Optimization of the noise performance of a single BM@N STS module

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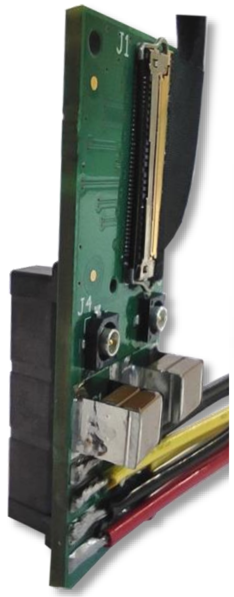
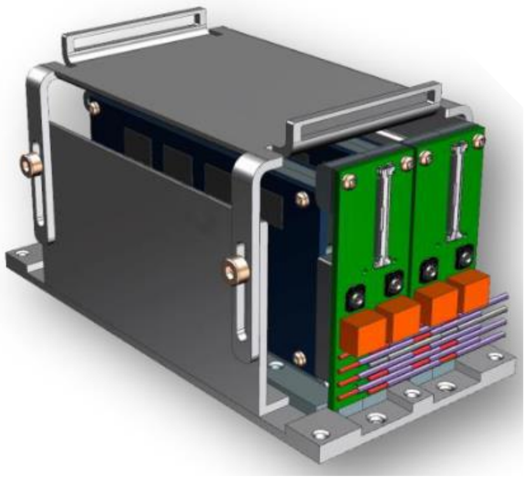
BM@N module

BM@N module

FEBs with edge-card connectors

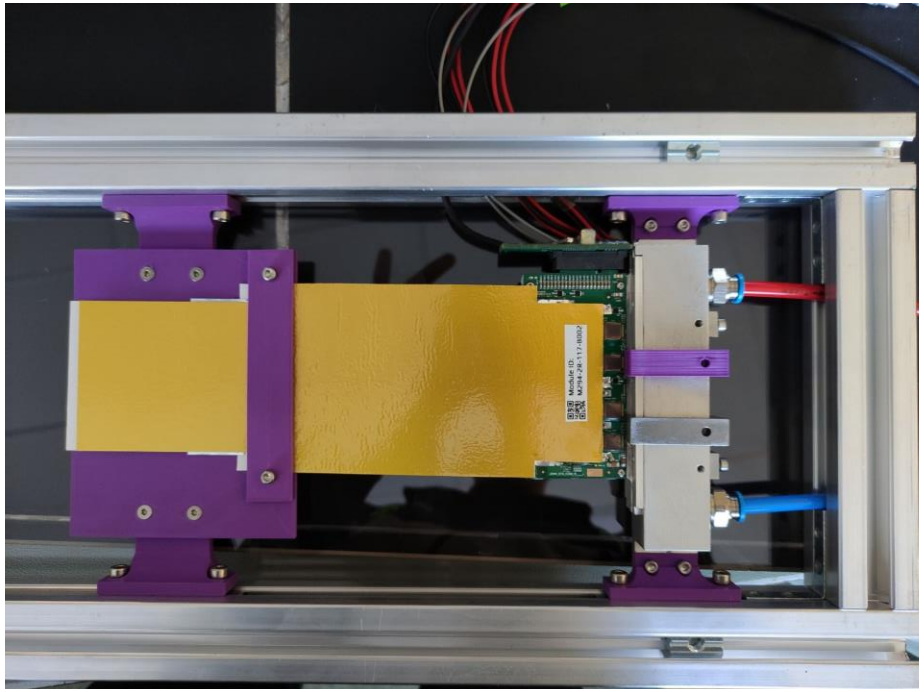


FEB-panel with HV filter



FEB box with FEB-panels

Test bench

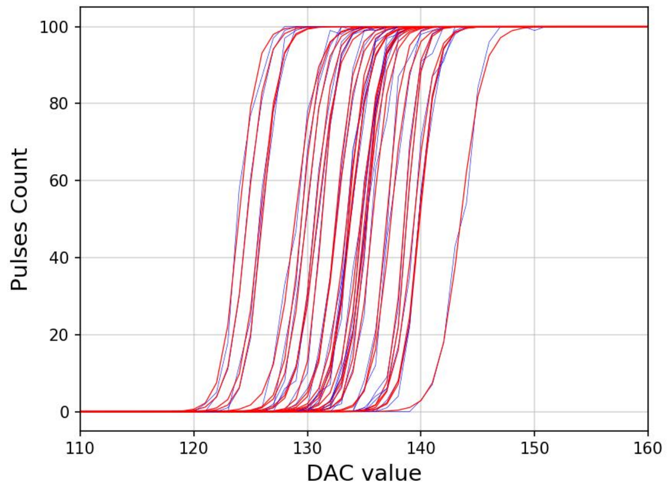


Module in the carrying tool (prototype) under tests

Module parameters:

- Sensor: HPC 22*62 mm², single metallization layer;
- Measured sensor thickness: 325 μ;
- Cable length: PSB: 155 mm, NSB: 165

Noise measurements



1. S-curves measuring for 3x ADC comparators for each channel

The continuous distribution with parameters m and $b > 0$ having probability and distribution functions

$$P(x) = \frac{e^{-(x-m)/b}}{b\left[1+e^{-(x-m)/b}\right]^2}$$

$$D(x) = \frac{1}{1+e^{-(x-m)/b}}$$

(correcting the sign error in von Seggern 1993, p. 250). The distribution function is similar in form to the solution to the continuous logistic equation

$$x = \frac{1}{1+e^{-rt}\left(\frac{1}{x_0}-1\right)},$$

giving the distribution its name.

The logistic distribution is implemented in the Wolfram Language as LogisticDistribution[*mu*, *beta*].

The mean, variance, skewness, and kurtosis excess are

$$\mu = m$$
$$\sigma^2 = \frac{1}{3}\pi^2 b^2$$
$$\gamma_1 = 0$$
$$\gamma_2 = \frac{6}{5}.$$

2. Calculation of **σ** (Noise) in the DAC counts

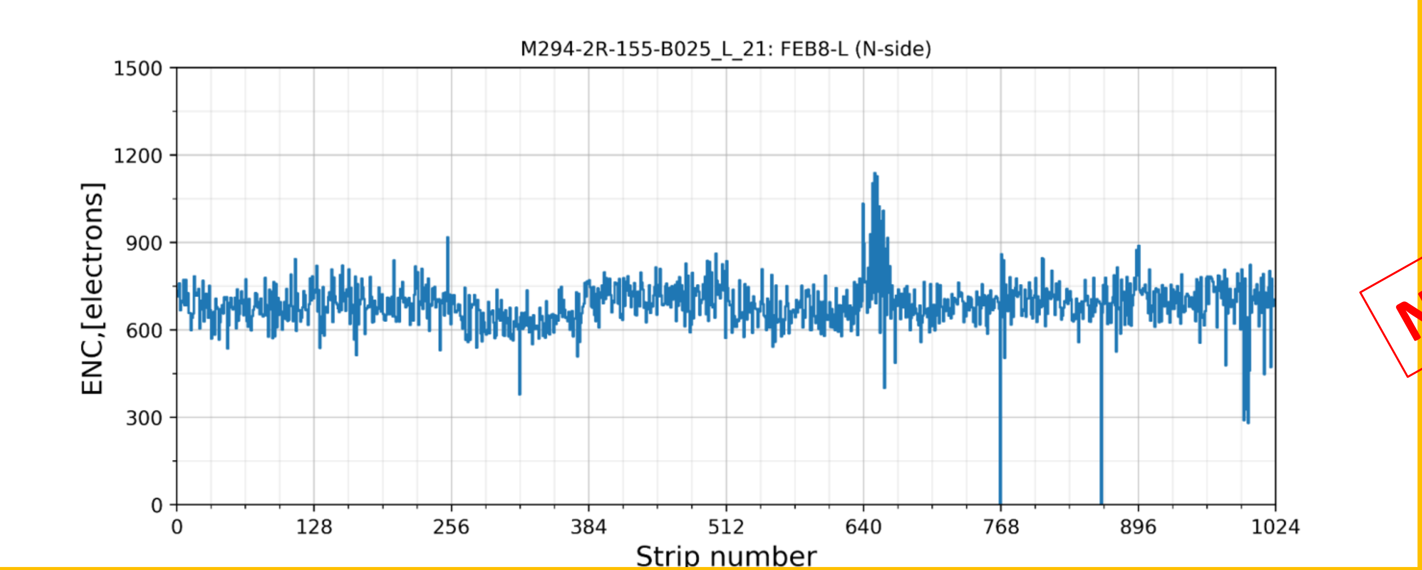
$$ENC = \mathbf{0.56\ mV/LSB} \times \frac{100\cdot10^{-15}\ F}{1.6\cdot10^{-19}\mathrm{C}}$$

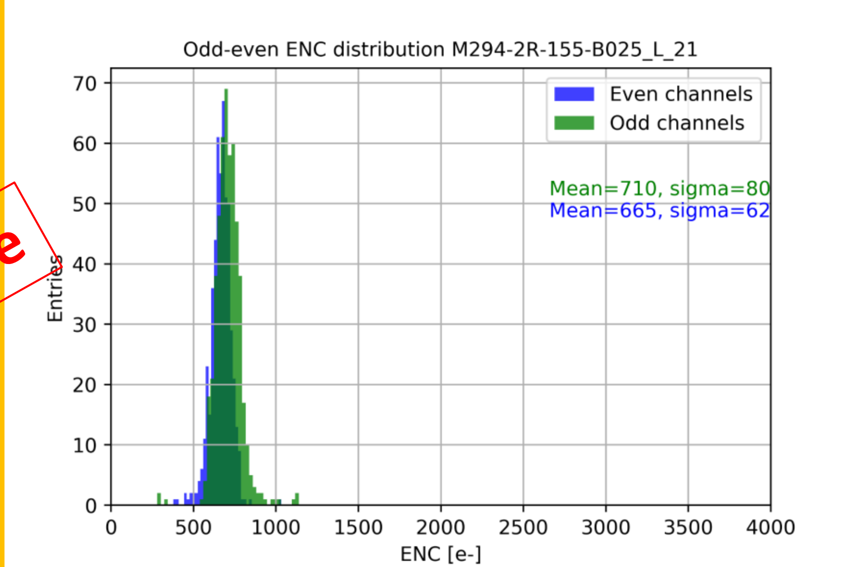
3. Conversion of the DAC counts in the ENC [electrons]

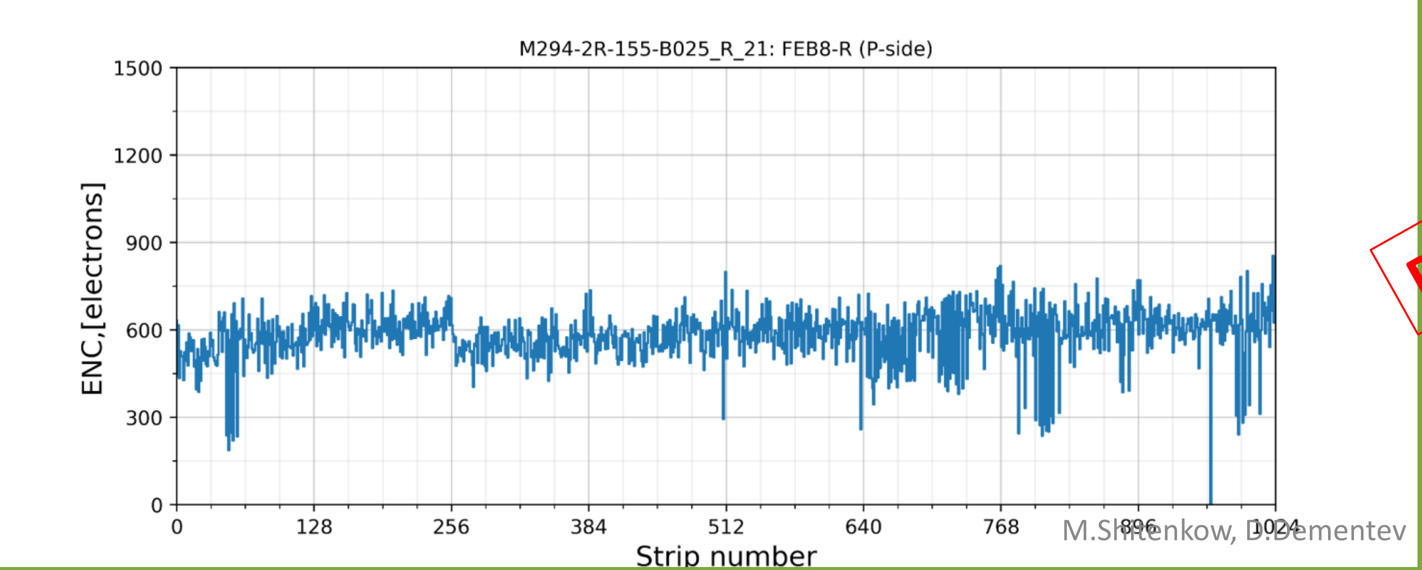
DAC gain measured for 14x ASICs is 0.5-0.56 mV/LSB.

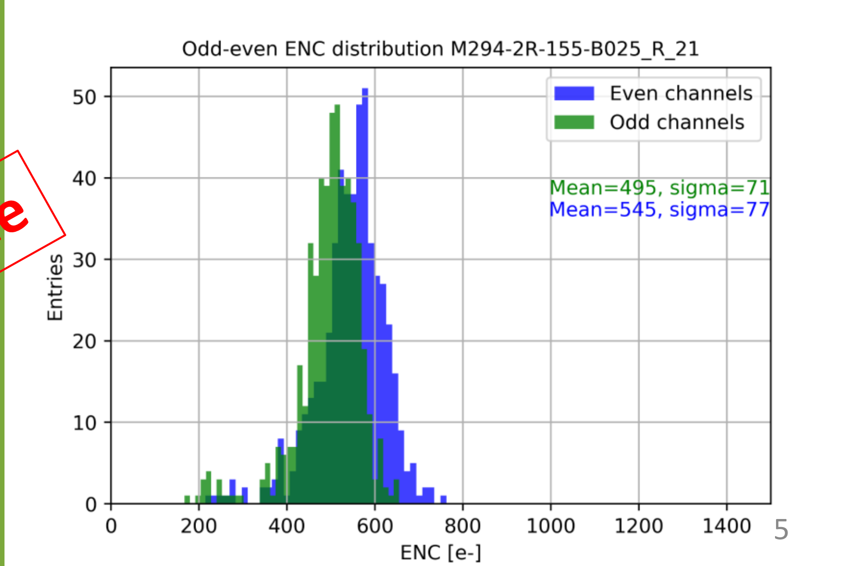
*For the noise measurements we use **0.56 mV/LSB** for all ASICs.*

General noise/channel distribution picture (best result)

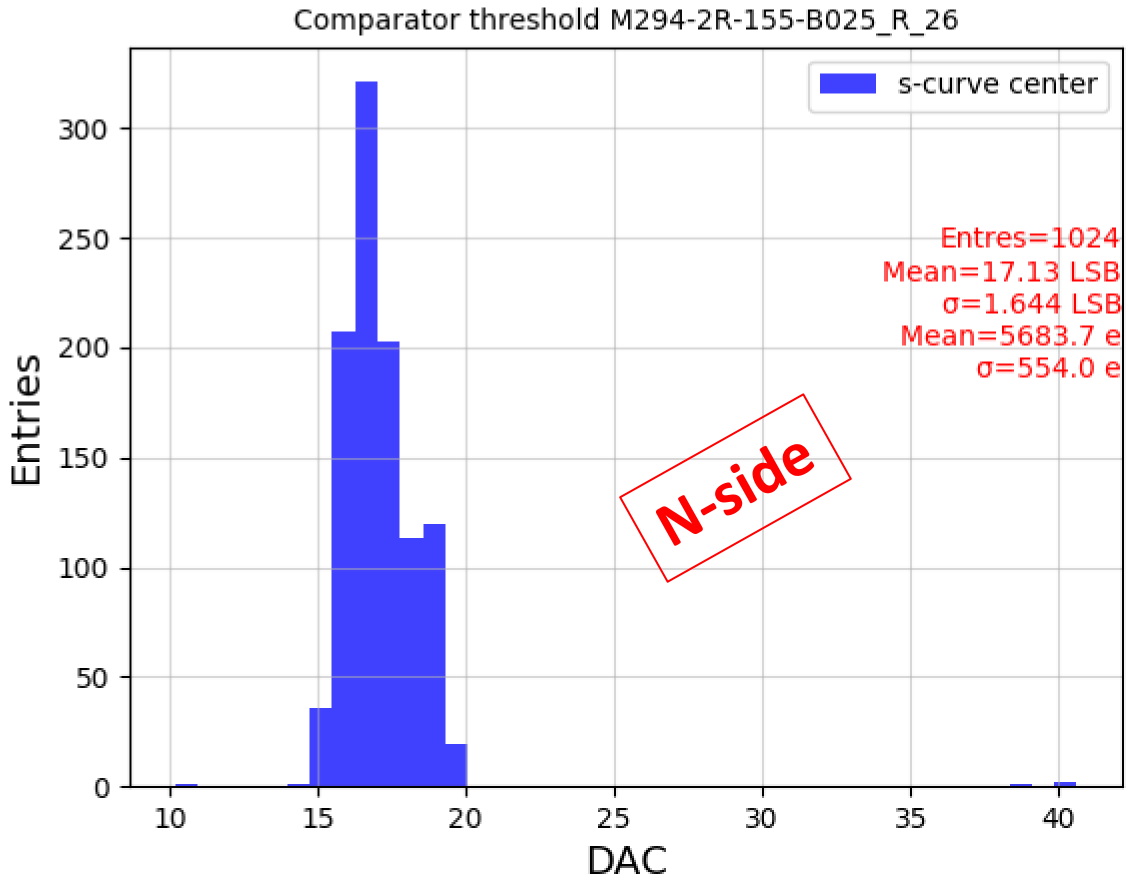


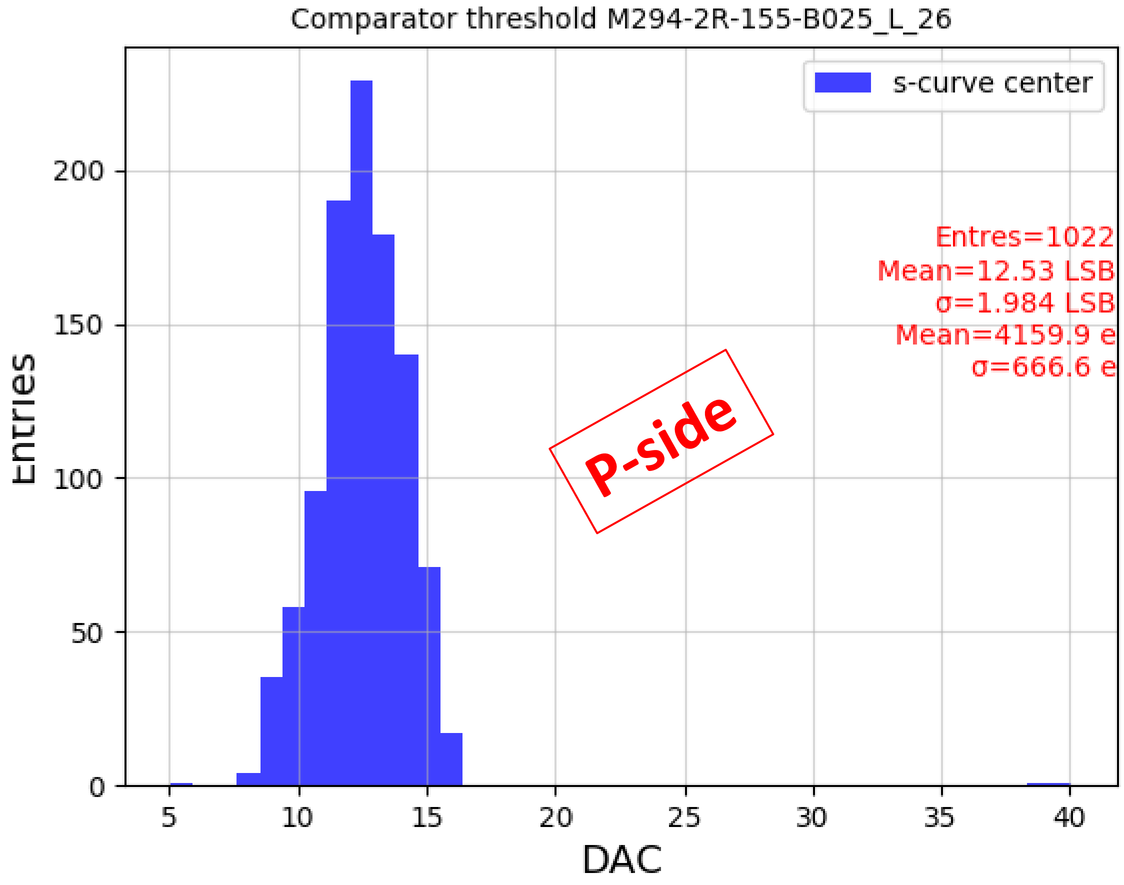






Threshold setting





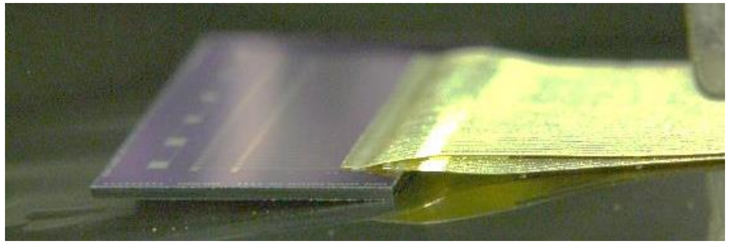
-> ~100 Hz frequency of noise hits (~0.3 kbps) with 10 channels masked

General conclusions

- *N-side noise* is always **bigger** than the *P-side noise;*
- *Even-odd effect is always seen. Bigger noise corresponds to the bottom micro-cable (same for both sides)*

  Depends on the stack alignment:

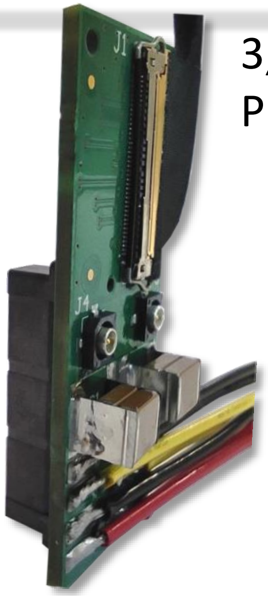
  flat cable-stack corresponds lower noise difference



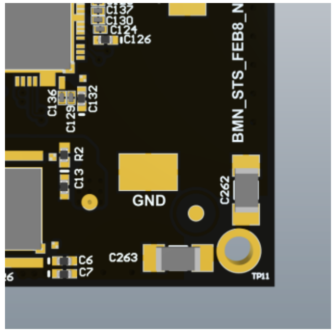
In order to achieve the best results the following configurations were tested:

- *Different parameters of HV filter;*
- *Different PS configurations*

HV filtering scheme: starting point

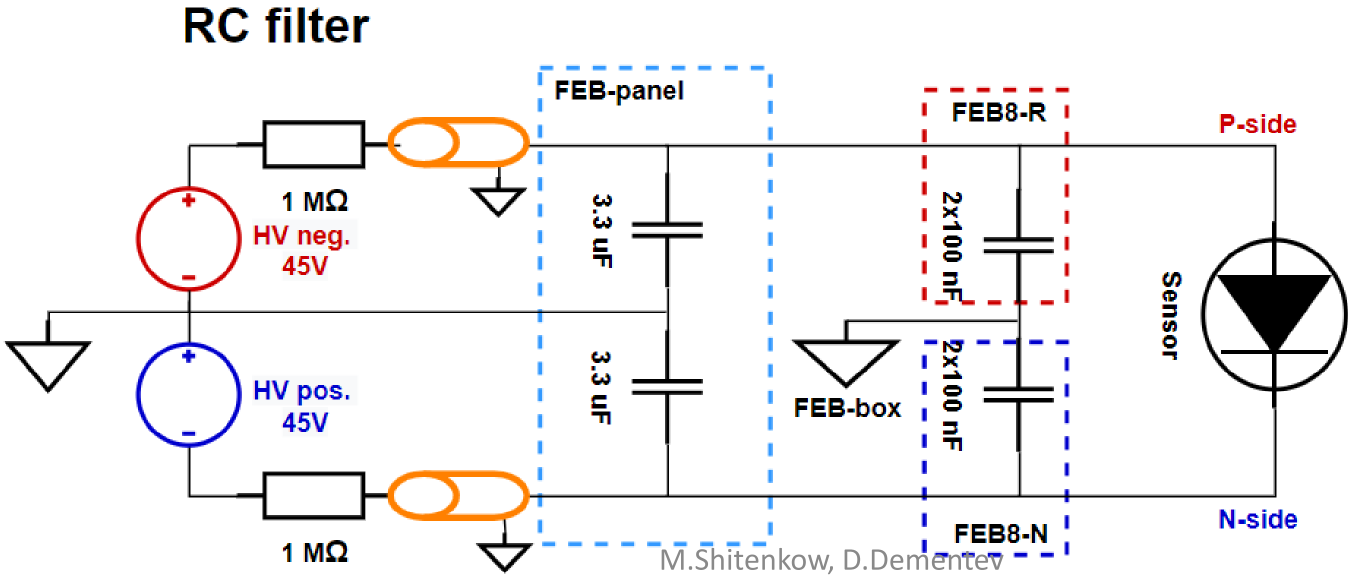


3,3 uF caps on the FEB-panel
Play the main role for the HV filtering

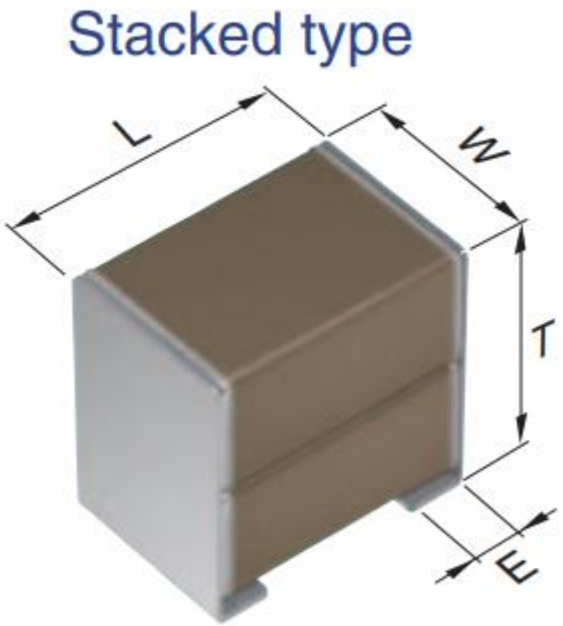


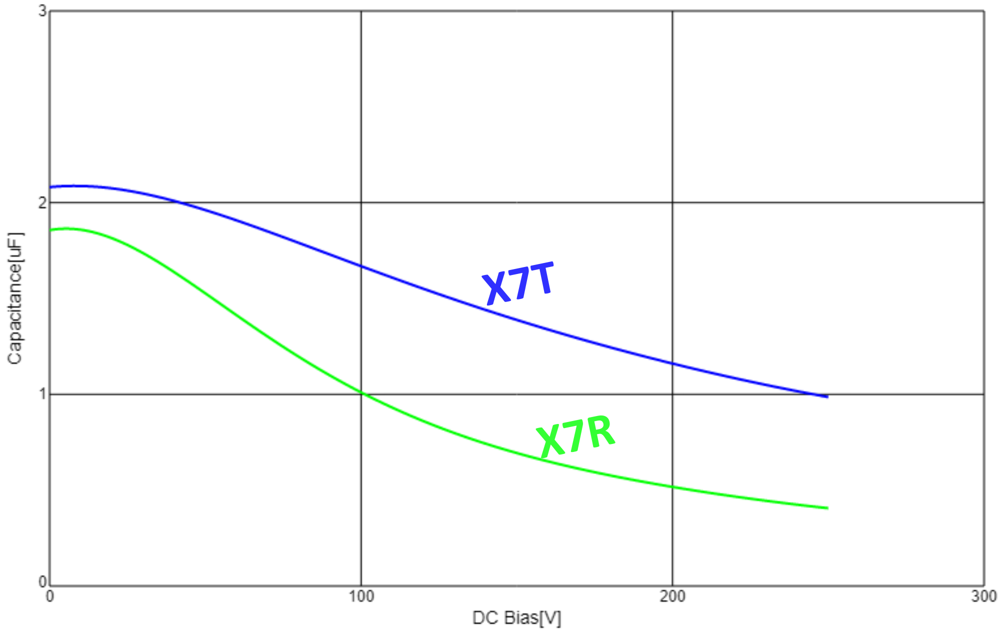
100 nF caps on the FEBs connected through the FIN: Noise improvement on the level of ~30 electrons;

1MΩ Resistor used for the filtering/protection with Kevthlev PS



Feb-panel Caps





From Murata Simsurfing

TDK
Capacitance: 3,3 uF;
Dielectric: **X7T**;
Voltage rating: 250 VDC;
LWT: 6 mm*5mm*5mm

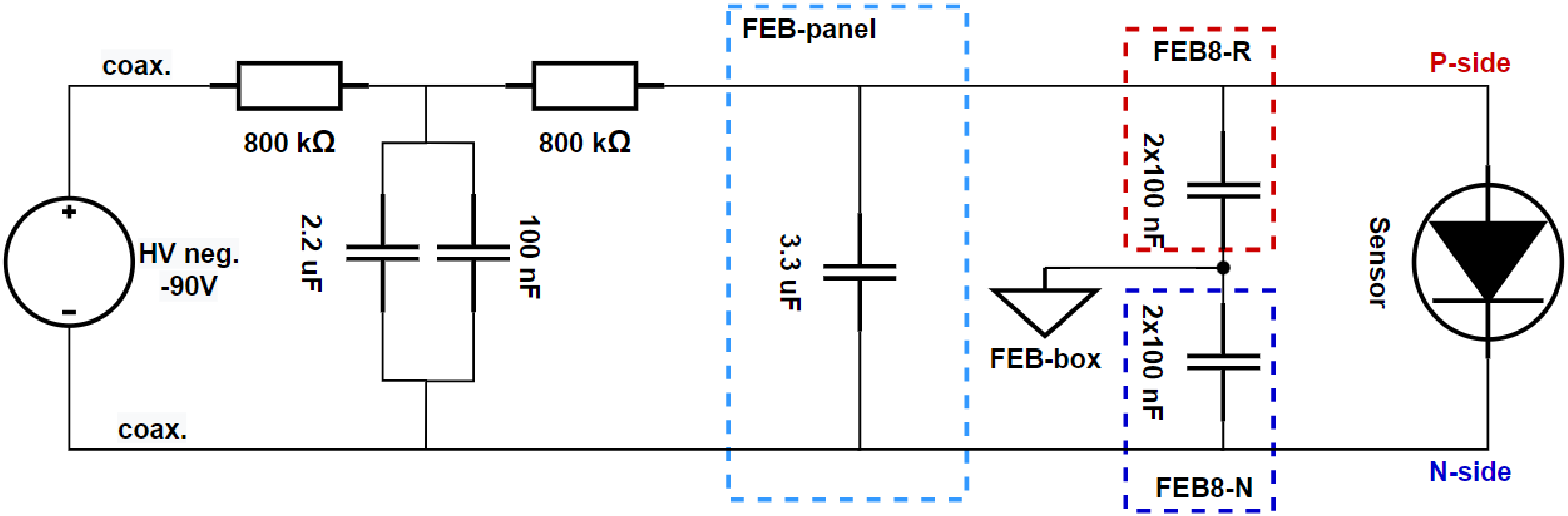
Factory lead-time: 28 weeks

United Chemi-Con (UCC)
Capacitance: 2,2 uF;
Dielectric: **X7R**;
Voltage rating: 250 VDC;
LWT: 7.5 mm*6.3mm*5mm

Factory lead-time: 26 weeks

HV filtering: RC^2 filter & Asymmetric biasing

RC^2 filter



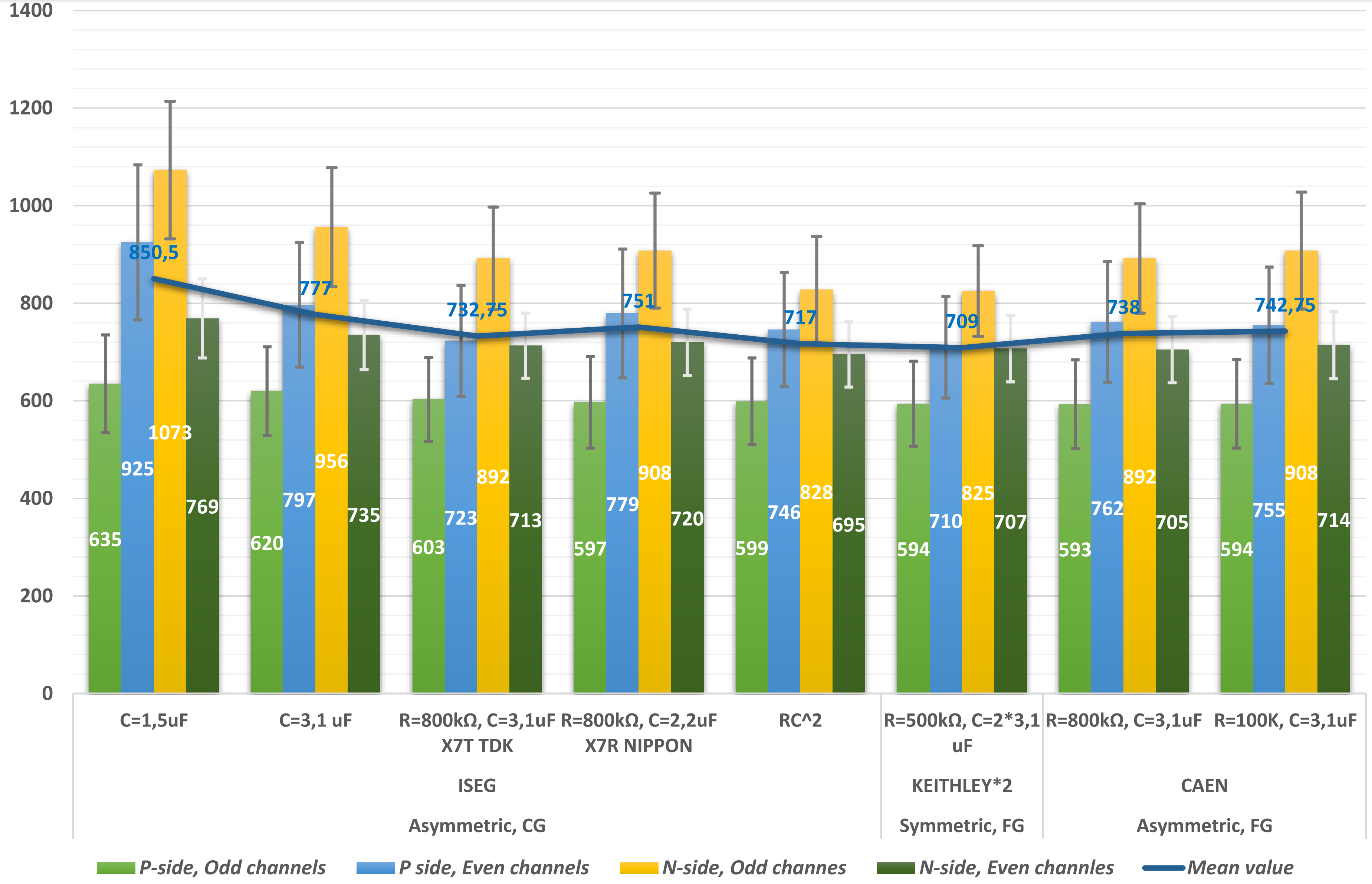
Power supplies

✓2* Keythley: bipolar, floating ground;

✓ ISEG: negative, common floating ground

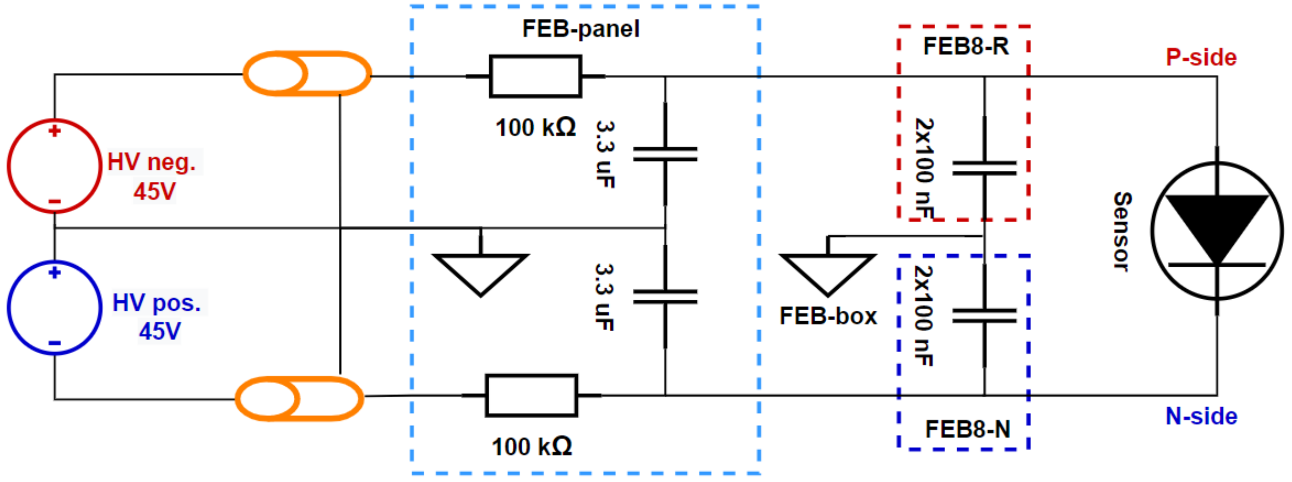
✓ CAEN, negative, floating ground;

Comparison of the different configurations



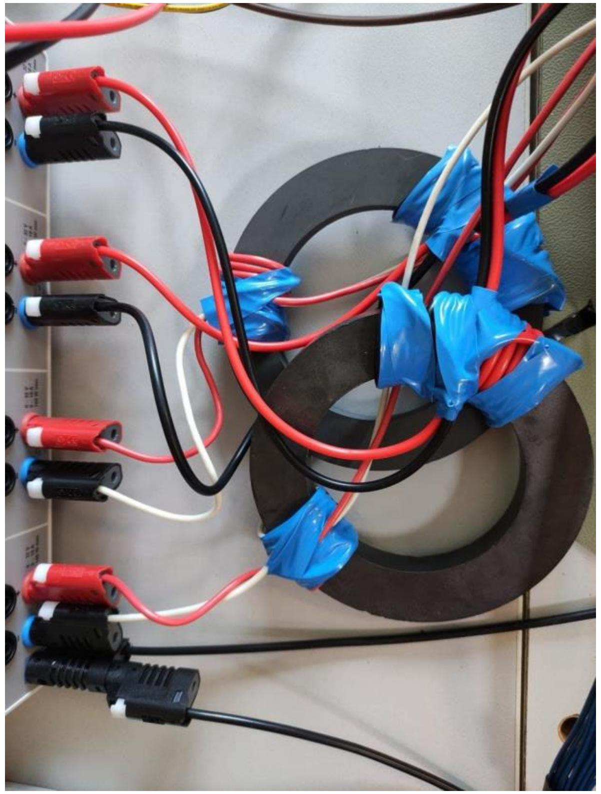
Main conclusions

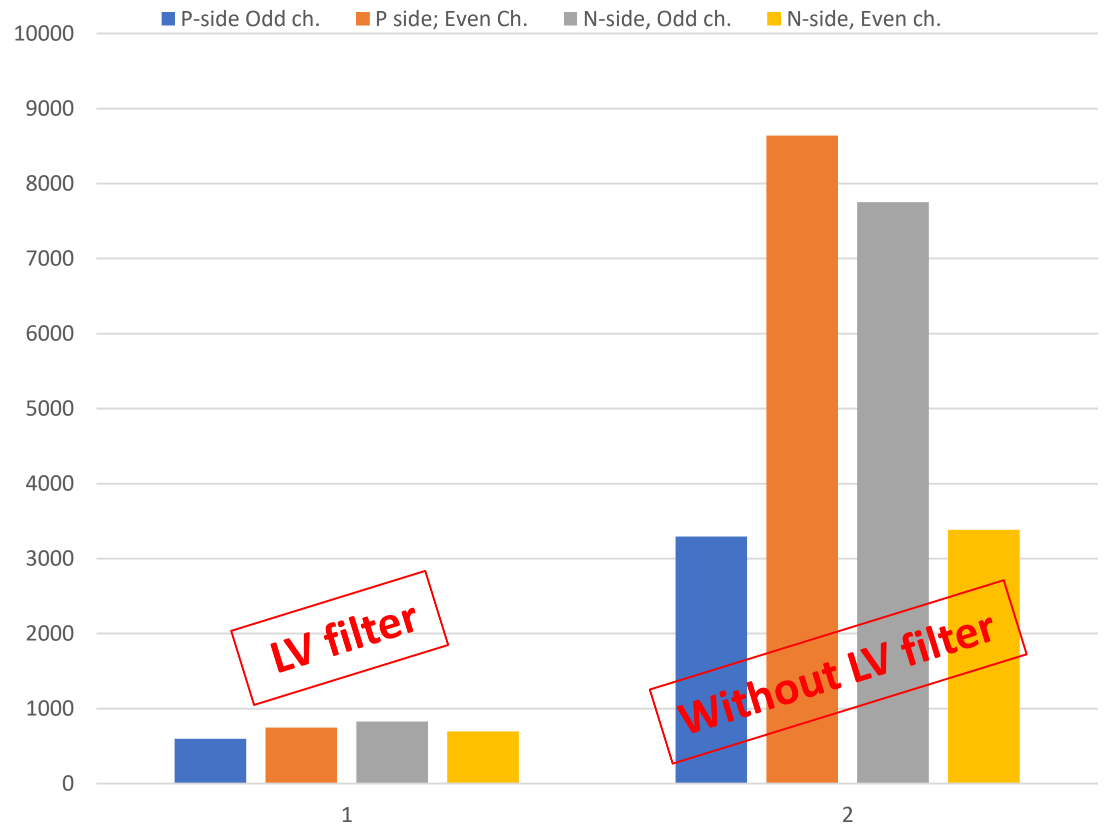
- No significant difference between different HV supplies and Sym./Asym. biasing scheme for a single module system;
- Best result with RC^2 filter with X7T TDM caps; No difference between 100 kOhm & 800 kOhm filtering resistor;
- RC filter is only 3% worse than RC^2, but requires much less space;



Proposed modification of the FEB-panel

LV filter

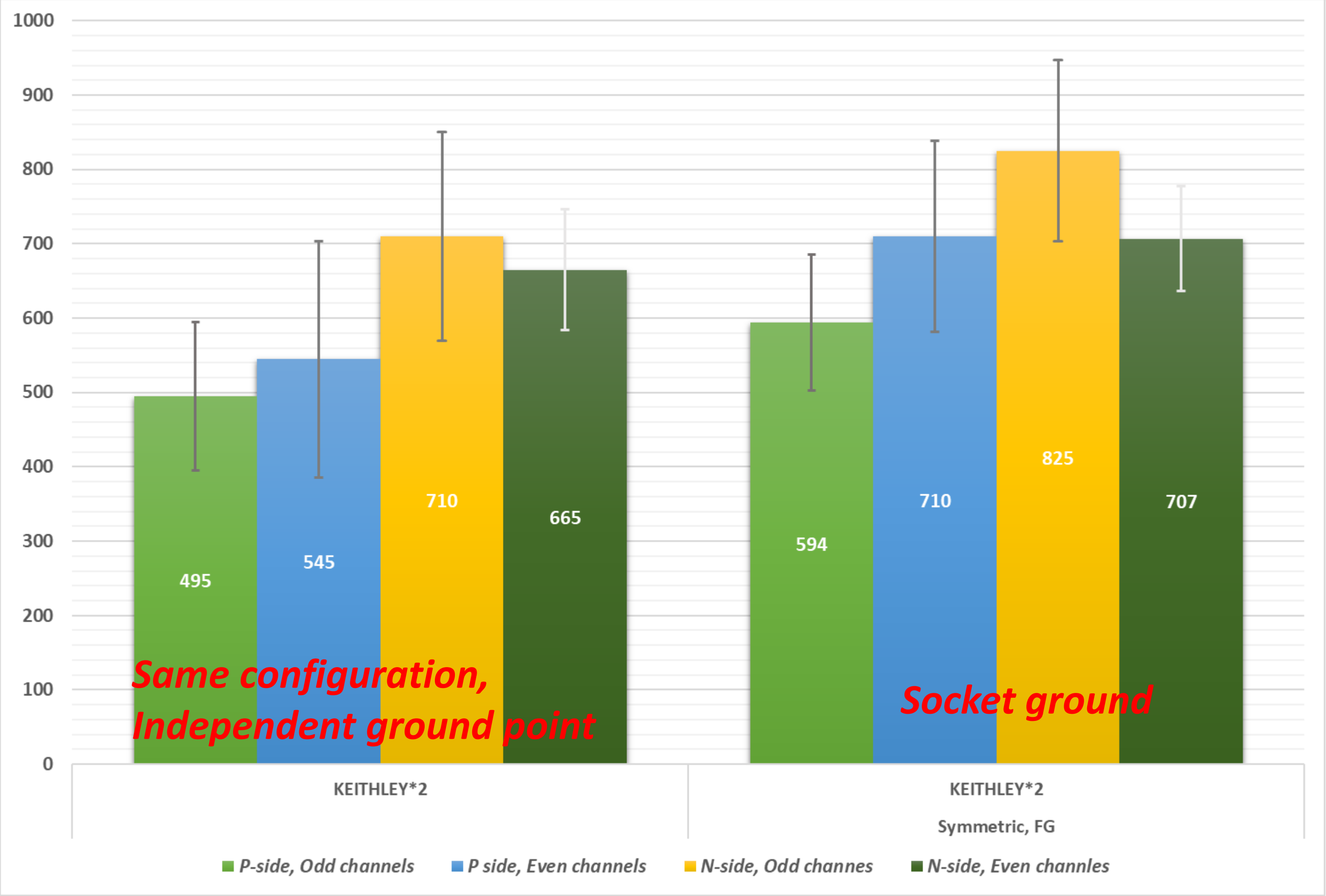




The main source of noise is common mode noise from the LV power supplies.
Probably, using of FEASTMPs will improve situation

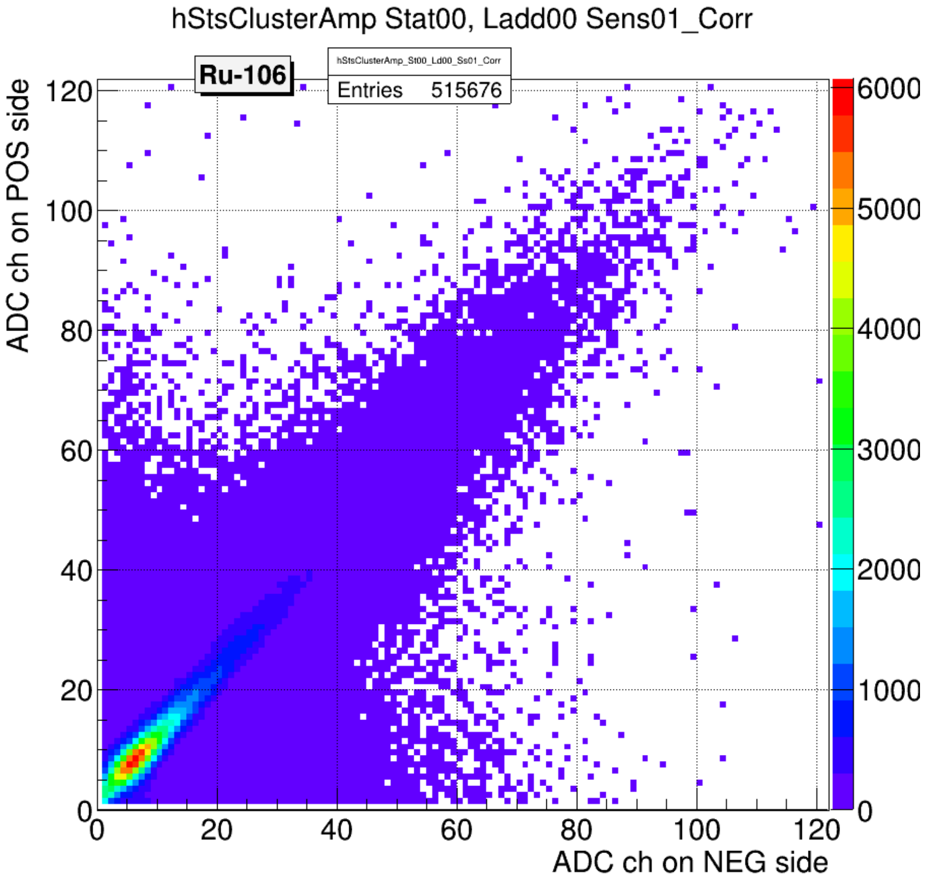
Thank you for your attention!

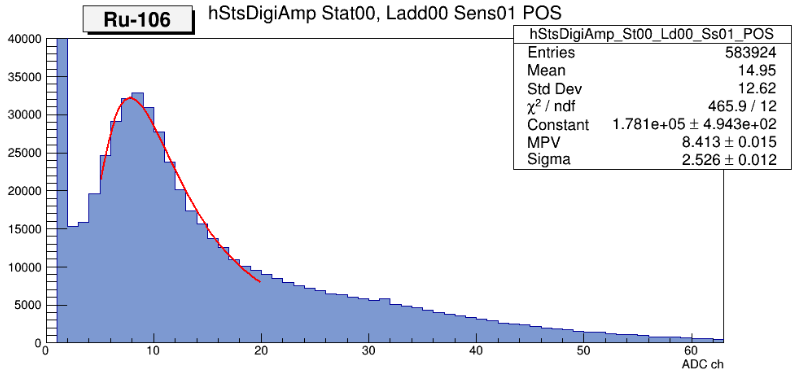
Playing around with a ground connection

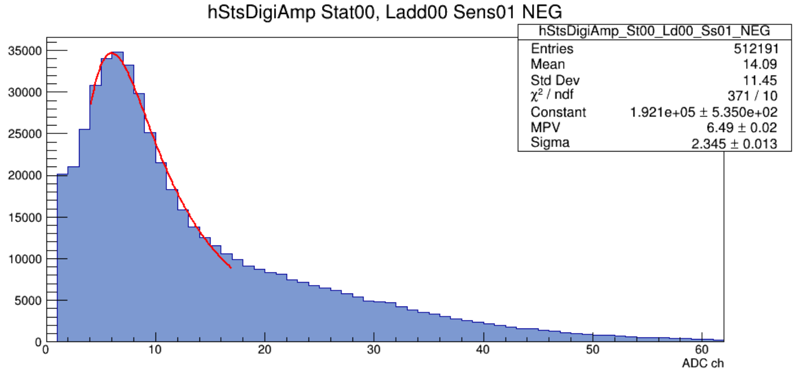


Changing of the of LV&HV grounding from socket-gnd to metal construction "clean" ground results in up to 15% improvement in noise

Signal measurement with Ru-106







Deposited charge: 80 electrons*300 microns = 24 800 electrons;
Measured on the P side: 24 300 electrons;
Measured on N side: 22 200 electrons;
Preliminary