ILD standard reconstruction with Gaudi

ILD Software/Analysis meeting

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Goals for migration to Gaudi

Why? Why now?

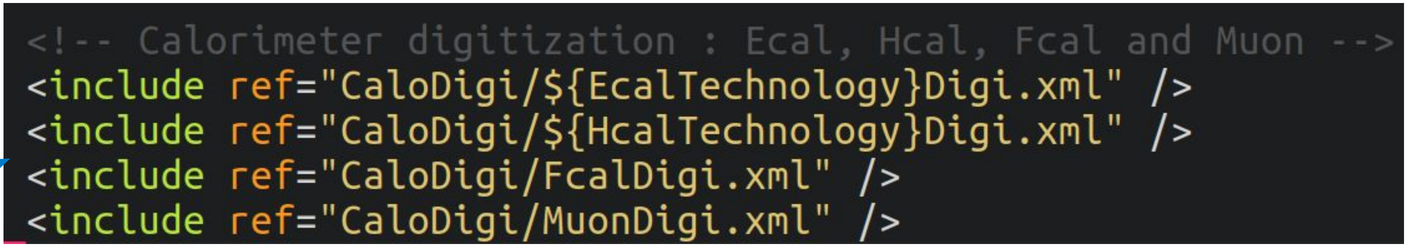
ILDConfig#137

- ILD reconstruction works in Key4hep
- Standard reconstruction workflow still based on Marlin and Marlin xml steering files
- Want to start migration towards Gaudi and more core Key4hep tools
  - **EDM4hep** as data format
- Key4hep comes with conversion tools to convert xml files to Gaudi python option files
  - Somewhat manual process still
  - Can convert everything once and then provide this centrally (less work for everyone 🎉)
- Decision at ILD workshop @CERN to start this migration
  - Also allows to more easily collaborate with CLD and others
- Major goal: **Keep existing functionality**
  - Everything that works now with Marlin should also work with Gaudi
  - Disclaimer: Some details will have to be defined after some usage experience

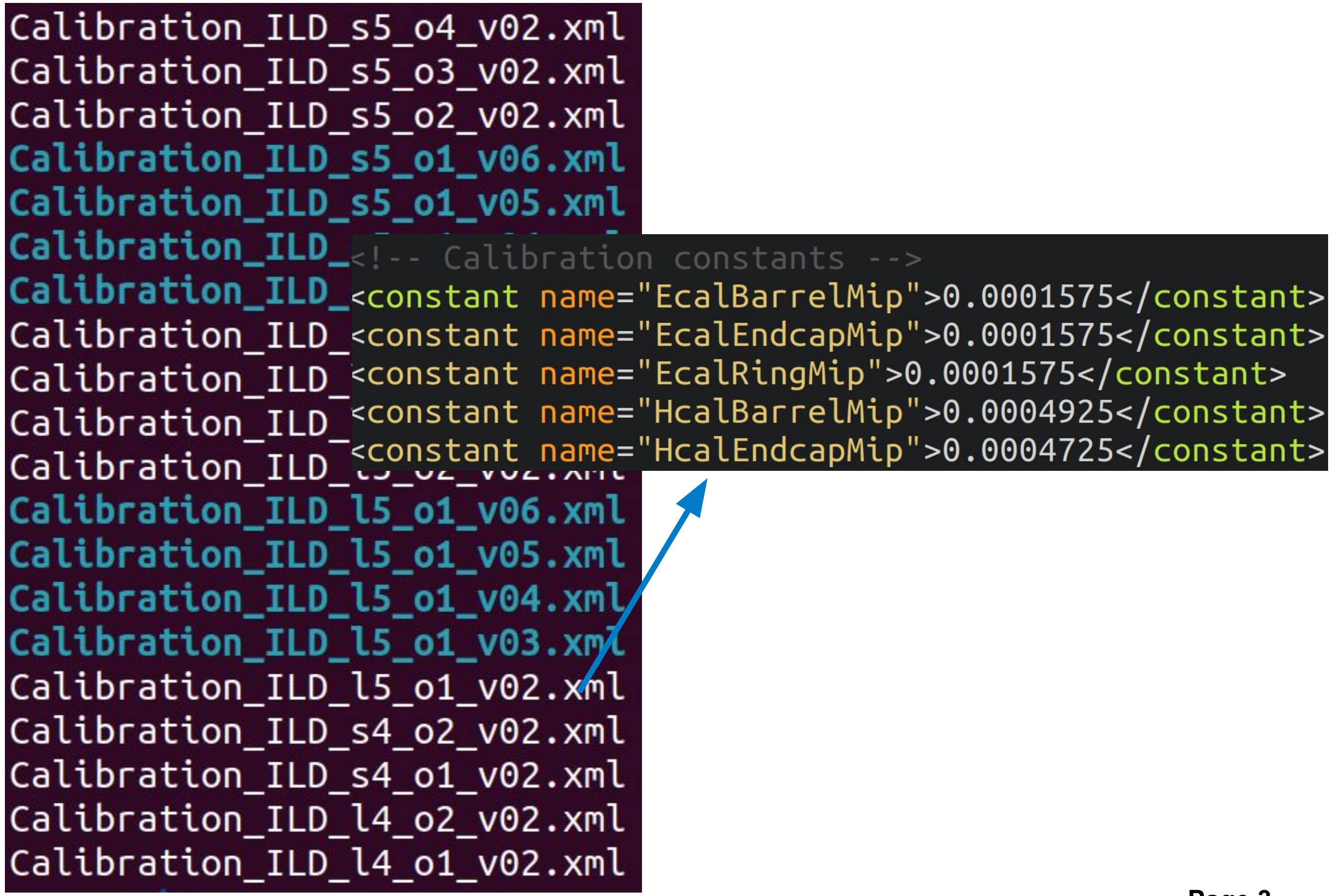
ILDConfig organization

Contents of StandardConfig/production

- Top level `MarlinStdReco.xml`
  - Incluces other steering and calibration files dynamically depending on values of `constants`
- Several subfolders with dedicated configuration for parts of the reconstruction
  - Tracking, Calorimetry, ParticleFlow, HighLevelReco
- Detector dependent calibration files
  - Define geometry and technology specific constants
- Center-of-mass energy dependent configuration files
  - Some minor cross-referencing with the former
- Some constants depend on the values of other constants



```
<!-- Calorimeter digitization : Ecal, Hcal, Fcal and Muon -->
<include ref="CaloDigi/${EcalTechnology}Digi.xml" />
<include ref="CaloDigi/${HcalTechnology}Digi.xml" />
<include ref="CaloDigi/FcalDigi.xml" />
<include ref="CaloDigi/MuonDigi.xml" />
```



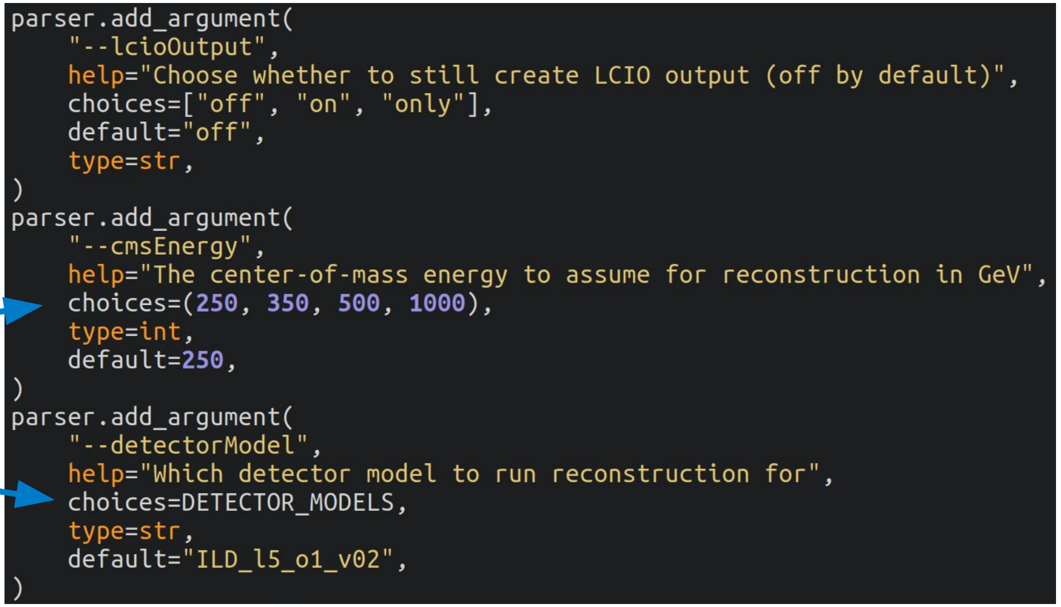
```
Calibration_ILD_s5_o4_v02.xml
Calibration_ILD_s5_o3_v02.xml
Calibration_ILD_s5_o2_v02.xml
Calibration_ILD_s5_o1_v06.xml
Calibration_ILD_s5_o1_v05.xml
Calibration_ILD_
Calibration_ILD_
Calibration_ILD_
Calibration_ILD_
Calibration_ILD_
Calibration_ILD_
Calibration_ILD_l5_o1_v06.xml
Calibration_ILD_l5_o1_v05.xml
Calibration_ILD_l5_o1_v04.xml
Calibration_ILD_l5_o1_v03.xml
Calibration_ILD_l5_o1_v02.xml
Calibration_ILD_s4_o2_v02.xml
Calibration_ILD_s4_o1_v02.xml
Calibration_ILD_l4_o2_v02.xml
Calibration_ILD_l4_o1_v02.xml
```

```
<!-- Calibration constants -->
<constant name="EcalBarrelMip">0.0001575</constant>
<constant name="EcalEndcapMip">0.0001575</constant>
<constant name="EcalRingMip">0.0001575</constant>
<constant name="HcalBarrelMip">0.0004925</constant>
<constant name="HcalEndcapMip">0.0004725</constant>
```

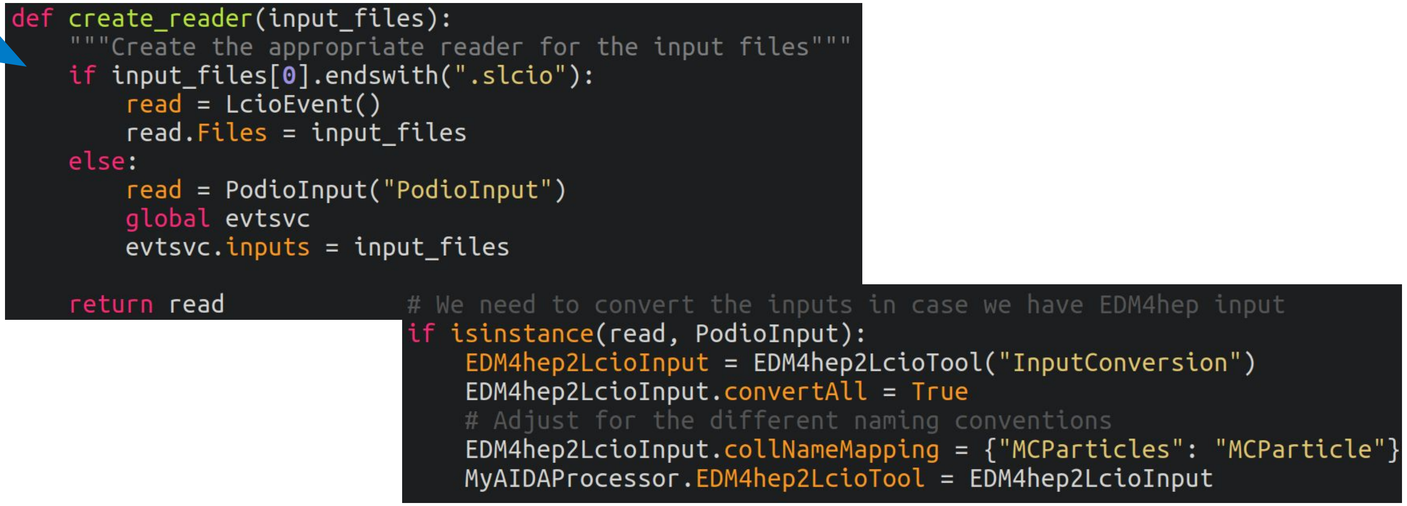
ILDReconstruction.py features

High level view

- Use `argparse` for argument parsing
  - Allows to catch configuration mistakes very early (e.g. non-existent calibration, …)
- Automatic input file format detection
  - Choose correct reader and if necessary inject a conversion directly
- EDM4hep output by default
  - Effectively equivalent to REC
  - LCIO output can be toggled via command line arguments
- Some new conventions on how to modularize configuration
  - Not yet fully finalized (i.e. voice your opinion now)



```
parser.add_argument(
    "--lcioOutput",
    help="Choose whether to still create LCIO output (off by default)",
    choices=["off", "on", "only"],
    default="off",
    type=str,
)
parser.add_argument(
    "--cmsEnergy",
    help="The center-of-mass energy to assume for reconstruction in GeV",
    choices=(250, 350, 500, 1000),
    type=int,
    default=250,
)
parser.add_argument(
    "--detectorModel",
    help="Which detector model to run reconstruction for",
    choices=DETECTOR_MODELS,
    type=str,
    default="ILD_l5_o1_v02",
)
```



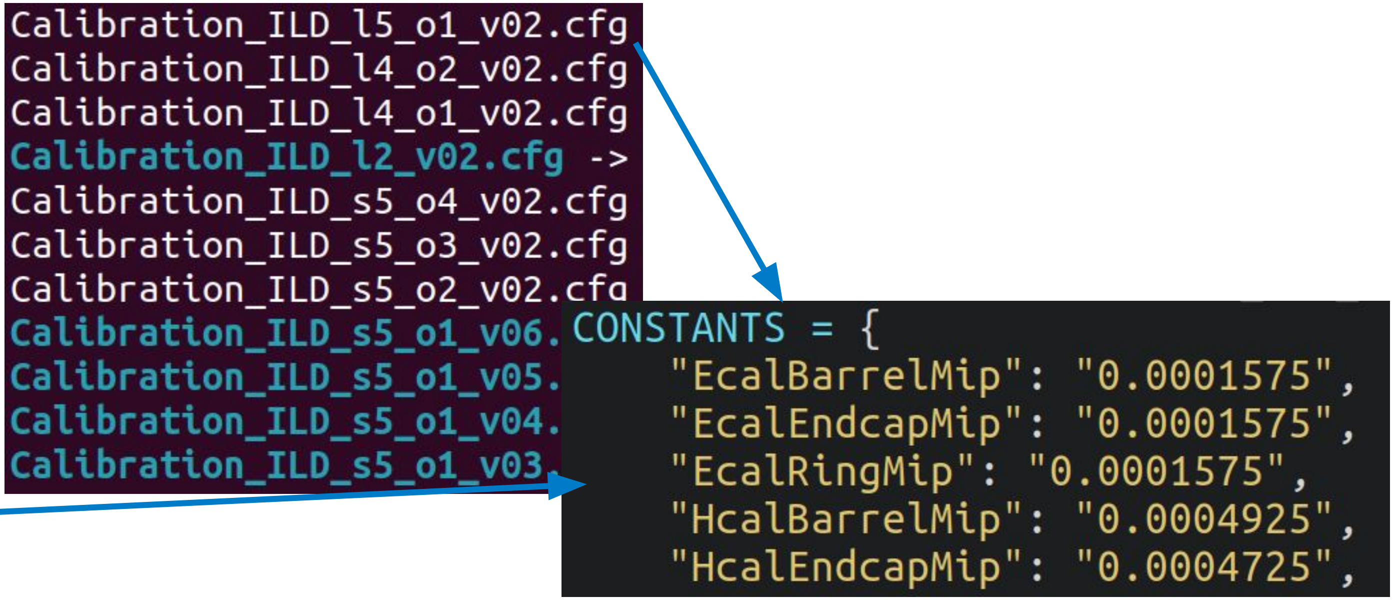
```
def create_reader(input_files):
    """Create the appropriate reader for the input files"""
    if input_files[0].endswith(".slcio"):
        read = LcioEvent()
        read.Files = input_files
    else:
        read = PodioInput("PodioInput")
        global evtsvc
        evtsvc.inputs = input_files

    return read
```

```
# We need to convert the inputs in case we have EDM4hep input
if isinstance(read, PodioInput):
    EDM4hep2LcioInput = EDM4hep2LcioTool("InputConversion")
    EDM4hep2LcioInput.convertAll = True
    # Adjust for the different naming conventions
    EDM4hep2LcioInput.collNameMapping = {"MCParticles": "MCParticle"}
    MyAIDAProcessor.EDM4hep2LcioTool = EDM4hep2LcioInput
```

Converted calibrations

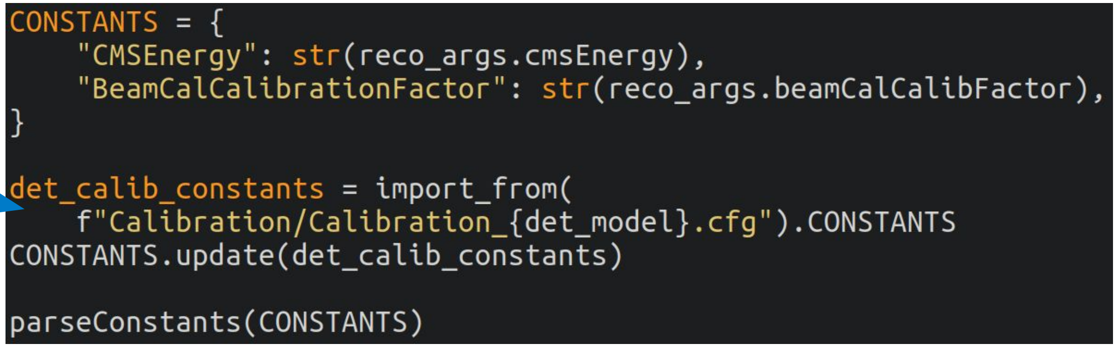
Same, same, but different

- Mirrored structure to existing XML calibration files
  - Simply converted all of them using converter script
  - Large python dictionary of constants
  - .cfg ending to signify that these are somewhat static configuration bits
- Dynamically imported into ILDReconstruction.py
  - Before nested constants are parsed
- Exactly the same mechanism for CMS energy dependent configuration
- Recursive resolution of nested constants in ILDReconstruction.py



```
Calibration_ILD_l5_o1_v02.cfg
Calibration_ILD_l4_o2_v02.cfg
Calibration_ILD_l4_o1_v02.cfg
Calibration_ILD_l2_v02.cfg ->
Calibration_ILD_s5_o4_v02.cfg
Calibration_ILD_s5_o3_v02.cfg
Calibration_ILD_s5_o2_v02.cfg
Calibration_ILD_s5_o1_v06.
Calibration_ILD_s5_o1_v05.
Calibration_ILD_s5_o1_v04.
Calibration_ILD_s5_o1_v03.
```

```
CONSTANTS = {
    "EcalBarrelMip": "0.0001575",
    "EcalEndcapMip": "0.0001575",
    "EcalRingMip": "0.0001575",
    "HcalBarrelMip": "0.0004925",
    "HcalEndcapMip": "0.0004725",
```

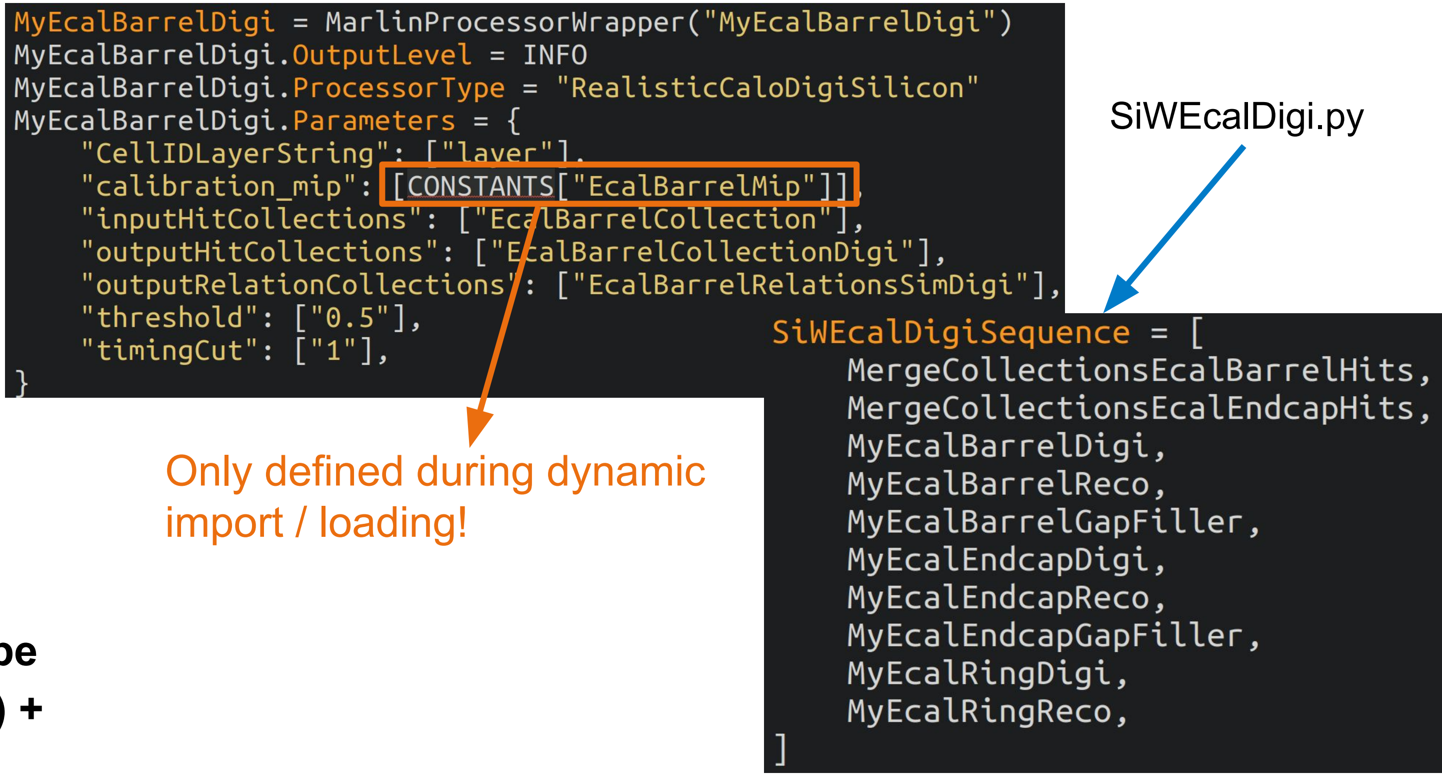


```
CONSTANTS = {
    "CMSEnergy": str(reco_args.cmsEnergy),
    "BeamCalCalibrationFactor": str(reco_args.beamCalCalibFactor),
}

det_calib_constants = import_from(
    f"Calibration/Calibration_{det_model}.cfg").CONSTANTS
CONSTANTS.update(det_calib_constants)

parseConstants(CONSTANTS)
```

New standard sequences

Plus a new convention

- Converted existing sequences (groups) from xml to python
  - Filenames: `s/.xml/.py/`
- All algorithms of a sequence go into a python list
  - New convention: **The name of this list has to be the same as the filename (without extension) + Sequence**
  - This defines the order of execution
- Provide helper functionality to facilitate dynamic inclusion
  - Also deals with passing in the configuration constants at load time
  - k4FWCore#178

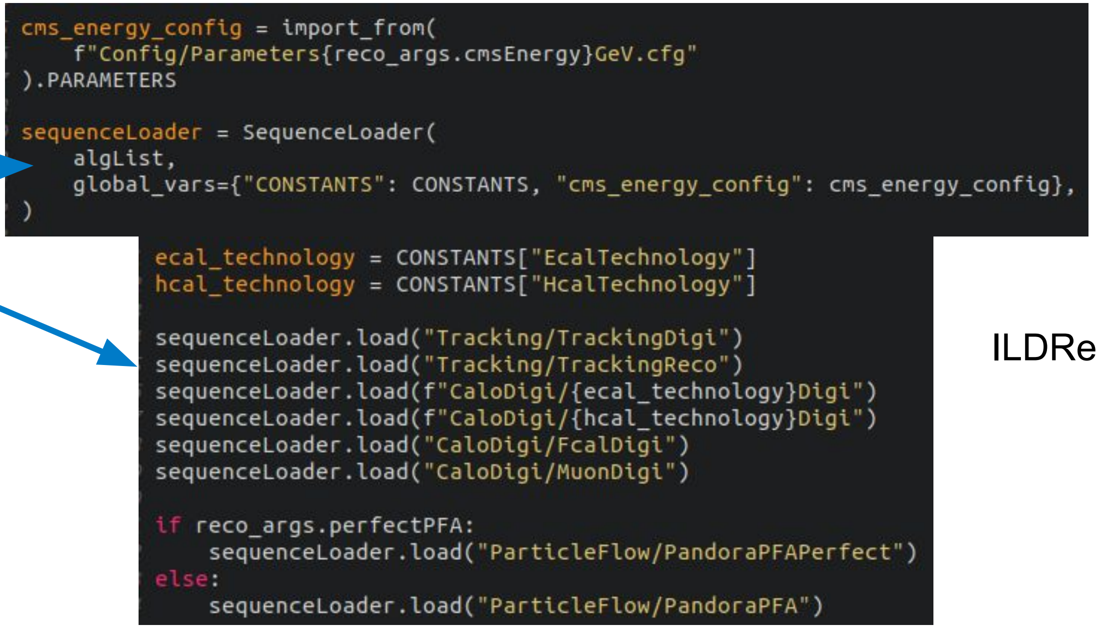


```
MyEcalBarrelDigi = MarlinProcessorWrapper("MyEcalBarrelDigi")
MyEcalBarrelDigi.OutputLevel = INFO
MyEcalBarrelDigi.ProcessorType = "RealisticCaloDigiSilicon"
MyEcalBarrelDigi.Parameters = {
    "CellIDLayerString": ["layer"],
    "calibration_mip": [CONSTANTS["EcalBarrelMip"]],
    "inputHitCollections": ["EcalBarrelCollection"],
    "outputHitCollections": ["EcalBarrelCollectionDigi"],
    "outputRelationCollections": ["EcalBarrelRelationsSimDigi"],
    "threshold": ["0.5"],
    "timingCut": ["1"],
}
```

Only defined during dynamic import / loading!

SiWEcalDigi.py

```
SiWEcalDigiSequence = [
    MergeCollectionsEcalBarrelHits,
    MergeCollectionsEcalEndcapHits,
    MyEcalBarrelDigi,
    MyEcalBarrelReco,
    MyEcalBarrelGapFiller,
    MyEcalEndcapDigi,
    MyEcalEndcapReco,
    MyEcalEndcapGapFiller,
    MyEcalRingDigi,
    MyEcalRingReco,
]
```



```
cms_energy_config = import_from(
    f"Config/Parameters{reco_args.cmsEnergy}GeV.cfg"
).PARAMETERS

sequenceLoader = SequenceLoader(
    algList,
    global_vars={"CONSTANTS": CONSTANTS, "cms_energy_config": cms_energy_config},
)
```

```
ecal_technology = CONSTANTS["EcalTechnology"]
hcal_technology = CONSTANTS["HcalTechnology"]

sequenceLoader.load("Tracking/TrackingDigi")
sequenceLoader.load("Tracking/TrackingReco")
sequenceLoader.load(f"CaloDigi/{ecal_technology}Digi")
sequenceLoader.load(f"CaloDigi/{hcal_technology}Digi")
sequenceLoader.load("CaloDigi/FcalDigi")
sequenceLoader.load("CaloDigi/MuonDigi")

if reco_args.perfectPFA:
    sequenceLoader.load("ParticleFlow/PandoraPFAPerfect")
else:
    sequenceLoader.load("ParticleFlow/PandoraPFA")
```

ILDReconstruction.py

How to run ILDReconstruction.py

The most important bit

- All arguments except input files have defaults; simplest case:

```
k4run ILDReconstruction.py --inputFiles=<your input files>
```

- Override the default detector model (ILD_l5_o1_v02) and CMS energy (250)

```
k4run ILDReconstruction.py --inputFiles=<your input files> \
      --cmsEnergy=500 \
      --detectorModel=ILD_s5_o4_v02
```

- Run current reconstruction through Gaudi (with default detector)

```
k4run ILDReconstrution.py --inputFiles=<your input files> \
      --lcioOutput=only
```

Summary & Next steps

- First version of modular Gaudi configuration for ILD standard reconstruction workflow
  - Possible to dynamically configure algorithms depending on calibration constants, etc.
  - Keeping existing functionality and basic concepts
  - Introduce a new convention
  - ILDConfig#137
- Develop a few python helpers to support dynamic imports
  - Directly upstream them to k4FWCore to make them available to everyone
  - k4FWCore#178
- Next steps:
  - Finalize all of the above (some details still need to be fixed) and make available
- Short term plans:
  - Integrate ILD_l5_v11 into this chain and run a first reconstruction
  - Convert miniDST workflow
- Mid term plans:
  - Make it possible to import standard sequences from “everywhere”

Thank you