

# Gas systems for gaseous detectors

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EP-DT  
Detector Technologies

# Outline

## LHC gas systems @ CERN

Open, closed loop systems \*      Recuperation systems \*

## Other gas systems @ CERN

NA gas systems\*, AMBER,  
CLOUD\*, LINAC\*

## Gas systems outside CERN

T2K ND280 TPC @ JParc\*

CBM TOF

and many more

## Gas systems

## Small size gas systems

Laboratory sized systems

Systems for remote applications

## Medium size gas systems

Gas systems for facilities and laboratories

\* Developed by CERN EP-DT

# LHC Gas systems - overview

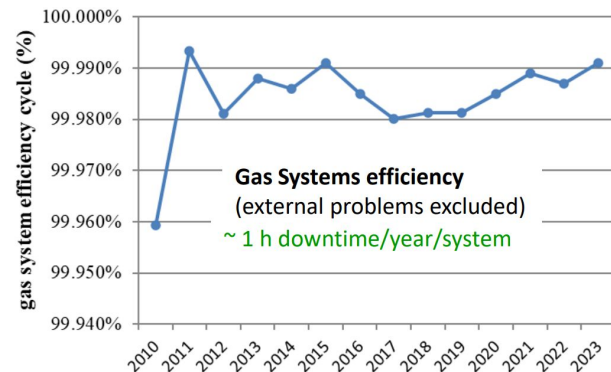
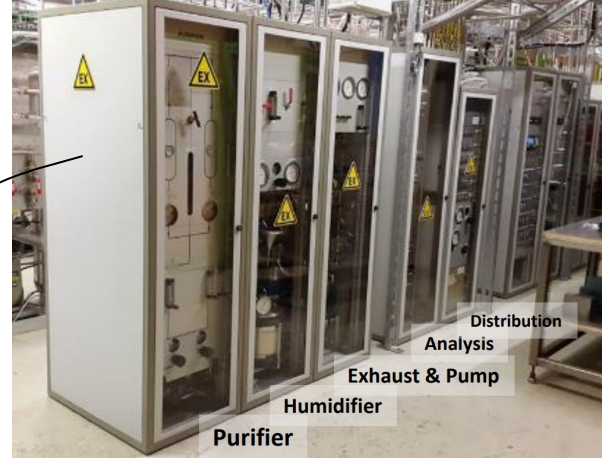
Gaseous detectors at CERN LHC experiments covers **large surface areas** (up to 5000-10000 m<sup>2</sup> and **extensive volumes** (from few m<sup>3</sup> up to ~150 m<sup>3</sup>)

## Gas systems for LHC

- 30+ installations
- More than 300 racks
- O(100 km) of pipes
- O(10<sup>4</sup>) sensors and actuators
- Running with CERN unified control system framework (UNICOS)

## Gas systems provide

- Reliability → 24/7 availability
- Automation → industrial operation
- Stability → ensure best detector performance

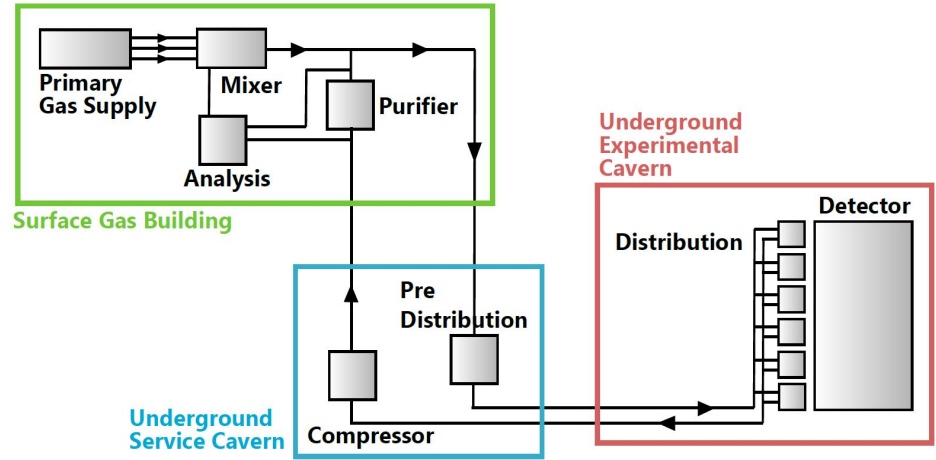
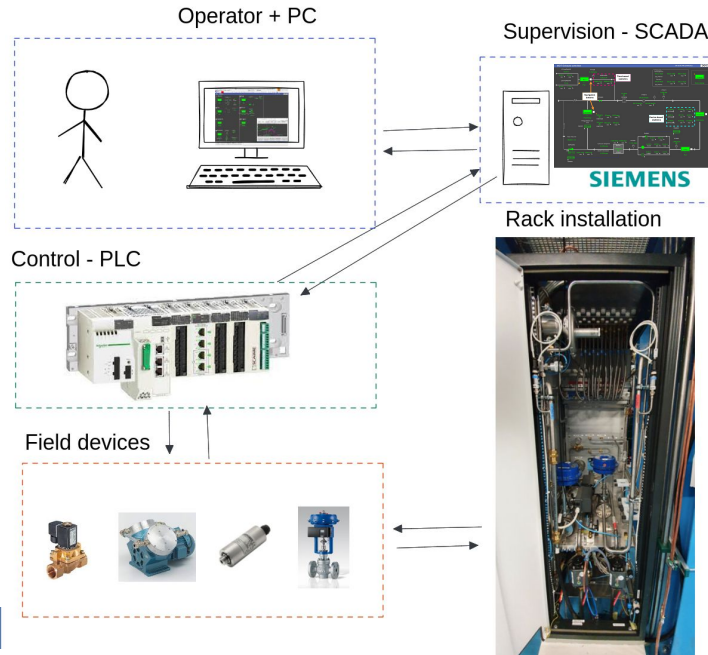


# LHC Gas systems - modular design

## Gas systems are organized in modules

Each module has a precise purpose

**Standardization** ⇒ reduces costs and person power, allows easier design, operation and maintenance



## Gas Control Systems

Industrial **PLCs** and fieldbuses used for process reliability

**SCADA** application used to both control and monitor

Applications designed and generated from templates following the modular design

# Recirculating and recuperating gas systems

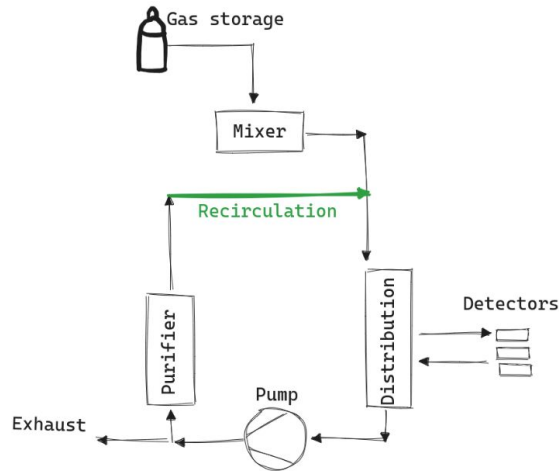
## Gas recirculation

- **Gas mixture** at the output of the detector is **reinjecte**d at the **input**
- Needed for both **small** and **large** installations, for expensive gases and GHGs

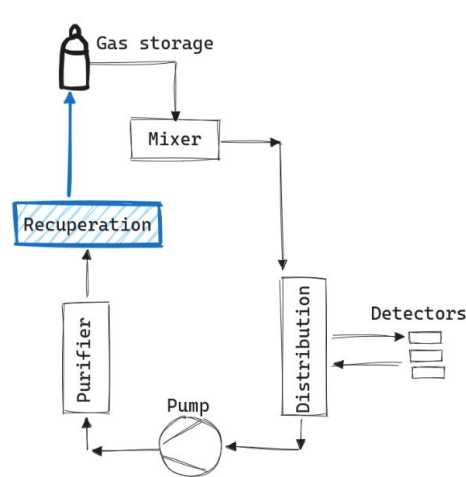
## Gas recuperation

- “Separate” a gas components from a gas mixture
- Mainly targeting **large installations** with GHGs and/or expensive gases

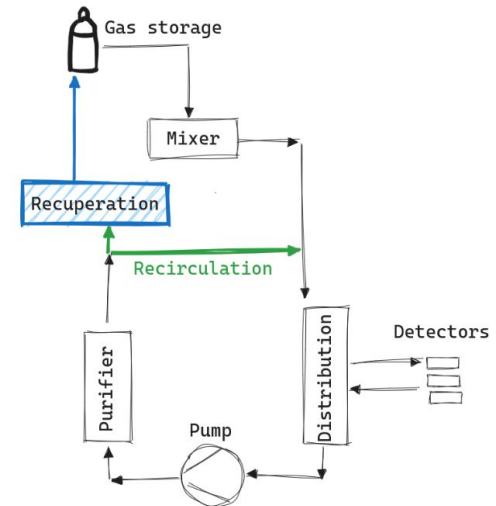
### Gas recirculation



### Gas recuperation



### Gas recirculation + recuperation



# Gas recuperation systems

## Gas recuperation fundamental for expensive and GHG gases

- Suitable for large installations
- Different gases required different recuperation techniques
- Dedicated R&D needed

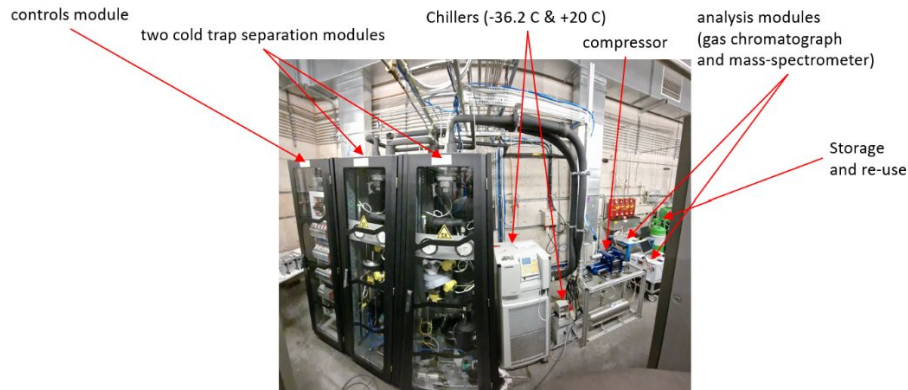
## GHG Recuperation systems

- CMS RPC  $\Rightarrow$  R-134a (R&D ongoing for SF<sub>6</sub>)
- CMS CSC  $\Rightarrow$  CF<sub>4</sub>
- LHCb RICH1  $\Rightarrow$  C<sub>4</sub>F<sub>10</sub>
- LHCb RICH2  $\Rightarrow$  CF<sub>4</sub>

## Other gas recuperation systems

- ALICE TRD  $\Rightarrow$  Xenon
- ATLAS TGC  $\Rightarrow$  N-Pentane
- ATLAS TRT  $\Rightarrow$  Xenon

CMS RPC R-134a recuperation



CMS CSC CF<sub>4</sub> recuperation



LHCb RICH1 C<sub>4</sub>F<sub>10</sub> recuperation



# Non LHC gas systems at CERN

## Several gas systems for gaseous detectors present in other facilities and experiments

- NA61/SHINE  $\Rightarrow$  for timing RPCs
- NA62  $\Rightarrow$  CEDAR, Straw tubes, RICH
- AMBER  $\Rightarrow$  MPGDs, Straws, RICH
- Test facilities (e.g. 904 for CMS, GIF++)



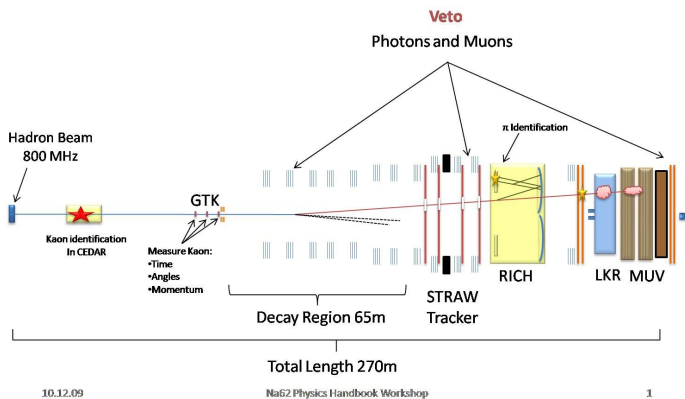
NA61 SHINE



AMBER

## Gas systems smaller than LHC

- Industrial components and controllers
- Modularization where possible
- Custom modules when required

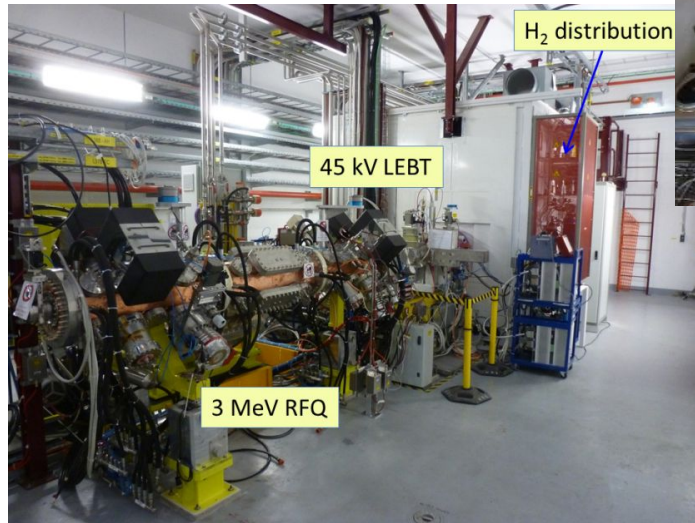


NA62

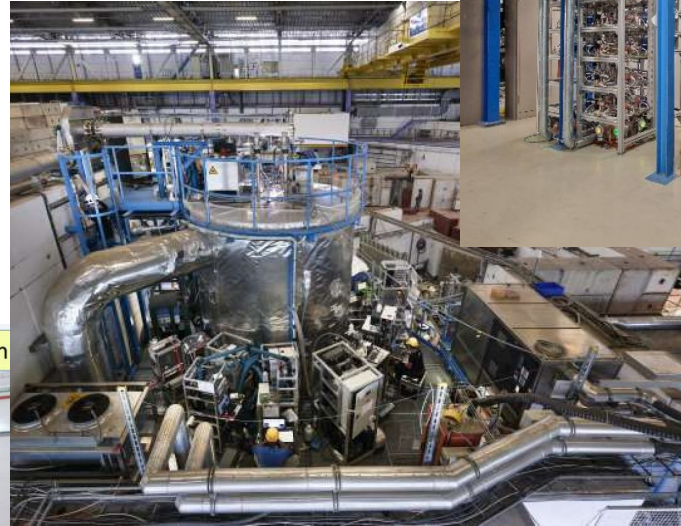
# Gas systems for non gaseous detectors

## Gas systems sometimes required for non gaseous detectors

- CLOUD  $\Rightarrow$  one of the biggest gas systems
- LINAC4  $\Rightarrow$  one of the most critical gas systems
- Flushing  $\Rightarrow$  required for correct operation of pixels, trackers, calorimeters, etc.



LINAC4



CLOUD chamber



CLOUD gas system

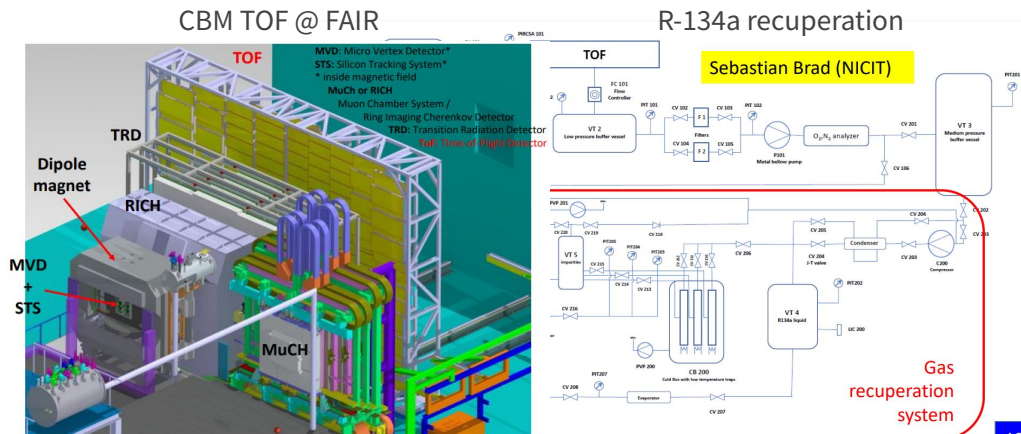


# Gas Systems outside CERN

Small to large gas systems used also in other experiments and facilities. Few examples:

## CBM TOF FAIR @ GSI

- Design done @ GSI for timing RPCs
- Includes gas recuperation for R-134a



*I. Deppner, 66th INFN ELOISATRON WORKSHOP*

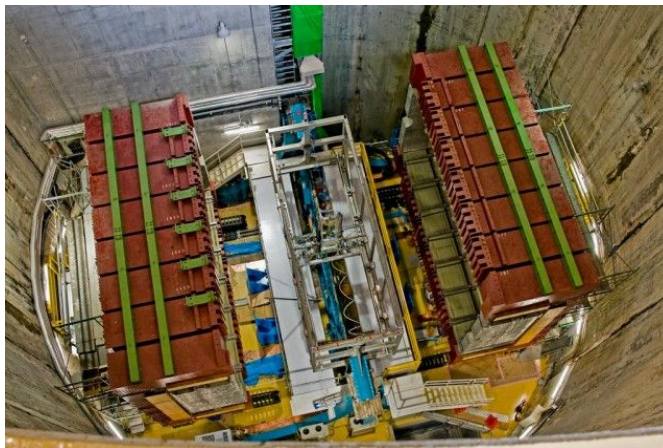
## T2K ND280 TPC @ JParc

- System designed and built at CERN
- Commissioned and tested at @JParc

Single modules often built for laboratories as well

- Mixer, humidifier modules for RPCs, MPGDs, etc.

T2K ND280 TPC



TPC gas system



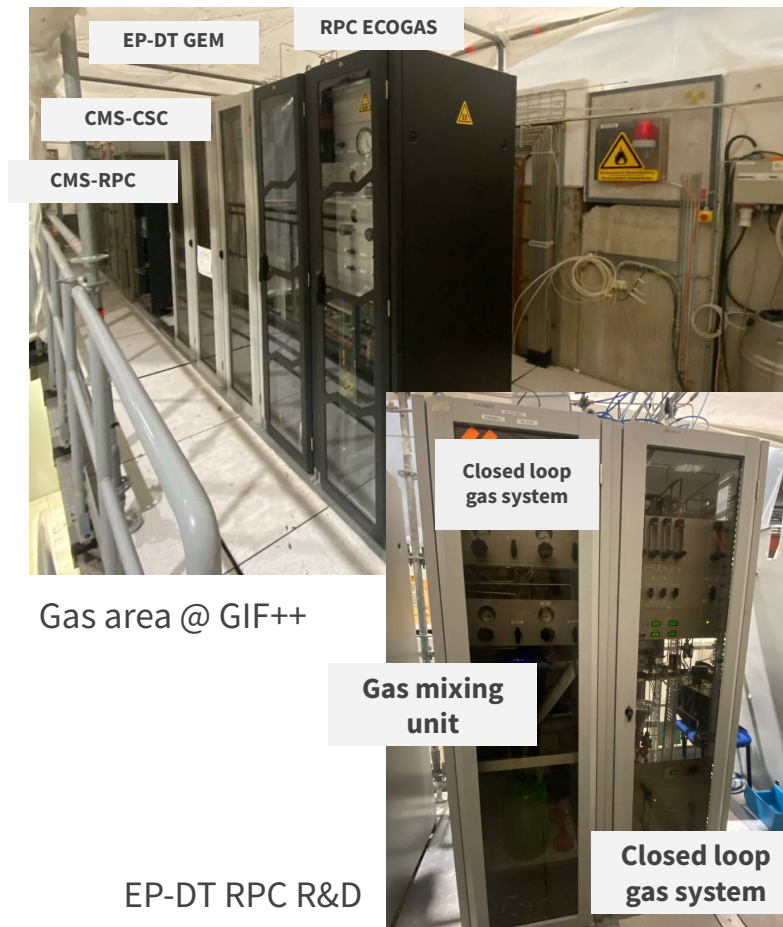
# Smaller gas systems for testing facilities

## Several detector installations spread across testing facilities

- Few to tens detectors, few liters of volume
- Use of industrial components for reliability
- Need to validate detector operation under gas recirculation:
  - Extensive R&D studies on detector performance
  - Muon systems for future upgrades

## Gas systems @ The Gamma Irradiation facility (GIF++)

- Small replicas of LHC gas systems
- More than 20 gas panels
- 7 Mixing units
- 4 recirculating systems
- 2 Infrared analyzer + 10 analyzers for O<sub>2</sub> and H<sub>2</sub>O



Gas area @ GIF++

EP-DT RPC R&D  
gas system

# Mini recirculating gas systems

## Mini to micro recirculating gas systems

- Required for specific applications (harsh environment, safety rules)
- Could be used to save expensive or **greenhouse gases** also for **small** laboratories

## Differences from medium-to-large gas systems

- **Size** of the gas systems: as small as possible
- **Price** of the components: should be reduced as much as possible for accessibility
- **Alternatives** to **industrial** controllers and components might be needed to reduce costs
- **Components** should be **validated** for their use with gaseous detectors

## Ongoing design and development from different groups

- Targeting **different detectors** types and different applications
- Ongoing **collaboration** between CEA Saclay and CERN EP-DT to develop new systems ⇒ knowledge sharing

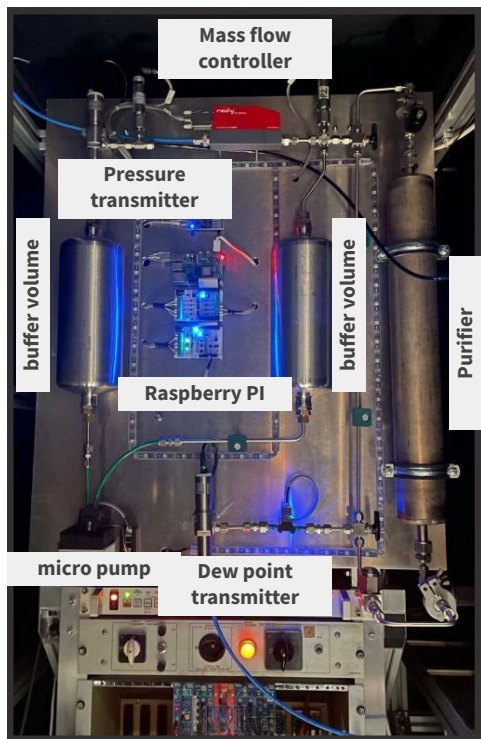


[Muon system for pyramids by CEA, D. Attié](#)

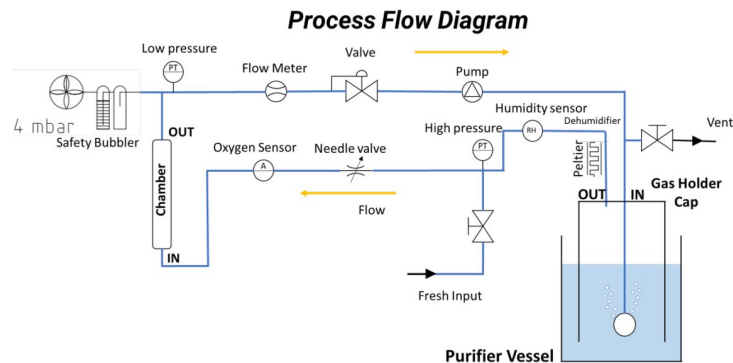


[EEE telescope installation, D. De Gruttola](#)

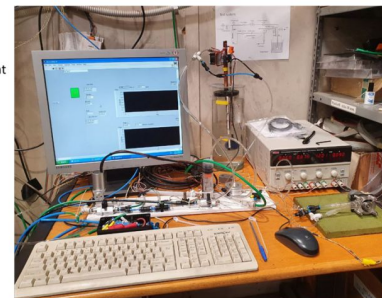
# Examples of small recirculating gas systems



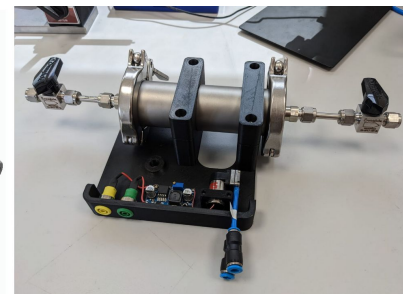
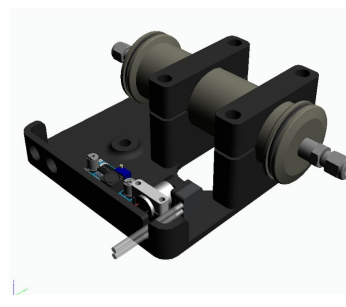
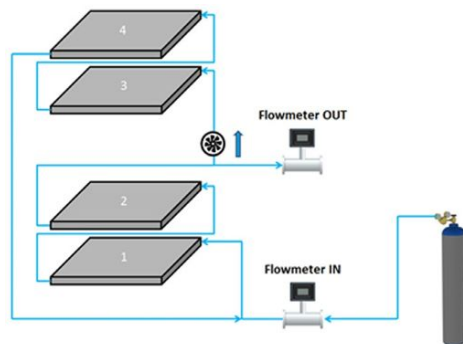
uloop for spark chamber at the CERN Science gateway  
Ne/He 70/30



A picture of the system



Rome Tor Vergata recirculation system for RPCs (B. Liberti, E. Pastori)  $\Rightarrow$  RPCs ( $R-134a/SF_6/iso + H_2O$ )



CEA Recirculation system  $\Rightarrow$  MPGDs ( $Ar/CO_2/iso$ )

# Conclusions

## Gas systems are fundamental for detector operations

- Every gaseous detector installation requires a gas system
- LHC Modules designed and built with **industrial components** for robustness and reliability
- Modules allows **standardization**
- Recirculation and recuperation allow sparing GHG and expensive gases
- **Recuperation** systems require dedicated **development**

## Gas systems are also needed for medium sized experiments and facilities

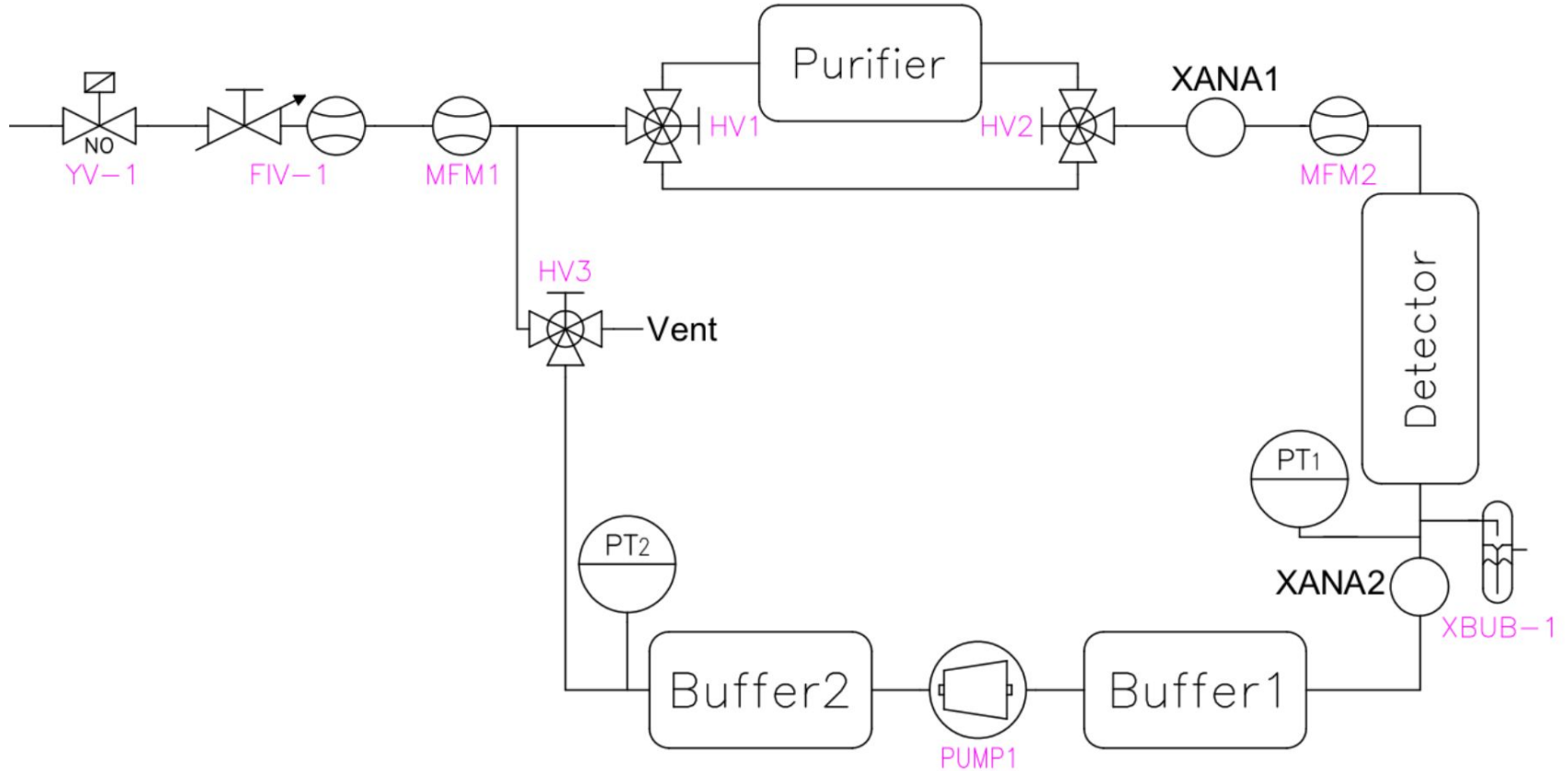
- Few to tens of chamber volumes
- Gas recirculation used to spare GHG and to emulate LHC-like conditions

## Several applications for small recirculating systems

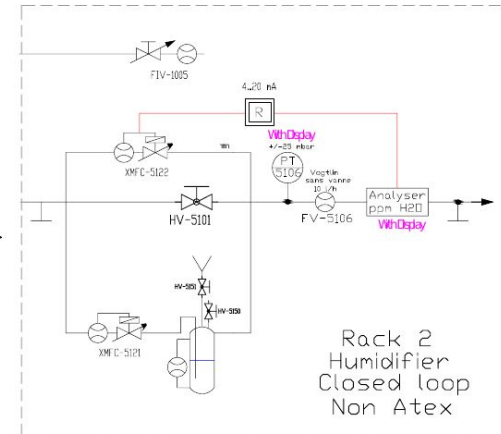
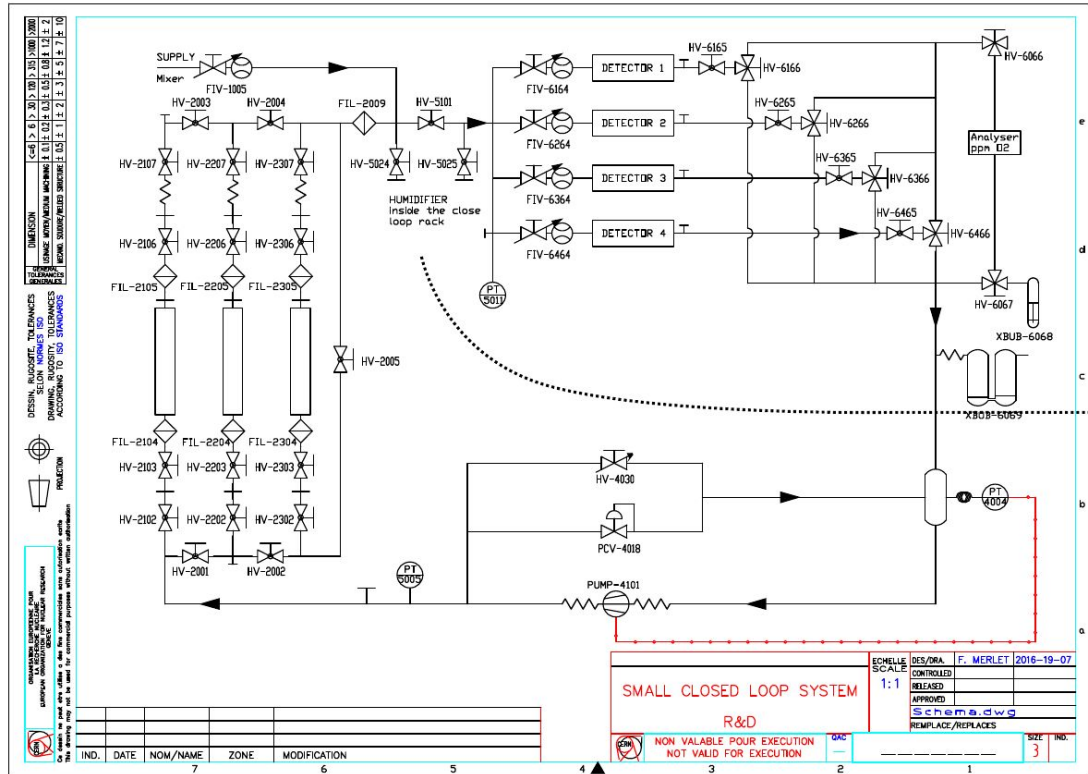
- Useful in **special** applications (e.g. remote/nuclear sites) as well as **laboratories, institutes, small facilities**
- Can be adopted where gas prices are less accessible (e.g. small labs, schools)
- Lot of effort from different communities  $\Rightarrow$  synergy between institutes, collaboration opportunities

**Thank you!**

# CERN general micro loop system

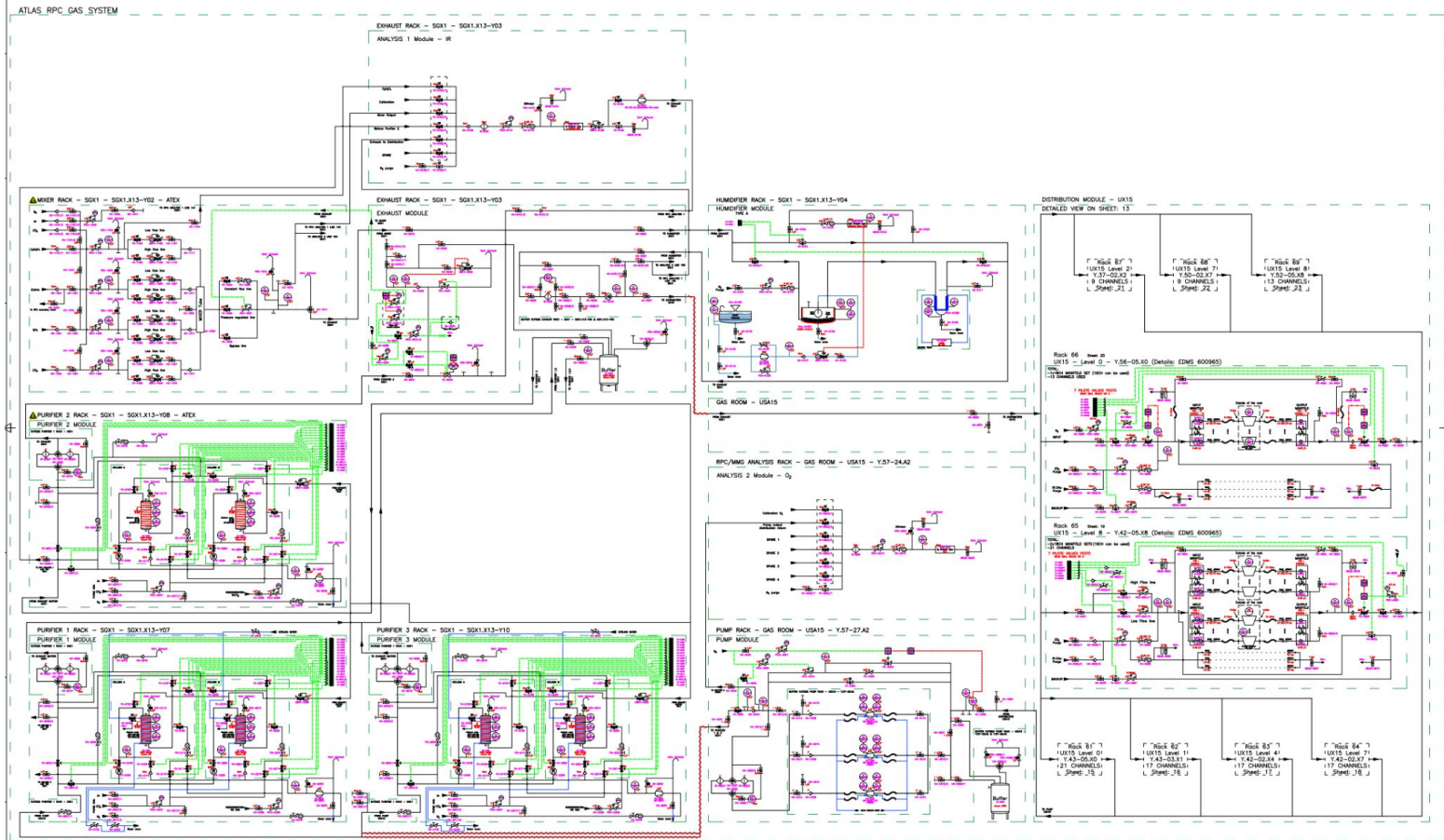


# CERN schema for RPC R&D gas system @ GIF++





# Modules of a large CERN LHC gas system (ATLAS RPC)



# Modules of a large CERN LHC gas system (ATLAS RPC)

