A high performance Front End Electronics for Drift Chamber readout in MEG experiment upgrade

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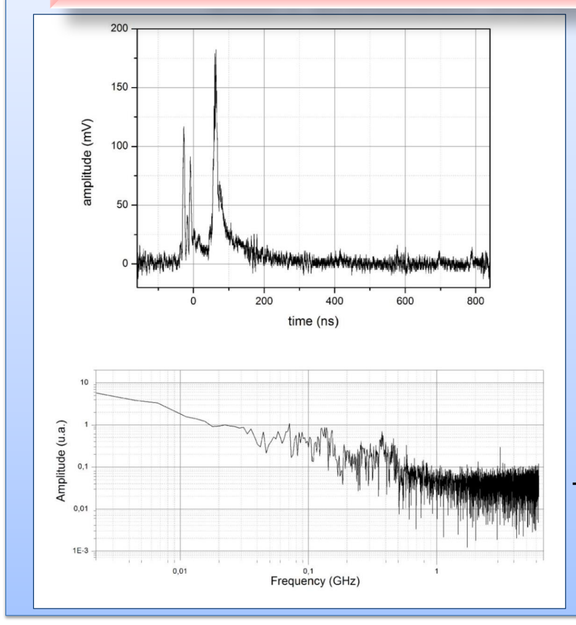
ABSTRACT

The new positron tracker for the spectrometer of the MEG experiment at Paul Scherrer Institute (Zurich), based on a high resolution drift chamber, produces typical time separation between consecutive ionization acts in helium-based gas mixture of few nanoseconds. Therefore the electronic readout interface has to be able to process such high speed signals. In order to reach this goal we propose a high performance eight-channels front end electronics which amplifies weak signals from MEG drift chamber tracker. The front end board is designed and tested at INFN of Lecce electronics laboratory and it is based on commercial devices.
Each front end channel is a two stage amplifier with low noise and low power consumption. In order to compensate the attenuation introduced by the output cable a double stages of pre-emphasis is implemented to produces a high frequency peak in frequency response and a 1GHz -3dB bandwidth over 5m cable is achieved. A careful consideration of design rules preserves signal integrity by minimizing crosstalk between channels, moreover a dedicated networks guarantees protection, matching and decoupling from high voltage wires supply.
Simulation performed by Spice shows a voltage gain of the order of 10 constant over the entire bandwidth, in agreement with preliminary measurements.

DRIFT CHAMBER SIGNAL



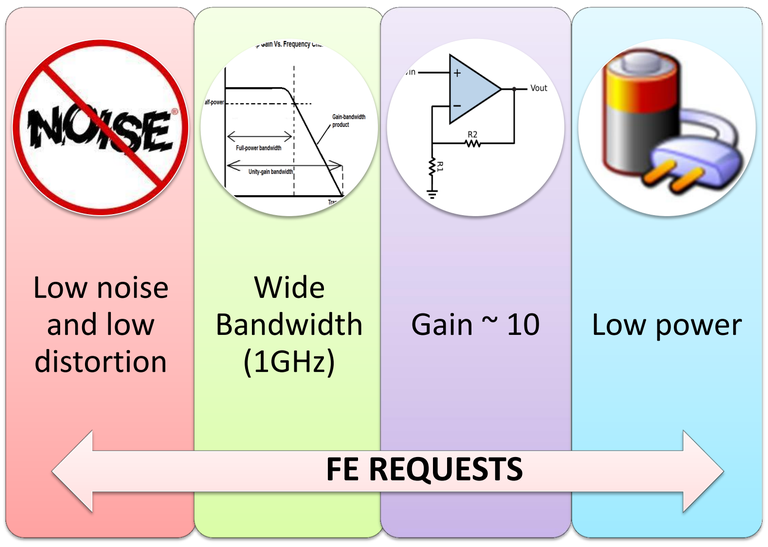
DC signal

Fourier Transform

Study of the signals spectral density done using a single 8 mm diameter drift tube with the 90% helium - 10% isobutane mixture

i. Signal bandwidth of the order of 1 GHz
ii. Peak separation clusters: few ns to few tens of ns

Spatial resolution 100 µm

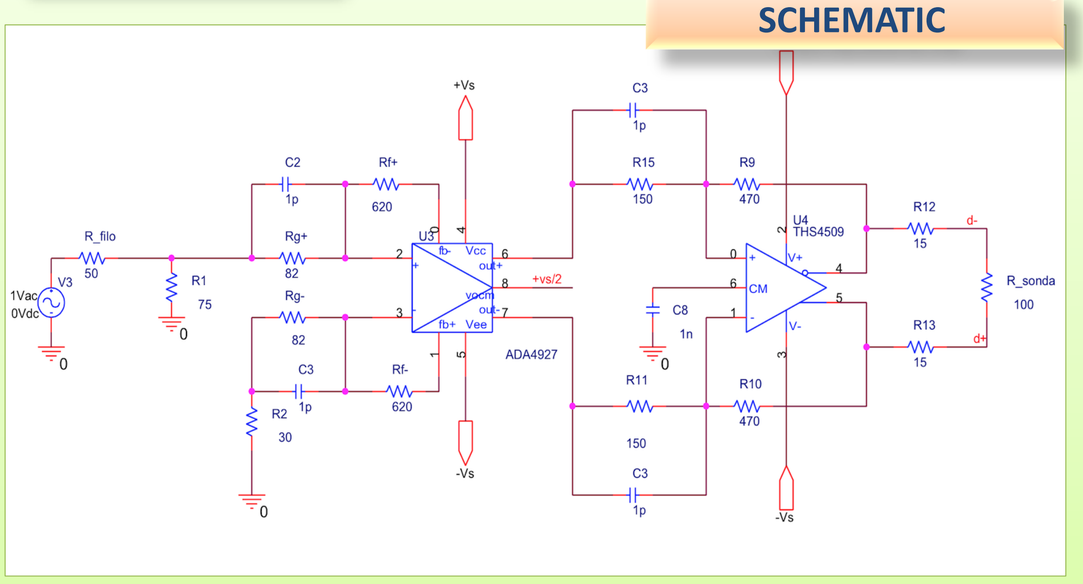


Low noise and low distortion | Wide Bandwidth (1GHz) | Gain ~ 10 | Low power

FE REQUESTS

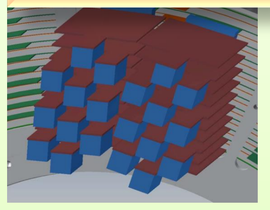
FRONT END

SCHEMATIC



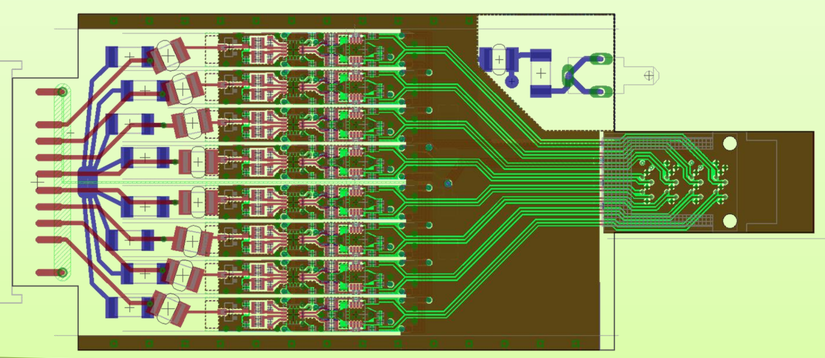
- 8 channels, each channel amplifies a single drift wire
- FE schematic tested by PSpice Simulator
- PCB board designed by Eagle PCB Design Software
- 2 gain stages performed by ADA4927 and THS4509
- Differential output in order to improve the noise immunity
- Pre-emphasis on both gain stages to balance the attenuation of the output cable

BOARDS

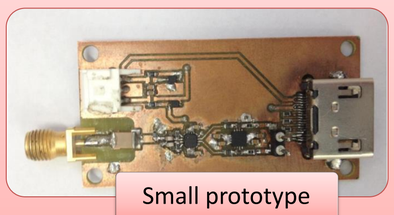


3 different cards versions due to the Drift Chamber layers spacing

Power consumtion ~ 380 W per single end plate (1920 channels)

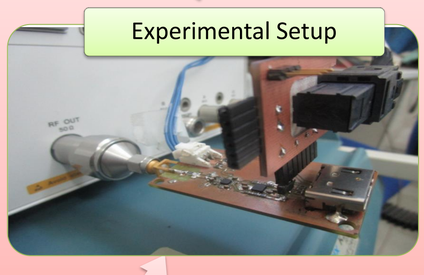


PRELIMINARY MEASUREMENT

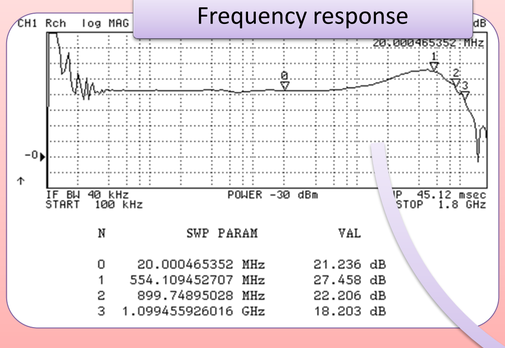


Small prototype

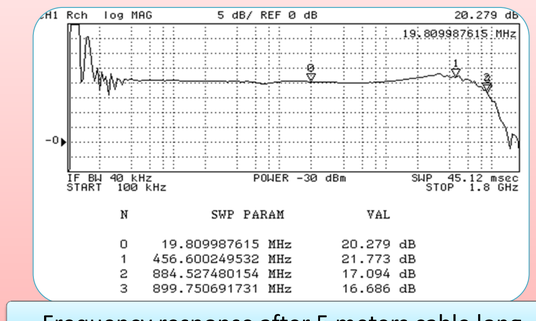
Experimental Setup



Frequency response



N	SWP PARAM	VAL
0	20.000465352 MHz	21.236 dB
1	554.109452707 MHz	27.458 dB
2	899.74895028 MHz	22.206 dB
3	1.099455926016 GHz	18.203 dB



N	SWP PARAM	VAL
0	19.809987615 MHz	20.279 dB
1	456.600249532 MHz	21.773 dB
2	884.527480154 MHz	17.094 dB
3	899.750691731 MHz	16.686 dB

Frequency response after 5 meters cable long

High performance custom cable: Amphenol Spectra Strip Skewclear that introduces an attenuation of 0.91 dB/m at 1250 MHz, a skew (within pair) less than 10 ps.

CONCLUSIONS

The MEG experiment is currently under upgrade. The new cylindrical Drift Chamber used as positron tracker is supposed to achieve a resolution of 100 µm in the measurement of the impact parameter. For this reason a high performance Front End electronics is mandatory. In particular the Front End must have a wide bandwidth, low noise and low distortion in order to amplify the signal coming from DC. For this purpose a FE Board is designed in Lecce Electronics Laboratory and will be tested soon. Preliminary test and measurements done on prototypes show a bandwidth of 1 GHz and a gain of the order of 10.

REFERENCES

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[8] Eagle Software: http://www.cadsoftusa.com