2x2 PrM and Gas Analyzers

aah

6/28/21

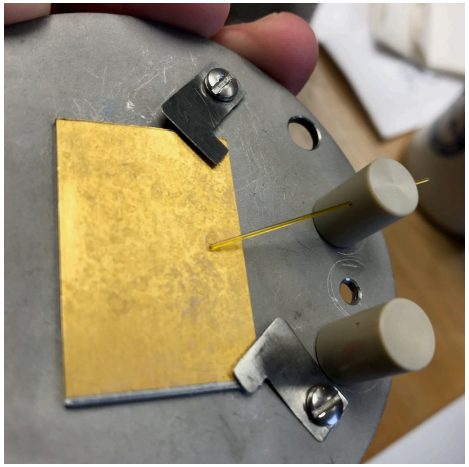
Amended 7/12/21

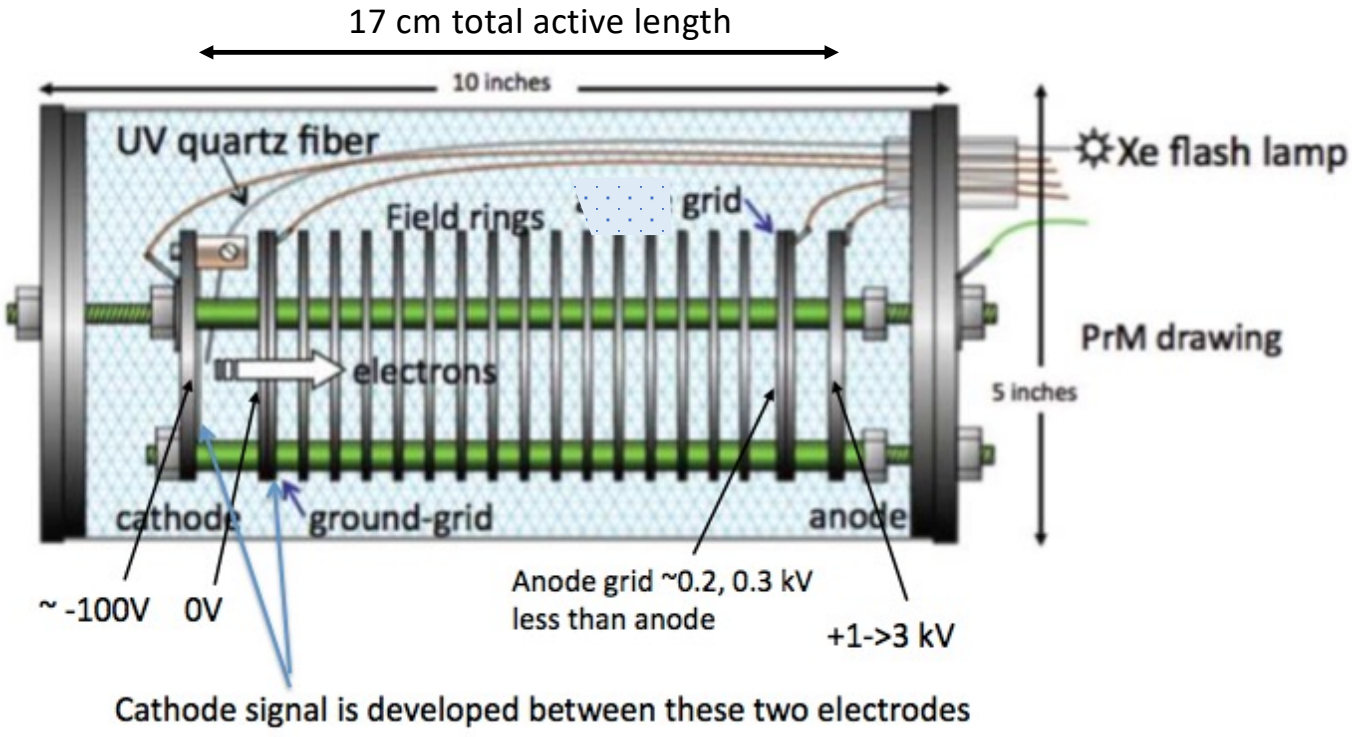
Purity Monitors (PrM) and Gas Analyzers

- Purity Monitor
  - A single channel drift chamber that determines the electronegative impurities in LAr by measuring the attenuation of drifting electrons from a cathode to an anode electrode.
  - Can't distinguish the type of impurity
    - Typically is either O_2 or H_2O at the ppb (or lower) concentration levels in LAr
      - Imps(ppb) = 0.3/lifetime(ms) or 1 ms lifetime corresponds to 0.3 ppb O_2 equivalent impurity.
    - N_2 at levels of 1-10 ppm does not attenuate the drifting electrons.
    - PrMs can measure impurities at the 10's of ppt level of O_2 equivalent
      - Depends on drift times of PrM as well of systematics of Qa/Qc measurement.
- Gas Analyzers
  - Commercial Hardware modules that are sensitive to impurities in an argon gas stream
  - Ones we use are single purpose modules that detect impurity levels from ~air levels to 100's of ppt).
  - By definition, they can distinguish the type of impurity
    - We specifically look for O_2, H_2O (both impact electron lifetimes) and N_2 (impacts photon yields)

Drawing of FNAL “Short” PrM

Gold Cathode



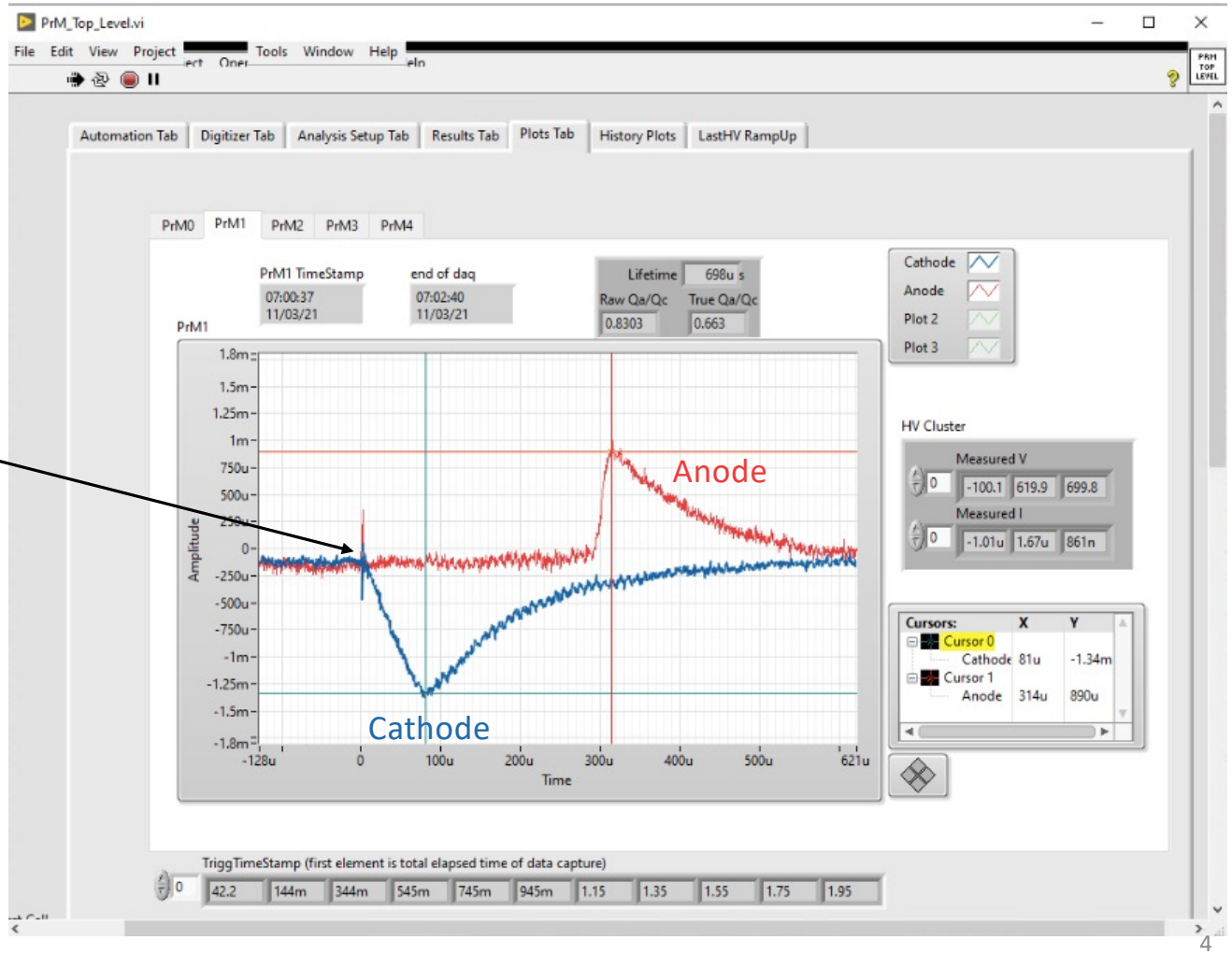


ICEBERG PrM

Lifetime =

$$-\text{DriftTime}/\ln(Q_A/Q_C)$$

Flash lamp start



Traces are the integral of the Cathode and anode currents (with 120 us RC time constant in integrating preamp).

Traces are average of 400 flashes @ 10Hz)

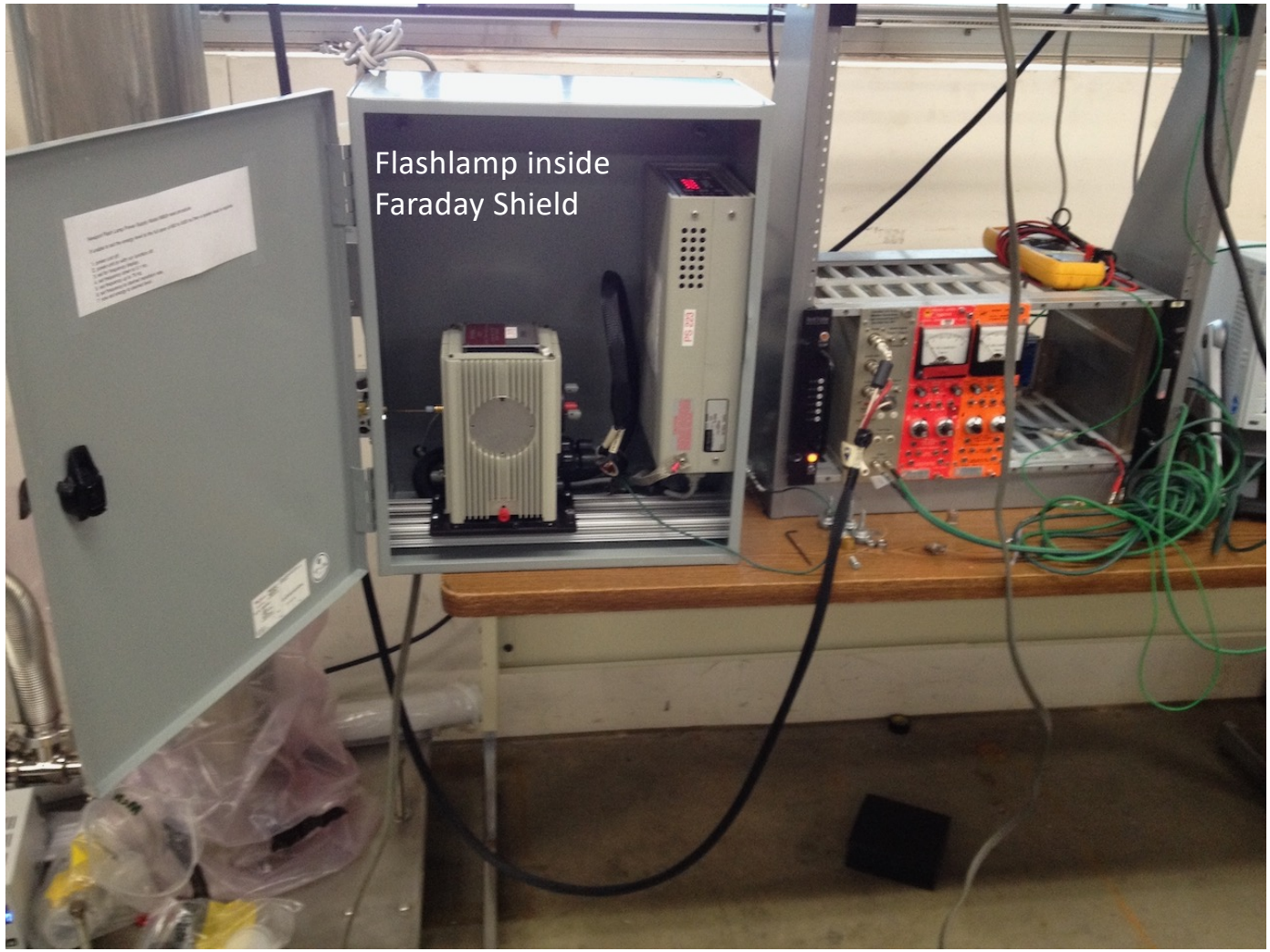
2x2 Short PrM

IB PrM Flange with HV/signal
& Fiber Feedthrus

Underside of HV/Signal Feedthru

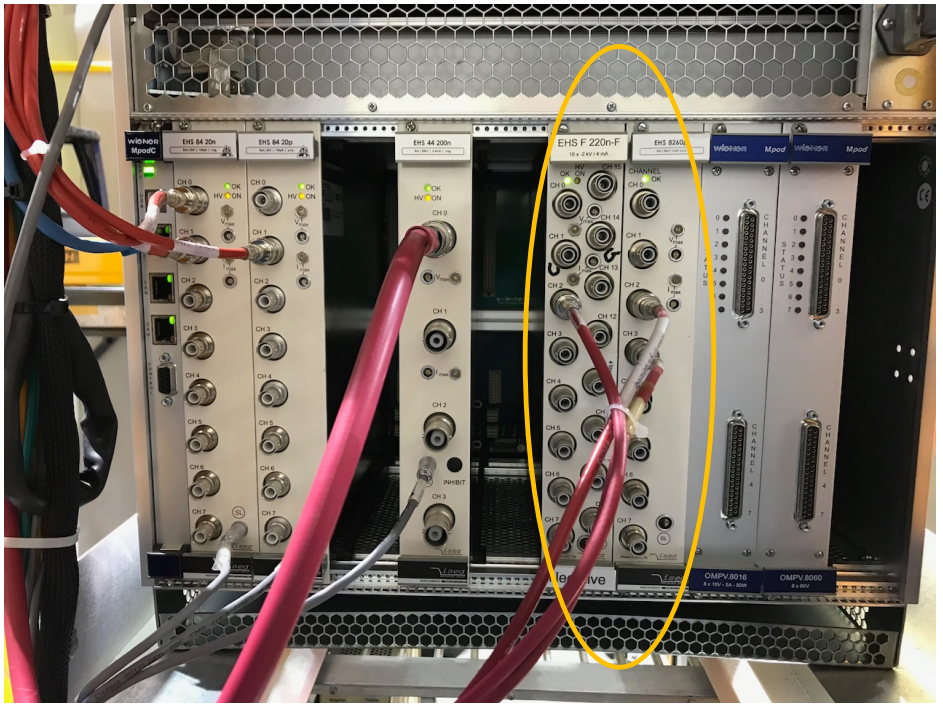

Installing IB PrM into ICEBERG Cryostat


Flashlamp
PrM Flange


Flashlamp inside
Faraday Shield

PrM Integrating Amplifier

PrM DAQ PC with Cathode&Anode Digitizer Card + USB Digital Control for Flashlamp



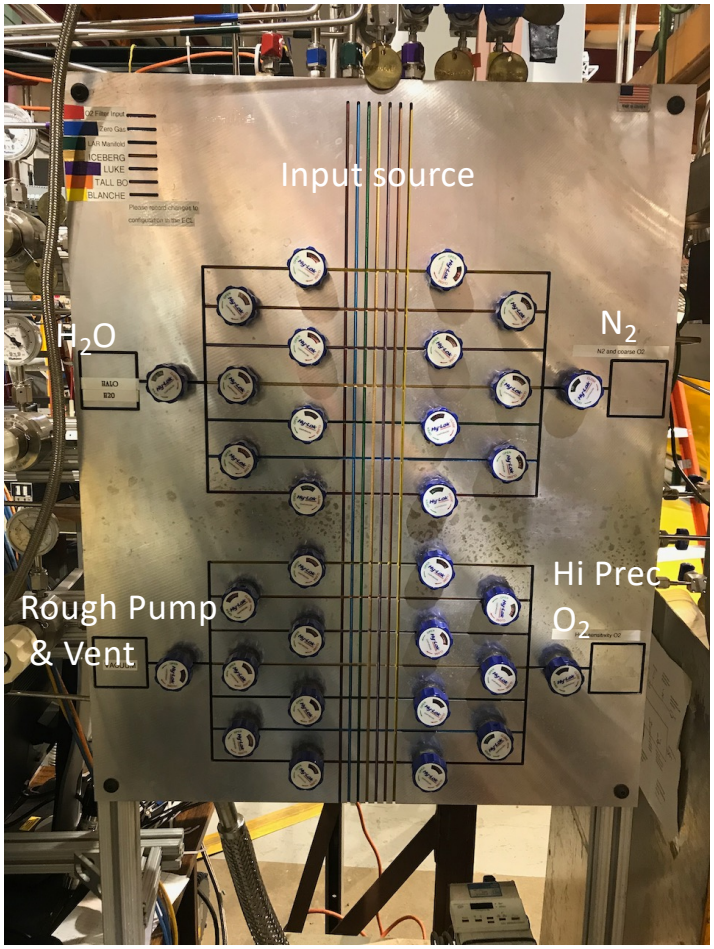
HV for IB PrM (ISEG ± 2kV modules)

Where are we?

- Already existing
  - Short PrM
  - Integrating Amp Module
  - PC 2 chan Digitizer Card
  - Flashlamp
  - HV/Signal Feedthru
  - CONAX Fiber feedthru
  - Cabling from PrM to Amp.
  - App for PrM
- Need
  - DAQ PC with full PCI backplane
    - Can also be used for VFW control
  - ISEG HV
    - Could use Droeges
  - Modified NIM bin for amplifier module
    - Droeges might be an issue here.
  - Flange for Cryostat with
    - PrM internal support
    - Adapt for Feedthru penetrations
    - Internal wiring from feedthru to PrM
    - Tech/shop/welder support for above
- Once we have LArTF PrM setup, more or less have MINOS Hall setup

Gas Analyzers

The entire GA setup takes~2 rack widths of setup space

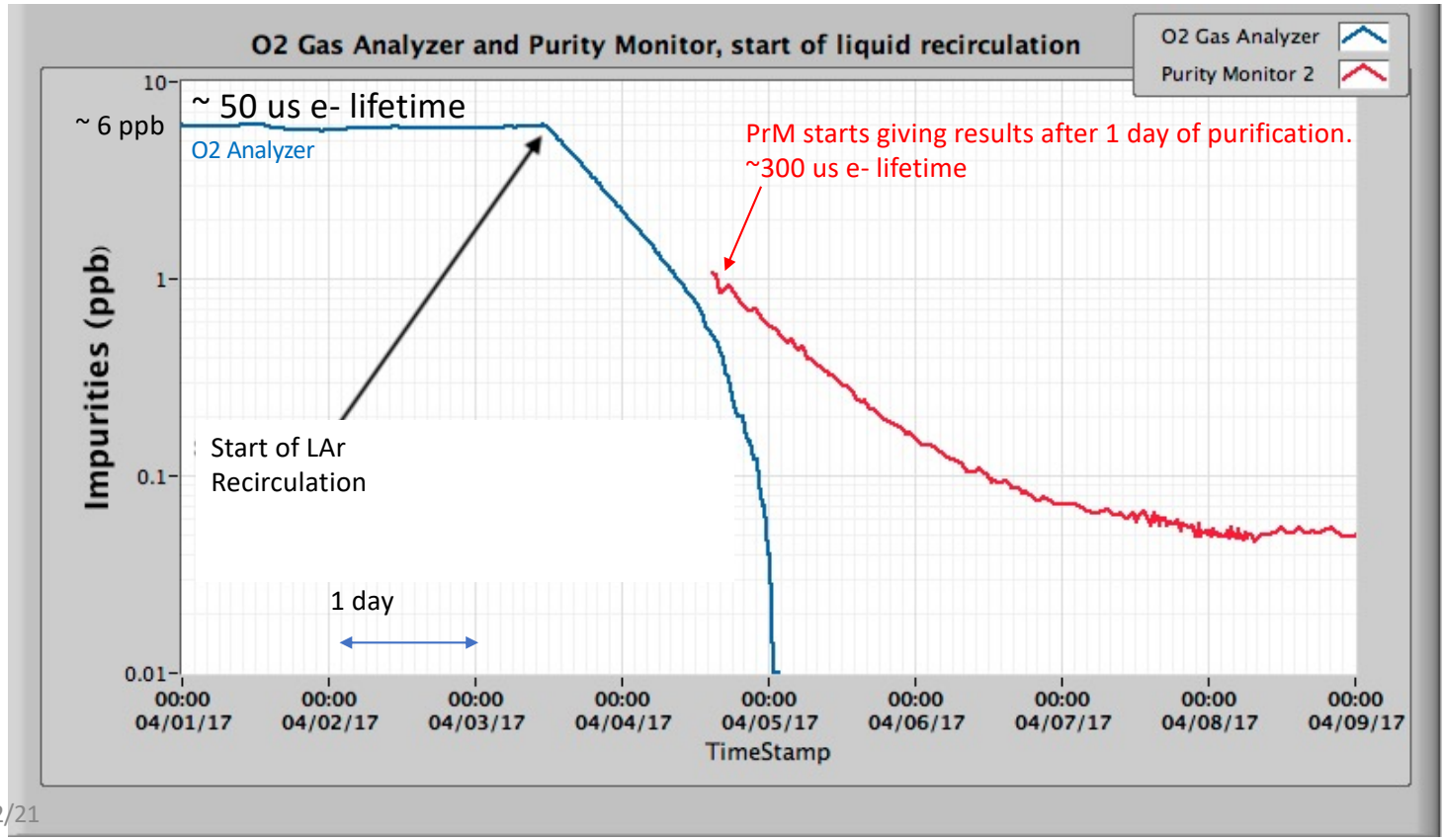


Switchyard to connect Source Points to Individual Gas analyzers

Gas Analyzers Sampling points in cryostat

Example of how PrM and Gas Analyzers complement each other

Cryostat Impurities as seen by O_2 Gas Purity Monitor and PrM as LAr purification starts in first 35 Ton HV run



Where are we now?

- For LArTF
  - Assumptions: We use the MicroBoone Gas Analyzer system and router
  - Need capillary feedthru flange and port (could we share PrM Flange?)
    - Needs shop and welder time
    - Valves, insulators
    - Note added:Mike Z. suggests sampling from high pressure port from pump output.
  - Need tubing from 2x2 to existing Gas analyzer rack.
    - How many sampling lines to GasAnalyzer rack?
      - Default two—allows two simultaneous samplings, with any 2x2 source sampling points switched at 2x2 location.
    - Some welding needed along with SS tubing. Engineering time for design + tech time to bend the tubing.
    - Sampling points for fill?
    - Mike Z. wants to use existing lines already in garage area
      - It is a long run from garage to location of existing GAs
      - Long runs mean some time delay to clear out gas in tubing .
  - Need small clean roughing pump. Not sure if we need vapor compressor to have enough flow to MicroBoone GA setup.
  - Sampling scenarios
    - During Fill: Sample input LAr from vendor and sample after filter to monitor filter performance (PrM samples what is going on in Cryostat).
    - After fill, sample either LAr or GAr sample points during purification or if there are any purity issues.
    - I assume there is a GAr source for the GA's in event we are not sampling.

MINOS

- Assume we can find a Gas Switchyard/Router to use and not have to build it.
  - e.g. PC4 existing Switchyard/Router or ?
- Do not know what the status will be for MicroBoone Gas Analyzers
  - Stay or Go??
  - Steve B. says 2x2 can use MicroBoone analyzers
- ~~At PAB we have backup GA's for N_2, H_2O, and O_2 ("Precision", but not "High Precision")~~
  - ~~From LAPD/35T/PC4 operation~~
  - ~~But at any time before we install in MINOS hall, if we lose an existing GA at PAB, we may replace it with one of these "spares").~~
  - ~~Don't have any of the lower precision Ga's but not sure we need those if we evacuate and fill cryostat.~~
- Will need some tubing runs, but 2x2 from LArTF will bring some infrastructure with it.
- Will need electrical hookup to Slow Controls.
  - I assume GA's are on building ground….
- Need engineering support for cost estimates for August review.

~~Gas Analyzer Costs (if we have to buy)~~

Assume we can find a Switchyard/Router Panel

Cost Breakdown				
N2 Gas Analyzer	$30,000.00	1	$30,000.00	Range is 100 ppm ->10 ppb. Note: DUNE currently owns one unit
~~Coarse precision O2 Analyzer~~	~~$2,000.00~~	~~1~~	~~$2,000.00~~	~~20% (air) to ~1/2 %. Used at start of purge~~
~~Intermediate O2 Analyzer~~	~~$5,000.00~~	~~1~~	~~$5,000.00~~	~~0.5% to ~ ppm. Remainder of purge~~
Precision O2 Analyzer	$10,000.00	1	$10,000.00	50 ppm -> 3 ppb. End of purge to through gas recirculation. Monitor filter inputs
High precision O2 Analyzer	$40,000.00	1	$40,000.00	20 ppm -> 100 ppt. Monitor filter outputs. Bottoms out at ~ 1 ms lifetime.
~~Coarse H2O analyzer~~	~~$3,500.00~~	~~2~~	~~$7,000.00~~	Commonly referrd to as "Dewpoint" meters. From ~20kppm (normal air humidity) to ~ 10 ~~ppm~~
~~High precision H2OAnalyzer~~	~~$34,000.00~~	~~1~~	~~$34,000.00~~	~~20 ppm -> 1 ppb. Sample ullage of cryostat or chimneys:.~~