Explanation of empirical ratios

of N-N cross-sections

$\sigma_{tot} \sim 5\sigma_{el}$, $\varepsilon \sim 5 - 10^{4}$ GeV, ($\varepsilon = S^{1/2}$)

$\sigma(\varepsilon) \sim \sigma(\varepsilon_0)\,(\varepsilon / \varepsilon_0)^{1/5}$, $\varepsilon > \varepsilon_0 \sim 70$ GeV

G.M. Amalsky (PNPI, Gatchina)

Plane

1) Empiric ratios of (N,N) and (γ,N) cross-sections.

2) Derivation of ratio $\sigma_{inel}=4\sigma_{el}$ for “black balls” scattering.

3) Hard border $r_{12}=R_1+R_2$ of interaction as quantum effect.

4) Law $\sigma(\varepsilon)= \sigma(\varepsilon_0)(\varepsilon/\varepsilon_0)^{1/\nu}$ with $\nu=\sigma_{inel}/\sigma_{el}=1+(R_1+R_2)^2/R_1^2$.

5) Estimates for (γ,γ), (π,N), (K,N) cross-sections.

6) Comments.

(p,p) and (p⁻⁻,p) scattering data (2005)

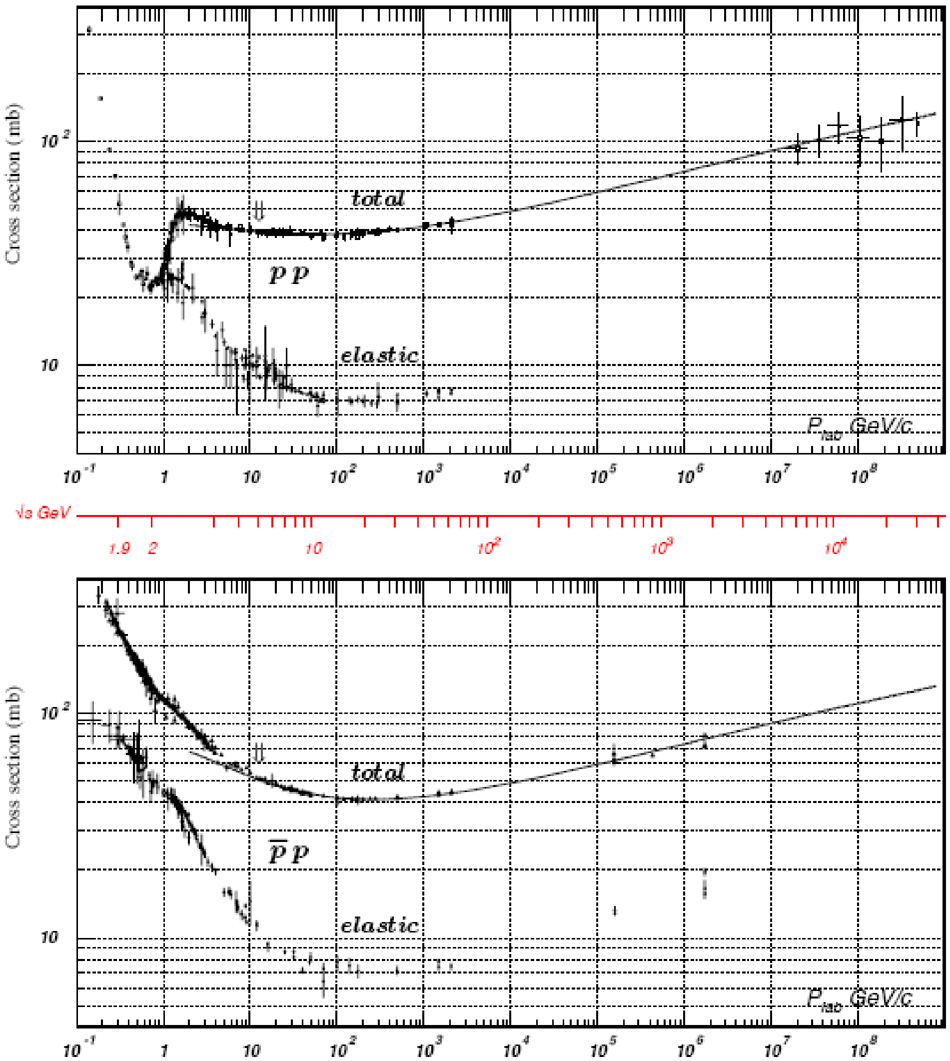
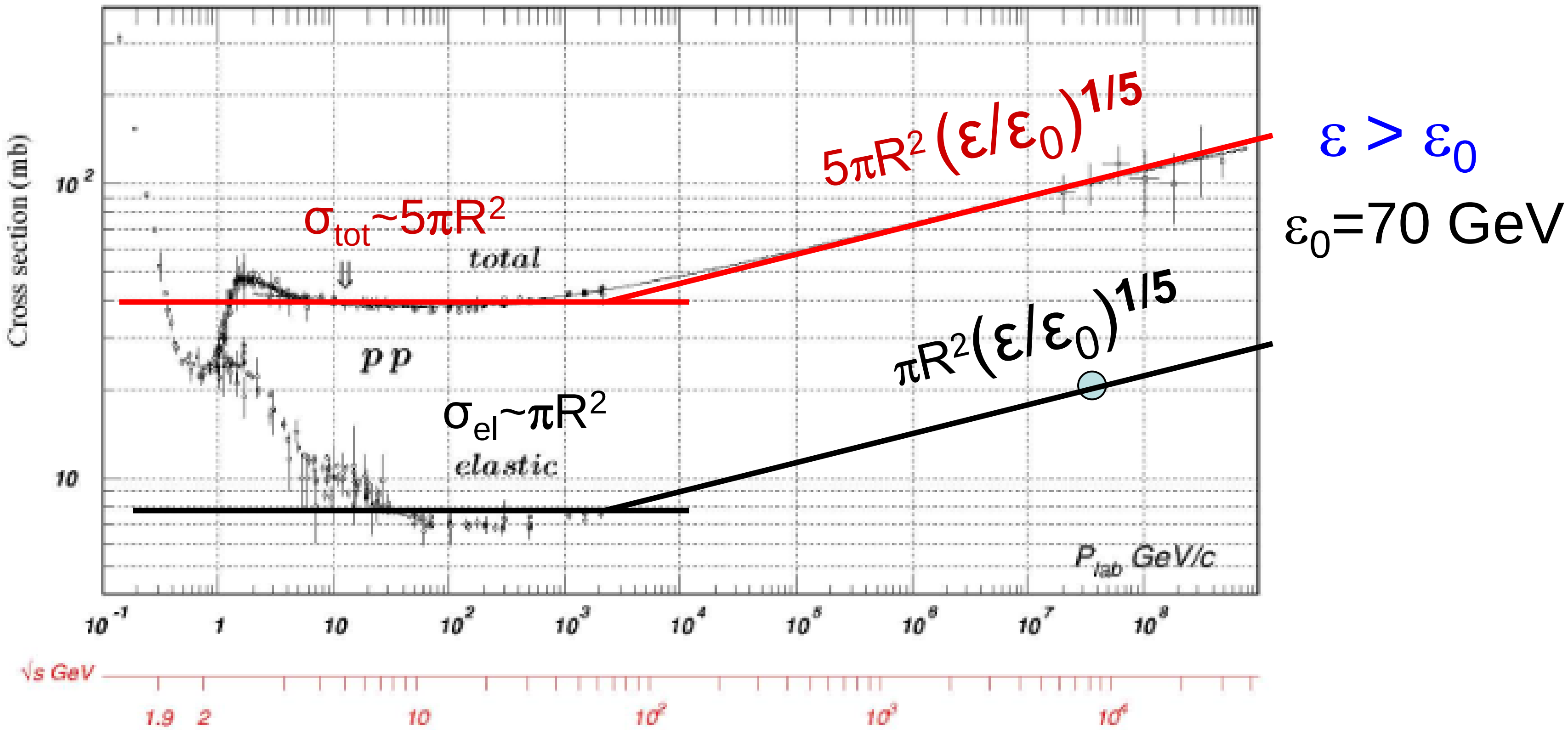


Figure 40.11: Total and elastic cross sections for pp and p̄p collisions as a function of laboratory beam momentum and total center-of-mass energy. Corresponding computer-readable data files may be found at http://pdg.lbl.gov/current/xsect/. (Courtesy of the COMPAS group, IHEP, Protvino, August 2005)

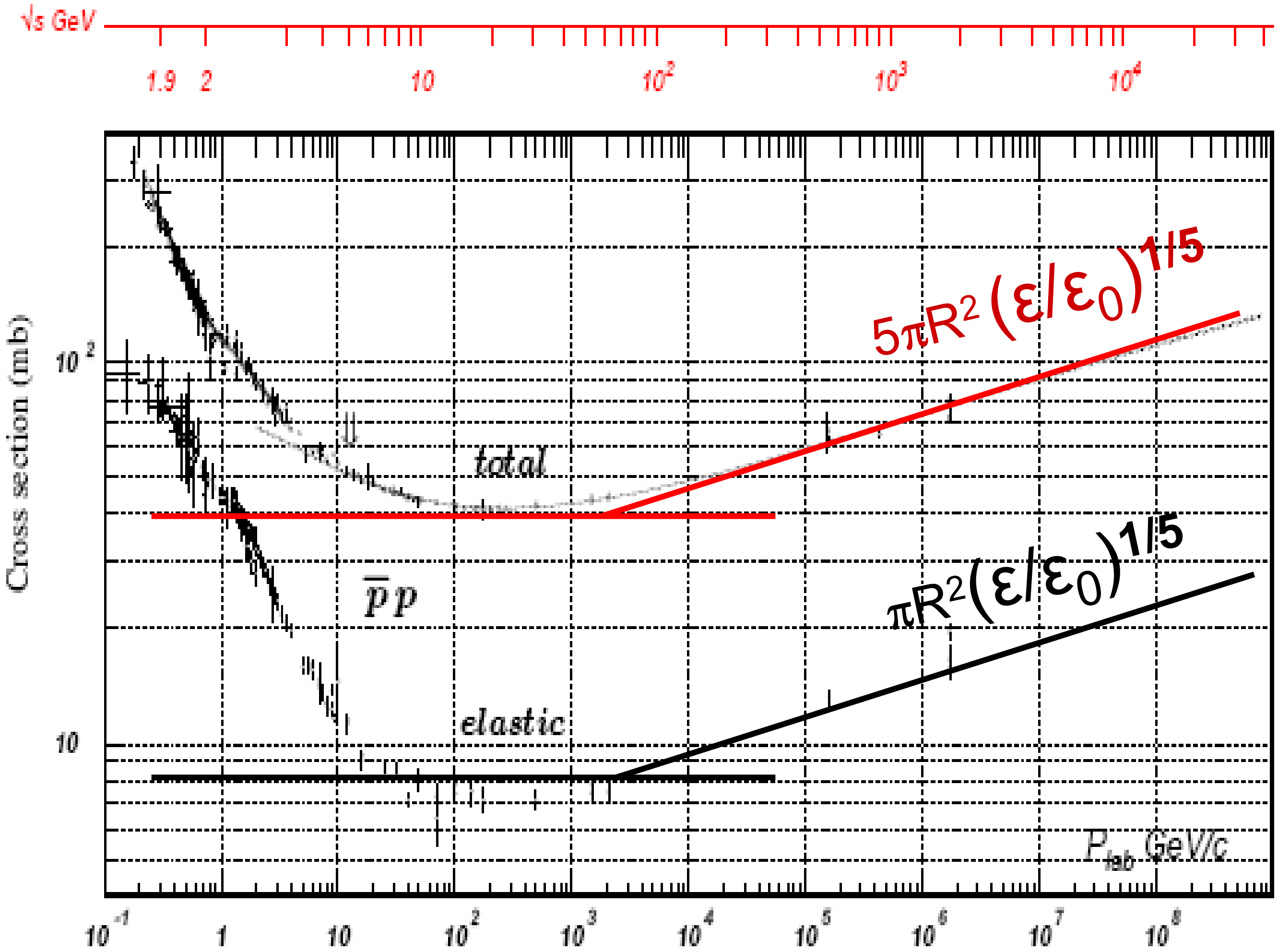
Proton-proton cross sections



ε ~ 5 - 100 GeV: σ_{el}~ 8mb = πR^2, R =0.50 fm,

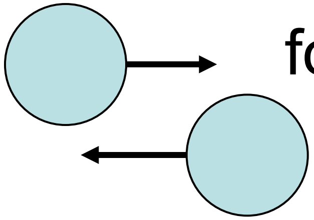
σ_{tot}~40mb = $5\pi R^2$, σ_{inel} ~ 4 σ_{el} = $4\pi R^2$

Antiproton-proton cross sections



Cross sections ratio $\sigma_{tot}=5\sigma_{el}$ is in "black balls" scattering

$\sigma_{inel} = \sigma_{tot} - \sigma_{el} \sim$ const (ε) at $\varepsilon \sim$ 5-100 GeV --- "geometrical"



for "black balls" $\sigma_{el} = \pi R^2$, $\sigma_{inel} = \pi(2R)^2 = 4\sigma_{el}$.

Scattering theory (L.D.Landau, E.M.Lifshits, "Quantum mechanic", M., 1974, ch.XVIII, par.142, p.675)

gives another prediction: $\sigma_{el} = \sigma_{inel}$, $\sigma_{tot} = 2\sigma_{el}$.

It is incorrect value σ_{el} .

Ratio $\sigma_{el} = \sigma_{inel}$ in common scattering theory

$$\psi = \frac{1}{2ikr}\sum_{l=0}^{\infty}(2l+1)P_l(\cos\vartheta)[(-1)^{l+1}e^{-ikr} + S_l e^{ikr}],$$

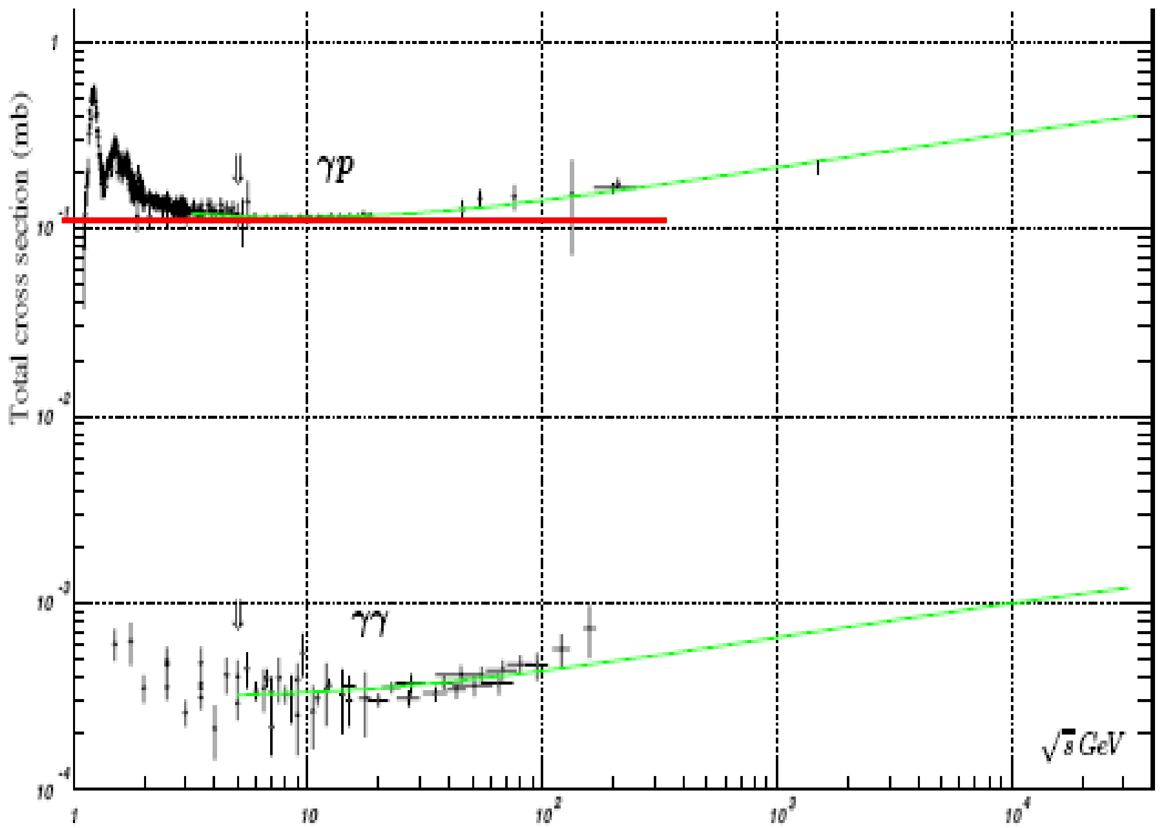
$$f(\vartheta) = \frac{1}{2ik}\sum_{l=0}^{\infty}(2l+1)(S_l - 1)P_l(\cos\vartheta),$$

$$\sigma_{el} = \frac{\pi}{k^2}\sum_{l=0}^{\infty}(2l+1)|1 - S_l|^2,$$

$$\sigma_{inel} = \frac{\pi}{k^2}\sum_{l=0}^{\infty}(2l+1)(1 - |S_l|^2);$$

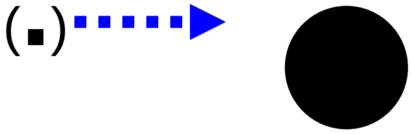
Total absorption of particles with momentum *l* corresponds $S_l=0$ and equality $\sigma^{(l)}_{el} = \sigma^{(l)}_{inel} = \pi(2l+1)/k^2$.

Gamma-proton cross sections



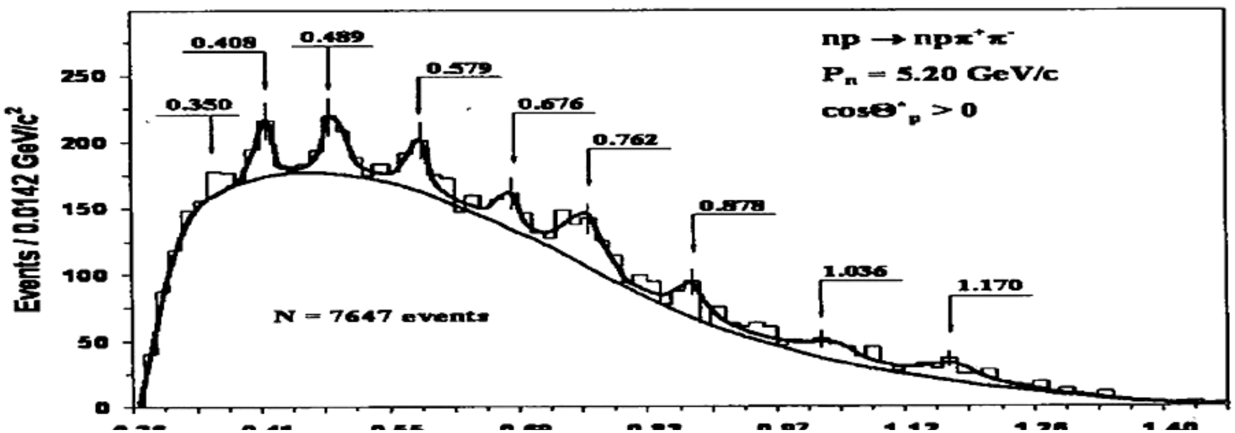
$\sigma^{\gamma,p}_{tot} \sim 0.12\text{mb} \sim \alpha\, 2\sigma^{N,N}_{el} = \alpha\, 2\pi R^2,\ \alpha \sim 1/137$

$\sigma^{\gamma,p}_{inel} = \sigma^{\gamma,p}_{el}$, $\sigma^{\gamma,p}_{tot} = 2\sigma^{\gamma,p}_{el}$, as



$np \rightarrow np\pi^+\pi^-$ and $np \rightarrow npK^+K^-$ at P_n=5.2 GeV/c

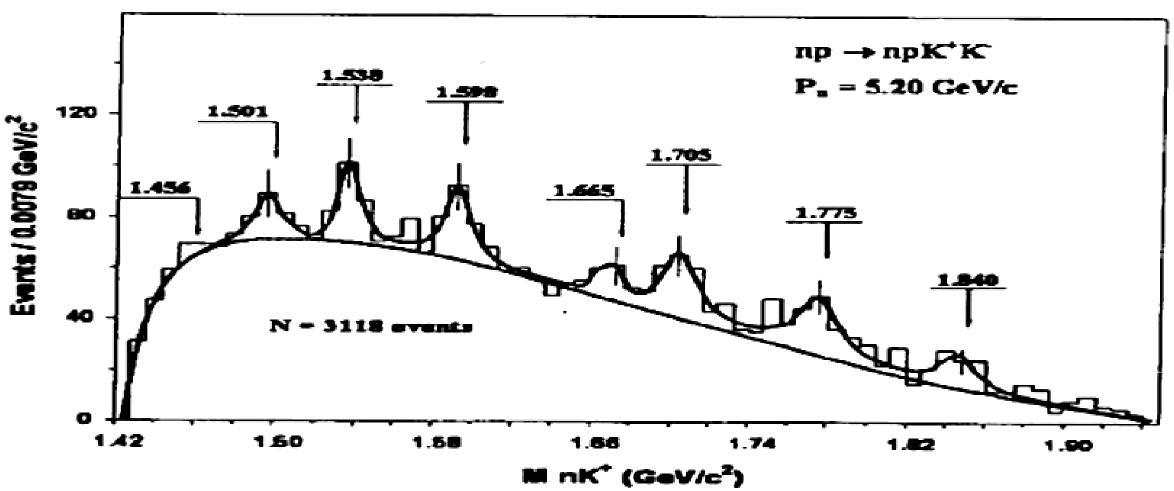
(**JINR**)Yu.A.Troyan, A.V.Beljaev, A.Yu.Troyan, E.B.Plekhanov, A.P.Jerusalimow, S.G.Arakelian **Proc. XVIII ISHEPP**, **v**.1, p.114, and **v**.2, p.186



$np\pi^+\pi^-$ channel

with cos θ'_p>0

~2mb

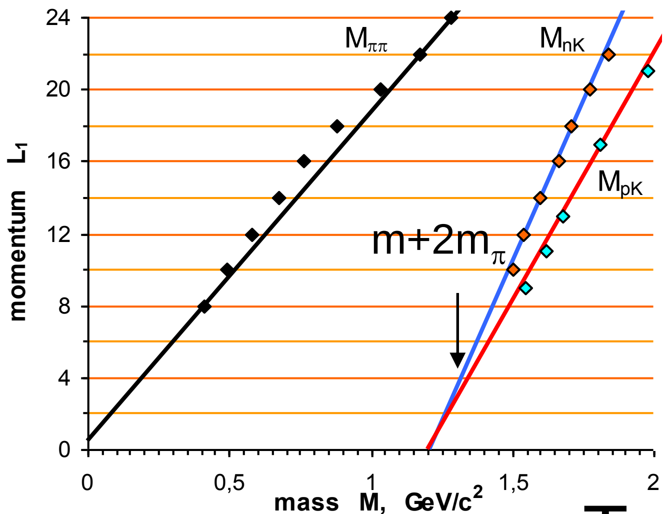


npK^+K^- channel

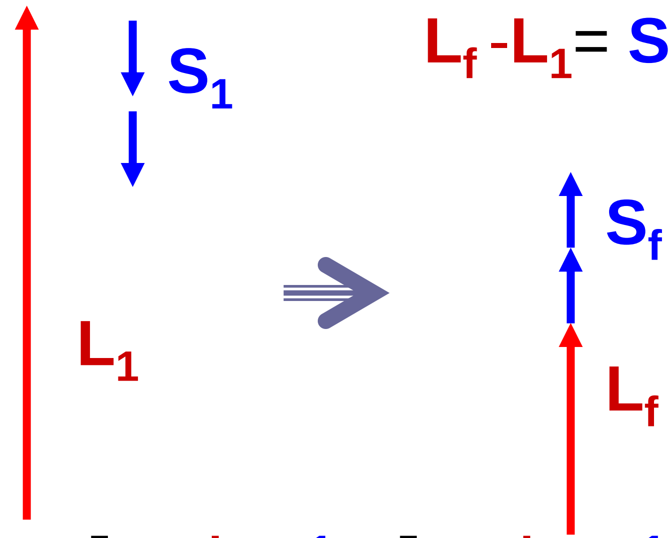
~1mb

Description np→npπ⁺π⁻ and npK⁺K⁻ data by “black balls” model

Quantization of angular momentum L_1=bp_n of two-nucleons rotating system and its inelastic transition into state with L_f=L_1-2



$L_f - L_1 = S_1 - S_f = -2$



Transition $J_1 = L_1 - 1 = J_f = L_f + 1$

with energy emitting $V(2L_1-1)$,

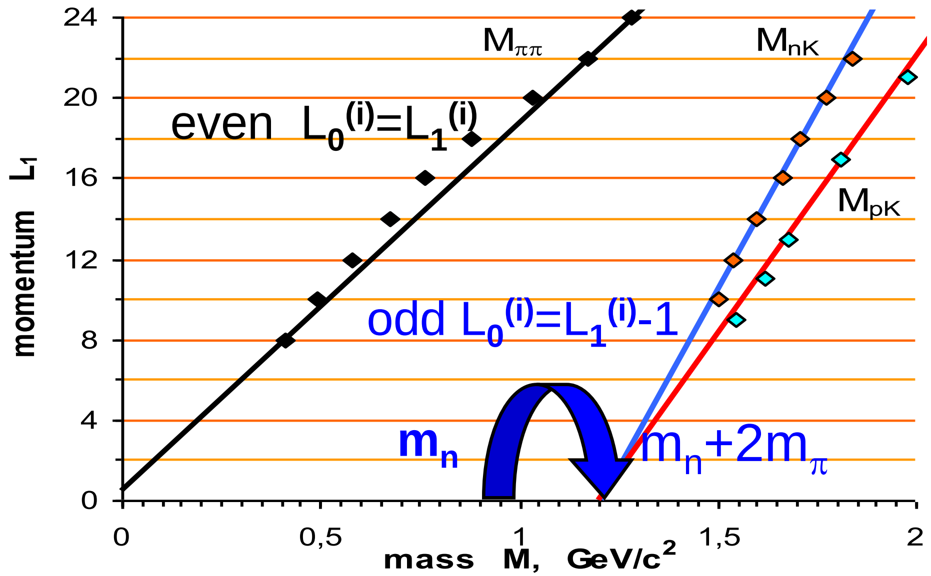
$V = V_{LS} = \hbar^2/(6mR^2)$~28 MeV is const. of LS interaction,

one par. R is determined by data: $R = L_1^{(max)}/p_0 \sim 26\hbar/p_0 = 0.50$fm

Description of spectra by rotary model of two-nucleon system

(ISHEPP XIX,

v.1, p. 208)



(black line) $M_{\pi\pi}^{(i)}=2V\,(L_1^{(i)}-1/2)/c^2$, (even $L_0^{(i)}=L_1^{(i)}$)

(blue line) $M_{nK}^{(i)}=V\,(L_1^{(i)}-1/2)/c^2+m+2m_\pi$ (odd $L_0^{(i)}=J^{(i)}=L_1^{(i)}-1$)

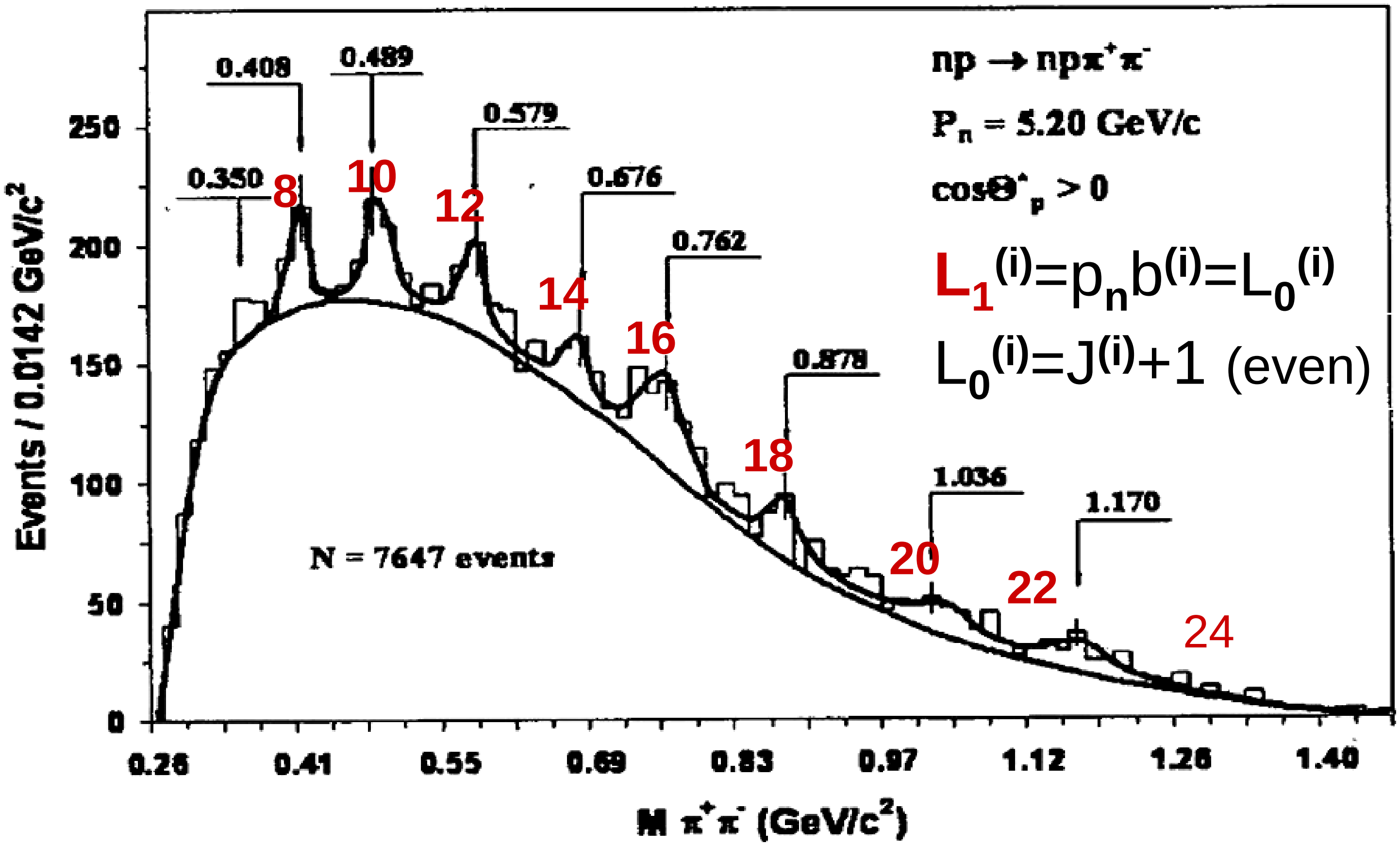
$V=\hbar^2/(6mR^2)$, m is nucleon mass, $R=(0.50 \mp 0.01)$fm

(red line) $M_{pK}^{(i)}=V'(L_1^{(i)}-1/2)/c^2+m+2m_\pi$ in $pp\to ppK^0_s+X$ with $p_p=10$ GeV/c

$np \to np\pi^+\pi^-$ at P_n=5.2 GeV/c, pairs $\pi^+\pi^-$ in state $J^\pi=0^+$

Final proton moves forward in c.m.s., 7647 events are σ'~ 2 mb

Theory allows only 17% of observed events!   Forbids ~83% σ'

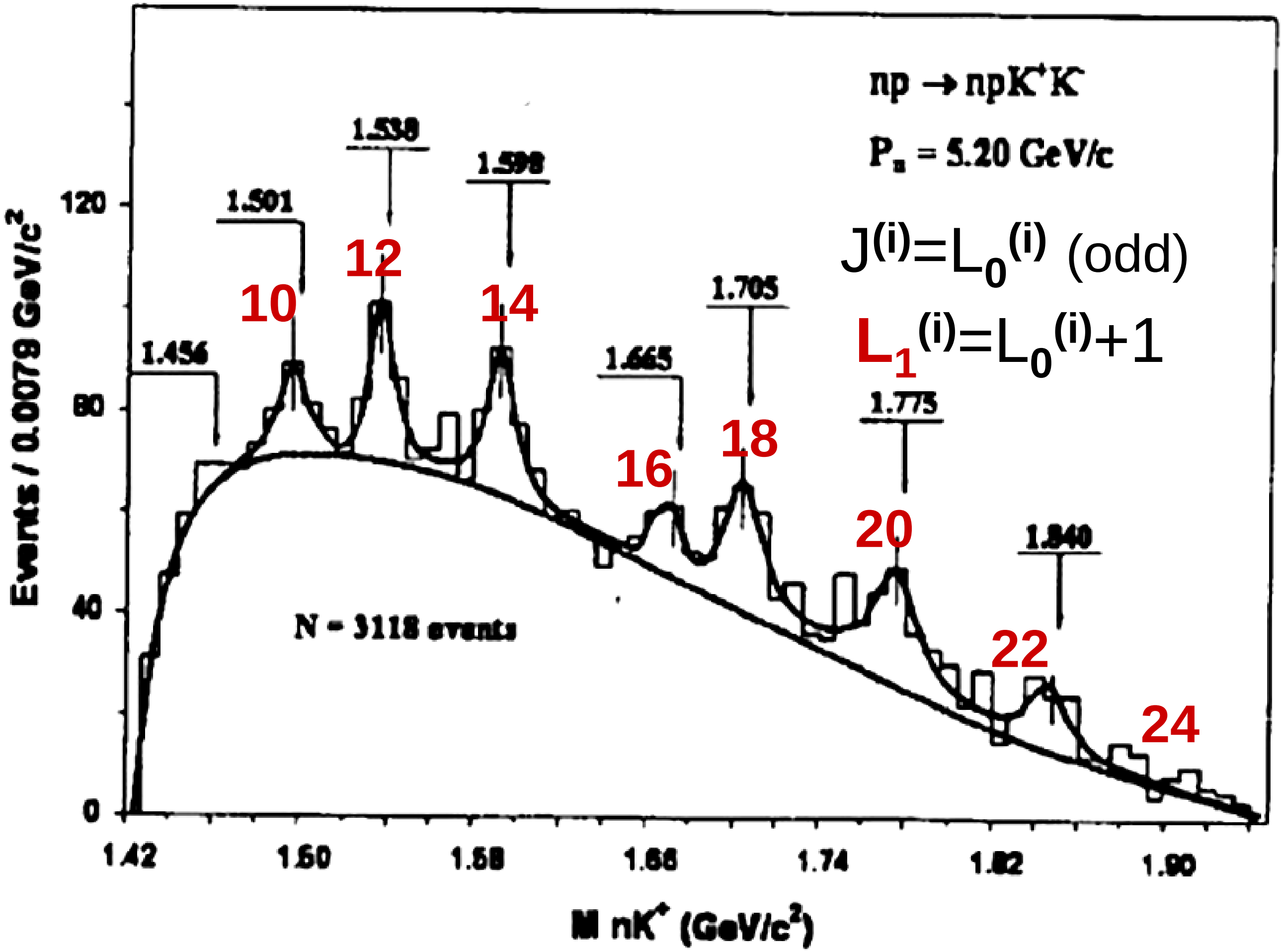


$M_{\pi\pi}^{(i)}\, c^2 = \mathbf{V}(2\mathbf{L}_1^{(i)}-1)$, $\mathbf{V}=\hbar^2/(6mR^2)$, m is nucleon mass, R=0.50 fm

$np \rightarrow npK^+K^-$ at P_n=5.2 GeV/c

3138 K^+K^-events: ~ (1-0.17)7647 / 2 = 3173 - half of forbidden $\pi^+\pi^-$ events

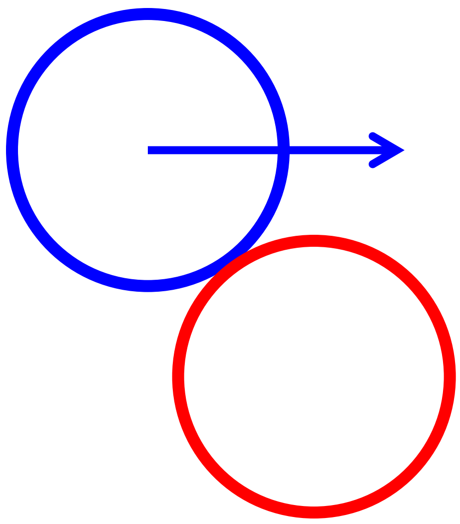
Two transitions $np \rightarrow (n+2\pi)(p+2\pi) \rightarrow npK^+K^-$, it explains $N_{2K} \sim 1/2\, N_{2\pi}\, (0^+)$



$M_{nK}^{(i)}\, c^2 = m + 2m_\pi + V\, (L_1^{(i)} - 1/2)$, $V = \hbar^2/(6mR^2)$, R= 0.50 fm

Non-equilibrium rotating two-nucleons system

Energy of rotation $T_{rot} = \hbar^2 L(L+1)/2J \sim 10\text{-}20$ GeV,



$T_{rot} + U \sim E_0$, $E_0 \ll T_{rot}$,

$\Delta t \sim \hbar/\Delta E$, $\Delta E \sim T_{rot}$.

If $b<2R$, isospin $\tau=0$, spin $S_z=1$

then with probability 1 strong increased interaction $\sim U \sim T_{rot}$ (in point $r_{12}=2R$)

with decreasing of momentum L and energy liberation $\sim E_{2\pi}$

Consistent scattering theory for black balls is absent

Quantum mechanics appears (and is remained at present) as agreement to use some calculations with classic waves ψ for predictions of possible results, observed with particles.

Argument --- right predictions. (Why --- it is not known.)

Scattering theory describes scattering of plane wave $\psi(z)=e^{ikz}$ and is version of classic theory "diffraction in parallel rays" of Fraunhofer.

(L.D.Landau, E.M.Lifshits, "Quantum mechanic", M., 1974, ch.XVII, par.131, p.612.)

Theory of "thin rays" (size-less particle) can not give consistent predictions for "thick rays" scattering (for black balls colliding).

Quantum effects make discrepant events by unobservable

Quantum effects are result of invisibility of possible “exact” events with microscopic particle in unit phase value h.

Invisibility of possible microscopic events is necessary in order to its incompatible “inner” properties be left unobserved.

Being of objects with unobservable contradictions are allowed.

Quantum theory is stat-physics of indistinguishable events.

Quantum state is multitude of probabilities of indistinguishable possible microscopic events in unit phase volume h.

Complex function $\psi(x)= |\psi(x)|e^{i\varphi(x)}$ is suitable for description of magnitudes and distinction of subsets with possible values (x).

Sense of complex function $\psi(x)$ of distribution into subsets (x)

Complex function $\psi(x) = |\psi(x)|e^{i\varphi(x)}$ describes simultaneously magnitudes and distinction of subsets of events with values (x).

$|\psi(x)|$ --- magnitude of subset of possible events with (x), $\delta x=0$. It defines realization probability of subset (x): $W_{real}(x) = |\psi(x)|$.

Phase $\varphi(x)$ is used for description of separability of subsets: events from subsets (x_2) and (x_1) are indistinguishsable with probability $\text{Cos}^2(\varphi(x_1) - \varphi(x_2))$.

Quantum state with $p_x=p$: $\psi(x) \sim Ce^{ixp/\hbar}$ in infinite range $\delta x = \hbar/\delta p_x$.

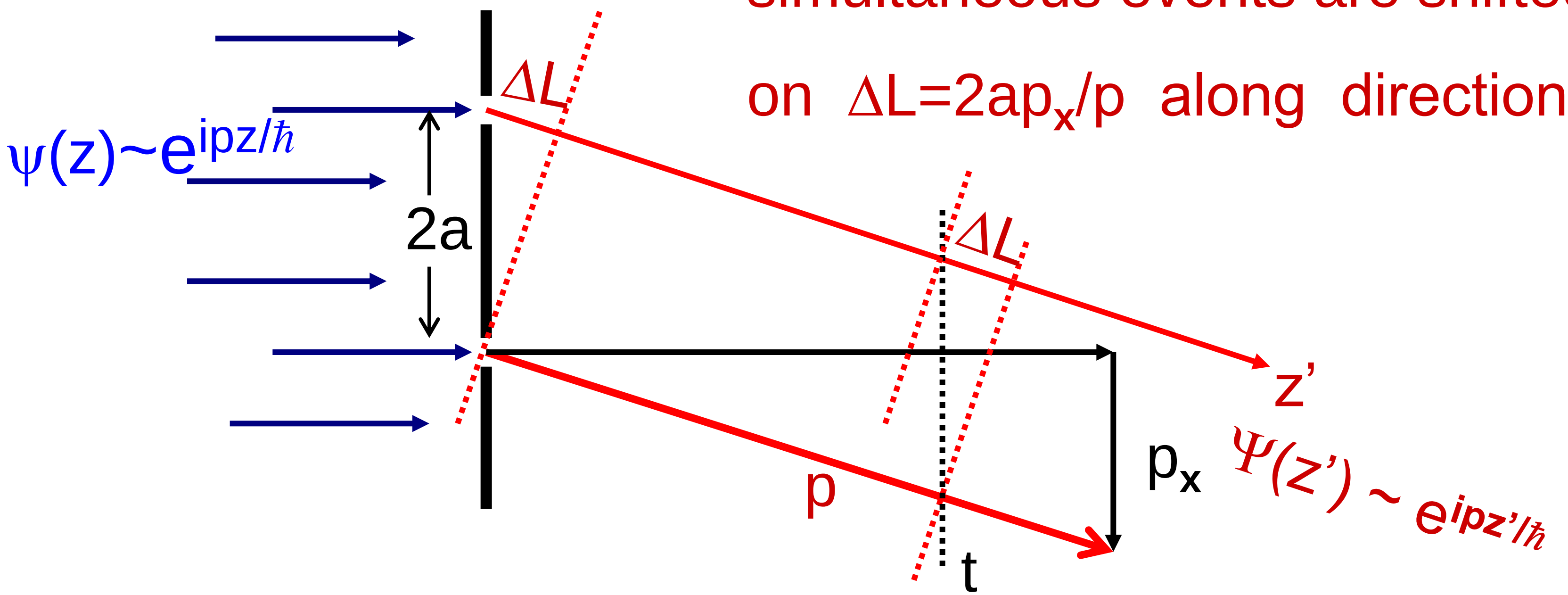
Because of stochastic nature of measurement, detection of subset (x) is possible with probability $W_{det}(x) = |\psi(x)|$, and so probability of observation (x) $W_{obs}(x) = W_{real}(x)\, W_{det}(x) = |\psi(x)|^2$.

One-dimension scattering of particle-point

In double-slotted experiment two source of particles are

simultaneous events are shifted

on $\Delta L = 2ap_x/p$ along direction z'

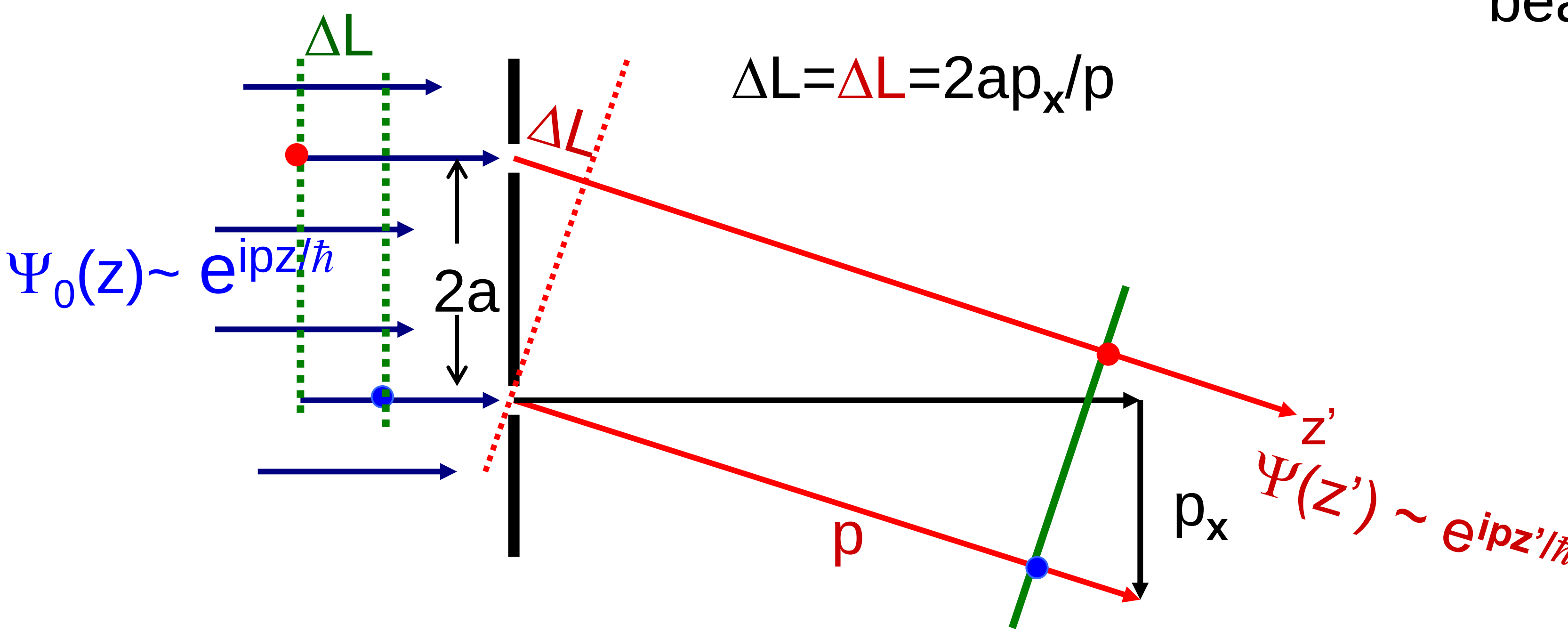


two beams with p , phase-shifted on $\Delta\varphi = p\Delta L/\hbar$:

$$f(p_x) \sim e^{i\Delta\varphi/2} + e^{-i\Delta\varphi/2} = 2\cos\Delta\varphi/2 = 2\cos ap_x/\hbar$$

One-dimension scattering of particle-point

Events ● and ● with p_x are shifted on $\Delta L = 2ap_x/p$ in incident beam

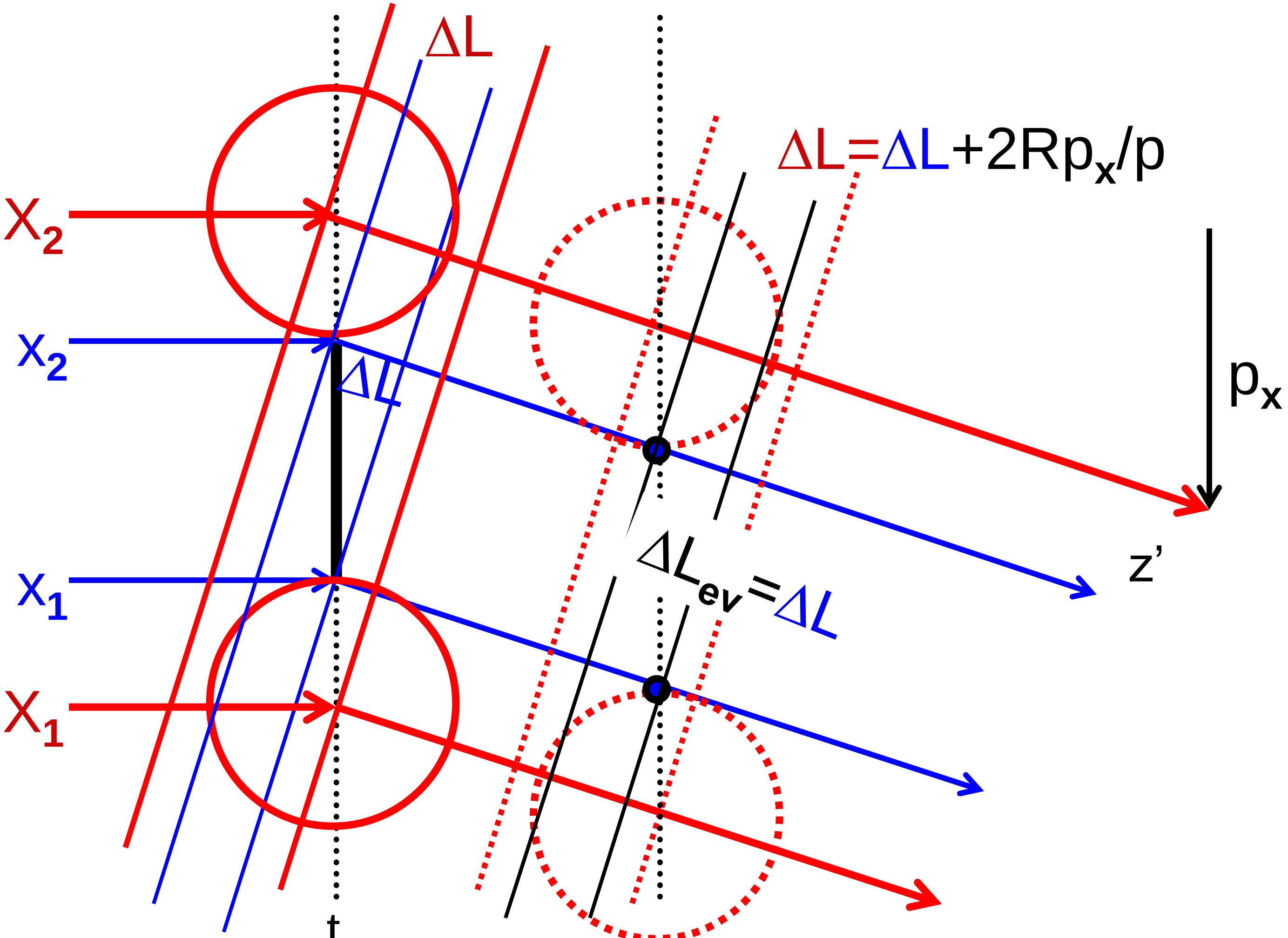


Contribution of indistinguishable events ● and ●

in incident beam with phase shift $\Delta\varphi = p\Delta L/\hbar$

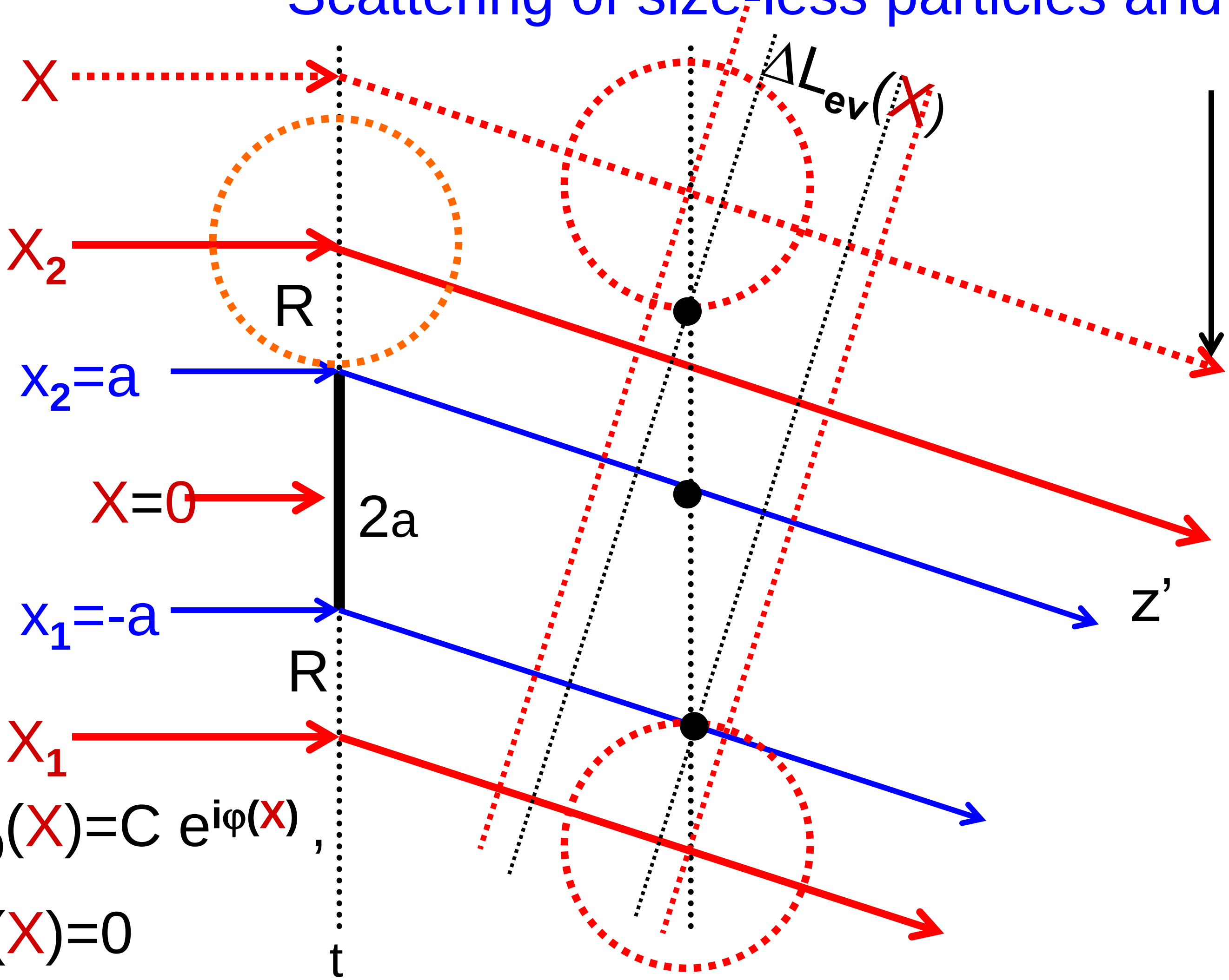
$$\sim e^{i\Delta\varphi/2} + e^{-i\Delta\varphi/2} = 2\cos\Delta\varphi/2 = 2\cos ap_x/\hbar$$

Shift of simultaneous events with scattered black ball



Shift of simultaneous events ΔL_{ev} of scattered with p_x balls with X_2-X_1=x_2-x_1+2R is the same as $\Delta L=(x_2-x_1)p_x/p$ for size-less particles: $\Delta L_{ev} = (x_2-x_1)p_x/p = (X_2-X_1-2R)p_x/p = \Delta L - 2Rp_x/p$

Scattering of size-less particles and black balls



$\Psi_0(X)=C\, e^{i\varphi(X)}$,

$\varphi(X)=0$

$\Psi(X)=C' e^{i\delta\varphi(X)}$, $\varphi(X)-\varphi(X_1)=\Delta L_{ev}(X)p/h=(X-X_1-2R)p_x/\hbar$

shift of events X and 0: $\varphi(X)-\varphi(0)=(X-R)p_x/\hbar$ for $X>a+R$,

$\varphi(X)-\varphi(0)=(X+R)p_x/\hbar$ for $X<-a-R$; $\varphi(0)=0$.

One-dimension scattering of size-less particles, $p >> p_x$

In ranges $x<x_1=-a$ and $x>x_2=a$ $\psi(x)=(1+\delta)\psi_0(x)=C$ (const (x)),

in range $-a<x< a$ $\psi(x)=0$,

$$f(p_x) = \int_{-\infty}^{\infty} \psi(x) e^{-ixp_x/\hbar} dx = C\int_{-\infty}^{-a} e^{-ixp_x/\hbar} dx + C\int_{a}^{\infty} e^{-ixp_x/\hbar} dx =$$

$$C\delta(p_x) - C\int_0^a (e^{ixp_x/\hbar} + e^{-ixp_x/\hbar}) dx = C\delta(p_x) - \frac{2C\hbar}{p_x}\sin\frac{ap_x}{\hbar}$$

Elastic scattering are done by events without direct interaction.

$|f(p_x)|$ is the same as for a passing through slit with width 2a,

probabilities of a scattering and of a passing are equal and

are the same as probability of absorption by screen 2a ---

this is “Babine principle”.

What takes place in one-dimension elastic scattering :

Possibility of interaction leads to transition of defined in $-D<x<D$ ($D >>a$) quantum state $\psi_0(x)$ → mixed state $W_{el}+W_{inel}=1$ of normalized quantum states $\psi_{el}(x)$ in ranges $-D<x<-a$, $a<x<D$, and $\psi_{inel}(x)$ in range $–a<x<a$.

Normalized $\psi_{el}(x)$ differs from $\psi_0(x)$: $\psi_{el}(x) =\psi_0(x)\, D/(D-a)$.

Probabilities of free movement in events $-D<x<-a$, $a<x<D$ change simultaneously $\psi_0(x) \rightarrow \psi_{el}(x)$ in the moment t' of possible interaction in other events $–a<x<a$.

In the case of compound particles fast change of its free movements probabilities can lead to disturbance of inner state.

One-dimension scattering of “black balls”, $p >> p_x$

$$f(p_x) = C\int_{-\infty}^{-(a+R)} e^{-i(X+R)p_x/\hbar}dX + C\int_{a+R}^{\infty} e^{-i(X-R)p_x/\hbar}dX =$$

$$= C\int_{-\infty}^{-a} e^{-ixp_x/\hbar}dx + C\int_{a}^{\infty} e^{-ixp_x/\hbar}dx = C\delta(p_x) -$$

$$-C\int_{0}^{a}(e^{-ixp_x/\hbar} + e^{ixp_x/\hbar})dx = -\frac{2C\hbar}{p_x}\sin\frac{ap_x}{\hbar}$$

$f(p_x)$ and scattering probability W_{el} ~2aC

are the same as for size-less particles.

Absorption probability W_{abs} ~2(a+R)C

is dependent of radius black balls R

Size-less particles scattering by disk with radius a, ($\hbar q = p_r << p$)

$$f(q) = C\int_0^a r dr \int_0^{2\pi} e^{-iqr\cos\varphi} d\varphi$$

$$= 2\pi C \int_0^a J_0(qr) r dr,$$

$$\int_0^a J_0(qr) r dr = \frac{a}{q} J_1(aq)$$

Probabilities of absorption and scattering are equal: $\sigma_{\mathbf{el}} = \sigma_{\mathbf{inel}}$

"Black balls" scattering by disk with radius a, ($\hbar q=p_r \ll p$)

$$f(q) = C\int_0^{a+R} r\,dr \int_0^{2\pi} e^{-iq(r-R)\cos\varphi}\,d\varphi =$$

$$C\int_0^{a} r'\,dr' \int_0^{2\pi} e^{-iqr'\cos\varphi}\,d\varphi =$$

$$2\pi C\int_0^{a} J_0(qr)\,r\,dr = \frac{2\pi a C}{q} J_1(aq)$$

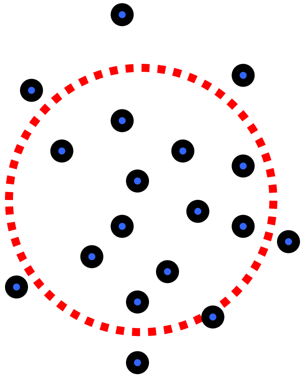
Distribution f(q) and probability of scattering

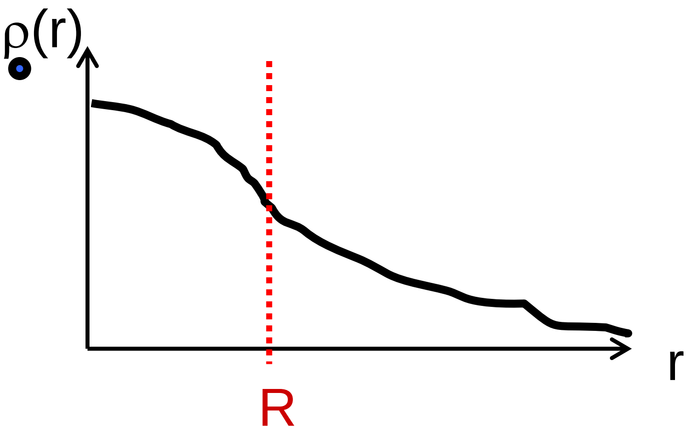
are the same as for size-less particles: $\sigma_{el}=\pi a^2$.

Probability of absorption is $\sigma_{inel}=\pi(a+R)^2$.

For collision of black balls a=R and $\sigma_{inel}=4\pi R^2=4\sigma_{el}$, $\sigma_{tot}=5\sigma_{el}$.

Nucleon as probability distribution of possible inner events



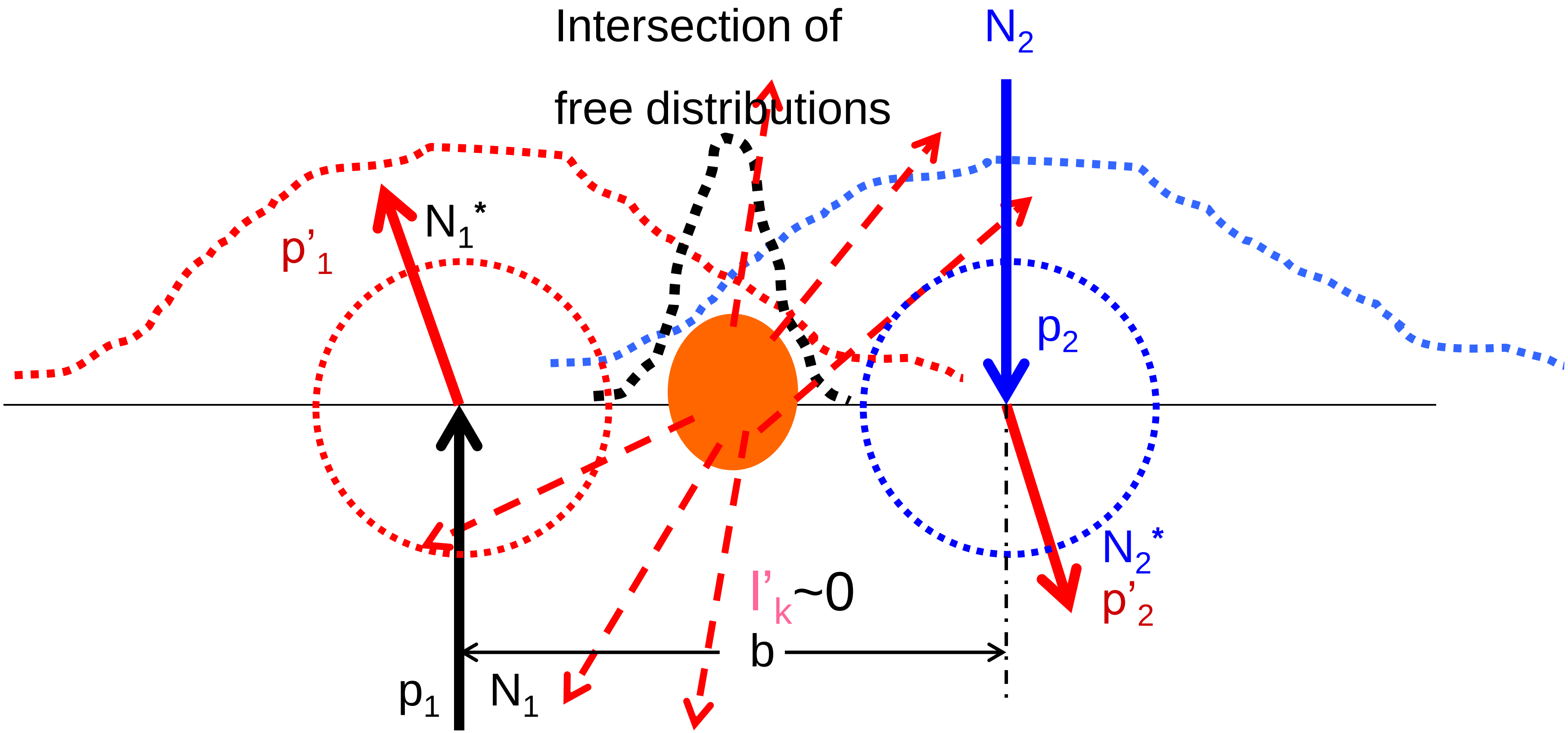


Stationary "equilibrium" probability distribution of inner events in free nucleon without border R.

Probabilities of indistinguishable possible events is abstract.
Material–less probability distribution of local events can be change without transfer of energy and impulse.
Such changes can happen instantaneously in whole volume.

Peripheral interaction ($r_{1,2}$>2R) and free distributions are absent

If nucleons with b>2R are two intersected inner distributions,
N-N interaction is possible with probability W_{int} ~ intersection



Momentum in final state L'<(p'$_1$+p'$_2$)b/2 +Σl'$_k$ <(p_1+p_2)b/2 = L_0.
Law of conservation L'=L_0 forbids realization of such events.

Non-equilibrium inner probability distributions

Causality and law $L' = L_0$ forbid realization of events with peripheral N-N interaction on distances $r_{12} > 2R$.

For this inner probability distributions must be with abrupt borders $R' < r_{12}/2$.

Compressed inner distributions $\rho(r)$ remain isotropic, as free.

Observed value R=0.50 fm corresponds to possibility of N-N interaction with conservation of total angular momentum $J' = J_0$.

Value $b = 2R$ determines maximum momentum $L^{(max)} = bp = 2Rp$ in events with interaction of colliding nucleons with impulses p.

Elastic and inelastic events are incompatible

Absence of interference of any elastic and inelastic events and causality (latent) of its realization in collision :

$$\int_{-\infty}^{\infty} \psi_q^{(el)}(x)\psi_i^{(inel)}(x)dx = 0$$

for any q and reaction *i*

take place if

$$\psi_q^{(el)}(x)\psi_i^{(inel)}(x) = 0$$

Different spheres of existence: $\Psi^{(\mathbf{inel})}{}_{i}$ (x) =0 for x<-R and x>R

Absence of elastic events with $r_{12}<2R$; some consequences

100% probability of reactions in events with $r_{12}<2R$ on a path $\Delta z \sim \hbar/p$ can not be result of casual events in N-N interaction.

Instability and disintegration of compressed to radius R non-equilibrium inner distributions are causal events.

Compressed inner distributions with $r_{12}>2R$ are not crossed.

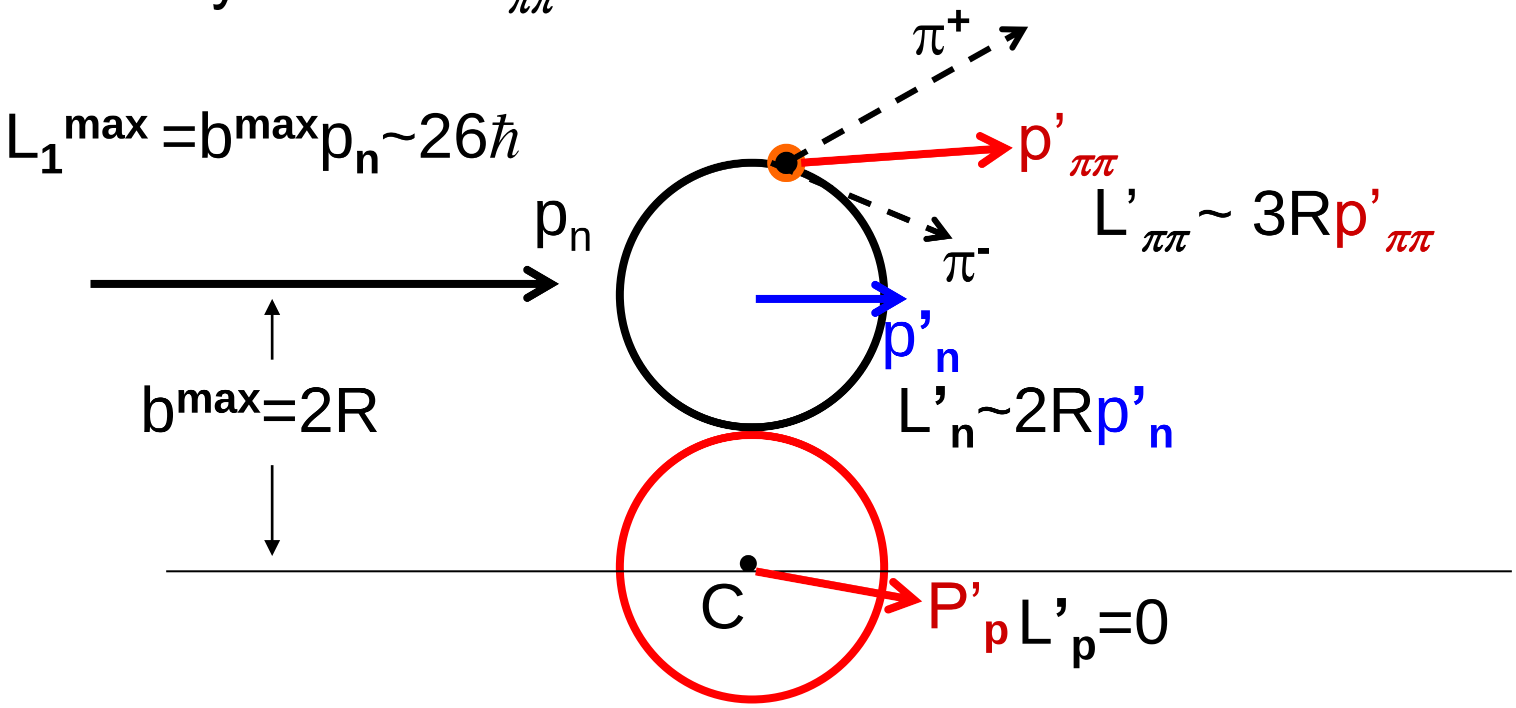
All events with interaction are happened on border $r_{12}=2R$.

Thickness of border $\Delta r_{12}<\hbar/2p$ determines short time of interaction $\Delta t_{int} \sim \Delta r_{12}/c < \hbar/(2cp)$:

Strong non-equilibrium interaction $U^* \sim \hbar/\Delta t_{int} > 2cp$ of nucleons as whole can exist during short time Δt_{int}.

Events $np \rightarrow np\pi^+\pi^-$ at P_n=5.2 GeV/c with $M_{\pi\pi}^{(max)}$ ~1.4GeV/c^2

In such events on border of $M_{\pi\pi}$ (**0**$^+$) spectrum all 3 final particles n',p', $M_{\pi\pi}$ are nearly at rest in c.m. system ;
in lab. system final momentum $L'_n + L'_p + L'_{\pi\pi} = L_1^{max} - 2 \sim 24\hbar$ created by n' and $M_{\pi\pi}$:



L_1 and L' are angular momenta of movement relatively point C

Sense of empirical ratio $\sigma_{el} = \sigma_{tot}/5$ of N-N cross-sections

Properties of free nucleons are unobservable in its scattering.

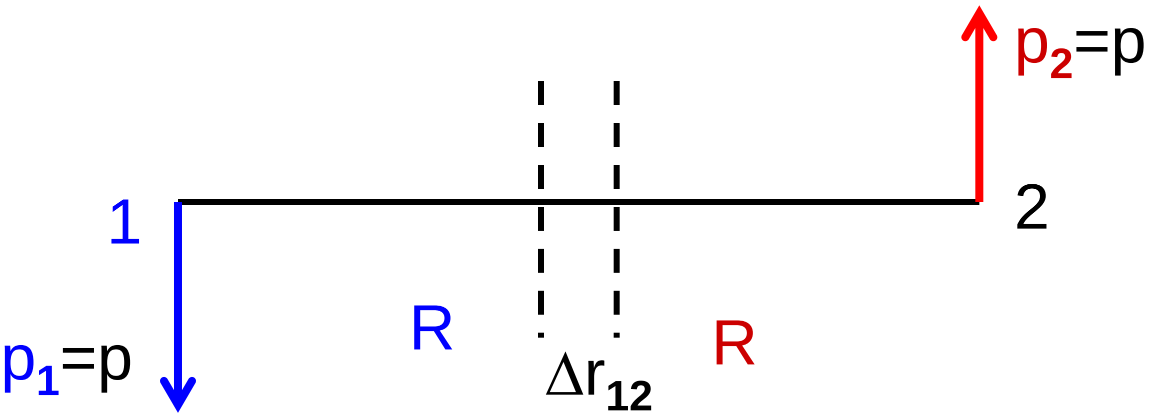
Observed with energies ε~5-100 GeV N-N interaction
is similar to interaction of “black balls” with radius R=0.50 fm.

It follows from :
definition of quantum state,
isotropic distributions of inner events of nucleon,
causality of possible events
and angular momentum conservation law.

Thickness of border Δr_{12} and short time of interaction

Thickness of border between elastic and inelastic events:

from $\Delta L < \hbar/2$ estimate $\Delta r_{12} < \hbar/4p$ is followed.



It defines time of interaction

$\tau_{int} \sim \Delta r_{12}/c = \hbar/4cp \sim \hbar/2\varepsilon, \quad (\varepsilon = s^{1/2})$

Part of possible elastic events may be disturbed

Size δr of possible inner events defines a time of determination of its probabilities $\tau_0 \sim \delta r/c$ in inner distribution (in volume R).

Inner probability distribution of scattered nucleon must be determined during time of inelastic interaction $\Delta t_{int} \sim \hbar/2\varepsilon = \tau_{int}$.

If $\tau_{int} < \tau_0$, then part $\sim \sigma_{el}/\tau_{int}$ of elastic events with any nucleon may be disturbed.

These events may transform into inelastic or remain by elastic,

give contribution $\sim \sigma_{el}/\tau_{int}$ in “total” probability $\sigma_{tot} = \sigma_{el} + \sigma_{inel}$

Possible origin of ratio $\sigma(\varepsilon) \sim \sigma(\varepsilon_0)(\varepsilon/\varepsilon_0)^{1/5}$, $\varepsilon > \varepsilon_0 \sim 70$GeV

In the case of $\tau_{int} < \tau_0$ increasing of energy $d\varepsilon/\varepsilon$ leads to decreasing $d\tau_{int}/\tau_{int} = -d\varepsilon/\varepsilon$ and to transformation of $\sigma_{el} d\tau_{int}/\tau_{int}$ elastic events with nucleon into "total" (elastic or inelastic):

$$d\sigma_{tot} = -\sigma_{el}\, d\tau_{int}/\tau_{int}.$$

Empirical law $\sigma_{el} \sim \sigma_{tot}/5$ is just for energies $\varepsilon \sim 5 - 1000$ GeV:

$$5 d\sigma_{tot} = -\sigma_{tot}\, d\tau_{int}/\tau_{int}.$$

Equation $5\, d\sigma_{tot}/\sigma_{tot} = -d\tau_{int}/\tau_{int}$ gives observed ratio

$$\sigma_{tot}(\varepsilon) = \sigma_{tot}(\varepsilon_0)\, (\varepsilon/\varepsilon_0)^{1/5}.$$

Empirical value $\varepsilon_0 = 70$ GeV conforms to size of inner events (in compressed to R distribution) $\delta r_0 \sim c\hbar/2\varepsilon_0 = 0.0015$ fm

Probable sense of expression $\sigma_{tot}(\varepsilon)=\nu\pi R^2(\varepsilon/\varepsilon_0)^{1/\nu}$

R is minimum size of (stable) inner distribution for $\varepsilon<\varepsilon_0$,

$\sigma_{el}=\pi R^2$ is defined by observed size of particle-target for $\varepsilon < \varepsilon_0$,

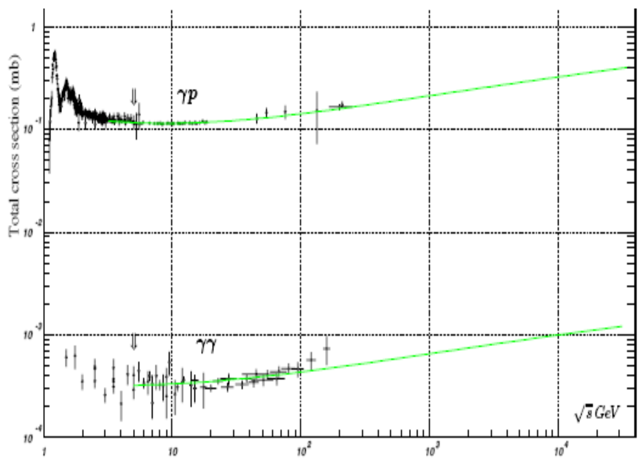
$\sigma_{inel}=\pi(R+r)^2$ takes into account size r of incident particle (r<R),

$\nu=(R+r)^2/R^2$ is ratio of inelastic and elastic cross-sections,

$\varepsilon_0 \sim c\hbar/2\delta r$ is connected with size δr of possible inner events,

$(\varepsilon/\varepsilon_0)^{1/\nu}$ describes disintegration of inner distribution with R'>R in result of its excitation, which appears at energy $\varepsilon > \varepsilon_0$.

“Geometrical” interpretation of (γ,N) cross-section



In range $\varepsilon \sim 2$ -50 GeV

(γ,p) total cross-section

$\sigma^{(\gamma,p)}_{tot} \sim 0.12$ mb

is nearly const(ε) and

$\sigma^{(\gamma,p)}_{tot} \sim 2\alpha\sigma^{(N,N)}_{el.} = 2\alpha\pi R^2$.

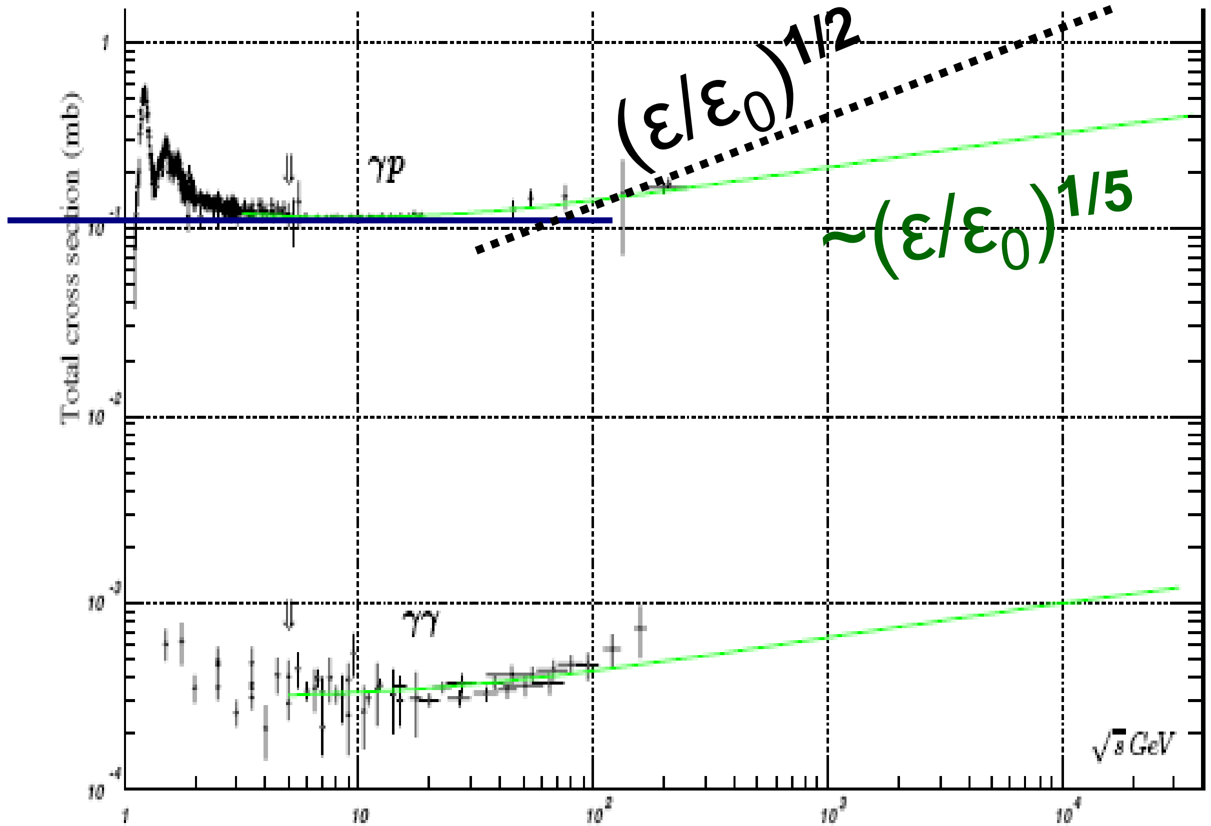
It is like size-less particle scattering on black ball with radius R

$\sigma_{el} = \sigma_{inel} = \pi R^2$, $\sigma_{tot} = \sigma_{el} + \sigma_{inel} = 2\pi R^2$,

and $\alpha \sim 1/137$ is probability, that γ interacts with whole inner nucleon distribution (as distributions in (N,N) scattering).

$\nu = \sigma_{inel}/\sigma_{el} = 2$ gives law $\sigma_{tot}(\varepsilon) = \nu\pi R^2(\varepsilon/\varepsilon_0)^{1/\nu} = 2\pi\alpha R^2(\varepsilon/\varepsilon_0)^{1/2}$

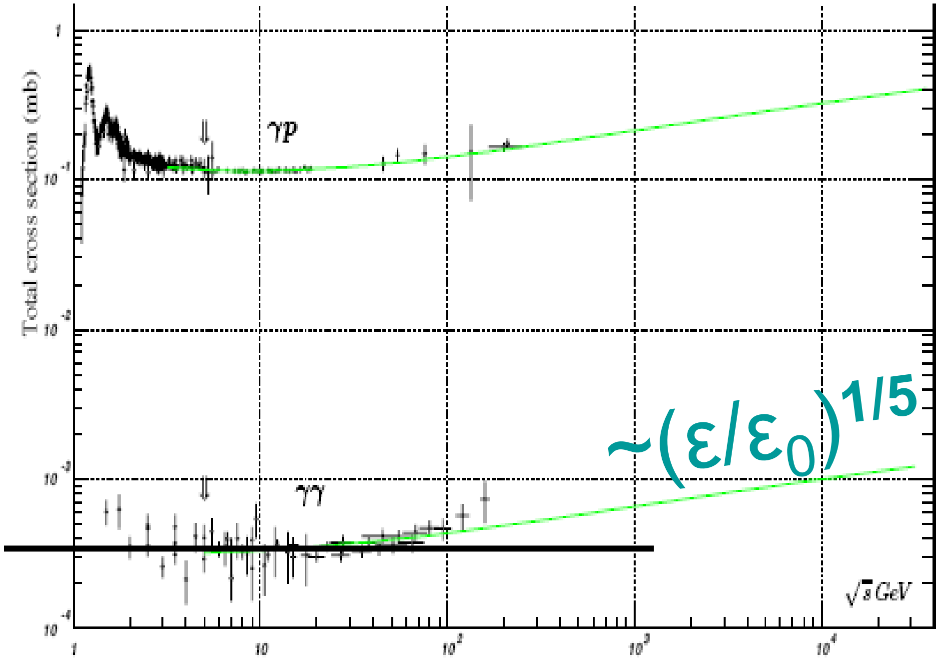
Prediction for (γ,N) scattering: $\sigma^{(\gamma,N)}_{tot}(\varepsilon)=2\pi\alpha R^2(\varepsilon/\varepsilon_0)^{1/2}$ ($\varepsilon>\varepsilon_0$)



With $\nu=\sigma_{inel}/\sigma_{el}=2$ $\sigma_{tot}(\varepsilon)=\nu\sigma_{el}\,(\varepsilon/\varepsilon_0)^{1/\nu}=2\pi\alpha R^2(\varepsilon/\varepsilon_0)^{1/2}$.

(Green line $\sim(\varepsilon/\varepsilon_0)^{1/5}$ is other prediction, given in “particle data”)

Estimate from “geometric” interpretation of (γ,γ) cross-section

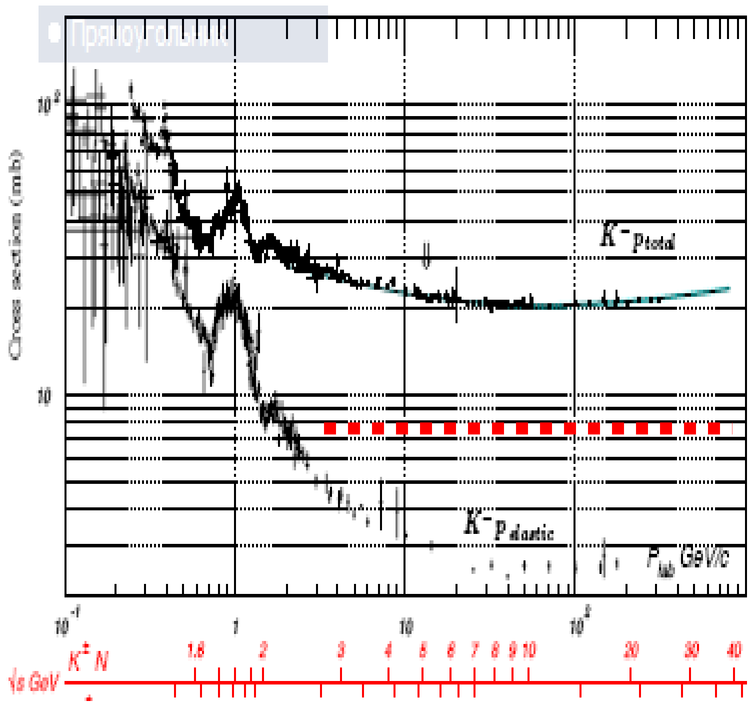


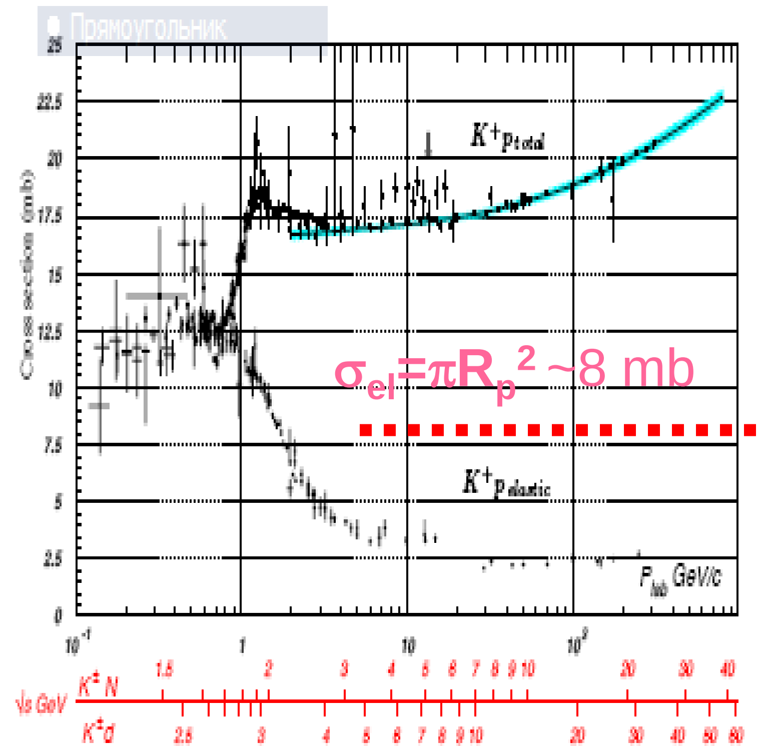
Nearly constant $\sigma^{(\gamma,\gamma)}_{tot}$ ~3.5 10^{-4}mb in energy range 1-100 GeV may be considered as geometric value $\sigma^{(\gamma,\gamma)}_{tot}=5\pi R_\gamma^2$ of “black balls” colliding with radius $R_\gamma \sim (\sigma^{(\gamma,\gamma)}_{tot}/5\pi)^{1/2} = 0.0015$ fm.

R_γ coincides with size of inner nucleon events $c\hbar/2\varepsilon_0$=0.0015fm

size of inner distribution in γ equals to size of inner events r ?

(K^+,p) and (K^-,p) cross-sections



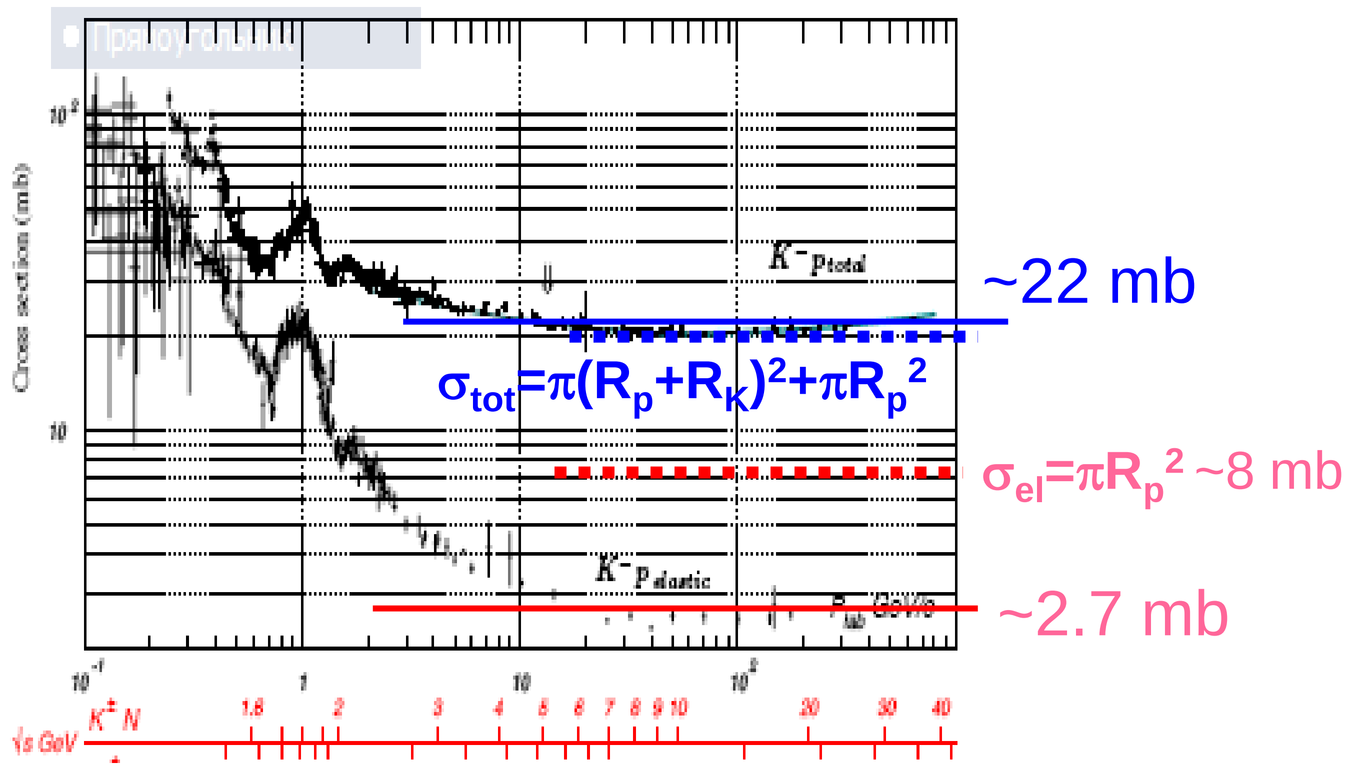


In events r_{12}>R_p+R_k inner distribution of unstable K-meson can decay during its compression without excitation of proton.

Part $\sim\pi R_p^2 - \sigma^{(K,p)}_{el}$ of elastic events (K,p) becomes quasi-elastic

Cross-section $\sigma^{(K,p)}_{tot} \sim \pi(R_p+R_K)^2+\pi R_p^2$ roughly doesnot change

(K^-,p) cross-sections



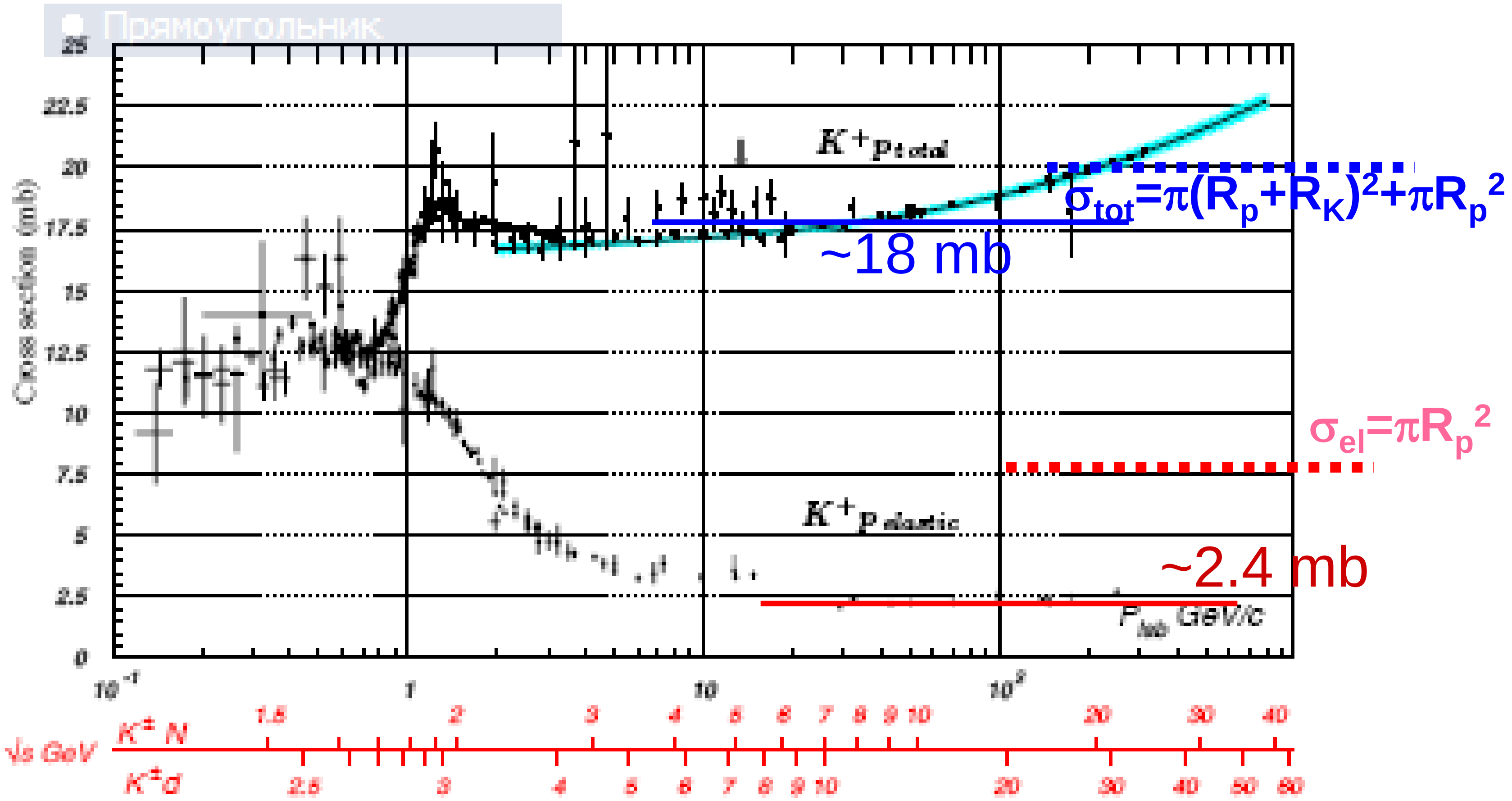
Mean for K^+ and K^- value $\sigma^{(K,p)}_{tot}=20$ mb, $R_p=0.50$ fm

and $\sigma^{(K,p)}_{tot}=\pi(R_p+R_k)^2+\pi R_p^2=20$ mb gives $R_K=0.12$ fm

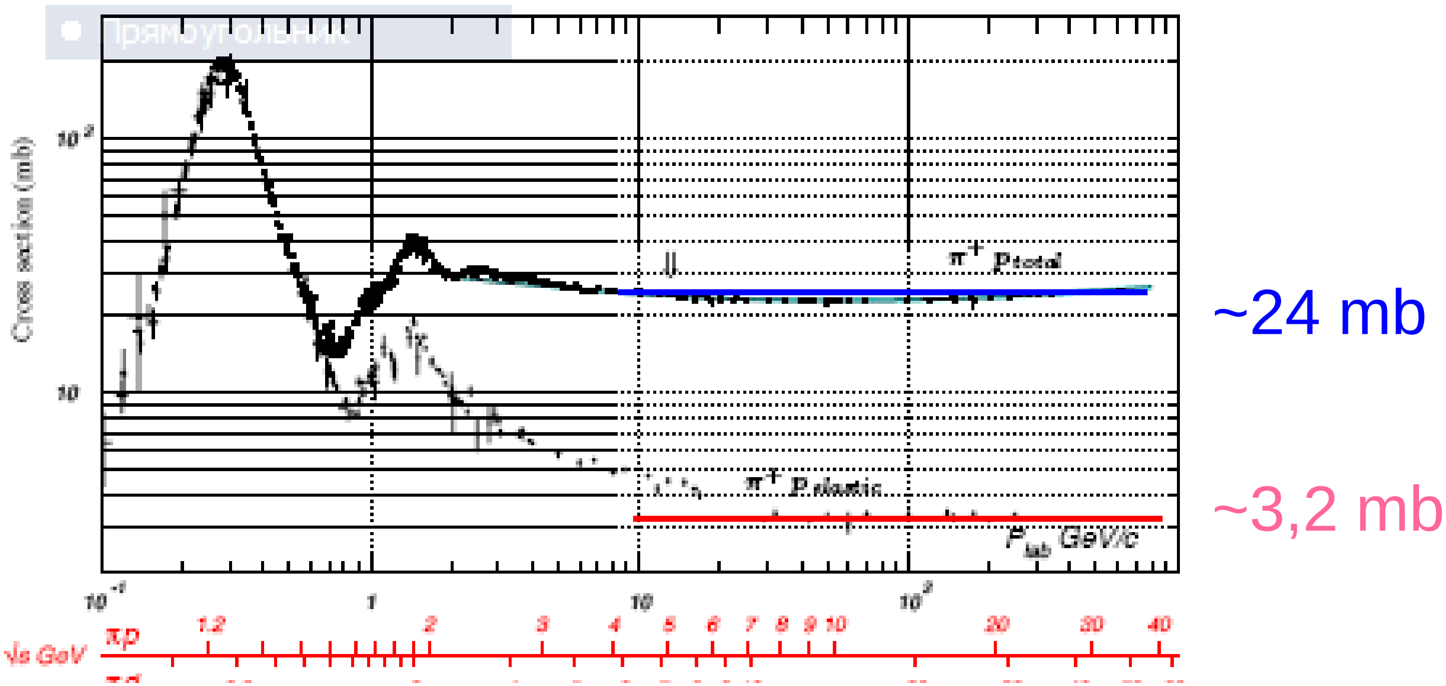
Value $\nu=\sigma_{tot}/\sigma_{el}=1+(1+R_K/R_p)^2=1/0.39$

gives dependence $\sigma^{(K,p)}_{tot}(\varepsilon)=\sigma^{(K,p)}_{tot}(\varepsilon_0)(\varepsilon/\varepsilon_0)^{0,39}$

(K^+,p) cross-sections



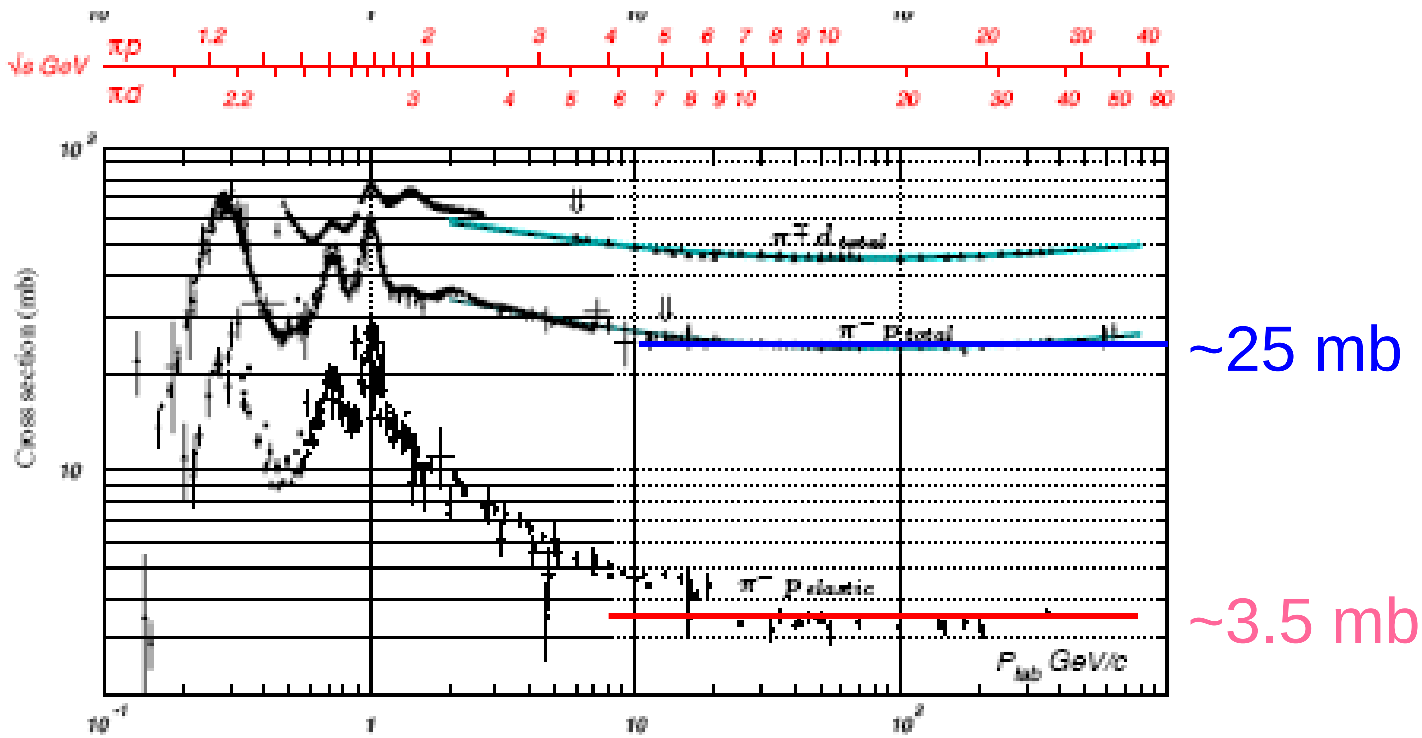
(π^+,p) cross-sections



π-meson may decay under $r_{12}>R_p+R_k$ without proton excitation.

Part of elastic events $(\pi,p)\sim\pi R_p^2-\sigma^{(\pi,p)}_{el}$ becomes quasi-elastic, total cross-section $\sigma^{(\pi,p)}_{tot}=\pi(R_p+R_\pi)^2+\pi R_p^2$ does not change.

(π^-,p) cross-sections



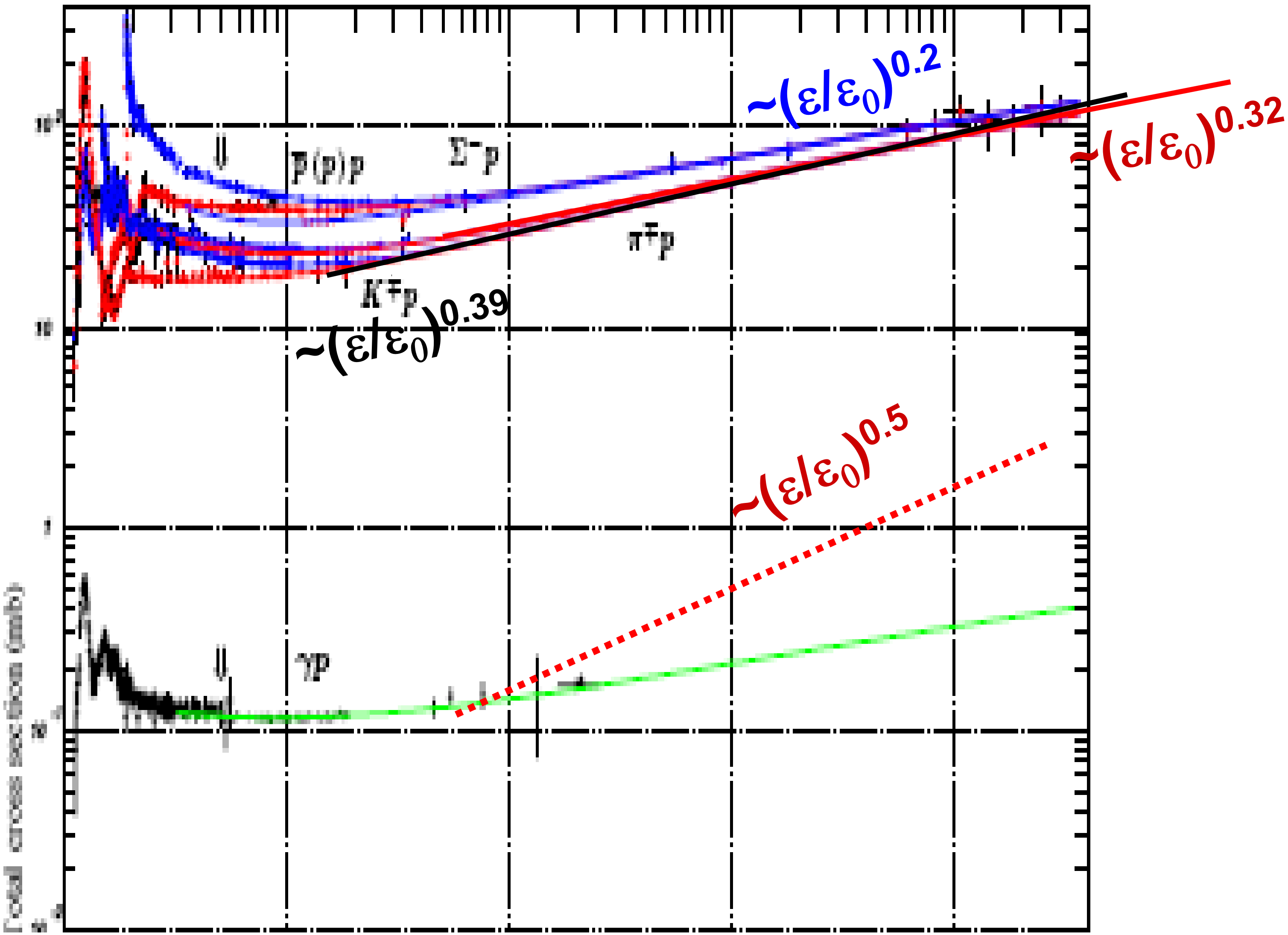
Mean for π^+ and π^- value $\sigma^{(\pi,p)}_{tot}$=24.5 mb, R_p=0.50 fm

and $\sigma^{(\pi,p)}_{tot}=\pi(R_p+R_\pi)^2+\pi R_p^2$=24.5 mb gives R_π =0.23 fm.

Ratio $\nu=\sigma_{tot}/\sigma_{el}=1+(1+R_K/R_p)^2=1/0.32$

gives law $\sigma^{(\pi,p)}_{tot}(\varepsilon) = \sigma^{(\pi,p)}_{tot}(\varepsilon_0)(\varepsilon/\varepsilon_0)^{0,32}$

Dependences $\sigma_{tot}(\varepsilon)=\sigma_{tot}(\varepsilon_0)(\varepsilon/\varepsilon_0)^{1/\nu}$ roughly conform with data



Peculiarity of instable mesons scattering (mes,N)

"Real" interaction of colliding particles happens for $b<R_N+R_{mes}$ gives $\sigma^{(N)}_{inel} = \sigma^{(mes)}_{inel} = \pi(R_N+R_{mes})^2$ of reactions with them.

Events with $b>R_N+R_{mes}$ without "real" interaction give elastic scattering of nucleons $\sigma^{(N)}_{el} = \pi R_N^2$, but instable mesons may decay in such "quasi-elastic" events: $\sigma^{(mes)}_{el} < \pi R_N^2$.

Difference $\sigma^{(N)}_{el} - \sigma^{(mes)}_{el} = \pi R_N^2 - \sigma^{(mes)}_{el} = \sigma^{(N,mes)}_{quasi\text{-}el}$ describes "quasi-elastic" events with elastic nucleon scattering and decay of meson in result of its "potential" interaction with N.

Strong increase of non-equilibrium interaction in compressed inner distribution of meson can explain its accelerated decay and difference of $\sigma^{(mes)}_{inell} = \sigma^{(N)}_{inel} + \sigma^{(N)}_{el} - \sigma^{(mes)}_{el}$ from $\sigma^{(N)}_{inel}$.

Comments

"Equilibrium" inner distributions are not observed in scattering .

Particles interact as whole objects with abrupt borders R_k.

Strong interaction of compressed non-equilibrium distributions happens if $b<R_1+R_2$ on distance $r_{12}= R_1+R_2$ with probability 1.

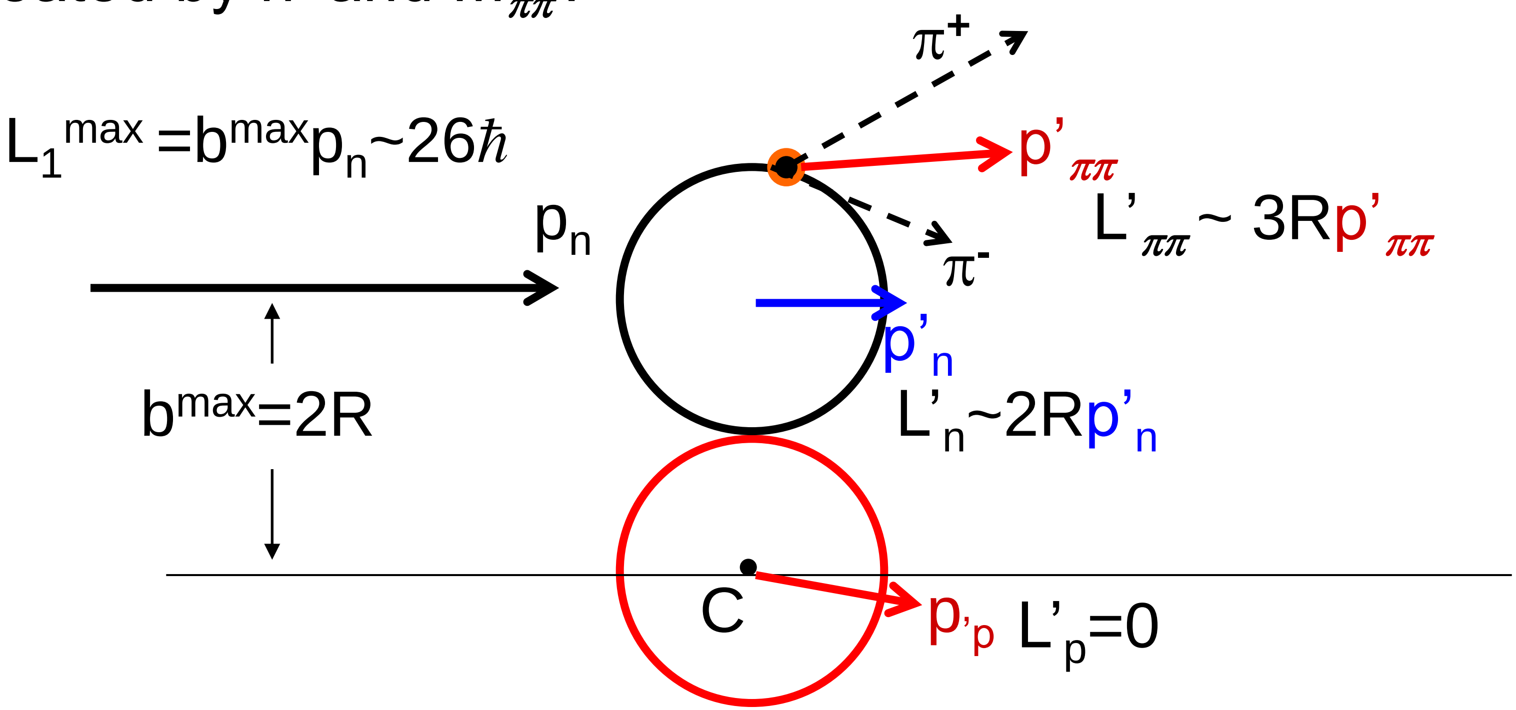
Increasing of cross-section with energy $\sigma_{tot}(\varepsilon)=\sigma_{tot}(\varepsilon_0)(\varepsilon/\varepsilon_0)^{1/\nu}$ is defined by ratio $\nu=\sigma_{tot}/\sigma_{(el+quasi\text{-}el)} =1+(1+R_2/R_1)^2$, $R_2 < R_1$

Inner events of nucleons, mesons and photon with r~0.0015 fm are similar.

Thank you very much!

Events **np→npπ⁺π⁻** at **P_n=5.2 GeV/c** with $M_{\pi\pi}^{(max)}$ ~1.4GeV/c^2

In such events on border of $M_{\pi\pi}$ (**0⁺**) spectrum all 3 final particles n',p', $M_{\pi\pi}$ are nearly at rest in c.m. system ;
in lab. system final momentum $L'_n + L'_p + L'_{\pi\pi} = L_1^{max} - 2 \sim 24\hbar$ created by n' and $M_{\pi\pi}$:



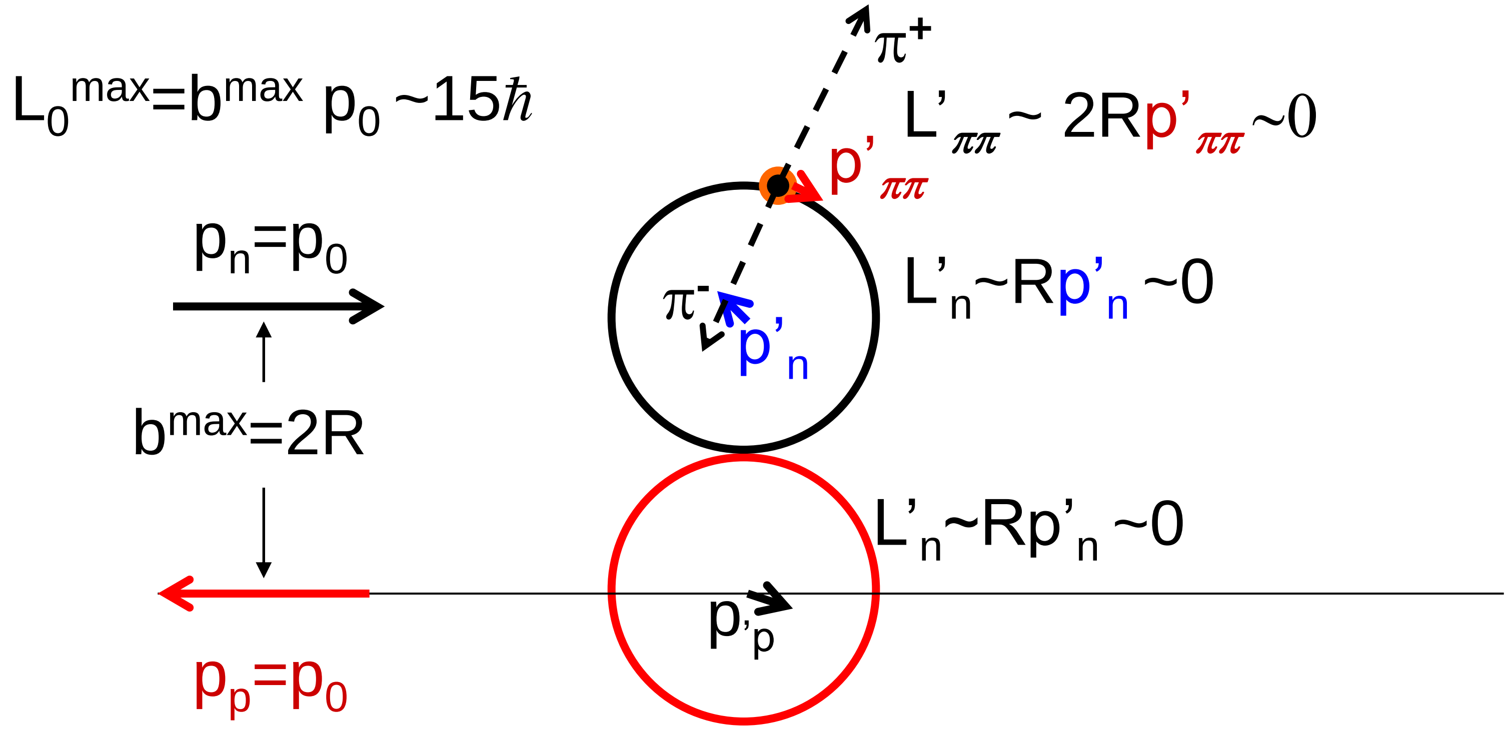
L_1 and L' are angular momenta of movement relatively point C

The same events **$np \rightarrow np\pi^+\pi^-$** with $M_{\pi\pi}^{(max)}$~1.4GeV/c^2 **in c.m.s.**

All 3 final particles n',p', $M_{\pi\pi}$ are nearly at rest in c.m.s.

Final momentum $L'_n + L'_p + L'_{\pi\pi} \sim 0$ is not equal to initial $L_0 \sim 15\hbar$:

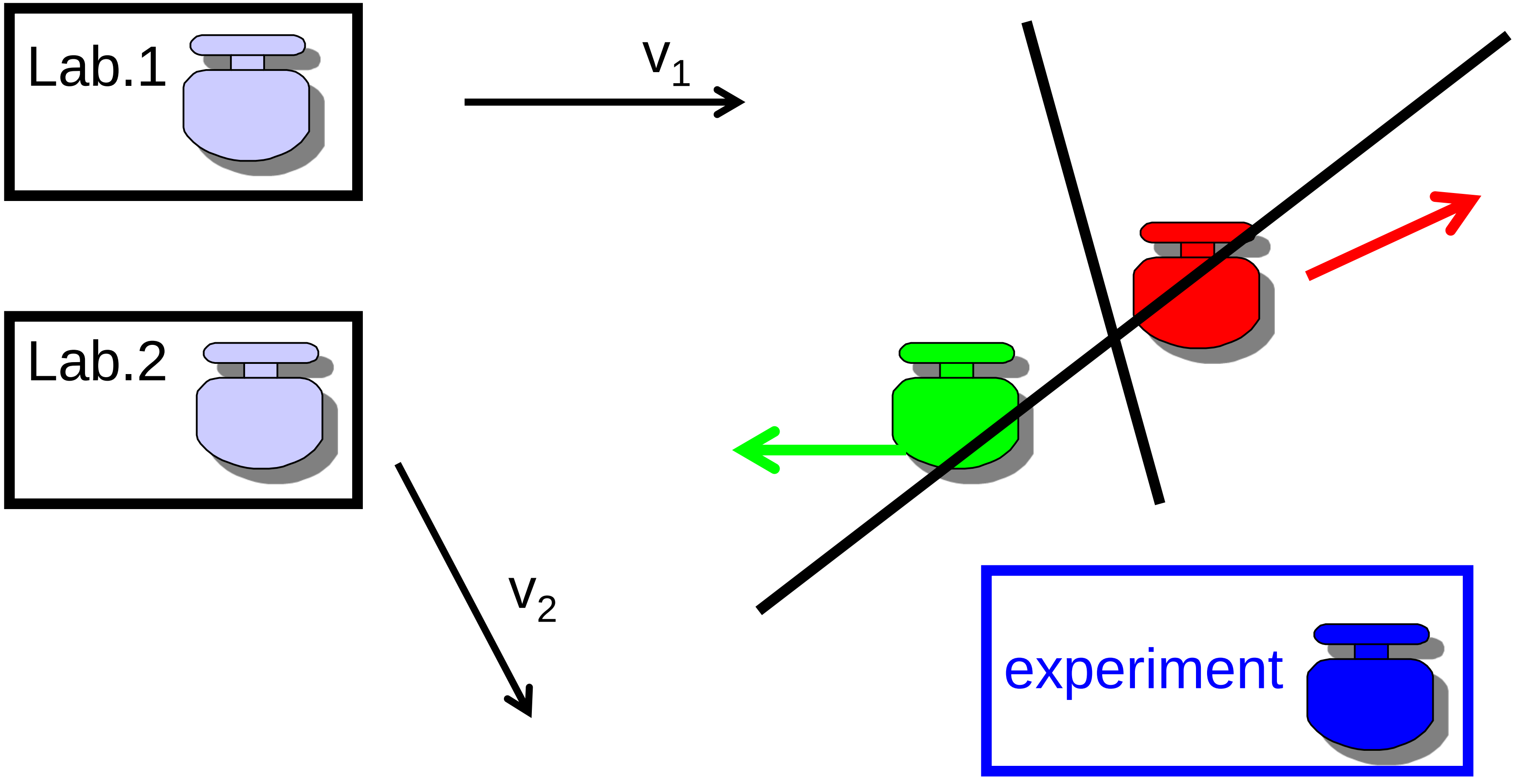
moved with c.m.s. observer sees violation of law $J' = J_0$!



Idea, that moving observers see "the same laws", is mistaken.

Exact wording of "relativity of movement" principle

Outcomes of any experiments
are independent of stationary movement of laboratory

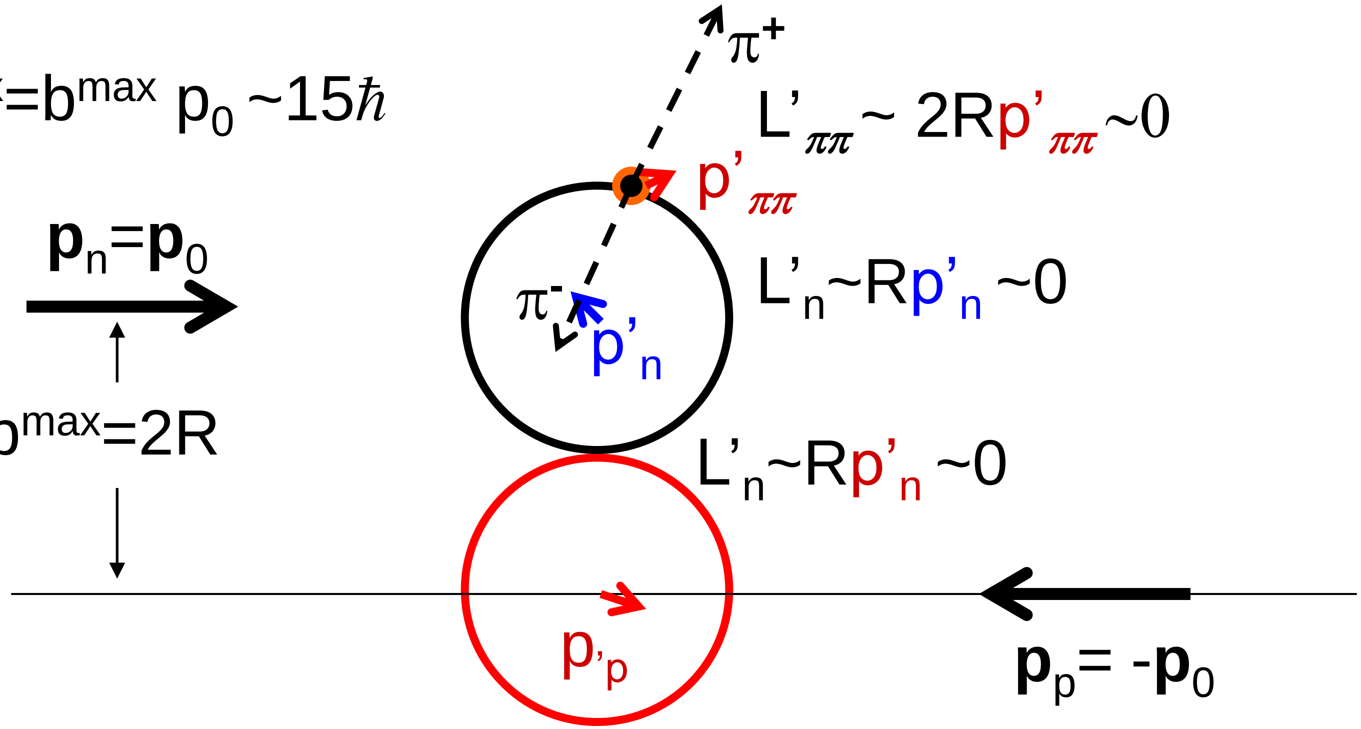


Colliding beams: events $\mathbf{np \rightarrow np\pi^+\pi^-}$ ($\mathbf{0^+}$) with $L'=L_1-2$ are absent

All 3 final particles n',p', $M_{\pi\pi}$ are nearly at rest **in lab. system**.

Final momentum $L'_n+L'_p+L'_{\pi\pi}\sim 0$ is not equal to initial $L_0\sim 15\hbar$:

law $J'=J_0$ forbids events with $J'\sim 0$

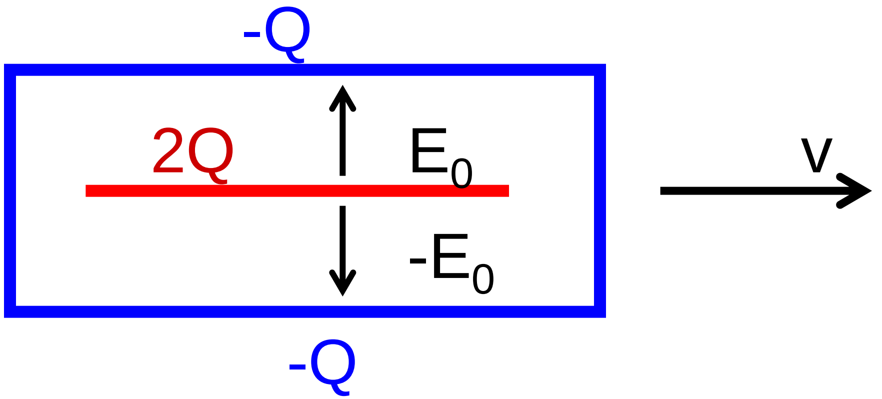


Experiments with target at rest in lab. system and with colliding beams are not identical: different events can happen in them.

Lorentz transformations give mistaken predictions

Let calculate energy of moving plain condenser

$W=\gamma W_0$, $\gamma=(1-v^2/c^2)^{-1/2}$



$W_0=V_0\ E_0^2/2$

$W=V(E^2+H^2)/2$

$E_z=\gamma E_0$, $E_x=E_y=0$, $H_x=H_z=0$, $H_y=vE_0\gamma/c$, $V=V_0/\gamma$

$W=\gamma^2 E_0^2\ (1+v^2/c^2)/2\ V_0/\gamma=\gamma\ (1+v^2/c^2)W_0$ instead of γW_0

Logic of anecdote in special relativistic theory

$$\Delta\xi=\gamma\Delta\xi',$$

$\Delta\xi'$ is value in moving system, $\Delta\xi$ --- in lab. syst.

$\Delta\xi'<\Delta\xi$ --- it is compression or expansion of $\Delta\xi'$?

If $\Delta\xi = \Delta x$ then $\Delta\xi'$ is compressed,

but if $\Delta\xi = \Delta t$ then $\Delta\xi'$ is expanded.