Introduction to the analysis package.

Yo Sato (Tohoku University)

Belle II Starter Kit workshop, KEK, January 2020

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

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- What is basf2?
- Invoking basf2 and the equivalent of "Hello World"
- Modules, paths, the DataStore and how to steer them all
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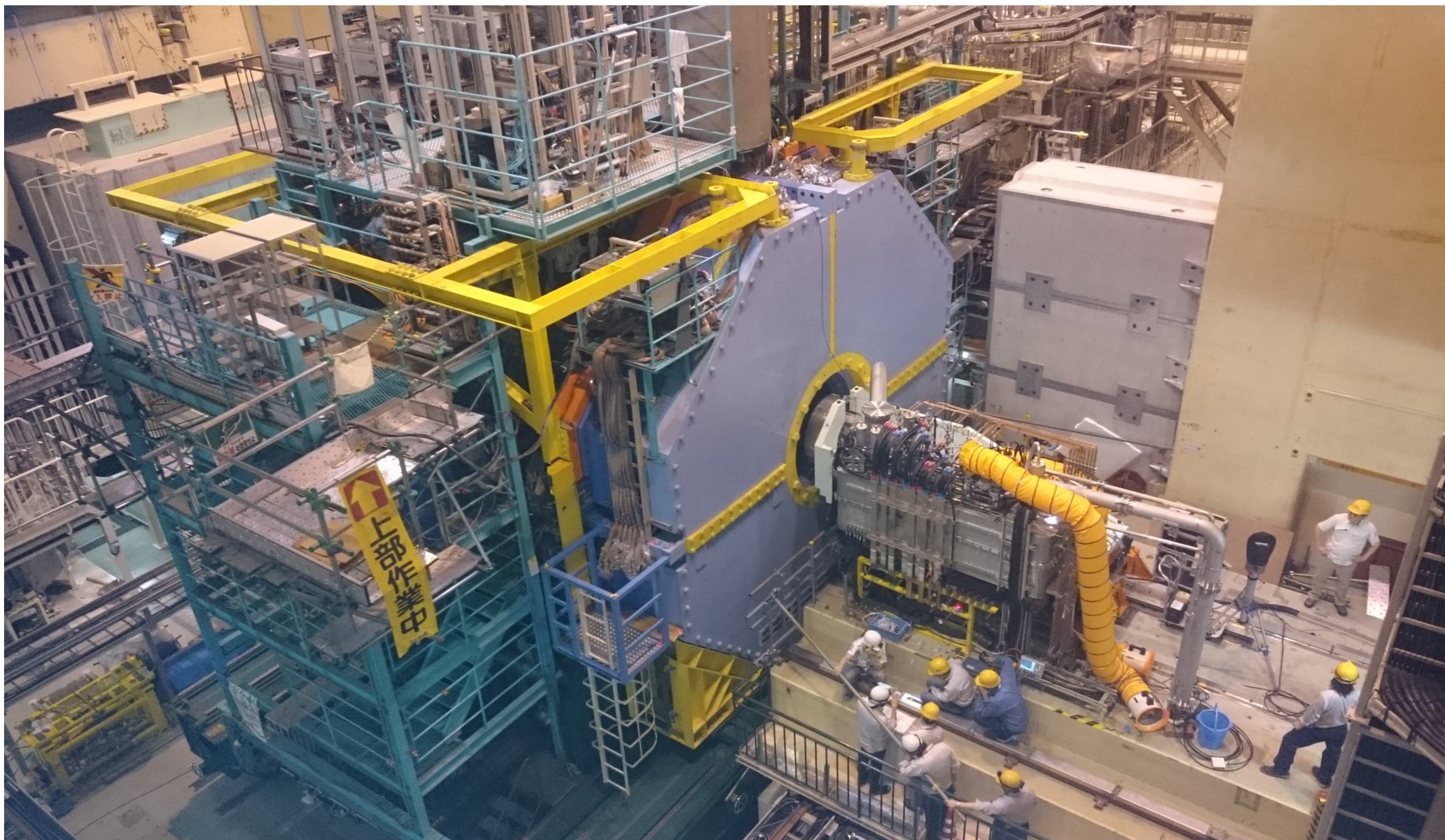
- Now let's step through an example
- Candidate/particle based analysis
- Physics quantities and the VariableManager
- How to get data out
- Nomenclature
- One final thing about Belle vs. Belle II

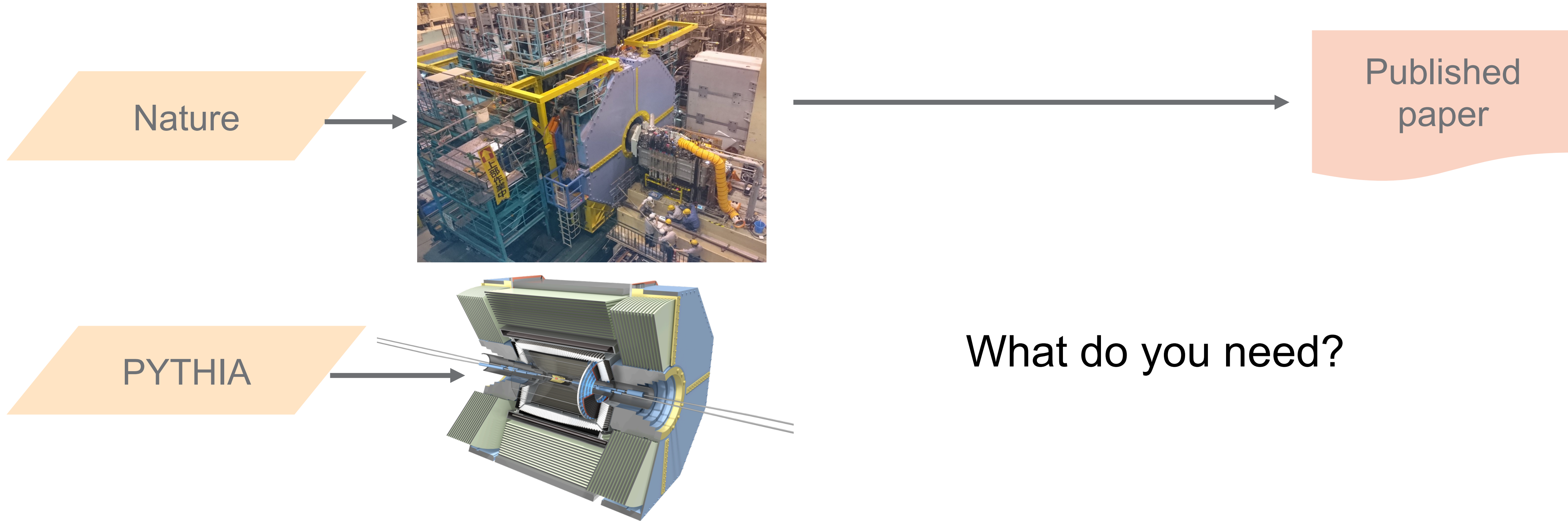
An experiment's workflow

The big picture

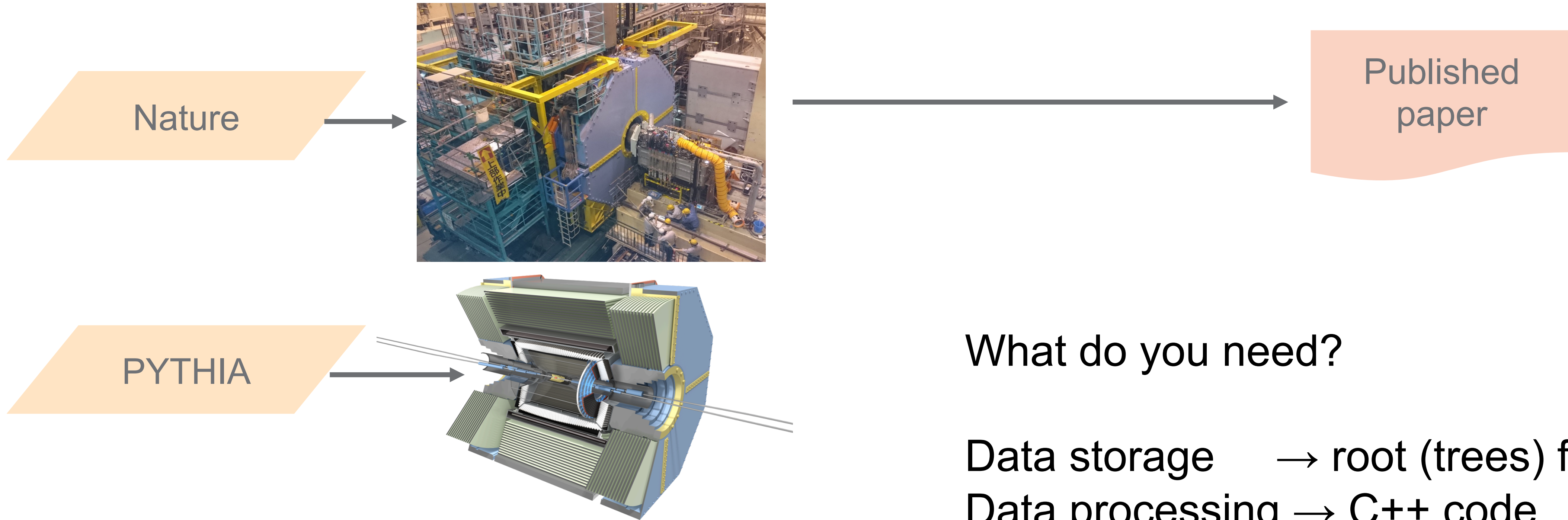
Tsukuba Hall



The big picture



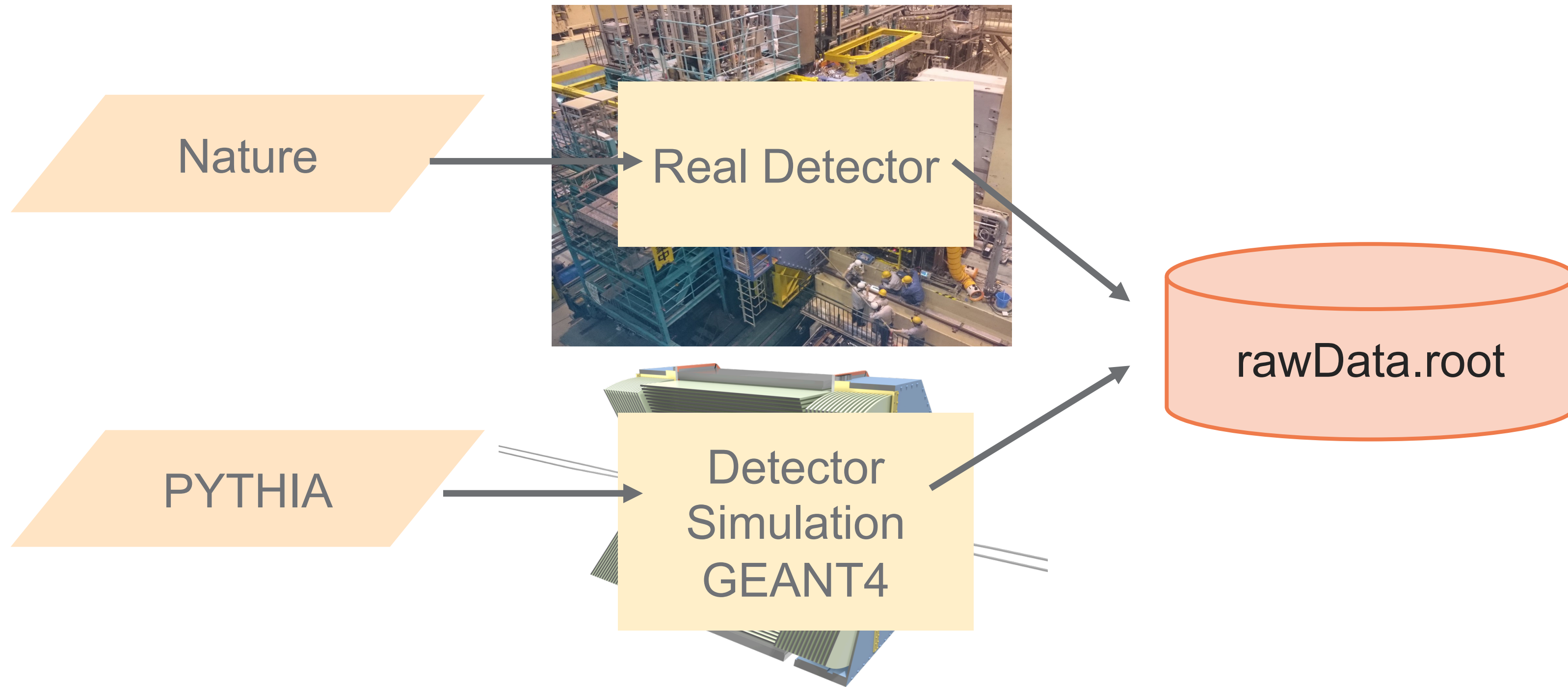
The big picture



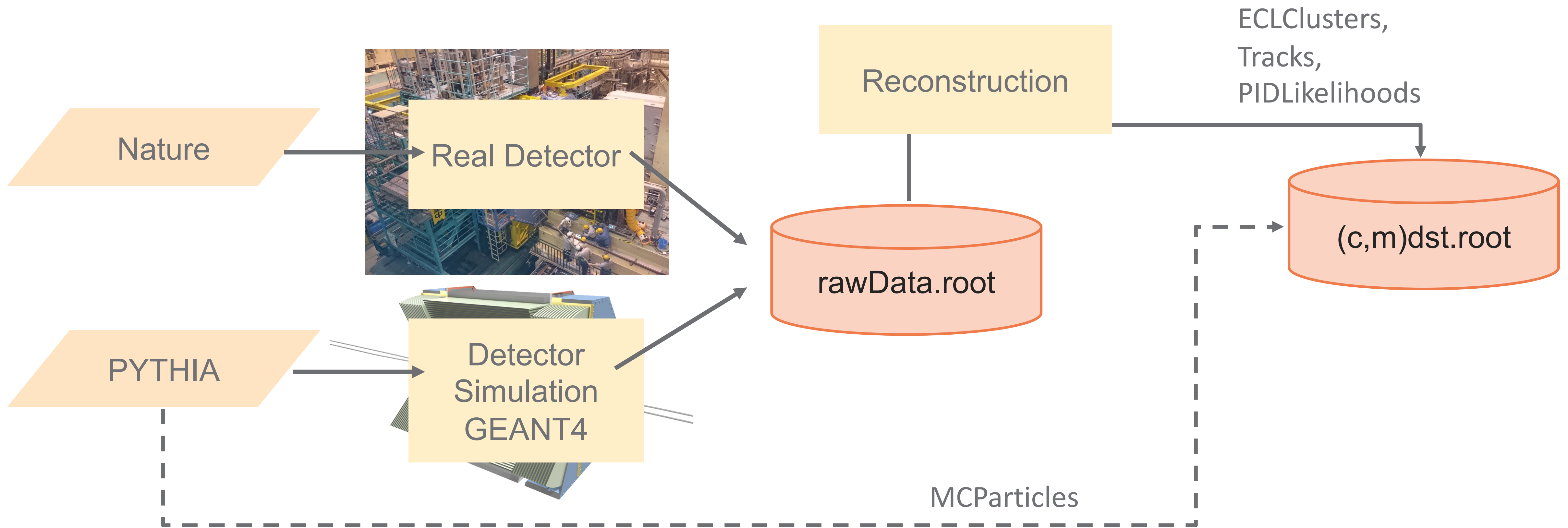
What do you need?

Data storage → root (trees) files
Data processing → C++ code
Scripting → Python

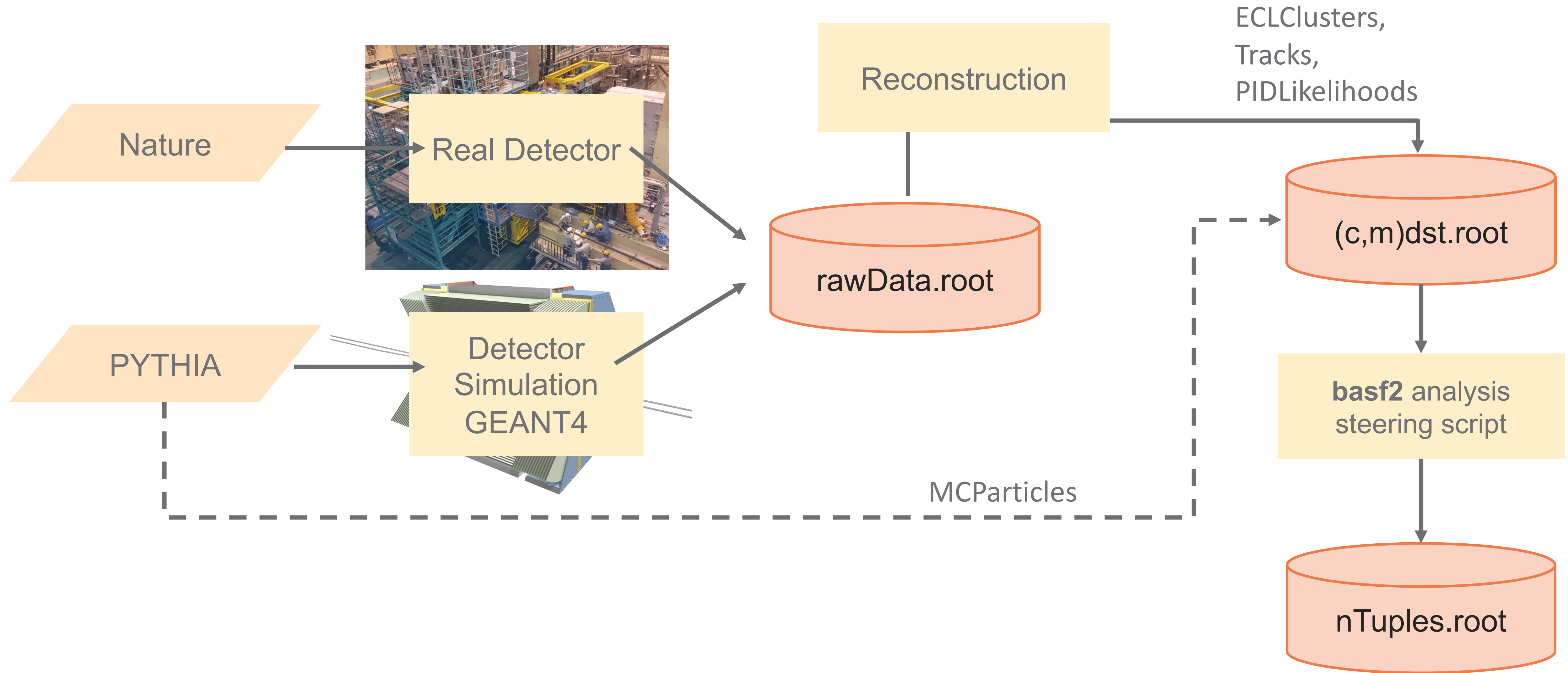
The big picture



The big picture



The big picture



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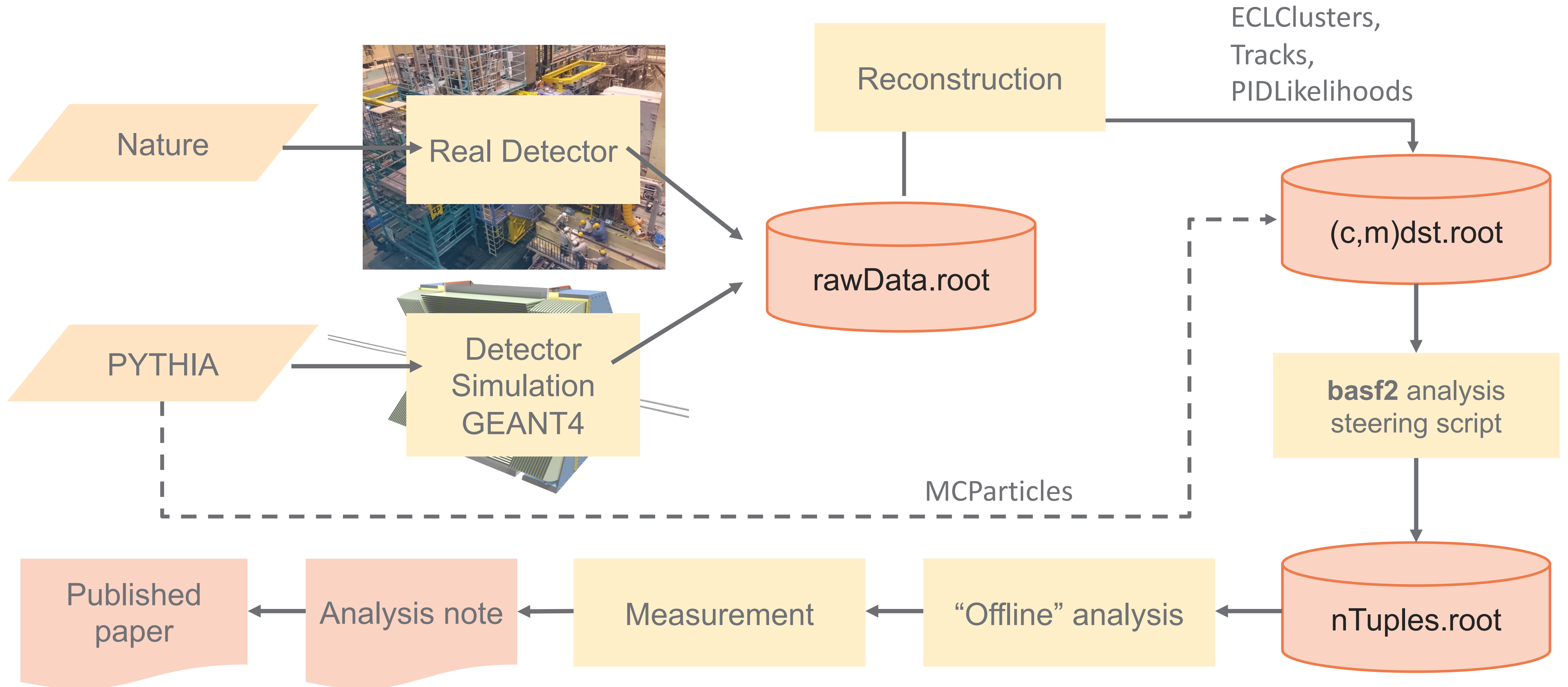

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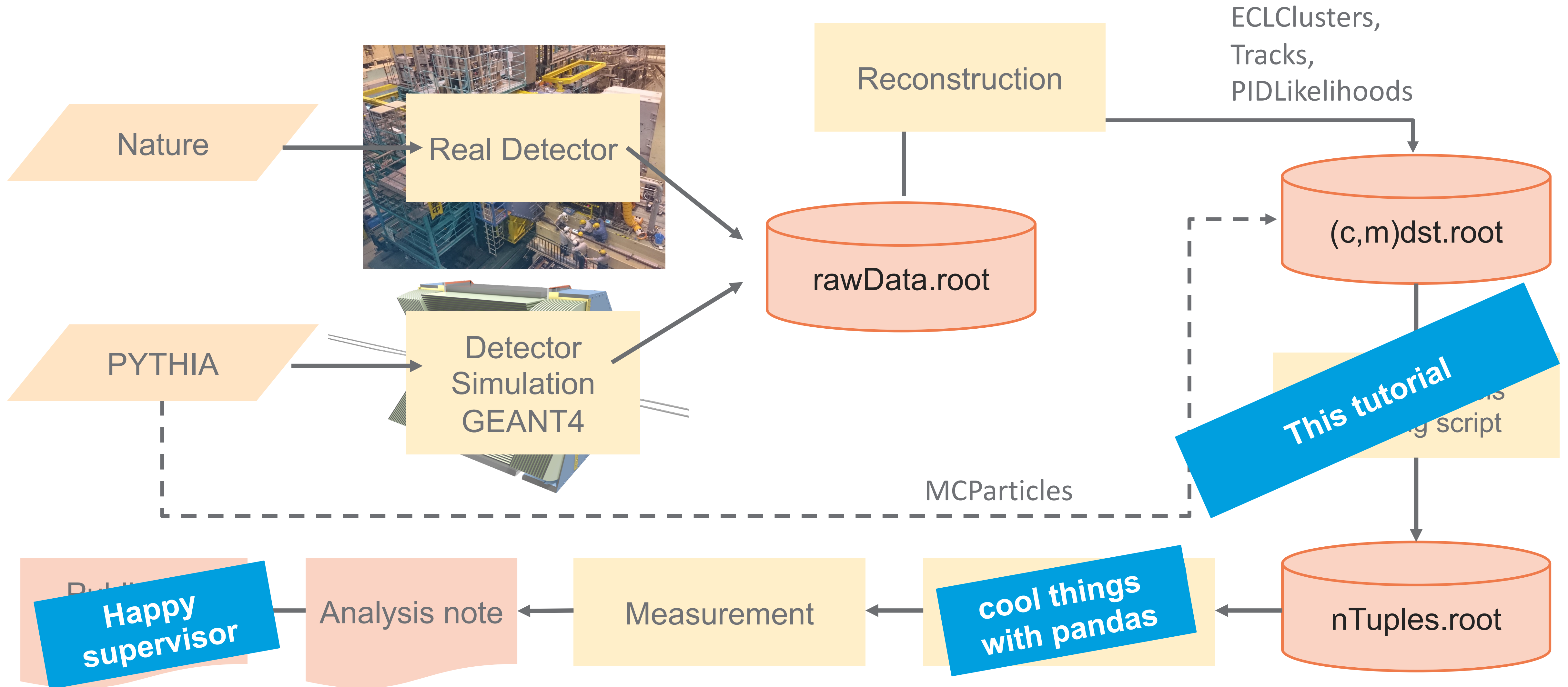

What is basf2?

The code

`basf2` is C++14 "**under the hood**"

- Packages contain C++ **modules** to manipulate data.
- In analysis: we have code to build **particles** from primitive objects (like tracks and calorimeter clusters).
- We also calculate physics quantities, and apply cuts.

Python 3.6 code for **steering**

- Load and configure C++ modules
  - analysis modules and modules from other packages
- Also python does *some* high-level analysis tasks.
- You will write a fair bit of python during the workshop.

The code

`basf2` is C++14 "**under the hood**"

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Heavy lifting

Python 3.6 code for **steering**

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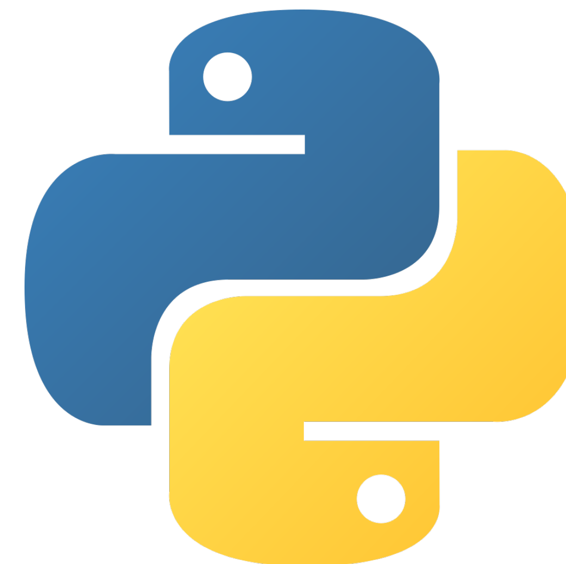
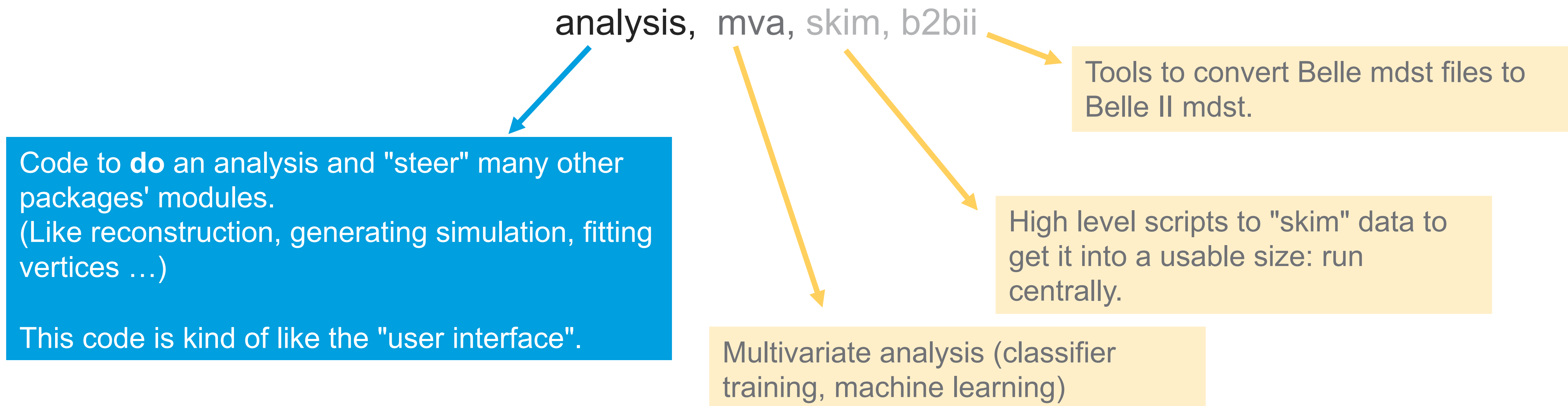
Readable scripts



What is the analysis package?

- Our software is organised into "packages".
  - https://stash.desy.de/projects/B2/repos/software/browse
  - There are packages for subdetectors, tracking, simulation…
  - As a student/postdoc/collaborator you might work on some of them.

- BUT! When you want to do a physics measurement. You really only care about:



I’m stuck, where do I go for help?

Probably the most important slide

questions https://questions.belle2.org
for anything really, not just analysis package

documentation https://software.belle2.org
there is fairly good documentation

examples `$BELLE2_RELEASE_DIR/<packagename>/examples`
so, for us <packagename> = analysis

the code https://stash.desy.de/projects/B2/repos/software/browse
`$BELLE2_RELEASE_DIR`

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$BELLE2_RELEASE_DIR

Invoking basf2 and the equivalent of “Hello World”

How to invoke basf2

Belle analysis software framework 2

- Let’s setup basf2 !
- But, first of all, you should know which release can be and should be used.

```
$ . /cvmfs/belle.cern.ch/tools/b2setup
$ b2setup --help # You can see available releases of basf2
...
  The following releases are available:
...
    release-04-01-00
    release-04-01-01
    light-1912-icarus

$ b2help-releases # or you can ask the recommended release
release-04-01-01
```

How to invoke basf2

Belle analysis software framework 2

Q. Which release should I use?

A. I really recommend you to use the latest `release-AA-BB-CC` or `light-YYMM-CODENAME`.

`release-AA-BB-CC`

A full release, such as `release-04-01-01` and `release-03-02-04`.

If you execute `b2help-releases`, it tells the latest full release.

`light-YYMM-CODENAME`

A light release, such as `light-1912-icarus` and `light-1911-heracles`.

Made from only a few packages, analysis, mdst, skim, b2bii (from light-1912) etc..

They are suitable for doing analysis!

How to invoke basf2

Belle analysis software framework 2

- Hopefully you've seen this already.
- If not you will see it many times in this workshop.
- At the command line:

```
$ . /cvmfs/belle.cern.ch/tools/b2setup
$ b2setup release-04-01-01
$ basf2 --info
```

How to invoke basf2

Belle analysis software framework 2

- Then Let’s setup basf2 for the release!
- `` `. /cvmfs/belle.cern.ch/tools/b2setup` `` needs only once per session.

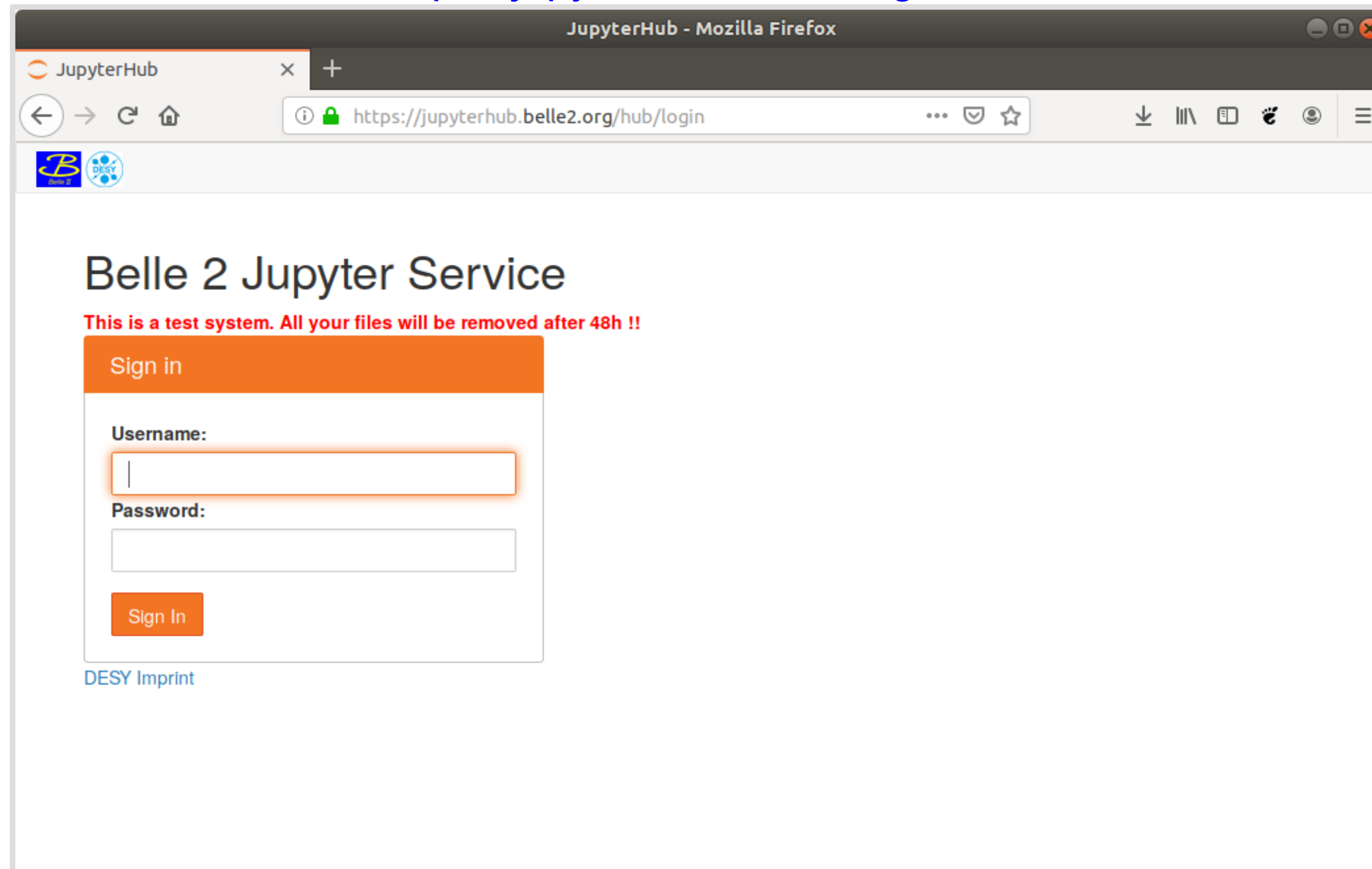
```
$
$
$
```

```
$ . /cvmfs/belle.cern.ch/tools/b2setup release-04-01-01
$ basf2 --info
```

Today we'll use jupyter

You will cover command line usage later in the workshop

https://jupyterhub.belle2.org



Start a server, open the first exercise...

https://jupyterhub.belle2.org

B2T_Basics_1_GettingHelp - Mozilla Firefox

b2-starterkit/ | B2T_Basics_1_GettingHe

https://jupyterhub.belle2.org/user/scunliff/notebooks/b2-s

B2T_Basics_1_GettingHelp (autosaved)

Logout | Control Panel

File Edit View Insert Cell Kernel Widgets Help | Not Trusted | Python 3 (Belle2)

Run | Markdown

BASF2 Basics

If you run things at the command line (for example at KEKCC or NAF) you will need to set up your environment and whatever release.

```
source /cvmfs/belle.cern.ch/tools/b2setup
b2setup release-03-01-01
```

Actually if you already know what release you want then you can do it all in once step:

```
source /cvmfs/belle.cern.ch/tools/b2setup release-03-01-01
```

To list all available releases:

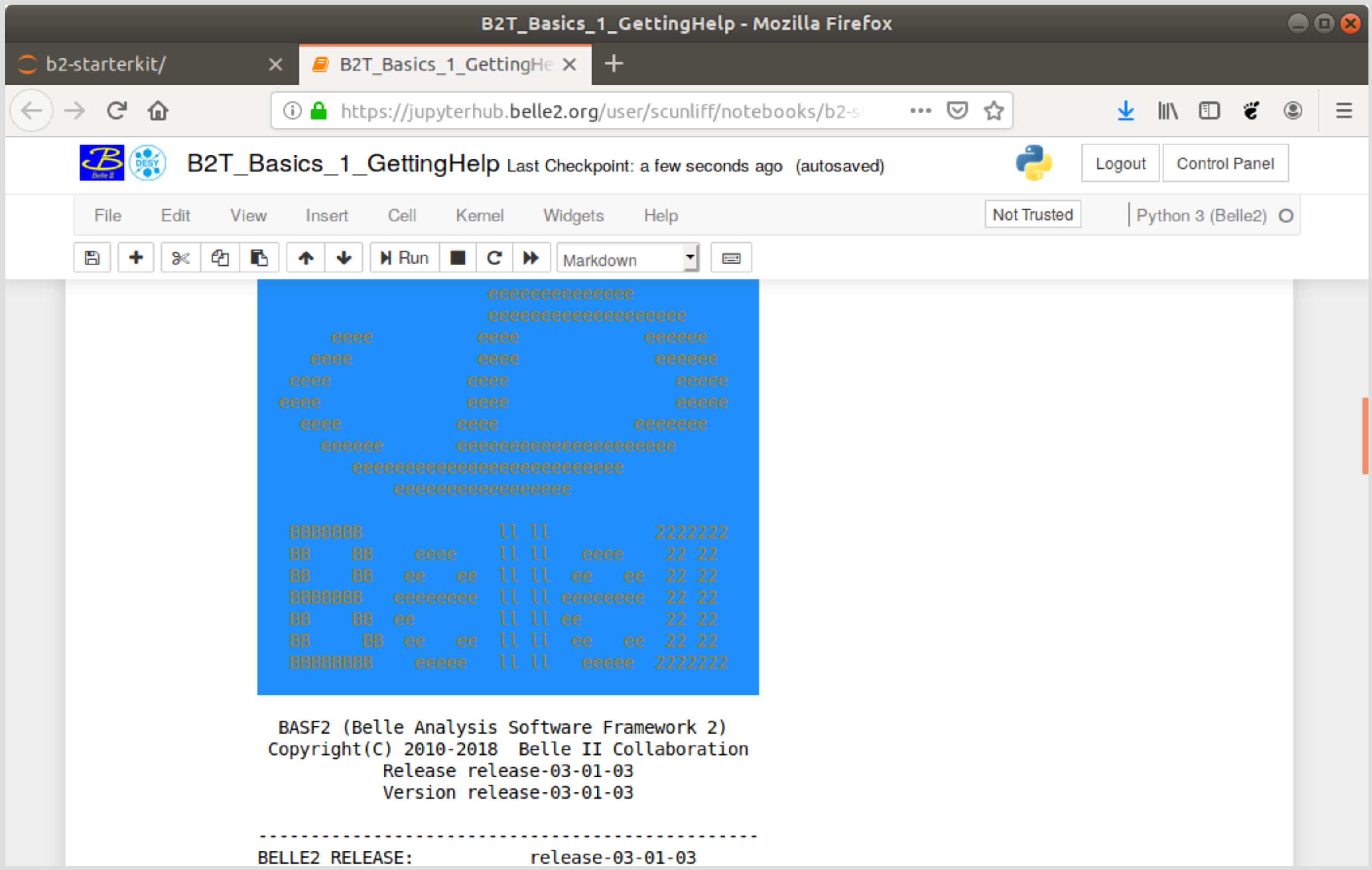
```
b2setup --help
```

You **don't** need to do that in this ipython/jupyter environment (we've set it all up for you). But please remember this, you'll need it later.

```
In [ ]: !basf2 --info
```

basf2 --info

https://jupyterhub.belle2.org



basf2 --info

Also works on a terminal to KEKCC or NAF

Source the logon script, pick a release

Execute this

Terminal

File Edit View Search Terminal Help

```
> source /cvmfs/belle.cern.ch/tools/b2setup release-03-01-03
Belle II software tools set up at: /cvmfs/belle.cern.ch/tools
Environment setup for release: release-03-01-03
Central release directory    : /cvmfs/belle.cern.ch/ubuntu1804/releases/release-03-01-03


> basf2 --info

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   BB      BB  ee    ee  ll ll  ee    ee  22  22
   BBBBBBBB    eeeee   ll ll   eeeee  2222222


  BASF2 (Belle Analysis Software Framework 2)
 Copyright(C) 2010-2018  Belle II Collaboration
            Release release-03-01-03
            Version release-03-01-03

-------------------------------------------------
BELLE2_RELEASE:           release-03-01-03
BELLE2_RELEASE_DIR:       /cvmfs/belle.cern.ch/ubuntu1804/releases/release-03-01-03
```

basf2 --info

Also works on a terminal to KEKCC or NAF

Useful information

```
 BASF2 (Belle Analysis Software Framework 2)
 Copyright(C) 2010-2018  Belle II Collaboration
           Release release-03-01-03
           Version release-03-01-03

------------------------------------------------
BELLE2_RELEASE:            release-03-01-03
BELLE2_RELEASE_DIR:        /cvmfs/belle.cern.ch/ubuntu1804/releases/release-03-01-03
BELLE2_LOCAL_DIR:
BELLE2_SUBDIR:             Linux_x86_64/opt
BELLE2_EXTERNALS_VERSION:  v01-07-01
BELLE2_ARCH:               Linux_x86_64
Default global tags:       release-03-01-00_rev3
Kernel version:            4.15.0-48-generic
Python version:            3.6.6
ROOT version:              6.14/06

basf2 module directories:
  /home/scunliff
  /cvmfs/belle.cern.ch/ubuntu1804/releases/release-03-01-03/modules/Linux_x86_64/opt
------------------------------------------------
```

Modules, paths, the DataStore and how to steer them all

Modules, paths, the DataStore

What do we need to process the data?

Kuhr, Pulvermacher, Ritter, Hauth, Braun
Comput. Softw. Big Sci. 3 (2019) no.1

1) A set of classes (modules) that process the data
→ **BASF2 module**

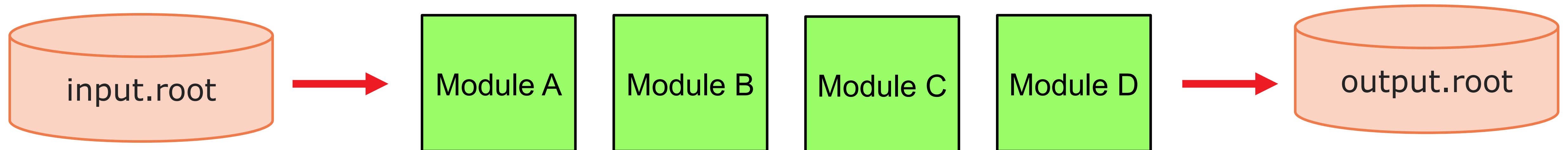
A module is written in C++ or Python and derived from a `Module` base class that defines the following interface methods:

- `initialize()`: called before the processing of events to initialize the module.
- `beginRun()`: called each time before a sequence of events of a new run is processed, e.g., to initialize run-dependent data structures like monitoring histograms.
- `event()`: called for each processed event.
- `endRun()`: called each time after a sequence of events of the same run is processed, e.g., to collect run-summary information.
- `terminate()`: called after the processing of all events.

Modules, paths, the DataStore

What do we need to process the data?

1) A set of classes (modules) that process the data
   → **BASF2 module**

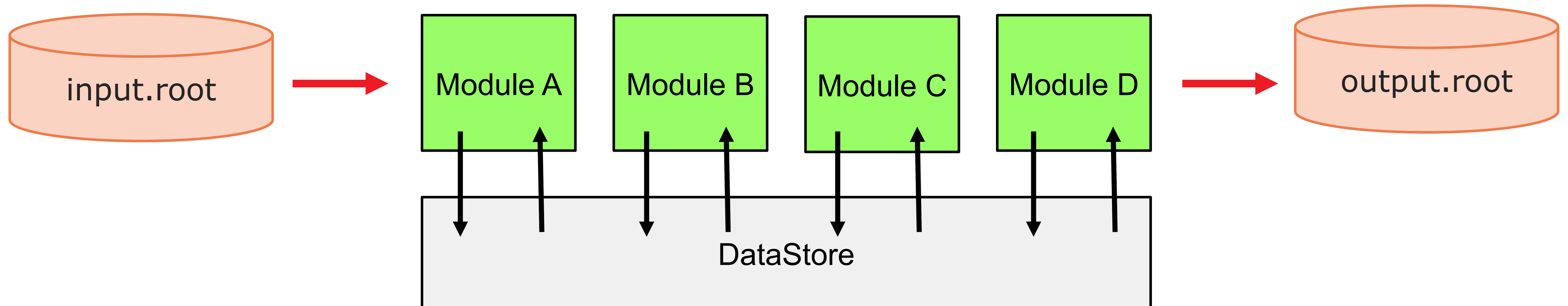


Modules, paths, the DataStore

What do we need to process the data?

1) A set of classes (modules) that process the data
→ **BASF2 module**

2) A set of classes (dataobjects) that hold the data and allow module to pass thing one to the other
→ **BASF2 dataStore**



Modules, paths, the DataStore

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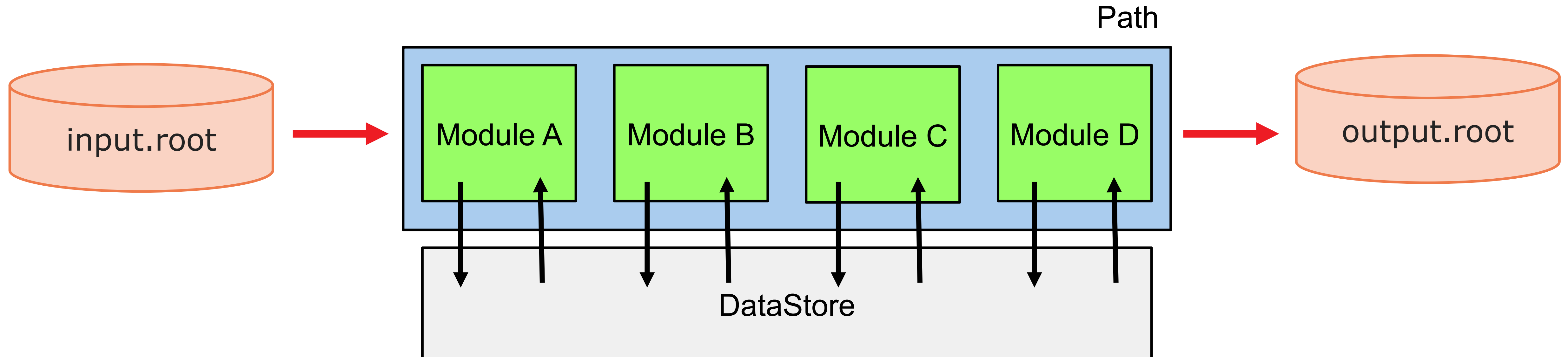

3) An order in which the modules must be executed
   → **BASF2 path**

What does a steering file look like?

How to I implement all this?

A steering file is a python script that runs
→ the modules that you need
→ in the order you need
→ on the data you need

A word about file types and why you should use the analysis package

File types

That basf2 can read and/or create

- A **dst** contains basf2 objects which will populate a **DataStore**.
  - **d**ata **s**ummary **t**able
  - Basically: a special ROOT file.

- The data for physics analysis are "**mdst**"
  - **m**ini **d**ata **s**ummary **t**able.
  - Same structure of a **dst, but with much less information**
  - Input to your analysis package scripts

- The calibration & performance are **"cdst"**
  - **c**alibration **d**ata **s**ummary **t**able.
  - mdst + digits

- At the end of your analysis chain you will write out a "normal" root file containing a TTree, TNtuple, or histograms

A relevant question
https://questions.belle2.org/question/219

Objects allowed in an *m*dst:
https://goo.gl/AB15Ud

Why use the analysis package?

Can I read the mdst by myself?

mdst are basically root trees containing lists of:

→ Track
→ TrackFitResult
→ V0
→ PIDLikelihood
→ ECLCluster
→ KLMCluster
→ KlId
→ TRGSummary
→ SoftwareTriggerResult
→ (MCParticle)
→ ...

The analysis package has modules to convert these
Into more friendly quantities like
→ Particle
→ ParticleList
→ EventShapeContainter
→ TagVertex
→ …

Why use the analysis package?

Can I read the mdst by myself?

Can I open the mdst with my own, custom-made macro and run the analysis?

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The mdst contains also the relations bewteen the objects stored in it, which are not trivially handeled by a stand-alone root macro. **Use always basf2-based code.**

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The mdst contains also the relations bewteen the objects stored in it, which are not trivially handeled by a stand-alone root macro. **Use always basf2-based code.**

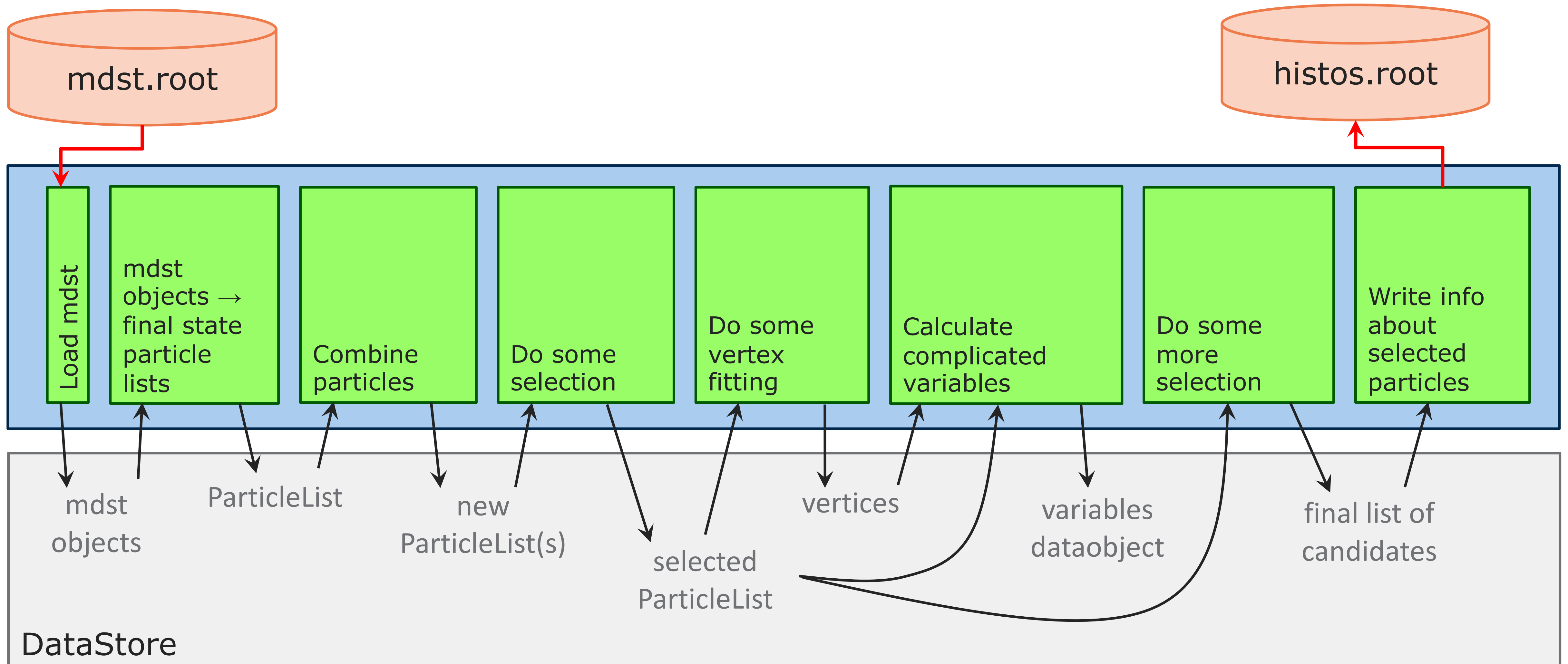
Should I write my own module that loops over reconstructed objects like the ECLClusters and do the analysis (i.e. Belle-style)?

NO

The relation bewteen analysis object (particles) and the reconstructed objects is not always trivial.
One particle may have many trackFitResults
The ECLClusters are not photons.
Use the modules provided by a detector expert

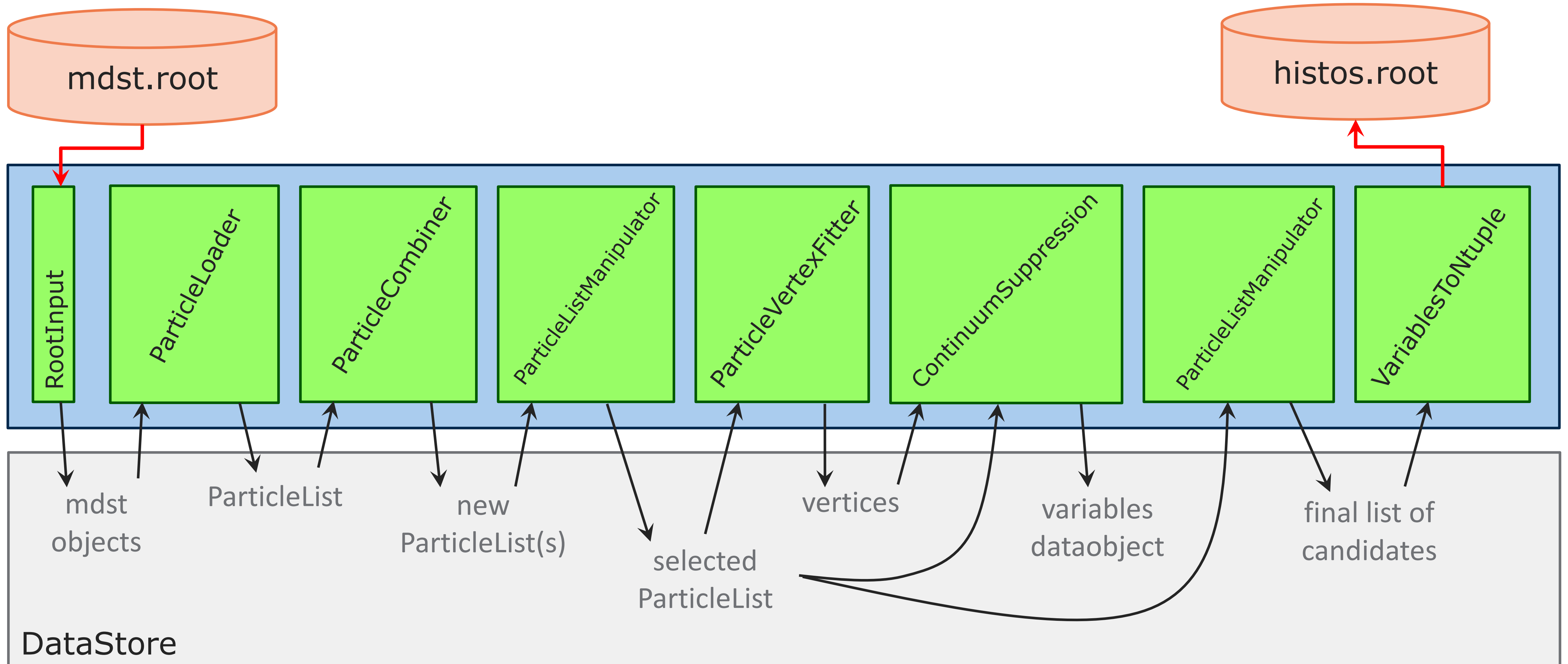
Now let’s step through an example

A typical path for an analysis job



A typical path for an analysis job

Now with the real names for the modules



How to make a path and load a module

- First of all, you have make your path.

```
import basf2

mypath = basf2.Path()
# mypath basf2.create_path() # Both are OK!
```

How to make a path and load a module

- Call a function to load a module and add it to your path.
- That is all you need to do!

```
from modularAnalysis import fillParticleList

fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

Load a module to fill a list of particle, ParticleList.
We'll see details of ParticleList later.

- What is happening in the function?

The ParticleLoader

An analysis module which loads particles

```
fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

```
pload = register_module('ParticleLoader')
pload.param('decayStringsWithCuts', [('pi+:highMom', 'p > 1')])
mypath.add_module(pload)
```

- The function wraps these steps in a line.
- Of course, you can write them by hand.
  - **But quite quickly scripts become unreadable**

The ParticleLoader

An analysis module which loads particles

- The procedure is same no matter what module you want in path.
  - "Register" the module you want
  - Set "param"eters to the module
  - "Add" the module to you path

```
pload = register_module('ParticleLoader')
pload.param('decayStringsWithCuts', [('pi+:highMom', 'p > 1')])
mypath.add_module(pload)
```

How to find module documentation

In general

- At the command line:

```
$ basf2 -m
$ basf2 -m ParticleLoader
```

Take a look at
B2T_Basics_1_GettingHelp.ipynb
on jupyterhub

Q: Can you find the **source code** for ParticleLoader?
What do you notice about the C++ class name? How does this compare to the module name?

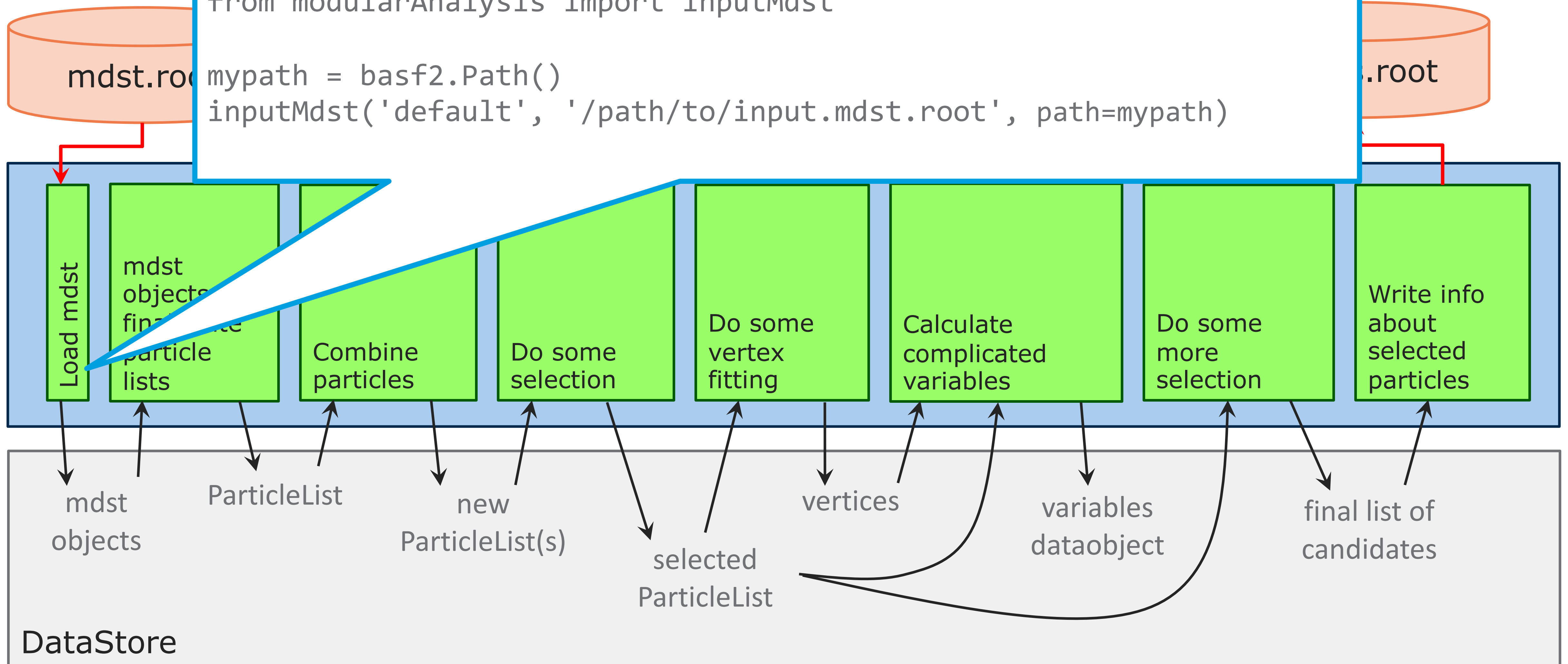
Wrapper functions

- Functions such as fillParticleList are found in <package>/scripts/*.py
- The script that you will probably use a lot is **analysis/scripts/modularAnalysis.py**

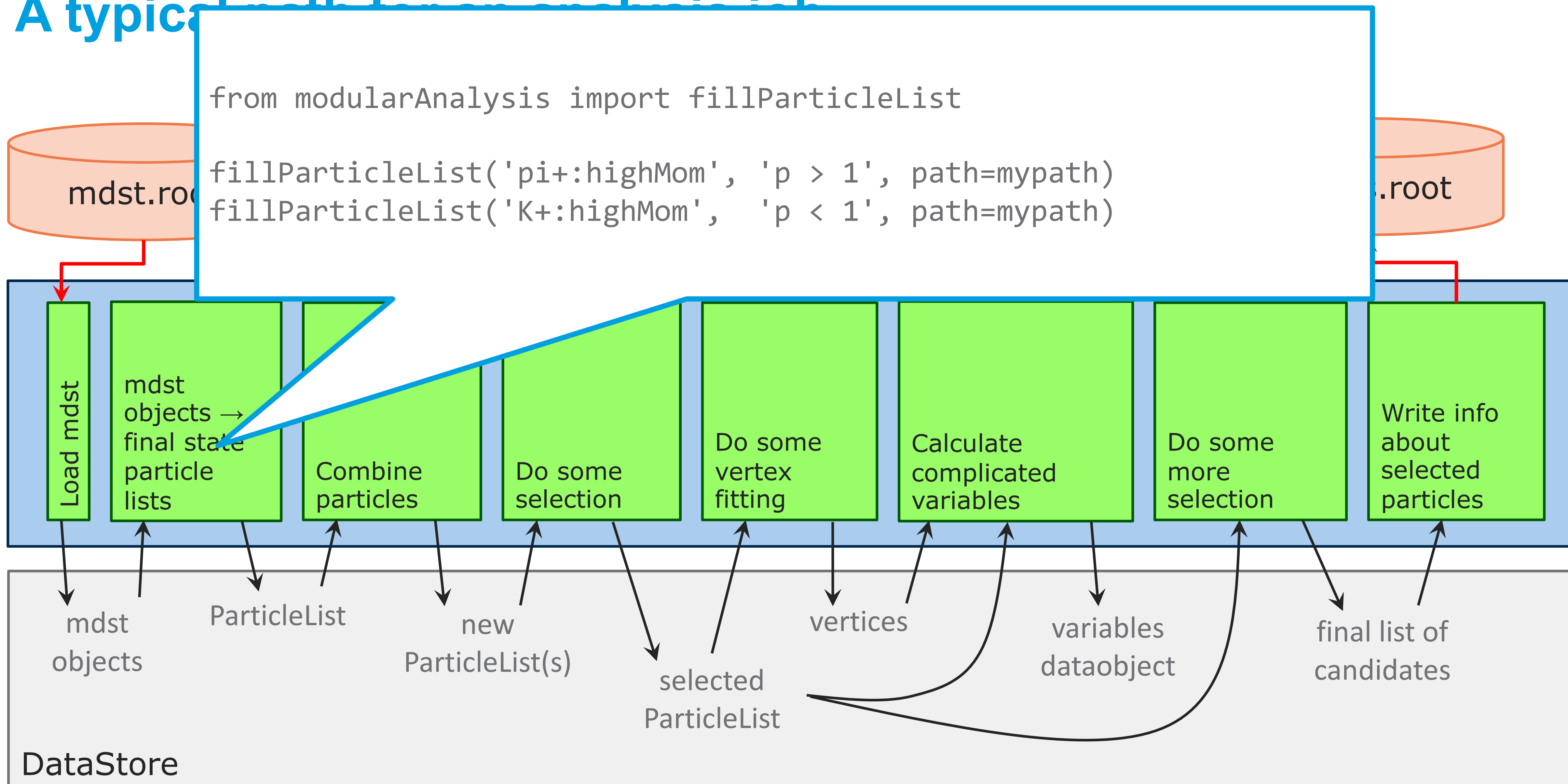
```
# analysis/scripts/modularAnalysis.py
from modularAnalysis import fillParticleList
fillParticleList('pi+:highMom', 'p > 1', path=mypath)


# analysis/scripts/vertex.py
from vertex import fitVertex
fitVertex('K*0:myKst', conf_level=0.0, path=mypath)
```

A typical path for an analysis job

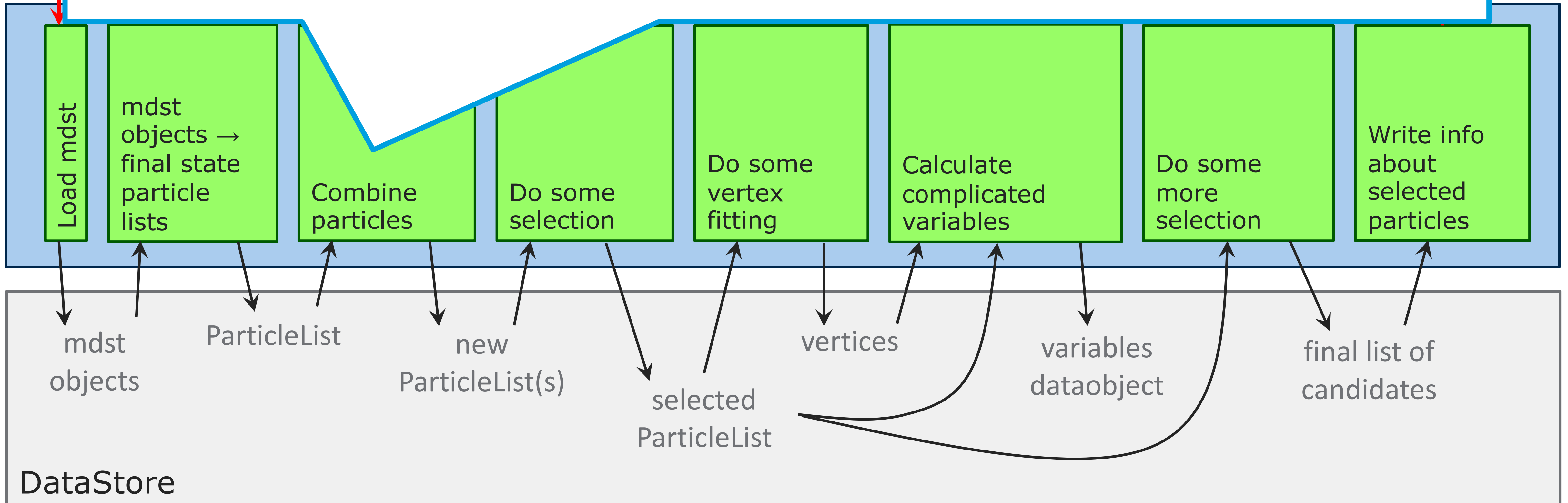


A typical path for an analysis job



A typical path for an analysis job

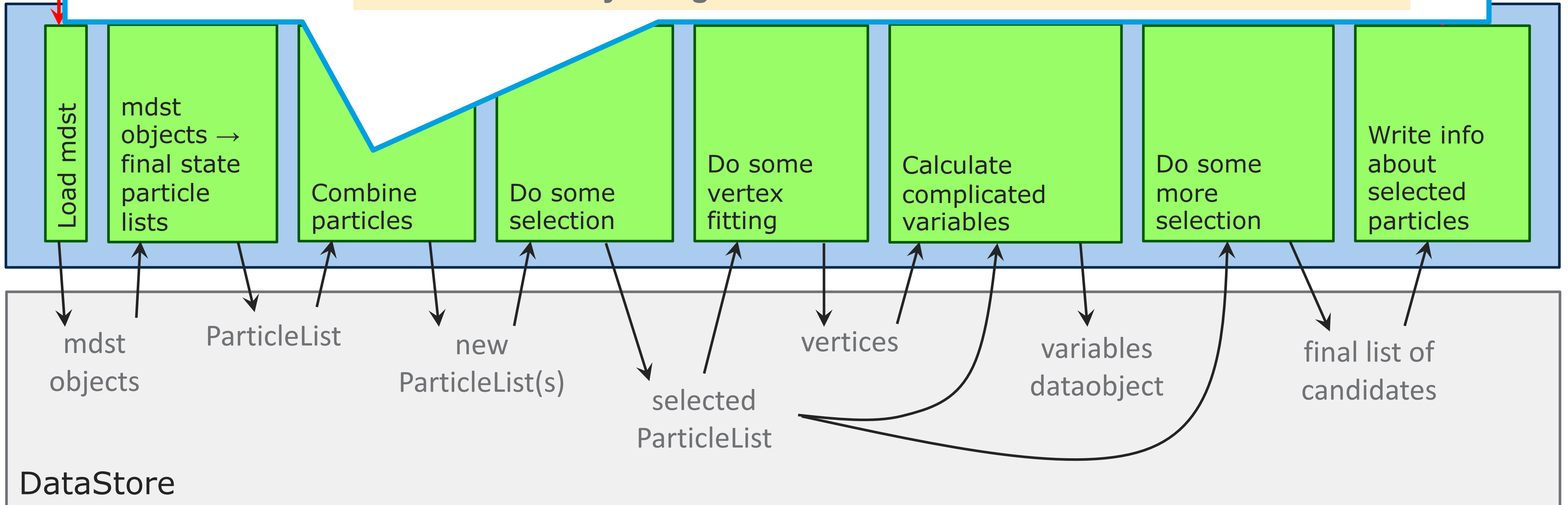
```
from modularAnalysis import reconstructDecay
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```



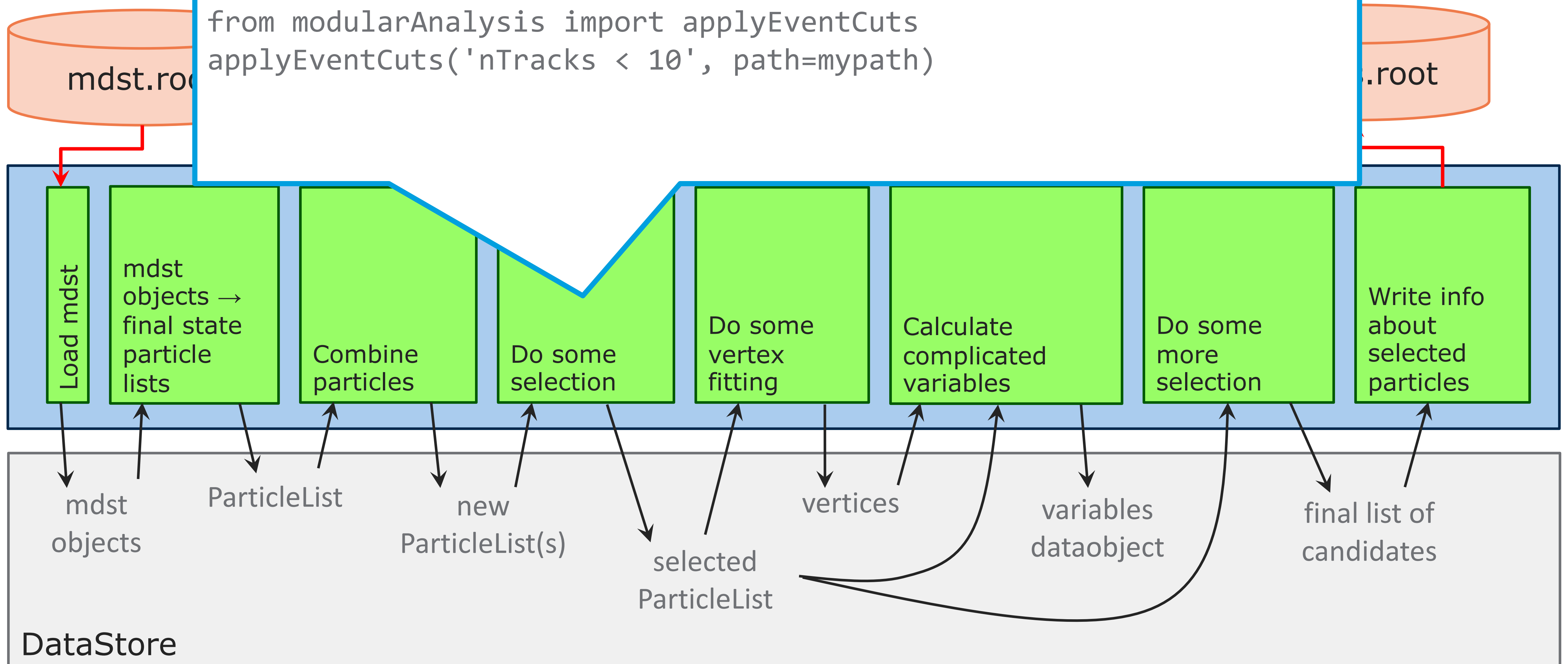
A typical path for an analysis job

```python
from modularAnalysis import reconstructDecay
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

You can probably guess what this means already. But don't worry, we'll discuss the **DecayString** a bit later…



A typical path for an analysis job



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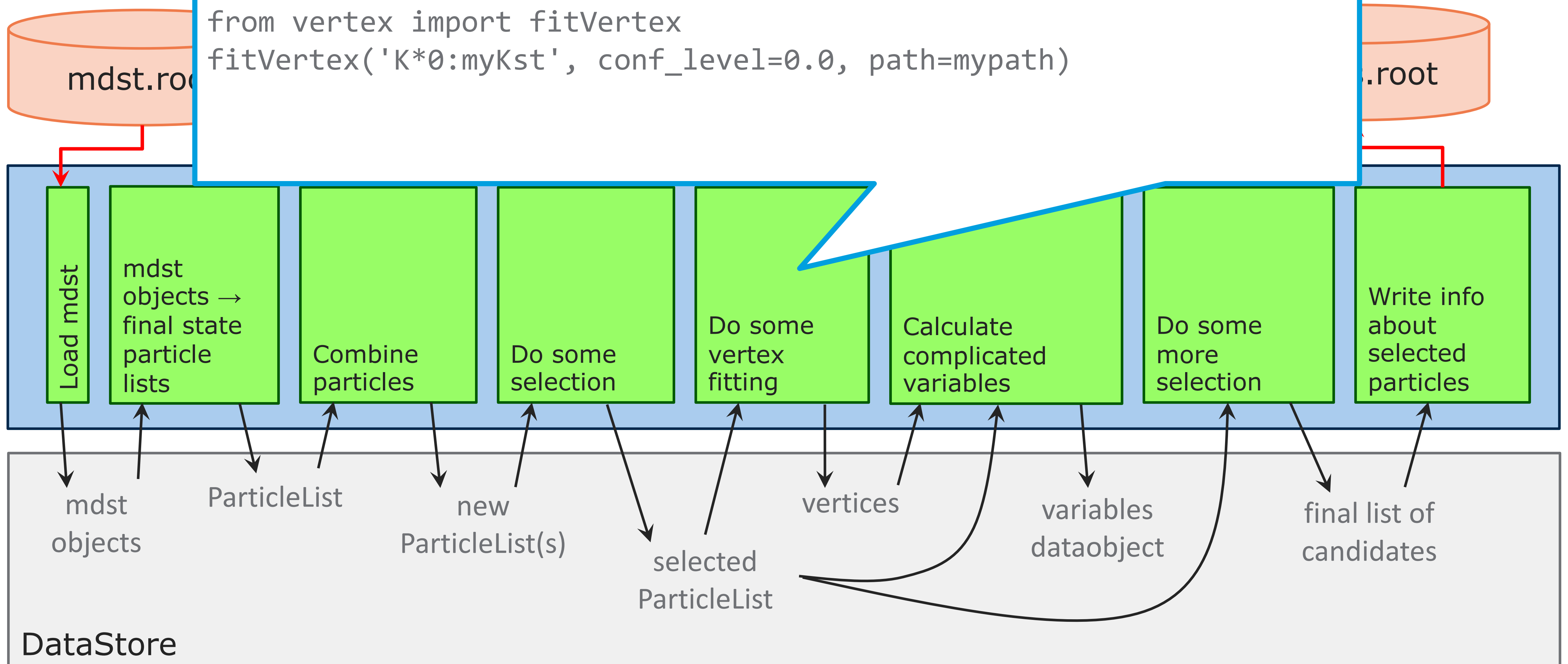

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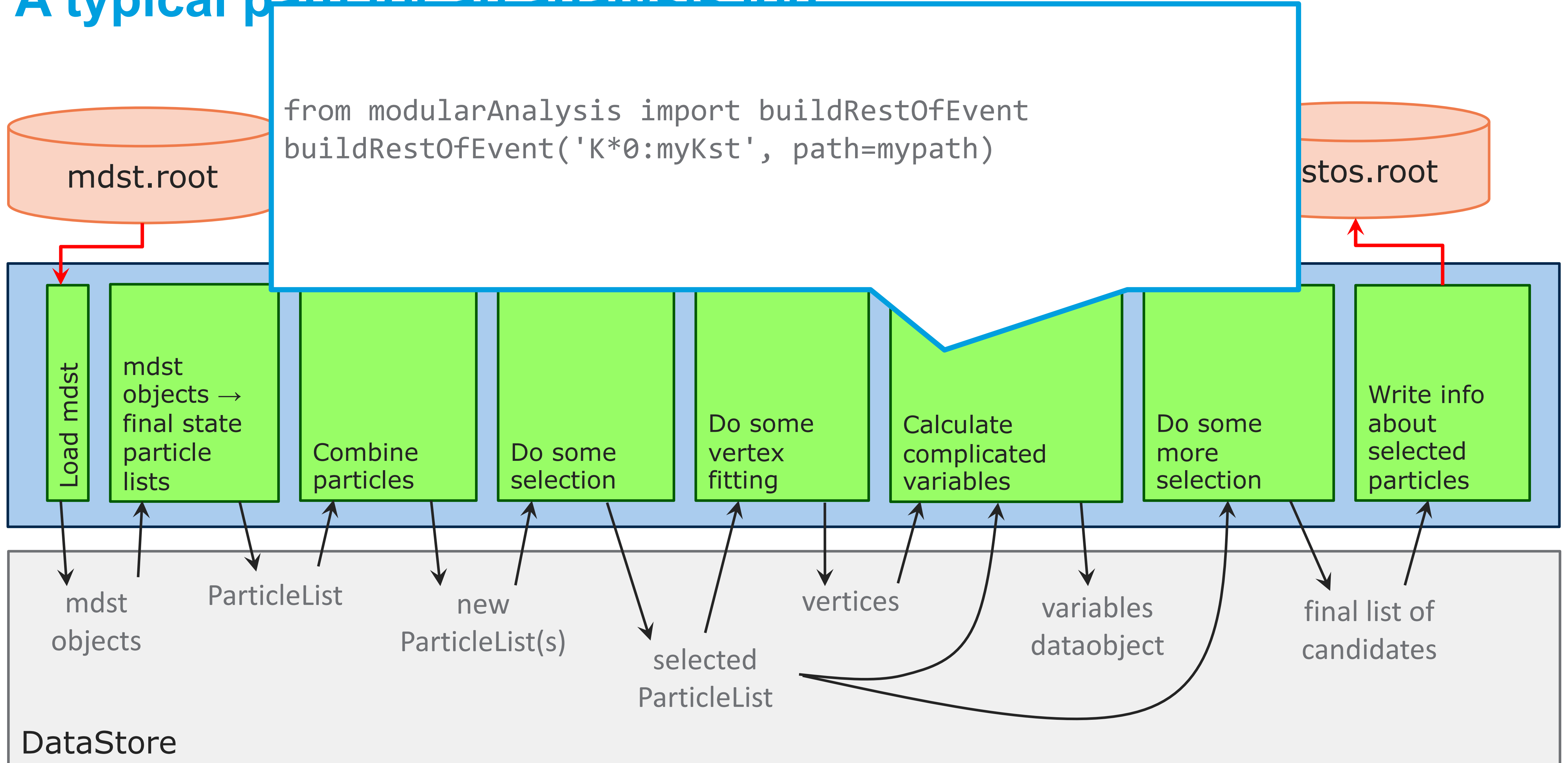

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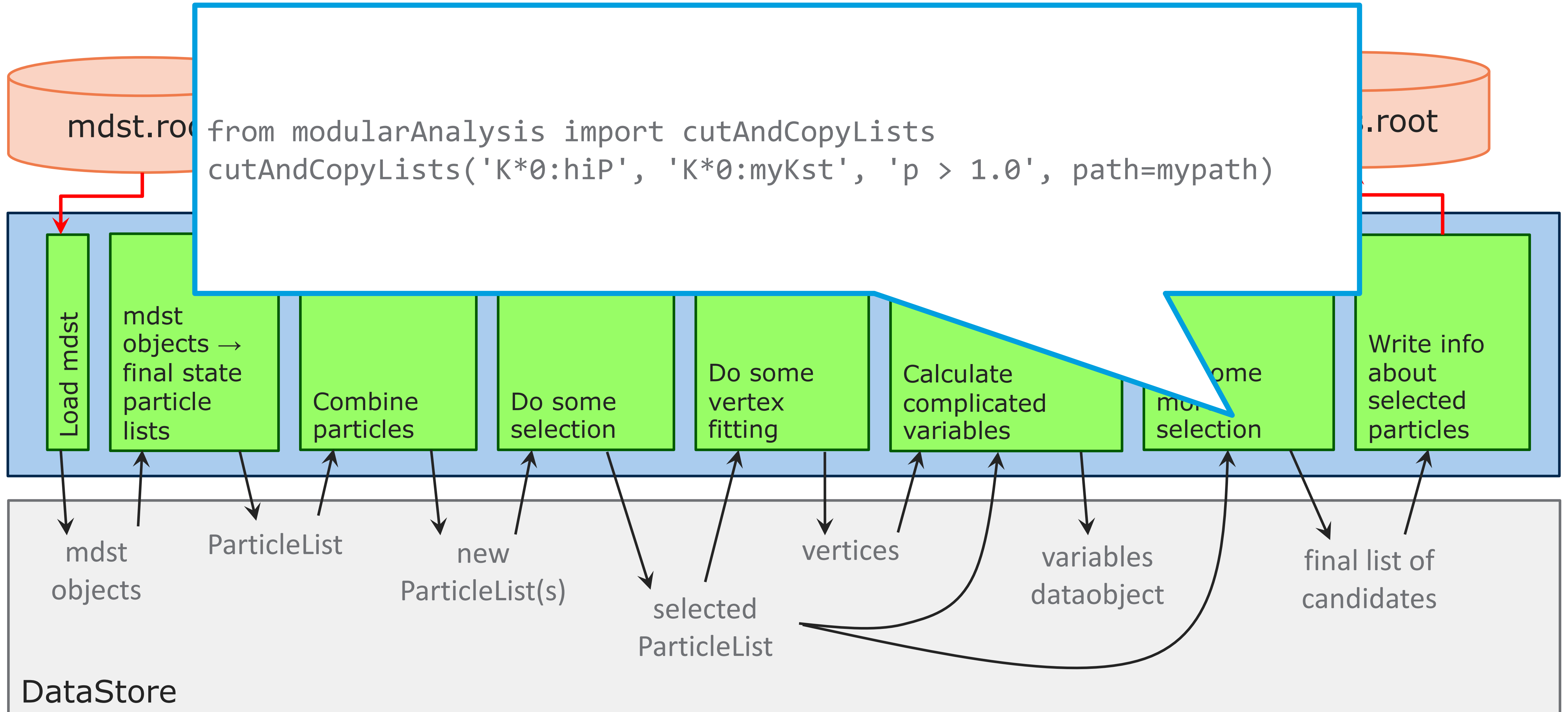
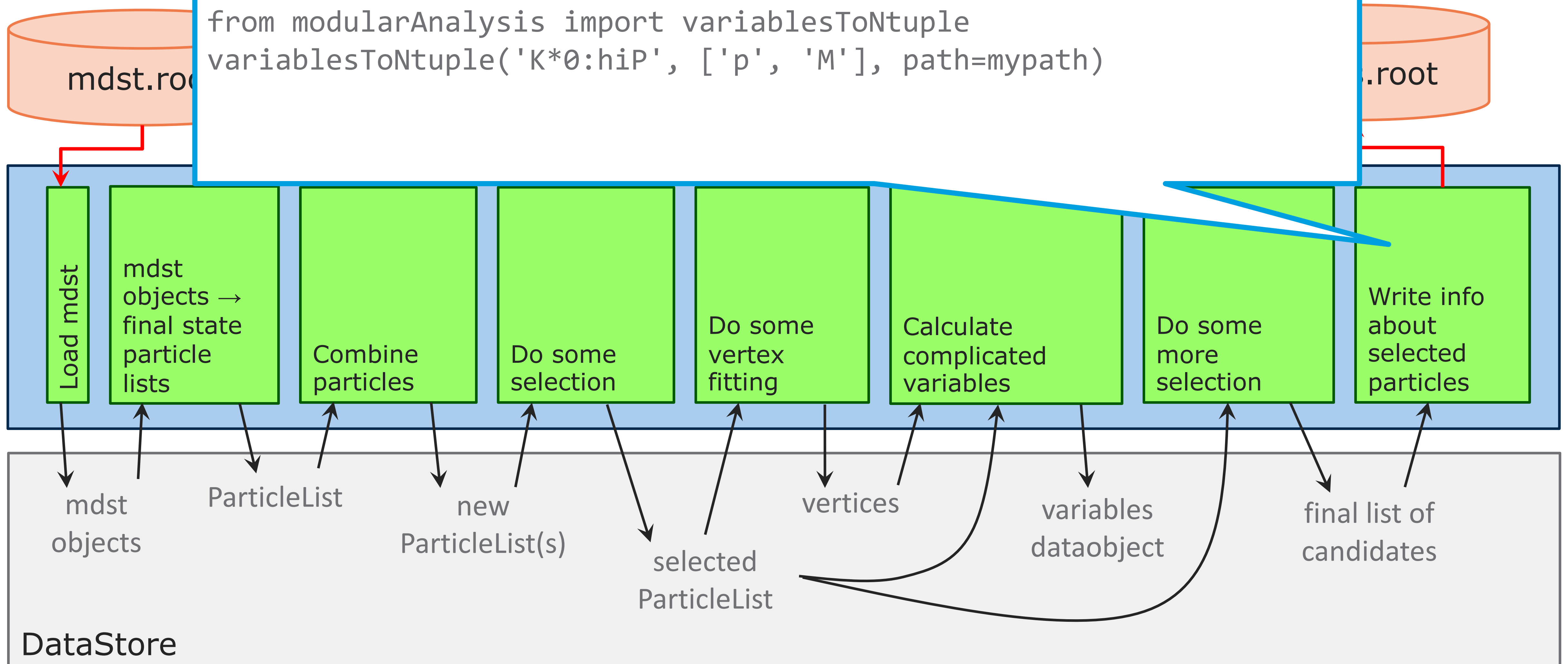


A typical path for an analysis job



A template steering script

```
#!/usr/bin/env python3
# -*- coding: utf-8 -

import basf2
import modularAnalysis as ma

# create a path
mypath = basf2.Path()

# input mdst file
ma.inputMdst('default','inputMdstFile.root', path=mypath)

# PUT YOUR CODE HERE

# process the events
basf2.process(mypath)
# print out the summary
print(basf2.statistics)
```

A template steering script

```
#!/usr/bin/env python3
# -*- coding: utf-8 -

import basf2
import modularAnalysis as ma

# create a path
mypath = basf2.Path()

# input mdst file
ma.inputMdst('default','inputMdstFile.root', path=mypath)

# PUT YOUR CODE HERE

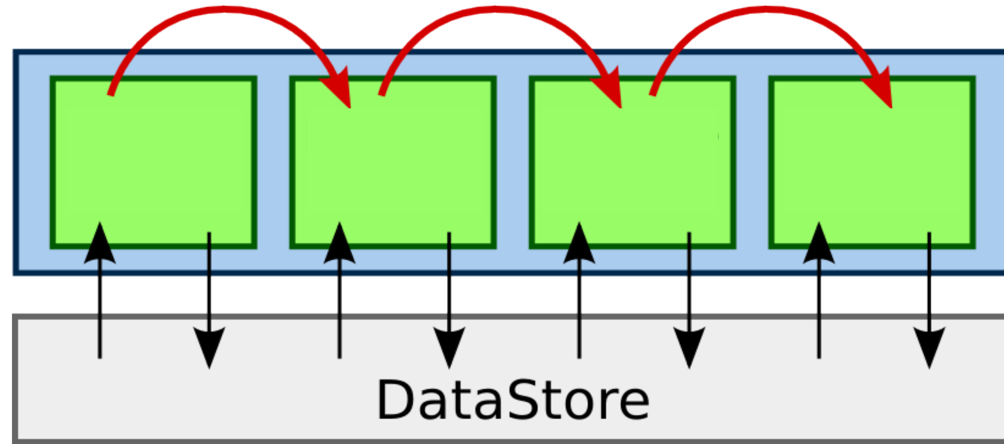
# process the events
basf2.process(mypath)
# print out the summary
print(basf2.statistics)
```

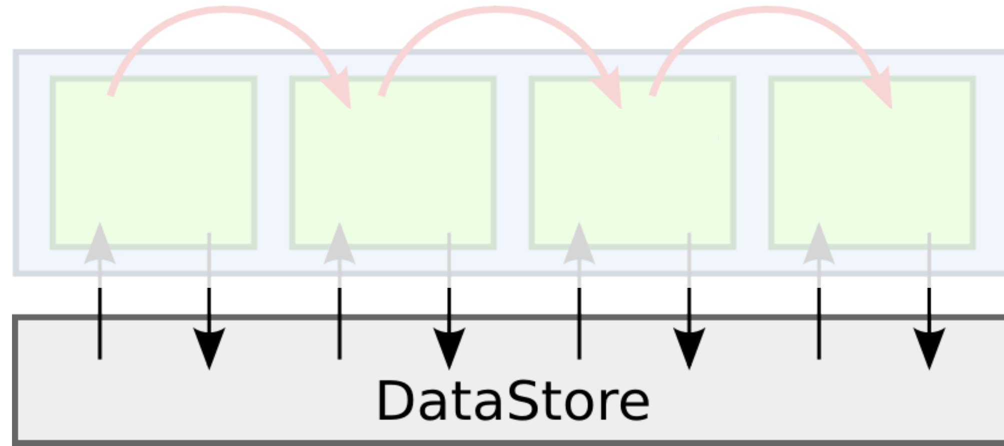
Q: what does 'default' mean?

What is the argument called?
Can you find the documentation?
Is there a questions post?

Candidate/particle based analysis

Before we get started, here's this diagram again





You can take a look at examples in <package>/dataobjects

- The datastore contains the **dataobjects**
- At the level of analysis, the main dataobject is: **ParticleList**

Particle-based paradigms

In the wild

Event based analysis frameworks

Babar, ATLAS, ILC

Particle/candidate based analysis frameworks

LHCb, Belle II

Particle-based analysis

- Take particle lists
- Build up decay parents from daughters
- Make ***candidate***s for your decay of interest
- Filter/cut/keep.

- You might have more than one candidate per event.
  - We deal with this after the fact.
  - This is fine. I promise.
  - https://arxiv.org/abs/1703.01128

The Particle class

It's not crucial to understand the details

- A common representation of all particle types
  - Charged: e / μ / π / K / p / d [built up from track + hypothesis]
  - γ [built up from ECLClusters + !Track]
  - K^0_L, n [built up from KLMlusters + ECLClusters + !Track]
  - K^0_S, Λ^0, γ [built up from V0 (2 tracks)]
  - Composite particles: π^0 / K^0_S / D / B [built up from combinations]
- Data members of the class are **common to all particle types**: mass, momentum, position, PDG code, …
- Information which is only relevant to certain kinds of particle is saved in separate **analysis package dataobjects** and accessible by **relations**.
  - e.g. ContinuumSuppression
  - …. FlavorTaggerInfo

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- Data members of the class are **common to all particle types**: mass, momentum, position, PDG code, …

- Information which is only relevant to certain kinds of particle is saved in separate **analysis package dataobjects** and accessible by **relations**.
  - e.g. ContinuumSuppression
  - …. FlavorTaggerInfo

Q: what is the name of the module to combine particles?

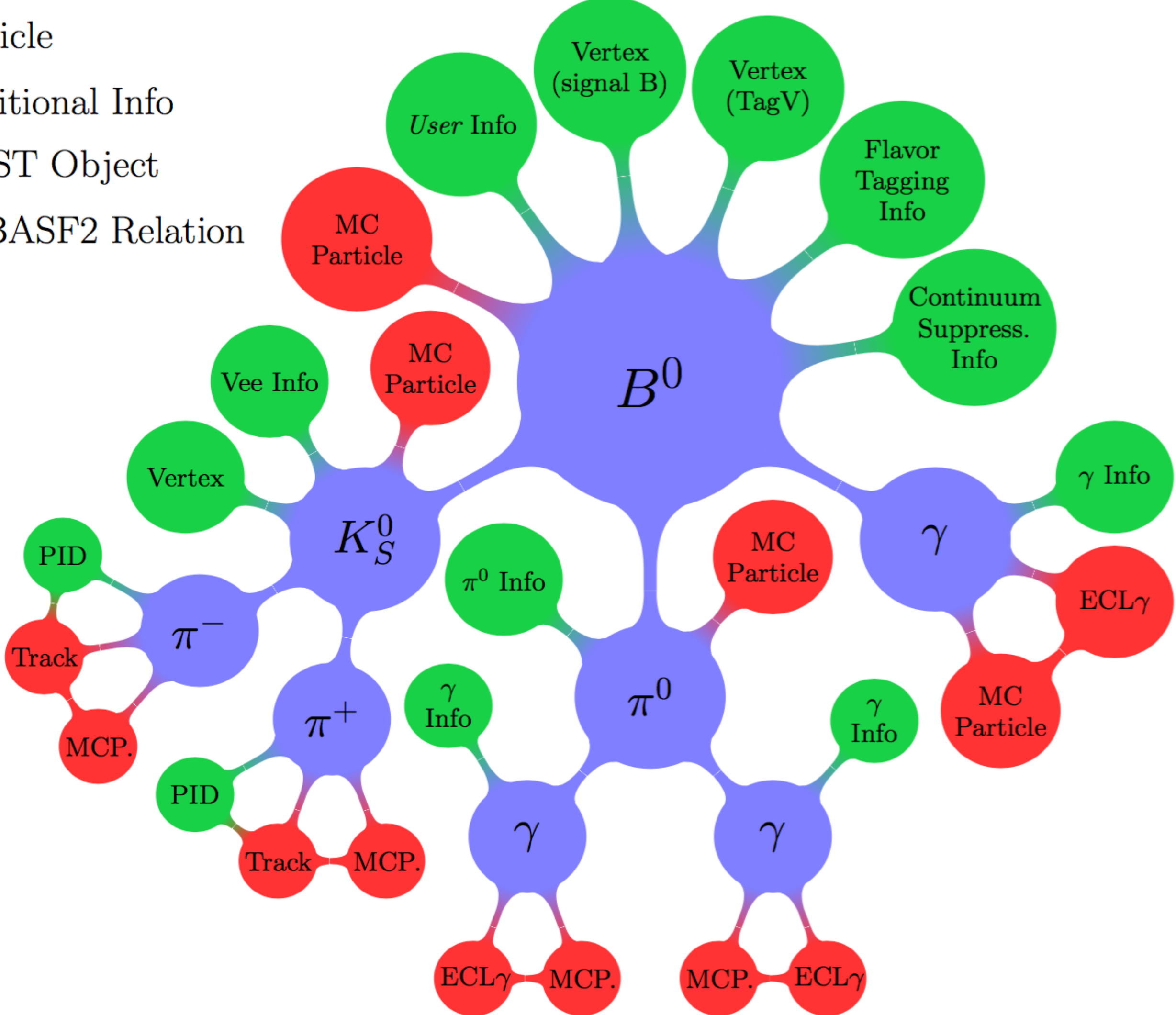
Q: which things on this slide are dataobjects?

ParticleList

- A group of all particles and anti-particles that belong together logically.
  - e.g. K^{*0} s (decaying to $K^{\pm}$ and $\pi^{\mp}$ with invariant mass in a certain window)
- Can only store particles of the same PDG code (can be different decay modes).
- Doesn’t have ownership of the **Particle** objects.
- **ParticleList** is the **dataobject** on which analysis modules operate.

- The physics-performance group provides **Standard Particle Lists** for which quality benchmarks exist, and systematics will be provided.
  - Currently you may need to optimize selection criteria of ParticleLists by yourself.
  - This will be really recommended to use in future.

Some more details on Particles, ParticleLists and Relations



- At each stage we build relations between the dataobjects
  - Like vertex information, ContinuumSuppression → all related to Particles
  - Particles themselves related to primitive mdst objects (clusters, tracks)

Fill a ParticleList

There are two possible ways to fill a list of **stable* particles**

Q: What is a stable particle in this context?

1) fill it by hand

```
import modularAnalysis as ma

ma.fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

Fill a ParticleList

There are two possible ways to fill a list of **stable* particles**

1) fill it by hand

```
import modularAnalysis as ma

ma.fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

Particle name.
Tells basf2 if the list has to be created from tracks, ELCClusters, KLMClusters or V0
Must given in evt.pdl (or b2help-particles)

`evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl`

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Must given in evt.pdl (or b2help-particles)

Label name.
Used to distinguish different lists of the same particle type: you choose the name.
(But maybe call it something helpful)

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(But maybe call it something helpful)

ParticleList name
Same label name can be set to another particle name.
e.g. `pi+:highMom, K+:highMom`

`evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl`

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Must given in evt.pdl (or b2help-particles)

Label name.
Used to distinguish different lists of the same particle type: you choose the name.
(But maybe call it something helpful)

List name
Same label name can be set to another particle name.
e.g. `pi+:highMom, K+:highMom`

Selection criteria
Cuts used to select this list. **More on this later**

`evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl`

Fill a ParticleList

There are two possible ways to fill a list of **stable* particles**

1) fill it by hand

```
import modularAnalysis as ma

ma.fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

Once you call the function, `pi-:highMom` is created automatically.
You **don’t** have to call

```
ma.fillParticleList('pi-:highMom', 'p > 1', path=mypath)
```

```
evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl
```

Fill a ParticleList

There are two possible ways to fill a list of **stable* particles**

1) fill it by hand

```
import modularAnalysis as ma

ma.fillParticleList('pi+:highMom', 'p > 1', path=mypath)
```

2) Use the **standard particles lists** with pre-defined names and cuts

```
from stdPhotons import stdPhotons
from stdCharged import stdK

stdPhotons('all', path=mypath) # --> gamma:all
stdK('95eff', path=mypath)     # --> K+:95eff
```

First argument will be a label name of the particle list.

```
evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl
```

DecayString

The last of the infrastructure things, I promise

- You've already seen the decay string in action.
- Now we can formally describe what this line is doing:

```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

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Decay string

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```

ParticleList ParticleList ParticleList

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```

Arrow
(Indicate K*0 decays to K+ pi-)

Decay string

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```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

mother arrow daughter0 daughter1 ...

Decay string

DecayString

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- Now we can formally describe what this line is doing:

```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

Particle name.
Of your composite particle.
Must given in evt.pdl
(or b2help-particles)

Decay string

```
evt.pdl = $BELLE2_EXTERNALS_DIR/share/evtgen/evt.pdl
```

DecayString

The last of the infrastructure things, I promise

- You've already seen the decay string in action.
- Now we can formally describe what this line is doing:

```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

You can choose this.

List name that exist already

Decay string

- reconstructDecay() : Reconstruct mother particle from daughters with a given DecayString. List names for daughters must exist already. You can choose a list name of a mother.

You don't have to call

```
reconstructDecay('anti-K*0:myKst -> K-:95eff pi+:95eff', '0.6 < M < 1.0', path=mypath)
```

DecayString

One final thing...

- Sometimes you will need to select a particle within a decay string.
- This is done by "carat":   ^

```
'K*0:myKst -> ^K+:highMom ^pi-:highMom'
```

- You will see this in action in the exercises later.

Physics quantities and the VariableManager

The VariableManager

It manages variables

- VariableManager is a place in the analysis package to store variables
  - physics quantities: invariant mass, beam-constrained mass, E, p, p_T, θ, ϕ, highest energy in a cluster
  - counters: event_number, nhits, i_candidate

- Every variable takes at least a `Particle*` as input and returns a `double` (even integer counters like event_number where this doesn't make much sense)

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  - counters: event_number, nhits, i_candidate

- Every variable takes at least a `Particle*` as input and returns a `double` (even integer counters like event_number where this doesn't make much sense)

- You’ve already seen it in **python**, when we used a cut on “M”.
  - This comes from the VariableManager.

```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

Where can I get the documentation?

- At the command line:

```
$ basf2 variables.py
```

- Online, the documentation is software.belle2.org.

Take a look at B2T_Basics_1_GettingHelp.ipynb on jupyterhub

Q: What is the beam-constrained mas, M_{bc} called in the VariableManager?

Have you been listening?

Q: Can you figure out the cut string and code to reconstruct B0 -> K*0 gamma?
Supposing you have already reconstructed K*0:myKst.

```
import modularAnalysis as ma

ma.fillParticleList('pi+:highMom', 'p > 1', path=mypath)
ma.fillParticleList('K+:highMom’,  'p < 1', path=mypath)
ma.reconstructDecay('K*0:myKst -> K+:lowMom pi-:highMom', '0.6 < M < 1.0', path=mypath)
```

Q: How can we fill a particle list of gamma?

Q: How can we reconstruct B0 from K*0 and gamma?

Q: Can you apply following selection on the B0 candidates?

$$M_{bc} > 5.2\,\mathrm{GeV}/c^2$$

Aliases

Are awesome and you should use them

- With more advanced variables, we deliberately give them verbose names in the VariableManager.
- It's important to be clear.

- Some examples:
  - cosAngleBetweenMomentumAndVertexVector
  - totalPhotonEnergyOfEvent
  - trackFindingFailureFlag

- You can also use formula(), abs(), cos() for simple math:
  - formula(missingEnergyOfEventCMS/Ecms)
  - …

Aliases

Are awesome and you should use them

- For your code, you can make short aliases.
- This makes your offline data more manageable, and can help with code readability.

```
from variables import variables as vm
vm.addAlias('cosPVtx',
            'cosAngleBetweenMomentumAndVertexVector')
```

There is no path here like `path=mypath`.
The VariableManager exists alongside the path

How to get data out

Flat ntuples and histograms

Getting output data

There are some modules to store variables.

VariablesTo*

a) VariablesToNtuple
b) VariablesToHistogram
c) VariablesToEventBasedTree

Flat ntuples and histograms

Getting output data

There are some modules to store variables.

VariablesTo*

a) VariablesToNtuple
b) VariablesToHistogram
c) VariablesToEventBasedTree

```
from modularAnalysis import variablesToNTuple

from modularAnalysis import variablesToHistogram
```

VariablesToNtuple

- You want to store physics quantities for one ParticleList from the VariableManager.
- Get an ttree (ntuple) of candidates (one row per candidate).

VariablesToHistogram

- Perhaps you just want a quick histogram.
- Candidate information not preserved.

VariablesToNtuple

```
# ... at the end of your script
from modularAnalysis import variablesToNTuple
variablesToNTuple('K*0:myKst', ['M', 'p', 'daughter(0,p)', 'daughter(1,p)'], path=mypath)

# process the events
basf2.process(mypath)
```

Daughter’s variables can be stored with `daughter(i, variable)`.
`i` is the daughter index, i.e. `0 = K+, 1 = pi-`.

VariablesToHistogram

```
# ... at the end of your script
from modularAnalysis import variablesToHistogram
variablesToHistogram('K*0:myKst',
                     [('M', 100, 0.7, 1.0),
                      ('p', 100, 0.1, 3.0)], path=mypath)

# process the events
basf2.process(mypath)
```

VariablesToNtuple

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```

Q: Can you guess what these numbers do?
What is the (python) structure created by the parentheses?

Utilities

Helper functions to make daughter’s aliases.

- You can store variables of daughters with `daughter(i, variable)` in a same ntuple.
- You may also want to short aliases for these variables.

```
reconstructDecay('K*0:myKst -> K+:highMom pi-:highMom', '0.6 < M < 1.0', path=mypath)

from variables import variables as vm
vm.addAlias('K_M', 'daughter(0,M)')
vm.addAlias('K_p', 'daughter(0,p)')
vm.addAlias('pi_M', 'daughter(1,M)')
vm.addAlias('pi_p', 'daughter(1,p)') # You may want to add more aliases

vars = ['M', 'p', 'K_M', 'K_p', 'pi_M', 'pi_p']
variablesToNTuple('K*0:myKst', vars, path=mypath)
```

Utilities

Helper functions to make daughter's aliases.

- A helper function creates aliases from a list of variables and a DecayString with carat '^'.

```
import variables.utils as vu
vars = vu.create_aliases_for_selected(['M', 'p', 'px', 'py', 'pz'],
                                      'K*0 -> ^K+ ^pi-')
# The function makes aliases for selected particles, for example,
# 'K_M' --> 'daughter(0,M)'
```

- All aliases can be checked with `printAliases()`.

```
from variables import variables as vm
vm.printAliases()
# [INFO] ========================
# [INFO] Following aliases exists:
# [INFO] 'K_M' --> 'daughter(0,M)'
# ...
```

Nomenclature

Nomenclature

https://confluence.desy.de/display/BI/Main+Glossary

- **Experiment** (chunk of data-taking ~months).
- **Run** (chunk of data-taking w/ stable beams ~hours),
- Event.

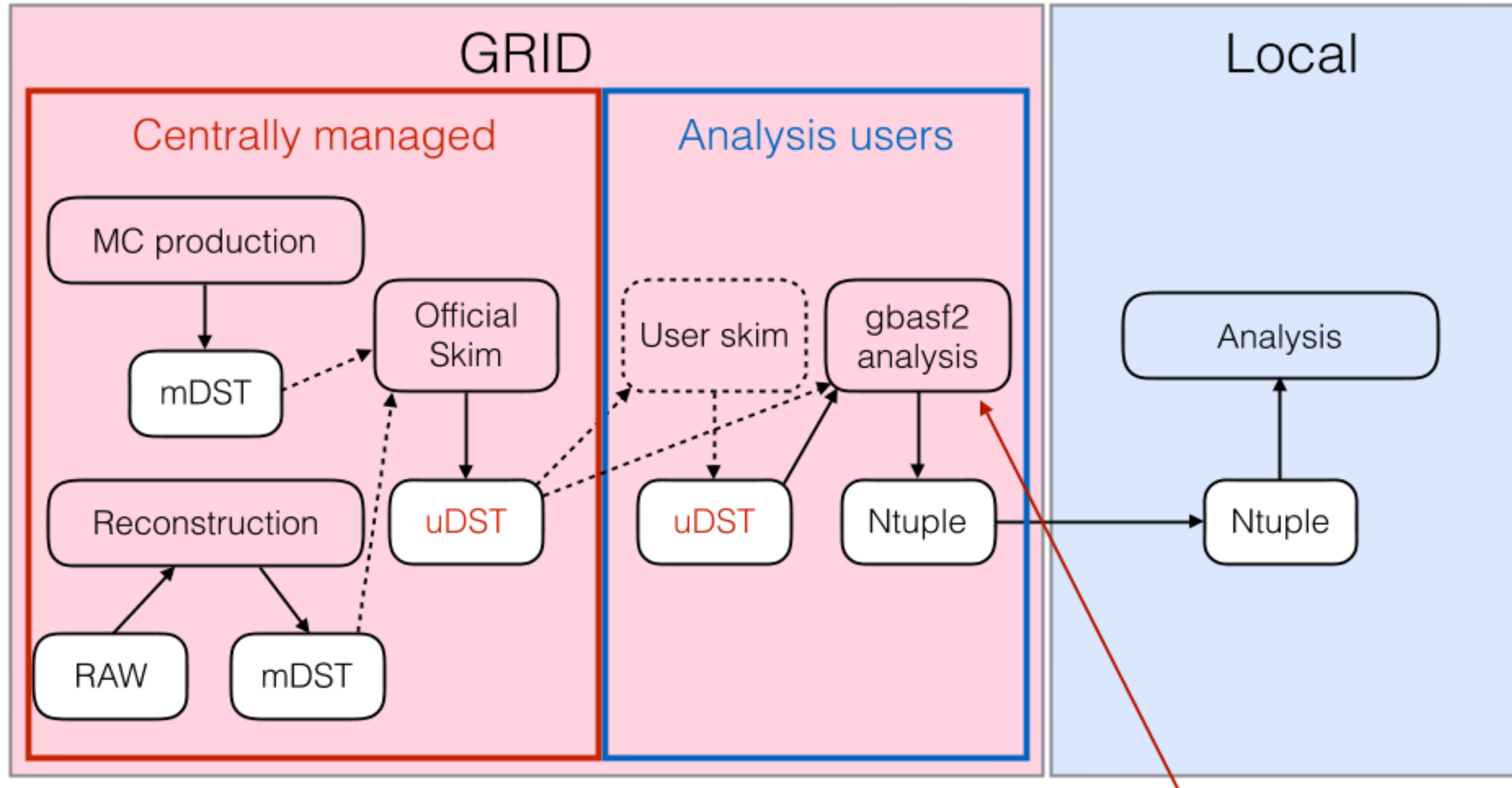
- **TRG** the hardware trigger (group, device, DAQ)
- **L1** the hardware trigger (used interchangeably)

- SoftwareTrigger / **HLT** (the softeare trigger)

- **basf2** “Belle 2 analysis software framework” “the software”
- **gbasf2** “The grid job submission tool” “computing”

One final thing about Belle vs. Belle II

The Belle II analysis model



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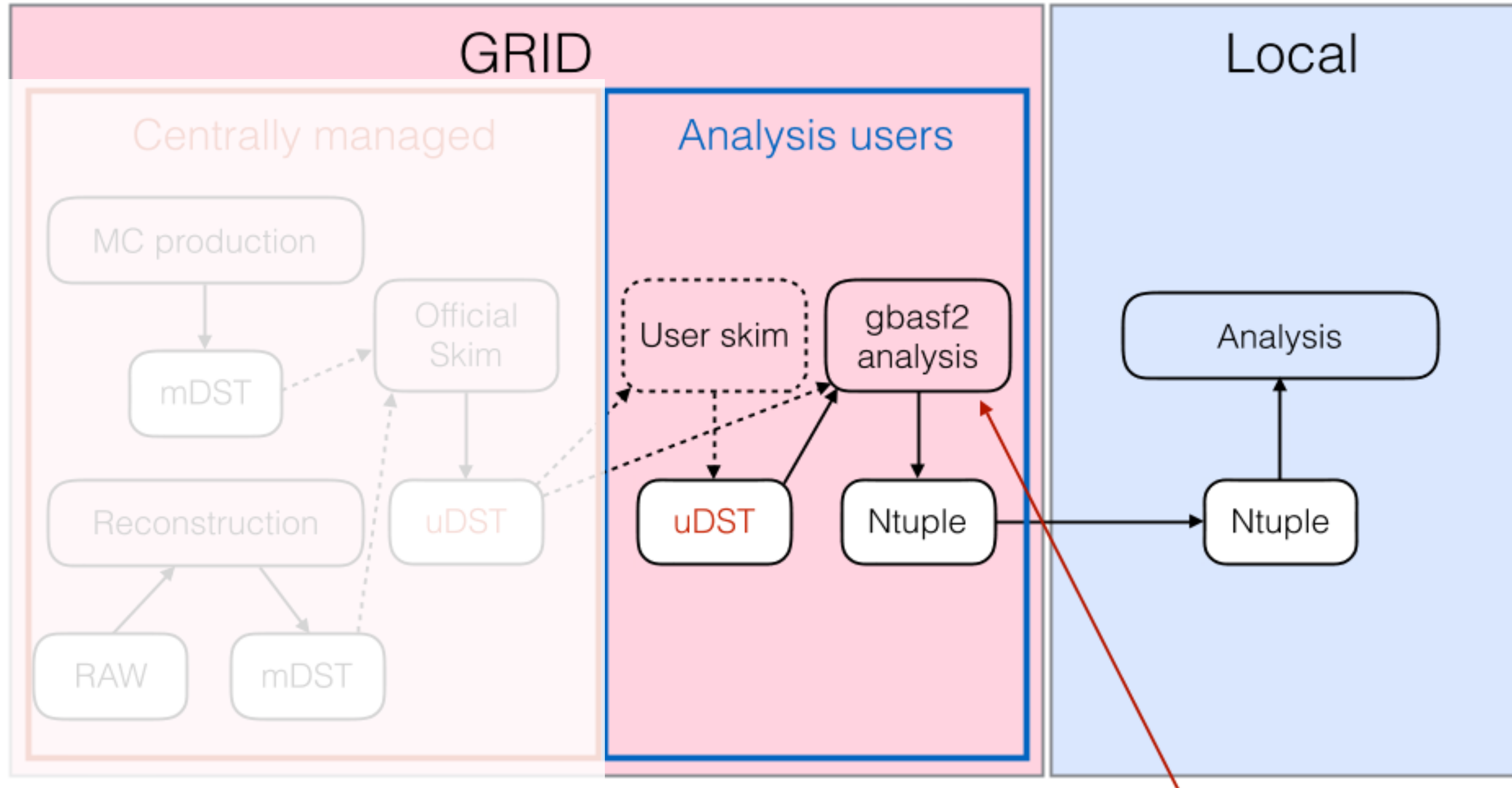
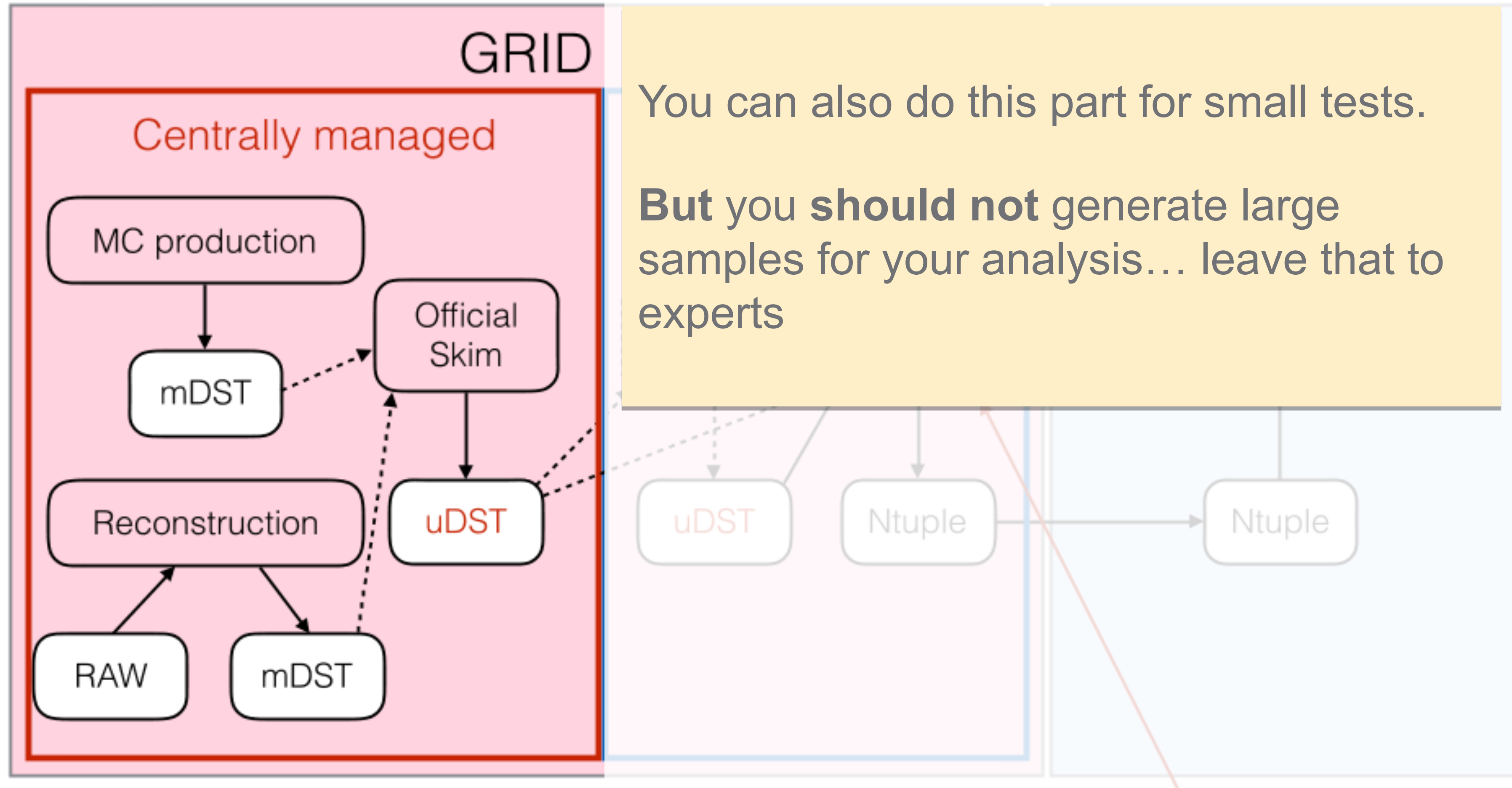


The Belle II analysis model



You can also do this part for small tests.

But you **should not** generate large samples for your analysis… leave that to experts

Acknowledgements

- Much of the material for these slides (and ideas for how to present it) has been stolen from:
-

Jake Bennett and **Anže Zupanc**

Versions of this tutorial material

- Version 1: Sam (February 2018).
- Version 2: Ilya and Sam (June 2018).
- Version 3: Sam (November 2018).
- Version 4: Umberto (February 2019)
- Version 5: Hannah and Sam (June 2019)
- Version 6: Yo and Ilya (January 2020)