Quality assurance during module production for the OT

I. Tests performed during construction

II. Tests performed for finished modules

Tests performed for all modules

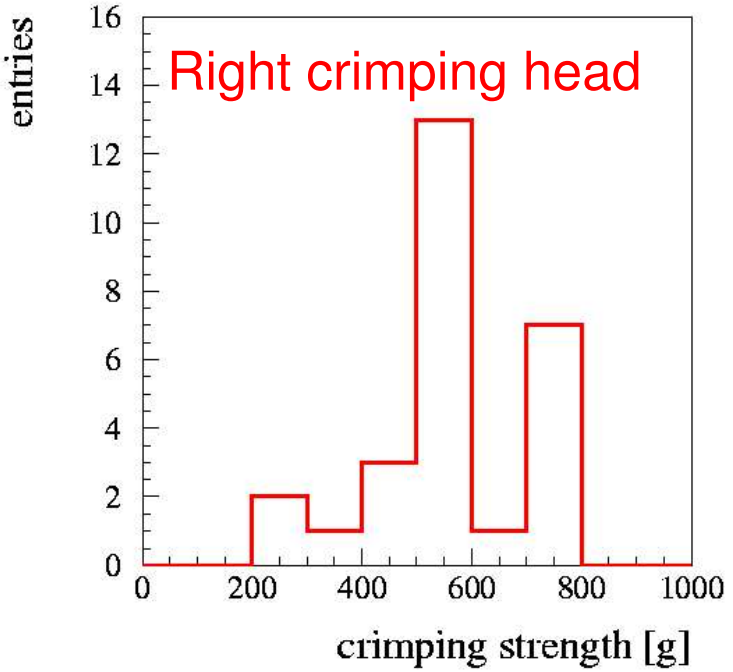
III. Validation tests for final 5m modules

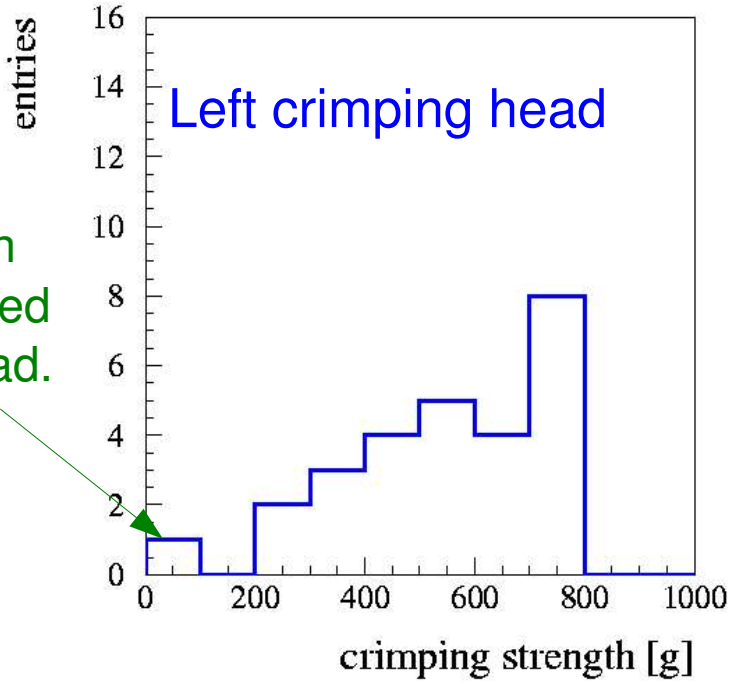
Tests performed for selected modules

Quality assurance during straw preparation

During straw preparation regular tests on:

- length of straws
- quality of tongues and soldering
- crimping strength of wire locators





Problem with mal-positioned crimping head.

Quality assurance during wiring

After wiring we measure

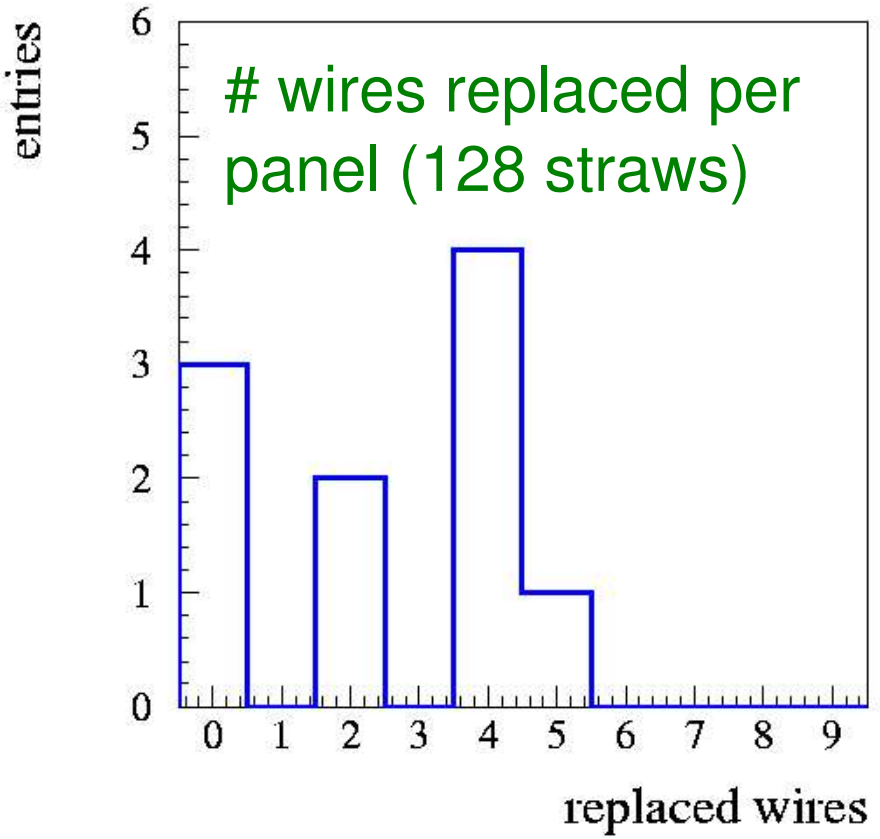
- HV stability
- Wire tension

Wires are replaced if

- current at 1600V in air exceeds 100nA

or

- wire tension is not in the limits 60 g < T < 85 g



With these limits we never observed HV problems for the finished modules!

Limits on wire tension

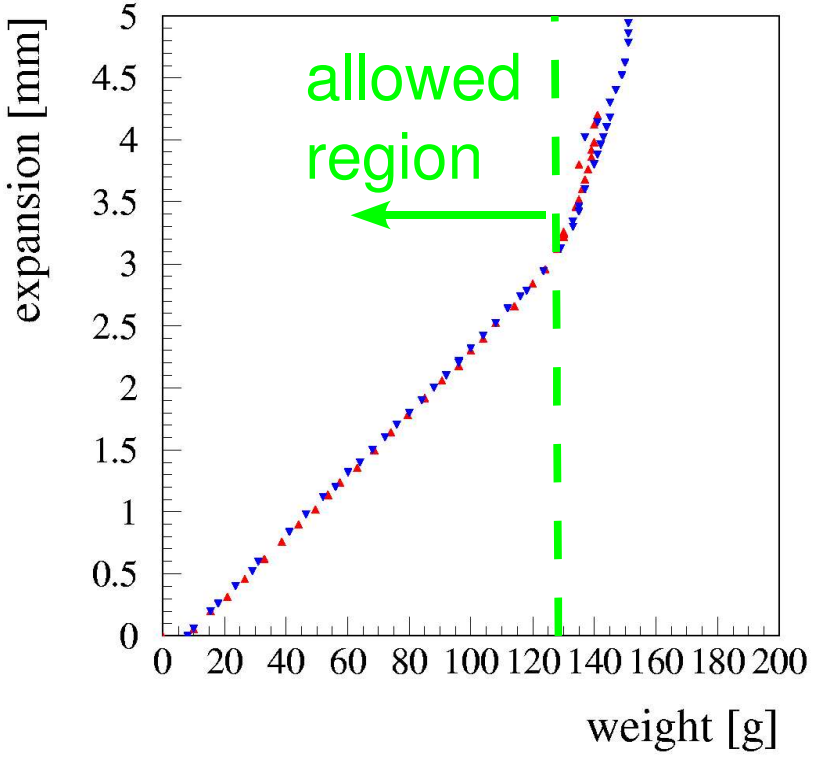
Upper limit:

Critical tension:

Data sheet:

Critical tension before non elastic deformations: ~130 g for 25µm wire.

Our measurements:



Limits on wire tension

Lower limit:

HV-breakdown:

- *Theory:*

For L=0,8m; T=40g:

V_{max} = 2750V

- *Praxis:*

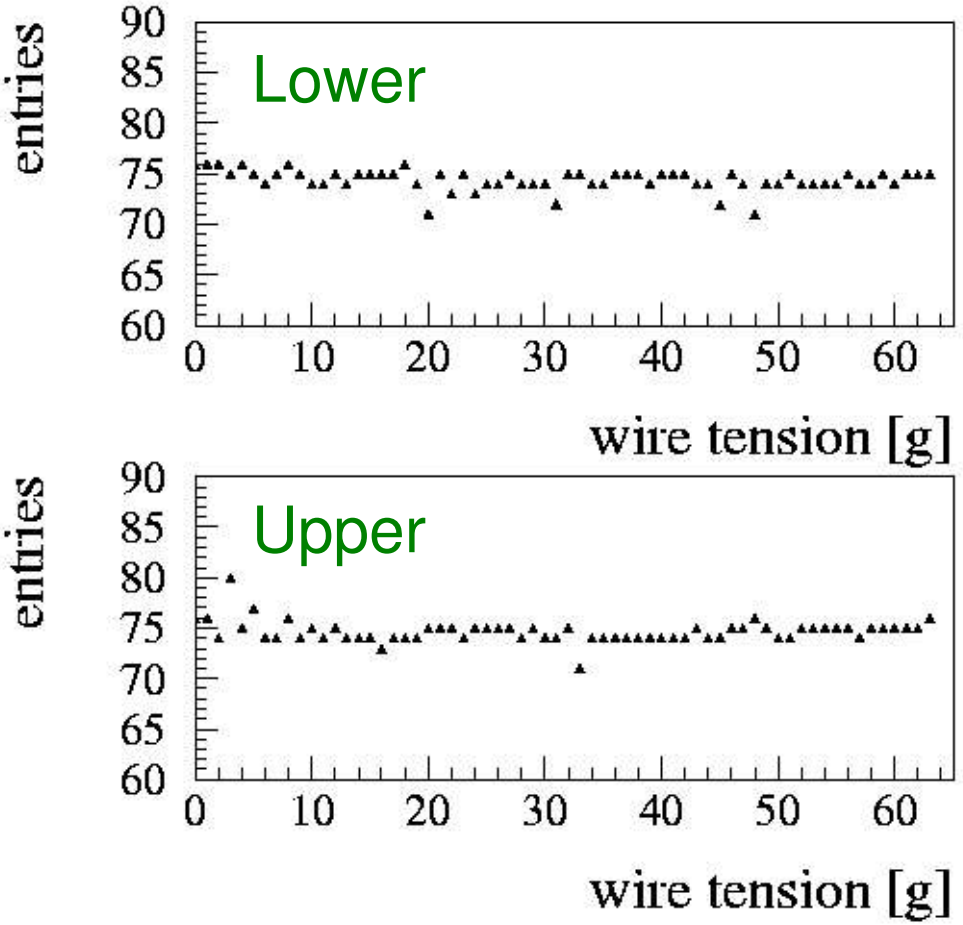
Test module with L=0,8m; T=40g
has been operated up to 1800V

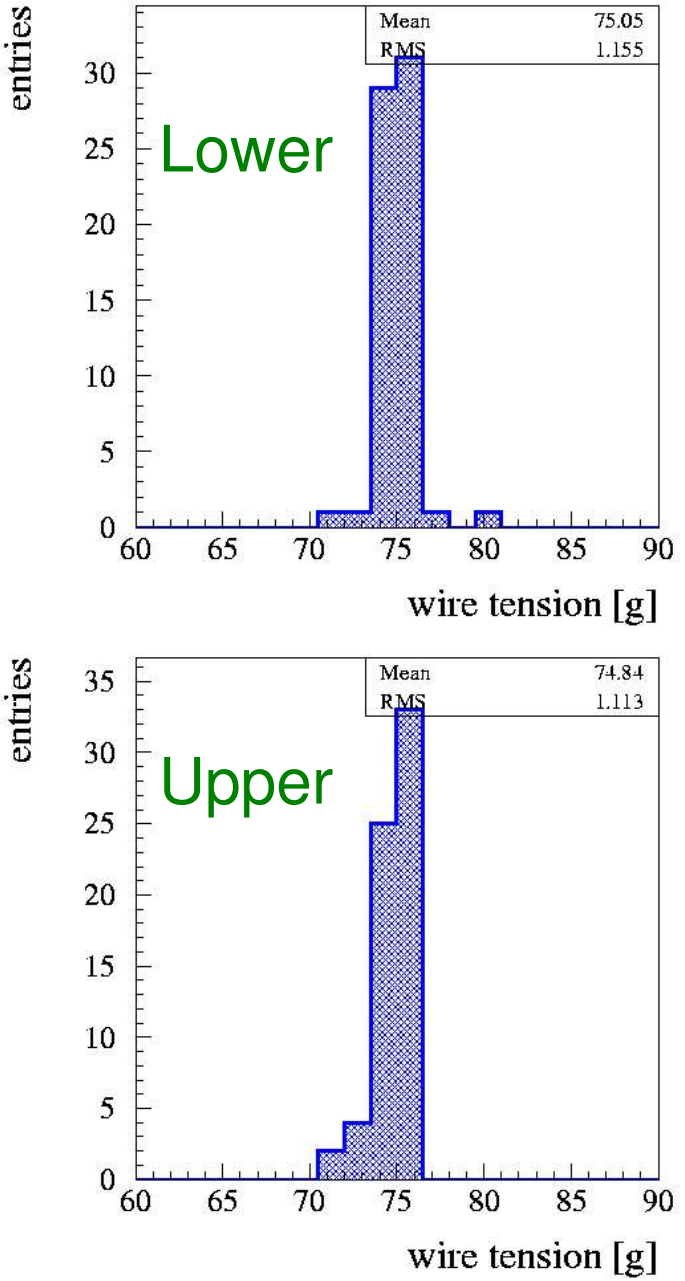
Sagitta: (theory)

For L=0,8m; T=40g:

$s < 20\mu m$

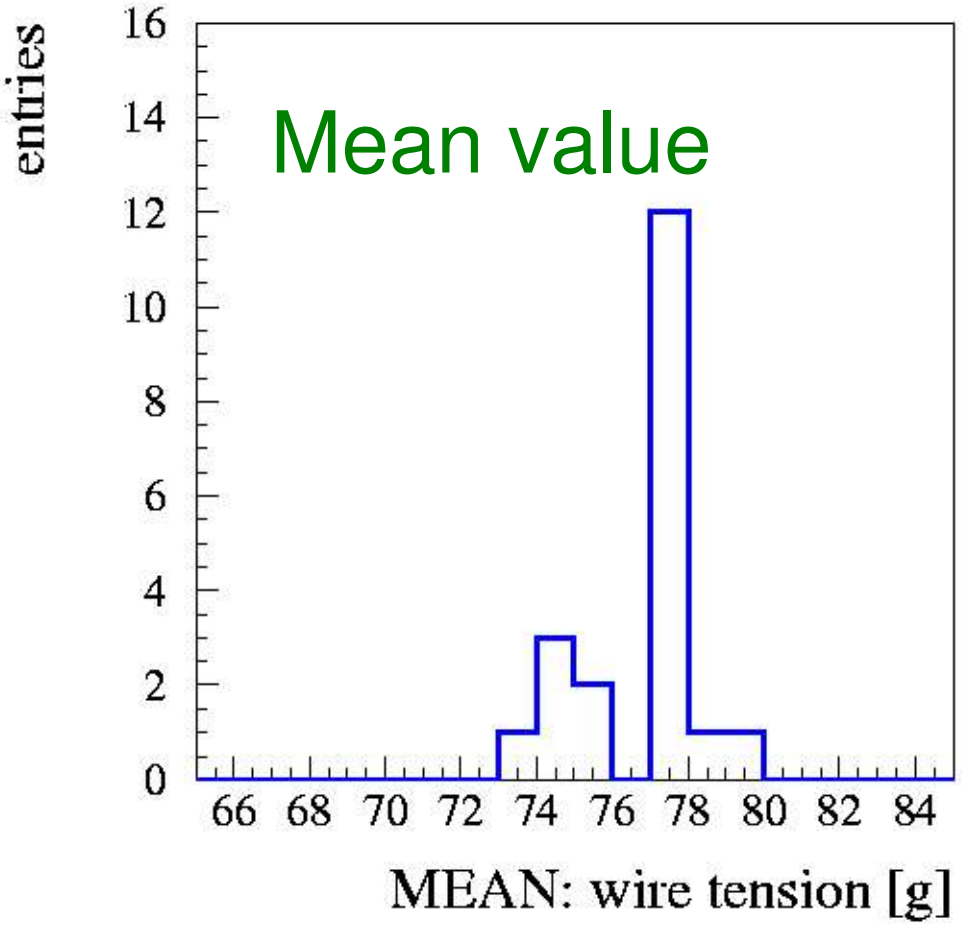
Wire tension
Example: Module 3, Panel A

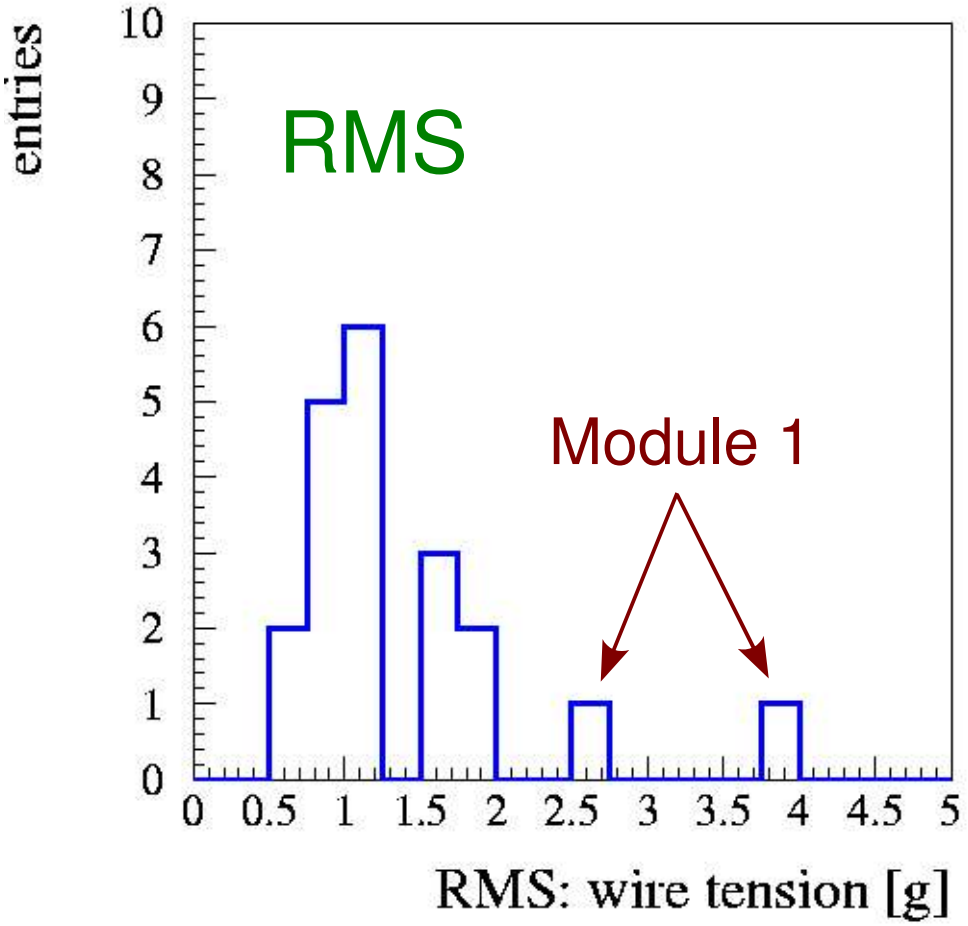




Wire tension:

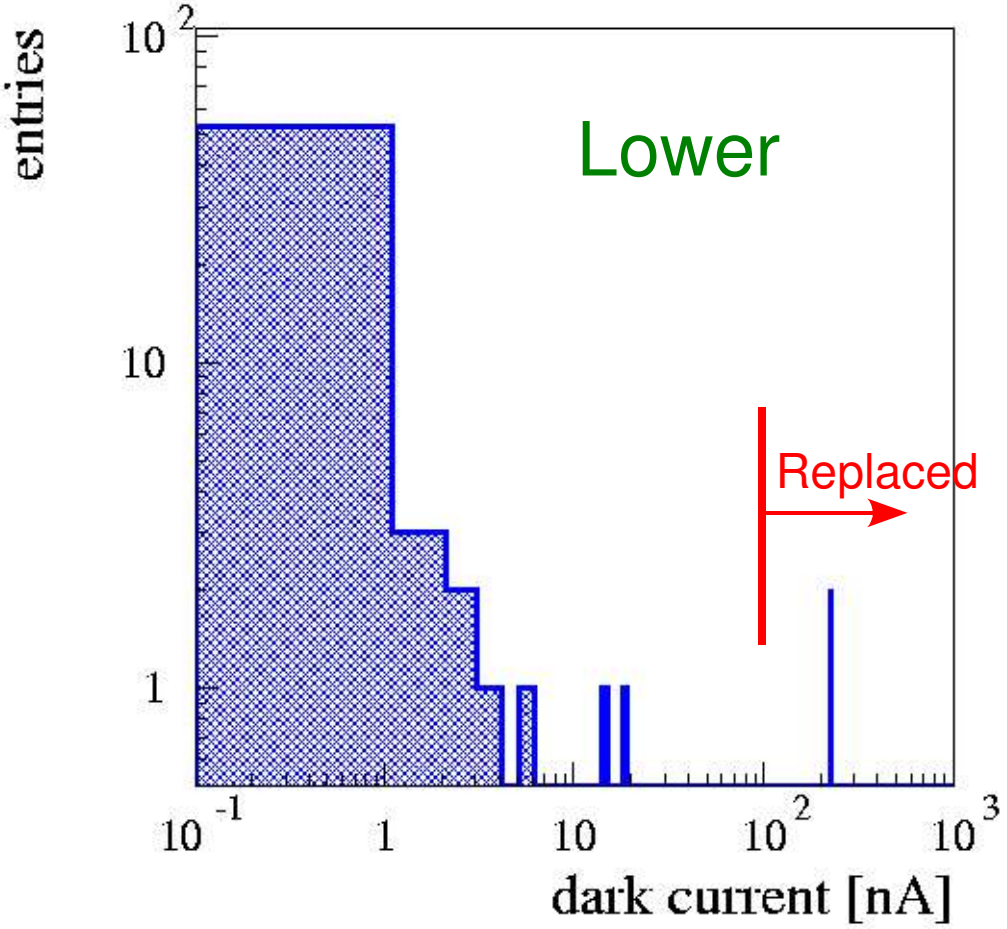
Mean and RMS for series modules 1-5

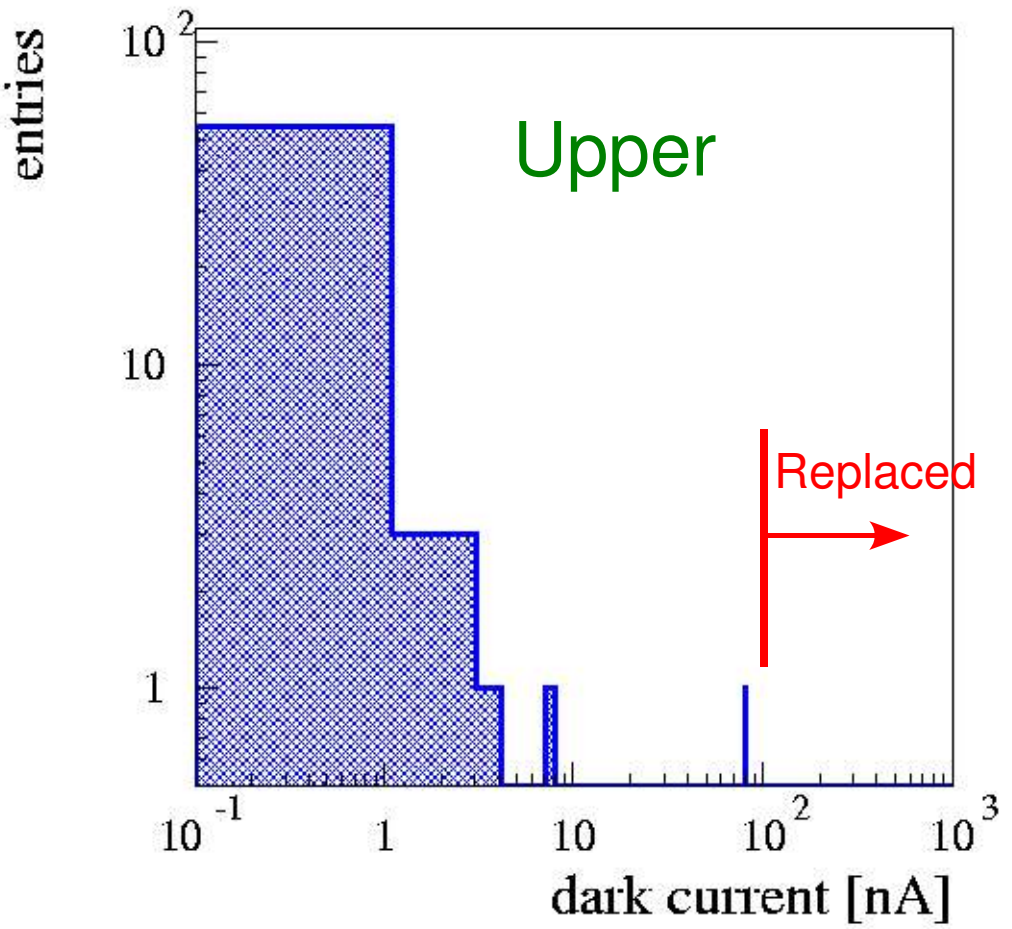




HV stability:
Example: Module 3, Panel A

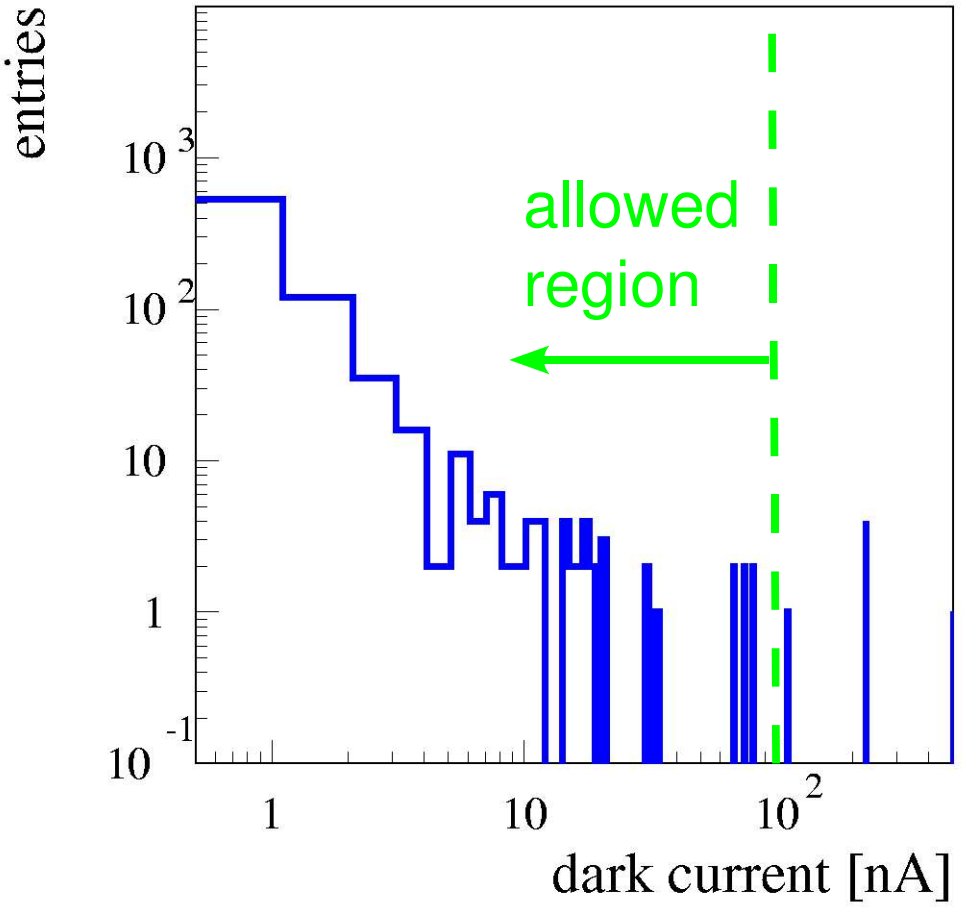
Dark current at 1600V in air:





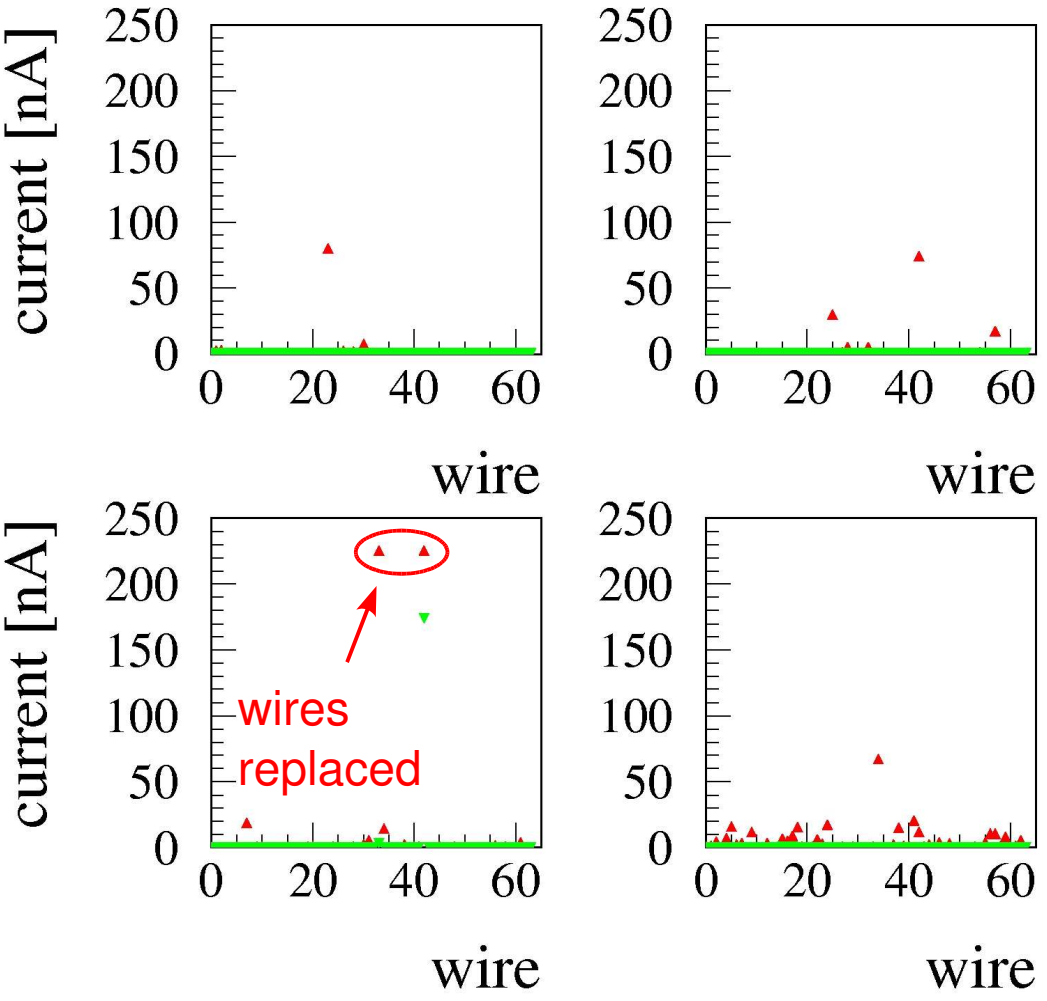
HV stability:
Series modules 1-3

Dark current at 1600V in air:



Dark currents:

Module 2:

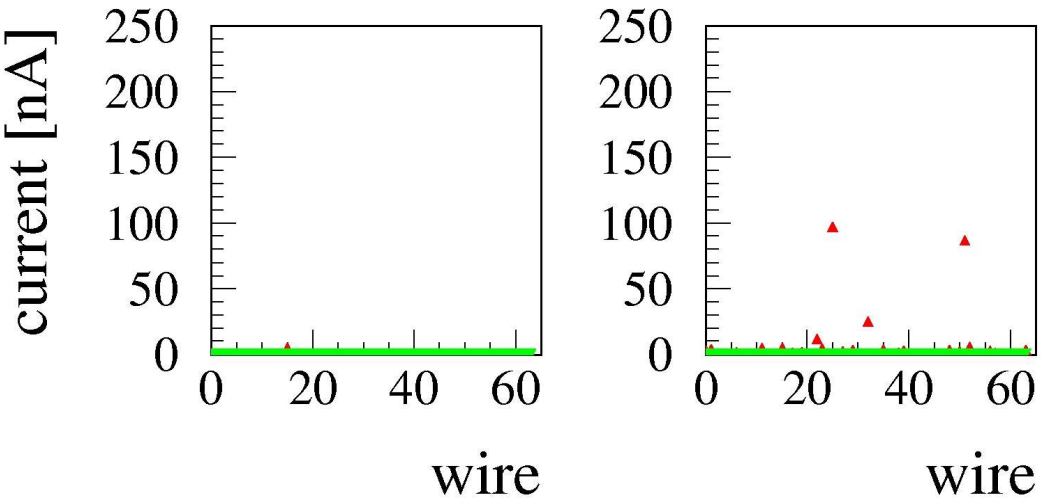


Red: Dark current at 1600 V in air after wiring

Green: Dark current after training at 1600 V in Ar/CO_2 (70/30)

Dark currents:

Module 2 (Panel B):



Red: Dark current at 1600 V in air after wiring

Green: Dark current after training at 1600 V in Ar/CO_2 (70/30)

===> dark current limit of 100 nA at 1600 V in air is sufficient for safe operation in final module.

HV stability: Summary

Series modules 1-5:

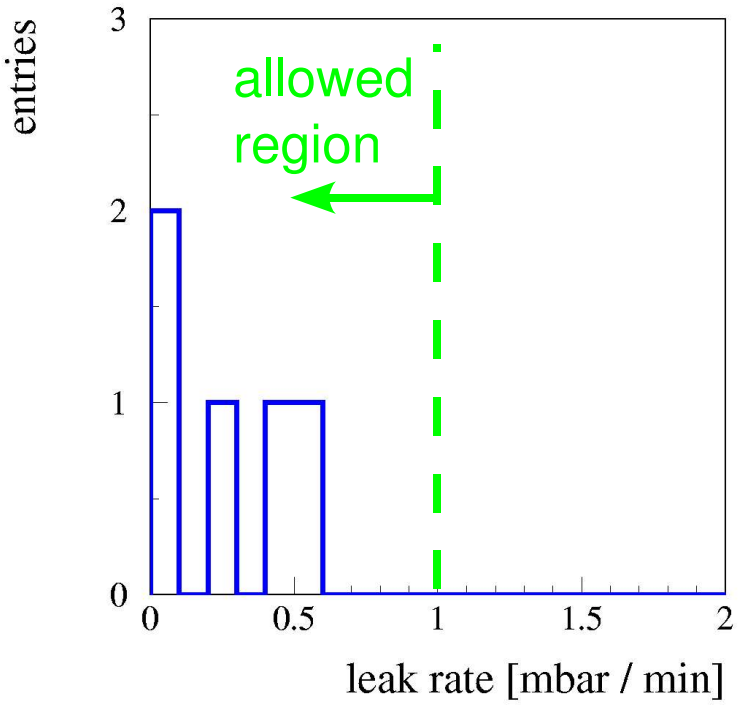
In total: 1280 wires in 5 modules

- 25 wires have been replaced
  (1,9 %, mostly due to high currents)
- 3 wires not operational (2,3 ‰)
  2 shorts
  1 problem with connector

Gas tightness

To avoid pollutions (N_2, O_2, H_2O) entering the module by leaks, all modules are tested for gas tightness.

Measurement:



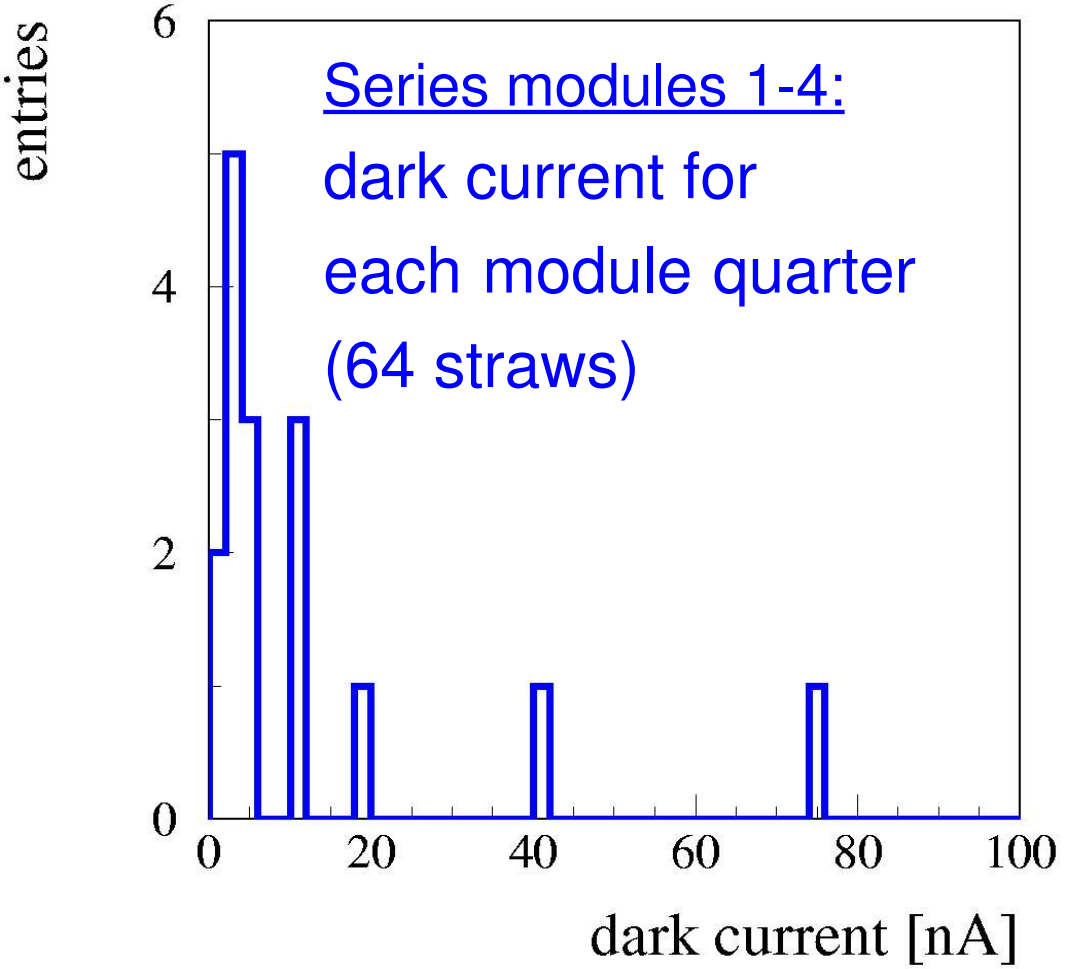
Limit for gas tightness:

Pressure drop per minute:

< 1mbar @ Δp of 5mbar

Dark currents in closed modules

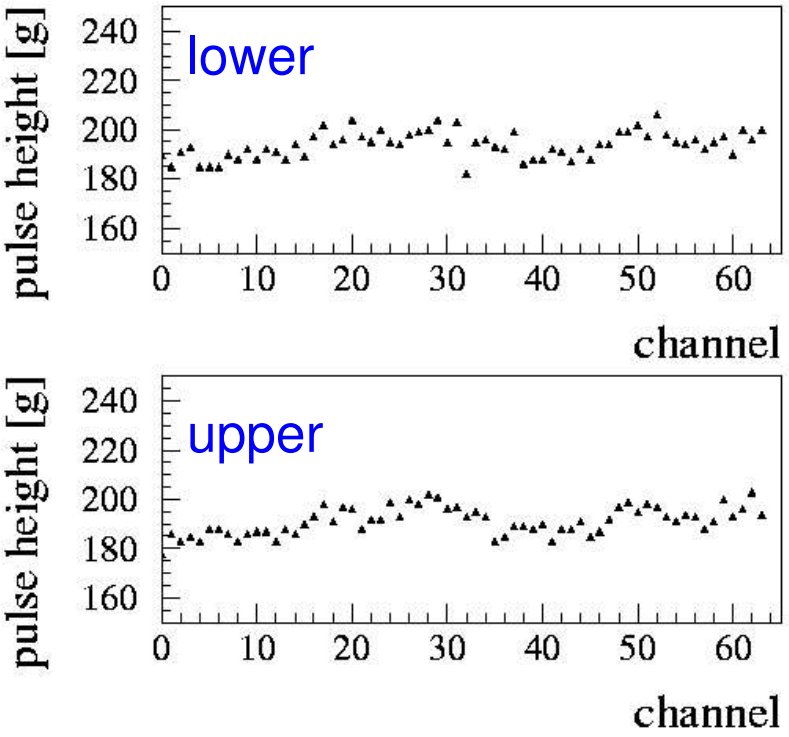
After some training dark currents are measured in Ar/CO2 (70/30)@1600V



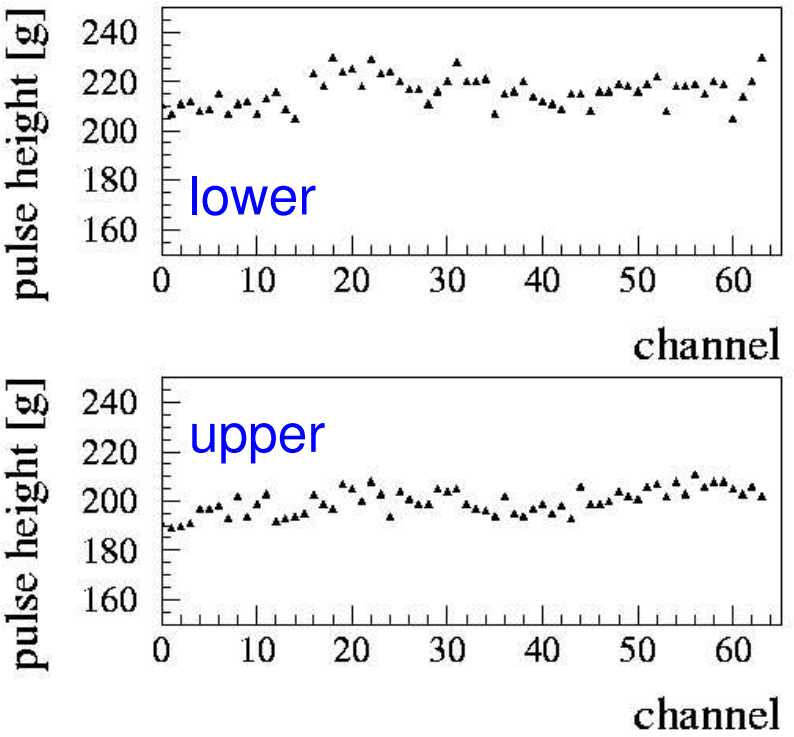
Uniformity of module
Example: Module 2

Peak position for ^{55}Fe-source for all channels:
Ar/CO_2 (70/30)@1520V

Panel A

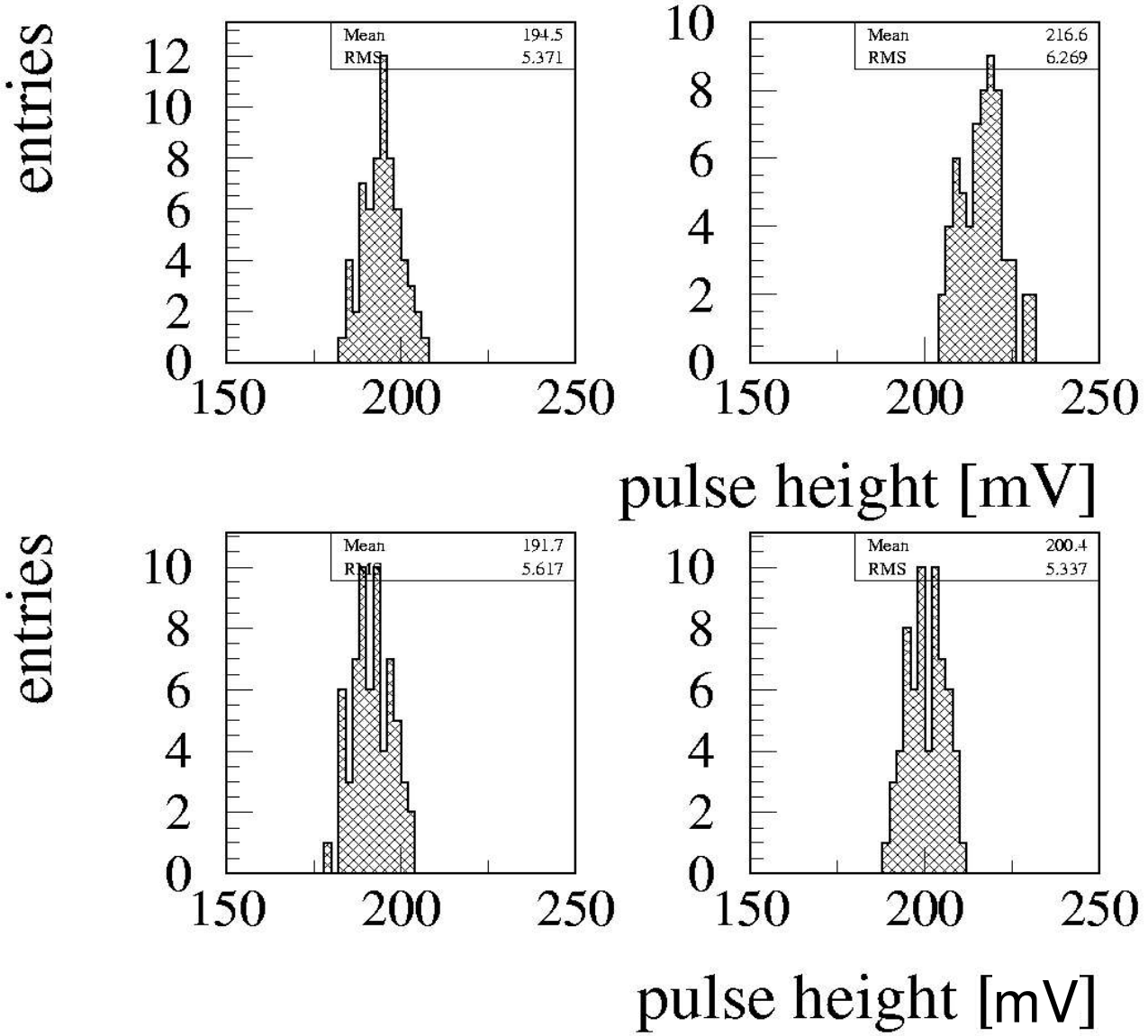


Panel B



Uniformity of module response

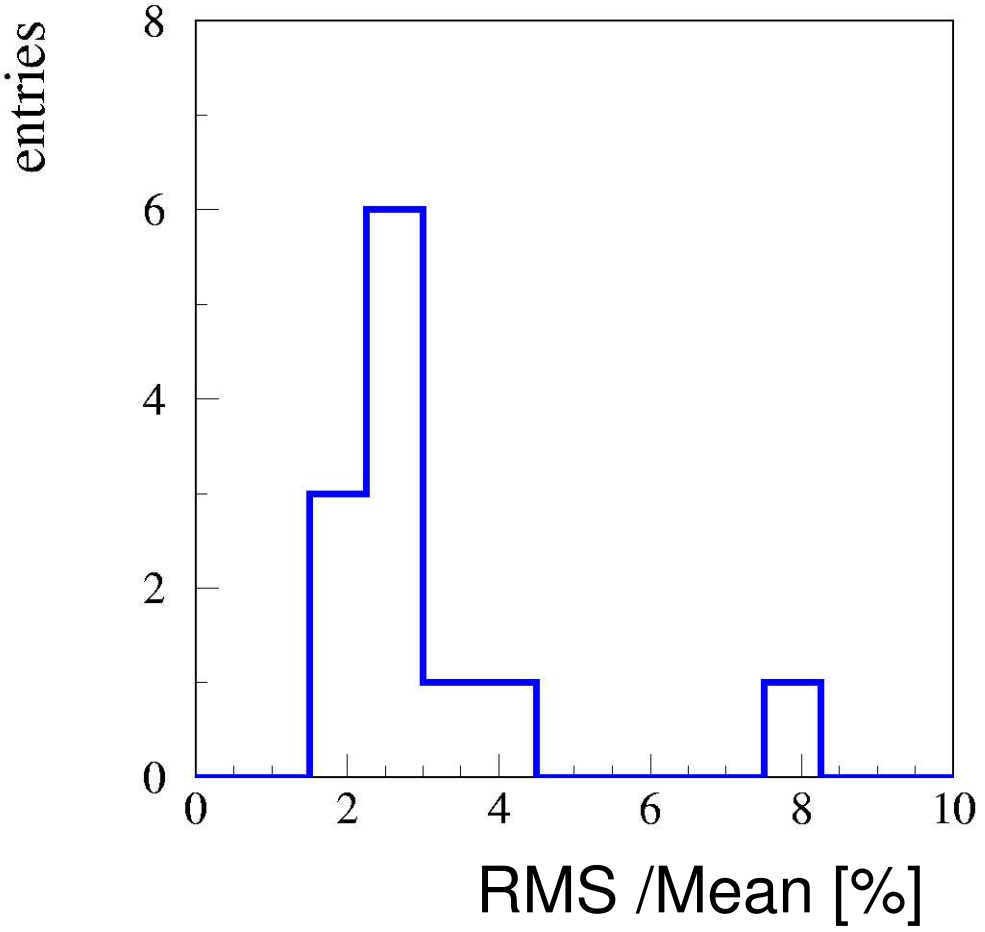
Example: Module 2



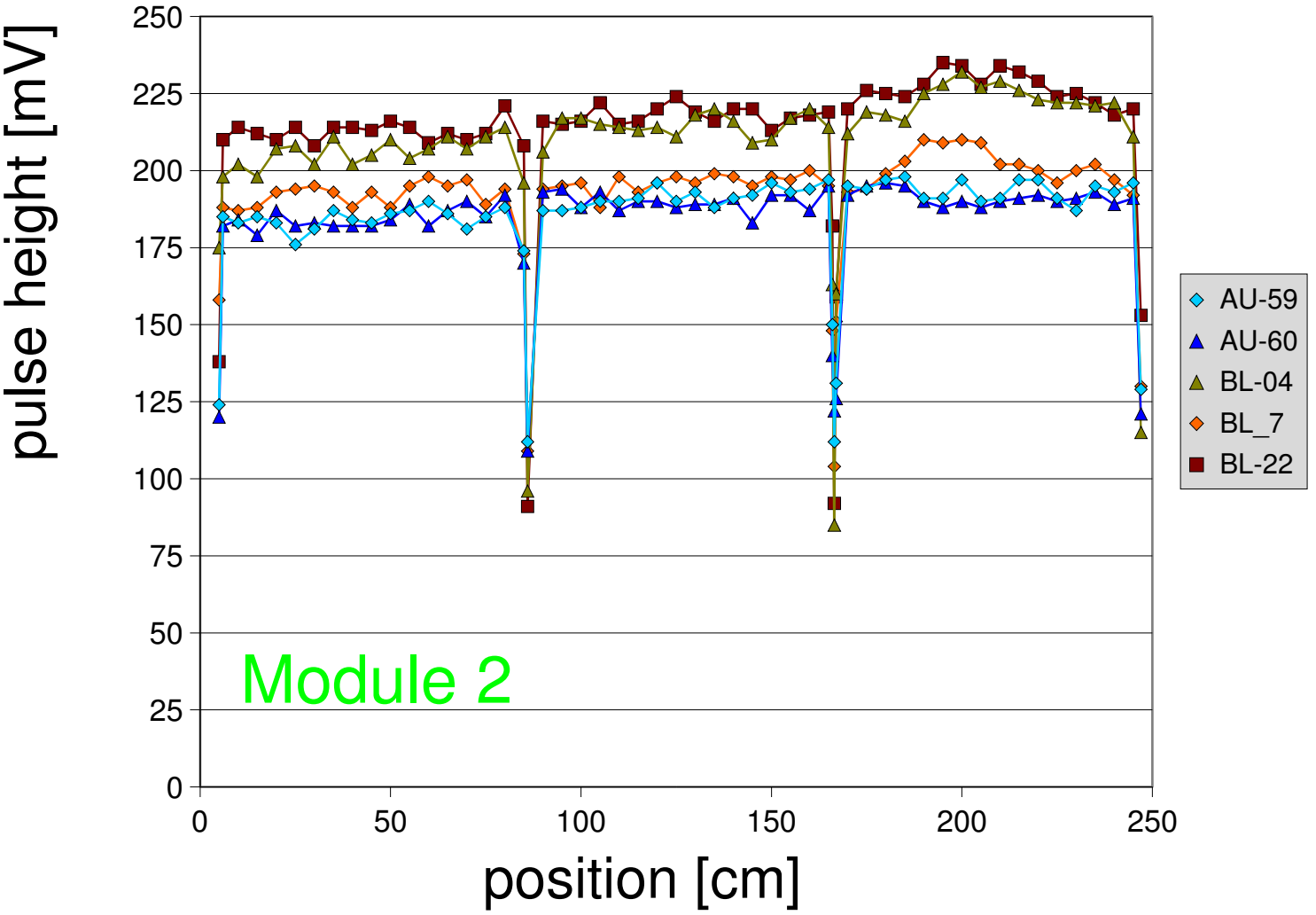
Same data as last slide, histogrammed

Uniformity of module response

Series modules 2-4



Scan along wires
(only for few wires!)

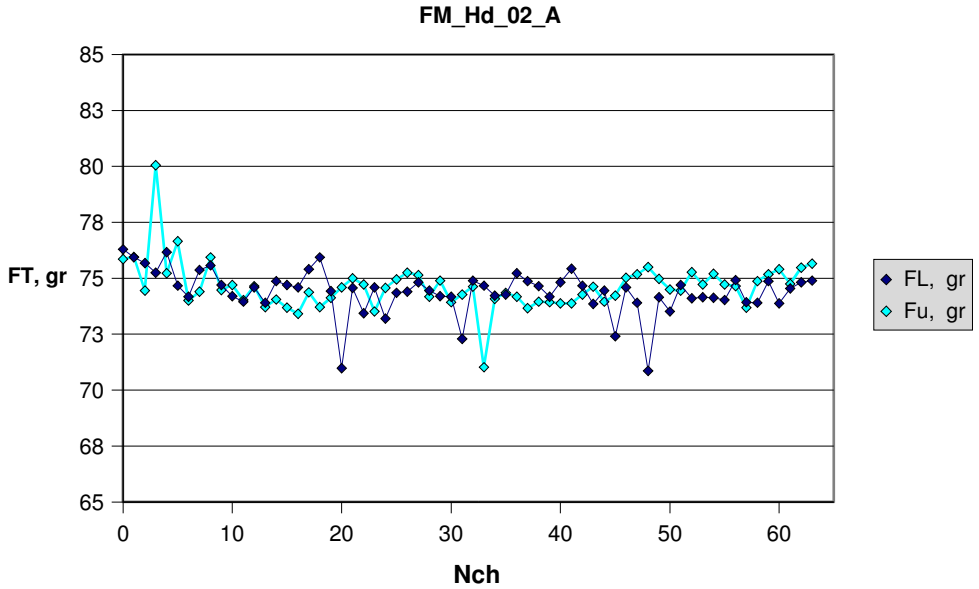


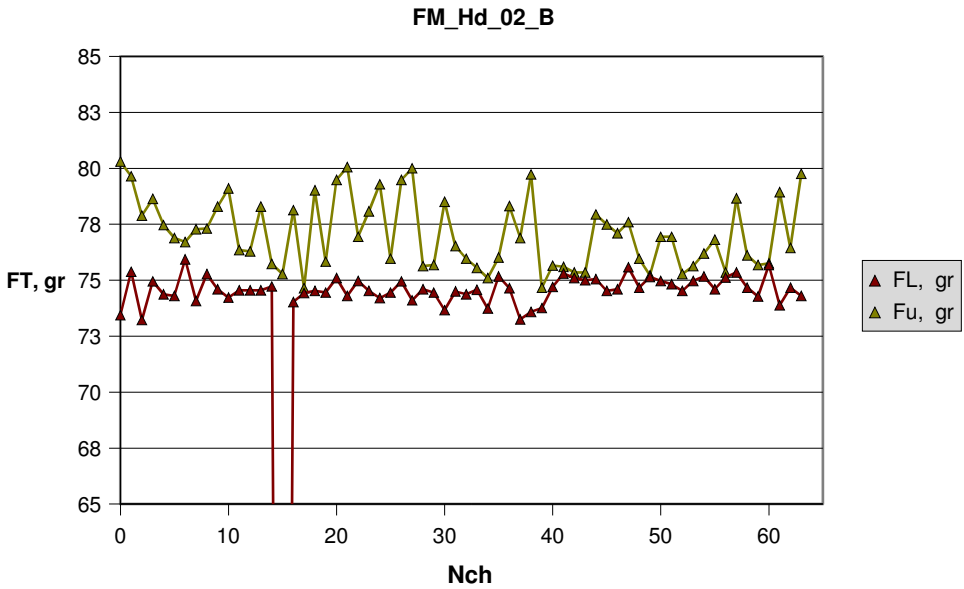
MODULE FM_Hd_02 — MODULE FM_Hd_02

Panel	A038							B050							Panel
Date		06/04/04			06/04/04				06/09/04			06/09/04			Date
Nch	I_L, nA	T_L, ms	F_L, gr	I_U, nA	T_U, ms	F_u, gr	Repl.	I_L, nA	T_L, ms	F_L, gr	I_U, nA	T_U, ms	F_u, gr	Repl.	Nch
0	0.0	5.93	76	0.0	5.95	76		1.2	6.04	73	0.0	5.78	80	S	0
1	0.0	5.94	76	2.5	5.94	76		1.0	5.96	75	0.0	5.8	80	S	1
2	0.0	5.95	76	3.0	6	74		4.7	6.05	73	0.0	5.87	78		2
3	0.0	5.97	75	0.0	5.79	80		0.0	5.98	75	0.0	5.84	79		3
4	0.1	5.93	76	0.0	5.97	75		7.0	6	74	0.0	5.88	77		4
5	0.5	5.99	75	0.0	5.91	77		16.0	6.01	74	0.3	5.91	77		5

Nch	I_L, nA	T_L, ms	F_L, gr	I_U, nA	T_U, ms	F_u, gr	Repl.	I_L, nA	T_L, ms	F_L, gr	I_U, nA	T_U, ms	F_u, gr	Repl.	Nch
Mean		6.0	74.4		5.99	74.6			5.9	73.4		5.9	77.1		Mean
σ		0.0	1.0		0.04	1.1			0.7	9.3		0.1	1.6		σ
Max	225.2	6.2	76.3	80.3	6.14	80.1			6.1	75.9	74.3	6.0	80.3		Max
Min		5.9	70.9	0.0	5.79	71.0			0.0	0.0	0.0	5.8	74.6		Min
F_T<70 gr			0			0				1			0		F_T<70 gr
F_T>80 gr			0			1				0			3		F_T>80 gr
I_a > 50 nA	2			1											I_a > 50 nA
repl. Str.							0							13	repl. Str.
repl. Wr.							5							2	repl. Wr.
Panel	A038							B050							Panel

MODULE FM_Hd_02 — FM_Hd_02 MODULE

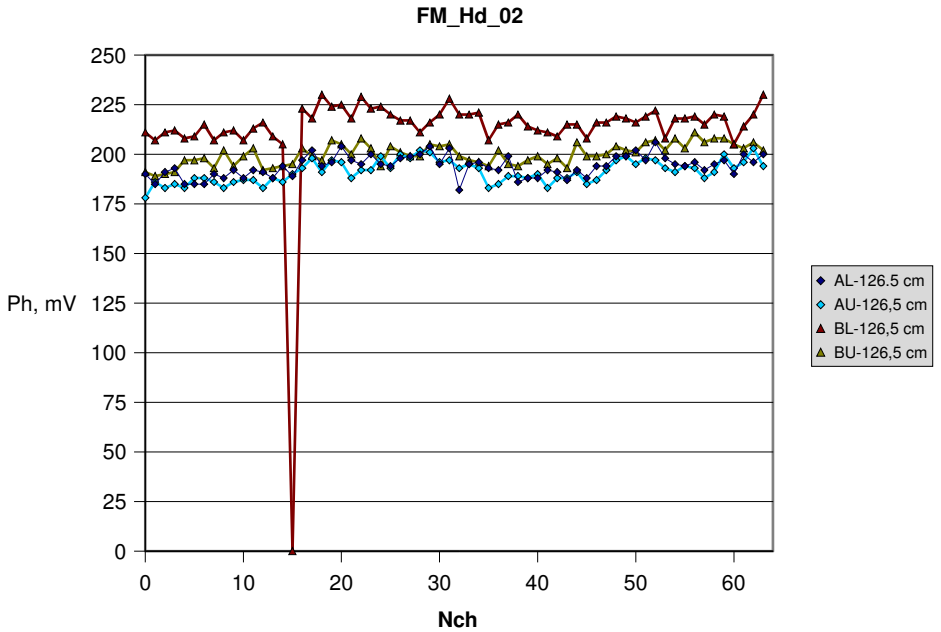




MODULE FM_Hd_02	Date:17-21.06		U = 1520V		Tresh. = -40 mV
Panel	A_038		B_050		$Ar:CO_2$ 70:30
I_{dc}, nA	2	2	40	10	
	Position				
N_{ch}	AL-126.5 cm	AU-126,5 cm	BL-126,5 cm	BU-126,5 cm	Comment
0	190	178	211	191	
1	185	186	207	189	
2	191	183	211	190	
3	193	185	212	191	
4	185	183	208	197	
5	185	188	209	197	
62	196	203	220	206	
63	200.0	194	230	202	

Position	AL-126.5	AU-126,5	BL-126,5	BU-126,5
Mean	193.9	191.3	212.7	199.9
σ	5.4	5.6	27.7	5.3
Max	206.0	203.0	230.0	211.0
Min	182.0	178.0	0.0	189.0
Panel	A_038		B_050	
MODULE FM_Hd_02				

0



Properties of 5m modules

Validation tests for the 5m modul solution

- Many tests have been performed on small prototypes.
- Most results can be scaled to 5m modules, e.g.
  - general performance (resolution, efficiency)
  - rate capability
  - HV stability of endpieces
  - ageing

. . .

Here:

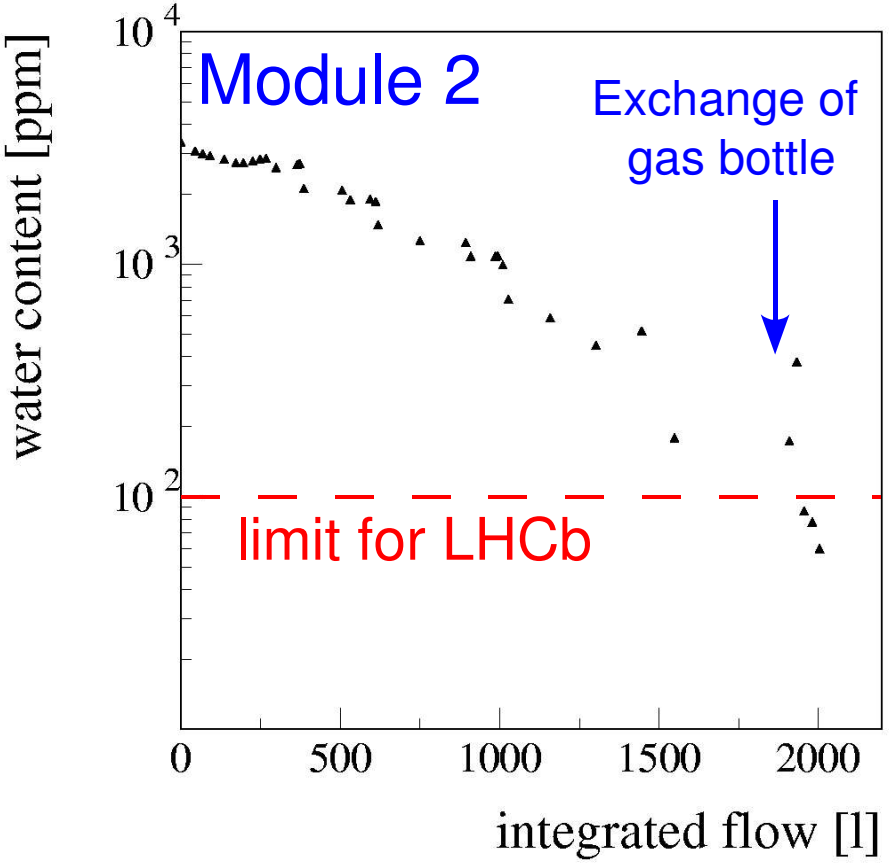
Tests to validate final techniques for 5m modules

- water content in the counting gas vs. time
- gas flow: uniform gas exchange for all straws?
- straightness of box
- HV stability in case of module bending

. . .

Water content

Water content very high when module is flushed for the first time!
Can not be explained by residual water from air.

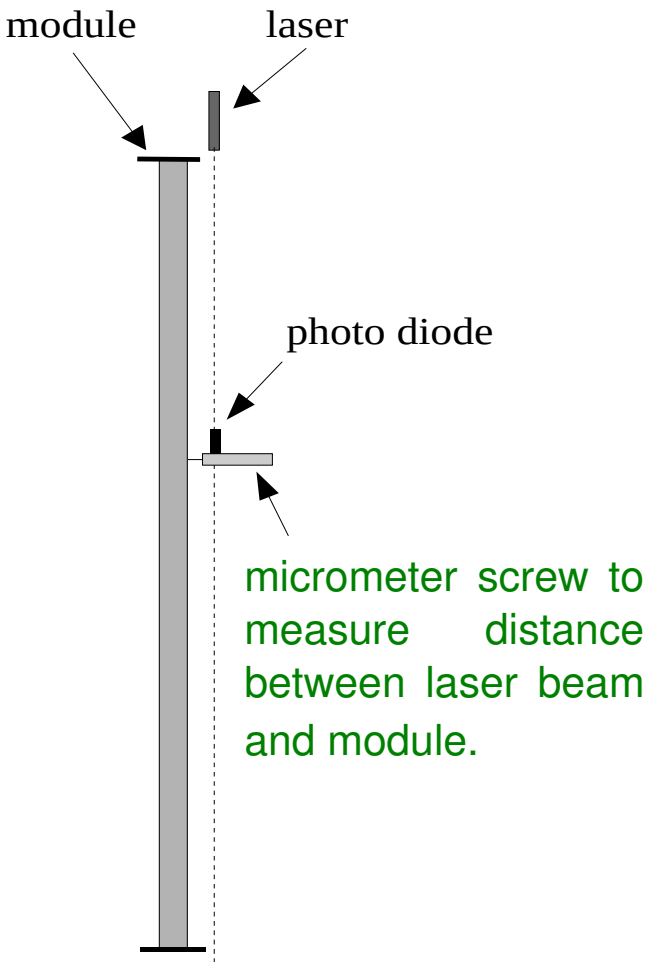


Estimate from data:
Total amount of water ~3l (vapor!).

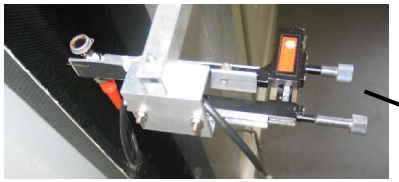
Kapton absorbs water:
~2% by weight at 50% rel. humidity
corresponds to ~6l for Kapton XC
in straws

---> water seen in module is released from the straws!

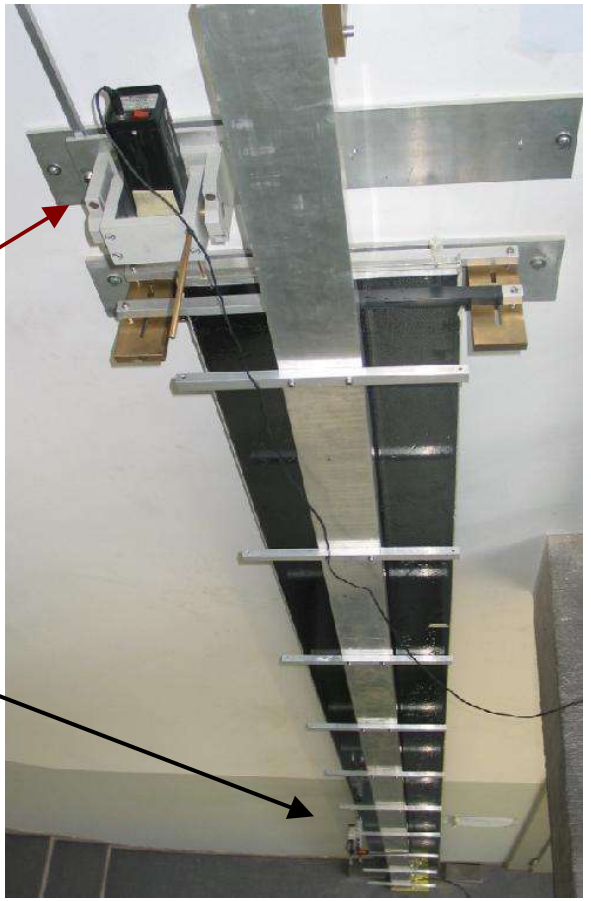
Straightness of modules
Principle of measurement



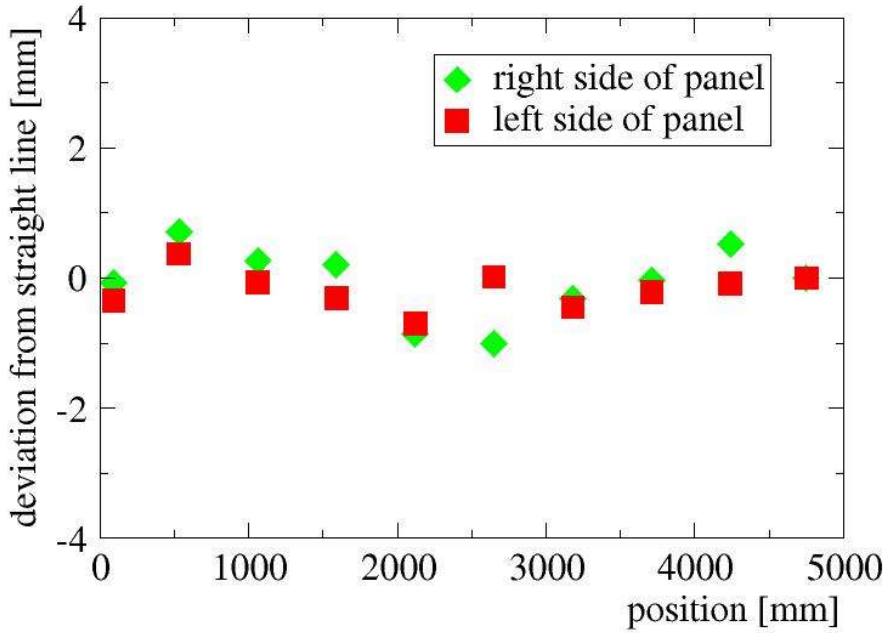
Fixation of module by dowel pin



Micrometer screw and photo diode



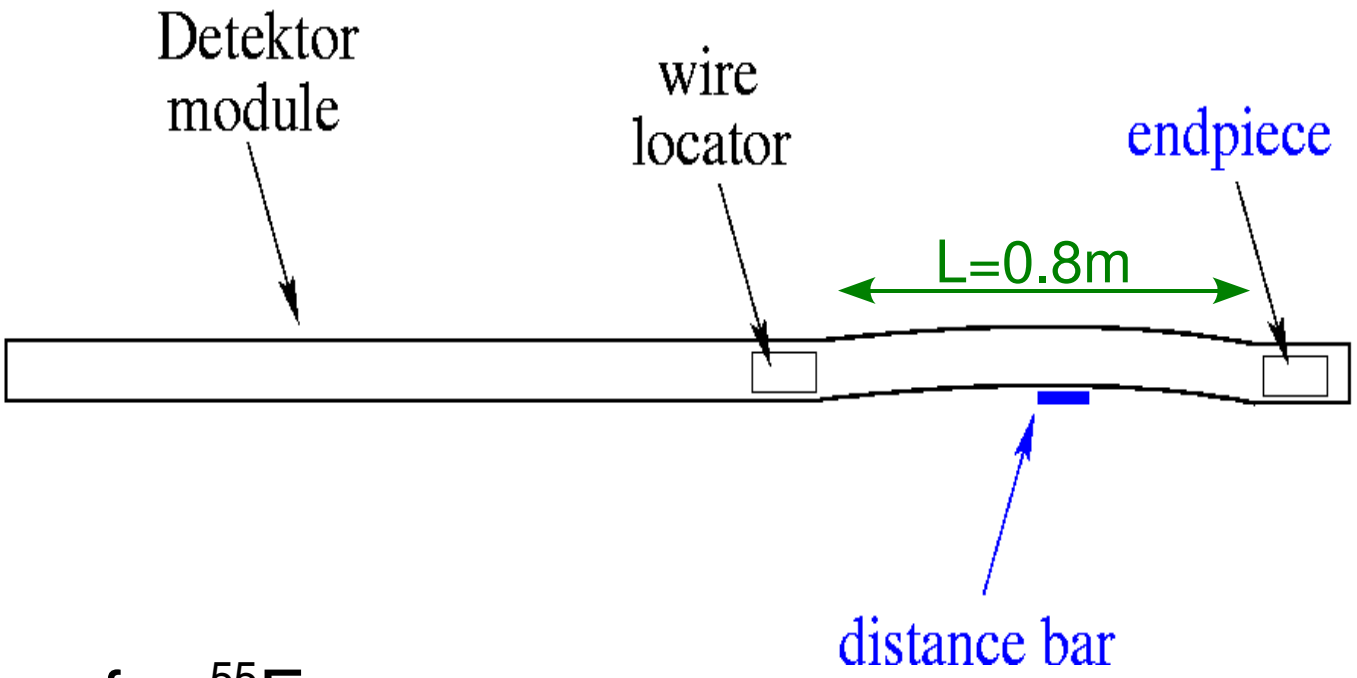
Straightness of module
Results



Uniformity of the module is within specifications:

	Max. deviation [mm]	*RMS [mm]*
Left	*0.8*	*0.22*
Right	*1*	*0.33*

HV stability for bent modules
Principle of measurement



Measure

1.) peak position for ^{55}Fe-source

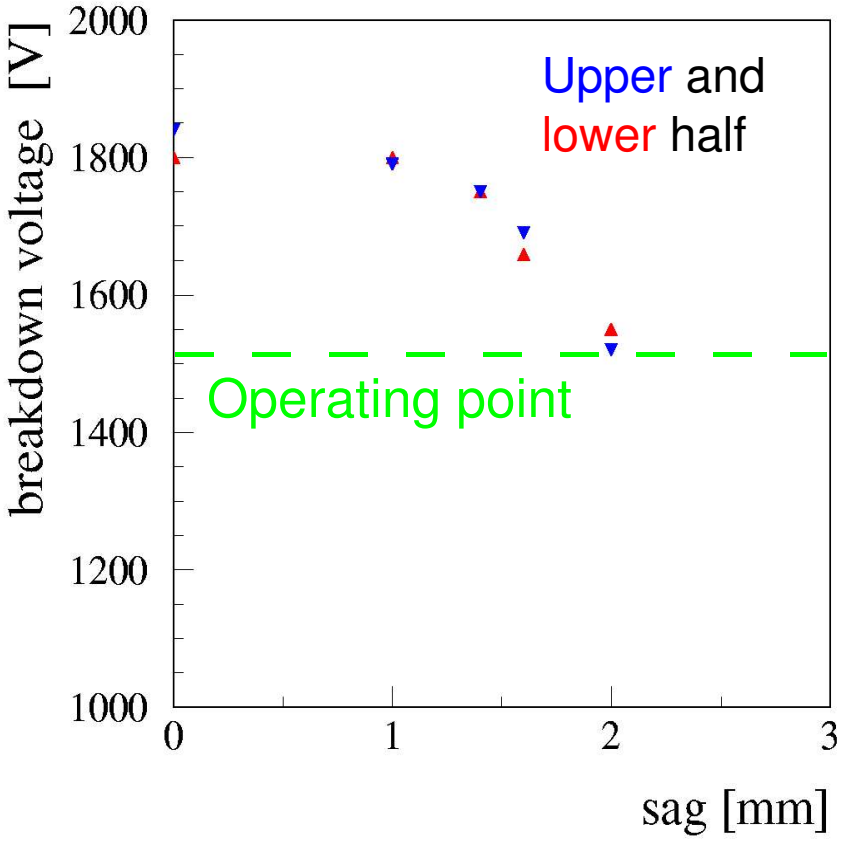
2.) breakdown voltage

as a function of wire displacement s from straw centre

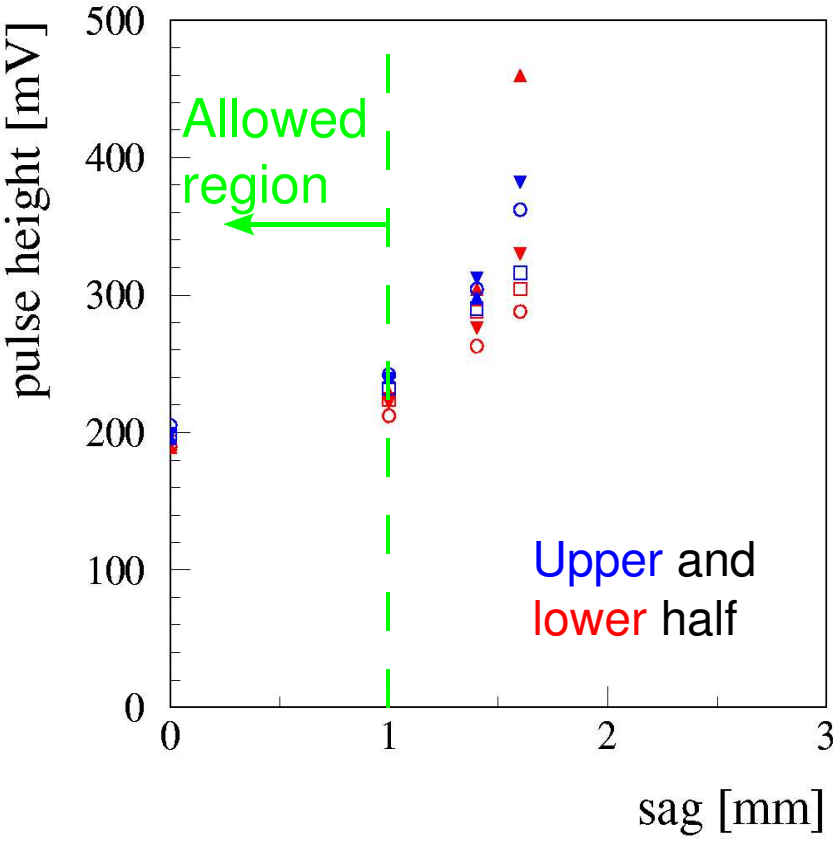
Stability for bend modules

Results for preseries module

Breakdown voltage

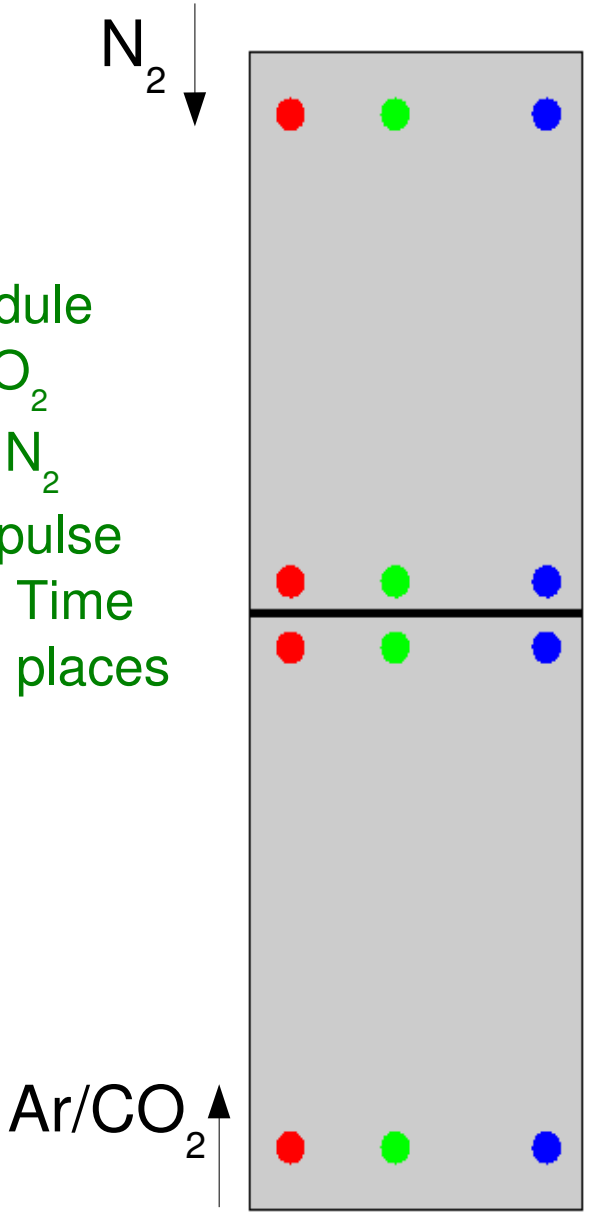


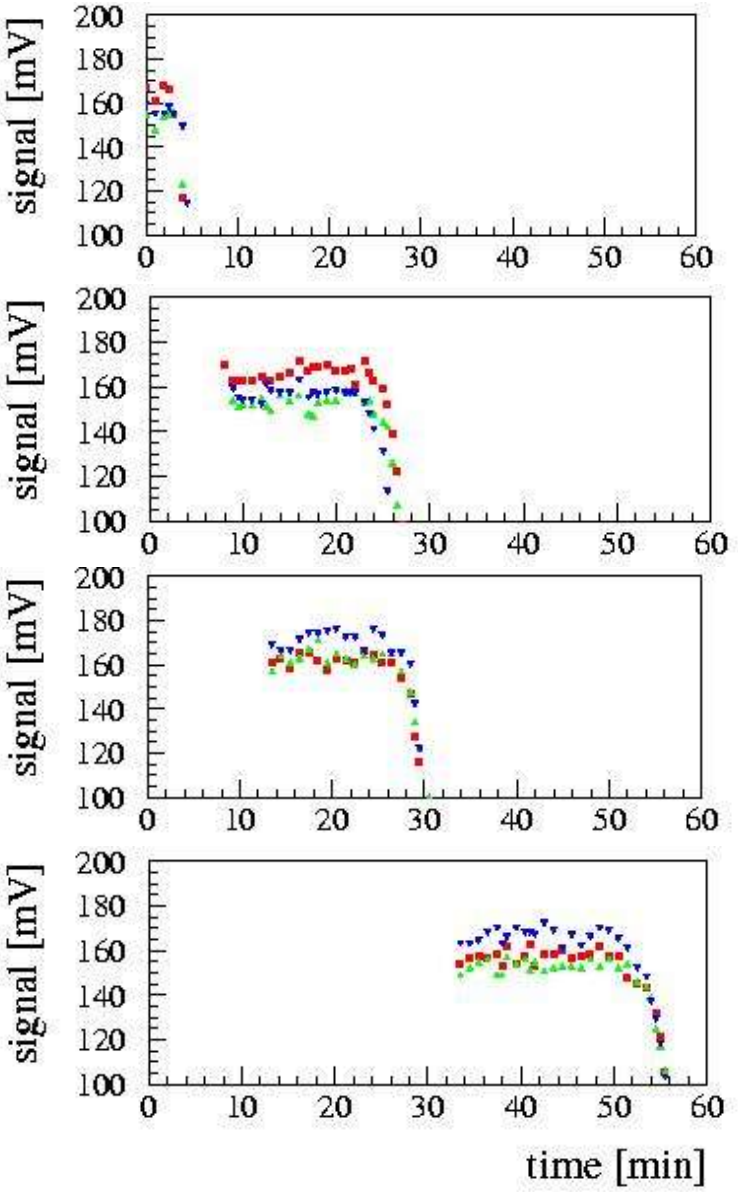
Gain



Gas flow in the module

1. Flush module with Ar/CO_2
2. Switch to N_2
3. Measure pulse height vs. Time in various places





HV stability of endpieces under irradiation

We irradiated endpieces with a ^{106}Ru-source and monitored the current.

Conditions:

- Ar/CO_2 (70/30) @ 1520V
- gain: $2x10^4$
- beam spot: ~3x3 cm^2
- total current: ~200nA

In total 576 straws out of 1280 have been irradiated

No abnormal effects observed yet!