# Reconstruction of stereoscopic CTA events using deep learning with CTLearn

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This work is conducted in the context of the CTA Analysis & Simulations Working Group.

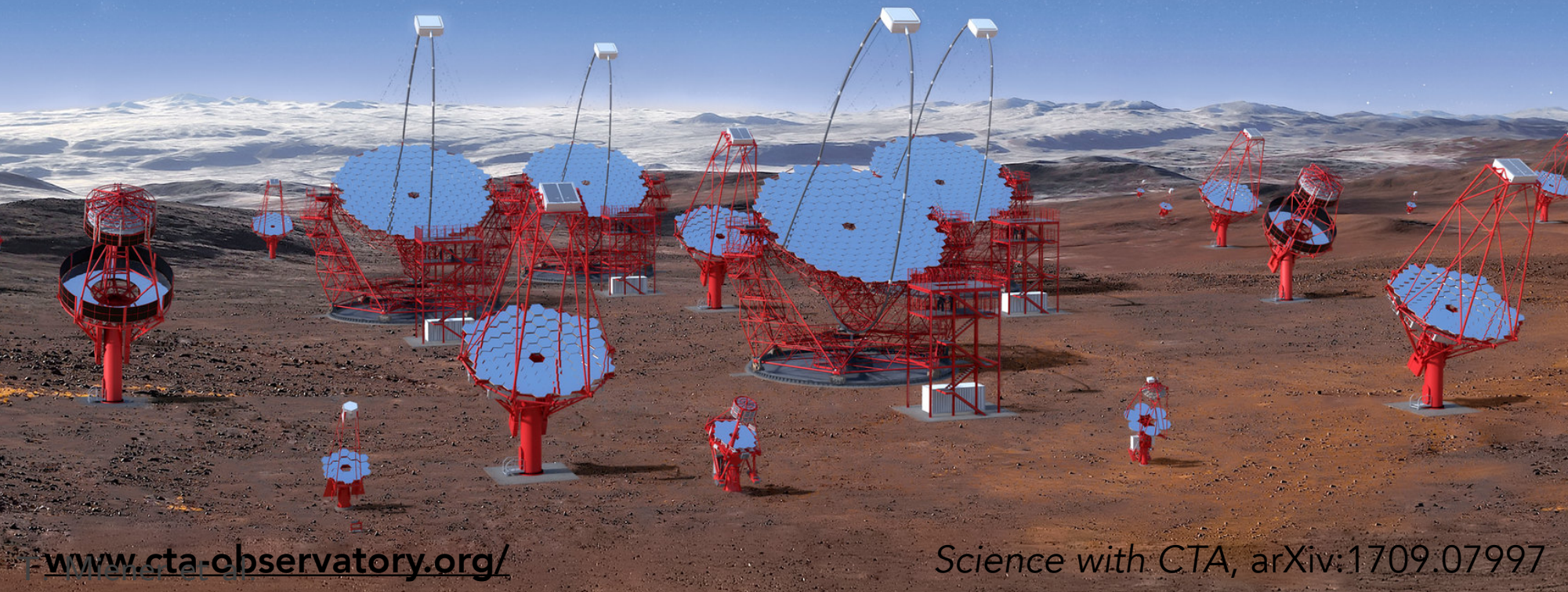
# Cherenkov Telescope Array (CTA)

- 5-20 fold better sensitivity w.r.t. current IACTs
- 4 decades of energy coverage: 20 GeV to 300 TeV
- Improved angular and energy resolution
- Two arrays (North/South)

**Low-energy range:**
23 m ø
Parabolic reflector
4.3° FoV
Energy threshold 20 GeV

**Mid energy-range:**
11.5 m ø modified Davies-Cotton reflector
9.7 m ø Schwarzschild-Couder reflector
7.5° - 7.7° FoV
Best sensitivity in the
150 GeV – 5 TeV range

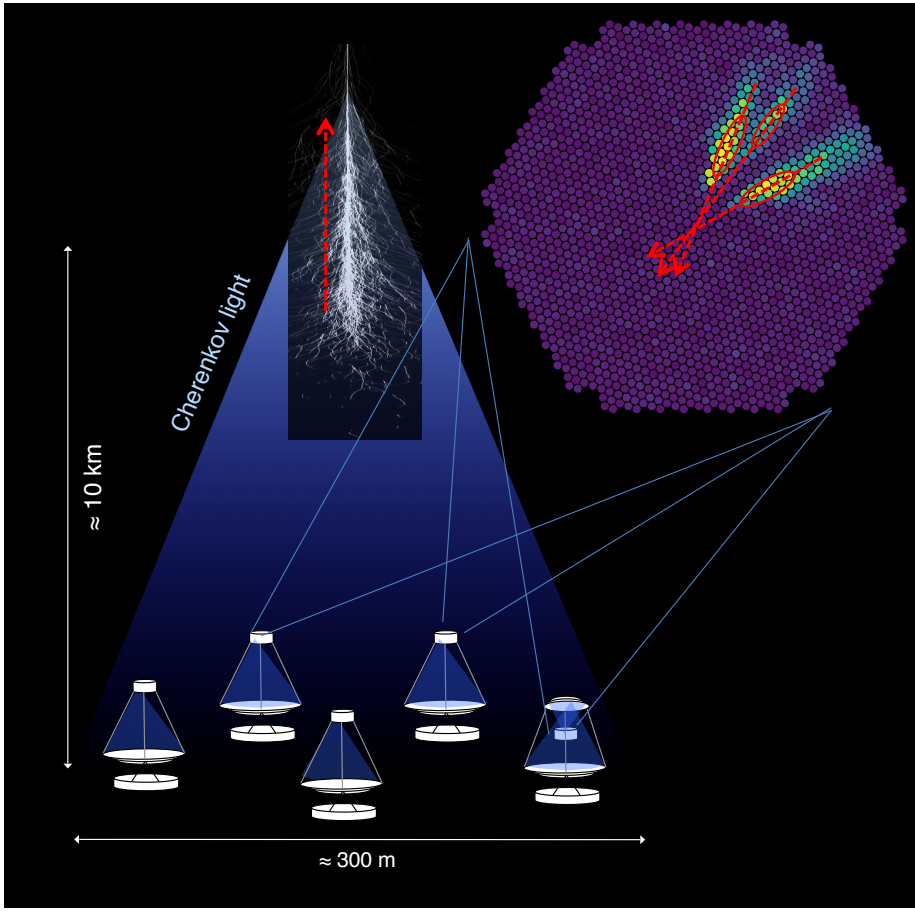
**High-energy range:**
4.3 m ø Schwarzschild-Couder reflector
10.5° FoV
Several km$^2$ area at
multi-TeV energies



www.cta-observatory.org/

*Science with CTA*, arXiv:1709.07997

# IACT technique




- Detection of extended air showers using the atmosphere as a calorimeter
- Huge γ–ray collection area (~$10^5$ $m^2$)
- Large background from charged CR
  - Partly irreducible ($e^-/e^+$ , single-EM, with current methods)
- Energy window: tens GeV - tens TeV
- Event reconstruction from image:
  - Type of primary event
  - Primary energy estimation
  - Primary arrival direction

Figure: Imaging atmospheric Cherenkov telescope technique.
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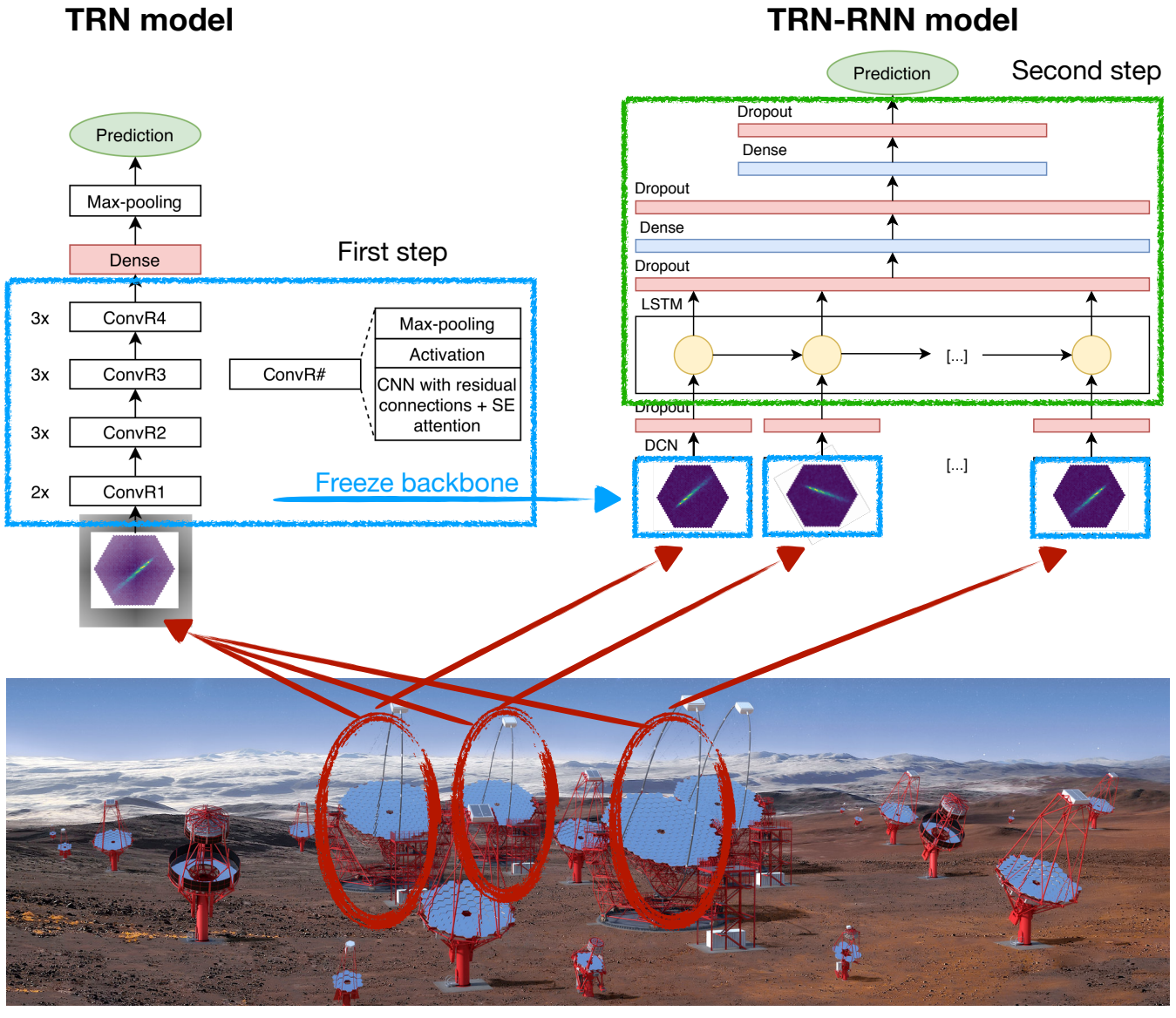
# CTLearn - DCN-based models

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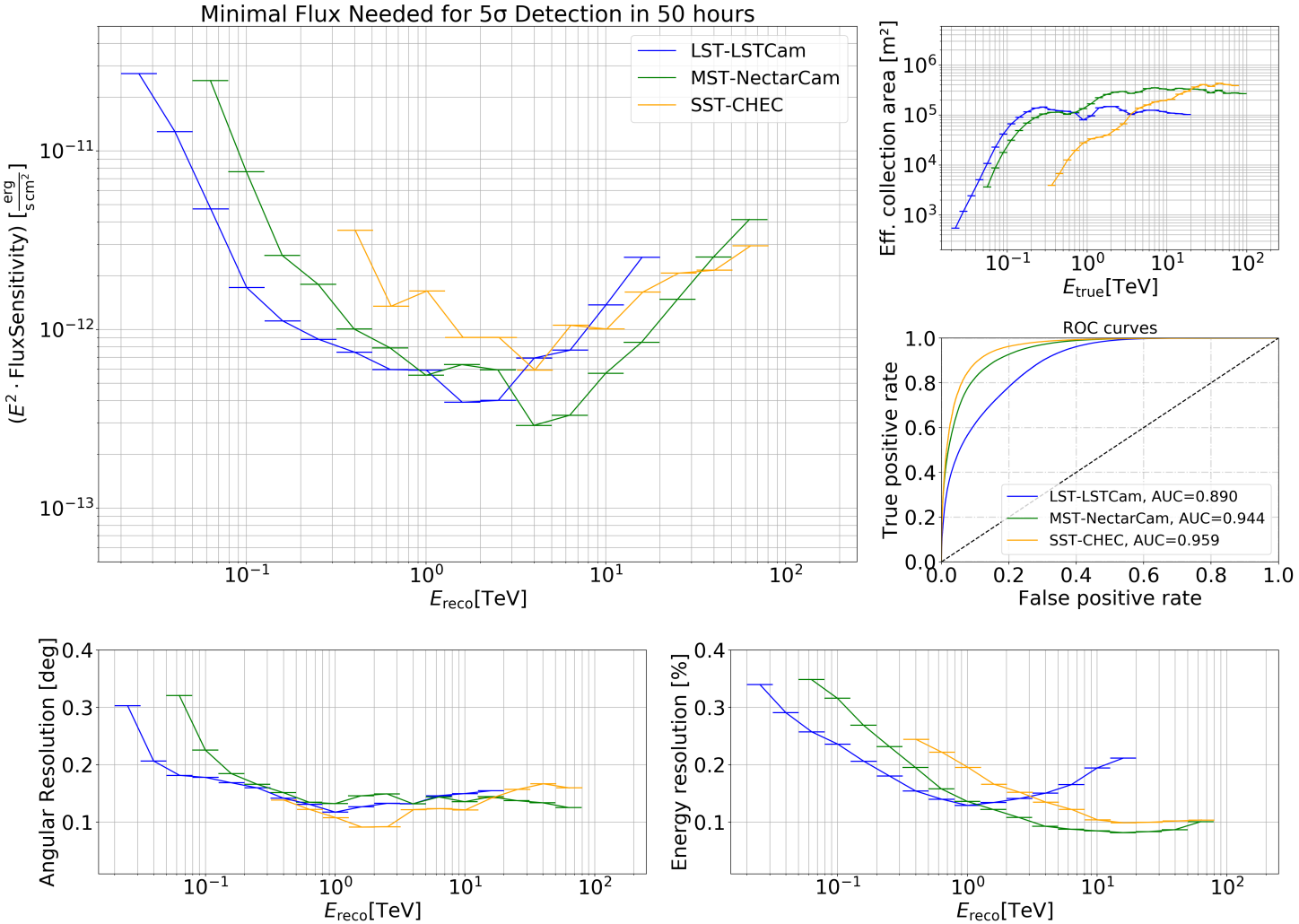
# First DCN-based full-event reconstruction on all CTA telescope types (single-telescope)

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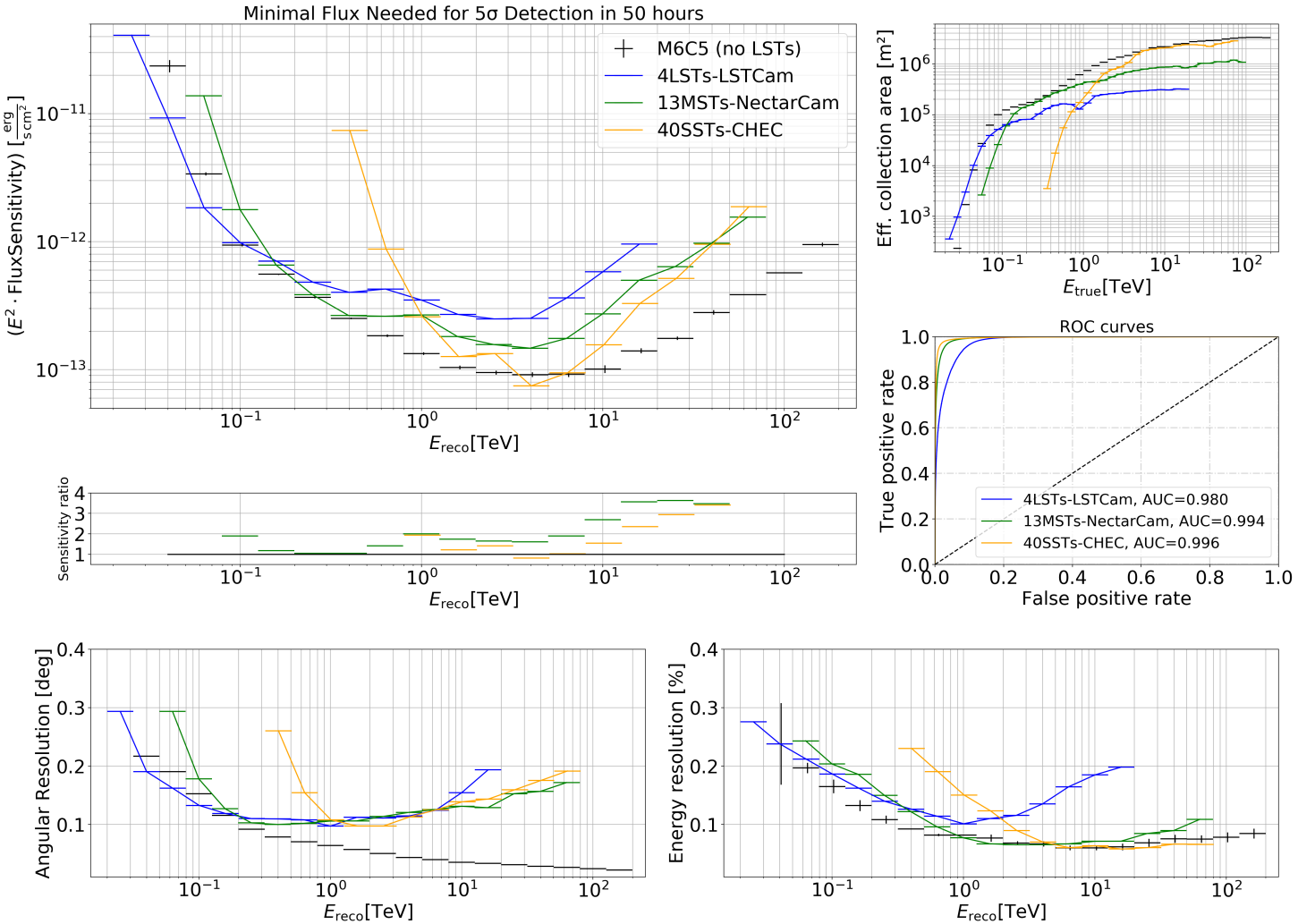
# First DCN-based full-event reconstruction on all CTA telescope types (multi-telescope)

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# Summary & outlook

- This contribution shows for the first time that DCN-based full-event reconstruction works for all sizes of CTA telescopes, in both single-telescope and stereo modes.
- Future developments of CTLearn will include the combination of different telescope types to evaluate the full-array performance of CTA North and South with deep learning models.
- Further validation of DCN-based full-event reconstruction under various circumstances (i.e. off-axis performance, divergent pointing, different zenith angles and night sky backgrounds, etc.) is very important and will be considered in future works.

# ¡Gracias por su atención!

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# Back up

# DL1-Data-Handler

- A package of utilities for reading and applying image processing to Cherenkov Telescope Array (CTA) & current IACTs DL1 data (calibrated images). The DL1DH writer has been deprecated in favour of the stage1 tool.
- Installation via pip/setuptools from source or as a conda package.
- Event-wise image reading using generators to handle big data.
- Open source on GitHub: https://github.com/cta-observatory/dl1-data-handler

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# CTLearn

- High-level Python package for using Deep Learning for IACT full event reconstruction
- Configuration-file-based workflow and installation with conda drive reproducible training and prediction
- Supports any TensorFlow model that obeys a generic signature
- Detail description in PoS(ICRC2021)730 and PoS(ICRC2019)752
- Open source on GitHub: https://github.com/ctlearn-project/ctlearn


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