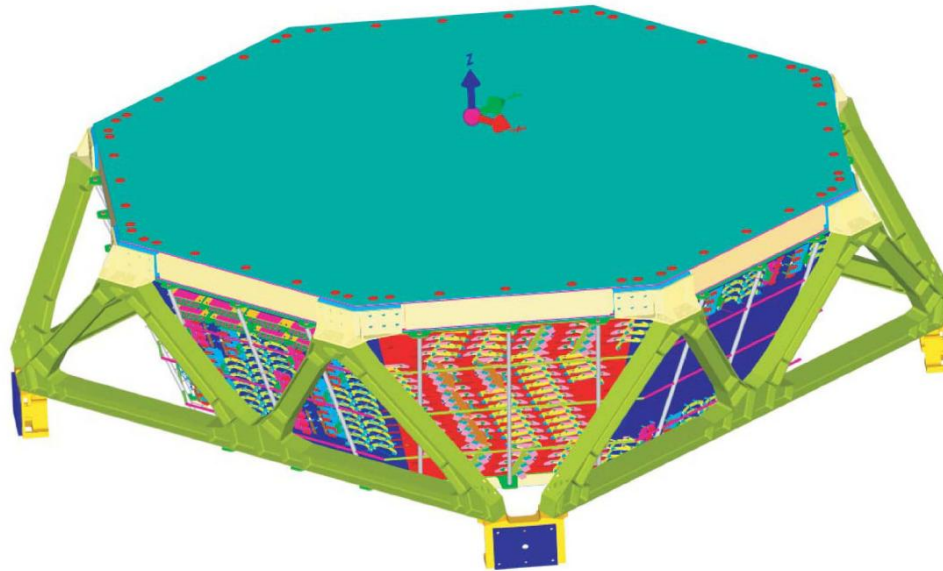


AMS TIM and General Meeting

Status of TRD Straw Modules



Th. Kirn
I. Phys. Institute B

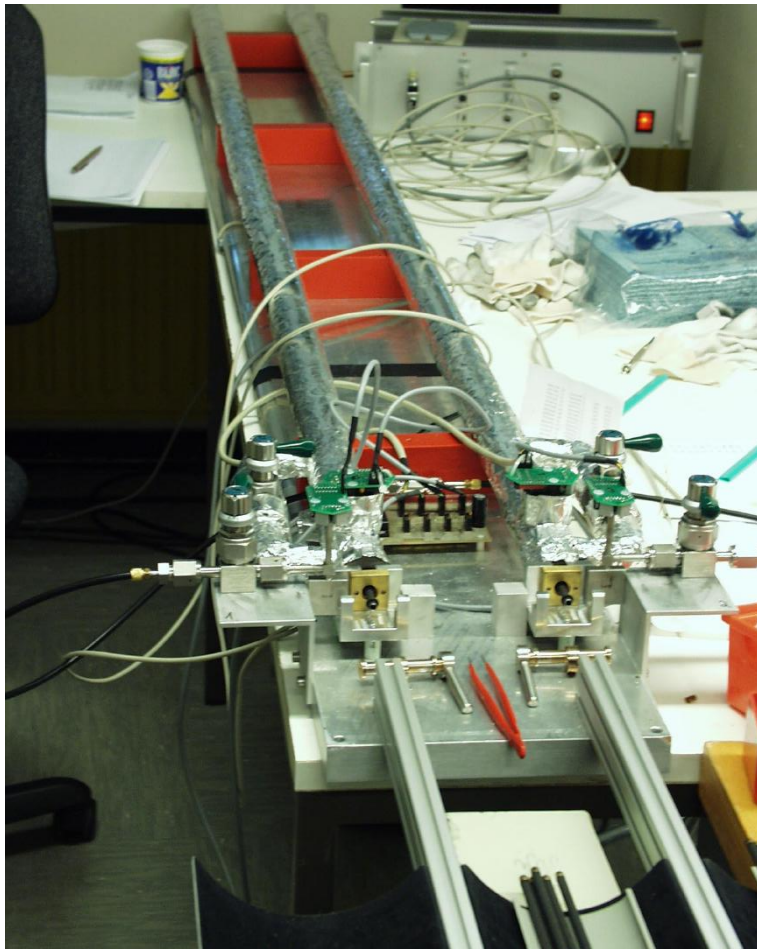
RWTH
Physics AC-I

CERN, 28th October 2003

Status TRD Straw Modules

C.H. Chung, F. Dömmecke, S. Fopp, K. Lübelmeyer, W. Karpinski, Th. Kirn, S. Schael, G. Schwering, Th. Siedenburger, A. Schultz von Dratzig, M. Wlochal

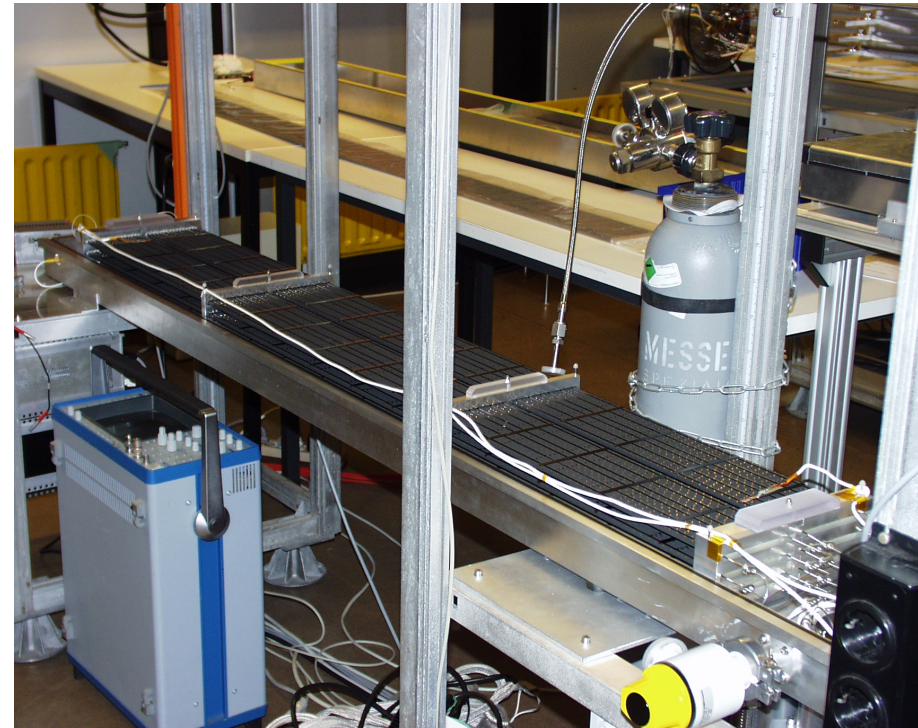
1.) Single Straw Test

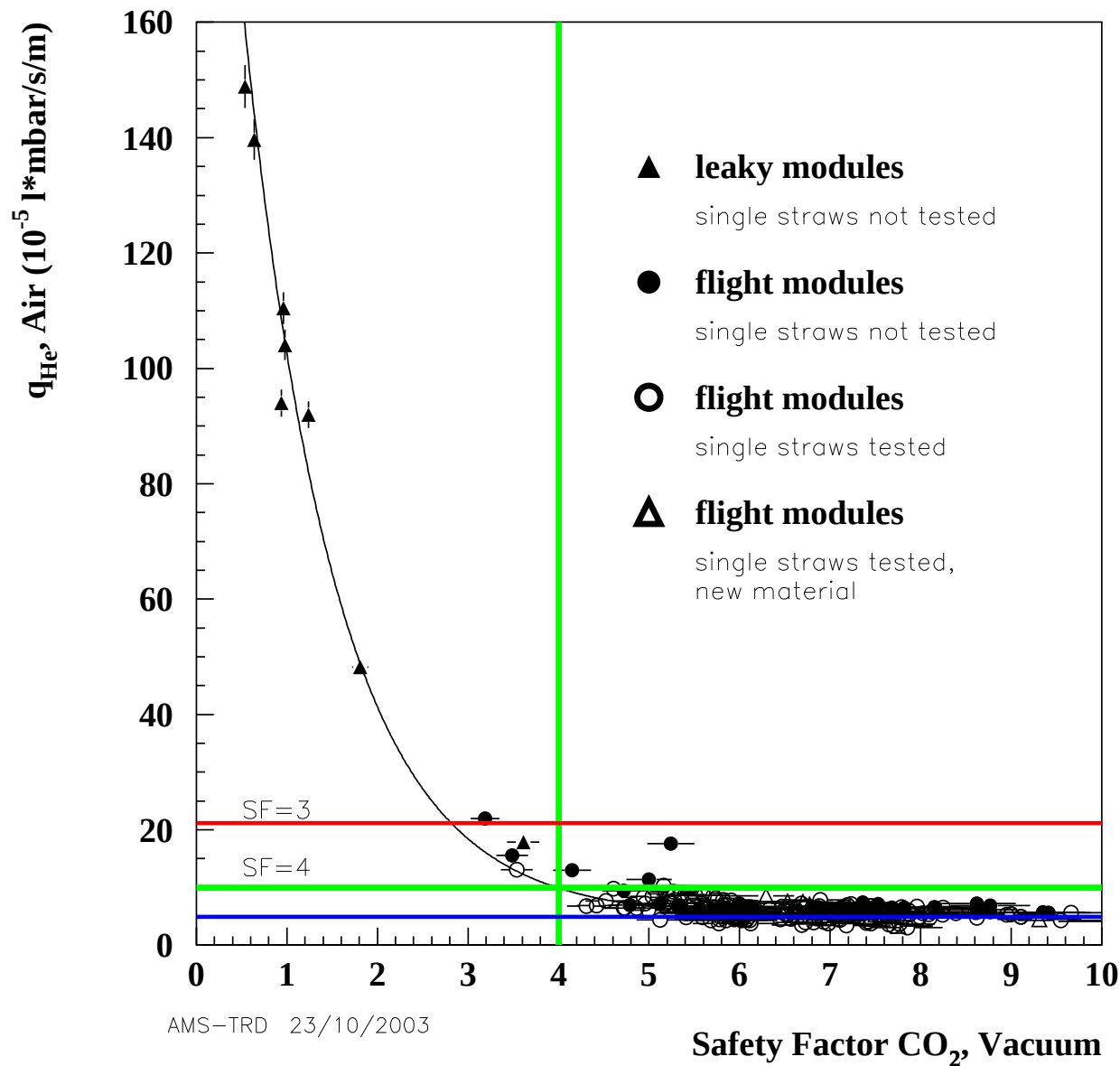


2.) Module Production



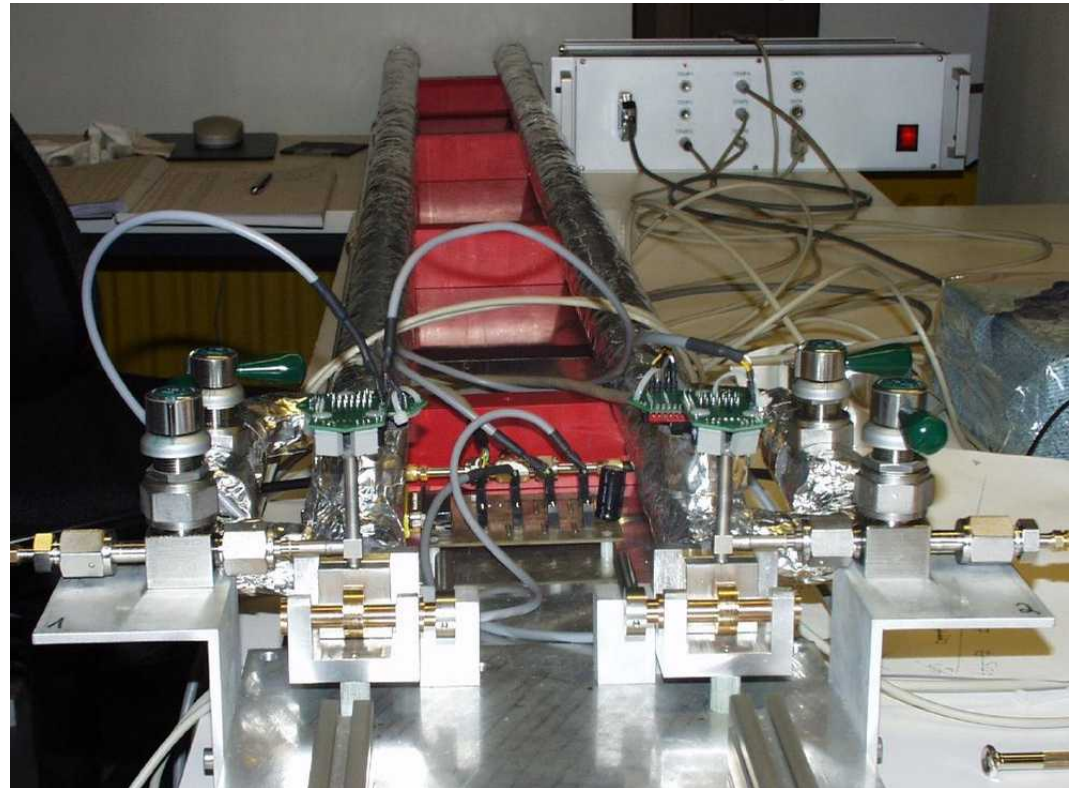
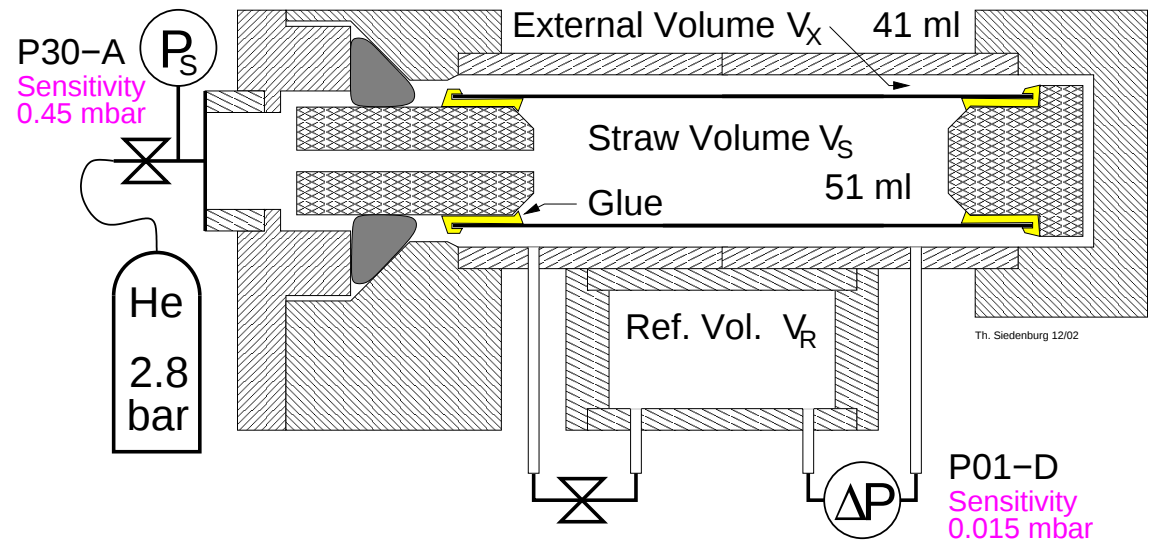
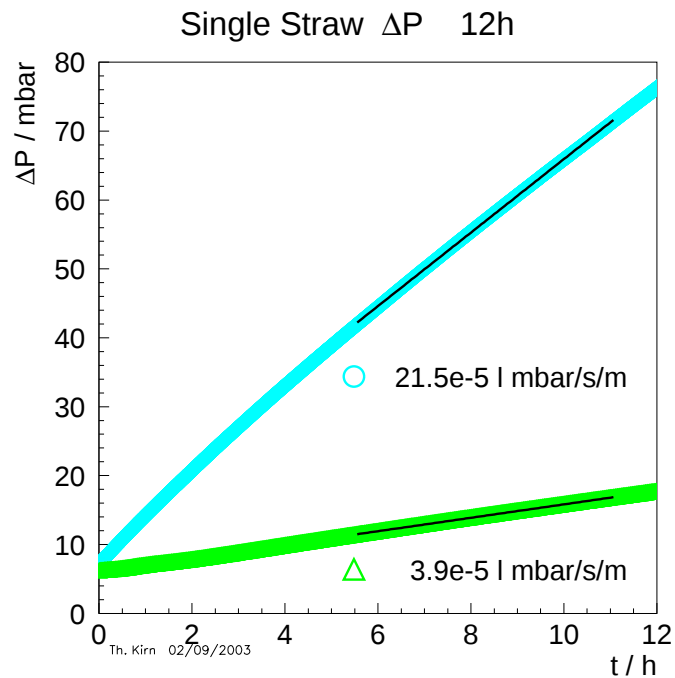
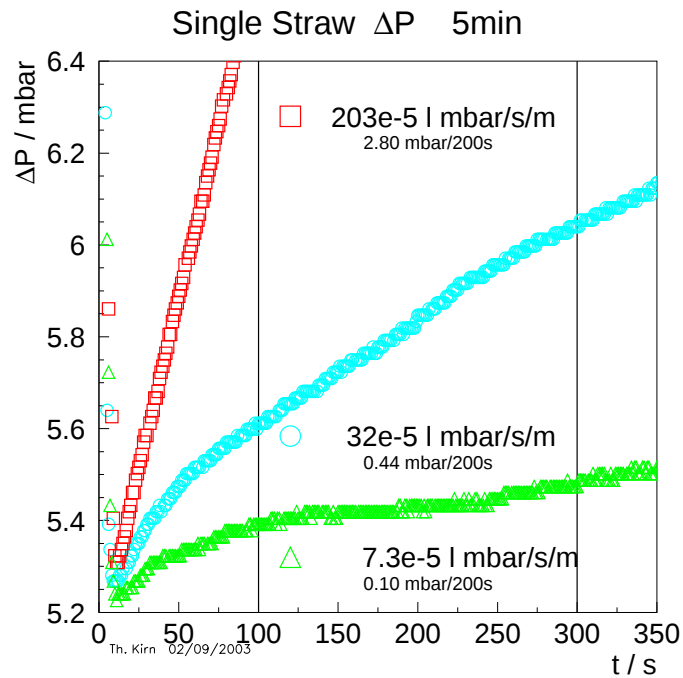
3.) Longterm-Vacuum-Test



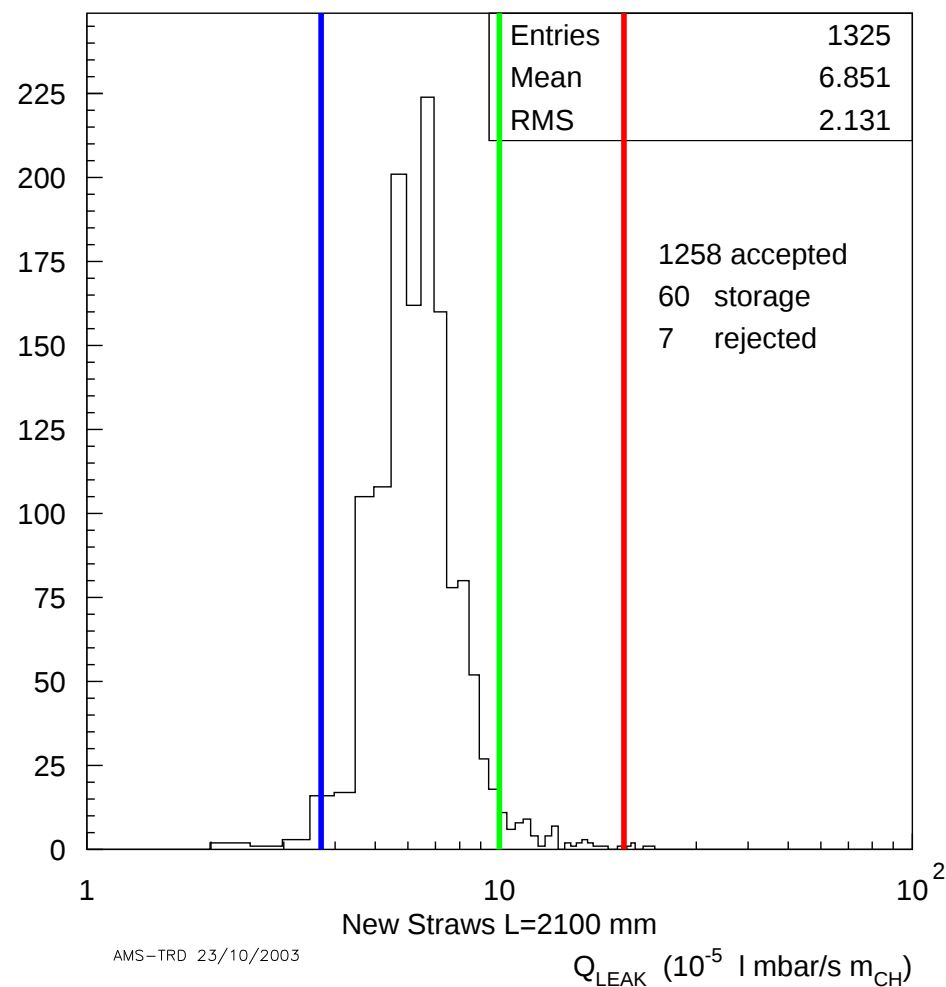
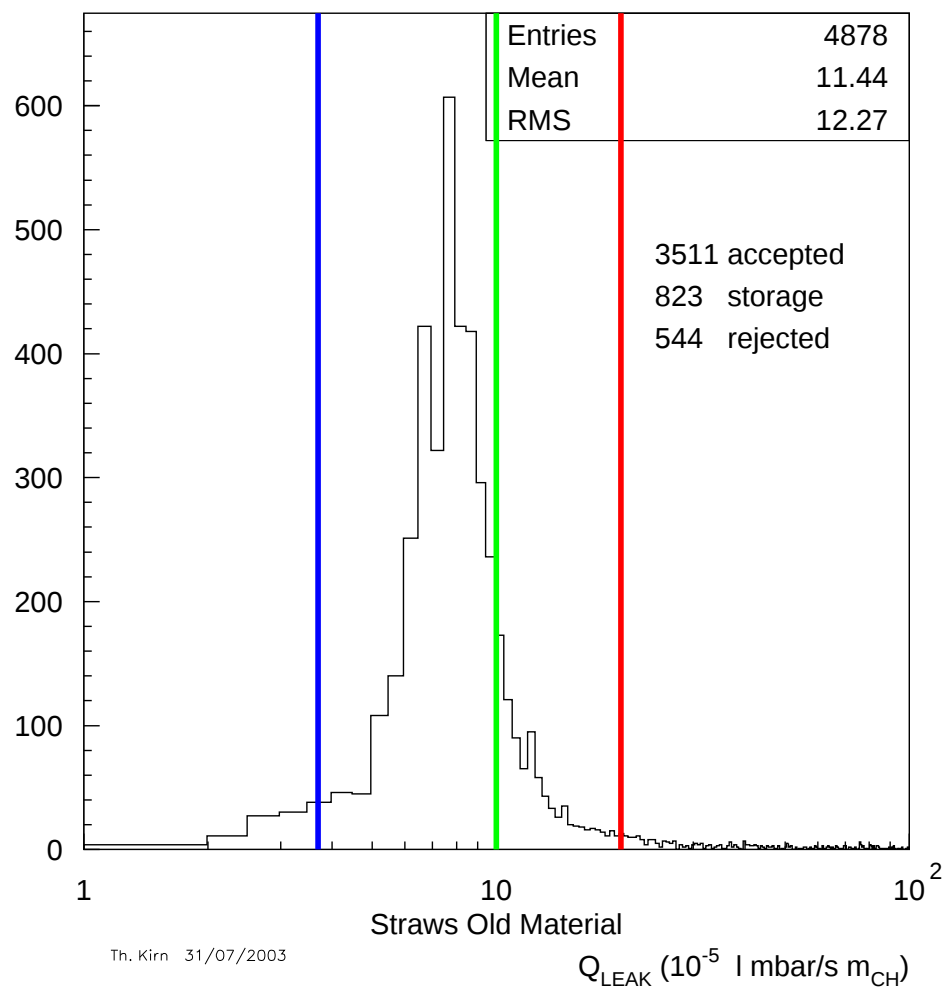
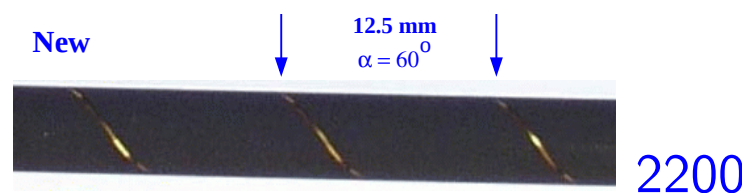
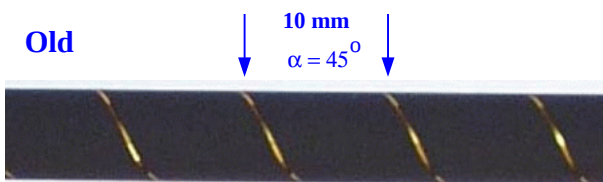


- Aim: Safety Factor of $> 4 \Leftrightarrow > 12$ years on ISS $\rightarrow$ He: $10 \cdot 10^{-5} \text{ l} \cdot \text{mbar/s/m}$
 $\Rightarrow$ Need to test each of 5248 straws

Single Straw Test



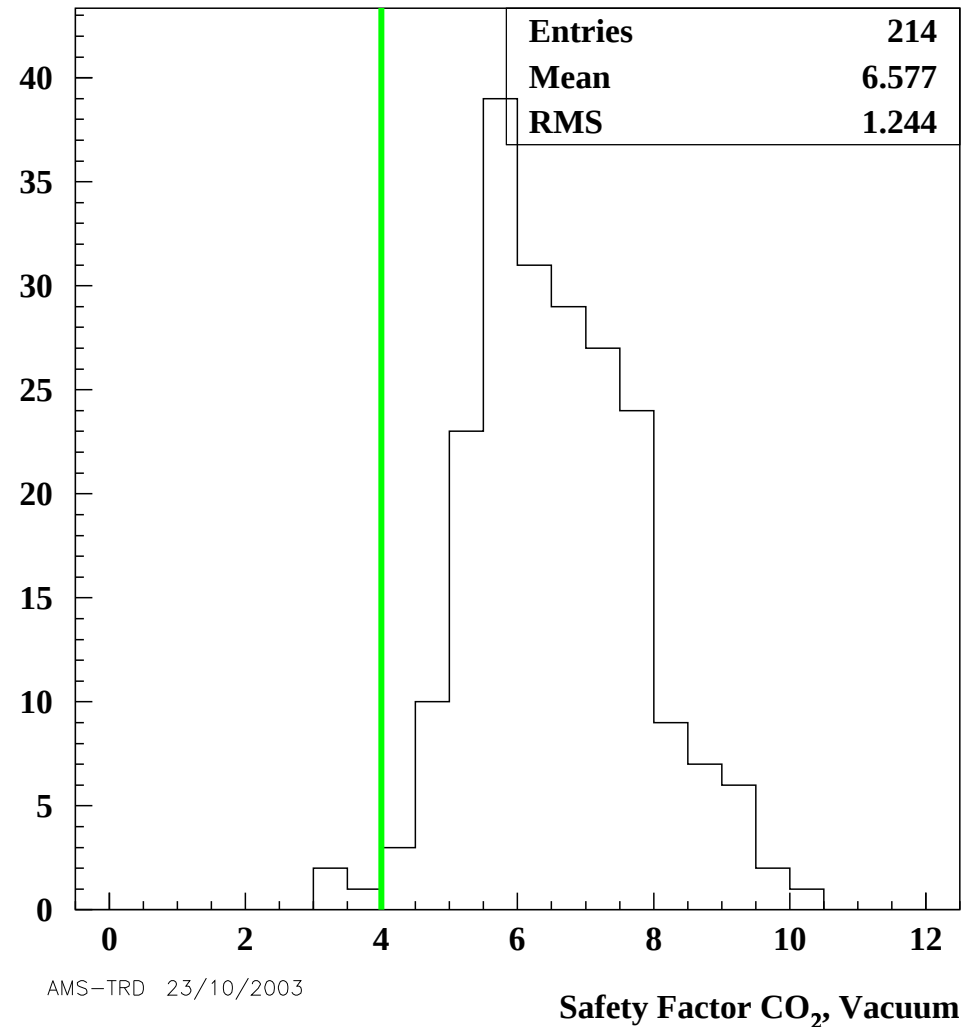
Single Straw Test: 16 Straws/Module $\times$ 328 Modules = 5248 Straws



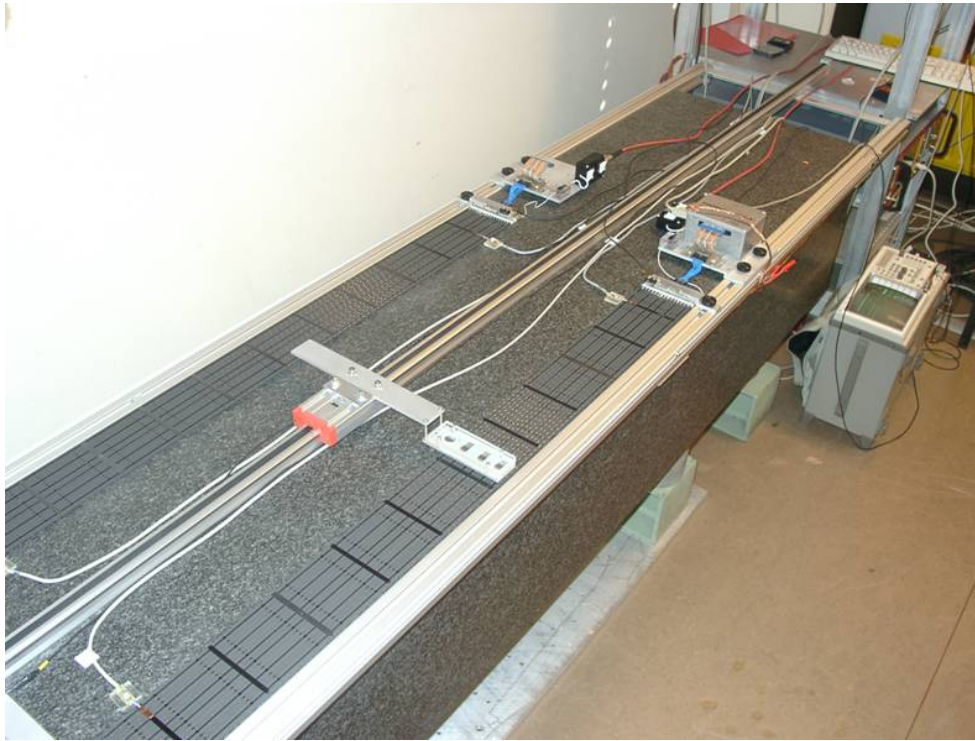
Straw Module Production



214 Straw Modules:
Safety Factor for TRD: ~ 6.6
 $6.6 \times 3y \sim 20$ years operation on ISS

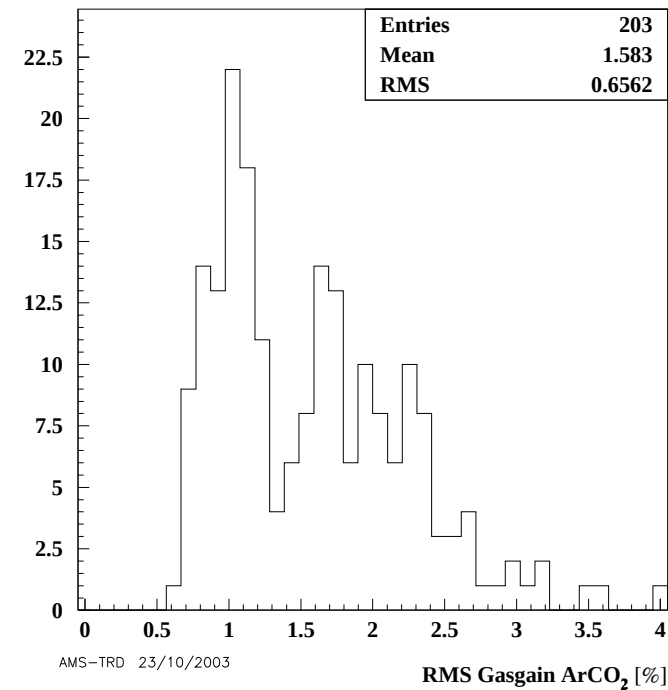
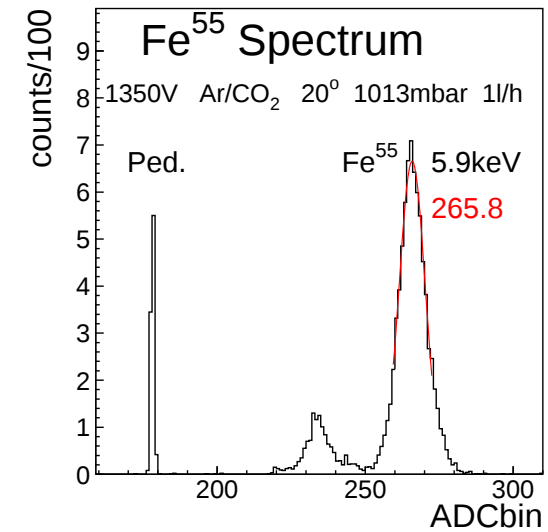


Measurement of Gas Gain with Fe^{55} source



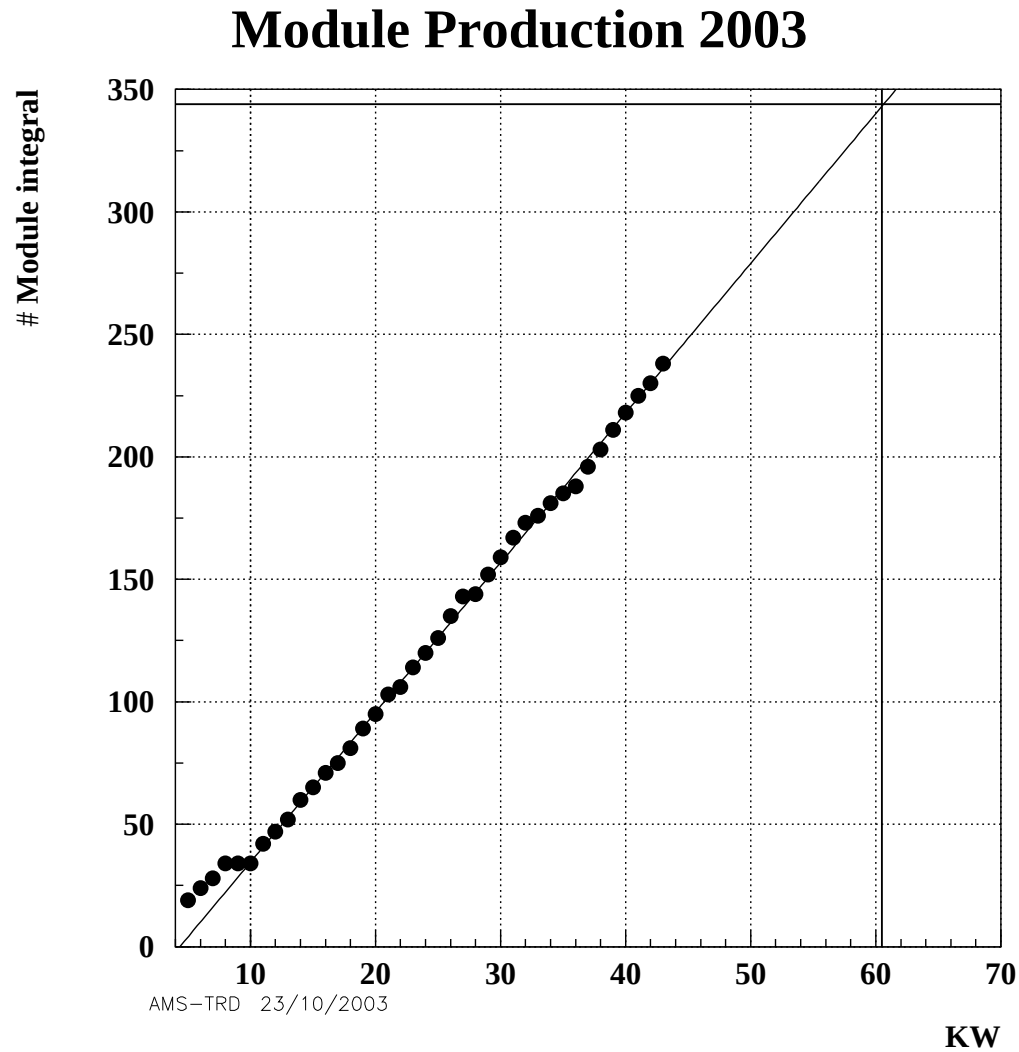
Mean: 5720.69 RMS: 63.90
c:\ggdata\progs\027_3S.pas

Straw	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2.1	1.6	-2.1	1.0	1.4	1.9	-0.3	0.5	1.6	0.5						
2	-0.8	1.2	0.0	-0.7	1.2	1.0	1.7	-0.2	1.9	1.3						
3	-0.4	-0.5	0.8	-1.3	-0.3	1.6	2.4	0.7	2.9	2.4						
4	-0.4	-1.0	-0.7	-0.5	-1.6	-1.2	0.4	0.5	0.4	0.7						
5	-0.3	0.2	-1.4	0.2	0.3	0.1	0.5	0.8	1.5	0.1						
6	-0.4	0.7	-1.7	-0.1	0.4	-1.3	-0.2	1.4	-0.8	-1.2						
7	-1.1	0.9	-1.9	-1.1	0.3	-0.3	-1.1	1.4	0.6	-0.0						
8	-0.4	-0.1	-1.2	-0.8	-0.0	-2.0	0.4	1.4	-1.4	-1.2						
9	-0.1	-0.3	-0.2	-0.7	-0.8	-1.4	0.2	1.4	-1.2	-0.2						
10	-0.1	0.6	-2.5	-0.3	1.0	0.0	-0.5	0.6	1.2	-1.3						
11	-1.7	-0.6	-1.1	-2.3	0.3	0.1	-0.6	-0.3	0.6	0.3						
12	0.2	-0.9	-2.8	-0.7	-0.9	-0.5	-1.0	-0.5	-0.4	-1.3						
13	-0.3	0.6	-2.3	-0.3	1.4	-0.5	-2.0	0.2	0.5	-1.1						
14	-0.2	0.4	-0.3	0.2	0.3	0.6	-0.1	1.1	0.8	1.4						
15	-2.2	-0.8	0.1	-0.6	-1.0	0.5	0.9	-0.8	2.0	1.9						
16	0.8	1.3	-1.1	2.1	2.4	0.6	0.2	1.7	1.0	-1.2						



Average variation of gas gain: 1.6%

Straw Module Production Status



End of Module Production: March 2004



Straw Module Production Status

	-9	-8	-7	-6	-5	-4	-3	-2	-1	+1	+2	+3	+4	+5	+6	+7	+8	+9	
	260		268		276		284		292		300		308		316		324		20
		264		272		280		288		296		304		312		320		328	
	259		267		275		283		291		299		307		315		323		19
		263		271		279		287		295		303		311		319		327	
	258		266		274		282		290		298		306		314		322		18
		262		270		278		286		294		302		310		318		326	
	257		265		273		281		289		297		305		313		321		17
		261		269		277		285		293		301		309		317		325	
	188		196		204		212		220		228		236		244		252		16
		192		200		208		216		224		232		240		248		256	
	187		195		203		211		219		227		235		243		251		15
		191		199		207		215		223		231		239		247		255	
	186		194		202		210		218		226		234		242		250		14
		190		198		206		214		222		230		238		246		254	
	185		193		201		209		217		225		233		241		249		13
		189		197		205		213		221		229		237		245		253	
		128		136		144		152		160		168		176		184		12	
	124		132		140		148		156		164		172		180		183		11
		127		135		143		151		159		167		175		183		11	
	123		131		139		147		155		163		171		179		182		10
		126		134		142		150		158		166		174		182		10	
	122		130		138		146		154		162		170		178		181		9
		125		133		141		149		157		165		173		181		9	
	121		129		137		145		153		161		169		177		120		8
		064		072		080		088		096		104		112		119		8	
	060		068		076		084		092		100		108		116		118		7
		063		071		079		087		095		103		111		115		7	
	059		067		075		083		091		099		107		115		117		6
		062		070		078		086		094		102		110		114		6	
	058		066		074		082		090		098		106		114		117		5
		061		069		077		085		093		101		109		113		5	
	057		065		073		081		089		097		105		113				4
		004		012		020		028		036		044		052		056		4	
		008		016		024		032		040		048		056				3	
		003		011		019		027		035		043		051		055		3	
		007		015		023		031		039		047		055				2	
		002		010		018		026		034		042		050		054		2	
		006		014		022		030		038		046		054				1	
		001		009		017		025		033		041		049				1	
		005		013		021		029		037		045		053				1	

BODY

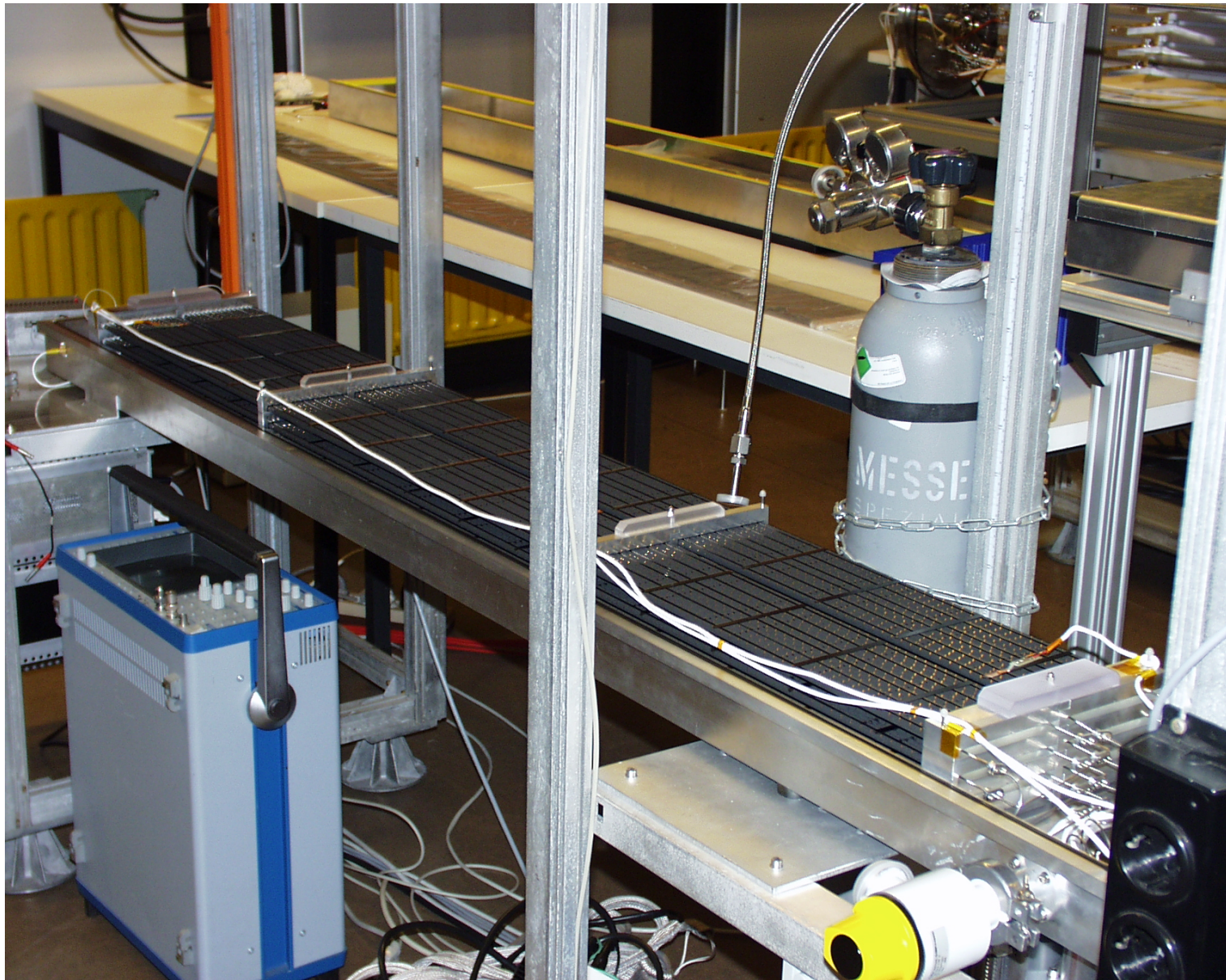
produced

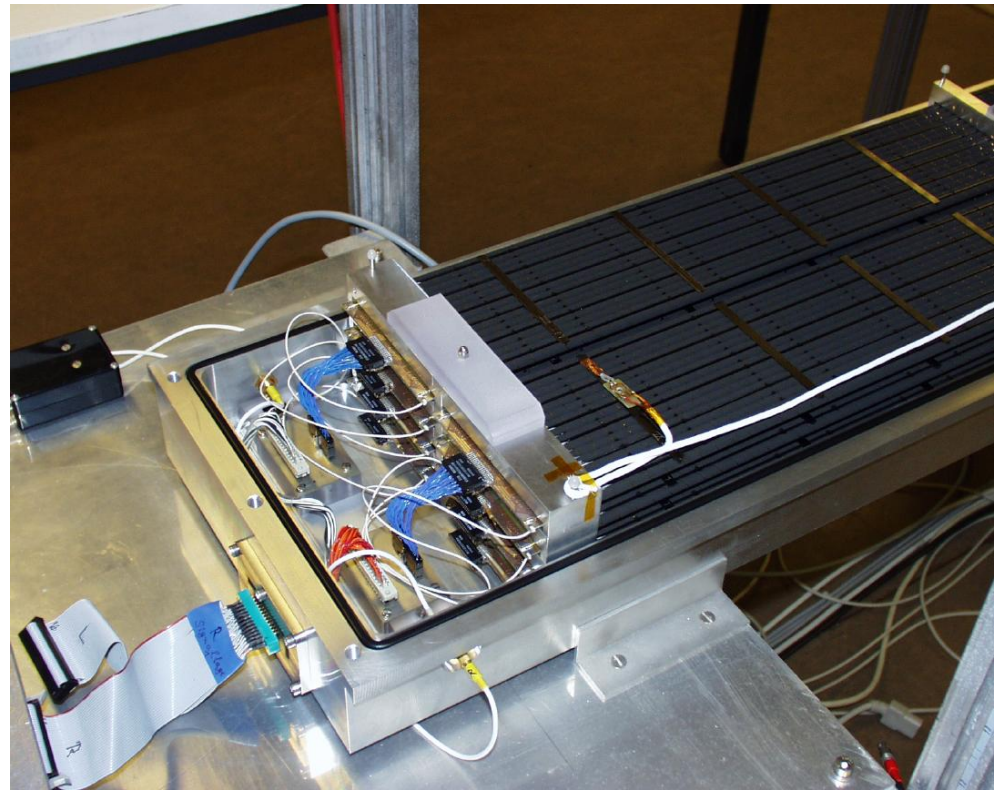
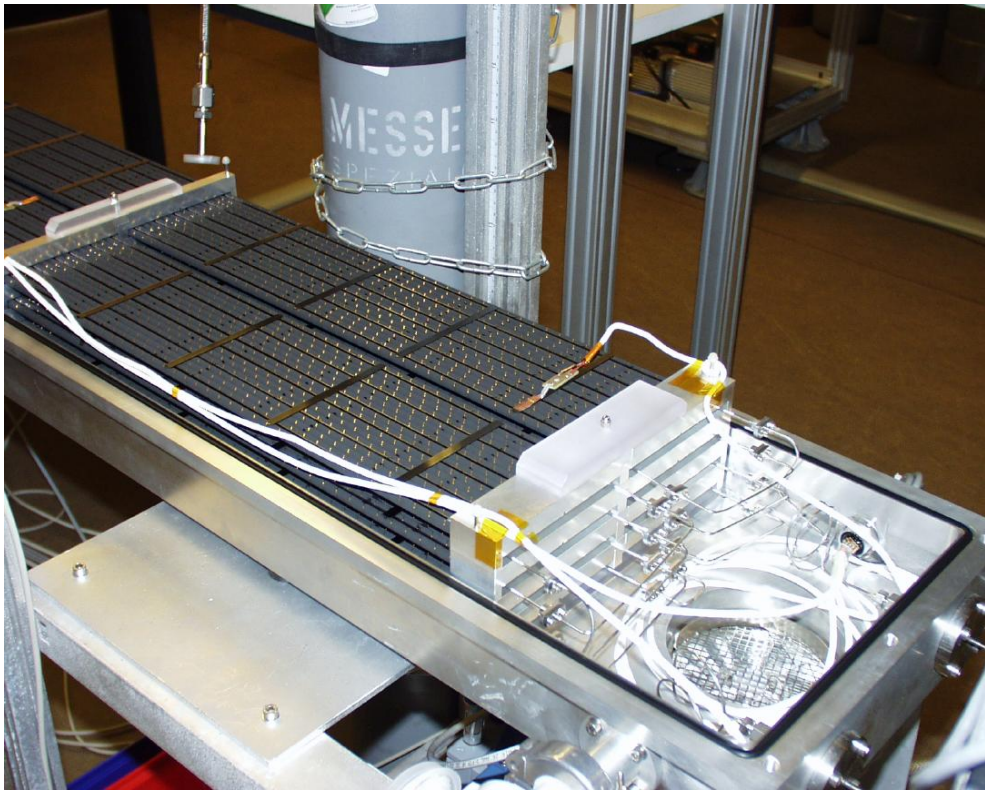
MODULE

under test

ok

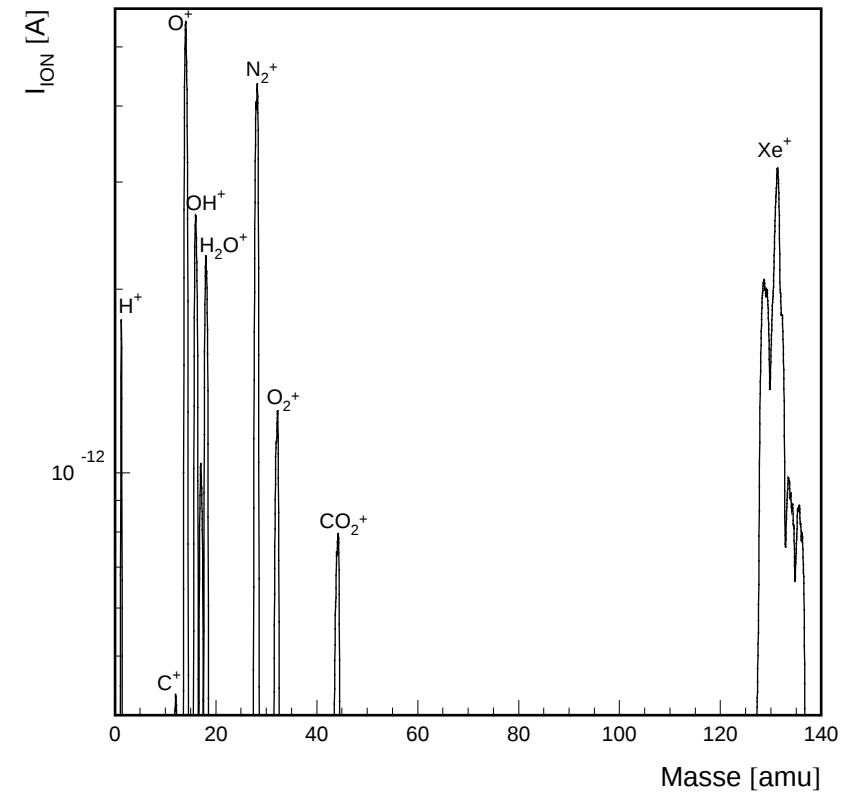
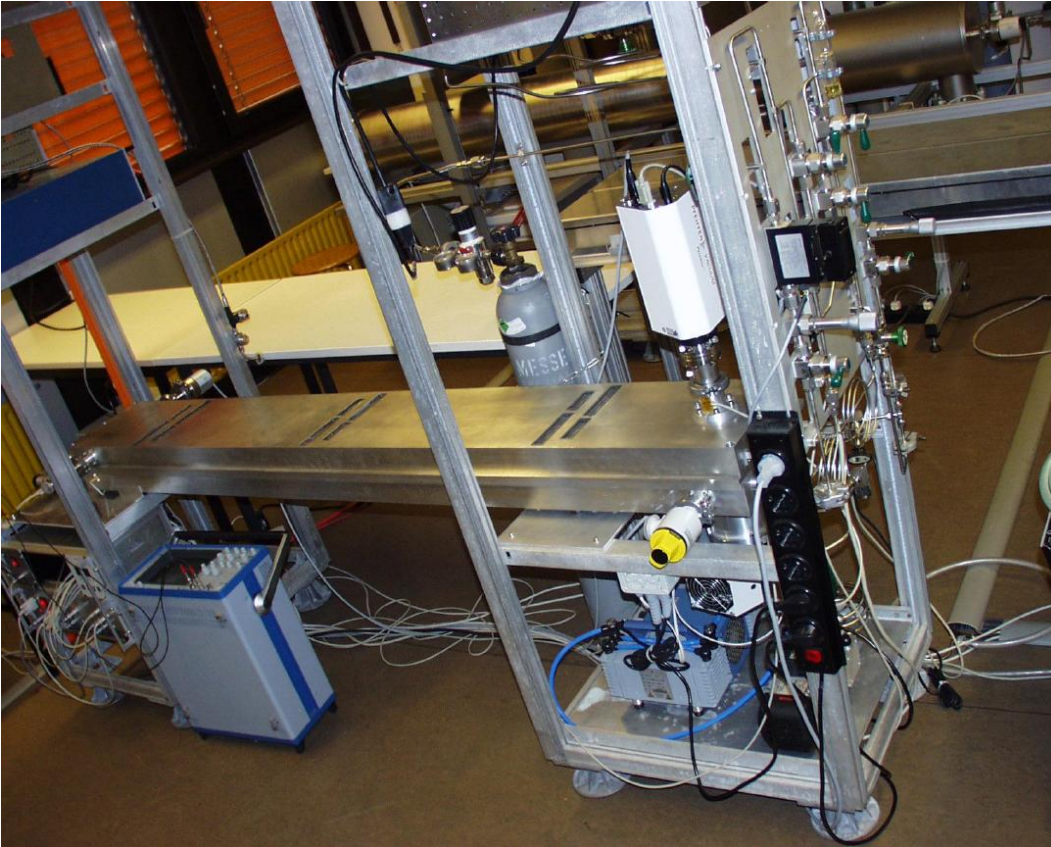
Longterm-Vacuum-Test:





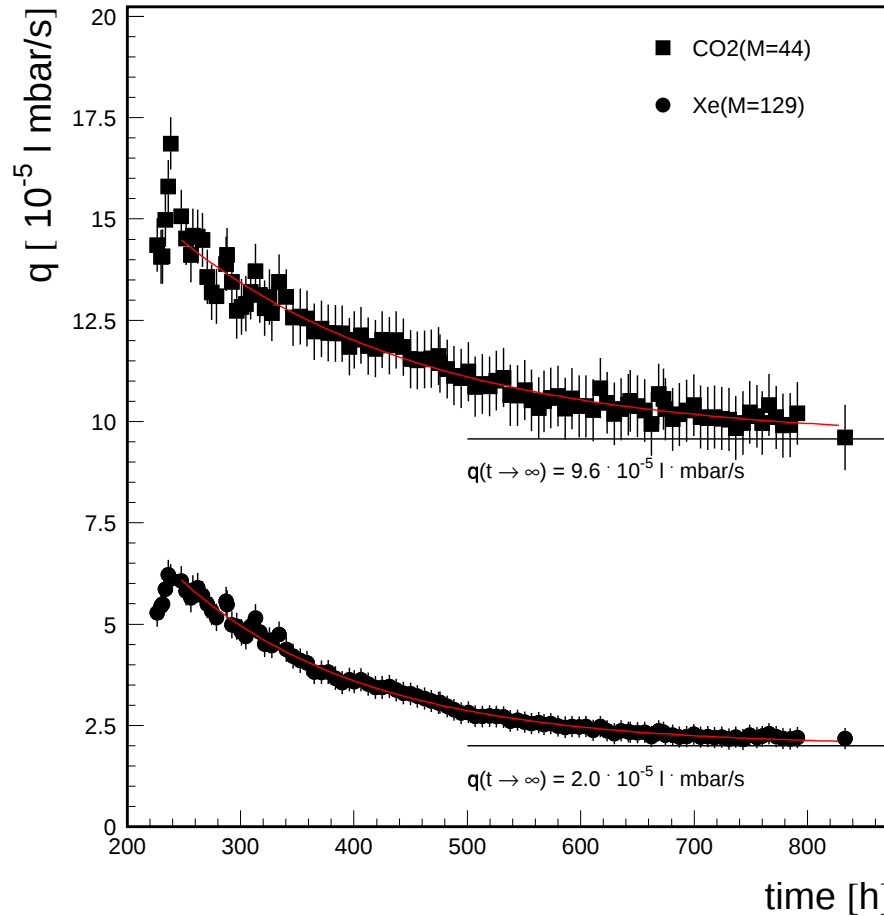
Mod. No.	Length [mm]	Air q_{He} [$10^{-5} \frac{l \cdot mbar}{s}$]	Vacuum Safety- Factor CO_2	Gas Gain $ArCO_2$ U = 1350V	
				Mean	RMS [%]
LZT I	1534.61	6.0	7.40	6018.6	1.65
LZT II	1534.61	5.7	7.8	5922.2	1.82
LZT III	1534.61	5.2	7.2	5891.4	1.70
LZT IV	1534.61	5.8	7.5	5756.6	2.17
LZT V	1534.61	6.3	6.9	5902.3	1.64
LZT VI	1534.61	5.1	7.7	5737.9	1.11
LZT VII	1534.61	4.7	7.9	5906.7	1.99
LZT VIII	1534.61	5.5	7.7	5867.4	1.25

Longterm-Vacuum-Test:

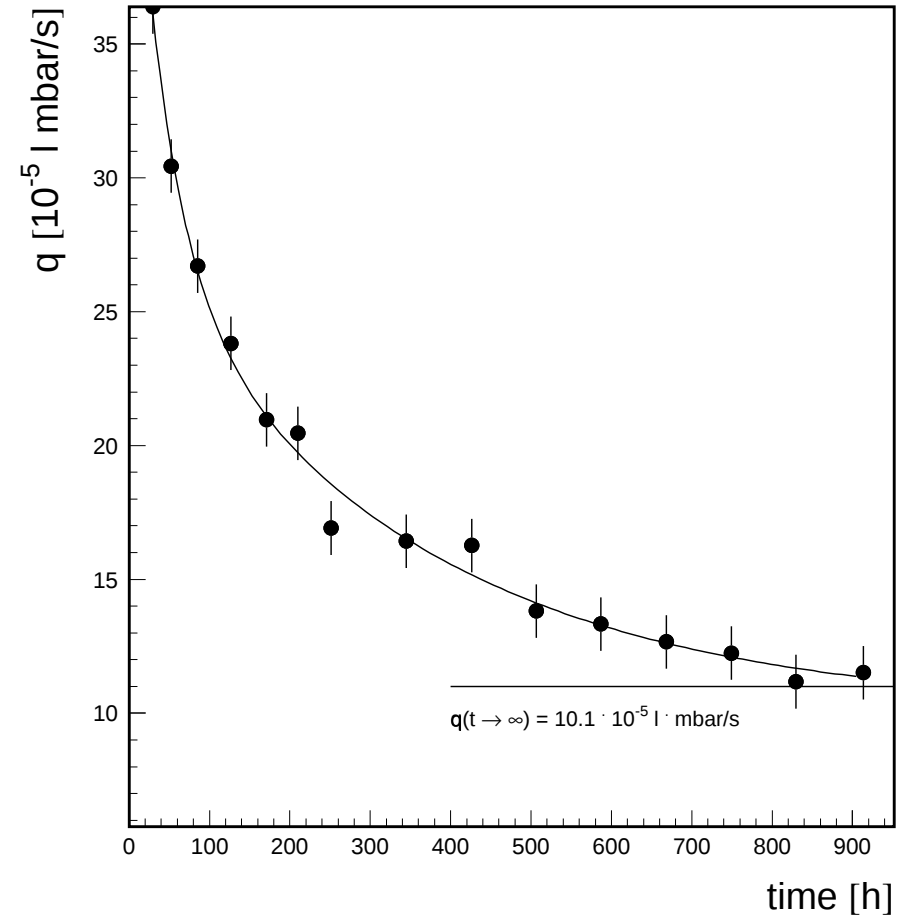


Longterm-Vacuum-Test:

Leak Rate of CO₂ and Xe (Mass-Spectrometer)



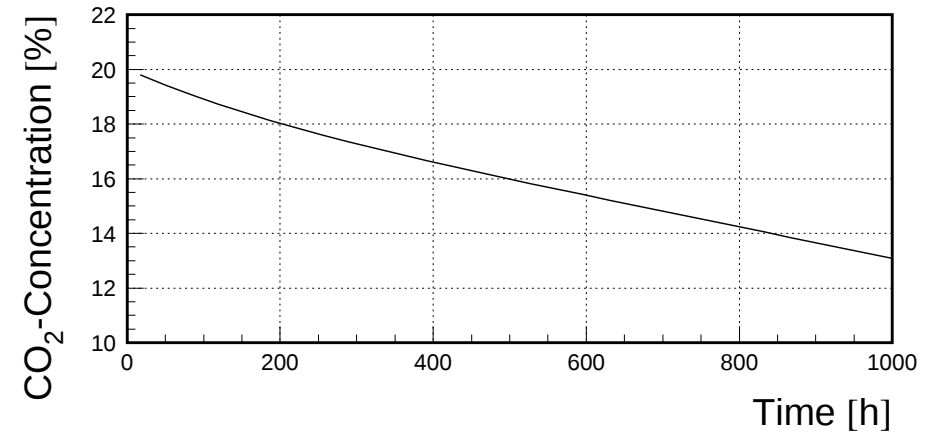
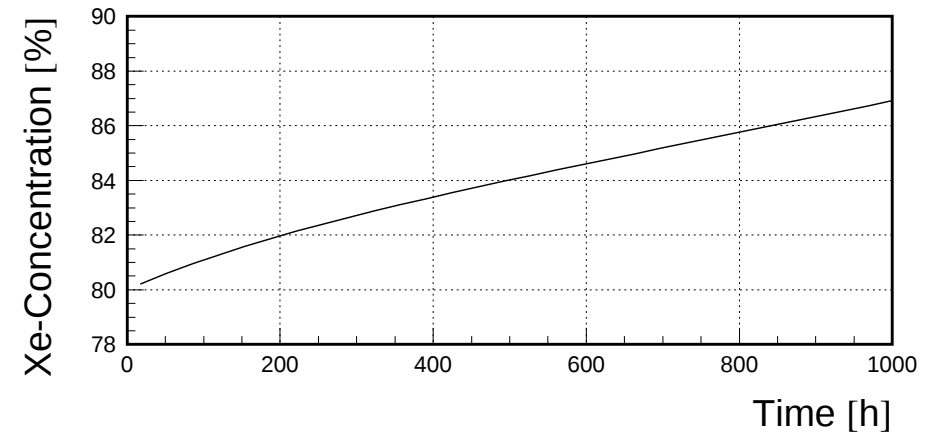
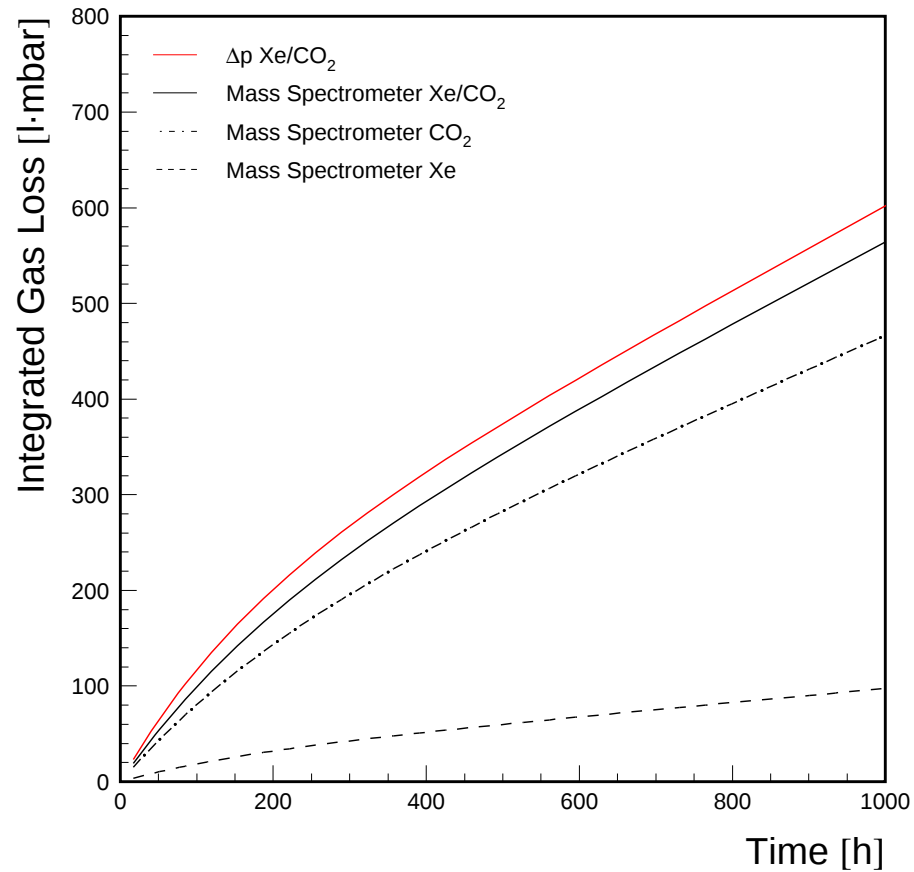
Leak Rate of CO₂ and Xe (Δp - Measurement)

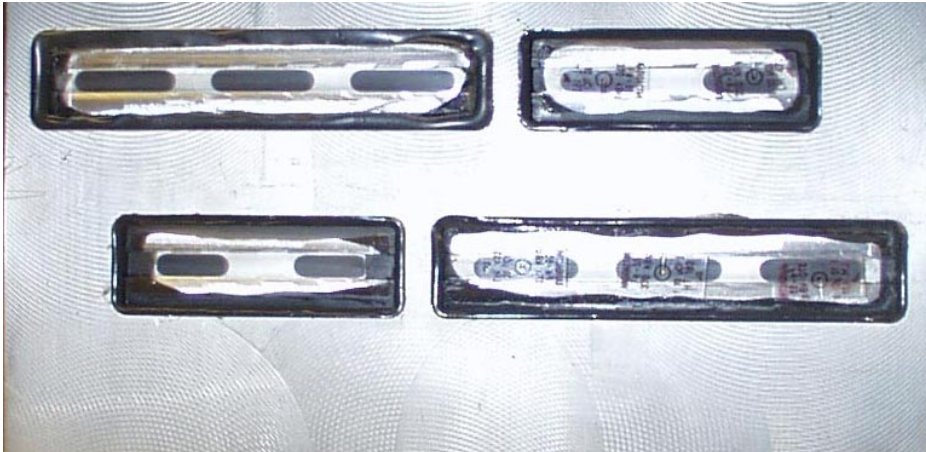
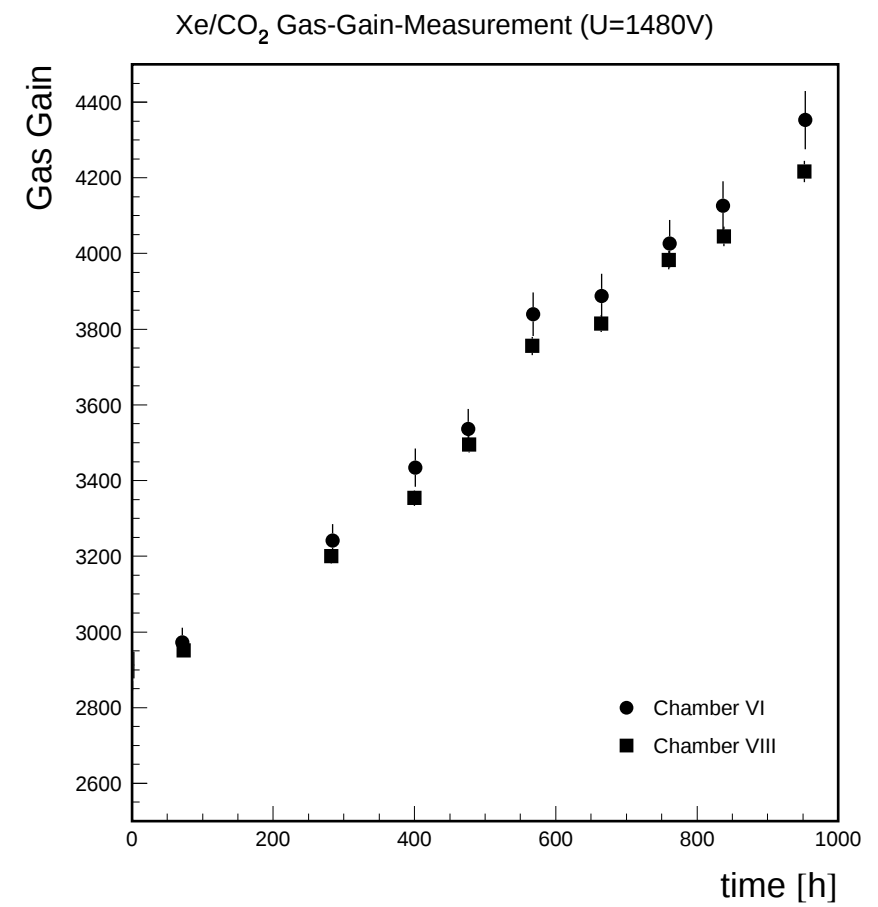


CO₂-Prediction:

$$q_{\text{Module}} = q_{\text{straws}} + q_{\text{endpieces}} = 4.5 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s}} + 4.0 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s}} = 8.5 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s}}$$

Longterm-Vacuum-Test:





$$\frac{dG}{G} = 53.6\%$$

$$df_{\text{CO}_2} = 7\%$$

$$\frac{1}{G} \cdot \frac{dG}{df} = \frac{8\%}{1\% f_{\text{CO}_2}}$$

Conclusion

TRD: 328 Flight Modules

- Flight Modules ready for installation: 191
- Flight Modules under test: 21
- Flight Modules in production: 16

$$\rightarrow \sum \text{FlightModules} = 228$$

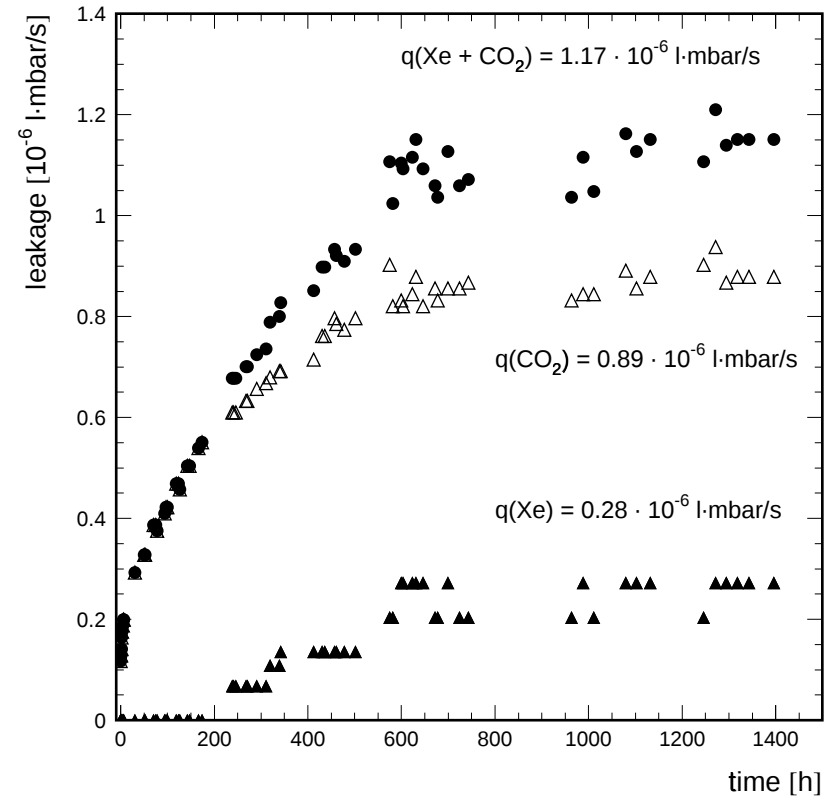
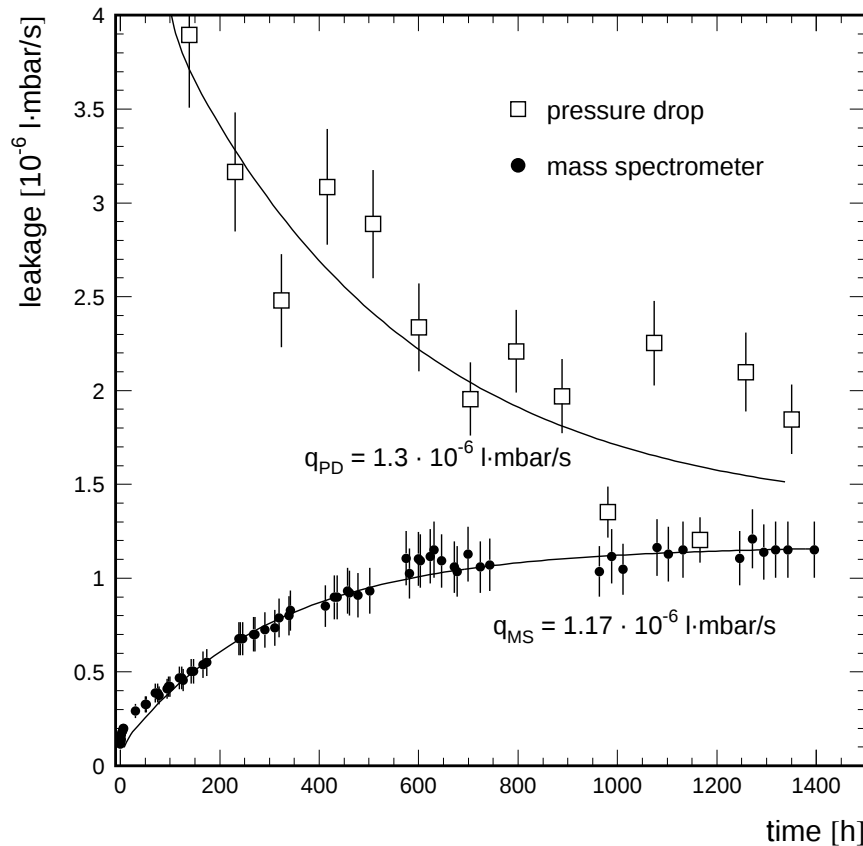
- Production ready March 2004



Longterm-Vacuum-Test:

- 8 Straw Modules in series (1 loop) operating for 1000 h
 - $\hookrightarrow q_{\Delta p}$ and $q_{I_{ion}}$ in good agreement
 - $\hookrightarrow$ Recirculating Gas System + Gas Analyzer





- Xe/CO₂ (80/20) Leak rate 3 single Straw Tubes L=1.3 m

$$q_{Xe}(80\%, 16\text{straws}) = 0.12 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s} \cdot m_{\text{Module}}},$$

$$q_{Xe, \max} = \frac{8100 \text{ l} \cdot 1013 \text{ mbar}}{1000 \cdot 86400 \text{ s}} \cdot \frac{1}{500 \text{ m}} = 19 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s} \cdot m_{\text{Module}}} \rightarrow \text{Safety factor :158}$$

$$q_{CO_2}(20\%, 16\text{straws}) = 0.37 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s} \cdot m_{\text{Module}}},$$

$$q_{CO_2, \max} = \frac{2000 \text{ l} \cdot 1013 \text{ mbar}}{1000 \cdot 86400 \text{ s}} \cdot \frac{1}{500 \text{ m}} = 4.7 \cdot 10^{-5} \frac{\text{l} \cdot \text{mbar}}{\text{s} \cdot m_{\text{Module}}} \rightarrow \text{Safety factor :12.7}$$

AIM: CO₂ Safety Faktor: 4