

REC::* Banks
&
Event Builder

Event Builder Overview

- The last CLAS12 service run, after all detectors' reconstructions
- Retrieve event-based quantities, e.g. RF, helicity, live-time
- Associate detector responses to create “particles”
 - Forward Detectors, Central Detector, Forward Tagger
- Define event start time based on CLAS12 and RF
- Perform particle identification
- Provide all info in high level CLAS12 data banks

REC::* Banks

- High level banks for analysis
 - In the end, we'll keep only REC banks for analysis, and drop all lower level info
 - EVENT.json
- REC::Event
 - run/event #, helicity, event time, live time, faraday cup charge, etc
- REC::Particle
- REC::"ResponseType"
 - e.g. Calorimeter, Scintillator, Cerenkov
 - contains index pointers to
 - REC::Particle
 - lower-level detector banks
- REC::Trajectory, REC::TBCovMat, REC::VertDOCA, etc.

<https://github.com/JeffersonLab/clas12-offline-software/blob/master/etc/bankdefs/hipo/EVENT.json>

```
etc/bankdefs/hipo/  
└─ BMT.json  
└─ BST.json  
└─ CLAS6EVENT.json  
└─ CND.json  
└─ CVT.json  
└─ DATA.json  
└─ DC.json  
└─ DETECTOR.json  
└─ ECAL.json  
└─ EVENT.json  
└─ FT.json  
└─ HEADER.json  
└─ HTCC.json  
└─ LTCC.json  
└─ MC.json  
└─ TOF.json
```

```
***** EVENT # 2 *****
```

id	name	entries	group	items
0	DC::tdc	79	20612	5
1	DC::doca	79	20614	5
2	HTCC::adc	2	21511	7
3	REC::Event	1	330	13
4	RUN::config	1	11	10
5	REC::Particle	3	331	11
6	RUN::rf	3	12	2
7	REC::Calorimeter	5	332	25
8	HitBasedTrkg::HBHits	78	20621	17
9	REC::Cherenkov	2	333	16
10	HitBasedTrkg::HBClusters	12	20622	23
11	HitBasedTrkg::HBSegments	12	20623	28
12	REC::Scintillator	5	335	17
13	REC::Track	2	336	16
14	HitBasedTrkg::HBCrosses	6	20625	18
15	HitBasedTrkg::HBTracks	2	20626	34
16	HTCC::rec	1	21522	17
17	TimeBasedTrkg::TBHits	78	20631	17
18	TimeBasedTrkg::TBClusters	12	20632	23
19	ECAL::calib	5	20824	9
20	TimeBasedTrkg::TBSegments	12	20633	30
21	TimeBasedTrkg::TBCrosses	6	20635	18
22	TimeBasedTrkg::TBTracks	2	20636	34
23	FTOF::rawhits	12	21220	13
24	FTOF::hits	12	21221	25

<https://github.com/JeffersonLab/clas12-offline-software/blob/master/etc/bankdefs/hipo/EVENT.json>

```
"bank": "REC::Event",
"group": 330,
"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": 4, "type": "int8", "info": "Event Type (Data or MC)"},
  {"name": "EvCAT", "id": 5, "type": "int16", "info": "Event Category, if >0: e-, e-p, e-pi+..."},
  {"name": "NPGP", "id": 6, "type": "int16", "info": "Number of Final (Timed-based) Reconstruct"},
  {"name": "TRG", "id": 7, "type": "int32", "info": "Trigger Type (CLAS12_e-, FT_CLAS12_h, CLA"},
  {"name": "BCG", "id": 8, "type": "float", "info": "Faraday Cup Gated (Coulomb)"},
  {"name": "LT", "id": 9, "type": "double", "info": "Clock"},
  {"name": "STTIME", "id": 10, "type": "float", "info": "Event Start Time (ns)"},
  {"name": "RFTIME", "id": 11, "type": "float", "info": "RF Time (ns)"},
  {"name": "Helic", "id": 12, "type": "int8", "info": "Helicity of Event"},
  {"name": "PTIME", "id": 13, "type": "float", "info": "Event Processing Time (UNIX Time = second"}
]
```

```
"bank": "REC::Particle",
"group": 331,
"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 coll"}
]
```

<https://github.com/JeffersonLab/clas12-offline-software/blob/master/etc/bankdefs/hipo/EVENT.json>

```
"bank": "REC::Particle",
"group": 331,
"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 coll"}
]
```

```
"bank": "REC::Scintillator",
"group": 335,
"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": "int8", "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": "energy", "id": 7, "type": "float", "info": "Energy associated with the hit"},
  {"name": "time", "id": 8, "type": "float", "info": "Time associated with the hit"},
  {"name": "path", "id": 9, "type": "float", "info": "Path from vertex to the hit position"},
  {"name": "chi2", "id": 10, "type": "float", "info": "Chi2 (or quality) of hit-track matching"},
  {"name": "x", "id": 11, "type": "float", "info": "X coordinate of the hit"},
  {"name": "y", "id": 12, "type": "float", "info": "Y coordinate of the hit"},
  {"name": "z", "id": 13, "type": "float", "info": "Z coordinate of the hit"},
  {"name": "hx", "id": 14, "type": "float", "info": "X coordinate of the matched hit"},
  {"name": "hy", "id": 15, "type": "float", "info": "Y coordinate of the mathced hit"},
  {"name": "hz", "id": 16, "type": "float", "info": "Z coordinate of the matched hit"},
  {"name": "status", "id": 17, "type": "int16", "info": "hit status"}
]
```

to REC::Particle

status to be propagated from detector bank, not complete yet

<https://github.com/JeffersonLab/clas12-offline-software/blob/master/etc/bankdefs/hipo/EVENT.json>

```
"bank": "REC::Particle",
"group": 331,
"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 coll"}
]
```

```
"bank": "REC::Scintillator",
"group": 335,
"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":"int8", "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": "energy", "id":7, "type":"float", "info":"Energy associated with the hit"},
  {"name": "time", "id":8, "type":"float", "info":"Time associated with the hit"},
  {"name": "path", "id":9, "type":"float", "info":"Path from vertex to the hit position"},
  {"name": "chi2", "id":10, "type":"float", "info":"Chi2 (or quality) of hit-track matching"},
  {"name": "x", "id":11, "type":"float", "info":"X coordinate of the hit"},
  {"name": "y", "id":12, "type":"float", "info":"Y coordinate of the hit"},
  {"name": "z", "id":13, "type":"float", "info":"Z coordinate of the hit"},
  {"name": "hx", "id":14, "type":"float", "info":"X coordinate of the matched hit"},
  {"name": "hy", "id":15, "type":"float", "info":"Y coordinate of the mathced hit"},
  {"name": "hz", "id":16, "type":"float", "info":"Z coordinate of the matched hit"},
  {"name": "status", "id":17, "type":"int16", "info":"hit status"}
]
```

to
detector
bank

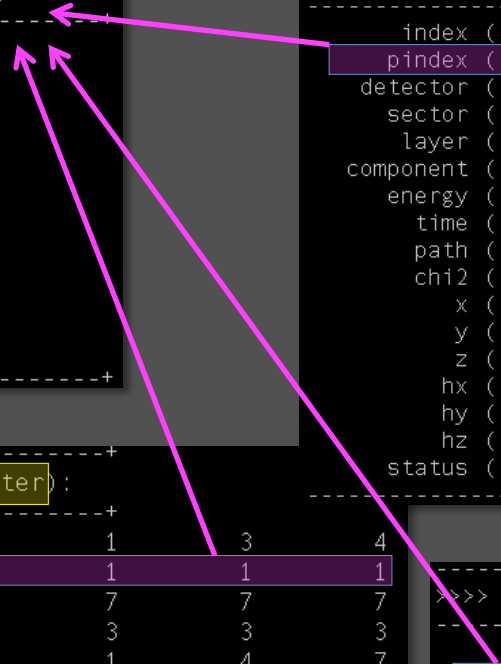
status to be propagated from detector bank, not complete yet

```
+-----+
>>>> GROUP (group= 1) (name=REC::Particle):
+-----+
pid ( INT) : 11 2212
px ( FLOAT) : 0.539 -0.327
py ( FLOAT) : 0.056 0.610
pz ( FLOAT) : 0.884 1.337
vx ( FLOAT) : 0.443 -0.000
vy ( FLOAT) : -0.270 -0.004
vz ( FLOAT) : -0.757 0.060
charge ( BYTE) : -1 1
beta ( FLOAT) : 1.000 0.850
chi2pid ( FLOAT) : 0.000 0.169
status ( SHORT) : 1 1
+-----+
```

```
+-----+
>>>> GROUP (group= 1) (name=REC::Scintillator):
+-----+
index ( SHORT) : 3 7 14 15
pindex ( SHORT) : 0 0 1 1
detector ( BYTE) : 12 12 12 12
sector ( BYTE) : 2 2 3 3
layer ( BYTE) : 1 2 1 2
component ( SHORT) : 11 31 20 53
energy ( FLOAT) : 14.957 24.519 12.120 15.849
time ( FLOAT) : 147.825 147.061 151.889 151.339
path ( FLOAT) : 703.898 685.681 708.658 690.006
chi2 ( FLOAT) : 0.000 0.000 0.000 0.000
x ( FLOAT) : 176.596 174.577 -36.160 -45.768
y ( FLOAT) : 148.958 149.897 373.262 363.888
z ( FLOAT) : 654.273 635.921 596.435 579.537
hx ( FLOAT) : 176.498 174.526 -41.133 -45.155
hy ( FLOAT) : 150.456 149.709 373.824 363.469
hz ( FLOAT) : 654.081 635.952 595.431 579.943
status ( SHORT) : 0 0 0 0
+-----+
```

```
+-----+
>>>> GROUP (group= 1) (name=REC::Calorimeter):
+-----+
index ( SHORT) : 0 2 1 3 4
pindex ( SHORT) : 0 0 1 1 1
detector ( BYTE) : 7 7 7 7 7
sector ( BYTE) : 2 2 3 3 3
layer ( BYTE) : 1 4 1 4 7
energy ( FLOAT) : 0.218 0.039 0.041 0.036 0.088
time ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
path ( FLOAT) : 719.328 753.230 724.410 758.471 778.090
chi2 ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
x ( FLOAT) : 177.769 180.673 -47.404 -51.682 -54.978
y ( FLOAT) : 151.546 156.002 387.580 408.672 421.500
z ( FLOAT) : 669.475 702.966 604.552 631.003 645.546
hx ( FLOAT) : 177.903 181.151 -47.453 -51.061 -53.552
hy ( FLOAT) : 152.783 157.280 386.048 407.239 419.772
hz ( FLOAT) : 669.292 702.741 605.780 632.226 647.096
lu ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
lv ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
lw ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
du ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
dv ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
dw ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
m2u ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
m2v ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
m2w ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
status ( SHORT) : 0 0 0 0 0
+-----+
```

```
+-----+
>>>> GROUP (group= 1) (name=REC::Cherenkov):
+-----+
index ( SHORT) : 0
pindex ( SHORT) : 0
detector ( BYTE) : 16
sector ( BYTE) : 0
nphe ( SHORT) : 23
time ( FLOAT) : 152.149
path ( FLOAT) : 0.000
chi2 ( FLOAT) : 0.000
x ( FLOAT) : 118.379
y ( FLOAT) : 127.690
z ( FLOAT) : 612.804
theta ( FLOAT) : 0.000
phi ( FLOAT) : 0.000
dtheta ( FLOAT) : 0.175
dphi ( FLOAT) : 0.175
status ( SHORT) : 0
+-----+
```




```

-----+-----
>>>> GROUP (group= 1) (name=REC::Particle):
-----+-----
pid ( INT) : 11 2212
px ( FLOAT) : 0.539 -0.327
py ( FLOAT) : 0.056 0.610
pz ( FLOAT) : 0.884 1.337
vx ( FLOAT) : 0.443 -0.000
vy ( FLOAT) : -0.270 -0.004
vz ( FLOAT) : -0.757 0.060
charge ( BYTE) : -1 1
beta ( FLOAT) : 1.000 0.850
chi2pid ( FLOAT) : 0.000 0.169
status ( SHORT) : 1 1
-----+-----

```

```

-----+-----
>>>> GROUP (group= 1) (name=REC::Calorimeter):
-----+-----
index ( SHORT) : 0 2 1 3 4
pindex ( SHORT) : 0 0 1 1 1
detector ( BYTE) : 7 7 7 7 7
sector ( BYTE) : 2 2 3 3 3
layer ( BYTE) : 1 4 1 4 7
energy ( FLOAT) : 0.218 0.039 0.041 0.036 0.088
time ( FLOAT) : 0.000 0.000 0.000
path ( FLOAT) : 719.328 753.230 724.410
chi2 ( FLOAT) : 0.000 0.000 0.000
x ( FLOAT) : 177.769 180.673 -47.404
y ( FLOAT) : 151.546 156.002 387.580
z ( FLOAT) : 669.475 702.966 604.552
hx ( FLOAT) : 177.903 181.151 -47.453
hy ( FLOAT) : 152.783 157.280 386.048
hz ( FLOAT) : 669.292 702.741 605.780
lu ( FLOAT) : 0.000 0.000 0.000
lv ( FLOAT) : 0.000 0.000 0.000
lw ( FLOAT) : 0.000 0.000 0.000
du ( FLOAT) : 0.000 0.000 0.000
dv ( FLOAT) : 0.000 0.000 0.000
dw ( FLOAT) : 0.000 0.000 0.000
m2u ( FLOAT) : 0.000 0.000 0.000
m2v ( FLOAT) : 0.000 0.000 0.000
m2w ( FLOAT) : 0.000 0.000 0.000
status ( SHORT) : 0 0 0
-----+-----

```

to
detector
bank

```

-----+-----
>>>> GROUP (group= 1) (name=ECAL::clusters):
-----+-----
id ( SHORT) : 0 0 0 0 0
status ( SHORT) : 0 0 0 0 0
sector ( BYTE) : 2 3 2 3 3
layer ( BYTE) : 1 1 4 4 7
x ( FLOAT) : 177.769 -47.404 180.673 -51.682 -54.978
y ( FLOAT) : 151.546 387.580 156.002 408.672 421.500
z ( FLOAT) : 669.475 604.552 702.966 631.003 645.546
energy ( FLOAT) : 0.218 0.041 0.039 0.036 0.088
time ( FLOAT) : 0.000 0.000 0.000 0.000 0.000
widthU ( FLOAT) : 1.000 2.000 2.000 1.000 3.000
widthV ( FLOAT) : 3.000 2.000 2.000 1.000 4.000
widthW ( FLOAT) : 2.000 2.000 3.000 1.000 2.000
idU ( BYTE) : 2 8 5 11 14
idV ( BYTE) : 3 9 6 12 15
idW ( BYTE) : 4 10 7 13 16
coordU ( INT) : 356 522 143 276 276
coordV ( INT) : 451 445 271 268 268
coordW ( INT) : 204 41 152 28 32
-----+-----

```

REC::* Banks – “Reverse” Indexing

An analysis framework would load the mapping for you, or you can do it yourself:

```
"bank": "REC::Scintillator",
"group": 335,
"info": "Scintillator Responses for Particles bank",
"items": [
  {"name":"index", "id":1, "type":"int16"},
  {"name":"pindex", "id":2, "type":"int16"},
  {"name":"detector", "id":3, "type":"int8"},
  {"name":"sector", "id":4, "type":"int8"},
  {"name":"layer", "id":5, "type":"int8"},
  {"name":"component", "id":6, "type":"int16"},
  {"name":"energy", "id":7, "type":"float"},
  {"name":"time", "id":8, "type":"float"},
  {"name":"path", "id":9, "type":"float"},
  {"name":"chi2", "id":10, "type":"float"},
  {"name":"x", "id":11, "type":"float"},
  {"name":"y", "id":12, "type":"float"},
  {"name":"z", "id":13, "type":"float"},
  {"name":"hx", "id":14, "type":"float"},
  {"name":"hy", "id":15, "type":"float"},
  {"name":"hz", "id":16, "type":"float"},
  {"name":"status", "id":17, "type":"int16"}
]
```

```
public void loadMap(Map<Integer,List<Integer>> map,
                   DataBank fromBank,
                   DataBank toBank,
                   String idxVarName) {
    map.clear();
    if (fromBank==null) return;
    if (toBank==null) return;
    for (int ii=0; ii<fromBank.rows(); ii++) {
        final int iTo=fromBank.getInt(idxVarName,ii);
        if (map.containsKey(iTo)) {
            map.get(iTo).add(ii);
        }
        else {
            List<Integer> iFrom=new ArrayList<Integer>();
            map.put(iTo,iFrom);
            map.get(iTo).add(ii);
        }
    }
}
```

Load: (recPartBank=DataEvent::getBank("REC::Particle"), recCalBank=DataEvent::getBank("REC::Calorimeter"))

```
Map <Integer,List<Integer>> recCalMap=new HashMap<Integer,List<Integer>>();
```

```
loadMap(recCalMap,recCalBank,recPartBank,"pindex");
```

Use:

```
if (recCalMap.containsKey(iPart)) {
    // REC::Particle index=iPart has at least one associated calorimeter response.
    // Loop over those responses:
    for (int iCal : recCalMap.get(iPart)) {
        recCalBank.getFloat("energy",iCal);
    }
}
```