

“High p_T (> 1 GeV/c) physics: cumulative processes”

Shimanskiy S.S.

PARTICLE AND NUCLEAR SCATTERING AT LARGE P_T *)

V.A.Matveev

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USSR.

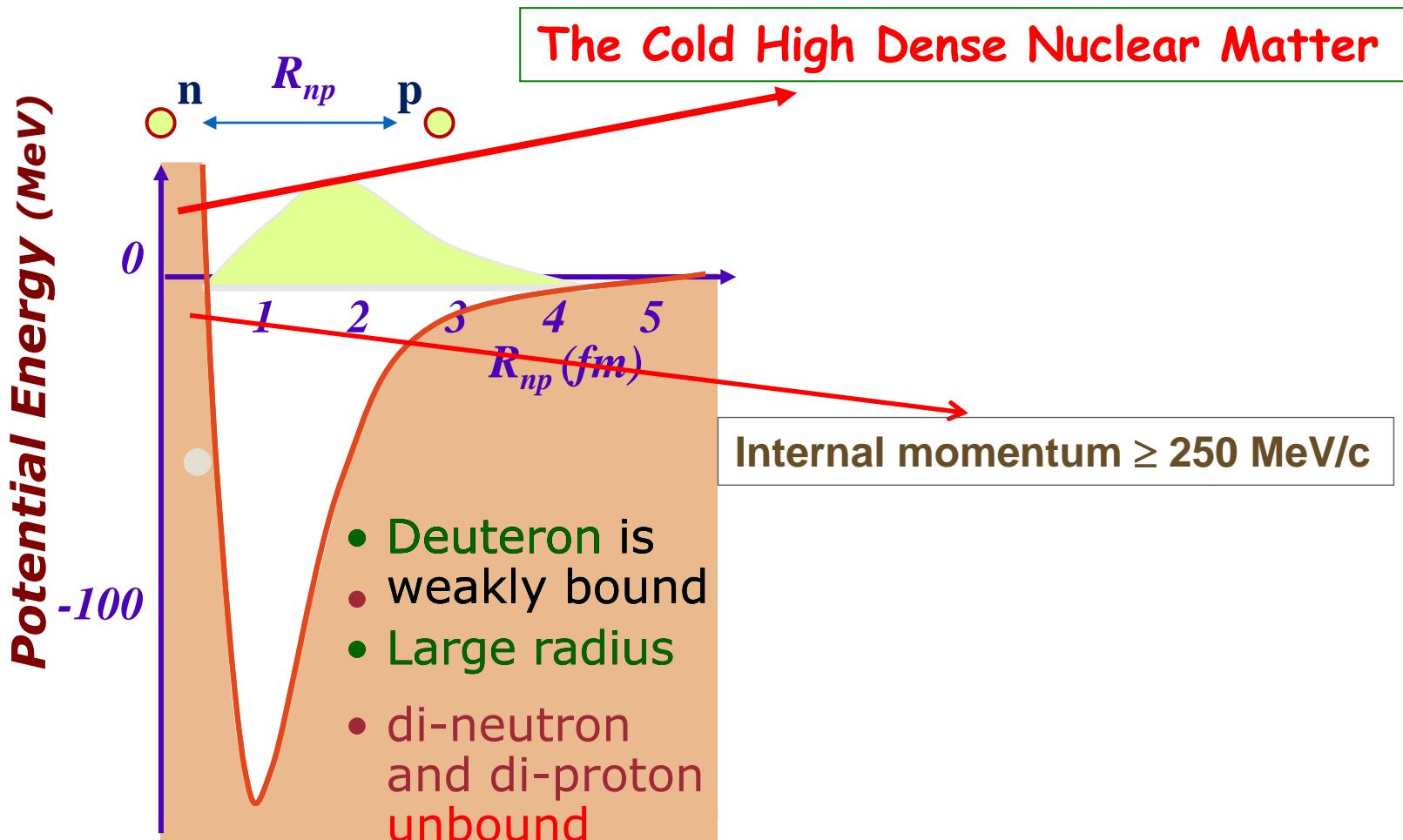
Today we shall discuss the following questions:

- nucleus form factors at large transferred momenta;*)
- exotic multiquark states (dibaryons, tribaryons etc.);
- deutron as a 6-quark system;
- hidden colour inside nuclei;
- quark theory of nuclear forces.

Тема Re: Cumulative at high p_T
От [Boris Kopeliovich](#)
Кому [Stepan](#)
Ответить bzk@mpi-hd.mpg.de
Дата 23.01.2012 7:42

«I think that the main problem in understanding of high pT hadrons at the energies of Serpukhov is why you see more protons than pions. This was claimed long time ago by the Sulyaev's group and I remember hot debates in that back in the 80s. Those debated ended up with no clear conclusion. Much later an excess of baryons was observed by the STAR at RHIC and was called "baryon anomaly". Again, no good explanation has been proposed so far. I might have my own explanation, but haven't written anything so far. Anyway, my point is, if we do not understand the mechanism of production of baryons dominating at high pT, we should not make any certain conclusions about the cumulative mechanisms.»

Let us look at the nucleon-nucleon interaction:



RHIC Physics: 3 Lectures*

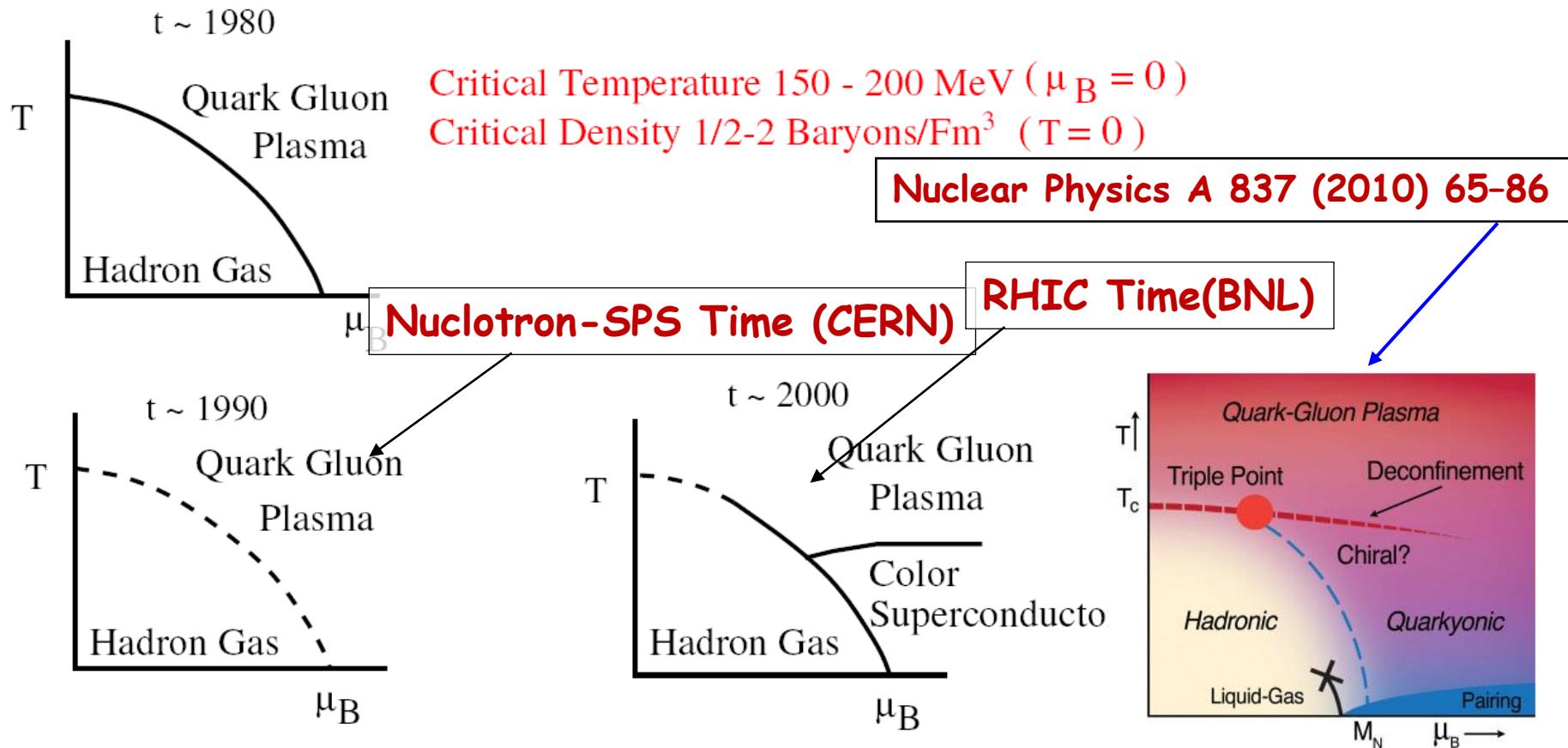
Larry McLerran

Physics Department PO Box 5000 Brookhaven National Laboratory Upton, NY 11973 USA

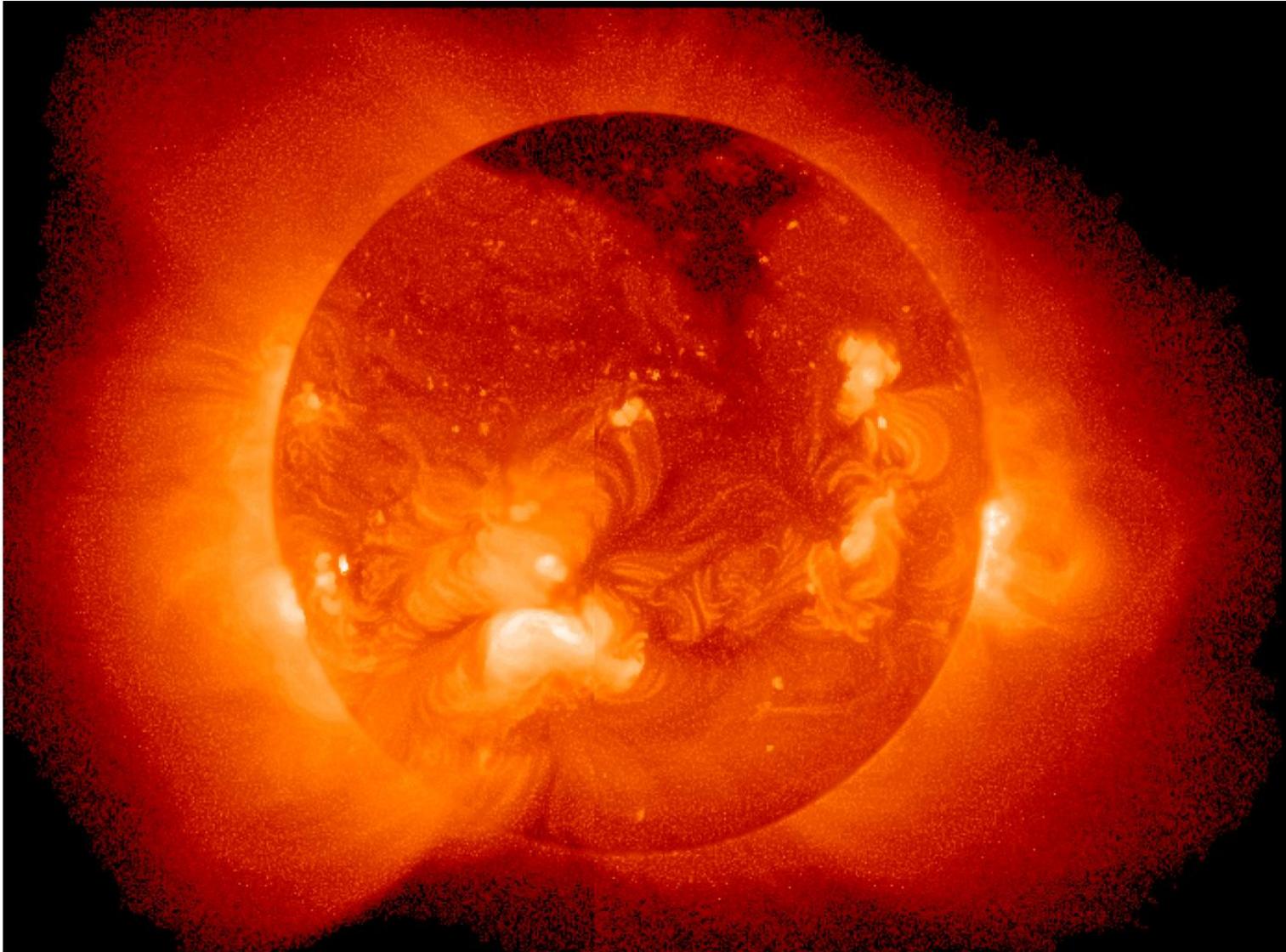
September 13, 2003

+ CERN Yellow Report
2007-005, p.75
2008-005

The Evolving QCD Phase Transition



Temperature at the centre of the Sun $\sim 15\,000\,000$ K



A medium of 170 MeV is **more than 100 000 times hotter !!!**

CUMULATIVE PROCESSES

The first introduction of the term “cumulative effect”

Выражая глубокую благодарность С. Б. Герасимову, А. Б. Говоркову и Г. Н. Флерову за обсуждение изложенных соображений. Как мне стало известно, Г. Н. Флеров еще несколько лет назад высказывал мысль о возможных **кумулятивных эффектах** при соударениях рентгенитических ядер.

Поступила в редакцию
11 ноября 1970 г.

1978

УДК 539.171.1

I4I

РАССЕЯНИЕ ЧАСТИЦ ВЫСОКОЙ ЭНЕРГИИ
КАК МЕТОД ИССЛЕДОВАНИЯ
МАЛОНУКЛОННЫХ КОРРЕЛЯЦИЙ В
ДЕЙТОНЕ И ЯДРАХ

М. И. Стрикман, Л. Л. Франкфурт

Ленинградский институт ядерной физики им. Б. П. Константина, Ленинград

572 М. И. СТРИКМАН, Л. Л. ФРАНКФУРТ

кумулятивные нуклоны
и короткодействующие корреляции в ядре

М.И.Стрикман и Л.Л.Франкфурт

малых расстояний в ядрах и о способе их описания представляет самостоятельный интерес. Цель обзора — показать, что отбор событий, содержащих кумулятивные частицы, увеличивает относительный вклад от конфигураций в волновой функции ядра, содержащих несколько нуклонов (два, три) на малых относительных расстояниях *. (Кумулятивными частицами мы, следуя [6], называем вторичные частицы, образующиеся в кинематической области, запрещенной для рассеяния на свободном нуклоне. Независимо от теоретической интерпретации этот термин удобен для обозначения указанной кинематической области.)

6. Балдин А. М.— Краткие сообщ. по физике, 1971, т. 1, с. 35.

THERMODYNAMICS OF STRONG INTERACTIONS

V.I.Yukalov, E.P.Yukalova

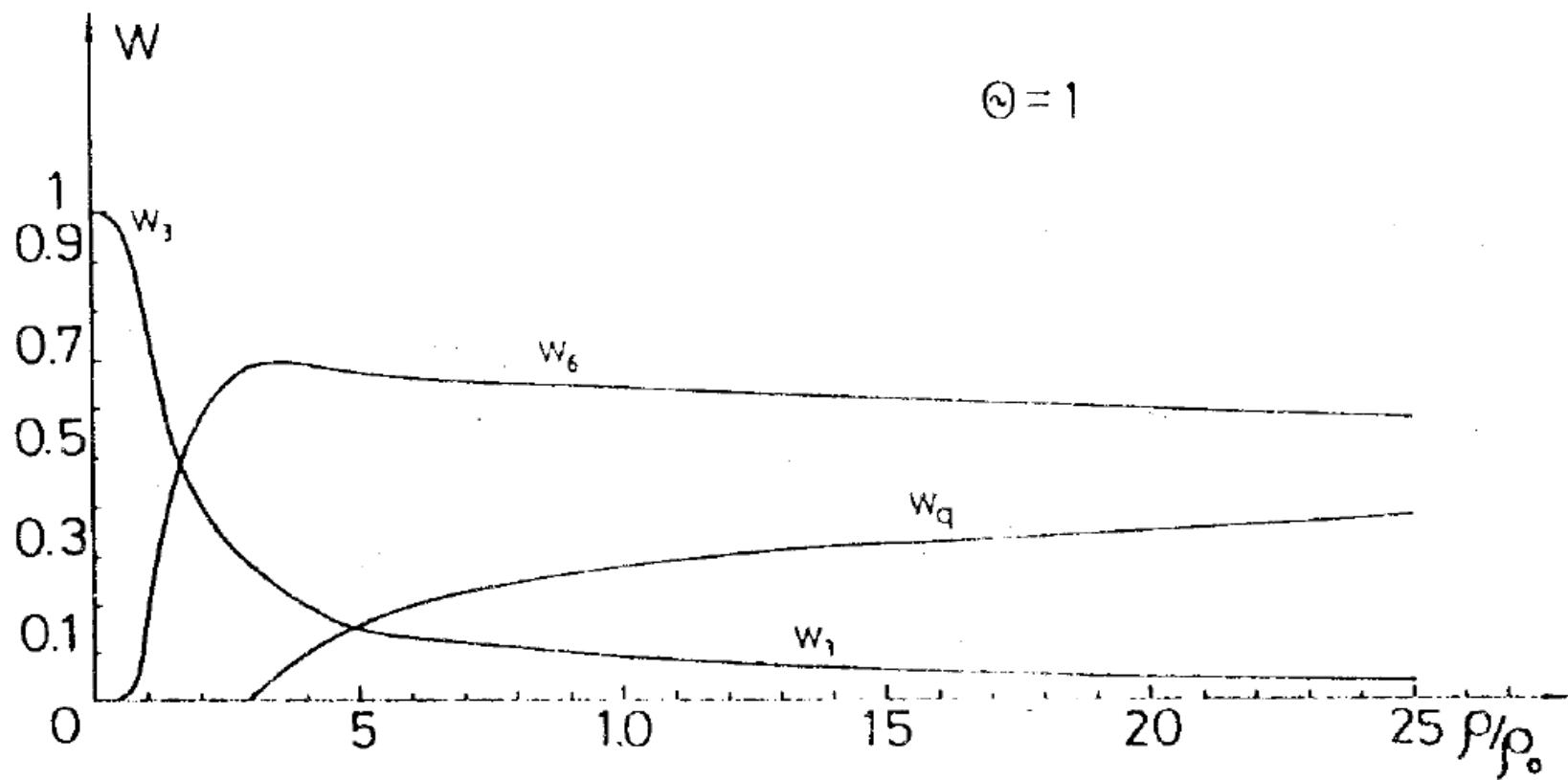
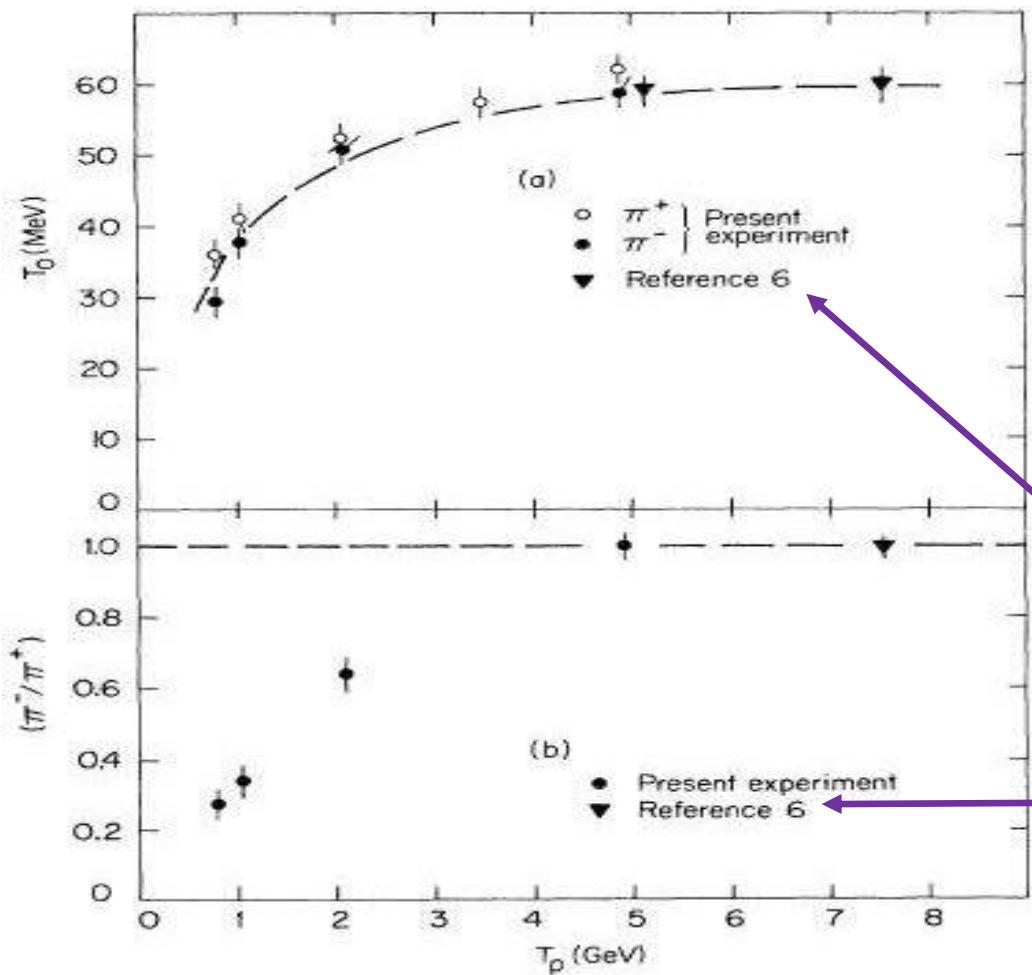


Fig.6. Nucleon, $6q$ -cluster, and unbound quark probabilities as functions of the relative density at $\Theta = 0$



[6] A.M. Baldin et al.,
Yad.Fiz., 20,
1975, p.1201

FIG. 1. Energy dependence of (a) T_0 parameter for pions, and (b) the π^-/π^+ ratio at 180° obtained by integrating each spectra up to 100 MeV for p -Cu collisions from 0.8 to 4.89 GeV. The dashed curve in both cases refers to the predictions of the "effective-target" model (Refs. 3 and 4).

REVIEWS

Methods for Investigating Nuclear Matter under the Conditions Characteristic of Its Transition to Quark–Gluon Plasma

G. A. Leksin

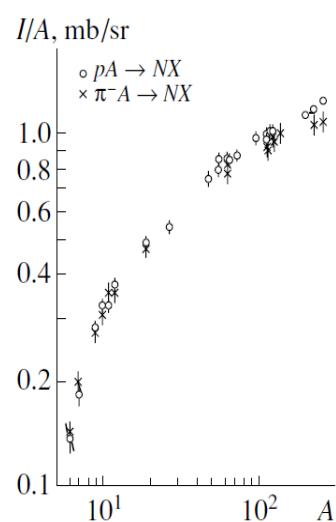


Fig. 10. A dependence of the nucleon yields normalized to the number of nucleons in the target nucleus escaping at an angle of 120° in the reactions $p(\pi^-)A \rightarrow NX$. The energies of the incident protons and π^- mesons are 7.5 and 5 GeV, respectively.

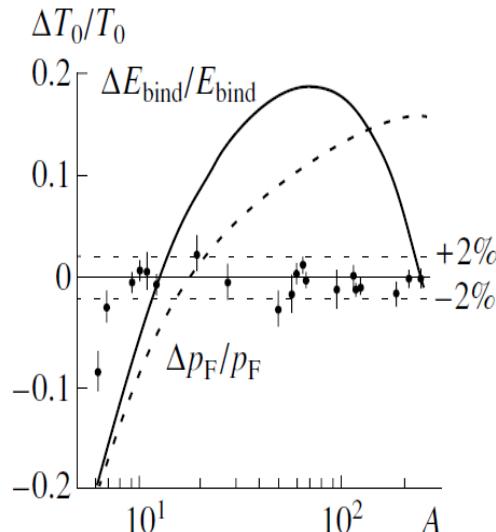


Fig. 8. Slope of the proton invariant function normalized to the mean slope versus atomic number A of the target nucleus: binding energy versus A (solid curve) and Fermi momentum normalized to the mean Fermi momentum versus A (dashed curve).

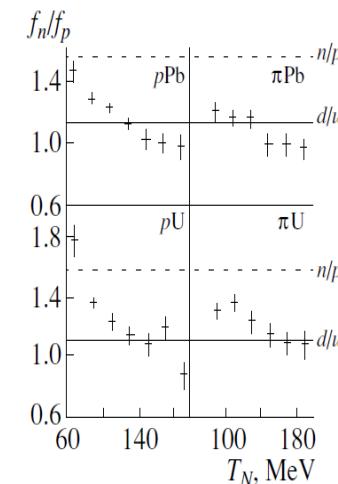


Fig. 12. The ratio of the neutron and proton yields from isononsymmetric Pb and U nuclei versus the kinetic energy of the escaping nucleons; the escape angle is 120° and the initial energy is 7.5 GeV for protons and 5 GeV for pions. The π^\pm data are averaged. The dashed lines represent the neutron-to-proton ratio in the target nuclei, and the solid lines represent the d/u -quark ratio in the Pb and U nuclei.

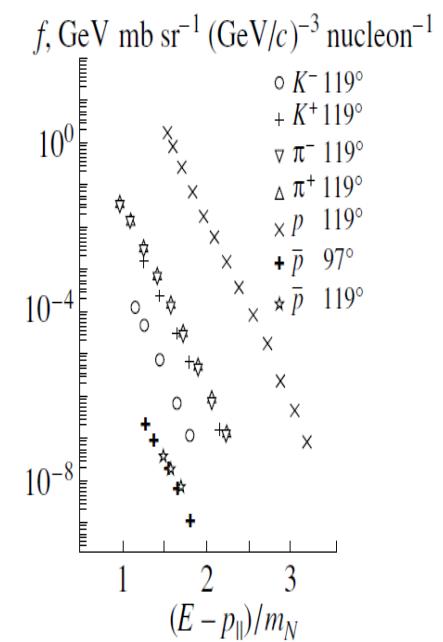


Fig. 9. Invariant functions of the protons, π^\pm mesons, K^\pm mesons, and antiprotons escaping from Cu at an angle of 119° in the laboratory frame for initial energy of 10 GeV versus light-cone variable $(E - p_\parallel)/m_N$.

Fiz. Elem. Chast. At. Yadra. 2005. V. 36. P. 954



**CURRENT EXPERIMENTS USING POLARIZED
BEAMS OF THE JINR VBLHE ACCELERATOR
COMPLEX**

F. Lehar

DAPNIA, CEA/Saclay, Gif-sur-Yvette Cedex, France

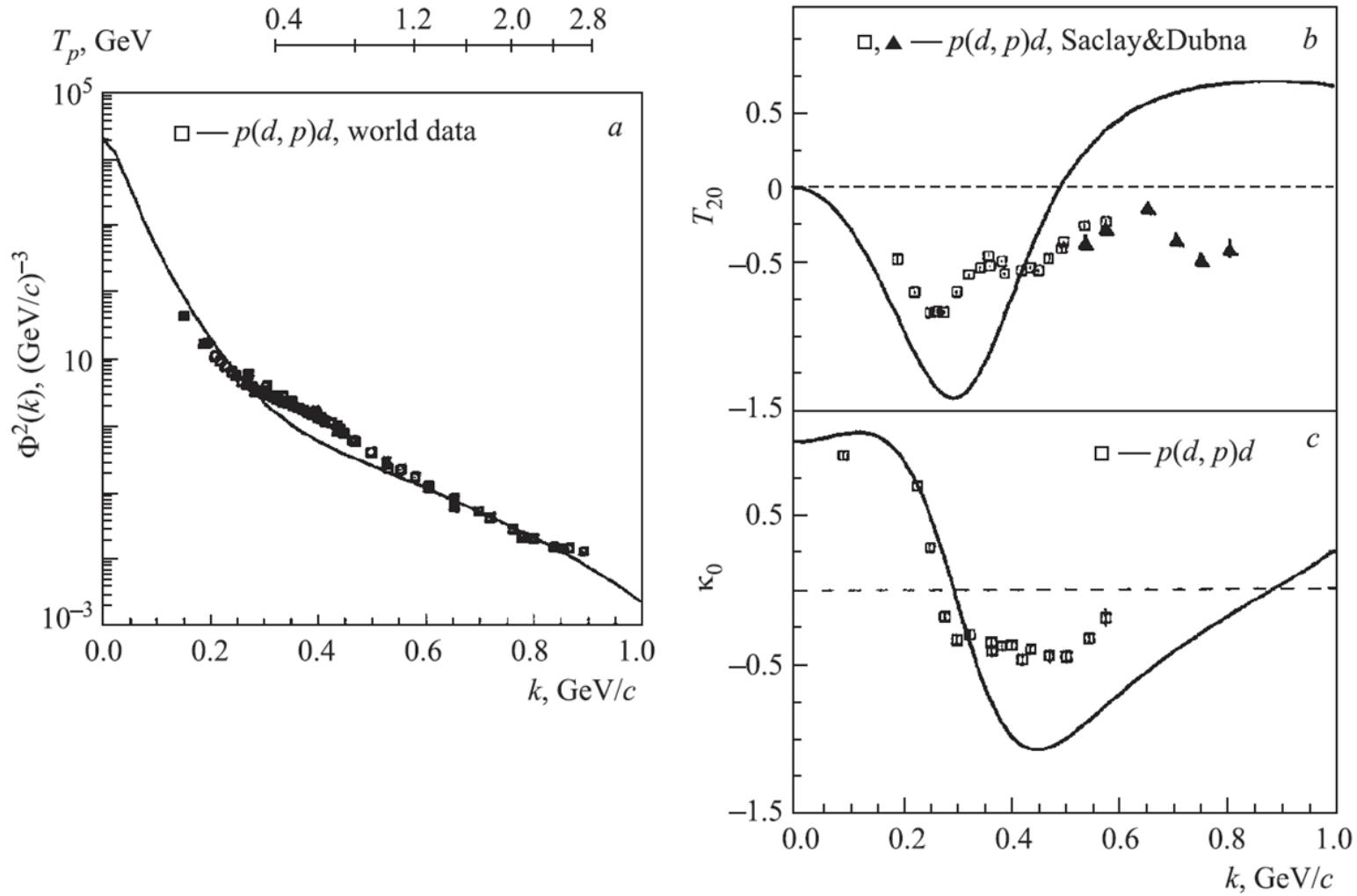


Fig. 16. The summary of the data for backward elastic scattering $p(d, p)d$. The EMD is extracted from the data presented in Fig. 15. Line — One-Nucleon-Exchange (ONE) predictions with Paris DWF. The upper scale illustrates the correspondence between T_p and k

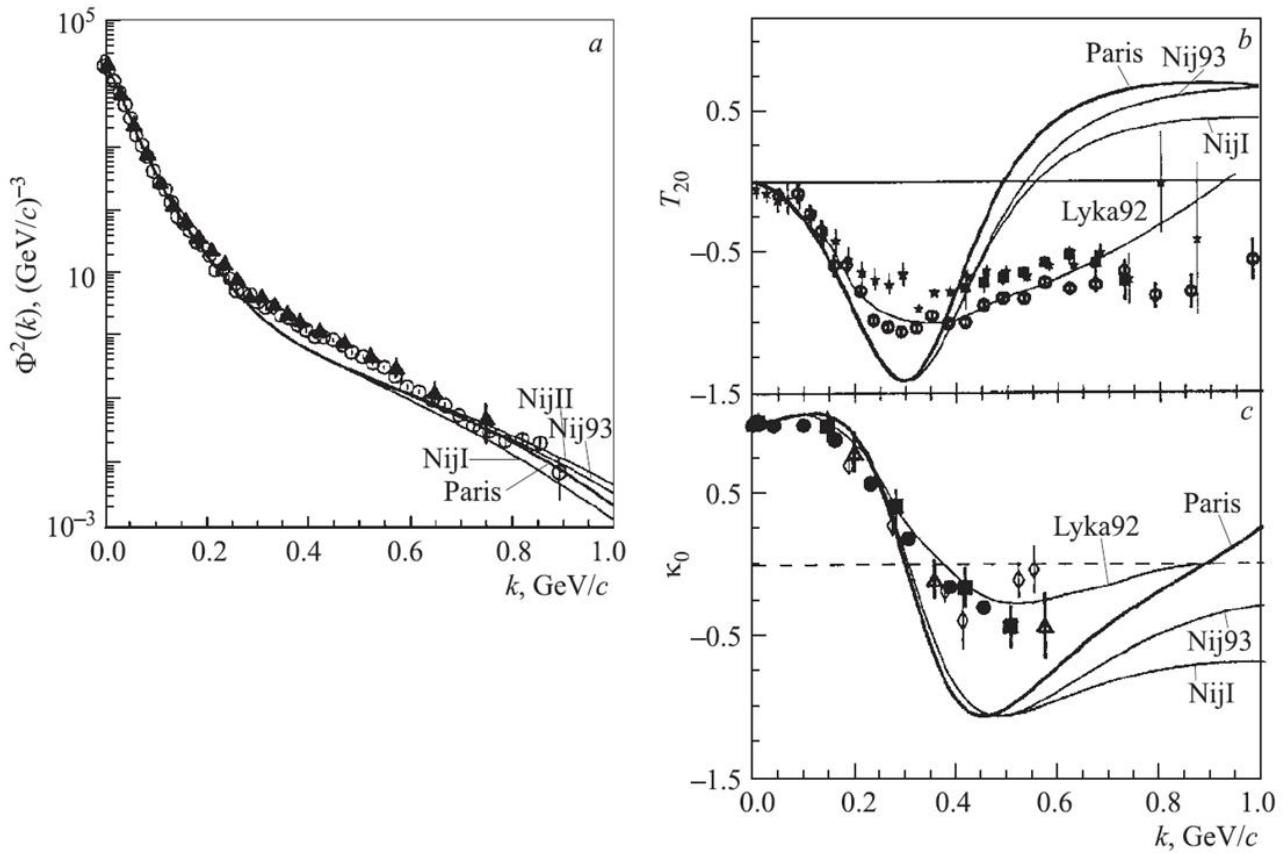
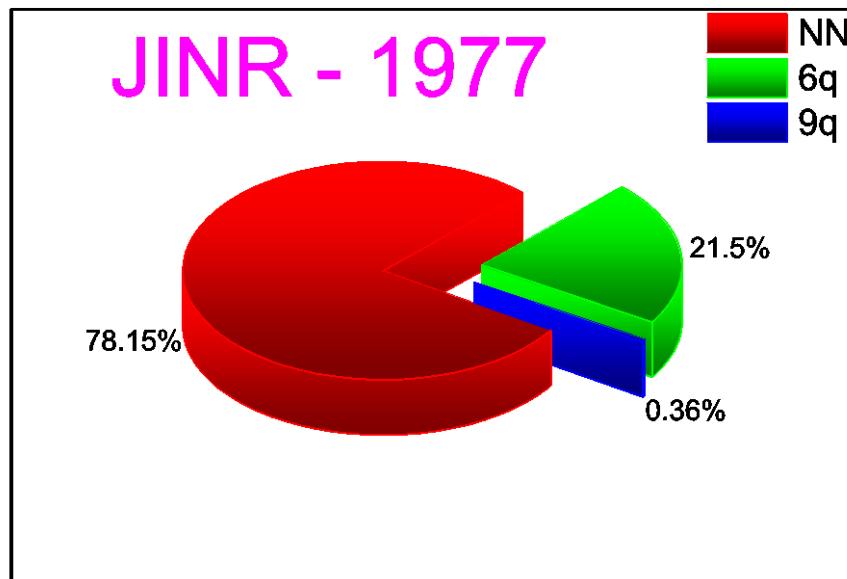


Fig. 13. World data for deuteron break-up on protons and carbon nuclei. The Empirical Momentum Density (EMD), denoted here as Φ^2 , is defined in the text. Lines are calculated in the quasi-impulse approximation with different models for the deuteron wave function (DWF) (labels «Paris», «Nij93», «NijI» for the Paris and Nijmegen DWFs) and in the model where rescattering effects and final state interactions are taken into account («Lyka92»[103, 104]). *a)* \circ — $H(d,p)X$ (Dubna); \blacktriangle — $d(e,e')X$ (SLAC); *b)* \star — $C(d,p)X$ (Dubna, 1988); \circ — $p(d,p)X$ (Dubna, 1994); \blacksquare — $C(d,p)X$ (Dubna, 1995); *c)* \bullet — Saclay (1991); \blacksquare — ALPHA (1992); \diamond — ANOMALON (1993); \triangle — ALPHA (1994)

^{12}C - structure

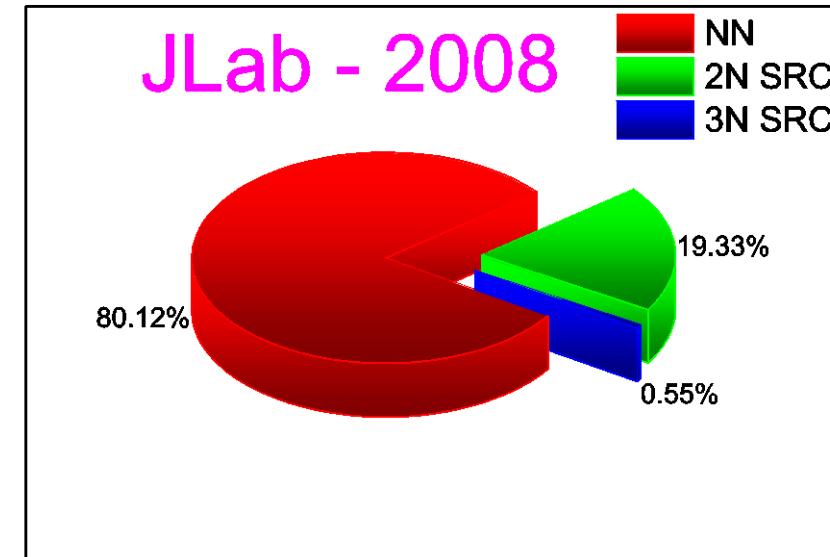
RNP - program at JINR

V.V.Burov, V.K.Lukyanov,
A.I.Titov, PLB, 67, 46(1977)



eA - program at JLab

R.Subedi et al., Science 320
(2008) 1476-1478
e-Print: arXiv:0908.1514 [nucl-ex]



A - dependence (1974-...)

$$\varepsilon \frac{d\sigma}{dp}(p + A \rightarrow \pi) \sim \begin{cases} A - \text{heavy_nuclei} \\ A^{n>1} - \text{light_nuclei} \end{cases}$$

$$\varepsilon \frac{d\sigma}{dp}(p + A \rightarrow B) \sim \begin{cases} A^{5/3} - \text{for_} d \\ A^2 - \text{for_} t \end{cases}$$

The same time Cronin team at FNAL have seen about the same A-dependence for pA (for 200, 300, 400 GeV protons) high p_T Particle production

Production of hadrons at large transverse momentum at 200, 300, and 400 GeV *

J. W. Cronin, H. J. Frisch, and M. J. Shochet

The Enrico Fermi Institute, University of Chicago, Chicago, Illinois 60637

J. P. Boymond, P. A. Piroué, and R. L. Sumner

Department of Physics, Joseph Henry Laboratories, Princeton University, Princeton, New Jersey 08540

(Received 5 December 1974)

We have measured, as a function of transverse momentum (p_{\perp}), the invariant cross section $E d\sigma/d^3p$ for the production of π^\pm , K^\pm , p , \bar{p} , d , and \bar{d} in proton collisions with a tungsten (W) target at incident proton energies of 200, 300, and 400 GeV. The measurements were made in the region of 90° in the c.m. system of the incident proton and a single nucleon at rest. Measurements were also made with 300-GeV protons incident on Be, Ti, and W targets of equal interaction length. These p -nucleus measurements, which show a strong dependence on atomic number at high p_{\perp} , were used to extract effective proton-nucleon cross sections by extrapolation to atomic number unity. At large values of the scaling variable $x_{\perp} = 2p_{\perp}/\sqrt{s}$, where s is the square of the c.m. energy, the pion data are found to be well represented by the expression $(\sqrt{s})^{-n} e^{-ax_{\perp}}$, with $n = 11.0 \pm 0.4$ and $a = 36.0 \pm 0.4$. At $x_{\perp} < 0.35$, where similar measurements have been made at the CERN ISR, our data are in good agreement with the ISR data.

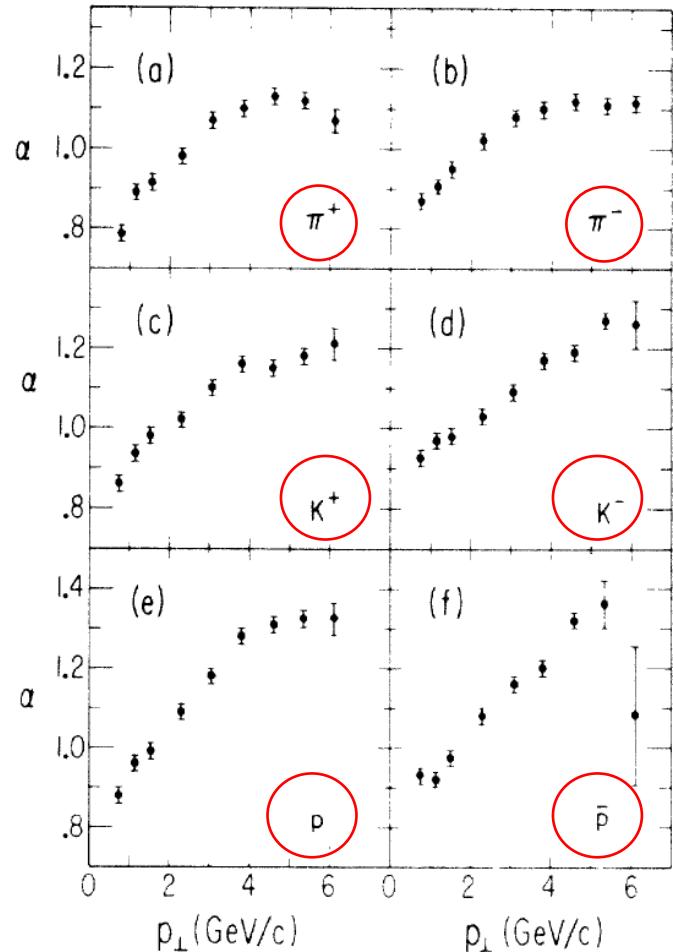


FIG. 17. Plots of the power α of the A dependence versus p_{\perp} for the production of hadrons by 300-GeV protons; (a) π^+ , (b) π^- , (c) K^+ , (d) K^- , (e) p , and (f) \bar{p} .

Other processes to investigate the high dense state
of the cold nuclear matter - high p_T physics. Stavinsky
tried to describe by the same way as cumulative
processes.

Краткие сообщения ОИЯИ №18-86
УДК 539. 12. 01

JINR Rapid Communications No. 18-86

ЕДИНЫЙ АЛГОРИТМ ВЫЧИСЛЕНИЯ ИНКЛЮЗИВНЫХ СЕЧЕНИЙ
РОЖДЕНИЯ ЧАСТИЦ С БОЛЬШИМИ ПОПЕРЕЧНЫМИ ИМПУЛЬСАМИ
И АДРОНОВ КУМУЛЯТИВНОГО ТИПА

В.С.Ставинский

Предложен единый алгоритм вычисления инклюзивных сечений рождения частиц с большими поперечными импульсами и адронов кумулятивного типа. Возможность единого описания этих процессов обусловлена введением нового аргумента – минимальной энергии сталкивающихся конституентов, необходимой для рождения наблюдаемой частицы. Проведено сравнение с экспериментальными данными.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Unique Algorithm for Calculation of Inclusive Cross Sections of Particle Production with Big Transverse Momenta and of Cumulative Type Hadrons

V.S.Stavinskij

Unique algorithm is proposed for calculating inclusive cross sections of particle production with big transverse momenta and cumulative type hadrons. A possibility of unique description of these processes is due to introduction of a new argument – of minimal energy of colliding constituents needed for the production of observed particle.

The investigation has been performed at the Laboratory of High Energies, JINR.

The variables X , Q , N_{min}

«Cumulative processes» - in the kinematic forbidden for the free nucleon-nucleon interactions.

$$h + A \rightarrow c + X$$

$$\mu + N_{min} \cdot m \rightarrow m_c + [N_{min} \cdot m + \Delta]$$

for $E_\mu \gg m_i, E_c$

$$X = N_{min} = Q \cong \left[\frac{(E_c - \beta_\mu \cdot P_c \cdot \cos \theta_c)}{m} \right] + \dots \equiv X_I(X_{II}) \text{ Stavinsky (1970's)}$$

The variables from the «quasibinary» kinematic!

Fragmentation regions

$$\mu + N_{min} \cdot m \rightarrow m_c + [N_{min} \cdot m + \Delta]$$

for $E_\mu \gg m_i, E_c$

$$X = N_{\min} = Q \cong \frac{(E_c - \beta_\mu \cdot P_c \cdot \cos \theta_c)}{m} + \dots \equiv X_I(X_{II}) \quad \text{Stavinsky (1970's)}$$

Common case for AA-collisions

V.S. Stavinsky JINR Rapid Communications N18-86, p.5 (1986)

$$(X_I \cdot M_I) + (X_{II} \cdot M_{II}) \rightarrow m_c + [X_I \cdot M_I + X_{II} \cdot M_{II} + m_2]$$

$$S_{\min}^{1/2} = \min(S^{1/2}) = \min[(X_I \cdot P_I + X_{II} \cdot P_{II})^{1/2}]$$

A.A. Baldin's parameterization

Phys. At. Nucl. 56(3), p.385(1993)

$$\Pi = \frac{1}{2} (X_I^2 + X_{II}^2 + 2 \cdot X_I \cdot X_{II} \cdot \gamma_{I,II})^{\frac{1}{2}} = \frac{1}{2 \cdot m} \cdot S_{\min}^{\frac{1}{2}}$$

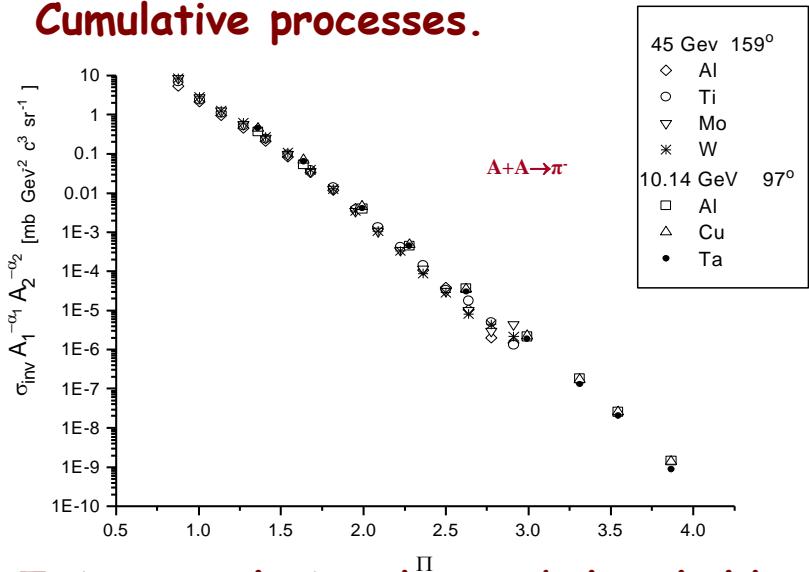
$$\gamma_{I,II} = \frac{(P_I \cdot P_{II})}{M_I \cdot M_{II}}$$

Inclusive data parameterization

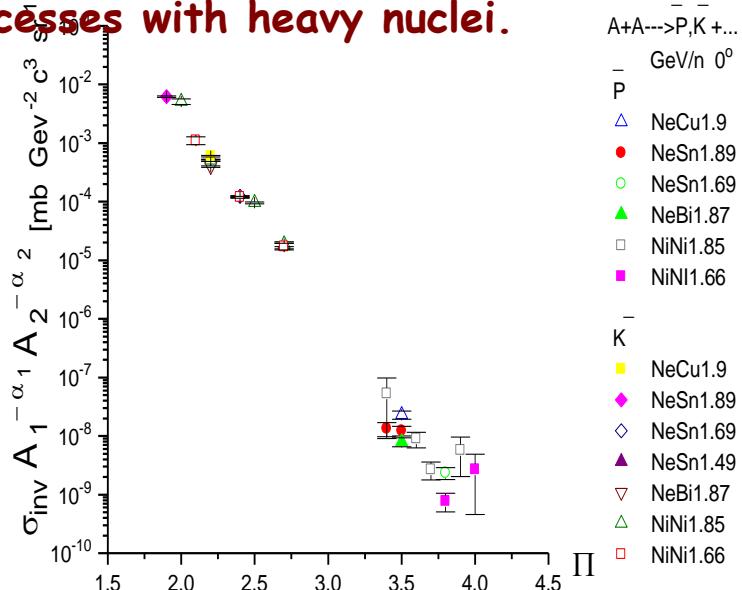
$$E \cdot \frac{d^3\sigma}{dp^3} = C_1 \cdot A_I^{\frac{1}{3} + \frac{X_I}{3}} \cdot A_{II}^{\frac{1}{3} + \frac{X_{II}}{3}} \cdot \exp(-\frac{\Pi}{C_2}),$$

$$C_1 = 2200 [mb \cdot GeV^{-2} \cdot c^3 \cdot sr^{-1}], C_2 = 0.127$$

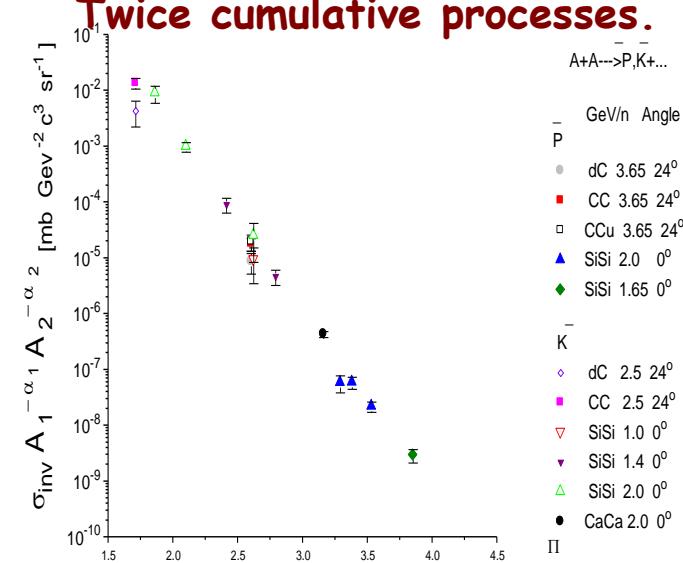
Cumulative processes.



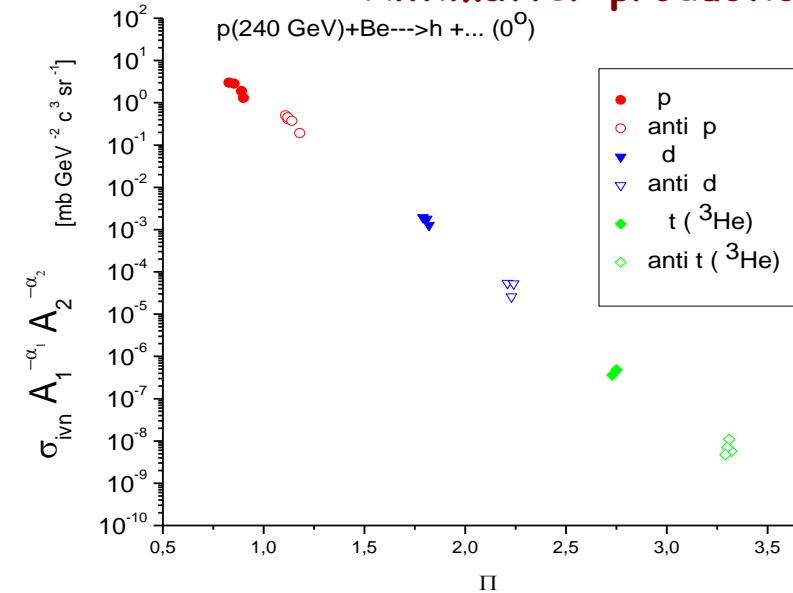
Twice cumulative deep subthreshold processes with heavy nuclei.



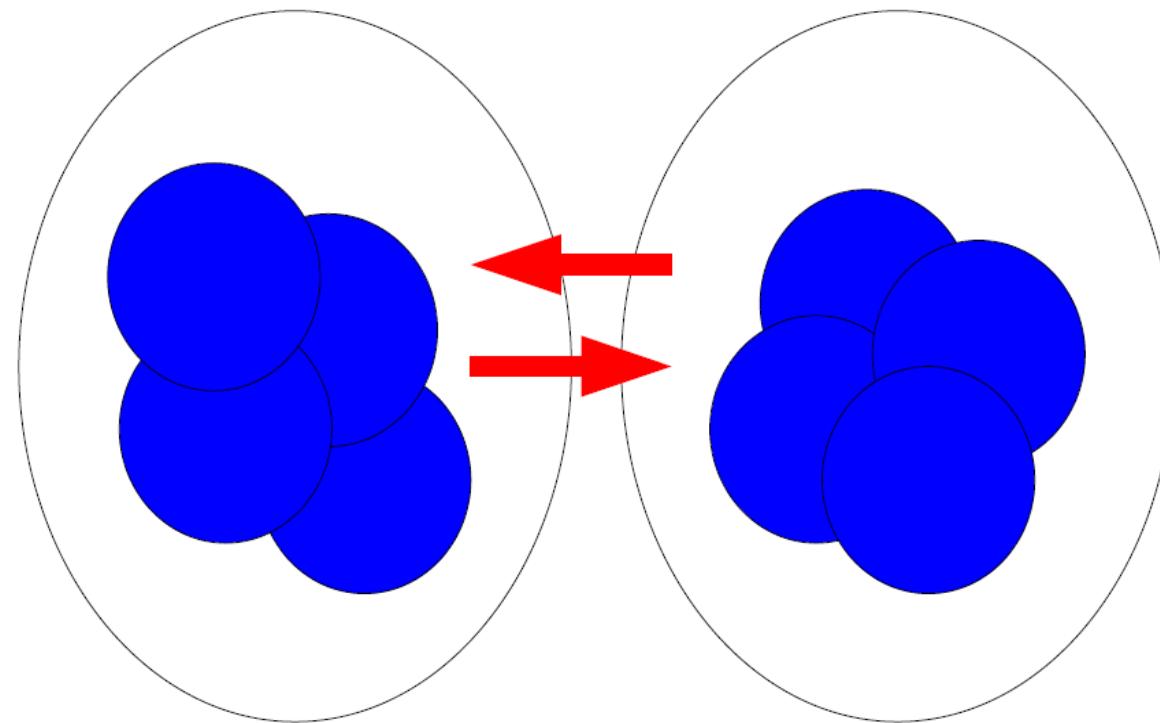
Twice cumulative processes.



Antimatter production.

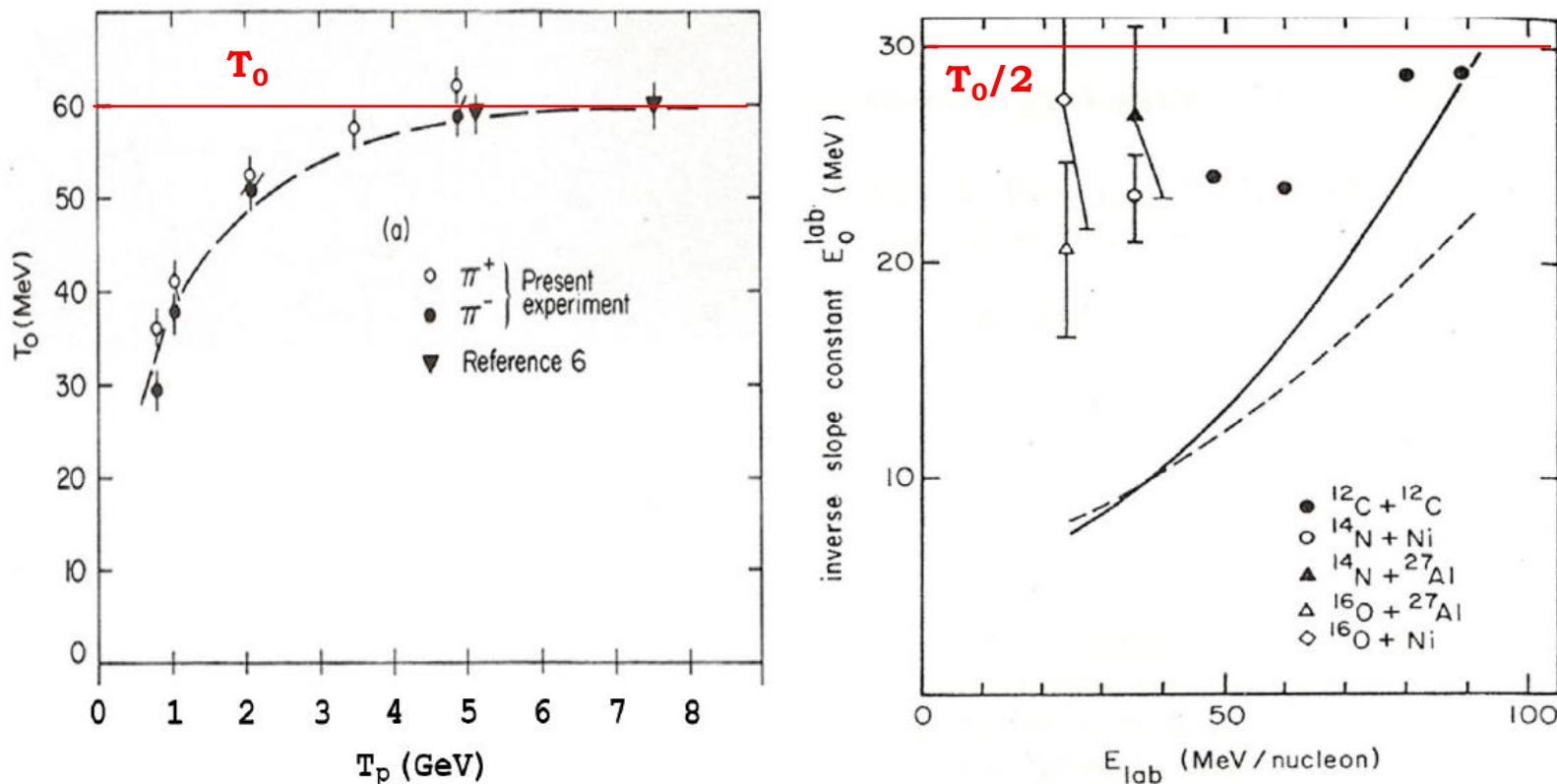


Subthreshold flucton-flucton production



$$\sigma_h \sim P_K^2 \cdot G_{h/K}^2(K)$$

Inverse slope for subthreshold production must be less than $T_0/2$
 (near the phase space border).



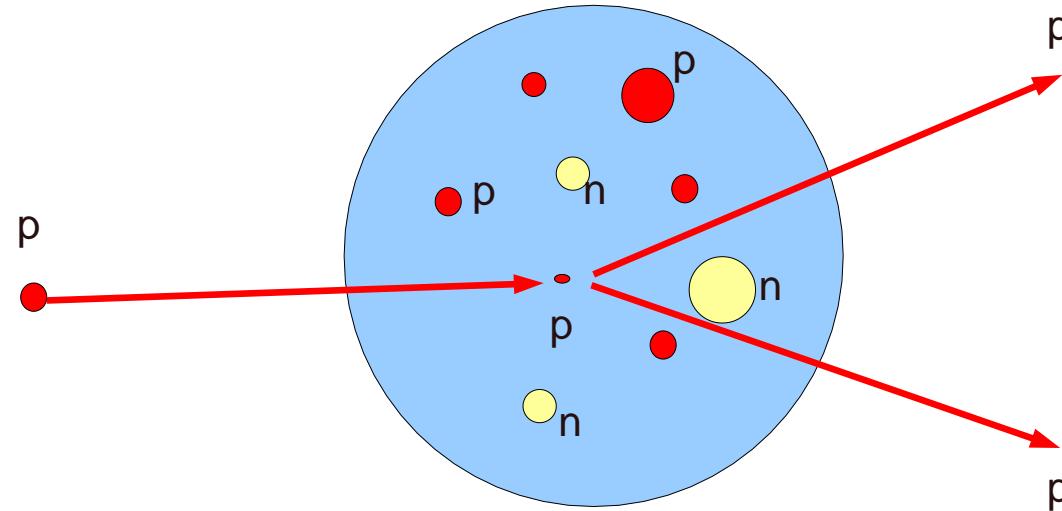
$$P_{cum} \sim \exp(-T/T_0) \quad \Rightarrow \quad P_{subthresh} \sim \exp(-T/T_0) \cdot \exp(-T/T_0) \sim \exp(-T/(T_0/2))$$

High p_T processes

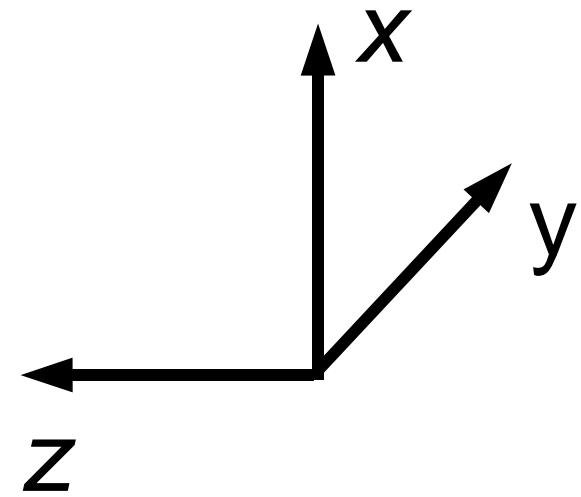
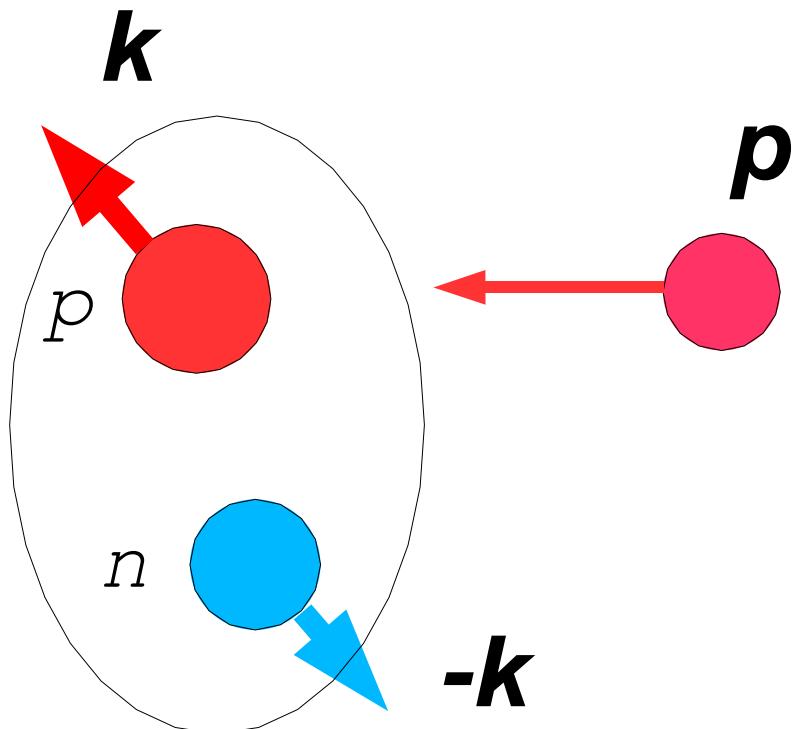
Color(nuclear) transparency in 90° c.m. quasielastic $A(p, 2p)$ reactions

The incident momenta varied from 5.9 to 14.4 GeV/c,
corresponding to $4.8 < Q^2 < 12.7 (\text{GeV}/c)^2$.

$$T = \frac{\frac{d\sigma}{dt}(p + "p" \rightarrow p + p)}{Z \frac{d\sigma}{dt}(p + p \rightarrow p + p)}$$



$p + "D"$



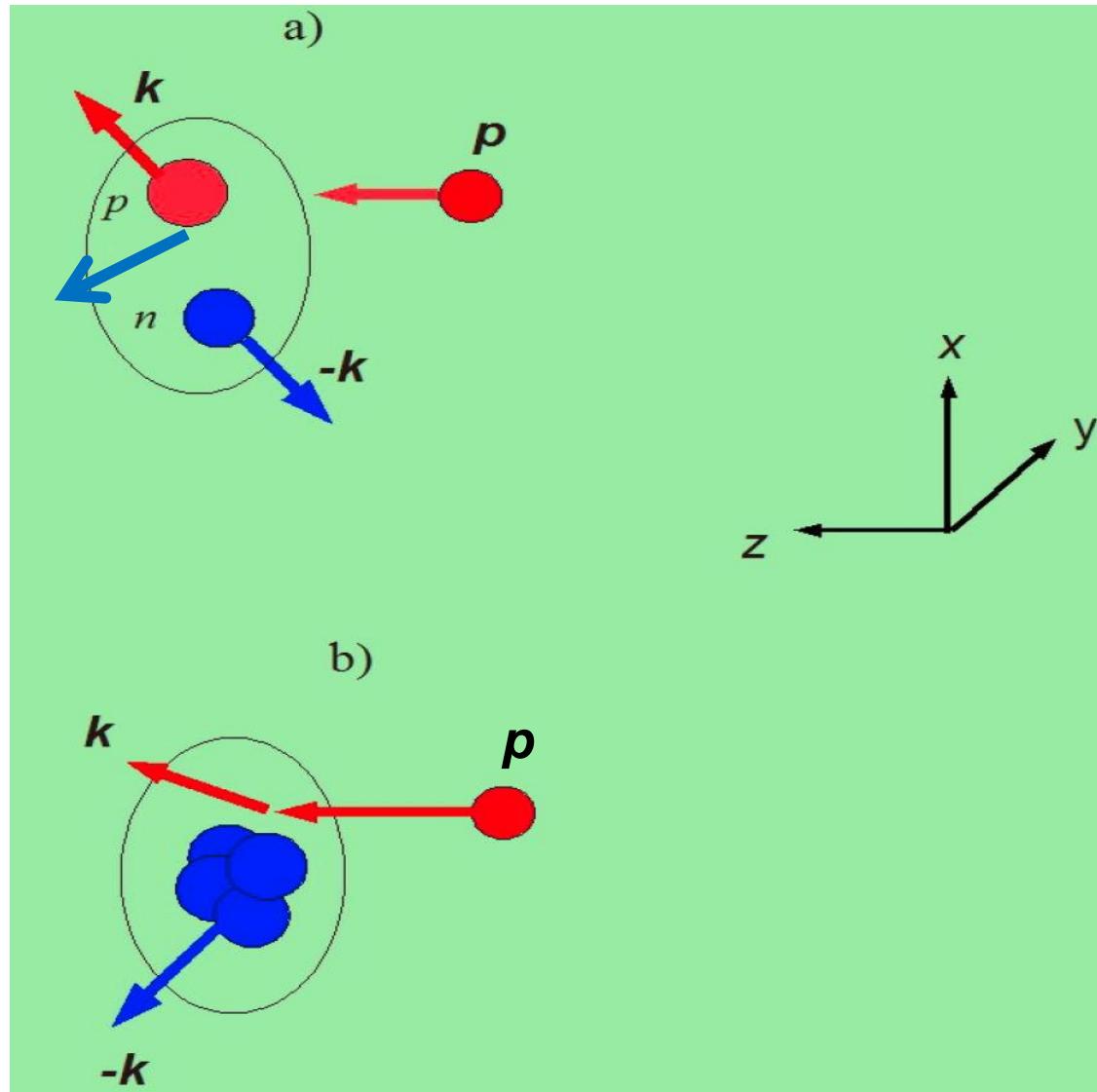
Knot out cold dense nuclear configurations

SRC configuration

$$\langle B \rangle \sim 1$$

$$\langle B \rangle ?$$

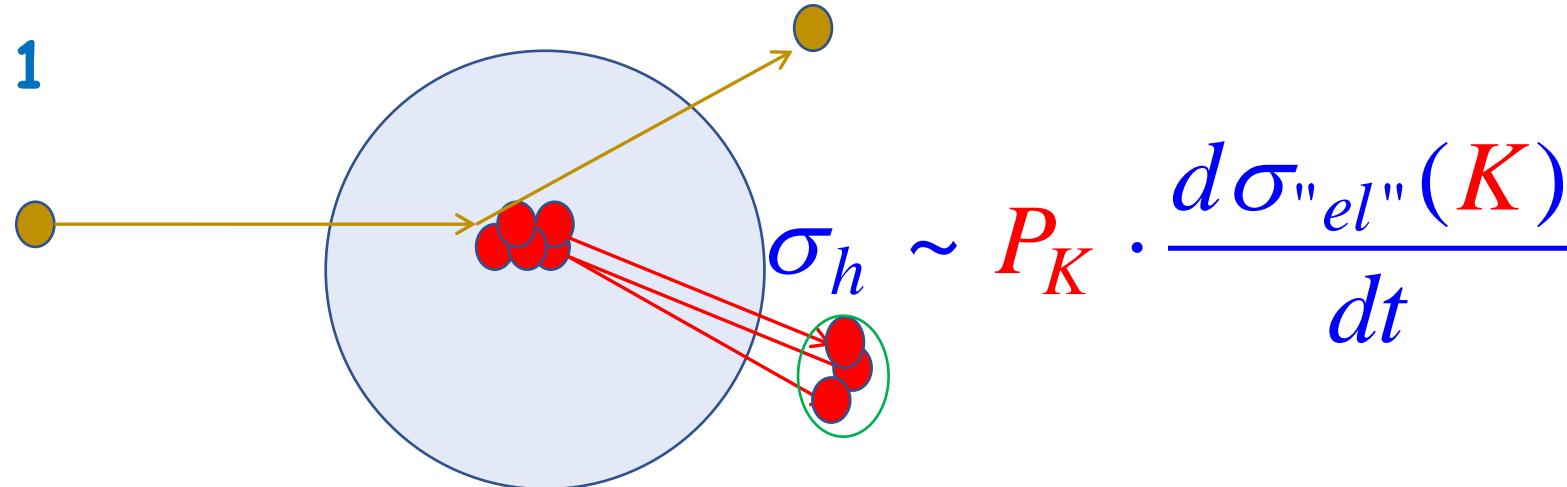
Multiquark
configuration



Flucton case

Knock out of a nuclear fragment

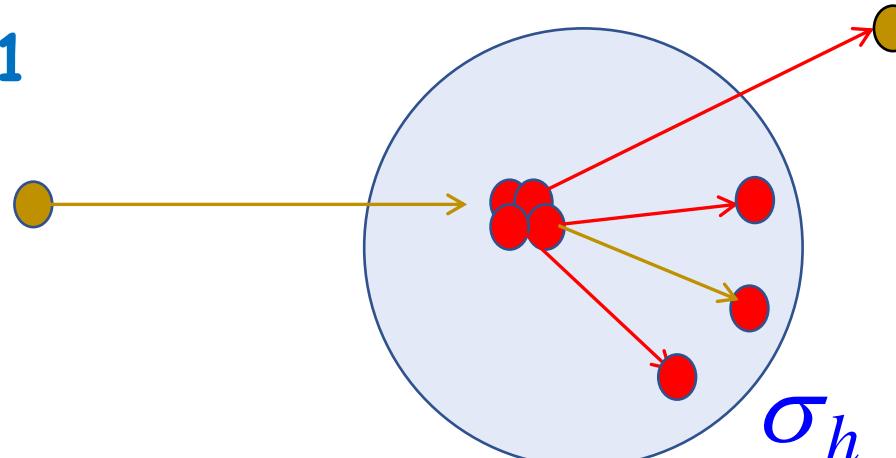
$$\langle B \rangle > 1$$



$$\sigma_h \sim P_K \cdot \frac{d\sigma_{el}''(K)}{dt}$$

Collision with hot flucton - small explosion

$$\langle B \rangle < 1$$

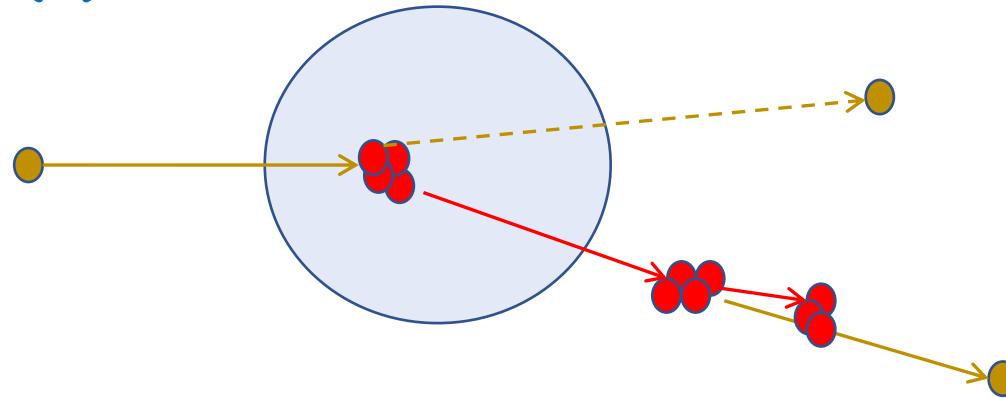


$$\sigma_h \sim P_K \cdot \frac{d\sigma_{inel}(K)}{dt}$$

Flucton case

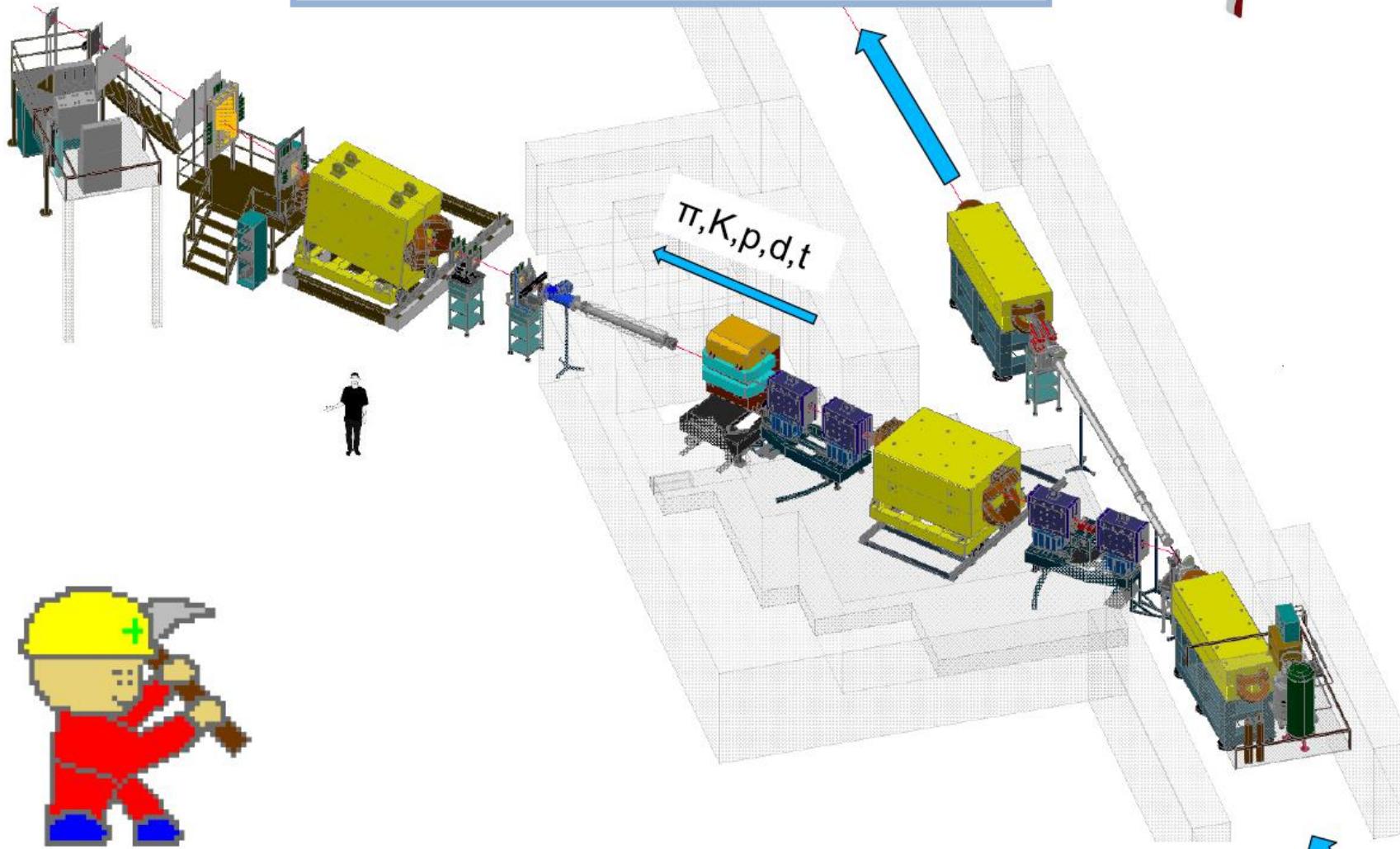
Knock out of a flucton in an excited state

$\langle B \rangle > 1 (?)$



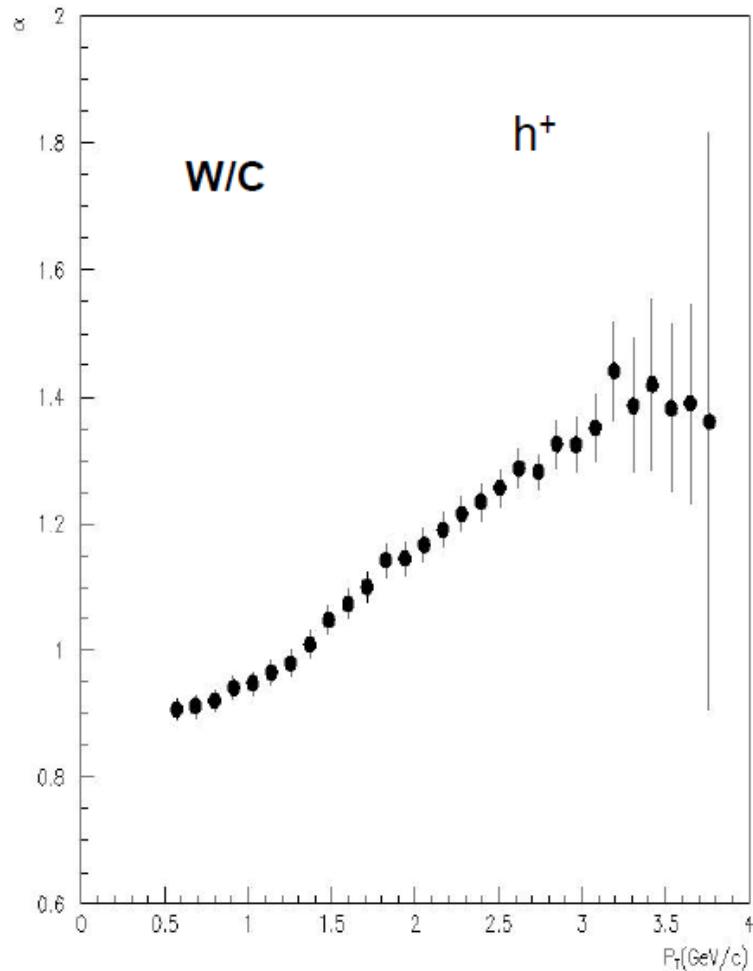
**SPIN – narrow acceptance spectrometer,
beam line #8**

Spin



protons
 $10^{12} - 10^{13}/\text{s}$

A-dependence



Показатель степенной зависимости сечения от атомной массы, приведенный как функция поперечного импульса.

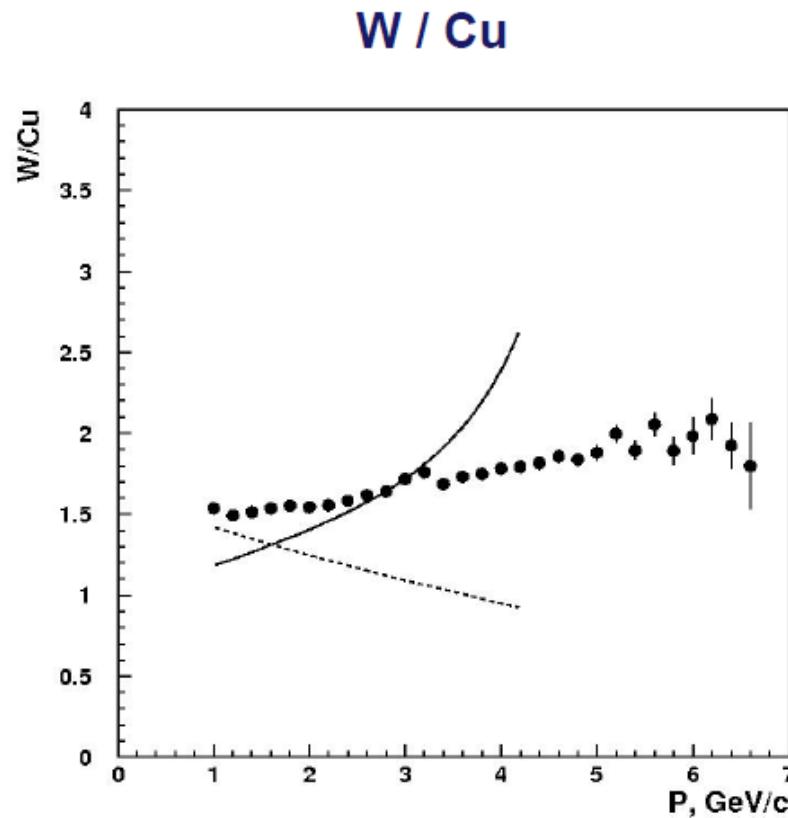
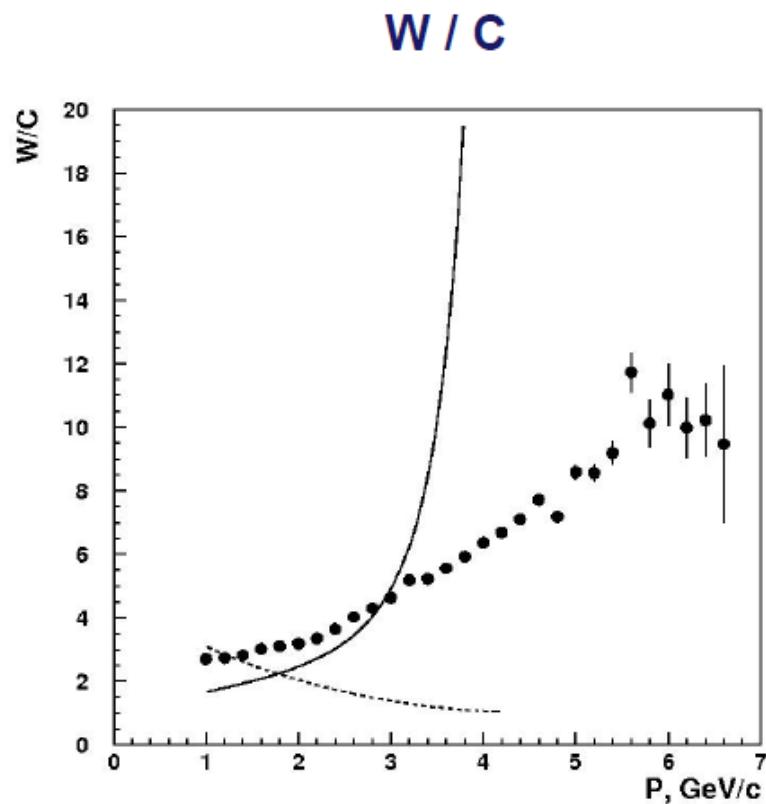
$$\alpha = \ln\left(\frac{\sigma_w}{\sigma_c}\right) / \ln\left(\frac{A_w}{A_c}\right)$$

Наблюдается сильная A-зависимость, что характерно для куллоновских процессов

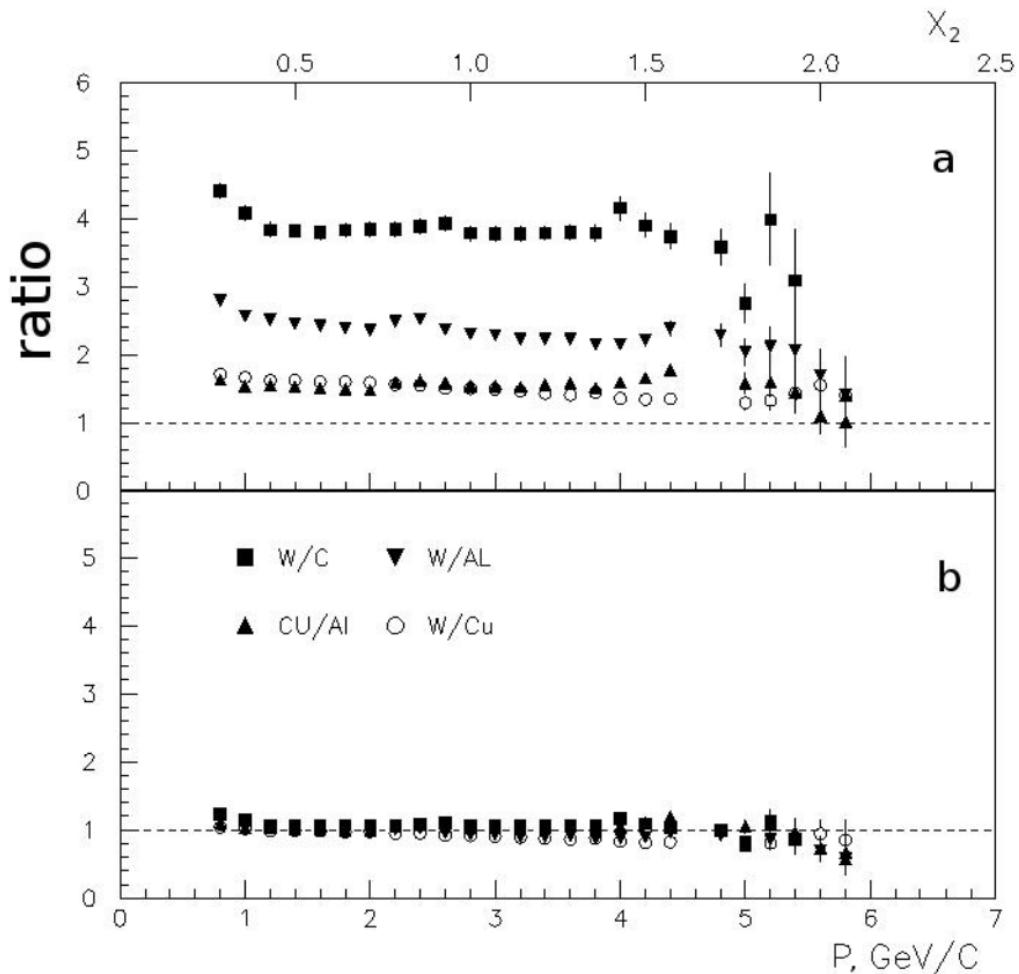
h^+ – spectrum

Сплошные кривые: HIJING 1.3 <http://www-nsdth.lbl.gov/~xnwang/hijing/doc.html>

Пунктирные кривые: UrQMD 3.3 <http://urqmd.org/>

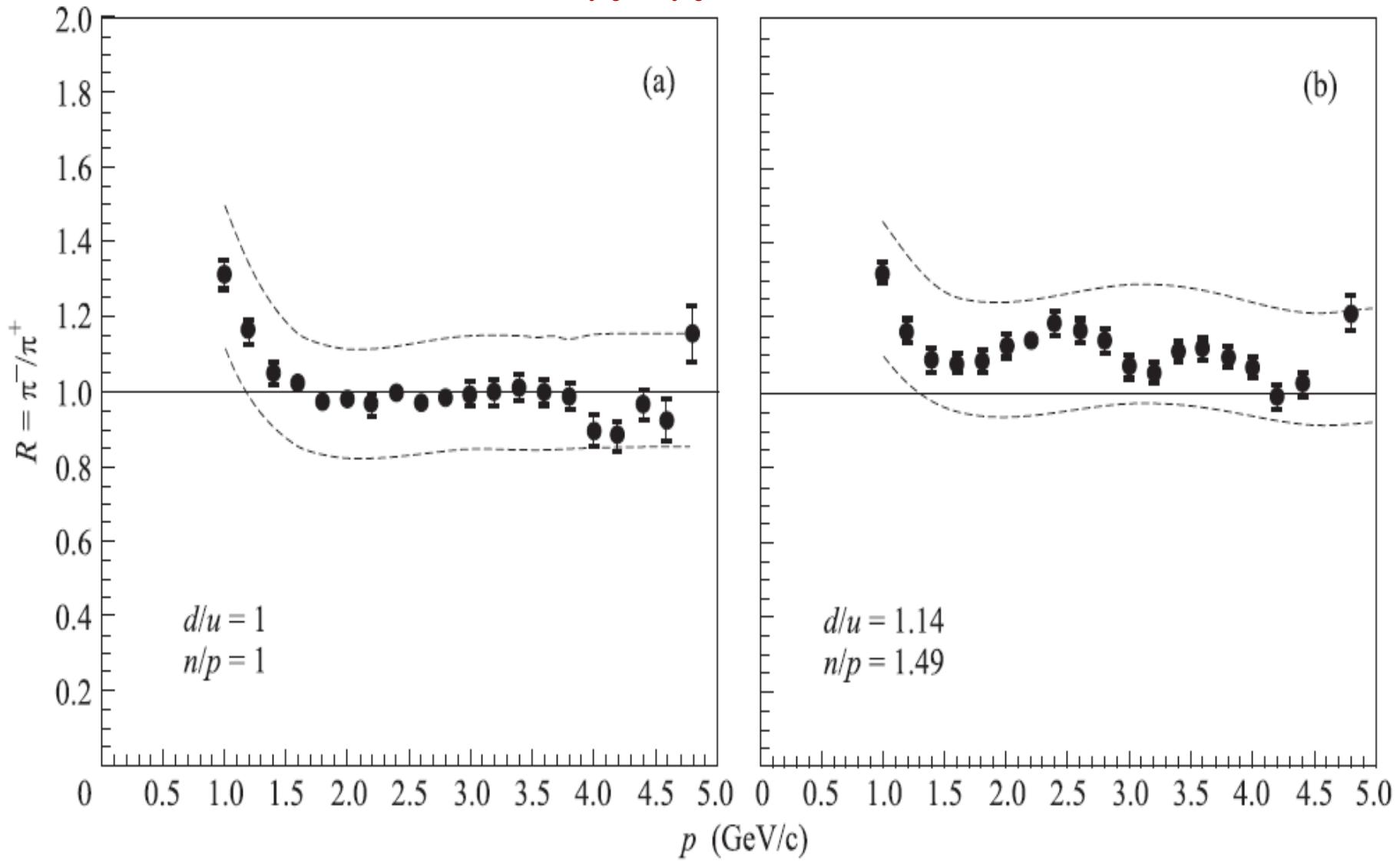


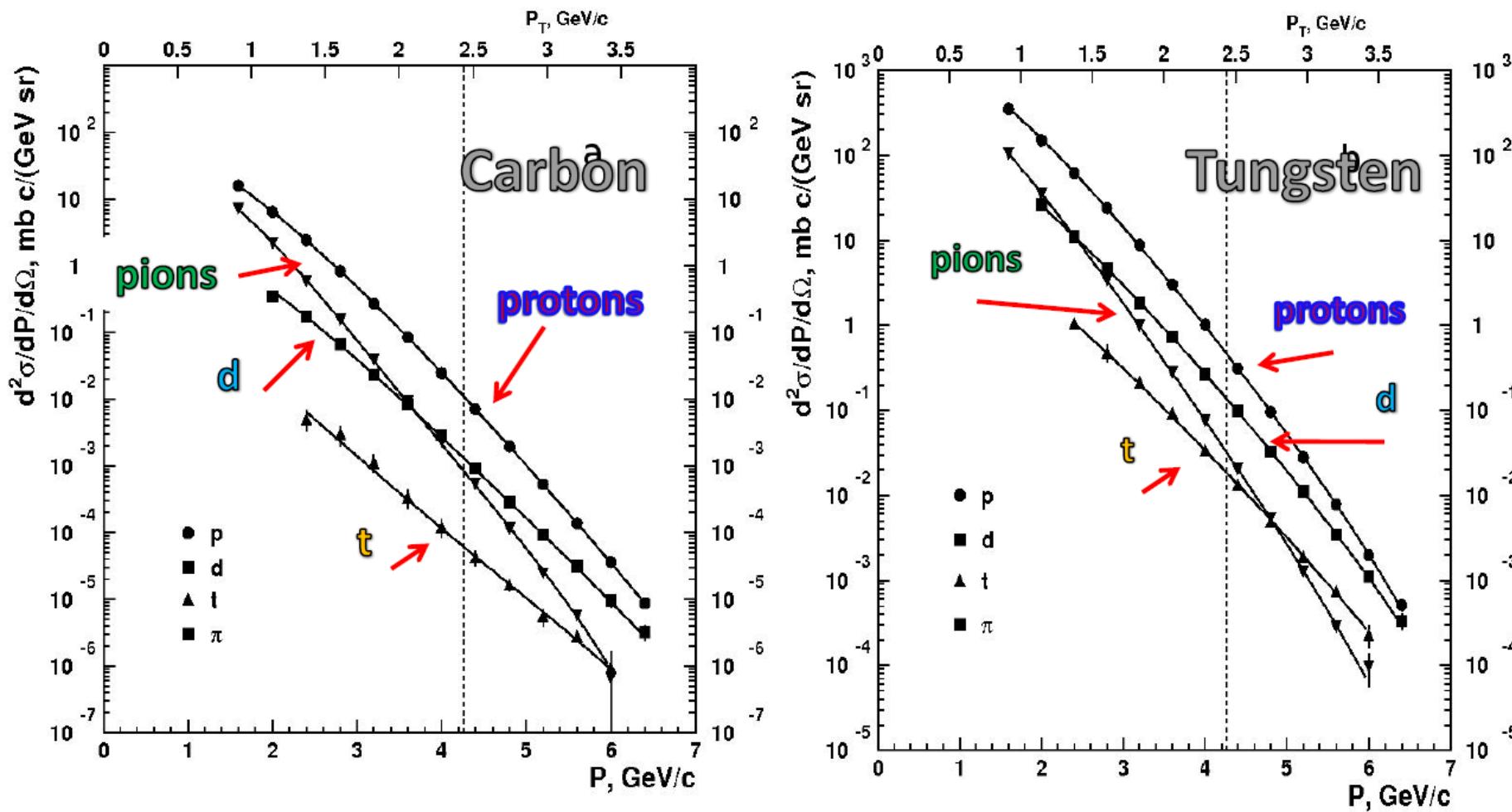
$$\frac{f_{(p+A_I)}}{f_{(p+A_{II})}} \times \left(\frac{A_I}{A_{II}} \right)^{-\left(\frac{1}{3} + \frac{X_2}{3}\right)} = 1$$



$$A^{-\left(2.45 + X_2\right)/3}$$

Fig.5 Ratio of cross sections of negative pion production on different nuclei multiplied by inverse A-dependence (see the text). The lower axis shows the momentum, the upper axis, X_2 . (a) The ratios are obtained using the A-dependence in the form [8] $A^{(1+X_2)/3}$, (b) the ratios are obtained using the A-dependence in the form $A^{(2.45+X_2)/3}$.

π^-/π^+ 



Invariant function found for positive pion, proton, deuteron and triton.

The vertical dashed lines indicate the kinematical limit for elastic nucleon-nucleon scattering. The upper horizontal scale shows values of the transverse momentum p_T .

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Russian Text © The Author(s), 2020, published in Pis'ma v Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki, 2020, Vol. 111, No. 5, pp. 291–294.

Scaling Behavior of Spectra of Protons, Deuterons, and Tritons Produced with High Transverse Momenta in pA and ^{12}CA Collisions

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$$g(\Pi) = E \frac{d^3\sigma}{dp^3} / (C_1 A_1^{\alpha(X_1)} A_2^{\alpha(X_2)})$$

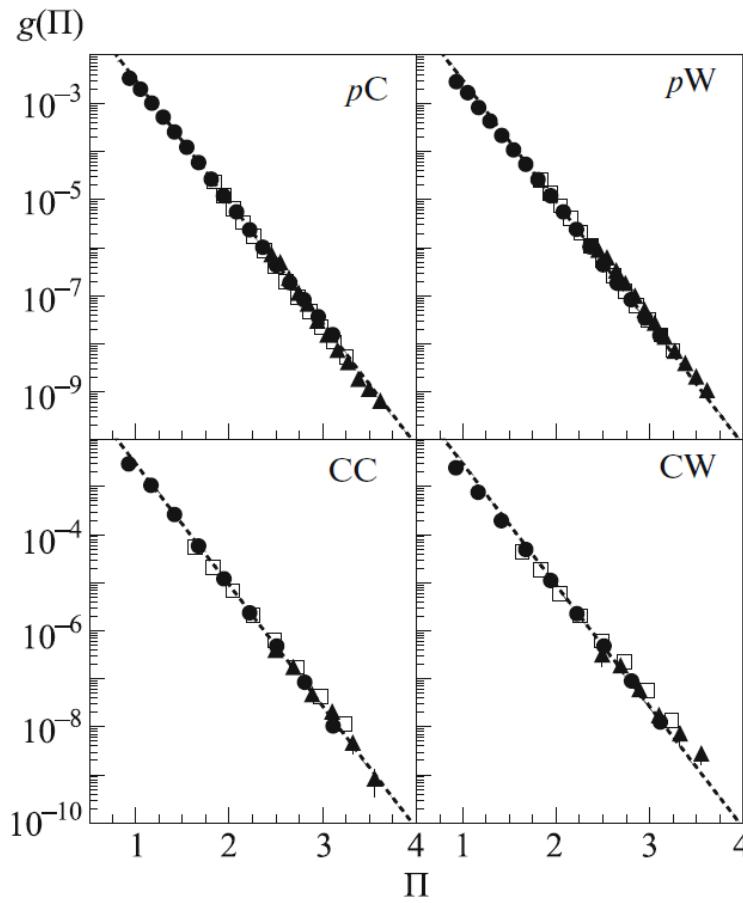


Fig. 4. Exponential dependence of the cross sections on Π for (circles) protons, (squares) deuterons, and (triangles) tritons. The dashed lines represent the function $\exp(-\Pi/0.172)$.

The first data on the yield of the lightest nuclear fragments (protons p , deuterons d , and tritons t) with high transverse momenta p_T at an angle of 40° in the laboratory reference frame from nuclear targets bombarded by $50\text{-GeV}/c$ protons and $20A\text{-GeV}/c$ carbon nuclei obtained in the SPIN experiment (IHEP, Protvino, Russia) have been reported. It has been shown that the pA and CA data can be described within a common scaling approach, which possibly indicates that the mechanism of formation of high- p_T nuclear fragments is common for these reactions.

$$f_{A_1+A_2} = E \frac{d^3\sigma}{dp^3} = C_1 A_1^{\alpha(X_1)} A_2^{\alpha(X_2)} \exp(-\Pi/C_2),$$

$$R = \frac{f_{p+A_{2a}}}{f_{p+A_{2b}}} \left(\frac{A_{2b}}{A_{2a}} \right)^{\alpha(X_2)} = 1$$

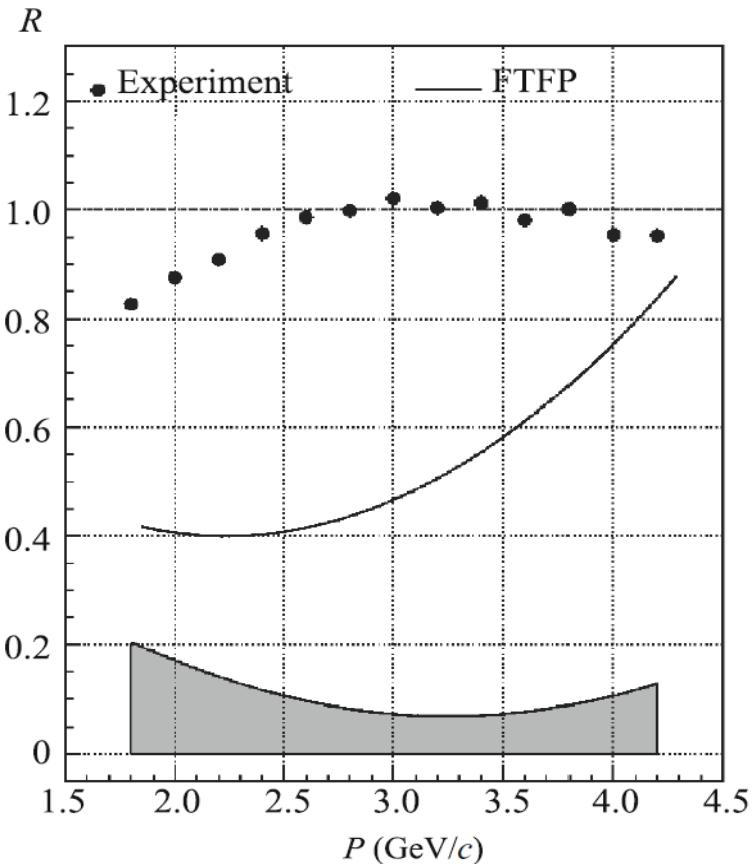


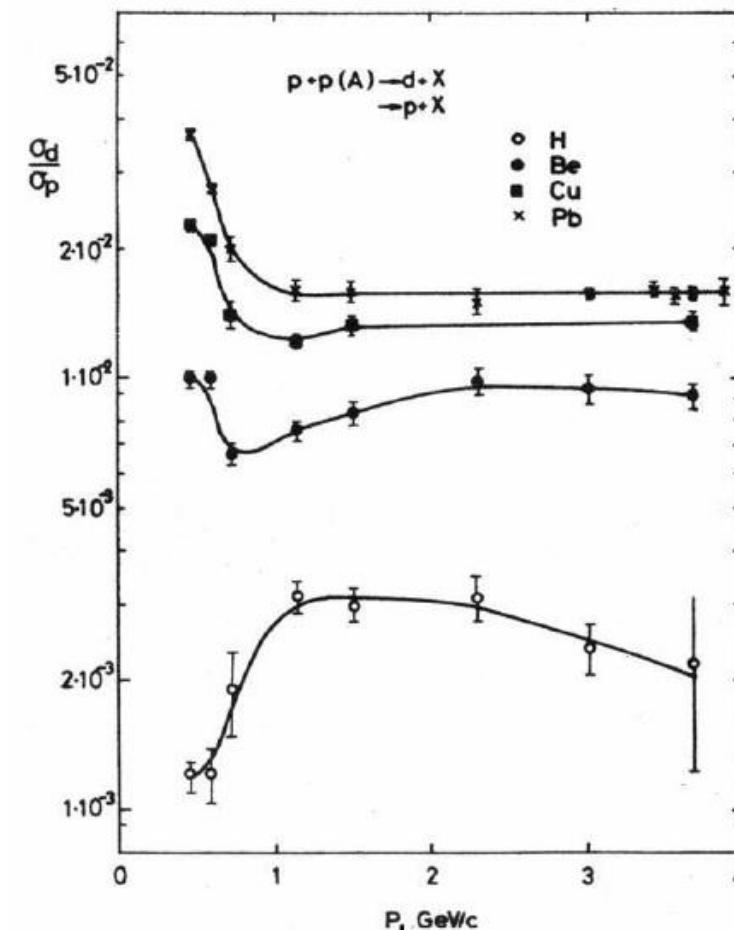
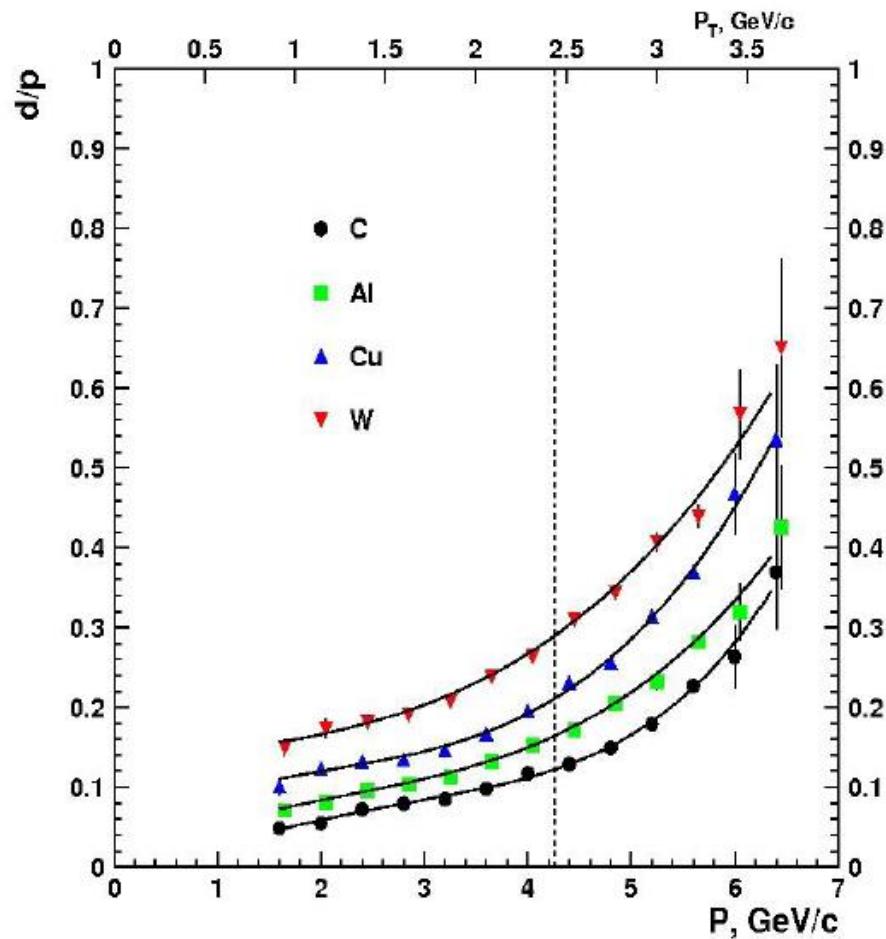
Fig. 3. Ratios R calculated for (points) experimental data and (line) values simulated by the FTFP algorithm [8]. The width of the gray band at the bottom represents the possible systematic error in the measured R values.

SPIN data

Ratio d/p

ФОДС

В.В.Абрамов и др.,
ЯФ 45(5) (1987), 845–851



Particle Production at Large Angles by 30- and 33-Bev Protons Incident on Aluminum and Beryllium*

V. L. FITCH, S. L. MEYER,[†] AND P. A. PIROUÉ
Palmer Physical Laboratory, Princeton University, Princeton, New Jersey
(Received February 12, 1962)

A mass analysis has been made of the relatively low momentum particles emitted from Al and Be targets when struck by 30- and 33-Bev protons. Measurements were made at 90°, 45°, and 13½° relative to the direction of the Brookhaven AGS proton beam. Magnetic deflection and time-of-flight technique were used to determine the mass of the particles.

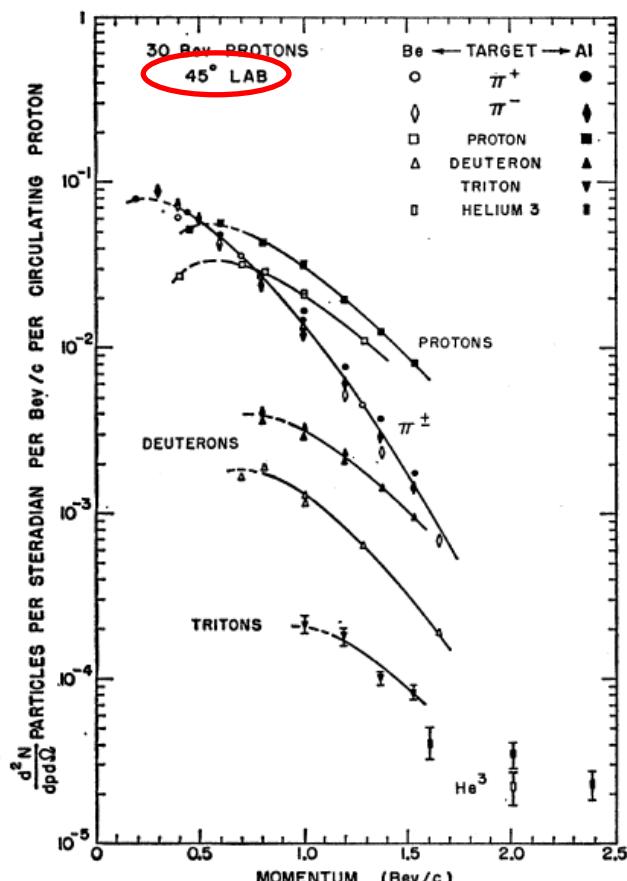


FIG. 3. Momentum spectra of particles emitted at 45° from aluminum and beryllium targets when struck by 30-Bev protons. Tritons from Be were not measured. For general remarks refer to Fig. 2 caption.

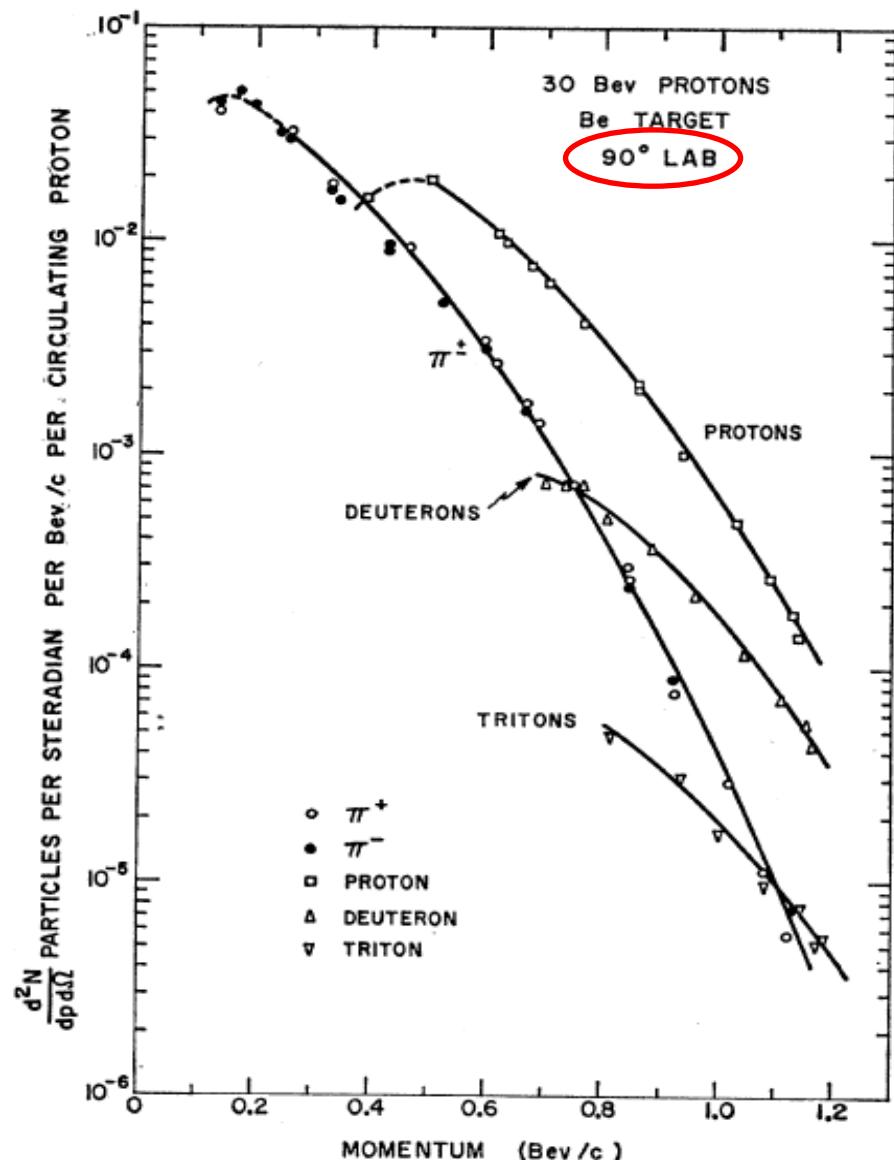
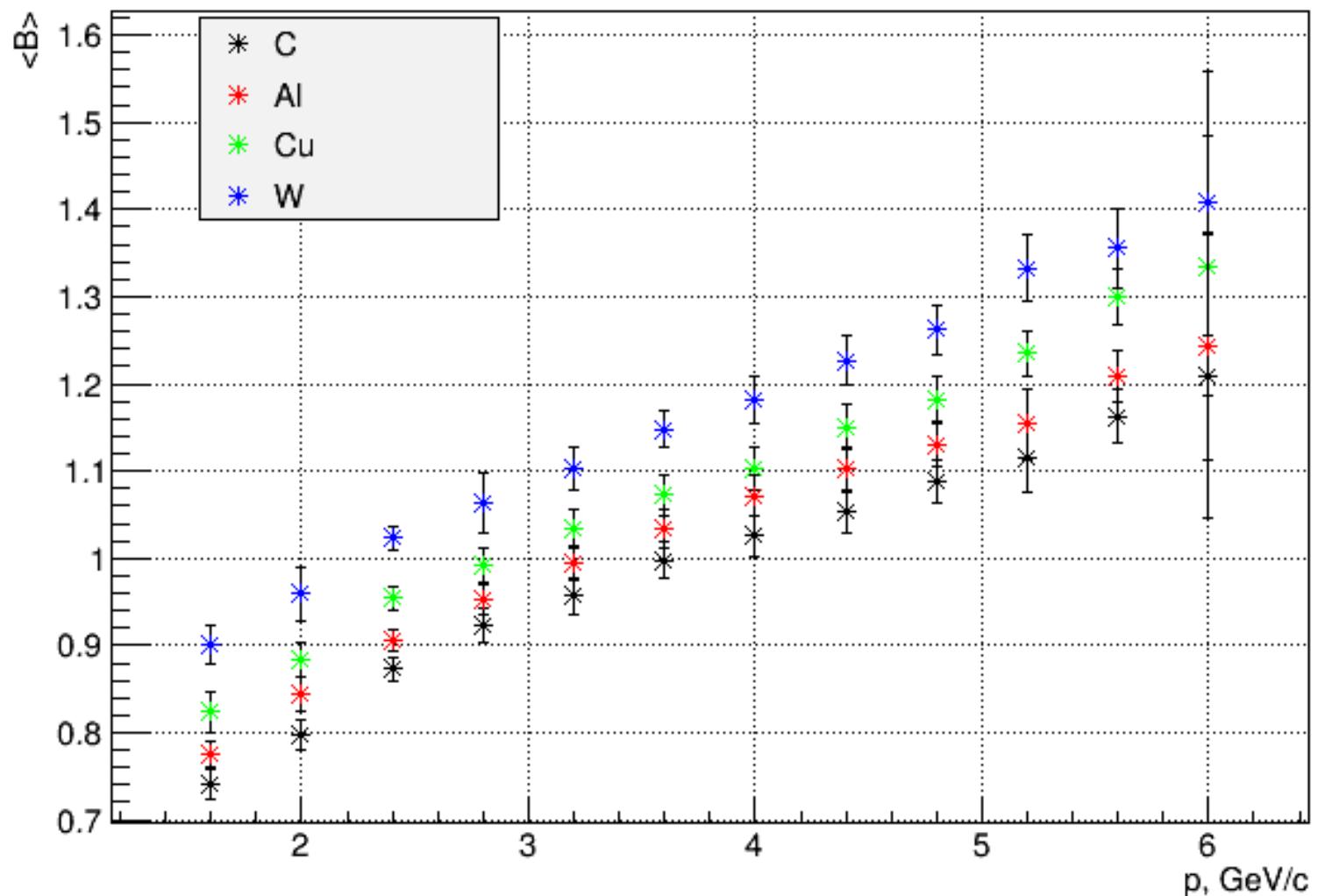


FIG. 2. Momentum spectrum of particles emitted at 90° from a beryllium target struck by 30-Bev protons. The ordinate is the number of particles produced at the target per steradian per Bev/c per circulating proton. The dashed portions of the curves indicate regions where the corrections due to multiple scattering exceed 15%. At the time these data were taken no effort was made to detect He^3 .

Average baryon number $\langle B \rangle$



Knockout of Deuterons and Tritons with Large Transverse Momenta in pA Collisions Involving 50-GeV Protons

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A. A. Semak^a, V. I. Terekhov^a, V. Ya. Uglekov^a, M. N. Ukhanov^a,
B. V. Chuiko^{a†}, and S. S. Shimanskii^b

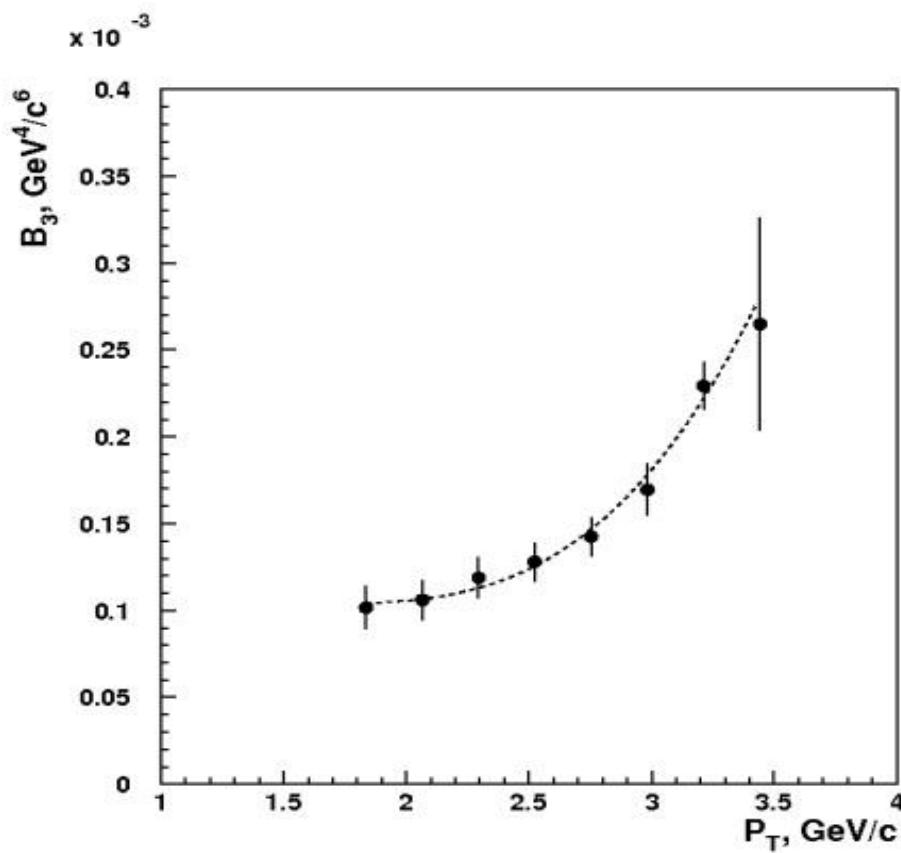
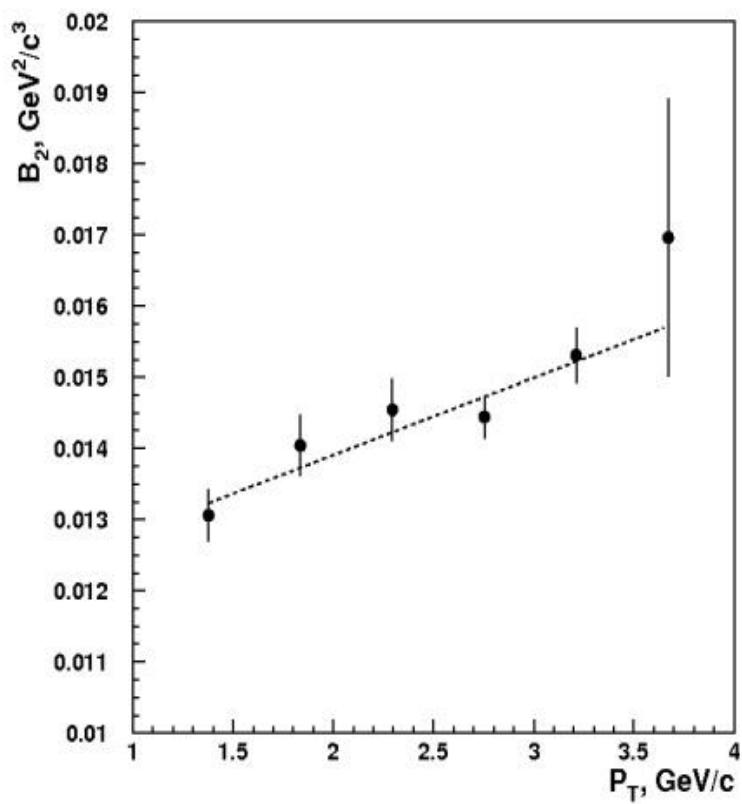
$$\frac{E_d}{\sigma_{inel}} \frac{d^s \sigma_A}{dp_A^s} = B_A \times \left(\frac{E_p}{\sigma_{inel}} \frac{d^s \sigma_p}{dp_p^s} \right)^A$$

Mean values of the B_2 parameter

Target	C	Al	Cu	W
$B_2 \times 10^2, \text{GeV}^2/c^3$	1.41 ± 0.10	1.56 ± 0.08	1.51 ± 0.07	1.41 ± 0.06

$$B_2 \sim V^{-1}$$

$$B_3 \sim V^{-2})$$



Beck(Editor), Clusters in Nuclei Volume 1,2010

p.v

A great deal of research work has been performed in the field of alpha clustering since the pioneering discovery, by D. A. Bromley and co-workers half a century ago, of molecular resonances in the excitation functions for $^{12}\text{C} + ^{12}\text{C}$ scattering. The aim of this new series of Lecture Notes in Physics entitled Clusters in Nuclei is to deepen our knowledge of this field of nuclear molecular physics whose history was so well recounted in 1995 by W. Greiner, J. Y. Park and W. Scheid in their famous book on Nuclear Molecules (World Scientific Publishing Co.).

Nuclear clustering remains, however, one of the most fruitful domains of nuclear physics, and faces some of the greatest challenges and opportunities in the years ahead.

ON THE FLUCTUATIONS OF NUCLEAR MATTER

D. I. BLOKHINTSEV

Joint Institute for Nuclear Research

Submitted to JETP editor July 1, 1957

J. Exptl. Theoret. Phys. (U.S.S.R.) 33, 1295-1299 (November, 1957)

It is shown that the production of energetic nuclear fragments in collisions with fast nucleons can be interpreted in terms of collisions of the incoming nucleon with the density fluctuations of the nuclear matter.

1. INTRODUCTION

THE motion of nucleons in nuclei can result in short-lived tight nucleon clusters, in other words, in density fluctuations of nuclear matter. Since such clusters are relatively far removed from the other nucleons of the nucleus, they become atomic nuclei of lower mass in a state of fluctuating compression.

In their study of the scattering of 675-Mev protons by light nuclei, Meshcheriakov and coworkers^{1,2} observed recently certain effects which confirm the existence of such fluctuations, at least for the simplest nucleon-pair fluctuations, which lead to the formation of a compressed deuteron.

CsDBM

1. **Cold** - exists inside ordinary nuclear matter as a quantum component of the wave function (with some probability and life time).
2. **superDense** - several nucleons can be in a volume less than the nucleon volume. The mass will be several nucleon masses. The small size means that the multinucleon(multiquark) configuration seeing as point like objects in processes with high transfer energy.
3. **Baryonic Matter** - enhancement of baryonic states and suppression of sea and gluon degrees of freedom (mesons and antiparticles production).

END

DEUTERON STATIC PROPERTIES FROM NN-POTENTIALS

Table 1: Deuteron properties in the dressed bag model.

Model	E_d (MeV)	P_D (%)	r_m (fm)	Q_d (fm 2)	μ_d (μ_N)	A_S (fm $^{-1/2}$)	$\eta(D/S)$
RSC	2.22461	6.47	1.957	0.2796	0.8429	0.8776	0.0262
Moscow 99	2.22452	5.52	1.966	0.2722	0.8483	0.8844	0.0255
Bonn 2001	2.224575	4.85	1.966	0.270	0.8521	0.8846	0.0256
DBM (1) $P_{in} = 3.66\%$	2.22454	5.22	1.9715	0.2754	0.8548	0.8864	0.0259
DBM (2) $P_{in} = 2.5\%$	2.22459	5.31	1.970	0.2768	0.8538	0.8866	0.0263
experiment	2.224575		1.971	0.2859	0.8574	0.8846	0.0263

**Problem to built SPIN from the constituents
- for deuteron too!**

ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна



P1 - 5819

А.М. Балдин, Н. Гиордзеску, В.Н. Зубарев,
А.Д. Кириллов, В.А. Кузнецов, Н.С. Мороз,
В.Б. Радоманов, В.Н. Рамжин, В.А. Свиридов,
В.С. Ставинский, М.И. Янута

НАБЛЮДЕНИЕ ПИОНОВ
ВЫСОКОЙ ЭНЕРГИИ
ПРИ СТОЛКНОВЕНИИ РЕЛЯТИВИСТИЧЕСКИХ
ДЕЙТОНОВ С ЯДРАМИ

1971

КАВАРИИЧНЫ ВЫСОКИХ ЭНЕРГИЙ

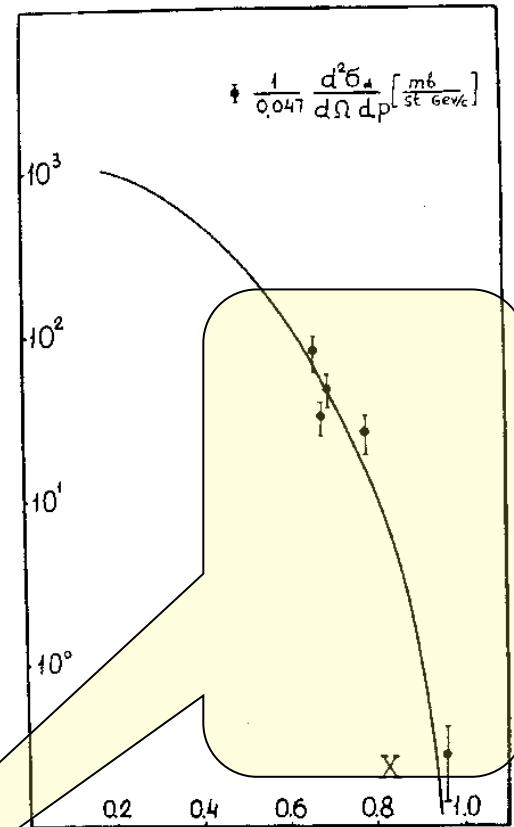
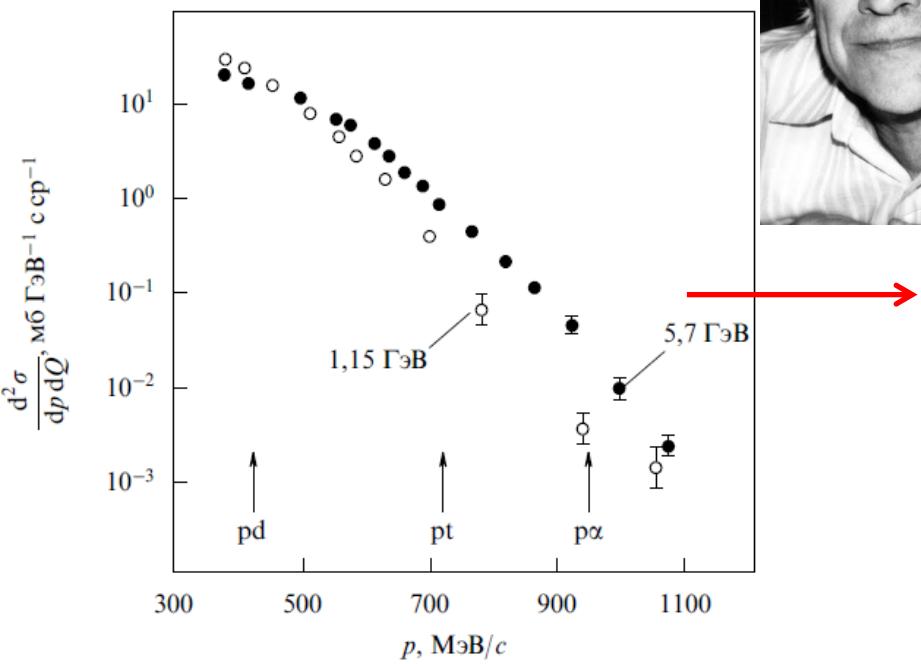
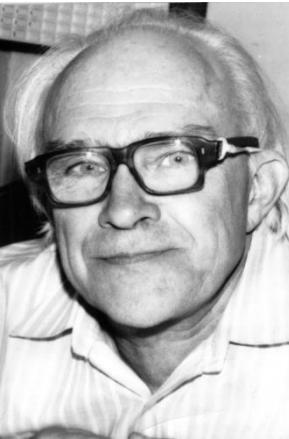


Рис. 3. Сравнение экспериментальных данных по сечению рождения пионов дейtronами с теоретической функцией, описывающей сечение рождения пионов протонами.



ITEP data for proton spectra (G.A.Leksin et al.)



На рисунках приведены спектры протонов, измеренные на ускорителе ИТЭФ под углом 137° в реакции $p+C \rightarrow p+X$ [2]. Стрелки показывают положения ожидавшихся квазиупругих максимумов для рассеяния на многонуклонных кластерах типа d, t, He . Присутствие в спектре частиц, за пределами ограничений кинематики $p p$ взаимодействия ясно видно. Это были первые измеренные спектры протонов в кумулятивной области при начальных энергиях несколько ГэВ.

Баюков и др., Изв. АН СССР т.30, 1966, с.521

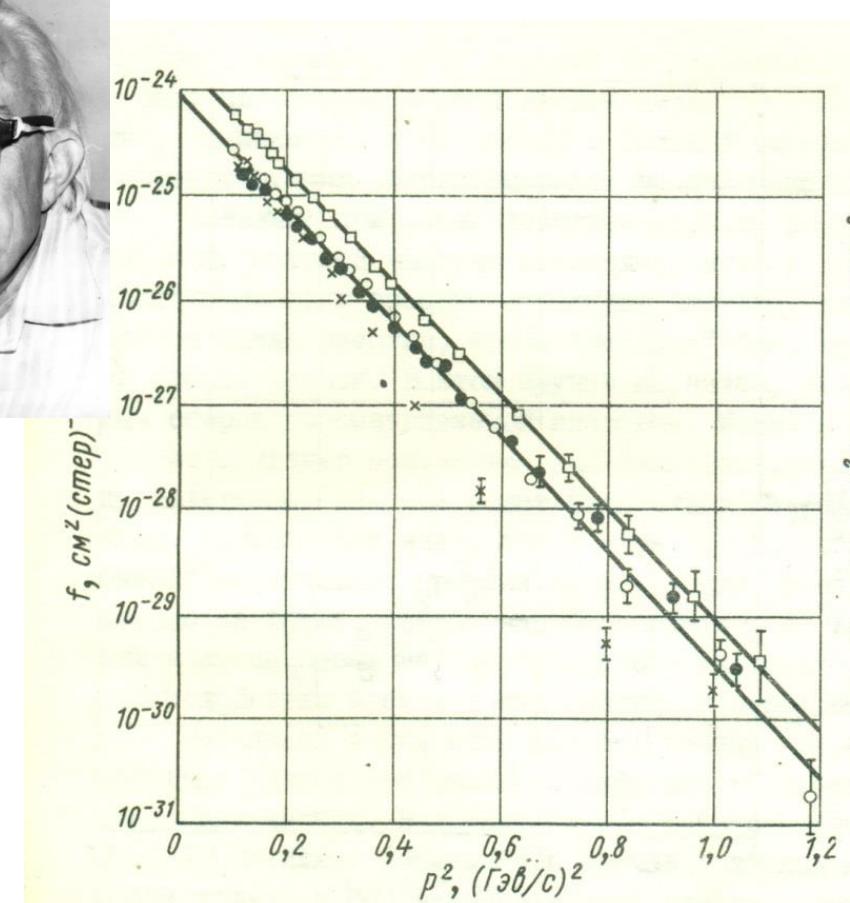


Рис. 6. Зависимость инвариантной функции от квадрата импульса вторичного протона, вылетающего из меди, облученной протонами с энергией 3,66 ГэВ \square ; из углерода, облученного протонами с энергией 1,15 ГэВ $*$; 3,66 ГэВ \diamond и 5,7 ГэВ \bullet

ЯФ т.18, с.1246, 1973

Energy Dependence of Nuclear Transparency in C($p, 2p$) Scattering

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The transparency of carbon for ($p, 2p$) quasielastic events was measured at beam momenta ranging from 5.9 to 14.5 GeV/c at 90° c.m. The four-momentum transfer squared (Q^2) ranged from 4.7 to 12.7 (GeV/c)². We present the observed beam momentum dependence of the ratio of the carbon to hydrogen cross sections. We also apply a model for the nuclear momentum distribution of carbon to obtain the nuclear transparency. We find a sharp rise in transparency as the beam momentum is increased to 9 GeV/c and a reduction to approximately the Glauber level at higher energies.

$$T_{\text{CH}} = T \int d\alpha \int d^2 \vec{P}_{FT} n(\alpha, \vec{P}_{FT}) \frac{\left(\frac{d\sigma}{dt}\right)_{pp}(s(\alpha))}{\left(\frac{d\sigma}{dt}\right)_{pp}(s_0)}$$

$$\alpha \equiv A \frac{(E_F - P_{Fz})}{M_A} \simeq 1 - \frac{P_{Fz}}{m_p}$$

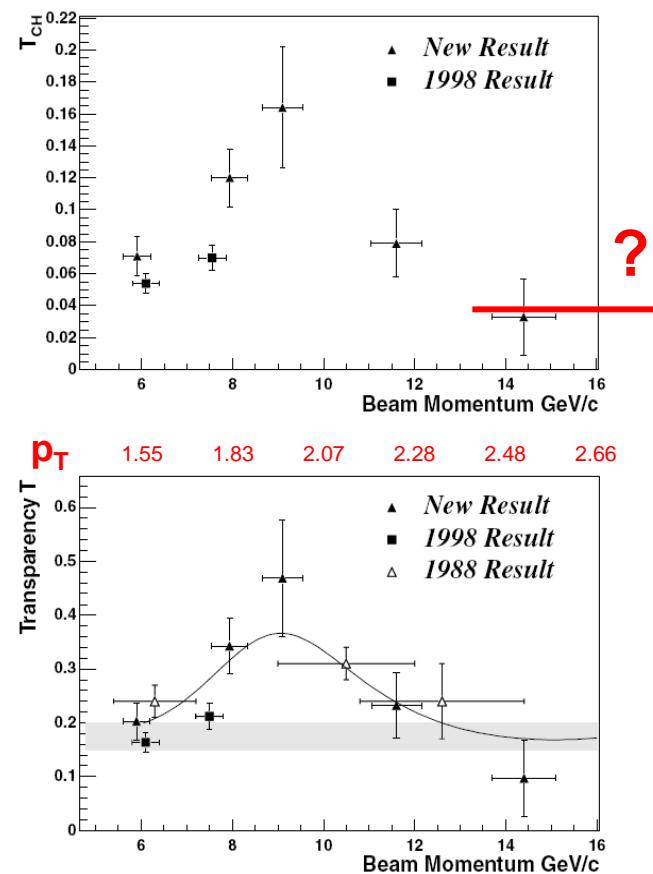
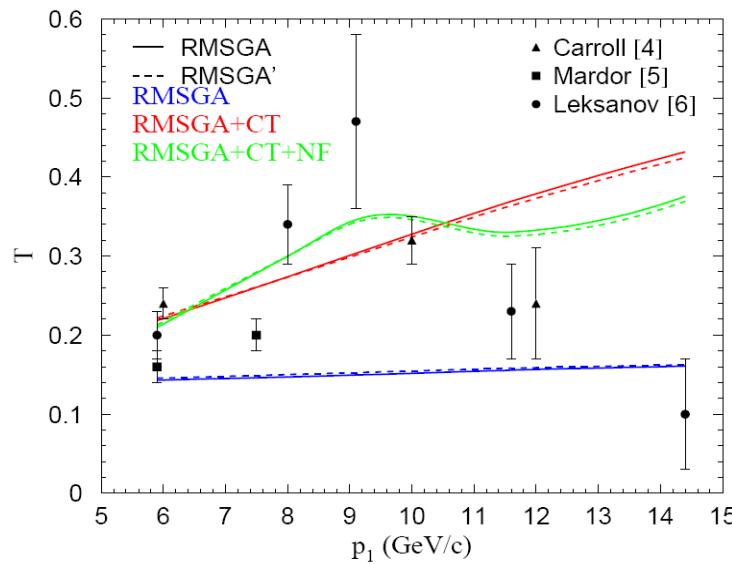


FIG. 2. Top: The transparency ratio T_{CH} as a function of the beam momentum for both the present result and two points from the 1998 publication [3]. Bottom: The transparency T versus beam momentum. The vertical errors shown here are all statistical errors, which dominate for these measurements. The horizontal errors reflect the α bin used. The shaded band represents the Glauber calculation for carbon [9]. The solid curve shows the shape R^{-1} as defined in the text. The 1998 data cover the c.m. angular region from 86°–90°. For the new data, a similar angular region is covered as is discussed in the text. The 1988 data cover 81°–90° c.m.

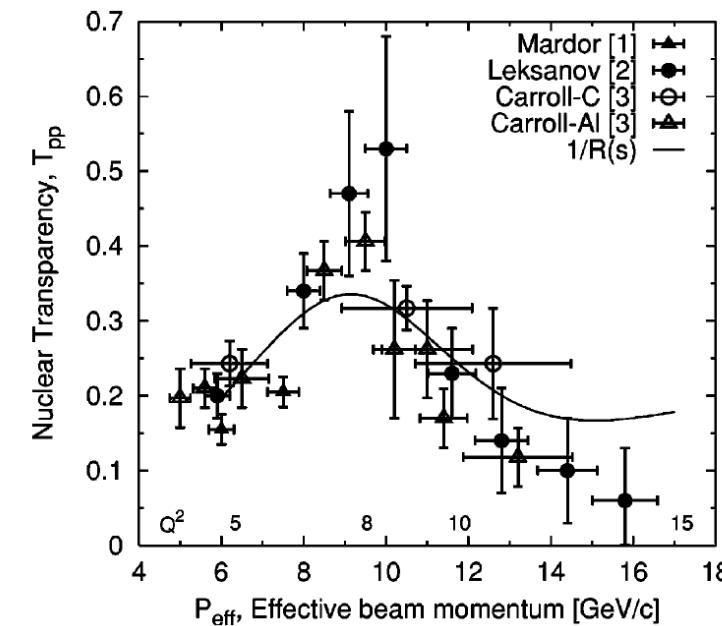
Energy Dependence of Nuclear Transparency in $C(p,2p)$ Scattering

A. Leksanov,⁵ J. Alster,¹ G. Asryan,^{3,2} Y. Averichev,⁸ D. Barton,³ V. Baturin,^{5,4} N. Bukhtoyarova,^{3,4} A. Carroll,³
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 H. Yoshida,⁶ and D. Zhalov⁵

B.Van Overmeire, J.Ryckebusch, nucl-th/0608040



J. Aclander et al., Phys.Rev. C 70, 015208 (2004)



A.V. Efremov (1976) Parton description



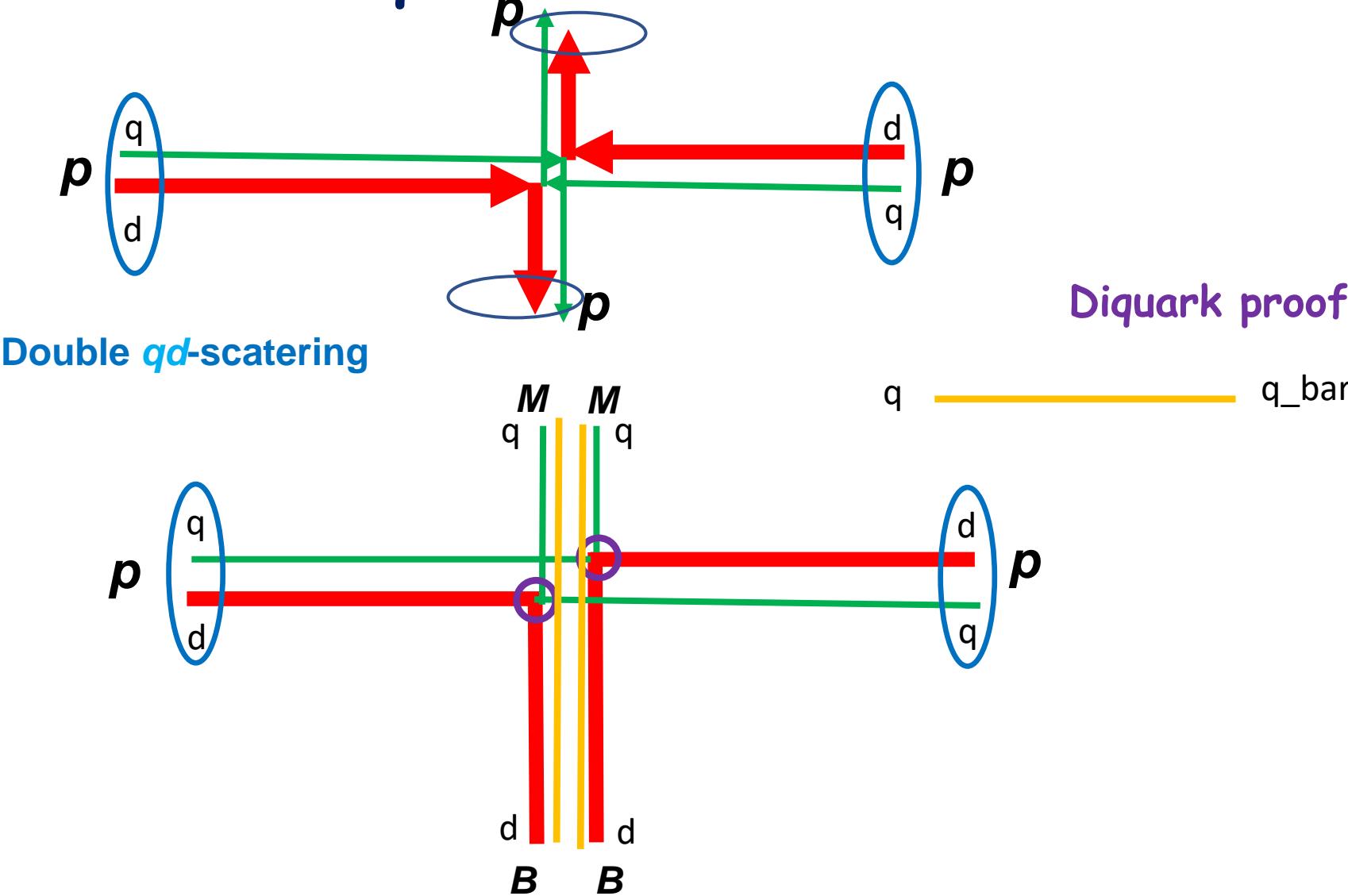
$$\varepsilon \frac{d^3\sigma}{d^3p} = \int dx dy dz F_B(y) F_A(x) G_C(z) v(xys, t \frac{x}{z}, u \frac{y}{z})$$

x_{II} x_I



Kim's mechanisms in exclusive reactions

$pp \rightarrow pp + X, pp \rightarrow D(H, N\Lambda...) + X$
reactions with diquarks



Review

Color transparency: Past, present and future

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ABSTRACT

We review a unique prediction of Quantum Chromo Dynamics, called color transparency (CT), where the final (and/or initial) state interactions of hadrons with the nuclear medium must vanish for exclusive processes at high momentum transfers. We retrace the progress of our understanding of this phenomenon, which began with the discovery of the J/ψ meson, followed by the discovery of high energy CT phenomena, the recent developments in the investigation of the onset of CT at intermediate energies and the directions for future studies.

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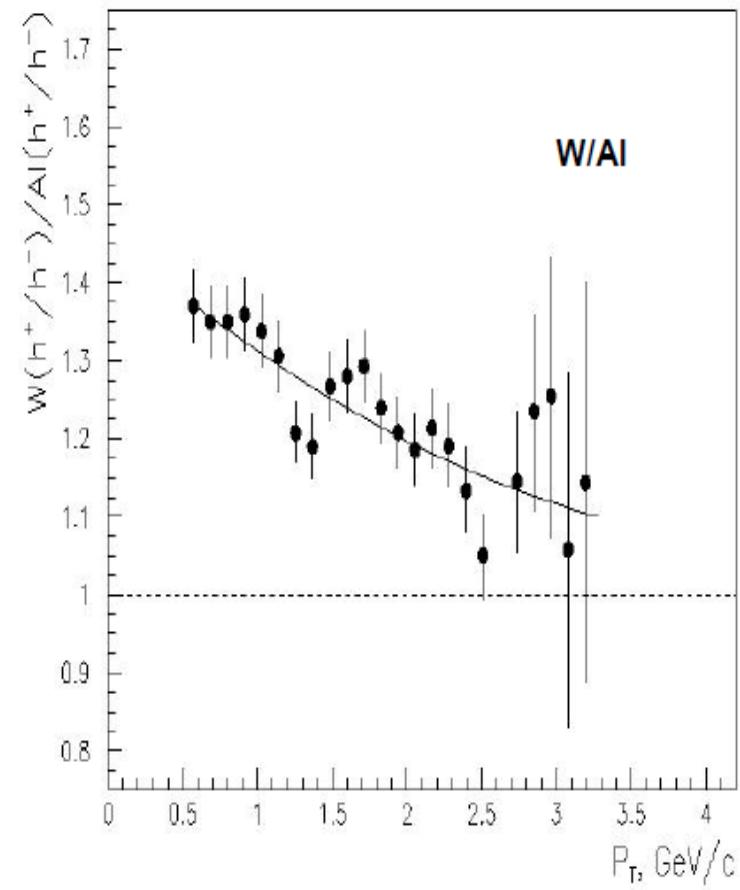
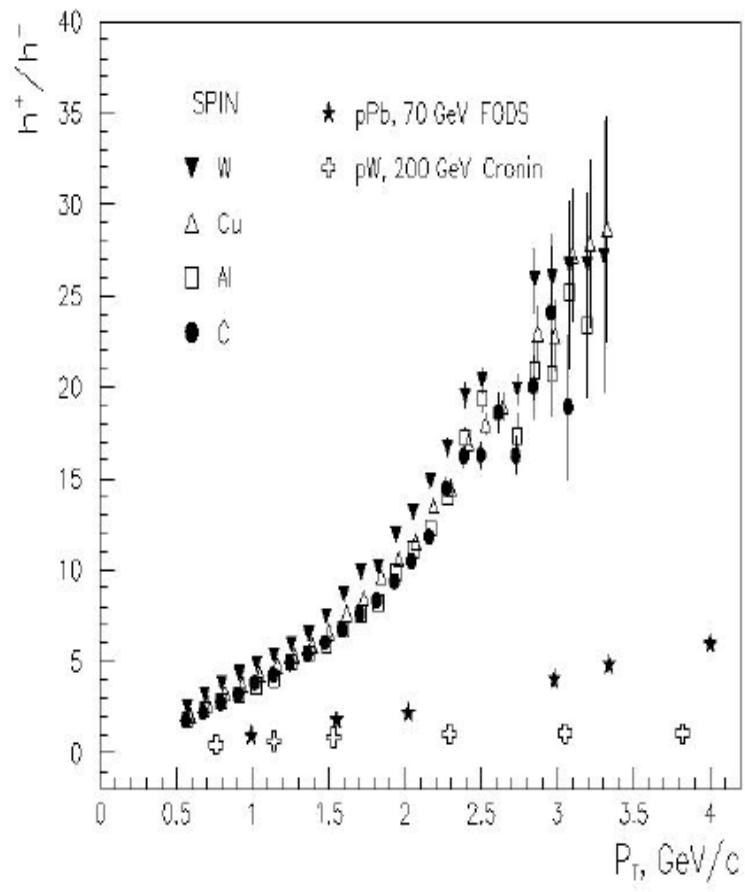
Distortions of the Spectra of Cumulative Mesons by Multiscattering in Nuclei

V. F. Peresedov and L. S. Zolin

Abstract

The quantitative estimates of multiscattering distortions of momentum spectra for cumulative pions and kaons in $p + A \rightarrow \pi(K^\pm) + X$ reaction at angles close to 180° are reported. The calculations for C, Al, Mo, W nuclei were made by using Monte Carlo simulation on the basis of the intranuclear cascade model. The fluctuon model of cumulative particles generation was used to give initial momentum and angular distributions of mesons. Multiscattering on the intranuclear nucleons causes the difference between the initial and observed (distorted by FSI-final state interactions in nuclei) meson spectra, which increases with increasing of atomic number. Due to the rescattering and absorption of pions and kaons by intranuclear nucleons their absolute yields decrease by about 2–5 times in the momentum range $p = 0.3\text{--}1 \text{ GeV}/c$ for medium and heavy nuclei. The relative distortions of the slope parameters of the momentum spectra are 3–10%. The correction of cross sections with account of FSI leads to the amplification of A -dependences for π , K^\pm and to their bringing together. Taking into account FSI is also important when the ratios of particles yield of different types are considered. The K^+/K^- -ratio corrections can reach a factor of about 3. Obtained values of distortions effects for cumulative reactions demonstrate evidently the necessity to account of FSI for data obtained in experiments with nuclei at momenta of reaction products $< 1\text{--}2 \text{ GeV}/c$.

Ratios



Ratio p/π^+ (2015)

