

Annual Report

<b>Funding Programme:</b>	<b>Helmholtz-Russia Joint Research Groups</b>
Project ID No.:	HRJRG-303
Project Title:	<b>Measurements of Gamma Rays and Charged Cosmic Rays in the Tunka-Valley in Siberia by Innovative New Technologies</b>
Principal Investigator:	<b>Dr. Ralf Wischnewski, DESY</b>
Report period:	<b>2012</b>

**We split the activity report into two parts: Tunka- HiSCORE and Tunka-Rex**

**Activity report – Part 1: Tunka-HiSCORE**

a) Progress within the work plan delineated in the application

In the framework of cooperation via internet conferencing and face-to-face meetings, we were able to establish a productive working environment, allowing us to reach all the goals detailed within the work packages.

*HS-WP1 (hardware development and deployment):* We have made significant progress towards final detector components. Different solutions were developed, tested in the laboratory, deployed and tested in the field, i.e. during our expeditions in October 2012 and April 2013 to the Tunka site. All hardware components were developed and funded with additional funds from the corresponding institutes.

A PMT-signal summator board with trigger-functionality was developed, tested and deployed. Improvements to its design are currently under-way. Further existing electronic components (PMTs, divider bases, pre-amplifiers, readout systems) were used together with developed mechanical components (Station and electronic boxes, Winston cones) to deploy three HiSCORE prototype stations in the Tunka valley (original goal was one prototype for the 1st year).

For the Winston cones, we could optimize the production process by a separation of the manufacture of parts (UHH and ISU) and final assembly on-site (ISU).

A first version of a data acquisition software was developed and successfully used with the 3 prototype stations. Cross-calibration data (Milestone HS-MS2) as well as air shower data were partly analysed and published (ECRS, HDGS), and will be presented in upcoming international conferences (RICAP, ICRC).

Some modifications of the station design were introduced, leading to improved performance. In particular, DESY decided to contribute to a precision timing system, based on a technology only made available recently. This attracted as new collaborator the Department of Informatics from Humboldt-University Berlin. Consequently, the program of the DESY-PhD student is now focused also on experimental timing data analysis and MC-modelling.

*HS-WP2 (Simulation and reconstruction):* Simulations of different detector configurations were performed, including usage of larger PMTs for a reduction of the energy threshold and various array geometry optimizations (Diploma thesis, D. Spitschan, UHH). Adaptations of the reconstruction framework and convergence of data format and processing is work in progress. Work has started to investigate the effect of adding imaging air Cherenkov detectors at the level of simulation (Maiké Kunnas, UHH).

*HS-WP3:* Using simulations for effective areas, angular and energy resolutions and model assumptions on cosmic ray abundancies, we estimated expected gamma-ray event rates for the future HiSCORE detector (Master thesis, U. Einhaus, UHH; L. Sveshnikova, MSU).

b) Milestones achieved

HS-MS2: cross-calibration data from the first HiSCORE prototype, with additional data from the 3-station prototype array.

c) Compliance with financial plan and schedule

Sergey Epimakhov was hired for HiSCORE on the HRJRG position funded by Helmholtz, starting 1st of Mai 2012. He had made his diploma in the Tunka-133 project at MSU, Moscow. The PhD position contributed by University of Hamburg was filled with Maiké Kunnas, starting 1st of August 2012. Andrea Porelli was hired for the DESY-HRJRG PhD-position, starting 1<sup>st</sup> of November, 2012.

The abovementioned reconsideration of hardware component solutions has lead to a slight shift of schedule concerning the final station components.

d) Publications, talks, prizes, etc. Please attach as annex if applicable (until March 2013).

International conference contributions with proceedings for Tunka-HiSCORE :

M. Tluczykont, D. Hampf, U. Einhaus, et al.(2012), "The HiSCORE experiment and its potential for gamma ray astronomy", To appear in Proc. Of European

Cosmic ray Symposium 2012, Moscow, Russia,  
Journal of Physics: Conference Series (JPCS), to be published.

R. Nachtigall, M. Kunnas, S. Epimakhov, et al.(2012), "First deployment and prototype data of HiSCORE" , to appear in Proc. Of European Cosmic ray Symposium 2012, Moscow, Russia, Journal of Physics: Conference Series (JPCS), to be published.

M. Kunnas, R. Nachtigall, S. Epimakhov, et al.(2012), "Hardware components of the HiSCORE detector and results from the first prototype measurements", AIP 1505, 825, Heidelberg Gamma-ray Symposium 2012, Heidelberg, Germany

M. Tluczykont, D. Hampf, U. Einhaus (2012), "HiSCORE - The Hundred\*1 Square-km CosmicORigin Explorer", AIP 1505, 821, Heidelberg Gamma-ray Symposium, Heidelberg, Germany

#### Conference talks (no proceedings):

M. Tluczykont, "Gamma-astronomy and cosmic rays above 10 TeV with HiSCORE" (group presentation, german), DPG 2012, March, Goettingen

R. Wischnewski, "WhiteRabbit in Siberia - Tunka-HiSCORE" , 6th White Rabbit Workshop, GSI-Darmstadt, 22./23.3.2012,  
<http://www.ohwr.org/projects/white-rabbit/wiki/Mar2012Meeting>

M. Tluczykont, "HiSCORE", Invited talk at german astroparticle meetingAstroteilchenphysik in Deutschland, Zeuthen, Sep. 2012

M. Brueckner, R. Wischnewski, "First Results from the HiSCORE/Siberia White Rabbit setup and Plans for CTA", 7th White Rabbit Workshop, Madrid, Nov.2012 <http://www.ohwr.org/projects/white-rabbit/wiki/Nov2012Meeting>

R. Wischnewski et al., "A HiSCORE prototype at the Tunka-EAS array", UHECR2012 Symposium, CERN, 2012  
<http://indico.cern.ch/conferenceDisplay.py?confId=152124>

M. Tluczykont, "HiSCORE", Invited talk, Splinter meeting at the annual meeting of the German astronomical society (Astronomische Gesellschaft), Hamburg, Dec. 2012

#### Talks given at the Spring Meeting of the German Physics Society:

D. Spitschan, S. Epimakhov, et al. (2013), "Simulation and performance optimization for HiSCORE", DPG, Dresden

R. Nachtigall, M. Kunnas, S. Epimakhov, et al. (2013), "The hardware of the HiSCORE detector, DPG, Dresden

M. Tluczykont (talk held by R. Nachtigall), et al. "HiSCORE" (group talk) DPG, Dresden

A. Porelli, R Wischnewski, "White Rabbit - Results for HiSCORE", DPG, Dresden

## Activity report – Part 2: Tunka-Rex

### e) Progress within the work plan delineated in the application

Due to additional own funding by KIT we could build the required hardware for the Tunka Radio Extension (Tunka-Rex) as planned in summer 2012. In particular, the analogue electronics for Tunka-Rex was developed and built by KIT, while many other parts for Tunka-Rex, e.g., cables and rods for the antennas, have been built or purchased by our Russian partners. Together with the Russian partners we started the deployment of Tunka-Rex in summer 2012, finalized it in autumn, and started operation on 8 October 2013, i.e. with less than a month of delay compared to our original plan in the application. With the first measured data we could confirm that Tunka-Rex indeed measures the radio emission of ultra-high energy showers detected by the Tunka-133 photomultiplier-based array: In the first weeks of measurement, we identified already 10 high energy events with a clear signal in at least three antennas, for which the measured radio arrival direction coincides with the arrival direction reconstructed from the Tunka-133 photomultipliers. This event rate is roughly within our previous expectations. We will start the physics analysis of the measurements in the coming months.

The main part of the work in the first year was dedicated to the work package RA-WP1, i.e. the construction of the hardware, and the configuration of the Tunka-Rex array. We also started with the calibration, and foresee to have fully calibrated measurements this year. Within the work package RA-WP2, we started to adapt the analysis software of the Pierre Auger Observatory to the needs of Tunka-Rex. We already can read Tunka-Rex data and correct them for the special hardware properties of Tunka-Rex. This means that in the last years we have made the software basis to develop dedicated analysis modules for the Tunka-Rex measurements, which we plan for this year. As soon as the calibration is finished, we will start with work package RA-WP3, too, i.e. the physics analysis of the measurements and in particular the cross-calibration between the radio and the air-Cherenkov signal.

### f) Milestones achieved

With Tunka-Rex we could already achieve two milestones in 2012, namely milestones RA-MS1 and RA-MS2 as defined in the application: We made the design for the radio array, deployed it, and started the operation. Furthermore, we foresee to achieve the next milestones RA-MS3 and RA-MS4 in time, i.e., to have first analysis results ready for the international conferences in summer 2013, and to connect a few more Tunka-Rex antennas to HiSCORE stations this summer.

### g) Compliance with financial plan and schedule

For Tunka-Rex two PhD students have been hired by KIT: Roman Hiller and Dmitriy Kostunin. Roman Hiller already did his diploma thesis at KIT, though at another project, and started as PhD student for Tunka-Rex in June 2012. Dmitriy Kostunin did his diploma at the Irkutsk State University, one of our partner institutions within the HRJRG. He started as PhD student at KIT for Tunka-Rex in August 2012. Both PhD students have 3 year contracts. Since they started a few months after the start of the HRJRG, we will have to shift some of the funding from 2012 into 2015. Apart from that, Tunka-Rex is within the financial plan. Moreover, we stick to our original schedule for the next steps.

h) Publications, talks, prizes, etc. Please attach as annex if applicable (until March 2013).

**International conference contributions with proceedings (attached) for Tunka-Rex:**

F.G. Schröder et al. (Tunka-Rex), "Tunka-Rex: a Radio Antenna Array for the Tunka Experiment", in Proc. of the ARENA 2012 (Erlangen, Germany), AIP Conf. Proc., accepted.

F.G. Schröder et al. (Tunka-Rex), "Tunka-Rex: a Radio Extension of the Tunka Experiment", in Proc. of the ECRS 2012 (Moscow, Russia), Journal of Physics: Conference Series (JPCS) 409 012076, <http://iopscience.iop.org/1742-6596/409/1/012076>

**Talks given at the Spring Meeting of the German Physics Society:**

F.G. Schröder et al. (Tunka-Rex), "Tunka-Rex - ein Radioantennfeld zur Messung kosmischer Strahlung beim Tunka-Experiment", DPG 2012, Göttingen

R. Hiller et al. (Tunka-Rex), "Tunka-Rex: The Radio Extension of the Tunka Experiment", DPG 2013, Dresden

D. Kostunin et al. (Tunka-Rex), "Status of the Data Analysis of Tunka-Rex", DPG 2013, Dresden

**Poster at the national meeting Astroteilchenphysik in Deutschland, Zeuthen, 2012:**

R. Hiller et al. (Tunka-Rex), "Tunka-Rex: The Radio Extension of the Tunka Experiment", Astroteilchenphysik in Deutschland 2012, Zeuthen