High performance DAQ for muon spectroscopy experiments

M. Soldani1-2 (mattiasoldani93@gmail.com), G. Ballerini1-2, M. Bonesini1-3, F. Fuschino4-5, A. Hillier6, K. Ishida7, E. Mocchiutti8, P. Oliva9-10, L. Rignanese5-11, L. Tortora12, A. Vacchi12, E. Vallazza8, M. Clemenza1-3

1 INFN Milano Bicocca 2 Università degli Studi dell’Insubria 3 Università degli Studi di Milano Bicocca 4 INAF/OAS Bologna 5 INFN Bologna 6 RAL 7 RIKEN 8 INAF Trieste 9 INFN Cagliari 10 Università degli Studi di Sassari 11 Università degli Studi di Bologna 12 INFN Roma Tre 13 Università degli Studi di Udine

Beam from the RIKEN-RAL Muon Facility @ ISIS Neutron and Muon Source
- extracted from ISIS proton synchrotron
- (20,120)MeV/c muons
- momentum tuning with a sensitivity of 1MeV/c
- 2 successive spills (~100ns wide) at ~37.5Hz
- 10^4 muons per spill (with μ^- @ ~50MeV/c

FAMU Fisica degli Atomi MUonici
- high time resolution spectroscopy: study of out-of-spill X-ray emission resulting from muon transfer between muonic hydrogen and higher-Z elements in gaseous mixtures, with the aim of measuring the hyperfine splitting in the ground state of muonic hydrogen

Cultural Heritage NETwork Tecniche Analitiche Non Distruttive per l’archEoMetria
- high energy resolution spectroscopy: study of X-ray emission of decaying muonic atoms in metallic artifacts - internal composition analysis with good depth resolution via beam momentum tuning

Beam on target with 64 fibers (size: 1x1mm^2)
- 16 fibers with Hamamatsu ORTEC preamp & ORTEC 672 amplifier (shaping in 500ns)
- 16 fibers with ORTEC GALILEO preamp & ORTEC 579 fast-filter amplifier (shaping in 250ns)
- rest of the fibers with other amplifiers

HODOSCOPES configuration
- one with 64 1x1mm^2 squared fibers with EMA & SiPM-based readout - AdvanSiD with side 3mm (cell side 40μm)
- 2 with 64 3x3mm^2 squared fibers with Al wrap & SiPM-based readout - Hamamatsu S12752 with side 3mm (cell side 25μm)

HI-RES SPECTROSCOPY
- ORTEC HPGe: one GLP and one GEM-S from INFN Milano Bicocca, one GEM-S and one GMX from RIKEN-RAL Muon Facility
- FWHM < 1keV @ 122keV for all the detectors

FAST SPECTROSCOPY
- many LaBr3(Ce) crystals - decay time 16ns
  - PMT-read with Hamamatsu R1265-200
  - SiPM-read with various sensors
- one standard cylindrical 1”x1” BrilLaNe 380

Hi-performance DAQ
- ORTEC V1724
- CAEN V1730C
- CAEN V1742

<table>
<thead>
<tr>
<th>nr. of channels</th>
<th>resolution</th>
<th>input range</th>
<th>sampling rate</th>
<th>memory depth</th>
<th>single channel settings</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>14 bit</td>
<td>0.5 or 2</td>
<td>100</td>
<td>512 kS/ch</td>
<td>yes</td>
<td>wide range needed for HPGe preamplified signals</td>
</tr>
<tr>
<td>8</td>
<td>14 bit</td>
<td>12 bit</td>
<td>500</td>
<td>640 kS/ch</td>
<td>yes</td>
<td>high speed good for fast spectroscopy setup</td>
</tr>
<tr>
<td>32+2</td>
<td>14 bit</td>
<td>12 bit</td>
<td>750 to 5k</td>
<td>128 ev/ch</td>
<td>no</td>
<td>large nr. of channels needed for hodoscopes (3 in beam focus search config.)</td>
</tr>
</tbody>
</table>

Electronics for HPGe: ORTEC preamp & ORTEC 672 amplifier (shaping in 500ns) for GLP; GALILEO preamp & ORTEC 579 fast-filter amplifier (shaping in 250ns) for GEM-S

CHNET_TANDEM
- C++ and ROOT-based tool for real time automatic raw data conditioning, first level analysis and results display; every few seconds bash scripts search in raw data directory for new files
- backup at CNAF;
- level 1 analysis for each detector (from raw waveforms to PH, peaking time, etcetera);
- online logbook pages and quicklook plots filling.

Full-run automatic analysis in a few tens of seconds!