PROJECT: **Studi di Cosmologia**		WP REF.: **6-6X2**
WP TITLE: **Readout electronics for Future CMB missions**		Sheet: 1 of 1
CONTRACTOR: **Istituto Nazionale di Fisica Nucleare/Pisa**		
START EVENT: KO		Issue Ref: 1
END EVENT: RF		Issue Date:01/09/2016
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1. OBJECTIVES

Read-out electronics provides the interface between the radiation detector and the acquisition computer, between analogue and digital signals, between sub-millikelvin temperatures and "room" temperature. It receives the analogue signals from the detectors and translates them to digital form by means of dedicated and specially designed hardware.

This must be taylored depending on the specificity of the detector (TES, KIDs, CEBs…). The activity of this working package will start from a review of the status-of-the-art of both detectors (in close collaboration with WP5) and electronics readout chain, trying to undestand how to cover the technological gap between present activities in Italy and abroad.

The comparison of different architectures and readout techniques (frequency, time domain or time-coded multiplexing just to name a few) is of utmost importance, together with the investigation of possible departures from the present implementations by means of Field-Programmable Gate Arrays (FPGAs) by using dedicated ASICs or Graphic Process Units (GPUs) with special emphasis on power consumption and noise level with future balloon and space experiments in mind, not neglecting an evaluation of the costs of all implementations.

The study of the necessary steps towards spatialization are as well part of this WP (survey, study and selection of rad-hard components, development of watch-dog algorithms, study of the performance in space environment).

A survey of the technologies and expertise present in industries in Italy is also mandatory in order to assess the possible commitment of italian community in future experiments.

Here is a breakout of the foreseen activities:

- Survey of the present technologies for readout in the various frequency bands (40 GHz – 600 GHz);
- Evaluation of the needs for a future experiment in term of multiplexing multiplicity, electronics noise, power needs ;
- Detailed evaluation (also supported by simulation) of the readout chain as a function of the detector technology in all the frequency bands;
- Survey of present or future implementation technologies for the warm readout (FPGAs, ASICs, GPUs);
- Survey, implementation and tests of software and firmware algorithms to accomplish the desired readout;
- Survey of expertise and technologies present in italian industries to estabilish possible partnerships in view of the deployment of the technology studied;
- Techniques for noise and glitches (e.g. cosmic rays) reduction in the data stream;

At the end of the study the relation between electronics performance and sensitivity to physics results will be clear enough to speed up the real implementation of a readout chain for future experiments.

All the activity will be carried on in close connection with WP5 (new detector technologies) and WP4 (test facilities). For the survey to be effective collaborations with WP2 and WP3 (future balloon-borne and space experiments) are vital. A collaboration in data analysis (WP11) is essential in designing the path from the physics signal to the physics result.

2. INPUTS

- Contract and Technical Annex
- Work plan & Schedule

3. TASKS

- Survey of present worldwide technology for detectors and related readout electronics in all the frequency range. Comparative table of the readout techniques being devised with particular emphasis on noise and sensitivity performance – 6 m;

- Analysis of possible implementation platforms to be used in a future experiment compatible with the expected multiplexing, multiplicity, noise – 6m;

- Design and simulation of alternative detector-readout schemes compatible with the physics requirements and the technological limitations (e.g. simulation of cross talk between adjacent signals, behavior of transmission lines, definition of optimal parameters such as ADC/DAC resolution) – 12 m;

- Study of possible implementations of readout chains from a realization viewpoint (cost, power consumption, ADC/DAC model availability, transmission line details) – 12 m

- Design of the software and firmware algorithms for the control and readout of detector chains – 18 m;

- Survey of possible industrial partnerships in Italy to be able to deploy a complete detector-electronics chain – 6 m;

- Develop a complete design concept for next generation balloon and/or space experiments with detailed evaluation of noise and sensitivity level, costs, power needs – 12 m.

- Study of the impact of cosmic rays in the signal of various detectors and development of dedicated algorithms for raw data cleaning – 12 m;

- Application of such techniques to perform LSPE SWIPE experiment data reduction – 12 m;

4. OUTPUTS

SEMESTER 1

- (to other WPs) Comparative table of readout technologies being developed in the various frequency ranges;

- (from WP6-6X1) Comparative table of detector technologies being developed with respective readiness level and technical characteristics;

- (from WP3-6X1 and WP4-6X1) Preliminary table containing assessments on sensitivity/objecives to perform physics searches;

SEMESTER 2

- (to other WPs) Comparative table of current and possible implementation platforms;

- (to other WPs) Comparative table of alternative detector-readout schemes compatible with the physics requirements and the technological limitations;

- (to other WPs) Preliminary algorithms for CR removal in SWIPE/LSPE data;

- (from WP3-6X1 and WP4-6X1) Table containing assessments on sensitivity/objecives to perform physics searches;

SEMESTER 3

- (to other WPs) Table of noise/power performance based on detailed simulation/implementation of some possible detection chains;

- (to other WPs) Assessment of CR immunity of various detector schemes;

- (to other WPs) Preliminary scheme of firmware and software needs for the control/readout of the detector chain;

- (from data analysis WPs) Software architecture for the implementation of raw signal cleaning algorithms for the LSPE/SWIPE data;

- (from WP3-6X1 and WP4-6X1) Possible calibration schemes for detector/readout chains

SEMESTER 4

- (to other WPs) Table of possible implementations of readout chains from a realization viewpoint (cost, power consumption, ADC/DAC model availability, transmission line details);

- (to other WPs) Detailed performance study of raw signal cleaning and CR/glitch removal for the SWIPE/LSPE data;

SEMESTER 5

- (to other WPs) Complete scheme of firmware and software needs for the control/readout of the detector chain;

- (to other WPs) Table of industrial and technological partnerships and interlinks that could give a major contribution to the construction of a detector/readout scheme;

SEMESTER 6

- (to other WPs) Final report containing a complete design of a realistic implementation of a readout chain for future ground, balloon and space experiments with clear plans from the technological choices to the details of the implementation including firmware/software, costs, power needs, calibrations;

- (to other WPs) Clean TOD for SWIPE/LSPE data flagged for glitch/CR;