Cross-sections of hadron production by 3-15 GeV/c beams of protons and charged pions

Joint Institute for Nuclear Research
A. Bolshakova
for the HARP-CDP group

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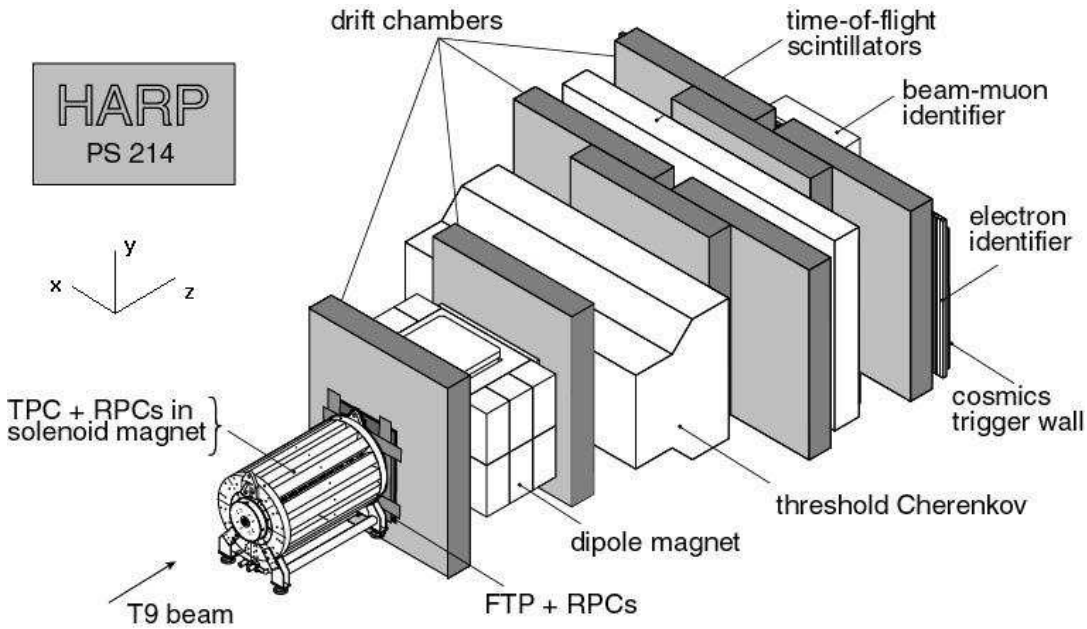
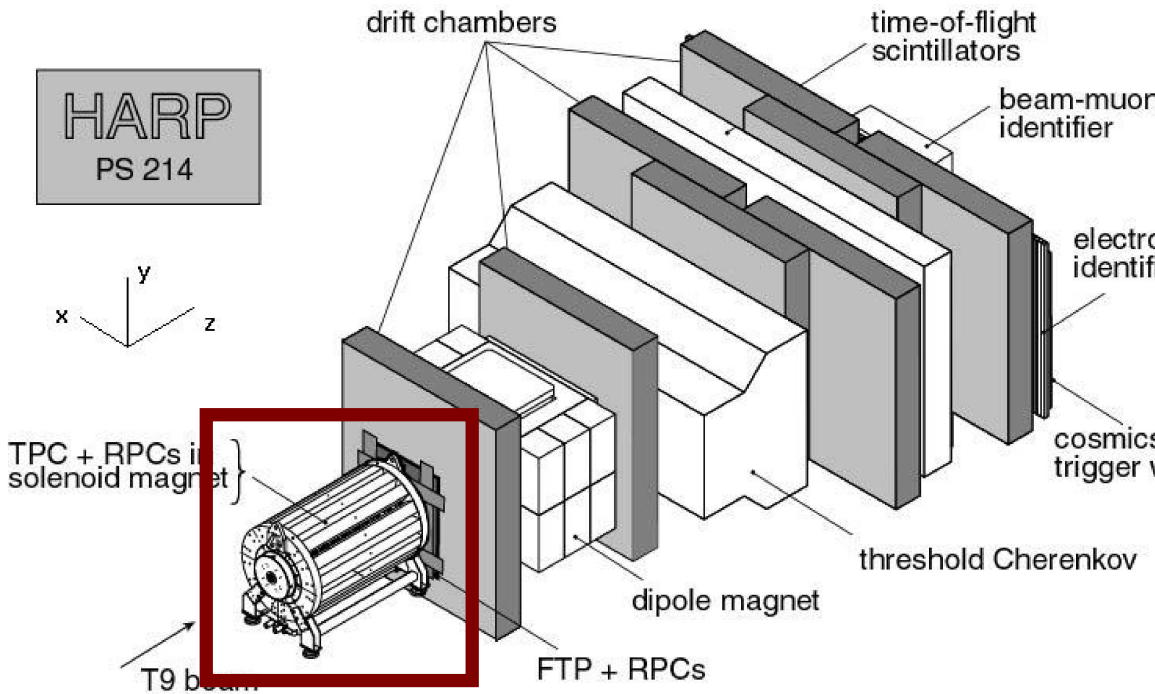
The HARP detector at the CERN PS

- Protons and $\pi^{\pm}$ beams of 1.5 – 15 GeV/c
- Targets:
  Be C Al Cu Sn Ta Pb
  H_2 D_2 N_2 O_2
  H_2O.



The HARP Large Angle detector

- Time Projection Chamber
- Resistive Plate Chambers
- Polar-angle range $20^\circ < \Theta < 125^\circ$



Characteristics of the HARP large-angle spectrometer

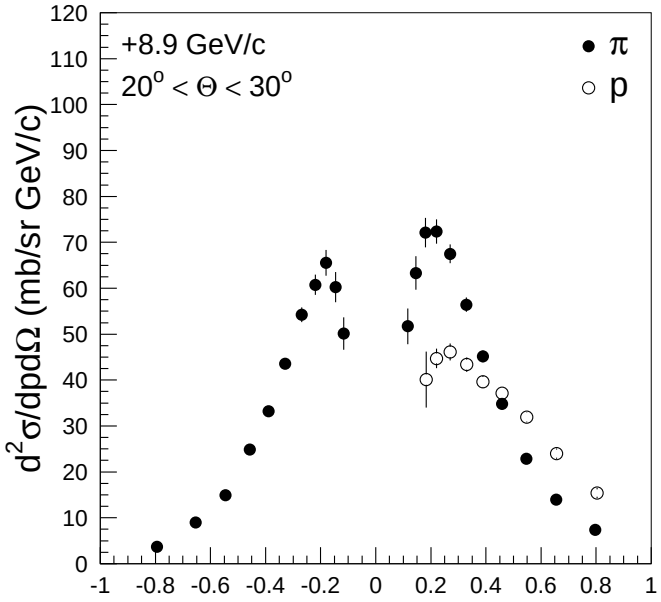
TPC: **NIM A 588 (2008) 294–317**	
$r \cdot \phi$ resolution	0.6 – 2.4 mm
z resolution	$\sim$ 3.5 mm
Θ resolution for $\Theta = 60^o$	$\sim$ 9 mrad
$1/p_T$ resolution	0.20 – 0.25 $(GeV/c)^{-1}$
dE/dx resolution over 300mm	$\sim$ 16%

RPC: **NIM A 578 (2007) 119–138**	
Intrinsic efficiency	98%
TOF resolution	175 ps

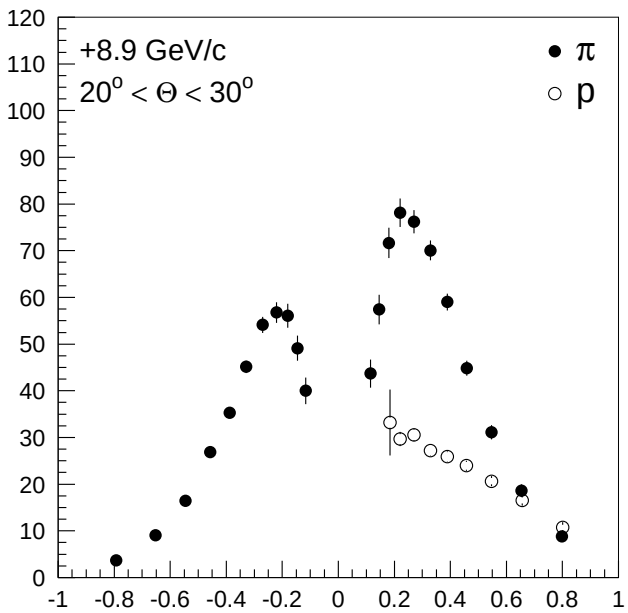
Cross-sections on Be as a function of the charge-signed p_{T}

- Be 5% λ_{abs} thin target
- polar-angle range $20^\circ < \Theta < 30^\circ$
- total errors are shown

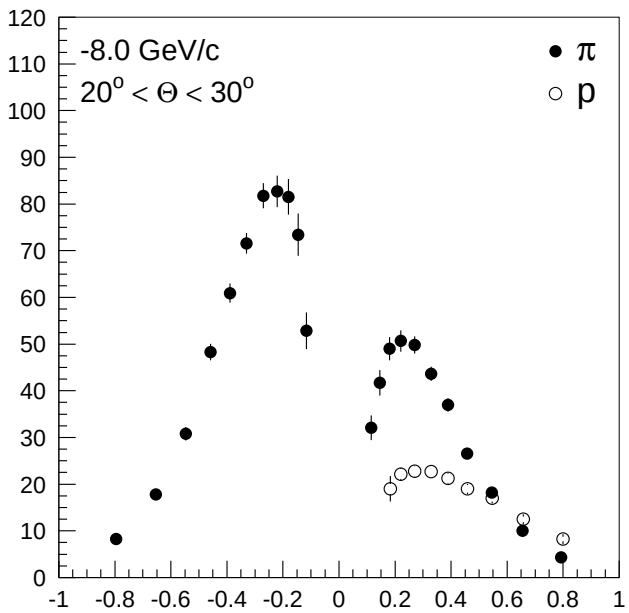
+8.9 GeV/c protons



+8.9 GeV/c π^+



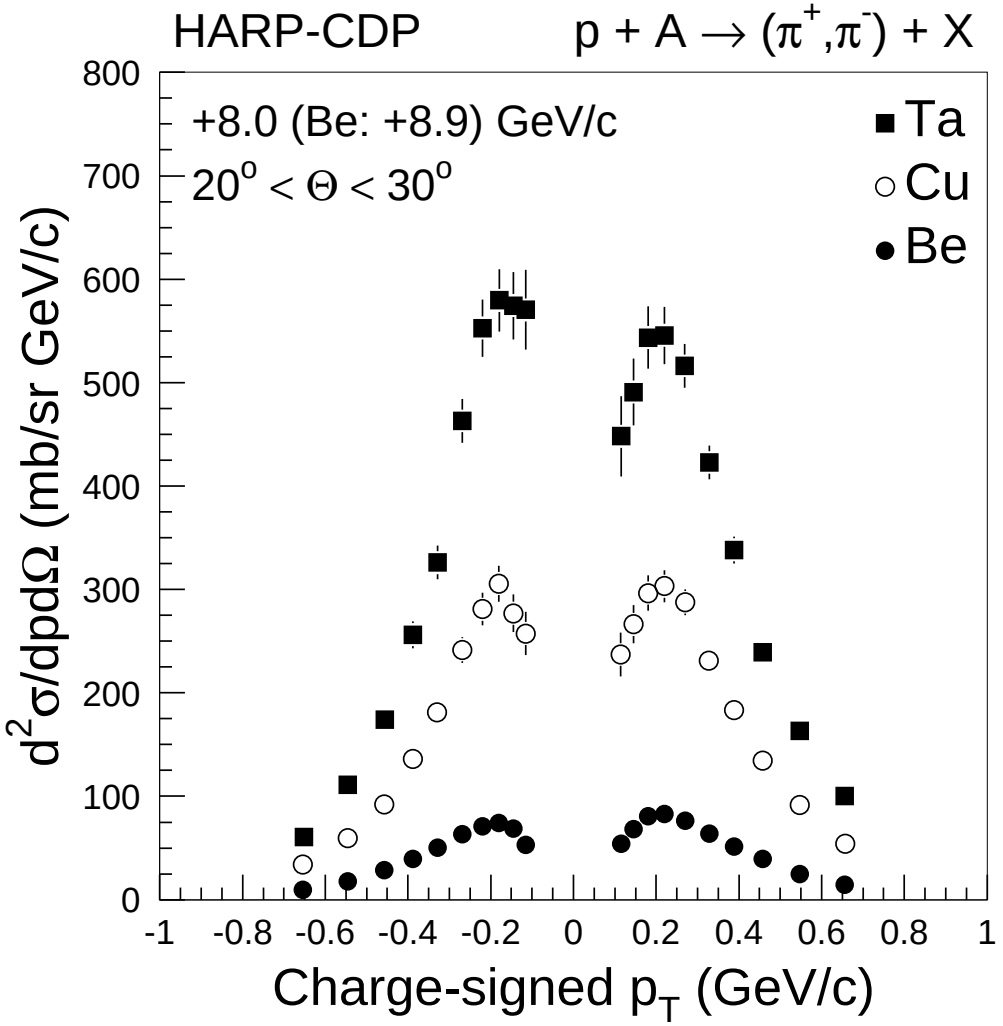
−8.0 GeV/c π^-



Charge-signed transverse momentum (GeV/c)

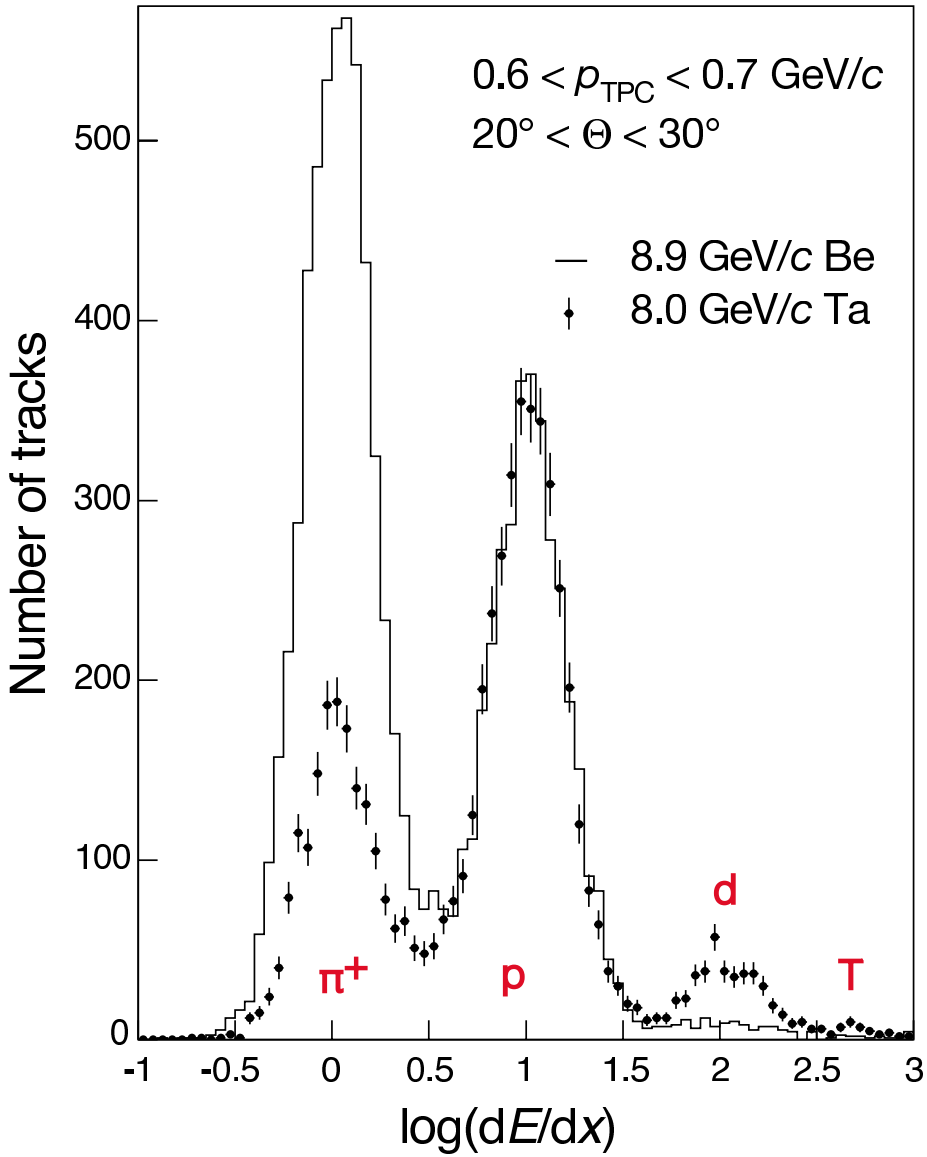
Comparison of π^+ and π^- cross-sections on Ta, Cu and Be

- +8.0 (Be: +8.9) GeV/c proton beam
- Ta, Cu and Be 5% λ_{abs} thin targets
- polar-angle range $20^\circ < \Theta < 30^\circ$
- total errors are shown



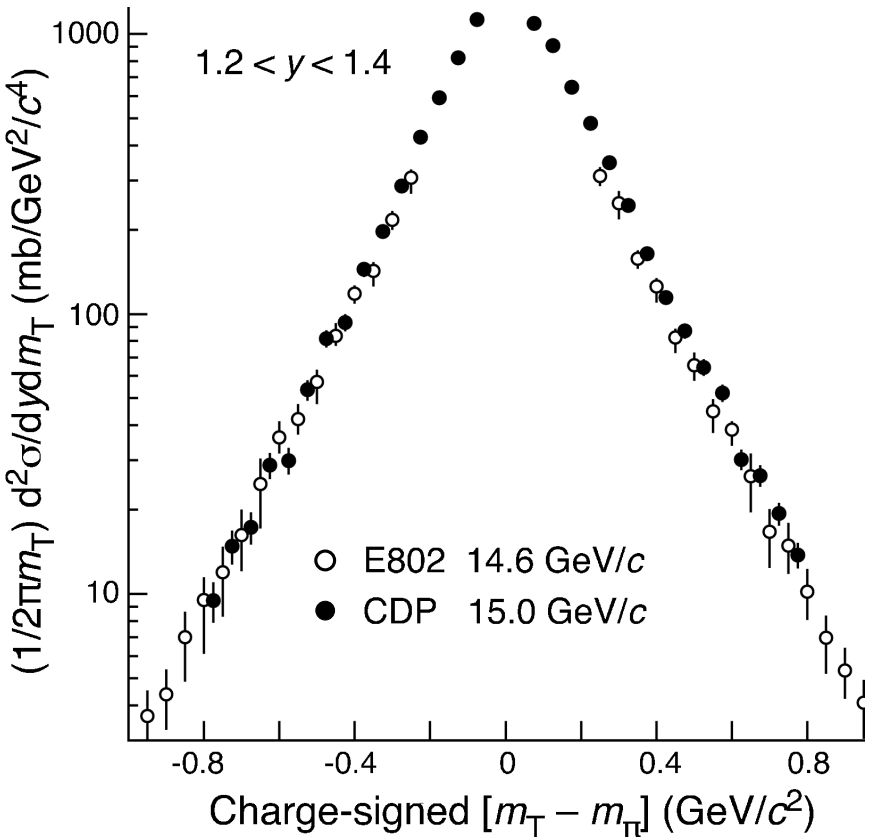
Comparison of particle production on Be and Ta

- Be (A = 9)
  Ta (A = 181)
  5% λ_{abs} thin targets
- +8.9 GeV/c (Be)
  +8.0 GeV/c (Ta)
  proton beam energy
- polar-angle range
  $20^\circ < \Theta < 30^\circ$
- momentum range
  $0.6 < p_{TPC} < 0.7 GeV/c$
- statistical errors are shown



Comparison with E802 results

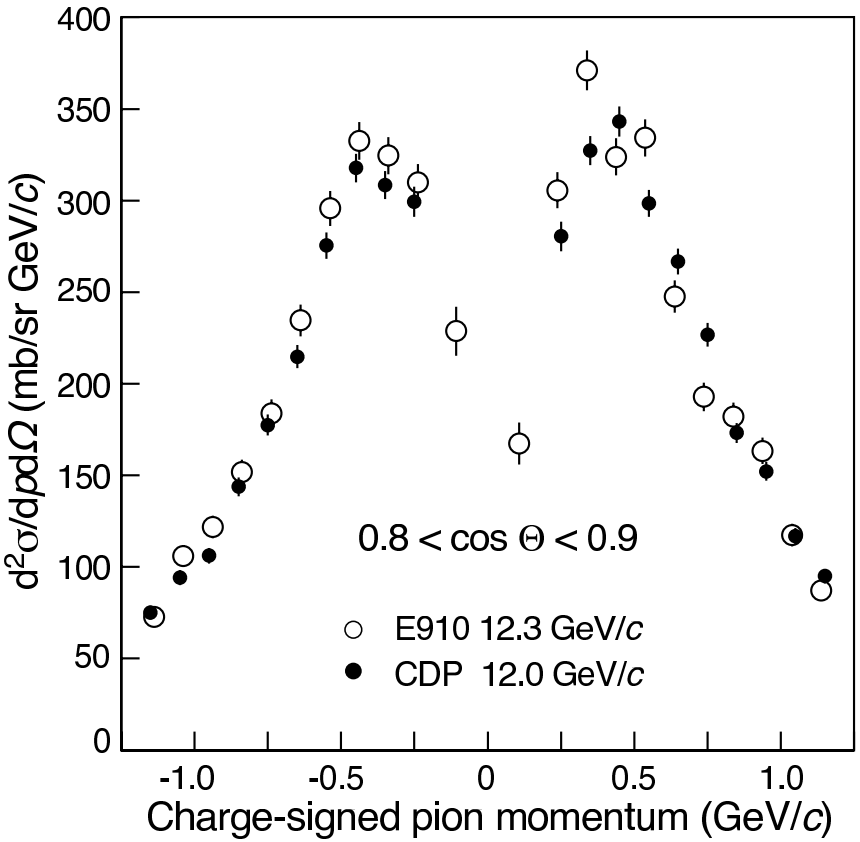
E802 at Brookhaven National Laboratory [Phys.Rev.**D45** (1992) 3906]



- $+14.6$ GeV/c protons on Be ($+15$ GeV/c for HARP-CDP)
- Lorentz-invariant cross-section as a function of $m_{\mathrm{T}} - m_{\pi}$ (m_{T} is the pion transverse mass)
- $\pi^{\pm}$ secondaries
- rapidity $1.2 < y < 1.4$
- statistical uncertainties only

Comparison with E910 results

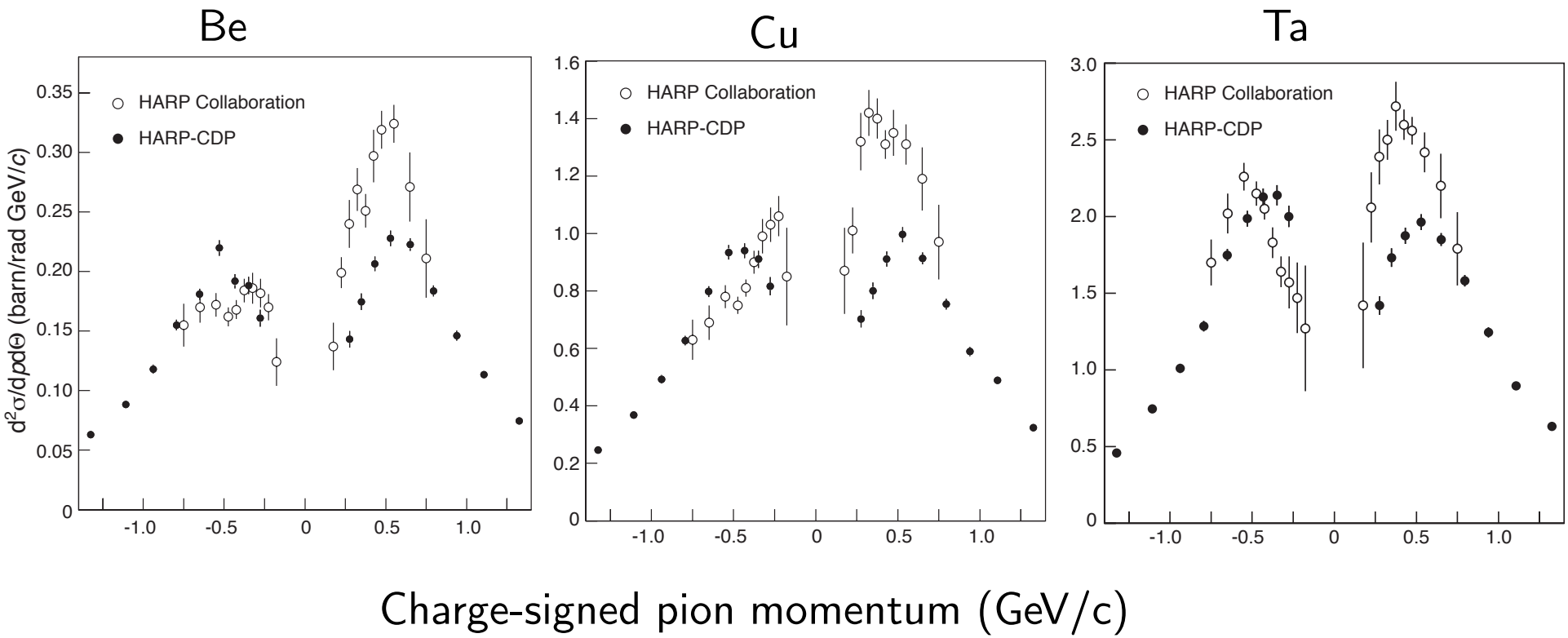
E910 at Brookhaven National Laboratory [Phys.Rev.**C65** (2002) 024904]



- $+12.3$ GeV/c protons on Cu ($+12$ GeV/c for HARP-CDP)
- $\pi^{\pm}$ secondaries
- polar-angle range: $26^\circ \lesssim \Theta \lesssim 37^\circ$
- statistical uncertainties only

CDP group vs Harp Collaboration

- +12GeV/c proton beam
- Be, Cu and Ta 5% λ_{abs} thin targets
- polar-angle range $20^\circ < \Theta < 30^\circ$
- total errors are shown



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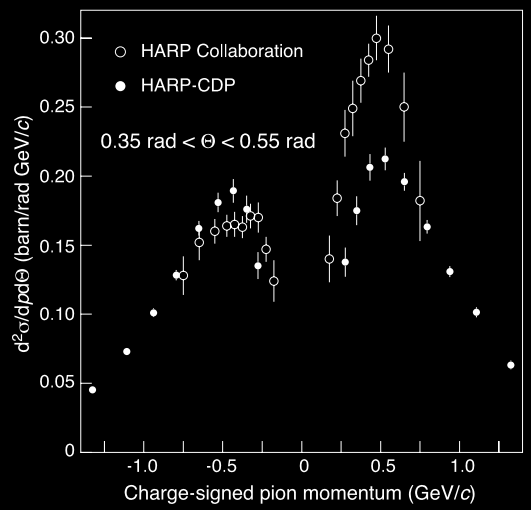
Particles and Fields



Comparison of cross-section measurements for charged pion production by +8.9 GeV/c protons off beryllium nuclei.
From A. Bolshakova et al.: Cross-sections of large-angle hadron production in proton- and pion-nucleus interactions I: beryllium nuclei and beam momenta of +8.9 GeV/c and −8.0 GeV/c

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Prospects for further results from HARP-CDP

the available data for 5% λ_{abs} thin targets
1.5 - 15.0 GeV/c beam energy

nucleus	Be	C	Al	Cu	Sn	Ta	Pb
A =	9	12	27	64	119	181	207

ready in progress intended

Conclusion

- The design of the proton driver of a neutrino factory can proceed with our Ta data
- We offer precise systematic measurements for the understanding of the mechanism of hadron production on nuclei:
  - dependence on secondary particle type (p, π^+, π^-)
  - dependence on beam particle (p, π^+, π^-)
  - dependence on beam momentum (1.5 to 15 GeV/c)
  - dependence on atomic number A of the target nucleus
- Our measurements are ready to be incorporated in hadron generator models