Very-High-Energy Gamma-Ray Astronomy with the ALTO observatory

http://alto-gamma-ray-observatory.org

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The ALTO project

A Wide Field-of-View (~ 2 sr) gamma-ray observatory:

• In the Southern hemisphere → Daily observations of Southern sources
• At high altitude (> 5 km) → Low threshold $E \geq 200$ GeV
• Particle detectors → Observations may be done 24h per day
• Hybrid detectors → Improved S/B discrimination
• Excellent timing accuracy → Improved angular resolution (~ 0.1° at few TeV)
• Modular design → Phased construction and easy maintenance
• Simple to construct → Minimize human intervention at high-altitude
• Long duration → Should operate for 30 years
• “Open Observatory” → Distribute data to the community “à la Fermi-LAT”
ALTO Science Goals

**Daily monitoring of Southern targets:**

- Transients and variable sources;
- Active Galactic Nuclei, Gamma-Ray Bursts (if spectra favourable), X-ray binaries;
- Galactic centre and central region;
- Alerts to other observatories;
- Multi-year light-curves;
- High-end of the sources’ spectra;
- Search for Pevatrons;

**H.E.S.S. PKS 2155-304 (blazar) flare**

Credit: NASA/DOE/Fermi LAT Collaboration, Capella Observatory, and Ilana Feain, Tim Cornwell, and Ron Ekers (CSIRO/ATNF), R. Morganti (ASTRON), and N. Junkes (MPIfR)

**Study of extended sources:**

Fermi Bubbles, Vela SNR, AGN radio lobes;

Credit: NASA/DOE/Fermi LAT Collaboration, Capella Observatory, and Ilana Feain, Tim Cornwell, and Ron Ekers (CSIRO/ATNF), R. Morganti (ASTRON), and N. Junkes (MPIfR)

**Other accessible goals:**

- Search in past data if detections of:
  - gravitational waves or
  - neutrinos;
- Study of the cosmic-ray composition and anisotropy;
- Dark matter searches;
- EBL studies (if threshold low enough);
- Search for Lorentz invariance violation;
- Axion-like particles from distant AGNs.
## Current Collaboration

### Sweden
- Department of Physics and Electrical Engineering, Linnaeus University, Växjö
- Industry: TBS Yard AB, Torsås

### France
- APC Laboratory, IN2P3/CNRS, Paris
- Aix-Marseille University

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Discussions with other parties in Academia/Research Institutes:

- Los Alamos Laboratory, U.S.
- CEA/Saclay, France
- North-West University, Potchefstroom, South Africa
Key design characteristics of the full array

- Altitude (＞5km):
  - For Physics goals, as a survey/alert instrument for transients

- Fine-grained array of 1242 units:
  - Smaller Water Cherenkov Detector (WCD) tanks than HAWC
  - Low dead-space
  - Improved angular resolution

See also poster by S. Thoudam et al.
An ALTO detection unit

- Water Cherenkov tank: contains one photomultiplier (ANTARES optical module may be used);
- Muon-detector scintillator tank for background rejection:
  - Liquid scintillator box (Scintillator Layer Detector, SLD) with one PMT;
- Advanced electronics for 6-tank “cluster”, NectarCam (WaveCatcher for prototype) + White Rabbit:
  - Trigger channel precisely time-stamped with “White Rabbit” system;
  - Analogue memories + ADCs measure the waveform of the detector pulses;
  - No cables from central DAQ room, only fibres.

See also poster by S. Thoudam et al.

preliminary detector unit design
An ALTO “cluster”

Cluster = Group of 6 Units
= 6 x (WCD + SLD)

- WCDs on concrete “table”
  (1 concrete pour for cluster)
- SLDs below “table”,
  on telescopic rails

Each cluster to have common:

- Electronics readout unit
- Solar panel + battery (TBD)
- Communication/data
to central DAQ room by fibre only
ALTO response to single particle

Muon, 1 GeV

Electron, 1 GeV

See also poster by S. Thoudam et al.
Shower reconstruction is done through iterative Nishimura-Kamata-Greisen (NKG) fits;

Final S/B analysis cuts still under development:

- Ideal detector would only see muons in the scintillator layer, but still some faint signal from gamma-rays leaks beyond the concrete layer;
- Several S/B parameters under investigation on Water-Cherenkov and scintillator tanks;
- Final S/B analysis using Boosted Decision Trees in TMVA (not shown here).

See also poster by S. Thoudam et al.
ALTO prototype at Linnaeus University in Växjö, Sweden

- Final mechanical design being finalized now
- Construction starts in August 2017
- Several PMT solutions will be tested;
- Fully funded: construction of two full ALTO units, with 4-tank concrete layer
- The empty slots will be equipped with (smaller) additional scintillator boxes

Additional scintillator layers recycled from an on-board air-shower array used for ANTARES calibration purposes
• 2018 - Validation of prototype design;
• 2019 - If design successful:
  • Installation of one or more ALTO clusters at the final site in the Southern hemisphere;
Conclusions

• ALTO is a new project, financially supported primarily by Linnaeus University and Swedish private Foundations for now;

• The project’s aim:
  → to build a wide FoV VHE gamma-ray observatory with enhanced sensitivity with respect to current WCDA technology;

• Simple design:
  → limits costs of construction in full production phase; Prototype costs higher;

• Collaboration between Academia and Industry:
  → cost-effective solutions;
  → knowledge transfer benefiting both parties;

• Possible location of the observatory:
  → Chile or Argentina;

• Aimed investment cost for full deployment
  → ~ 20M€ excluding salaries;

• Expansion of collaboration:
  → to cover costs, electronics integration, expertise in DAQ, deployment, etc., most welcome!

• Status of the project with further information can be found at the website:
  → http://alto-gamma-ray-observatory.org/

• For enquiries about the project, please contact yvonne.becherini@lnu.se
Backup slides
Funding for salaries and prototype equipment

- **Design study** phase 2014-2017
  - Linnaeus University
  - APC Laboratory CNRS/IN2P3 (Paris)
  - Crafoord Foundation
  - The Magnus Bergvall’s Foundation
  - The Foundation at the memory of Lars Hierta

- **Prototyping** phase 2017
  - Linnaeus University
  - APC Laboratory CNRS/IN2P3 (Paris)
  - Aix-Marseille University
  - Crafoord Foundation
  - Märta and Eric Holmberg Endowment (Swedish Royal Physiographic Society)
  - The Foundation Helge Ax:son Johnson
  - The Magnus Bergvall’s Foundation
  - Längmanska kulturfonden
  - The Foundation at the memory of Lars Hierta
Acknowledgements

The ALTO project is being supported by the following Swedish private foundations or public institutes:

- the Crafoord Foundation, the Foundation in memory of Lars Hierta, the Magnus Bergvall's Foundation, the Crafoord stipendium of the Royal Swedish Academy of Sciences (KVA), the Märta and Erik Holmberg Endowment of the Royal Physiographic Society in Lund, the Långmanska kulturfonden, the Helge Ax:son Johnson's Foundation and Linnaeus University.

We thank the Swedish National Infrastructure for Computing at Lunarc (Lund, Sweden).

We thank Bertrand Vallage from CEA/Saclay (France) for providing us with two ANTARES optical modules.

Thanks also to Staffan Carius, Dean of the Faculty of Technology at Linnaeus University, for all the local support for the project.