



Some insights about HerdSoftware

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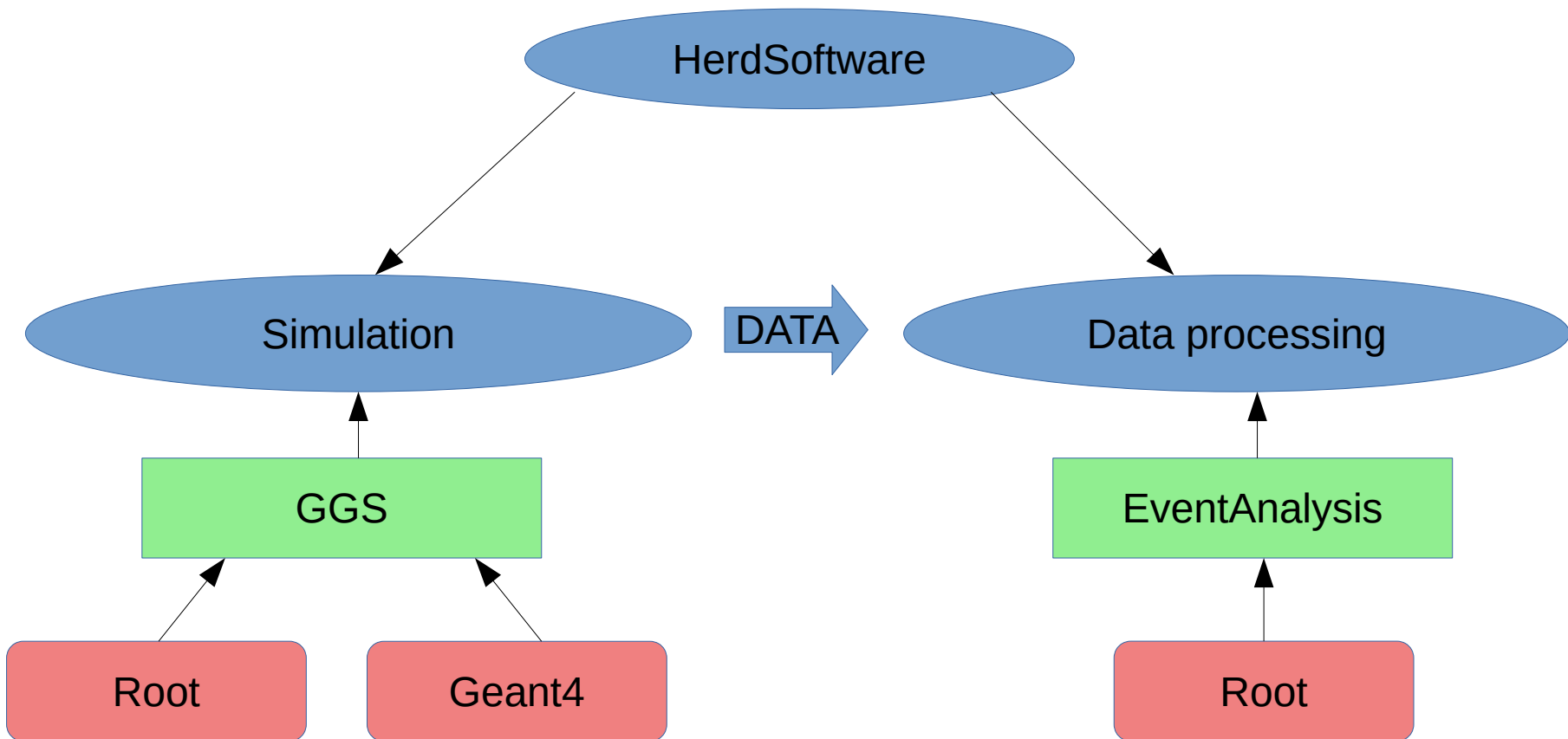


Introduction

- General HerdSoftware presentation on 17th December 2019 at 8th HERD workshop in Xi'an
- Additional info and some technical details in the following

Introduction

- Architecture





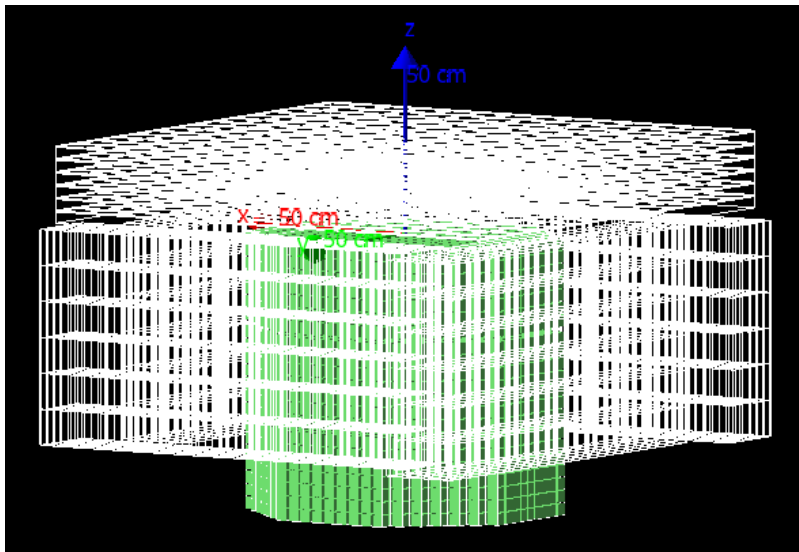
MC simulation

- Based on the GGS framework
 - Provides particle generation, hits, output on Root file, readout routines
- In HerdSoftware: detector geometry
 - Default: CALO+STK+PSD
 - Optional: SCD, FIT (replaces STK)
 - Missing: TRD (need help from Chinese colleagues)
 - Settings with G4 macro file

MC simulation

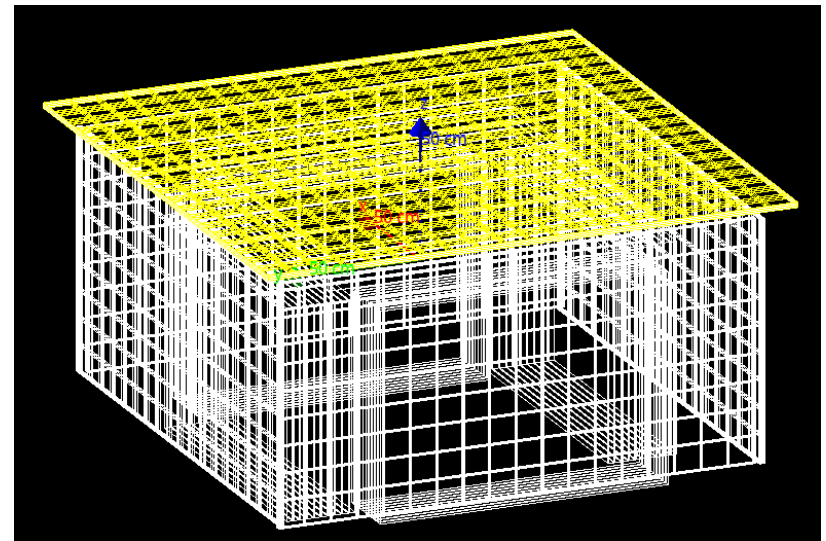
- Fully customizable for comparative performance studies:
 - Detectors in simulation
 - Geometry parameters (n. of layers, PSD tiles or bars, SCD Si thickness etc.)

CALO+STK



```
/herd/geometry/parametric/general/tracker stk  
/herd/geometry/parametric/general/antiCoincidence none  
/herd/geometry/parametric/general/calorimeter calo  
/herd/geometry/parametric/general/chargeID none
```

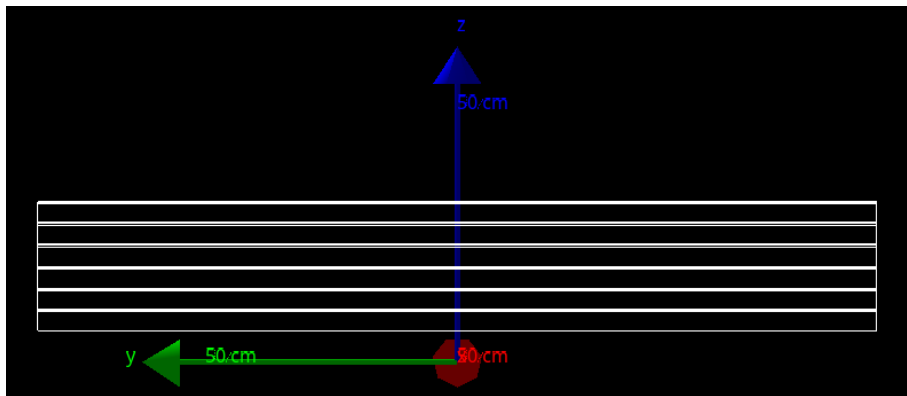
FIT+SCD



```
/herd/geometry/parametric/general/tracker fit  
/herd/geometry/parametric/general/antiCoincidence none  
/herd/geometry/parametric/general/calorimeter none  
/herd/geometry/parametric/general/chargeID scd
```

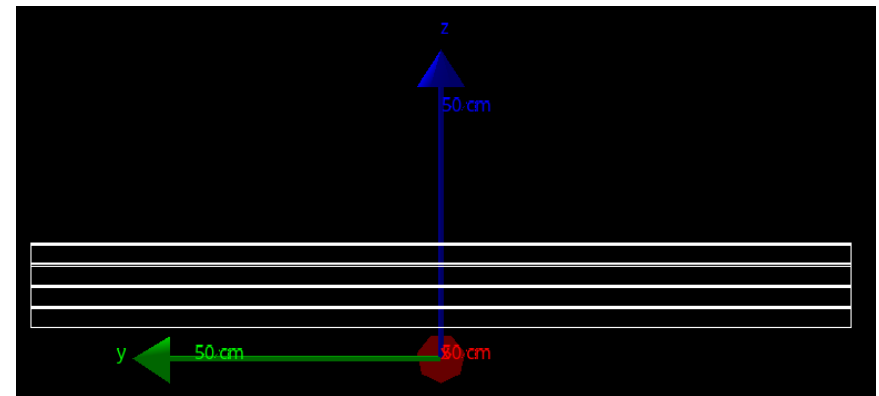
MC simulation

TOP STK with 6 layers



```
/herd/geometry/parametric/general/tracker stkTop  
/herd/geometry/parametric/general/antiCoincidence none  
/herd/geometry/parametric/general/calorimeter none  
/herd/geometry/parametric/general/chargeID none
```

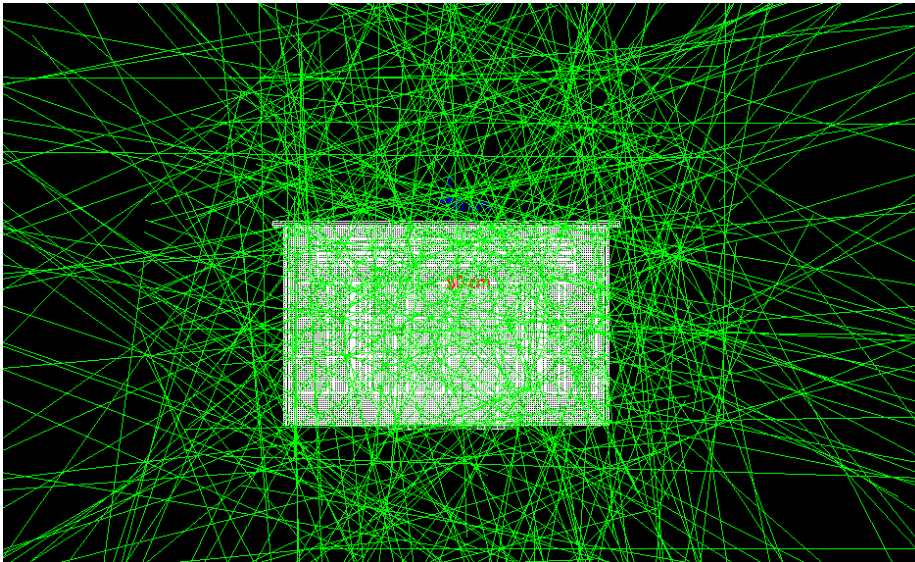
TOP STK with 4 layers



```
/herd/geometry/parametric/general/tracker stkTop  
/herd/geometry/parametric/general/antiCoincidence none  
/herd/geometry/parametric/general/calorimeter none  
/herd/geometry/parametric/general/chargeID none  
/herd/geometry/parametric/stk/nTopLayers 4
```

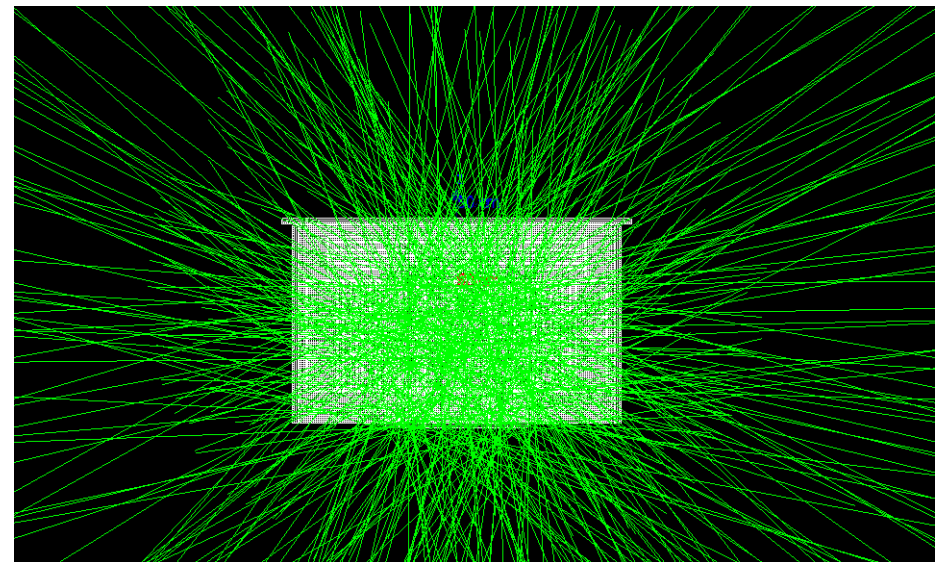
MC simulation

Isotropic flux from a sphere



```
/GGS/generatorActions/gun/sphereCenter 0 0 0 m  
/GGS/generatorActions/gun/sphereCapPosition 0 0 160 cm  
/GGS/generatorActions/gun/sphereCapExtension 160 deg
```

Generation inside acceptance



```
/GGS/generatorActions/gun/sphereCenter 0 0 0 m  
/GGS/generatorActions/gun/sphereCapPosition 0 0 160 cm  
/GGS/generatorActions/gun/sphereCapExtension 160 deg  
/GGS/generatorActions/gun/checkAcceptance
```

MC simulation

- Energy deposit:

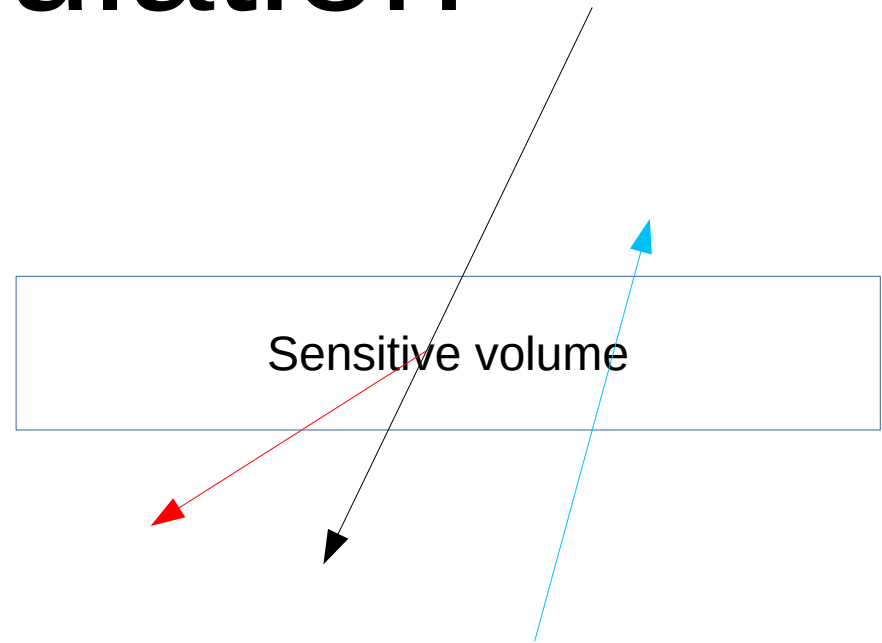
- Integrated

$$\Delta E_0 + \Delta E_1 + \Delta E_2$$

- Particle

ΔE_0	ΔE_1	ΔE_2
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- Definition of sensitive volumes at runtime



```
/GGS/scoring/addGGIntHitSD tiletopPSD # Add integrated hits for top PSD tiles
/GGS/scoring/tiletopPSD.GGIntHitSD/storeParticleHits # Store also particle hits
/GGS/scoring/addGGIntHitSD tilesidePSD # Add integrated hits for side PSD tiles
/GGS/scoring/tilesidePSD.GGIntHitSD/storeParticleHits # Store also particle hits
```

- Output on Root file

```
/GGS/userActions/addGGSHitsAction
```




MC simulation

- Other features:
 - Runtime plugins
 - Geometry
 - Particle generators
 - Hits
 - Persistence
 - Reader class for offline analysis
 - Written in C++, build system based on Cmake
 - Extensive GGS user manual

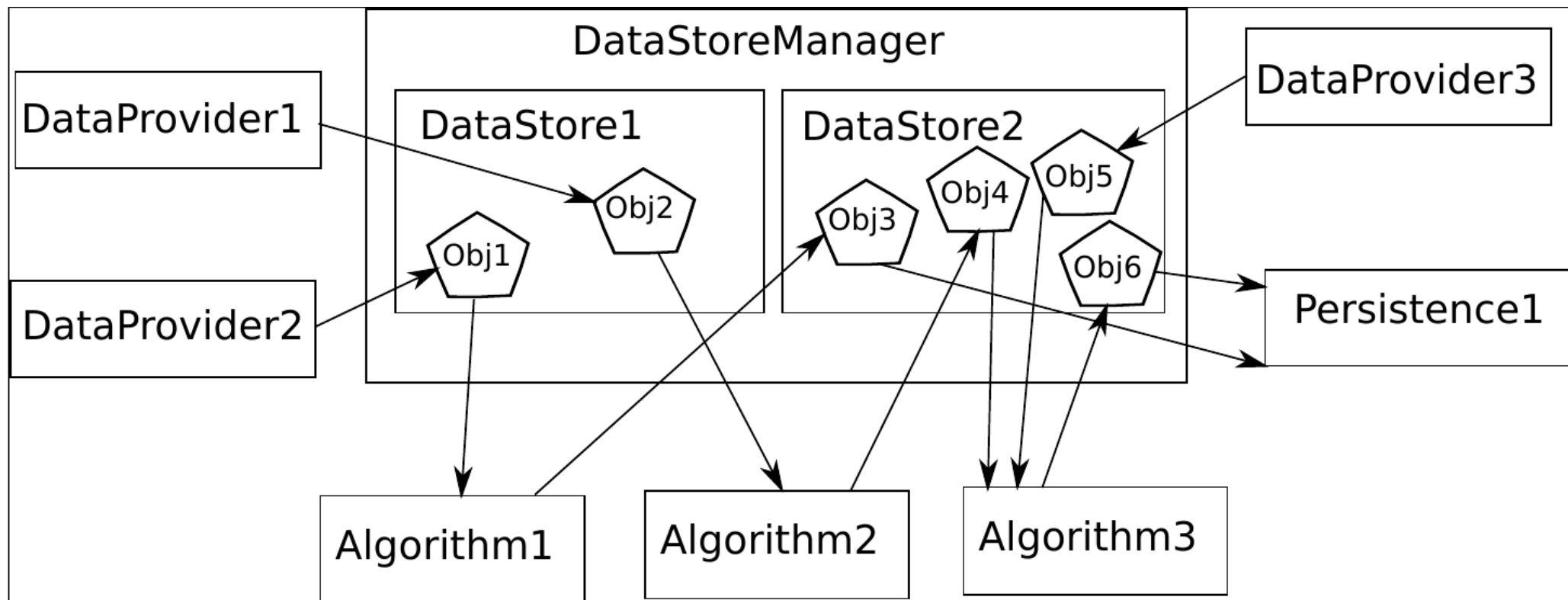


Data processing

- Based on the EventAnalysis framework
 - Generic implementation of the usual HEP data processing procedure
 - Initialize, Process, Finalize
 - Reconstruction
 - Analysis

Data processing

- User-facing components:
 - Data objects
 - Data providers
 - Algorithms
 - Persistence services



Data processing

- Data access:

```
bool RefitterAlgo::Process(){
    auto evStore = GetDataStoreManager()->GetEventDataStore("evStore");
    auto track = evStore->GetObject<Track>("track");
    // ... refit the track and then ...
    evStore->AddObject<Track>("refittedTrack", refitted);
    return true;
}
```

- Transparent I/O for algorithms:

- Ask a data object to a data store
- The data store:
 - Returns the object if it's present
 - Otherwise it asks a data provider and eventually returns the provided object
- Produce an object and put it on the store
- Persistence service will eventually save the object

Data processing

- Job configuration:

```
Plugin HerdDataProviders
Plugin HerdAlgorithms
Plugin RootPersistence
Plugin HerdDataObjectsDict

DataProvider GGSDDataProvider ggsDataProvider electrons_10GeV_sphere.root
  AttachToStore evStore event
  AttachToStore globStore global

Persistence RootPersistenceService rootPersistence electrons_10GeV_sphere.dig.root
  Book mcTruth event evStore
  Book caloHitsMC event evStore
  Book caloGeoParams global globStore
  Book stkHitsCollMC event evStore
  Book stkGeoParamsColl global globStore
  Book scdHitsCollMC event evStore
  Book scdGeoParamsColl global globStore
  Book psdHitsCollMC event evStore
  Book psdGeoParamsColl global globStore

EventLoop
  Algo StkGeometricDigitizerAlgo stkGeomDig
  Set pitch 0.0150
  Algo ScdGeometricDigitizerAlgo scdGeomDig
  Set pitch 0.0150
# Simulate 4cm x 4cm tiles on top and sides
  Algo PsdGeometricDigitizerAlgo psdGeomDig
  Set topAggrFactorX 4
  Set topAggrFactorY 4
  Set latAggrFactorXY 4
  Set latAggrFactorZ 4
```



Data processing

- Features:
 - Runtime plugins
 - Generic DataProvider and PersistenceService based on ROOT
 - Work for every class with a dictionary
 - User doesn't have to write code for I/O
 - Written in C++14, build system based on CMake, automated test suite
 - User manual with architecture description



HerdSoftware

- Monte Carlo:
 - Detector geometry
 - DataProvider for GGS output files
 - Algorithms:
 - Geometric digitization: PSD, STK, SCD
 - Full digitization: FIT

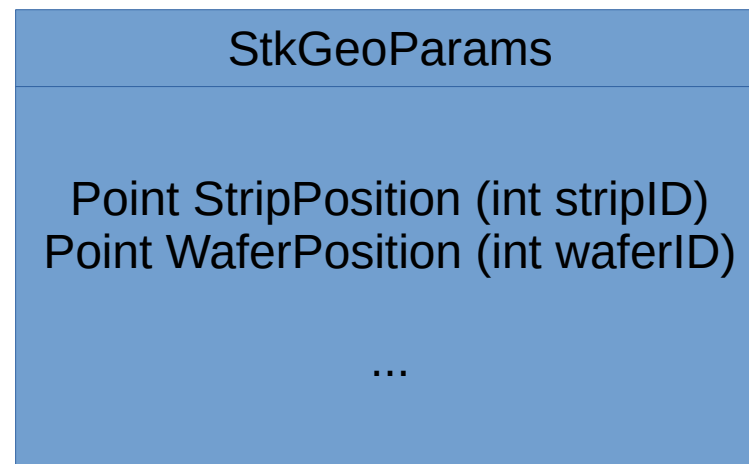


HerdSoftware

- Reconstruction algorithms:
 - Clustering
 - Tracking
- Analysis algorithms:
 - Acceptance
- Miscellaneous algorithms:
 - Event display

HerdSoftware

- Data model:
 - Geometry parameters
 - Hits
 - Heavy optimization for memory usage and I/O



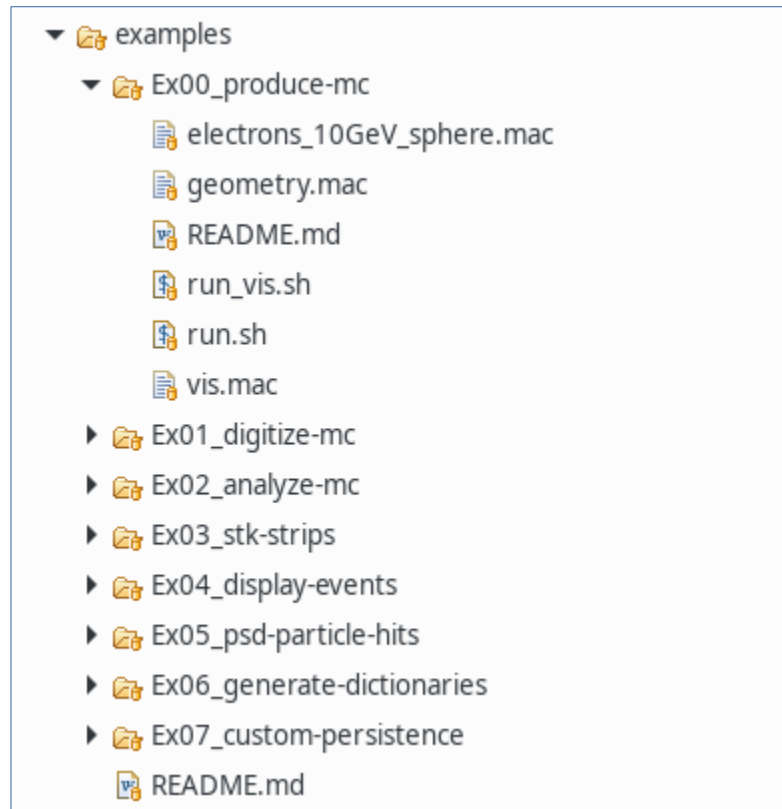


HerdSoftware

- Particle hits
- MC truth
- Reconstructed quantities (tracks, clusters, ...)

HerdSoftware

- Examples:



- Online documentation (wiki)
 - See V. Formato's presentation



HerdSoftware

- Supported platforms:
 - CentOS 7
 - Ubuntu 18.04, 16.04
 - OSX 10.15 “Catalina”, 10.13 “High Sierra”
- Automated tests on all the supported platforms
 - See V. Formato’s presentation



Summary

- HerdSoftware features:
 - MC geometry with all the sub-detectors (except TRD) and settable parameters
 - I/O classes for MC files and for reconstruction/analysis products
 - Robust and extensible processing pipeline (EventAnalysis algorithms)
 - Resources for newcomers (examples, user guides, wiki)