Digital Signal Processing in Nuclear Physics

Riken, July 28, 2003

Michael Momayezi
www.xia.com
momayezi@xia.com

Akinori Yamaguchi, ayama@nikiglass.com

X-Ray Instrumentation Associates, 8450 Central Ave,
Newark, CA 94560, USA, Phone: 510-494-9020, FAX: 510-494-9040
web: www.xia.com, email: sales@xia.com

© XIA, July 2003

Outline

The Goal

- Improve detector performance through better data acquisition.
- More intelligent, more compact, cheaper data acquisition.

The Technology

- High-speed digitizers, real time digital signal processing, algorithm-driven intelligent front-ends.

The Business Model

- Combine do-it-yourself with standard software

© XIA, July 2003

Old vs New

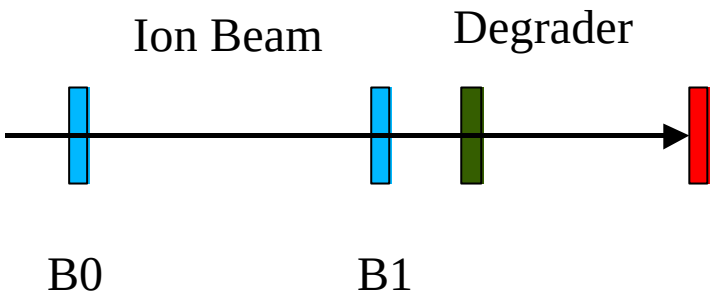
Old: Dedicated electronics for each function

- Measurement: Shaper, Pulse height analyser, TDC
- Triggering: Discriminators, gate generators
- Everything is carefully tuned manually and hardwired.

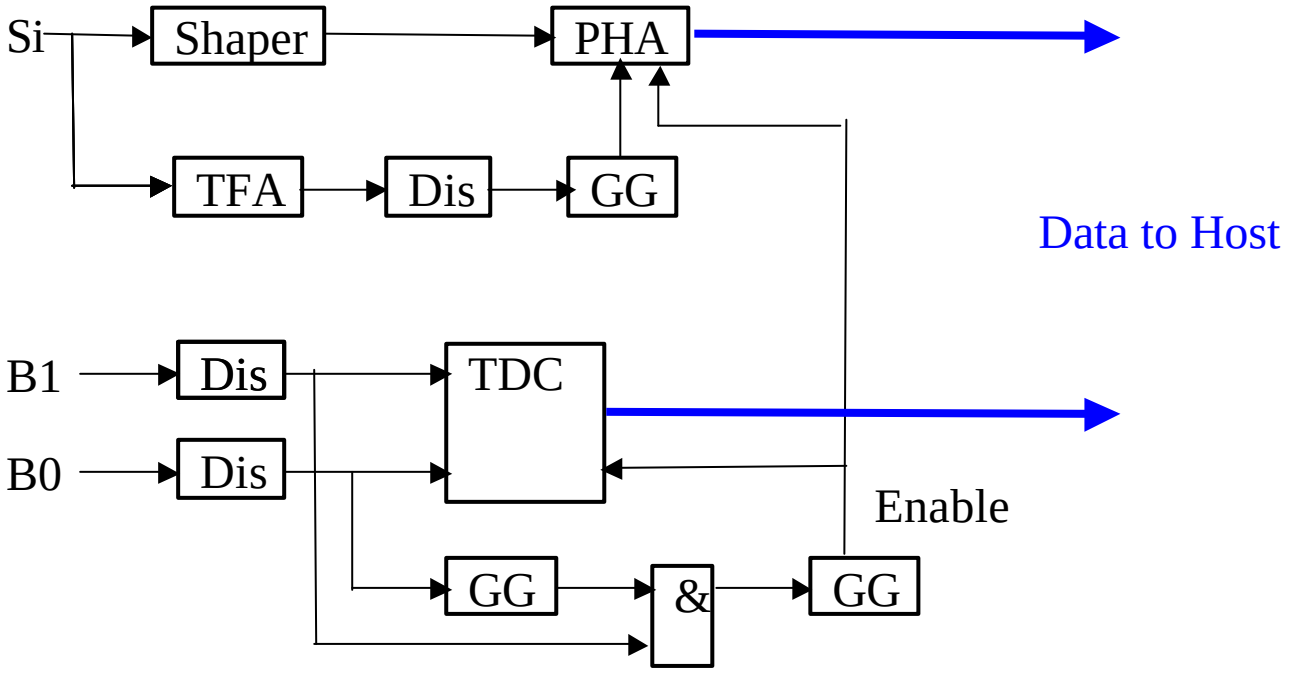
New: Intelligent front-end measures energy and time, triggers and records the pulse shape.
No manual adjustments.

© XIA, July 2003

A Decay Experiment



Ion Implantation and Decay



© XIA, July 2003

The New Way

Every channel provides complete signal measurement, including:

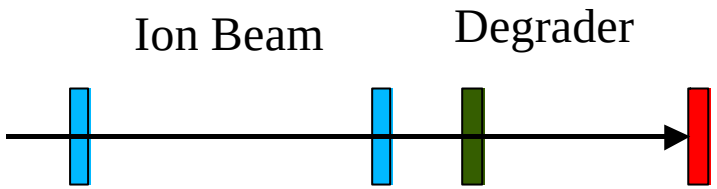
- Energy
- Time
- Trigger
- Pulse shape

All Parameters are set by Computer / User

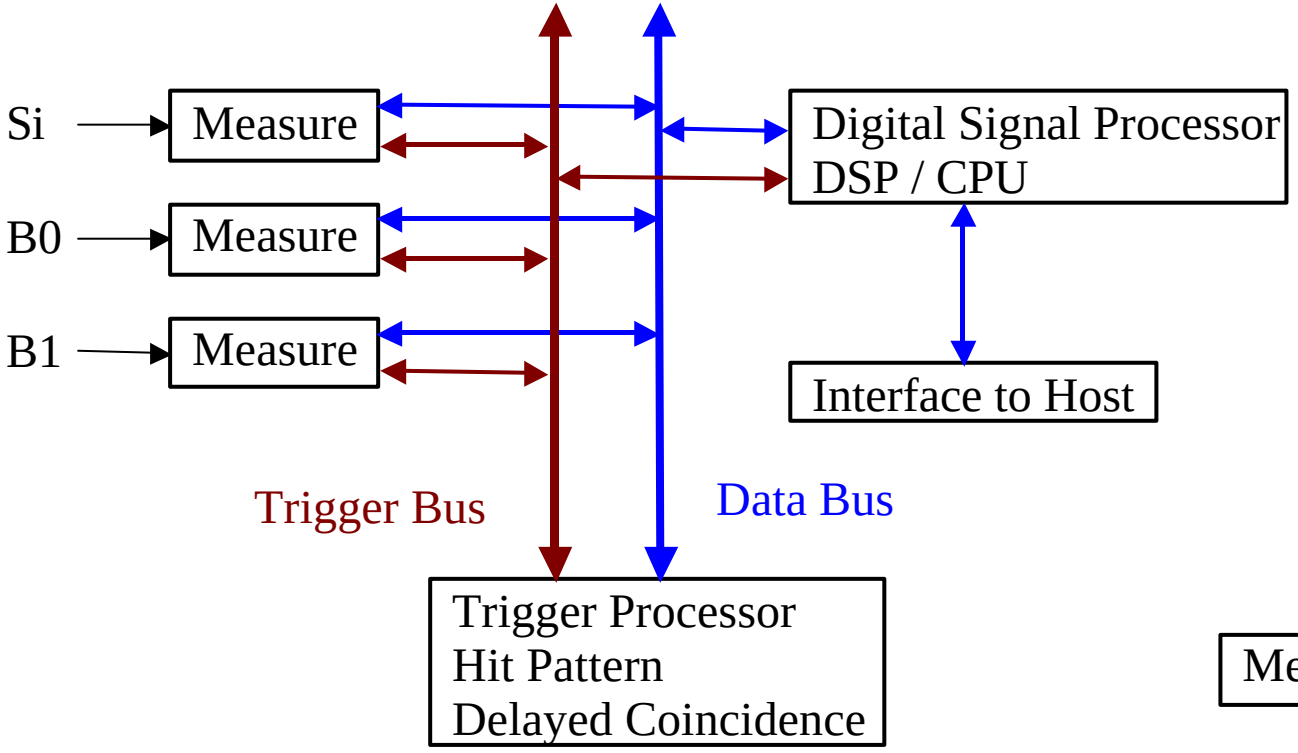
All Algorithms are set by Computer / User

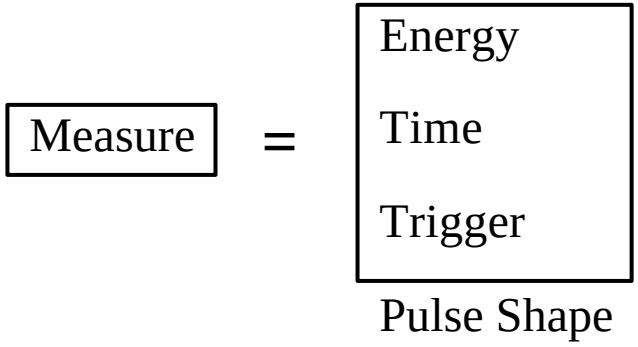
© XIA, July 2003

The Same Experiment



Ion Implantation
and Decay





© XIA, July 2003

Analog vs Digital

Specialized Analog Electronics:

- Shapers and PHA for energy measurement.
- Discriminators for triggering
- TDCs for time measurement.

Unspecialized Digital System:

- High Speed digitizers preserves waveform, and maximum information.
- Mathematical algorithms determine energy, timing, triggering, pileup inspection, etc.

© XIA, July 2003

The Front End

Energy: 64k MCA
HP-Ge, Scintillator, CdZnTe.

Time: timestamps in 10ns .. 25ns
intervals
t = 0.5ns(fwhm)

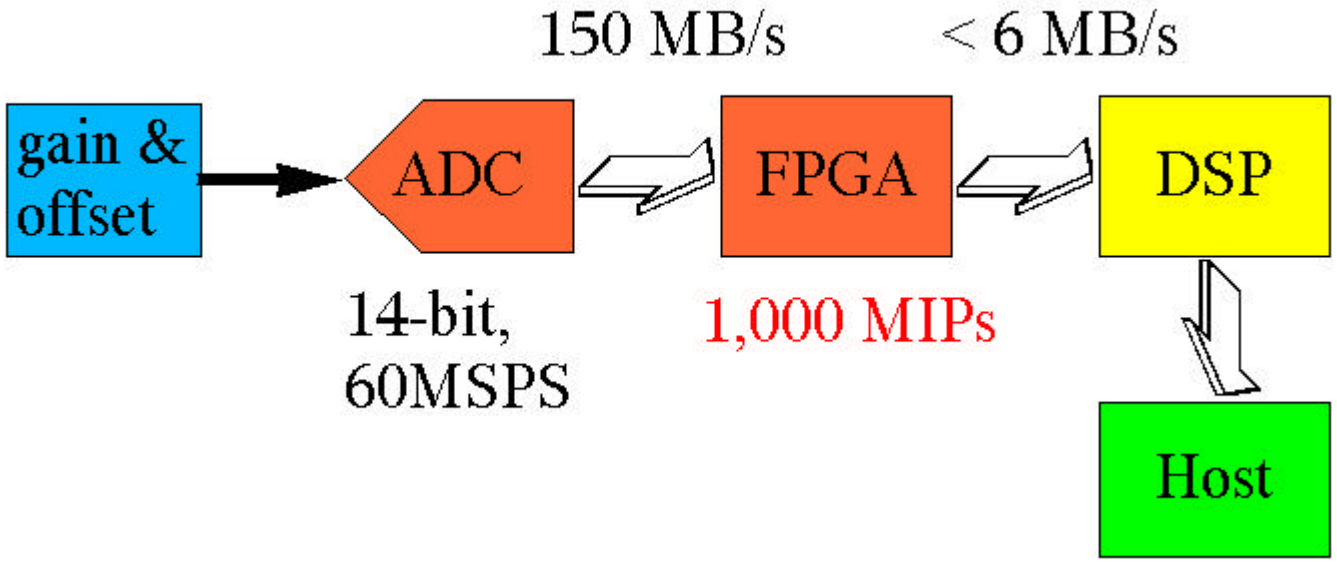
Trigger: Leading Edge (CFD)

Waveform: 512 .. 4192 samples
40MSPS .. 100MSPS
12-bit to 14-bit ADCs

© XIA, July 2003

Building Blocks

Division of labor:
ADC: 12-bit 40MSPS to 14-bit 100MSPS
FPGA: Real-time measuring, Energy, Time, Trigger, Pulse Shape.
DSP: Event-by-event reconstruction and storage.



© XIA, July 2003

The Pixie Series

Multi-channel coincidence ã-ray spectrometers measure:

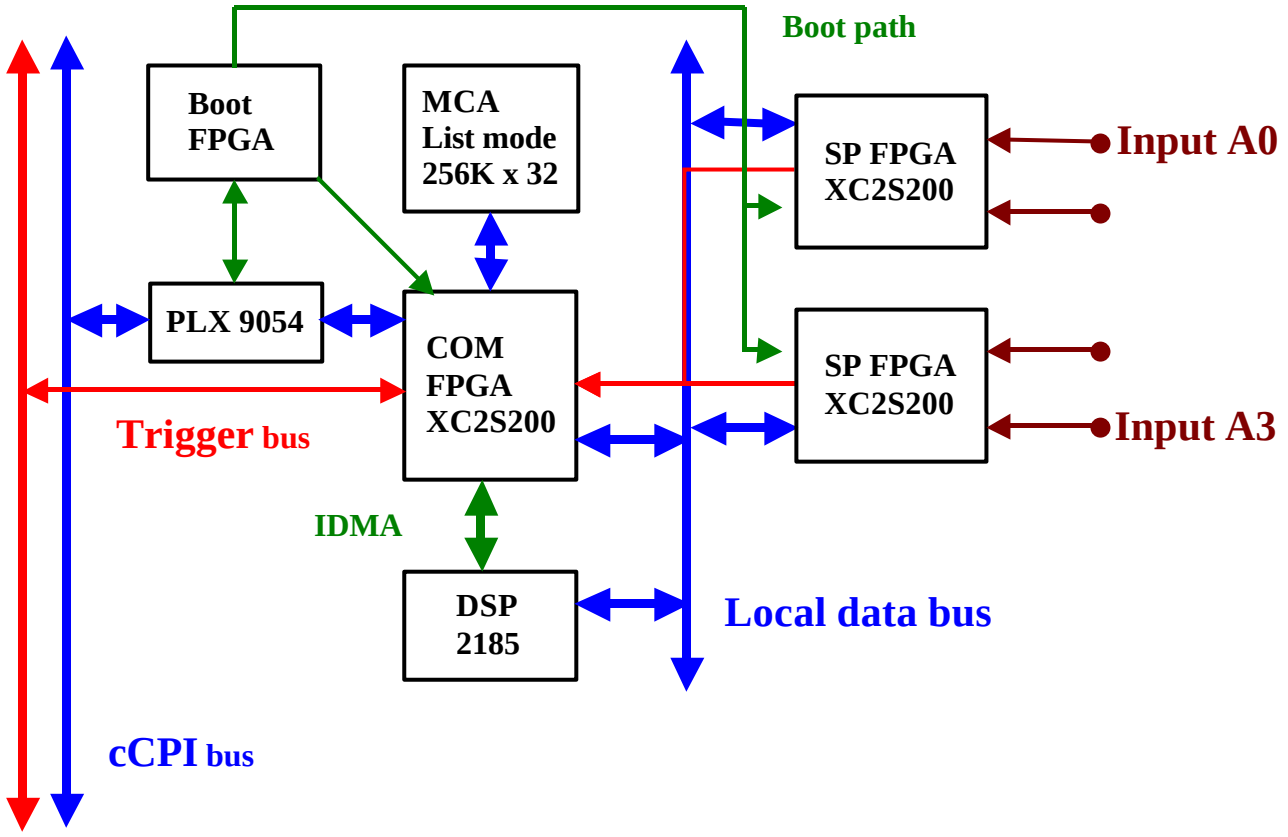
- Energy and Time
- Provide triggering using hit patterns, multiplicity etc.
- Acquire digitized waveforms
- Perform on-line pulse shape analysis
- Require no auxiliary electronics

CompactPCI environment for high speed, low cost.

Many vendors provide instrumentation cards, and powerful embedded computers / DSPs.

© XIA, July 2003

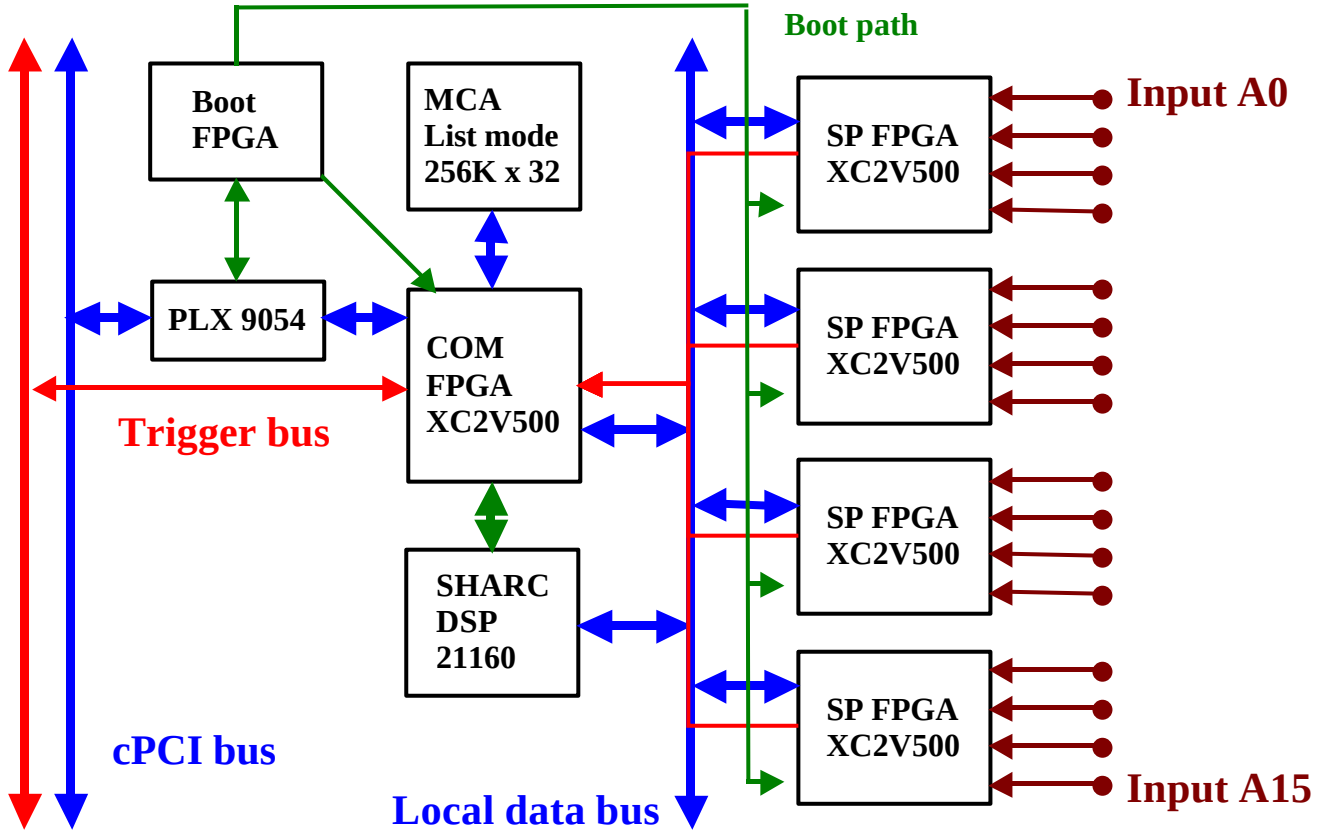
Pixie 4-Channel Spectrometer



Highlights:	**ADC: 14-bit, 75MSPS;**
Data movement:	**MCA: 109Mbyte/s, List mode: 40Mbyte/s;**
Available:	**Now**

© XIA, July 2002

Pixie 16-Channel Spectrometer



Highlights:	**ADC: 12-bit, 100MSPS;**
Data movement:	**MCA: 109Mbyte/s, List mode: 109Mbyte/s;**
Target cost:	**$500 to $1,000/channel**

© XIA, July 2002

Software

Traditional hardware has no software.

XIA provides device drivers and
complete front-end data acquisition software.
No programming necessary to get started.
Data go to hard disk – Ready for your analysis.

Use device drivers to integrate XIA into your
Data Acquisition System.

Users can add to the software running on the DSP
via user hook functions.

© XIA, July 2002

Business Models

Standard Usage

- Off-the-shelf Hardware and Software combination
- Application specific code for a fee

Advanced R&D Usage

- Off-the-shelf Hardware and Software combination
- Users can add signal processing code
- Software development contract

Large Scale Applications

- Dedicated Hardware and Basic Software
- Open Source contract: Users create their own code

© XIA, July 2002

Experience

XIA has the experience and the understanding necessary to make your experiments fly.

We employ eleven personnel with a PhD or B.S. in physics, nuclear physics and engineering.

We have instrumented MiniBall, a large European gamma-ray detector array.

We have collaborated with the ORNL-Warsaw group who discovered the 2-proton emission from the ground state of Fe-45.

© XIA, July 2002

Conclusion

All physics experiments are special.

XIA provides fully customizable
front-end data acquisition modules.

XIA provides complete software solutions
for its front-ends.
Set up simple experiments within days.
No programming necessary.

XIA offers a low-risk path to develop large-scale applications.

© XIA, July 2002