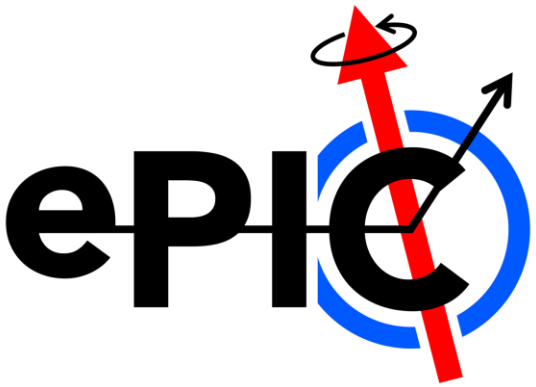
MPGD Gas System Requirements

Stefano Gramigna (sgramigna@roma2.infn.it) on behalf of the ePIC MPGD DSC Group

Jan 21st, 2026 – ePIC Collaboration Meeting



Outline

- Preliminary considerations
- Gas storage and supply
- Mixer
- Distribution
- Exhaust
- Hazards and environmental concerns

Stefano Gramigna - sgramigna@roma2.infn.it

Preliminary Considerations

Purpose of the gas system:

Supplying **the MPGD subdetectors** with the **operating gas mixture** during commissioning/data taking and with an **inert** dry **gas** during shutdowns

The cleanliness of components/piping in contact with the gases is a fundamental requirement for MPGDs:

- **Outgassing safe polymers/resins**
- **Low wear metallic parts**
- **Particulate Filters**

Integration with slow-control (SC) / interlock (IL) is necessary to ensure the **safe operation** of the detectors

As the MPGD Gas System will be **common to all three subdetectors** and requires **integration with on-site facilities** we feel that **Project should lead its design and manufacturing**, with the close collaboration of experts from all involved subdetectors

Gas Storage and Supply

All three subdetectors will operate with the **same gas mixture:**

$Ar:CO_2:iC_4H_{10}$ (93:2:5) is the main candidate

To be validated in the coming 2026 test beam campaigns

Flushing with nitrogen will be required whenever the operating gas mixture is not circulating to **prevent humidity** from entering the detectors

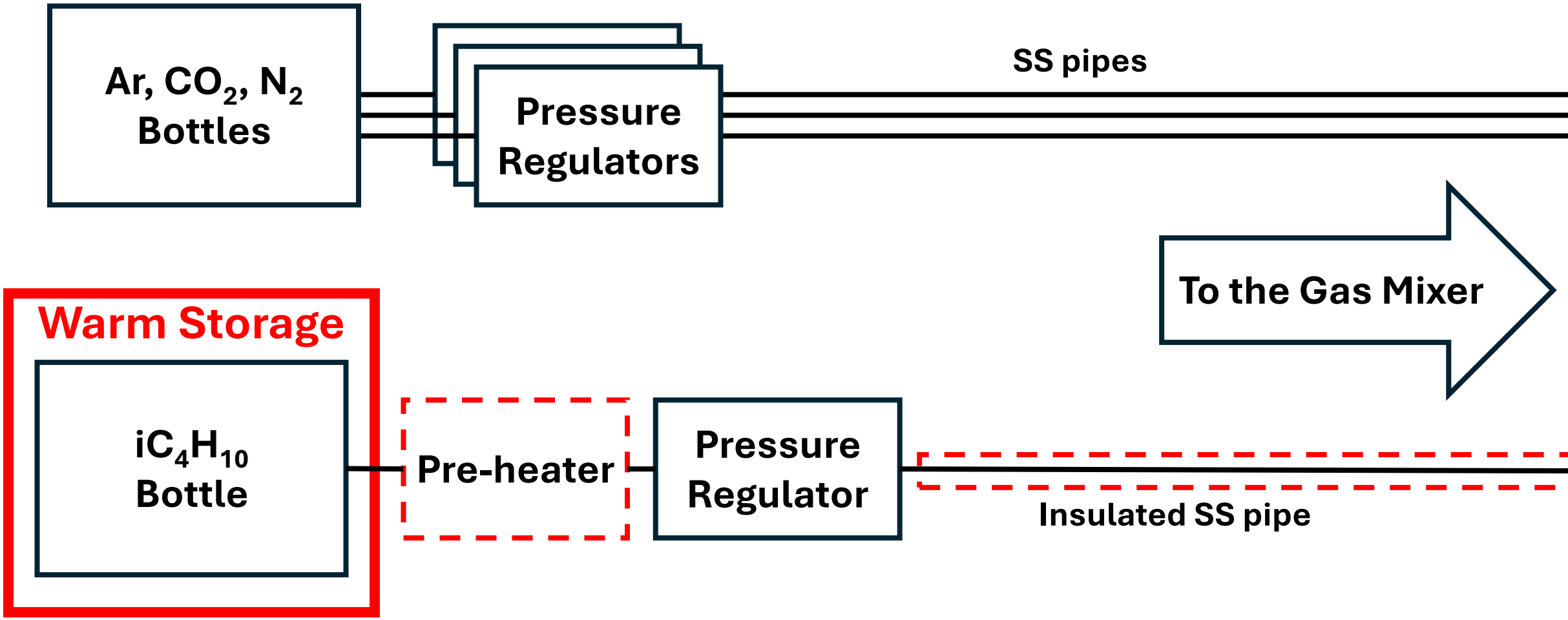
The **operating mixture** should be **as pure as realistically possible** to achieve consistent gas gains and reduce aging:

- **Ar → Grade 6.0 (99.999%)**
- **CO_2 → Grade 4.5 or better (99.995%)**
- **iC_4H_{10} → 99.5% or better**

Grade 5.0 (99.999%) N_2 is sufficient for flushing

Isobutane requires **warm storage** and/or **pre-heating** to avoid transition to liquid phase in the colder months

Example Gas Storage and Supply Block Diagram



Stefano Gramigna - sgramigna@roma2.infn.it

Gas Mixer

O(1%) **errors in mixing ratio can significantly change the detectors' behavior**

No. 3 Thermal Mass Flow Controllers (MFCs) required to ensure **reliable mixing ratios**

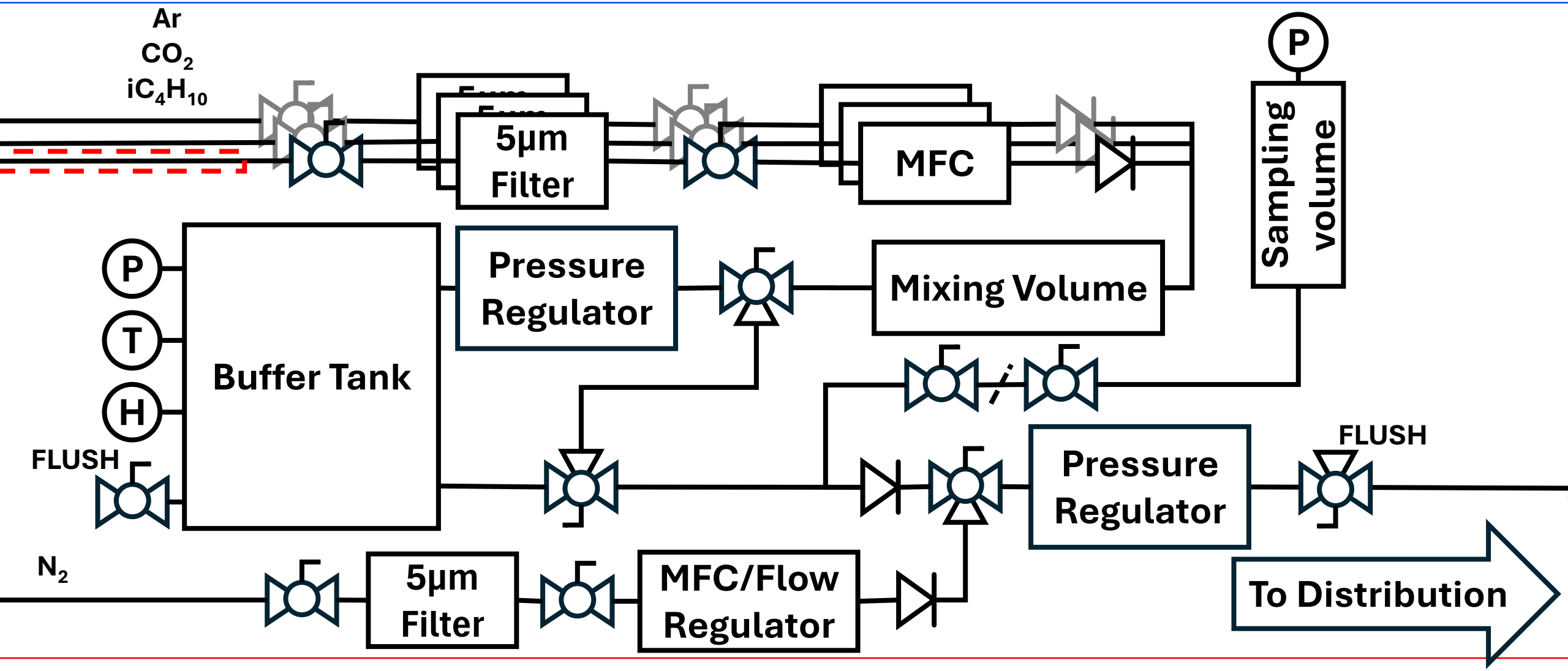
5 µm particulate filters upstream of MFCs to prevent clogging and ensure accurate readings

MFCs could be used **for Nitrogen and distribution** too but **flow regulators are likely sufficient**

Clean vessels:

- **Mixing volume** → Homogeneous gas mixing
- **Sampling volume** → Offsite gas analysis
- **Buffer tank** → Limit downtime during bottle changes/malfunctions

Example Gas Mixer Block Diagram



Distribution

3 main lines, 1 per subdetector

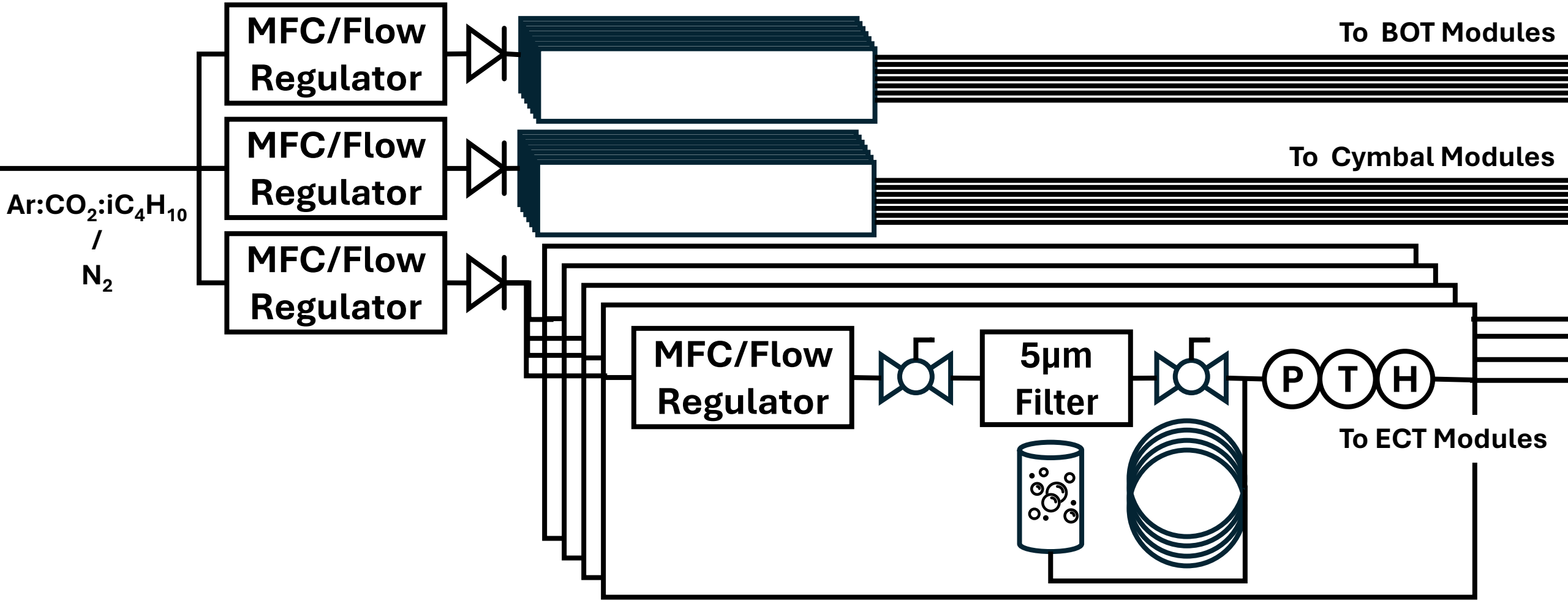
Distribution to modules or groups of modules can be handled by flow regulators

The total number of distribution lines per subdetector is determined by operation requirements and service routing constraints:

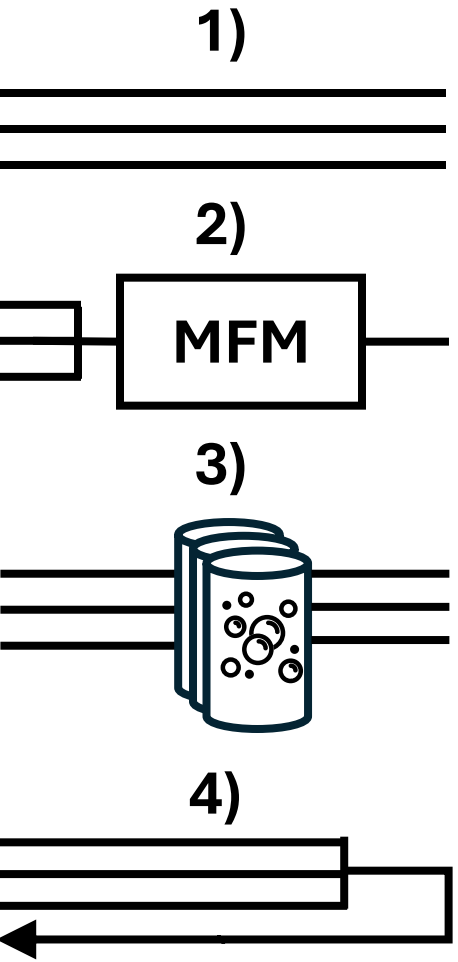
Subdetector	Total Gas Volume (l)	Max Gas Changes per Hour	Max Total Flow (l/h)	Lines to Central Detector	Max Flow per line (l/h)
BOT	60	2	120	24	2
Cymbal	29	1	30	24	2
ECT	19	4	80	4/16	20/2.5

Each subdetector group will address connection to the modules and local distribution

Example Distribution Block Diagram



Exhaust Schemes



1. Free exhaust
Risk of backflow → long lines
Susceptible to rapid pressure variations → outlet protection

2. Monitored exhaust
Risk of backflow → long lines
Increases the modules internal pressure
Dangerous if clogged → regular maintenance
Easy leak quantification

3. Bubblers
No backflow
Risk of water contamination
Slightly increases the modules internal pressure
Requires periodic refilling

4. Recirculation
High initial cost
Complex → more downtime due to failures
Independent from external pressure
Increases the modules internal pressure

If not mandated by unmanageable sustained costs or environmental concerns **open circuit schemes are the preferred solution**

Hazards and Environmental Concerns

GAS SPECIFIC HAZARDS

iC_4H_{10}:

- Flammable at 2-9% concentration
- Liquifies around -12°C @ standard pressure
- Not easily purified (99.99% max)
- Heavy (relative density ~2) → might separate if it stagnates
- Minor environmental concern (GWP = 3)

CO_2:

- Corrosive → Requires SS piping, fittings, etc.
- Minor environmental concern (GWP = 1)

Hazards and Environmental Concerns

SYSTEM SPECIFIC HAZARDS

Cleanliness:

Pipes, fittings, controllers, regulators, valves should be rated for high purity gas lines

Assembly of the system should be performed with particular care to dust formation

High flow nitrogen flushing recommended before connecting to the detectors

Pressure:

Pressure spikes can damage the detectors, safety measures and procedures should be implemented both at system design level and during operation

Rapid pressure variations at the outlets could affect the flow → exhausts should be protected

Contamination:

Residual humidity and leaks compromise detector performance

Potential outgassing from polymer components must be taken into consideration

Operational risks:

Flows in the distribution lines may depend on each other, procedures should be devised for safely varying flow rates to the modules

Conclusions

- The MPGD gas system has to **supply both a three-gas mixture and nitrogen**
- **Design and manufacturing should be entrusted to Project**, as it requires integration with onsite facilities
- Ample **support by the experts of all involved subsystems will be provided** to ensure maximum compatibility
- **Block diagrams** of the system main components have been provided as an example to **illustrate expected operation requirements**
- **Hazards to people, environment and the subdetectors** have been **laid out** to the best of current knowledge

Thanks for your attention!
Questions?

Stefano Gramigna - sgramigna@roma2.infn.it

Backup Slides

The Role of CF_4

CF_4 might be necessary to boost timing performance but introduces additional environmental concerns

CF_4 Specific Hazards:

- Major environmental concern (GWP ~6500) → might require recirculation system
- Heavy (relative density ~3) → might separate if it stagnates

Very **important to** precisely **define timing performance requirements** to decide if CF_4 should be employed as a last resort