Summary of our knowledge on target impurities in MuCAP Run8

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This summary is meant to collect all of our present knowledge on target impurity determinations during Run 8. We give the results of the following impurity analysis methods, for the different TPC fills:

- direct observation of impurity capture events in the TPC via digital TDC400 E-high and E-very high triggers (time information only). These events are found with Tom's impurity tracking and "good" muon stop analysis routines with an applied ±25μs pile-up protection window. The yield is calculated as the ratio of impurity events per "good" muon stop. From Peter's yield determination for "hydrogen impurities in MuCAP'04" (ELOG: http://kaon.physics.berkeley.edu:8080/run9-prep/10) , we take the conversion factors to derive the impurity concentration from the observed yield. These factors depend on the individual muon transfer and capture rates and were calculated to be 159 (carbon), 99 (nitrogen), 342 (oxygen) and 60 (neon) . For a given concentration of water the respective oxygen concentration is only half and hence the conversion factor is 342/2=171.

- direct observation of impurity events in the TPC using the analog FADC system (energy information), a special event trigger, and Oleg's analysis routines. The given yield is calculated per "good" muon stop.

- determination of gas impurities via volumetric methods during the filling procedures of Claude and Malte. The content is calculated via known volumes, pressures, and expansions.

- determination of gas impurities using the PNPI gas-chromatographic analysis system (GC analysis) (Georghii, Volodja, Gennady)

The following target/TPC fillings will be listed:

0) before data taking
1) clean fill with protium
2) N2-doped
3) D2-doped
4) O2-doped
5) natural hydrogen
6) H_2O-doped

0) Before start of data taking

On September 25 the CHUPS system was filled with 720 liters of protium through the palladium filter. During preparation the CHUPS system was filled with nitrogen, then pumped and heated, and then flushed with protium. A sample was taken after 12 hours storage in the dummy TPC volume.

GC analysis:	Sample A	N2	0.19 ± 0.01 ppm
		O2	< 0.01 ppm

Then the hydrogen mass-flow controller had to be replaced and afterwards a second sample was taken after running the CHUPS system for several purification cycles.

GC analysis:	Sample B	N2	0.015 ± 0.0002 ppm
		O2	not visible

These results show CHUPS could remove efficiently the N2 content. The 0.19 ppm N2 are likely from outgassing inside the dummy TPC volume.

1) The "clean" fill

On October 8, the TPC and the CHUPS system were connected and CHUPS started continuous running.

TPC analysis:

Fig.1 shows the impurity yield results from Tom's analysis, plotted together with the concentrations resulting from the GC analysis. One clearly sees that CHUPS running results in a decrease of the impurity yield. It reaches a plateau at the 2×10^{-5} level. 56 hours after starting, the CHUPS system was separated from the TPC system for ~20 hours. The observed TPC impurity yield increased by a factor of 2. This outgassing rate agrees with the rate observed in the MuCAP Run7 data. This might have been caused by outgassing or microleaks. Then CHUPS was reconnected again and slowly cleans the system, reaching a final impurity yield plateau at the $\sim8\times10^{-6}$ level. Tom's data points from μ^+ measurements are much lower (yield = 1×10^{-6}) and therefore show the sensitivity of the method at the given background level.

The standard CHUPS hydrogen flow rate was 1.6 l/hour. Tests were done with reduced CHUPS flow to 0.9 l/hour (hours 336-364) and increased CHUPS flow 2.6 l/hour (hours 364 and later) – see Fig.2 and Fig.3. The reduced flow rate caused an increase impurity yield which leveled at a new higher equilibrium value between outgassing and cleaning after a short latency period. After these tests, CHUPS was left on with the ~2.6 l/hour flow rate (October 25). Tom's and Oleg's analyses agree on the observed change and on the absolute impurity yield for this period.

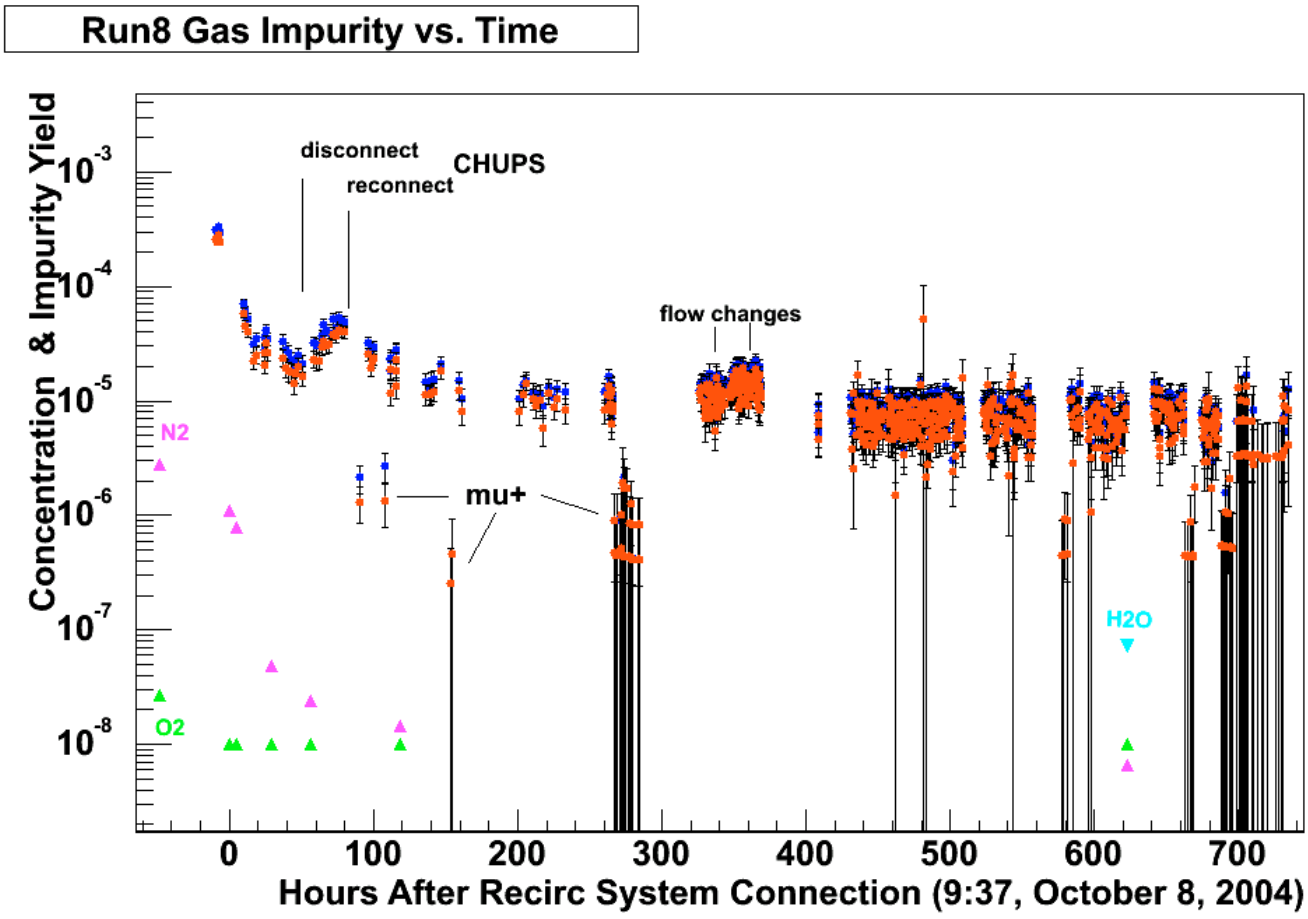

Fig.1: Data points from Tom's impurity finder analysis over the entire clean fill period after CHUPS was connected to the TPC. Blue dots refer to yields from Ehigh-Ehigh events, red to yields from Ehigh-Everyhigh events. The GC analysis results are plotted as pink triangles for N2, green triangles for O2 (lower points), and one H2O point. Note that yields are not converted to concentrations; we have plotted yields and concentrations on the same scale.

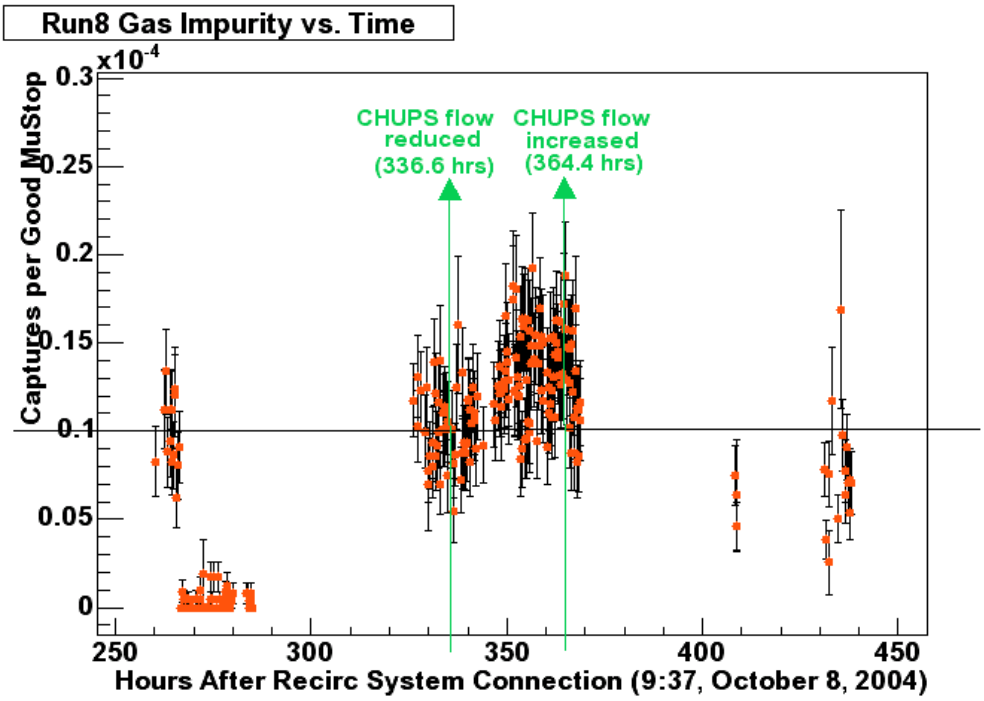

Fig.2: Tom's impurity yields with reduced and increased hydrogen flow rate in CHUPS. The starting time of the flow rate changes are indicated with arrows. With the reduced flow rate the TPC detects more impurity events.

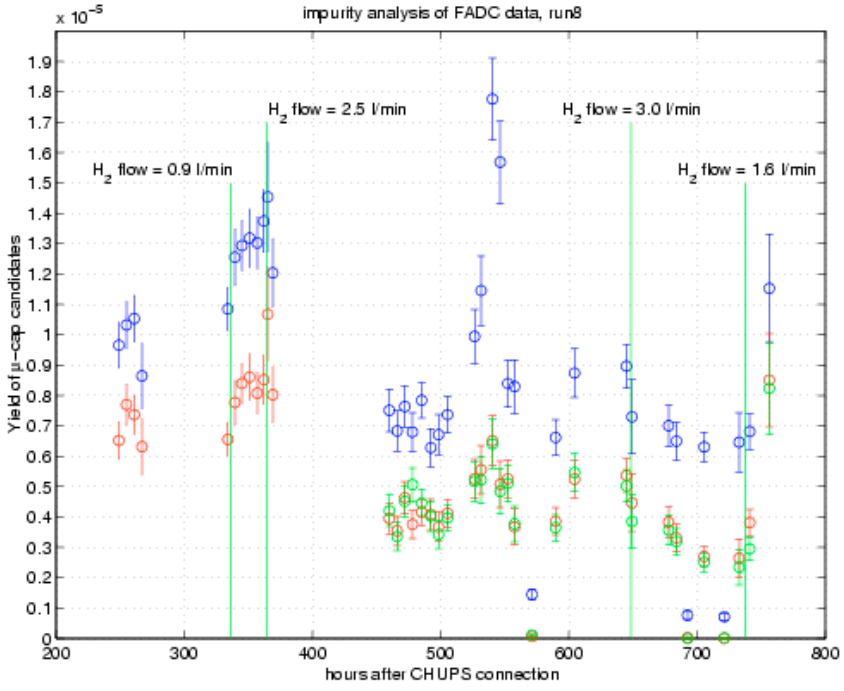

Fig.3: Oleg's FADC analysis impurity yields for the time of the indicated hydrogen flow rate changes.

GC analysis:

Results from the gas-chromatographic analysis of the samples taken from the TPC clean fill are given in Tab.1.

Sample	time	N2	O2	H2O
Sample 0	-50	2.75 ± 0.05 ppm	0.027 ppm	
Sample 2	5	0.787 ± 0.003 ppm	< 0.01 ppm	
Sample 3	29	0,0485 ± 0.0015 ppm	< 0.01 ppm	
Sample 4	57	0.024 ± 0.001 ppm	< 0.01 ppm	
Sample 5	154	0.0145 ± 0.0015 ppm	< 0.01 ppm	
Sample 6	670	0.0066 ± 0.0002 ppm	< 0.001 ppm	0.072 ± 0.004 ppm

Table 1: Results of the gas-chromatographic analyses of several TPC samples during the clean fill. Sample 0 was analyzed when the TPC was brought from storage, before connection to CHUPS. The time is given in hours after CHUPS connecting and running.

All values reported for N2 and O2 are plotted in Fig.1. We can clearly see the cleaning behavior of CHUPS acting on N2 and O2. After turn-on the small O2 content immediately reaches the GC sensitivity limit. However, the N2 level plateaus at 0.006 ppm, which is much lower then the one indicated by the direct TPC analyses.

Summary:

Tom's direct TPC impurity yield analysis plateaus at 8×10^{-6}, which is a factor of ~ 10 above its sensitivity level (determined with μ+). This yield could be explained by the following impurity concentrations:

N2 - 0.08 ppm
H2O - 0.046 ppm
O2 - 0.023 ppm
carbo-hydrates - 0.05 ppm (C-concentration)

or any combination of these "most likely" contents.

However, these numbers are in strong disagreement with the GC-results for N2 (factor 12), for O2 (factor 23). The level of H2O however seems to approximately agree.

The GC analysis follows the expected trend in impurity attenuation after CHUPS was switched on. Given only the comparison of the clean fill data and GC-analyses, one could conclude that the observed impurity events are dominated by H2O (moisture is likely to stick to the walls).

However, all following GC-analyses found the approximately same content of H2O in all samples, regardless of the fill. Reliability and trustworthyness of the H2O analysis can therefore be severely questioned.

Tom's direct TPC impurity yield analysis follows quickly all changes in the expected manner. Considering the direct TPC analysis being incorrect, one has to explain the high number of observed impurity events with either

1) a large H2O content, which was not seen in the GC analysis,
2) an unidentified impurity contribution hidden to the GC analysis (e.g. carbo-hydrates),
3) misidentification of impurity events on a gross level in Tom's event finder software.

Presently, we have no consistent explanation for the large observed mismatch of our analyses methods. There is no clear indication of the nature of the observed impurities in the clean fill. There is no indication, that the software finder is wrong by a large factor.

2) The nitrogen-doped fill

Volumetric analysis:

On Nov. 9, 2004 Claude and Malte added ~10ppm of nitrogen, as derived from volumetric calculations (ELOG 927). Since the calculation is based on pressure and volume, the atomic versus molecular concentrations (10 ppm N2 in H2, or 10 ppm N in H) should not affect the result. C&M's final released numbers for the N2 content are 11 ppm ± 2%. One shold mention that one expansion more (or less) would have changed the concentration by a factor of ~10 rather than a factor 2.

TPC analysis:

Tom's impurity yield analysis is shown in Fig.4. It clearly tracks the operation of the CHUPS system.

The observed yield can be converted into a approximately 8 ppm nitrogen concentration if one assumes a negligible contribution from other impurities and a capture yield to concentration conversion factor of 99. No impurity yield increase due to outgassing was observed. It was speculated that this could be an indication of water adsorption on the TPC walls.

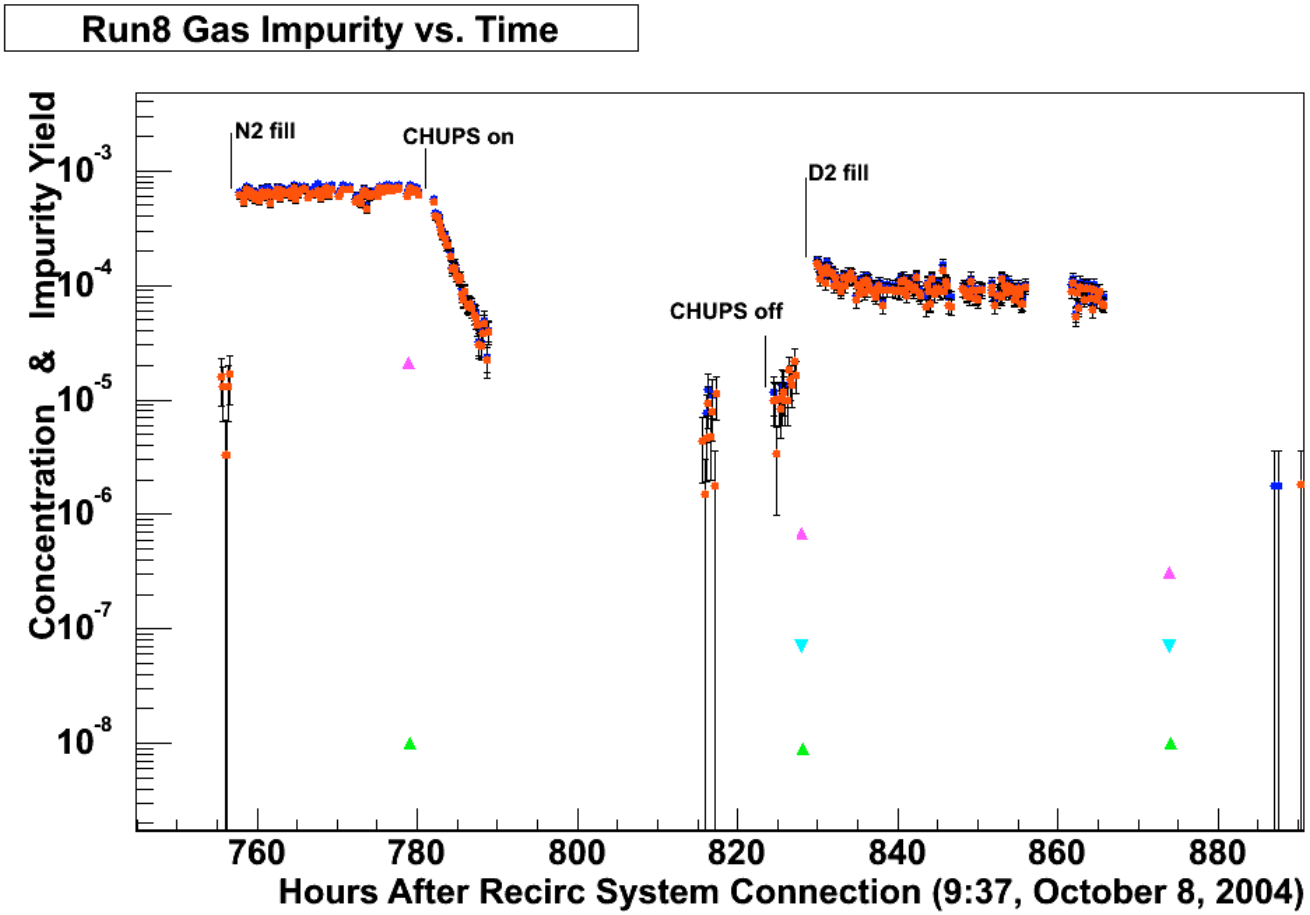

Fig.4: Impurity yields from Tom's TPC analysis, for the N2-doped fill and the D2-doped fill. CHUPS was switched off before the D2 doping. The plotted triangles indicate the corresponding concentrations found in GC-analyses for N2 (pink), O2 (green), and H2O (blue, upside-down). No increase due to outgassing was observed for both fills. It was speculated that this could be an indication of water adsorption on the TPC walls. Note that yields are not converted to concentrations. We have plotted yields and concentrations on the same scale.

Fig.5 shows Oleg's FADC analysis of the corresponding time period. The observed behavior qualitatively agrees with Tom's analysis; however, the event yield is a factor of ~3 lower, corresponding to ~3 ppm of nitrogen. This could originate in the trigger of the FADC system, which raised some concerns during the run.

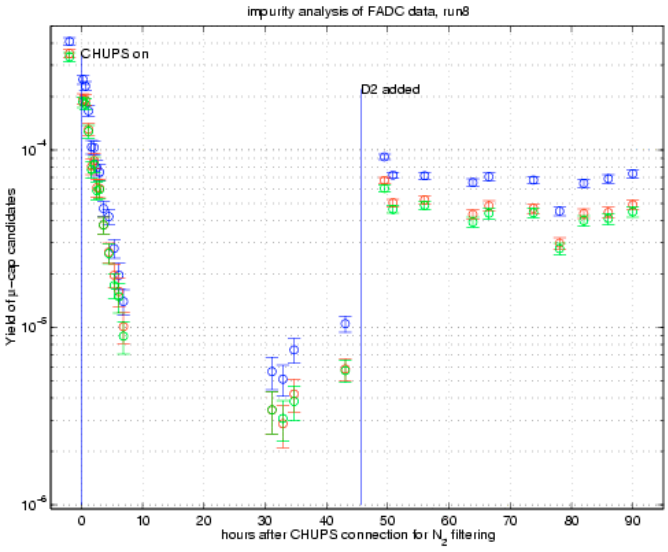

Fig.5: FADC analysis of the impurity event yield for the time when CHUPS is cleaning the N2 doped fill, and for the D2 doped fill.

GC analysis:

Table 2 shows the results from the GC analysis which are also displayed in Fig.4. The GC analysis also confirms the N2 cleaning by CHUPS.

Sample	N2	O2	H2O
N2-doped fill	21 ± 0.8 ppm	< 0.01 ppm	
after CHUPS cleaning	0.68 ± 0.02 ppm	< 0.01 ppm	0.07 ppm
after D2-doped fill	0.31 ± 0.01 ppm	< 0.01 ppm	0.07 ppm

Tab.2: GC analysis results for samples taken directly from the TPC system.

Summary:

1) There is a factor of 2 difference between the volumetric method and the GC analysis for the total amount of N2 in the TPC gas.
2) Tom's TPC data and Oleg's FADC data disagree roughly by a factor of 2-3 but, both support a N2 content of 10 ppm or lower. Tom's TPC yield analysis clearly supports a ~10 ppm filling.

Presently we do not have an explanation why the GC N2 analysis is at least a factor of 2 higher then all other results. Whether the discrepancy can be explained by uncertainties in the filling line volumes, or by the previous use of nitrogen in the sampling volume, should be dicussed by the experts.

3) The deuterium-doped fill

Volumetric analysis:

After CHUPS cleaned a large fraction of the doped N2 from the TPC system, CHUPS was disconnected. 1.2 bar protium was removed from the TPC, and natural hydrogen (6.0 purity) was filled directly from the red pressure bottle in order to achieve a ~20 ppm deuterium doping, assuming a 140 ppm deuterium content (ELOG 993). The natural hydrogen from the bottle was checked beforehand by GC analysis, and found to contain:

Sample	N2	O2
natural H2 (red bottle)	0.3 ppm	0.1 ppm

Tab.3: Results of the GC analysis for the natural hydrogen red gas bottle.

Consequently, the direct filling procedure without passing the hydrogen through the palladium filter should have proportionally added these impurities, resulting in a negligible additional amount of ~0.04 ppm of N2 and ~0.01 ppm of O2 in the TPC protium.

TPC analysis:

Tom's impurity analysis (Fig.4) shows that this filling resulted in an impurity increase to a yield of 10^{-4}, corresponding to 1 ppm of nitrogen. Oleg's FADC analysis (Fig.5) is roughly agreeing with Tom's result.

GC analysis:

The GC analysis (Table 2) shows that, after the 20 ppm D2-doping with natural hydrogen, the nitrogen level is a factor of 2 lower than before, with the O2 and H2O level staying the same. One should mention here again that the CHUPS system was disconnected before the filling and remained disconnected during all subsequent data taking.

Summary:

Directly-observed TPC impurity data indicate an increase of roughly one order of magnitude after the natural hydrogen fill.

The GC analysis shows a factor of 2 decrease in N2 content with O2 and H2O remaining on the same level. There is no likely explanation how adding natural hydrogen decreases the N2 level as observed in the GC analysis.

One can always claim an additional introduction of impurities to explain the rise in directly-observed TPC impurity events; however, they must be of a type which the GC analysis is insensitive to.

There is yet no explanation why the GC analysis sees a decrease in impurities when the TPC impurity yield analysis indicates an increase. However, it is hard to see how adding the small amount of natural hydrogen decreases the N2 content by a factor of 2.

4) The O2-doped fill

An O2-protium mixture was prepared to add a few ppm of oxygen to the TPC gas. According to Claude and Malte's calculation, the filling bottle should have contained 780 ppm of oxygen (ELOG 1023). Unfortunately, due to the electro-negativity of the oxygen, the filled amount of ~10 ppm reduced the TPC drift-time ~1 μs, and the data was useless. A subsequent GC analysis of the filling bottle (Prep. O2 bottle sample) found

Sample	N2	O2	H2O
O2 filling bottle	not visible	813 ppm	900 –1000 ppm

Tab.4: Results of the GC analysis for the filling bottle of the O2 doped fill.

It is not clear where this high amount of water came from. Probably it comes from $H2+O \rightarrow H2O$. However, if one adds up the oxygen atoms the chemists result is again two times higher of what Claude and Malte believed having filled in.

5) The natural hydrogen fill

Volumetric analysis:

After the O2 fill, the TPC was fully emptied, pumped and then filled with the gas from the natural hydrogen (6.0 purity) bottle via the palladium filter. This should have added between 40 and 140 ppm of deuterium to the TPC gas. The exact deuterium content of the bottle is not known.

TPC analysis:

Fig. 6 shows the corresponding result from Tom's TPC analysis. Strangely, in this fill one does not observe a fast impurity yield increase as expected from previous outgassing rates. A small increase of the observed events seems to be hidden by the small event statistics per run.

Figure 7 shows Oleg's FADC analysis where one can see the small yield increase due to outgassing. Oleg's blue points also agree with Tom's analysis on the absolute yield.

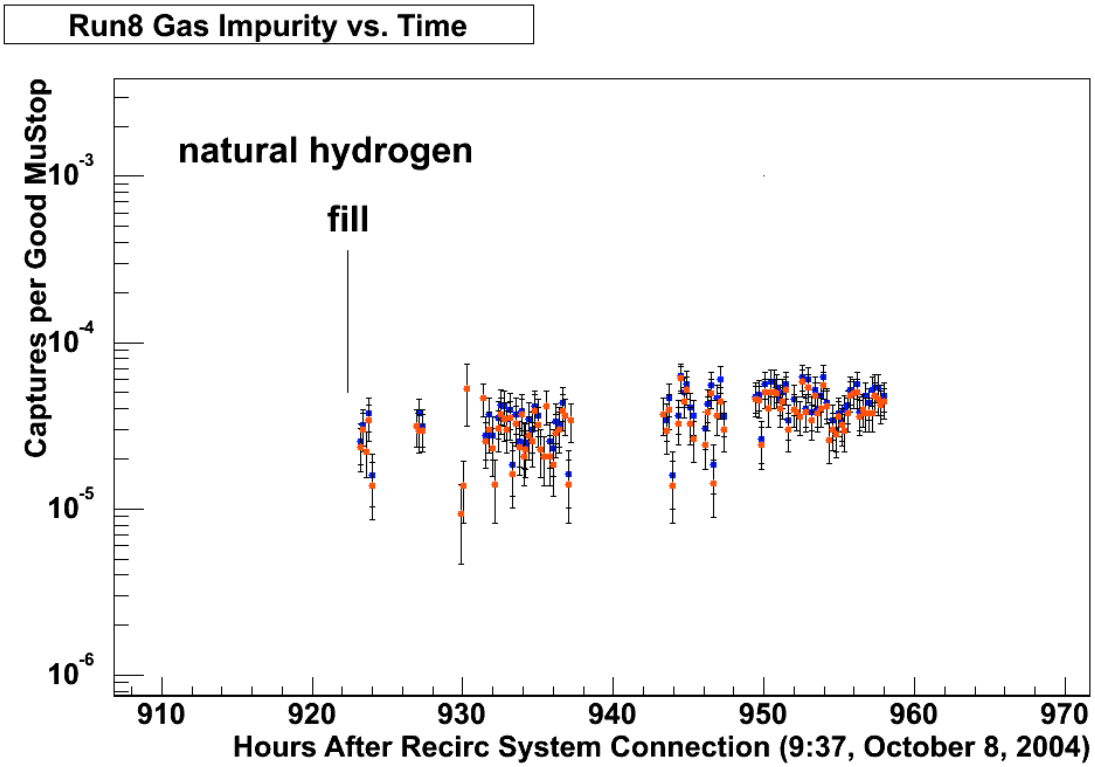

Fig.6: Tom's TPC impurity yield analysis of the natural hydrogen fill. Only a tiny yield increase over time is visible; a larger outgassing rate was expected.

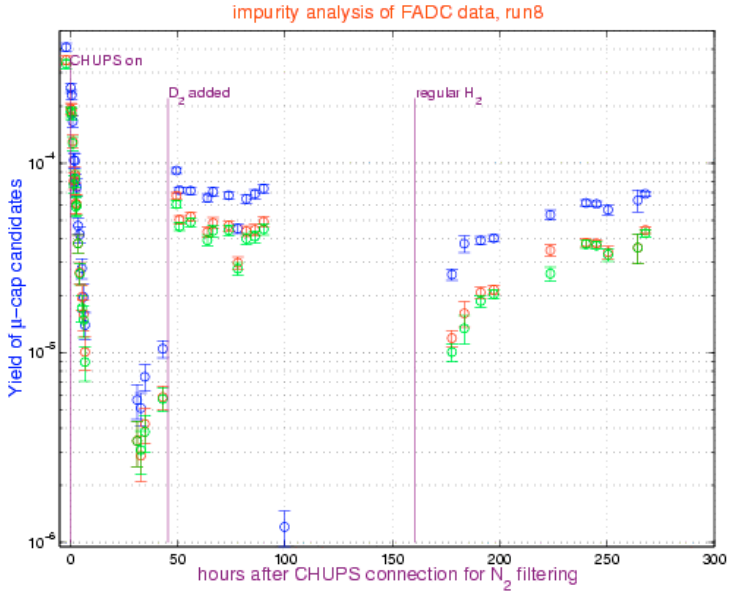

Fig.7: Oleg's FADC analysis of the natural hydrogen fill.

GC analysis:

While the water and oxygen content remained unchanged over 3 days, an increase of a factor of 2 in nitrogen was observed (see Tab.5).

sample taken	N2	O2	H2O
after filling	~0.2 ppm	< 0.01 ppm	~ 0.065 ppm
at end of fill data taking	0.4 ppm	< 0.01 ppm	~ 0.060 ppm

Tab.5: Results of the GC analysis for the natural hydrogen fill.

Summary:

This filling shows a rough agreement between the direct TPC data and the GC analysis in terms of

i) absolute yield with respect to the nitrogen content if one disregards the GC water analysis;
ii) the trend and relative amount of impurity increase.

The measured H2O content would contribute 0.2×10-5 to the impurity yield in the TPC analysis; a contribution as high as from the N2.

6) the H_2O doped fill

Volumetric analysis:

As the previous O2-fill could not be analyzed properly, we tried a final fill which contained oxygen in the form of water rather than in the form of the electro-negative O2. The following procedure was undertaken:
The GC analysis of the prepratory bottle for the previous mix was analyzed to contain 813 ppm oxygen, ~1000 ppm water, and one could assume that maybe some of the oxygen turned into water since the measurement. Believing this water content, we follwoed Marat's suggestion and put this bottle into a liquid nitrogen-alcohol equilibrium mix, which was measured to have a temperature of about –70 to –80 degrees C. We left the bottle cooled as it was mounted on the TPC gas apparatus. At this temperature, all water must be frozen at the bottle's surface. The low partial pressure of water, below 10^{-4} mbar at this temperature, should have kept the ice on the surface when the bottle was pumped. We pumped the bottle in the cooled state down to below 1 mbar pressure. Then protium from the hydride storage bed was added to fill the bottle to ~16 bar pressure. The volume was finally connected to the TPC, where the hydrogen pressure was raised to ~9.65 bar.

TPC analysis:

Tom's and Oleg's analysis find a slight increase in the impurity yield for this fill in comparison to the natural hydrogen fill. They agree on the yield level of 1×10^{-4}.

GC analysis:

The GC analysis results are shown in Tab.6. No change was observed in the water level, however, there was an increase in the N2 level which is higher than would be expected from outgassing. A subsequent analysis of the filling bottle for this fill yielded surprisingly high values of N2 and as expected ~3.5 ppm value of H2O (see Tab.5). There is no explanation where the N2 could have come from, as it seems impossible that such high levels of N2 originate from the protium in the hydride storage bed. To recall, this filling bottle was measured before cooling and pumping to contain 800 ppm O2 and 1000 ppm H2O, but no N2. It is unclear why the 3.5 ppm water of the filling bottle does not show up in the GC analysis of the TPC sampel volume.

sample taken	N2	O2	H2O
at the end of fill	1 ppm	~ 0.01 ppm	~ 0.060 ppm
H2O filling bottle	12 ppm	< 0.01 ppm	3.5 ppm

Tab.6: GC analysis from the H2O doped fill. TPC sample and filling bottle

Summary:

The directly-observed impurity yield in the TPC, if due to nitrogen, agrees with the GC analysis. Though there should have been only water in the filling bottle, the GC analysis reported an increase in nitrogen only. This is only possible if there was a nitrogen contamination in the protium hydride storage. We have no reason to believe that this is true on that level, but we have not checked the cleanliness of the stored protium.

The fact, that the GC analysis does not see any water increase at all can be explained by one of the following scenarios:

i) the 1000 ppm water originally measured by the GC analysis in the filling bottle was wrong;
ii) although the bottle was cooled and all water should have frozen to the inside walls, the water was still pumped out of the bottle;
iii) the water remained in the bottle during filling and did not mix into the TPC hydrogen.

The subsequently measured 3.5 ppm of H2O in the filling bottle should have resulted in a much larger water content from the target sample than 0.06 ppm. This points to an internal inconsistency of the GC analysis results.

7) Conclusions

Impurity concentrations derived from a) impurity yields directly observed in the TPC and b) gas-chromatographic analysis differ largely for several TPC fills.

The GC analysis also differs from the volumetric method for the N2 fill by a factor of 2.

All but one water analysis from the TPC gas samples yielded the same result around 0.07ppm, independently of the fill and of the assumed increase due to outgassing in the TPC or added moisture from the filling bottle. This suggests the moisture analysis to be untrustworthy.

The direct impurity yield determination in the TPC using only time or energy information proved to be very sensitive. However, the observed absolute yield only agrees with the gas-chromatographic analysis for the natural hydrogen fill, and not for any of the other fills.

We are therefore stuck with the following questions:

1) Why is the GC analysis not reflecting the TPC gas, and for which type of contaminant i) N2, ii) O2, iii) H2O is this true ?
2) Do our gas samples accurately reflect the TPC content, or are they being contaminated on the way to the gas chromatographic analysis? It is hard to explain lower impurity contaminations observed on the chromatograph this way.
3) Are there unknown contaminations in the gas which are not seen by the PNPI gas-chromatography, like hydrocarbons ? Why is the GC analysis not reflecting the TPC gas, and for which type of contaminant i) N2, ii) O2, iii) H2O is this true ?
4) How could it be that Tom's impurity tracker and Oleg's FADC analysis are wrong by the same large factor? What type of events could mimic impurity events?

One obvious suggestion for the next run is to have the gas analysis directly inline, and thereby avoid any uncertainty introduced by sample taking. This is likely the only for a reliable and trustworthy moisture determination.
Off-site analysis of two of the run samples (blue bottles) will hopefully also help to solve the puzzle.

Addendum:

a) Peter's (usual) summary spread-sheet.

b) List of all gas samples, analyses, and sample taking times as known on Dec. 5, 2004.

filling	end of clean protium fill	N2 doped	D2 doped		O2 doped	nat. H2	H2O doped
yields and c in ppm							
TPC							
yield Tom selection (red)	7	800.0		80.0		40.0	100
yield Oleg selection (green)	4	400.0		50.0		40.0	100
c_H2O (derived from Tom's yield) >	0.041			0.468		0.23	
c_N2 (derived from Tom's yield) >		8		0.8		0.40	1.00
gas preparation			filling		filling		
description		elog 927	52/400 added				needs info Malte
result		11			780.0		
error		0.22					
comment		indicates Tom's efficiency= 8/11					
expected based chemists analysis and filling fraction							
N2				0.039			
H2O							
O2				0.013			
chemists	TPC	TPC	filling mix	TPC	filling		
result H2O	0.072			0.07	1000.0	0.06	0.06
error	0.004						
comment							
result N2	0.0066	21	0.3	0.31		0.40	1.00
error	0.0002	0.8		0.01			
comment							
result O2			0.1		813.0		
error							
comment				total O2 =	1313.0		

inconsistencies and comments		
	1	chemist's H2O analysis gets always same results for low H2O conc, not in agreement with clean fill yield
	2	chemist's N2 inconsistent, problem with sampling volume?
	3	yield in D2 doped sample not explained by observed impurities
	4	factor ~2 discrepancy between O2 gas preparation and chemist's analysis
	5	TPC/chemists agree for N2 in nat. H2 fill and H2O fill (though the later is not really understood)
	6	H2O fill completely ununderstood, water was lost?
	7	Oleg's efficiency usually 1/2 of Tom's, only the same for nat. H2 and H2O doped

	Gas Analysis	Date	Time	Sample Size	Fill	N2	O2	H2O	Deuterium	Time (CHUPS)	Comment	E-Log	Author
2	SampleA CHUP	09/25/04	morning	5 liters	clean protium	0.19 ± 0.01 ppm	< 0.01 ppm			-100	fill from CHUPS	240	Claude, Malte et al
3	SampleB CHUP	09/28/04		5 l	clean protium	0.015 ± 0.0002 ppm	not visible			-100	fill from CHUPS after mass flow controler ex	341	Gennady S.
4	Sample-storage	10/04/04	13:00		protium	2.2 ± 0.13 ppm	0.25 ± 0.01 ppm			-100	Protium from storage vessel used for PNPI	TPC fill	Gennady S.
5													
6	Sample 0	10/06/04			clean protium	2.75 ± 0.05 ppm	0.027 ppm			-50	TPC after storage	463	Claude
7	calculation	10/08/04	10:20	calculation	clean protium	1.1 ppm	0.01 ppm			0	assumption wrong	463, 478	Claude
8	Sample 2	10/09/04	15:20		clean protium	0.787 ± 0.003 ppm	< 0.01 ppm			5	CHUPS 5 hours working	463	Claude
9	Sample 3	10/09/04	15:20		clean protium	0,0485 ± 0.0015 ppm	< 0.01 ppm			29	CHUPS 29 hours working	463	Claude
10	Sample 4	10/10/04	19:30	6 l	clean protium	0.024 ± 0.001 ppm	< 0.01 ppm			57	CHUPS 56 hours working	463465	Claude, Peter
11	Sample 5	10/13/04				0.0145 ± 0.0015 ppm	< 0.01 ppm			154	CHUPS ~154 hours working	541	Marat
12													
13	Sample 6	11/03/04		5 l / 10 l	clean protium	0.0066 ± 0.0002 ppm	< 0.001 ppm	.072 ± 0.004 ppm		670	from TPC / sample also for isotopic analysis	899, 937	Gennady S., Claude
14	Sample 7	11/09/04	21:00	11 l	N2 doped	21 ± 0.8 ppm	< 0.01 ppm				doped N2 - no CHUPS	994	Claude
15	Sample 8	11/11/04	22:00 (21:0	11 l	cleaned N2 mix	0.68 ± 0.02 ppm	< 0.01 ppm	0.07 ppm			doped N2 - cleaned with CHUPS -before na	994	Claude
16	Sample 9	11/13/04	20:48 (20:30)		D2 doped	0.31 ± 0.01 ppm	< 0.01 ppm	0.07 ppm			D2 Mix		Gennady S.
17	Sample 10	11/17/04	13:30	11 l	nat H2	~0.2 ppm	< 0.01 ppm	~ 0.065 ppm			nat H2 at start	1115	Gennady S.,Tom, Peter
18	Sample 11	11/20/04	13:30		nat H2	0.4 ppm	< 0.01 ppm	~ 0.060 ppm			nat H2 end of data taking	1115	Gennady S.,Tom, Peter
19	Sample 12	11/21/04			H2O doped	1 ppm	~ 0.01 ppm	~ 0.060 ppm			H2O doped run after bottle freezing	1115	Gennady S.,Tom, Peter
20													
21	Blue Sample 1	11/11/04	12:00	300 ccm	cleaned N2 mix							979	Bernhard
22	Blue Sample 2	11/17/04	18:30	300 ccm	nat H2 fill							1068	Malte
23	Blue Sample 3	11/20/04	18:30	300 ccm	nat H2 fill						end of H2 run		Malte
24													
25	red H2 bottle	before 11/11			natural H2	0.3 ppm	0.1 ppm				from bottle	993	Claude
26	Prep bottle O2 I	11/14/04	19:00 (20:0	9.4 l (old sa	O2 doped	not visible	813 ppm	900 - 1000 ppm			TPC filling bottle analysed, not a standard s	1023	Malte
27	Prep bottle H2O	11/20/04	18:30		H2O doped	~ 12 ppm	< 0.01 ppm	~ 3.5 ppm			cooled, pumped to 1mbar, filled with protiun	1023,11	Malte, Gennady S, Tom, Peter
28													
29													
30	Claude and Malte's Fillings										Volumetric Calculations		
31	N2	11/09/04			N2 mix	11 ppm ± 2 %					TPC content		
32	D2	11/11/04			D2 mix				~ 20 ppm		TPC content	993	Claude
33	O2	11/14/04			O2 mix		10 ppm				TPC content		
34	O2	same as above			O2 mix		800 ppm				filling sample volume		Claude
35	H2O	11/20/04			H2O mix						should contain only water + previous TPC impurities		Malte
36													
37													
38	Doebeli - ETH												
39	original pure pr	before the run			protium				1.72 ± 0.09 ppm			746	Claude
40													
41	Saurer-PSI												
42	Ontario Water	mid september			protium				1.71 ± 0.12 ppm			390	Claude
43	PNPI "old"				protium				3.27 ± 0.17 ppm			390	Claude
44	PNPI " new"				protium				12.35 ± 0.1 ppm			390	Claude