



# Update on RICH activities

Fulvio Tassarotto ( I.N.F.N. – Trieste )

**The 2017 run MAPMT status**

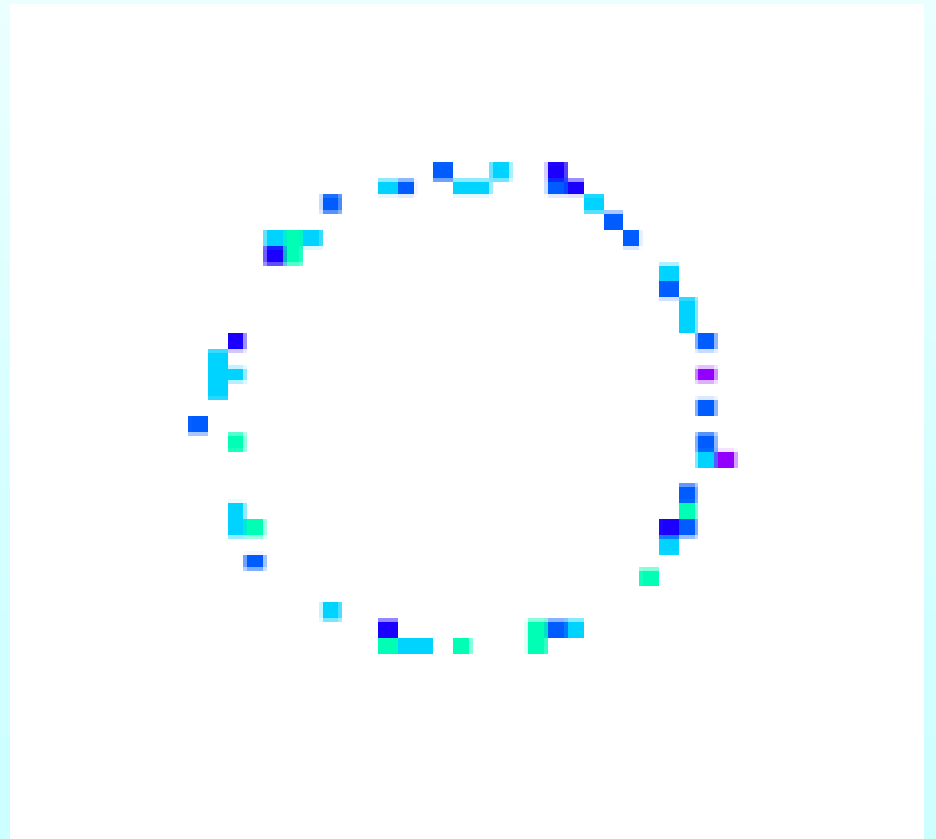
**The RICH-1 gas radiator status**

**The HYBRID PDs status**

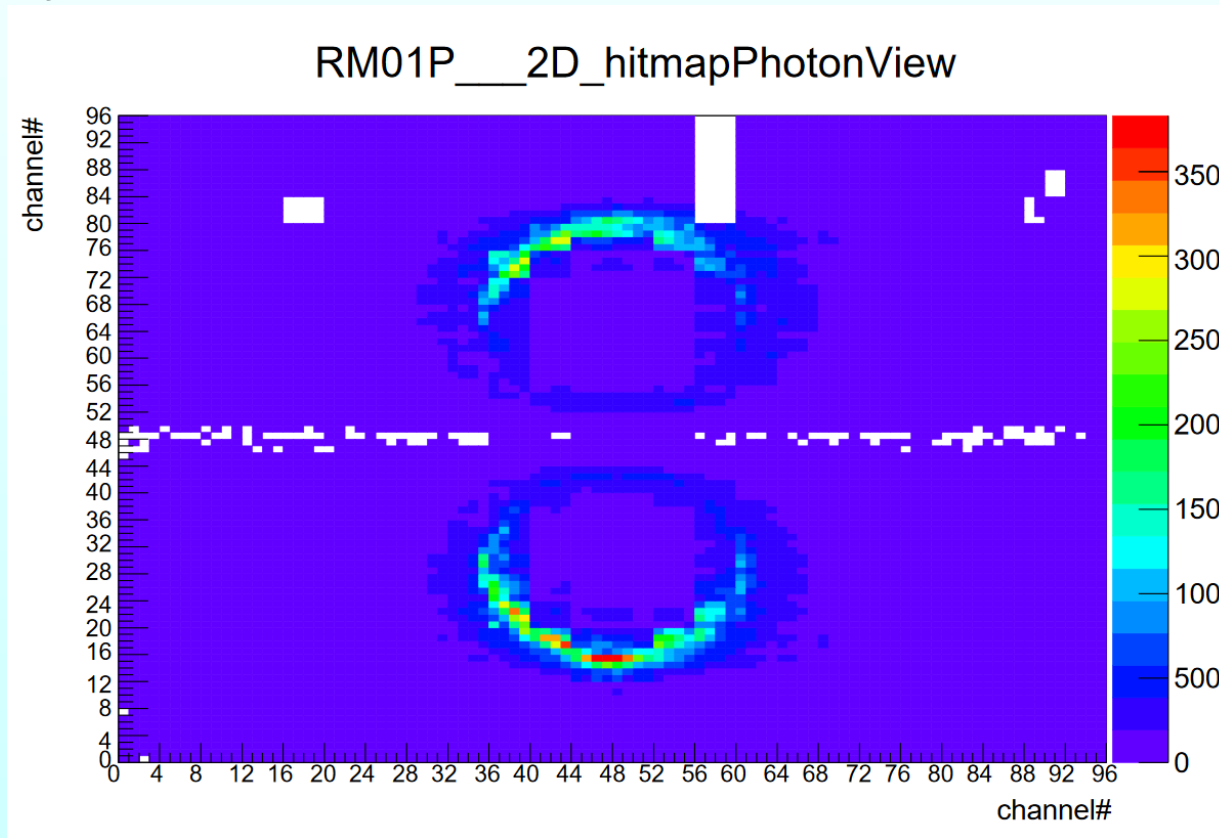
**The gaschromatography**

**Preliminary analysis of our gas**

**Next steps**



At the beginning of the run all MAPMTs and all DREISAMs were checked to be o.k. presently 1 DREISAM sends no data (roof problem?) and 1 MAPMT is missing



**SLIDE  
FROM  
LAST  
TB**

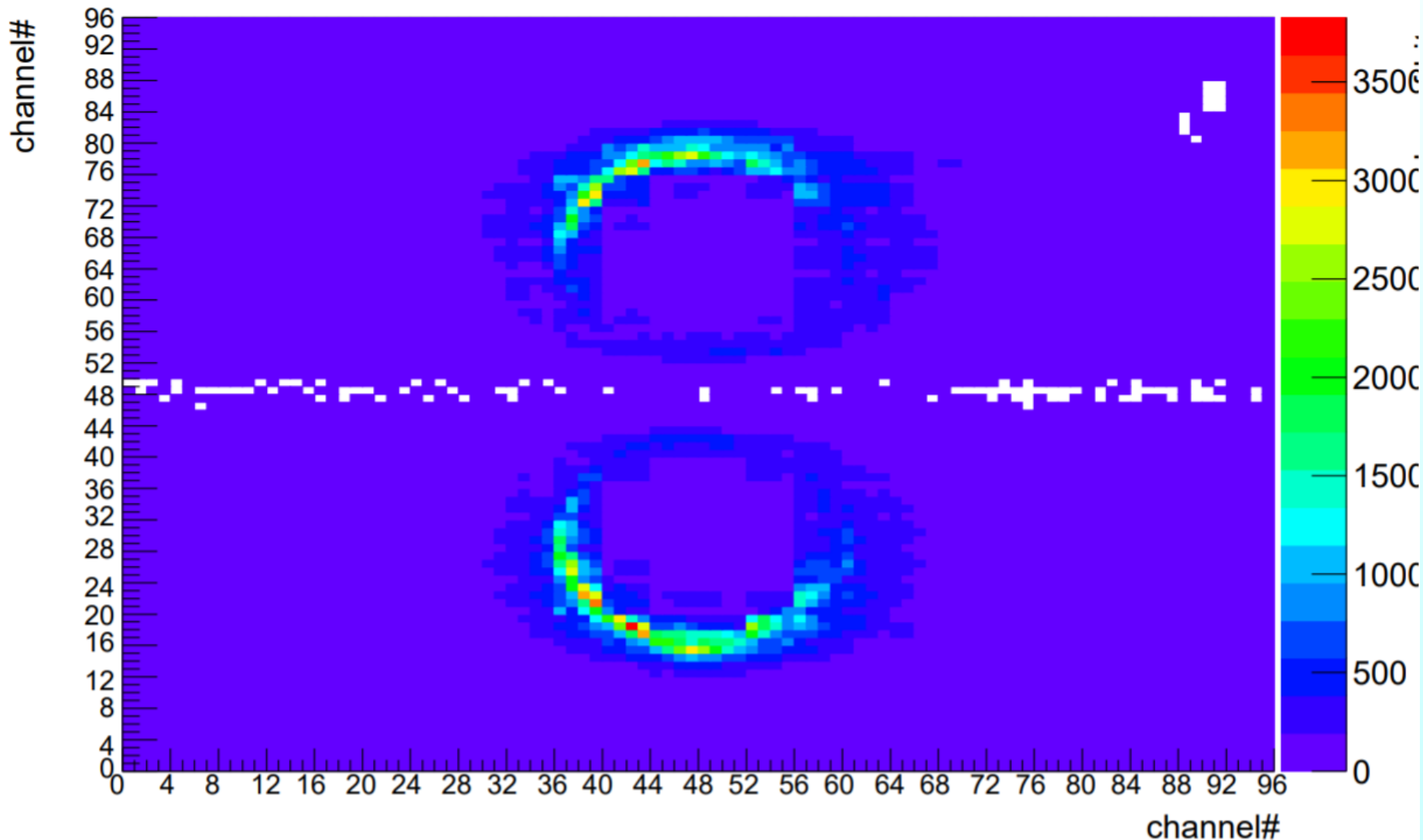
**1% of the active surface is off.**

**To fix it access in front of the RICH is needed. We are ready to do it.**



# MAPMTs status now

## RM01P\_\_\_2D\_hitmapPhotonView





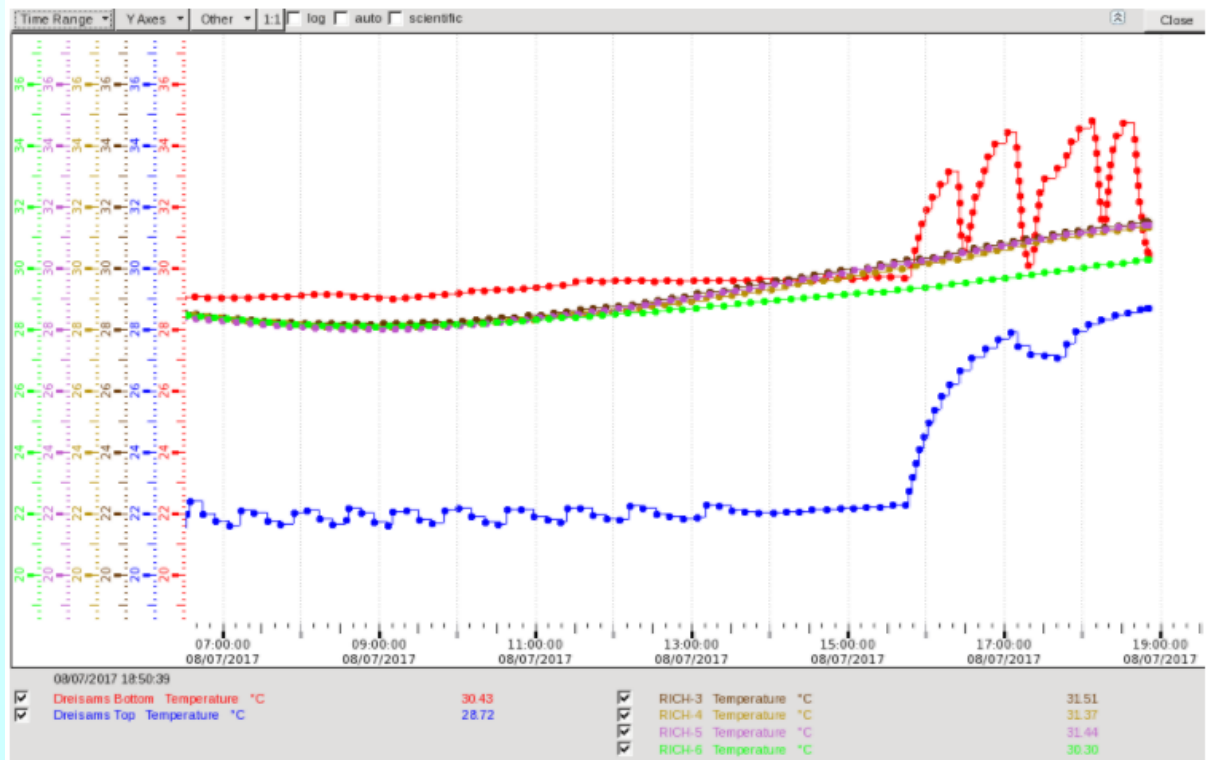
# LV failure (temperature) issue

Every year we faced some LV failure on the hottest data taking period

57627 F. Tessarotto Sat 08 July 2017, 18:51

The power supply for LV MAPMT Digital Bottom Jura failed twice (at 16 this comment.

It seems that starting from 15:45 a temperature issue appeared



This year we have a new, more powerful water cooling system for the FE

The last time a problem appeared, for the LV only, was July 8<sup>th</sup>: new fan units were installed and no further problems were experienced

## Scheme of the purification system

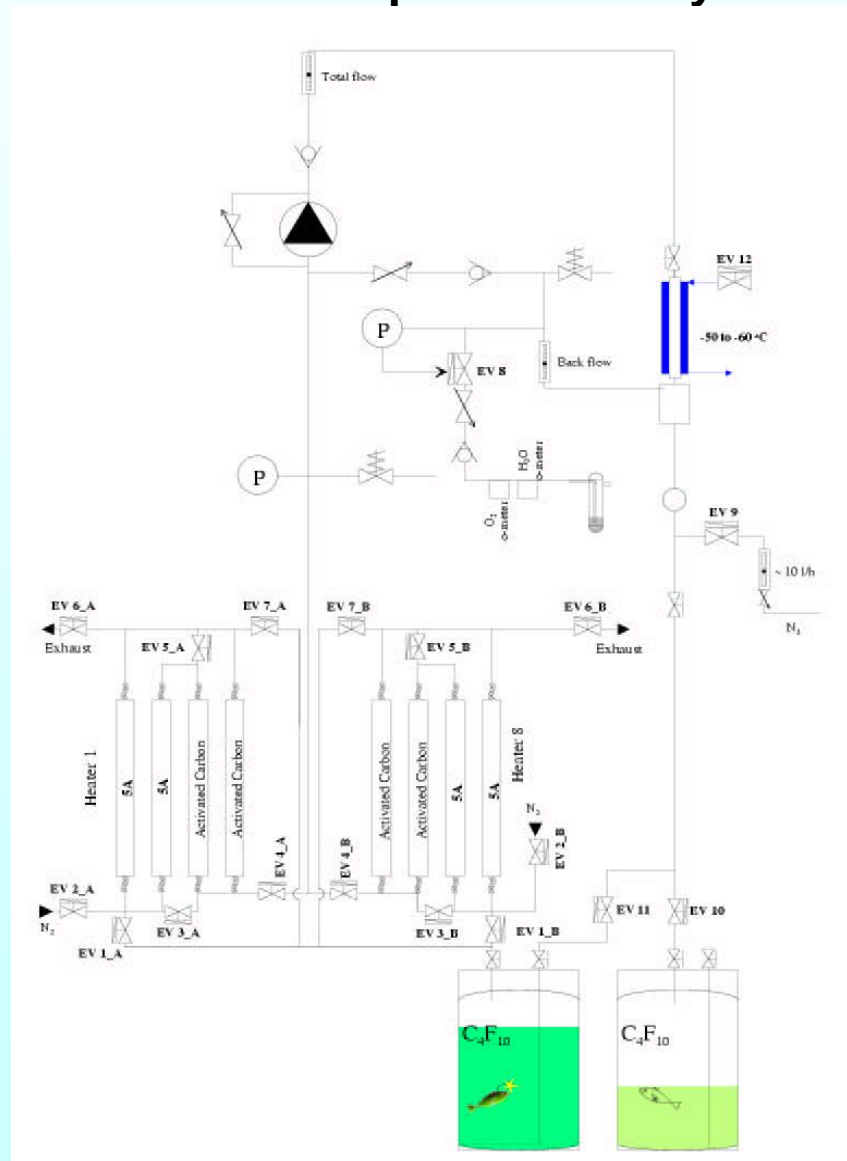
for 2017 run we foresaw adding C<sub>4</sub>F<sub>10</sub> to the gas recovered from 2016 run.

a bottle with ~ 450 kg was purchased (last possibility to purchase C<sub>4</sub>F<sub>10</sub>), no other C<sub>4</sub>F<sub>10</sub> is available in these quantities on the market worldwide.

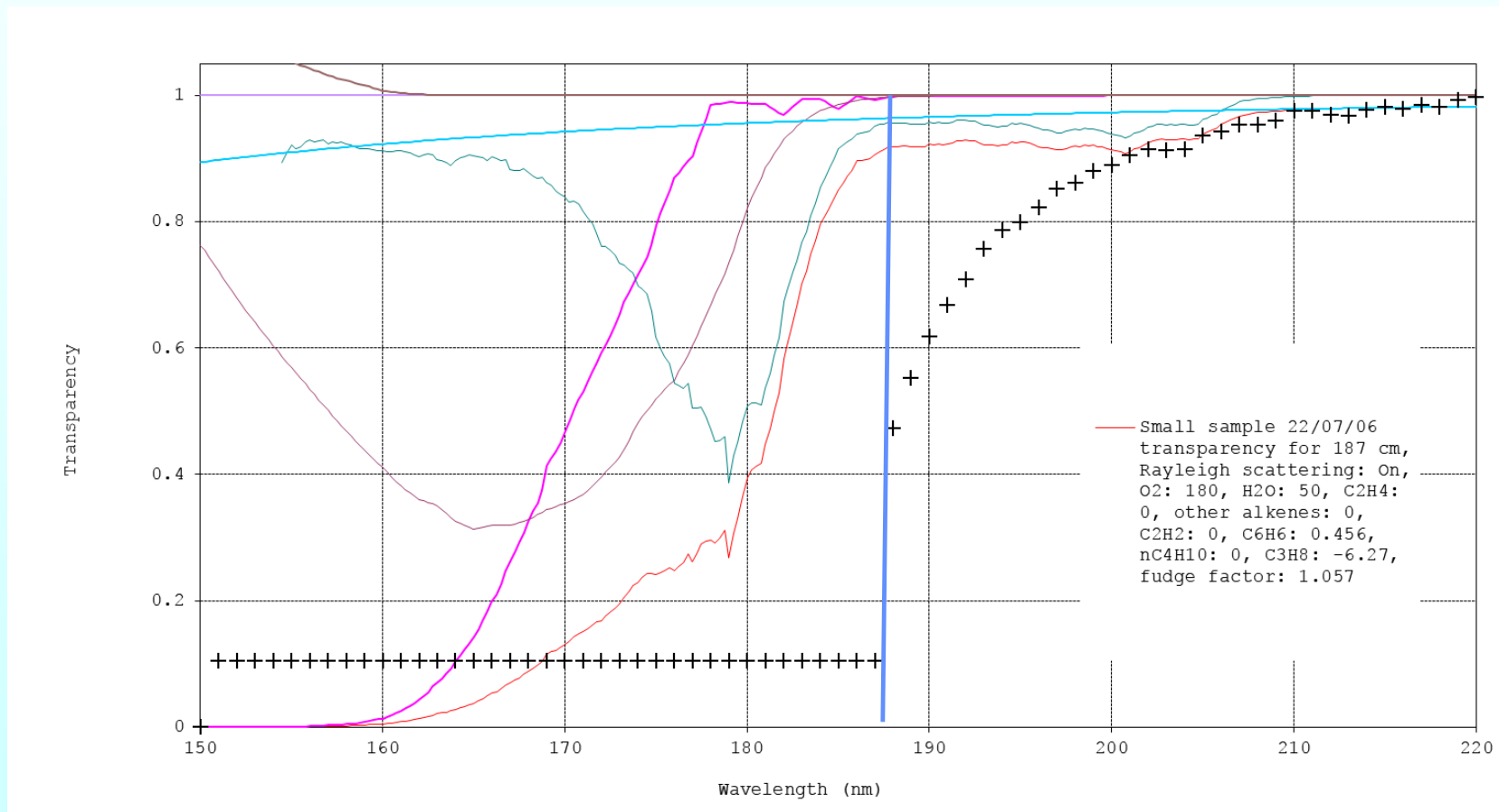
We always need to purify the new gas in view of our extreme purity requirements

The purification process is slow, delicate and requires experts

The purification process was performed on part of the new gas

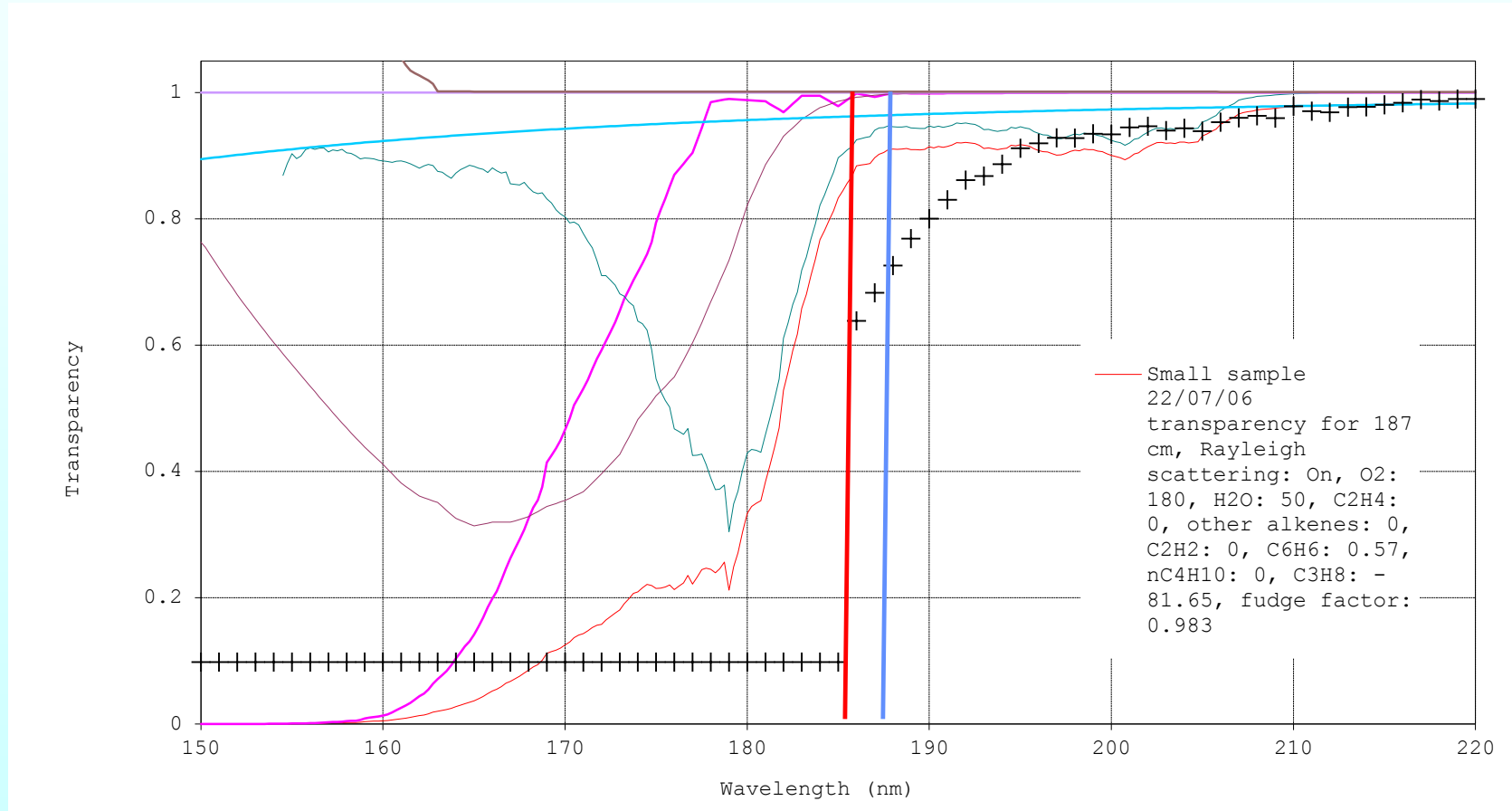


The transparency of the C<sub>4</sub>F<sub>10</sub> from the new bottle is really bad



before applying the purification process

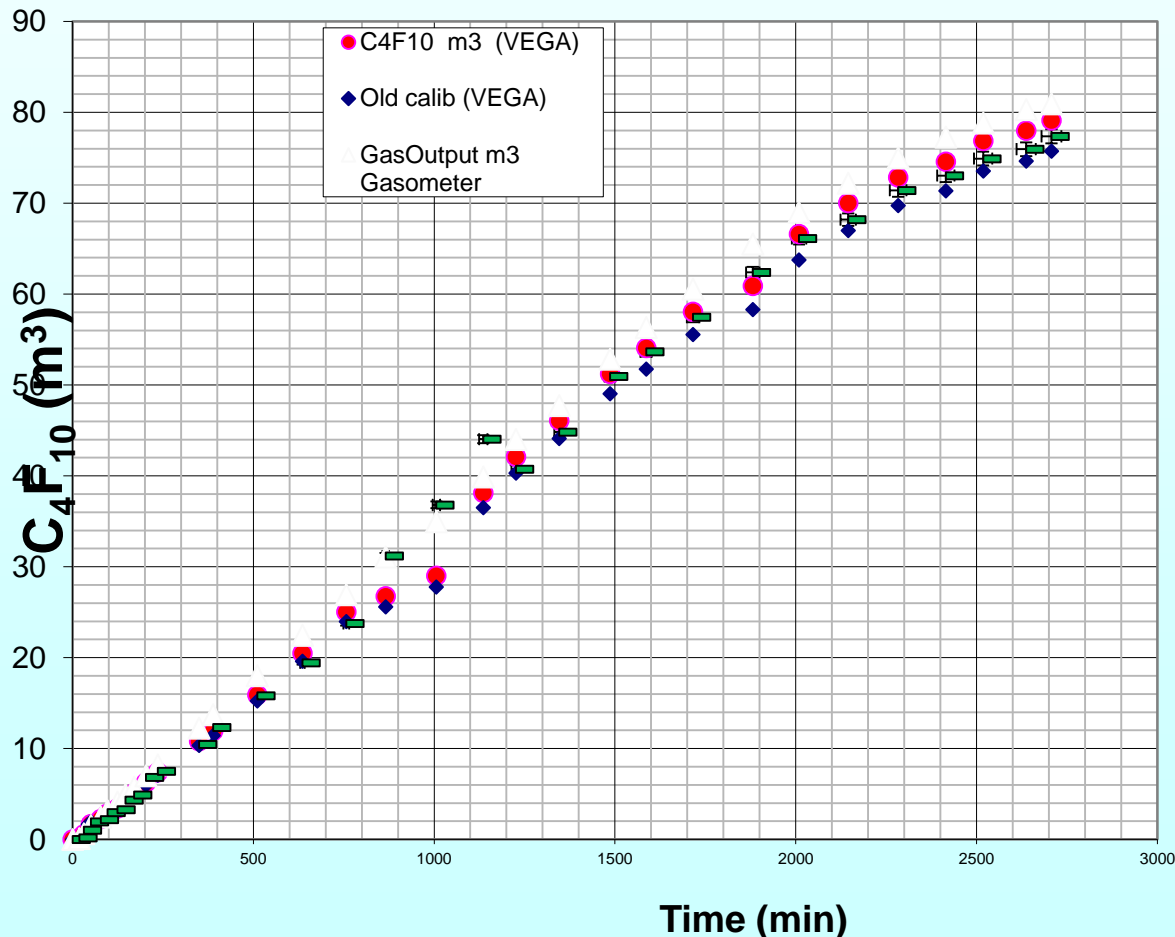
Surprisingly, the transparency of the C<sub>4</sub>F<sub>10</sub> remains bad



after applying the purification process. Many tests were done to make sure that the purification system works fine: it does.

The filling was performed using the gas in the reservoir: we decided to stop it when 90% of C<sub>4</sub>F<sub>10</sub> in the RICH was reached (instead of the 95 -97 %).

Having a bit of C<sub>4</sub>F<sub>10</sub> in liquid form is essential for the RICH “breathing”



at the beginning of COMPASS physics data taking we secured the RICH operation by adding 2 m<sup>3</sup> of N<sub>2</sub> in the vessel because there was no liquid any more in the reservoir. (2.5% decrease of C<sub>4</sub>F<sub>10</sub> fraction)

With the present leak (~6 l/h) we will need extra gas (either C<sub>4</sub>F<sub>10</sub> or N<sub>2</sub> within two weeks)

We will need further filling in the near future: the operation of MAPMTs is almost unaffected, not so the gas-based PDs





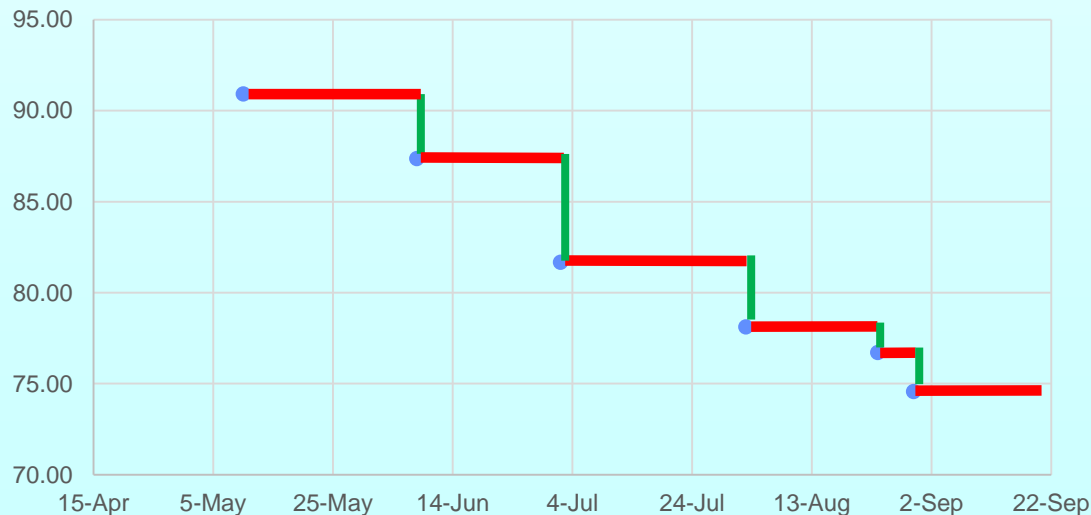
# Nitrogen in RICH-1

date	N2 (m <sup>3</sup> )	N2 corr. (m <sup>3</sup> )	N2 fraction (%)	C4F10 (%)
10-May	8	8	9.09	90.91
8-Jun	2.5	3.125	3.55	87.36
2-Jul	4	5	5.68	81.68
2-Aug	2.5	3.125	3.55	78.13
24-Aug	1	1.25	1.42	76.70
30-Aug	1.5	1.875	2.13	74.57
tot:	0	22.375	25.43	74.57

After the C<sub>4</sub>F<sub>10</sub> filling, nitrogen has been added 5 times (see table), for a total of about 16 m<sup>3</sup> so far.

The fraction of C<sub>4</sub>F<sub>10</sub> in the radiator gas versus time is represented by the red lines in the graph: it went from ~91% down to ~75%

Fraction of C4F10 in the RICH vessel (%)



With the present leak (~6 l/h) we will need extra nitrogen filling and will reduce the C<sub>4</sub>F<sub>10</sub> fraction by ~5% per month of data taking, unless we succeed in cleaning new C<sub>4</sub>F<sub>10</sub> in the meantime

During the commissioning phase the fast circulation compressor could not be started.

An intervention from HAUG technician took place on June, Wednesday 21<sup>st</sup>

The problem was identified: a loss of reference parameters in the PLC control system. The correct parameters were recharged (after a long struggle).

Since then we are circulating the radiator gas at ~90% of the maximum flow (which is 20 m<sup>3</sup>/h)

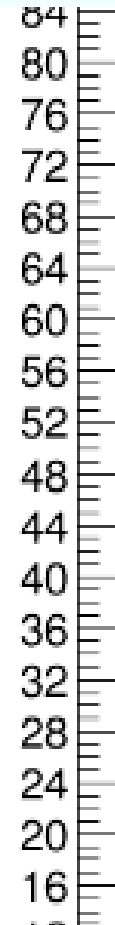
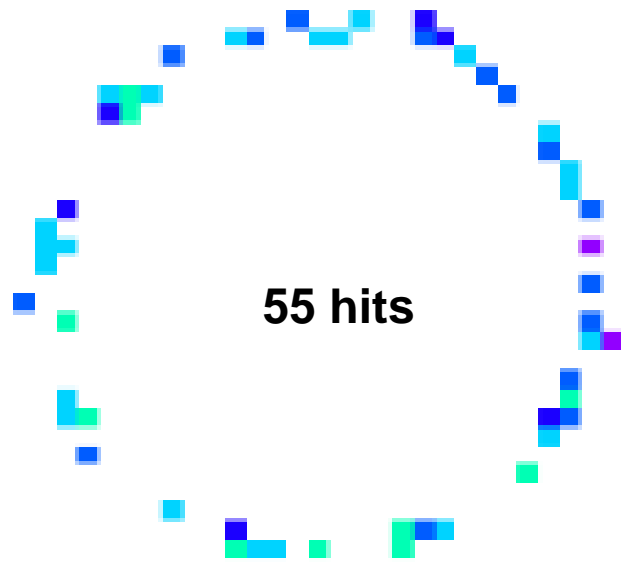
The fast circulation is really important because of the reduced C<sub>4</sub>F<sub>10</sub> percentage.

We had no interruption of the fast circulation so far.



# Number of photons

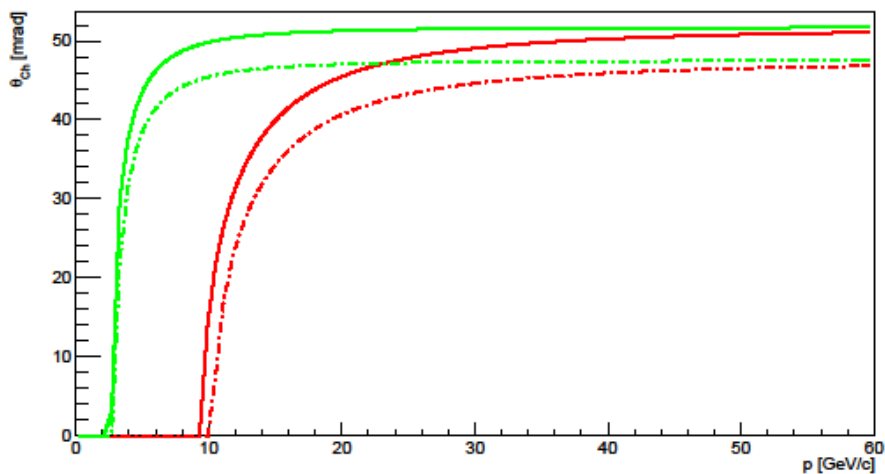
Typical (randomly chosen) rings (from Friday 01/09/2017)



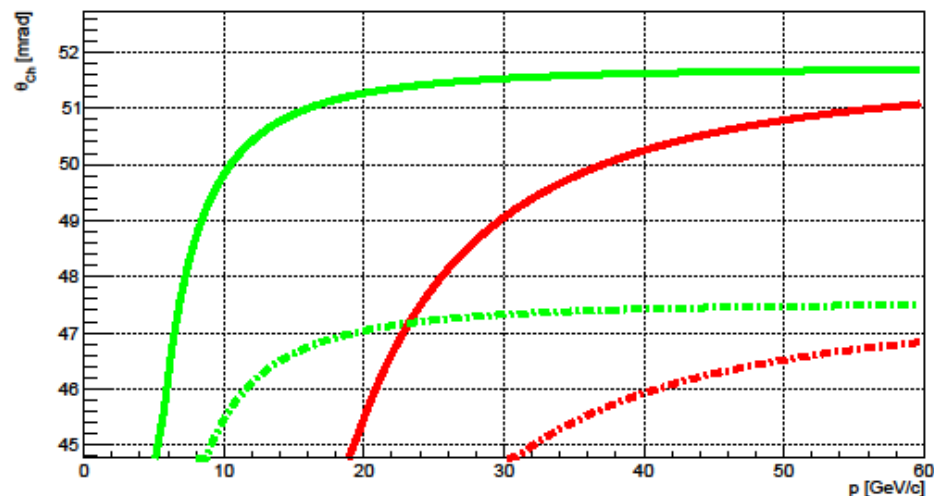
The expected effect of 15-20% reduction in the number of detected photons is being investigated. On-line images suggest there is no major impact.

# Cherenkov angle vs p

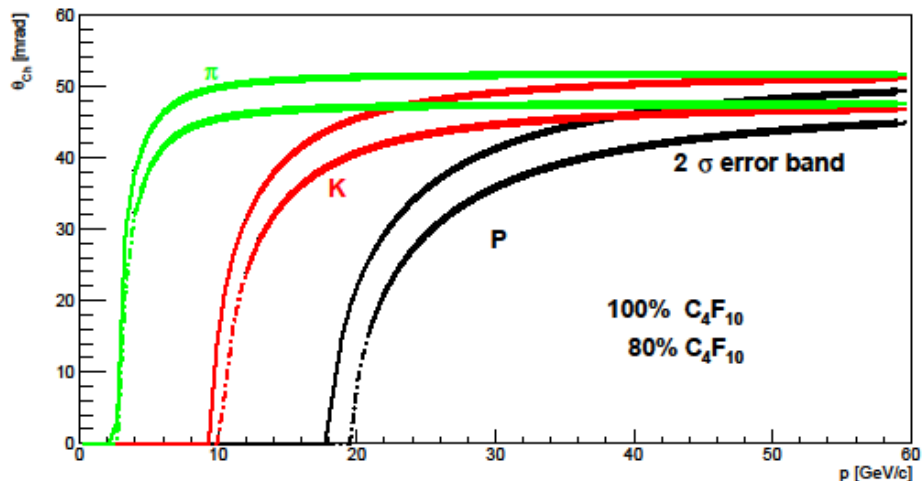
$\theta_{Ch}$  vs momentum for different  $n_{Rad}$  for K,  $\pi$



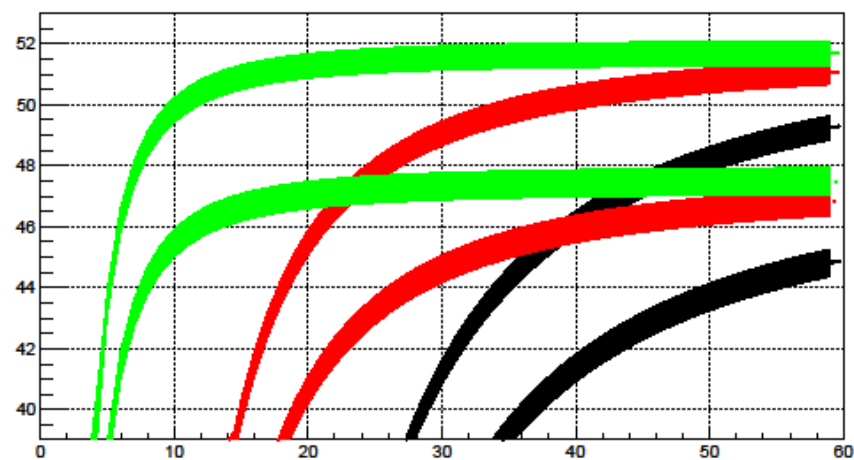
$\theta_{Ch}$  vs momentum for different  $n_{Rad}$  for K,  $\pi$



$\theta_{Ch}$  vs momentum for different  $n_{Rad}$  for p, K,  $\pi$



$\theta_{Ch}$  vs momentum for different  $n_{Rad}$  for p, K,  $\pi$



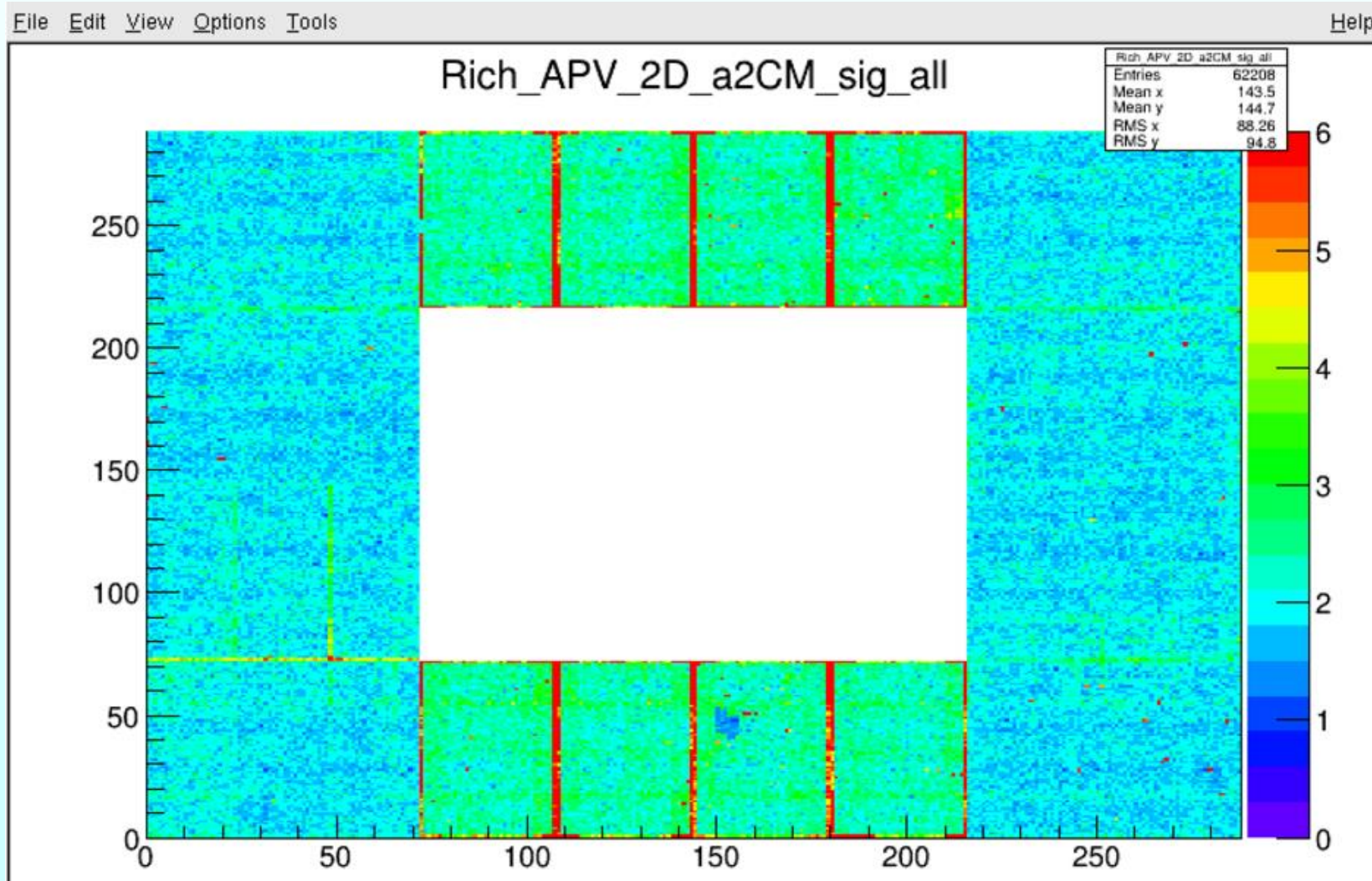


# Noise figure from last MD ped. runs

MWPCs

Hybrids

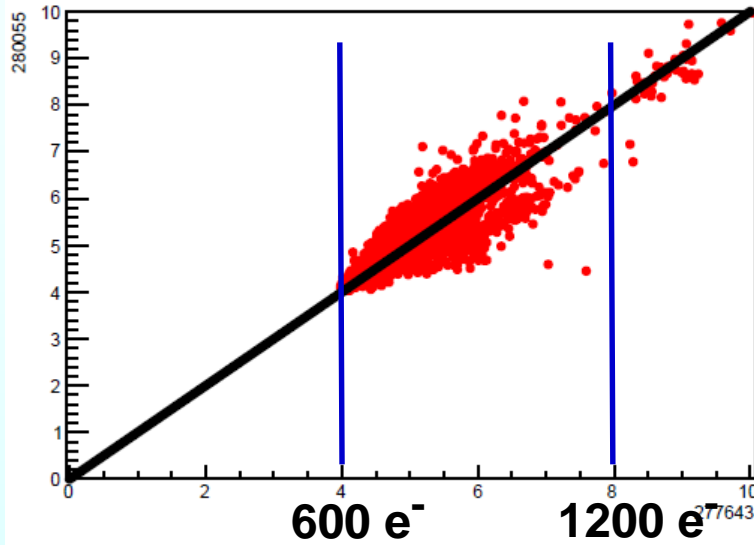
MWPCs



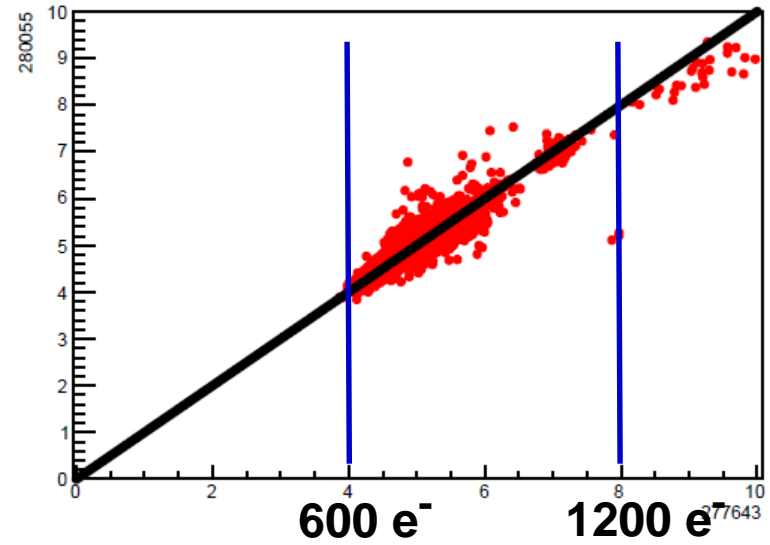


# New vs previous pedestal sigmas

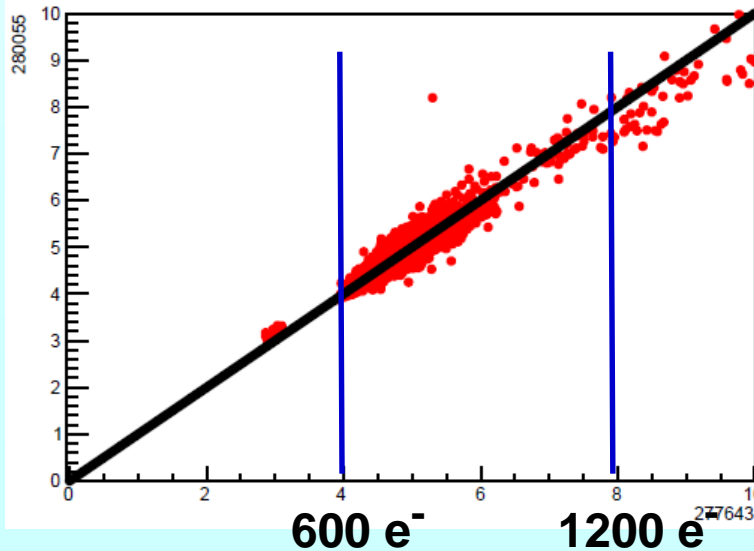
correlation\_RA01H02\_277643\_280055\_plot\_Sigmas



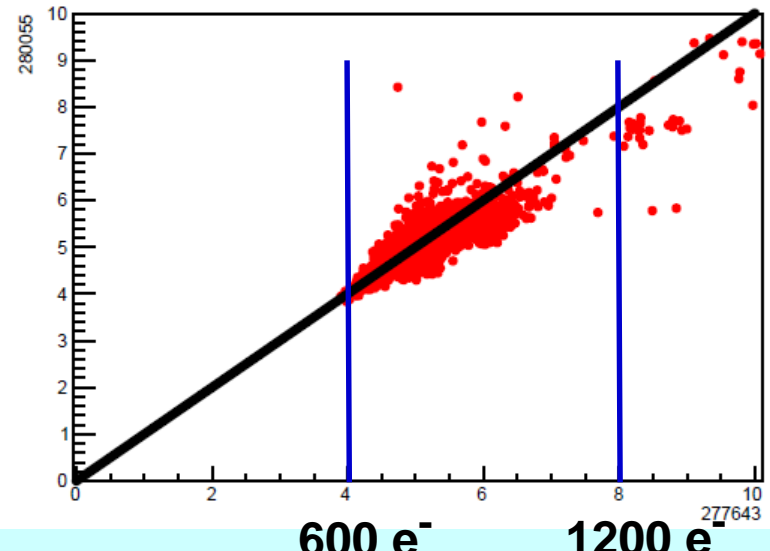
correlation\_RA01H04\_277643\_280055\_plot\_Sigmas



correlation\_RA01H11\_277643\_280055\_plot\_Sigmas



correlation\_RA01H13\_277643\_280055\_plot\_Sigmas

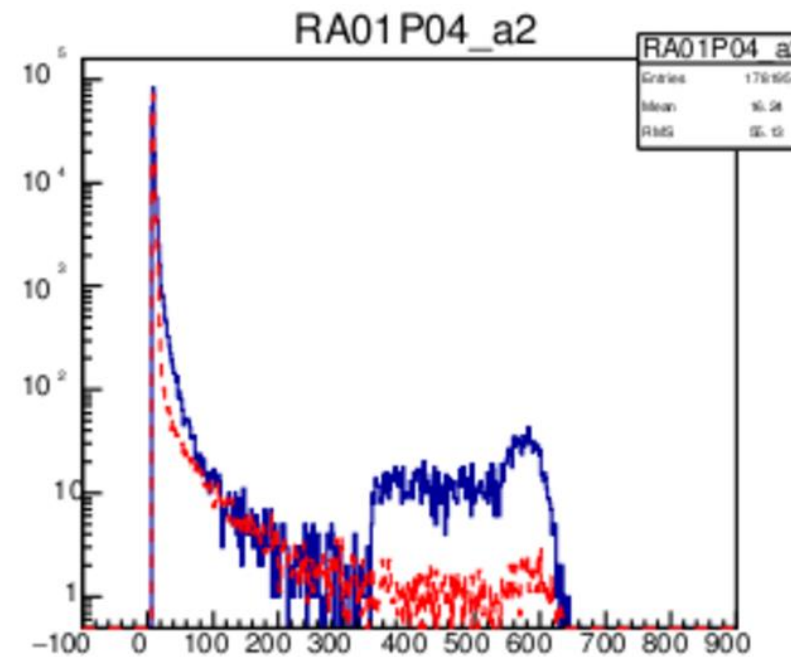
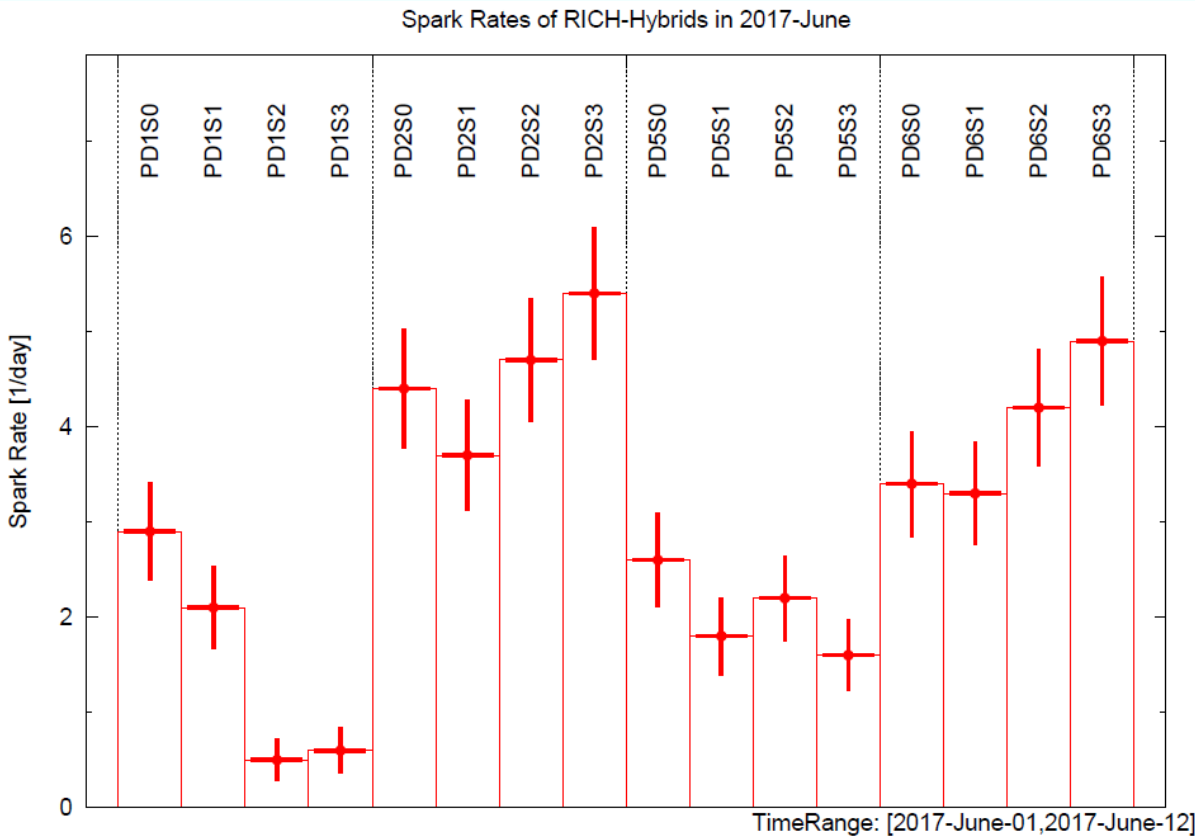




# Rate of discharges in Hybrid PDs

We have on average about 3 discharges/day per sector

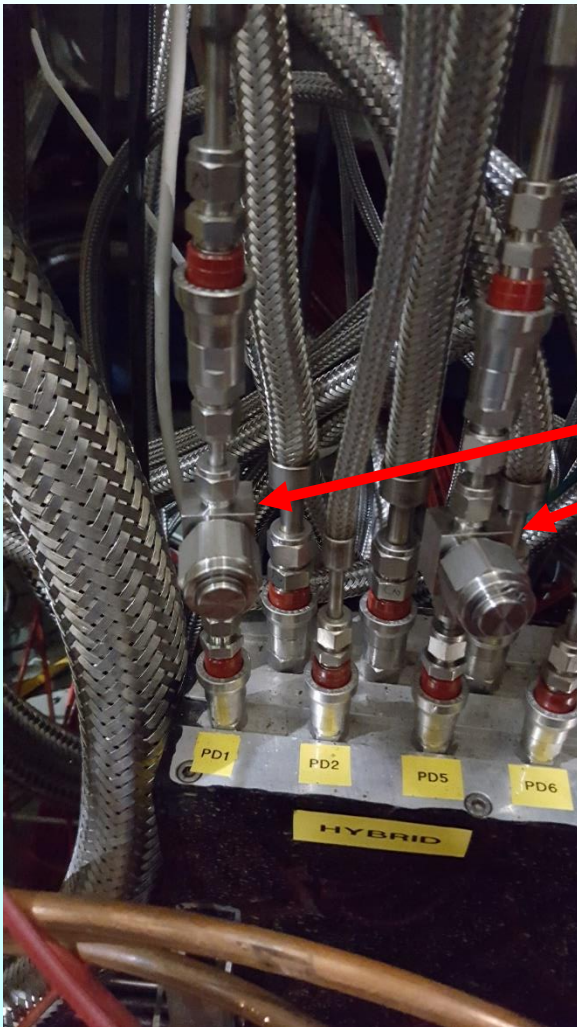
APV error rate:  
SrcID 547: 8-10/day  
SrcID 549: 4-5/day  
SrcID 550: 4-5/day



The OFFSPILL LOAD procedure does work.  
failure rate: ~ once-twice per month

# New (7 $\mu\text{m}$ pores) filters installed

We have 20 shorted pads (in 12000) in the Micromegas: to avoid micro-dust particulate contamination from the input gas, new filters have been installed



Swagelok 316 stainless steel  
particulate filter 7  $\mu\text{m}$  pore size

No new shorts have developed in the last month





# Our bad $C_4F_{10}$ is good for LHCb

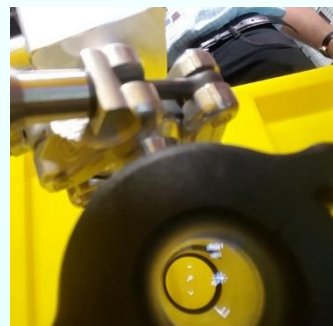
The only owner of significant amount of  $C_4F_{10}$  apart from COMPASS is LHCb

They use it as radiator for LHCb RICH1 (4 m<sup>3</sup> volume) which operates in the visible range (Hybrid vacuum-Si)PMS.

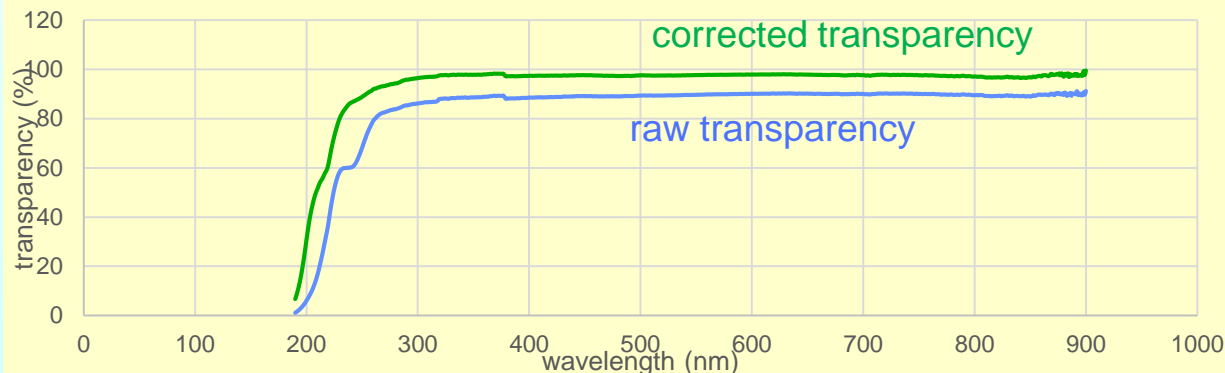
We explored the possibility to exchange our bad gas with better one from them.

We provided evidence to LHCb that our gas is fully transparent in the visible region.

Cell for the transparency measurement of liquid  $C_4F_{10}$  in the visible range

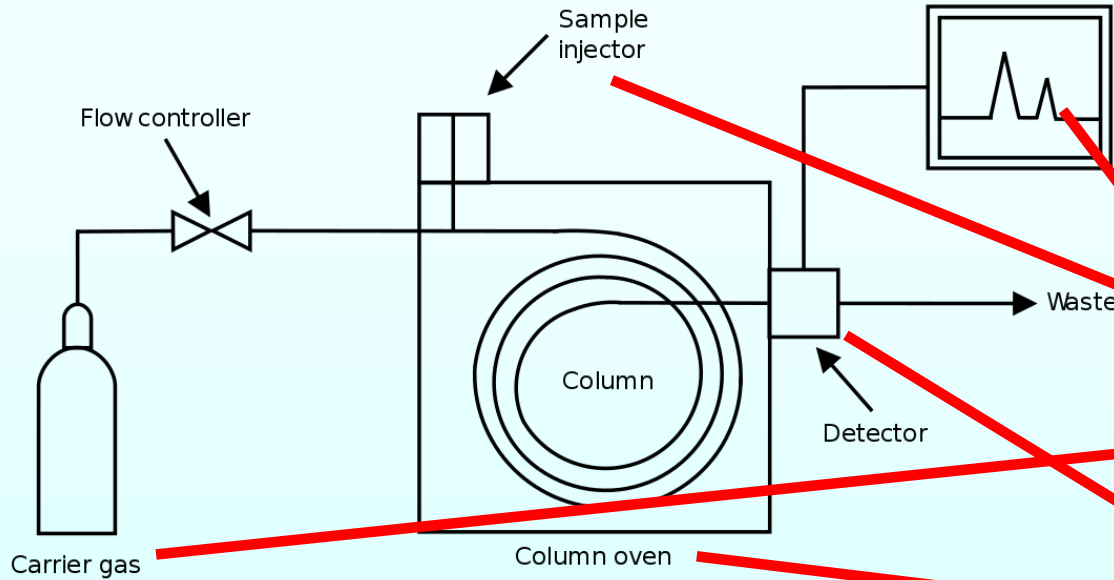


TRANSPARENCY MEASUREMENTS (cell filled with liquid  $C_4F_{10}$ )



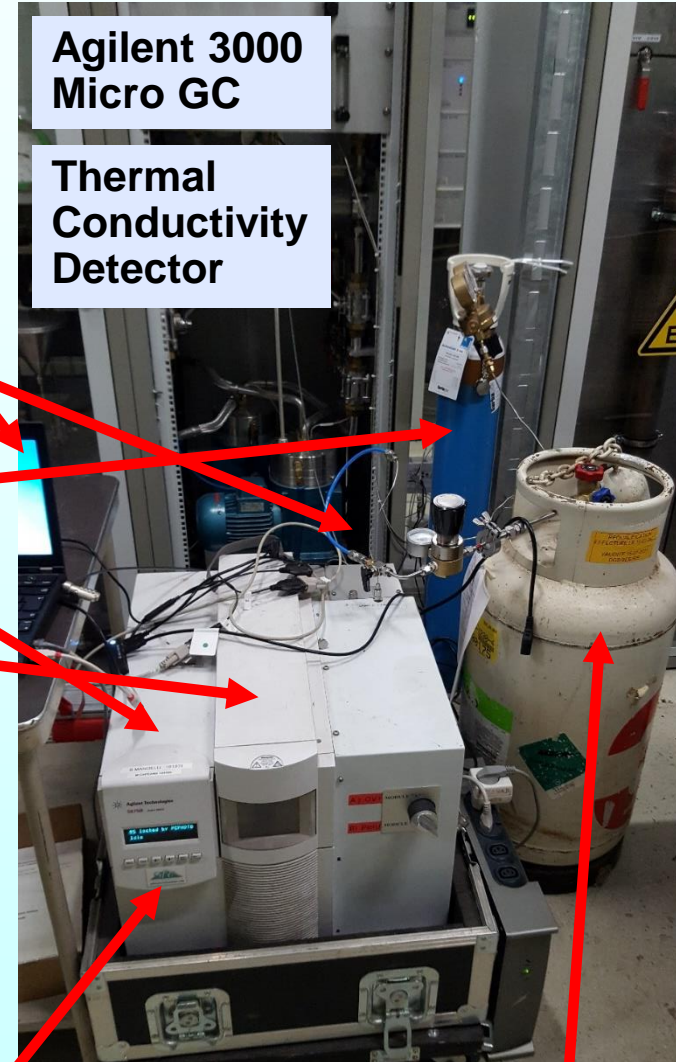
We received a small bottle from LHCb: the transparency of this gas, after passing through our active carbon and molecular sieve is unfortunately very similar to our bad gas.

New sample from a different production lot will be provided and a new transparency measurement is foreseen soon.



Agilent 3000 Micro GC

Thermal Conductivity Detector



COMPASS C4F10 small bottle

Mass Spectrometer Agilent 5975

He carrier “mobile phase” in 8 m long capillary column, coated with a special “stationary phase” material.

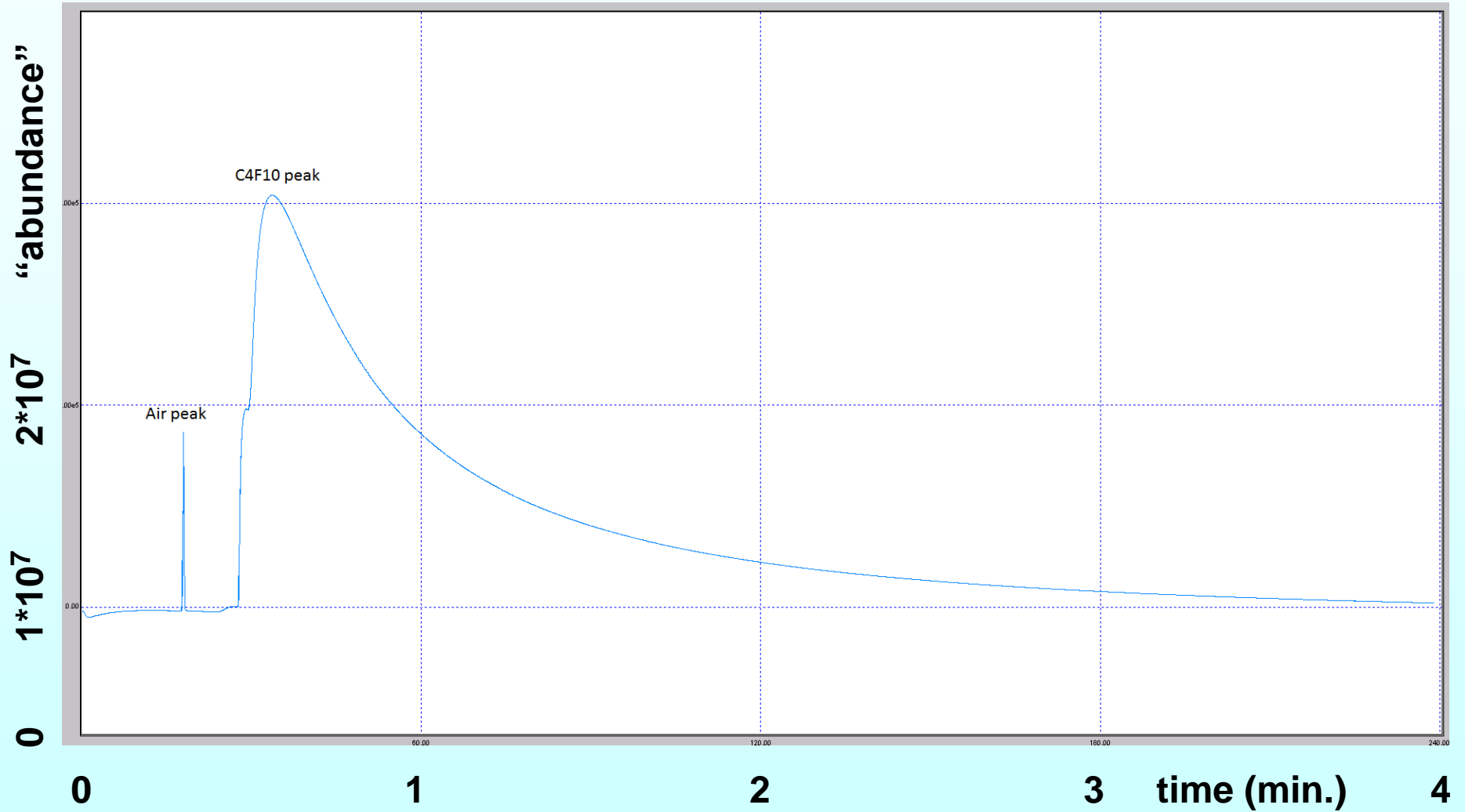
Gaseous compounds elute at different times because the “retention time” of each compound is different (Van der Waals bonds with the stationary phase coating)

Thermal conductivity versus time is measured.

Different measurements with different temperature and He flow



# C<sub>4</sub>F<sub>10</sub> gas chromatography spectrum



Preliminary analysis performed by Roberto Guida, Beatrice Mandelli and Giulio Candreva

EDMS 1434322



PH Department  
Detector technologies

EDMS id 1434322

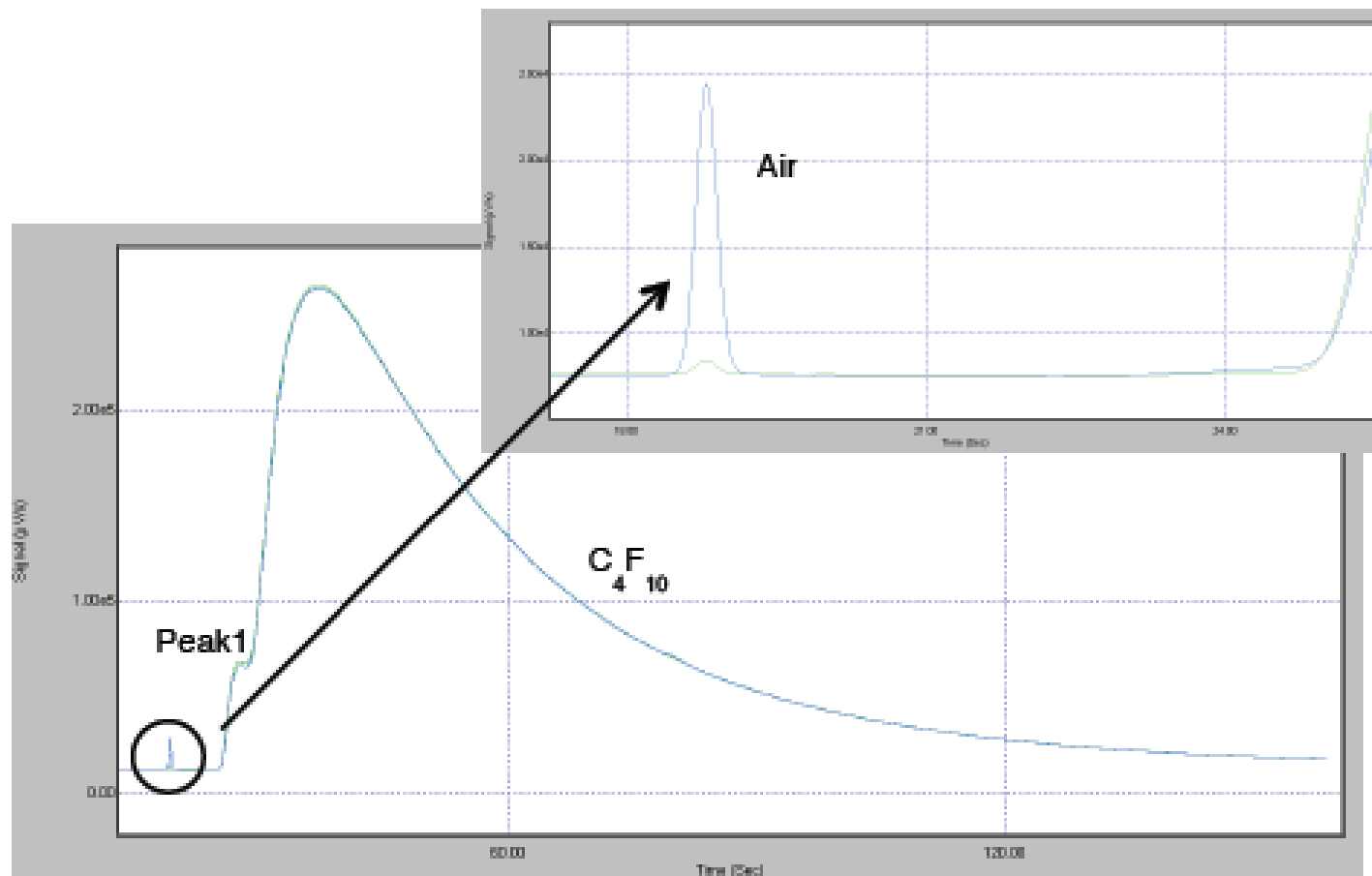
Created: 12/11/2014  
Last modified: 12/11/2014

Nb. Of pages: 7  
Version: 1

LHCb RICH1 Detector:  
Gas chromatographic analysis of  $C_4F_{10}$  containers

<https://edms.cern.ch/document/1434322>

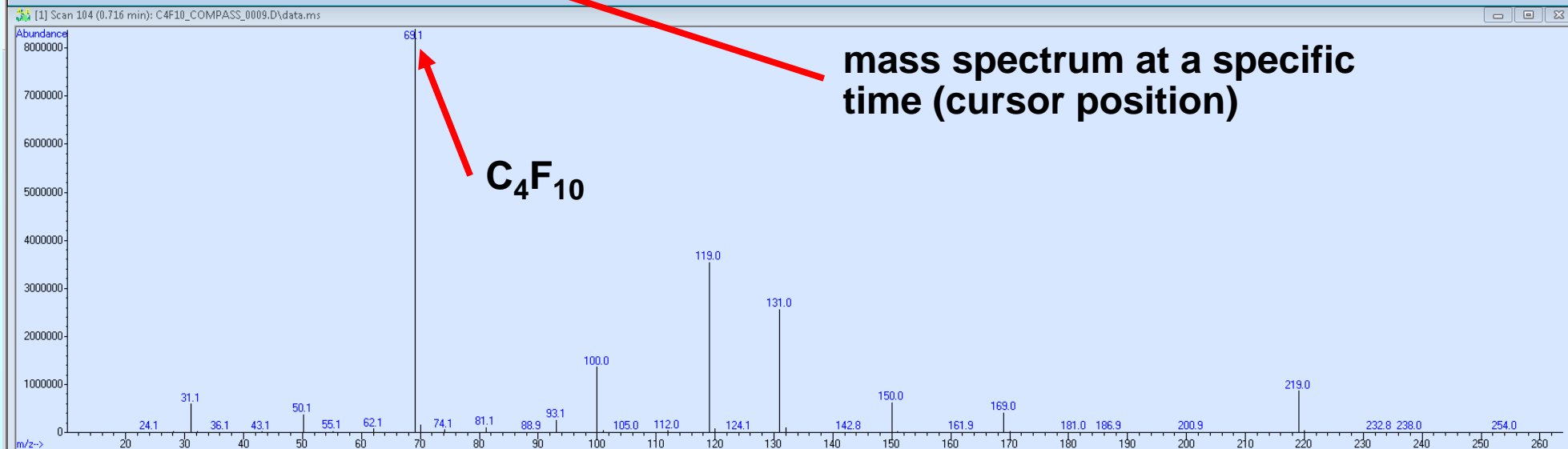
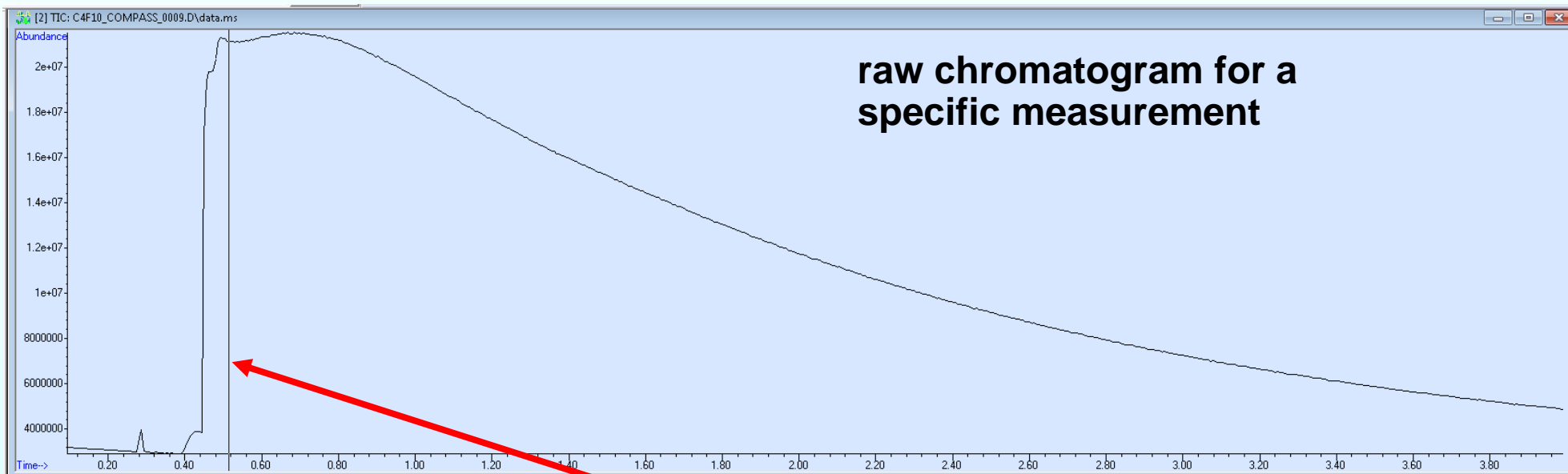
Roberto GUIDA  
Beatrice MANDELLI  
PH-DT-DI

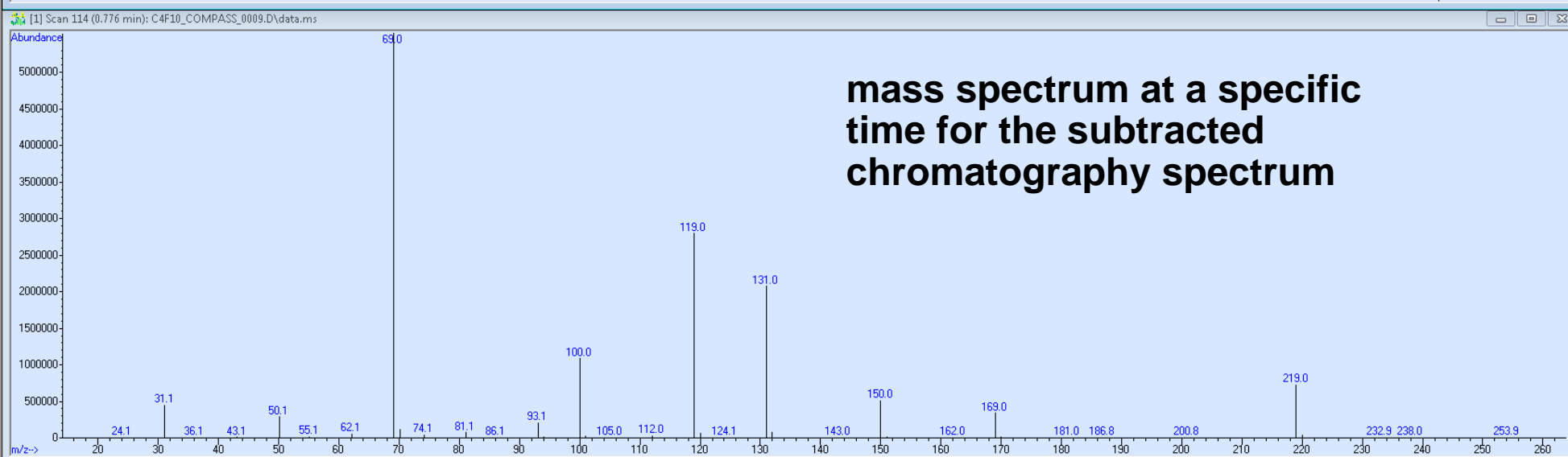
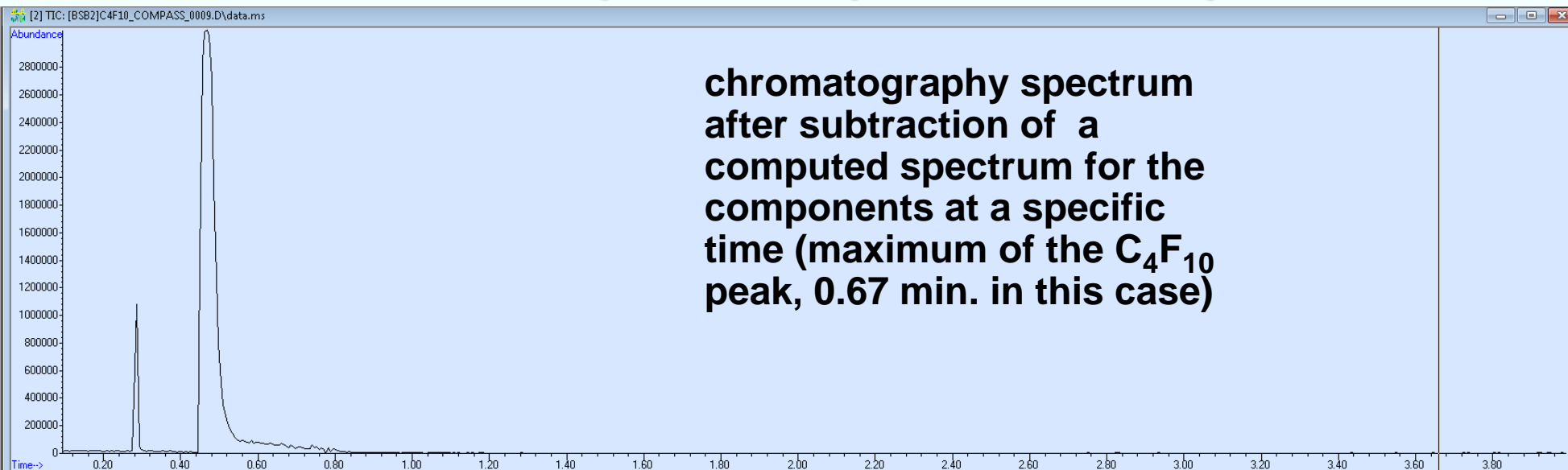


**Fig. 2** Comparison of two chromatograms. The blue line is the vapour chromatogram while the green line is the liquid phase chromatogram. The circle shows the Air peak while the unknown peak is named "Peak1" in the chromatogram. In the zoomed window the Air peak is shown: in the vapour phase it could be also 20 times higher than in the liquid phase.



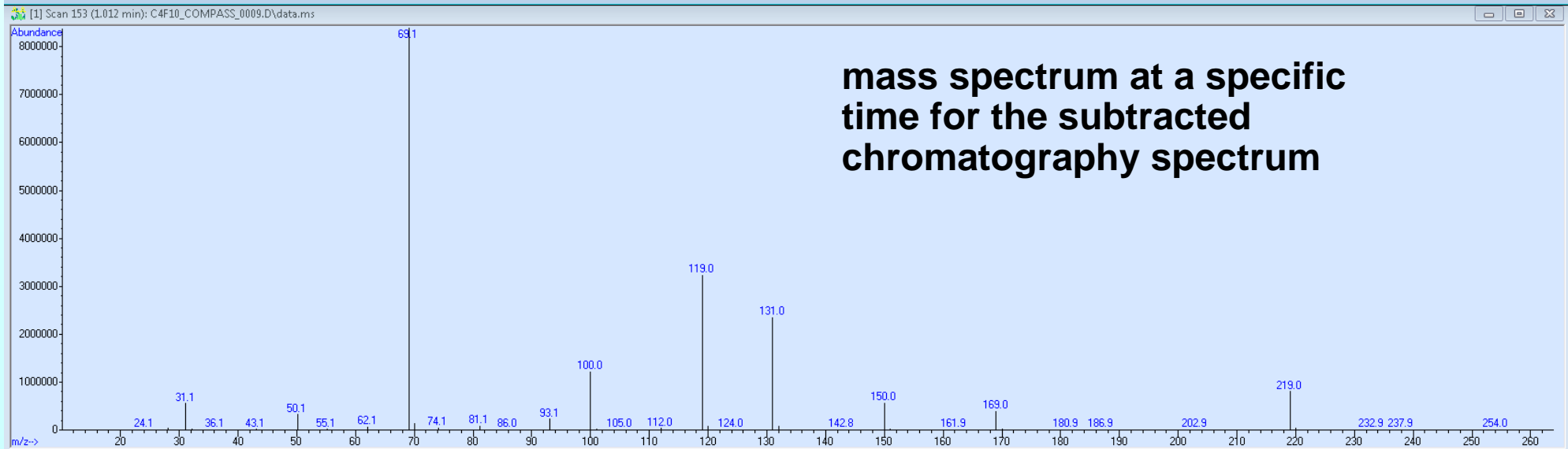
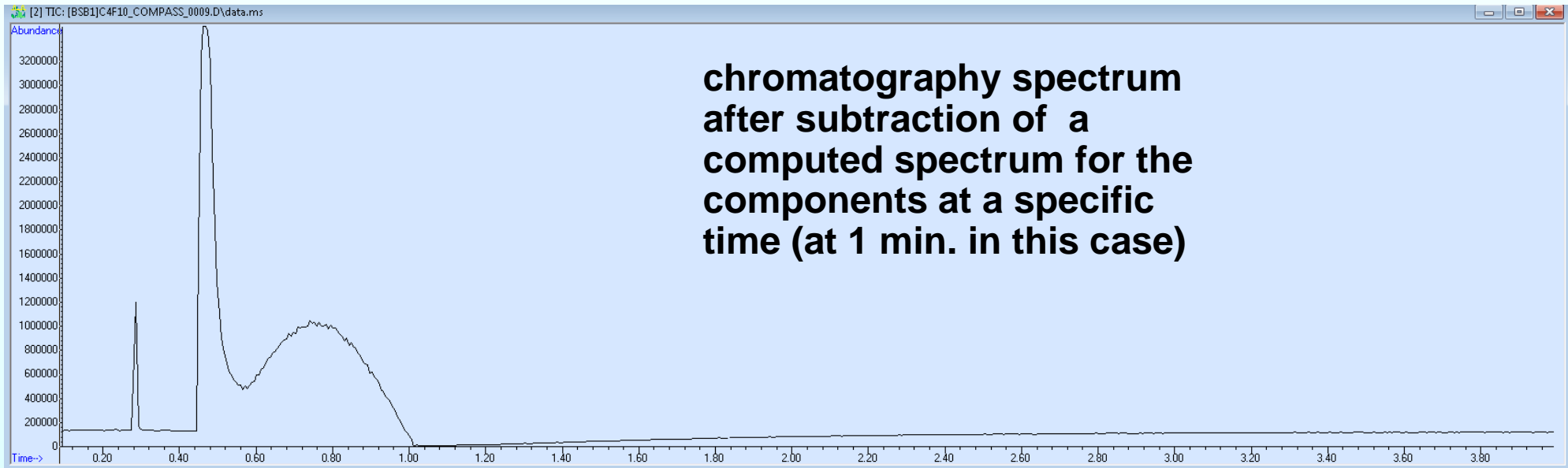
# Mass spectrum at given time







# Preliminary analysis: step 2





# Preliminary results

NIST MS Search 2.2 - [Ident, Presearch Default - InLib = -781, 100 spectra]

File Search View Tools Options Window Help

1. Scan 114 (0.776 min): C4F10\_COMPASS

Names Structures / Spec List

mainlib; repib; 276248 total spectra

Plot/Text of Search Spectrum / Plot of Search Spectrum / Spec List

Name: Scan 114 (0.776 min): C4F10\_COMPASS\_0009.D\data.ms  
 MW: N/A ID# 446 DB: Text File  
 10 largest peaks:  
 119 9991 | 131 666 | 100 440 | 219 188 | 150 176 |  
 50 121 | 169 95 | 31 86 | 93 77 | 70 52 |  
 Synonyms:  
 no synonyms.

The results are not convincing

Scan 114 (0.776 min): C4F10\_COMPASS\_0009.D\data.ms  
 Side by Side MF=643 RMF=647  
 Perfluorooctane 643 647R 35.1P

#	Lib.	Match	R.Match	Prob. (%)	RI	Name
1	M	643	647	35.1	341	Perfluorooctane
2	M	642	648	33.8	-	Perfluoro[1,2-bis(tetrahydrofury)etha...
3	R	601	609	35.1	341	Perfluorooctane
4	R	598	599	7.31	-	Hexane, tetradecafluoro-
5	M	594	596	6.18	-	Nonafluoro-1-bromobutane
6	M	594	595	6.18	282	Heptane, hexadecafluoro-
7	R	581	582	3.99	-	Perfluoro-n-pentanoic acid
8	M	574	629	3.05	863	Butanoic acid, heptafluoro-
9	M	574	575	7.31	-	Hexane, tetradecafluoro-
10	R	543	592	3.05	863	Butanoic acid, heptafluoro-
11	R	527	542	7.31	-	Hexane, tetradecafluoro-
12	M	526	539	0.63	-	Butane, decalfluoro-
13	M	524	570	0.58	-	1-Heptafluorobutyl(4-methylpiper...
14	M	518	519	0.45	-	Hexane, 1-bromo-1,1,2,2,3,3,4,4,5...
15	R	517	519	7.31	-	Hexane, tetradecafluoro-
16	R	517	517	0.44	1...	Pentadecafluorooctanoic acid
17	R	512	515	0.35	1...	Perfluorononanoic acid
18	R	506	521	6.18	282	Heptane, hexadecafluoro-
19	M	505	712	0.27	-	Butanoic acid, heptafluoro-, sodium ...
20	M	504	553	0.26	266	Propene, hexafluoro-
21	M	500	503	3.99	-	Perfluoro-n-pentanoic acid
22	M	496	496	0.19	-	Perfluorobutyl iodide
23	M	493	493	0.35	1...	Perfluorononanoic acid
24	M	492	495	0.16	-	1H,1H-Perfluoro-1-heptanol
25	R	490	700	0.15	308	Cyclobutane, octafluoro-
26	M	489	530	0.14	-	Hexanedioic acid, octafluoro-
27	M	485	535	0.15	308	Cyclobutane, octafluoro-
28	M	485	487	0.12	312	Perfluoro-1-heptene
29	M	479	479	0.44	1...	Pentadecafluorooctanoic acid
30	M	479	479	0.44	1...	Pentadecafluorooctanoic acid

Name: Perfluorooctane  
 Formula: C<sub>8</sub>F<sub>18</sub>  
 MW: 438 Exact Mass: 437.971258 CAS#: 307-34-6 NIST#: 283595 ID#: 36175 DB: mainlib  
 Other DBs: Fine, TSCA, RTECS, HODDC, EINECS  
 Contributor: A. Pleshkova, Nesmeyanov Inst. Org. Elem. Cpds, Moscow  
 InChI Key: YVBRRLBYAZBM-UHFFFAOYSA-N Non-stereo  
 10 largest peaks:  
 69 9991 | 119 4371 | 131 426 | 169 258 | 100 238 |  
 219 371 | 93 791 | 181 701 | 50 52 | 263 251 |  
 Synonyms:  
 1-Octadecafluorooctane  
 2-Perfluorooctanes  
 3-Octane, octadecafluoro-  
 4-n-Perfluorooctane  
 5,1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-Octadecafluorooctane #  
 Experimental RI median±deviation (RdData)  
 Semi-standard non-polar: 341±N/A (1)  
 Retention index:  
 ...

Lib. Search Other Search Names Compare Librarian MSMS

SOPRANE

Ident Ident

12:06 PM 8/31/2017





# Preliminary results

NIST MS Search 2.2 - [Ident, Presearch Default - InLib = -814, 100 spectra]

File Search View Tools Options Window Help

1. Scan 112 (0.764 min): C4F10\_COMPASS\_0009.D\data.ms

[A] Scan 112 (0.764 min) ... [2] [A] Scan 93 (0.650 min) ... [3] [A] Scan 114 (0.776 min) ... [4] [A] Scan 82 (0.583 min) ...

Name: Scan 112 (0.764 min): C4F10\_COMPASS\_0009.D\data.ms  
 MW: N/A ID# 448 DB: Text File  
 10 largest peaks:  
 119 999 | 131 659 | 100 427 | 219 179 | 150 171 |  
 50 136 | 31 87 | 93 77 | 169 77 | 70 51 |  
 Synonyms:  
 no synonyms.

(Text File) Scan 112 (0.764 min): C4F10\_COMPASS\_0009.D\data.ms

mainlib: repib; 276248 total spectra

The results are not convincing

Name: Perfluoro[1,2-bis(tetrahydrofuryl)ethane]  
 Formula: C<sub>10</sub>H<sub>2</sub>F<sub>16</sub>O<sub>2</sub>  
 MW: 458 Exact Mass: 457.97993 NIST# 222755 ID# 73432 DB: mainlib  
 Contributor: Chemical Concepts  
 InChIKey: B00FLOHUYFPBKD-UHFFFAQYSA-N Nonstereo  
 10 largest peaks:  
 100 999 | 131 955 | 69 492 | 169 445 | 119 363 |  
 150 143 | 197 135 | 181 60 | 147 56 | 31 48 |  
 Synonyms:  
 1,2,2,3,3,4,4-Hexafluoro-5-[1,1,2,2-tetrafluoro-2-(3,3,4,4,5,5-hexafluorotetrahydro-2-furyl)ethyl]tetrahydrofuran #  
 Estimated non-polar retention index (n-alkane scale):  
 Value: 230 iu  
 Confidence interval (Diverse functional groups): 89(50%) 382(95%) iu

#	Lib.	Match	R.Match	Prob. (%)	RI	Name
1	M	635	641	41.5	-	Perfluoro[1,2-bis(tetrahydrofuryl)ethane]
2	M	625	629	29.3	341	Perfluorooctane
3	R	587	595	29.3	341	Perfluorooctane
4	R	585	585	6.79	-	Hexane, tetradecafluoro-
5	M	578	631	5.20	863	Butanoic acid, heptafluoro-
6	M	577	579	5.00	-	Nonafluoro-1-bromobutane
7	M	576	577	4.81	282	Heptane, hexadecafluoro-
8	R	562	563	3.01	-	Perfluoro-n-pentanoic acid
9	M	556	558	6.79	-	Hexane, tetradecafluoro-
10	R	537	585	5.20	863	Butanoic acid, heptafluoro-
11	M	528	572	0.77	-	1-Heptafluorobutyl-4-methylpiper...
12	R	524	539	6.79	-	Hexane, tetradecafluoro-
13	M	522	535	0.60	-	Butane, decafluoro-
14	M	516	519	0.47	-	1H,1H-Perfluoro-1-heptanol
15	R	509	511	6.79	-	Hexane, tetradecafluoro-
16	M	507	714	0.34	-	Butanoic acid, heptafluoro-, sodium ...
17	R	507	522	4.81	282	Heptane, hexadecafluoro-
18	R	505	905	0.31	1...	Pentadecafluorooctanoic acid
19	M	504	950	0.30	266	Propene, hexafluoro-
20	M	500	501	0.25	-	Hexane, 1-bromo-1,1,2,2,3,3,4,4,5,5...
21	M	495	542	0.20	308	Cyclobutane, octafluoro-
22	M	495	499	3.01	-	Perfluoro-n-pentanoic acid
23	R	490	494	0.16	1...	Perfluorononanoic acid
24	M	486	527	0.14	-	Hexanedioic acid, octafluoro-
25	M	485	485	0.13	-	Perfluorobutyl iodide
26	R	484	693	0.20	308	Cyclobutane, octafluoro-
27	M	481	482	0.11	312	Perfluoro-1-heptene
28	M	479	479	0.16	1...	Perfluorononanoic acid
29	M	473	486	0.08	-	Pentane, dodecafluoro-
30	M	472	472	0.21	1...	Perfluorooctanoic acid

InLib = -814, Hit List

Lib. Search Other Search Names Compare Librarian MSMS

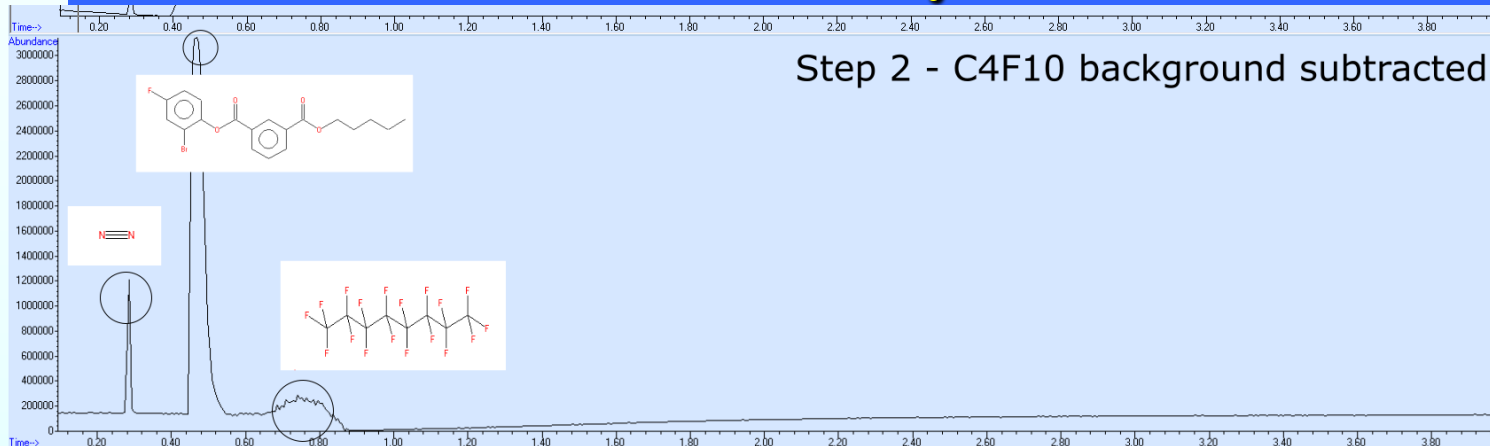
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FR 12:07 PM 8/31/2017

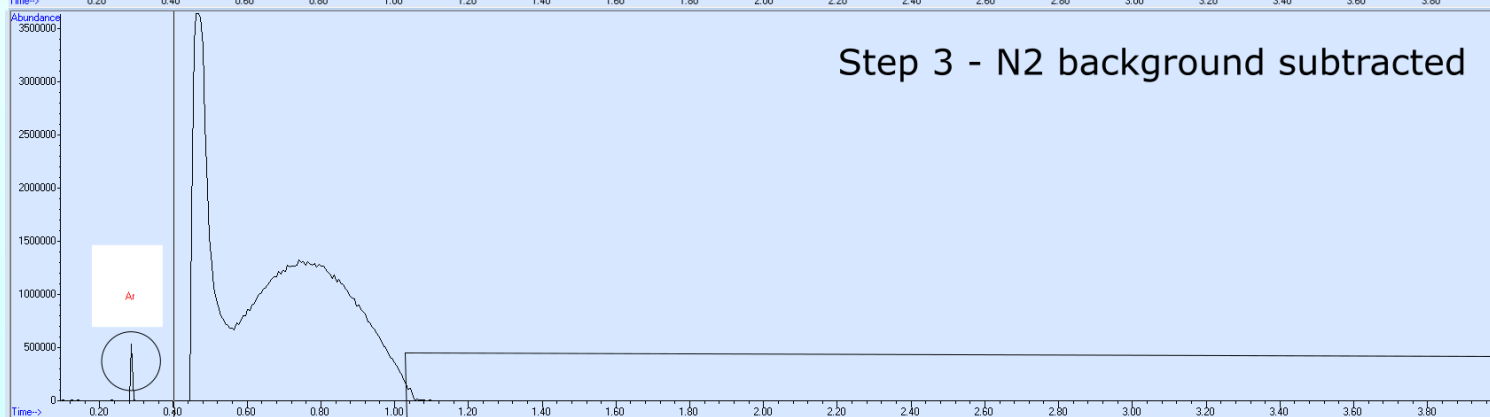


# Preliminary results

Step 2 - C4F10 background subtracted



Step 3 - N2 background subtracted

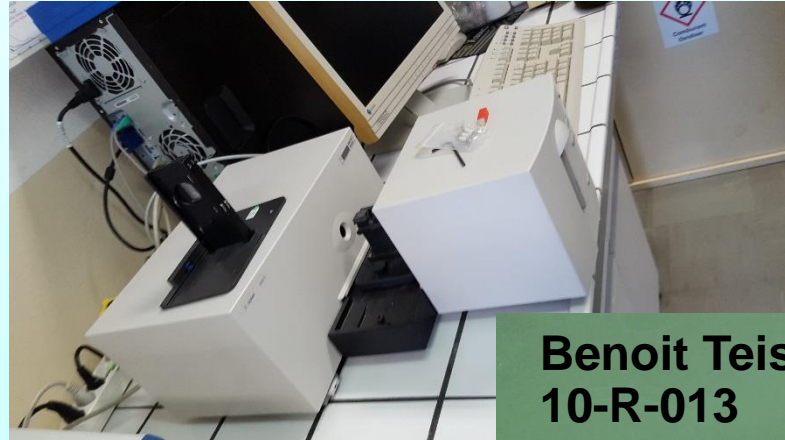


Step 4 - Zoom the above selected area



The results are not convincing but they hint at the presence of longer chains and do not exclude the presence of aromatic rings

# Next step: further analysis



The CERN VSC (Vacuum Surface and Coating) Group has a chemical laboratory equipped with analysis instruments: Gas-chromatograph (60 m long column) with Mass Spectroscopy, IR and UV gas spectroscopy - UV transparency analyzer. We agreed on a first measurement of our gas in September