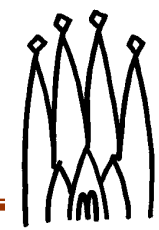
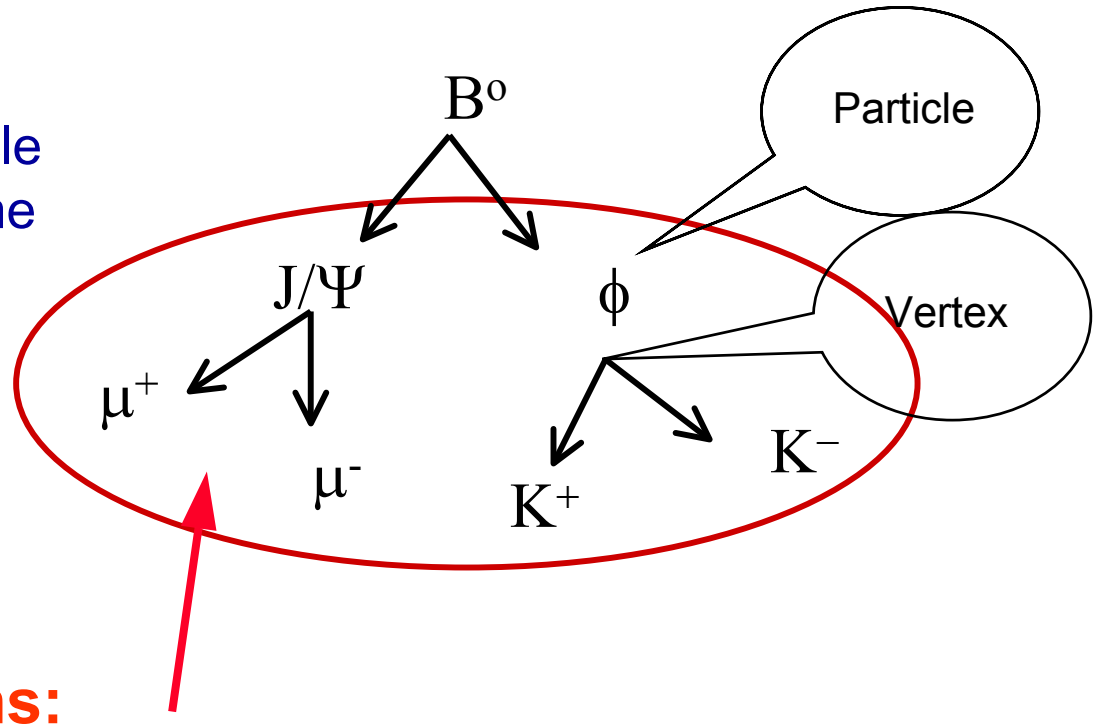
3
Beginning to Write a selection algorithm



A "Possible" Example

Make a 4 particle vertex with some constraints??

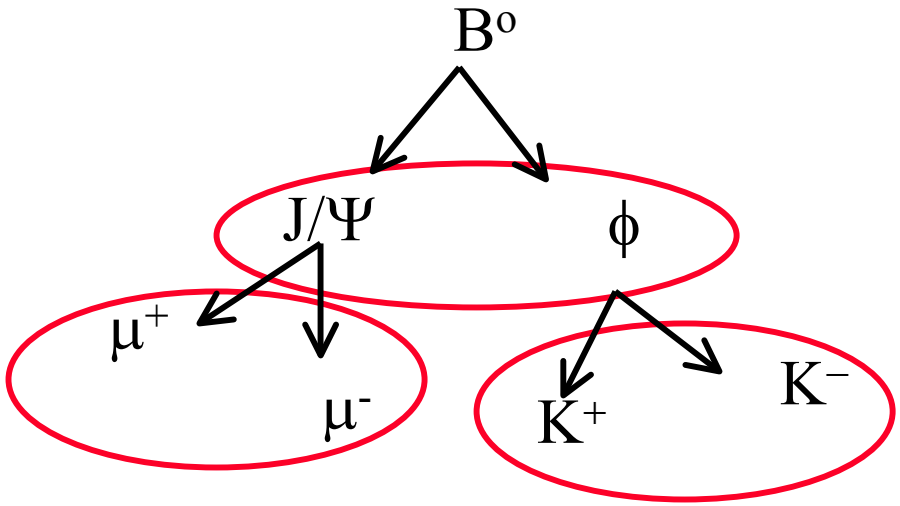


- **Two options:**
  - **A selection algorithm that makes vertices of 4 particles with some cuts in the invariant mass of the lepton and Kaon Pairs**
- **Three algorithms called in sequence**

A "Possible" Example (cont'd)

All are particle pairs with "roughly" the same algorithmic sequence

- Select two particles with some PiD
- Make a vertex
- Cut in some mass window and some "Geometrical variables"
- Use a switch for additional cuts in "decaying vertex point distance of daughters"
- Use the daughters for the B vertex



Can program a Select2ParticleDecay algorithm with carefully selected option

Two Main Components in a Selection

- **Algorithms itself (the code)**
  - **An "end user" will usually develop algorithms that will use DaVinci Tools**

```
MySelAlgorithm::DVAlgorithm {
  declareProperty{"CutName",cutVariable=defaultvalue) ;
}
MySelAlgorithm::initialize {
  Initialize all needed tools and services;
  Histograms;
}
MySelAlgorithm::execute {
  Where the work is done
}
MySelAlgorithm::finalize{
  Final statistics
}
```

Inherits from DVAlgorithm where the retrieving of the most frequently used tools is done

Recommended to make all analysis variable cuts available in job options.

Use emacs: it will create an Algorithm skeleton for you !

Naming convention: SelectBd2Jpsi2mumu_Ks2pipi
SelectJpsi2mumu_forBd2JpsiKs

Two Main Components in a Selection

- **Options file (its running configuration for a job)**
  - **Customize the tool used:**
    - PhysDesktop tool
    - the chosen ParticleMaker
    - the ParticleFilter and
    - each FilterCriterion

    Naming convention:
    Must specify the full decay chain
    SelectBd2Jpsi2mumu_Ks2pipi
  - **Configure the user defined properties**
    - Cuts, histograms filling, etc
- **The same algorithm could be configured for different decays:**

```
ApplicationMgr.TopAlg+={Select2ParticleDecay/SelectJPsi};
ApplicationMgr.TopAlg+={Select2ParticleDecay/SelectPhi};
SelectXXXXX.MassWindowLoose = zzz;
SelectXXXXX.DaughterCandidates= {“Part1”,”Part2”};
SelectXXXXX.MotherPArticleName= {“Mother”};
……
```

Select*.h

Since a Selection Algorithm inherits from the DVAlgorithm, it should include:

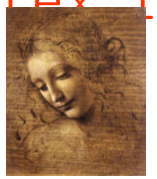
```
#include "DaVinciTools/DVAlgorithm.h"
```

and

```
class SelectJPsi2MuMu :  public DVAlgorithm { ...  }
```

The cuts will be properties of the algorithm, so they should be data members:

```
private:
double m_JPsiMassWin; ///< Mass window for the two Muons
double m_JPsiZWin; ///< Z vertex window for the two Muons
double m_chi2ConVtxCut; ///< chi2 of constrained vertex fit
```

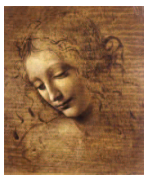


Usually some histograms will be produced:

```
// Forward declarations
class IHistogram1D;
private:
bool m_produceHistogram; ///< flag for histo production
IHistogram1D* m_hSum4p;///< Histo of two muons mass
IHistogram1D* m_hChi2ConFit;///< Histo of the Chi2
```

some SdtHep information and counters:

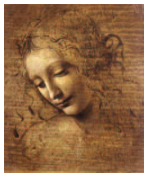
```
long m_jpsiID; ///< SdtHep ID for JPsi
double m_jpsiMass; ///< SdtHep mass for JPsi
int m_nEvents; ///< N events processed
int m_JPsiCount; ///< Number of JPsi's
```



Select*.cpp

Files to be included:

```
// from Gaudi
#include "GaudiKernel/AlgFactory.h"
#include "GaudiKernel/SmartDataPtr.h"
#include "GaudiKernel/IDataProviderSvc.h"
#include "GaudiKernel/IParticlePropertySvc.h"
#include "GaudiKernel/ParticleProperty.h"
#include "GaudiKernel/IHistogramSvc.h"
#include "AIDA/IHistogram1D.h"
// from Event
#include "Event/EventHeader.h"
#include "Event/Vertex.h"
#include "Event/Particle.h"
```



```
// CLHEP
#include "CLHEP/Units/PhysicalConstants.h"
#include "CLHEP/Geometry/Point3D.h"
// local
#include "SelectJPsi2MuMu.h"
```

Constructor

Declare the Properties in the Constructor:

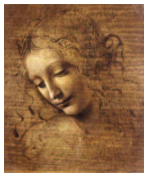
```
SelectJPsi2MuMu::SelectJPsi2MuMu( const std::string& name,
                                  ISvcLocator* pSvcLocator)
  :  DVAlgorithm ( name , pSvcLocator),
    m_nEvents(0),
    m_JPsiCount(0){
  declareProperty("HistogramFlag",m_produceHistogram = false);
  declareProperty("JPsiMassWindow", m_JPsiMassWin = 0.2*GeV);
  declareProperty("JPsiZWindow", m_JPsiZWin = 50.0 * cm);
  declareProperty("Chi2ConFit", m_chi2ConVtxCut = 20.0);
}
```

initialize()

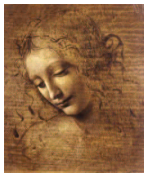
The initialize() method is where the tools are retrieved, the Particle Property Service is requested and the histograms are booked.

Remark: When a StatusCode is returned it is because it has the possibility of FAILURE, so it has always to be tested. I put here one example of testing, but it will be omitted from then on.

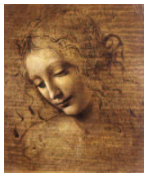
```
StatusCode SelectJPsi2MuMu::initialize() {
  MsgStream log(msgSvc(), name());
  log « MSG::DEBUG « "==> Initialize" « endreq;
  StatusCode sc = StatusCode::SUCCESS;
```



```
// Load all necessary tools via the base class
sc = loadTools();
if( sc.isFailure() ) {
  log « MSG::ERROR « " Unable to load tools" « endreq;
  return StatusCode::FAILURE;
}
// Access the ParticlePropertySvc
IParticlePropertySvc* ppSvc = 0;
sc = service("ParticlePropertySvc", ppSvc);
ParticleProperty* partProp;
partProp = ppSvc->find( "J/psi(1S)" );
//Note that the particleID().pid() is the jetsetID() code
m_jpsiID = (*partProp).jetsetID();
m_jpsiMass = (*partProp).mass();
```



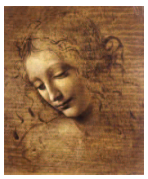
```
// If histograms are required initialize them
if( m_produceHistogram ) {
  m_hChi2ConFit = histoSvc()-> book("/stat/simple/5",
            "Chi2 of Constrained J/Psi vertex Fit",
            100, 0.0, 20.0);
  if( 0 == m_hChi2ConFit ) {
    log « MSG::ERROR « " Cannot register histogram 5"
        « endreq;
    return StatusCode::FAILURE;
  }
  m_hSum4p = histoSvc()->book("/stat/simple/6",
        "Mass of 2 Muons", 100, 3.05, 3.15);
}
return StatusCode::SUCCESS;   }
```



finalize()

Print out some statistics

```
StatusCode SelectJPsi2MuMu::finalize() {
  MsgStream log(msgSvc(), name());
  log « MSG::DEBUG « "==> Finalize" « endreq;
  // Print out counters
  log « MSG::INFO « " Number of events processed = "
    « m_nEvents « endreq;
  log « MSG::INFO « " Number of selected JPsi = "
    « m_JPsiCount « endreq;
  // End of finalization step
  return StatusCode::SUCCESS;
}
```



The Execute Member Function

Create Particles from ProtoParticles according to some criteria (ex: all possible Kaons and Pions) (PhysDesktop) Note: it can also start from particles from a previous algorithm.

Filter particles and classify them in different “containers” in the transient store (ex: K+,K-,pi+,pi-) (ParticleFilter)

Make possible particle combinations and vertex them (VertexingTools)

Apply some cuts to the “new” particle candidate (ex: Inv mass, ch2 of vertex, etc…)

If candidate is selected, create a new particle and vertex; give it a name and create all relations(for example a J/Psi)

Make sure the new particle is saved for use in the next algorithm

Tools Needed

- A creator of Particles from ProtoParticles and collector of existing Particles: **PhysDesktop** and **ParticleMakers**
- A Particle Filter Interface and several Filter Criteria implementations:
  - **PIDFilter**
  - **KinematicalFilter**
  - **…..**
- Vertexing algorithms, included constrained and unconstrained fit and the possibility to use the daughters in the vertexing.
- Tools to compute Geometrical variables
  - **Impact parameter**
  - **Distance between vertexes and particles.**
  - **….**
- Particle transporter: Transports a particle to a given z
- Particle stuffer: create “consistent” particles from daughters
- Decay finders and Channel Selection Algorithms, Flavour Tagging
- MCDecay finder
- Debugging tool, Histograms, Ntuples
- Associators
- ….

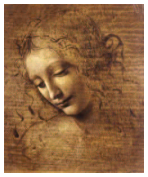
execute()

The execute() method is where event by event is processed.

```
StatusCode SelectJPsi2MuMu::execute() {
  MsgStream log( msgSvc(), name() );
  // Counter of events processed
  log « MSG::INFO « ">> Execute" « endreq;
  log « MSG::INFO « " processing event number " « ++m_nEvents
            « endreq;
  // Retrieve informations about event
  SmartDataPtr<EventHeader> evt(eventSvc(),
                                EventHeaderLocation::Default );
  if ( evt ) {
    log « MSG::INFO « " retrieved EVENT: " « evt->evtNum()
          « " RUN: " « evt->runNum() « endreq;
```

```
  }
  else {
    log « MSG::ERROR « " not able to retrieve event" « endreq;
    return StatusCode::FAILURE;
  }
  //Fill the PhysDesktop particle and vertex vectors.
  //Use the configuration set in the corresponding job options
  StatusCode scDesktop = desktop()->getInput();
  // Retrieve the particles and vertices from PhysDesktop
  const VertexVector& verts = desktop()->vertices();
  const ParticleVector& parts = desktop()->particles();
  log « MSG::DEBUG « " Particle Vector size " « parts.size()
« endreq;
  // Print out some Primary Vertex Information
```

```
// Save the z position of the first one
VertexVector::const_iterator ivert = 0;
double zPrim = 0.;
for(ivert = verts.begin();ivert != verts.end();ivert++){
  if( (*ivert)->type() == Vertex::Primary ){
    log « MSG::DEBUG « "Primary Vertex z coordinate ="
        « " , " « (*ivert)->position().z() « endreq;
    HepSymMatrix primVertexErr = (*ivert)->positionErr();
    log « MSG::DEBUG «"z error on prim vertex = "
        « sqrt(primVertexErr(3,3))/cm «" cm"« endreq;
    zPrim = (*ivert)->position().z();
    break;
  }
}
```



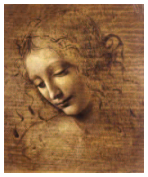
```
// ParticleFilter according to job options
ParticleVector vMuPlus, vMuMinus;
StatusCode scFilPos = ParticleFilter()->
      filterPositive( parts, vMuPlus );
StatusCode scFilNeg = ParticleFilter()->
      filterNegative( parts, vMuMinus );
log « MSG::DEBUG« "vMuPlus size" « vMuPlus.size()«endreq;
log « MSG::DEBUG« "vMuMinus size" « vMuMinus.size()«endreq;
```

```
// Do all mu+/mu- combinations
ParticleVector::iterator iMuPlus;
ParticleVector::iterator iMuMinus;
for( iMuMinus = vMuMinus.begin();
     iMuMinus != vMuMinus.end(); iMuMinus++ ) {
  for (iMuPlus = vMuPlus.begin(); iMuPlus != vMuPlus.end();
       iMuPlus++) {
    // Find invariant mass
    HepLorentzVector twoMuComb(0.0, 0.0, 0.0, 0.0);
    twoMuComb = (*iMuMinus)->momentum() +
                (*iMuPlus)->momentum();
    //Units are MeV/mm/nsec.  I want histos in GeV/cm
    if( m_produceHistogram )
      {m_hSum4p->fill( twoMuComb.m()/GeV, 1.);}
```

```
//Check that muon-antimuon invariant mass is close
 to the J/Psi mass
if (fabs(twoMuComb.m() - m_jpsiMass)< m_JPsiMassWin){
  //Perform Unconstrained vertex fit
  Vertex MuMuVertex;
  StatusCode scMuMuVertex =
    vertexFitter()->fitVertex(*(*iMuMinus),*(*iMuPlus),
                              MuMuVertex);
  log « MSG::DEBUG « "Unconstrained vertex position "
      « MuMuVertex.position().x()/cm « " "
      « MuMuVertex.position().y()/cm « " "
      « MuMuVertex.position().z()/cm « endreq;
  log « MSG::DEBUG « " Chisquare " « MuMuVertex.chi2()
      « endreq;
```

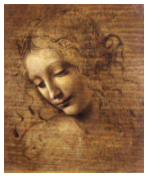
```
//Check that muon-antimuon vertex is within a
//reasonable window around z = 0
if ( fabs(MuMuVertex.position().z()) < m_JPsiZWin){
  // Cut on Chi2 of J/Psi unconstrained vertex fit
  if (MuMuVertex.chi2() < m_chi2UncVtxCut) {
    // Create Particle from Vertex (ParticleStuffer)
    Particle candJpsi;
    ParticleID jpsiPID( m_jpsiID );
    StatusCode scStuff =
      particleStuffer()->fillParticle( MuMuVertex,
            candJpsi, jpsiPID );
```

```
// Debug it, Access the daughters through the vertex
SmartRefVector<Particle>::const_iterator it;
for ( it = candJpsi.endVertex()->products().begin();
      it != candJpsi.endVertex()->products().end();
      it++ ){
   log « MSG::DEBUG « "Momentum of daughters "
       « (*it)->momentum().px() « " "
       « (*it)->momentum().py() « " "
       « (*it)->momentum().pz() « endreq;
}
```

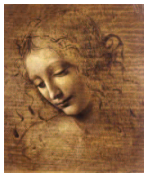


```
//How to use the geometrical Displacement Tools.
double ip=0.;
Hep3Vector ipVector;
HepSymMatrix errMatrix;
double ipErr=0;
double dist=0.;
double distErr=0;
for(ivert = verts.begin();ivert != verts.end();ivert++){
   if ((*ivert)->type()==Vertex::Primary){
    // Calculate the IP vector(and its error) of the
    mu- wrt primary vertex (other signatures are provided)
    StatusCode scImp = geomDispCalculator()->
        calcImpactPar(*(*iMuMinus),*(*ivert),
          ip,ipErr,ipVector,errMatrix);
```

```
    log« MSG::DEBUG« " IP = "« ipVector.mag()« endreq;
    // Calculate the distance (and its error) of closest
     approach between two particles
    StatusCode scCda = geomDispCalculator()->
       calcCloseAppr(*(*iMuMinus),(*(*iMuPlus)),
          dist, distErr);
    log « MSG::DEBUG « " CDA = " « dist « endreq;
    // Calculate the magnitude of the distance (and its
    error) between the primary and secondary vertex
    StatusCode scDist = geomDispCalculator()->
     calcVertexDis(MuMuVertex,*(*ivert),dist,distErr);
    log « MSG::DEBUG « " DIST = " « dist « endreq;
  }
}
```

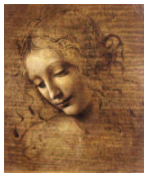


```
//Perform mass constrained vertex fit
Vertex jpsiVtx;
Particle jpsi;
StatusCode scLagFit =
     massVertexFitter()->fitWithMass("J/psi(1S)",
     *(*iMuMinus),*(*iMuPlus), jpsiVtx, jpsi);
//Fill the Chi2 histogram
if( m_produceHistogram ) {
  m_hChi2ConFit->fill(jpsiVtx.chi2(), 1.);
}
//Cut on Chi2 of J/Psi constrained vertex fit
if (jpsiVtx.chi2() < m_chi2ConVtxCut) {
  log « MSG::INFO « " Passed all cuts " « endreq;
  m_JPsiCount++;
```



```
      //saving THIS particle and its vertex to deskTop
      //The pointer to the particle is returned ->
      it is created
      Particle* pInDesktop= desktop()->createParticle(&jpsi);
      if( pInDesktop) {
        log « MSG::DEBUG « "J/Psi added to PhysDesktop "
      }
      else {
        log «MSG::DEBUG« "not able to save J/Psi in desktop"
            « endreq;          }
    //Close all the if's
    }//for(iMuMinus = vMuPlus.begin() ...
}//for( iMuPlus = vMuMinus.begin()...
```

```
// Now save desktop to TES in the location specified in
jobOptions
// Notice that this delete particles from desktop
 at the moment
// It can only be called once per Algorithm
scDesktop = desktop()->saveDesktop();
if (scDesktop) {
   log « MSG::INFO « " PhysDeskTop Saved to TES"«endreq;
}
else {
   log « MSG::ERROR « "not able to save desktop in TES"
      « endreq;
   return StatusCode::FAILURE;
}
```



```
  // End of execution for each event
  return StatusCode::SUCCESS;
}
```