B-physics analysis software: FDR and beyond

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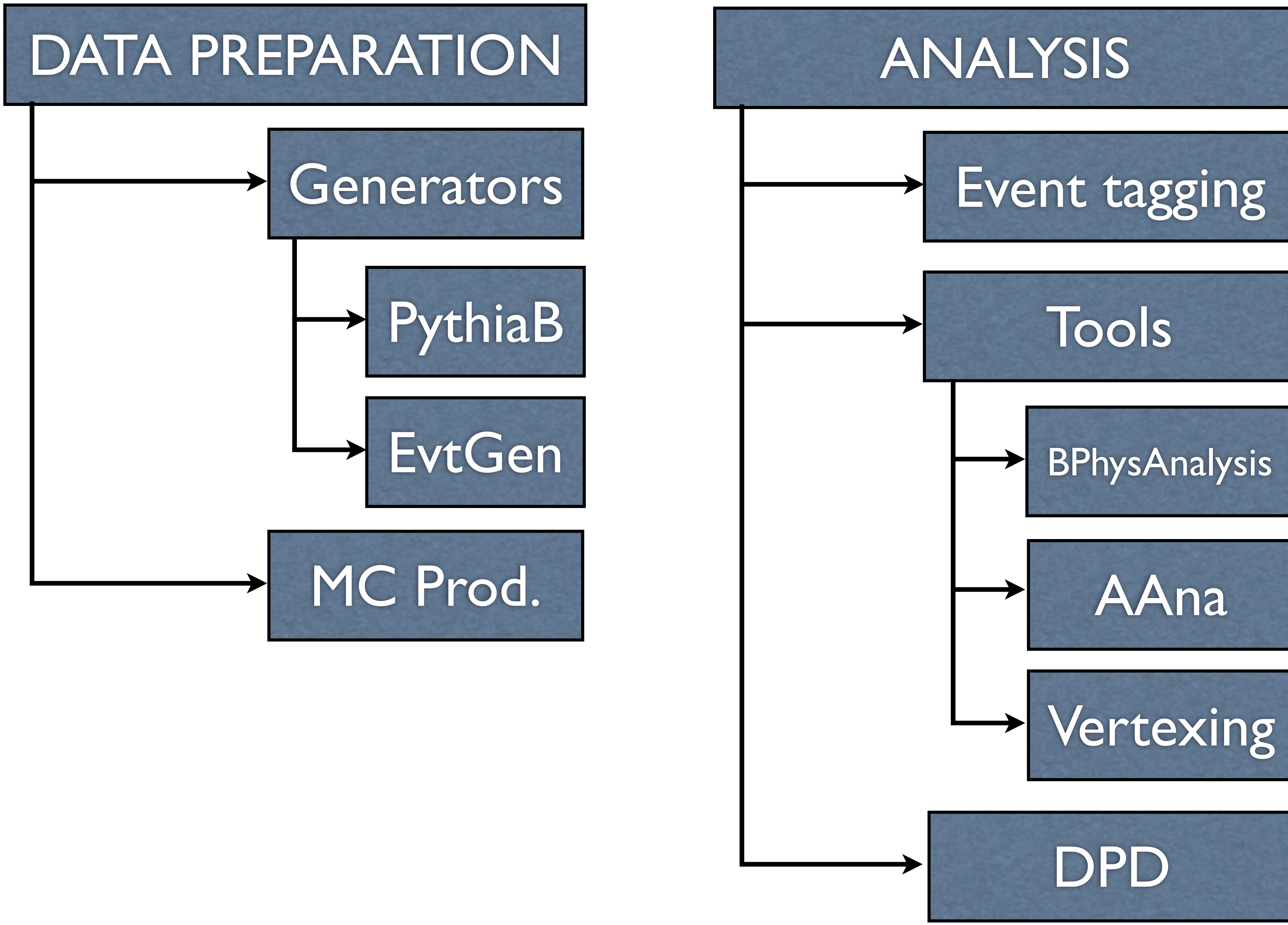
B-physics software activities



Full Dress Rehearsal

- The group will play a full part in FDR-1 as B-physics will play an important role in the early measurements of ATLAS
- Requirements of FDR:
  - Preparation of data for bytestream sample
  - Defining content of analysis data (DPD)
  - Defining event TAG content and preparing code
  - Preparing analysis code for FDR analysis (Feb-Apr)

What makes B-physics events unique?

- B-hadron decays are long chains typically containing several nodes
  - There are a wide variety of decay topologies
- B-trigger signatures (muons, electrons and jets) are low-pt objects which lead to smaller event sizes
- To find B-decay chains
  - Start from identified leptons to form J/ψ or dilepton signatures
  - Form up all possible combinations of remaining tracks matching a topology (can be dozens of possibilities for the complex channels)
  - Select/reject them with constrained vertexing
    - Each topology requires a different vertexing configuration

Typical decay processes

$$B_s^0 \to J/\psi\,(\to \mu\mu)\;\; \phi\,(\to KK)$$

$$B_s^0 \to D_s^{\pm}\,(\to \phi\,(\to KK)\;\pi^{\pm})\;\; \pi^{\pm}$$

$$B_c^{\pm} \to B_s^0\,(\to J/\psi\,(\to \mu\mu)\;\; \phi\,(\to KK))\;\; \pi^{\pm}$$

$$\chi_b \to J/\psi\,(\to \mu\mu)\;\; J/\psi\,(\to \mu\mu)$$

$$\Lambda_b \to \Lambda^0\,(\to p\pi^{-})\;\; J/\psi\,(\to \mu\mu)$$

$$B_s^0 \to \mu\mu$$

$$B_s^0 \to K^{\pm}\mu^{\mp}\nu_{\mu}$$

Implications

- Only practical to search for one type of topology in a single analysis task
- We must be able to run vertexing in the physics analysis
- Not practical to make "User Data" before the final ROOT-based analysis
  - Too many potential decay candidates
  - Too many topologies with different vertexing configurations
  - DPD would become impractically large
- No thinning possible (or necessary due to small event sizes)
- Final output of the analysis should be the final n-tuples containing B-meson candidates and their descendants

B-Physics preparations for FDR-1: data sample and content

1. Data sample preparation
    - The B-events selected for the FDR-1 will dominate the early data taking
    - $pp \to J/\psi\ X$, $pp \to \Upsilon$, $bb \to J/\psi\ X$, $bb \to \mu\mu$, $cc \to \mu\mu$
2. Analysis data content
    - Analysis data for FDR is Derived Physics Data (DPD) = slimmed, thinned AOD with UserData added if required
    - No UserData in B-physics DPD
    - No thinning possible (or necessary due to smaller event sizes)

B-physics DPD contents for FDR-1

- Stream1.ItemList = ['EventInfo#*', 'TrackRecordCollection#*']
- Stream1.ItemList += ["VxContainer#VxPrimaryCandidate"]
- Stream1.ItemList += ['ElectronContainer#ElectronAODCollection']
- Stream1.ItemList += ['PhotonContainer#PhotonAODCollection']
- Stream1.ItemList += ['egDetailContainer#egDetailAOD']
- Stream1.ItemList += ['Analysis::MuonContainer#*StacoMuonCollection']
- Stream1.ItemList += ['Analysis::MuonContainer#*MuidMuonCollection']
- Stream1.ItemList += ['Analysis::MuonContainer#*CaloMuonCollection']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*MuTagTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*MuidCombTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*MuonboyTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*StacoTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*MooreTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*MuonboyMuonSpectroOnlyTrackParticles']
- Stream1.ItemList += ['Rec::TrackParticleContainer#*TrackParticleCandidate']
- Stream1.ItemList += ['ParticleJetContainer#*Cone4H1TowerParticleJets']

Event info

PriVtx

E-gamma

Muons

Tracks

Jets

B-Physics preparations for FDR-1: Event TAG

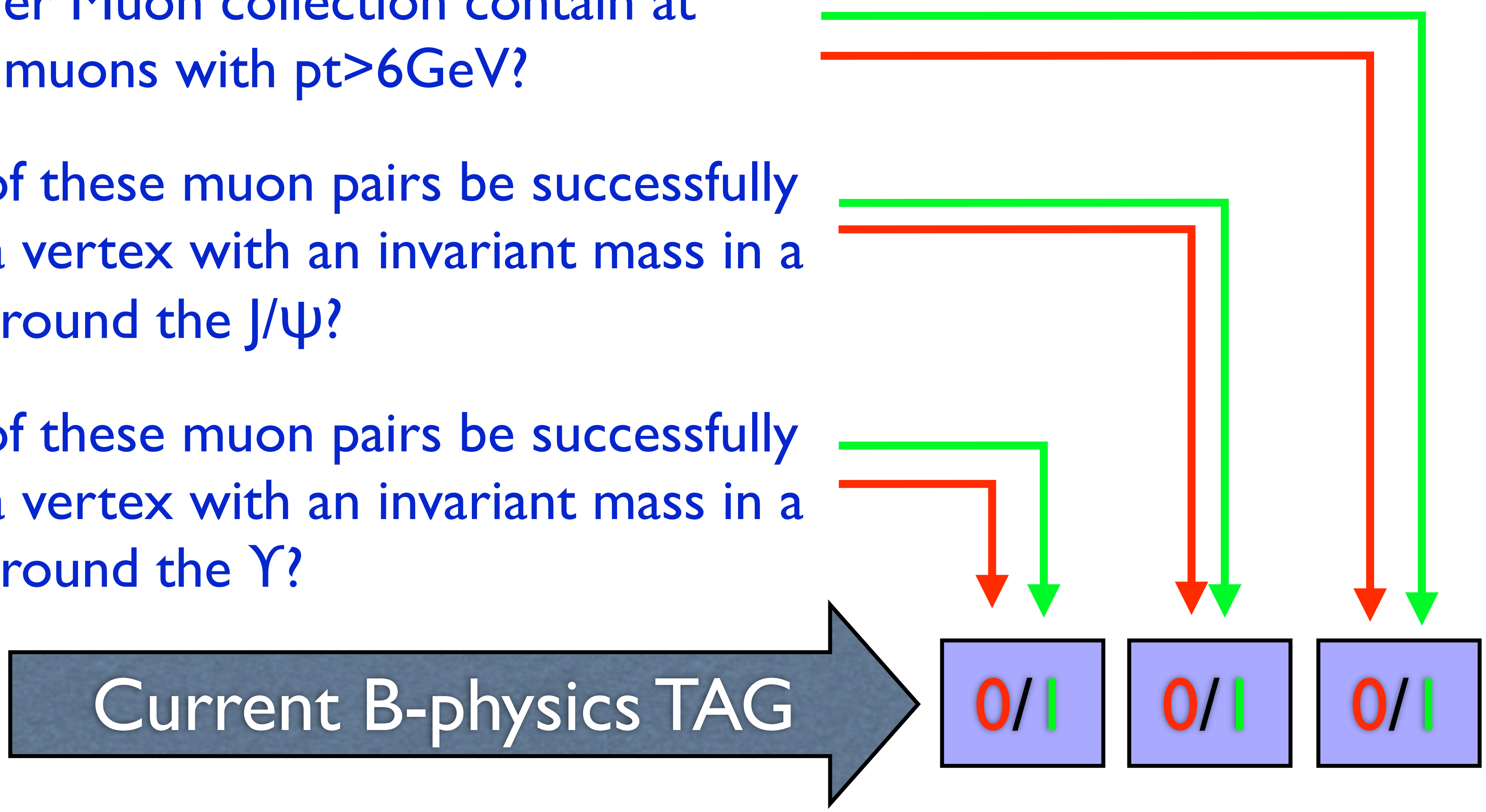
- All B-physics events are contained in the Muon Stream
- The group has committed code to PhysicsAnalysis/BPhys/BPhysTagTools to be run in FDR-1 and data taking
  - Three tag signatures are ready for FDR-1 which represent early physics

    ① Any μμ ② J/ψ→μμ ③ ϒ→μμ

BPhysTagTools

- Currently writing three bits of information
- Algorithm proceeds as follows:

1. Does either Muon collection contain at least two muons with pt>6GeV?
2. Can any of these muon pairs be successfully fitted to a vertex with an invariant mass in a window around the J/ψ?
3. Can any of these muon pairs be successfully fitted to a vertex with an invariant mass in a window around the Υ?



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B-physics TAG list (under development)

FDR-1:

- $\Rightarrow \quad J/\psi \rightarrow \mu\mu$
- $\Rightarrow \quad \mu\mu$ (later changed to "rare" mu mu)
- $\Rightarrow \quad \Upsilon \rightarrow \mu\mu$
- $\Rightarrow \quad \mu + D_s \rightarrow hadrons$
- $\Rightarrow \quad \mu + J/\psi \rightarrow ee$
- $\Rightarrow \quad B \rightarrow \mu\mu$
- $\Rightarrow \quad \mu + \gamma$
- $\Rightarrow \quad \mu + e$

B-Physics preparations for FDR-1: physics analysis code

- The group currently has two analysis platforms

BPhysAnalysis

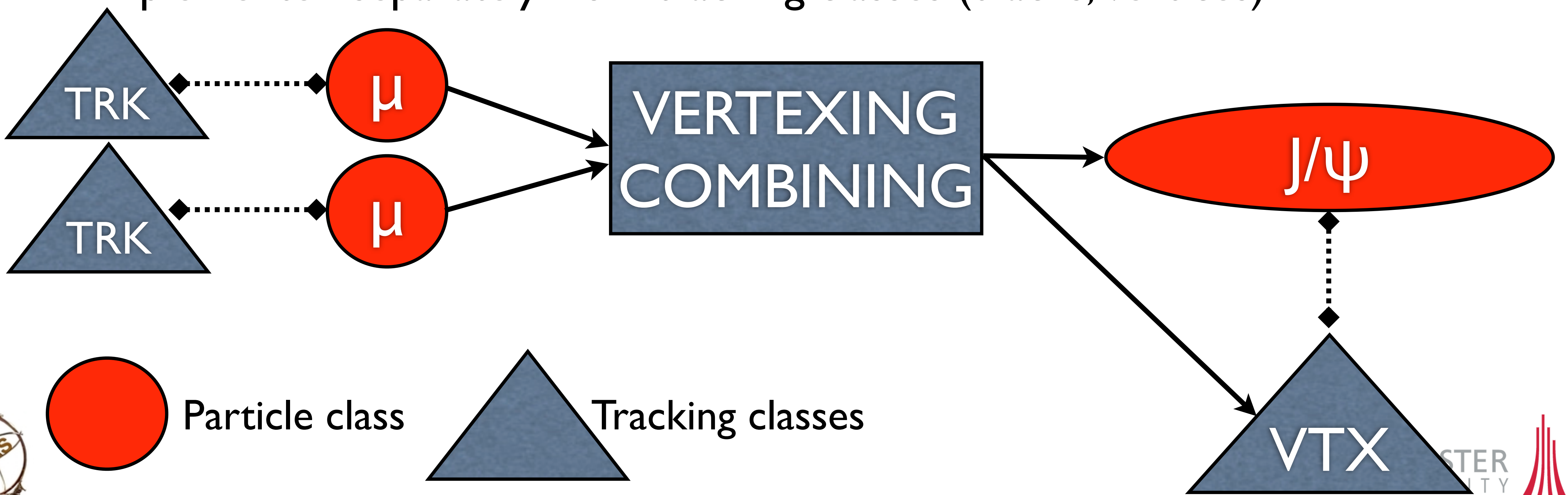
- Well established; used for CSC
- PhysicsAnalysis/BPhys
- Direct analysis on AOD objects in Athena
- Input = AOD file
- Output = flat ROOT n-tuple

AAna

- New code under development
- PhysicsAnalysis/BPhys/AAna
- Converts AOD into a simple binary format which allows analysis to be run *outside Athena* as a stand-alone C++ program
- Output = flat ROOT n-tuple

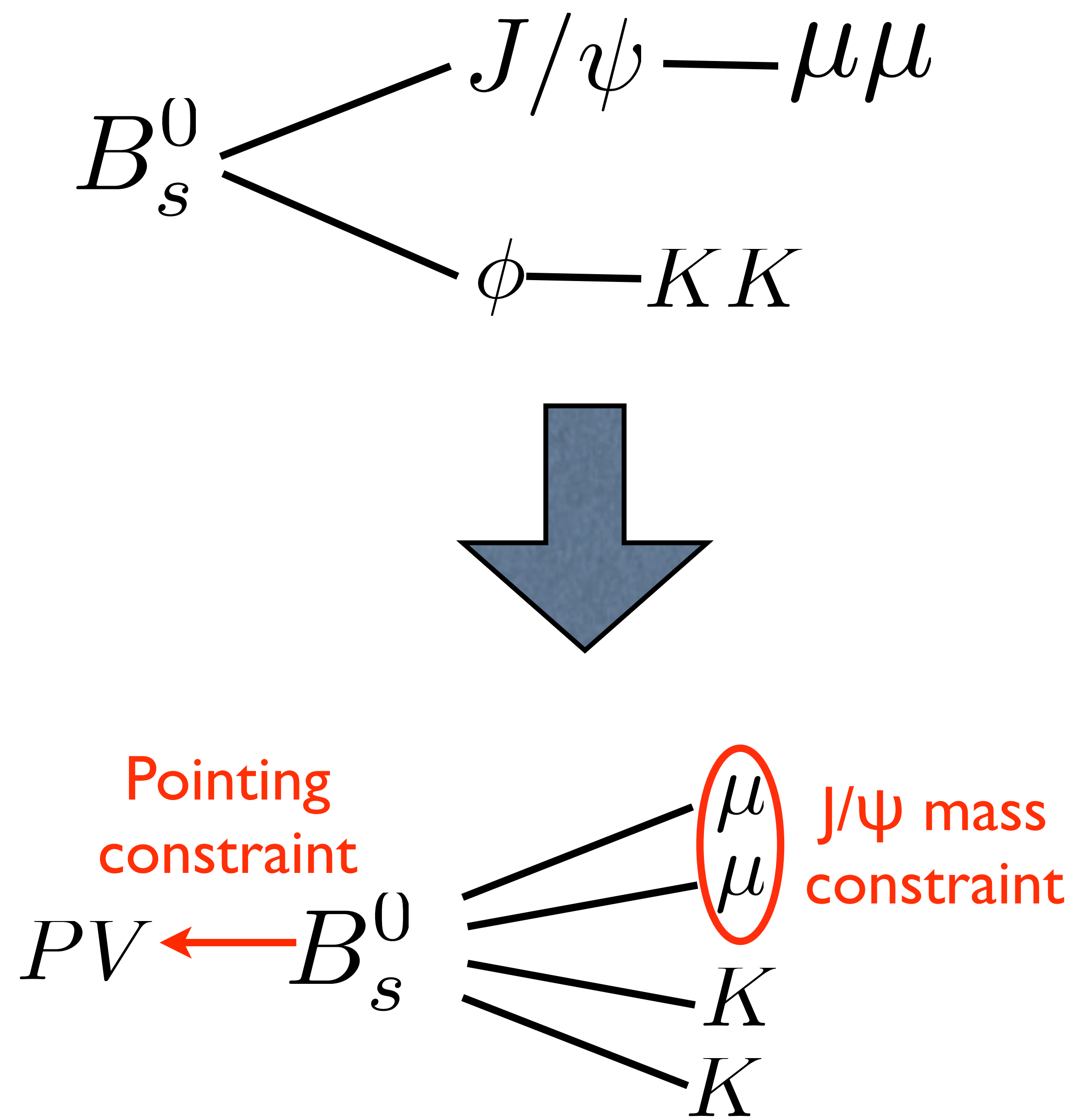
Vertexing and composite particles

1. Vertex finding
   - All tools available to reconstruction are available in analysis
   - Mass and pointing constraints available
2. Composite particles
   - E.g. it is possible to combine two muons to make a J/ψ
   - J/ψ is of the same class as the muons
   - Implemented separately from tracking classes (tracks, vertices)



Vertexing requirements

- B-physics group hold regular meetings with the ID reconstruction group
- MASS constraints
- POINTING constraints
- Complete covariance matrix
- Ability to simultaneously fit multi-node decays
- Highly flexible



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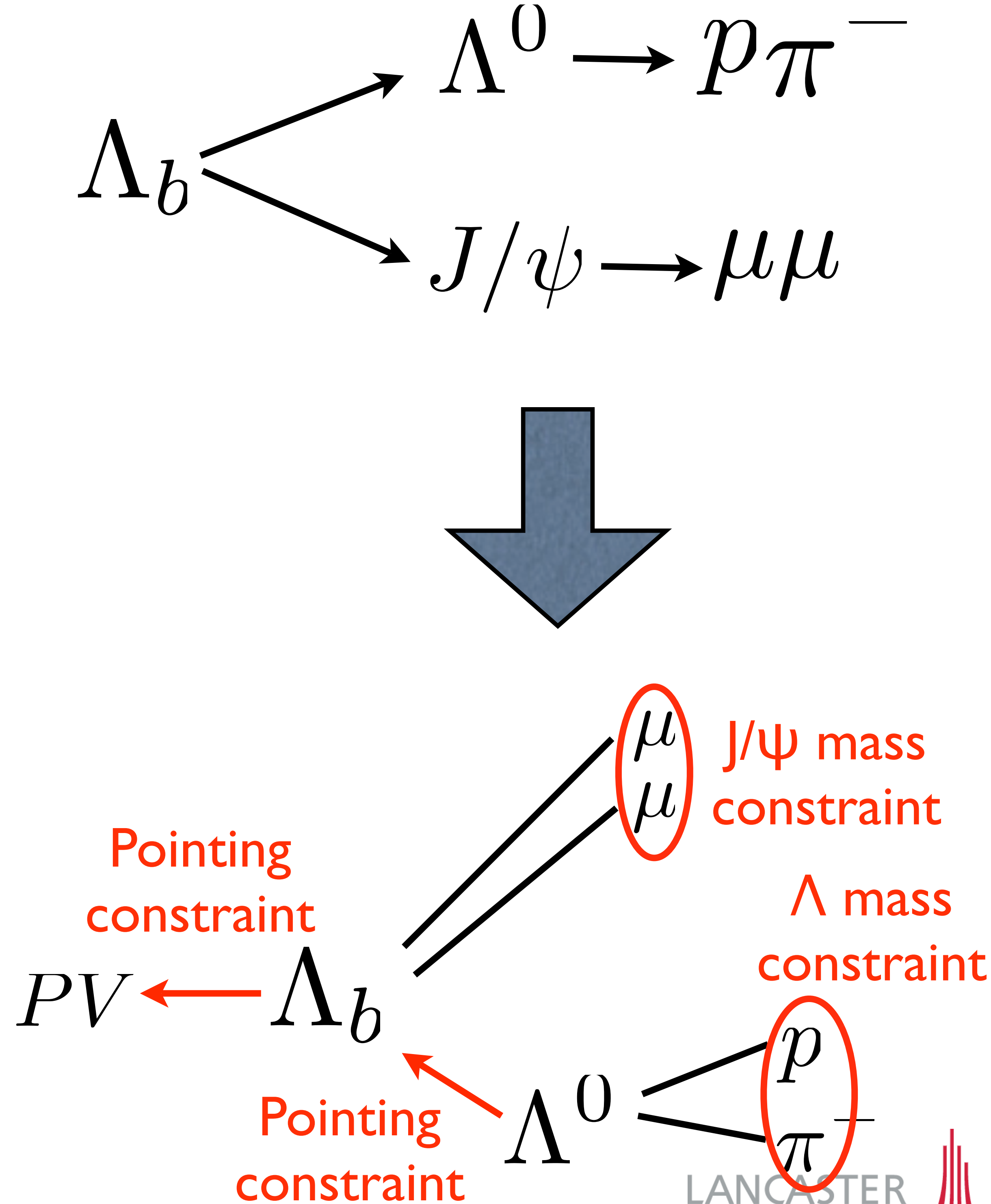

BPhysAnalysis package

- Consists of three sub-packages
  - BPhysAnalysisObjects - utility classes for vertexing
  - BPhysAnalysisTools - tools for vertexing, selection, combinatorics, truth
  - BPhysExamples - the analysis algorithms which read AOD and produce ntuples
    - Analysts design their own ntuple structure
    - One n-tuple structure per decay topology
    - All CSC analyses implemented as examples
- Full access to all Athena services including vertexing (CDF, VKalVrt)
- Composite particle being implemented in collaboration with I.D. reconstruction group

AAna analysis package

- New package currently under development; based on code deployed in the D0 experiment
  - Exists as an Athena package; can run “as is” Athena or can convert AOD into a binary format to allow running as stand-alone C++
  - Simple, easily extendible analysis classes; composite particles and vertexing implemented
- Very rapid compilation (<1 second) and execution (<1ms/event) leading to efficient development cycle
- Can run on any Linux or Mac platform; complete package occupies ~230kb; can send whole distribution in Sandbox so trivial to run on Grid
- Stand-alone mode cannot access Athena services and Athena tools cannot handle non-Athena classes
- FDR-1 will be an excellent opportunity to test the value of this code as a means of quick algorithm development and cross-checking

Summary

- The B-physics group's involvement for the FDR include
  - Data preparation and definition of DPD
  - Event TAG definition, implementation and testing
  - Preparation of physics analysis code
- Two complementary analysis platforms available for development of analyses and final processing
  - FDR-1 will provide essential experience which will guide our preparations for data taking