High p_T phenomena at SPD

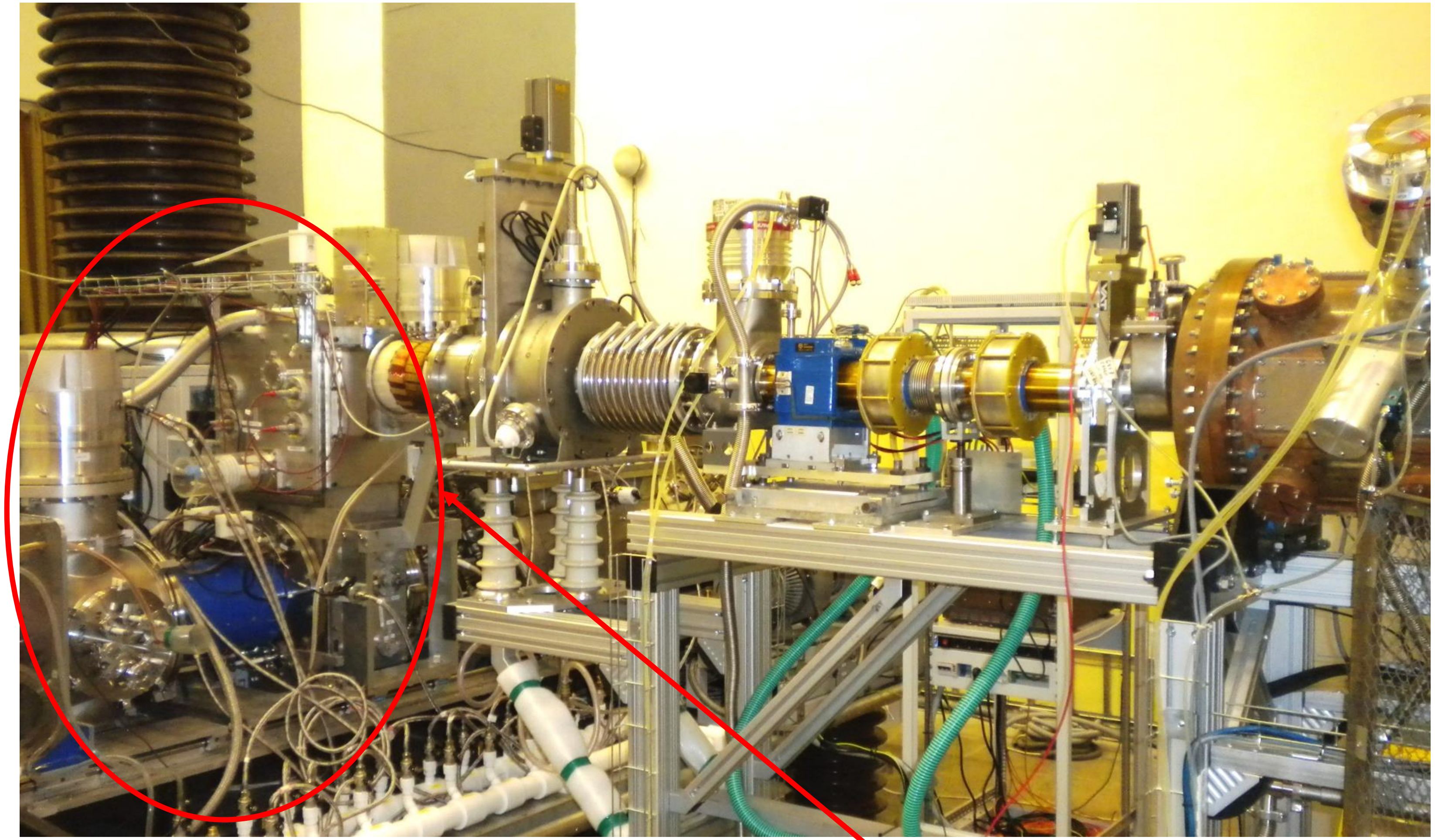
Shimanskiy S.S. (JINR, Dubna)

"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'

SPI

Implementation of polarized beam program



Equipment of new polarized ion source SPI and LEBT part of beam channel to RFQ section

A.D.Kovalenko

ISSN 1547-4771, Physics of Particles and Nuclei Letters, 2009, Vol. 6, No. 1, pp. 48–58. © Pleiades Publishing, Ltd., 2009.
Original Russian Text © S. Vokal, A.D. Kovalenko, A.M. Kondratenko, M.A. Kondratenko, V.A. Mikhailov, Yu.N. Filatov, S.S. Shimanskii, 2009, published in Pis'ma v Zhurnal Fizika Elementarnykh Chastits i Atomnogo Yadra, 2009, No. 1 (149), pp. 81–96.

PHYSICS OF ELEMENTARY PARTICLES AND ATOMIC NUCLEI. EXPERIMENT

Program of Polarization Studies and Capabilities of Accelerating Polarized Proton and Light Nuclear Beams at the Nuclotron of the Joint Institute for Nuclear Research

S. Vokal[a], A. D. Kovalenko[a], A. M. Kondratenko[b], M. A. Kondratenko[b], V. A. Mikhailov[a], Yu. N. Filatov[a], and S. S. Shimanskii[a]

(i) investigate *pp*, *pd*, *dd*, p^3He, d^3He, ^{3}He^{3}He collisions with polarized beams, which will allow one to solve the puzzles of the spin structure of nucleons and lightest nuclei and elucidate the specific features of the spin structure of interaction in the region of nonperturbative QCD; it is especially important that it will be possible for the first time to study the interaction of polarized nuclear matter whose properties may determine the structure of the core of massive stars with great magnetic fields;

(ii) elucidate the nature of strong polarization effects in *NN* interactions at $p_{\text{lab}} > 6$ GeV in the region of limiting large p_T, which has not been explained yet, and find out how these specific features are related to the change of behavior of valence quarks in this kinematic region; the availability of polarized nuclei at a collider will allow one to study the complete isotopic set of states of nucleon–nucleon system (*nn*, *pn*, and *pp*) for the first time;

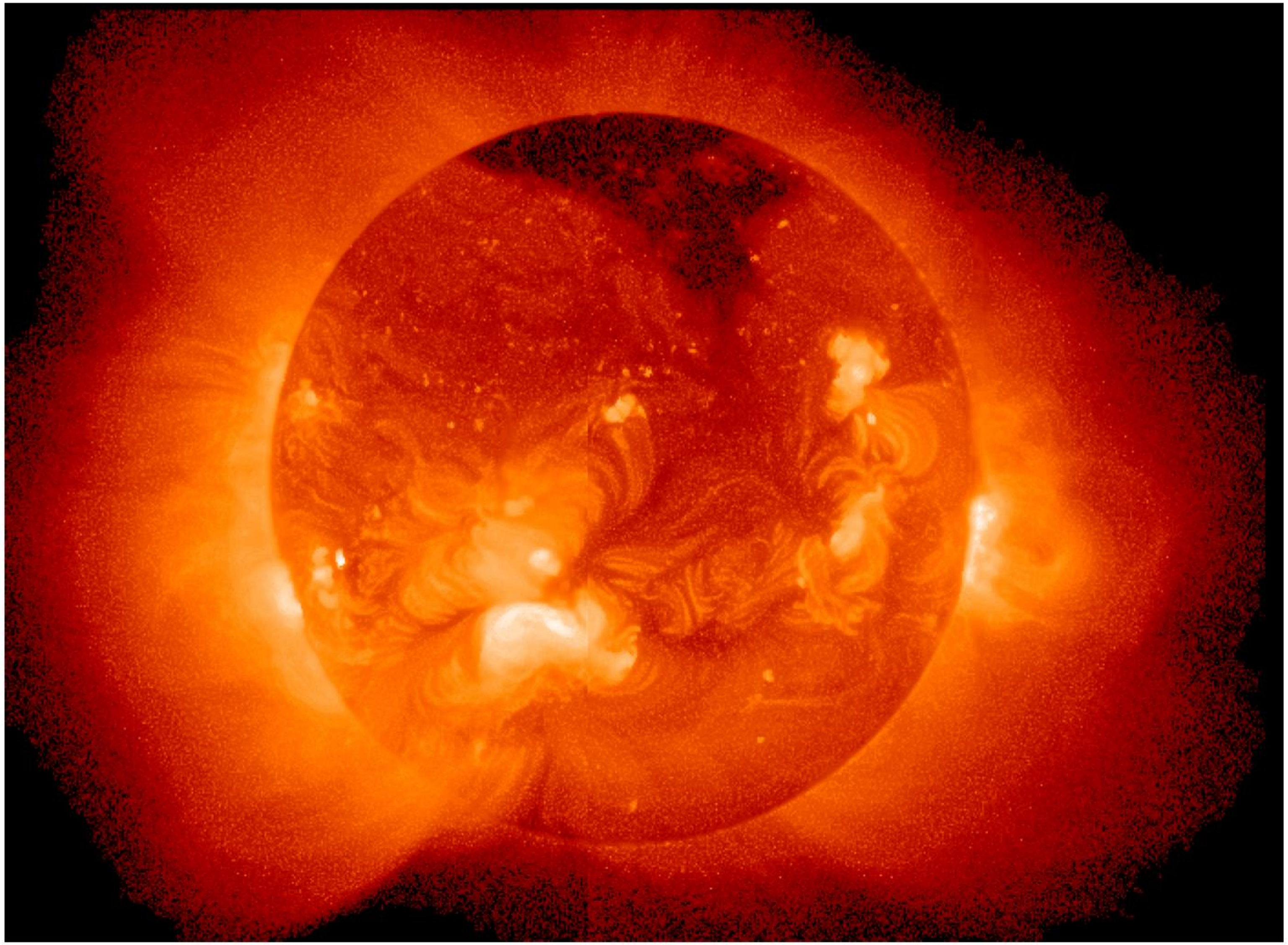
(iii) study in detail the problems of *P* and *T* parity violation in *NN* interactions;

(iv) solve the problem of the nature of cumulative (subthreshold) processes;

(v) elucidate the nature of quark counting rules violation and determine the region of their applicability (including at interaction of lightest nuclei);

(vi) solve the puzzle of resonance behavior of color transparency at $p_{\text{lab}} \sim 9.5$ GeV/*c* ($p_T \sim 2$ GeV/*c*).

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



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

astro-ph/0604422 v1 20 Apr 2006

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

H ~ 10^{17} Gs

E~ 10^{19} V/cm

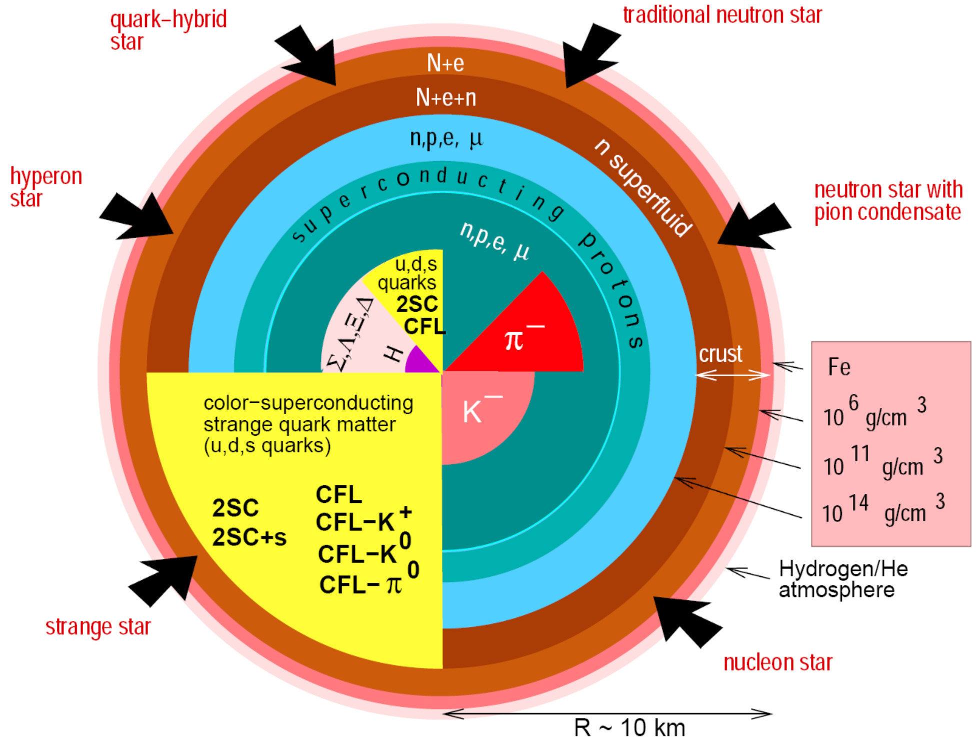


Fig. 1. Competing structures and novel phases of subatomic matter predicted by theory to make their appearances in the cores ($R \lesssim 8$ km) of neutron stars[4].

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

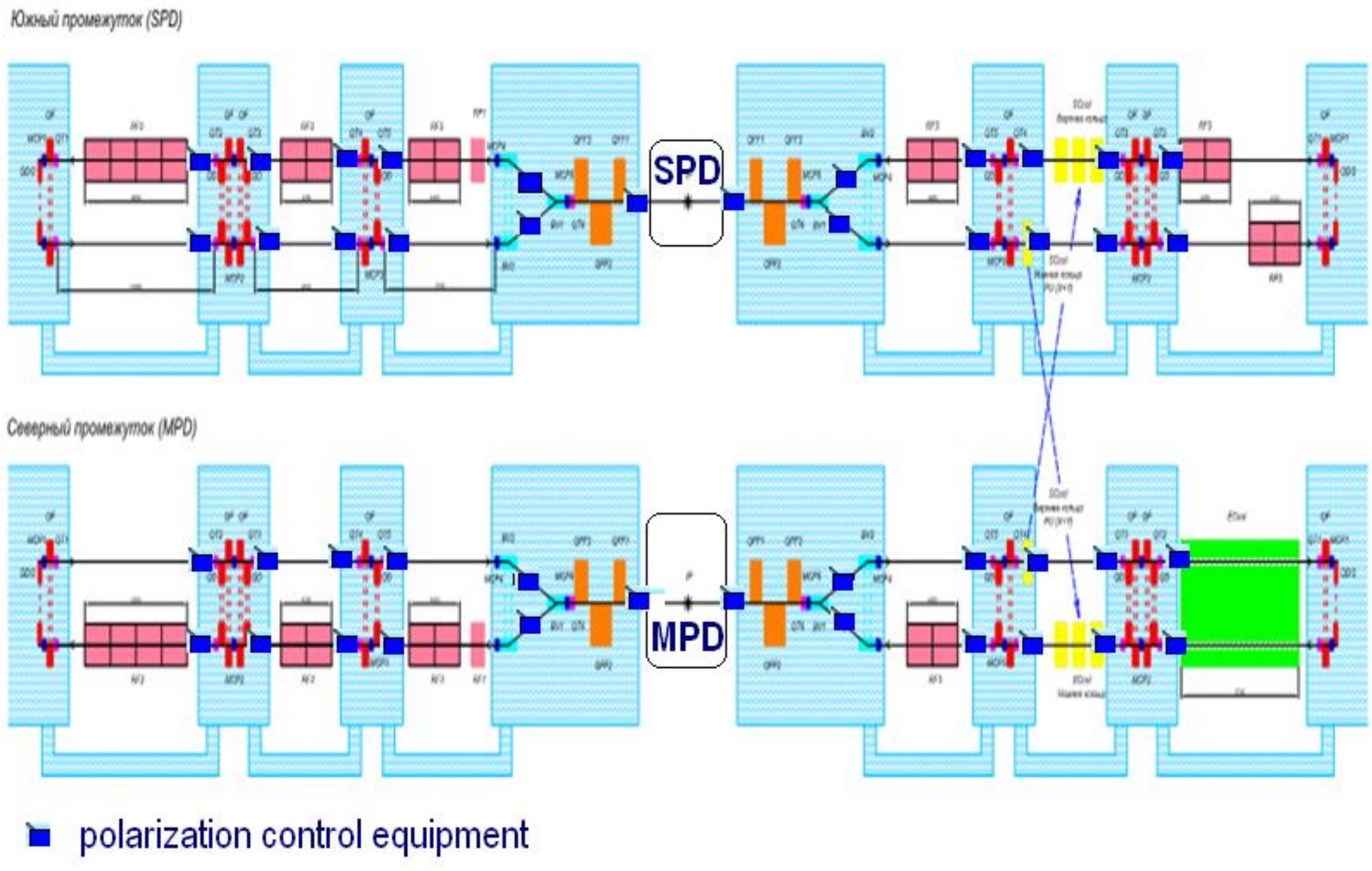
color−superconducting strange quark matter (u,d,s quarks)

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.

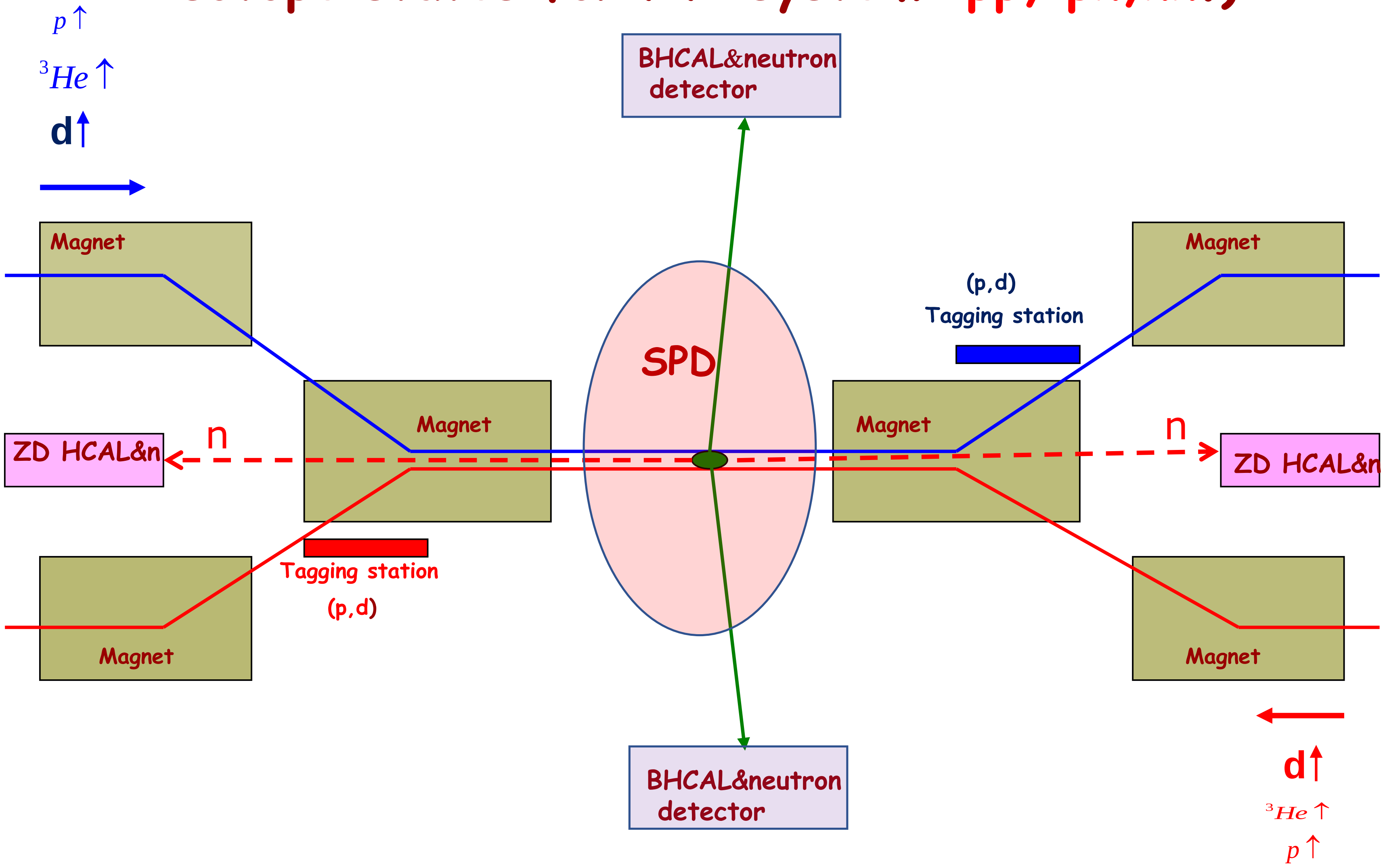
Collider NICA

Polarization control in the Collider at $\nu_s = 0$

option 1: combination of the solenoids and RF

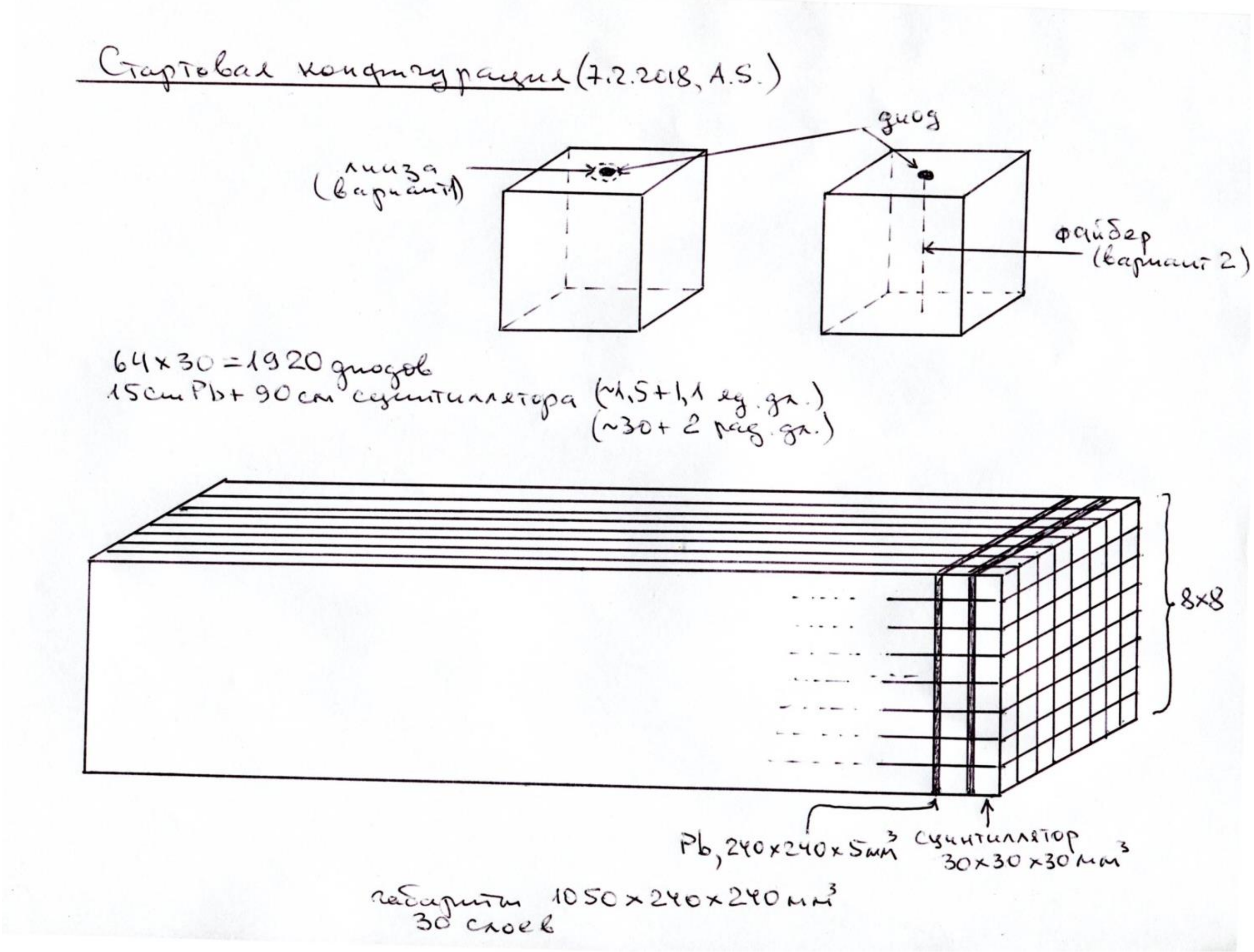


NICA Collision place for SPIN physics (deuteron and other beams, the first time all isotope states for NN system: pp, pn,nn.)



The tagging stations can be used as polarimeter!

Neutron Calorimeter



Available online at www.sciencedirect.com
SCIENCE DIRECT®
Nuclear Instruments and Methods in Physics Research A 553 (2005) 70–75
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

Focusing aerogel RICH (FARICH) ☆

A.Yu. Barnyakov[a], M.Yu. Barnyakov[a], V.S. Bobrovnikov[a], A.R. Buzykaev[a], A.F. Danilyuk[b,*], V.L. Kirillov[b], S.A. Kononov[a], E.A. Kravchenko[a], A.P. Onuchin[a]

[a] *Budker Institute of Nuclear Physics, Novosibirsk, Russia*
[b] *Boreskov Institute of Catalysis, Novosibirsk, Russia*

Available online 9 September 2005

For the first time in the world we have developed a technique for production of multilayer aerogels (SAN-MULTI). A few samples consisting of four aerogel layers with indices from 1.022 to 1.030 have been produced.

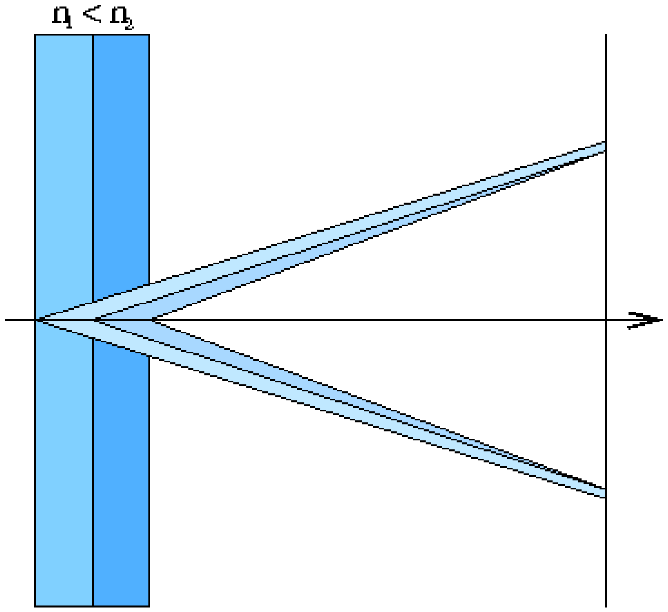
A GEANT4 based simulation program has been developed. Velocity resolution was investigated for different momenta and particle incidence angles. It was shown that velocity resolution of 5×10^{-4} is achievable. This permits us to have π/K separation at the level of more than 3σ up to momentum 8.0 GeV/c, π/μ separation up to momentum 1.6 GeV/c.

FARICH concept

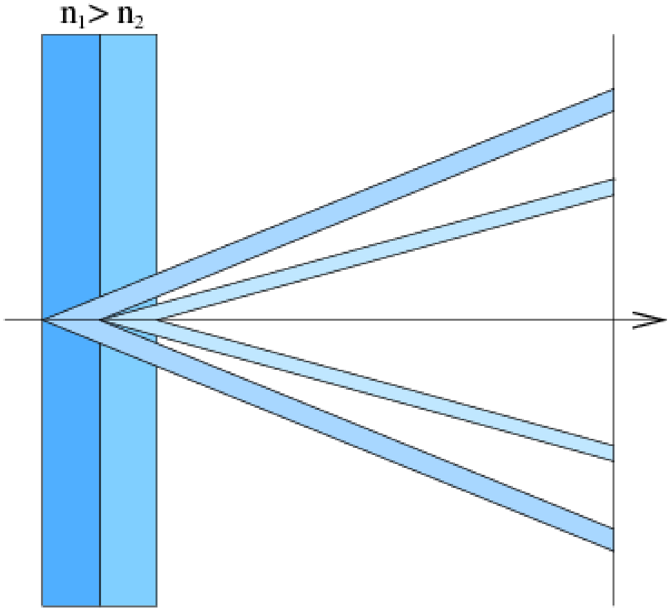
Focusing Aerogel RICH – FARICH

Improves proximity focusing design by reducing radiator thickness contribution into the Cherenkov angle resolution

Single ring option



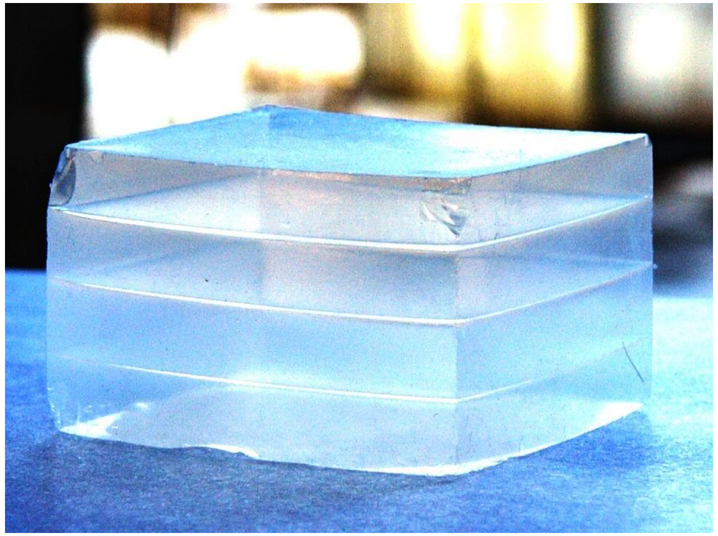
Multi-ring option



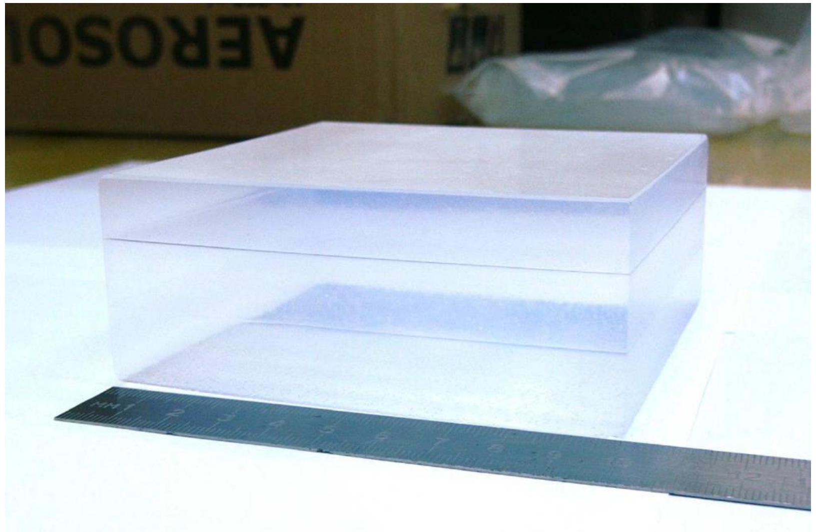
T.Iijima et al., NIM A548 (2005) 383
A.Yu.Barnyakov et al., NIM A553 (2005) 70

Multi-layer 'focusing' aerogels

- Produced by Boreskov Institute of Catalysis (Novosibirsk) in cooperation with Budker Institute since 2004

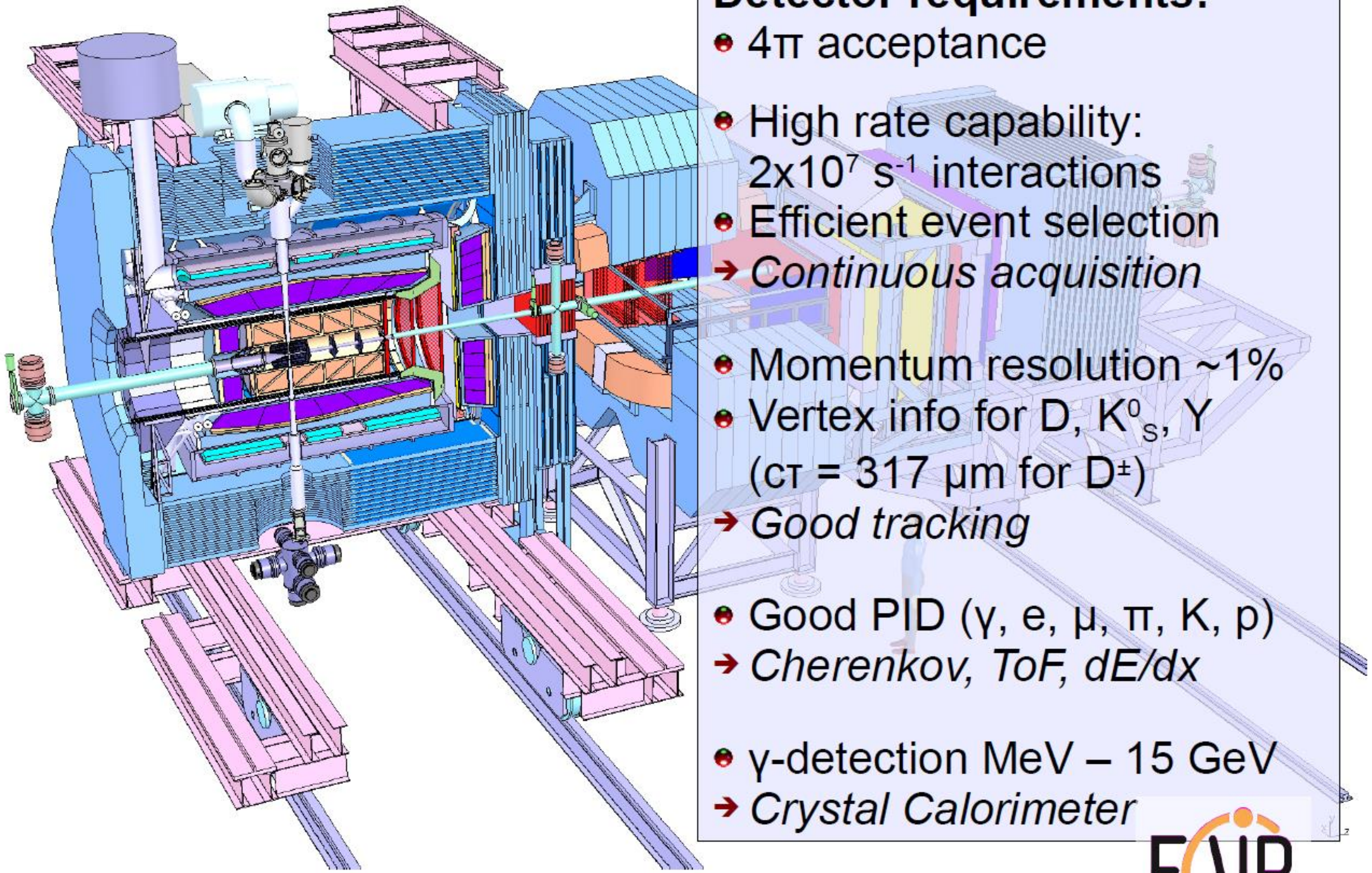


First 4-layer sample produced in 2004
A.Yu.Barnyakov et al., NIM A553 (2005) 70



DETECTOR

PANDA Spectrometer



Detector requirements:

- 4π acceptance

- High rate capability: $2\text{x}10^7\ s^{-1}$ interactions
- Efficient event selection

→ *Continuous acquisition*

- Momentum resolution ~1%
- Vertex info for D, K^0_S, Y ($c\tau$ = 317 μm for $D^{\pm}$)

→ *Good tracking*

- Good PID (γ, e, μ, π, K, p)

→ *Cherenkov, ToF, dE/dx*

- γ-detection MeV – 15 GeV

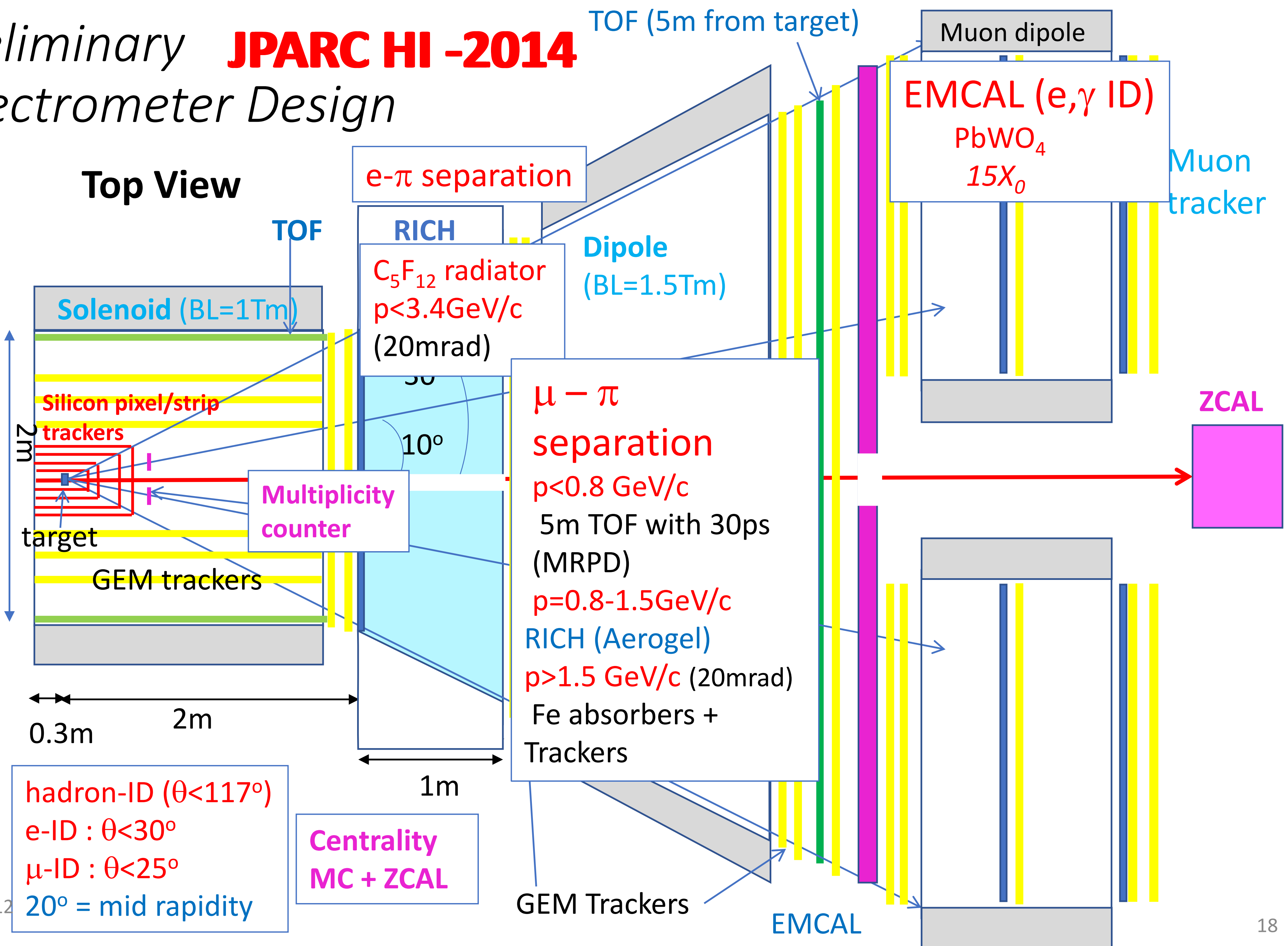
→ *Crystal Calorimeter*

Main PANDA advantages

The unique beam – no worldwide (FNAL closed antiproton activity) and $\Delta p/p \sim 10^{-5}$.

The unique detector - $\Delta\Omega \sim 4\pi$ -exclusive reactions investigation (correlations, backward range); working at luminosity ~ 10^{32} cm^{-2} s^{-1} – the very rare event can be investigated; PID – close to full energy range and high momentum resolution.

Preliminary JPARC HI -2014
Spectrometer Design



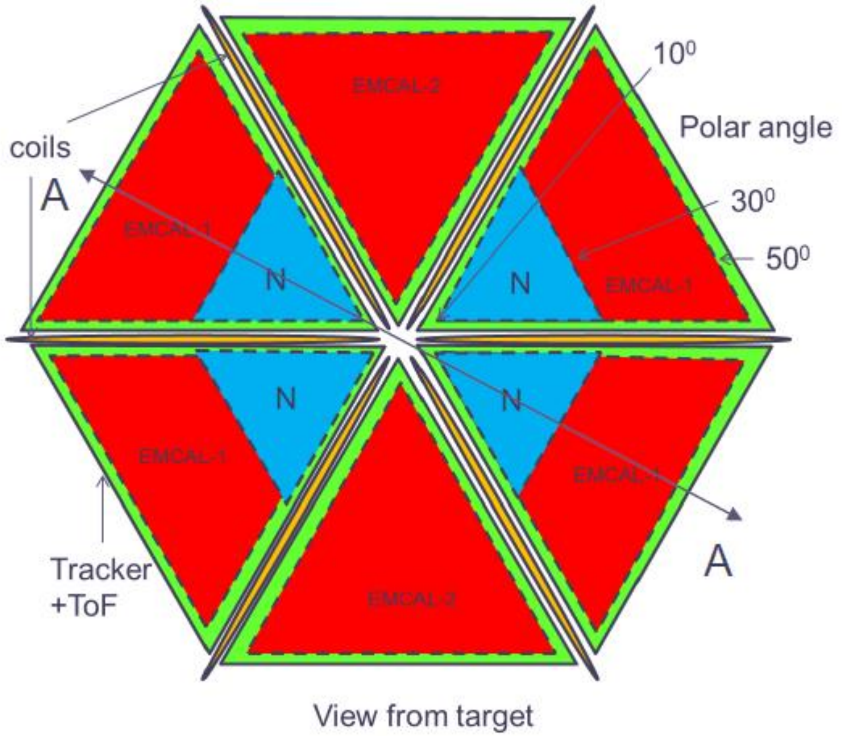
Dense Cold Matter (DCM) project

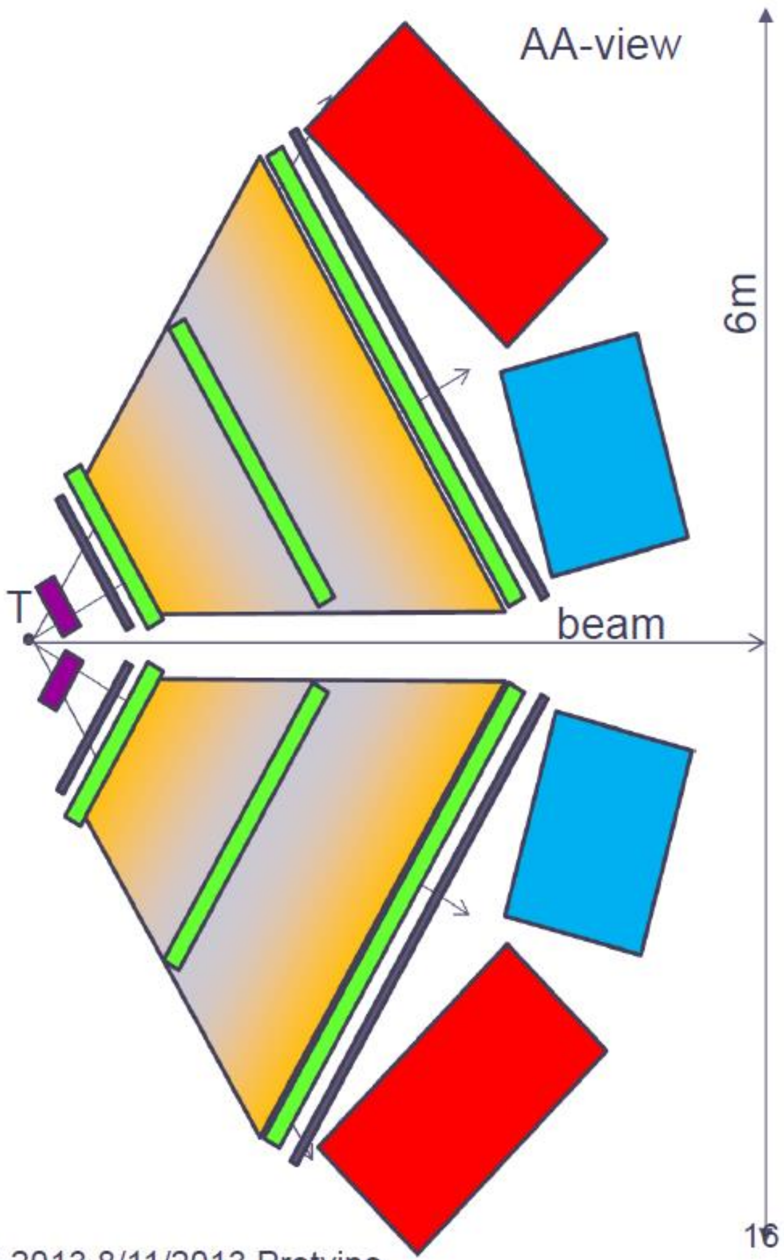
Search for and study of cold dense baryonic matter
(Letter of intent)

O.A.Chernishov [1],A.A.Golubev[1], V.S.Goryachev[1], A.G.Dolgolenko[1], M.M.Kats[1],
B.O.Kerbikov[1], S.M.Kiselev[1], Yu.T.Kiselev[1], A.Kogevnikov [1], K.R.Mikhailov[1],
N.A.Pivnyuk[1], P.A.Polozov[1], M.S.Prokudin[1], D.V.Romanov[1], V.K.Semyachkin[1],
A.V.Stavinskiy[1], V.L.Stolin[1], G.B.Sharkov[1] , N.M.Zhigareva[1], Yu.M.Zaitsev[1],
A.Andronenkov[2], A.Ya. Berdnikov[2] , Ya.A. Berdnikov[6], M.A. Braun[2], V.V. Vechernin[2],
L. Vinogradov[2], V. Gerebchevskiy[2], S. Igolkin[2], A.E. Ivanov[6], V.T. Kim[3,6],
A. Koloyvar[2], V.Kondrat'ev[2], V.A.Murzin[3], V.A. Oreshkin[3], D.P. Suetin[6] ,
G. Feofilov[2],A.A.Baldin[4], V.S.Batovskaya[4], Yu.T. Borzunov[4], A.V. Kulikov[4],
A.V. Konstantinov[4], L.V.Malinina[4,7],G.V.Mesheryakov[4],A.P.Nagaitsev[4], V.K. Rodionov[4],
S.S.Shimanskiy[4], O.Yu.Shevchenko[4] , A.V.Gapienko[5], V.I.Krishkin[5] , I.N.Dorofeeva[7],
M.M.Merkin[7], AA.Ershov[7], N.P.Zotov[7]

1). ITEP NRC KI , Moscow, 2). SPbSU, S.Peterburg, 3). PINP NRC KI, S.Peterburg,
4). LPHE,JINR,Dubna, 5). IHEP NRC KI, Protvino , 6). SPbSPU, S.Peterburg,
7).MSU,Moscow

4.Detector for DCM study





JPARC HI -2016

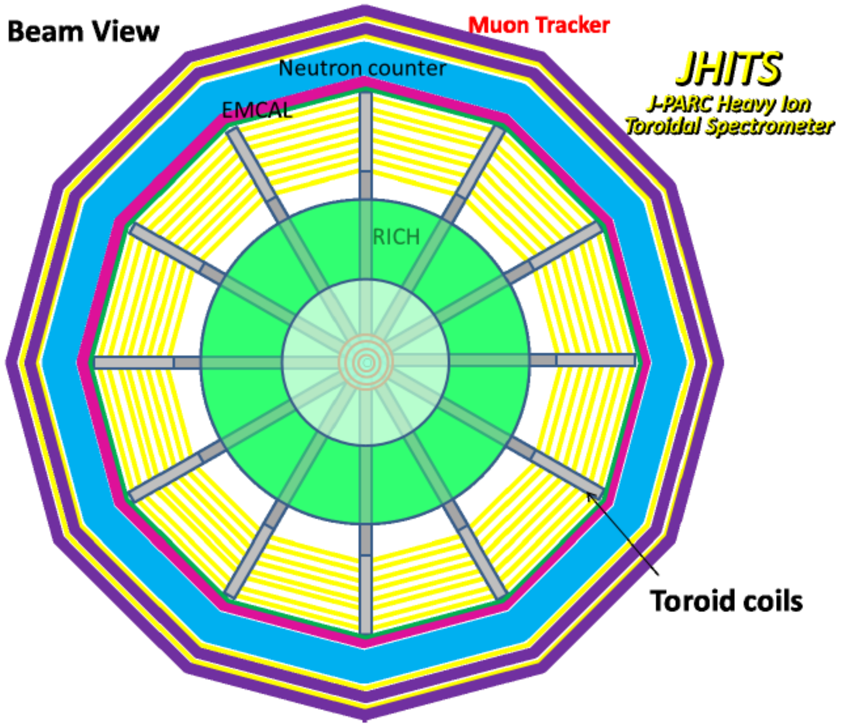


Figure 31: The beam view of the toroidal spectrometer (JHITS; J-PARC Heavy-Ion Toroidal Spectrometer).

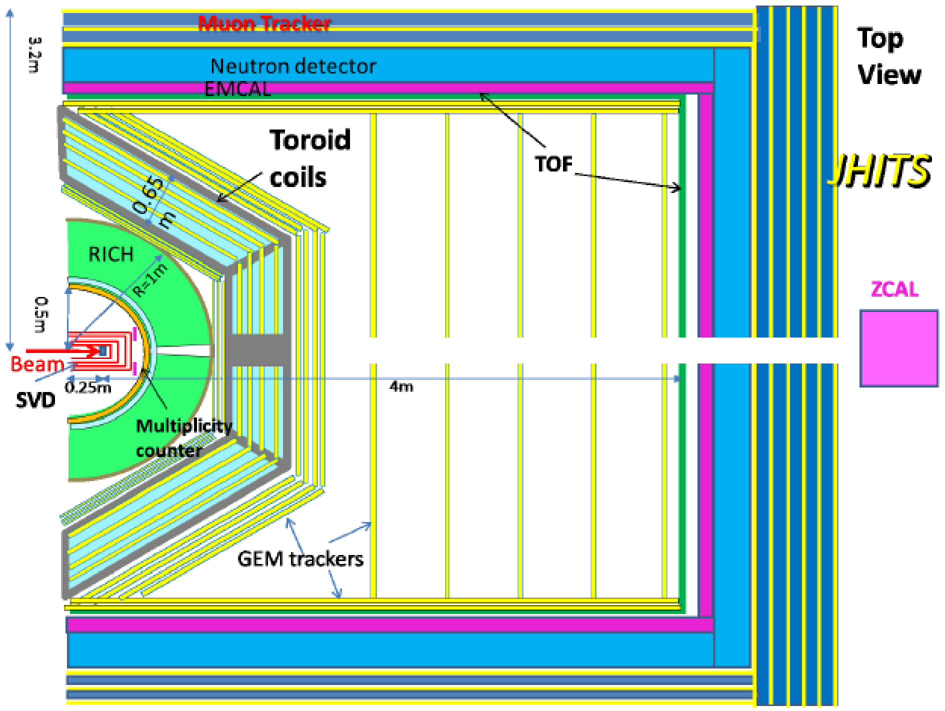


Figure 32: The top view of the toroidal spectrometer (JHITS; J-PARC Heavy-Ion Toroidal Spectrometer).

SPD ?!

High p_T Physics

ISSUES

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.

…

DIQUARK

Volume 8, number 3 PHYSICS LETTERS 1 February 1964

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

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**.

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.

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

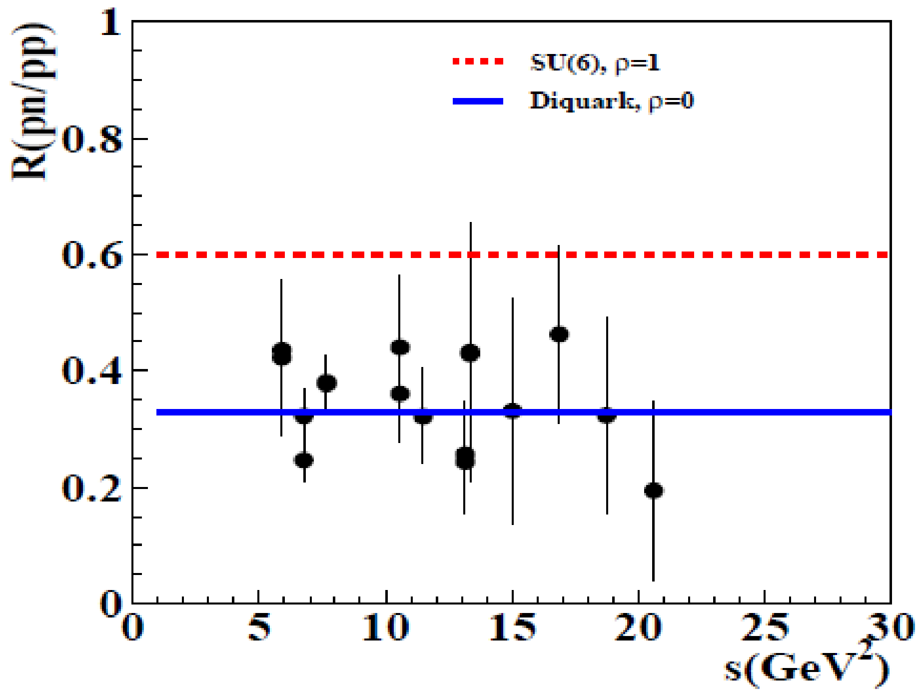
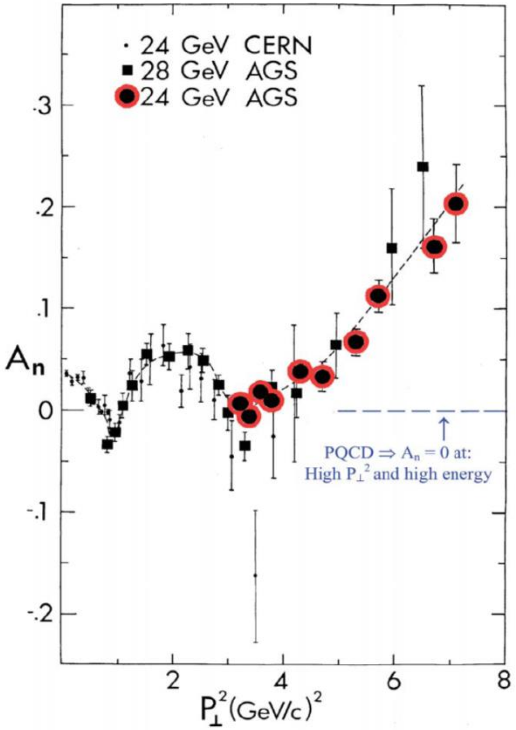


FIG. 2: (Color online) Ratio of the $pn \to pn$ to $pp \to pp$ elastic differential cross sections as a function of s at $\theta^N_{c.m.} = 90^0$.

“SPIN PROBLEMS” and NN-interaction



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})

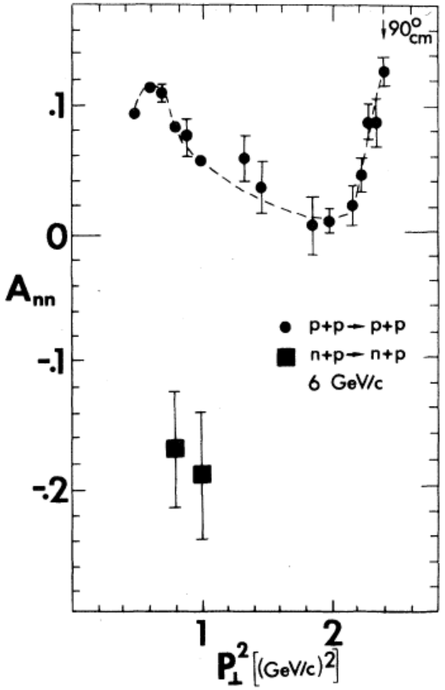
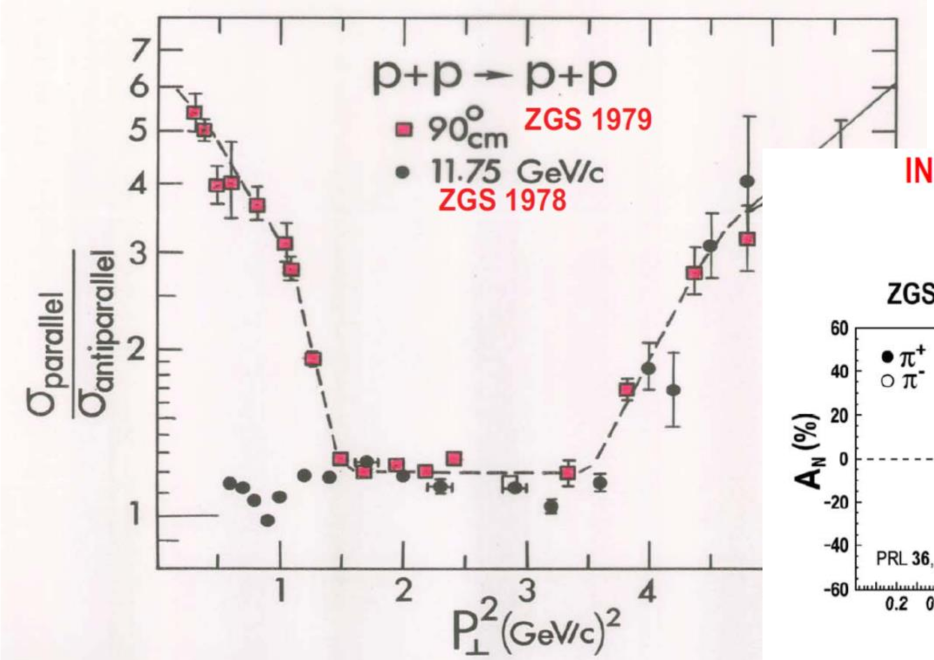
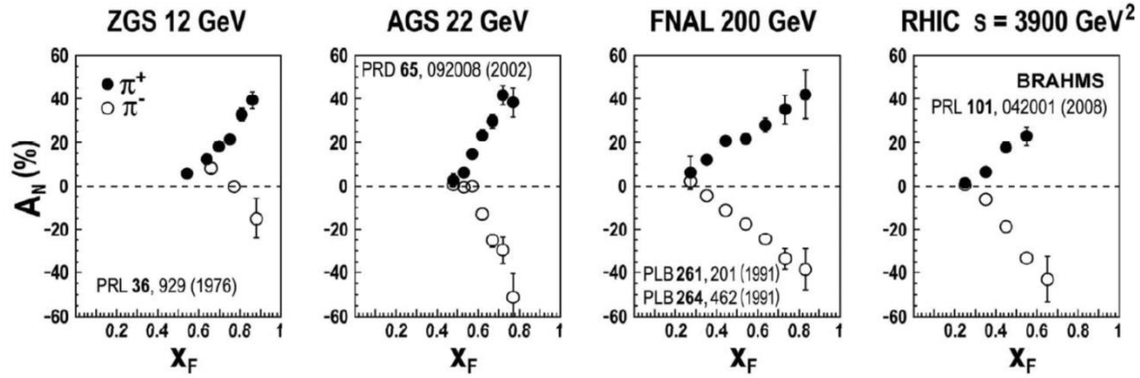


FIG. 2. The spin-spin correlation parameter, A_{nn}, for pure-initial-spin-state nucleon-nucleon elastic scattering at 6 GeV/c is plotted against the square of the transverse momentum. The proton-proton and neutron-proton data are quite different.

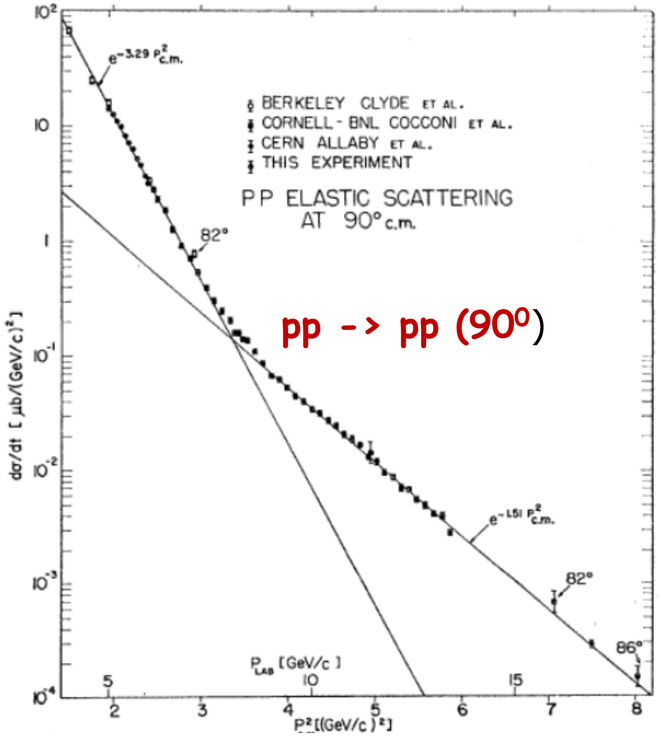


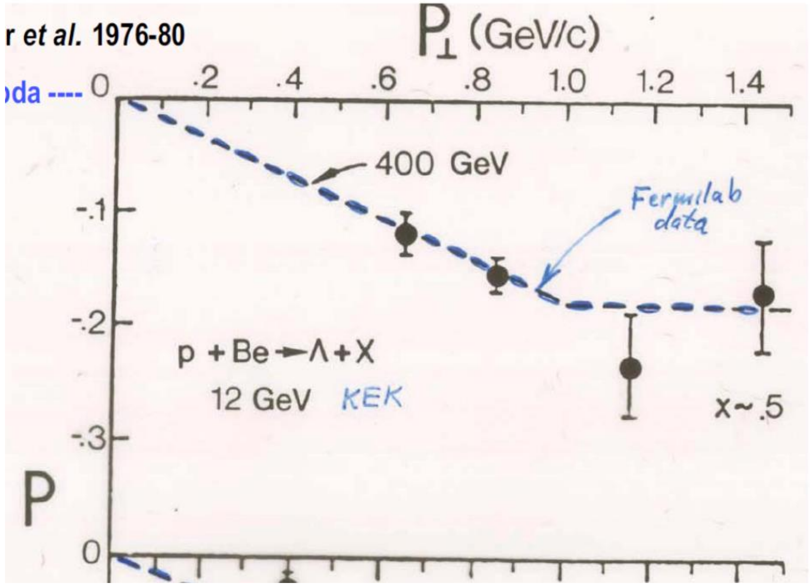
INCLUSIVE PION ASYMMETRY IN PROTON-PROTON COLLISIONS

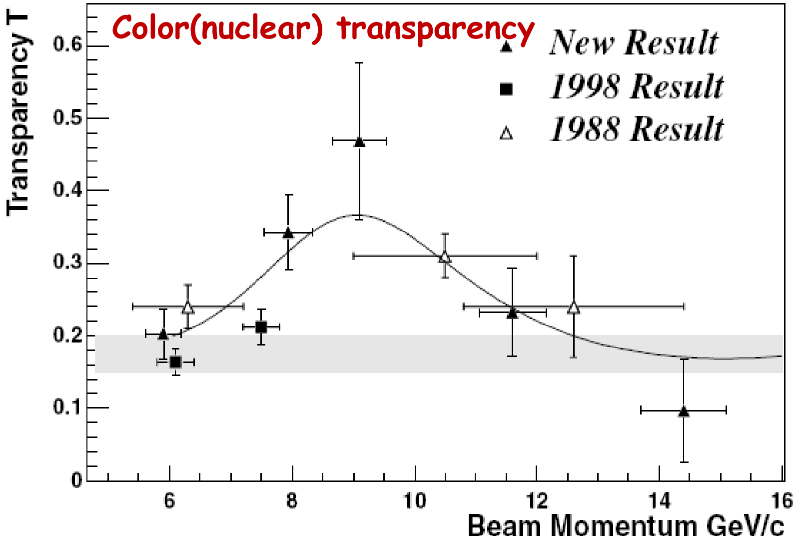
C. Aidala SPIN 2008 Proceeding and CERN Courier June 2009



Nonpolarized beams







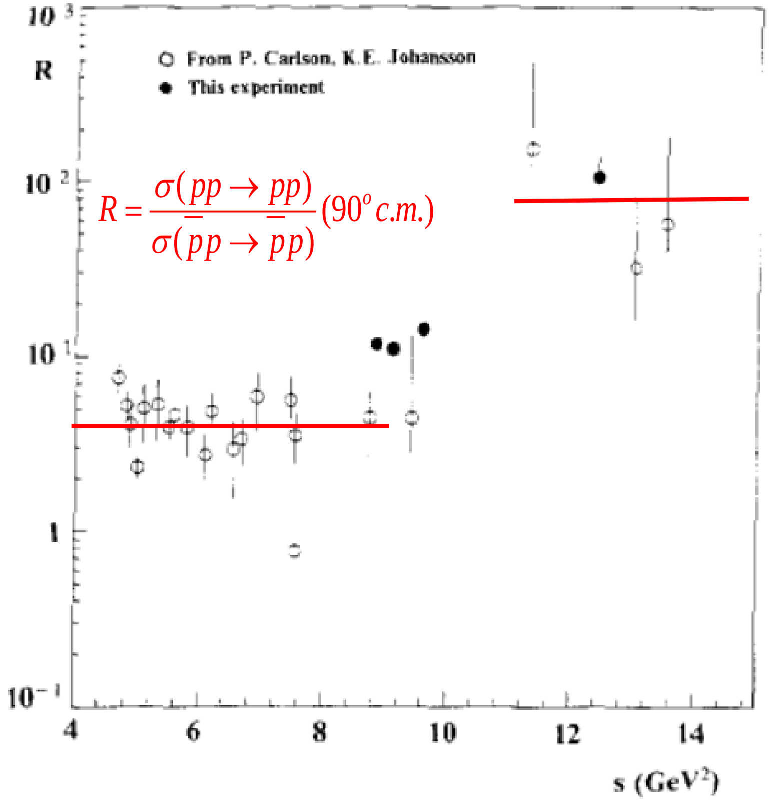


TABLE I. Proton-proton elastic scattering cross sections at 90° in the center-of-mass system.

$P_{c.m.}^2$ $(GeV/c)^2$	P_0 (GeV/c)	$(d\sigma/d\Omega)_{c.m.}$ (μb/sr)	$(d\sigma/dt)_{c.m.}$ μb/$(GeV/c)^2$	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 $L \sim 10^{30}$ $cm^{-2}c^{-1}$:

→ $\sim 0.2\ c^{-1}$ (at P_0 = 8.0 GeV/c)

→ $\sim 0.01\ c^{-1}$ (at P_0 = 12.0 GeV/c)

See Victor Kim report

Diquarks

V.T. Kim (1987)

pp -> p+X, pp -> pp+X

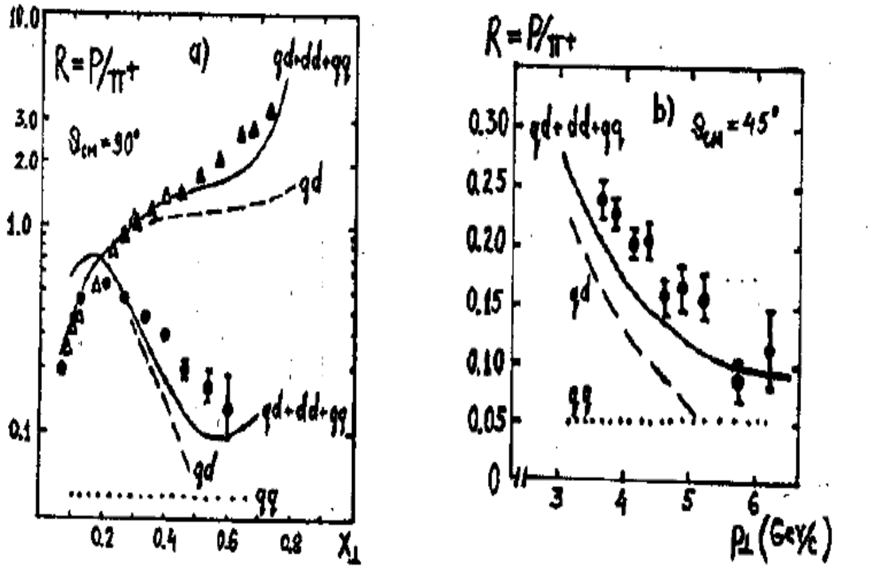


Fig. 1. $R = P/\pi^+$ -ratio in pp-collisions.a) $\vartheta_{CM} = 90°$: ● – FNAL data/16/ at $\sqrt{s} = 23.4$ GeV (E_L = 300 GeV); Δ , ▲ – IHEP (Serpukhov) data/19,20/ at $\sqrt{s}$ = 11.5 GeV (E_L = 70 GeV). b) $\vartheta_{CM} = 45°$: ● – ISR CERN data/18/ at $\sqrt{s}$ = 62 GeV ($E_L \simeq$ 1900 GeV).

The result of calcuations of $pp \to ppX$ processes/29/ (symmetric -proton-pair production) according to the formula in work/30/ for the double inclusive cross section, which in general must be applied carefully/31/ , is shown in Fig.2. The main contribution to the cross section of production of proton pairs with transverse momenta opposite and equal in values is given by diquark-diquark scattering.

- Date: Wed, 27 Feb 2013 13:58:35 +0100
- Subject: Re: test
- From: yuri@lpthe.jussieu.fr
- To: "Stepan" <Stepan.Shimanskiy@jinr.ru>
- User-Agent: SquirrelMail/1.4.22-2.fc15
- MIME-Version: 1.0

Уважаемые коллеги,

Позвольте поделиться некоторыми соображениями по поводу программы корреляционных исследований при взаимодействии адронов и ядер на ФОДС, в той её части, которая касается многопартонных соударений.

С недавнего времени многопартонные взаимодействия (MPI) привлекают пристальное внимание как теоретиков, так и экспериментаторов. С одной стороны, MPI – дополнительный источник многоструйных КХД событий, которые являются фоновыми для поисков новой физики на LHC. С другой стороны,

MPI – потенциальный источник новой информации о партонной структуре нуклона. В конце 90–ых начале 00–х появились результаты первых экспериментальных исследований на Tevatron'e. Они продемонстрировали, во–первых, существование двойных жёстких соударений и, во–вторых, существование существенных корреляций между партонами в протоне (сечение MPI оказалось вдвое больше, чем если бы два

партона внутри протона были независимы). На сегодняшний день теоретики разработали адекватный инструмент для описания двойных жёстких соударений – обобщённое двухпартонное распределение (generalized double parton distribution) GPD. Адекватные монтекарловские модели для описания MPI находятся

в стадии разработки. Используя данные HERA по елктророждению векторных мезонов, структуру этого нового объекта можно предсказать в области 0.001 < x < 0.1. В то же время, в области x > 0.1 информация о GPD практически отсутствует. Пертурбативные эффекты в GPD (весьма серьёзные при больших поперечных импульсах регистрируемых частиц и/или струй) находятся под контролем. Однако, о непертурбативной корреляции партонов внутри волновой функции адрона информации у нас нет. Без прямой

экспериментальной информации прогресс в этой области вряд ли возможен. Важно, что для экспериментального изучения этих корреляций не нужны сверхвысокие энергии. Достаточно правильно заданных вопросов и грамотного поставленного эксперимента. Чрезвычайно важной представляется возможность разделения процессов по флейвору участвующих партонов. Измерять корреляции частиц в конечном состоянии вместо адронных струй представляется мне предпочтительным. Дело в том, что эта наблюдаемая содержит ту же информацию о корреляции начальных партонов, что и измерение струй, однако свободна от неопределённостей, связанных с выбором и использованием алгоритма по определению

струй. Серпуховскому ускорителю и установке ФОДС важная задача изучения партонных корреляций в протоне вполне по плечу.

Ю. Докшицер

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 p_T 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 p_T, we should not make any certain conclusions about the cumulative mechanisms».

NN Elastic scattering with polarized deuteron beams :

$$p\uparrow + p\uparrow \rightarrow p\uparrow + p\uparrow$$ for calibration

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

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

New data!

By the way we will have the counting rules verification!

pd, nd and dd – too!

Exclusive NN study at $x_T \sim 1$

$$N\uparrow + N\uparrow \rightarrow BB + MM$$

B (p,n,Λ, Δ...), M (π, K , ...)

Mechanisms of hyperons polarization

$$N\uparrow N\uparrow \rightarrow NN$$

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

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

$$N\uparrow N\uparrow \rightarrow \Delta\Delta$$

Detail vertexes studies and spin structure of the interaction vertex:

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

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

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

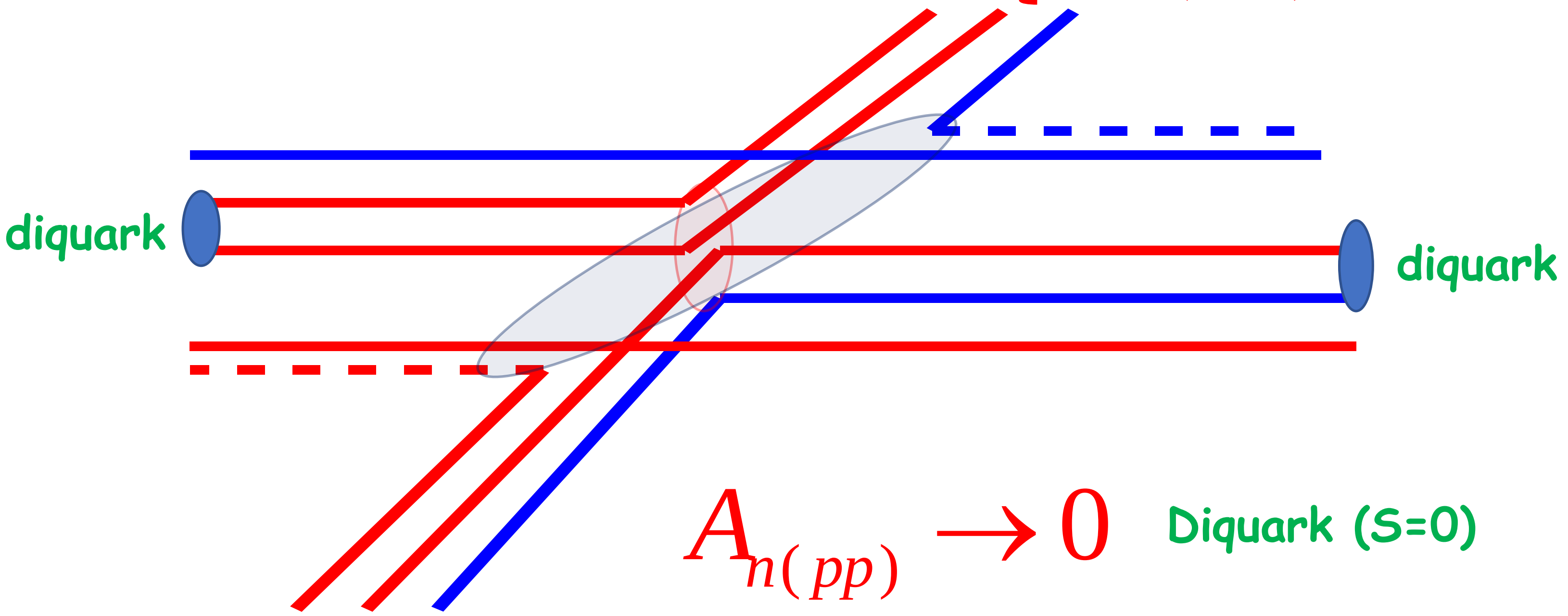
High p_T exclusive reactions -> MPI

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

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

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

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



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

DEUTERON SPIN STRUCTURES

DEUTERON STATIC PROPERTIES FROM NN-POTENTIALS

Таблица 1: Статические свойства дейтрона

	$E_D(MeV)$	$P_D(\%)$	$< r_D^2 >^{1/2} (fm)$	$Q(fm^2)$	$\eta = \frac{A_D}{A_S}$	$f^2_{\pi NN}$	$\mu_D(n.m)$
Exp.	2.224579(9)	–	1.9560(68)	0.2859(3)	0.0271(4)	0.0776(9)	0.857406(1)
MU	2.2246	6.78	1.9611	0.2860	0.0271	0.07745	0.843
Paris	2.2250	5.77	1.9716	0.2789	0.0261	0.078	0.853
RHC	2.2246	6.50	1.9602	0.2770	0.0259	0.0757	0.840
RSC	2.2246	6.47	1.9569	0.2796	0.0262	0.0757	0.843
Bonn	2.225	4.58	1.86	0.2856	0.0267	–	–

Table 1: Deuteron properties in the dressed bag model.

Model	E_d(MeV)	$P_D(\%)$	r_m(fm)	$Q_d(\text{fm}^2)$	$\mu_d\,(\mu_N)$	$A_S(\text{fm}^{-1/2})$	$\eta(D/S)$
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) $P_{\text{in}} = 3.66\%$	2.22454	5.22	1.9715	0.2754	0.8548	0.8864	0.0259
DBM (2) $P_{\text{in}} = 2.5\%$	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

Поляризованные D

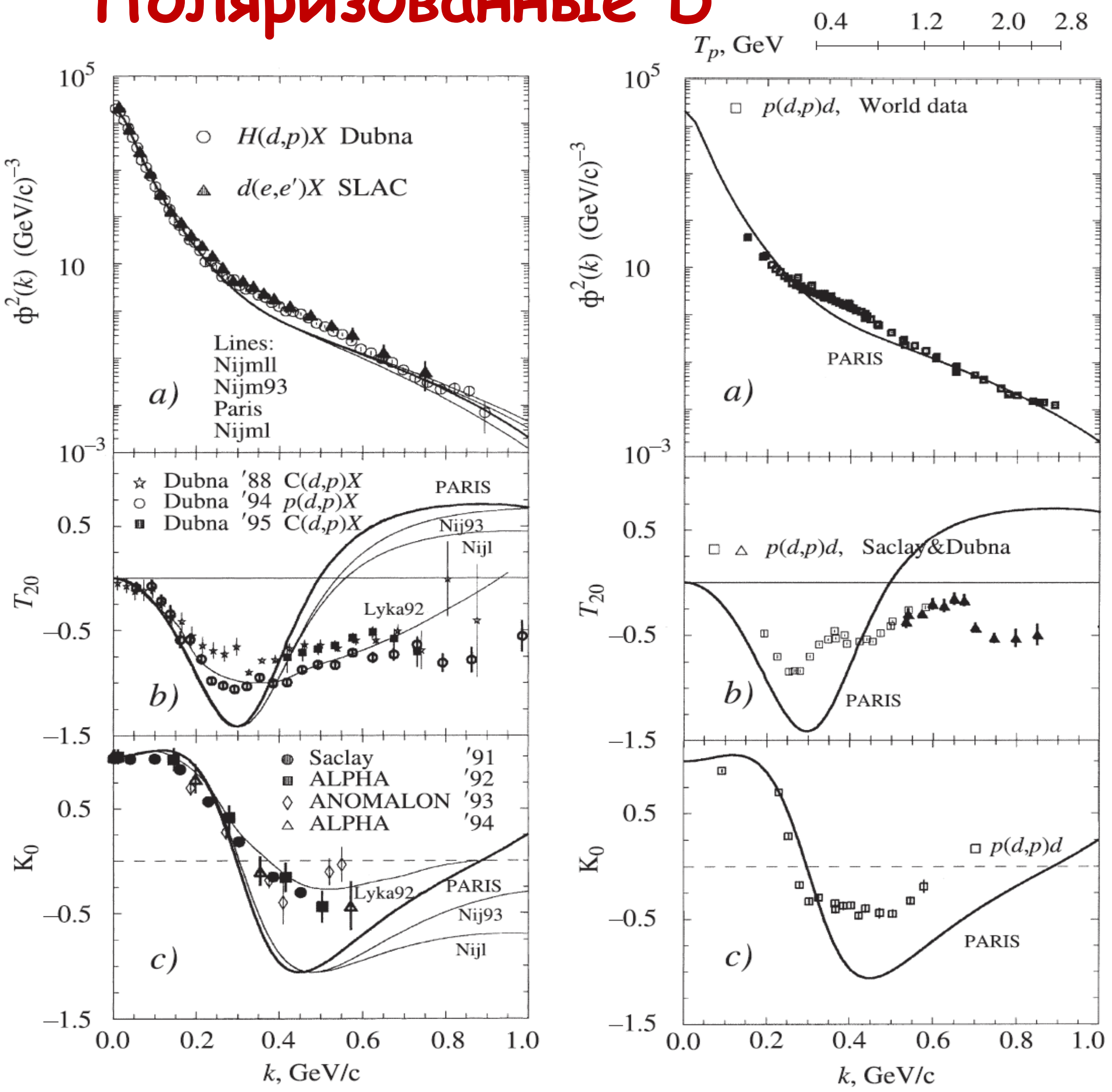


Рис. 5. Сводка данных экспериментов по фрагментации (слева) и упругому рассеянию «назад» (справа) поляризованных и неполяризованных дейтронов

CsDBM investigation

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).

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

V.V. BUROV
The Moscow State University, Moscow, USSR

and

V.K. LUKYANOV and A.I. TITOV
Joint Institute for Nuclear Research, Dubna, USSR

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.

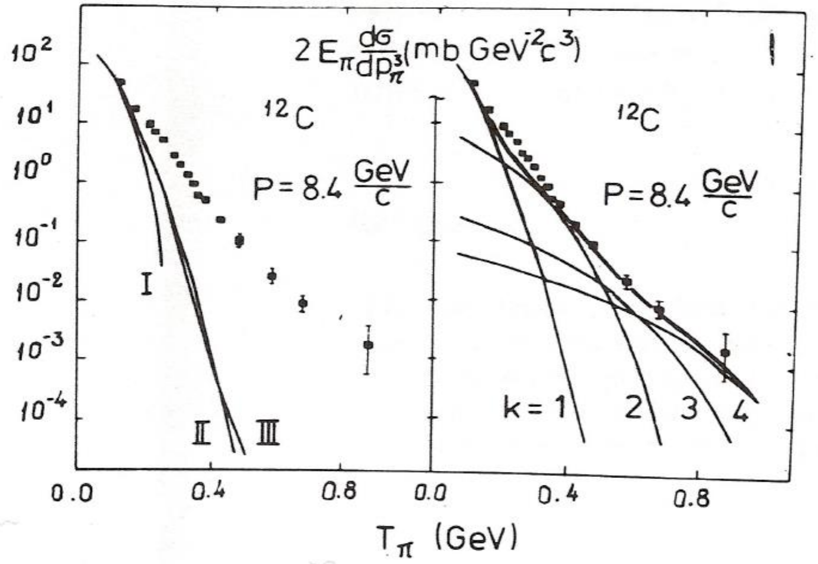


Fig. 1. (a) Calculations of the invariant pion production cross section for ^{12}C: I – for the free proton target; II – with fermi motion; III – the relativization effect. (b) The contributions of separate fluctuons with mass $M_k = km_p$ where k is the order of cumulativity.

PHYSICAL REVIEW C VOLUME 45, NUMBER 4 APRIL 1992

Nuclear structure functions at $x > 1$

B. W. Filippone, R. D. McKeown, R. G. Milner,* and D. H. Potterveld†
Kellogg Radiation Laboratory, California Institute of Technology, Pasadena, California 91125

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

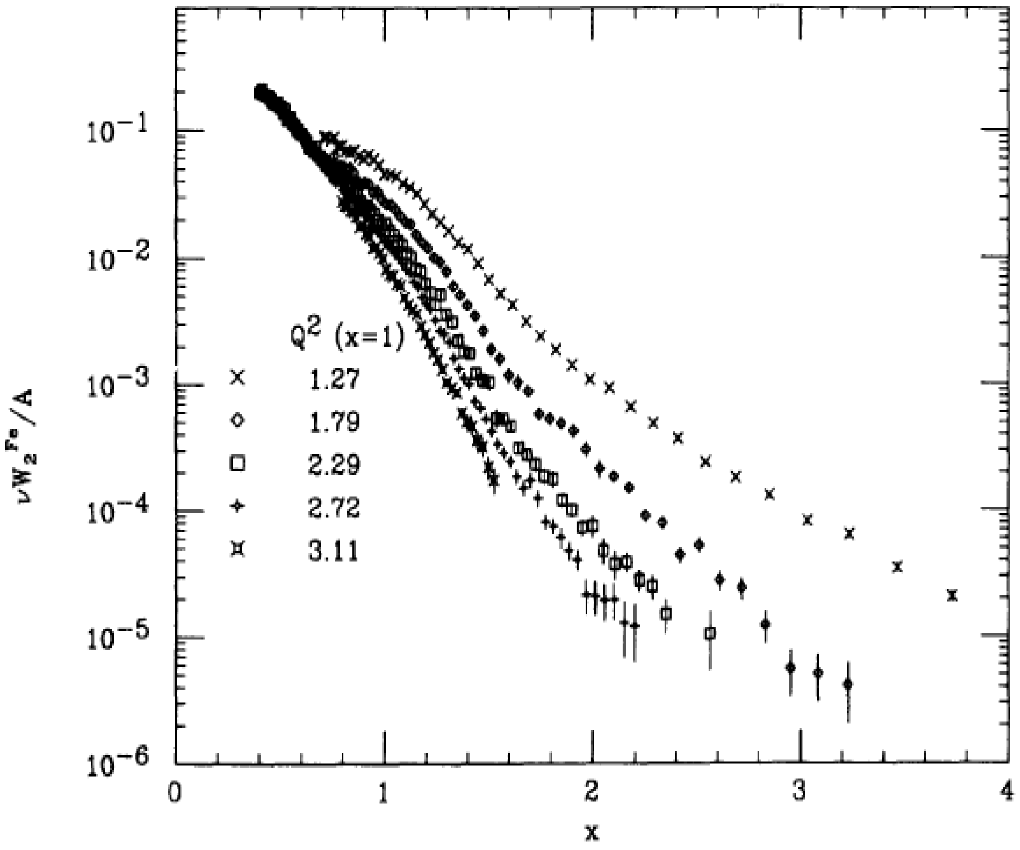


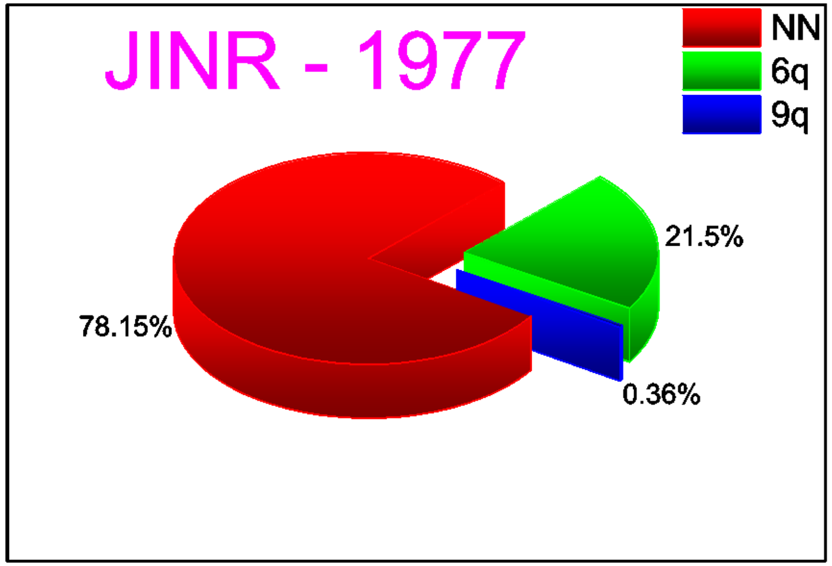
FIG. 1. Measured structure function per nucleon for Fe vs x. The Q^2 value at $x = 1$ is also listed for the different kinematics.

 46

^{12}C - structure

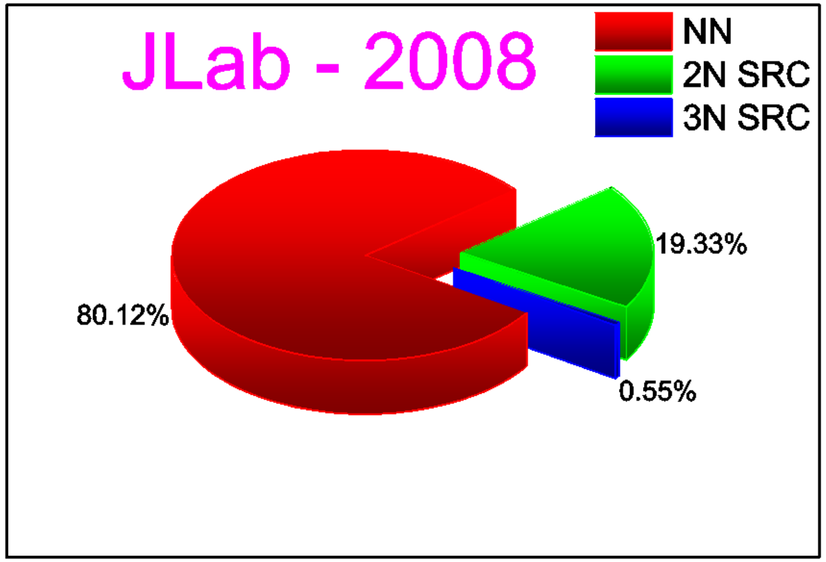
RNP – program at JINR

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



eA – program at JLab

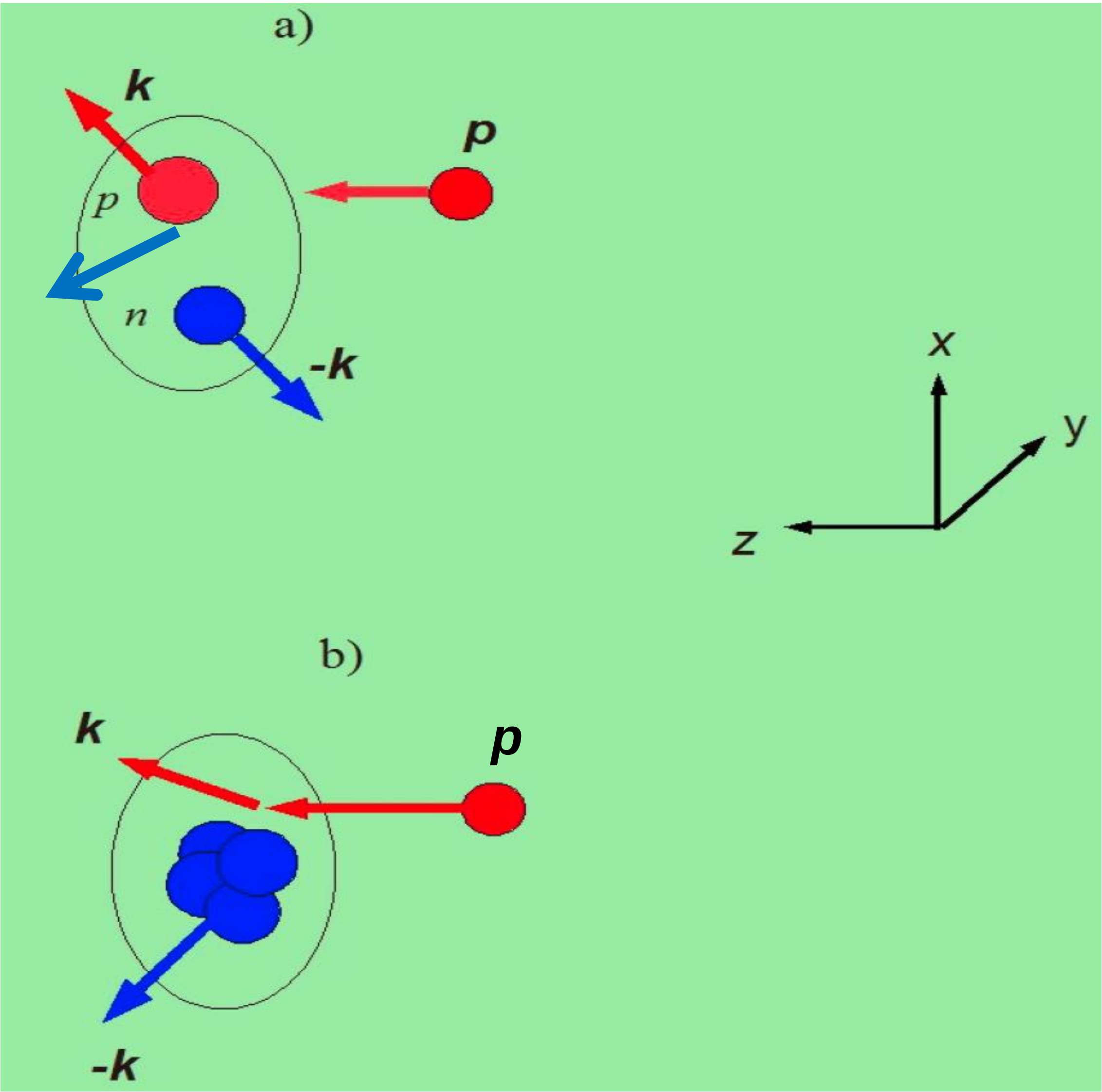
R.Subedi et al., Science 320 (2008) 1476-1478
e-Print: arXiv:0908.1514 [nucl-ex]



Knot out cold dense nuclear configurations

SRC configuration

Multiquark configuration

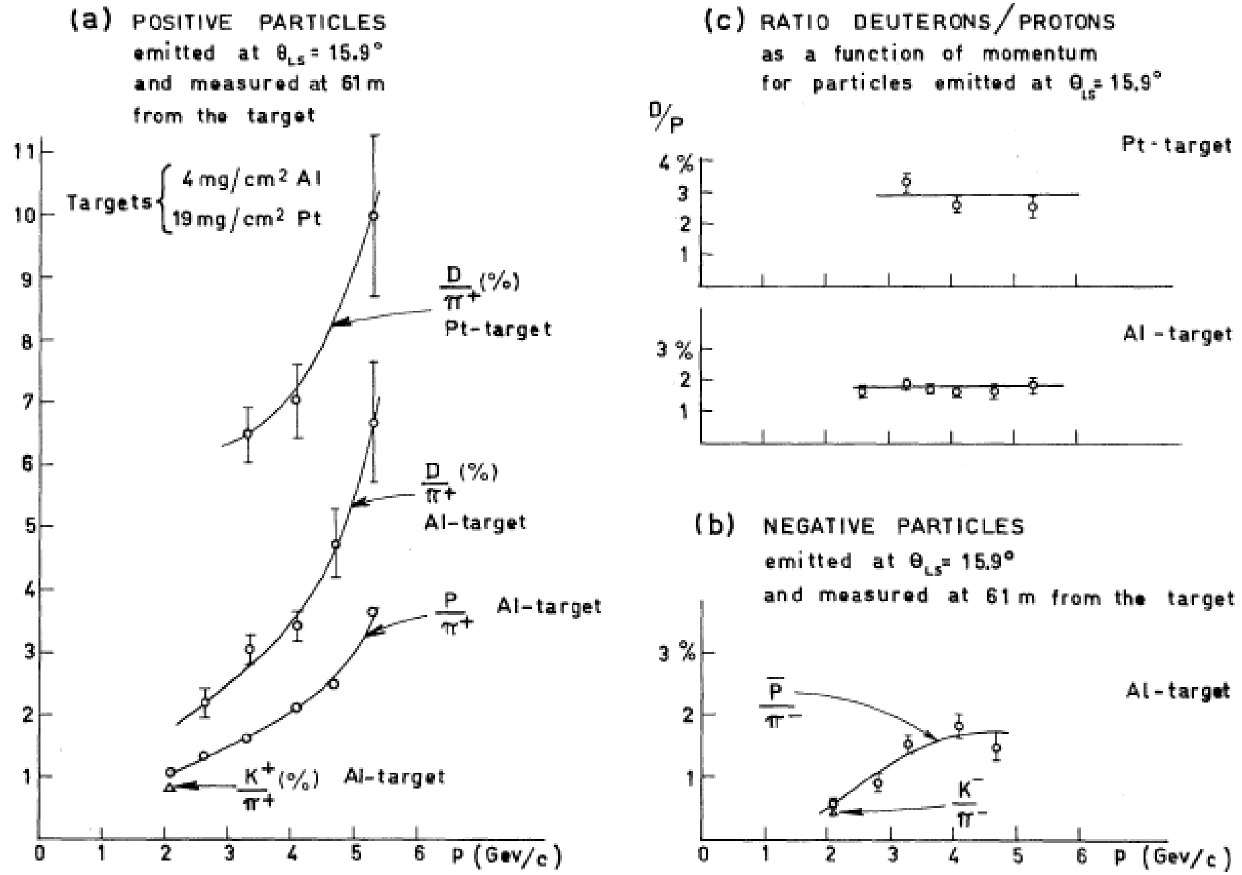


VOLUME 5, NUMBER 1 PHYSICAL REVIEW LETTERS JULY 1, 1960

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.



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.

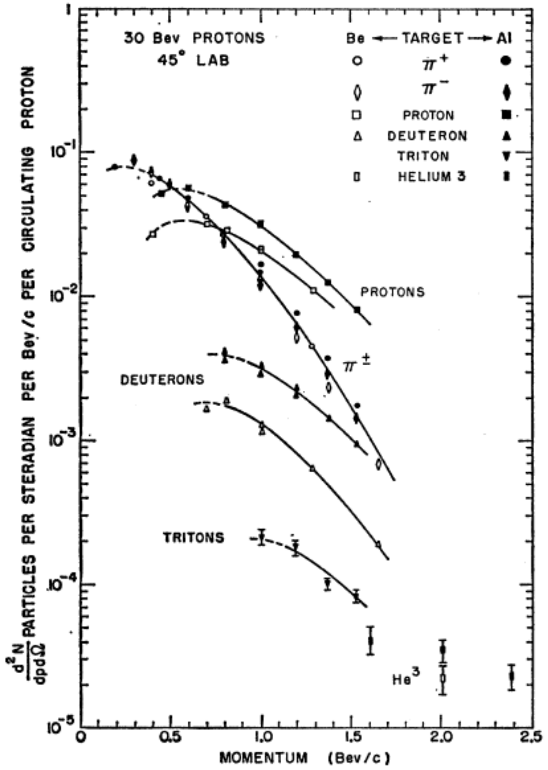


Fig. 3. Momentum spectra of particles emitted at 45° from aluminum and beryllium targets when struck by 30-Bev protons. Tritons from Be were not measured. For general remarks refer to Fig. 2 caption.

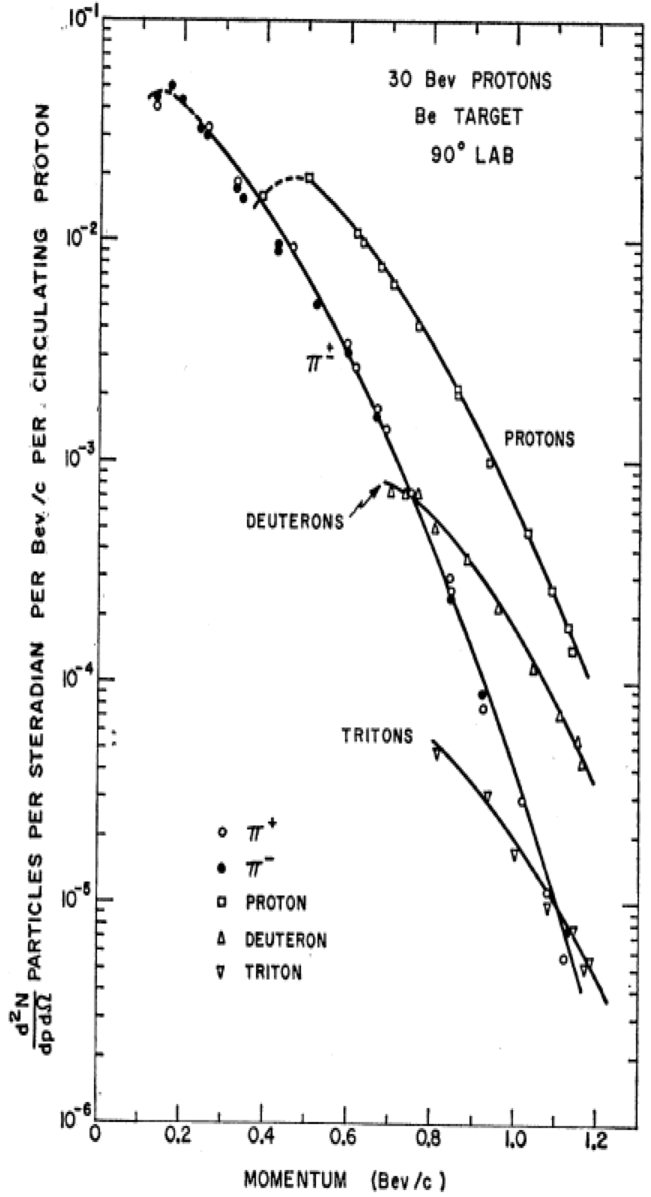
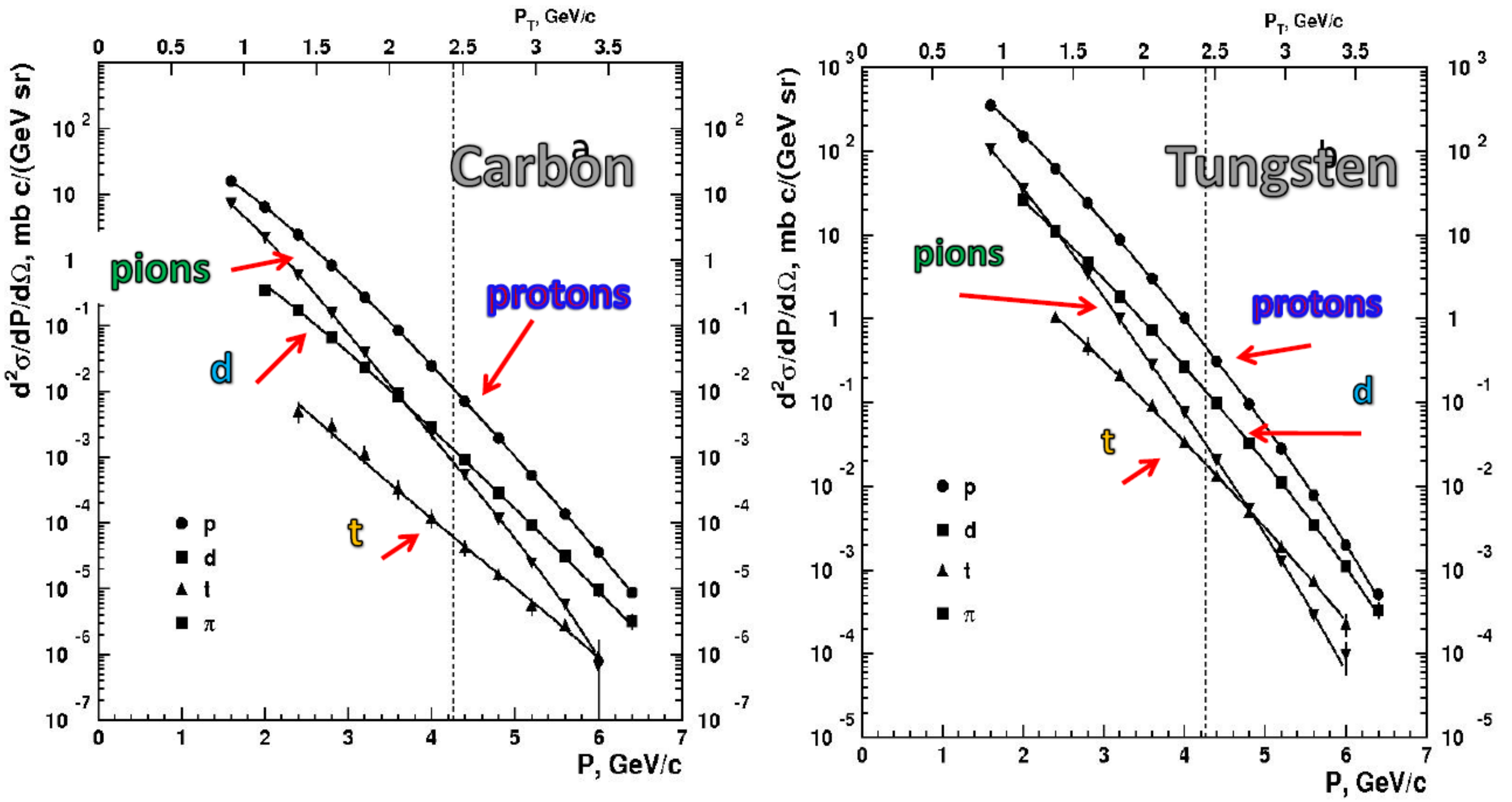


Fig. 2. Momentum spectrum of particles emitted at 90° from a beryllium target struck by 30-Bev protons. The ordinate is the number of particles produced at the target per steradian per Bev/*c* per circulating proton. The dashed portions of the curves indicate regions where the corrections due to multiple scattering exceed 15%. At the time these data were taken no effort was made to detect He³.

SPIN data

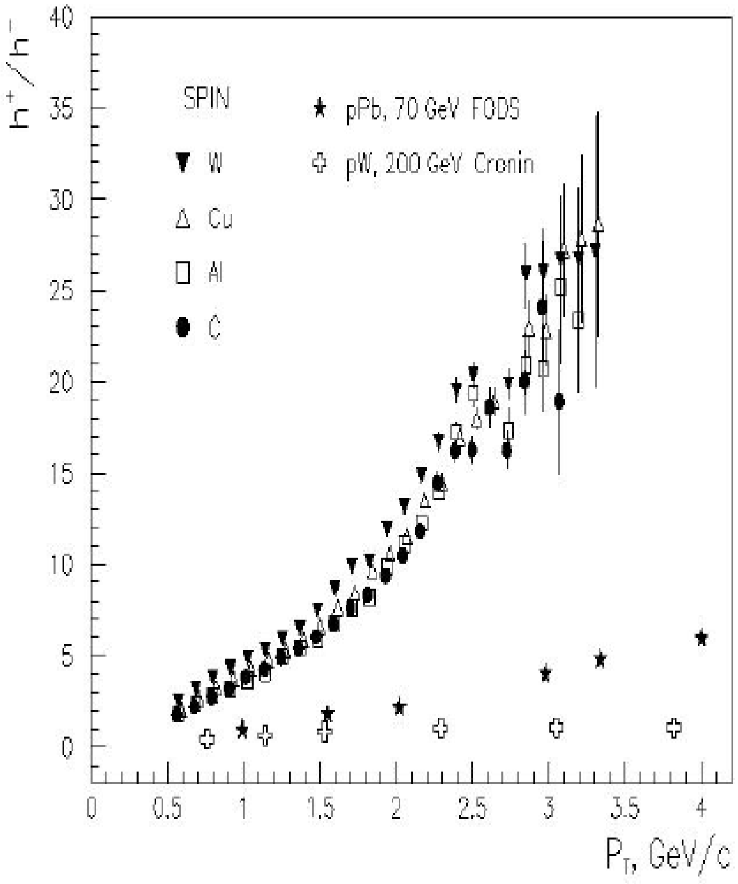
N.N. Antonov et al., *JETP Letters*, Vol.101, No.10, pp.670-673(2015)



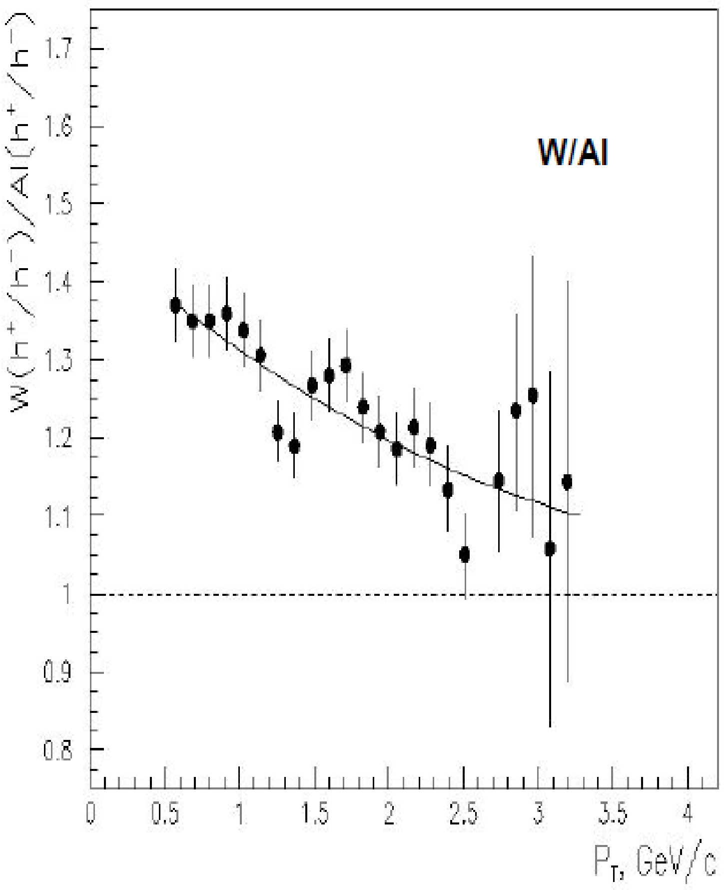
Invariant function found for positive pion, proton, deuteron and triton.

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 .

Ratios



SPIN
W
Cu
Al
C
pPb, 70 GeV FODS
pW, 200 GeV Cronin
h^+/h^-
P_T, GeV/c

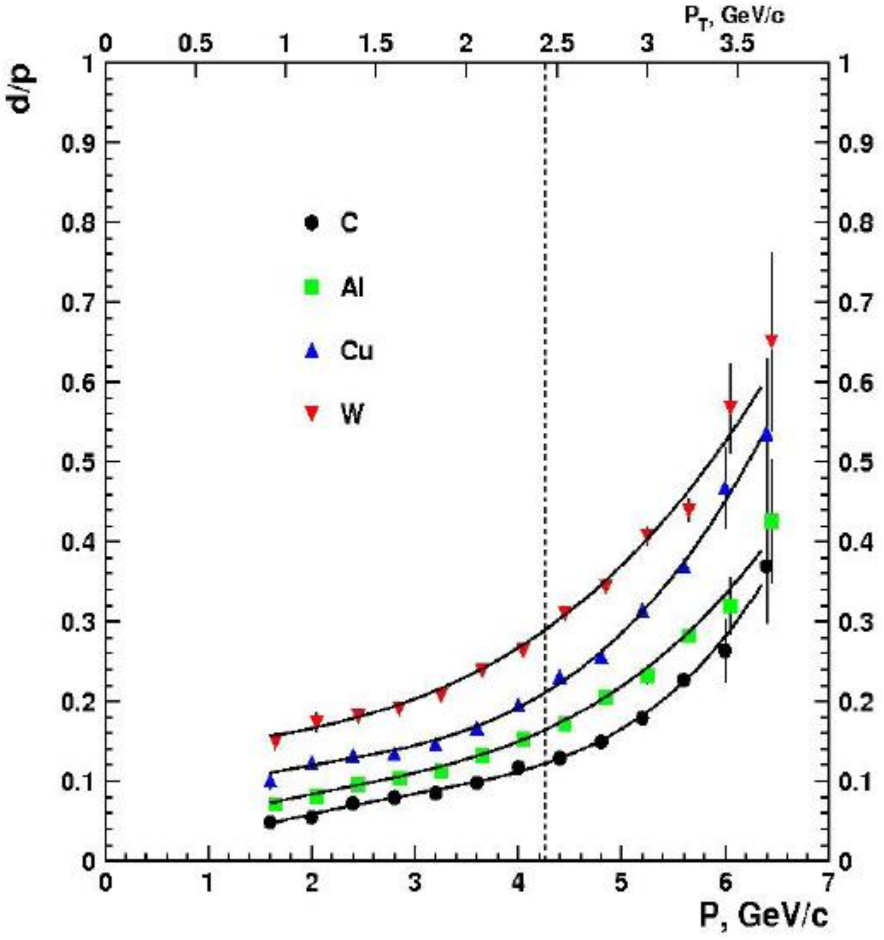


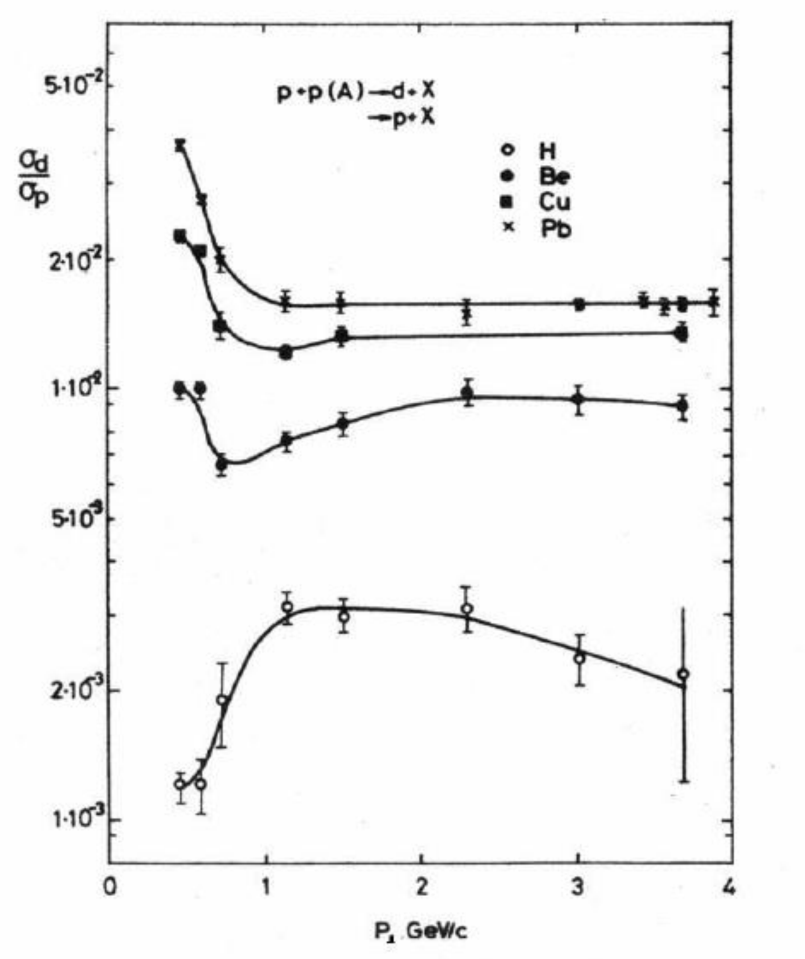
W/Al
$W(h^+/h^-)/Al(h^+/h^-)$
P_T, GeV/c

Ratio d/p

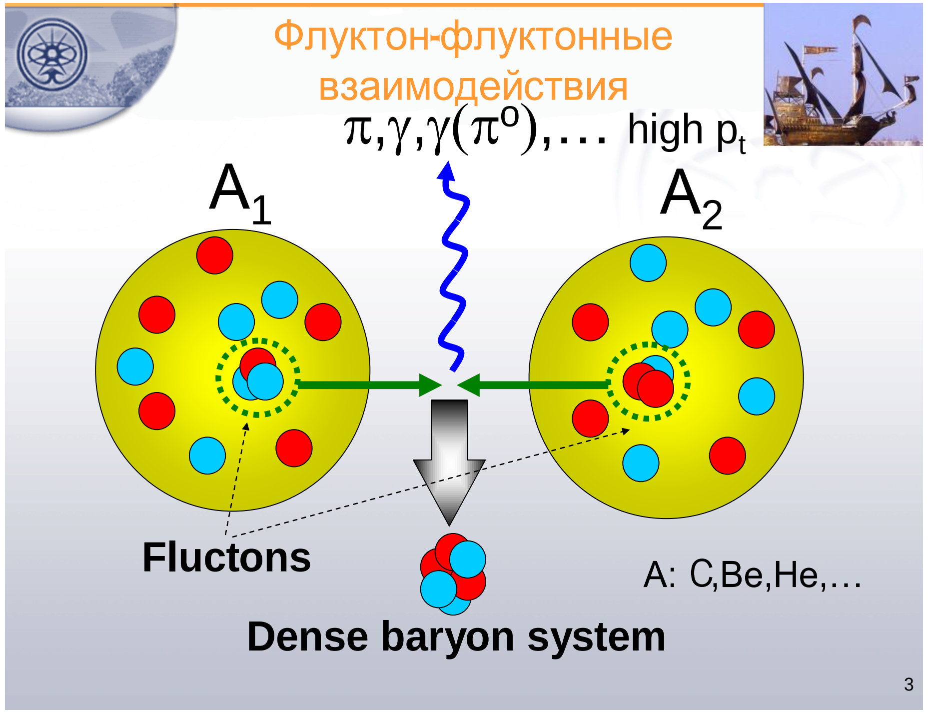
SPIN data

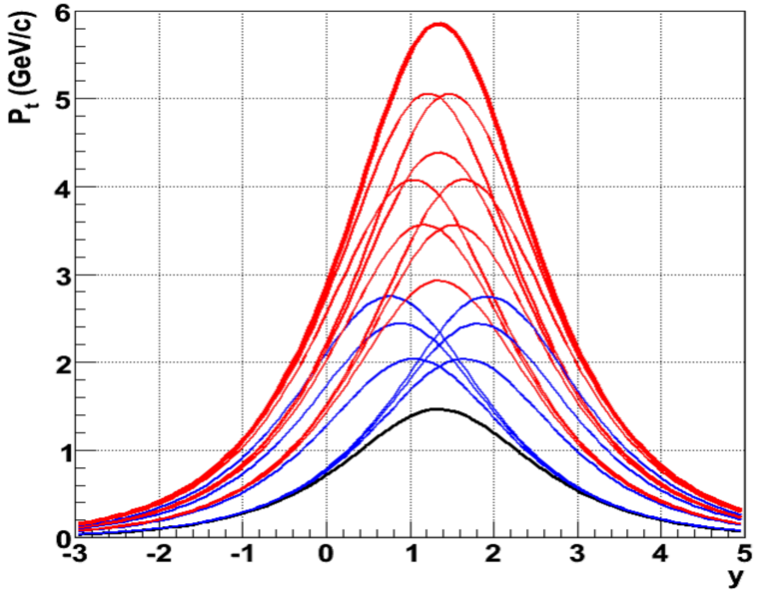
ФОДС В.В.Абрамов и др., ЯФ 45(5) (1987), 845–851

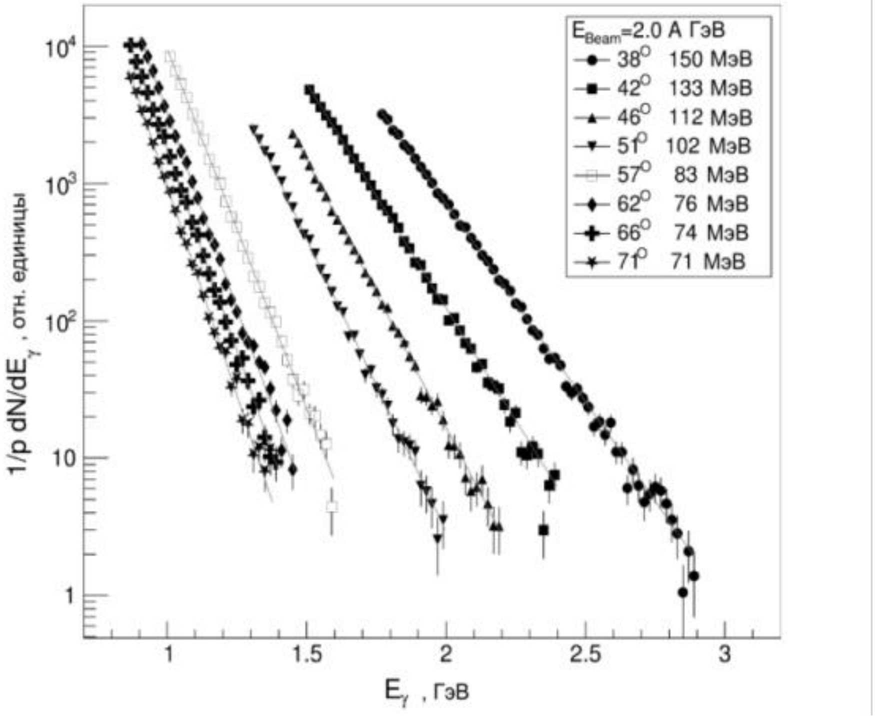




ITEP high p_T data







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

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.

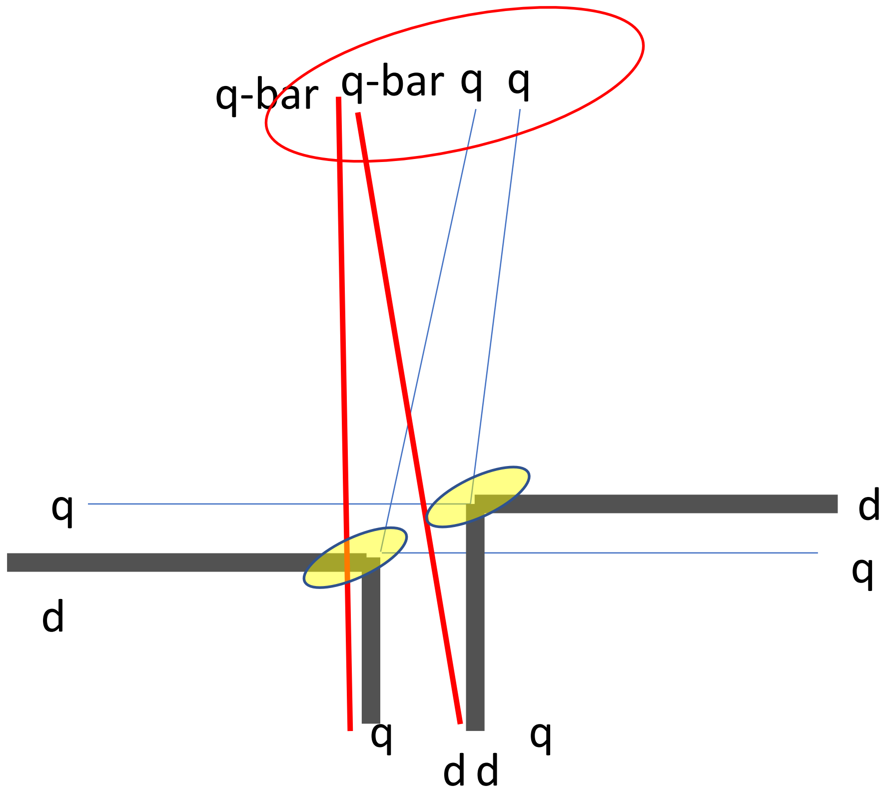
- Experiment : about ten papers with positive evidences;
  about ten papers with negative results
  (some of them with higher statistics).

- Common opinion and PDG position
  (since edition of 2008) :

  Pentaquark is dead !

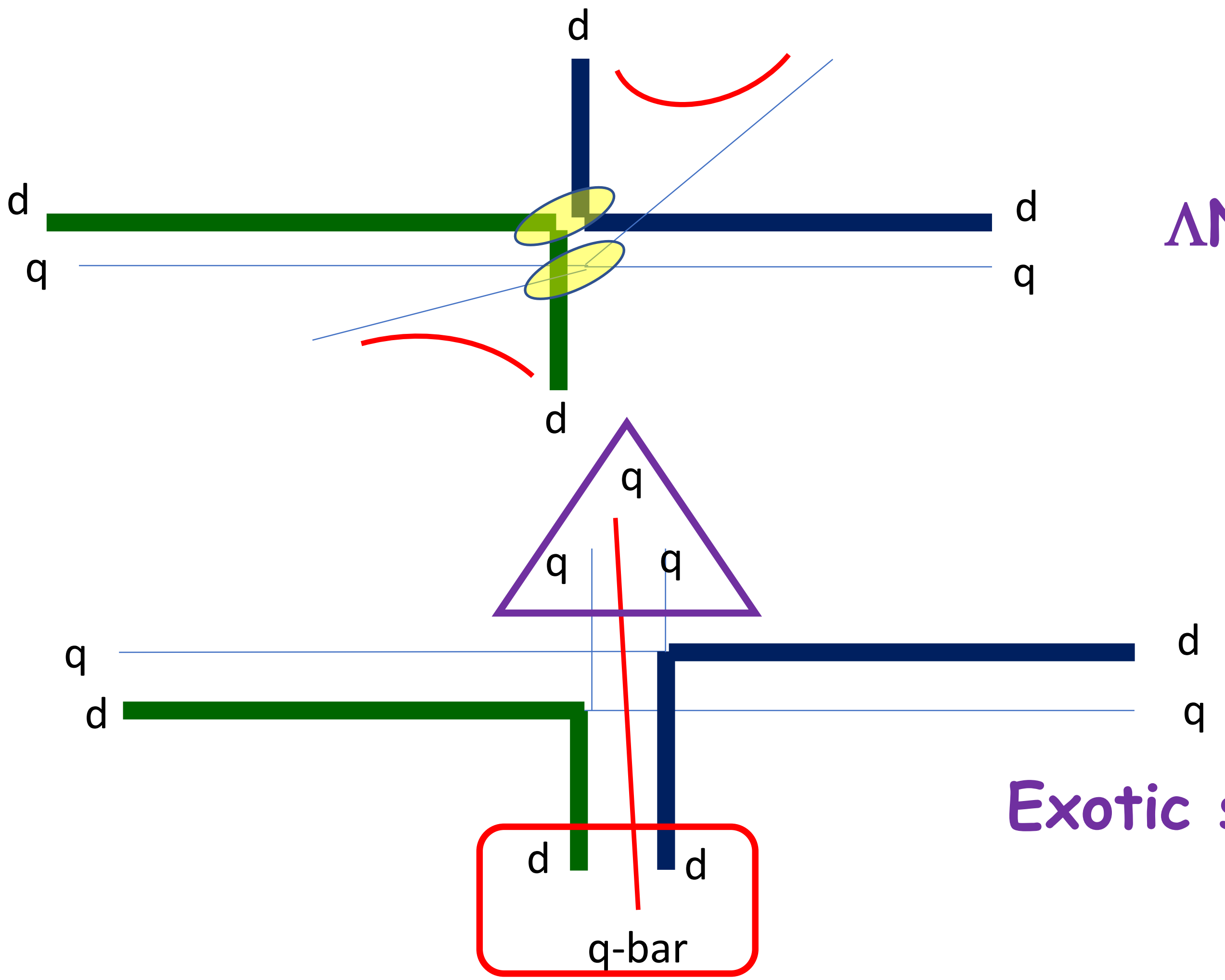
  (Note, at the same time, great enthusiasm
  in searches for tetraquarks !)

pp - reactions with diquarks and тетракварки



Kim's mechanisms

pp - reactions with pentaquarks production and …



ΛN - interaction

Exotic states production

END

J.W. Cronin et al., Production of hadrons at large transverse momentum at 200, 300, and 400 GeV, Phys.Rev. D, v.11, N 11, 3105-3123 (1975)

p_T ~ 2 GeV/c region

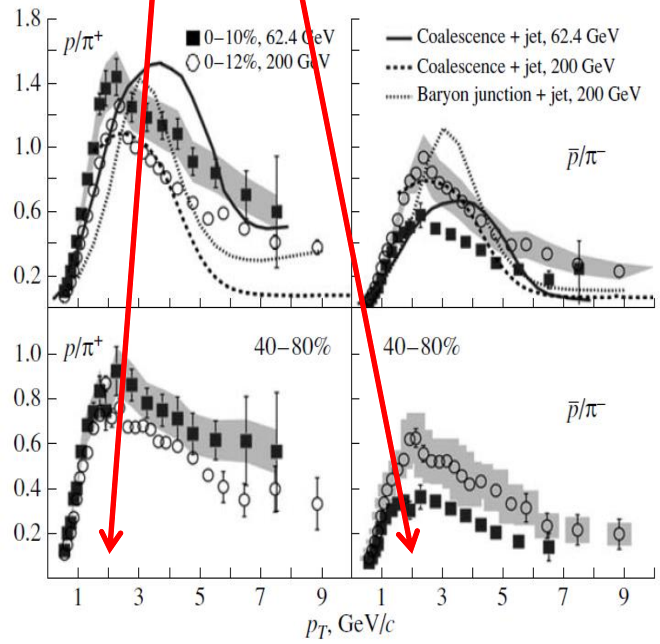


Fig. 3. [10] Ratio of the cross sections for the production of protons and charged pions as a function of the transverse momentum for various degrees of centrality and two beam energies of 62.4 and 200 GeV: (points) results of the STAR experiment and (curves) results of model calculations.

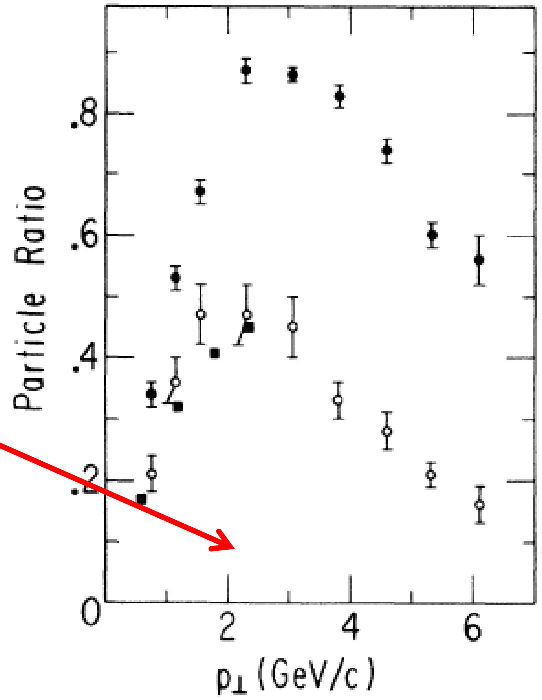
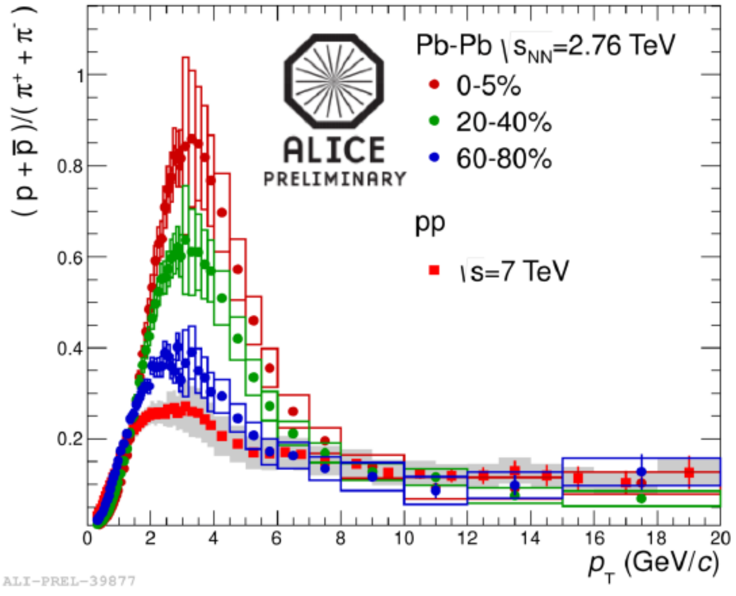
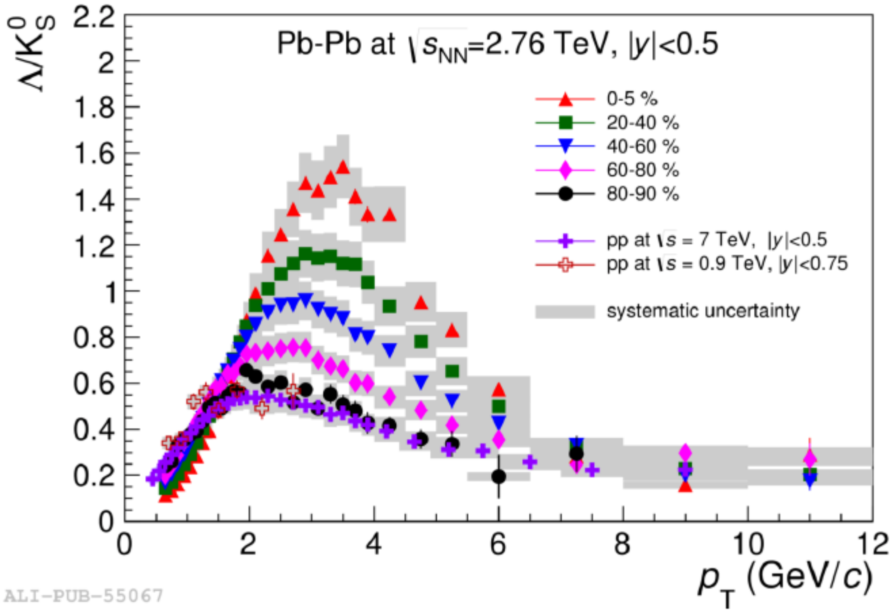


FIG. 20. Comparison of the cross-section ratio p/π^+ measured on tungsten at $\sqrt{s}$ =23.7 GeV (closed circles), with that obtained by extrapolation to A =1 (open circles). Ratios obtained from the British-Scandinavian collabortion (Ref. 23) at $\sqrt{s}$ =23.4 GeV are also plotted (closed squares).

V.S. Pantuev *Physics of Atomic Nuclei, 2009, Vol. 72, No. 12, pp. 1971–1981*

Baryon anomaly in Pb-Pb





- Baryon to meson ratio increasing with centrality for p_T < 8 GeV/c.
  - Enhancement at moderate p_T is consistent with radial flow
  - May be explained by quark recombination from QGP (coalescence model)
- For p_T > 8 GeV/c no dependence on centrality and collision system
  - Consistent with fragmentation in vacuum