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Editors: T. Jakoubek, V. Pacík, M. Sedláčková, M. Vlasák
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Faculty of Nuclear Sciences and Physical Engineering
Address: KF FJFI ČVUT, Břehová 7, 115 19 Praha 1
tomas.jakoubek@cern.ch, +420724966697
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Foreword

This year, for the 8^{th} time, students, graduates, and teachers from the field of Experimental Nuclear and Particle Physics at FNSPE CTU met at the annual winter workshop. The meeting was held during the week of 11.–18. 01. 2014 at *Penzion Krakonoš* in the Jizera Mountains in the Czech Republic. The main goal of the workshop is to follow the progress of students, discuss problems and experiences and also to get to know each other better. Each participant gave a talk about their work or progress during the previous year. Extended abstracts of these talks are published in the proceedings you are holding now.

Editors

Collisions of light at the LHC

Jaroslav Adam *(adamjaro@centrum.cz)*

Ultra-relativistic heavy ions generate strong electromagnetic fields which offer the possibility to study collisions of light in gamma-gamma, gamma-nucleus and gamma-proton interactions at the LHC. Such a collisions are called the ultra-peripheral Pb-Pb or p-Pb collisions (UPC). In the case of UPC the nuclei or protons are passing each other at a distance greater than the sum of the nuclear radii in the ion-ion case, or at impact parameter large enough to strongly suppress the hadronic interactions in the case of ion-proton system or proton-proton collisions. The physics of ultra-peripheral collisions is reviewed in [1] and [2].

As the hadronic interactions are suppressed, the only mechanism in question is via the strong electromagnetic field, whose intensity is proportional to the square of the electric charge of the ion. The electromagnetic field is described as a flux of virtual photons [3]. As a consequence of the proportionality to the square of the electric charge, in Pb-Pb UPC each lead ion is a photon source or a target with equal probability, but in the proton-lead case the lead ion is most likely the photon source.

The J/ψ photoproduction off Pb-ions in γ-Pb interactions allows to study nuclear gluon shadowing, while the photoproduction reactions off protons in γp reactions are sensitive to saturation phenomena. In terms of perturbative QCD the photonuclear reactions are described in leading order as two-gluon exchange between virtual $c\bar{c}$ pair created by photon and the target object, which is in our case the proton or the lead nucleus.

In the case of a Pb-Pb UPC two mechanisms for J/ψ exclusive production may occur. The coherent production is a result of coherent photon coupling to the nucleus, while the coupling to a single nucleon is characterized as the incoherent production. In p-Pb collisions the γp reactions are dominant and the exclusively produced J/ψ come from the collision with the proton.

Both the Pb-Pb and p-Pb exclusive J/ψ production is accompanied by the QED process $\gamma\gamma \to \mu^+\mu^-$ or e^+e^-, which is two-photon interaction producing a lepton pair, having thus the same experimental signature as lepton pairs coming from the J/ψ decays.

The ALICE experiment provided the first LHC measurement on exclusive J/ψ photoproduction in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [4], [5] and now the analysis on J/ψ photoproduction in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV is well advanced.

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Mid-rapidity anti-baryon to baryon ratios in pp collisions measured by the ALICE experiment

Michal Broz *(Michal.Broz@cern.ch)*

The ratios of yields of anti-baryons to baryons probes the mechanisms of baryon-number transport. Results for $\overline{\text{p}}/\text{p}$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ and $\overline{\Omega}^{+}/\Omega^{-}$ in pp collisions at $\sqrt{s} =$ 0.9, 2.76 and 7 TeV, measured with the ALICE detector at the LHC, are reported. Within the experimental uncertainties and ranges covered by our measurement, these ratios are independent of rapidity, transverse momentum and multiplicity for all measured energies. The results are compared to expectations from event generators, such as PYTHIA and HIJING/B, that are used to model the particle production in pp collisions. The energy dependence of $\overline{\text{p}}/\text{p}$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ and $\overline{\Omega}^{+}/\Omega^{-}$, reaching values compatible with unity for $\sqrt{s} = 7$ TeV, complement the earlier $\overline{\text{p}}/\text{p}$ measurement of ALICE. These dependencies can be described by exchanges with the Regge-trajectory intercept of $\alpha_{\text{J}} \approx 0.5$, which are suppressed with increasing rapidity interval Δy. Any significant contribution of an exchange not suppressed at large Δy (reached at LHC energies) is disfavoured.

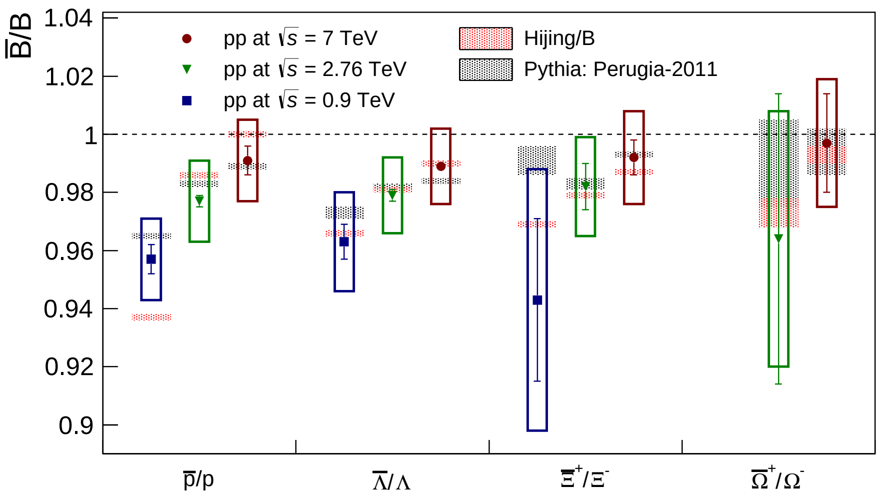

Figure 1: The mid-rapidity yields ratio integrated over $|y| < 0.5$ for $\overline{\text{p}}/\text{p}$ and $|y| < 0.8$ for $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ and $\overline{\Omega}^{+}/\Omega^{-}$. Squares, triangles and circles are for the data from pp at $\sqrt{s} = 0.9$, 2.76 and 7 TeV, respectively. The strangeness content increases along the abscissa.

Figure 1 shows the measured $\overline{\mathrm{p}}/\mathrm{p}$, $\overline{\Lambda}/\Lambda$, $\overline{\Xi}^{+}/\Xi^{-}$ and $\overline{\Omega}^{+}/\Omega^{-}$ together with the same ratios extracted from PYTHIA (Perugia2011) and HIJING/B. HIJING/B models the baryon number stopping mechanism via string-junction transport; in contast, PYTHIA employs a pure multi-parton interaction model. The models reproduce the data reasonably well, although HIJING/B shows a steeper rise in the ratio as a function of beam energy for $\overline{\mathrm{p}}/\mathrm{p}$ than the measured points. Within the uncertainties of our data, we cannot observe an increase of the ratio with the strangeness content, for the given energy. For all species (except the severely statistics limited $\overline{\Omega}^{+}/\Omega^{-}$), the ratio increases with increasing beam energy, reaching values compatible with unity for $\sqrt{s} = 7$ TeV, which sets a stringent limit on the amount of baryon transport over 9 units in rapidity. The existence of a significant difference between the spectra of baryons and anti-baryons even at infinite energy is therefore excluded.

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Coherence effects in hadron-nucleus and heavy-ion collisions at high energies

Jan Čepila *(jan.cepila@fjfi.cvut.cz)*

It is known for a long time that the cross section of the particle production in proton-nucleus collisions is not equal to A times the cross section of the particle production in proton-proton collisions, where A is the mass number of a nucleus. The ratio of these two cross sections is called nuclear modification factor and the deviation of this quantity from unity is a measure of nuclear effects. The suppression of the production rate in the region of high Feynman x_F was first observed in BRAHMS experiment at RHIC collider for the charged hadron production, but later was rediscovered in NA49 experiment at SPS for the pion production and even in E772 experiment at FNAL for the dilepton production. Coherence phenomena(shadowing) are expected to be responsible for the suppression, but one has to interpret it carefully. If a particle with mass M and transverse momentum p_T is produced in a hard reaction with pseudo-rapidity η then the corresponding values of Bjorken variable in the beam and the target are $x_{1,2} = \frac{\sqrt{M^2+p_T^2}}{\sqrt{s}} e^{\pm\eta}$ with $x_F = x_1 - x_2$ and the region, where coherence phenomena are expected to be strongest, corresponds to forward pseudo-rapidity for energies accessible at RHIC. As a result coherence effects exhibit the x_2 scaling, but as shown in [1] this scaling is known to be broken. The fact, that the suppression has been also observed at any reaction studied so far at any energy suggest that the effect which suppresses particle yields has to be energy independent and as shown in [1] or [2] has to scale with x_F. Such mechanism was formulated in [2, 3] as energy conservation restrictions in the multiple parton rescattering inside the nuclear medium. As a result the effective projectile parton distribution correlates with the nuclear target and can be expressed in term of the suppression factor $S(x) = 1 - x$[4] as

$$f^A_{q/N}(x, Q^2, \vec{b}) = C f_{q/N}(x, Q^2) exp(-(1 - S(x))\sigma_{eff} T_A(\vec{b})),$$

where $T_A(\vec{b})$ is the nuclear thickness function , $\sigma_{eff} = 20$mb and the normalization factor C is fixed by the Gottfried sum rule.
Results of the calculation including all relevant effects show very good agreement with all available data. Moreover, the effect of energy conservation restrictions in the multiple parton rescattering allows to reproduce the unexpected suppression of direct photons in nuclear collisions at RHIC, which has been a long standing puzzle.

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STAR beam energy scan

Petr Chaloupka *(petr.chaloupka@fjfi.cvut.cz)*

Quantum Chromodynamics (QCD) predicts that at sufficiently high temperature T or baryon chemical potential μ_B a phase transition from hadrons to a state of deconfined quarks and gluons will occur [5]. Indeed, results from RHIC and ALICE experiments provide convincing evidence that this novel state of strongly interacting matter is created in the central collisions of heavy nuclei. However, the nature of this phase transition is not completely known and pose a challenge to high-energy nuclear and particle physics.

One of the most important tasks is now to map out as much of the QCD phase diagram in T, μ_B plane as possible trying to discover and understand in which ways the hadron-to-QGP transition may occur. This so called "Beam Energy Scan" (BES), first proposed in 2008 [4], is a program aiming to search for the "turn-off" of QGP signatures, signals of QCD phase boundary and existence of a critical point in the QCD phase diagram. The almost uniform acceptance for different particles species at different collision energies at midrapidity makes the STAR detector an ideal experiment for the BES program. After few small-statistic Au+Au exploration runs at $\sqrt{s_{NN}}$ =22 GeV in 2005 and at $\sqrt{s_{NN}}$ = 9.2 GeV in 2008, STAR collected large-statistics data sets at $\sqrt{s_{NN}}$ = 7.7, 11.5 and 39 GeV in 2010, and 19.6 and 27 GeV in 2011 [6]. Left panel of Figure 2 shows the statistics of the recorded heavy-ion data from all RHIC runs by the STAR detector.

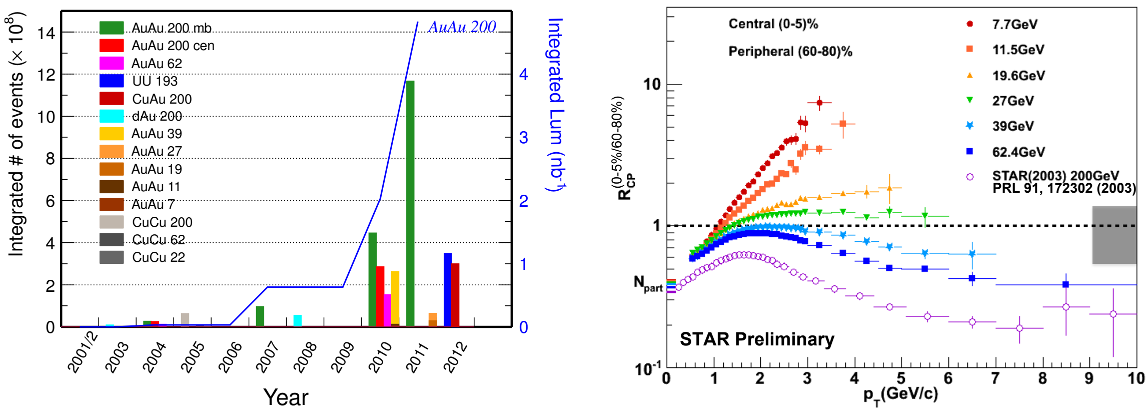

Figure 2: Left panel: Data sets (histograms) and integrated luminosity (line) recorded by the STAR detector. Right panel: $R_{\rm CP}^{(0-5\%/60-80\%)}$ for charged hadrons in Au+Au collisions at $\sqrt{s_{NN}}$ =7.7–39 GeV.

One of the most prominent signatures of QGP at RHIC is the Nuclear Modification Factor $R_{\rm CP}$ - ratio of yields at central collisions to peripheral collisions, scaled by the corresponding number of binary collisions $N_{\rm bin}$ The $R_{\rm CP}$ of different particles at high p_T was observed to be less than unity and is attributed to the energy loss of the partons in the dense deconfined QGP medium. Right panel of Figure 2 shows results of $R_{\rm CP}$ of charged hadrons in Au+Au collisions from STAR Beam Energy Scan events at $\sqrt{s_{NN}}$ =7.7–200 GeV [6]. From $\sqrt{s_{NN}} > 39$ GeV the $R_{\rm CP}$ is below unity, indicating a dominant role of partonic effects. However, the $R_{\rm CP}$ is more than unity at 27 GeV and the value increases with decreasing beam energy. Hence the energy-dependence of high-p_T hadron suppression provides a promising signal for "turn-off" of QGP existence.

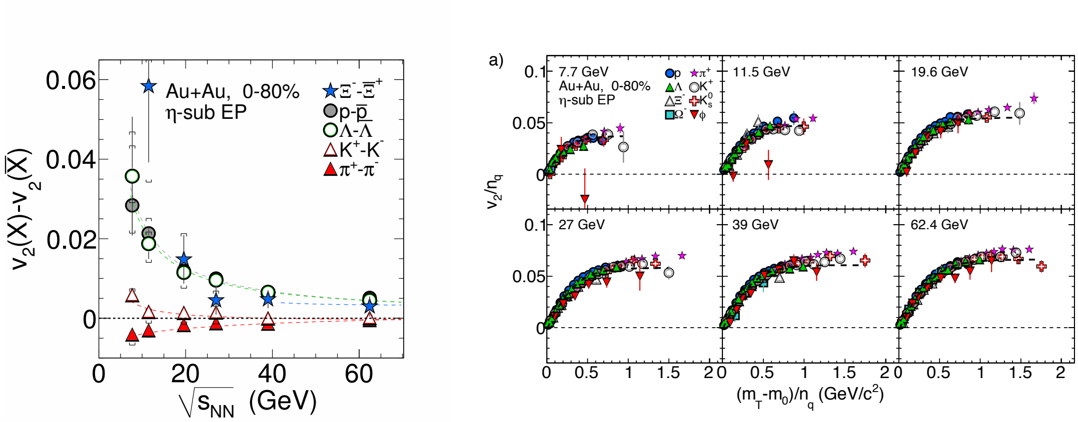

Figure 3: Left panel: The difference in v_2 between particles (X) and their corresponding anti-particles $(\overline{\rm X})$ as a function of $\sqrt{s_{NN}}$ for 0–80% central Au+Au collisions [3].
Right panel: v_2/n_q versus $(m_T - m_0)/n_q$, for 0–80% central Au+Au collisions for selected particles [2].

Study of the conversion of coordinate space anisotropies into momentum space anisotropies plays a central role in the ongoing efforts to characterize the transport properties of QGP. The azimuthal anisotropic flow strength is usually characterized by v_2 - the second coefficient of Fourier expansion of azimuthal dependence of particle production with respect to an event plane. The large value of v_2 observed at RHIC and later on at LHC together with its scaling with the number of constituent quarks(NCQ) is one of the cornerstones of the claim of the discovery of perfect QGP liquid. STAR BES results [1, 2] on v_2 of identified particles are presented in Fig.3. A beam-energy dependent difference of the values of v_2 between particles and corresponding anti-particles is shown in the left panel. As can be seen the particle-antiparticle asymmetry increases with decreasing beam energy and is larger for baryons compared to mesons. It implies that, at lower energies, particles and anti-particles are not consistent with the universal NCQ scaling of v_2. This could be explained by increased contribution from hadronic interactions with decreasing beam energy. Nevertheless, as shown in the right panel of Fig.3 , for each given energy particles appear to follow the NCQ scaling.

Recent results from Phase-I of the RHIC BES program have substantially extended our knowledge of hot and dense deconfined QCD matter. There is a compelling evidence of "turn-off" of some of the QGP signature. However, statistics for several other important observables are not sufficient to draw quantitative conclusions. To strengthen the message from Phase-I, higher statistics at lower energies is needed, especially at 7.7 and 11.5 GeV. In order to confirm the trends between 11.5 and 19.6 GeV, another energy point is needed around 15 GeV in order to fill the 100 MeV gap in μ_B. For these reasons STAR has proposed a "BES Phase-II program" which strongly depends on a necessary luminosity increase. This is planned to be achieved installation of RHIC beam electron cooling. Altogether a factor of 10 improvement in luminosity is expected after these modifications.

To maximize the use of collisions provided by RHIC for the BES II program an installation of thin Au target in the beam pipe is considered. This will allow to run STAR concurrently as a fixed-target experiment. Table 1 lists the proposed collision energies together with corresponding fixed target center-of-mass energies.

Collider mode $\sqrt{s_{NN}}$ (GeV)	Fixed-target mode $\sqrt{s_{NN}}$ (GeV)
19.6	4.5
15	4.0
11.5	3.5
7.7	3.0
5	2.5

Table 1

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Heavy quarkonia production at the STAR experiment

Jana Fodorová *(fodorjan@fjfi.cvut.cz)*

According to the theory of strong interaction, under the conditions of high energy density and temperature a phase transition to a quark gluon plasma (QGP) occurs. This colour-deconfined state of matter is expected to be formed in high energy heavy ion collisions.

Collisions performed at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory reach energies above the critical value creating a deconfined phase of quarks and gluons – that is why the experiments at RHIC play an important role in the study of the QGP. One of these experiments is the Solenoidal Tracker at RHIC (STAR). A unique strength of the STAR experiment is its large, uniform acceptance capable of measuring and identifying the particles produced in the heavy ion collisions.

In the presence of QGP strong supression of particle production in central collisions and at high p_T is predicted. Measurements made at the STAR experiment observed the suppression of produced particles with $p_T > 3$GeV/c in Au-Au collisions at the energy of $\sqrt{s} = 200$ GeV. No suppression was observed in peripheral collisions, a large suppression, by a factor of 5, was observed in central collisions.

Heavy-flavour hadrons (containing c or b quarks) are effective probes of the conditions of the medium formed in nucleus-nucleus collisions at high energy. They are produced at the initial stage of the collision and their interaction with the medium differs from the light quarks. The heavy-flavour hadrons can be studied through direct reconstruction, indirect reconstruction (non-photonic electrons) or quarkonia production.

Quarkonia ($c\bar{c}$ and $b\bar{b}$) are found to be effective probes of the QGP. The quarkonia suppression has been proposed as a signature of the formation of QGP. Measurements made at the STAR experiment observed the suppression of J/ψ and Υ via the decay channel $J/\psi \rightarrow e^+e^-$ in Au-Au collisions at the energies of 200, 62.4 and 39 GeV. Sequential melting of different states of quarkonia allows us to use the quarkonia as a thermometer. If we measure which state was melted, we can determine the temperature of the QGP.

The current analysis focuses on the detection of J/ψ in U+U collisions performed at RHIC at 193 GeV. The uranium collisions are interesting because uranium nuclei are heavier than Au and they are non-spherical - so the initial energy density in the collisions U-U is higher than in the collisions of the spherical nuclei. Our aim for the nearest future is to use data from U-U collisions to measure ψ' meson and to use central trigger data for another analysis of J/ψ .

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Non-photonic electrons on STAR

Katarína Gajdošová *(gajdokat@fjfi.cvut.cz)*

Main purpose of the STAR experiment is to study the hot and dense matter that is believed to be created in heavy-ion collisions on RHIC accelerator in BNL. In this medium there are free quarks and gluons, and for that reason we call it the quark-gluon plasma (QGP). We cannot observe this medium directly, just through study of the particles that are created during the end stages of the collision.

Particles that contain heavy quarks are good probes to study this form of matter because heavy quarks are created in the early stage of heavy-ion collisions. One of many observables from which it is possible to know what happened with heavy quarks in QGP are non-photonic electrons. These electrons come from semileptonic decays of D and B mesons. Studying this channel of decay has big advantage. We can use high-tower triggers that trigger on energy deposition in the BEMC (Barrel Electro-Magnetic Calorimeter), so we can study open charm and beauty in bigger interval of p_T.

Quark-gluon plasma is expected to be created in heavy-ion collisions, on the other hand, in proton-proton collisions there is not expected any such medium. Thus we have to compare the production of particles in heavy-ion to proton-proton collisions. For this purpose we use nuclear modification factor, R_{AA}, that is defined as follows.

$$R_{AA} = \frac{d^2N_{AA}/dydp_T}{\langle T_{AA}\rangle d^2\sigma_{pp}/dydp_T} \tag{1}$$

The ratio of production of particles has to be scaled by overlap function T_{AA} obtained from Glauber model. If the R_{AA} is less than one, that means that nucleus-nucleus collisions are not just a superposition of nucleon-nucleon collisions, so probably the QGP is created.

The invariant spectrum was obtained from proton-proton collisions at energy $\sqrt{s} = 200$ GeV in the years 2005 and 2008. Spectra agree with each other even that in year 2005 there was large photonic background due to larger amount of material around the beam pipe in the STAR detector. They are also consistent with the upper limit of the FONLL calculations [1].

In order to know if the suppression of c and b quarks is different from each other and from the suppression of light quarks, we have to divide the relative contributions. For this purpose we do e-h correlations which we compare to simulation in PYTHIA. We get that the contribution of B mesons is increasing with p_T and with the energy of collision.

STAR Collaboration has also subtracted spectrum of non-photonic electrons in Au-Au collisions at energy $\sqrt{s} = 200$ GeV. In the erratum of article from the year 2007 the R_{AA} of NPE is suppressed more than expected and in comparison with the

R_{AA} of light hadrons it is not different [2]. The same situation we have when using data from year 2010 [3]. The model of the energy loss by gluon radiation does not describe the data well, meanwhile the combination of radiative and collisional energy loss computed for D mesons only fit the data better [2], [3].

The elliptic flow of NPE at low p_T is rising, that implies that heavy quarks interact with the created medium. At very high p_T the v_2 is much higher than flow for light hadrons which can be caused by jet-like correlations or path length dependence of energy loss [3].

In close future the STAR experiment is expecting upgrade by installing new detectors HFT and MTD, that can help us distinguish much better the contribution of D and B mesons to NPE spectra.

My future work will consist of generating PicoDst followed by the analysis of NPE in U-U collisions at $\sqrt{s} = 193$ GeV.

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Future of LHC and others acceleraters

Petr Gallus *(pgallus@cern.ch)*

First step to the new era of accelerators is High luminosity LHC (HL-LHC), which could give us two times more peak luminosity that LHC today. But before HL-LHC we will need to operate machines which we have. So there is upgrade plans for all experiments on LHC. We will look at ATLAS timetable. What we now operate and how it will be change to operate full luminosity of LHC, after that what will change on LHC to make HL-LHC. On the other part, upgrade of LHC also depends on physics. That is why we also consider other accelerators, like ILC or CLIC, even proton - electron colliders (combining LHC and CLIC). ATLAS upgrade will have 3 main phases. First Phase 0, now in process, is concentrated on repair of radiations damages and give us better resolutions in Inner Detector (ID), by giving one more layer in to the pixel detector. In Phase I, there will be upgrades of trigger, added new forward detector AFP, Muon Small Wheels. Last Phase II will contain the upgrade of almost the whole detector, there will be new ID, changes in HCAL and ECAL readout for higher granularity, some more muon chambres and new trigger and DAQ. ILC is electron-positron collider which will be probably build in Japan, in this moment there is chosen place in Japan. Another electron-positron collider approach is CLIC, this CERN bases concept use same detectors as ILC but use different accelerating technology, it use two beams, second with lower energy but bigger currents. ILC and CLIC also can be used as gamma-gamma colliders, by using undulators to make strong coherent electromagnetic fields. One of the advantage of CLIC is that it can be combine with LHC to make lepton-hadron collider. Detectors for ILC and CLIC will have some difference in design compare to the LHC detectors. All of the concepts focus more on the tracking in both ID and calorimetry, because there is less particles and background in electron-positron collisions, so we can measure momentum and mass with higher resolution. To achieve this goal, they use silicon detector with smaller cells than in LHC experiments, because they will receive less radiation damage.

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Pixel detectors for electron microscopy

David Horák *(horda13@gmail.com)*

Electron microscope (EM) is a device that uses an electron beam to produce a magnified image of a specimen. EM can reveal the structure of much smaller objects than a light microscope, because electrons have about 10^5 times shorter de Broglie wavelengths than visible photons. There are two types of electron microscope - transmission electron microscope (TEM) and scanning electron microscope (SEM).

In the TEM, electron beam with energy in range of 100 to 400 kV is produced by an electron gun. The electron beam is focused by electrostatic and electromagnetic lenses and transmitted through the specimen, which must be very thin (10 to 500 nm). After that, the electron beam is magnified by the objective lens system of the microscope. The image can be viewed by projecting it onto a fluorescent screen and recording subsequent photons in the visible range by a CCD (charge-coupled device) camera, or by direct recording of the electron pattern by an imaging plate. The former is usually equipped with the YAG (yttrium aluminum garnet) scintillator, the latter records the image in a layer of sensitive crystals embedded within the resin of the imaging plate. An important mode of the TEM is electron diffraction, where a single crystal grain or a specimen particle may be selected for the diffraction measurements. Furthermore, electron diffraction in the TEM can be combined with direct imaging of the sample, including high resolution imaging of the crystal lattice.

The imaging properties of an electron microscope can be significantly enhanced by using a direct-imaging pixel detector (such as the Medipix detector) instead of CCD cameras or imaging plates.

The main advantage of using such semiconductor detection system in the transmission electron microscopy is virtually noiseless read-out, high dynamic range and single electron sensitivity resulting in a substantial increase in contrast of the recorded image, improved diffraction spot position resolution as well as the specimen absorbed dose reduction. At present, it is planned that a Medipix-based detector will be used for diffracted electrons detection. The detector consists of a readout chip onto which a semiconductor sensor is attached by means of bump bonding. The Medipix is a hybrid pixel detector readout chip developed at CERN in a 250 nm CMOS technology. It consists of a matrix with 256×256 identical pixel elements. Each pixel cell has its own read-out electronics (amplifier, discriminator, counter), capable of accepting count rates of up to 1 MHz. Each pixel contains around 500 transistors and occupies a total surface area of $55 \times 55\ \mu\,\mathrm{m}^2$, which defines the detector spatial resolution. The total active area is $14 \times 14\ \mathrm{mm}^2$, or $28 \times 28\ \mathrm{mm}^2$ in the quad-chip configuration.

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Analysis of the decay $B_s^0 \to J/\psi\phi$

Tomáš Jakoubek *(tomas.jakoubek@cern.ch)*

The $B_s^0 \to J/\psi\phi$ decay channel is expected to be sensitive to new physics contributions in CP violation field of study. In this channel, CP violation occurs due to interference between direct decays and decays occurring through $B_s^0 - \overline{B_s^0}$ mixing. The frequency of this mixing is characterized by the mass difference ΔM_s between light (B_L) and heavy (B_H) mass eigenstates. Difference between decay widths can be described using a CP-violating phase ϕ_s

$$\Delta\Gamma_s = \Gamma_L^s - \Gamma_H^s = 2\ |\Gamma_{12}^s|\ \cos\phi_s. \quad (2)$$

ϕ_s is small in the concept of the Standard Model and can be related to CKM quark mixing matrix via the relation

$$\phi_s \simeq -2\ \arg\left(-\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*}\right). \quad (3)$$

Predicted value is $\phi_s = -0.0368 \pm 0.0018$ rad. Many new physics models predict large ϕ_s values whilst satisfying all existing constraints, including the precisely measured value of ΔM_s.

For our analysis we have used 4.9 fb^{-1} of $\sqrt{s} = 7$ TeV data from proton-proton collisions collected with the ATLAS detector in the year 2011. In total 131k $B_s^0 \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$ candidates within a mass range of $5.15 < m(B_s^0) < 5.65$ GeV have been used in the fit. Various track quality and trigger cuts have been applied (details can be found in [2]) to obtain good candidates and then an unbinned maximum likelihood fit have been performed on the selected events to extract the parameters characterising the decay.

In this paper, an update to the previous measurement [1]] with the addition of flavour tagging, is presented. Flavour tagging significantly reduces the uncertainty of the measured value of ϕ_s. Initial flavour of (neutral) B_s can be inferred using the other B-meson, typically produced in the event (Opposite-Side Tagging). To study and calibrate the these methods, events containing the decays of $B^\pm \to J/\psi K^\pm$ can be used, where flavour of the B-meson at production is provided by the kaon charge.

Detector effect have been studied using Monte Carlo (MC) samples. So-called "acceptance maps" (relying on three angles and p_T) have been created and applied to the data. Also an observed time dependence of the muon trigger have been corrected by weighting function (derived using real data and MC).

The full unbinned maximum likelihood fit contains 25 free parameters. Below the important parameters are summarized: mean B_s^0 lifetime, the decay width difference $\Delta\Gamma_s$, the transversity amplitudes $|A_0(0)|$ and $|A_\parallel(0)|$ and the CP-violating week phase

ϕ_s. All of them are consistent with the world average values. Comparison between untagged and tagged analysis is shown in Figure 4.

$$\begin{aligned}
\phi_s &= 0.12 \pm 0.25 \text{ (stat.)} \pm 0.05 \text{ (syst.) rad} \\
\Delta\Gamma_s &= 0.053 \pm 0.021 \text{ (stat.)} \pm 0.010 \text{ (syst.) ps}^{-1} \\
\Gamma_s &= 0.677 \pm 0.007 \text{ (stat.)} \pm 0.004 \text{ (syst.) ps}^{-1} \\
|A_\parallel(0)|^2 &= 0.220 \pm 0.008 \text{ (stat.)} \pm 0.009 \text{ (syst.)} \\
|A_0(0)|^2 &= 0.529 \pm 0.006 \text{ (stat.)} \pm 0.012 \text{ (syst.)}
\end{aligned}$$

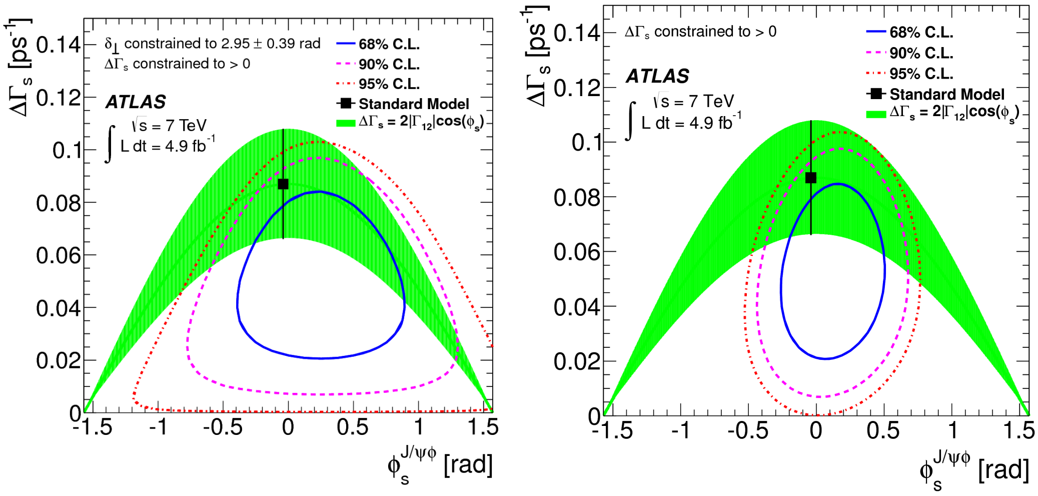

Figure 4: Likelihood contours in the $\phi_s - \Delta\Gamma_s$ plane for untagged (left) and tagged (right) analysis. The blue line shows the 68% likelihood contour, the dashed pink line shows the 90% likelihood contour and the red dotted line shows the 95% likelihood contour (statistical errors only). The green band is the theoretical prediction of mixing- induced CP violation.

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Transverse flow anisotropies in ultrarelativistic nuclear collisions

Renata Kopečná *(rekopecna@seznam.cz)*

The quark-gluon plasma (QGP) is a newly-discovered form of matter, where quarks and gluons are asymptotically free. Hadrons are dissolved into deconfined colored degrees of freedom. Although it was predicted to behave as a gas, its behavior meets the requirements of perfect fluid behavior. Our goal is to study its properties via so-called *anisotropic flow.*

QGP is produced in high-energy nuclear collisions, reached in facilities such as Relativistic Heavy Ion-Collider (RHIC) or Large Hadron Collider (LHC). This form of deconfined matter is very similar to the matter produced few miliseconds after the Big Bang.

The anisotropic flow reflects the initial energy density fluctuations, due to the low shear viscosity, leading to a better knowledge of the initial state of collision. Furthermore, it can help us better understand the evolution of the collision.

The main phenomenon we focus on is the *freeze-out.* The quark-gluon plasma is changed into hadrons. There are two types of freeze-out; chemical, when the temperature of the system is no longer big enough for the inelastic collisions to happen, resulting into constant yields of various hadron species, and kinetic, when handrons no longer interact - the system becomes weakly-coupled.

For subsequent computation, it is needed to consider the *blue shift.* This effect is well-know phenomena, caused by the Doppler's effect. Since transverse momenta p_T inversely depends on wavelength, the spectra measured by detectors is flattened.

The pre-equilibrium evolution of fireball is different in every direction. Due to this phenomenon, the anisotropic pressure gradient is present, resulting into the anisotropic flow. The qualification of this phenomena can be done by the decomposition of the momentum distribution in azimuthal angle into Fourier's series. So far, the most important decomposition coefficient is the second one, *elliptic flow.* However, data suggest higher coefficients, *triangular* and *quadrangular flow*, are worth further studying.

For illustration, the results from the ALICE experiment[5] at LHC are presented.

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Study of b-jet tagging at ALICE

Lukáš Kramárik *(kramaluk@fjfi.cvut.cz)*

One of the actual data analysis problem at ALICE (A Large Ion Collider Experiment) experiment in CERN is b-jet tagging. Algorithms are being invented or modified from other experiments.

The b-tagging was done also at CMS (Compact Muon Solenoid) experiment. This detector has a huge performance to detect particles at $\sqrt{s_{NN}} = 5.5TeV$ in pp and PbPb collisions. In central section one can find 10 layers of SSD (silicon strip detector) and 3 layers of pixel detectors, which offer great resolution used for successive b-tagging.

ALICE is constructed to detect particle in pp and pPb collisions. It is composed of 18 different detector systems. For jet finding we use mainly Inner Tracking System, Time Projection Chamber, Transition Radiation Detector and Electromagnetic Calorimeter.

Jets are collimated particles, composed of quarks and gluons in their final state. They are produced by different particles in several moments after collision. Main advantages of b-jet finding are bigger lifetime and mass of b-quark in comparison with other, light flavor quarks. B-quarks are produced after collision, they are not influenced by medium and they suffer smallest radiation loses.

Firstly, it is important to find (ideal all) jets. Main groups of algorithms used for jet finding are cone algorithms and clustering algorithms. After finding a jet, there are several algorithms used for its b-tagging. Some of them used at CMS will be described.

Track counting calculates impact parameter (IP – 2D/3D distance between track and primary vertex) for all tracks in jet. These track are than classified by decreasing IP significance, which can be for example fraction IP/(its error). We can then choose only first n tracks, n is modified to reject tracks with small IP (light quark jets).

Jet probability (JP) algorithm calculates probability that track comes from primary vertex, then it calculates probability that jet comes from primary vertex (PV).

Simply secondary vertex (SSV) algorithm looks for reconstructed vertices with big invariant mass and large distance from PV and identify them as secondary vertices, produces by b-quarks.

These algorithms were compared for CMS and ALICE data. In CMS data, discriminators in JP were set to b-jet efficiency approx. 0.45 with light jet mis-tag 0.01. Final b-jet fraction for SSV algorithm (35%) and B-jet efficiency of JP (40%) are in coherence with simulated data.

These algorithms were used for ALICE simulated data. Results are not good, because of very small efficiencies for all quark types (b-jet: 0.01 - 0.1). It may be caused by smaller transverse momentum range (10 - 50 GeV/c) than that at CMS (80 - 200 GeV/c). Some new algorithm for ALICE are being invented, for example electron identification alg., which works with electron spectrum. It is important to find new alg. for ALICE data analysis by combining well-known ones from other experiments or by setting different discriminators in actually used ones.

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Measurement of edge plasma density by energetic beam of Li atoms on the COMPASS tokamak.

Jaroslav Krbec *(krbecja1@jfi.cvut.cz)*

During the era of massive plasma heating to reach higher plasma temperature the scientist Fritz Wagner observed a radical growth of confinement time at tokamak ASDEX in 1982 [1]. The regime advantages were higher confinement time and higher energy stored in the plasma that is why the regime was named H-mode. A new instability type called Edge Localized Mode was observed in H-mode plasma [2]. The bunch of plasma particles is thrown from the plasma to the chamber wall during ELM instability. Particle losses associated with energy losses prevents achieving high plasma densities and the energetic particles hitting the chamber wall also reduce a chamber wall durability and also damage sensitive diagnostic systems. A creation of bunches is connected with plasma edge region. It is the reason why the edge plasma region measurement with high temporal resolution is necessary for understanding of the ELM generation mechanism.

The presetation deals with diagnostic system which uses an injection of lithium atoms for measurement plasma parameters in the edge plasma region. At present the lithium beam device is installed on COMPASS tokamak.

BES (Beam Emission Spectroscopy) [3] is used for electron density measurement in the plasma edge region. Injected lithium atoms are ionised and excited due to collisions with electrons and ions in plasma. Produced line radiation at wavelength 670.8 nm is detected by a CCD camera and APD detector. The time resolution of CCD camera is 20 ms and of APD detector 10 μs. The spatial resolution is influenced by spontaneous emission decay length and is about 1cm. An electron density profile can be reconstructed from the light intensity profile. The plasma-beam interaction is described by collisional-radiative model. The system of fifth ordinary differential equation is solved by Runge-Kutta 4th order method. This system is suplemented by equation for absolute calibration [4] solved by five step Adams-Bashforth method.

This measurement technique can acquire absolutely calibrated edge plasma density profile with μs time scale.

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Nuclear effects of high-p_T hadrons in pA interactions

Michal Křelina *(michal.krelina@fjfi.cvut.cz)*

Introduction

Recent experimental measurements of particle production at different transverse momenta p_T in proton-nucleus ($p + A$) collisions at RHIC and LHC allows to study various nuclear phenomena. This gives a good baseline for interpretation of the recent heavy-ion results.

Nuclear effects in inclusive hadron (h) production are usually studied through the nucleus-to-nucleon ratio, the so called nuclear modification factor, $R_A(p_T) = \sigma_{p+A\to h+X}(p_T)/A\,\sigma_{p+p\to h+X}(p_T)$.

The Cronin effect, resulting in $R_A(p_T) > 1$ at medium-high p_T, was studied in [1] within the color dipole formalism. Corresponding predictions were confirmed later by data from the PHENIX Collaboration [2] at RHIC and recently by the ALICE experiment [3] at LHC. However, none from other models presented in a review [4] was able to describe successfully the last ALICE data [3].

Another interesting manifestation of nuclear effects leads to nuclear suppression at large p_T, $R_A(p_T) < 1$. Such a suppression is indicated by the PHENIX data [2] on π^0 production in $d + Au$ collisions at mid rapidity, $y = 0$. However, much stronger suppression has been investigated at forward rapidities by the BRAHMS and STAR Collaborations [5]. This allows to investigate already in the RHIC kinematic region the coherent phenomena (shadowing, Color Glass Condensate (CGC)), which are expected to suppress particle yields.

The interpretation of large-y suppression at RHIC via CGC [6] should be done with a great care since the assumption that CGC is the dominant source of suppression leads to severe problems with understanding of a wider samples of data at smaller energies (see examples in [7]) where no coherence effects are possible. These data demonstrate the same pattern of nuclear suppression increasing with Feynman x_F and/or with $x_T = 2p_T/\sqrt{s}$, where $\sqrt{s}$ is c. m. energy. Threfore it is natural to expect that the mechanisms, which cause the nuclear suppression at lower energies, should be also important and cannot be ignored at the energy of RHIC and LHC. Such a mechanism related to initial state interactions (ISI), which is not related to coherence and is valid at any energy, was proposed in [7].

Calculations and results

Calculations of proton-proton and proton-nucleus cross sections were made within the QCD improved parton model with intrinsic transverse momenta [8].

In all calculations we took the scale $Q^2 = \mu_F^2 = p_T^2/z_c^2$. The parton distribution, fragmentation and nuclear parton distribution functions functions were taken with NNPDF2.1 paramatrization [9], with DSS parametrization [10], and with EPS09 [11] or nDS [12].

The recent data on hadron production in $p+Pb$ collisions from the ALICE experiment [3] at LHC allow to test our model predictions. The corresponding comparison is presented in Fig. 5 demonstrating a reasonable agreement. While the dashed line represents predictions without NPDFs, the dashed and solid lines including different parametrizations of NPDFs bring our calculations to a better agreement with data at small and medium-high p_T.

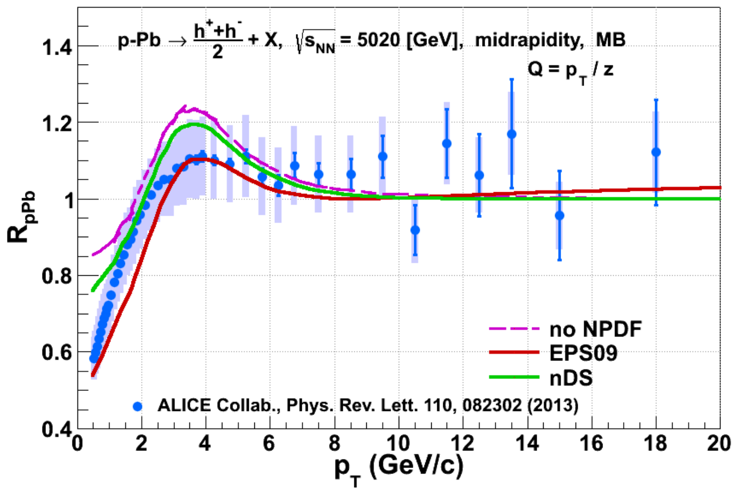

Figure 5: Predictions for the Cronin effect vs. ALICE data [3].

Besides predictions at $y = 0$ in Fig. 5 where ISI effects are irrelevant we present also calculations for $R_{p+Pb}(p_T)$ at forward rapidities, where we expect a significant nuclear suppression at large p_T due to ISI effects. The results are shown in Fig. 6 for rapidities $y = 0$, 2 and 4. The dotted lines represent calculations without ISI effects and NPDFs. The dashed lines include additionally ISI effects and solid lines represent the full calculation including both ISI effects and NPDFs.

Conclusions

Using the QCD improved parton model we predict the correct magnitude and the shape of the Cronin effect in accordance with data from experiment at LHC. Initial state energy loss is expected to suppress significantly inclusive hadron production at large p_T and/or at forward rapidities. Effects of ISI at LHC are irrelevant at $y = 0$ but we predict a strong suppression at forward rapidities that can be verified by the future measurements.

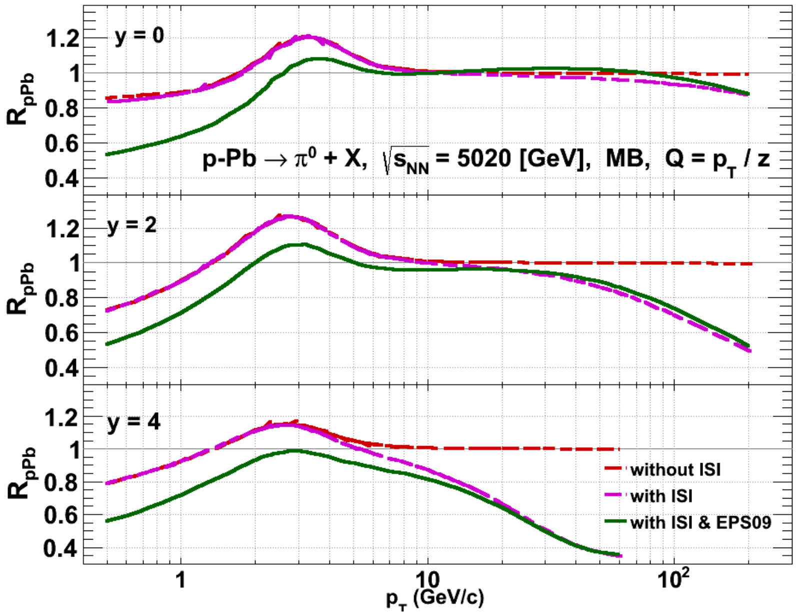

Figure 6: Nuclear modification factor $R_{p+Pb}(p_T)$ for hadron production at c.m. energy 5.02 TeV and at several rapidities.

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Correlation femtoscopy study of nucleus-nucleus collisions dynamics at the STAR experiment

Jindřich Lidrych *(lidryjin@fjfi.cvut.cz)*

Nucleus-nucleus collisions are a key to study the nuclear matter under extreme conditions, which is called quark-gluon plasma. It is assumed that this hot and dense state of matter existed in the early stages of the Universe. Nucleus-nucleus collisions can be studied at the experiments, which are located e.g. on Relativistic Heavy Ion Collider (RHIC), where the Solenoidal Tracker at RHIC (STAR) is used to measure these collisions.
To describe the heavy-ion collision in one space and one time dimension, the space-time diagram is used. A space evolution can be illustrated by the space-time diagram, where all phases, from the collision, the thermal equilibrium to the chemical and kinetic (thermal) freeze-out, can be seen. During the thermal equilibrium the matter is in the phase of quark-gluon plasma. After a critical temperature the quark-gluon plasma is changed into a hadrongas. In the kinetic (thermal) freeze-out hadrons are seperated and do not interact, thus they do not change their energy. In this phase the hadrons are emitted from the source - hadrongas.
To study source size, correlation femtoscopy is used. The aim of this thesis is to explain what is a correlation femtoscopy and summarizes findings about the correlation femtoscopy and construction of correlation function from experimental data. The correlation function contains information about the source and about the interaction between particles, which are emitted from this source. Knowledge of information about source and experimentally measured correlation function, information about the interaction can be better determined. This method is used to study the interaction in an exotic system e.g. it was used to study interaction between π and Ξ. This thesis also tries to focus on study of nucleus-nucleus collisions dynamics at the STAR experiment, analyse data and study the interaction between K^+K^- from Au-Au collisions and observe the ϕ resonance. This resonance is important, because it contains information about the size of the source and the results from analyses interaction between K^-K^- and K^+K^+ are known today. After the STAR detector upgrade, when the Time of Flight (TOF) detector was installed, it can measure and better recognize the kaons, electrons and positrons, thus the data can be used to our analysis. Our analysis can be compared with analysis, which was made using data from Pb+Pb collision at SPS at energy 158GeV.

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Diboson production

Kateřina Moudrá *(k.moudra@seznam.cz)*

Measurements of vector boson pair production at particle colliders provide important tests of the electroweaksector of the Standard Model. Deviations of the production cross section or of kinematic distributions from their SM predictions could arise from anomalous triple gauge boson interactions or from new particles decaying into vector bosons.

One of the most important channels for vector boson pair production is the lepton channel. Vector bosons are searched in W$\rightarrow$ $e\nu e\nu$,W$\rightarrow$ $\mu\nu\mu\nu$ and W$\rightarrow$ $e\nu\mu\nu$ decays. Also the contributions from W$\rightarrow$ $e\nu\tau\nu$, W$\rightarrow$ $\mu\nu\tau\nu$ and W$\rightarrow$ $\tau\nu\tau\nu$ are dealt as a signal.

The main sources of background are SM non-WW diboson production processes, W + jets production process, SM top-quark production processes and Drell-Yan production process. The contributions from the last two SM background physics processes are estimated using MC simulation as described in the paragraphs below.

Both signal and background WW events are modeled using MC-simulated samples . The simulation of the WW signal production is based on samples of qq-WW and gg-ww events generated with MC@NLO and GG2WW respectively. The SM background processes, are simulated using ALPGEN for the Drell-Yan and something for TOP.

The signal is being searched in fiducial phase space. The fiducial phase space is defined with the following criteria:

Leptonp_T > 20 GeV, muon pseudorapidity$|\eta|$ < 2.47, electron pseudorapidity $|\eta|$ < 2.45, excluding the crash region 1.35< $|\eta|$ <1.57. Leptons are sorted by pT. Leading lepton p_T is requiered to be above 30 GeV. Events with exactly two opposite charged leptons in the fiducial phase space are preselcted. In order to reduce background, following cuts are applied:

- Invariant mass of the dilepton pair M_{inv}^{ll} is required to be above 15, 15, and 10 GeV for ee, mumu and emu channel, respectively.
- $|M_{inv}^{ll} - 91|$ >15,15,0 GeV for ee, mumu, and emu channel respectively. This cut is reffered to as" Z veto" cut.
- The transverse missing energy E_T^{miss} must be above 25,25 and 45 GeV for ee, mumu, and emu channel respectively.
- Events with generator level jets with p_T >25 GeV and $|y|$ < 4.5 are vetoed. This cut is reffered to as "jet veto" cut.
- Transverse momentum of the lepton pair p_T^{ll} must be higher than 30 GeV

Background contributions from top-quark production processes are suppressed by the jet veto requirement.

The Drell-Yan background is one of the dominant background contributions in the ee and mumu channels. Its contribution is suppressed by the requirements on M_{inv}^{ll}, E_T^{miss}, and p_T^{ll}.

After appliing above mentioned cuts, the fiducial cross section is calculated in all channels.

The MC analysis is also rewrited in the C++ object oriented routine reffered to as Rivet. The Rivet project (Robust Independent Validation of Experiment and Theory) is a toolkit for validation of Monte Carlo event generators.

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Heavy quarkonium production at ATLAS experiment

Radek Novotný *(novotr14@fjfi.cvut.cz)*

The production of heavy quarkonium at hadron colliders provides particular challenges and opportunities for an insight into the theory of Quantum Chromodynamics (QCD). Data provided by the Large Hadron Collider (LHC) can help existing theoretical models to compare their results at high energy and rapidity range.

Quarkonium is a bounded state of quark and antiquark with the same flavour and its structure is reminiscent to positronium. By heavy quarkonium is meant charmonium ($c\bar{c}$) and bottomonium ($b\bar{b}$). Top quark is too heavy to bound. There are many models trying to describe all charmonium and bottomonium family members and studying its properties can prove the validity of their predictions. In addition there are many observed states, which are not well described by theoretical models and more precise measurement can help to design a new one.

This thesis studies inclusive fidutial J/Ψ production cross-section and fraction of J/Ψ mesons produced in B-hadron decays as a function of the transverse momentum and rapidity of the J/Ψ in $\mu^+\mu^-$ decay chanel. Data are measured in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector at the LHC. The cross-section is measured up to 100 GeV of p_T and for rapidities splitted in $|y| = 1.5$ giving the biggest range of J/Ψ production measurement availiable today.

Data from EF_2mu4_Jpsimumu trigger are divided in p_T and rapidity bins and separately fitted by roofit to calculate number of appropriate events. Each event has to be weighted by ratio to compensate ATLAS detector efficiency. The ratio consists of the trigger efficiency, $\mu^+\mu^-$ detection efficiency and prescale.

We have not final results yet, but we made first step of approximations, that confirm our expectations.

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Open-charm meson production at ALICE experiment

Vojtěch Pacík *(pacikvoj@fjfi.cvut.cz)*

The main goal of heavy ions physics done at large collider experiments such as Large Hadron Collider (LHC) at CERN is to study a state of hot and dense matter created in relativistic collisions, where quarks and gluons are no longer confined in hadrons, and its physical properties. This particular region in QCD matter phase diagram is generally known as Quark-Gluon Plasma (QGP). One of the tools of testing QGP is studying the production of high-transverse-momentum heavy-flavour quarks, mainly produced in the beginning of the collision and thus affected by passing through QGP reflecting its properties, in comparison with light flavour quarks.

Measurement of open-charm mesons production in p-p collisions at $\sqrt{s} = 7$ TeV, Pb-Pb collisions at $\sqrt{s} = 2.76$ TeV and p-Pb collisions at $\sqrt{s} = 5.02$ TeV via hadronic decay channels of prompt D^0, D^+, D^{*+} and D_s^+ at LHC using ALICE detector gives first insights in charm production at the highest available energy.

Measured p_T-differential cross section of prompt D mesons were compared to theoretical predictions based on perturbative QCD and appears to be well-described within uncertainties by general-mass variable-flavour-number scheme (GM-VFNS) and fixed order next-to-leading-log (FONLL) models. Comparison of p-p and Pb-Pb data shows a strong centrality dependent suppression by factor of 3 - 4 in all measured D mesons species. Any similar suppression is not observed in the case of p-Pb collisions where QGP is not supposed to be formed. Moreover, suppression measured in Pb-Pb collisions is lesser than suppression of charged particles production (as an alternative for light pions). This observation seems to be consistent with the theory in which light flavour quarks are supposed to lose more energy than heavy flavour quarks.

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Medipix2 collaboration and its chips

M. Sedláčková *(sedlam19@fjfi.cvut.cz)*

Medipix2 is a semiconductor detector developed in collaboration with CERN. The aim of this collaboration, that was funded in 1999, is to extend a pixel technology used in high energy physics (HEP) experiments to other fields, namely medicine. During its existence the collaboration has succesfully developed two chips: Medipix and Timepix chip. Both these chips are bump bonded on silicon sensor.

The chips consist of 256×256 pixels with pixel size 55 μm. The total active area is 1.4×1.4 cm, on top of that the chips can be connected into quadruple 2×2 configuration, thus extending the total active area to $\approx 3 \times 3$ cm. The maximum imaging speed of the chips is 20 fps. Accompanying readout software and hardware were developed. Muros2 and USB interface and the software developed to be used with this hardware are Medisoft4 and Pixelman.

Semiconductor pixel detectors have a list of advantages for which they are used. Among them can be found: low noise, single photon counting in a given energy range, quick readout. Among the applications, that Medipix2 collaboration has promised to seek, are (as listed in Ref. [3]) e.g. neutron imaging and monitoring, Single Photon Emission Computed Tomography (SPECT), nuclear power plant decommissioning, electron microscopy , HEP tracking and vertexing, dosimetry, education and many more. There is also ongoing search for new materials to be used except the high resistivity silicon that is used nowadays. The two that seem most promising are CdTe and GaAs.

Medipix2 pixel chip, whose definitive version called MPIX2MXR2.0 was put into production in 2005, has a mode that counts incoming pulses. Timepix chip, which was launched in 2006, can function in three different modes: Medipix2, Time over Threshold (ToT) ad Time of Arrival (ToA). ToT measures energy of incoming particles that is stored in each pixel and ToA measures the arrival time of the pulses in pixels, thus providing the time stamp of each measurement.

The results of measurement performed with the Timepix chip have been presented during the oral presentation. They concern with the radiation damage effects on the chip.

The chip was irradiated irradiated by a ^{60}Co radiation source producing 1.17 and 1.33 MeV photons. It was shown that with increasing irradiation time, the number of hits in the sensor diminished, even though the high-flux γ-ray source was uniformly delivering the ionizing radiation. The burnout performed by the radiation is also visible when comparing the results of an equalization process before and after irradiation. Both the analog and digital current consumption steadily rose throughout the irradiation. After annealing, the default analog current value of the irradiated Medipix2 chip increased for 0.1 A.

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Quarkonium polarization

Kamila Šramková *(sramkovakamila@gmail.com)*

Understanding of quantum chromodynamics can be provide by detailed stud of quarkonium production. Studies of polarization of the $J^{PC} = 1^{--}$ states of quarkonia, will give useful information. In different theoretical approaches the same mechanism of quarkonia production leads to different expected polarization of produced quarkonia. J/ψ production mechanism is modeled in several way and describes measured cross section well [1]. Clearly, given this situation, cross section is not adequate to specify quarkonium production process.

On one hand, the non-relativistic quantum chromodynamics calculationes dominated by the color octet component, predict that at asymptotically high p_T direct produced J/ψ and ψ' mesons are almost fully transversaly polarized. This is in good agreement with with observed J/ψ p_T spectra in experiments at different energies [3]. For low-p_T region, measurement of polarization of J/ψ at PHENIX experiment at $\sqrt{s}$ = 200 GeV is in good agreement. But for small p_T data are not able to destuingish between Color Octet Model and Color Singlet Model. Furthermore with measurements in CDF experiment at FermiLab at energy $\sqrt{s}$ =1.96 TeV faild to describe of J/ψ polarization at high p_T ($p_T > 5$ GeV/c).

On the other hand, new next-to-leading-order calculation of color singlet quarkonium production predicts strong longitudinal J/ψ polarization in the helicity frame at low and mid p_T at mid rapidity [2]. As well as before, the prediction for polarization of J/ψ are for low p_T in good agreement with PHENIX data. However; for higher p_T the data disagree with prediction.

The measurement of the J/ψ polarization at high p_T region can distinguish between color octet model and color singlet model. Increasing of p_T polarization in color octet model leads to transverse polarization, while the color singlet model continues to predict longitudinal polarization with no dependence on p_T.

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Processes with direct photons and heavy quarks

Michal Svatoš *(michal.svatos@fjfi.cvut.cz)*

Processes with direct photons and heavy quarks are sensitive to densities of heavy quarks and gluon inside of colliding protons. Precise measurement of differential cross-section of these processes can put constraints on parton distribution functions (PDF) of heavy quarks and gluon [1]. Some processes producing direct photons and heavy quarks are also sensitive to effects of intrinsic charm theory. Usually, heavy quarks in proton are only radiatively generated. It means that they originate only from QCD evolution. The intrinsic charm theory suggests that c quark exist in proton with u and d quarks from the beginning (as $c\bar{c}$ pair). Analysis of data from the SELEX experiment (Fermilab) [2] suggests that amount of intrinsic charm in hadrons is between 0.1% and 1%.
The analysis of generator level events now also includes events generated by Pythia8 at energy $\sqrt{s} = 8$ TeV. Structure of events was analysed and photon and heavy quark going out from hard scattering were identified. Distributions of these outgoing particles were used to find differential cross-section. Together with generator level events generated by Pythia and Herwig at energy $\sqrt{s} = 7$ TeV, the comparison of p_T of hard scattering photon and quark with other photons and quarks, antiquarks and gluons was made. The results are: more than 99% of hard photons are leading photons in the event in all generators and more than 90% of hard heavy quarks or antiquarks are the leading particles which could produce a jet. As a conclusion of this part, only leading photons and jet will be investigated in data.
The analysis of data collected by the ATLAS detector [3] at the energies $\sqrt{s} = 7$ TeV and $\sqrt{s} = 8$ TeV started by basic cut flow, i.e. using many different criteria to remove many possible detector effects to increase the quality of data. To be specific, events with failure in LAr or Tile calorimeter, incomplete events, events outside of GoodRunsList, events below trigger, events with photon or jet outside of kinematic range, events with photon or jet that do not pass the cleaning requirements, and events with photon that do not pass object quality or identification criteria were removed. From these cleaned events, very preliminary cross-section was obtained (see figure 7).

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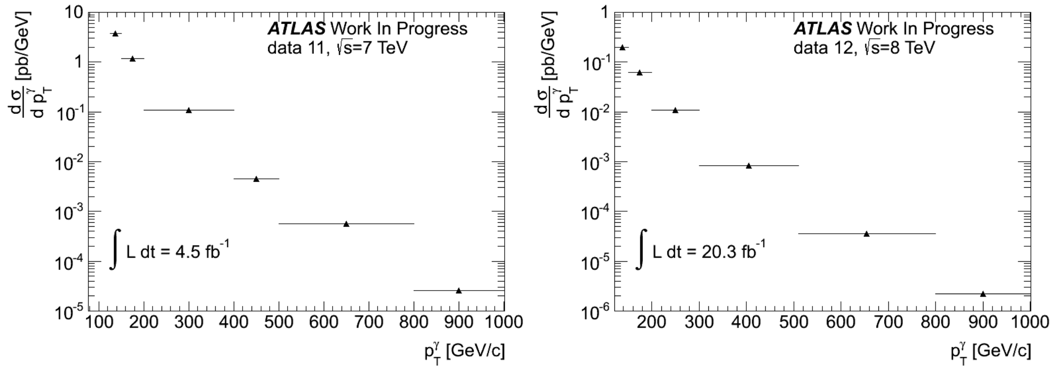

(a) $\sqrt{s} = 7$ TeV (b) $\sqrt{s} = 8$ TeV

Figure 7: Very preliminary differential cross-section of photon and jet in data at energies $\sqrt{s} = 7$ TeV and $\sqrt{s} = 8$ TeV

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Signal Attenuation of Surface Detectors of Extended Cosmic Ray Showers

Jakub Vícha *(vicha@fzu.cz)*

The process of origin and composition of ultra–high energy cosmic rays (above 10^{18} eV) is still an unsettled issue. Whereas the largest experiment at the southern hemisphere (Pierre Auger Observatory) measures the combination of elctromagnetic (EM) and muonic (μ) component of shower at ground, the surface detectors of the largest experiment located at the northern hemisphere (Telescope Array) are sensitive to the electromagnetic component only. Both experiments are hybrid detectors, which means that they combine array of particle detectors at ground with a measurement of fluorescence light produced in the atmosphere during shower propagation. The latter type of detection provides a reliable energy calibration of the surface detector signal. However, the size of signal needs to be corrected for different development stage of shower reaching the ground (the shower with larger zenith angle passes larger amount of atmosphere).

The above mentioned experiments use different methods how to correct for the attenuation of the signal with zenith angle. The Pierre Auger Observatory applies the Constant Intensity Cut (CIC) method to the measured data [1] to obtain the signal attenuation curve (relative dependence of signal on shower zenith angle). In this case isotropy at certain energy is assumed. The Telescope Array uses simulation of detector response to pure proton Monte Carlo (MC) showers to obtain a dependence of signal size on the zenith angle for various energies [2]. In this case composition of primary particles is assumed.

In the contribution [3] CORSIKA [4] simulations of showers at energy 10^{19} eV were produced to determine attenuation of different shower components. Responses of EM and EM+μ types of detectors were assumed in Toy MC arrays to provide sets of signals with a wider range in energy.

Summarising results from [3], both methods (CIC method and MC–based method) are equivalent to obtain the attenuation curve in case of pure composition scenarios. In case of mixed composition, the CIC method eliminates zenith angle biases, whereas the MC–based method shows zenith angle biases. Even a presence of a very strong source at the highest energies has very small impact on the shape of attenuation curve inferred using CIC method (assuming isotropy). The effect is minimised by choosing a flux cut value corresponding to energies lower then the presence of anisotropy.

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Magnetic Fields in Universe

M. Vlasák *(vlasakmich@gmail.com)*

Understanding magnetic fields presents one of the essential key to understanding the Universe. Magnetic fields, measured in or around practically all celestial objects such as the Earth, the Sun, solar planets, stars, pulsars, the Milky Way, nearby galaxies, more distant (radio) galaxies, quasars and even intergalactic space in clusters of galaxies, affect the evolution of galaxies and galaxy clusters and contribute significantly to the total pressure of interstellar gas. Moreover, they are fundamental for the beginning of star formation and they control the density and distribution of cosmic rays in the interstellar medium.

The studies of magnetic fields within the cosmic objects began in the last century when the experiments of Pieter Zeeman gave astronomers a method of looking for magnetic fields. This new observational method was put promptly to use and George Ellery Hale could announce the detection of a magnetic field in the Sun in 1908 by observing the Zeeman splitting of optical spectral lines [1].

In the following years several other observation methods were developed, for example, optical polarization, synchrotron emission or Faraday rotation. In 1962 the detection of radio polarization in the Galaxy gave the final proof of existence of magnetic field in the Milky Way. Later, the regular magnetic fields were also detected in the nearby galaxies as, e.g., in the Whirlpool galaxy, M51, (1972) or in the Andromeda galaxy, M31, (1978).

Despite of about one century of research and increasing knowledge on magnetic fields in recent years, many important questions on the origin and evolution of magnetic fields, their first occurrence in young galaxies, or the existence of large-scale intergalactic fields remain unanswered. A lack of knowledge of strength and structure of galactic and extragalactic magnetic fields might present a key problem of the absence of powerful astrophysical counterparts in the arrival directions of ultra-high energy cosmic rays, as depicted in Fig. 8.

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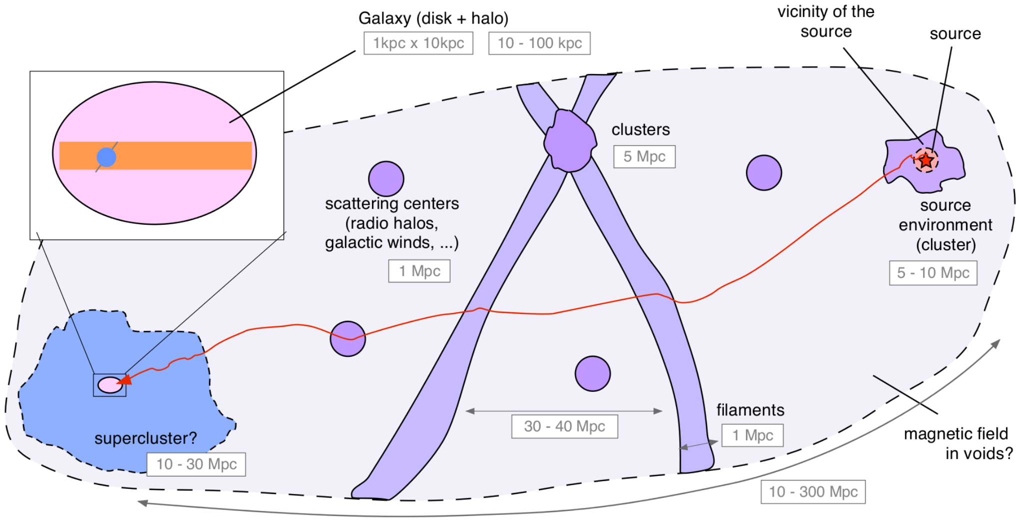

Figure 8: Schematic representation of magnetized regions intervening in UHECR propagation. Their approximative characteristic length scales are indicated in grey [3].