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February 2002 Measurements and Calibration of the AP0 Stack Emissions

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I. Introduction

As part of Fermilab's continuing air monitoring program, a sample of air from the AP0 stack was taken during stable stacking operations, on February 2002. The radioisotopes composition of the sample was determined. Based on the proton intensity rates during sampling, a calibration factor for converting the count rates from the stack monitor to released activity was determined.

This note will briefly touch on the methodology used in the measurement and analysis. Interested readers are referred to RP106 [1] for the details of the methodology. Throughout this document "protons" refer to protons used on target for anti-proton production.

II, Experimental Setup

The setup (Fig. 1) was exactly the same as that described in RP106 [1]. For the details of the MCS and HPGe detector systems refer to that document.

III. Measurements

The production of radioactivity around the AP0 target depends on the beam parameters such as pulse rate and protons on target intensity. The MCS and HPGe measurements were done during the stable anti-proton stacking operations, to reduce systematic errors and provide a more understandable background for the analysis of the data. To monitor the proton beam stability during the measurements and to obtain an average proton rate, the number of protons per pulse as obtained from a toroid (Tor109) beam-pickup coil was recorded (Fig.2) using the Beams Division's Lumberjack data logger [2].

A. MCS measurements

The MCS data was obtained with the module set to 2 seconds integration steps, for 2.3 hours. First a background was collected, and then a grab sample was taken using the leadpig, which is a lead shielded version of the "paintcan" stack monitor. The lead pig data, after subtracting the background, was used to determine the isotopic composition of AP0 stack emissions.

B. HPGe measurements

The calibration of the HPGe was first checked using the calibration mixed sources of the Radioisotope Analysis Facility. Then the detector was setup with a regular paintcan stack monitor. First a background and then a grab sample of the air from the stack were counted.

C. Air flow measurements

The AP0 stack flow rate was measured at two perpendicular sample ports at nine distances from the inside wall of AP0 stack along the diagonal. Velocity measurements were done following the prescription of the 40CFR part 60, Appendix A, Method 2 [3]. A J-type Pitot tube was used for the measurements. Measure velocities at different distances from the long axis of the stack were recorded for later analysis.

IV Analysis and results

A Multichannel decay curve fitting

The data were fit with several candidate isotopes and the information obtained from gamma ray spectroscopy of the sample. Best chi-square fit was obtained with carbon, nitrogen and argon isotopes. The results of the analysis are given in table I.

Isotope	^{11}C	^{13}N	^{41}Ar
Fraction of total activity	70.9%	28.1%	1.0%

Table I. Fractional activity of each isotope in the air sample.

The results are qualitatively reasonable for a point source. There is about 20 minutes of flow time for the activity to get to the stack. Given the almost similar production cross sections, one would expect the activity of the ^{13}N to be about half of the ^{11}C at the measurement point.

B Gamma ray analysis of the Paintcan

The background-subtracted gamma ray spectrum, acquired with the HPGe, showed that beside the positron emitters (showing up as the 0.511 MeV annihilation peak) and the ^{41}Ar, no other radionuclides were present in the sample.

C Flow Rate of AP0 Stack

The inner diameter of AP0 stack is 25.4 cm (10 inches). Weather conditions for these measurements were an ambient temperature of ~34-39 °F with gusting winds of ~5-15 mph [4]. Table II gives the results.

AP0 Stack Air Flow Measurements						
40CFR60, Appendix A, Method 1 requires at least 8 point						
Stack Diameter = 10		inches				
Stack Area = 0.55		ft2				
Probe offset1 due to connector=			0.8125 in			
Probe offset2 due to connector=			1.09375 in			
Point	%Diameter	points (in)	points (cm)	Total distance on Probe (in)	Velocity (fpm)	Flow Rate (CFM)
1	3.20%	0.32	0.8	1.41375	1040.71	567.65
2	10.50%	1.05	2.7	2.14375	1040.41	567.48
3	19.40%	1.94	4.9	3.03375	1040.04	567.28
4	32.30%	3.23	8.2	4.32375	1039.50	566.99
*5	50.00%	5	12.7	6.09375	1038.76	566.58
6	67.70%	6.77	17.2	7.86375	1038.02	566.18
7	80.60%	8.06	20.5	9.15375	1037.49	565.89
8	89.50%	8.95	22.7	10.04375	1037.12	565.69
9	96.80%	9.68	24.6	10.77375	1036.81	565.52
					Average(CFM)	**566.58**
* supplementary point, not required by regulation.					Stand.Dev.=	0.80
					Stand.Dev.=	0.14%

Table II. Measurements of the AP0 stack flow rate. The table shows the airflow velocity and the corresponding flow rate for each of the points measured.

IV. Conclusion

The results of this latest measurements give 1.57E-18 Ci/proton of activity released from AP0 stack. Assuming that a total of 100 Ci of activated air released per year (per our current site permit), if AP0 was our only emission source, the total allowable stacking protons per year from AP0 would be ~6.4E19. This is much less than the intensity limit set by the groundwater limit. The air emissions permit is for the sum total of all air emissions from the site. If other sources of air activation are operating in addition to anti-proton (such as the future MiniBooNE and NuMI) the above proton intensity limit may have to be reconsidered. Based on this result, the Anti-Proton annual proton intensity limit will most likely arise from the annual air emissions limit rather than the groundwater limit. For the future high intensity operations of the Anti-Proton source, it may be necessary to look into methods of reducing the air emissions rather than operating at the EPA/IEPA allowed limit.

For operational considerations, in 2001, the AP0 stack monitor gave 7.11E-13 MUX counts/proton from the AP0 stack monitor. This count rate combined with our current results will give a calibration factor of 2.21 microCi/MUX count.

References

1. K. Vaziri, V. Cupps, D. Boehnlein, D. Cossairt, A. Elwyn, T. Leveling, APO Stack Monitor Calibration, RP Note 106, Fermilab ES&H Section (1993).

2. Private communications with Gary Lauten and Roger Zimmermann (2002)

3 United States Code of Federal Regulations, Title 40, Part61, Subpart H, "National emissions standard for hazardous air pollutants (NESHAP) for the emission of radionuclides other than radon from Department of Energy Facilities", 1989.

4. Batavia Weather web site, Feb. 7, 2002 data. http://www.mdweather.com/conditions.html

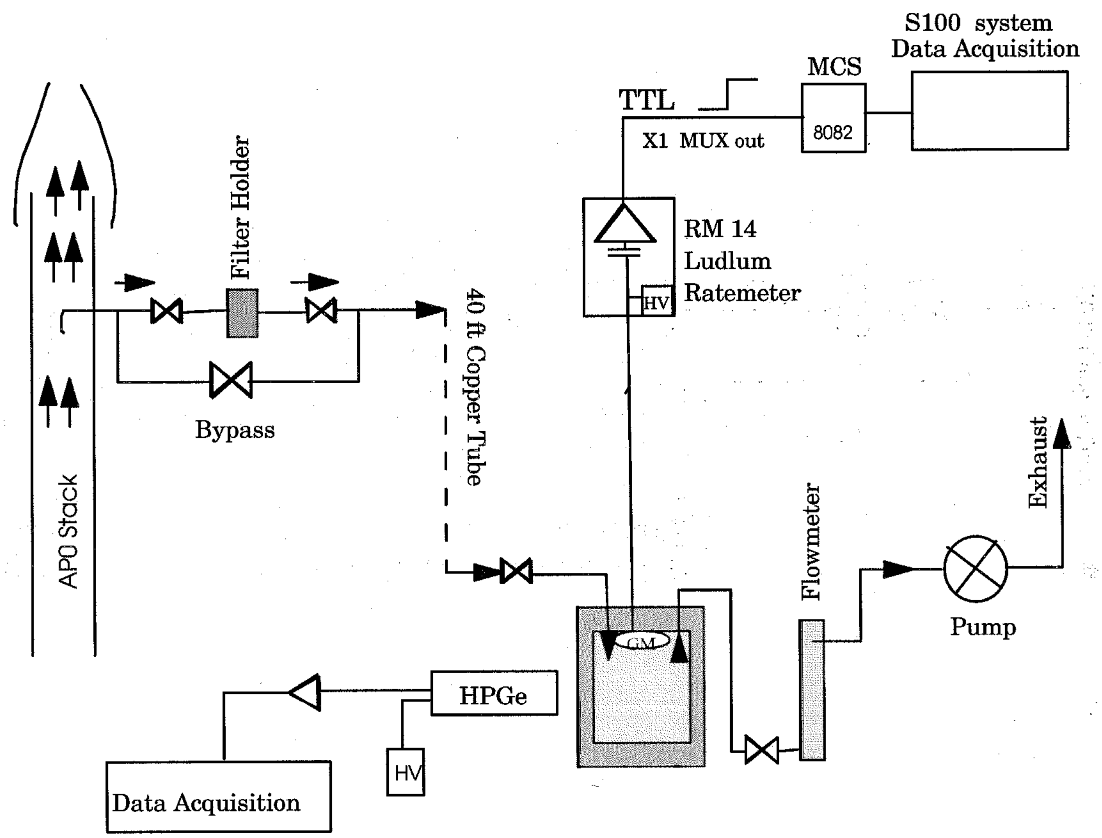

Figure 1. Schematic diagram of the air emissions sampling and measurements.

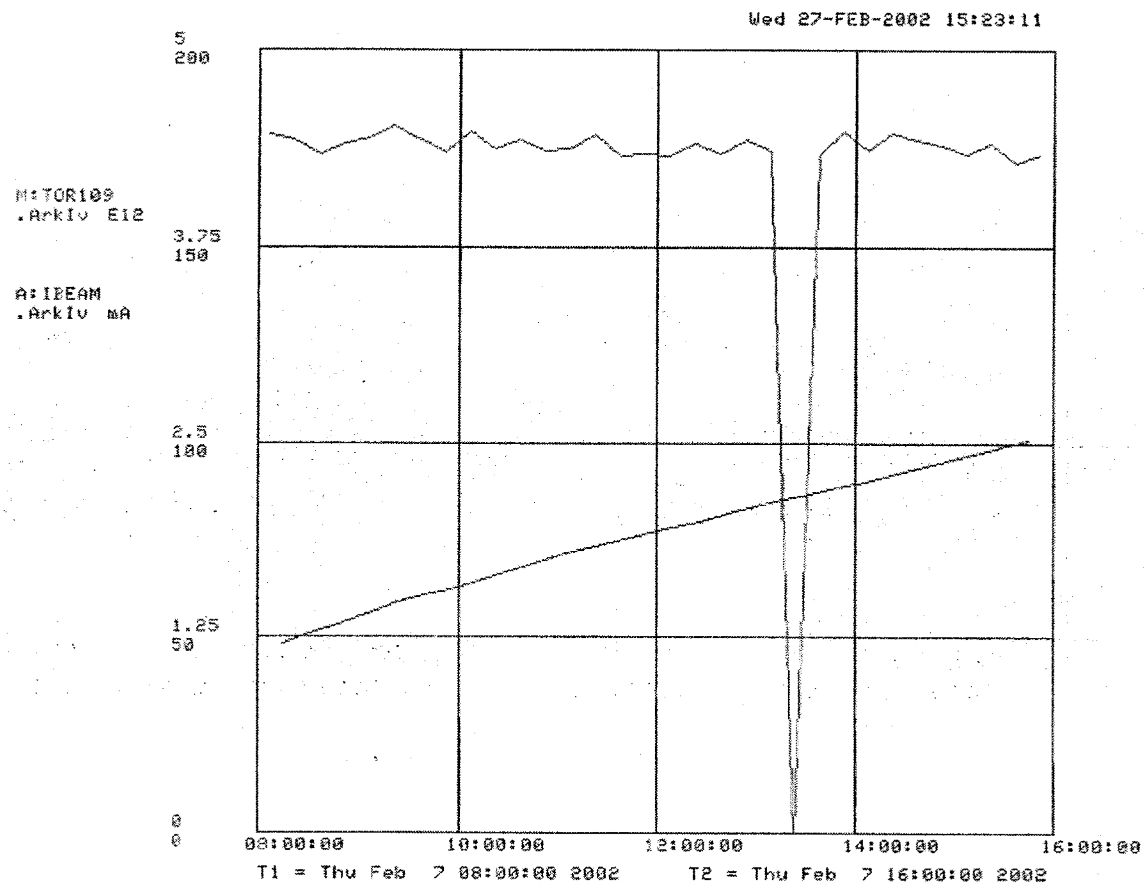

Figure 2. Graphical representation of the proton data on the day of the measurement.