ATLAS Software tutorial
9th – 12rd February 2010

Trigger Data for Analysis

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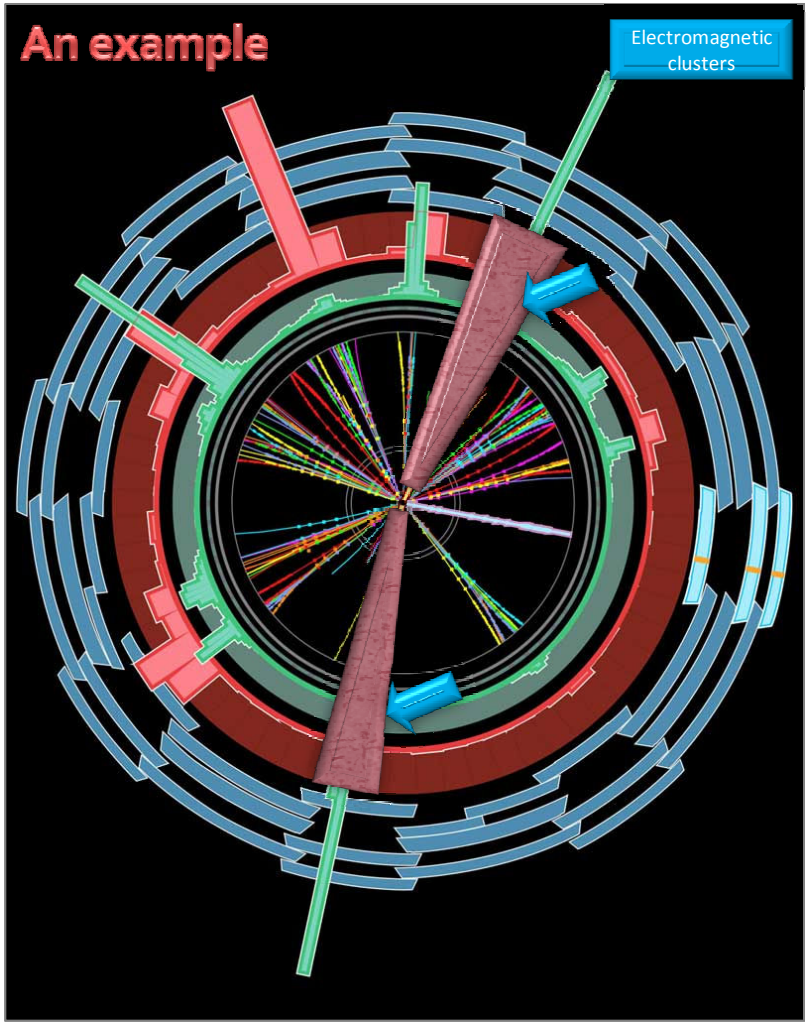
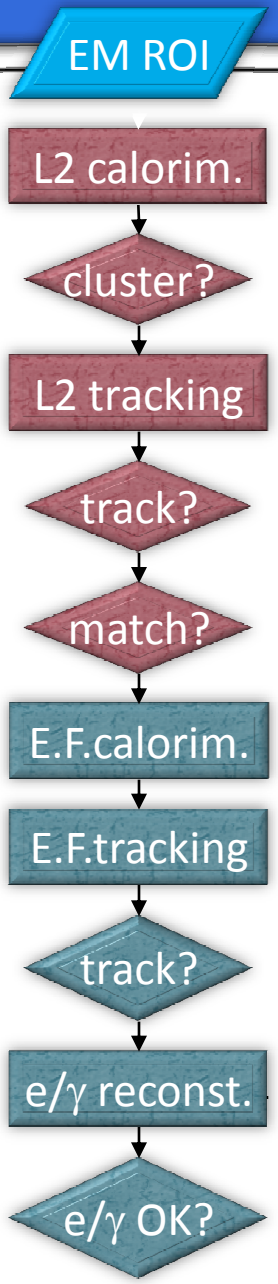
The Trigger



Level1:
Region of Interest is found and position in EM calorimeter is passed to Level 2

Level 2 seeded by Level 1
- Fast reconstruction algorithms
- Reconstruction within RoI

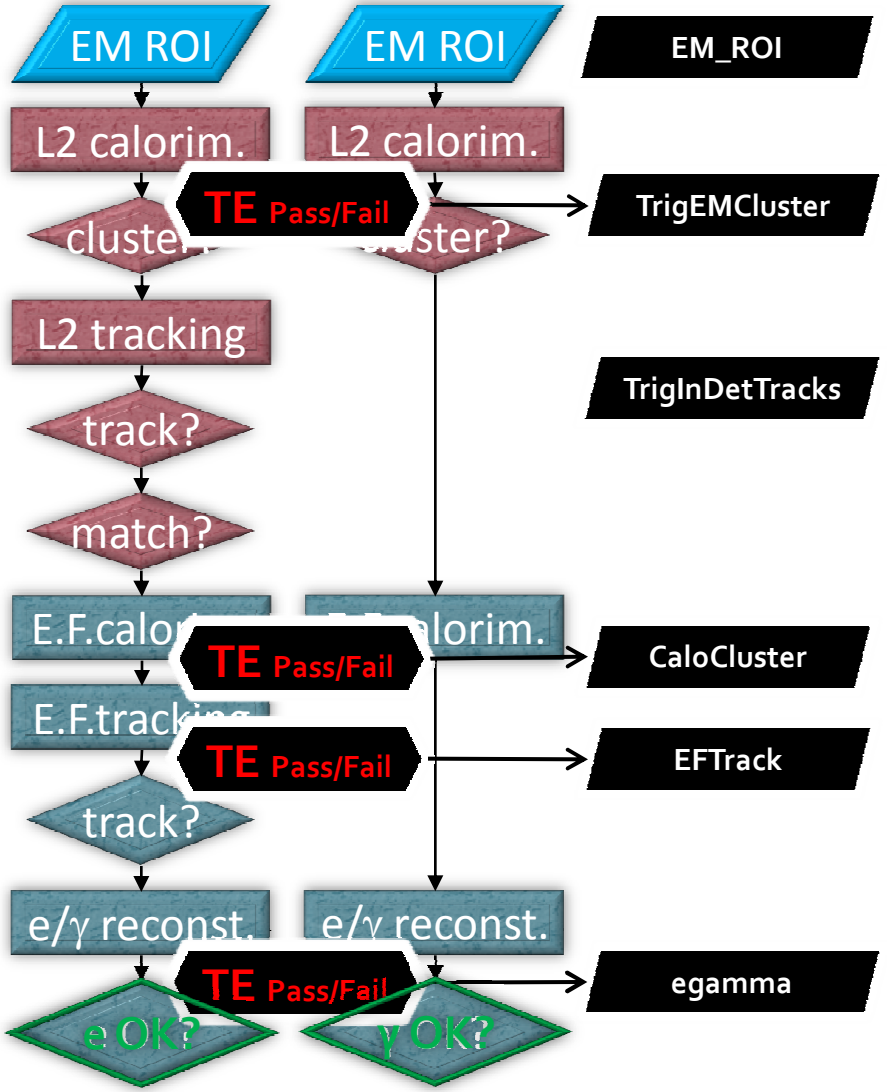
Ev.Filter seeded by Level 2
- Offline reconstruction algorithms
- Refined alignment and calibration



The Trigger Execution

FEX FEX algo's are executed to create Feature features on which selection in HYPO HYPO algo's is based

- Chain:
  - Started, if seed has fired and chain is not **PRESCALED**
  - Stopped **AT STEP**, if a HYPO is not passed
  - Last HYPO passed → **CHAIN PASSED**
- Event:
  - Passed, if at least one EF chain is passed
  - Put into all streams that are associated with the passed EF chains
- Trigger objects associated with triggers through Navigation TriggerElements
- Trigger information in **ESD** **AOD** **DPD** **TAG**
  - **TRIGGER DECISION** + **Configuration** + **Navigation** + **Feature**



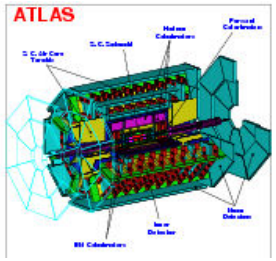
Trigger Configuration + Data

Preparation

Data taking

Reconstruction

Trigger aware analysis



Configures

TriggerDB
All configuration data

Stores decoded Trigger Menu

Online Conditions Database COOL

Encoded trigger result from all 3 levels

Decoded trigger menu

Trigger Result

- passed?, passed through?, prescaled?, last successful step in trigger execution?

Trigger EDM

- Trigger objects for trigger selection studies

Trigger Configuration

- Trigger names, prescales, pass throughs

access through TrigDecisionTool

ESD

AOD

DPD

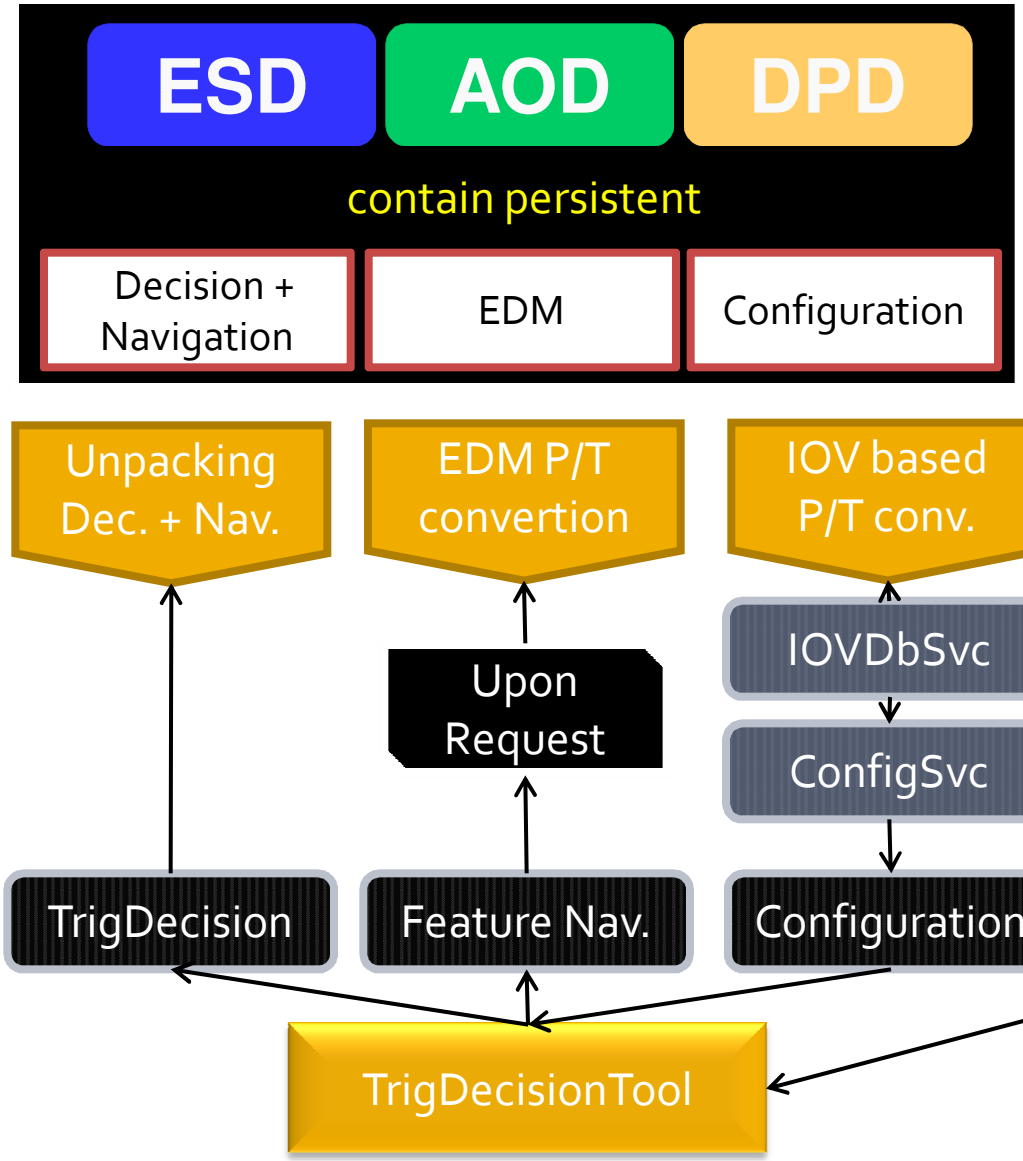
TAG

With decreasing amount of detail

Trigger-Aware Analysis – Introductory Comments

- Analysis based on single trigger chain or an 'OR' of a few chains (a 'ChainGroup')
- Chain definition – algorithms, cuts, multiplicities – do not change during a run, but can change between runs
  - Important for analysis on DPD, where multiple runs are merged, check the ChainGroup content between each run
- Prescales at LVL1 and at HLT can change between luminosity blocks
  - A negative prescale means that this trigger is off. This is important for calculating the integrated luminosity. Check each luminosity block.

Bringing it Together – TrigDecisionTool



Configuration can change between runs

BUT:

Prescales can change between lumiblocks (trigger on/off)

What's there? – Trigger Decision

- Lvl1 decision after dead-time veto
- HLT decision, information for pass-through'ed and for resurrected triggers
- Bunch groups that fired
- For more detailed studies:
  - Lvl1 decision before prescale, before veto
  - Error codes for HLT-algorithms
  - Last step of chain execution

Tool Usage

1. Alg.h: define ToolHandle to a TrigDecisionTool

```
private:
    ToolHandle<Trig::TrigDecisionTool>  tdt;
```

2. Alg.cxx – Alg::Alg(): declare ToolHandle as public tool

```
MyAlgo::MyAlgo(const std::string &name, …)
tdt("Trig::TrigDecisionTool/TrigDecisionTool")
{…}
```

3. Alg.cxx – Alg::initialize(): retrieve tool
   - Has to be in initialize()!

```
StatusCode sc = tdt.retrieve();
```

4. Alg.cxx – Alg::execute(): use tool

```
if (tdt->isPassed ("L2_e15i"))  {
    log << MSG::INFO << "I'm happy!" << endreq;
}
```

TWIKI: https://twiki.cern.ch/twiki/bin/view/Atlas/TrigDecisionTool15
Doxygen: http://atlas-computing.web.cern.ch/.../TrigDecisionTool/html/

Working with ChainGroups

1. Alg.h: define ChainGroup pointer

```
const Trig::ChainGroup* mMyTrigger;
```

2. Alg.cxx – Alg::initialize(): declare ChainGroup
   - Note: the ChainGroup automatically updates with each run (chain content) and lumiblock (prescales)
   - Use regular expressions, e.g. "EF_e.*"

```
mMyTrigger =

tdt.createChainGroup("EF_e10_loose","EF_mu10",...);
```

3. Alg.cxx – Alg::execute():
   - Access to trigger configuration
   - Access to trigger decision
   - Access to trigger objects

```
bool useLB = ! mMyTrigger->getListOfTriggers().empty();
```

```
bool myEvent = mMyTrigger.isPassed();
```

```
const Trig::FeatureContainer fc = mMyTrigger.features();
const std::vector< Trig::Feature< TrigTau > > taus =
      fc.get();
```

Anonymous ChainGroups:

- Note that one can work without steps 1 and 2. In Alg::execute() define the triggers on the fly:
- Equally fast (TDT keeps ChainGroups)

```
string  tr ("EF_e10_loose");
bool useLB = ! tdt->getListOfTriggers().empty(tr);
bool myEvent = tdt->isPassed(tr);
const Trig::FeatureContainer fc = tdt.features(tr);
```

What's there? – Features and Navigation

- Access to features through the "TriggerNavigation"
- Features are created by FEX algorithms, they appear in StoreGate. A FEX also creates a "TriggerElement" (TE)
  - A TE is used as handle to the feature
  - A TE has a pass/fail state set by the corresponding HYPO
- The navigation gives you all the features that were created in a chain
  - Or just those that were successful (features in ROI's which passed all cuts) – that is the default!
  - Can also give you combinations of features (for multi-object triggers)
  - Ancestor function to navigate, e.g. from electron to track and cluster

Athena Example for using Features

FeatureContainer for 'EF_tau16i_loose_2j23'

Access the feature
You need to know the type of the Feature: 'JetCollection' in EF

Access the object (implicit conversion)

Access information of object

Find corresponding L2 jet using TDT::ancestor<T>

```
FeatureContainer f = tdt->features("EF_tau16i_loose_2j23");  // creating the feature container
std::vector< Feature<JetCollection> > jetColls = f.get<JetCollection>();
mLog << MSG::INFO << "Number of JetCollections: " << jetColls.size() << endreq;
if(jetColls.size()>0) {
   const Feature<JetCollection>& jcf = jetColls[0]; // get the first Feature
   mLog << MSG::INFO << "Label: " << jcf.label() << endreq;
   const JetCollection* jc = jcf;    // implicit Feature -> object conversion
   mLog << MSG::INFO << "Number of Jets: " << jc->size() << endreq;
   JetCollection::const_iterator jIt = jc->begin();
   for (; jIt != jc->end(); ++jIt ) {
      Jet* jet = *jIt;
      mLog << MSG::INFO << "Jet e : " << jet->e() << endreq;
   }
   // find the corresponding jets in Lvl2 through the inheritance tree (navigation does that all)
   Feature<TrigT2Jet> l2jetF = tdt->ancestor<TrigT2Jet>(jcf);
   mLog << MSG::INFO<<"Found "<< (l2jetF.empty()?"no ":"")<< "corresponding L2 Jet."<<endreq;
   if ( !l2jetF.empty() ) {
      const TrigT2Jet* t2jet = l2jetF.cptr(); // explicit Feature -> object conversion
      mLog << MSG::INFO << " e : " << t2jet->e() << endreq;
   }
}
```

Output:

```
Number of JetCollections: 1
TE Label: TrigJetRec
Number of Jets: 1
Jet e : 82827.9
Found corresponding L2 Jet.
e : 83197.4
```

Trigger Object Matching

- Why?
  - Some analyses require object level trigger information: Tag and Probe
  - Some analyses have multiple objects of same type and need matching for detailed efficiency estimation
  - Trigger selection design and optimisation

- Matching framework available in Trigger/TrigAnalysis/TrigObjectMatching package in release 15.3.0 and later
- Examples available in Trigger/TrigAnalysis/TrigAnalysisExamples in release 15.4.0 and later
  - TrigMatchExAlg - Athena example of matching for each common offline type
  - TrigMatchExampleARA - Example of trigger matching in ARA
  - TagAndProbeExAlg - Athena example of tag and probe analysis with trigger matching
- TWiki available with detailed information for users and developers
  - https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerObjectsMatching

What's there? – Configuration Data

- L1 Items: name, prescale
  - For more detailed studies: version, CTP-Id, bunch group, thresholds and multiplicities
- HLT Chains: name, level, prescale, streams
  - For more detailed studies: version, counter, trigger elements and multiplicities
- Trigger Release, configuration keys (useful for lookup in the TriggerDB)
  - No access with the TDT, but checkConfigTrigger.py

Configuration Access with the TDT

std::vector< std::string >	**getListOfTriggers (const Trig::ChainGroup *chaingroup) const**
	List of trigger names of the ChainGroup chaingroup
std::vector< std::string >	**getListOfStreams (const Trig::ChainGroup *chaingroup) const**
	List of stream names of the ChainGroup chaingroup
std::vector< std::vector< std::string > >	**getListOfTriggerElements (const Trig::ChainGroup *chaingroup) const**
	List of lists of TE names in ChainGroup chaingroup. *Inner vectors are for a single trigger step, the length of those is the trigger multiplicity.*
float	**getPrescale (const Trig::ChainGroup *chaingroup, unsigned int condition=TrigDefs::Physics) const**
	Prescale of the ChainGroup chaingroup.

- All methods come with two flavors, argument:

  const Trig::ChainGroup *chaingroup

  const std::string &triggerNames=".*"

  Here the ChainGroup is created on the fly from the pattern 'triggerNames' (regexp - ".*" means 'all')

- All functions are forwarded from ChainGroup, tdt->fnc(chgr,...) is equivalent to chGr->fnc(...)

- Prescales: For single triggers the prescale combined for all levels is returned. If a multi-trigger ChainGroup contains an unprescaled trigger, the return value is 1. It is 0 otherwise.

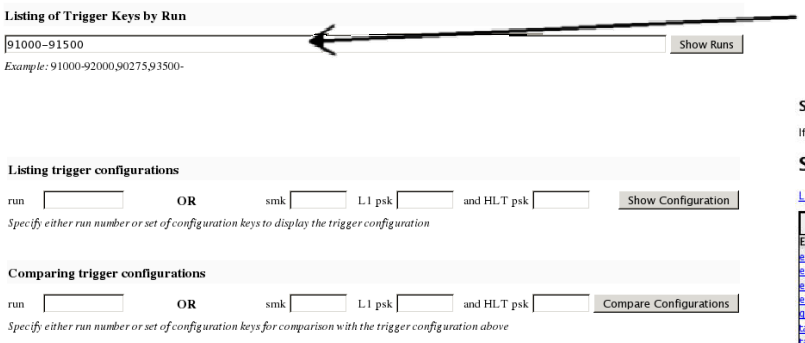
Tools to Investige the Trigger Setup

- http://trigconf.cern.ch:
  - Main web portal to trigger configuration by run number, MC menu name, configuration keys
  - Uses TriggerTool and AtlCoolTrigger.py underneath
- TriggerTool:
  - Java based GUI to browse the TriggerDB (replica) for all information
  - Also used at point 1 for preparation of trigger
- AtlCoolTrigger.py:
  - Command line tool to show release, configuration keys, menu information, streams for data
- http://atlas-runquery.cern.ch/
  - Query page for trigger chains, prescales, trigger release for data

Example for the Configuration Portal

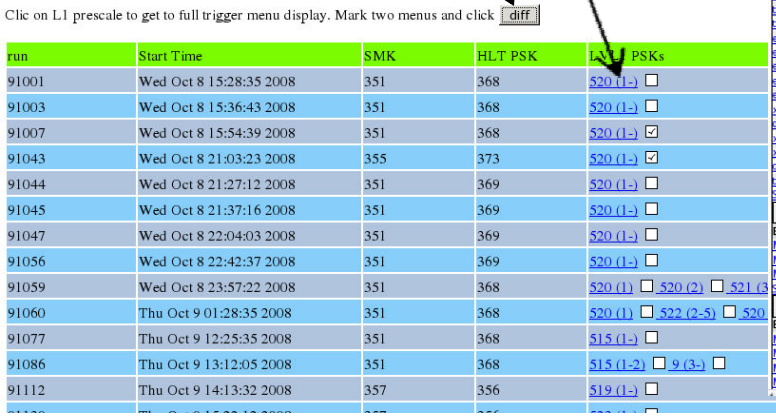
- Go to http://atlas-trigconf.cern.ch

1. Enter run-range

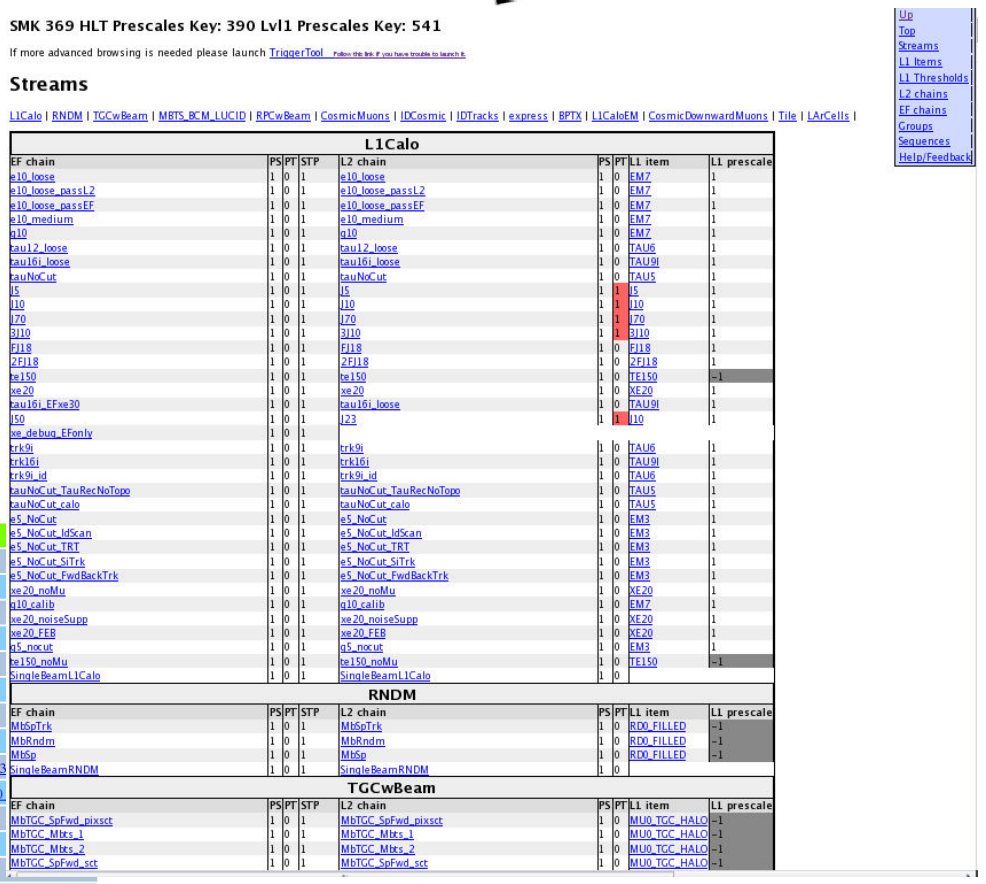


2. Click on link in resulting run list

Also with simple comparison functionality



3. Browse the trigger configuration (definition, algorithms, selection cuts)

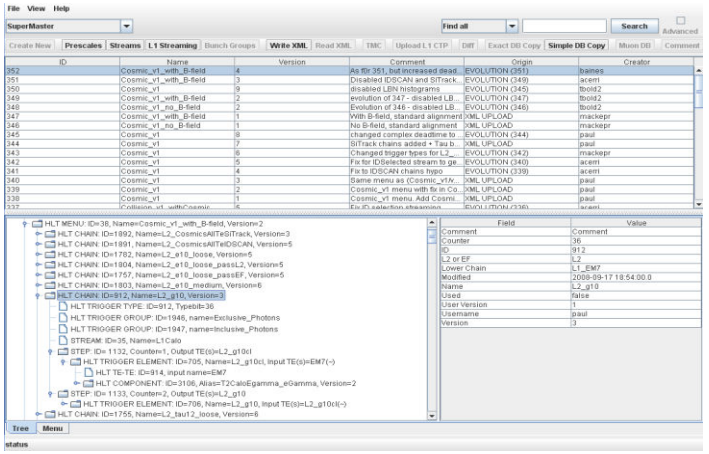


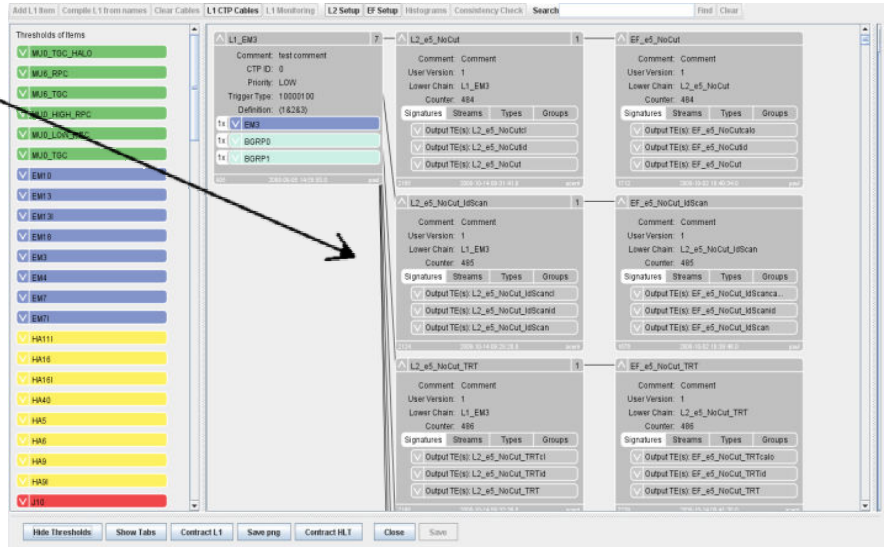
Trigger Menu Listing

- Trigger Menu and L1 rates stored in COOL, HLT rates coming. Quick access via
  - AtlCoolTrigger.py (command line tool)
    - AtlCoolTrigger.py –r 91000-99000 (many run summary)
    - AtlCoolTrigger –v –m –r 90272 (single run menu)
      - Prints keys, trigger menus, streams, allows diff-ing of menus in different runs, creates menu in xml format
  - Run summary pages (WEB based):http://atlas-service-db-runlist.web.cern.ch/atlas-service-db-runlist/query.html
    - Trigger names, rates for single run

TriggerTool

- Java based front end to TriggerDB, launch from the web (Java web-start): http://www.cern.ch/triggertool
  - Overview of all trigger configurations (data taking and MC)
  - Detailed and convenient investigation of trigger menus
    - Trigger definition L1->L2->EF: prescales, threshold algorithms, selection criteria, streaming information, etc.





- Possibility to compare different trigger configurations
- Used at point 1 for trigger operation
- TDAQ training tutorial for the TT

Scripts to Check Pool File Content

- checkTrigger.py AOD.pool.root
  - Runs over ESD/AOD/DPD and presents detailed (chain-wise) counts of the trigger decision

```
File:AOD.pool.root
Size:   55955.492 kb
Nbr Events: 250

Trigger configuration summary:
SMK: 0, HLTpsk: 0, L1psk: 0
Config source: TriggerMenuXML/LVL1config_MC_lumi1E31_no_prescale_15.1.0.xml and
TriggerMenuXML/HLTconfig_MC_lumi1E31_no_prescale_15.1.0.xml
L1 Items  : 146
HLT Chains : 556

================================================================================
 ID level    Trigger name    Passed events:  raw, after PS, after PT/Veto
================================================================================
    LVL1  Global LVL1              250
    LVL2  Global LVL2              250
     EF   Global EF (LVL3)         250
--------------------------------------------------------------------------------
 13 LVL1  L1_2EM13               71    71       71
 14 LVL1  L1_2EM13I              34    34       34
 163 LVL1  L1_2EM13_MU6           8     8        8
....
--------------------------------------------------------------------------------
...
 77 LVL2  L2_2g10               118   118      118
 246 LVL2  L2_2g10_mu6           12    12       12
....
--------------------------------------------------------------------------------
...
 477  EF  EF_2e6_medium           8     8        8
 478  EF  EF_2e6_medium1          7     7        7
 79  EF  EF_2g20                39    39       39
 248  EF  EF_2j42_xe30            3     3        3
....
================================================================================
```

- checkTriggerConfig.py -d AOD.pool.root
  - Runs on ESD/AOD/DPD and presents detailed trigger configuration(s)
  - Shows multiple configurations (merged DPD)

```
> checkTriggerConfig.py –d data09_cos.00121733.physics_L1Calo.recon.ESD.r733_tid073522/ESD.073522._000001.pool.root.1
…
EF: EF_muo_tgc_halo_IDSCAN (1.00), L2: L2_muo_tgc_halo_IDSCAN (1.00), L1: L1_MUo_TGC_HALO (1) [streams: TGCwBeam]
…
```

Trigger Content of Atlas-Runquery

- Search for runs by release, configuration key, trigger content
- Display and have links to run-summary, AMI, trigconf.ch, e-log

Run	Links	#LB	#Events	#Events (SFO)	#L2A	SMK	HLT PSK	L1 PSK	Release	Trigger Chains
91890	RS, AMI, Trigger, ELOG	35	2,022,080	2,297,668	5,787,181	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0), EF_e5_NoCut_FwdBackTrk (1|0)
91891	RS, AMI, Trigger, ELOG	24	n.a.	n.a.	n.a.	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0), EF_e5_NoCut_FwdBackTrk (1|0)
91892	RS, AMI, Trigger, ELOG	1	2,344,840	2,620,933	6,743,545	n.a.	n.a.	n.a.	n.a.	
91893	RS, AMI, Trigger, ELOG	1	23,316	26,452	75,012	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0), EF_e5_NoCut_FwdBackTrk (1|0)
91894	RS, AMI, Trigger, ELOG	1	0	0	0	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0), EF_e5_NoCut_FwdBackTrk (1|0)
91895	RS, AMI, Trigger, ELOG	3	20	22	20	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0), EF_e5_NoCut_FwdBackTrk (1|0)
91896	RS, AMI, Trigger, ELOG	2	40	46	40	368	388	n.a.	14.2.23.2	EF_e5_NoCut (1|0), EF_e5_NoCut_IdScan (1|0), EF_e5_NoCut_TRT (1|0), EF_e5_NoCut_SiTrk (1|0),

Summary

- Trigger data access in Athena, ARA, C++, or python with the TrigDecisionTool!
  - Many examples, plus a large number of people to provide help when needed (hn-atlas-TriggerHelp at cern.ch)
- Tools to check the trigger information for given run
  - Configuration: TriggerTool or http://atlas-trigconf.cern.ch
  - Pool files: checkTrigger.py and checkTriggerConfig.py
- Prescales to be checked for each lumiblock → luminosity
  - Remember that negative prescale means trigger did not run
- Important for analysis: matching of offline reconstruction and trigger objects

Additional Information

Trigger user info:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerUserPages
Tutorials:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerSoftwareTutorialPage
TDT Twiki:	https://twiki.cern.ch/twiki/bin/view/Atlas/TrigDecisionTool
TDT Doxygen:	http://atlas-computing.web.cern.ch/atlas-computing/links/nightlyDevDirectory/AtlasOffline/latest_doxygen/InstallArea/doc//TrigDecisionTool/html/index.html
Trigger obj matching:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerObjectsMatching
TrigAnalysisExample:	http://atlas-computing.web.cern.ch/atlas-computing/links/nightlyDevDirectory/AtlasOffline/latest_doxygen/InstallArea/doc/TrigAnalysisExamples/html/index.html
UserAnalysis example:	https://twiki.cern.ch/twiki/bin/view/AtlasProtected/UserAnalysis
Trigger Configuration:	http://trigconf.cern.ch
TriggerTool:	http://www.cern.ch/triggertool
Run query:	http://atlas-runquery.cern.ch/
Trigger EDM:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerEDM, http://alxr.usatlas.bnl.gov/lxr/source/atlas/Trigger/TrigEvent/TrigEventARA/TrigEventARA/selection.xml
TriggerMenu group:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerPhysicsMenu
TriggerSW group:	https://twiki.cern.ch/twiki/bin/view/Atlas/TAPMCoreSW
TriggerConfig group:	https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerConfiguration
Help on e-groups:	hn-atlas-TriggerHelp at cern.ch

Details

On the issues described above

What's there? – Trigger Decision

- Lvl1 decision after dead-time veto
- HLT decision, information for pass-through'ed and for resurrected triggers
- Bunch groups that fired
- For more detailed studies:
  - Lvl1 decision before prescale, before veto
  - Error codes for HLT-algorithms
  - Last step of chain execution

Decision Access with the TDT

bool	isPassed (const Trig::ChainGroup *chaingroup, unsigned int condition=TrigDefs::Physics) const
	true if given group of chains passed
char	getBGCode () const
	Get the bunch group code byte. BG X fired (X=0..7): getBGCode() & (0x1<<X)

All trigger decisions through "isPassed()", behavior depends on "condition" argument:

- **TrigDefs::Physics:** [default]
  - Pseudonym for **requireDecision | enforceLogicalFlow**, which means that both conditions are applied. Default for isPassed() and for getPrescale().
- **TrigDefs::enforceLogicalFlow, TrigDefs::fullChain:**
  - combination of all three trigger levels.
- **TrigDefs::requireDecision:**
  - A decision must have been made, pass due to *pass-through* or *resurrection* is not enough.
- **TrigDefs::passedThrough:**
  - Event was passed through. A trigger chain can have a pass-through factor in order to record events independent of the decision. This is useful for understanding the trigger behavior. Restrict the isPassed() to those events, requireDecision must be off.
- **TrigDefs::allowResurrectedDecision:**
  - If a trigger is prescaled on a given event, that trigger chain is not executed. If that event is accepted it is often important to know also the trigger decision and features of the prescaled trigger (orthogonal triggers for efficiency determination.) For a fraction of these cases we execute the trigger and safe its decision. This is accessed with allowResurrectedDecision (requireDecision must be off.)

What's there? – Configuration Data

- L1 Items: name, prescale
  - For more detailed studies: version, CTP-Id, bunch group, thresholds and multiplicities
- HLT Chains: name, level, prescale, streams
  - For more detailed studies: version, counter, trigger elements and multiplicities
- Trigger Release, configuration keys (useful for lookup in the TriggerDB)
  - No access with the TDT, but checkConfigTrigger.py

Configuration Access with the TDT

std::vector< std::string >	getListOfTriggers (const Trig::ChainGroup *chaingroup) const
	List of trigger names of the ChainGroup chaingroup
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	List of lists of TE names in ChainGroup chaingroup. *Inner vectors are for a single trigger step, the length of those is the trigger multiplicity.*
float	getPrescale (const Trig::ChainGroup *chaingroup, unsigned int condition=TrigDefs::Physics) const
	Prescale of the ChainGroup chaingroup.

- All methods come with two flavors, argument:

  const Trig::ChainGroup *chaingroup

  const std::string &triggerNames=".*"

  Here the ChainGroup is created on the fly from the pattern 'triggerNames' (regexp - ".*" means 'all')

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  - A TE is used as handle to the feature
  - A TE has a pass/fail state set by the corresponding HYPO
- The navigation gives you all the features that were created in a chain
  - Or just those that were successful (features in ROI's which passed all cuts) – that is the default!
  - Can also give you combinations of features (for multi-object triggers)
  - Ancestor function to navigate, e.g. from electron to track and cluster

Feature Access with the TDT

const FeatureContainer	features (const ChainGroup *group, unsigned int condition=TrigDefs::Physics) const
	returns all features related to given chain group
template<class T> const Feature< T >	ancestor (const HLT::TriggerElement *te, std::string label="") const
	gives back feature matching (by seeding relation) te - is trigger element to start with, note that thanks to conversion operators Feature object can be given here as well

- condition == TrigDefs::Physics: contains features where ROI passed the last HYPO
- condition != TrigDefs::Physics: all features created in trigger

FeatureContainer:

template<class T> const std::vector < Trig::Feature< T > >	get (const std::string &label="", unsigned int condition=TrigDefs::Physics, const std::string &teName="") const
	returns flattened vector of Features of given type This method is in fact sullied by 3 arguments.
const std::vector < Trig::Combination > &	getCombinations () const
	returns reference to combinations collected through append

Combination

template<class T> const std::vector < Trig::Feature< T > >	get (const std::string &label="", unsigned int condition=TrigDefs::Physics, const std::string &teName="") const
	Method used to get objects.

Working with Features

- Access always a two or three step process
  1. FeatureContainer *fc* from the TDT
  2. List of Features<T> from *fc*

  or

  2. List of Combinations from *fc* and 3. list of Features<T> from each Combination
- Feature< T > has access to
  - Its constant object: const T*
  - The TriggerElement to which the object has been attached
    - This can be used with TDT::ancestor(TriggerElement*) method to find predecessors
  - Label (key in SG)

Feature< T >:

	operator const T * () const
	implicit conversion to object pointer (explicit conversion cptr () for python)
	operator const HLT::TriggerElement * () const
	implicit conversion to TriggerElement (explicit conversion te () for python)
	operator const std::string () const
	explicit conversion to feature label (explicit conversion label () for pyton)

Expert Access with the TDT

- Some methods are not needed for most physics analyses, but for detailed trigger investigation (rate tool, timing tools, trigger validation)
- Access via

```
Trig::ExpertMethods* em = tdt->ExperimentalAndExpertMethods();
em->enable();
```

ExpertMethods:

const TrigConf::TriggerItem *	**getItemConfigurationDetails (const std::string &chain)**	Access to trigger configuration
	return TrigConf::TriggerItem chain: name of the item	
const TrigConf::HLTChain *	**getChainConfigurationDetails (const std::string &chain)**	
	return TrigConf::HLTChain chain: name of the chain	
const LVL1CTP::Lvl1Item *	**getItemDetails (const std::string &chain) const**	Access to complete trigger decision
	return LVL1CTP::Lvl1Item chain: name of the item	
const HLT::Chain *	**getChainDetails (const std::string &chain) const**	
	return HLT::Chain chain: name of the chain	
const HLT::NavigationCore *	**getNavigation () const**	Access to Navigation
	return HLT::NavigationCore	

Trigger Object Types

- **FEXs** create **trigger objects**, which they attach to a **TriggerElement**, sometimes with a ***Label***.
  - Two examples for the current 10^{31} menu and 15.4.0:
    - InDet::Pixel_TrgClusterization/PixelClustering_Tau_EFID attaches PixelClusterContainer objects to EFtau16i_loosetr.
    - TrigJetRec/TrigJetRec_Cone attaches JetCollection objects to EF_j23, this time with the extra label "*TrigJetRec*"
- Q: Which FEX creates what type of object and what label ?
  - A: One needs to know the trigger software, and read the *literature* or look at the code. Use LXR and the algorithm classname to find out what is produced.
  - This can be of help:
    - Looking at the **Trigger EDM TWIKI** (type, label, slice, LXR): https://twiki.cern.ch/twiki/bin/view/Atlas/TriggerEDM
    - Checking the **AOD content** (which labels exist for which type in the file):
      - checkFile.py AOD.pool.root
    - I recommend looking at TrigEventARA/selection.xml for the type used in the navigation (the one you need)

Trigger Object Labels

- Feature access methods in the TrigDecisionTool have an optional argument "label". These correspond to the StoreGate keys (minus "HLT_").

```
> checkFile.py AOD.pool.root |grep TrigRoiDescriptor
```

```
    52.334 kb      5.552 kb      0.022 kb      0.199     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_TrigCaloRinger
    56.061 kb      7.773 kb      0.031 kb      0.186     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_secondaryRoI_EF
    63.160 kb     10.673 kb      0.043 kb      0.164     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_forMS
    63.160 kb     10.679 kb      0.043 kb      0.164     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_forID
    66.552 kb     11.474 kb      0.046 kb      0.156     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_secondaryRoI_L2
    96.685 kb     25.609 kb      0.102 kb      0.108     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_TrigT2CaloEgamma
    96.325 kb     27.150 kb      0.109 kb      0.108     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_TrigT2CaloTau
   110.456 kb     31.728 kb      0.127 kb      0.095     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_TrigT2CaloJet
→  163.605 kb     38.949 kb      0.156 kb      0.065     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_initialRoI
   217.361 kb     60.725 kb      0.243 kb      0.050     250  (B) TrigRoiDescriptorCollection_tlp1_HLT
   240.863 kb     70.211 kb      0.281 kb      0.046     250  (B) TrigRoiDescriptorCollection_tlp1_HLT_T2TauFinal
```

Correct way to get the initial RoIDescriptor (build from LVL1 ROI):

```
vector< Feature<TrigRoiDescriptor> > roi = fc.get<TrigRoiDescriptor>("initialRoI");
```

Note: the persistent data the type is *TrigRoiDescriptorCollection*, while through the navigation you get *TrigRoiDescriptor* objects. Again, the best way to find out is, at the moment, to look at TrigEventARA/selection.xml.

Athena / ARA | C++ / python

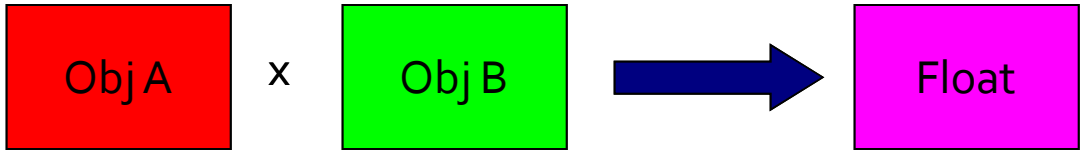
- 14.2.22+: ARA with trigger data works, but limited to configuration and trigger object access. TrigDecisionTool and Navigation don't work with ARA here.
- 15.3.0+: new TrigDecisionTool. Everything works with ARA and **like in Athena**.
  - Running over multiple files with different configurations works seamlessly
- Athena and ARA work both in C++ and in python
  - Note templated functions syntax:
    - C++: fc.get<TrigRoiDescriptor>("initialRoI")
    - Python: fc.get('TrigRoiDescriptor')('initialRoI')
  - Implicit convertions don't work in python
    - Use Feature::cptr() and Feature::te()
  - Examples for all 4 cases are in Trigger/TrigAnalysis/TrigAnalysisExamples

Matching Framework Overview

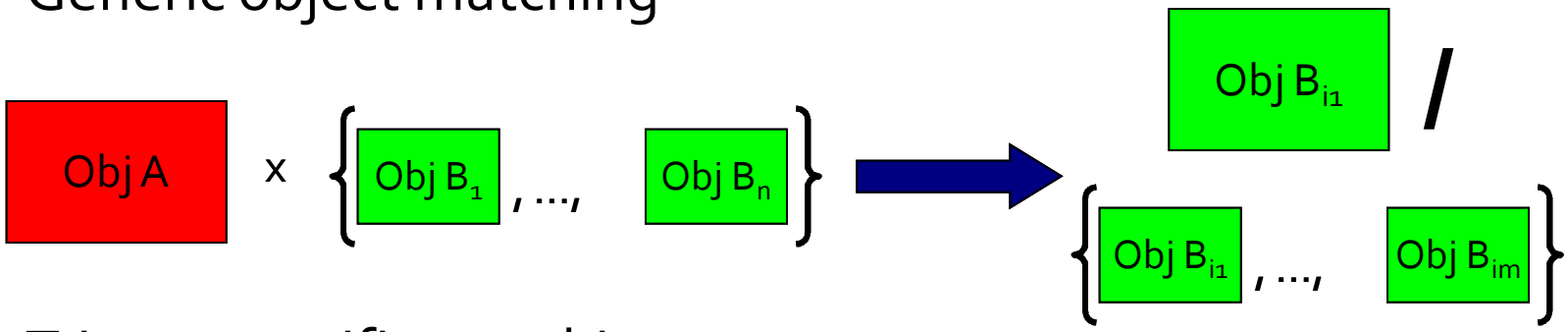
- Two basic questions
  - What chains is the offline object associated with?
    - chainPassedByObject - does reco object match a passed trigger object in a given chain?
    - chainsPassedByObject - list of chains that reco object passes
  - What are the properties of the trigger object the offline object is associated with?
    - matchToTriggerObjects - vector of trigger objects matching to reco object in given chain
    - matchToTriggerObject - return best matching trigger object in given chain

Matching Framework Implementation

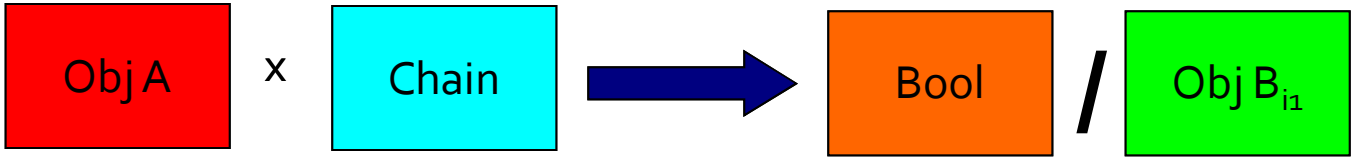
- Three basic problems:
  - Object distance



  - Generic object matching



  - Trigger specific matching



Some subtleties

- Distance definition is implemented as a function object and passed as an argument
  - By default, ΔR is used
  - Arbitrarily complex matching possible
- Quality of matches
  - Smallest ΔR is not a guarantee of a good match
- Container type objects
  - EF trigger objects attached as containers, so matches are to a container rather than an individual trigger object
- What it means to pass a chain
  - Chain passed if match to trigger object associated with active trigger element
  - For multi-object triggers or intermediate trigger objects, an offline object can pass a failed chain
- Relative trigger level efficiencies
  - Possible to pass EF without passing L2 (passthrough, direction resolution effects)