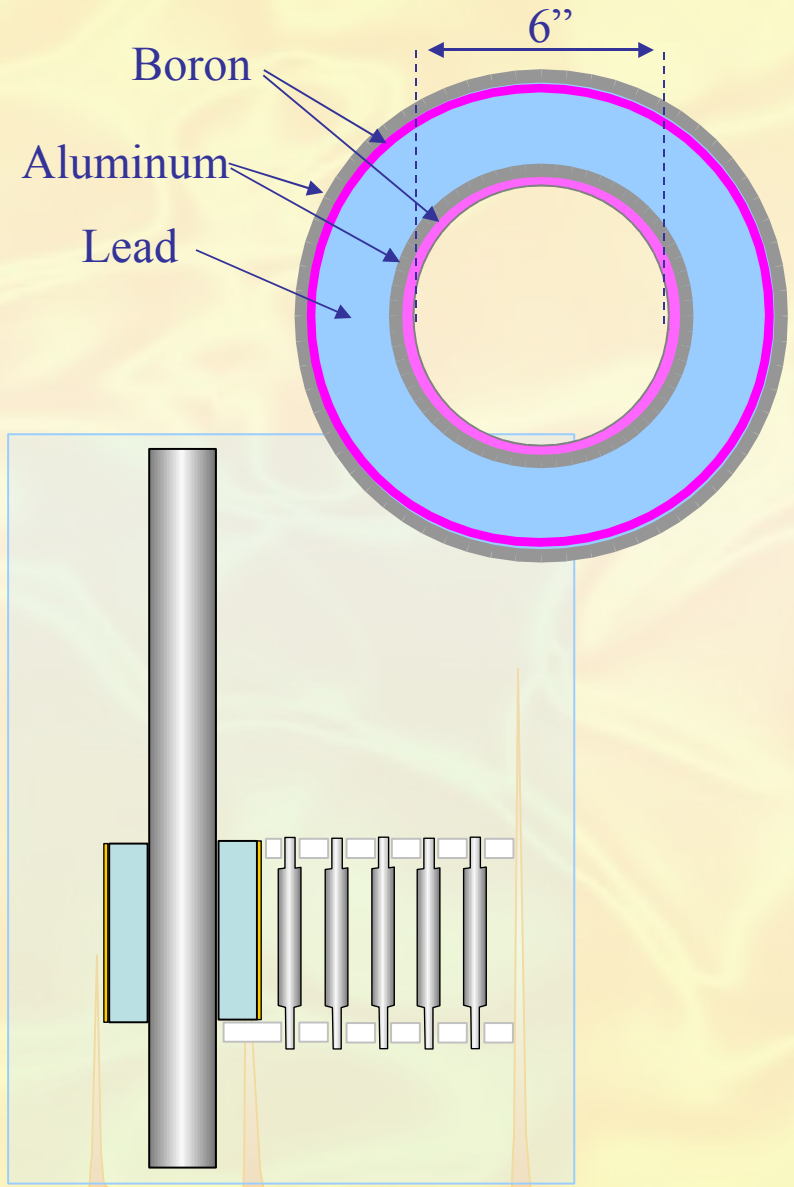
  3.8×10^{11} n/cm^2/s thermal
  3.7×10^{11} n/cm^2/s epi-thermal
  6×10^{12} n/cm^2/s fast

- **Position**

  Against the front core place for Irradiations

- **Advantages**

  The lead, boron and cadmium shielding supply a fast neutron beam. The diameter makes it convenient for for 5” silicon wafer irradiations. Built in 1984.



Irradiation Facilities

Fast Neutron Irradiator

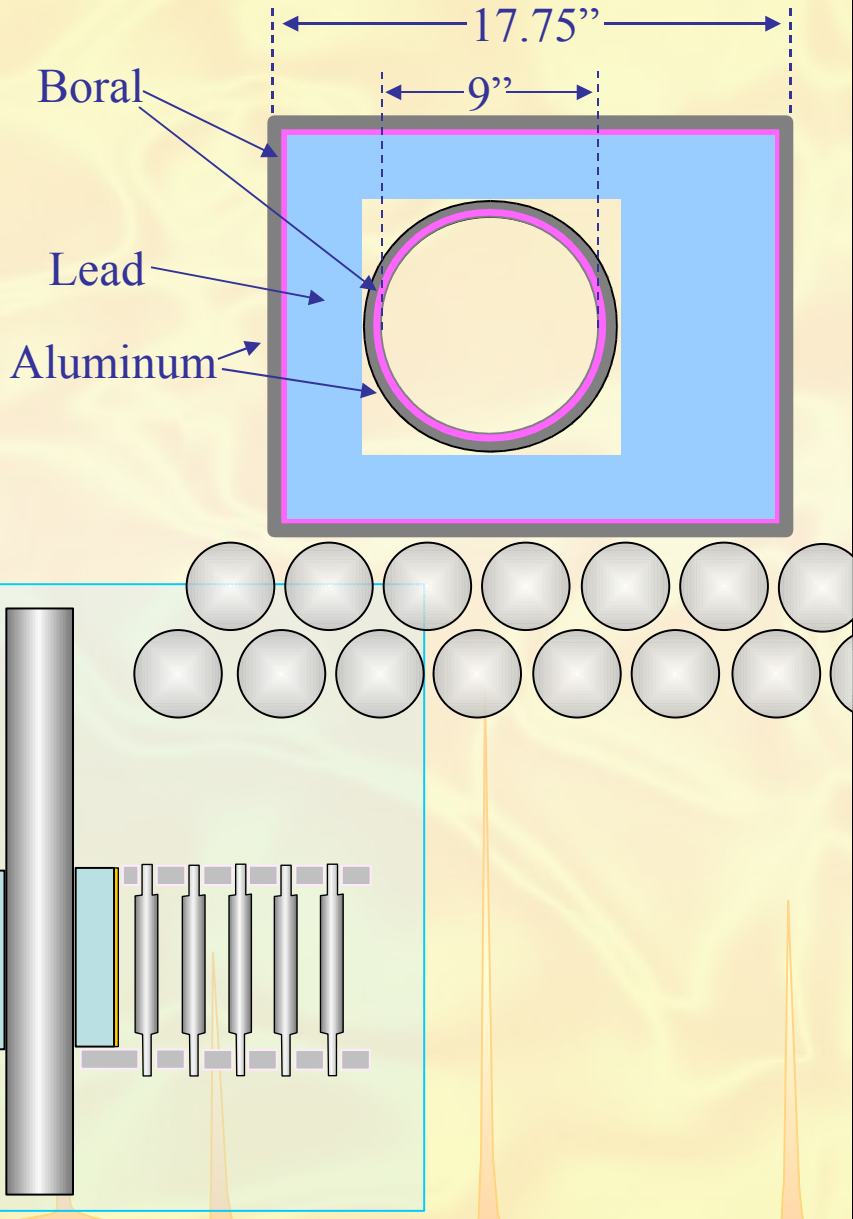
- **Neutron Flux**
  - 3.8×10^{11} n/cm^2/s thermal
  - 3.7×10^{11} n/cm^2/s epi-thermal
  - 6×10^{12} n/cm^2/s fast

- **Position**

  Against the flat core face during irradiation

- **Advantages**

  The larger 9” diameter is an improvement over the FFT. In addition, the rectangular shield allows for a cleaner coupling against the core face. Also used for silicon wafer experiments

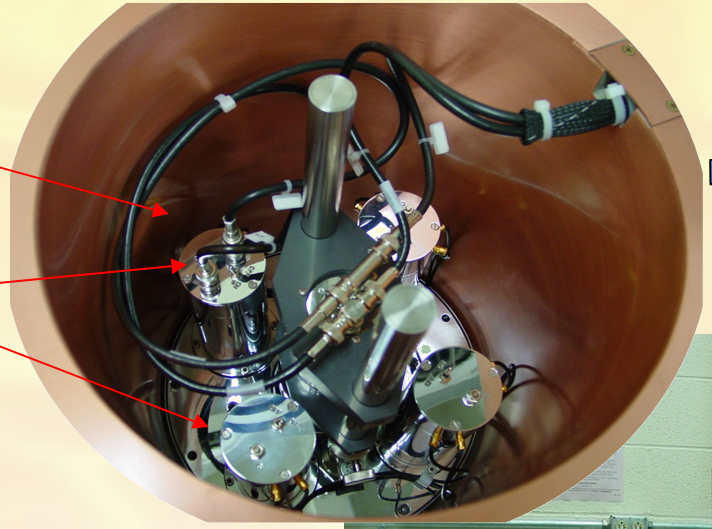


Detection Systems

Compton Suppression System

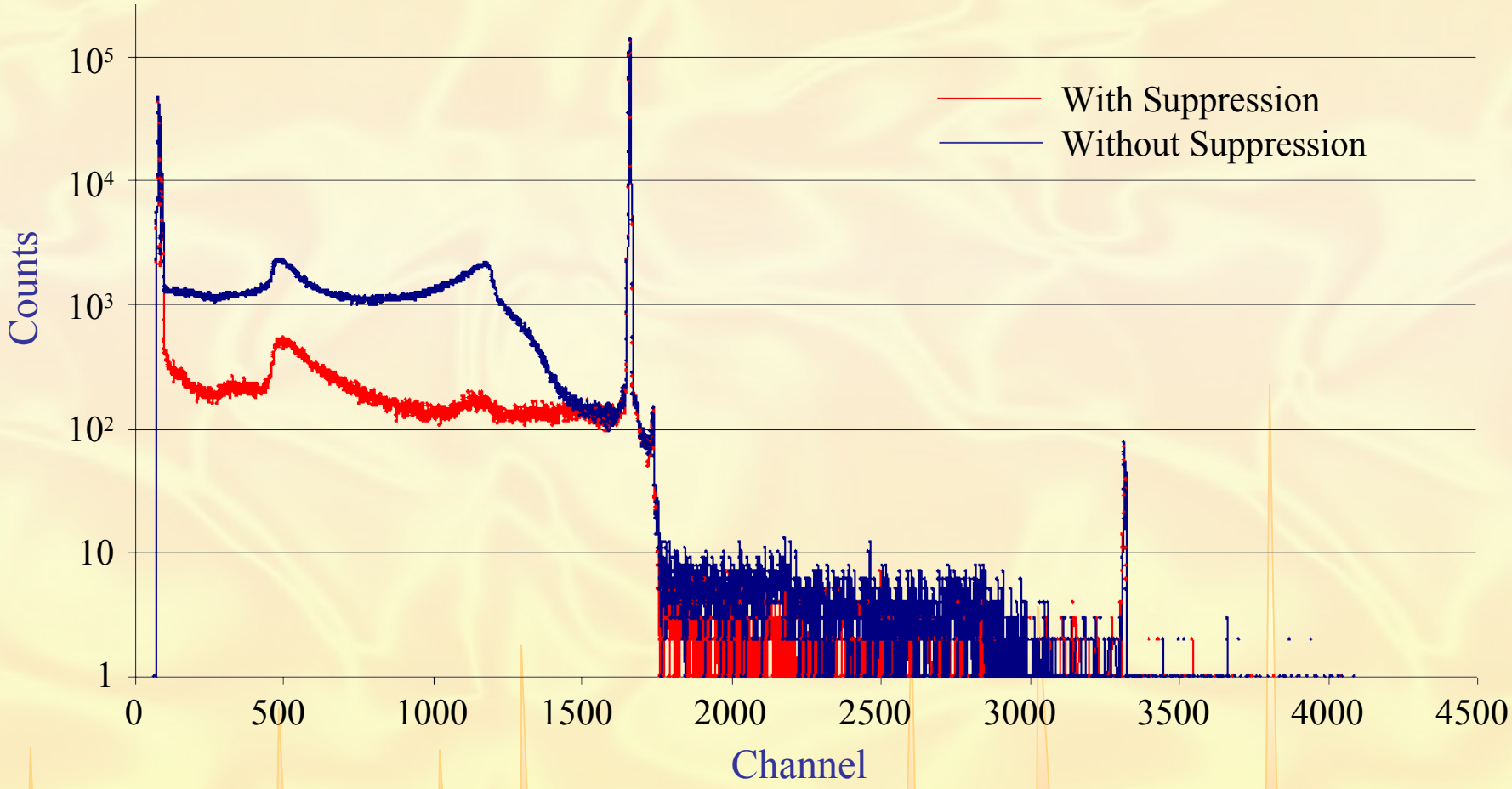
Cylindrical 9”x9” NaI detector (below)

5 2” photomultiplier tube s(PMTs)



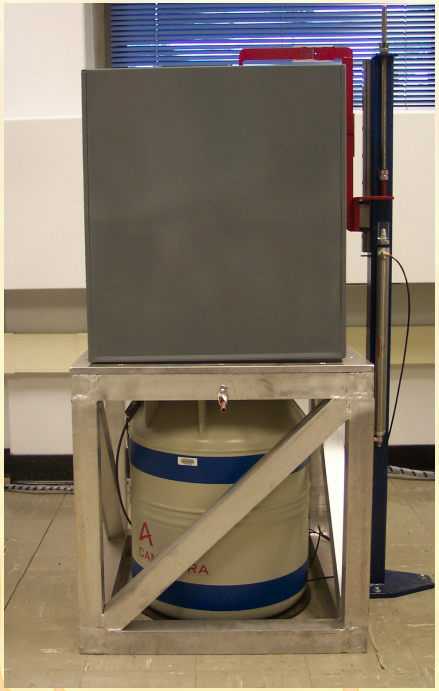
- For samples emitting many high energy photons, the Compton background can outweigh environmental background and increase detection limits and counting errors.
- A suppression system designed to gate data acquisition when coincident gamma rays are detected by the annulus detector.
- Peak to Compton Ratio = 1001.00

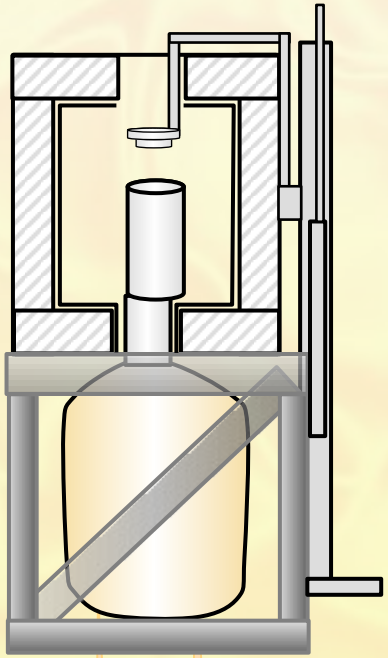
Cesium 137 Gamma Spectrum
The benefit of Compton Suppression



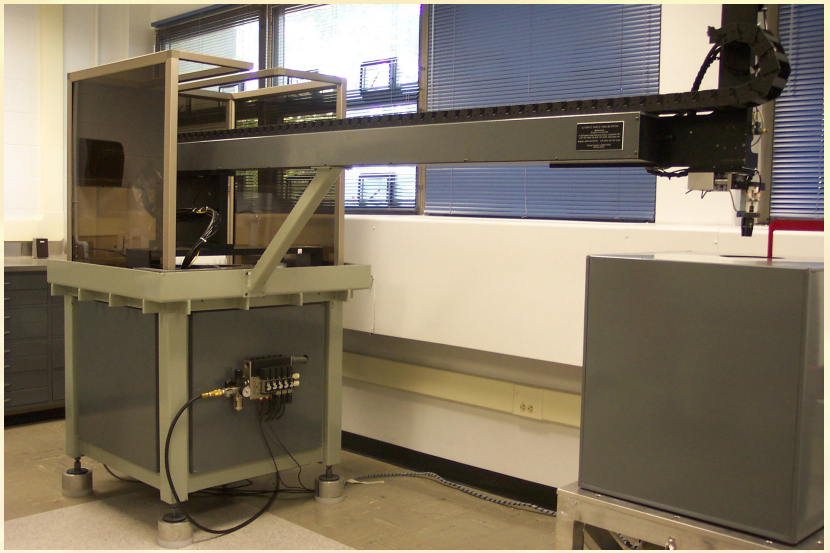
Detection Systems

- Rotary sample table which holds up to 90 samples.
- Pneumatic horizontal transfer arm and sample nest
- Cycle time of about 120 seconds
- Can be run manually or through the gamma spectroscopy computer.





Automatic Sample Handling System



- HpGe Detector with 36% relative efficiency
- 1.8 keV FWHM at 1732 keV
- Shielded by 4” of pre-war lead bricks and copper/aluminum lining
- Used with Digital Spectrum Analyzer and Genie 2000

Utilization

In House Research

NAA of Dendrochronologically dated tree rings

Out-of-House Research

"Tracing the Transitional: Examining Metarhyolite Use Along the Atlantic Seaboard During the Archaic-Woodland Transition" Bondar, G. H., Hirth, K. G. -analyzing spear heads which help trace the archaeological migration along the Atlantic 4,000 years ago. (recent)

NAA of Crab Shell Chitin used in Soil Remediation, Schoenebeck, G., Brennan, R. A., Sanford, R. A., Werth, C. J. -determination of trace elements and possible pollutants in crab chitin that may be used for soil remediation (de-chlorination of Tri-Chlorethene (TCE)) (current)

Dating the Great Oxidation Event, c. 2.3 Billion Years Ago, Horodyskyj, L., Kump, L. –measuring iodine concentrations in precambian paleosols which originated from aerobic phytoplankton and algae. (current)

Impurity Determination in Carbon Nanotubes, D. Allara, K. Ünlü (future)

Education

Nuclear Engineering Freshman Seminar
Radiation Detection and Measurement Laboratory
Westinghouse Scholars
Science Teachers Workshop

Research

Particulates released by the eruption increase Earth's albedo.

SO_2 forms H_2SO_4 due to chemical reactions in the atmosphere.

Explosive eruptions inject sulfur directly into the stratosphere.

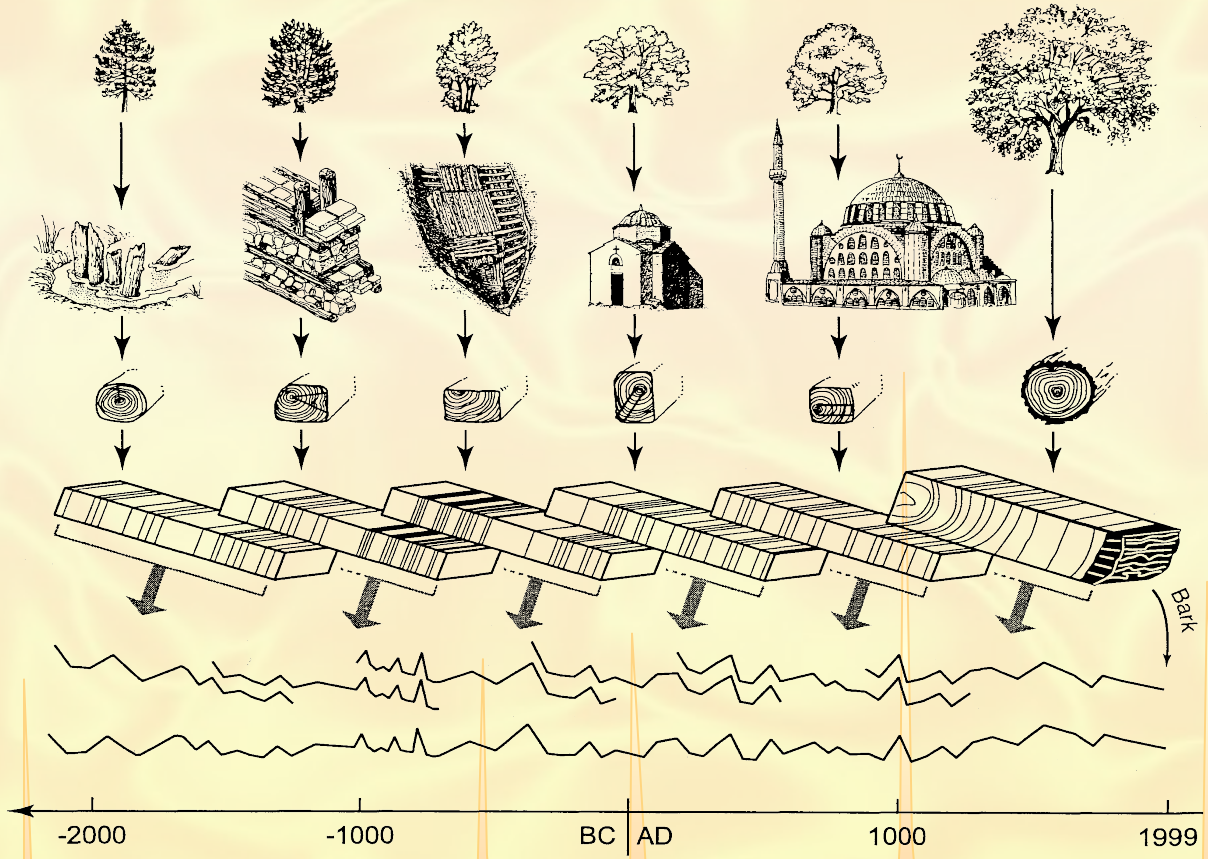
Aerosols are "washed out" of the atmosphere in the form of acid rain.

Increased soil acidity causes stress to plants and increased nutrient uptake.

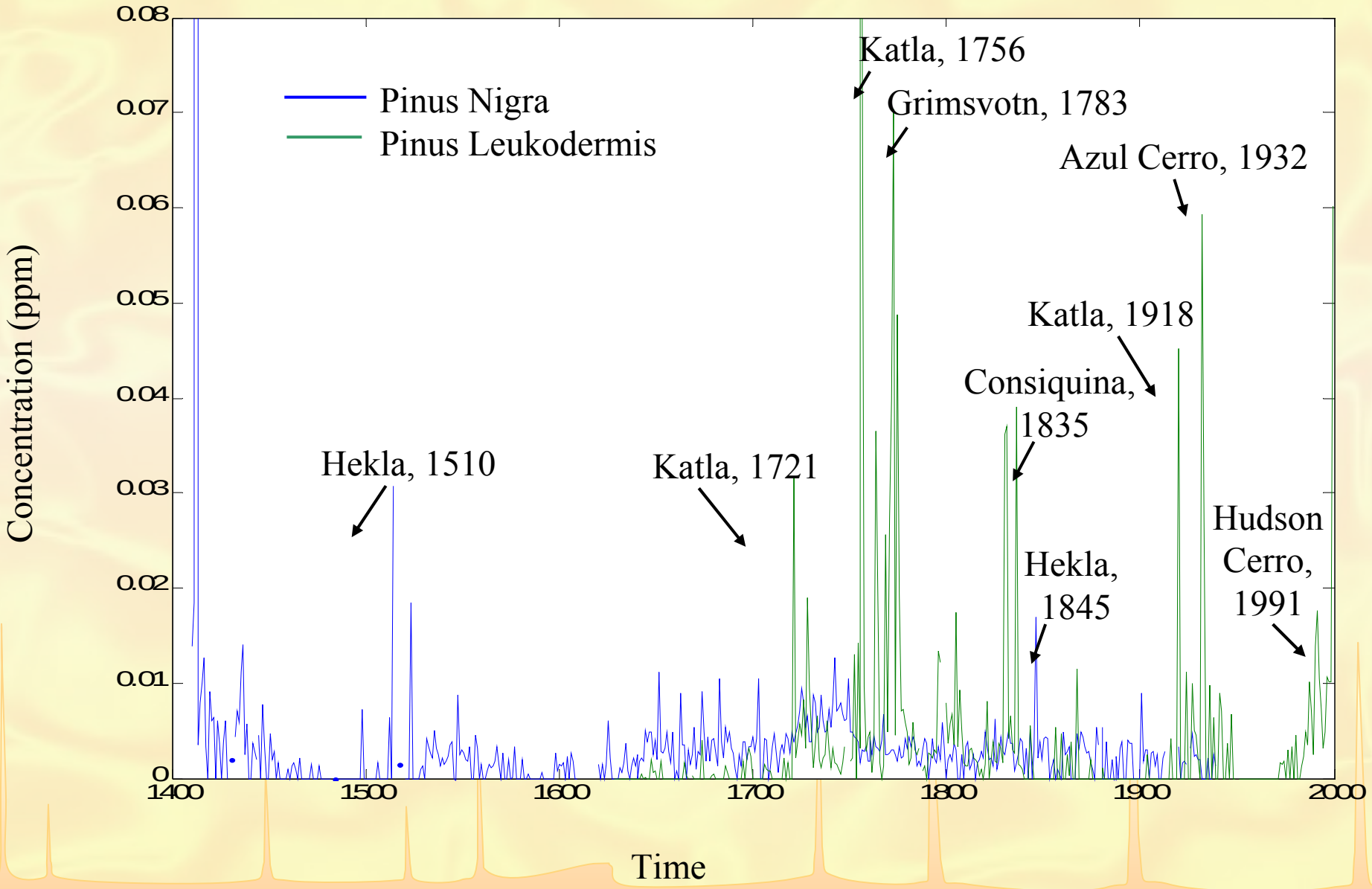
Dendrochronology – Tree-Ring Dating

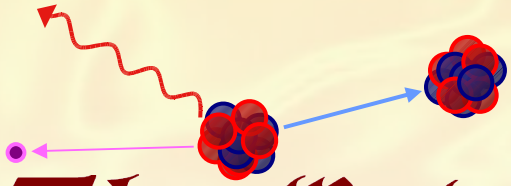
Trees in temperate zones grow one ring per year, forming an annual record or ring pattern that reflects climatic conditions. These patterns can be compared and matched ring for ring with trees growing in the same geographical zone. Following these tree-ring patterns, or chronologies, trees can be cross-dated to determine the age of the wood.

At right: The overlapping of successively older ring patterns, from a living tree sampled in 1999, to a Turkish mosque, to a Byzantine church, to a Roman shipwreck, to an Iron Age wall, to a prehistoric pile-dwelling.



Six Hundred Years of Gold Data





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