CHARGE SENSITIVE PREAMPLIFIER DESIGN OPTIMIZATION FOR LOW-PRESSURE MICROMEGAS GASEOUS DETECTOR OPERATIONS

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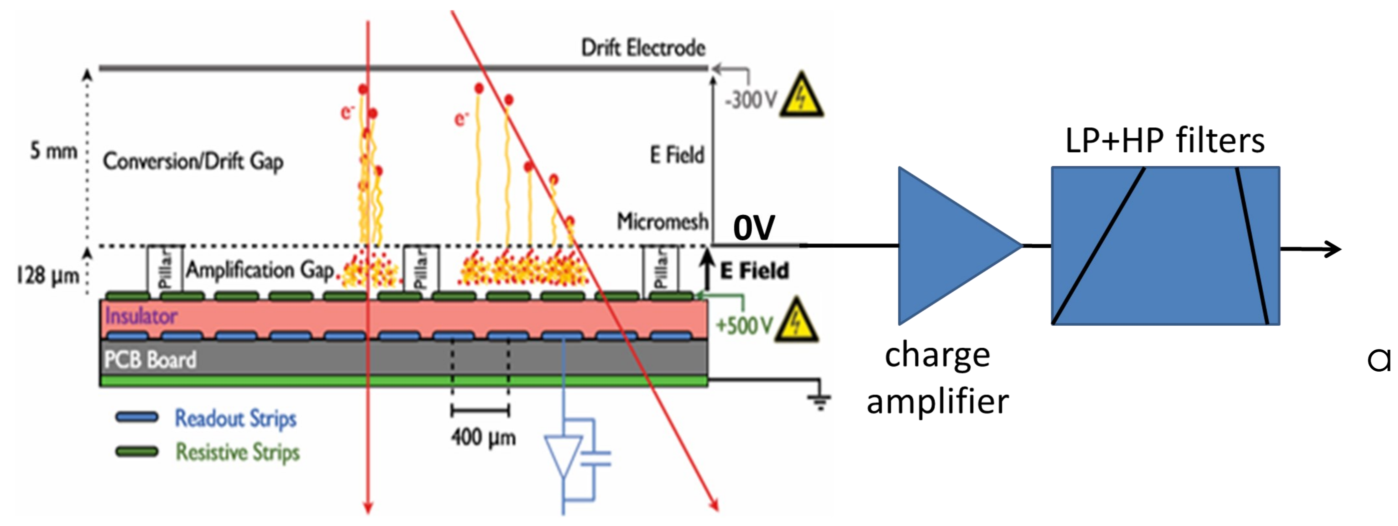
INTRODUCTION

We have evaluated the possibility to use the Micro-Megas (MM) technology to detect low energy (below 100 keV) ionizing particles. Using this device, a precise energy measurement can be obtained collecting the total charge reaching the mesh electrode connected to a low noise charge sensitive preamplifier. When operating it at low-pressure gas regime [1], it is necessary to modify the amplification gap geometry to reach the optimal detector gain, reducing the discharge probability between the anode and the mesh with a reasonable avalanche volume for track length development and resolution. This implies changes in the input capacity of the preamplifier which influences its signal to noise ratio and thus the detector energy resolution.

An ad-hoc high-gain and low-noise charge preamplifier to cope with the requirements of our application field has been developed. We present the development activities focused to the study of a configurable charge amplifier to be connected to a MM detector having different mesh capacitances. The most relevant parameters to be optimized are:

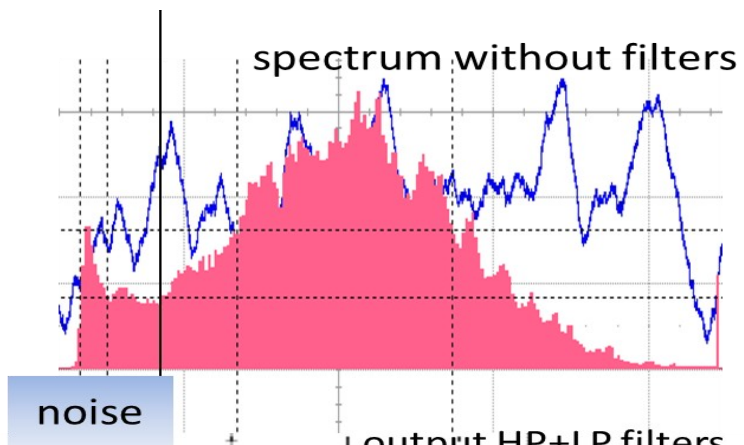
1. mitigate as better as possible the environmental noise in the lab -> common mode chokes and the output filters
2. detect a few fC charge
3. optimize different electrical capacitance detectors -> the Equivalent Noise Charge (ENC) of the amplifiers has to be matched to the detector capacitance

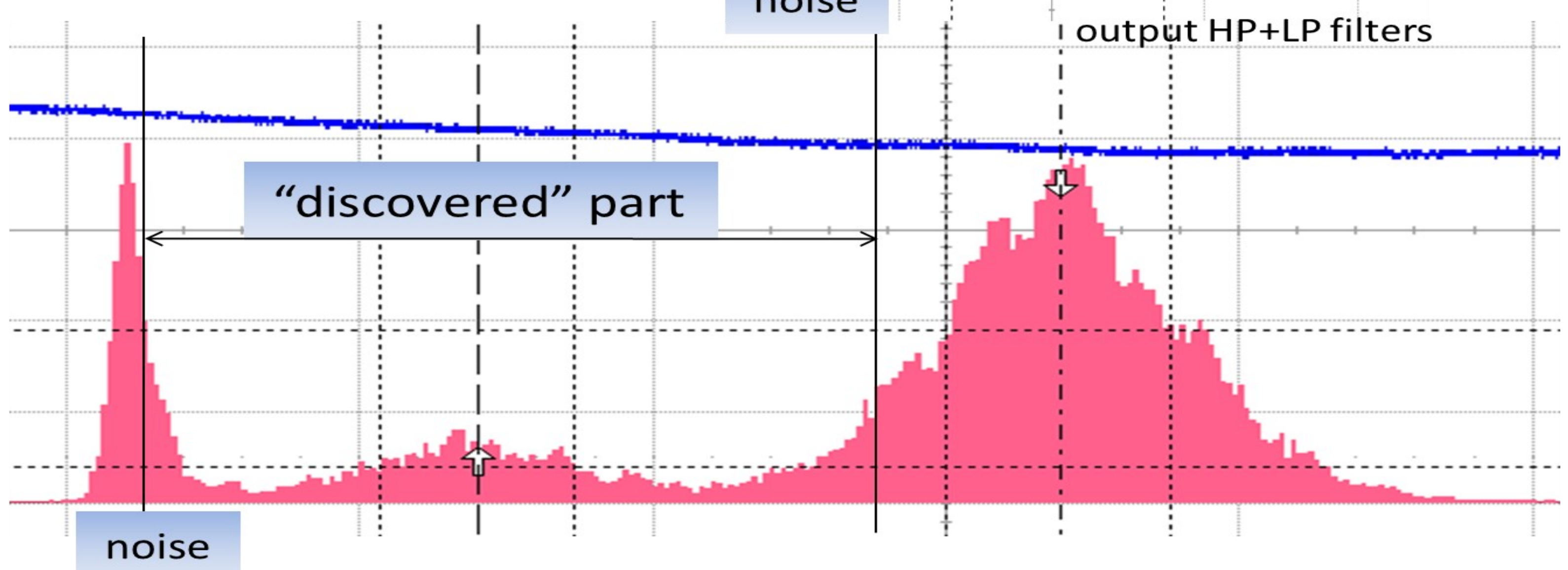


First of all a measurement campaign has been performed by using a ^{55}Fe source at normal temperature and pressure (NTP, are the LAB conditions, gas fluxed at slightly more the atmospheric pressure) conditions. Then, set of tests operating the detector with an Ar-CO_2 (93:7) gas mixture maintained at low pressure down to a few tens of mbar has been carried on to complete the experimental activity. In agreement with our requirements, the best performance has been obtained with 192 µm gap (minimum avalanche gap we will use) XY type bulk MM. For a x-ray of 6 keV from our ^{55}Fe the MM at STP generates $2 \cdot 10^5$ e- (32 fC).

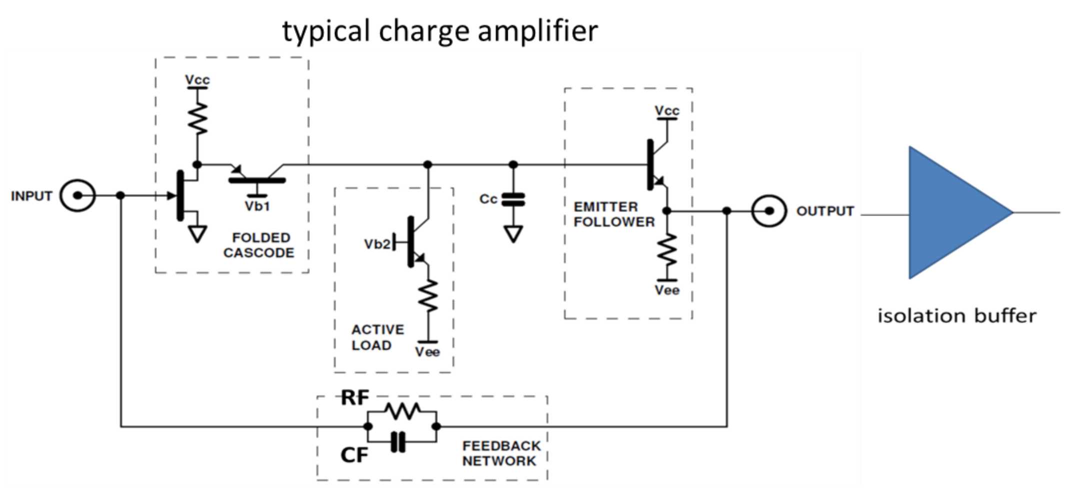
With our set-up, it has been evaluated $3 \cdot 10^4$ e- (4.8 fC) for one 1 keV particle, corresponding to an amplifier having a noise level lower than 0.4 fC

Effect of the HP-LP combination filters on commercial charge amplifier signal out for a ^{55}Fe source at STP conditions with a MM BULK 128 µm

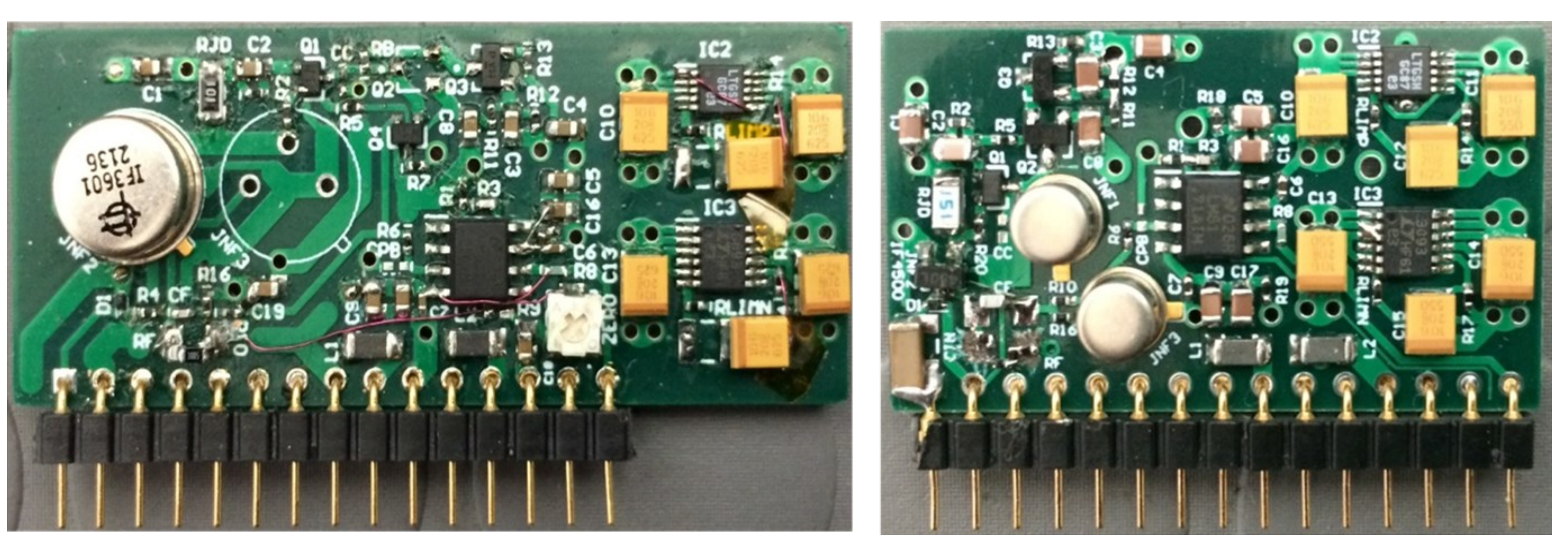




Operating the MM at **low 530V anode bias** (MM BULK 192 µm XY; amplification measurement @540V is 940 +- 140; calculated @530V from fit 740 +- 150) and using our *no-feedback added* amplifier, with no output LP filter, with a ENC of about 0.23 fC

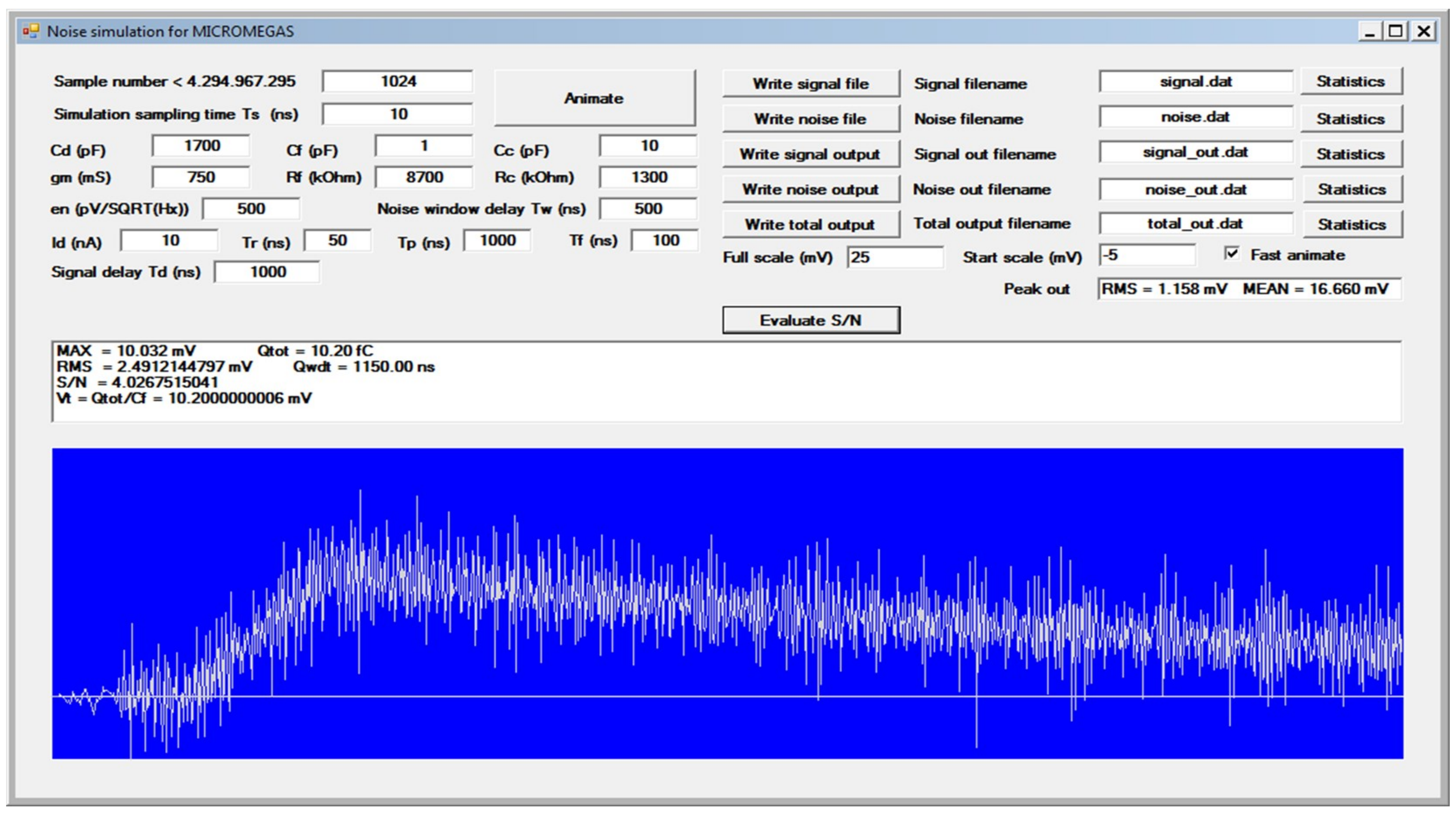


First steps in optimized low-noise charge preamplifier.

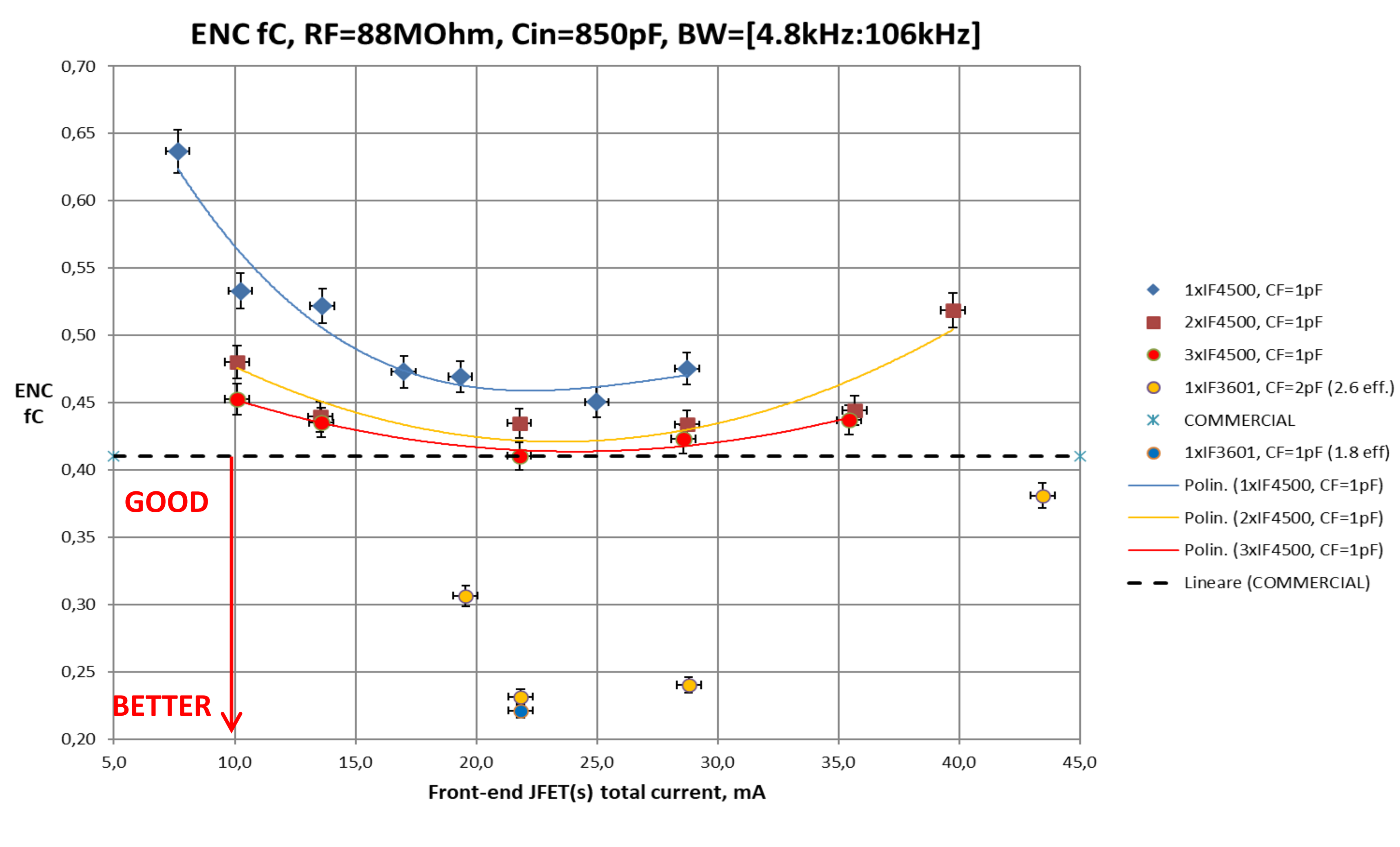


Preamplifier prototypes for MM of about 850pF and 50pF mesh electrode capacitance.

A time-domain simulator (developed by AGE Scientific [2]) with detector and front-end JFET parameters helps the JFET choice.



The test observations using Internet's IF4500 [3] and IF3601 [4] JFETs, an input emulated detector capacitance of 850 pF (as the 192mm MM), an output filter to eliminate unnecessary noise: as expected, best ENC is with IF3601 and CF=1pF . The "no feedback added" amplifier has a gain noticeably dependent from temperature and components characteristics.



SUMMARY OF THE MEASUREMENTS CAMPAIGN

Ampl. with Interfet's 2xIF4500 @ 40mA total, *no feedbak added*, RF=96M, no output filters

Cin (pF)	NOISE RMS (mV)	NOISE PP (mV)	Vout@13.4fC (mV)	ENC (fC)
850	**1.17+/-0.37**	**n.m.**	**67.9**	**0.23**

Amplifier with Interfet's IF3601, CF=2pF (2.6 effective), RF=88MOhm, output filters

Cin (pF)	NOISE RMS (mV)	NOISE PP (mV)	Vout@13.4fC (mV)	ENC (fC)
0	0.27+/-0.09	0.88+/-0.22	24.3	0.15
850	**0.36+/-0.11**	**1.16+/-0.30**	**21.3**	**0.23**

Amplifier with Interfet's IF3601, CF=1pF (1.8 effective), RF=88MOhm, output filters

Cin (pF)	NOISE RMS (mV)	NOISE PP (mV)	Vout@13.4fC (mV)	ENC (fC)
0	0.41+/-0.13	1.25+/-0.35	39.5	0.14
850	**0.53+/-0.17**	**1.64+/-0.49**	**32.4**	**0.22**

Commercial amplifier [5], output filters

Cin (pF)	NOISE RMS (mV)	NOISE PP (mV)	Vout@13.4fC (mV)	ENC (fC)
0	0.22+/-0.09	0.69+/-0.19	49.0	0.06
850	**1.38+/-0.42**	**4.38+/-1.31**	**45.5**	**0.41**

ACKNOWLEDGMENTS

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REFERENCES

[1] F. Pilo, "Characterization of a low-pressure Micromegas-like gaseous detector with low energy x-ray sources", Gas Detectors - Poster session, PM2021, 2022
[2] http://agescientific.com/age/it_IT/index
[3] https://www.interfet.com/jfet-datasheets/jfet-if4500-interfet.pdf
[4] https://www.interfet.com/jfet-datasheets/jfet-if3601-interfet.pdf
[5] https://www.caen.it/products/a1422h/

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