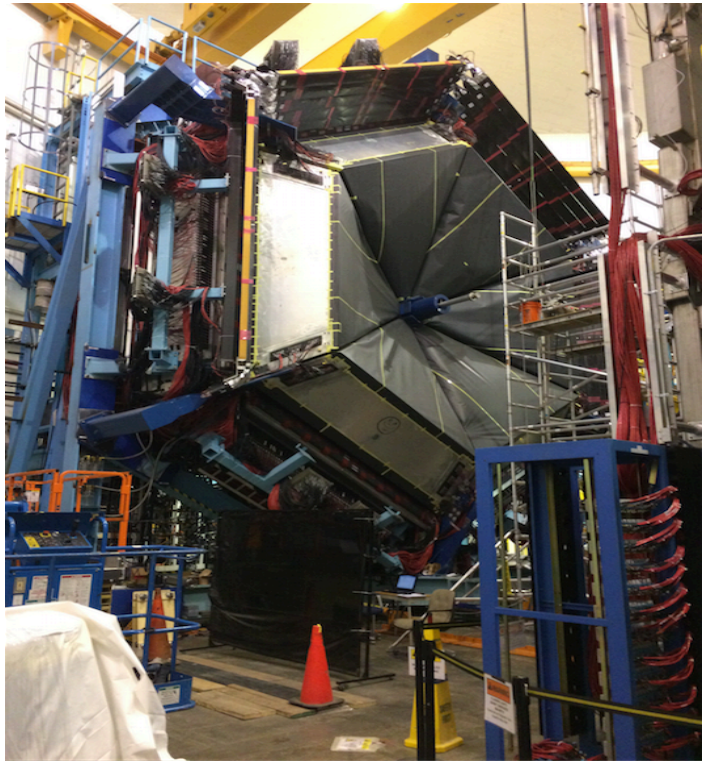
CLAS12 Event Builder



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CLAS Collaboration Meeting

June 13, 2017

EB Concept

- Event Builder processes information at the hit-based and time-based level in the FD and CD
- Geometrical Matching of FD and CD tracking with detector hits
- Forward Tagger information collected independently
- Algorithm searches for an electron as a trigger particle candidate (unless otherwise specified by user) from the following criteria: Hits in at least two layers of the EC, Hits in at least one layer of the FTOF, EC Sampling Fraction, and Number of Photoelectrons in HTCC
- Using the electron candidate's reported FTOF time and its path distance from the vertex, the electron's vertex time is calculated and corrected by an RF correction term, which gives the event start time.
- After the hit-based level of the Event Builder, the speed of each track and the event start time are inside the bank structure allowing for access to Time-Based Tracking for enhanced fitting of DC tracks
- Particle ID is performed at the time-based level using the comparison between a track's vertex time and projected vertex time for a certain particle ID hypothesis in addition to Cherenkov counters and calorimeters.
- Quality of the particle ID and geometrical matching will be preserved for the user with the addition of an EB database with detector hit and timing resolutions

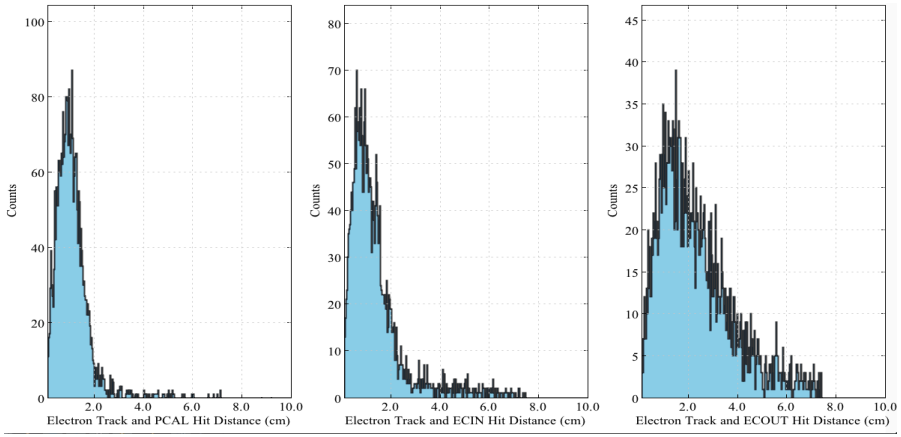

Fig. 1. Quality of Geometrical Matching in the PCAL/EC

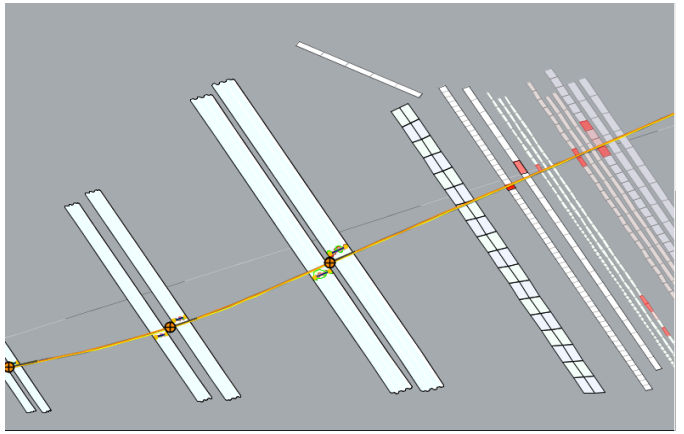

Fig. 2. Matching is determined by the distance of closest approach of the reconstructed track with the detector hit

EB Bank Structure

Event Builder Banks

- Particles (ID, Charge, Momentum, Vertex, Beta)
- Track Information
- Track Cross Information
- Time-Based Tracking Covariant Matrices
- Cherenkov Response Information
- Calorimeter Response Information
- Scintillator Response Information
- Forward Tagger Response Information
- Event-by-Event Information (HEVT in CLAS6)

Bank Examples


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{
   "bank": "REC::Event",
   "group": 20,
   "info": "Event Header Bank",
   "items": [
     {"name":"NRUN", "id":1, "type":"int32", "info":"Run Number"},
     {"name":"NEVENT",  "id":2, "type":"int32", "info":"Event Number"},
     {"name":"EVNTime",  "id":3, "type":"float", "info":"Event Time"},
     {"name":"TYPE",  "id":3, "type":"int8", "info":"Event Type (Data or MC)"},
     {"name":"EvCAT", "id":4, "type":"int16", "info":"Event Category, if >0:  e-, e-p, e-pi+....."},
     {"name":"NPGP",  "id":5, "type":"int16", "info":"Number of Final (Timed-based) Reconstructed Particles*100 + Number of Geometrically Reconstructed Particles"},
     {"name":"TRG",  "id":6, "type":"int16", "info":"Trigger Type (CLAS12_e-, FT_CLAS12_h, CLAS12_H,...) + Prescale Factor for that Trigger"},
     {"name":"BCG",  "id":11, "type":"float", "info":"Beam charge, gated (Coulomb)"},
     {"name":"LT",  "id":12, "type":"double", "info":"Lifetime"},
     {"name":"STTime",  "id":14, "type":"float", "info":"Event Start Time (ns)"},
     {"name":"RFTime",  "id":15, "type":"float", "info":"RF Time (ns)"},
     {"name":"Helic", "id":16, "type":"int8", "info":"Helicity of Event"},
     {"name":"PTIME",  "id":21, "type":"float", "info":"Event Processing Time (UNIX Time = seconds)"}
   ]
},
  {
     "bank": "RECHB::Tracks",
     "group": 26,
     "info": "Track information for Particles bank",
     "items": [
         {"name":"index",      "id":1, "type":"int16",  "info":"index of the track in the specific detector bank"},
         {"name":"pindex",     "id":2, "type":"int16",  "info":"row number in the particle bank hit is associated with"},
         {"name":"detector",   "id":3, "type":"int16",  "info":"Detector ID, defined in COATJAVA DetectorType"},
         {"name":"status",     "id":4, "type":"int16",  "info":"status of the track"},
         {"name":"q",          "id":5, "type":"int8",   "info":"charge of the track"},
         {"name":"px_nomm",   "id":6, "type":"float", "info":"x component of the momentum with no MM"},
         {"name":"py_nomm",   "id":7, "type":"float", "info":"y component of the momentum with no MM"},
         {"name":"pz_nomm",   "id":8, "type":"float", "info":"z component of the momentum with no MM"},
         {"name":"vx_nomm",   "id":9, "type":"float", "info":"x component of the vertex"},
         {"name":"vy_nomm",   "id":10, "type":"float", "info":"y component of the vertex"},
         {"name":"vz_nomm",   "id":11, "type":"float", "info":"z component of the vertex"},
         {"name":"NDF_nomm",  "id":12, "type":"float", "info":"number of degrees of freedom in track fitting with no MM"},
         {"name":"NDF",       "id":13, "type":"float", "info":"number of degrees of freedom in track fitting"},
         {"name":"chi2_nomm", "id":14, "type":"float", "info":"Chi2 (or quality) track fitting"},
         {"name":"chi2",      "id":15, "type":"float", "info":"Chi2 (or quality) track fitting"}
     ]
  },
  {
     "bank": "RECHB::TrackCross",
     "group": 27,
     "info": "Track Cross information for Particles bank",
     "items": [
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         {"name":"pindex",     "id":2, "type":"int16",  "info":"row number in the track bank hit is associated with"},
         {"name":"detector",   "id":3, "type":"int16",  "info":"Detector ID, defined in COATJAVA DetectorType"},
         {"name":"sector",     "id":4, "type":"int8",   "info":"sector of the track"},
         {"name":"layer",      "id":5, "type":"int8",   "info":"layer of the track"},
         {"name":"c_x",        "id":6, "type":"float",  "info":"Cross x-position in the lab (in cm)"},
         {"name":"c_y",        "id":7, "type":"float",  "info":"Cross y-position in the lab (in cm)"},
         {"name":"c_z",        "id":8, "type":"float",  "info":"Cross z-position in the lab (in cm)"},
         {"name":"c_ux",       "id":9, "type":"float",  "info":"Cross unit x-direction vector in the lab"},
         {"name":"c_uy",       "id":10, "type":"float", "info":"Cross unit y-direction vector in the lab"},
         {"name":"c_uz",       "id":11, "type":"float", "info":"Cross unit z-direction vector in the lab"}
     ]
  },
```

More Bank Examples

```
{
    "bank": "REC::Particle",
    "group": 29,
    "info": "Reconstructed Particle Information",
    "items": [
      {"name":"pid", "id":1, "type":"int32", "info":"particle id in LUND conventions"},
      {"name":"px",  "id":2, "type":"float", "info":"x component of the momentum"},
      {"name":"py",  "id":3, "type":"float", "info":"y component of the momentum"},
      {"name":"pz",  "id":4, "type":"float", "info":"z component of the momentum"},
      {"name":"vx",  "id":5, "type":"float", "info":"x component of the vertex"},
      {"name":"vy",  "id":6, "type":"float", "info":"y component of the vertex"},
      {"name":"vz",  "id":7, "type":"float", "info":"z component of the vertex"},
      {"name":"charge",  "id":8,  "type":"int8",  "info":"particle charge"},
      {"name":"beta",    "id":9, "type":"float", "info":"particle beta measured by TOF"},
      {"name":"chi2pid", "id":10, "type":"float", "info":"Chi2 of assigned PID"},
      {"name":"status",  "id":11, "type":"int16", "info":"particle status (represents detector collection it passed)"}
    ]
},
{
    "bank": "REC::Scintillator",
    "group": 30,
    "info": "Scintillator Responses for Particles bank",
    "items": [
        {"name":"index",     "id":1, "type":"int16", "info":"index of the hit in the specific detector bank"},
        {"name":"pindex",    "id":2, "type":"int16", "info":"row number in the particle bank hit is associated with"},
        {"name":"detector",  "id":3, "type":"int16", "info":"Detector ID, defined in COATJAVA DetectorType"},
        {"name":"sector",    "id":4, "type":"int8",  "info":"Sector of the Detector hit"},
        {"name":"layer",     "id":5, "type":"int8",  "info":"Layer of the Detector hit"},
        {"name":"component", "id":6, "type":"int16", "info":"Component of the Detector hit"},
        {"name":"x",  "id":7,  "type":"float", "info":"X coordinate of the hit"},
        {"name":"y",  "id":8,  "type":"float", "info":"Y coordinate of the hit"},
        {"name":"z",  "id":9,  "type":"float", "info":"Z coordinate of the hit"},
        {"name":"hx", "id":10, "type":"float", "info":"X coordinate of the matched hit"},
        {"name":"hy", "id":11, "type":"float", "info":"Y coordinate of the mathced hit"},
        {"name":"hz", "id":12, "type":"float", "info":"Z coordinate of the matched hit"},
        {"name":"path",   "id":13, "type":"float", "info":"Path from vertex to the hit position"},
        {"name":"time",   "id":14, "type":"float", "info":"Time associated with the hit"},
        {"name":"energy", "id":15, "type":"float", "info":"Energy associated with the hit"},
        {"name":"chi2", "id":16, "type":"float", "info":"Chi2 (or quality) of hit-track matching"}
    ]
},
```

Trigger ID Schematic

- The primary trigger particle type is the electron. Most of the experiments need an electron to be in the final state. The electron can be identified without timing information or hypothesis of particle mass, just using signals from HTCC and PCAL/EC.
- If no electron is found, fast-moving non-electron tracks can be an alternative trigger particle assuming they are pions
- There will be the capability for the user to define more complex software triggers

$$t_0^r = t_{det} - R/v$$

$$t_0 = t_0^r - [Mod(\delta t^r, \delta t) - \frac{\delta t}{2}]$$

$$\delta t^r = t_0^r - t_{RF} - \frac{(z_t - z_0)}{c} + m * \delta t$$

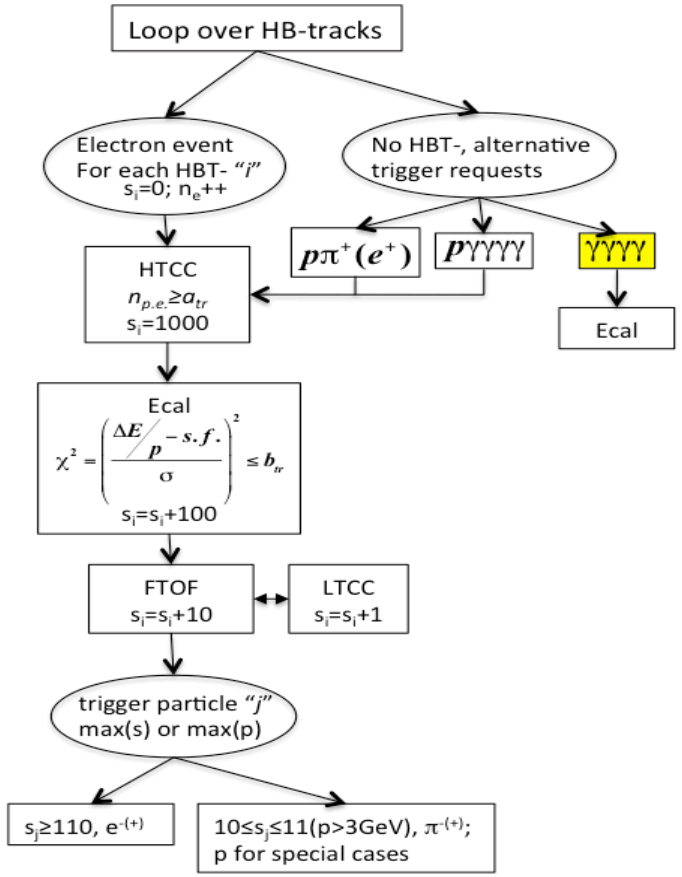


Fig. 3. Strategy for selecting a trigger particle among a list of tracks

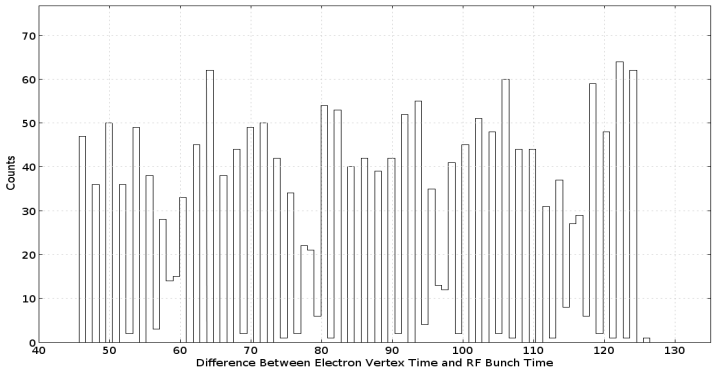


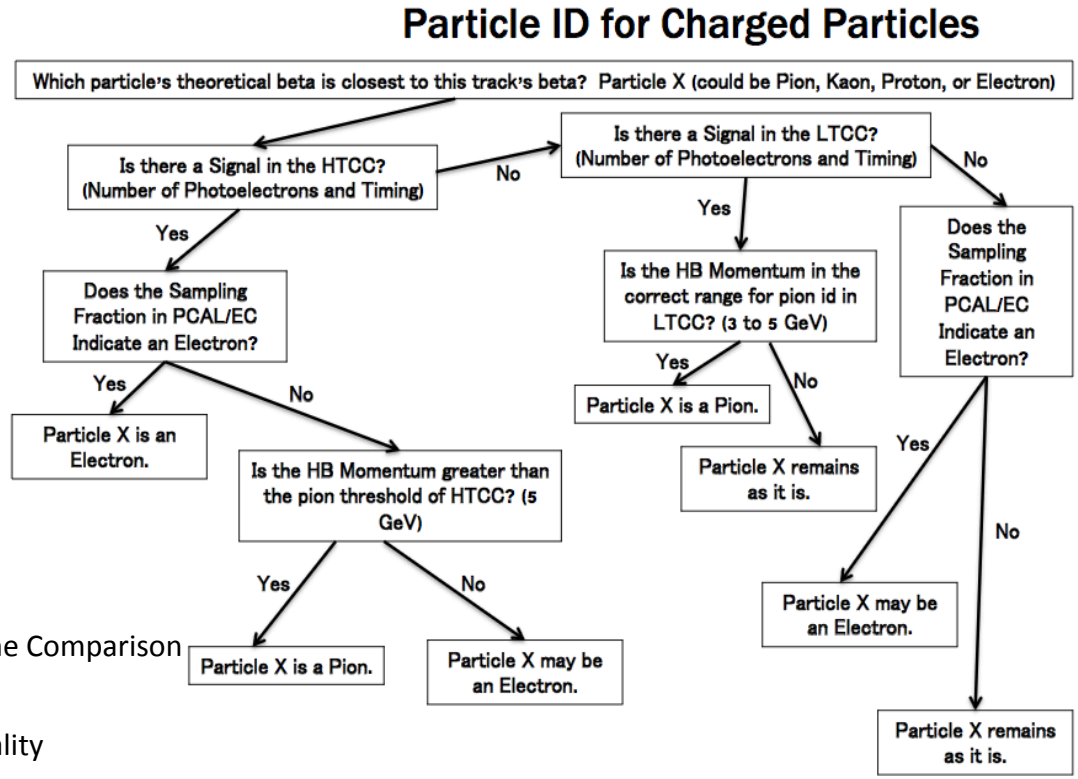
Fig. 4. RF Beam Bunch Structure

Event Builder CCDB Variables

- Electron Sampling Fraction Function Fit Parameters for Mean and Standard Deviation
- Photon Sampling Fraction Function Fit Parameters
- User-determined software trigger (e-, e+, π- by default)
- User-determined PID Hypotheses
- RF information (# of signals, iteration chosen, offset, bucket, etc.)
- Target Position
- Detector Hit Position Resolutions
- Detector Timing Resolutions, which depend on momentum and particle ID
- Cherenkov Counter # of Photoelectrons Required for Particle ID

Event Builder Particle Identification

- After time-based tracking, particle identification for non-electrons will be primarily based on a comparison between the particle's projected vertex time and the event start time.
- The quality of the particle id will be based off of the time-of-flight detector's resolution

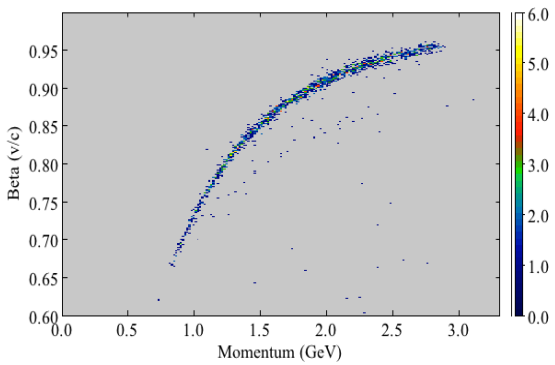


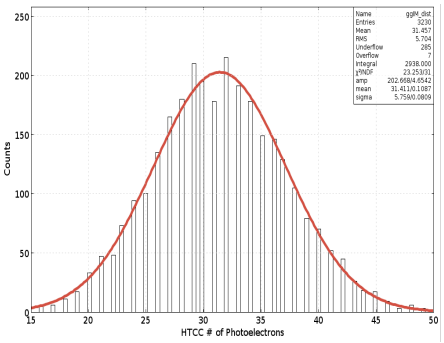
$$\Delta t_i = t_0 - \left[t_{FTOF,i} - \frac{R_{FTOF\,i}}{\beta_i} \right]$$

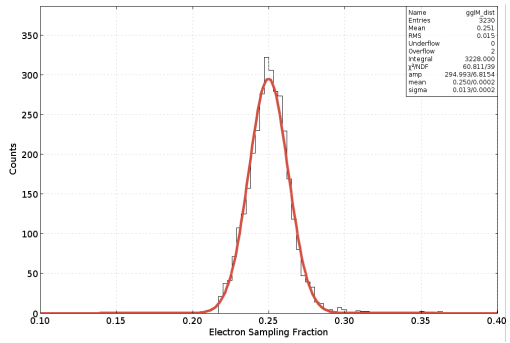
Vertex Time Comparison

$$\chi^2 = \left(\frac{\Delta t_i - 0}{\sigma_i} \right)^2$$

PID Quality







Latest Developments and Plans

- New Features
  - Completed Bank Structure
  - LTCC in Geometrical Matching and PID algorithms
  - More Flexible Software Trigger Routine
- Next Steps
  - Event Builder Database for Better Quality
  - API to Interpret the Event Builder Banks and make data analysis compact and convenient