precision were developed: one is 10 pC/pulse and another is 0.5 pC/pulse. The circuit with conversion precision of 10 pC/pulse can measure current from 0.01 nA to 60 μA, the bipolar current can be measured The linearity is better than 0.464 34% in the full range The circuit with conversion precision of 0.5 pC/pulse can measure current from 0.01 nA to 500 nA, and the linearity is better than 0.04168% in full range.

4. A new readout electronics system for our prototype of TOF-PET has been developing. There are five parts mainly in the system: the detector unit, the front-end electronics module (FEM), signal processing board (SPB), coincidence Interface board (CI), and PC. The FEM board and SPB board have been developed and tested successfully. Each FEM board can process 4-channel energy signals and one-channel timing signal from the detector, the filter, shaping, amplify, discrimination, *etc.* are implemented by FEM. The output signals of FEM are sent through a LVDS bus to SPB, one SPB can face two FEMs. The energy signal is digitalized with a fast ADC, and then sent to a field programmable gate array (FPGA) on SPB board to extract pulse height information for calculating hit position. The leading edge discriminators on SPB board discriminate the signals from FEM and generate timing signals. The timing signals are sent to a time-to-digital converter (TDC) constructed inside the FPGA for measuring the time of photon flight. Also, the timing signal can be used to trigger SPB or coincidence circuit on CI board. The data in the FPGA can be pre-processed depending on the algorithm selected, the crystal, energy and timing relationship are acquired, and related corrections is performed if it is needed.

5. Some instruments and modules, such as eight channel constant fraction discriminator (CFD), fast logic level adapter, weak current and charge measurement boards/modules(multi-channel integrator, multi-channel I/V convertor, charge to frequency convertor QFC), *etc.* are continuously produced for physics experiment system beam diagnostic system of Cancer therapy facility and beam diagnostic system of HIRFL

6. In 2016, four papers has been published in the domestic core journals, Chinese Physics C, Nuclear Science and Techniques, Atomic Energy Science and Technology, *etc*, two papers among them have been included in SCI, and other two paper has been included in EI. Three national patents of invention were authorized. Two PhD students and three Master students have graduated from group.

7. Three researchers attended the 20^{th} Real Time Conference held by IEEE in Padova, Italy, and also visited the Detector, Electronics and Computing Division of CEA/Irfu in Saclay, Paris, France, in June, 2016.

8. In Nov. 2016, a mini-workshop on TPC physics and readout electronics was held in Lanzhou by our group, more than thirty physicists, researchers, engineers and students from CEA/Irfu, Saclay, France, local Universities, and our institute attended the meeting.

5 - 12 TPC Readout System Based on AGET and μTCA

Pu Tianlei, Zhao Hongyun and Qian Yi

Based on AGET (ASIC for Generic Electronics for TPC) chip and μTCA (Micro Telecommunication Computing Architecture) crate, a 256-channel readout system for Time Projection Chambers (TPC) has been build.

One chip of AGET contains 64 channels, each channel includes a CSA (Charge Sensitive Preamplifier), an analog filter, a discriminator and a 512-sample analog memory constructed based on a SCA (Switched Capacitor Array). 64 channels receive signals directly from each PAD of TPC. 4 AGET chips are soldered on each AsAd (ASIC support & Analog-Digital conversion) card and matched with 4 chips of 4-channel 12-bit ADCs. The digital outputs of the 4 ADCs are transmitted via 4 pairs of differential lines with a maximum transmission speed of 1.2 Gbit/s to the R-Cobo (Reduced Concentration Board).Then the signals are compressed and upload to a control & monitoring computer which also works as a Data Server to receive and store the signals. On the computer, a series of software work on Linux platform are compiled or installed to server the data acquire system, the main software component is "GetController". The R-Cobo system can afford 256-channel signals acquirement.

Since R-Cobo is unable to afford more channels, we use Cobo and μTCA crate to rebuild the system. Signals from AsAd are transmitted into Cobo which is plugged into μTCA crate. Through MCH (MicroTCA Crate Hub), the computer server receives and stores signals. A series of software which name "Ganil" are built to replace "GetController", in order to server the system with thousands of channels. Fig. 1 demonstrates the main block of system building continuously now, which will achieve a date acquire system with ten thousands channels.

The software run in computer server includes two branches, one is "GetController" and the other is "Ganil". They all work on Linux based system, and have complex dependencies. We build them on Centos6 according the softwares' dependencies figure shown in Fig. 2. As there are some errors with software compiled, it needs to be installed with debug function. We have successfully built the "GetController" software and used it in some experiments. We have also built the "Ganil" software and it is being tested.

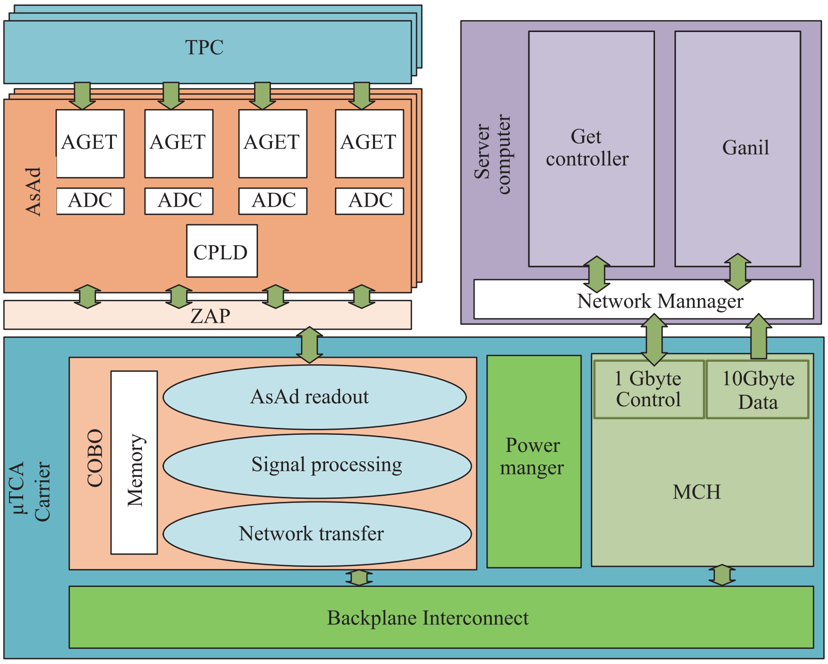

Fig. 1 (color online) TPC Readout System based on AGET and μTCA.

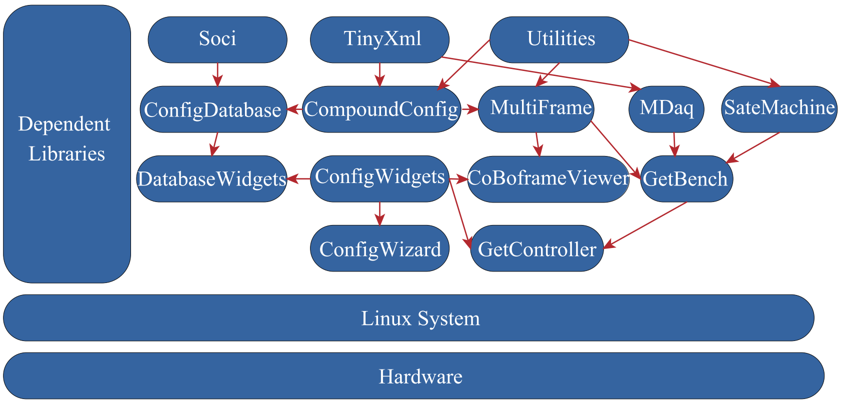

Fig. 2 (color online) Dependencies between the packages for the GET.

The R-Cobo system has already been used, and system based on Cobo and μTCA will be used in the following more complex TPC experiments.

Reference

[1] S. Anvar, P. Baron, B. Blank, et al., AGET, the GET front-end ASIC, for the readout of the Time Projection Chambers used in nuclear physic experiments[C]//Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), IEEE, (2011)745.