

# Experiment control and data acquisition using BlackBox Component Builder

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# Projects developed using BlackBox

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- Student projects at the Department of Physics and Astronomy, UofR.
  - Measurement of Light Attenuation in Plastic Scintillators.
  - Detection and Analysis of Stopping Muons.
  - Digital Signal Processing of Scintillator Pulses.
- R&D project at the Laboratory for Laser Energetics, UofR.
  - Adaptive Optics Control System for Tiled Diffraction Gratings.
- Industrial project, SkuTek Instrumentation.
  - Data acquisition and instrument control for multichannel waveform digitizer DDC-8.

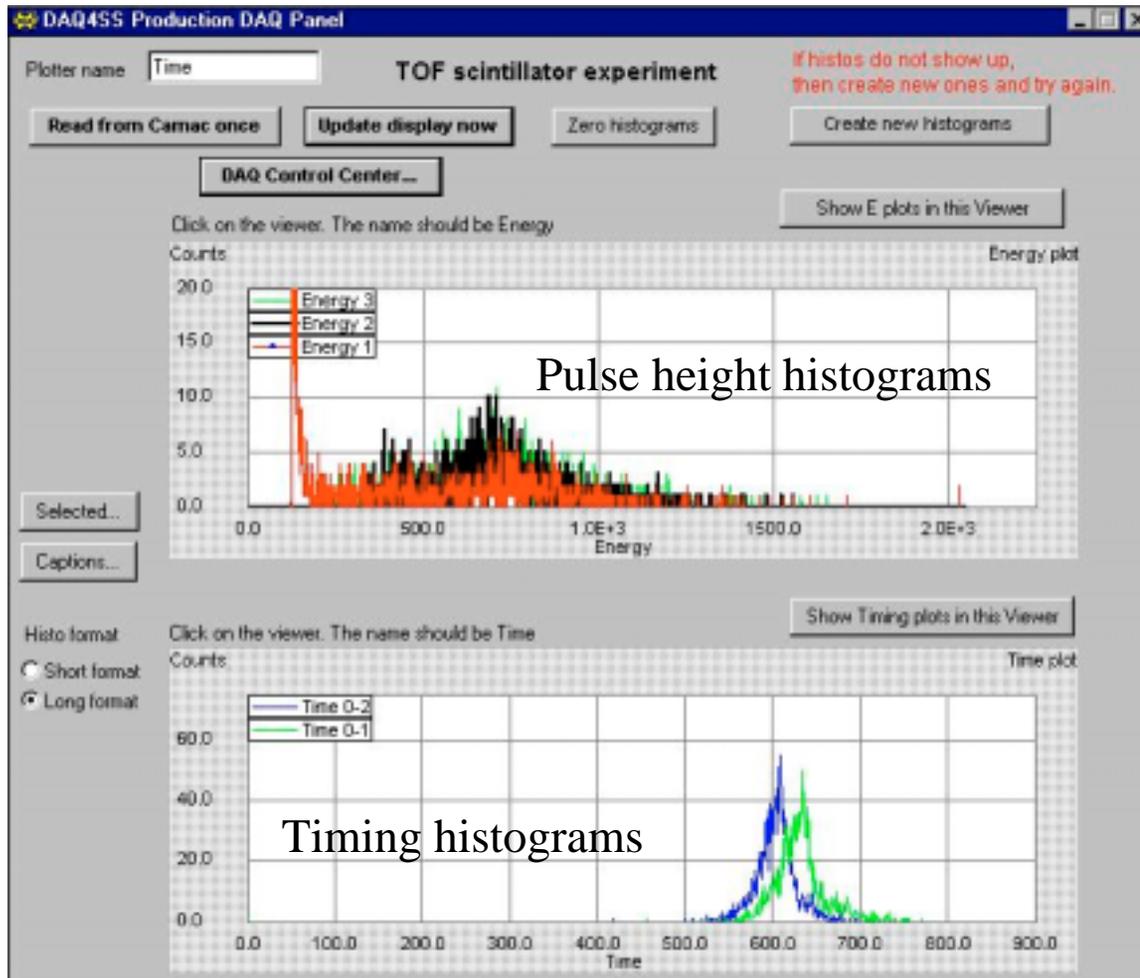
# Why BlackBox and Component Pascal?

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- Very robust runtime environment.
- No memory leaks, no dangling pointers.
- Instantaneous compile/load/debug cycle.
- Comprehensive graphics.
  - Scientific plotting by Robert Campbell, BAE Systems.
  - Waveform graphics by Wojtek Skulski, University of Rochester.
- Comprehensive math libraries by Robert Campbell.
- Easy to interface with hardware.
- Excellent support from the vendor.
- Knowledgeable user community, quick response to questions.
- Free for educational institutions.

# Measurement of Light Attenuation in Plastic Scintillators

## Student project #1

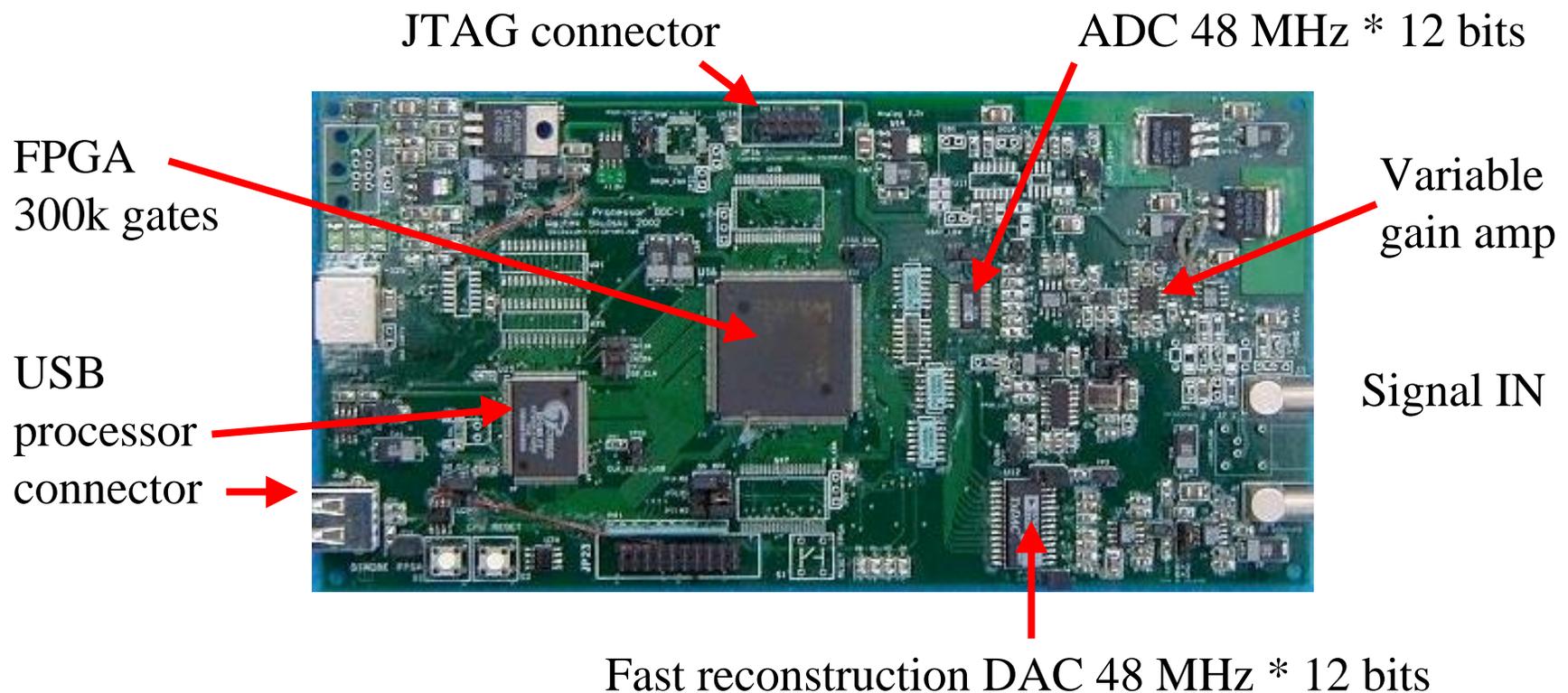


- Data acquired from CAMAC:
  - Jorway controller 73A.
  - ORTEC ADC AD811 .
  - LeCroy QDC 2249W.
- DAQ and experiment control:
  - BlackBox Component Builder.
  - Waveform graphics by WS.
- Radiation source: cosmic rays.
- Measured:
  - pulse height,
  - pulse timing.
- Analysis: correlation between amplitude and timing.

# BlackBox used as an interface for Digital Pulse Processor

## Student projects #2 and #3

- Single-channel Digital Pulse Processor DDC-1 from SkuTek Instrumentation
- Field-programmable gate array (FPGA) for waveform triggering and storage
- **BlackBox** controls DDC-1 and reads the waveforms over USB link

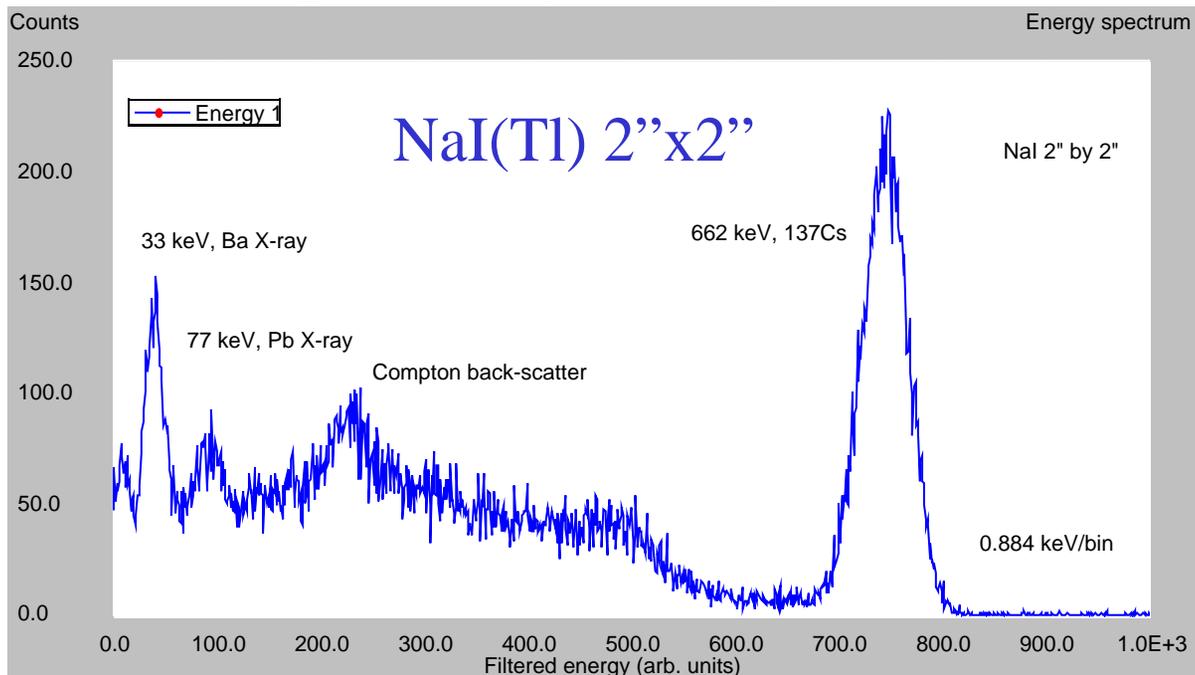


# Digital Signal Processing of Scintillator Pulses

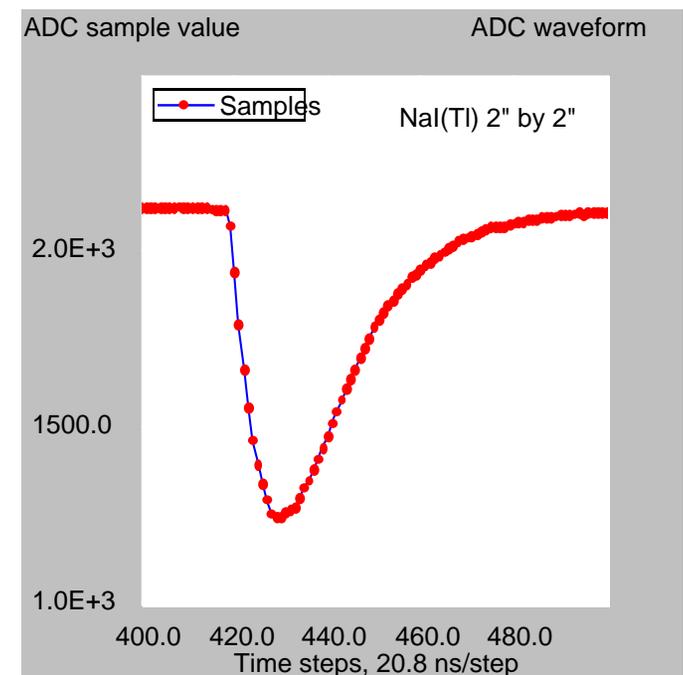
Best Senior Thesis Award '03 in the Department of Physics and Astronomy

- Signals from scintillation detectors recorded with DDC-1.
- Waveforms displayed and processed using **BlackBox**.

$^{137}\text{Cs}$  pulse-height histogram



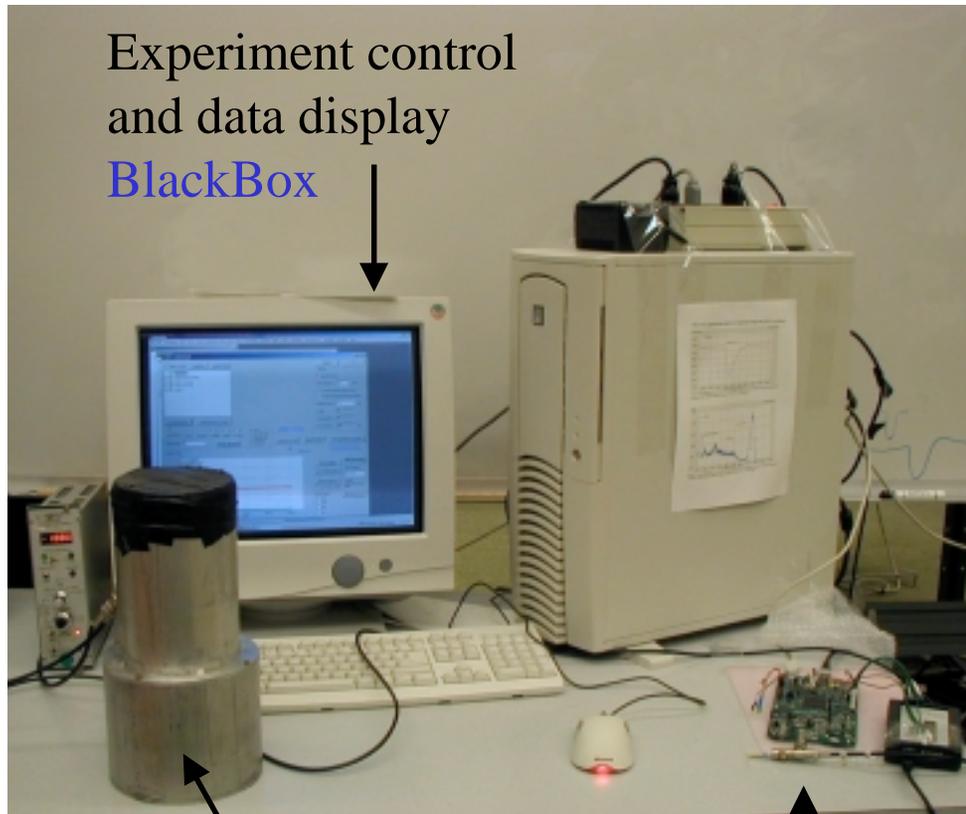
Waveform from NaI(Tl)



# Detection and Analysis of Stopping $\mu$ -mesons

2003 Summer Research Experience for Undergraduates

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- Radiation source: cosmic rays.
- Detector: BC-400 5" x 6"
- Data recording: DDC-1.
- DAQ and control: **BlackBox**.
- Analysis: **BlackBox**.
- Cosmic ray  $\mu$ -mesons stop and decay.
- Energies and lifetimes are measured.

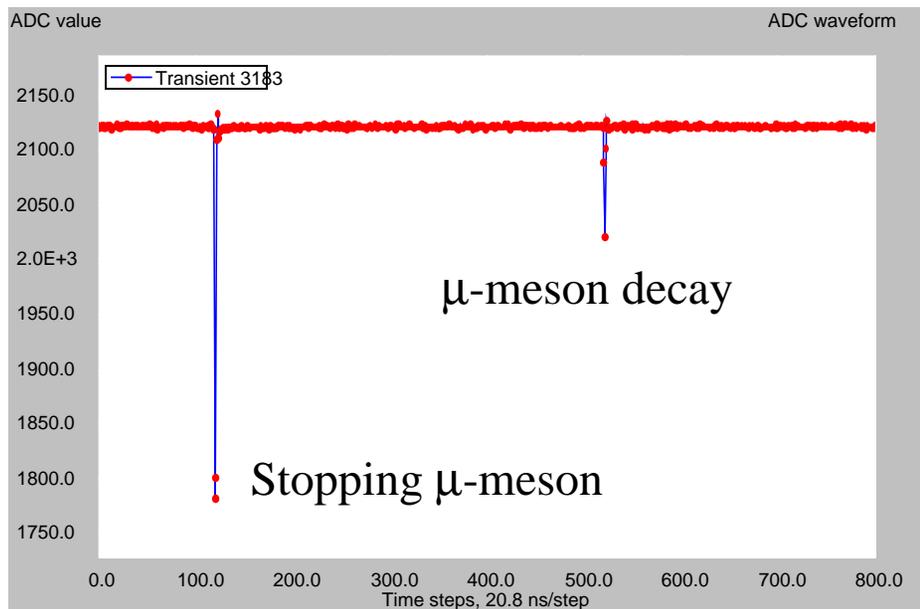
# Detection and Analysis of Stopping $\mu$ -mesons

2003 Summer Research Experience for Undergraduates

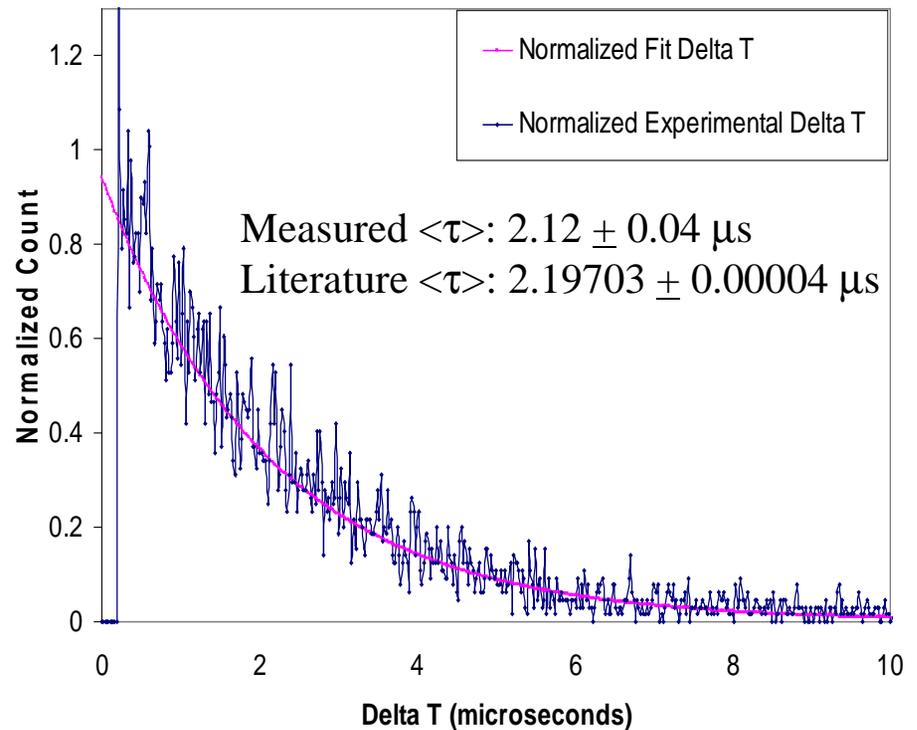
Signals from a BC-400 5''x6'' scintillator recorded using DDC-1 waveform digitizer from SkuTek, and displayed using BlackBox waveform graphics.

After 4% capture correction the measured and accepted lifetimes agree to within 0.35%.

Waveform from plastic scintillator



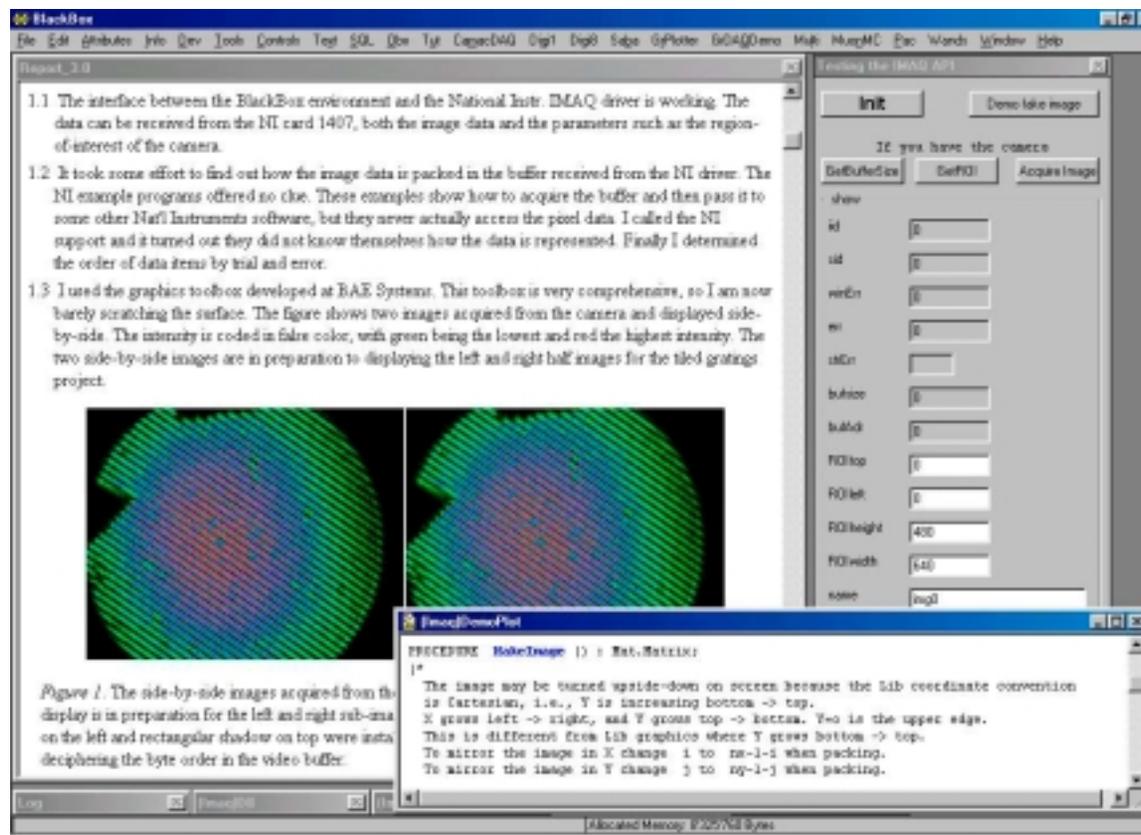
Time between leading and trailing pulses



# Adaptive Optics Control System for Tiled Diffraction Gratings

## Laboratory for Laser Energetics, University of Rochester

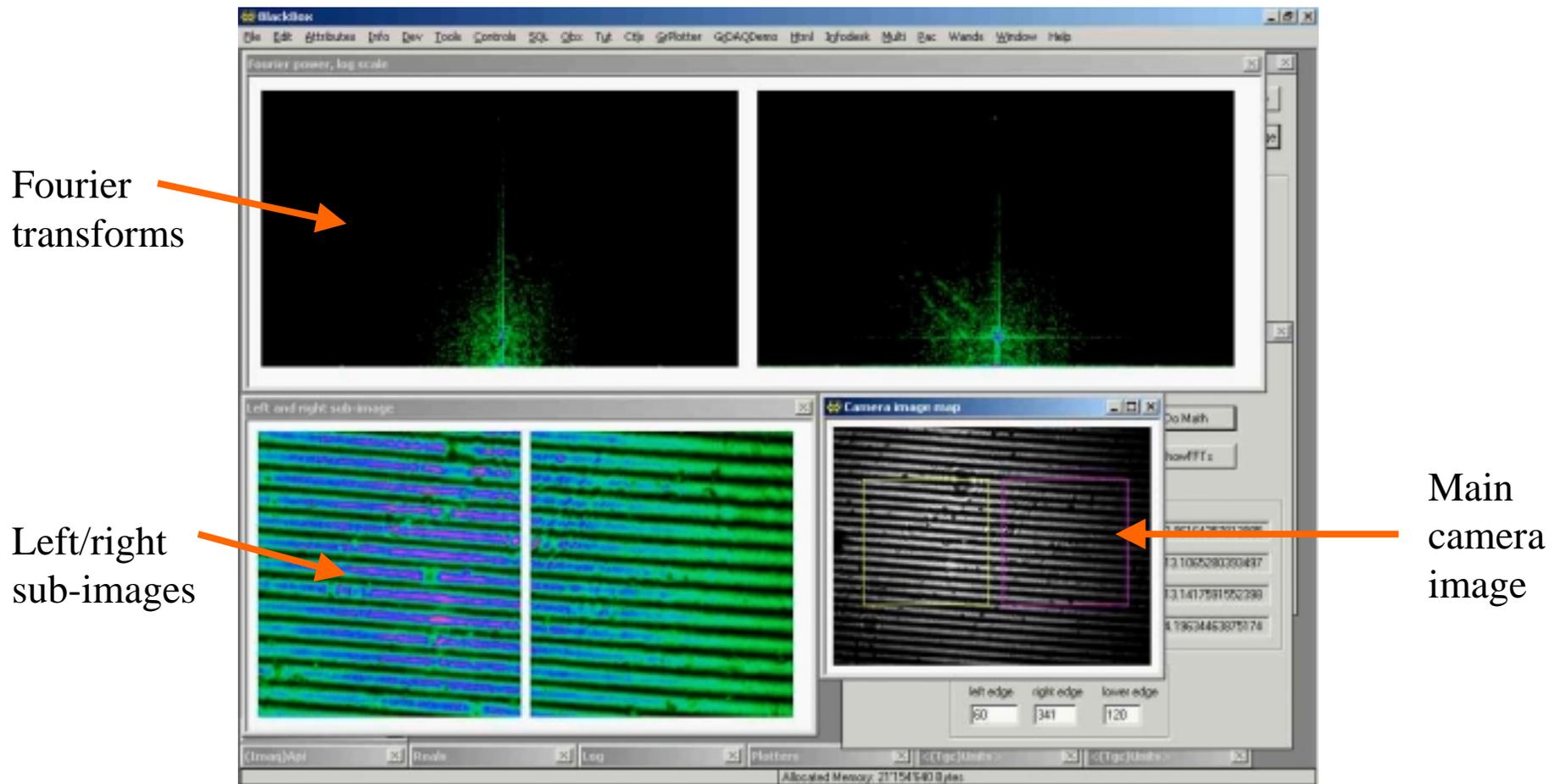
The project started in February/2004. Positions of tiled diffraction gratings will be controlled by BlackBox in a closed loop, based on CCD camera images. The screenshot shows false-color diffraction images embedded in the BlackBox document editor. The images were acquired by a [BlackBox](#) program directly from a CCD camera.



# Adaptive Optics Control System for Tiled Diffraction Gratings

## Laboratory for Laser Energetics, University of Rochester

Fourier transform maps calculated by **BlackBox**, based on data acquired by a **BlackBox** program directly from a CCD camera. Many thanks to Robert for his magnificent graphics!



# DAQ and control for 8-channel waveform digitizer DDC-8

Industrial project, SkuTek Instrumentation

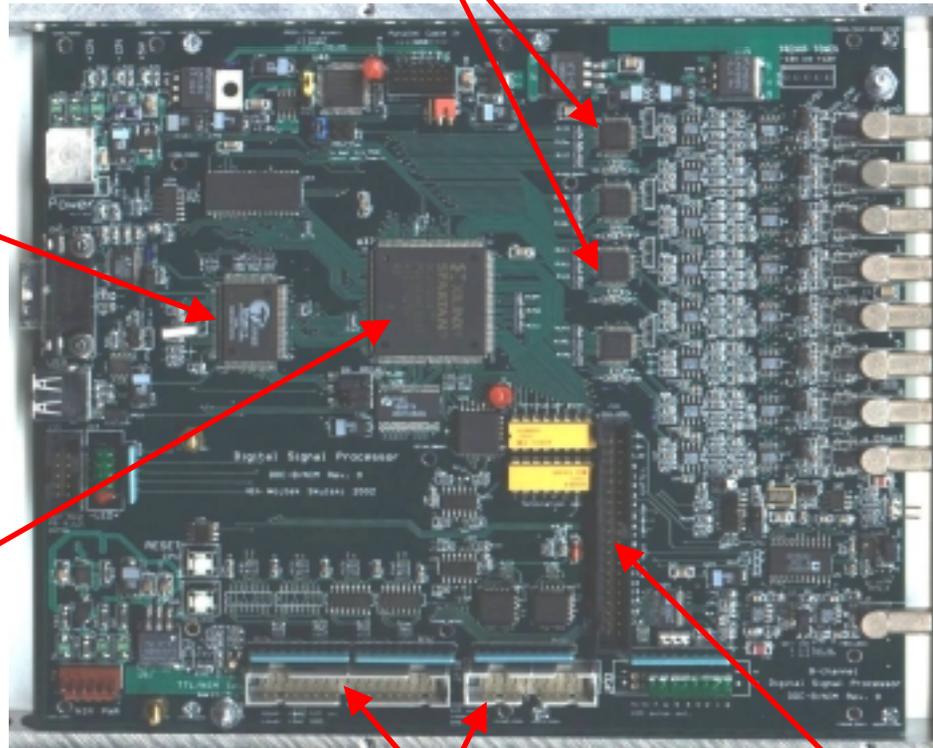
ADC 40 MHz \* 10 bits, 8 channels

micro  
processor

RS-232

USB

FPGA



Analog  
signal IN  
8 channels  
with  
digital offset  
and gain control

ECL clock IN  
(optional)

Signal OUT  
40 MHz \* 10 bits

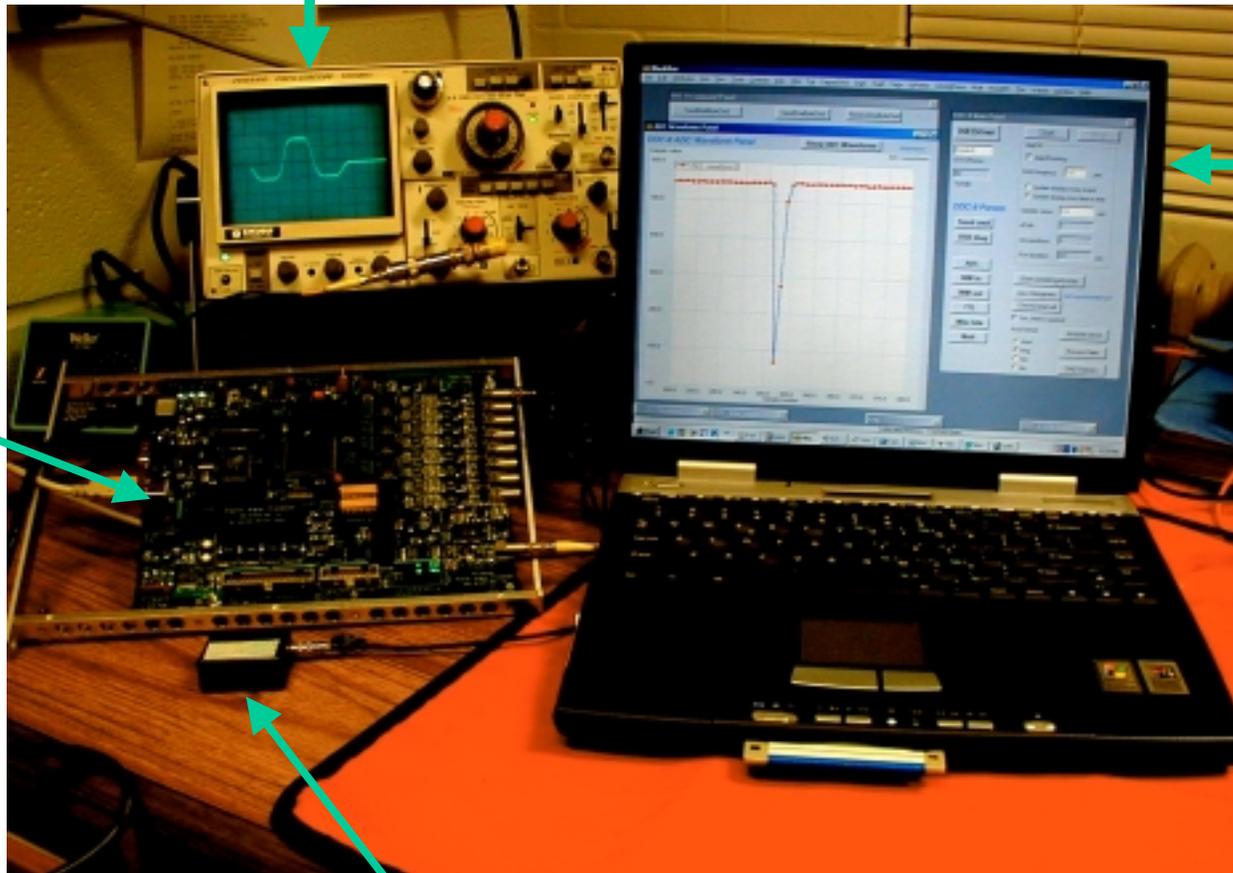
Logic signals NIM  
16 lines IN, 8 lines OUT

16 bidirectional TTL lines + 1 in  
(fast parallel interface to VME)

# DDC-x development system using BlackBox

Industrial project, SkuTek Instrumentation

Analog signal reconstruction: digital FIR filter output



Control &  
waveform  
display:  
BlackBox

DDC-8

NIM pulser

# DDC-x software development using BlackBox

The screenshot displays the BlackBox software interface. The main window is titled "BlackBox" and contains several panels:

- DDC-1 Main DAD Panel:** This panel includes a "DDC-1 Panel" with an "Init Device" button. Below it are input fields for "sDriverName" (Ezusb-0) and "handle" (116). A graph shows "Counts" vs "Energy" with peaks labeled "Energy 1 137 Cs" and "33 keV, Ba X-ray". Below the graph are radio buttons for "end" (0-4) and a "Setup Device" button.
- Sample value:** A graph showing "Sample value" vs "Sample number" with a red line labeled "Samples" showing a sharp dip.
- Digi8\_Report\_Nal:** A report window titled "4. DDC-8 software development environment." containing text about software development for measurements.

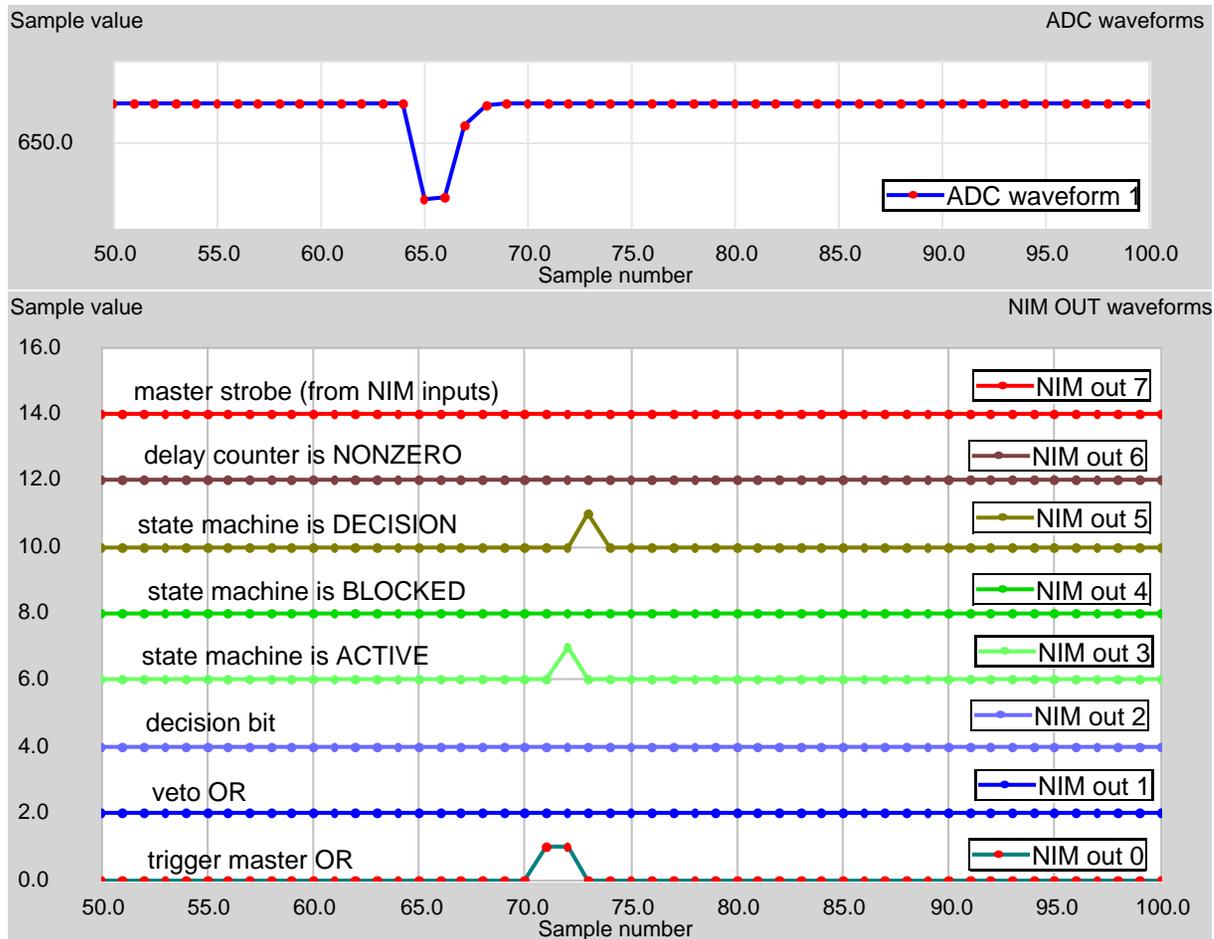
The text in the Digi8\_Report\_Nal window reads:

4. DDC-8 software development environment.

The software development for the measurements took one afternoon. The software includes filtering algorithms, histogramming, as well as the GUI specific for the data collection. Existing I communication and control software was used to host the experiment. This rather rapid development possible thanks to the "rapid development environment" used for the DDC-8 software. This report composed, using the same environment, while the data acquisition from DDC-1 was in progress demonstrates this feature, which turns out quite convenient in practice.

# Example of real-time waveform display

## DDC-8 control and graphics: BlackBox Component Builder



# Summary

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- Several projects were successfully developed using BlackBox.
- Students could learn BlackBox programming very rapidly.
- BlackBox and Component Pascal provide robust development system: excellent debugger, no memory leaks, no dangling pointers.
- Instantaneous compile/load/debug cycle helps to meet deadlines.
- BlackBox is easy to interface with hardware.
- Excellent support provided by the vendor.
- Knowledgeable user community, quick response to questions.
- Free for educational institutions.

# Acknowledgements

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- I wish to thank the following persons and institutions:
- Oberon Microsystems for making BlackBox freely available to educational institutions, for their generous help, and for many discussions.
- Robert Campbell for help and many discussions.
- Fyodor Tkachov for never giving up.
- Professor Frank Wolfs, University of Rochester.
- BlackBox user community.
- SkuTek Instrumentation.
- Students: Susanne Levine, Daniel Miner, Len Zheleznyak , Saba Zuberi.