Software Aspects of Data Acquisition

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Overview

- Requirement of DAS Software for CAMAC, VME and Digital
- Programs were specifically written in individual labs in those days
- VME Systems continued as of today
- Digital Systems taking over
- XIA Supplies complete software
- CAEN Supplies complete software (but many features missing)
- Supplied software is good for monitoring raw spectra, but physics analysis not possible. Many labs just monitor the incoming data with no intent of online analysis
- CAEN - Compass will provide a link to the data stream allowing users to attach their own software
- In house built DSP-FPGA systems will require custom software
- Study of software concepts will help students to understand better
- Present talk explains the software concepts in the context of LAMPS

Evoloution of LAMPS

Linux **A**dvanced **M**ulti **P**arameter **S**ystem

In 2000: AMPS (on Windows)
Single CAMAC Crate
Controller: CC2000 (built at BARC)
Used for First Inga Campaign at TIFR in 2001
Program written by ELD (BARC) in Microsoft Visual C++

LAMPS: From 2001 to present (practically phased out)
Versions for various CAMAC controllers including 2 CAMAC crates

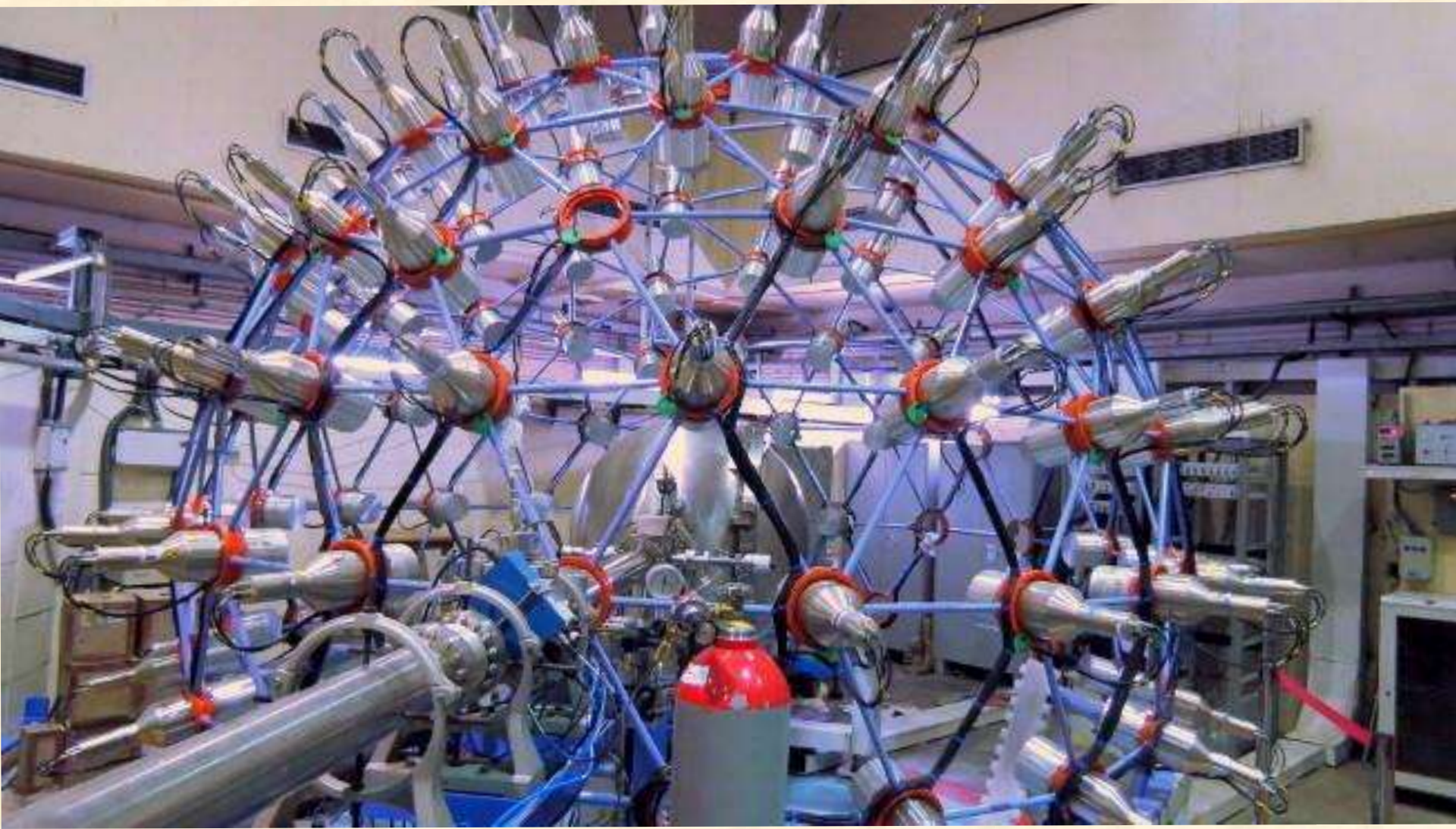
LAMPS_VME: From 2009 to present

LAMPS_OFFLINE with optional ROOT Capability: From 2012 to present

Scattering Chamber at BARC - TIFR

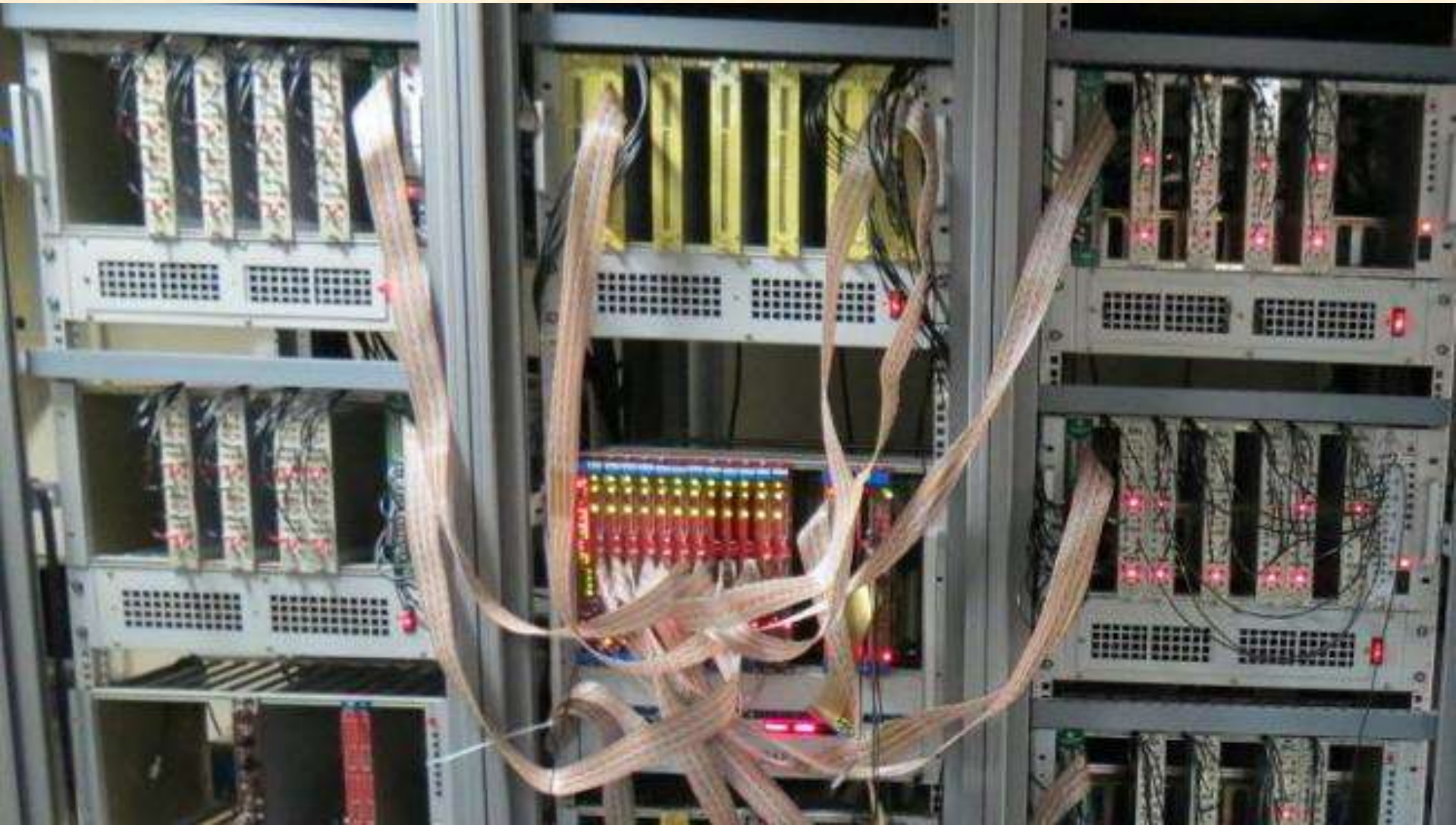
NAND ARRAY AT IUAC

100 neutron detectors
TOF path 175 cm



VME Data Aquisition System at NAND

- LAMPS from 2009 to 2019
- 2019 onwards: ROSE-NIAS



DAQ Systems in India

CAMAC

Controllers: BARC, IUAC, CMC-100, Kinetic
Modules: BARC, IUAC, ORTEC, CAEN, LeCroy, Phillips
CANDLE, FREEDOM at IUAC
LAMPS at BARC-TIFR (in use also at IUAC and VECC)
CAMACDAQ at VECC

VME

VMEDAQ at VECC Kolkata first VME system in India (around 2008)
LAMPS_VME at BARC-TIFR and NAND-IUAC (around 2010)
ROSE-NIAS at IUAC (2019)

DIGITAL

XIA System at TIFR (around 2010)
CAEN Digital systems:
Tabletop digitisers
VME Module digitizers
CoMPASS: Multiparametric DAQ Software for Physics Applications

Testing a DAS System

- Speed, Dead Time, Throughput
- Random events
- Measurement using regular pulser, random pulser, oscilloscope and scalers

$$f = n\tau/(1 + n\tau) \qquad (non - paralyzable\ model)$$

- Testing by simulated data separates hardware and software dead-times, resolves software *errors* and *mistakes.* Improvement in software.
- Testing with detectors and source - additional detector deadtime and pileup
- In-beam testing (never done for LAMPS)

Software Considerations

Choice of Operating System

Windows not a good choice

(Security, Malware/Virus, Unresponsive)

PIXIE-VIEWER (XIA, TIFR 2010) on Windows

AMPS (BARC-TIFR) on Windows

Realtime OS not needed on user side

Linux: much better choice

HARDWARE ACCESS

- Low level driver written for CAMAC CC2002

Probably not a requirement any more

- Higher level drivers for CAMAC Controllers

C-1111 (CAEN), CCUSB (WIENER), CMC-100

May require if building own FPGA-DSP System

- CAEN Library used for CAEN VME Controller

Manufacturers now providing complete software for digital DAQ (CAEN ComPASS, XIA PIXIE-VIEWER)

SOFTWARE COMPONENTS

- GUI
- Acquiring Data Buffers (Usually 2 buffers)
- Writing the acquired data buffers to disk
- Processing the list-data into (gated) histograms
- Updating status of acquisition, scalers etc
- Updating screen view of histograms

LANGUAGE

C/C++ most suitable

Most of LAMPS is C

FORTRAN for the user module

C++ for parts linked with ROOT

TOOL KITS

X Motif
Tcl / Tk
GTK 4
Qt
FLTK
ROOT GUI Classes

Candle, Freedom
One of the oldest toolkits
LAMPS uses GTK 2

Design Features

Keep it simple!

Multi-threaded with 2 data buffers

GUI at top level + 2 main threads

1. Acquire Buffers alternately and write to disk
2. Process the previous buffer

(Abort processing if next buffer ready)

Why not 3 buffers and 3 threads?

Hardware acquisition part kept completely separate from rest of software

- Allows separate versions for different hardware
- Allows simulated acquisition for testing and student learning
- LAMPS_OFFLINE for data analysis

FILE FORMATS – LIST MODE FILES

LAMPS zls
Freedom/Candle: 001
RADWARE
Many formats used in other labs (in the old days!)
ROOT

List Files de-mystified: CSV
Compression, Zero suppression and Ease of analysis (Column/Row)

Supported list file formats in LAMPS_OFFLINE:

LAMPS	zls
Freedom/Candle	001
Excel	csv
Root	root

FILE FORMATS – HISTOGRAMS

Less important, because histograms are to be built from list files

ROOT:

One Dimensional: TH1C, TH1S, TH1I, TH1F, TH1D

Two Dimensional: TH2C, TH2S, TH2I, TH2F, TH2D

LAMPS:

Has its own formats with choice between S and I only

LIST FORMAT for DIGITAL DAQ is very different

IEC 63047:2018

Data format for list mode digital data acquisition

Timestamp, energy information

Possibly also digital signals or properties like rise time or sub-areas of signals (useful for PSD)

Conversion of these digital DAQ outputs to conventional ADC List Data in ROOT format

Provided by manufacturer (CAEN)

PHYSICS ANALYSIS

ROOT:

Requires to write macros / programs in C++

Library of macros / programs needed

TCUTG (graphical cut)

Limited GUI features

LAMPS:

Calibration of parameters

Auto calibration for ^{152}Eu

Built in Pseudo Parameters (Virtual ADCs)

Banana gates

Gamma-Gamma Matrix

Spectrum analysis tools

Thank you