The Design & Operation of a Monitoring System which Separates & Measures High & Low Concentration Tritium in Air

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Tritium Monitoring System

- Design Criteria Questions
- Design Criteria Answers
- Applied Design Principle
- Detector Types
- Unique Challenges
- Construction Methods
- Applicable Standards; ANSI, IEC, ISO, etc.
- Testing and Calibration

Tritium Monitoring System Design Questions

- Total Tritium, HT or HTO?
- Range of Measurement?
- Minimum Detectable Activity?
- Response Time
- Gamma Compensation?
- Portable or Fixed Unit?
- Materials of Construction; Preferences or Prohibitions
- Other considerations about site conditions?

Tritium Monitoring System Design Answers

- Total Tritium Measurement
- Dual Level System, 8 Decade Range of Measurement

  Low Level: 1E-3 to 1E1 MBq/m^3 (3E-8 to 3E-4 Ci/m^3)

  High Level: 1E-1 to 2E3 MBq/m^3 (3E-6 to 5.4 E-2 Ci/m^3)
- Detector Types

  Low Level: Proportional Counters

  High Level: Ionization Chambers
- Minimum Detectable Activity (MDA):

  Low Level: 1 kBq/m^3 (0.03 μCi/m^3)

  High Level: 0.1 MBq/m^3 (3 μCi/m^3)

Tritium Monitoring System Design Answers, continued

- Response Time
  Low Level Proportional Counter: 40 minutes
  High Level Ionization Chambers: <1 minute
- Gamma Compensation is required.
  Dual detectors for both low & high level
- Fixed Unit in a floor standing cabinet with a total weight of 300kgs (660 lbs)
- Site: provide supply of P10 counting gas and Instrument Air (dew point of -40° C)

Design Principle:

A semi-permeable membrane is used to isolate Tritium Oxide for passage into the instrument measuring system

Why use the semipermeable membrane?

All other sample constituents, including pollutants, radioisotopes, aerosols or particulates are removed and eliminated from the sample measurement

Design Principle:

Total Tritium Measurement

Design Limitation: only Tritium Oxide will pass through the semi-permeable membrane

Solution: An oxidizer is incorporated into the sample stream

Design Principle:

Two Level Measurement System

Low Level Proportional Counters
and
High Level Ionization Chambers

Design Principle:

Two Level Measurement System

Automatic solenoid operated valves direct the sample to the two detector systems

Prevents exposure of Proportional Counters to High Level sample

Interrupts P10 gas usage during High Level operation

Low Level Proportional Counter Detectors

The dual chamber system is used because Gamma compensation is necessary when measuring ultra-low levels of Tritium

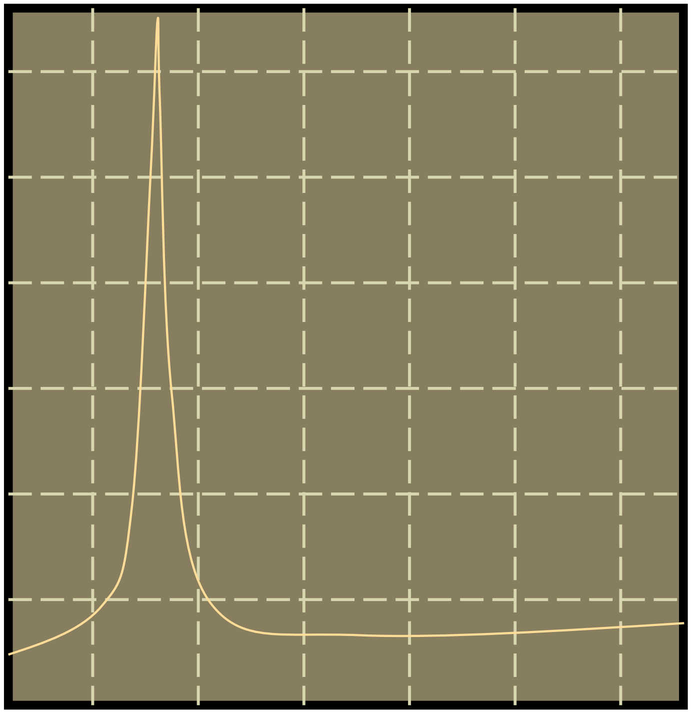
Low Level Proportional Counter Detectors

A pair of balanced proportional counters

Detector housing:

- 4mm steel shell
- 22mm lead shielding to reduce gamma interference

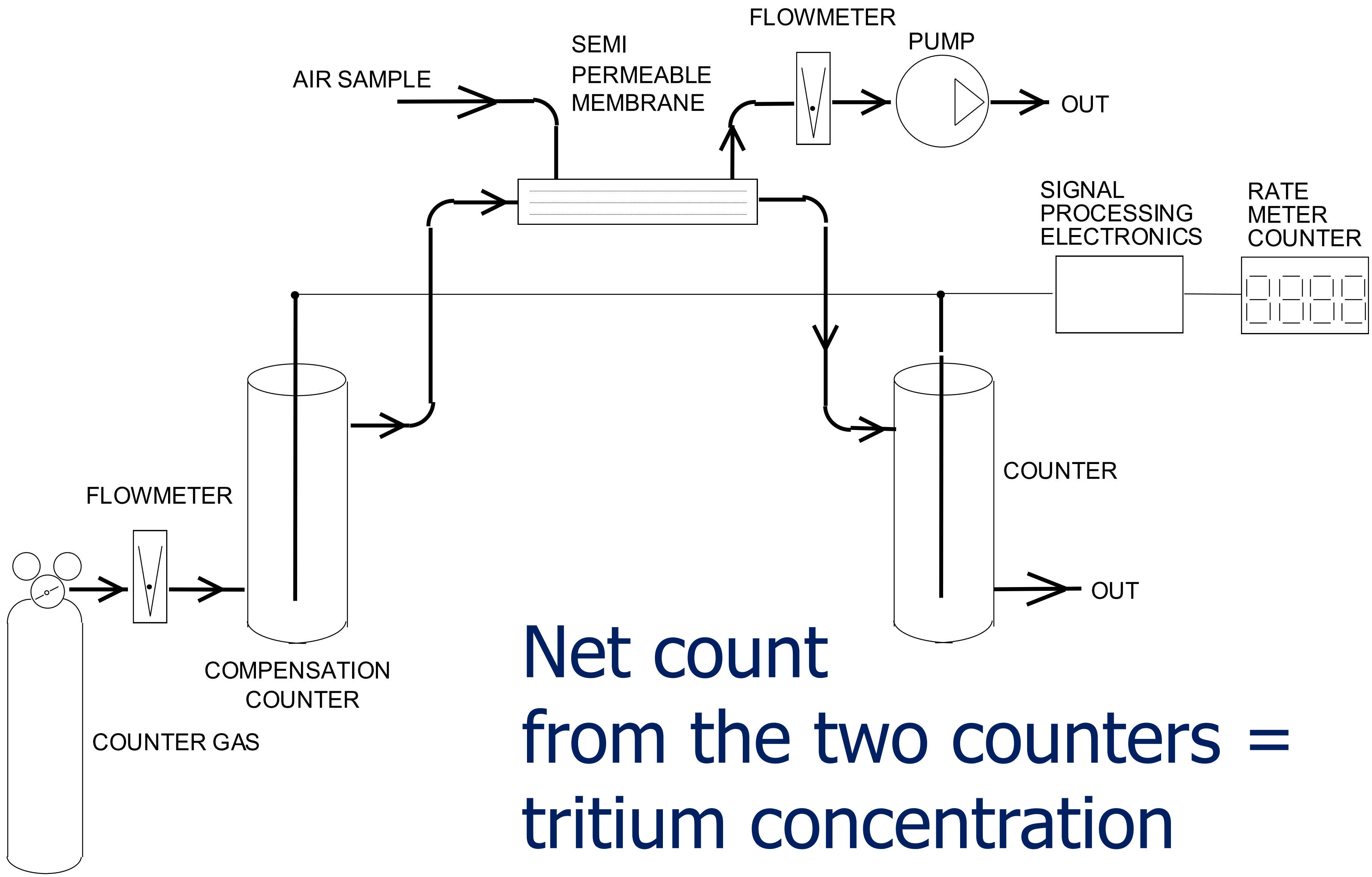
Low Level Proportional Counter Measurement



Electronic signal processing:

Simultaneous pulse <u>rise</u> and pulse <u>duration</u> signal processing is used to select only those pulses which correspond to tritium beta decay

Low Level Proportional Counter Measurement



Net count
from the two counters =
tritium concentration

Dual Level System, 8 Decade Range of Measurement

Low Level MDA:
1 kBq/m^3 (0.03 μCi/m^3)

Measurement range:
1E-3 to 1E1 MBq/m^3 (3E-8 to 3E-4 Ci/m^3)

High Level MDA
0.1 MBq/m^3 (3 μCi/m^3)

Measurement range:
1E-1 to 2E3 MBq/m^3 (3E-6 to 5.4 E-2 Ci/m^3)

High Level Ionization Chamber Measurement

The dual chamber system is for Gamma compensation.

Recommended for detecting Tritium:

<4 MBq/m^3 (100 $\mu Ci/m^3$)

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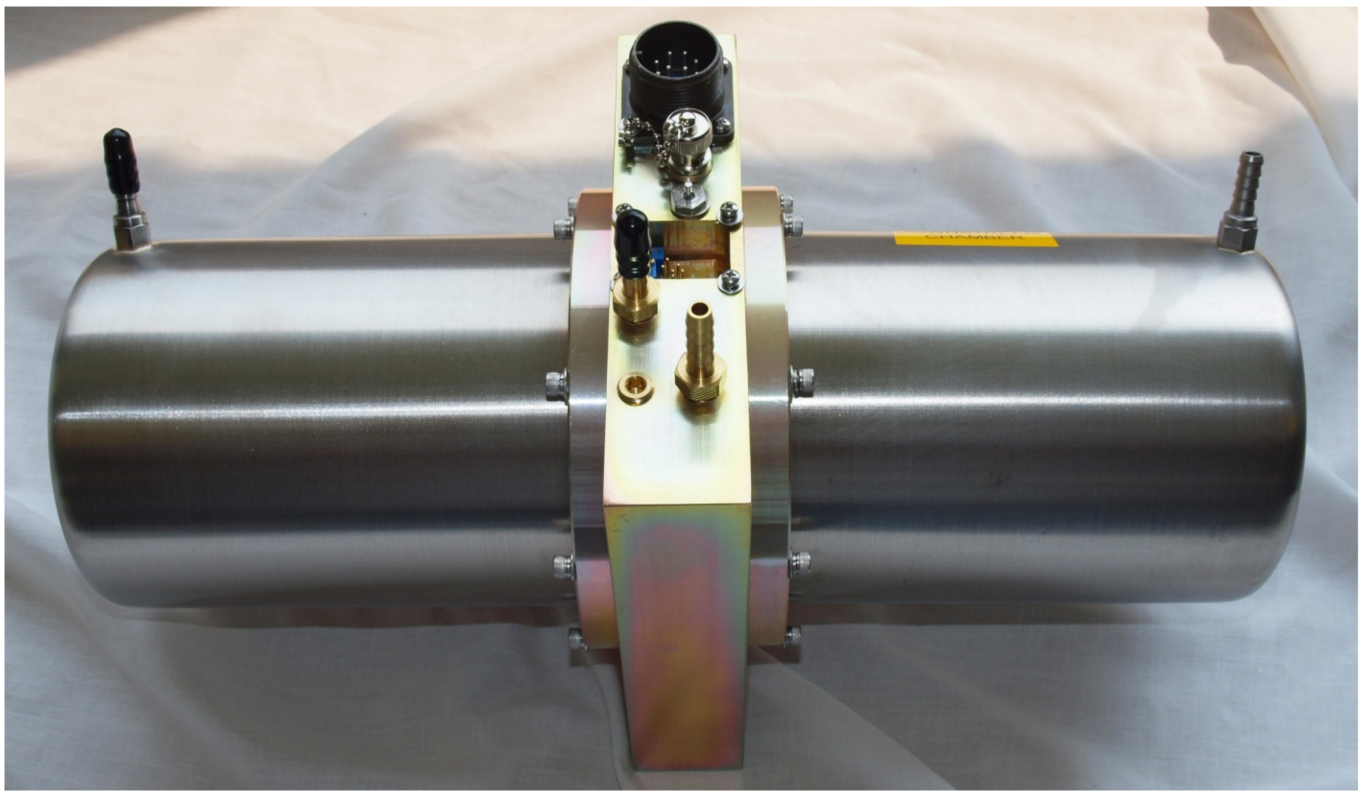
High Level Ionization Chamber Measurement

The dual chamber system

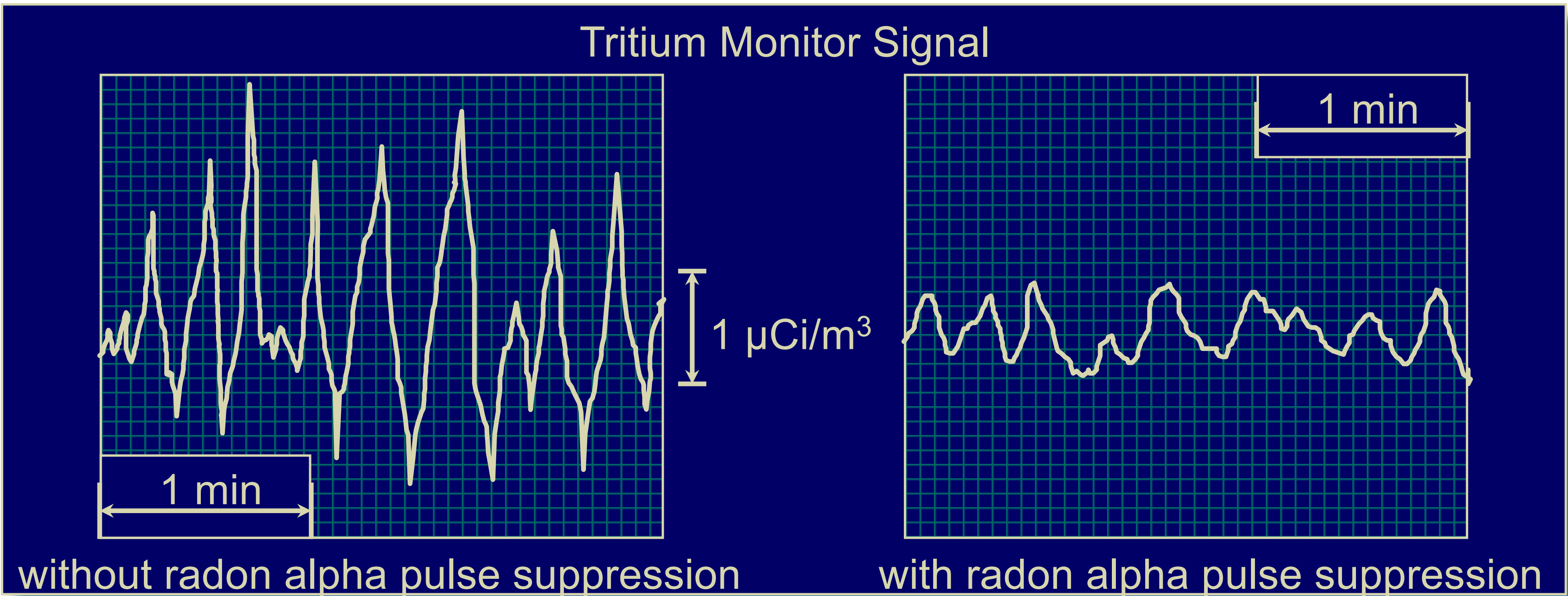
2 Liter nominal volume for each chamber

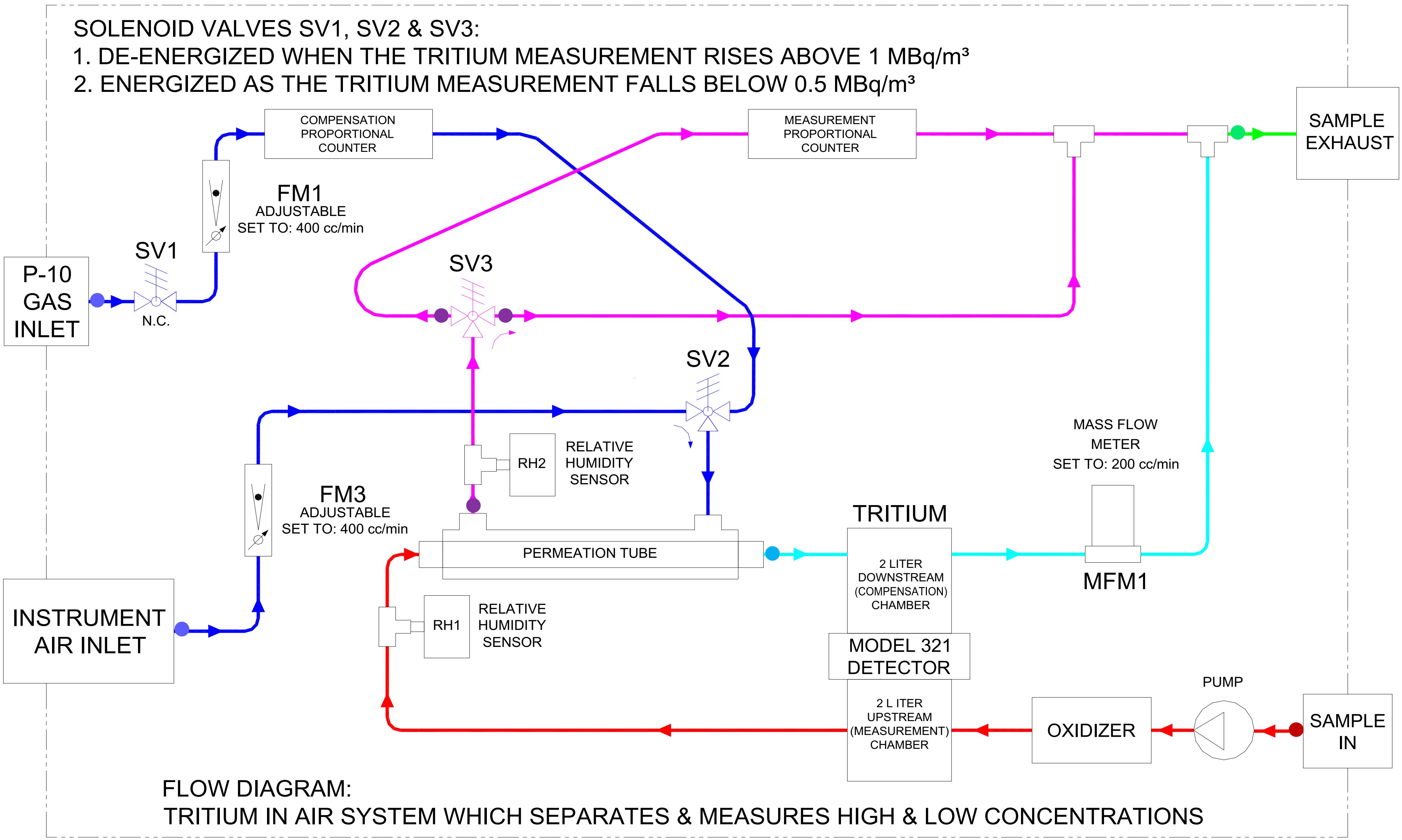


Ionization Chamber Measurement

RADON

Decay energy 4 to 5 Mev compared to Tritium mean 5.6 kev
About 1,000 : 1 in energy
at 1μCi/m^3 in an ionization chamber with a volume of 1 liter
There are 3.71 decays per second or 2,226 decays per minute
Thus, 2 radon decays per minute generate
the same mean ion current as 1 μCi/m^3 of Tritium!





Flow - High Concentration Operation

Flow - Low Concentration Operation

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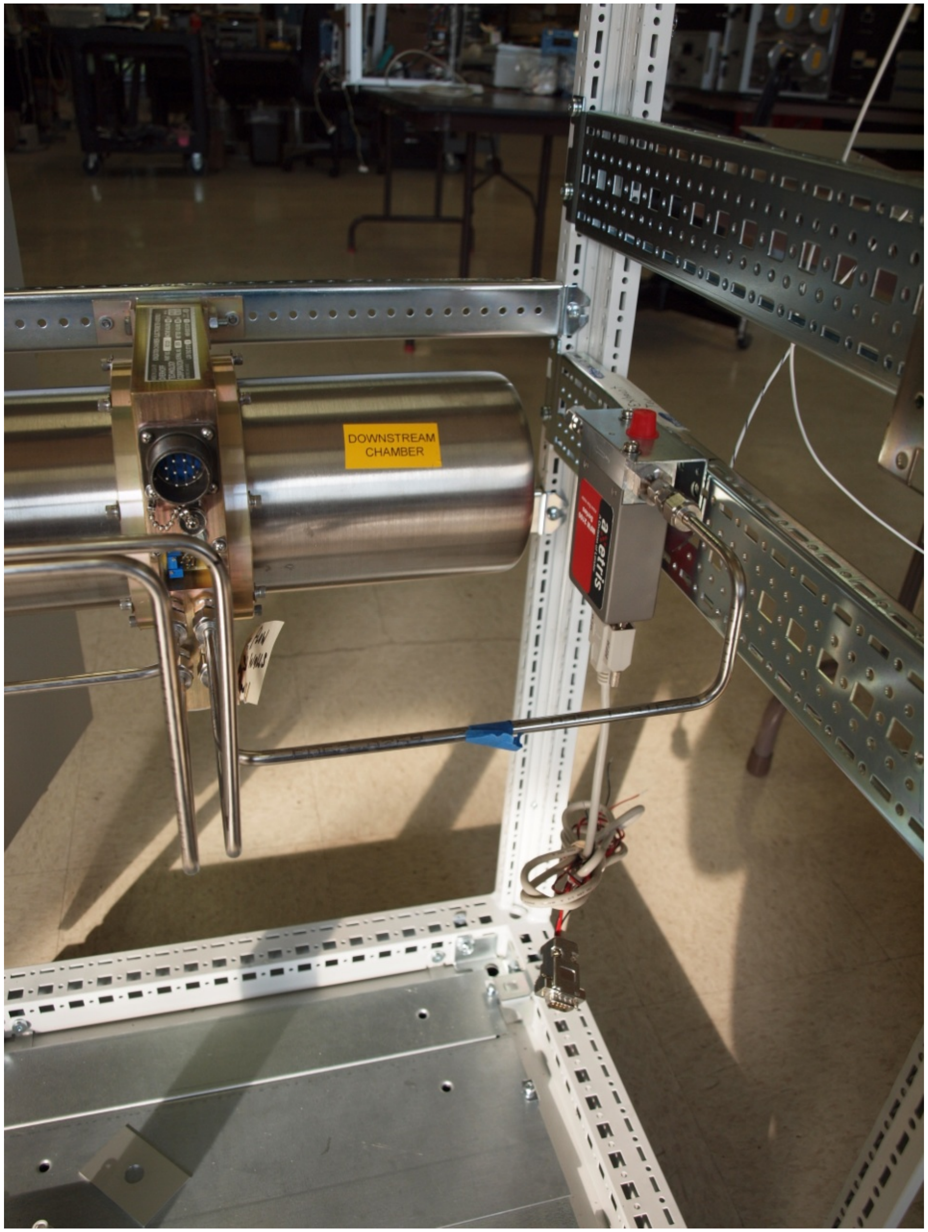
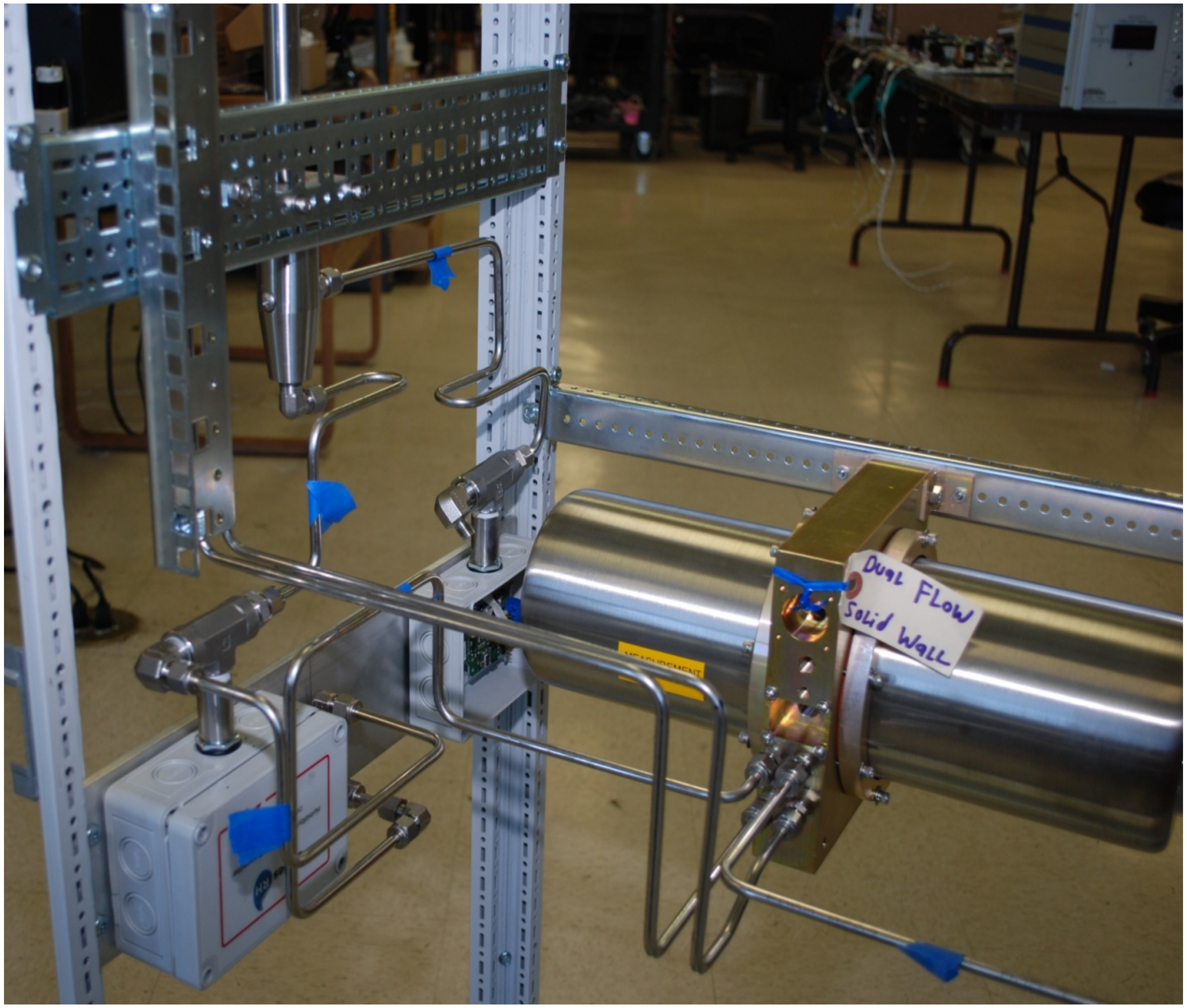
Tritium Focus Group Oct 2016
Laboratory For Laser Energetics

Under Construction: Basic Components Mounted to the Cabinet Frame

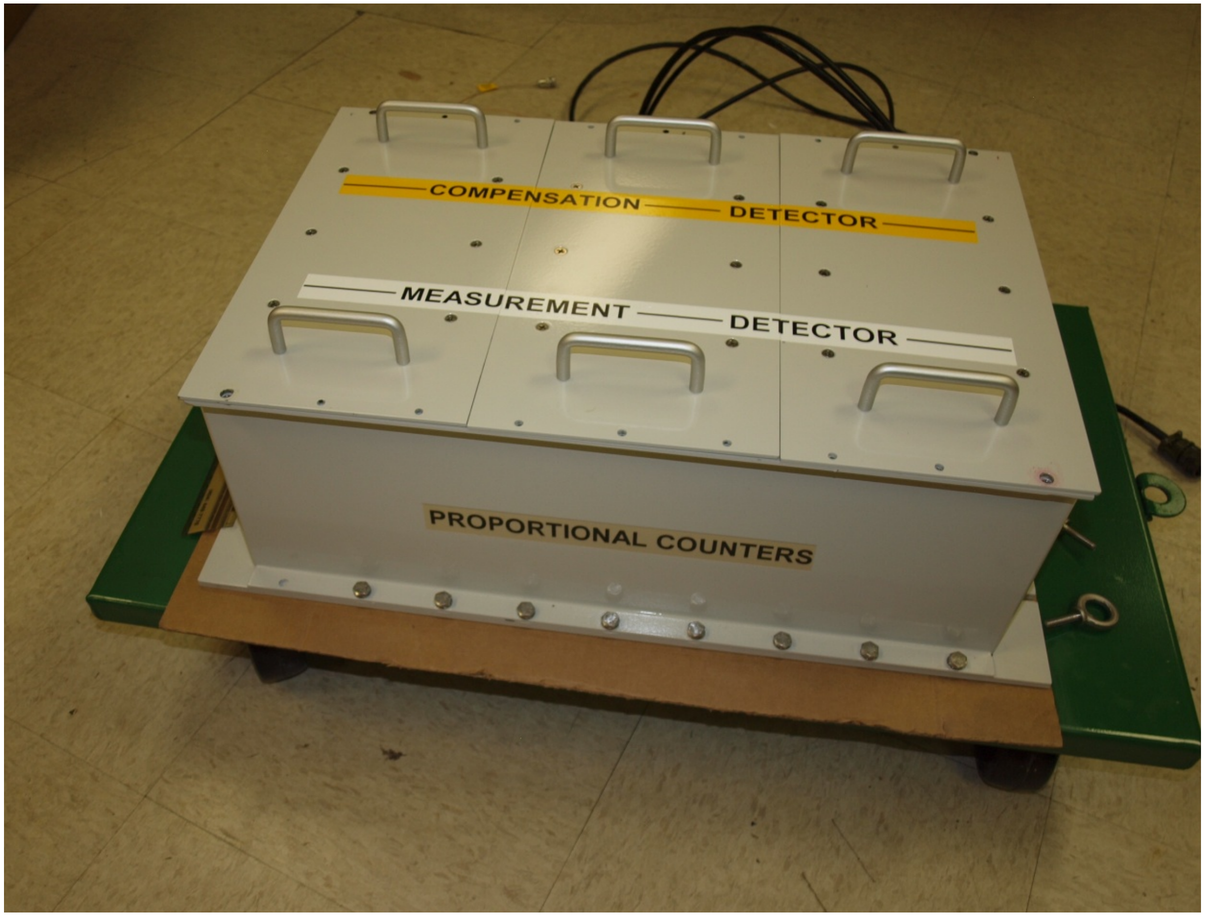
Under Construction: Sample piping, Ionization Chamber & Mass Flow Meter



Under Construction: Sample piping, Ionization Chamber & Relative Humidity Sensors



Proportional Counter Detector Housing Prior To Installation



Monitoring System which Separates & Measures High & Low Concentration Tritium in Air

The finished equipment

Questions?