“High P_T measurements with SPD. Status and plans”

S.S.Shimanskiy

Plan

1. Which problems and energies are interesting to study at high p_T range?

2. How we could make discoveries.

3. The nearest plan.

NN-interactions and the nucleon quark structure

A. Krisch, 28.02.2010 LHEP Seminar

SUMMARY

For the past 30 years QCD-based calculations have continued to disagree with the ZGS 2-spin & AGS 1-spin elastic data and the ZGS, AGS, Fermilab & RHIC inclusive data.

* These large spin effects do not go to zero at high-energy or high-$P_{\perp}$ as was predicted.
* No QCD-based model can explain all the large spin effects.

BASIC PRINCIPLE OF SCIENCE:

If a theory does not agree with reproducible experimental data, then the theory must be modified.

These precise spin experiments provide experimental guidance for the required modification of the theory of Strong Interactions.

Elastic $d\sigma/dt$, A_{nn} and A_n experiments at higher energy and $P_{\perp}$ could provide more guidance, just as the RHIC inclusive A_n experiments confirmed the similar Fermilab experiments. (E-704 Yokosawa et al.).

NICA energy range?

In 1973 were published two artiles :

Matveev V. A., Muradyan R. M., Tavkhelidze A. N. ***Lett. Nuovo Cimento 7,719 (1973);***

Brodsky S., Farrar G. ***Phys. Rev. Lett. 31,1153 (1973)***

Predictions that for momentum $p_{beam} \geq 5$ GeV/c in any binary large-angle scattering ($\theta_{cm} > 40^o$) reaction at large momentum transfers $Q = \sqrt{-t}$:

$$A + B \to C + D$$

$$\frac{d\sigma}{dt}_{A+B\to C+D} \sim s^{-(n_A+n_B+n_C+n_D-2)} f\left(\frac{t}{s}\right)$$

where n_A, n_B, n_C and n_D the amounts of elementary constituents in A,B,C and D.

$s=(p_A+p_B)^2$ and $t=(p_A-p_C)^2$,

$$\frac{d\sigma}{dt}_{pp\to pp} \sim S^{-10}$$ and $$\frac{d\sigma}{dt}_{\pi p\to \pi p} \sim S^{-8}$$

SLAC – PUB – 4749
October 1988
(M)

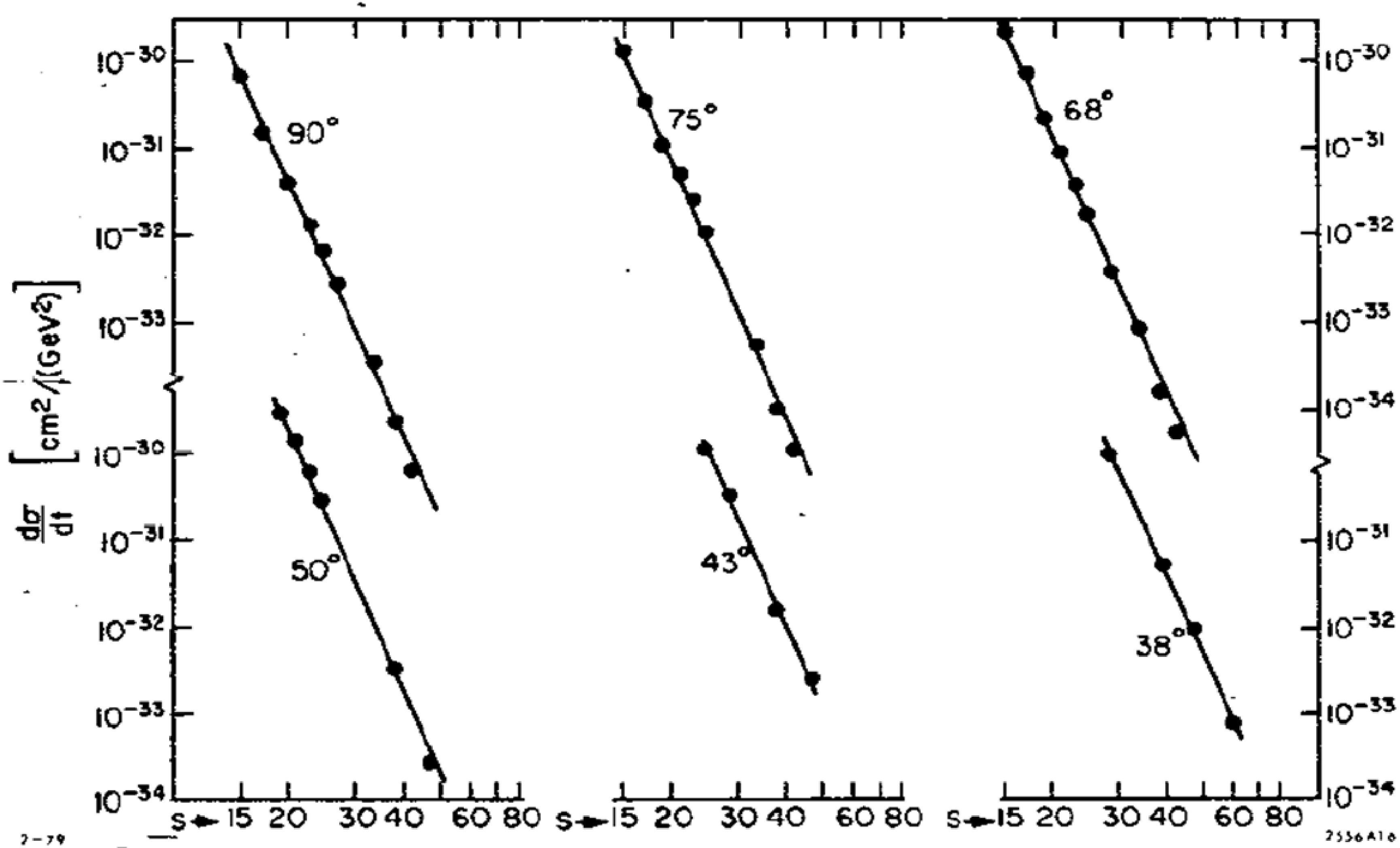


Fig. 16. Test of fixed θ_{CM} scaling for elastic pp scattering. The best fit gives the power $N = 9.7 \pm 0.5$ compared to the dimensional counting prediction $N=10$. Small deviations are not readily apparent on this log-log plot. The compilation is from Landshoff and Polkinghorne.

TABLE V. The scaling between E755 and E838 has been measured for eight meson-baryon and 2 baryon-baryon interactions at $\theta_{c.m.} = 90°$. The nominal beam momentum was 5.9 GeV/c and 9.9 GeV/c for E838 and E755, respectively. There is also an overall systematic error of $\Delta n_{syst} = \pm 0.3$ from systematic errors of $\pm 13\%$ for E838 and $\pm 9\%$ for E755.

No.	Interaction	Cross section E838	Cross section E755	n-2 ($\frac{d\sigma}{dt} \sim 1/s^{n-2}$)
1	$\pi^+ p \to p\pi^+$	132 ± 10	4.6 ± 0.3	6.7 ± 0.2
2	$\pi^- p \to p\pi^-$	73 ± 5	1.7 ± 0.2	7.5 ± 0.3
3	$K^+ p \to pK^+$	219 ± 30	3.4 ± 1.4	$8.3^{+0.6}_{-1.0}$
4	$K^- p \to pK^-$	18 ± 6	0.9 ± 0.9	≥ 3.9
5	$\pi^+ p \to p\rho^+$	214 ± 30	3.4 ± 0.7	8.3 ± 0.5
6	$\pi^- p \to p\rho^-$	99 ± 13	1.3 ± 0.6	8.7 ± 1.0
13	$\pi^+ p \to \pi^+ \Delta^+$	45 ± 10	2.0 ± 0.6	6.2 ± 0.8
15	$\pi^- p \to \pi^+ \Delta^-$	24 ± 5	≤ 0.12	≥ 10.1
17	$pp \to pp$	3300 ± 40	48 ± 5	9.1 ± 0.2
18	$\bar{p}p \to p\bar{p}$	75 ± 8	≤ 2.1	≥ 7.5

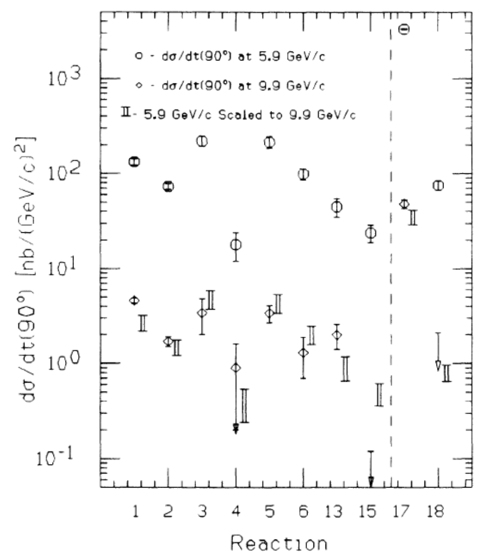
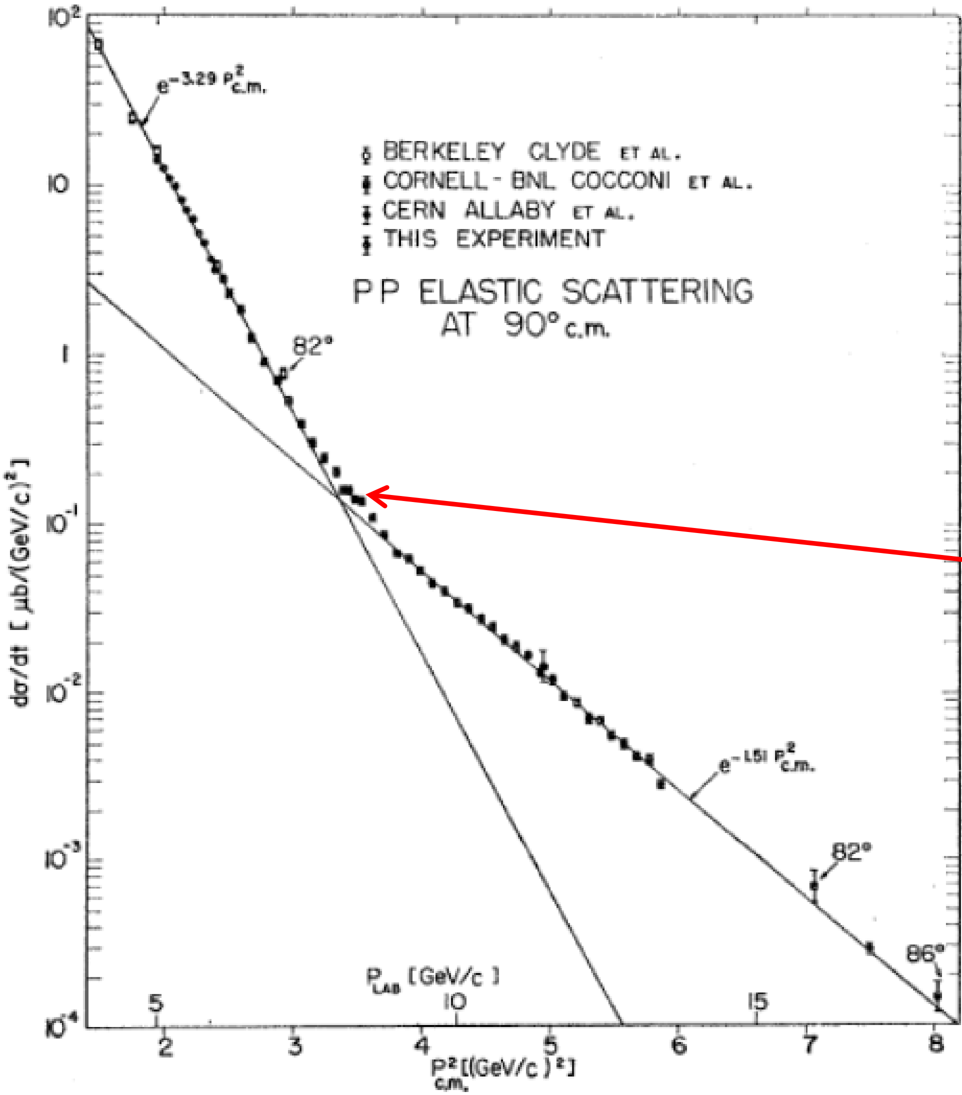


FIG. 26. The scaling between E755 and E838 has been calculated for eight meson-baryon and 2 baryon-baryon interactions at $\theta_{c.m.} = 90°$. The beam momentum for E838 was 5.9 GeV/c, corresponding to $s = 11.9$ GeV^2 for meson-baryon reactions and $s = 12.9$ GeV^2 for baryon-baryon reactions. For the 9.9 GeV/c momentum of E755, the corresponding values of s are 19.6 and 20.5 GeV^2.

pp -> pp (90^0)

C.W. Akerlof et al., Phys.Rev., vol.159, N5, 1138-1149, 1967



Krisch A. and Leksin G. – non pointlike structure of nucleon

p_T ~ 2 GeV/c

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

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

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

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

Pis'ma v ZhETF, vol. 81, iss. 7, pp. 387 – 390 April 10

Indication of asymptotic scaling in the reactions $dd \to p^3$H, $dd \to n^3$He and $pd \to pd$

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Joint Institute for Nuclear Research, LNP, 141980 Dubna, Moscow region, Russia

Submitted 11 January 2005
Resubmitted 28 February 2005

It is shown that the differential cross sections of the reactions $dd \to n^3$He and $dd \to p^3$H measured at c.m.s. scattering angle $\theta_{cm} = 60^\circ$ in the interval of the deuteron beam energy 0.5–1.2 GeV demonstrate the scaling behaviour, $d\sigma/dt \sim s^{-22}$, which follows from constituent quark counting rules. It is found also that the differential cross section of the elastic $dp \to dp$ scattering at $\theta_{cm} = 125-135^\circ$ follows the scaling regime $\sim s^{-16}$ at beam energies 0.5–5 GeV. These data are parameterized here using the Reggeon exchange.

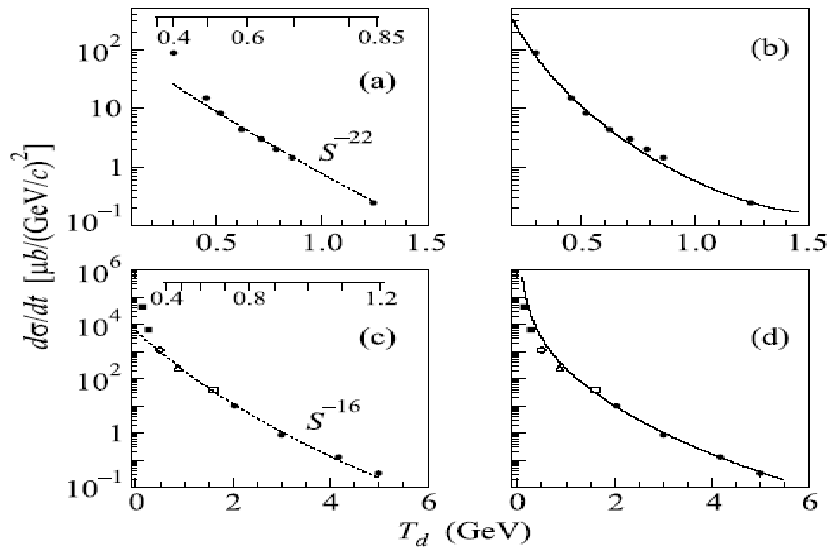
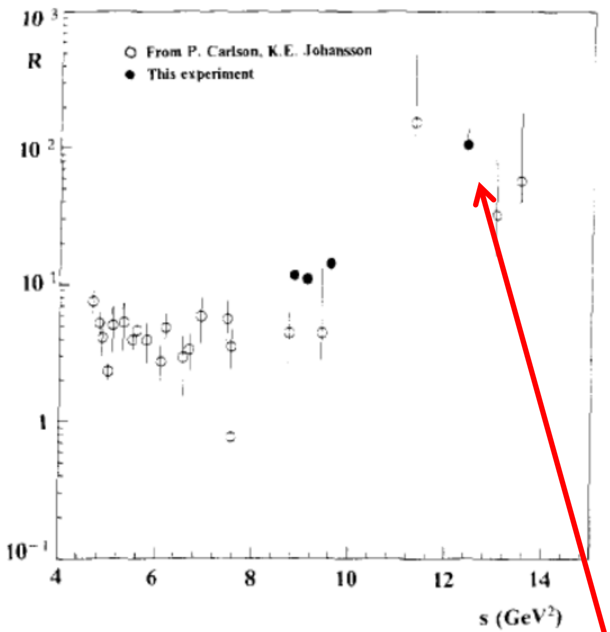
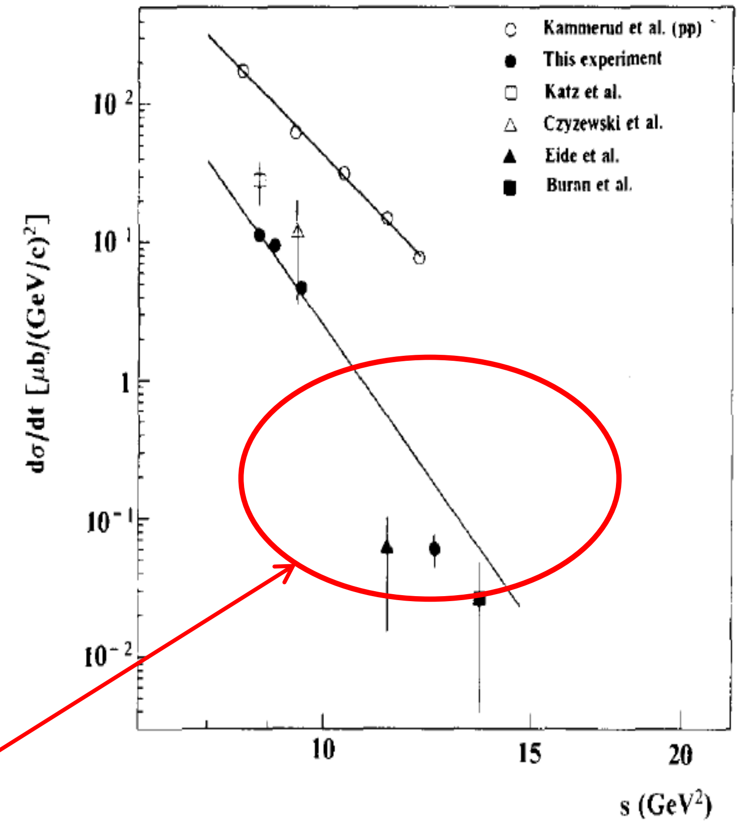


Fig.2. The differential cross section of the $dd \to n^3$He and $dd \to p^3$H reactions at $\theta_{cm} = 60^o$ (a), (b) and $dp \to dp$ at $\theta_{cm} = 127^o$ (c), (d) versus the deuteron beam kinetic energy. Experimental data in (a), (b) are taken from [20]. In (c), (d), the experimental data (black squares), (∘), (△), (open square) and (•) are taken from [22 – 26], respectively. The dashed curves give the s^{-22} (a) and s^{-16} (c) behaviour. The full curves show the result of calculations using Regge formalism given by Eqs. (2), (3), (4) with the following parameters: (b) – $C_1 = 1.9\,\mathrm{GeV}^2$, $R_1^2 = 0.2\,\mathrm{GeV}^{-2}$, $C_2 = 3.5$, $R_2^2 = -0.1\,\mathrm{GeV}^{-2}$; (d) – $C_1 = 7.2\,\mathrm{GeV}^2$, $R_1^2 = 0.5\,\mathrm{GeV}^{-2}$, $C_2 = 1.8$, $R_2^2 = -0.1\,\mathrm{GeV}^{-2}$. The upper scales in (a) and (c) show the relative momentum q_{pn} (GeV/c) in the deuteron for the ONE mechanism

$p\bar{p}$

Cross-sections at 90 degrees





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

p_T ~ 2 GeV/c region

Fig. 3. The p$\bar{\text{p}}$ and pp elastic differential cross sections at 90° CM as function of the square of the CM energy, s. Open circles are pp data from ref. [6]. These data fit well to the drawn curve proportional to s^{-9}. The remaining points are p$\bar{\text{p}}$ data. Shaded from this experiment. Otherwise from ref. [7] (open square), ref. [8] (open triangle) ref. [9] (shaded triangle) and ref. [10] (shaded square). The lower curve is an s^{-n} fit to four data points of this experiment, neglecting systematic errors. One obtains $n = 12.3 \pm 0.2$, but evidently the data do not seem to follow this kind of a power law.

C. Baglin et al., Phys.Lett. B, vol.225, N3, 296-300, 1989

Color(nuclear) transparency

VOLUME 87, NUMBER 21 PHYSICAL REVIEW LETTERS 19 NOVEMBER 2001

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] S. Heppelmann,[5] T. Kawabata,[6] Y. Makdisi,[3] A. Malki,[1] E. Minina,[5] I. Navon,[1] H. Nicholson,[7] A. Ogawa,[5] Yu. Panebratsev,[8] E. Piasetzky,[1] A. Schetkovsky,[5,4] S. Shimanskiy,[8] A. Tang,[9] J. W. Watson,[9] H. Yoshida,[6] and D. Zhalov[5]

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

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

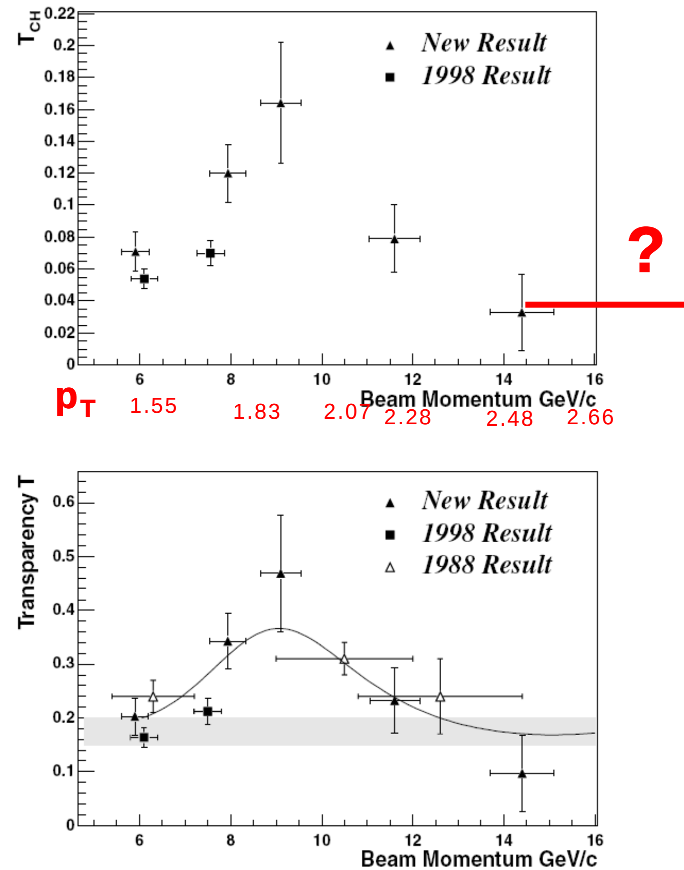
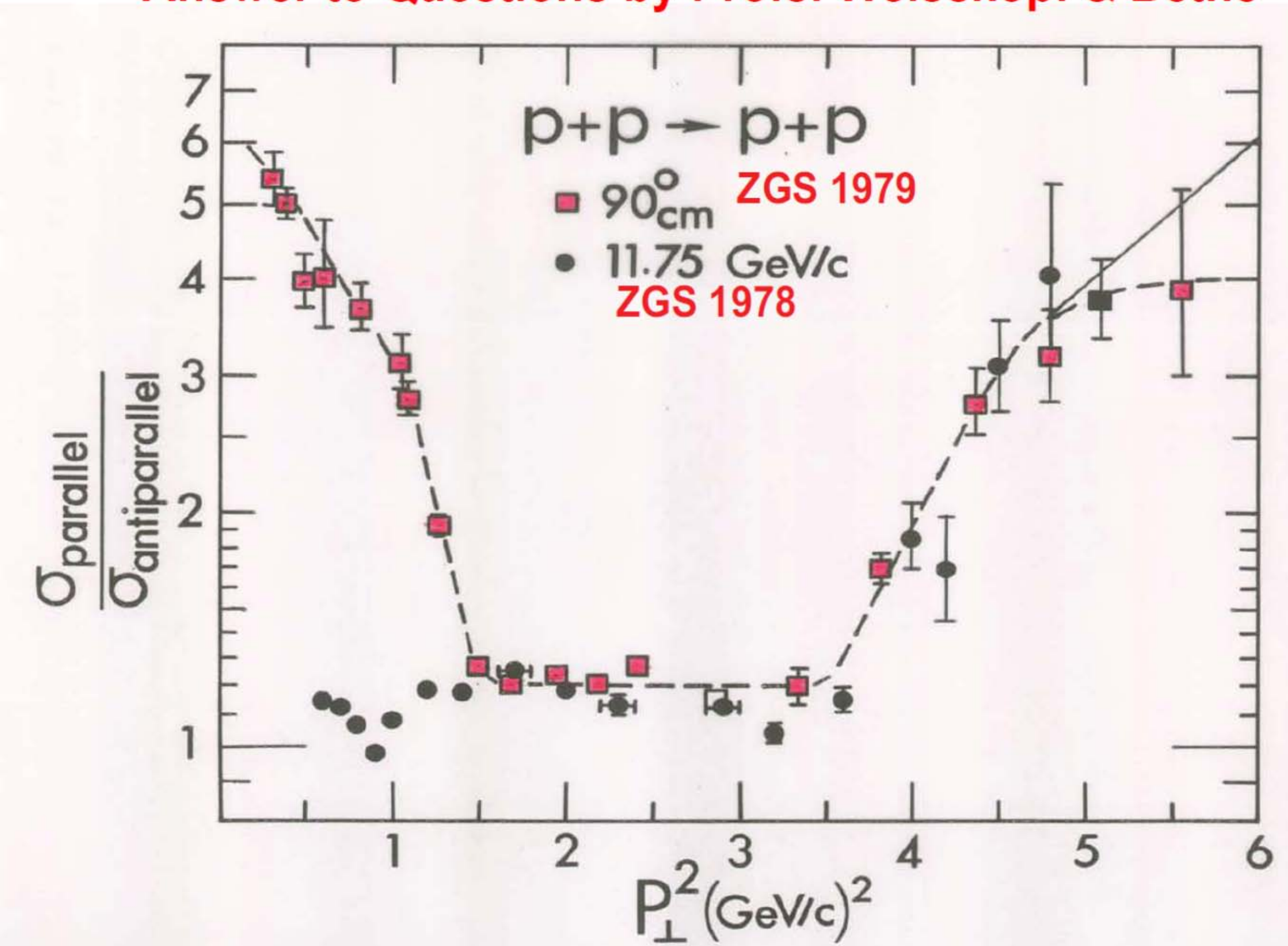


FIG. 2. Top: The transparency ratio T_{CH} as a function of the beam momentum for both the present result and two points from the 1998 publication [3]. Bottom: The transparency T versus beam momentum. The vertical errors shown here are all statistical errors, which dominate for these measurements. The 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.

SPIN problems

Answer to Questions by Profs. Weisskopf & Bethe



Volume 43, Number 14 PHYSICAL REVIEW LETTERS 1 October 1979

Spin-Spin Forces in 6-GeV/c Neutron-Proton Elastic Scattering

D. G. Crabb, P. H. Hansen, A. D. Krisch, T. Shima, and K. M. Terwilliger
Randall Laboratory of Physics, The University of Michigan, Ann Arbor, Michigan 48109

and

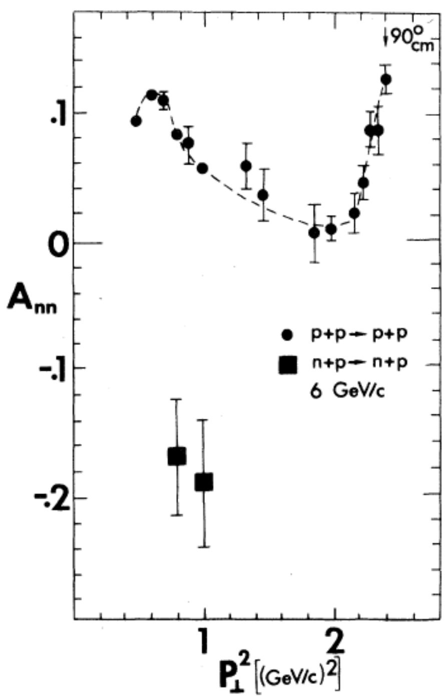


FIG. 2. The spin-spin correlation parameter, A_{nn}, for pure-initial-spin-state nucleon-nucleon elastic scattering at 6 GeV/c is plotted against the square of the transverse momentum. The proton-proton and neutron-proton data are quite different.

This large negative A_{nn} for n-p elastic scattering is quite unexpected. No theoretical models predicted this effect, although a very recent constituent-interchange model[12] predicts $A_{nn} = -44\%$. This may support the suggestion that large spin effects are related to the composite nature of the nucleon.[12,13] An earlier Regge-model prediction[14] is inconsistent with our data. It seems somewhat surprising that A_{nn} is so large at a $P_\perp^2$ of only 1 (GeV/c)^2.

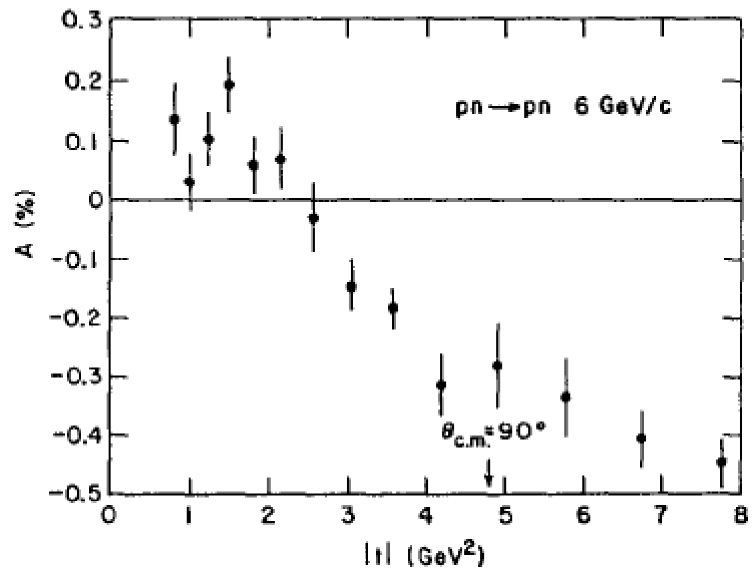
[12]G. R. Farrar, S. Gottlieb, D. Sivers, and G. H. Thomas, Phys. Rev. D 20, 202 (1979).

Nuclear Physics B279 (1987) 97 - 118
North-Holland, Amsterdam

SPIN EFFECTS IN HADRONIC REACTIONS

J. SOFFER

Fig. 1 - The analyzing power A for np elastic scattering at 6 GeV/c (taken from Ref. 5)



Unfortunately the energy is too low to draw definite conclusions on the nature of this effect and hopefully it will be remeasured at higher energies with the polarized proton beam on a deuterium target at BNL.

AGS 1985-1990 A_n

PERTURBATIVE QCD ⇒

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

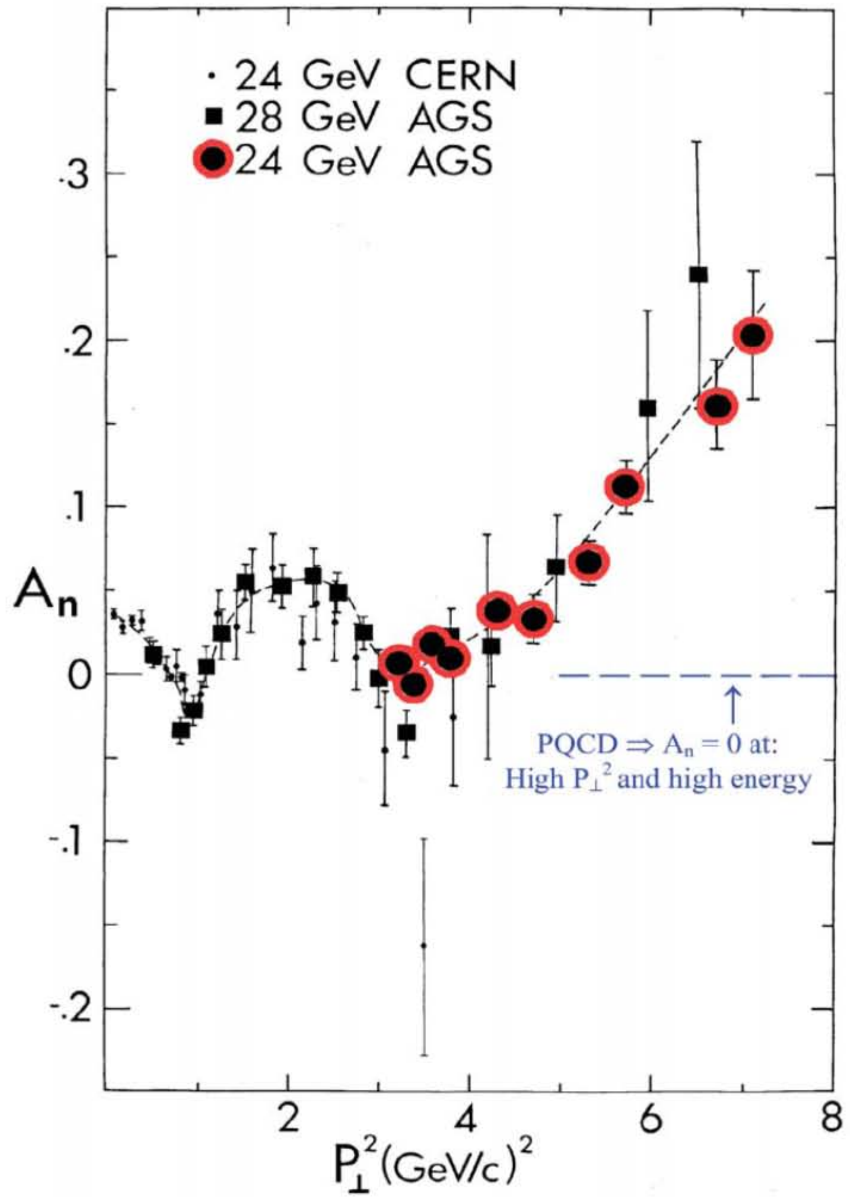
$A_n \neq 0 \Rightarrow$

PROBLEM with PQCD?

NO MODEL can EXPLAIN ALL HIGH-$P_{\perp}^2$ SPIN EFFECTS (A_n & A_{nn})

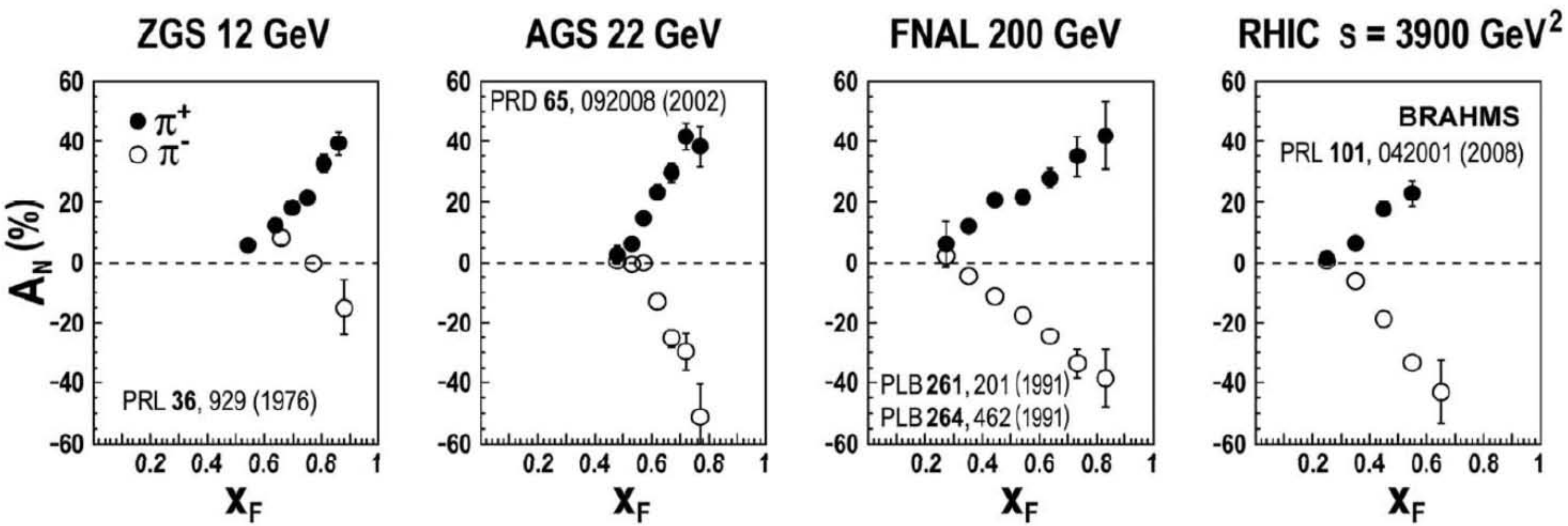
GOAL

MEASURE A_n (and A_{nn}) up to $P_{\perp}^2$ = 12 (GeV/c)



INCLUSIVE PION ASYMMETRY IN PROTON-PROTON COLLISIONS

C. Aidala SPIN 2008 Proceeding and CERN Courier June 2009



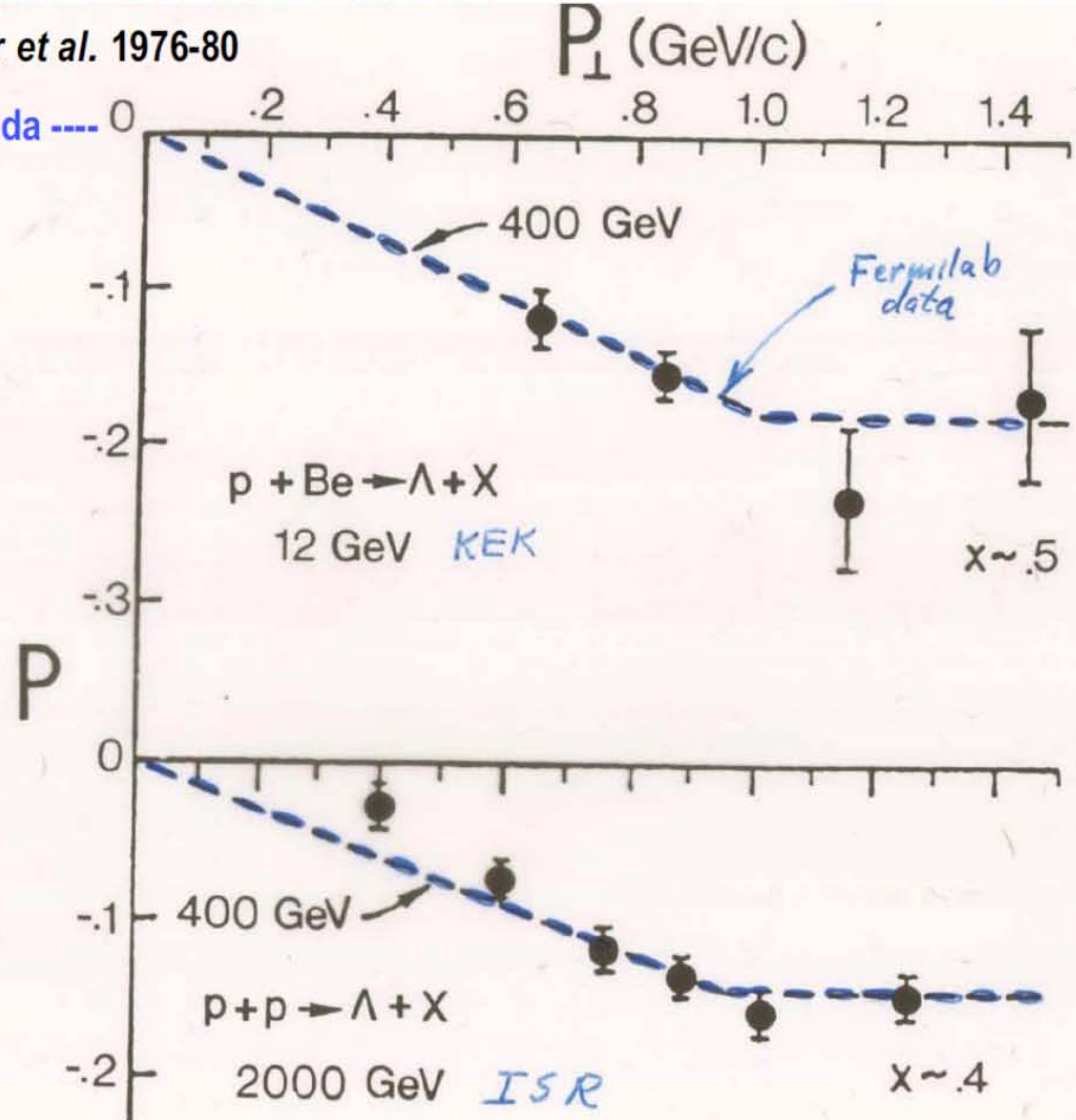
INCLUSIVE HYPERON POLARIZATION

Devlin, Pondrum, Bunce, Heller *et al.* 1976-80

Fermilab 400 GeV p+p -> Lambda ----

Plot by Heller ~1980
with KEK & ISR data

P ~ 15-20 %
QCD says P ~ 0



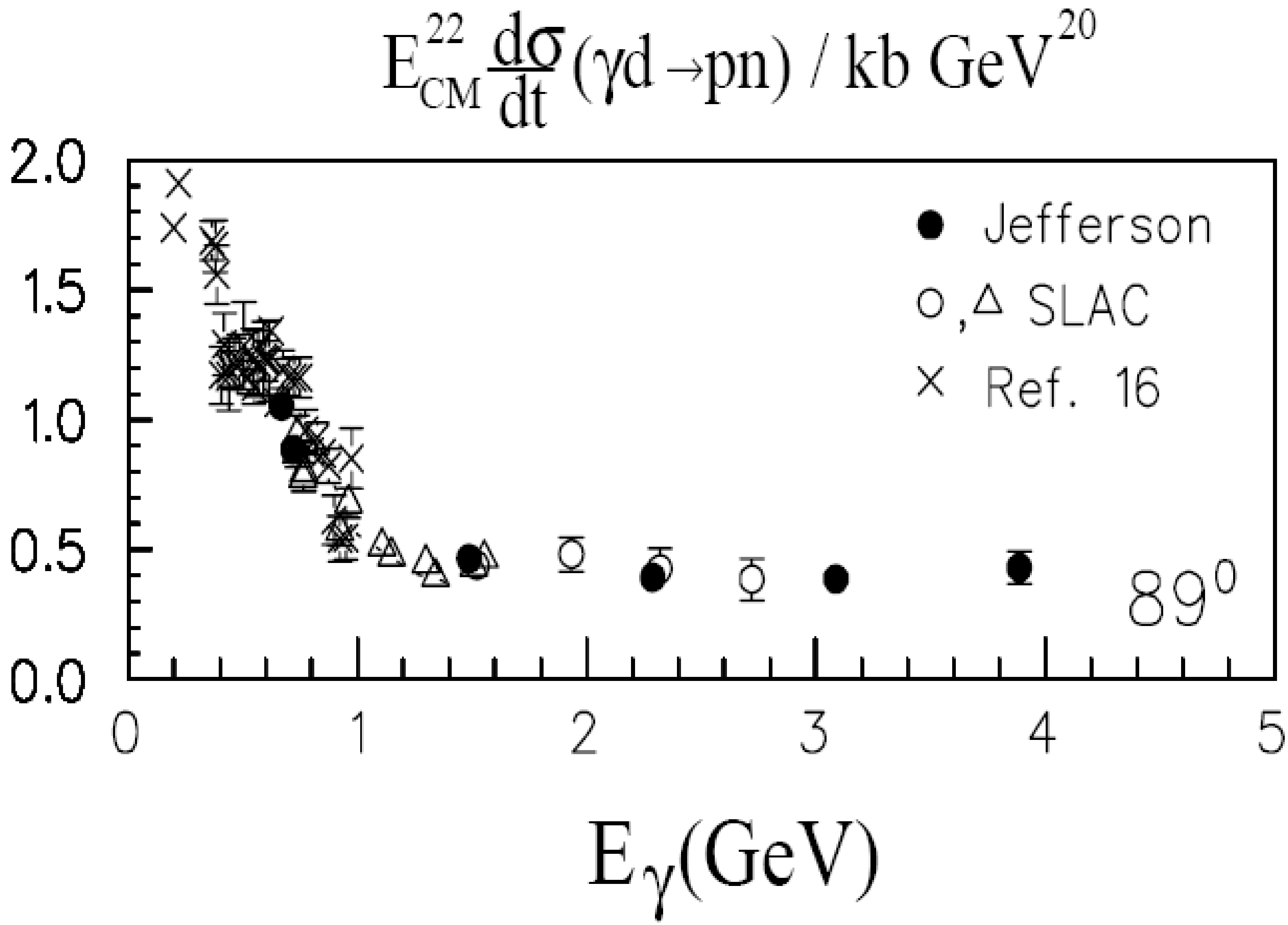


Fig. 1: Large angle γ-disintegration of a deuteron [28].

$$\Sigma(\theta) = (d\sigma_{||} - d\sigma_T)/(d\sigma_{||} + d\sigma_T)$$

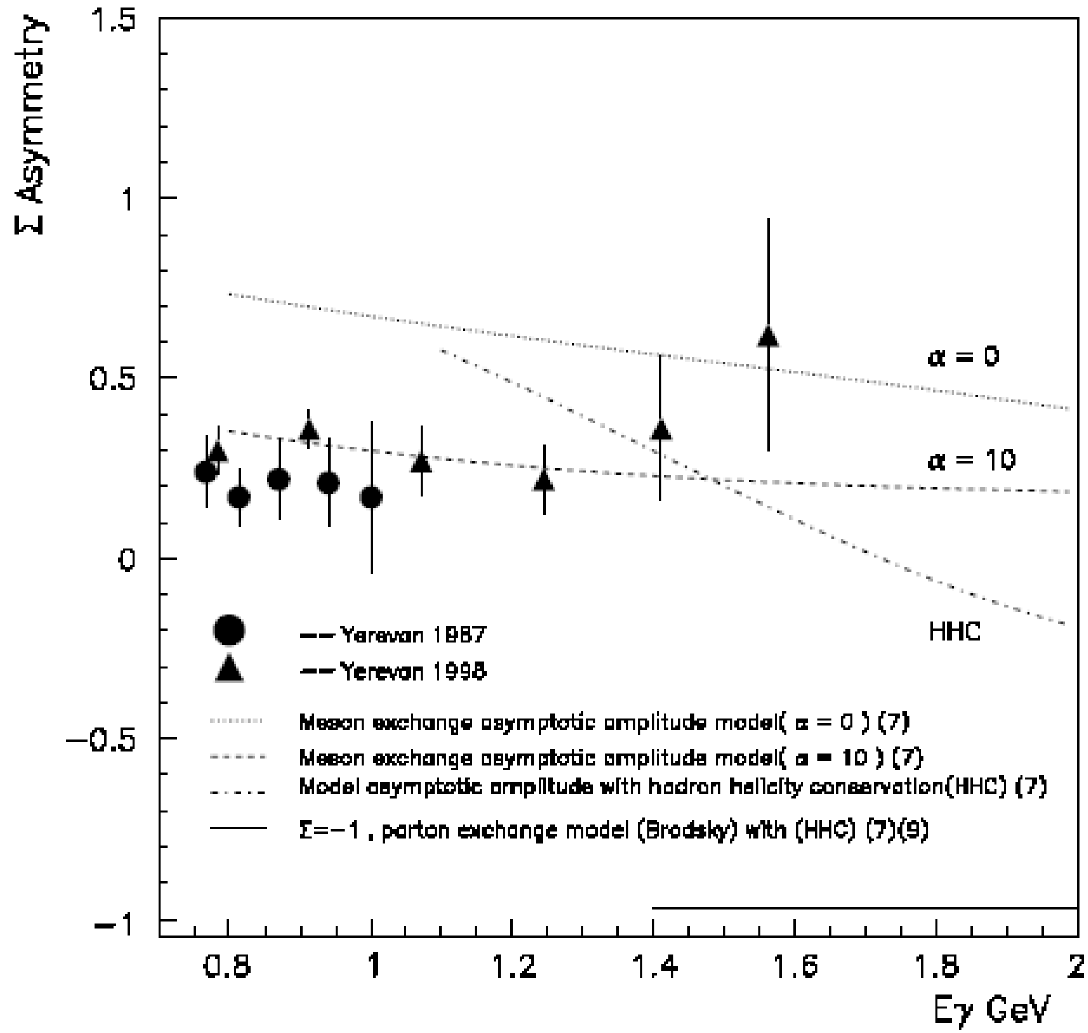


Fig. 8. The energy dependence of the cross-section asymmetry Σ for $\theta_{\mathrm{p}} = 90°$ in the cms.

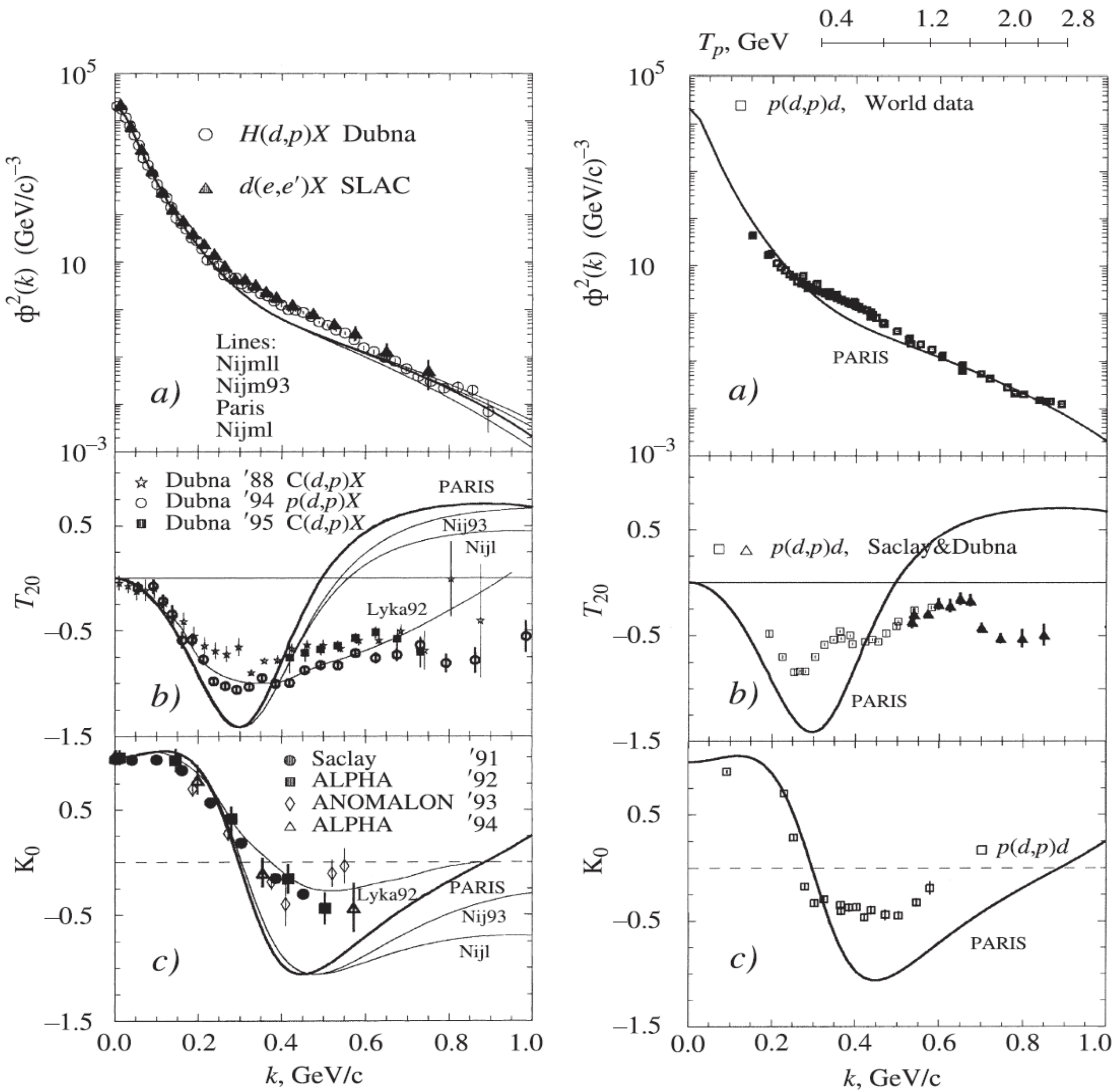


Рис. 5. Сводка данных экспериментов по фрагментации (слева) и упругому рассеянию «назад» (справа) поляризованных и неполяризованных дейтронов

CsDBM investigation

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

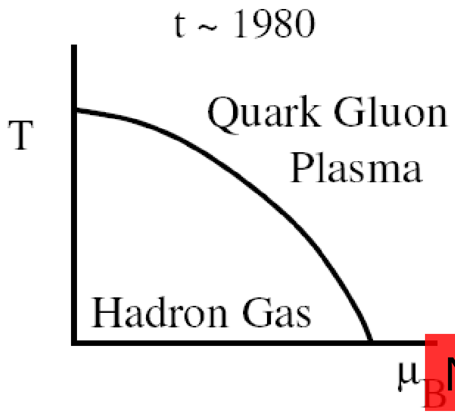
RHIC Physics: 3 Lectures*

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

September 13, 2003

With time the complexity is growing for the cold high density region

The Evolving QCD Phase Transition

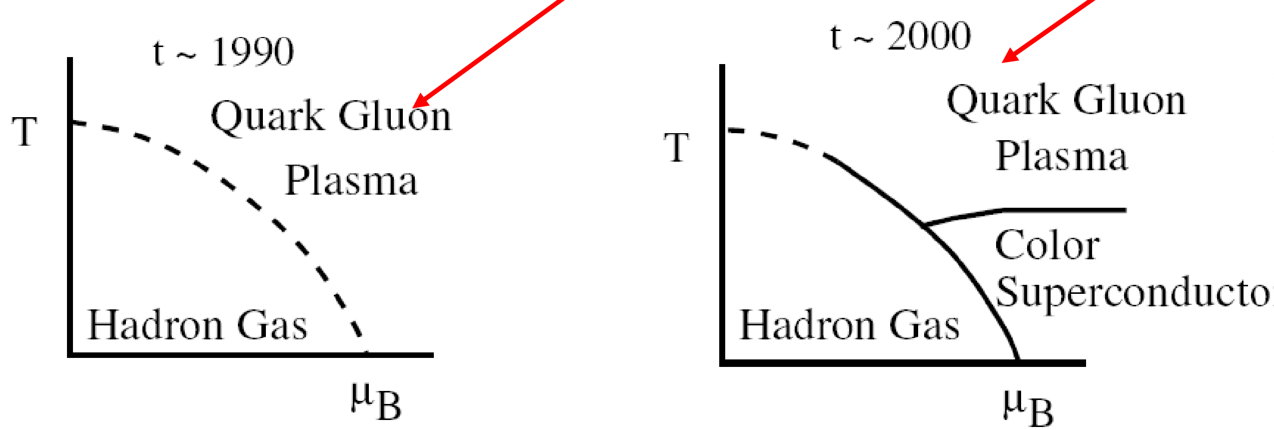


Critical Temperature 150 - 200 MeV ($\mu_B = 0$)
Critical Density 1/2-2 Baryons/Fm^3 ($T = 0$)

Nuclear Physics A 837 (2010) 65–86

Nuclotron-SPS Time (CERN)

RHIC Time(BNL)



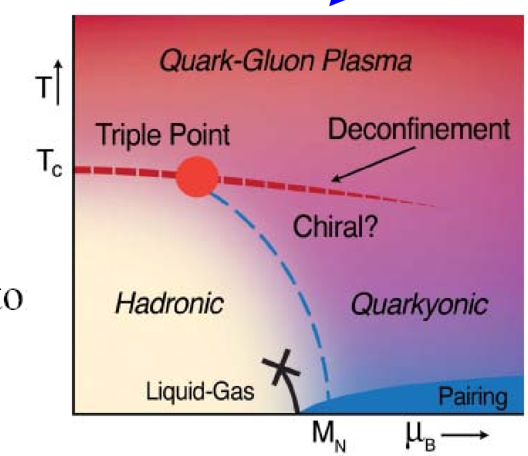
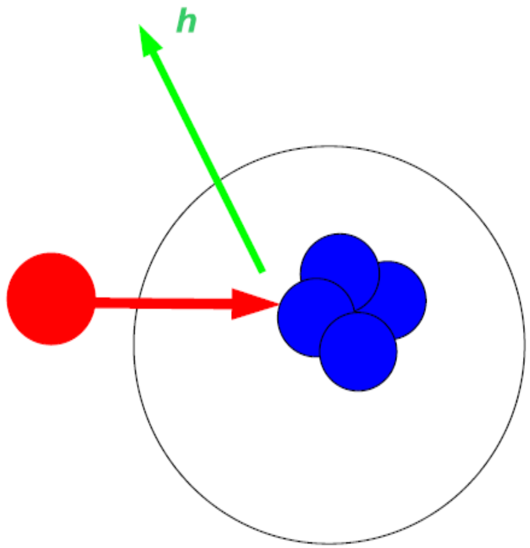
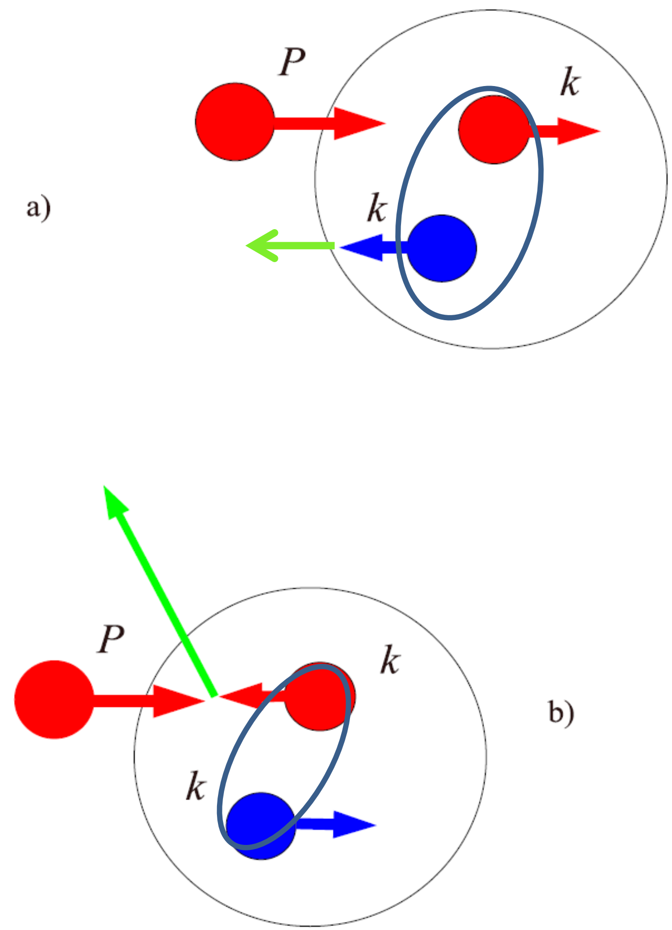


Figure 4: A phase diagram for QCD collisions.

«Fluctons»



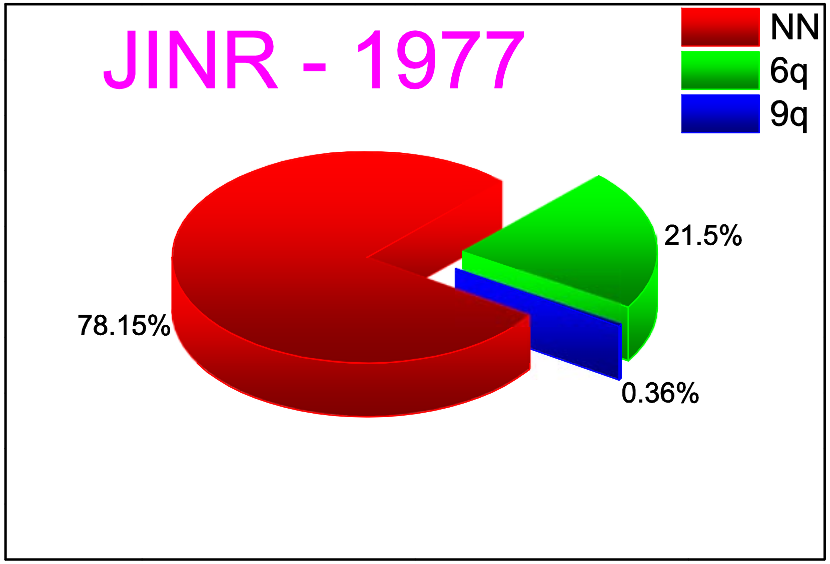
“SRC”



^{12}C - structure

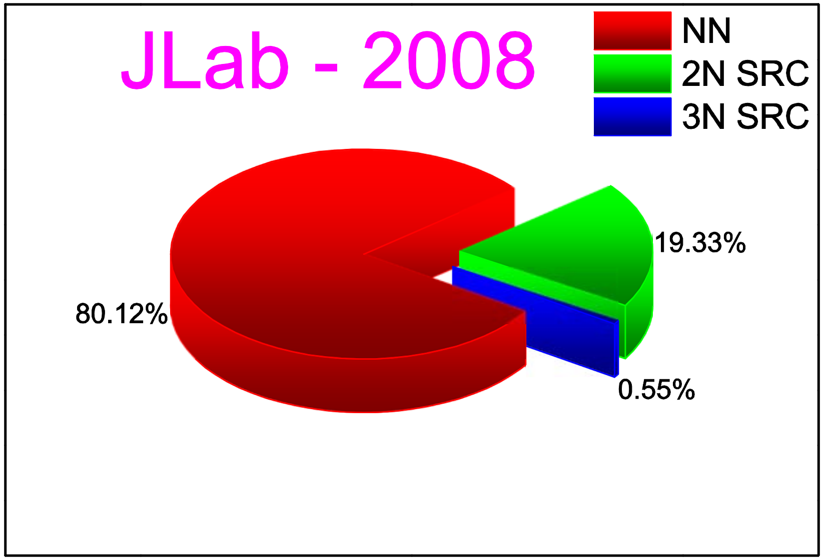
RNP - program at JINR

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



eA - program at JLab

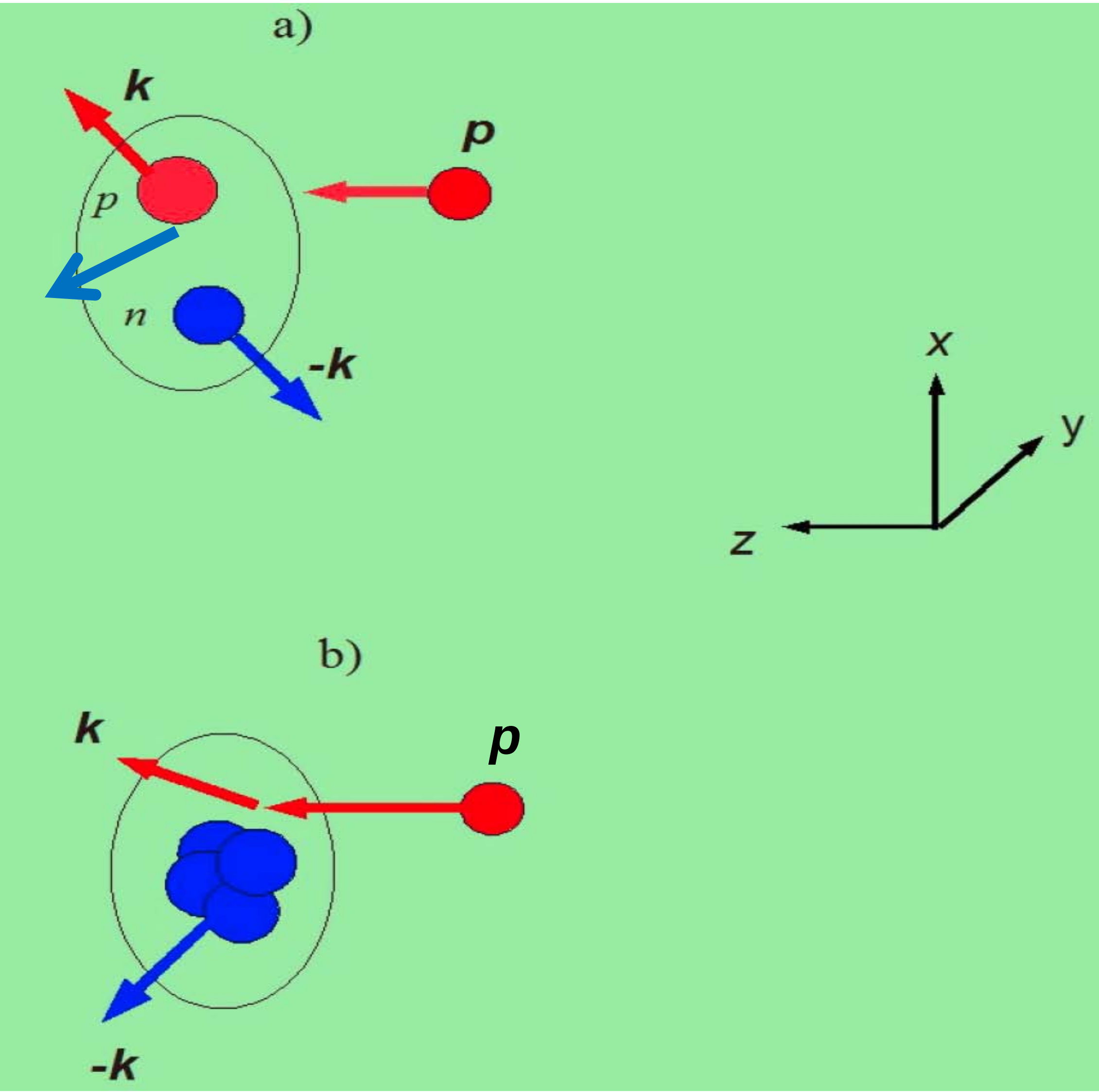
R.Subedi et al., Science 320 (2008) 1476-1478
e-Print: arXiv:0908.1514 [nucl-ex]



Knot out cold dense nuclear configurations

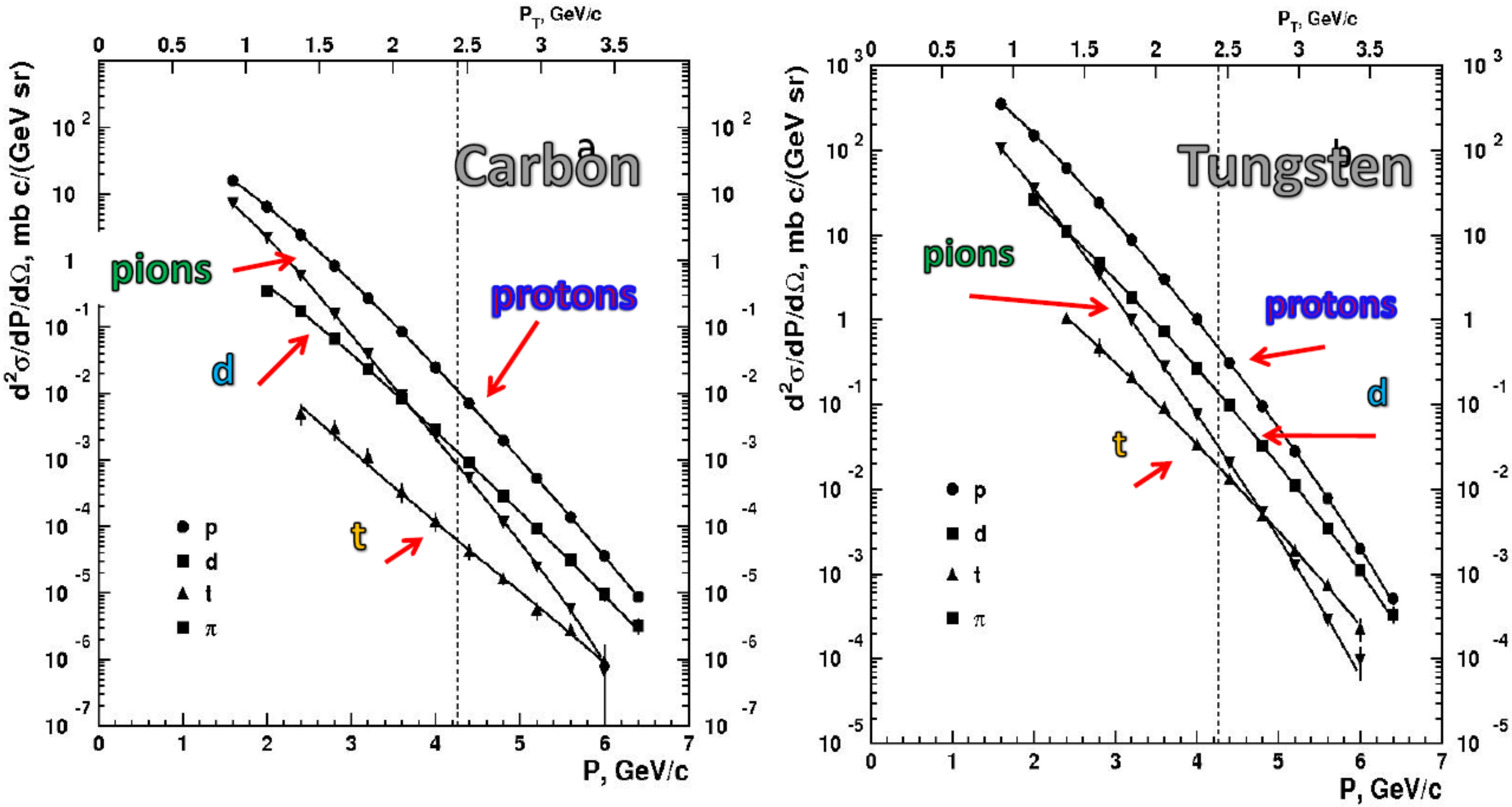
SRC configuration

Multiquark configuration



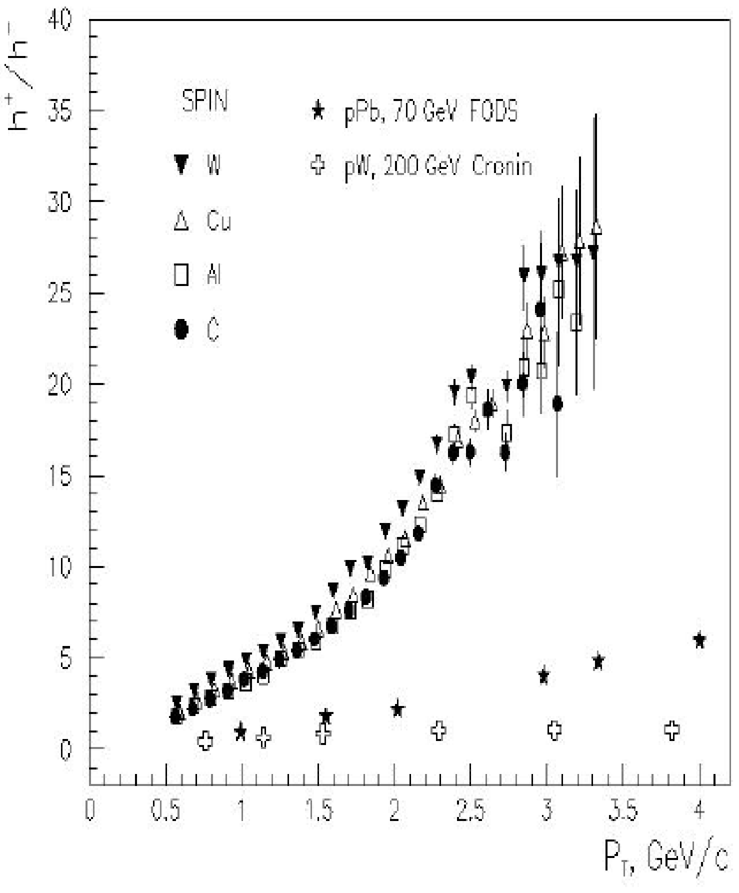
SPIN data

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

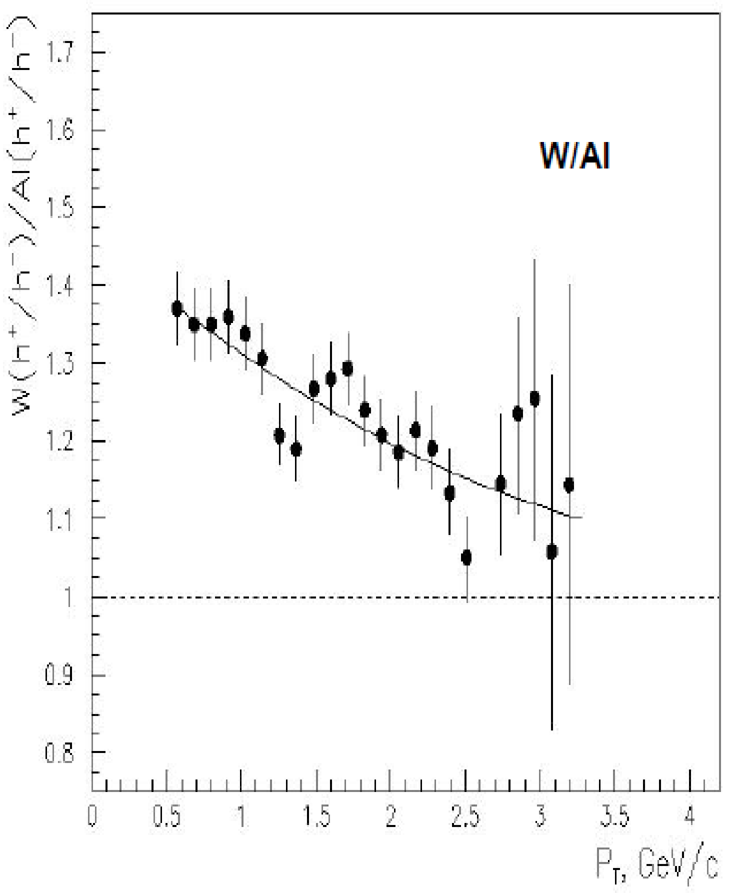


Invariant function found for positive pion, proton, deuteron and triton.
The vertical dashed lines indicate the kinematical limit for elastic nucleon–nucleon scattering. The upper horizontal scale shows values of the transverse momentum p_T .

Ratios



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

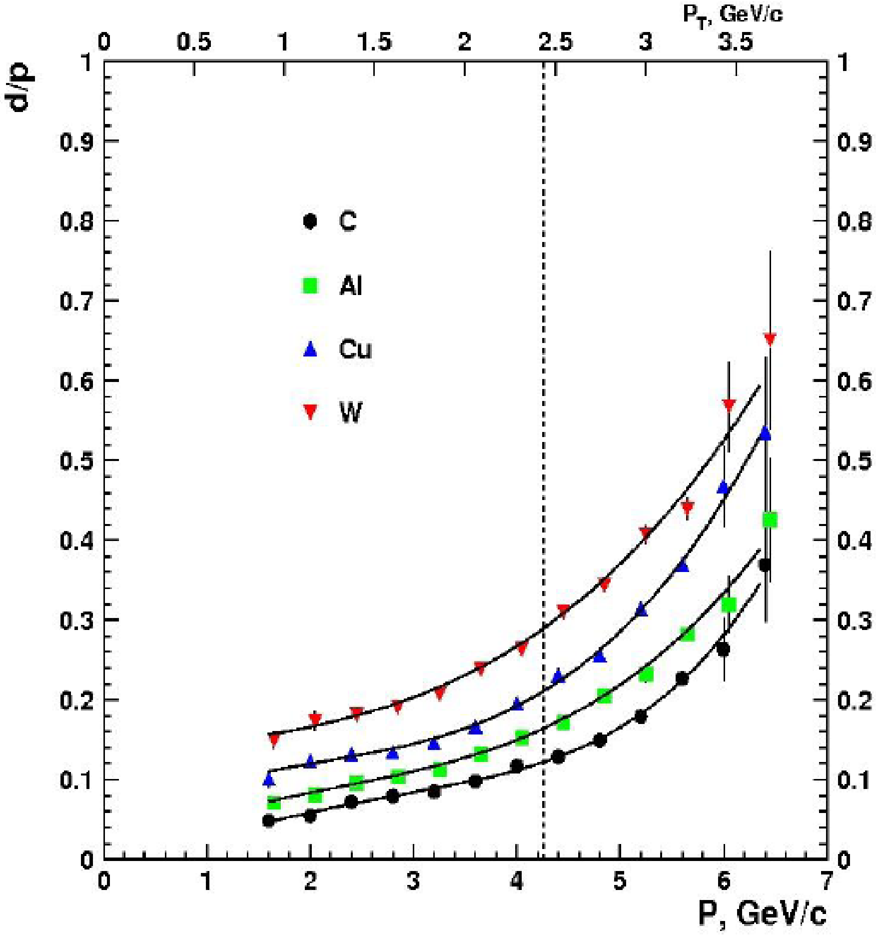


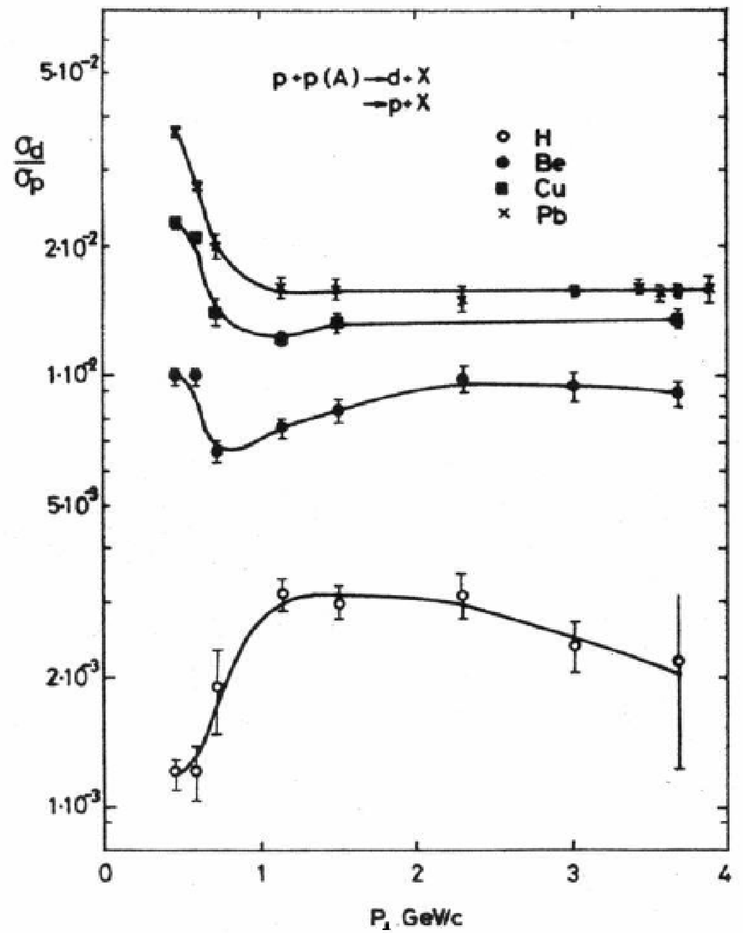
$W(h^+/h^-)/Al(h^+/h^-)$
W/Al
P_T, GeV/c

SPIN data

Ratio d/p

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





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».

arXiv:1605.04090v1 [hep-lat] 13 May 2016

Study of the phase diagram of dense two-color QCD within lattice simulation

V. V. Braguta,[1,2,3,4,*] E.-M. Ilgenfritz,[5,†] A. Yu. Kotov,[2,6,‡] A. V. Molochkov,[3,§] and A. A. Nikolaev[3,2,¶]

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[4] *Moscow Institute of Physics and Technology, Institutskii per. 9, Dolgoprudny, Moscow Region, 141700 Russia*
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In this paper we carry out a low-temperature scan of the phase diagram of dense two-color QCD with $N_f = 2$ quarks. The study is conducted using lattice simulation with rooted staggered quarks. At small chemical potential we observe the hadronic phase, where the theory is in a confining state, chiral symmetry is broken, the baryon density is zero and there is no diquark condensate. At the critical point $\mu = m_\pi/2$ we observe the expected second order transition to Bose-Einstein condensation of scalar diquarks. In this phase the system is still in confinement in conjunction with nonzero baryon density, but the chiral symmetry is restored in the chiral limit. We have also found that in the first two phases the system is well described by chiral perturbation theory. For larger values of the chemical potential the system turns into another phase, where the relevant degrees of freedom are fermions residing inside the Fermi sphere, and the diquark condensation takes place on the Fermi surface. In this phase the system is still in confinement, chiral symmetry is restored and the system is very similar to the quarkyonic state predicted by SU(N_c) theory at large N_c.

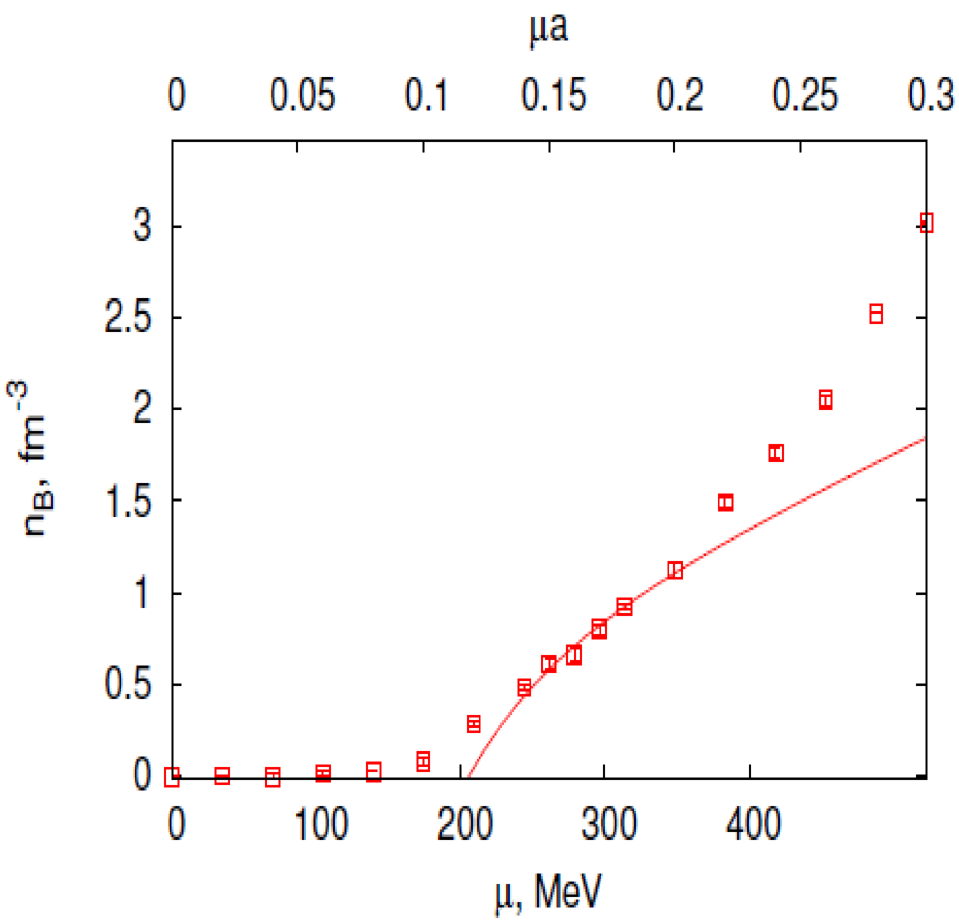

FIG. 10: The baryon density n_B in physical units, as a function of μ. The chemical potential is expressed in physical units (lower scale) and in lattice units (upper scale).

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).

Nucleon's Spin

$$\frac{1}{2} = \langle S_q \rangle + \langle S_g \rangle + \langle L_q \rangle + \langle L_g \rangle$$

Are there all?

Diquarks part? $+\left\langle S_{(qq)} \right\rangle + \left\langle L_{(qq)} \right\rangle + \ldots$

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

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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
Carlos Granados and Misak Sargsian

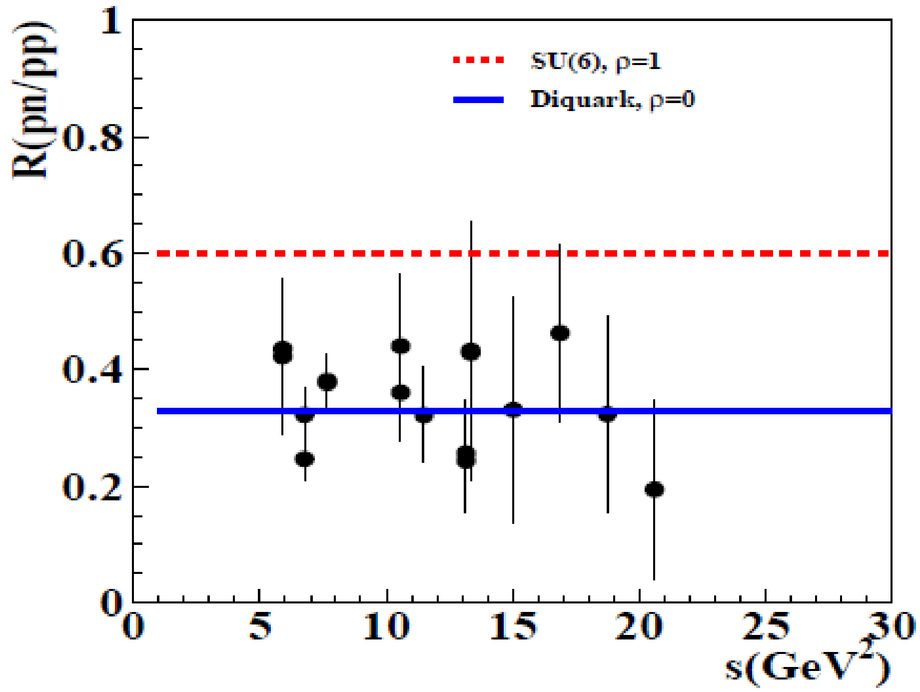


FIG. 2: (Color online) Ratio of the $pn \to pn$ to $pp \to pp$ elastic differential cross sections as a function of s at $\theta^N_{c.m.} = 90^0$.

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 $x_T \sim 1$

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

$B\ (p, n, \Lambda, \Delta \ldots)$, $M\ (\pi, K, \ldots)$

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:

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

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

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

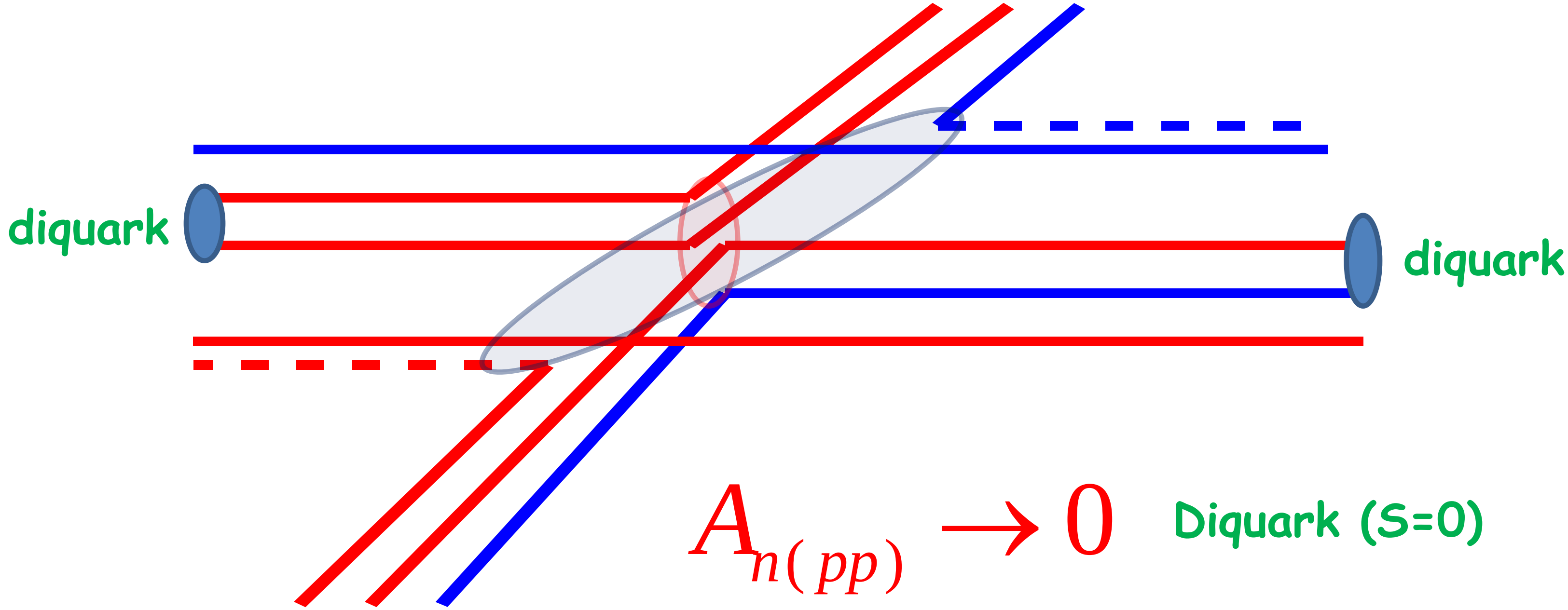
High p_T exclusive reactions -> MPI

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

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

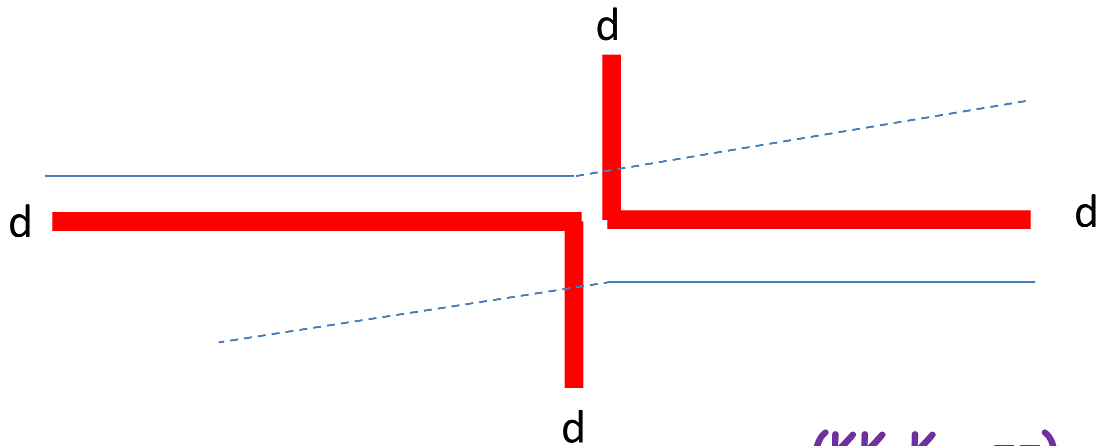
$$R = \frac{N(\pi^+\pi^-)}{N(\pi^0\pi^0)} = \frac{2}{7}$$ Without diquark

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



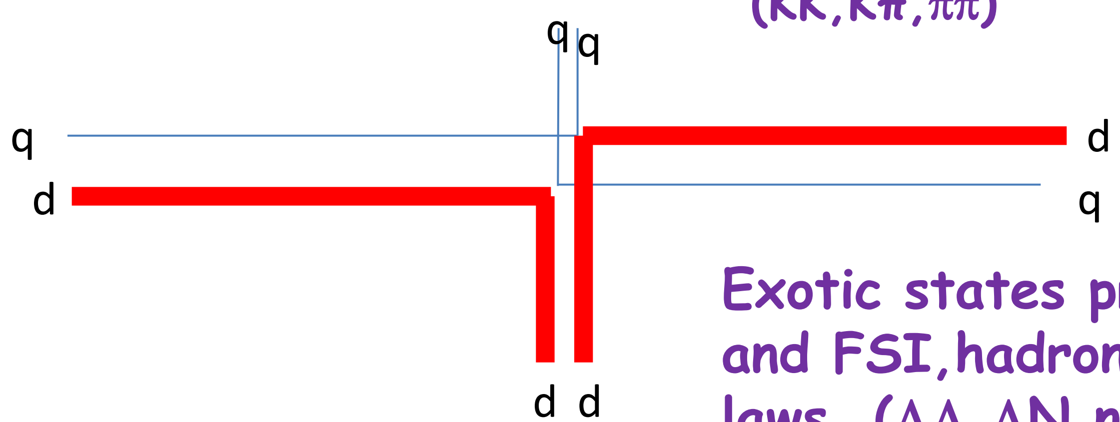
$$A_{n(pp)} \to 0$$ Diquark (S=0)

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



Diquark proof

(KK,Kπ,ππ)

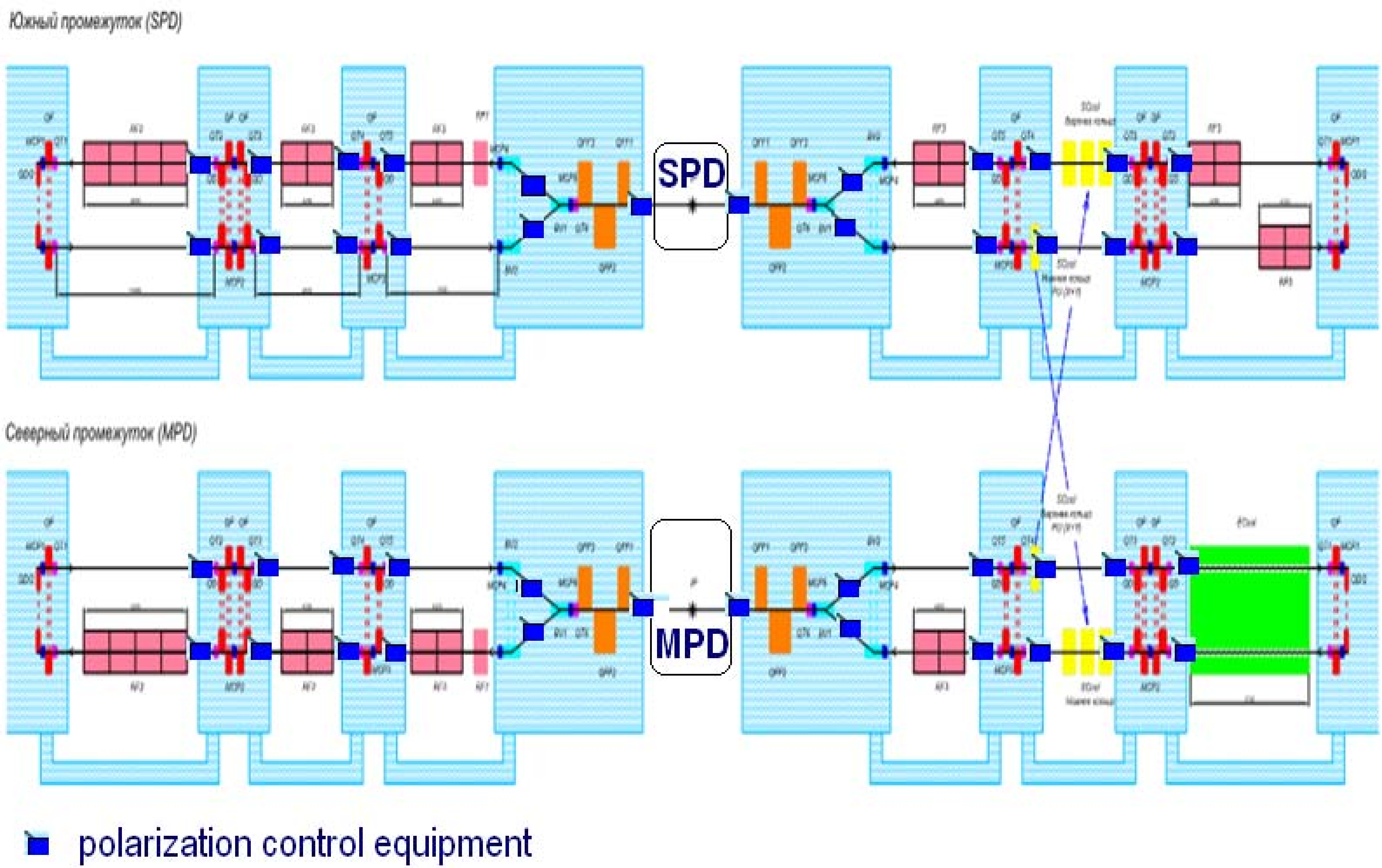


Exotic states production and FSI, hadronization laws (ΛΛ,ΛN,nn)

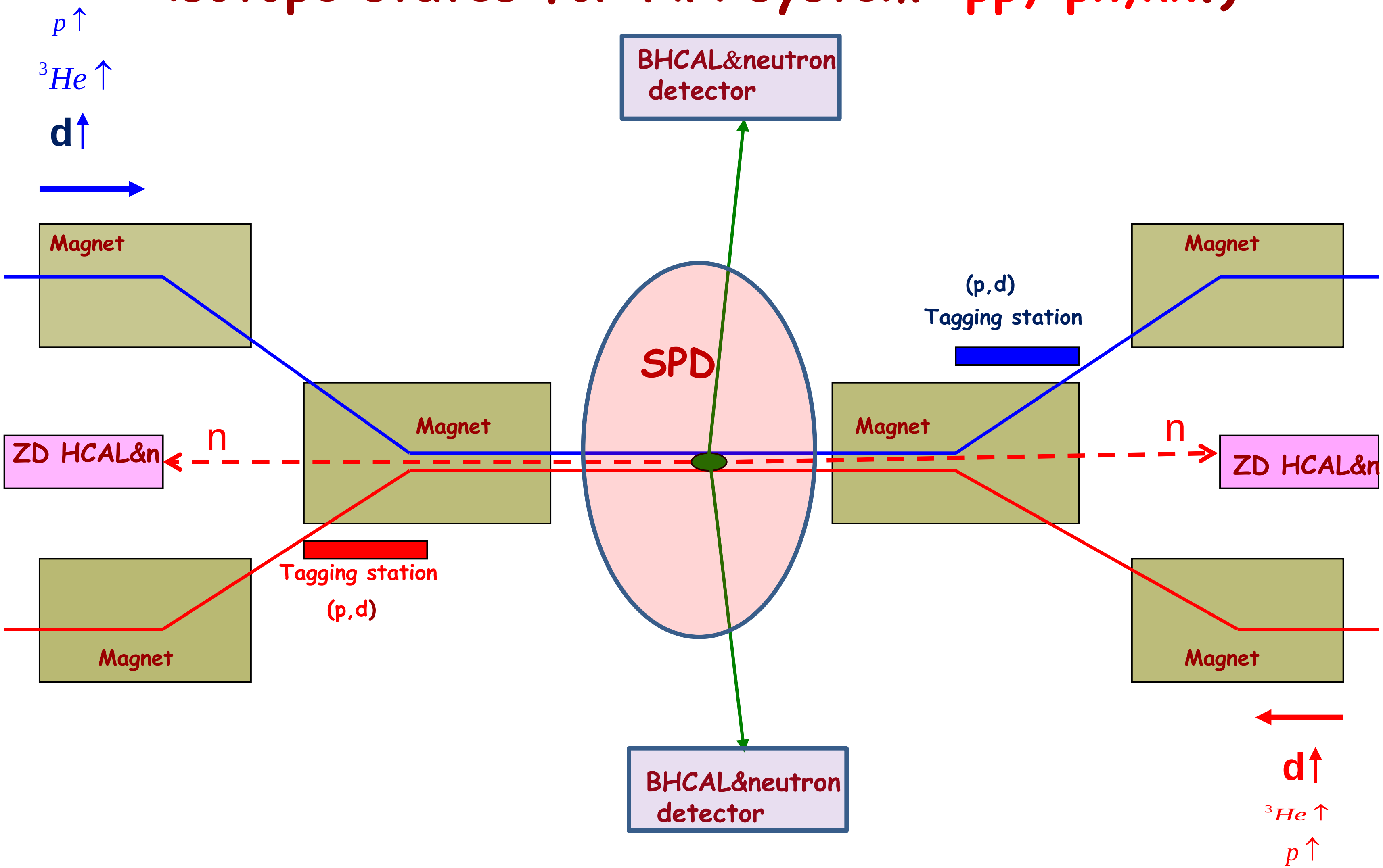
Kim's mechanisms

Polarization control in the Collider at $\nu_s = 0$ (4)

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!

Available online at www.sciencedirect.com
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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)☆

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[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.

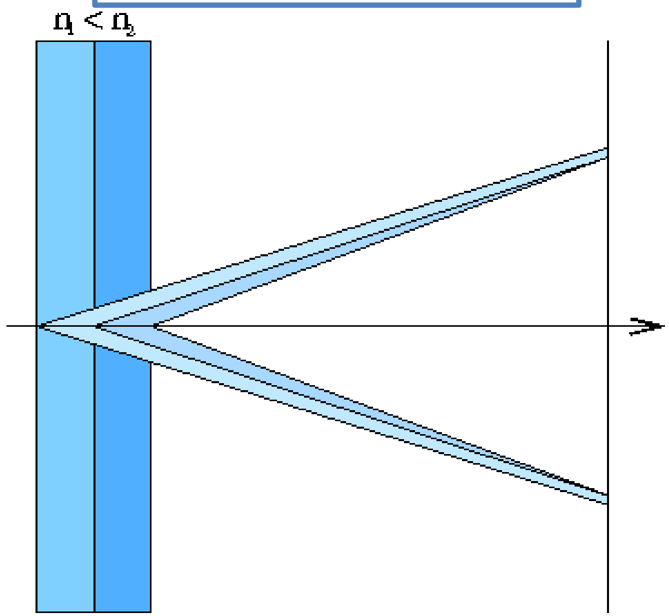
A GEANT4 based simulation program has been developed. Velocity resolution was investigated for different momenta and particle incidence angles. It was shown that velocity resolution of 5×10^{-4} is achievable. This permits us to have π/K separation at the level of more than 3σ up to momentum 8.0 GeV/c,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

FARICH concept

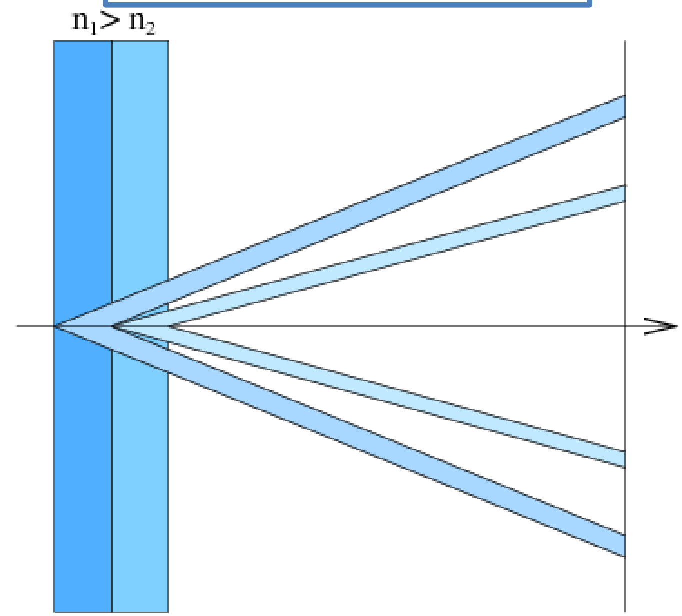
Focusing Aerogel RICH – FARICH

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

Single ring option



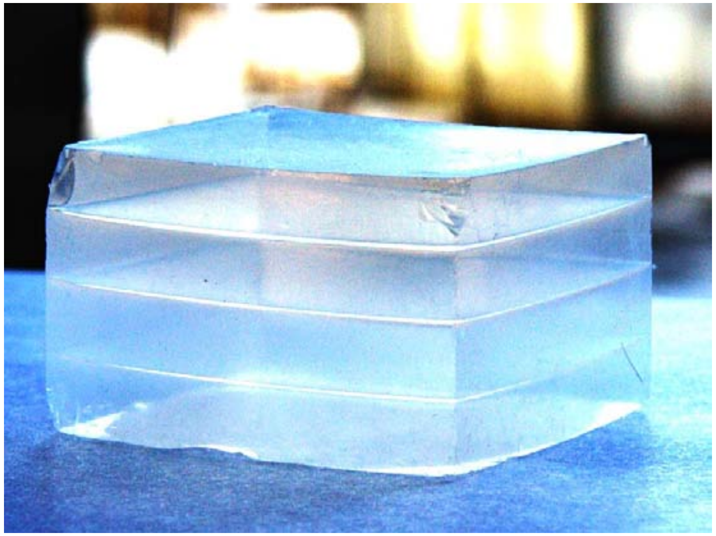
Multi-ring option

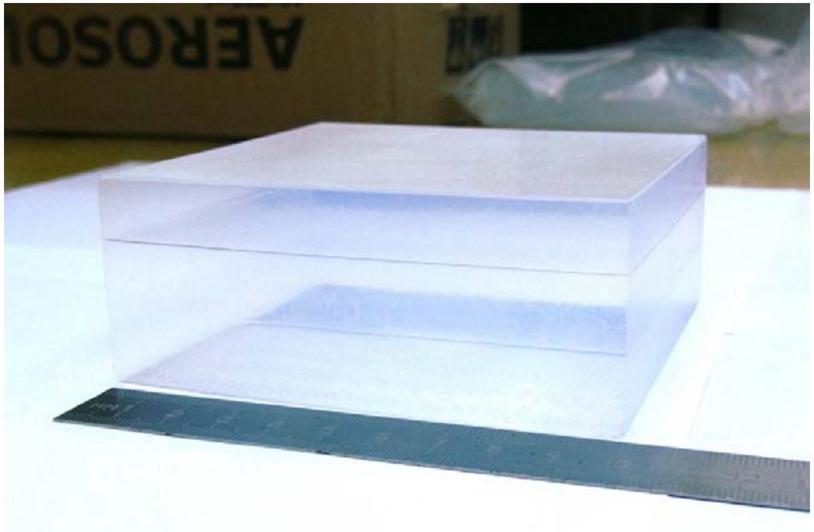


T.Iijima et al., NIM A548 (2005) 383
A.Yu.Barnyakov et al., NIM A553 (2005) 70

Multi-layer 'focusing' aerogels

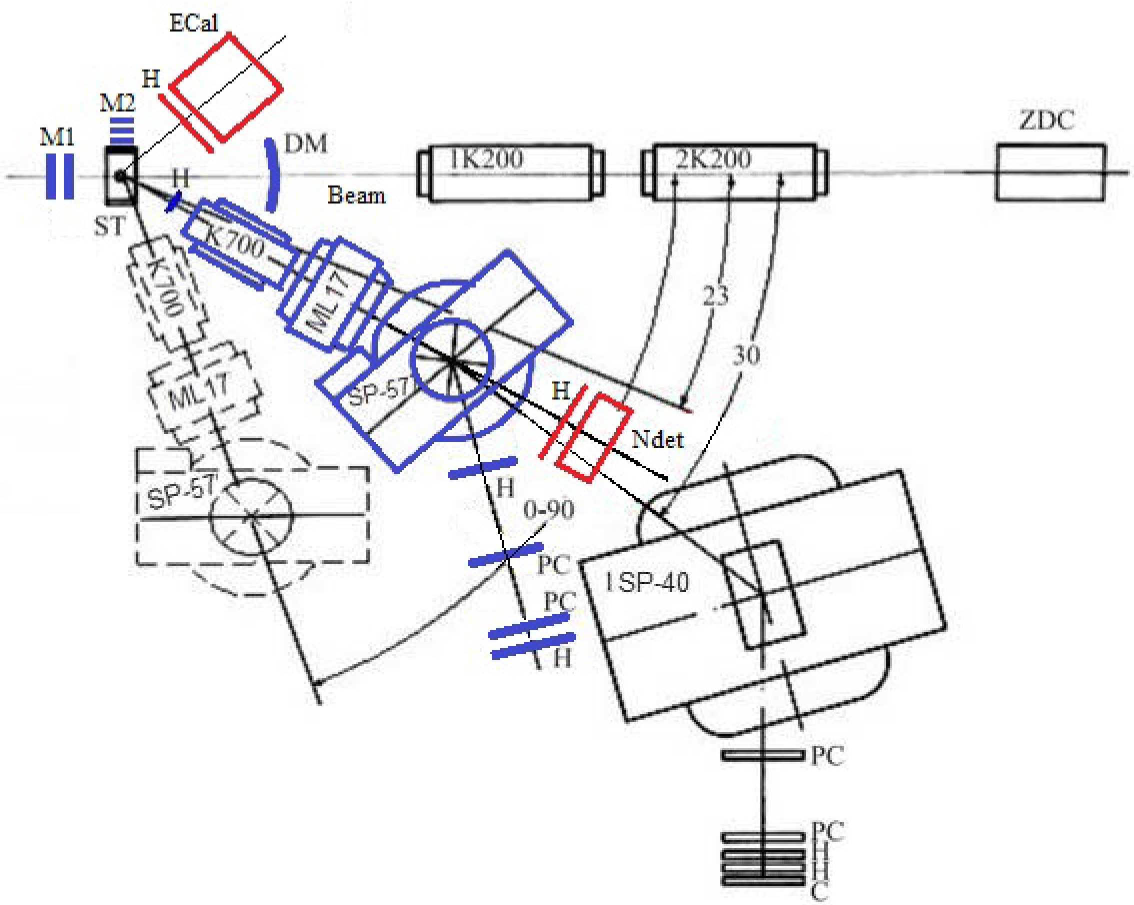
- Produced by Boreskov Institute of Catalysis (Novosibirsk) in cooperation with Budker Institute since 2004





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

Experiment MARUSYA-FLINT at JINR



Scheme of experimental set-up MARUSYA-FLINT: ST - target station,
M1, M2- scintillation monitors,
DM- multiplicity detectors,
H- scintillation hodoscopes,
ZDC - hadron calorimeter,
PC - proportional chambers,
C – cherenkov counter,
ML17, K100 - quadrupole lens,
SP-57, SP-40 - dipole magnets,
ECal - electromagnetic calorimeter

Magnetic spectrometer:

For P_t = 0,3-0,8 GeV/s used magnet SP-57

For P_t = 0,6-2 GeV/s used magnet SP-57 and SP-40

ISSUES

1. Diquark properties.
2. The Confinement laws.
3. Nature of the spin effects.
4. The Deuteron spin structure.
5. FSI (with s-quark participation).
6. Nature of CsDBM.
7. np dilepton production anomaly.
8. …

1. Conditions to accelerate the polarized beams (p, d, ^3He -?) and the spin-flip system!

2. The target stations for pp, pn, nn and …–interactions + polarimetry. Magnets and cryostats design. Close cooperation with acceleration people is needed since now!

3. Design ZDC with high neutron efficiency.

4. Design and prototype testing of detectors for target stations.

5. MC simulations (detectors and processes).

THANK YOU