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Elettronica di front end per la camera a deriva del nuovo tracciatore di MEG

Summary

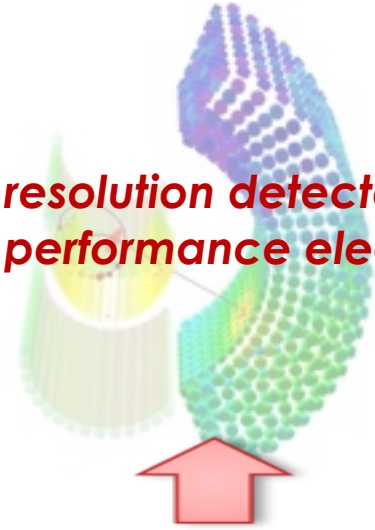
- MEG experiment upgrade
- The MEG tracker upgrade
- Drift chamber signal characteristics
- Front End schematic
- Front End Board
- Preliminary tests and results
- Conclusions and next steps

The MEG experiment

High energy Particle physic experiment @ **Paul Scherrer Institute (PSI, Zurich)**

BR $= \dfrac{N_{\mu \to e\gamma}}{N_{\mu \to anything}}$ { 10^{-54} SM ; ~ $10^{(-12)}$-10^{-14} SUSY

The decay is reconstructed to look for a back-to-back positron and monochromatic photon



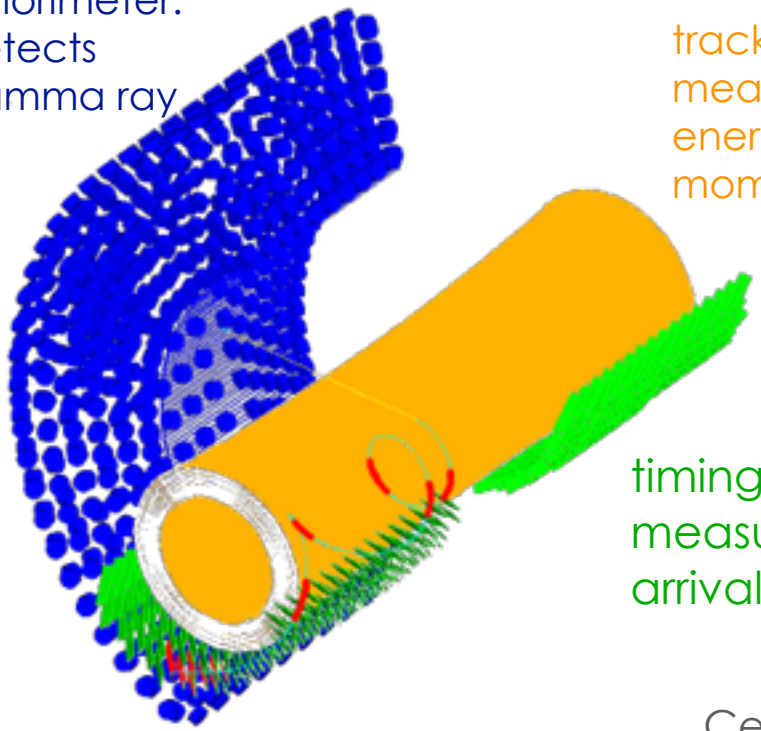
✓*High resolution detector*
✓*High performance electronics*

$\begin{cases} E_\mu = E_e + E_\gamma \\ \vec{0} = \vec{p_e} + \vec{p_\gamma} \end{cases}$ Momentum conservation; Energy conservation

- $E_e = E_\gamma = 52.8$ MeV
- $t_e = t_\gamma$ & $\theta_{e\gamma} = 180°$

MEG Drift Chamber Upgrade

Liquid xenon calorimeter: detects gamma ray



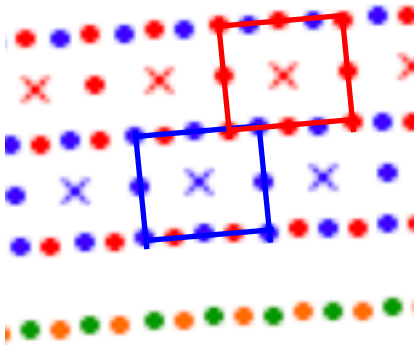
tracker: measures e^+ energy and momentum

timing counter: measures e^+ time arrival

Improvement on granularity, resolution and efficiency
Resolution x-y: 120 μm
(210μm present MEG)
Resolution z: 300 μm
(800μm present MEG)

Cylindrical wire DC:
12 cylinder sectors
10 layers per sector
8 cells per layer

gas mixture: 85% He-15% iC_4H_{10}



stereo angle +

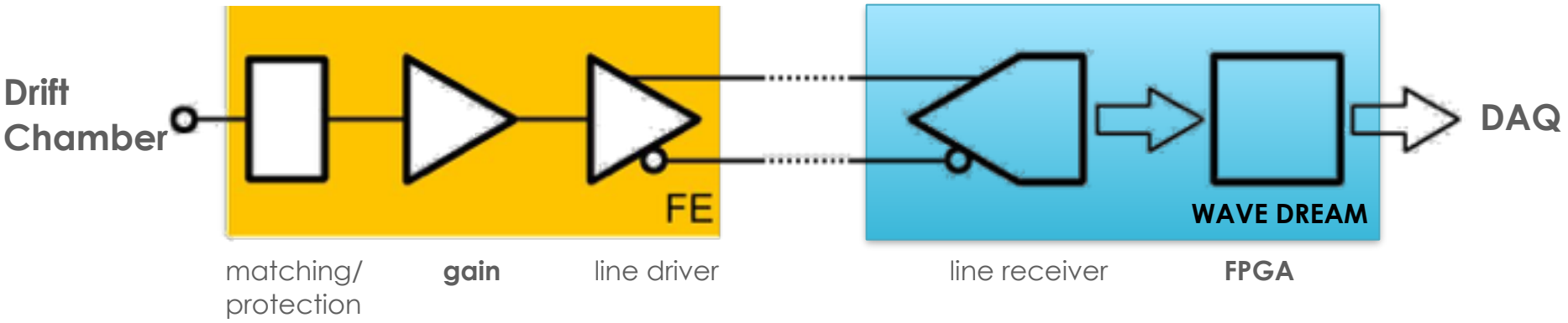
stereo angle −

guard layer

Cells are placed along beam axis with a stereo angle (8°) in order to reconstruct z coordinate by combining the information of adjacent layers

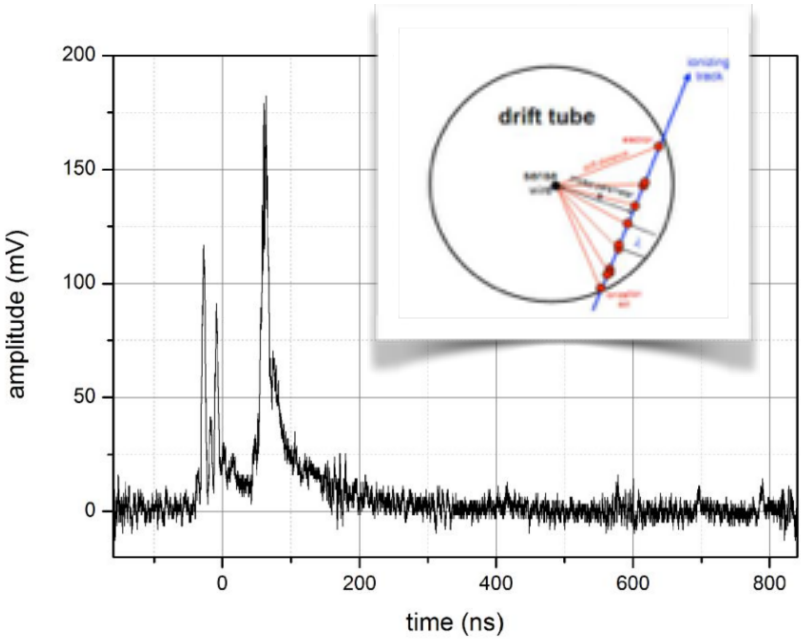
sense wires:	20 μm diam W(Au)	=> 1920 wires
field and guard wires:	50 μm diam Al(Ag)	=> 2688 wires
potential wires:	40 μm diam Al(Ag)	=> 7680 wires

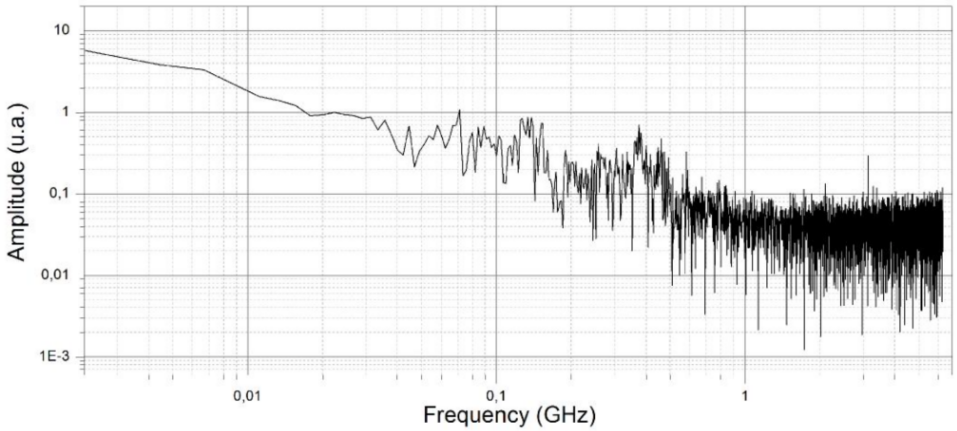
MEG Drift Chamber signal acquisition



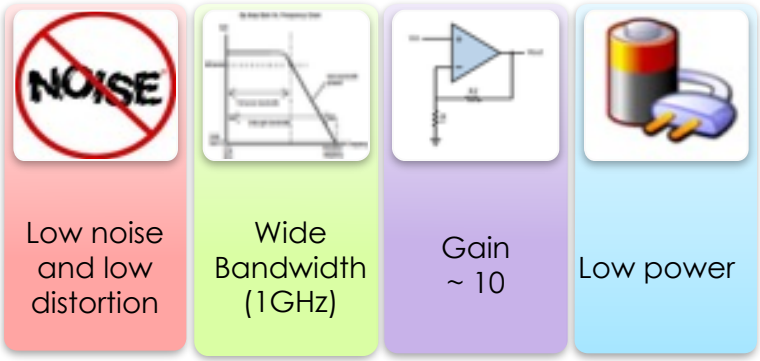
In order to amplify signal coming from Drift Chamber a multistage, low noise and low distortion Front End was designed that provides a total voltage gain of the order of 10 with a suitable bandwidth. Finally signals will be digitized by the MEG Wave Dream digitizer developed at PSI

Typical Drift Chamber Signal

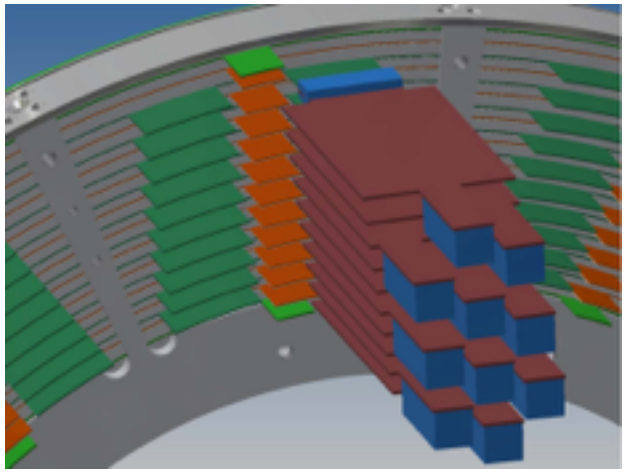


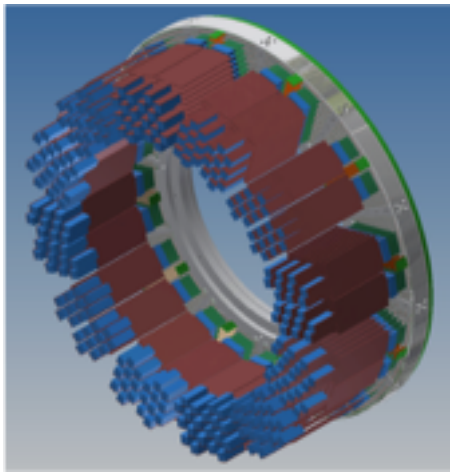


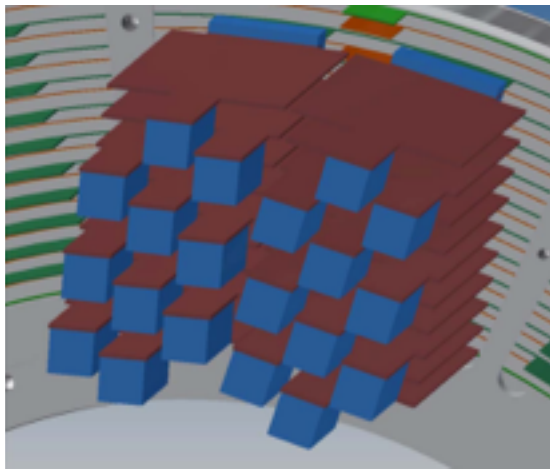
- **FE** is an essential aspect for reaching acceptable time resolution and therefore an efficient spatial resolution on particle identification purpose
- **Cluster timing technique** consists in measuring the timing of all the individual ionization clusters in the gas due to a high energy particle crossing through => promising approach to reach resolution below 100 μm
- Opposed to the determination of the impact parameter, which uses only the arrival time of the first cluster, it produces a bias free estimator using also the timing of the clusters following the first one
- Study of the signals spectral density done using a single 8 mm diameter drift tube with the 90% helium - 10% isobutane gas mixture
- Signal bandwidth is of the order of 1 GHz
- Peak separation clusters: few ns to few tens of ns => separated pulses without overlapping



Front End boards arrangement





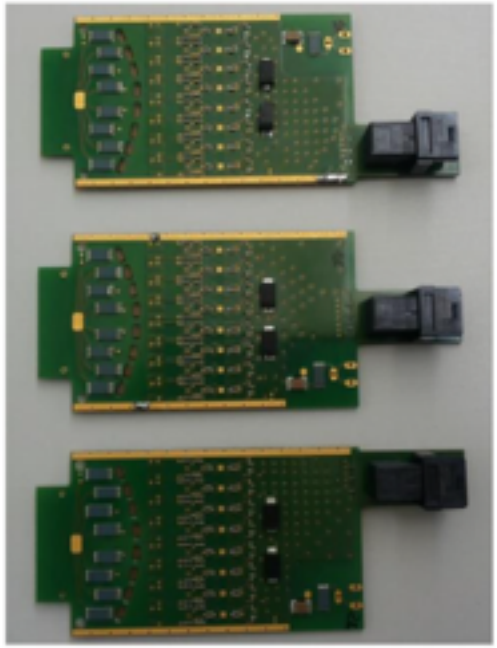


3 different card versions need for DC layers stacking

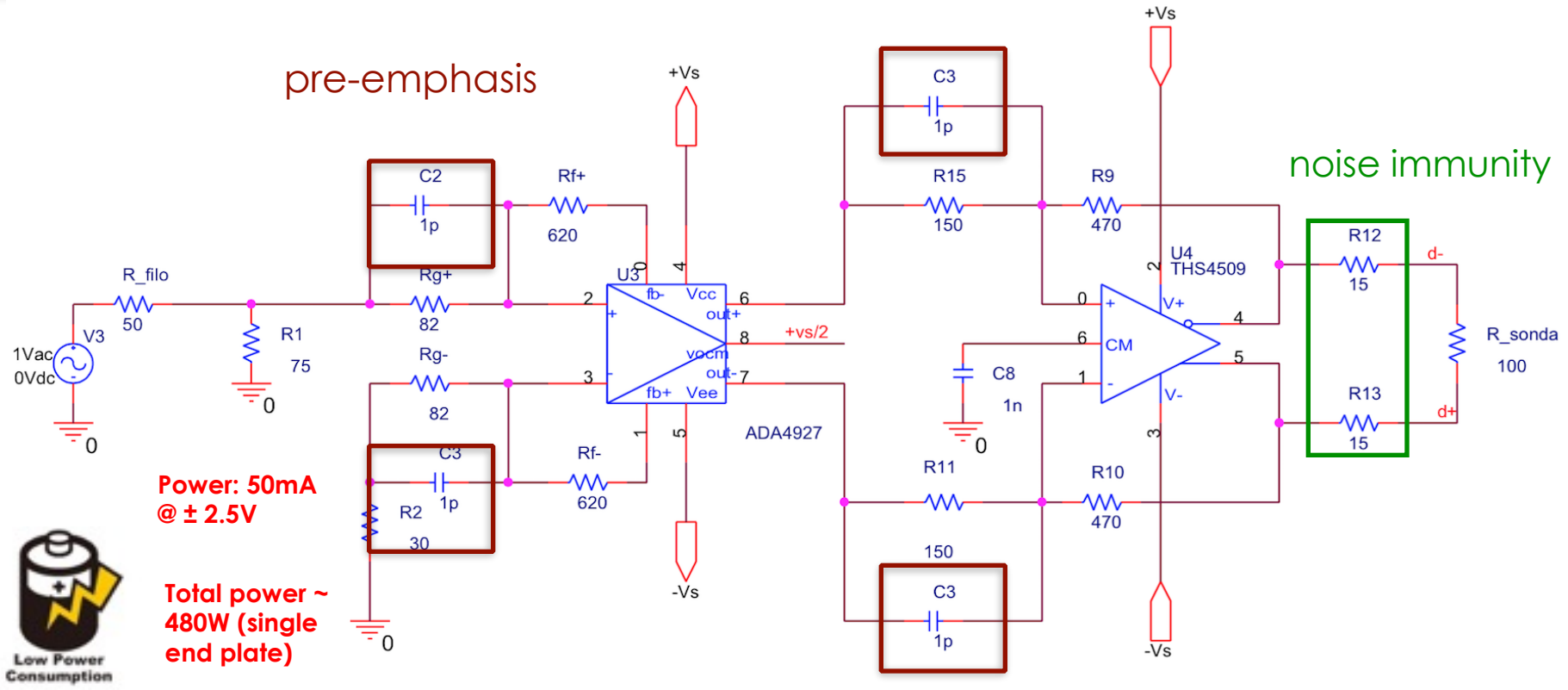
Right

Centre

Left



Front End schematic



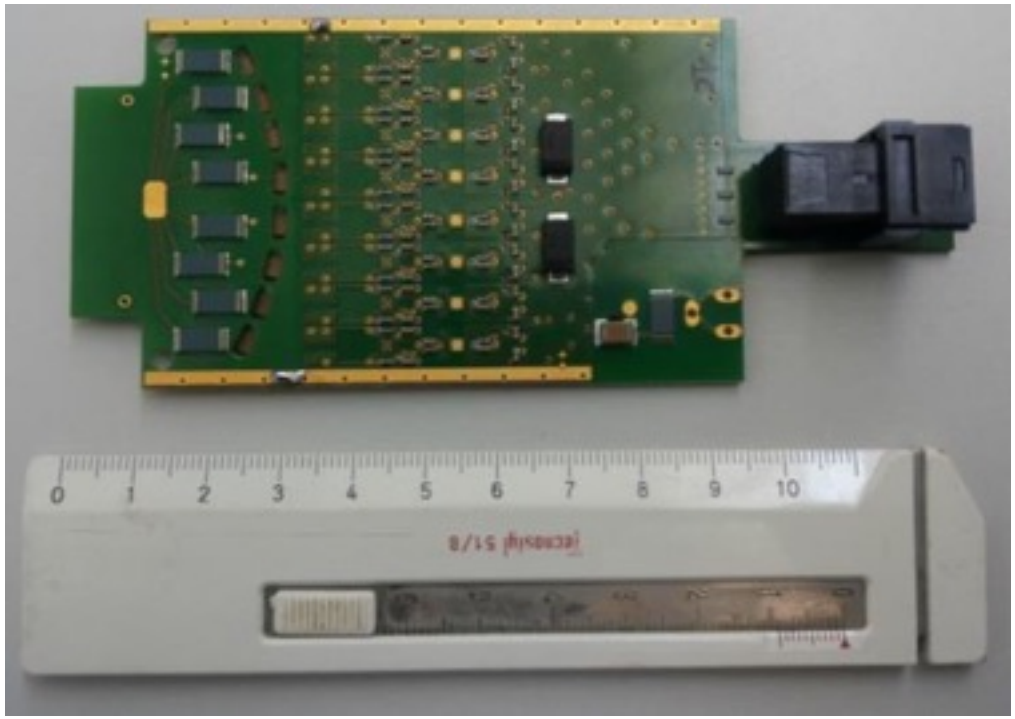
The input network provides decoupling and protection, signal amplification is realized with a double gain stage.

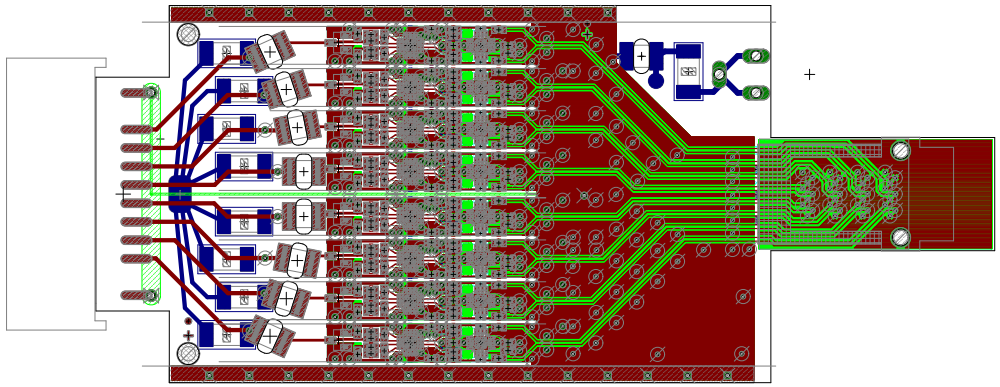
Analog Device op-amp **ADA4927** (first gain stage). It is a low noise (input voltage noise of only 1.3 nV/√ Hz), ultralow distortion, high speed, current feedback differential amplifier

The **THS4509** by Texas Instruments (second gain stage and output driver). It is a wideband, fully differential operational amplifier with a very low noise (1.9 nV/√ Hz), and extremely low harmonic distortion of −75 dBc HD_2 and −80 dBc HD_3 at 100 MHz. It is ideal for pulsed applications.

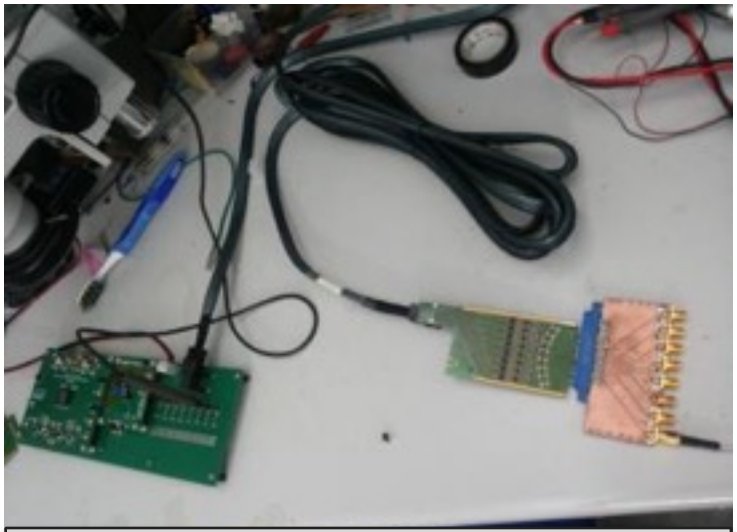
Front End Board

- **Input connector**
  - Custom made by Sullins (edge card type)
- **Output connector:**
  - miniSAS HD internal
- **Ground:**
  - Output connector ground and board ground separated in order to preserve ground loops
  - Possibility to connect the two grounds throughout 0 ohm resistors
- **HV:**
  - Low cost, high reliability connector: Faston
  - HV supply will take place by means of an external wire soldered
- **Layout:**
  - Channels distance to guarantee electrical insulation: 0,6 mm
  - Central channels distance: 1 mm
  - Power dissipation edge: 2,9 mm (2.3 mm reserved for mechanical rail - 0,6mm for electrical insulation)
  - HV decoupling capacitors arranged in order to make board more robust



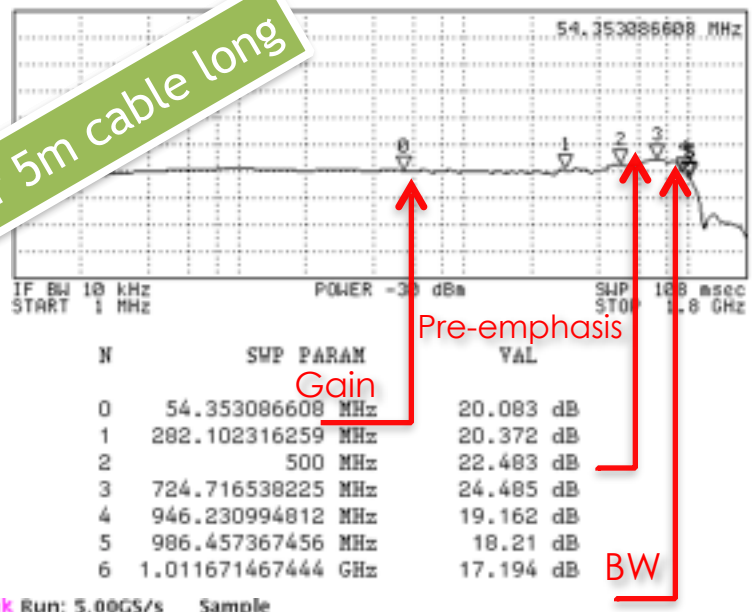


Preliminary tests

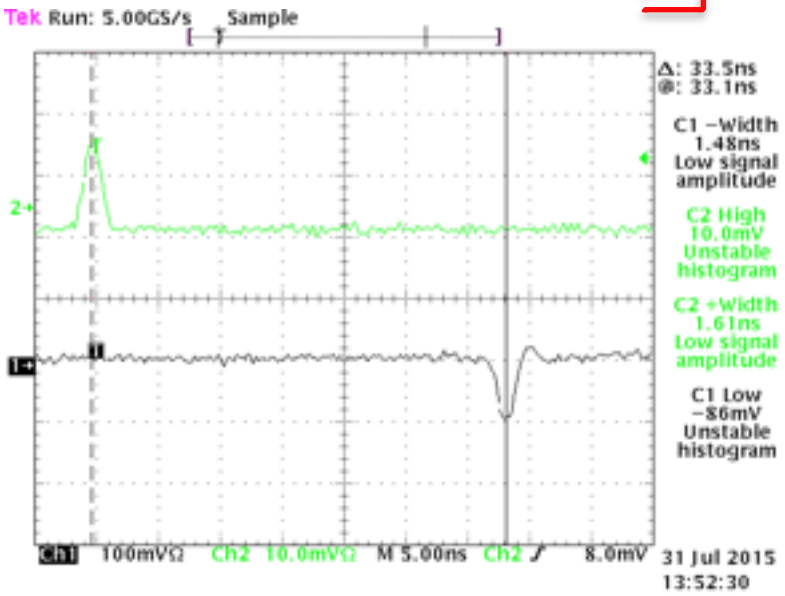


A power supply board based on the same ICs (LTM4614EV, LTM8022V) used on the WD board to power the FE has built
The board host a receiver (differential to SE) to test cables/FE cards

after 5m cable long



N	SWP PARAM	VAL
0	54.353086608 MHz	20.083 dB
1	282.102316259 MHz	20.372 dB
2	500 MHz	22.483 dB
3	724.716538225 MHz	24.485 dB
4	946.230994812 MHz	19.162 dB
5	986.457367456 MHz	18.21 dB
6	1.011671467444 GHz	17.194 dB



Conclusions and next steps

- MEG experiment is currently under upgrade in order to increase the decay sensitivity by improving the experimental resolutions.
- The upgrade of the positron tracker consists in a new cylindrical wire drift chamber, with the axis parallel to the muon beam
- The characteristics of the drift chamber signal establish the Front End Electronics requirements.

  The time separation between different ionizations clusters goes from a few nanoseconds to a few tens of nanoseconds and the main signal information content is contained within a bandwidth of 1 GHz.
- In order to separate in time the single pulses due to the different ionization clusters, a large signal sampling rate and a **low noise and distortion electronics is necessary**.
- The Front End Electronics is a multichannel board based on a double stage gain amplifier providing a **bandwidth** of 1GHz and a **gain** of the order of **10**.
- In order to balance the attenuation of the output cable, a **pre-emphasis** on both gain stages has been implemented.
- The eight channel board preliminary tests exhibits a 3 dB bandwidth of 1 GHz thanks to the implemented pre-emphasis which introduces a high frequency peak the voltage gain is of the order of 10.
- **NEXT steps:**

  crosstalk measurements

  signal integrity

  tests on DC

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