“Multiquark configurations in baryons and nuclei“

Stepan Shimanskiy (JINR)

PLAN

1. SPD at NICA

2. DIQURKS

3. MULTIQURKS

SPD at NICA

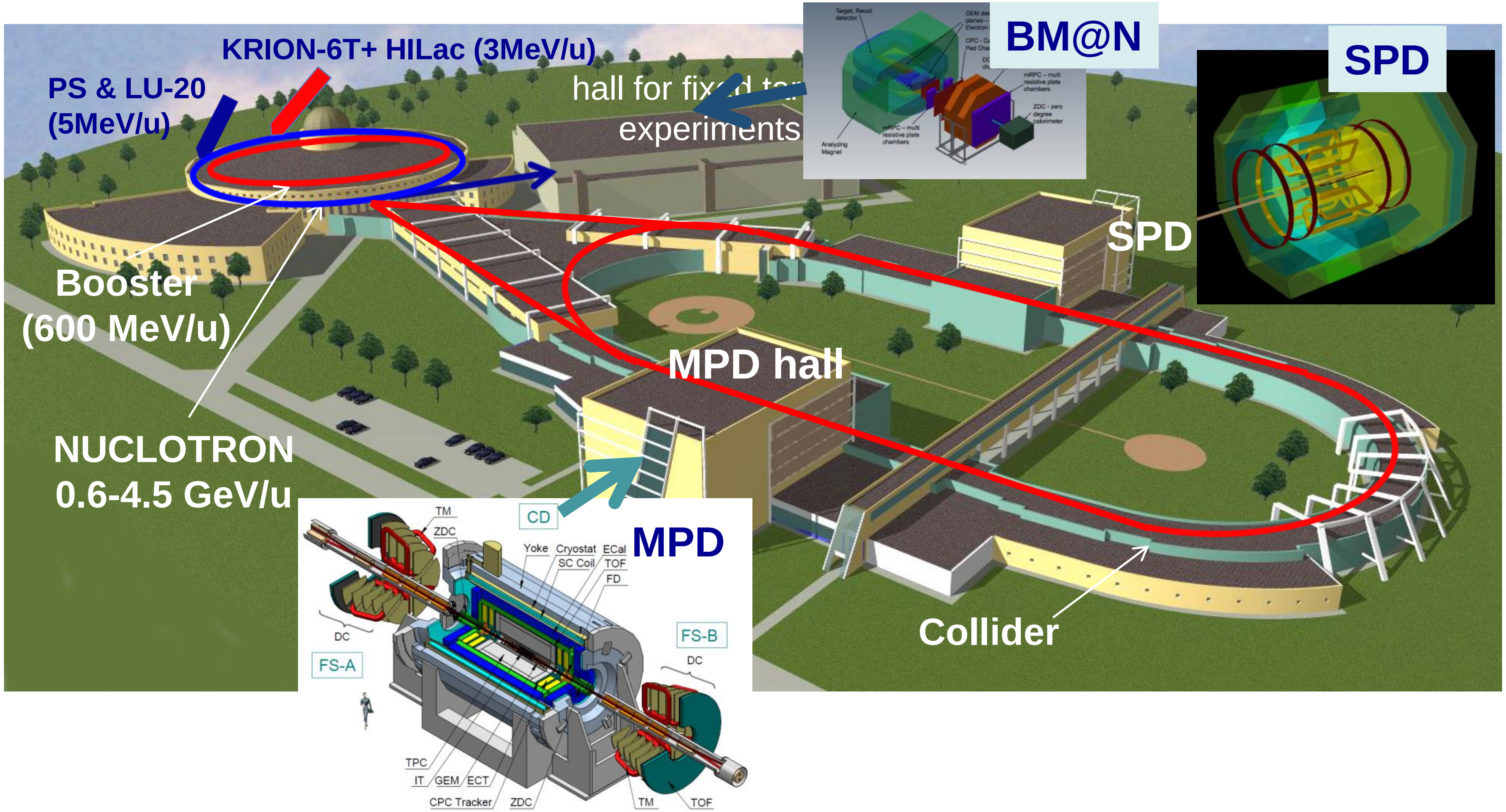
“New directions in science are launched by new tools much more often than by new concepts.
The effect of a concept-driven revolution is to explain old things in new ways.
The effect of a tool-driven revolution is to discover new things that have to be explained”

From Freeman Dyson ‘Imagined Worlds’

The NICA complex

existing facilities

to be constructed



KRION-6T+ HILac (3MeV/u)

PS & LU-20 (5MeV/u)

hall for fixed target experiments

BM@N

SPD

SPD

Booster (600 MeV/u)

MPD hall

NUCLOTRON 0.6-4.5 GeV/u

MPD

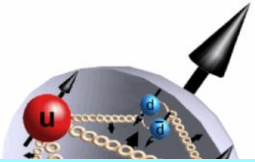
Collider

Civil Construction, bld.17

September 2018

readiness for equipment installation in the MPD Hall - 2019

Spin Physics Detector (SPD)

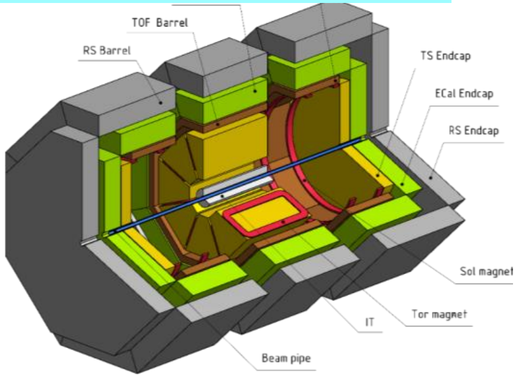


Physics tasks

Timeline

❖ open a project for the **SPD design:**	Jan. 2019
❖ preparation of **CDR:**	2019
❖ preparation of **TDR** (+ prototyping); stage I:	2020 – 2022
stage II:	2023
❖ construction of the detector:	2022 – 2025
❖ first measurements:	2025

- *spin effects in production of hadrons with high p_T*

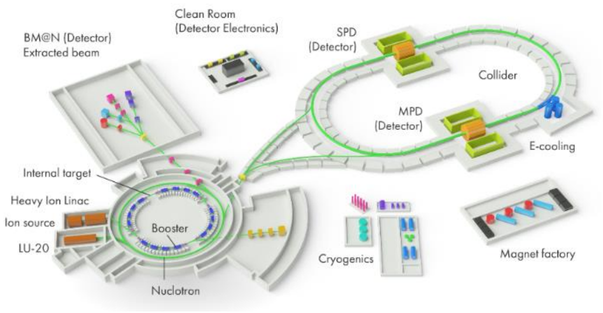


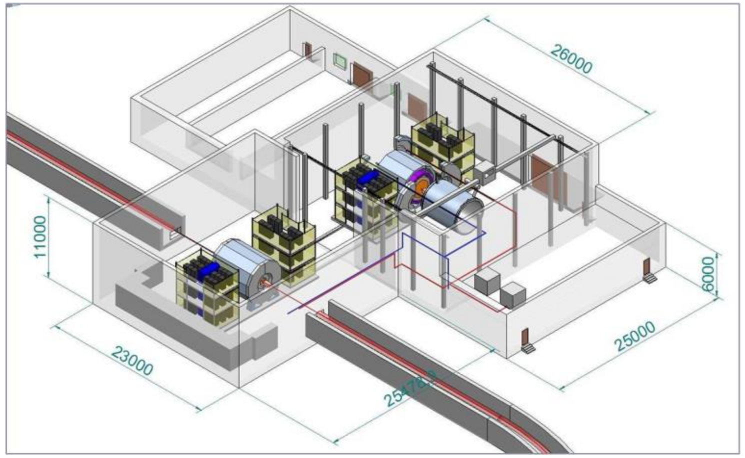
Polarized beams

- **p↑p↑** at $\sqrt{s_{pp}}$ **= 12 - 27 GeV,** $L_{av} \approx 10^{32}\ cm^{-2}s^{-1}$
- **d↑d↑** at $\sqrt{s_{NN}}$ **= 4 - 13 GeV**
- *longitudinal and transverse polarization in SPD and MPD*

SPD/NICA will provide a unique opportunity ***not available at other facilities***
to study all **the eight nucleon PDF** in one experiment
and obtain comprehensive information on the nucleon spin structure
at high statistical level and with minimal systematic uncertainties.

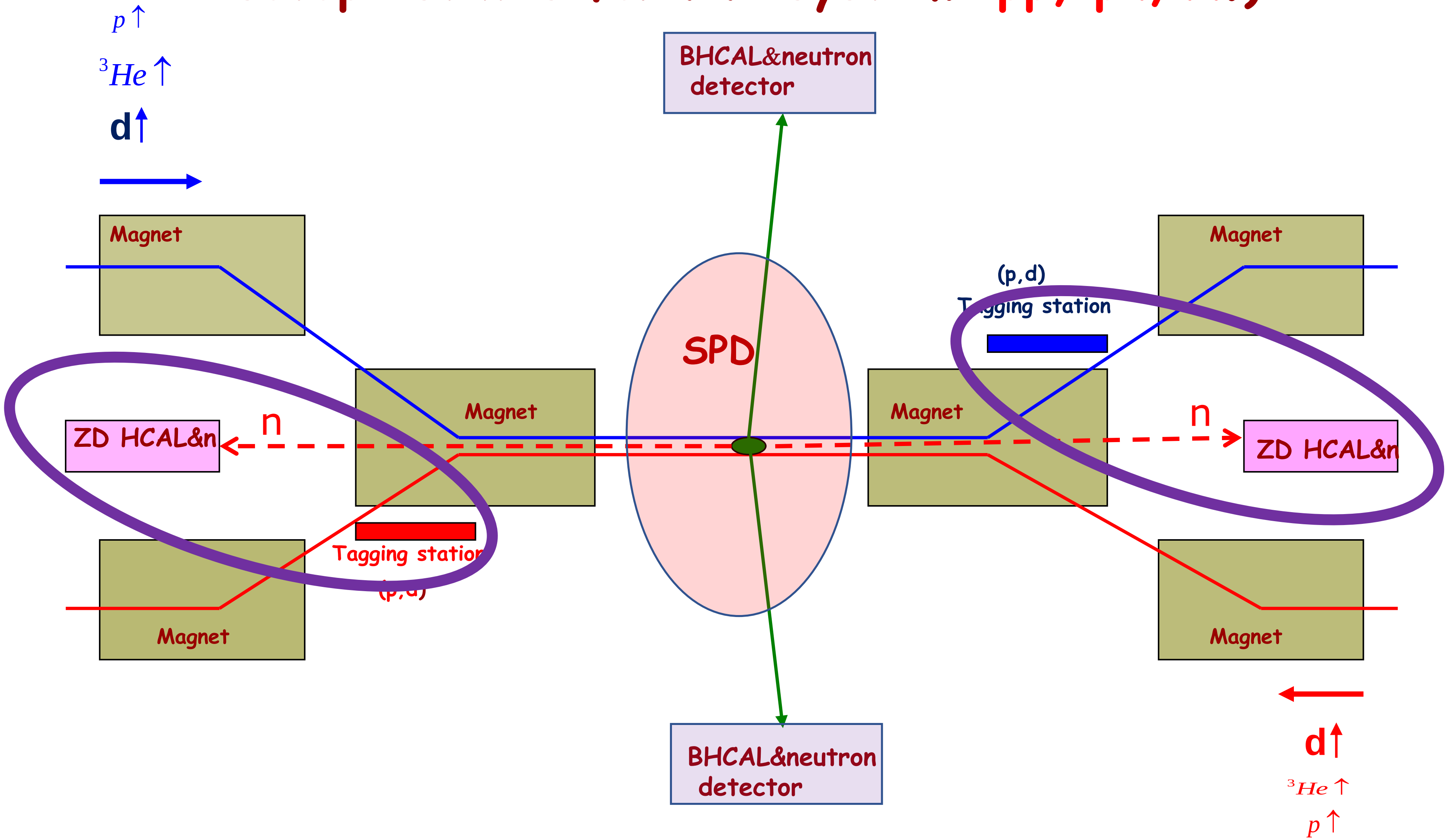
Requirements for the SPD





- close to 4π geometrical acceptance;
- high-precision (~50 μm) and fast vertex detector;
- high-precision (~100 μm) and fast tracker,
- good particle ID capabilities;
- efficient muon range system,
- good electromagnetic calorimeter,
- low material budget over the track paths,
- trigger and DAQ system able to cope with event rates at luminosity of 10^{32} $(cm.s)^{-1}$,
- modularity and easy access to the detector elements, that makes possible further reconfiguration and upgrade of the facility.

NICA Collision place for SPIN physics (deuteron and other beams, the first time all isotope states for NN system: pp, pn,nn.)

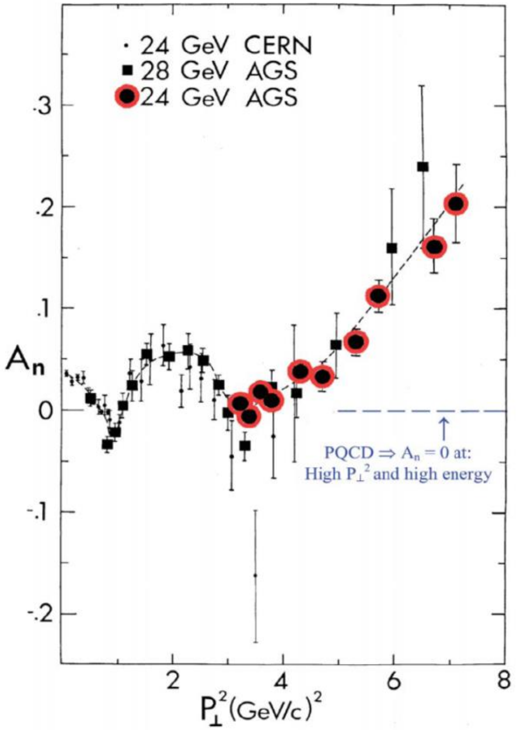


The tagging stations can be used as polarimeter!

HIGH p_T ISSUES at SPD

1. Diquark properties.
2. The Confinement laws.
3. Nature of the spin effects.
4. The Deuteron spin structure.
5. FSI (with s,c-quarks participation).
6. Nature of CsDBM.
7. np dilepton production anomaly.
8. Exotic states.
9. Subthreshold J/Ψ production.

…



AGS 1985-1990 A_n

PERTURBATIVE QCD ⇒

$A_n = 0$ at HIGH $P_\perp^2$ and HIGH ENERGY

$A_n \neq 0$ ⇒

PROBLEM with PQCD?

NO MODEL can EXPLAIN ALL

HIGH-$P_\perp^2$ SPIN EFFECTS (A_n & A_{nn})

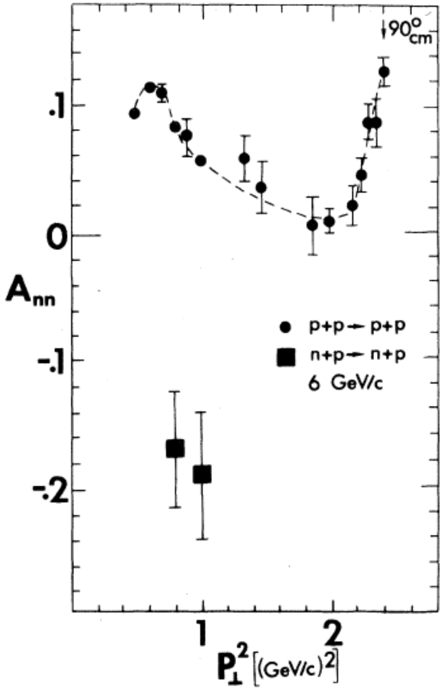
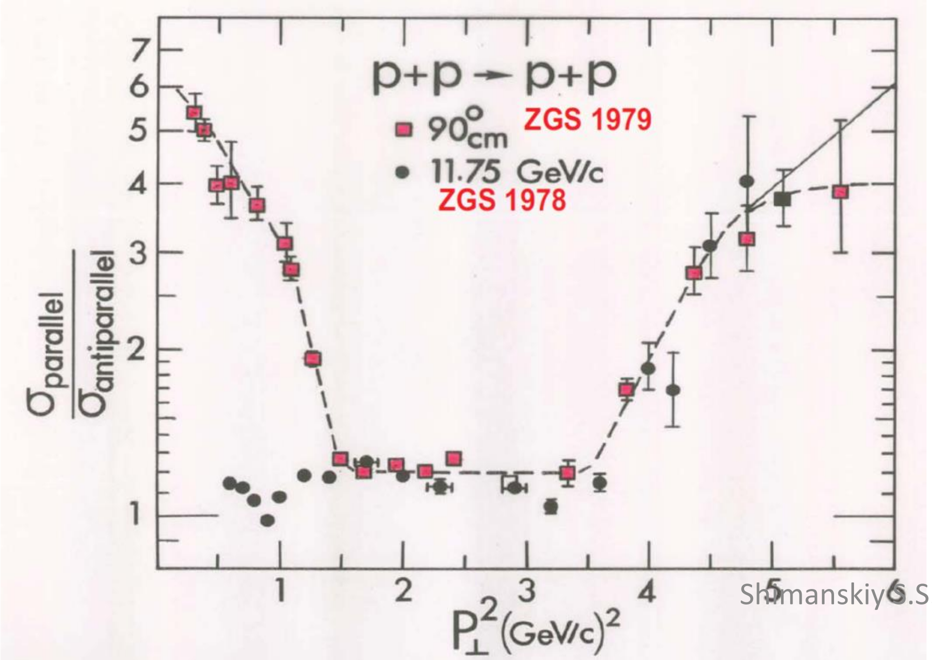
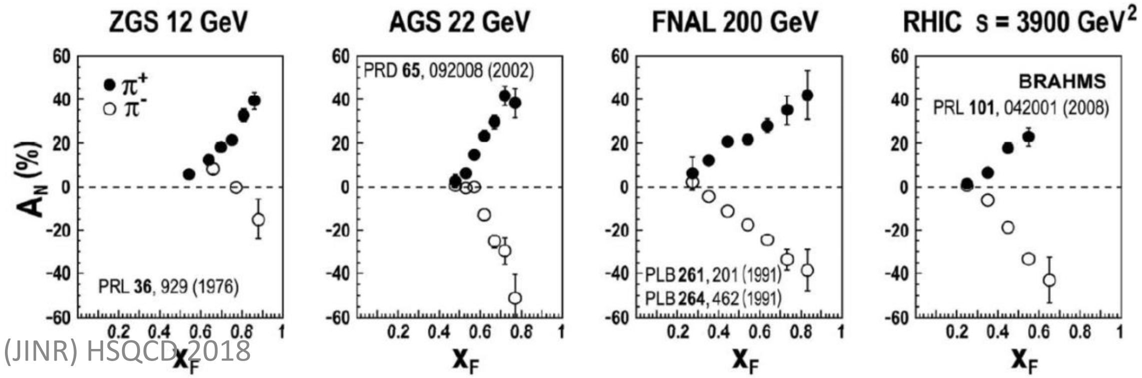


FIG. 2. The spin-spin correlation parameter, A_{nn}, for pure-initial-spin-state nucleon-nucleon elastic scattering at 6 GeV/c is plotted against the square of the transverse momentum. The proton-proton and neutron-proton data are quite different.

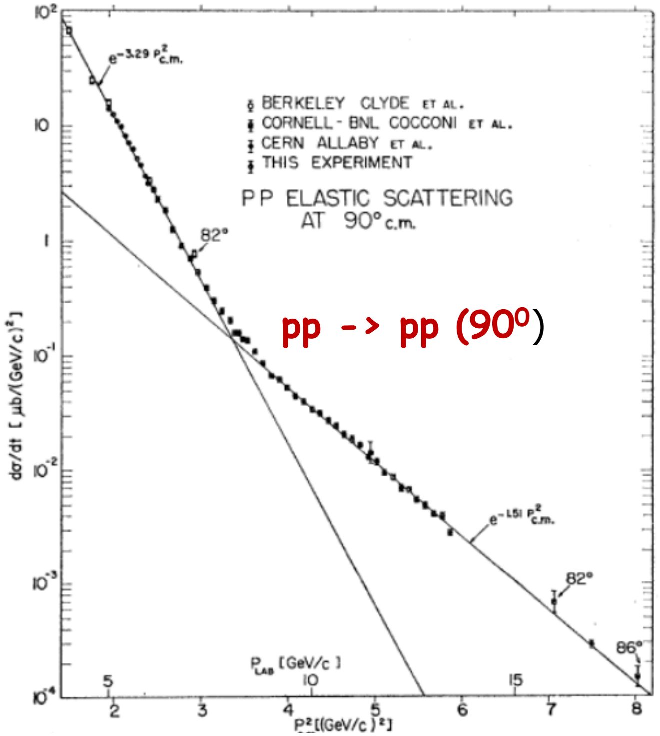


INCLUSIVE PION ASYMMETRY IN PROTON-PROTON COLLISIONS

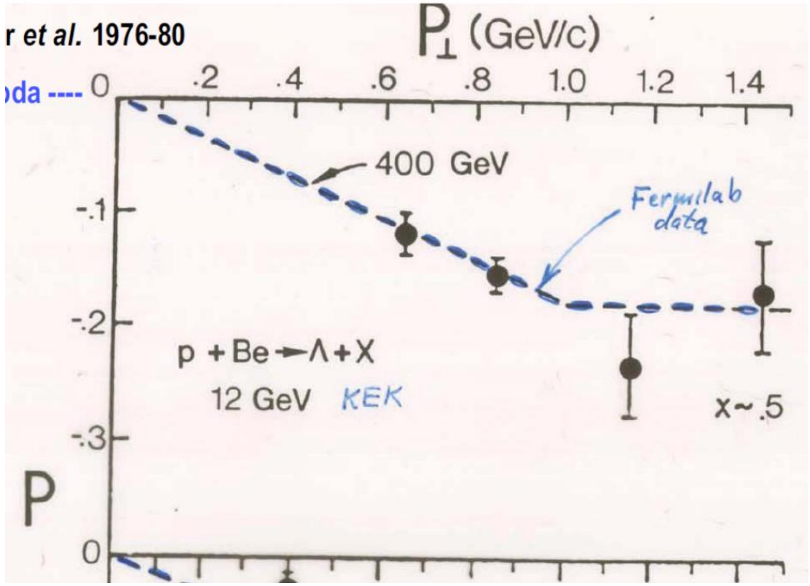
C. Aidala SPIN 2008 Proceeding and CERN Courier June 2009

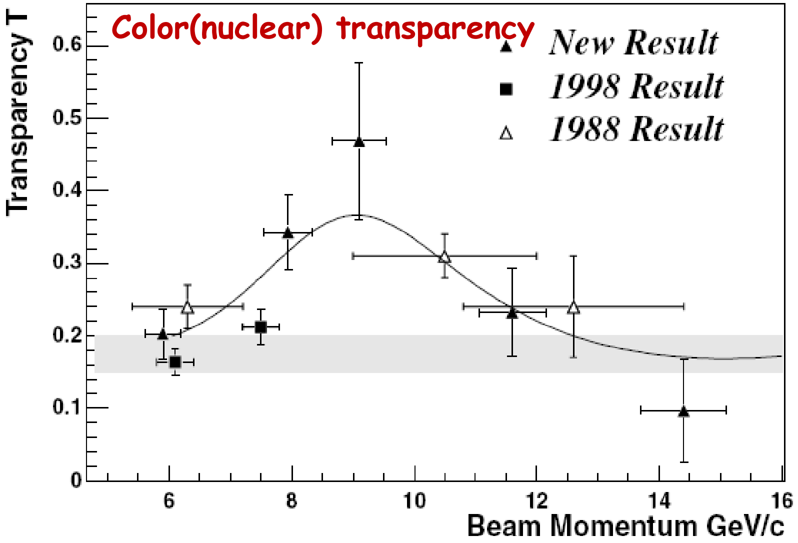


Nonpolarized beams

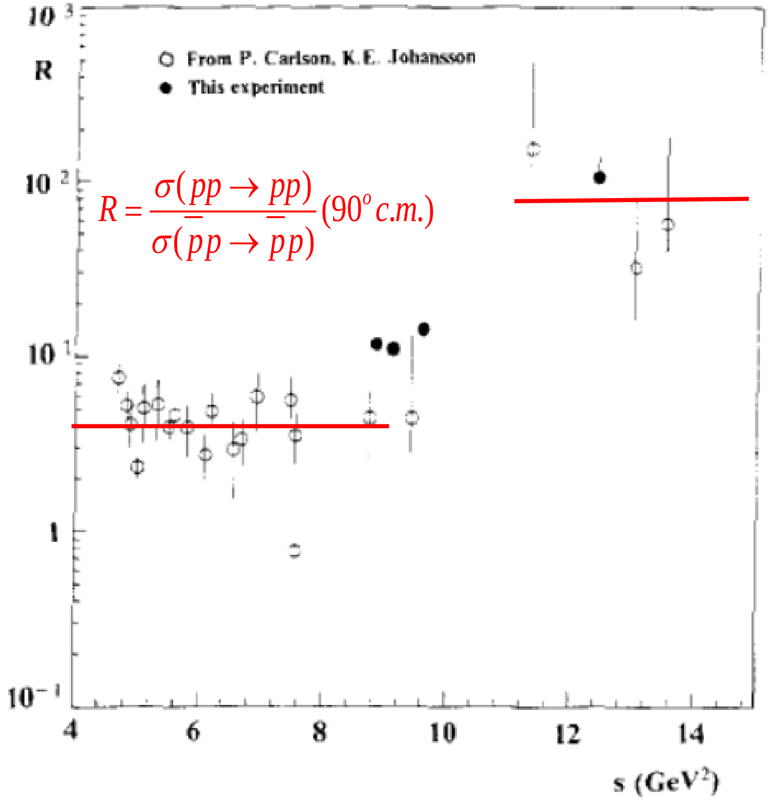


pp -> pp (90^0)





Color(nuclear) transparency



$$R = \frac{\sigma(pp \to pp)}{\sigma(\bar{p}p \to \bar{p}p)} (90^o\, c.m.)$$

DIQURKS

Multiquark states have been discussed since the 1st page of the quark model

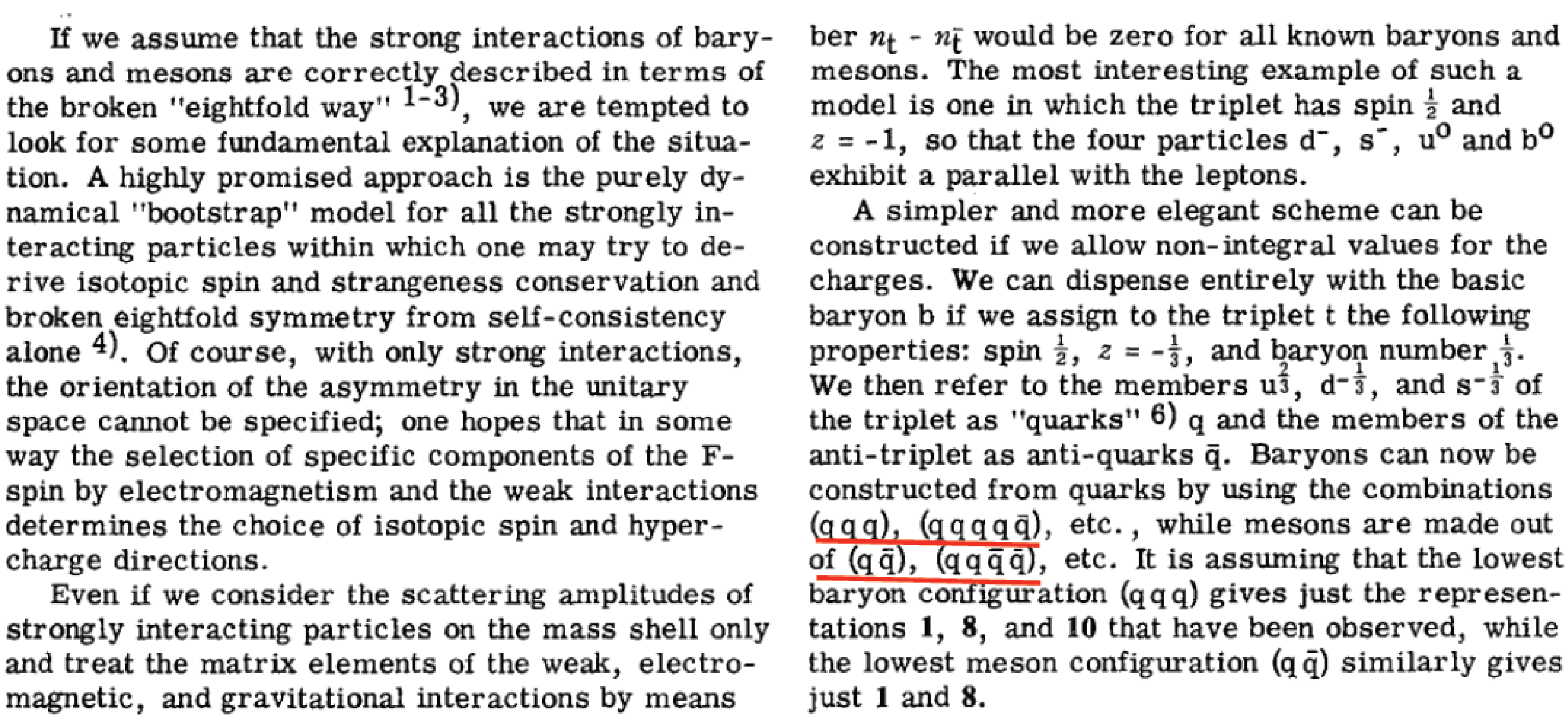
STATIC

Volume 8, number 3 PHYSICS LETTERS 1 February 1964

A SCHEMATIC MODEL OF BARYONS AND MESONS *

M. GELL-MANN
California Institute of Technology, Pasadena, California

Received 4 January 1964



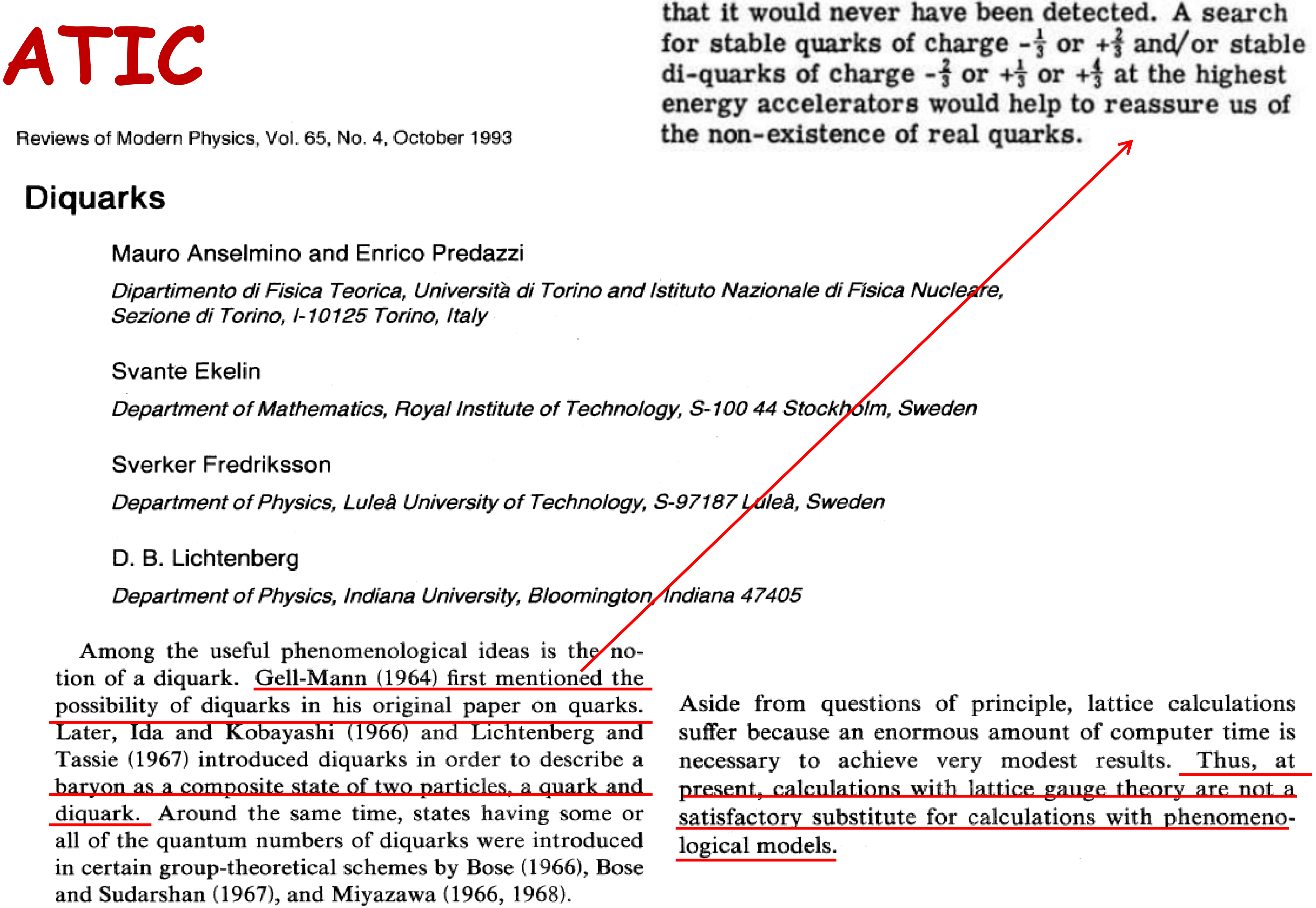
If we assume that the strong interactions of baryons and mesons are correctly described in terms of the broken "eightfold way" 1-3), we are tempted to look for some fundamental explanation of the situation. A highly promised approach is the purely dynamical "bootstrap" model for all the strongly interacting particles within which one may try to derive isotopic spin and strangeness conservation and broken eightfold symmetry from self-consistency alone 4). Of course, with only strong interactions, the orientation of the asymmetry in the unitary space cannot be specified; one hopes that in some way the selection of specific components of the F-spin by electromagnetism and the weak interactions determines the choice of isotopic spin and hypercharge directions.

Even if we consider the scattering amplitudes of strongly interacting particles on the mass shell only and treat the matrix elements of the weak, electromagnetic, and gravitational interactions by means

ber $n_t - n_{\bar{t}}$ would be zero for all known baryons and mesons. The most interesting example of such a model is one in which the triplet has spin $\frac{1}{2}$ and $z = -1$, so that the four particles d^-, s^-, u^0 and b^0 exhibit a parallel with the leptons.

A simpler and more elegant scheme can be constructed if we allow non-integral values for the charges. We can dispense entirely with the basic baryon b if we assign to the triplet t the following properties: spin $\frac{1}{2}$, $z = -\frac{1}{3}$, and baryon number $\frac{1}{3}$. We then refer to the members $u^{\frac{2}{3}}$, $d^{-\frac{1}{3}}$, and $s^{-\frac{1}{3}}$ of the triplet as "quarks" 6) q and the members of the anti-triplet as anti-quarks $\bar{q}$. Baryons can now be constructed from quarks by using the combinations (qqq), $(qqqq\bar{q})$, etc., while mesons are made out of $(q\bar{q})$, $(qq\bar{q}\bar{q})$, etc. It is assuming that the lowest baryon configuration (qqq) gives just the representations **1**, **8**, and **10** that have been observed, while the lowest meson configuration $(q\bar{q})$ similarly gives just **1** and **8**.

STATIC



that it would never have been detected. A search for stable quarks of charge $-\frac{1}{3}$ or $+\frac{2}{3}$ and/or stable di-quarks of charge $-\frac{2}{3}$ or $+\frac{1}{3}$ or $+\frac{4}{3}$ at the highest energy accelerators would help to reassure us of the non-existence of real quarks.

Reviews of Modern Physics, Vol. 65, No. 4, October 1993

Diquarks

Mauro Anselmino and Enrico Predazzi

Dipartimento di Fisica Teorica, Università di Torino and Istituto Nazionale di Fisica Nucleare, Sezione di Torino, I-10125 Torino, Italy

Svante Ekelin

Department of Mathematics, Royal Institute of Technology, S-100 44 Stockholm, Sweden

Sverker Fredriksson

Department of Physics, Luleå University of Technology, S-97187 Luleå, Sweden

D. B. Lichtenberg

Department of Physics, Indiana University, Bloomington, Indiana 47405

Among the useful phenomenological ideas is the notion of a diquark. Gell-Mann (1964) first mentioned the possibility of diquarks in his original paper on quarks. Later, Ida and Kobayashi (1966) and Lichtenberg and Tassie (1967) introduced diquarks in order to describe a baryon as a composite state of two particles, a quark and diquark. Around the same time, states having some or all of the quantum numbers of diquarks were introduced in certain group-theoretical schemes by Bose (1966), Bose and Sudarshan (1967), and Miyazawa (1966, 1968).

Aside from questions of principle, lattice calculations suffer because an enormous amount of computer time is necessary to achieve very modest results. Thus, at present, calculations with lattice gauge theory are not a satisfactory substitute for calculations with phenomenological models.

STATIC

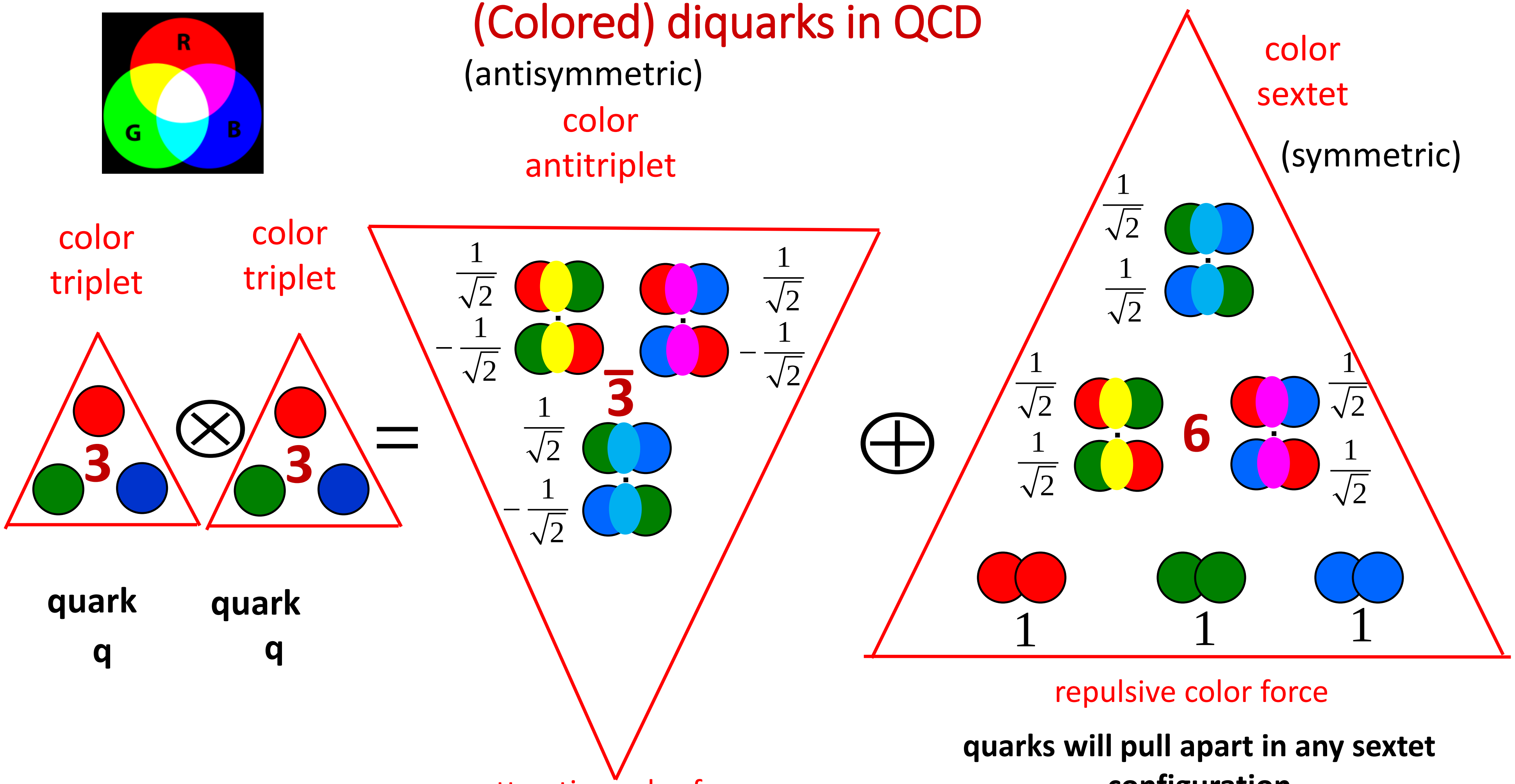
18.09.2018 ISHEPP XXIV 2018

Tomasz Skwarnicki (Syracuse, USA)

Exotic hadrons with heavy quarks: experimental perspective

(Colored) diquarks in QCD

STATIC



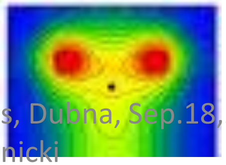
repulsive color force

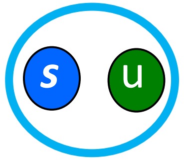
quarks will pull apart in any sextet configuration

attractive color force

(perturbatively: half as strong as in the meson)

(qq) diquark





Not a particle, just a building block in QCD

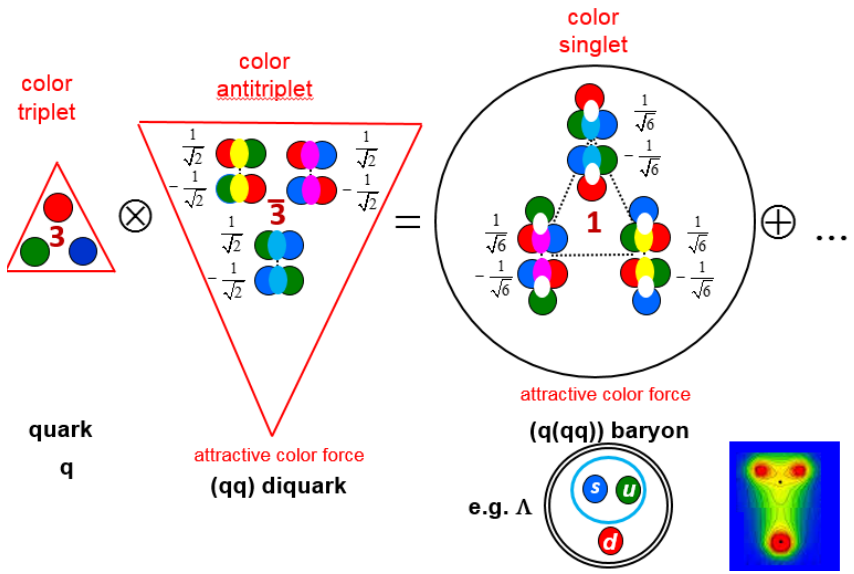
Diquark can go in a place of antiquark in a hadron; antidiquark in place of quark.

Hadrons from diquarks?

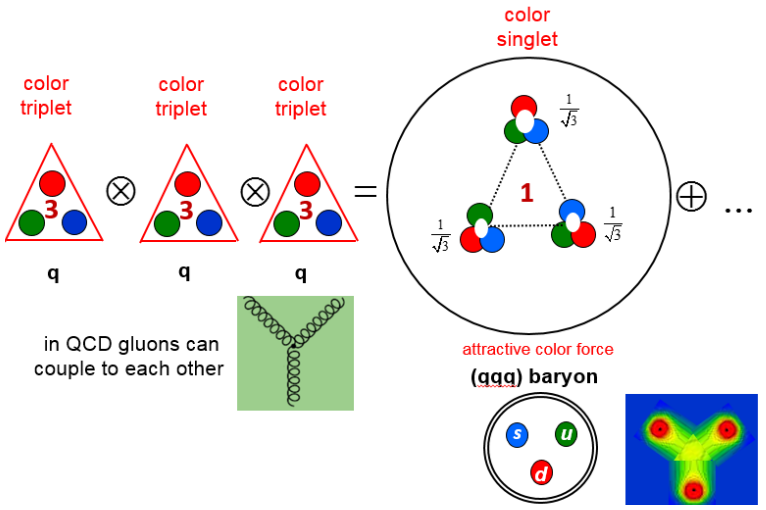
STATIC

Still an open question!

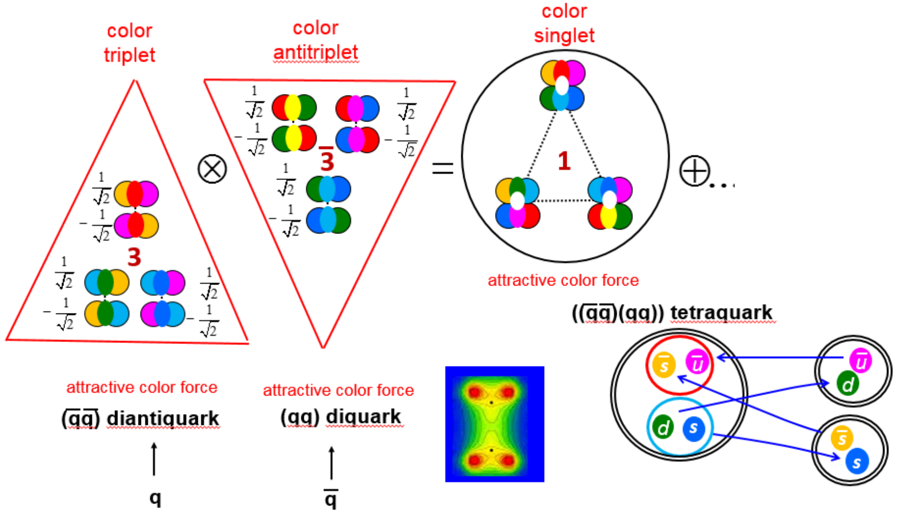
Role of diquarks in building hadrons?

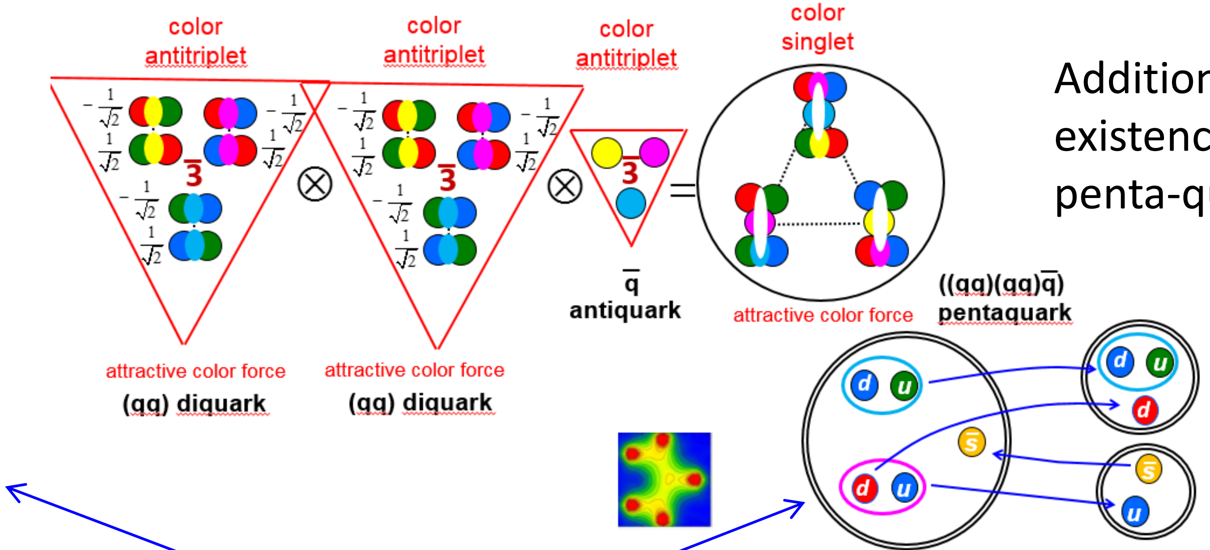


vs.



Light and heavy baryon spectroscopy is sensitive to this question

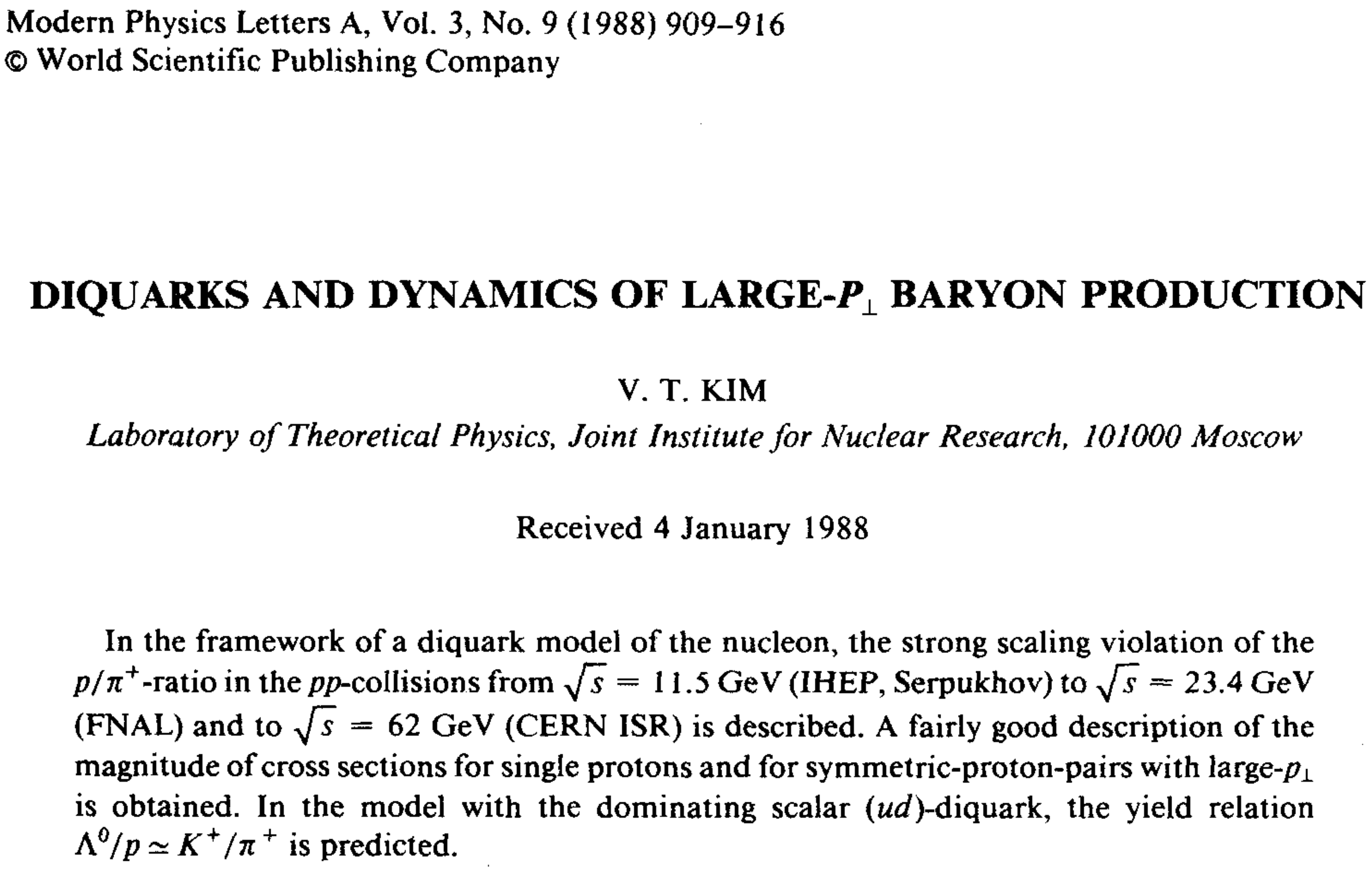




Additional motivation for existence of tetra- and penta-quarks.

Does effective mechanism to suppress rapid fall-apart exist?

DYNAMIC



Modern Physics Letters A, Vol. 3, No. 9 (1988) 909–916

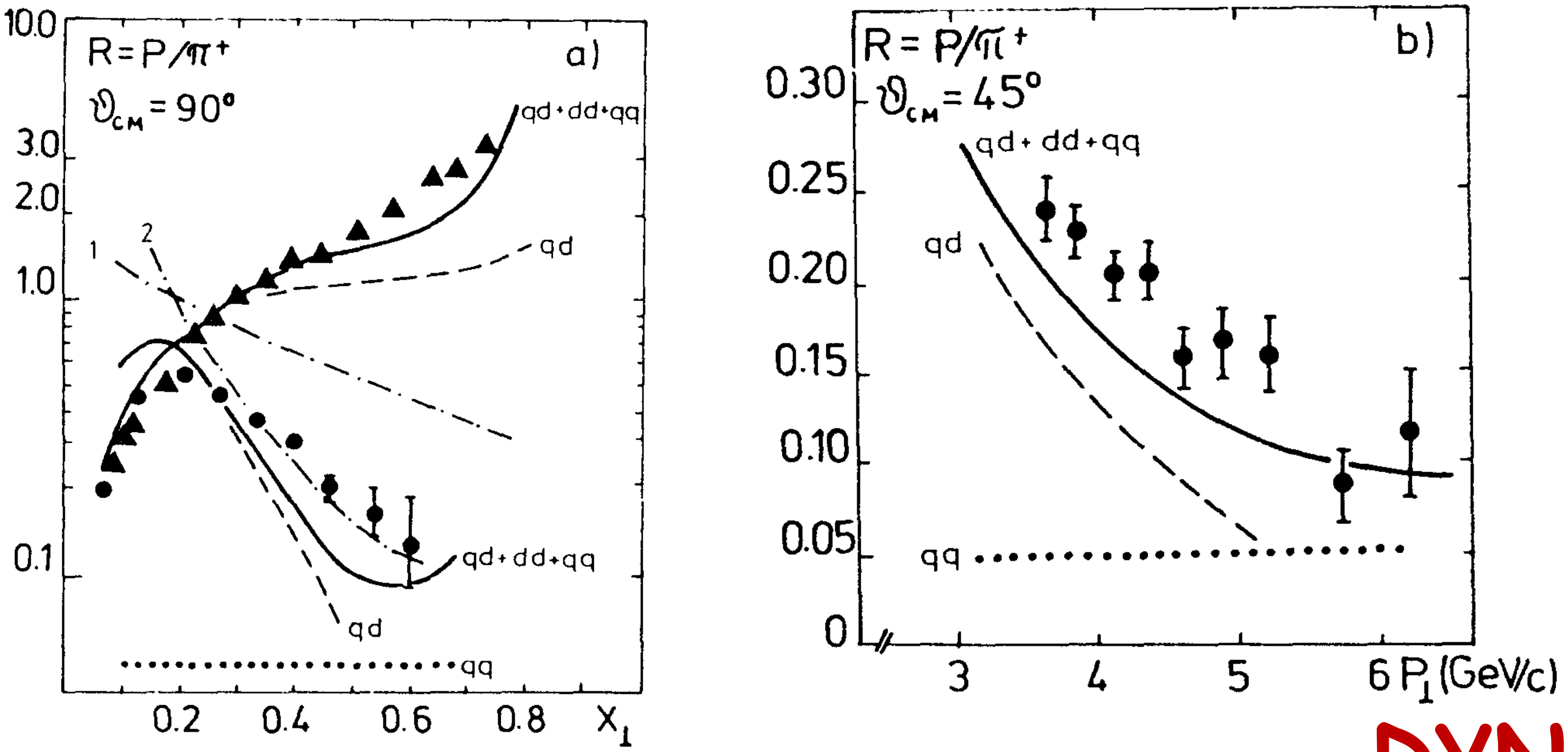
DIQUARKS AND DYNAMICS OF LARGE-$P_\perp$ BARYON PRODUCTION

V. T. KIM

Laboratory of Theoretical Physics, Joint Institute for Nuclear Research, 101000 Moscow

Received 4 January 1988

In the framework of a diquark model of the nucleon, the strong scaling violation of the p/π^+-ratio in the pp-collisions from $\sqrt{s} = 11.5$ GeV (IHEP, Serpukhov) to $\sqrt{s} = 23.4$ GeV (FNAL) and to $\sqrt{s} = 62$ GeV (CERN ISR) is described. A fairly good description of the magnitude of cross sections for single protons and for symmetric-proton-pairs with large-$p_\perp$ is obtained. In the model with the dominating scalar (ud)-diquark, the yield relation $\Lambda^0/p \simeq K^+/\pi^+$ is predicted.



DYNAMIC

Fig. 1. $R = p/\pi^+$ is the particle yield ratio in the *pp*-collisions.
a) $\vartheta_{CM} = 90°$: ● the FNAL data[1] at $\sqrt{s} = 23.4$ GeV ($E = 300$ GeV); ▲ the IHEP (Serpukhov) data[2] at $\sqrt{s} = 11.5$ GeV ($E = 70$ GeV).
b) $\vartheta_{CM} = 45°$: ● the CERN ISR data[3] at $\sqrt{s} = 62$ GeV ($E \simeq 1900$ GeV).
The dotted curve shows the contribution of the *qq*-subprocess, the dashed one shows the contribution of the *qd*-subprocess. The total contribution of the *qq*-, *qd*- and *dd*-subprocesses is denoted by the solid lines. The dashed-dotted curves show the calculations with the diquark function $G_d^N(x) \sim (1 - x)/x$ at 70 GeV (curve 1) and at 300 GeV (curve 2).

DYNAMIC

arXiv:1007.4705v5 [hep-ph] 25 Sep 2010
&Phys.Rev. C83 (2011) 054606
Carlos Granados and Misak Sargsian

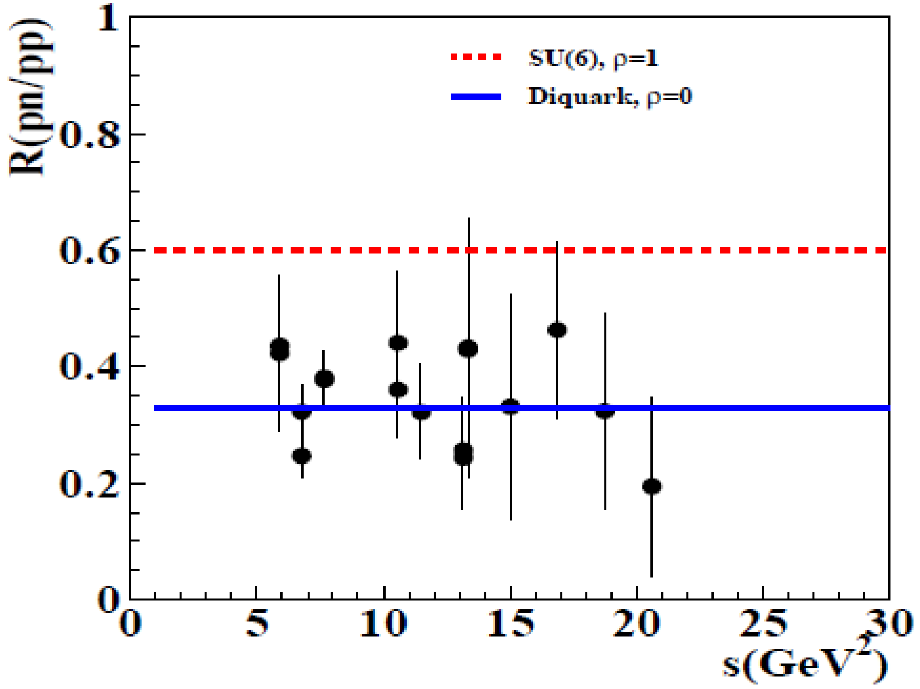
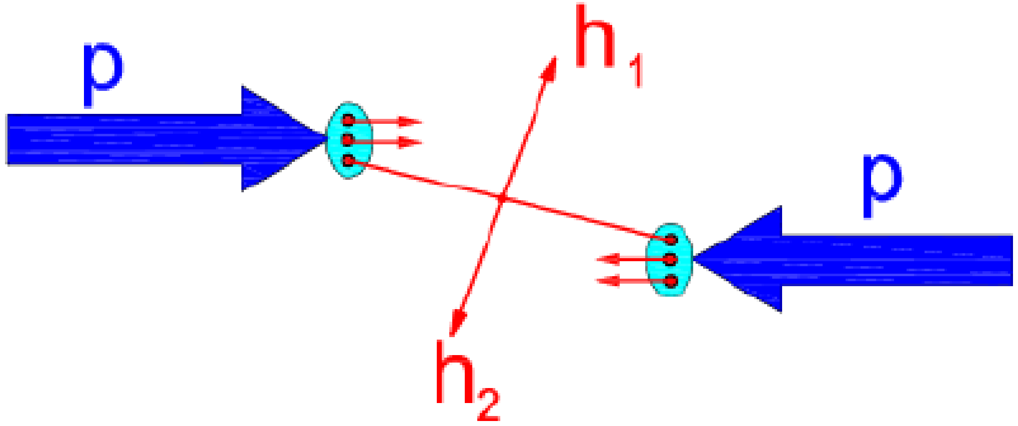


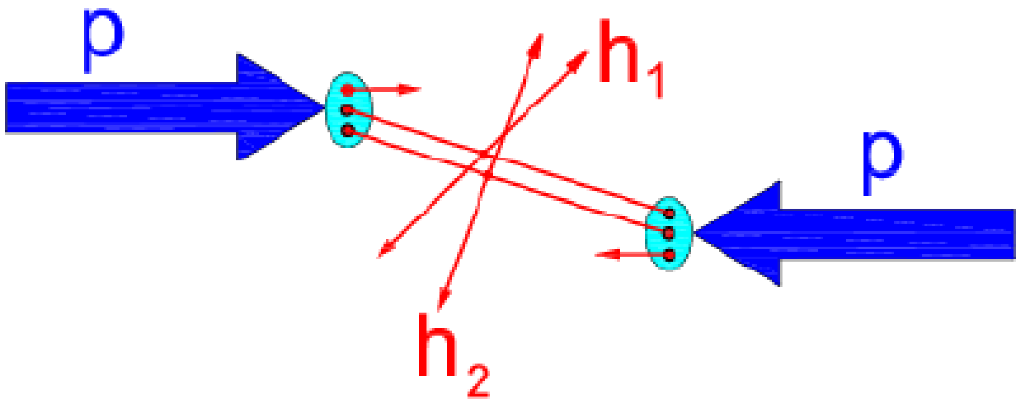
FIG. 2: (Color online) Ratio of the $pn \to pn$ to $pp \to pp$ elastic differential cross sections as a function of s at $\theta^N_{c.m.} = 90^0$.

How can we prove the existence of diquarks and determine their properties?

MPI



а



б

NN Elastic scattering with polarized deuteron beams :

$$p\uparrow + p\uparrow \rightarrow p + p$$

for calibration

$$p\uparrow + n\uparrow \rightarrow p + n$$

$$n\uparrow + n\uparrow \rightarrow n + n$$

New data!

By the way we will have the counting rules verification!

pd, nd and dd – too!

Exclusive NN study at $x_T \sim 1$

$$N\uparrow + N\uparrow \to BB + MM$$

B (p,n,Λ, Δ...), M (π, K , ...)

Mechanisms of hyperons polarization

$$N\uparrow N\uparrow \to NN$$

The counting rules and isotopic symmetry studies, $p_T \sim 2$ GeV/c anomaly

$$N\uparrow N\uparrow \to BB + \pi\pi(KK)$$

$$N\uparrow N\uparrow \to \Delta\Delta$$

Detail vertexes studies and spin structure of the interaction vertex:

$$q + (q) - (quark - quark)$$

$$q + (qq) - (quark - diquark)$$

$$(qq) + (qq) - (diquark - diquark)$$

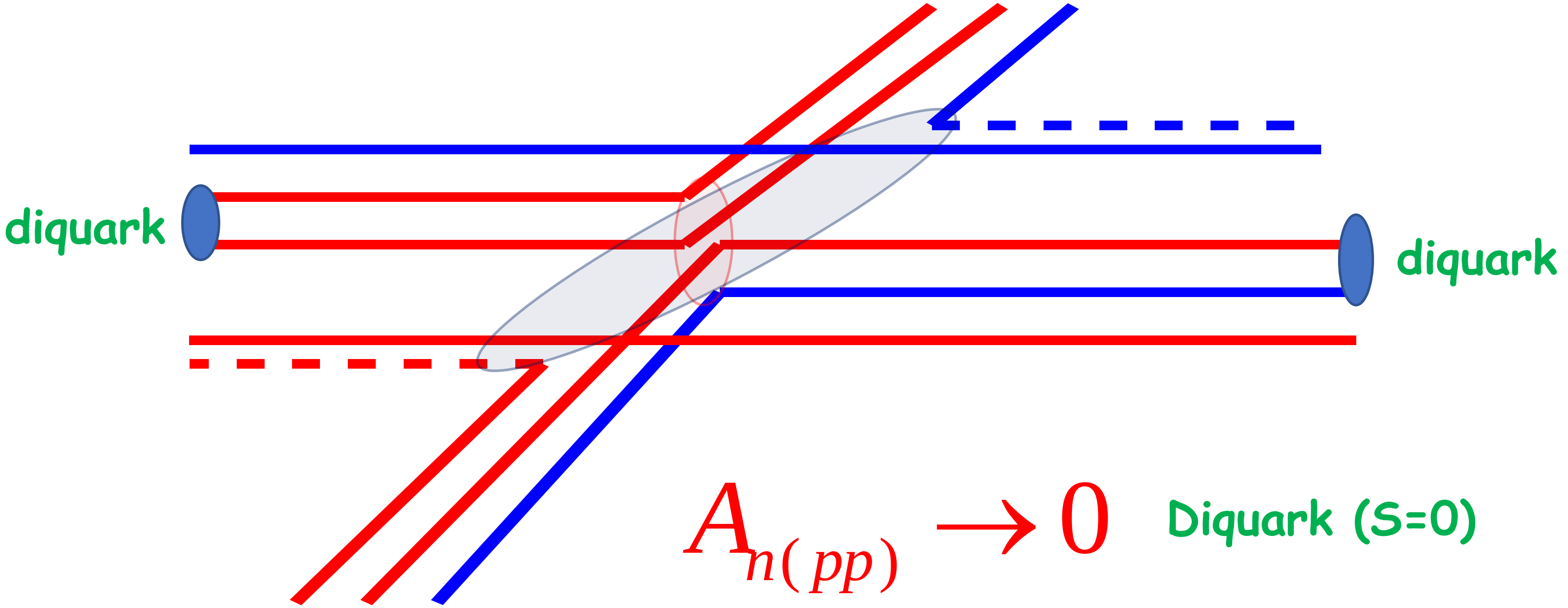
High p_T exclusive reactions -> MPI

$$p\uparrow + p\uparrow \rightarrow B + B + M\overline{M}$$

$$p\uparrow + p\uparrow \rightarrow p + p + \pi^0\pi^0(\pi^+\pi^-)$$

$$R = \frac{N(\pi^+\pi^-)}{N(\pi^0\pi^0)} = \frac{2}{7}$$ Without diquark

$$R = \frac{N(\pi^+\pi^-)}{N(\pi^0\pi^0)} \rightarrow 0$$ diquark



$$A_{n(pp)} \rightarrow 0$$ Diquark (S=0)

EXOTICS

Status of the pentaquark problem

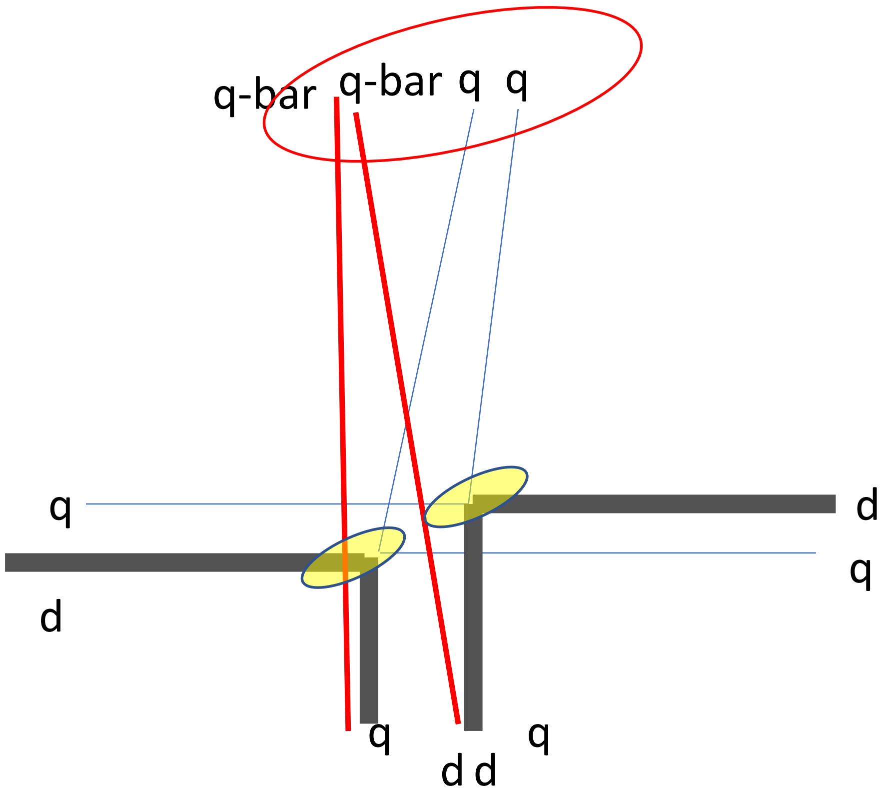
- 1st relatively certain theoretical suggestion
  of mass ~1530 MeV and width < 15 MeV :

  Diakonov, Petrov, Polyakov, Z.Phys., A**359** (1997) 305.
- Experiment : about ten papers with positive evidences;
  about ten papers with negative results
  (some of them with higher statistics).
- Common opinion and PDG position
  (since edition of 2008) :

  Pentaquark is dead !

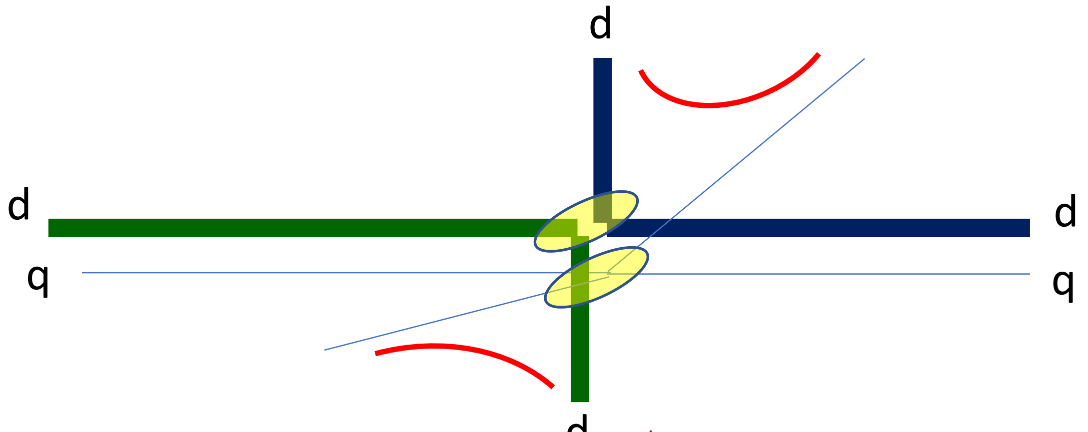
  (Note, at the same time, great enthusiasm
  in searches for tetraquarks !)

pp - reactions with diquarks and тетракварки

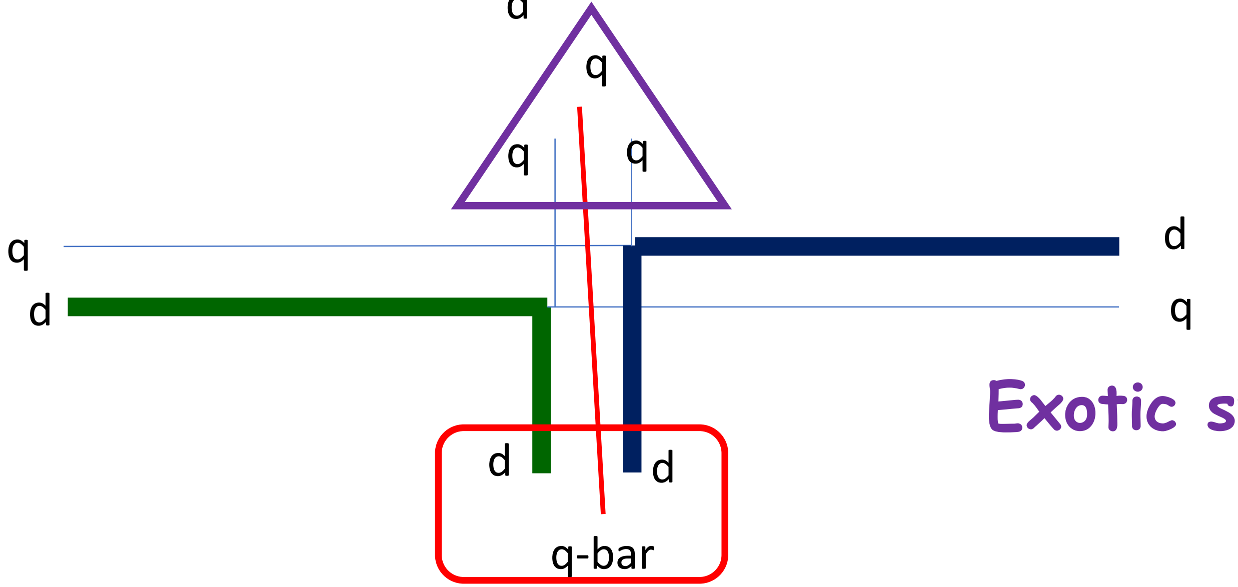


Kim's mechanisms

pp - reactions with pentaquarks production and …



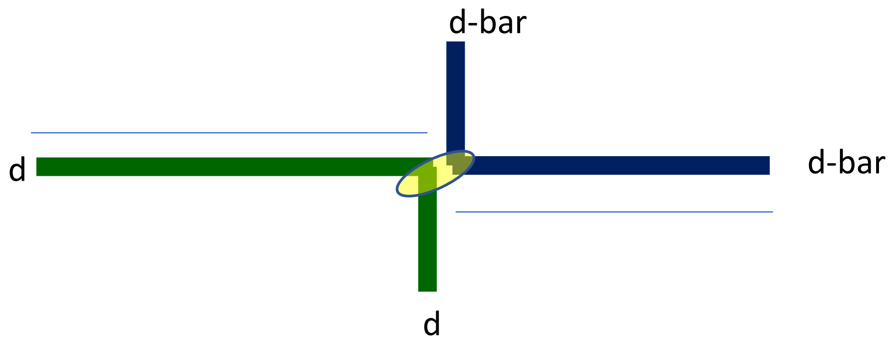
ΛK - interaction



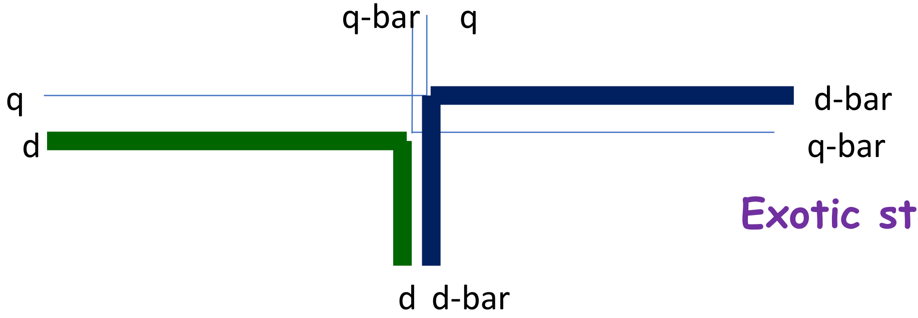
Exotic states production

Exotic states production

$\bar{p}p$ - reactions with tetraquarks production



Diquark proof

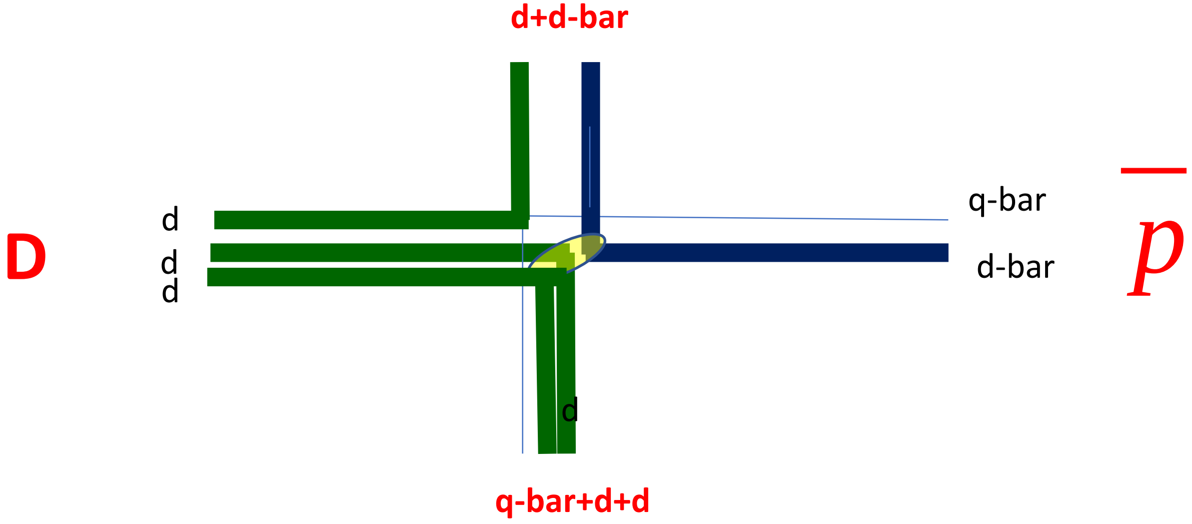


Exotic states production

Kim's-bar mechanisms

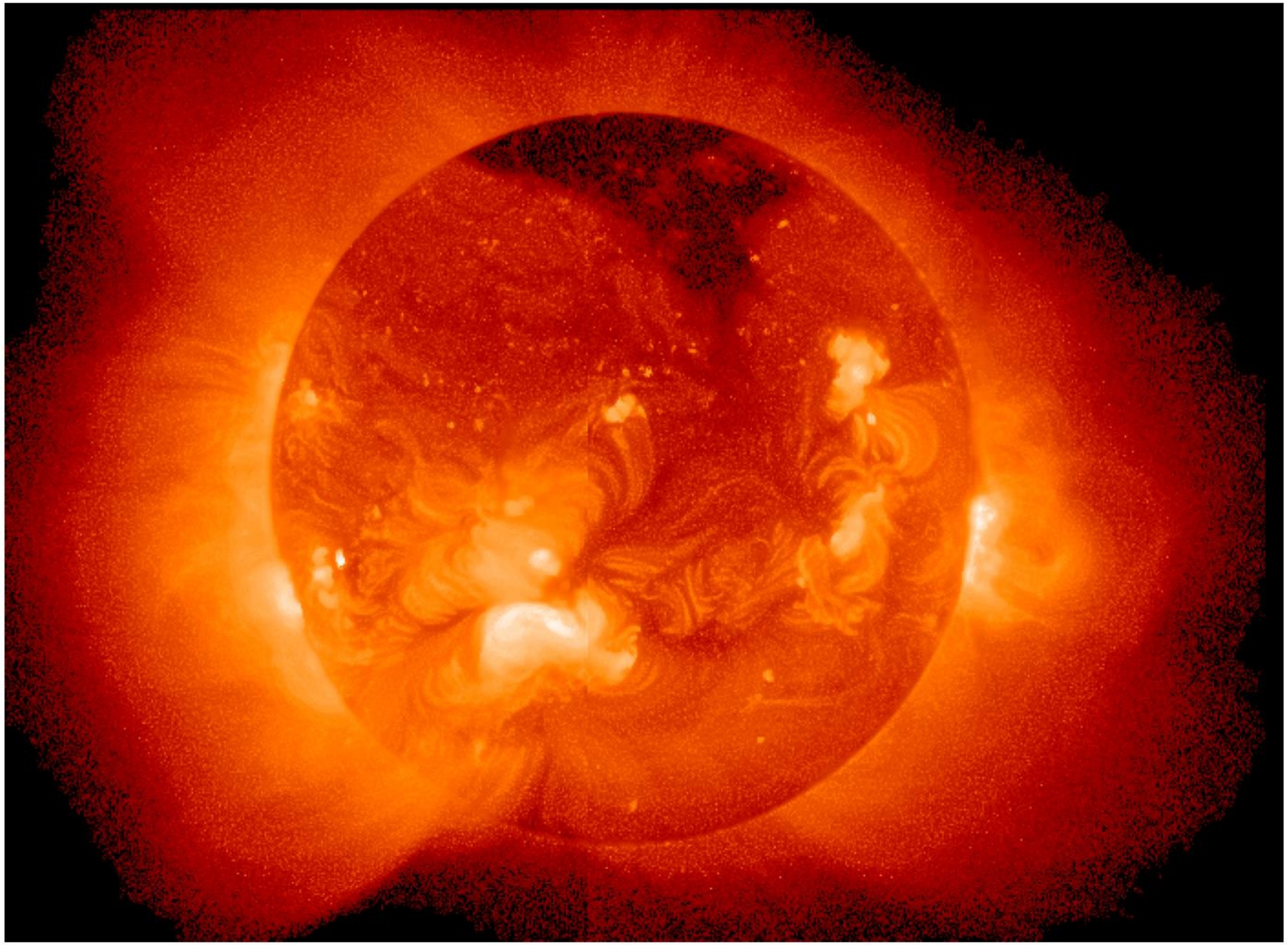
Exotic states production

$\bar{p}d$ - reaction with tetraquarks +pentaquark production



MULTIQUARKS
AND
CsDBM investigation

Temperature at the centre of the Sun ~ 15 000 000 K



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

Strangeness in Neutron Stars

astro-ph/0604422 v1 20 Apr 2006

FRIDOLIN WEBER[*], ALEXANDER HO[†], RODRIGO P. NEGREIROS[‡],
PHILIP ROSENFIELD[§]

H ~ 10^{15} Gs

E~ 10^{19} V/cm

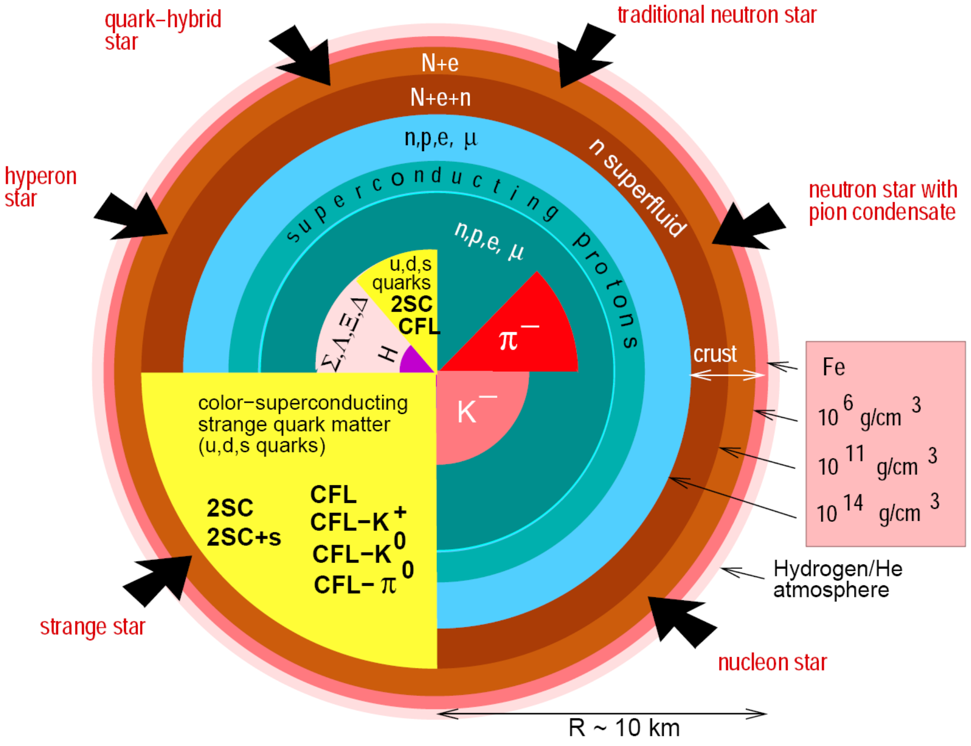


Fig. 1. Competing structures and novel phases of subatomic matter predicted by theory to make their appearances in the cores ($R \lesssim 8$ km) of neutron stars[4].

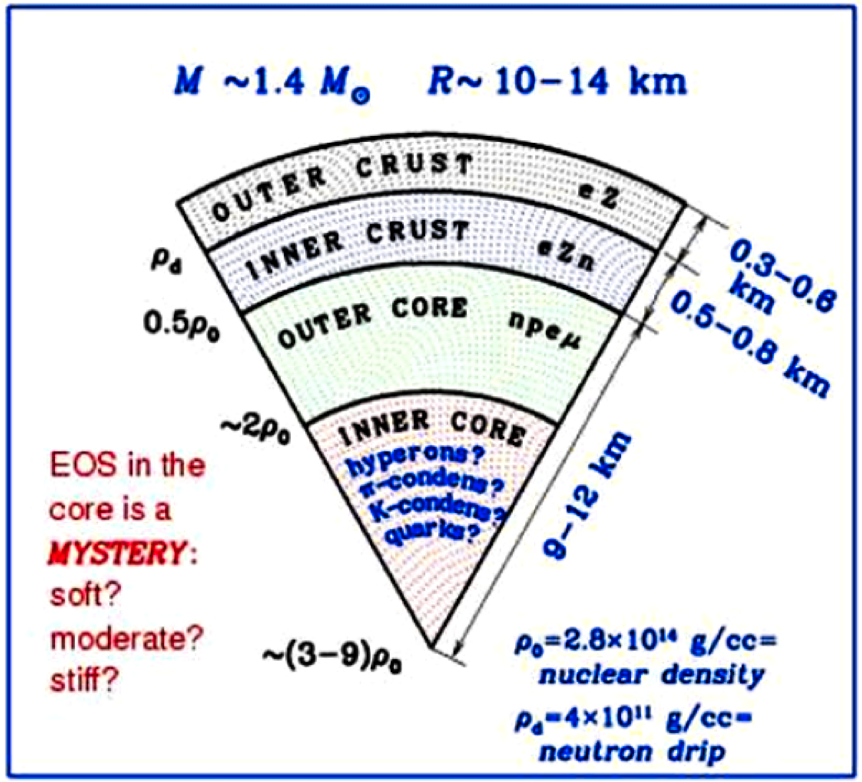
significant range of chemical potentials and strange quark masses[51]. If the strange quark mass is heavy enough to be ignored, then up and down quarks may pair in the two-flavor superconducting (2SC) phase. Other possible condensation patters

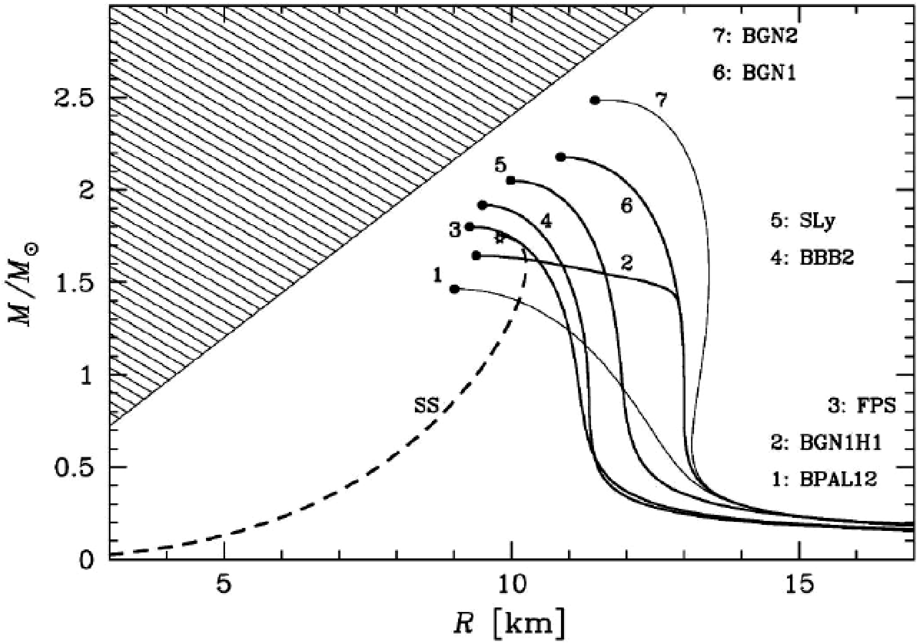
color−superconducting strange quark matter (u,d,s quarks)

K. Rajagopal and F. Wilczek, *The Condensed Matter Physics of QCD*, At the Frontier of Particle Physics / Handbook of QCD, ed. M. Shifman, (World Scientific) (2001).
M. Alford, Ann. Rev. Nucl. Part. Sci. **51** (2001) 131.

Remnants of the collapse: Neutron stars

NS internal structure is determined
by equation of state which is poorly known





The Beginning

SOVIET PHYSICS JETP VOLUME 6 (33), NUMBER 5 MAY, 1958

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.

We recall in this connection reports in earlier works[3,4] that high-energy nucleons can split nuclei into "supra-barrier" fragments, i.e., fragments with an energy much larger than their binding energy and the energy of the Coulomb barrier. However, there was a lack of quantitative experimental data on which to base the theoretical analysis.

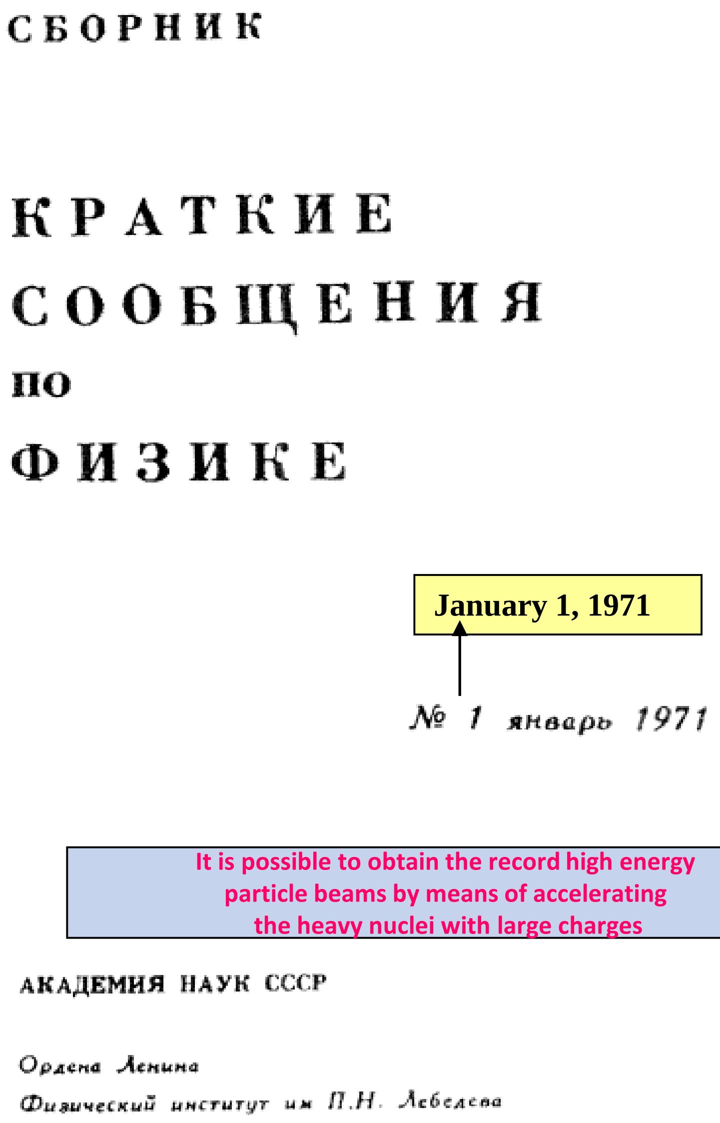
Some authors related this curious process, without foundation, to hypothetical long-range nuclear forces. Others tried to connect it with nuclear many-body forces.

The experimental data on the emission of high-energy deuterons from light nuclei give support to the idea that "supra-barrier" fragments are produced also by direct collision of an incoming nucleon with a tight nucleon cluster that results from density fluctuations of the nuclear matter. We offer in the following a quantitative argument in favor of the production of fast deuterons and other "supra-barrier" fragments by such fluctuations.

Concerning the nuclear many-body forces, it should be noted that, according to existing estimates,[5] there is no reason to believe that they are considerably stronger than the two-body forces. At the instant of dense clustering both paired and collective interactions may take place. However, at present there exists no experimental information which would allow an explanation of this interaction, or in particular allow a determination of the relative contributions of the paired and the collective interactions.

2. INTERACTION OF DEUTERONS WITH FAST PROTONS

It was shown experimentally[1,2] that scattering of 675-Mev protons by deuterium produces, in addition to scattered nucleons, a small number of undestroyed deuterons of high energy (up to 660 Mev). This shows that in such collisions the nucleon imparts an appreciable fraction of its momentum to the deuteron as a whole.



СБОРНИК

КРАТКИЕ СООБЩЕНИЯ ПО ФИЗИКЕ

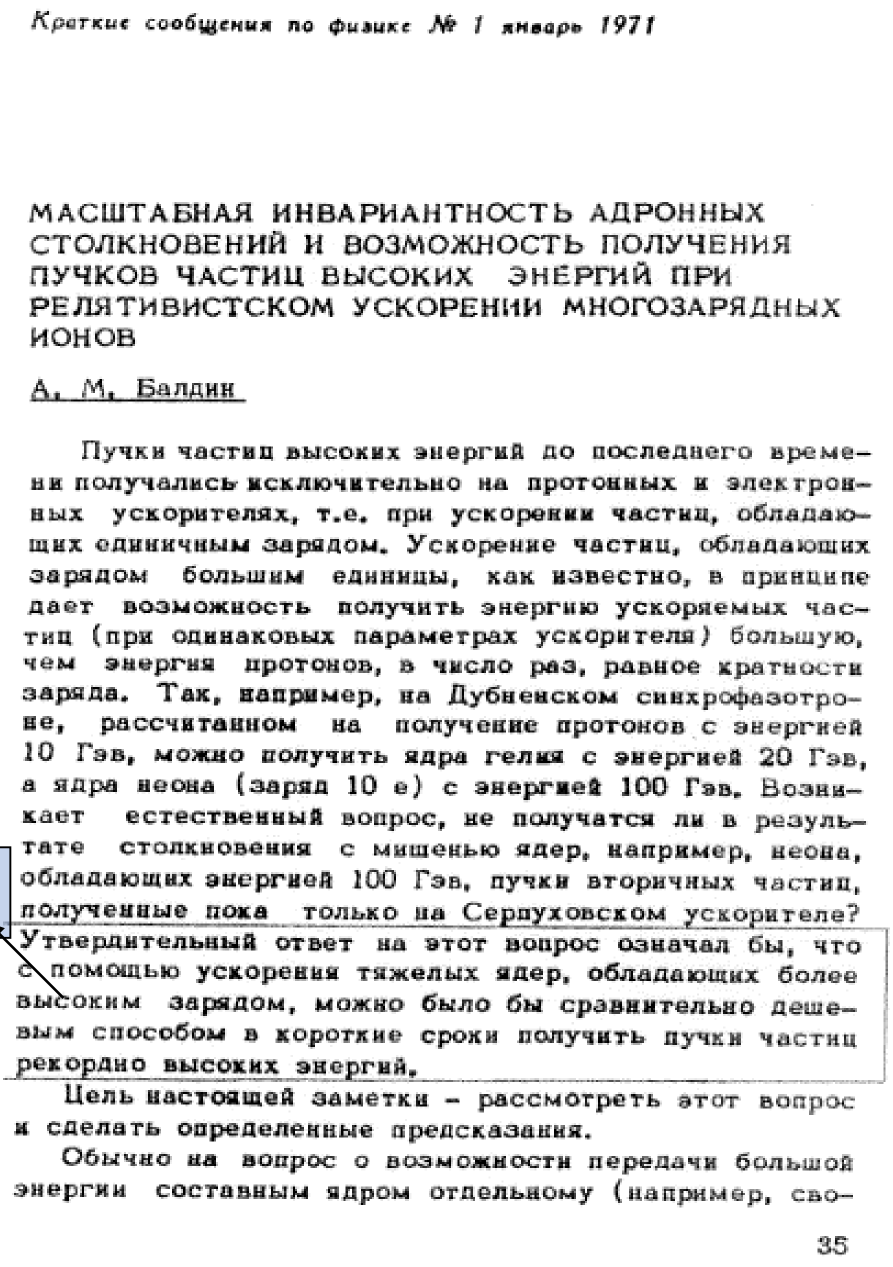
№ 1 январь 1971

АКАДЕМИЯ НАУК СССР

Ордена Ленина
Физический институт им П.Н. Лебедева

January 1, 1971

It is possible to obtain the record high energy
particle beams by means of accelerating
the heavy nuclei with large charges



Краткие сообщения по физике № 1 январь 1971

МАСШТАБНАЯ ИНВАРИАНТНОСТЬ АДРОННЫХ СТОЛКНОВЕНИЙ И ВОЗМОЖНОСТЬ ПОЛУЧЕНИЯ ПУЧКОВ ЧАСТИЦ ВЫСОКИХ ЭНЕРГИЙ ПРИ РЕЛЯТИВИСТСКОМ УСКОРЕНИИ МНОГОЗАРЯДНЫХ ИОНОВ

А. М. Балдин

Пучки частиц высоких энергий до последнего времени получались исключительно на протонных и электронных ускорителях, т.е. при ускорении частиц, обладающих единичным зарядом. Ускорение частиц, обладающих зарядом большим единицы, как известно, в принципе дает возможность получить энергию ускоряемых частиц (при одинаковых параметрах ускорителя) большую, чем энергия протонов, в число раз, равное кратности заряда. Так, например, на Дубненском синхрофазотроне, рассчитанном на получение протонов с энергией 10 Гэв, можно получить ядра гелия с энергией 20 Гэв, а ядра неона (заряд 10 е) с энергией 100 Гэв. Возникает естественный вопрос, не получатся ли в результате столкновения с мишенью ядер, например, неона, обладающих энергией 100 Гэв, пучки вторичных частиц, полученные пока только на Серпуховском ускорителе? Утвердительный ответ на этот вопрос означал бы, что с помощью ускорения тяжелых ядер, обладающих более высоким зарядом, можно было бы сравнительно дешевым способом в короткие сроки получить пучки частиц рекордно высоких энергий.

Цель настоящей заметки – рассмотреть этот вопрос и сделать определенные предсказания.

Обычно на вопрос о возможности передачи большой энергии составным ядром отдельному (например, сво–

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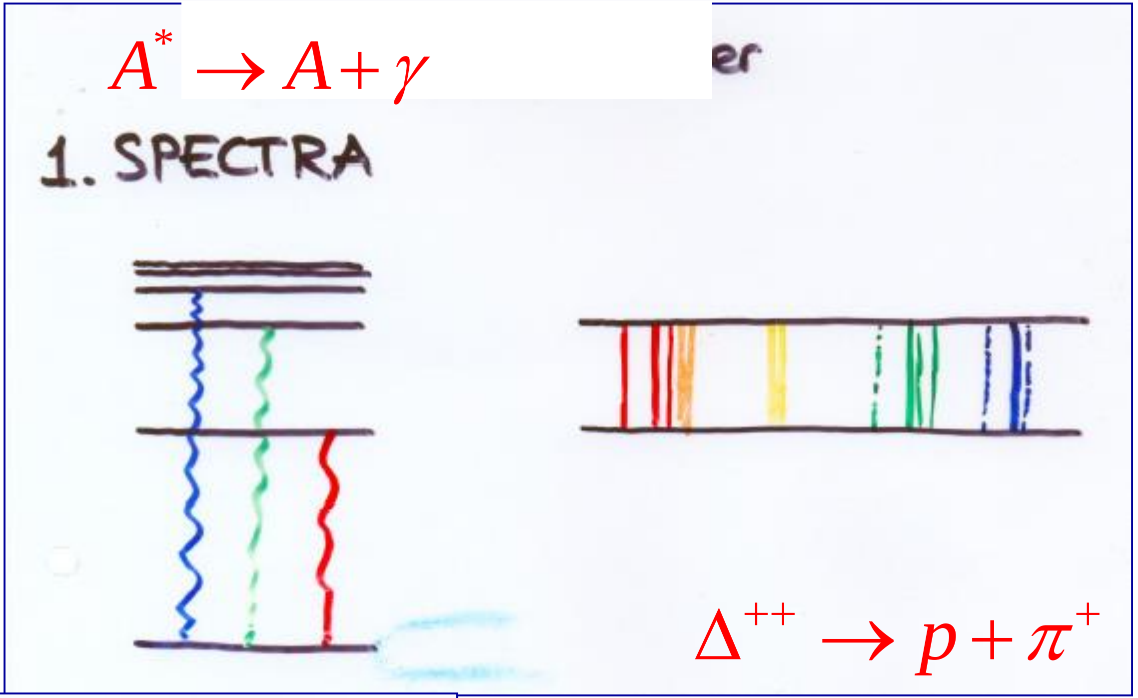
F. Close

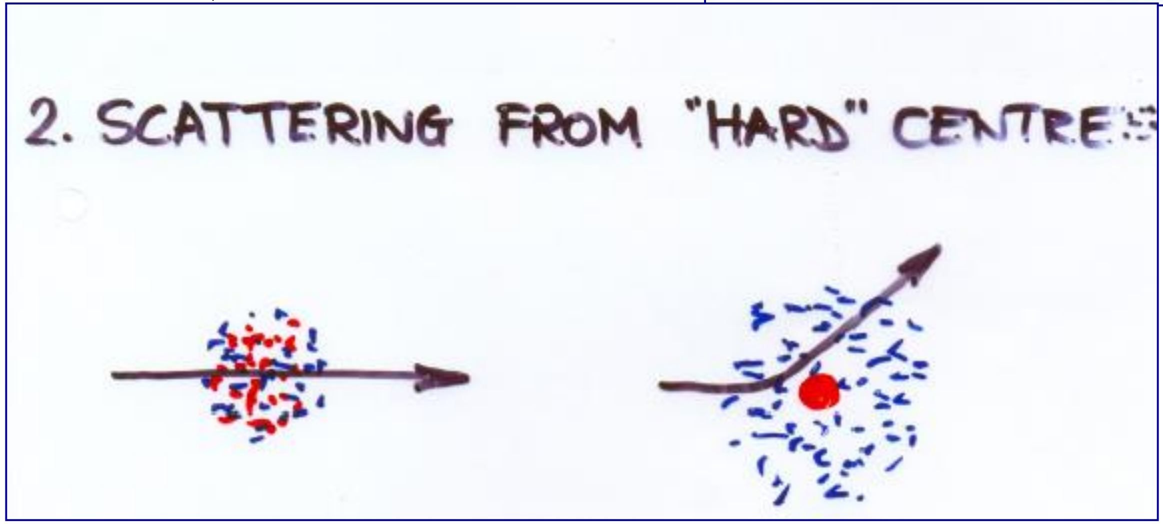
Structure of Matter

Two ways that structure is revealed:



$A^* \to A+\gamma$

$\Delta^{++} \to p+\pi^+$



True from atoms to particles…..

Schroeder L.S. et al. // Phys. Rev. Lett. 1979. V. 43, n. 24. P. 1787
A.M.Baldin et al., Yad.Fiz., 20, 1975, p.1201

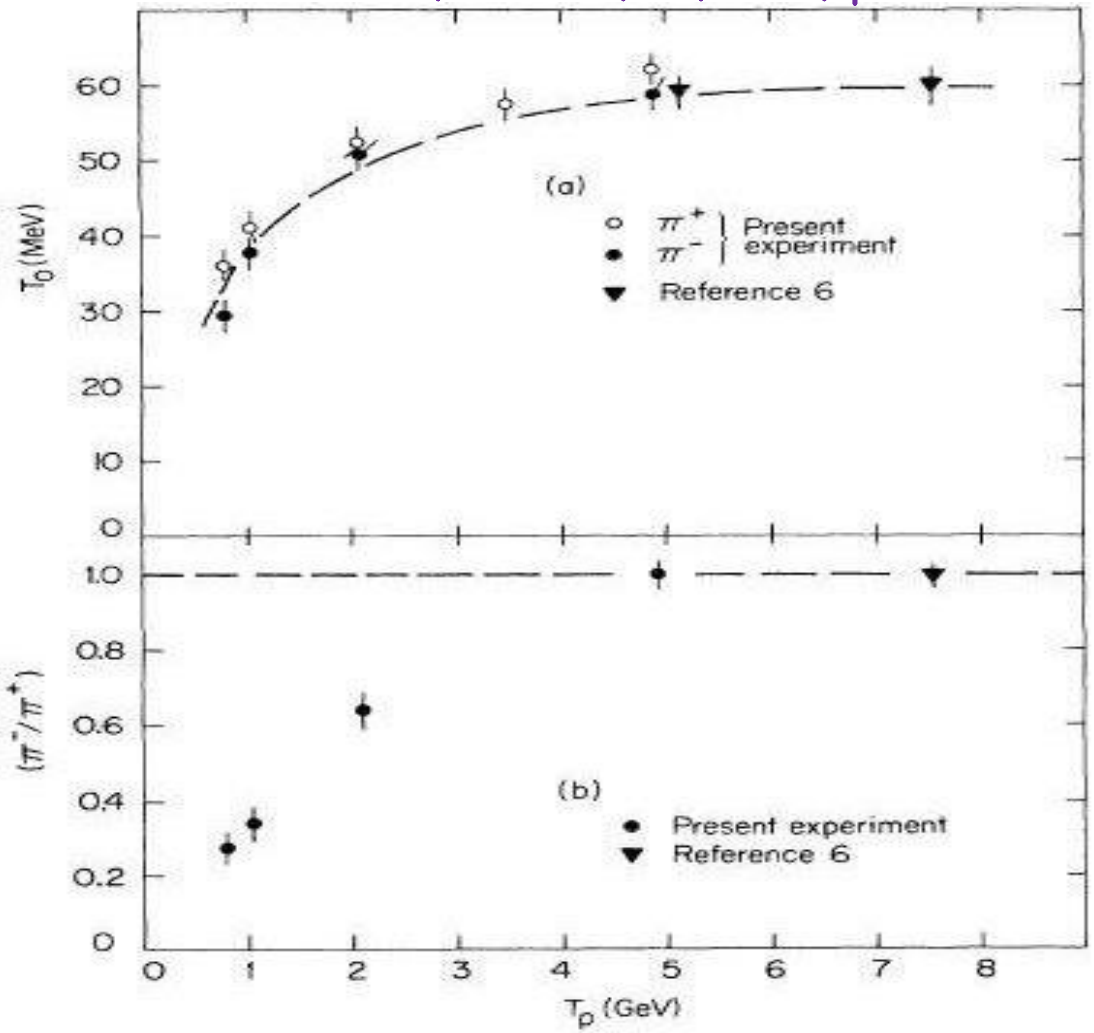


FIG. 1. Energy dependence of (a) T_0 parameter for pions, and (b) the π^-/π^+ ratio at 180° obtained by integrating each spectra up to 100 MeV for p-Cu collisions from 0.8 to 4.89 GeV. The dashed curve in both cases refers to the predictions of the "effective-target" model (Refs. 3 and 4).

Г.А. Лексин, Яд.Физ. т.65 (2002) 2042

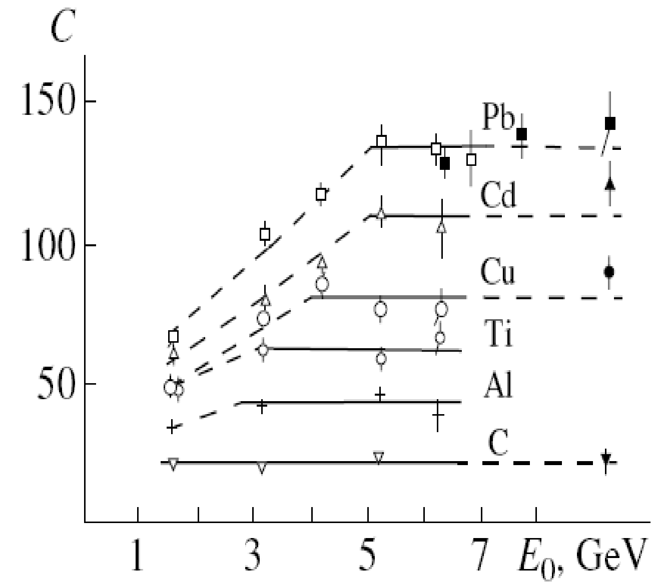


Fig. 3. The coefficient $C(T_0 = 125\ \text{MeV})$ in the parametrization of the invariant function $f = C\exp(-T/T_0)$ in the reaction pA(C, Al, Ti, Cu, Cd, Pb) $\to pX$ for a proton escape angle of 120° in the laboratory frame versus the incident-proton energy. The filled circles refer to the initial energy of 400 GeV.

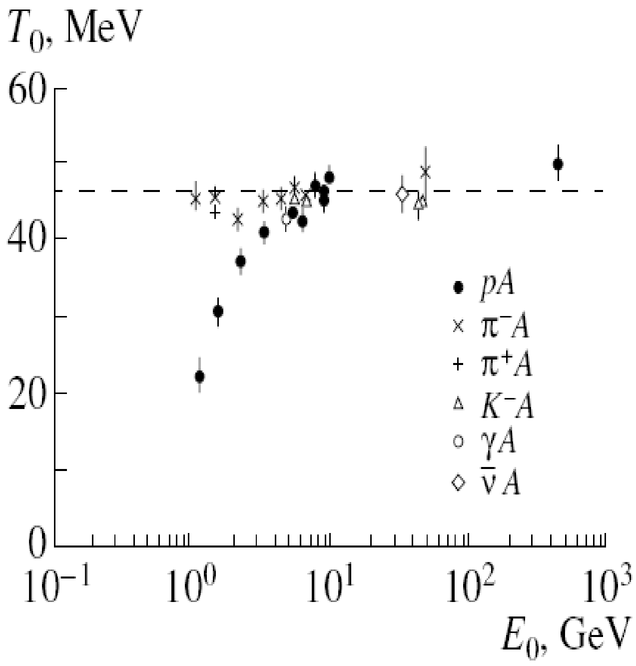


Fig. 5. Dependence of the slope parameter T_0 for the invariant function of the protons escaping under the action of $p, \pi^{\pm}, K^-, \gamma, \bar{\nu}$ with various energies E_0; the escape angle is 120° in the laboratory frame.

Volume 67B, number 1 PHYSICS LETTERS 14 March 1977

ТЕОРИЯ

LARGE MOMENTUM PION PRODUCTION IN PROTON NUCLEUS COLLISIONS AND THE IDEA OF "FLUCTUONS" IN NUCLEI

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and

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Received 27 January 1977

It is shown that in proton-nucleus collisions, the production of pions with large momenta can be explained by the assumption of the existence of nuclear density fluctuations ("fluctuons") at short distances of the nucleon core radius order, with the mass of several nucleons.

The purpose of this note is to realize the idea [4] that the cumulative effect is connected largely with a suggestion on the existence in nuclei of the so-called fluctuons. Earlier fluctuons were proposed [7] in order to understand the nature of the "deuteron peak" in the pA-scattering cross section at large momentum transfers [8] and also to interpret the pd-scattering cross section [9]. Compressional fluctuations of mass $M_k = km_p$ of nucleons in the small volume $V_\xi = \frac{4}{3}\pi r_\xi^3$ where r_ξ is the fluctuon radius were assumed.

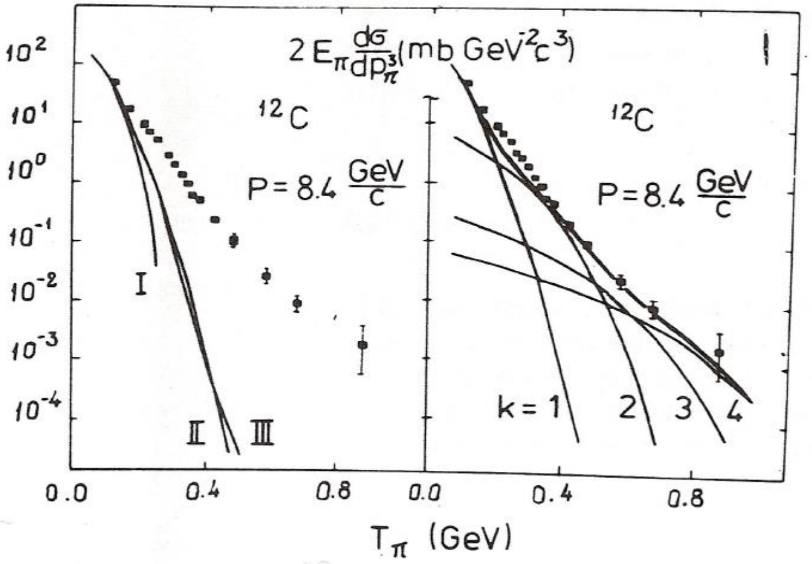

Fig. 1. (a) Calculations of the invariant pion production cross section for ^{12}C: I – for the free proton target; II – with fermi motion; III – the relativization effect. (b) The contributions of separate fluctuons with mass $M_k = km_p$ where k is the order of cumulativity.

PHYSICAL REVIEW C VOLUME 45, NUMBER 4 APRIL 1992

Nuclear structure functions at $x > 1$

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D. B. Day, J. S. McCarthy, Z. Meziani,‡ R. Minehardt, R. Sealock, and S. T. Thornton
Institute of Nuclear and Particle Physics and Department of Physics, University of Virginia, Charlottesville, Virginia 22901

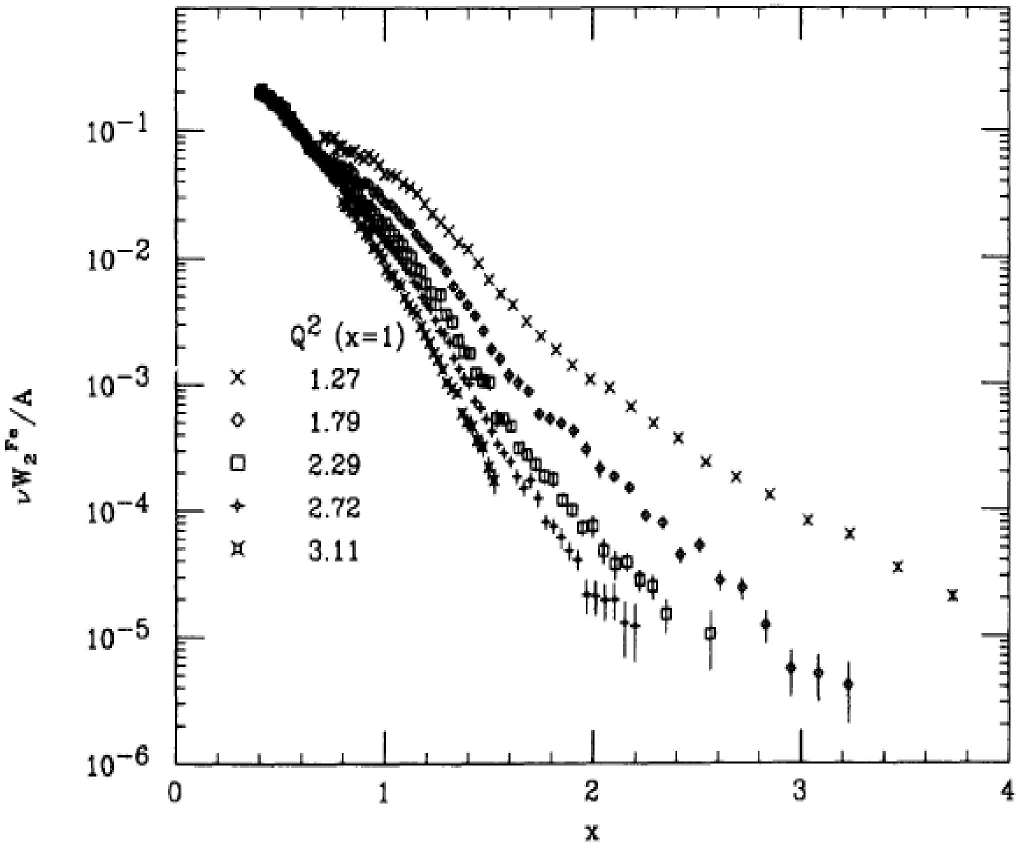


FIG. 1. Measured structure function per nucleon for Fe vs x. The Q^2 value at $x = 1$ is also listed for the different kinematics.

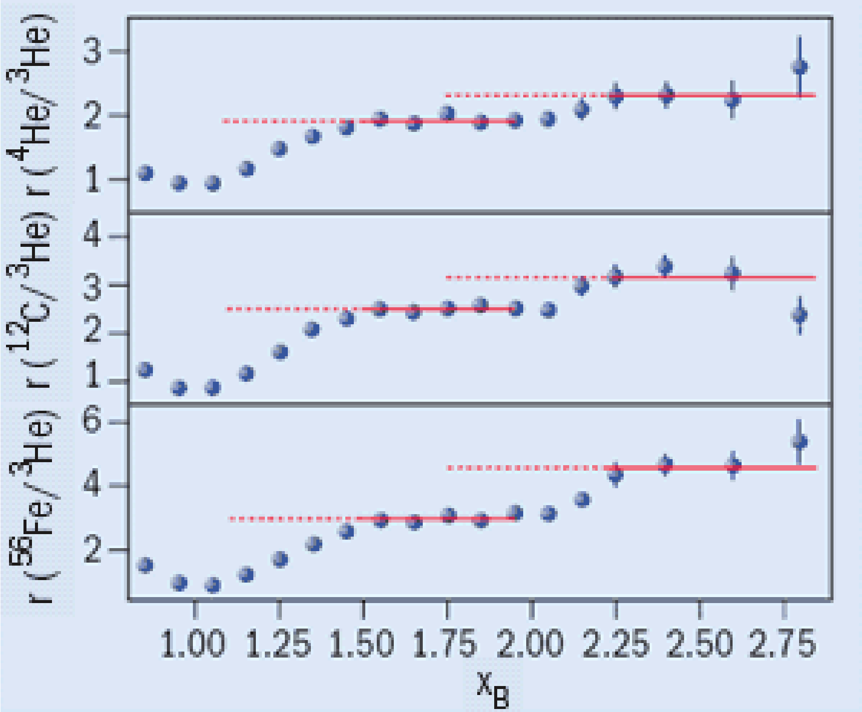
Phys.Rev.Lett. 96 (2006) 082501

Measurement of 2- and 3-Nucleon Short Range Correlation Probabilities in Nuclei

K.S. Egiyan,[1] N.B. Dashyan,[1] M.M. Sargsian,[10] M.I. Strikman,[28] L.B. Weinstein,[27] G. Adams,[30] P. Ambrozewicz,[10]
M. Anghinolfi,[16] B. Asavapibhop,[22] G. Asryan,[1] H. Avakian,[34] H. Baghdasaryan,[27] N. Baillie,[38] J.P. Ball,[2]

$$r(A, {}^3\mathrm{He}) = \frac{A(2\sigma_{ep} + \sigma_{en})}{3(Z\sigma_{ep} + N\sigma_{en})} \frac{3\mathcal{Y}(A)}{A\mathcal{Y}({}^3\mathrm{He})} C^A_{\mathrm{rad}}, \qquad (2)$$

where Z and N are the number of protons and neutrons in nucleus A, σ_{eN} is the electron-nucleon cross section, $\mathcal{Y}$ is the normalized yield in a given (Q^2,x_B) bin [30] and C^A_{rad} is the ratio of the radiative correction factors for A and ^{3}He ($C^A_{\mathrm{rad}} = 0.95$ and 0.92 for ^{12}C and ^{56}Fe respectively). In our Q^2 range, the elementary cross section correction factor $\frac{A(2\sigma_{ep}+\sigma_{en})}{3(Z\sigma_{ep}+N\sigma_{en})}$ is 1.14 ± 0.02 for C and ^{4}He and 1.18 ± 0.02 for ^{56}Fe. Fig. 1 shows the resulting ratios integrated over $1.4 < Q^2 < 2.6$ GeV^2.



Having these data, we know almost full (≈99%) nucleonic picture of nuclei with $A \leq 56$

Fractions / Nucleus	Single particle (%)	2N SRC (%)	3N SRC (%)
^{56}Fe	**76** ± 0.2 ± 4.7	**23.0** ± 0.2 ± 4.7	**0.79** ± 0.03 ± 0.25
^{12}C	**80** ± 02 ± 4.1	**19.3** ± 0.2 ± 4.1	**0.55** ± 0.03 ± 0.18
^{4}He	**86** ± 0.2 ± 3.3	**15.4** ± 0.2 ± 3.3	**0.42** ± 0.02 ± 0.14
^{3}He	**92** ± 1.6	**8.0** ± 1.6	**0.18** ± 0.06
^{2}H	**96** ± 0.8	**4.0** ± 0.8	-----

Using the published data on (p,2p+n) [PRL,90 (2003) 042301] estimate the isotopic composition of 2N SRC in ^{12}C

$a_{pp}(^{12}C) \approx$ 4 ± 2 %

$a_{2N}(^{12}C) \approx 20 \pm 0.2 \pm 4.1$ % $\Rightarrow$ $a_{pn}(^{12}C) \approx 12 \pm 4$ %

$a_{nn}(^{12}C) \approx$ 4 ± 2 %

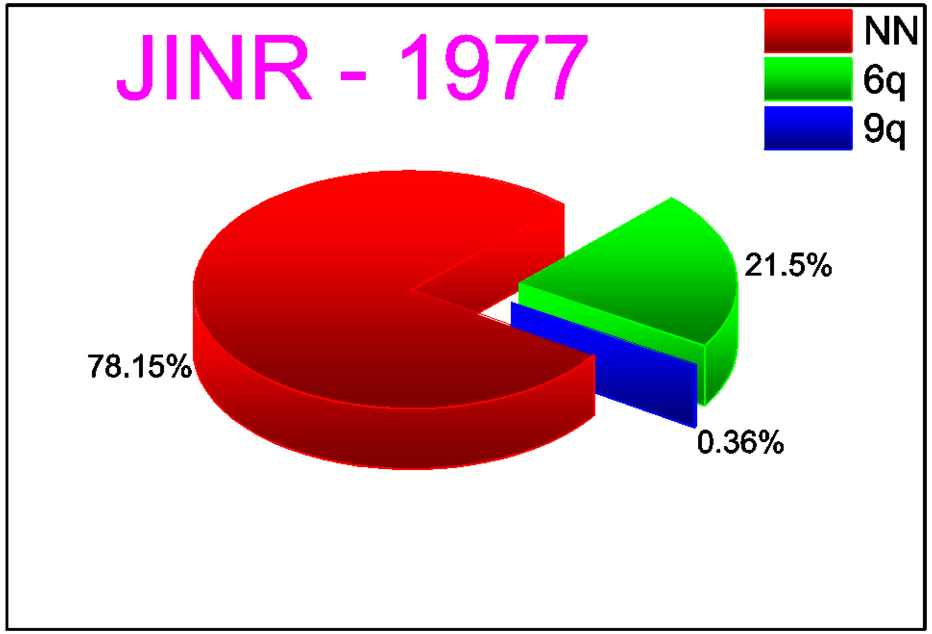
^{12}C - structure

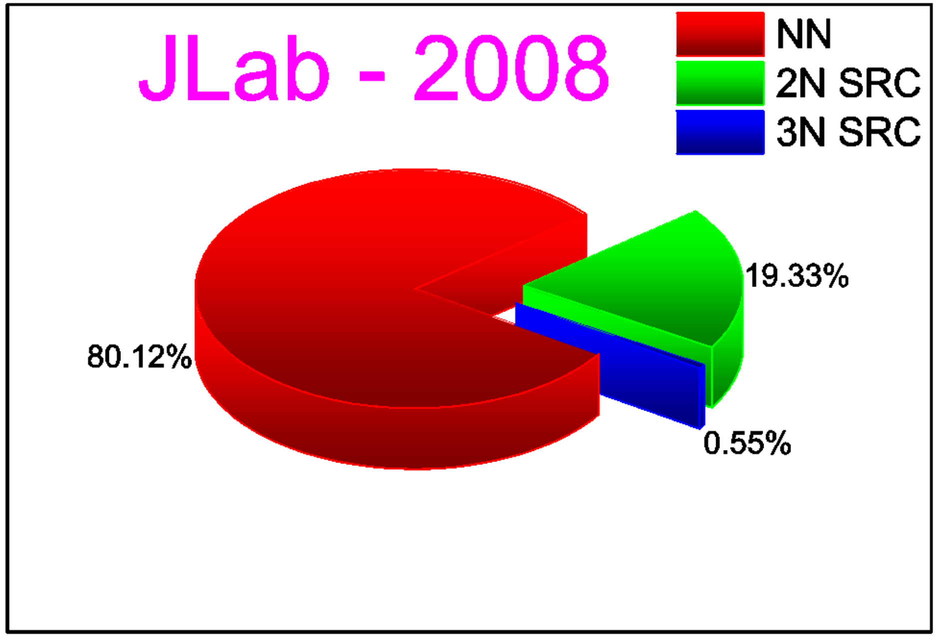
RNP - program at JINR

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]





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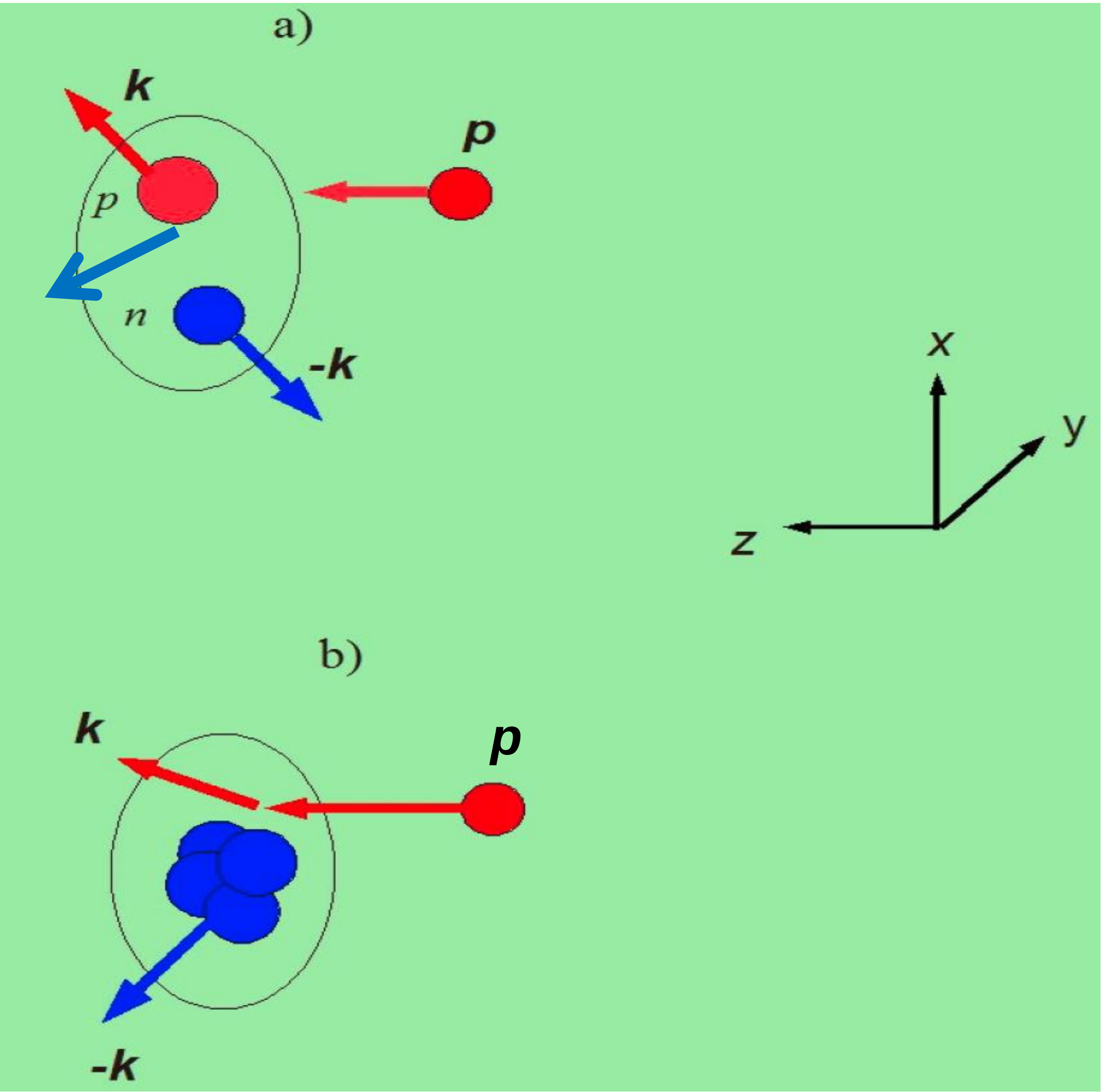
Knot out cold dense nuclear configurations

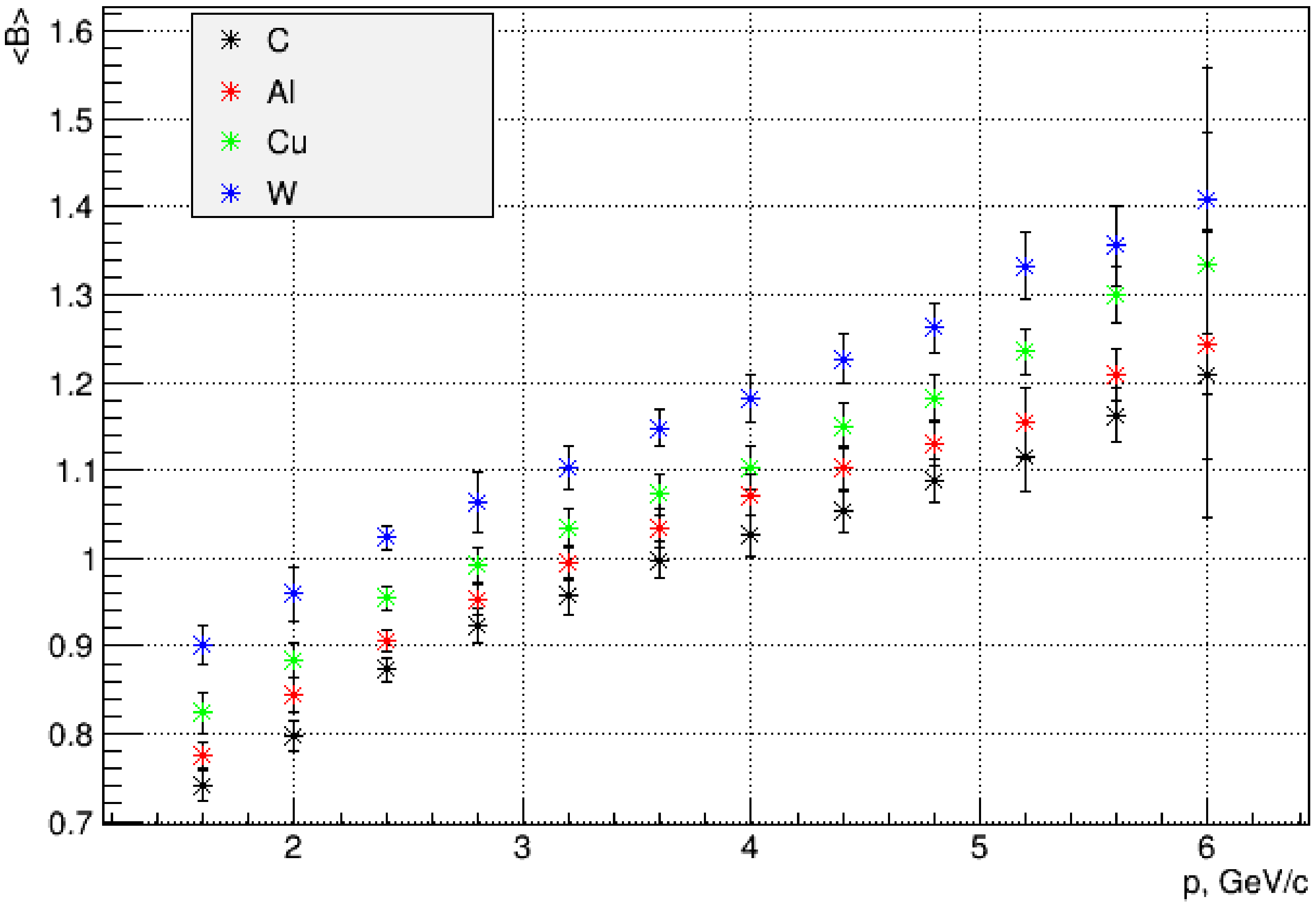
SRC configuration

Multiquark configuration



N.N. Antonov et al., JETP Letters, Vol.101, No.10, pp.670-673(2015)

Average baryon number <B>



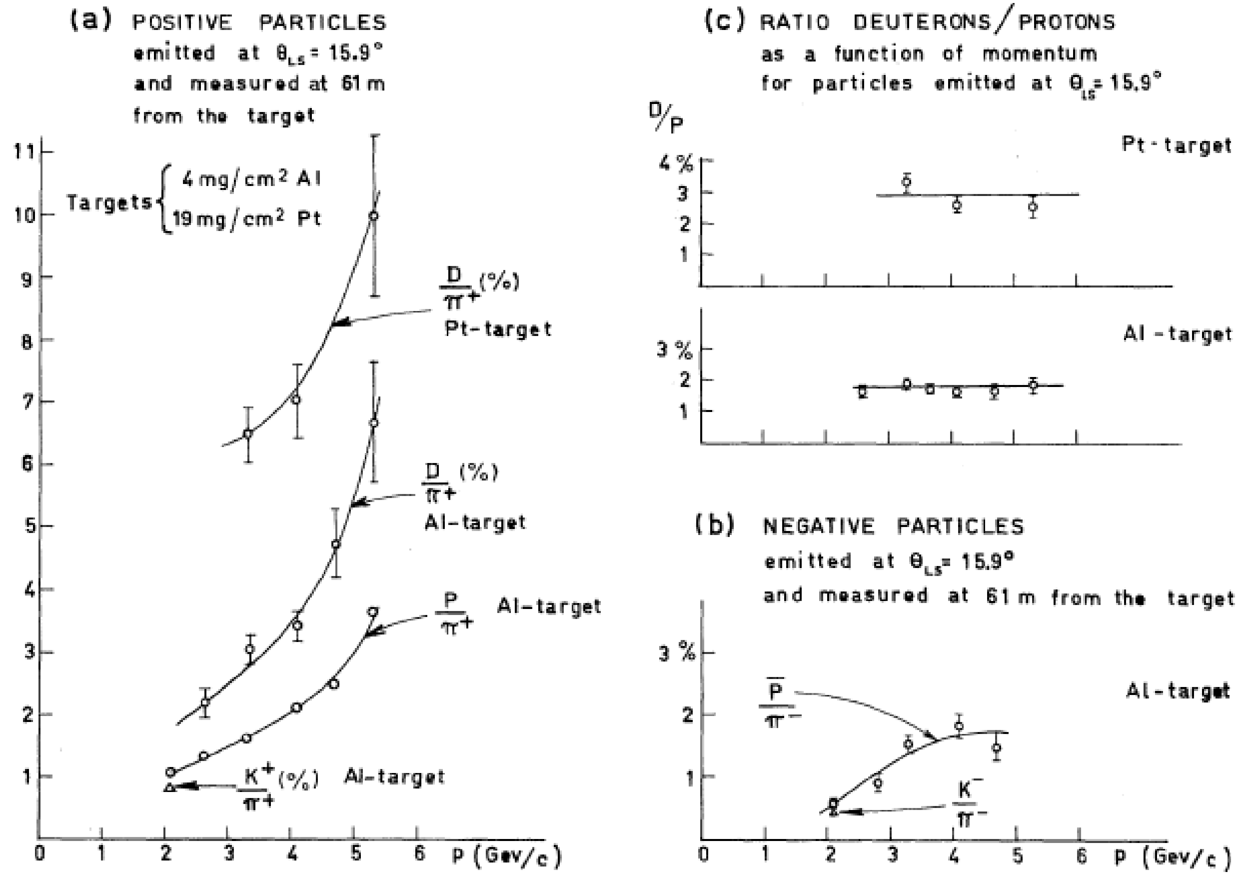
VOLUME 5, NUMBER 1 PHYSICAL REVIEW LETTERS JULY 1, 1960

MASS ANALYSIS OF THE SECONDARY PARTICLES PRODUCED BY THE 25-GEV PROTON BEAM OF THE CERN PROTON SYNCHROTRON

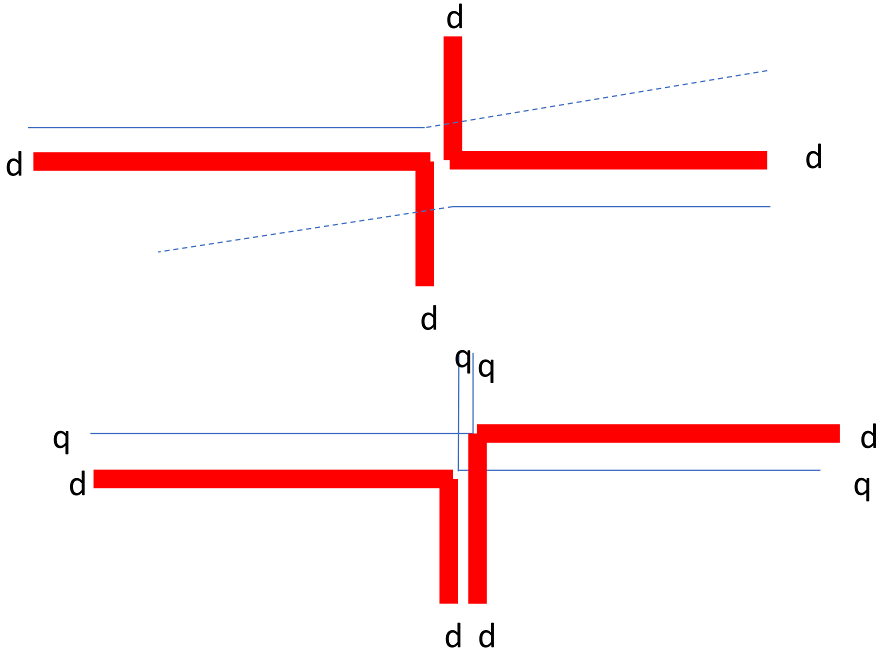
V. T. Cocconi,* T. Fazzini, G. Fidecaro, M. Legros,† N. H. Lipman, and A. W. Merrison
CERN, Geneva, Switzerland

(Received June 1, 1960)

We present here some results of a mass analysis of the secondary particles produced at 15.9° to the circulating beam in an aluminum target bombarded by 25-Gev protons in the CERN proton synchrotron.



pp - > p + X, pp -> D + X reactions with diquarks

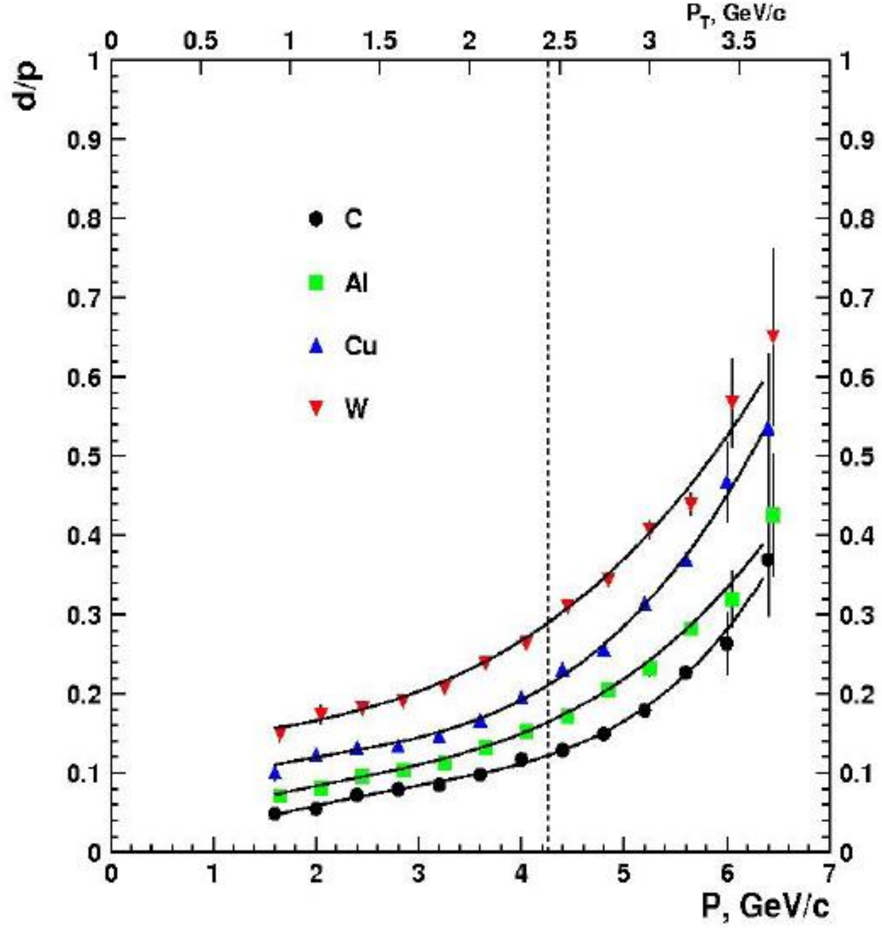


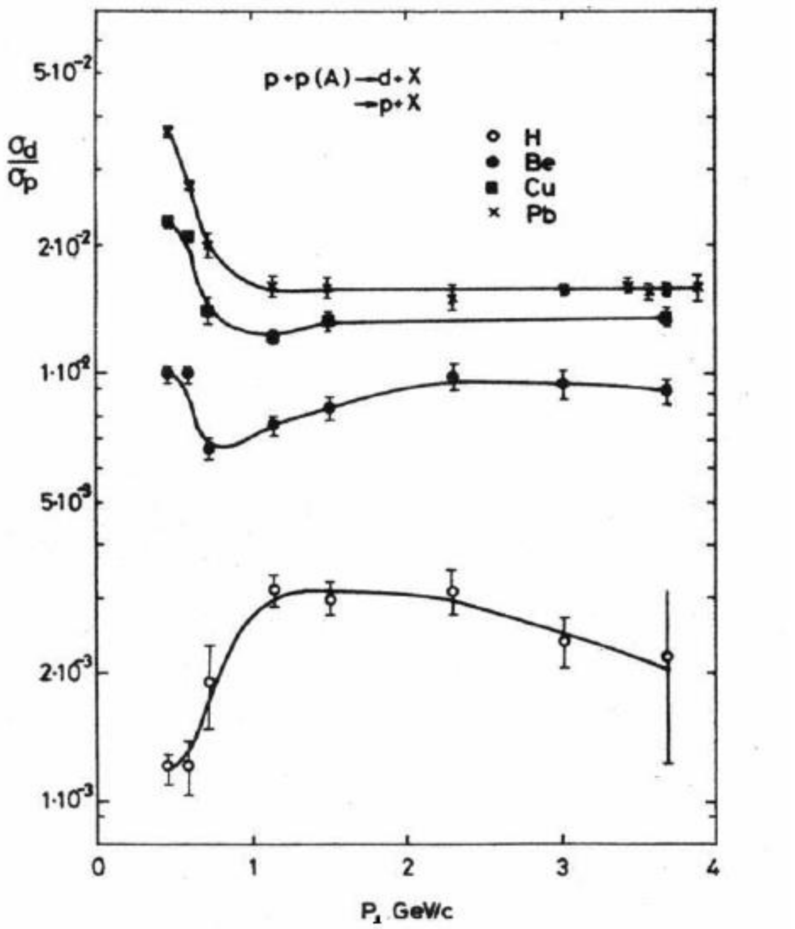
Kim's mechanisms

Ratio d/p

SPIN data

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





PHYSICAL REVIEW VOLUME 126, NUMBER 5 JUNE 1, 1962

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 $13\frac{1}{4}$° 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.

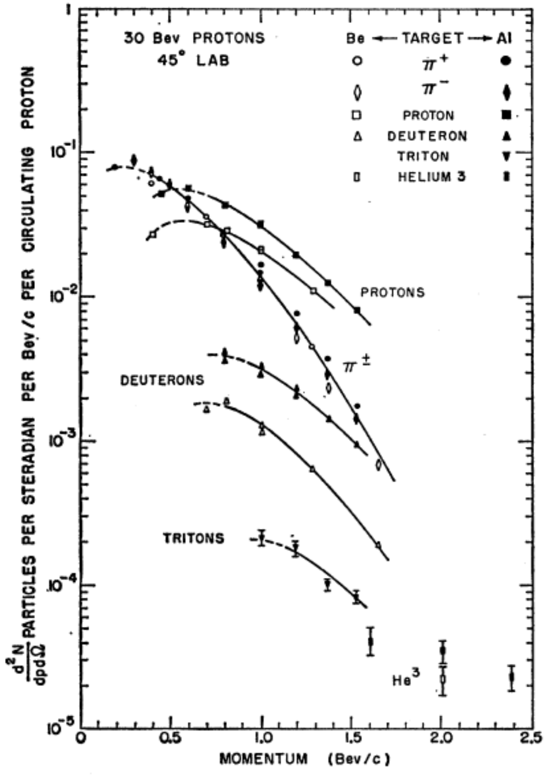


FIG. 3. Momentum spectra of particles emitted at 45° from aluminum and beryllium targets when struck by 30-Bev protons. Tritons from Be were not measured. For general remarks refer to Fig. 2 caption.

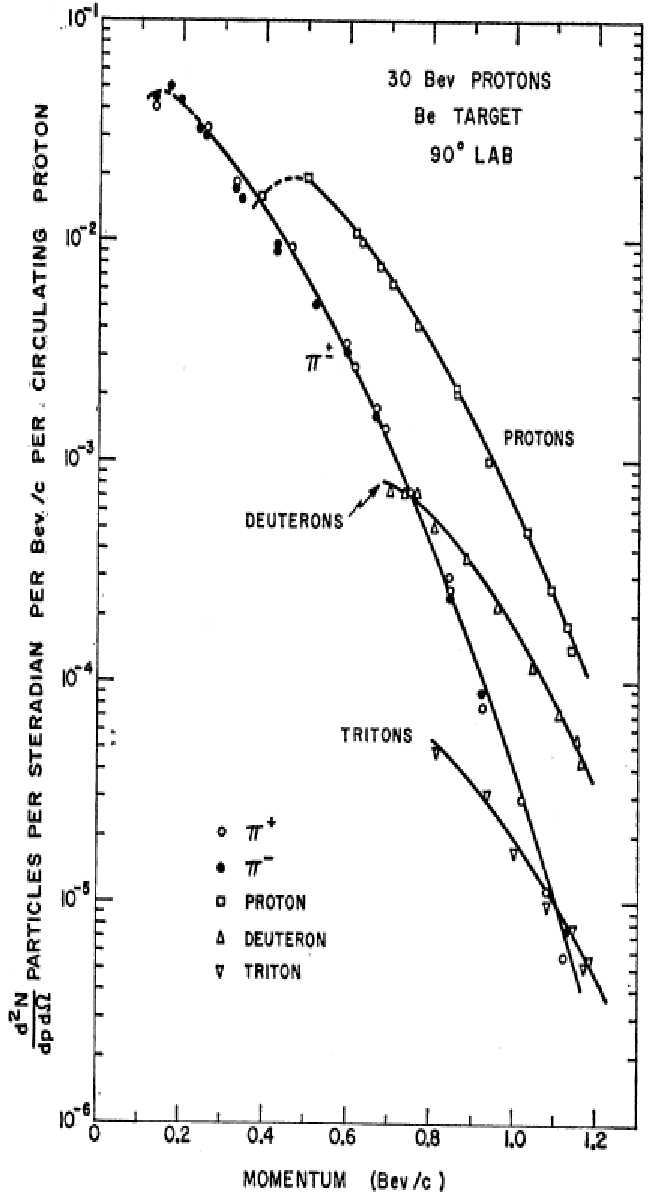
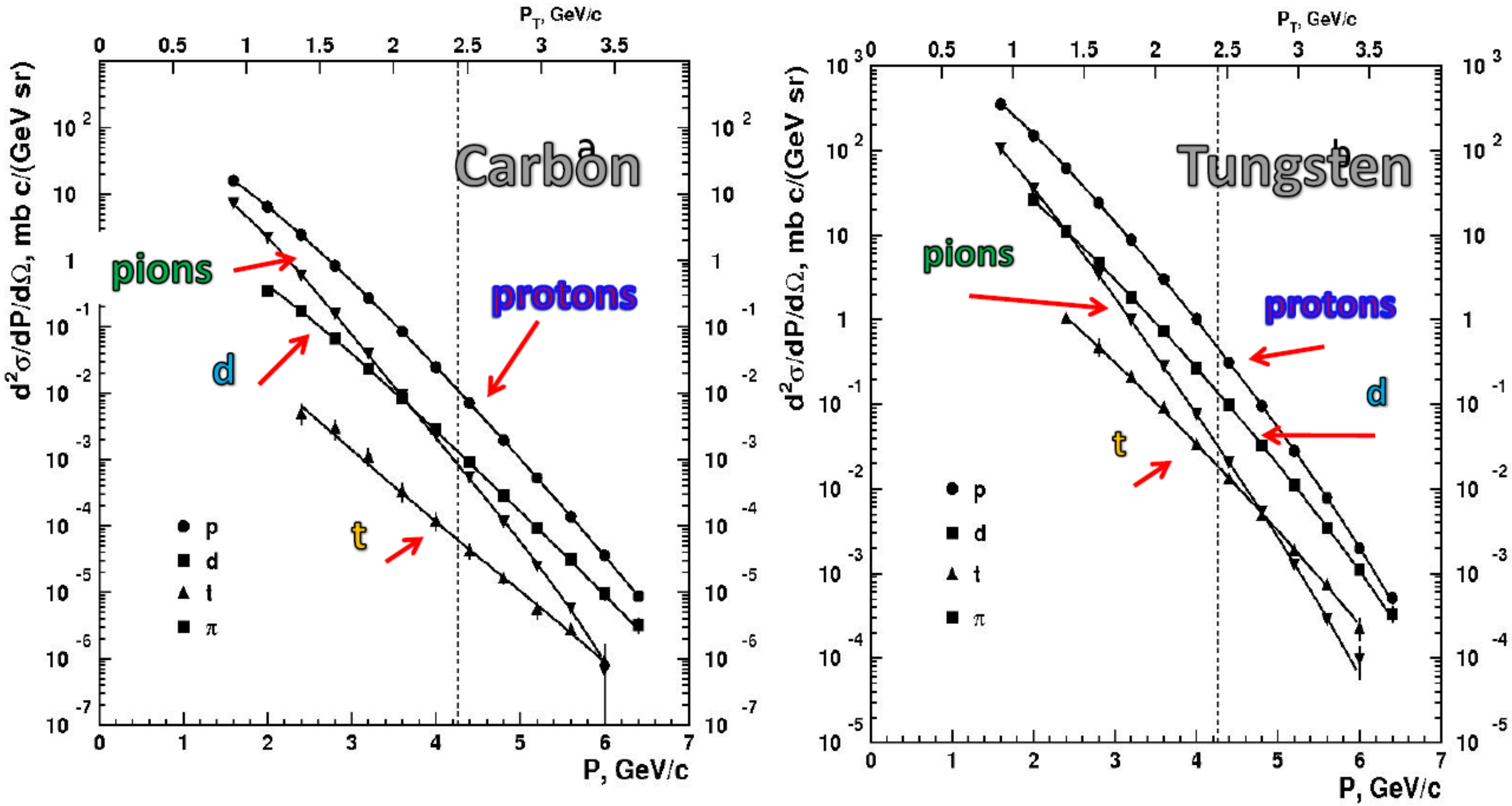


FIG. 2. Momentum spectrum of particles emitted at 90° from a beryllium target struck by 30-Bev protons. The ordinate is the number of particles produced at the target per steradian per Bev/c per circulating proton. The dashed portions of the curves indicate regions where the corrections due to multiple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

SPIN data

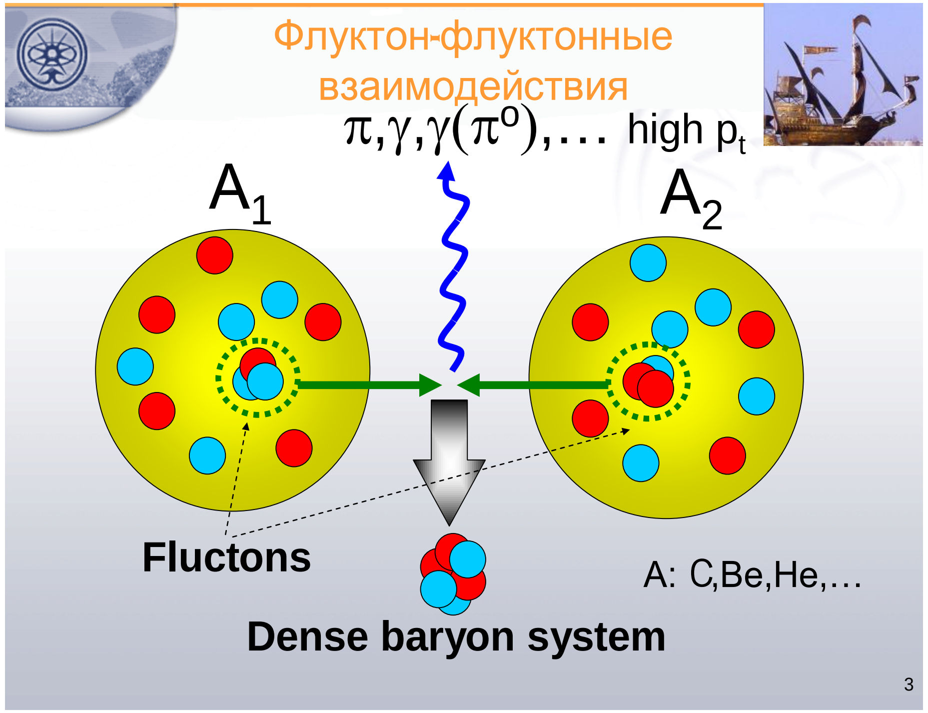
N.N. Antonov et al., *JETP Letters*, Vol.101, No.10, pp.670-673(2015)



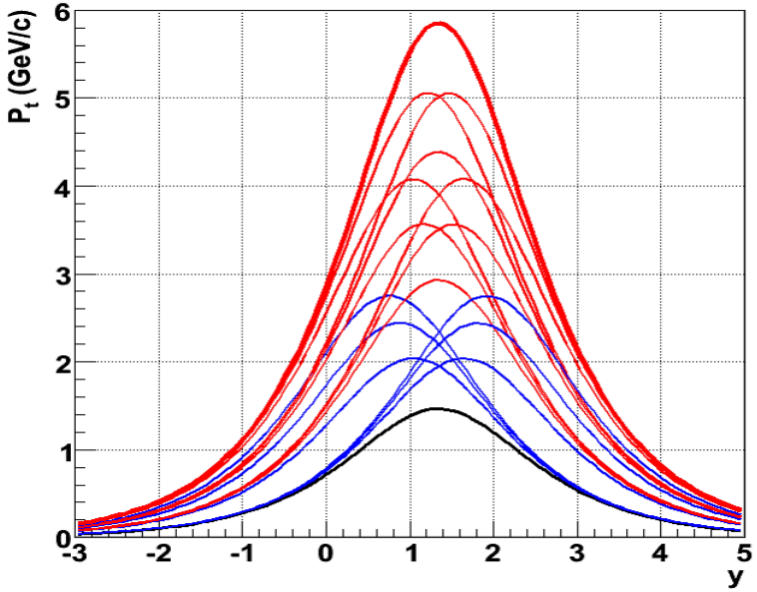
Invariant function found for positive pion, proton, deuteron and triton.

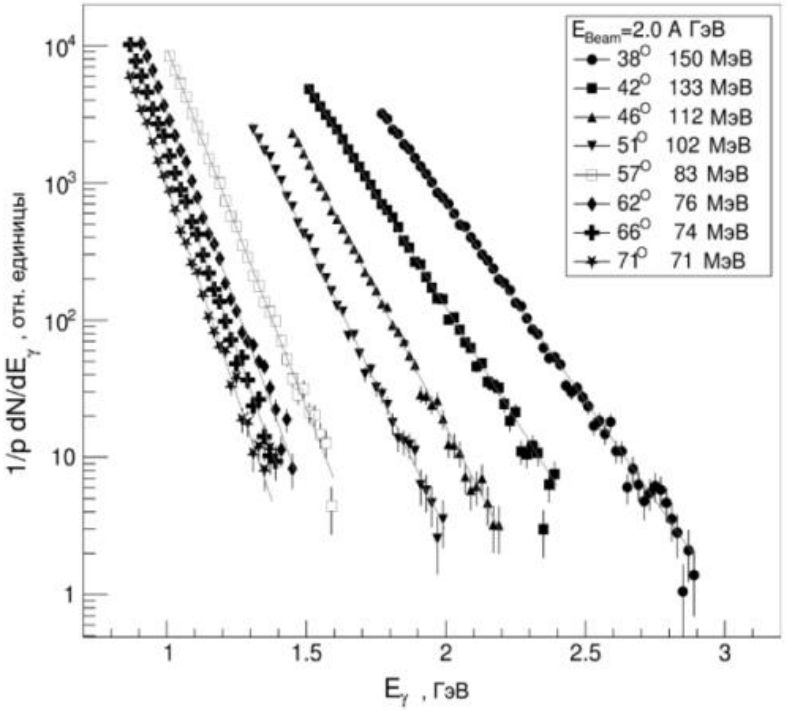
The vertical dashed lines indicate the kinematical limit for elastic nucleon–nucleon scattering. The upper horizontal scale shows values of the transverse momentum p_T .

ITEP high p_T data



Флуктон-флуктонные взаимодействия





I.G.Alekseev et.al.(FLINT), ЯФ 71(2008)1;
A.Stavinskiy, EPJ Web Conf. 71 (2014) 00125;
K.R. Mikhailov et al.,_Phys.Atom.Nucl. 77 (2014) 576;
ЯФ 77 (2014) 610

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

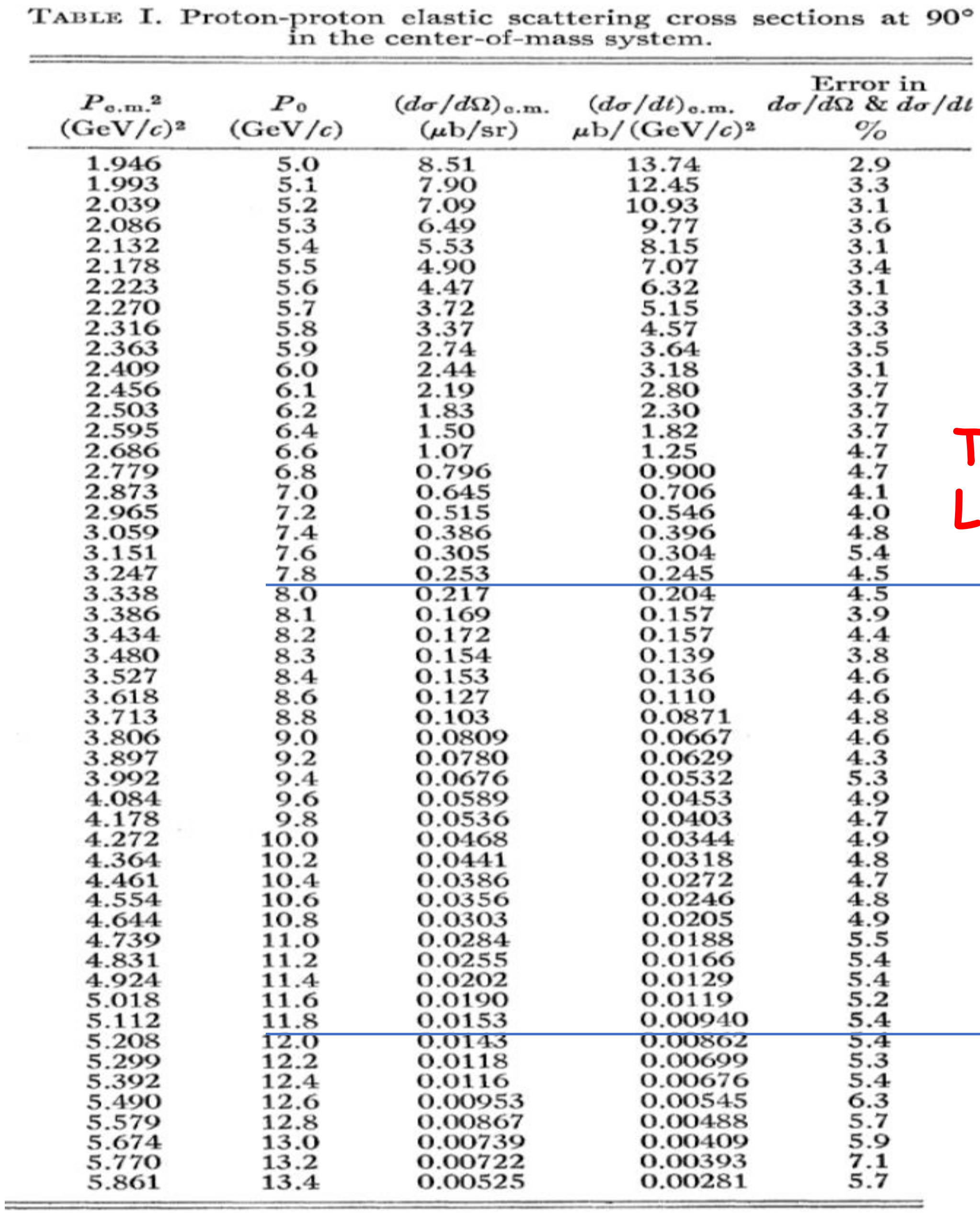


TABLE I. Proton-proton elastic scattering cross sections at 90° in the center-of-mass system.

$P_{c.m.}^2$ $(GeV/c)^2$	P_0 (GeV/c)	$(d\sigma/d\Omega)_{c.m.}$ $(\mu b/sr)$	$(d\sigma/dt)_{c.m.}$ $\mu b/(GeV/c)^2$	Error in $d\sigma/d\Omega$ & $d\sigma/dt$ %
1.946	5.0	8.51	13.74	2.9
1.993	5.1	7.90	12.45	3.3
2.039	5.2	7.09	10.93	3.1
2.086	5.3	6.49	9.77	3.6
2.132	5.4	5.53	8.15	3.1
2.178	5.5	4.90	7.07	3.4
2.223	5.6	4.47	6.32	3.1
2.270	5.7	3.72	5.15	3.3
2.316	5.8	3.37	4.57	3.3
2.363	5.9	2.74	3.64	3.5
2.409	6.0	2.44	3.18	3.1
2.456	6.1	2.19	2.80	3.7
2.503	6.2	1.83	2.30	3.7
2.595	6.4	1.50	1.82	3.7
2.686	6.6	1.07	1.25	4.7
2.779	6.8	0.796	0.900	4.7
2.873	7.0	0.645	0.706	4.1
2.965	7.2	0.515	0.546	4.0
3.059	7.4	0.386	0.396	4.8
3.151	7.6	0.305	0.304	5.4
3.247	7.8	0.253	0.245	4.5
3.338	8.0	0.217	0.204	4.5
3.386	8.1	0.169	0.157	3.9
3.434	8.2	0.172	0.157	4.4
3.480	8.3	0.154	0.139	3.8
3.527	8.4	0.153	0.136	4.6
3.618	8.6	0.127	0.110	4.6
3.713	8.8	0.103	0.0871	4.8
3.806	9.0	0.0809	0.0667	4.6
3.897	9.2	0.0780	0.0629	4.3
3.992	9.4	0.0676	0.0532	5.3
4.084	9.6	0.0589	0.0453	4.9
4.178	9.8	0.0536	0.0403	4.7
4.272	10.0	0.0468	0.0344	4.9
4.364	10.2	0.0441	0.0318	4.8
4.461	10.4	0.0386	0.0272	4.7
4.554	10.6	0.0356	0.0246	4.8
4.644	10.8	0.0303	0.0205	4.9
4.739	11.0	0.0284	0.0188	5.5
4.831	11.2	0.0255	0.0166	5.4
4.924	11.4	0.0202	0.0129	5.4
5.018	11.6	0.0190	0.0119	5.2
5.112	11.8	0.0153	0.00940	5.4
5.208	12.0	0.0143	0.00862	5.4
5.299	12.2	0.0118	0.00699	5.3
5.392	12.4	0.0116	0.00676	5.4
5.490	12.6	0.00953	0.00545	6.3
5.579	12.8	0.00867	0.00488	5.7
5.674	13.0	0.00739	0.00409	5.9
5.770	13.2	0.00722	0.00393	7.1
5.861	13.4	0.00525	0.00281	5.7

The rate for
L~ 10^{30} $cm^{-2}c^{-1}$:

~ 0.2 c^{-1}

~ 0.01 c^{-1}