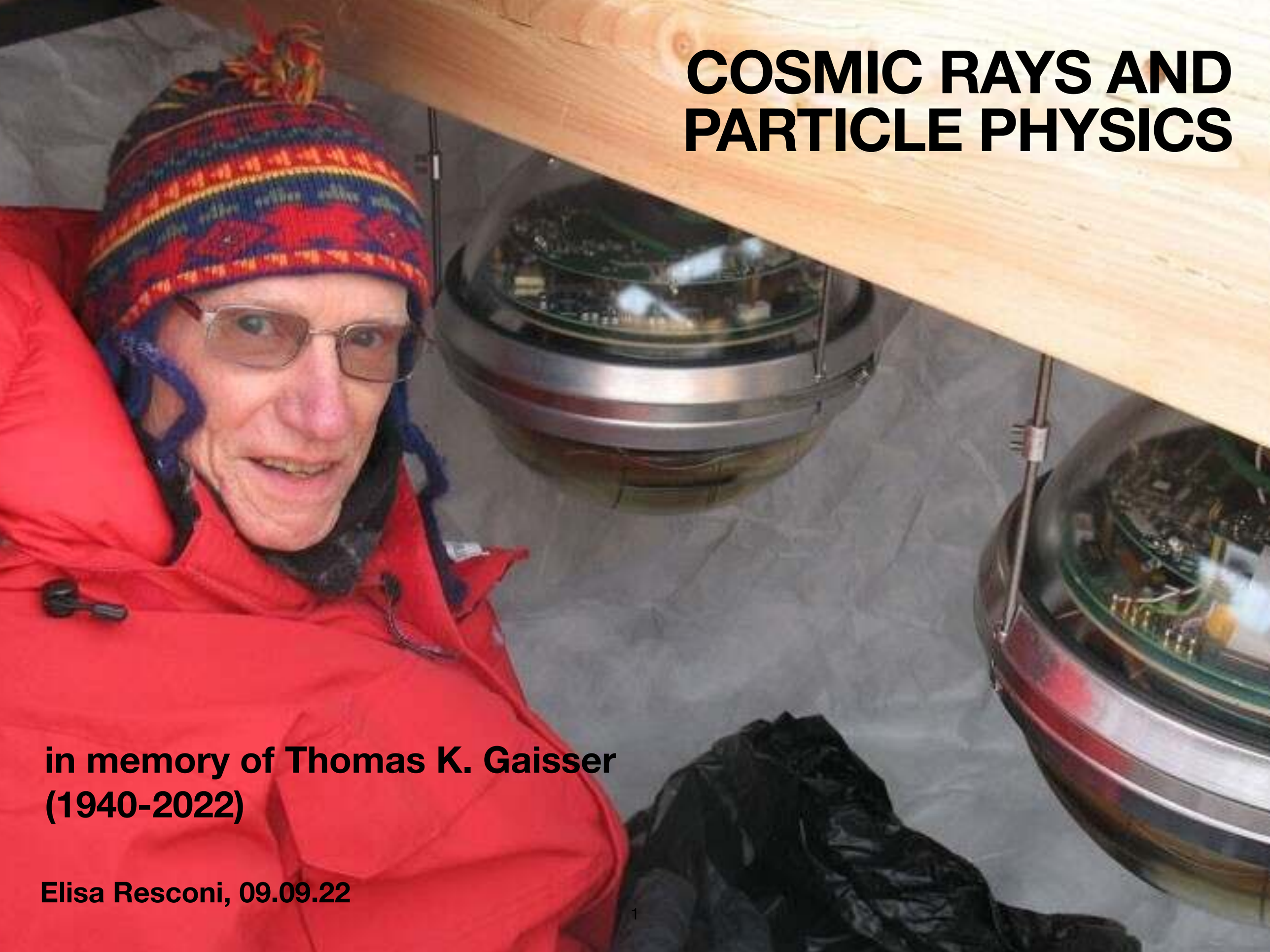
COSMIC RAYS AND PARTICLE PHYSICS

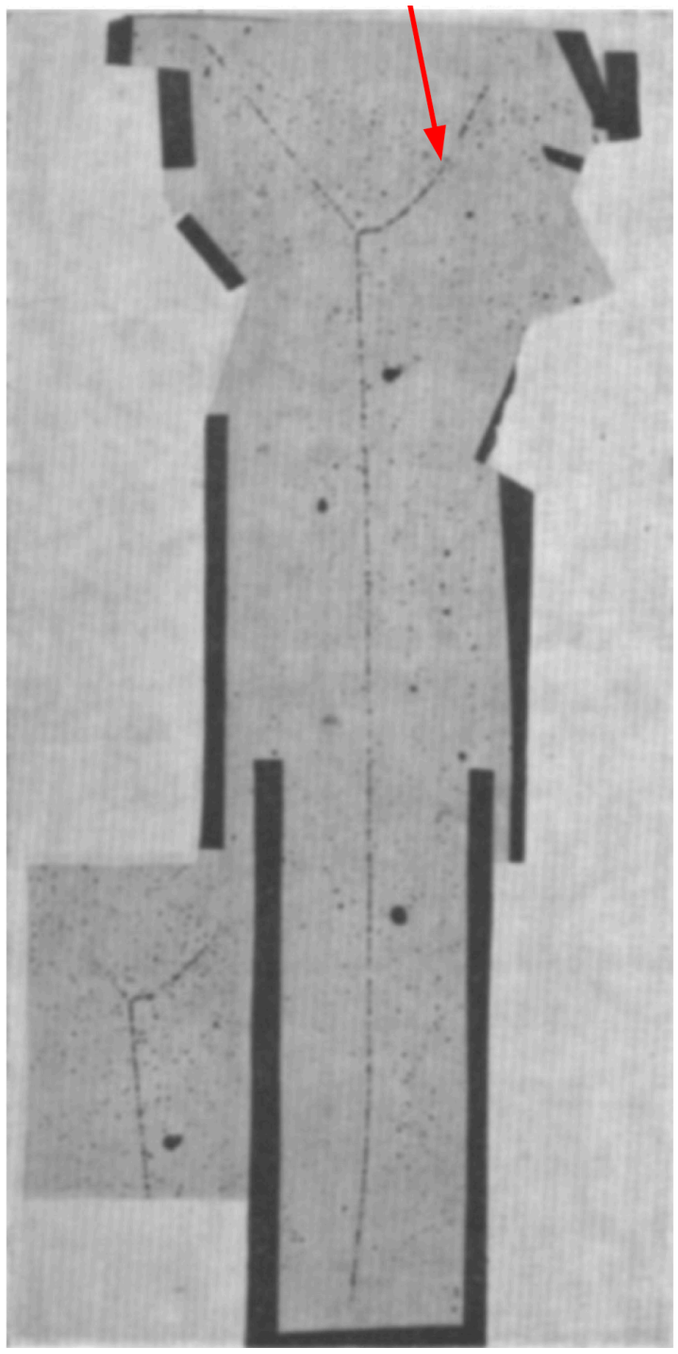


in memory of Thomas K. Gaisser (1940-2022)

Elisa Resconi, 09.09.22

First discoveries in cosmic rays and in particle physics (1930-1950)

Pion discovery



Feb 1947, observed by Powell, Occhialini

Air Showers Observation

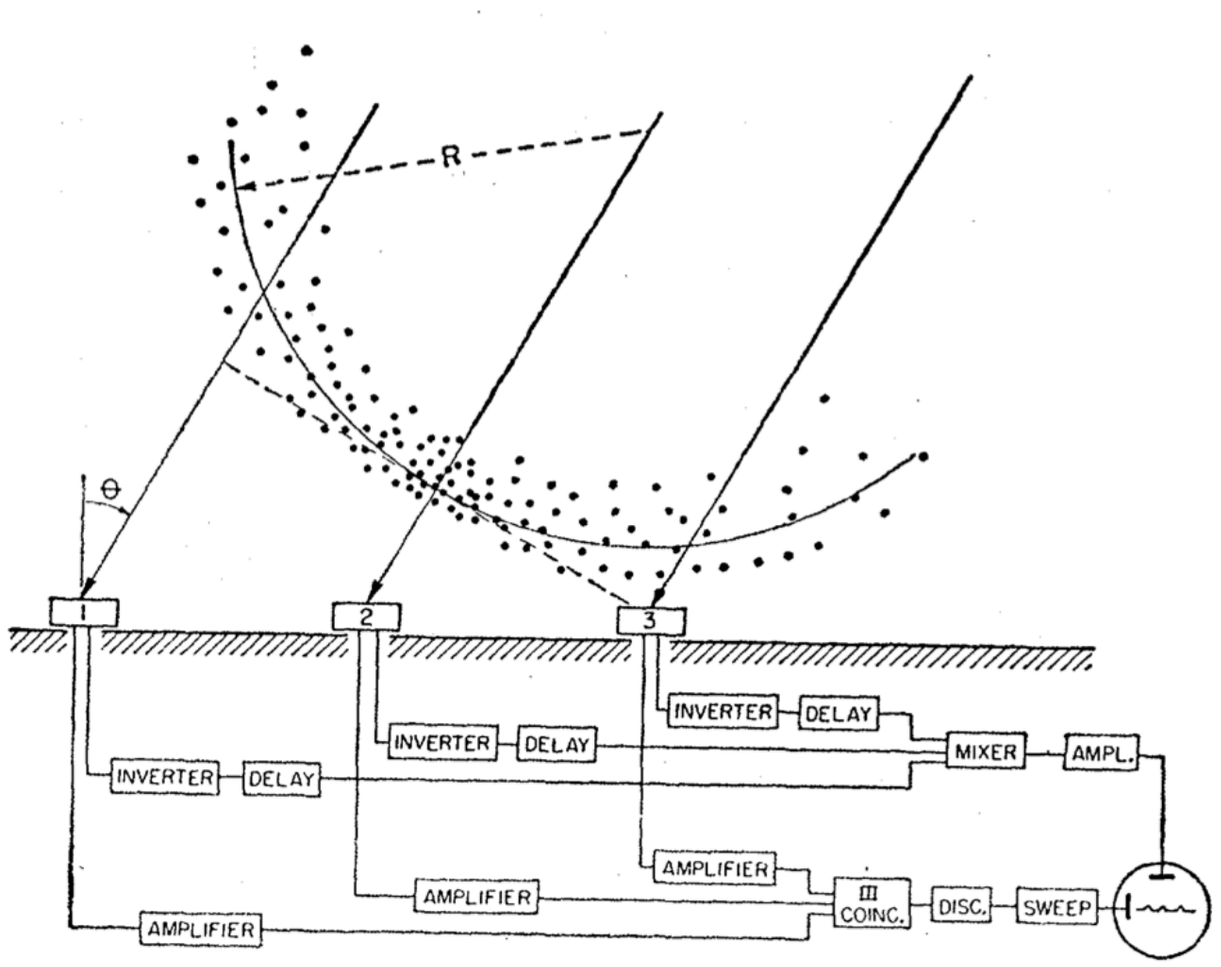


FIG. 2. Block diagram of the apparatus with a schematic representation of an air shower about to strike the counters. The counters are in arrangement II.

P. Bassi, G. Clarck, B. Rossi, Phys. Rev. 92, 441, 1953

Pioneering the primary cosmic rays energy spectrum

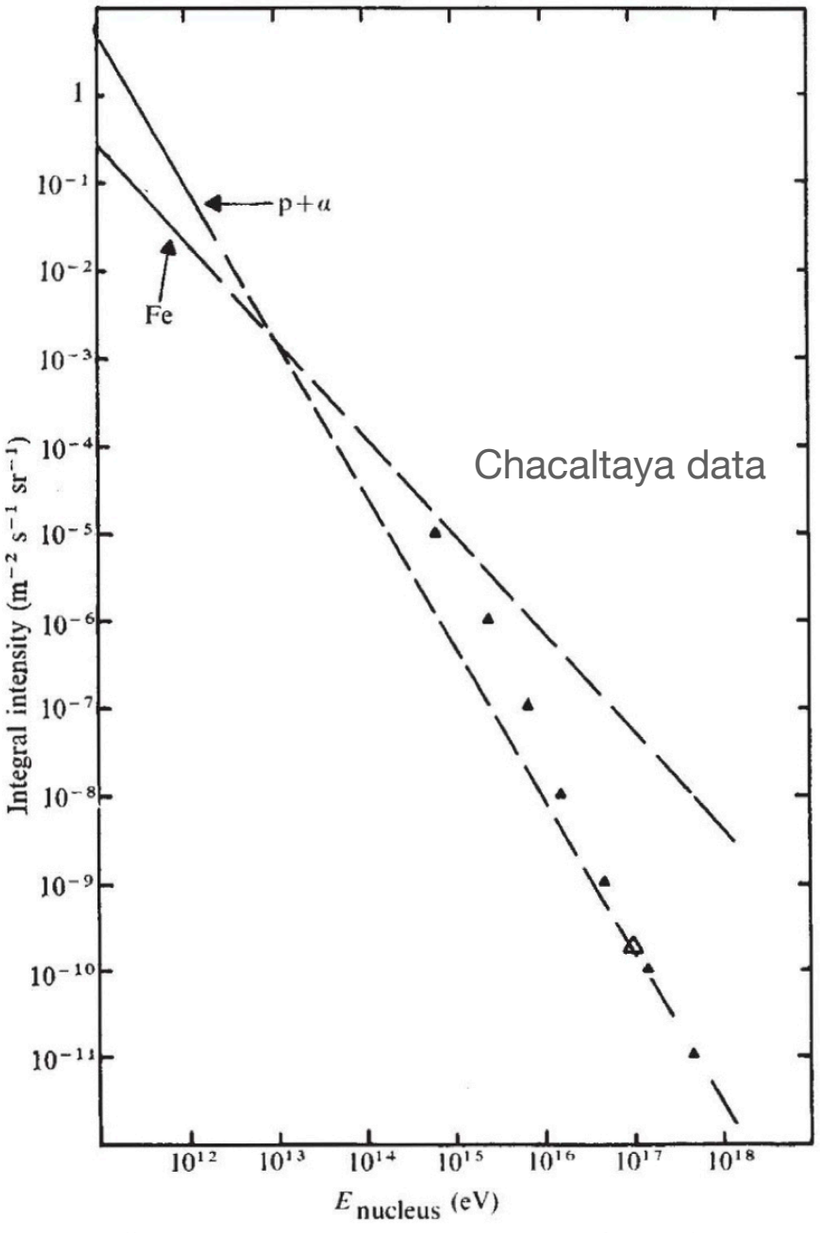
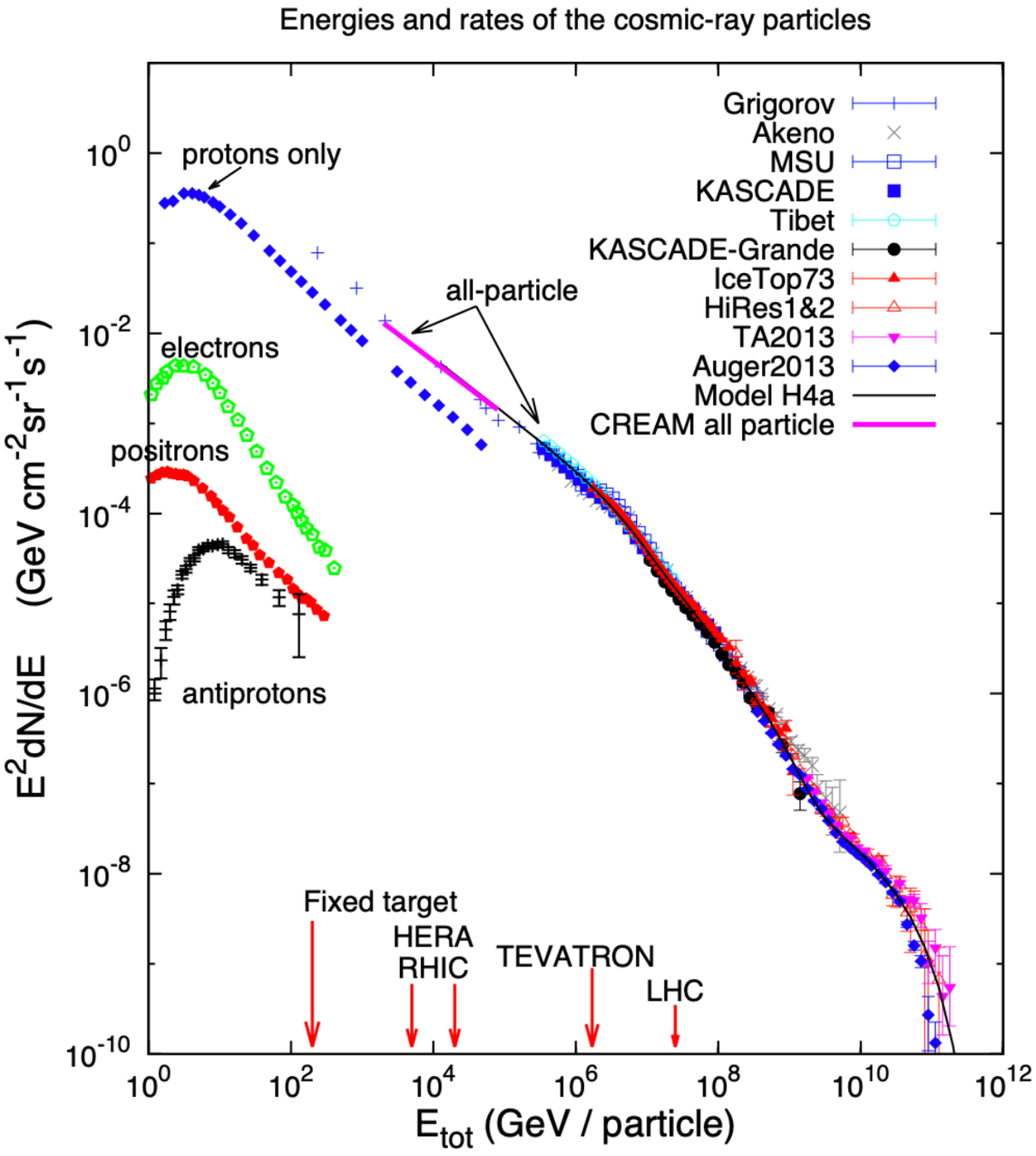


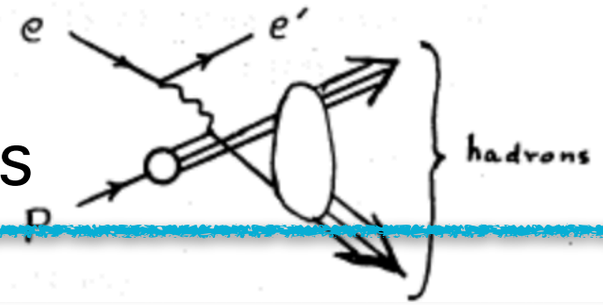
FIG. 2 Data points represent the primary integral energy spectrum obtained from Fig. 1 as described in the text. The normalisation obtained at 10^{17} eV from the EAS calibration of refs 4 and 5 is also shown as a △. – – –, Extrapolations of Fe and $\rho + \alpha$ spectra measured at lower energies in balloon experiments (refs 10 and 11).

T. K. GAISSER, Cosmic-ray energy spectrum from 10^{15} to 10^{18} eV, Nature 248, (1974)



T. K. GAISSER Ralph Engel and E. R., Cosmic Rays and Particle Physics (Cambridge Univer- sity Press, 2016).

Pioneering the interaction of cosmic rays



D. High energy — Extensive air showers.

To probe the energy range beyond 1000 TeV, it is necessary to use the atmosphere as the target and to use arrays with very large effective detection area in order to overcome the extremely low flux of primary cosmic rays (∿1 particle per $m^2 \cdot sr \cdot$ year above 10^{16} eV). This is the realm of extensive air showers (EAS). A conventional EAS array samples the content of one or more types of particles (electrons, muons, hadrons) at one depth in the cascade initiated by a single energetic primary cosmic ray high in the atmosphere. The particles actually detected are thus very far removed from the high energy interaction of interest. This is the fundamental problem with interpretation of air shower data, particularly from the point of view of high energy physics.

Despite such difficulties, it became apparent very early [Gaisser and Maurer, 1972; Wdowczyk and Wolfendale, 1972] that the assumption of standard particle physics together with standard composition of cosmic rays leads to predictions in gross disagreement with the EAS data. By "standard particle

T. K. GAISSER, High energy interactions above 10 TeV, ICRC'77

Pioneering the interaction of cosmic rays: modelling and experiments

Photo courtesy of the University of Wisconsin-Madison

PRIMARY MODELS

HADRONIC INTERACTION MODELS

COUPLES CASCADE EQUATIONS, EVOLUTION OF PARTICLE FLUXES

PHYSICS OF ATMOSPHERIC MUONS AND NEUTRINOS, inclusive spectra of atmospheric leptons

SYBILL EVENT GENERATOR

PHYSICAL REVIEW D **100,** 103018 (2019)

Hadronic interaction model SIBYLL 2.3c and inclusive lepton fluxes

Anatoli Fedynitch*

llee 6, 15738 Zeuthen, Germany, Karlsruher Institut für Technologie, für Kernphysik, Postfach 3640, 76021 Karlsruhe, Germany
nstitute for Cosmic Ray Research, the University of Tokyo, -1-5 Kashiwa-no-ha, Kashiwa, Chiba 277-8582, Japan

Felix Riehn

Instrumentação e Física Experimental de Partículas (LIP)—Lisbon, Av. Prof. Gama Pinto 2, 1649-003 Lisbon, Portugal
Karlsruher Institut für Technologie, Institut für Kernphysik, Postfach 3640, 76021 Karlsruhe, Germany

Ralph Engel

chnologie, Institut für Kernphysik, Postfach 3640, 76021 Karlsruhe, Germ

Thomas K. Gaisser and Todor Stanev

Research Institute, Department of Physics and Astronomy, niversity of Delaware, Newark, Delaware 19716, USA

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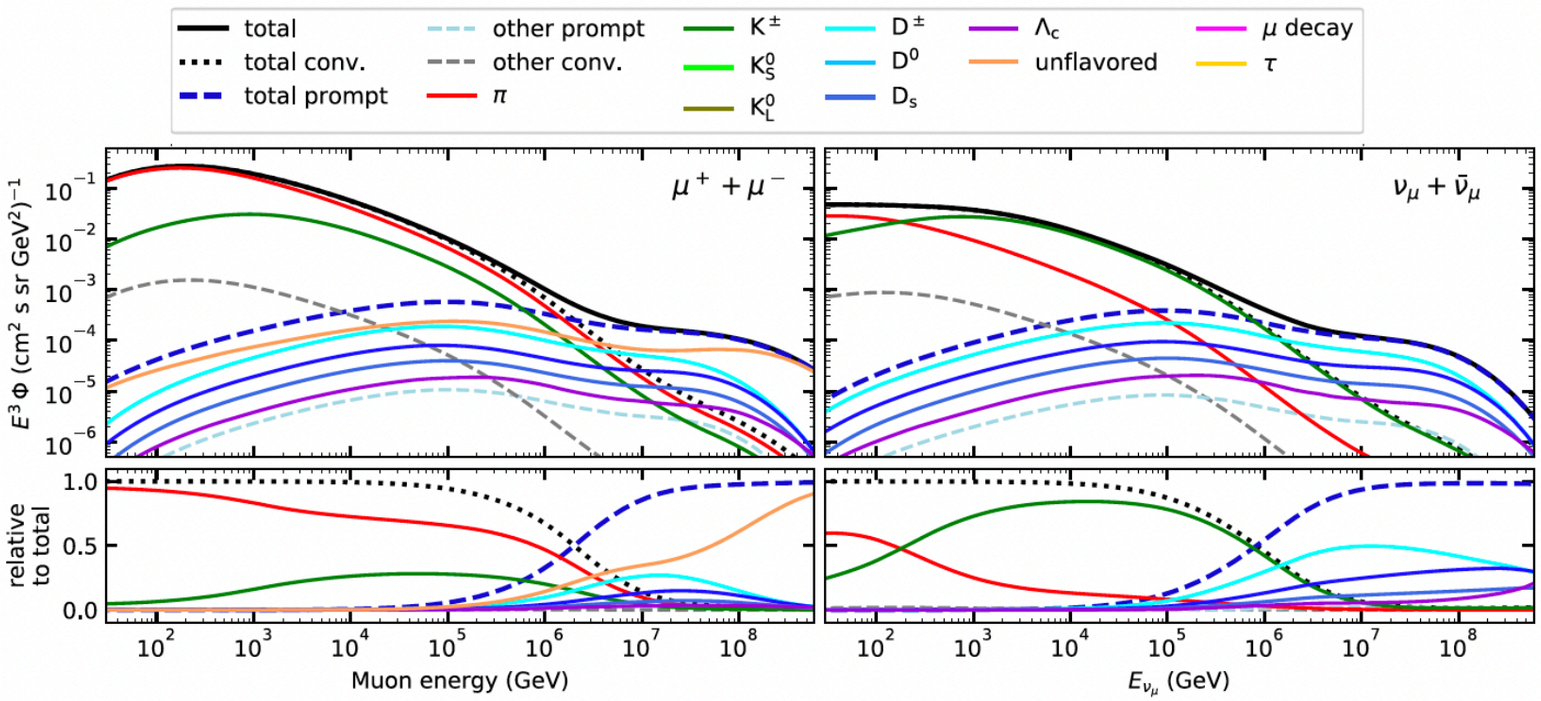
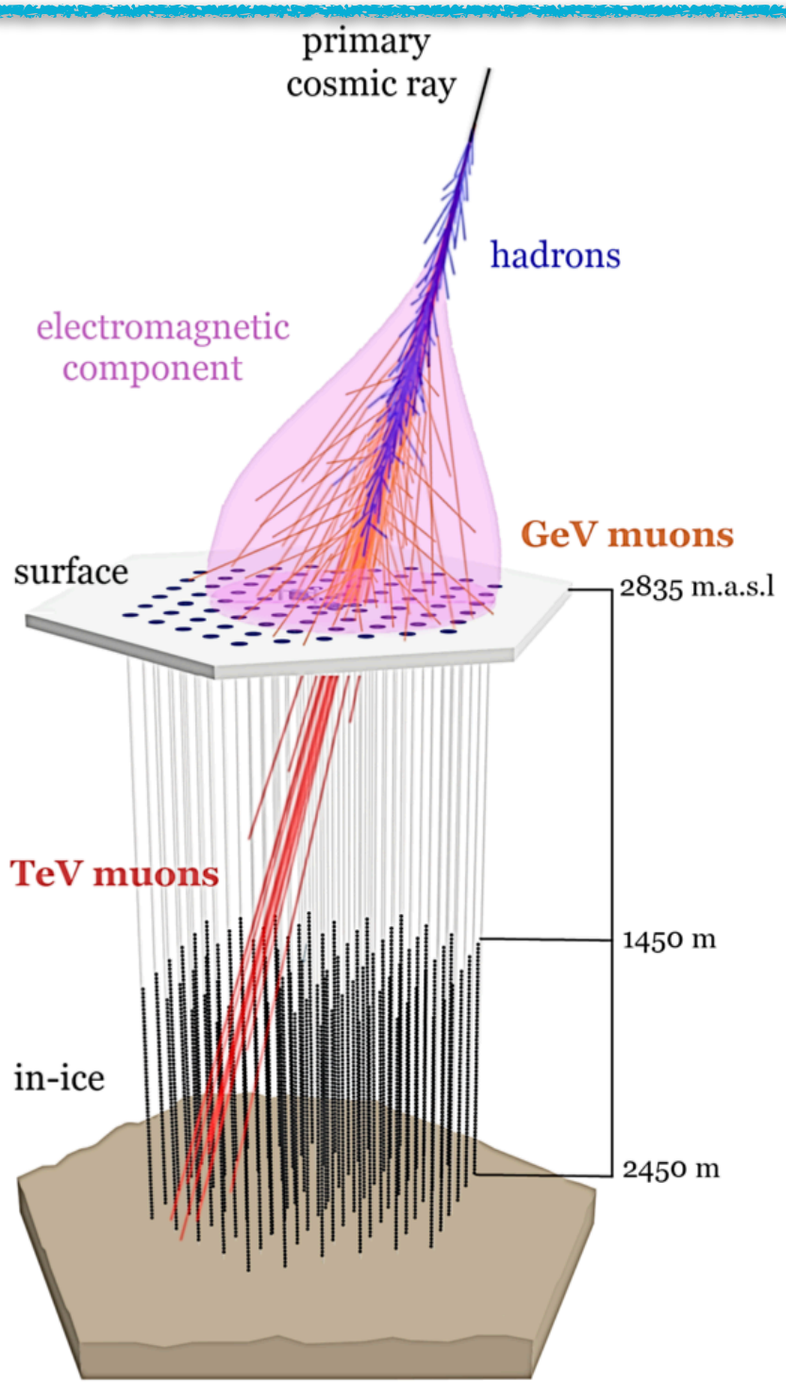
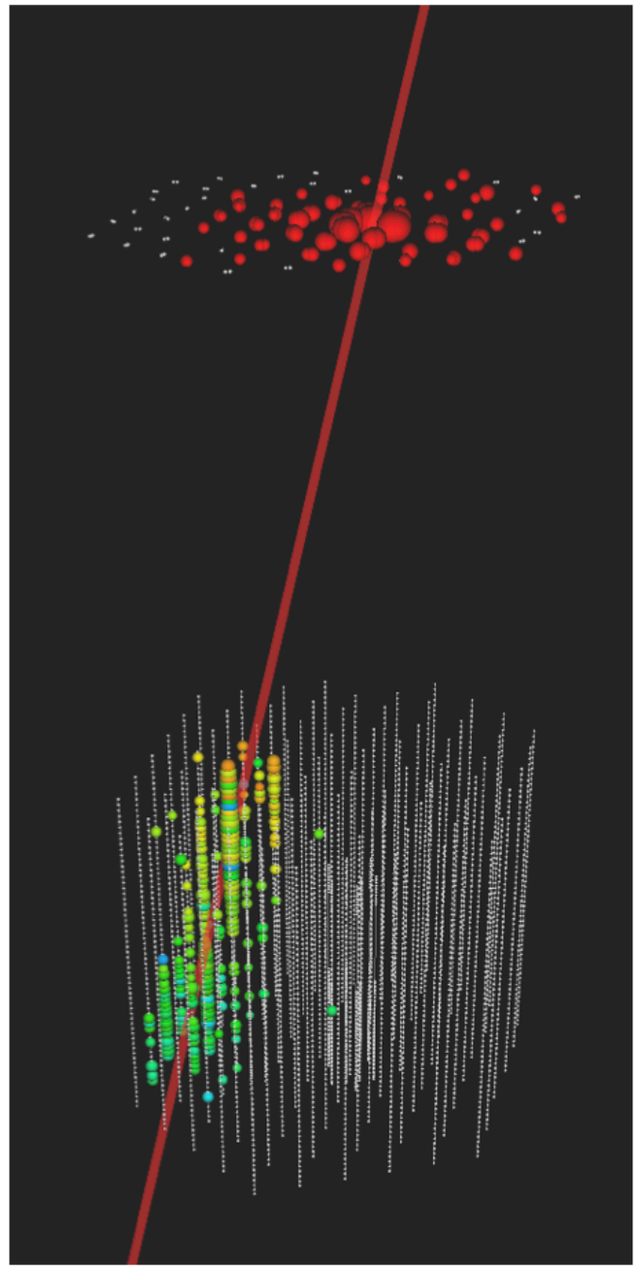


Pioneering the interaction of cosmic rays: modelling and experiments

Photo courtesy of the University of Wisconsin-Madison





Stef Verpoest, Dennis Soldin, Sam De Ridder, and IceCube, ICRC'21

Pioneering the interaction of cosmic rays: modelling and experiments

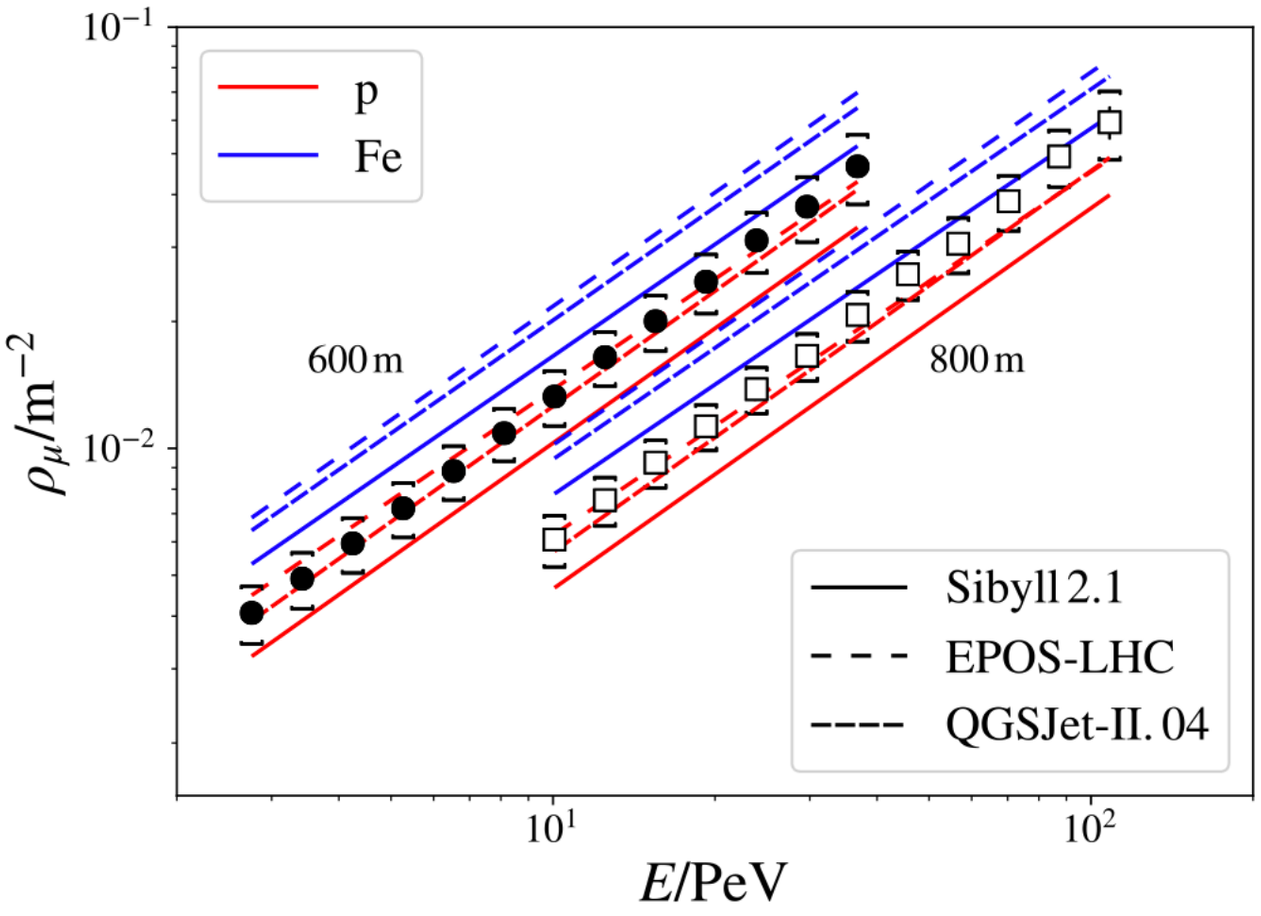


FIG. 13. Measured muon density at 600 m (solid circles) and 800 m (white squares) lateral distance after applying the average correction from Fig. 10. Error bars indicate the statistical uncertainty, brackets the systematic uncertainty. Shown for comparison are the corresponding simulated densities for proton and iron (red and blue lines). Tables of these data are available in a separate public data release [54].

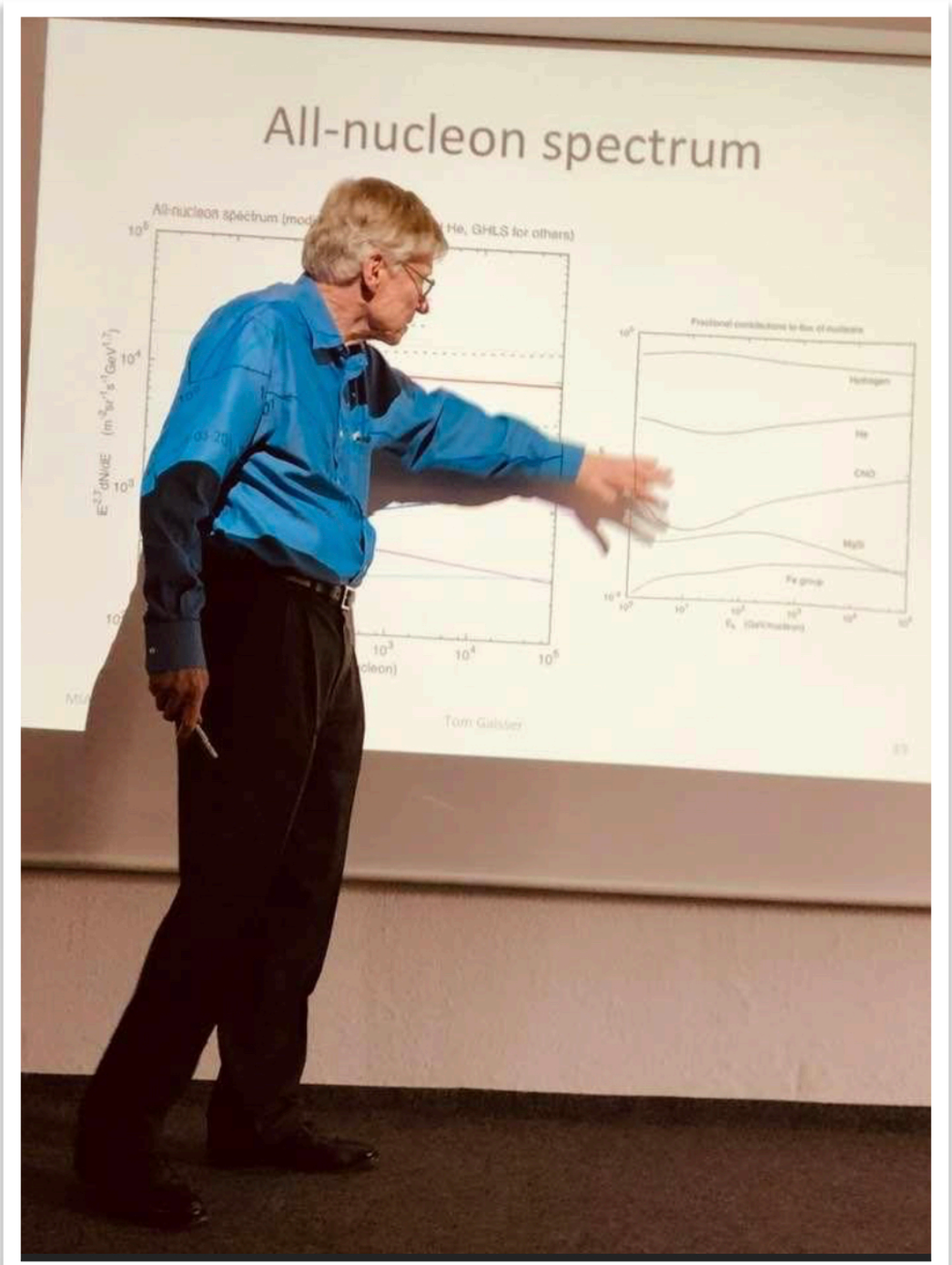
The IceCube Coll., Density of GeV muons in air showers measured with IceTop, https://arxiv.org/pdf/2201.12635.pdf

IceCube Spokesperson (2007 - 2011) and mentor

HAVE AN ICE DAY

Photo courtesy of Kim Kreiger (the Queen)

Lecturer and writer



@MIAPP workshop, Munich 2017

Lecturer and writer: THE book, a ‘working instrument’

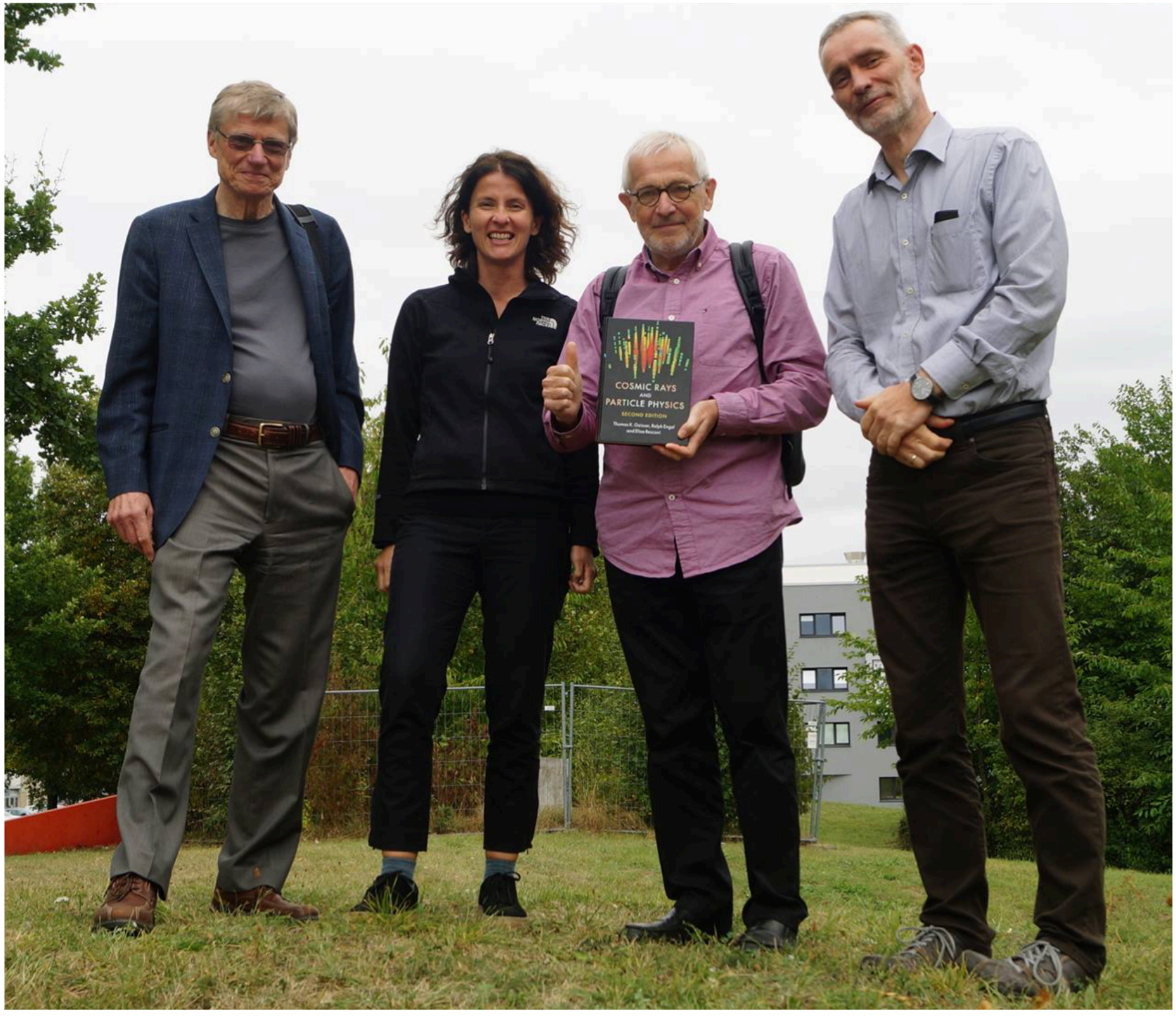


Photo courtesy of Francis Halzen