R-F. HADRON PHYSICS AT CERN SPS AND LHC

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CERN-ALICE experiment. — We took part in the data analysis of the HMPID subdetector, as well as in the research and development of the DAQ system for the planned VHMPID detector. Beside these activities, we also participated in the operation of the ALICE GRID Tier-2 site, and performed detector control tasks. Our most important result was the theoretical and experimental analysis of the pseudorapidity density and nuclear modification factors in $\sqrt{s}$ = 5 TeV center-of-mass energy p-Pb collisions. Our model predictions, published at the beginning of the year, are in good agreement with the results of these first measurements.

CERN-CMS experiment, hadron physics. — We have determined the inelastic p-p cross section with a simple event counting method at $\sqrt{s}$ = 7 TeV, and have contributed to a combined cross section paper, together with a pile-up counting analysis. We have measured the spectra of identified charged hadrons in p-p collisions at $\sqrt{s}$ = 0.9, 2.76, and 7 TeV. Charged pions, kaons, and protons in the transverse-momentum (p_T) range 0.1-1.7 GeV/c were identified via their energy loss in the silicon tracker. The average $p_T$increases rapidly with the mass of the hadron and the event charged-particle multiplicity, independently of the center-of-mass energy. We have presented both results at the DIS2012 conference.

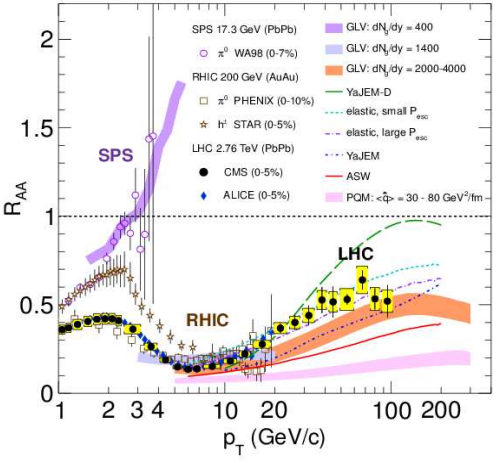

Fig 1. CMS: The nuclear modification factor R_{AA} in central heavy-ion collisions for neutral and charged hadrons, at several center-of-mass energies.

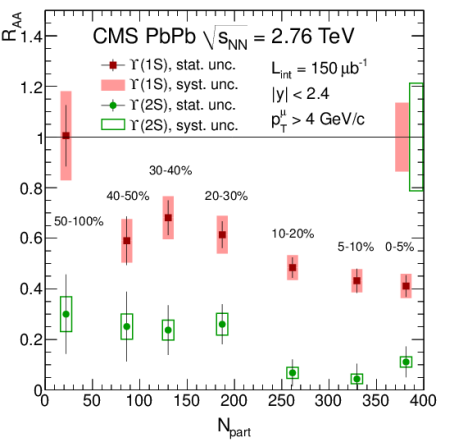

Fig 2. CMS: The nuclear modification factor R_{AA} for upsilon states as a function of the centrality of the heavy-ion collision.

We have participated in the measurement of the relative and absolute suppression of Y states in Pb-Pb collisions. We see the expected sequential melting of quarkonium states. We have

PhD student

performed a study of Z boson production in Pb-Pb collisions with a high statistics data set, obtained in 2011. The measurements compared to NLO calculations show that the production of Z bosons is not modified by the strongly interacting matter produced in heavy-ion collisions. We also have participated in the measurement of the nuclear modification factor of charged particles in Pb-Pb collisions, using the data set mentioned above. The results were presented at the HP2012 conference. We took part in the analysis of jet-track correlations by evaluating the performance of tracking and the related uncertainties of the final results. We have developed the trigger menu used to record the first p-Pb collisions, and also contributed to the measurement of two-particle correlations by developing the event selection and performing various cross-checks.

CERN-NA61 experiment. — We have measured the spectra of charged pions and kaons in minimum bias p-C collisions at 31 GeV/c beam momentum. These data have been used as reference data to for a precise calculation of neutrino fluxes produced at the T2K neutrino beam experiment. We have also recorded a large statistics minimum bias p-Pb data set at 158 GeV/c beam momentum, a unique reference for comparisons with heavy-ion collisions. For event centrality determination in these collisions a new detector, the Low Momentum Particle Detector, was developed in the framework of the REGARD group, in close collaboration with us. We have significantly upgraded the DAQ system of the experiment, making it possible to record data with sufficient speed and quality. Furthermore, we also started to develop a new offline software system, for fast data reconstruction and analysis.

Independent works. — We have studied the estimation of energy loss rate (*dE/dx*) for charged particles in tracking detectors. The truncated mean method was generalized to the weighted mean of the measurements. The optimized weights are rather independent of particle momentum and track segment length, and their values are given by a simple universal description as a function of the number of measured track segments. We have approximated the energy loss distribution of charged particles in silicon by a simple analytical parametrization. With the help of energy deposits in sensing elements of the detector, the position of track segments and the corresponding deposited energies were estimated with improved accuracy and less bias. The parametrization was successfully used to estimate the energy loss rate of charged particles, and applied to detector gain calibration tasks.

GRANTS AND INTERNATIONAL COOPERATION

OTKA K 81614	New analysis methods and tests of quantum chromodynamics at the LHC (F. Siklér, 2010-2014)
OTKA NK 81447	Hungary in the CMS experiment of the Large Hadron Collider (D. Horváth, 2010-2013)
OTKA K 68506	Experimental and model study of high momentum transfer phenomena at pp, pA and AA reactions (Z. Fodor; 2007-2012)
CERN-NA49	D. Barna, Z. Fodor, A. László, G. Pálla, F. Siklér, Gy. Vesztergombi
CERN-NA61	L. Boldizsár, Z. Fodor, A. László, G. Pálla, Gy. Vesztergombi
CERN-ALICE	A. Agócs, GG. Barnaföldi, D. Berényi, L. Boldizsár, E. Dénes, G. Hamar, P. Lévai, S. Pochybova, L. Molnár
CERN-CMS	Cs. Hajdu, P. Hidas, D. Horváth, F. Siklér, V. Veszprémi, Gy. Vesztergombi, AJ. Zsigmond, K. Krajczár

GSI-FOPI Z. Fodor, J. Kecskeméti, Z. Seres Swiss National Science Foundation (SNSF) SCOPES 128079, First years of data taking with the CMS experiment at the LHC; Dissertori G; 2009-2012

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♦ Highlighted publication, where the contribution of our group was decisive.

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R-G. PARTICLE DETECTOR RESEARCH AND DEVELOPMENT

György Bencze, *Gyula Bencédi, Ervin Dénes, Gergő Hamar, Tivadar Kiss, Levente Kovács, Tamás Tölyhi*

Our task is to study and develop advanced micropattern gas-avalanche detector technologies for applications in and outside high energy physics in close collaboration with the Lorand Eötvös University, including frontend and data acquisition electronics and software.

In 2012 the work was concentrated on further improvement of the detectors and technologies,which has been started during the past three years:

VUV-photon detector for the ALICE-VHMPID upgrade project. —A 200x200 mm^2 prototype detector based on CsI-covered ThickGEM (Fig. 1) has been tested at CERN with 6 GeV pions, and a full Cherenkov ring could be seen for the first time with GEM-type detector (Fig. 2).

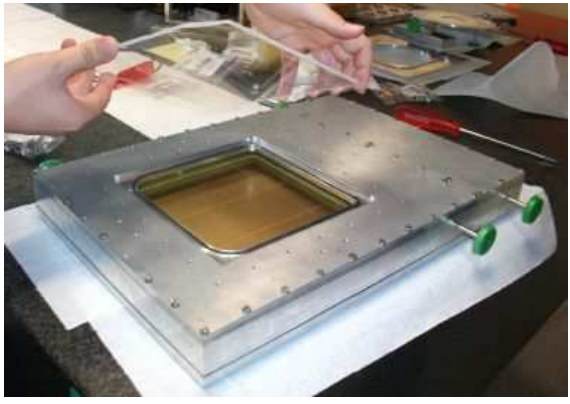

Fig. 1: ThickGEM-based photon detector during assembly

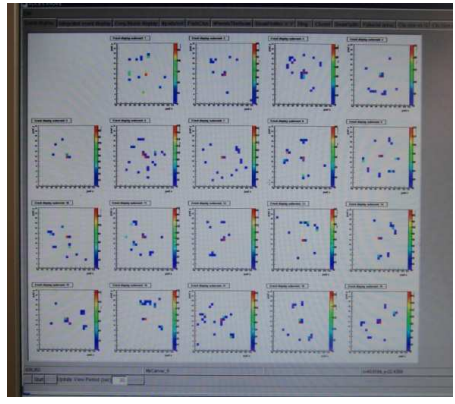

Fig. 2: Some detected Cherenkov ring events

A new and very perspective method has been developed for characterization of the TGEM-based detectors by scanning and extracting photo-electrons from the surface with focused UVlight (Fig. 3).

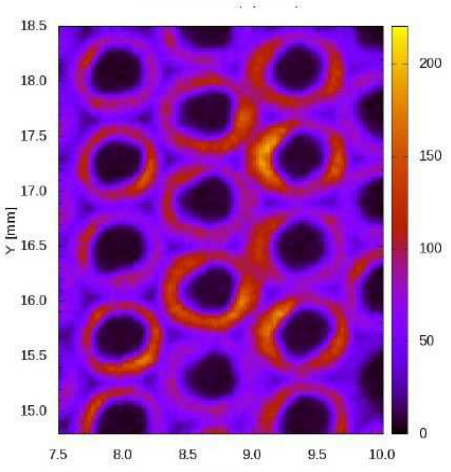

Fig.3: Efficiency-map of the ThickGEM detector surface

Fig. 4: Large-size CCC-chamber

Further development of the CCC (Close Cathode Chamber) technology and its application for muon tomography. — We have proposed and developed a light-weight low-cost chamber which can be built in large size (Fig.4). The design has been acceptedas the candidate for the particle-track detector of the VHMPID. A small prototype (Fig. 5) was already used during the VHMPID beam tests at CERN.

Fig. 5: CCC-chamber used during the VHMPID-beamtests at CERN

Fig. 6: The portable Muon Tomograph in the Ajándék-cave

The improved version of the Muon Tomograph based on CCC-chambers has been applied in different caves in Hungary and measured the relief and possible cavities by detecting cosmic muons. The particuliarity of this device is its portability and autonomy during data taking (Fig.6).

GRANTS AND INTERNATIONAL COOPERATION:

OTKA-NKTH CK77815 (György Bencze, 2009-2013)

CERN CMS collaboration (Gy. Bencze)

CERN RD51 collaboration, (Gy. Bencze Wigner group leader, G. Hamar, L. Kovács, E. Dénes)

CERN NA61 collaboration (T. Tölyhi)

CERN ALICE collaboration (Gy. Bencédi, G. Hamar, E. Dénes, T. Kiss)

CERN ALICE VHMPID upgrade project (Gy. Bencze, Gy. Bencédi, G. Hamar, E. Dénes)

PUBLICATIONS

Articles

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See also: R-B.1., R-F (Alice, NA61)

R-H. NEW PHYSICS AT CERN

György Vesztergombi, *Ádám Agócs,*[#] *Dániel Barna, Lajos Diósi, Csaba Hajdú, Pál Hidas, Dezső Horváth, Gabriella Pásztor, Viktor Veszprémi*

Higgs-boson discovery. — All members of the CMS collaboration got the following message in July 5 from Joseph Robert Incandela, the spokesperson of the experiment, who was returning from the Melbourne conference presentation of Higgs discovery on July 4th:

Dear CMS colleagues - dear friends!

I want to congratulate the whole collaboration on an amazingly beautiful result under incredible time pressure. It is the consequence of decades of work and it is something we all made possible and we now all share together.

I had to rush off to Melbourne so I could not send this message sooner than this moment while waiting for a connecting flight in Singapore, reading Wall Street Journal Asia which has a CMS event display on the front page and another one covering a full half page on the inside!!

We have really made an impression worldwide.

Enjoy the moment everyone. It is a truly historic one.

Joe

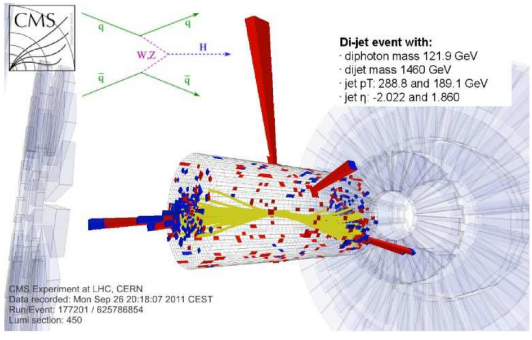

Fig. 1. The figure shows a CMS event similar to a Higgs particle. The boson is born when two quarks are scattered on each other and decays to two high energy photons denoted by red rectangles. The two quarks are flying away and initiate a hadron shower (yellow). The two hadron showers show the possible starting point of the Higgs boson, where the photons are initiated, and this is helpful in the determination of the mass of the boson.

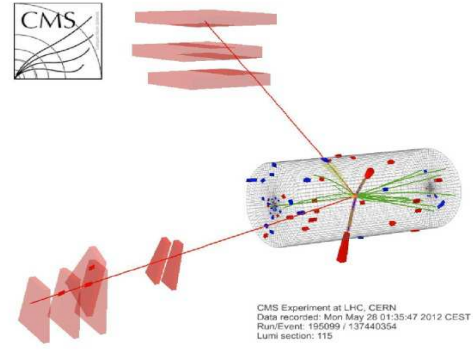

Fig. 2 A CMS event where the hypothetic Higgs boson decays onto a pair of electrons and muons, respectively. The electrons are absorbed by the electromagnetic calorimeter, but the muons leave the system, triggering the muon detectors farther away.

PhD student

The Hungarian physicists as senior funding fathers of RD5=proto-CMS and junior members of the Wigner CMS team had the feeling that the 2 events mentioned by WSJ and shown below really represent the reward of their 20-year work.

Of course, the Wigner team's contribution was marginal in size, but essential in the final outcome, like in a very long chain the breaking of one single element would destroy the whole system. Though the expert teams consisted of much more members than the Hungarian collaborators, the Wigner participants had a considerable share in the pixel and the alignment.

The heart of the CMS detector is the Silicon TRACKER which contains almost 100 million active channels. The heart of the heart is the pixel detector which, practically, consists of hundreds of CCD cameras producing pictures with nanosecond time resolution. It was the responsibility of the Hungarian team to ensure that these cameras make the exposition in the right time. The method was worked out and the continuous monitoring was accomplished.

Another task of the Wigner team was the radiation damage control. The pixel detector is standing in the very front-line only few centimeters away from the collision point (which is one of the hottest points of the Universe). Due to the wonderfully intensive collision rate these detector elements are rapidly collecting huge radiation dose, which causes the performance of the system to deteriorate. This effect was foreseen during design, and one can correct for it by adjusting the voltage on the detector chips. The work-out of this correction method and its regular updating application was also done by the Wigner team.

The in-situ determination of alignment constants for the CMS Silicon Tracker is also an important task. Though it is not known for the public, the accurate determination of the alignment constants is crucial for the physics performance of the experiment. Position and angular orientation, as well as shape parameters are determined at the level of individual sensors, resulting in up to 200000 alignment parameters. An algorithm based on the global minimization of track-to-hit residuals is used, which determines all alignment and track parameters simultaneously. Systematic biases in the geometry are controlled by adding further information into the alignment workflow in form of the known mass of resonances decaying into muons. The time evolution of the position of large structures in the tracker is also a central issue. The Hungarian contribution in these activities mainly was concentrated on the monitoring task. Recently a new method was proposed for the treatment of the so-called weak modes by the Wigner team.

SUSY search. — The discovery of Higgs-boson has double meaning: it is the END and the BEGINNING at the same time. It is the coronation of the Standard Model, the last missing element in the jig-saw puzzle. But if there exsists one Higgs then any number of additional Higgs bosons may exist, too. One of the most popular candidates with 5 bosons is the SUSY model which would solve many fundamental problems of particle physics.

Unfortunately the observed 125 GeV/c^2 mass for Higgs is strongly disfavouring the most popular SUSY versions (CMSSM, mSUGRA)

, therefore working out a new search strategy is on the agenda, where the Wigner team is actively participating in the Single Lepton group.

GRANTS AND INTERNATIONAL COOPERATION

OTKA NK 81447 Hungary in the CMS experiment of the Large Hadron Collider (D. Horváth, 2010-2013)

OTKA K 72172 Study of fundamental symmetries using antiprotons (D. Horváth, 2008-2012)

OTKA K 75129 Theory of quantum effects in nano-systems (L. Diósi, 2009-2013)

SCOPES 128079 (Swiss National Science Foundation) First years of data taking with the CMS experiment at the LHC (Dissertori* G; 2009-2012)

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