# Use of MCNPX for Alpha Spectrometry Simulations of a Continuous Air Monitor

**Robert B. Hayes, Ph.D., CHP, PE**
**Senior Scientist**

Remote Sensing Laboratory
PO Box 98521, Mail Stop RSL-47
Las Vegas, Nevada 89193

**American Nuclear Society Annual Meeting – June 24-28, 2007**
**Boston, Massachusetts**

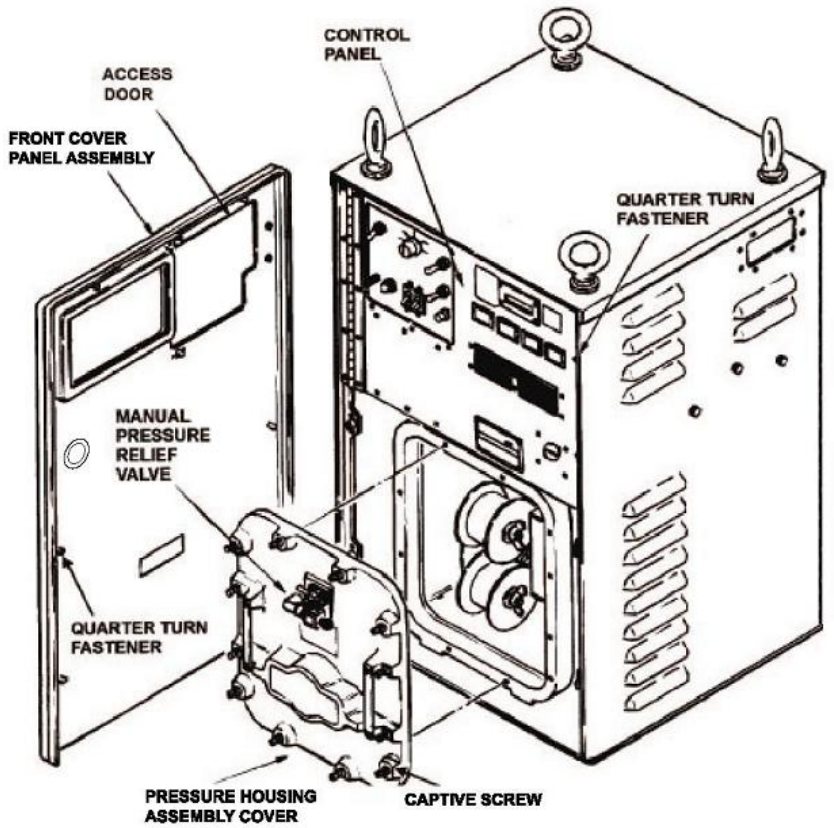
This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy.

# The Next Generation Air Particle Detector (NGAPD)

- Large occurrence of false alarms on current system.
- False alarms are caused almost exclusively when the boat is docked and external air is brought in.
- Current detection system utilizes gross counts after a nominal 30 minute wait time for radon progeny to decay.

# How does the present design work?

- Air is brought through a paper filter via a pump mechanism.
- The filter is continuously moving from a roll paper feed source.
- The detector is a scintillator/PMT combination placed approximately 1 inch offset from the active sampling location.
- The paper takes approximately 30 minutes to move from the sampling location to the counting position.
- Alarms are based on gross counting thresholds.
- Only local alarm capability.



# Why Spectrometry?

- Alarms are attributed to radon progeny causing high beta activity during a temperature inversion on shore.
- By measuring the alpha simultaneously with the beta, the beta due to radon can be accurately predicted allowing it to be subtracted from the total beta being monitored.
  - The NGAPD is primarily a beta air monitor.
- By compensating for the radon progeny under all credible source term distributions (including interaction on the air filter), a robust algorithm can be developed to prevent false alarms.
  - False alarms are entirely deleterious as too many will cause sailors to not respond accordingly, they will assume any alarm is a false alarm.
  - If the alarm threshold is raised, the sensitivity of the instrument is compromised.

# Why a spectrum simulator?

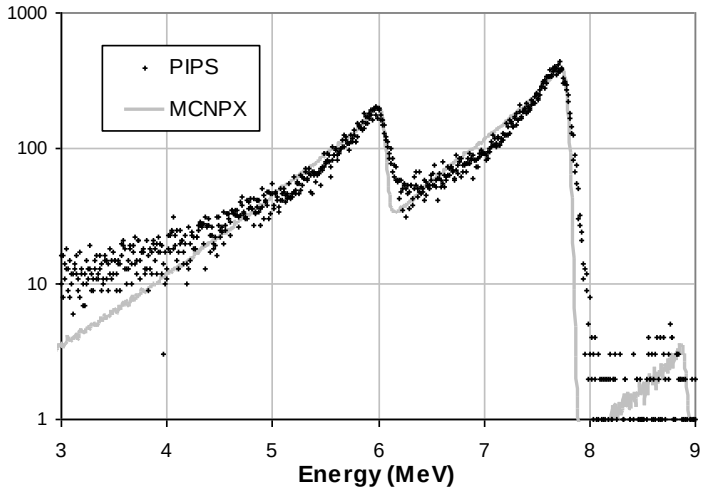
- This will allow the source spectrum of the isotope intended to be detected to be superimposed on the interfering radon progeny spectrum for definitive real world evaluation of efficacy.
- All commercial systems presently available require the air flow to be disabled and the measurement filter containing the radon progeny to be removed to count the NIST traceable source.
  - This means the radon stripping algorithm is bypassed altogether!
    - The radon stripping algorithm is the actual means by which an alarm would trip if an actual release were being detected!
- The NGAPD would have the capability to functionally test if the alarm will set at the predetermined activity level, no other continuous air monitor presently has this capability as the alarming criteria is fallacious without the radon progeny spectrum present to be stripped out and the algorithm actually tested under real world conditions.

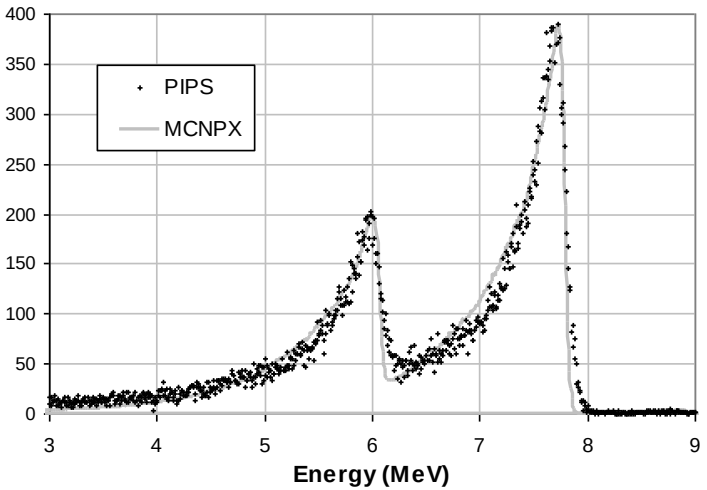
# Why actively simulate a source spectrum?

- Functional testing of the alarm levels can be verified as often as desired.
- Functional testing could be done remotely.
- Functional testing can be done on a single update period minimizing down time for the testing to be carried out.
- The source spectrum can be read in from a NIST traceable source allowing for the spectrum to have the correct pedigree for regulatory compliance applications.
- The source spectrum can be updated each time an efficiency calibration is carried out on the system.
  - A source spectrum simulator can not be used to replace efficiency calibration.
  - Efficiency checks and calibrations will still have to be conducted periodically.

# Results obtained to date

- Excellent agreement was obtained using literature values for air deposition on filter substrate (R. Pollanen, T Siiskonen. *Health Phys*. **90**, 167-175, 2006).
- Attenuated deposition into the filter was modeled.
- Credible radon, thoron and actinon distributions were modeled (100:10:1 source term ratios).
- Spectral agreement is deemed adequate to begin testing humidity, disequilibrium and particle size distribution effects on algorithms.



# Conclusions

- Spectral simulation capability deemed adequate for testing real world loading conditions on filters.
  - Important as final design is still at least 2 years away and algorithm should be working on first unit utilized in field testing.
- MCNPX will also allow testing beta and gamma effects although these will require separate input stacks where superposition of each particle effects.
- Initial algorithm tests utilizing 2 window algorithm suggests adequate sensitivity (Chen et al. *Health Physics*, 66(5):557-564; 1994).
- All needed capability exists to effectively type test algorithms.
- Recommendations have been made to the Navy to consider commercial units for shore based radiological work monitoring activities.