POSSIBLE ORIGIN OF EVENTS pp → pp + nπ WITH ANOMALOUS MULTIPLISITY,

OBSERVED AT INSIDENT PROTON ENERGY 50 GeV (PROT E-190)

(Yad.Phys. **75** (3), 343 (2012) **)**

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“E-190” data pp → pp+nπ (Yad.Phys. **75** (3), 343 (2012) **)**

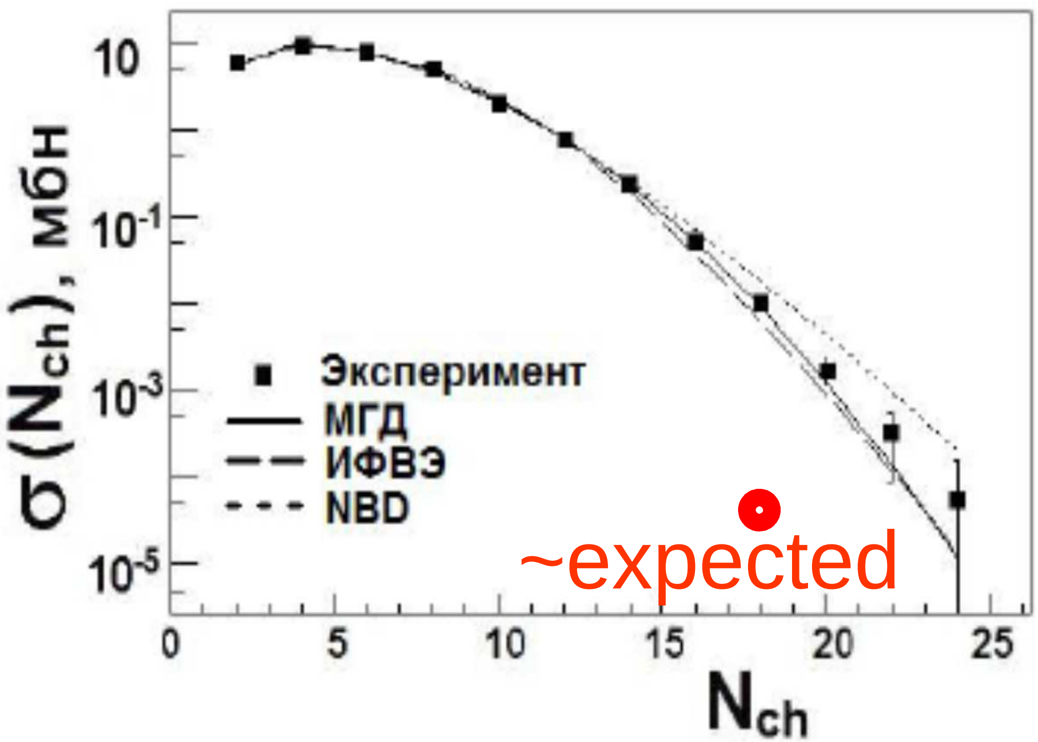


Рис. 7. Сравнение топологических сечений с МГД [11], моделью ИФВЭ [12] и NBD [13].

“Anomalous” observed probabilities for large nπ

plane

- Considered data.
- “Black balls” model for NN scattering.
- Non-equilibrium short-life rotational states.
- “Forced” emission of mesons.
- Estimates for peripheral collisions with $n_\pi = 36$.

Considered data pp → pp+nπ (up to $n_\pi^{max} = 36$)

$P_0 = 50$ GeV/c, $E_0 = 50{,}947$ GeV, ($v_{s.c.m.} = 0.981c$)

$E'_0 = 9.78$ GeV, $T'_0 = 7.90$ GeV,

$n_\pi^{max} = 36$ with mean energy ~70 MeV, $E'_{36\pi} = 7.56$ GeV

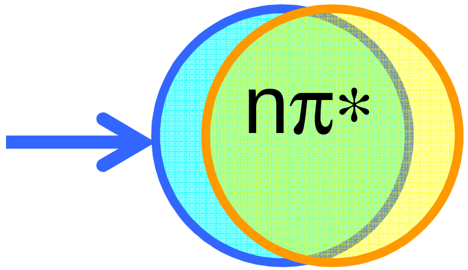
(7.56 / 7.90 = 96% of pp kin. energy into 36π emission)

Consistent theory is absent for the present.

“Special” hypotheses: “active” gluons

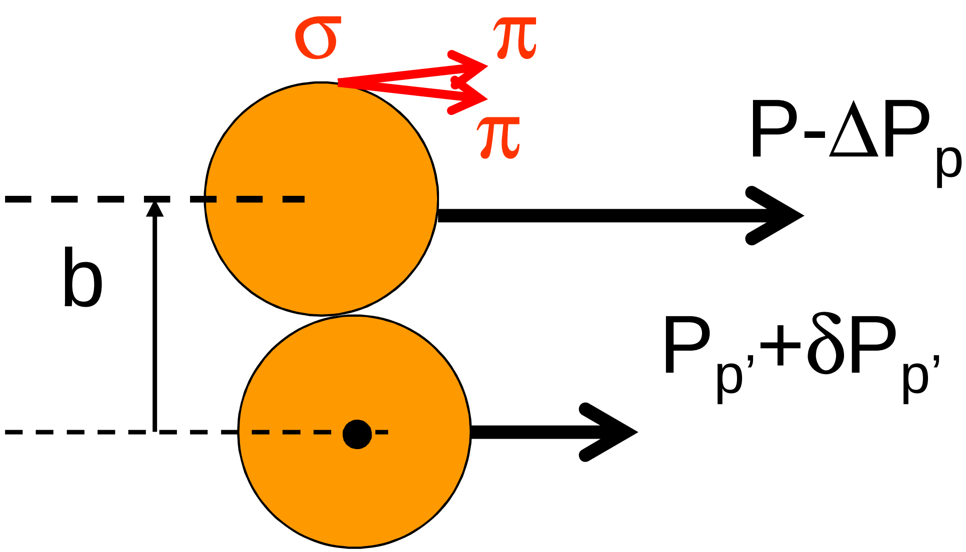
in q-g plasma (central collisions),

“clan” structure of interaction, …



Possible mechanism in “black balls” model

Emission of pairs of π-mesons in $n_\pi/2$ short-life rotary states



$L_p = bP_p$,

$\Delta P_p = \delta P_{p'} + P_\sigma = \Delta L_p/b$

$\Delta L_p = L_\sigma = b_\sigma P_\sigma$ $(=12\eta)$

$n_\sigma = n_\pi/2$ short-life rotary states appear during interact.

$n\pi$ appear far away ~ 2R ~1f from “interaction point” in result of $n_\pi/2$ transitions with $\Delta L_p = L_\sigma = 12\eta$.

Empirical ground of “black balls” model of NN interact.

- “Geometric” cross-sections of NN scattering

(σ_{el}~8 mb and σ_{inel}~31,5 mb at P~ 5 - 1000 GeV/c)

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

  (Yu.A.Troyan et al.,

  Proc. XVIII ISHEPP, 2006, V.1, p.114 and V.2, p.186)

(p,p) and (p--,p) scattering data

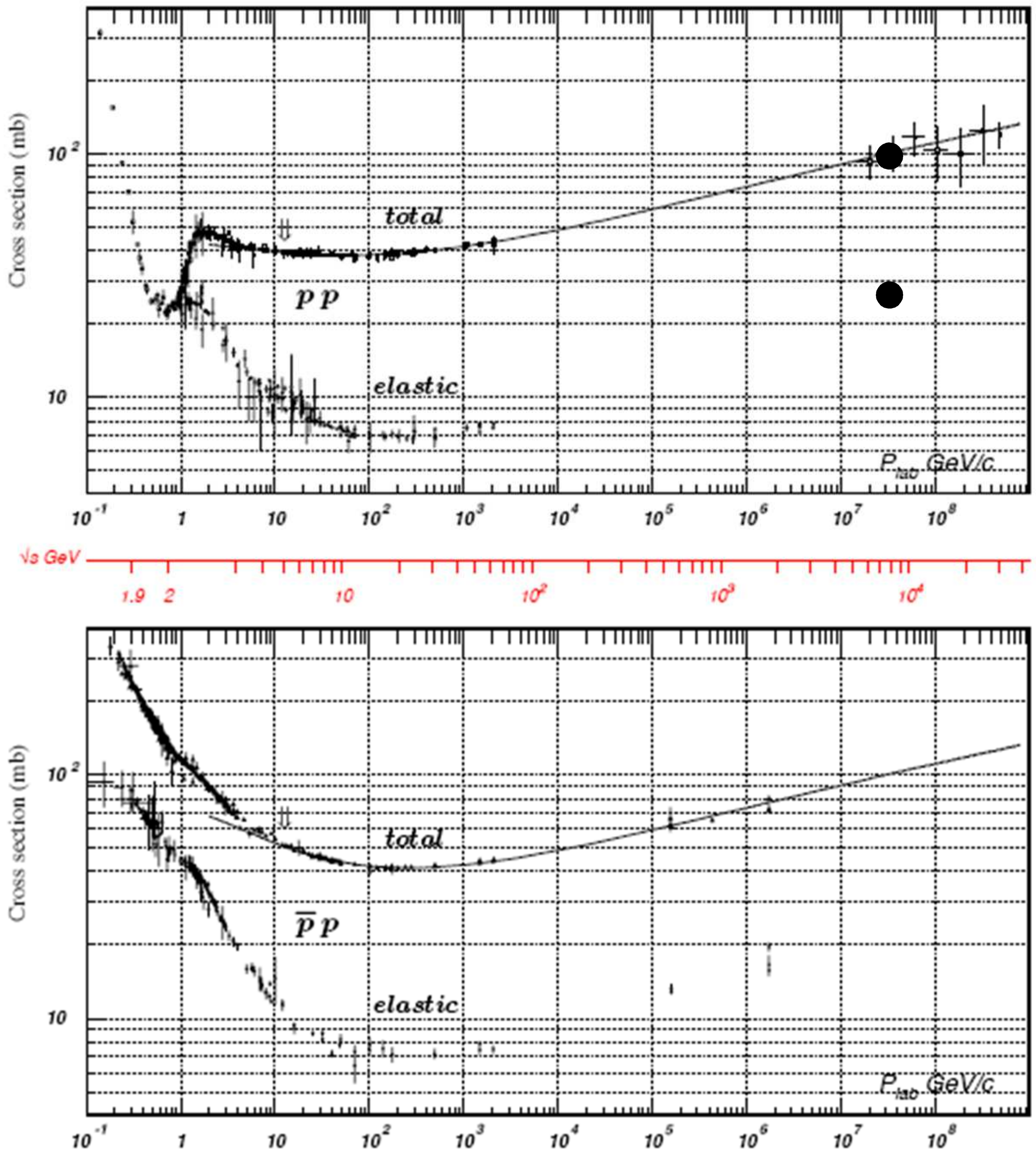
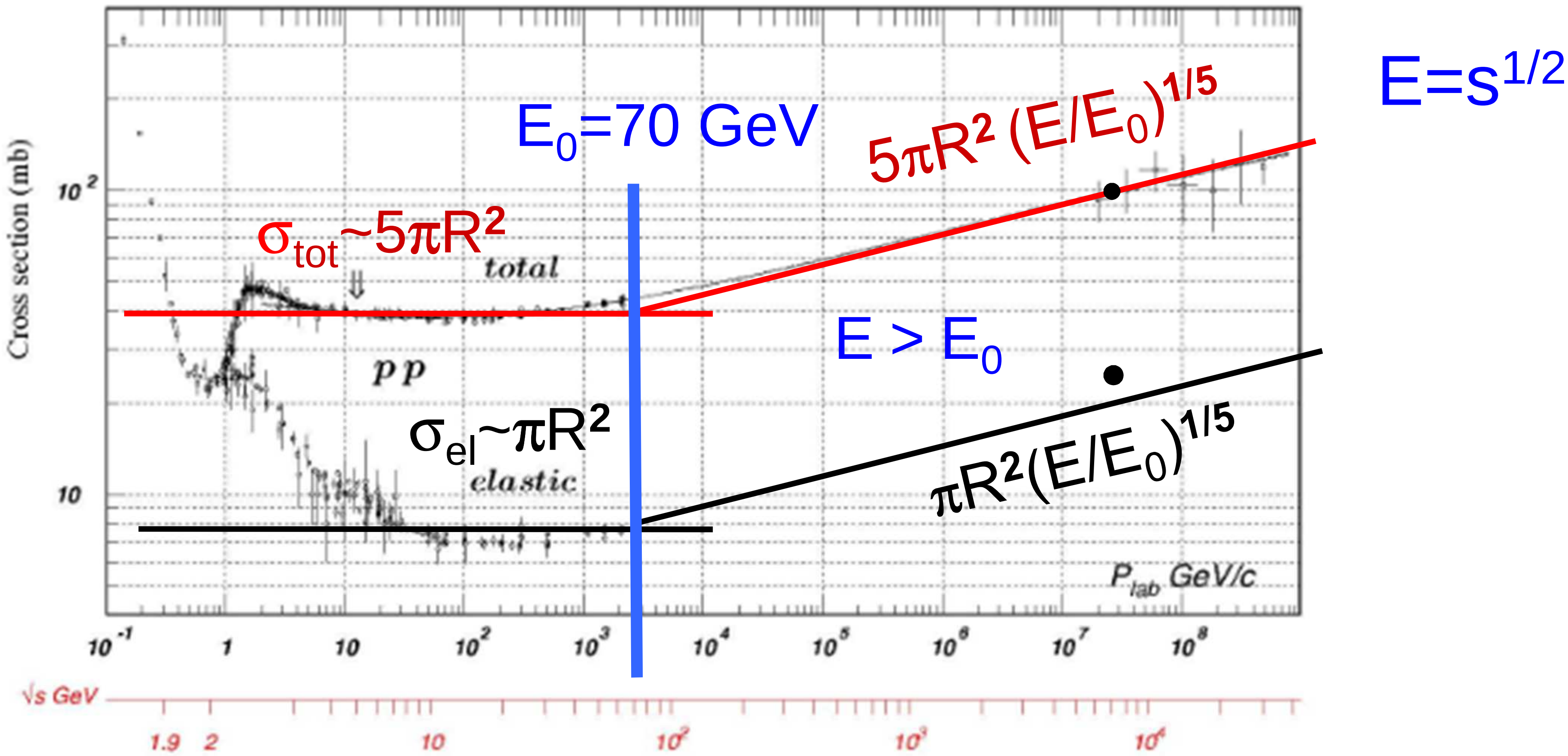


Figure 40.11: Total and elastic cross sections for pp and $\bar{p}p$ collisions as a function of laboratory beam momentum and total center-of-mass energy. Corresponding computer-readable data files may be found at `http://pdg.lbl.gov/current/xsect/`. (Courtesy of the COMPAS group, IHEP, Protvino, August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

Proton-proton cross-sections $\sigma_{inel} = 4\sigma_{el}$



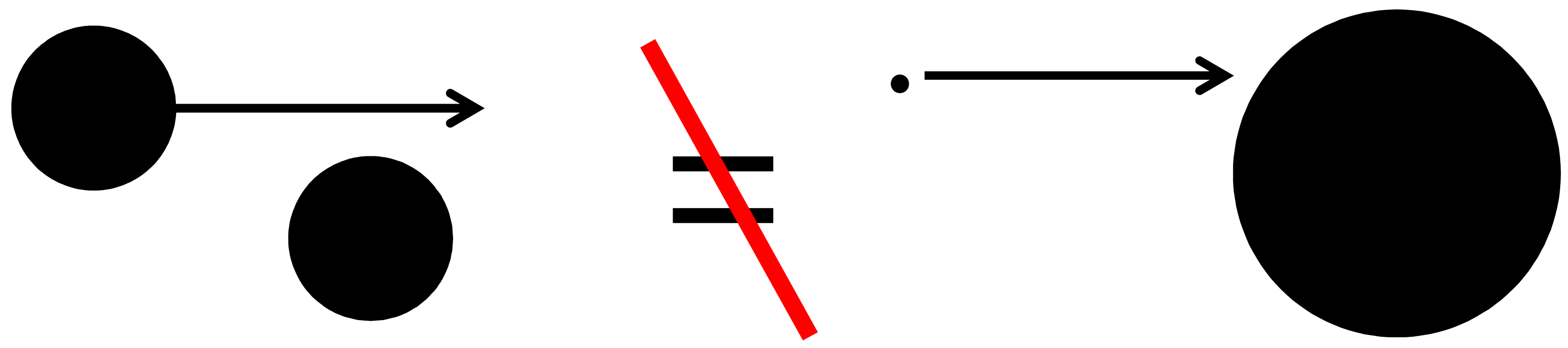
$E \sim 5 - 100$ GeV: $\sigma_{el} \sim 8\text{mb} = \pi R^2$, R =0.50 fm,

$\sigma_{tot} \sim 40\text{mb} = 5\pi R^2$, $\sigma_{inel} \sim 4\,\sigma_{el} = 4\pi R^2$

“Geometrical” view of NN cross-sections

Empirical equality $\sigma_{el} = \sigma_{inel}/4$ **is “black balls” ratio**

with $\sigma_{el} = \pi R^2$ and $\sigma_{inel} = 4\pi R^2$.



$\sigma_{el} = \sigma_{inel}/4$ $\qquad\qquad$ $\sigma_{el} = \sigma_{inel}$

Present theory is not suited for “black balls” scattering.

(This is variant of Fraunhofer theory of diffraction)

Empirical ratio $\sigma_{tot} = 5\pi R^2 (E/E_0)^{1/5}$, $R=0.50f$, $E_0=70GeV$

(E is $s^{1/2}$), for $E = 7$ TeV this expression gives

$$5\pi(0.5\ f)^2\ (100)^{1/5} = 39{,}3\ mb * 2.51 = 98.7\ mb$$

coincides with value LHC (2011) $\sigma_{tot} = 98.5$ mb(μ 2?)

"Black balls" model can explain dependence $(E/E_0)^{1/5}$

($c\eta/2E = r$ – "size" of virtual inner events with $\tau \sim r/c$)

($2E_0 \sim 140$ (μ 10) GeV as mass of free real particle)

Unobserved properties of “free” particles

Observed interacted particles – with non-equilibrium inner states.

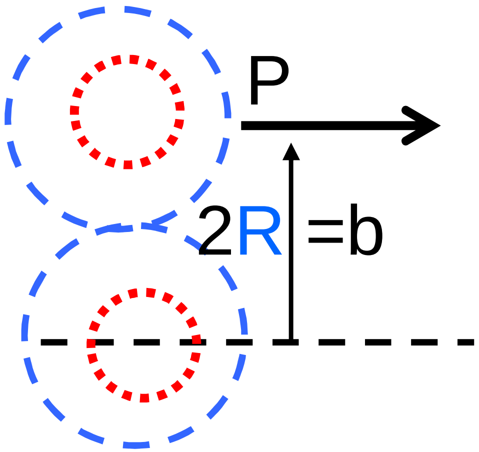
”Equilibrium” state of free particle is unobserved and therefore unknown.

Non-equilibrium nucleons states in NN scattering are similar to “black balls”.

Non-equilibrium inner states of interacted nucleons

Nucleon as probability distribution of constituent virtual events.
Distributions of interacted nucleons turn into compressed to b/2
Probability is a **possibility** of some event, it is **abstract** notion.
If transfer of energy or momentum is absent, all probabilities of considered distributions may be redefined **instantaneously**,

without effects of lateness,



R=b/2, if b/2 > R – elastic NN scattering,

if b/2 < R – inelastic interaction, R = 0.50 f.

Boundary b=2R of inelastic NN interaction,
“thickness” $\Delta b_{el\text{-}inel} = \eta/P$ separates elastic and inelastic events

Instability of non-equilibrium distributions R<R=0,50f

100% probability of reactions for collision with b<2R can not be probability of some casual local events,

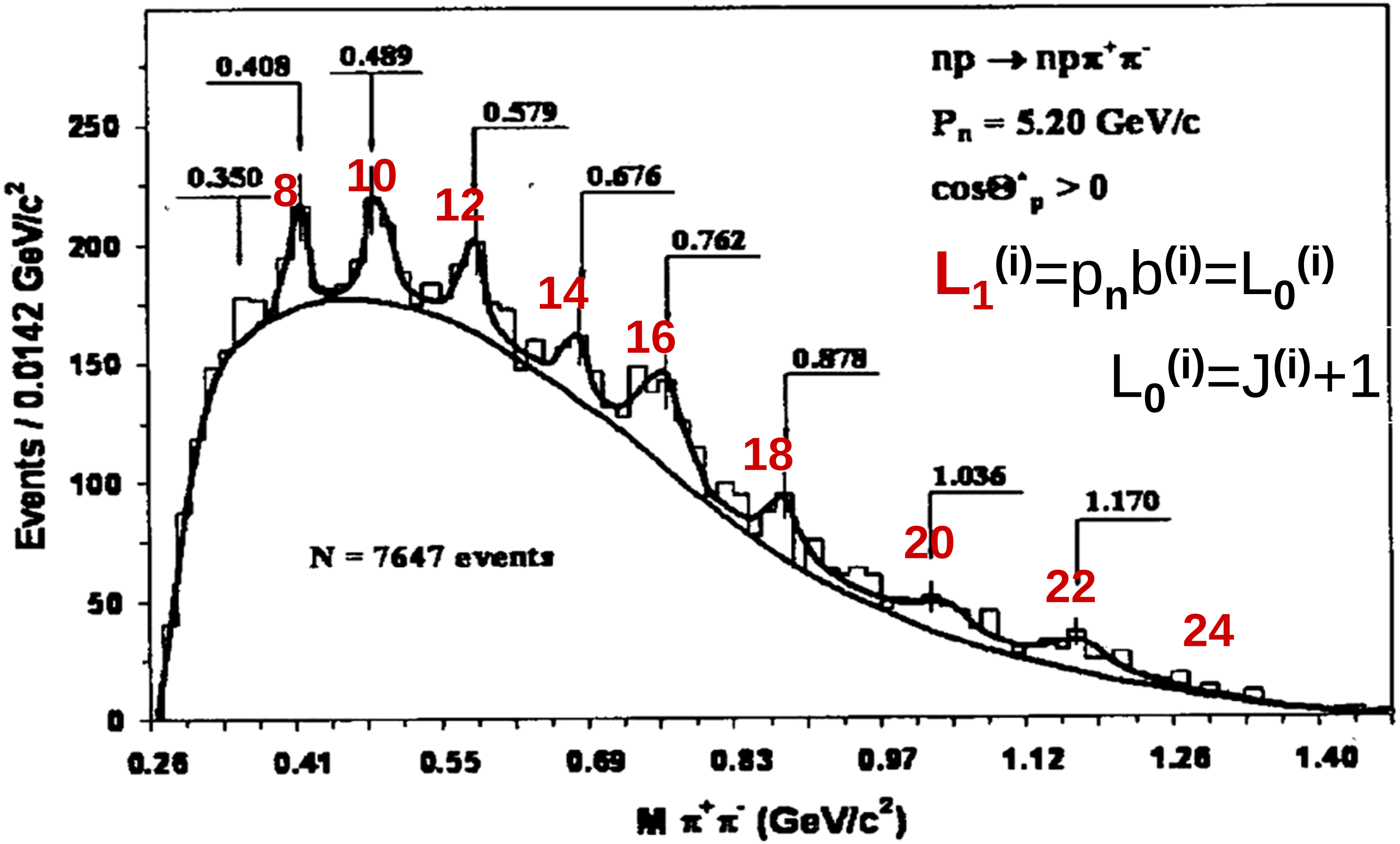
this is nonrandom “regular” result – “surface” of compressed to R<R distribution becomes unstable:

due to violation of indistinguishability of possible ev.? (or other condition of keeping of stable distribution?)

$np \rightarrow np\pi^+\pi^-$ at P_n=5.2 GeV/c, $(\pi^+\pi^-)$ in state $J^\pi=0^+$

Final proton **moves forward in c.m.s.**, 7647 events $\sigma' \sim 2$ mb

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



$L_1^{(i)}=p_n b^{(i)}=L_0^{(i)}$

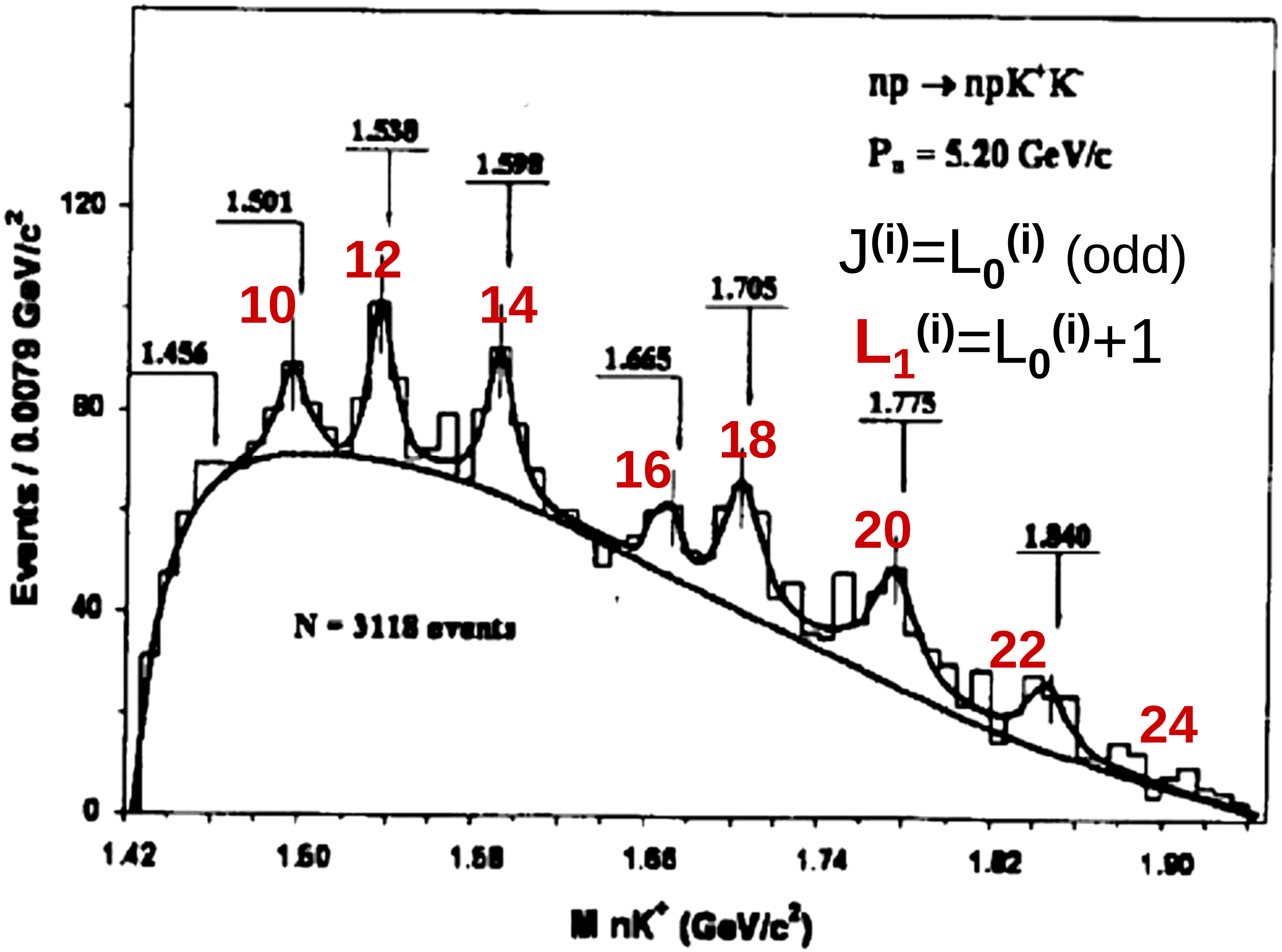
$L_0^{(i)}=J^{(i)}+1$ (even)

$M_{\pi\pi}^{(i)} c^2=V(2L_1^{(i)}-1)$, $V=\eta^2/(6mR^2)$, m of nucleon, R=0.50 fm

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

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

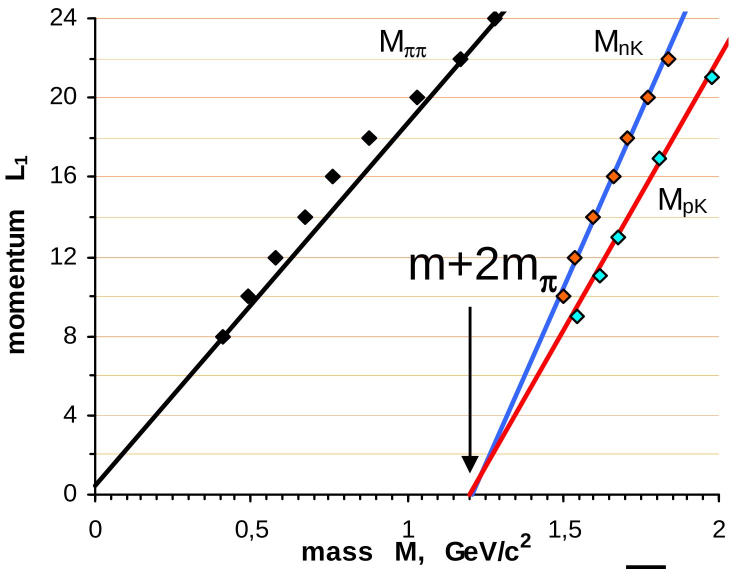
Two transitions $np \to (n+2\pi)(p+2\pi) \to npK^+K^-$, it explains $N_{2K} \sim 1/2\, N_{2\pi}\,(0^+)$



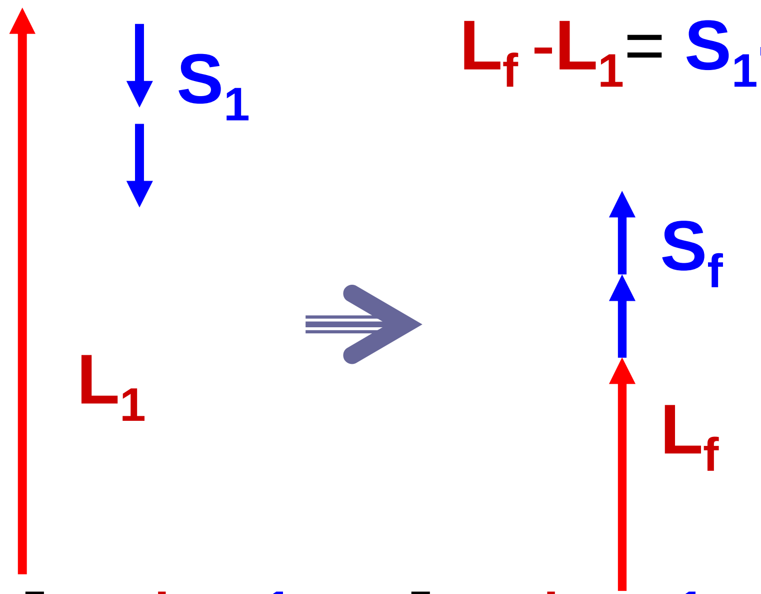
$M_{nK}^{(i)}\,c^2 = m+2m_\pi+V\,(L_1^{(i)}-1/2)$, $V=\eta^2/(6mR^2)$, R= 0.50 fm

“Black balls” description of $np \rightarrow np\pi^+\pi^-$ and npK^+K^- data

Quantization of angular momentum $L_1=bp_n$ of two-nucleons rotating system and its 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 $V(2L_1-1)$,

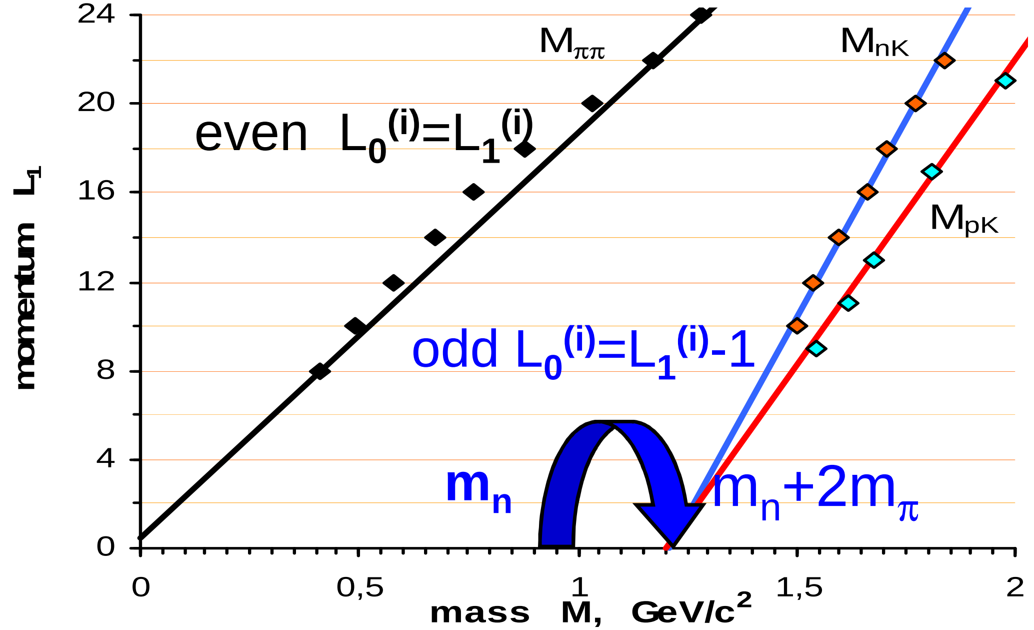
$V = V_{LS} = \eta^2/(6mR^2) \sim 28$ MeV is const. of LS interaction,

Parameter R is defined by data: $R=L_1^{(max)}/p_0 \sim 26\eta/p_0 = 0.50$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 $L_0^{(i)}=L_1^{(i)}$)

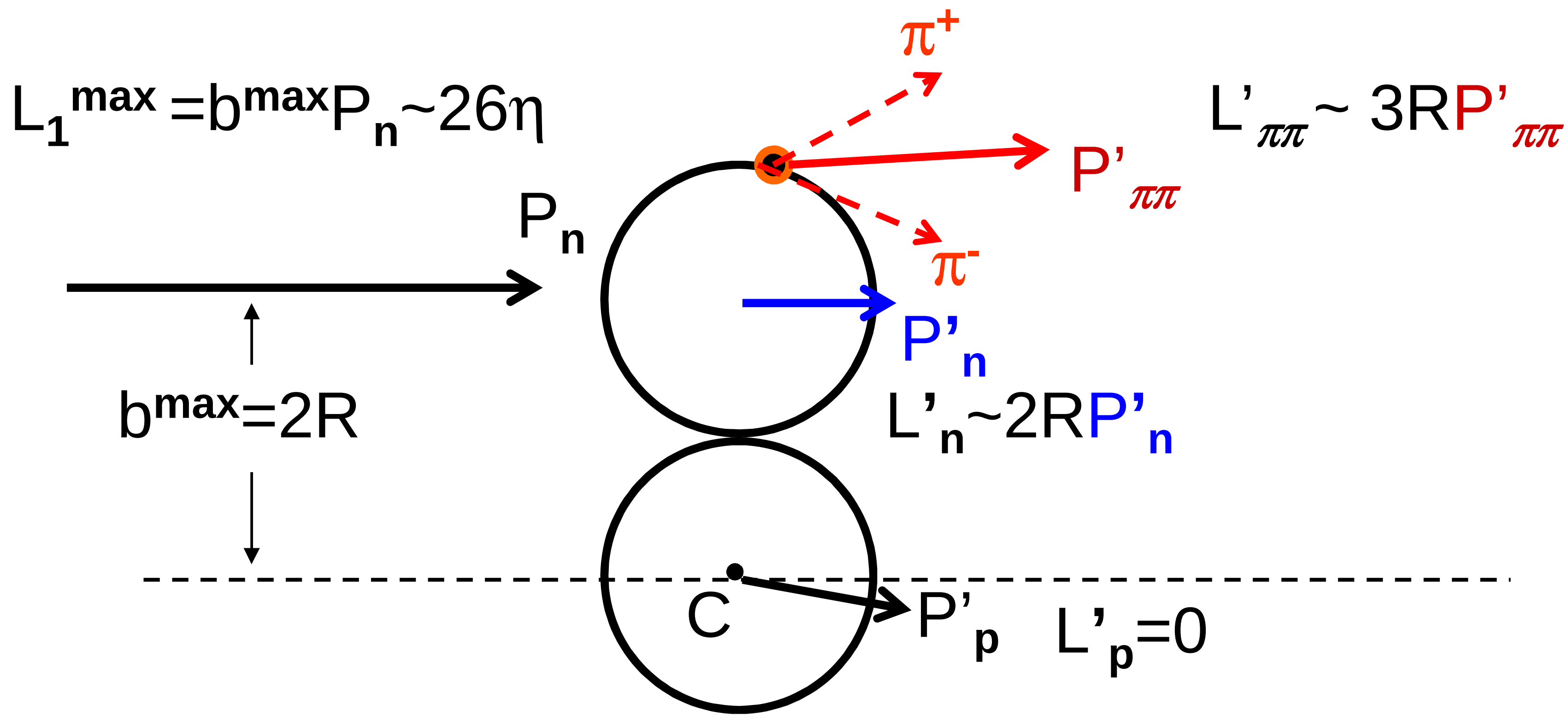
(blue line) $M_{nK}^{(i)}=V\ (L_1^{(i)}-1/2)/c^2+m+2m_\pi$, (odd $L_0^{(i)}=J^{(i)}=L_1^{(i)}-1$)

$V=\eta^2/(6mR^2)$, m of nucleon, $R=(0.50\ \mu\ 0.01)$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

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

in lab. system final momentum $L'_n + L'_p + L'_{\pi\pi} = L_1^{max}$ -2~24η created by n' and $M_{\pi\pi}$:



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

Borders of spectra $\mathbf{M}^{(max)}_{\pi+\pi-}$, $\mathbf{M}^{(max)}_{nK+}$ and radius R

$\mathbf{M}^{(max)}_{\pi+\pi-}$=1.42 GeV/c^2 and $\mathbf{M}^{(max)}_{nK+}$=1.96GeV/c^2

give $L_{\mathbf{1}}^{(max)} = 26.4\ \mu\ 0.5$ (η)

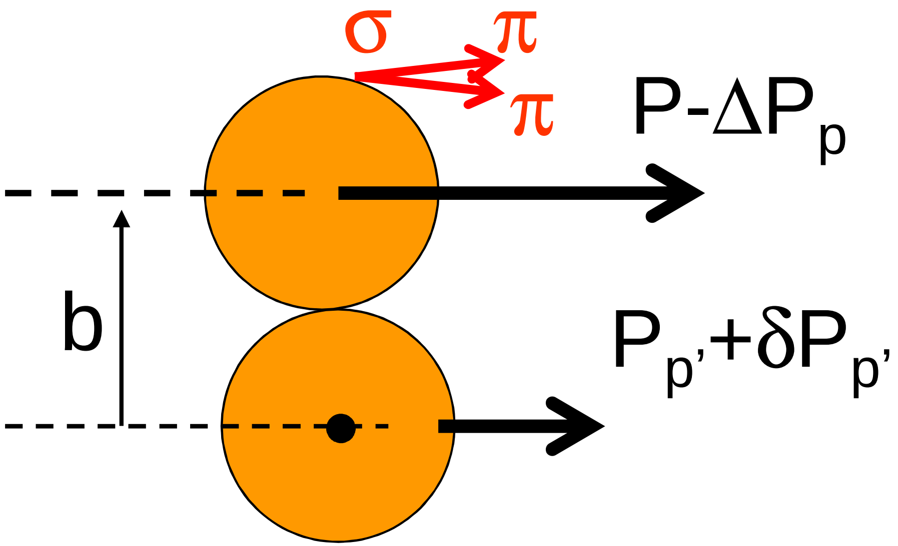
and $2R = b^{(max)} = \eta\ L_{\mathbf{1}}^{(max)}/p_n$=1.00 µ 0.02 f.

$\pi(2R)^{\mathbf{2}}$ = 31.4 mb conforms to empirical value

$\sigma^{NN}_{\mathbf{inel}} \sim 32$ mb .

“Tangential” collision $b=2R$, $P_0= 50$ GeV/c

$$L_0= bP_p = L= 2RP_0 = 253\ \eta,$$



$$\Delta P_p= \delta P_{p'}+ P_\sigma = \Delta L_p/b$$

$$\Delta L_p= L_\sigma= b_\sigma P_\sigma$$

moment of inertia $Y= 2m_pR$ ($R = 0.50$ f),

$E_{rot}= L^2/2Y \sim 2700$ GeV $>> E_0$

$E_{rot}= L^2/2Y \sim 2700$ GeV $>> E_0$ must be compensated

by potential energy $\Delta U \sim -E_{rot}$ of non-equilibr. interaction

Short-life rotational states of pp system ()

$L = 2RP_0 = 253\ \eta$, $E_{rot} = L^2/2Y \sim 2700$ GeV $\gg E_0$,

Shifted on $\Delta E \sim E_{rot}$ rotary state may exist $\tau_{rot} \sim \eta/\Delta E$.

Minimum time of inelastic interaction $\tau_{int} \sim \Delta b/2c \sim \eta/2E_0$

$$\tau_{int}/\tau_{rot} \sim E_{rot}/2E_0 \sim 25 \gg 1$$

Decelerated rotation and forced emission of mesons

Each appearance of rotary state and interaction ΔU with transfer of $\delta P_{p'}$ to proton-target leads to decreasing of angular momentum of pp-system.

Total angular momentum can keep, if simultaneously with momentum decrease $\delta P_{p'}$ meson will be emitted with such values $b_{mes} > b$ and longit. momentum P_{mes}, that $\Delta L_p = b(\delta P_{p'} + P_{mes}) = b_{mes} P_{mes} = L_{mes}$.

Parity of L_p-L_{mes} must be kept for repeated rot. states. This is fulfilled for σ-meson $0^+(0^+)$ emission, and $\sigma \rightarrow 2\pi$

Possible increase of soft photons bremsstahlung

In event with n_σ emission n_σ sudden accelerations are.

Addition of bremsstahlung amplitudes may increase probability of soft photon radiation with $\Delta > \eta/50$ MeV,

which is more than expected from other hypotheses.

Estimates for tang. collision b=2R with 36π emission

In the case of $L_0=253\eta$ and even L_σ of 18 σ-mesons only $L_\sigma=12\eta$ is suitable value for meson momentum.

Equality $\Delta L_p= L_\sigma$ gives $\Delta P_p=\Delta L_p/2R$ = 2.36 GeV/c and final longitud. momentum $P_p= P_0 - 18\Delta P_p$= 7.3 GeV/c of incident proton after 18 σ-mesons emission.

Final angular momentum of this proton $L_p=2RP_p=$ 37η

(it is value $L_0 - 18L_\sigma= (253 - 216)\eta = 37\eta$).

Values P_σ and $\delta P_{p'}=\Delta P_p - P_\sigma$ depend on parameter b_σ.

Estimates for P_σ and momentum of proton-target $P_{p'}$

In the case of maximum value b_σ=3R=1.5 f

P_σ=12η/b_σ=1.58 GeV/c , $\delta P_{p'}$ =ΔP_p- P_σ= 0.78 GeV/c.

Final p-target momentum $P_{p'}$=18$\delta P_{p'}$ = 14.22 GeV/c

Difference of velocities of mesons and protons system

$P_p + P_{p'} = 21.56$ GeV/c $= P_{pp'}$ (longitudinal)

$E_{pp'} \sim 21.65$ GeV (without transverse momentum)

$v_{pp'} \sim 0.995\,c$, $\gamma_{pp'} = (1 - v^2_{pp'}/c^2)^{-1/2} \sim 10$

($v_{c.m.} = 0.981\,c$, $\gamma_{c.m.} = 5.21$)

$P_{18\sigma} = 28.44$ GeV/c (long.)

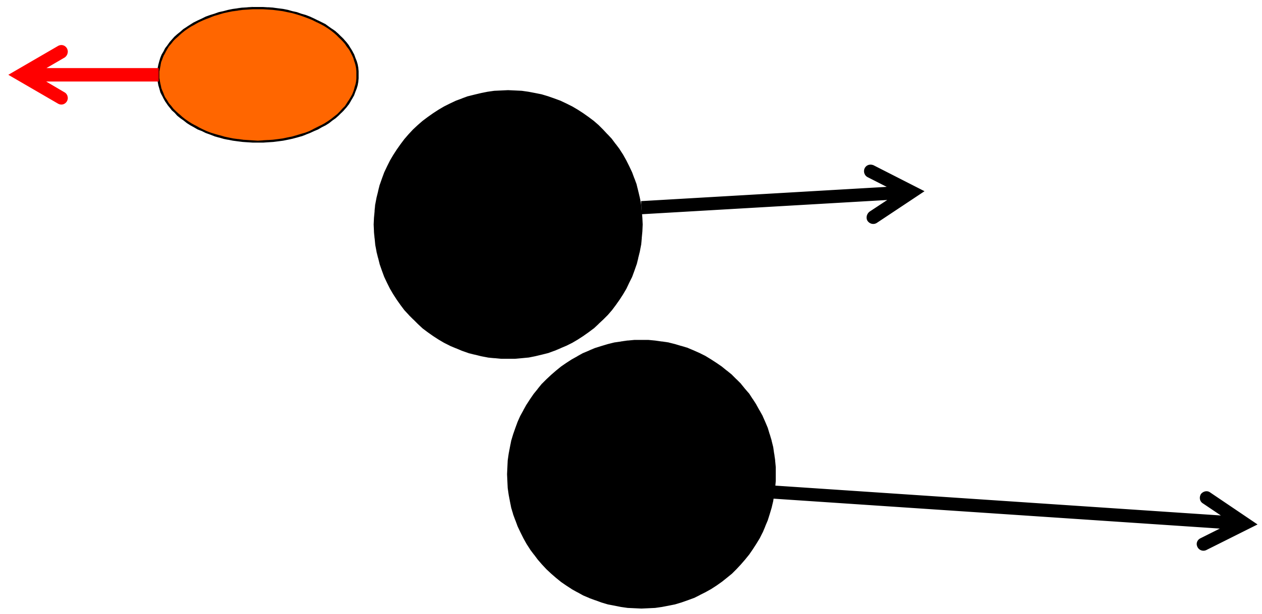
$E_{18\sigma} = E_0 - E_p - E_{p'} = 29.30$ GeV

$v_\sigma \sim 0.971\,c$, $\gamma_\sigma \sim 4.2$

$v_{pp'} > v_{c.m.}$, $v_\sigma < v_{c.m.}$. (Mean $\langle v_\pi \rangle = v_\sigma$)

Possible view of events with 36π in s.c.m.

Possible movement of final particles relative to s.c.m.



If this effect exists it may be observed and treated as confirmation of “black balls” model for NN interaction.

Thank you

for attention !