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Status of the Calibration and Alignment Framework at the Belle II Experiment

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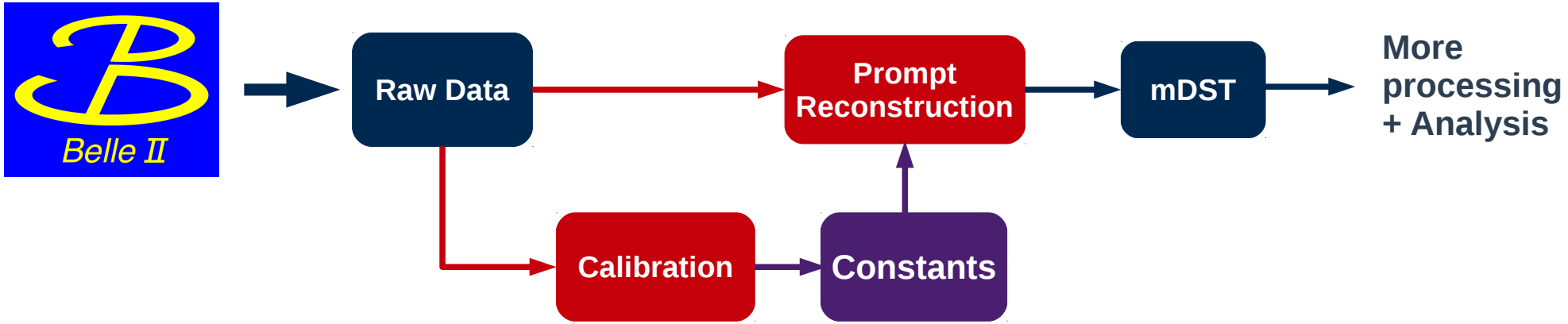
Belle II Experiment

- SuperKEKB e^+-e^- collider at KEK Tsukuba, Japan
- Will provide 40x the luminosity of KEKB
- Running mainly at upsilon 4S resonance to produce ~10^{10} B-$\overline{B}$ pairs/year
- Start of full detector collisions planned for 2018

Calibration at Belle II

- **What we need to do (the basics):**
  - Support experts with tools to create algorithms and database payloads
  - Create an automated system to produce/upload/monitor constants for prompt reconstruction



C++ Framework

- **C++ classes built upon the Belle II analysis software framework (basf2)**
- **Collector Module:**
  - Produces ntuples/histograms/etc from Belle II event data
  - Data separated into runs
  - Used as input to algorithm step
- **Algorithm Class:**
  - Reads collected data for a range of Intervals of Validity (IoV) defined by user
  - Produces constants and saves to local database payloads
  - Can request iteration of collector step

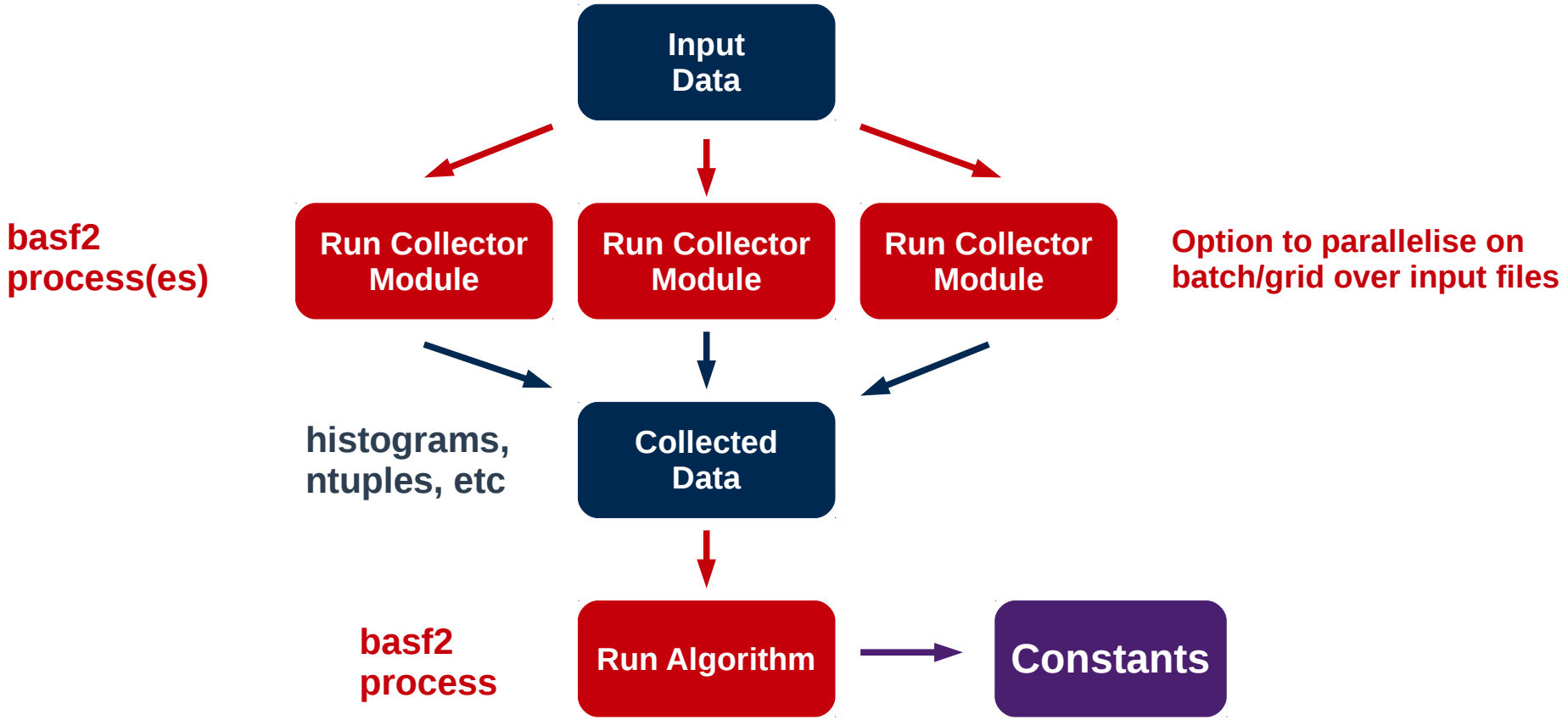
C++ Framework

- **Algorithm developers only need to create two classes:**

Collector Module: Developer overrides prepare() and collect() functions

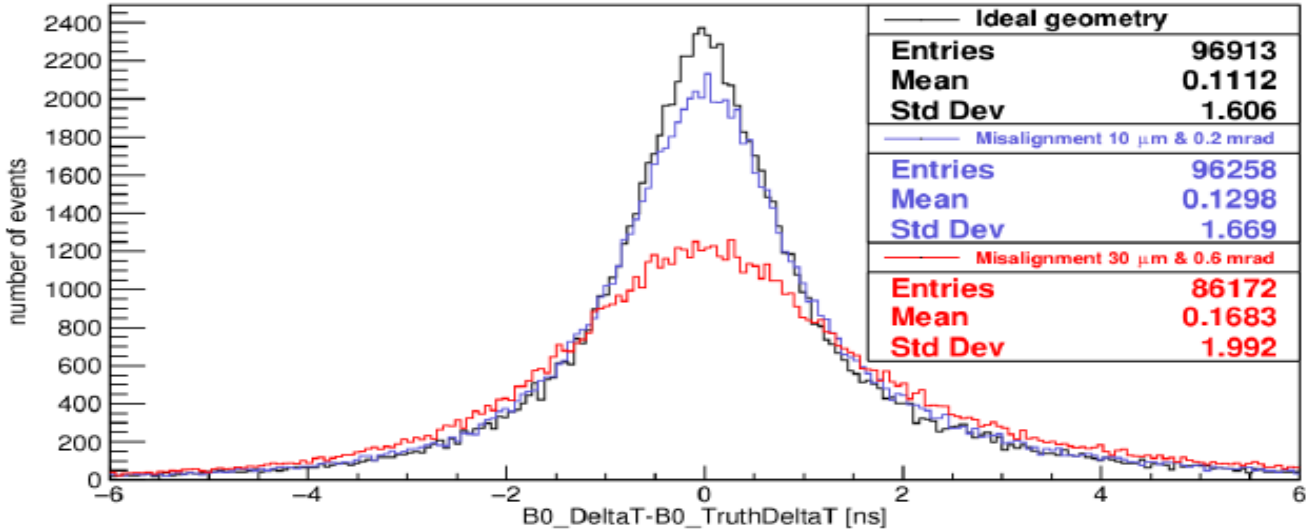
Algorithm Class: Developer overrides calibrate() function

Running Order



Example: VXD Alignment Effect on Physics

- Sub 5μm and 0.06mrad systematics already achieved
- No significant effect on measurements sensitive to alignment



Ideal Geometry

10μm misalignment
0.2mrad twist

30μm misalignment
0.6 mrad twist

Python Framework

- **Created a user friendly interface that developers can call from their normal steering files.**
- **Some Features:**
  - Setup as many calibrations (collector + algorithms) as you want, with input data files
  - Define dependencies of calibrations on one another → pass constants to each subsequent step
  - Can submit collector step to local multiprocessing or batch systems to parallelise
  - If an algorithm doesn't have enough data in a run it will merge with the next and re-run.
  - Automatic iteration if requested +passing constants to new iteration
- **Should allow the future automation framework and developers to run nearly the same code**

Example code 1

- **Simplest use case: One calibration, run locally**

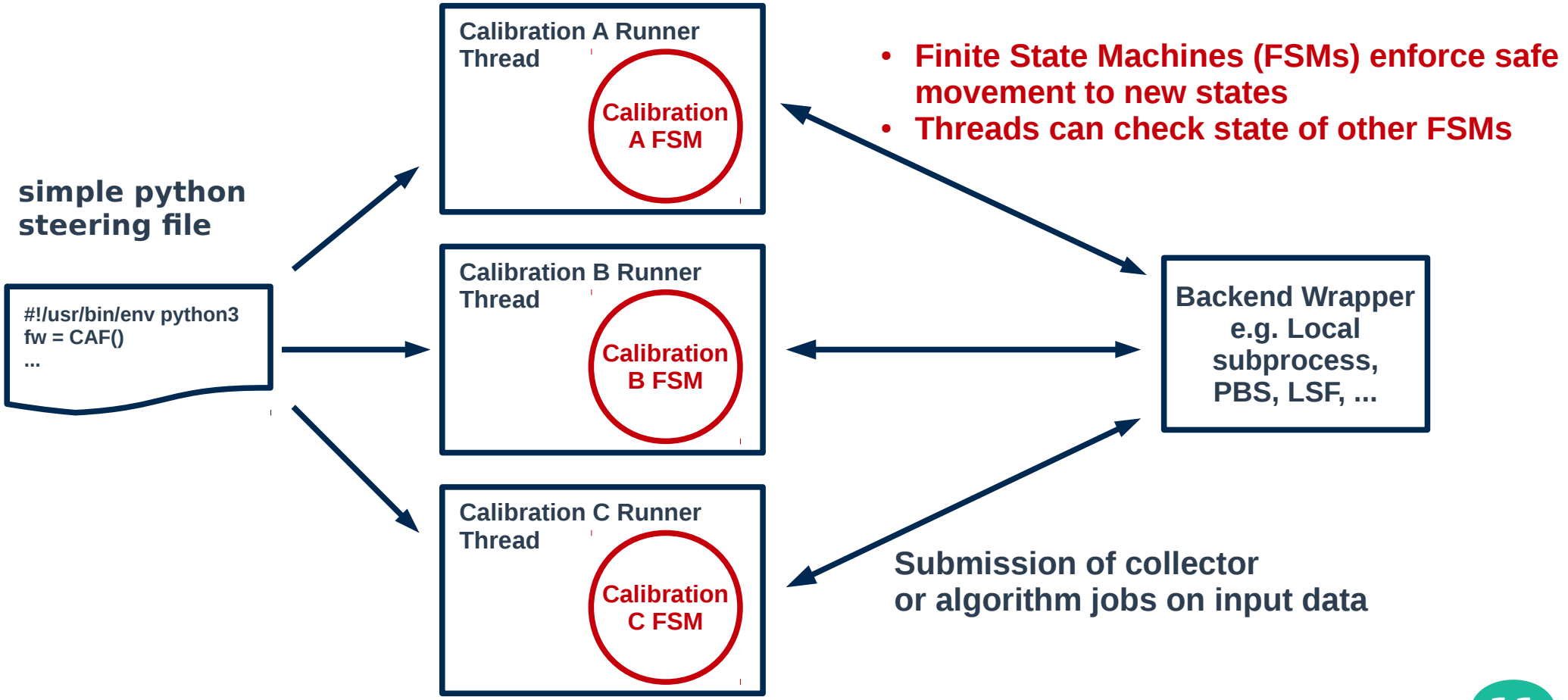
```
# import statements
…
alg = TestAlgorithm()
cal = Calibration(name = “Test1”,
                  collector = “collector_module_name”,
                  algorithms = [alg],
                  input_files = [”/path/to/test1.root”,…])
fw = CAF()
fw.add_calibration(cal)
fw.run()
```

Example code 2

- **Multiple calibrations, dependencies and PBS backend**

```
…
cal_b.depends_on(cal_a)  # cal_a MUST complete before cal_b
fw = CAF()
fw.add_calibration(cal_a)
fw.add_calibration(cal_b)
fw.backend = PBS()  # Configurable if needed
fw.run()
```

Inner Workings (Roughly)

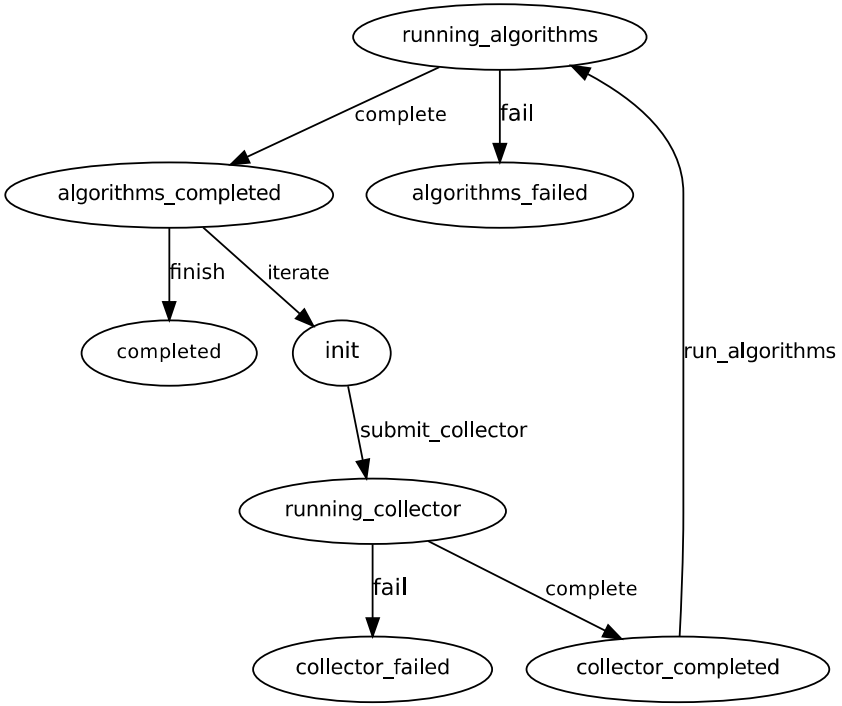


- Finite State Machines (FSMs) enforce safe movement to new states
- Threads can check state of other FSMs

FSM Framework

- **Moved to an explicit FSM framework to reduce code complexity in flow logic**
- **Nicely defines transitions between states**
- **Adding new states/transitions is very easy**
- **Potential to allow 'checkpoints' so that a calibration can be restarted from an intermediate step**

Easy to visualise logic



Outlook

- **C++ and Python frameworks are quite mature and easy for developers to use, even with large quantities of data or interdependencies.**
- **Some algorithms already in the framework:**
  - **Millepede for alignment of VXD**
  - **PXD Cluster Shape**
  - **EKLM Time Calibration**
- **Supporting detector experts while they develop new algorithms**
- **Automating/monitoring constants production will now be the focus**