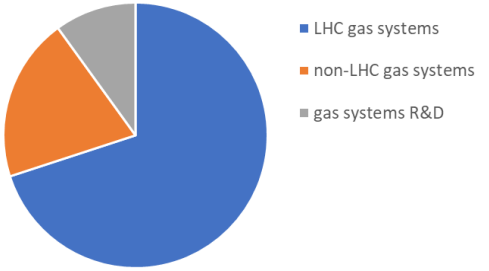
The Gas Systems project

June 22, 2017

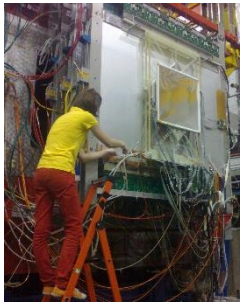
on behalf of the gas team:
Albin, Andrea, Beatrice, Frederic, Kacper, Louis-Philippe, Patrick, Roberto
Students: Giulio, Mara, Vincent, Tomoo
FS (Cooling & Gas) workshop: Abdel, Cedric, Hervé, Jonathan, Vincent

Team

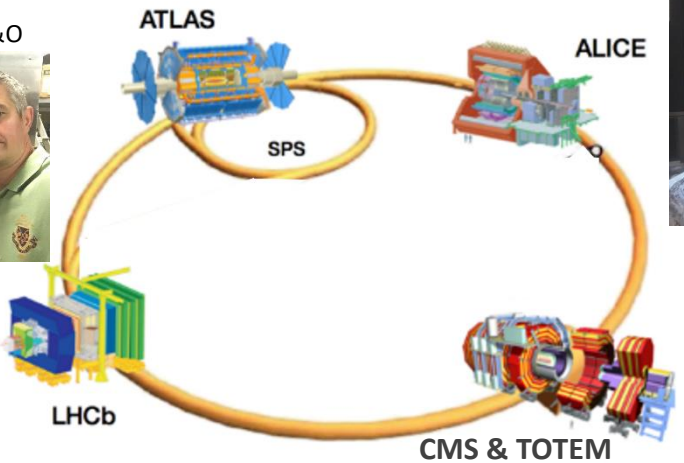


Roberto
Project leader

Beatrice
LHC-M&O and R&D



Frederic*
ATLAS and LHC-M&O

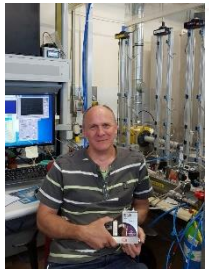


Louis-Philippe
ALICE

Albin

soon on retirement

Patrick
LHCb

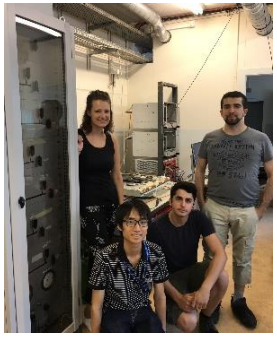


Andrea*
CMS

Kacper

Just arrived to replace Albin

Students
Giulio, Mara, Vincent, Tomoo



FS - Gas & Cooling workshop

* Also involved in other not gas systems projects

Outlook

- The team
- Mandate & expertise
- LHC gas systems
- Non-LHC gas systems
- Project oriented R&D for sustainable operation in the future

Mandate & Expertise

Mandate:

1) **Maintenance, operation and consolidation of the gas systems for the LHC experiments**
2) Design and construction of gas systems for small experiments at CERN
3) Support to users for test beam and debugging (i.e. MFCs calibration, gas analysis, …).
4) Access to ‘standardized gas modules'

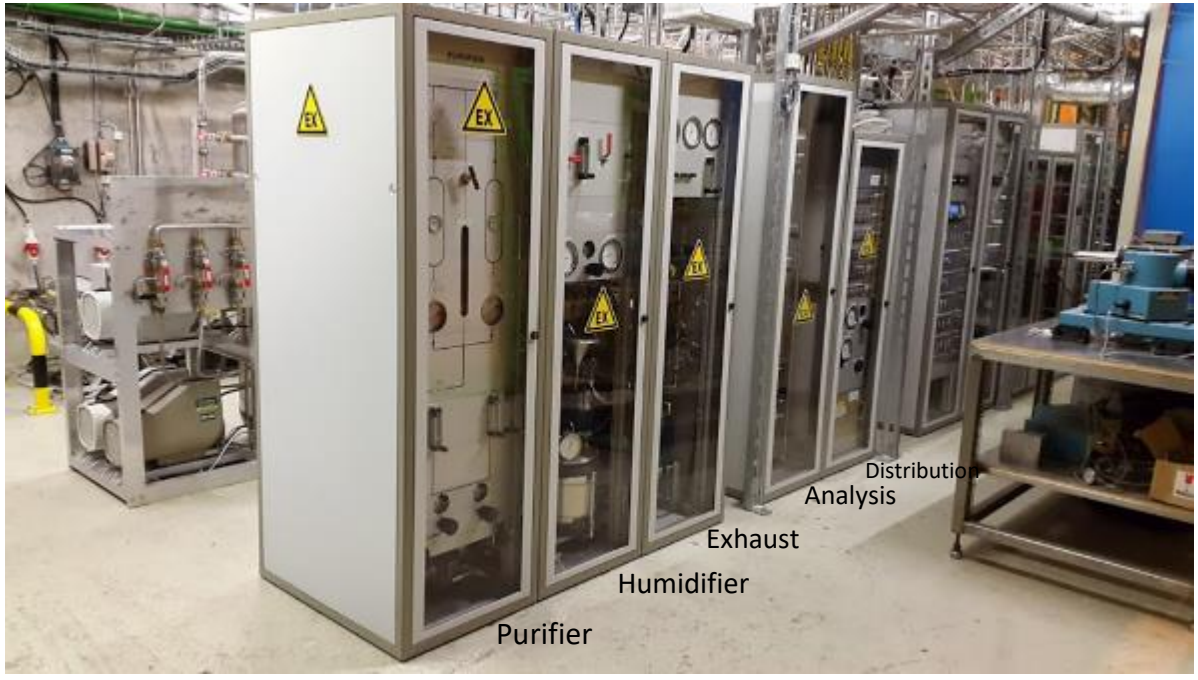
Expertise:

1) **Long experience in developing gas systems for particle detectors: from design to operation and maintenance**
2) Fully automated systems. Software developed in collaboration with BE-ICS.
3) Gas analysis (quality and mixture composition) for good long term detector operation

Gas Systems

- A gas system is:
  - Mixing the different gas components in the appropriate proportion
  - Distributing the mixture to the individual chambers

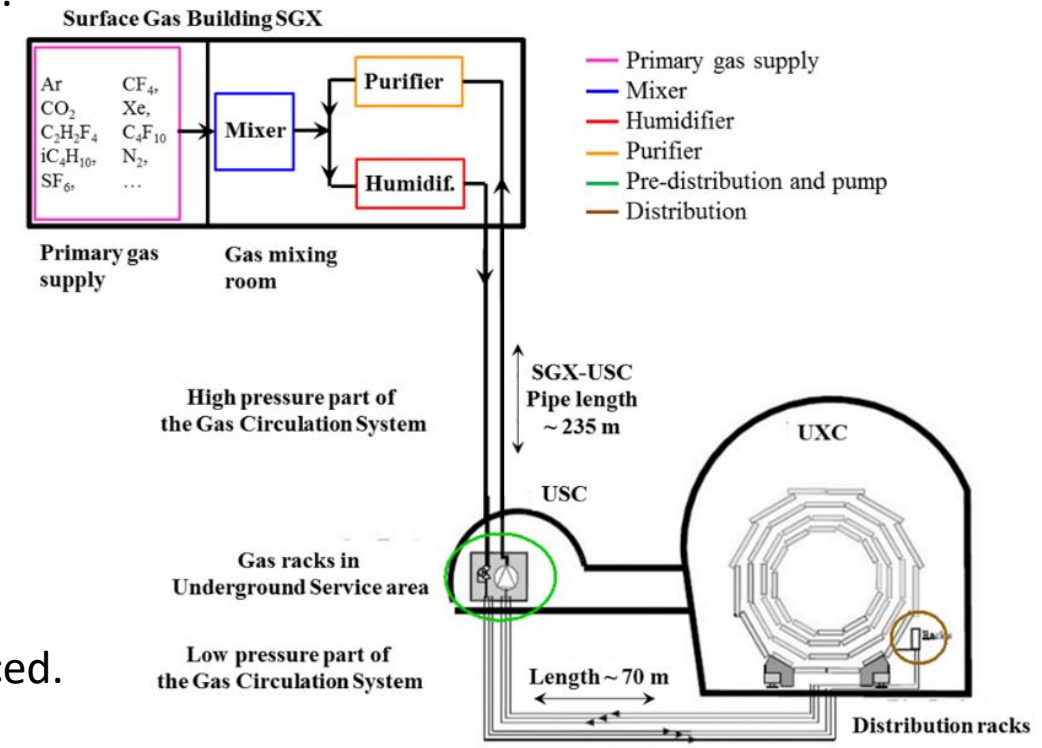
- Gas systems are made of several configurable functional modules (*building blocks*):
  - It simplifies maintenance, operation, training of personnel, …



LHC Gas Systems

Gas systems extend from the surface building to the service balcony on the experiment following: a route few hundred meters long.

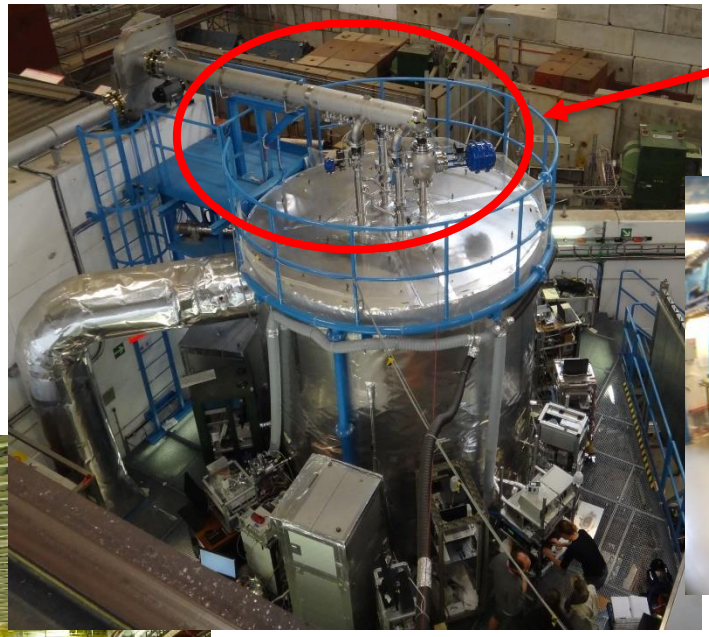
- Gas system distributed in three levels:
  - Surface (SG)
  - Gas Service room (USC)
  - Experimental cavern (UXC)

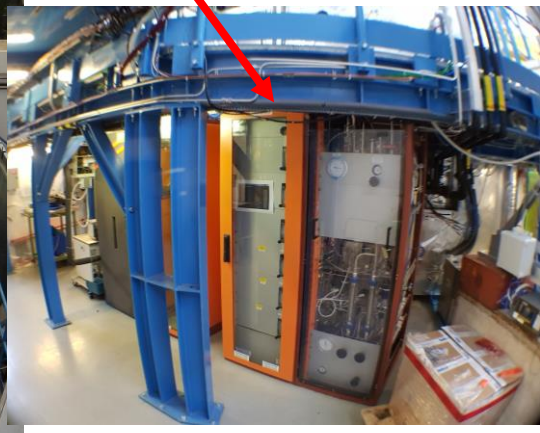


Large detector volume
(from < m^3 to several 100 m^3)
Use of expensive gas components:
(i.e. ALICE-TRD 500 kCHF Xenon for 30 m^3)
→
Complex operation with gas recirculation:
operational costs and gas emissions reduced.

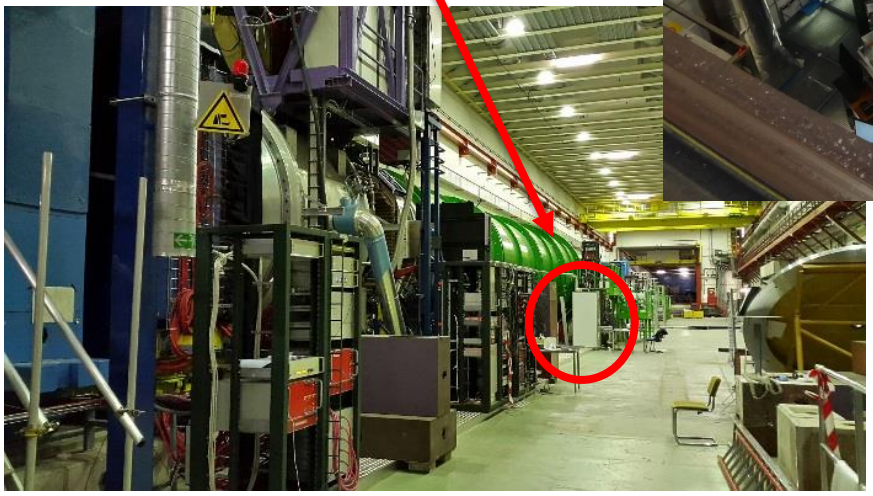
Non-LHC gas systems

CLOUD

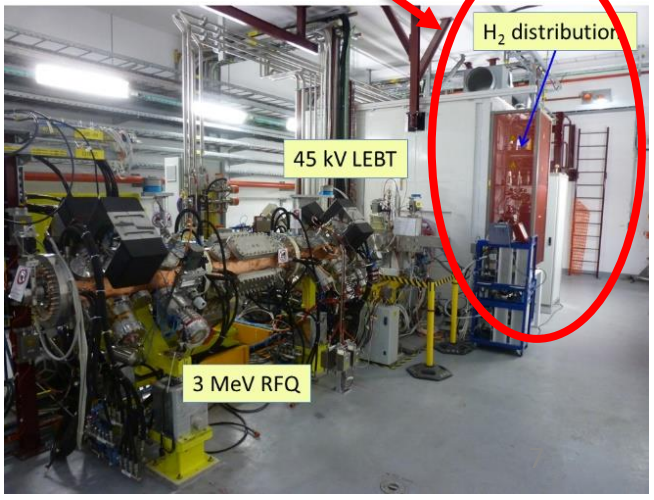




NA62



LINAC4

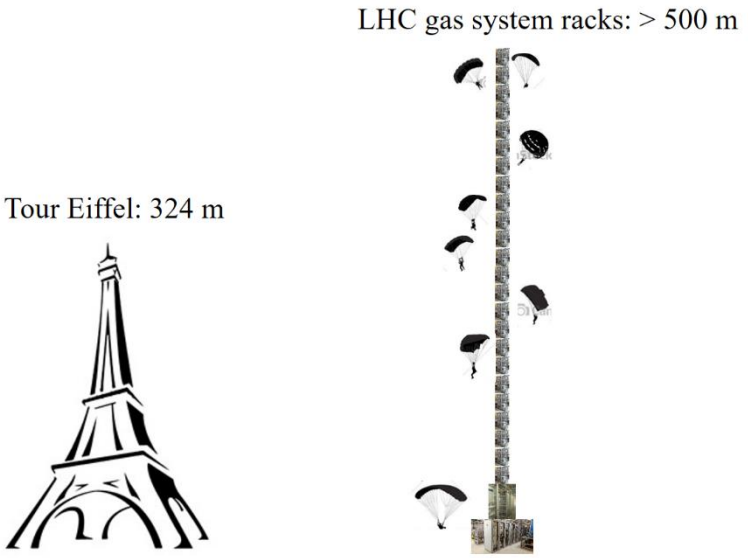


LHC Gas Systems M&O

It is core of our mandate:

30 gas systems, i.e.:

- double the height of the Eiffel tower
- > 1000 interventions recorded in our elog
- > 99.98% availability



EP-DT Detector Technologies

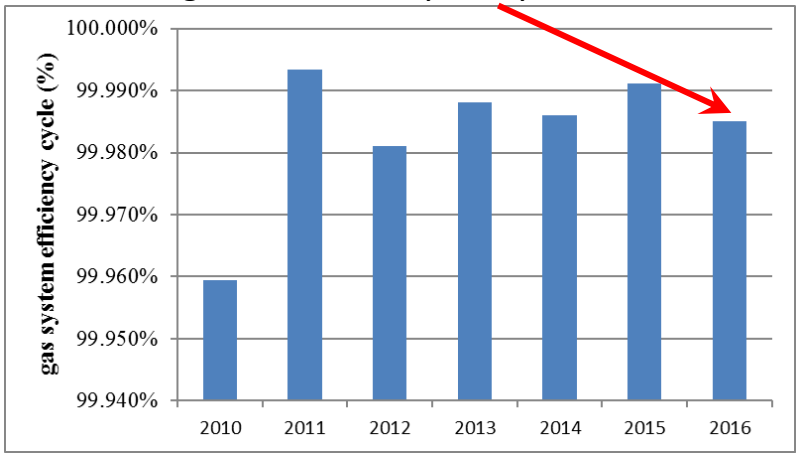
CERN GAS Team eLog

In case of question please contact eLog responsibles: B.Mandelli , A.Diez or G.Candreva

Logbook	Entries	Last submission
Maintenance and Operation		
GASSYSOperation&Maintenance Gas System ELOG Operation (v1.0)	638	19/05/2017, 16:09 by albin wasem
GAS_PIQUET Gas System ELOG Operation (v1.0)	227	20/05/2017, 01:51 by Patrick CARRIÉ
Non-LHC Experiments Gas System ELOG Operation (v1.0)	90	18/05/2017, 19:15 by Patrick CARRIÉ
Material_Borrowed Gas System ELOG Operation (v1.0)	8	18/05/2017, 16:41 by Roberto Guida
New Projects		
CLOUD Gas System ELOG Operation (v1.0)	20	08/11/2016, 15:14 by albin wasem
CLOUD Water Gas System ELOG Operation (v1.0)	3	17/01/2017, 14:23 by Louis-Philippe De Menezes
sClosedLoop Gas System ELOG Operation (v1.0)	12	12/10/2016, 13:43 by Roberto Guida
ATL-sTGC Gas System ELOG Operation (v1.0)	4	12/08/2016, 15:44 by Frederic Merlet
Mixer-IR Gas System ELOG Operation (v1.0)	2	16/09/2016, 22:02 by ALVARO DIEZ GONZALEZ PARDO
Analysis Boxes Gas System ELOG Operation (v1.0)	1	01/08/2016, 13:38 by Louis-Philippe De Menezes
Portable GC Gas System ELOG Operation (v1.0)	3	07/12/2016, 16:12 by ANDREA D'AURIA
CMS_GEM Gas System ELOG Operation (v1.0)	12	26/10/2016, 10:24 by Roberto Guida
MFC Gas System ELOG Operation (v1.0)	62	24/02/2017, 10:35 by vdarras
CF4 Recovery CMS CSC CF4 Recovery eLog	23	05/04/2017, 15:41 by Giulio Candreva
FlowCell Gas System ELOG Operation (v1.0)	3	10/05/2017, 17:07 by Roberto Guida
Gas System Status		
ATLAS ATLAS Gas System Status	1	06/01/2017, 14:52 by Frederic Merlet
CMS CMS Gas System Status	1	16/01/2017, 08:41 by ANDREA D'AURIA
ALICE ALICE Gas System Status	1	06/01/2017, 15:23 by Louis-Philippe De Menezes
LHCb LHCb Gas System Status	1	15/02/2017, 12:21 by Patrick CARRI◆D: 15
TOTEM TOTEM Gas System Status	1	06/01/2017, 16:41 by Giulio Candreva

Gas Systems efficiency

On average less than 1h/year/system of downtime



LHC Gas Systems M&O

Few more numbers:

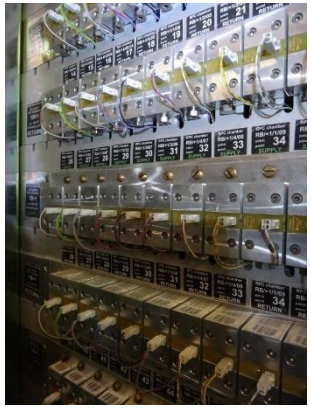
- Construction started in 2000
- Operational since 2005-2006
- 30 gas systems
- 300 Universal Euroracks

Controls module

60 PLCs

Flow meters

4000 in distribution modules

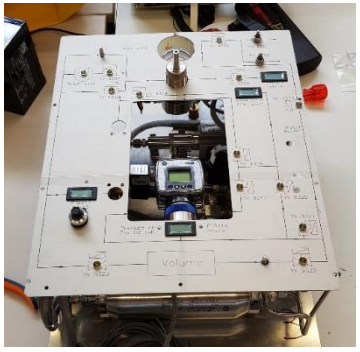


Mass-flow controllers

150 MFCs

Gas analysis

~ 70 gas analyzers and 6 gas chromatographs



Per gas system:

- ~ 2-3 km pipes
- > 1000 connectors and 500 welds
- ~ 40 Pressure sensors
- ~ 10 Regulation valves
- < 0.1 l/h leak rate

LHC Gas Systems and new challenges

- Present detectors will be actors in discovery challenges for many other years
  - Increased level of attention (stability and quality)
  - New requirements for operation (higher flow, more stable pressure, …)
  - Development of new systems (cost and environmental issues)
- Ongoing project oriented R&D activities fundamental to keep current standard on new requirements. Three research lines.
- Support from the experiments is needed to go at full speed and deliver on-time

1) Detector operation and mixture purification with new recirculation systems at HL-LHC

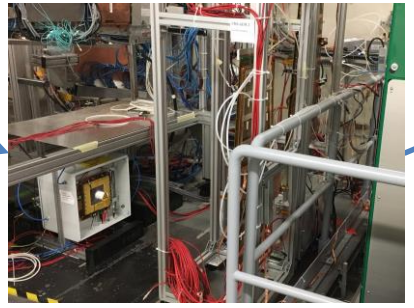
Example: Gas recirculation system for GEM

Tests in Lab
2013-2015

LHCb-GEM upgrade:
2016

operational cost and gas emission reduced

GEM @ GIF++
2016



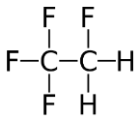
GEM @ HL-LHC ?

Generic R&D on GEM
→ GDD team

2) Gas systems for new environmental friendly gases

Greenhouse gases are responsible for the greenhouse effect.

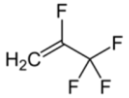
GHG gases are used in particle detection.



R134a

GWP 1430

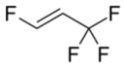
«green» alternatives



HFO-1234yf (flam)

($C_3H_2F_4$)

GWP 4



HFO-1234ze

($C_3H_2F_4$)

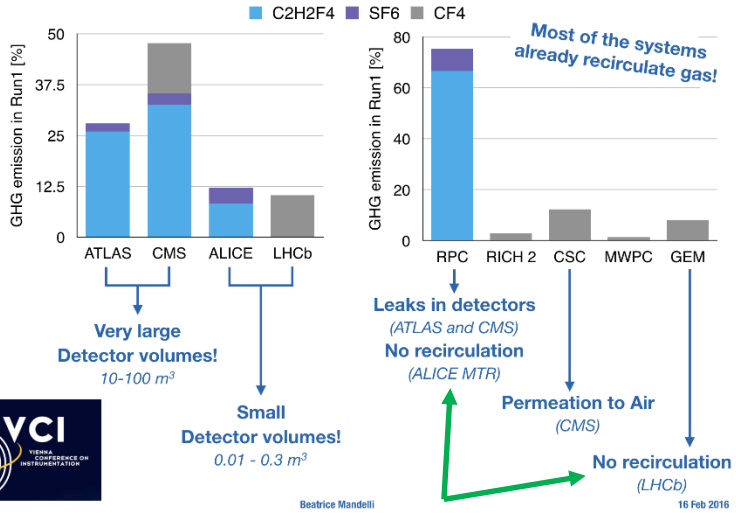
GWP 6

Other GHG used:

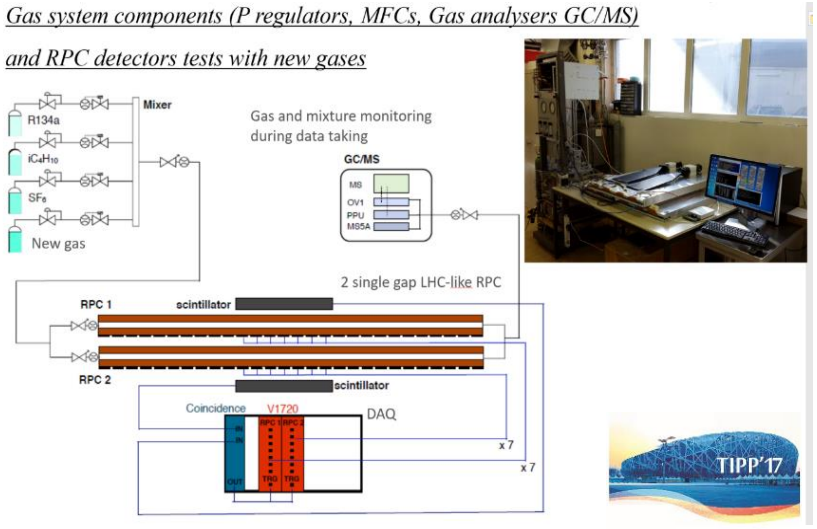
GAS	GWP
SF_6	22900
CF_4	5700
C_4F_{10}	7000

GWP = Global warming potential: relative measure of how much heat a GHG traps in the atmosphere

Where does the GHG emission come from?



Improved with gas system upgrades (2014-2016)



Summary

Several gas system components tested successfully

More than 50 different mixtures testes. Most relevant results summarized below.

Mixture	Chem. Struct.	GWPmix	HV (V)	Strem (%)
R32 -iC4H10 4.5 - SF6 0.6	C	1027	7500	14.0
R134a -iC4H10 4.5 - SF6 0.3	**C-C**	**1491**	**9581**	**1.5**
R152a -iC4H10 4.5 - SF6 0.6	C-C	430	10000	10.0
R245fa -iC4H10 4.5 - SF6 0.6 - He 50	C-C-C	1263	6666	20.0
HFO1234 -iC4H10 5 - SF6 0.3 - Ar 42.5	C=C-C	134	8900	70.0
HFO1234 -iC4H10 4.5 - SF6 0.6 - He 50	C=C-C	373	9020	22.0
HFO1234 - R134a 37.45 - iC4H10 4.5 - SF6 0.6 - He 20	**C=C-C**	**889**	**10450**	**1.8**
HFO1234 - R134a 40.1 - iC4H10 4.5 - SF6 0.6 - He 20	C=C-C	726	10500	8.0
HFO1234 - R134a 50 - iC4H10 4.5 - SF6 0.6 - He 20	C=C-C	434	10800	50.0

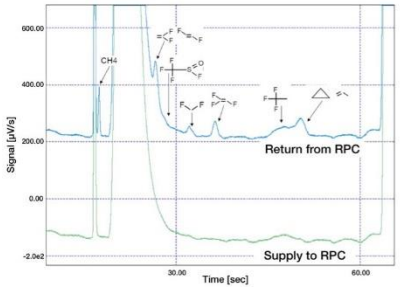
3) Gas systems project oriented R&D

Very close to gas systems operation. Main topics are:

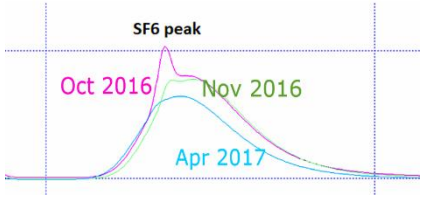
. Upgrade and consolidation of current systems

ALICE-MTR,
LHCb-GEM,
Several modules,
…

. Gas analysis:
Day to day detector and gas system operation



GC-MS, O_2, H_2O, IR, …



. New or upgrade of gas recuperation systems

. New developments → portable gas recirculation systems (for detector R&D, GIF, …)

6 modules built

Expensive or GHG gas recuperation
(CMS-CSC CF_4 plant)

Conclusions

- The LHC Gas Systems M&O is the core activity of the team:

Maintenance, operation, consolidation bring a multitude of small projects difficults to handle

- The challenge is well represented by three numbers:
  - double the height of the Eiffel tower
  - > 1000 interventions recorded in our elog
  - > 99.98% availability

- Gas system project oriented R&D program crucial for a good development of present and new systems
  - keep on to fulfil new requirements (including gas recuperation systems to reduce GHG emissions)
  - Development of “portable units” for detectors R&D
  - Gas systems must be ready for using new environmental friendly gases

- A huge thank to everybody in the gas team (staff, students and FSU in the FS workshop) for all the work and the commitment to the project!