Prototype of White Rabbit Network in LHAASO

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Synchronization is a crucial concern in distributed measurement and control systems. White Rabbit provides sub-nanosecond accuracy and picoseconds precision for large distributed systems. In the Large High Altitude Air Shower Observatory project, to guarantee the angular resolution of reconstructed air shower event, a 500 ps overall synchronization precision must be achieved among thousands of detectors. A small prototype built at Yangbajin, Tibet, China has been working well for a whole year. A portable calibration node directly synced with the grandmaster switch and a simple detectors stack named Telescope are used to verify the overall synchronization precision of the whole prototype. The preliminary experiment results show that the long term synchronization of the White-Rabbit network is promising and 500 ps overall synchronization precision is achievable with individual calibration and temperature correction.

LHAASO

Tracing galactic cosmic rays sources > 30 TeV
With angular resolution < 0.5°
KM2A sub-detector array:
Covering 1.2km²

- 5632 electron detectors
- 1221 muon detectors
- Timestamps Synchronization < 500 ps (rms)
- Jitter of Synchronous ADC clock < 100 ps
- High data throughput (26 Gbps) with minimum loss

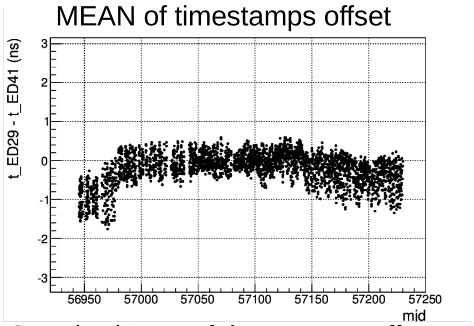
Prototype

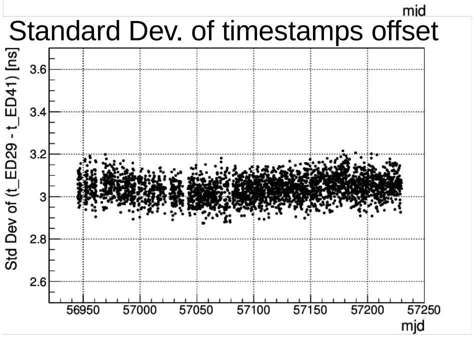
Locations & Components:

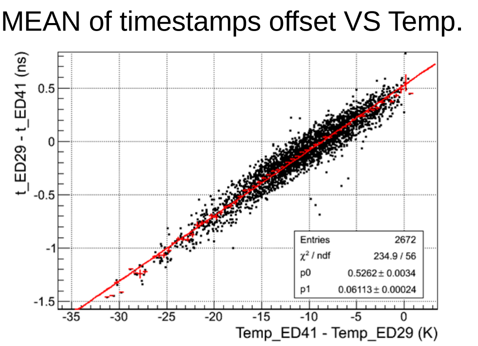
- ARGO Experiment hall, Yangbajin, Tibet, China (4300m)
- Rubidium clock constrained GPS
- 4 White-Rabbit Switches V4.0.1
- 50 Compact Universal Timing Endpoint(CUTE), WRPCV2.1

Feature:

- 4-layer heirachy
- Node by node calibration
- Dynamic Temperature correction





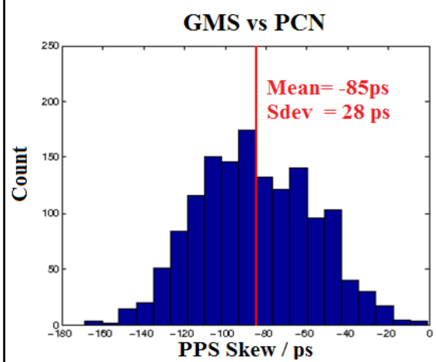


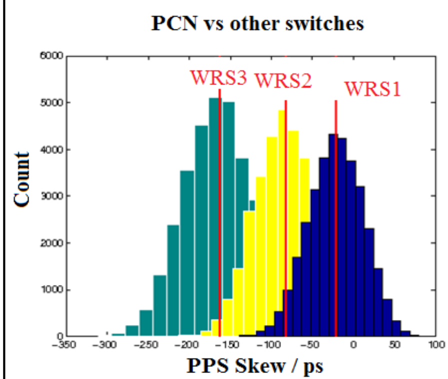
Telescope

- Simple Detectors Stack
- High possibility of Synchronizing Detection
- Sync Deviation = Timestamps offset
- Large Standard Deviation (~3ns) and the temperature dependency (61ps / °C) is mainly caused by the detectors.

Portable Calibration Node

- Normal CUTE WR Node inside box, water sealed
- Armored optical power composite cable
- Rugged composite connector
- Directly connected to/synced with Grand Master Switch (GMS)
- reference PPS for field measurement





Node index	Node vs PCN (ps)	
	Accuracy	precision
2	-138	100
5	-56	28
8	28	28
12	-27	150
16	5	28
17	-15	162
24	97	156
32	-40	34
39	-28	41
42	-157	135
44	-102	26
50	-45	34

- WRPC as IP core integrated with detector electronics (ED & MD)
- Power noise causes bad precision
- Remote Status Monitor