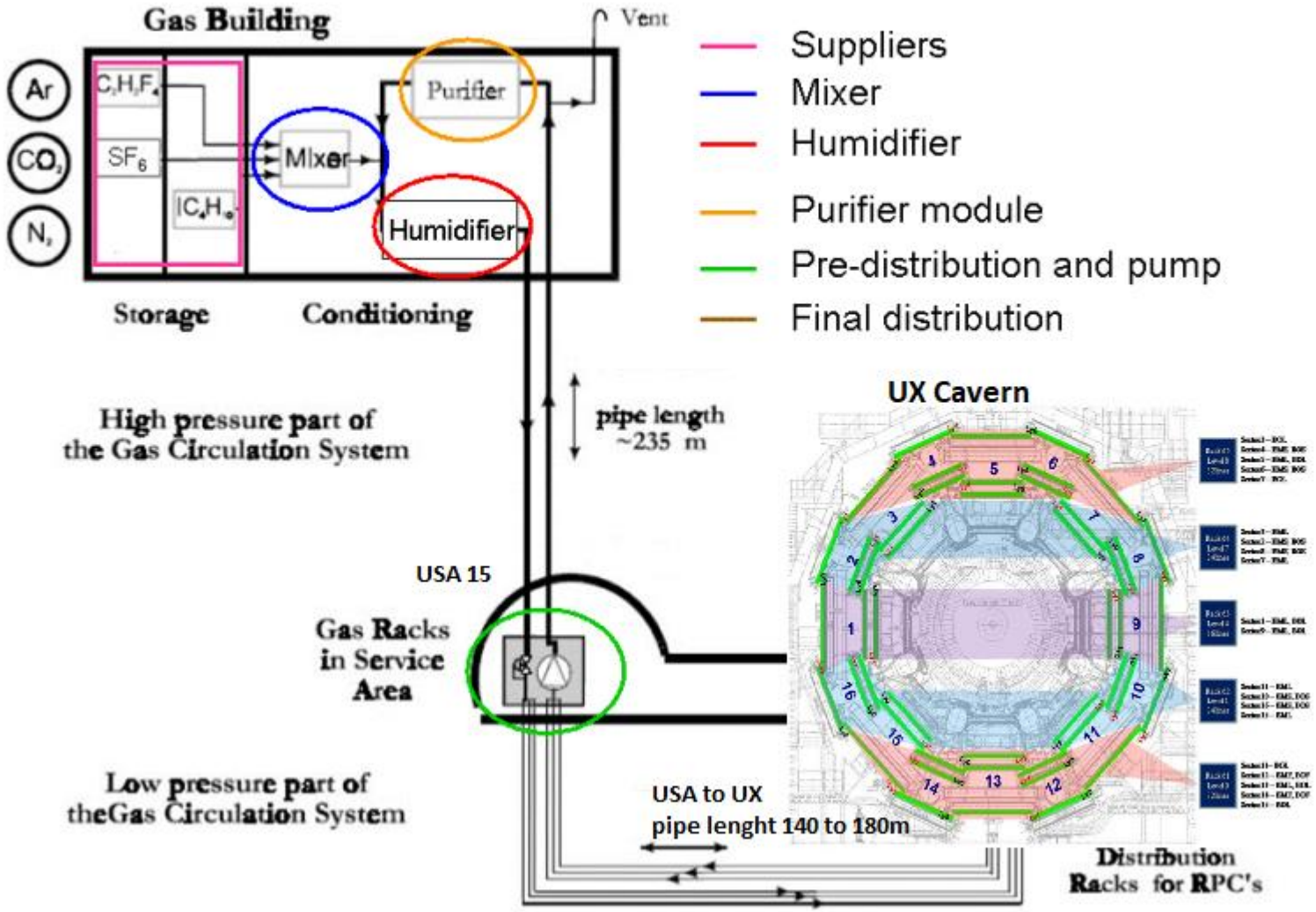
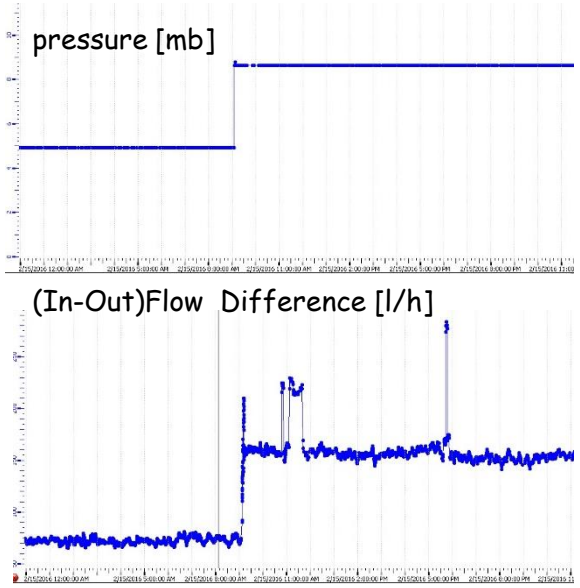
Present Gas system



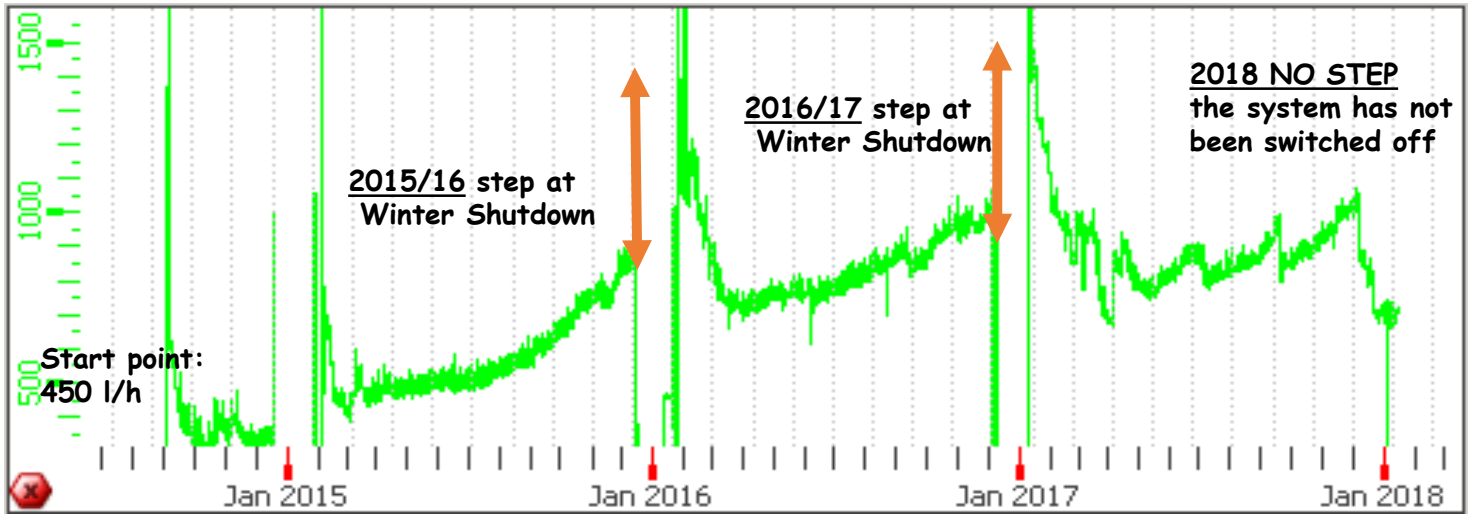
Reasons for upgrading…

- ✓ **The RPC's Gas Inlets are quiet fragile, but:**
- ✓ Many times was observed a strong correlation between abrupt changes of operation pressure and punctual leaks develops.
- ✓ After long start and stop cycles during the EYETS a massive number of new leaking point was developed

Racks62

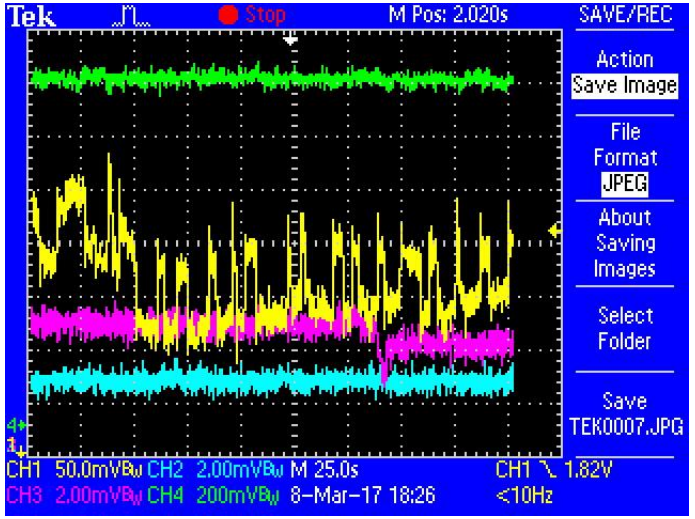


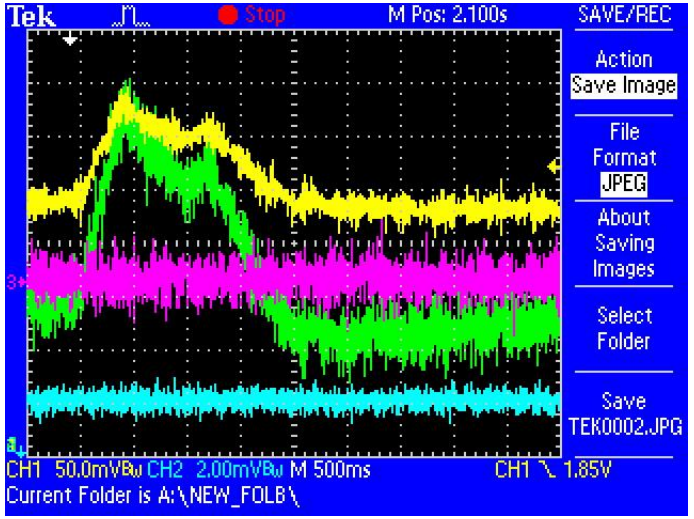
Fresh Gas Consumption loss rate



Pressure spikes and shock waves…

- ✓ Due to the slow response time of the sensors used to monitor the system is it possible that some pressures spike that can damage the chambers are completely invisible?
- ✓ Is there any mechanism that accelerate the inlets breakage rate?

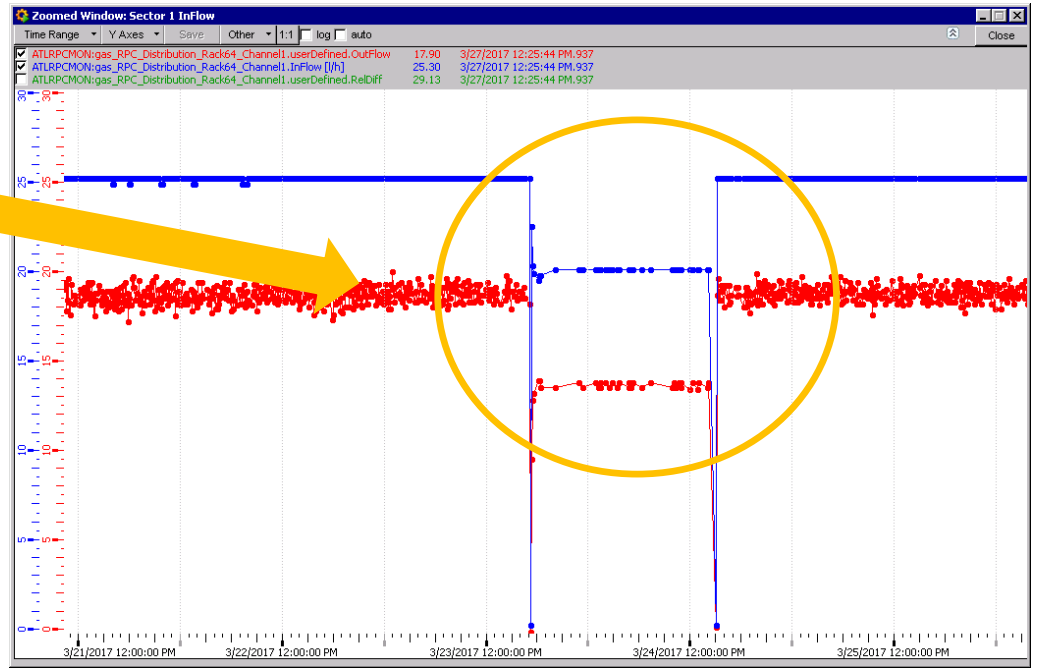




In yellow and green two flow measurements in the output of two different chambers connected at same output manifold

- ✓ By the means of a waveform the output of some Flow sensors was analyzed.
- ✓ Fast pulses were clearly detected at the output of each chambers measured.
- ✓ The rise time of the pulses is about 150ms limited by the integration time of the sensor. The amplitude is 1-5 % of the total flow.
- ✓ The repetition rate of these pulses is quite random is about 15 s

- ✓ An impedance (about 1,5 mb) was installed in the output line the fast noise readout on the chambers flow meter was reduced of 1/5, the same reduction is also visible in the Output Flow Cell slow readout.

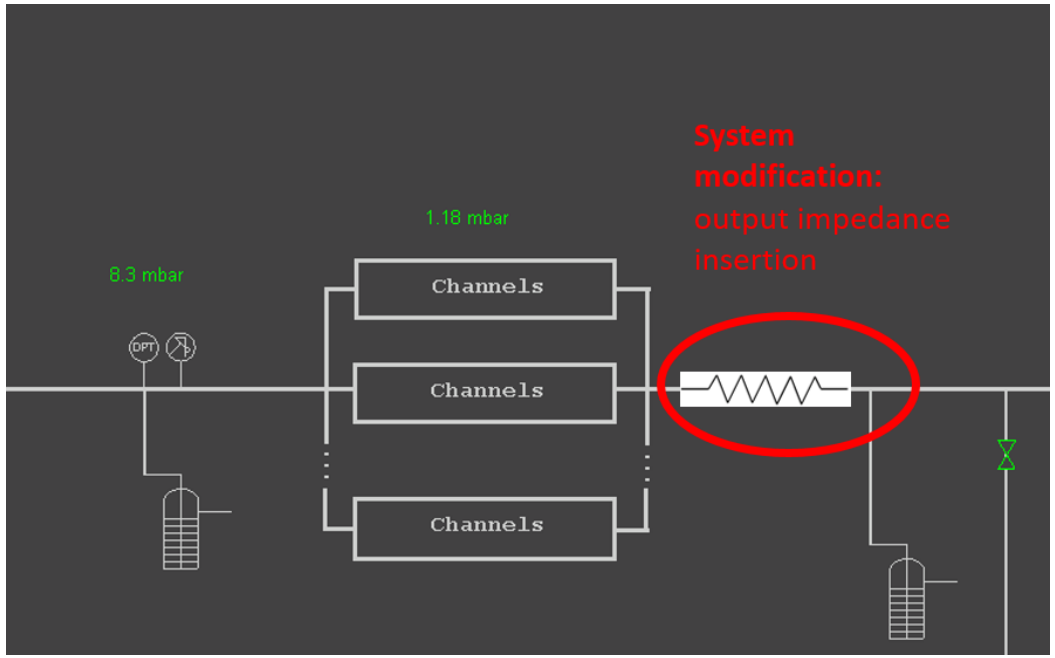


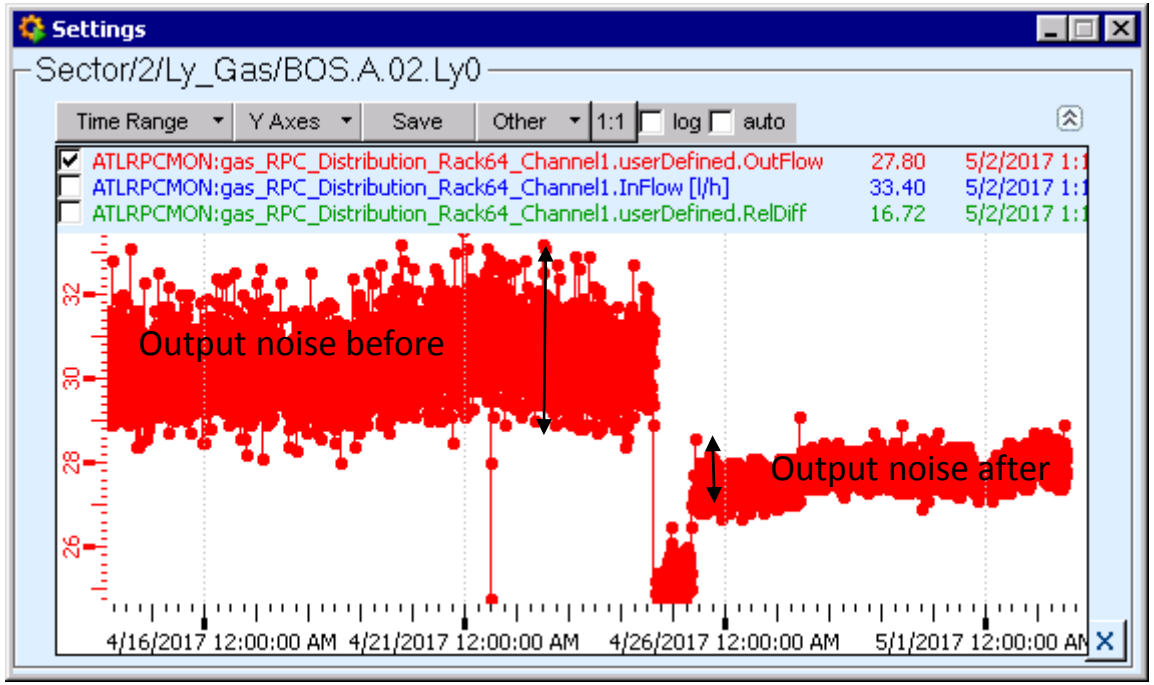
- ✓ The system responsible for the pulses generation has been found in the output pressure regulation loop located in each Rack
- ✓ The amplitude and rate of the pulses train could be lowered with a different setting of the PID parameter, the best PID parameters set compatible with system functionality is under the study of the Gas Group.

It is not possible to give a clear connection between inlets breakage and fast noise but:

- ✓ the inlet fracture happen with a significant statistic excess in the output
- ✓ leak rate seem to increase during the year
- ✓ None of the existing sensor would be able to detect an unwanted high amplitude fast pulse, very fragile inlets apart.

As precautionary principle in two Racks were modified adding an output impedance in 2017.

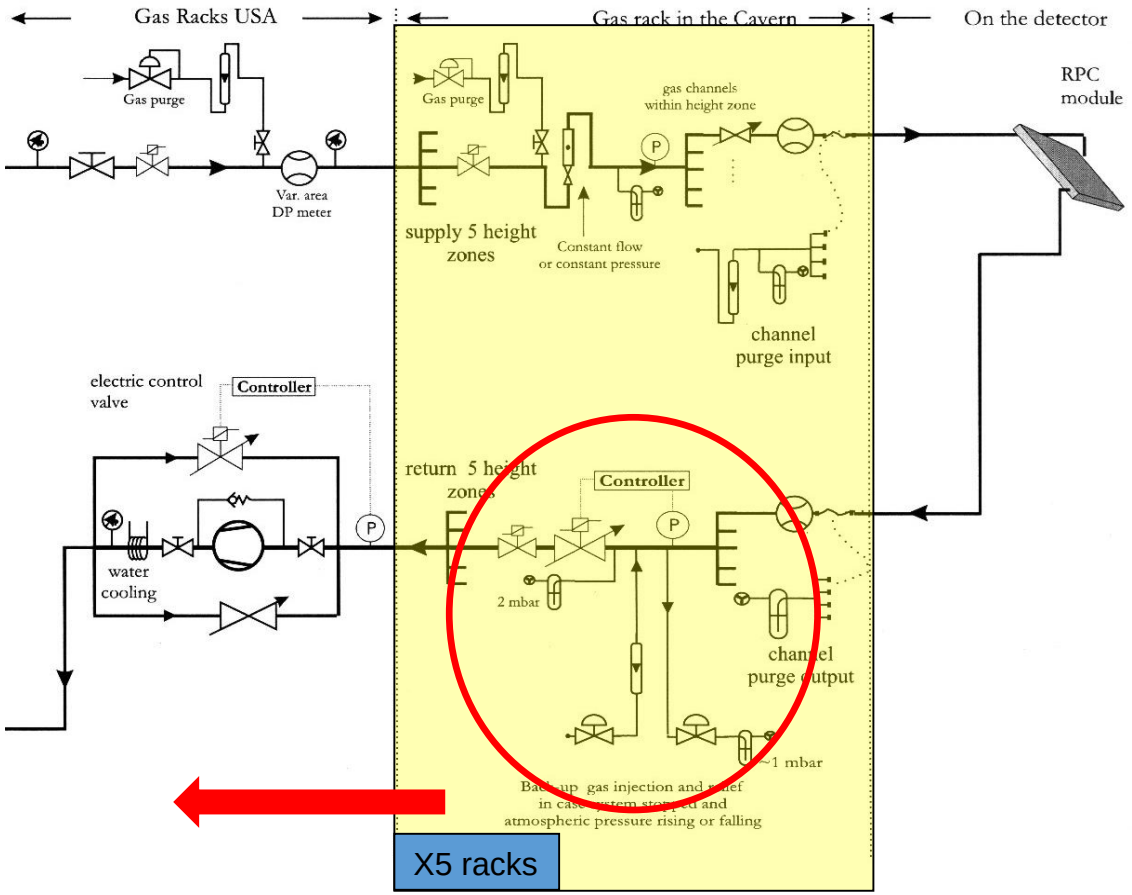




The output noise was halved but it is still not clear if the breakage rate is now lowered.

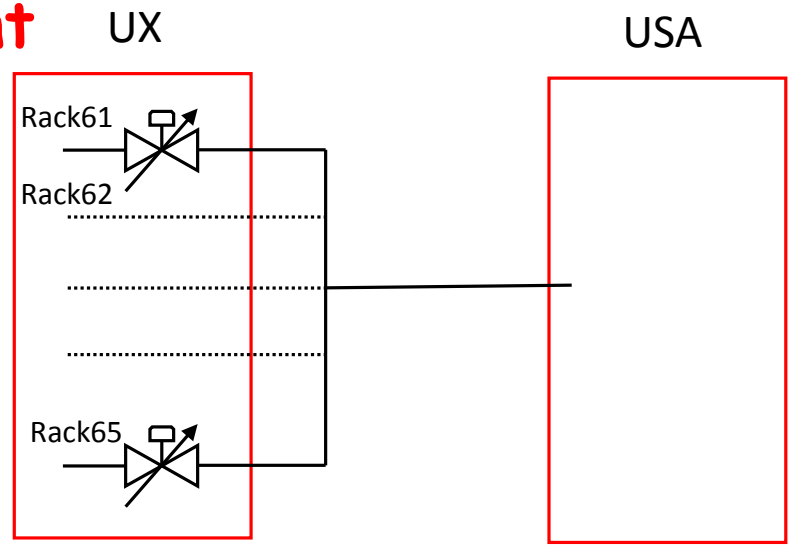
A better mitigation of the output noise was suggested by the Gas Group,

it consists in the movement of the pulses generators as far as possible from the chambers

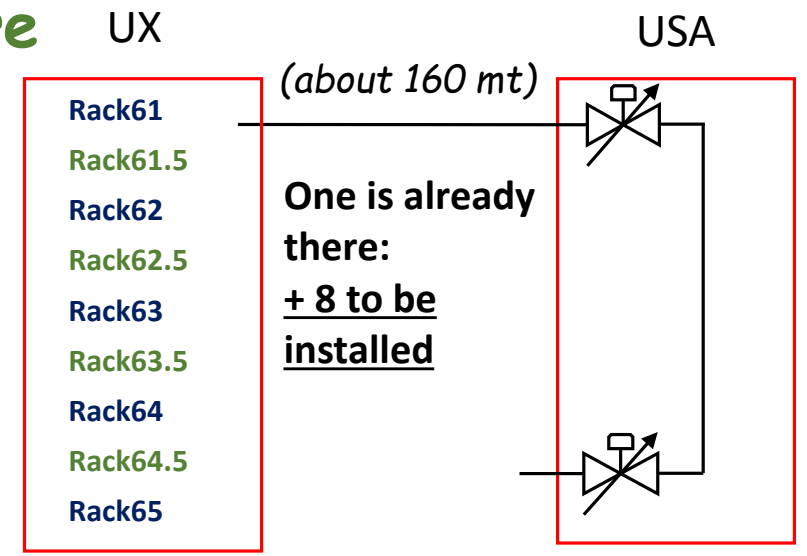


The Output pressure regulator in each Racks has to be moved in USA Gas Room

Present

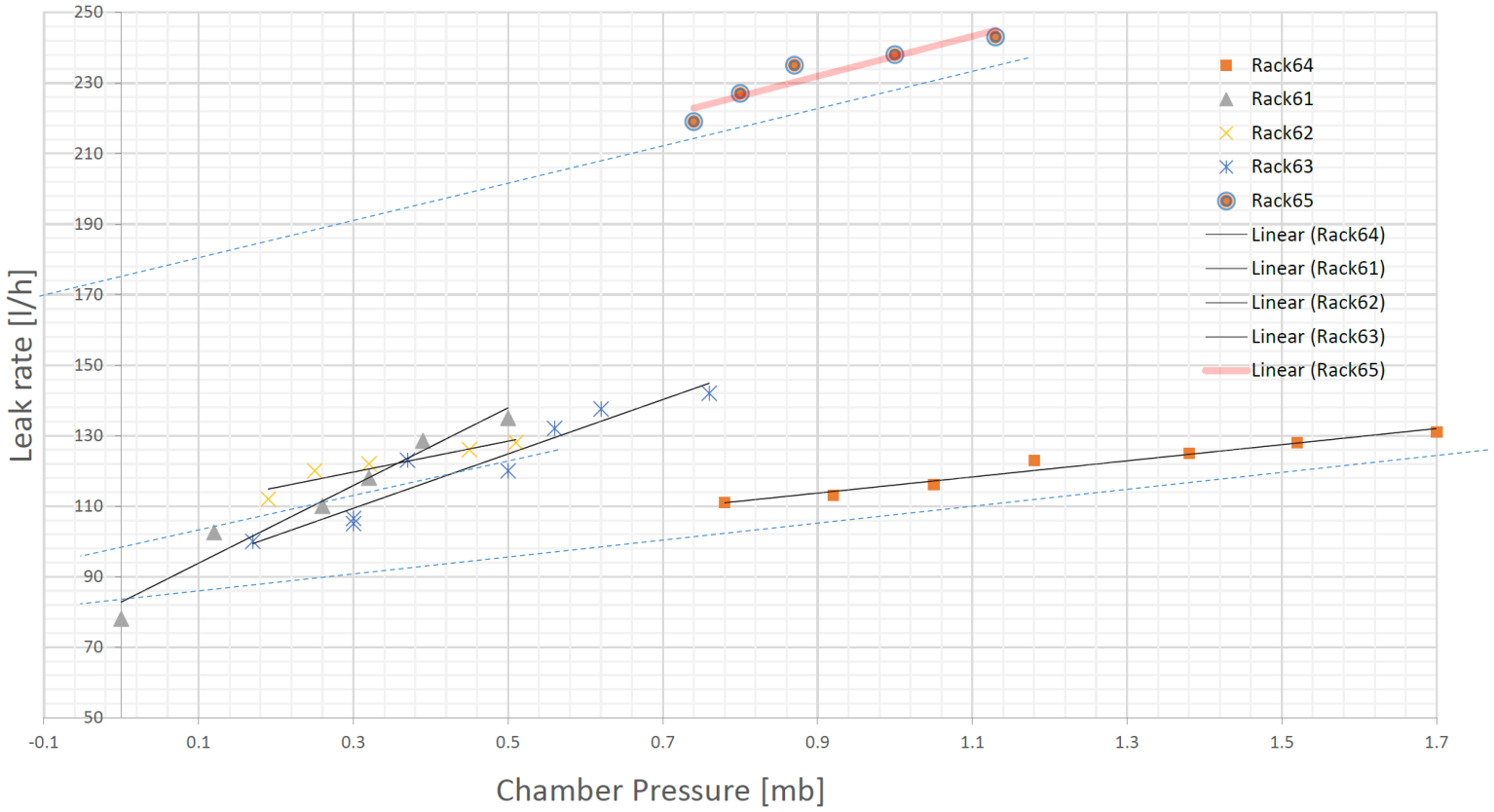


Future



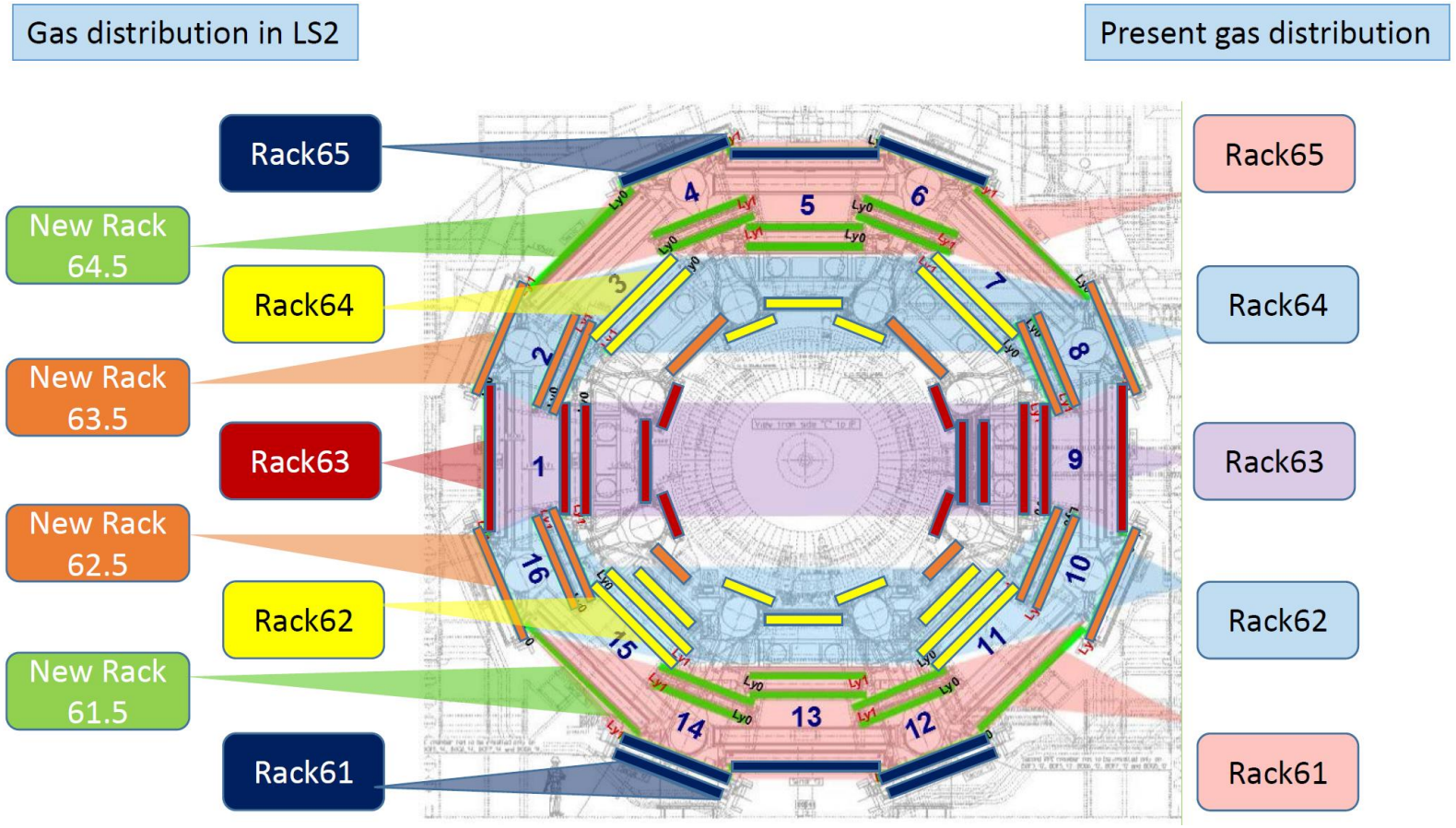
Mitigation of the leaks from cracked inlet

- ✓ The leaking rate of the chambers connected to the system depend from the gas pressure inside the output manifold
- ✓ Several smaller leak in development represent an important fraction of the total leak.



- ✓ There is a linear correlation between the leak rate and the overpressure
- ✓ The overpressure to compensate the hydrostatic pressure is 0.3 mbar/m
- ✓ *Since that pressure chambers below zero is not allowed (possible air intake) the minimum Pmax* has to compensate the hydrostatic pressure of the Gas Mixture, 0.3 mbar/m

New 4 Racks to minimize the pressure inside the chambers



- ✓ The solution is to increase the vertical partition
- ✓ Less DeltaP = less leaks
- ✓ Additional 4 new Racks foreseen in LS2 also useful for the BI project in phase2
- ✓ 56 out 128 manifold to be moved to the new Racks

Manifold to be moved to the new Racks

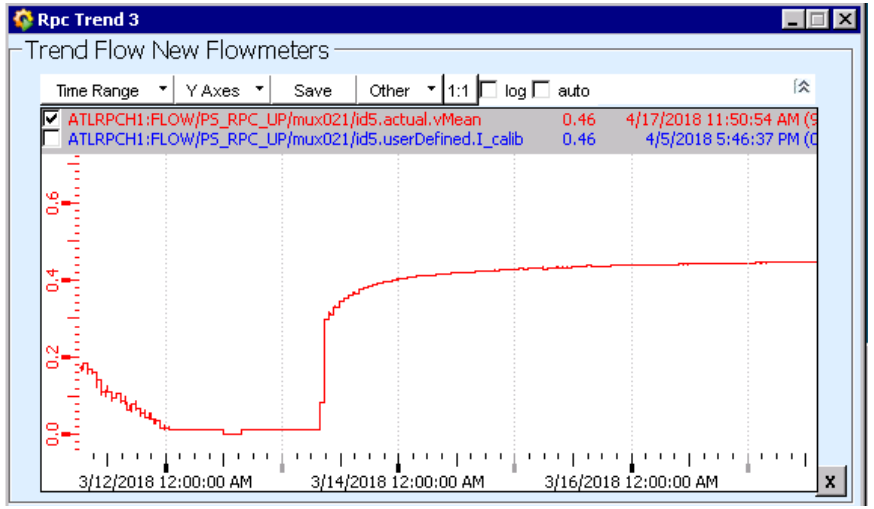
Rack 61	Ch 1	*BOL11A.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 2	*BOL11A.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 3	*BOL11C.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 4	*BOL11C.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 9	*BMS12.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 10	*BMS12.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 11	*BMS12.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 12	*BMS12.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 17	*BML13.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 18	*BML13.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 19	*BML13.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 20	*BML13.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 25	*BMS14.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 26	*BMS14.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 27	*BMS14.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 28	*BMS14.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 29	*BOL15A.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 30	*BOL15A.Ly1*	move to	**Rack 61.5**
Rack 61	Ch 31	*BOL15C.Ly0*	move to	**Rack 61.5**
Rack 61	Ch 32	*BOL15C.Ly1*	move to	**Rack 61.5**
Rack 62	Ch 1	*BOS16A.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 2	*BOS16A.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 3	*BOS16C.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 4	*BOS16C.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 5	*BMS16.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 6	*BMS16.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 7	*BMS16.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 8	*BMS16.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 17	*BMS10.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 18	*BMS10.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 19	*BMS10.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 20	*BMS10.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 21	*BOS10A.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 22	*BOS10A.Ly1*	move to	**Rack 62.5**
Rack 62	Ch 23	*BOS10C.Ly0*	move to	**Rack 62.5**
Rack 62	Ch 24	*BOS10C.Ly1*	move to	**Rack 62.5**

Rack 64	Ch 1	*BOS2A.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 2	*BOS2A.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 3	*BOS2C.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 4	*BOS2C.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 5	*BMS2.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 6	*BMS2.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 7	*BMS2.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 8	*BMS2.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 17	*BMS8.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 18	*BMS8.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 19	*BMS8.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 20	*BMS8.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 21	*BOS8A.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 22	*BOS8A.Ly1*	move to	**Rack 63.5**
Rack 64	Ch 23	*BOS8C.Ly0*	move to	**Rack 63.5**
Rack 64	Ch 24	*BOS8C.Ly1*	move to	**Rack 63.5**
Rack 65	Ch 1	*BOL3A.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 2	*BOL3A.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 3	*BOL3C.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 4	*BOL3C.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 9	*BMS4.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 10	*BMS4.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 11	*BMS4.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 12	*BMS4.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 17	*BML5.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 18	*BML5.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 19	*BML5.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 20	*BML5.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 29	*BOL7A.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 30	*BOL7A.Ly1*	move to	**Rack 64.5**
Rack 65	Ch 31	*BOL7C.Ly0*	move to	**Rack 64.5**
Rack 65	Ch 32	*BOL7C.Ly1*	move to	**Rack 64.5**

The Rack 63 is unchanged because is connected only to vertical chamber. In the Racks 62, 62.5, 63, 63.5, 64 will be connected in phase 2 to the new 48 manifold for the BI project

Another leaking mitigation strategy: Check valves

- ✓ The yearly leak rate increasing should be reduced installing a check valve to prevent the reverse flow in the output of each chamber.
- ✓ A valve with a crack pressure below 1 mb is not commercially available.
- ✓ A possible design for the valve consists in a very light Mylar flag
- ✓ A first prototype was built and successful installed, but the possibility to extend the project over the whole system (about 1260 pcs. to be installed closed to the chambers output) should be carefully evaluated.
- ✓ The expected amount of gas saved could increase in case of long term access restriction or multiple loss chambers.



Summary of Gas System upgrades costs

ISSUE	UPGRADE		Responsibility		TOT. KCHF
Shockwave	Movement of pressure regulators in USA	New Rack in USA	Gas Group		75 ?
		Pipe from UX to USA	Gas Group	?	?
Chamber pressure lowering	4 new Racks	Racks	Gas Group	75 KCHF x4	300
		Pipe movement between Racks x56	TC + Muon RPC	?	?
				Total	**550 ?**

LS2 Gas ordinary maintenance and repairs

✓ Inlet fixing

- 183 Gas layer still to be fixed (33 not easy or impossible)
- 6 new ruptures by the end of this EYETS
- Improved fixing technique and tools would be developed but also difficult cases are increasing

✓ BIS 7,8 piping

- The impedances, the connections and pipes for the new 32 x 3= 96 Gas Layers have to be provided and installed (total cost about 4KCHF)

✓ Broken sensors replacement

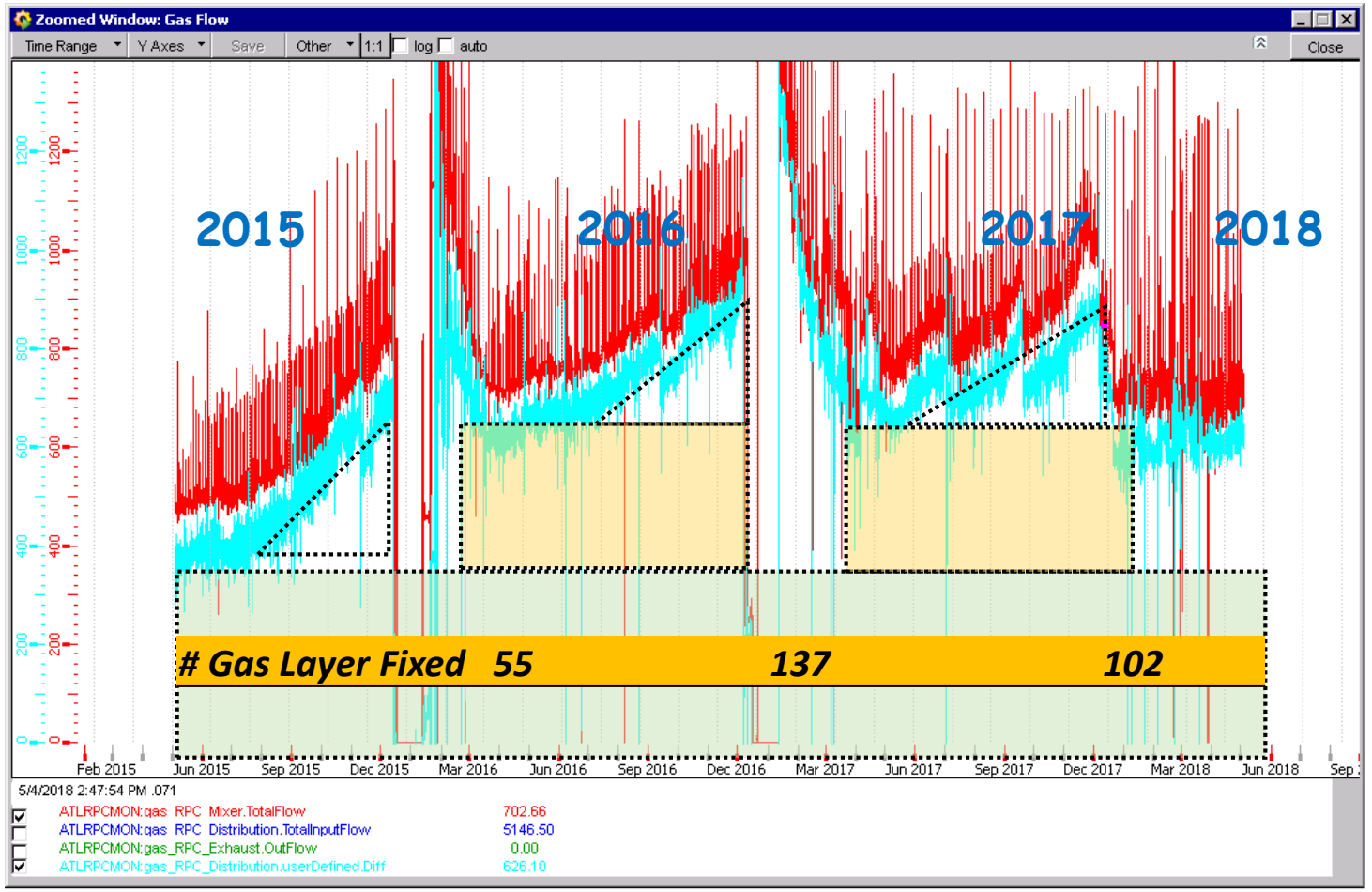
- About 20 out of 1200 Flow sensors has to be provided and replaced (50 spare parts 1.9 CHF)
- A mechanical protection for the more exposed flow meter should be designed, provided and installed.

Requirements

- ✓At least 2 team of two or three people working for 1.5 year in the gas inlet fixing. **The presence of the very skilled Russian Team will be essential** (not enough skilled people available new people are welcome)
- ✓The whole system should be kept continuously under DCS control flowing the chambers with an inert humidified gas
- ✓For the tests and the gas leak detection **during the working hours at least one Racks should be flowed with a TFE mixture**.
- ✓A test stand with glue dispensers should be deployed for new technique development, new material test end for teams training
- ✓**Financial supports should be guaranteed for all the material and the involved people as soon as possible**

BACKUP SLIDES

History, present status, future…



Gas Consumption

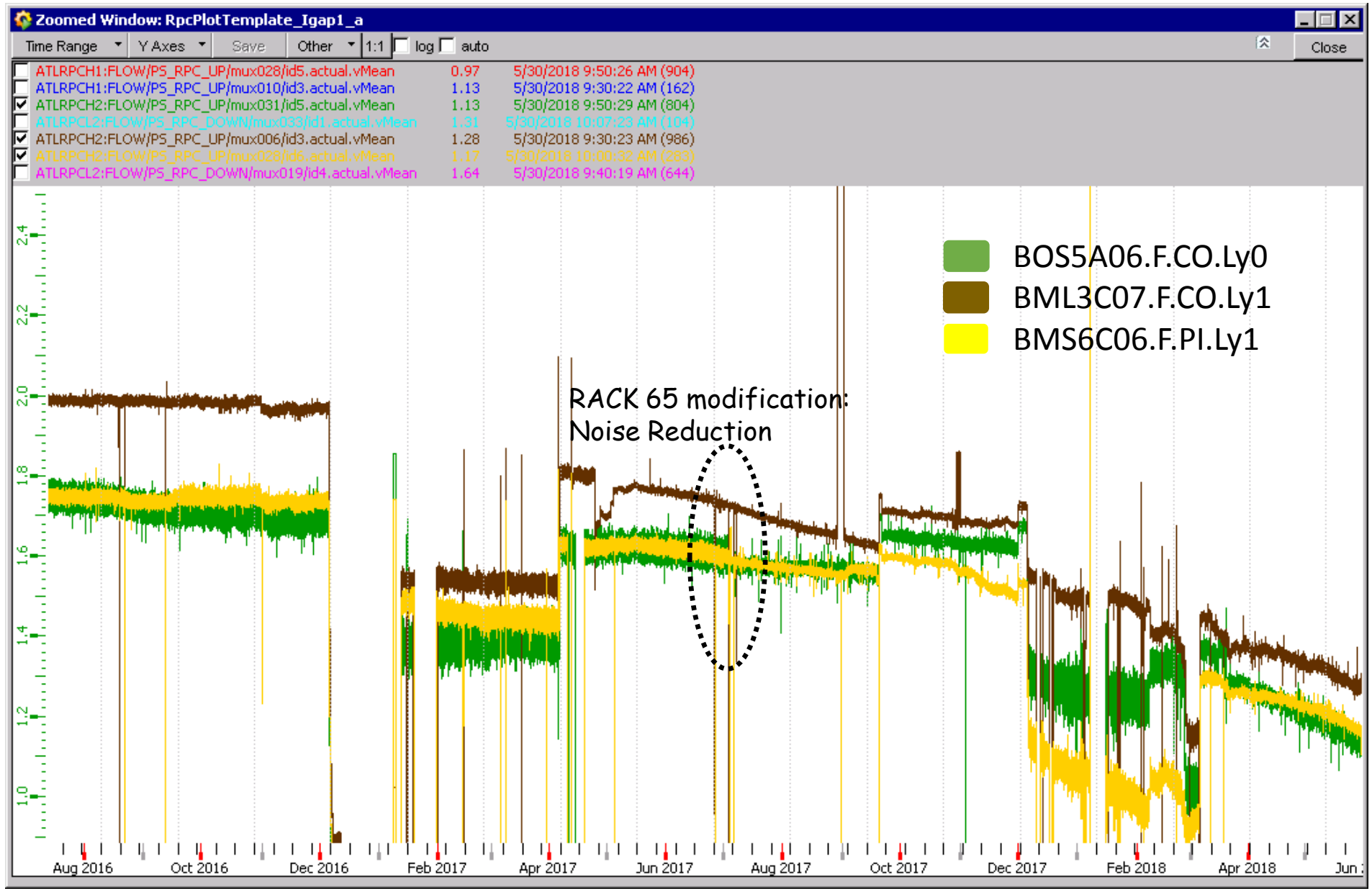
Yearly increase

Not repaired from previous year

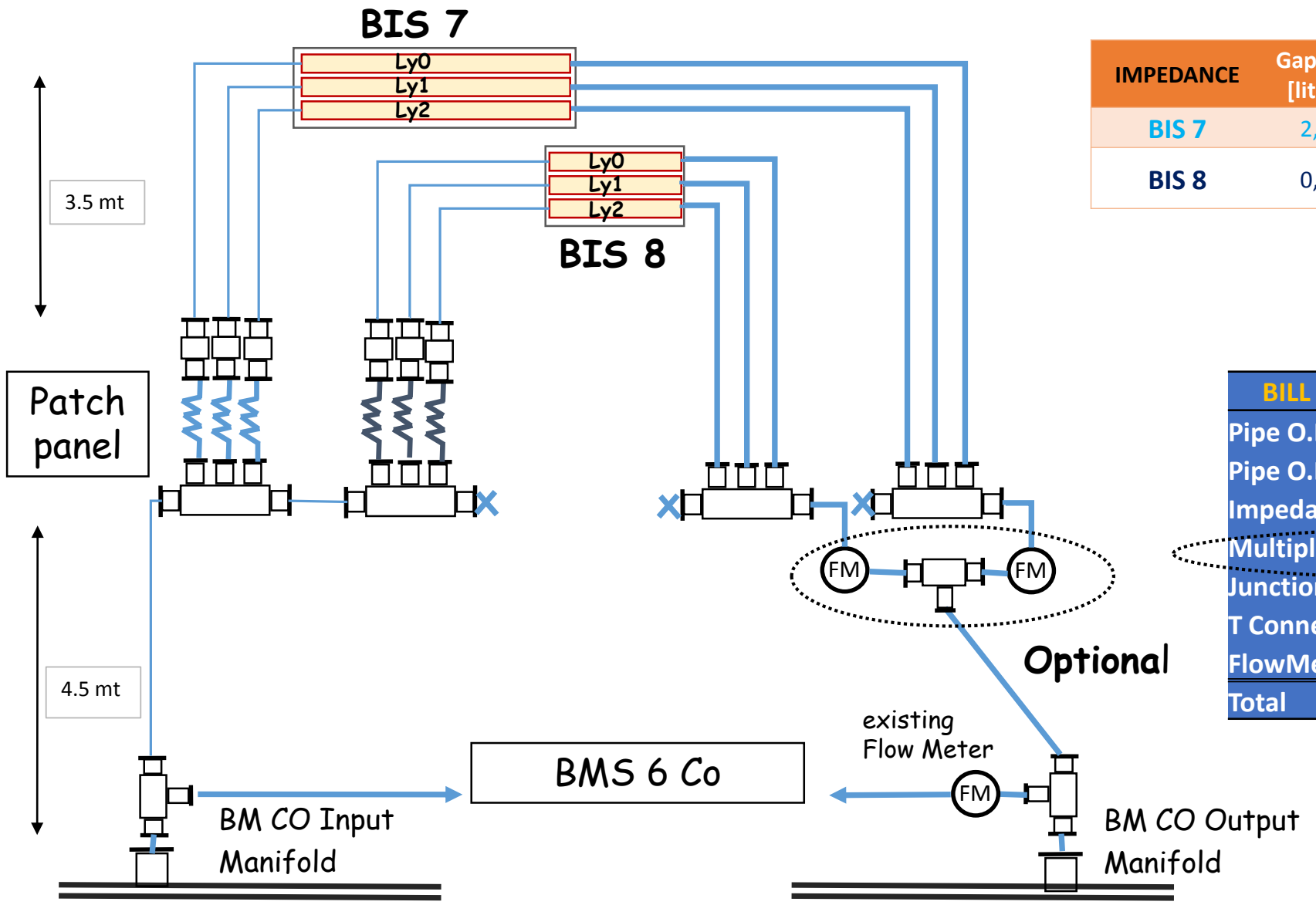
Natural limit ?

LS1 **LS2** **?**

Long term leak development



BIS 7/8 Gas System



IMPEDANCE	Gap Vol [liter]	Type	l/h @ 8mb	Change per hour	Needle type
BIS 7	2,1	6	2,0	0,9	KDS 2512P
BIS 8	0,8	0	0,8	1,0	2 x TC-TE7250050PK

BILL OF MATERIAL	Total	EU/unit	Tot.
Pipe O.D. 4mm	400	1	400
Pipe O.D. 6mm	550	1	550
Impedance	110		0
Multiple tee	70	15	1050
Junction	120	3	360
T Connection	70	3,5	175
FlowMeter + Connector	40	40	1600
Total			4135