

Progress of the Cherenkov Telescope Array project in Poland

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for the Polish Consortium of the Cherenkov Telescope Array Project,

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Cherenkov Telescope Array (CTA) is the project of a global astronomical observatory studying the Universe in very high energy gamma rays. The international CTA Consortium involves researchers from 32 countries from 5 continents. A large Polish Consortium of the Cherenkov Telescope Array Project is formed by 13 scientific institutions contributing to the project. The numerous proceedings of the Polish Consortium with designing and manufacturing prototypes of equipment intended for application in CTA, including the small Cherenkov telescope SST-1M and new technology mirrors for medium size telescopes (MST). For CTA, Poland provides large computing and data storage resources and contributes also into a number of other activities of the project.

1 The CTA Project

The results of the current Imaging Atmospheric Cherenkov Telescopes (IACT) observatories, in particular H.E.S.S., MAGIC and VERITAS, proved their great scientific potential and wide new research possibilities. In Fig. 1 left panel, we show a list of

exemplary topics, where such observations can qualitatively contribute, while a detailed description of the main scientific plans of CTA Consortium – the Key Science Problems – are described in Cherenkov Telescope Array Consortium, Acharya et al. (2017). Starting in the year 2006, a wide scientific community initiated proceedings toward construction of a new IACT observatory with sensitivity an order of magnitude higher than the currently operated facilities, and the extended measurement energy range from 20 GeV to 300 TeV (Fig. 1, right panel), as described, e.g., in Actis et al. (2011). The CTA project proceedings were initiated by Germany, France and Poland by proposing and introducing CTA into the European Strategy Forum on Research infrastructures (ESFRI) roadmap. Currently the project involves more than 1400 people from 32 countries of the world.

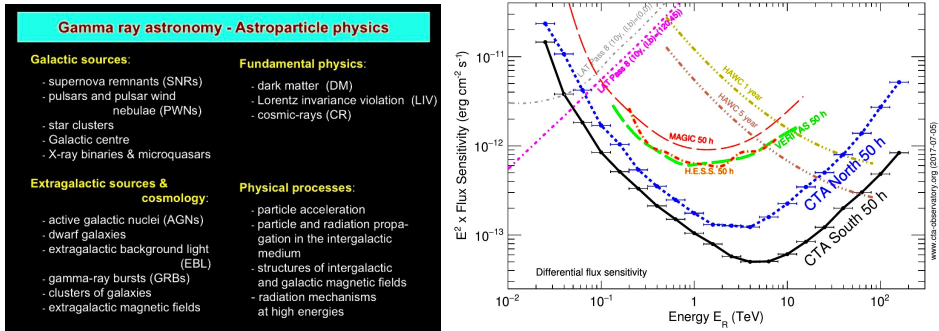


Fig. 1: Left: Research topics in astronomy, cosmology and fundamental physics with possible significant contributions of CTA. Right: Expected CTA South and North observatory sensitivities compared to currently operated gamma ray observatories.

In Poland the project is realised by the Polish Consortium of the Cherenkov Telescope Array Project involving 13 scientific institutions (see institutions on the authors' affiliations list) and, depending on time, from 60 up to above 70 scientists and engineers. The Consortium coordinator is Jagiellonian University, and the coordinator of the main Polish instrumental project – designing and prototyping of the small Cherenkov telescope SST-1M – is the Institute of Nuclear Physics, Polish Academy of Sciences (INP PAS). The resulting equipment is proposed as a part of possible in-kind contribution to the final CTA observatory.

2 Instrumental, Computing and Programming Contributions

2.1 The small Cherenkov telescope SST-1M and its innovative camera

The main instrumental project of the Polish Consortium is designing and manufacturing the small telescope SST-1M. The work done in collaboration with groups from Switzerland and Czech Republic, with smaller contributions from Ukraine and Ireland, is coordinated by T. Montaruli from University of Geneva. In Poland, a telescope structure (Fig. 2) and digital electronics DigiCam for the camera were designed and prototypes built, while the complete camera was assembled in Geneva (Fig. 3 and 4, right panel). Czech groups from Prague and Olomuc were responsible for optical system. One should note the novelty of our camera for this research field



Fig. 2: SST-1M telescope prototype at a testing site in INP PAS in Cracow.

by both: using the digital electronic signal processing and applying the silicon photomultipliers in its front-end. A first light, a few nanoseconds Cherenkov light trace generated by a high energy gamma ray, was registered by the camera on Aug. 31st, 2017 (Fig. 4, right panel).

The fact that the digital camera is programmable allows us to tune its parameters to the observing conditions as well as to consider its application for non-standard measurements. In particular, we plan to test applicability of an SST-1M telescope array for stellar intensity interferometry and for searches of micro- or mili-second optical flushes from the space, similar to the ones discovered in radio frequencies.

2.2 Mirrors for the medium size telescope

A significant achievement of the group from INP PAS was elaborating a new technology – involving glass composites and aluminium – mirrors for the Cherenkov medium size telescopes (MST) (Fig. 5, left panel). The mirrors exhibit perfect optical properties, as illustrated in right panel of Fig. 5. Currently, a full set of mirrors is manufactured to be tested installed at the MST prototype built in Germany.

2.3 Programming, computing and storage resources

From the very beginning of the CTA proceedings two Polish institutions: Academic Computer Center (CYFRONET) and Nicolaus Copernicus Astronomical Center of

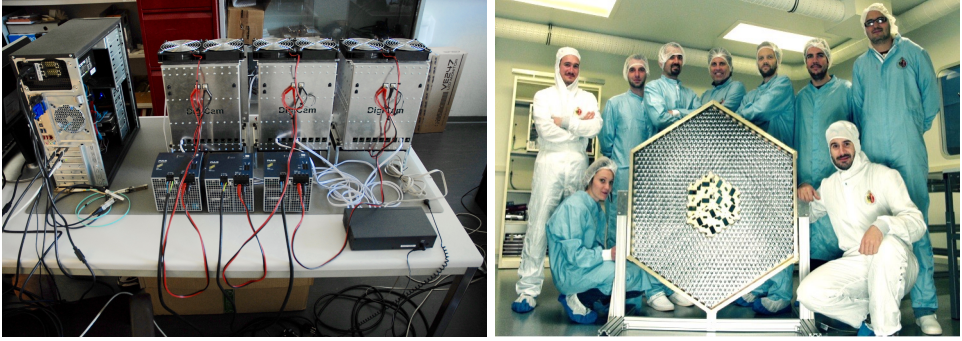


Fig. 3: Left: Camera manufacturing: testing the DigiCam electronics in Cracow. Right: Camera front-end manufactured in Geneva.

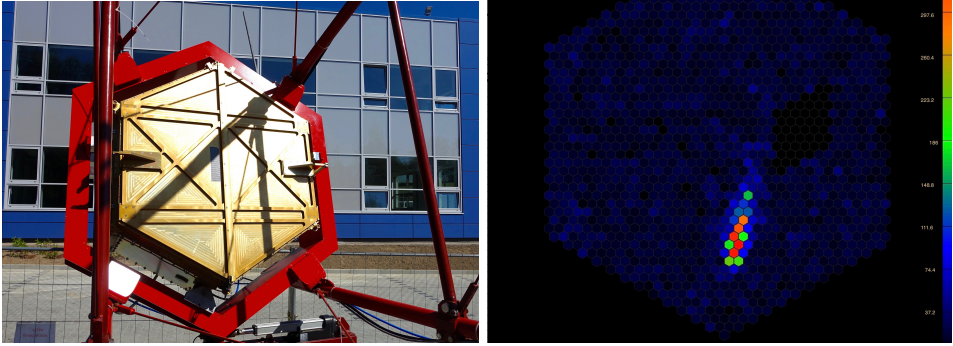


Fig. 4: Left: Camera installed at the SST-1M prototype in Cracow. Right: A first light on Aug. 31st, 2017.

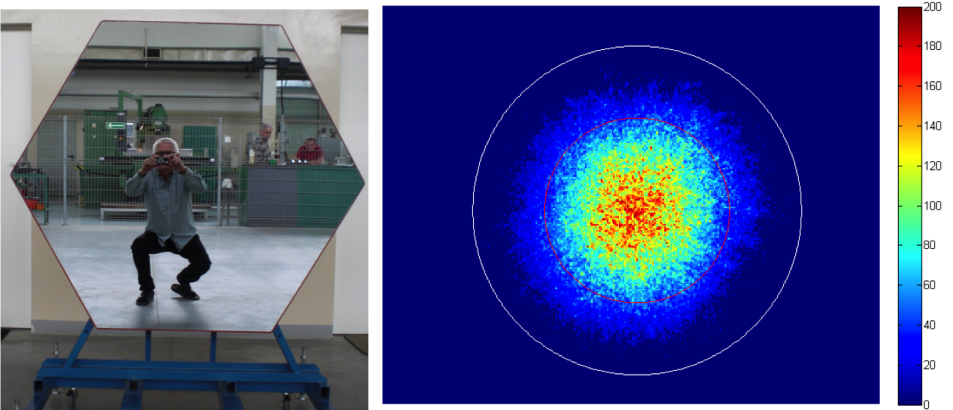


Fig. 5: Left: MST mirror prototype presented on the INP PAS workshop. Right: The mirror Point Spread Function size (inner red circle) is well within CTA requirements (outer circle).

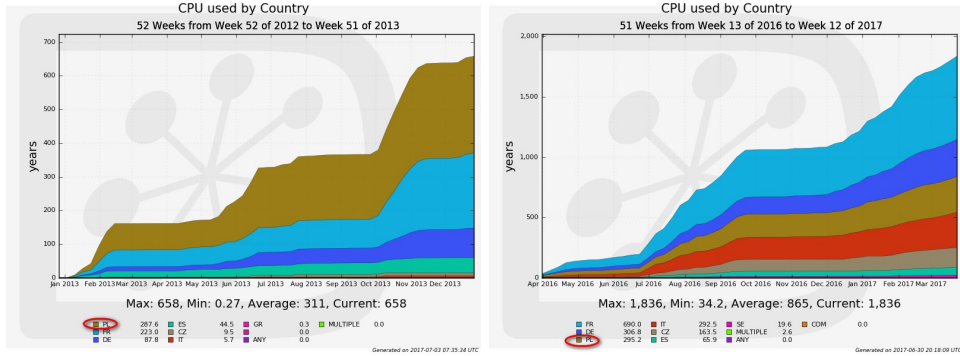


Fig. 6: Polish contribution to computing resources for CTA in the year 2013 (left panel), and in the year 2017 (right panel).

Polish Academy of Sciences (NCAC PAS) contribute in a significant way to extended computing efforts of the international collaboration, in particular by providing large computing and storage resources for the Monte Carlo modeling. As a rule CYFRONET is the one of three main providers of these resources, in some years being even the leading one (Fig. 6).

CYFRONET significantly contributes to CTA in elaborating and providing software for the project operation, an innovative CTA Science Gateway. The system enables to realize the project's multiple tasks and activities, and can be continuously expanded by including into the system procedures and codes elaborated by third parties.

3 Contributions to the CTA SITE and PHYSICS working groups

In previous years, one of the main project activities was the selection of the best sites for construction of CTA observatories on both hemispheres. The extended effort, including climatic studies involving satellite monitoring as well as construction and operation of the automatic stations monitoring the weather conditions, was led by the Warsaw University Observatory. Basing on this work, the CTA Resource Board selected the ESO site in Chile for Southern observatory and La Palma Island in Spain for the Northern observatory.

Scientists from all institutes of the Polish CTA Consortium are involved in extended work of the Physics Working Groups elaborating the science program for the research facility. Results of the extended effort in preparation of the CTA Key Science Projects are presented in a recent publication (Cherenkov Telescope Array Consortium, Acharya et al., 2017).

Our activities include also participation (sometimes as a chair) in numerous CTA boards, committees and evaluation panels. Poland contributed also to all CTA Collaboration Board decisions and to shaping various project documents and the Collaboration policies.

4 Final remarks

At present a final decision of the Polish Ministry of Science and Higher Education on the national scale of the project financing within the international collaboration is anticipated. Depending on the decision, the Polish CTA Consortium will be able to propose the elaborated and tested with prototyping technical designs and software solutions for the final research infrastructure.

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