Software Project for Hall B 12 GeV Upgrade

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Software Review
Jefferson Lab
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Outline

- Introduction to Hall B Upgrade
- Science Program
- Requirements
- Scope Overview
- Project Management and Organization
- Schedule and Manpower
- Summary


Hall B, CLAS: Dec 1997- May 2012

CEBAF *L*arge *A*cceptance *S*pectrometer (*CLAS*)

Torus magnet
6 superconducting coils

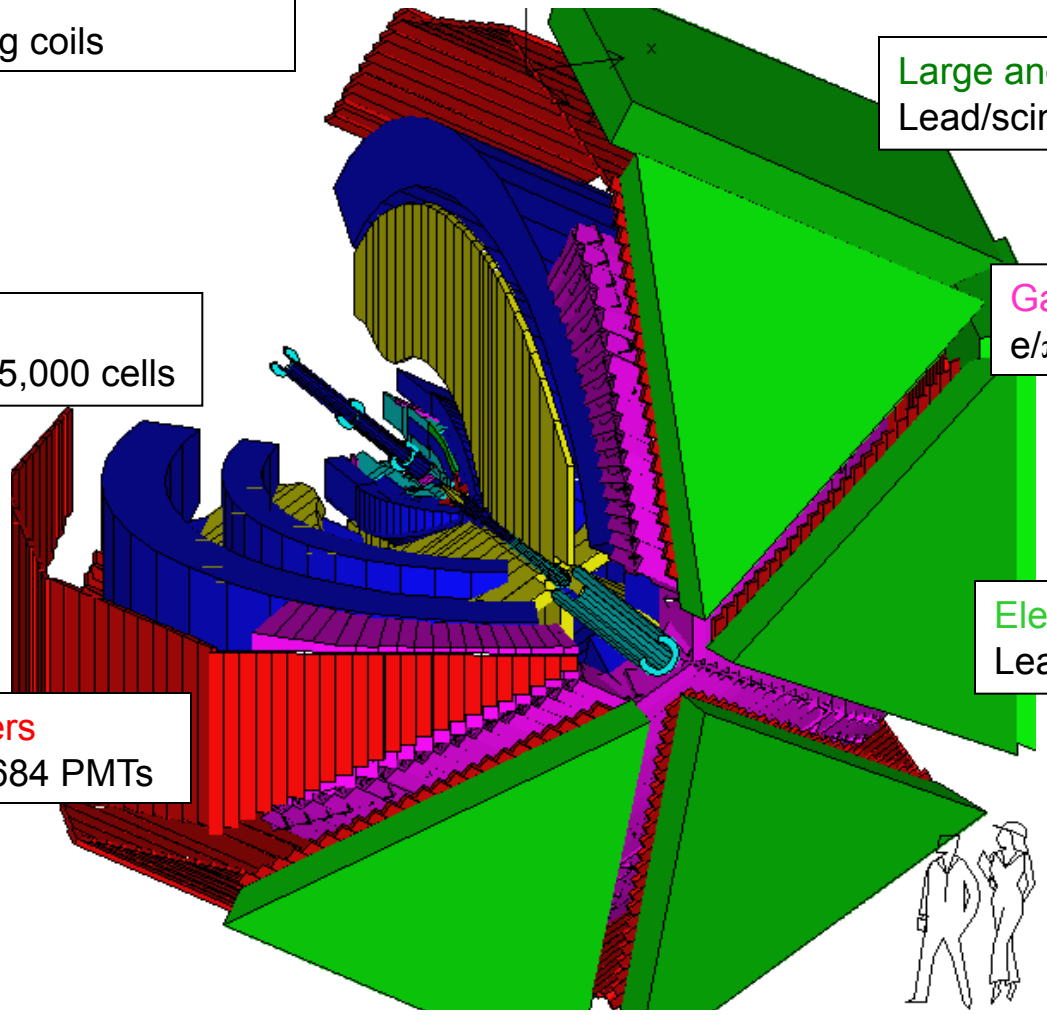
Large angle calorimeters
Lead/scintillator, 512 PMTs

Drift chambers
argon/CO_2 gas, 35,000 cells

Gas Cherenkov counters
e/π separation, 216 PMTs

Electromagnetic calorimeters
Lead/scintillator, 1296 PMTs

Time-of-flight counters
plastic scintillators, 684 PMTs



CLAS12 - Initial 12 GeV Physics Program

- **Generalized Parton Distribution and 3D-Imaging of the Nucleon**
  - Deeply Virtual Compton Scattering - DVCS
  - Deeply Virtual Meson Production at low/high t
- **Valence Quark Distributions**
  - u- and d-Quark Spin Distributions in Proton and Neutron
  - Neutron Structure Function $F_2^n(x,Q^2)$, d/u
  - Transverse Momentum Distribution Quark Distribution Functions in SIDIS
- **Form Factors and Resonance Excitations**
  - The Magnetic Structure of the Neutron – G_M^n
  - N* Transition Form Factors at high Q^2
- **Hadrons in the Nuclear Medium**
  - Space-Time Characteristics of Quark Hadronization
  - Color Transparency
  - Short Distance Dynamics of Light Nuclei
- **Meson and Baryons Spectroscopy**

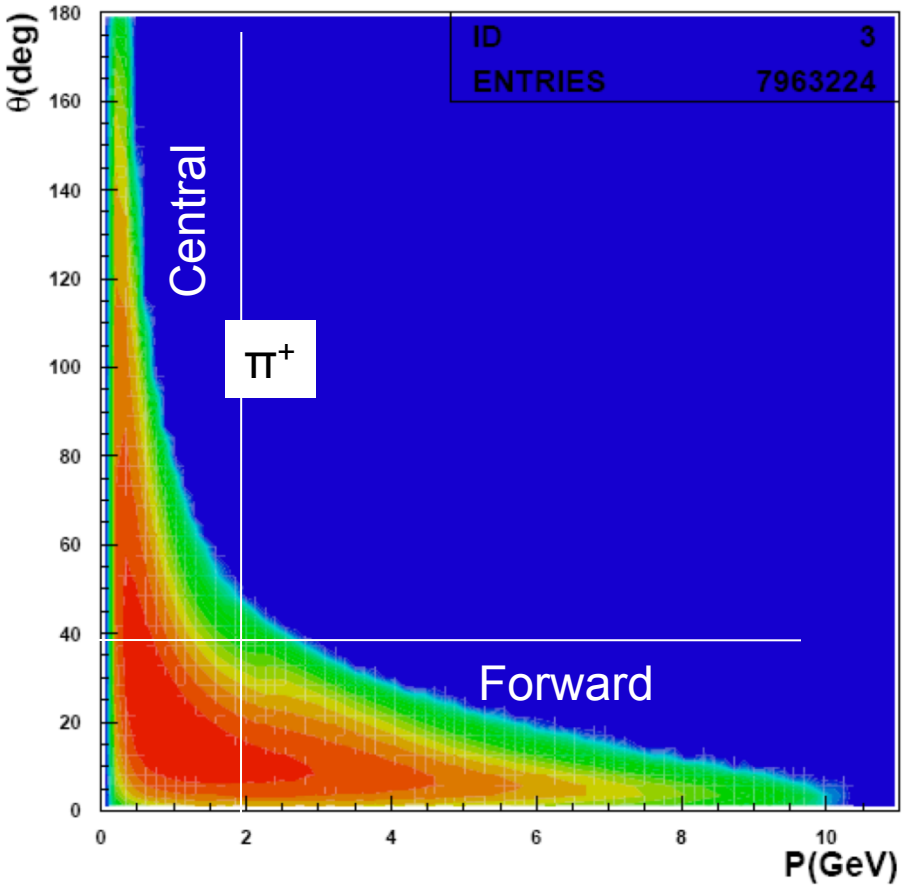
CLAS12 - PAC Approved Experiments

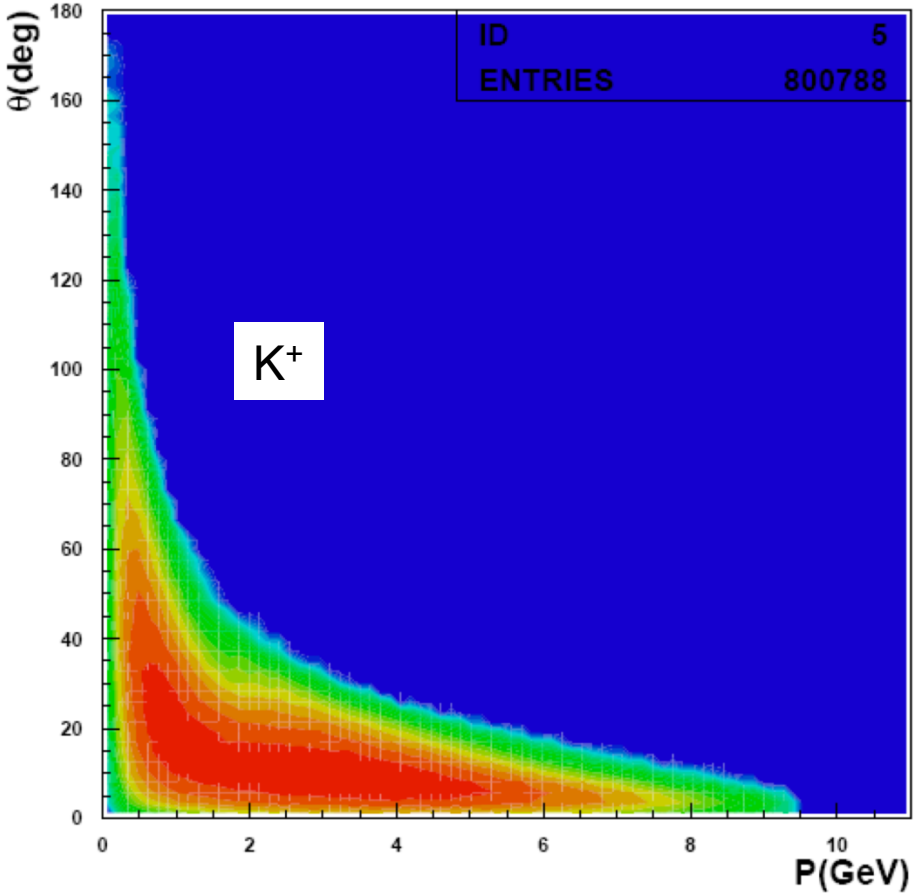
Proposal	Physics	Contact	Rating	Days	Group	New equipment	Energy	Group	Target
E12-06-108	Hard exclusive electro-production of π^0, η	P. Stoler	B	80	119	RICH IC Forward tagger	11	RG-A F. Sabatié	liquid H_2
E12-06-112	Proton's quark dynamics in SIDIS pion production	H. Avakian	A	60					
E12-06-119	Deeply Virtual Compton Scattering	F. Sabatie	A	80					
E12-09-103	Excitation of nucleon resonances at high Q^2	R. Gothe	B+	40					
E11-005	Hadron spectroscopy with forward tagger	M. Battaglieri	A-	119					
PR12-11-103	DVMP of ρ, ω, φ	M. Guidal		D					
E12-07-104	Neutron magnetic form factor	G. Gilfoyle	A-	30	90	Neutron detector RICH IC	11	RG-B K. Hafidi	liquid D_2 target
PR12-11-109 (a)	Dihadron DIS production	Avakian		D					
E12-09-007a	Study of partonic distributions in SIDIS kaon production	K. Hafidi	A-	56					
E12-09-008	Boer-Mulders asymmetry in K SIDIS w/ H and D targets	M. Contalbrigo	A-	TBA					
11-003	DVCS on neutron target	S. Niccolai	A	90					
E12-06-109	Longitudinal Spin Structure of the Nucleon	S. Kuhn	A	80	170	Polarized target RICH IC	11	RG-C S. Kuhn	NH_3 ND_3
E12-06- 119(b)	DVCS on longitudinally polarized proton target	F. Sabatie	A	120					
E12-07-107	Spin-Orbit Correl. with Longitudinally polarized target	H. Avakian	A-	103					
PR12-11-109 (b)	Dihadron studies on long. polarized target	H. Avakian		D					
E12-09-007(b)	Study of partonic distributions using SIDIS K production	K. Hafidi	A-	110					
E12-09-009	Spin-Orbit correlations in K production w/ pol. targets	H. Avakian	B+	103					
E12-06-106	Color transparency in exclusive vector meson production	K. Hafidi	B+	60	60		11	RG-D	Nuclear
E12-06-117	Quark propagation and hadron formation	W. Brooks	A-	60	60		11	RG-E	Nuclear
E12-10-102	Free Neutron structure at large x	S. Bueltman	A	40	40	Radial TPC	11	RG-F	Gas D_2
PR12-11-109	SIDIS on transverse polarized target	M. Contalbrigo		C2		Transverse target	11	RG-G	HD
TOTAL run time				1231	539				

Note: Color code shows experiments that will take data in parallel

Distribution of π^+, K^+ in DIS Kinematics

$e^-p \rightarrow e^-hX$, $h=\pi^+, K^+$





CLAS12

Forward Detector (FD):

- TORUS magnet (6 coils)
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter

Central Detector (CD):

- SOLENOID magnet
- Barrel Silicon Tracker
- Central Time-of-Flight

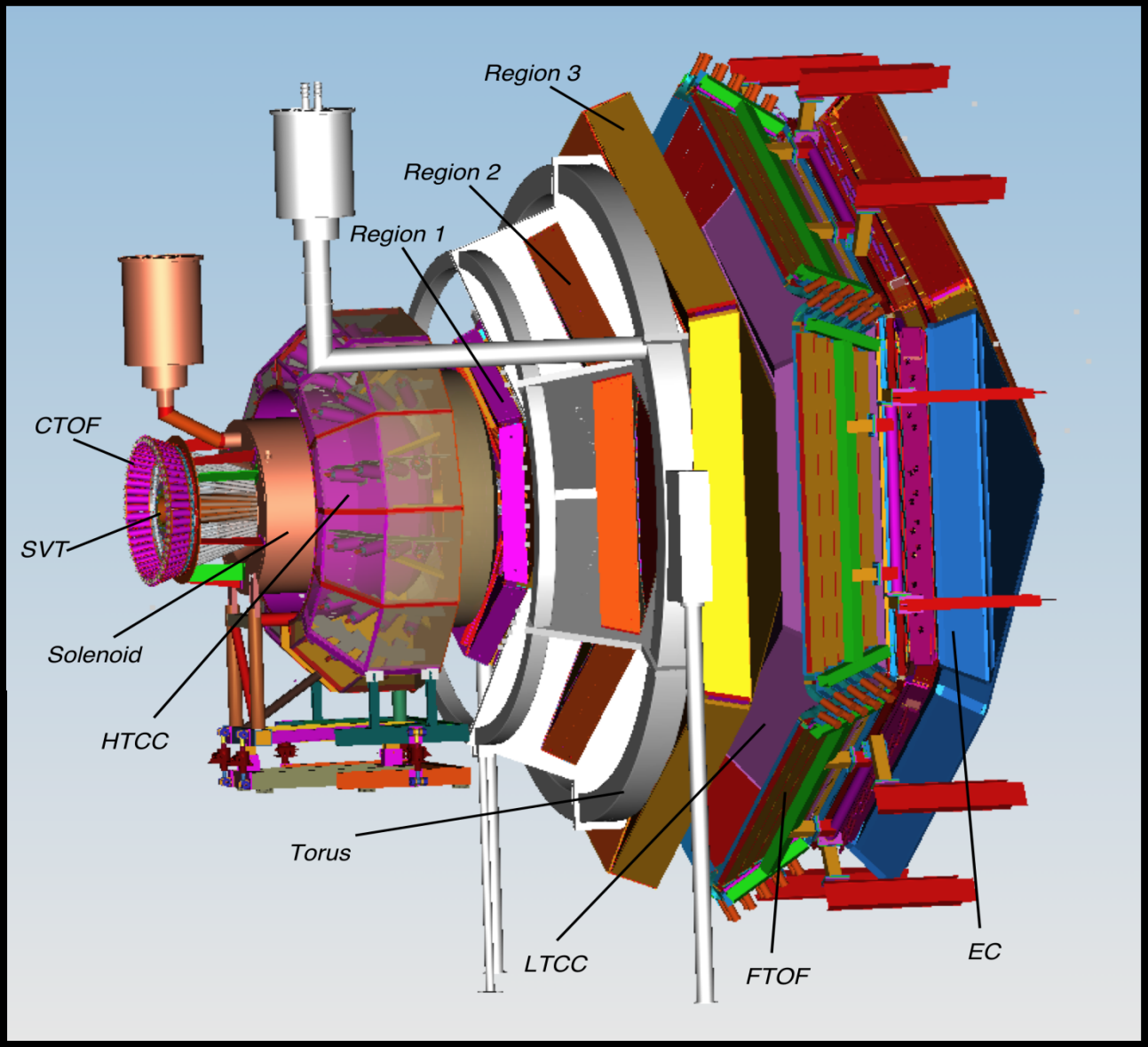
Upgrades to the baseline:

<u>Under construction</u>

-Micromegas (CD)
-Micromegas (FD)
- Neutron detector (CD)
- Forward Tagger (FD)

<u>In prototyping stage</u>

-RICH detector (FD)



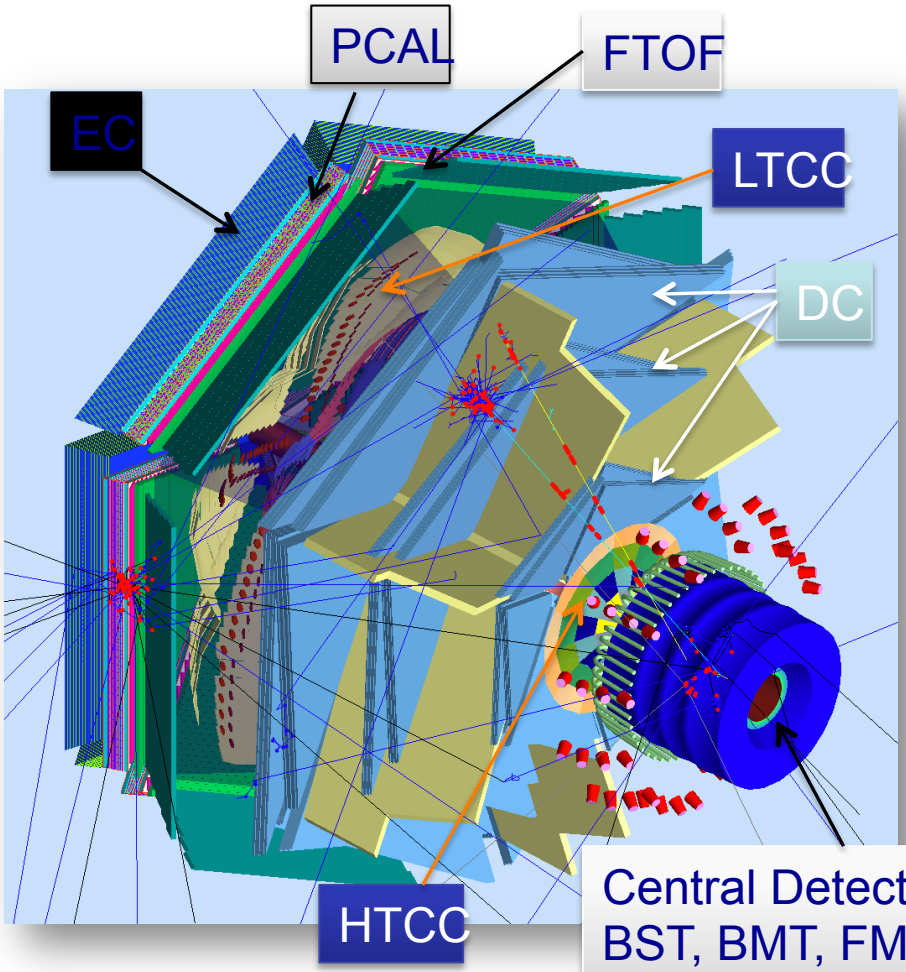
Design Luminosity $10^{35}cm^{-2}s^{-1}$

CLAS12 - Event Rates &Trigger

- **Full event and background load has been simulated in GEANT 4 for CLAS configuration and reproduces the measured hit occupancy on CLAS detectors. The calibrated simulation code was then used to simulate *CLAS12* configuration.**
- **Typical deep inelastic events contain**
  - 3.5 charged particles per event at $\theta < 35^{o}$ (Forward Detector)
  - 0.75 charged particles at $\theta > 35^{o}$ (Central Detector)
- **Total hadronic interaction rate is ~5×10^{6} sec^{-1}**
- **CLAS12 Trigger System is Level 1: reliably identify electrons (expected factor 2 improvement from new trigger logic and additional improvement from new detectors) and select multi-particle events**
- **Level 1 trigger rate is up to 10KHz (inclusive electron rate below 4KHz, non-electron triggers below 5KHz**
- **Data rate is 50-80Mb/sec for beam energies from 6.6 to 11 GeV**

GEant4 Monte-Carlo (GEMC)

- **Object Oriented Design**
  - c++ classes, Standard Template Library
- **Includes the complete CLAS12 base line**
- **Includes all detectors upgrades to CLAS12**
- **In use since 2007 for:**
  - input for detector design and optimization
  - event reconstruction
  - high level physics analysis
  - beam background
- **No hardcoded numbers: geometry, digitization from database**

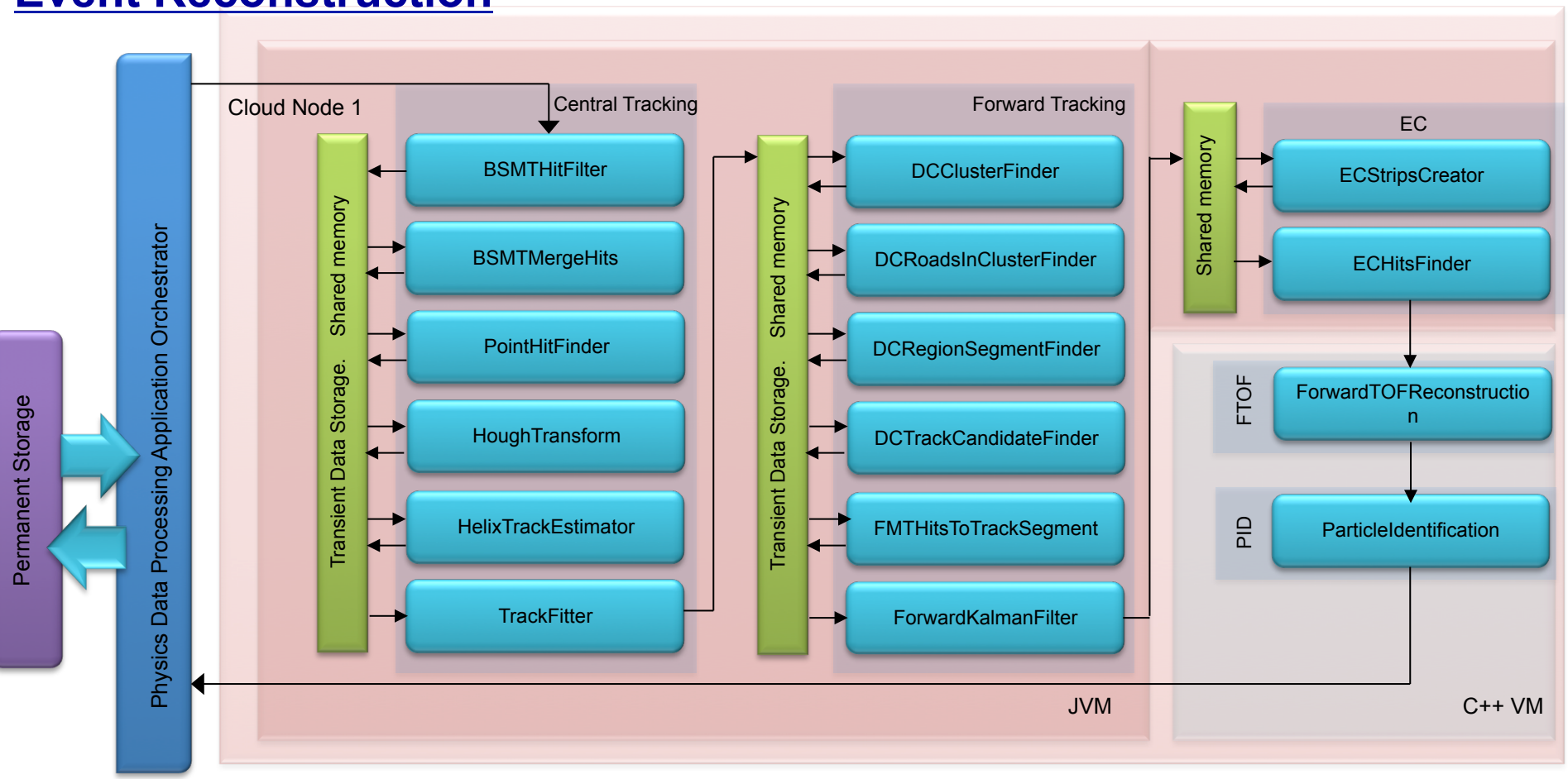


Clas12 Reconstruction and Analysis (ClaRA) Framework

A multi-treaded analyses framework, based on Service Oriented Architecture (SOA)

SOA is a key architecture choice for ClaRA to leverage cloud computing

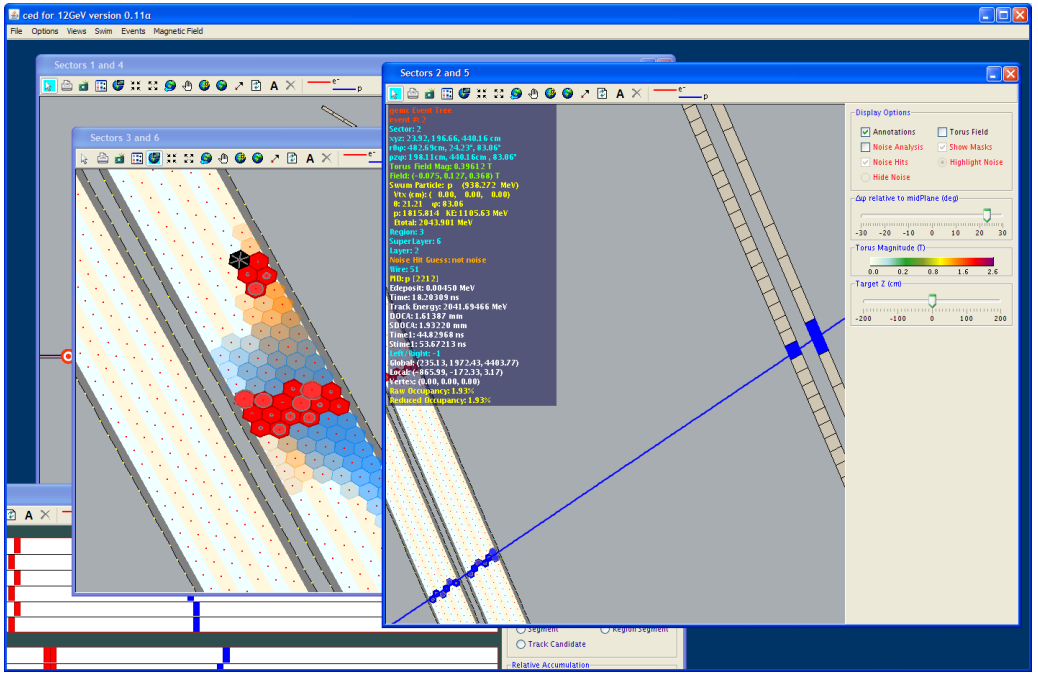
List of services successfully developed and tested using ClaRA for Event Reconstruction



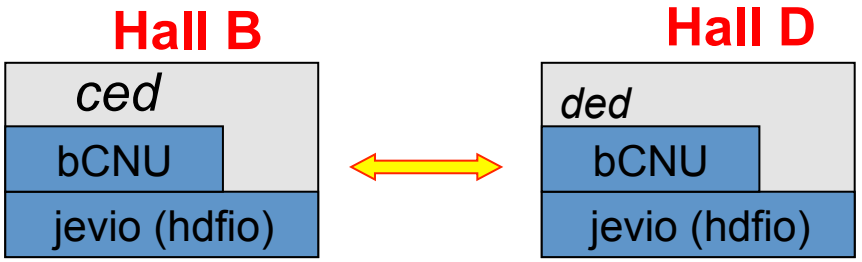
CLAS12 - Event Display

- **ced (cLAS eVENT dISPLAY) has been operating since 1995. It is used for online detector diagnostics and offline analysis support.**

- **It is being entirely rewritten for the 12 GeV upgrade to leverage modern technology**
  - **A modern object-oriented computer language (JAVA)**
  - **A modern structure– Service Oriented Architecture (SOA)**
  - **With ClaRA as the service container**



Christopher Newport University(CNU)



Goal:

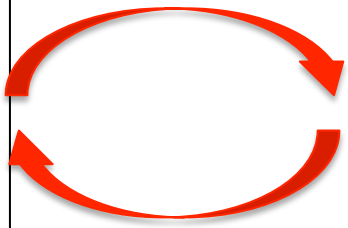
Common features for Hall D and Hall B are developed in *bCNU* (or migrated to *bCNU*) with the intent that the *ced* and *ded* code bases are <~ ¼ the size of the *bCNU* code base.

CLAS12 - Calibration and Commissioning (CalCom)

- The development of detailed **COMMISSIONING** and **CALIBRATION** procedures for all the ***CLAS12*** detector systems and for the whole spectrometer is crucial for an efficient startup of data taking

Commissioning Plan:

- addresses all detector systems with **coherent** plan from construction and installation phase to in-beam commissioning
- Addresses **hardware software** and **manpower** requirements
- ensures all **necessary data for the checkout and calibration** of the CLAS12 spectrometer are collected in efficient and timely manner



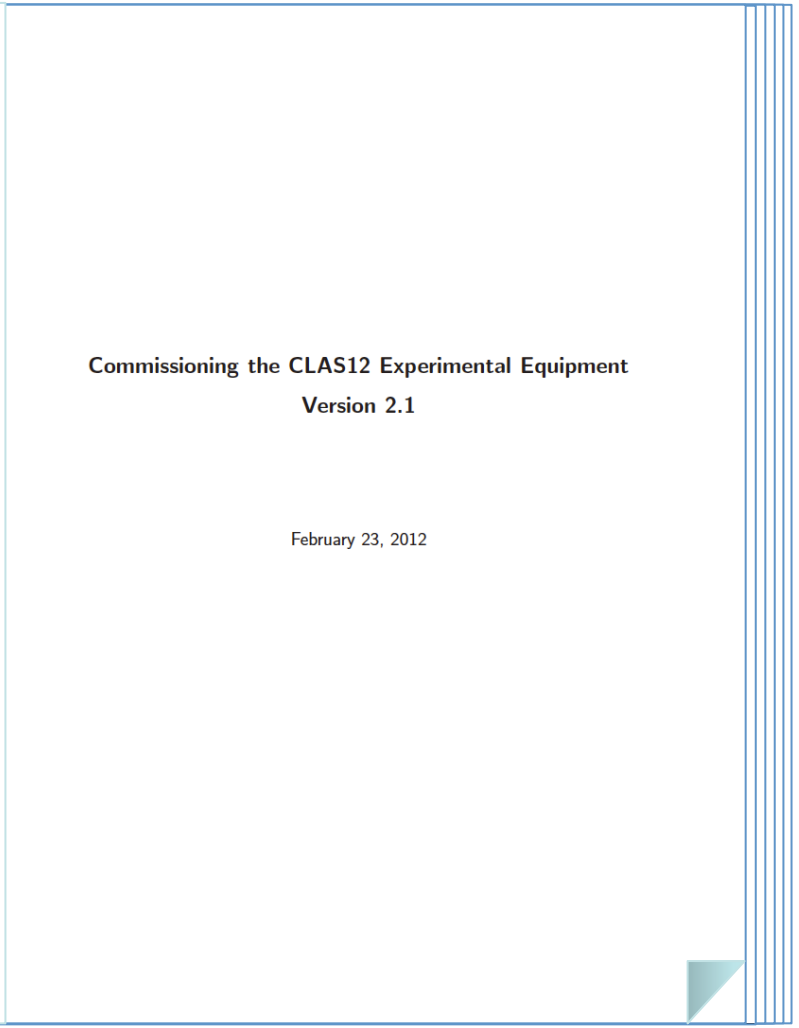
Calibration Procedures:

- develop and test procedures for **each detector systems**
- define **input data** (data type and statistics) for calibration algorithms
- develop and test necessary **software tools** needs to be developed and tested
- evaluate **manpower and computing resources** needed
- provide all relevant **parameters** to perform full reconstruction and evaluate **detector performances**

CLAS12 - Calibration and Commissioning

First version of the commissioning document completed

- Introduction: explain general strategy
- Summaries of:
  1. Quality assurance and system checkout procedures
  2. Commissioning without beam
  3. Commissioning with beam
- List of subsystems and contact persons
- Subsystem templates
- Timeline
- Planning of initial data taking for full detector checkout:
  1. Beam condition and detector configuration
  2. Test reactions for efficiency and resolution measurements

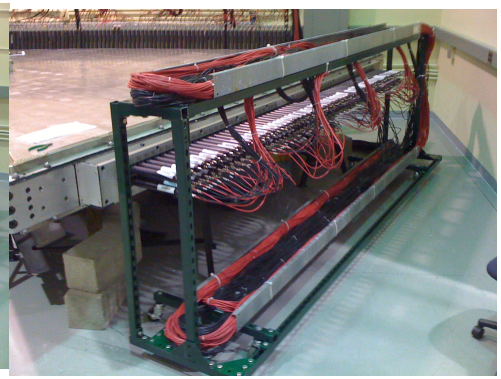


Commissioning the CLAS12 Experimental Equipment

Version 2.1

February 23, 2012

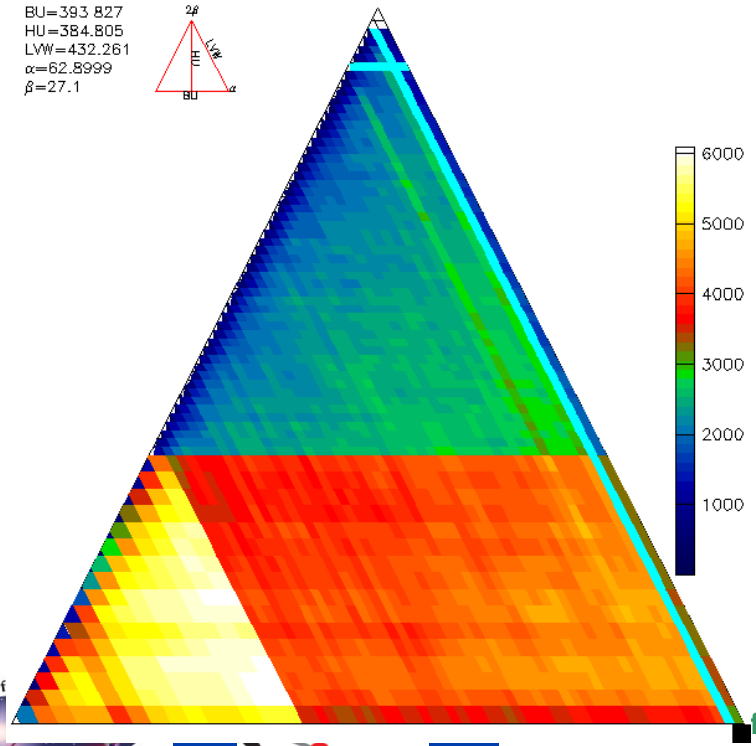
Example of Checkout and Calibration: PCAL

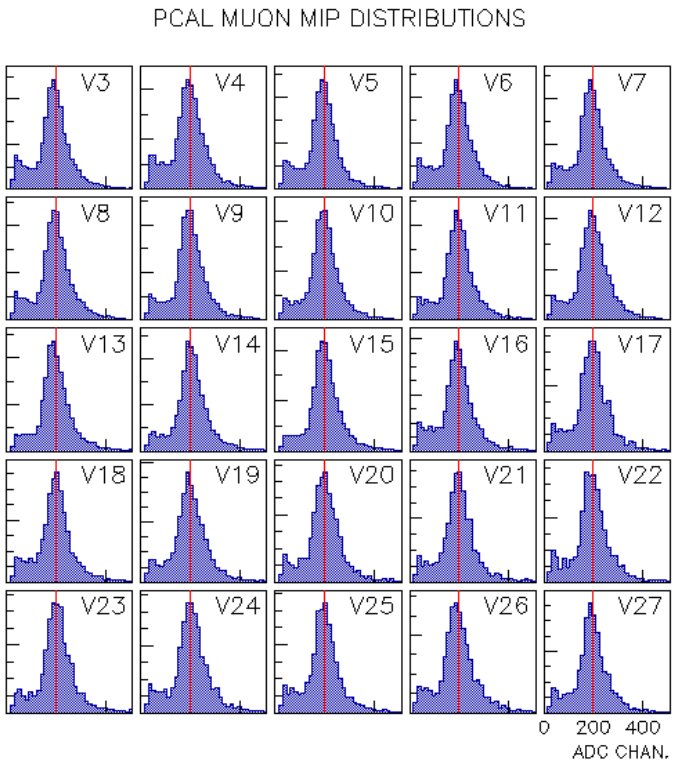


Full checkout/calibration of first sector module with cosmic rays

- PMT gain matching
- Light attenuation
- Light Yield (in progress)

Full detector calibration



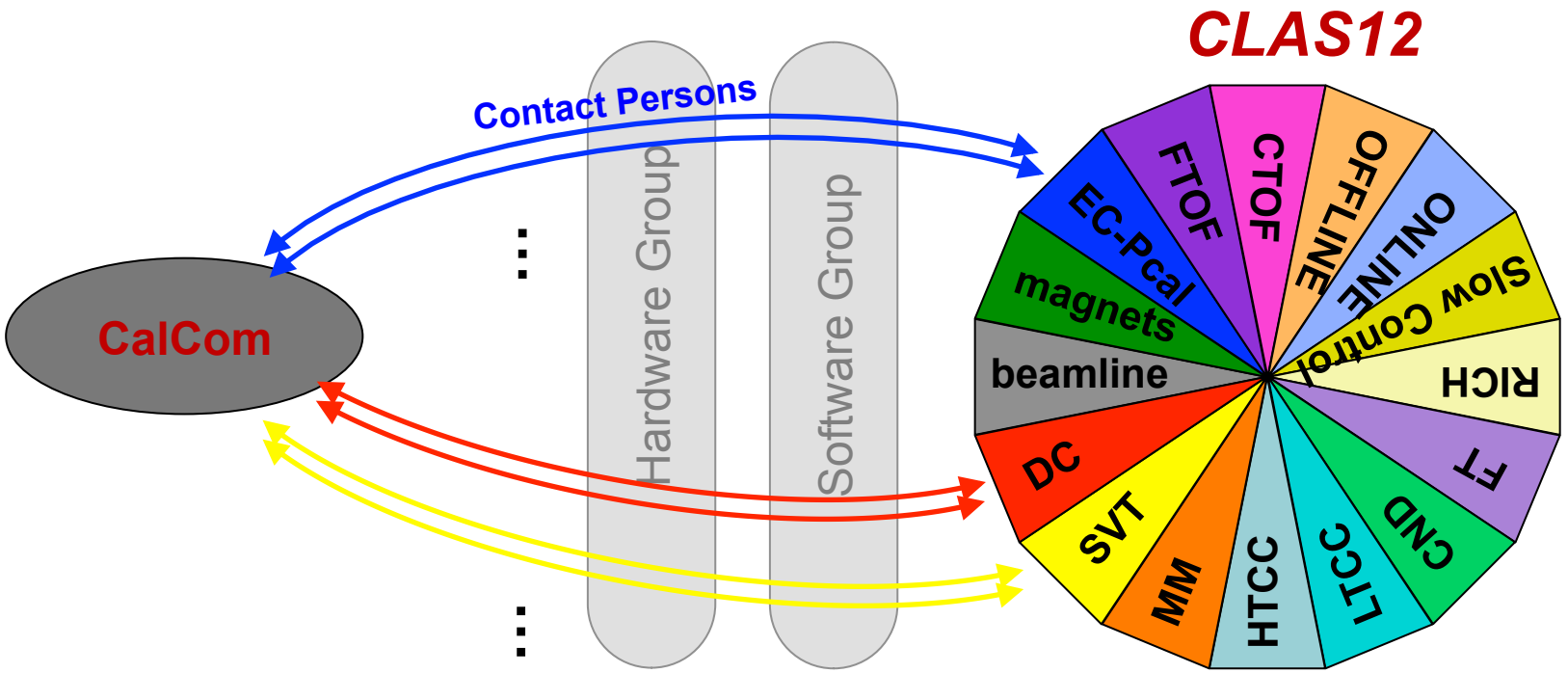


CLAS12 Software Project Organization

Name	Responsible Staff	Responsible User
Hall B Leader	**V. Burkert**	
CLAS12 Control Account Manager	**L. Elouadrhiri**	
Software Management	**D. Weygand**	**K. Hicks**
ClaRA Framework	**V. Gurjyan, D. Weygand**	**D. Heddle**
Framework	V. Gyurjyan	
Subsystem Implementation		G. Gavalian
Event Reconstruction	**M. Mestayer**	**G. Gavalian**
Charged Track Tracking	V. Ziegler	S. Procureur, S. Paul
Neutral Track Reconstruction		S. Mancilla, M. Wood, C. Smith
Electron Identification	A. Puckett, H. Avakian	
Charged Hadron Identification	A. Puckett, H. Avakian	M. Palone
Simulation (GEMC)	**M. Ungaro**	
Event Display and Monitoring	**S. Boiarinov**	**D. Heddle**
Data-Base	**Y. Prok**	**J. Goetz**
Calibration and Commissioning	**D. Carman**	**R. De Vita**
Analysis Coordination	**TBD**	**TBD**
Computing resources	**D. Weygand**	**G. Gilfoyle**

Calibration and Commissioning Organization

Two contact persons have been nominated for each subsystem



- A mechanism to strengthen the link between the ***CLAS12*** subsystem groups and the collaboration has been implemented with the definition of service work
- Joint effort of the CalCom and Service Work Committees
- Fundamental for an efficient identification and utilization of resources

CLAS12 - Institutions

Armenia:
- Yerevan Physics Institute, Yerevan

Belgium:
- Universite de Liege, Liege

Chile:
- **University Santa Maria, Valparaiso**

France:
- Grenoble University, IN2P3, Grenoble
- Orsay University, IN2P3, Paris
- **CEA Saclay, IRFU, Paris**
- CPhT, Ecole Polytechnique, Palaiseaux

Italy:
- INFN - LNF, Frascati, Roma
- INFN - University di Catania, Catania
- **INFN - Genova, Genova**
- INFN - Lecce, Lecce
- INFN - University di Bari, Bari
- INFN - University Ferrara, Ferrara
- INFN - Pavia, Universita di Pavia
- INFN - Roma I, and ISS, Roma
- INFN - University di Roma Tor Vergata, Roma
- INFN - Sez. di Torino, University di Torino

Japan:
- Japan Atomic Energy Agency, Ibaraki-Ken

Republic of Korea:
- Kyungpook National University, Daegu

Poland:
- Natioanl Center for Nuclear Research, Warsaw

Russian Federation:
- **MSU, Skobeltsin Institute for Nuclear Physics, Moscow**
- MSU, Institute for High Energy Physics, SiLab, Moscow
- **Institute for Theoretical and Experimental Physics, Moscow**
- Petersburg Nuclear Physics Institute, Gatchina, St. Petersburg

Spain:
- University of the Basque Country, Bilbao

United Kingdom:
- Edinburgh University, Edinburgh
- **Glasgow University, Glasgow**

United States of America:
- Argonne National Laboratory, Argonne, Il
- Arizona State University, Tempe, AZ
- California State University, Dominguez Hills, CA
- Catholic University of America, Washington, DC
- College of William and Mary, Williamsburg, VA
- **Christopher Newport University, Newport News, VA**
- Fairfield University, Fairfield, CT
- Florida International University, Miami, FL
- Florida State University, Tallahassee, FL
- Hampton University, Hampton, VA
- Idaho State University, Pocatella, ID
- James Madison University, Harrisionburg, VA
- Norfolk State University, Norfolk, VA
- **Ohio University, Athens, OH**
- **Old Dominion University, Norfolk, VA**
- Rensselaer Polytechnic Institute, Troy, NY
- **Temple University, Philadelphia, PA**
- **Jefferson Lab, Newport News, VA**
- University of Connecticut, Storrs, CT
- University of New Hampshire, Durham, NH
- **University, of Richmond, Richmond, VA**
- University of South Carolina, Columbia, SC
- University of Virginia, Charlottesville, VA

Highlighted institutions have major commitments to software development and detector calibration/commissioning

Time Line

Training and Accessibility

- Wikis
- Tutorials
- Workshops

Documentation

- CLAS12 Software TDR
- Calibration & Commissioning Document

Summary