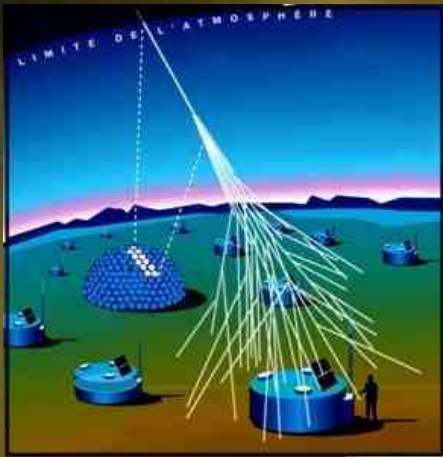


Astroparticle physics in Poland

Auger, Magic, HESS, CTA, DM, GW ...



Michał Ostrowski
Jagiellonian University

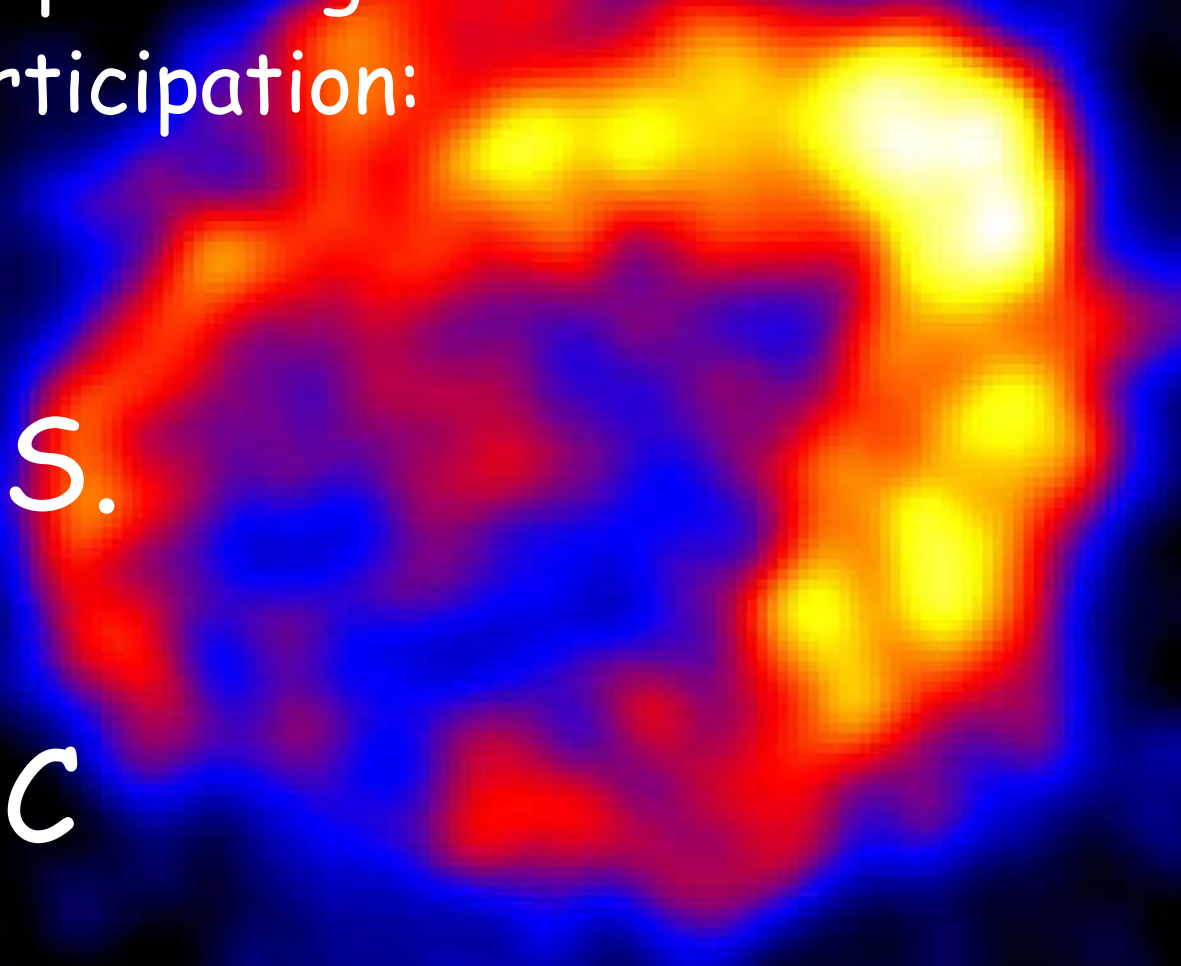


VHE Gamma Ray Astronomy

Actually operating observatories with
Polish participation:

H.E.S.S.

MAGIC



Gamma-ray

Particle shower

Cherenkov light

~ 10 km

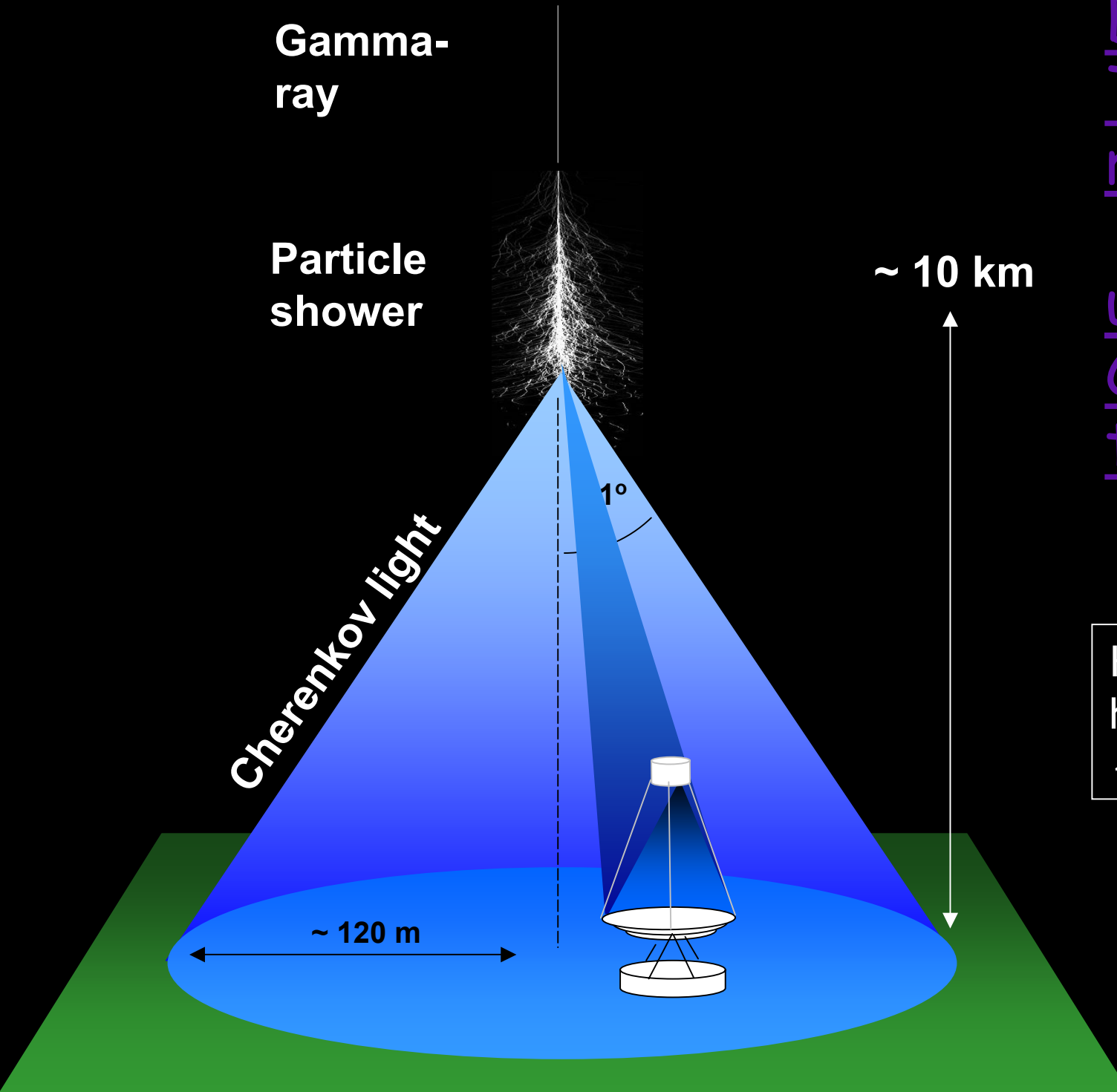
~ 120 m

1°

Detection of
TeV gamma
rays

using
Cherenkov
telescopes

Key issue:
huge detection area
 $\sim 10^5 \text{ m}^2$



MAGIC

(earlier HEGRA)



University of Lodz

4 staff + 1 PhD

~60 kEuro total financial contribution

Monte Carlo simulations, Data analysis, Data Taking,
Hardware, Theoretical modelling, Organization
responsibilities

Financing from NCS through the HESS-MAGIC grant



High Energy Stereoscopic System (H.E.S.S.)



Warsaw:

- Nicolaus Copernicus Astronomical Center PAS (NCAC PAS)
- University of Warsaw (UW)

Cracow:

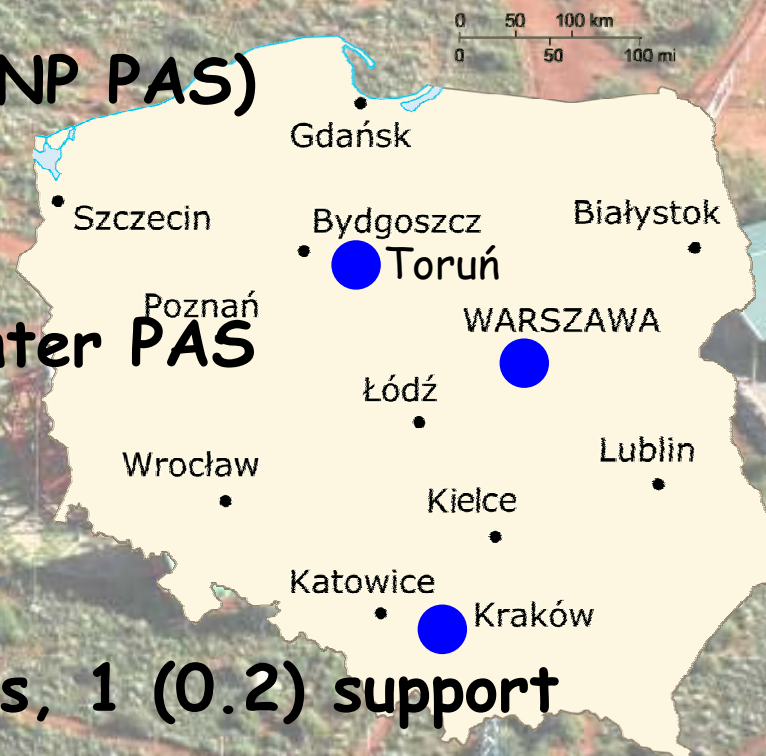
- Jagiellonian University (JU)
- Institute of Nuclear Physics PAS (INP PAS)

Toruń:

- Nicolaus Copernicus Astronomical Center PAS
- Nicolaus Copernicus University (NCU)

People (FTE):

13 (4.6) staff, 5 (4.2) PhD students, 1 (0.2) support



High Energy Stereoscopic System (H.E.S.S.)



Main hardware contribution:

- manufacture of actuators for the HESS II mirror collimation system (1000 sets) 400 kEUR
- purchase of 84 mirror tiles for the HESS II telescope - 100 kEUR

Main responsibilities:

data taking, data analysis, manuscript preparation

Polish representatives in the Collaboration Board

Financing:

2006-2009 - special research project of Ministry of Science and Higher Education
~3 mln zł (750 kEuro) -> HESS II actuators and mirrors

2010-2015 - international project of Ministry of Science and Higher Education
(currently of National Science Centre) ~4 mln zł (1 MEuro)

MSHE

NSC

Future TeV Gamma Ray Astronomy

Cherenkov Telescope Array (CTA)

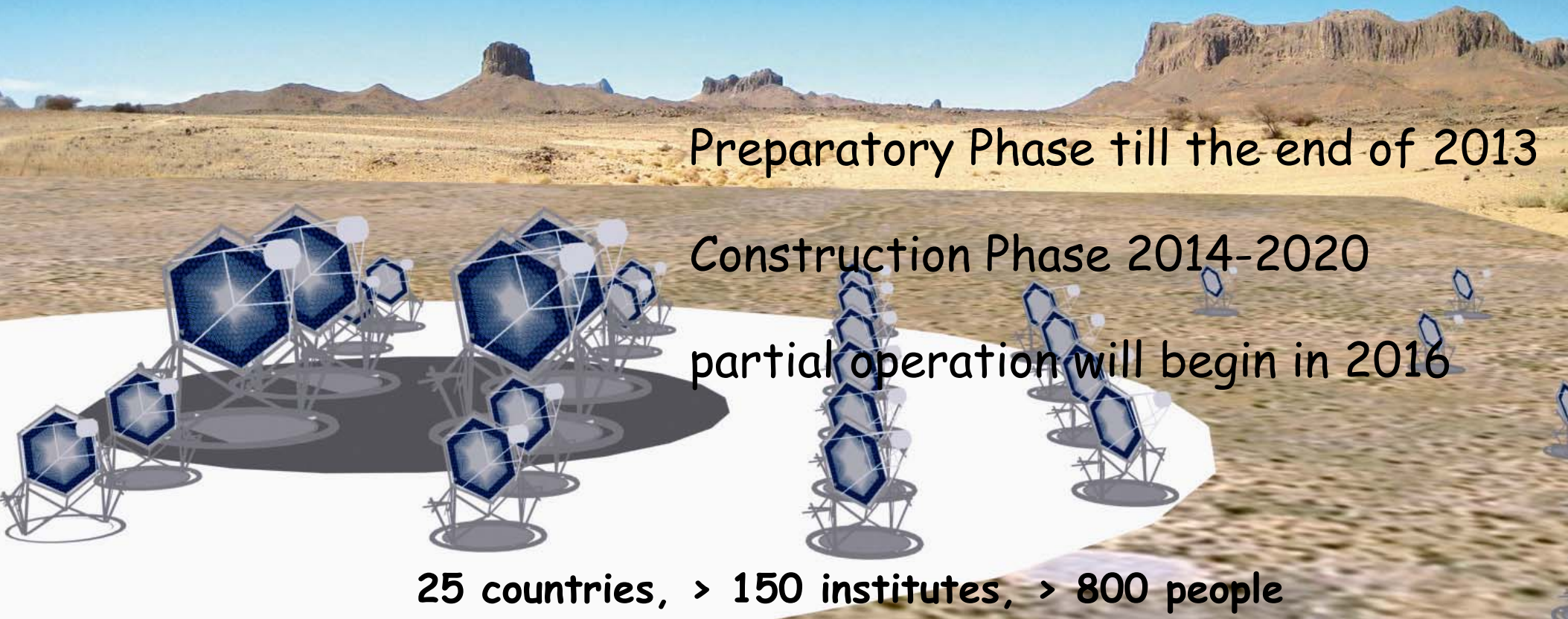
A full sky VHE gamma ray observatory

Preparatory Phase till the end of 2013

Construction Phase 2014-2020

partial operation will begin in 2016

25 countries, > 150 institutes, > 800 people



Cherenkov Telescope Array



Polish CTA Consortium

Warsaw:

Nicolaus Copernicus Astronomical Center PAS
Space Research Centre PAS
University of Warsaw

Cracow:

Jagiellonian University
Institute of Nuclear Physics PAS
AGH University of Science nad Technology
Academic Computer Centre "CYFRONET AGH"

Toruń:

Nicolaus Copernicus Astronomical Center PAS
Nicolaus Copernicus University

Łódź

University of Łódź

People (FTE): 61 (28)



Current CTA-PP responsibilities of the Polish groups

WP Physics (many contributors, Prof. B. Rudak is a coordinator of pulsar studies)

WP Site - T. Bulik is the WG leader and a member of the CTA Project Committee

WP Mirror - significant efforts in a composite mirror technology by INP and SRC

WP ELEC - significant contribution of UJ and AGH to the digital camera electronics

WP MC - contribution to Monte Carlo simulations by UŁ

WP CEIN - contributions by CYFRONET, NCAC and UJ

WP DATA (contributions from NCAC)

WP LEGAL - M. Puwalski is the Polish Consortium representative

WP Small Size Telescope - a DC prototype constructed in Poland

Requirements Review internal committee - M. Ostrowski is a chairman

Representatives in

- CTA Collaboration Board,

- CTA Executive Board

- CTA Resource Board - M. Ostrowski is the MSHE representative

- CTA Administration and Finance Advisory Committee

CTA Project Office in Heidelberg - a quality and assurance engineer

Funding

1 EUR \approx 4 zł

Design Phase and Preparatory Phase- approx. 15 mln zł in years 2006-2013

Grant support for the Polish CTA Network - 0,8 mln zł from MSHE (2008-2009)

Contribution to Polish participation and CTA technical developments - 1,75 mln zł from the European grant ERA-NET-ASPERA/01/10 from NCRD (2010-2012)

Contribution to the Small Size Telescope construction - 9,6 mln zł from FNiTP (2010-2013)

Contribution from the European grant Infrastructures - 390 kEuro from FP7 (2010-2013) appended with a recent MNiSW grant for ~400 kzl

Grant PMN for the international collaboration in CTA - 3,0 mln zł from NCN (2011-2014)

CTA Construction Phase (2014-2020) - funds proposed to MSHE ~10% of total cost

Polish CTA scientists intend to play comparable significant role in the CTA Construction Phase as in the CTA Preparatory Phase

Cosmic Ray Physics

Actually operating or finished experiments:

Pierre Auger Experiment

KASKADE, KASKADE GRANDE

The Pierre Auger Observatory



0 50 100 km
0 50 100 mi

Institutions in Poland:

INP PAS, Cracow

University of Łódź

People:

10 staff, 1 PhD student



The Pierre Auger Observatory

Main contributions:

INP : Construction of structure and electronics of
Fluorescence Detectors (175 kUSD)

UŁ: Triggers for water Cherenkov detectors (~25 kUSD).

Shower reconstruction programs from Fluorescence Detector data.

Main responsibilities:

INP: Identification of photons and neutrinos, shower measurements.

UŁ : Reconstruction programs for low energy showers.

Financing: 2010-2013 grants from MSHE/NSC

KASCADE / KASCADE-Grande (1989 – 2011)

- multiparameter EAS measurements 10^{15} eV - 10^{18} eV
and development of EAS radio detection – LOPES
(LOFAR Prototype Station)

Main achievements:

- Solving the 50-years old problem of the „knee” region in the CR Spectrum
(*Ap. Ph.* 24 (2005) 1;
PRL 107 (2011) 171104)
- Development of radio detection technique of EAS – **LOPES** experiment
(*Nature*, 435 (2005) 313)
- **Over 70** publications in the top peer-reviewed journals
- **60** PhD theses
- **85** Master's Theses

Karlsruhe Institute of Technology

Main Polish Contributions:

- **10 scientists** from Lodz (NCNR and UŁ) participated over the whole period of > 20 years.

Currently - 2 only from NCNR (one is chairing the Steering Committee and Collaboration Board)

- **3** PhD theses
- Hardware contributions:
 - **Main trigger** electronics for KASCADE
 - **Front-end** electronics for the Muon Tracking Detector (ca. 25 000 chan.)
- **Development** of data analysis methods and software
- **Tests** of hadronic interaction models

Funding:

- **5** research grants from the Polish Ministry of Science and Higher Education/KBN
- **7** collaboration and research grants
BMBF, DFG, DAAD)

Future Cosmic Ray Experiments

Auger Next

JEM-EUSO

Auger Next

Innovative Studies for the Next Generation Ground-Based Ultra-High Energy Cosmic-Ray Experiment

Institutions in Poland:

INP PAS, Cracow

University of Łódź

Contributions:

INP - CROME experiment in Karlsruhe

INP - Microwave detection of air showers

UŁ - Optimization of AERA experiment in Argentina

UŁ - Development of a Front-End prototype and algorithms (linear predictor and wavelet trigger) for EAS radio detection in MHz range

Financing 2011-2014 ASPERA grant through the NCRD

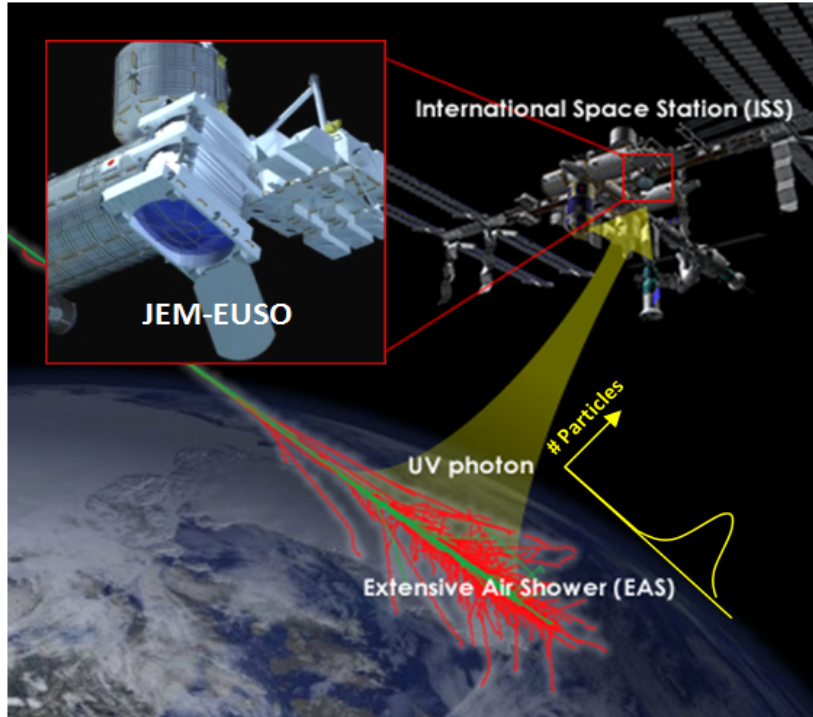


JEM-EUSO

JEM - Japan Experiment Module

EUSO - Extreme Universe Space Observatory

Main scientific target:
Measurements of ultra high energy
cosmic rays (UHE CR)



about 300 participants
from 13 countries

13 scientists from Poland

2 tonnes, mini bus size,
UV telescope directed downwards
from International Space Station,
5000 64-anodes PMTs
ultra fast camera (400 000 frames/s)

plan to launch at 2016/17

<http://jemeuso.riken.jp>



JEM-EUSO



Polish Institutes:

NCNR, Łódź

SRC PAS, Warsaw

UKSW, Warsaw

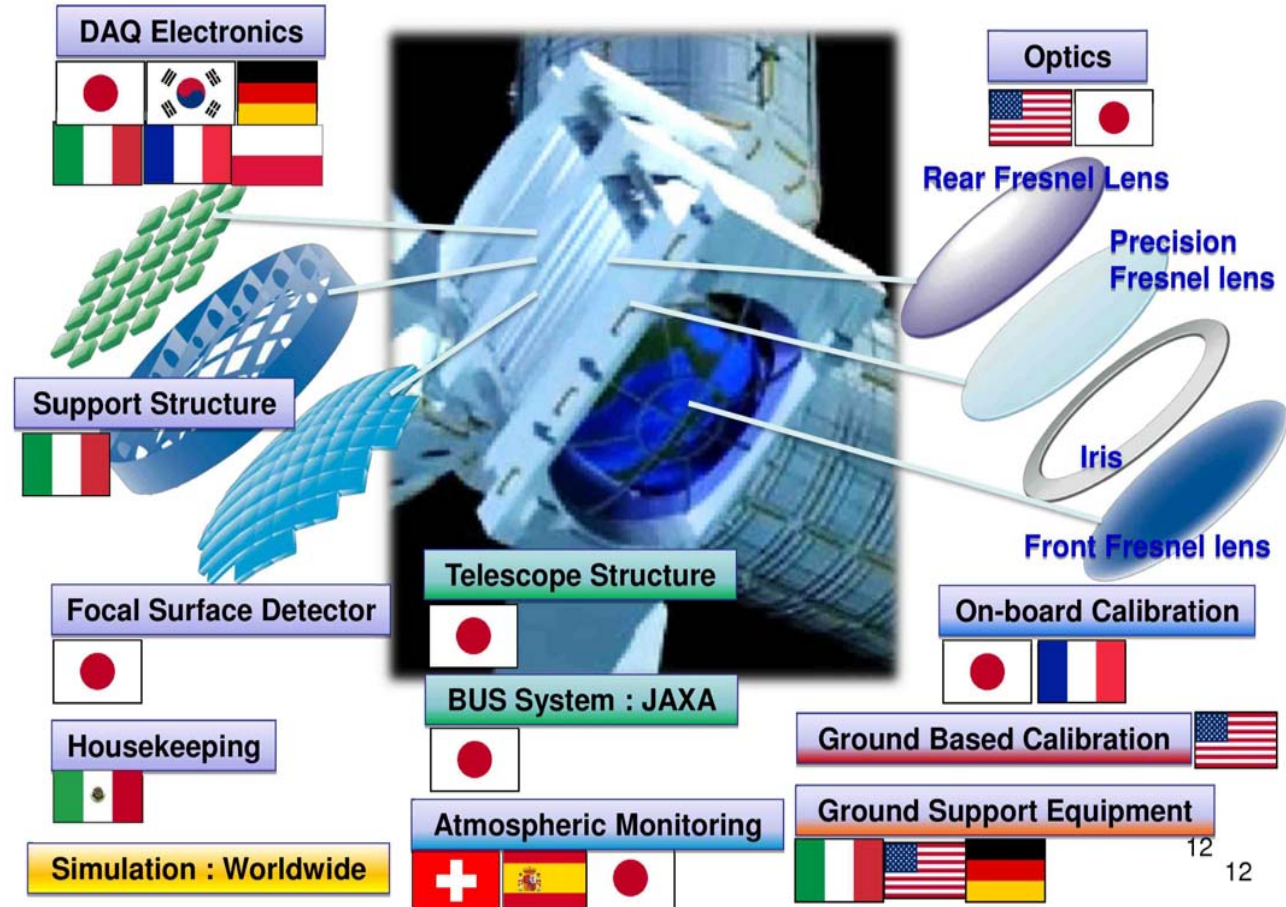
NCNR, Warsaw

UJ, Cracow

UJK, Kielce

Polish contribution:

- science
- hardware (electronics)
- simulations



Financing: no grants (yet) in Poland

JEM-EUSO test experiments:

EUSO – Balloon

TA - EUSO

planned to run during 2013 - 2014

Polish contribution:

- hardware (high voltage)
- science



Institutes:

Warsaw: NCNR, UKSW

Łódź: NCNR

Functionality and calibration tests (single detection module):

EUSO - Balloon

at altitude 40 km (EAS – Extensive Air Shower detection from top)

and TA - EUSO

at the Telescope Array (TA) site (Utah, USA) with ground EAS experiment

Direct Dark Matter detection

DarkSide

small contributions to WArP (INP PAS, Cracow)
ARDM (NCNR, Warsaw)

Possible Polish underground site

The DARKSIDE Experiment in LNGS

1 Institutions in Poland:

➤ **Kraków: UJ**

1 Participants:

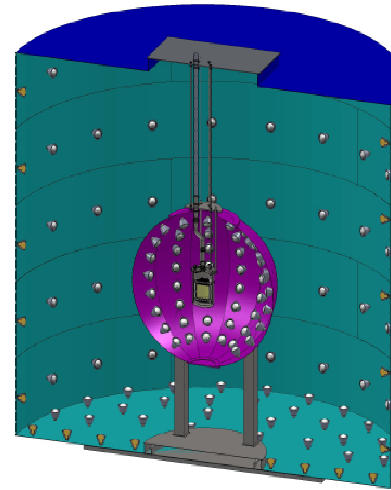
➤ **2 staff**

1 Main contributions:

- Investigation of background sources,
- Investigations and control of the LAr purity,
- Data analysis,

1 Financing:

➤ Grant proposal submitted to NSC for 2012-2016



The DARKSIDE Collaboration



Detector Design

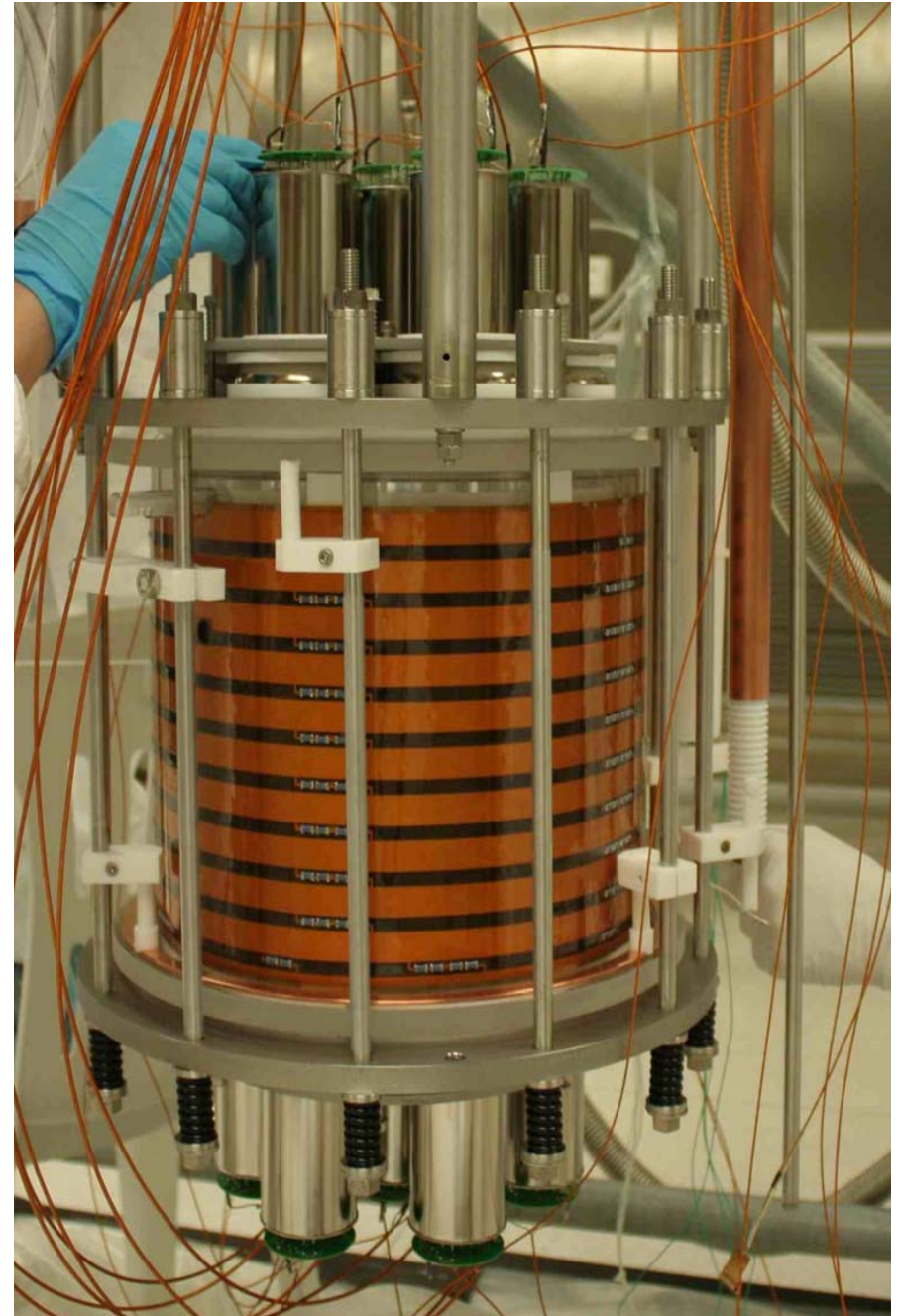
- Ultra-low background technology
 - Argon depleted in ^{39}Ar
 - Low background photodetectors
- Active suppression to both reject and assay background:
 - Electron recoil rejection capability of liquid argon
 - Highly efficient neutron veto
 - BOREXINO CTF water tank for suppression of cosmogenics



DARKSIDE Status

DARKSIDE

- Production of depleted Ar ongoing (85 kg in hand)
- The DS-10 prototype successfully operated at LNGS
- Construction of the DS-50 detector started in the CTF Tank early 2012
- **Start-up of DS-50 foreseen for 2013**
- **Proposal for a 5 kt detector ready to be submitted**



Sieroszowice salt mine site

SUNLAB



Very low background

Possible site for DM searches and neutrino phys.

Cracow; Warsaw; Katowice, Wrocław, ...



Astronomical Dark Matter studies

galactic dynamics, gravitational lensing, GRBs and SN Ia

Institutions:

Copernicus Astronomical Center PAS, Warsaw

University of Warsaw

Jagiellonian University, Cracow

Institute of Nuclear Physics PAS, Cracow

~10 staff + 5 PhDs

Financing through grants from NSC

Gravitational Waves

VIRGO



Institutions in Poland:

Białystok: UwB

Toruń: NCU

Warsaw: NCAC PAS, IM PAS, NCNR, UW

Zielona Góra: UZ

Participants:

5 staff, 2 PhD students, 3 support

Main contribution:

Data analysis, Electronic engineer (90 kEURO) Vacuum system (40 kEURO)

Main responsibilities:

Analysis of data, astrophysics, organization of meetings

Financing: 2010-2014 through the grant from NSC



Gravitational waves (GW)



1. Verification of general relativity
2. Gravitational wave astronomy

- VIRGO is a French-Italian project to detect gravitational waves using a long arm (3 km) Michelson interferometer. Today, this collaboration involves 19 laboratories with more than 200 scientists in France, Italy and also in Hungary, Netherlands and Poland.

- ***Polgraw** group from Poland has joined the project in April 2008.*

- Members of VIRGO have full access to data from LIGO detectors in the USA.

By a MOU all data analysis of the VIRGO and LIGO projects is carried out jointly and all publications are signed by the author lists from both projects.

POLGRAW group member of the VIRGO project



**Group of astronomers, physicists and mathematicians
from 7 institutions in Poland (coordinator: A. Królak):**

NCAC PAS, UZ, IM PAS, NCNR, NCU, UW, UB

1. Astrophysical sources of gravitational waves
2. Search for GW from rotating neutron stars
3. Search for GW from compact binaries
4. Coincidences with observations of Pi of the Sky telescopes
5. Development of computing centers
6. Contribution to advanced Virgo construction (hardware, one experimentalist)
7. Organization of meetings (LIGO/VIRGO - Kraków 2010, GR20/Amaldi10, School of Gravitational Waves – Warsaw 2013)

Astroparticle Physics in Poland:

~100 physicists and astrophysicists +

~20 PhD students and students

> 10 institutes and universities

Basic financing is provided by agencies,
additional support exist in some cases
from EU FP7 funds.

More significant investment into
hardware/infrastructure can be possible
in a near future (?)

Problems: bureaucracy, administrative burden,
slow procedures, ...