

中国科学技术大学

TIPP 2017

Design of a Data Acquisition Module Based on PXI for Waveform Digitization

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May 25th, 2017

Beijing International Convention Center

University of Science and Technology of China





Outline

Waveform digitization in physics experiment

Description of the module

Performance of the system

Summary and Prospect



Waveform digitization

- **SCA**

- Switch Capacitor Arrays
- High resolution ADC

- **Experiments**

- ANTARES
- AMANDA
- H.E.S.S.-II
- MAGIC-II
- Etc.

- **ADC**

- High speed & high resolution ADC

- **Experiments**

- DANCE
- TAC
- GTAF
- Darkside
- LUX
- XENON
- *PANDAX IV*
- Etc.



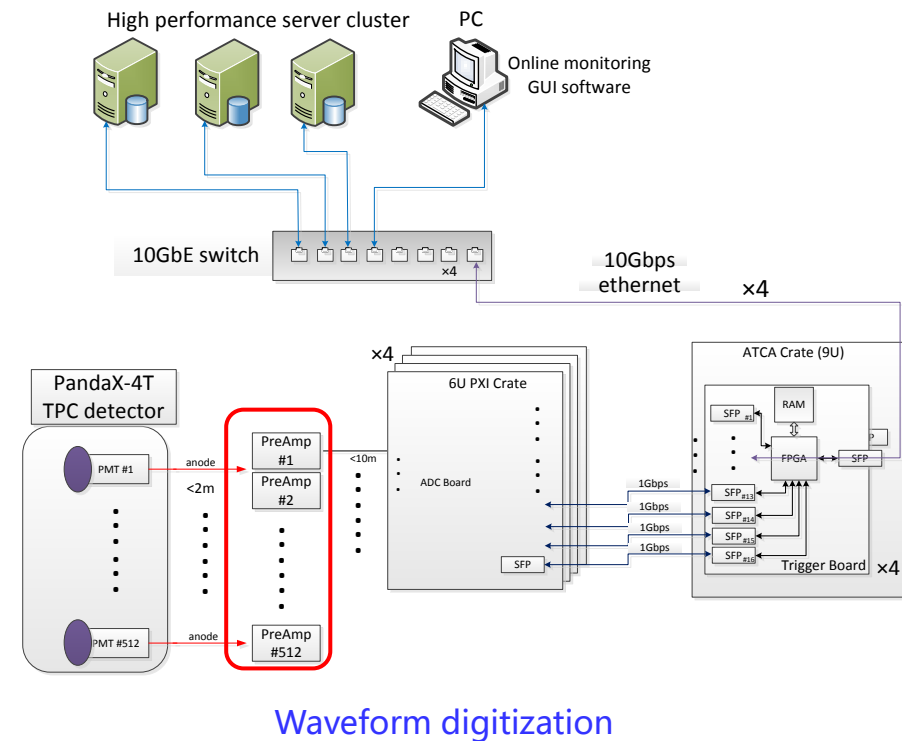
PandaX-4T

- **Particle and Astrophysical Xenon Experiments**

- China Jinping underground laboratory
- Dark matter direction detection
- 4-ton Double phase Xenon TPC

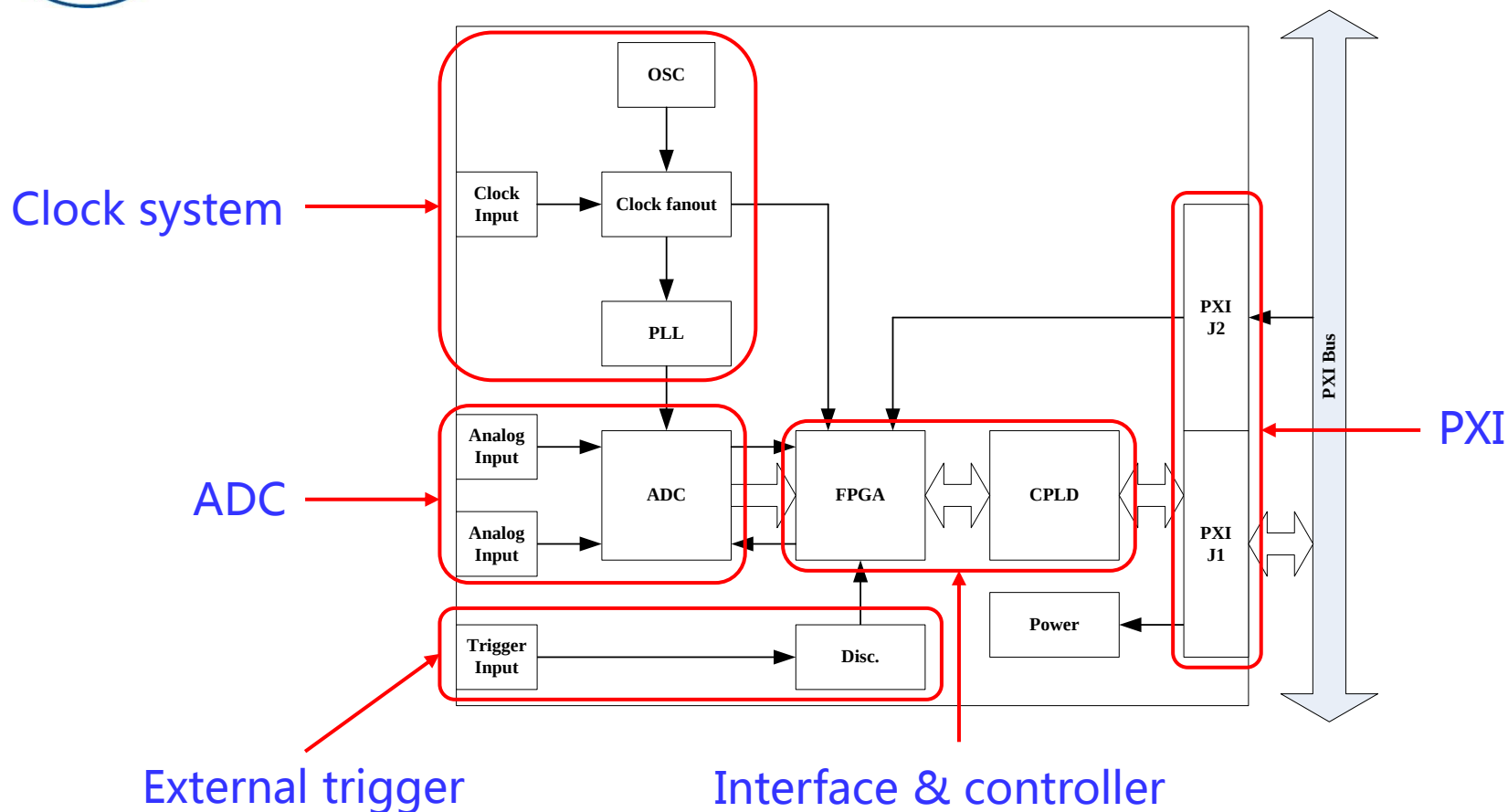
- **Principle verification**

- Waveform digitization
- Trigger mode
- Data buffer & storage





Scheme of the module





ADC & EPLD

• ADC12D1800

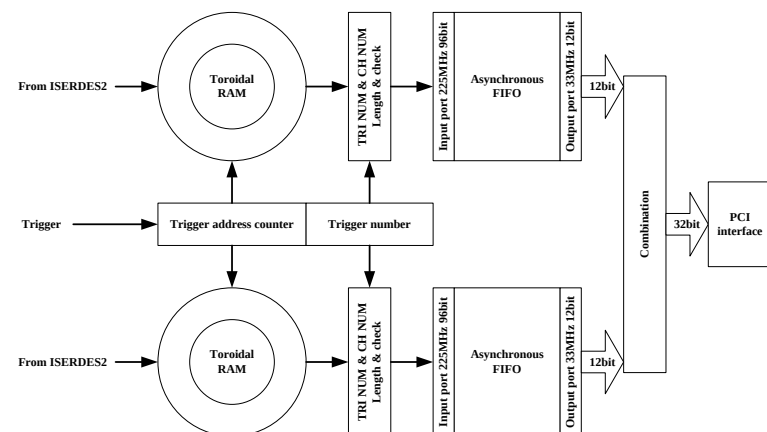
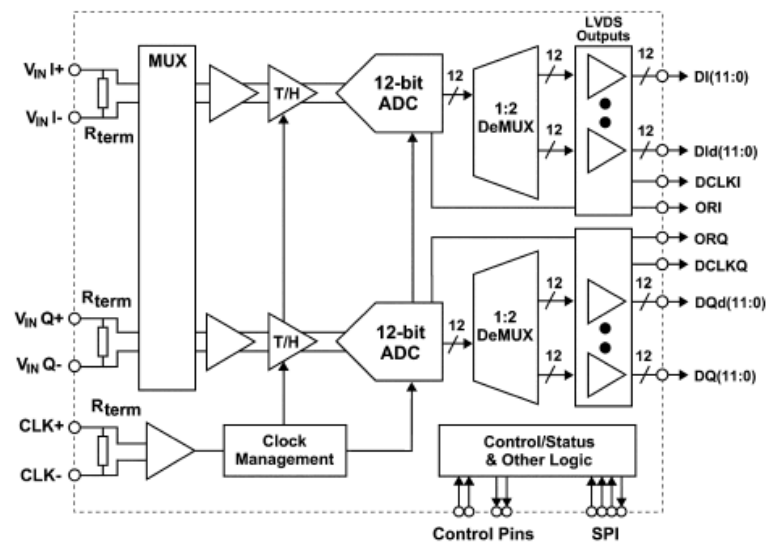
- TI co.
- folding interpolating
- 2 ch.
- 12 bits
- Up to 1.8 GSPS

• Artix7

- Config, control & status
- Buffer & storage
- Find triggered data
 - -100us to $+\infty$

• MAX II

- PXI interface
- Module reuse
- DMA transfer





Clock & trigger

- **Clock**

- Local or external

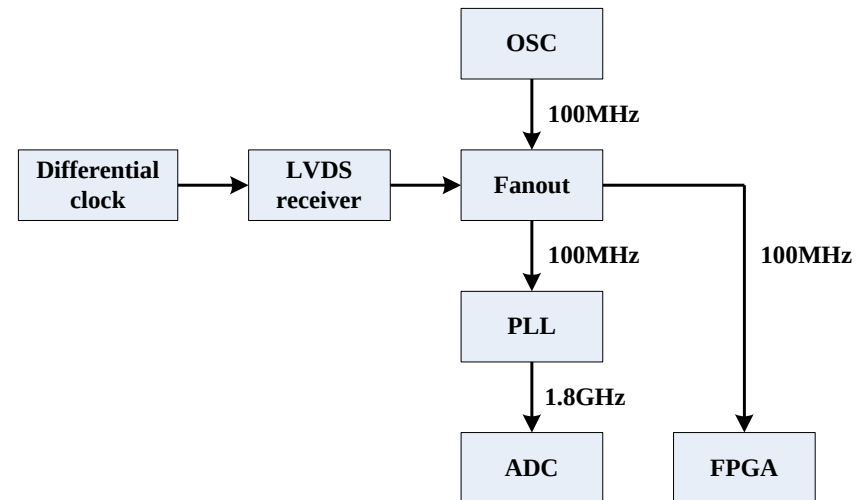
$$SNR = -20 \log(2\pi f_{in} t_{jitter})$$

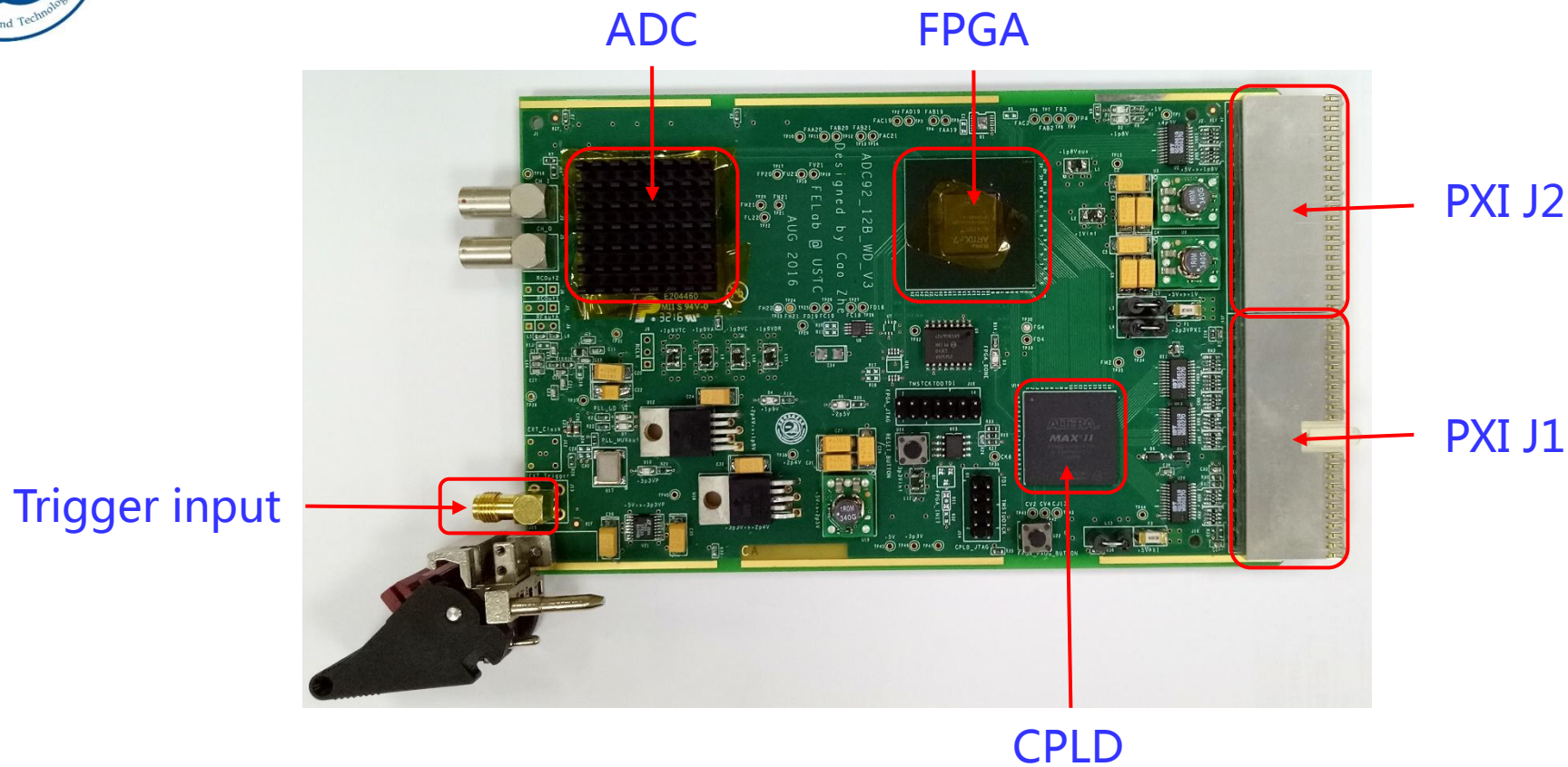
- PLL

- Low frequency to high frequency
- RMS jitter=139fs

- **Trigger**

- External
 - Discriminator
- Internal
 - Star trigger from slot2
- Self
 - Software

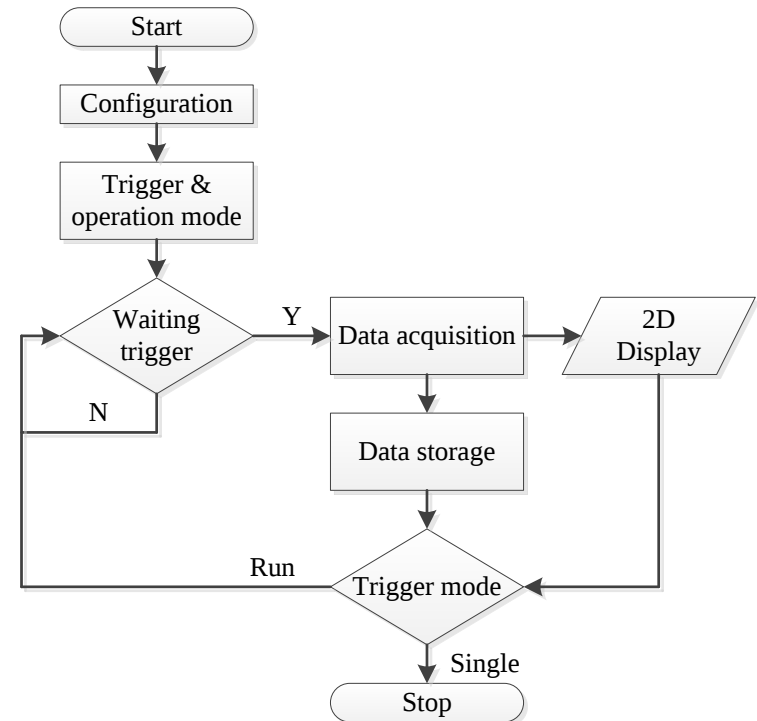






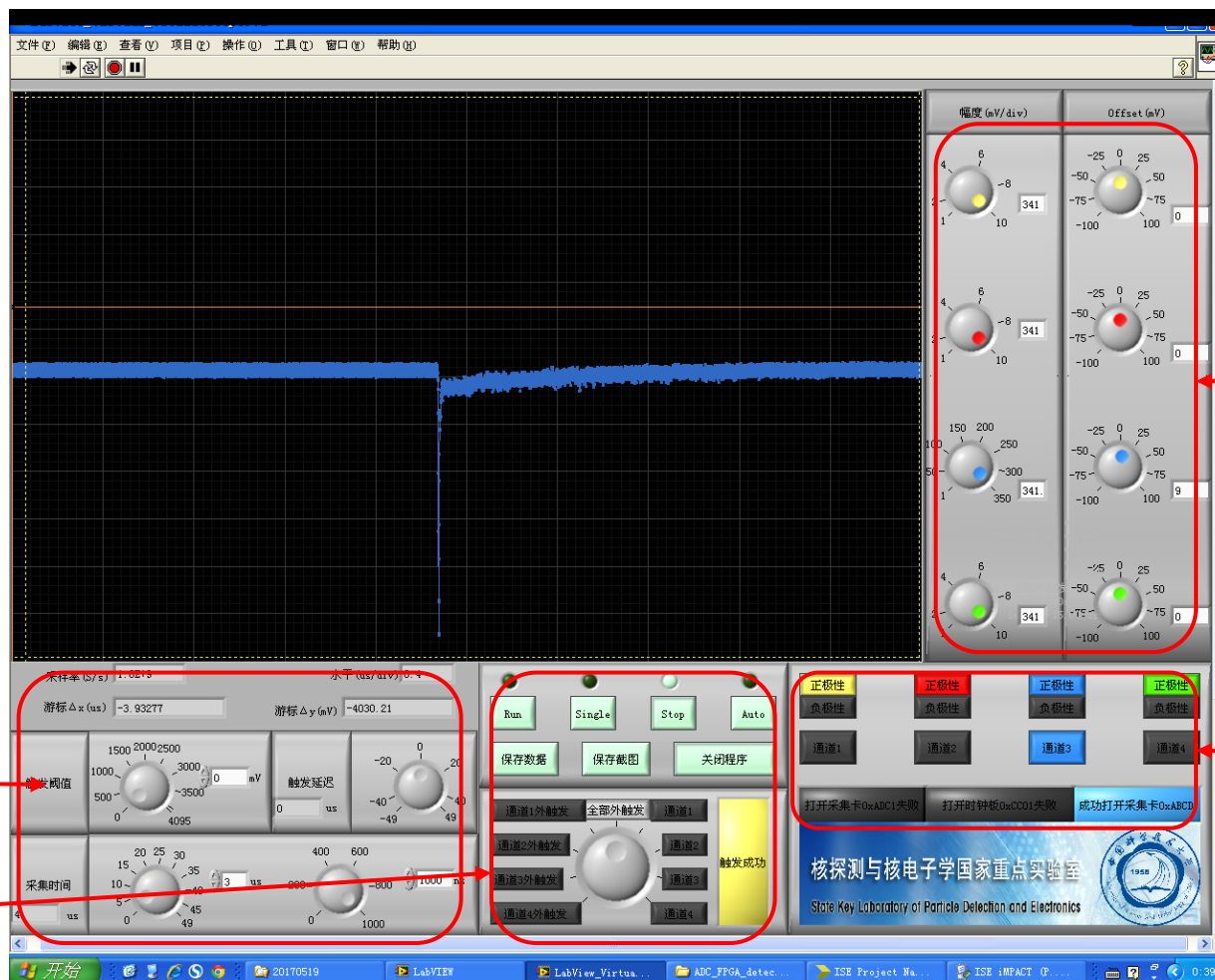
Virtual instrumentation

- **Benefit of test, measurement, automation**
 - Powerful application software
 - Cost-effective hardware
- **LabVIEW**
 - Configuration: ADC, PLL, FPGA
 - Channel: up to 4 ch.
 - Trigger: external or channel, trigger level, trigger delay
 - Operation mode: run, single
 - Sample depth (horizontal): up to 50 us
 - Display (vertical): amplitude, offset





GUI



Horizontal
set

Vertical
set

Channel
config

Trigger config

2017-5-25

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10



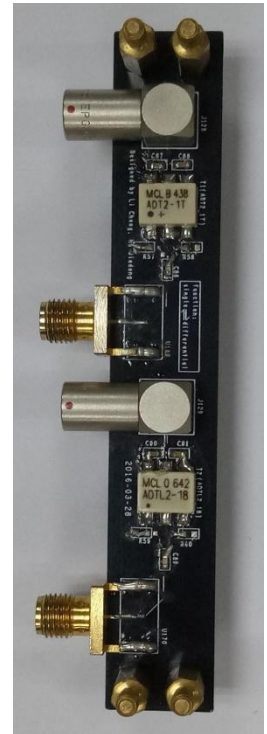
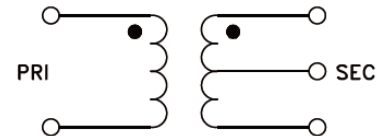
System test

- **Performance test**
 - Frequency response
 - ENOB
- **Detector test**
 - BaF₂ with PMT
- **Test equipment**
 - PXI platform
 - Adlink PXIS-3320 with controller: 15-slot, 6U
 - Oscilloscope
 - Lecroy 715Zi: 20GSPS, 8bits, 1.5GHz
 - Lecroy HDO6104: 2.5GSPS, 12bits, 1GHz
 - Vector signal generator
 - R&S SMA100A: 9kHz~6GHz
 - Bandpass filter
 - A series of filter from 2.4MHz~798MHz



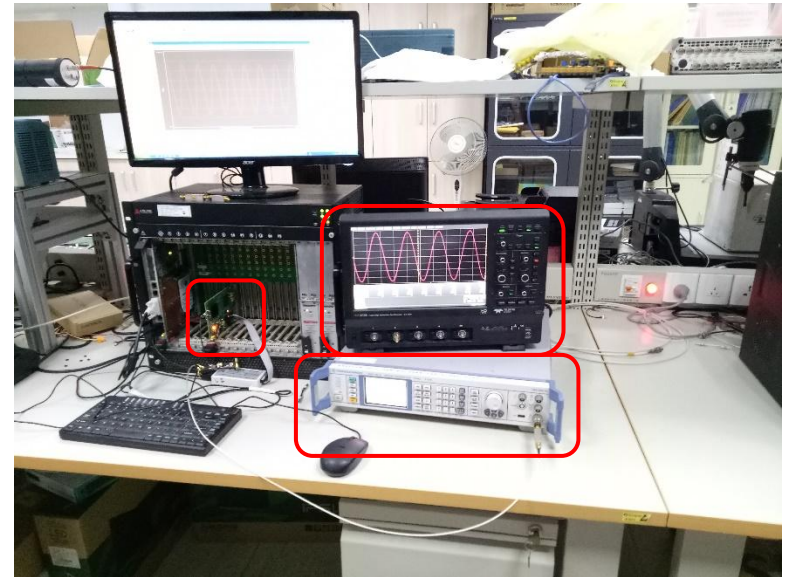
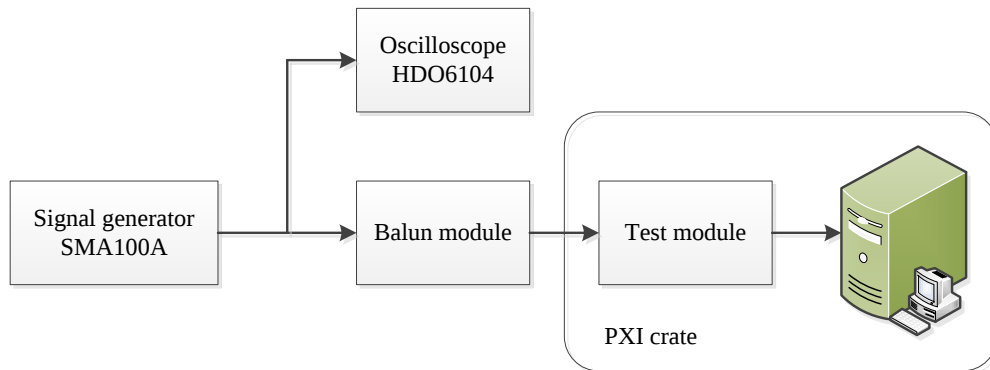
Balun module for test

- **Single end to differential**
 - From generator or detector to module
- **ADT2-1T**
 - Conventional
 - Insertion loss:
0.4~450MHz@3dB
- **ADTL-18**
 - Transmission line
 - Insertion loss:
30~1800MHz@3dB



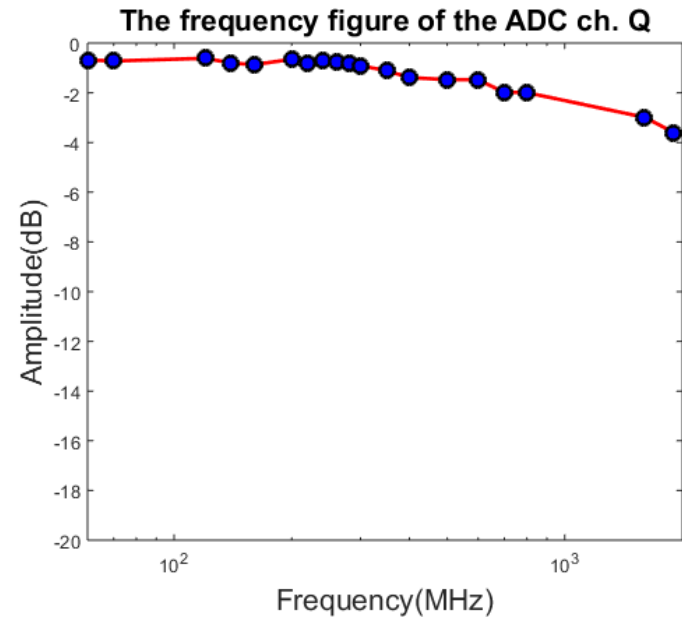
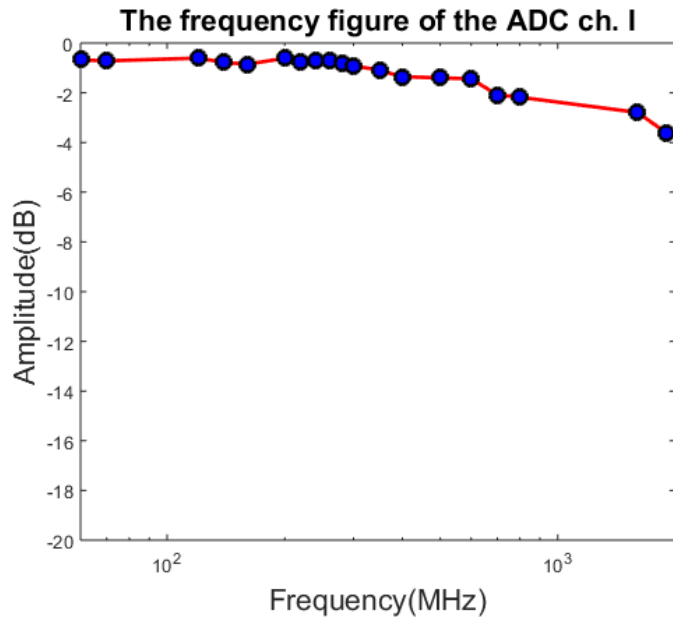


Frequency response test





Result@1.8GSPS



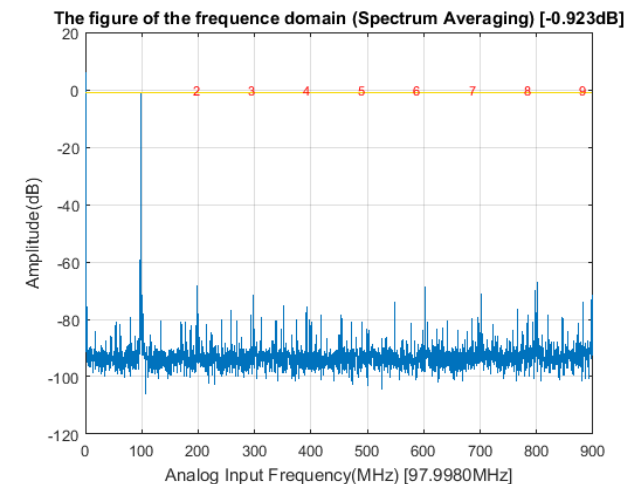
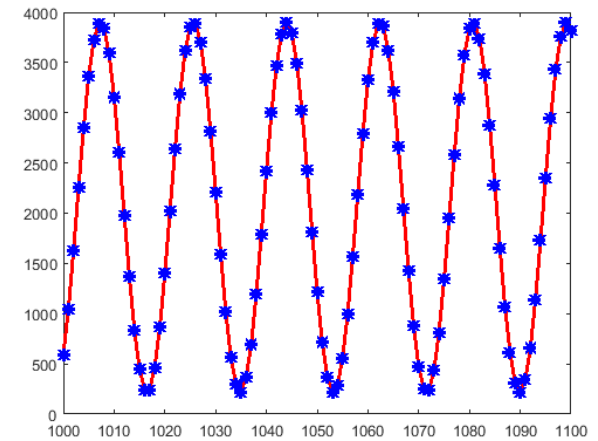
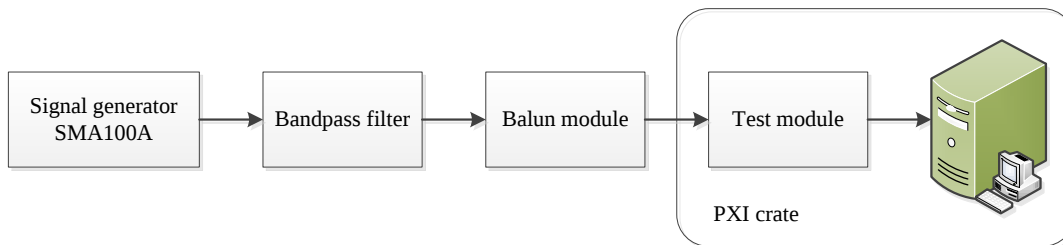


ENOB test

$$SINAD = 20 \lg \frac{RMS_{signal}}{RMS_{(noise+distortion)}}$$

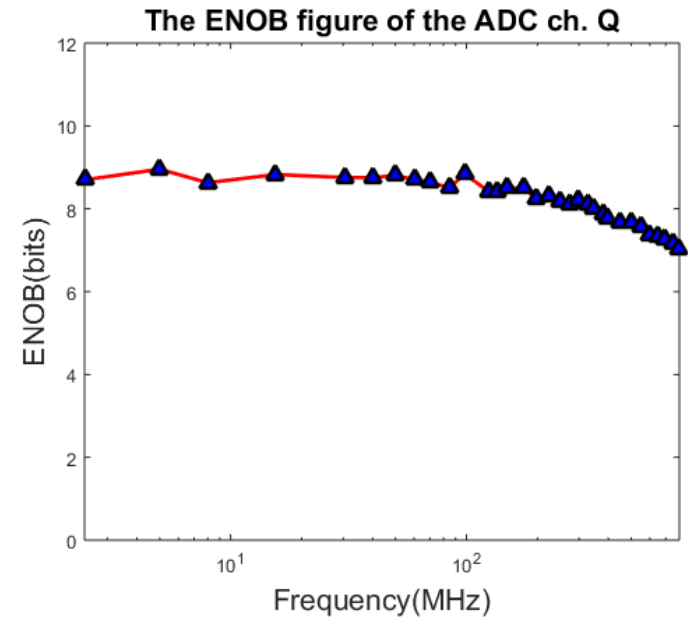
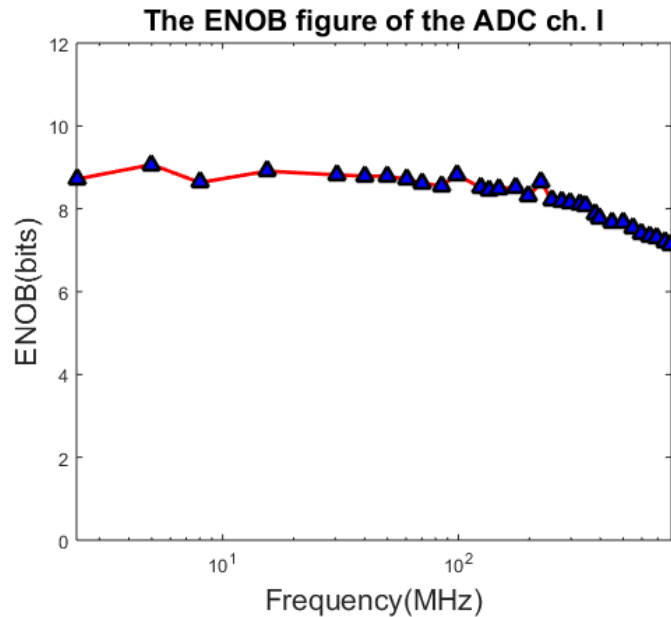
$$ENOB = \frac{SINAD - 1.76 \text{ dB}}{6.02}$$

- **IEEE STD 1241-2000**



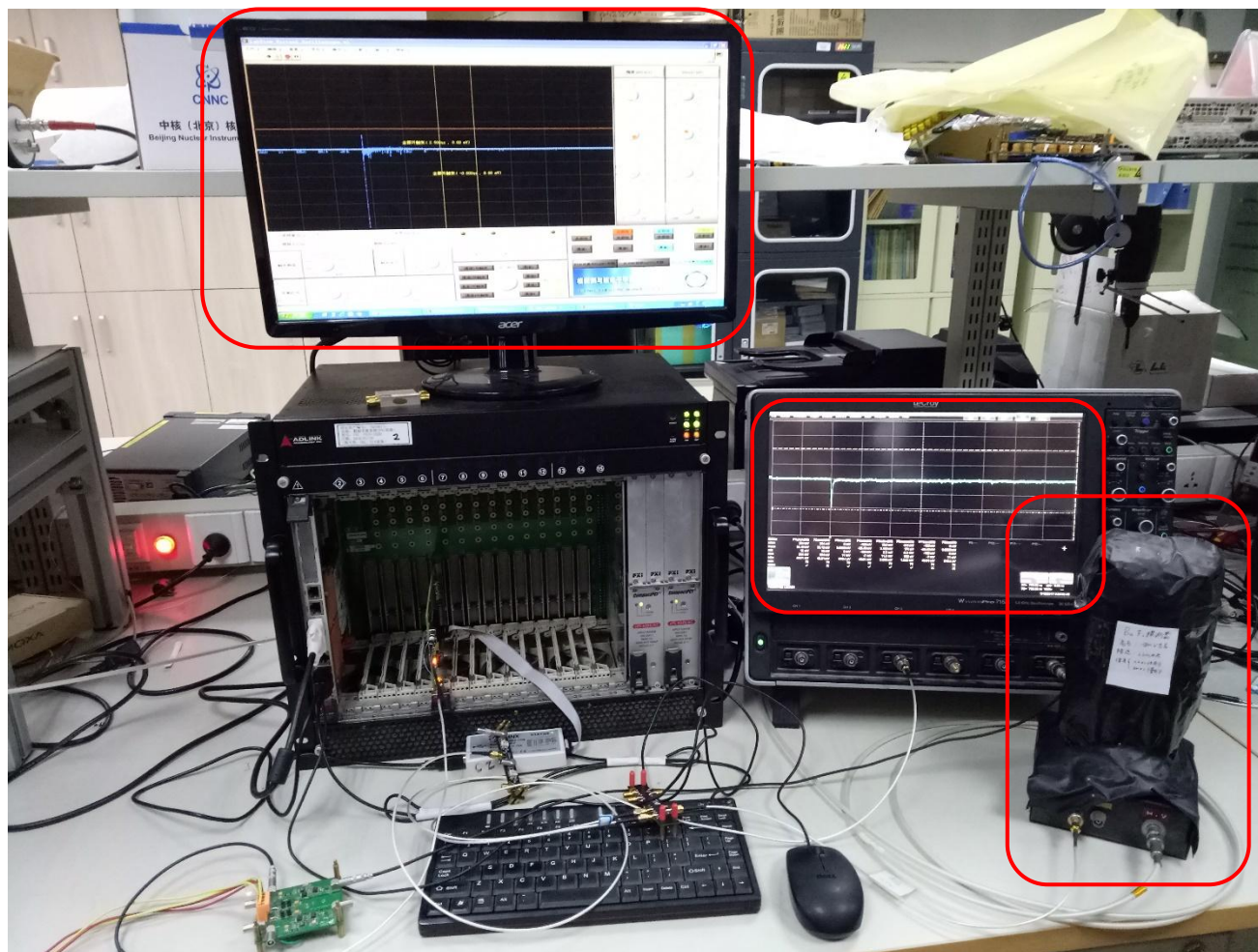


Result@1.8GSPS



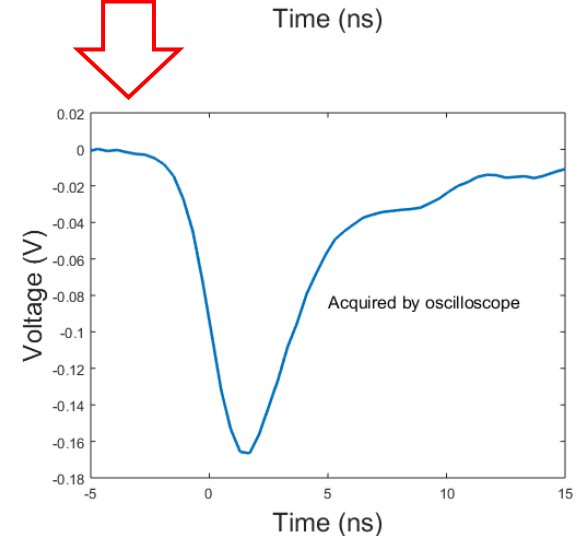
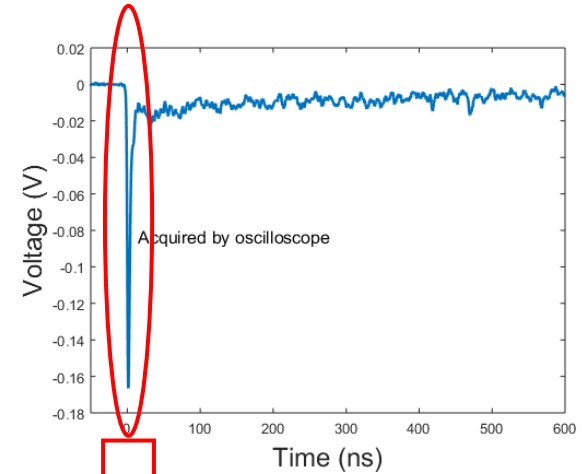
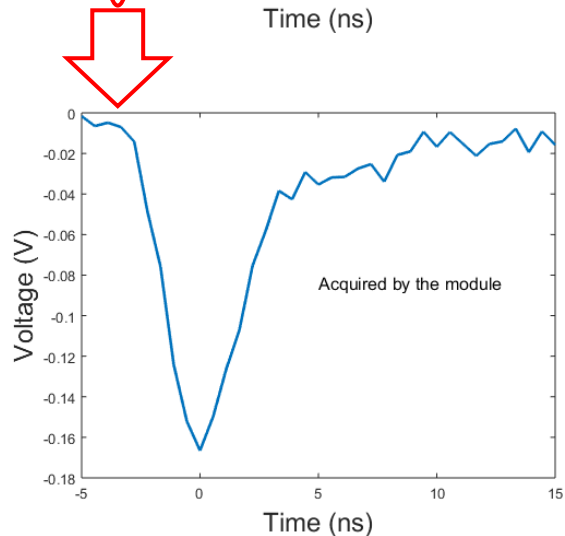
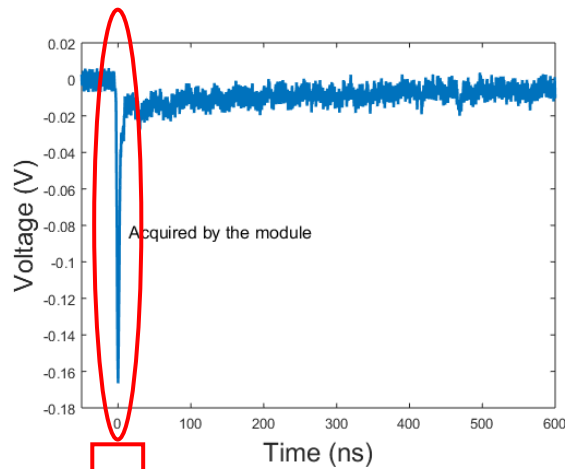


BaF₂ with PMT





Result vs. oscilloscope





Next & Acknowledgment

- **Next**
 - Test with TPC
 - Extract T & Q
 - Improve data transmission bandwidth
- **Supported by**
 - National Natural Science Foundation of China (Grant No. 11505182).
 - Anhui Provincial Natural Science Foundation (Grant No. 1608085QA21).



MAHALO!