KM3NeT Instrument Response Function for DM and EU TSPs

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EOSC-Future ESCAPE Science Projects progress meeting

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Motivation

- Provide an effective tool, which can extract IRF information from KM3NeT simulation data
- Flexibility in operation and user-defined IRF interface
- Compatibility with other astrophysical analysis, like CTA which is based on gammapy
- Easy installation procedure (preferred pip installation package)
- Different options for output (fits, histograms, tables, GADF)

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Overview of the KM3NeT detector

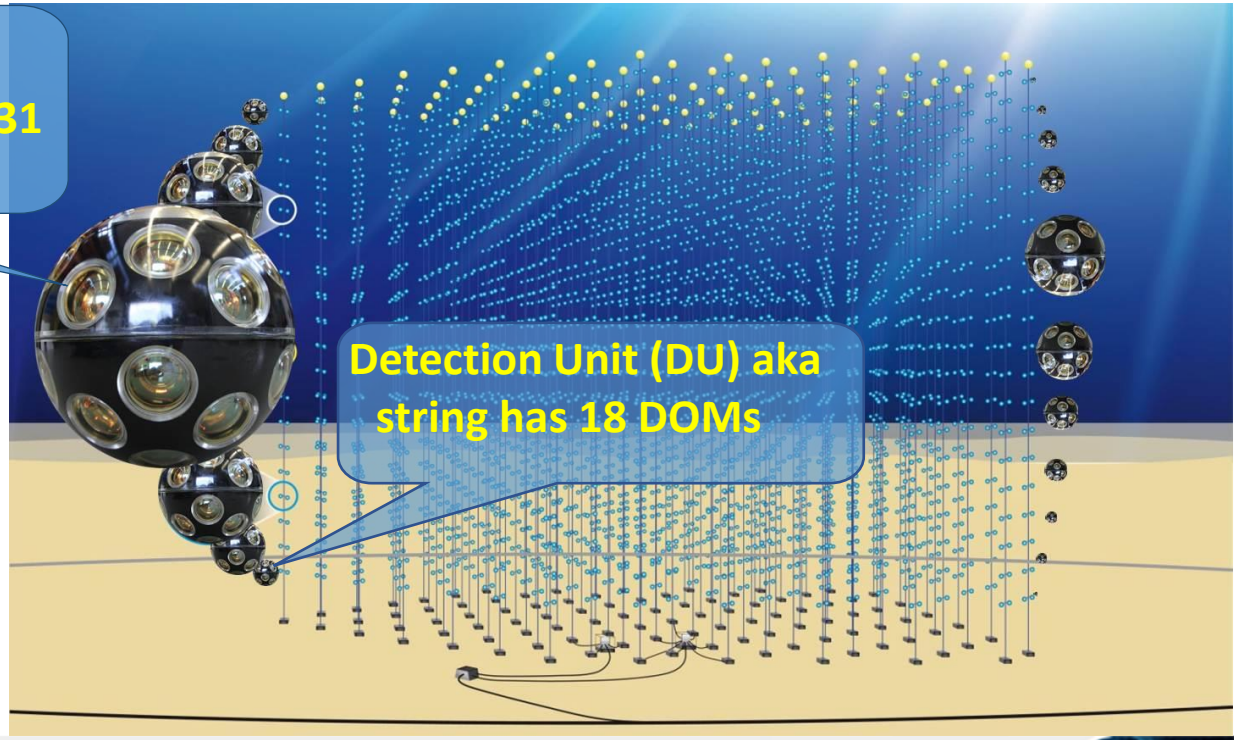
KM3NeT is a setup of two underwater neutrino telescopes with broad physical program (cubic kilometer neutrino telescope)

J.Phys. G43 (2016) 084001

KM3NeT/ARCA (**A**stroparticle **R**esearch with **C**osmics in the **A**byss)
discovery and observation of HE cosmic neutrino sources
(E_ν ~ GeV-PeV) high energy neutrinos
Depth – 3500 m – offshore Sicily (Italy)

KM3NeT/ORCA (**O**scillation **R**esearch with **C**osmics in the **A**byss)
determination of the neutrino mass hierarchy
(E_ν ~ MeV – GeV) low energy neutrinos
Depth – 2500 m – offshore Toulon (France)

Parameter	ARCA	ORCA
DU distance	90 m	20 m
DOM spacing	36 m	9 m
DU height	~ 800 m	~ 200 m
Instrumented mass	2*500 Mton	7 Mton
Amount of DUs	115*2	115



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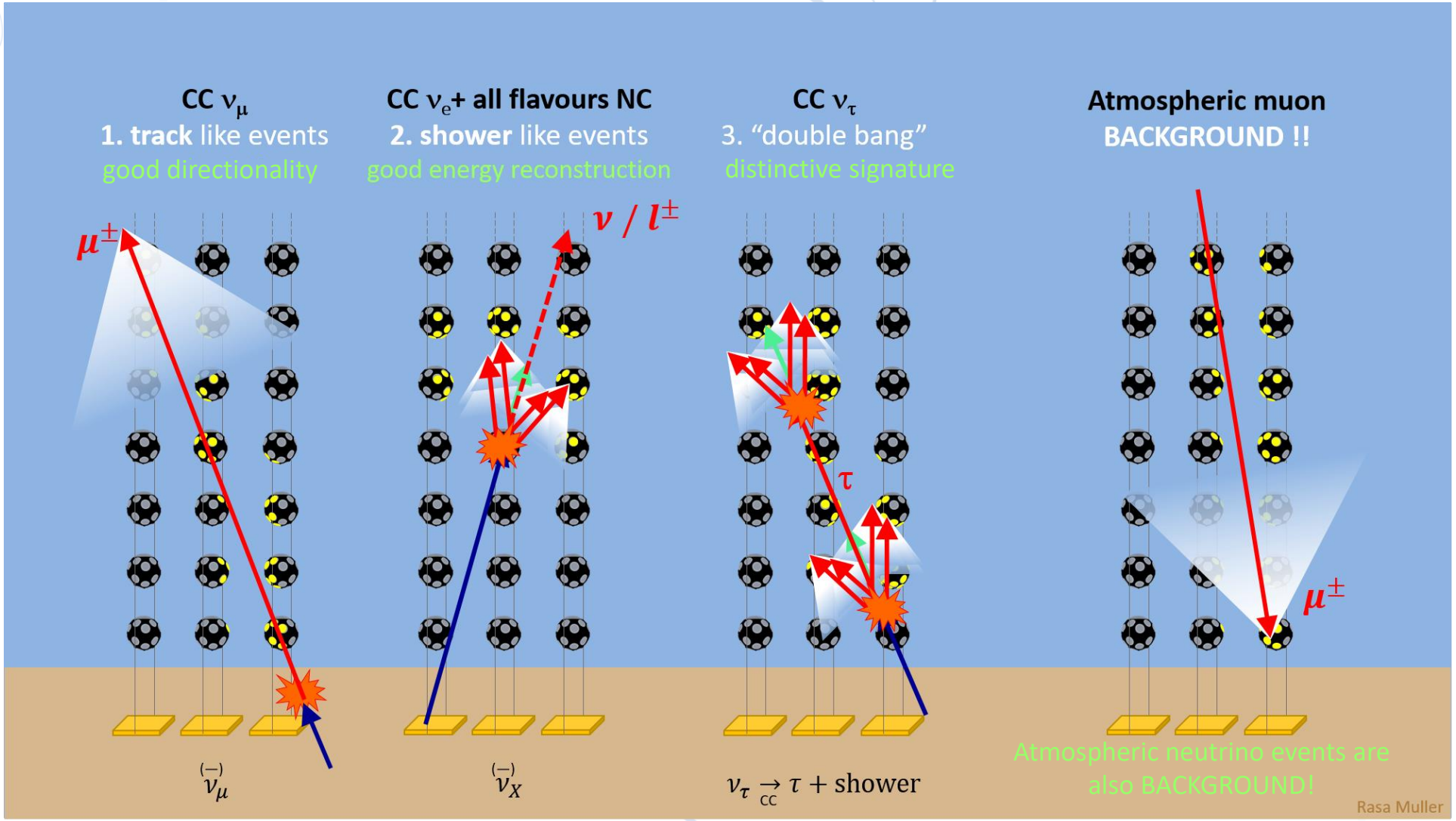
Neutrino event topology



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What is IRF in KM3NeT?

- IRF is a property of a neutrino telescope
- It contains information about the physical characteristics of the detector, such as angular resolution, energy resolution, effective area or volume of the detector
- It allows to quickly estimate the background
- In gammapy the IRF consists of 4 parts:
  - Effective area
  - Energy dispersion
  - Point spread function
  - Background

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Required improvements of gammapy IRF

- Flexibility in choice of particle types and interactions
- Adding more realistic parameter for neutrino telescope such as the effective volume
- User-defined selection cuts and reweighting procedure
- Optionally using shower events in reconstruction
- Multiple choice of background sources
- Using different event source configurations

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Simulation data in KM3NeT

Neutrino and Cosmic Rays generators

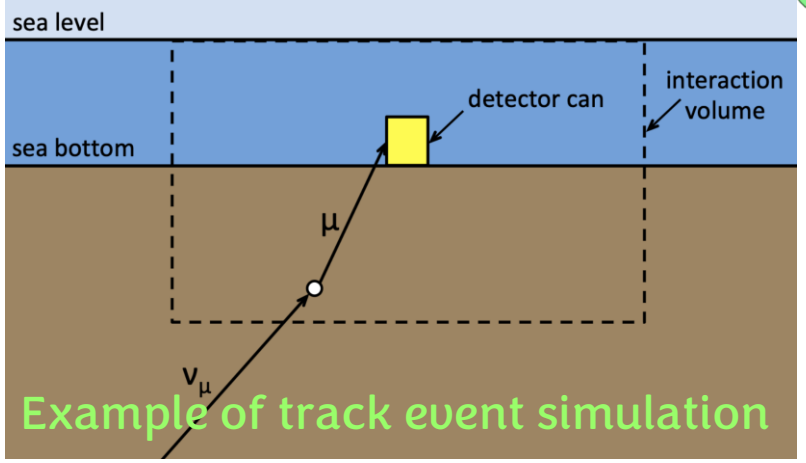
Light generators

Light propagation and collection

Reconstruction

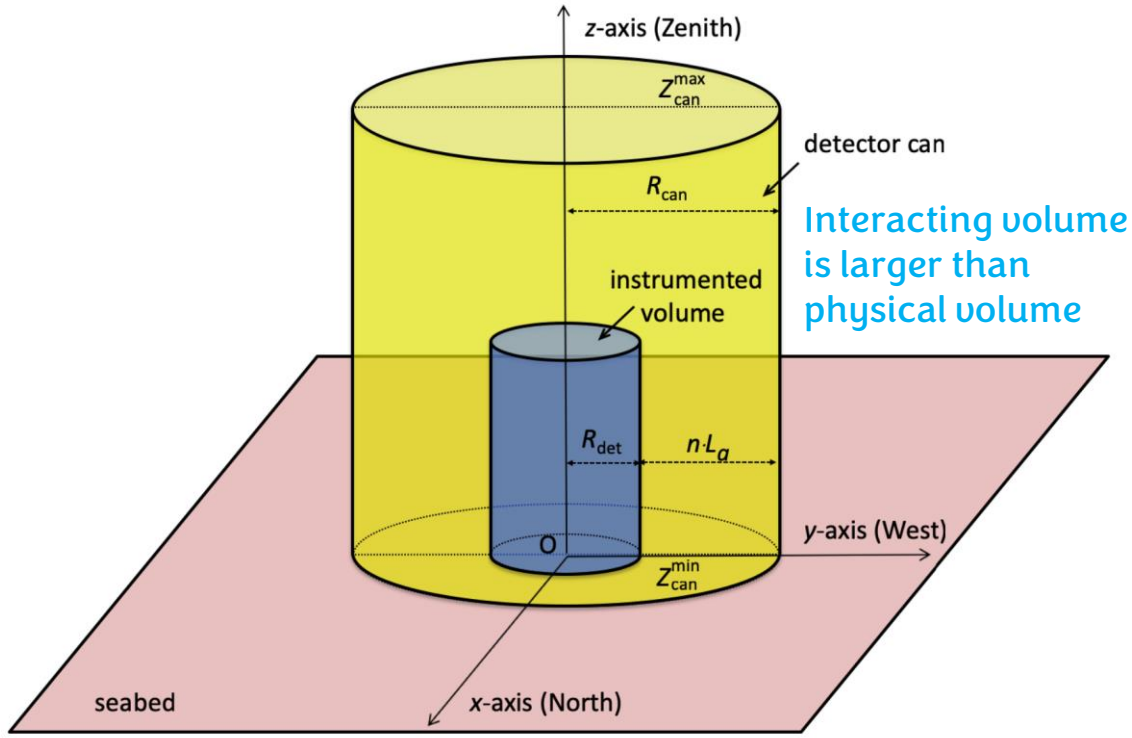
Data production

https://doi.org/10.1016/j.cpc.2020.107477



Example of track event simulation

Geometry definition in neutrino generator gSeaGen



Interacting volume is larger than physical volume

MC data are stored as ROOT files with several branches and size ~ Gb

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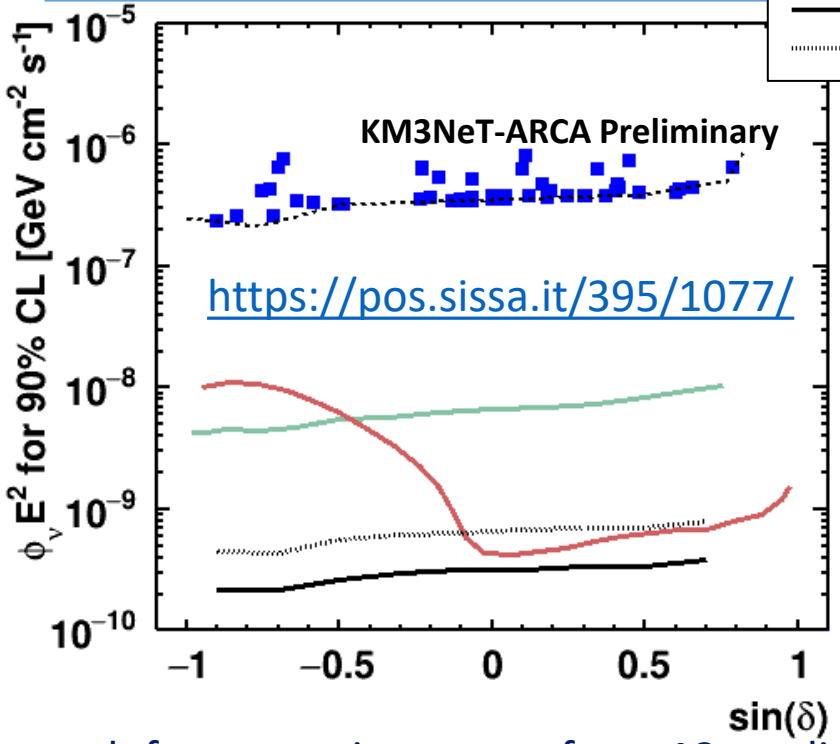
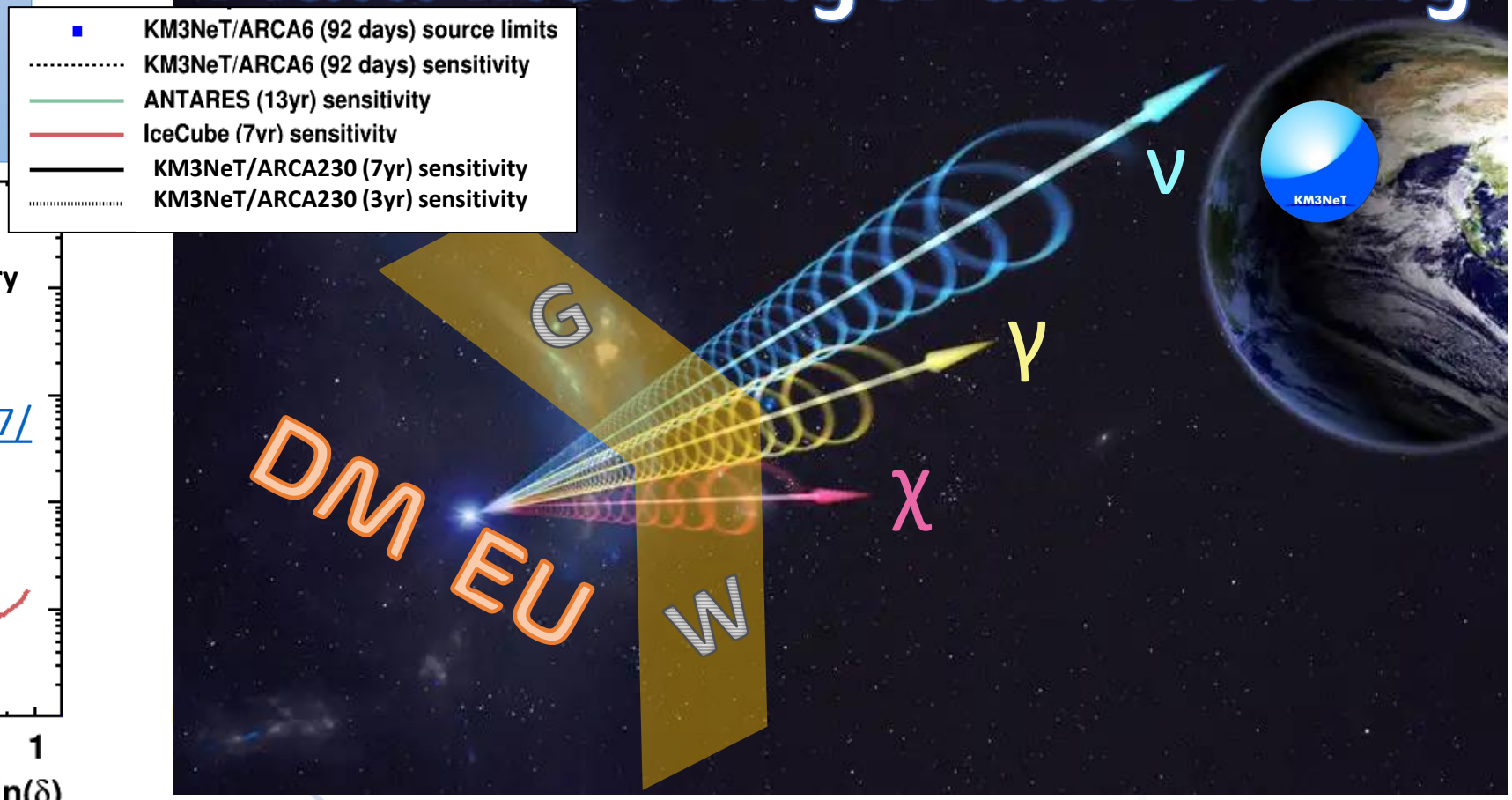
Sensitivity of KM3NeT to distant sources

Neutrino source types:
- Point-like
- Diffuse
- Extended

Follows to power law ~ $A \cdot E^{-\alpha}$



https://pos.sissa.it/395/1077/



search for a neutrino excess from 46 candidate sources 92 days of data taking: May 2021 --> Sep 2021

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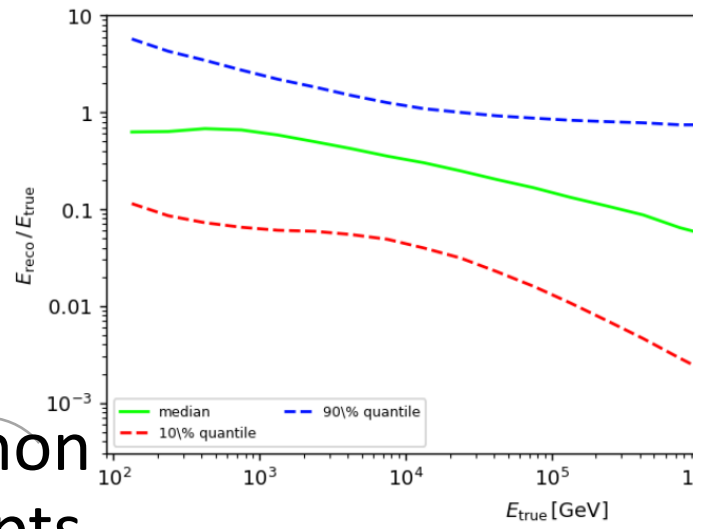
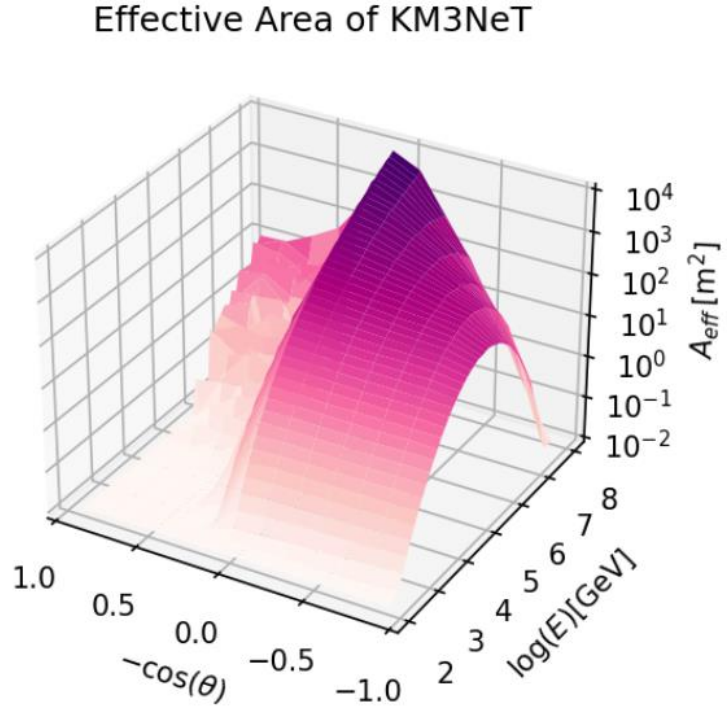
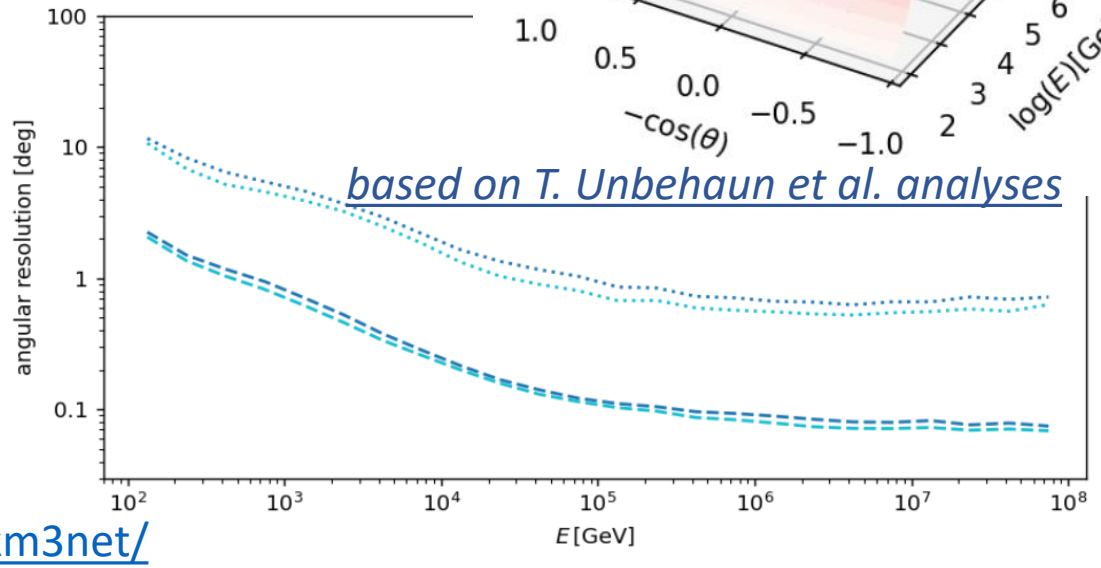
What is done in gitlab repository?

IRF from KM3NeT

- Data
  - fits files
- Notebooks
  - Create fits files
  - Plot fits files
- Python scripts
  - processing flow







based on T. Unbehaun et al. analyses

https://gitlab.in2p3.fr/escape2020/virtual-environment/irf-from-km3net/

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Conclusions and future plans

- Integration of KM3NeT IRF with ESCAPE services is ongoing
- Some simulations data are stored in the Data Lake and can be used inside notebooks
- Interaction with REANA platform
- Create standard output as defined in GADF format
- Add real examples of sensitivity analysis
- Developing of the independent **km3irf** python package

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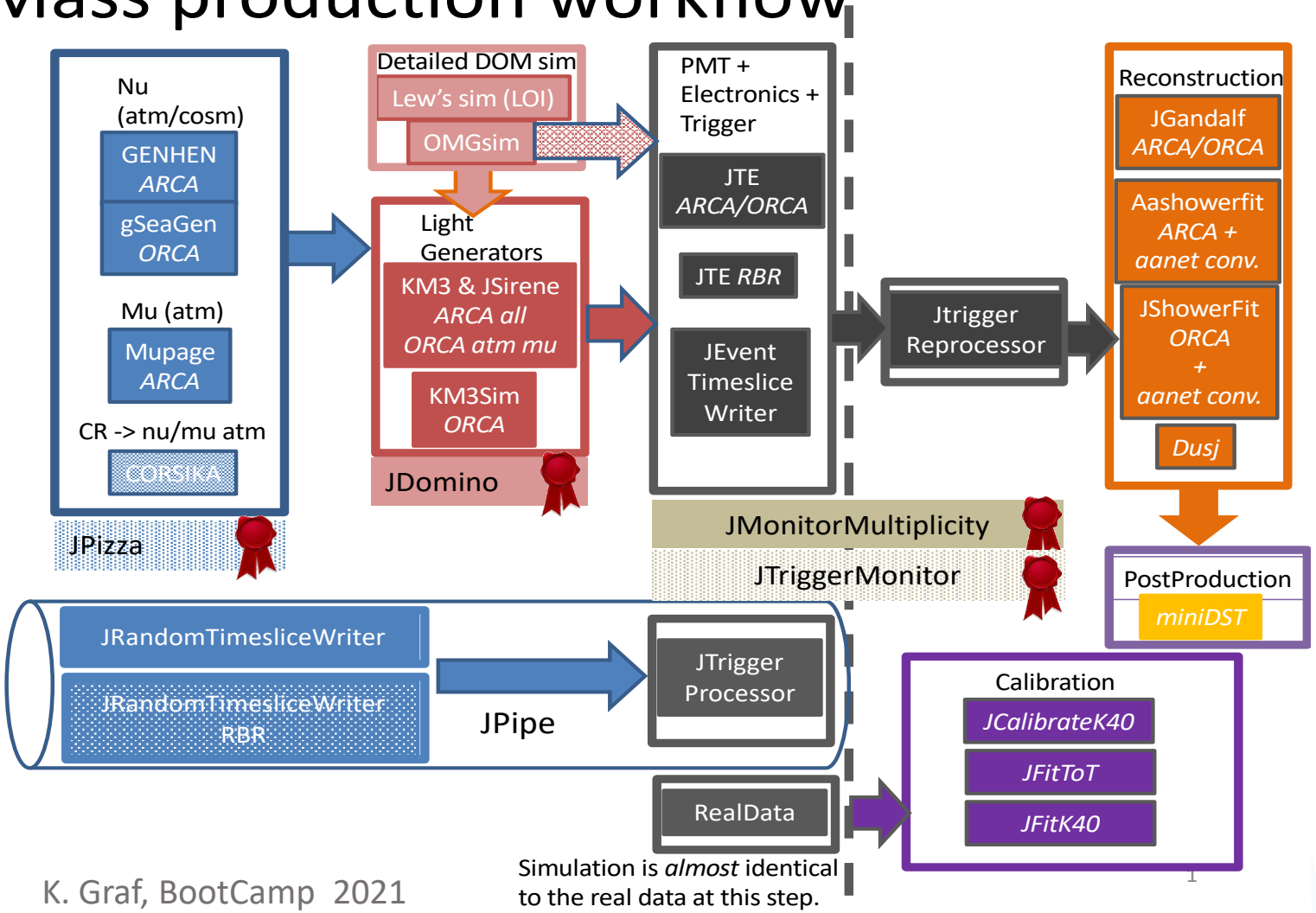
Backups

Mass production workflow



K. Graf, BootCamp 2021

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