

The gas systems infrastructure for the CERN Gamma Irradiation Facility

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on behalf of the CERN Gas Service Team (EP-DT-FS)

- GIF++ overview
- Gas systems infrastructure
 - supply
 - distribution
 - Gas recirculation units
 - Gas analysis modules
- Conclusions

Strong needs from the LHC and HL-LHC detector and accelerator communities

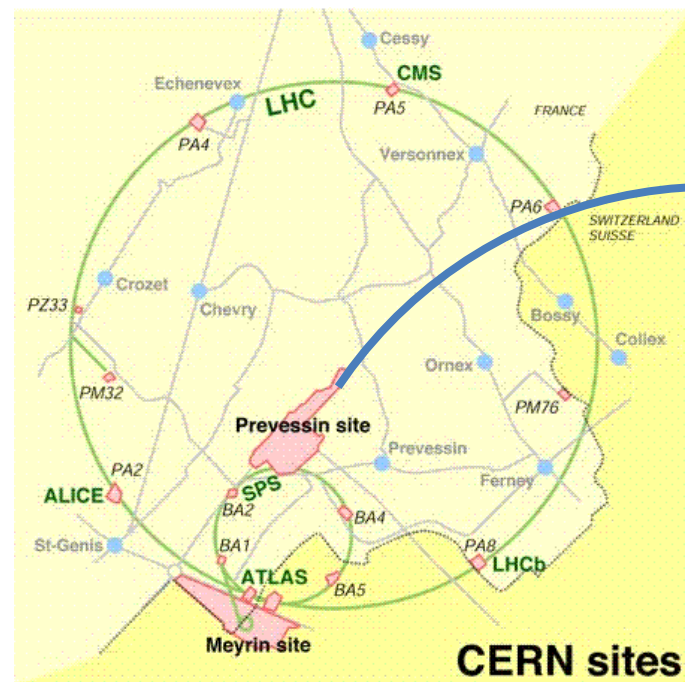
- GIF++ follows up on the very successful GIF facility
- The GIF++ facility presented takes into account the requirements from the users and has been discussed extensively with them.

GIF++ is a unique place for detector R&D tests:

- Strong gamma source
- Particle beam available
- Excellent gas and electronic infrastructures
- Unified control/monitoring system
- Setups for beam & cosmic trigger, radiation monitoring, environmental monitoring, DAQ, ...



GIF++ facility: location

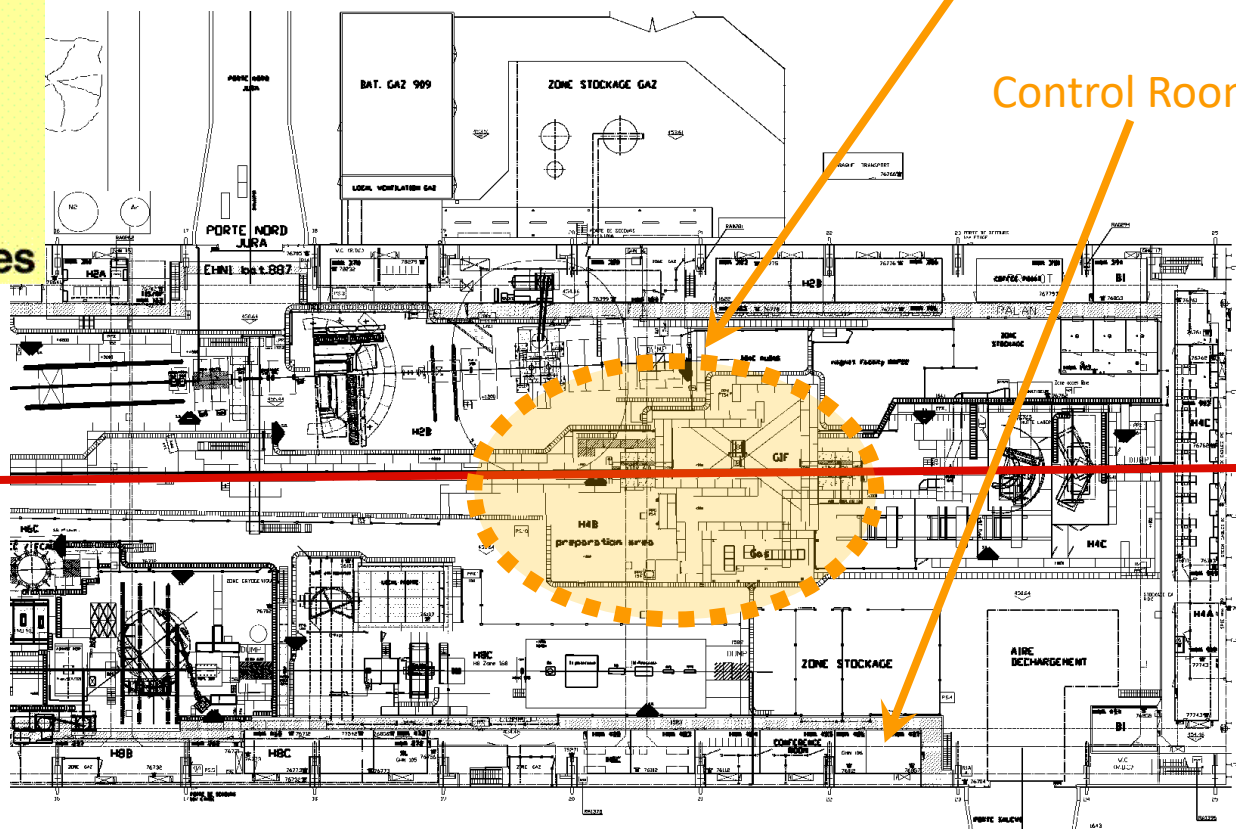


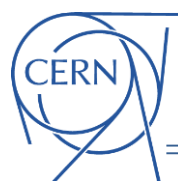
Bldg.887



Control Room

H4 beam line





GIF++ collaboration

- The CERN EN-department (EN-MEF)



- provides the infrastructure for housing the irradiator and detectors: **civil engineering** components (shielding, false floor ...), **beam line elements**, **control room** and the **supply of general infrastructure** (electricity, gas ...)
- provides the **gas distribution lines inside the facility** (about 5 km)

- The CERN PH-department (EP-DT)

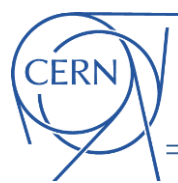


- provides the **irradiator & attenuator**, the **facility controls** (GIF control system), the **gas systems**, as well as the **user management**

- The user community



- providing the **detector specific infrastructures** (beam trigger, cosmic trigger, ...)



GIF++ facility: key numbers

Details		Dimensions
GIF++ facility	Building 887 - H4 beam line in EHN1	225 m ²
Detector preparation area	Area for detector preparation directly accessible from control room	83 m ²
Services area	Area hosting large part of the peripheral infrastructure and services (gas supplies and systems)	2 x 40 m ²
Bunker	Experimental area: 14 TBq ¹³⁷ Cs source (662 keV gammas)	100 m ²
Control room	Control rooms for services and users close to the preparation area	

Detector preparation area

equipped with gas lines, electricity & network.
Signal cables and HV/LV patch panels will be added during a first upgrade

full-size detectors can be setup and commissioned
before moved to the radiation zone

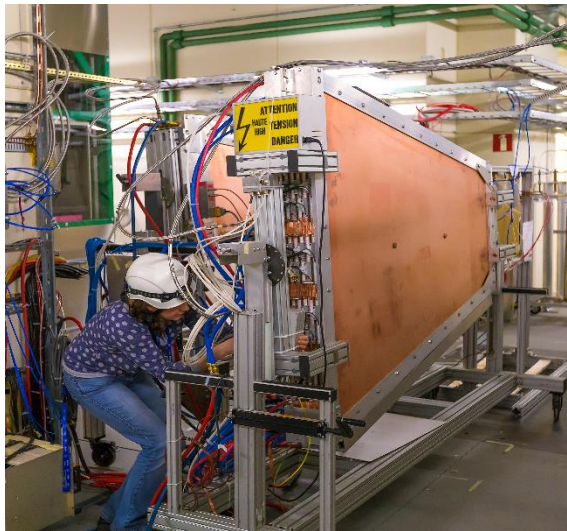
Irradiation bunker

Electronic and gas services

Gas systems and gas distribution panels
Irradiator controls, DCS, user electronic equipment, fire detection, ...

A large variety of tests on gaseous detectors

- Detector validation up to new HL-LHC expected dose
 - Detector and electronic development
 - Performance of «recent» detector developments
 - Test on real size detectors ($>> \text{m}^2$) and prototype
 - Studies with new environmentally friendly gases
 - New gas systems and operation for new detector upgrades
 - Large detector productions at high rate before installation
- 6 detector technologies:
- DT, MDT
 - CSC
 - RPC, iRPC, GRPC
 - MM
 - GEM
 - sTGC



The gas systems infrastructure is fundamental for the operation of gaseous detectors at GIF



First floor:

Gas service area

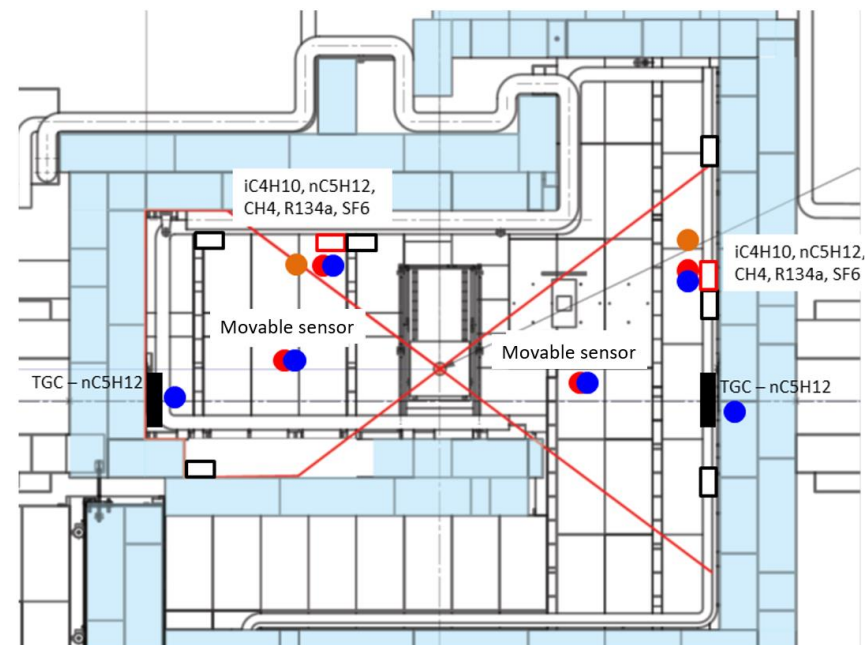
~ 20 gas racks and
distribution panels
(40 m² net area)

Ground floor:

Electronics area

~ 20 electronic racks hosting the
irradiator controls, DCS, user
equipment, fire detection, ...

- Gas supply
- Gas distribution
- Control rack (basic functionality, i.e. connection to systems, gas systems status, distributions of monitored parameters...)
- Gas mixing racks for fixed installations (beam and cosmic trigger setups).
- 1 IR analysis rack for cosmic trigger
- 1 analysis rack
($O_2 + H_2O$ + gas chromatograph).
- New gas recirculation systems developed



Gas supply panels

- neutral gases: Ar, CO₂, N₂, He, SF₆, CF₄ and 3 additional gas lines (spare and/or pre-mixed)
- flammable gases or gases with low vapour pressure: iC₄H₁₀, CH₄, Ar/H₂, C₂H₂F₄ and 2 additional (spare and/or pre-mixed)

Gas supply and distribution in the service area



Example of neutral gas supply panels



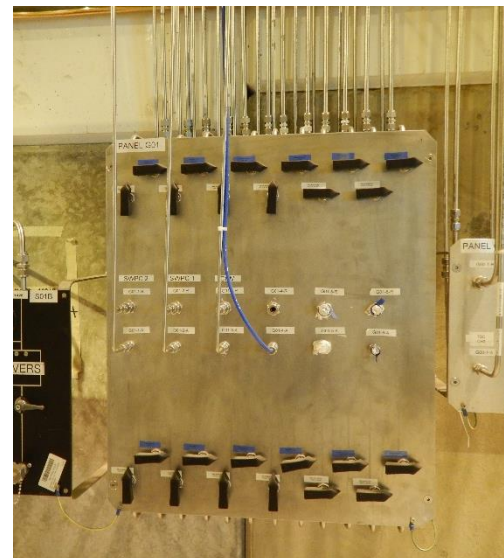
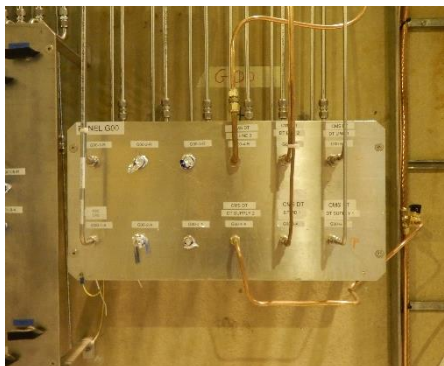
Gas mixture distribution panels

- 21 distribution panels (6 lines each)

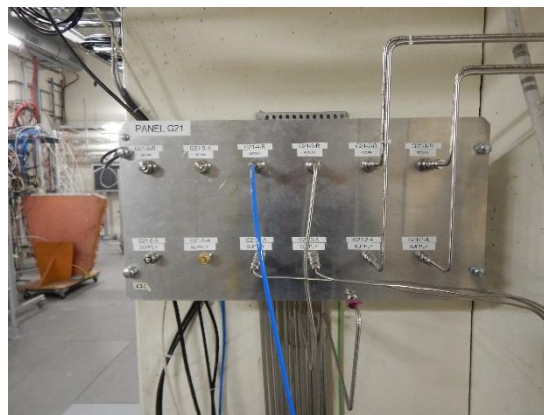
- Two types:

From service area to bunker and preparation area

From service area to bunker only

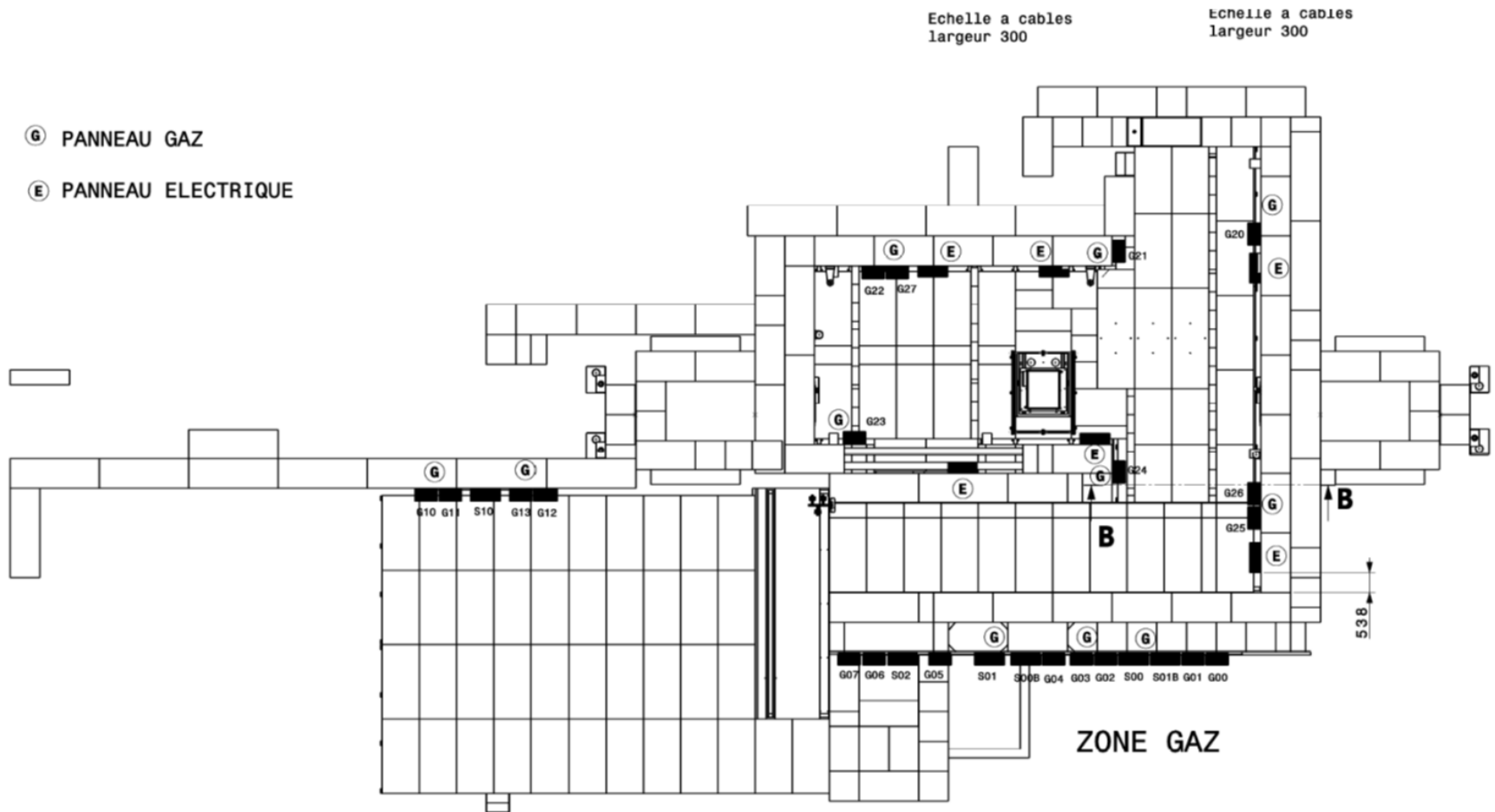


Corresponding gas panels in the GIF bunker



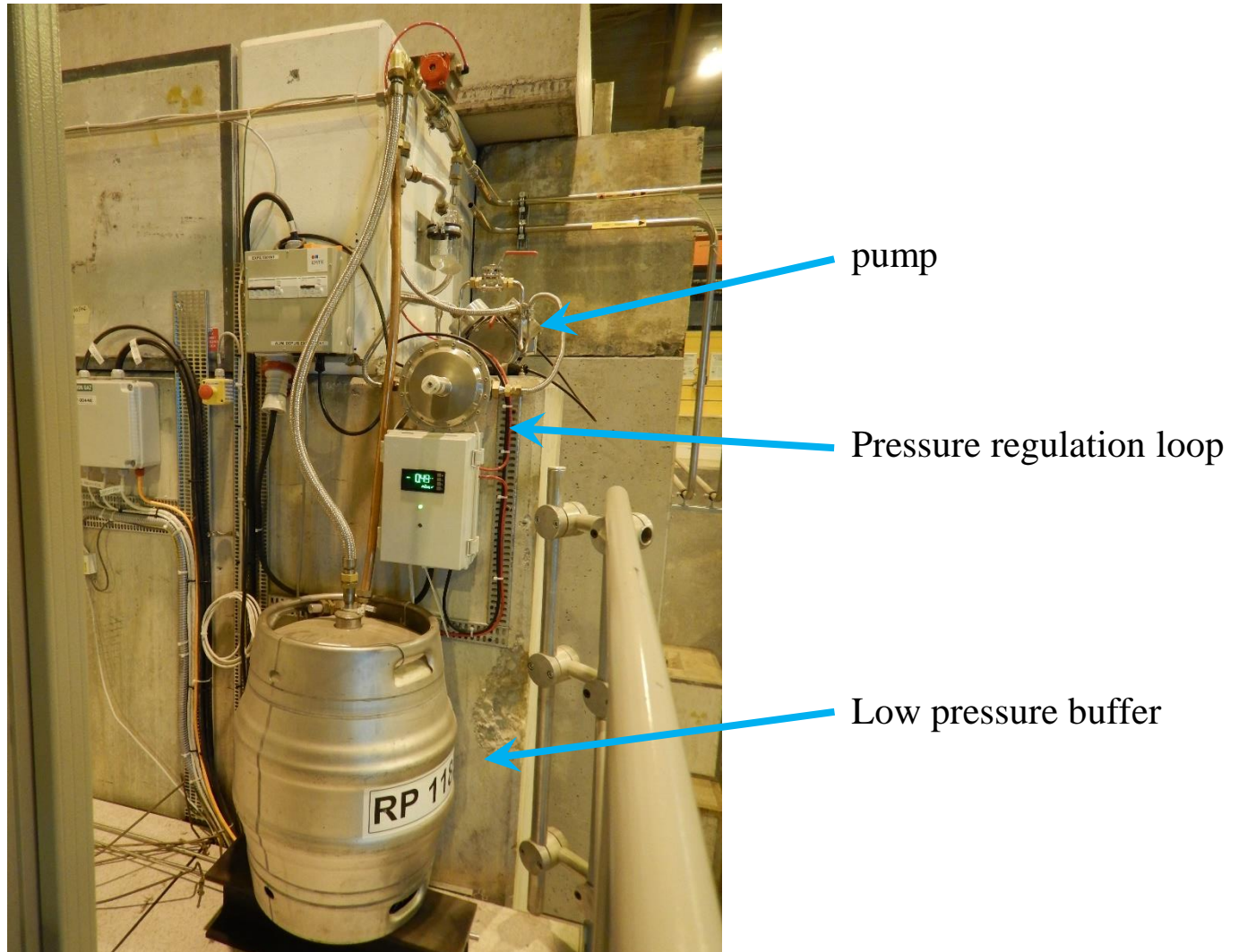
Gas mixture distribution panels

■ Location of distribution panels

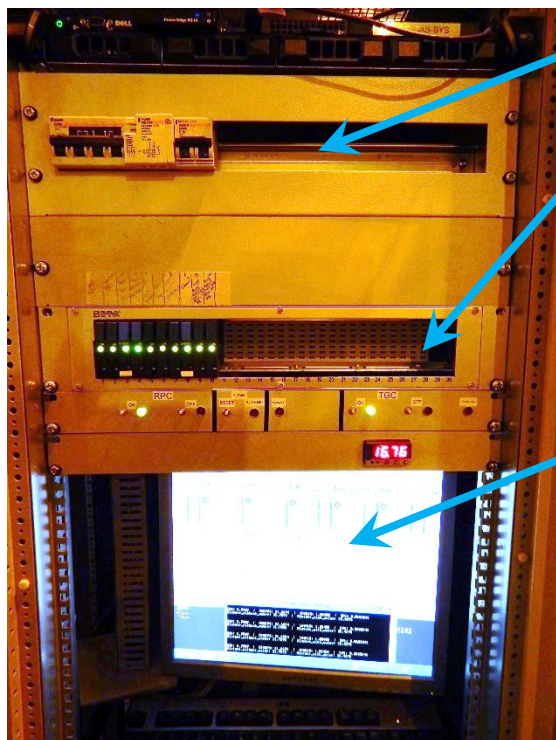


Exhaust pressure regulation

- Extraction systems needed to create slight under-pressure in the exhaust line
- needed to guarantee that gases are really exhausted through the exhaust line out of the building



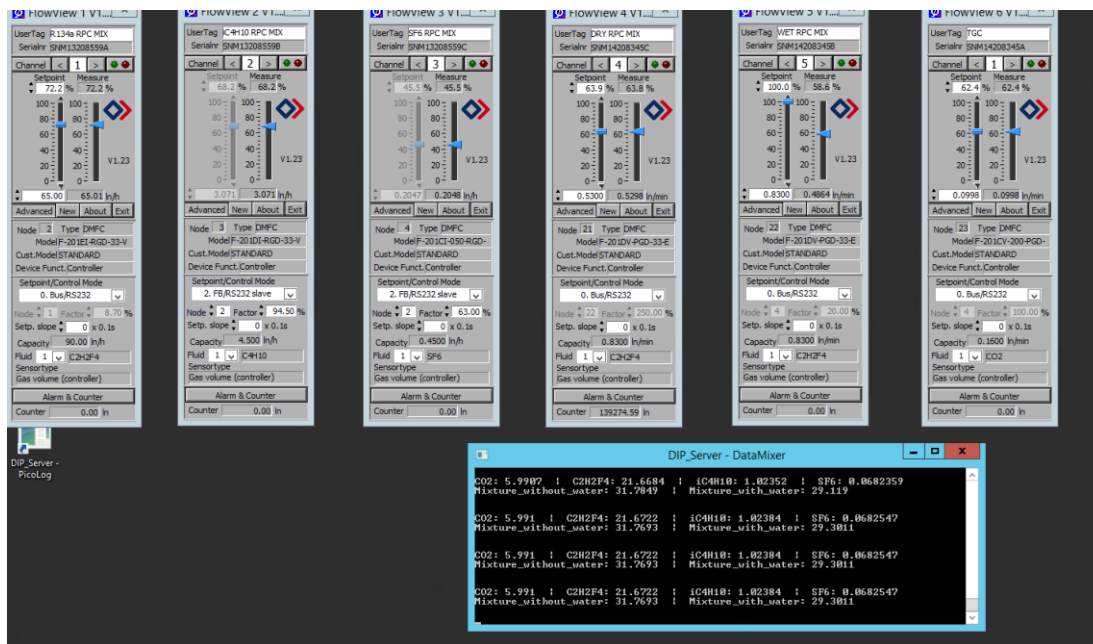
- Beam and cosmic triggers



Power supply

On-site interface and temperature monitoring for nC5H12 thermal bath

Software controls and parameters distribution through DIP protocol

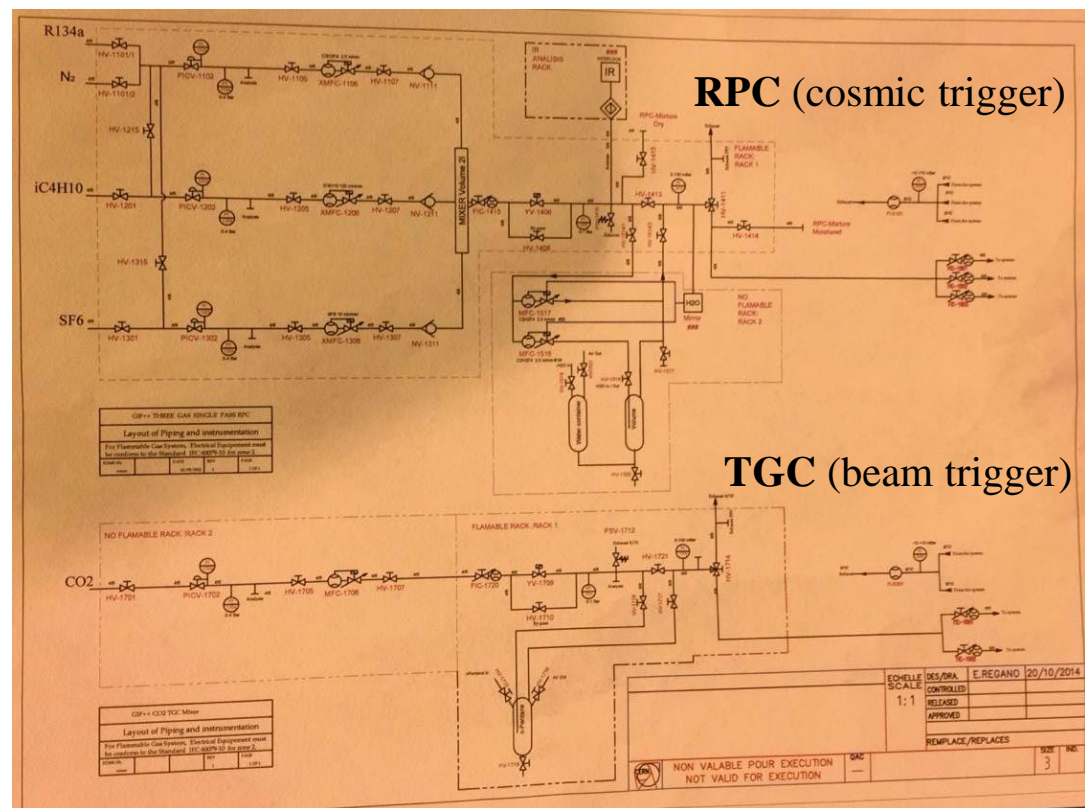


- Beam and cosmic triggers

Beam and cosmic mixers:
ATEX components



P&I diagram



- Beam and cosmic triggers

RPC and TGC mixture distribution



RPC humidifier



IR monitoring and flammability
interlock of RPC mixer



Gas recirculation systems

- In real systems gas mixture is often recirculated (at LHC experiments 90% of gas systems are recirculating the gas mixture)
 - Two main reasons: reducing operational costs and greenhouse gas emission
- As a result of a R&D on gas system we developed a new portable gas recirculation unit
 - advantages: much cheaper of previous version (25 kCHF wrt 90 kCHF) and, most important, much more reliable and easier to operate
- 5 systems produced (2 operational at GIF since almost 2 years)



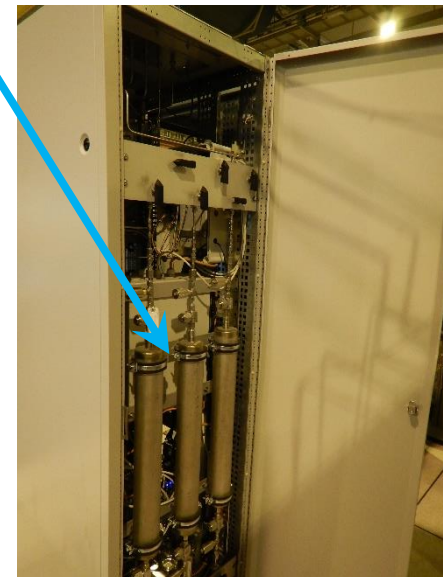
Mixture distribution

Monitoring of pressure,
O₂/H₂O, temperature,
atmospheric pressure

Additional software controlled
pressure regulation for very
low flow regimes

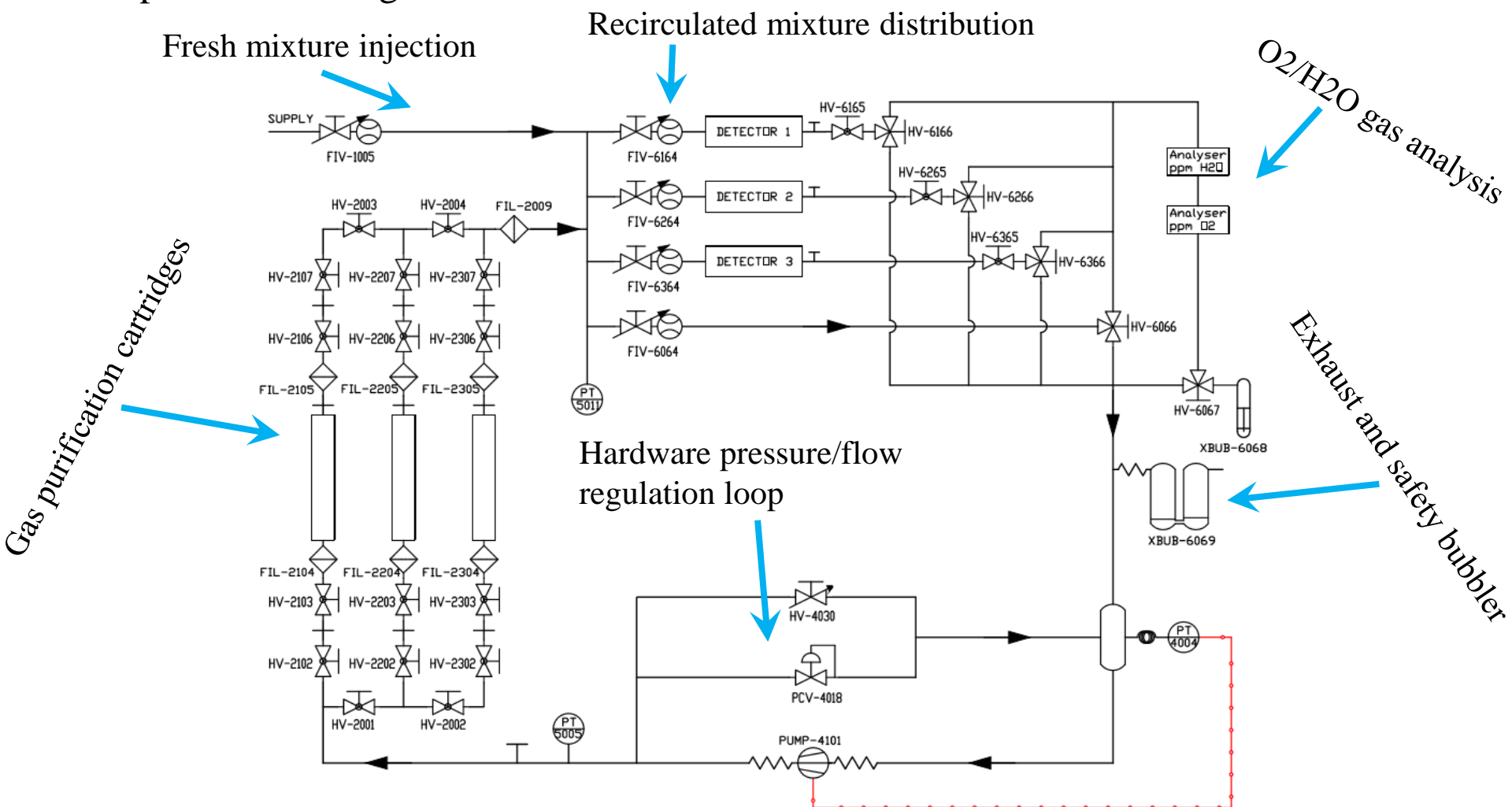
Gas mixing unit

Gas purification cartridges



Gas recirculation systems

■ Simplified P&I diagram



B. Mandelli et al., A new portable gas recirculation unit for gaseous detector R&D, CERN EDMS note 1734199.

Gas recirculation systems

- Second generation of new gas recirculation system
- It includes a fully automated purifier module (suitable for detectors requiring regeneration of absorber material too often)
- Installation completed; Being commissioned at GIF

Gas recirculation module



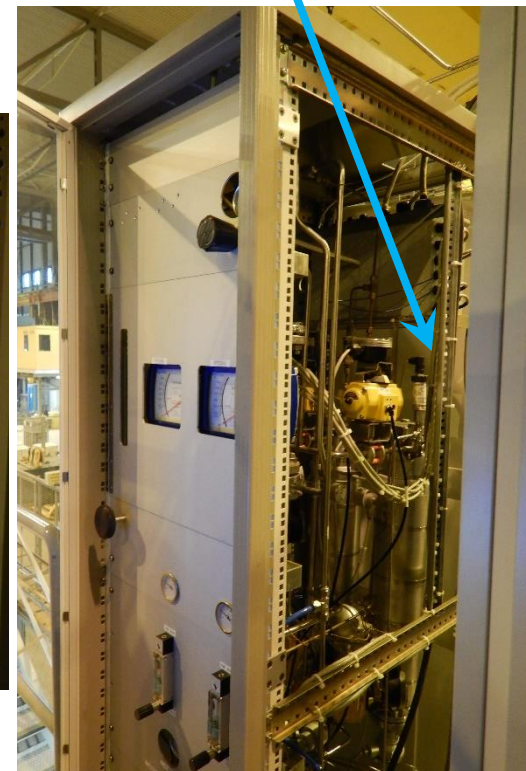
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Gas mixture purification module



Monitoring and controls panel

Cartridges with cleaning agents



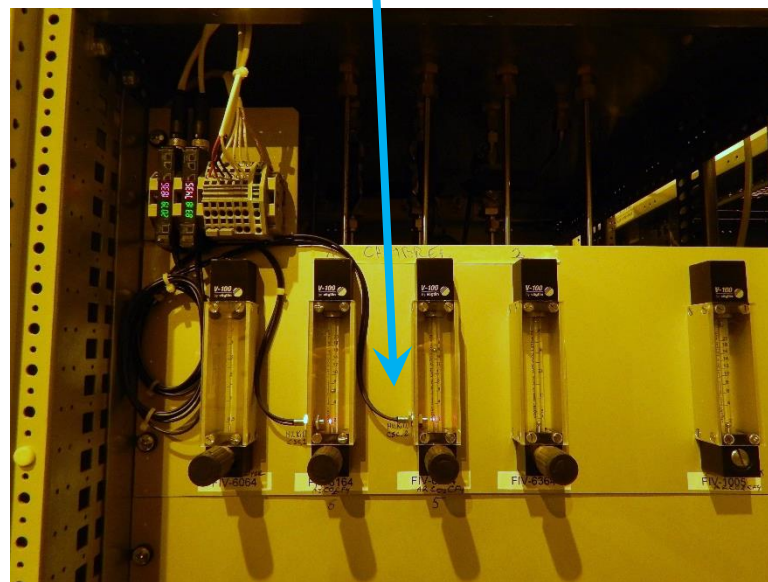
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Gas flow monitoring and alarms

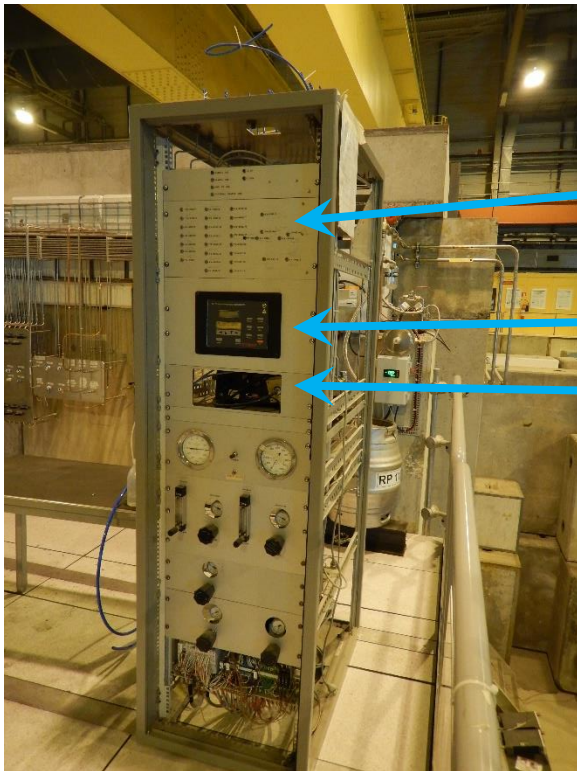
- Developed a system to check if flow in each recirculation loop is according to required values. In case of problems, warning and/or interlock signals are sent to DCS or HV system



Gas flow is verified by means of optical sensors without contact with the gas mixture



- O₂/H₂O: standard LHC experiments - like analysis rack

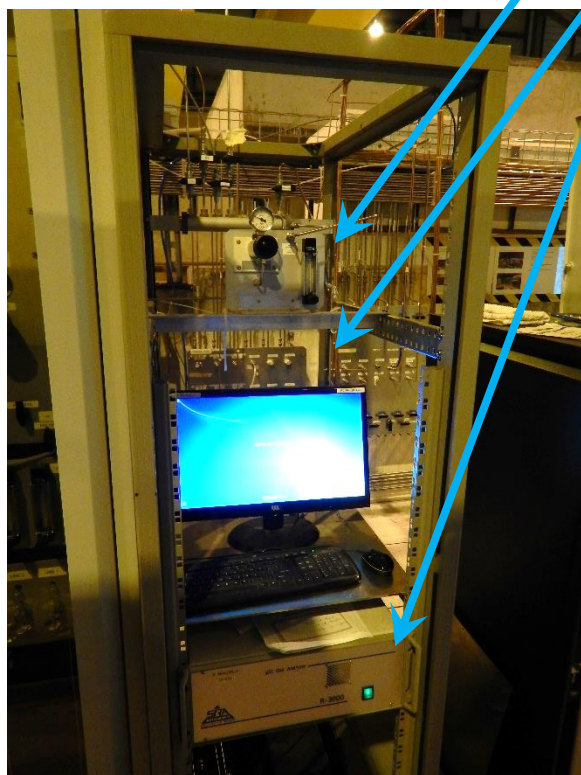


Gas streams connected for
analysis and/or calibration

O₂ analyser

H₂O analyser

- Gas chromatographic analysis: allows monitoring gas mixture composition and presence of impurities on return from detectors under test

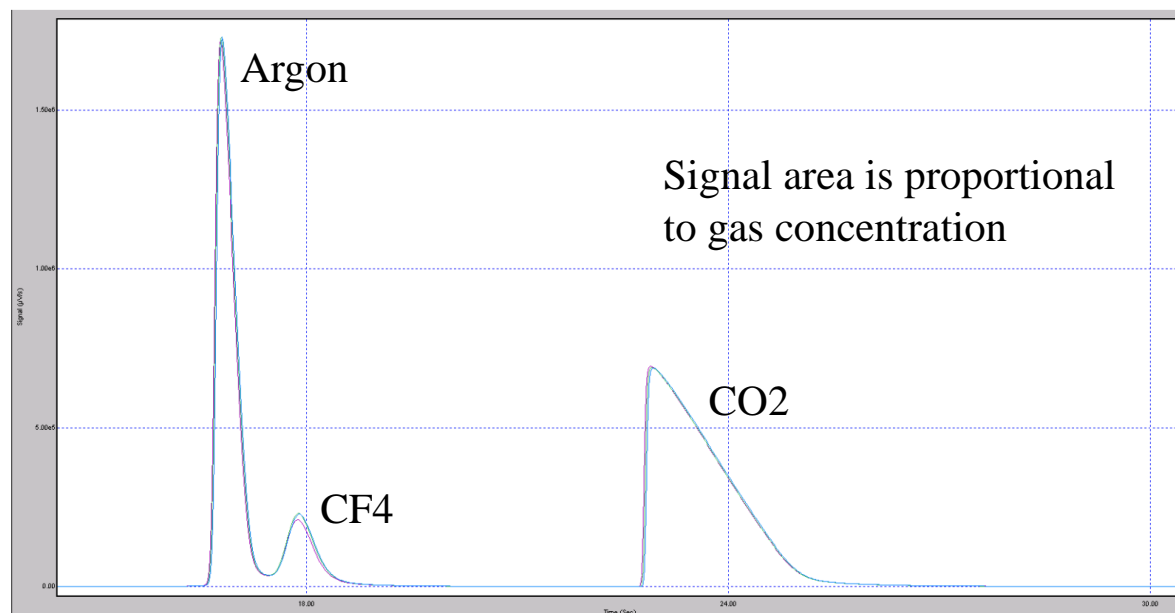


Sampling manifold

PC for GC software controls

GC analyser (3 modules for large spectra gas separation)

Gas chromatogram



- The CERN-GIF++ irradiation facility is operational since 2015:
 - GIF++ is a unique place for detector R&D

- The gas systems infrastructure is a key element of the successful R&D programs performed at GIF++
 - New mixing units and gas recirculation modules have been developed and build for GIF++
 - Further development are ongoing to have systems allowing operation of detectors requiring high gas filtering capacity
 - Design, components and construction procedures follow from experience and development of the gas systems for the LHC experiments
 - Gas analysis and especially gas chromatography are now available to all GIF++ users