Space-Time Picture of String Fragmentation and the Fusion of Colour Strings

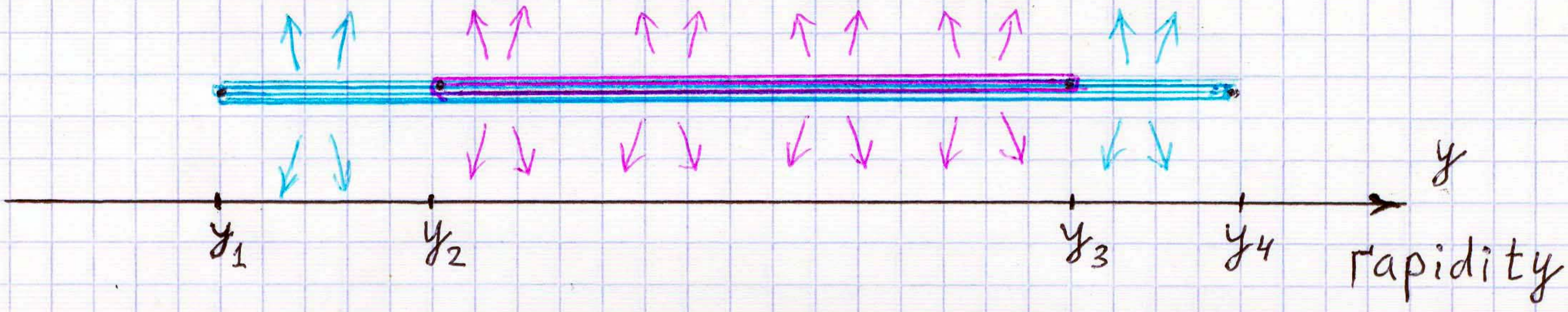
V.V. Vechernin

St.-Petersburg State University

E-mail: vechernin@pobox.spbu.ru

The String Fusion Model

$r_{str} = 0.2 \div 0.25 fm$



Two stage scenario

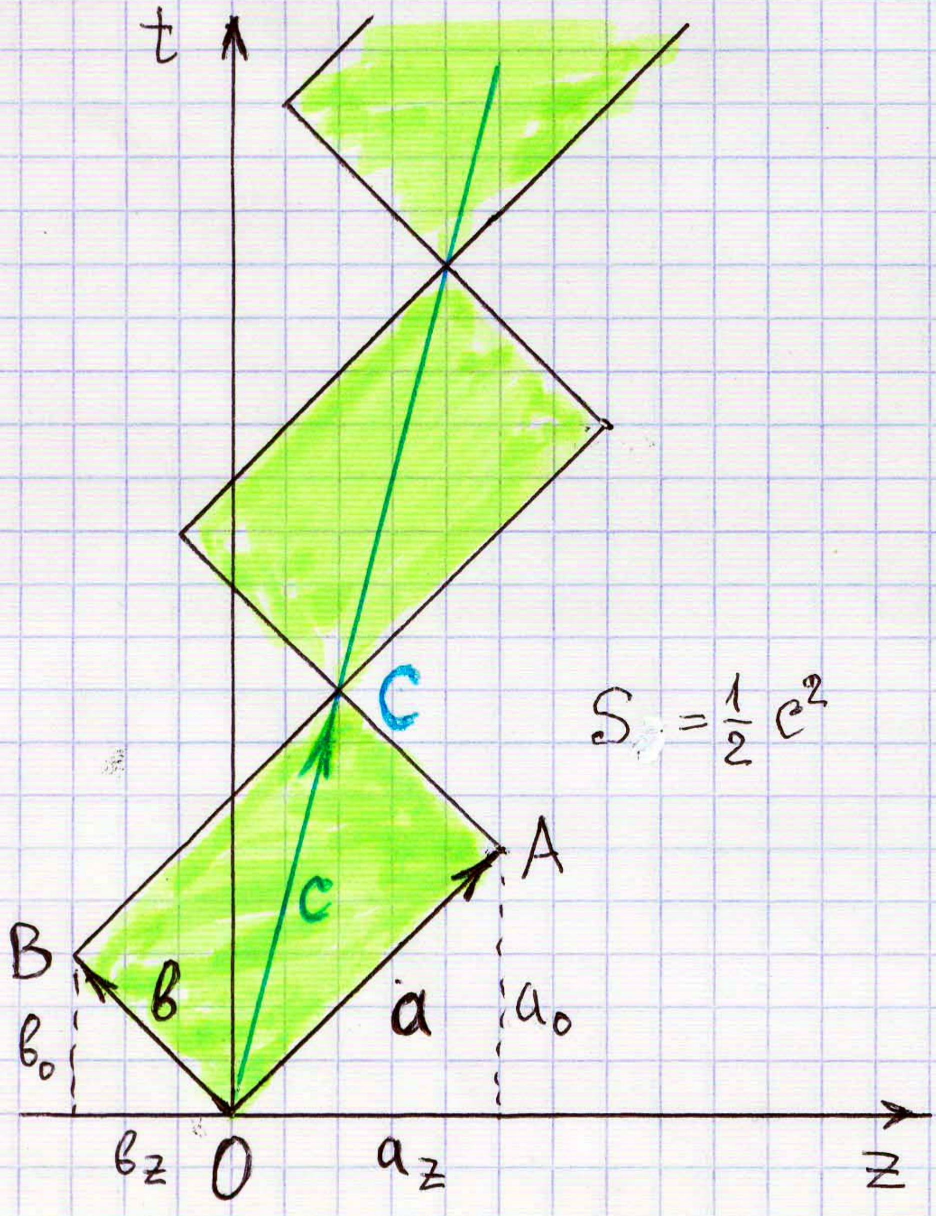
QGSM (Quark-Gluon String Model) A.B. Kaidalov, K.A. Ter-Martirosyan

DPM (Dual Parton Model) A. Capella

SFM (String Fusion Model) M.A. Braun, C. Pajares

PSM (Parton String Model) N.S. Amelin, M.A. Braun, C. Pajares

The Space-Time Picture



The yo-yo string

$$I = -\gamma \int \sqrt{(\dot{x} x')^2 - \dot{x}^2 x'^2}\, d\sigma\, d\tau$$

$$P = \gamma c$$

$$a^2 = b^2 = 0; \quad a_- = 0; \quad b_+ = 0$$

$$a_\pm \equiv a_0 \pm a_z$$

$$M^2 = P^2 = \gamma^2 c^2 = \gamma^2 (a+b)^2 =$$

$$= 2\gamma^2 (ab) = \gamma^2 a_+ b_-$$

$$a_+ = a_0 + a_z = 2a_0 = \sqrt{2}\, |OA|$$

$$b_- = b_0 - b_z = 2b_0 = \sqrt{2}\, |OB|$$

$$M^2 = 2\gamma^2 S_E(OACB)$$

B. M. Barbashov, V. V. Nesterenko "Relativistic String Model in Physics of Hadrons", M., 1987, 176p. (In Russian)

S_E and S_M $\quad a=(a_0,\vec{a})$; $b=(b_0,\vec{b})$ $\quad \vec{a},\vec{b}$ - (D-1) vectors

$$S_M^2=(ab)^2-a^2b^2=(a_0b_0-\vec{a}\vec{b})^2-(a_0^2-\vec{a}^2)(b_0^2-\vec{b}^2)=S^2-\Delta$$

$$S^2=(a_0\vec{b}-b_0\vec{a})^2\;;\quad \Delta=\vec{a}^2\vec{b}^2-(\vec{a}\vec{b})^2;$$

$$S_E^2=(a\times b)^2=a^2b^2-(ab)^2=(a_0^2+\vec{a}^2)(b_0^2+\vec{b}^2)-(a_0b_0+\vec{a}\vec{b})^2=S^2+\Delta$$

$$D=2;\; D-1=1\Rightarrow \Delta=\vec{a}^2\vec{b}^2-(\vec{a}\vec{b})^2=a_z^2b_z^2-(a_zb_z)^2=0;$$

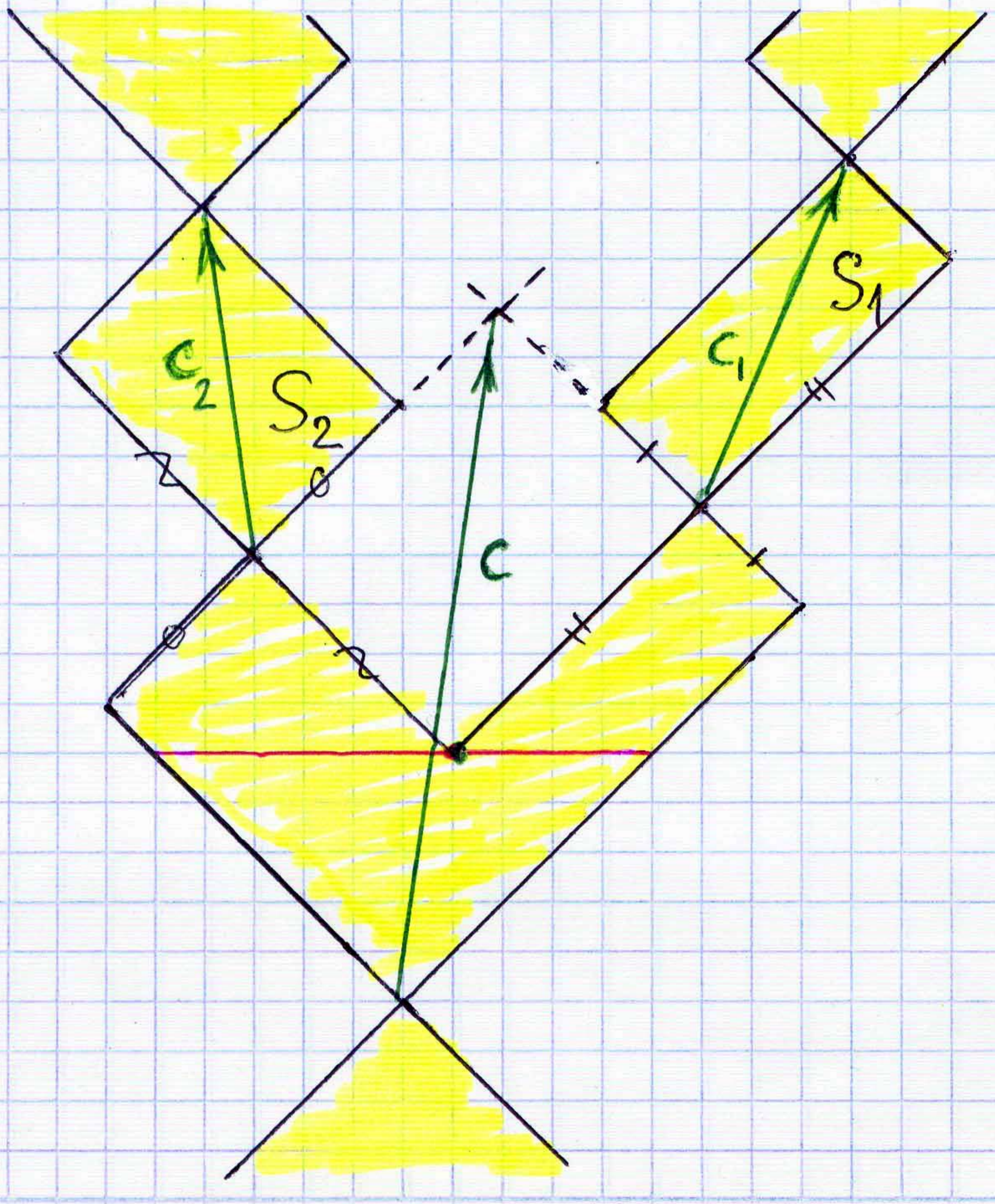
$$S_M=S_E=S.$$

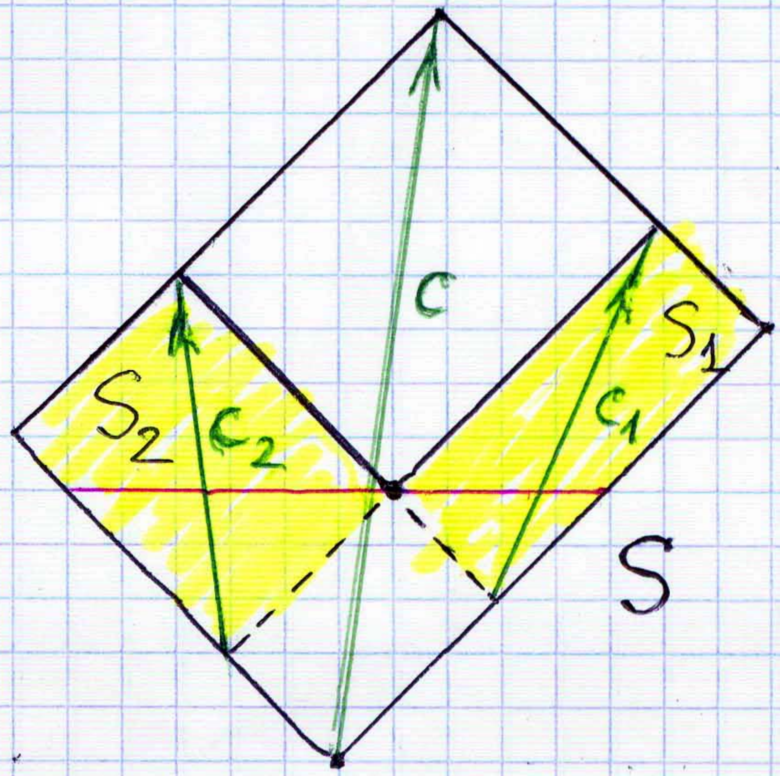
The String Decay

$P = \gamma c\ ;\ P_1 = \gamma c_1\ ;\ P_2 = \gamma c_2$

$M^2 = 2\gamma^2 S;\ M_1^2 = 2\gamma^2 S_1$

$M_2^2 = 2\gamma^2 S_2$



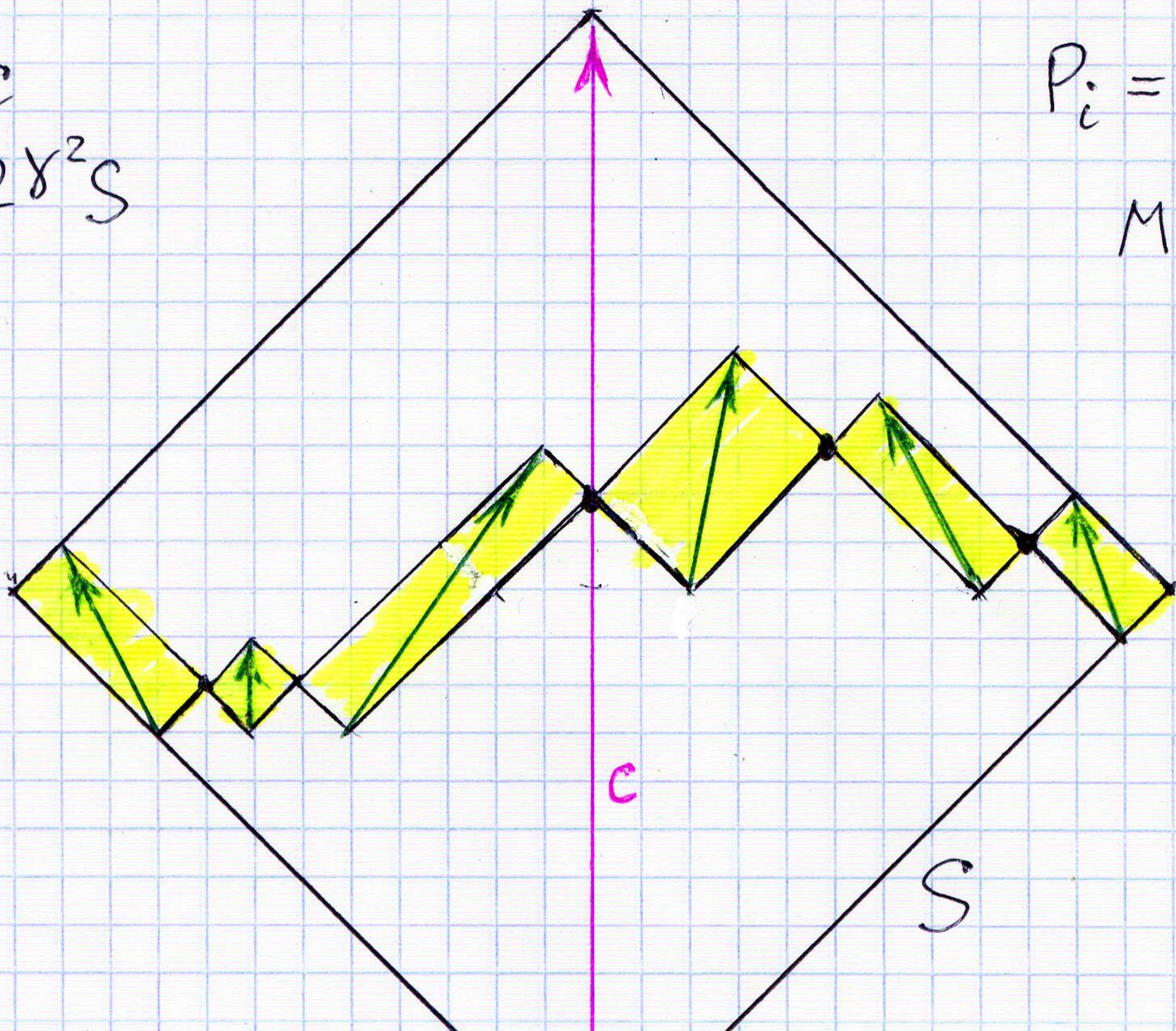


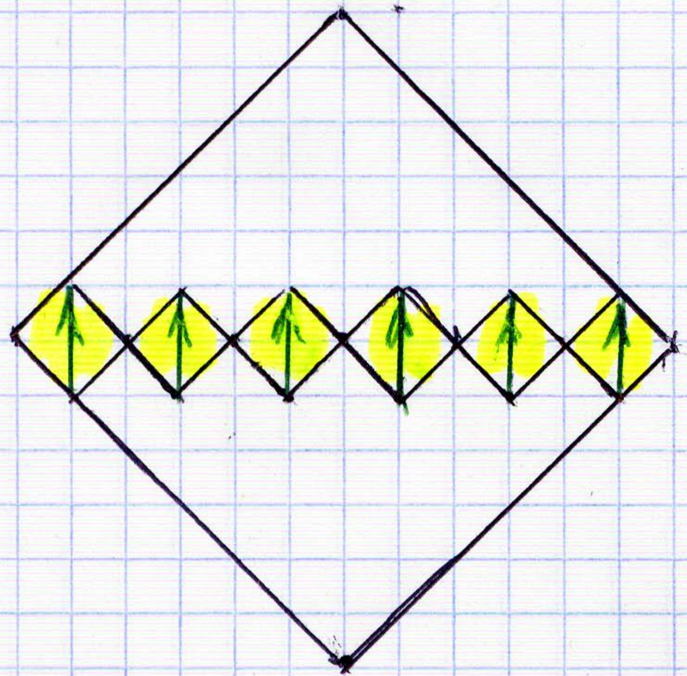
$$P = \gamma c$$

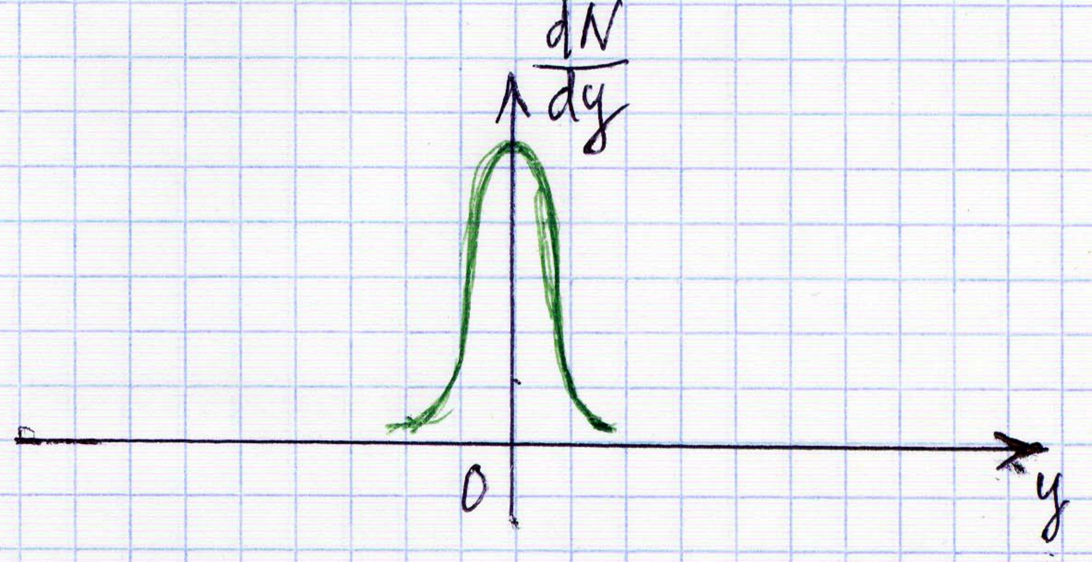
$$M^2 = 2\gamma^2 S$$

$$P_i = \gamma c_i$$

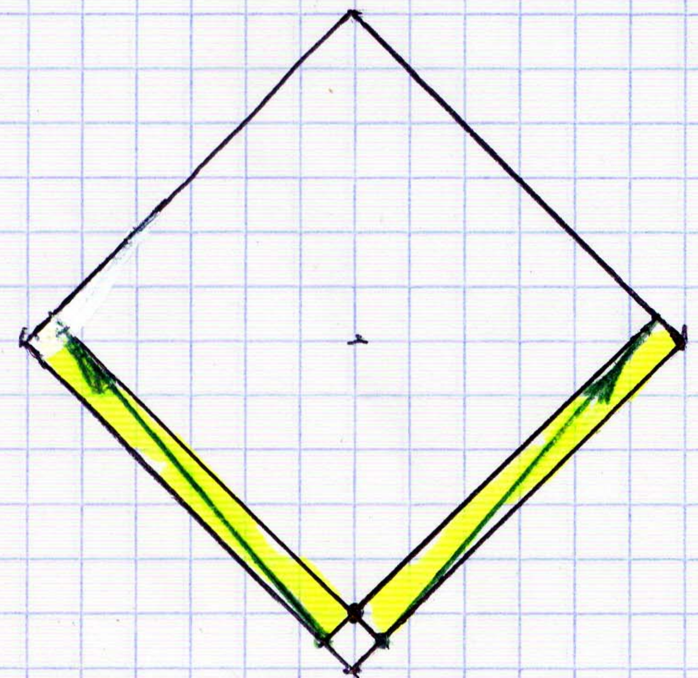
$$M_i^2 = 2\gamma^2 S_i$$

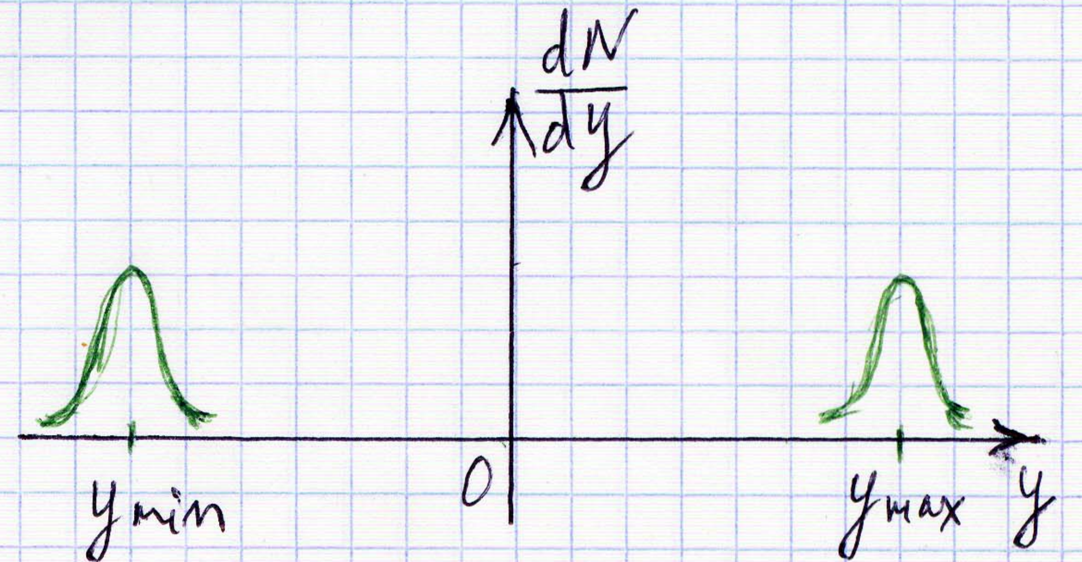






$\frac{dN}{dy}$
0
y





$\frac{dN}{dy}$
0
y
y_{min}
y_{max}

AMOR (Artru-Mennessier Off-shell Resonance)

VENUS (Very Energetic NUclear Scattering) K. Werner

Decay of the unstable particle:

$$dP = \alpha(1-P)\,dT; \Rightarrow P = 1-e^{-\alpha T}; \quad T\to\infty \Rightarrow P\to 1.$$

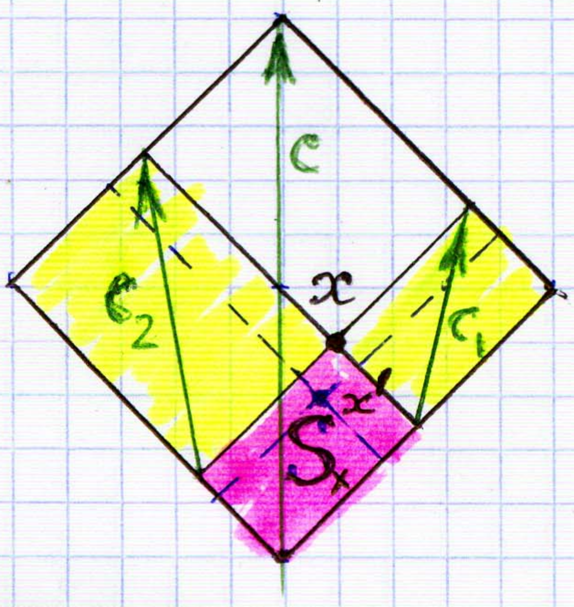
$$\rho(T) = \frac{dP}{dT} = \alpha e^{-\alpha T}; \quad \langle T\rangle = \frac{1}{\alpha}; \quad \int_0^\infty \rho(T)\,dT = 1$$

Decay of the string:

$$dP(x) = \frac{1}{S_0}(1-P)\,dS_x;$$

$$P = 1-e^{-S_x/S_0}; \quad \langle S_x\rangle = S_0$$

$$\rho = \frac{dP}{dS_x} = \frac{1}{S_0}e^{-S_x/S_0}$$



The Value of Parameters

$c = \hbar = 1$ | $1\,fm = 5.05\,GeV^{-1}$

$1\,fm \approx \frac{1}{200\,MeV}$

(1) γ; $\gamma = \frac{1}{2\pi\alpha'}$; $\alpha' = 0{,}9\,GeV^{-2} \Rightarrow \gamma = 0.18\,GeV^2$

$Q\bar{Q}$ potential $\Rightarrow \gamma = 0.19\,GeV^2$

$\gamma = 0.18\,GeV^2 = 4.6\,fm^{-2} = (0.47\,fm)^{-2}$

(2) S_0; VENUS: $S_0 = \frac{1}{2\alpha_0\gamma}$; $\frac{dN}{dy} \Rightarrow \alpha_0 = 0.6$; AMOR

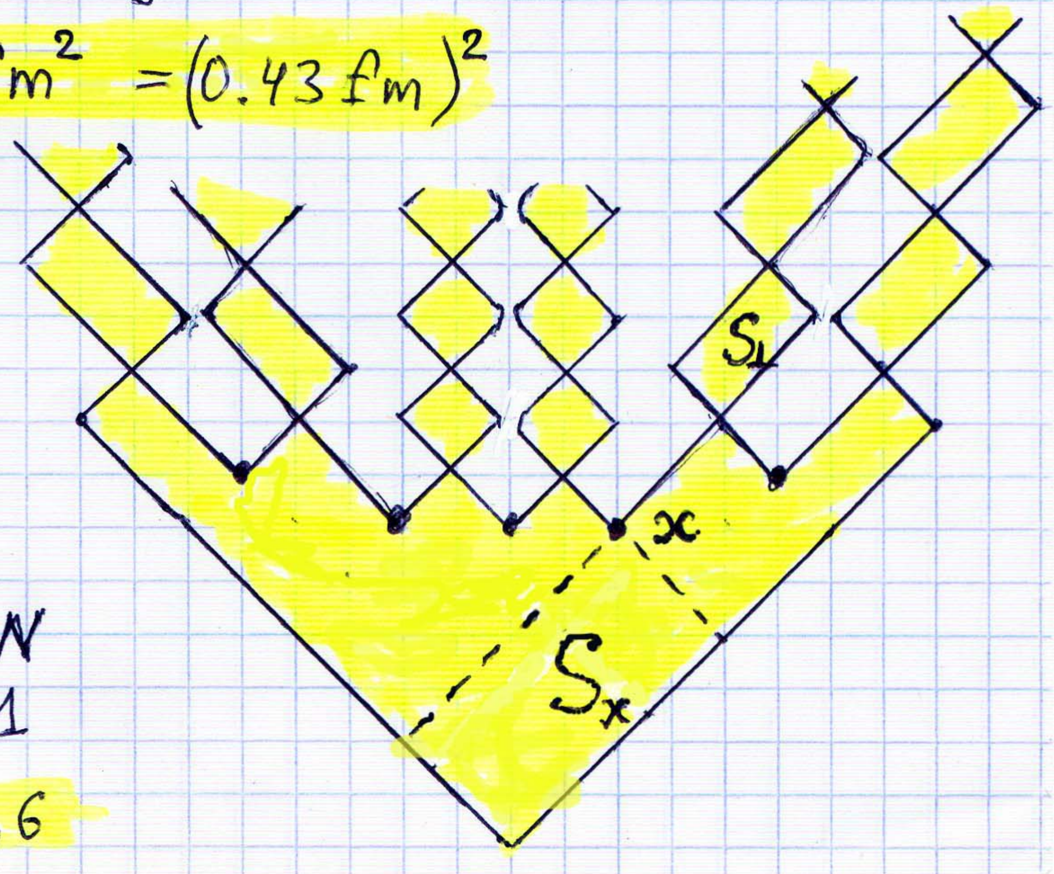
$\langle S_x \rangle = S_0$ $\quad S_0 = 4.6\,GeV^{-2} = 0.18\,fm^2 = (0.43\,fm)^2$

(3) $m_{0\perp}^2$; $m_{0\perp}^2 \equiv \langle m^2 + p_\perp^2 \rangle$;

$m_{0\perp}^2 = 2\gamma^2 S_{0\perp}$;

$\langle S_\perp \rangle = S_{0\perp}$;

	π	ρ	N
$m_{0\perp}^2\,(GeV^2)$	0,11	0,6	1
$S_{0\perp}\,(fm^2)$	0,07	0,36	0,6



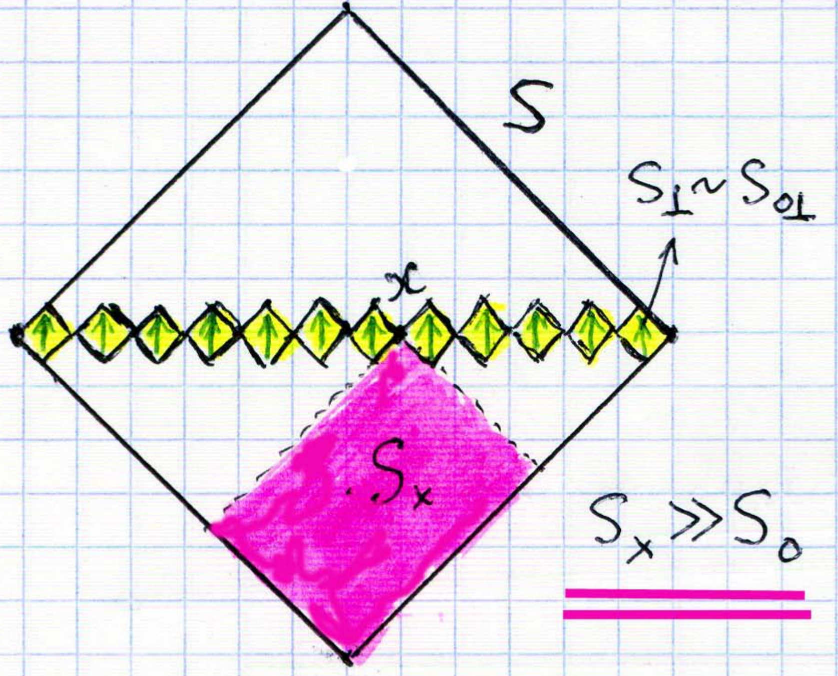
$$M^2 = 2\gamma^2 S;\quad M^2 = (100\,\mathrm{GeV})^2;\quad S = (78\,\mathrm{fm})^2$$

$$dP(x) = \frac{1}{S_0}\, e^{-S_x/S_0}\, dS_x$$

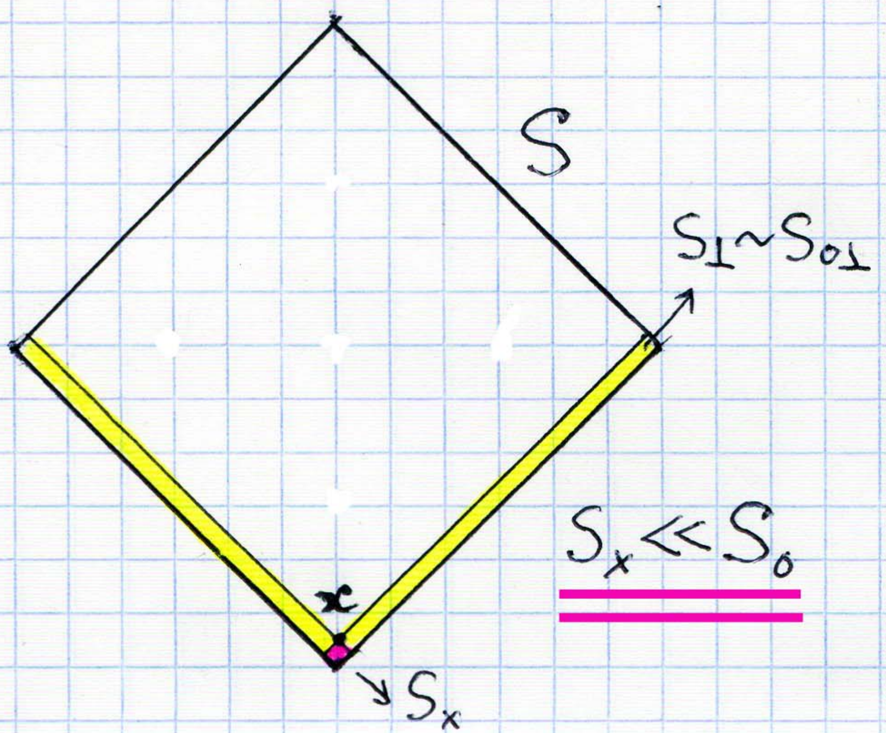
$$\langle S_x \rangle = S_0 = (0{,}43\,\mathrm{fm})^2$$

$$S_{0\perp} = (0.26 \div 0.78\,\mathrm{fm})^2$$

$$S \gg S_0;\, S_{0\perp}$$



$S_x \gg S_0$

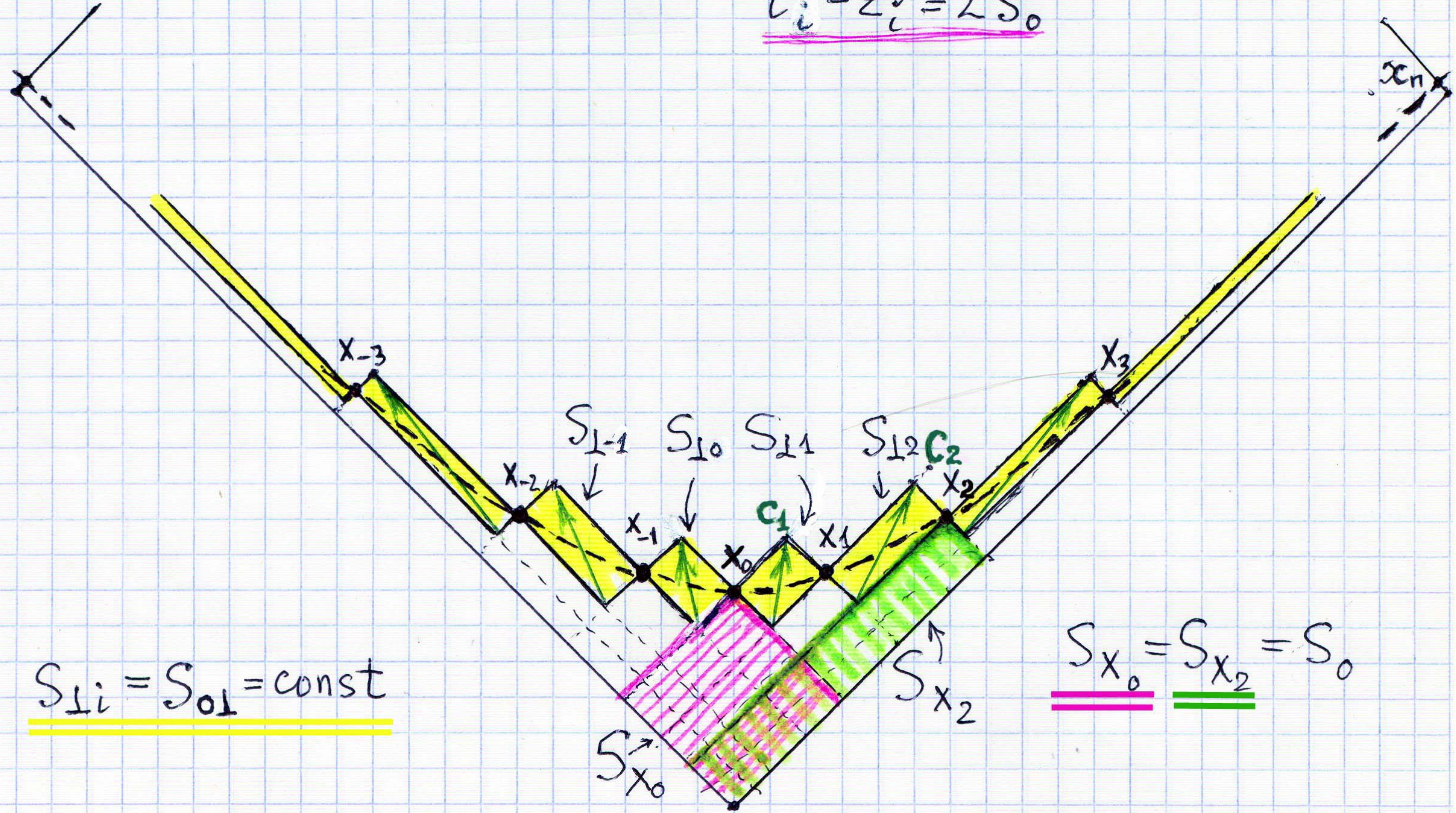


$S_x \ll S_0$

Dominant Process

$$S_{x_i} = S_0; \quad \frac{1}{2} x_i^2 = S_0$$

$$t_i^2 - z_i^2 = 2S_0$$



$$S_{\perp i} = S_{0\perp} = \text{const}$$

$$S_{x_0} = S_{x_2} = S_0$$

$$S_{x_i} = S_0 \Rightarrow \frac{1}{2} x_i^2 = S_0 \,; \quad t_i^2 - z_i^2 = 2 S_0$$

$$S_{\perp i} = S_{0\perp} \Rightarrow \frac{1}{2} c_i^2 = S_{0\perp} = \frac{1}{2} \frac{m_{0\perp}^2}{\gamma^2} = \frac{1}{2} \frac{\langle m^2 + p_\perp^2 \rangle}{\gamma^2} \,;$$

$$p_{i0}^2 - p_{iz}^2 = p_i^2 = \gamma^2 c_i^2 = \langle m^2 + p_\perp^2 \rangle \,; \quad p_i = \gamma c_i \,; \quad \begin{cases} p_{i0} = \gamma c_{i0} \\ p_{iz} = \gamma c_{iz} \end{cases}$$

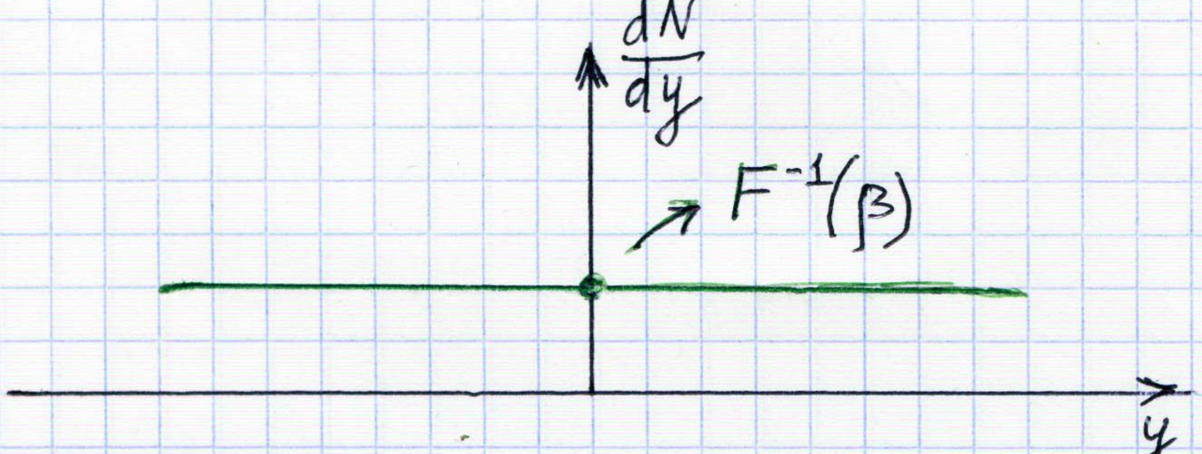
rapidities of produced particles:

$$\Rightarrow \boxed{y_i \equiv \frac{1}{2} \ln \frac{p_{i+}}{p_{i-}} = \left(i - \frac{1}{2}\right) F(\beta)}$$

⇒ Homogeneous distribution!

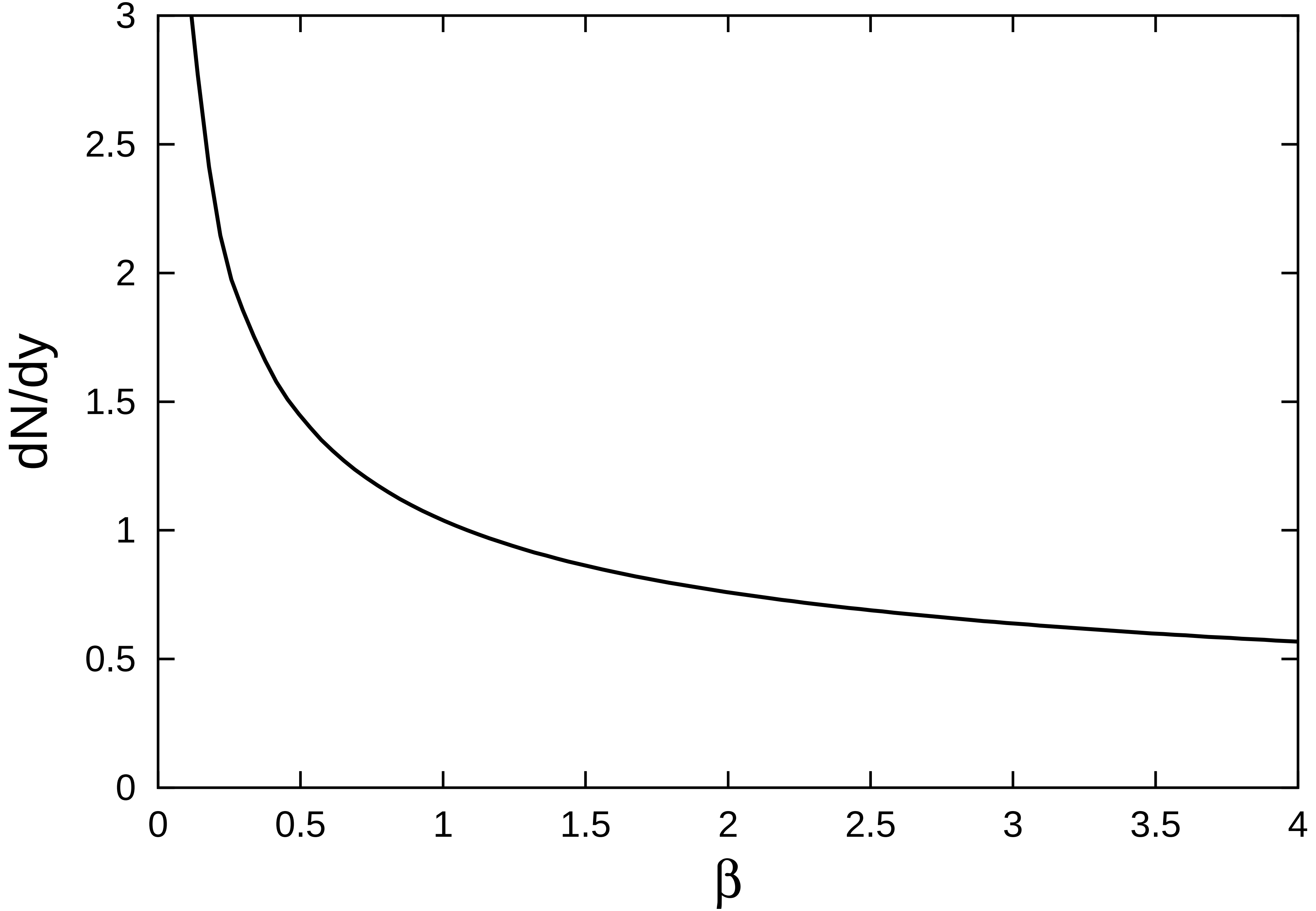
$$F(\beta) = \ln\left[1 + \beta/2 + \sqrt{\beta(1+\beta/4)}\right] ; \quad \boxed{\beta = \frac{S_{0\perp}}{S_0}} = \frac{\langle m^2 + p_\perp^2 \rangle}{2\gamma^2 S_0}$$

$$\boxed{\beta = \alpha_0 \frac{\langle m^2 + p_\perp^2 \rangle}{\gamma}} ; \quad \gamma = 0.18\ \mathrm{GeV}^2$$



$$S_0 = \frac{1}{2\alpha_0 \gamma} ; \quad \alpha_0 = 0{,}6$$

VENUS



dN/dy
β
0
0.5
1
1.5
2
2.5
3
3.5
4

	$\langle m^2+p_\perp^2\rangle$	β	$dN/dy = F^{-1}(\beta)$
π	0,11	0,4	1.5
ρ	0,6	2	0,75 (×2)
N	1	3,3	0,63

~VENUS

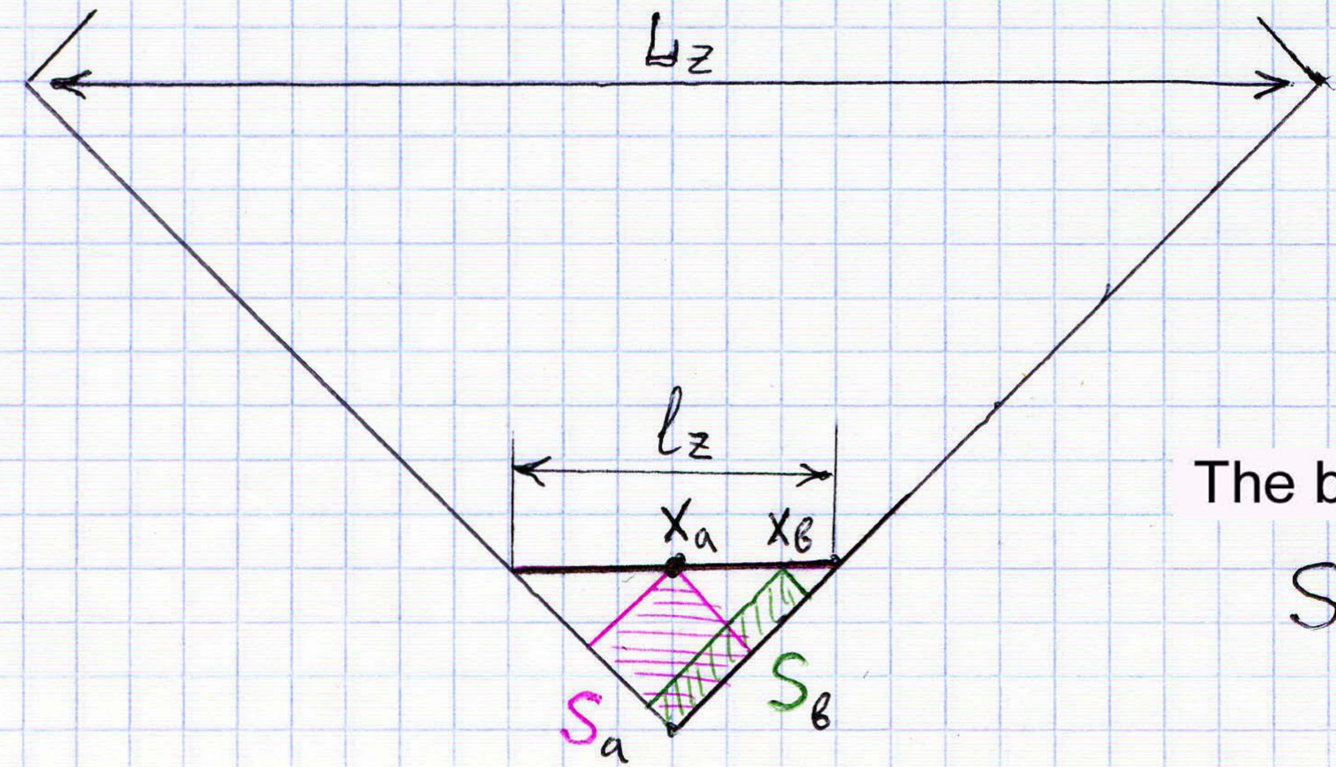
$$M^2 = (100\,\mathrm{GeV})^2;\quad S = M^2/2\gamma^2$$

$$L_z = \sqrt{2}\sqrt{S} = \sqrt{2}\cdot 78\,\mathrm{fm} = 110\,\mathrm{fm}$$

$$S_a = S_0 \Rightarrow$$

$$l_z = 2\sqrt{2}\sqrt{S_0} = 2\sqrt{2}\;0{,}43\,\mathrm{fm}$$

$$l_z = 1{,}2\,\mathrm{fm}$$



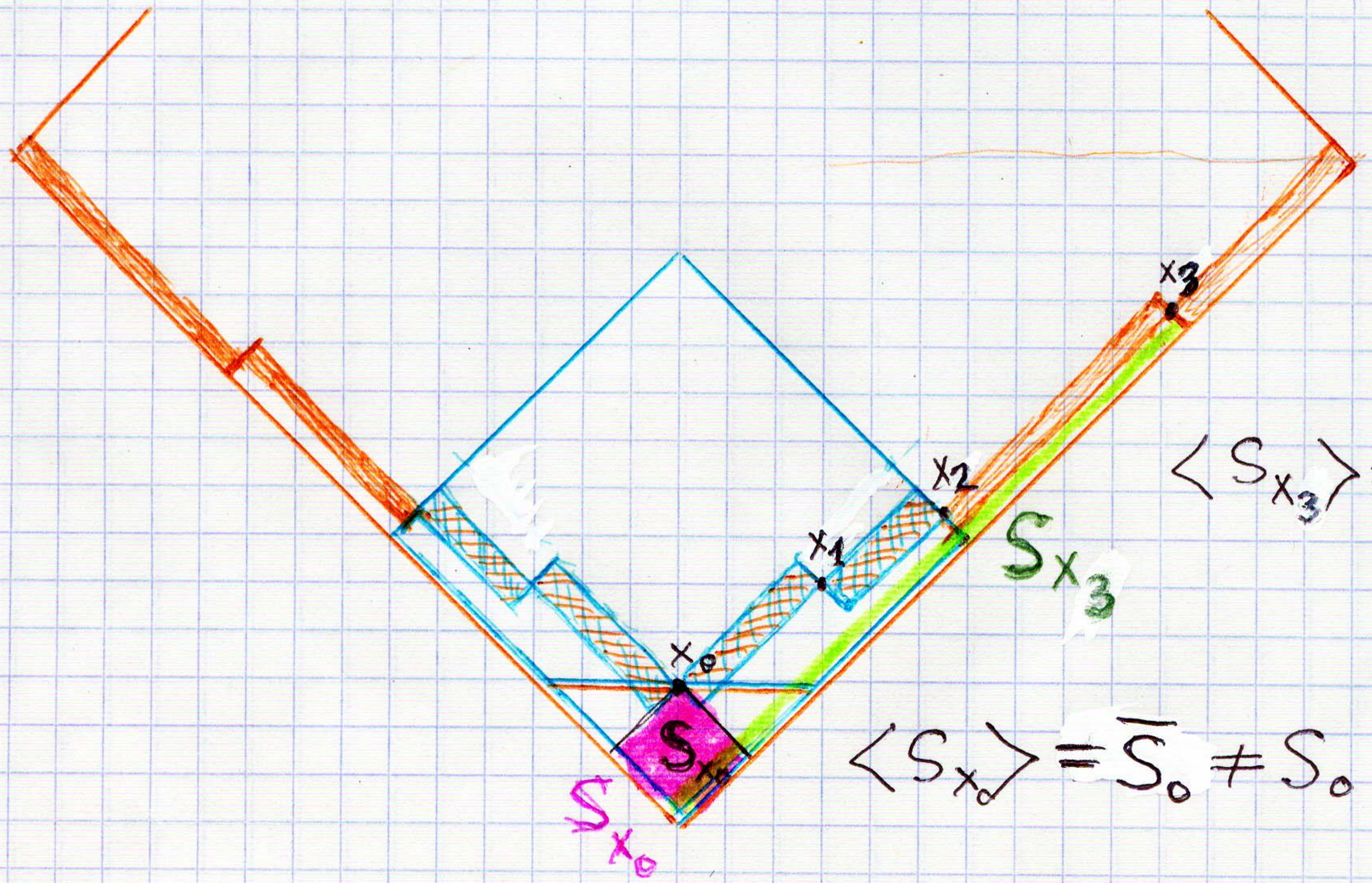
$$dP = \frac{1}{S_0} e^{-\frac{S}{S_0}} dS$$

The break is in the middle, as

$$S_a > S_b$$

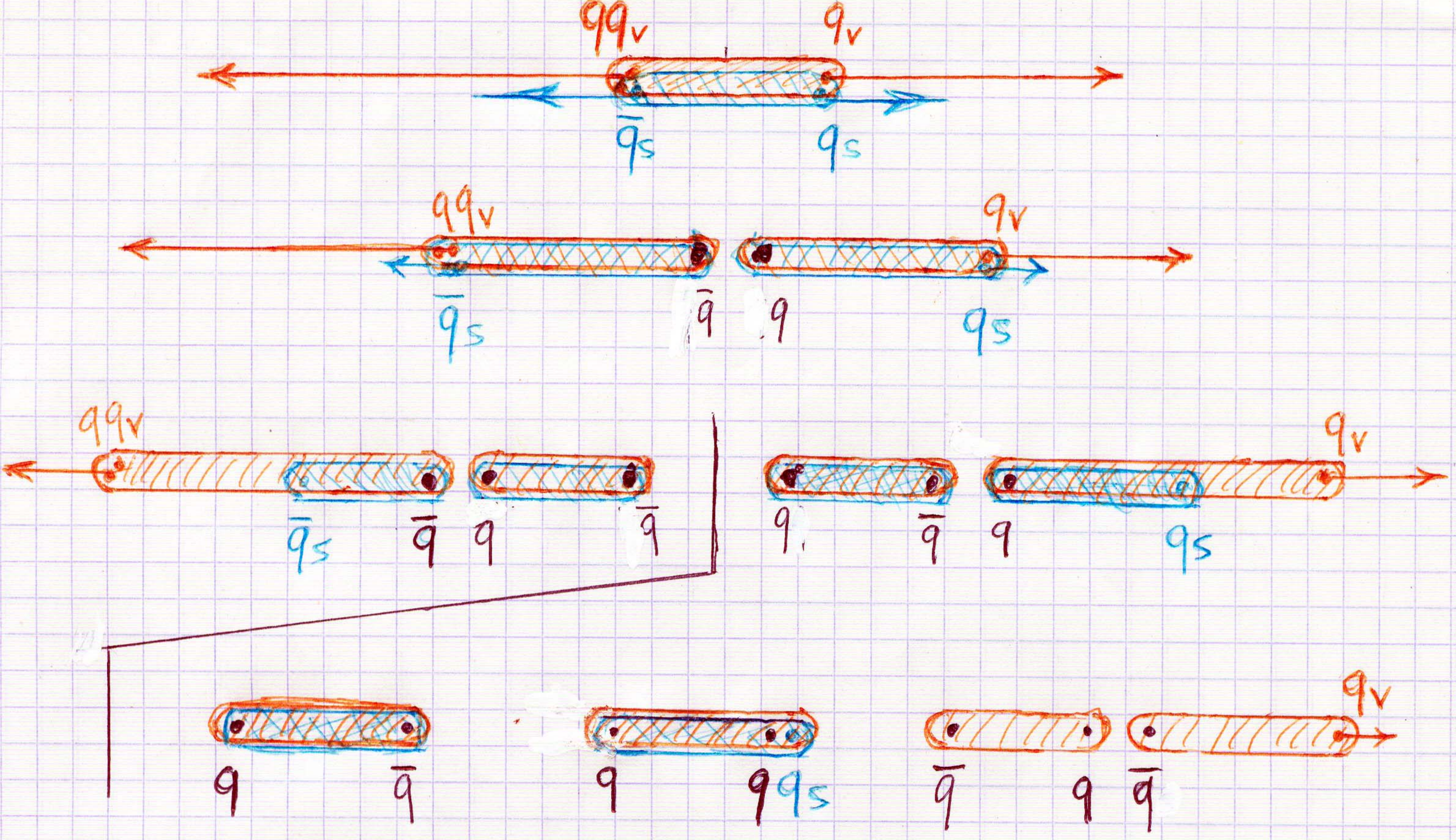
The Space-Time Picture of String Fusion

$M^2 > M^2$



$\langle S_{x_3} \rangle = f(\bar{S}_0, S_0)$

$\langle S_{x_0} \rangle = \bar{S}_0 \neq S_0$



qq_v
q_v
$\bar{q}_s$
q_s
qq_v
q_v
$\bar{q}_s$
$\bar{q}$
q
q_s
qq_v
q_v
$\bar{q}_s$
$\bar{q}$
q
$\bar{q}$
q
$\bar{q}$
q
q_s
q_v
q
$\bar{q}$
q
$q\,q_s$
$\bar{q}$
q
$\bar{q}$