Hadronic Interactions at the CERN SPS: Resonance Decays versus Parton Dynamics

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1) Introduction
2) Pion Data
3) Hadron Spectra from Resonance Decays
4) Inclusive Particle Production
5) Discussion
6) Summary

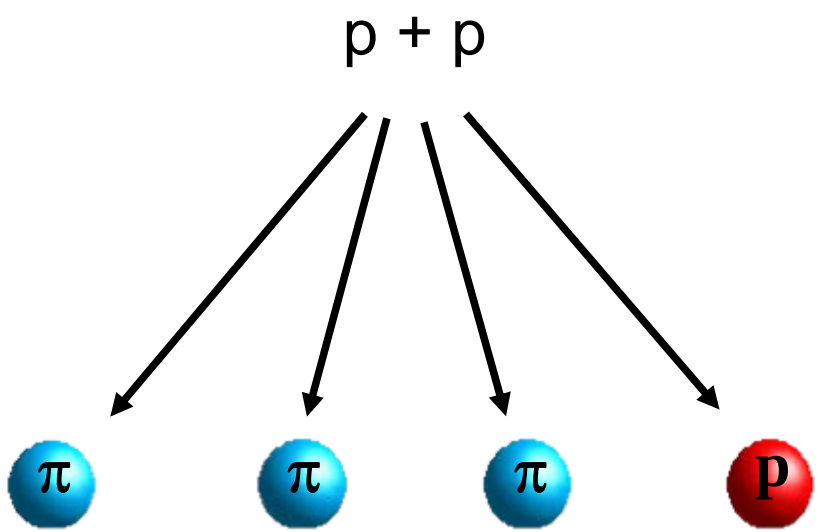
1) Introduction

- **This is a "production experiment" talk, which deals with the mechanism of inclusive particle production in inelastic collisions of hadrons at high energies;**

- **I will demonstrate the connection between this mechanism and resonance production and decay;**

- **Starting from final state hadrons, I will try to assess the next layer of more primary states as they go into ground state particles:**

Analysis:
model-independent



Data:
NA49 at CERN SPS
√s=17 GeV

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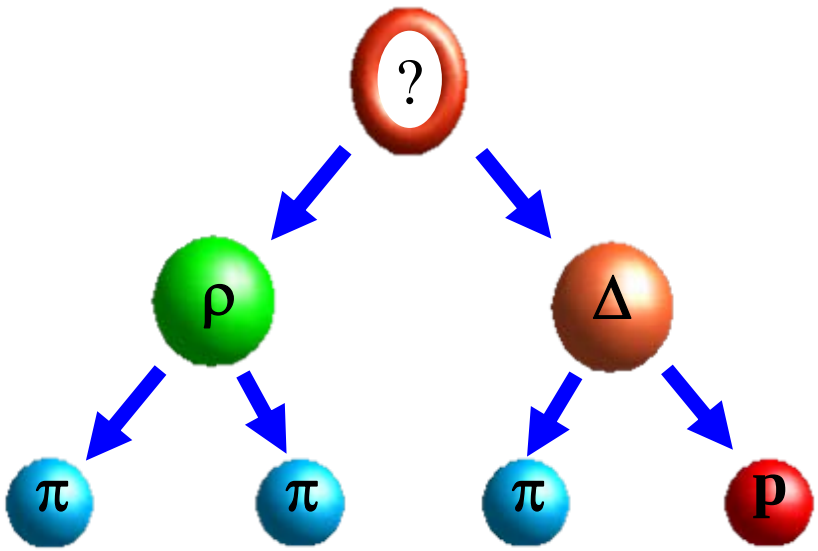

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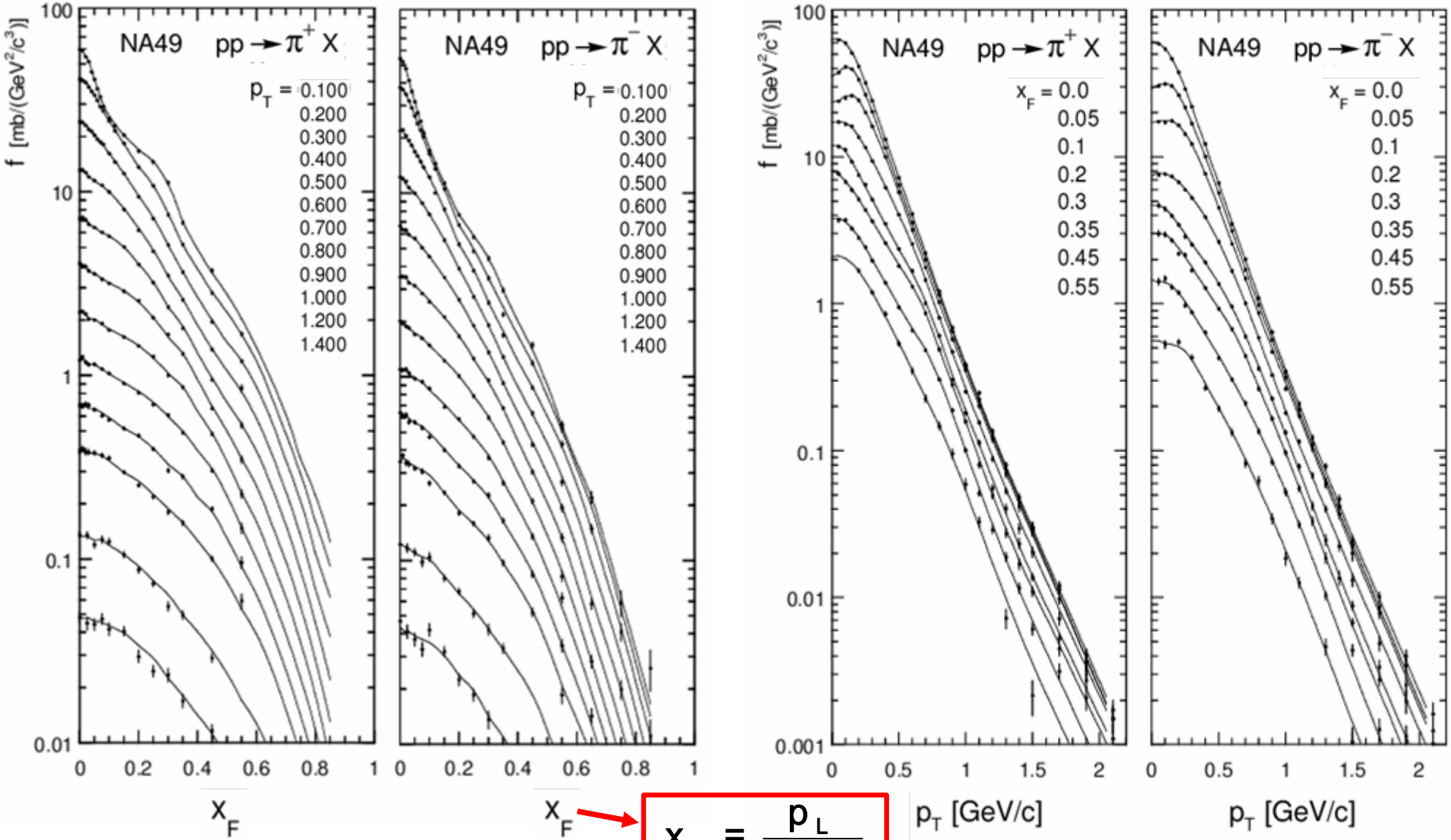
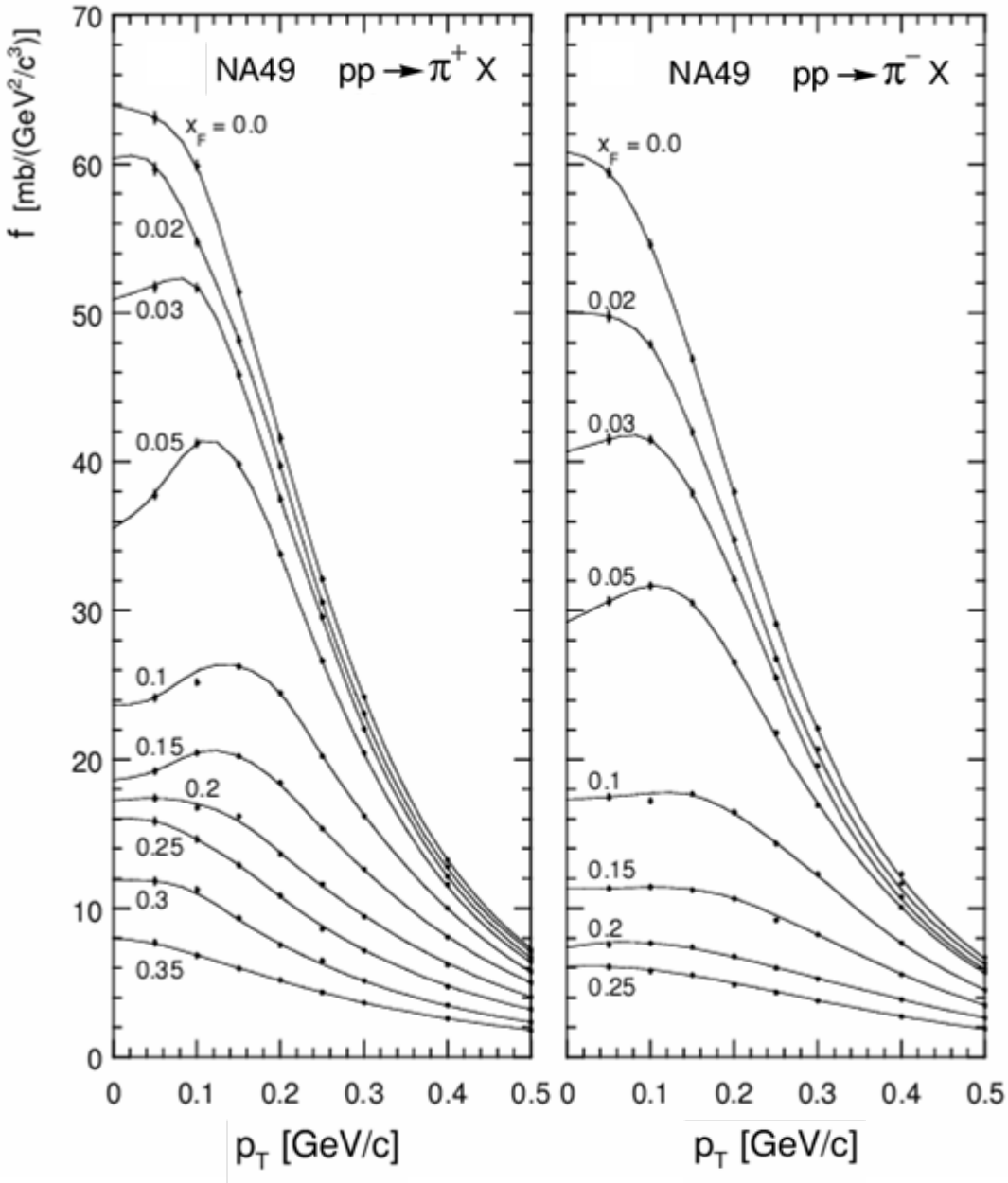
2) Pion Data

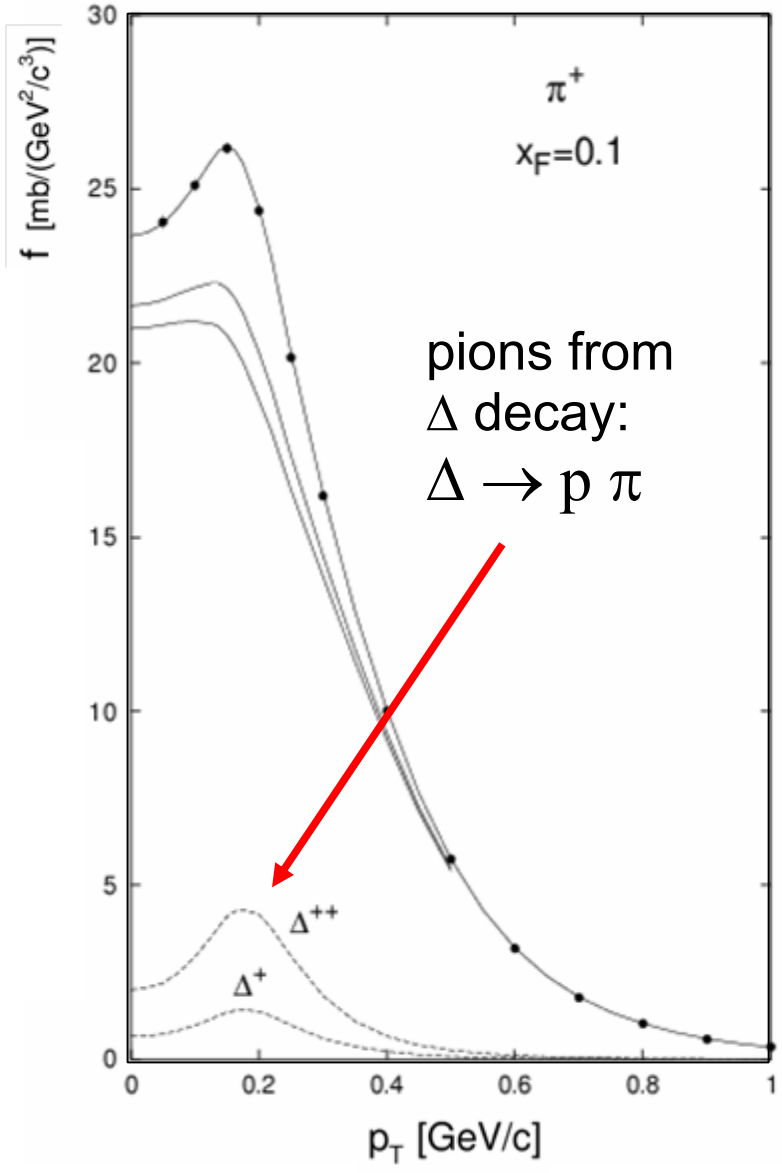
- Inclusive π^+, π^- distributions from 5M p+p events
- Experimental excellence (corrections, systematics)
- Unprecedented phase-space coverage



$$x_F = \frac{p_L}{p_L^{MAX}}$$

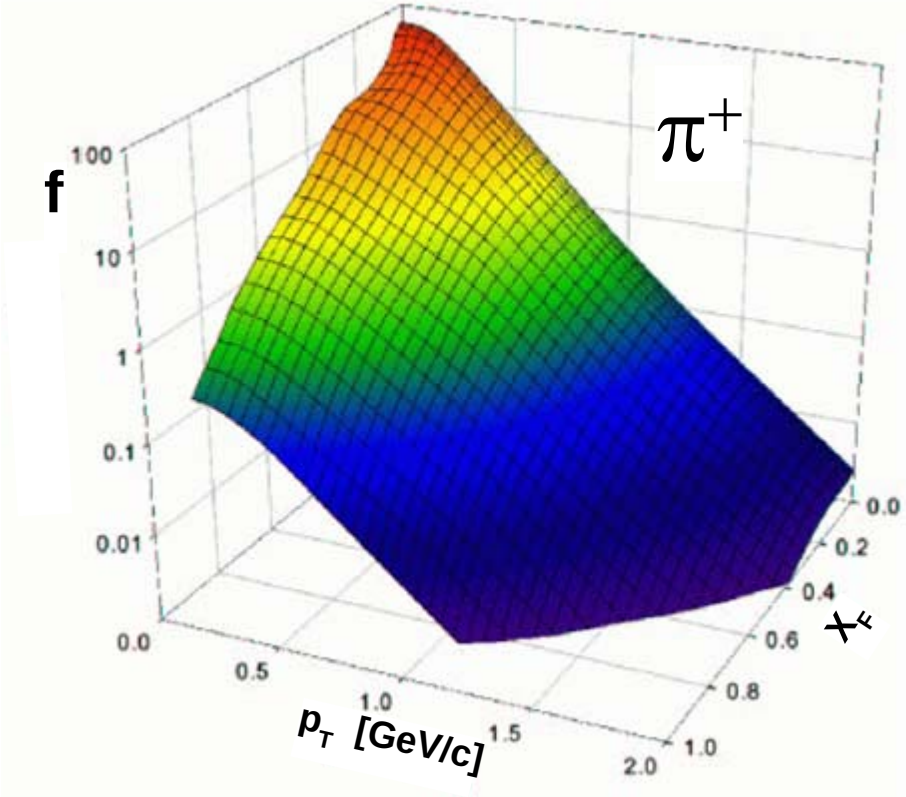
- Structures in pion density are caused by the Δ decay





2) Hadron Spectra from Resonance Decays

ALL positive pions produced
in p+p collisions (NA49 data)



- **Where are they?**

Note common belief:
low x_F, low p_T

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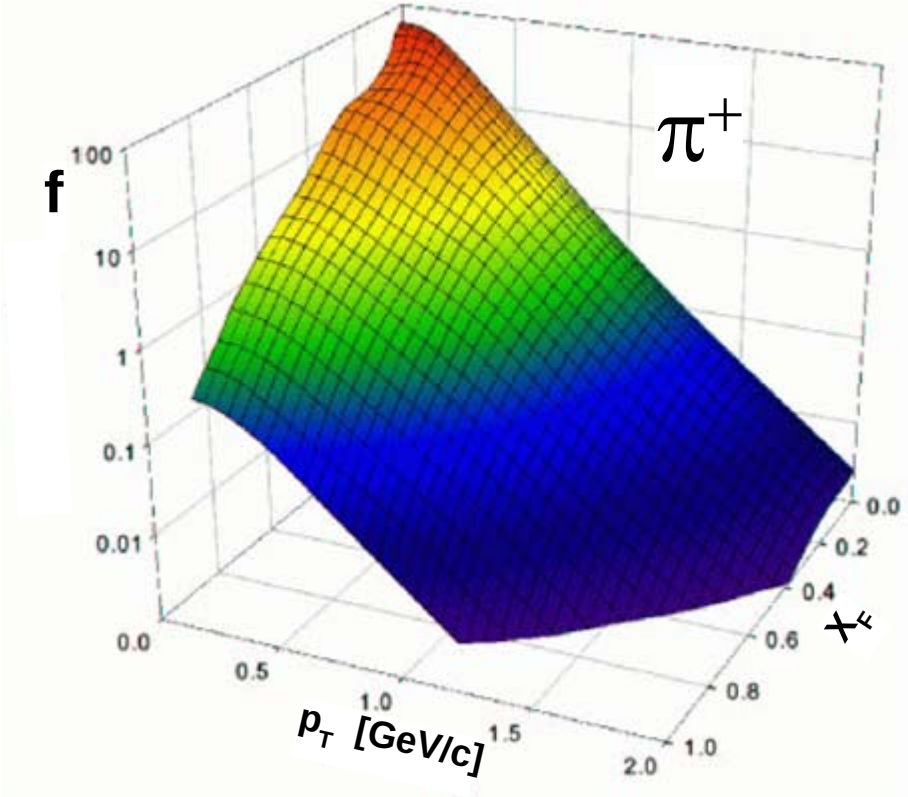

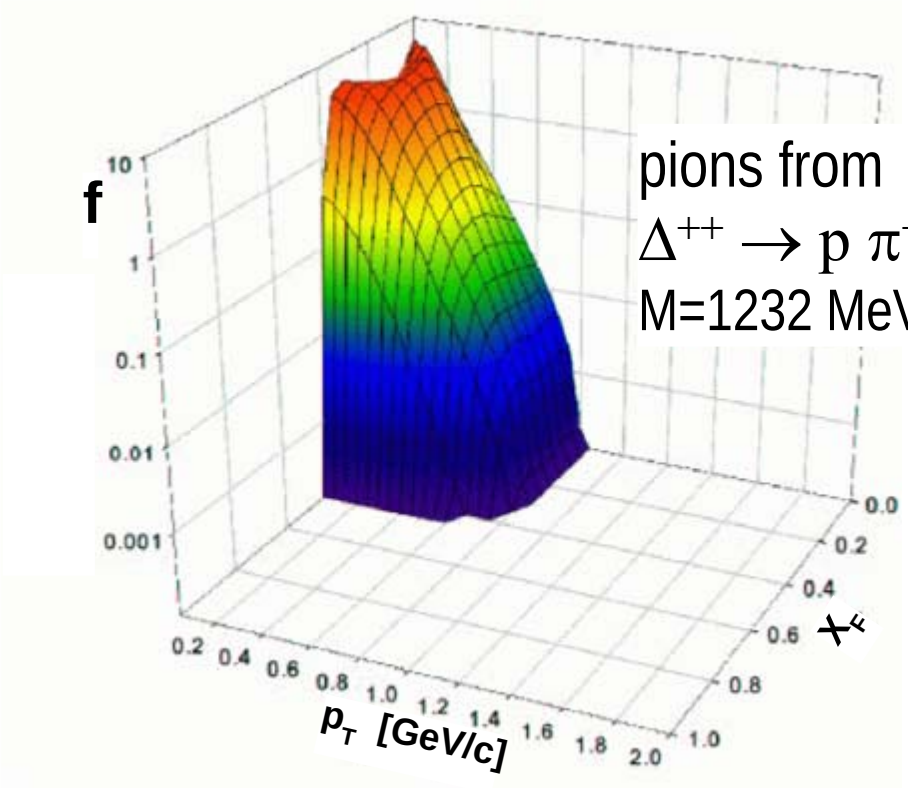

pions from
$\Delta^{++} \rightarrow p\ \pi^+$
M=1232 MeV

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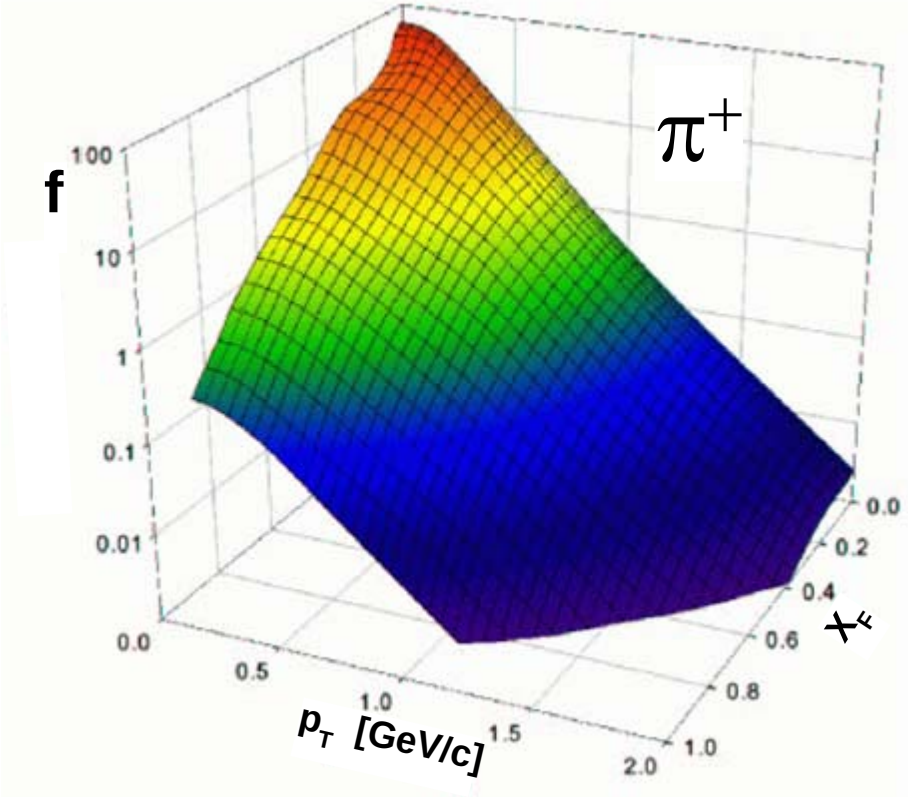
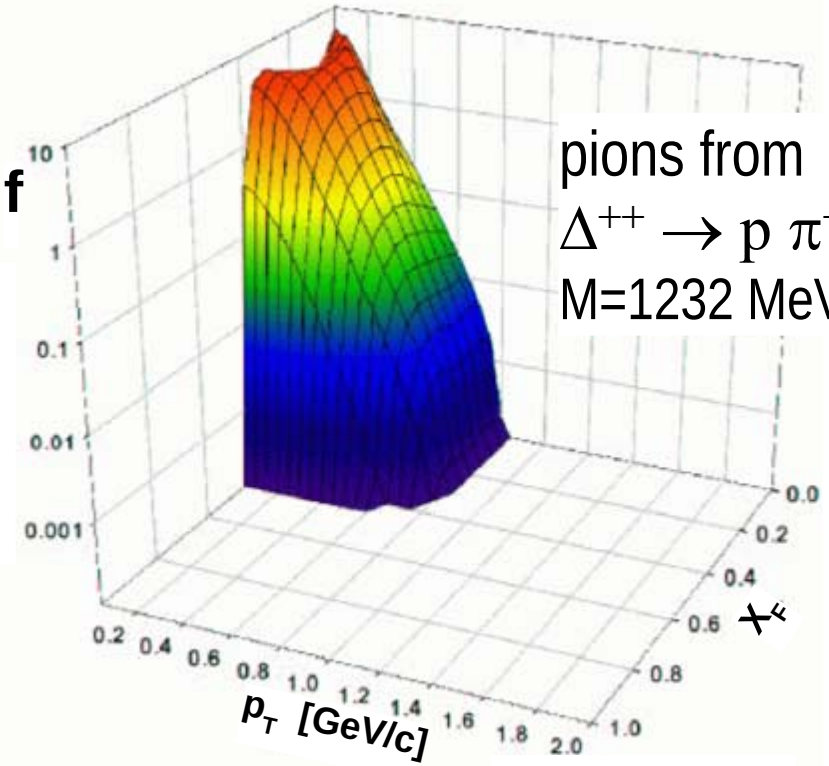
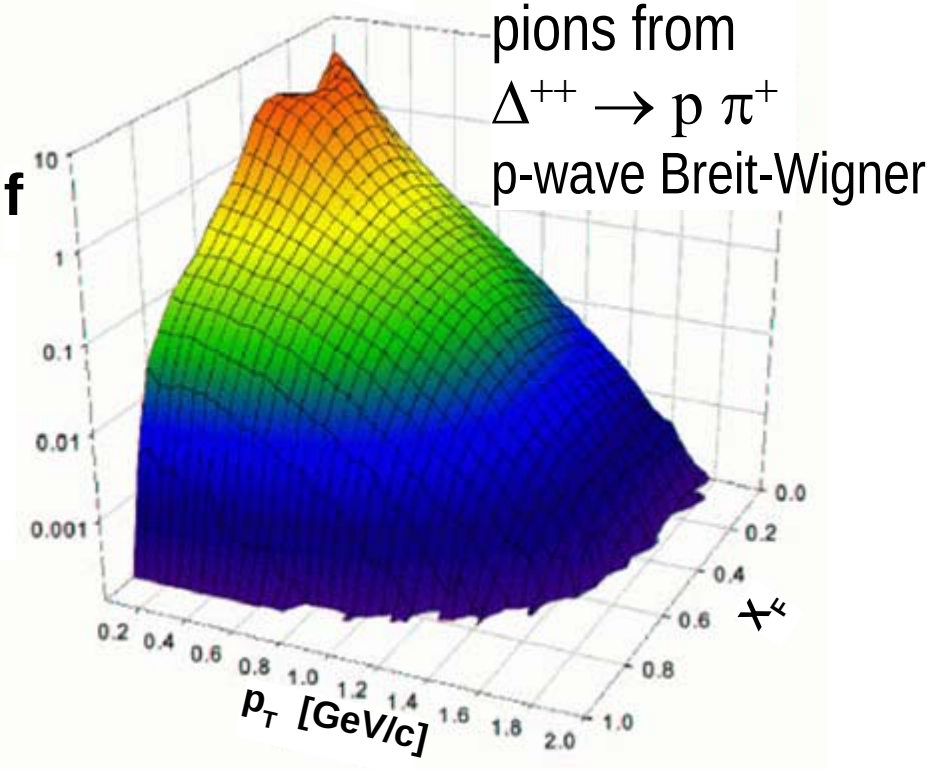
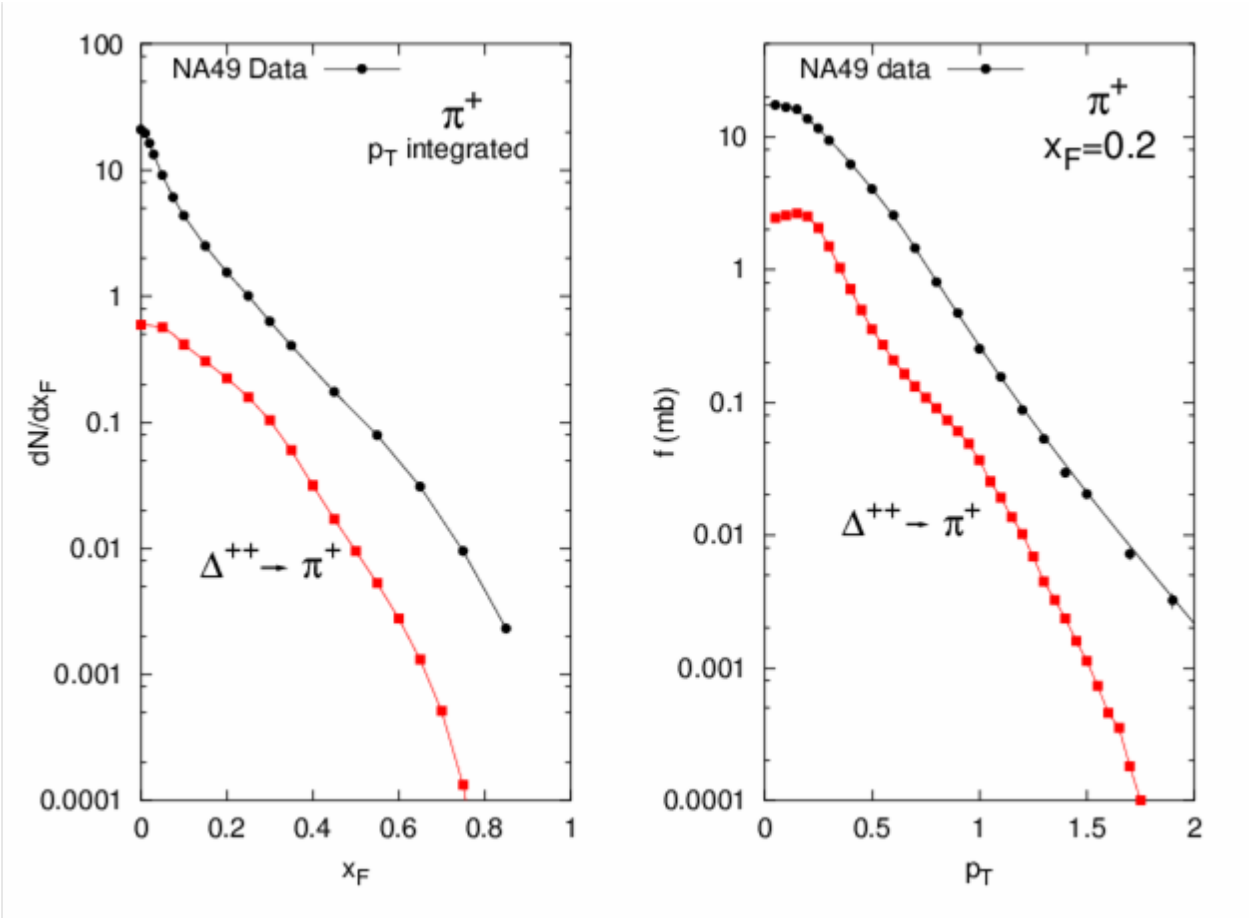






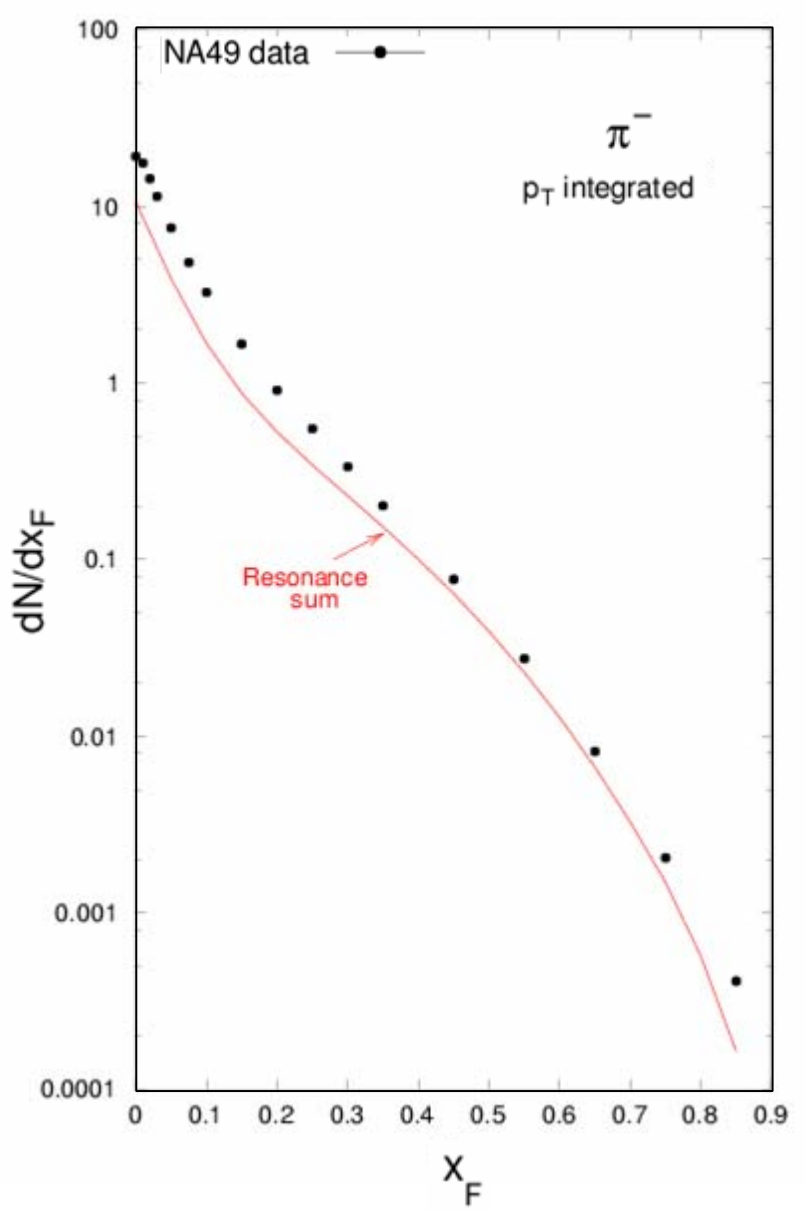
Projections of pion spectra



- The contribution of the $\Delta^{++} \rightarrow p\ \pi^+$ decay to inclusive spectra of pions is <u>not</u> confined to any specific region of x_F or p_T

3) Inclusive Particle Production

Resonance Contribution to Negative Pions

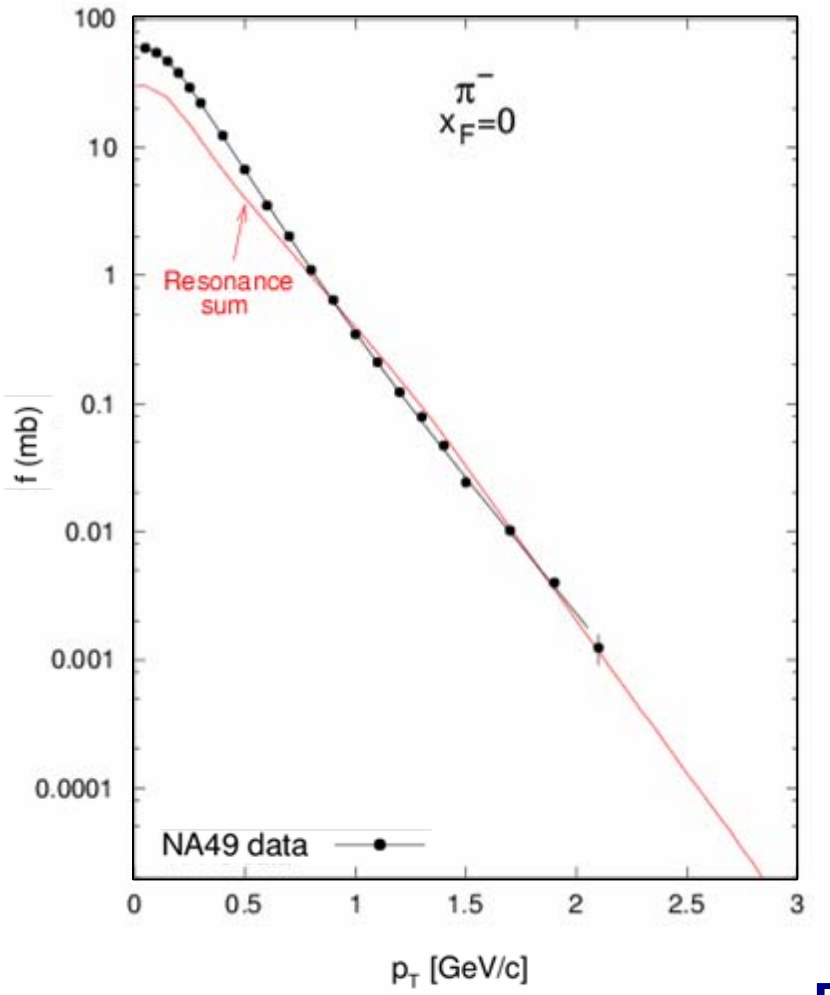


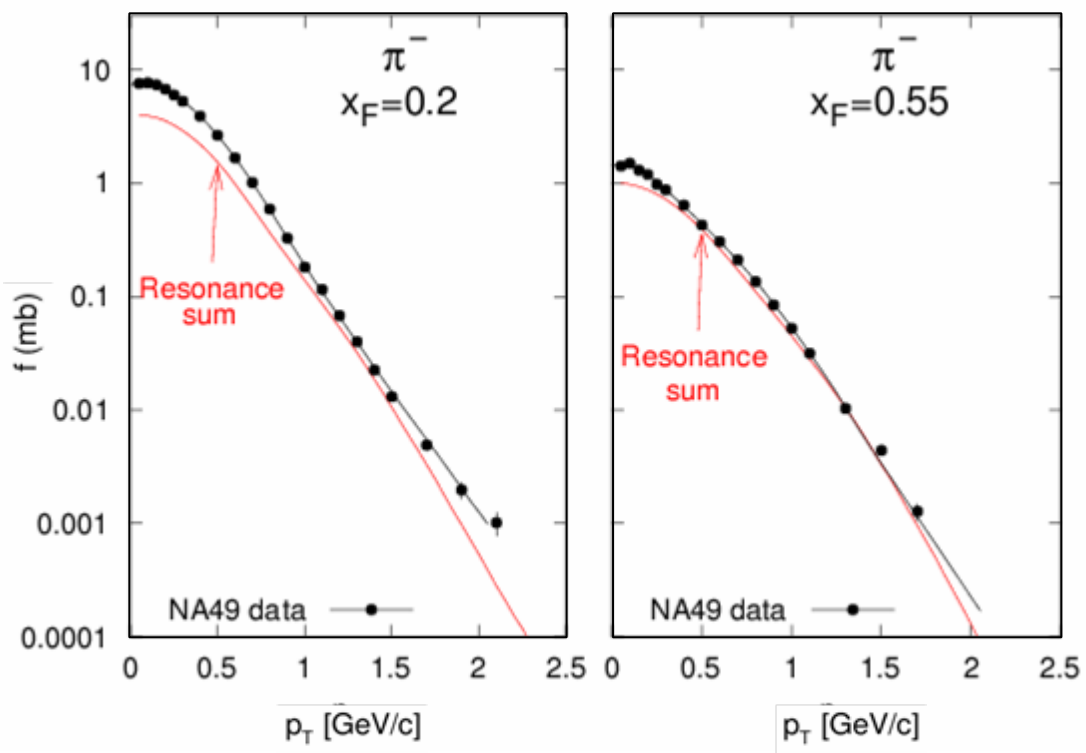
- Sum up measured resonances:

η^0	Δ^0
ω^0	Δ^-
ρ^0	$N^*(1440)$
ρ^-	$N^*(1520)$
f_2^0	$N^*(1680)$
ρ_3^0	
ρ_3^-	
f_4^0	

- **Problem: cascading** $\rho_3 \to \omega\pi$, $N^* \to \Delta\pi$, etc.
- Take only 2-body decays, to avoid double-counting (3π for η and ω).
- **Lower limit.**
- Cascading expected to contribute to lower x_F, p_T.

Transverse momentum distributions

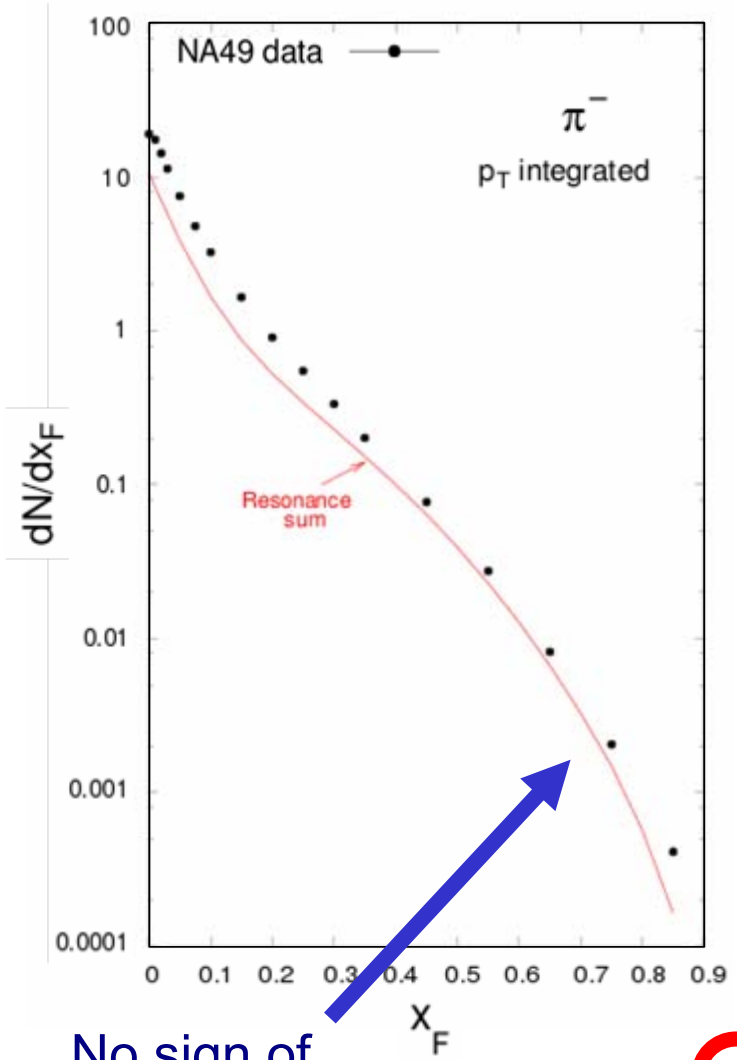




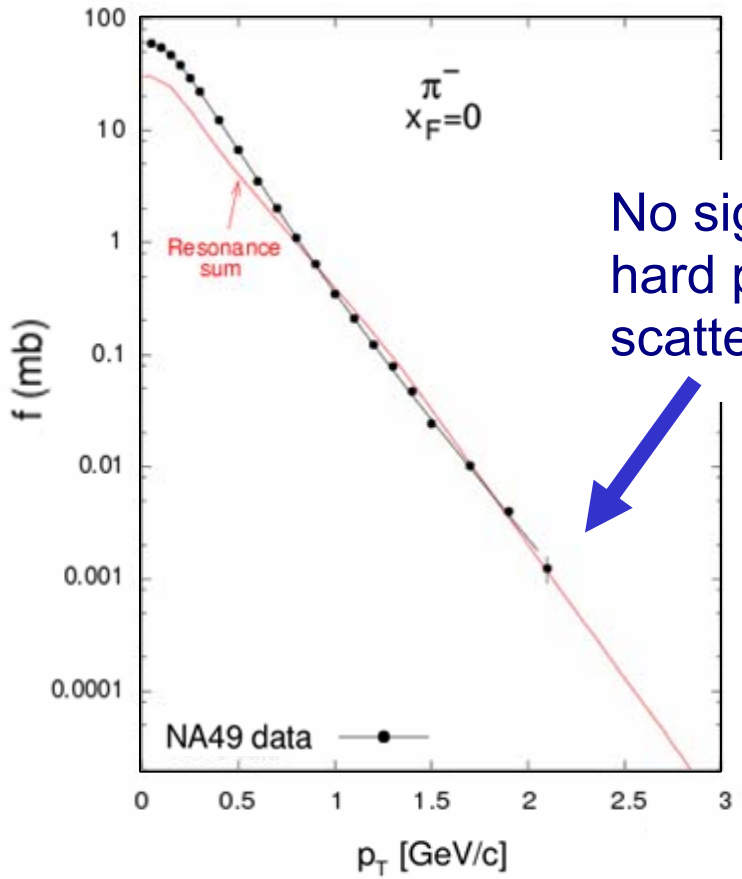
Resonances saturate the inclusive pion yield?

4) Discussion

Discussion (1): Parton Dynamics



No sign of valence quark fragmentation



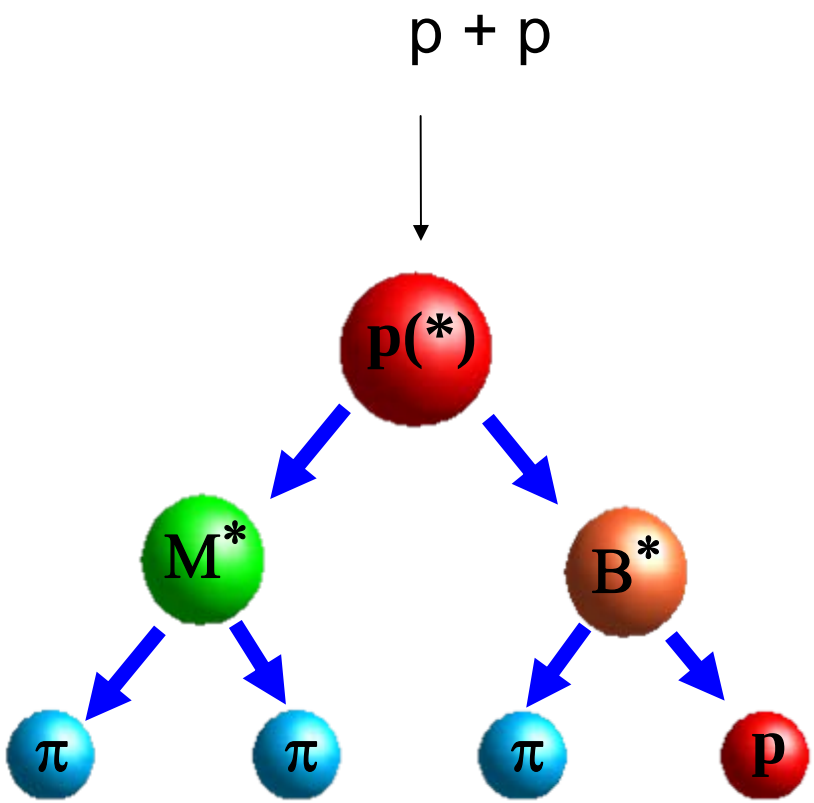
No sign of hard parton scattering

Where is the intermediate partonic phase?

Discussion (2): Particle Production

- parton fragmentation?
- string dynamics?

- resonance cascading?



6) Summary

- New, high precision data on particle production allow a detailed scrutiny of the mechanism of the hadronic interaction.
- The final state hadron distributions show direct evidence for the presence of resonance decays.
- Intermediate excited states appear as the main source of particle production at all longitudinal momenta and up to p_T=2 GeV/c and above.
- As such, parton dynamics scenarios assumed in most available microscopic models should be critically re-inspected.

Resonance formation and decay in production experiments is a key issue for the understanding of the non-perturbative strong interaction and of the transition from the elementary p+p reaction to the heavy-ion collision.