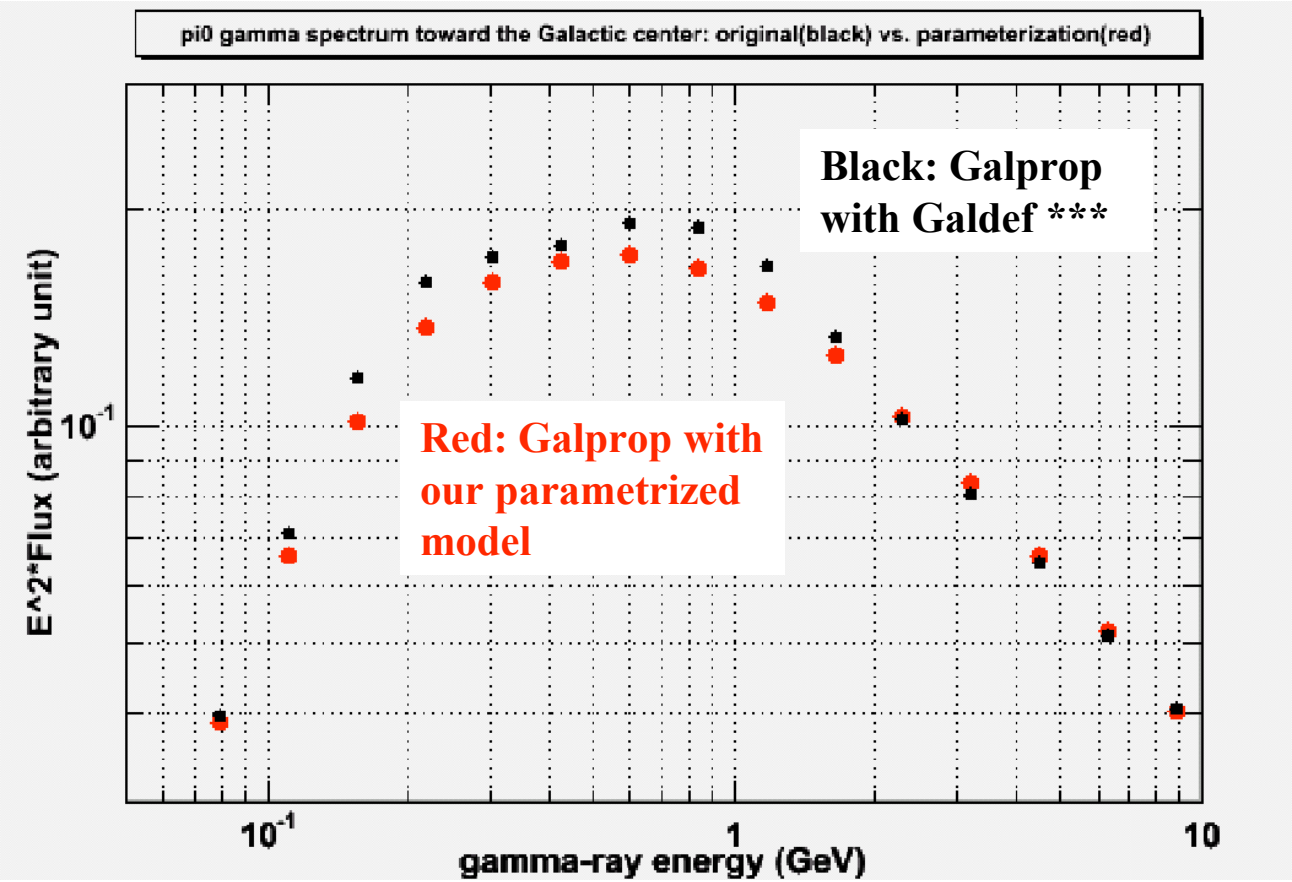
Implementation to Galprop

Work by T. Mizuno et al. (very preliminary)



Up-to-Date Proton-Proton Interaction Modeling and Secondary γ, e^-, e^+, ν, $\bar{\nu}$ Spectra

Dark Matter Working Group Session in 2005 GLAST-LAT Collaboration Meeting

T. Kamae, N. Karlsson, T. Abe, T. Koi, T. Mizuno, J. Cohen-Tanugi, H. Tajima (SLAC)

History of *pp* Interaction Modeling in Astrophysics (1/2)

Galactic diffuse emission by pp->pi0: Speculated by S. Hayakawa, Ginzburg, et al.
Early models of PP->pi0 for astrophysical applications: Stecker, Stephens & Badwar, Dermer

Table 1. Integrated galactic γ emissivity due to secondary π^0 production from this and previous work. Units: 10^{-25}(s-H atom)$^{-1}$

Reference	Model	$q_\gamma(>100\,\mathrm{MeV})$	$q_\gamma(>0)$
Stecker (1970)	Isobar + Fireball	1.1	1.6
Cavallo and Gould (1971a)	Isobar + Phase Space	1.8	2.4
Levy and Goldsmith (1972)	Scaling	3.2	3.7
Badhwar and Stephens (1977)	Scaling	1.2	1.6
Stephens and Badhwar (1981)	Scaling	1.37–1.63	1.92–2.34
Morris[a]	Scaling	1.22	1.68
This work	Isobar + Scaling	1.53	2.02

[a] Calculation cited in Fichtel and Kniffen (1984); see also Morris (1984)

* NAS/NRC Research Associate

Chuck Dermer's model has been the norm since 1986.

Dermer's model consists of:
- **Stecker's "Isobar Model"**
- **Stephens & Badhwar's "Scaling Model"**
- **Adjusted to fit exp. pion incl. cross-sections**

New findings since lating late 1970's:
- **Rising inelastic cross-section**
- **Diffraction Dissociation**
- **Scaling violation (CERN-SPS, FNAL)**

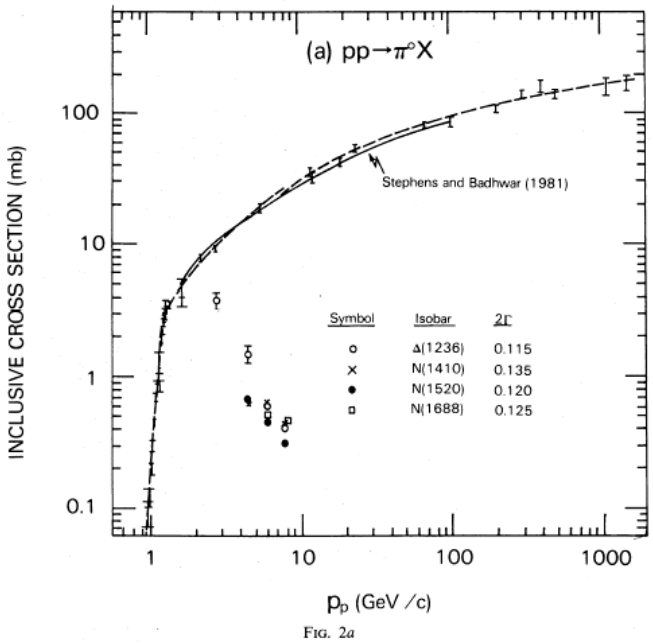


FIG. 2a

History of *pp* Interaction Modeling in Astrophysics (2/2)

High energy gamma-ray emission from supernova remnants J. Phys. G: Nucl. Part. Phys. 20 (1994) 477–486.

Tsuguya Naito and Fumio Takahara
Department of Physics, Tokyo Metropolitan University,

Proton's index = 2.0

⇓

Gamma's index = 2.0

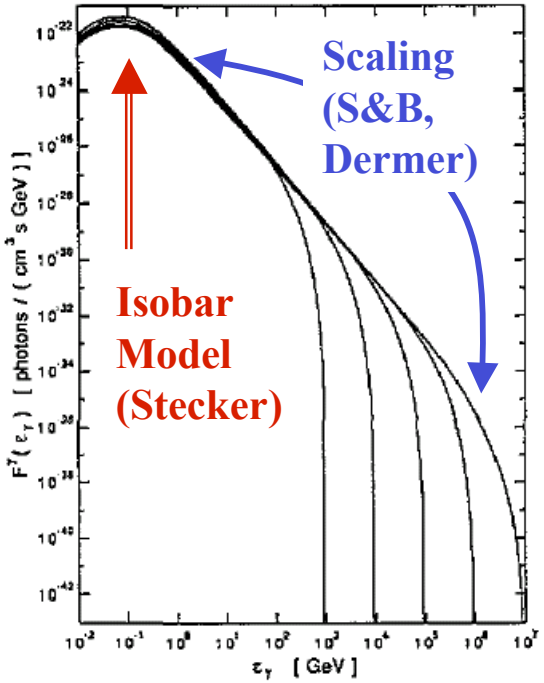


Figure 1. The γ-ray spectra for a fixed spectral index of CRs $\alpha = 2.0$ and different E_p^{max} of 10^3 GeV, 10^4 GeV, 10^5 GeV, 10^6 GeV, and 10^7 GeV.

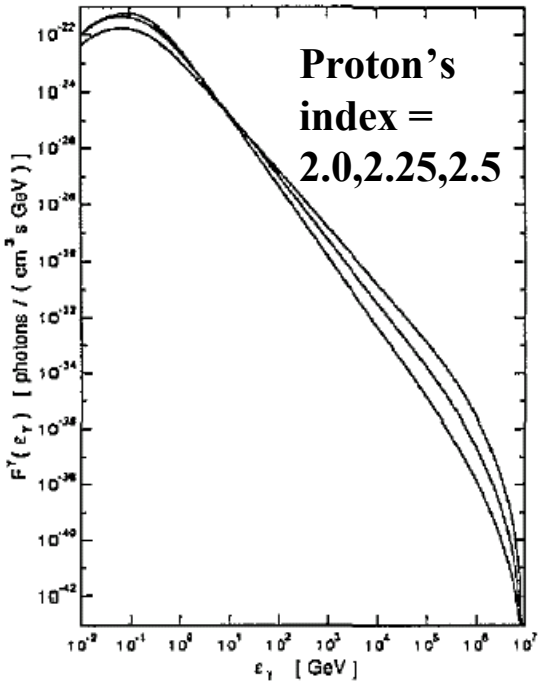
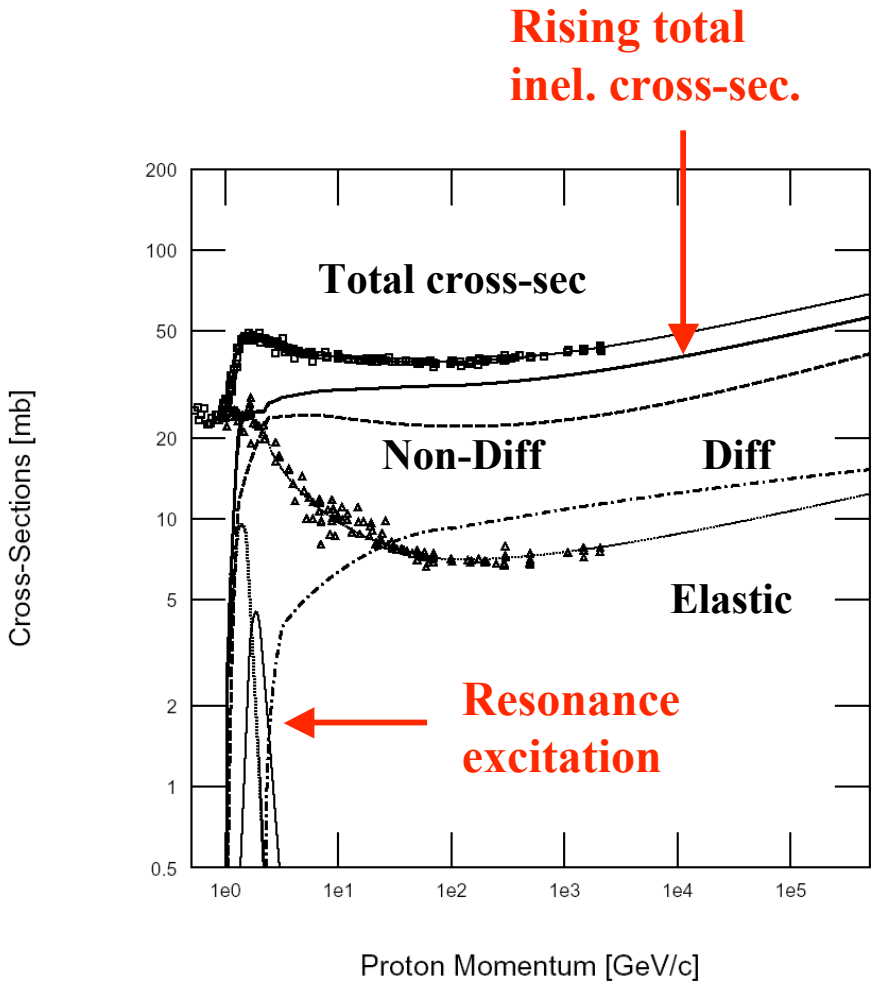
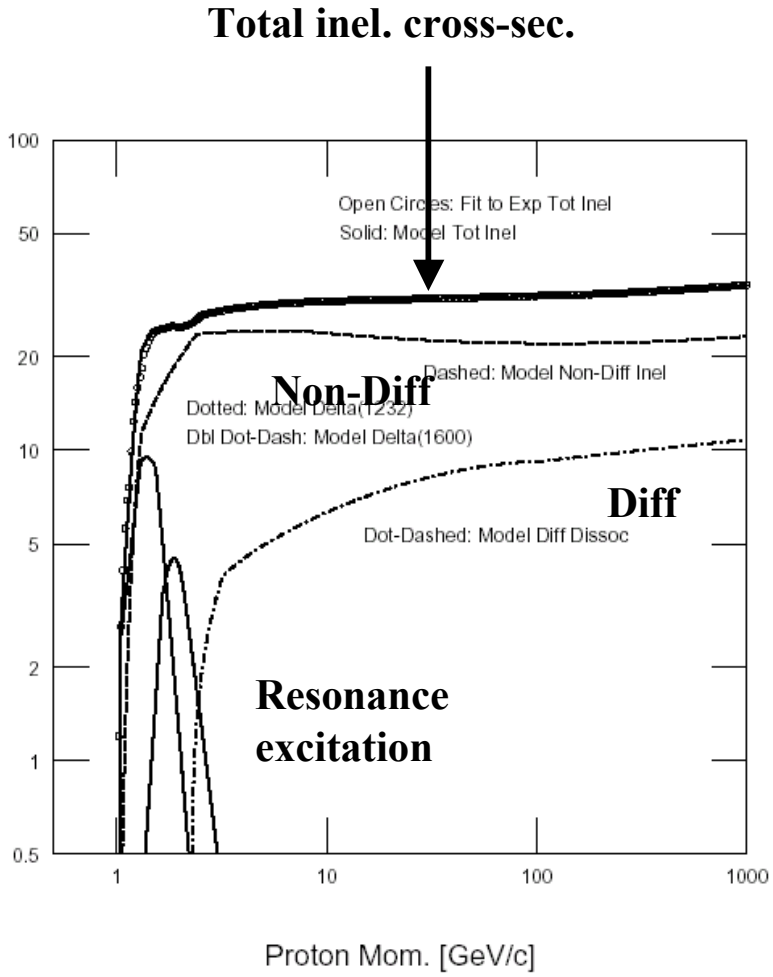


Figure 2. The γ-ray spectra with the spectral indices of CRs $\alpha = 2.0$, $\alpha = 2.25$, and $\alpha = 2.5$. E_p^{max} is fixed at 10^7 GeV.

Rising PP Inelastic Cross-Section

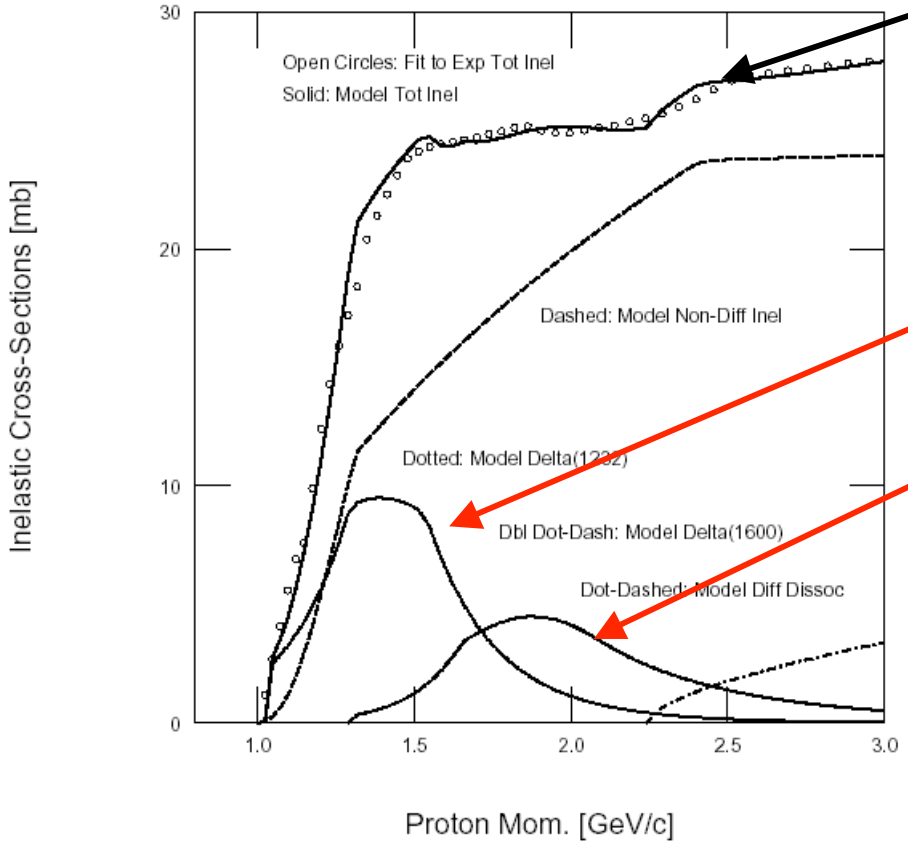
- New Model and Exp. Data -





Inelastic Cross-Sections

- Model vs. Exp. Data -



Total inelastic cross-section is tightly constraint by experimental data (circles).

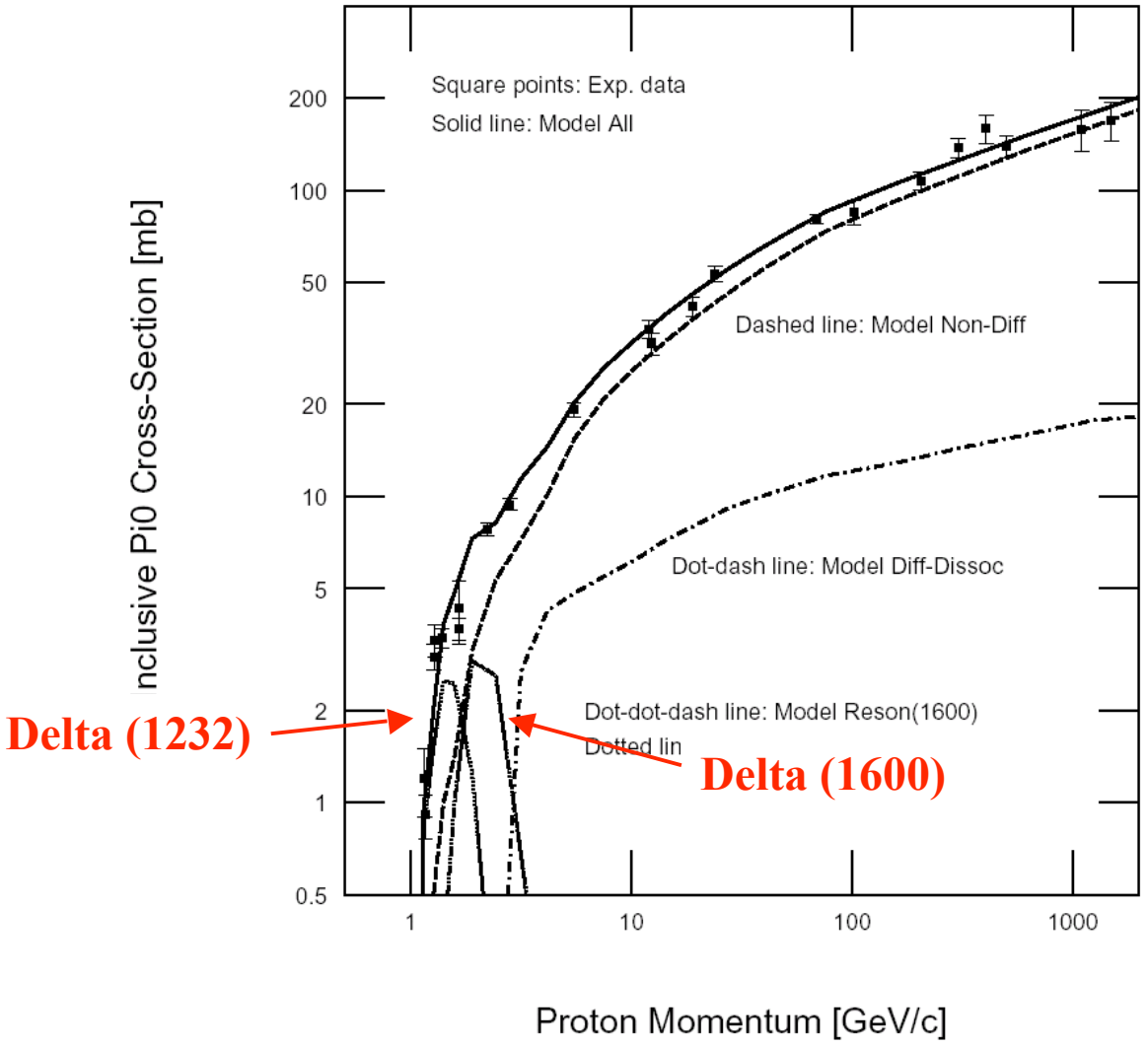
Delta(1232)

Delta(1600)

Diff Dissoc

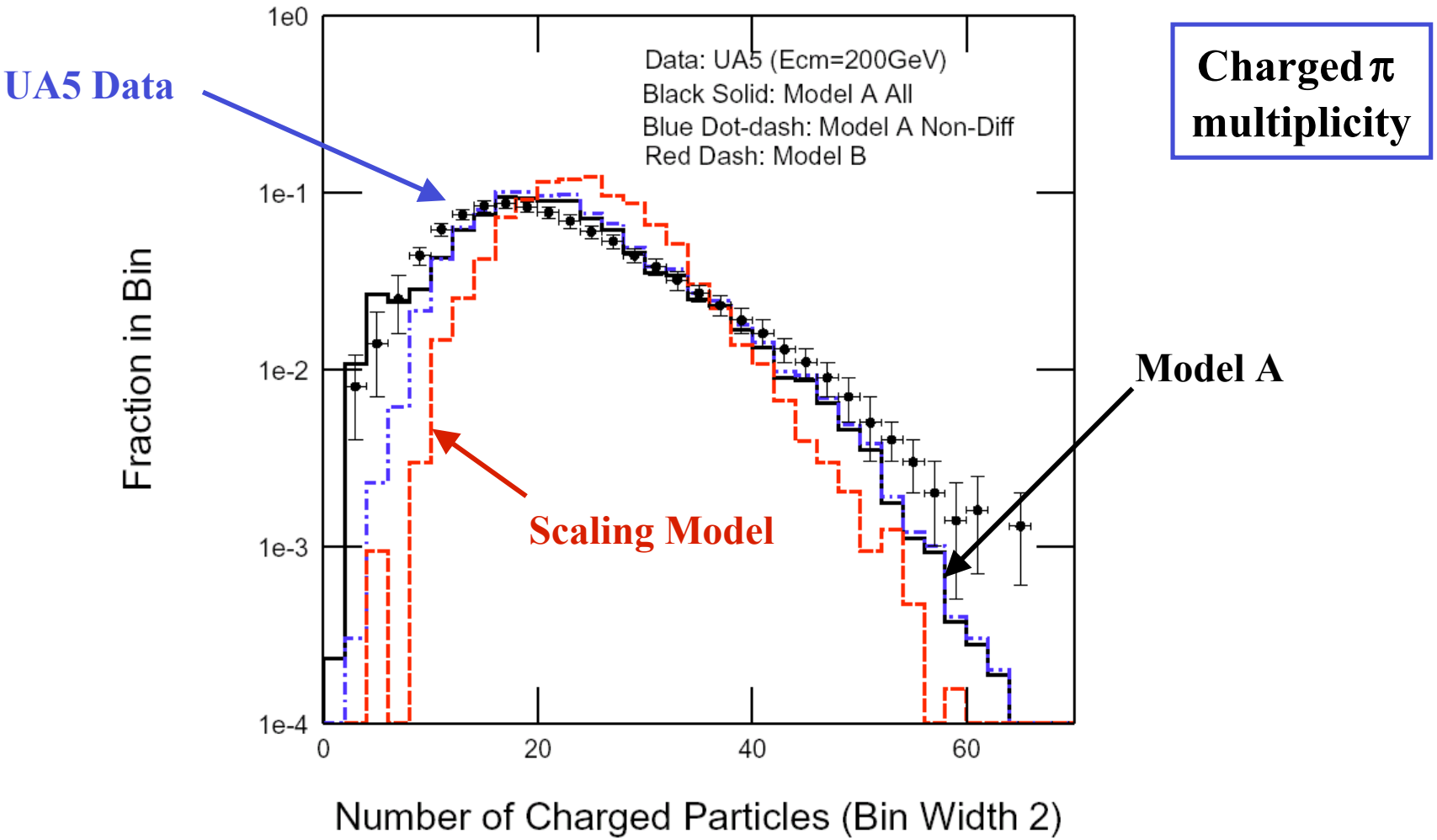
Inclusive Pi0 Cross-Section

- Average Multiplicity -



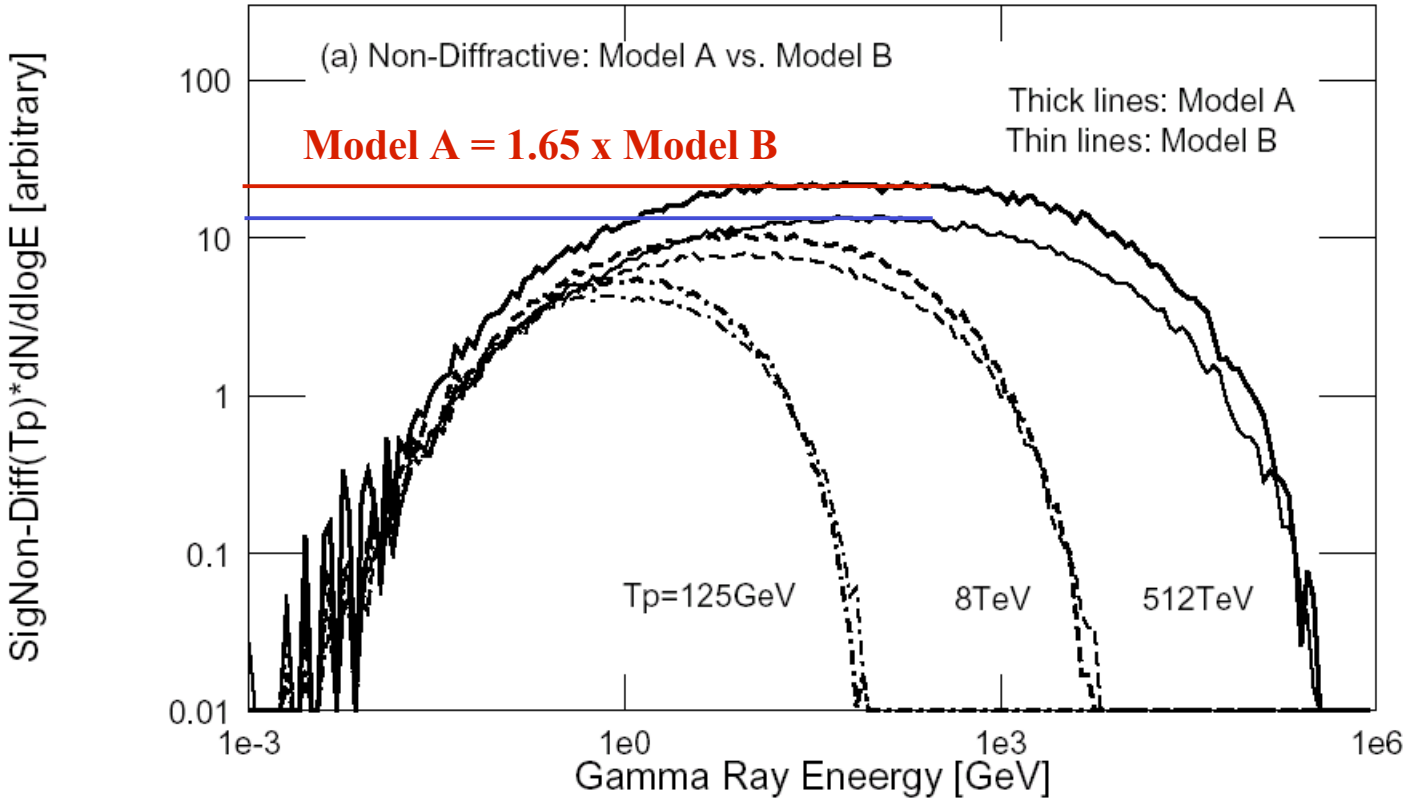
Charge Pion Multiplicity Distribution at E_{CM}=200GeV

- Model vs. Exp. Data -



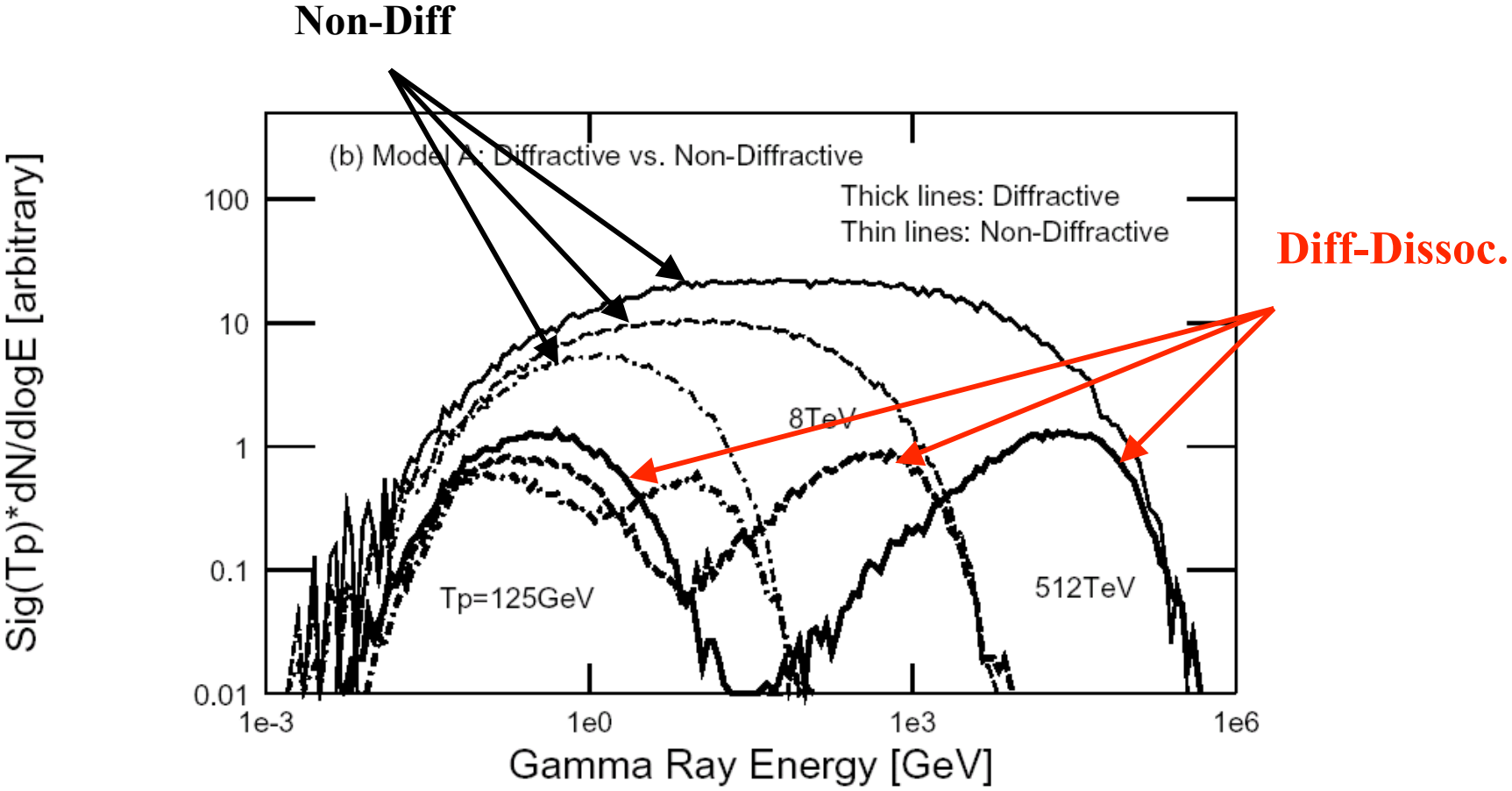
Rising Cross-Sec. and Scaling Violation in Non-Diffractive Process

Gamma-ray inclusive cross-sec. by Pythia tuned to CDF Data for Tp=125GeV, 8TeV, 512TeV



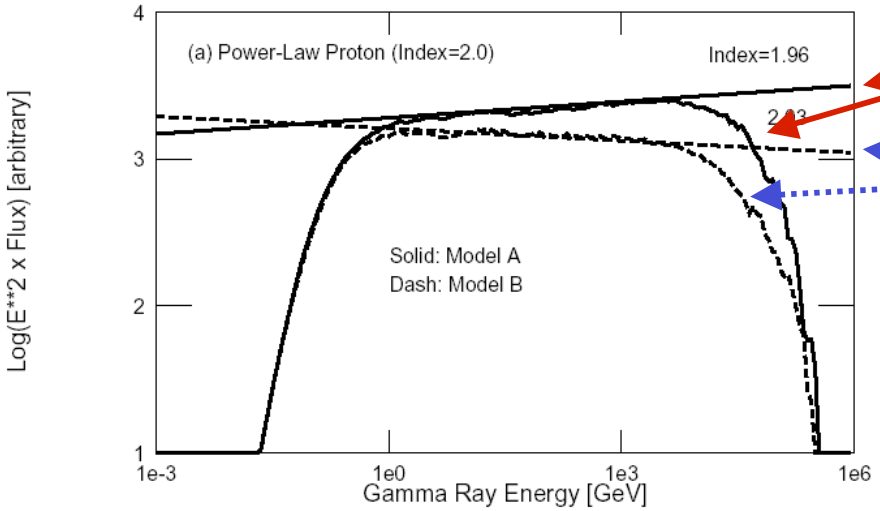
Rising Cross-Sec. in Diffr. Dissoc. Process

Gamma-ray inclusive cross-sec. by Diff. Dissoc. process for Tp=125GeV, 8TeV, 512TeV



Gamma-ray Spectra for Proton Spectra

- Index 2, 2.7 and broken power-law (2.2, 2.5) -



Prediction of Model A

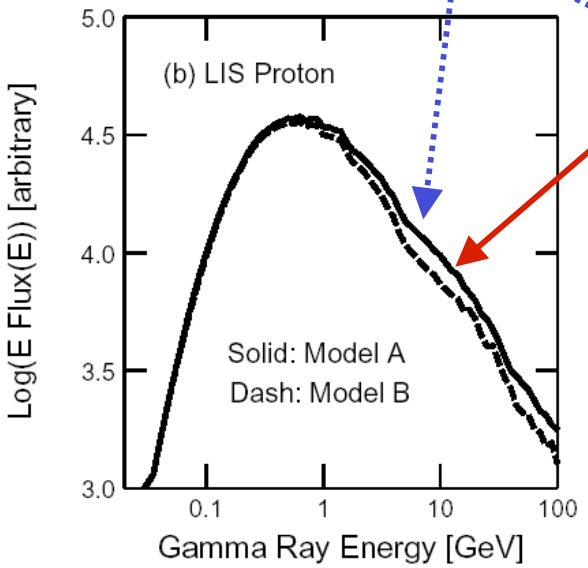
Prediction of Scaling Models

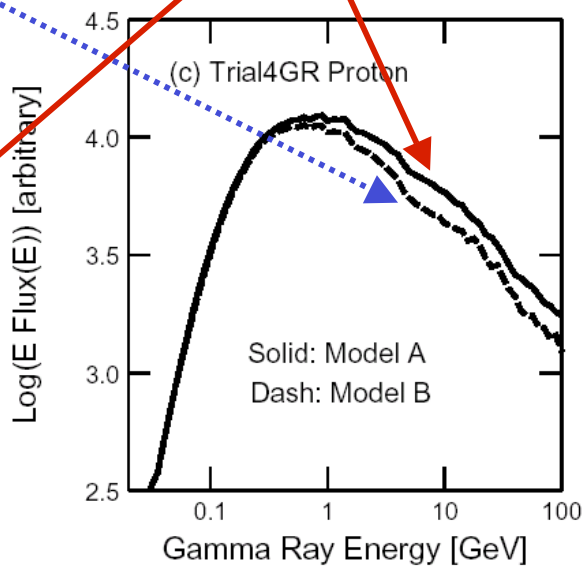
Scaling Models **Model A**

Model A predicts:

1) **a harder γ-ray spectrum**
   (diffractive process)
2) **a higher flux**
   (rising non-diff. cross-sec. and scaling violation)

than scaling models





Electron and Positron Inclusive Cross-Section

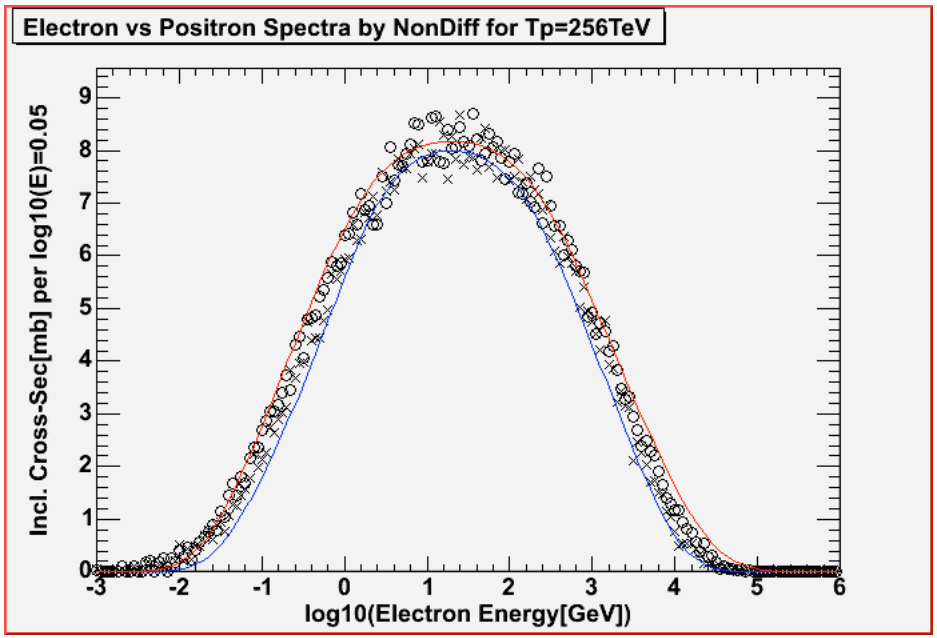
- For Tp=256TeV Protons -

Electron/positron spectra

Non-diffractive

red: parameterization for e+

blue: parameterization for e−

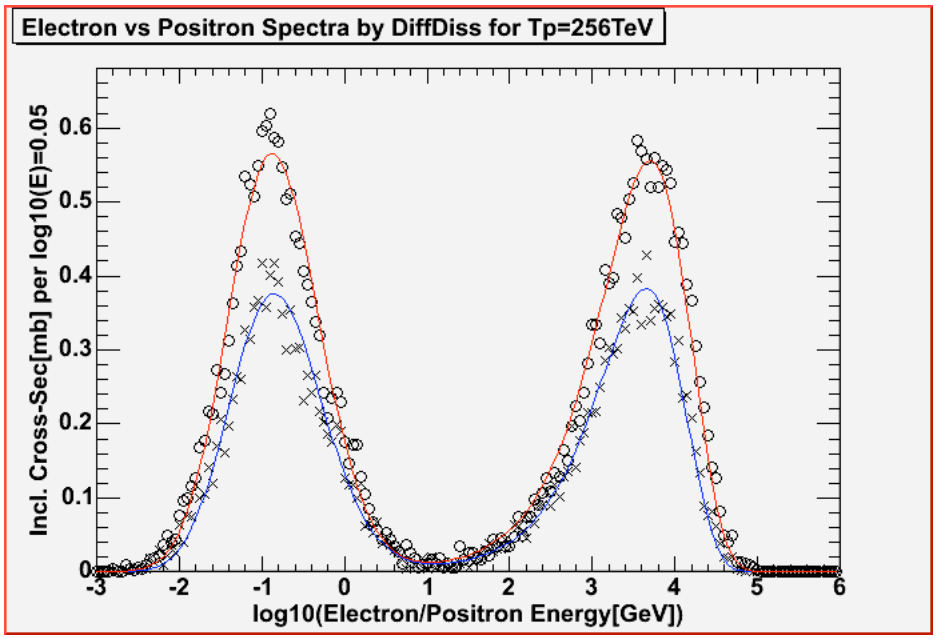


Electron/positron spectra

Diffractive dissoc.

red: parameterization for e+

blue: parameterization for e−



Electron and Positron Inclusive Spectra

- Power-Law (index=2.0) Proton -