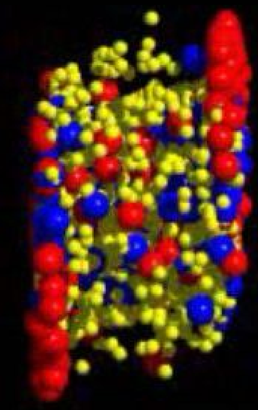
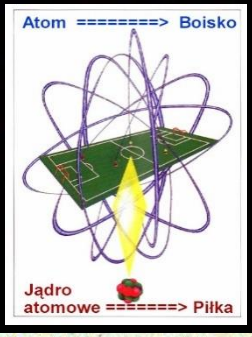
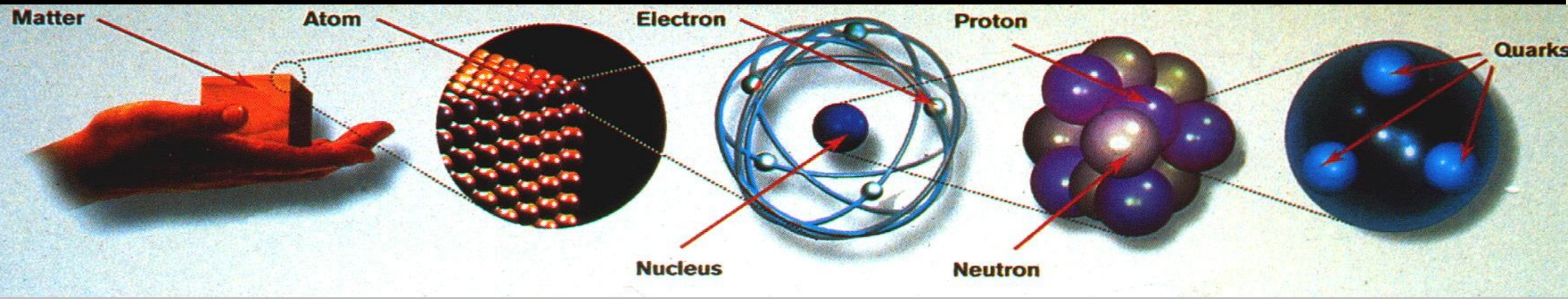
Au+Au E_{cm}=200 AGeV t= 03.11 fm/c

Brief history of femtoscopy and WPCF
- a personal view

very



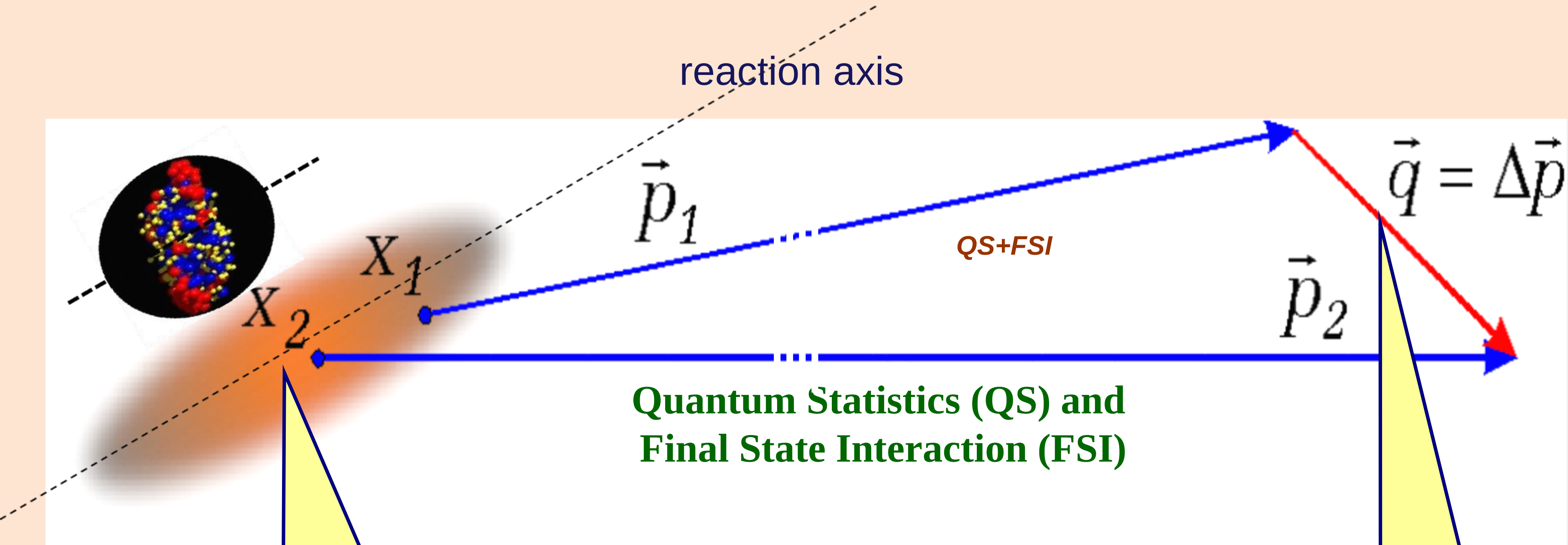




~10^{-1} m ~10^{-10} m ~10^{-15} m


Au+Au E_{cm}=200 AGeV
t=-19.89 fm/c
H. Weber / UrQMD Frankfurt/M

Particle correlations as a tool to measure space-time sizes of high energy collisions



$$\Delta p \cdot \Delta x \approx \hbar; \quad \hbar c = 197.3 \;\; MeV \cdot fm$$

Space-time sizes (10^{-15} m, 10^{-23}s

(directly unmeasurable) ☹

Particle correlations at small relative velocities

Momentum difference

(can be measured) ☺

A pre-femtoscopy period

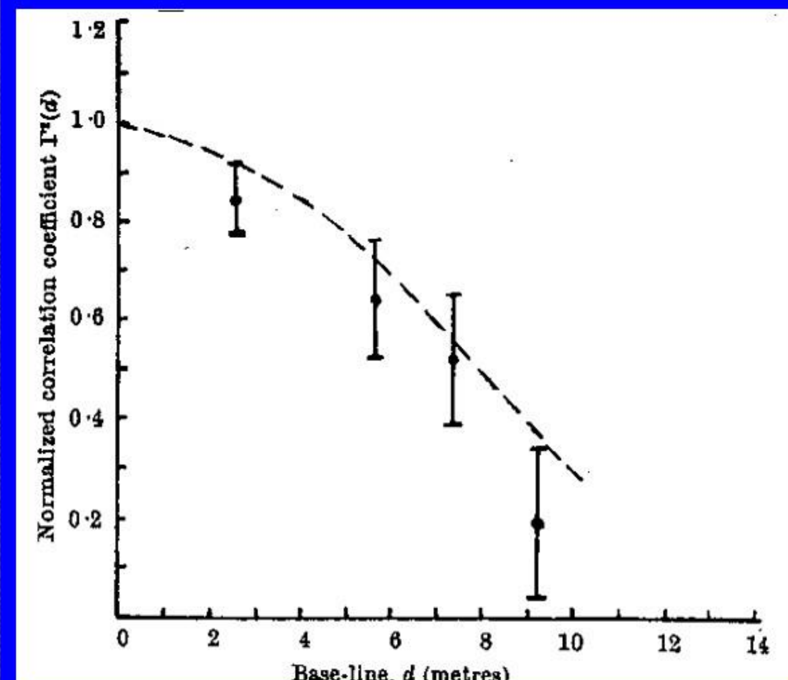
HBT measurement of the angular size of Sirius

$N_e \sim 10^8$ e/sec, $\Delta f \sim 10^{13}$ Hz, $\Delta f_F \sim$ 5-45 MHz

Required $T \sim (2\Delta\omega / N_e)^2 / \Delta\omega_F \sim$ hours

$\langle S_T \rangle / \langle S_T^2 - \langle S_T \rangle^2 \rangle^{1/2}$

Normalized to 1 at d=0



Phys. Rev. 120 (1960) 300

Influence of Bose-Einstein Statistics on the Antiproton-Proton Annihilation Process*

GERSON GOLDHABER, SULAMITH GOLDHABER, WONYONG LEE, AND ABRAHAM PAIS†
Lawrence Radiation Laboratory and Department of Physics, University of California, Berkeley, California

1960

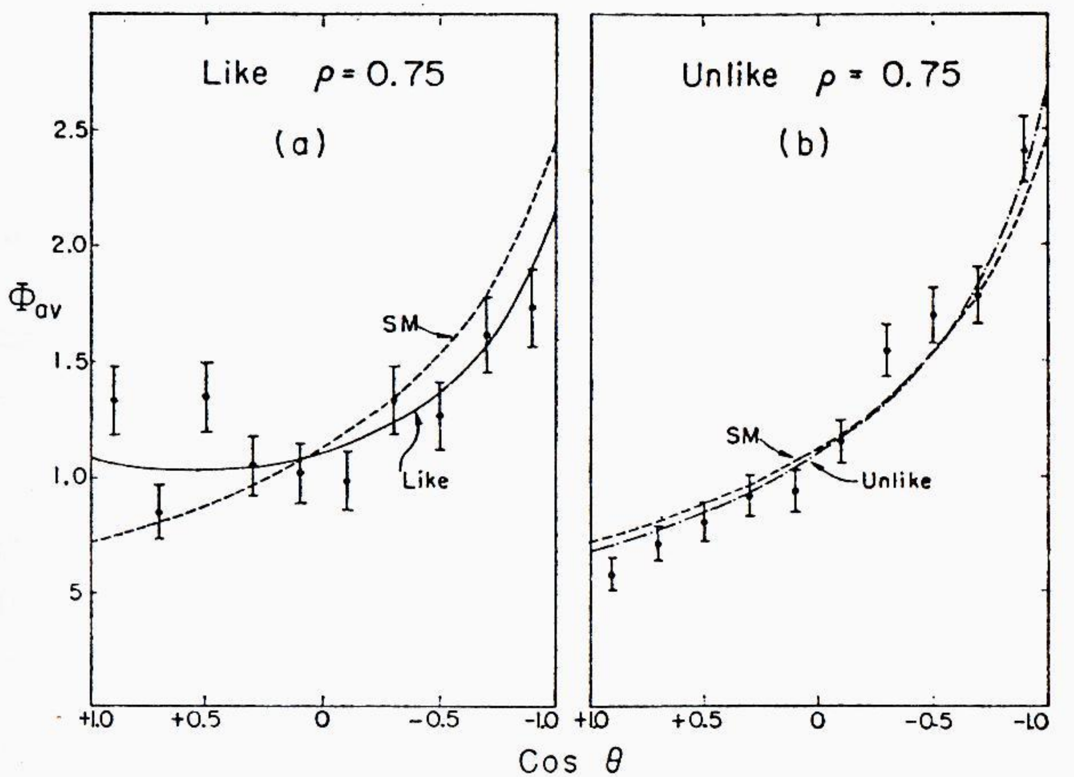


FIG. 6. The functions $\Phi_{av}(\cos\theta)$ computed at $\rho=0.75$ are compared with the experimental distribution of angles between pion pairs. Figures 6(a) and 6(b) give the distributions for like and unlike pions respectively. Also shown in each is the curve for $\Phi_{av}^{SM}(\cos\theta)$, the statistical distribution, without the effect of correlation functions. Here Φ_{av} represents an average of Φ_4, Φ_5, and Φ_6, weighted according to the individual charge channels. The experimental data comes from reference 1 (see also Table I, footnote a).

1967

CORRELATED PROTON PAIRS IN A HIGH ENERGY NUCLEAR REACTION

T. SIEMIARCZUK and P. ZIELIŃSKI
Institute of Experimental Physics of the University of Warsaw and
Institute of Nuclear Research, Warsaw, Poland

Emission of correlated proton pairs in 780 interactions of 9 GeV negative pions with xenon nuclei has been observed.

It has been pointed out by Ericson [1] that in analogy to the frequent emission of fast deuterons in high energy nuclear reactions [2], the frequent emission of fast correlated proton pairs ("diprotons") is to be expected.

In the present note some experimental results of a search for correlated proton pairs in reactions induced by high energy negative pions in xenon nuclei are presented.

The xenon bubble chamber has been irradiated by a beam of the 9 GeV negative pions at the proton synchrotron of the Joint Institute of Nuclear Research in Dubna. Scanning for ine-

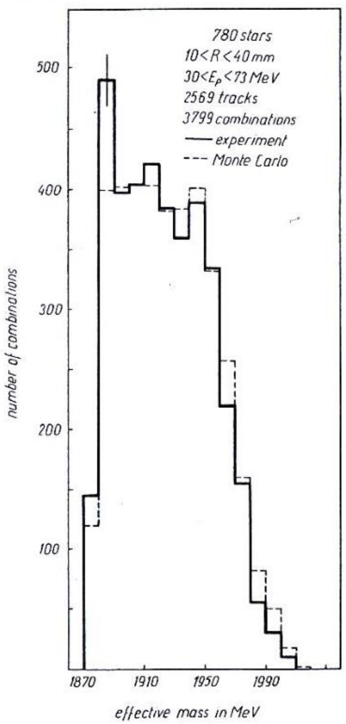


Fig. 1.

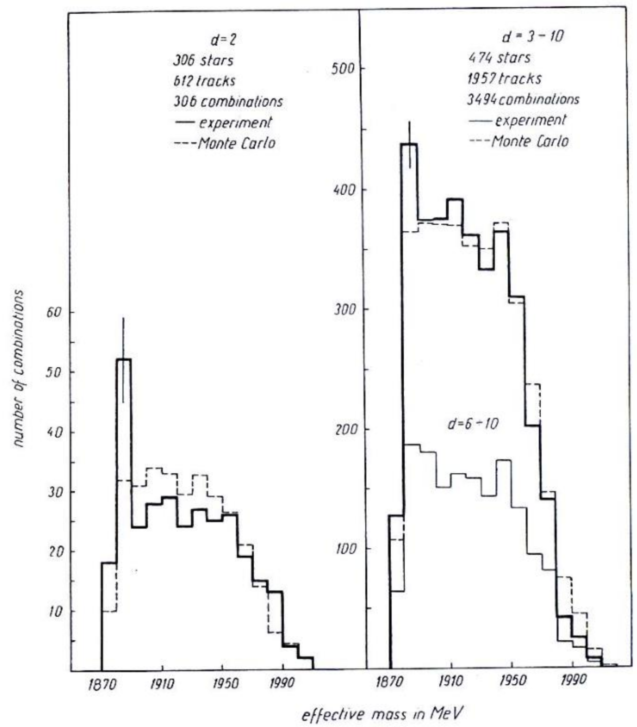


Fig. 2.

Vol. XXXVI (1969) ACTA PHYSICA POLONICA Fasc. 2 (8)

ANGULAR CORRELATIONS BETWEEN π° MESONS PRODUCED IN π^- Xe INTERACTIONS AT 9 GeV/c π^- INCOMING MOMENTUM

By K. Eskreys

Academy of Mining and Metallurgy, Cracow*

1969

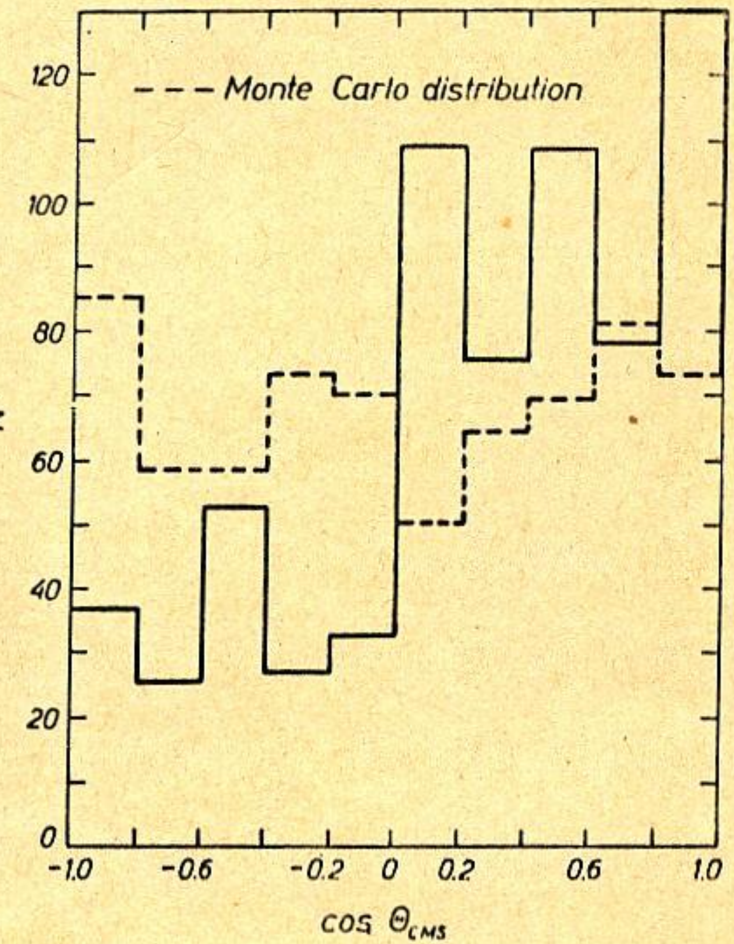


Fig. 2. Distribution of the opening angle of π° meson pairs in the coordinate system moving with the Lorentz factor $\gamma = 1.47$. The experimental distribution is given by the solid line, the Monte-Carlo distribution by the dashed line

The begin of femtoscopy

1972 ~ 4

Kopylov and Podgoretsky settled the basics of correlation femtoscopy:

- **correlation function,**
- **mixing technique,**
- **role of space-time characteristics etc.**

Podgorecki, Kopylov, Smorodinski
Dubna, 1974

1970

INTERFERENCE OF IDENTICAL PARTICLES IN PROCESSES INVOLVING EXCITED NUCLEI AND RESONANCES

V. G. GRISHIN, G. I. KOPYLOV and M. I. PODGORETSKIĬ

Joint Institute for Nuclear Research

Submitted August 16, 1970

Yad. Fiz. 13, 1116—1125 (May, 1970)

The paper considers the interference of identical particles in processes involving either excited nuclei or resonances. The possibility of measuring the widths of resonant states by this method is discussed.

1973

Multiple production and interference of particles emitted by moving sources

G. I. Kopylov and M. I. Podgoretskiĭ

Joint Institute for Nuclear Research

(Submitted February 5, 1973)

Yad. Fiz. **18**, 656–666 (September 1973)

Interference phenomena arising when the products of a multiple production process include identical particles with close momenta are considered. It is shown that the distribution with respect to the momentum differences enables one to estimate the shape and the lifetime of region in which the multiple production takes place.

1974

Volume 50B, number 4 PHYSICS LETTERS 24 June 1974

LIKE PARTICLE CORRELATIONS AS A TOOL TO STUDY THE MULTIPLE PRODUCTION MECHANISM

G.I. KOPYLOV

Joint Institute for Nuclear Research, Dubna, USSR

Received 18 February 1974

The measurement of correlations between like pions in the inclusive processes $a + b \to \pi^\pm + \pi^\pm + X$ permits us to study the space-time mechanism of multiple production. Similar measurements for neutrons evaporated from highly excited nuclei give the shape of nuclei and their mean lives; for pions from the resonance decay – the mean resonance life.

A large amount of information has recently appeared concerning particle correlations in inclusive processes, especially in counter experiments [1]. But the theoretical conclusions drawn from these experiments are comparatively poor; the usual correlation coefficient $C(y_1, y_2)$ has no deep meaning. We want here to focus attention on another type of correlations which can be extracted from the same statistics and give physical information about the space-time properties of multiple production.

In a number of papers of Podgoretsky and his co-workers it is shown [2–7,12] that there exist the so-called interference correlations between like particles. These correlations generalize the idea of famous Brown-Twiss correlation experiment in astronomy [8] and Goldhaber-Goldhaber-Lee-Pais effect [9] in meson physics.

Let us consider two sources which emit identical particles with four-momenta p_1, p_2. These sources are so close that we cannot distinguish which of them emits this or that particle. Therefore the amplitude A of double counts consists of two terms, and an interference term in $|A|^2$ depends, for $p_1 \approx p_2$, on the four-difference $q = p_1 - p_2$, more exactly, on the dimensionless combination sq/h where s is some characteristic space-time interval between the sources. So the measurement of correlations in double counts of like particles makes it possible to determine the space-time conditions of their generation. This main idea can be used in various physical conditions differently.

Multiple production. Consider the reaction $a + b \to \pi_1^\pm + \pi_2^\pm + X$ and calculate for each event the pion energy difference $q_0 = \omega_1 - \omega_2$ and the projection of $\boldsymbol{q} = \boldsymbol{p}_1 - \boldsymbol{p}_2$ onto the plane perpendicular to $\boldsymbol{p}_1 + \boldsymbol{p}_2$: $\boldsymbol{q}_T = \boldsymbol{q} - \boldsymbol{n}(\boldsymbol{q}\cdot\boldsymbol{n})$ where $\boldsymbol{n} = (\boldsymbol{p}_1 + \boldsymbol{p}_2)|\boldsymbol{p}_1 + \boldsymbol{p}_2|^{-1}$. Let us [...] can switch on and off the interfere[nce ...] pions at our own will. Then it can [...] ing [6]; see also [10]) that the distribu[tion]

$$w(q_T^2, q_0)_{\text{on}} \equiv \frac{d^2\sigma}{dq_T^2\, dq_0}\bigg|_{\text{with interf[eren]ce}}$$

is connected with a smooth fun[ct]ion $w(q_T^2, q_0)_{\text{off}}$ by the relation

$$w(q_T^2, q_0)_{\text{on}} = w(q_T^2, q_0)_{\text{off}} \times [1 + I^2(q_T R)(1 + q_0^2\tau^2)^{-1}]. \qquad (1)$$

Here $I(x) = 2J_1(x)/x$, J_1 b[ei]ng the first Bessel function, $I(0)$ [...], $I(\infty) = 0$. W[e se]e that the interference [...]t the or[...] (q_T^2, q_0). The [...]ak give[s ...] [mu]ltiple genera[...] [...] region R and the duration of generation process τ.

There exist the ways to switch the interference on and off. If the pions are generated in accordance with the statistical theory of Pomeranchuk or Fermi (i.e. independently; it is widely believed that this theory holds in $\bar{p}p$ annihilations), then the interference is switched on between like pions and off between unlike ones. That is why for $\bar{p}p$ annihilation we can write (1) in the form

$$w(q_T^2, q_0)_{\pi^\pm\pi^\pm} = Cw(q_T^2, q_0)_{\pi^+\pi^-}[1 + I^2(q_T R)(1 + q_0^2\tau^2)^{-1}] \qquad (2)$$

Correlation function

Space

Time

1974

Mixing technique

where C is the normalization constant. This is the generalization of GGLP-effect [9] taking into account the duration of multiple production p... criticism of the GGLP-effect theory i...

The interference always exists in t... teraction because the pion generation ... cesses is believed to be described by d... tiperipheral) technique (not statistically a... n order to switch off the interference, we pr... to take the pions from different events: the fi... on from the nth event, the second from the (n...)th etc. Consequently, in these processes one ca... put

$$w(q_T^2, q_o)\Big|_{\substack{\text{both pions}\\ \text{from one event}}} =$$

$$= Cw(q_T^2, q_o)\Big|_{\substack{\text{pions from}\\ \text{two events}}} [1+|b(qR, q_o\tau)|^2] \qquad (3)$$

where the function $b(\xi, \eta)$ has properties similar to $I^2(q_T R)(1+q_o^2\tau^2)^{-1}$ in (4): $b(0,0)^2 = 1$, $|b(\infty, 0)|^2 = |b(0,\infty)|^2 = 0$. As a first step, one can put $|b(\xi,\eta)|^2 = I^2(\xi)/(1+\eta^2)$.

To extract the correlation effect from (2), (3), it is necessary to divide $w(q_T^2, q_o)_{\text{on}}$ by $w(q_T^2, q_o)_{\text{off}}$ and to fit the quotient to the expression in brackets. The effect is sufficiently two- or more-dimensional, it can be seen in the neighbourhood of the origin only; the integration over q_o or q_T can cancel it. Probably, that is why this effect has not been seen previously (and why the data on GGLP-effect taken from one-dimensional measurements are so contradictory). The second reason is a necessity to compare the results of "on" and "off" experiments.

Formulae (2), (3) were derived in the framework of the model in which the surface of the excited generation volume filled with point-like heavy pion oscillators emit pions randomly according to the Lambert law. Besides, it was assumed that $c\tau \gg R$. In ref. [6] were considered other emission models (from transparent sphere of pion sources, non-point like sources, sources moving randomly or as fireballs); in all cases the general structure of (1) conserves, only the meaning of parameters changes. If the oscillators are nonuniformly distributed in the volume, some function $\phi(\xi)$ should be put instead of the factor $I^2(\xi)$ in (1)‡. Having found it from the experiment, we can obtain the distribution of the distances $\boldsymbol{r}_2 - \boldsymbol{r}_1$ between the pion sources

$$\rho(\boldsymbol{r}_2 - \boldsymbol{r}_1) = \int \phi(\boldsymbol{q}) \cos(\boldsymbol{q}\cdot(\boldsymbol{r}_1 - \boldsymbol{r}_2))\, \mathrm{d}\boldsymbol{q}.$$

The three- or four-pion correlations (observed in [11]) were considered by this method in ref. [7].

...us consider some details of possible experiments. ...aking the pairs of like mesons with $p_1 + p_2$ ... in a given direction, one can measure R in a ...dicular plane. Varying these directions, it is ...e to determine the shape of the interaction volume V and check various models of multiple production (such as Fermi's or Pomeranchuk's or Landau's or fireballs) because they predict different shapes of V. In particular, the question on the real existence of fireballs in the coordinate (not momentum) space can be solved.

2) The diagram mechanism of multiple production (for example, multiperipheral) predicts the existence of the correlations between unlike pions. They can be described by formula (3) (if they indeed exist), but the meaning of the parameters R, τ which make the arguments of b dimensionless is not clear now (in any case R does not coincide with the correlation length L resulting from $C(y_1, y_2)$).

3) It would be better to study the interference effect not in the inclusive reactions but in the exclusive processes where the influence of uncontrolled factor is much weaker.

The application of these ideas for nuclear and resonance physics is seen in refs. [2–5].

‡ For example, if random sources are distributed in a gauss-like manner $g(r_i) \sim \exp(-r_i^2/2R^2)$, $i = 1, 2$, then $\phi(\boldsymbol{q}) \sim \exp(-q^2R^2)$. In this case the two-dimensional plot (q_T^2, q_o) gives the effective values of parameters R^2 and $\tau^2 + R^2/v^2$ where v is the velocity of particles.

References

[1] S.R. Amendolia, G. Bellettini et al., paper submitted to Intern. Conf. at Aix-en-Provence, 1973; B. Alper, H. Boggild et al. (British-Scandinavian Collaboration), ibidem.

[2] V.G. Grishin, G.I. Kopylov and M.I. Podgoretsky, Soviet Nuclear Phys. 13 (1971) 1116; 14 (1971) 600; S.F. Bereshnev, L.S. Vertogradov and G.I. Kopylov, JINR, PI-7033, Dubna, 1973. (in Russian).

[3] G.I. Kopylov and M.I. Podgoretsky, Soviet Nuclear Phys. 14 (1971) 1084.

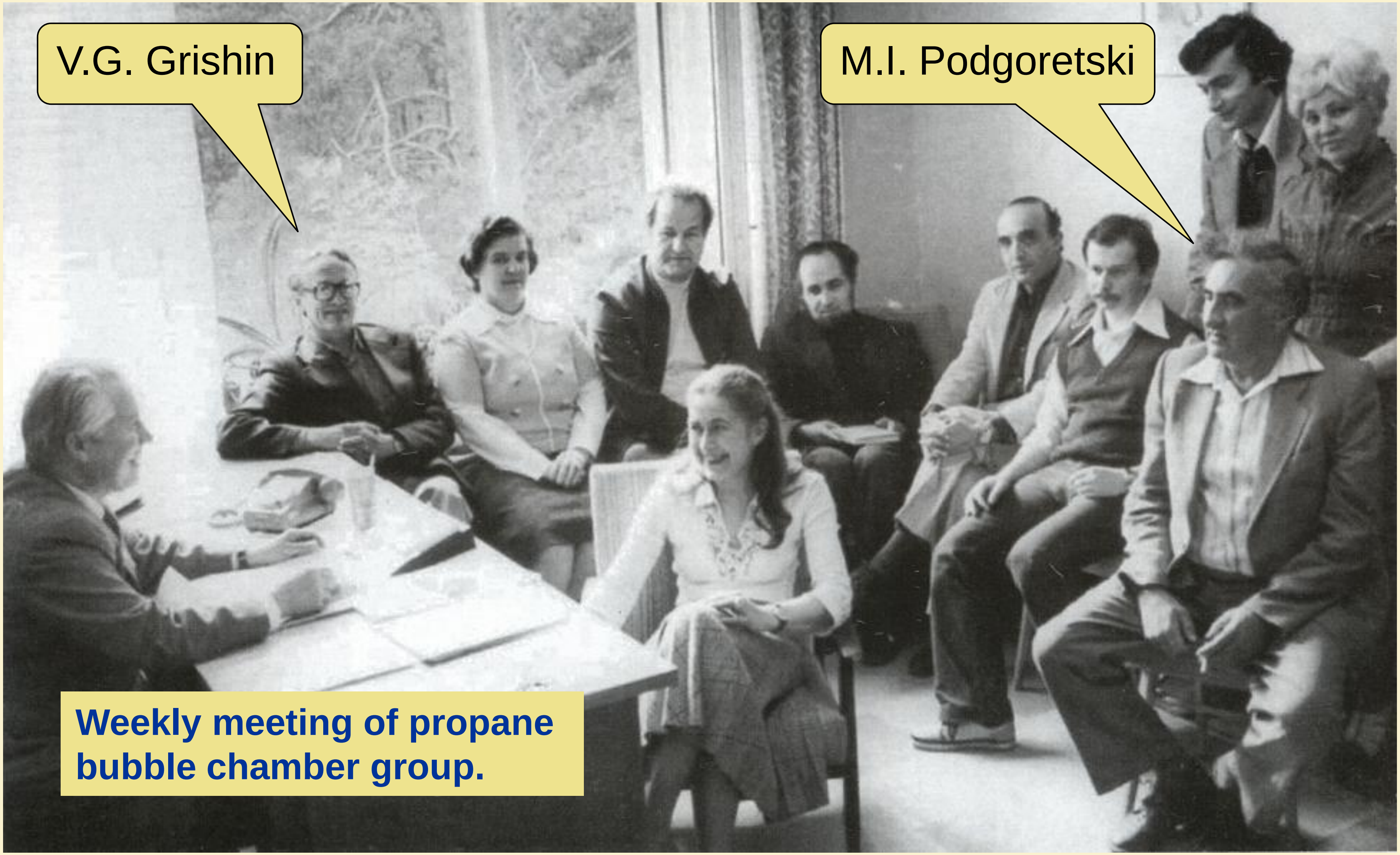
[4] G.I. Kopylov and M.I. Podgoretsky, ibid. 15 (1972) 178.

[5] G.I. Kopylov and M.I. Podgoretsky, ibid. 15 (1972) 392.

[6] G.I. Kopylov and M.I. Podgoretsky, ibid. 18 (1973) 656.

[7] G.I. Kopylov, JINR, P2-7120, Dubna, 1973; P2-7211, Dubna, 1973 (in Russian).

1975 ~1990 - Grishin, propane bubble chamber group and others in Dubna - measured two-particle correlations for various reactions and two-particle systems in the energy domain of several GeV/nucleon



Weekly meeting of propane bubble chamber group.

G.N. Agakishiev et al.
Dimensions of the secondary pion emission region in multi-nucleon collisions of nuclear projectiles D,He,and C with C and Ta nuclei at the incident momentum of 4.2 Gev/c per nucleon,
Sov. Journ. Of Nucl. Phys, 39 (1984) 543

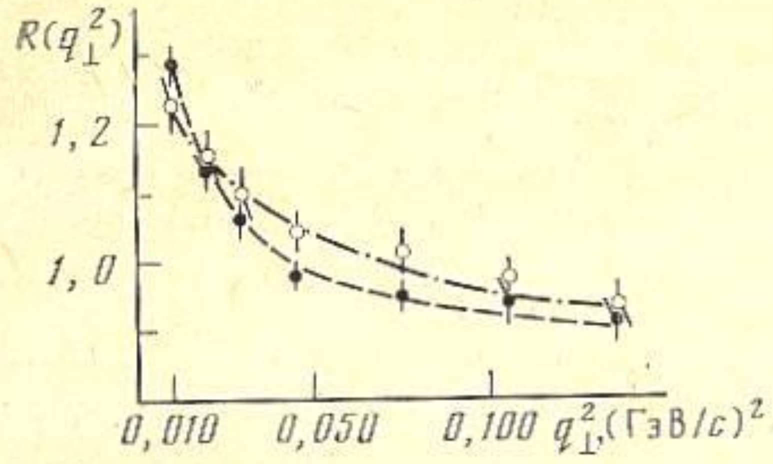


Рис. 1

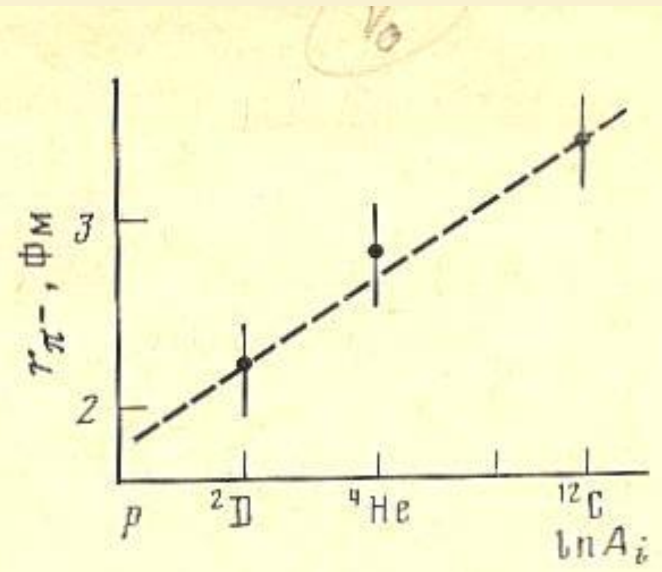


Рис. 2

Рис. 1. Экспериментальные распределения $R(q_\perp{}^2)$ для пар π^--мезонов, образованных в DTa (○)- и CTa (●)-столкновениях; аппроксимирующие кривые получены с помощью формулы (6)

Рис. 2. Зависимость r_{π^-} от атомного веса ядра-снаряда для столкновений ядер D, He и C с ядрами Ta; аппроксимирующая прямая проведена от руки

The first attempt to „participant dependence"

First correlation function for two neutral pions

Observation of the effect of $\pi^0\pi^0$ interference and the size of the region of emission of π^0 mesons in π^-Xe interactions at 3.5 GeV/c

V. G. Grishin, K. Miller, J. Pluta, T. Paulak,[1] W. Peryt,[1] and Z. Strugalski[1]

Joint Institute for Nuclear Research

(Submitted 9 September 1986)
Yad. Fiz. **47**, 439–445 (February 1988)

The results are given of investigation of the two-particle correlations of π^0 mesons emitted with close momenta in π^-Xe interactions at the incident-pion momentum 3.5 GeV/c. The interference correlations of π^0 mesons are observed. The size of the region of emission of negative pions is determined and an estimate of the time of their generation is given: $\langle r^2 \rangle^{1/2} = 1.2 \pm 0.3$ fm, $c\tau = 0.8^{+0.4}_{-0.3}$ fm. These values are consistent with the results obtained in hadron-hadron interactions but are lower than the r and $c\tau$ values in nucleus-nucleus interactions at the same energies.

1981
Lednicky and Lyuboshitz
solved the problem of
final state interaction

1981

R. Lednicky and V.L. Lyuboshitz

Influence of Final-state interaction
on the correlatins of two particles
with nearly equal momenta

Dubna report: E2-81-453
Sov. Journ. Nucl. Phys. 35 (1982) 770

J. Bartke,
Size of the pion emission region in collisions of relativistic nuclei from intensity interferometry, Phys. Lett B (1986) 32

Summary (and the END) of static source period

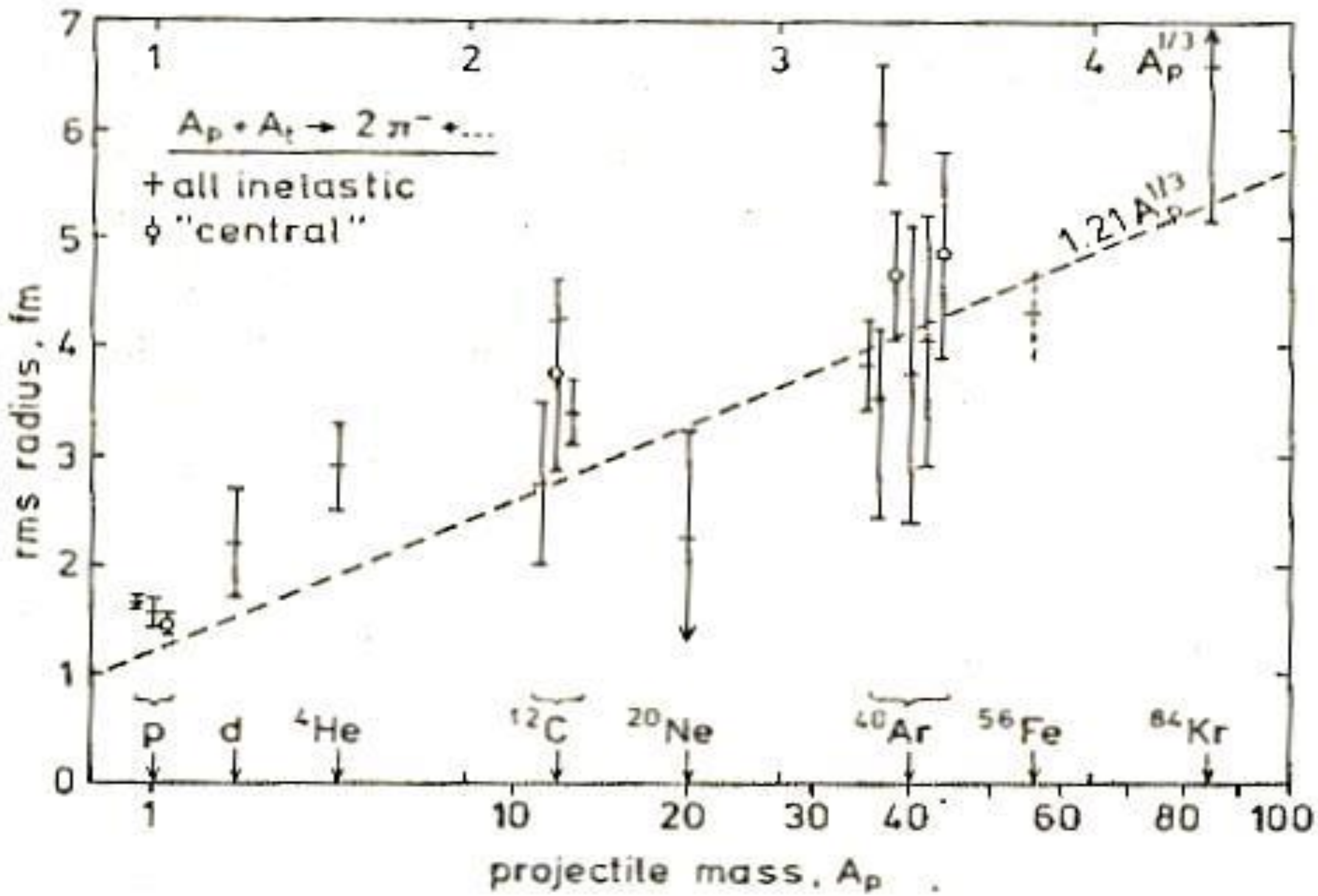


Fig. 1. Radii of the pion emission region in collisions of relativistic nuclei plotted versus the cube root of the mass number of the projectile nucleus. The straight line represents the effective nuclear radius of the projectile.

Q G P

NA35 1988

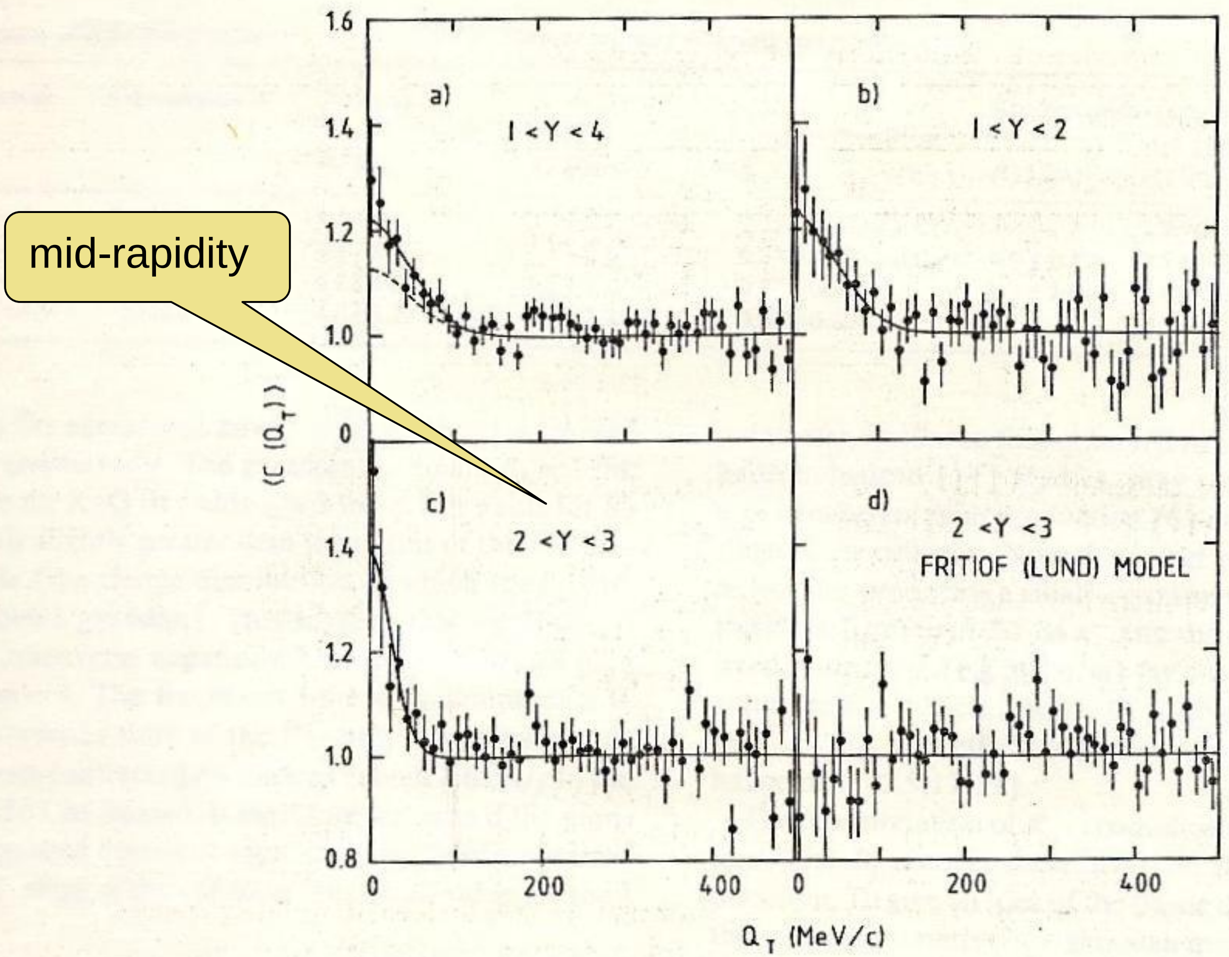

Volume 203, number 3 PHYSICS LETTERS B 31 March 1988

Fig. 2. Correlation function projected on to the Q_T-axis (for pairs with $Q_L < 100$ MeV/c) for different rapidity intervals: (a) $1<y<4$, (b) $1<y<2$, and (c) $2<y<3$, data; (d) $2<y<3$, Fritiof calculation. The projected gaussian fit is shown (solid curve) for each case, and in (a) the dashed curve shows the fit to the non-Gamow-corrected correlation function.

NA35 1988

Volume 203, number 3 PHYSICS LETTERS B 31 March 1988

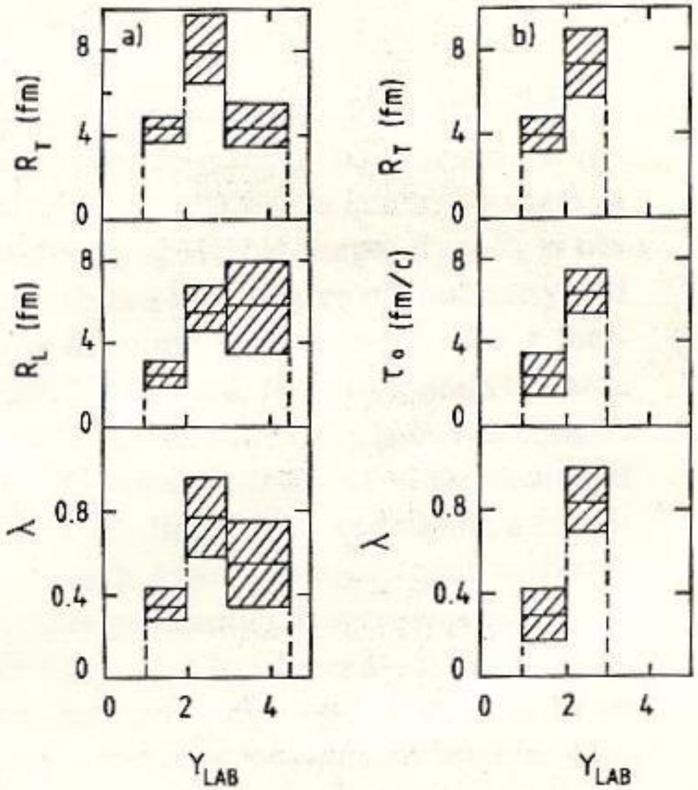


Fig. 4. Comparison of (a) gaussian and (b) Kolehmainen–Gyulassy source parameters fitted to the data for different rapidity intervals.

$$\lambda_{\pi\pi}=\tfrac{4}{3}\pi R^3/N_\pi\sigma_{\pi\pi}\,. \qquad (7)$$

Freeze-out will occur at the radius $R_{FO}=\lambda_{\pi\pi}$. Inserting this condition in eq. (7), assuming $\sigma_{\pi\pi}=20$ mb [20] and $N_\pi=3N_{\pi^-}$ we find

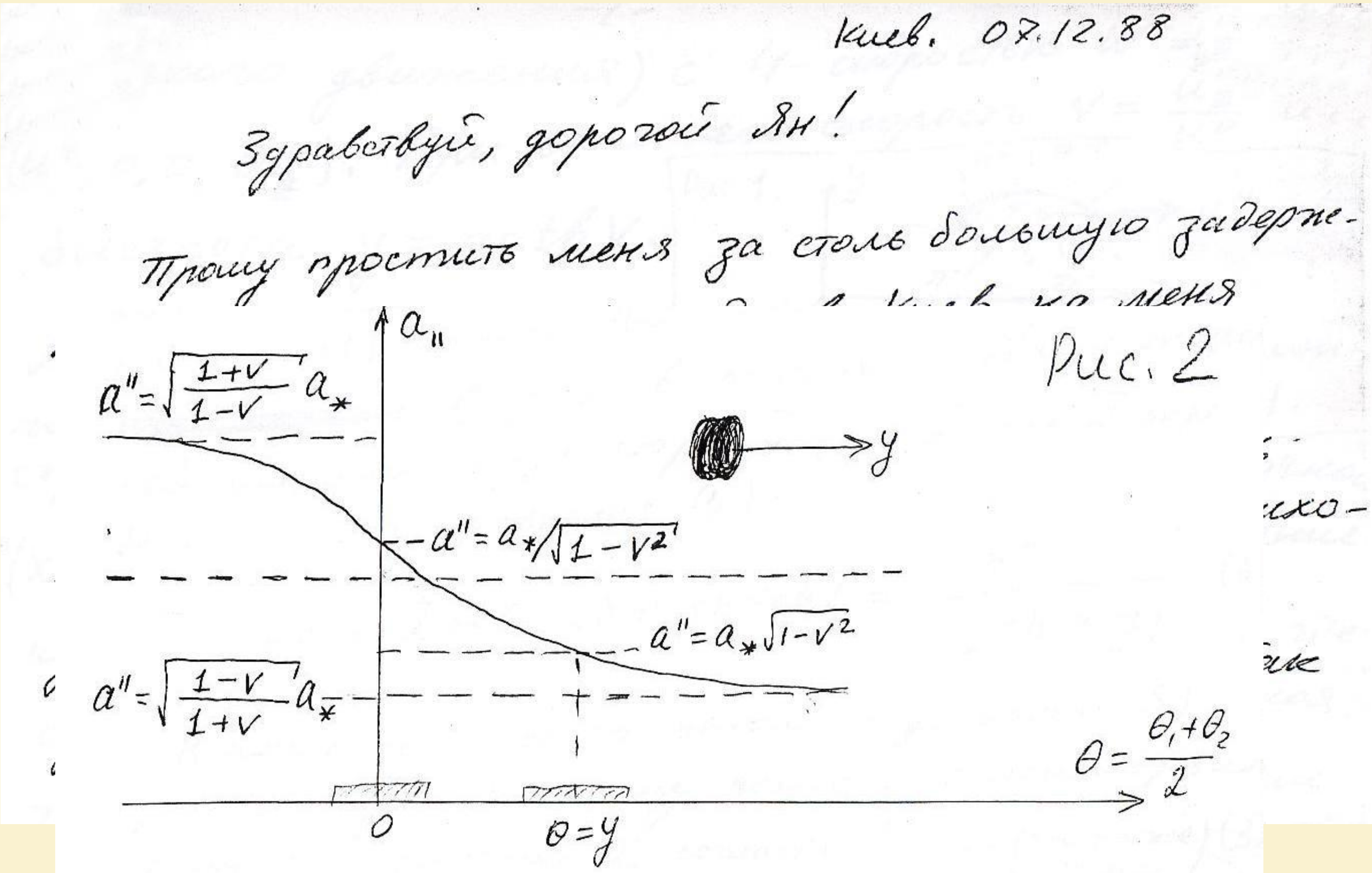
$$R_{FO}\cong 1.2\sqrt{N_{\pi^-}}\,. \qquad (8)$$

For the central rapidity interval the corrected rapidity distribution for negative pions (see fig. 1) yields $R_{FO}\cong 7.9$ fm, in agreement with the large radius parameter obtained from pion interferometry. For the adjacent rapidity intervals this method predicts too large radii. The simultaneous changes in both freeze-out time and chaoticity suggest that a completely different mechanism occurs there.

A Lorentz invariant form of the simple gaussian model of eq. (2) can be constructed by replacing Q_T and Q_L with the invariant momentum difference Q_I, where $Q_I^2=(p_1-p_2)^2$, such that eq. (2) then becomes

$$C(Q_I)=A[1+\lambda\exp(-Q_I^2R^2/2)]\,. \qquad (9)$$

1988 - Seminar of Yu.Sinyukov in Dubna



Киев. 07.12.88

Здравствуй, дорогой Ян!

Прошу простить меня за столь большую задерж-

... в Киев на меня

Yu. M Sinyukov,
Hanbury-Brown/Twiss correlations for expanding hadron and quark-gluon matter,
Nucl.Phys. A498 (1989) 151c

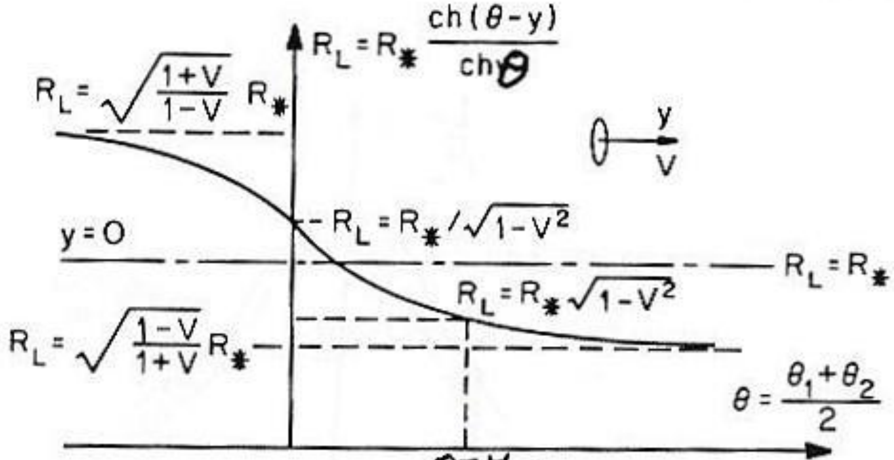


Fig. 1. The dependence of the interferometrical length $R_L = 1/Q$ on the rapidity halfsum θ of pions emitted by a source moving in the rest frame for interferometry analysis.

SUMMARY

The correlation analysis of multiple processes in the presence of internal collective motion differs essentially from that for motionless sources. In the case of strong hydrodynamical motion the width of the correlator defines an effective size which is much smaller than the natural size of the system. This size depends upon the hydrodynamical velocity gradient and the heat broadening of the hydrodynamical velocity spectrum. In order to clear

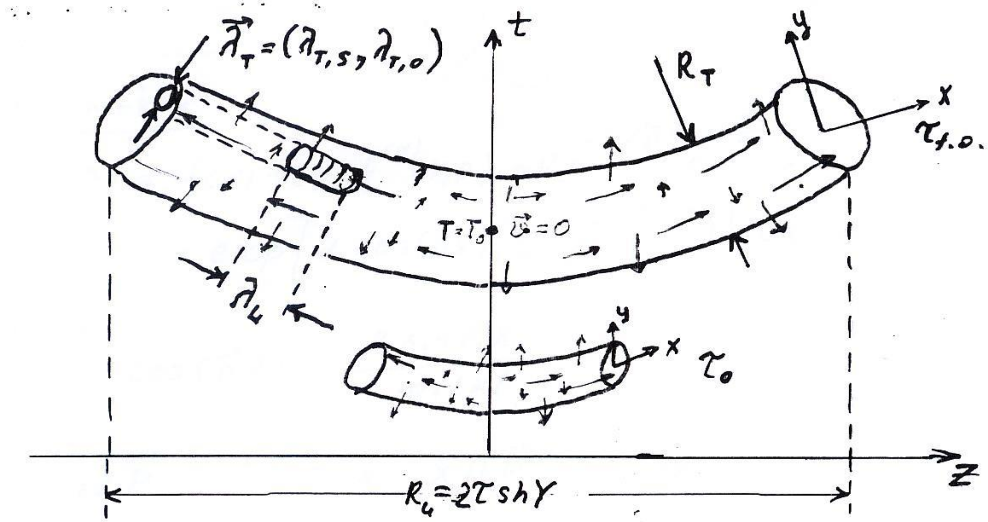
Yuri Sinyukov

„Length of homogeneity”

Boson spectra and correlations in small thermalized systems.

Yuri Sinyukov, Kiev

Divonne, 29 June 1994



Definition: $\dfrac{f(p, x_0+\lambda) - f(p, x_0)}{f(p, x_0)} \approx 1$

λ is length of homogeneity, $f(p, x_0)$ is Wigner function

$$f(p, x_0) = (2\pi)^{-3}\left[\exp\left(\frac{p^\mu u_\mu}{T} - \frac{\mu}{T}\right) \mp 1\right]^{-1}$$

Length scales:

- The total geometrical size occupied by a thermalized system: $\vec{R}$
- Length of homogeneity: $\lambda_i = (\vec{\lambda}_T, \lambda_L)$

$$\lambda_i^{-1} = \left\langle \left|\frac{\partial f(p,x)}{\partial x_i}\right| \Big/ f(p,x) \right\rangle_{p|x_0} \text{ or } \lambda_i^{-2} = \left\langle \left|\frac{\partial^2 f(p,x)}{\partial^2 x_i}\right| \Big/ 2f(p,x) \right\rangle_p$$

if $\partial f(p,x)/\partial x_i|_{x_0} = 0$

where $\langle \dots \rangle_p$ is the average over momenta

Example: $\lambda_L = \tau$ for boost-invariant expansion.

Nucl.Phys. A 498 (1989) 173c

PION INTERFEROMETRY AS A PROBE OF THE PLASMA

George F. BERTSCH

National Superconducting Cyclotron Laboratory and Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA

' high-
This
density

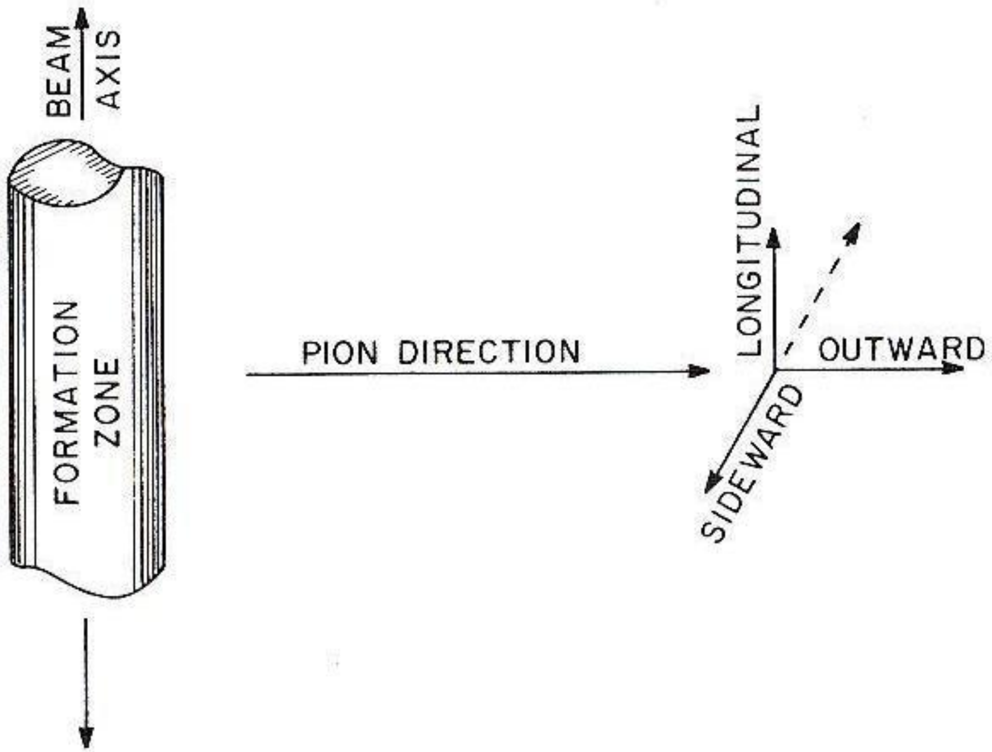
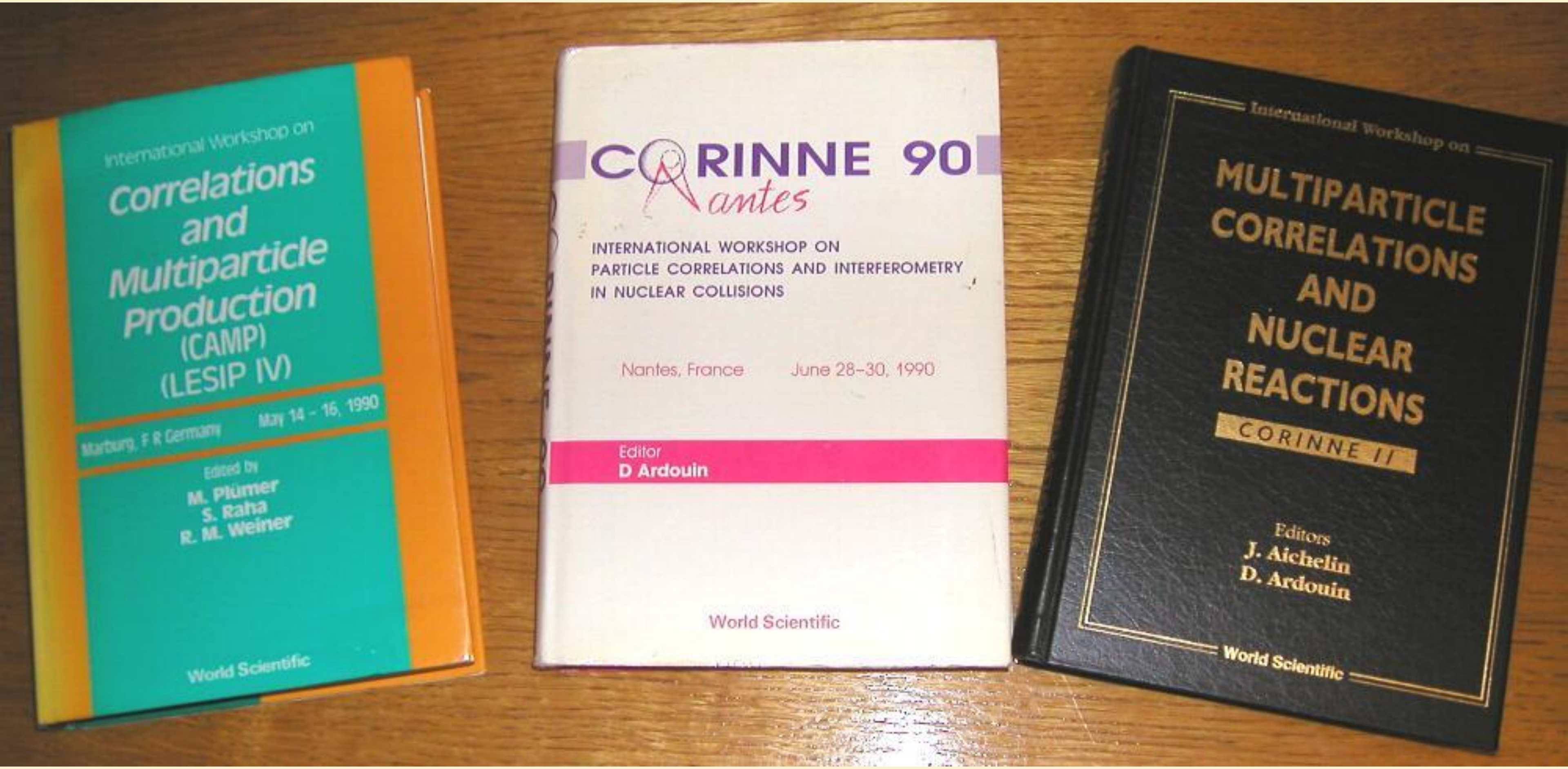


FIGURE 1
Coordinate system for pions emerging from an ultrarelativistic heavy ion collision. The beam axis is vertical and the pions are viewed in a frame where their rapidity is small.

Correlation Workshops

Meetings dedicated to particle correlations

1990 **1990** **1993**



My way to „femtoscopy”

$\pi\pi$ CORRELATIONS AND PION ABSORPTION

J. Pluta, A. Rahmani, D. Ardouin

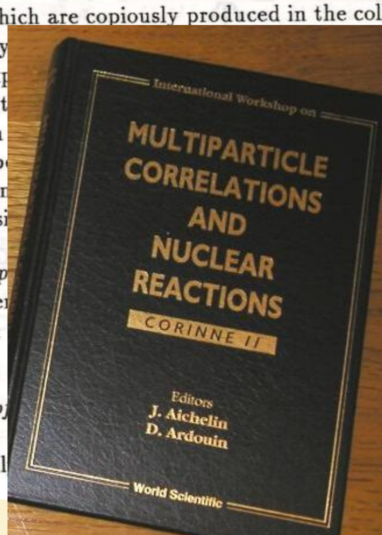
Laboratoire SUBATECH

Let us finish with a more general conclusion. Correlations of particles carry important information about the development of the interaction process. To extract it properly from the results of measurements all contributing effects should be taken into account, however. Meetings like CORINNE can stimulate the idea to create some unified approach allowing to explore the processes which occur in the space-time dimensions of the order of 1fm; ($1 fm = 10^{-15} m = 1 femtometer$).

The name for this developing branch of studies was proposed by Prof. G.A. Leksin from ITEP, Moscow. FEMTOMETRY — like micrometry in a different size scale can unify all the contributed effects, theoretical approaches and experimental methods of data analysis.

Pions — particles which are copiously produced in the collisions of relativistic l
ions interact strongly … registering history of
complicated life. Exp… probe of the develop
of heavy-ion interact… tive (optimistic) val
the middle-eightieth … nions some years lat
and now appear to b… ectation scale. Indee
complexity of pion in… reveal or obscure dif
features of the collisi… elated questions.

- "Is collective p… w?" - the question o
Bass and other… ics Letters [3]. (Coll
effects in pion… artnack in his talk a
Conference.)
- *Is the radius o… e of the projectile or
generally) the…* on/suggestion of J. F
[4] is frequentl… rimental data.



what corresponds to the M_{inv} about 420MeV and is similar to our observations for different charge pions. Note also that the effect of pion azimuthal correlations was clearly seen in the other results of WA80 Collaboration [17].

5 Conclusions

Let us finish with a more general conclusion. Correlations of particles carry important information about the development of the interaction process. To extract it properly from the results of measurements all contributing effects should be taken into account, however. Meetings like CORINNE can stimulate the idea to create some unified approach allowing to explore the processes which occur in the space-time dimensions of the order of 1fm; ($1 fm = 10^{-15} m = 1 femtometer$).

The name for this developing branch of studies was proposed by Prof. G.A. Leksin from ITEP, Moscow. FEMTOMETRY — like micrometry in a different size scale can unify all the contributed effects, theoretical approaches and experimental methods of data analysis.

1993

References

[1] R. Stock, *Phys.Rep.* **135**, Nb.5, (1986) and references therein.

[2] J. Aichelin, *Phys.Rep.* **202**, Nb.5,6 (1991) and references therein.

[3] S.A. Bass et al., *Phys.Lett.* **B302** (1993) 381.

[4] J. Bartke, *Phys.Lett.B* **174** (1986) 32.

Workshops on Particle Correlations and Femtoscopy

Faculty of Physics, Warsaw University of Technology, Poland

Particle Correlations From STAR to ALICE

via Warsaw, 8 – 11 May 2002

Invited Speakers:

Roberto Barbera (INFN, Catania)
Tamas Csorgo (MTA KFKI RMKI, Budapest)
Barbara Erazmus (Subatech, Nantes)
Ludovic Gaudichet (Subatech, Nantes)
Tom Humanic (Ohio State University)
Richard Lednicky (JINR, Dubna)
Mike Lisa (Ohio State Univ & BNL)
Ludmila Malinina (JINR, Dubna)
Sergey Panitkin (BNL)
Gael Renault (Subatech, Nantes)
Yuri Sinyukov (ITP Kiev, Ukraine)
Aleksey Stavinsky (ITEF, Moscow)
Boris Tomasik (CERN, Geneva)
Wladyslaw Trzaska (Univ of Jyvaskyla)
Nu Xu (LBNL)

visit http://hirg.if.pw.edu.pl/en/meeting

Second Warsaw Meeting on Particle Correlations and Resonances in Heavy Ion Collisions

Warsaw (Poland), 15-18 October 2003

Agenda

Agenda printable version

ISO CD image with presentations [gzipped - 148Mb]

Wednesday, 15.10 *(room 111)*

- 08:30 Registration 30'
- 09:00 Opening talks 30'
  Presentation of Warsaw University of Technology and the Faculty of Physics (Jerzy Garbarczyk) [ppt]
  Short and long tradition of particle correlation studies in Poland (Jan Pluta) [ppt]

Chair: Sergey Panitkin

- 09:30 Shape analysis of HBT correlations (Tamas Csorgo) 30' [ppt]
- 10:00 Correlation femtoscopy (Richard Lednicky) 30' [ppt]
- 10:30 Phase-space density, its evolution and HBT puzzle in A+A collisions (Yuri Sinyukov) 30' [www] [zip]
- 11:00 *break 30'*

- 11:30 Sum rule of the correlation function (Stanislaw Mrówczynski) 30' [www] [zip]
- 12:00 Single particle spectra from information theory point of view (Grzegorz Wilk) 20' [www] [zip]
- 12:20 How to model BEC numerically? (Oleg Utyuzh) 20' [pdf]
- 12:40 BEC for photons and neutral pions (Grzegorz Wilk) 20' [www] [zip]
- 13:00 *lunch*

Chair: Tamas Csorgo

- 14:30 Elliptic flow and correlations from the Buda Lund model (Máté Csanád) 30' [ppt]

Second Warsaw Meeting on Particle Correlations and Resonances

Warsaw (Poland) 15 – 18 October, 2003

Budapest Meetings

RHIC SCHOOL 03

3rd BUDAPEST WINTER SCHOOL ON HEAVY ION PHYSICS

Dec. 8 - 11 (Mon -Thur), Budapest, Hungary

Kisfaludy, K. (1788-1830): Windstorm at night

2003

Welcome back to the web-page of the RHIC'03 Winter School, Budapest!

Dear Visitor,

The web-pages of the school are being finalized - have a look at the new electronic proceedings, prepared with the help of Tamás Novák. and the final list of participants. Although the meeting is over, but two tasks are still recommended.

1) Please have a look at the inspiring

illustrated chronicle

prepared by Professor Jan Pluta, Warsaw. Thank you Jan for the great pictures and the well organized illustrations, I think they captured the athmosphere of the meeting very well. Agnieska Bieniek collected a large number of

beautiful pictures .

Thanks a lot Agnieska for the nice collection, and thanks to Tamás Novák for editing the collection!

3rd BUDAPEST WINTER SCHOOL ON HEAVY ION PHYSICS December 8-11 (Mon.-Thur.), 2003, Budapest (Hungary)http://www.kfki.hu/~csorgo/school03/

Tamas Csorgo – personal view:

A new world discovered:

But is it India or America?

Is it QGP or some other new form of matter?

3rd BUDAPEST WINTER SCHOOL ON HEAVY ION PHYSICS
December 8-11 (Mon.-Thur.), 2003, Budapest (Hungary)
http://www.kfki.hu/~csorgo/school03/

QM in Budapest, 2005

qm2005.kfki.hu/organisers.html

Aplikacje | Google | Tłumacz Google | Mapy Google | Aktual | Dom | Praca | JP | Info | MTJ | Wydarzenia | Przydatne | » | Inne zakł

QM'05 – BUDAPEST, HUNGARY

Quark Matter 2005

18th International Conference on Nucleus-Nucleus Collisions

August 4-9, Budapest, Hungary

- Archive
- Proceedings

- International Advisory Committee
- Regional Advisory Committee

qm2005.kfki.hu/satellite.html

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QM'05 – BUDAPEST, HUNGARY

Quark Matter 2005

18th International Conference on Nucleus-Nucleus Collisions

August 4-9, Budapest, Hungary

- Archive
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- Calendar
- Announcements
- Committees
- General Information
- Technical Information
- Poster
- QM2004
- Nearby Meetings
- Privacy Policy
- Comment/Feedback
- Sponsors

days to go.

Conferences in the Neighbourhood

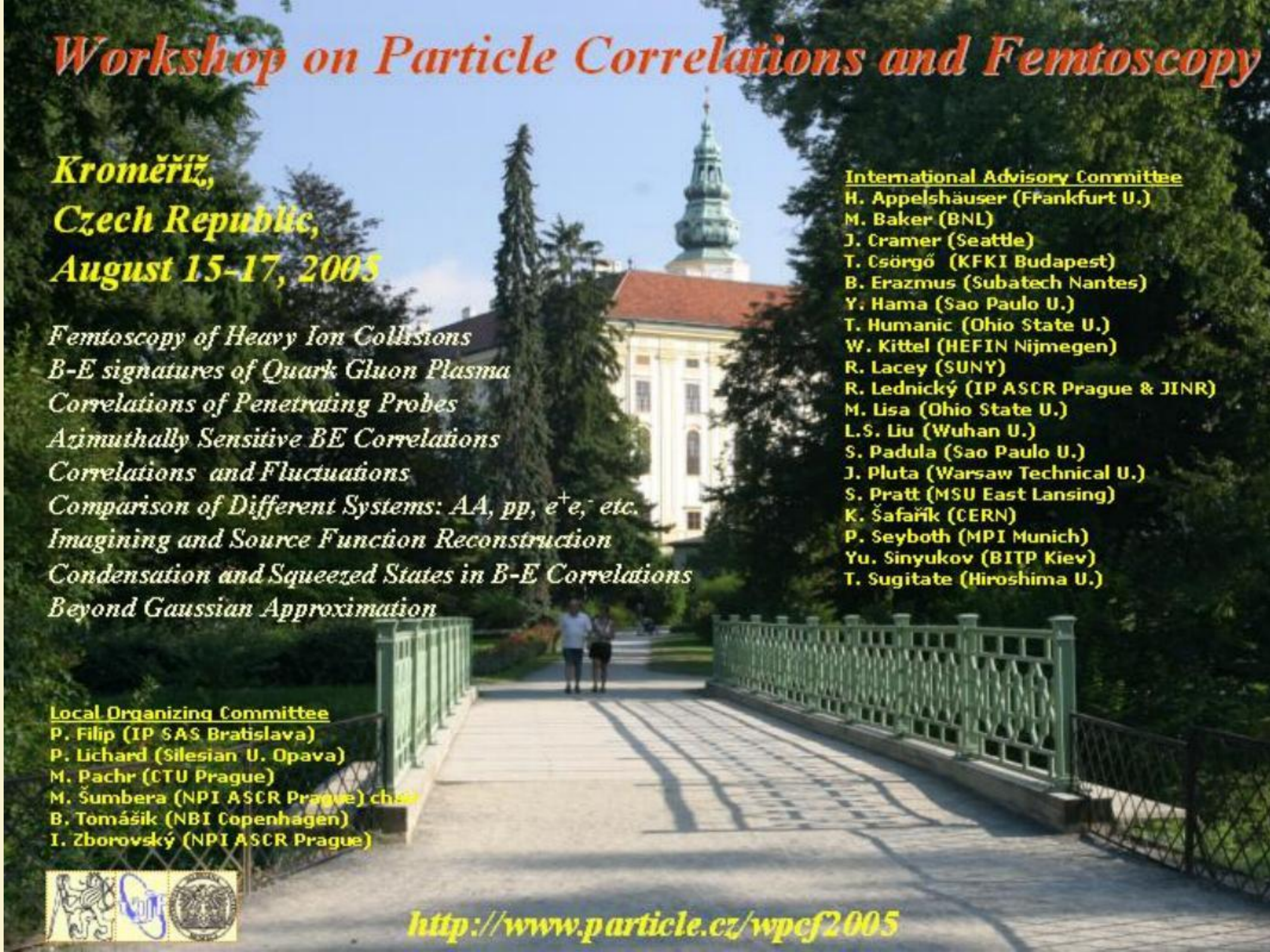
JHW2005, August 1-3, 2005,

29th Johns Hopkins Workshop in Theoretical Physics: Strong Matter in the Heaven,
Budapest, Hungary

ISDM 2005, August 9-15, 2005,
XXXV International Symposium on Multiparticle Dynamics
Kroměříž, Czech Republic

QGPTH05, August 10-12, 2005,
Quark-Gluon-Plasma Thermalization
TU Wien, Austria

WPCF 2005, August 15-17, 2005,
Workshop on Particle Correlations and Femtoscopy
Kroměříž, Czech Republic


Workshop on Particle Correlations and Femtoscopy
Kroměříž,
Czech Republic,
August 15-17, 2005
Femtoscopy of Heavy Ion Collisions
B-E signatures of Quark Gluon Plasma
Correlations of Penetrating Probes
Azimuthally Sensitive BE Correlations
Correlations and Fluctuations
Comparison of Different Systems: AA, pp, e+e- etc.
Imagining and Source Function Reconstruction
Condensation and Squeezed States in B-E Correlations
Beyond Gaussian Approximation
International Advisory Committee
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R. Lacey (SUNY)
R. Lednický (IP ASCR Prague & JINR)
M. Lisa (Ohio State U.)
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B. Tomášik (NBI Copenhagen)
I. Zborovský (NPI ASCR Prague)
http://www.particle.cz/wpcf2005

XI Workshop on Particle Correlations and Femtoscopy

Who participated in the first WPCF in Kromeriz?

3-7
Ce
Technology

Who participated in all WPCFs?

Committees

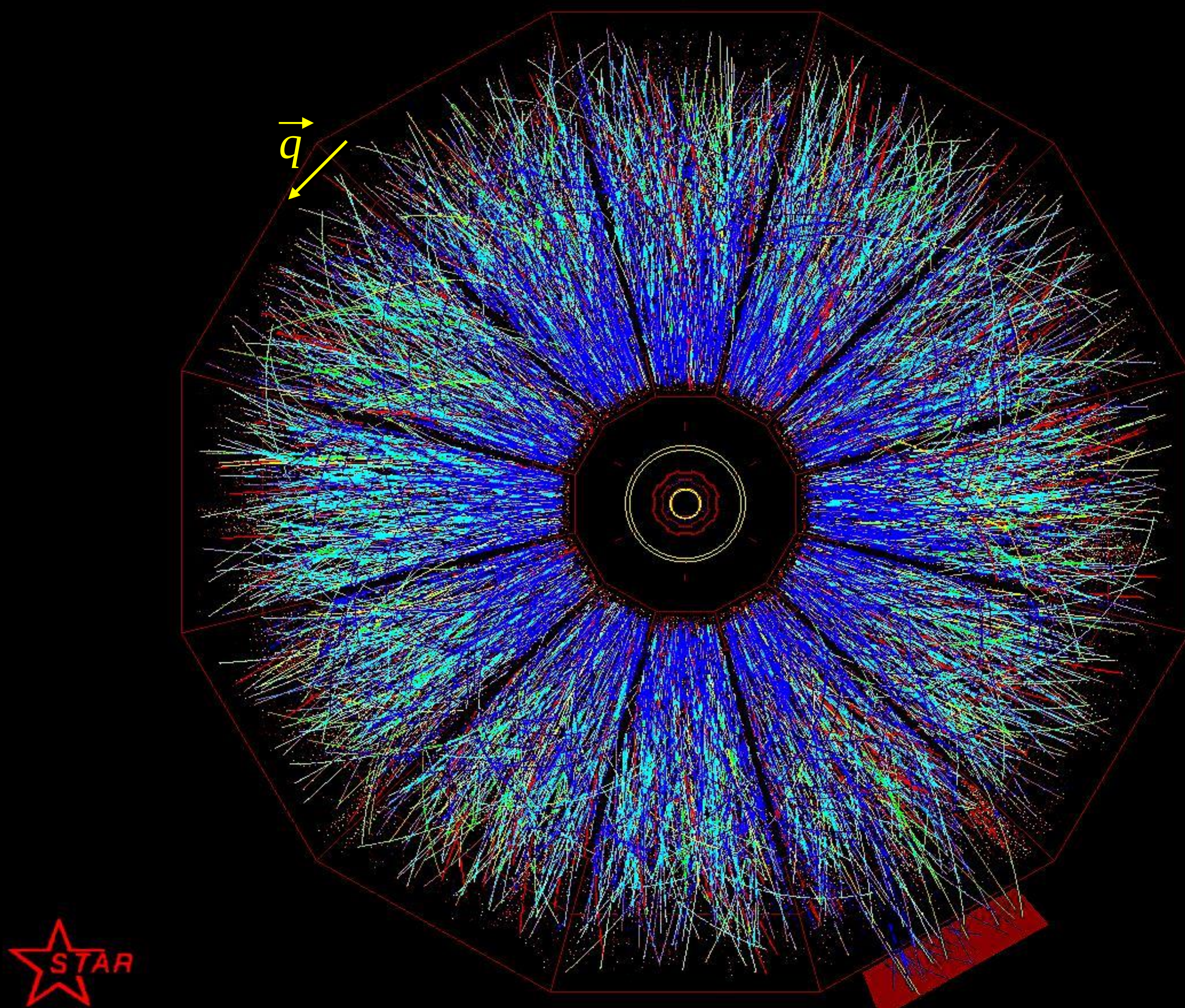
In this Workshop participate 86 persons.

Submit Abstract
Timetable
Registration
Participant List
Practical informations
Informati
Former W
Organizer
NICA-days

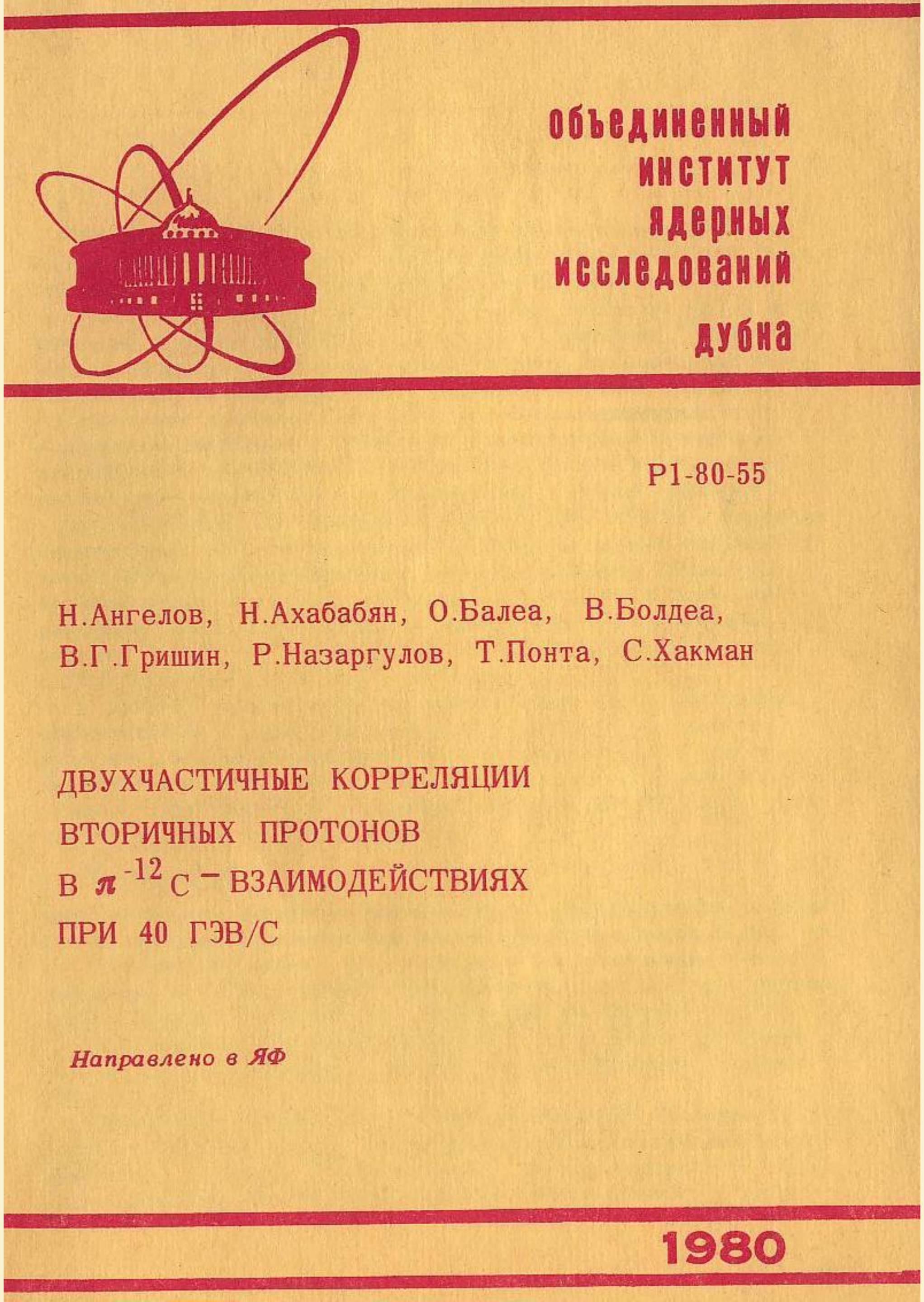
WPCF 2014	Gyöngyös, Hungary
WPCF 2013	Acireale, Italy
WPCF 2012	Frankfurt, Germany
WPCF 2011	Tokyo, Japan

…with my wishes of interesting reports,
fascinating discussions
and fruitful conclusions !!!
Jan Pluta

Contact
wpcf2015@if.pw.edu.pl
+48 22 234 7343



$\vec{q}$
STAR



объединенный
институт
ядерных
исследований
дубна

P1-80-55

Н.Ангелов, Н.Ахабабян, О.Балеа, В.Болдеа,
В.Г.Гришин, Р.Назаргулов, Т.Понта, С.Хакман

ДВУХЧАСТИЧНЫЕ КОРРЕЛЯЦИИ
ВТОРИЧНЫХ ПРОТОНОВ
В $\pi^{-12}C$ – ВЗАИМОДЕЙСТВИЯХ
ПРИ 40 ГЭВ/С

Направлено в ЯФ

1980

N. Angelov et al.
Two-particle correlations
of secondary protons
in pi-^{12}C interactions
at 40 GeV/c

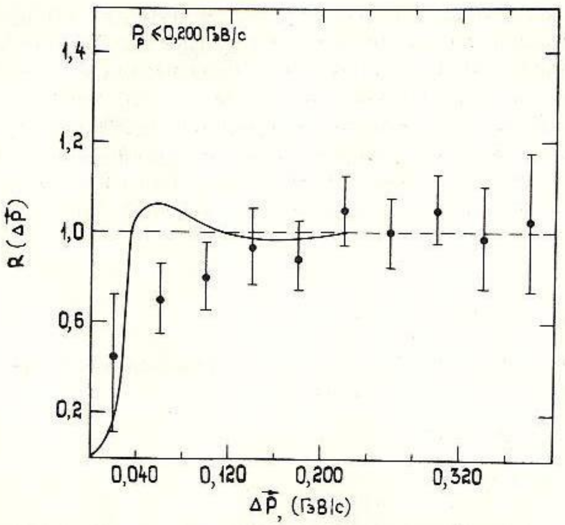


Рис.1. Распределение $R(\Delta p)$ для протонов с импульсами $p_p < 200$ МэВ/с. Сплошная линия соответствует расчетам Кунина /5/ для расстояния между протонами $r = 6$ Фм.

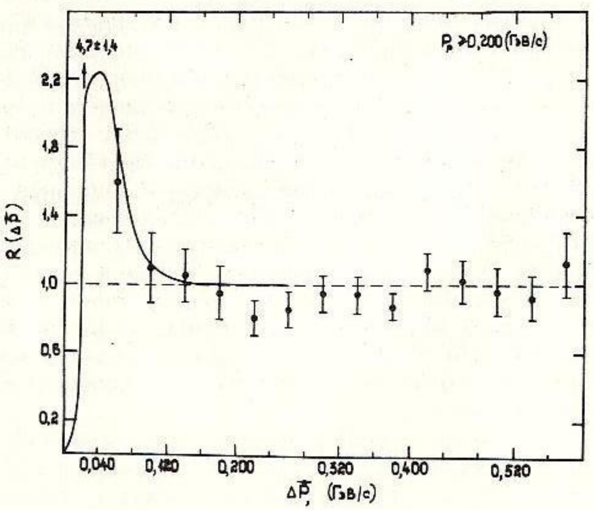


Рис.2. Распределение $R(\Delta p)$ для протонов с $p_p > 200$ МэВ/с. Сплошная линия соответствует расчетам Кунина для $r = 3$ Фм.

§4. РАСПРЕДЕЛЕНИЯ ПО Q

Теоретическое указание на возможное существование взаимодействия протонов в конечном состоянии было получено давно /9/, но тогда поиск коррелированного испускания пар протонов проводился путем анализа спектра эффективных масс:

$$M_{pp} = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}\ , \qquad /4/$$

где E_1, E_2, $\vec{p}_1$, $\vec{p}_2$ - энергия и импульсы двух протонов. Эффект искался в области малых относительных энергий двух протонов:

$$Q = M_{pp} - 2m_p\ , \qquad /5/$$

а его количественная оценка определялась как отношение сечения образования таких пар к сечению образования двух протонов при отсутствии взаимодействия в конечном состоянии. Экспериментальные исследования в области энергии взаимодействия меньше 10 ГэВ не дали однозначного ответа: в одних работах /10, 11/ наблюдали такой эффект, в других /12,13/ - он не проявлялся.

Легко показать, что между переменными Δp и Q существует однозначная связь:

$$Q = \frac{\Delta p^2}{4m_p}\ . \qquad /6/$$

В этом случае установленный эффект в переменных Δp должен проявляться и в области малых эффективных масс двух протонов.

Momentum dependence

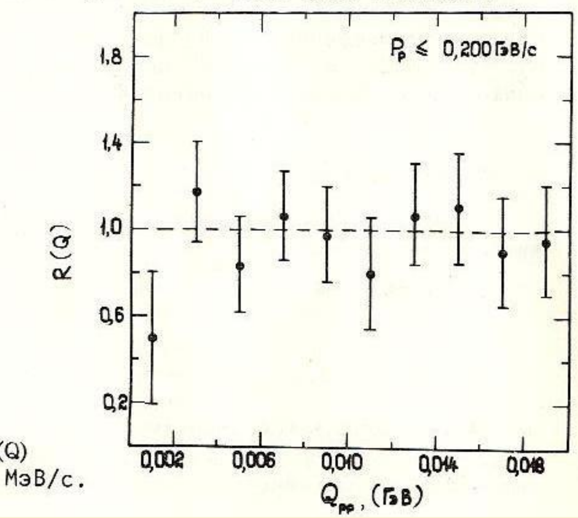


Рис.3. Распределение $R(Q)$ для протонов с $p_p < 200$ МэВ/с.

N° GANIL
E286
Ne pas remplir

PROPOSITION D'EXPERIENCE à GANIL

Période de programmation Avril à Décembre 1997

Date limite de dépôt à Ganil : 3 Janvier 1997

TITRE :
NUCLEAR INTERFEROMETRY FOR TWO-NUCLEON SYSTEMS

S'agit-il d'une suite d'expérience ? Non ~~Oui~~ Si Oui : Numéro :

PORTE-PAROLE :
si plusieurs souligner le correspondant

J.PLUTA, *IFPW, Warsaw*, F. HANAPPE, *ULB, Bruxelles*

Téléphone +48.22.660.73.75 | Téléfax +48.22.628.21.71 | E-mail pluta@if.pw.edu.pl

AUTRES PARTICIPANTS et APPARTENANCE :

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B. Benoit, E. de Goes Brennand, *ULB, Bruxelles*
P. Duda, K. Miller, T. Pawlak, K. Wosinska, *IFPW, Warsaw*
E.Doroshkevich, S.Kuleshov, K. Mikhailov, A. Stavinsky, L. Vorobyev *ITEP, Moscow*
R. Lednicky *IPh AS, Prague*

Résumé :
Simultaneous measurement of two-nucleon (*nn, pp, np*) correlations at small relative velocities is proposed. Special attention is paid to (*nn*) correlations as free of Coulomb effects. The physical goal of experiment is to find the space-time properties of nucleon emission dynamics in heavy-ion collisions and to clarify some related questions: sequence of particle emission, three-body Coulomb effects, deuteron production mechanism etc.

	Ions	Energies	Intensités	Caractéristiques (ΔW, Δt ou autres)
FAISCEAUX PRIMAIRES :	^{40}Ar	~~85~~ MeV/u	2 μAe	
FAISCEAUX SECONDAIRES :		74 MeV/u		

Cibles : Ni | Cibles SISSI et épaisseurs :

Nombre d'UT (8h) demandé — Au total : 15 — Pour cette période :

A partir de quelle date serez-vous prêts ? : 1 June 1997
Dates interdites : after 30 Sept. 1997

Dispositif ou voie de faisceau : SISSI | D1 | D3-D4 LISE | D6 LISE3 | D5 INDRA | G1 NAUTILUS | (G21) | G22 ORION | G3 SPEG | G4 | Autre : DEMON

Moyens d'acquisition : Ganil | Spécifique

Temps d'immobilisation des aires : Montage : Mai 1997 — Démontage et calib. :

Comité des Expériences de Physique Nucléaire du GANIL
Reunion 19-21 Février 1997

Dr J. Pluta
IFPW, Warsaw

Göteborg, le 4 mars 1997

Cher collègue,

Le Comité des Expériences de Physique Nucléaire du GANIL s'est réuni du 19 au 21 février 1997. Il a discuté de l'expérience **E286** dont vous êtes porte-parole et a fait les remarques et recommendations suivantes à la Direction du GANIL:

The experiment is being approved with the priority A1 and the scheduled time is 15UT.

Recommendation: 15 UT ; Priorité A1

Je vous prie de bien vouloir accepter, cher collègue, l'expression de mes sentiments les plus cordiaux.

Björn Jonson
Président du Comité des Experiences

E286 experimental set up

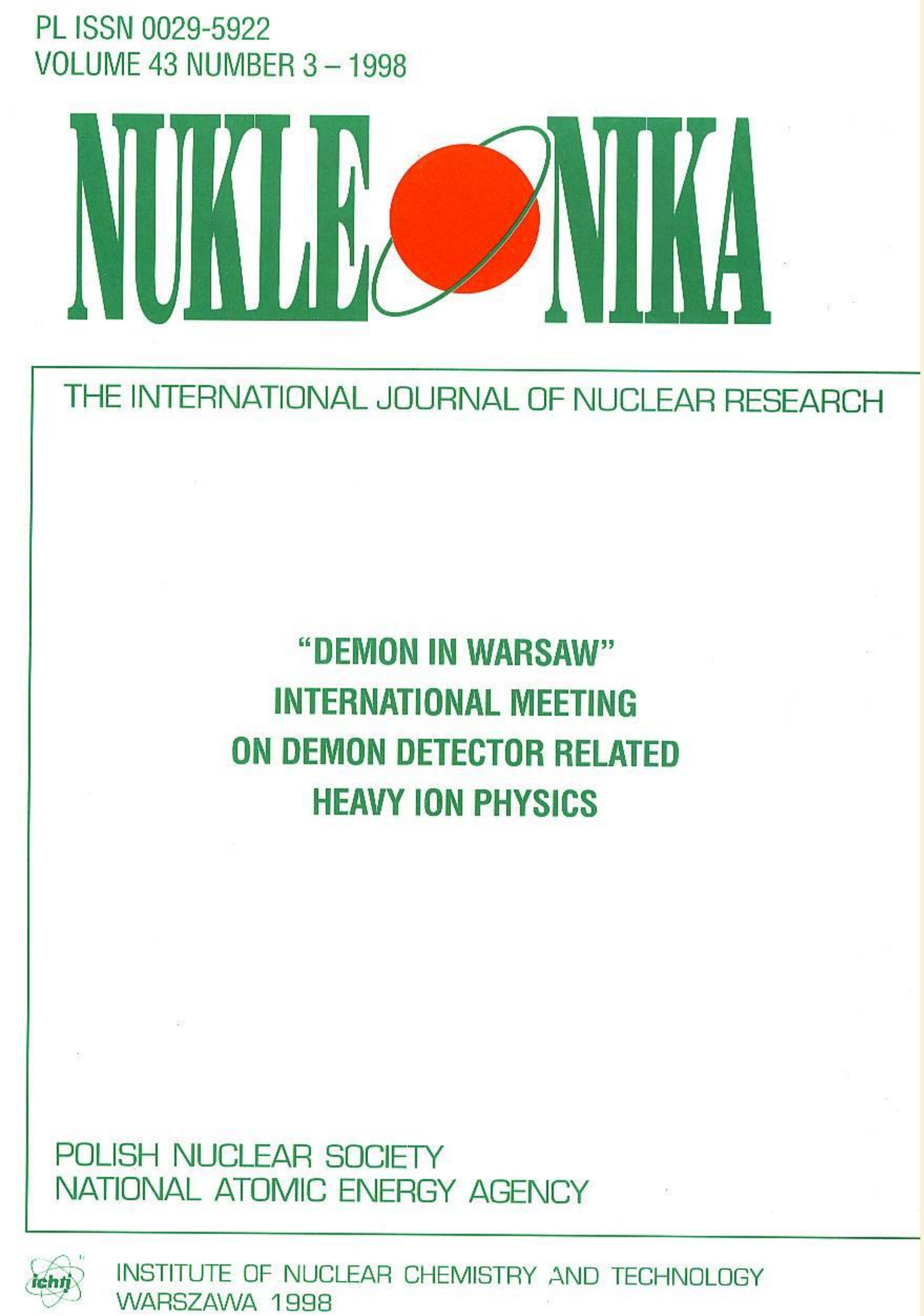
Richard Lednicky (1993) : Jan, for a static source, the correction of momentum for particle with the charge ±1 will be: …

Ян, для статического источника ~~…~~ частиц (с зарядом $+Z$) поправка к импульсу частицы с зарядом ± 1 и массой m будет

$$\vec{\delta} = \vec{k}_0 - \vec{k} = \mp \vec{k}\, \frac{Z\alpha\omega \cdot R}{1+(kR)^2} \cdot 1.473,$$

где $R = \langle 1/r \rangle^{-1} = \sqrt{\frac{\pi}{2}}\, r_0$, $\left(r_0 = \langle r^2 \rangle^{1/2} / \sqrt{3} \right)$, $\alpha = \frac{1}{137}$,

$\vec{k}$ – измеренный импульс частицы, $\omega = \sqrt{\vec{k}^2 + m^2}$ – энергия.



PL ISSN 0029-5922
VOLUME 43 NUMBER 3 – 1998

NUKLEONIKA

THE INTERNATIONAL JOURNAL OF NUCLEAR RESEARCH

"DEMON IN WARSAW"
INTERNATIONAL MEETING
ON DEMON DETECTOR RELATED
HEAVY ION PHYSICS

POLISH NUCLEAR SOCIETY
NATIONAL ATOMIC ENERGY AGENCY

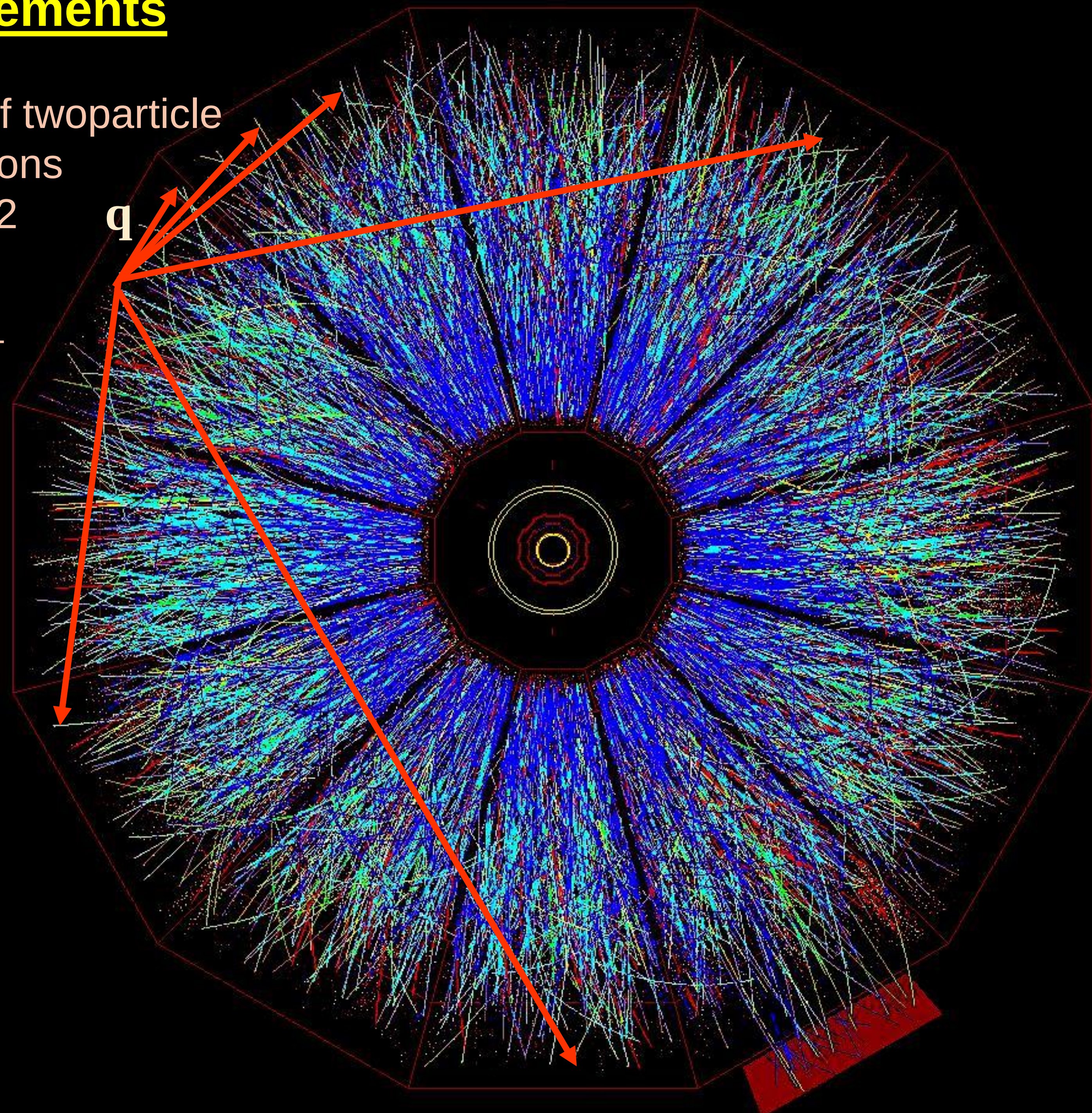
INSTITUTE OF NUCLEAR CHEMISTRY AND TECHNOLOGY
WARSZAWA 1998

...Meeting dedicated to
„DEMON" detector…
which was dedicated
to cerrelation measurements.

1998

Measurements

Number of twoparticle kombinations
N=n(n-1)/2



DO I =1, N-1
DO J=I+1, N
....