Karlsruhe Institute of Technology

Belle II

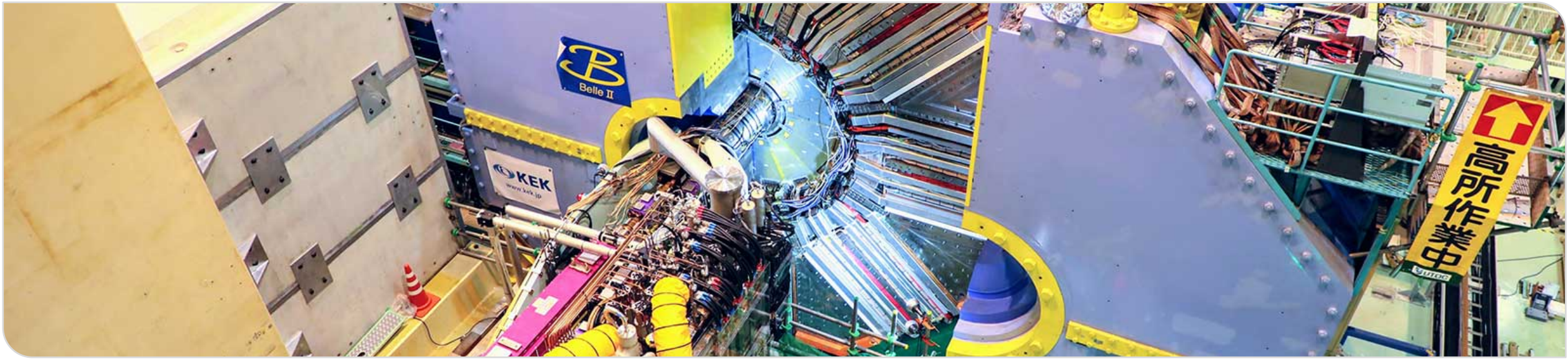
Institute of Experimental Particle Physics

b2luigi - Bringing Batch 2 luigi

Belle II Germany Meeting, October 1st, 2024

Alexander Heidelbach, Jonas Eppelt, Giacomo De Pietro

alexander.heidelbach@kit.edu



Analysis in a Nutshell

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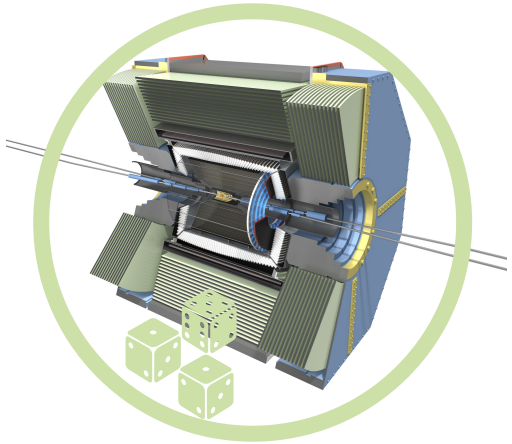
ETP, Karlsruhe Institute of Technology

Analysis in a Nutshell

Institute of Experimental Particle Physics

Data



Analysis in a Nutshell

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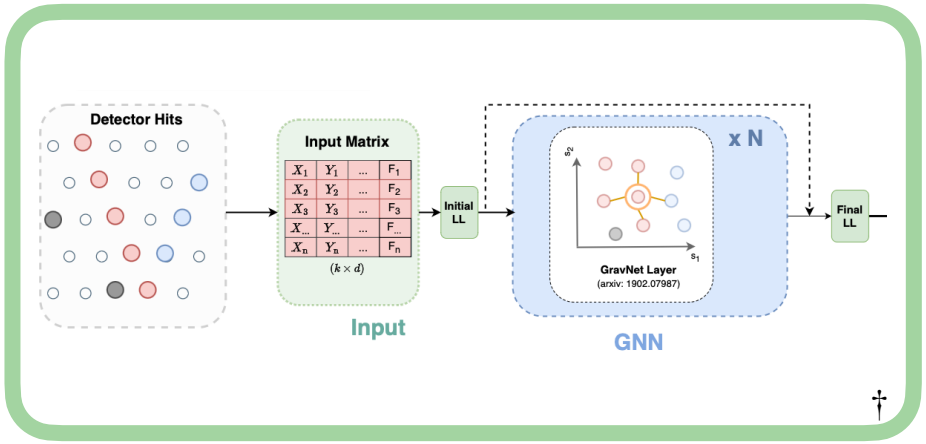
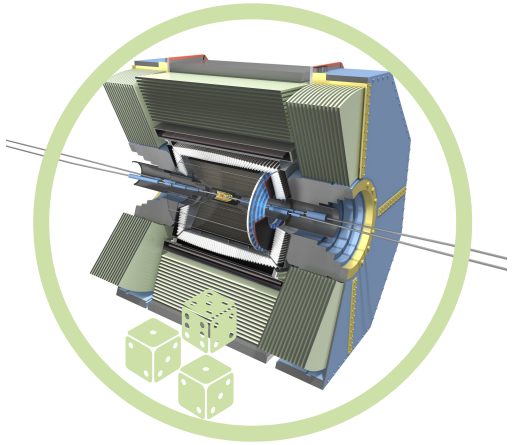
† from Lea Reuter



Data → Preprocessing



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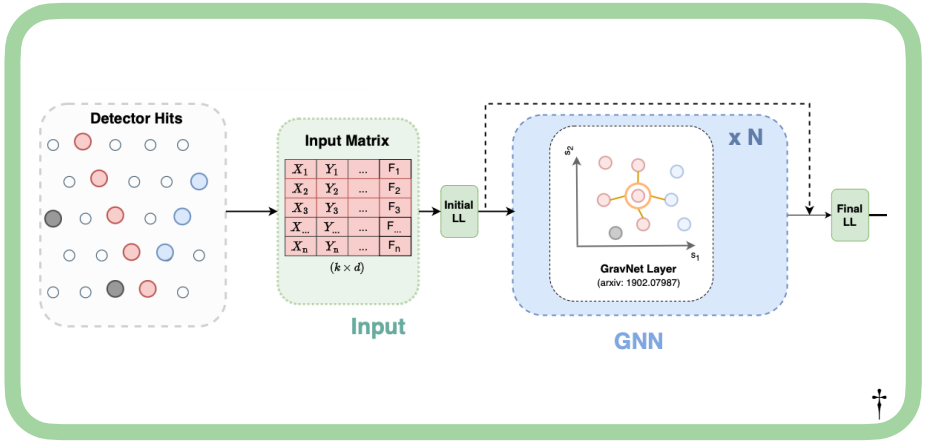
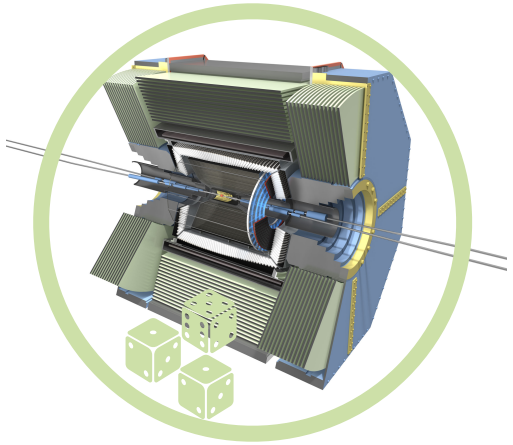
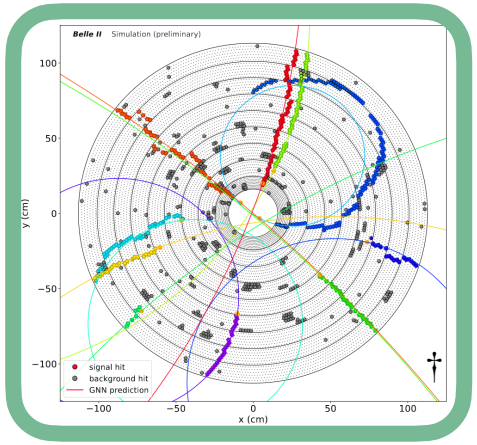
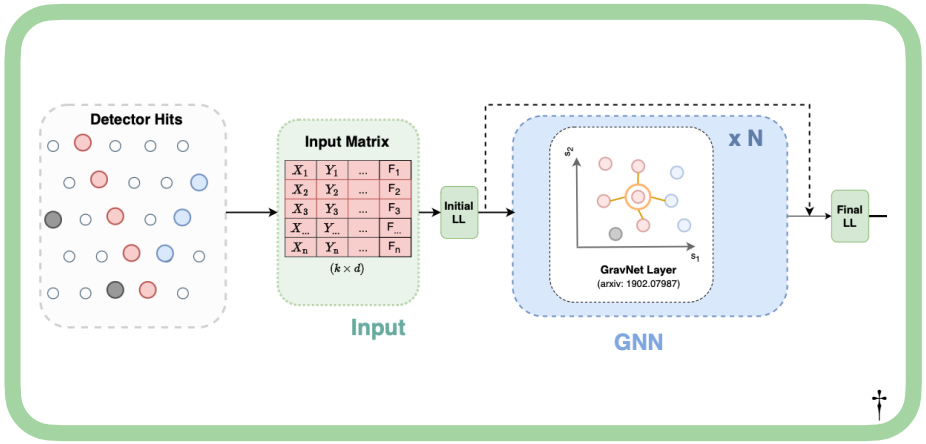


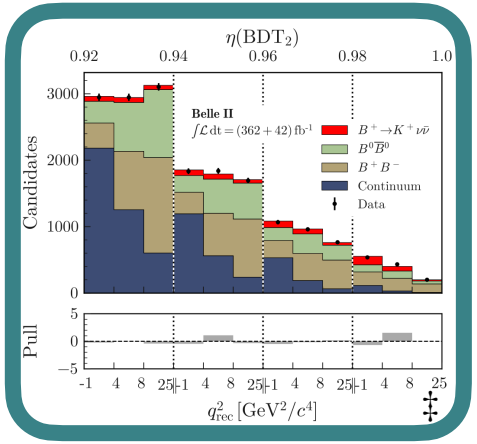
Data → Preprocessing → Reconstruction





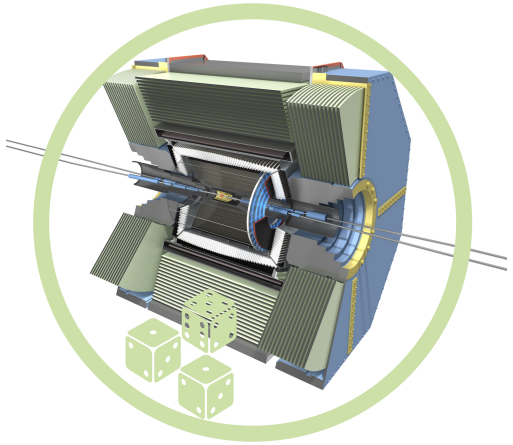
Analysis in a Nutshell

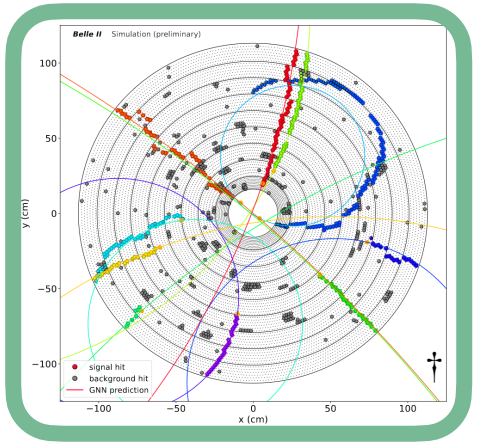




† from Lea Reuter
‡ PhysRevD.109.112006

Data → Preprocessing → Reconstruction → Selection





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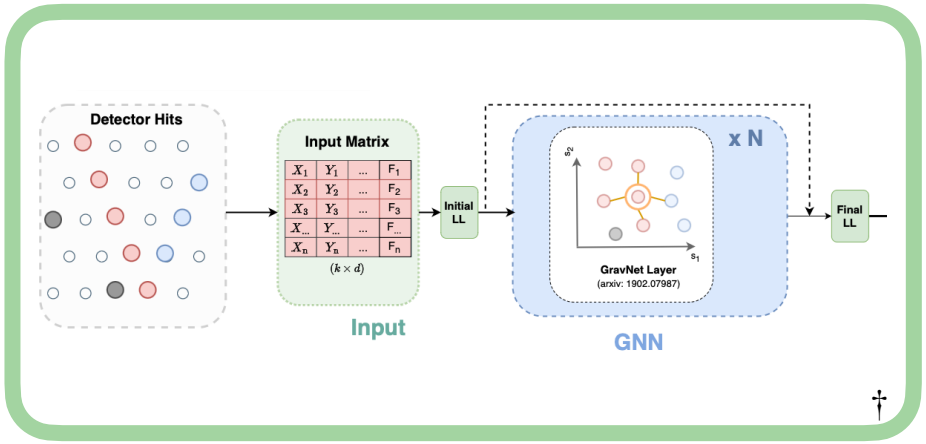
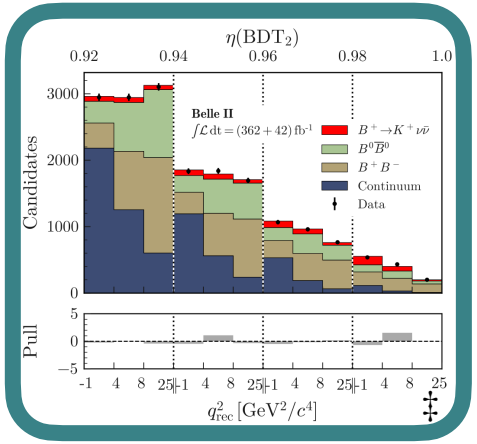
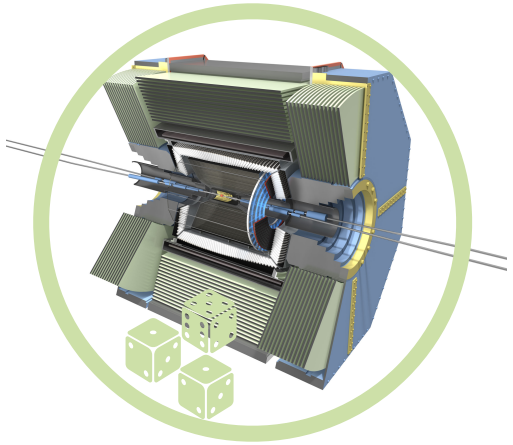
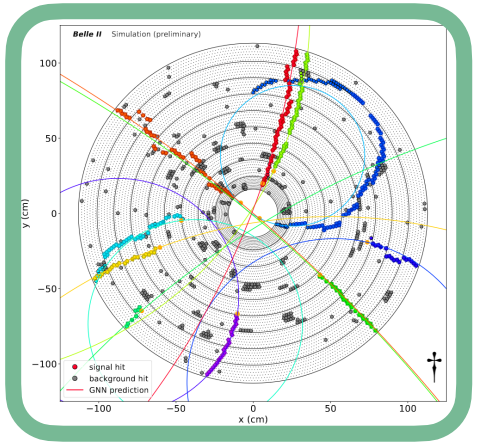
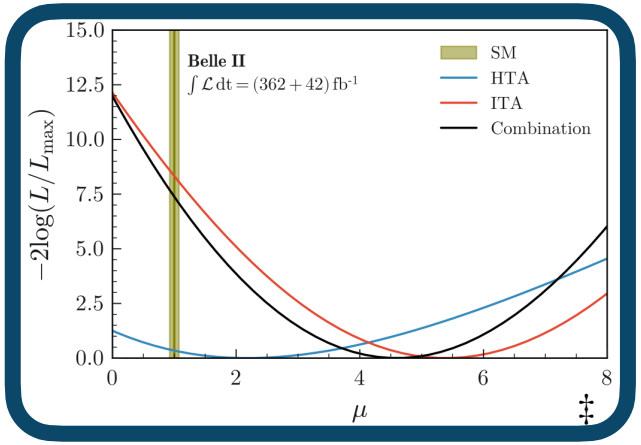




Data → Preprocessing → Reconstruction → Selection → Analysis







The Analysis Code

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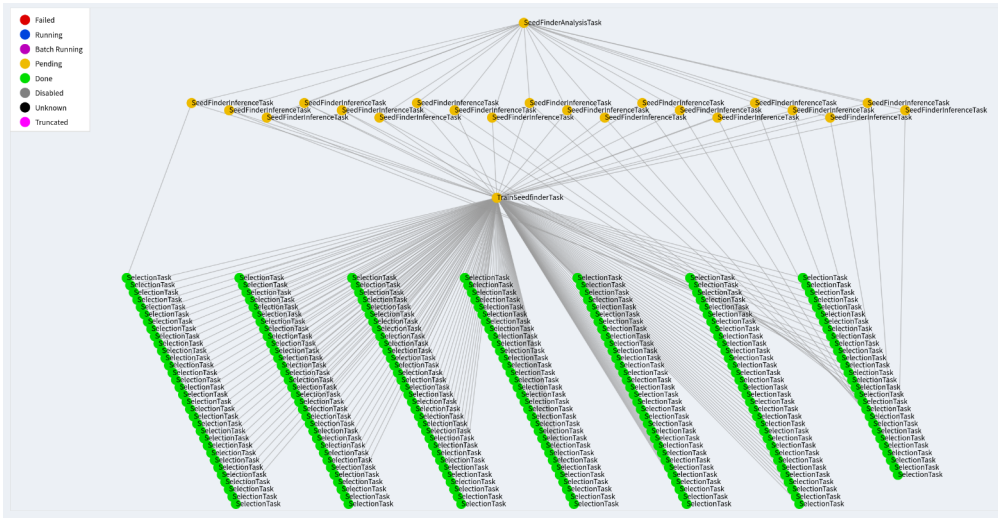
Without b2luigi

```
1_gamma                  feature_ana_paper
2_gamma                  losses.py
9_1_22_3.csv             models.py
9_1_22_4.csv             print_crystal_data.py
9_2_1_56.csv             __pycache__
9_2_1_57.csv             rebatch.py
dataset.py               run_1_barrel.py
feature_ana              run_2_barrel.py
feature_analysis.ipynb   run_2_full.py
```

```
run_2_nominal.py         utils_gnn.py
run_34_early.py          utils_train_inf.py
run_34_nominal.py        zaper_run_1_early.py
run_feature_ana_0b.py    zaper_run_1_nominal.py
run_feature_ana_0.py     zaper_run_feature_ana_early.py
run_feature_ana_1b.py    zaper_run_feature_ana_nominal.py
run_feature_ana_1.py
run_feature_ana_2.py
test.py
```

With b2luigi



- Workflow Management Systems…
  - … enable the user to structure the workflow by defining dependencies
  - … build the dependency graph and schedule the execution

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Luigi in a Nutshell

- **Building a pipeline**
  - Dependency Resolution
  - Workflow Management
  - Visualisation
  - Handling Failures
  - Command Line Integration
  - …
- https://github.com/spotify/luigi

Spotify®

"Hello World" in luigi:

```
class MyTask(luigi.Task):
        parameter = luigi.Parameter()

        def run(self):
                do_smth(self.parameter)

        def output(self):
                return Target("some/file")

        def requires(self):
                yield OtherTask()
```


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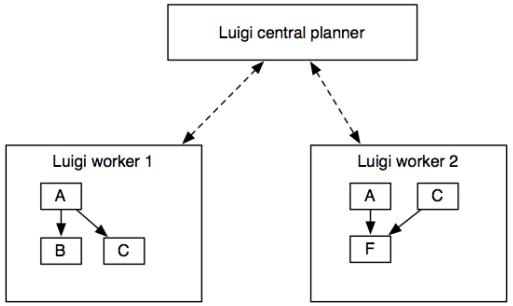
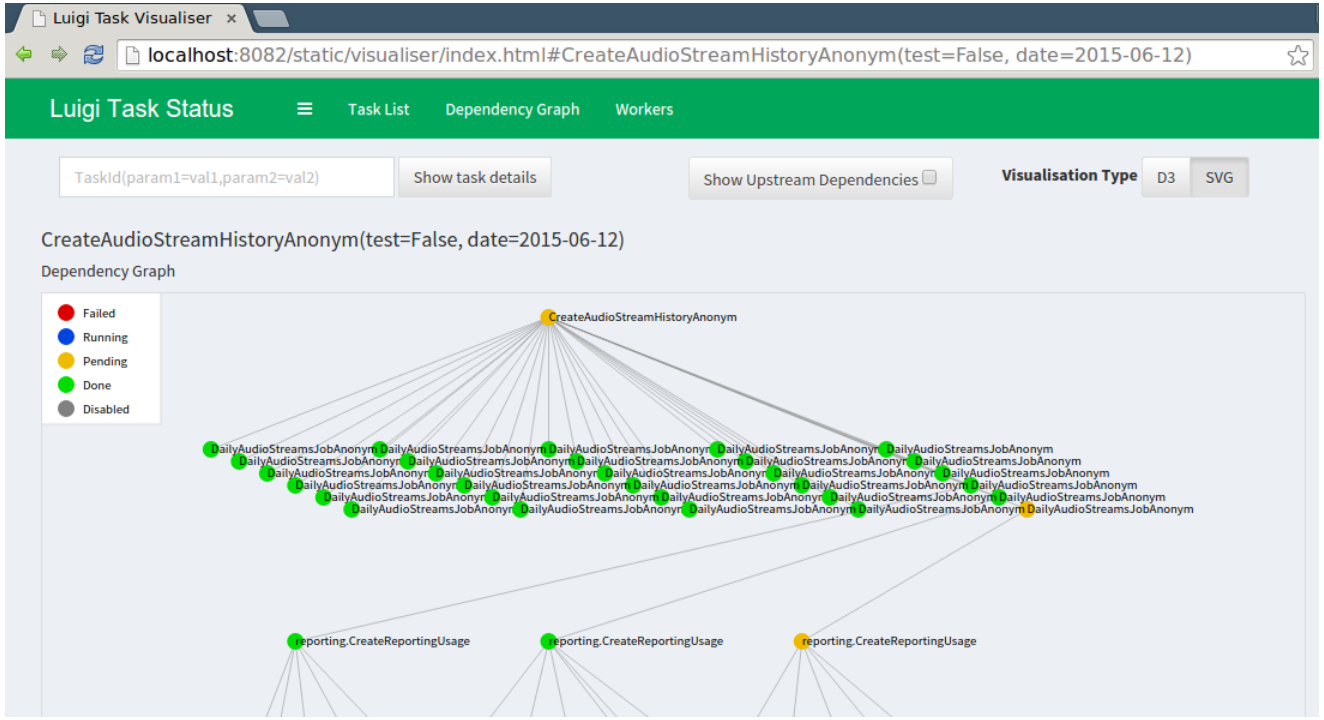
The luigi Scheduler

- User encodes dependencies of tasks
- The scheduler builds dependency graph and makes sure that multiple workers don't execute the same job
- Graphical visualisation provided





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A Simple Task

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```
import b2luigi
import random
from analysis import Other Task

class MyNumberTask(b2luigi.Task):
    some_parameter = b2luigi.IntParameter()
    batch_system = “local”

    def requires(self):
        yield OtherTask(other_parameter=self.some_parameter/2)

    def output(self):
        yield self.add_to_output("output_file.txt")

    def run(self):
        random_number = random.random()

        with open(self.get_output_file_name("output_file.txt"), "w") as f:
            f.write(f"{random_number}\n")
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- Parameter object for task steering
- Define dependency
  - Dependency is fulfilled when output exists
- Target object
  - Simple case: LocalTarget
- Execution logic

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A Simple Task Output

```
===== Luigi Execution Summary =====

Scheduled 100 tasks of which:
* 100 ran successfully:
    - 100 MyTask(some_parameter=0,1,10,11,12,13,14,15,16,17,18,...)

This progress looks :) because there were no failed tasks or missing dependencies

===== Luigi Execution Summary =====
```

```
❯ ls
results  simple-example.py
❯ ls results
'some_parameter=0'   'some_parameter=27'  'some_parameter=45'  'some_parameter=63'  'some_parameter=81'
'some_parameter=1'   'some_parameter=28'  'some_parameter=46'  'some_parameter=64'  'some_parameter=82'
'some_parameter=10'  'some_parameter=29'  'some_parameter=47'  'some_parameter=65'  'some_parameter=83'
'some_parameter=11'  'some_parameter=3'   'some_parameter=48'  'some_parameter=66'  'some_parameter=84'
'some_parameter=12'  'some_parameter=30'  'some_parameter=49'  'some_parameter=67'  'some_parameter=85'
'some_parameter=13'  'some_parameter=31'  'some_parameter=5'   'some_parameter=68'  'some_parameter=86'
'some_parameter=14'  'some_parameter=32'  'some_parameter=50'  'some_parameter=69'  'some_parameter=87'
'some_parameter=15'  'some_parameter=33'  'some_parameter=51'  'some_parameter=7'   'some_parameter=88'
'some_parameter=16'  'some_parameter=34'  'some_parameter=52'  'some_parameter=70'  'some_parameter=89'
'some_parameter=17'  'some_parameter=35'  'some_parameter=53'  'some_parameter=71'  'some_parameter=9'
'some_parameter=18'  'some_parameter=36'  'some_parameter=54'  'some_parameter=72'  'some_parameter=90'
'some_parameter=19'  'some_parameter=37'  'some_parameter=55'  'some_parameter=73'  'some_parameter=91'
'some_parameter=2'   'some_parameter=38'  'some_parameter=56'  'some_parameter=74'  'some_parameter=92'
'some_parameter=20'  'some_parameter=39'  'some_parameter=57'  'some_parameter=75'  'some_parameter=93'
'some_parameter=21'  'some_parameter=4'   'some_parameter=58'  'some_parameter=76'  'some_parameter=94'
'some_parameter=22'  'some_parameter=40'  'some_parameter=59'  'some_parameter=77'  'some_parameter=95'
'some_parameter=23'  'some_parameter=41'  'some_parameter=6'   'some_parameter=78'  'some_parameter=96'
'some_parameter=24'  'some_parameter=42'  'some_parameter=60'  'some_parameter=79'  'some_parameter=97'
'some_parameter=25'  'some_parameter=43'  'some_parameter=61'  'some_parameter=8'   'some_parameter=98'
'some_parameter=26'  'some_parameter=44'  'some_parameter=62'  'some_parameter=80'  'some_parameter=99'
❯ ls results/some_parameter=0
output_file.txt
```

- The scheduler **tracks** the **state** of each job and **takes action**
- **Job is done = Output file exists**
  - Unique output names per job
  - Add parameters to job output name
  - Create a folder structure for each parameter
  - b2luigi does this automatically
  - **No check of content!**

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A Simple Task Settings

```
class MyTask(b2luigi.Task):
    some_setting = “some value”
```

```
class MyTask(b2luigi.Task):
    @property
    def some_setting(self):
        return “some value”
```

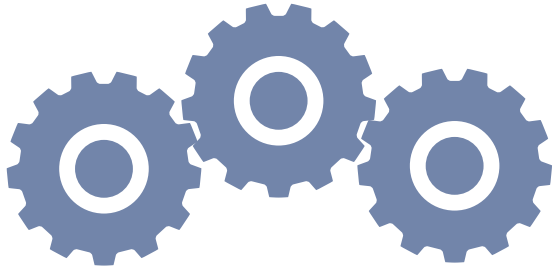
```
b2luigi.set_setting(“some_setting”, "some value")
```

settings.json

```
{
    “some_setting”: “some value”
}
```

Priority

- **Settings** are handled by b2luigi!
- **Control**:
  - batch system choice
  - output and log path
  - environment
  - workflow specific settings



A Simple Task Continued

```python
class MyAverageTask(b2luigi.Task):
    def requires(self):
        for i in range(100):
            yield self.clone(MyNumberTask, some_parameter=i)

    def output(self):
        yield self.add_to_output("average.txt")

    def run(self):
        summed_numbers = 0
        counter = 0
        for input_file in self.get_input_file_names("output_file.txt"):
            with open(input_file, "r") as f:
                summed_numbers += float(f.read())
                counter += 1

        average = summed_numbers / counter

        with open(self.get_output_file_name("average.txt"), "w") as f:
            f.write(f"{average}\n")
```

- More **helper functions**:
  - b2luigi.Task.get_input_file_names()
  - b2luigi.Task.get_output_file_name()

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        for input_file in self.get_input_file_names("output_file.txt"):
            with open(input_file, "r") as f:
                summed_numbers += float(f.read())
                counter += 1

        average = summed_numbers / counter

        with open(self.get_output_file_name("average.txt"), "w") as f:
            f.write(f"{average}\n")
```

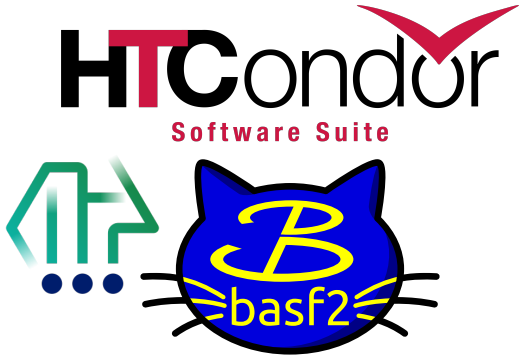
- More **helper functions**:
  - b2luigi.Task.get_input_file_names()
  - b2luigi.Task.get_output_file_name()
- Jobs that are done will not be run again!

```
❯ python3 simple-example.py --show-output
average.txt
        /home/aheidelbach/b2luigi/results/average.txt

output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=0/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=1/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=2/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=3/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=4/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=5/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=6/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=7/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=8/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=9/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=10/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=11/output_file.txt
        /home/aheidelbach/b2luigi/results/some_parameter=12/output_file.txt
```

Batch Processing

- Initial motivation: **Make batch submission easy!**
- Currently **fully supported**:
  - HTCondor
  - LSF
  - Gbasf2
- **Challenges**:
  - Using your environment
    - **Settings**: env_script, env,..
  - Ensuring consistent locations
    - **Settings**: working_dir, result_dir,…




```
class MyTask(b2luigi.Task):
    batch_system = "htcondor"
```

```
class MyTask(b2luigi.Task):
    @property
    def htccondor_settings(self):
        return {"request_memory": 4096}
```

```
b2luigi.set_setting("result_dir", "path/to/result")
```

settings.json

```
{
    "env_script": "setup.sh"
}
```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Example: HTCondor

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```
class MyTask(b2luigi.Task):
    parameter = b2luigi.IntParameter()
    batch_system = "htcondor"

    @property
    def executable(self):
        return ["$MY_PYTHON"]

    def output(self):
        yield self.add_to_output("test.txt")

    def run(self):
        with open(self.get_output_file_name("test.txt"), "w") as f:
            f.write(f"Test {self.parameter}")

class Wrapper(b2luigi.WrapperTask):
    def requires(self):
        for i in range(10):
            yield MyTask(parameter=i)

if __name__ == "__main__":
    b2luigi.set_setting("env_script", "setup.sh")

    b2luigi.set_setting("result_dir", "results")

    b2luigi.process(Wrapper(), batch=True, workers=100)
```

Example: HTCondor

```python
class MyTask(b2luigi.Task):
    parameter = b2luigi.IntParameter()
    batch_system = "htcondor"

    @property
    def executable(self):
        return ["$MY_PYTHON"]

    def output(self):
        yield self.add_to_output("test.txt")

    def run(self):
        with open(self.get_output_file_name("test.txt"), "w") as f:
            f.write(f"Test {self.parameter}")

class Wrapper(b2luigi.WrapperTask):
    def requires(self):
        for i in range(10):
            yield MyTask(parameter=i)

if __name__ == "__main__":
    b2luigi.set_setting("env_script", "setup.sh")

    b2luigi.set_setting("result_dir", "results")

    b2luigi.process(Wrapper(), batch=True, workers=100)
```

- Script executed on the batch job side

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Example: HTCondor

```
class MyTask(b2luigi.Task):
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    @property
    def executable(self):
        return ["$MY_PYTHON"]

    def output(self):
        yield self.add_to_output("test.txt")

    def run(self):
        with open(self.get_output_file_name("test.txt"), "w") as f:
            f.write(f"Test {self.parameter}")

class Wrapper(b2luigi.WrapperTask):
    def requires(self):
        for i in range(10):
            yield MyTask(parameter=i)

if __name__ == "__main__":
    b2luigi.set_setting("env_script", "setup.sh")

    b2luigi.set_setting("result_dir", "results")

    b2luigi.process(Wrapper(), batch=True, workers=100)
```

- Script executed on the batch job side
- Location needs to be accessible on the batch job side

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ETP, Karlsruhe Institute of Technology

Example: HTCondor

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class MyTask(b2luigi.Task):
    parameter = b2luigi.IntParameter()
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    @property
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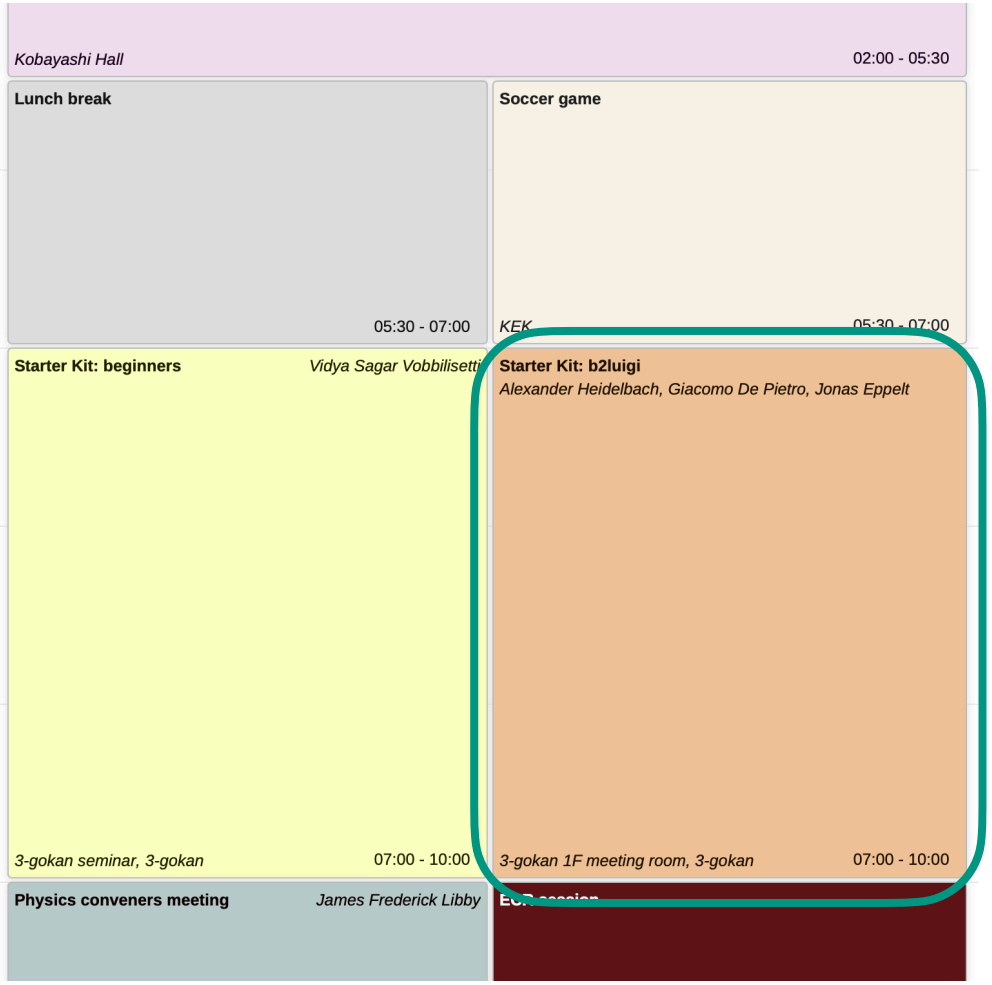
- Script executed on the batch job side
- Location needs to be accessible on the batch job side
- Wrapper tasks need no output
- Definition of the batch system
- Executable for this specific task
  - E.g. environment variable set in setup.sh

Advertisement

- **b2luigi workshop at the next B2GM**
  - Friday 11th October at 3pm
  - 3-gokan 1F meeting room
  - **In person only!**
- **Topics**:
  - (b2)luigi basics
  - basf2 analysis from simulation to ntuple
  - Sending b2luigi tasks to batch systems
  - Offline analysis hints



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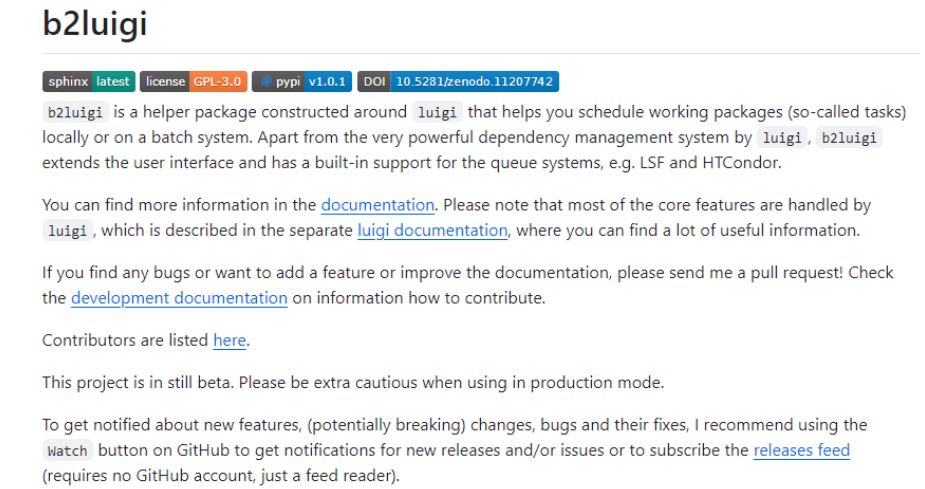
Summary & Discussion

Institute of Experimental Particle Physics

- b2luigi provides a simple and flexible implementation to run your workflow on batch systems!
- In case of questions, issues, wishes…
  ⇒ Reach out to us via GitLab issues, b2questions, email, …
- **Implementations in Belle II**
  - VIBE - Validation Interface for the Belle II Experiment
  - Systematic Corrections Framework
  - Your Analysis/Tool?



GitLab

Github

Zenodo

Documentation

PyPi

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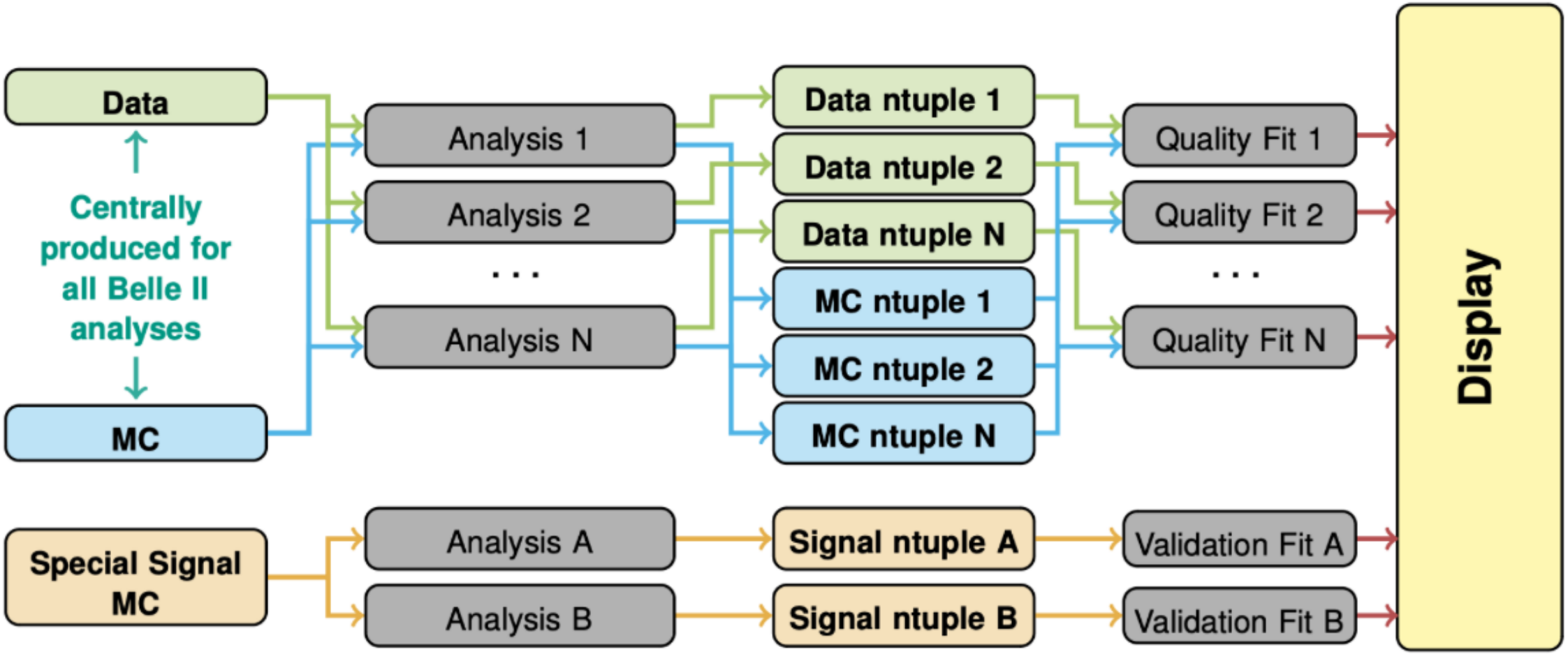
Backup

Validation Interface for the Belle II Experiment



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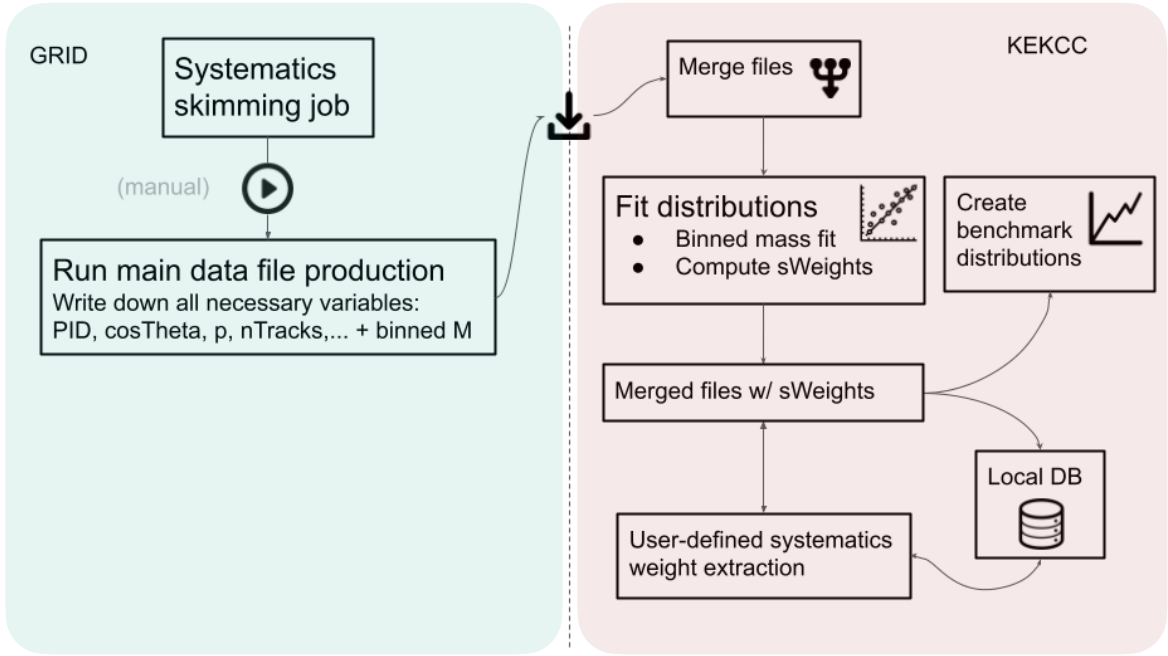
Systematic Corrections Framework

- 2 Stage Algorithm
  - Ntuple Production
    - Centrally run for every campaign
    - Running: Gbasf2
  - Data/MC Corrections
    - User runs their specific selection
    - Running: Locally, HTCondor, LSF
- Also: Validation of different datasets



Documentation

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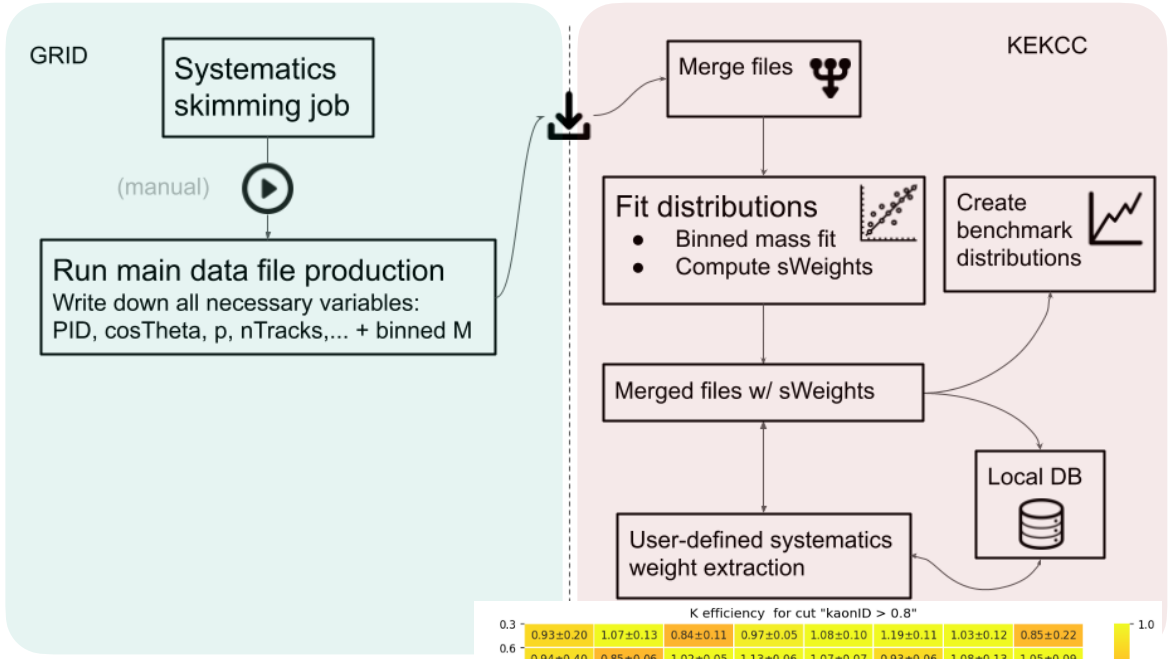

[Documentation]

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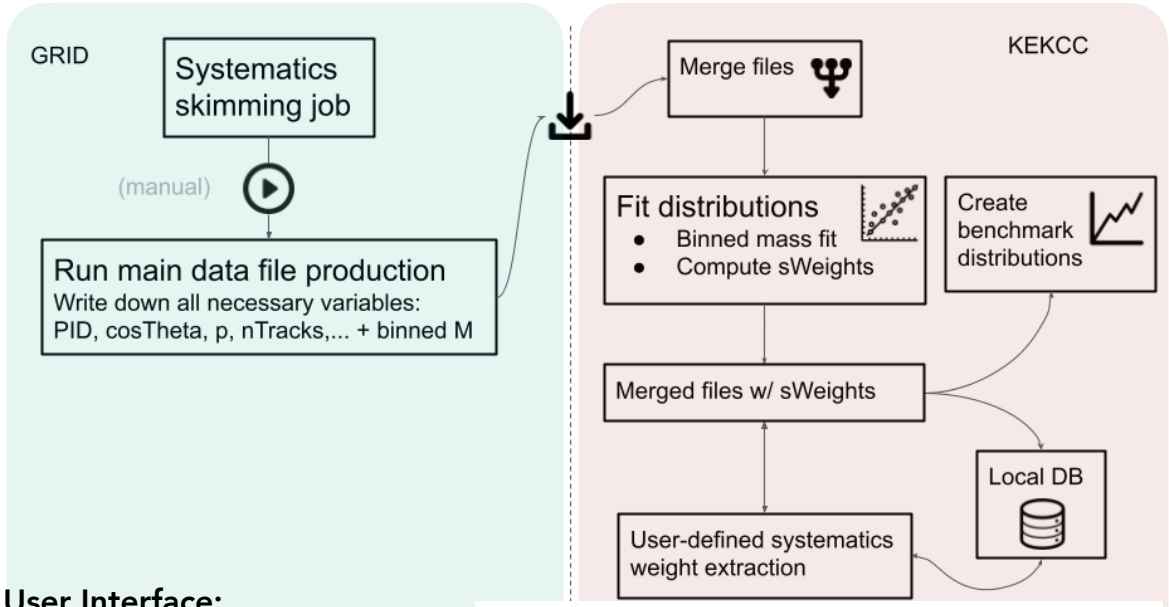
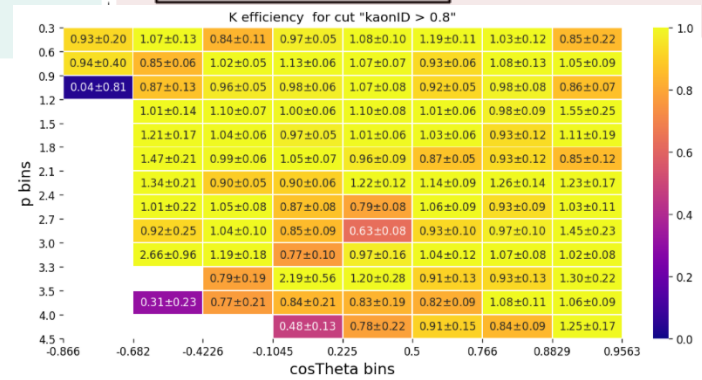


User Interface:

```
# ================================== #
#  Hadron ID weight configuration file  #
# ================================== #
weight_dir: 'fixed_weights/'
remove_tmp_files: True
weight_cfg_list:
-
  prefix_name: Rdtmc_v1
  efficiency particle type: 'K'
  fakerate particle type: 'pi'
  binning: [[0.5, 2.5, 4.5],
            [-0.8, 0.2, 0.9563]]
  track variables: [ "p", "cosTheta" ]
  cuts: [ "kaonID > 0.2", "kaonID > 0.8"]
  precuts: [ "", "charge > 0", "charge < 0" ]
  mc proc query: [ "MC14ri_1" ]
  data_proc_query: [ "proc12e7" ]
```



[Documentation]