Results from HARP-CDP
or
The irresistible Power of Truth

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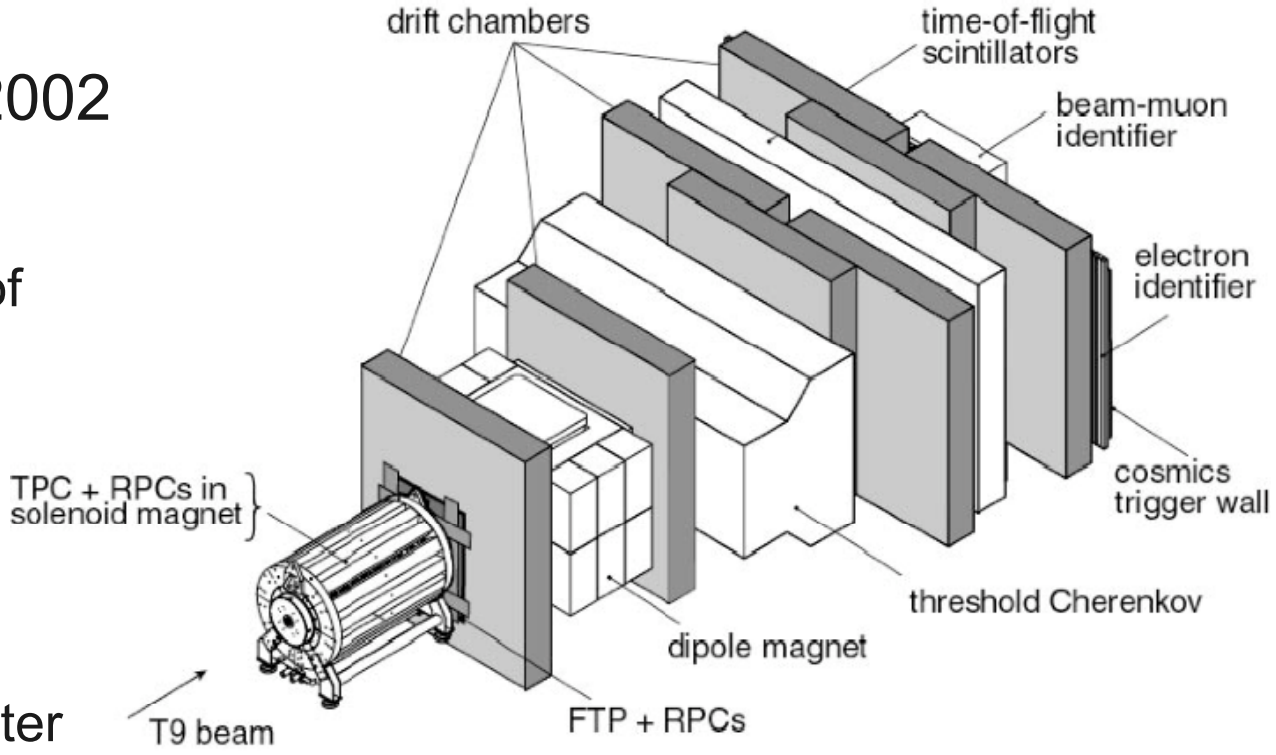
The HARP detector at the CERN PS

Data taking 2001/2002

- Proton 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
- Forward spectrometer
- Large-angle spectrometer
  - Time projection chamber (TPC)
  - Resistive plate chambers (RPC) for time of flight (TOF)



The HARP schism

- Beginning of data analysis = end of HARP
- Break into two parts over a deep split of opinion on quality of work and working methods
  - HARP Collaboration = Official HARP = OH
  - HARP-CDP Group = CDP
- In this seminar, we represent HARP-CDP
- Between HARP-CDP and OH only raw data and software infrastructure are common.
- Calibration and analysis algorithms and software are independent.

The HARP–CDP group

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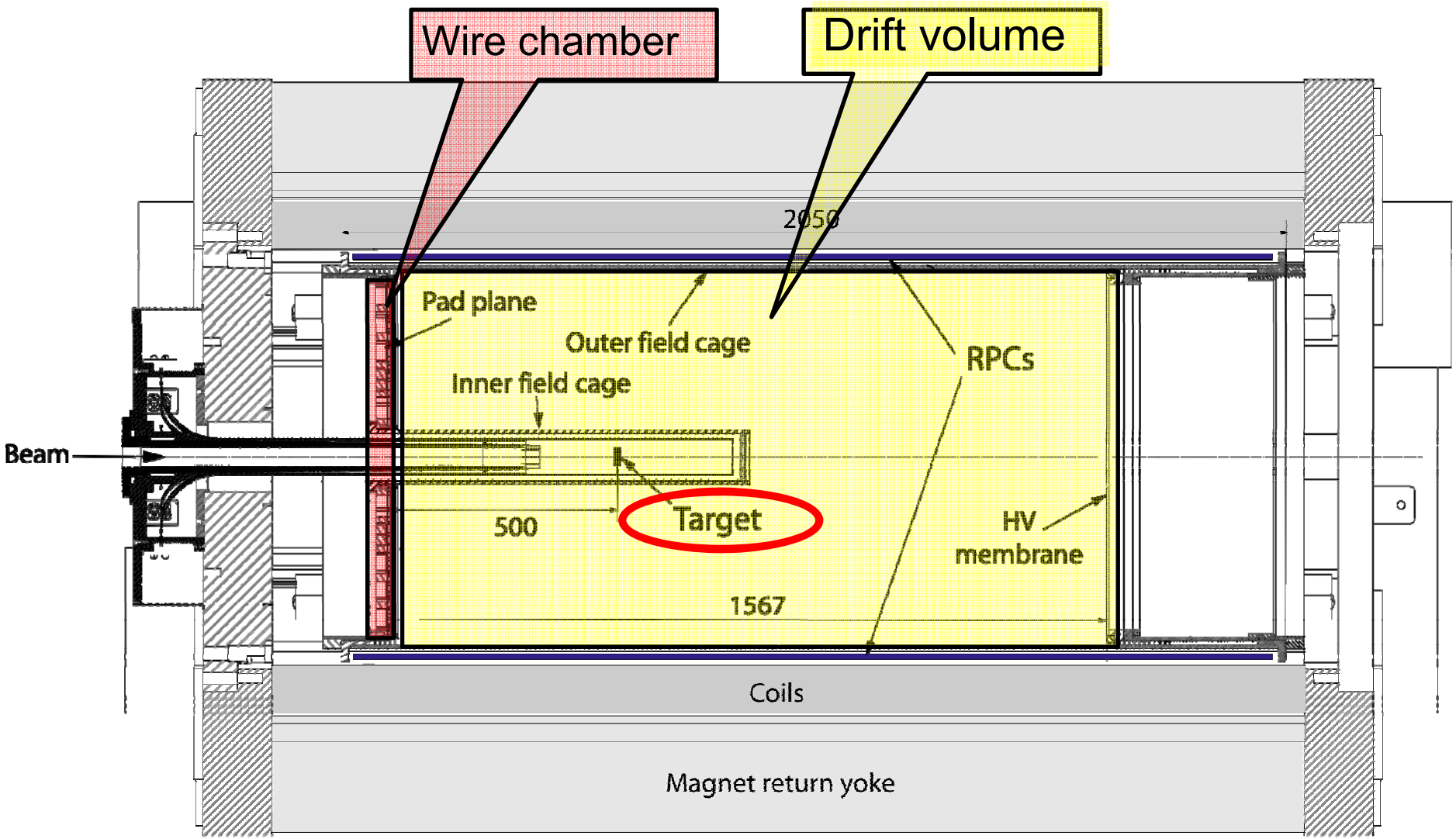
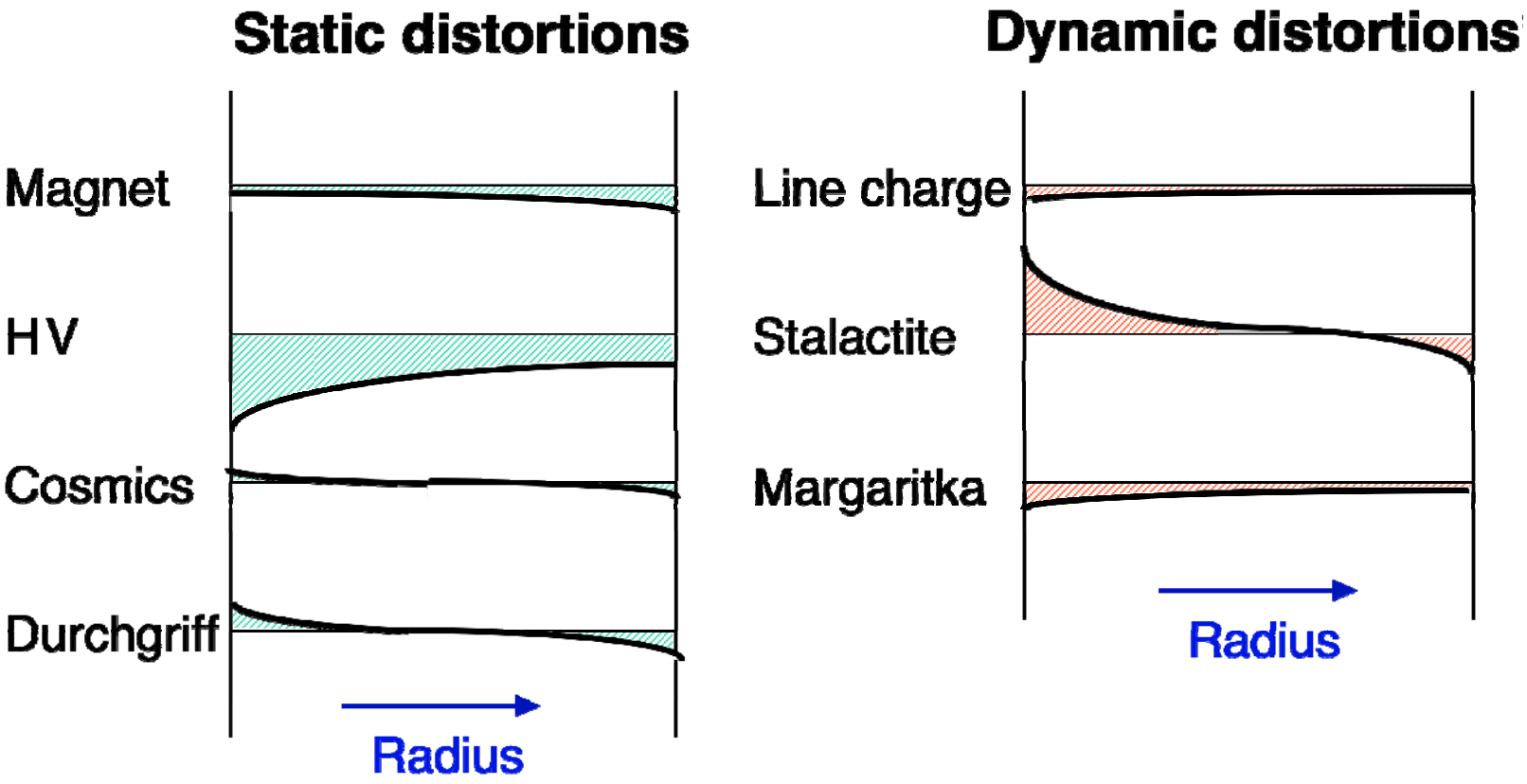
The HARP TPC


Wire chamber
Drift volume
2050
Pad plane
Outer field cage
Inner field cage
RPCs
Beam
500
Target
HV
membrane
1567
Coils
Magnet return yoke

TPC r·φ distortions

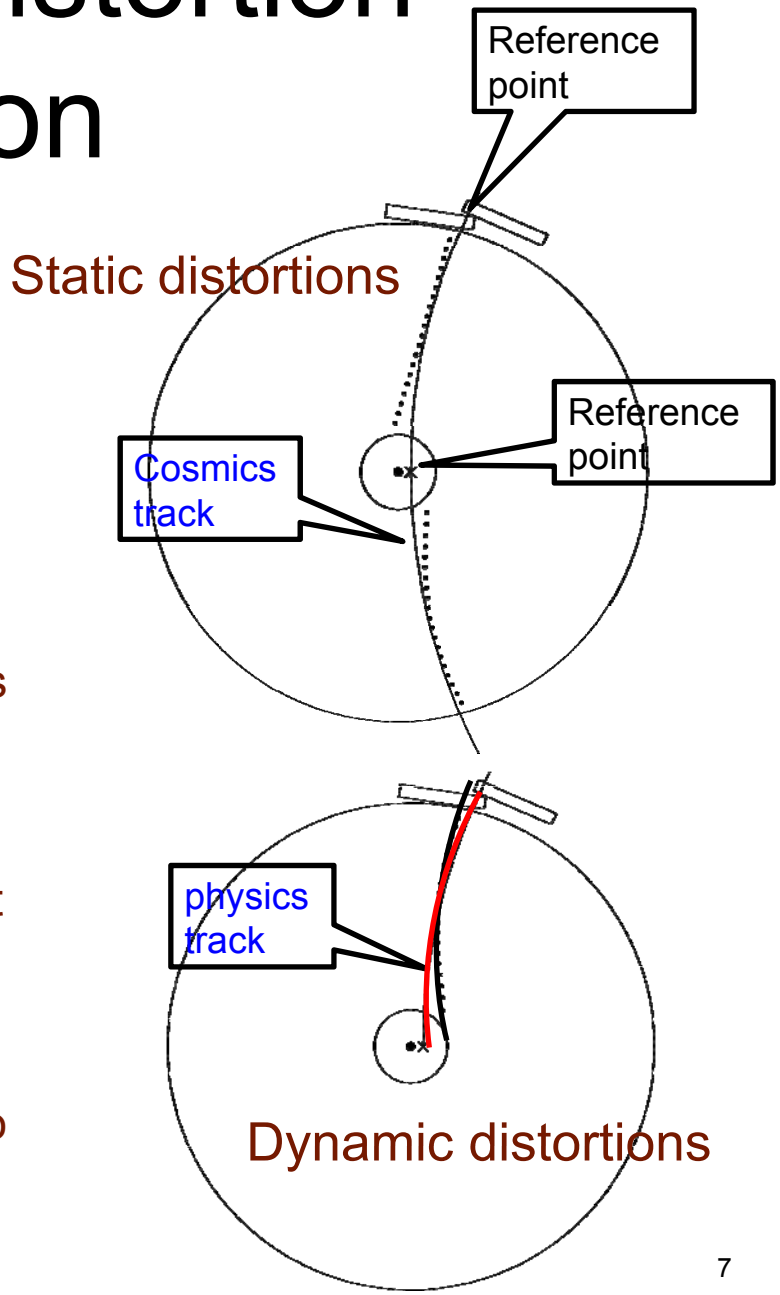


Also a strong z dependence

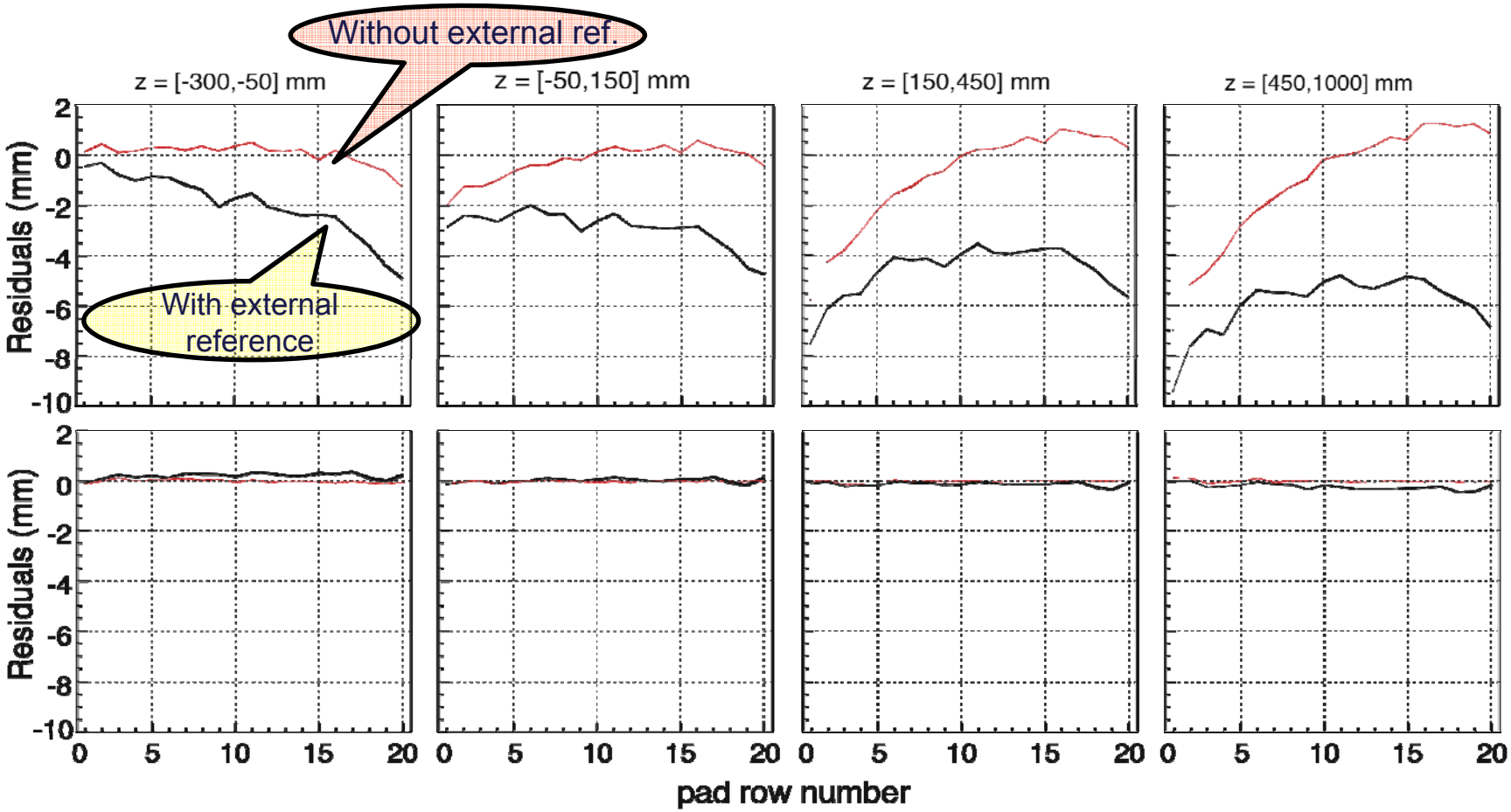
Rationale of distortion correction

- Use external reference points not affected by distortions
- For physics tracks, correction parameters determined by iterative procedure
  - Fit (distorted) cluster coordinates
  - Fitted curvature + reference points serve as estimator of real track
  - Determine the residuals $\Delta(r\cdot\varphi)$ between cluster coordinates and track estimator
  - Determine distortion model parameters that best reproduce average $\Delta(r\cdot\varphi)$
  - With these parameters the cluster positions are corrected
  - Repeat until $\Delta(r\cdot\varphi)$ are compatible with zero

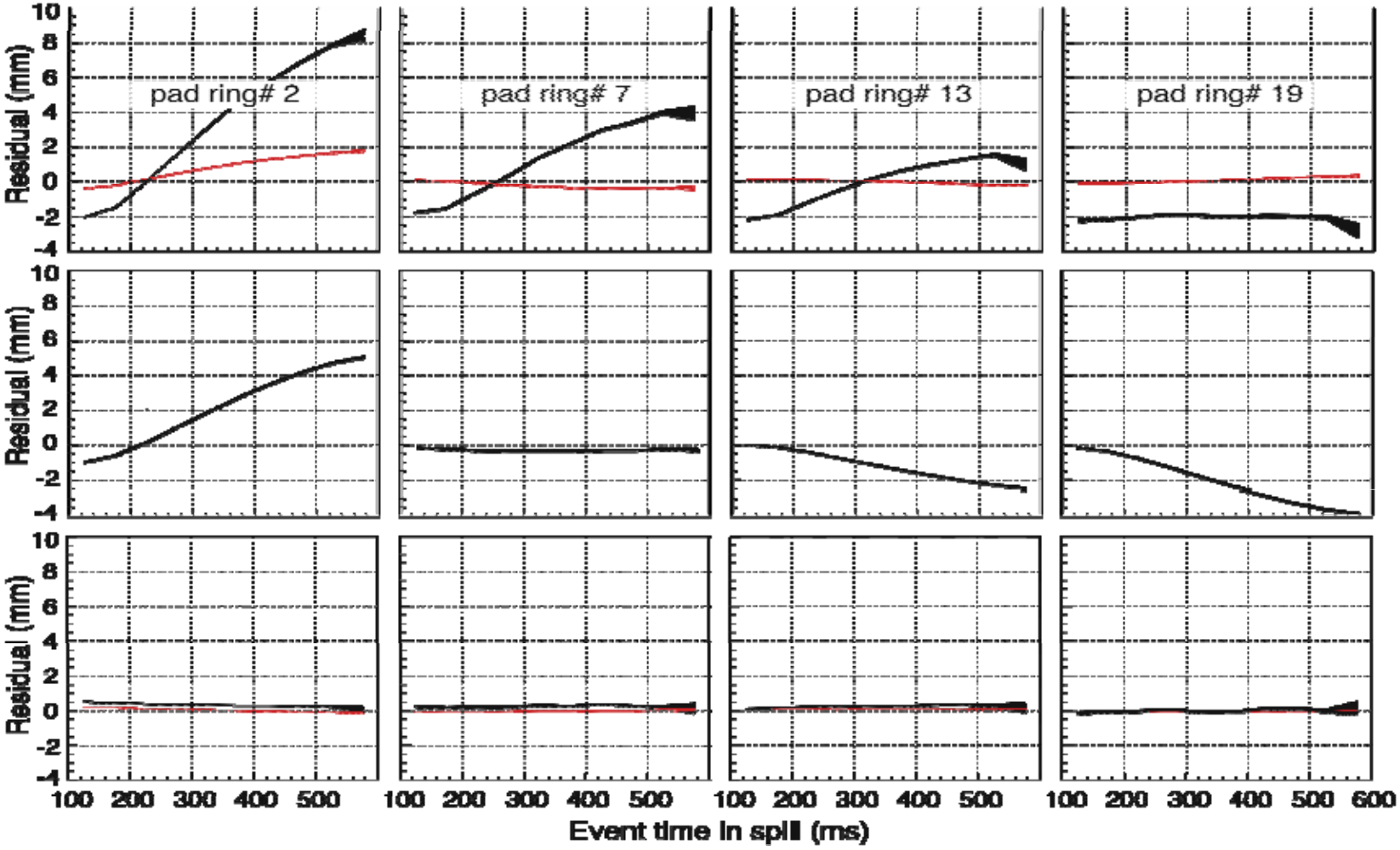
Converges typically after 2–3 iterations



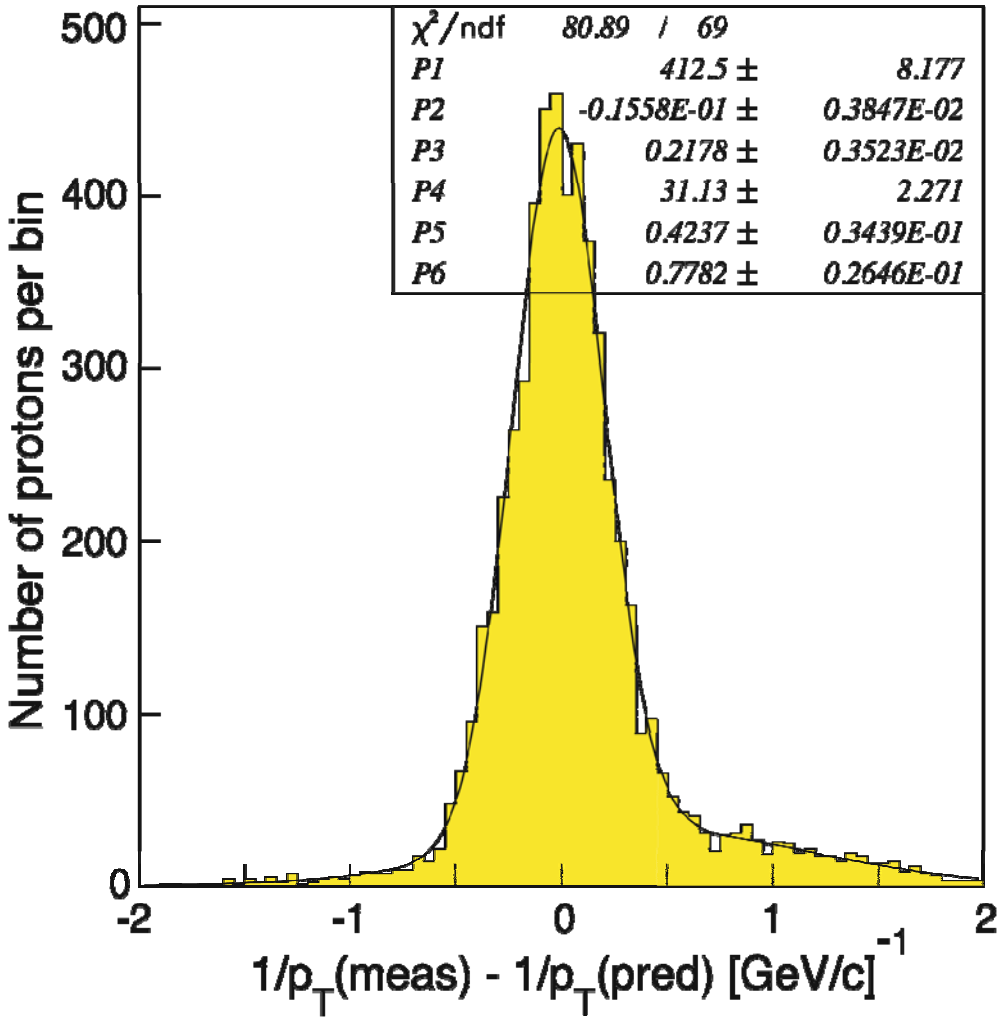
Static distortions



Dynamic distortions



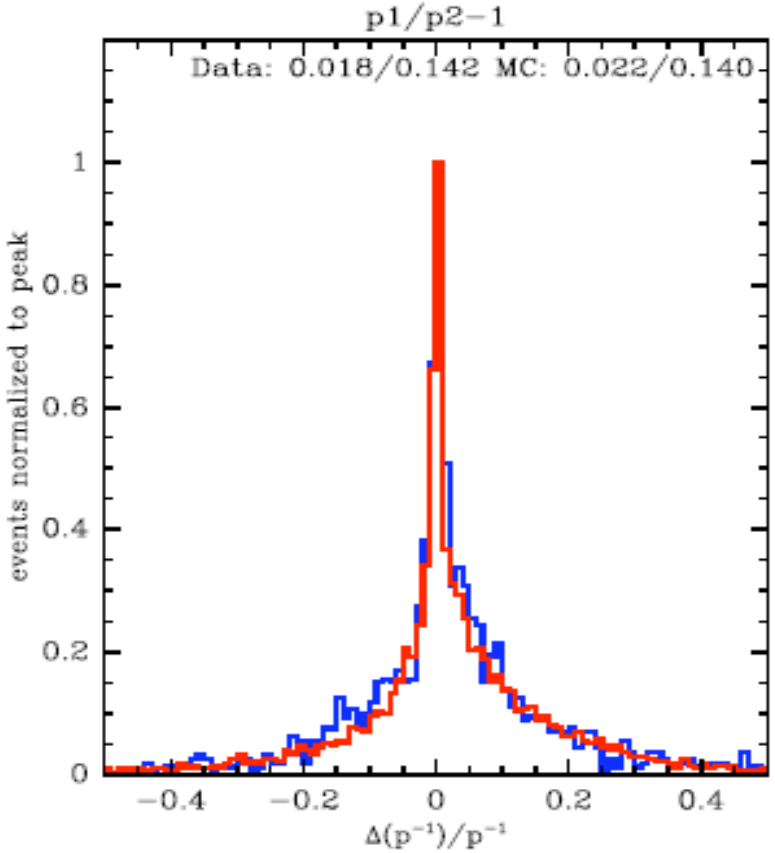
Momentum resolution from elastic proton-proton scattering



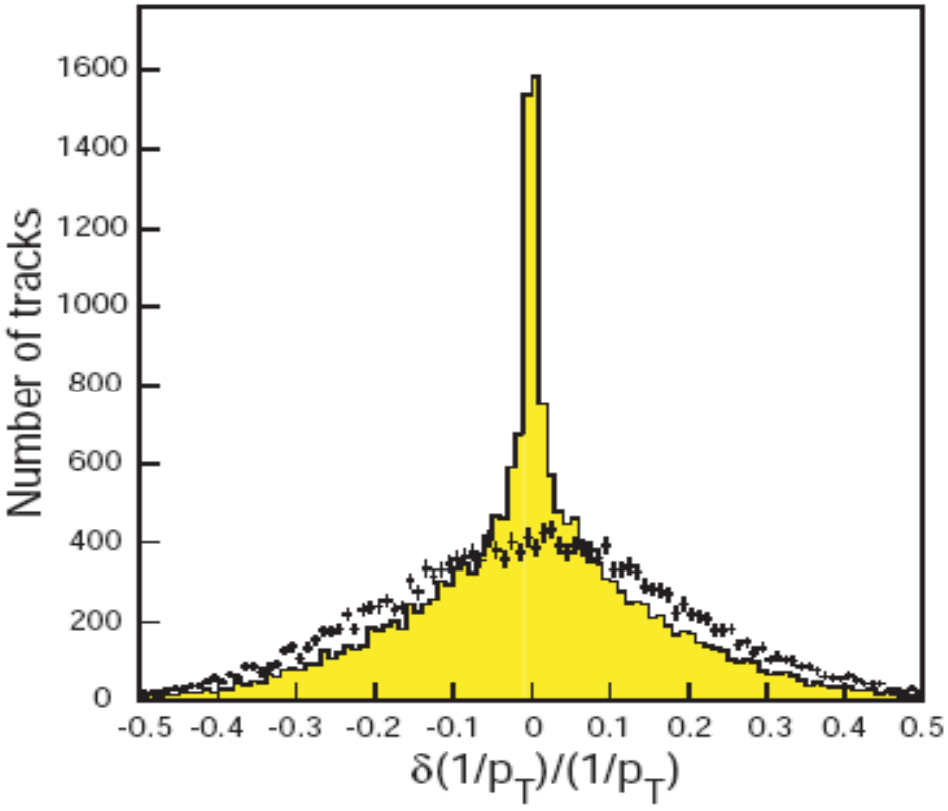
- Compare $1/p_T$ calculated from the scattering angle with $1/p_T$ from TPC track reconstruction
- $\sigma(1/p_T) = 0.20$ c/GeV
- Momentum scale better than 2%

By contrast: OH's Eiffel Tower

(OH) JINST 3 (2008) P04007



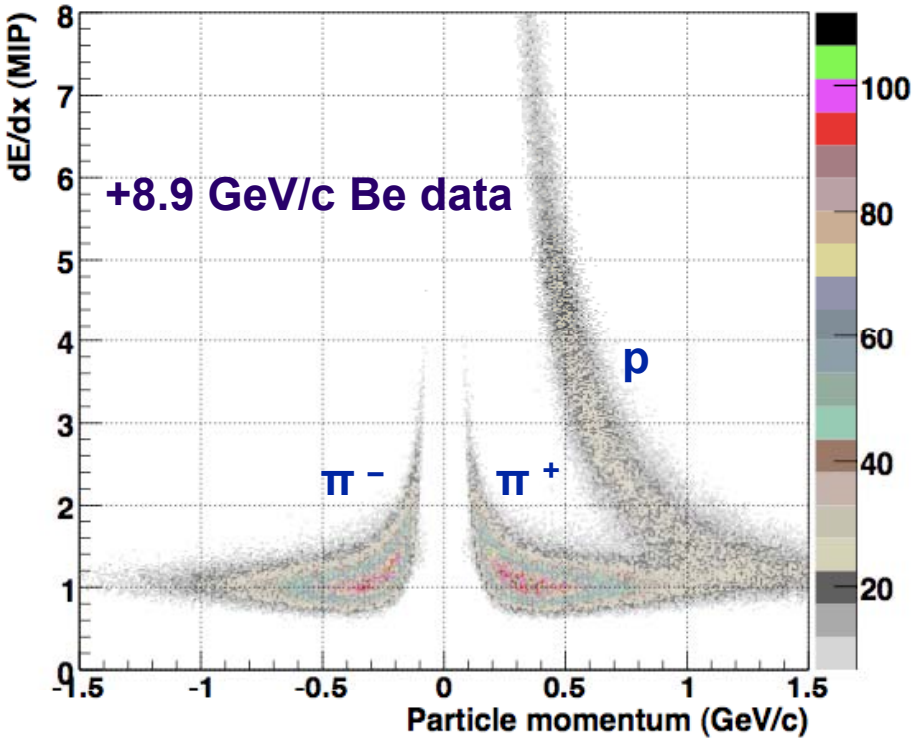
(CDP) JINST 3 (2008) P01002

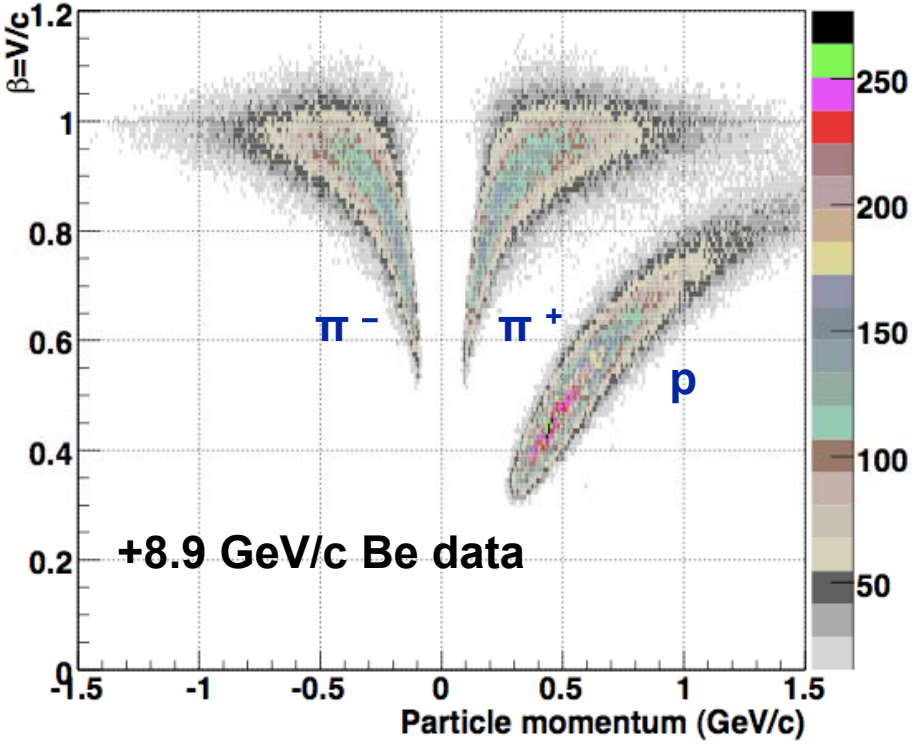


Particle identification

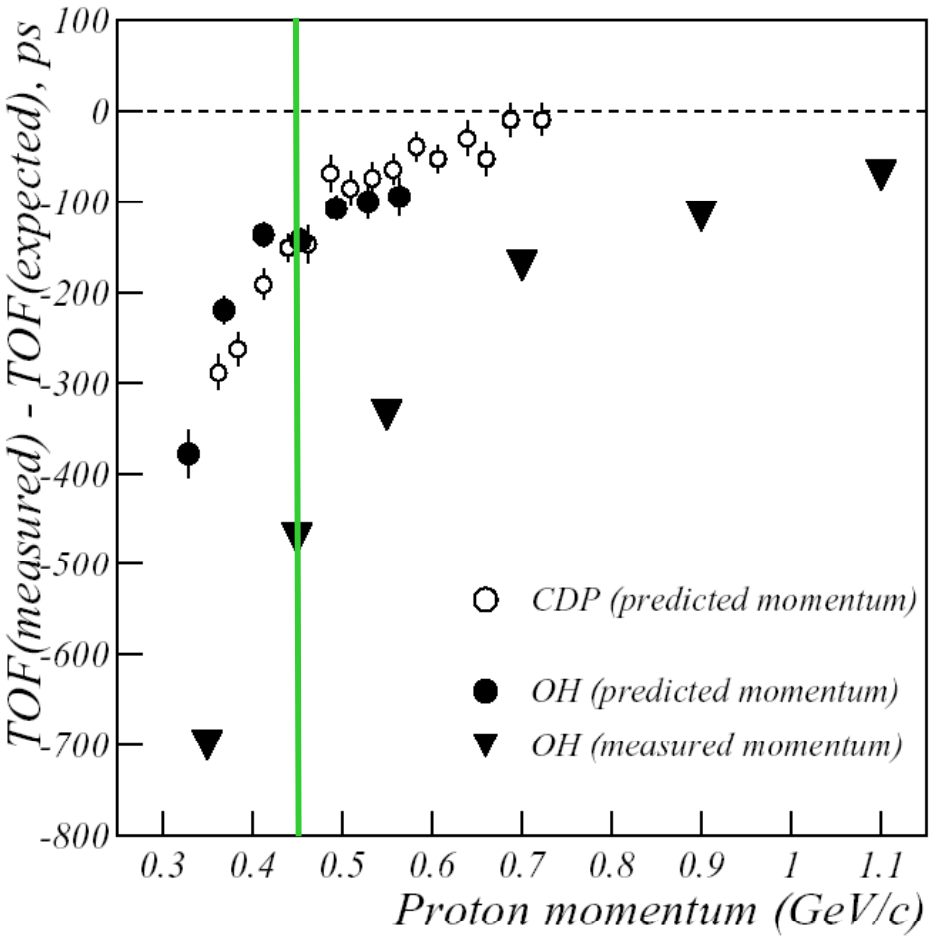
dE/dx in TPC only; difficult p/π separation for p > 600 MeV/c

RPC time of flight extends p/π separation up to p ≈ 1.5 GeV/c



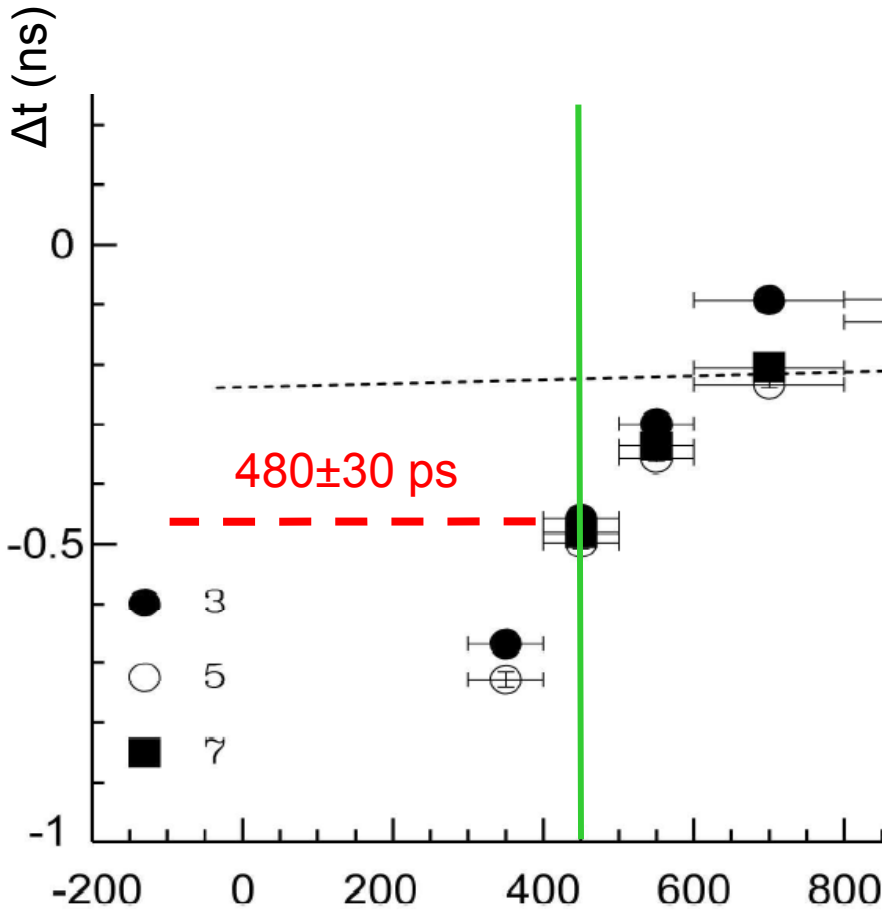


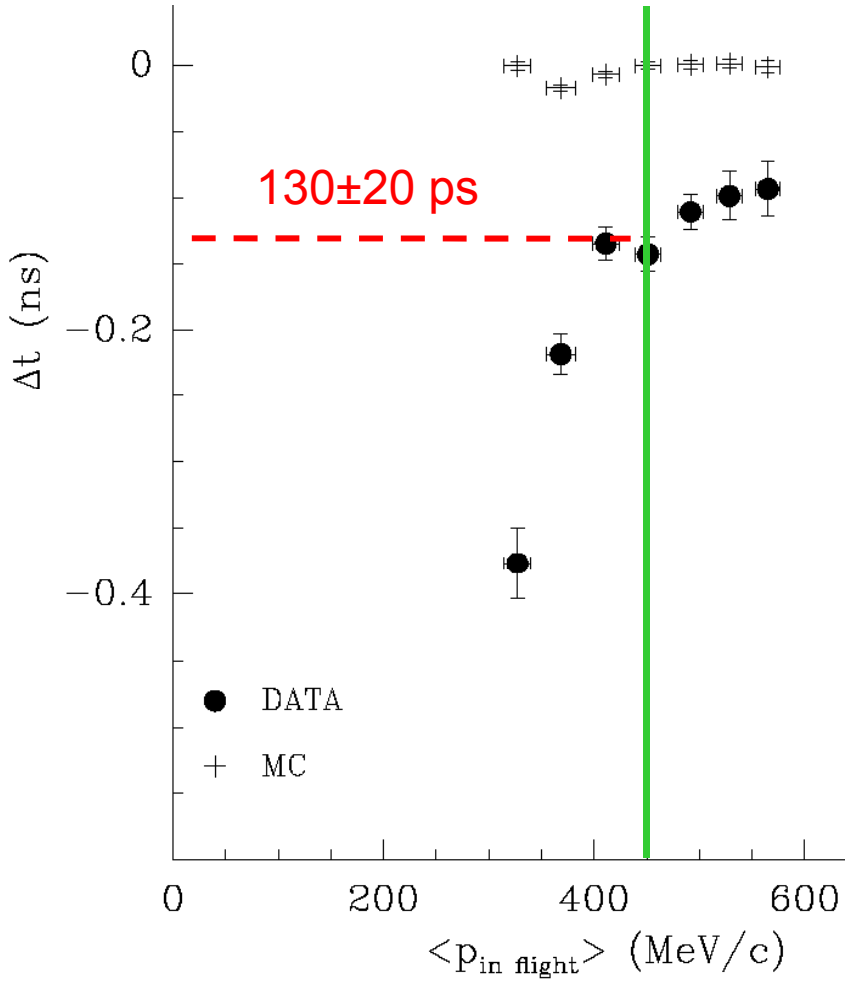
By contrast: OH's "500 ps effect"



JINST 3 (2008) P04007:
"*The remaining difference observed … is of the order of (150 ±100) ps at 450 MeV/c*"

(150±100) ps or (350±40) ps ?





What went wrong in the OH analysis ?

Dominant problem: No understanding of TPC distortions

- **Momentum bias $\Delta(1/P_T) = 0.3$ c/GeV**
- **Momentum resolution $\sigma(1/P_T) = 0.55 - 0.65$ c/GeV**

  HARP-CDP: $\sigma(1/P_T) = 0.20 - 0.25$ c/GeV
- **TOF resolution: σ(TOF) = 305 ps**

  HARP-CDP: σ(TOF) = 175 ps
- **"500 ps effect" in RPC**

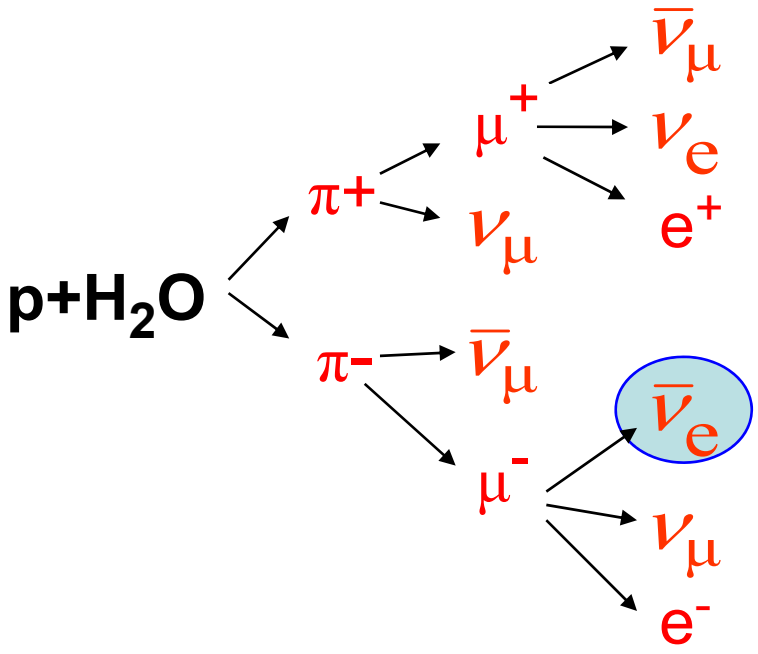
…not to speak of quite a number of further mistakes

(c.f. *http://cern.ch/harp-cdp/WhiteBookAddendum2.pdf*)

On the “LSND puzzle”

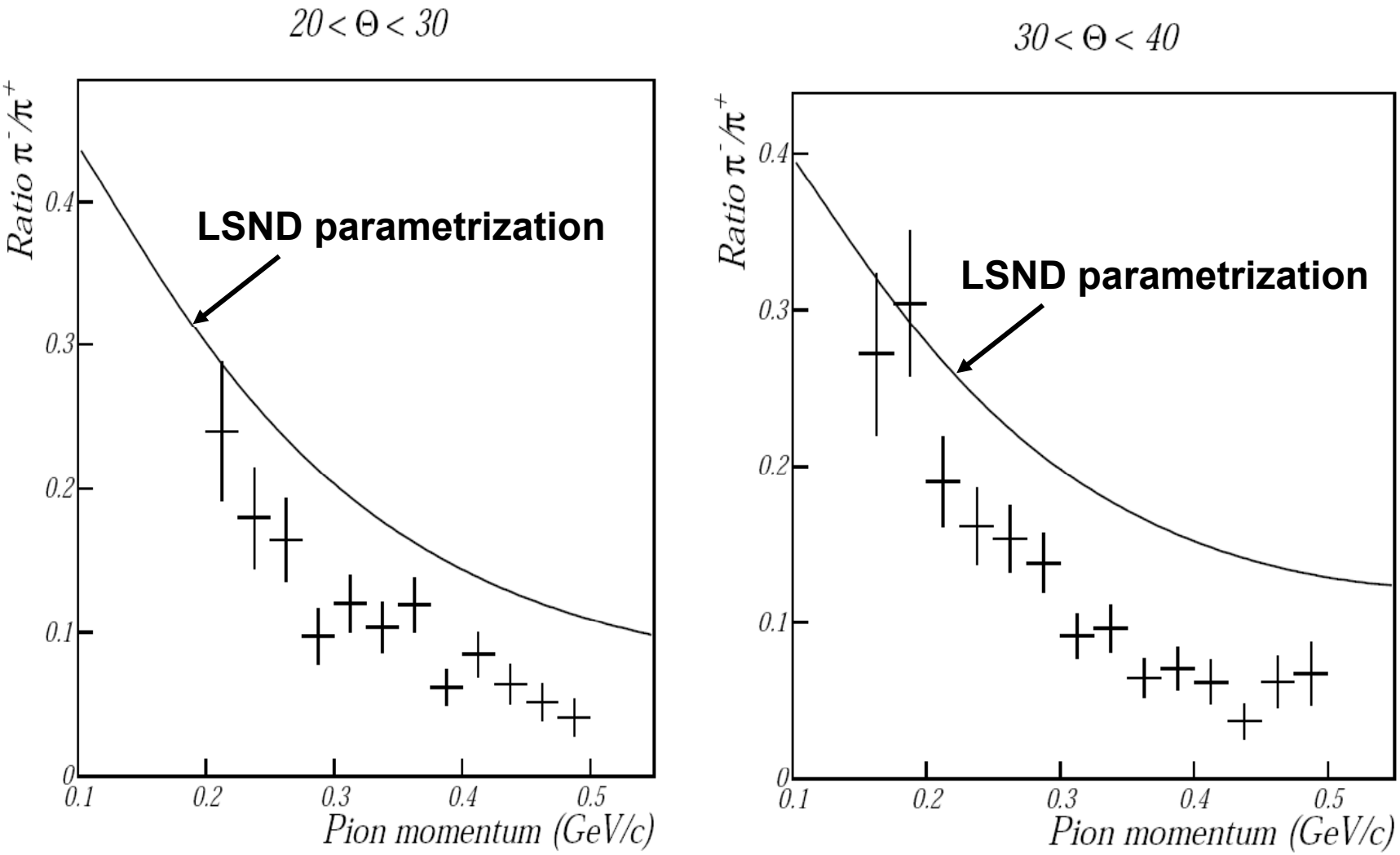
“LSND puzzle”

- Anomalous 4σ signal of $\bar{\nu}_e$ from the interactions of E_{kin}=800 MeV protons in water.



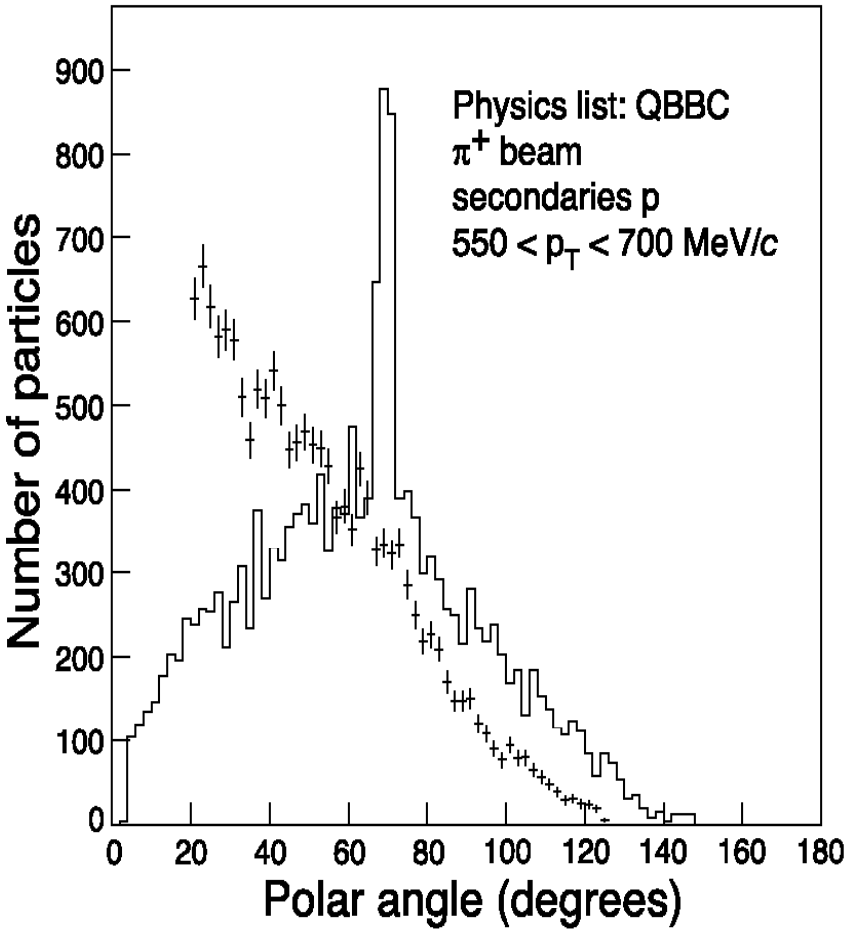
- LSND interpretation:
  - $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ oscillations with $\Delta m^2 \sim 1$ eV^2
- Sterile neutrinos?
- MiniBooNe disagrees with LSND
- Question: is π^-/π^+ ratio correct?

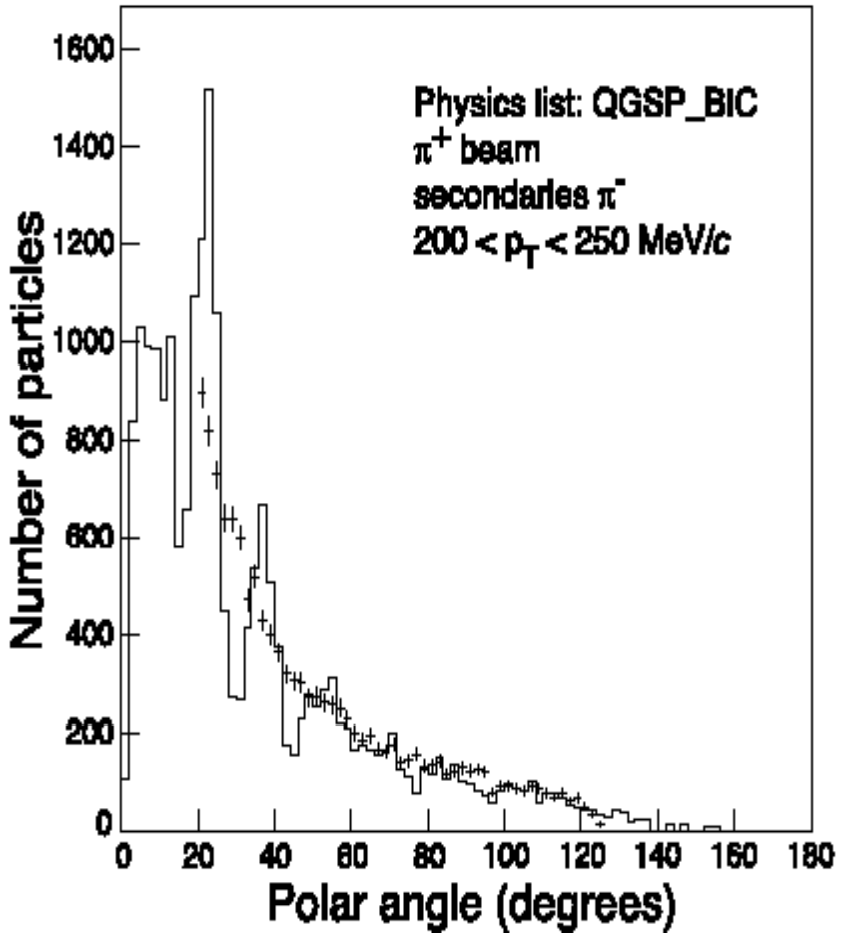
LSND vs HARP-CDP



On the comparison of GEANT4 hadronic models with HARP-CDP data

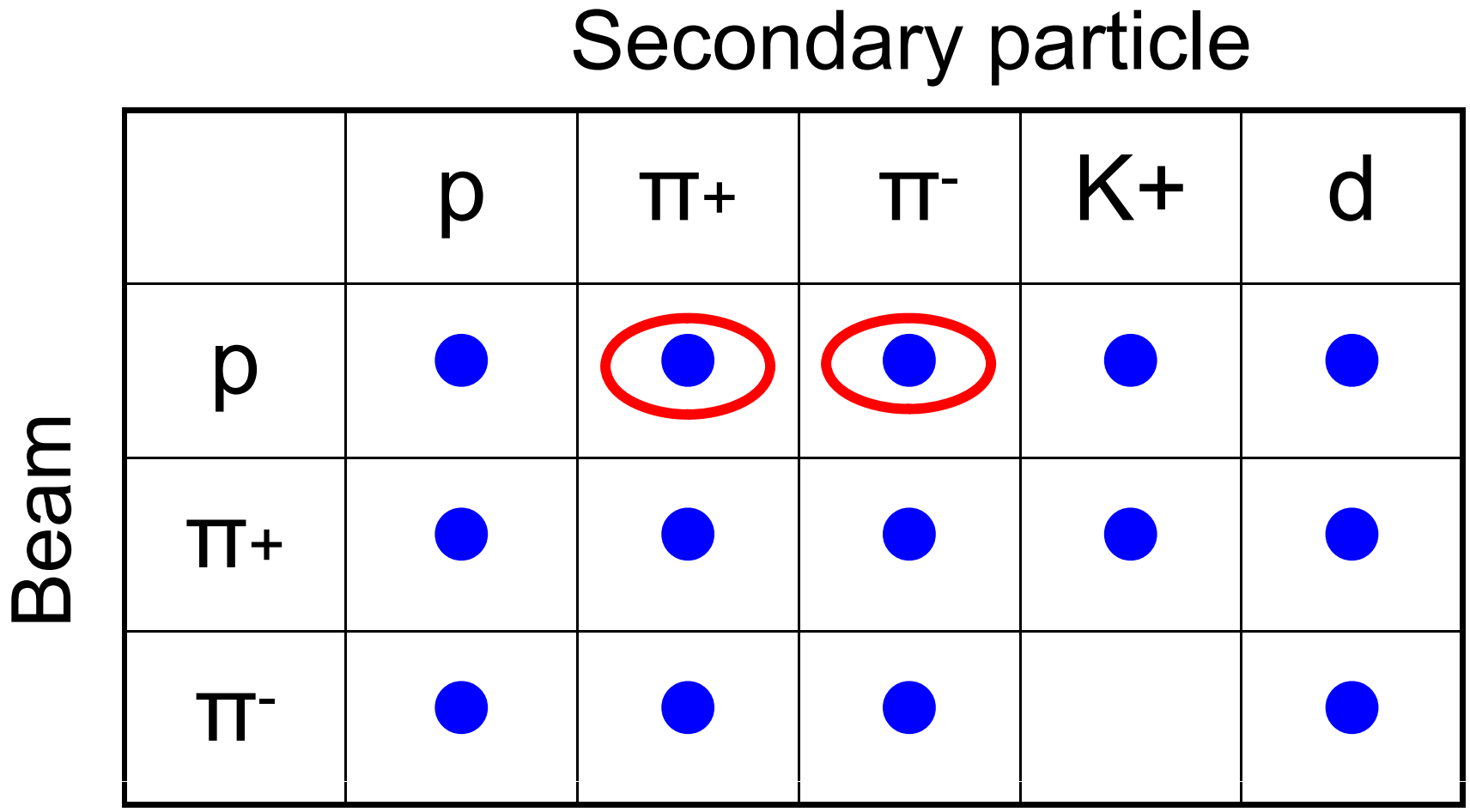
GEANT4.9.1 versus HARP-CDP data





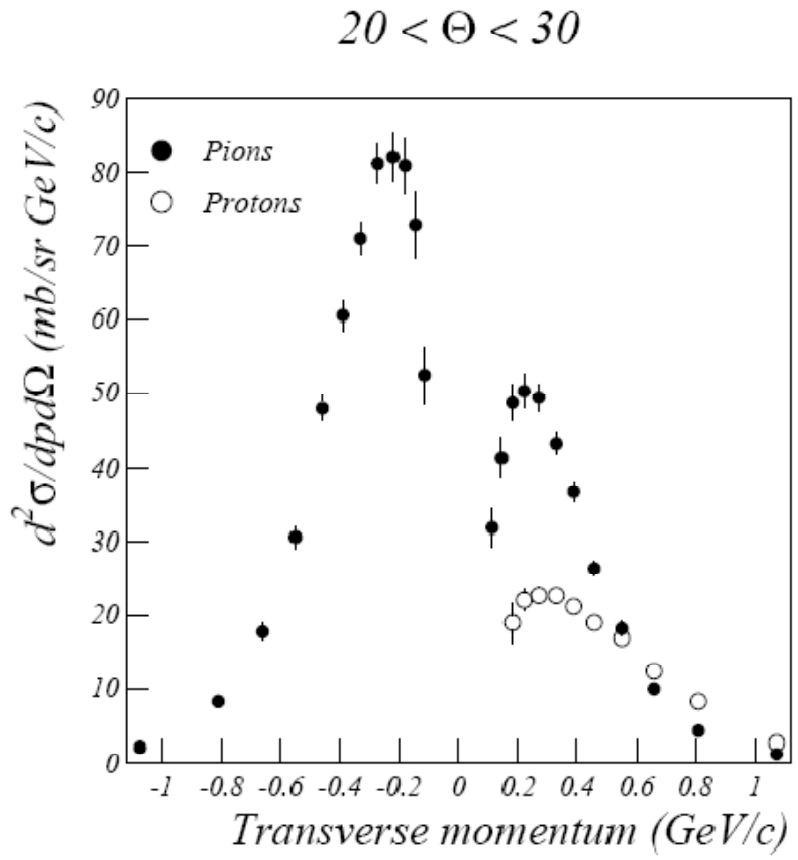
On inclusive hadron production by +8.9 GeV/c and -8.0 GeV/c proton and pion beams off a 5% λ Be target

Our programme of work

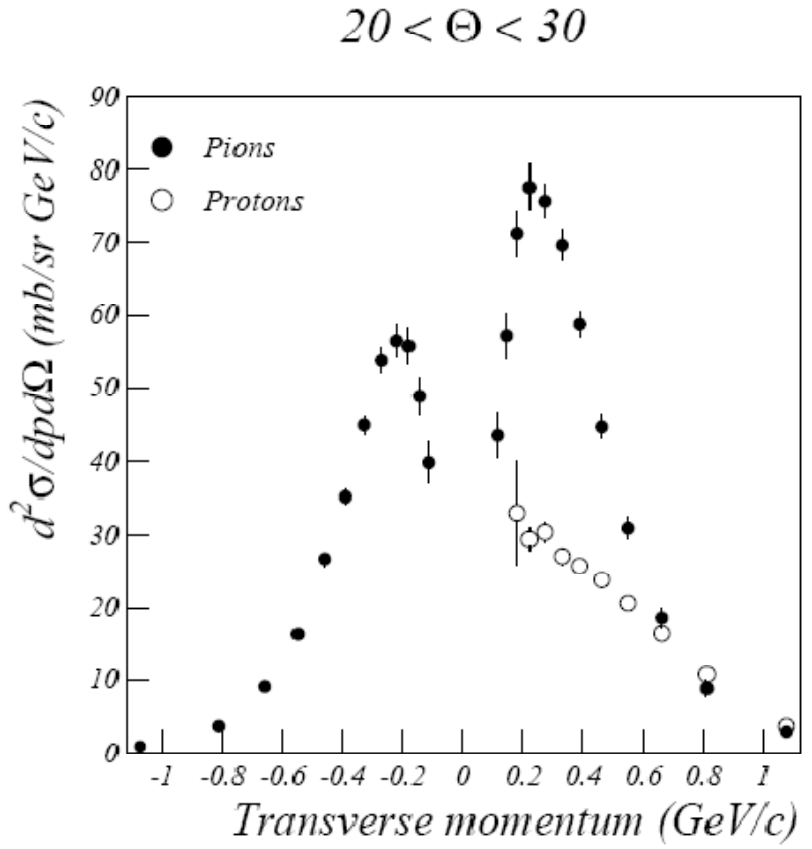


Inclusive cross-sections

Negative pion beam

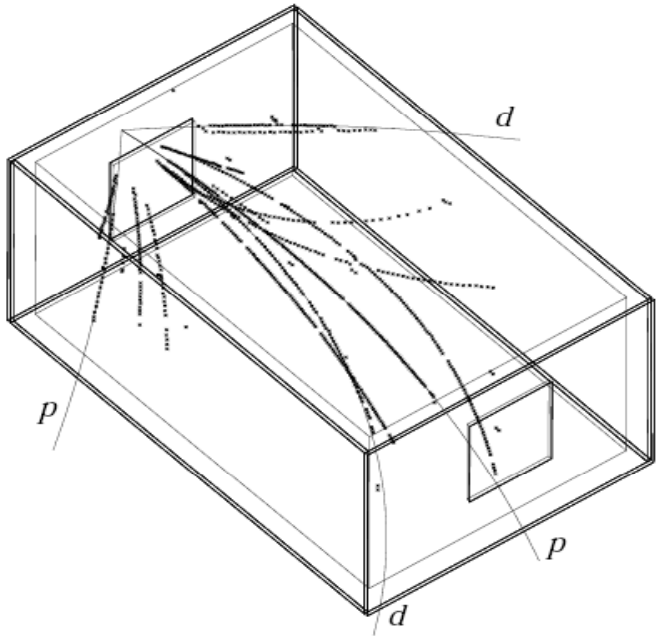


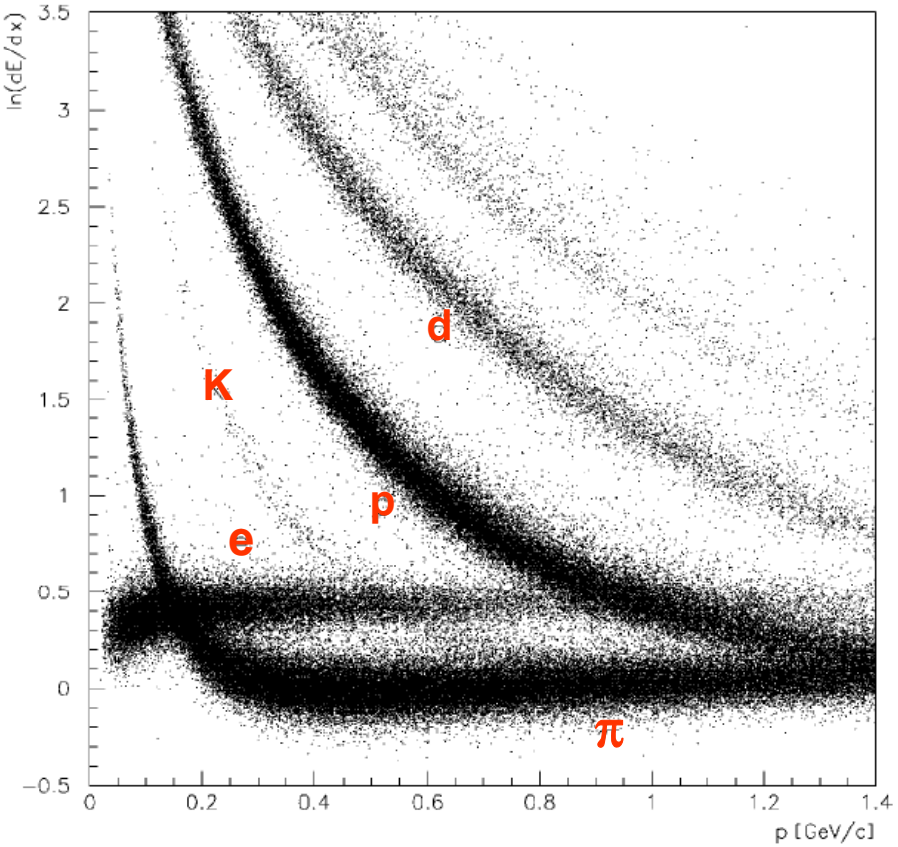
Positive pion beam



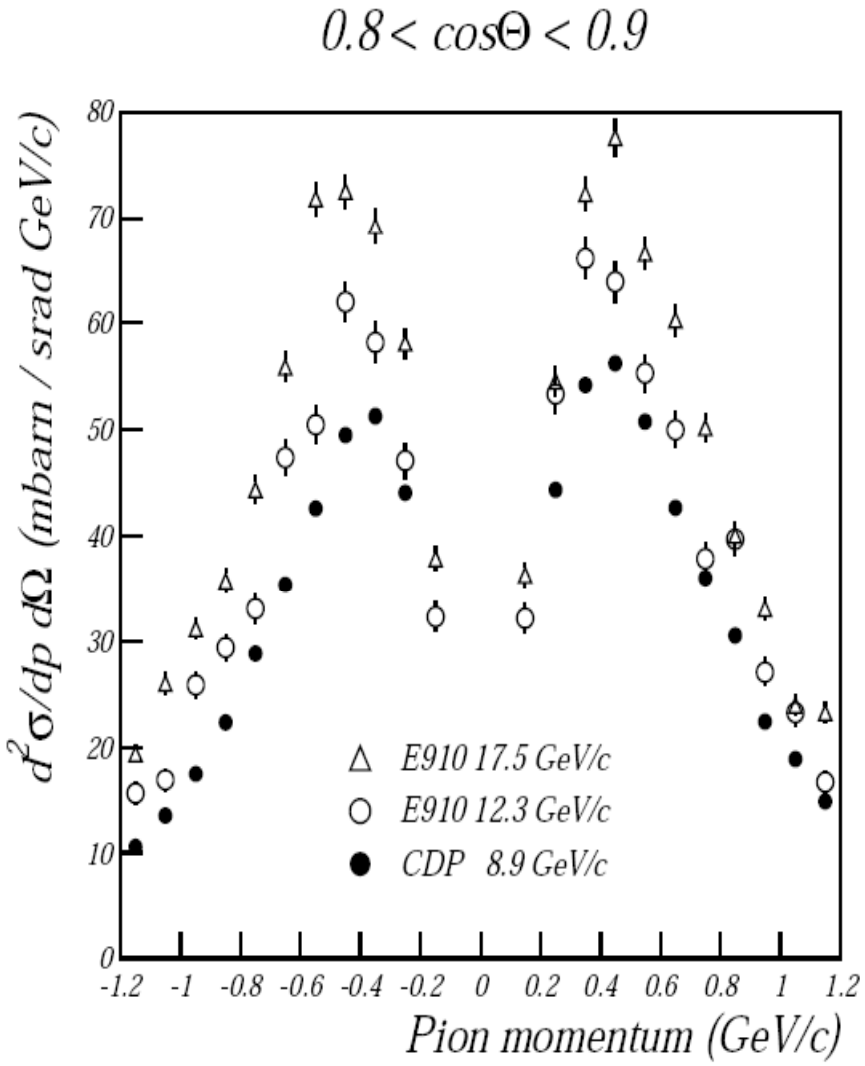
E910 at BNL

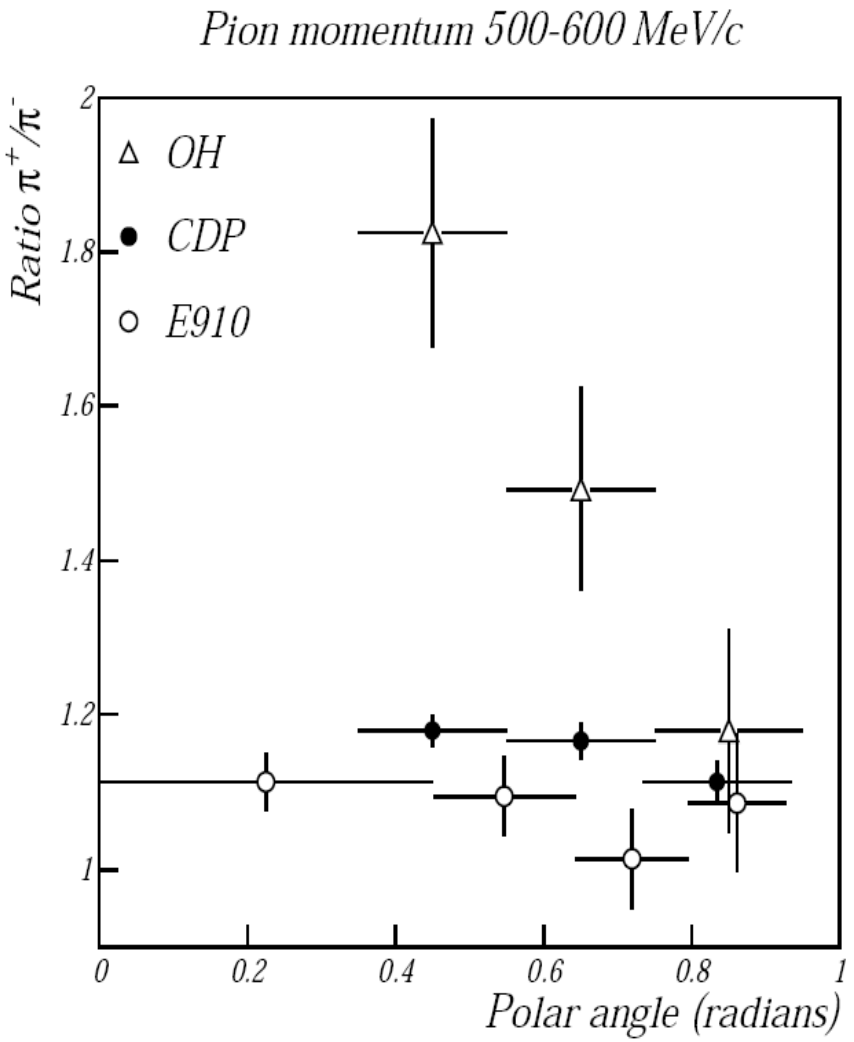
E910: 1.5 m long flat-geometry TPC



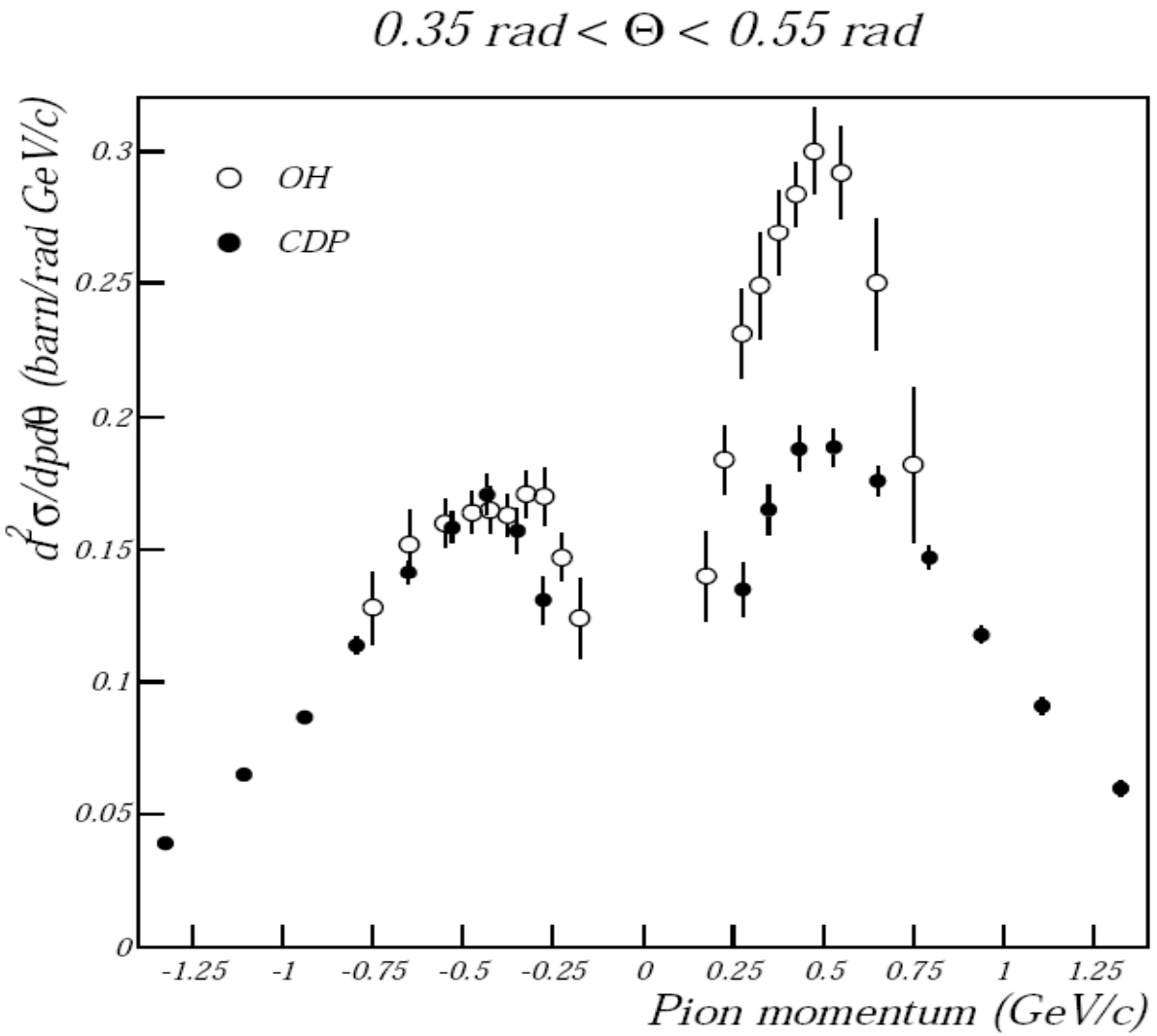


Comparison with E910





HARP-CDP vs OH



“Official HARP” consciously ignore

the conclusions of the CERN/INFN Review Board for HARP (chairman L. Foà): ”...*The Review Board for HARP finds clear evidence for a significant momentum bias in the OH analysis ... the Review Board for HARP finds no evidence of any significant momentum bias in the CDP analysis*...”

the conclusions of the CERN-SPSC Review (chairman J. Dainton): “...*This calls into question the validity of the results in recent publications by the HARP collaboration of their large angle data, based on the OH analysis*...”

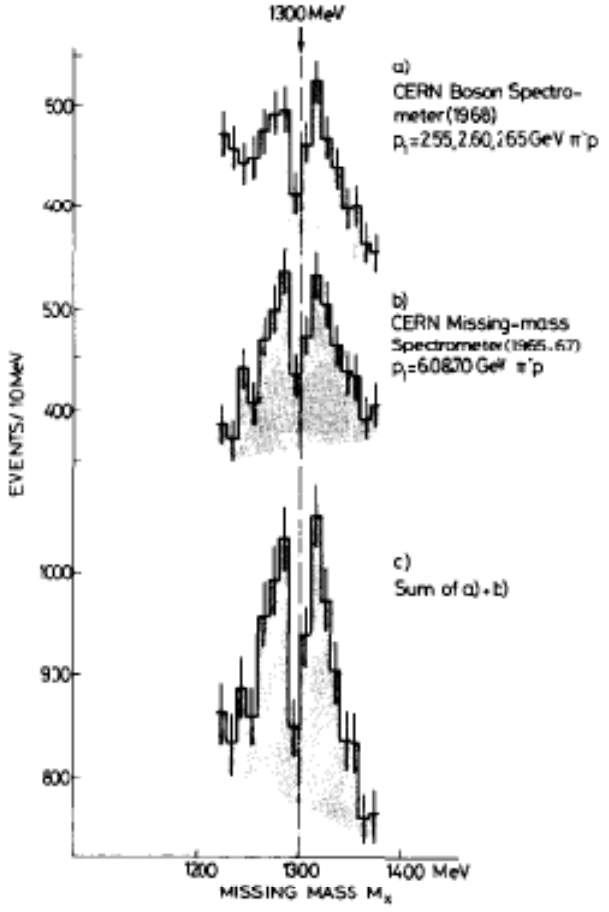
our published calibration work on the TPC and the RPCs

NIMA 578 (2007) 119 and NIMA 588 (2008) 294

our published criticisms of the OH detector calibrations

JINST 3 (2008) P01002 and *http://cern.ch/harp-cdp*

40 years ago: the “split A2” affair



- Lasted from 1967 to1972 and was plain wrong
- Beware of self-praise like “measured with high precision”, “in excellent agreement with Monte Carlo”, “errors were carefully evaluated”, “calibrations were fully benchmarked”, …

Summary and concluding commentary

- HARP-CDP are committed to publish correct inclusive hadron production cross-sections
- Cross-sections published by “Official HARP” cannot be trusted
- CERN Management could have taken lessons from the “Split A2” affair
- There is quite something to learn from the HARP affair for forthcoming LHC data analyses