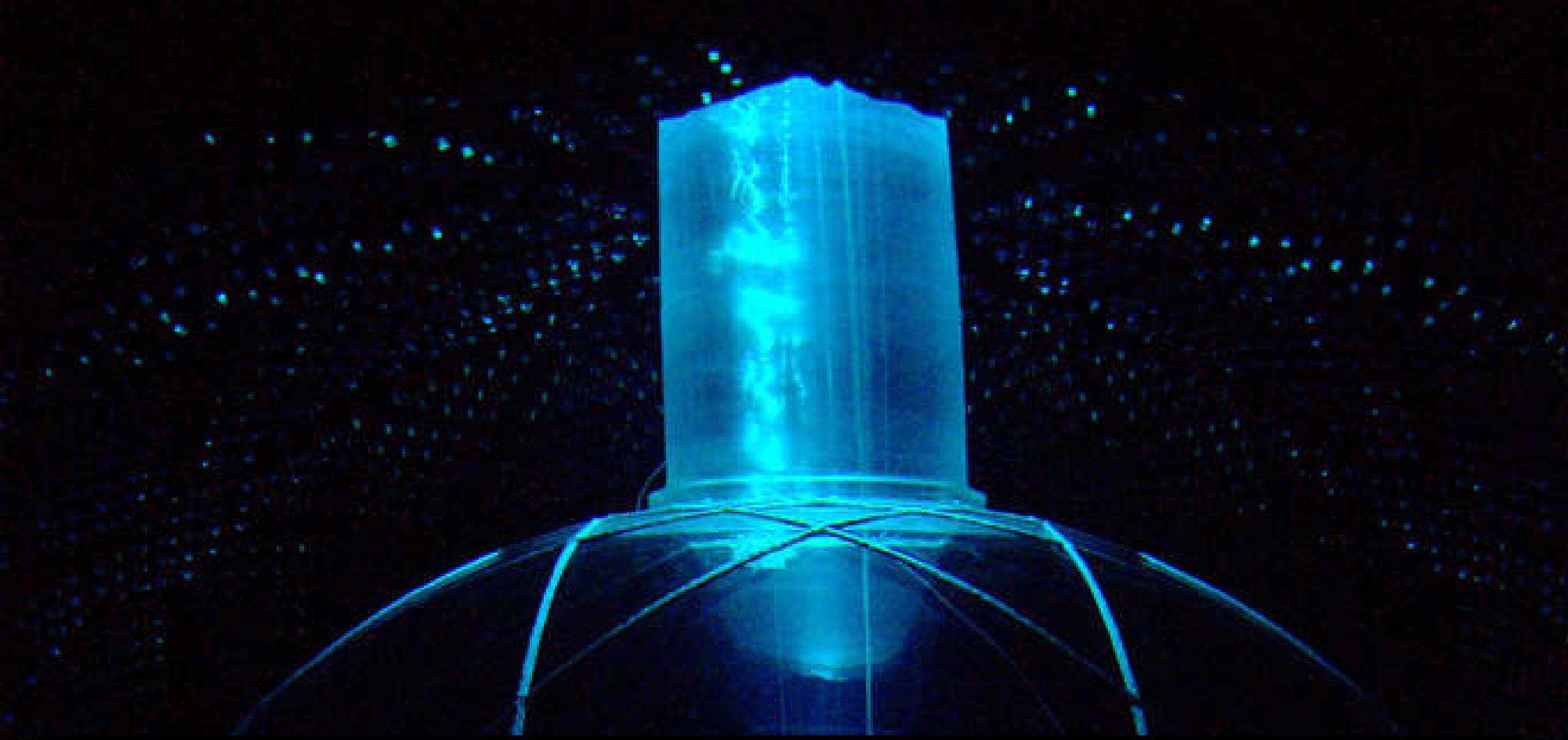


$^{222}\mathrm{Rn}$ Concentrations within the Water Phase of the SNO+ Experiment

Pooja Woosaree

CAP Congress 2018

June 13, 2018

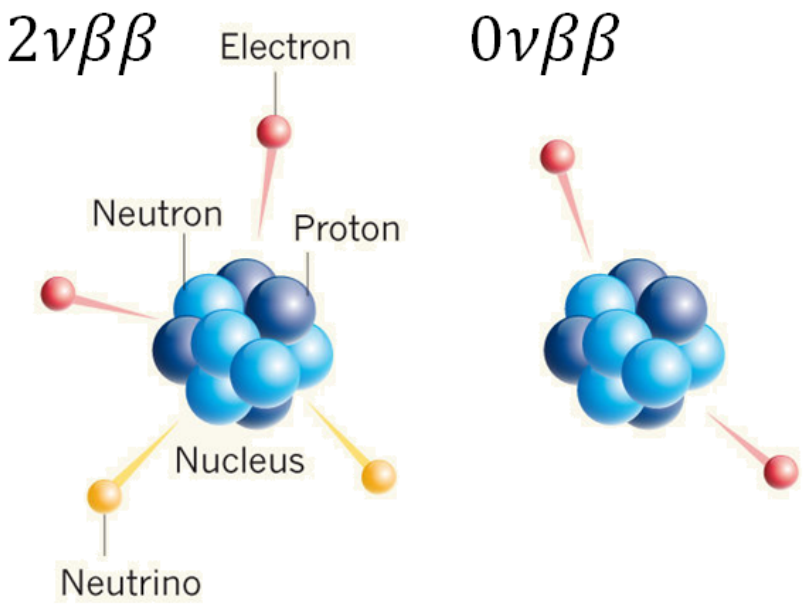
LaurentianUniversity
UniversitéLaurentienne

SNO+

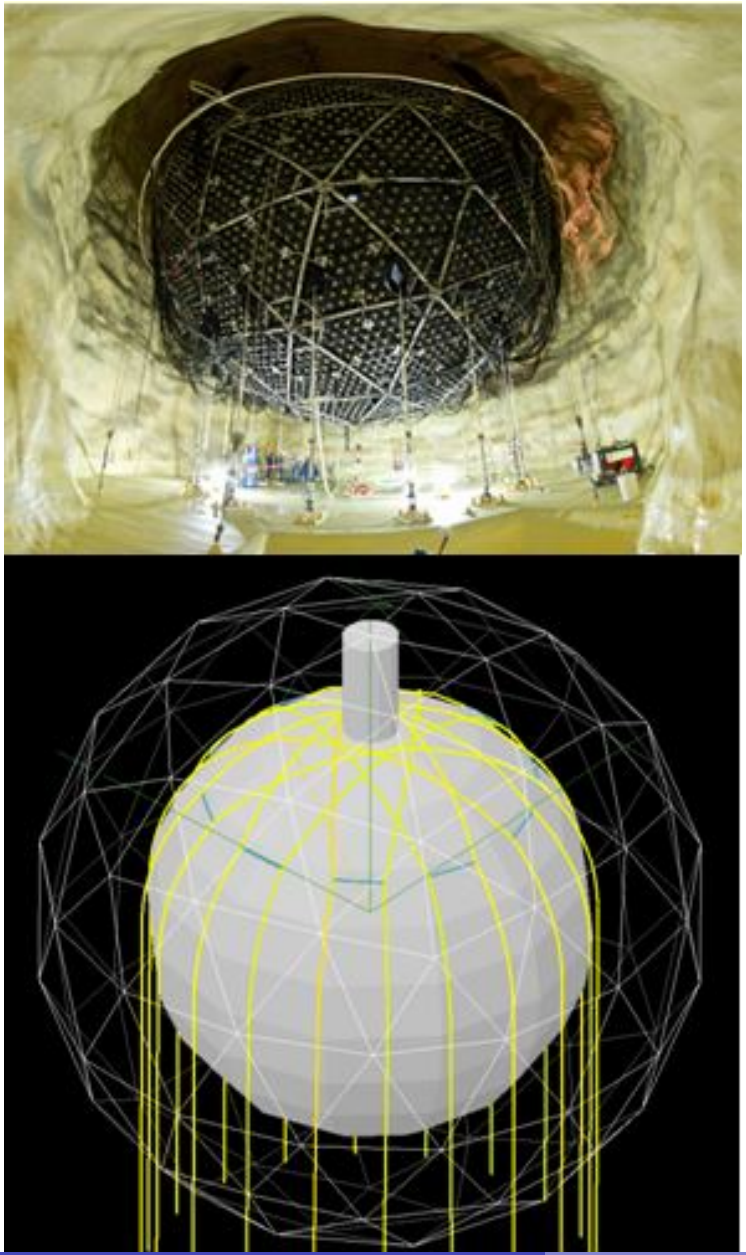
- Located 2km underground inside SNOLAB
- Inherited hardware from the SNO detector, which in 2015 was one of the experiments associated with the Nobel Prize Award in Physics for the discovery of neutrino oscillations.

The Physics

The primary goal of the SNO+ detector is to look for neutrinoless double beta decay ($0\nu\beta\beta$), a rare physics interaction where if its existence is proven, allows us to make precise measurements of the effective mass of neutrinos as they would be considered Majorana particles as opposed to Dirac.



The Detector



- 12 m diameter acrylic vessel (AV)
- 9600 Photomultiplier tubes (PMTs)
- 7000 tonnes of surrounding water
- Urylon layer/Radon seal

Detector Phases

PHASE I: Water

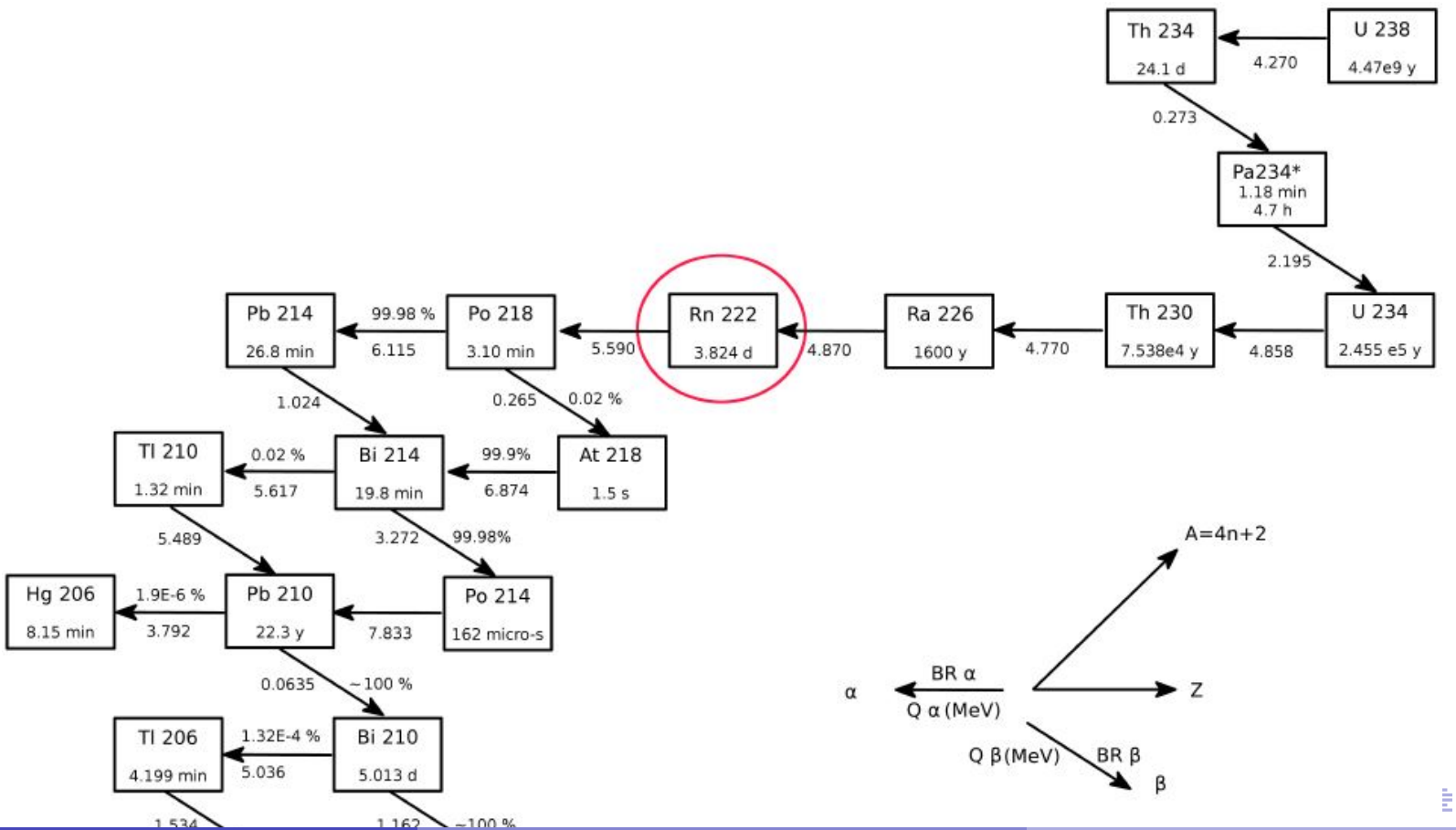
PHASE II: Scintillator

PHASE III: Tellurium Loading

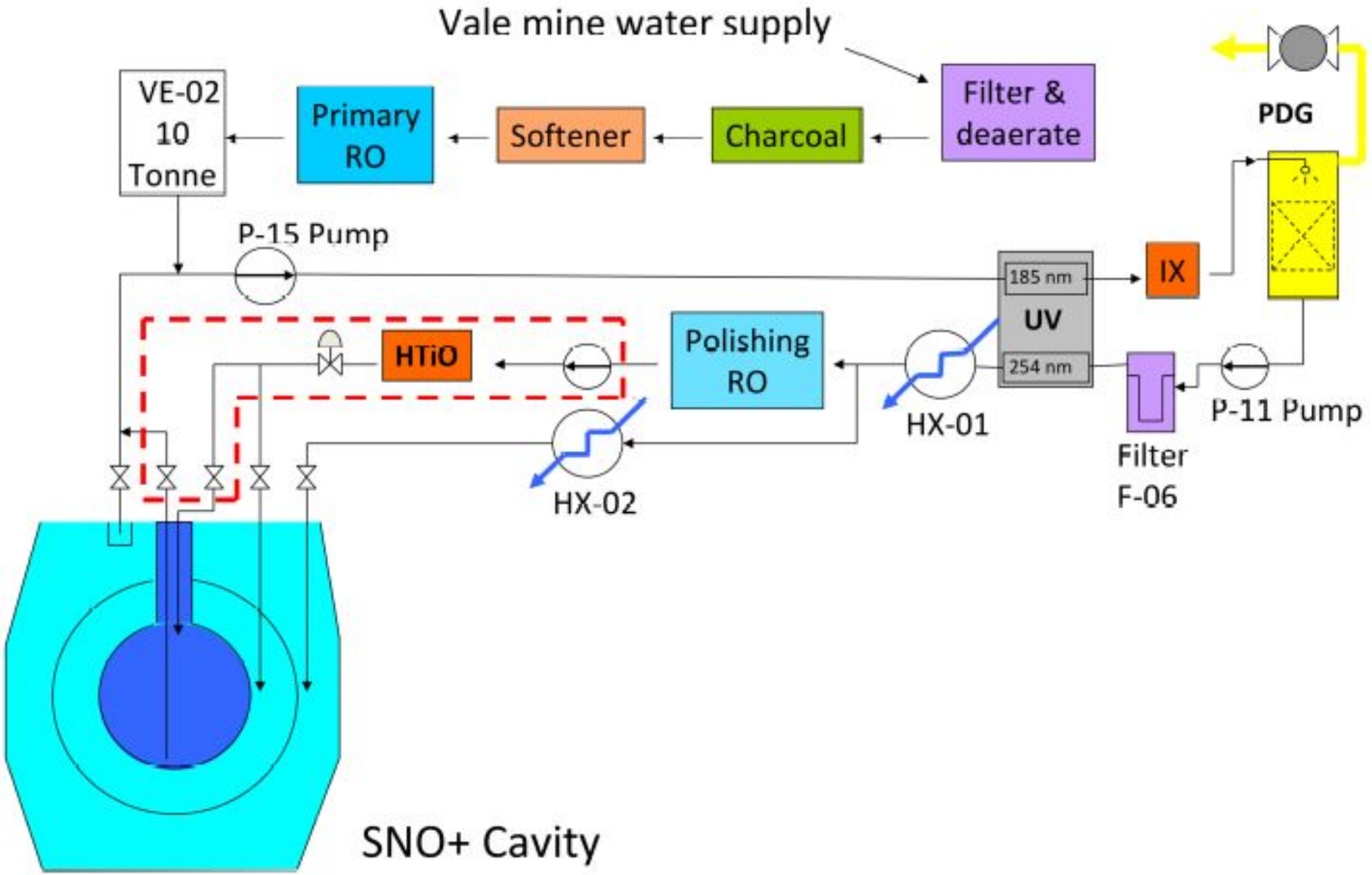
- Phase I observes more external backgrounds.
- Phase II observes more internal backgrounds.
- Phase III is the process of adding a Te compound to the scintillator in order to detect neutrinoless double beta decay.

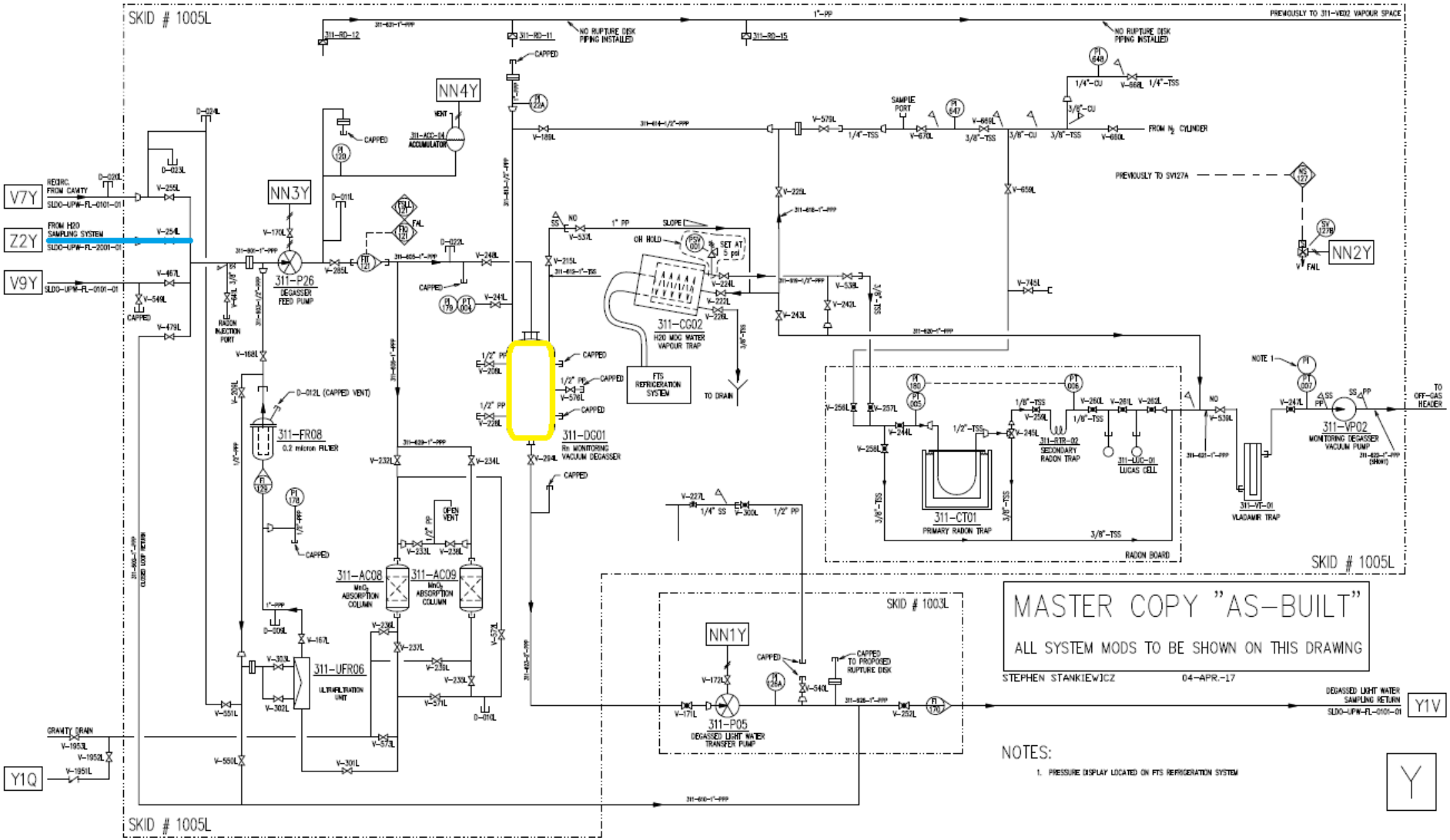
$^{222}\mathrm{Rn}$ as a Background

Backgrounds within physics experiments are anything that will overlap or interfere with the signal of interest. Radon-222 in particular emits α- and β particles at energies that can mimic physics events. As $^{222}\mathrm{Rn}$ decays, it will reach the more stable isotope of $^{210}\mathrm{Pb}$, which given its long half life of 22 years, is difficult to eliminate.



SNO+ Ultra Pure Water System

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STEPHEN STANKIEWICZ
04-APR-17
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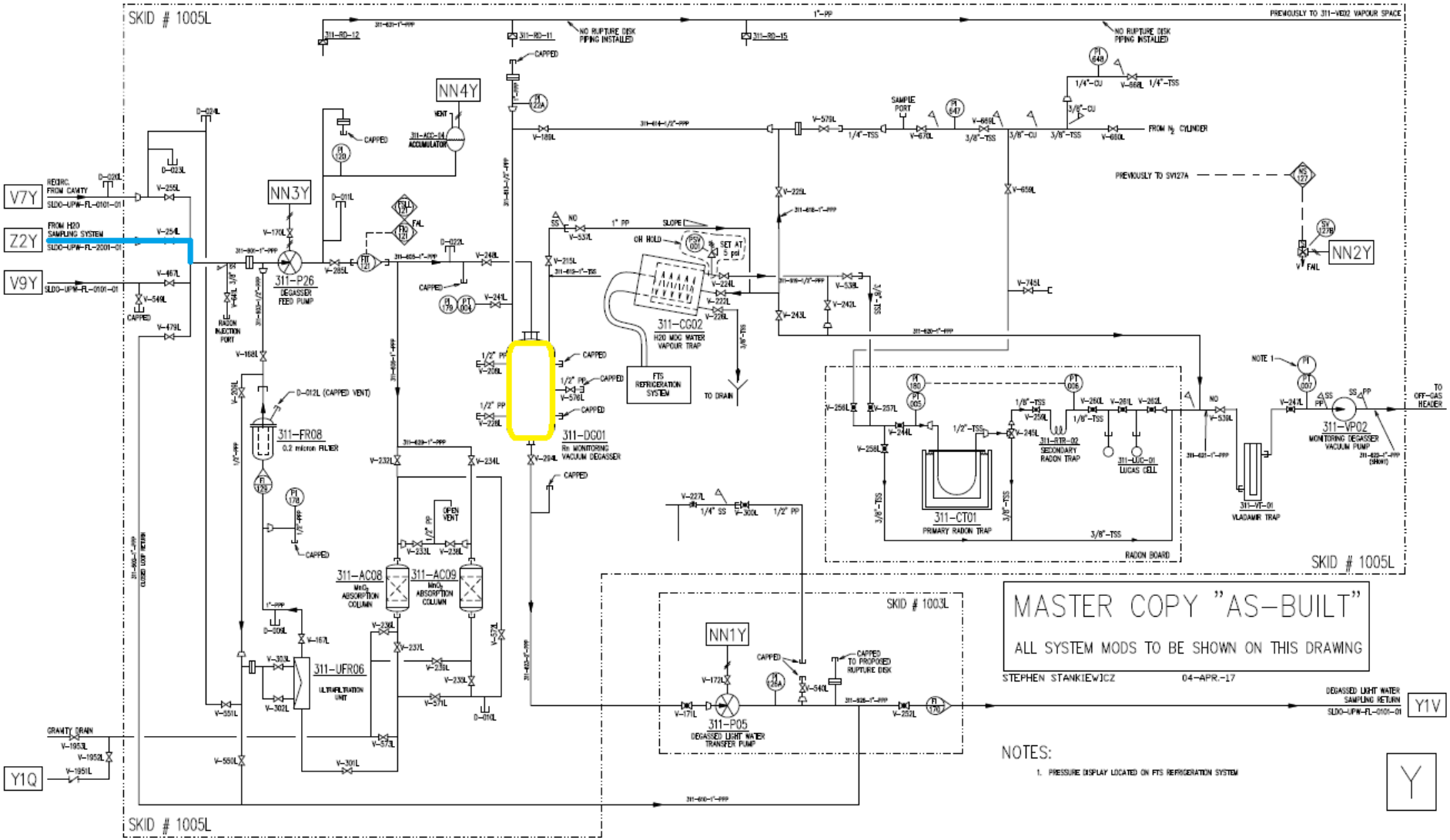
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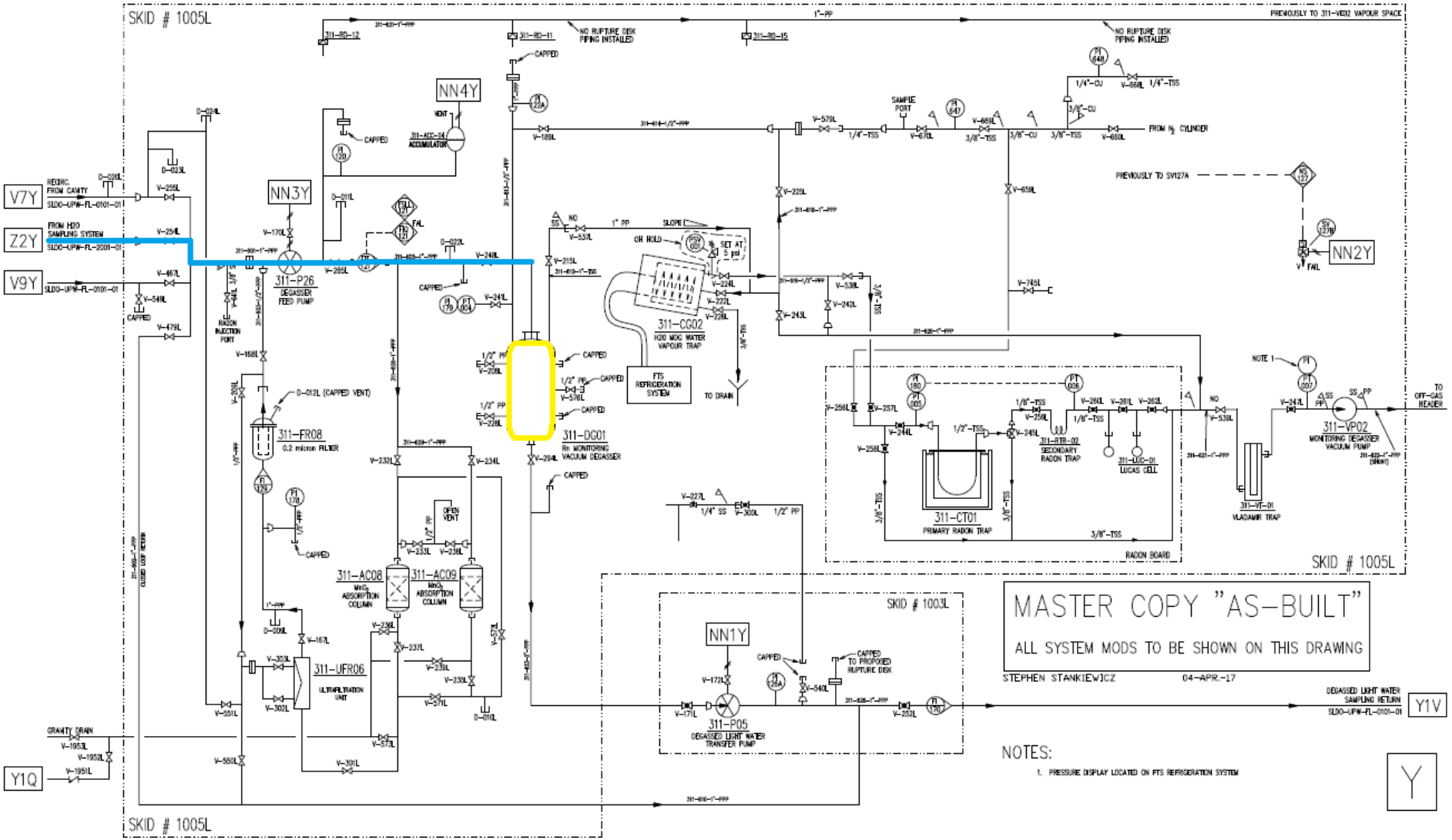
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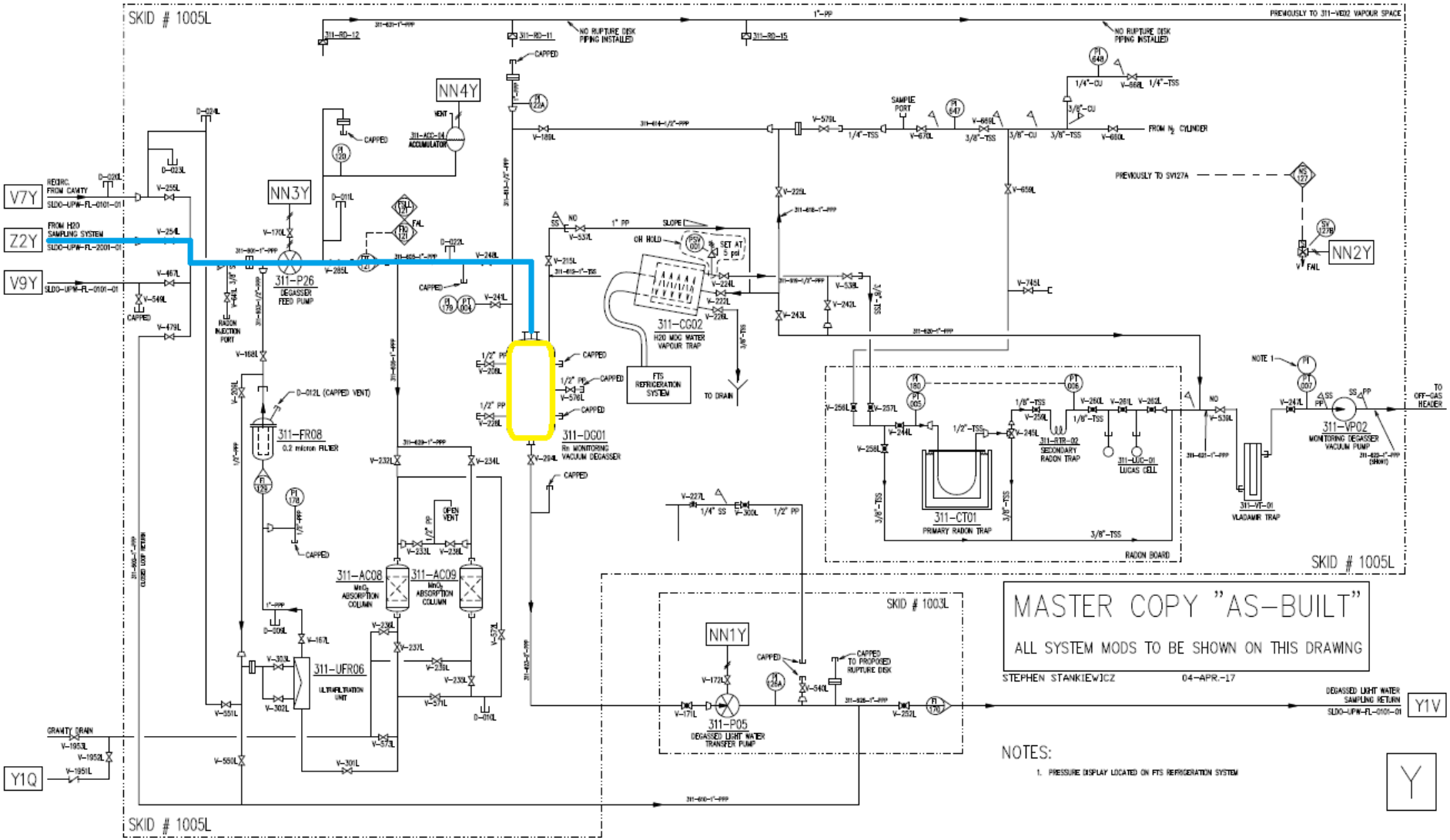
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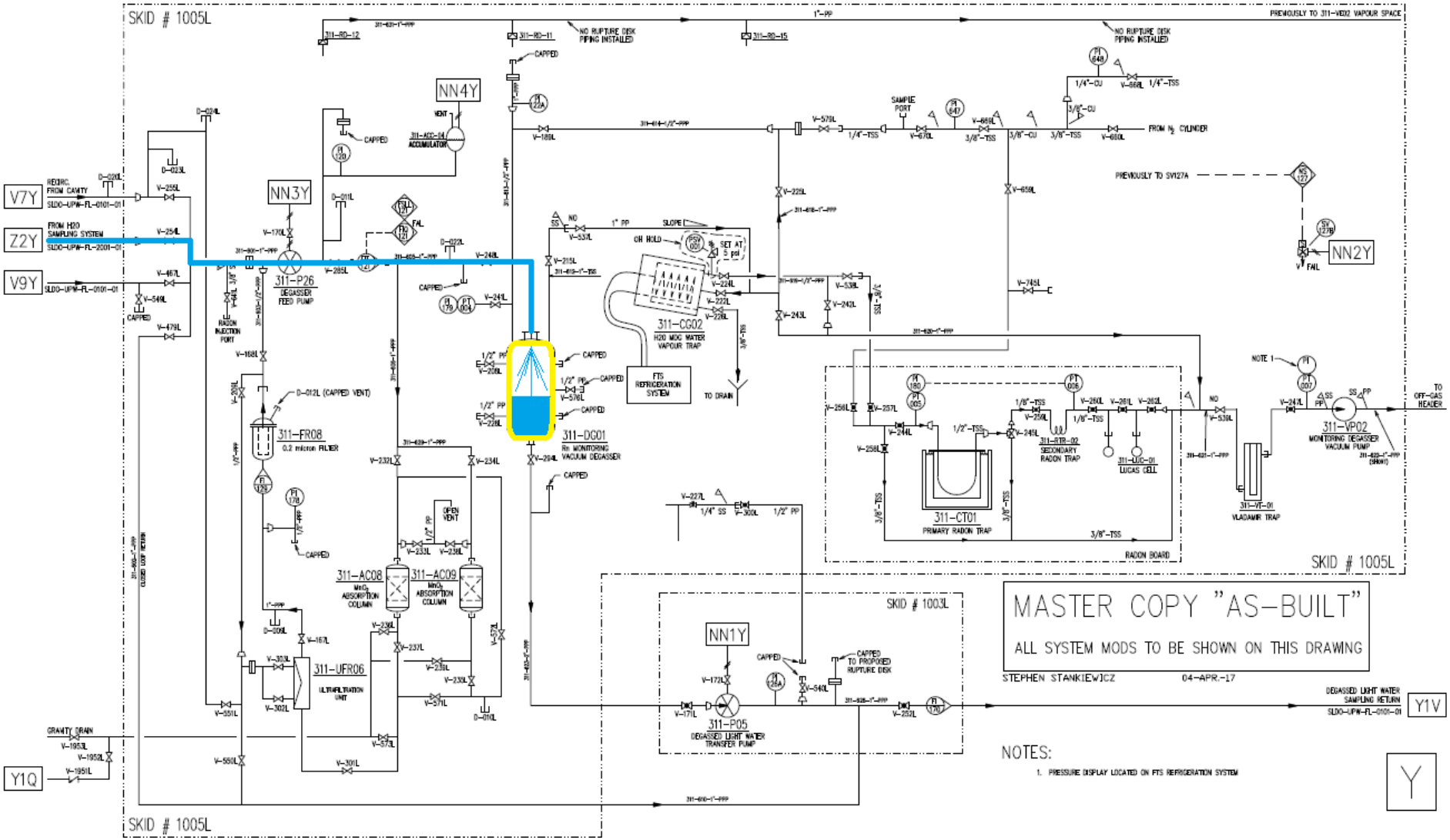
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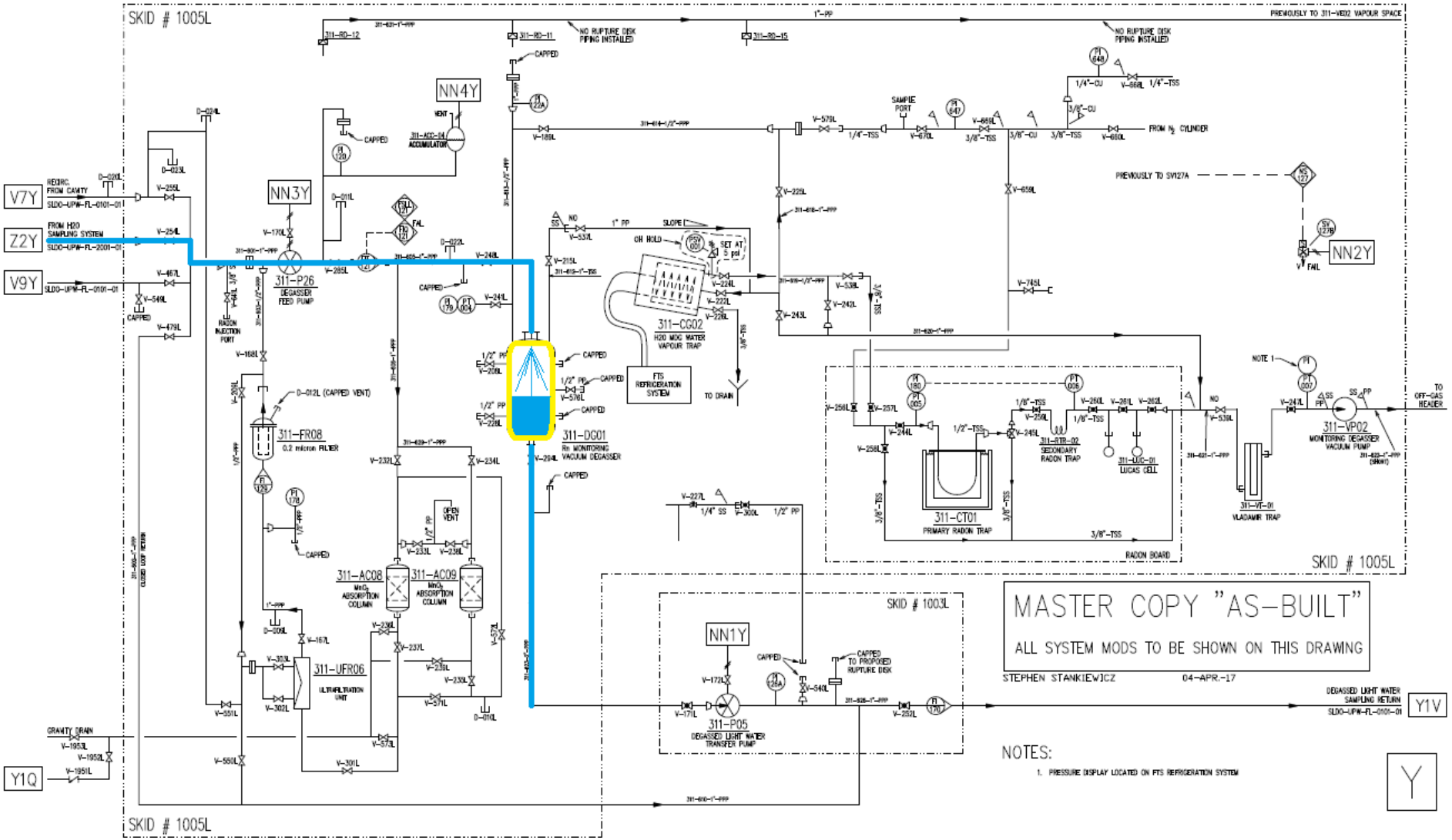
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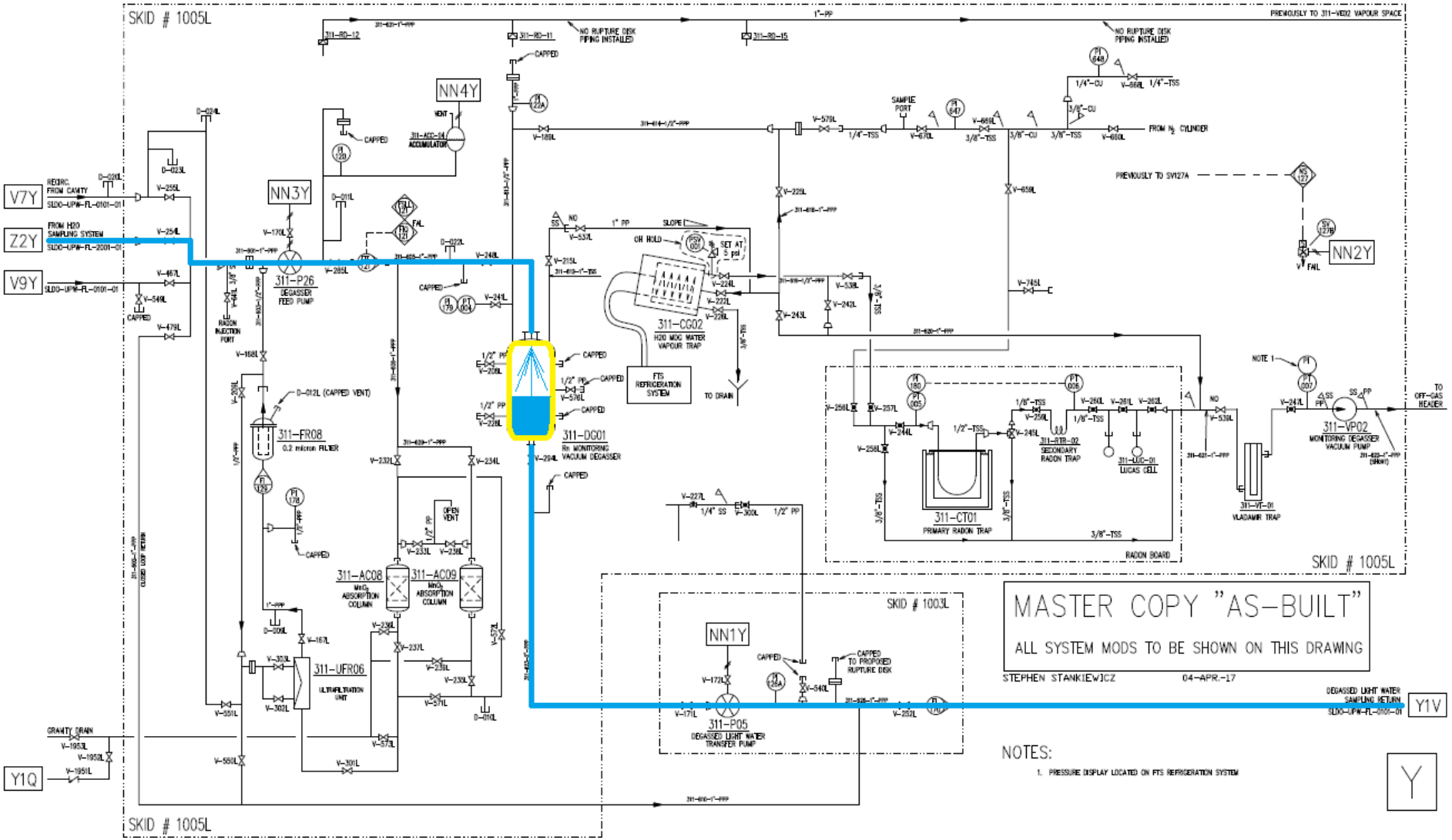
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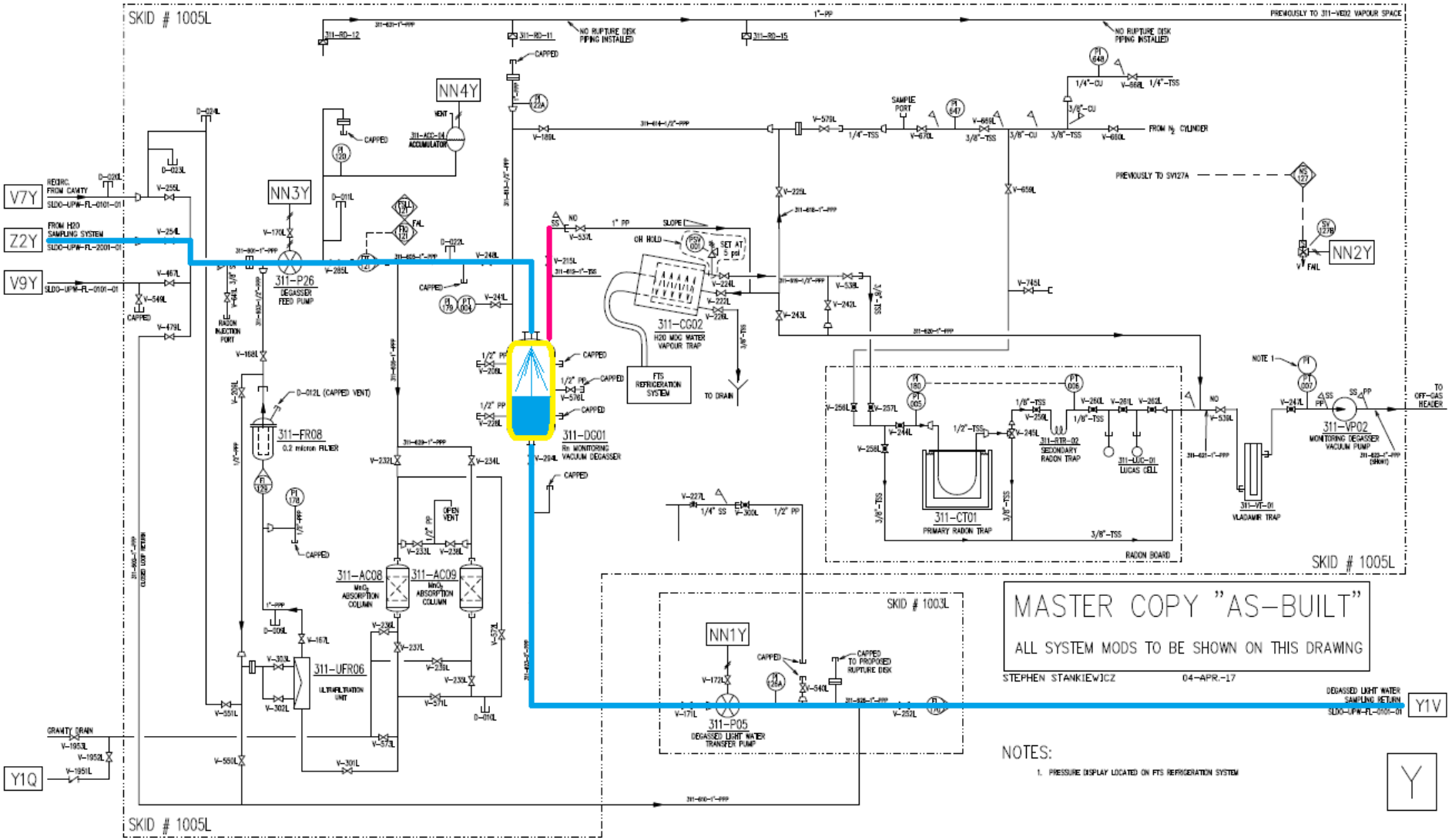
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TO DRAIN
TO OFF-GAS HEADER
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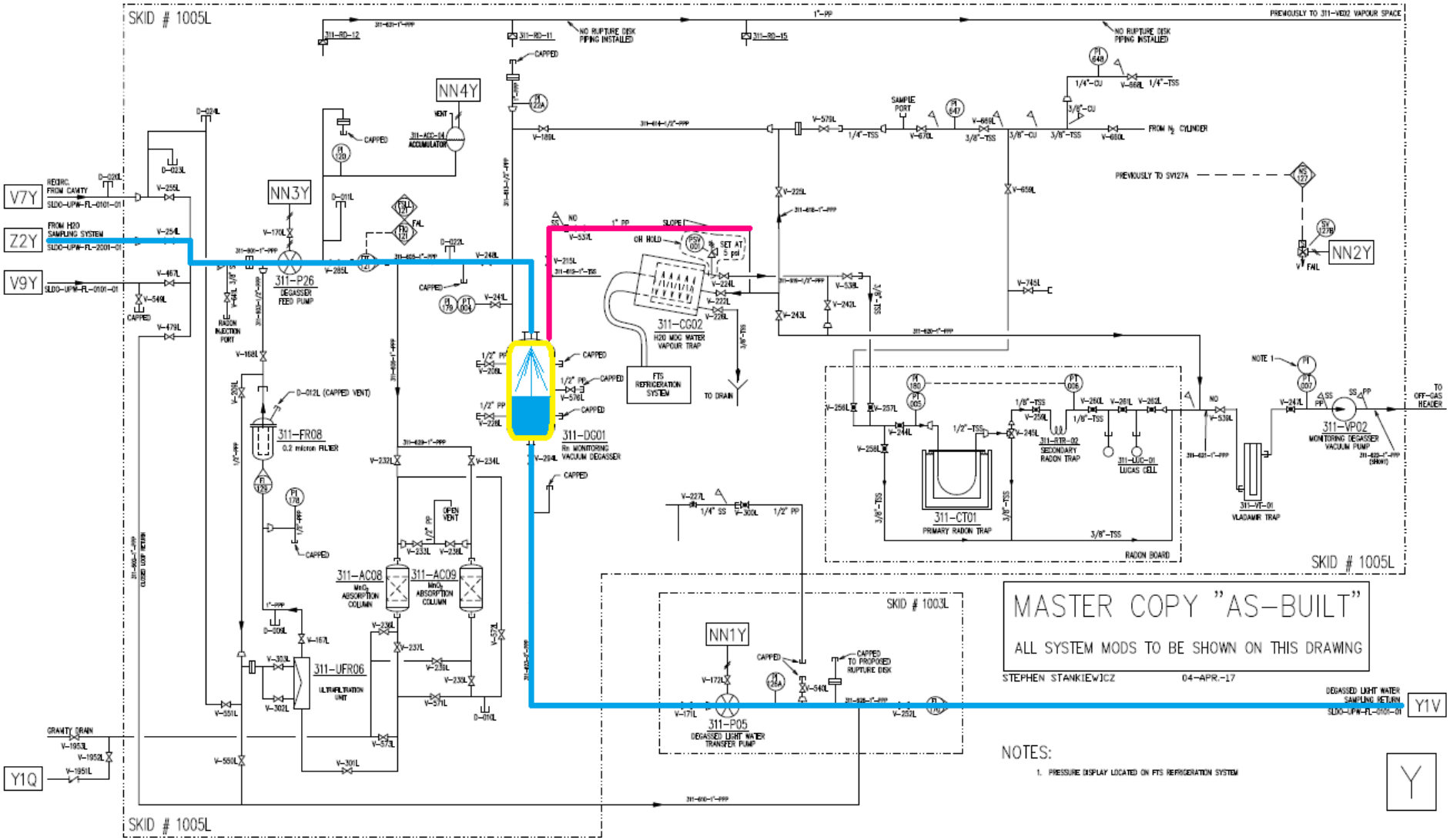
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TO OFF-GAS HEADER
TO DRAIN
FROM H2O SAMPLING SYSTEM
RECIRC. FROM CAVITY
DEGASSED LIGHT WATER SAMPLING RETURN
GRAVITY DRAIN
PREVIOUSLY TO SV127A
PREVIOUSLY TO 311-VE02 VAPOUR SPACE
NO RUPTURE DISK PIPING INSTALLED
FROM N2 CYLINDER
SAMPLE PORT
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CAPPED
CAPPED TO PROPOSED RUPTURE DISK
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ON HOLD
SLOPE
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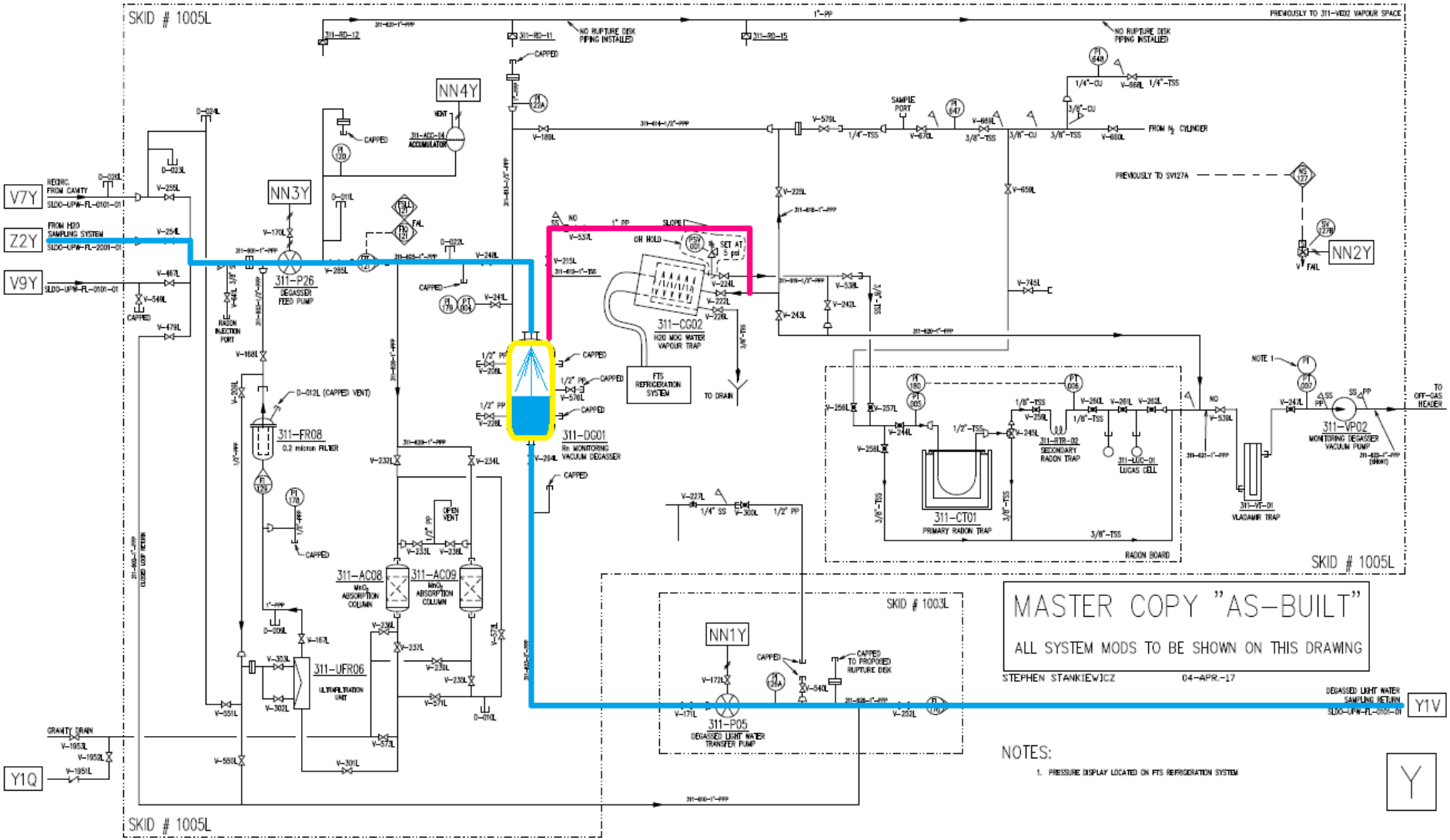
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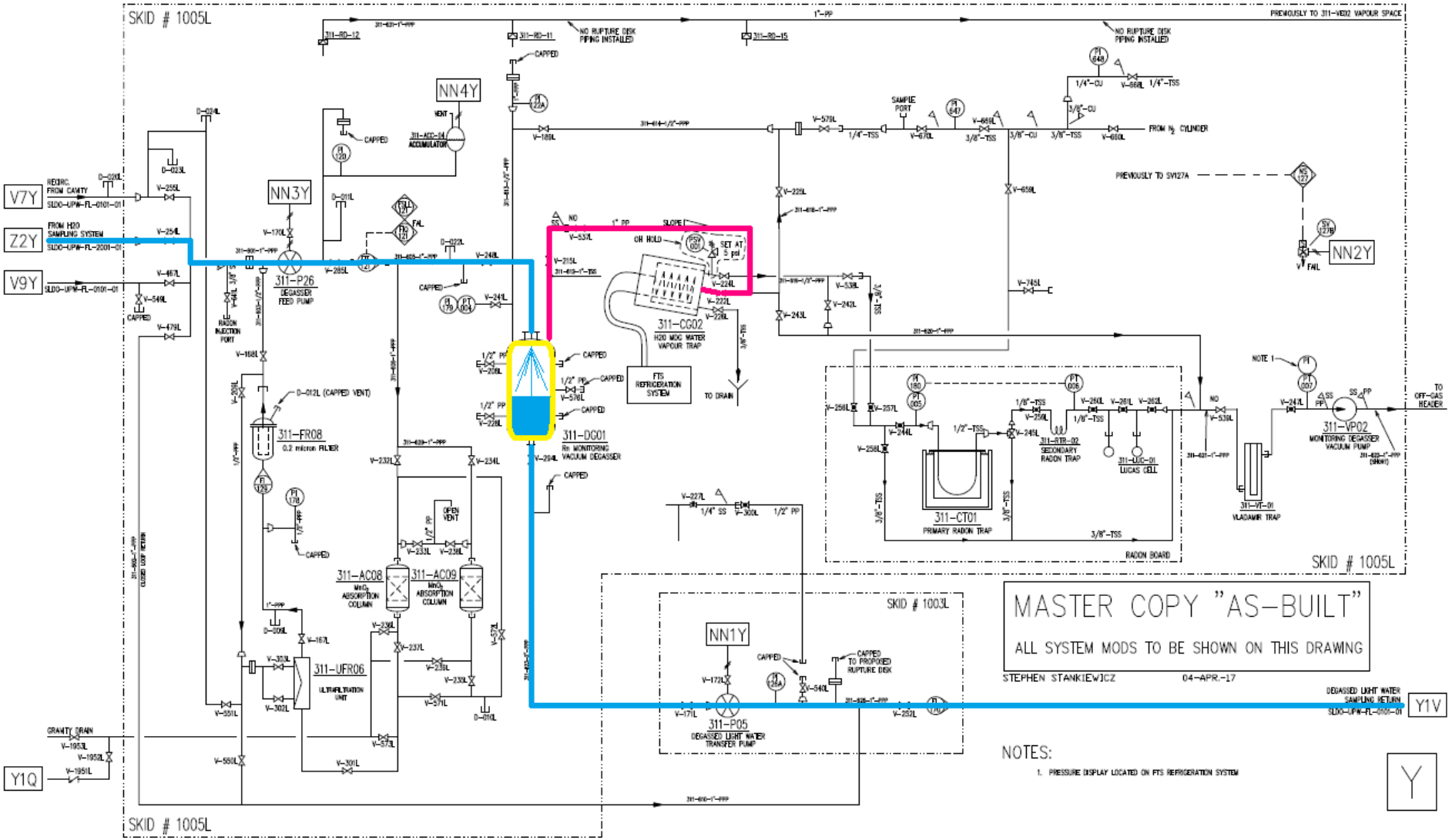
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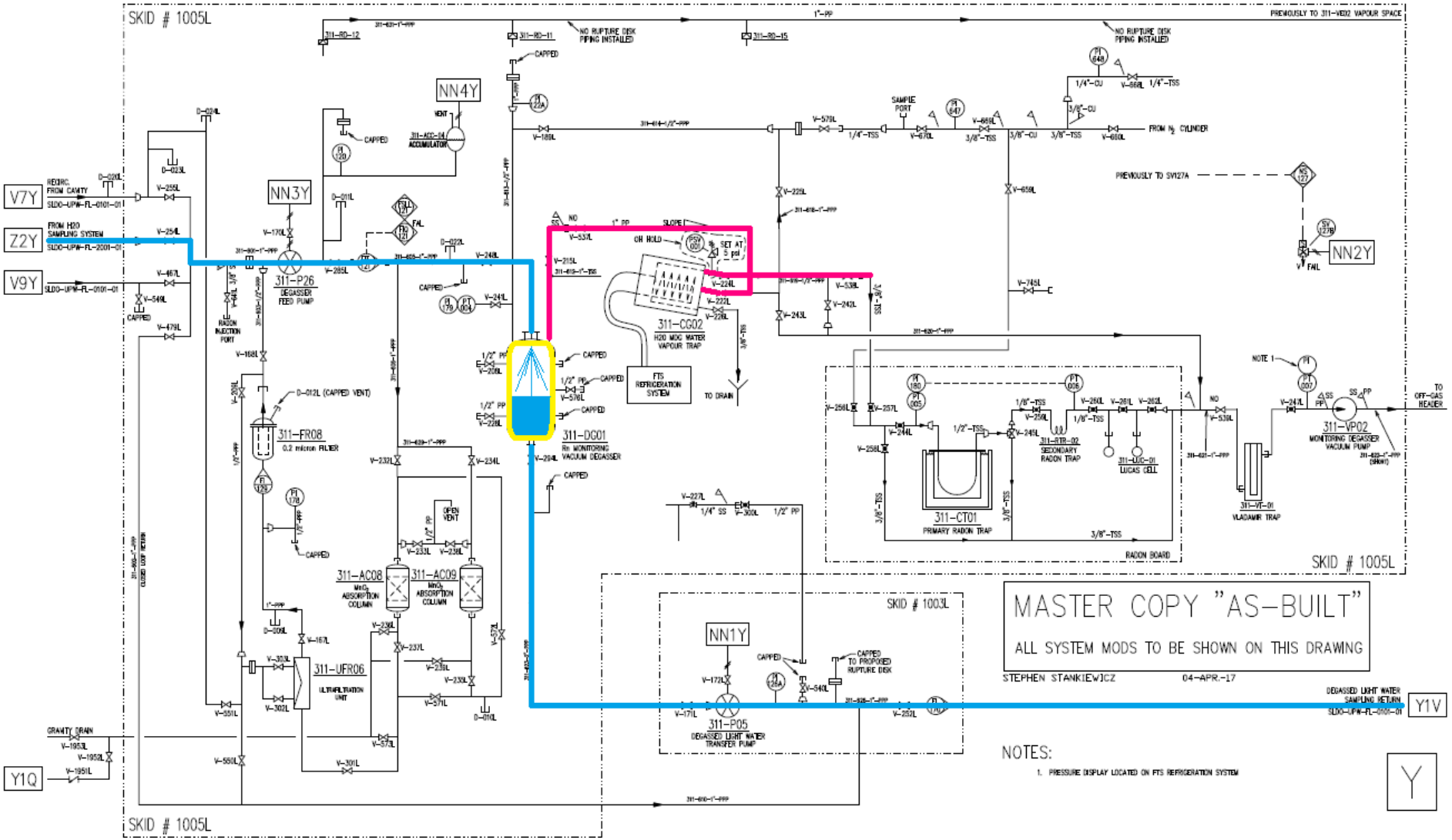
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TO OFF-GAS HEADER
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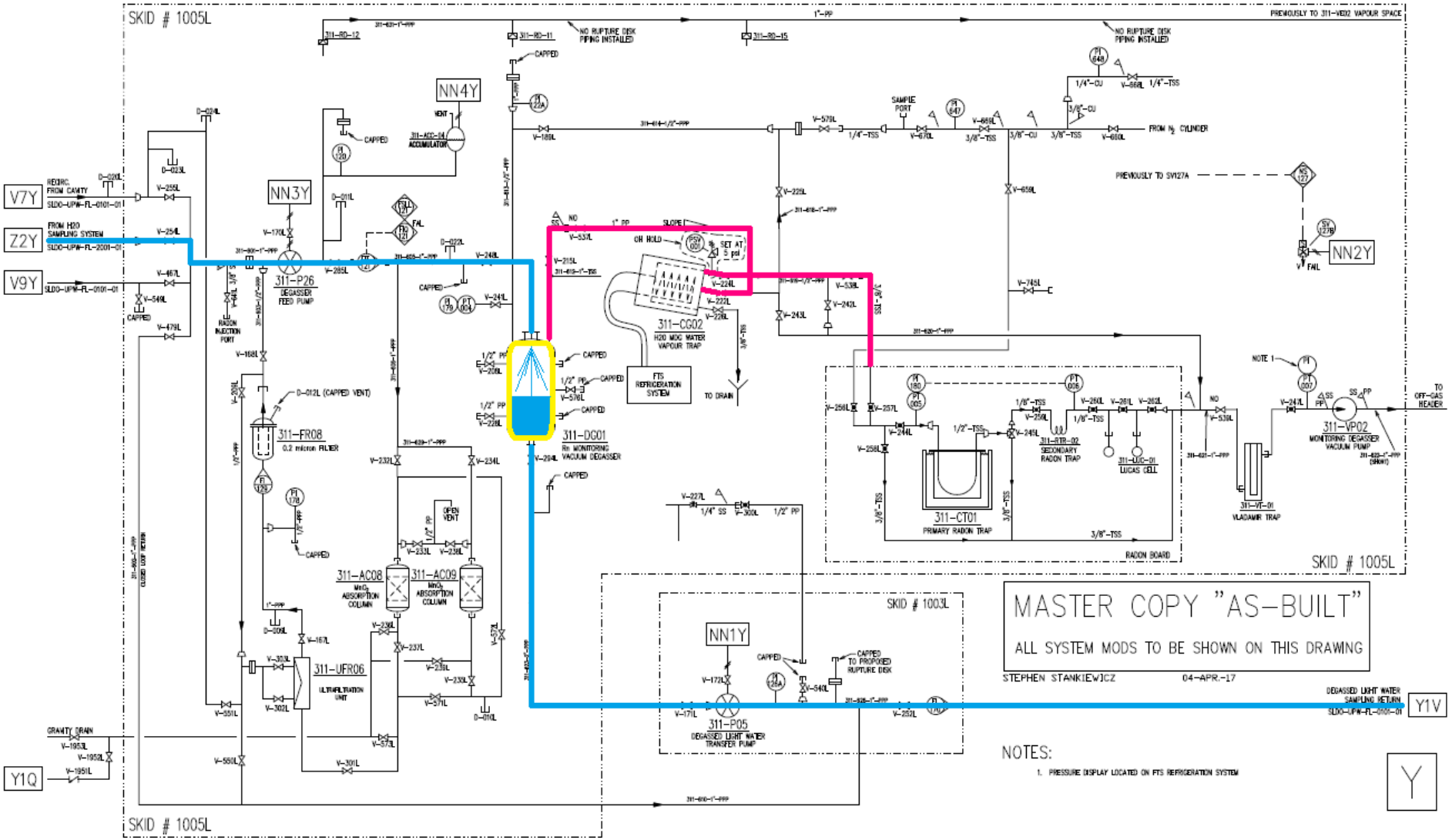
DEGASSED LIGHT WATER SAMPLING RETURN
GRAVITY DRAIN
Y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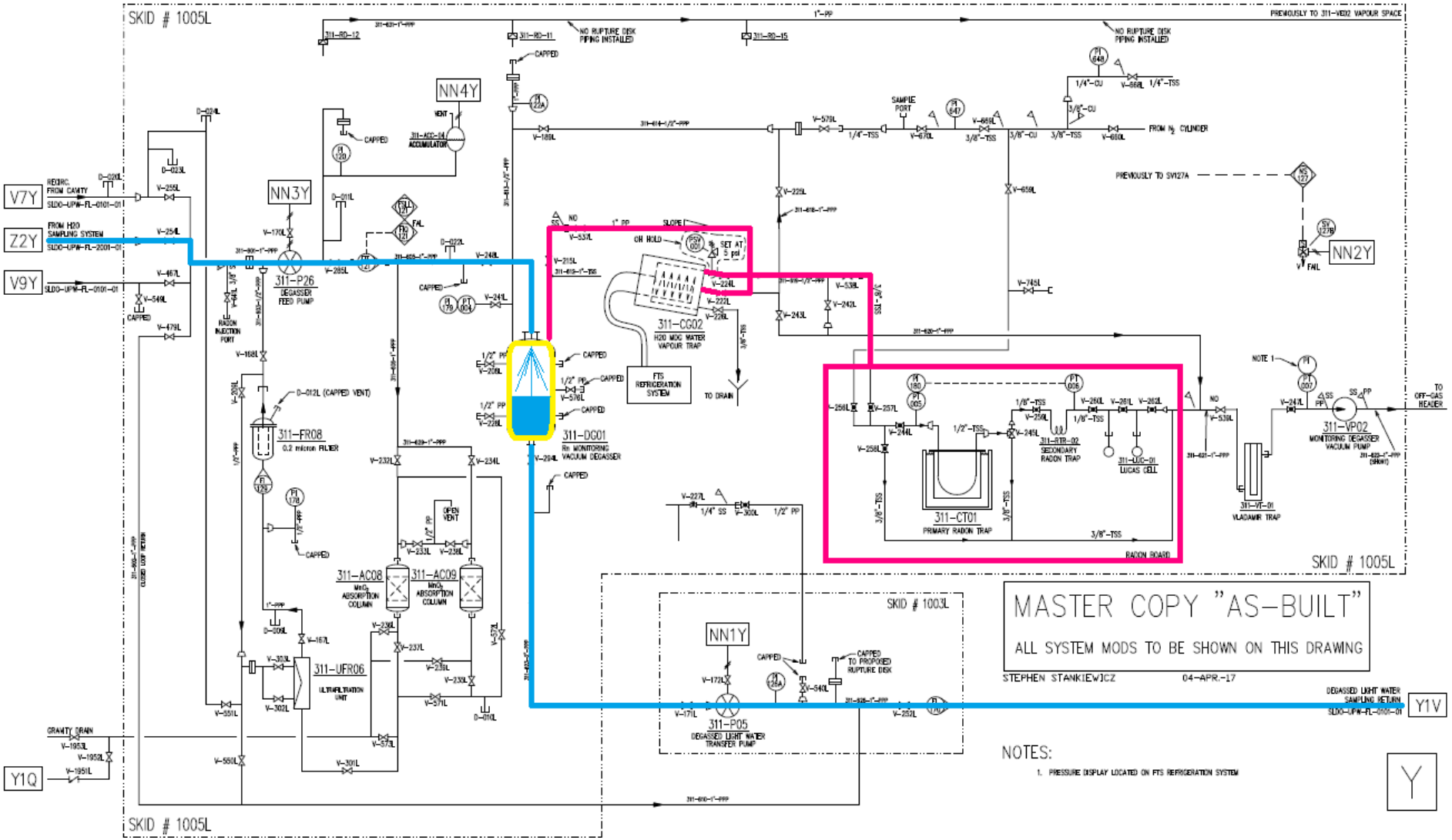
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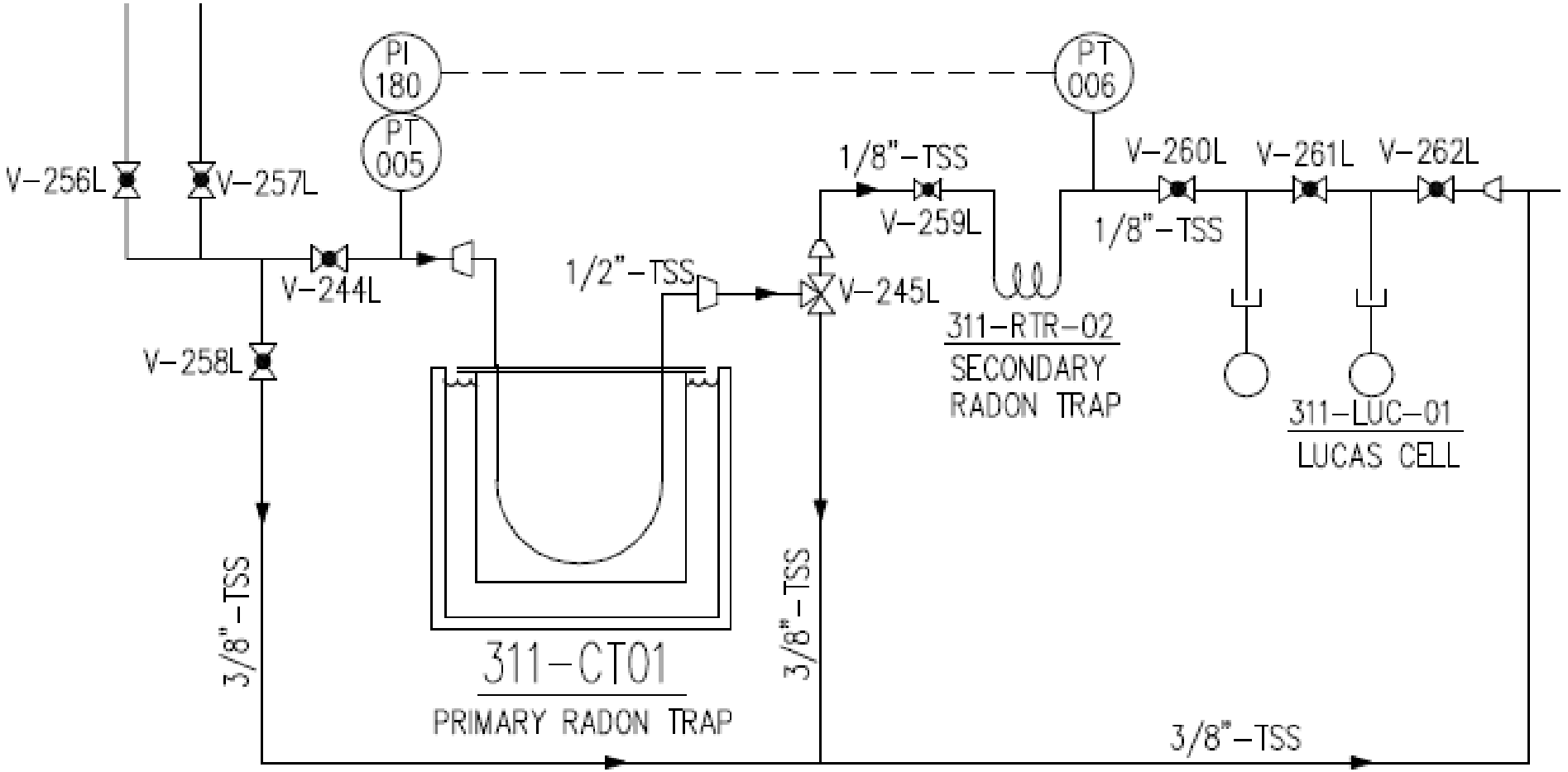
Radon Assays



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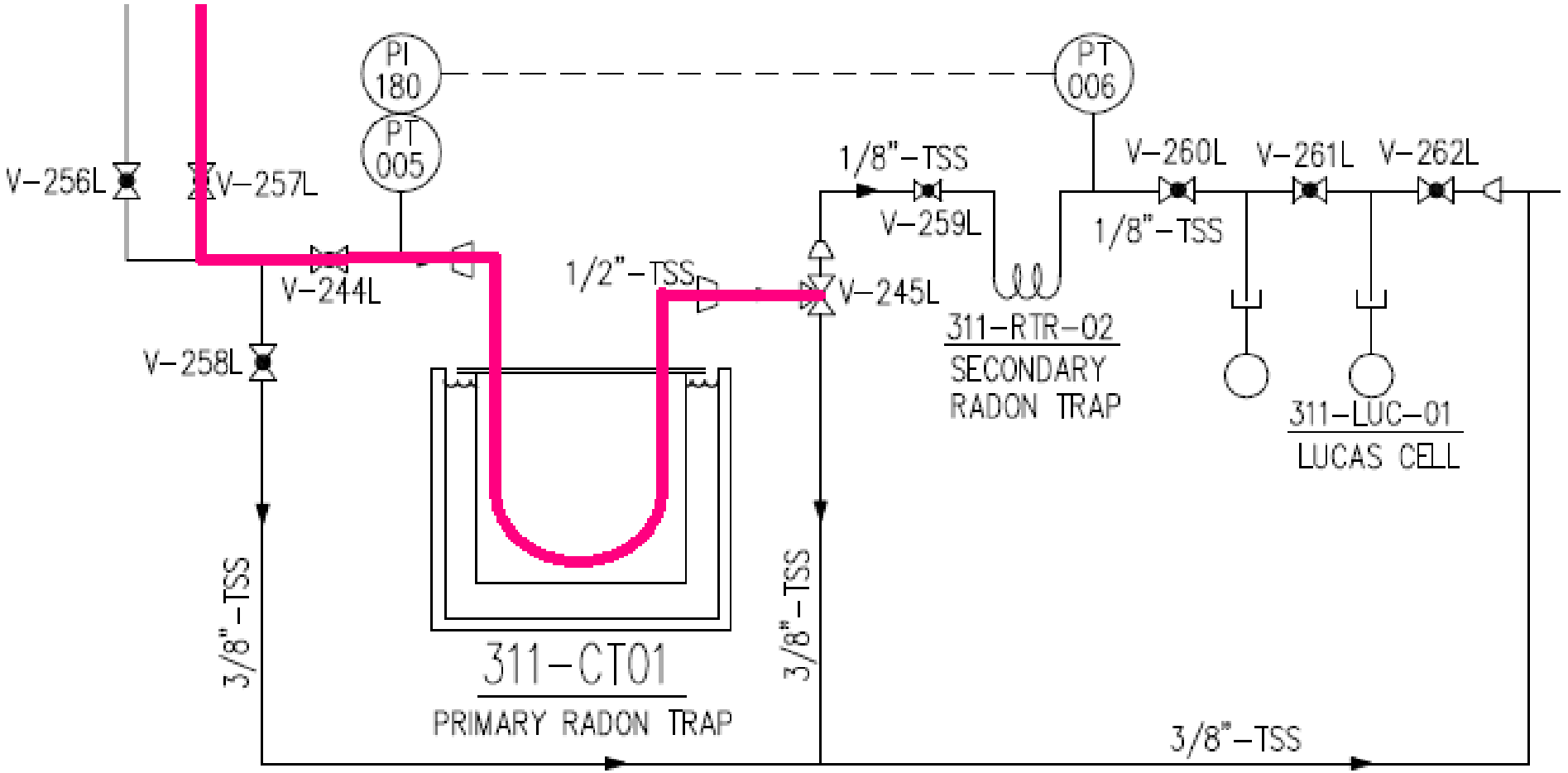

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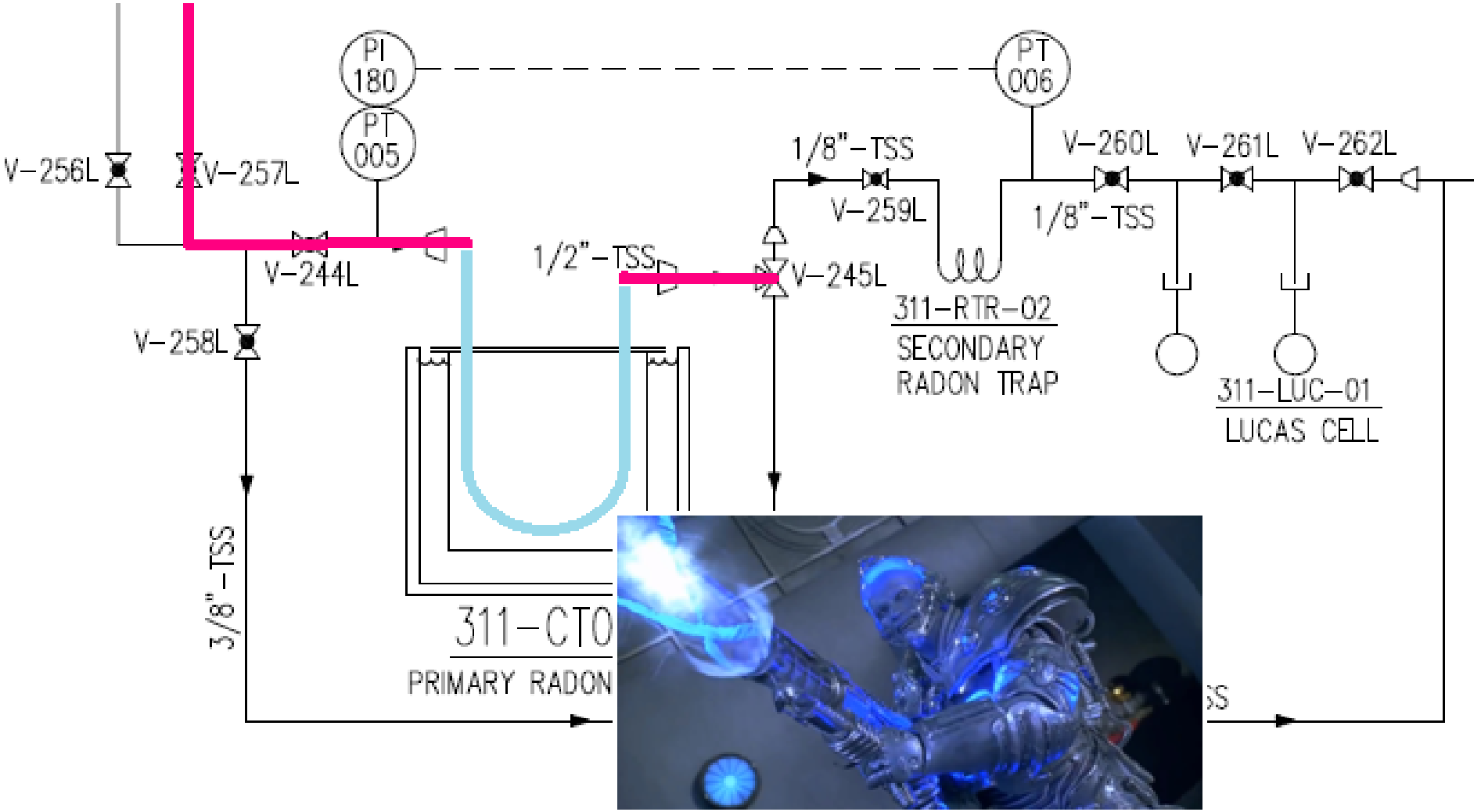

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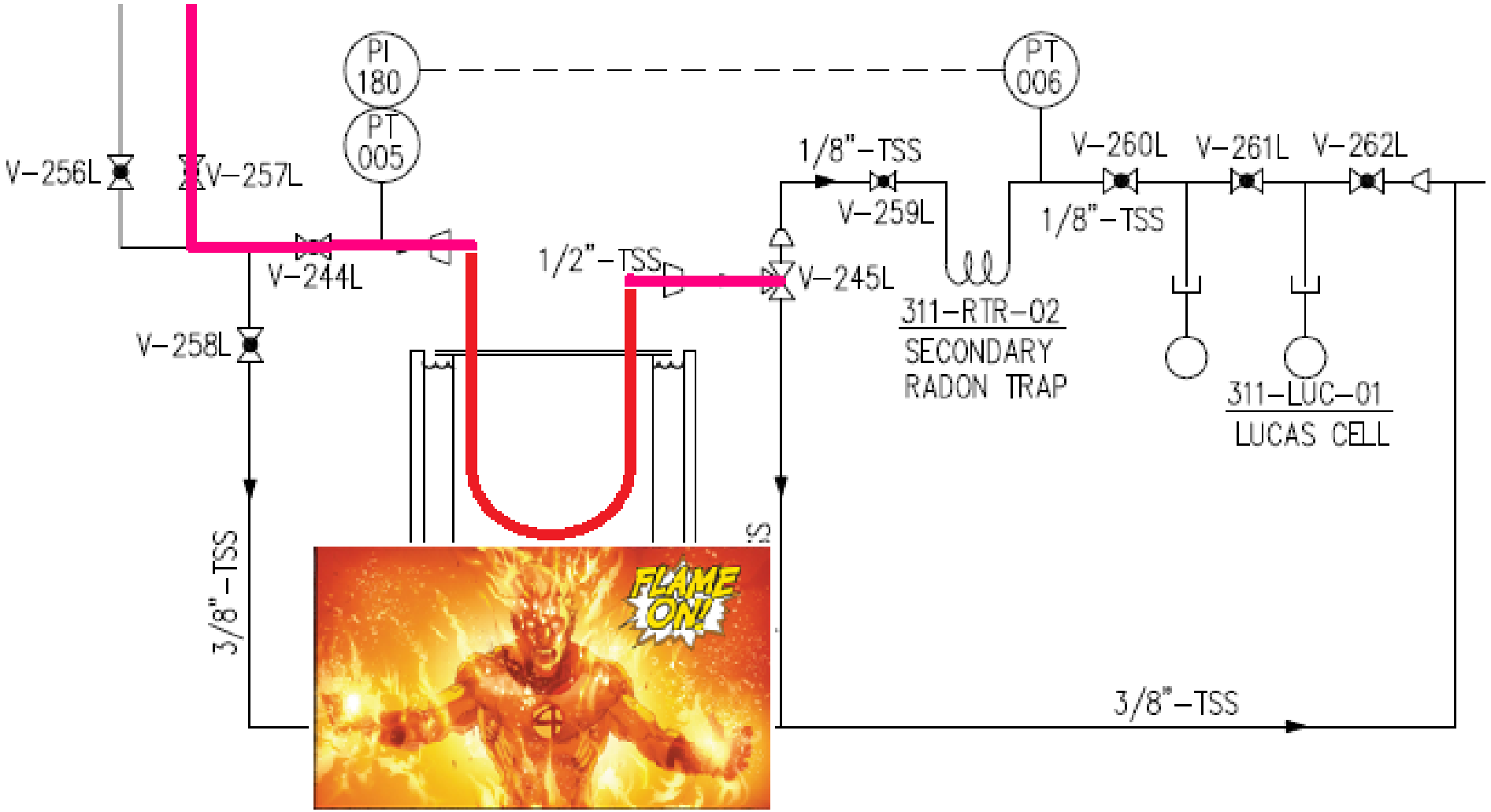

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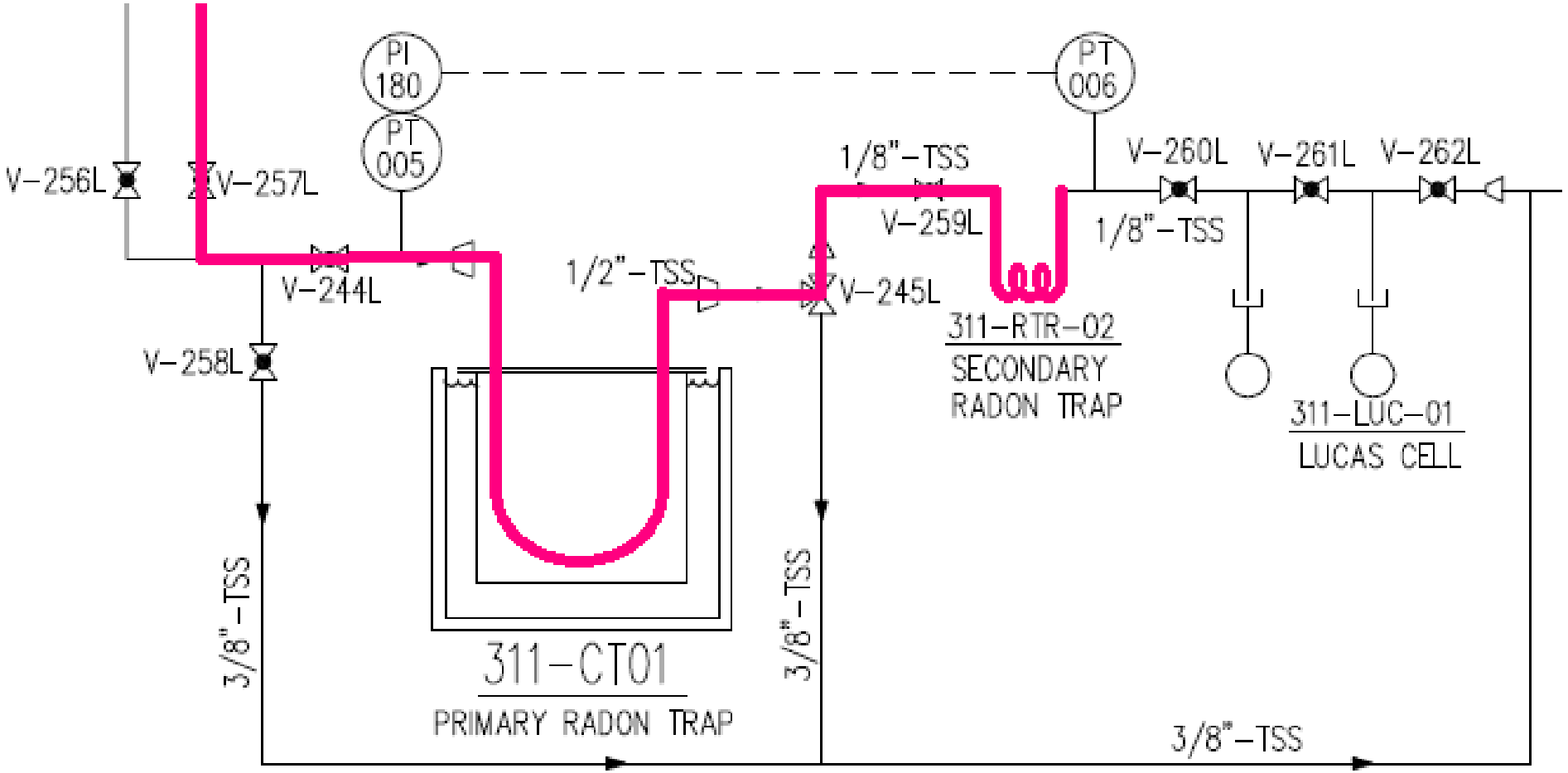
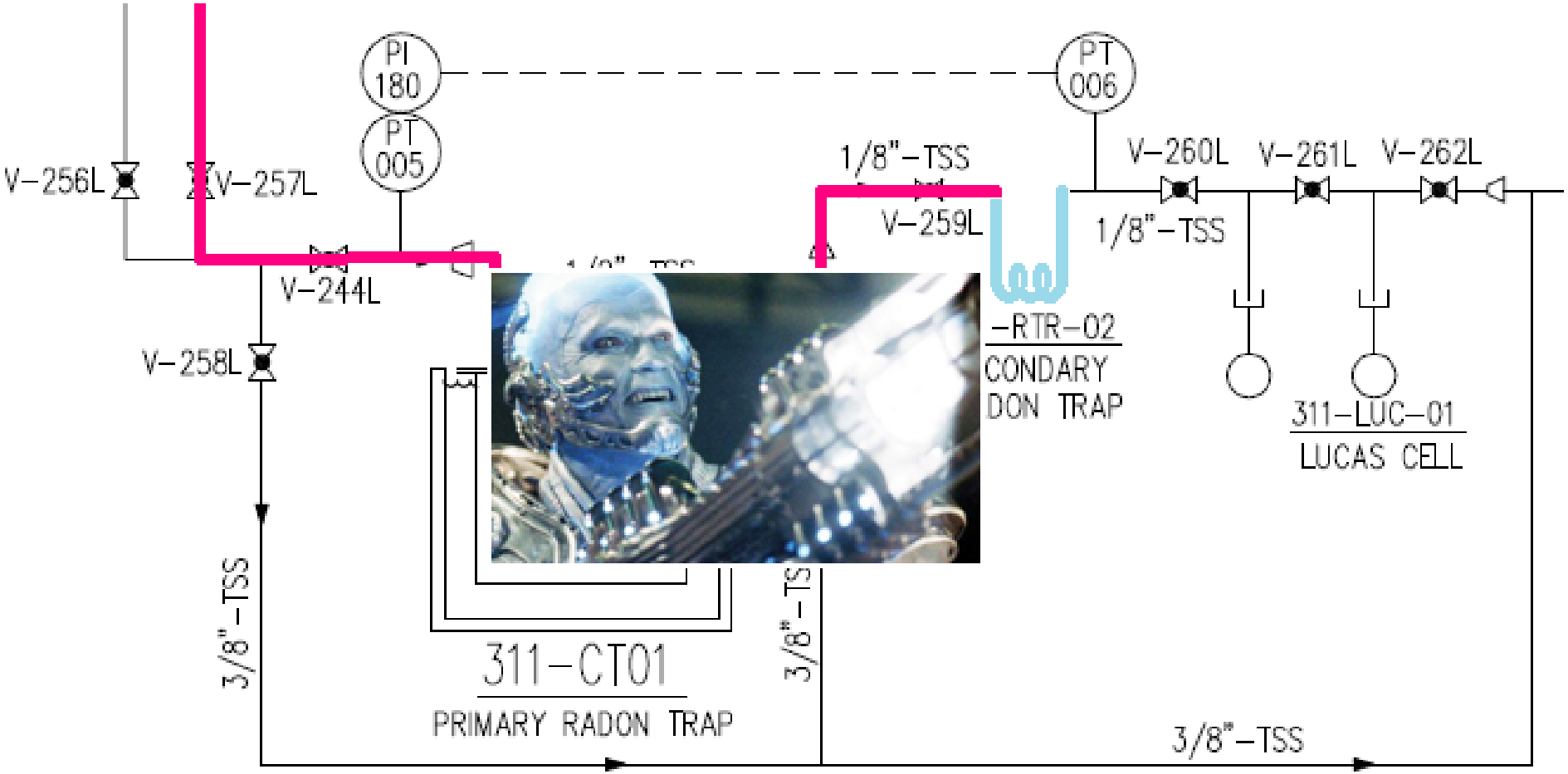
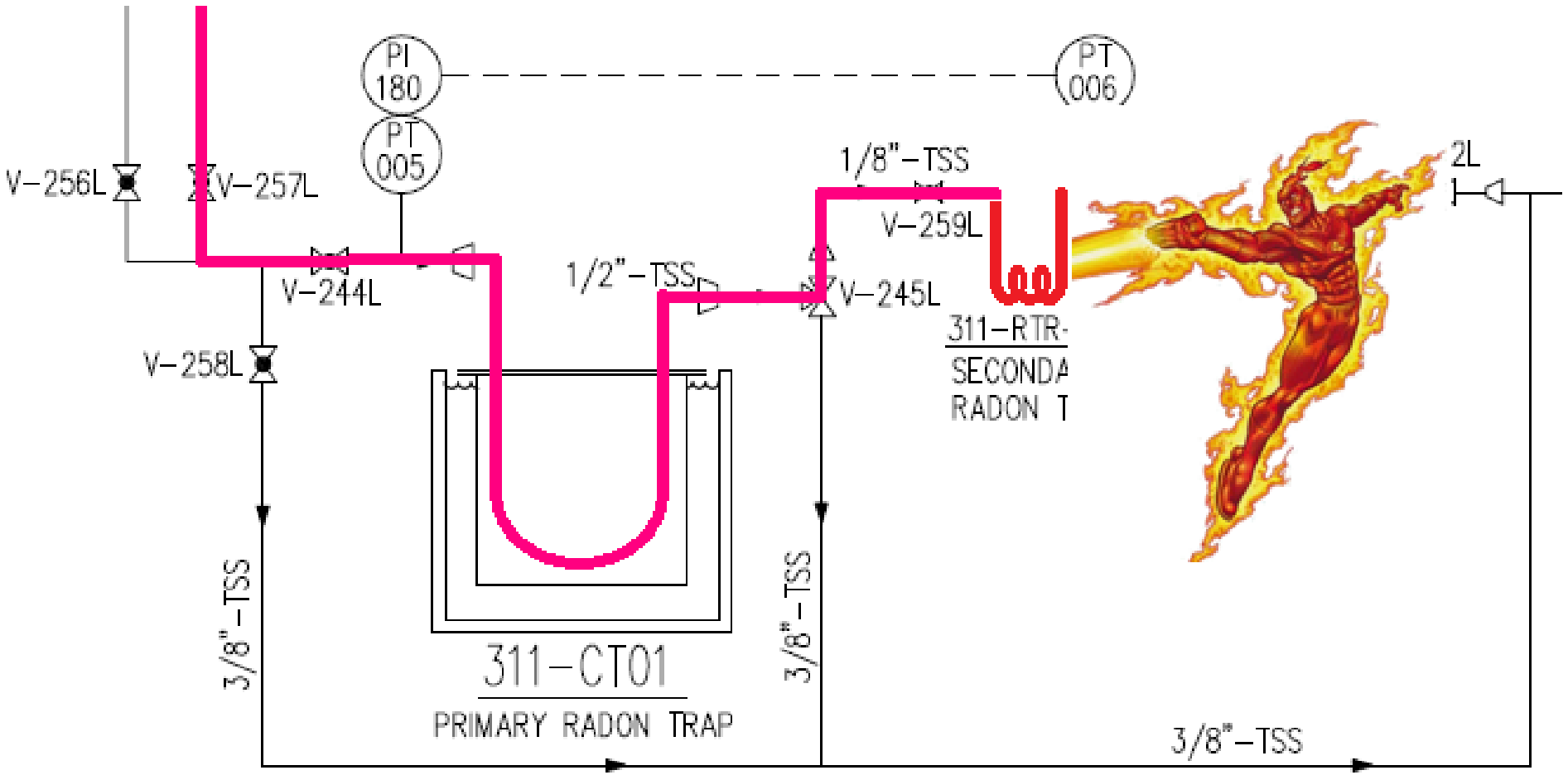


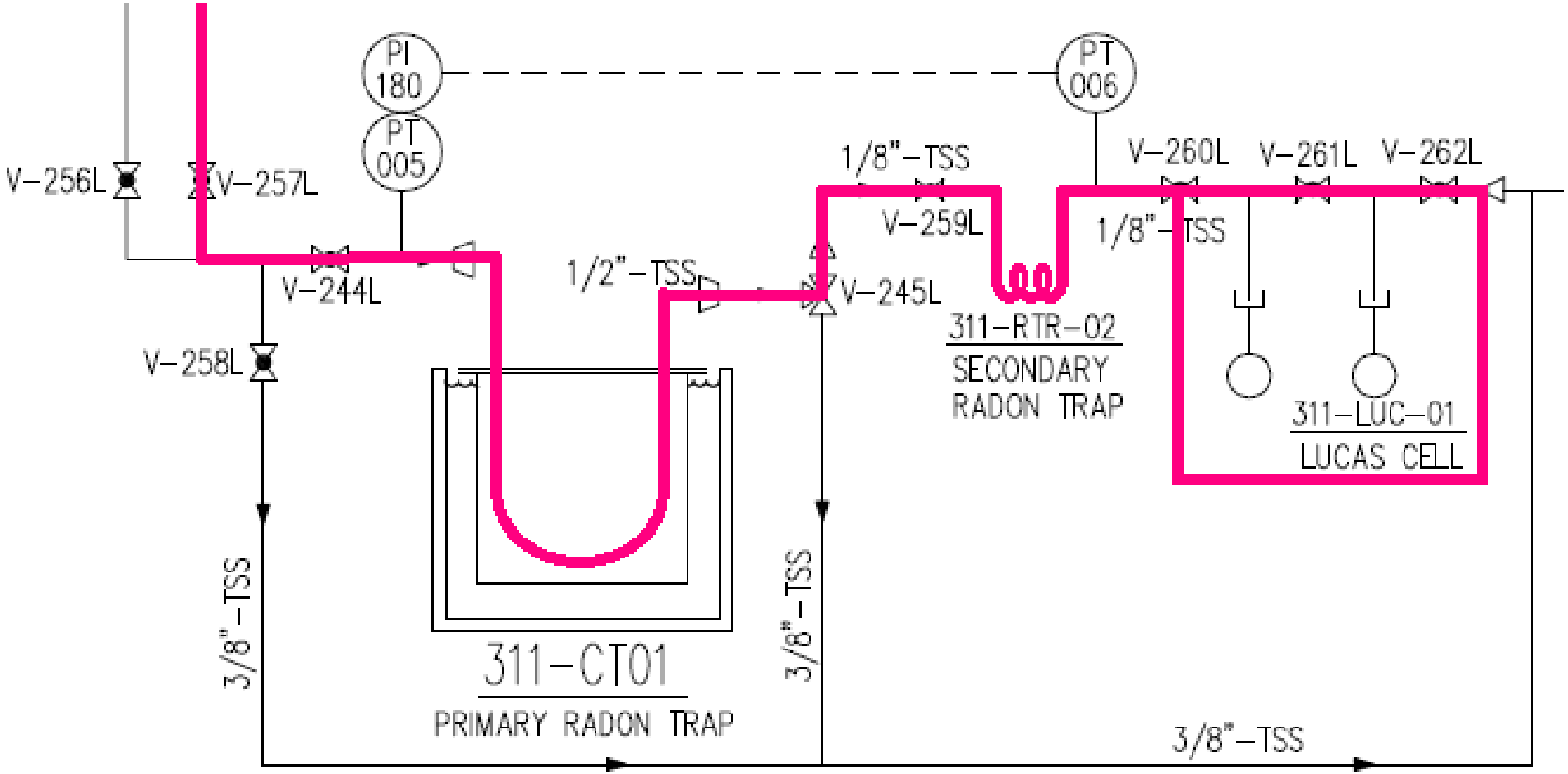
Radon Assays



Radon Assays

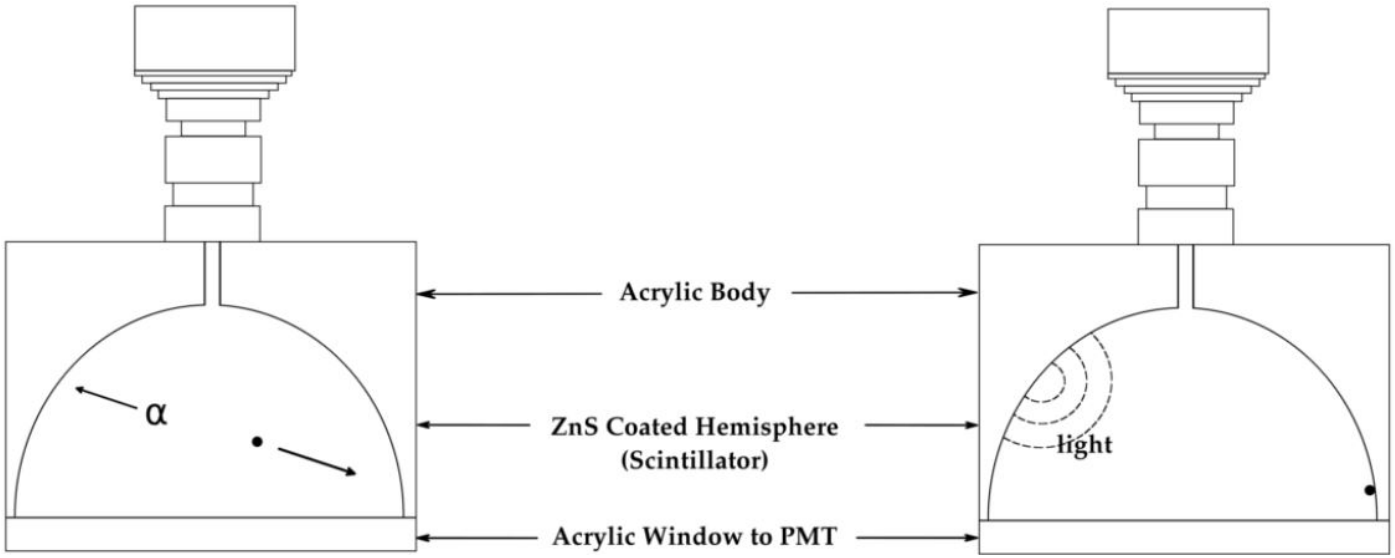


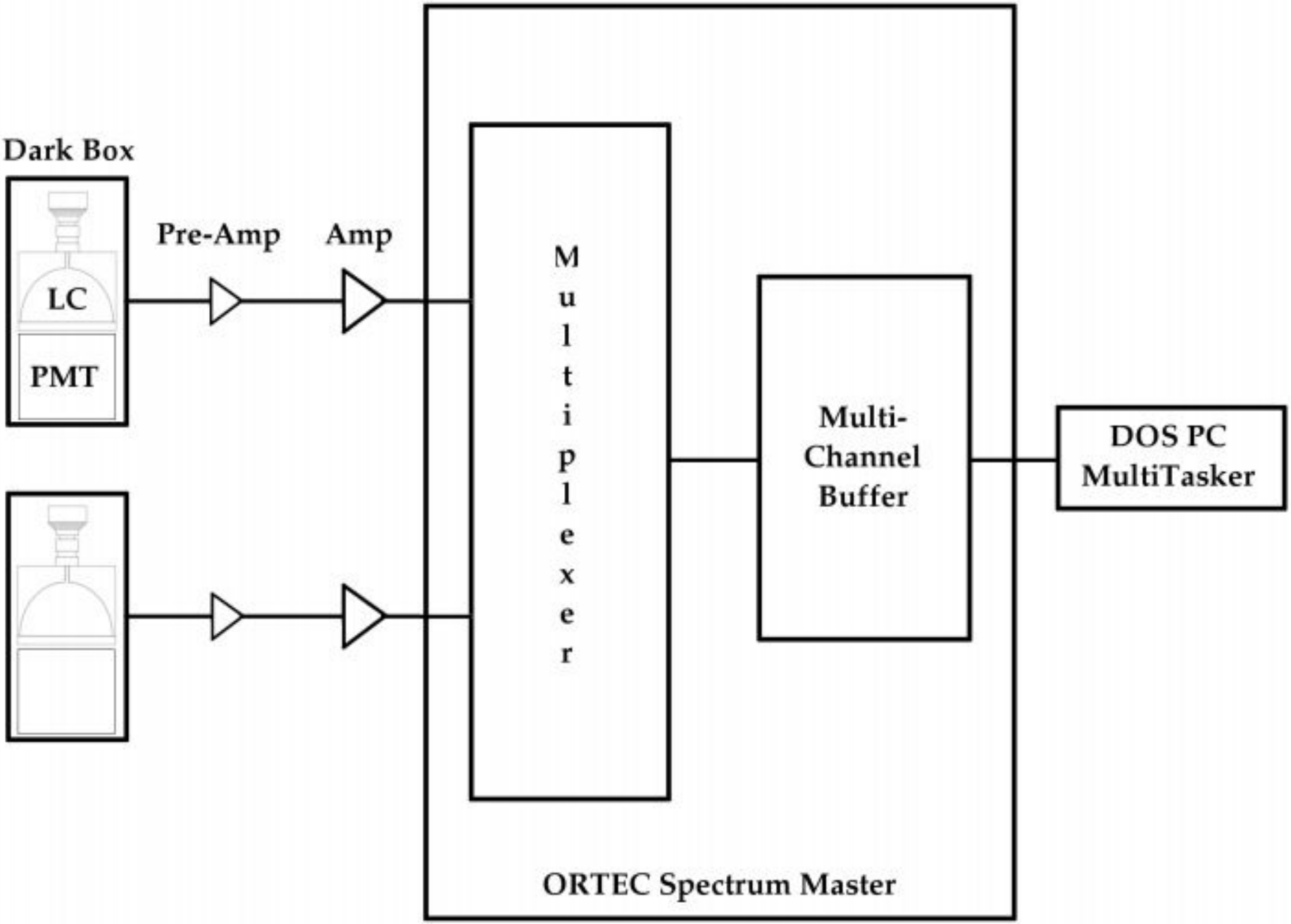
Radon Assays



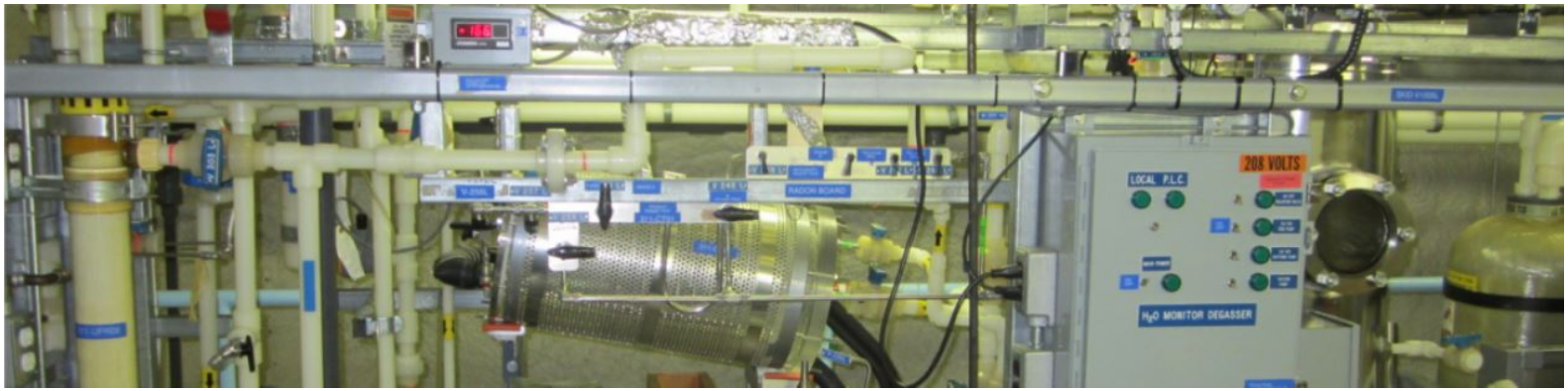
Lucas Cells

Lucas Cells are custom made 2" acrylic vessels with an inner hollow hemisphere coated with a ZnS scintillator. The entrapped $^{222}\mathrm{Rn}$ is decays, releasing α particles that interact with the scintillator, emitting light. The light is "seen" with optically coupled PMTs, and the raw data can be analyzed.



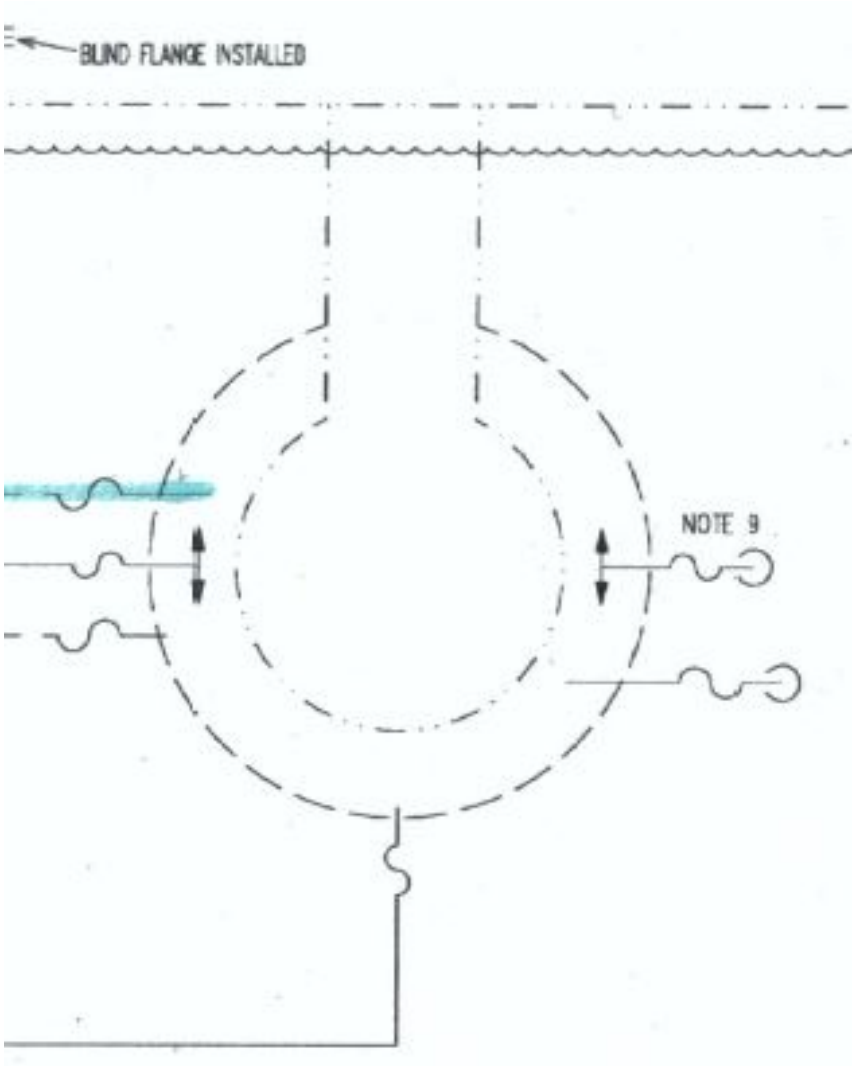

Dark Box
LC
PMT
Pre-Amp
Amp
Multiplexer
Multi-
Channel
Buffer
DOS PC
MultiTasker
ORTEC Spectrum Master

Background Assays

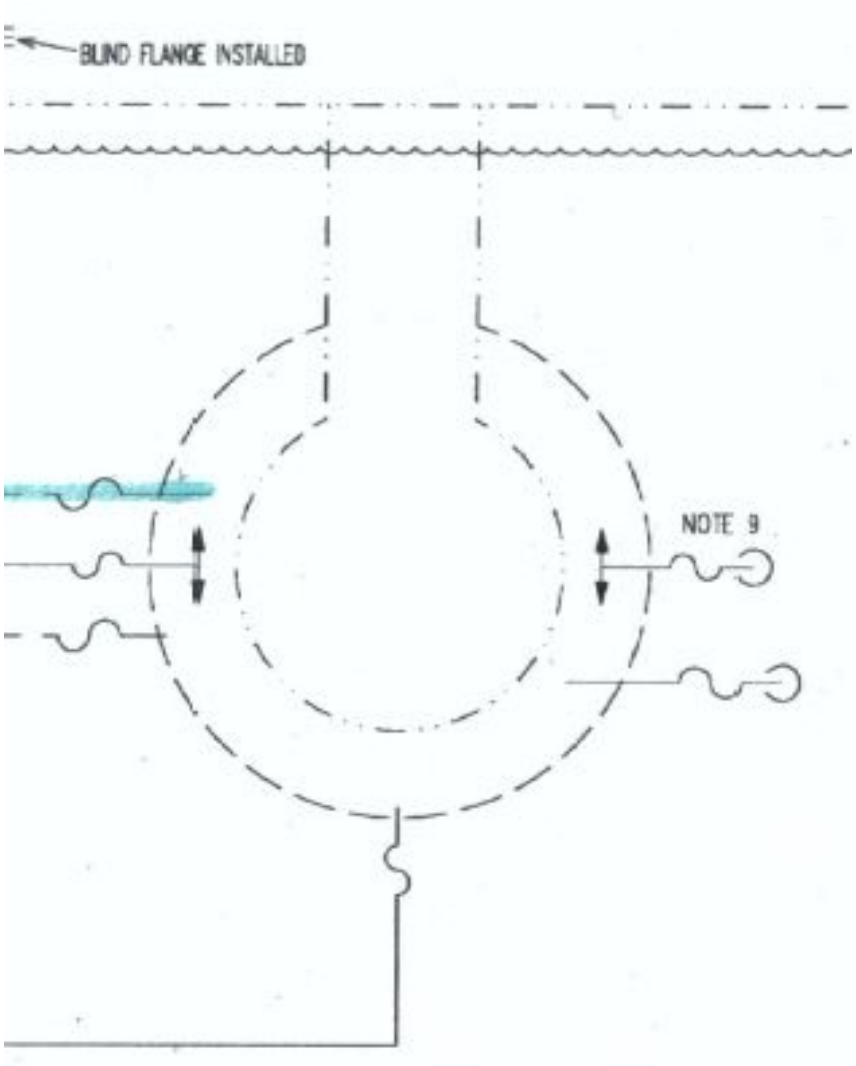


Parameters (With/Without Water, etc...)	Assay Date	Counts/day (cpd)	Radon Concentration Rn atoms/day
Without Water	Mar 29, 2017	75.63 ± 2.28	26869.4 ± 3312.6
	May 17, 2017	191.92 ± 13.92	38336.3 ± 4996.9
	Aug 17, 2017	102.89 ± 3.9	30461.8 ± 3610.2
	Aug 24, 2017	65.33 ± 4.15	11271.9 ± 2122.7
	Aug 31, 2017	214.39 ± 7.94	52928.7 ± 5893.2
	Sept 7, 2017	223.37 ± 9.33	51606.1 ± 5834.8
	Sept 14, 2017	66.03 ± 1.74	33269.4 ± 5408.8
	May 3, 2018	65.41 ± 3.68	18699.3 ± 2661.1
No MDG	May 10, 2018	33.65 ± 1.72	4157.3 ± 2403.9
No MDG, FTS sealed	May 24, 2018	125.41 ± 4.59	32900.5 ± 4720.3
With Water	May 17, 2018	76.52 ± 2.48	31623.0 ± 3912.8

PSUP Assay



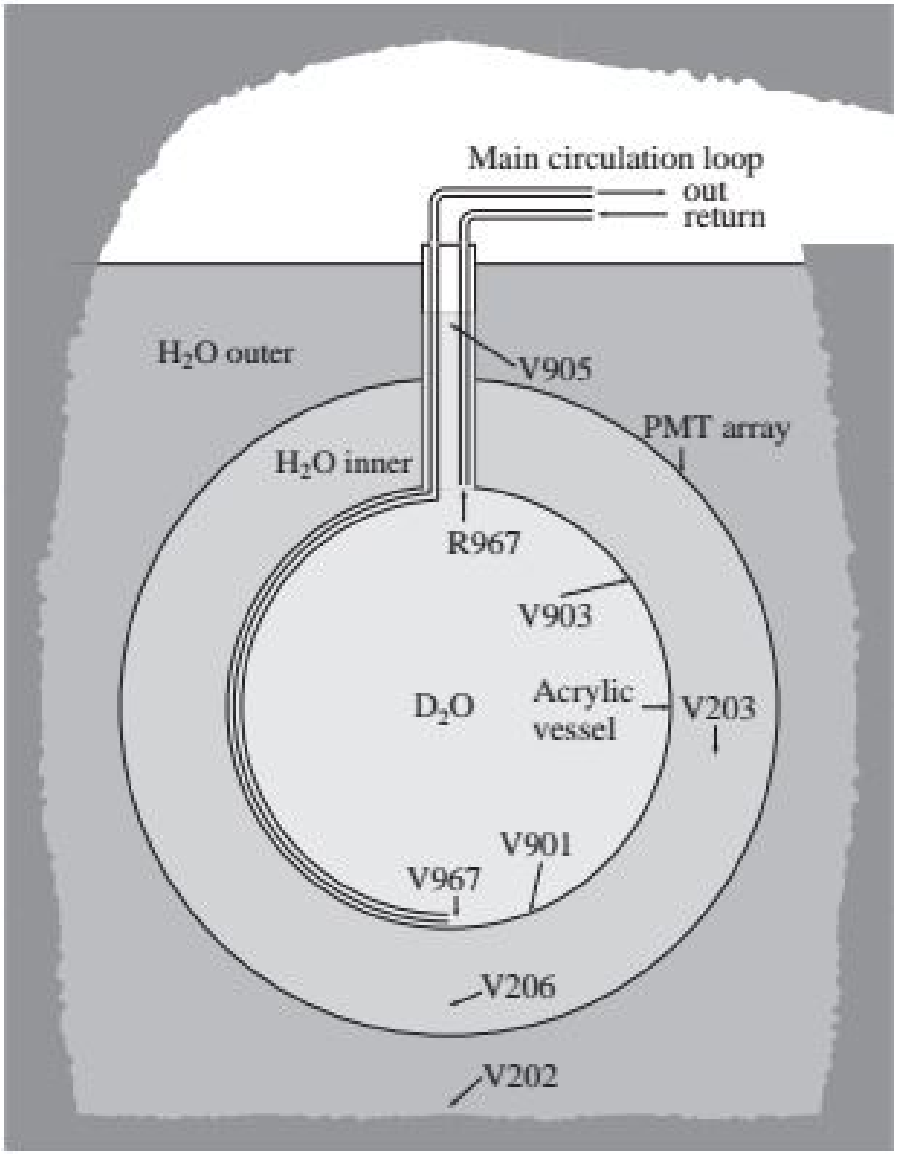
PSUP Assay



Assay Date: Jun 28, 2017

Measured Rate:
3.68×10^{-14} $g^{238}U/gH_2O$

AV Assay

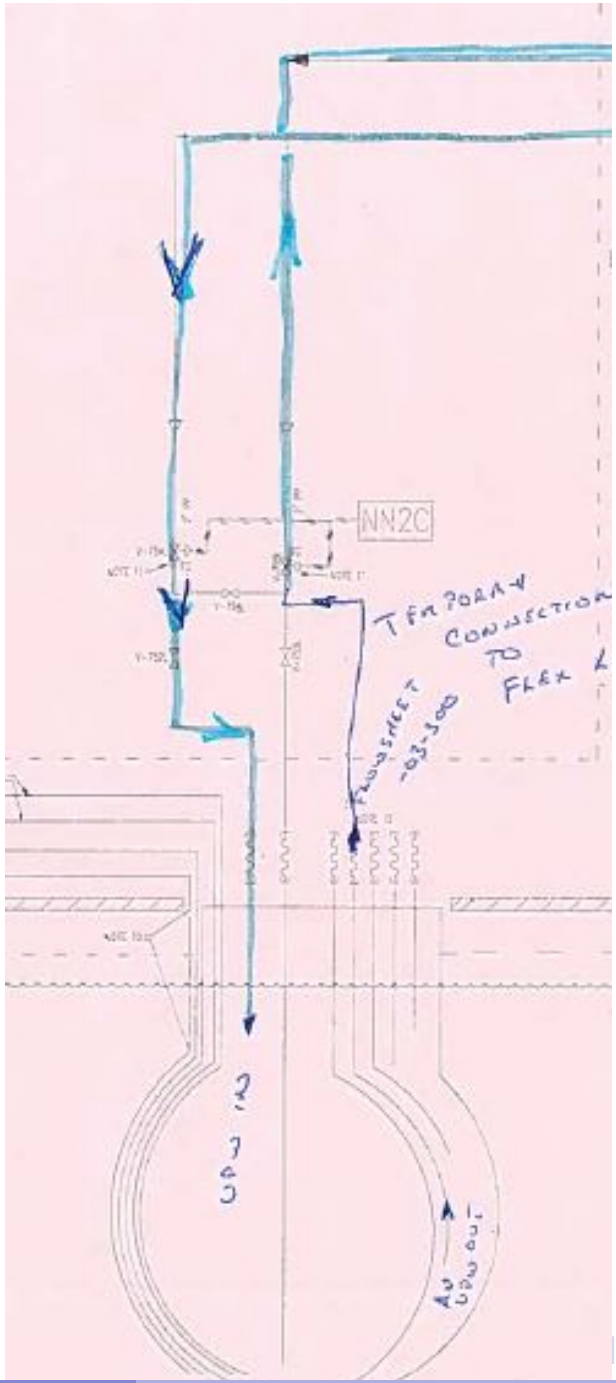


There are many sample points to chose from to gain an accurate representation of the background levels inside the detector.

Assay Date: Nov 7, 2017

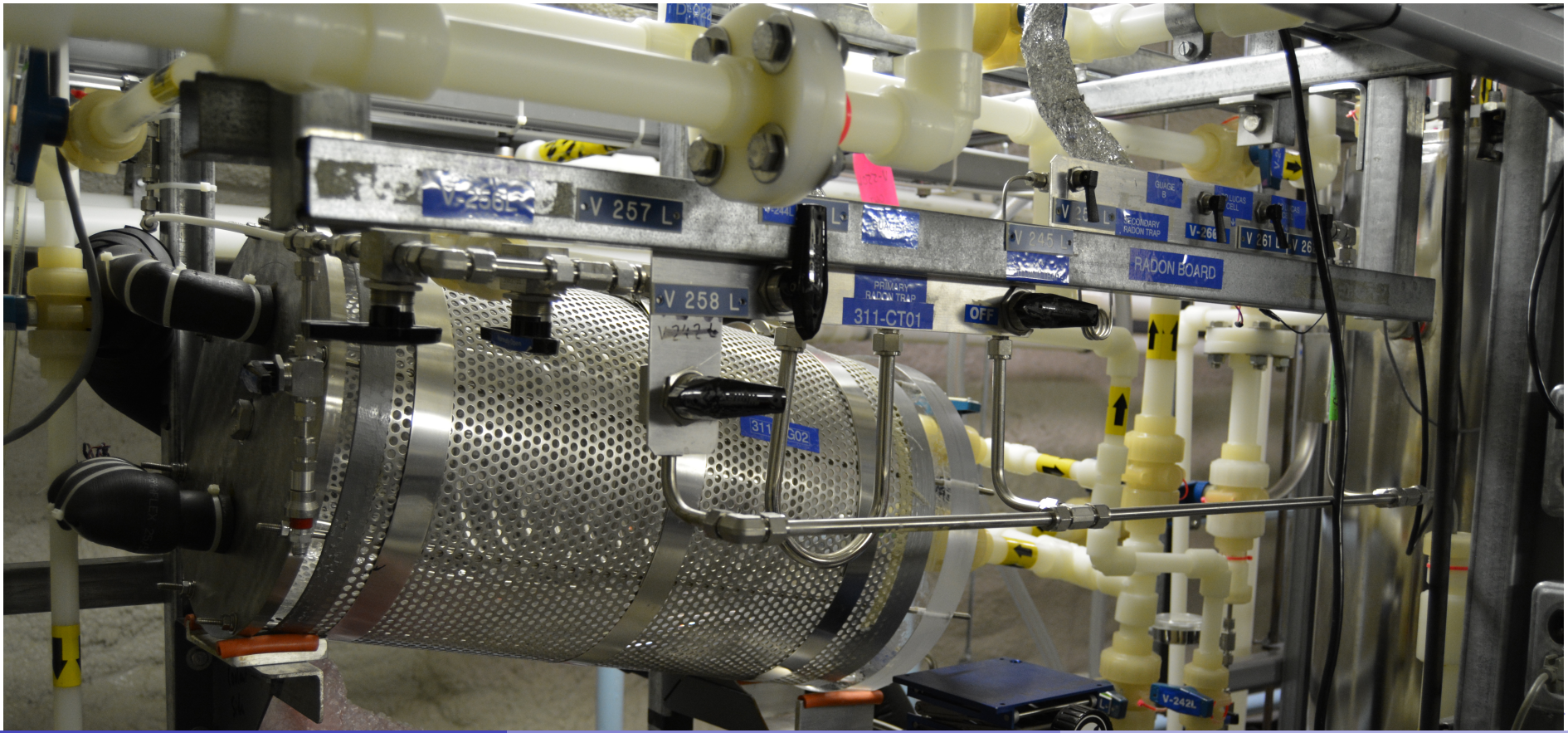
Measured Rate:
2.9×10^{-11} g^{238}U/gH$_2$O

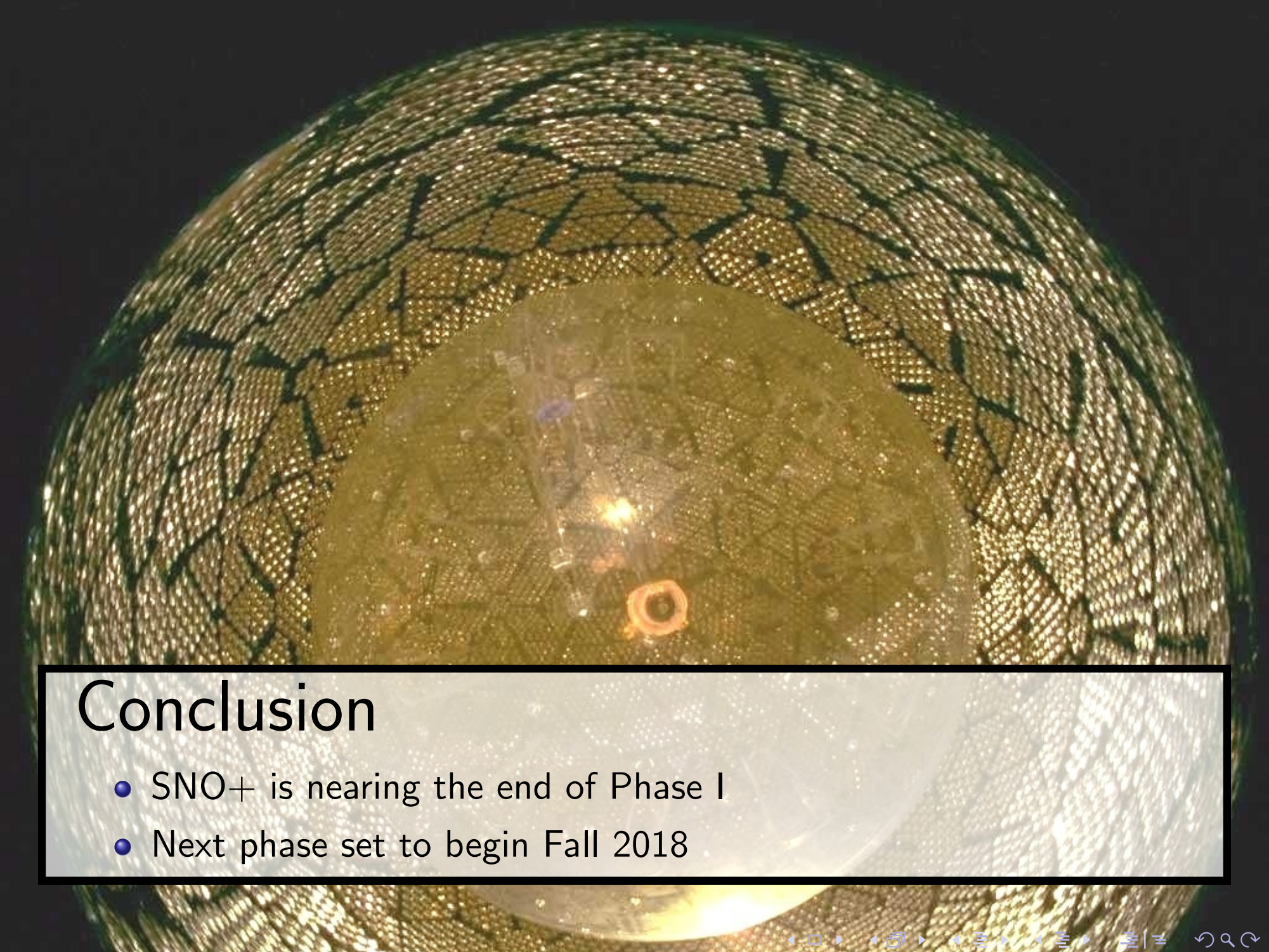
- Preliminary
- Not comparable to *in situ* analysis
- Continued debugging of Rn assay method for possible contamination



Assay Summary

- *in situ* analysis and other assay techniques will monitor internal $^{222}\mathrm{Rn}$ levels
- The current Rn assay system will be used to monitor cavity and PSUP $^{222}\mathrm{Rn}$ levels
- A scintillator Rn assay system will be built for the upcoming phases





Conclusion

- SNO+ is nearing the end of Phase I
- Next phase set to begin Fall 2018

Backup Slides

SNO+ $0\nu\beta\beta$ sensitivity