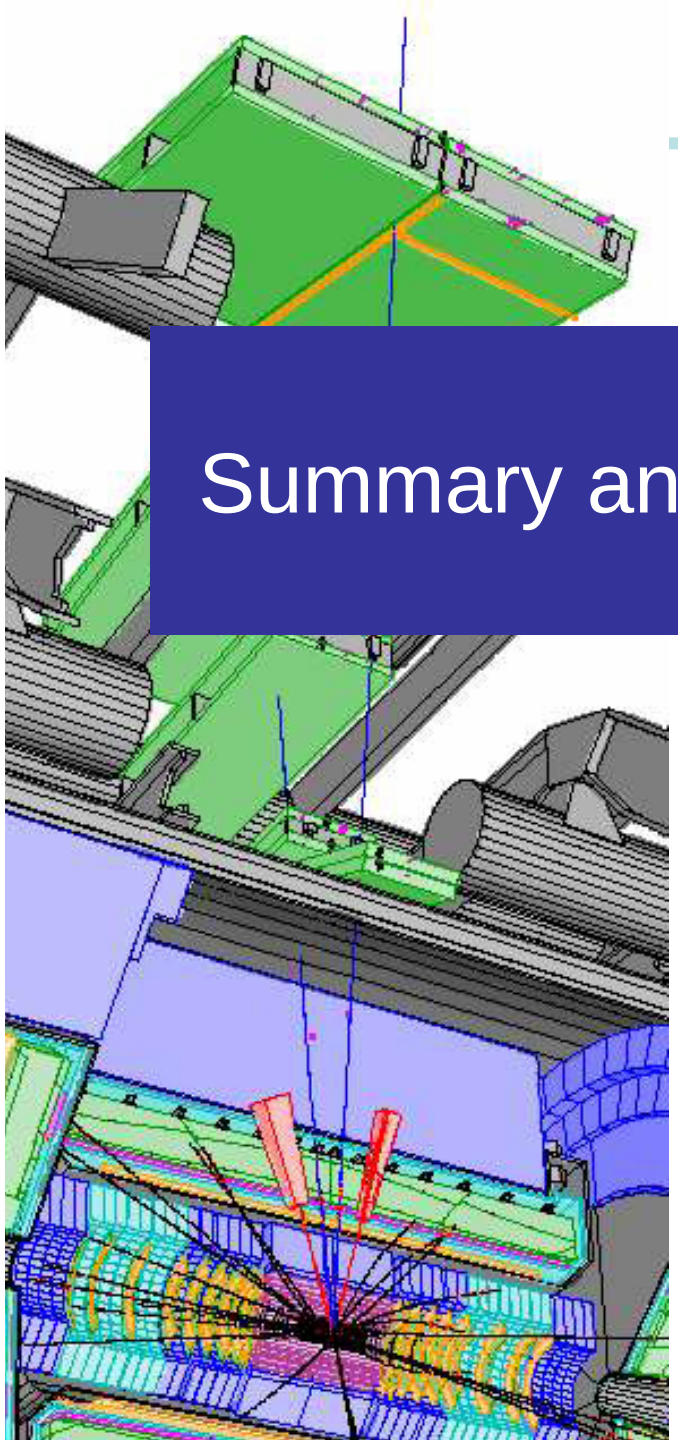


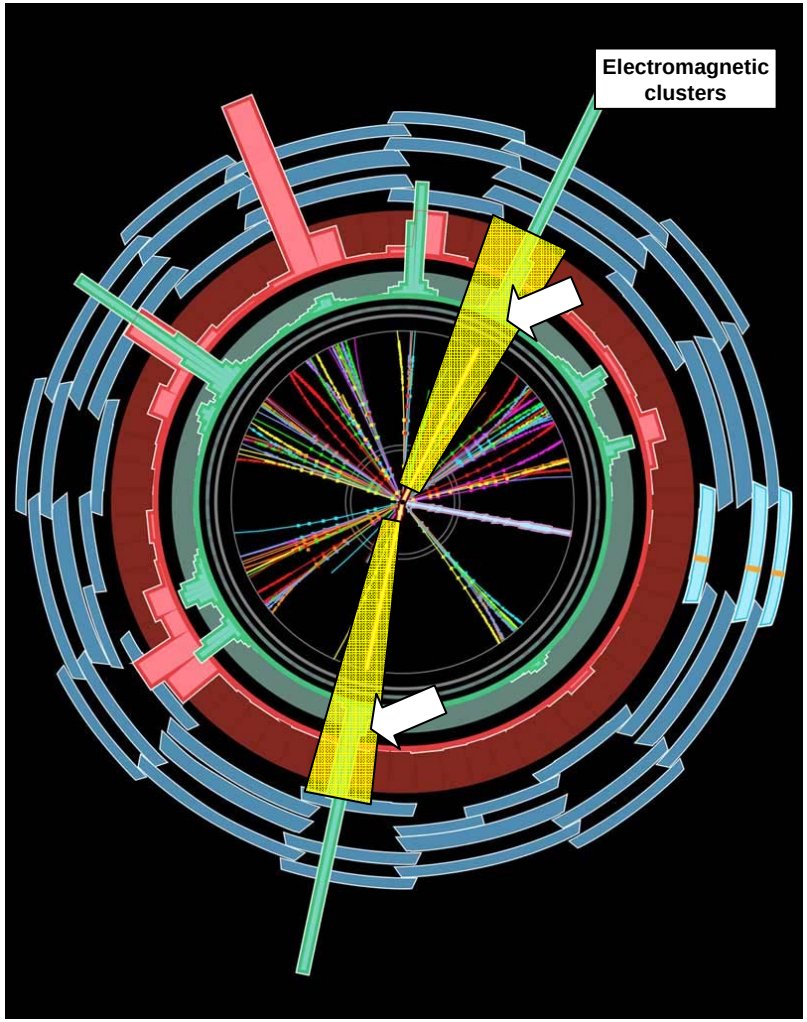
Summary and feedback on trigger AODs

- Introduction
- Overview of trigger data in the AODs
- Trigger-aware analyses and feedback
- Outlook

Ricardo Gonçalo (RHUL)

Introduction

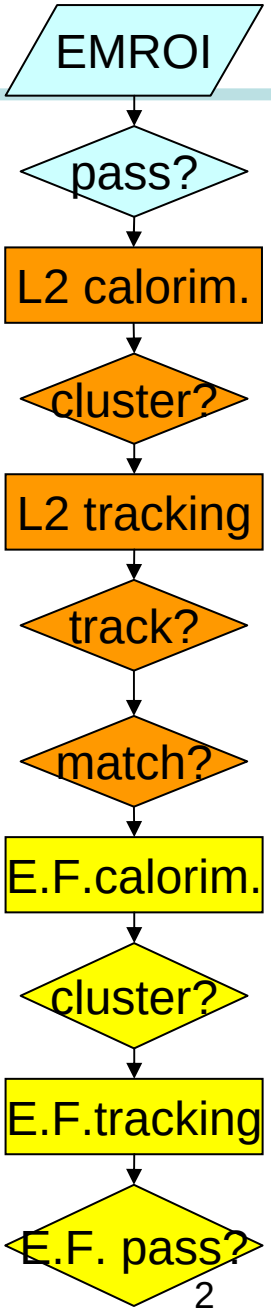
Chain can be abandoned at each step



Level1 **Region of Interest** is found with **coarse granularity** and position in EM calorimeter is passed to Level 2

Level 2 seeded by Level 1
Fast reconstruction algorithms
Full granularity Reconstruction **within RoI**

Ev.Filter seeded by Level 2
Offline reconstruction algorithms
Refined alignment and calibration



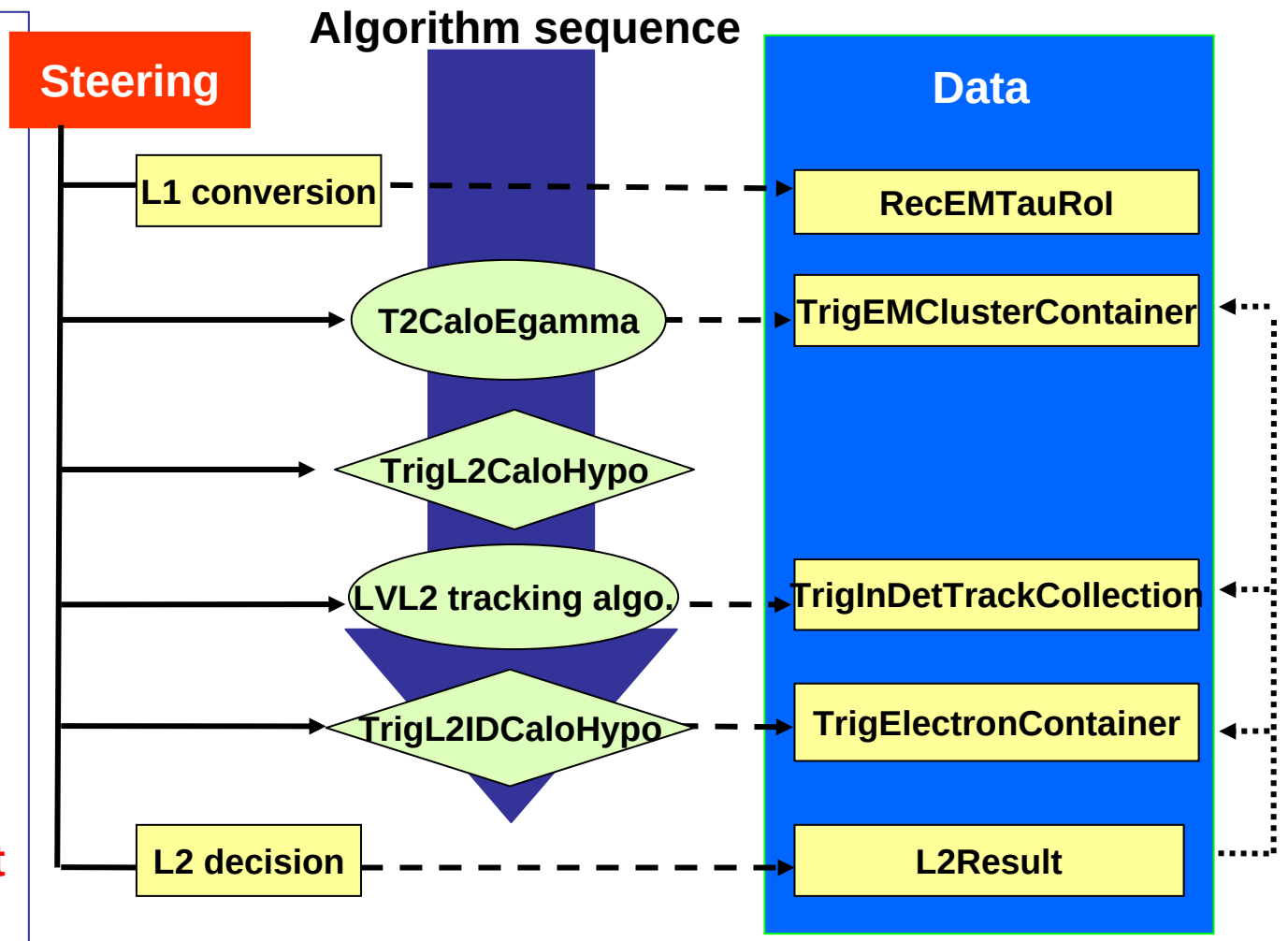
Concrete example: L2 electron chain

Level 1:

- **Level 1, emulated by software, produces EM region of interest**

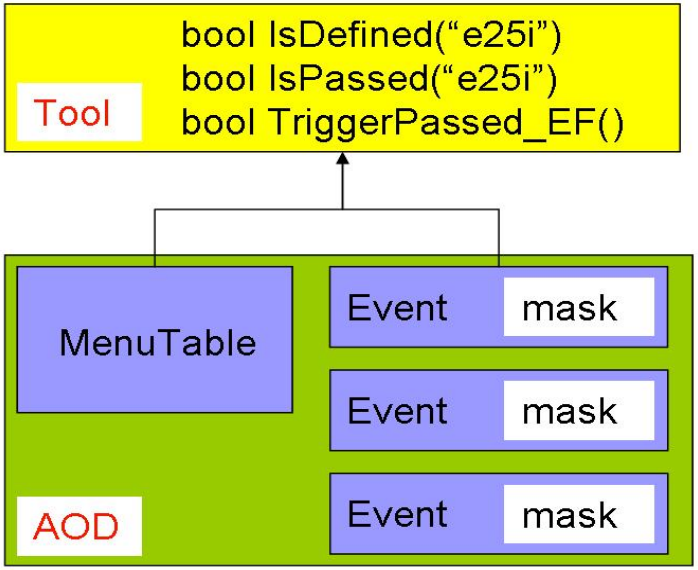
HLT:

- **Feature Extraction (FEX) algorithms interspersed with Hypothesis (Hypo) algorithms,to achieve early hypothesis rejection**
- **Steering also produces L2/EFResult which is attached to event**



TriggerDecision for physics analysis

- Typical application for ‘physicists’
  - Find out if event was trigger/not triggered
  - Find out if signature was in trigger menu
  - Note: trigger decision is event decision, not object decision



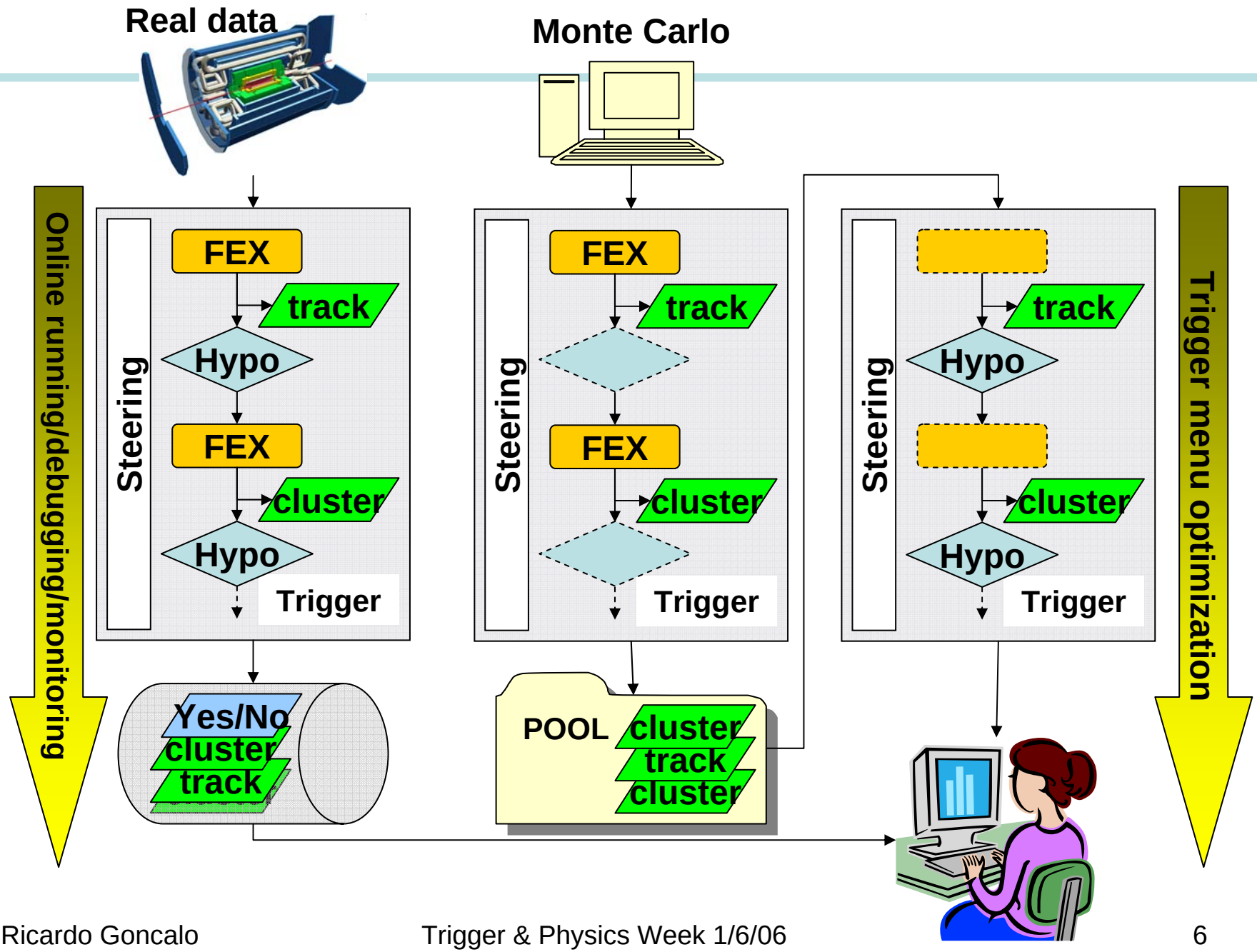
- Signatures passed/failed/prescaled encoded in a **bit pattern** for each reconstructed event: must be **interpreted** through a MenuTable

- This is the purpose of the TriggerDecision object

Advanced analysis for experts

- Using additional trigger information:
  - Compare with offline object and figure out e.g. why electron didn't trigger e25i whereas offline electron is 'good' electron
  - Needs some navigation from signature to particles, e.g. TrigElectron

- Re-run the hypothesis algorithms e.g. to do
    - Optimisation of given trigger item
    - Test new optimisations on physics channels
    - Develop new triggers
    - Debug trigger menu
  - Need to re-run trigger steering in AOD/ESD analysis


Real data
Monte Carlo
Online running/debugging/monitoring
Trigger menu optimization
Steering
FEX
track
Hypo
FEX
cluster
Hypo
Trigger
Steering
FEX
track
FEX
cluster
Trigger
Steering
track
Hypo
cluster
Hypo
Trigger
Yes/No
cluster
track
POOL
cluster
track
cluster

More information

- See Monika's tutorial in Japan for more information

http://agenda.cern.ch/fullAgenda.php?ida=a062235

- More on HLT persistency

https://uimon.cern.ch/twiki/bin/view/Atlas/HLTPersistencyRecipe

- List of available information in AOD/ESD

https://uimon.cern.ch/twiki/bin/view/Atlas/TriggerEDM

- PESA Wiki page

https://uimon.cern.ch/twiki/bin/view/Atlas/HighLevelTrigger#Physics_and_Event_Selection_Arch

- e/gamma analysis Wiki for example analysis job

https://uimon.cern.ch/twiki/bin/view/Atlas/EgammaTriggerAnalysis

Overview of trigger-aware analyses

- In 11.0.5, possible for the first time to produce TriggerDecision and re-run L2 hypothesis on ESD/AOD
- In 12.0.x same will be possible for EF
- Trigger-aware analyses presented this week:
  - **Trigger-aware analysis for Z to ee with 11.0.5 – T.Martin**
  - http://agenda.cern.ch/fullAgenda.php?ida=a062332#s2
  - **Trigger on GMSB – O.Jinnouchi**
  - http://agenda.cern.ch/fullAgenda.php?ida=a062380
  - **Trigger information in 11.0.5 – A. Krasznahorkay**
  - **http://agenda.cern.ch/fullAgenda.php?ida=a062471**
  - **Trigger -aware analysis for the H->4leptons channel, using CSC samples – S.Rosati**
  - http://agenda.cern.ch/fullAgenda.php?ida=a058304

Photon trigger for GMSB O. Jinnouchi

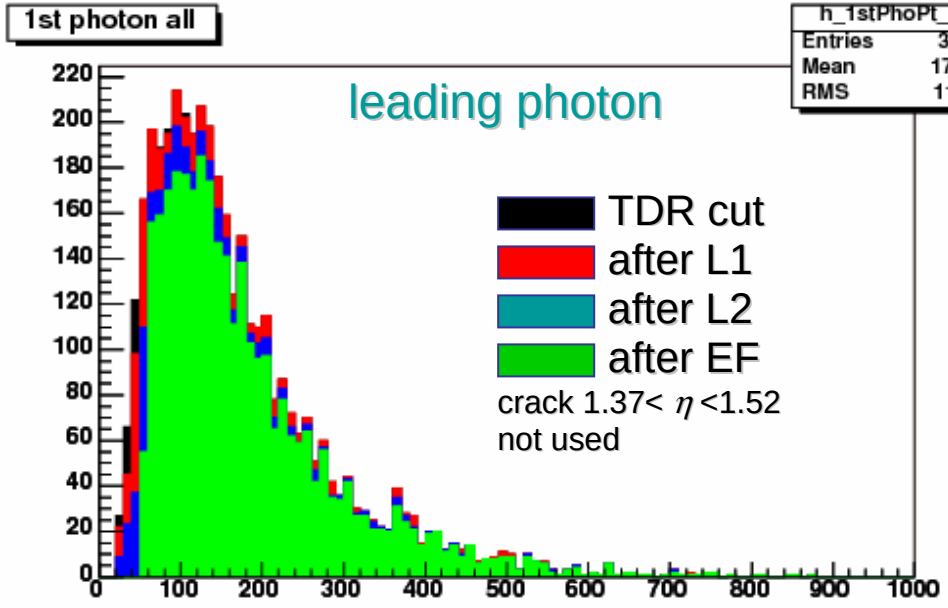
- Signature (G1a): *m* γ + *n* Leptons + Jets + E_T^{miss}
- Preselection: Meff>400 GeV; ETmiss>0.1 Meff; 2 leptons in |η|<2.5
- Investigated trigger efficiency wrt the TDR offline cuts:

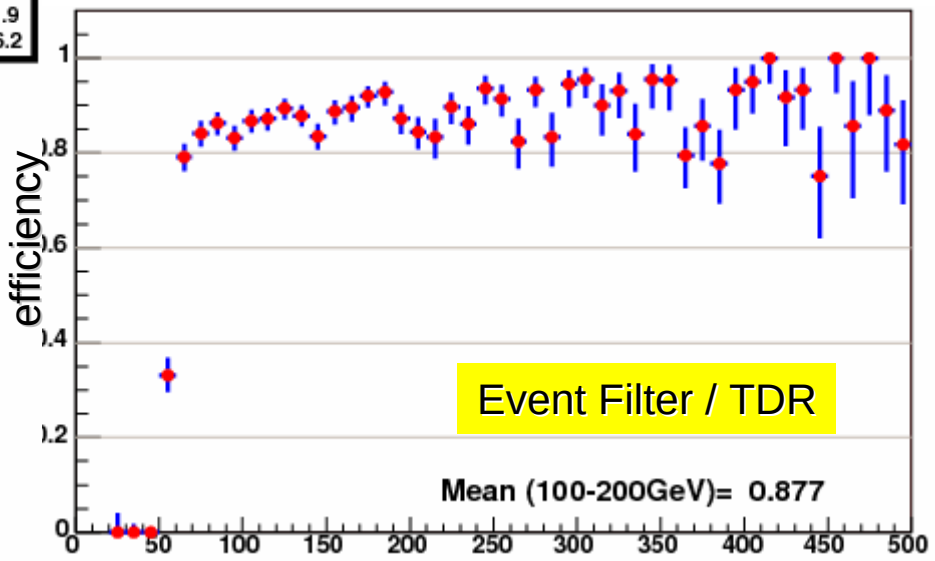
  2 photons with P_T>20 GeV and |η|<2.5
- Implemented photon signatures γ60 and 2γ20i in 11.0.5
- Replay hypothesis (cuts optimized on Rome data)

	1γ60	2γ20i	OR
after L1	*0.99*	*0.99*	*1.00*
after L2	*0.89*		*0.99*
after EF	*0.80*	*0.63*	***0.87***

Tested the machinery and produced feedback on L1 isolation

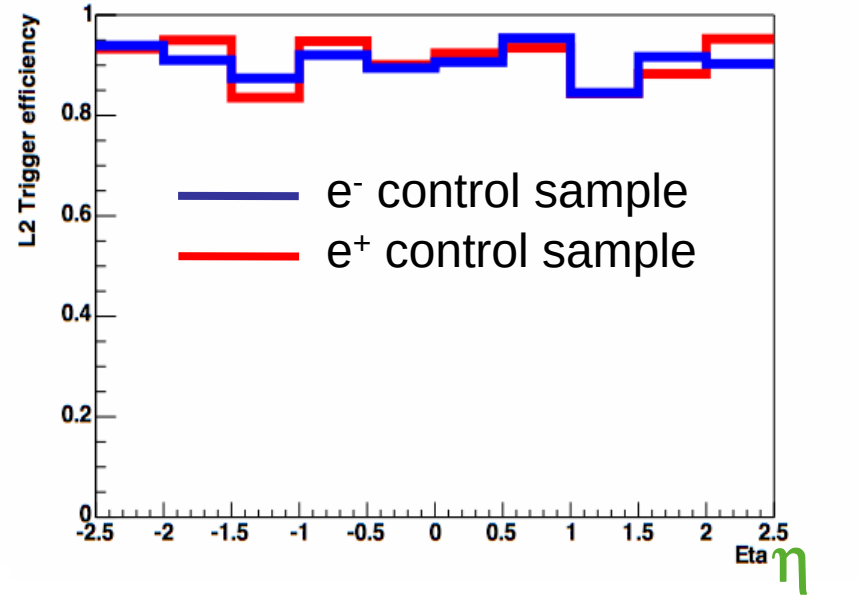
γ60



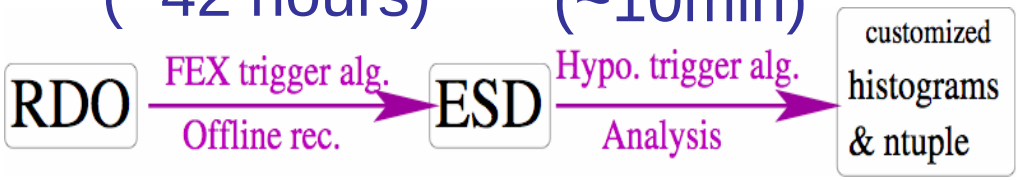


Electron efficiency from data T.Fonseca Martín

- Determine the single-electron trigger efficiency without relying on Monte Carlo
- Reconstructed control sample: "Good" $Z \rightarrow e^+e^-$ + single-electron signature
- Efficiency determined from fraction of events in which the second electron passed the trigger



(~42 hours) (~10min)



- Analysis done in rel. 11.0.5
- 10k $Z \rightarrow ee$ events from CSC validation sample
- Level 1: EM01 (E_T > 9 GeV)
- Level 2: default e25i (cuts optimised on Rome data)

Trigger Menus for H→ZZ$^{(*)}$→4l S.Rosati

- Adding trigger selection to the H→ZZ*→4l analysis (described in detail in previous talk and in previous meetings)

Signal M_H=130 GeV

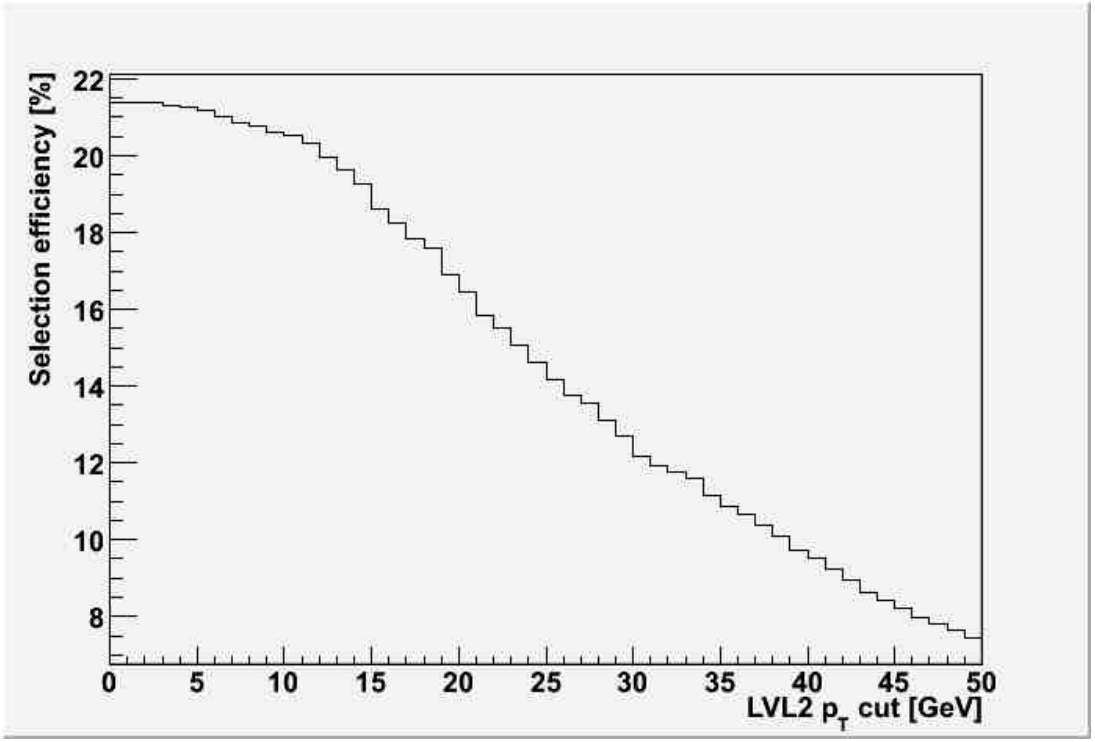
- LVL1 Efficiencies (in %) for:
  - all events in the sample (filter: 4-leptons with pT>5 GeV and |η|<2.7)
  - events after all H→4l offline selection cuts (kinematic cuts + Isolation + Impact parameter cuts)
- Errors are ~0.3% (~0.5%)

Trigger Menu	4e	4μ	2e2μ
1μ20	0.3 (0.0)	98.8 (99.8)	88.3 (90.2)
1e25i	98.5 (100)	2.9 (1.6)	77.3 (77.7)
1μ20 or 1e25i	98.5 (100)	98.8 (99.8)	98.7 (99.4)
1μ10 and 1e15i or 2μ10 or 2e15i	97.7 (100)	98.0 (99.5)	98.1 (99.7)
1μ20 and 1e25i or 2μ20 or 2e25i	86.2 (97.4)	89.8 (94.5)	87.1 (93.1)

LVL2 single muon trigger efficiency **A. Krasznahorkay**

AOD files produced with default trigger configurations for release 11.0.5 with LVL1 and LVL2 muon triggers

Absolute trigger efficiency with respect to full sample



- Selection efficiency of a LVL2 single muon trigger as a function of the LVL2 p_T cut, if there was a MU20 object at LVL1.

Feedback

- Had to do some things by hand in 11.0.5
- From user feedback, the need for a map between offline objects and RoIs became obvious (although it was already in our plans)
- Usefulness of running hypothesis algorithms on ESD was demonstrated (e.g. gains in speed)
- Demontration of muon slice running in level 2
- TriggerDecision was used intensively; will be filled automatically from 12.0.1

Trigger data in POOL

- All slices are running at L2 in 11.0.5
  - e/gamma
  - muon
  - tau
  - Jet/Etmiss
- Lots of progress in newer slices
- This generated lots of new data in AOD/ESD

List of trigger data classes available in AOD/ESD

Level	Class/Algorithm	11.0.5	12.0.x
L1	L1EtmissObject	✓	✓
L1	L1EMTauObjectContainer	✓	✓
L1	L1JetObjectContainer	✓	✓
L1	LVL1::JetElement	✓	✓
L1	LVL1::TriggerTower	✓	✓
L1	LVL1_ROI	✓	✓
L1	CTP_Decision	✓	?

Level	Class/Algorithm	11.0.5	12.0.x
L2	TrigTauCluster	✓	✓
L2	TrigEMCluster	✓	✓
L2	TrigInDetTrack	✓	✓
L2	TrigInDetTrackTruth	✗	12.0.3
L2	TrigElectron	✓	✓
L2	TrigPhoton	✗	12.0.1
L2	TrigTau	✓	✓
L2	TrigBjet	✓	✓
L2	TrigJet	✓	✓
L2	MuonFeature	✓	✓

Level	Class/Algorithm	11.0.5	12.0.x
EF	EDM classes (Offline)	✓	✓
EF	Track-truth association	✓	12.0.3
All	TriggerDecision	**Not filled**	✓

Conclusions and outlook

- Much was achieved in the last few months (even since the first T&P week)
- Release 11.0.5 has a lot more information available for analysis than 11.0.41
- With release 12 (most likely 12.0.3) there will be a significant amount of trigger information in the AODs and we will have a first partial menu
- This together with the possibility of re-running the trigger will generate enough information to tune signatures
- With several slices in good shape, we will have first baseline menu in time for third Trigger & Physics week

Backup slides

Size of AOD/ESD L1/L2 objects (DS 4022: top)

L1EMTauObjectContainer	0.09 kB
L1JetObjectContainer	0.05 kB
L1EtmissObject	~0 kB
LVL1_ROI	0.12 kB
CTP_Decision	0.004 kB
LVL1::JetElement	1.91 kB
LVL1::TriggerTower	6.18 kB
L2Result	1.44 kB
TrigElectron	4.32 kB
TrigEMCluster	0.16 kB
TrigInDetTrackCollection	5.33 kB
TrigTauClusterContainer	1.05 kB
TrigT2JetClusterContainer	0.09 kB
MuonFeature	~0 kB

<10% of AOD contents

few% of ESD contents

What do we have at present?

From: **https://uimon.cern.ch/twiki/bin/view/Atlas/TriggerEDM**

HLT

Class	level	Status	persistency		Documentation
			POOL?	Serializer?	in 11.0.5
L2Result	LVL2	ok	yes	n/a	Doxygen
TriggerElement	LVL2+EF	ok	no	n/a*	Doxygen
RoIDescriptor	LVL2+EF	ok	no	n/a*	Doxygen
LVL1::RecEMTauRoI	LVL2	ok	no	n/a*	Doxygen
LVL1::RecEnergyRoI	LVL2	ok	no	n/a*	Doxyegn
LVL1::RecJetEtRoI	LVL2	ok	no	n/a*	Doxygen
LVL1::RecJetRoI	LVL2	ok	no	n/a*	Doxygen
LVL1::RecMuonRoI	LVL2	ok	no	n/a*	Doxygen
TriggerDecision	LVL1 + LVL2 + EF	in development, planned for 11.0.5/11.4.0	Yes	n/a	Doxygen

Steering objects

Accessible from both BS and POOL

Algorithm to fill it in 12.0.1

* TriggerElement, RoIDescriptor and the various RecRoIs are included in the L2Result but this is done with special code, not the serializer.

MuonFeature	LVL2	ok	yes	yes	Doxygen
CombinedMuonFeature	LVL2	from 11.4.0	?	yes	Doxygen
TrigDiMuon	LVL2	?	?		Doxygen
TrigCaloCluster	LVL2	used from 11.0.5	yes	no (container)	Doxygen
TrigEMCluster	LVL2	used from 11.0.5	yes	no (array)	Doxygen
TrigTauCluster	LVL2	used from 11.0.5	yes	no (arrays)	Doxygen
TrigT2Jet	LVL2	used from 11.0.5	yes	yes	Doxygen
TrigMissingET	LVL2 & EF	new	probably	probably	Doxygen

New Calo EDM from 11.0.5

TrigElectron	LVL2	used from 11.0.5	yes	yes	Doxygen	Only electron and tau for now…
TrigTau	LVL2	used from 11.0.5	yes	yes	Doxygen	
CaloCluster	EF	ok	yes	no	Doxygen	From Offline EDM: not serial.
Rec::TrackParticle	EF	ok	yes	no	Doxygen	
tauObject	EF	ok	yes	no	Doxygen	
egamma	EF	ok	yes	no	Doxygen	
Jet	EF	ok	yes	no	Doxygen	

What's missing?

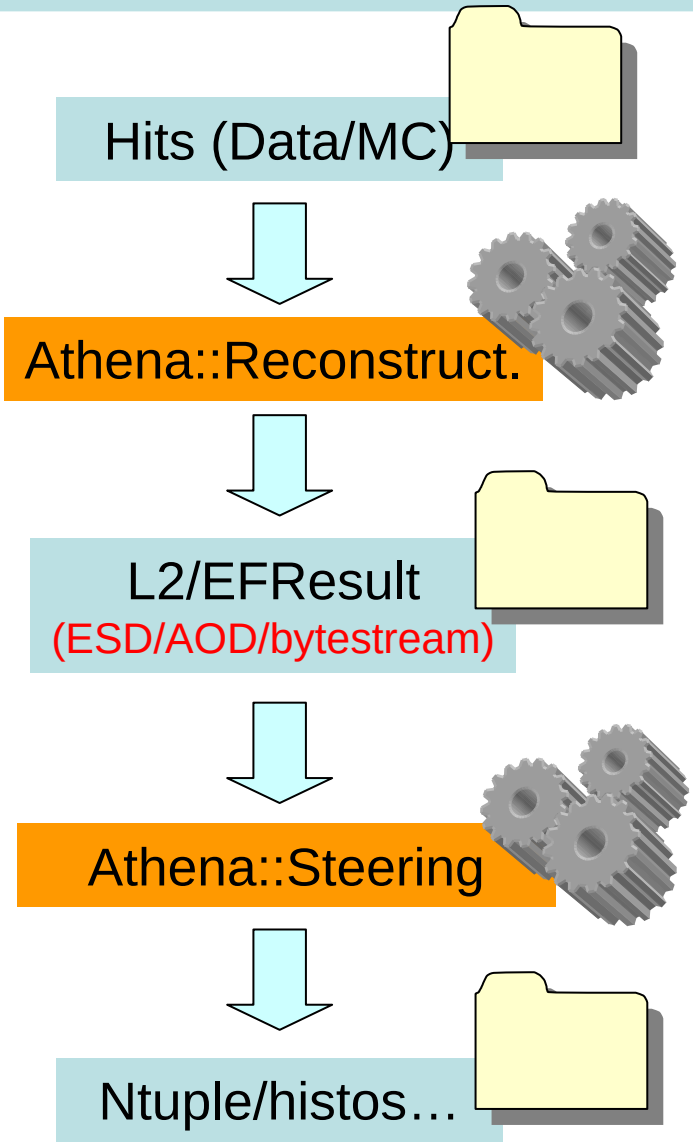
- **Truth-association classes**
- **New functionality in Serializer (STL container serialization)**
- **Having all objects in L2/EFResult (EF "persistent" EDM? Review started.)**
- **Some steering functionality: "accept all" mode**
- **What else?**

- Data objects (tracks, clusters, etc) are stored in L2/EFResult (some by reference, but this is a detail)
- L2/EFResult goes in AOD/ESD together with TriggerDecision object
- At L1/L2, the same objects stored in ESD as in AOD
  - No need to convert between ESD-type and AOD-type, they are all trigger objects
  - Same analyses runs on ESD and AOD
- At EF, re-use offline classes (needs to be reviewed)
- But most of the data classes are not accessible to physics user!
  - Interaction mostly through TriggerDecision (see below)

How to analyse ESD/AOD

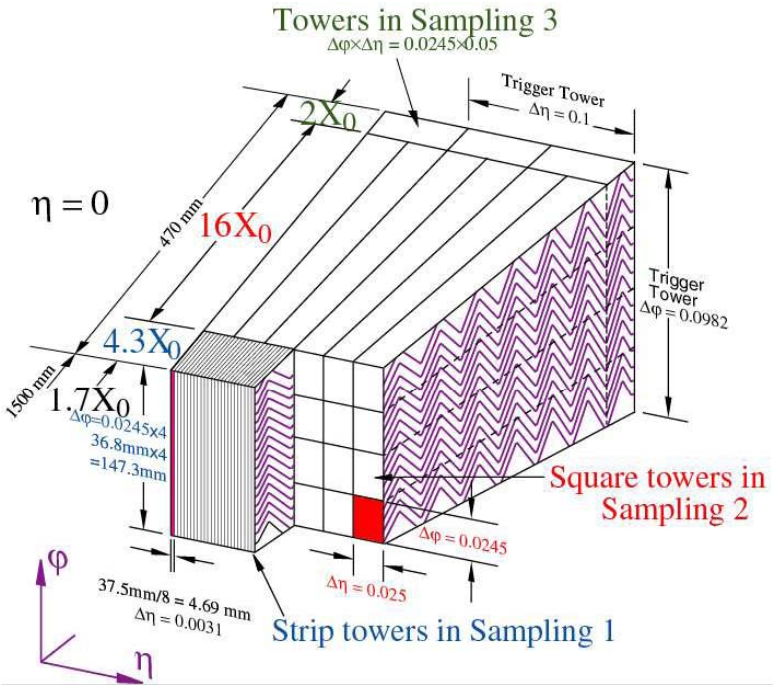
- To produce ESD/AOD:
  1. Just set doTrigger = True
  2. The Steering serializes all relevant data objects into L2/EFResult
  3. TriggerDecision object filled if Hypo algorithms run and put in ESD/AOD

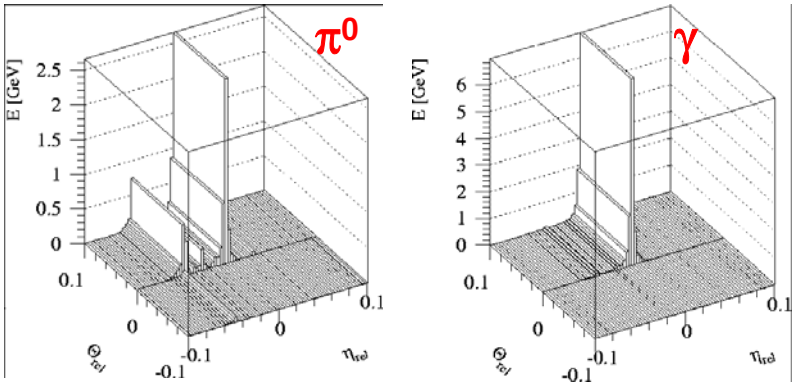
- To analyse ESD/AOD:
  A. Either:
     1. Set doTrigger = False
     2. Retrieve TriggerDecision and find result
  B. Or (for debugging/optimsation/)
     1. Set doTrigger = True (& etc)
     2. The Steering de-serializes all data objects
     3. Run hypothesis algorithms only on reconstructed features
     4. Retrieve new TriggerDecision at the end



Level 2: T2CaloEgamma

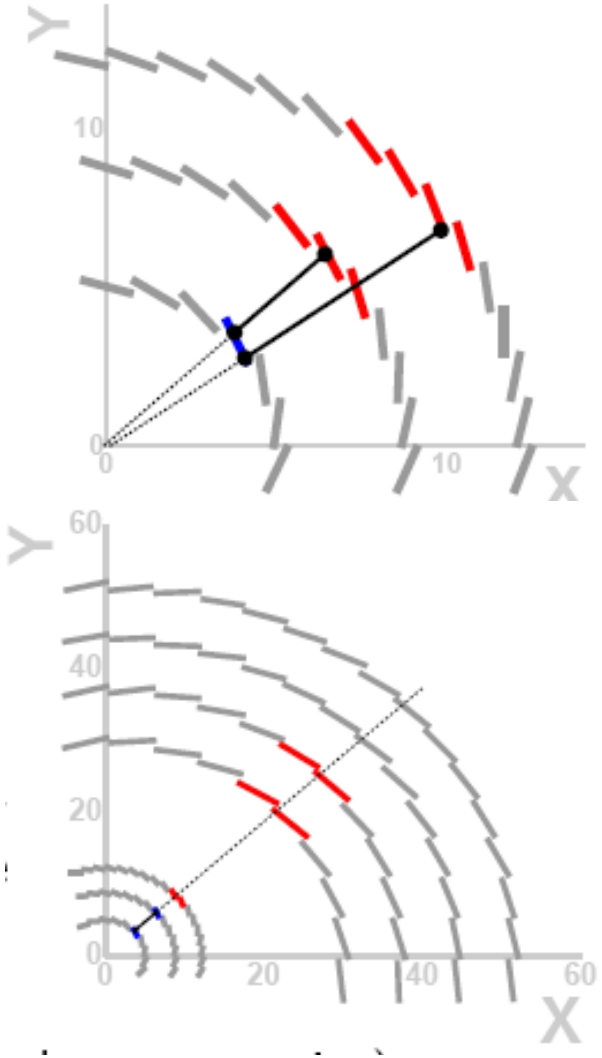
- Full granularity but short time and perhaps incomplete calibration & alignment
- Extends T2CaloCommon
- Data access factorized from algorithmic part
- T2CaloEgamma calls AlgTools:
  1. EgammaSamp2Fex: LAr sample 2; cluster position and size
  2. EgammaSamp1Fex: LAr sample 1; look for second maxima in strips
  3. EgammaEmEnFex: total cluster energy; include calibration
  4. EgammaHadEnFex: longitudinal isolation (leakage)
- Each calculates shower-shape variables with discrimination power
- Produced TrigEMCluster (since 11.0.5)
- Well developed code; important progress in time performance
- Review started last TDAQ week





Level 2 tracking: SiTrack

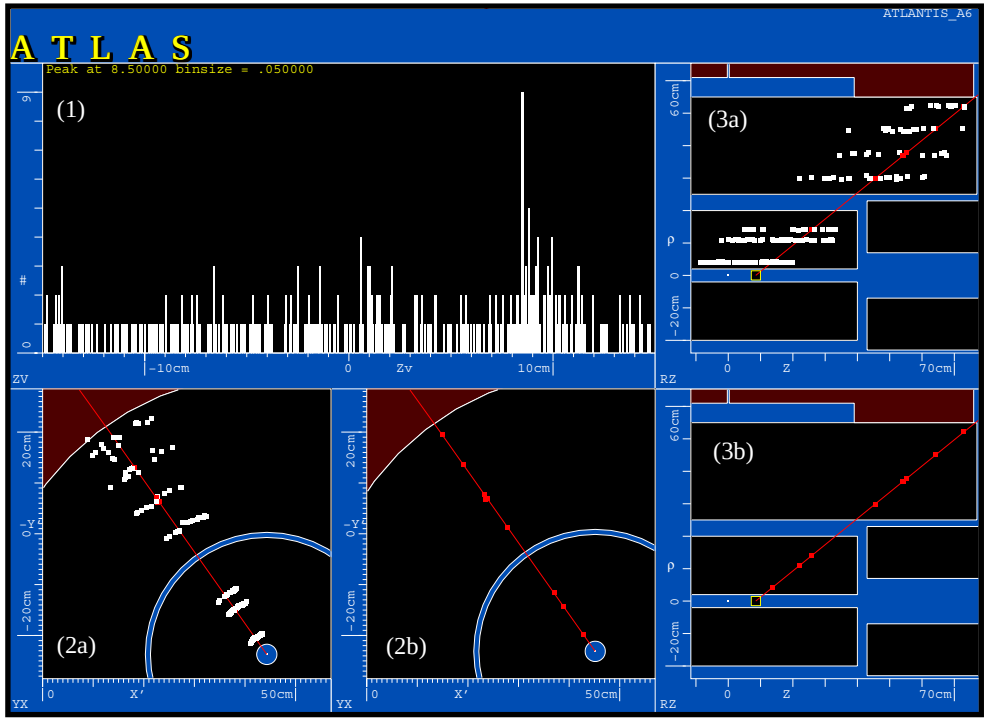
- SiTrack:
  1. Sorting: retrieve SpacePoints in ROI and sort them to speed up algorithm
  2. Seeding: look for pairs (seeds) of SpacePoints with one in b-layer
  3. Extension: extend outwards to find third point
  4. Merging triplets according to common hits
  5. Track fit: linear fit (analytic least squares) in r-Z; circle in r-ϕ
- Heavy use of lookup tables to achieve fast algorithm



Level 2 tracking: IDScan

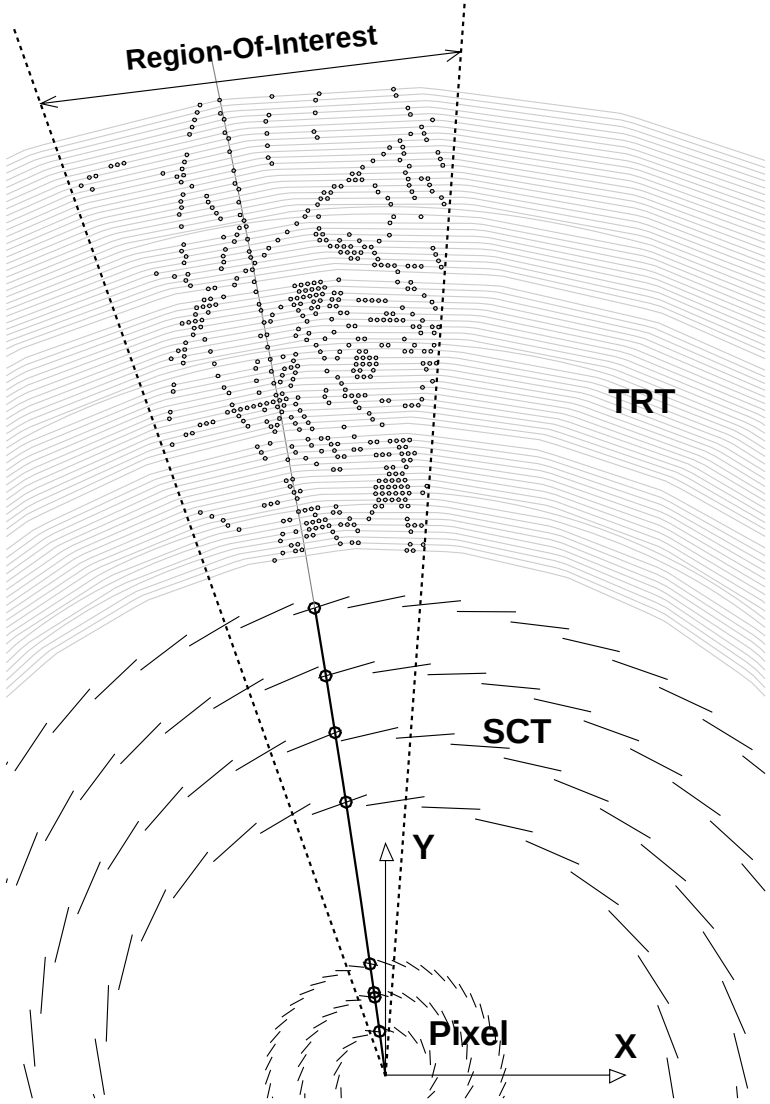
IDScan:

1. ZFinder: form pairs of hits in thin ϕ slices; extrapolate inwards to find Z_{vtx} at beamline from histogram
2. HitFilter: using Z_{vtx}, make 2D histogram of hits in η-ϕ plane; remove bins with hits from few layers
3. GroupCleaner: do 2D histogram using SpacePoint triplets in $1/p_T$-ϕ plane; tracks from bins with hits in 4/7 layers
4. Fitter: use Kalman technique on selected SpacePoints starting from already estimated Z_{vtx}, $1/p_T$, η, ϕ



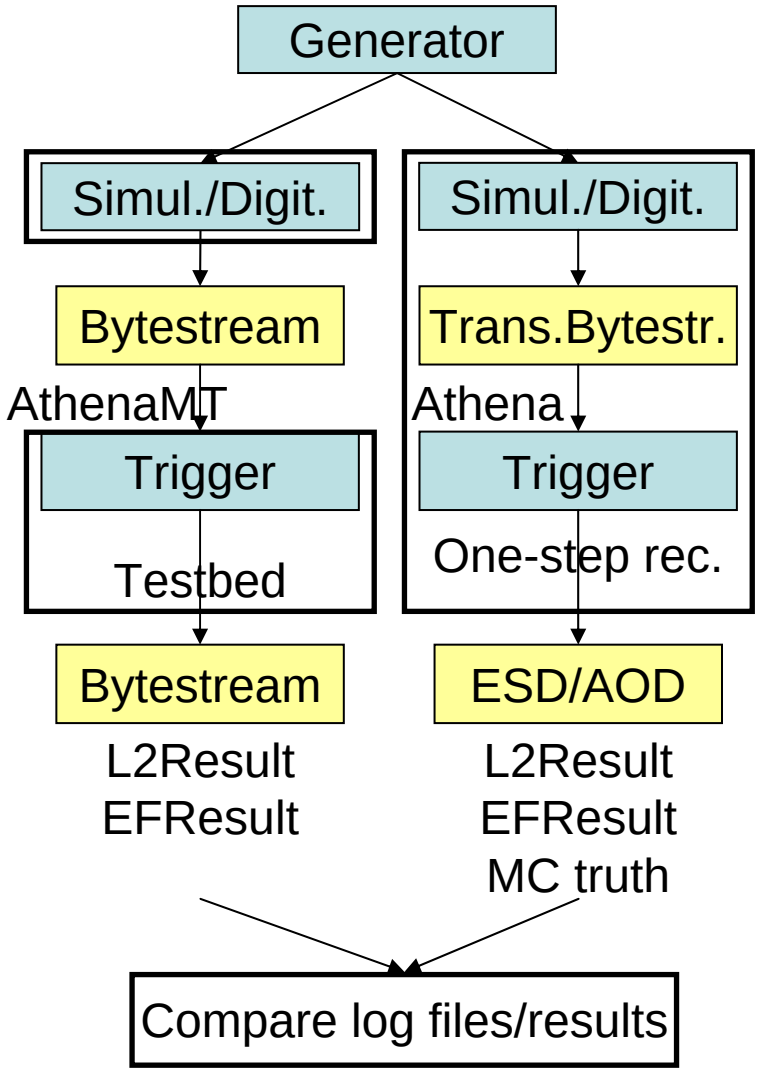
Level 2 tracking: TRT

- TRTxK
  - Wrapper for offline xKalman to be used in seeded mode
  - May be used to do standalone TRT tracking or using all ID detectors
- TRT extension tool
  - Extends tracks outwards to TRT by associating hits to the track according to the Probabilistic Data Association Filter (PDAF, com-daq-2005-022)
  - Tracking algorithms may be configured to use TRT extension



Trigger operation debugging

- Statistical: monitoring histograms
  - No need to store any data offline
  - Probably not useful if we're looking for small effects or unusual occurrences
- Event by event:
  - Only way to make HLT event data available is through L2/EFResult ⇒ Serializer
  - Regression-type test, running on bytestream data and comparing to ESD: in both cases, retrieve data from L2/EFResult and run hypothesis algorithms on it
  - MC truth information also available in ESD/AOD: compare reconstruction and truth



Global single electron Efficiency

$$\varepsilon^{trig} = \frac{2\,(N_2^z - B_2)}{(N_2^z - B_2) + (N_1^z - B_1)}$$

$$N_1^z = \varepsilon_z^{rec}\left(2\varepsilon_e^{trig} - \varepsilon_e^{trig\,2}\right)N_0^z + B_1$$

$$N_2^z = \varepsilon_z^{rec}\,\varepsilon_e^{trig\,2}\,N_0^z + B_2$$

N_1: counts in control sample

B_1: background below Z mass region in control sample

N_2: counts 2e trigger

B_2: bg. below Z mass for 2e trigger.

N_0: total number of $Z \to e^+e^-$ decays

ε^{rec}: Z reconstruction efficiency

ε^{trig}: global single electron trigger efficiency