

# Gas Handling for ND280 Upgrade TPCs

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# Outline

- Overview of existing gas system
- Requirements of updated gas system
- Possible method of modifying existing system

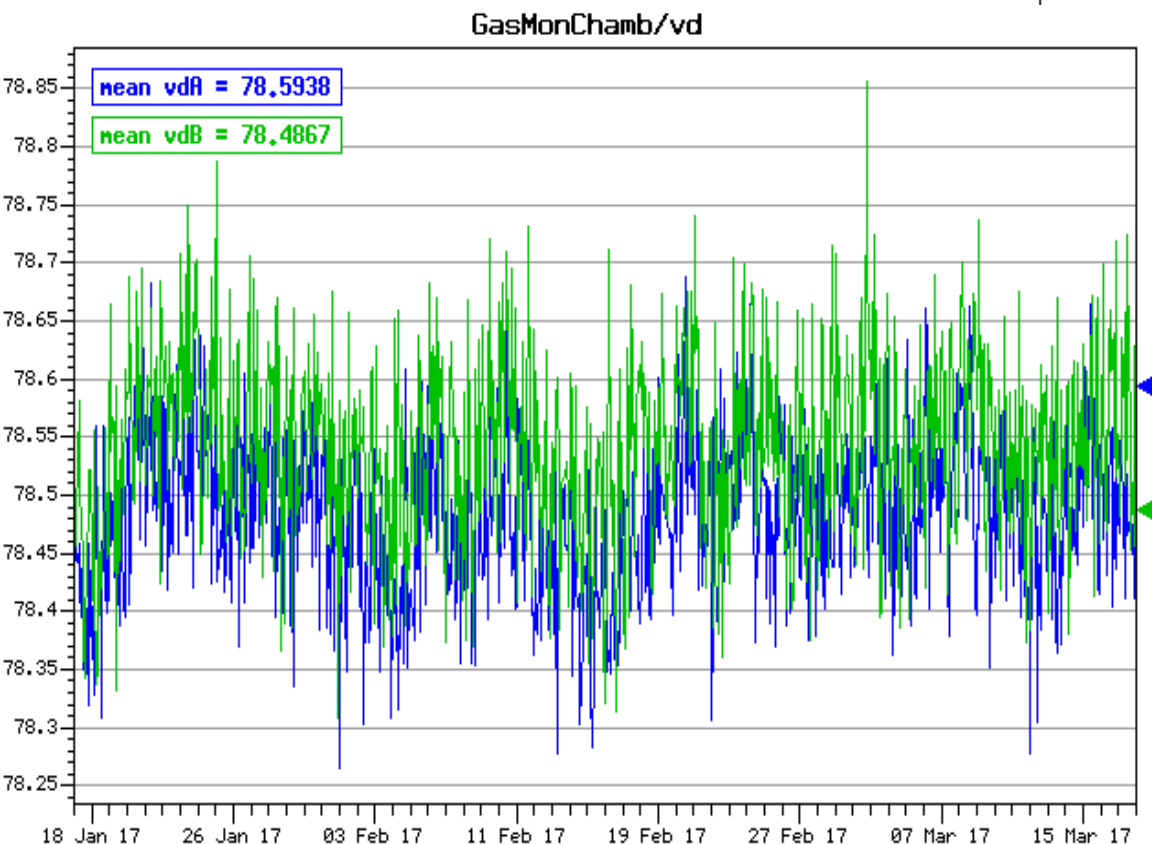
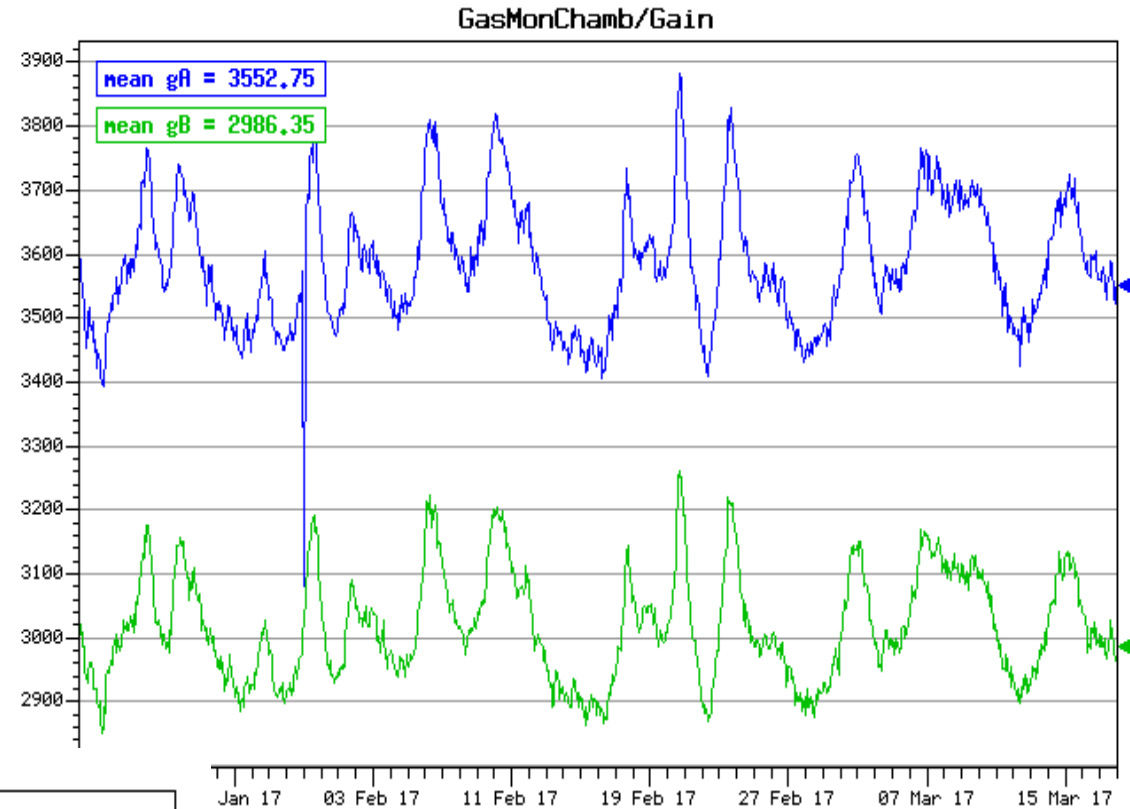
# Required and design specifications of gas for existing TPCs

	Required	Designed / achieved
Volume mix ratio (Ar/CF <sub>4</sub> /iC <sub>4</sub> H <sub>10</sub> )	95 / 3 / 2 %	95 / 3 / 2 %
Mixture accuracy (absolute)	~1 %	~0.7 %
Mixture stability	Ar,CF <sub>4</sub> : 0.01%, iC <sub>4</sub> H <sub>10</sub> : 0.025%	Ar, CF <sub>4</sub> , iC <sub>4</sub> H <sub>10</sub> : ~0.01%
Flow control stability	Ar, CF <sub>4</sub> : 0.3%, iC <sub>4</sub> H <sub>10</sub> : 1.2%	Ar, CF <sub>4</sub> , iC <sub>4</sub> H <sub>10</sub> 0.3 %
O <sub>2</sub> contamination	< ~ 10 ppm	< ~ 10 ppm
H <sub>2</sub> O contamination	< ~ 100 ppm	< ~ 10 ppm
CO <sub>2</sub> contamination	< ~ 100 ppm	< ~ 100 ppm

Main way of checking mixture is using the gas monitoring chambers – Measures drift velocity and gain.

Control of input flows is with Bronkhorst MFCs

# Gas gain and drift velocity



- As measured by witness chambers siphoning off gas from recirculation loop.



The diagram illustrates a complex gas analysis system with the following components and flow characteristics:

- Gas Sources:** Ar CYL'S, CF4 CYL, IC4H10 CYL, and Filter Regeneration Gas (Ar/H2 CYL'S).
- Pressure Control Loop (Red Highlighted):** A critical section for maintaining system pressure, involving components like DXTC1, DXTC2, DXPR7, DXPR8, DXVN1, DXVN2, DXVB5, DXVB6, DXVA1, and DXVA2.
- GAS ANALYSER MODULE:** Receives gas samples from various points (e.g., D0VS07, D0FM2, D0VS09, D0VS03, D0VR3, D0PD5, D0VS10, D0VA7, D0FC8) and provides feedback for flow control.
- PURIFIER MODULE:** Processes gas samples, with flow rates like max flow ~ 6 l/min for Ar/CF4/IC4H10 and max flow ~ 30 l/min for Ar/CF4/IC4H10.
- Test Chamber:** The final destination for gas samples, with a flow rate of max flow ~ 12 l/min per Det.
- Flow Control:** Various flow meters (e.g., D0VS01a,b, D0VS02a,b, D0VS05, D0VA5, D0VA4, D0FC7, D0VA1, D0VA2, D0VA3, D0VA4, D0VA5, D0VA6, D0VA7, D0VA8, D0VA9, D0VA10, D0VA11, D0VA12, D0VA13, D0VA14, D0VA15, D0VA16, D0VA17, D0VA18, D0VA19, D0VA20) and valves (e.g., D0VS01, D0VS02, D0VS03, D0VS04, D0VS05, D0VS06, D0VS07, D0VS08, D0VS09, D0VS10, D0VS11, D0VS12, D0VS13, D0VS14, D0VS15, D0VS16, D0VS17, D0VS18, D0VS19, D0VS20) are used to regulate gas flow.
- Other Components:** D0HT1, D0HT2, D0HT3, D0HT4, D0HT5, D0HT6, D0HT7, D0HT8, D0HT9, D0HT10, D0HT11, D0HT12, D0HT13, D0HT14, D0HT15, D0HT16, D0HT17, D0HT18, D0HT19, D0HT20, D0HT21, D0HT22, D0HT23, D0HT24, D0HT25, D0HT26, D0HT27, D0HT28, D0HT29, D0HT30, D0HT31, D0HT32, D0HT33, D0HT34, D0HT35, D0HT36, D0HT37, D0HT38, D0HT39, D0HT40, D0HT41, D0HT42, D0HT43, D0HT44, D0HT45, D0HT46, D0HT47, D0HT48, D0HT49, D0HT50, D0HT51, D0HT52, D0HT53, D0HT54, D0HT55, D0HT56, D0HT57, D0HT58, D0HT59, D0HT60, D0HT61, D0HT62, D0HT63, D0HT64, D0HT65, D0HT66, D0HT67, D0HT68, D0HT69, D0HT70, D0HT71, D0HT72, D0HT73, D0HT74, D0HT75, D0HT76, D0HT77, D0HT78, D0HT79, D0HT80, D0HT81, D0HT82, D0HT83, D0HT84, D0HT85, D0HT86, D0HT87, D0HT88, D0HT89, D0HT90, D0HT91, D0HT92, D0HT93, D0HT94, D0HT95, D0HT96, D0HT97, D0HT98, D0HT99, D0HT100.

SS Level  
Under Detector

## Pressure control loop

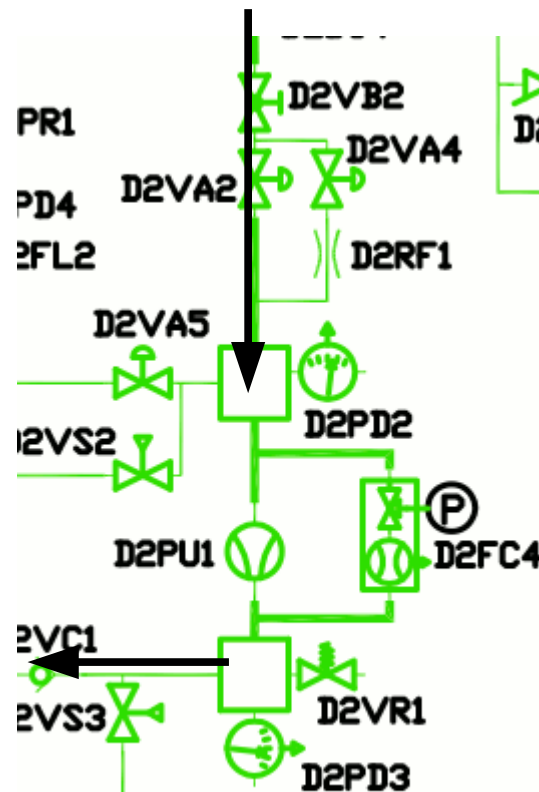
# Notes on existing gas system

- Pressure of detector is 0.4 mbar above pressure of CO<sub>2</sub> gap
  - Controlled by pump and mass flow controller
  - Over-pressure and under-pressure protected by two sets of bubblers
- In current operation we have 30 L/min total flow of which ~3 L/min is exhausted and 27 L/min is recirculated (~10 L/min goes through each detector)
  - Set by diffusion of O<sub>2</sub>, CO<sub>2</sub> and H<sub>2</sub>O
  - Existing TPCs limited by CO<sub>2</sub> diffusing in from CO<sub>2</sub> gaps
  - We have seen at most 150 ppm of CO<sub>2</sub> though, and recently much less
  - CO<sub>2</sub> contamination mainly affects drift velocity
  - Perhaps this flow could be reduced – would need some study
- Fresh gas from mixing is 3 L/min
- Excess gas is exhausted

# Notes on pressure control loop

- In current operation  $25 \pm 2$  L/min is flowed through the pump bypass valve (D2FC4)

Gas from  
TPCs



- Adjusts as necessary to control the chamber pressure ( $\pm 2$  L/min is what we historically observe)
- If we increased the total flow through the chambers from 30 l/min to 45 l/min:
  - Flow through D2FC4 would decrease to  $10 \pm 2$  L/min
  - Pump operates at constant  $\sim 55$  L/min

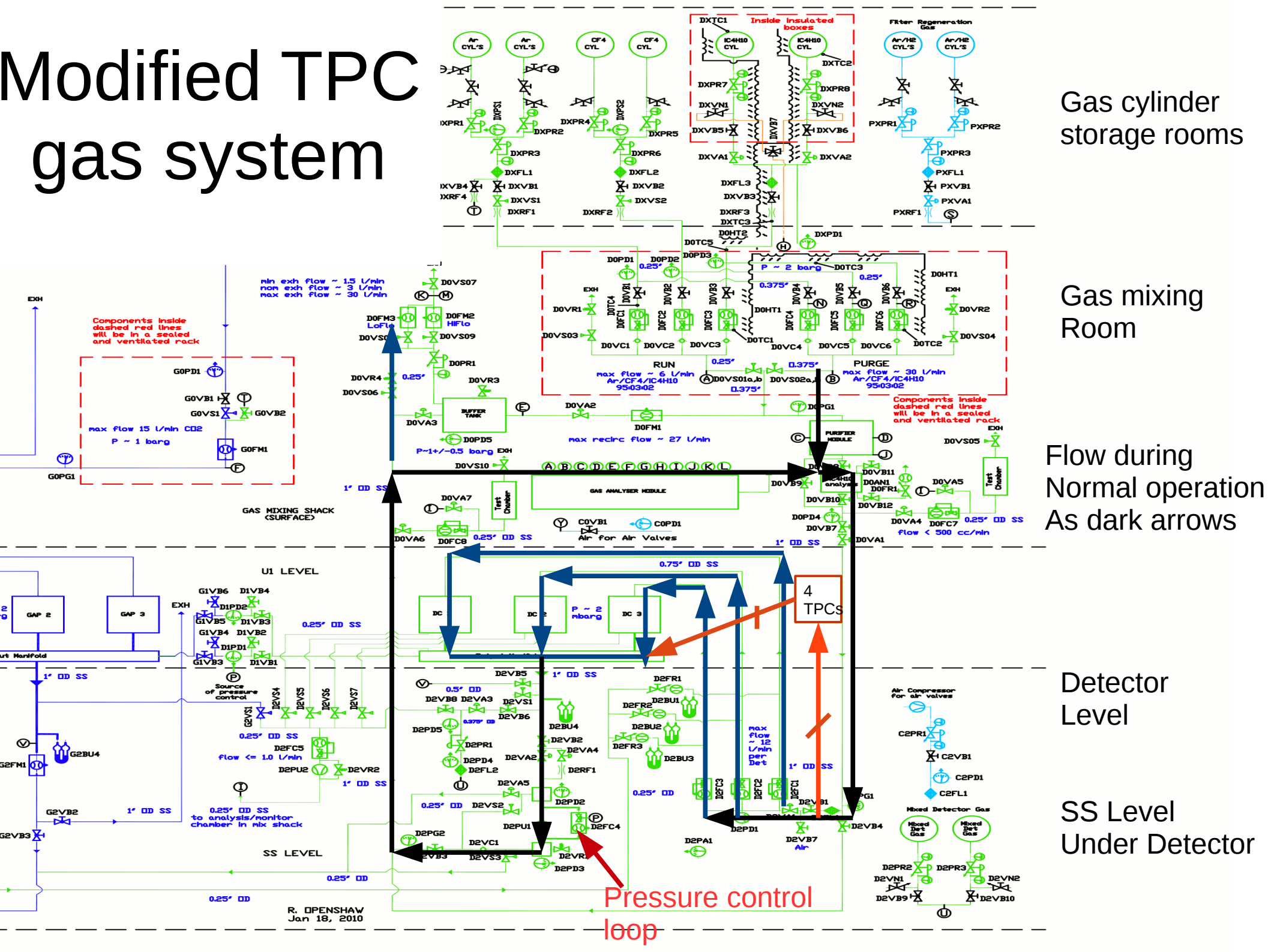
# Fitting new TPCs into existing gas system – check of flow rate capabilities

- Volume of TPCs requiring gas:
  - existing inner detectors is 10.3 m<sup>3</sup>
  - four new TPCs is about 13.8 m<sup>3</sup>
  - total in all 7 TPCs is 24.1 m<sup>3</sup>
- Existing pump and flow controllers could be adjusted to allow about 10+-2 L/min in the recirculation loop (currently 25+-2 L/min)
  - Therefore deliver 45 L/min to all TPCs
  - Change existing TPC flows to 5 L/min?
  - New TPC flows to 7.5 L/min
- Would need to check:
  - Are existing TPCs leak tight enough to reduce flows to 5 L/min each?
  - Will TPCs being build be able to reach leak tightness such that fresh flow of 7.5 L/min will not diffuse too much O<sub>2</sub> and H<sub>2</sub>O into the detectors?
  - \*\*\* New TPC designers should make “diffusion resistant” chambers \*\*\*

# Fresh gas supply

- Input gas MFCs are good up to 7 L/min – would increase current 3 L/min of fresh gas to 4.5 L/min to maintain 10% fresh mix flow
- 10 days between argon bank change would become 6.5 days... so would have pretty frequent update of gas supply!
  - Could move CF<sub>4</sub> bottles to “flammable gas room”
  - Add more Ar bottles – Tsukamoto-san and local regulations may not allow us to store more gas however
    - Would have to look into Japanese regulations
    - Could look into having liquid argon dewars delivered, instead of gas cylinders  
(Was refused by gas company back in 2008 when we were planning this)

# Modified TPC gas system



# Modified system

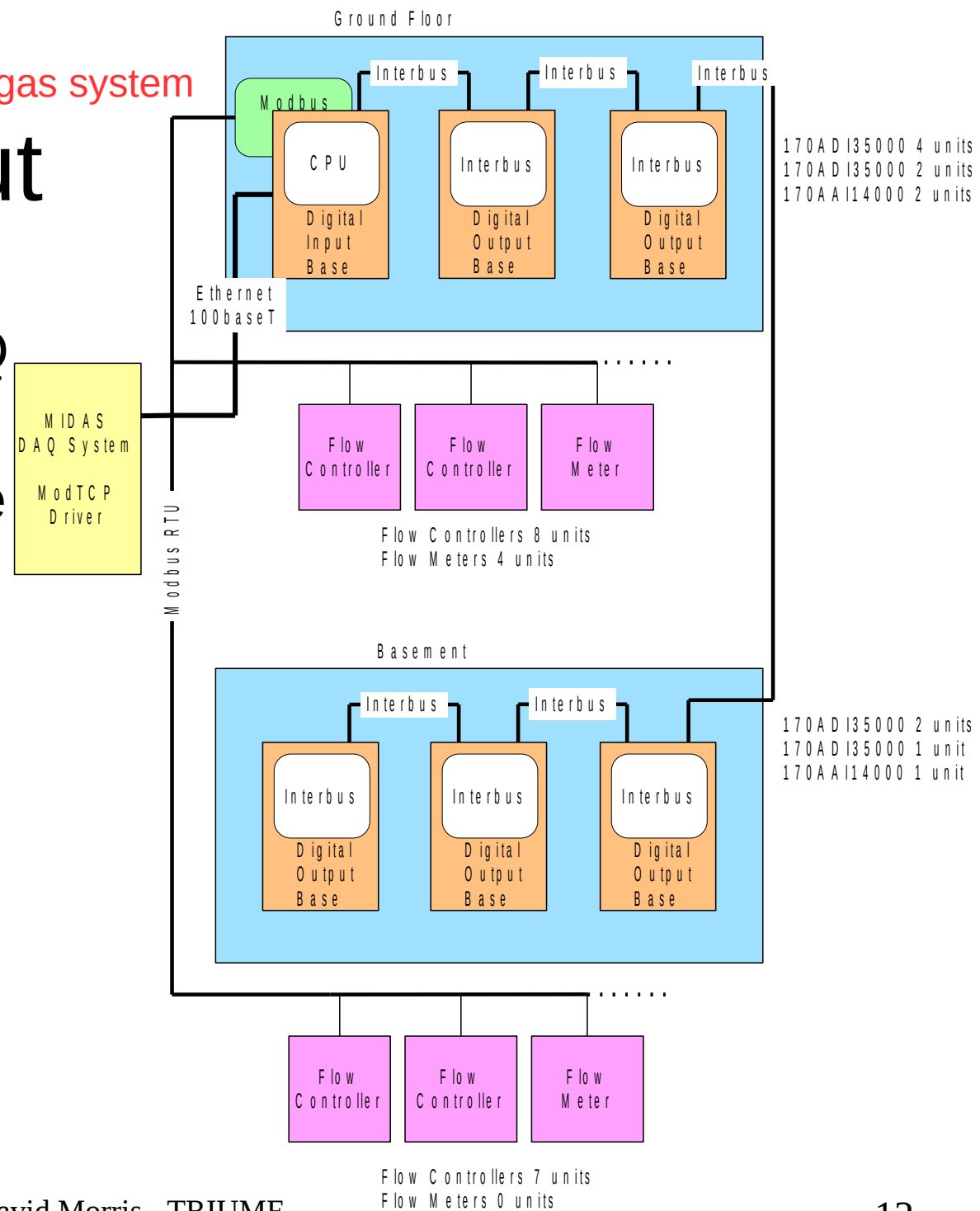
## Required changes

- Four additional mass flow controllers (MFCs), bubblers and manual flow meters (rotameters)
  - Manual flow meters for “standby” gas flows of Ar at 250 cc/min per chamber
  - Flow is parallel thru the CO<sub>2</sub> gap and TPCs (currently totals 1.5 L/min – increase to 2.5 L/min with addition of 4 TPCs)
  - May need additional rack to hold components and required plumbing
- Four additional gas lines to new TPCs
- Modification of PLC control logic to add new MFCs
  - PLC uses Modicon Quantum IEC Processor
  - PLC code is written in Concept (IEC programming)

Slide from 2007... not quite existing gas system

# PLC Layout

- PLC connected to DAQ slow control network
- Two cables link surface and B2 equipment racks
- Power supplies in each rack
- Update module names with Quantum instead of Momentum equivalents





# Midas Interface

- Slow Control Front End to Slow Control ODB
- Connect ODB to PLC database using Modbus protocol over TCP/IP (ModTCP) Currently in use on TWIST at TRIUMF
- Trigger actions in PLC via HotLinks in ODB
- Regular scanning of values and states from PLC database into ODB
- Requires tight coupling between PLC database and ODB structure. Changes to either database require manual synchronization.
- MIDAS interface is “read-only” – all control is done by EPICS system

# Something to consider

- Current TPCs control TPC-Gap pressure at a constant 0.4 mbar
  - Differential pressure gauges are 1 m below bottom of chambers (3 m below top of chambers)
  - Back pressure from gap flow plus negative head pressure from exhaust puts pressure at +0.7 mbar at bottom of chamber and -0.3 mbar at the top
  - Varies by  $\pm 0.1$  mbar during normal operation
- New TPCs would be in same control loop would see similar (small) variations
  - The new TPCs will sit at a pressure of  $0.4 \pm 0.1$  mbar
  - Bottom TPCs would be  $\sim 0.1$  mbar higher pressure than top due to difference in vertical position
- New TPCs must be capable of handling pressures of order 0.5 mbar, and instability in differential pressure of  $\pm 0.1$  mbar (not too difficult)

# Detector purging considerations

- Existing purge MFCs can supply maximum of 31 L/min – purging additional TPCs will take longer
  - Currently ~24 hours for 4 full purges
  - Would take ~50 hours for similar number of purges

# Conclusion

- Modification of existing gas system may be possible
  - Would need to check if existing TPCs can operate well enough using 5 L/min rather than 10 L/min
- Resources required (from CERN?) to make the changes – if these are all that are required:
  - Technician with gas system experience to obtain and plumb in the MFCs, MFMs, bubblers, valves, and feed the new gas supply lines to the new TPCs
  - Likely to need an additional rack on SS level to hold new gas system components.
  - PLC expert to modify existing PLC to accommodate the new MFCs, and mass flow meters
    - Would be simplest to stick to same brand PLC components to minimize problems with different communication protocols
    - Hardware is possibly reaching legacy stage, but hopefully can get additional components before they are extinct
- Acknowledgements:
  - Thanks to Robert Openshaw (retired) for discussions of these changes
  - Thanks to Jordan Myslik (now Majorana postoc) for comments on the PLC updates

Backup....

Photos of existing system

# Gas rack on SS Level



Photo from Y. Petrov's virtual tour – some issues with stitching images

# Mixing room

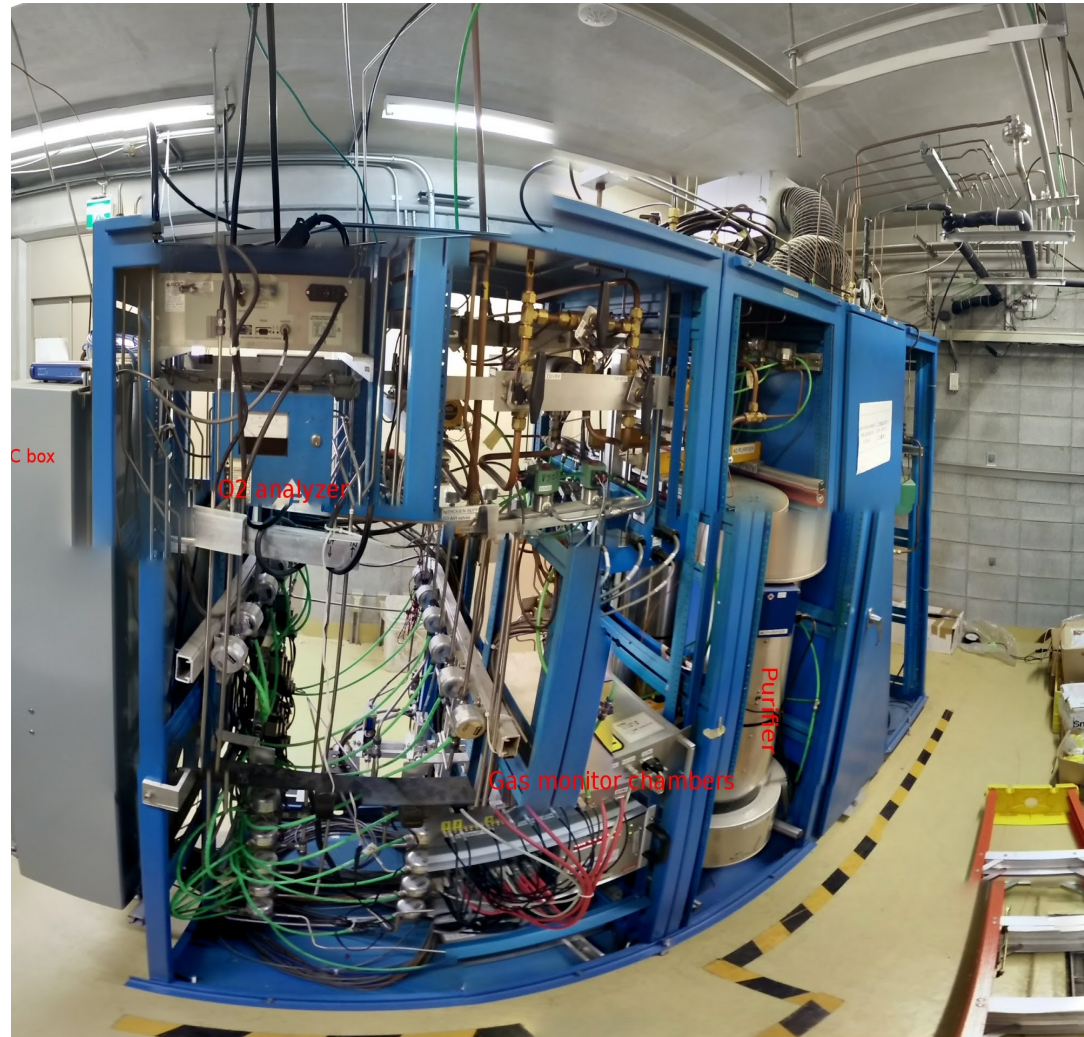
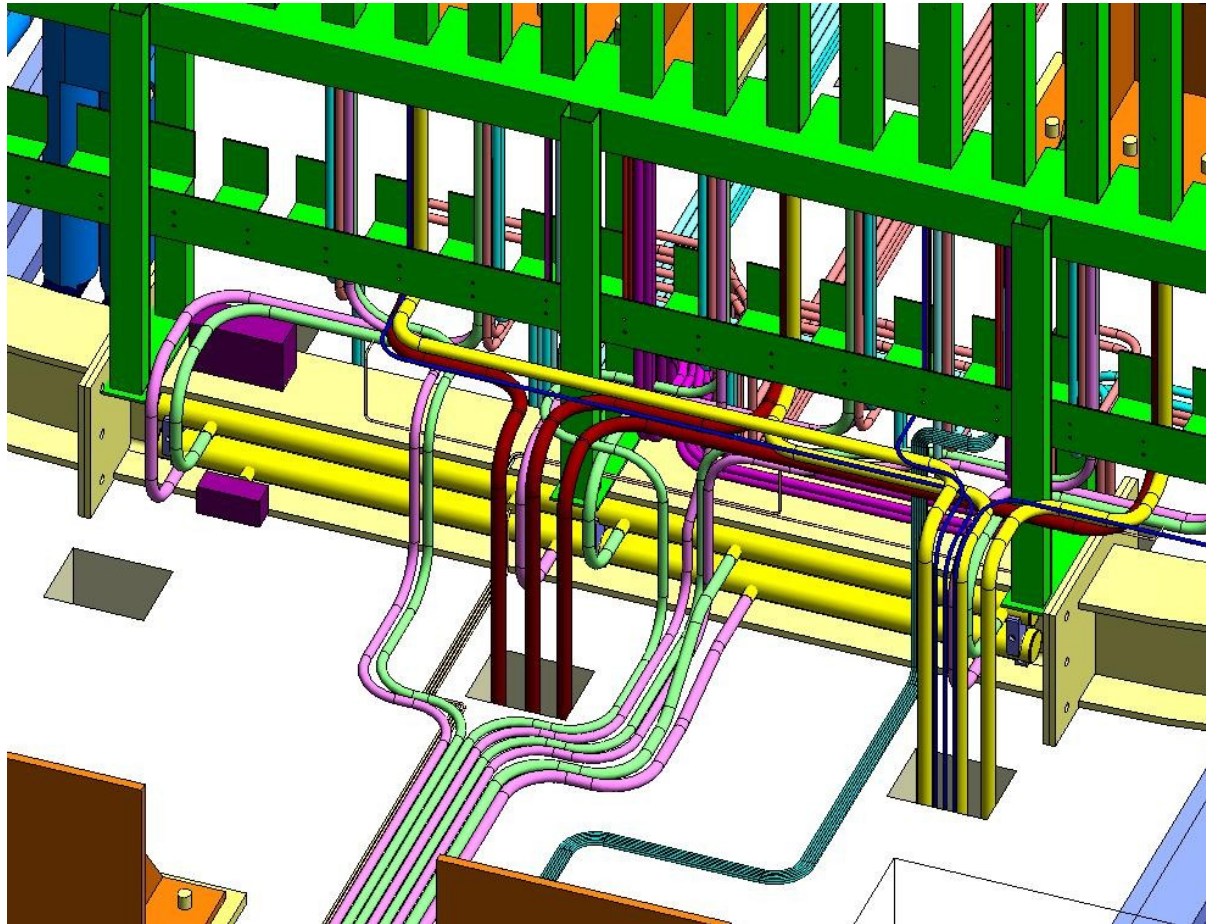


Photo from Y. Petrov's virtual tour – some issues with stitching images



# Detector gas return manifolds shown in yellow





# CO2 Room



Photo from Y. Petrov's virtual tour

# Ar/CF<sub>4</sub> Room



Photo from Y. Petrov's virtual tour



# Isobutane and Ar/H<sub>2</sub> room



Photo from Y. Petrov's virtual tour