

# THE FROISSART LIMIT...

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S Tomé, 2009**

# DO WE NEED FASTEST INCREASE OF THE SIGMA-TOT?

EXAMPLE: FIRST COLLISION IN COSMIC RAY SHOWER

$$P(X) = \frac{1}{\lambda} \exp\left(-\frac{X}{\lambda}\right) \quad \text{with} \quad \lambda = \frac{1}{\sigma}$$

$$\rightarrow \langle X \rangle = \lambda$$

$$\rightarrow \text{SQRT}\left(\langle X^2 \rangle - \langle X \rangle^2\right) = \lambda$$

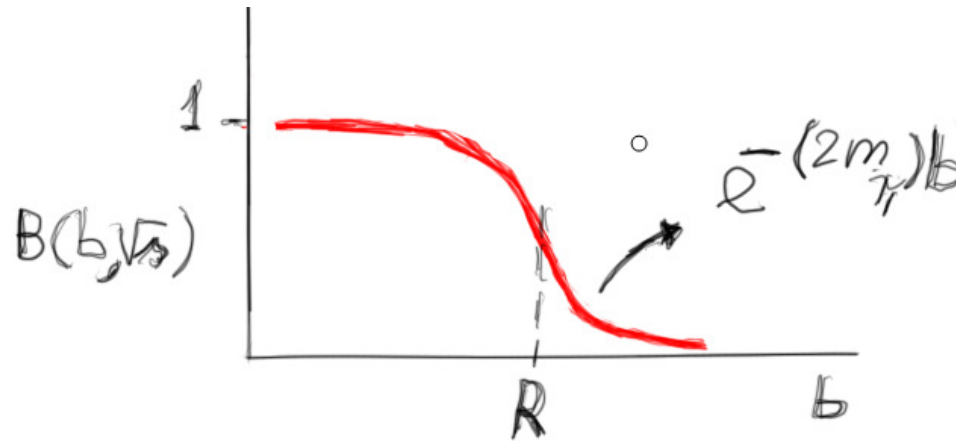
THIS IS IN THE DIRECTION  
OF AUGER RESULTS

## ORIGIN OF INCREASE?

- HEAVIER BEAM:  $p \rightarrow \text{Fe}$
- INTRINSIC INCREASE OF  $\sigma_{pp}$

## THE HEISENBERG-FROISSART ARGUMENT (50-60'S)

IN QCD THE LARGE DISTANCE LIMIT IS NOT CONTROLLED BY THE GLUONS ( $1/R$  POTENTIAL) BUT BY THE LIGHTEST EXTENDED HADRON (YUKAWA POTENTIAL, ROLE OF THE PION)



$$\sqrt{s} \exp(-2m_\pi R) \sim \sqrt{s_0} \geq m_\pi$$

$$R < \frac{1}{4m_\pi} \ln\left(\frac{s}{s_0}\right)$$

$$\sigma = \pi R^2$$

→

$$\sigma < \frac{\pi}{(4m_\pi)^2} \ln^2\left(\frac{s}{s_0}\right)$$

**MARTIN (1965):** RIGOROUS PROOF (ANALITICITY, UNITARITY, ... )

# NON LINEAR MODEL FOR THE HIGH ENERGY AMPLITUDE

LOGISTIC EQUATION WITH SATURATION (OF UNITARITY  $\rightarrow$  BLACK DISK)

$B(b, R)$      $R$ : ENERGY DEPENDENT PARAMETER

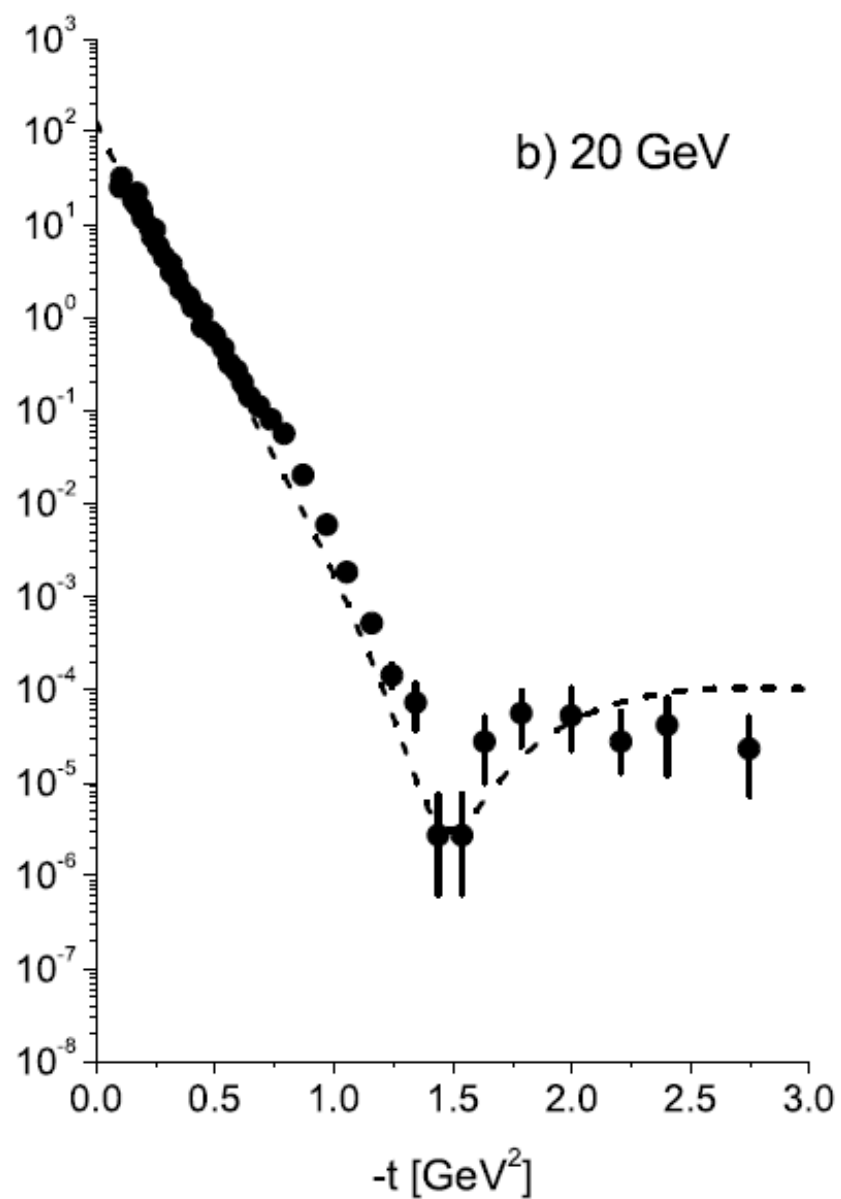
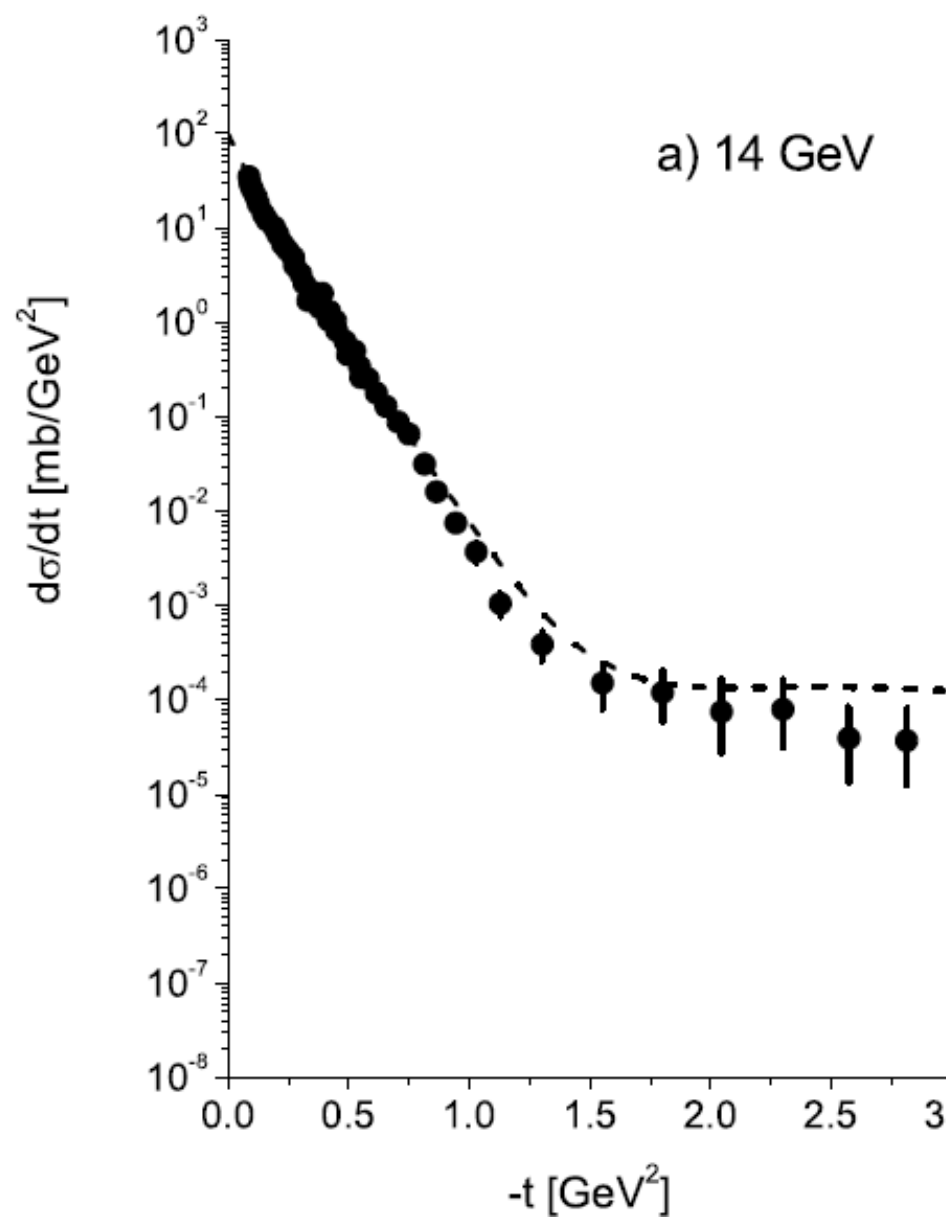
EQ:  $\frac{\partial B}{\partial R} = \frac{1}{\gamma} (B - B^2)$  ,  $B \leq 1$

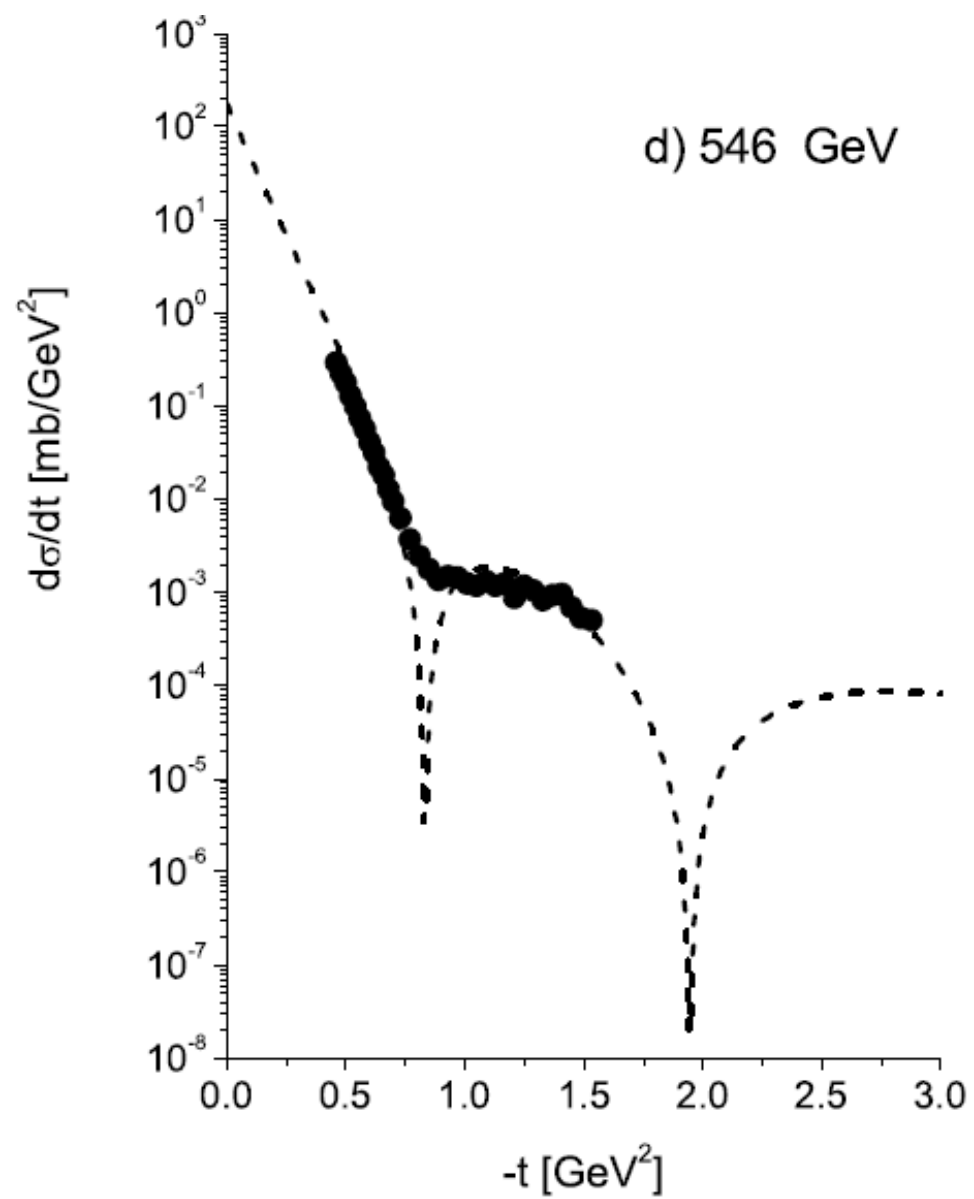
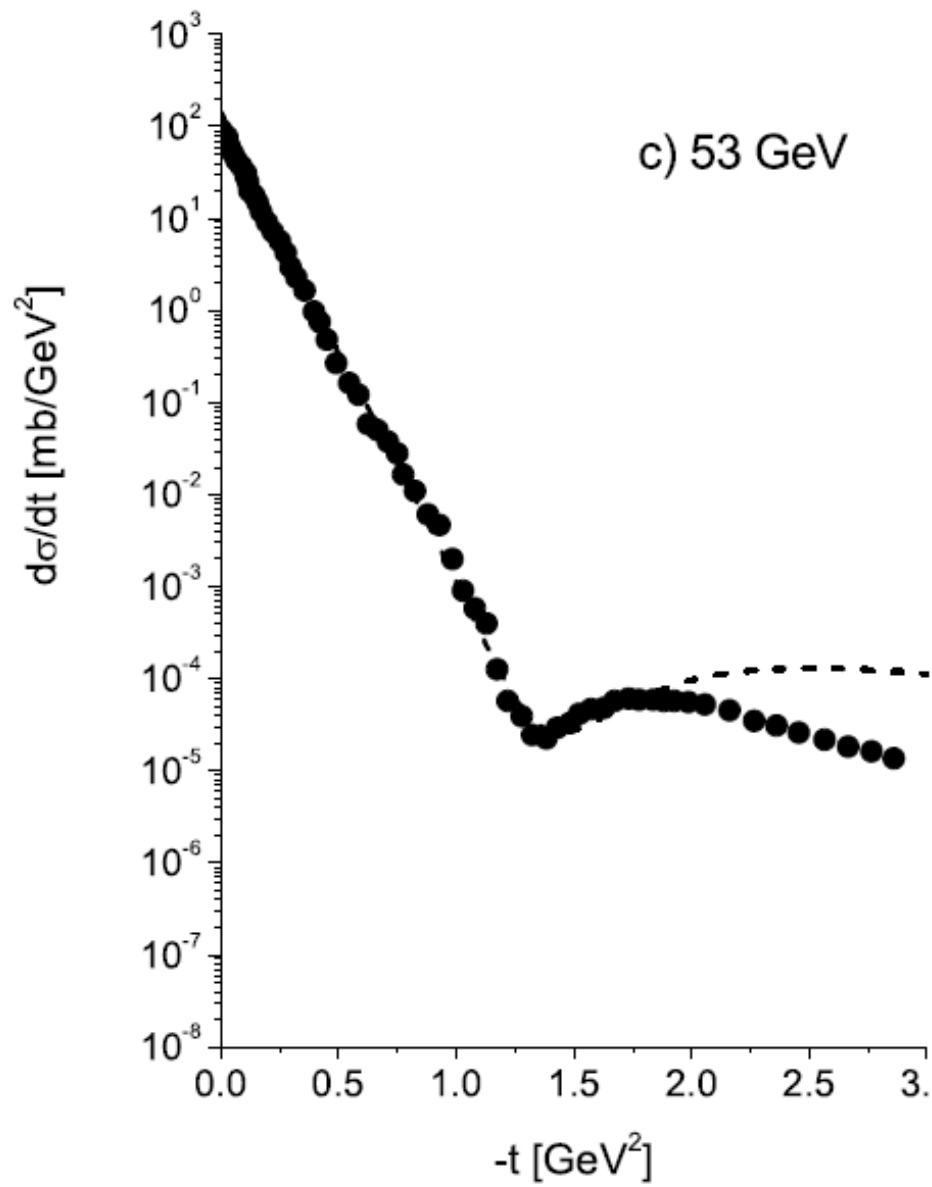
SOLUTION

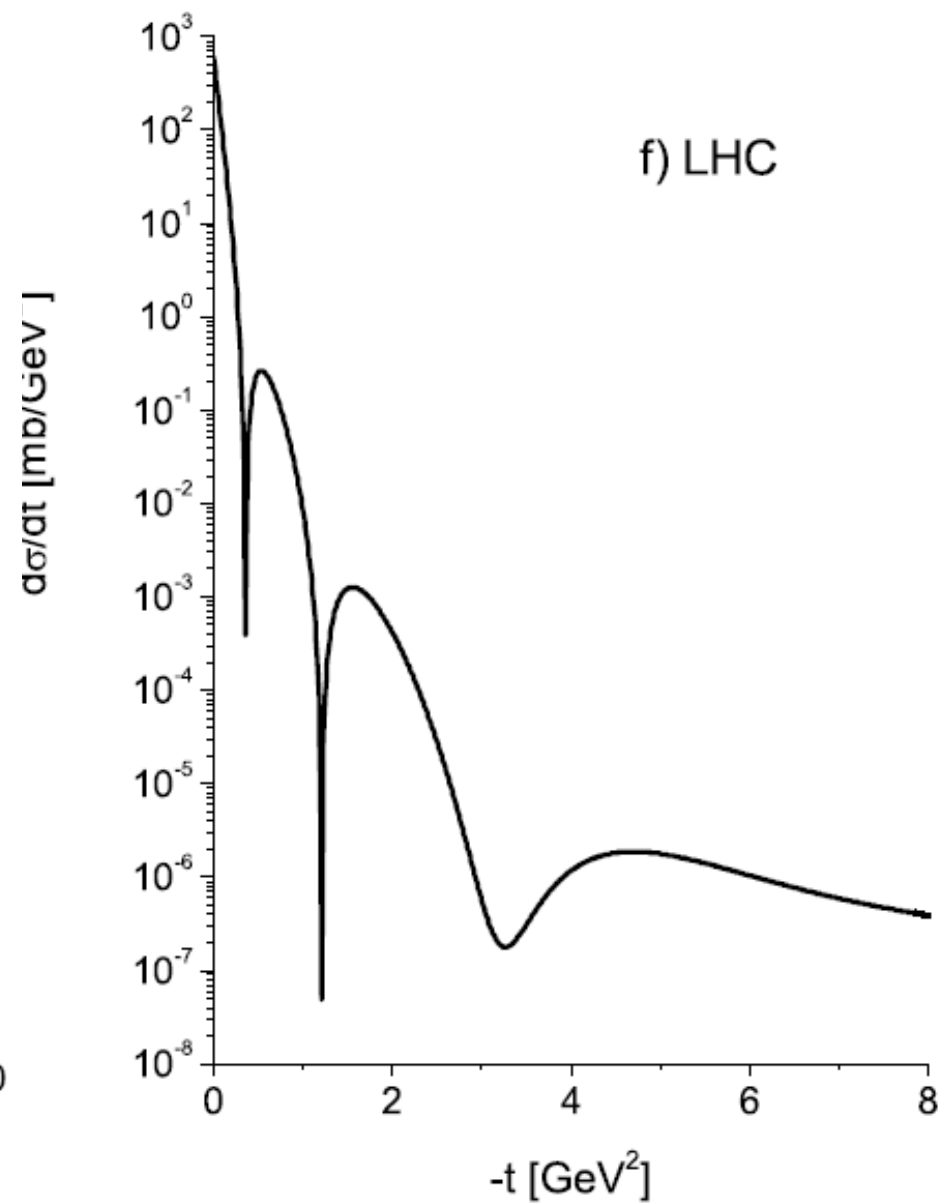
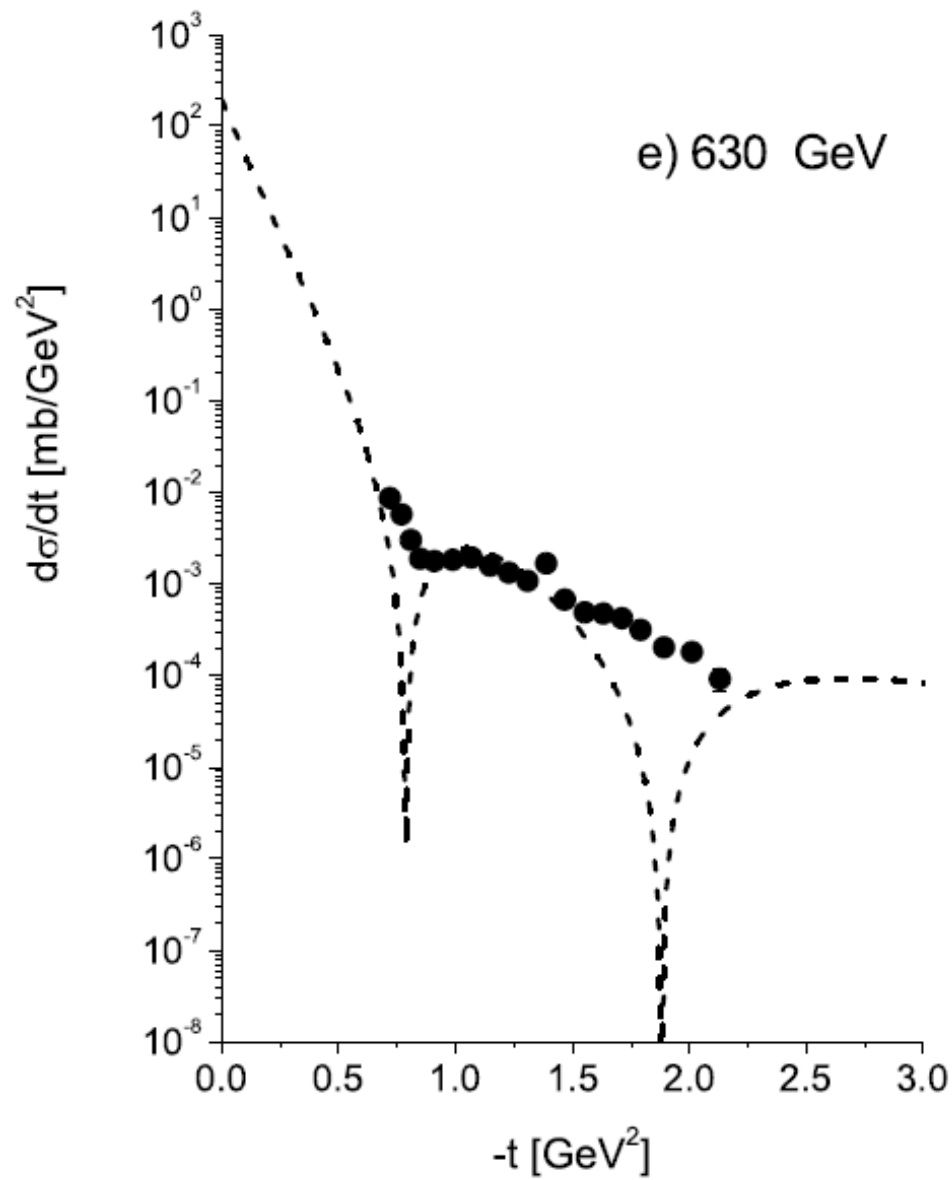
$B(b, R) = \frac{1}{\exp\left(\frac{b-R}{\gamma}\right) + 1}$

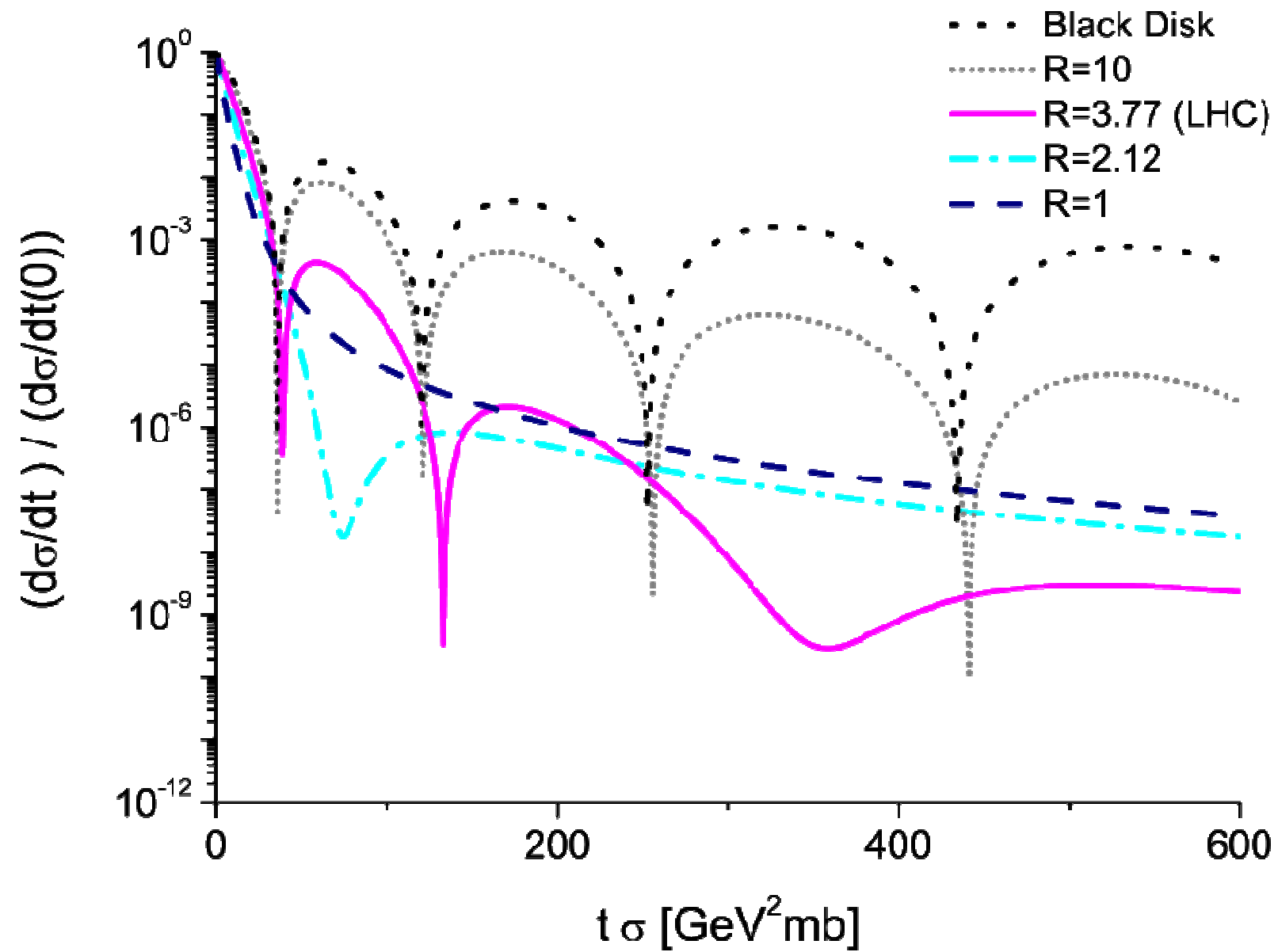
[FROM  $\exp\left(-\frac{b}{\gamma}\right)$  (AT SMALL  $R$ ) TO BLACK DISK (AT LARGE  $R$ )]

**RESULTS:**







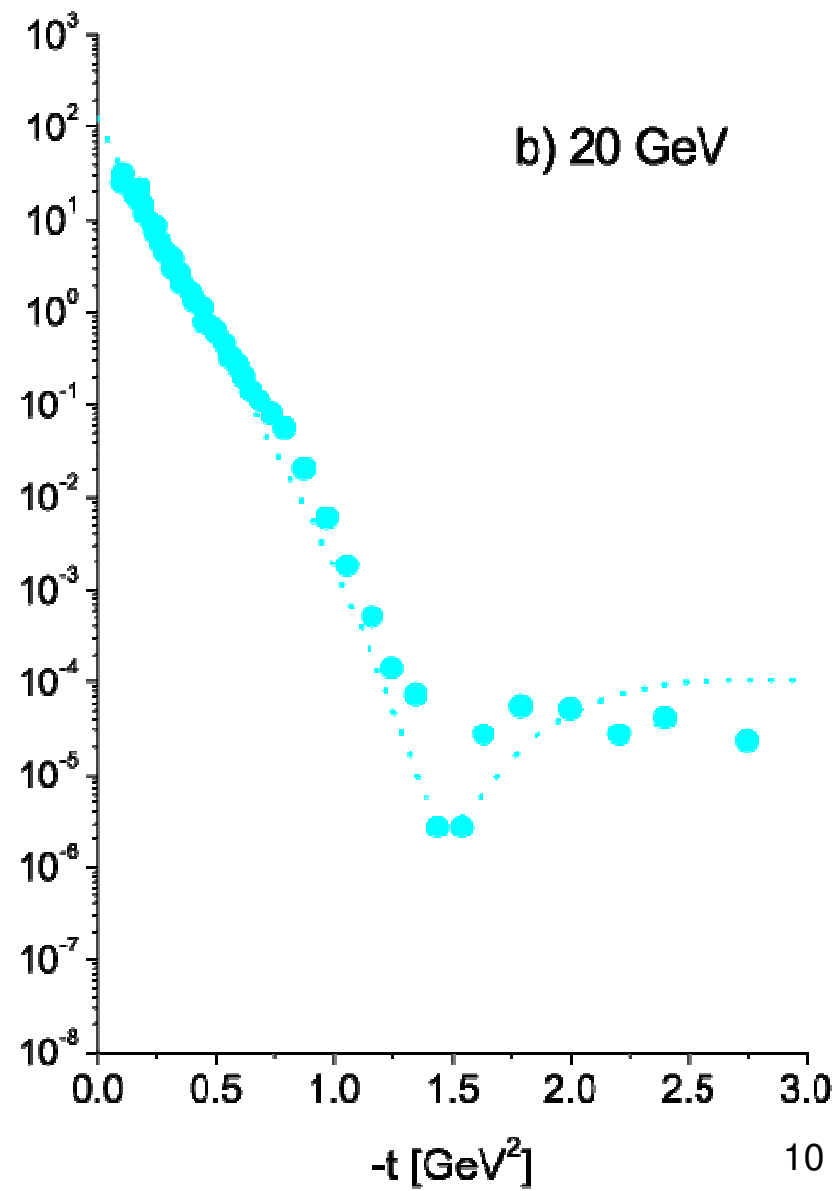
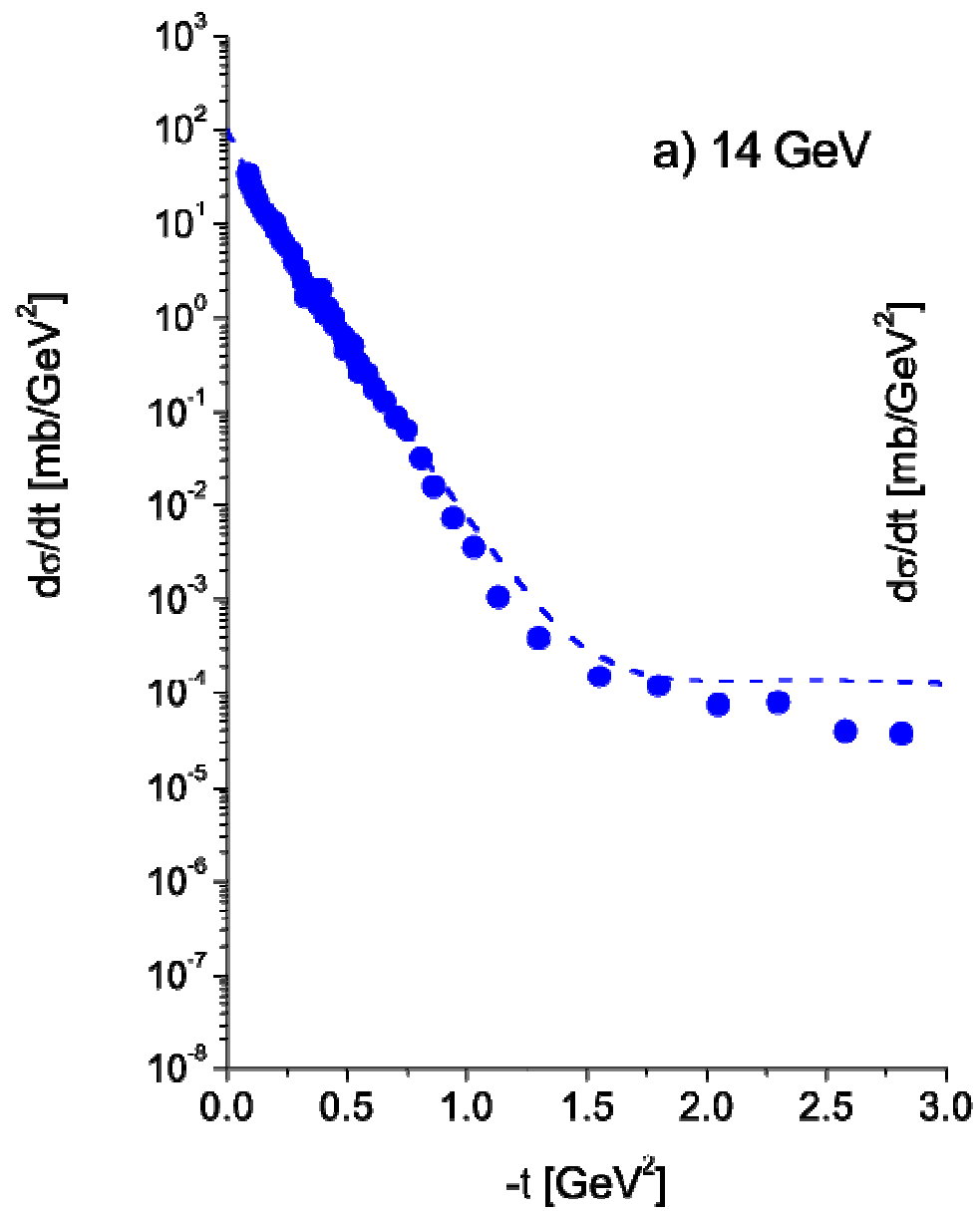


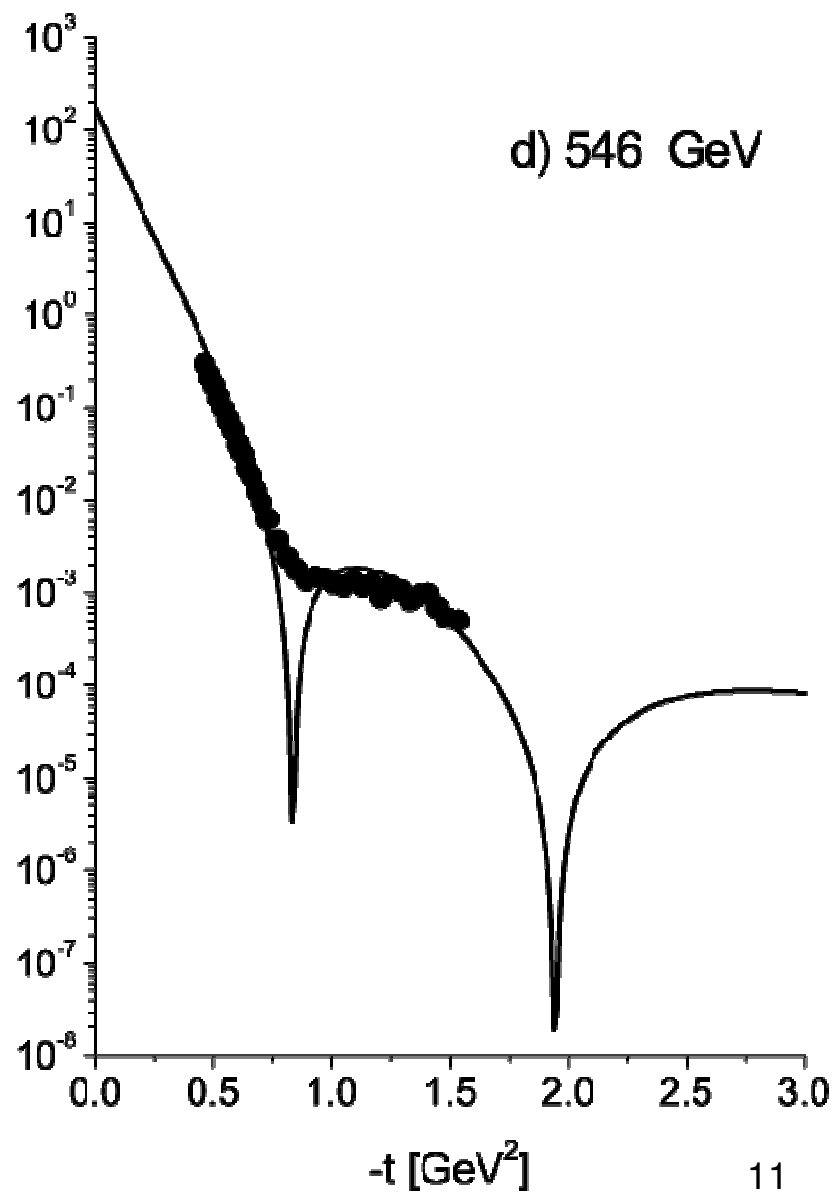
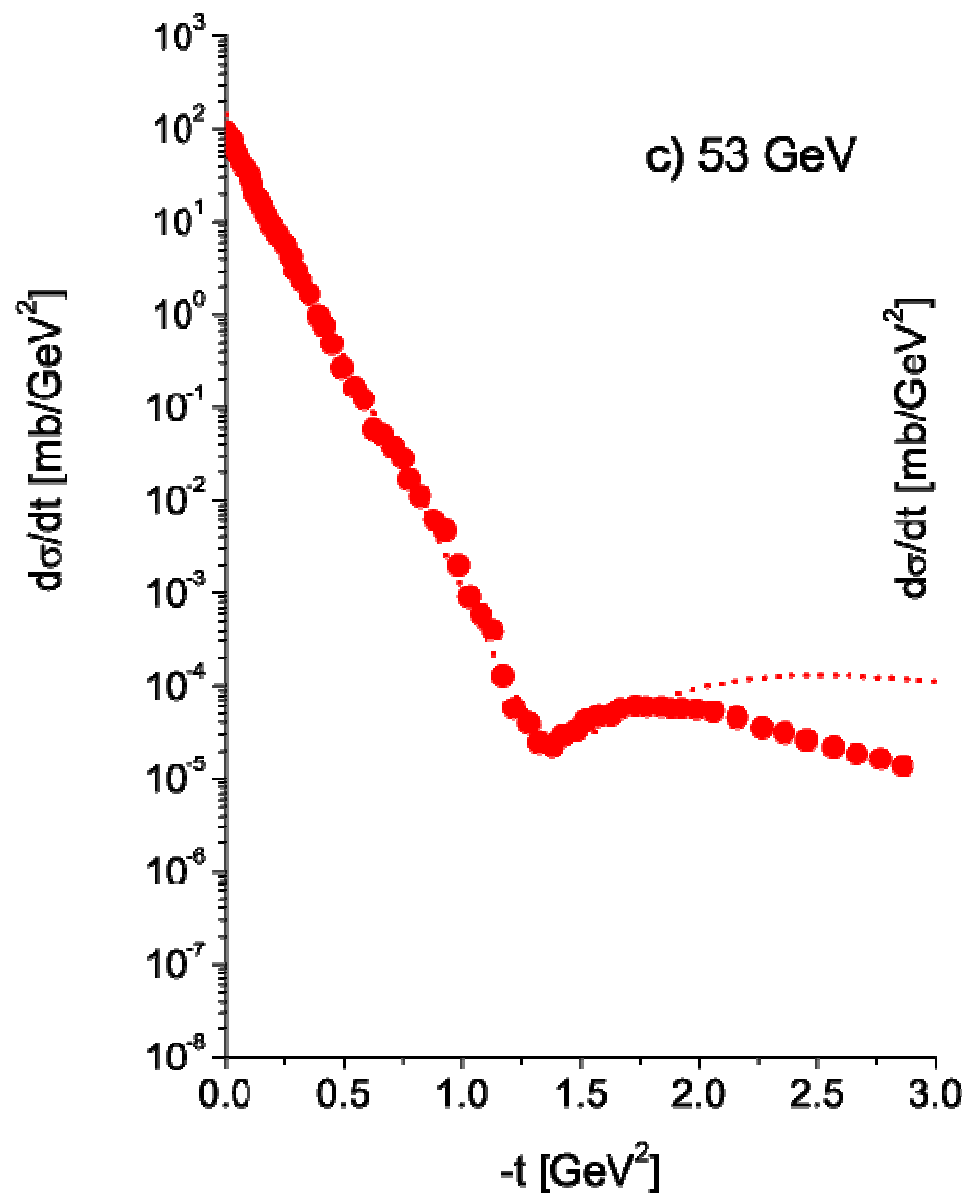


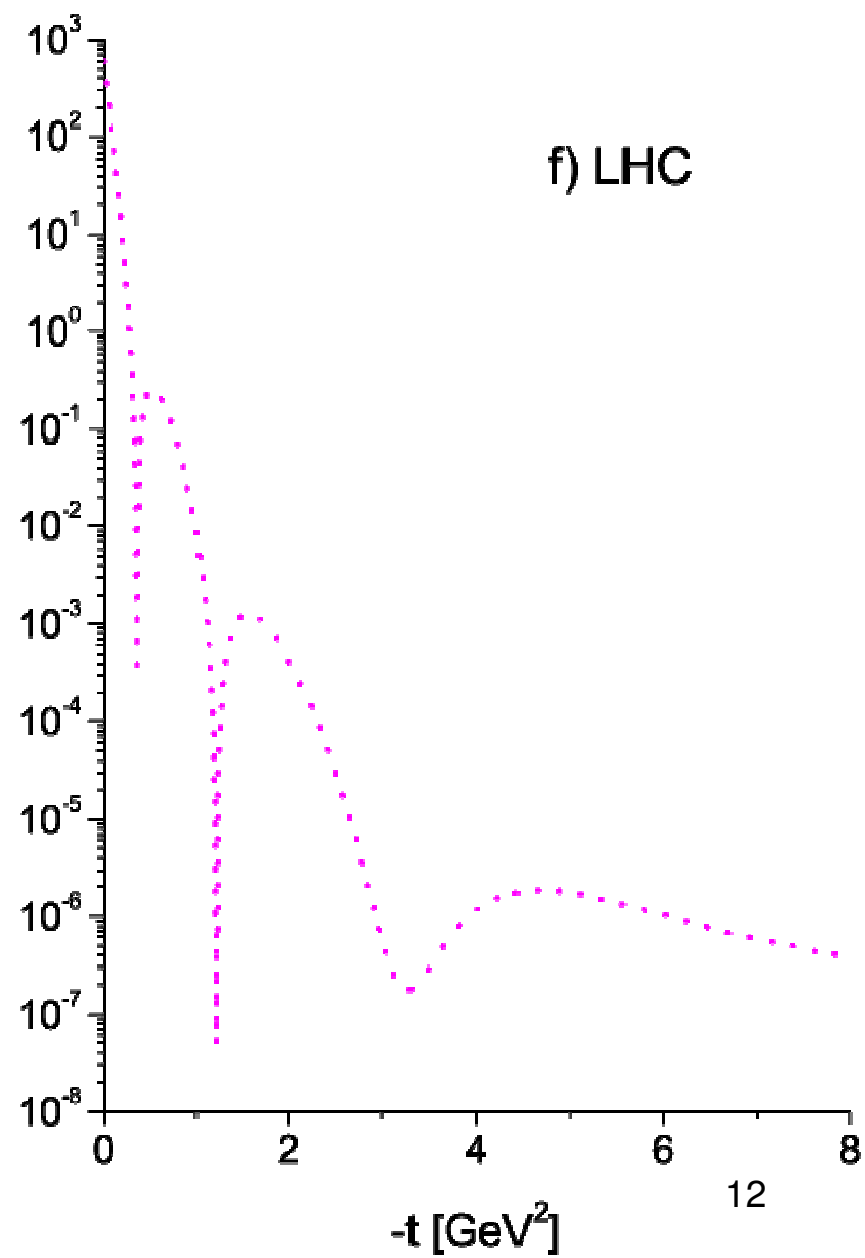
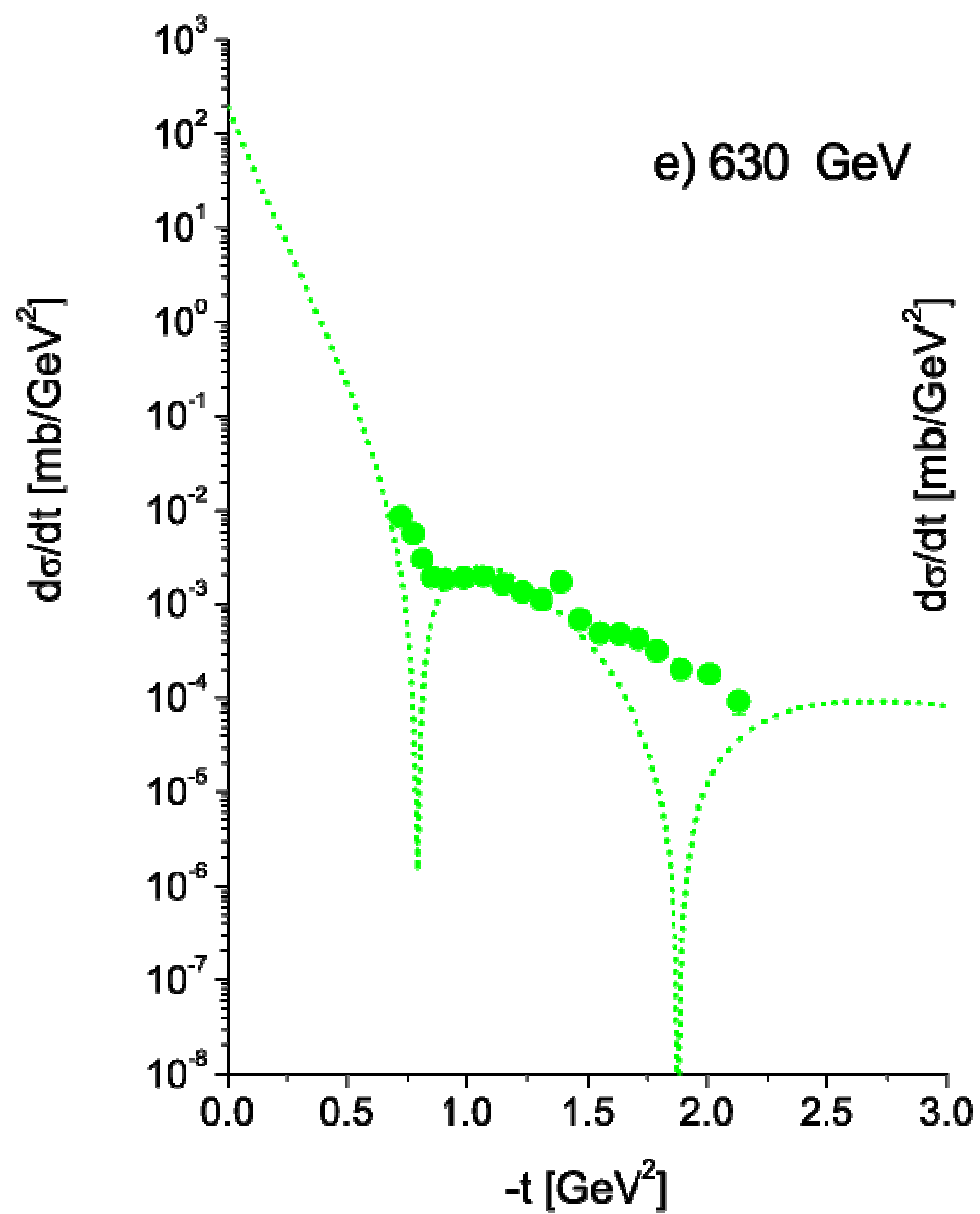
# CONCLUSION: IS FROISSART BOUND VIOLATED?

THERE IS NO INDICATION

- CROSS-SECTION MAY INCREASE WITHOUT VIOLATION OF THE FROISSART BOUND [ULRICH, JAIME ALVAREZ-MUNIZ]
- NUSSINOV IDEA  
GLUE BALLS BEFORE PIONS...







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