



# The Pineline:

## Industrialization of High-Energy theory predictions

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(Re)interpretation of LHC results for new physics

30/08/2023



NNPDF



N3PDF  
Machine Learning • PDFs • QCD



# Outline



Introduction and motivation



The Pipeline



Applications and outlook



Introduction and motivation



The Pipeline



Applications and outlook

# Problems and Goals



High runtime and development time for new observables



No straightforward way to reproduce results



Proliferation of short standing codes



## Including new computations

- Reduce **runtime** and **development** time
- Provide a **common I/O interface**



## Ensure reproducibility

- **Storing** intermediate steps
- Produce and track **logs** and **metadata**



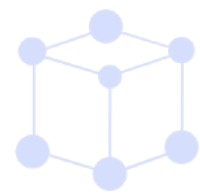
## Make it last

- **Open Source** from the beginning
- **Fully documented**

# The Pipeline

 <https://github.com/NNPDF/pipeline>

 <https://wnpdf.github.io/pipeline>



## Single I/O format

Provides *translation* layers



## Open Source

*and fully documented*



## Industrialization

*Assembly line* of generators



## Reproducibility

Easy inspection of metadata





Introduction and motivation



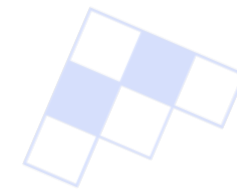
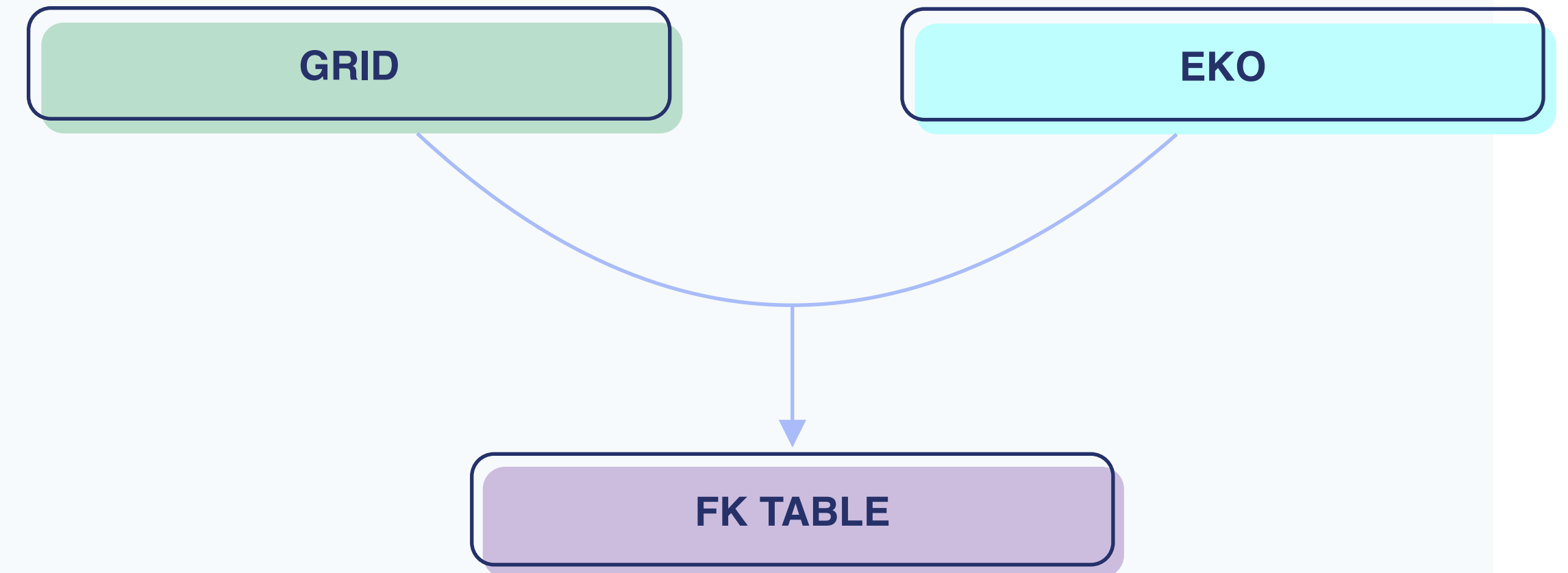
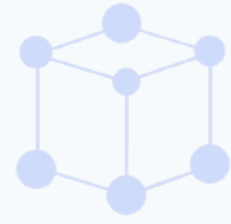
The Pipeline



Applications and outlook

# What we deliver

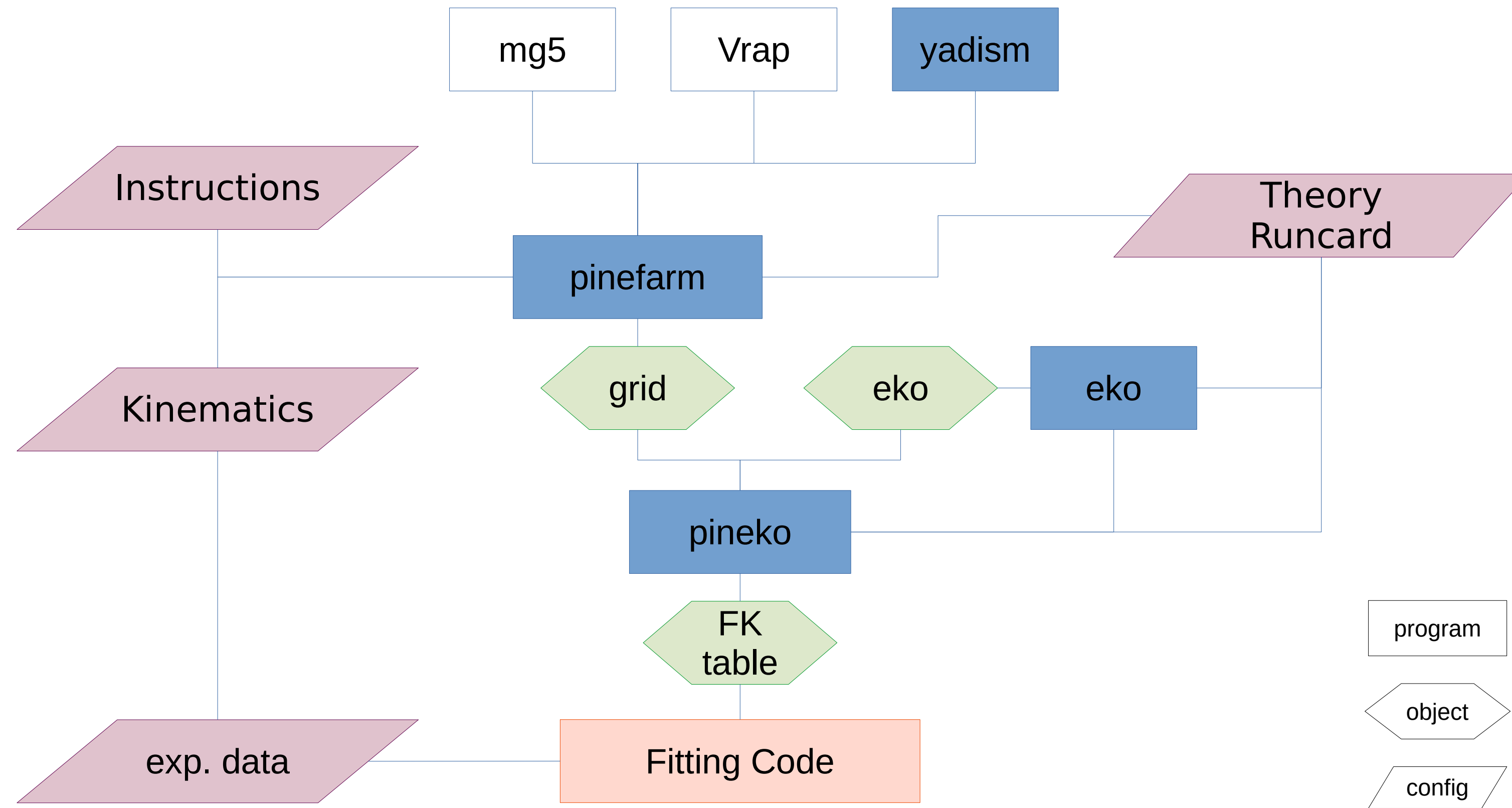
Fast Kernel (FK) tables [NuclPhysB838.136]



$$\begin{aligned} F(Q) &= \hat{\sigma}(Q) \otimes f(Q) \\ &= \hat{\sigma}(Q) \otimes E(Q \leftarrow Q_0) \otimes f(Q_0) \end{aligned}$$

$$F(Q) = FK(Q \leftarrow Q_0) \otimes f(Q_0)$$

# The pipeline flow



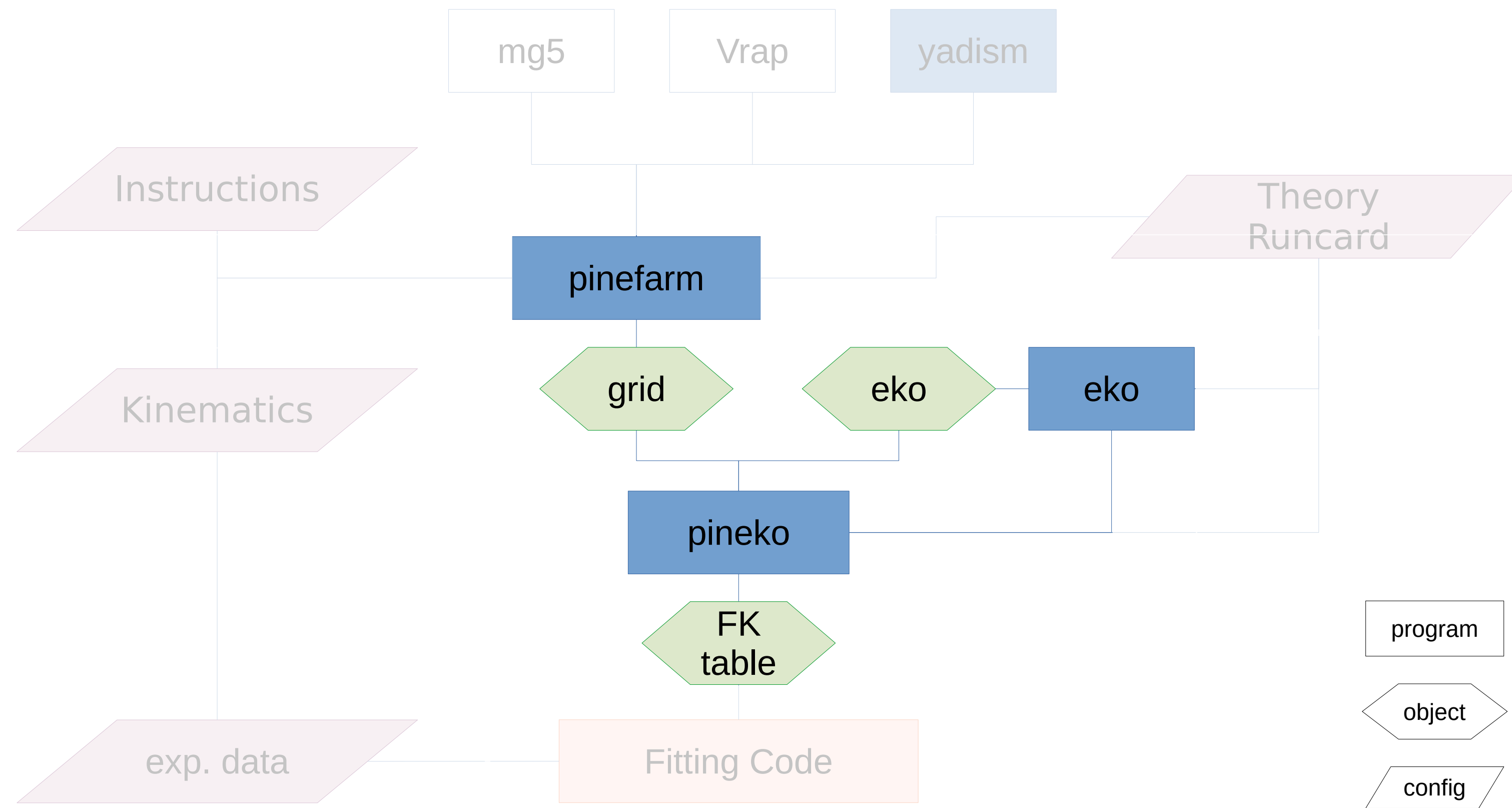
The workhorse in the background



PineAPPL



# The pipeline flow



The workhorse in the background

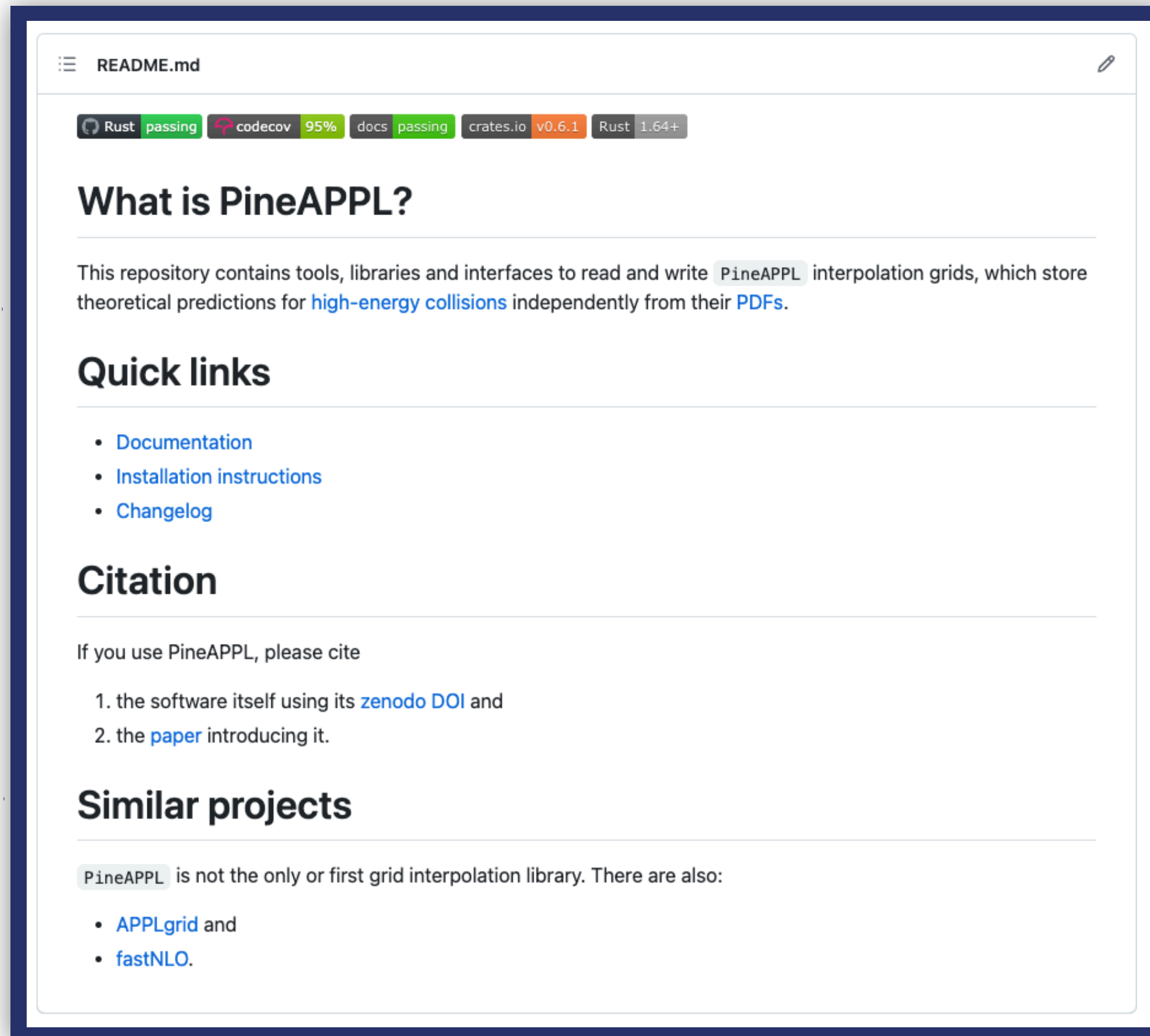


PineAPPL

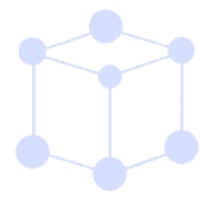
# PineAPPL [JHEP12.108]

 <https://github.com/NNPDF/pineappl>

 <https://nnpdf.github.io/pineappl>



The screenshot shows the README.md file for the PineAPPL repository. At the top, there are badges for Rust (passing), codecov (95%), docs (passing), crates.io (v0.6.1), and Rust (1.64+). The main heading is "What is PineAPPL?". Below it, a paragraph explains that the repository contains tools, libraries, and interfaces to read and write PineAPPL interpolation grids, which store theoretical predictions for high-energy collisions independently from their PDFs. There is a "Quick links" section with links to Documentation, Installation instructions, and Changelog. A "Citation" section provides instructions on how to cite the software, listing the software itself using its zenodo DOI and the paper introducing it. Finally, a "Similar projects" section mentions that PineAPPL is not the only or first grid interpolation library, and lists APPLgrid and fastNLO as other projects.



## Very flexible

Extends to arbitrary orders in QCD and EW



## Command line interface

*for everyday tasks*



## Fast interpolation grid library

Can convert APPLgrid and FastNLO

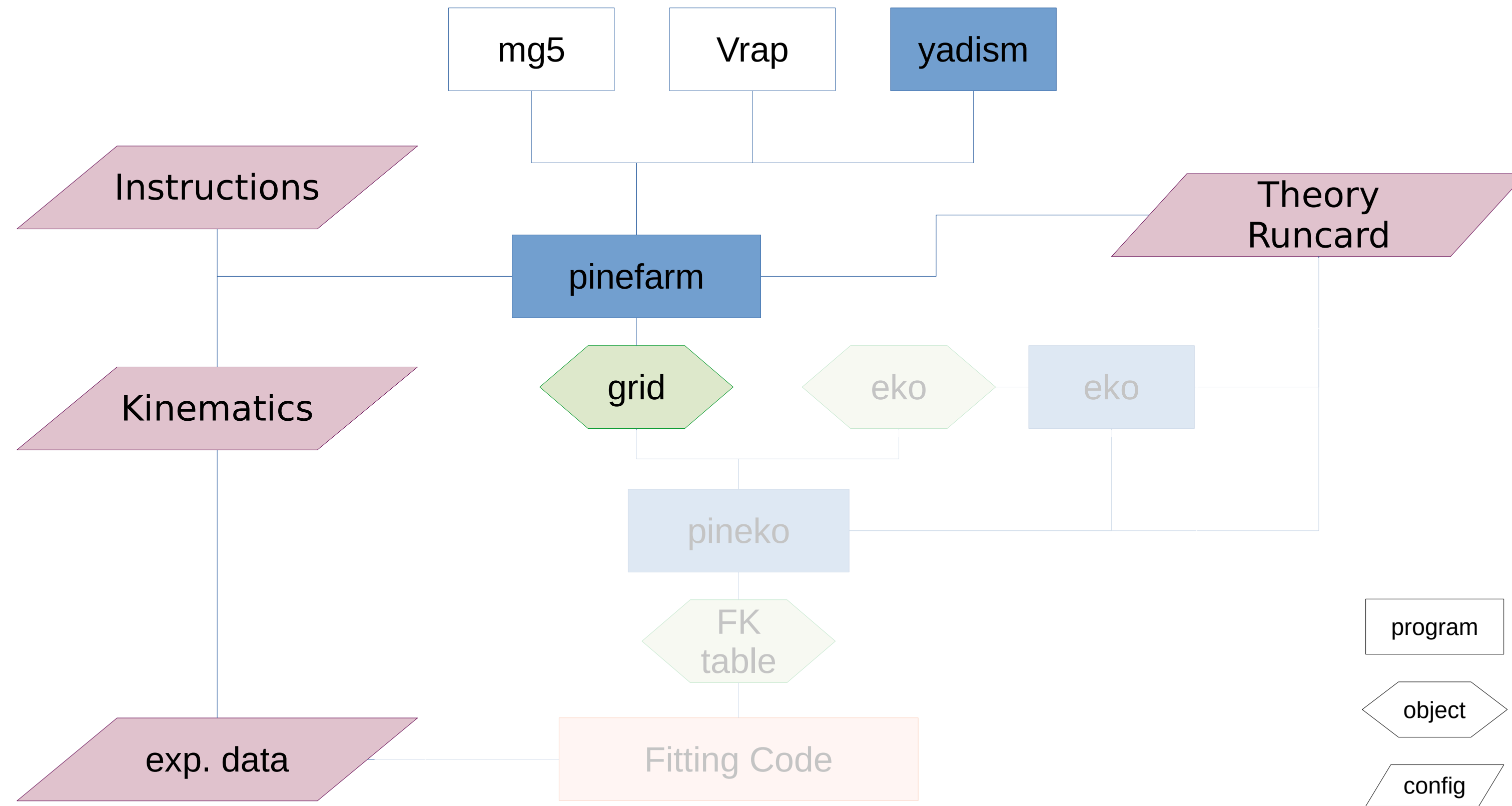


## Several interfaces

C, C++, Fortran, Rust, Python



# The pipeline flow



The workhorse in the background

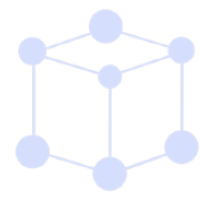


PineAPPL

# Pinefarm [HEP-PH2302.12124]

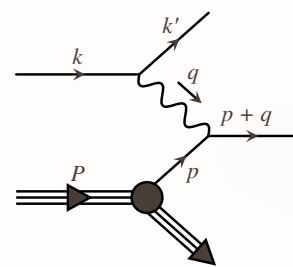
 <https://github.com/NNPDF/pinefarm>

 <https://pinefarm.readthedocs.io/en/latest>



## Different providers

MadGraph5, Vrap, Yadism, (Matrix)



## Yadism

Yet Another DIS Module

```

.....
. WELCOME to MADGRAPH5_aMC@NLO .
.                               .
.      *      *      *          .
.     * *    * *    * *       .
.    *  *  *  *  *  *  *      .
.   *   *   *   *   *   *     .
.  *    *    *    *    *    *  .
. *     *     *     *     *     .
.                               .
. The MadGraph5_aMC@NLO Development Team - Find us at
. https://server06.fynu.ucl.ac.be/projects/madgraph
. and
. http://amcatnlo.cern.ch
.
. Code download from:
. https://launchpad.net/madgraph5
.
. Please refer to: MadGraph5_aMC@NLO paper
. J. Alwall et al.
. arXiv:1405.0301, JHEP 1407 (2014) 079
.
.....
    
```



## Pinefarm

 tests passing  docs passing

Generate [PineAPPL grids](#) from [pinecards](#).

### Installation

pinefarm is available via

- PyPI: 

```
pip install pinefarm
```


### Dev

For development you need the following tools:

- `poetry`, follow [installation instructions](#)
- `poetry-dynamic-versioning`, used to manage the version (see [repo](#))
- `pre-commit`, to run maintenance hooks before commits (see [instructions](#))

See [below](#) for a few more dependencies (already available on most systems).

### Documentation

- The documentation is available here: 
- To build the documentation from source run these commands

```
poetry shell
cd docs
make html
make view
```



## Produces the grids

Calls a providers according to configs














## Standard input

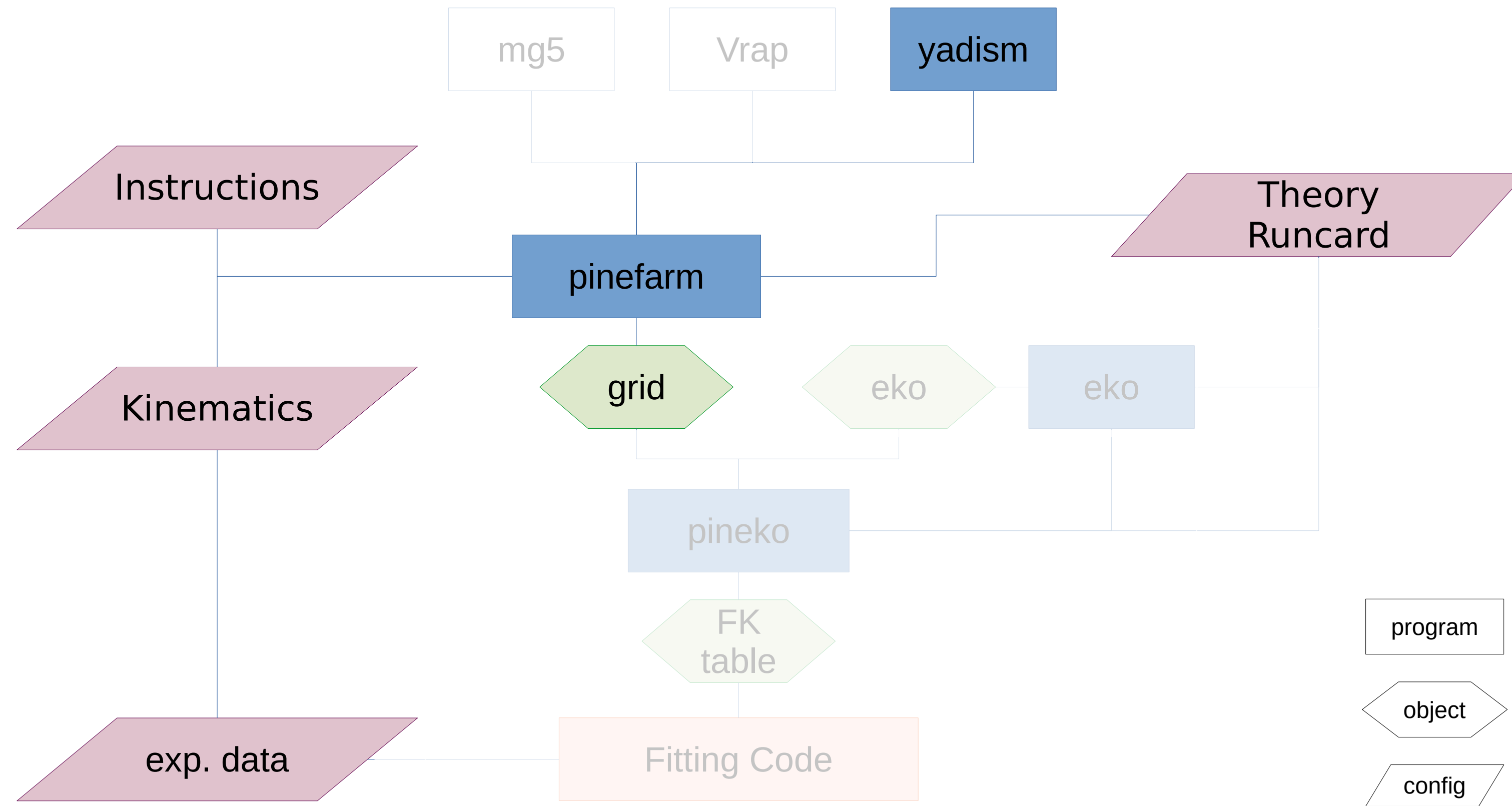
Pinecards format



<https://github.com/NNPDF/pinecards>

|  |   |              |
|--|---|--------------|
|  ATLAS_TTB_8TEV_IJ_TTRAP  | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  ATLAS_TTB_8TEV_TOT       | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  ATLAS_WM_7TEV            | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  ATLAS_WP_7TEV            | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  BCDMS_NC_EM_D_F2         | Export pinefarm to its own repo                           | 3 months ago |
|  BCDMS_NC_EM_P_F2         | Export pinefarm to its own repo                           | 3 months ago |
|  CHORUS_CC_NB_PB_SIGMARED | Export pinefarm to its own repo                           | 3 months ago |
|  CHORUS_CC_NU_PB_SIGMARED | Export pinefarm to its own repo                           | 3 months ago |
|  CMS_2JET_7TEV_0005       | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  CMS_2JET_7TEV_0510       | Fix ordering of model loading and model-specific settings | 2 weeks ago  |
|  CMS_2JET_7TEV_1015       | Fix ordering of model loading and model-specific settings | 2 weeks ago  |

# The pipeline flow

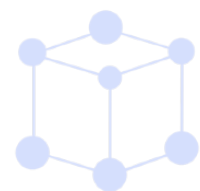


The workhorse in the background



PineAPPL

# Yadism [in preparation]

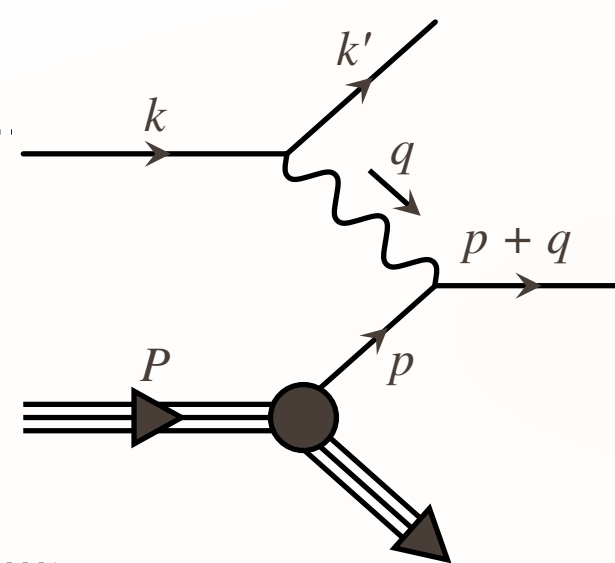


 <https://github.com/NNPDF/yadism>

 <https://yadism.readthedocs.io/en/latest/>

**Flavor number schemes**

FFNS, ZM-VFNS, FONLL



# Yadism

*Yet Another DIS Module*



**DIS provider**

Independent of boundary condition



**Benchmarked**

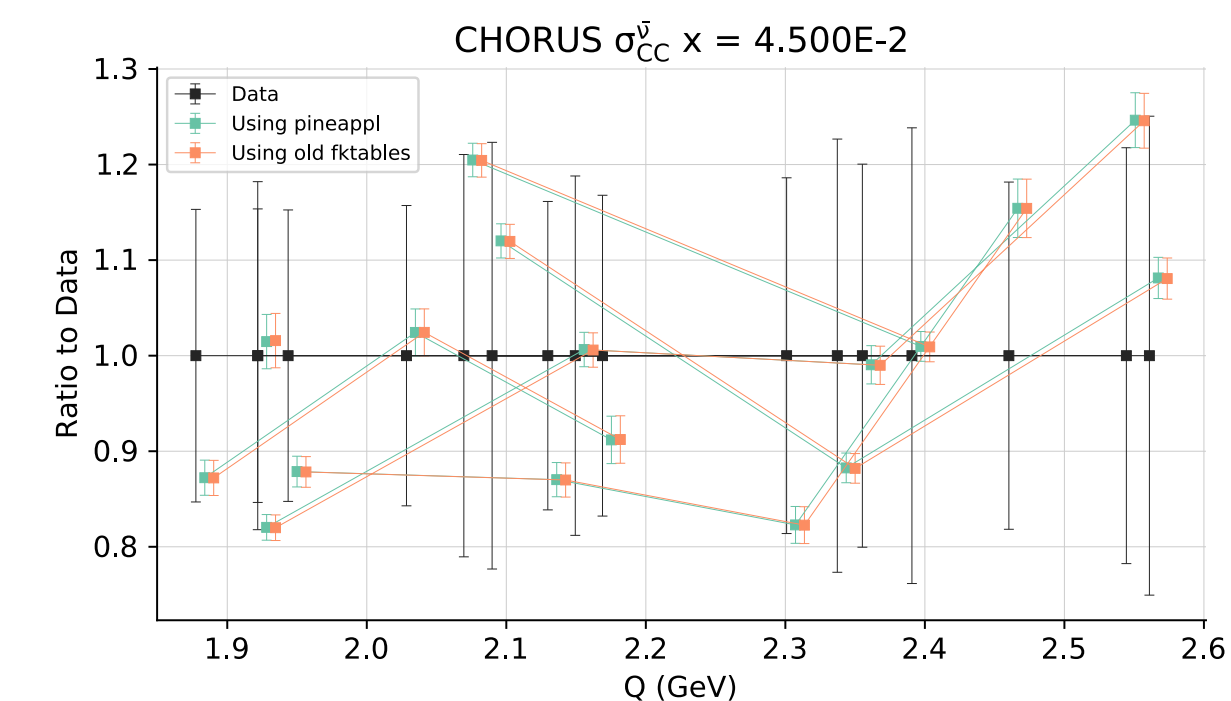
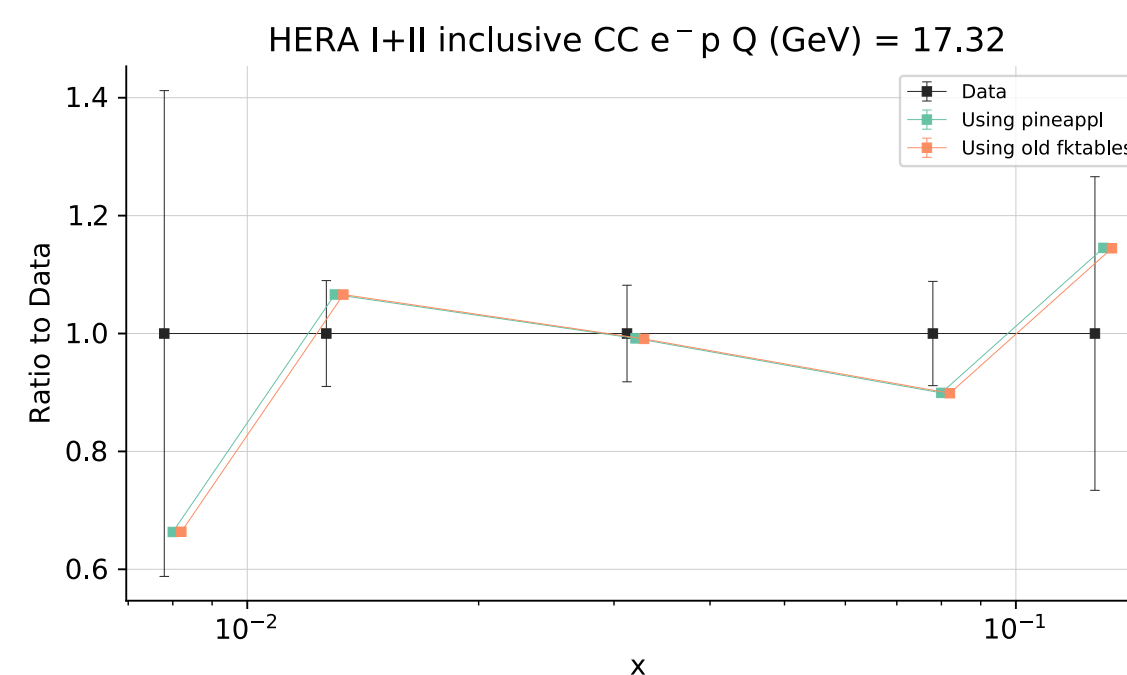
for example, with APFEL

**Coefficient function database**

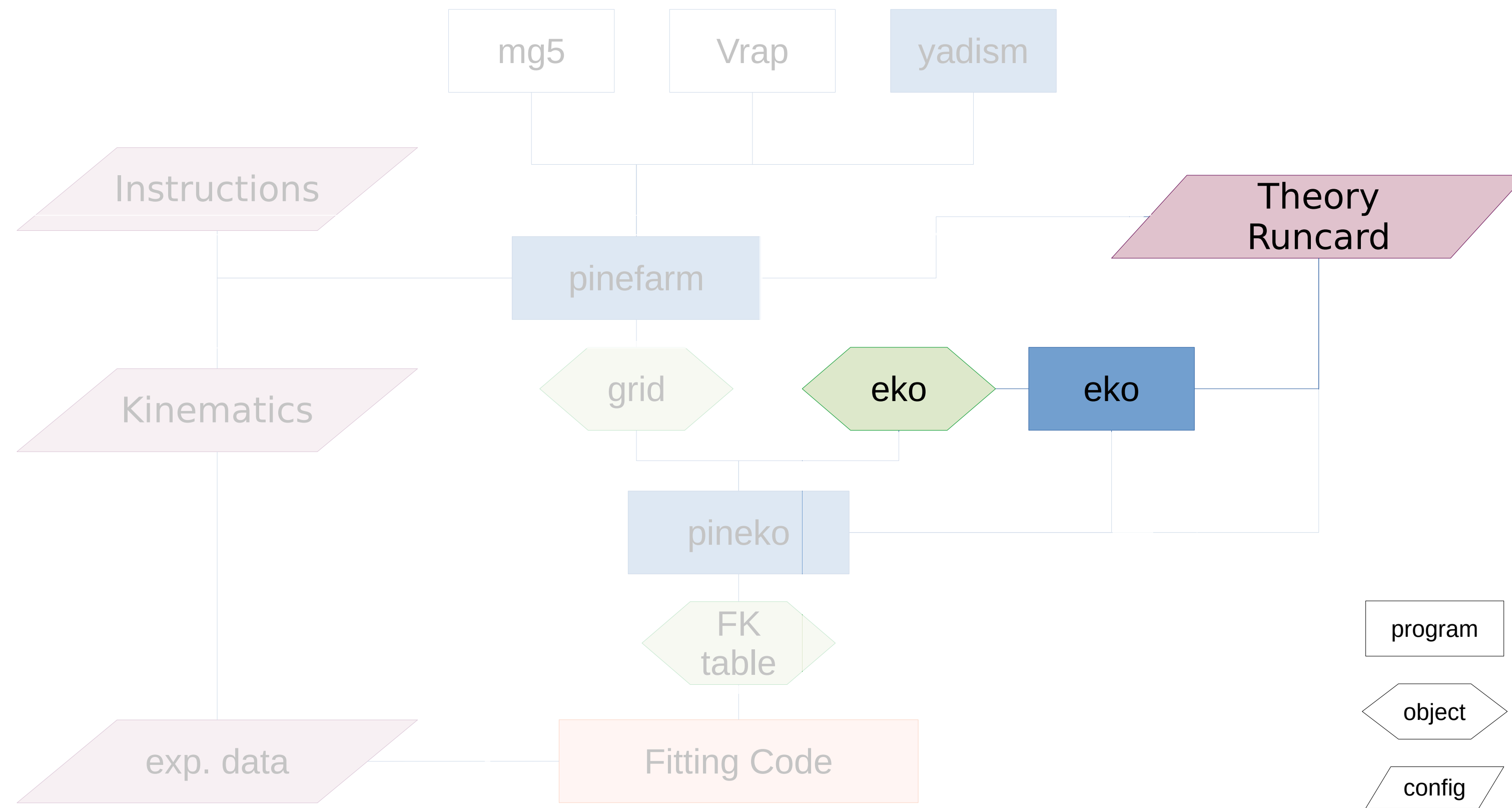
up to NNLO



|    | Light                     | Heavy                     | Intrinsic               |
|----|---------------------------|---------------------------|-------------------------|
| NC | $\mathcal{O}(\alpha_s^2)$ | $\mathcal{O}(\alpha_s^2)$ | $\mathcal{O}(\alpha_s)$ |
| CC | $\mathcal{O}(\alpha_s^2)$ | $\mathcal{O}(\alpha_s)$   | $\mathcal{O}(\alpha_s)$ |



# The pipeline flow



The workhorse in the background

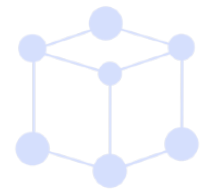


PineAPPL

# EKO [EPJC82.976]

 <https://github.com/NNPDF/eko>

 <https://eko.readthedocs.io/en/latest/>



**Mellin space solution**

but delivery in momentum space



**Backward VFNS evolution**

*across thresholds and with intrinsic*



**EKO**  
Evolution Kernel Operators



**Delivers DGLAP solution**

in terms of an evolution kernel operator (EKO)

$$f(Q) = E(Q \leftarrow Q_0) \otimes f(Q_0)$$



**Independent of boundary condition**







Introduction and motivation



The Pipeline



Applications and outlook

# Applications and (future) improvements



# Conclusions

- The Pipeline is a framework to produce High-Energy theory predictions in a fast and reproducible way
- It is completely Open Source and also provides interfaces to external providers
- It has been already used and it is being used for projects of PDF fitting but also for other kind of applications

## Industrialization of High-Energy theory predictions

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