



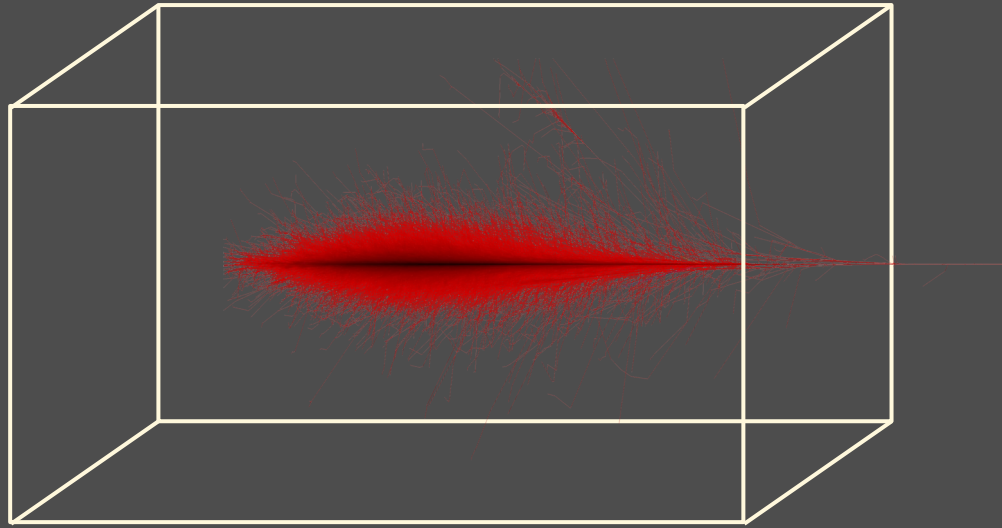
News on Universality-v2

Max Stadelmaier, supervised by

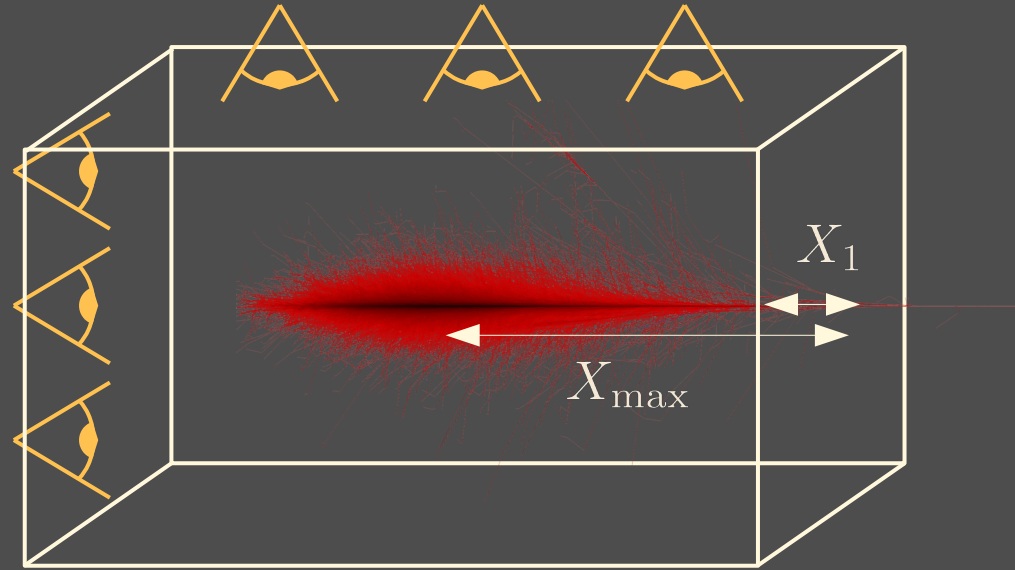
 Ralph Engel & Markus Roth

 Federico Sanchez

in a perfect world ...

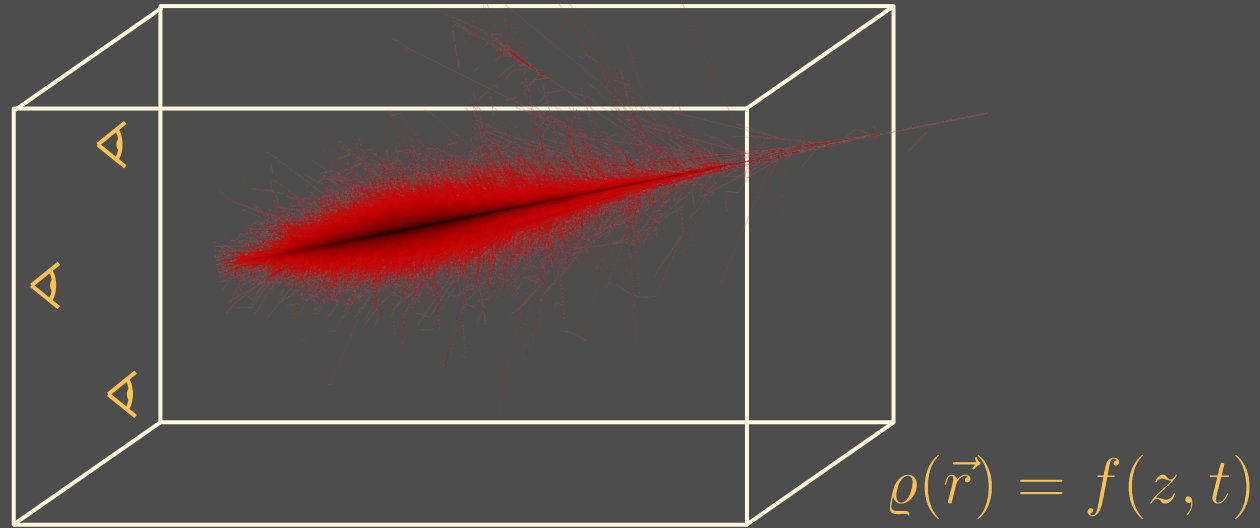


in a perfect world ...



$$\rho(\vec{r}) = \text{const.} \Rightarrow \sigma \simeq \frac{\rho}{\langle X_1 \rangle}$$

... sadly



- The atmosphere is not homogeneous, and
- we can not detect all particles or all light emitted by an air shower.

The solution: Universality

- Universality solves this issues by taking use of the fact that the development of air showers is very similar (*universal*), given only a few input parameters:

$$E, \vec{r}, R_{\mu}, X_{\max}$$

The solution: Universality

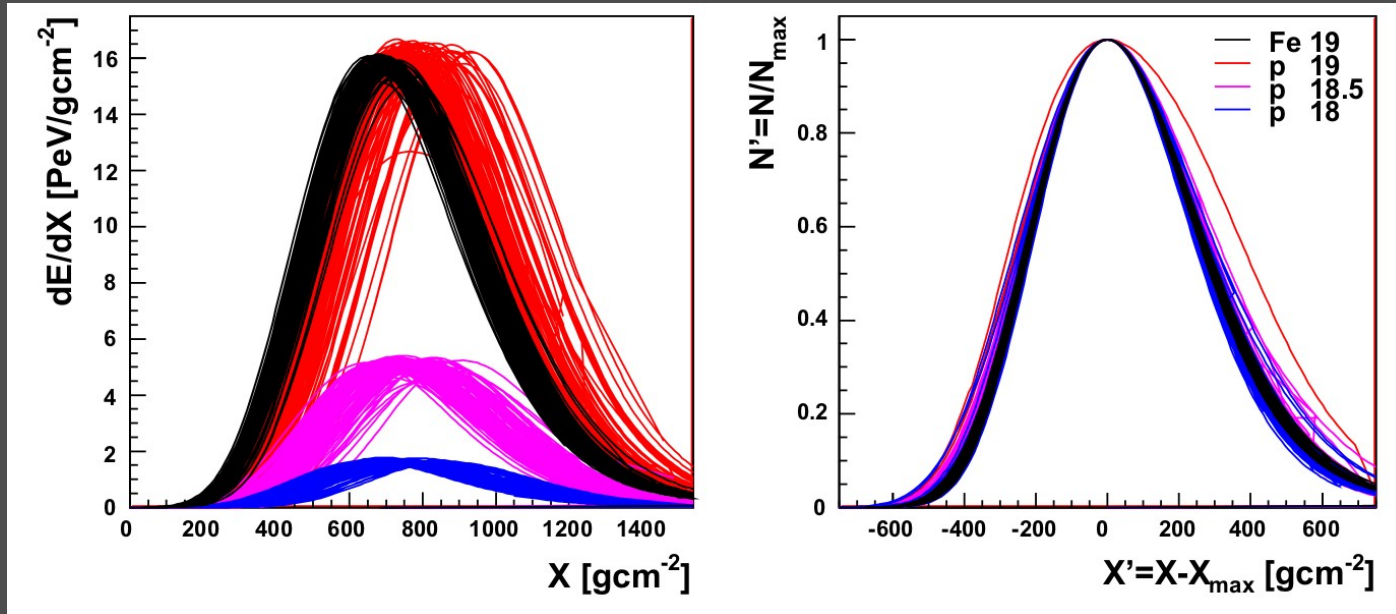
- Universality solves this issues by taking use of the fact that the development of air showers is very similar (*universal*), given only a few input parameters:

$$E, \vec{r}, R_{\mu}, X_{\max}$$

primary mass dependent!

In detail:

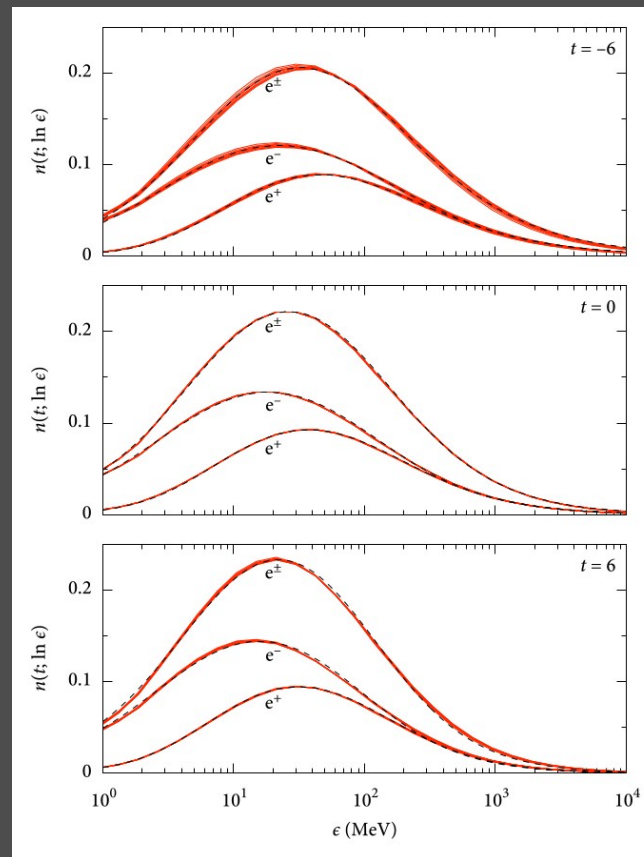
- Shape (energy deposit per depth) is universal w.r.t. $DX := X - X_{\max}$



[S. Andringa, R. Conceição, M. Pimenta, 2010]

In detail:

- Energy spectrum of most particles is universal w.r.t. $DX := X - X_{\max}$



In detail:

- The signal can be parametrized using a (modified) Gaisser-Hillas function.

$$S(\vec{r}) = \sum_{i=1}^4 S_{\text{ref}}^i(r) f_{\text{mod}}^i(\psi, r) f_{R_{\mu}}^i \left(\frac{E}{E_{\text{ref}}} \right)^{\gamma} \left(\frac{DX - DX_0}{DX_{\text{ref}} - DX_0} \right)^{\frac{DX_{\text{max}} - DX_0}{\lambda}} e^{-\frac{DX - DX_{\text{ref}}}{\lambda}}$$

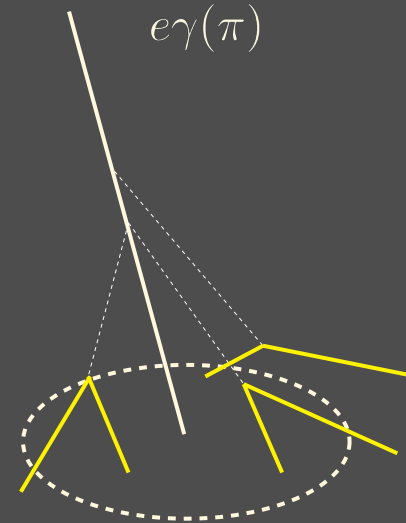
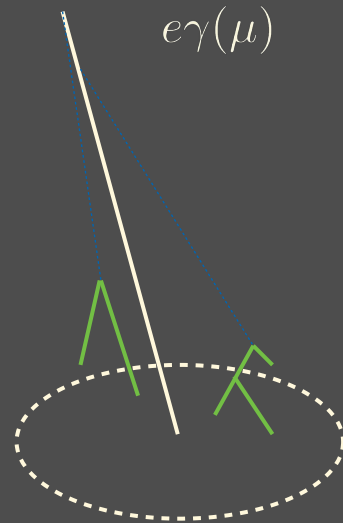
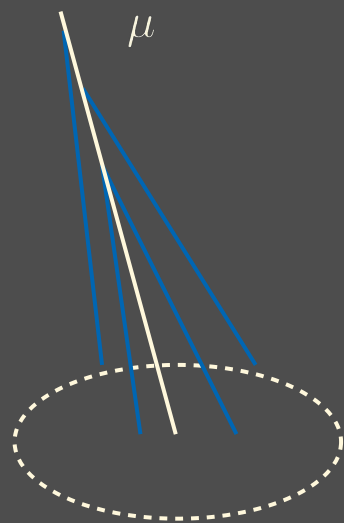
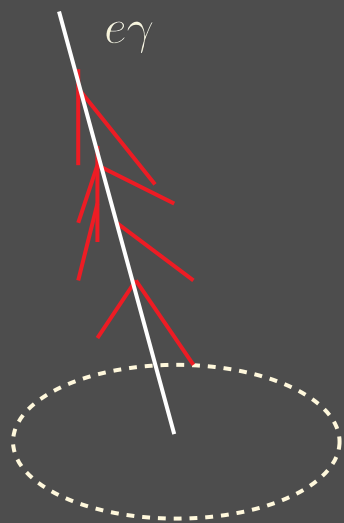
[M. Ave, R. Engel, M. Roth, A. Schulz, 2016]

- Also the time-dependent signal structure can be parametrized, using a log-normal function.

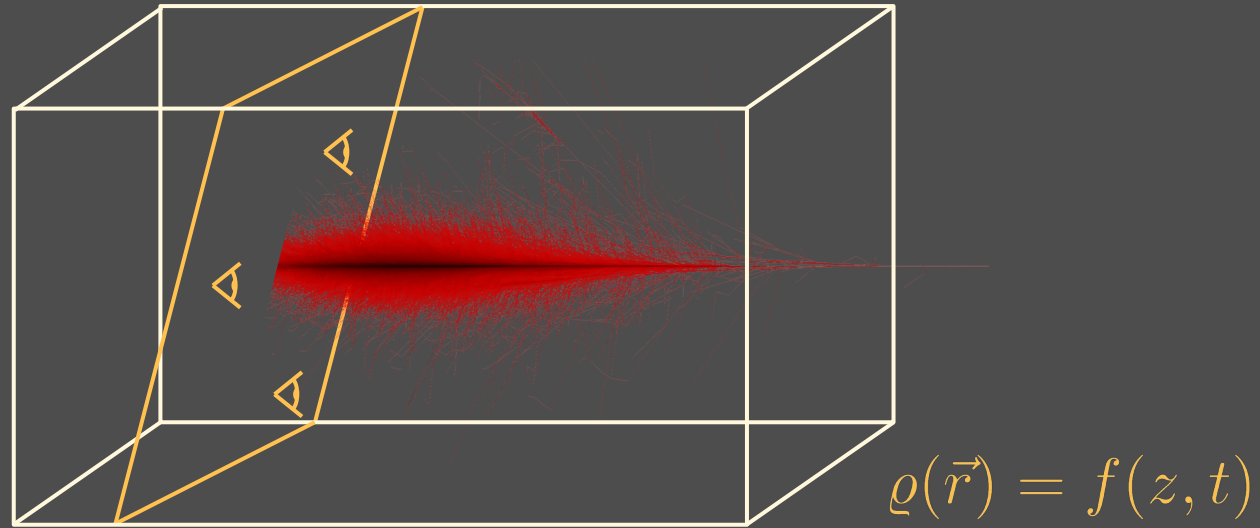
[M. Ave, M. Roth, A. Schulz, 2016]

In detail:

- The parametrization is done individually for all detectors and particle components.



Back to reality



- Given a two-dimensional cut through the shower (ground level), the whole shower shape can be reconstructed.

Status of Universality

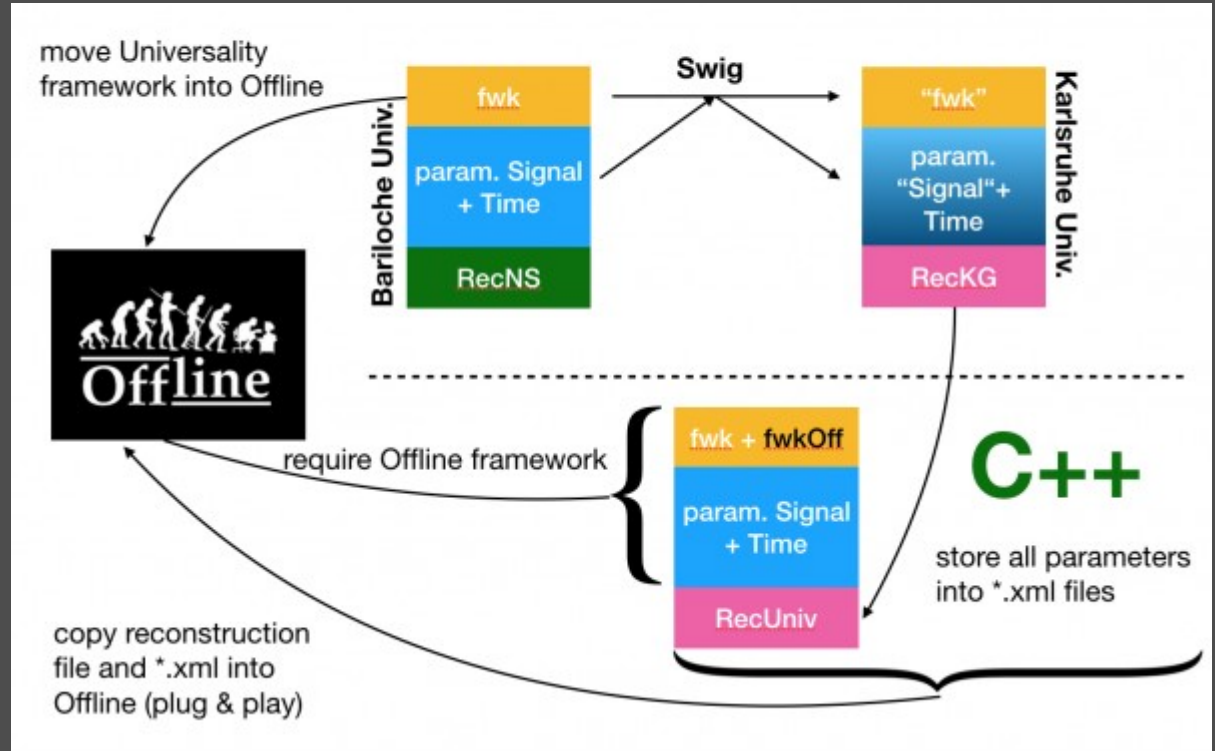
- Two frameworks present: Karlsruhe and Bariloche. Both have their own advantages and disadvantages.
- Both frameworks use an ideal detector response function (not sensitive to fluctuations).
- Both frameworks hard to further develop.

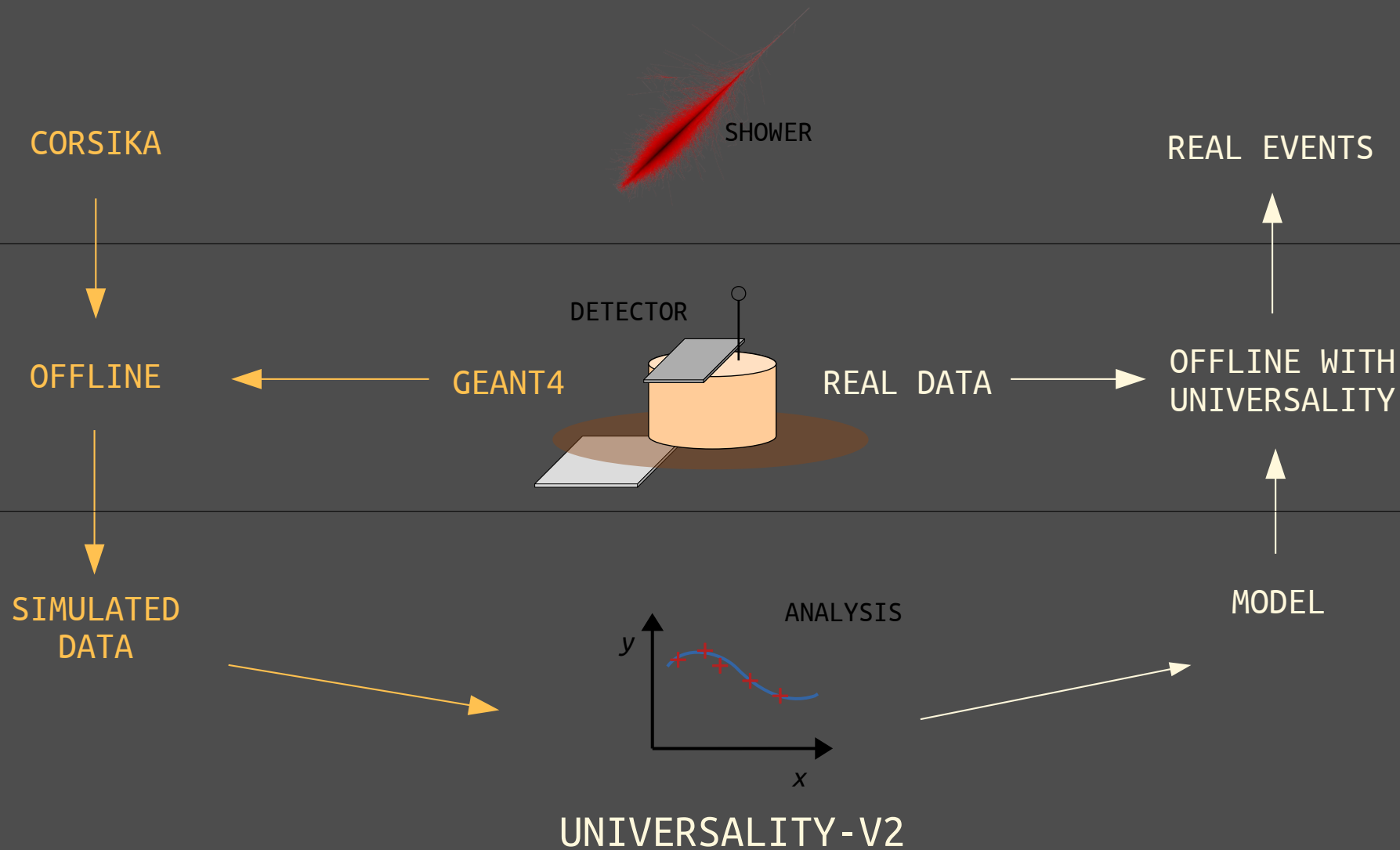
Start over!

→ Universality-v2

Code overview

- Avoid mixing of programming languages
- Use easy-to-handle file formats
- Use full Offline simulations



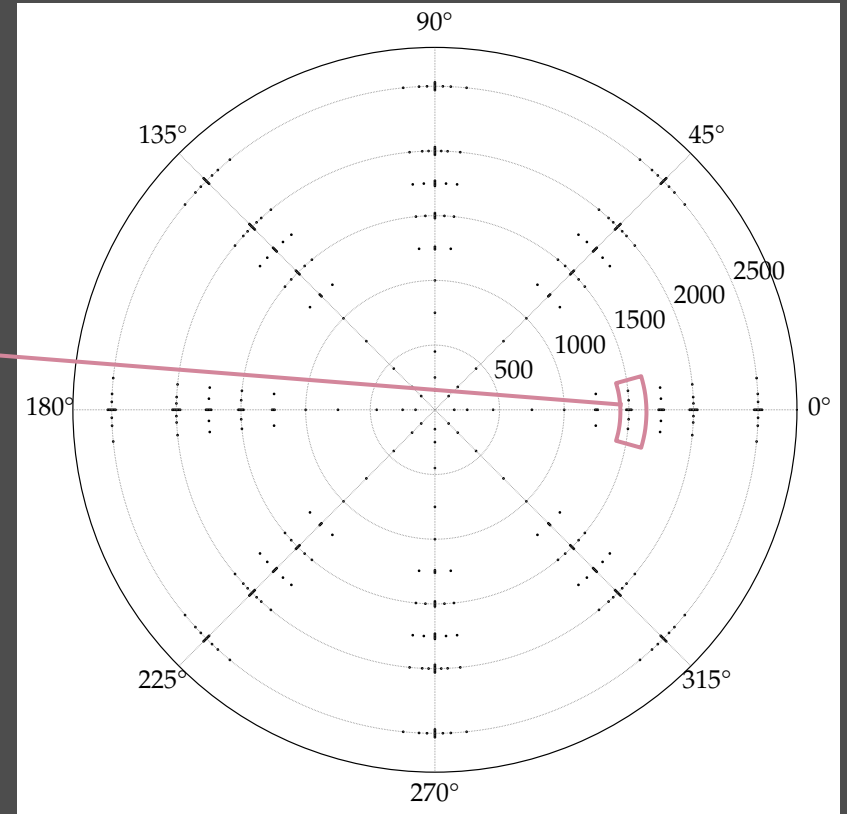
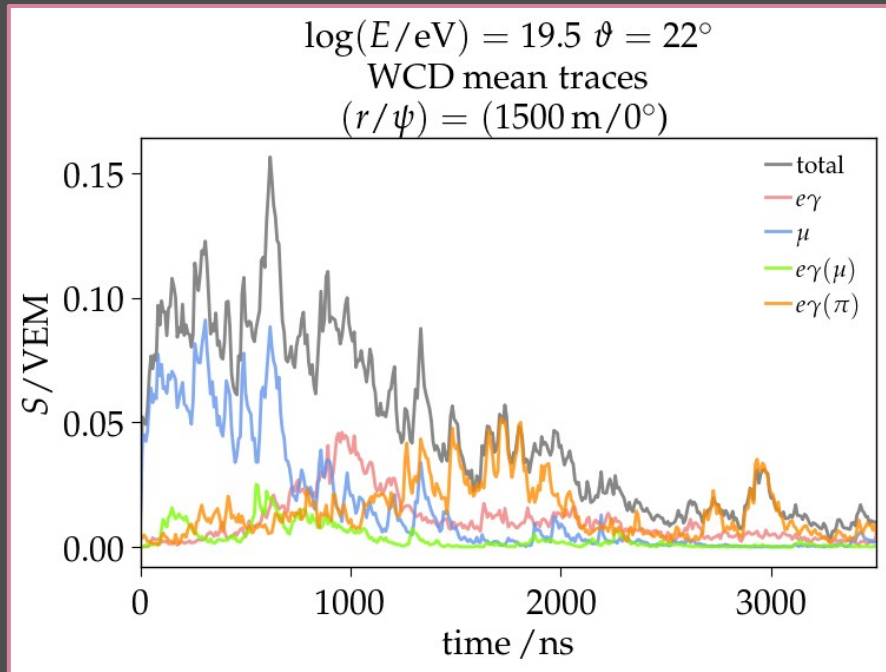


Universality-v2

- Currently in development
- Find it on git:

<https://gitlab.ikp.kit.edu/shower-universality/universality-v2>

Offline simulations

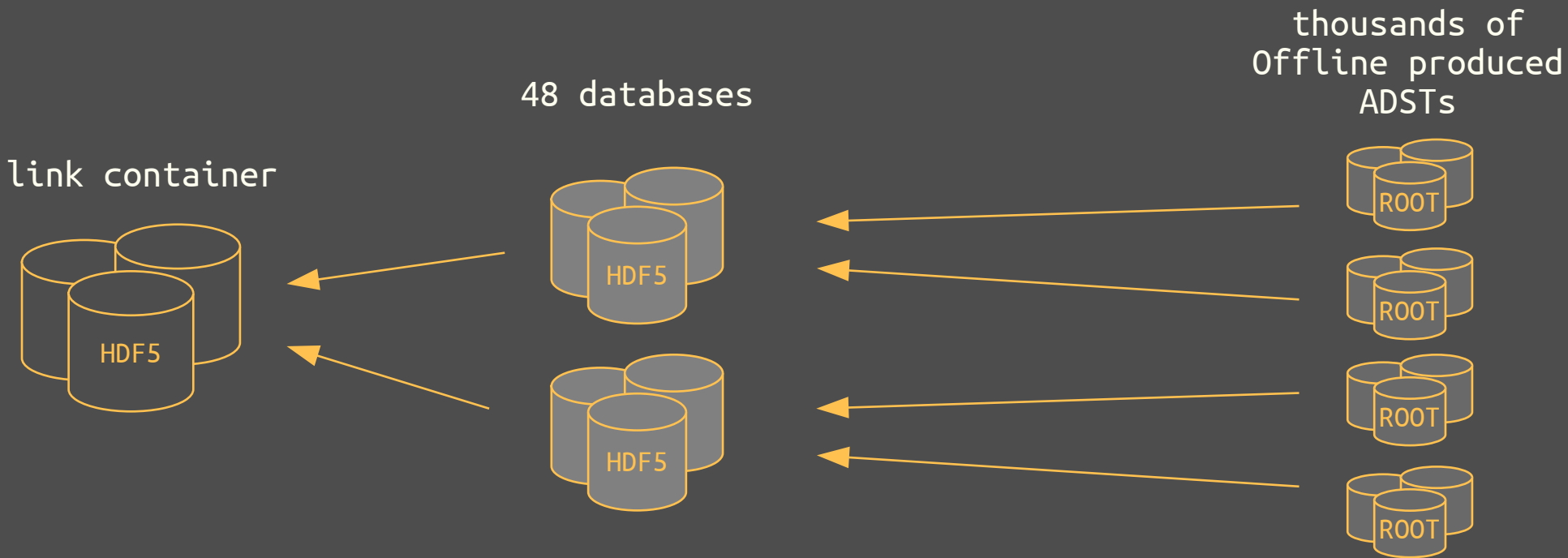


<https://gitlab.ikp.kit.edu/shower-universality/universality-v2/blob/master/python/denseGenerator.py.in>

Offline simulations

- This way we can account for (and estimate) fluctuations and still produce a mean expected signal.
- Sadly, a little computing effort is required.

Data handling

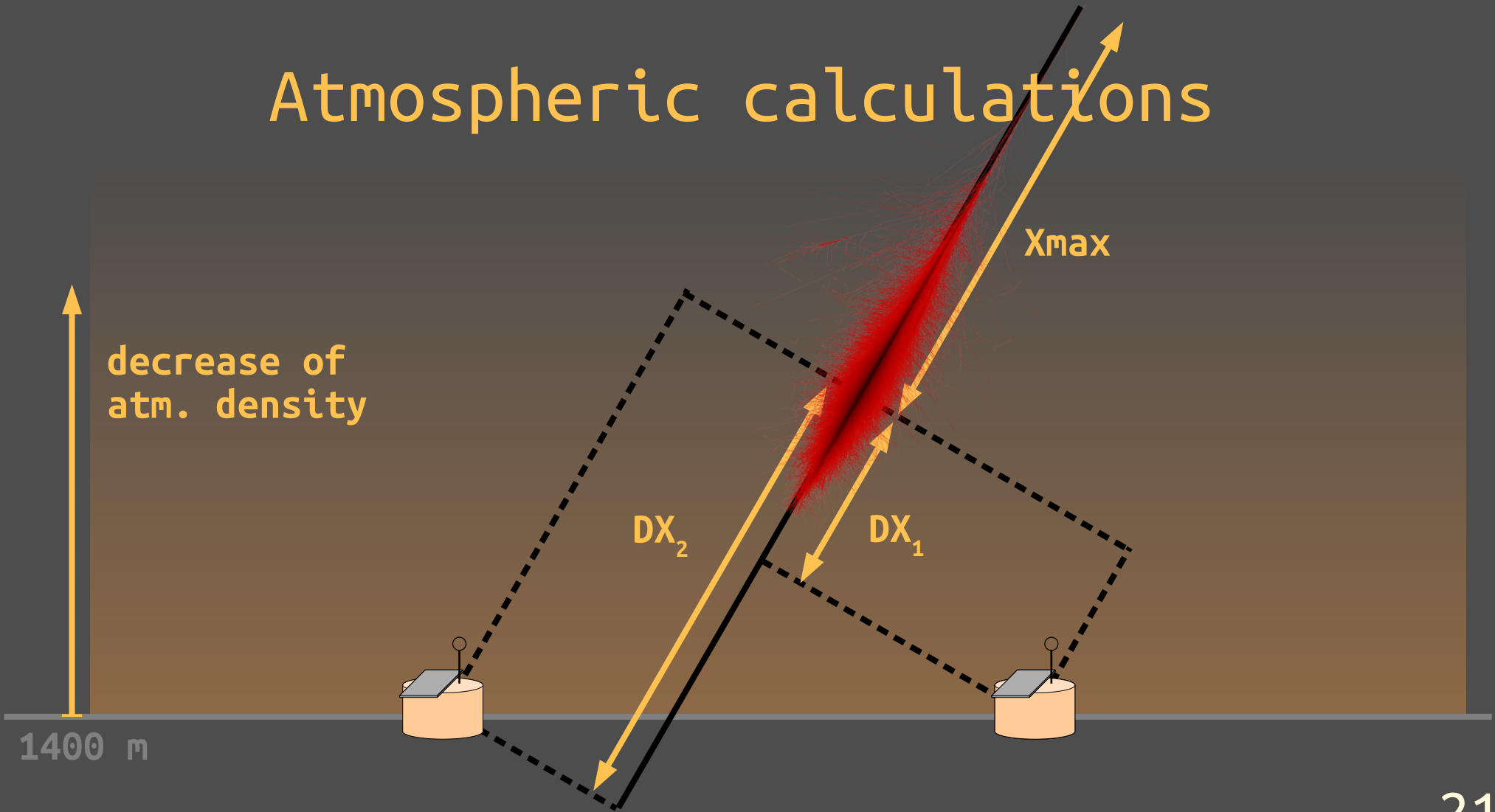


<https://gitlab.ikp.kit.edu/shower-universality/universality-v2/tree/master/data/>

Data handling

- Data is compressed by a factor of ~ 100 .
- Readout of multi-event-observables in microseconds.

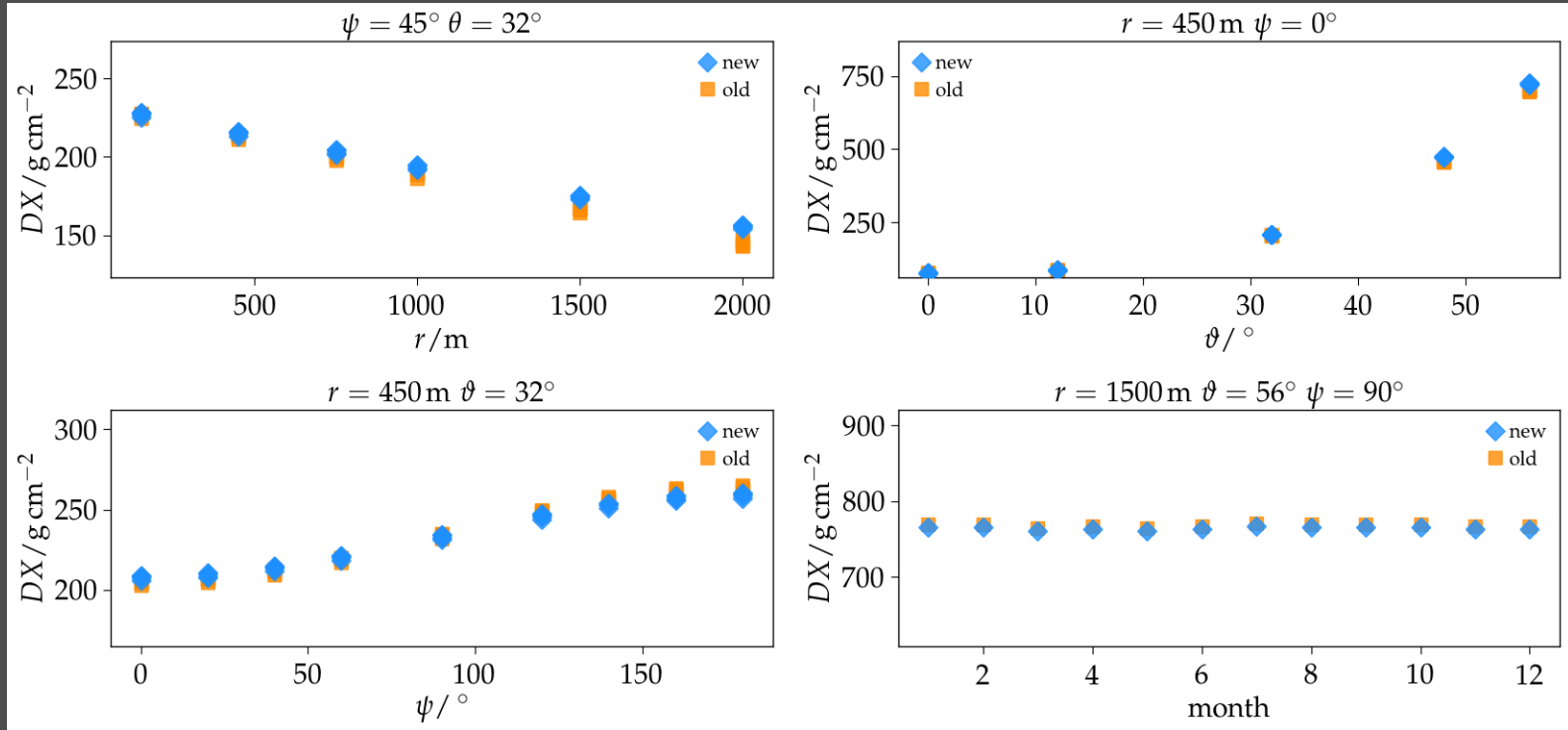
Atmospheric calculations



Atmospheric calculations

- Now:
Calculating DX only with hard-coded monthly CORSIKA atmospheres
Offline: `include/tls/Atmosphere.h`
- Future:
Use the same routines and data as FD (especially for real events), apply monthly corrections by “gauging” technique

Atmospheric calculations



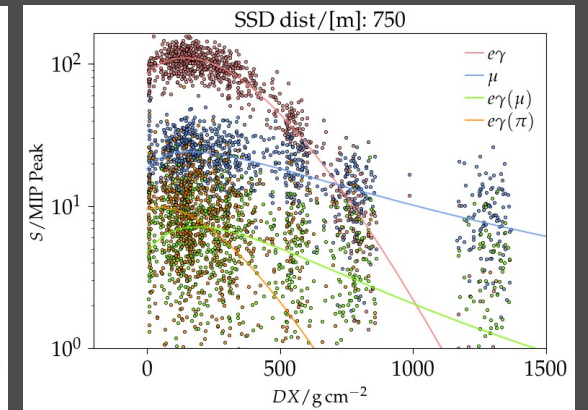
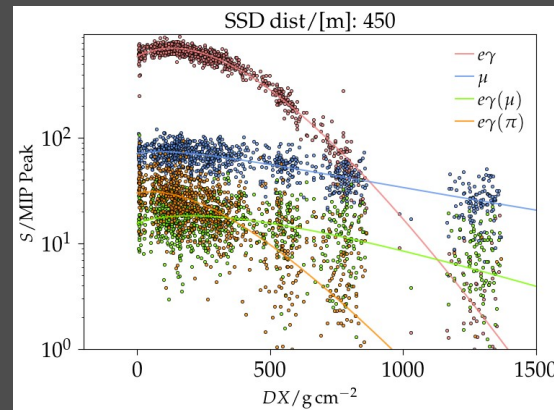
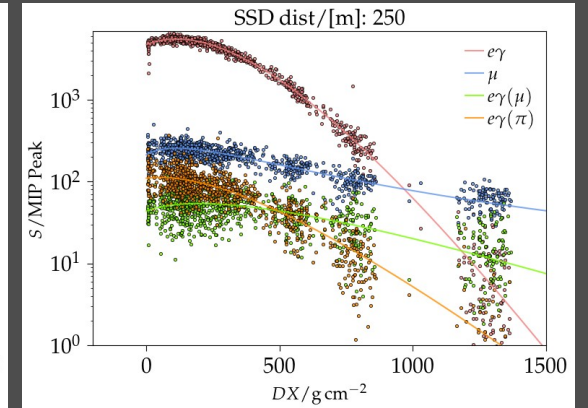
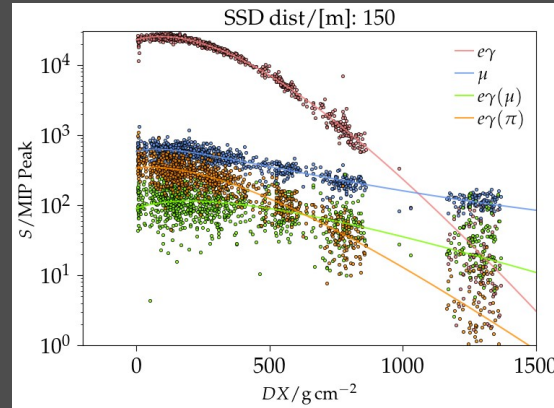
<https://gitlab.ikp.kit.edu/shower-universality/universality-v2/blob/master/misc/CalcDX.cc>

Signal parametrization

- Fit of the modified GH-function for all events and all sampling areas.

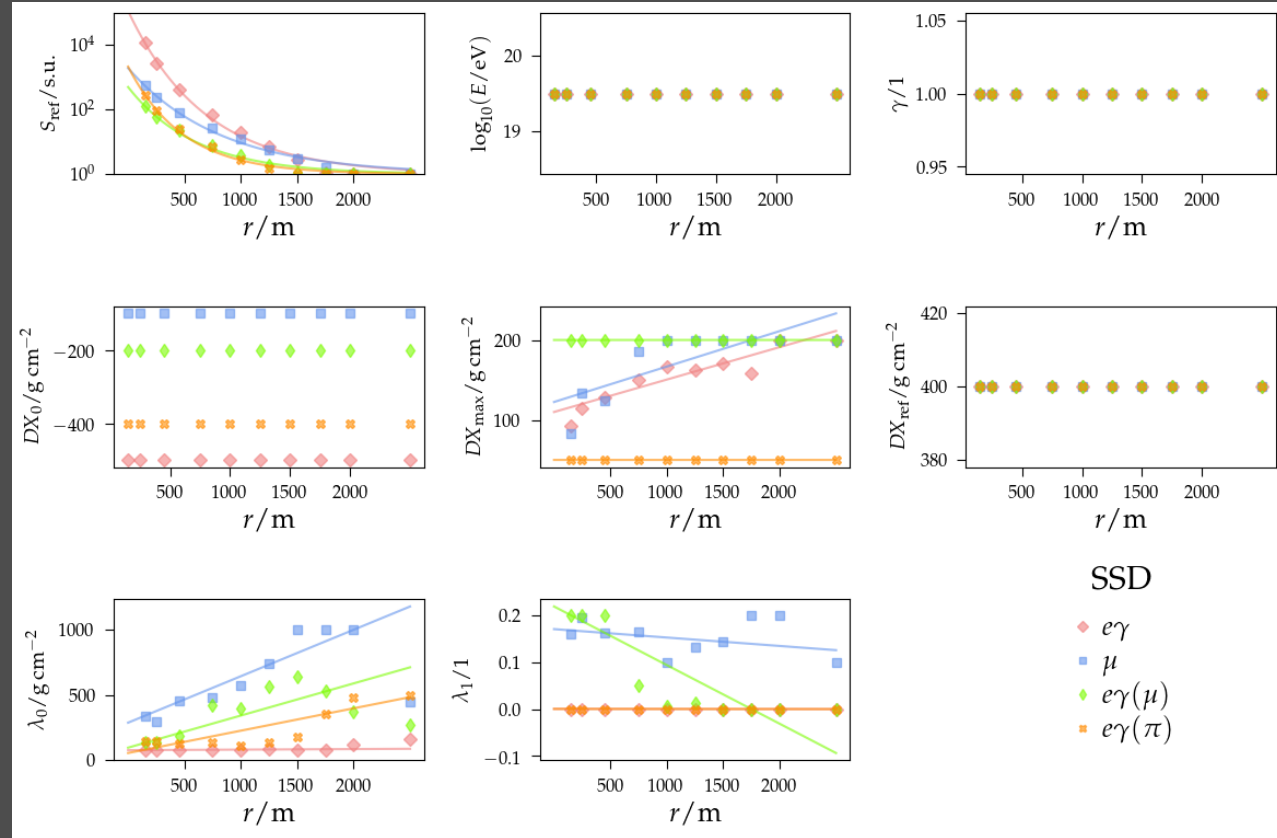
- All fits run by Minou.

[D. Veberic, M. Schimassek]



Signal parametrization

- Combined results yield the model (very preliminary!).
- Results stored in XML format!



Haptic of the framework

- Idea:
Plug-and-play
in the
bootstrap.xml
- Existent
parametrizations
could be imported
via XML.

```
1 <?xml version="1.0" encoding="iso-8859-1"?>$
2 $
3 <!DOCTYPE bootstrap [ $
4 <!ENTITY standardFdIdealDetConfig SYSTEM '$ENV{AUGEROFFLINEROOT}/share/auger-offline/config/standar
5 <!ENTITY standardSdIdealDetConfig SYSTEM '$ENV{AUGEROFFLINEROOT}/share/auger-offline/config/standar
6 ]>$
7 $
8 <bootstrap$
9   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"$
10  xsi:noNamespaceSchemaLocation='$ENV{AUGEROFFLINEROOT}/share/auger-offline/config/bootstrap.xsd'$
11  xmlns:xlink="http://www.auger.org/schema/types">$
12  $
13  &standardFdIdealDetConfig;$
14  &standardSdIdealDetConfig;$
15  $
16  <!--$
17    CAVEATS
18    this bootstrap is to be used for handling of simulations and$
19    simulations only. the detector config is therefore the ideal detector$
20  -->$
21  $
22  <centralConfig>$
23  $
24    <configLink$
25      id       = "PrototypeSignalModel"$
26      type    = "XML"$
27      xlink:href = "${prefix}/analysis/prototyping_fit_parameters.xml"/>$
28  $
29    <configLink$
30      id       = "AzimuthCorrectionParameters"$
31      type    = "XML"$
32      xlink:href = "${prefix}/analysis/azimuthal_corrections.xml"/>$
33  $
34  </centralConfig>$
35  $
36  <parameterOverrides>$
37  $
38  <!-- none -->$
39  $
```

Haptic of the framework

- Offline *and* universality functions are callable and configured with the bootstrap.xml!
- Offline must be installed!

```
22:19 eol:~/Universality/universality-v2 (*) master [46f9782] modified ✖
> ./bin/CalcDX -p 1000 90 1452 850 12 3 0 0 0

UNIVERSITY
UNIVERSALITY

you have chosen
r /[m]:          1000
psi /[degree]:   90
ground_level /[m]: 1452 (not used for simulations!)
Xmax /[g/cm**2]: 850
theta /[degree]: 12
month /[1..12]:  3
additional flags
silent:          0
use_DL:          0
use_old_routine: 0

[WARN] Utilities/Reader/Reader.cc:179: Parse: No schema (.xsd) document is available for file "/home/max/Universality/universality-v2/analysis/prototyping_fit_parameters.xml". It will not be validated!
[WARN] Utilities/Reader/Reader.cc:179: Parse: No schema (.xsd) document is available for file "/home/max/Universality/universality-v2/analysis/azimuthal_corrections.xml". It will not be validated!
[WARN] Framework/CentralConfig/CentralConfig.cc:741: CheckFingerprints: No configuration-time MD5 fingerprint found for the following configuration files. Checking the validity of these configuration files is impossible.
- azimuthal_corrections
- prototyping_fit_parameters

[INFO] Framework/FDetector/FdAlwaysUpManager.cc:39: Init: FdAlwaysUpManager initialized

[WARN] Framework/Manager/VManager.cc:32: FindConfig: Attempt to initialize an already initialized manager: FdAlwaysUpManager
[INFO] Framework/FDetector/FFixCalibManager.cc:61: Init: fixed calibration constant is 5 ph/ADC
[INFO] Framework/Detector/Detector.cc:81: Detector: Could not access a configuration file for the RManagerRegister. The Detector interface will not be able to get information about Radio (this is not an error, unless you are planning to use radio detector information).
[INFO] Framework/Detector/Detector.cc:96: Detector: Could not access a configuration file for the MManagerRegister. The Detector interface will not be able to get information about the MD (this is not an error, unless you are planning to use muon detector information).
```

Haptic of the framework

- Comes with a python package to plot data/fits/... directly from HDF5 and XML

```
17 import argparse # parse arguments from bash com
18 import subprocess # using the CalcDX executable$
19
20 # local stuff$
21 import scilmarill $
22 $
23 base = scilmarill.basedirectory.basedirectory$
24 $
25 ns_bin = scilmarill.constants.ns_bin$
```

```
22:28 eol:~/Universality/universality-v2 (*) master [46f9782] modified ✖
> py python/plot_DX.py
```



→ the python assistant

```
-> r 450 psi 45 theta 32 month 8 DX 213.672
```

Outlook

- 0(10) months:
Flexible, easy to handle framework for
Universality
- By the end of my thesis (*hopefully!*):
Primary mass estimation on event level

Questions?