

# LEP Model Verification

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# Outline

- Existing verifications
- Required verifications
  - urgent
  - desired
- Data provided by experiments
  - recent results
  - new proposals

# Existing Verifications

- **Few recent (last ~ 6 years) verifications**
  - most to show how bad LEP is
  - old GHEISHA verifications are probably close
    - have 37 GeV/c, 200-400 GeV/c
    - are there any for  $< 25$  GeV/c ?
- **Cascade energy range (150 MeV – 10 GeV)**
  - pion production (800 MeV)
  - $K^+$  quasi-elastic scattering (370 MeV)

# Required Verifications (1)

- **LEP models are the only ones used for:**
  - all hadrons  $\sim 5 \text{ GeV} < E < \sim 25 \text{ GeV}$
  - all anti-baryons  $E < \sim 5 \text{ GeV}$
  - d, t,  $\alpha$   $E < 100 \text{ MeV}$
  - maybe CHIPS in the future
- **Most urgent verifications:**
  - (p,pX), (p,nX), (p, $\pi$ X) on various A between 5 GeV and 25 GeV
  - ( $\pi$ ,pX), ( $\pi$ ,nX) on various A between 5 and 25 GeV

## Required Verifications (2)

- **Desired (but not urgent) verifications:**
  - $(n,pX)$ ,  $(n,nX)$ ,  $(n,\pi X)$  on various  $A$  below 25 GeV
  - $(\bar{p},pX)$ ,  $(\bar{p},nX)$ ,  $(\bar{n},pX)$ ,  $(\bar{n},nX)$  on various  $A$  below 25 GeV
  - $(K,pX)$ ,  $(K,nX)$  on various  $A$  below 25 GeV
  - look at 0 – 5 GeV: capture, precompound region, etc.
- **Measured quantities required:**
  - $d^2\sigma/dE/d\Omega$ ,  $d^2\sigma/dp_T/dy$ , etc. of secondary particle

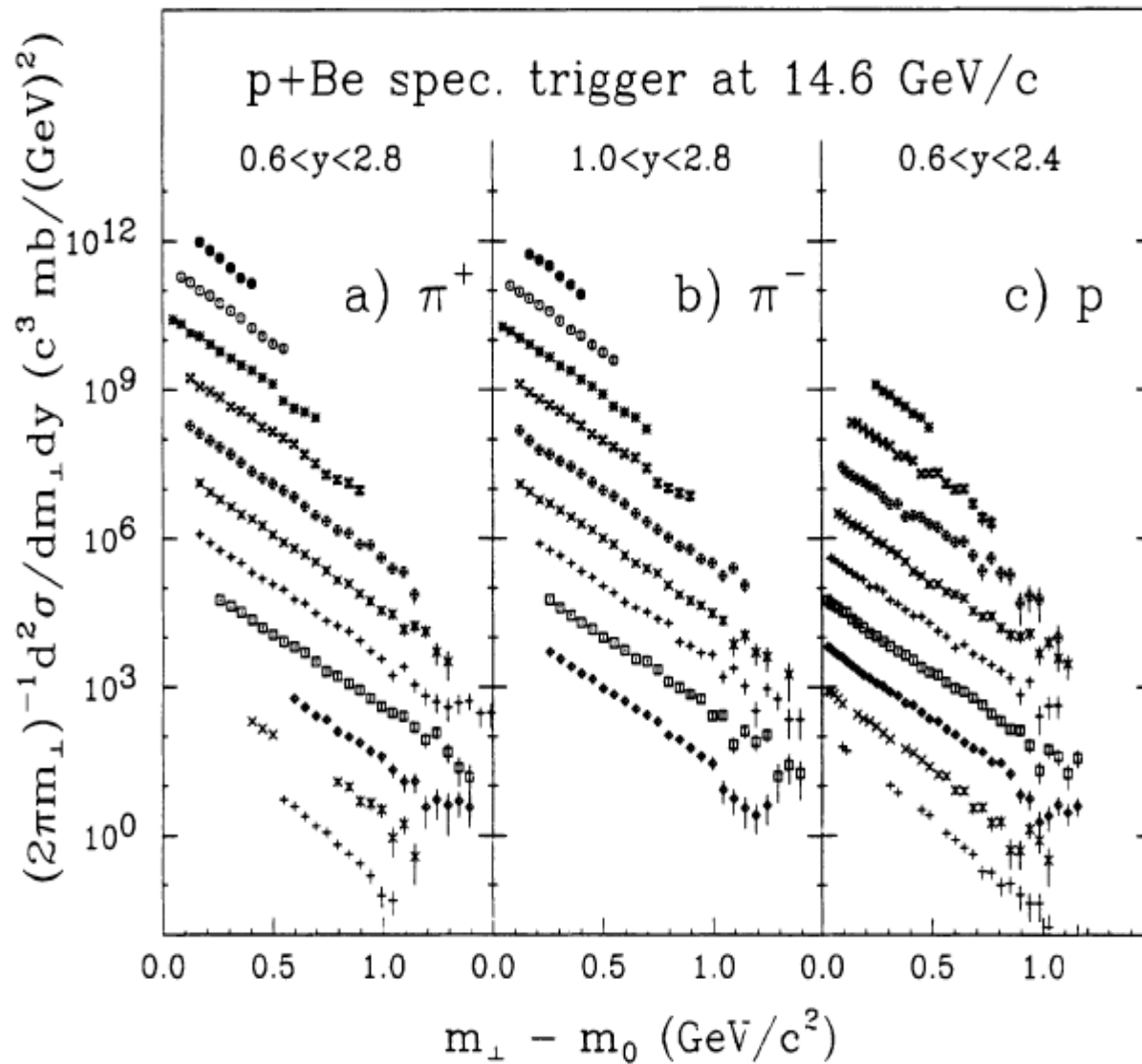
# Data Provided by Experiments (1)

- HARP, Nucl.Phys. B732, 1 (2006).
  - 12.9 MeV/c p-Al
- Chemakin et al., Phys.Rev. C65, 024904 (2002).
  - 12.3, 17.5 GeV/c p-Be, p-Cu, p-Au => inclusive pi final state
- Abbott et al., Phys. Rev. D45, 3906 (1992).
  - 14.6 GeV/c p-Be, p-Al, p-Cu, p-Au => inclusive pi, K, p final state
- Faessler et al., Nucl. Phys. B157, 1 (1979).
  - 20 GeV/c pi- => multiplicity
  - 37 GeV/c pi-, K-, pbar => multiplicity

## Data Provided by Experiments (2)

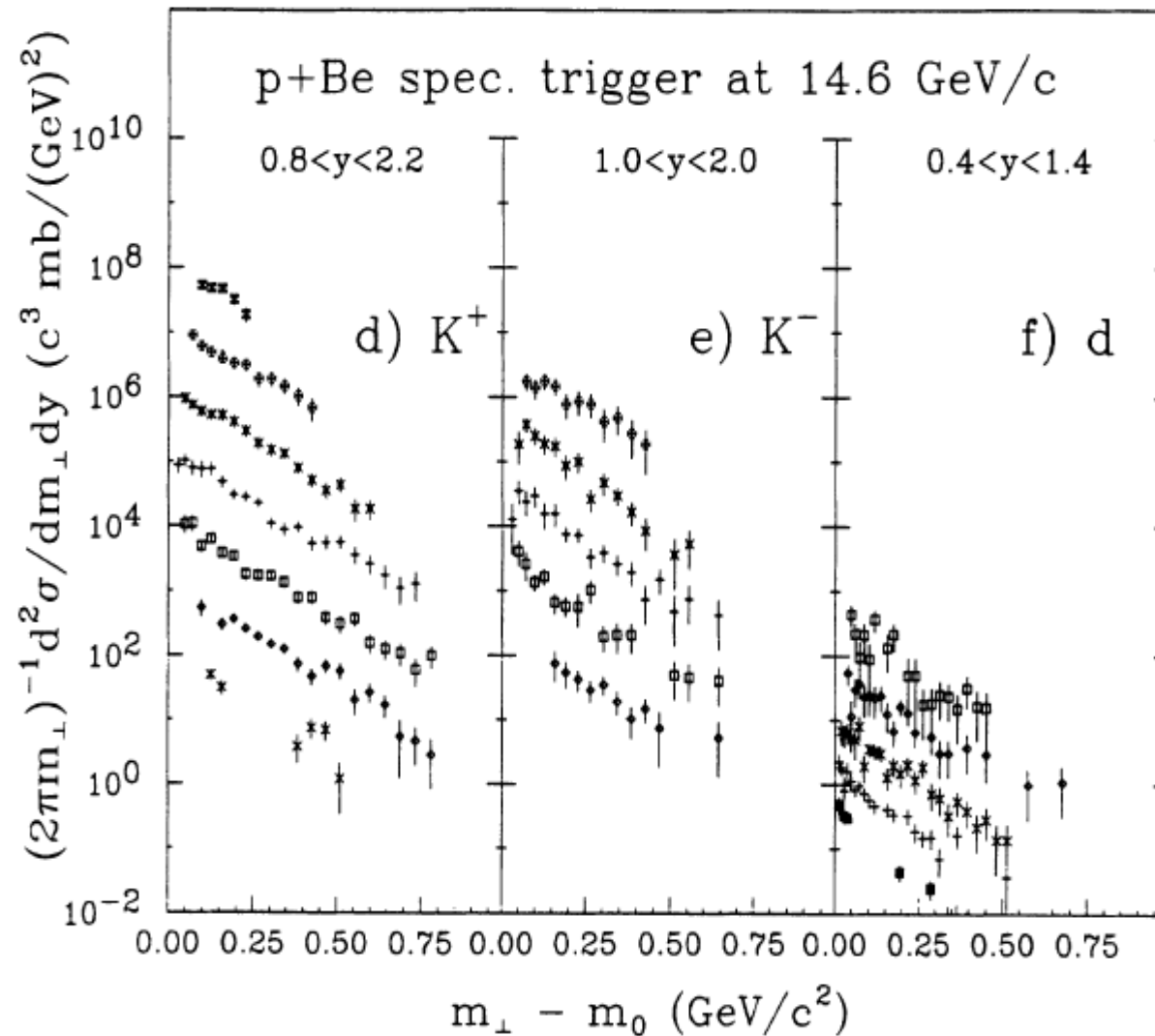
- Eichten et al., Nucl. Phys. B44, 333 (1972).
  - 24 GeV/c p+Be, p+Al, p+Cu, p+Pb => inclusive pi, K, pbar
- Armutliiski et al., Sov. J. Nucl. Phys. 48, 161 (1988).
  - 10 GeV/c p+C, p+Ta => inclusive pi-
- Sugaya et al., Nucl.Phys. A634, 115 (1998).
  - 3.5, 4, 5 GeV/c p+Cu -> pbar + X
- McGaughey et al., Phys.Rev.Lett. 56, 2156 (1986).
  - 608 MeV/c pbar-C, pbar-Y, pbar-U => inclusive pi+, p
- Raja, Phys. Rev. D16, 142 (1977).
  - pbar + p -> pi at 12 GeV/c

# Abbott (1992) 14.6 GeV/c p on Be

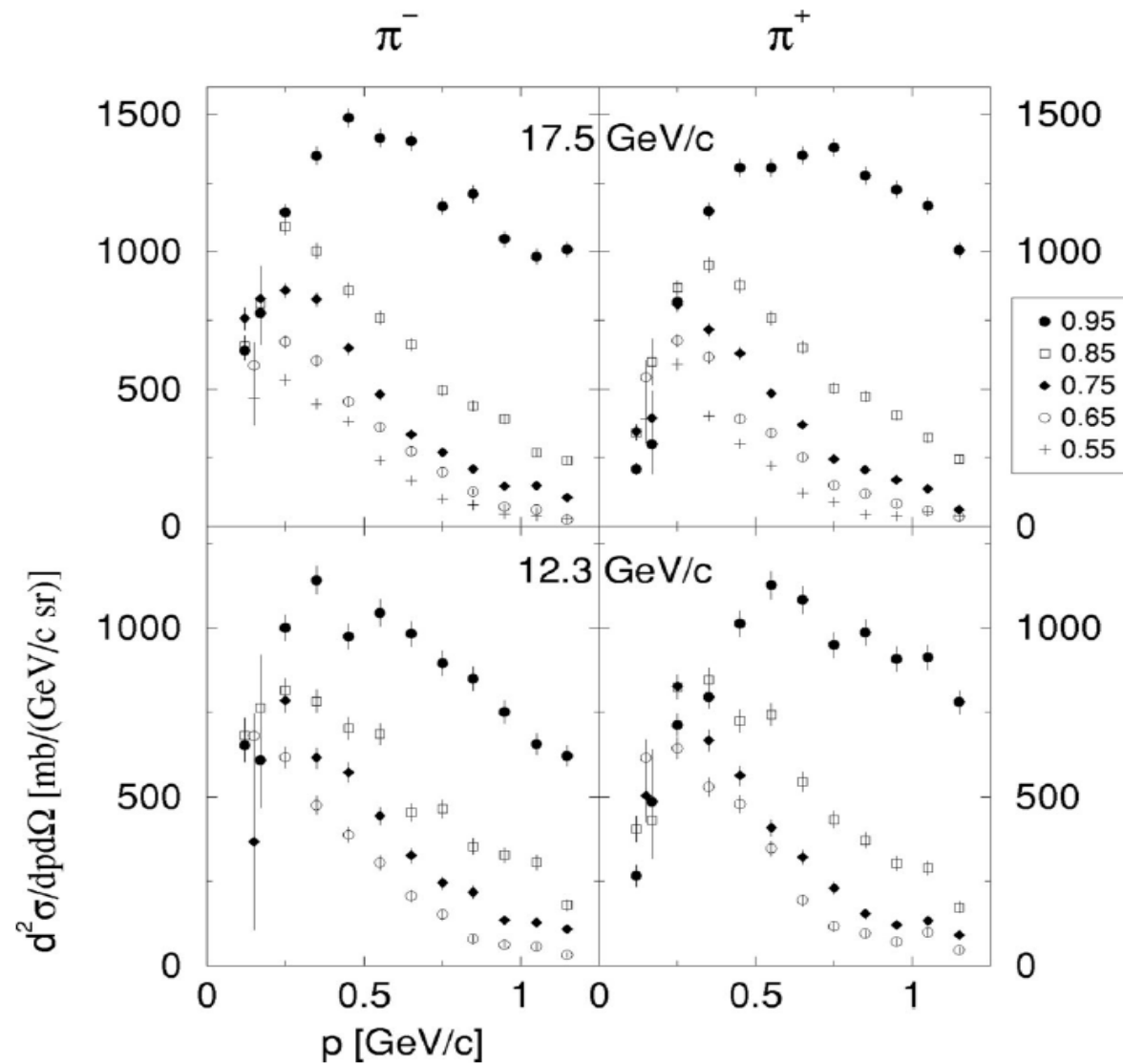




# Abbott (1992) 14.6 GeV/c p on Be



# Chemakin (2002) 12.3, 17.5 GeV/c p on Be, Cu, Au



# HARP, 12.9 GeV/c p on Al

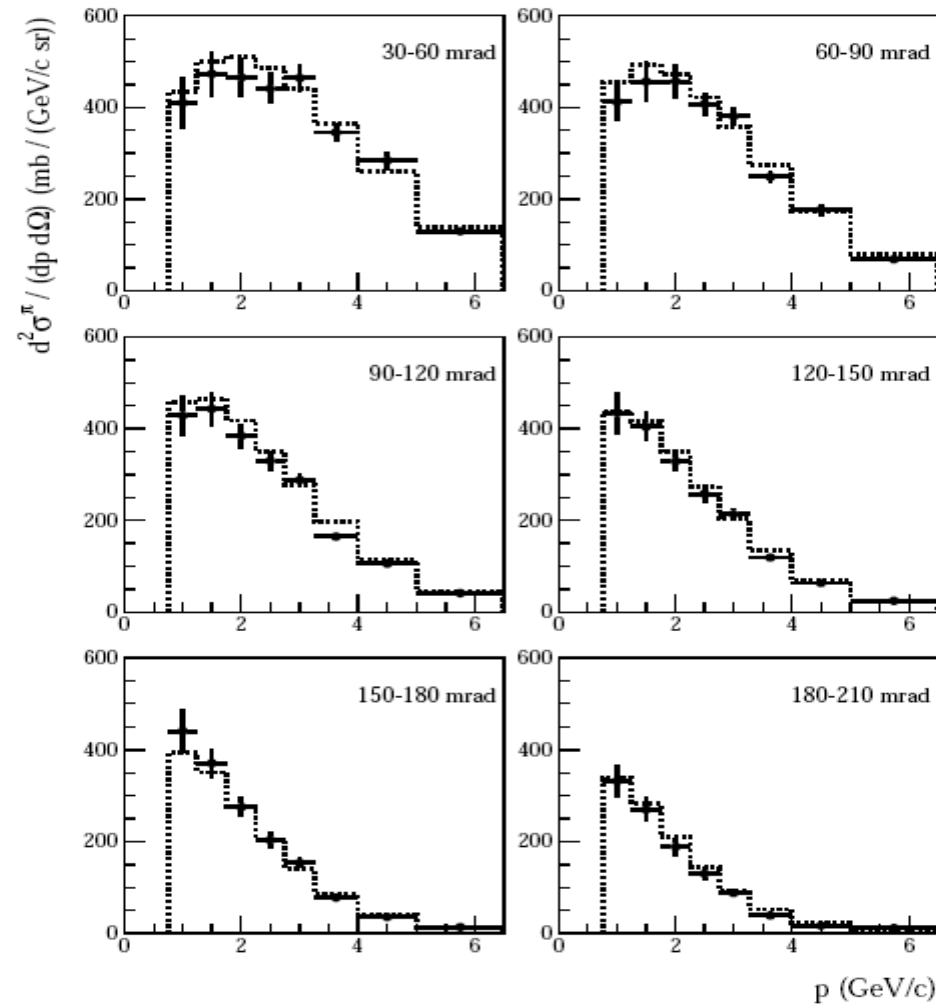
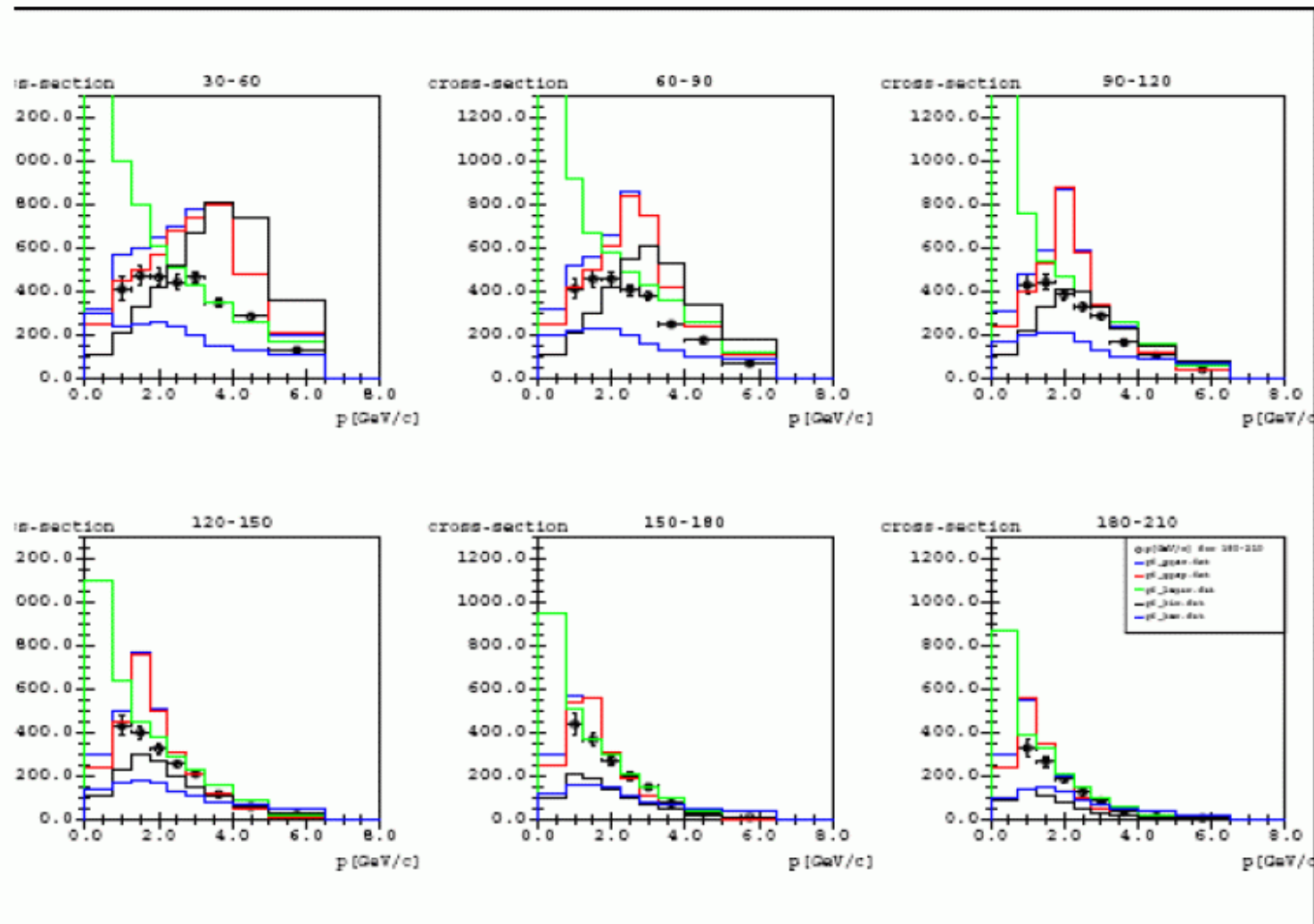


Figure 27: Measurement of the double-differential  $\pi^+$  production cross-section in the laboratory system  $d^2\sigma / (dp d\Omega)$  for incoming protons of 12.9 GeV/c on an aluminium target as a function of pion momentum  $p$ , in bins of pion polar angle  $\theta$ . The data points are the measurements, the histogram represents the Sanford-Wang parametrization fitted to the data.

# Double Differential Cross Section of $\pi^+$ Production by 12.9 GeV/c Protons in Al



# New and Recent Experiments

- **HARP**

- 12.9 GeV/c data published
- future publications at 15 GeV/c

- **MIPP**

- 5 – 85 GeV/c beams of  $\pi^{+/-}$ ,  $K^{+/-}$ , p, pbar
- wide range of A
- recently finished run (publications ?)
- upgrade could include n, nbar,  $K_L^0$  tagged beams of  $10 \text{ GeV/c} < p < 60 \text{ GeV/c}$

# Summary

- LEP models still needed for  $5 < E < 25$  GeV
- Verification and tuning needed in that range
  - (p,pX), (p,nX), (p, $\pi$ X), etc.
  - early verification against HARP data shows problems
- Published data are now available which cover most of above energy range:
  - 10, 12.3, 12.9, 14.6, 17.5, 24 GeV/c
  - need inclusive neutron spectra at these energies
- More data from HARP
- MIPP is analyzing recent runs, may be upgraded