Development of a novel pulse generator system for the prototyping and testing of new trigger electronics for the ALPACA experiment

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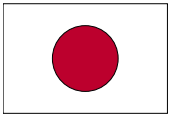
The ALPACA collaboration



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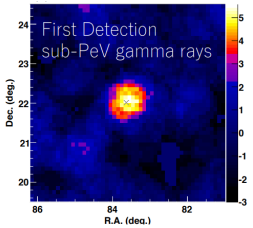
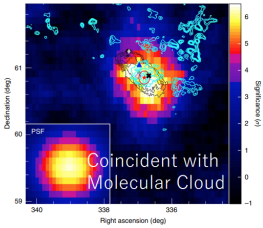
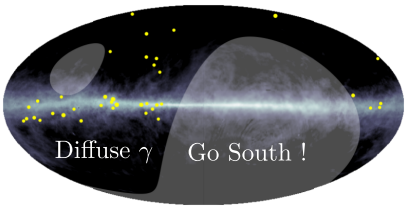
sub-PeV γ-ray Astronomy

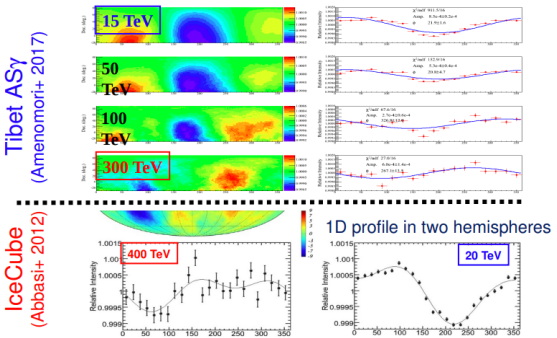
- First detection of sub-PeV γ-rays (Crab Nebula). Tibet ASγ, PRL (2019)
- Detection of PeVatron candidate (G106.3+2.7). HAWC, ApJ (2020), Tibet ASγ, Nat. Astron. (2021)
- First detection of PeV Galactic diffuse γ-rays. Tibet ASγ, PRL (2021)
- Detection of dozen PeV γ-ray sources. LHAASO, Nature (2021)







Other Physics: Cosmic Ray observation



- Observation of CR anisotropy at both Hemispheres.
- Interplanetary space physics with **Sun shadow of CRs**
- Composition of Primary Cosmic-Ray Nuclei around **knee** region.

ALPACA DAQ system

- Trigger system based on hit sum technique (timing coincidence).
- Hit signals arrive randomly to the trigger module.

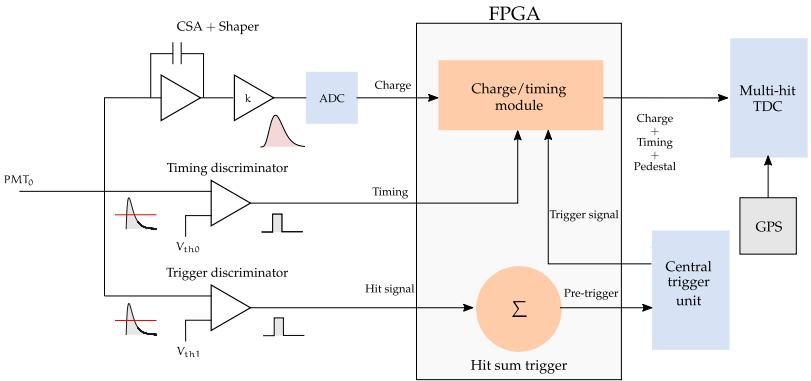


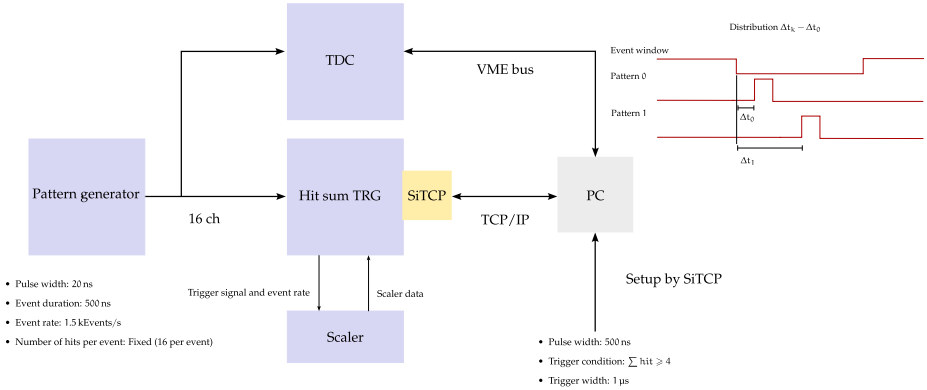
Figure: ALPACA DAQ system

Motivation: design new trigger system

- Digital system: flexibility, advance trigger method.
- Handle large number of channels.
- Pattern generator with timing and charge distribution is essential.

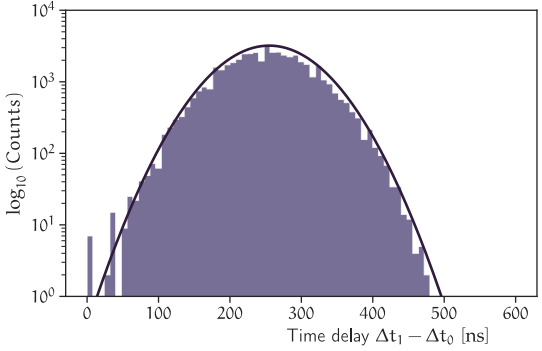
Previous results: 16 trigger system prototype — IURP 2022

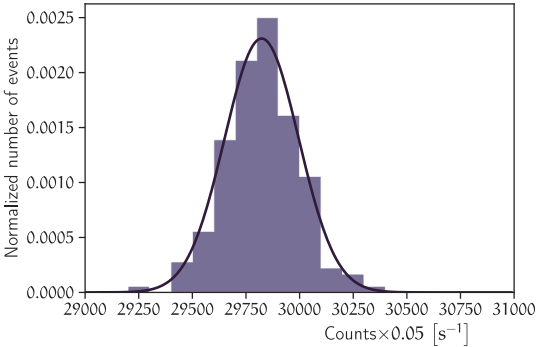
- Digital trigger system — hit sum technique.
- Prototype limited to 16 channel due to FPGA.



Previous results: 16 trigger system prototype — IURP 2022

- TDC results: Gaussian μ =255 ns, σ =60 ns.
- Trigger data: Obtained trigger rate with an input rate of 1.5 kHz.





Towards a 64 channel pattern generator

- New dev board can manage large number of inputs ($\sim$ 120 channels).
- Combines CPU+FPGA on same IC (sophisticated algorithms).

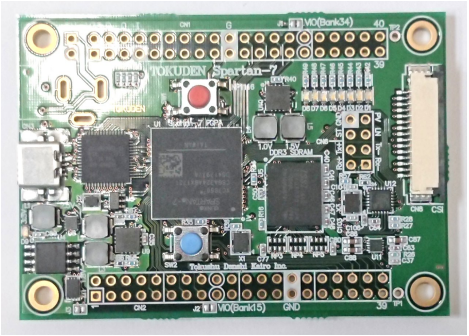


Figure: Old dev board

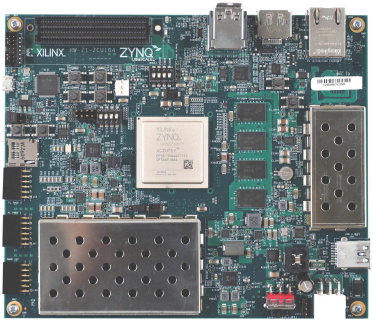


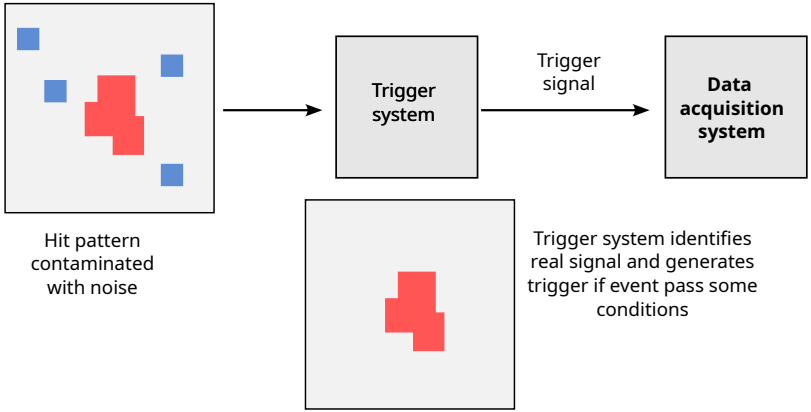
Figure: New dev board

Budget

- We received 20万円 from the ICRR Inter-University Research program.
- The budget was used to buy the ZCU104 dev board from Xilinx ($\sim$ 35万円).
- Thank you very much for your support.

Developing an improved trigger technique

- Advanced trigger algorithm using CPU+FPGA.
- Take advantage of spatial correlations.



Summary

- Southern sub-PeV γ-ray sky is yet to be explored.
- ALPACA is a new air shower array under construction in Bolivia.
- We are developing new trigger electronics.
- Our design have the goal of processing large number of input channels (ALPACA - Mega-ALPACA).
- A novel pattern generator system is being developed.
- The development of a new trigger technique is also being investigated.