THE IDEAS OF A.M. BALDIN ON OVERCOMING THE REDUCTIONISM PRINCIPLE IN RELATIVISTIC PHYSICS.

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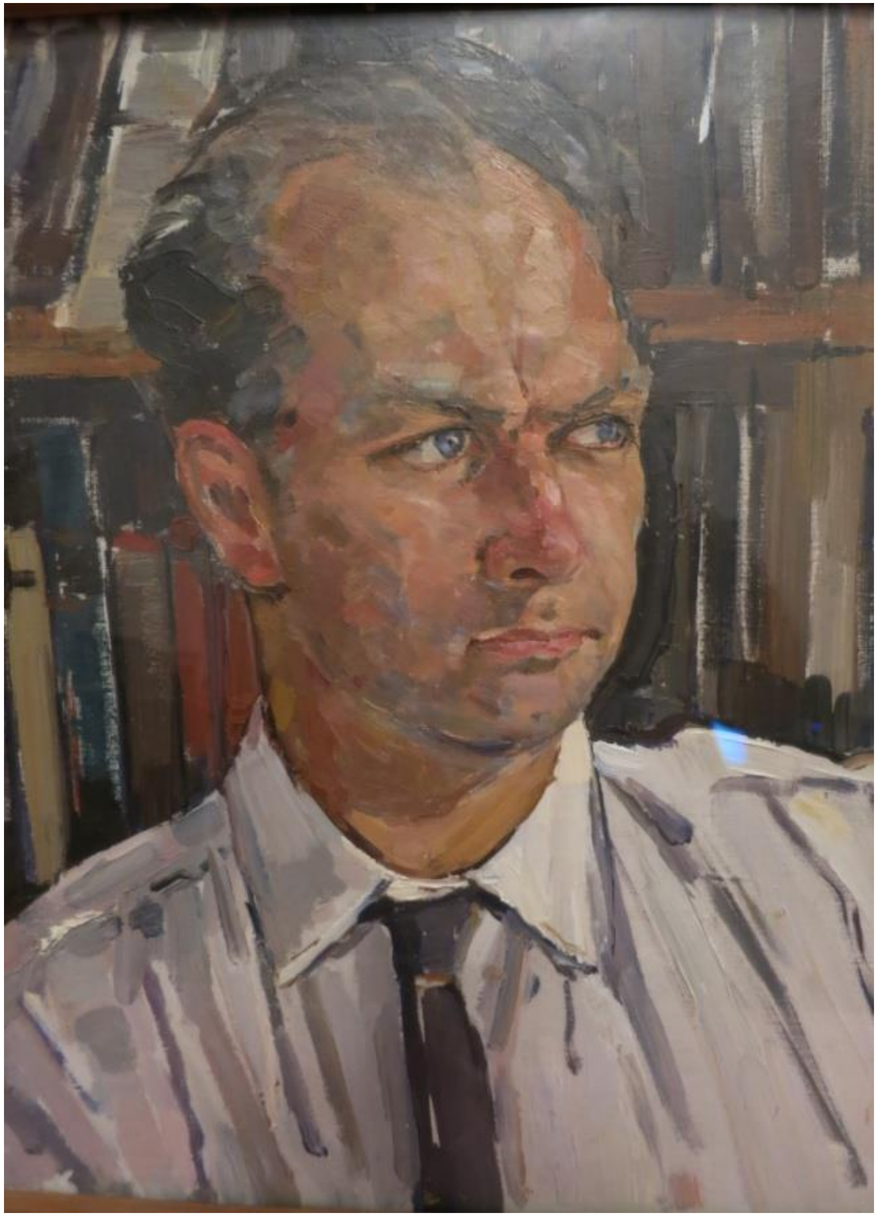


Reductionism

The practice of analyzing and describing a complex phenomenon in terms of its simple or fundamental constituents, especially when this is said to provide a sufficient explanation.

QUANTUM FIELD THEORY AND SYMMETRIES IN NUCLEAR PHYSICS

***A.M.Baldin** Particles and Nuclei,Letters No.2[99]-2000*

«The problem of describing nuclear processes, like all other physical processes, is solved on the basis of the construction of the space of defining the parameters linking real physical objects.

Nuclear physics originates from the discovery of the Mendeleev Periodic Law in which the parameters: atomic weight A and charge Z, play a fundamental role in the description of atomic properties. The proton-neutron structure of all the nuclei, including the synthesized ones, as a function of the parameters A and Z. The creation of quantum mechanics has resulted in the introduction of the quantum parameters of the ground and excited states of atomic nuclei.

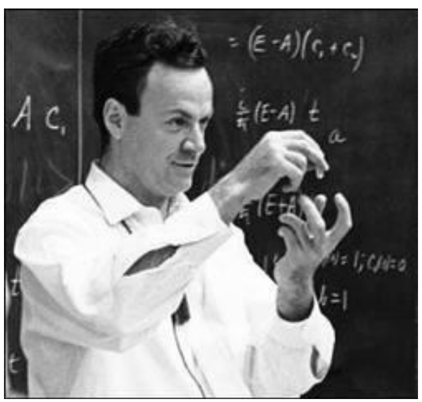
Later on, it was found that it was necessary to introduce the concept of non-nucleon degrees of freedom, as well as the concept of quark-gluon or colour degrees of freedom of nuclei.

Then, the idea itself that matter consists of elementary particles has undergone essential changes. However the idea that the primary concept of physics is the concept of space has kept its fundamental importance.

The comparison of the defining parameters space with the mathematical one is the essential point of the construction of mathematical models.»

Robert Hofstadter (1961, Nobel Foundationphoto)
"Electron Scattering and Nuclear Structure".

W. McAllister & Robert Hofstadter, "Elastic Scattering of 188 MeV Electrons from Proton and the Alpha Particle," *Physical Review*, V102, p. 851 (1956).



Richard Feynman
The parton model 1961

uclear Physics **18** (1960) 310—317, © *North-Holland Publishing Co , Amsterdam*

POLARIZABILITY OF NUCLEONS

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Received 18 December 1959

Abstract: Estimates of dipole polarizabilities of nucleons and the values they involve are given on the basis of data on photo-production of π-mesons and the Compton effect on nucleons It is indicated that no upper estimate of neutron polarizability exists at present The preliminary experimental data now available may be interpreted as indicating that a neutron has an abnormally large polarizability The effects leading to the inapplicability of the impulse approximation for describing the reaction $\gamma+\mathrm{d} \to \mathrm{p}+\mathrm{n}+\gamma'$ are estimated It is pointed out that the measurement of the cross section of the reaction $\gamma+\mathrm{d} \to \mathrm{d}+\gamma'$ would yield an answer for the value of neutron dipole polarizability †

1. Introduction

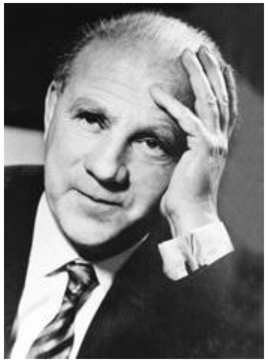
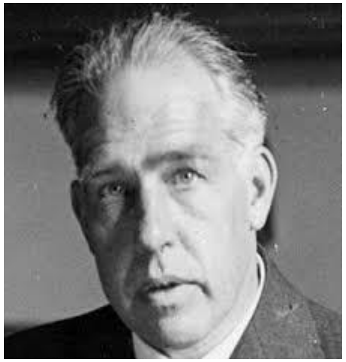
As is well known from classical electrodynamics, the interactions of photons with a system of charges may be described by a fairly small number of real parameters provided the wavelength of the photon considerably exceeds the dimensions of the system and the photon's frequency is essentially less than the resonance frequencies of the system These constants fully determine the behaviour of the system in static or slowly changing fields and are expressed through the charge, the magnetic moment and electric and magnetic polarizability tensors

These characteristics may in particular be considered for the nucleon [1]. Of especial interest are the electric and magnetic polarizabilities of the nucleon since these are its "structural" characteristics The aims of the present paper are a) determination of the frequency region of photons for which the interaction of a nucleon and electromagnetic field may be described by four constants (charge, magnetic moment, electric and magnetic polarizability) with satisfactory accuracy (say, 5 %), b) discussion of possible estimates of the magnitude of the polarizability on the basis of the available experimental data and discussion of the experiments which might be worthwhile for specifying polarizability quantities

Ahiezer A.I., Rekalo M.P., 1979 :

“It should be noted that it was assumed not long ago that an elementary particle cannot have a size and should necessarily be point-like. This opinion was related to the fact that a non-point-like particle was considered as a solid rigid sphere. As, for example, in the well known textbook by Landau and Lifshitz…

In reality, however, the existence of a particle size is not equivalent to its rigidity.”

W. Heisenberg:

“We have to remember that what we observe is not nature herself, but nature exposed to our method of questioning.”

“There is a fundamental error in separating the parts from the whole, the mistake of atomizing what should not be atomized. Unity and complementarity constitute reality.”

N. Bohr:

When searching for harmony in life one must never forget that in the drama of existence we are ourselves both actors and spectators. ”

B. Raushenbakh:

- d'Alambert told us that Nature does not show us anything but matter and motion. His successors, however, stated that the Universe consists of matter and motion, thus having transformed a reasonable statement into a dubious dogma.

QUANTUM FIELD THEORY AND SYMMETRIES IN NUCLEAR PHYSICS

A.M.Baldin *Particles and Nuclei,Letters No.2[99]-2000*

«Complicated real physical situations require simplified descriptions and determinations of the region of validity (measurability) of the introduced concepts. We have to define the region of applicability of the concept "elementary particle". By tradition, the elementary particles are taken to mean indecomposable structure constituents of matter. This concept has been formed in a close connection with the idea about the discrete structure of matter at the microscopic level. When constructing models, the elementary particles are thought of as absolutely identical and their ensembles are described by the quantum fields which are just the basis of the mathematical space of a model. However quantum field theory is successfully applied to both particles possessing inherent structure and decomposable objects, for example, helium atoms at low temperatures.»

A.M.Baldin proposed a classification of applicability of the notion "elementary particle" on the basis of the variable b_{ik} introduced by him.

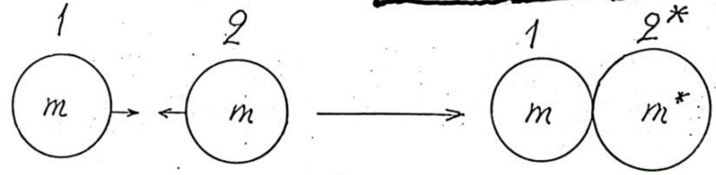
$$b_{ik} = -(U_i - U_k)^2 = 2[(U_i U_k) - 1] = 2\left[\frac{E_i E_k - \vec{p}_i \vec{p}_k}{m_i m_k} - 1\right]$$

$$b_{ik} = 2[(U_i U_k) - 1] = 2[\operatorname{ch} \rho_{ik} - 1]$$

THE PARTICLE IDENTITY VIOLATION CRITERION MUST BE EXPESSED IN TERMS OF THE QUANTITIES:

(A) MEASURABLE
(B) DIMENSIONLESS
(C) RELATIVISTIC INVARIANT

$u_i = \frac{P_i}{m_i}$ four-VELOCITIES



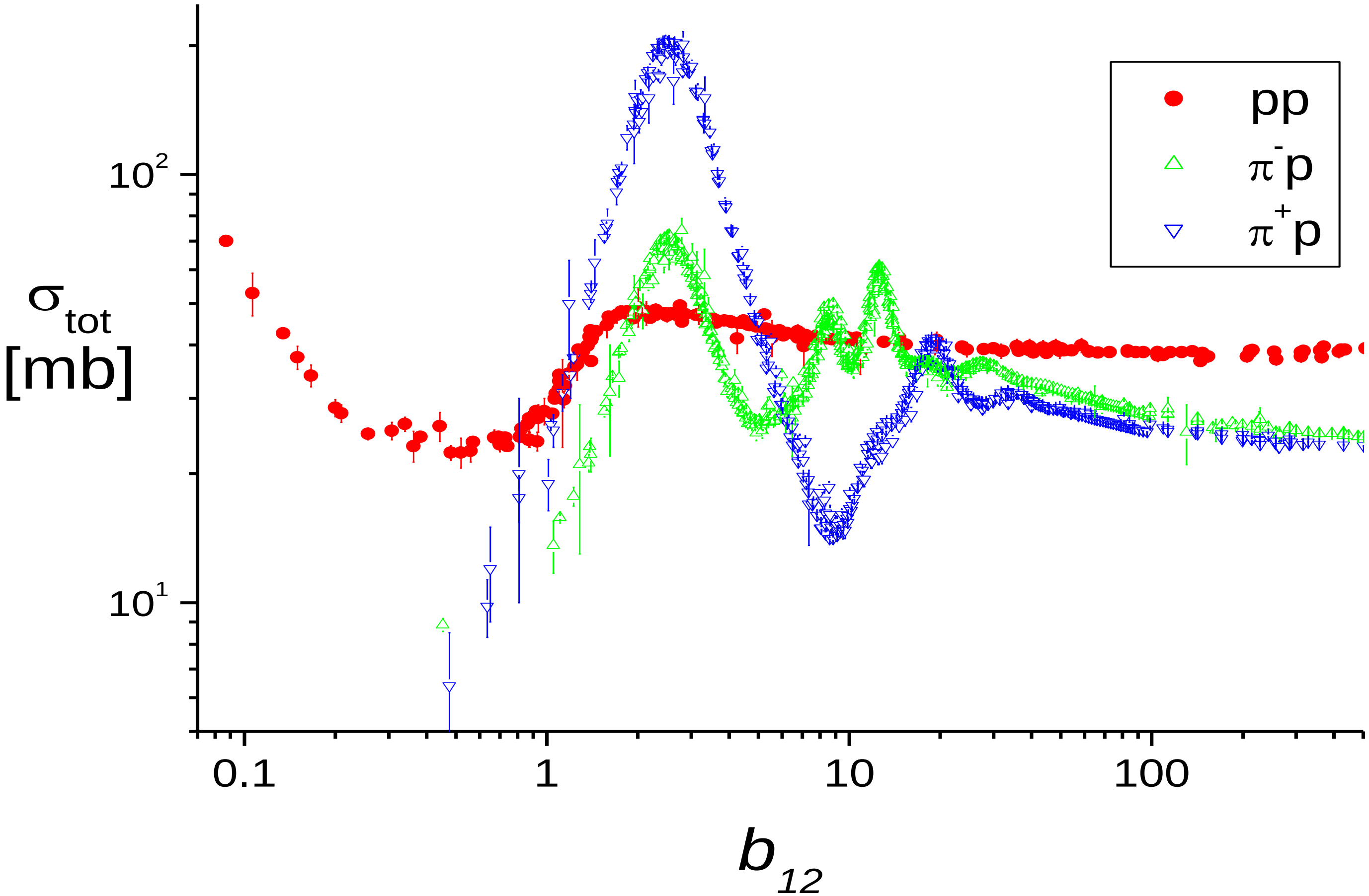
$m^* = m + \Delta$ $\qquad (P_1 + P_2)^2 = (P_1' + P^*)^2 = (m + m^*)^2$

FROM WHERE

$$\boxed{-(u_1 - u_2)^2 = \frac{\Delta}{m}\left(4 + \frac{\Delta}{m}\right) \equiv b_{12}} = 2\frac{T}{m}$$

		b_{12}
BOTTLES $\rightarrow$ FRAGMENTS		10^{-14}
ATOMS	$He + He \rightarrow He + He^+ + e$	10^{-9}
NUCLEI	$A + A \rightarrow A + A^* + n$	10^{-2}
NUCLONS $\rightarrow$ ISOBARS		~ 1
HADRONS $\rightarrow$ COLOR CHARGES		$\gg 1$

$\| \; T_{0s} \approx 3.5 \, A \cdot GeV \qquad b_{ik} \gtrsim 5 \; \|$

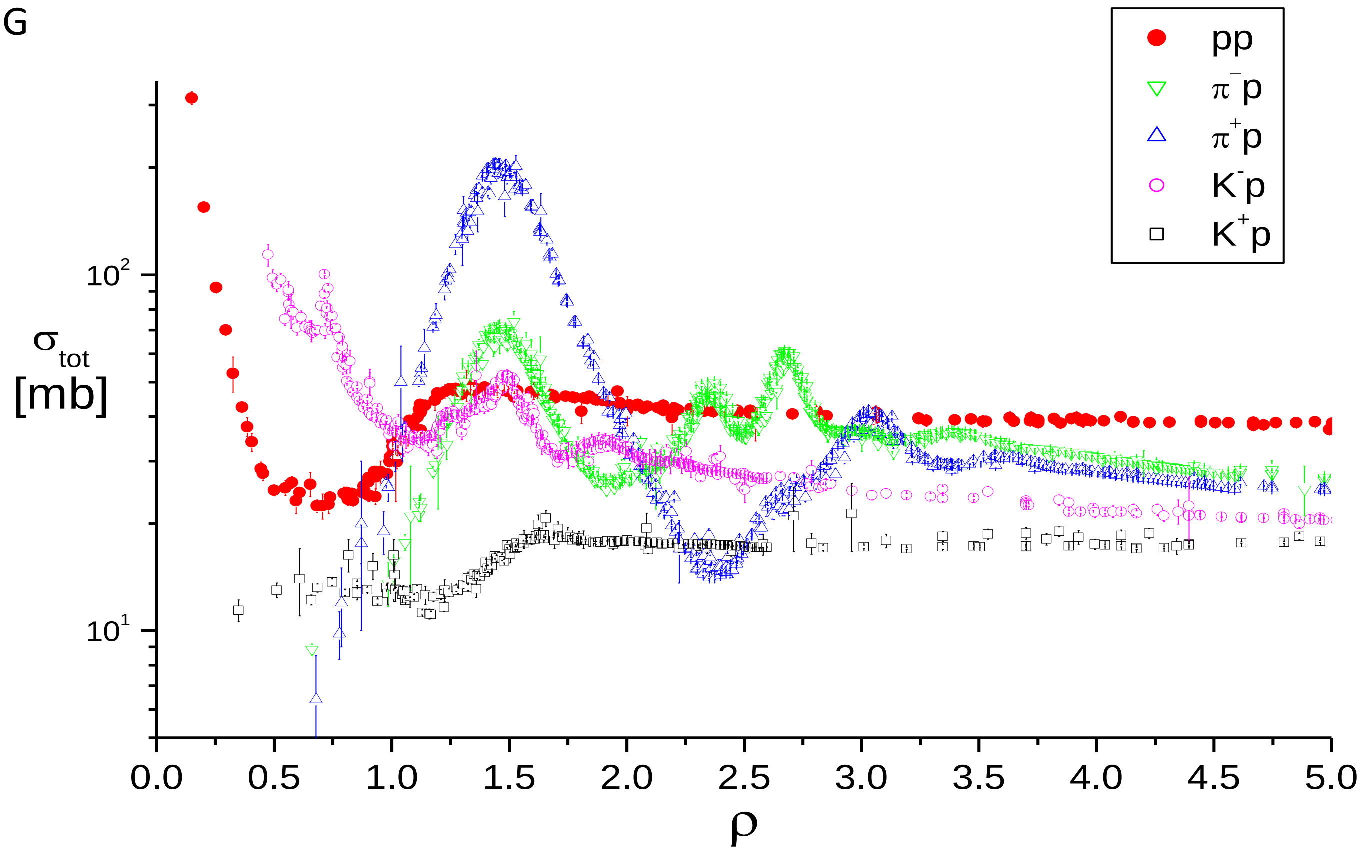


$$b_{ik} = 2[(U_i U_k) - 1] = 2[\frac{P_i P_k}{m_i m_k} - 1]$$

$$b_{12} = 2[\frac{E_{proj}}{m_{proj}} - 1]$$

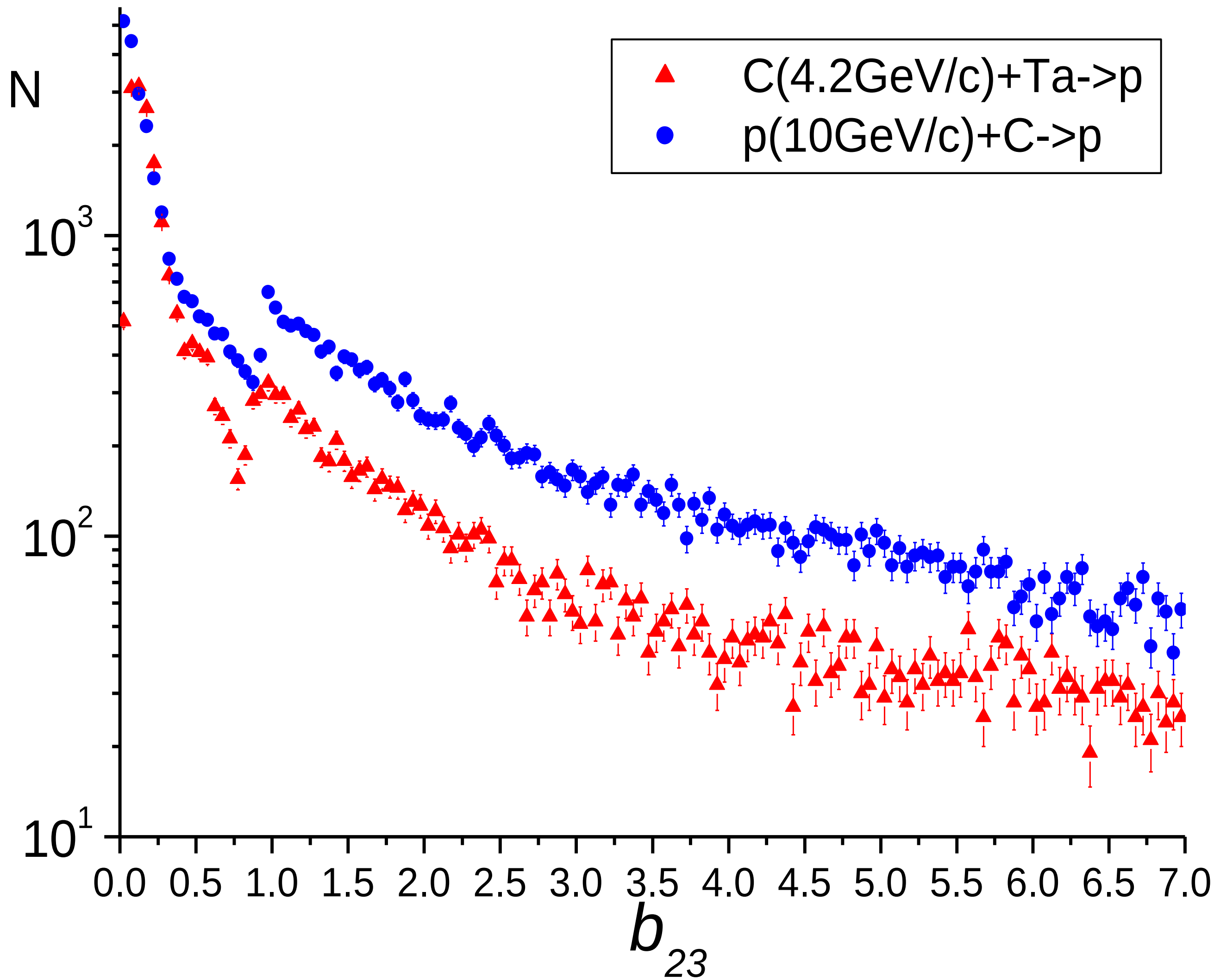
PDG K. Hagiwara *et al.,* Phys. Rev. D **66**, 010001 (2002) (http://www-pdg.lbl.gov/)

- PDG

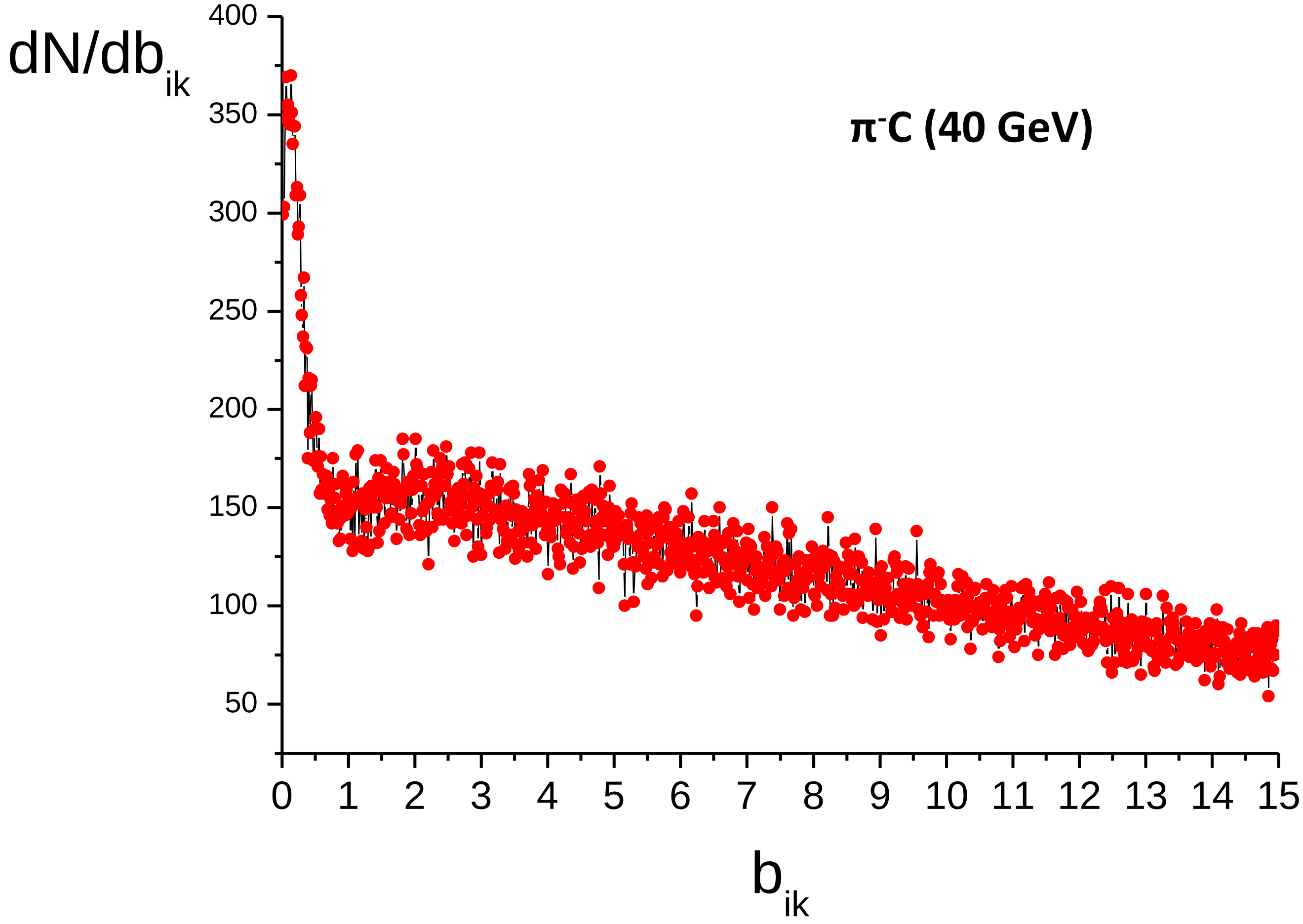


<-nucleon physics   transition region   QCD ->

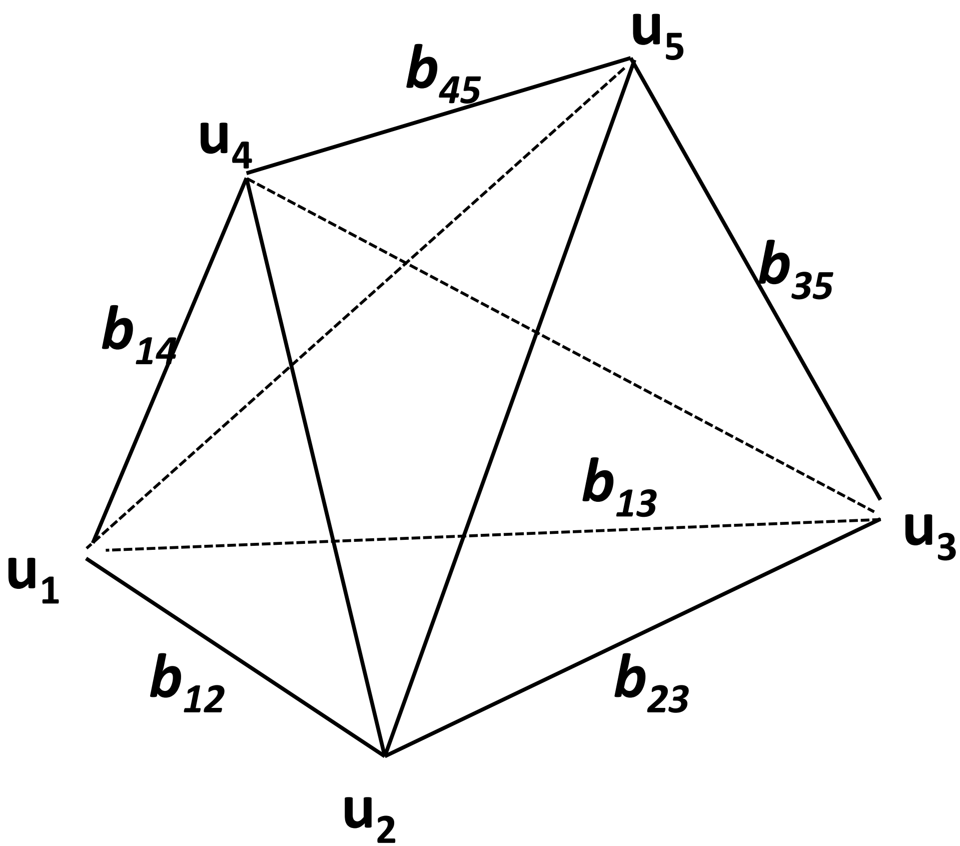
K. Hagiwara *et al.,* Phys. Rev. D **66**, 010001 (2002) (http://www-pdg.lbl.gov/)

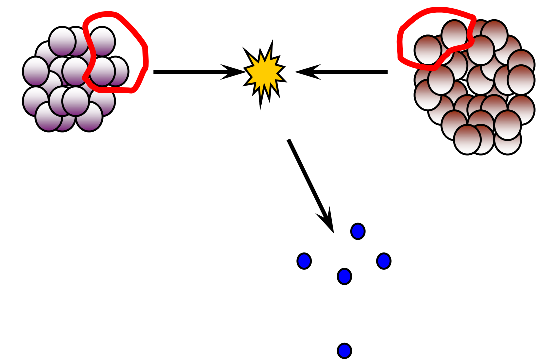


N
10^3
10^2
10^1
C(4.2GeV/c)+Ta->p
p(10GeV/c)+C->p
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
b_{23}



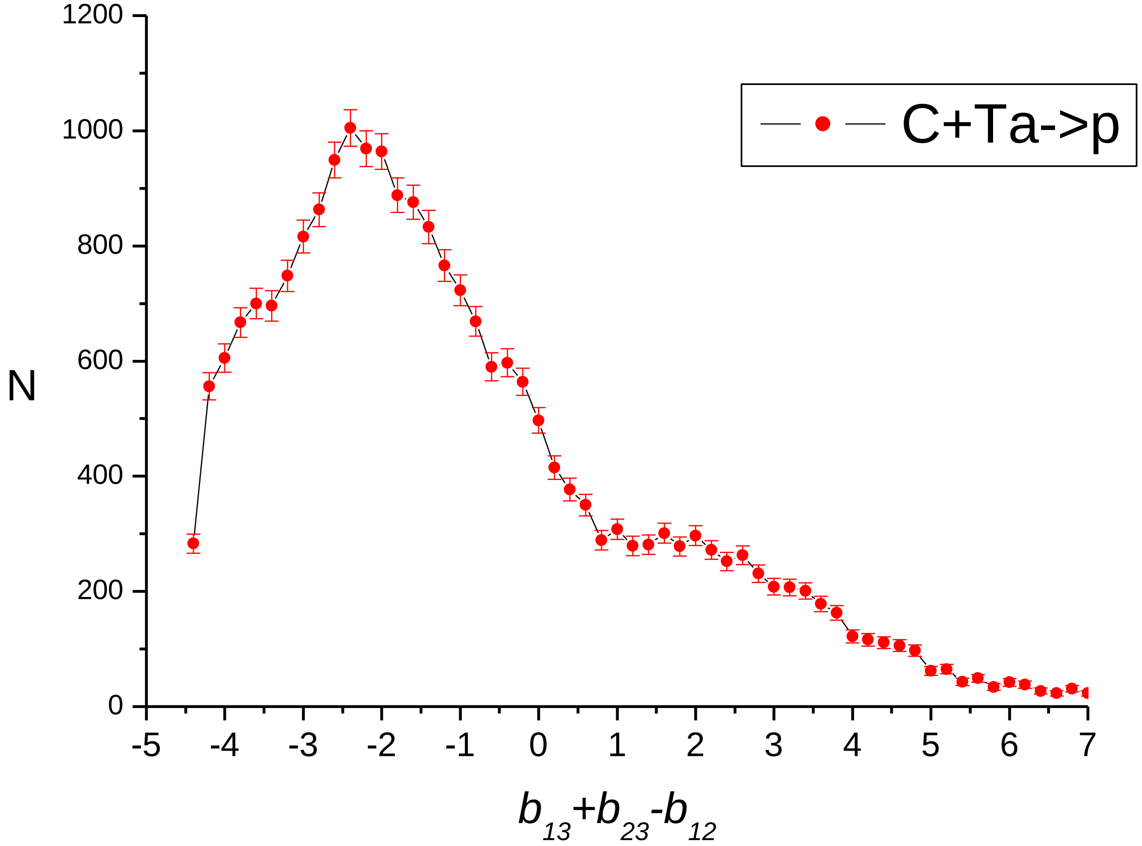
We consider b_{ik} of all particles in the reaction

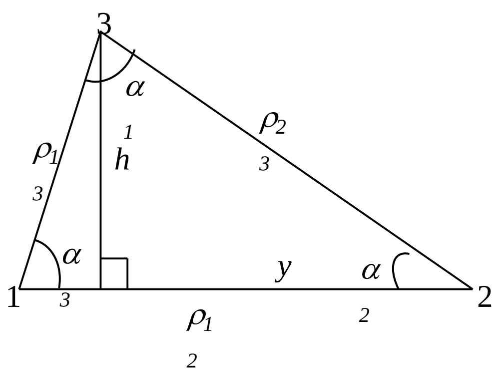

u_5
b_{45}
u_4
b_{35}
b_{14}
b_{13}
u_3
u_1
b_{12}
b_{23}
u_2



It is often said that experiments should be made without preconceived ideas. This is impossible. Not only would it make every experiment fruitless, but even if we wished to do so, it could not be done. Every man has his own conception of the world, and this he cannot so easily lay aside. We must, for example, use language, and our language is necessarily steeped in preconceived ideas, which are a thousand times the most dangerous of all. (Poincaré 1902, p. 143)

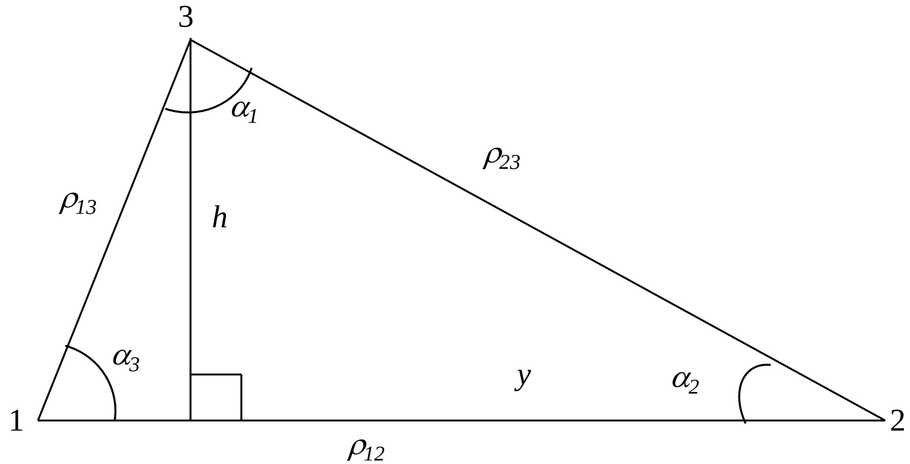
It should be noted that the variable b_{ik} does not form a metric space,
i.e. the relation $b_{12}+b_{13}\geq b_{23}$
is, generally speaking, wrong.

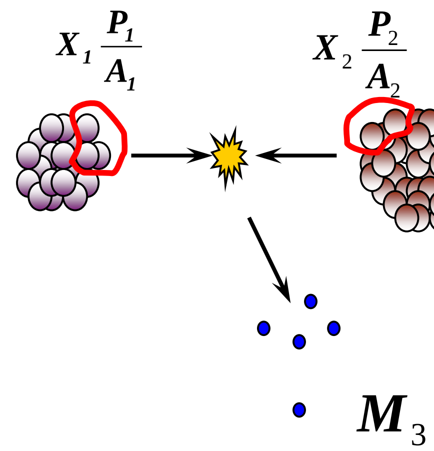




$$\min\left[-\sum_k\left(V_\alpha-u_k{}^{\alpha}\right)^2-\sum_i\left(V_\beta-u_i{}^{\beta}\right)^2\right]$$

According to F. Klein, the modern relativity principle in physics amounts to the same thing as the Lorentz group theory, which is isomorphic to the group of isometries of the Lobachevsky space.





longitudinal rapidity $$y = \frac{1}{2} \ln \frac{E + p_{\parallel}}{E - p_{\parallel}}$$

.

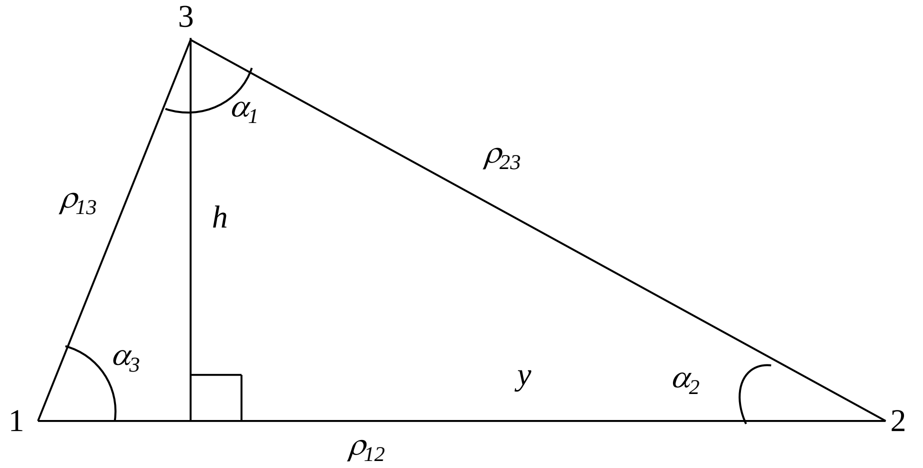
transverse mass : $$m_T = \sqrt{m^2 + p_T^{\ 2}}$$

transverse rapidity $$\mathrm{ch}\, h = \frac{m_T}{m}$$

$$ch(\rho_{12}) = ch(\rho_{13}) \cdot ch(\rho_{23}) - sh(\rho_{13}) \cdot sh(\rho_{23}) \cdot \cos(\alpha_3)$$

$$\frac{sh(\rho_{12})}{\sin(\alpha_3)} = \frac{sh(\rho_{13})}{\sin(\alpha_2)} = \frac{sh(\rho_{23})}{\sin(\alpha_1)}$$

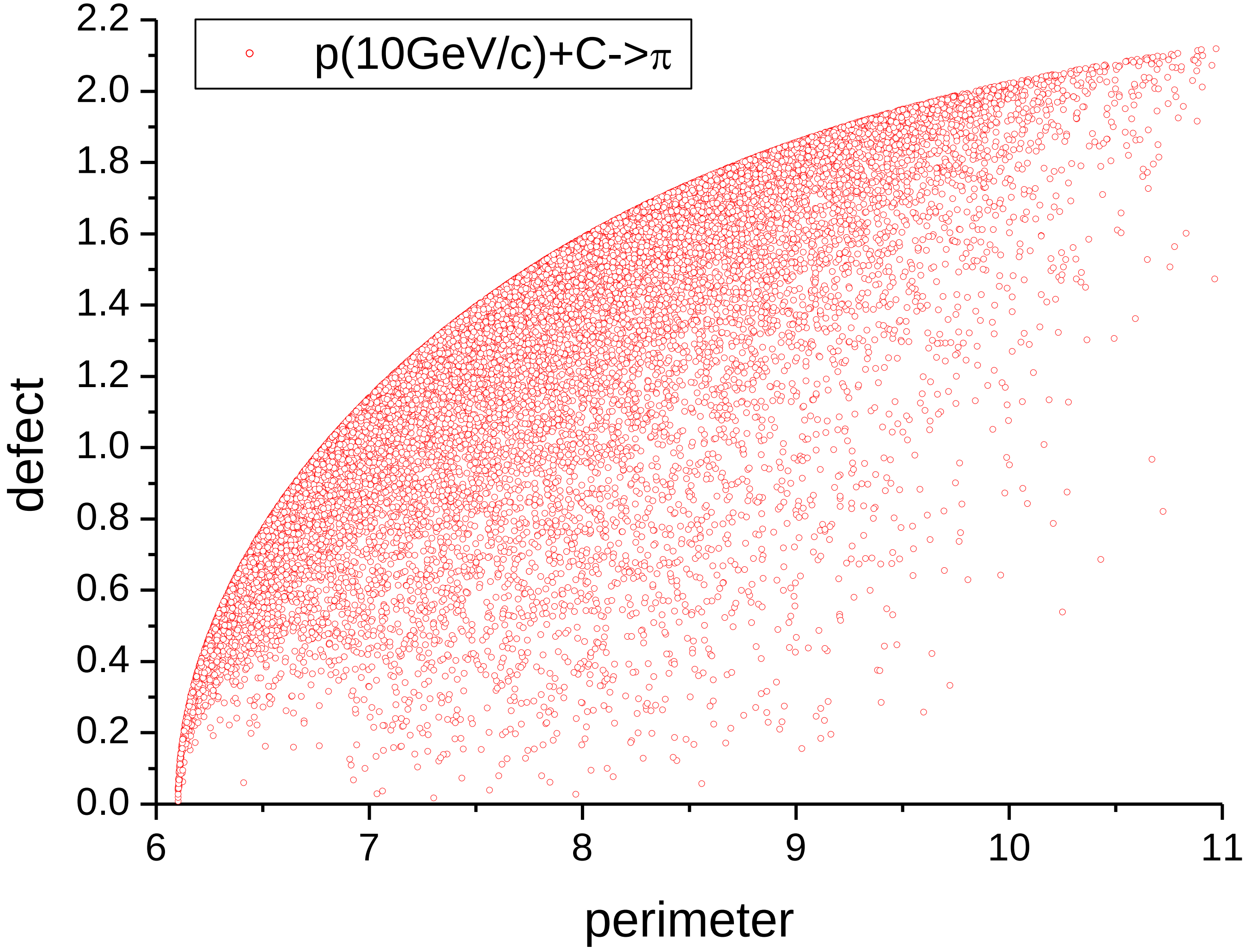
$$\mathrm{ch}\, \rho = \mathrm{ch}\, y \cdot \mathrm{ch}\, h$$



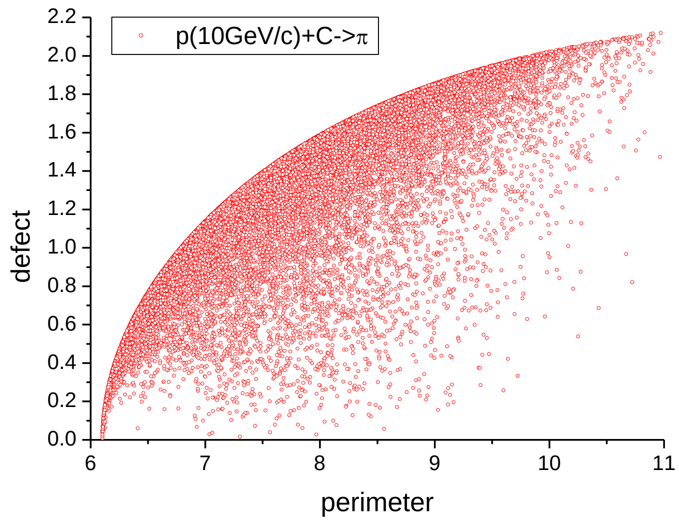
$$defect = \pi - \alpha_1 - \alpha_2 - \alpha_3$$

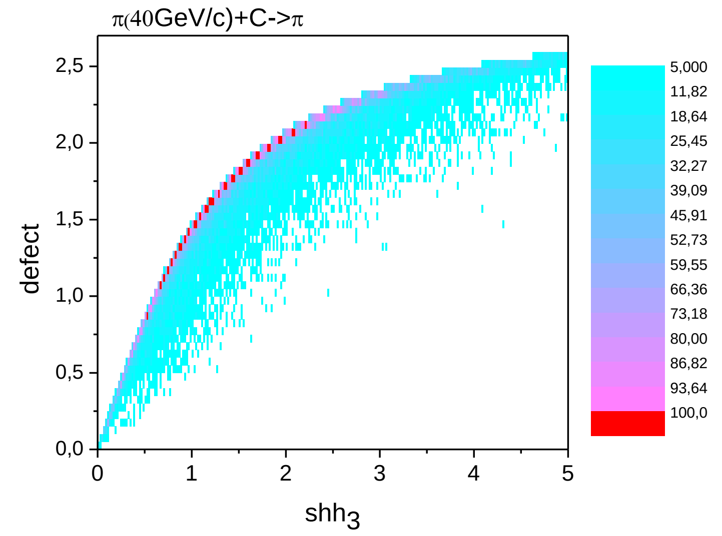
$$perimeter = \rho_1 + \rho_2 + \rho_3$$

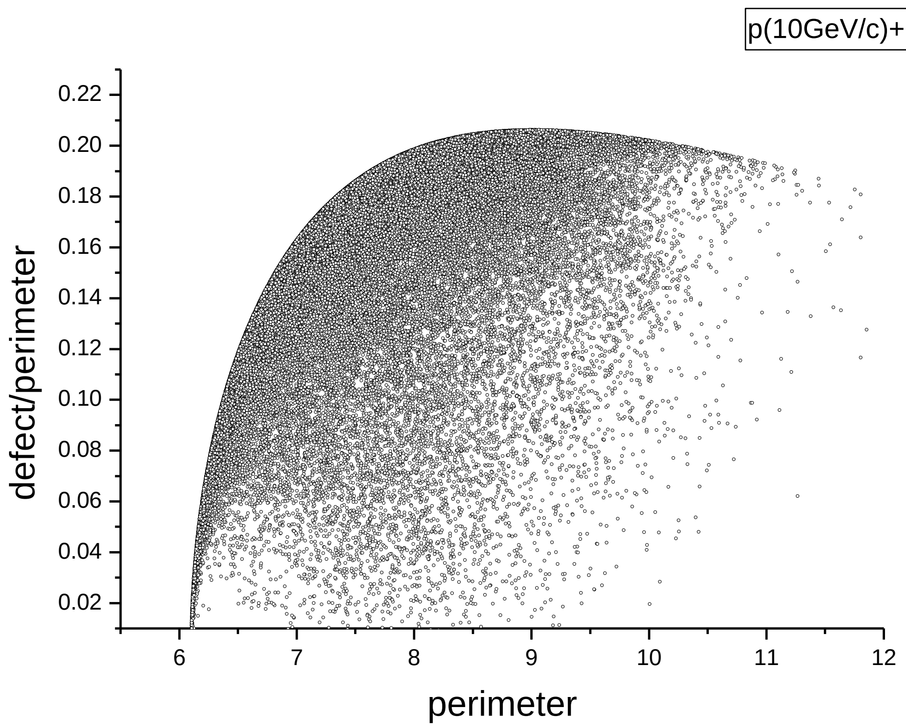
$$\Pi_L(h) = 2 \cdot arctg\left(e^{-h}\right)$$

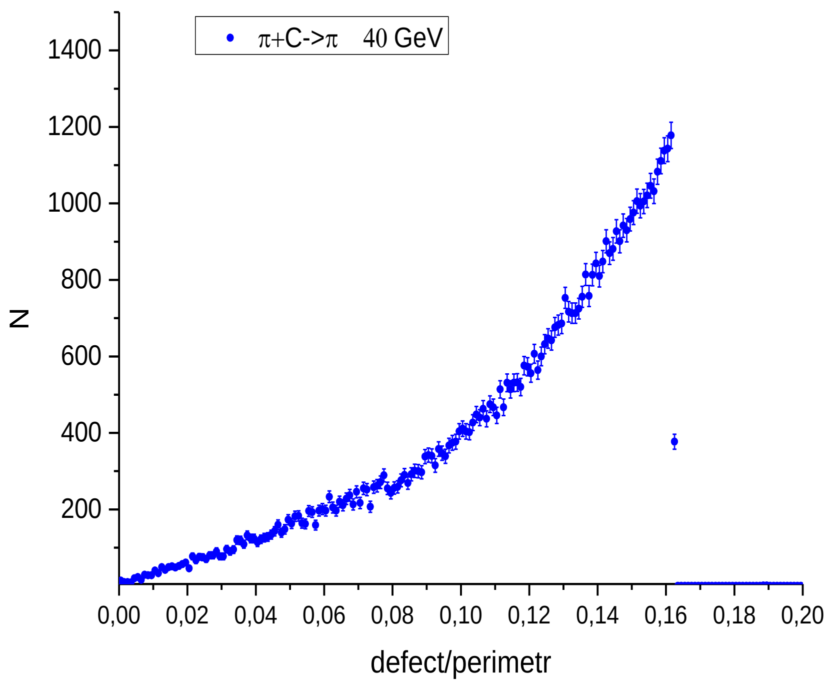


p(10GeV/c)+C->π
defect
perimeter
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
6
7
8
9
10
11

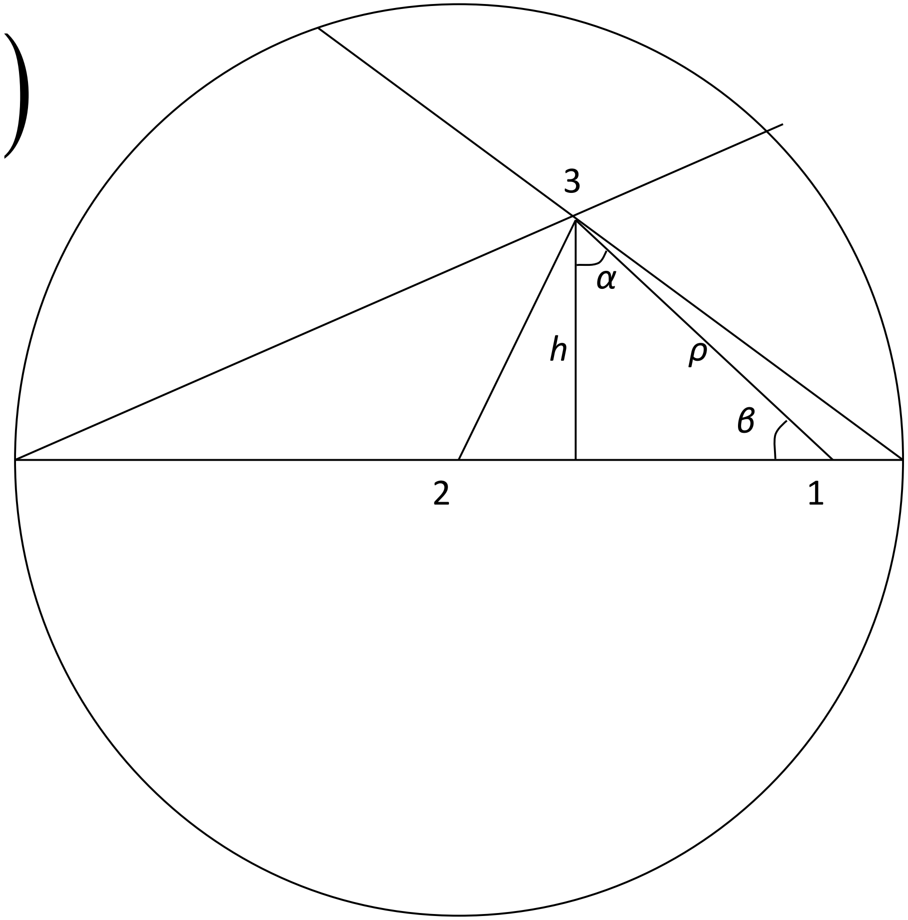

p(10GeV/c)+C->π
defect
perimeter


π(40GeV/c)+C->π
defect
shh3

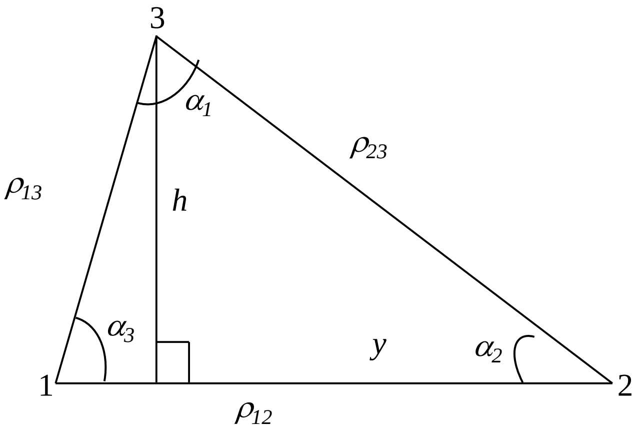

p(10GeV/c)+C->π
defect/perimeter
perimeter


π+C->π 40 GeV
N
defect/perimetr

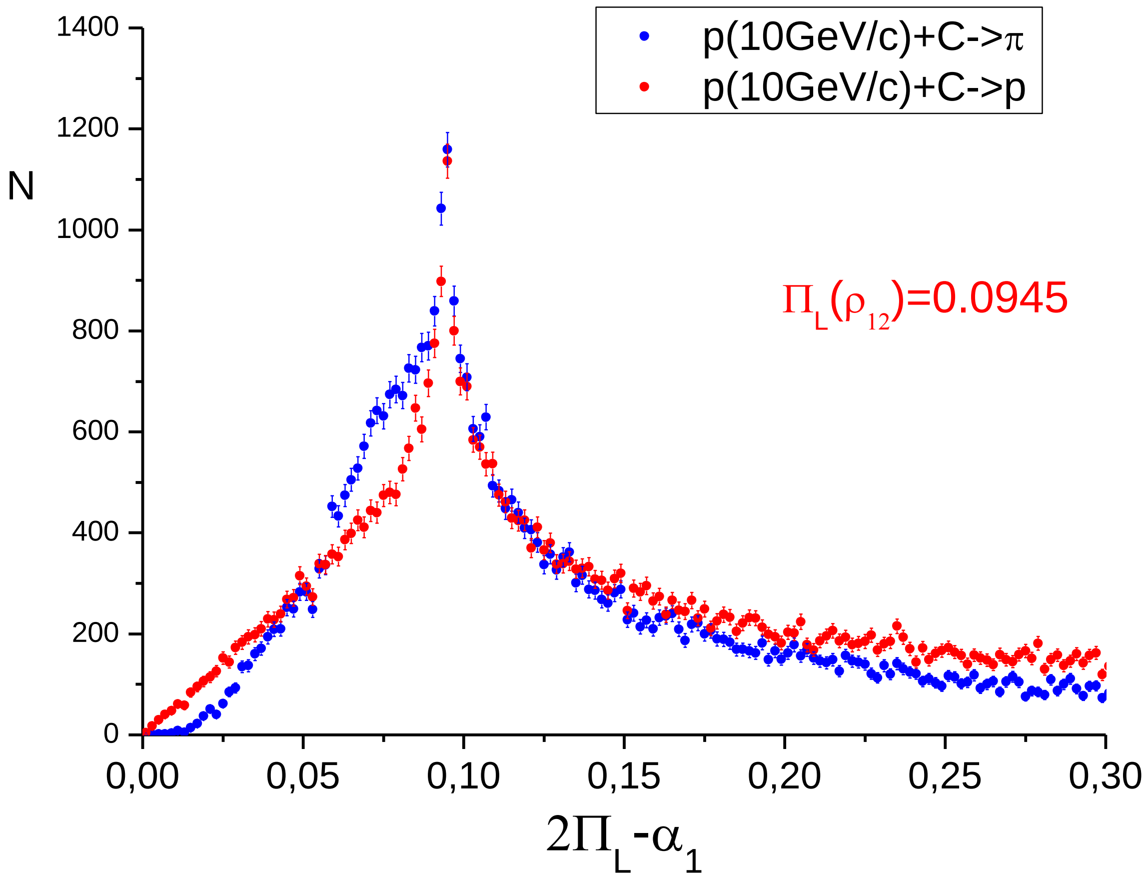
$$\Pi_L(h) = 2 \cdot arctg\left(e^{-h}\right)$$



$$\Delta_{12}^{3} = 2\Pi_L\left(h_3\right) - \alpha_3$$

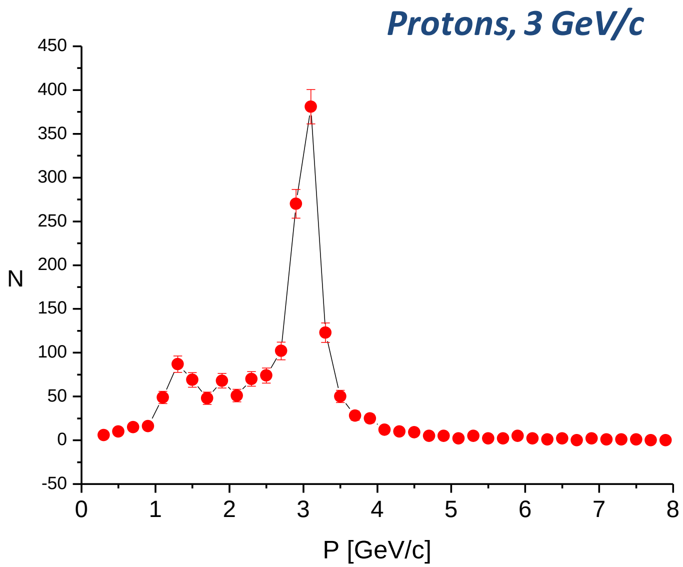


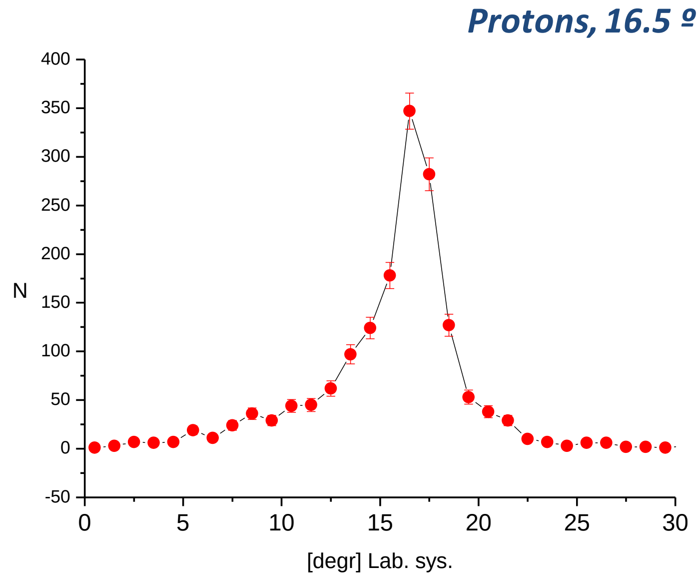
3
α_1
ρ_{23}
ρ_{13}
h
α_3
y
α_2
1
2
ρ_{12}

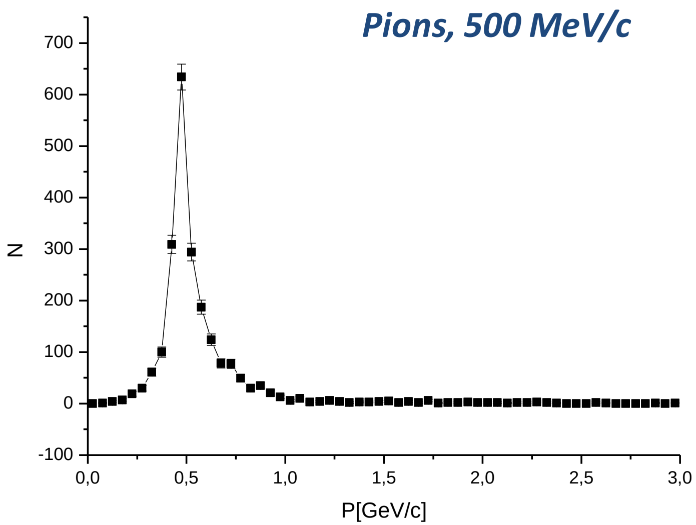


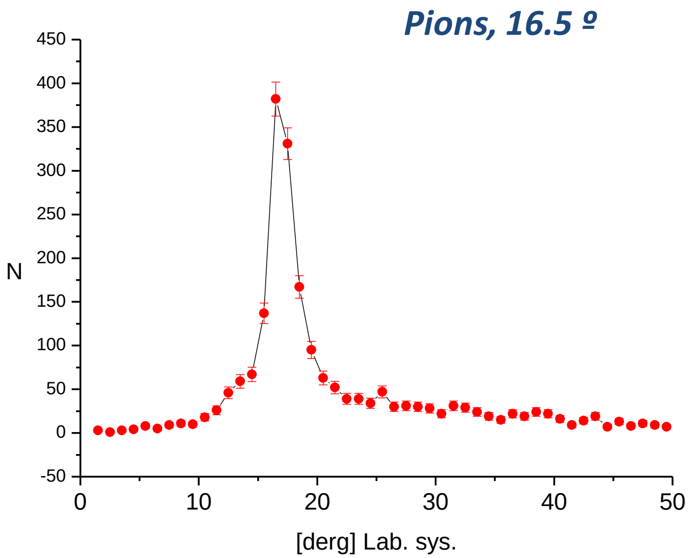
p(10GeV/c)+C->π
p(10GeV/c)+C->p
N
$\Pi_L(\rho_{12})$=0.0945
$2\Pi_L-\alpha_1$
0
200
400
600
800
1000
1200
1400
0,00
0,05
0,10
0,15
0,20
0,25
0,30

pC (10 GeV)

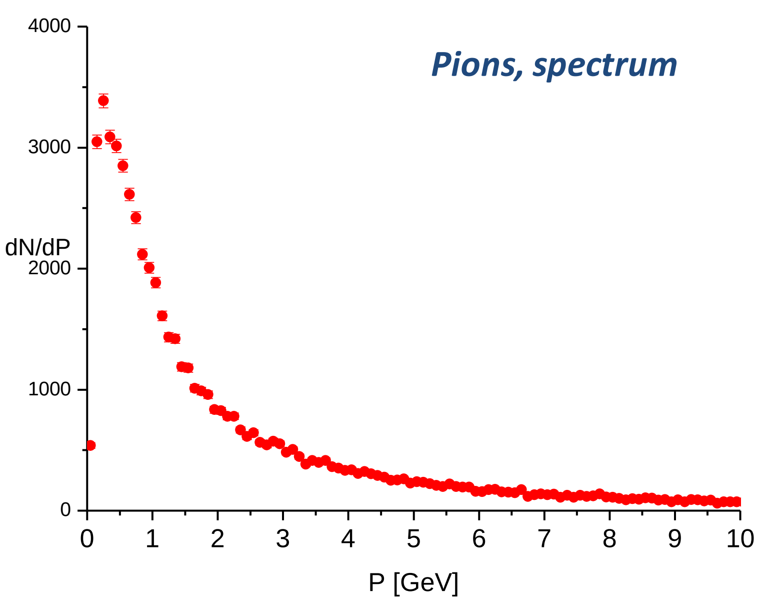

Protons, 3 GeV/c
N
P [GeV/c]

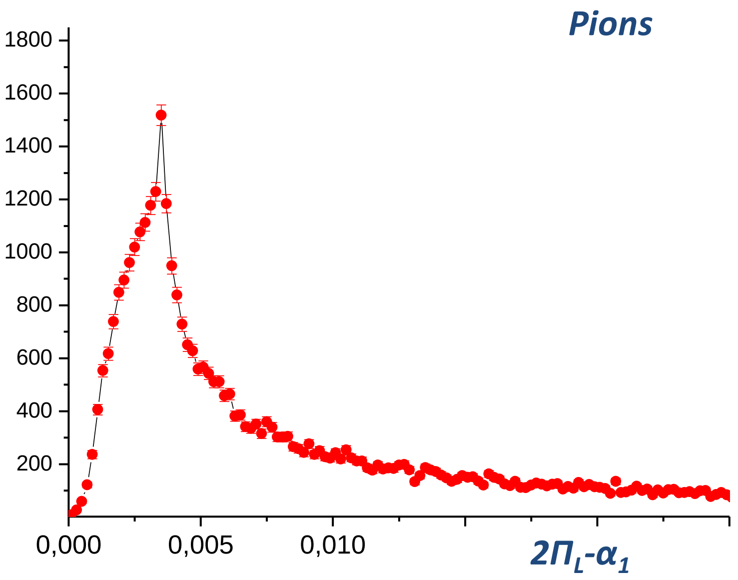

Protons, 16.5 º
N
[degr] Lab. sys.

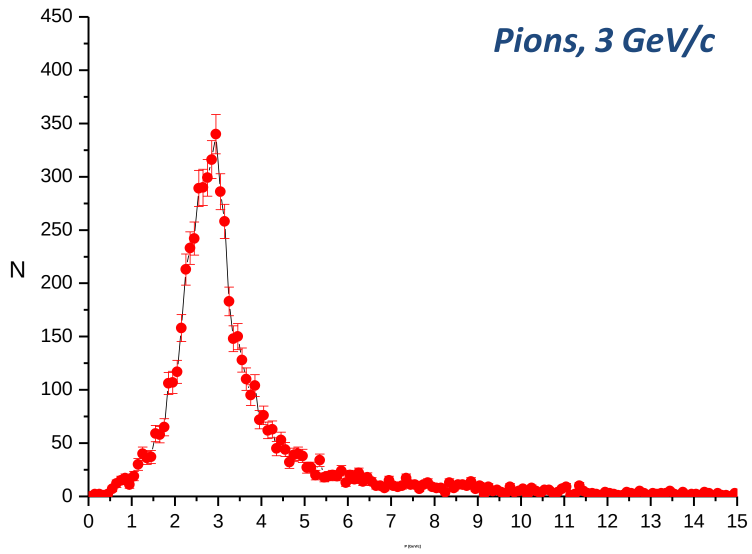

Pions, 500 MeV/c
N
P[GeV/c]

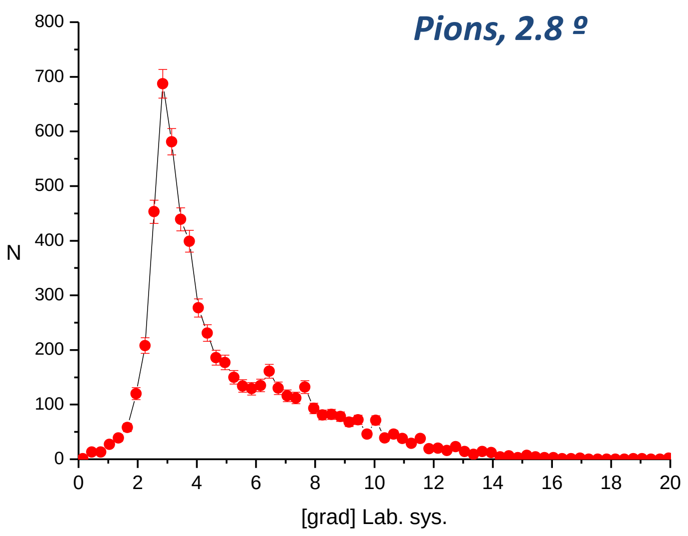

Pions, 16.5 º
N
[derg] Lab. sys.

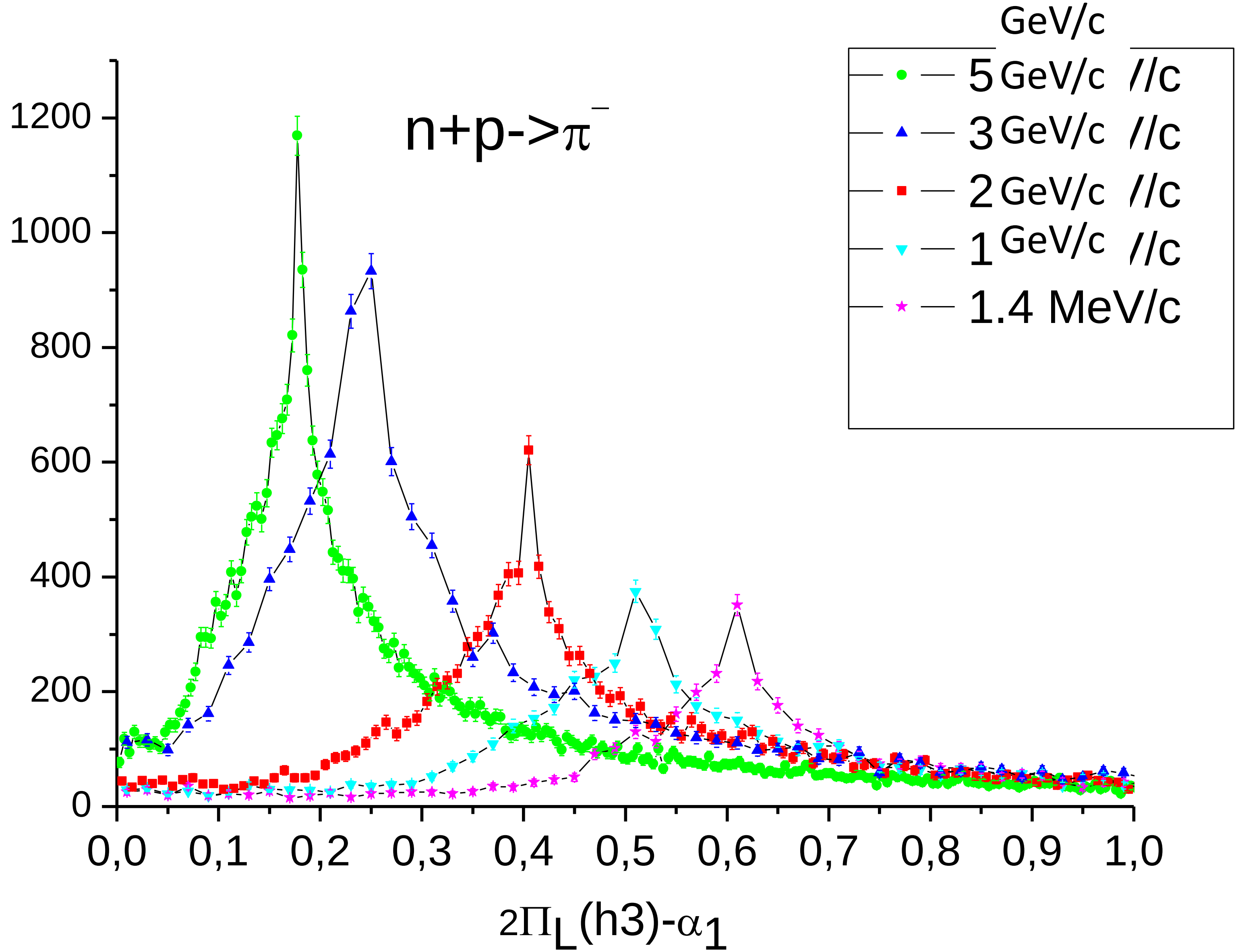
π⁻C (40 GeV)


Pions, spectrum
dN/dP
P [GeV]


Pions
2Π_L-α_1

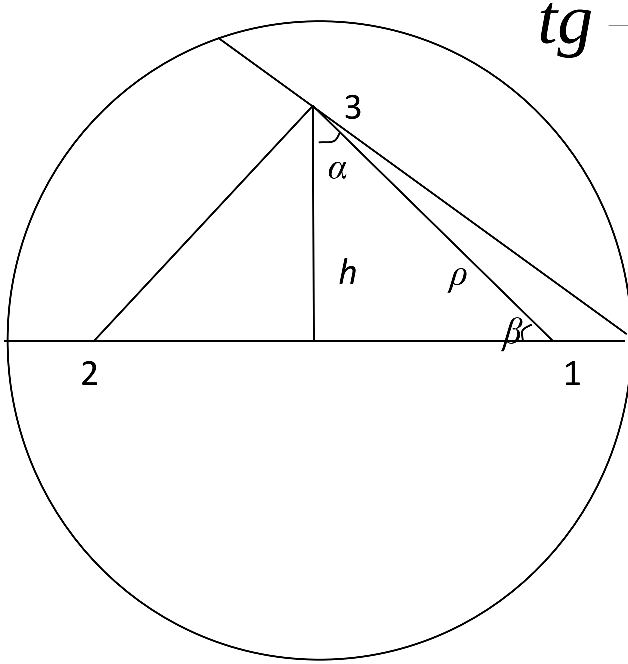

Pions, 3 GeV/c
N


Pions, 2.8 º
N
[grad] Lab. sys.

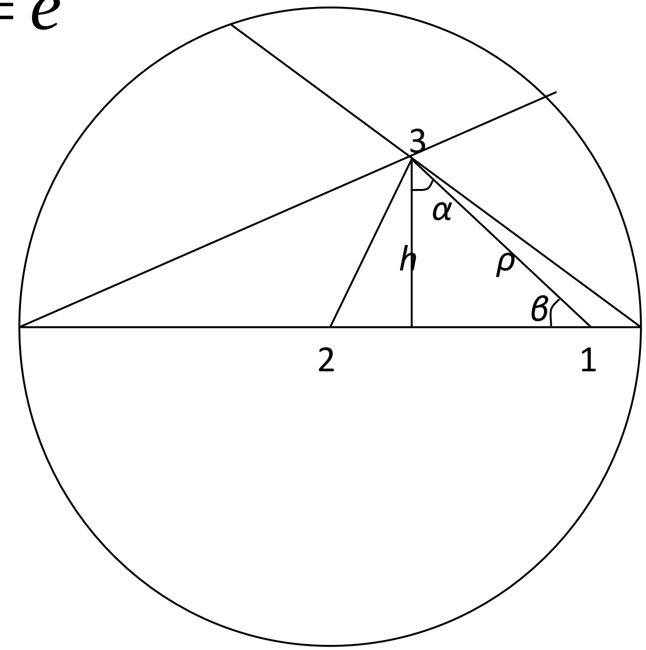


n+p->π⁻
GeV/c
5 GeV/c /c
3 GeV/c /c
2 GeV/c /c
1 GeV/c /c
1.4 MeV/c
1200
1000
800
600
400
200
0
0,0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1,0
2ΠL(h3)-α1

$$tg\frac{\Pi_L(h)}{2} = e^{-h}$$



Collider

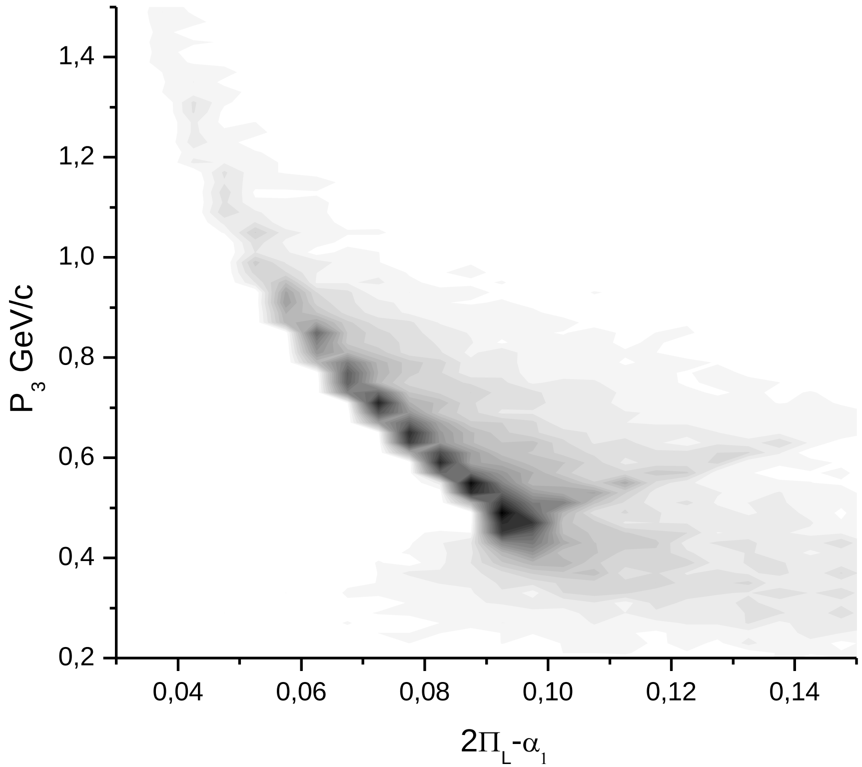


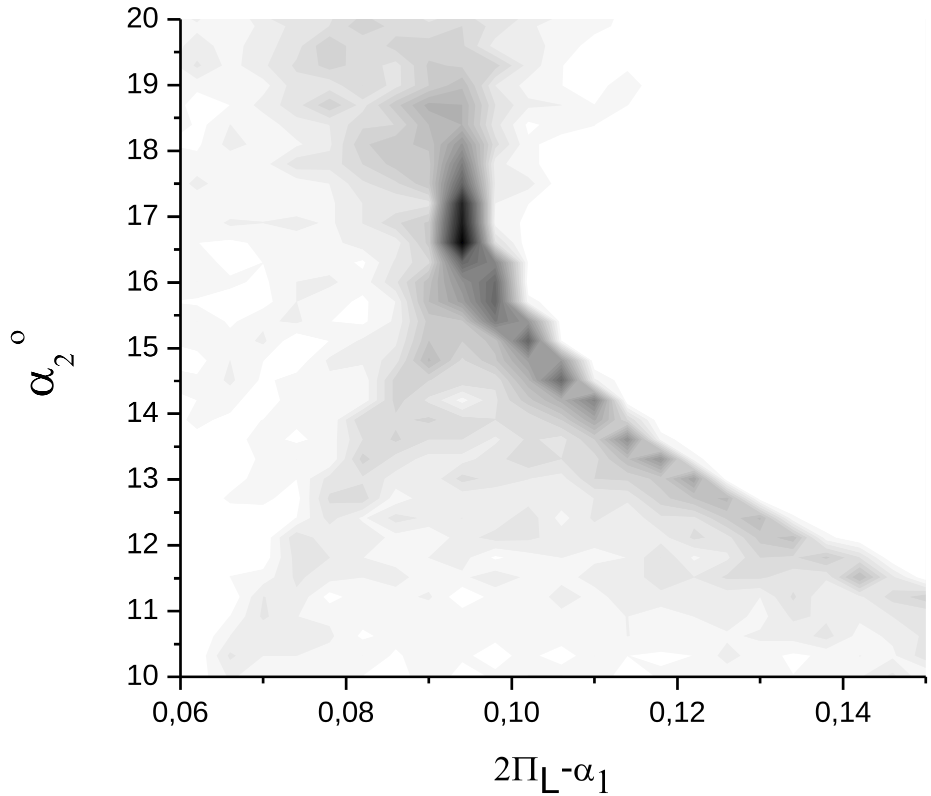
Fixed target

Angle of parallelism

$$\Pi_L(h) = 2 \cdot arctg\left(e^{-h}\right)$$

Directed Nuclear Radiation
P+C->pions at 10GeV

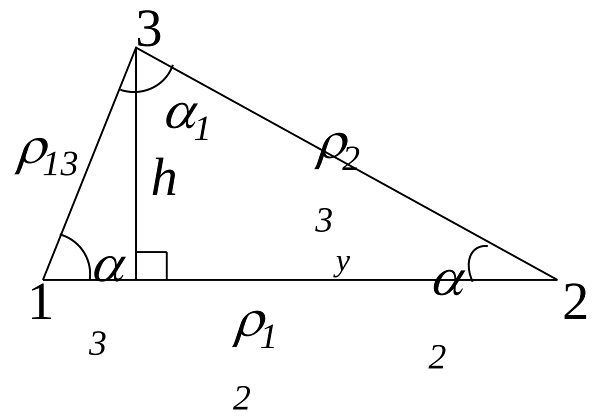


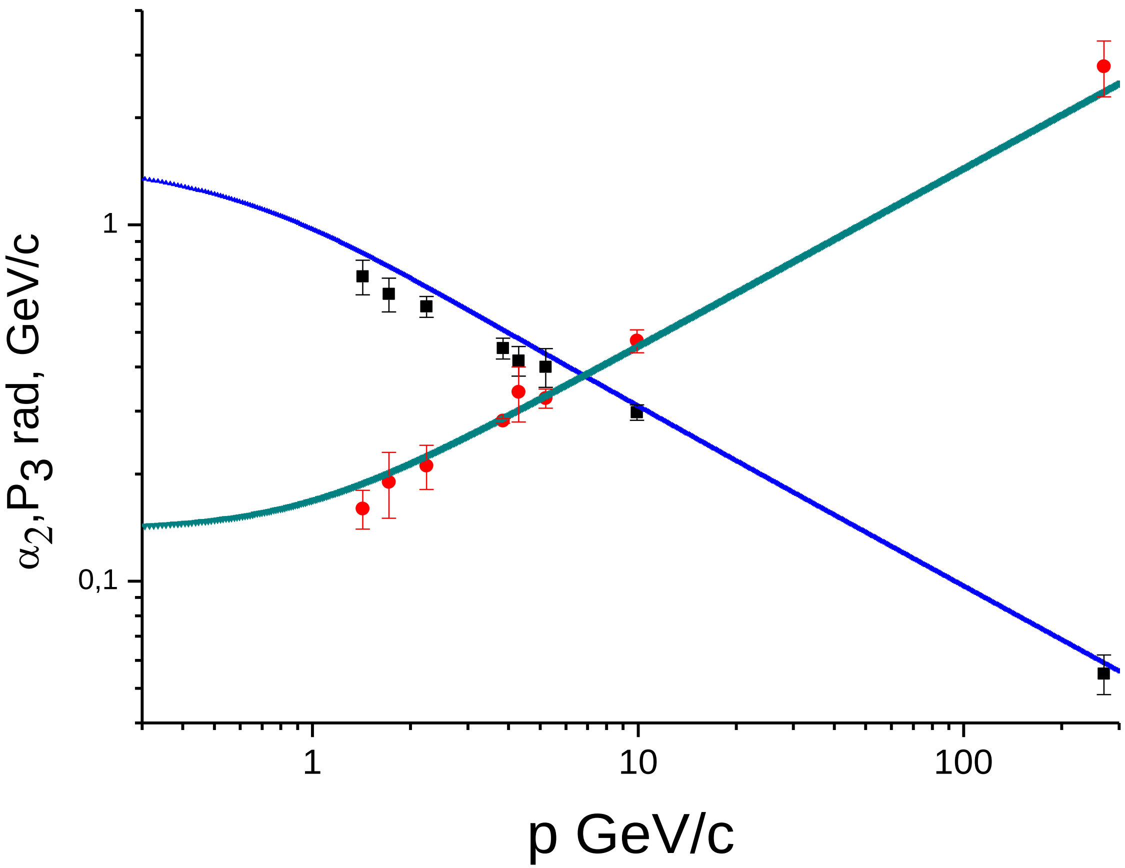


Directed Nuclear Radiation

$$\cos\alpha_2 = \sqrt{\frac{1+th(\rho_{12})}{2}} - sh(h)\sqrt{\frac{1-th(\rho_{12})}{2}}$$

$$P_{23} = m_3 \cdot \mathrm{sh}\, h \,/ \sin\alpha_2 \qquad sh(h) = \sqrt{th(\rho_{12}/2)}$$





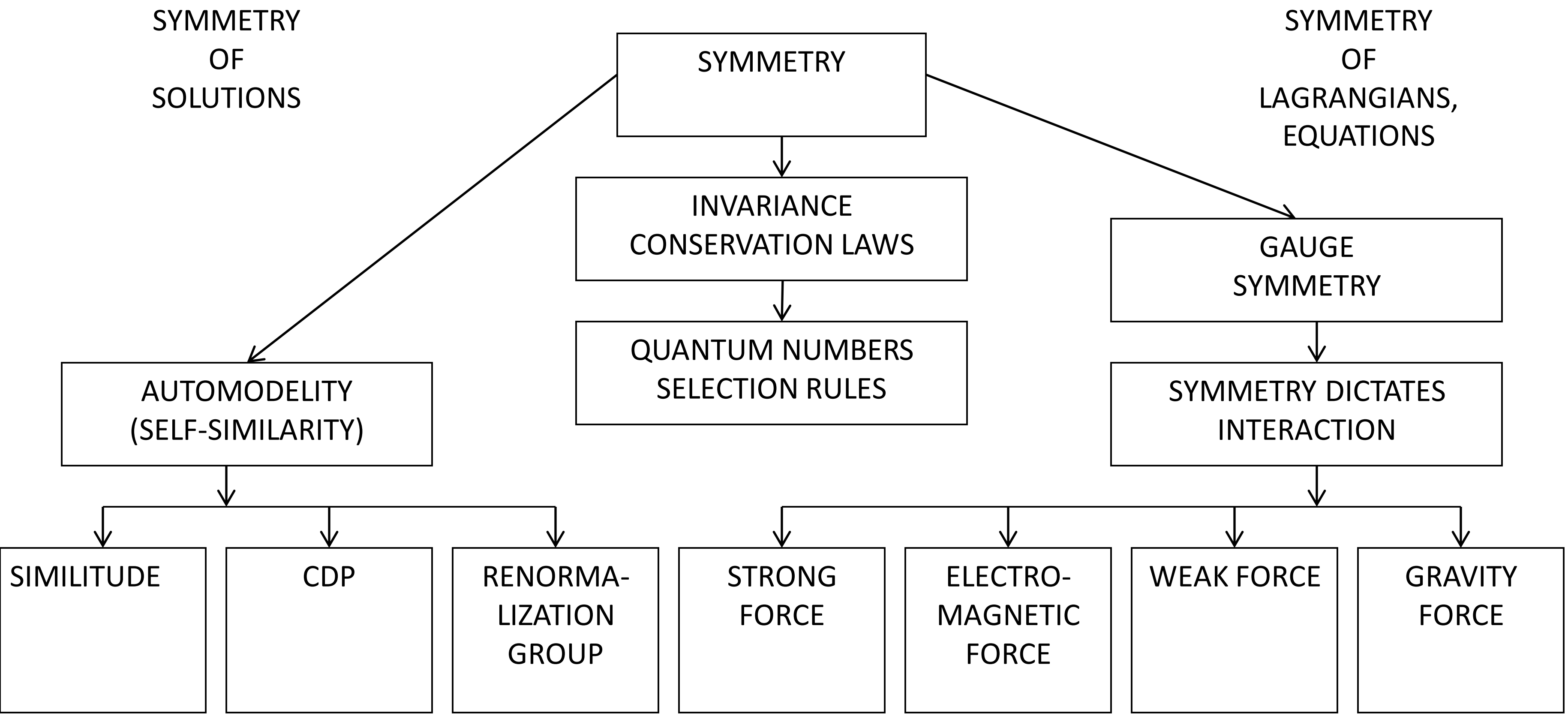
" The standard model in elementary particle physics claims to be capable of describing electroweak and strong interactions and is a great achievement of experimental and theoretical physics of the second half of the 20th century. However the standard model contains only those defining axioms which concern the lagrangian symmetries, but this is not enough for the description of physical processes. Some additional conditions (hypotheses) are needed : initial and boundary conditions, assumptions about the constants entering the lagrangians (masses, charges and so on).

It is impossible to deduce nuclear physics, including relativistic nuclear physics, from quantum chromodynamics without using auxiliary hypotheses needed to be checked experimentally. The verification of such hypotheses of a rather general nature is not less important than the verification of quantum chromodynamics. For instance, a detailed probe of the correlation depletion principles and the self-similarirty is a task of paramount importance.

However both the lagrangian properties and the self-similarity are consequences of symmetry. Symmetry was considered by ancient Greek philosophers as a particular case of harmony i.e. the concordance of the parts within the whole.

A.M.Baldin JINR, Dubna,1996

A.M.Baldin
JINR Rapid Comm. №5, 1996



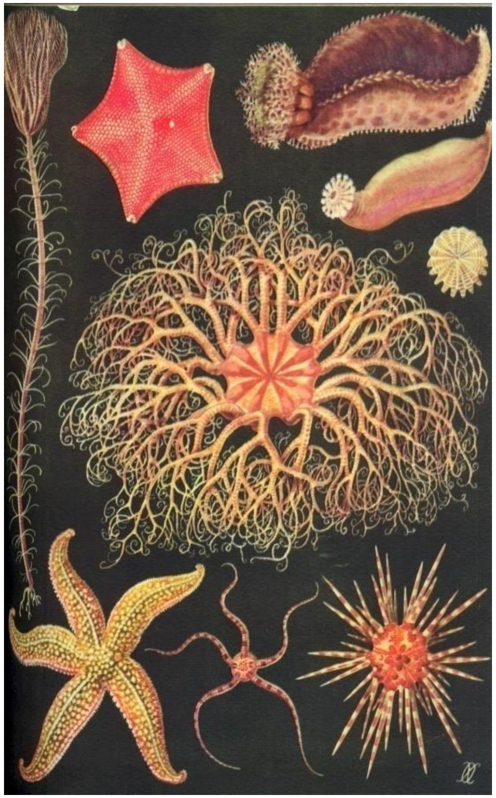
Schematic diagram illustrating the role of symmetry in fundamental physics.

ΣΙΜΜΕΤΡΙΑ

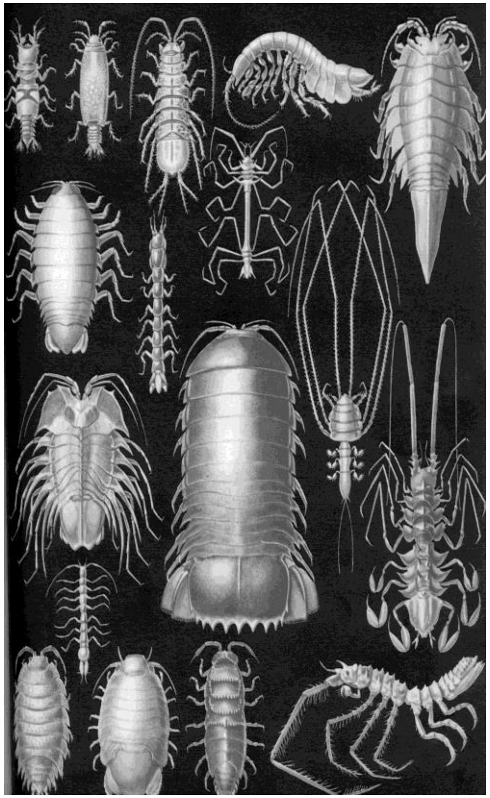
The Greek word “ΣΙΜΜΕΤΡΙΑ” means “commensurability, congruence, proportionality, symmetry”.

Symmetry in living matter

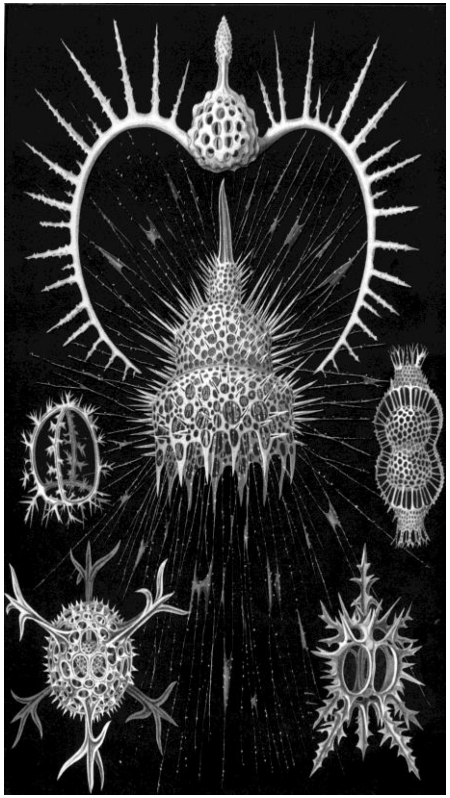
- Echinoderms



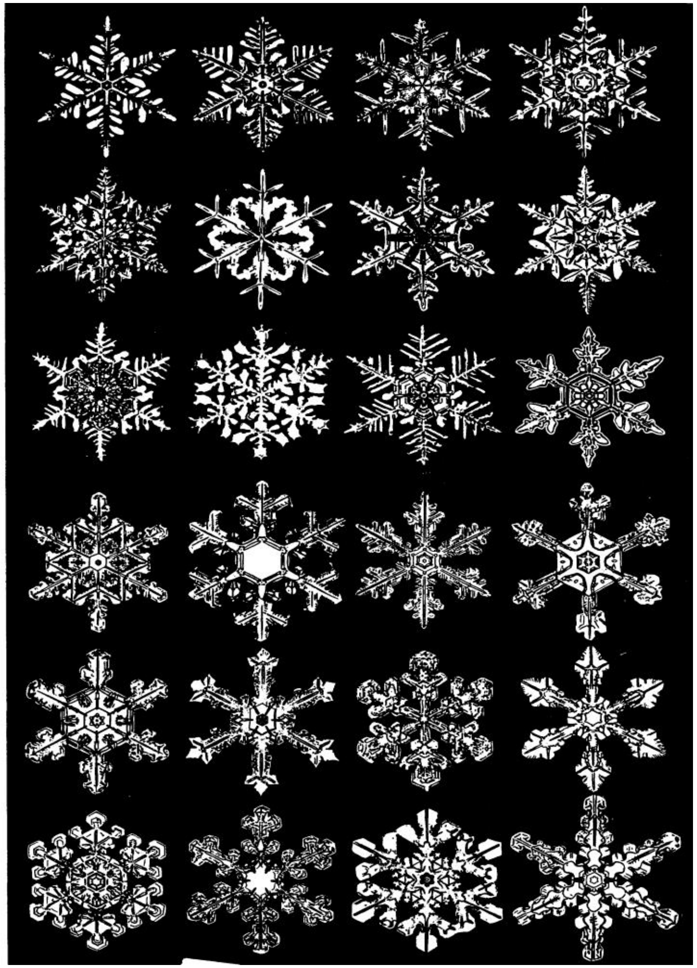
Crustaceans



Radiolaria

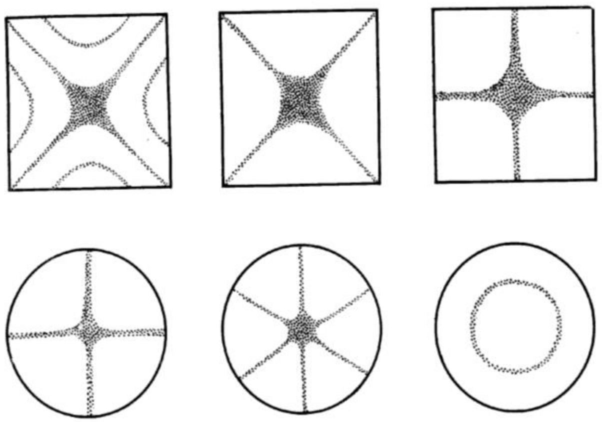


Symmetry in nonliving matter

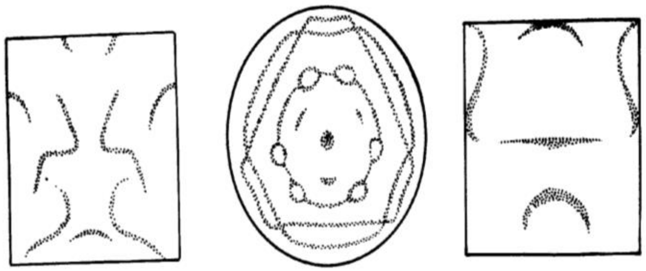


Symmetry in physics phenomena

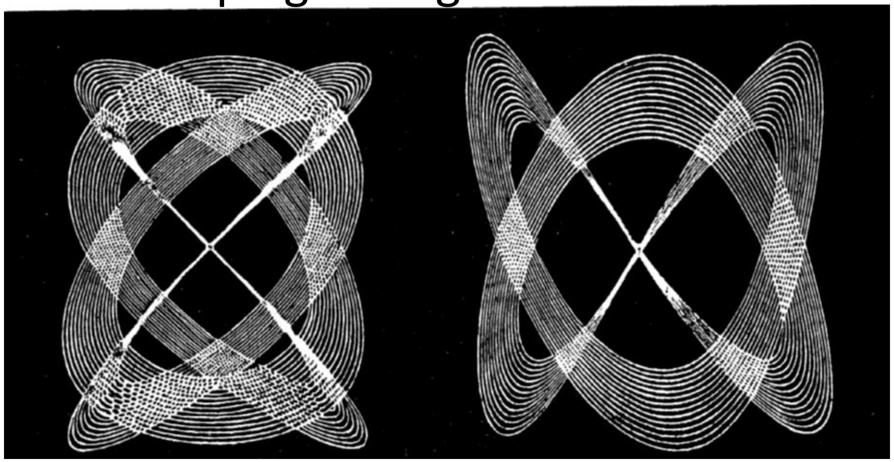
Chladni figures (acoustics)



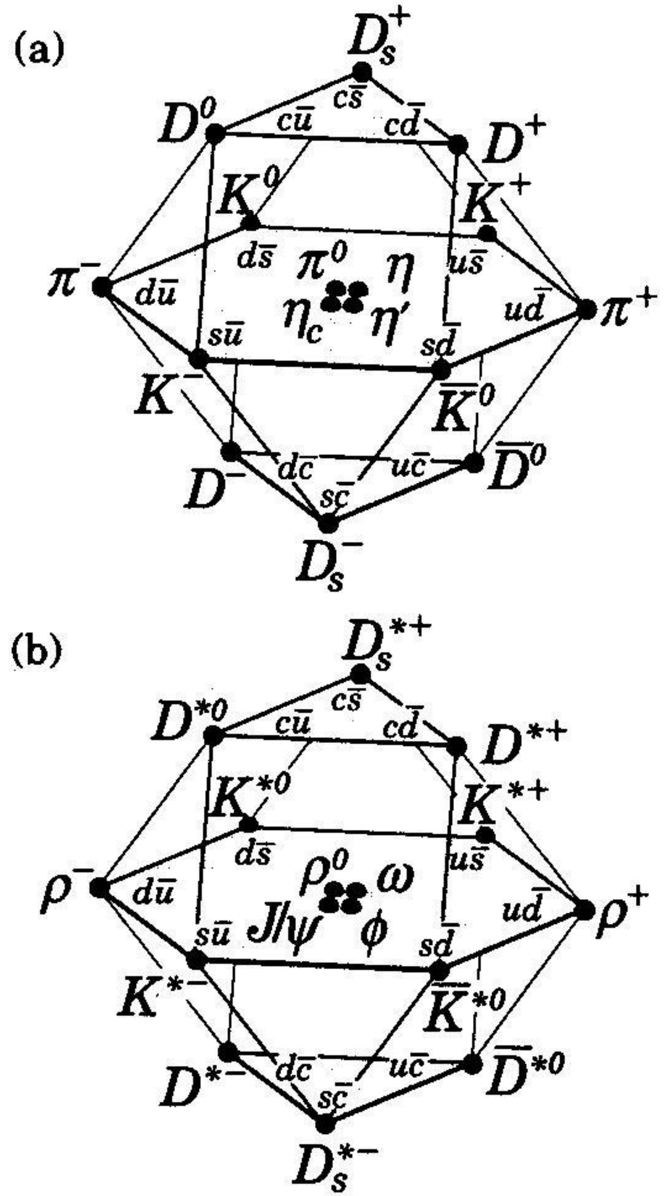
Dust contours on piezo quartz plates



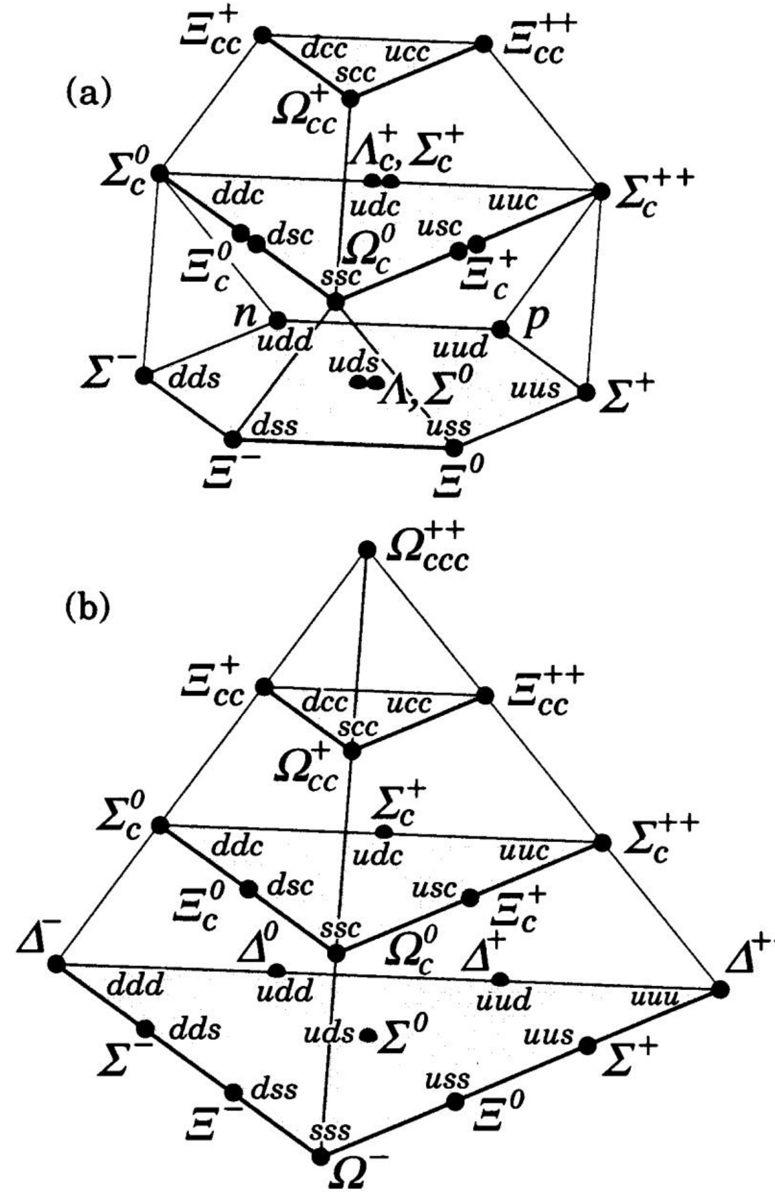
Lissajous figures – sum of oscillations of two damping tuning forks



quire four dimensions to draw the multiplets.



Mesons



Baryons

Emmy Noether's first theorem

which derives conserved quantities from symmetries

(published exactly 100 years ago, in 1918)

Noether's first theorem states that every differentiable symmetry of the action of a physical system has a corresponding conservation law.

- The invariance of physical systems with respect to spatial translation (in other words, that the laws of physics do not vary with locations in space) gives the law of conservation of linear momentum.
- The invariance with respect to rotation gives the law of conservation of angular momentum.
- The invariance with respect to time translation gives the law of conservation of energy.

The Curie principle of symmetry:

- The causality relation between the symmetry of the cause and that of the effect. The principle is composed of three parts:
- If certain causes yield the known effects, the symmetry elements of the causes should be contained in the generated effects.
- If the known effects manifest certain dissymmetry (absence of symmetry elements), this latter should be contained in the causes which have generated those effects.
- The converse to these two previous propositions is not true, at least in practical: i.e., the effects may have higher symmetry than the causes which generate these effects.

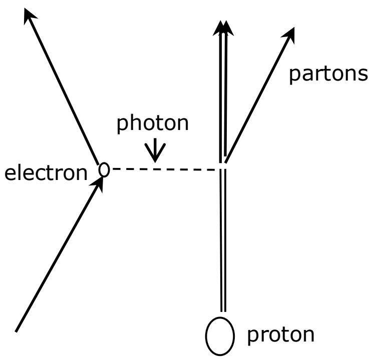
<u>A. V. Shubnikov:</u>

"Whatever interpretation of symmetry we consider, one thing is mandatory: symmetry cannot be considered without its antipode, dissymmetry. Symmetry reflects the aspect of phenomena corresponding to rest, while dissymmetry, the aspect corresponding to motion. The single idea of symmetry – dissymmetry is inexhaustible."

Self-similarity

- Self-similarity is a special symmetry of solutions, when a change in scales of independent variables can be compensated by a self-similarity transformation of other dynamical variables.
- The main idea of application of the self-similarity approach in physics (and science in general) is to reduce the number of variables in a physical law.

Bjorken variable – dimensional self-similarity

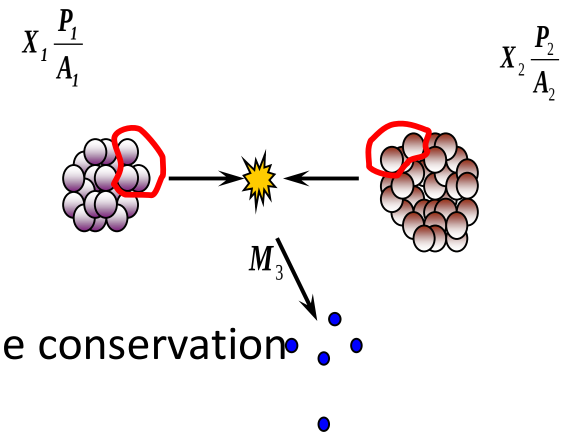


Historically, self-similarity in elementary particle physics was introduced in relation with the deep inelastic electron scattering on protons, it is the well known Bjorken scaling obtained directly from the conservation laws in the assumption that since the squared momentum of particles participating in the reaction is much lager than the squared mass, the latter can be neglected.

$$P_1 + xP_2 = P_1' + \sum_i P_i' \Rightarrow \left(P_1 + xP_2 - P_1'\right)^2 = \left(\sum_i P_i'\right)^2 \xRightarrow{q = P_1 - P_1'} \left(q + xP_2\right)^2 = \left(\sum_i P_i'\right)^2 \Rightarrow$$

$$2\sum_{k,l}\left(\gamma_{kl} - 1\right)M_k M_l \to 0 \Rightarrow q^2 + 2xP_2 q + x^2 P_2{}^2 = M^2 \xRightarrow{P^2 \gg M^2} x = -\frac{q^2}{2P_2 q}$$

General self-similarity solution for relativistic interacting particles



$$X_1 P_1 + X_2 P_2 = P_1' + \sum P_i'$$

The relationship between X_1 and X_2 is described by the conservation laws written in the form

$$\left(X_1 M_1 u_1 + X_2 M_2 u_2 - M_3 u_3\right)^2 = \left(M_n X_1 u_1' + M_n X_2 u_2' + \sum_{k=4} M_k u_k\right)^2$$

Essentially, we are using the correlation depletion principle in the relative four-velocity space which enables us to neglect the relative motion of not detected particles, namely the quantity in the right-hand side of the above equation.

$$2\sum_{k>1}\left(\gamma_{kl} - 1\right) M_k M_l$$

General self-similarity solution for relativistic interacting particles

$$X_1 X_2(\gamma_{12}-1) - X_1\left(\frac{M_3}{M_p}\gamma_{13}+\frac{M_4}{M_p}\right) - X_2\left(\frac{M_3}{M_p}\gamma_{23}+\frac{M_4}{M_p}\right) = \frac{M_4^2 - M_3^2}{2M_p}$$

In the case of production of antiparticle with mass M_3, the mass M_4 is equal to M_3 as a consequence of conservation of quantum numbers. In studying the production of protons and nuclear fragments

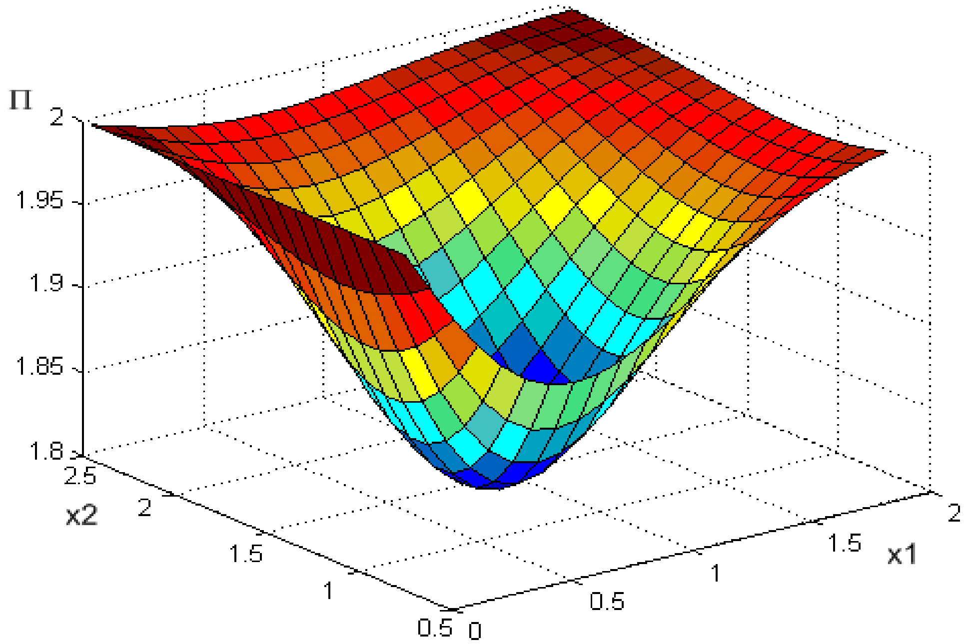
$M_4 = -M_3$ as far as the minimum value of Π corresponds to the case that no other additional particles are produced. The values of X_1 and X_2 obtained from the minimum Π are used to construct a universal description of the A-dependencies.

$$\Pi = \frac{1}{2}\left(X_1^2 + X_2^2 + 2X_1X_2\gamma_{12}\right)^{1/2} \qquad S = (P_1 + P_2)^2$$

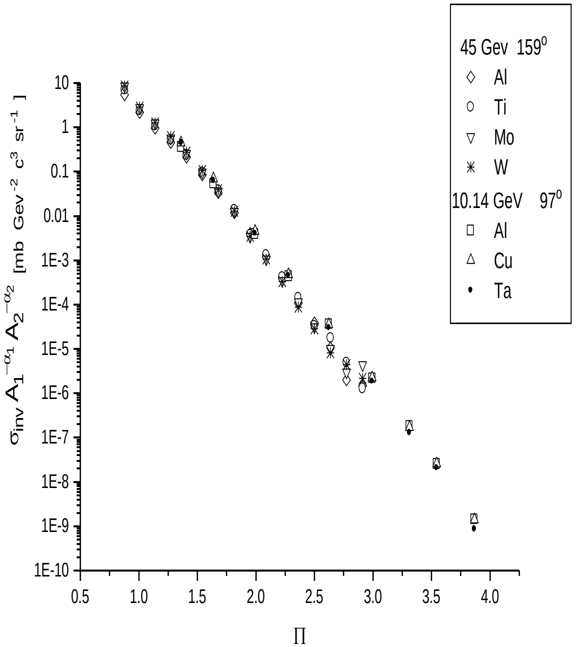
$$E\frac{d^3\sigma}{d^3p} = C_1 A_1^{\alpha(X_1)} A_2^{\alpha(X_2)} f(\Pi)$$

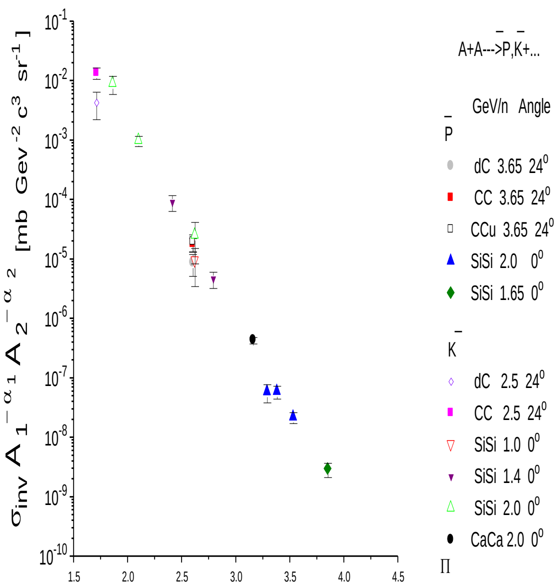
General self-similarity solution for relativistic interacting particles

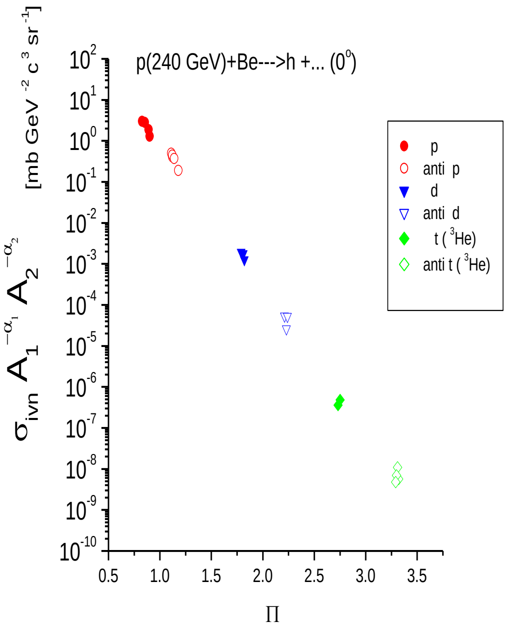
$$E\frac{d^3\sigma}{dp^3} = C_1 A_1^{\frac{1}{3}(1+X_1)} A_2^{\frac{1}{3}(1+X_2)} \exp\left(-\Pi/C_2\right)$$



Cumulative, twice cumulative, and antiparticle production







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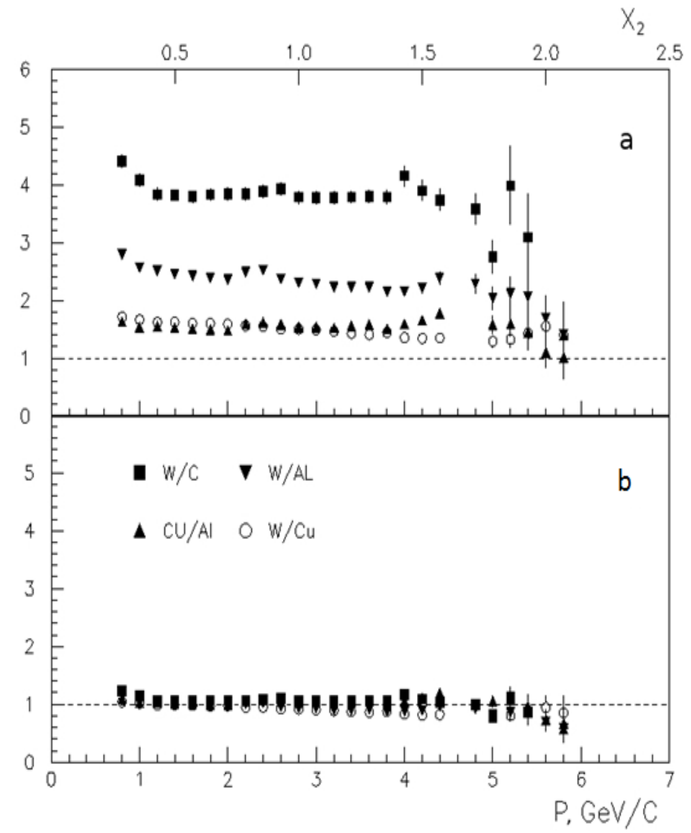
High-P_T region

The A-dependence of the form $A^{(1+X_2)/3}$ well describes the dynamic dependence of the cross sections on X2, while it fails to describe a stronger dependence on the mass number of the nucleus observed in this experiment.

Figure. Ratio of cross sections of negative pion production on different nuclei multiplied by inverse A-dependence.

(a) $A^{(1+X_2)/3}$ (b) $A^{(2.45+X_2)/3}$



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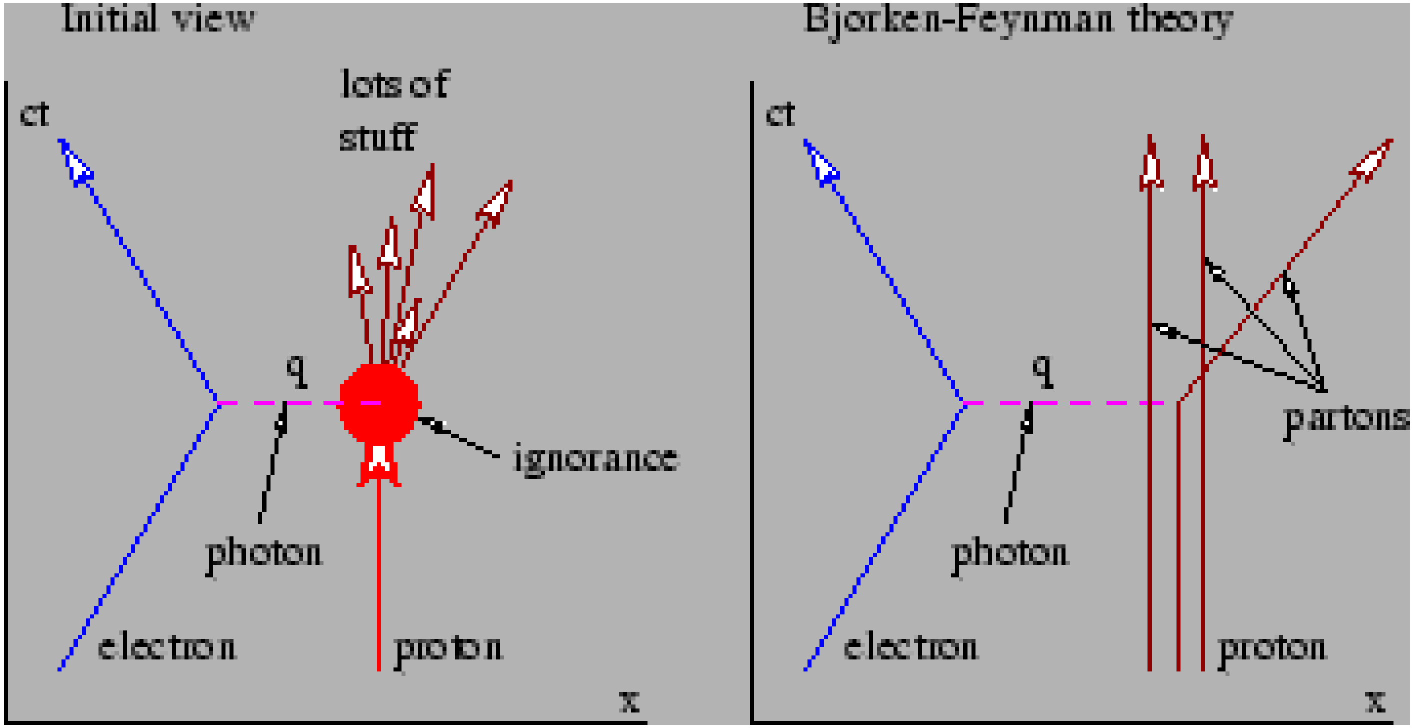
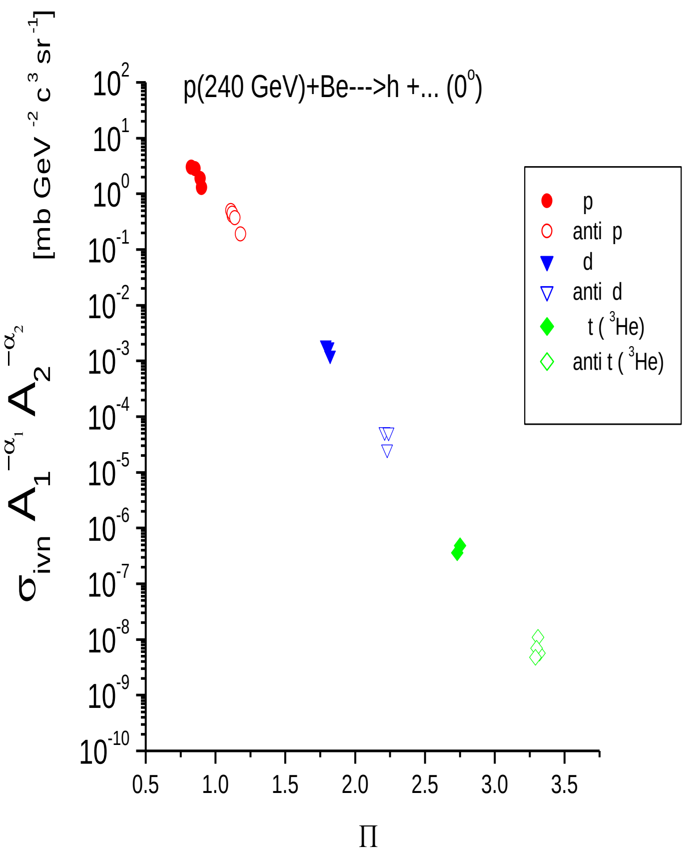
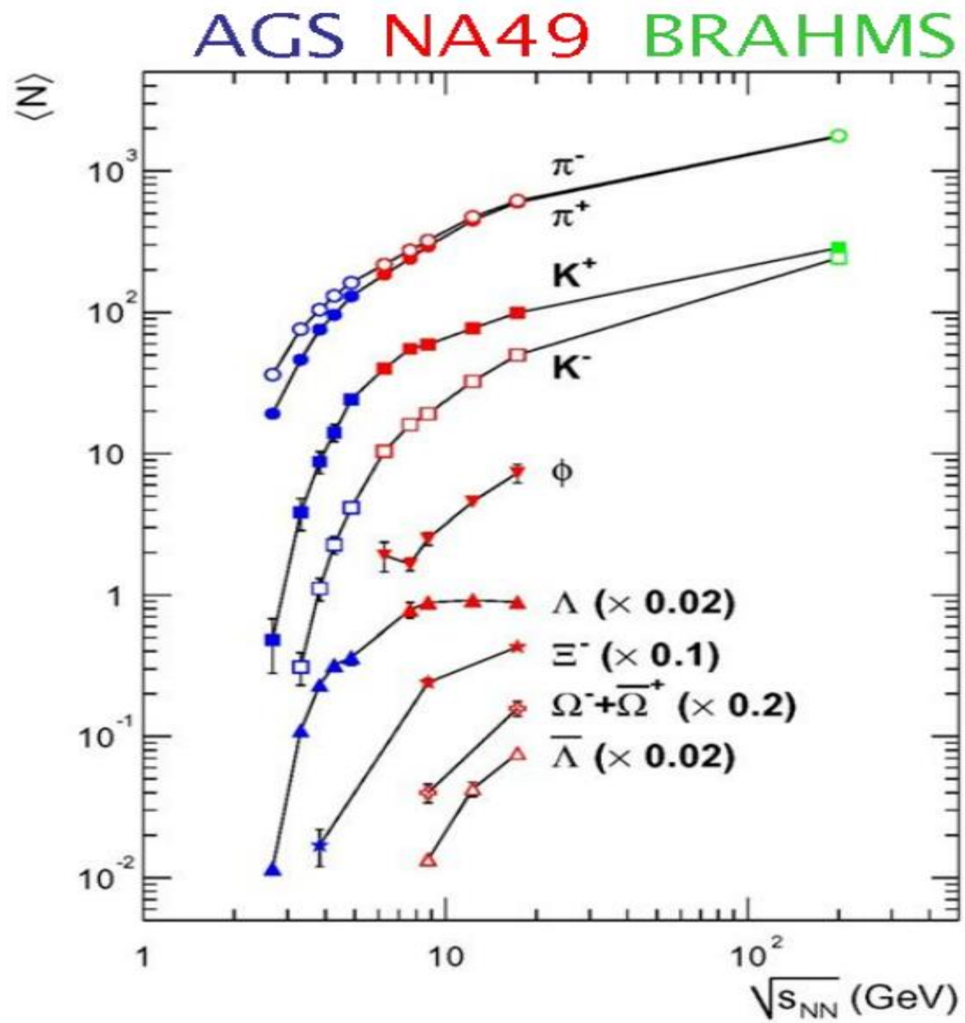


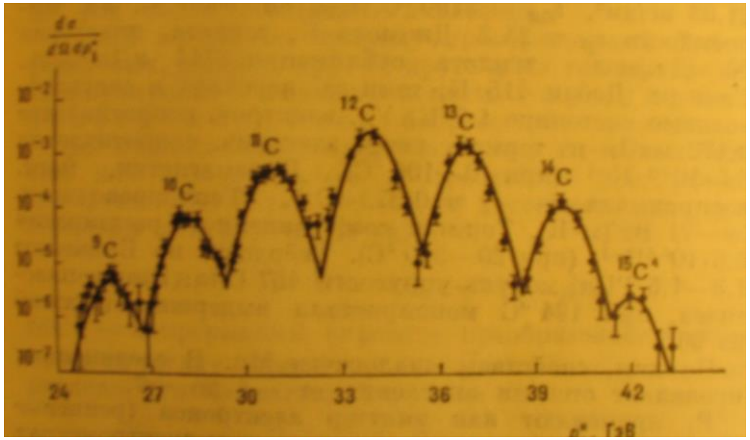
$$x = -\frac{q^2}{2P_2 q}$$

This is the way in which the self-similarity laws following from dimensionality considerations in the region

$P^2 \gg M^2$ are extensively applied

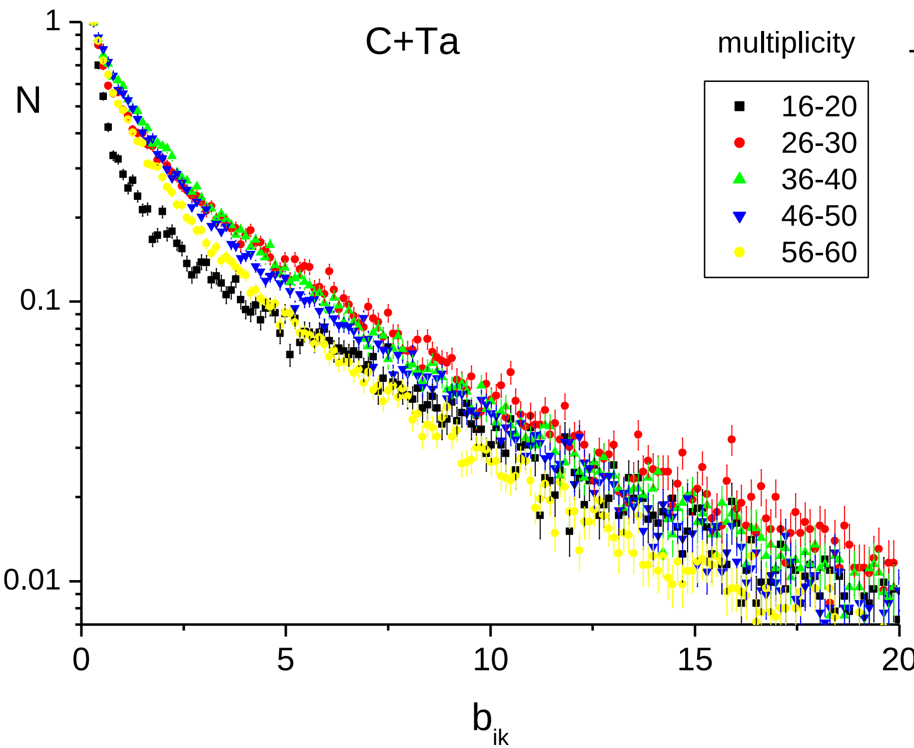

p(240 GeV)+Be--->h +... (0°)
p
anti p
d
anti d
t (³He)
anti t (³He)
[mb GeV⁻² c³ sr⁻¹]
Π


AGS NA49 BRAHMS
⟨N⟩
π⁻
π⁺
K⁺
K⁻
φ
Λ (× 0.02)
Ξ⁻ (× 0.1)
Ω⁻+Ω̄⁺ (× 0.2)
Λ̄ (× 0.02)
√s_NN (GeV)



A.M.Baldin, Dokl. Akad. Nauk, **222**, №5, 1064 (**1975).**

$$\frac{d\sigma}{dN} \approx \frac{C}{\left(b_{ik} + \alpha\right)^2}$$

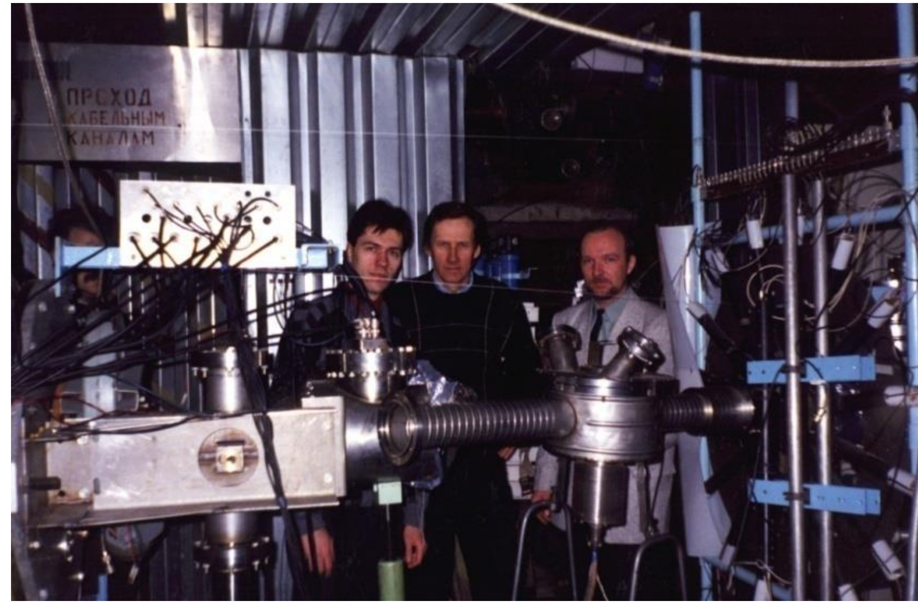


$$\frac{1}{\sqrt{b_{II1} + \frac{b^2{}_{II1}}{4}}} \cdot \frac{d\sigma}{db_{II1}} = \frac{1}{\left(b_{II1} + \alpha_{II1}\right)^2} \cdot C,$$

$$\alpha_{II1} = \frac{2\varepsilon_{II1}(m_{II} - m_1)}{m_{II} m_1}$$

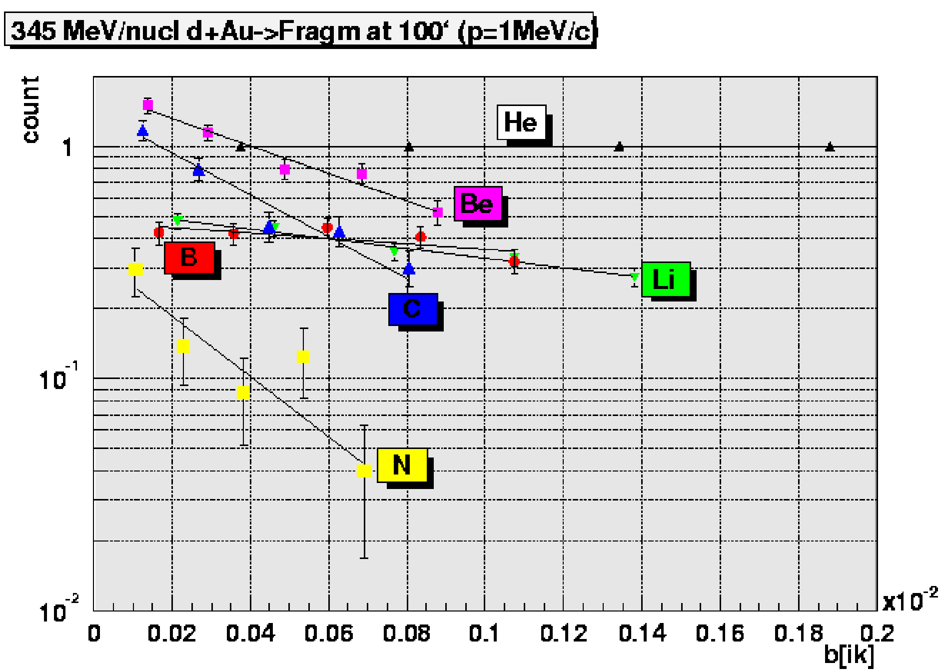
$$\alpha_{\text{II1}} \approx 10^{-2}$$

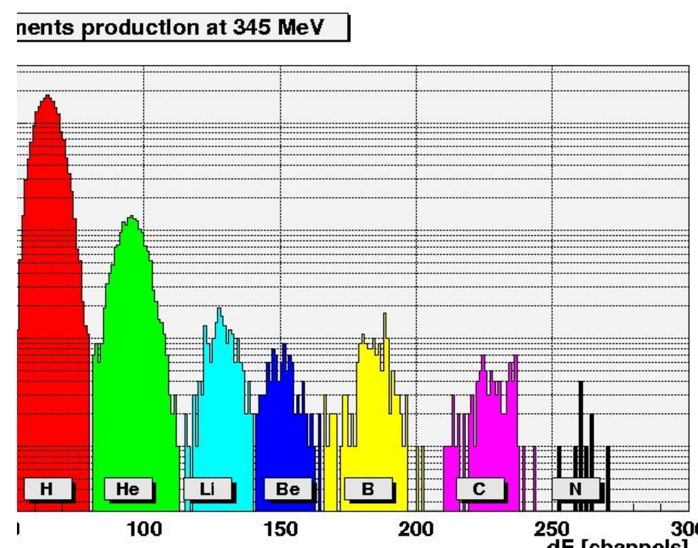
Collaboration MARUSYA
Experiment ITELEF



The luminosity in these conditions is $10^{33} \div 10^{35}$ cm^{-2} sec^{-1}.

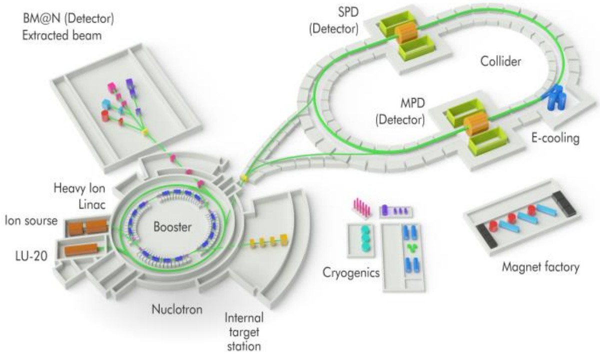
The processes with cross sections of the order of 10^{-2} nb become measurable.





“The logical form of the theory shall be such that it can be singled out, by means of empirical tests, in a negative sense: it must be possible for an empirical scientific system to be refuted by experience.”

Karl Popper, 1959.



That which was invented and works in the East, does not work in the West.

That which was invented and works in the West, does not work in the East.

All of those work in Russia, but in a different way…

V. Luzanov’s law.

THANK YOU FOR YOUR ATTENTION!