# MIPP

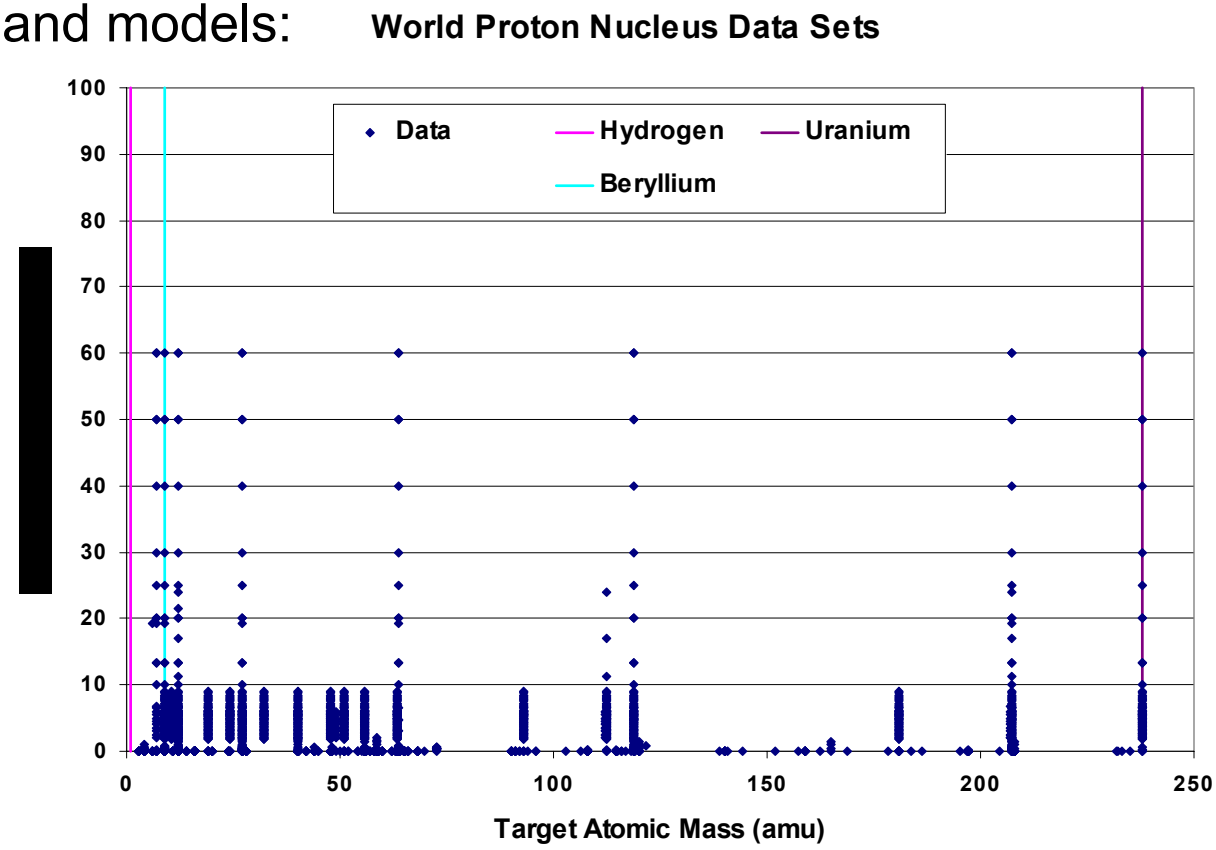
A scrounged, “open-data” venture

# What is MIPP?

- Main Injector Particle Production experiment
- Goal:
  - Systematically measure cross-sections in an open geometry, ~full acceptance experiment.
    - Beam: p (5➔120 GeV), $\pi$, k (5➔100GeV)
    - Target: $H_2$ ➔ Pb
  - Using suite of detectors predominantly scrounged from previous experiments
    - EOS TPC
    - E690 Chambers and CKOV
    - SELEX RICH
    - Etc.

# Why is MIPP? (or more importantly, why should you care…)

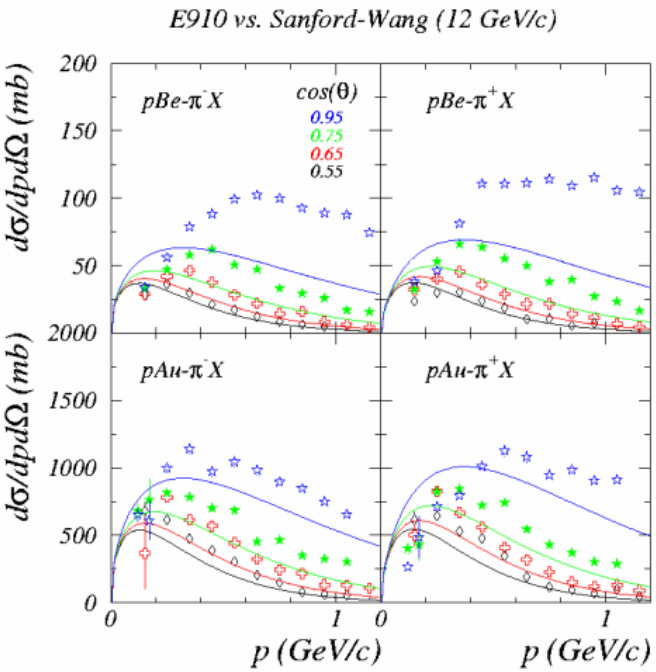
- Data is surprisingly sparse
- Subsets of these experimental data are used in standard particle production codes and models:
  - FLUKA
  - MARS
  - GHEISHA
  - Sanford-Wang
  - Malensek

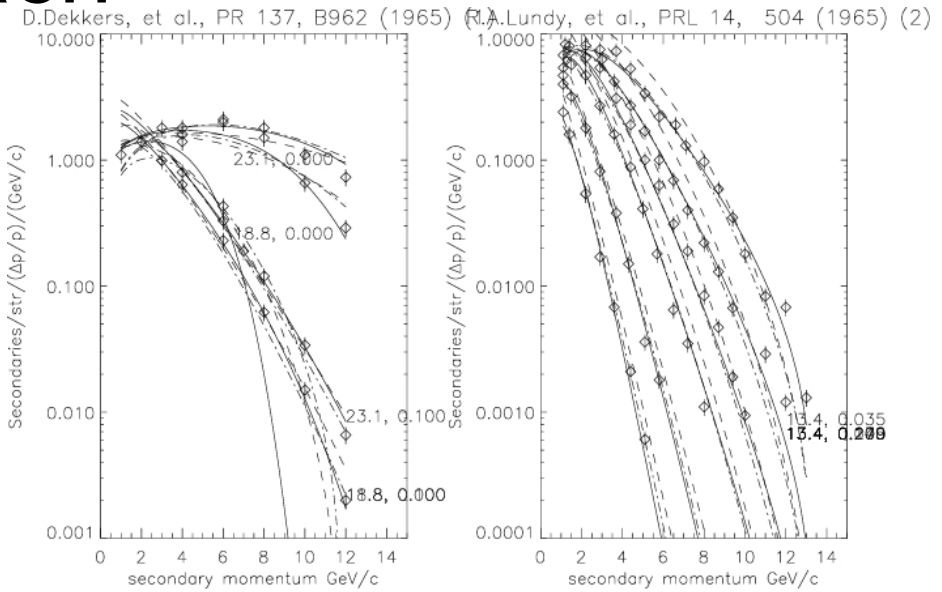


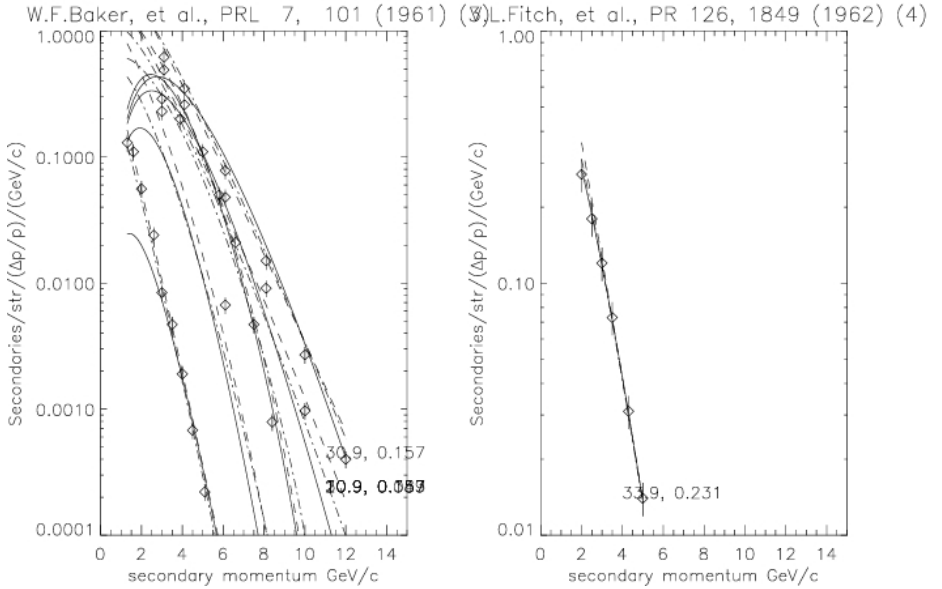

- E.g. S-W based on subset of 4 experiments, rescaled to match

# Limits of this approach

- Sanford-Wang (C.L. Wang, PRL 25, 1068 (1970) based on 4 datasets vs. A/E
  - Attempts to refit (E.P. Hartouni, unpublished) plagued with difficulties
  - Other regions of phase space poorly represented:

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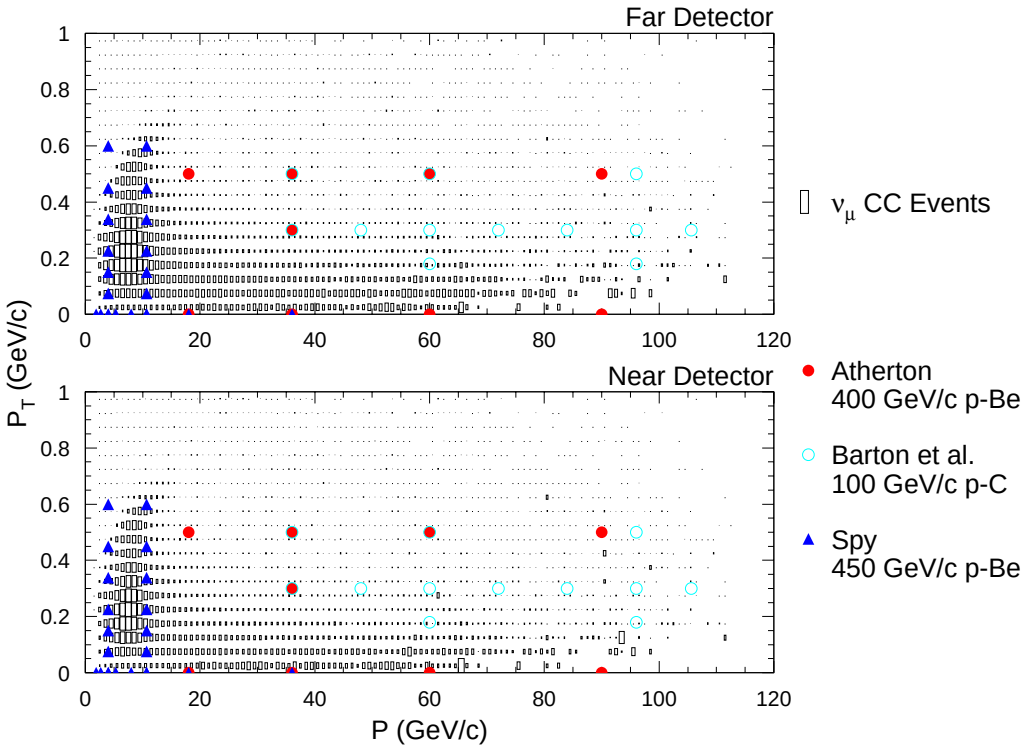
# (Again) why do you care?

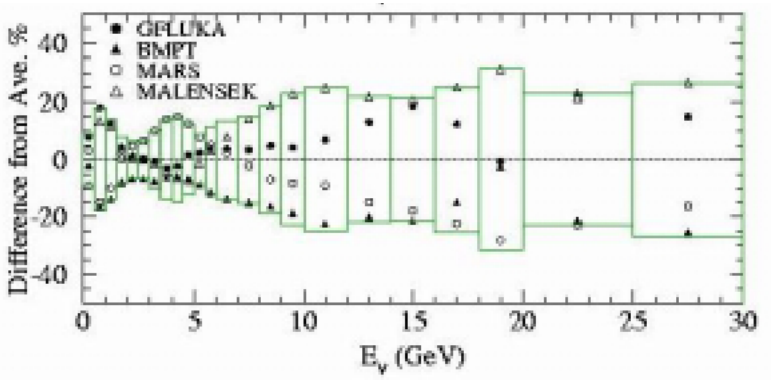
- Poorly determined production cross-section reflected in models' ineffectiveness in supporting physics programs in precision experiments
- E.g. MINOS experiment $\nu$ yields depend on production probabilities.
- Only relevant measurements are at:
  - 100, 400, 450 GeV; NuMI is 120 GeV
  - Be and C; NuMi is C

Simulation of $\pi$ momenta that produced detected a $\nu$

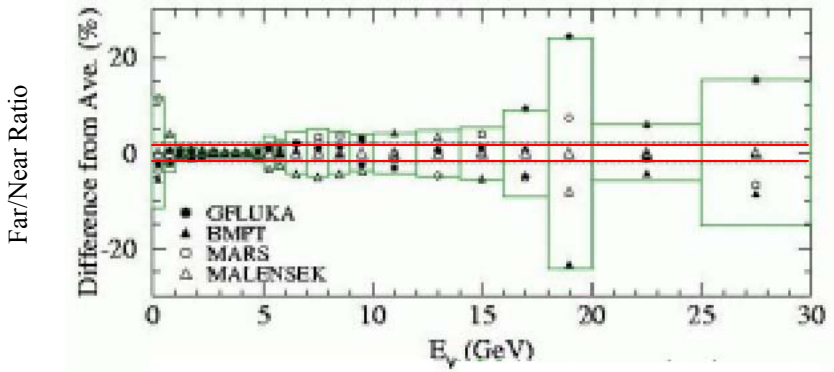


# MINOS Sensitivity to Particle Production Phase Space

- Model using all the standard models: GFLUKA, BMPT, MARS, Malensek.



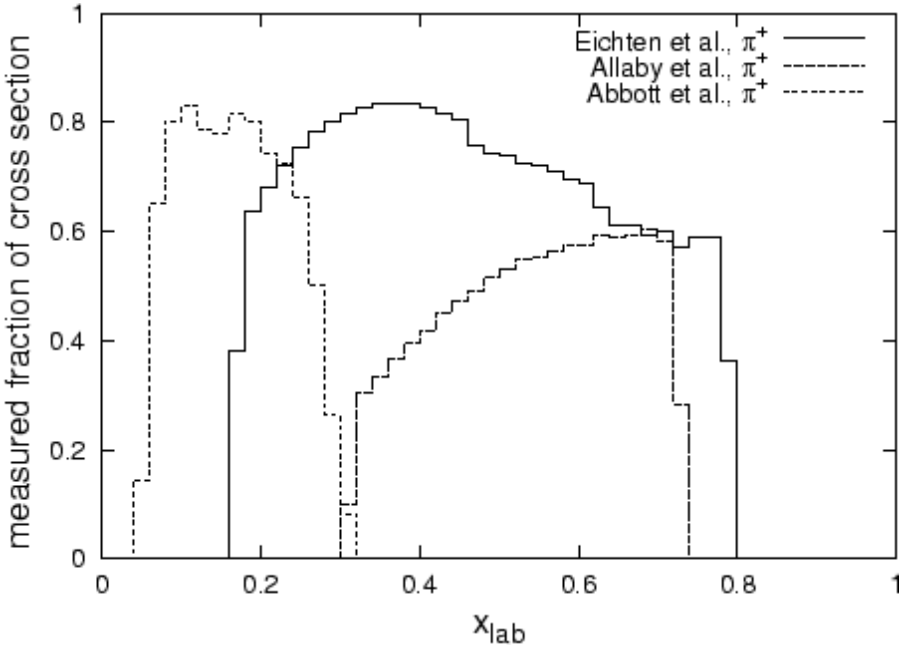

  - Absolute flux estimates vary by 20%.
- For the analysis, take the average. This introduces a 5–10% systematic error, spanning the range of likely models .

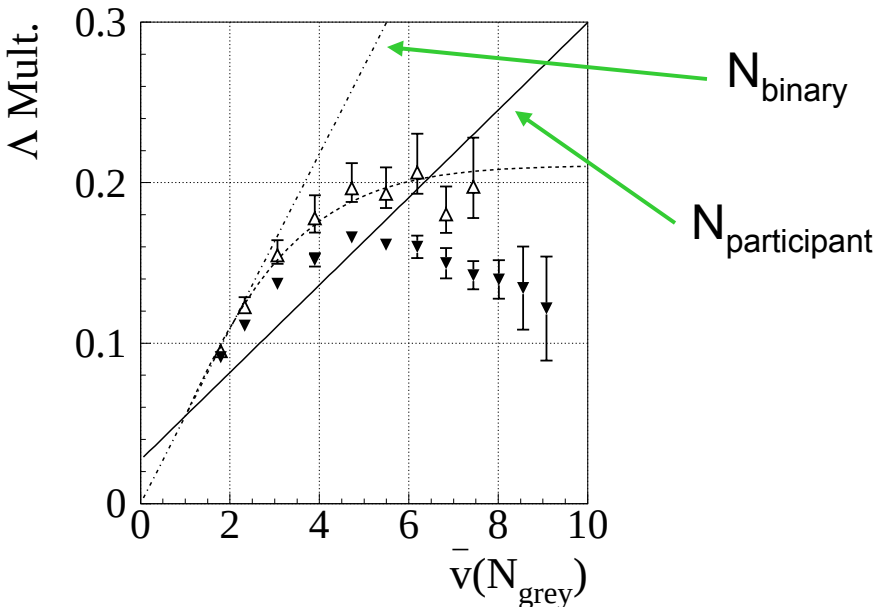



  - MIPP will reduce this systematic error to < 2%.

# Other Physics Measurements that Benefit from MIPP

- Study of scaling laws of hadronic fragmentation (R. Raja PRD **18**, 204 (1978).)
- Other $\nu$ experiments
  - Planned $\nu$ factories: AGS (24 GeV), JHF (50 GeV), FNAL (120 GeV)
- $\mu$ Collider parameters
  - Uncertainties in $\pi$ production strongly influence results
- Atmospheric neutrinos
- Any other HEP/NP experiment where you need to systematically understand backgrounds
- Other physics topics to be addressed:
  - Heavy ion physics comparisons:
    - Strangeness production vs root-s
    - Energy deposition (stopping) vs root-s and A
    - Etc.
  - Studies of nuclear matter and medium energy physics (analogous to eA measures)
  - Basis for light meson spectroscopy program (?)

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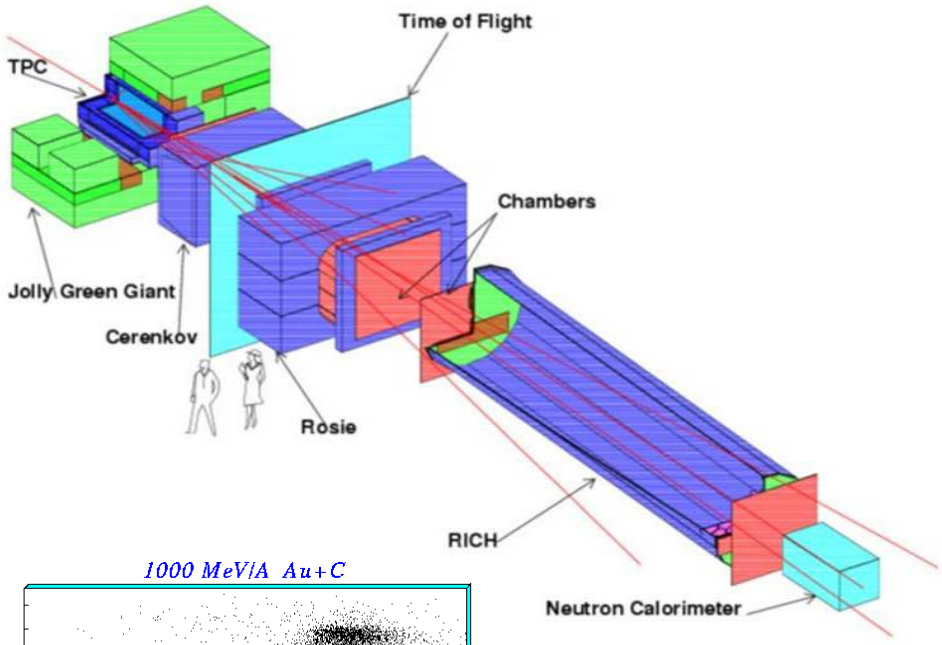
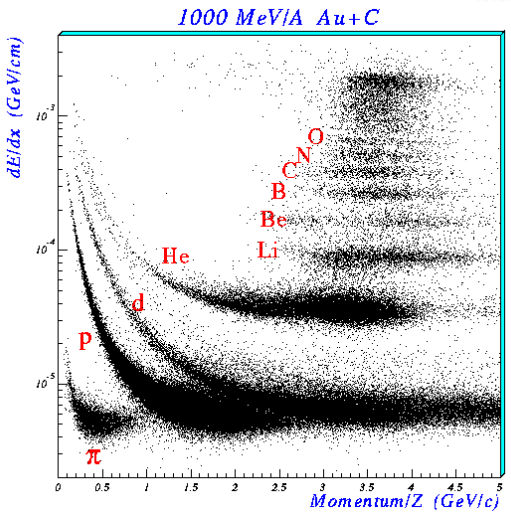
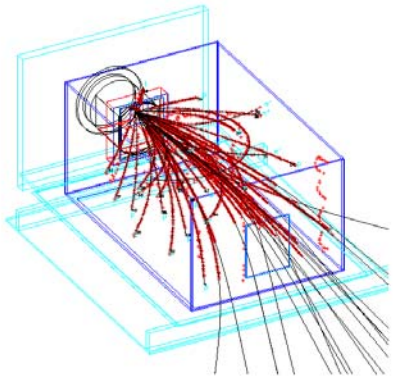
# MIPP

**Main Injector Particle Production Experiment (FNAL-E907)**



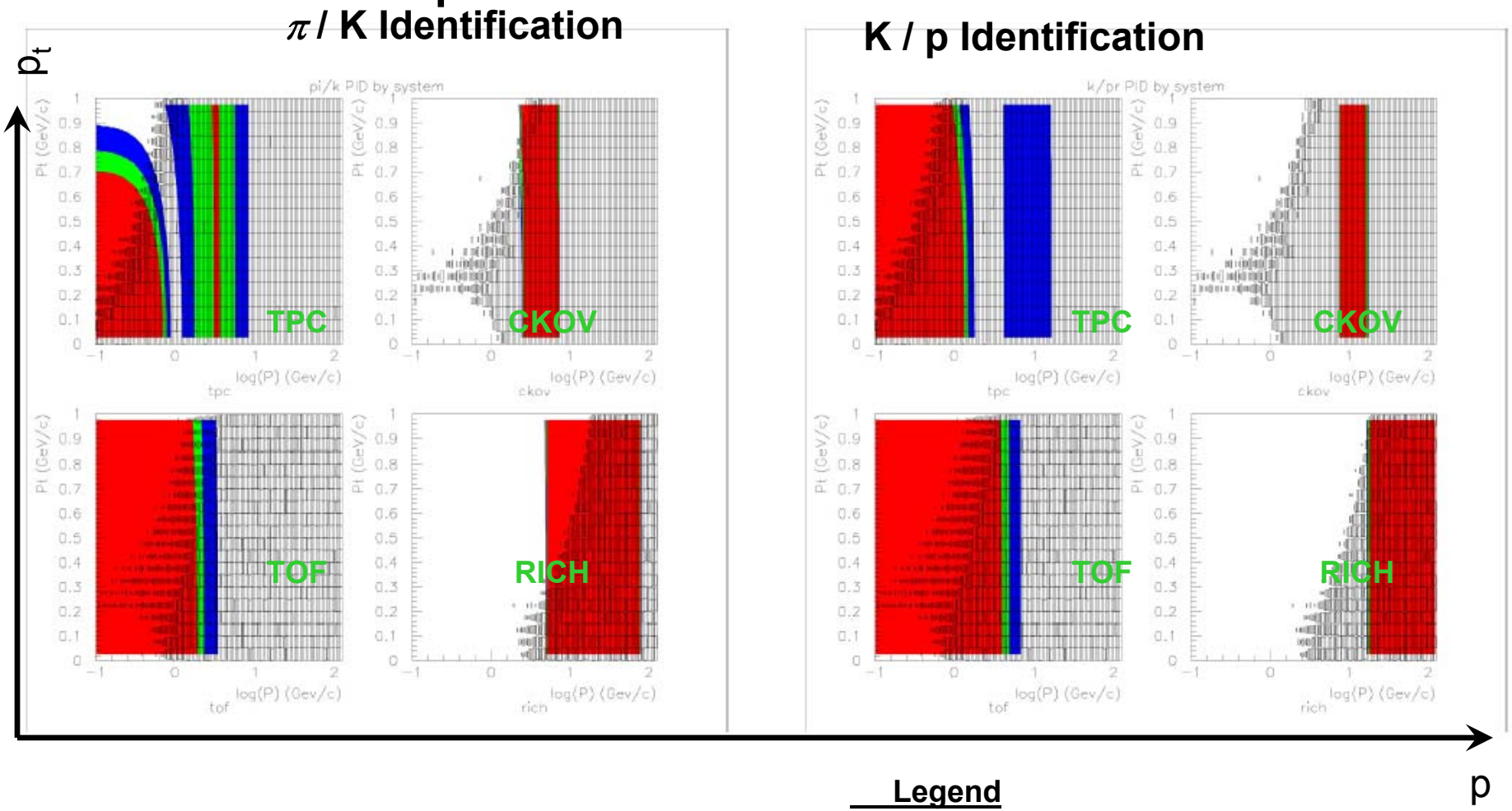




- EOS TPC (!)
  - EOS→E910→E895
  - Workhorse of experiment
  - Limits trigger rate to 60 Hz
- Chambers from E690
- CKOV from BNL-E910 (FNAL 690/766)
- TOF
- SELEX RICH ($\pi$/K/p to 120 GeV)
- Magnets: ROSIE and Jolly Green Giant
- Beam CKOV counters from previous FNAL experiments
- Forward neutron calorimeter (Hyper-CP)
- E-Cal, forward $\pi$ measurement

# MIPP Beam

- Main Injector 120 GeV/*c* primary beam
  - 1 second slow spill.
  - Initially 1 spill / 15 seconds.
  - “Double slow spill” will bring this up to 1 spill / 3 seconds.
- Secondary beam $p^{\pm}$, $\pi^{\pm}$, $K^{\pm}$ tagged
  - 50% interaction length secondary beam production target.
  - 60 m + 30 m Cerenkov counters, + time of flight, to tag beam species.
  - 5 – ~100 GeV/*c* secondary momentum range.
  - Few % momentum bite.
  - Particle by particle momentum and direction measurement.
- No event overlap
  - 8 μs drift time to clear ions from beam axis In TPC.

# MIPP Acceptance and Particle Identification




- Broad and flat acceptance.
- Complete particle ID coverage

**Legend**

**Red > 3 σ**

**Green > 2 σ**

**Blue > 1 σ**

**White < 1 σ**

**Boxes show acceptance**

J. Gronberg, unpublished.

# MIPP Targets And Data Samples

- Targets span hydrogen to lead (or uranium).
- 1% interaction targets, with selected thick targets.
- Typically $10^5$ events for each setting
  (target, beam momentum, beam species, beam charge sign).
- Additional $10^7$ events on the NuMI / MINOS target.

| Target | Physics | Beam Energies | Beam Charges | Factor(3 million events/data point) | data points |
|---|---|---|---|---|---|
| Cu | Engineering run | 3 | 2 | 0.5 | 3.0 |
| H2 | scaling | 12 | 2 | 1.0 | 6.0 |
| N2 | atm. Neutrinos | 3 | 2 | 0.5 | 3.0 |
| O2 | atm. neutrinos | 3 | 2 | 0.5 | 3.0 |
| Be | p-A | 1 | 1 | 2.0 | 2.0 |
| Be | survey | 5 | 2 | 0.1 | 1.0 |
| C | survey | 5 | 2 | 0.1 | 1.0 |
| Cu | p-A | 1 | 1 | 2.0 | 2.0 |
| Cu | survey | 5 | 2 | 0.1 | 1.0 |
| Pb | p-A | 1 | 1 | 2.0 | 2.0 |
| Pb | survey | 5 | 2 | 0.1 | 1.0 |
| Various | Nucl. Scaling | 5 | 2 | 0.1 | 1.0 |
| Total | | | | | 26.0 |

# Data Availability

- Data will be published
  - Distributed on DVD (or media of the day).
  - Particle ID and 3-vector for all produced particles,
  - Along with tuned MIPP Monte-Carlo.
- Allows data to be used in various studies
  - To fit Malensek/Sanford-Wang type models,
  - To fit your own new model,
  - As an event library.

# MIPP Schedule

- Current Status
  - Magnets assembled.
  - RICH vessel installed.
  - CKOV, DC, TPC awaiting stands (in fabrication).
- Schedule
  - First “engineering” beam late 2002.
    - Tune beam line.
    - Shake out DAQ with subset of detectors (TPC, CKOV, RICH, some DC).
  - Complete installation by March 2003.
  - Commence data taking March 2003.
  - Cryogenic targets available FY04.
  - Must turn off February 2005
    - NuMI / MINOS turn on monopolizes Main Injector protons.

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