Low temperature front-end in Milano-Bicocca

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Summary

- ✓ What we do;
- ✓ Know-how;
- ✓ Instrumentation;
- ✓ Electronic for Cryogenic Detectors;
- ✓ Cold Electronics;
- ✓ Conclusions.

What we do (I)

Developing of Electronic Systems for particle detectors for accelerating and non-accelerating physics.

Electronic Systems means all what concerns the readout from the detector to the acquisition system, DAQ.

The experience covers many detectors categories, considered at the basis of the design.

The technology for Electronic has been always optimized to face the detectors and the experiments.

What we do (II)

Detectors that has been worked belong to different categories:

- ✓ Bolometers;
- ✓ Liquid argon calorimeters;
- ✓ Silicon detectors;
- ✓ Germanium Detectors;
- ✓ Silicon Photomultiplier;
- ✓ Photomultiplier Tubes;
- ✓ Hybrid Photon Detectors.

What we do (III)

The technologies which are in our portfolio so far for detectors readout are:

- ✓ GaAs (Gallium Arsenide): discrete, Room tem. and Cryogenic tem.;
- ✓ GaAs: monolithic, Room tem. and Cryogenic tem.;
- ✓ Silicon Bipolar - CMOS: monolithic, Room tem.;
- ✓ SiGe Bipolar: discrete, Room tem. and Cryogenic tem.;
- ✓ SiGe Bipolar: monolithic, Room tem. (on the way);
- ✓ Silicon: discrete, Room tem. and Cryogenic tem.;
- ✓ Silicon CMOS: monolithic, Room tem.

What we do (IV)

A few references:

- ✓ Cryogenics, V 29, p. 857-862, 1989;
- ✓ IEEE TNS, V 43, p. 1649-1655, 1996;
- ✓ NIMB, V B155, p.120-131, 1999;
- ✓ IEEE TNS, V 50, p 921-927, 2003;
- ✓ CERN RICH Electronic Upgrade Meeting 12 April 2010;
- ✓ NIMA, v A517, p 313-336, 2004;
- ✓ CERN RICH Electronic Upgrade Meeting 12 April 2010.

What we do (V)

The laboratory is at present involved in a number of experiments:

- ✓ CUORICINO (just finished);
- ✓ CUORE;
- ✓ MARE;
- ✓ LHCb – RICH;
- ✓ LHCb – RICH - upgrade;
- ✓ CMS – Pixel - upgrade.

What we do (VI)

A number of responsibilities involved our activity:

- ✓ **CUORICINO**: front-end system $\rightarrow$ **leadership**;
- ✓ **CUORE**: front-end system $\rightarrow$ **leadership**;
- ✓ **MARE**: front-end system $\rightarrow$ **leadership**;
- ✓ **LHCb – RICH**: High-Voltage (20 KV) Distribution System $\rightarrow$ **leadership**;
- ✓ LHCb – RICH - upgrade: just started;
- ✓ CMS – Pixel - upgrade: just started.

Know-how (I)

Engineering:

- CUORICINO → 60 channels;
- CUORE 1000 → channels;
- MARE 300 → channels;
- LHCb – RICH → 500 channels.

Know-how (II)

Cryogenic Electronics design
- Fast Detector;
- Slow Detectors.

Room Tem. Electronics design
- Fast Detector;
- Slow Detectors.

Know-how (III)

- ✓ Testing setups;
- ✓ Slow control systems;
- ✓ Acquisition system for testing;
- ✓ Acquisition system for detectors (on the way).

Instrumentation (I)

Testing is fundamental when developing large channels systems. Very often, it cannot be made in close collaboration with industry owing to the stringent experimental requirements.

Instrumentation is essential for obtaining accurate results. Many instruments in our lab are dedicated to this aim:

- ✓ 7 standard power supply, medium current;
- ✓ 4 Programmable power supplies;
- ✓ 2 x Active load, high power;
- ✓ N6705A DC Power Analyzer;
- ✓ 4 multiplexed 6 ½ programmable multimeters;
- ✓ Environmental chamber, -70°C – 180°C;
- ✓ Environmental chamber with humidity control, -40°C – 180°C;
- ✓ 2 x 4-slots PXI crate with 4 multi-channels DAQs 18-bits, 500 Ks/s;
- ✓ 4 Arbitrary Waveform Generators.

Instrumentation (II)

And Lab Instrumentation:

- ✓ High Voltage power supply, 4 KV;
- ✓ High Voltage power supply, 30 KV;
- ✓ 5 x Oscilloscopes (medium bandwidth);
- ✓ 2.5 GHz Oscilloscope;
- ✓ Logic Analyzer;
- ✓ High speed pulse generator, 80 MHz;
- ✓ High speed Arbitrary Waveform Generator, 250 MHz;
- ✓ Spectrum Analyzer, 50 KHz;
- ✓ Spectrum Analyzer, 500 MHz;
- ✓ Network analyzer, 6 GHz;
- ✓ Curve Tracer;
- ✓ Semiconductor Analyzer;
- ✓ LCR Meter;
- ✓ Etc.

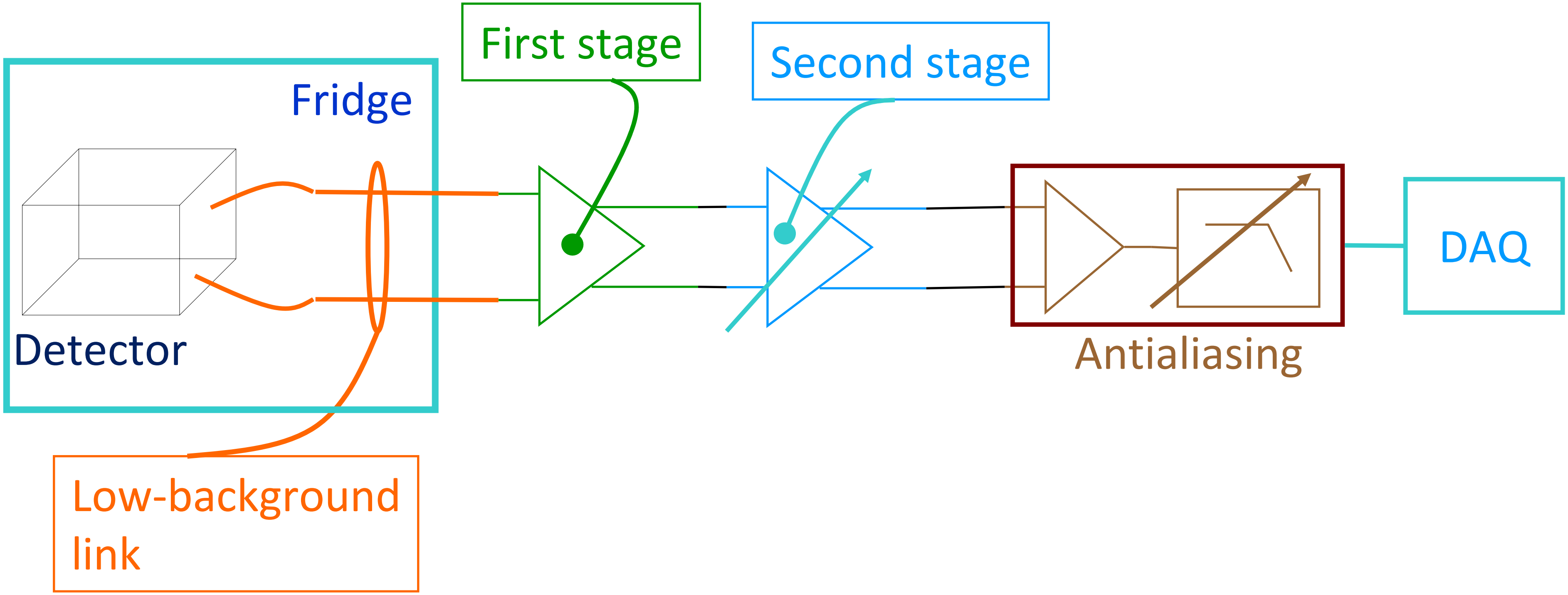
Electronic for Cryogenic Detectors (I)

The design of the Electronic Systems for cryogenic detectors has been pursued following 2 philosophy:

- ❑ All the amplifying sections at room.

- ❑ First amplifying stage at cold + second amplifying stage at room;

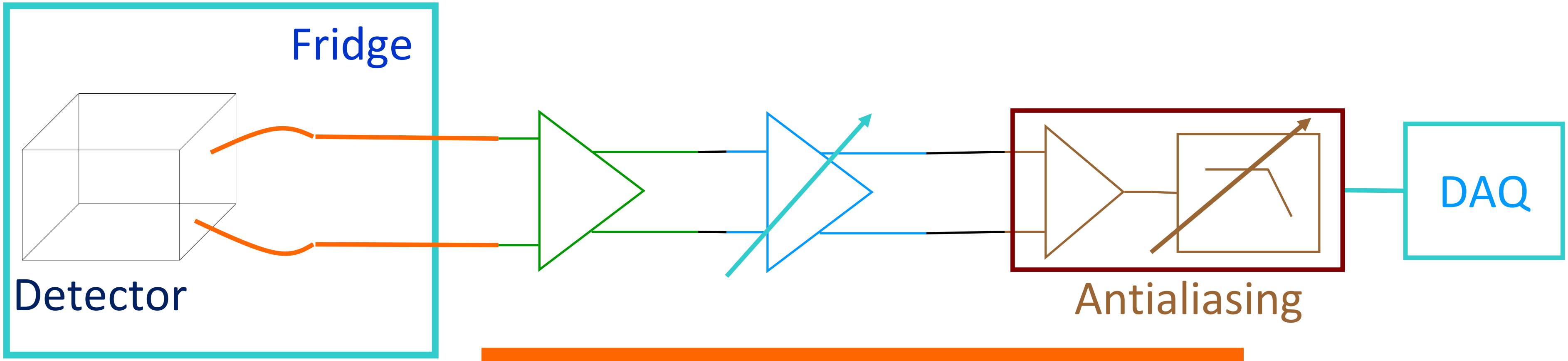
Option 1: All at room temperature



Jinst, V 4, P09003, p. 1-17, 2009
2009 NSS, pp 389 395
IEEE TNS, 49, 2440-2447, 2002

Electronic for Cryogenic Detectors (III)

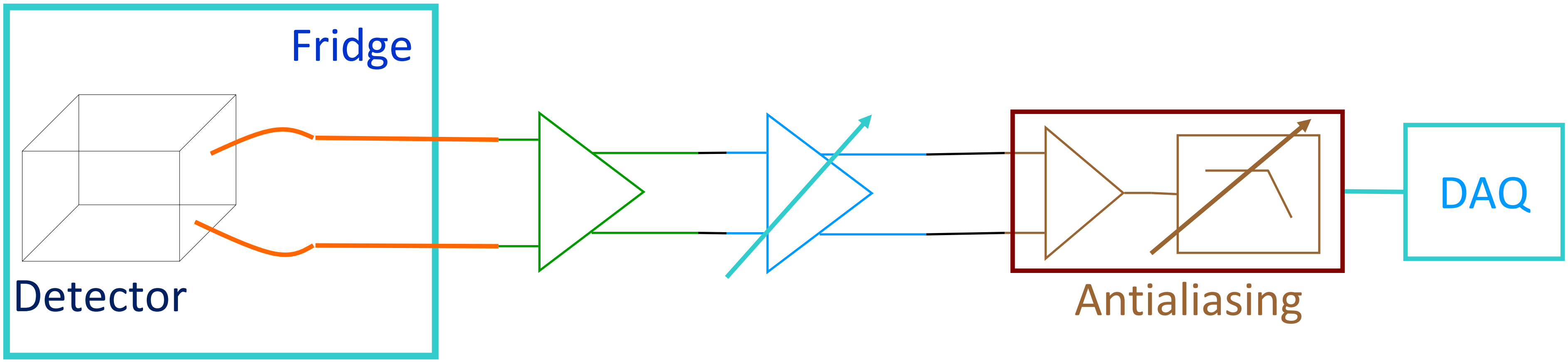
Option 1: All at room temperature



Very low noise preamplifier.

IEEE TNS, V. 47, p.1851-1856, 2000
Jour. of Low Tem. Phys., V 151, p.964-970, 2008
IEEE TNS, 49, 2440-2447, 2002
IEEE TNS, V. 53, pp. 2861-2868, 2006

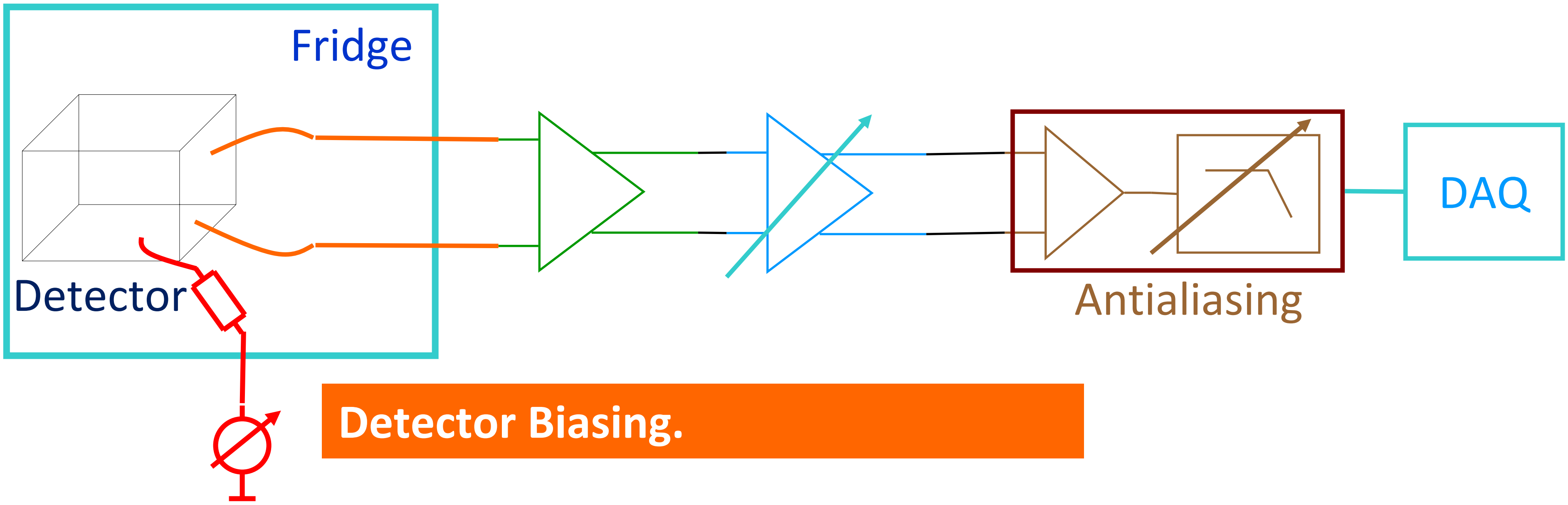
Option 1: All at room temperature



Almost all the parameters of interest are remote programmable (with the slow control μ-controller based).

LTD-13, ISBN: 978-0-7354-0727-5, pp 271-273, 2009

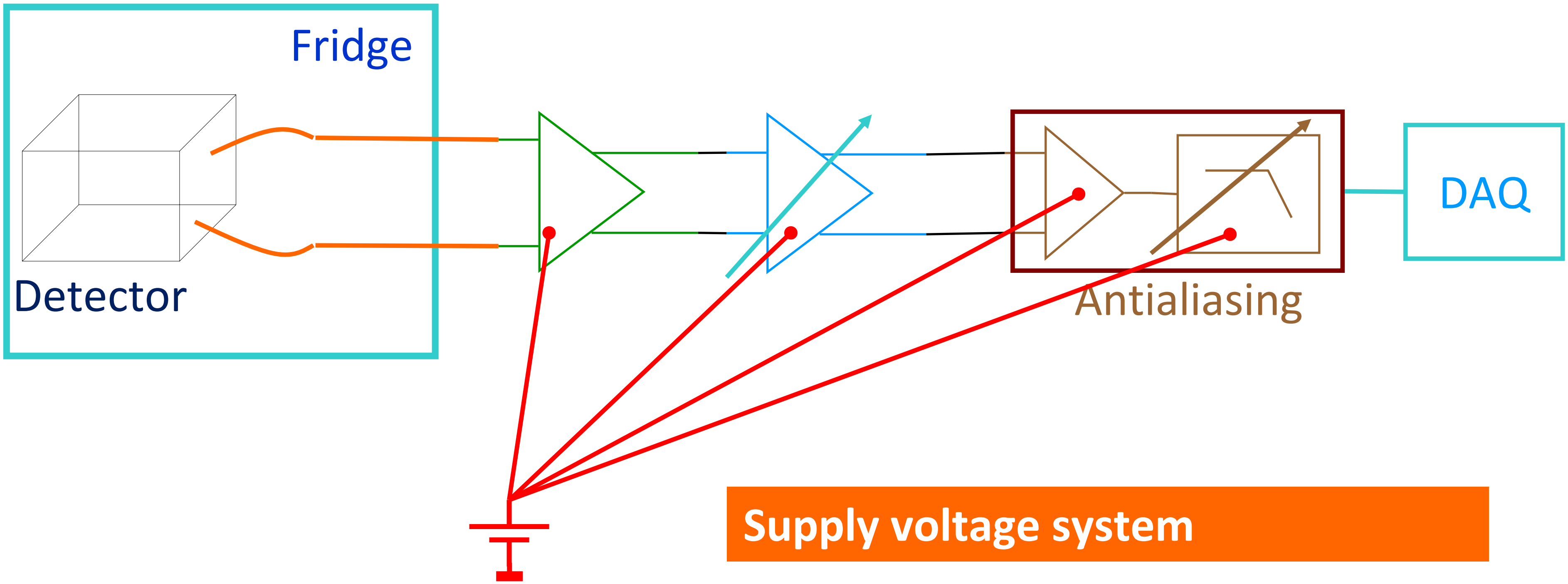
Option 1: All at room temperature



Detector Biasing.

IEEE TNS, v 49, pp. 1808-1813, 2002

Option 1: All at room temperature



Rev. of Sci. Instr., V 70, p.3473-3478, 1999

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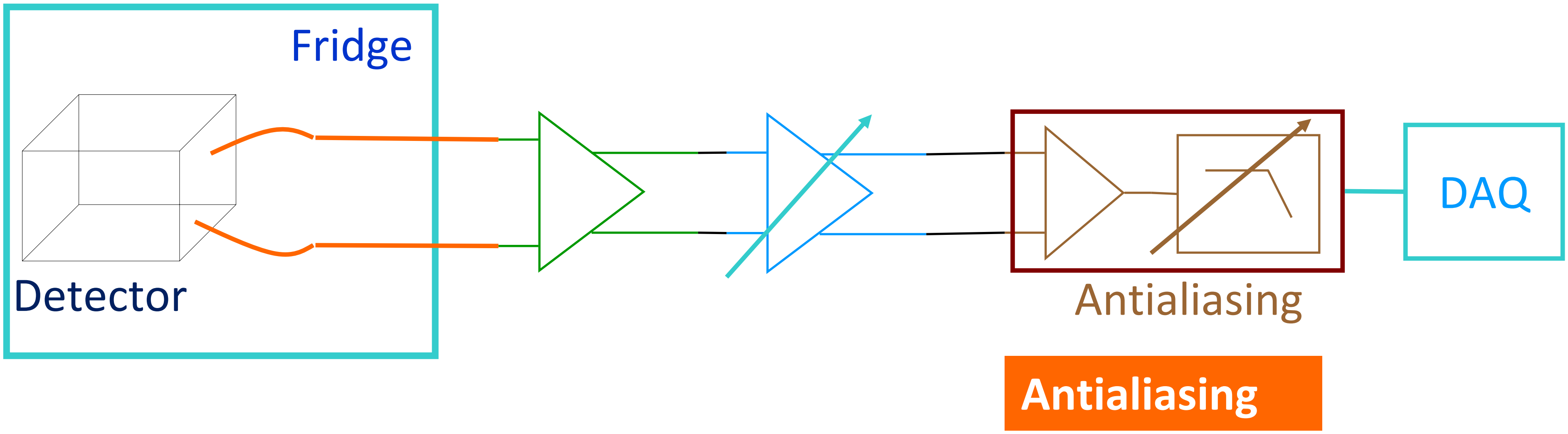
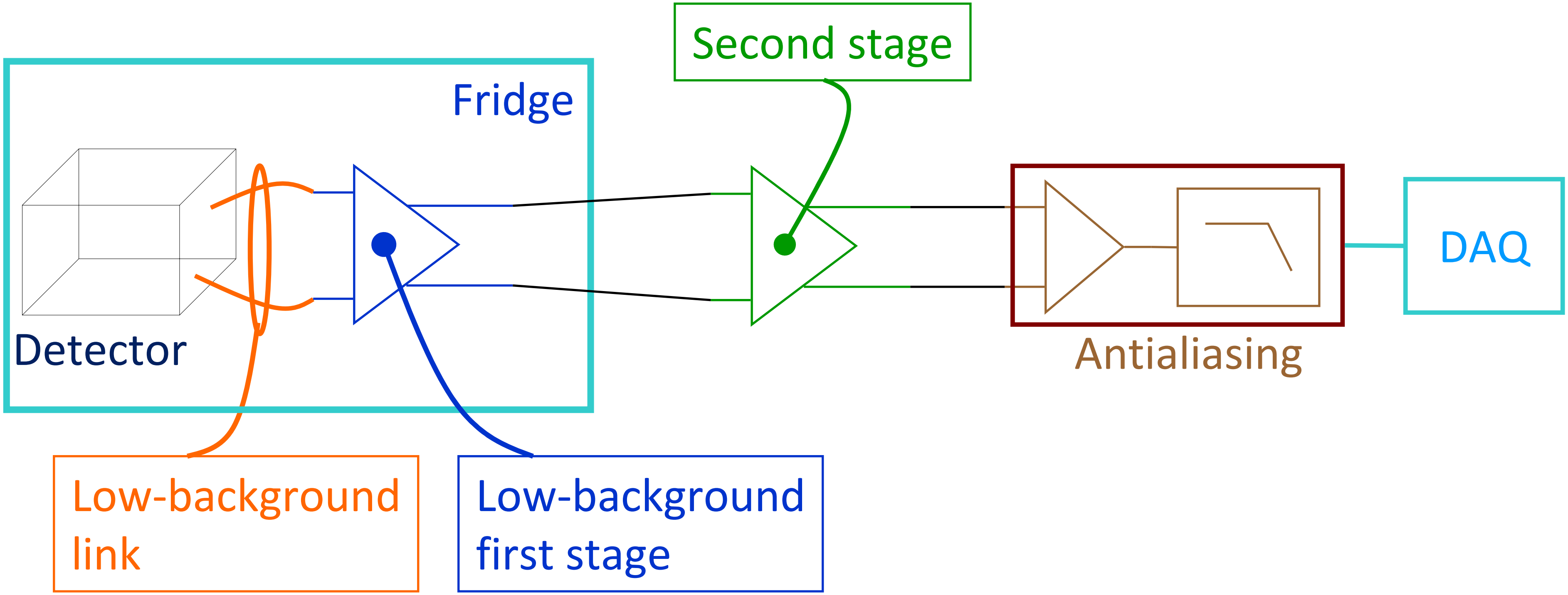
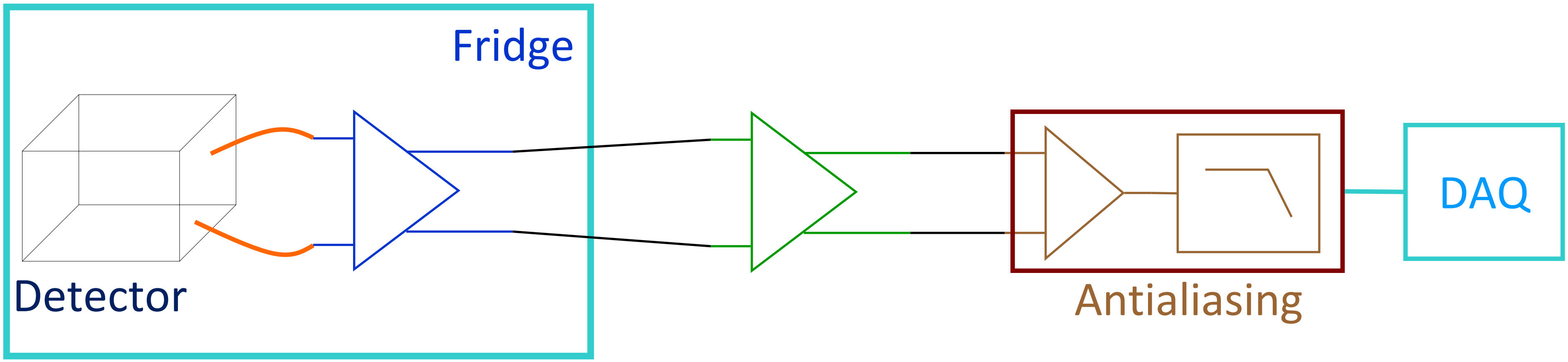


NIMAA, doi:10.1016/j.nima.2009.09.023, 2009

Option 2: First stage at cold + second stage at room



Option 2: First stage at cold + second stage at room



Extensive study has been made in the development and optimization of the cold stage.

The optimization was based in the minimization of the occupation space, noise, power dissipation and background material.

IEEE TNS, V. 51, pp. 2975-2982, 2004

Cold Electronics (I)

One very important step in characterizing solid state devices at cryogenic temperatures is the ability to take measurements lasting for long times at different temperatures.

This is crucial in particular when Low Frequency, LF, noise has to be characterized.

As we will see, when the "thermodynamic energy" becomes smaller than the ionization energy Generation Recombination, G-R, Noise starts to appear as "white noise" increase.

To study and modeling noise and electrical characteristics of devices at cryogenic temperatures we have developed an ad hoc instrument….

Cold Electronics (II)

The aim of the instrument is twofold:

1. complete absence of background noise of mechanical origin;

2. ability to measure in automatic way 24 hours per day, 7 days per week.

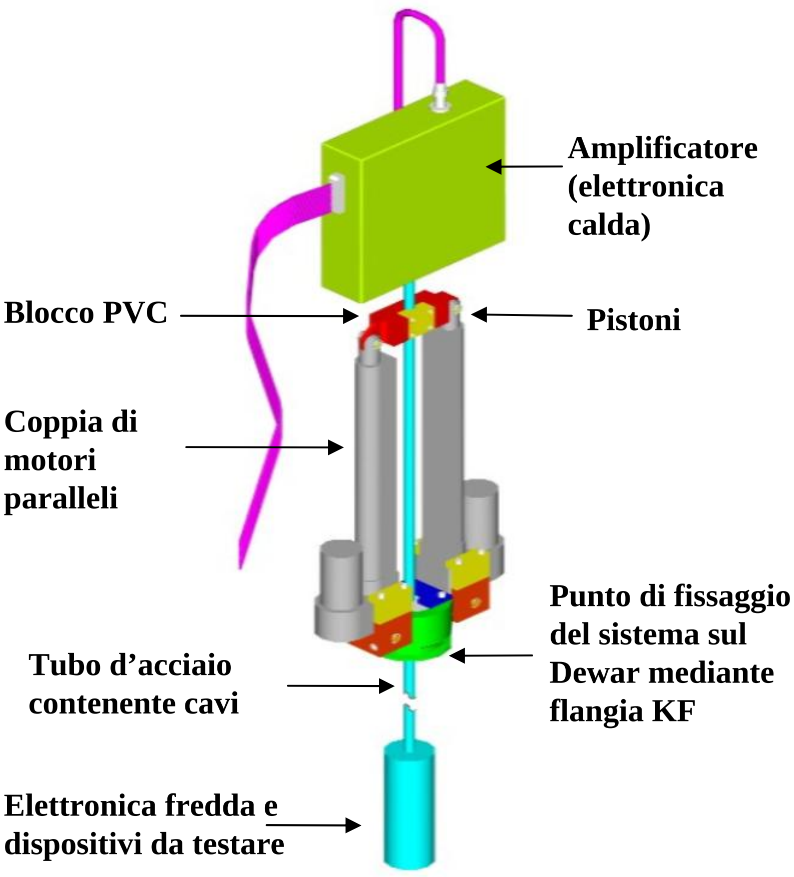
We called this instrument:

A\C-VISCASY: Ambient to Cryogenic VIbrationless SCAn SYstem

Cold Electronics (III)

A\C-VISCASY: Ambient to Cryogenic VIbrationless SCAn SYstem

The mechanical section:



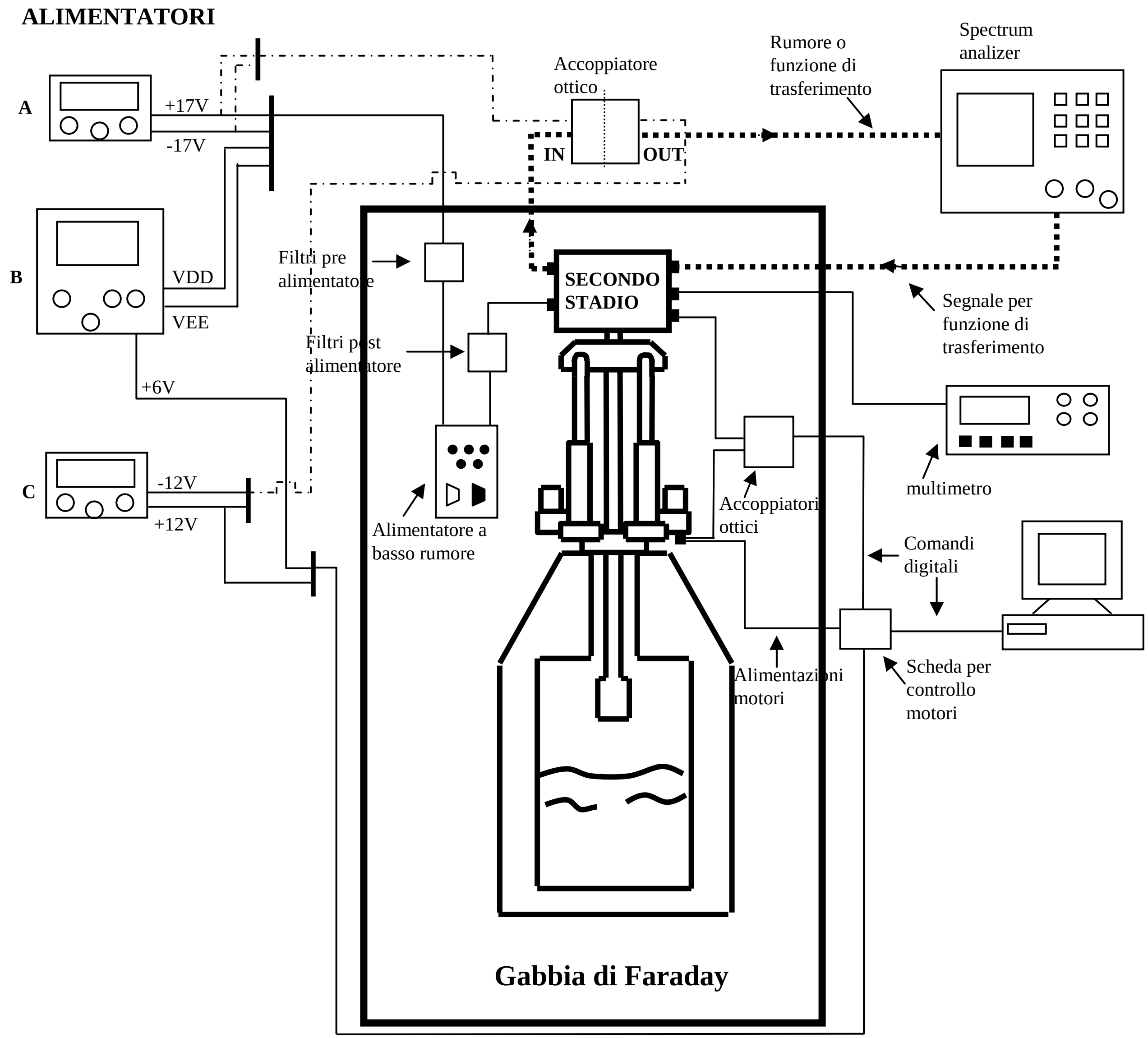
[NIMA, v A520, pp 644-646, 2004](#)

Cold Electronics (IV)

The complete apparatus:

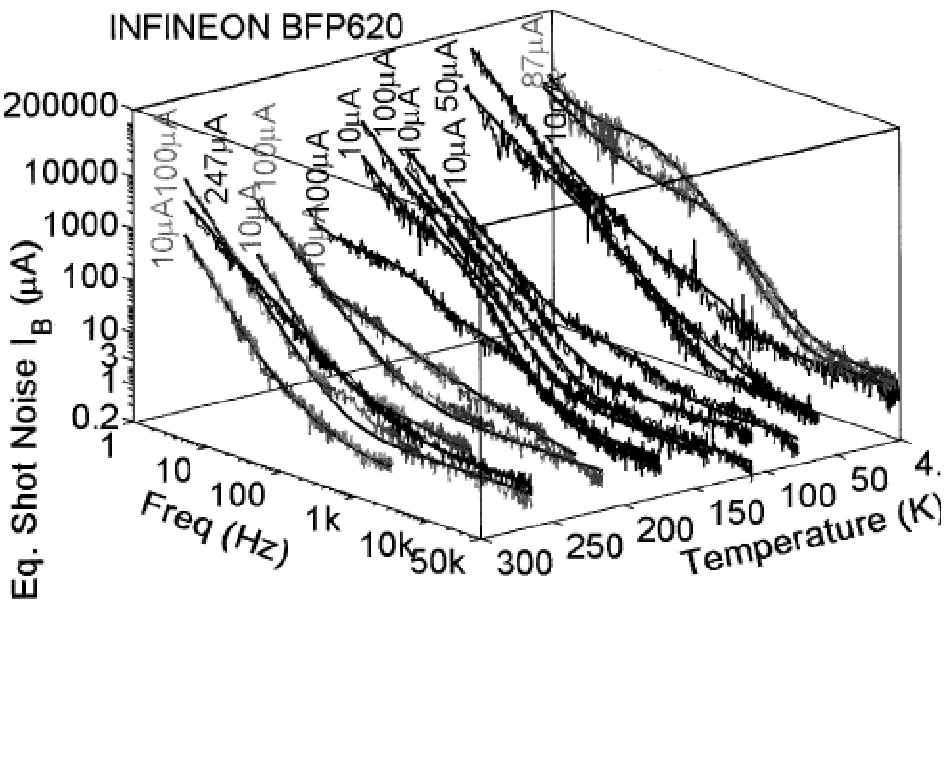
A/C-VISCASY is a completely remote controlled system capable to bias, measure and set the operating temperature per days.

In the present version it manages 2 devices at a time.



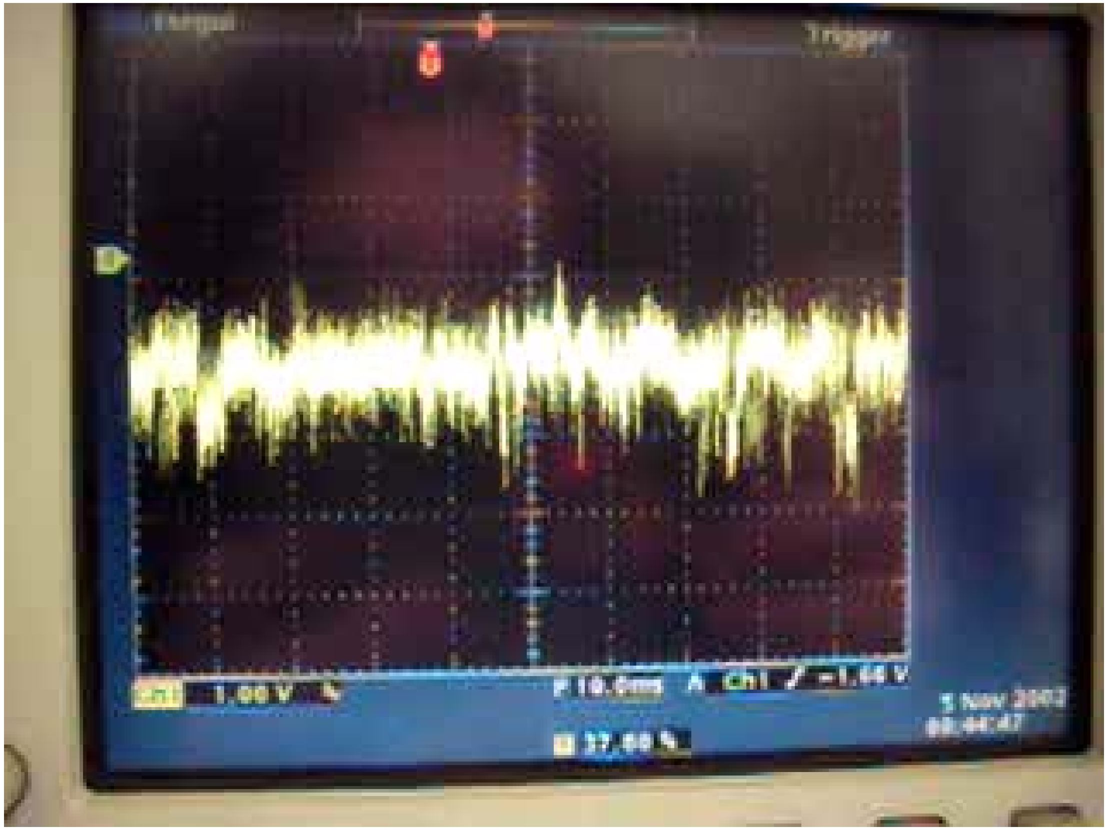
Cold Electronics (V)

The complete apparatus:



[IEEE TNS, V 50, p 921-927, 2003]

One of the important features



NIMA, v A520, pp 644-646, 2004

Conclusions

- A New front-end set-up for the Flat panel characterization has been tested.
- A R7600 flat panel, optimized for single-photon event and small cross-talk, is coming.