Level 2 ID-tracking truth association

Trigger AOD discussion
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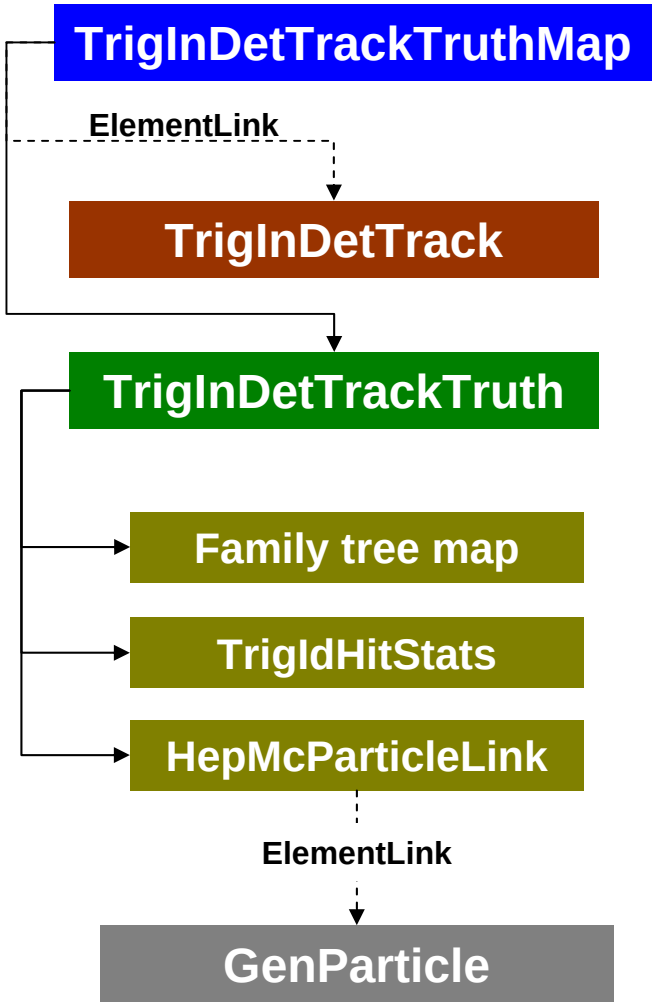
Level 2 track-truth association

- How it works:
  - GenParticles match TrigInDetTracks if they share common hits
  - More than one GenParticle can match a track

- Truth-association classes:
  - **`TrigInDetTrackTruth`**: one per track
    - `"Map"` of mother-daughter relationships
    - Pointers to matching GenParticles
    - number of common hits between track and a `GenParticle`
  - **`TrigInDetTrackTruthMap`**: a "map" between each `TrigInDetTrack` and a `TrigInDetTrackTruth` object



TrigInDetTrackTruthMap

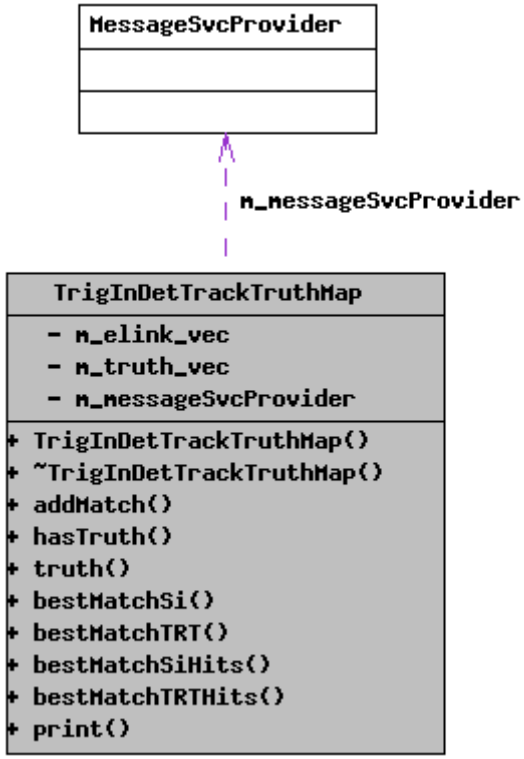
One per event: Acts as map between tracks and GenParticles

Data members:

std::vector< ElementLink<TrigInDetTrackCollection > > m_elink_vec;

std::vector< TrigInDetTrackTruth > m_truth_vec;

MessageSvcProvider m_messageSvcProvider;



Entry point for users:

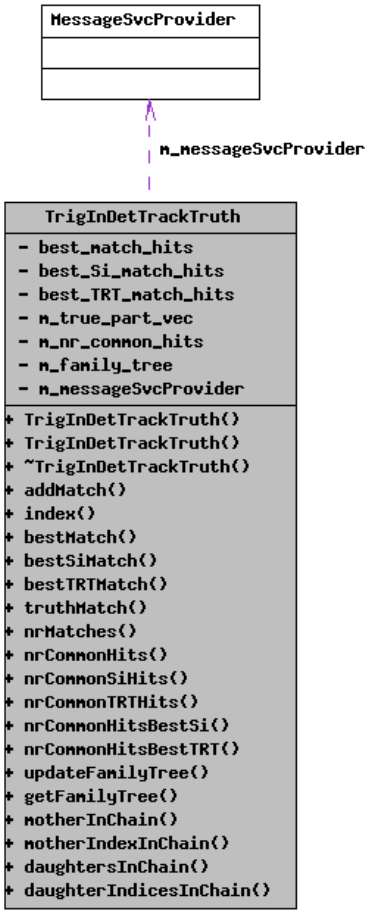
The pair of vectors works as a map with a TrigInDetTrack* as key

```
-----------------------------------------
Mem Size        Disk Size       Nbr evts
-----------------------------------------
2284.457 kb       244.904 kb       100
```

TrigInDetTrackTruth

One per track.

Makes the link between track and (a number of) GenParticles; contained by TrigInDetTrackTruthMap



Data members:

// reference best match quantities

int best_match_hits, best_Si_match_hits, best_TRT_match_hits;

// vector of HepMcParticleLink pointers and matching quantities

std::vector<HepMcParticleLink> m_true_part_vec;
std::vector<TrigIDHitStats> m_nr_common_hits;

// “bidirectional map” mother-daughter index in m_true_part_vec

std::vector<pair<unsigned int, unsigned int>> m_family_tree;

MessageSvcProvider m_messageSvcProvider;

TrigIDHitStats

One per GenParticle matching a track

Encodes number of common hits between GenParticle and track for each detector; contained by TrigInDetTrackTruth

Data members:

unsigned char[Num.Detectors]

Backup

How it works I

1. Starts from the ID `TrigSpacePoint` and `InDet::TRT_DriftCircle` stored with each `TrigInDetTrack`;

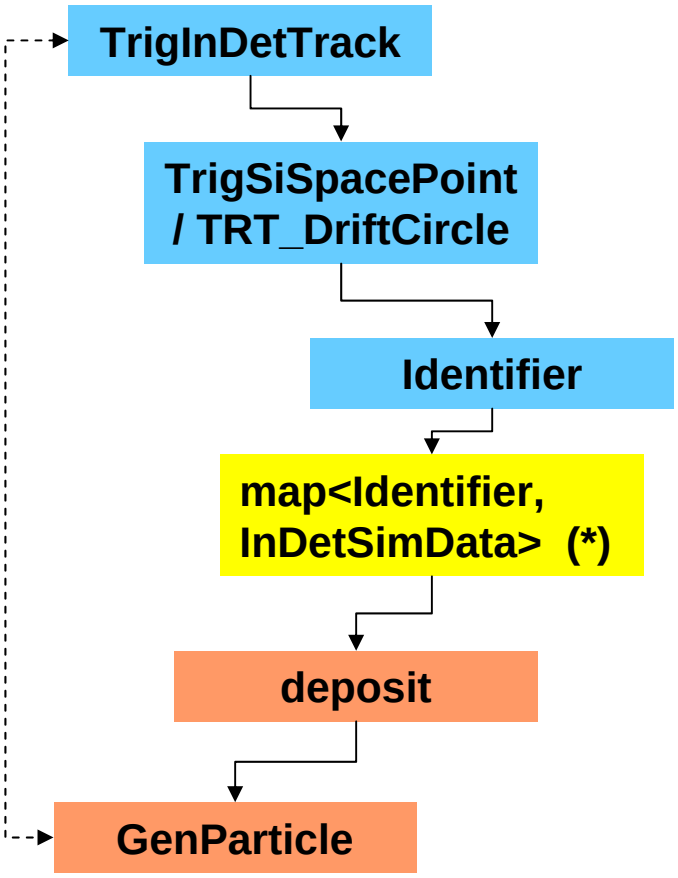
2. For silicon detectors, navigates to each `InDet::SiCluster` forming a `TrigSiSpacePoint`;

3. Gets vector of RDO `Identifier` for each space point and drift circle. Uses map between `Identifier` and `InDetSimData` to find all `Deposits` left by generated particles (`GenParticle`);

4. Retrieve list of generated particles (actually `HepMcParticleLink`, which points to `GenParticle`) which ontributed to clusters and drift circles;

5. A truth particle is considered a match if at least **one** of its deposits contributed to a cluster:
   - Should this be configurable? (match if >= N hits in common with track…)

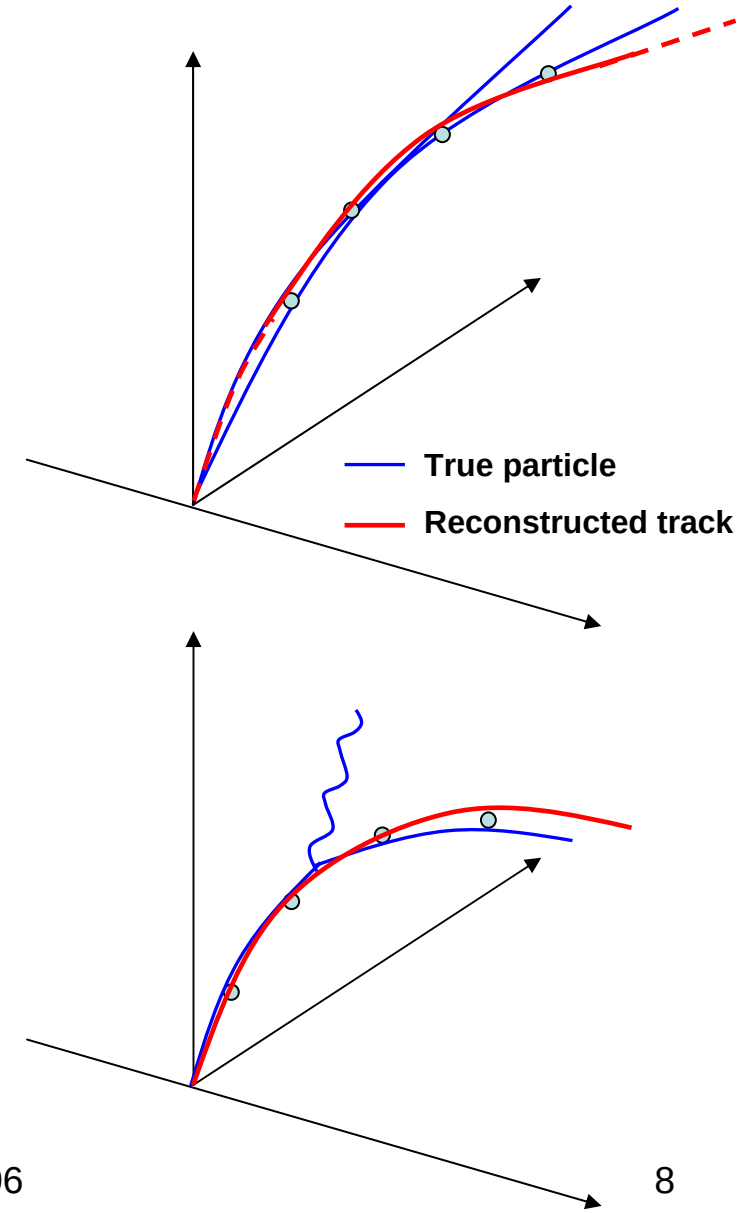
6. Does one last step to try to find each particle's mother.



(*) InDetSimData is a typedef of vector<Deposit>; Deposit is a typedef of pair<HepMcParticleLink, float>

How it works II

- Truth association found for all existing `TrigInDetTrackCollections` in StoreGate **after** Trigger has run
- `TrigInDetTracks` need to have vector of `TrigSiSpacePoints` or `InDet::TRT_DriftCircles`
- **All** particles matching a track are recorded and the information is kept in POOL
- Particles in a decay chain may match a track
  - Bremstrahlung: $e^{\pm} \rightarrow e^{\pm} \gamma$
  - Long-lived particles: $K^{\pm} \rightarrow \pi^{\pm} \pi^{0}$
  - Note: "mother K^{+}" different `GenParticle` from "daughter K^{+}"
- Last step is to search for a mother-daughter relations among matching particles
  - Only relationships between matching particles are searched
  - These relationships are kept in POOL



How to use it?

- Retrieve `TrigInDetTruthMap` from StoreGate (default key is "TrigInDetTruthMap")
- Use accessor methods to get `TrigInDetTrackTruth` object with highest number of hits in given detector
- Use methods in `TrigInDetTrackTruth` to get `HepMcParticleLink` or number of hits
- Relevant packages:
  - `Trigger/TrigTruthEvent/TrigInDetTruthEvent`: truth association data
  - `Trigger/TrigAnalysis/TrigInDetTruthAlgs`: algorithm to fill association
- More documentation will be written soon

```
bool hasTruth(const TrigInDetTrack* p_trig_trk);
TrigInDetTrackTruth* truth(const TrigInDetTrack* p_trig_trk);
HepMcParticleLink* bestMatchSi(const TrigInDetTrack* p_trig_trk);
HepMcParticleLink* bestMatchTRT(const TrigInDetTrack* p_trig_trk);
int bestMatchSiHits(const TrigInDetTrack* p_trig_trk);
int bestMatchTRTHits(const TrigInDetTrack* p_trig_trk);
void print();
```

To finish…

- Level 2 track-truth association evolved from code in TrigNtInDet by John Baines doing the same task to fill ntuple
- New packages now working, including decay-chain relationships
- Some improvements still necessary in persistent objects, but not much
  - Minimum nr.of common hits should probably be configurable, etc.

TrigInDetTruthMap: 4 track-truth associations

#track	algo	pT	eta	phi	#match	mother	Sihits	TRThits	ev.index	barcode	pdg id	pT	eta	phi
0	2	45542.7902	1.9754	2.1737	0	--	7	9	0	130	-11	110119.0415	1.9756	2.1732
					1	--	0	2	0	201970	-11	19.9880	1.9892	2.1639
					2	--	0	3	0	201971	11	610.5007	1.9751	2.1698
1	2	-24194.2319	1.9949	0.8350	0	--	7	0	0	935	-321	27343.0328	1.9941	0.8360
					1	--	0	8	0	938	-211	6995.6603	1.9273	0.8156
					2	0	0	6	0	200387	-211	17743.0850	1.9919	0.8342
					3	--	0	1	0	200403	11	46.6854	1.8569	0.6936
2	2	-16702.0341	0.0652	0.1004	0	--	7	17	0	140	11	16951.3472	0.0659	0.1005
3	2	3266.7995	2.4728	-1.5954	0	--	4	0	0	621	211	3565.7388	2.4748	-1.5972