Gas Handling for ND280 Upgrade TPCs

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ND280 Upgrade CERN Meeting
Mar. 20, 2017

Outline

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

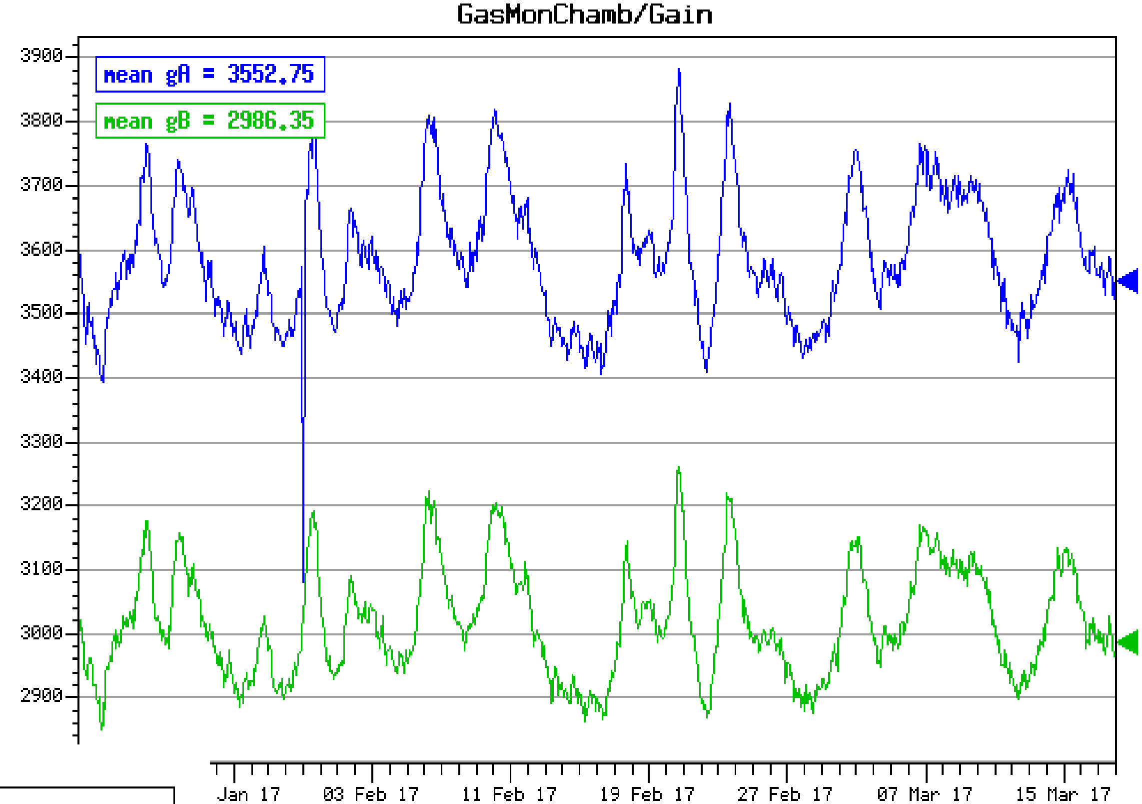
Required and design specifications of gas for existing TPCs

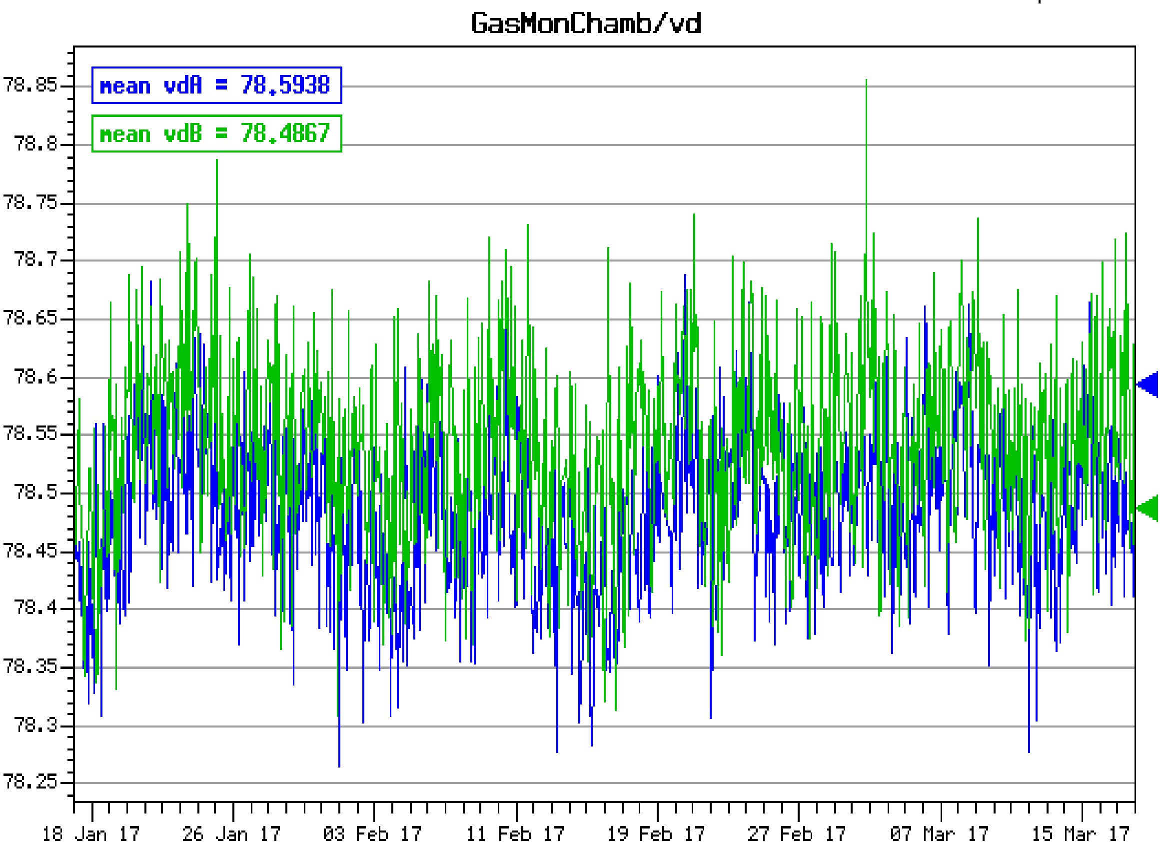
	Required	Designed / achieved
Volume mix ratio (Ar/CF_4/iC_4H_{10})	95 / 3 / 2 %	95 / 3 / 2 %
Mixture accuracy (absolute)	~1 %	~0.7 %
Mixture stability	Ar,CF_4: 0.01%, iC_4H_{10}: 0.025%	Ar, CF_4, iC_4H_{10}: ~0.01%
Flow control stability	Ar, CF_4: 0.3%, iC_4H_{10}: 1.2%	Ar, CF_4, iC_4H_{10} 0.3 %
O_2 contamination	< ~ 10 ppm	< ~ 10 ppm
H_2O contamination	< ~ 100 ppm	< ~ 10 ppm
CO_2 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

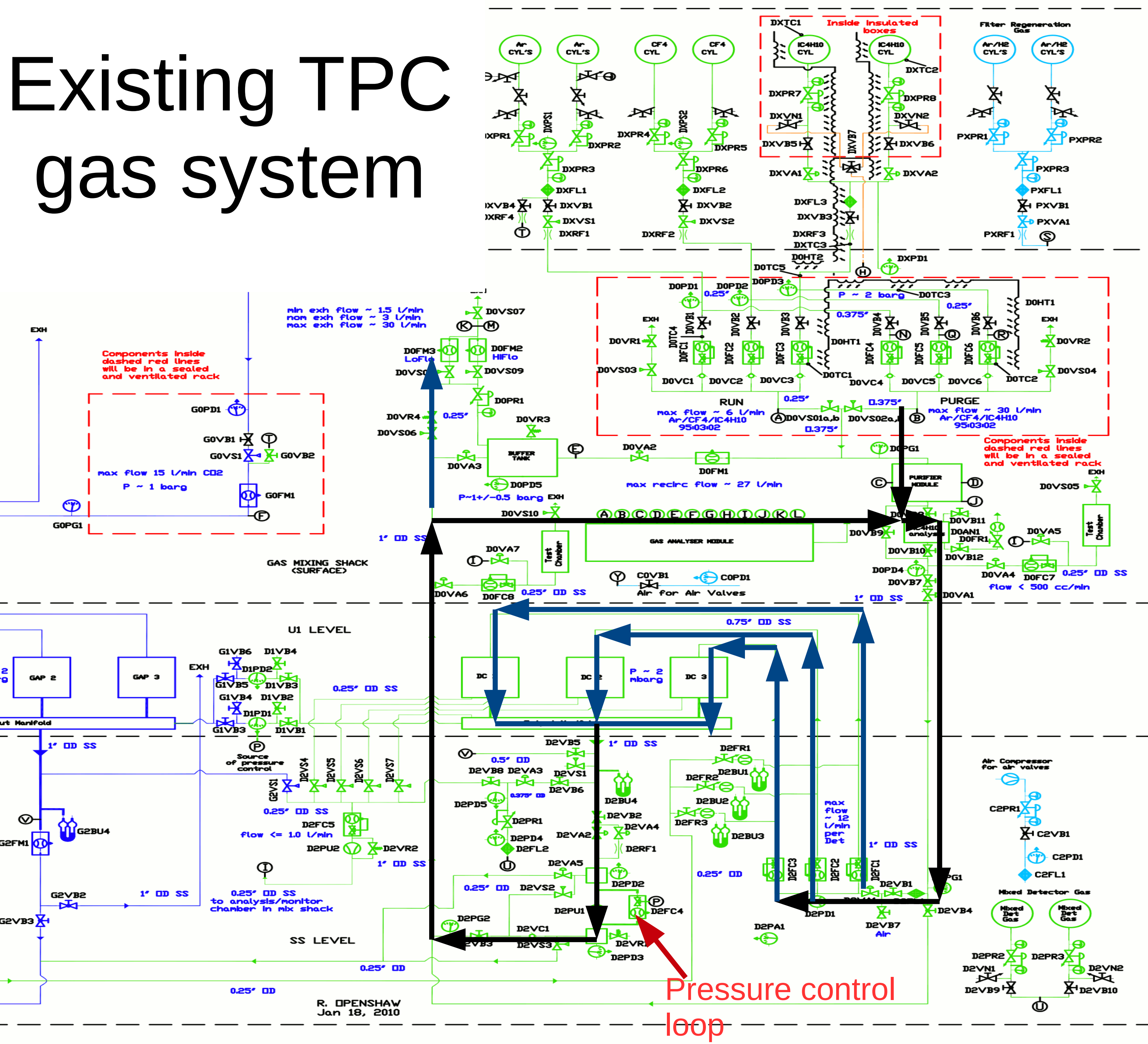
Gas gain and drift velocity





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

Existing TPC gas system



Gas cylinder storage rooms

Gas mixing Room

Flow during Normal operation As dark arrows

Detector Level

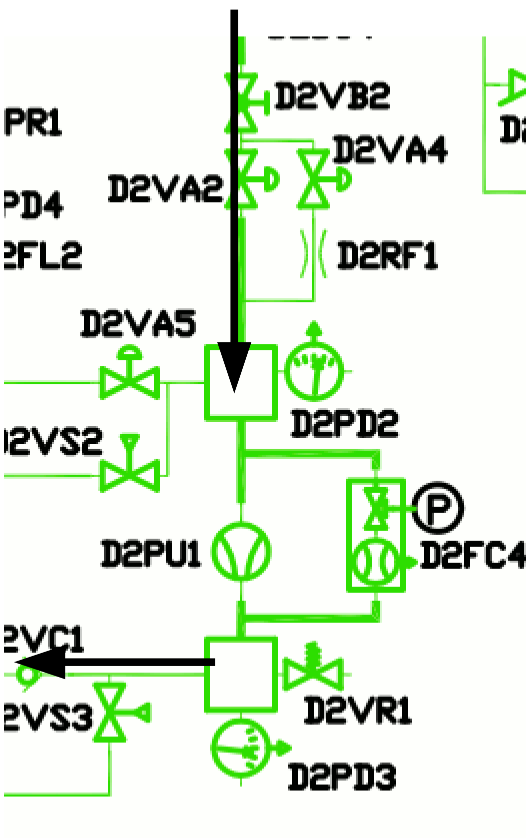
SS Level Under Detector

Notes on existing gas system

- Pressure of detector is 0.4 mbar above pressure of CO_2 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_2, CO_2 and H_2O
  - Existing TPCs limited by CO_2 diffusing in from CO_2 gaps
  - We have seen at most 150 ppm of CO_2 though, and recently much less
  - CO_2 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

Gas from
TPCs



Gas to
recirc.
and
exhaust

- In current operation 25 +- 2 L/min is flowed through the pump bypass valve (D2FC4)
  - Adjusts as necessary to control the chamber pressure (+-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 +- 2 L/min
    - Pump operates at constant ~55 L/min

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

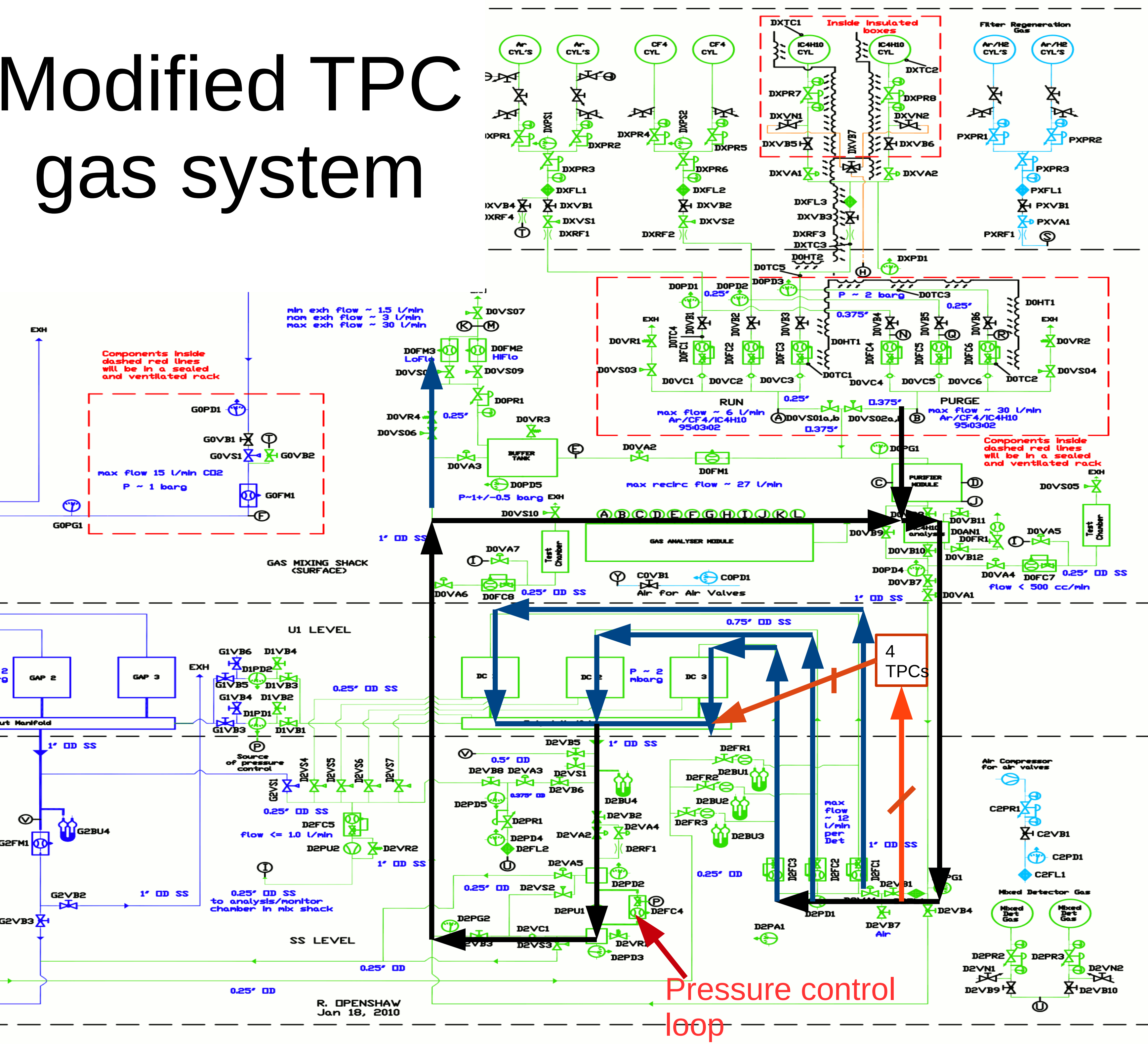
- Volume of TPCs requiring gas:
  - existing inner detectors is 10.3 m^3
  - four new TPCs is about 13.8 m^3
  - total in all 7 TPCs is 24.1 m^3
- Existing pump and flow controllers could be adjusted to allow about 10+-2 L/min in the recirculation loop (currently 25+-2 L/min)
  - Therefore deliver 45 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 O2 and H2O 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 CF4 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



Gas cylinder storage rooms

Gas mixing Room

Flow during Normal operation As dark arrows

Detector Level

SS Level Under Detector

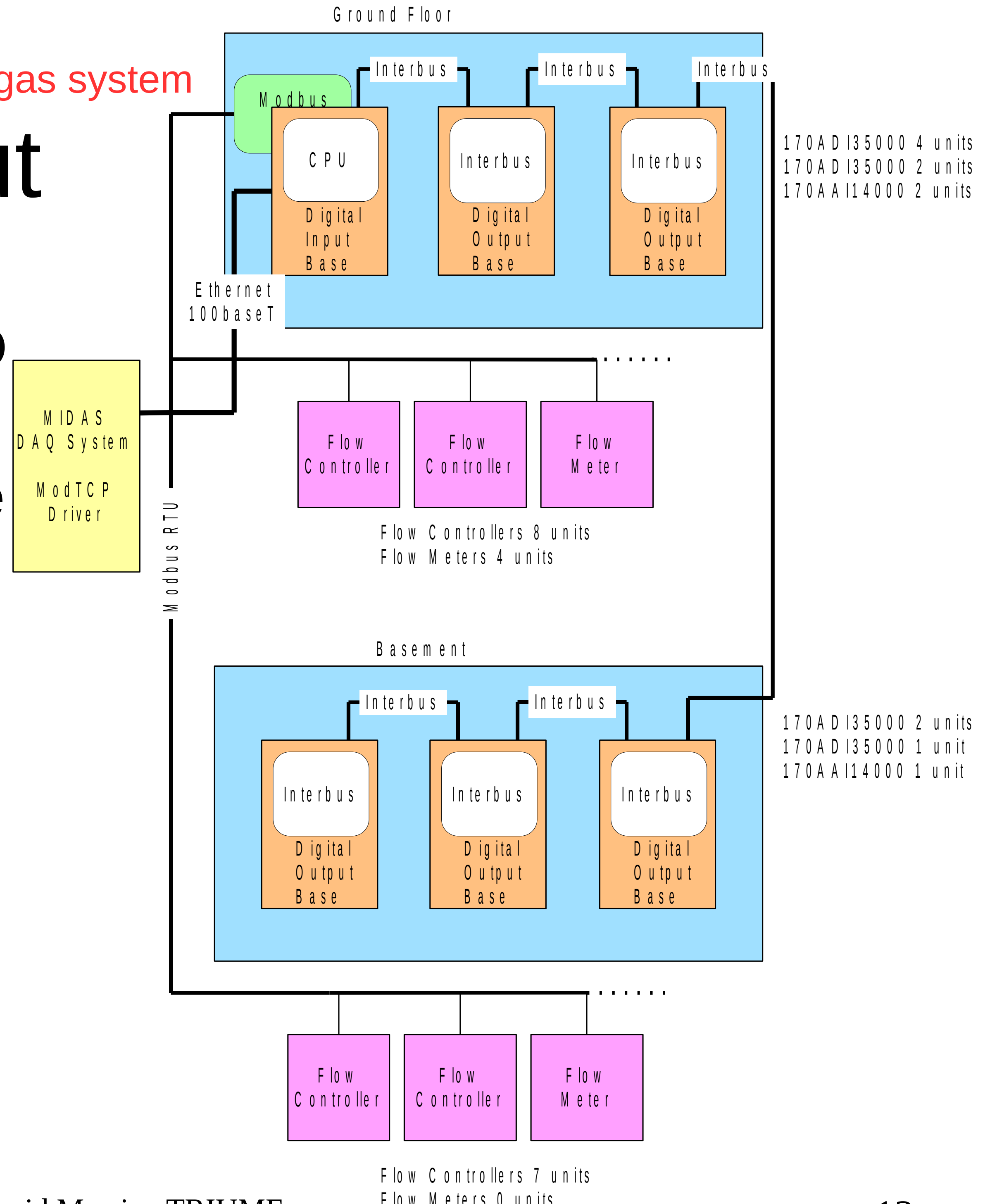
Modified system
Required changes

- 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_2 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



Slide from 2007... design of existing gas sytem

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 +-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 +- 0.1 mbar
  - Bottom TPCs would be ~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 +-0.1mbar (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

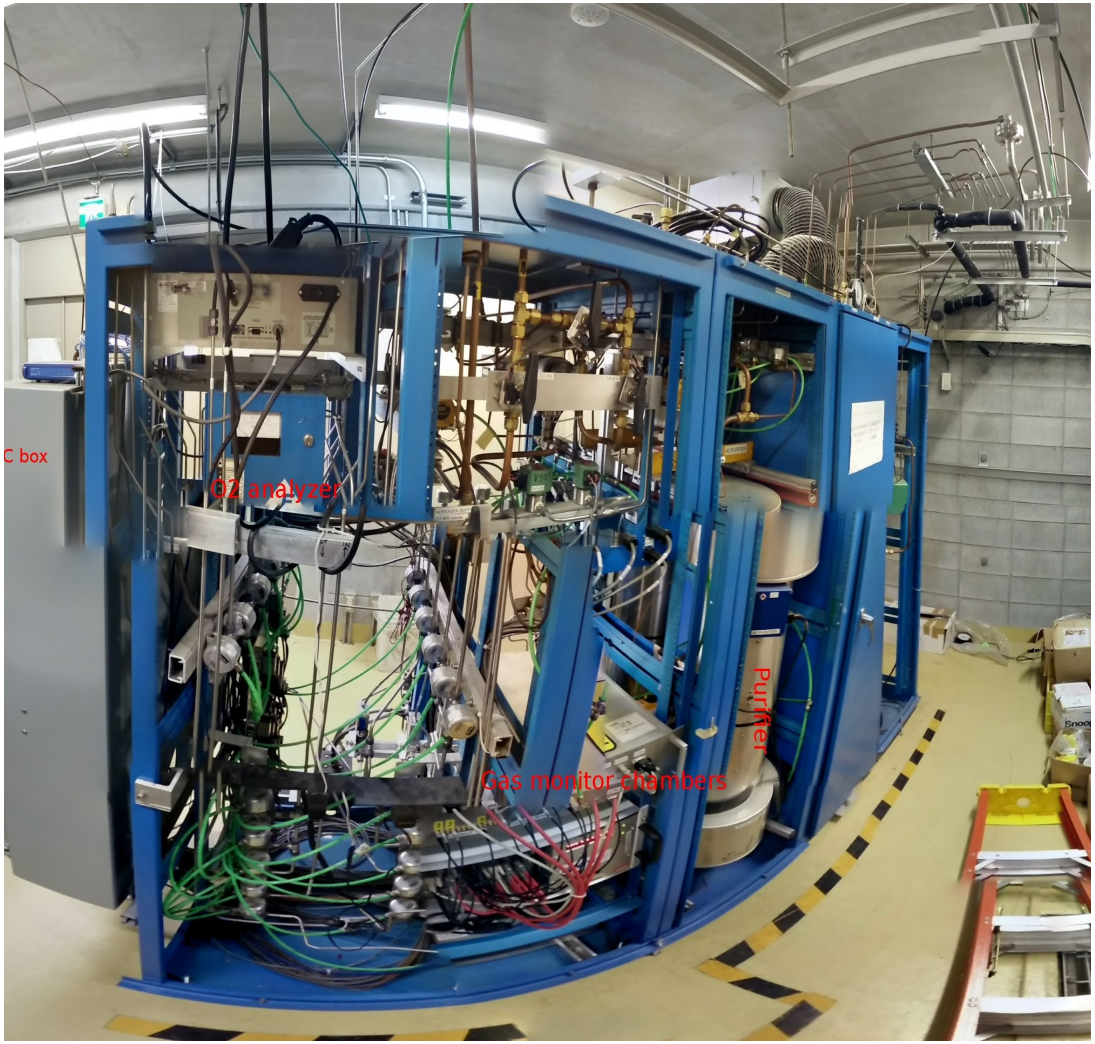
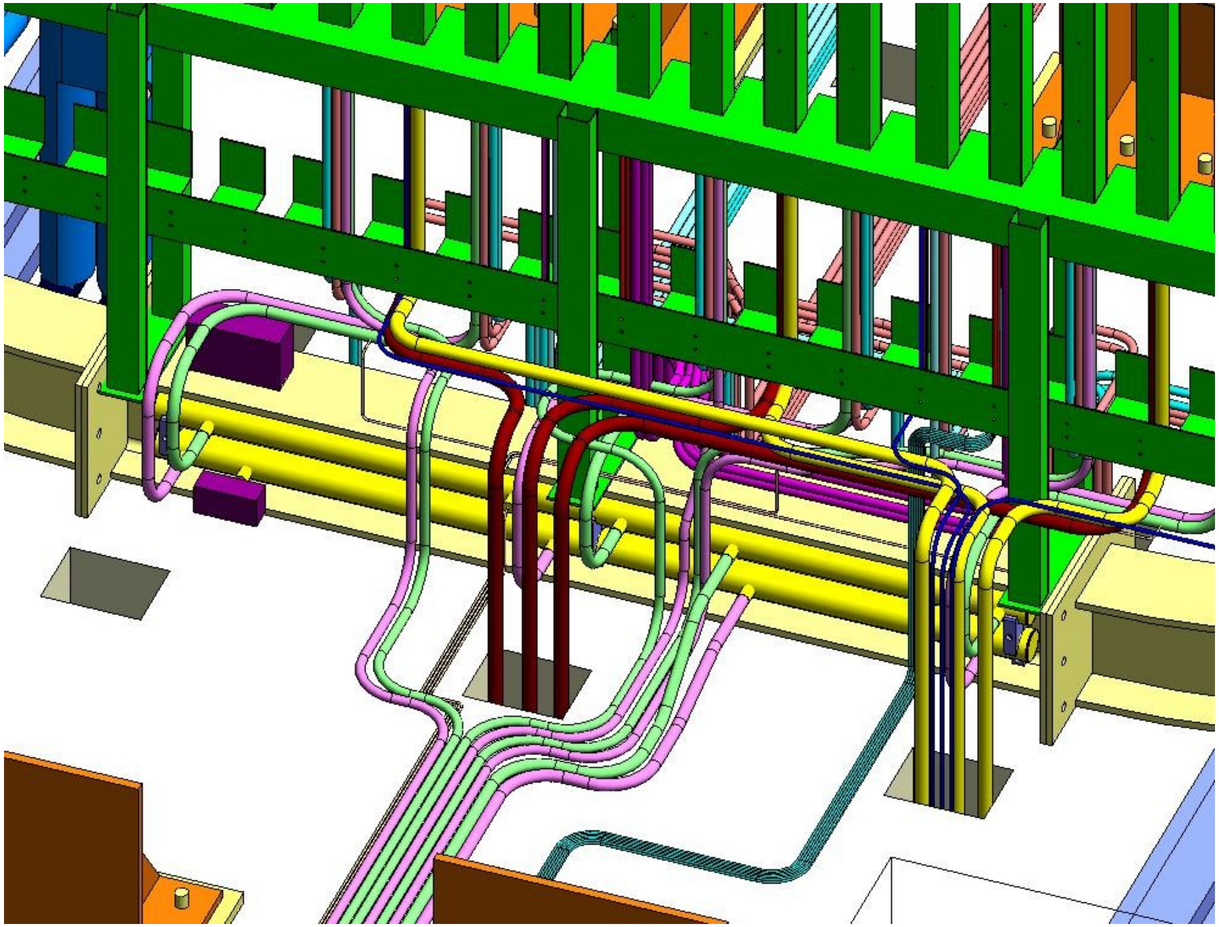


Photo from Y. Petrov's virtual tour – some issues with stitching images

Detector gas return manifolds shown in yellow



CO2 Room

Photo from Y. Petrov's virtual tour

Ar/CF4 Room

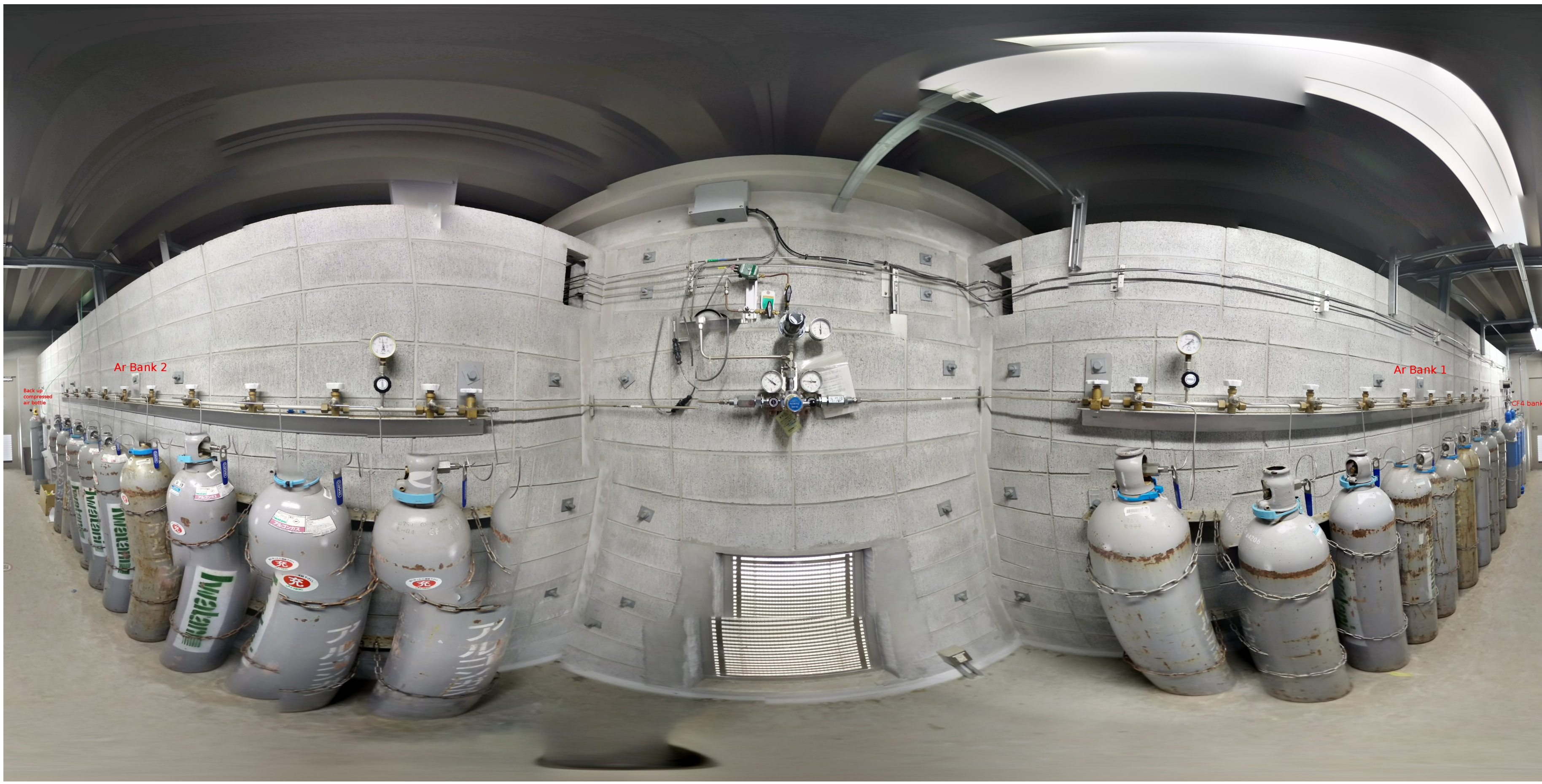
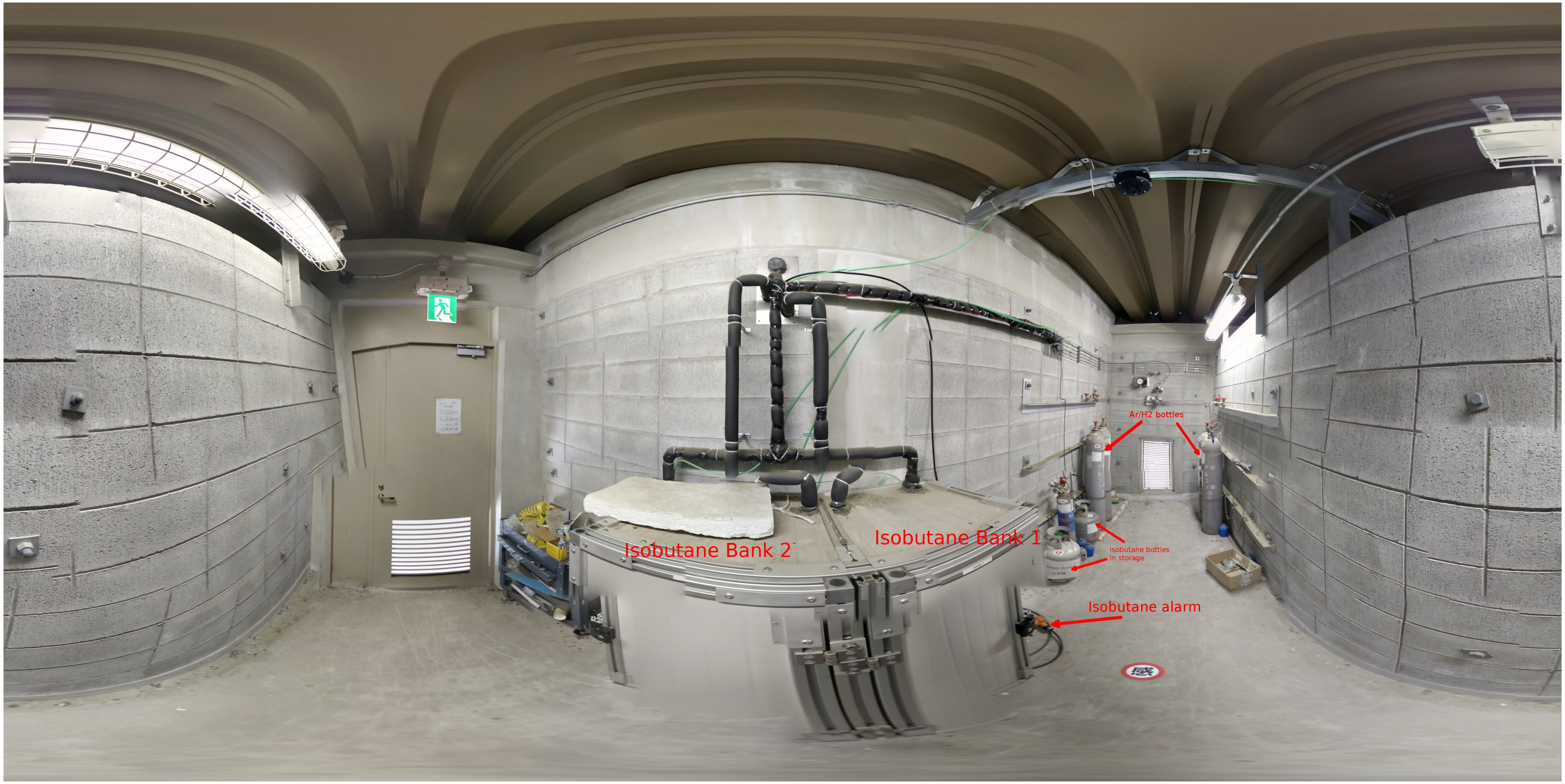


Photo from Y. Petrov's virtual tour

Isobutane and Ar/H2 room



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