

CLAS12 Forward Tracking Task Force Report



Forward Tracking Task Force

Hall-B Task Forces 2020

https://clasweb.jlab.org/wiki/index.php/Hall-B_Task_Forces_2020

Overview Analysis Framework Central Tracking Data Preservation Forward Tracking Novel Tracking Polarized Targets Particle ID Software Streaming GEMC BG Merging & Efficiency

Goal

To identify issues in current CLAS12 forward tracking and propose a path forward to obtain the maximum efficiency, resolution, and speed.

Members

- Daniel Carman (PI)
- Veronique Ziegler (core)
- Mac Mestayer (core)
- Maurizio Ungaro (external)
- Maxime Defurne (external)
- Maxence Vandenbroucke (external)

Charge

- Assess the current CLAS12 forward tracking efficiency, resolution, and execution speed
- Assess limitations in hardware, reconstruction software, calibrations, tracking algorithms, ...
- Quantify the expected improvement in efficiency, resolution, and execution time provided by the proposed solutions
- Define a work plan to move forward and provide a time chart and milestones for:
 1. Assessment
 2. Definition of alternative solutions
 3. Validation (data and Monte Carlo)
 4. Implementation in the current reconstruction framework
- Estimate resources needed in the different phases of the project
- Evaluate synergies with other projects at the lab providing a list of shared resources and common goals

Documentation

- Kick-off meeting outline [59] □
- HADES drift chamber poster [60] □ (time-over-threshold technique)
- COMPASS Micromegas detector [61] 🔒
- Forward Tracking Task Force Report [62] □ (June 29, 2020)

Meetings

February 17, 2020

- Agenda: Kick-off meeting of core task force members
- Minutes: [63] 🔒

March 9, 2020

- Agenda: Review near term, medium term, long term tasks from the last meeting and discuss next steps
- Minutes: [64] 🔒

April 2, 2020

- Agenda: Review status of report preparation and preparations for initial presentation
- Minutes: [65] 🔒
- Group Presentation Slides: [66] □

April 23, 2020

- Agenda: Review status of report, manpower estimates, high priority tasks, next steps
- Minutes: [67] □

April 28, 2020

- CLAS Collaboration Task Force Presentation: [68] □

June 26, 2020

- Close-out Report: [69] □

Forward Tracking Task Force Report

Five primary report sections:

1. Improve track resolution
2. Improve track efficiency
3. Improve matching of data and simulation
4. Improve speed of reconstruction
5. Validate tracking software and implement correction procedures

Assign priority: **HIGH**, **MEDIUM**, **LOW** based on duration to complete

(MEDIUM/LOW does not mean unimportant!)

Seek consistency of estimates:

- Priorities
- Resources

Estimate resources:

- Manpower
- Duration
- ID tasks for service work

ID synergies with other Task Forces:

- High Luminosity
- Artificial Intelligence
- Software
- Streaming Readout
- Momentum Corrections
- Background Merging

Forward Tracking Task Force Report

Forward Tracking Improvement Task Force Report

June 29, 2020

Members: Daniel Carman (lead); Mac Mestayer, Veronique Ziegler (core); Maxime Defurne, Maxence Vandendrucke, Maurizio Ungaro (external)

Abstract

This document identifies areas in which the CLAS12 forward tracking can be improved in terms of tracking efficiency, momentum resolution, and execution speed, and provides estimates of the time-scale and manpower requirements of the various tasks.

Tracking Improvement Goals

We have identified five work areas to improve CLAS12 forward tracking:

- Improve track resolution (momentum and angle)
- Improve efficiency of tracking; especially at high luminosity
- Improve the matching of data and simulation with respect to efficiency and resolution
- Improve the speed of reconstruction
- Validate tracking software and implement correction procedures

We identify 31 specific studies to accomplish our five goals. We characterize each task by time priority: **HIGH** (CY2020), **MEDIUM** (1-2 yrs), **LOW** (3-5 yrs). (Note: Tasks flagged with a "*" can be assigned as Service Work items for the collaboration.)

• Improve Track Resolution (Momentum and Angle)

Drift Chamber Time-to-Distance Calibration

1. Finish updating and validating the DC calibration suite
HIGH priority, 2 months, 0.5 FTE
2. Finalize the DC run calibration procedures*
HIGH priority, 4 months, 0.2 FTE
3. Determine metrics for necessity of partial or full DC recalibration*
HIGH priority, 2 months, 0.3 FTE
4. Study calibration stability and correlations with atmospheric pressure*
MEDIUM priority, 4 months, 0.3 FTE

Forward Tracker Alignment and Torus Field

5. Devise procedure to align FMT relative to DCs
HIGH priority, 6 months, 0.3 FTE
6. Study effects of misalignment on momentum and angle resolution*
HIGH priority, 4 months, 0.2 FTE

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7. Study forward tracker alignment techniques (e.g. MILLIPEDE, Kalman Filter)
HIGH priority, 6 months, 0.3 FTE

8. Study effect of different torus field maps on resolution and choose best map
MEDIUM priority, 6 months, 0.2 FTE

9. Decide if additional torus field map development is needed
MEDIUM priority, 4 months, 0.2 FTE

Beamline and Shielding Improvements

10. Re-do Monte Carlo studies with different shielding geometries (incl. removing air gap)
MEDIUM priority, 4 months, 0.2 FTE (incl. in High Lumi task force)

• Improve Efficiency of Tracking; Especially at High Luminosity

Track-Finding Algorithms

11. Study DC segment-finding pathologies and "ghost" tracks
MEDIUM priority, 4 months, 0.2 FTE
12. Develop new background rejection algorithms (for DC and FMT)
MEDIUM priority, 4 months, 0.2 FTE
13. Develop DC "4 superlayer" tracking (to improve eff and low momentum acceptance)
LOW priority, 6 months, 0.1 FTE
14. Develop artificial intelligence methods for optimizing tracking efficiency
MEDIUM priority, 12 months, 0.3 FTE (incl. in AI task force)

Hardware (or Firmware) Improvements

15. Reduce coherent noise in drift chambers
MEDIUM priority, 2 months, 0.2 FTE
16. Study modifications to DC HV system to allow operations at higher voltages/currents
MEDIUM priority, 6 months, 0.2 FTE (incl. in High Lumi task force)
17. Study dependence of track resolution and efficiency on HV setting
MEDIUM priority, 4 months, 0.2 FTE
18. Study implementation of "time-over-threshold" in DCRBs
MEDIUM priority, 4 months, 0.2 FTE (incl. in High Lumi task force)
19. Design "add-on" detector to augment DCs and reduce out-of-time backgrounds
LOW priority, 15 months, 0.2 FTE (incl. in High Lumi task force)
20. Investigate new detectors to replace drift chambers
LOW priority, 24 months, 0.2 FTE (incl. in High Lumi task force)
21. Study design, technology, and readout to allow FMT operations at higher luminosities
LOW priority, 18 months, 0.2 FTE

• Improve Matching of Data and Simulation for Efficiency & Resolution

22. Tune GEMC digitization to match data hit resolution and efficiency (DC+FMT)*
HIGH priority, 3 months, 0.2 FTE (incl. in Software task force)

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23. Study momentum and vertex resolution of data and Monte Carlo (DC+FMT)*
MEDIUM priority, 2 months, 0.2 FTE

24. Adjust detector status tables to match simulation and data "occupancies"*
MEDIUM priority, 4 months, 0.2 FTE

25. Study luminosity-dependence of tracking efficiency
HIGH priority, 3 months, 1.0 FTE (incl. in Background Merging task force)

• Improve the Speed of Reconstruction

26. Develop artificial intelligence methods for track segment finding
HIGH priority, 6 months, 0.4 FTE (incl. in AI task force)

27. Study feasibility and performance of streaming readout
MEDIUM priority, 24 months, 0.2 FTE (incl. in Streaming task force)

• Validate Tracking Software and Implement Correction Procedures

28. Implement kinematic fitting for forward tracking
MEDIUM priority, 6 months, 0.3 FTE (incl. in Software task force)

29. Develop a common package for momentum corrections
HIGH priority, 6 months, 1.0 FTE (incl. in Momentum Correction task force)

30. Implement/study energy loss in tracking
MEDIUM priority, 4 months, 0.1 FTE (incl. in Software task force)

31. Review current tracking algorithm and assumptions
MEDIUM priority, 3 months, 0.5 FTE

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Report and closeout presentation to Hall B group on June 26, 2020

Forward Tracking Task Force Report

1. Resolution:

- DC calibration optimization
- DC/FMT alignment
- Torus field map
- Momentum corrections & kinematic fitting

2. Efficiency:

- Background rejection algorithms/track loss pathologies
- AI segment finding
- Shielding
- New detectors

3. Speed:

- Streaming readout
- AI segment finding

Possible improvements:

- Estimates are speculative - rely on relatively modest improvements in multiple areas or on work that has not been completed

Max resolution gain:

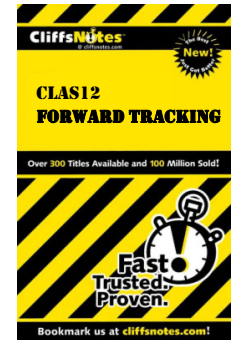
$\Delta p/p: 0.9\% \Rightarrow 0.6\%$

Max efficiency gain:

$(1-\epsilon): 0.4 \Rightarrow 0.2\%/nA$

Max speed gains:

750 ms/event \Rightarrow ???



Summary and Conclusions



- The CLAS12 Forward Tracking task force was formed to make recommendations to improve forward tracking with regard to resolution, efficiency, and speed:
 - We have identified the most promising areas to realize improvements on these fronts
 - Tasks are denoted as **HIGH** (CY2020), **MEDIUM** (1-2 yrs), and **LOW** priority (3-5 yrs) based on the duration to complete the tasks that are in progress or planned - *Note: the assigned priorities do not signal the task importance*
 - We have flagged tasks that could be taken as service work tasks by Collaborators
- Items that have synergies/overlaps with other task forces are noted:
 - High Luminosity
 - Artificial Intelligence
 - Software
 - Streaming Readout
 - Momentum Corrections
 - Background Merging
- The Forward Tracking task force invites you to review the report:
<https://clasweb.jlab.org/wiki/images/5/5e/Fwd-trk-closeout-06262020.pdf>