



## TB4: Supporting SiPMs for High Energy Physics

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### Introduction

We (like many other people) are excited by the development of SiPMs and the possibility of new detector developments for high energy physics. But it's often hard for a small group to get started with SiPM. Our labs and Universities have infrastructure for PMTs, but it is a poor match for SiPMs. Buying new equipment is expensive, while building custom electronics from scratch is a huge effort. Our goal is to provide a **simple, flexible, scalable, affordable** system to help people get started with SiPMs.

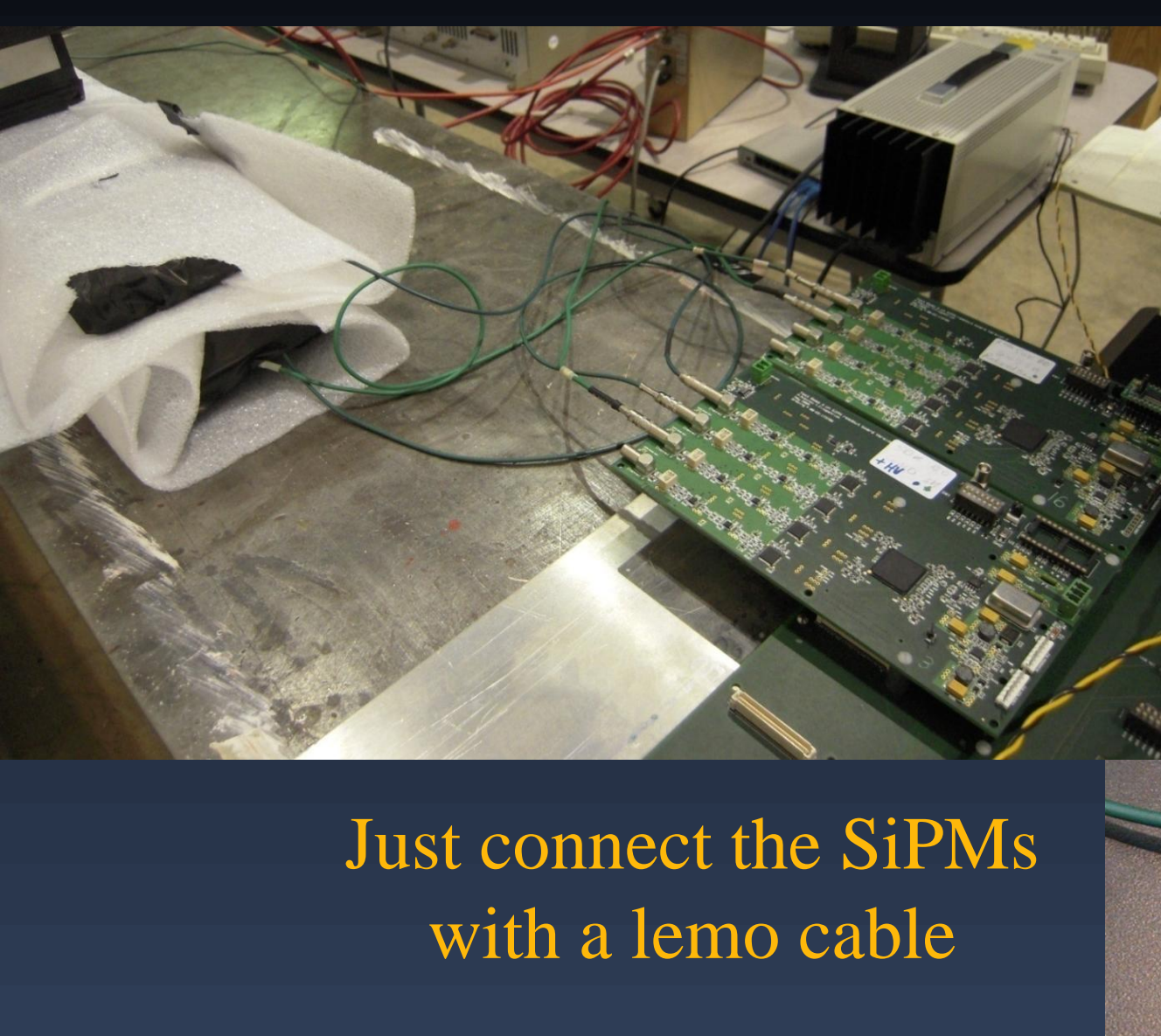


### Our solution

We have built a system (**TB4**) to support detector studies with SiPMs for small systems of up to ~50 channels. The system is composed of daughter boards (**DBs**), motherboards (**MBs**), and the software necessary to configure and run them.

### Main Characteristics

- Specifically designed for SiPMs
  - plenty of gain: typically x40
  - noise about 30uV, so one can easily see single PE for typical devices of up to 3x3mm
  - bias generator on the board, up to 100V
- Useful for many different applications that might require moderate dynamic range and speed:
  - voltage sampled at 212MSPS, bipolar
  - effective dynamic range about 1000:1
  - effective timing ~1ns
  - DBs can be used as a stand alone 4ch board or combined for up to 16ch using one MB
  - can sync multiple MBs to further expand # of ch
  - can self trigger, with coincidence of channels
  - can use external trigger
- To see SiPM specific features like after pulsing, capture a waveform, up to 4k pts per channel



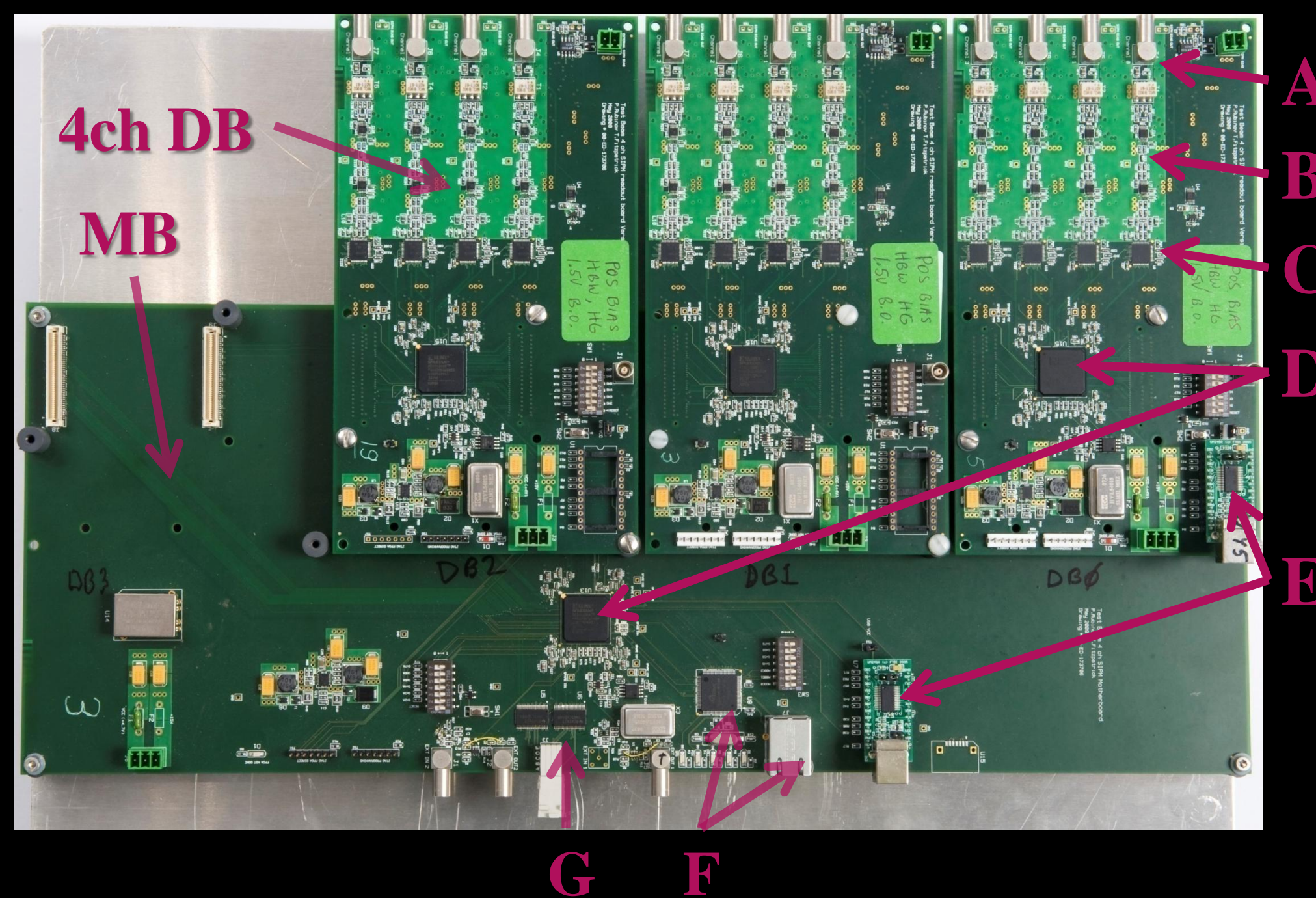
All you need is a 5V lab supply and a PC

bias gen and amplifier are on the board

Just connect the SiPMs with a lemo cable

### 4. Simple to use

- just plug the SiPM into a lemo cable
  - bias is carried on the cable
  - comes with software for setup and readout, writes plain ASCII files
  - includes a "scope" display
  - can readout over USB (1 Mbit/s) or Ethernet (UDP, 100 Mbit/s)
  - does not require cooling or clean power
5. Affordable: build cost is ~\$300 per channel, but for a worthy use, we can loan them out



### Parts

- A. ~50 ohm, transformer coupled lemo input, bias voltage for SiPM on center pin
- B. differ. amp and shaping network (AD8351)
- C. 210MSPS ADC, 12/14 bit (ADS6128/6148)
- D. FPGA (Xilinx Spartan3E 1500)
- E. USB module from FTDI (UM245)
- F. Ethernet chip from Wiznet (W5300)
- G. 2x1.1gbit LVDS TX links (RX on custom 6U VME)

Not visible: CW bias generator, current sensors

### Software & Firmware

Hardware alone is not a system. We provide and support firmware and software. We are happy to share it with interested users. Software uses Microsoft C#, firmware uses Xilinx ISE(VHDL)

### Operation

Many different modes currently supported  
Readout:

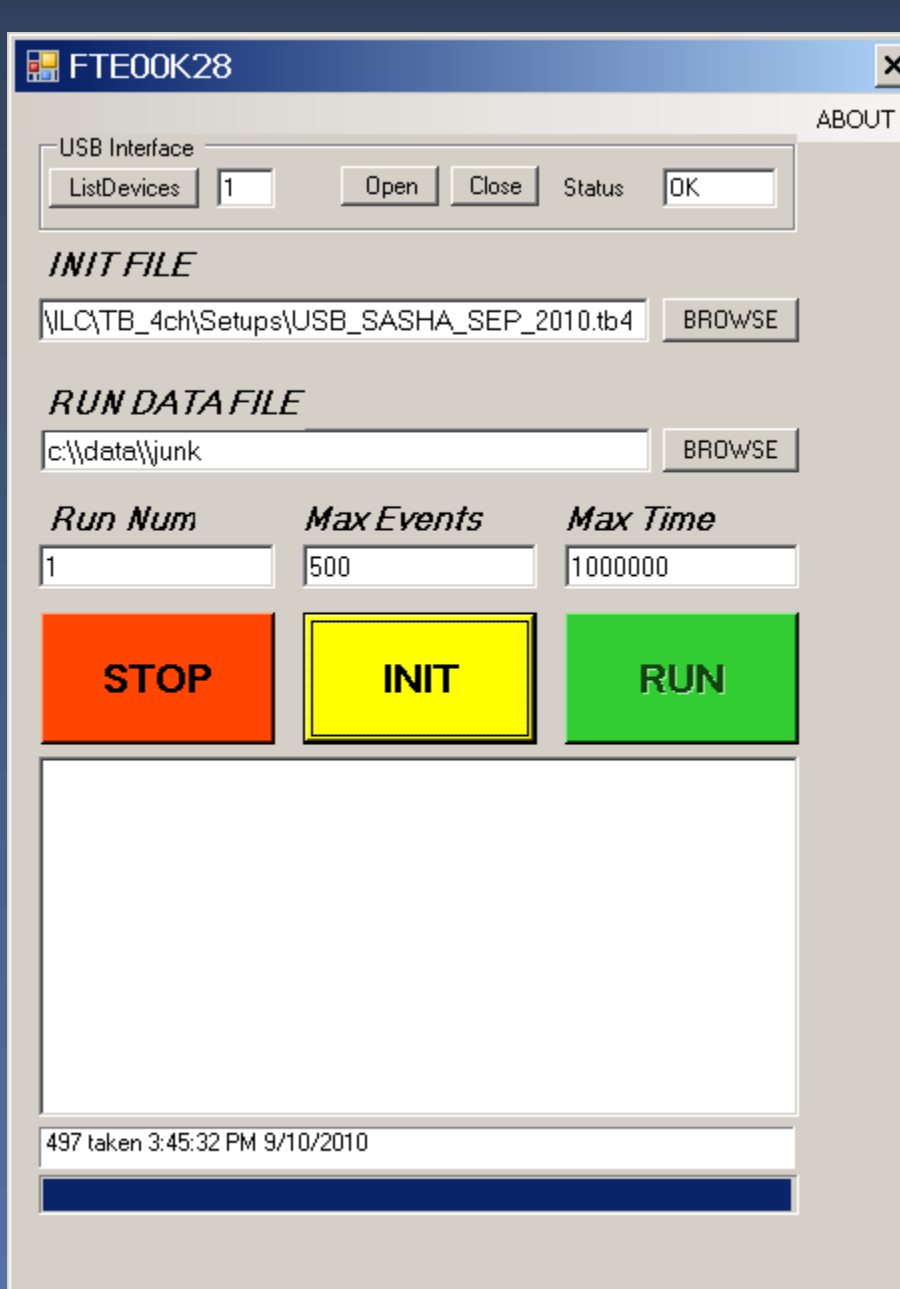
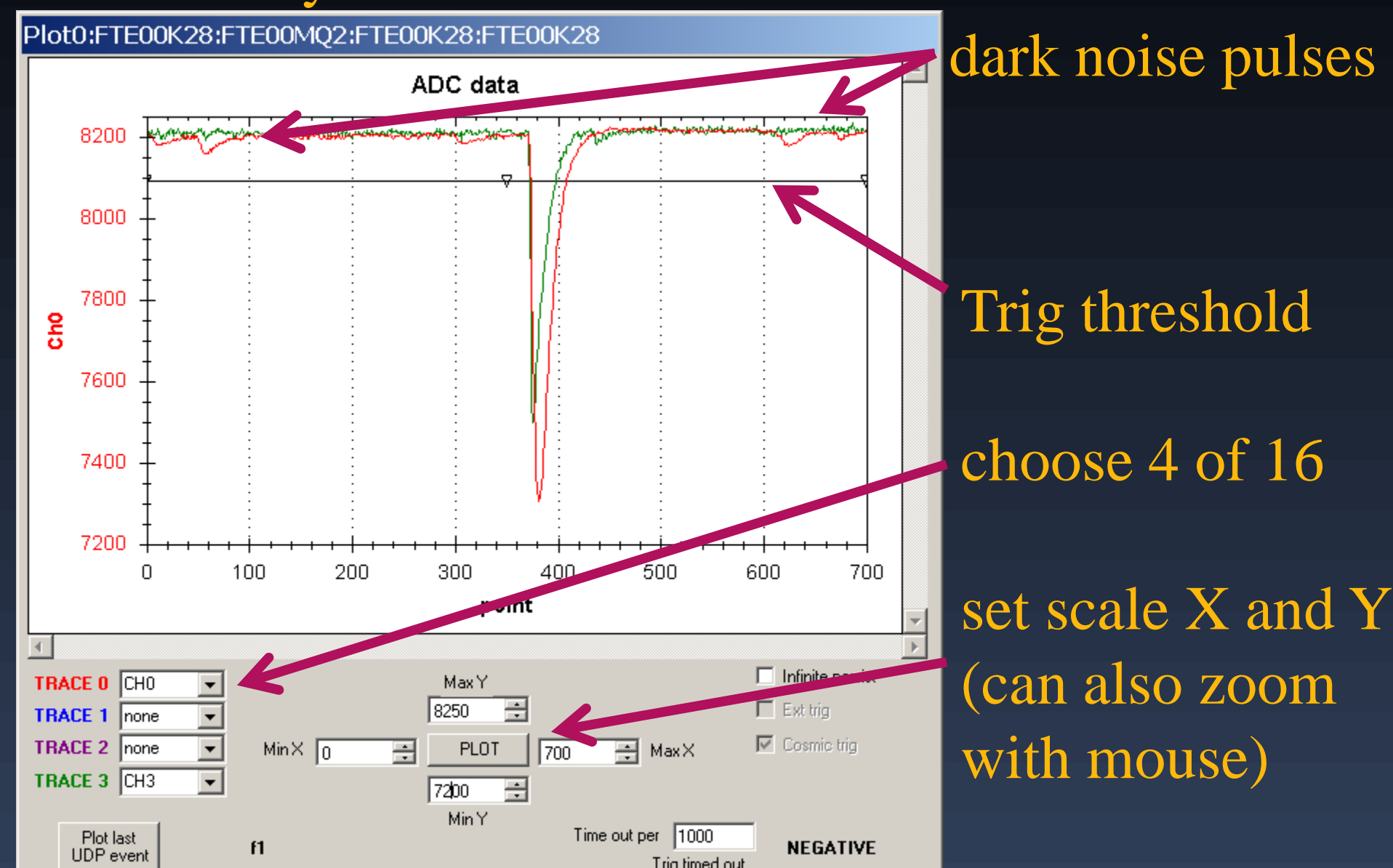
- USB from single DB, internal or ext trig
- USB from MB, internal or ext trig
- UDP (Ethernet) from MB
- Other modes possible

Front end can be easily configured for

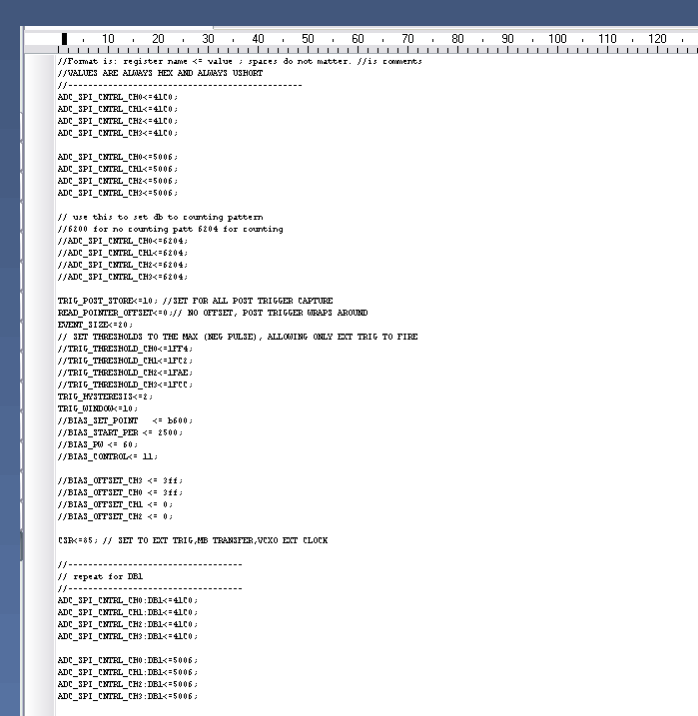
- different gain, bandwidth
- different bias (internal or external)
- can be used with PMT inputs

All hardware parameters can be stored in ASCII files or in flash memory on the boards

### Cosmic ray event

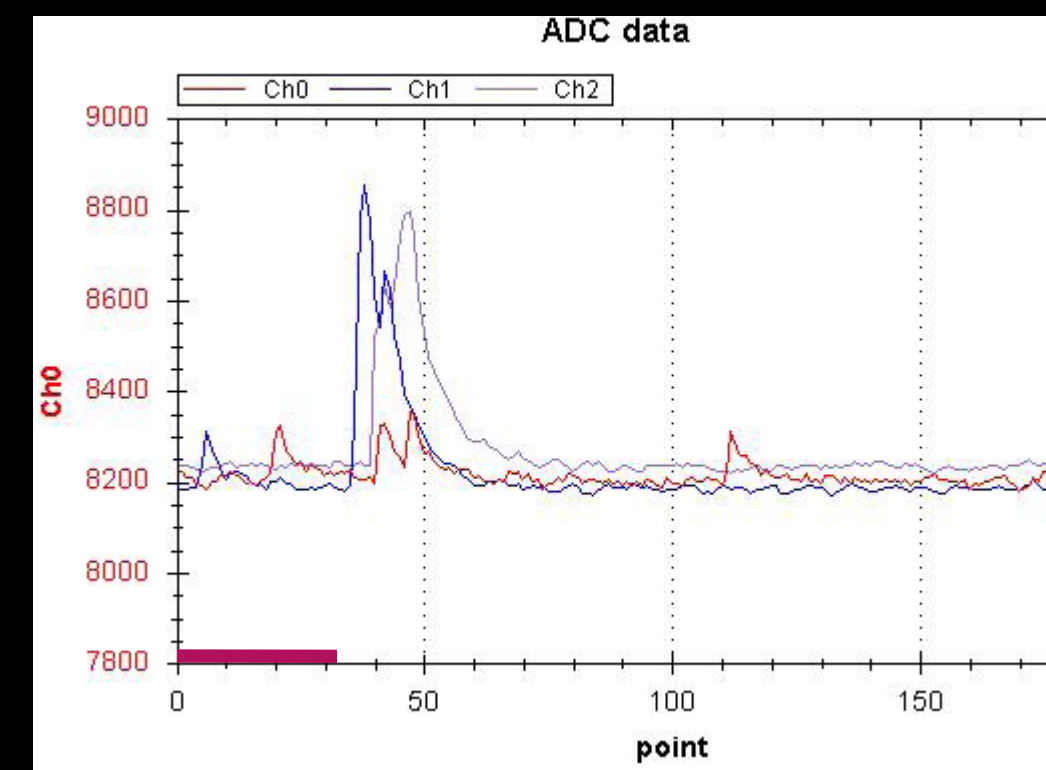


Gory details hidden from "casual" user in a setup file (ASCII format)  
Minimal operation: INITIALIZE and RUN



### Examples

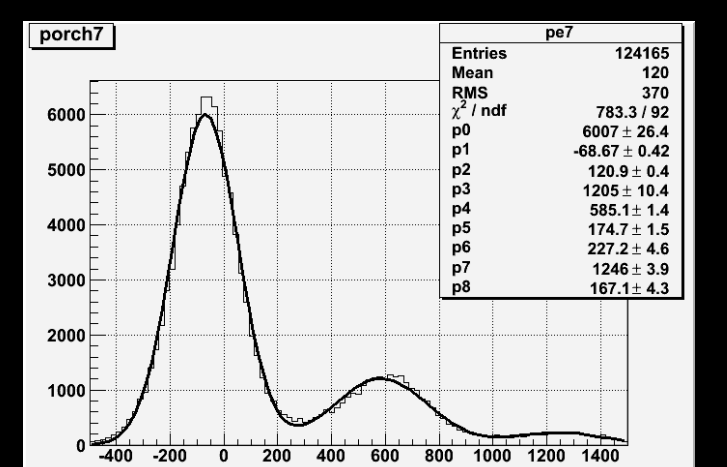
So far this system has been used in 4 test beams at Fermilab, 2 at CERN, and test stands at 4 universities. Experience is positive but this is a work in progress.



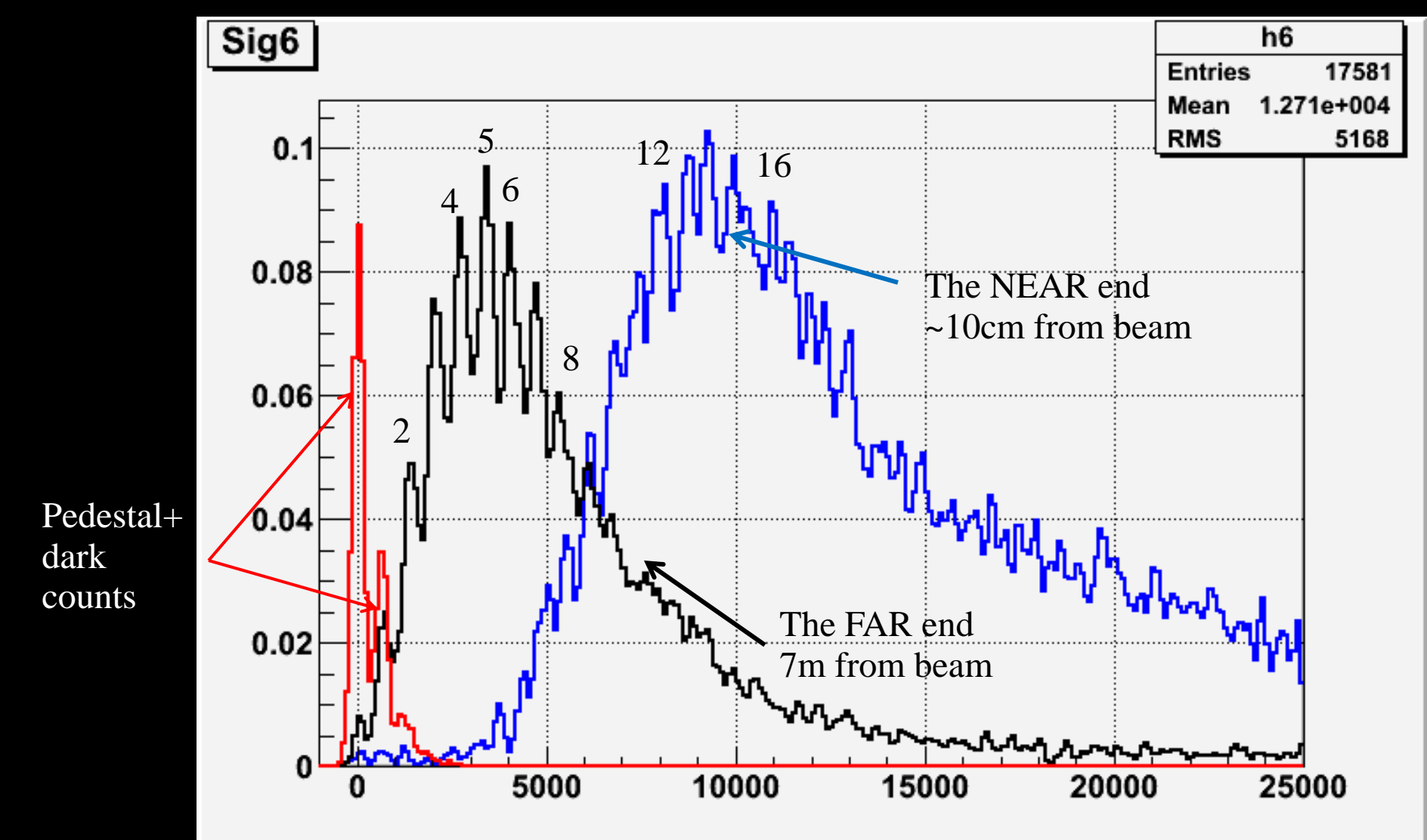
Capturing waveforms is key

- charge from area
- timing better than sample period
- can see after-pulses
- can calibrate *in situ* on dark pulses

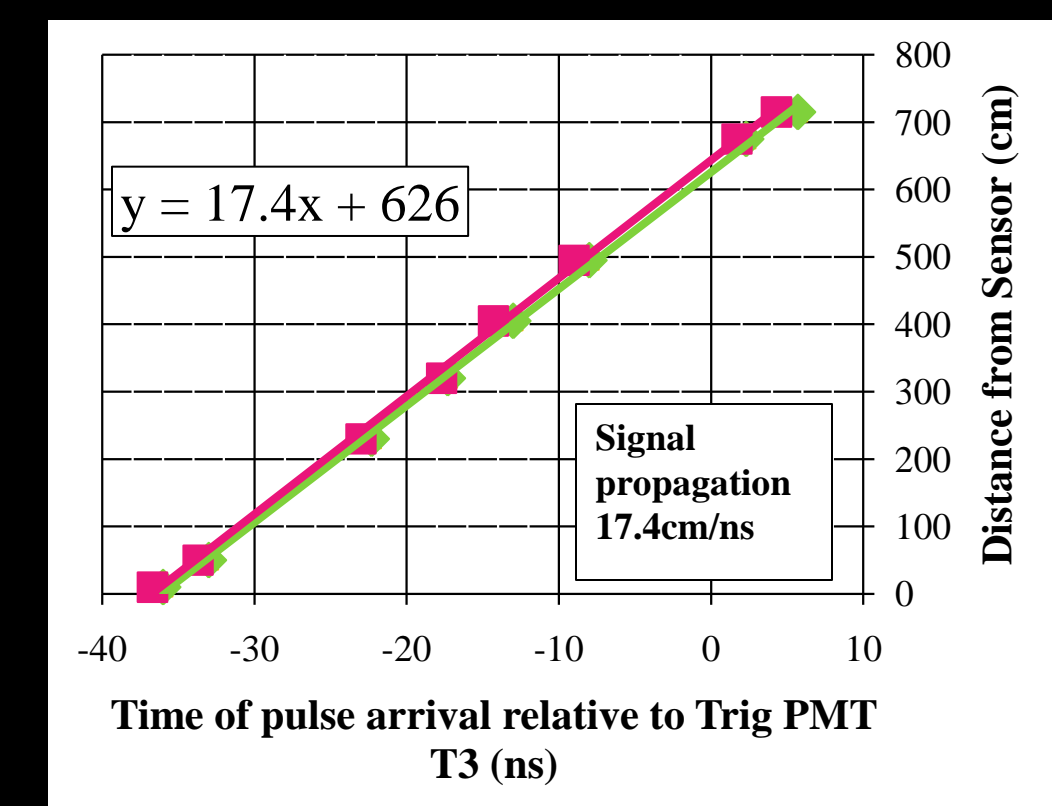
Example calibration from first 30 samples



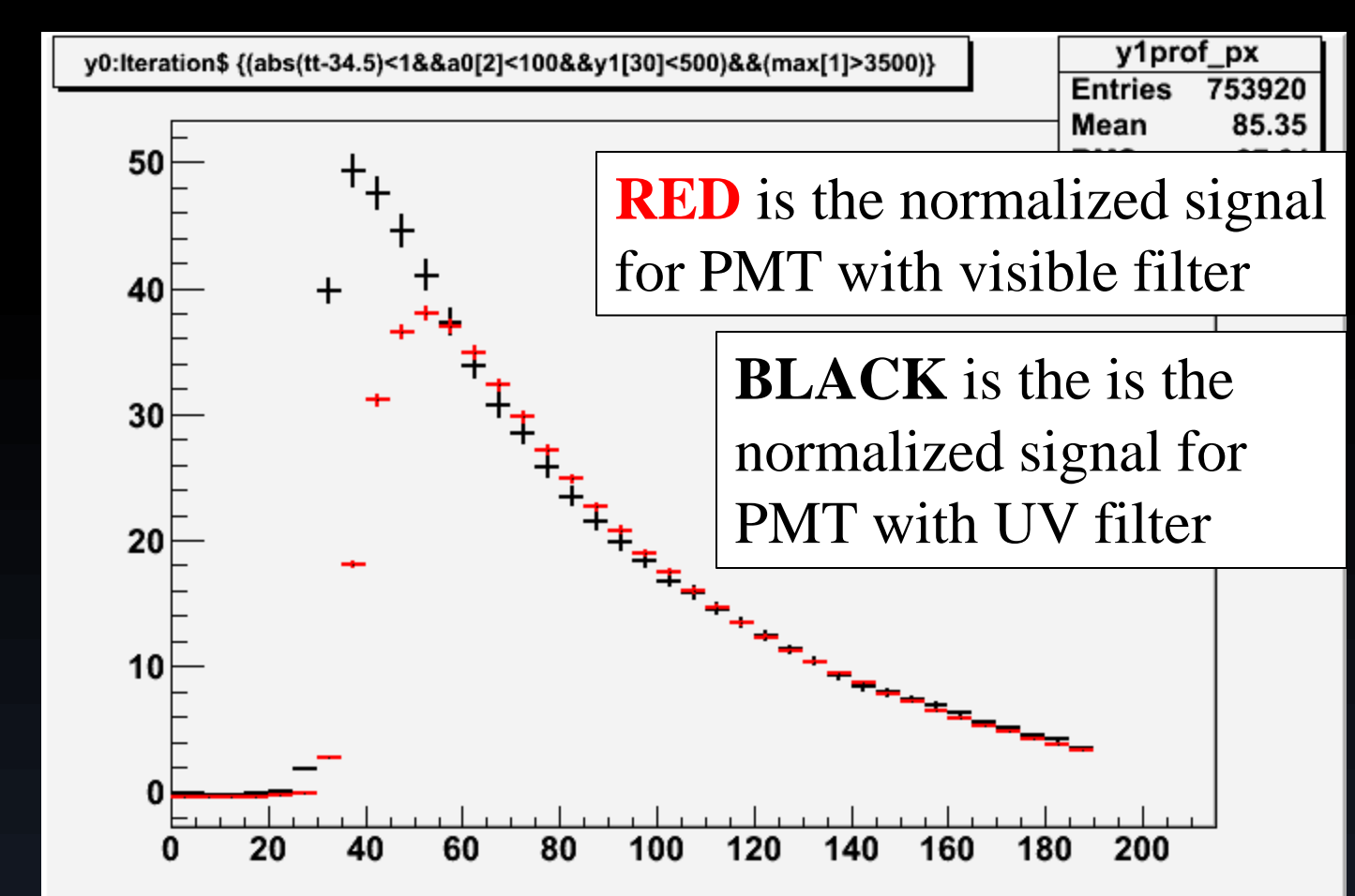
Example results from long scint strip with WLS fiber readout and IRST 1.2mm SiPM



example timing measurements for WLS fiber



Example: looking for Cherenkov signal in BGO with 1mm MPPCs



### Summary

We have built a system that can help researchers get started using SiPMs without large investment in infrastructure. If this can be helpful in your application let us know! We also welcome advice and requests. We'd love to help if we can.

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### Acknowledgements

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