The Upgraded MIPP Experiment P960 at Fermilab

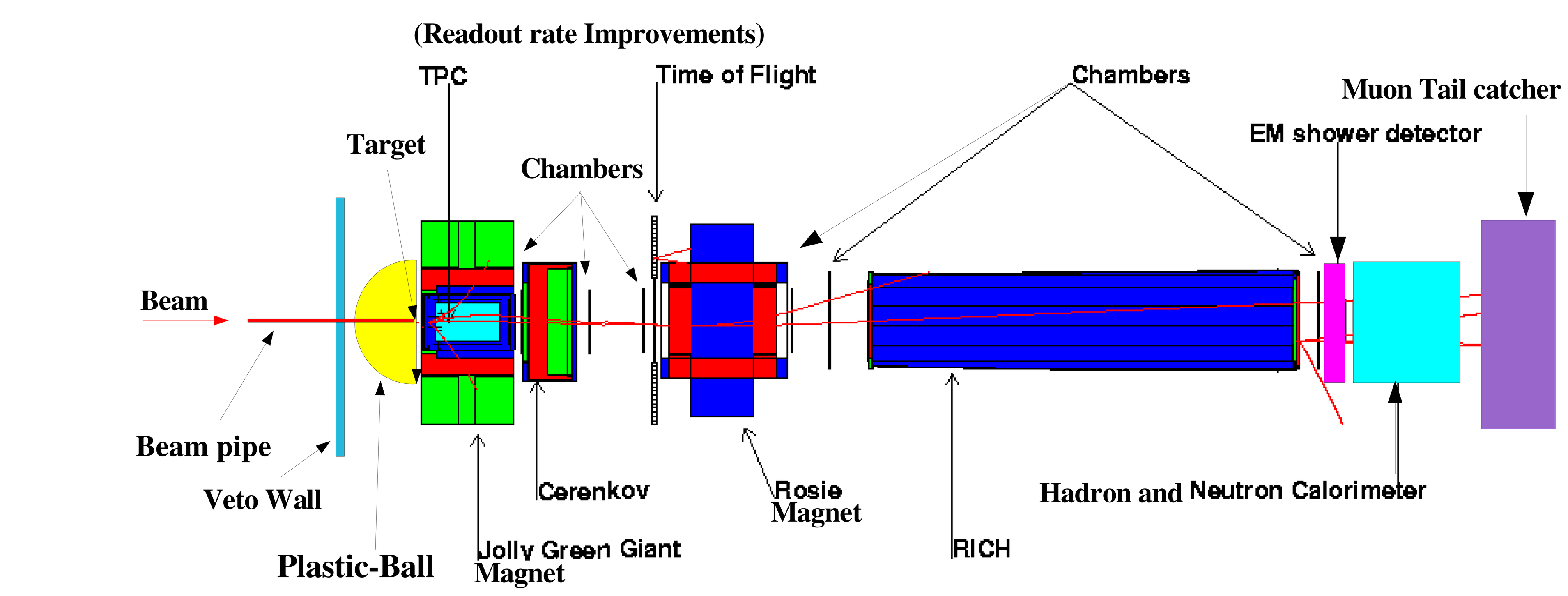
Prof. Nickolas Solomey, Wichita State Univ. (for the new MIPP Collaboration)

Upgraded Detector:

The extended MIPP experiment will utilize an upgraded detector, beam line and targets. The beam line performance will be expanded down to 1 GeV/c. Several new detectors will be added that enhance the physics performance and the data acquisition system for a hundred times faster readout.

The current MIPP collaboration extends a warm welcome to many new colleagues from around the world who will join the extended run. This is a small experiment where graduate students can be trained in a variety of detector components, electronics, data acquisition and analysis. It is a low cost experiment in a short time scale.

Upgraded MIPP Detector:



(Backward Hemisphere Detector from Extended Anti-proton cooperation) (New Calorimeters from ILC cooperation)

Improvements:

Extend good beam performance down to 1 GeV/c.
TPC and Wire Chamber readout upgraded to 3 kHz.
Repair analysis magnet coils.
Veto wall and backward hemisphere PID.
Silicon Detector interaction and vertex trigger.

Costs, Schedule and Impact:

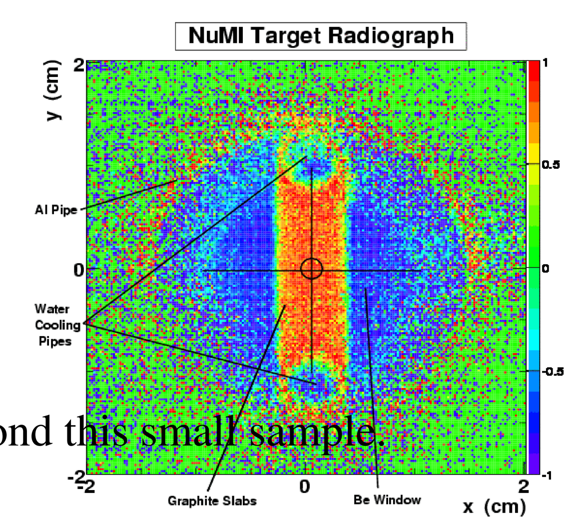
Cost for the upgrade is about half a million dollars.
After approval the experiment can be running within 9 months, and would only need a 9 month run..
The impact on Fermilab Main Injector operations would be minimal, less than 5%.

More Data for Current Physics:

The current MIPP data set taken in 2005 can be extended to higher statistics, this is especially useful for Scaling Law studies, NuMI target kaon and pion production and Nuclear Physics A dependence studies.

NuMI Target Study for the MINOS Experiment:

Using the NuMI target in MIPP and a pure proton beam, we took 2 million events that show the target structure. This data is important to understand the pion and Kaon production in the beam, the source of all MINOS neutrinos. Tracking projectile particles into the target and measurement of reaction particle yields determine the energy spectra of all neutrinos species. 10 million events with the NuMI target will be needed beyond this small sample.

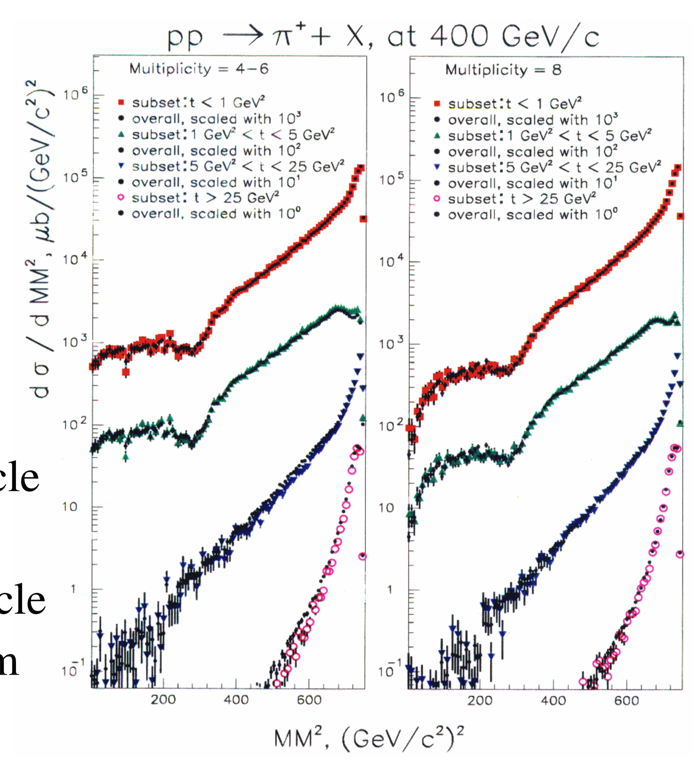


Hadronic Fragmentation Scaling Law Tests:

Ratio of a semi-inclusive to inclusive cross section where

$$\frac{f(a+b\rightarrow c+X_{subset})}{f(a+b\rightarrow c+X)} \circ \frac{f_{subset}(M^2,s,t)}{f(M^2,s,t)} = \beta_{subset}(M^2)$$

M^2,s and t are the Mandelstam variables for the missing mass squared, CMS energy squared and the momentum transfer squared between the particles a and c, see PRD v18, p204. Data from the EHS experiment shows this, but needs further confirmation. With the current data this can be tested for 36 single particle channels, more data will permit two charged particle channels and a Deuterium target for the neutron channels.



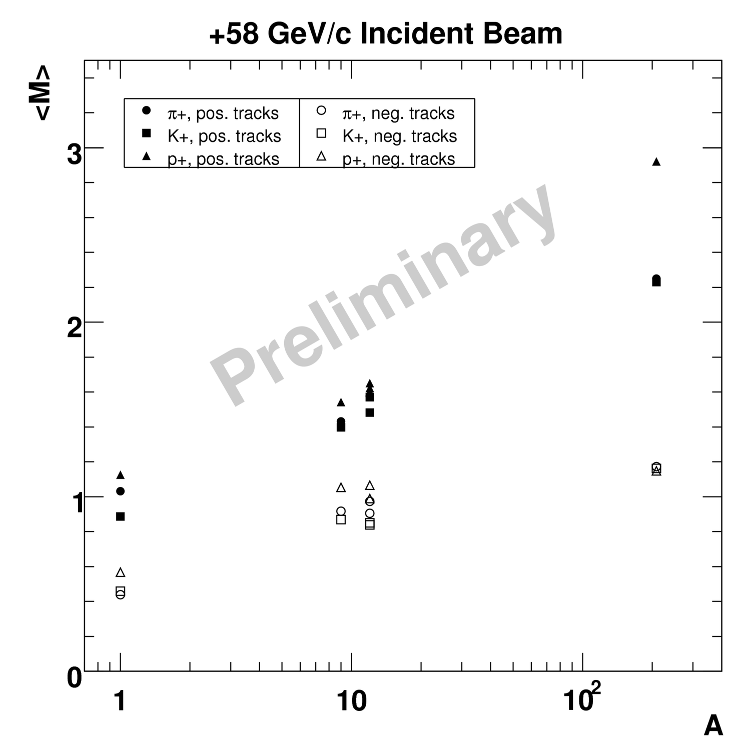
Physics Event Selection:

The true evidence of the successful start of the MIPP physics analysis program is the ability to separate our data by beam species and identification of produced particles. Our detector is demonstrating its excellent particle identification performance for all forward going particles. Combining this with our bubble chamber like tracking, event by event beam particle tracking and identification we can show we have far better data than anyone has done since bubble chambers experiments.

This data will be used to study the charged particle multiplicity from 5 to 120 GeV/c for six beam species on 8 targets: H, Be, C, Al, Cu, Ar, Bi and U.

Various physics interactions will be studied such as elastic, inelastic, associate production, diffraction, one body, two body exclusive states and neutron and π^0 production channels.

First publication expected by January 2008.



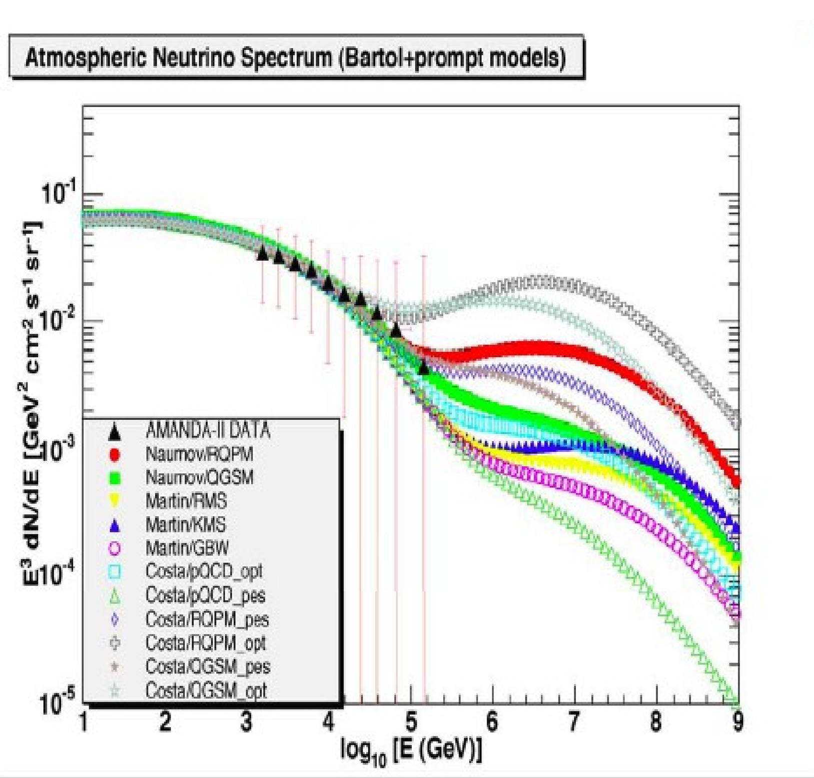
Expanded Physics Goals:

A new run of the MIPP experiment in 2007 has great physics potential to provide a leading role in both accelerator and atmospheric neutrino experiments, development of detectors for the ILC and keep Fermilab competitive in elementary particle physics with a small scale experiment.

Neutrino Production Targets:

An extensive run with a Liquid Nitrogen target is needed for the atmospheric neutrino experiments such as: Fermilab's Pierre Auger Observatory, Ice-Cube and Hyper-K, to improve their neutrino flux from π and K decays.

The graph at right shows the current limitation to the small Amanda experiment above 10^4 GeV/c, this comes from the Cosmic Ray uncertainties of atmospheric production of Kaons and pions. Current models are uncertain above 10^5 GeV/c.



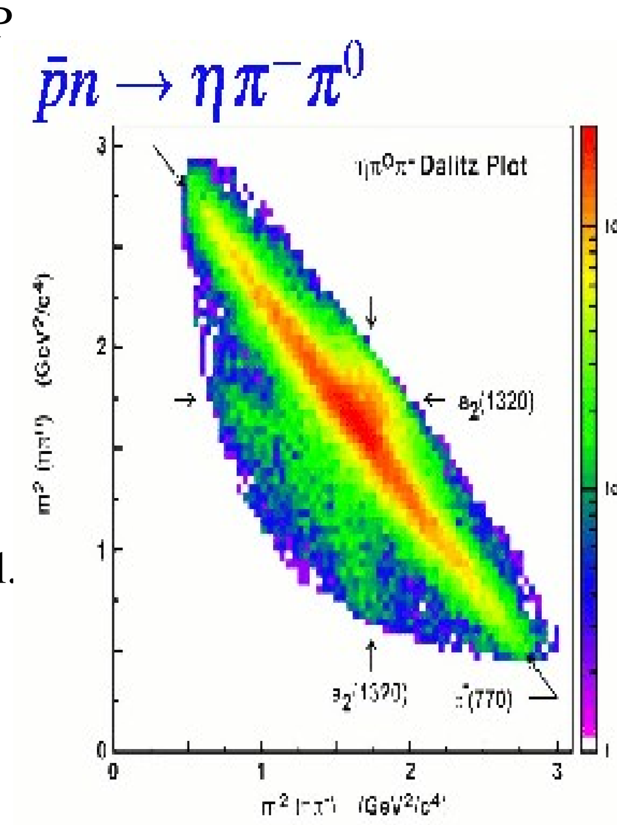
Special Minerva and NovA medium energy NuMI target runs along with the T2K and MiniBoone target are needed. This would permit those experiments to make full use of their large data samples.

Anti-proton Physics:

An important goal of the upgraded MIPP experiment would be anti-protons for studying:

1) Anti-protons on H, D, T, ^{3}He, ^{4}He, ^{6}Li, ^{7}Li and B. Of importance for early universe production Cosmology.
2) Charm production cross section
3) Fundamental Nuclear physics
4) Several experiments have seen exotic states unexplained by the current models but expected by the quark-model. MIPP's unique open geometry would be a first to permit resolving this question.

$$\bar{p}n \rightarrow \eta\pi^-\pi^0$$



Tagged neutron and K^0 Physics:

The ILC hadron calorimeter tagged neutron system will permit a unique opportunity for neutron and anti-neutron cross sections on nuclear targets. The tagged K^0 and K^0 bar physics potential of knowing exactly what species was created at production by a K^+ or K^- beam and >15000 events per day can expand our knowledge of the matter-antimatter symmetry.

Conclusion:

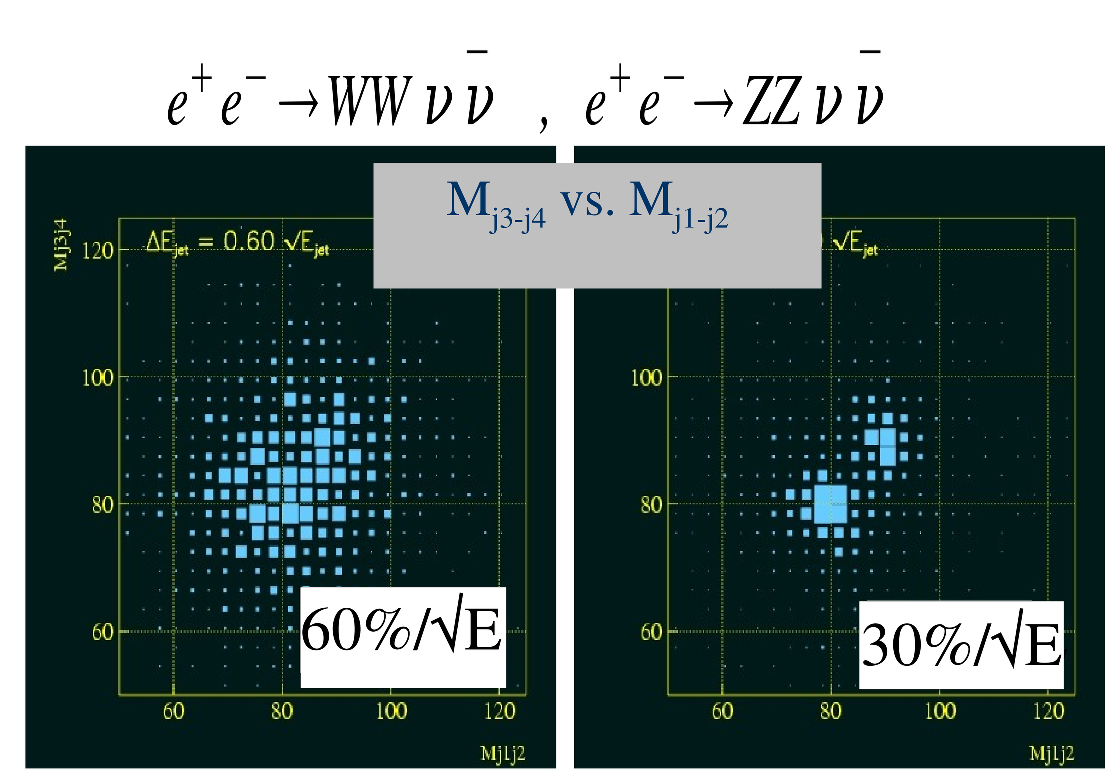
The demonstrated performance of our detector system, contributing to many important realms of particle physics at Fermilab and around the world shows the importance of our measurements.

The continued physics of the current run and the extended goals of the proposed 2007 run, which will assist the neutrino programs and provide for ILC developments are both important to Fermilab's future successes.

International Linear Collider Calorimeter Research and Development:

The future MIPP experiment run will have a major component to help provide measurements vital to improving Hadron Calorimetry, this is the most important detector in the ILC. As can be seen in the difference between a 60%/ √E and 30%/ √E resolution, crucial to separating the two jet background from W and Z:

$$e^+e^-\rightarrow WW\nu\bar{\nu} \quad , \quad e^+e^-\rightarrow ZZ\nu\bar{\nu}$$



Current Hadron Calorimetry designers rely upon Monte-Carlo codes where the various detector materials are not well known. The MIPP experiment will study 30 nuclei from 1 to 100 GeV/c.

The response of the ILC test calorimeter to neutrons and its efficiency is essential to the Particle Flow algorithms. By putting the ILC hadron calorimeter in the MIPP beam line we will be able to provide a direct measure of neutron energy and efficiency response. Detailed studies by MIPP (see MIPP note 130 by R. Raja et al.) show that tagged neutrons for energy resolution and efficiency can be readily available.