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Title:	LANSCE: Overview of Radioactive Air Emissions Monitoring (RAEM) program
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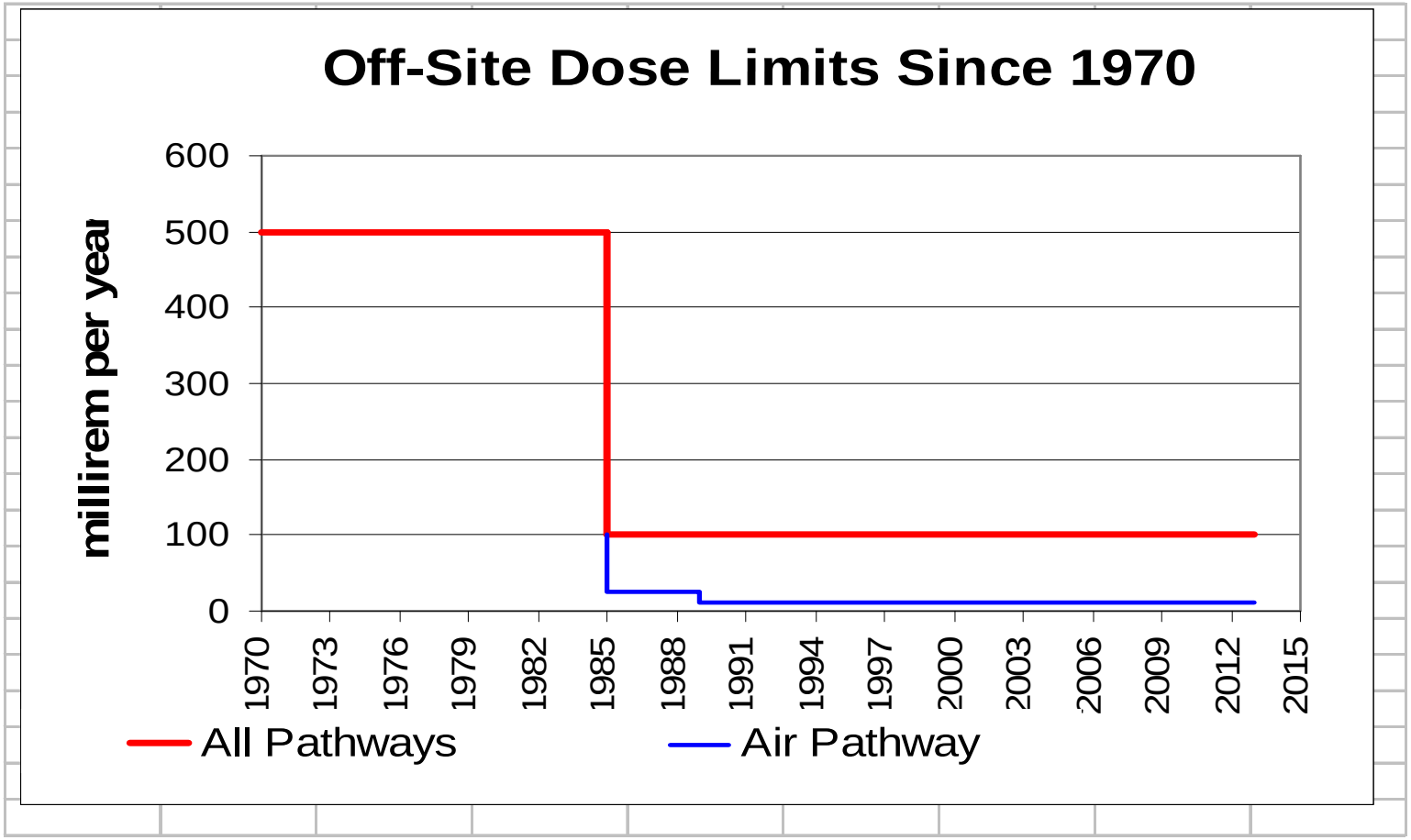
Overview of Radioactive Air Emissions Monitoring (RAEM) program

Los Alamos NATIONAL LABORATORY EST.1943

Presentation Outline

- Facility Background
- Radioactive Air Emissions
  - Stacks
  - What is monitored & how
  - Emissions controls systems
  - Diffuse emissions
  - Historical perspective

Emissions Limits



LANSCE Facility

- 800 meter long accelerator (1/2 mile)
  - generates high-energy ion beams
  - proton (H+) and negative-ion (H-) beams
  - high energy & velocity; 84% of light speed
  - high current; 1 milliampere of current (thru 1999)
  - = 6,240,000,000,000,000 protons per second
  - only facility of this power in nation
  - neutrons generated by impact of beam w/ target

LANSCE Research

- Accelerator Production of Tritium (‘97-’99)
- Science-Based Stockpile Stewardship
  - Proton Radiography
- Materials Studies
  - crystal structure
  - neutron resonance spectroscopy
- Medical Radioisotope Production
- Pure nuclear physics research

TA-53 Emissions Stacks

- Exhaust Stack 2 (ES-2)
  - Lujan Center (target 1), Weapons Neutron Research facility (targets 2 & 4), Line D beam tunnel. "South Side" of TA-53
- Exhaust Stack 3 (ES-3)
  - Area A, Area A-East (A6 beam stop), Line B, Line C, Beam Switchyard, Area C (HRS)
- Main accelerator tunnel held stagnant

ES-2 Stack

ES-3 Stack

Radioactive Air Emissions

- Formed by spallation or activation
- “Target” atoms include air (nitrogen, oxygen), water vapor, beam line components
- Three types:
  - Gaseous Mixed Activation Products
  - Particulate & Vapor Activation Products
  - Tritiated Water Vapor

Radioactive Material - Gases

When proton beam runs through ambient air…

- Generated by interaction of the ion beam, or secondary particles, with air & other materials. Mostly C-11, O-15, N-13
- Spallation: impact of high-energy particle with a target atom's nucleus, releasing protons or neutrons from target atom. Can also "shatter" nucleus.
- Activation: absorption of particle into nucleus

When beam line & targets are maintained under vacuum…

- Radiolysis: separation of cooling water into component parts under high incident radiation; subsequent activation/spallation. Results in mostly C-11 & O-15.

Radioactive Material – Particulates & Vapors

Particulate material

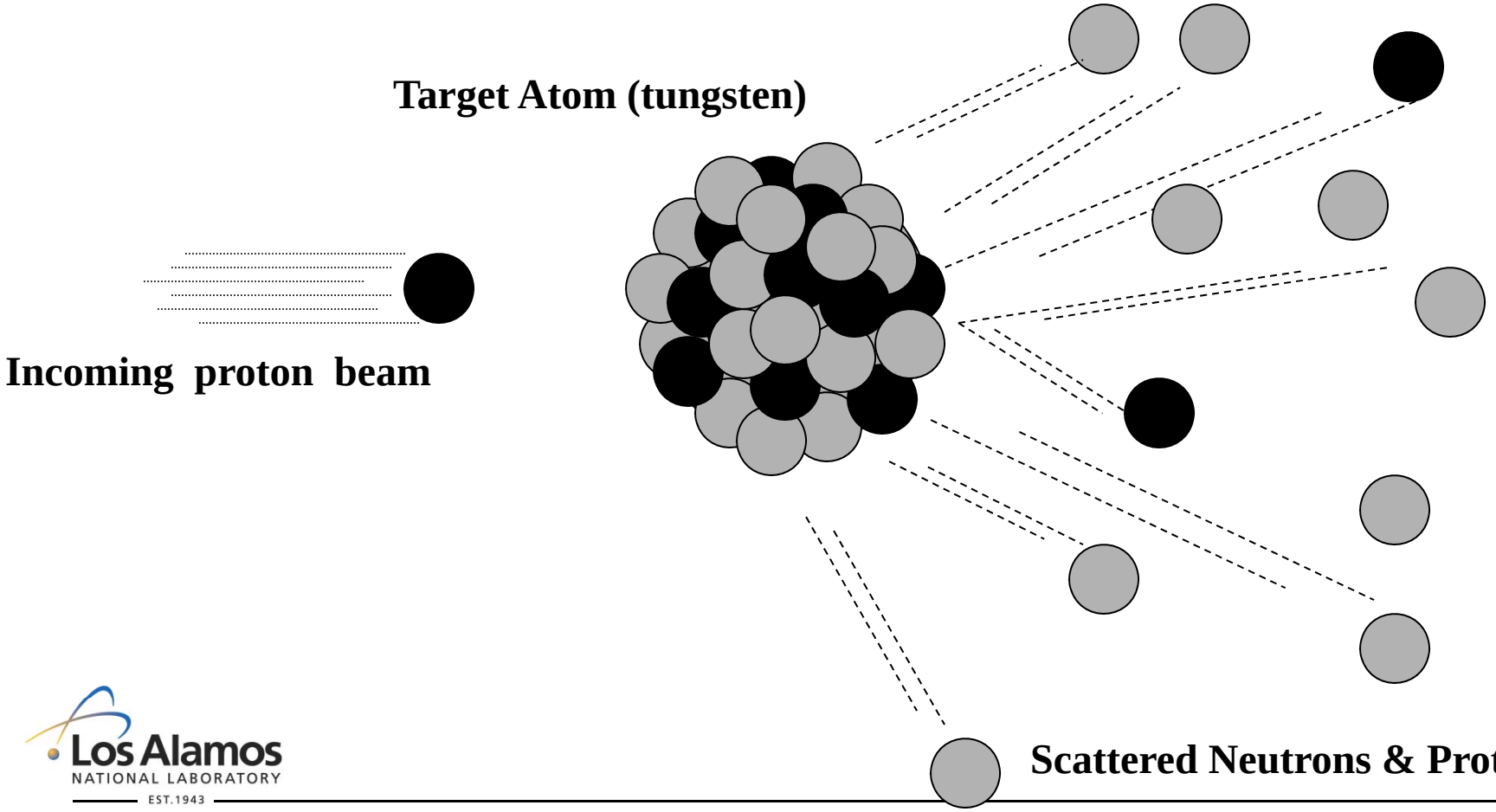
- Activation/spallation of beam line components or shielding
  Mn-54; Co-60; Na-22, Na-24
- Beryllium – cosmogenic nuclide, detections are usually rejected.
  But beryllium moderators; cannot assume naturally occurring.
- HEPA filtration on stack, particulates not seen in abundance

Vapors / Volatiles

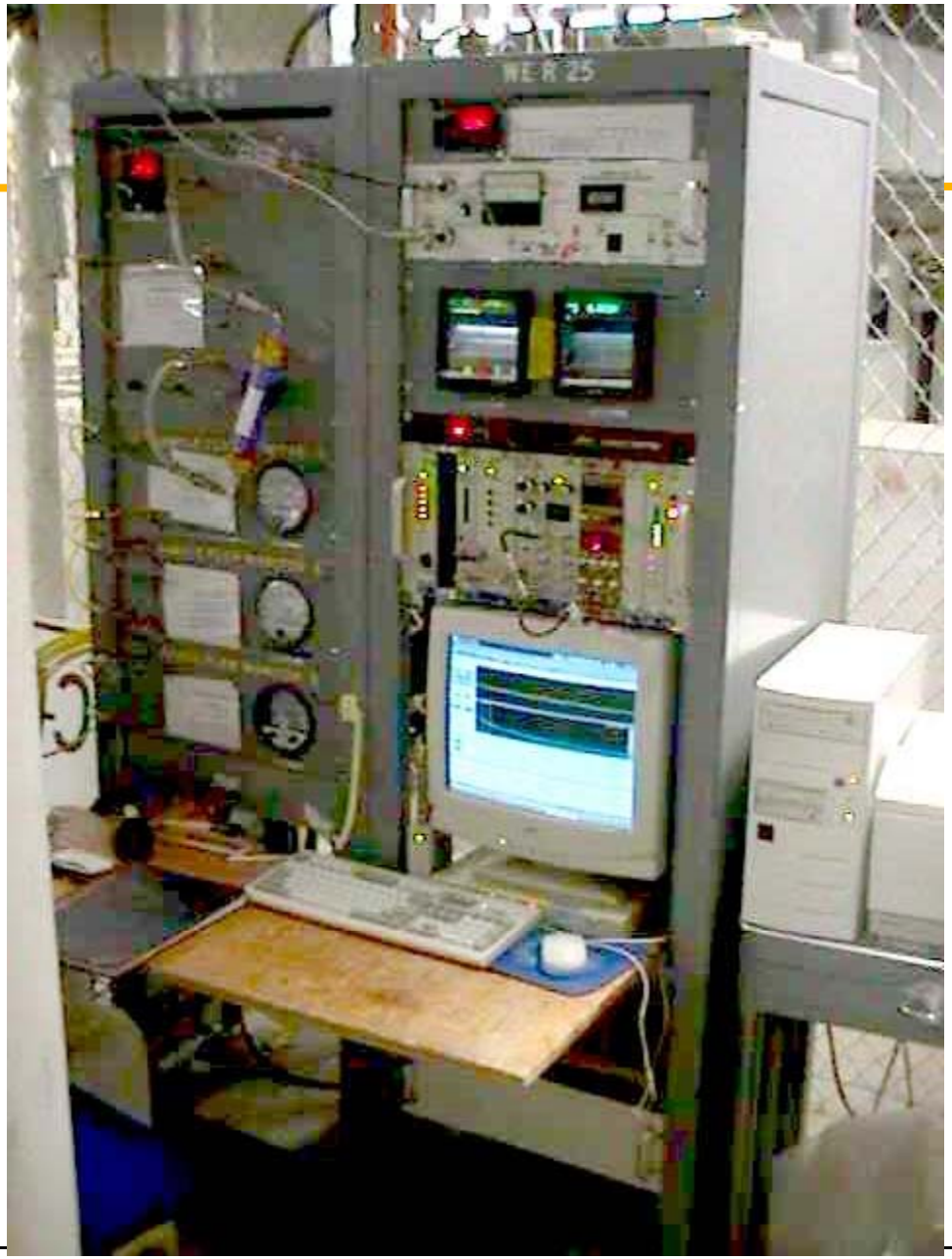
- Mercury isotopes – activation/spallation of shutter system.
- Bromine isotopes – naturally liquid/vapor
- Selenium & germanium – fluorine compounds, volatile

Spallation Example

proton beam incident on heavy target atom



Stack Sampling Station ES-2



Particulate & Vapor Activation Products (PVAP)

- Typically, spallation or activation of metal, concrete, etc.
- Airborne suspension of particles
- Particles subject to HEPA filtration; volatiles/vapors pass through
- Samples taken with paper filters (particulates) and charcoal filters (vapors)
- Exchanged weekly

Issues

- Short-lived nuclides; ship off-site for analysis, 36 hours after removal.
- Decay correct results; assume generation scales with current.
- Changing conditions can yield different emissions species

PVAP sample assemblies

PVAP sampler in-line

Tritiated Water Vapor (HTO)

- Activation of water vapor in the air
- Hydrogen + 2 neutrons = tritium
- Radioactive H_2O referred to as HTO
- Water collected on indicating silica gel
- Samples exchanged monthly or upon saturation
- LANSCE - NOT required to monitor HTO
- Sampling operations ceased in 2001; use historical ratios to determine emissions

HTO sample assembly

Gaseous Mixed Activation Products (GMAP)

- Spallation & activation of air
- Makes up >90% of rad air emissions
- Primary Source: "air gap" at A6 Beam Stop (thru 1999)
- Primary source since 2000 – cooling water system at 1L target.
- Gaseous; NOT affected by filters
- Primary Constituents:
  C-10, C-11, N-13, N-16, O-14, O-15, Ar-41
- All short-lived radionuclides
- Can cause off-site dose consequence if public receptors are nearby (1 km!)
- Water leaks, loss of vacuum can increase emissions
  (more "target" atoms)

A6 Beam Stop

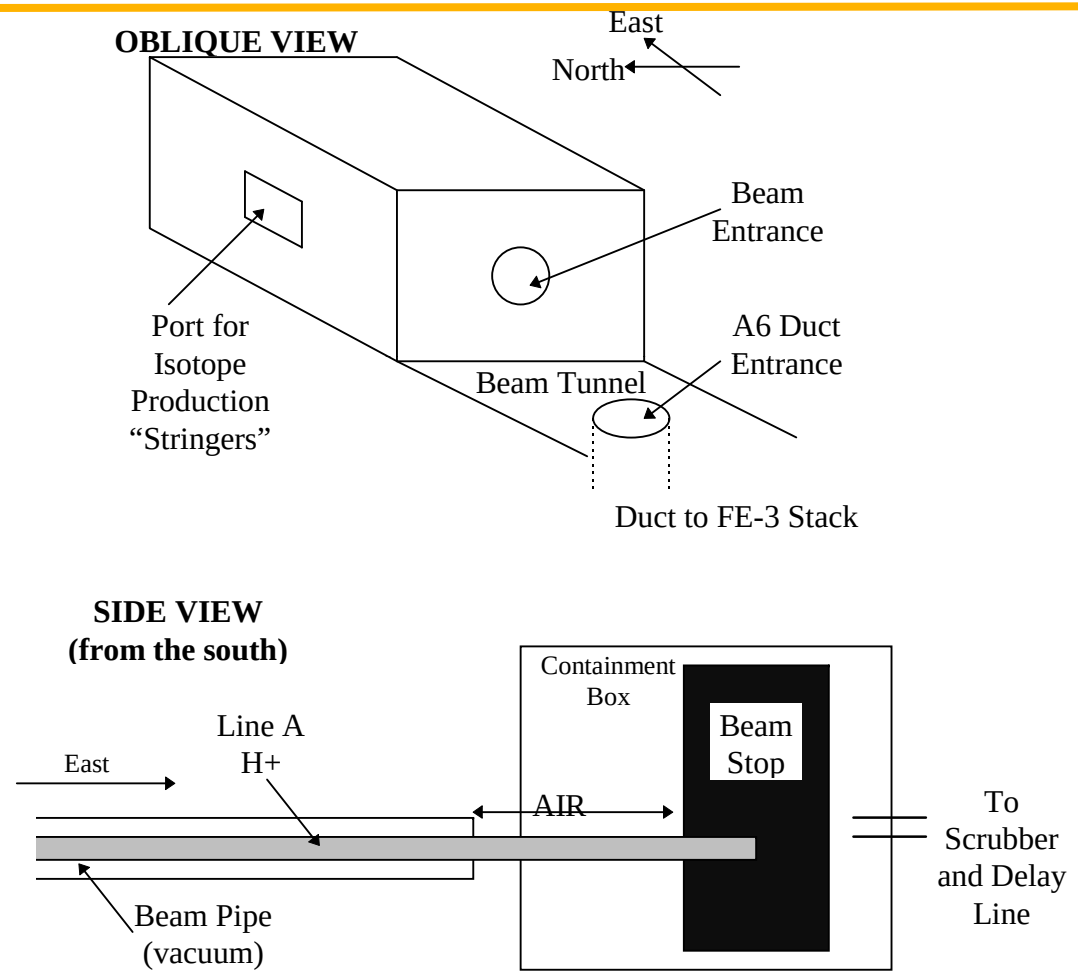


Figure 3: Block Diagrams of Containment Box

GMAP Monitoring

- Two detector systems in series

- Flow-through ionization chamber
  - Kanne air ionization chamber chamber
  - 300 volt bias
  - Measures “gross emissions,” total magnitude
  - Continuous operations – minimal down time due to Excel-based acquisition files; <5 mins/week
  - Total charge collected (picocoulombs) relates to magnitude of emissions (curies)
  - Tracks integrated current (charge) over time

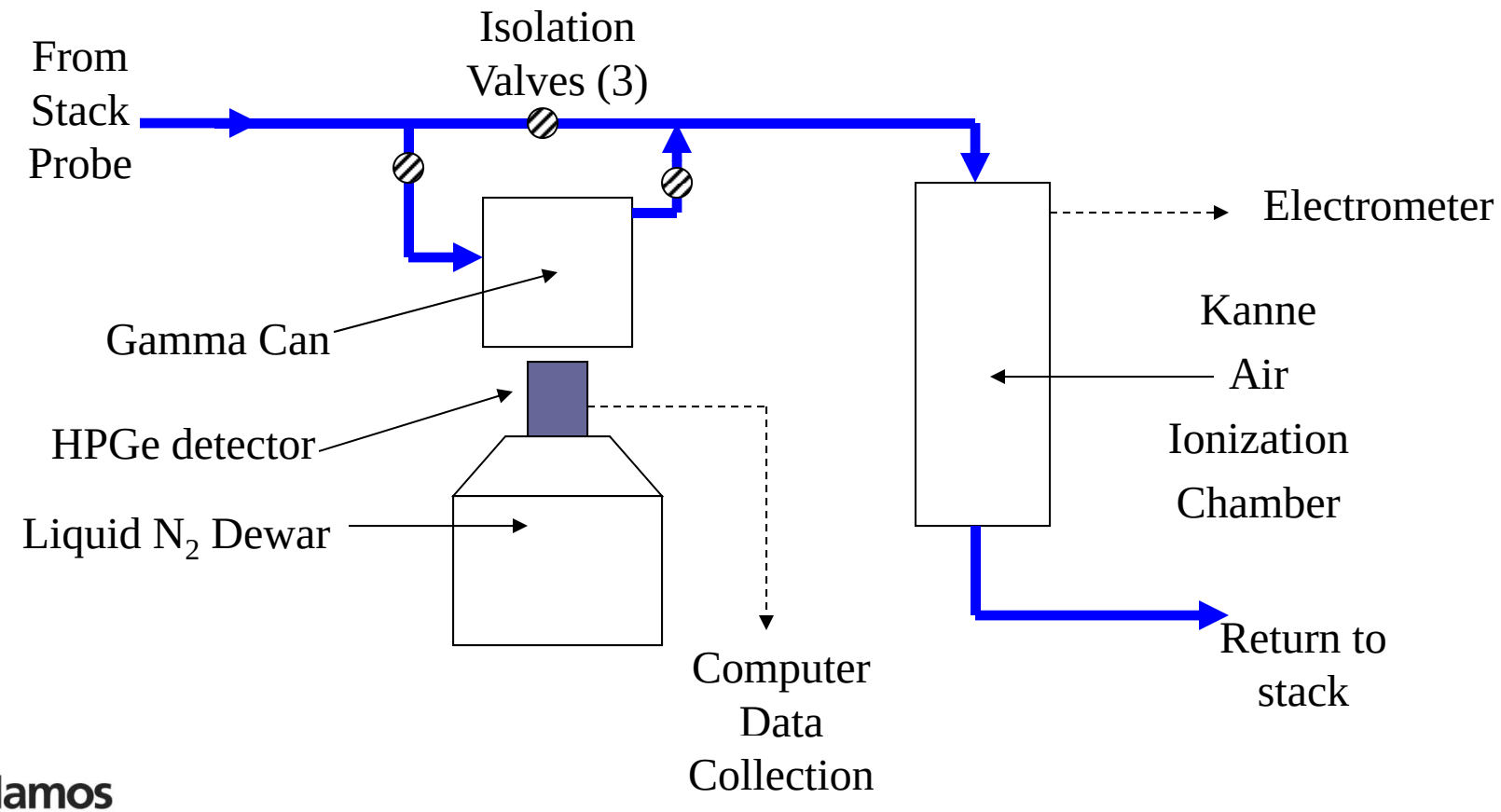
Gas Composition Measurements

- High-Purity Germanium detector (HPGe)
  - “quasi-continuous”; 3-7 day acquisitions
  - measures relative composition of stack air
  - Isolate system for “decay curves”

    Differentiate half-lives of pure 511 keV emitting radionuclides
  - All nuclides related to 511 keV line
  - Ratio, 511 keV peak area in HPGe to pC collected on ion chamber during acquisition.

  - Emission calculation uses total charge collected, 511 keV peak area per pC collected ratio, stack flow, ion chamber volume to determine curies of positron-emitting radionuclides emitted.
  - Other radionuclides calculated via ratio to 511 keV nuclides.

GMAP Detector Schematic



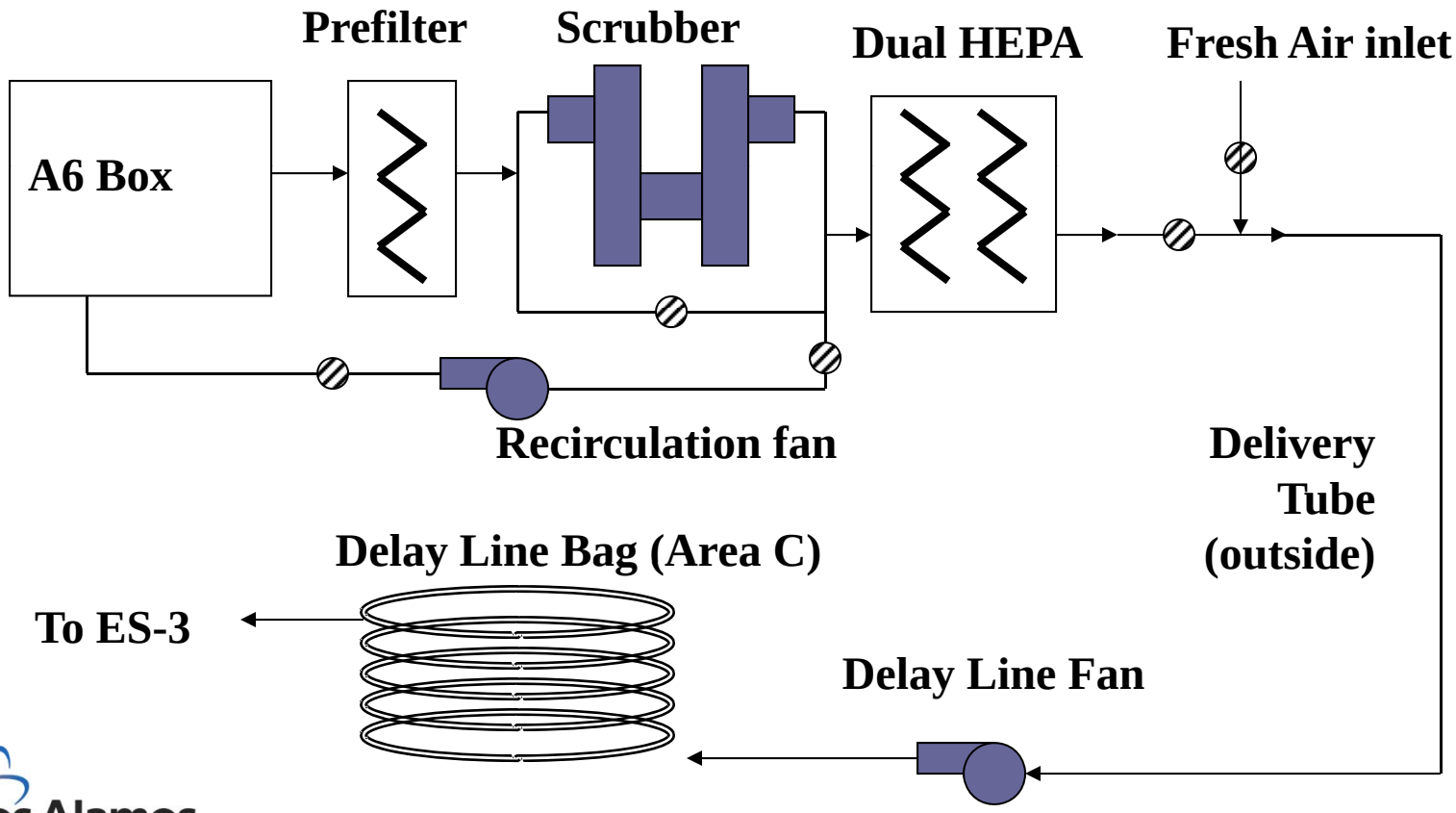
Controlling GMAP Emissions

- Short half-lives: nuclides subject to rapid decay, if containment is possible
- A6 Delay Line system: 1994-1998
  - Pulls low flow rate (~100 cfm) from A6 containment box
  - 4000 feet duct, 2’ diameter
  - > 100 minutes delay before ventilation out ES-3
  - Reduces A6 emissions by over 80%
- 1L Delay Line System: 2004-2005
  - Very low flow - < 1 cfm
  - Uses pressure buildup in cooling water loop as driving force
  - Pressure relief system vents into large-diameter copper tubing
  - Migrates through tubing, discharge to stack

More GMAP controls – A6 system

- Filters in Delay Line system (Line A, 1000 microamp beam)
  - shielded, disposable prefilter – removes major contamination from system
  - dual certified HEPA filter system – removes all remaining particulates
- Wet air scrubber system
  - two packed-bed towers
  - removes excess water (tritium), acid, carbon dioxide, vapors, particulates

Delay Line Schematic – 1990's A6 Beam Stop



Delay Line Bag (1998)

Delay Line 1998: Top View

Delay Line: Inlet & Outlet

Scrubber Schematic

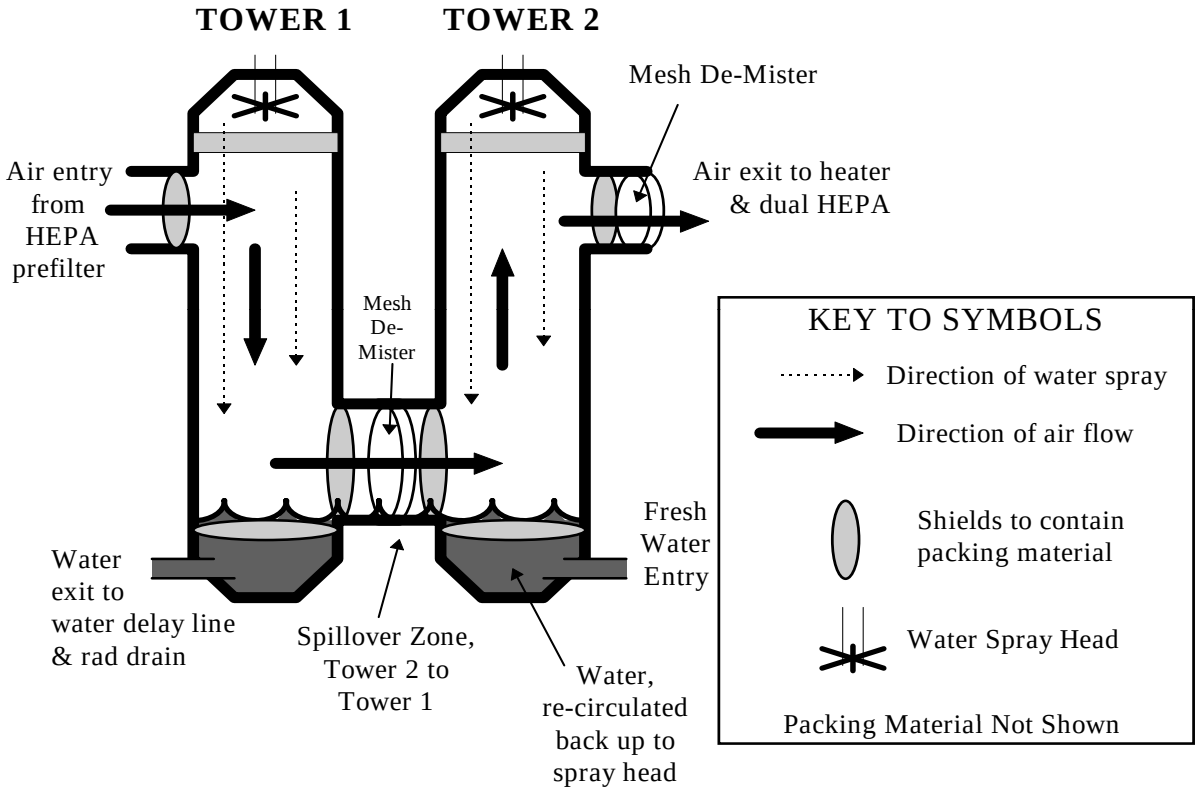


Figure 6: Diagram of Scrubber

Issues with Emissions Controls

A6 Beam Stop – high-intensity beam, air gap

- Air (nitrogen) activation leads to high-acid environment; damages diagnostic equipment.
- Scrubber water becomes acidic; control pH prior to discharge
- Direct radiation source from activated air in system
- “Transient” state nuclides bypass filters; Ne-24 (gas) to Na-24 contamination downstream

1L Target – 120 microamp beam, under vacuum

- No air activation, but radiolysis of water is major source
- Pressure buildup in cooling system
- Cracked valve at delay system entrance in 2005 – 300 Ci/day, 6 mrem off-site dose

Diffuse Emissions

- Radioactive air migrates from beam line area into buildings & rooms along Line A
- Measure concentration of radioactive air in room
- Measure, estimate outflow of air
- GMAP only, conservative composition
- Minimized by delay line & sealing efforts

Diffuse Emissions Monitor

50 Liter Kanne chamber

Diffuse Emissions Sites

- Area A-East
- Isotope Production building
- Beam Switchyard
- Area A (during A1 or A2 operations)
- 1L Service Area
- Other areas monitored for potential emissions, personnel protection, and diagnostic purposes

Issues

- Changing equipment & operations leads to different monitoring needs
- Generation rate can be subject to beam performance (spill)
- Emission rate can be subject to meteorological conditions

Summary

- Emissions are dominated by gaseous species – difficult to control
- Types & quantity of emissions can vary with facility conditions
- Changing regulations can increase importance of emissions management
- Different experiments can drive different emissions monitoring needs

- Thanks for your time

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