Python and ATLAS offline

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Python use by ATLAS offline

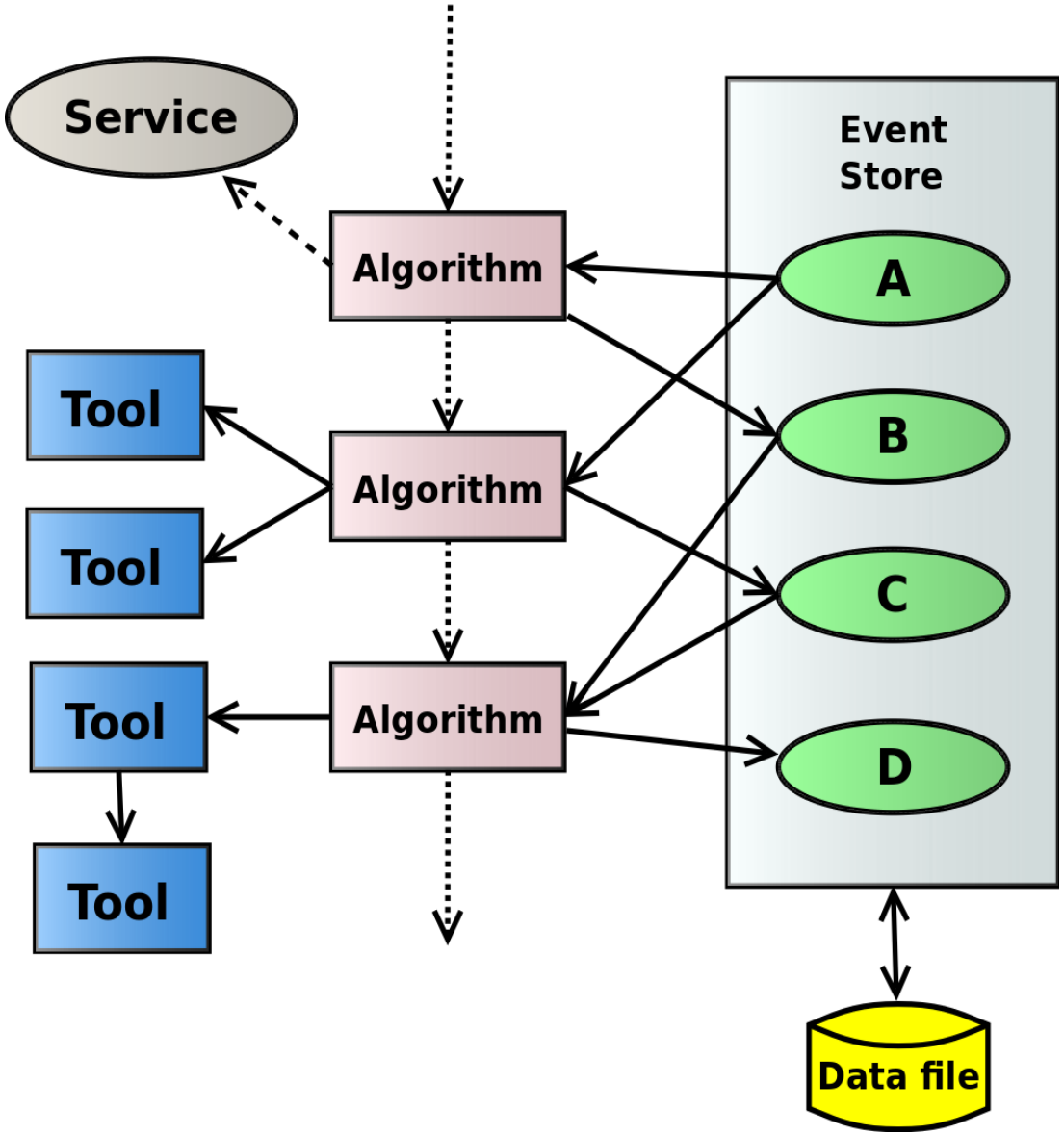
(Excluding here online and analysis use cases.)

- ATLAS offline (Athena) uses Python extensively.
- ATLAS repository contains $\sim$ 1M lines of python code ($\sim$ 20% of the total).
- Major uses:
  - Job configuration.
  - Direct use of reconstruction objects from Python.
  - Building/testing/general scripting.
- Python 2.7 used throughout.
  - No clear plans for Python 3 (but see later).
- Interaction with C++ code almost entirely through PyROOT.

Athena and Gaudi

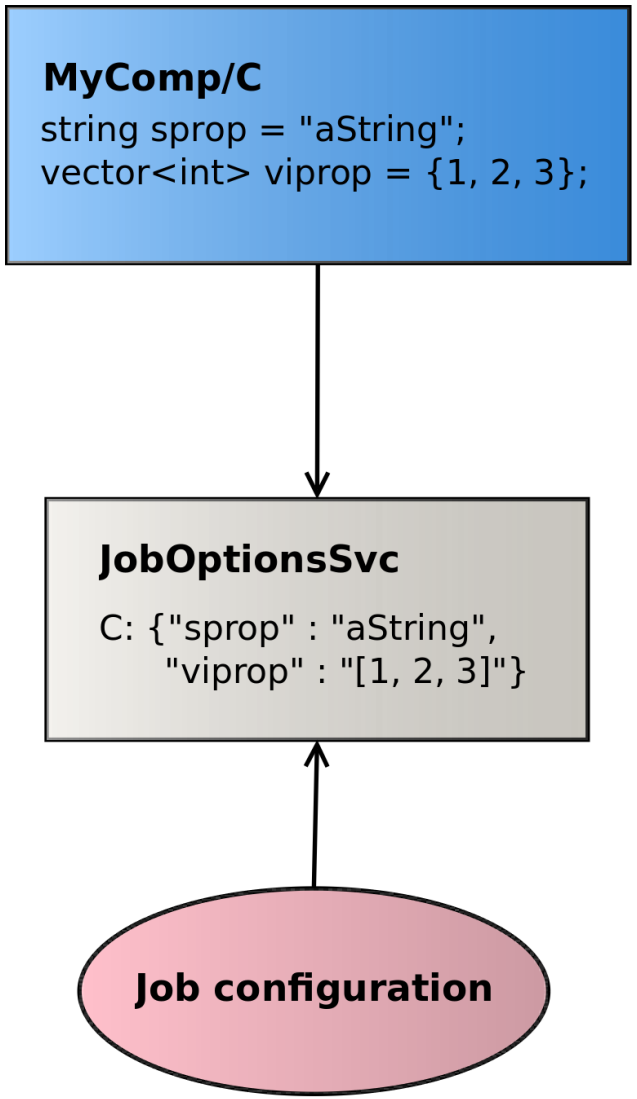
Athena uses Gaudi, shared with LHCb and other experiments.

- Dynamically loadable *components*.
  - Including algorithms, tools, services.
- Ideally used via abstract interfaces.
- Algorithms and tools can own other tools.
- Services are singletons.
- Identified with a type (C++ type) and name (instance).
- Each component has a list of *properties*.



Component properties

- Each component has a list of named properties.
  - Of various C++ types.
  - Corresponding to data members in the component C++ class.
- Also can have properties representing references to other components: ToolHandle and ServiceHandle.
- When a component initializes, it queries JobOptionsSvc for its properties.
- JobOptionsSvc holds property settings for each component, as strings.
- JobOptionsSvc populated by job configuration.



Python component configuration interface: Configurable

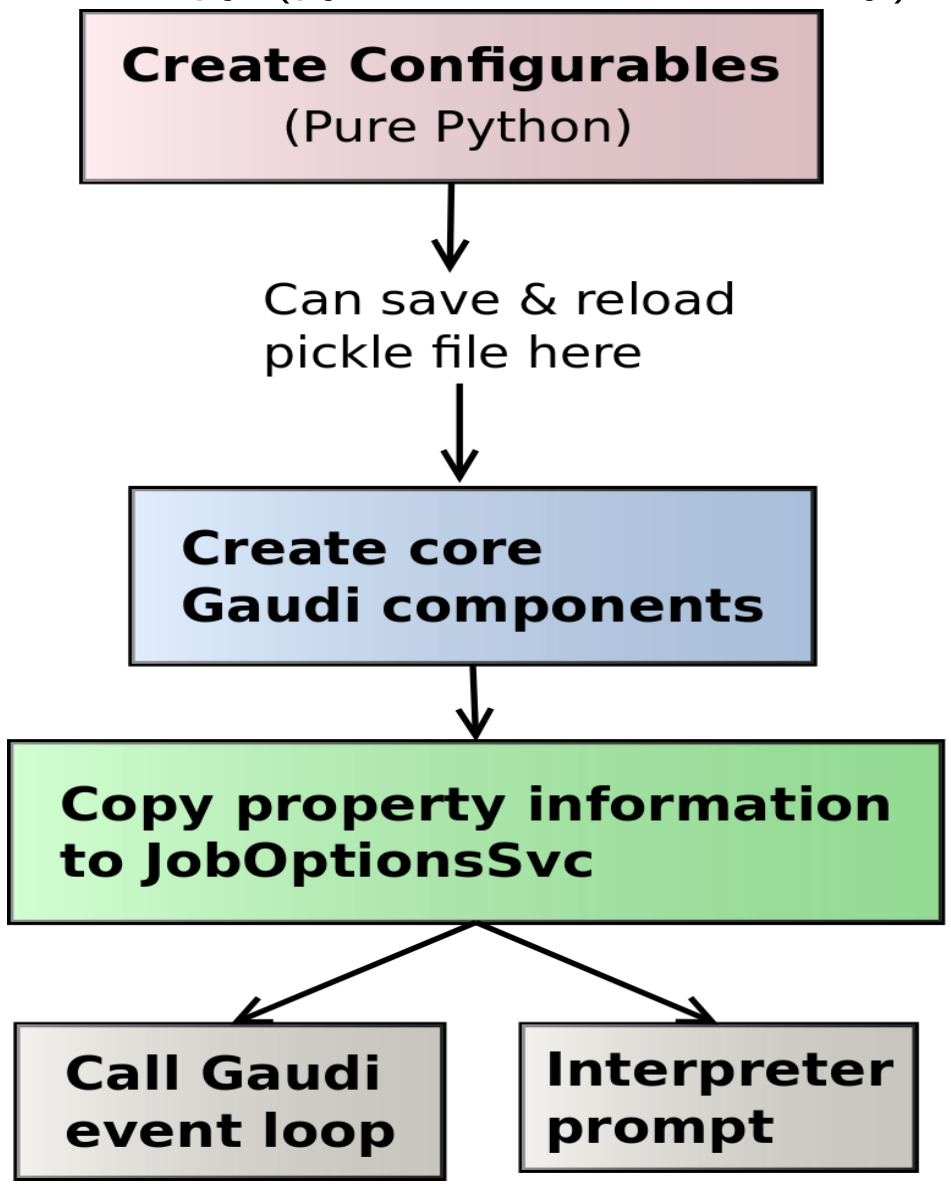
Each component has a Python "Configurable" class to collect information during job configuration:

```
from MyComponents.MyComponentsConf import MyComponent
# Create an instance of MyComponent named mycomp and
# set some properties.
mycomp = MyComponent ('mycomp',
                      sprop = "some string",
                      viprop = [3, 2, 1])
# Can change/set properties later.
mycomp.iprop = 10
mycomp.sprop = "some other string"
```

Configurables

- Configurables are pure Python classes.
  - Can be pickled, etc.
- Generated automatically during build from the shared libraries containing the components.
- Singleton behavior: `MyComponent("foo")` always gives the *same* object.
- Hold property settings, and can later transport them to JobOptionsSvc.

athena.py (python is Athena binary):



Component references

Configurables can reference other Configurables to build up a complete job configuration.

```
from MyComponents.MyComponentsConf import *

# Create a Service; register with ServiceMgr.
myserv = MyService ('myserv', parm=1)
svcMgr += myserv

# An algorithm using this service plus a tool.
myalg = MyAlgorithm ('myalg',
                     service = myserv,
                     tool = MyTool ('mytool',
                                    arg='something'))

# Schedule this algorithm to run in sequence.
topSequence += myalg
```

Other configuration helpers

- `include`: Textual inclusion of another Python fragment.

```
include('Calorimeter/CaloRec.py')
```

- Job configuration flags:

```
from CaloRec.CaloRecFlags import jobproperties as jp
jp.CaloRecFlags.doTileCorrection = True
if jp.CaloRecFlags.doTileMuID():
    ...
```

- Some properties set automatically from input file metadata:

```
tool = MyTool ('mytool',
               energy = jobproperties.Beam.energy)
```

Done? Maybe not.

- Doesn't scale — becomes unmanageable with thousands of components.
- Everything in the global namespace — easy to have collisions.
- Different pieces of the configuration can try to configure the same component in different ways.
- Many components have prerequisites that must be configured first.
  - Difficult even for experts to get it right.
- Several attempts made in the past to add more structure.
  - Put configuration into imported Python modules.
  - Various registries for looking up configuration information.
- Helped somewhat — but now different parts of the job are configured in different ways.

Run 3 job configuration

- Working on overhauling how job configuration works for run 3.
- Subject of a separate poster; only brief summary here.
- No global namespace; make dependencies explicit.
- Everything in imported modules; no include.
- Configuration of component also configures all its dependencies.
  - Configurations are self-contained.
- Modules can be run stand-alone and concatenated:
  - Need to remove duplicates if the some component is configured multiple times.
- Will probably be used for major parts of the Run 3 configuration.
  - May not have sufficient effort available to convert everything before Run 3, given other migrations also in progress.
- Trying to keep new code compatible with both Python 2 and 3.

Run 3 job configuration: simple example

```
def MyAlgoCfg(inputFlags):
    result=ComponentAccumulator()
    isMC=inputFlags.get("AthenaConfiguration.GlobalFlags.isMC"

    # Set up geometry.
    from Geometry.GeomConfig import GeomCfg
    result.addConfig (GeomCfg, inputFlags)

    form MyAlgoPackage.MyAlgoPackageConf import MyAlgo
    myAlgo = MyAlgo(isData = not isMC)
    result.addEventAlgo(myAlgo)
    return result
```

Access to event data and Athena components from Python

- Nearly all the Atlas event data classes are fully functional from Python.
- Can inspect event data interactively from the Python prompt.
- Many tools/services are callable from Python as well.
- Can write an algorithm entirely in Python:

```
import AthenaPoolCnvSvc.ReadAthenaPool
ServiceMgr.EventSelector.InputCollections = [ 'data.root' ]
from AthenaPython.PyAthenaComps import Alg, StatusCode
class MyAlg (Alg):
    def execute (self):
        for el in self.evtStore['Electrons']:
            print el.pt(), el.eta(), el.phi()
        return StatusCode.Success

from AthenaCommon.AppMgr import topSequence
topSequence += MyAlg ('myalg')
```

Python components in Athena

- Ability to access Athena components and event data has been very useful for testing and debugging.
- Numerous unit/regression tests are written in Python.
- Code to dump ATLAS events is written in Python.
- Used to have a few pure-Python algorithms in the standard reconstruction.
  - Eventually removed, not due to speed, but rather due to the memory required by the ROOT dictionaries.
- Some other workflows still use Python-based components (e.g., event display).
- Users also have Python analysis code that that processes ATLAS event data.

Building and scripting

- Python is the preferred ATLAS scripting language for tasks beyond what's appropriate for shell scripts.
  - Setting up Athena environment.
  - Managing the running of reconstruction jobs with complicated configurations.
  - Atlas-specific helpers for git.
  - Interacting with the conditions database.
  - Test drivers; test result validation.
  - Debugging; diagnostics; dumping.
  - Code generation.
  - Analysis of code performance and data quality.
- Much middleware / data handling code also heavily relies on Python.

Summary

- Python is heavily used in ATLAS offline code.
  - Second only to C++.
- Major use is for job configuration.
  - Currently being reworked to be more modular and maintainable.
- Access to Athena components and event data from Python is invaluable for debugging and testing.
- Python is also heavily used in building and testing Athena, and in many other roles.
- Currently no firm plans for moving to Python 3.
  - Would like to do it, but not a priority for Run 3.
  - Modernizing the way job configuration works should help prepare for this.
  - Being able to run both py2 and py3 with the same ROOT build would also be a help!