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DIS-CHICAGO
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New UA8 Diffractive Results: Implications and Predictions

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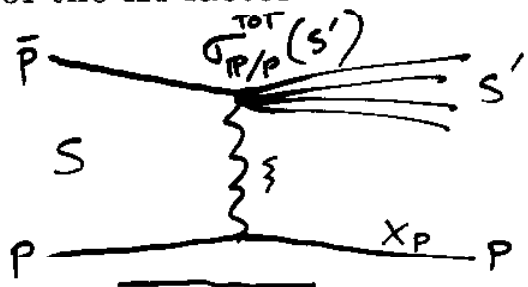
→ 1 Evidence for saturation of the Pomeron Flux Factor $F_{\mathbb{P}/p}(\xi, t)$ caused by damping small $\mathcal{P}$omeron momentum in the proton.

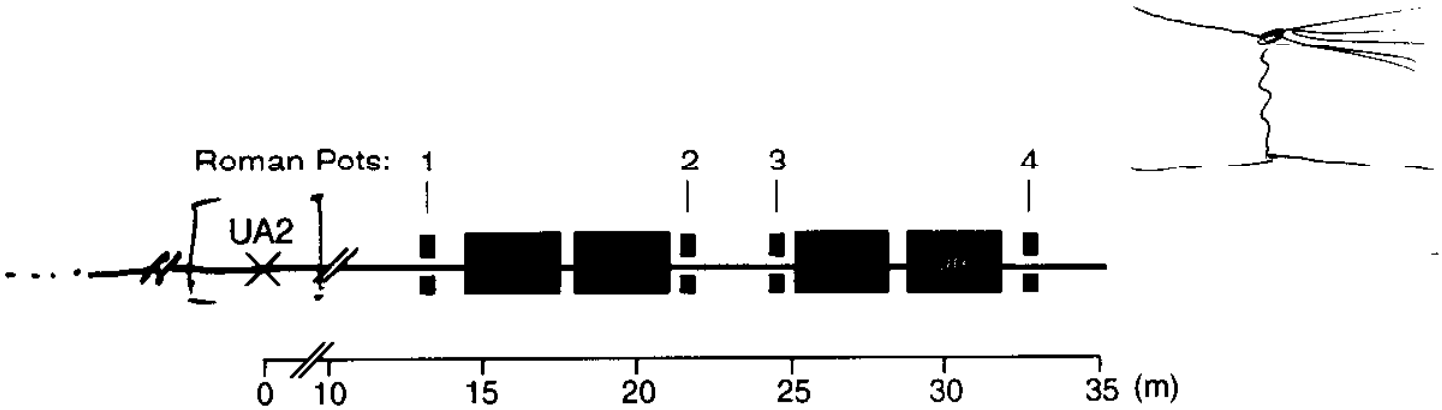
→ 2 Cross section measurements of Hard Diffraction at the S$p\bar{p}$S-Collider. Determination of the fK factor and predictions for the Tevatron.



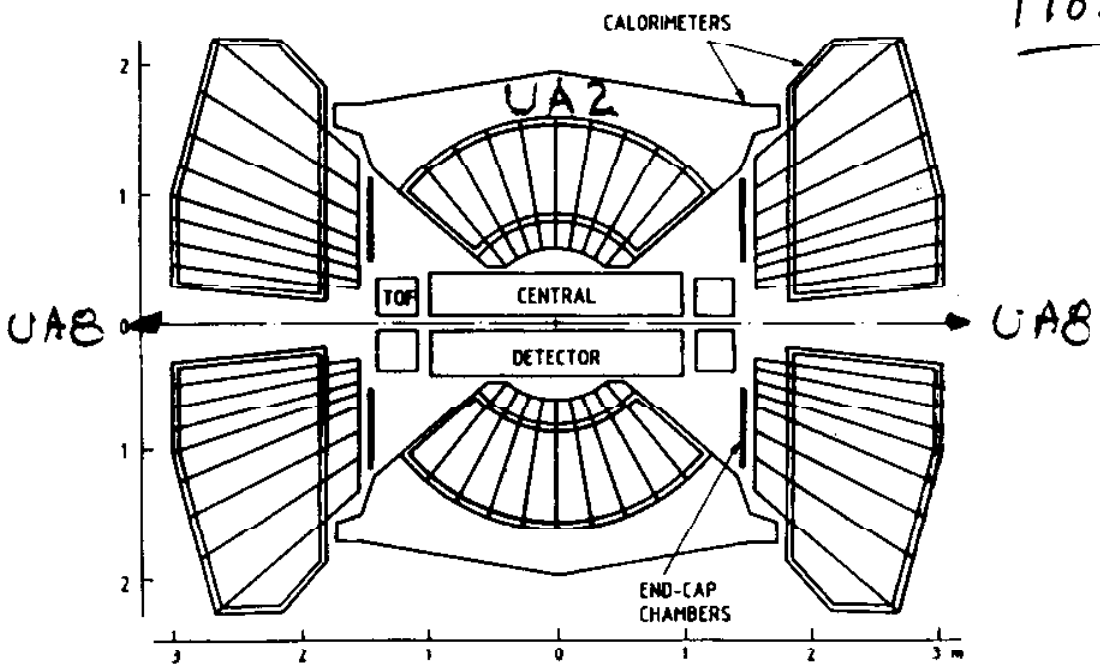
P. L. B211 (1988) 239
P. L. B297 (1992) 417

$\boxed{s' = \xi s}$ $\xi + x_p = 1$

~BACKGROUND-FREE FOR $\xi \lesssim .03$



1985-1989



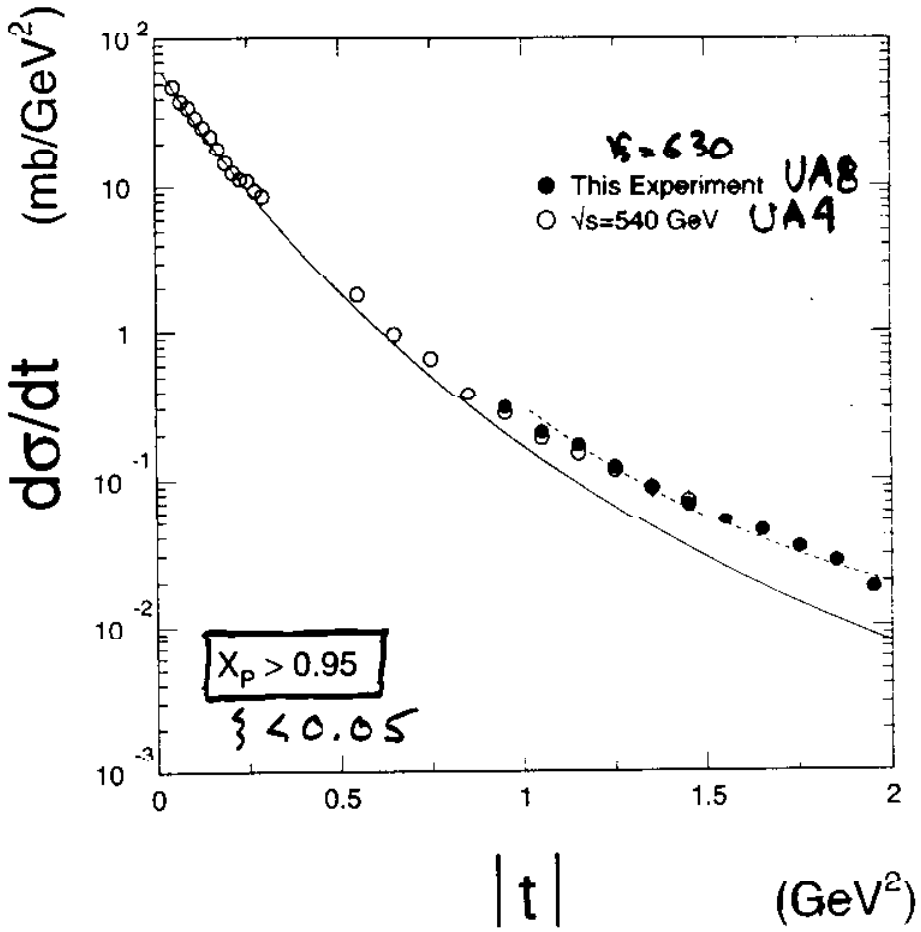
UA8 is the first experiment to trigger a large central detector with Roman-pot spectrometers.

Use ROMAN Pot Spectrometer to measure protons and provide tagged $\mathcal{P}$ beam.

System X studied in the UA2 calorimeter. $\bar{p}p \to X + p$
$\to \bar{p} + X$

$$\boxed{\bar{p}p \rightarrow \bar{p} + X \quad + \text{ c.c.}}$$

$$\frac{d\sigma}{dt} = \int_{\xi_{min}}^{.05} \frac{d^2\sigma}{d\xi\, dt}\, d\xi$$



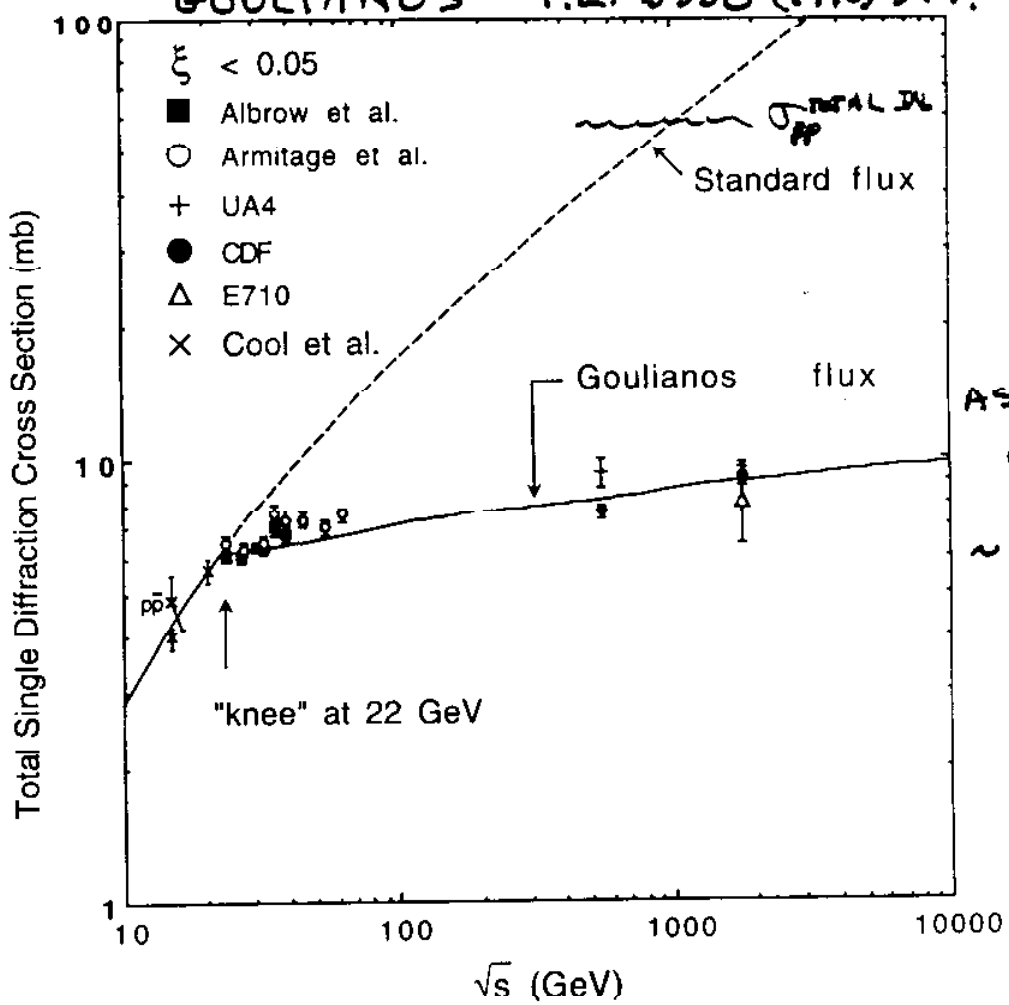
GOOD AGREEMENT

$$\frac{d^2\sigma}{d\xi\, dt} \propto \xi^{1-2\alpha(t)} \overset{t\sim 0}{\approx} \frac{1}{\xi}$$

$$\xi_{min} = \frac{s'_{min}}{s} = \frac{(m_p + m_\pi)^2}{s}$$

GOULIANOS P.L. B358 (1995) 379.

σ_{sd}^{TOTAL} (mb)



ASSUMES $\sigma_{p/p}^{TOT}(s') \sim (s')^{\epsilon}$

GOULIANOS SHOWS THAT DATA REQUIRE $\Longrightarrow \iint F_{p/p}(\xi,t)\, d\xi\, dt$ = CONSTANT (s-independe

AT LEAST TWO WAYS TO DO THIS
1. DIVIDE BY INTEGRAL ("RENORMALIZE GOULIANOS)
2. DAMP SMALL ξ VALUES

DECIDE BY STUDYING $\frac{d^2\sigma}{d\xi\, dt}$ AS FUNCTION OF

FIT TO ALL AVAILABLE DATA

$$\frac{d^2\sigma}{d\xi dt} = F_{\mathcal{P}/p}(\xi,t)\sigma^{total}_{\mathcal{P}p}(s')$$

$$F_{\mathcal{P}/p}(\xi,t) = K\,|F_1(t)|^2\,\xi^{1-2\alpha(t)}\,e^{bt}$$

$$\alpha(t) = 1 + 0.115 + 0.26t + \alpha'' t^2 \quad (\underline{CDF})$$

$$F_1(t) = \frac{4m^2 + 2.8|t|}{4m^2 + |t|}\,\frac{1}{(1+|t|/0.71)^2}$$

DONNACHIE LANDSHOFF

$$\sigma^{total}_{\mathcal{P}p}(s') = \sigma^{o}_{\mathcal{P}p}\,[(\xi s)^{0.08} + r\,(\xi s)^{-0.45}]$$

(s')

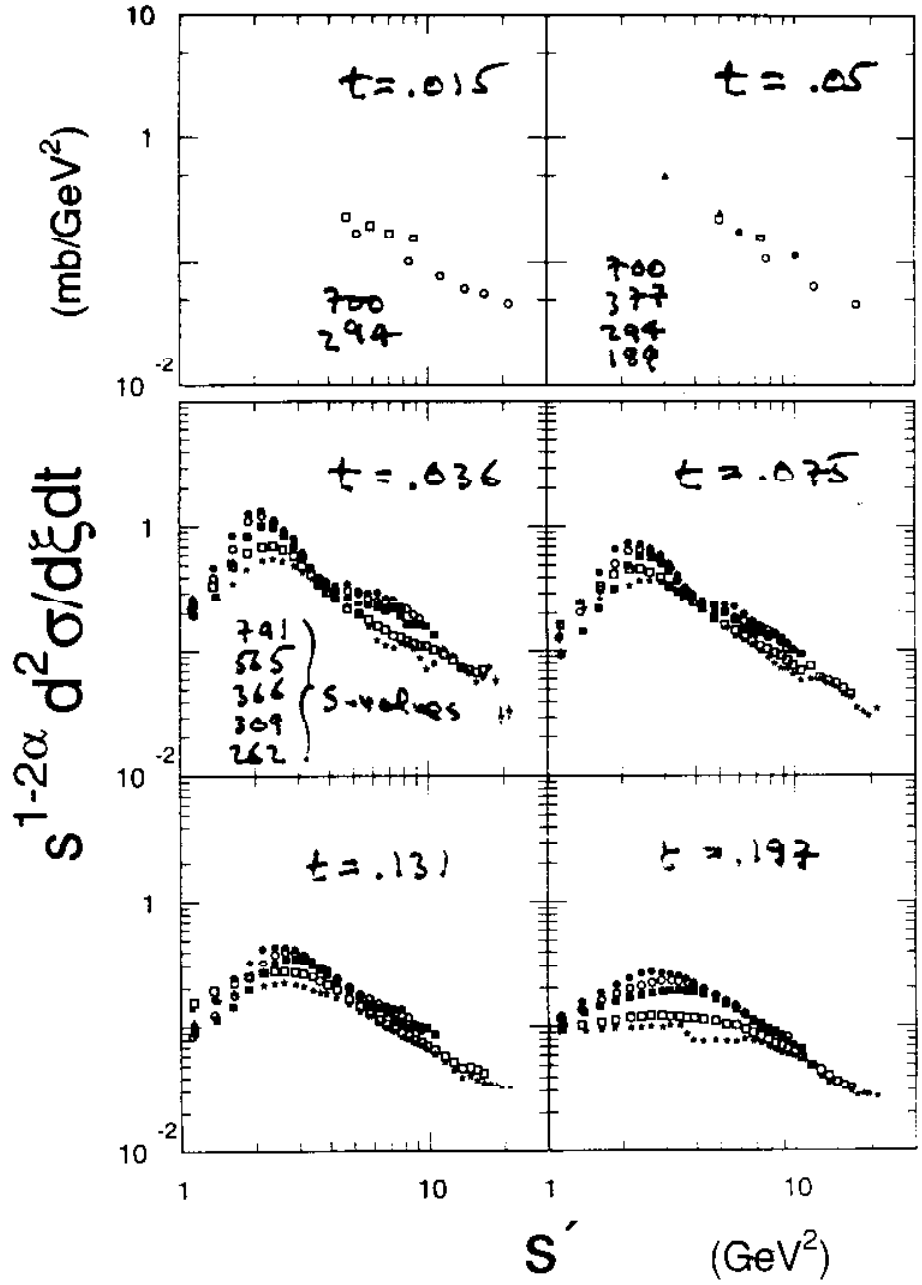
2 COMPONENTS AS ALL OTHER HADRONIC TOTAL σ'S

Fit with Four free parameters:

$$\begin{aligned}
\alpha'' &= 0.075 \pm 0.017\ \mathrm{GeV}^{-4} \\
b &= 0.75 \pm 0.27\ \mathrm{GeV}^{-2} \\
K\sigma^{o}_{\mathcal{P}p} &= 0.73 \pm 0.09\ \mathrm{mbGeV}^{-2} \\
r &- 5.0 \perp 0.6
\end{aligned}$$

Fermilab CΦ INTERNAL TARGET

$\xi_{max} = .03$



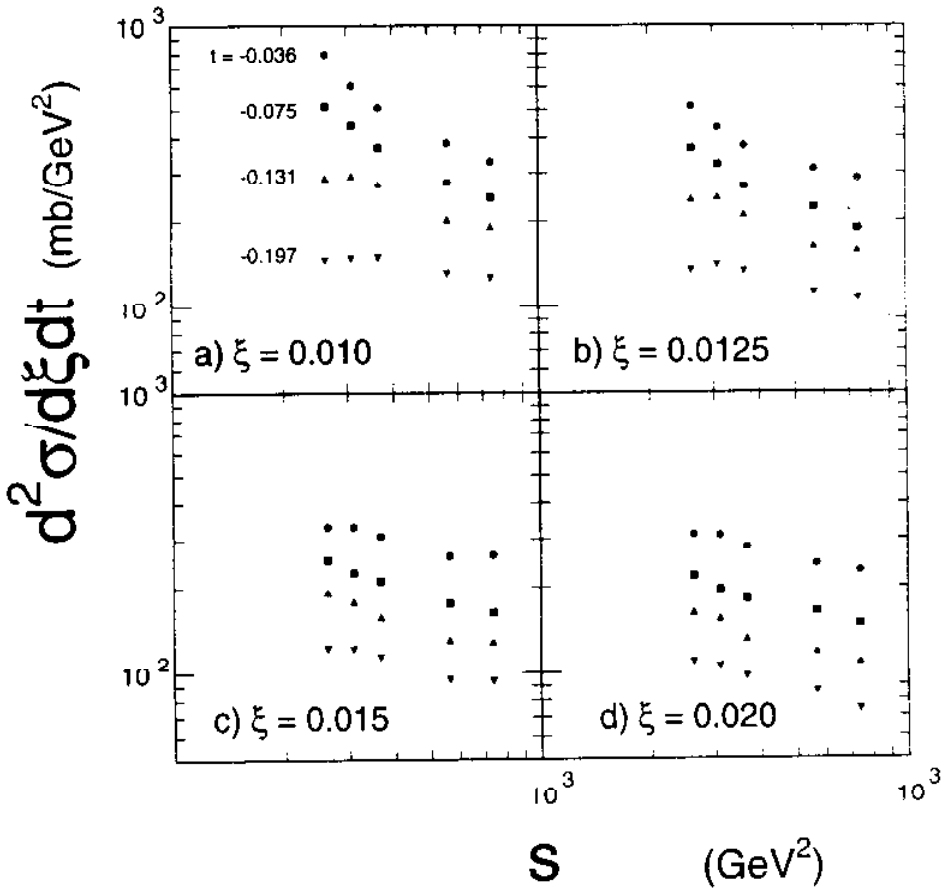
Akimov et al
Cool et al
Akison et al

SHAMBERGER et al.

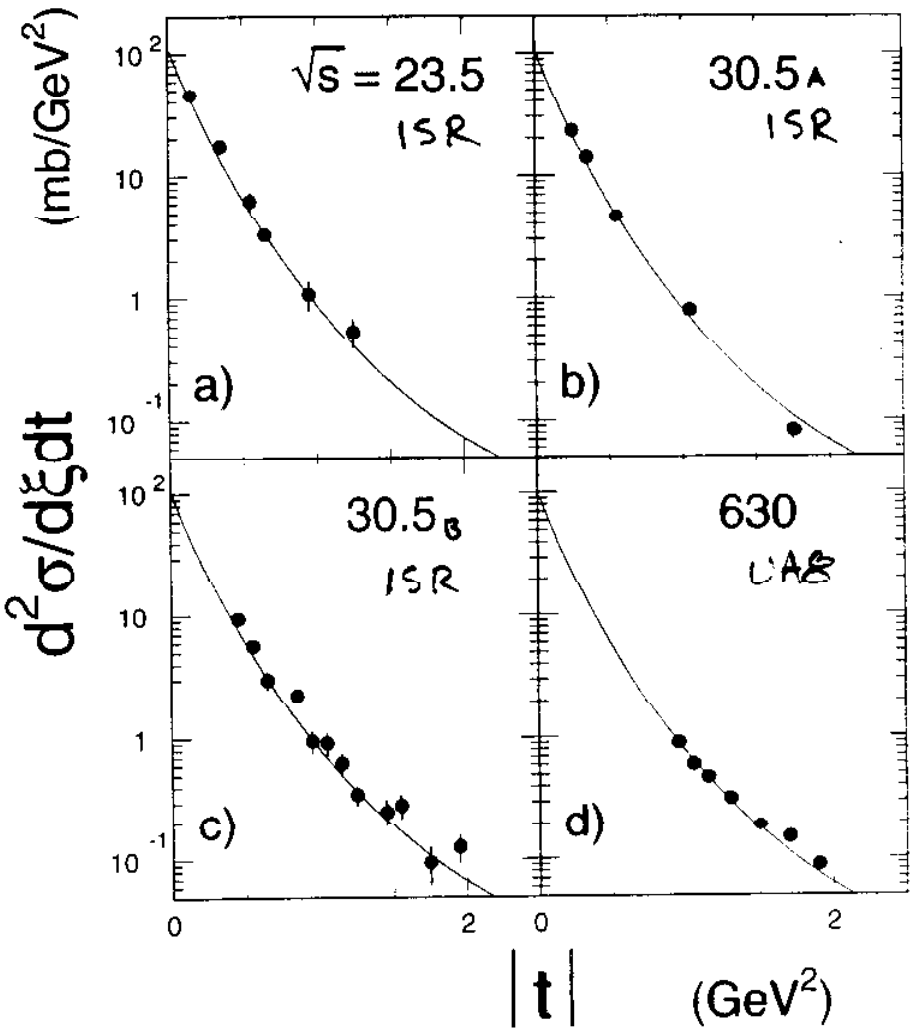
"

CONCLUDE: REGGE FORMULA NOT APPLICABLE FOR $s' \lesssim 10$ GeV^2

Fermilab Fixed Target σ_{sd} measurements (Schamberger at al (C0) [Phys. Rev. D 17(1978)1268]) demonstrate that $\sigma_{\bar{p}p}^{total}$ decreases with $s' = \xi s$ at small s'.

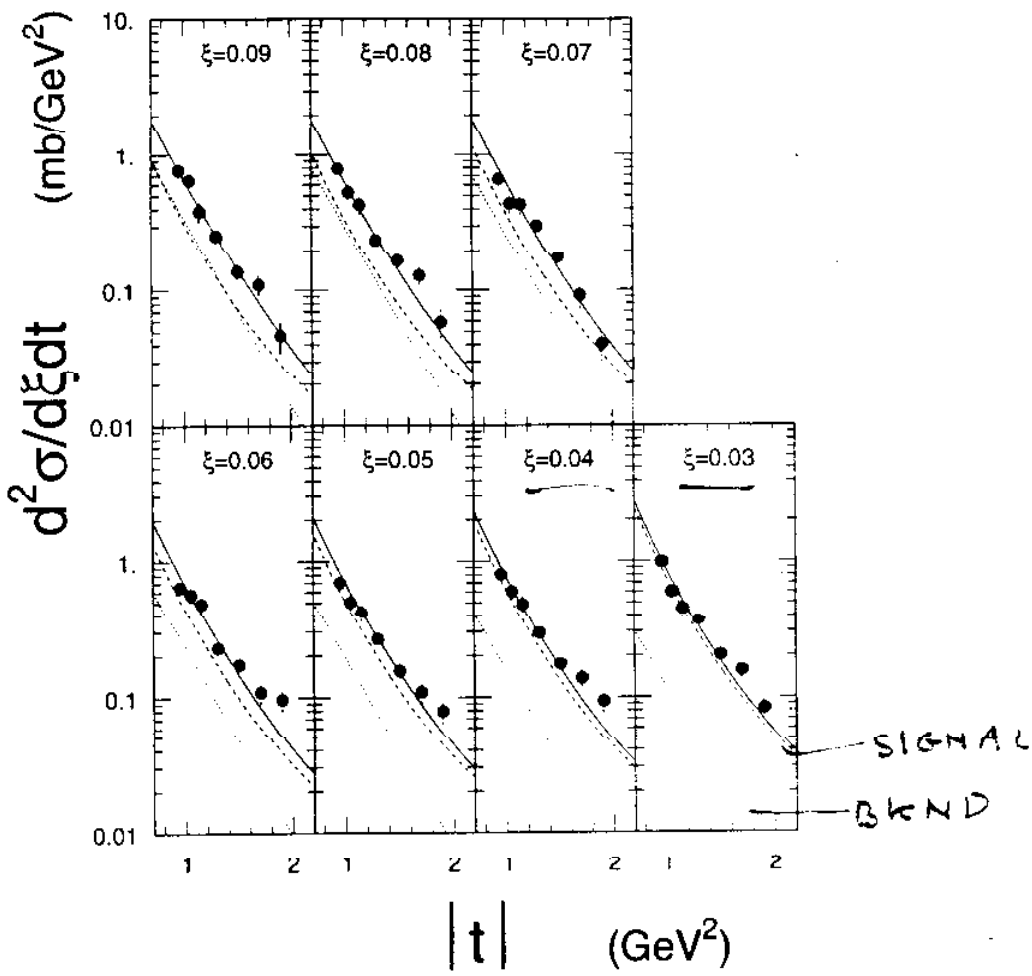


NON-P-EXCHANGE
BACKGROUND-FREE



Fit to UA8 data at larger ξ including background

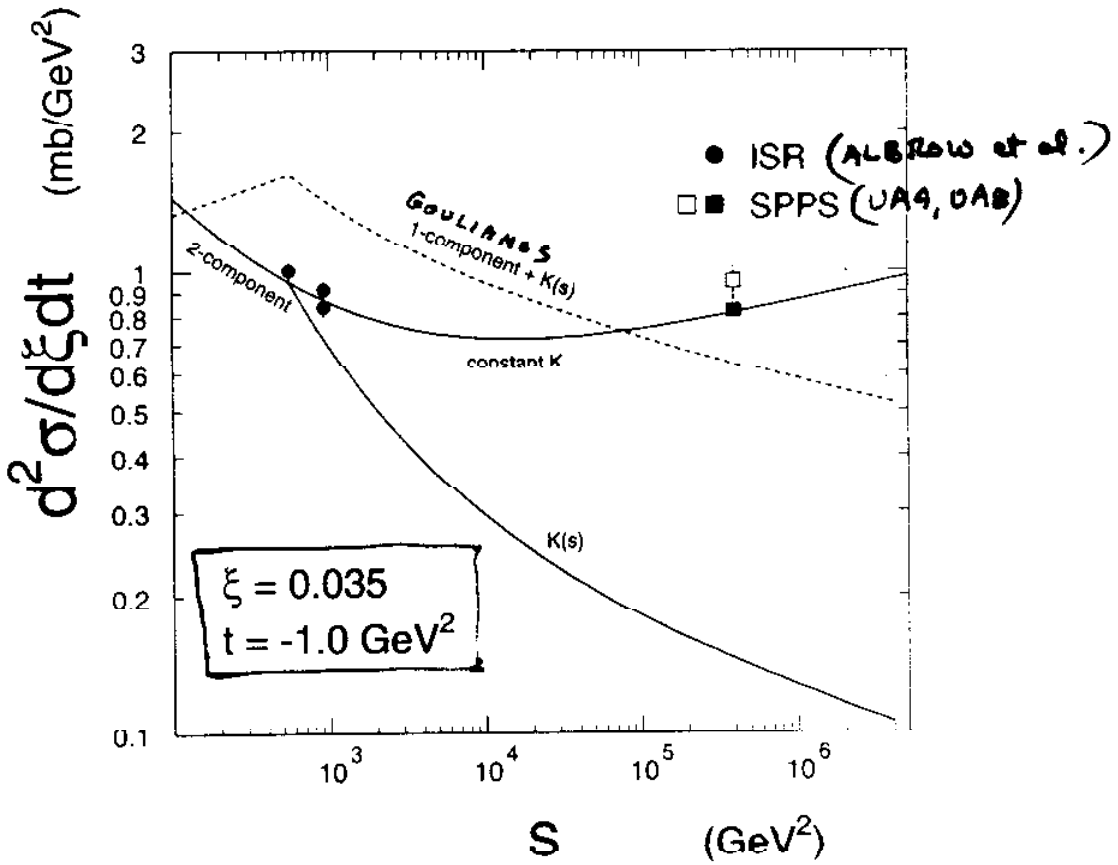
$$\frac{d^2\sigma}{d\xi dt}_{BG} = A\, e^{ct}\, \xi^{\gamma}$$



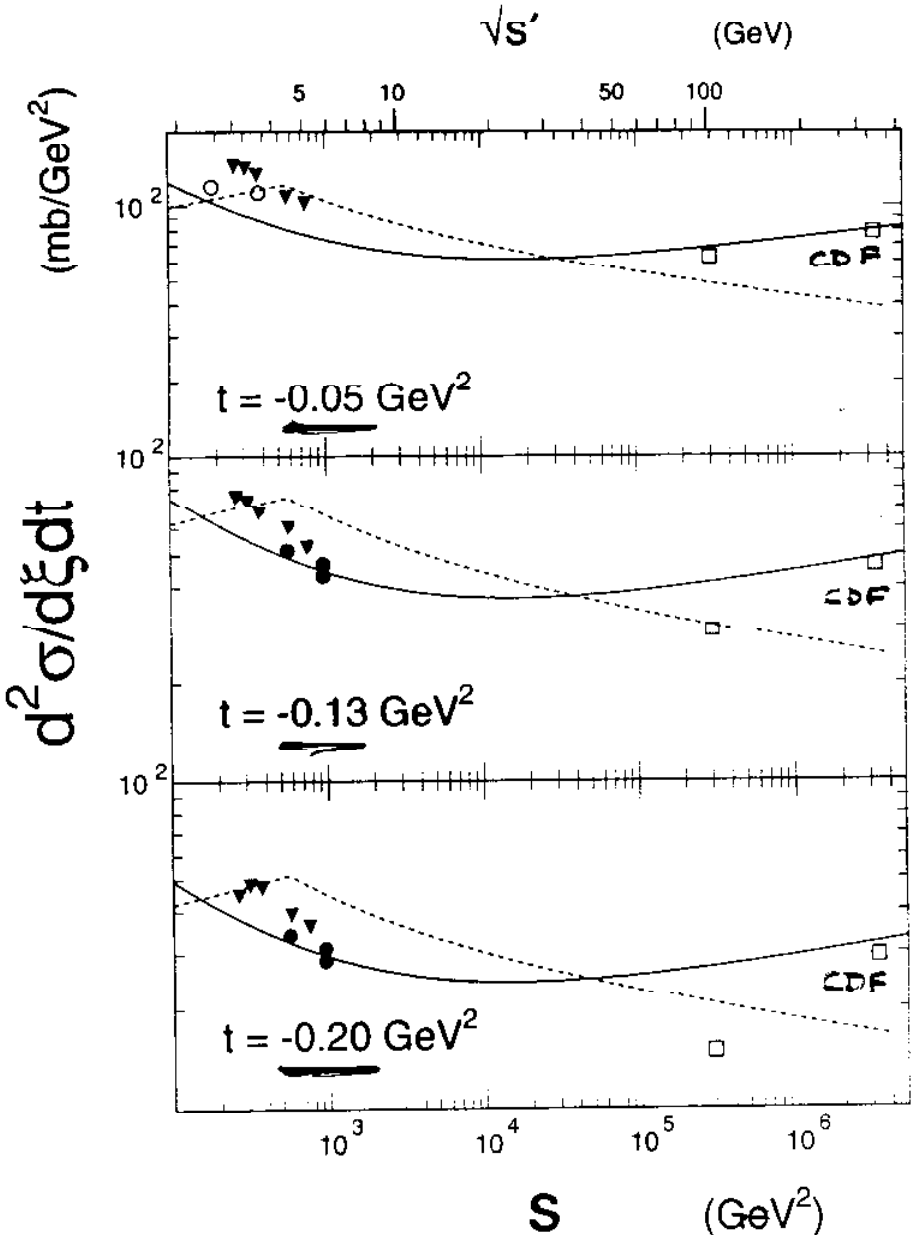
CONCLUDE

BACKGROUND NEGLIGIBLE FOR $\xi = 0.03 - 0.04$

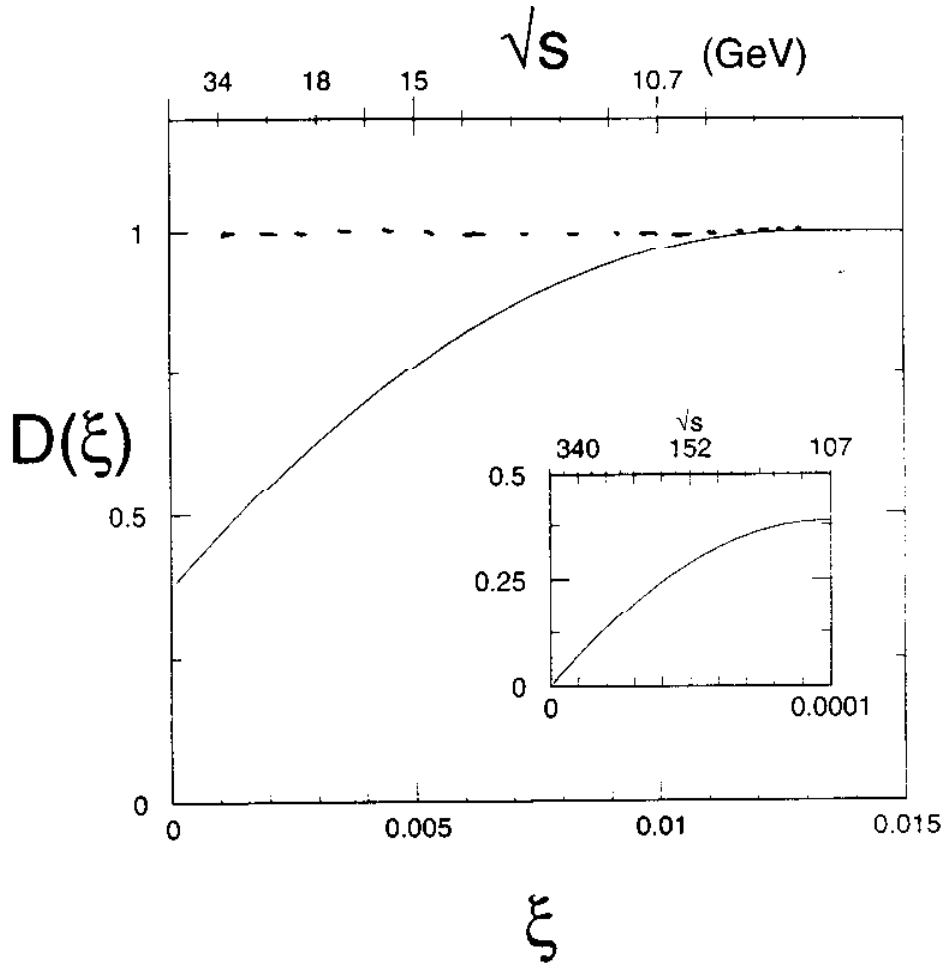
(A 20-year old conclusion from ISR - Albrow et


$d^2\sigma/d\xi dt$ (mb/GeV^2)
3
2
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
10^3
10^4
10^5
10^6
S (GeV^2)
ISR (ALBROW et al.)
SPPS (UA4, UA8)
GOULIANOS
1-component + K(s)
2-component
constant K
K(s)
$\xi = 0.035$
$t = -1.0$ GeV^2

$\xi = 0.035$

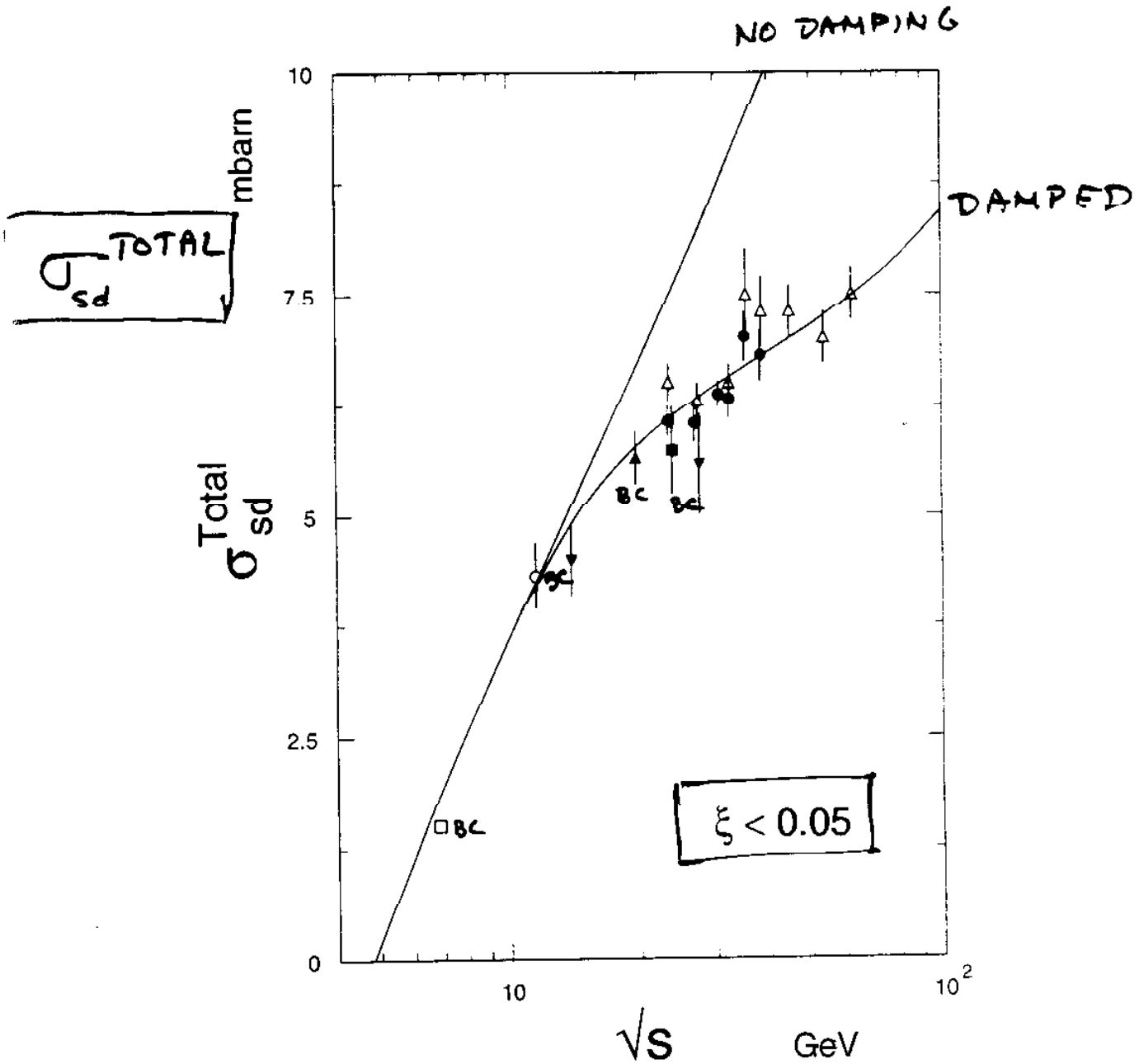

√s′ (GeV)
5
10
50
100
(mb/GeV²)
d²σ/dξdt
10²
t = -0.05 GeV²
CDF
t = -0.13 GeV²
t = -0.20 GeV²
10³
10⁴
10⁵
10⁶
S (GeV²)

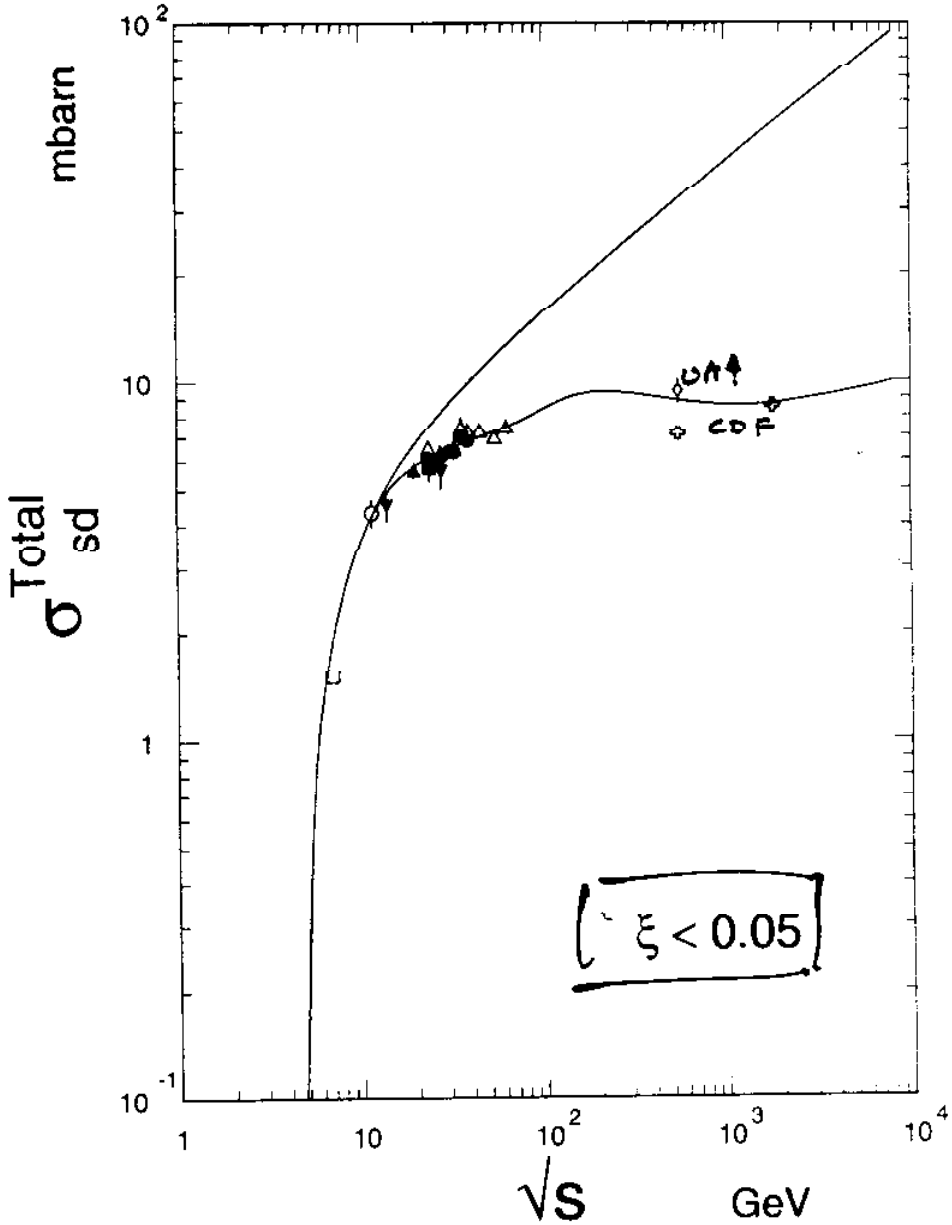
to understand σ_{sd}^{total}
need damping at small ξ



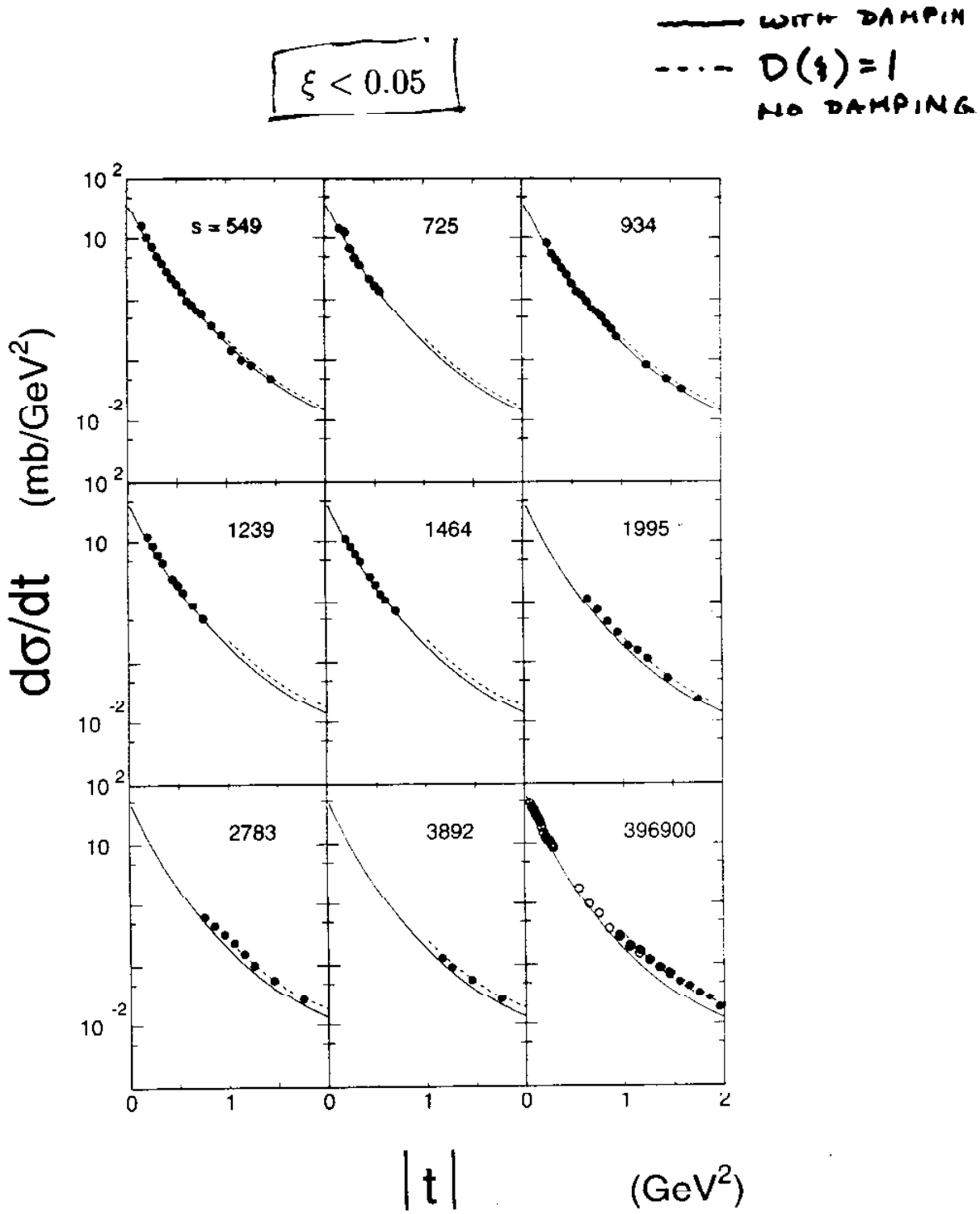
DEFINE NEW POMERON FLUX FACTOR IN PR

$$F'_{P/p}(\xi,t) = F_{P/p}(\xi,t) \cdot D(\xi)$$


NO DAMPING
DAMPED
σ_{sd}^{TOTAL}
mbarn
σ_{sd}^{Total}
10
7.5
5
2.5
0
10
10^2
$\sqrt{s}$ GeV
BC
$\xi < 0.05$


mbarn
σ_{sd}^{Total}
10^2
10
1
10^{-1}
1
10
10^2
10^3
10^4
$\sqrt{s}$
GeV
UA4
CDF
$\xi < 0.05$

$\frac{d\sigma}{dt}$



DAMPING NOT NEEDED FOR $|t| \gtrsim 0.5$

$\Rightarrow$ DAMP SMALL $P_{\mathbb{P}}$, NOT JUST LONGITUDINAL COMPONENT

EVIDENCE FOR DAMPING IN PUBLISHED CDF x_p DISTRIBUTION ?
[P.R. D50 (1994) 5535]

EVALUATE RATIO $\frac{\text{EVENTS IN } 1^{st} \text{ BIN } (x=1)}{\text{EVENTS IN } (1\text{-}5) \text{ BINS}}$

$$D = \frac{N_{peak}}{\sum_{i=1}^{5} N_i}$$

D

|t|	.0	.05	.10	.20
No Damp	.62	.61	.59	.56
Damp	.46	.44	.43	.40

Monte Carlo WITH RESOLUTION, EFFICIENCY, etc.

CDF (1800 GeV) D = 0.47

$\Longrightarrow$ CONSISTENT WITH DAMPING

UA8 JETS

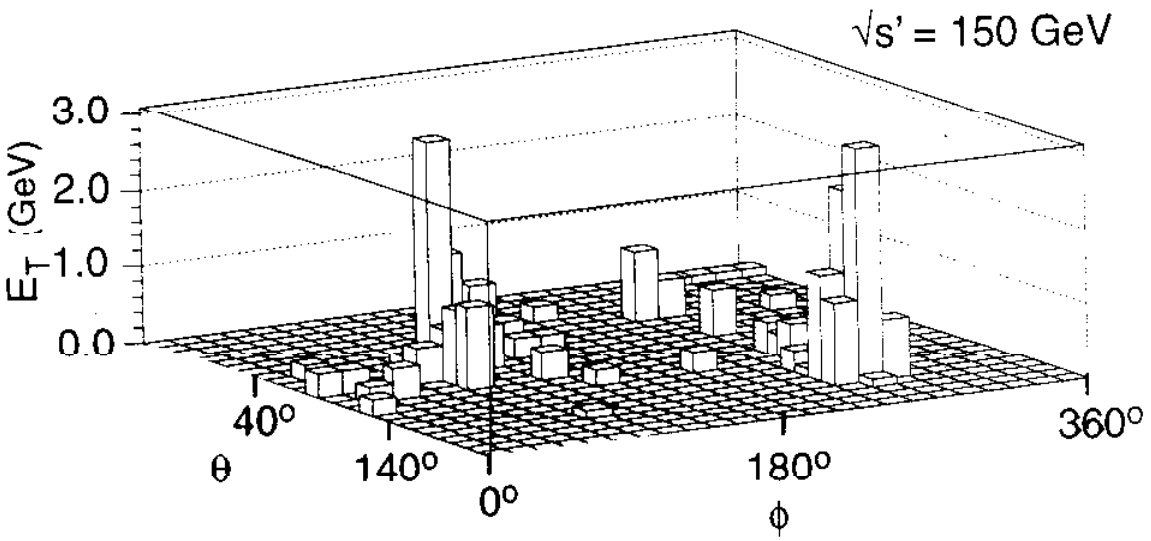
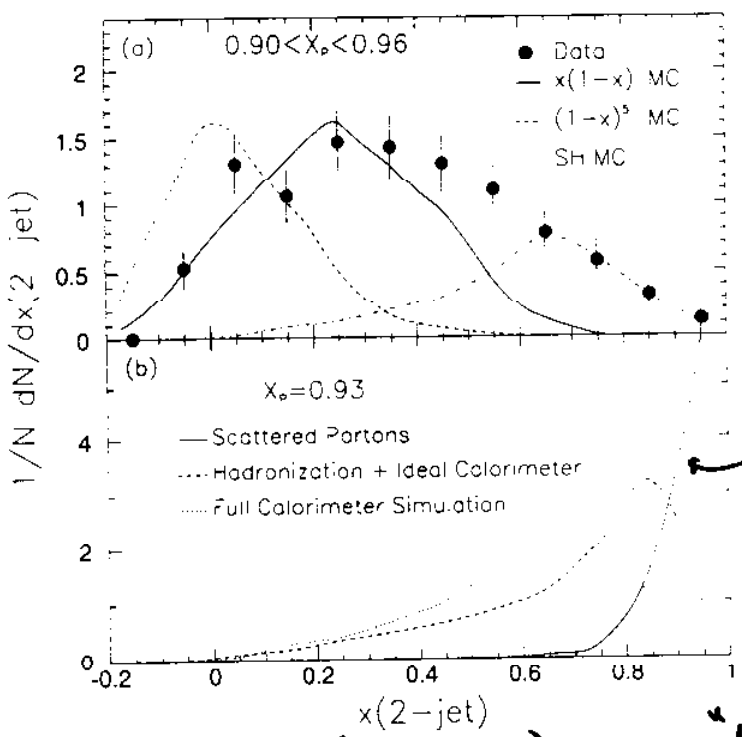


Figure 3: A typical raw UA8 2-jet event display in the UA2 calorimeter: cell energies in a θ vs. ϕ projection (the complete event is shown). Each jet has $E_T^{jet} > 8$ GeV. The proton in this event had a measured $\tau_p = 0.94$.

BRANDT ET AL. - 1
PL B297 (1992) 4

The longitudinal momentum of the complete 2-jet system along the $\mathcal{P}$omeron-proton axis in the $\sqrt{s'}$ system more directly reflects the differences between the parton distributions in the $\mathcal{P}$omeron and in the proton.



X (2-JETS)

"SINGULAR" GLUONS BEFORE SMEARING + HADRONIZATION + CALORIMETER

"HARDER THAN HARD" ≡ SUPER-HARD

The $\mathcal{P}$omeron exibits a hard structure like $1-x$. In (30%) of the observed events, entire momentum of the $\mathcal{P}$omeron seems to participate in hard scattering.

No detectable dependence on t or x_{p}

FACTORIZATION

$$\frac{d^2\sigma_{sd}^{jets}}{d\xi dt} = F_{\mathcal{P}/p}(\xi,t)\,\sigma_{\mathcal{P}p}^{jets}(s')$$

$$\frac{d^2\sigma_{sd}^{total}}{d\xi dt} = F_{\mathcal{P}/p}(\xi,t)\,\sigma_{\mathcal{P}p}^{total}(s')$$

$$R = \frac{\frac{d^2\sigma_{sd}^{jets}}{d\xi dt}}{\frac{d^2\sigma_{sd}^{total}}{d\xi dt}} = f \cdot \frac{\sigma_{\mathcal{P}p}^{jets}}{\sigma_{\mathcal{P}p}^{total}}.$$

$f = 1.0$ in INGELMAN/SCHLE

A new (unknown) multiplicative factor, f, explicitly introduced into the right-hand side of the equation where $f \neq 1.0$ corresponds to a possible breakdown of the momentum sum rule in the $\mathcal{P}$omeron.

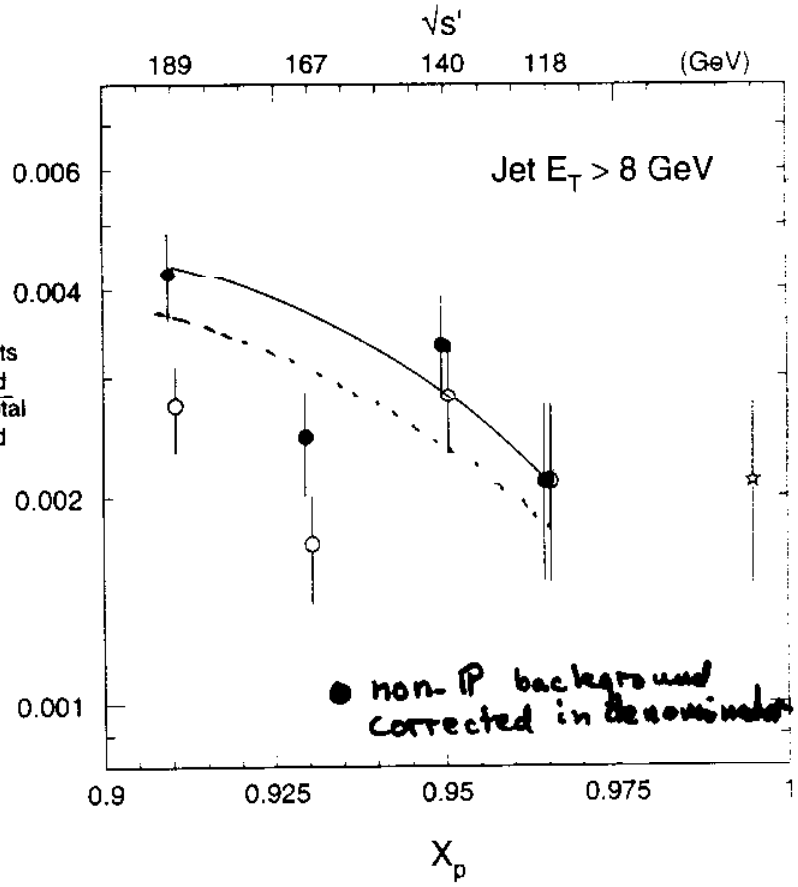
$$R = \frac{\Delta\sigma_{sd}^{jets}}{\Delta\sigma_{sd}^{total}} = \frac{N_j/(L_j\epsilon_j A_j)}{N_{sd}/(L_{sd}\epsilon_{sd})}$$

CROSS SECTION MEASUREMENTS OF HARD DIFFRACTION AT THE $S\bar{p}pS$ COLLIDER — UA8

TO BE SUBMITTED TO PHYSICS LETTERS

The s'-dependence of the experimental ratio R can be predicted using the calculated $\sigma_{\bar{p}p}^{jets}$ and assuming that $\sigma_{\bar{p}p}^{total} \sim (s')^{\epsilon}$ and the normalization is given by the low-background point at $\xi = 0.035$.

$$R = \frac{\Delta\sigma_{sd}^{jets}}{\Delta\sigma_{sd}^{total}}$$



curve is $= \dfrac{\sigma_{\bar{p}p}^{jets}(s')}{(s')^{\epsilon}}$

[CURVE VS $\sqrt{s'}$ IS A DIRECT FACTORIZATION FOR TEVATRON]

With the known form of $F_{\mathcal{P}/p}(\xi, t)$, we can extract a second measurable quantity, P:

$$P = \frac{d^2\sigma_{sd}^{total}/d\xi dt}{|F_1(t)|^2 e^{bt}\xi^{1-2\alpha(t)}} = K \cdot \sigma_{\mathcal{P}p}^{total}$$

Finally we calculate the product fK, in terms of P, R and $\sigma_{\mathcal{P}p}^{jets}$ at $\sqrt{s'}$= 118 GeV:

$$f \cdot K = \frac{P \cdot R}{\sigma_{\mathcal{P}p}^{jets}}$$

$fK = 0.24 \pm 0.07(\text{stat}) \pm 0.07(\text{sys})$ gluonic-$\mathcal{P}$,
$fK = 0.45 \pm 0.13(\text{stat}) \pm 0.13(\text{sys})$ $q\bar{q}$-$\mathcal{P}$.

If the $\mathcal{P}$ is like a real particle, the Donnachie-Landshoff value, $K = 0.78$, is thought to be "the only reasonable normalization of the Flux-Factor" and the momentum sum rule might be true ($f = 1.0$). PVL

However, if K has the Donnachie-Landshoff value, we obtain $f - 0.30$ for gluonic-$\mathcal{P}$, while for $q\bar{q}$-$\mathcal{P}$, $f = 0.58$.

It seems clear that the momentum sum rule is violated.

Conclusions

- $\sigma_{\mathcal{P}p}^{total}$ has two components as do other hadronic cross sections.

- effective $\mathcal{P}$omeron trajectory deviates from $\alpha(t) = 1.115 + 0.26t$ at t $> 1\mathrm{GeV}^2$

- Introducing an s-dependent constant in $F_{\mathcal{P}/p}(\xi, t)$ a la Goulianos, contradicts the observed s-dependence of $\frac{d^2\sigma}{d\xi dt}$ at fixed ξ and t.

- Damping of $F_{\mathcal{P}/p}(\xi, t)$ at small ξ values (and small t) reproduces the flattening of σ_{sd}^{total} and describes $\frac{d^2\sigma}{d\xi dt}$ in detail.

- Data for $t \gtrsim 0.5\, GeV^2$ does not show the effects of damping.

- The product fK at $\sqrt{s'}-$ 118 GeV:

$$fK = 0.24 \pm 0.07(\mathrm{stat}) \pm 0.07(\mathrm{sys}) \quad \text{gluonic-}\mathcal{P},$$
$$fK = 0.45 \pm 0.13(\mathrm{stat}) \pm 0.13(\mathrm{sys}) \quad q\bar{q}\text{-}\mathcal{P}.$$

- The momentum sum rule is violated if $K = 0.78$. $f = 0.30$ for gluonic-$\mathcal{P}$, while for $q\bar{q}$-$\mathcal{P}$, $f = 0.58$.