Main Injector Particle Production Experiment (FNAL-E907)

What is MIPP?

- Fixed target experiment
- Measure identities and momenta of particles produced in interactions of positive and negative pions and kaons, protons and antiprotons with various nuclear targets (from H to Pb)
- Beam momenta from 5 to 120 GeV/c, generated from Main Injector protons on copper primary target
- Low cost: reuse detectors from previous experiments

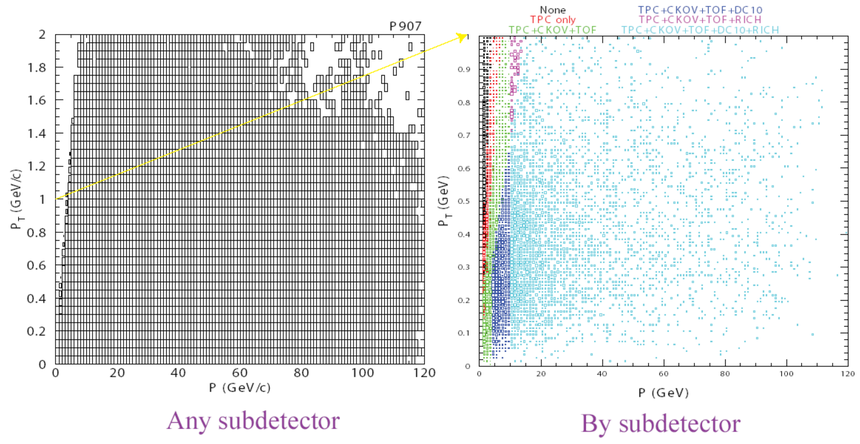
Why Do We Need MIPP?

- MIPP is unique since it combines open geometry, excellent acceptance, large beam momentum range, and high statistics
- The previous open geometry experiment (EHS) was using a bubble chamber
- The HARP experiment at CERN will only go to beam momentum of 15 GeV/c
- Equivalent experiments with single-arm spectrometers have inherent systematic uncertainties

MIPP Collaboration

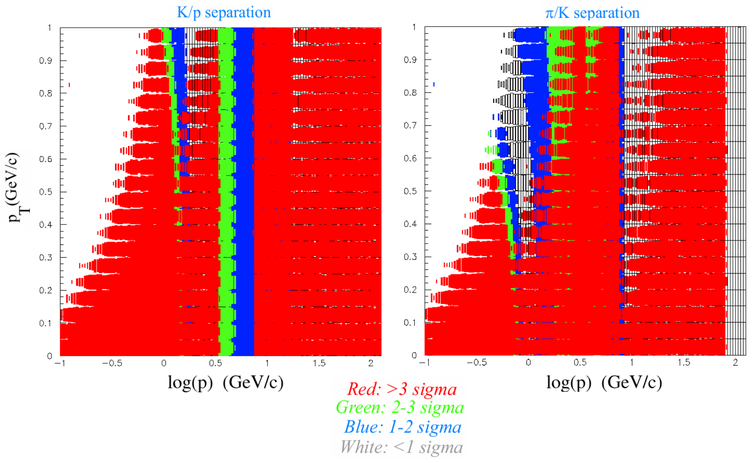
Brookhaven National Laboratory - Y.Fisyak
EFI, University of Chicago - R.Winston
University of Colorado, Boulder - M.Austin, R.J.Peterson
Elmhurst College and EFI - E.Swallow
Fermi National Accelerator Laboratory – W.Baker, D.Carey, J.Hylen, C.Johnstone, M.Kostin, H.Meyer, N.Mokhov, A.Para, R.Raja, S.Striganov
Harvard University - G.Feldman, A.Lebedev, S.Seun
Illinois Institute of Technology - P.Hanlet, O.Kamaev, D.Kaplan, H.Rubin, N.Solomey, C.White
Indiana University - N.Graf, M.Messier
Lawrence Livermore Laboratory – D.Asner, P.D.Barnes Jr., J.Gronberg, E.Hartouni, M.Heffner, D.Lange, R.Soltz, D.Wright
University of Michigan – R.L.Abrams, H.R.Gustafson, M.Longo, H-K.Park, D.Rajaram
Purdue University - A.Bujak, L.Gutay, D.E.Miller
University of South Carolina – T.Bergfeld, A.Godley, S.R.Mishra, C.Rosenfeld, K.Wu
University of Virginia - C.Dukes, L.C.Lu, K.Nelson, A.Norman

MIPP Acceptance



Any subdetector | By subdetector

MIPP Particle ID Separation



Red: >3 sigma
Green: 2-3 sigma
Blue: 1-2 sigma
White: <1 sigma

MIPP Physics

Who Wins?

- High Energy Physics community
  - »Reopen the field of non-perturbative QCD.
  - »Better modeling of hadron production
- MINOS: service measurement with MINOS target in MIPP beam line
- Atmospheric neutrino calculations: reduce uncertainties in present models
- Heavy Ion Physics: calibrate strangeness production in pA reactions
- Neutrino factory: we can do target measurements

Hadron Spectroscopy

- Improve limits on unobserved mesons predicted by SU(3) and SU(6) symmetries
- Search for exotic particles
  - » Pentaquarks
  - » Quark gluon hybrids
  - » Di-baryons

Relativistic Heavy Ions

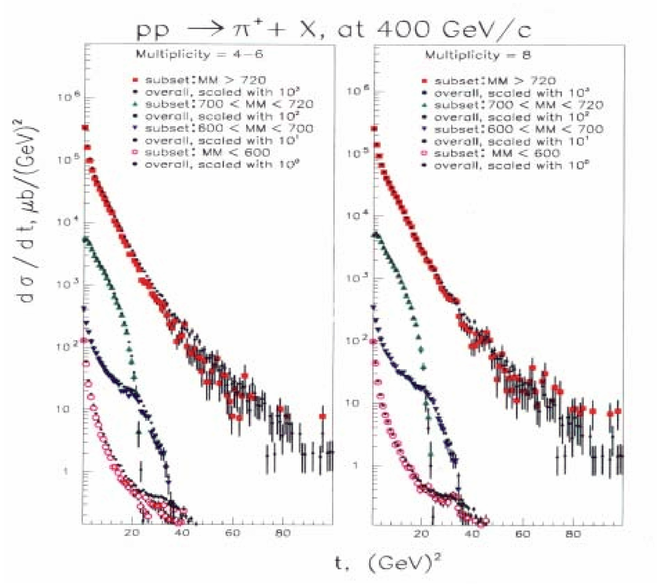
- Physics of *pA* collisions is important because it is essential to understand the nuclear medium and multiple collision effects
- Measurement of strangeness production per participant in *pA* collisions will calibrate the strangeness enhancement seen in *AA* collisions at CERN (QGP evidence)
- MIPP provides acceptance in beam direction lacking in collider experiments

Hadronic Fragmentation

- General law of scaling for inclusive reactions proposed in 1978
  - » The ratio of semi-inclusive to inclusive cross-section is only a function of Mandelstam variable $M^2 = u + t + s$

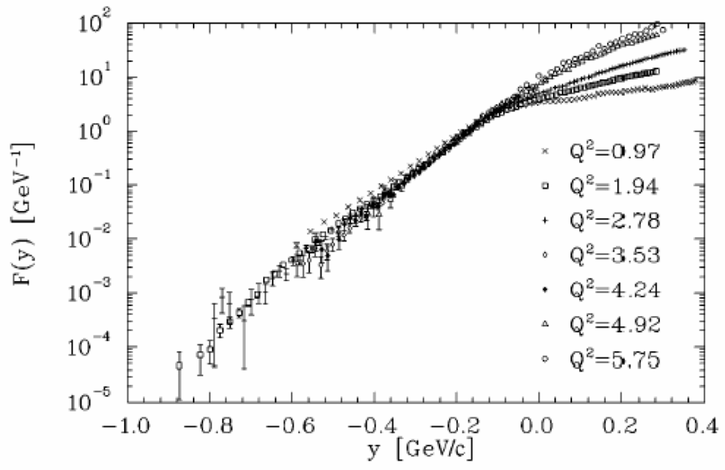
$$\frac{f_{subset}(a+b\to c+X)}{f(a+b\to c+X)} \equiv \frac{f_{subset}(M^2,s,t)}{f(M^2,s,t)} = \beta(M^2)$$

- » Tested in limited cases
- » Existing data is sparse
- » MIPP will be able to collect enough data to test the scaling law with a large number of reactions

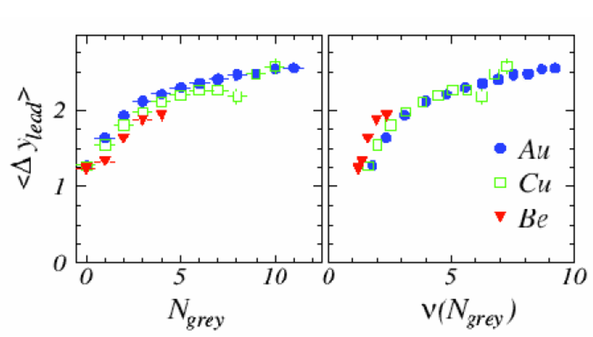


Nuclear Scaling

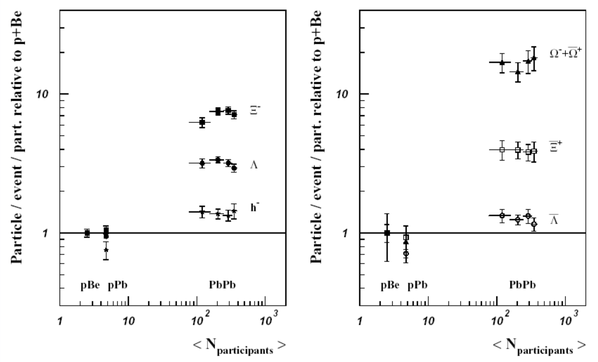
- MIPP can test scaling in *y* for hadron-nucleus scattering
- The scaling function is independent of q^2
  - »Represents nuclear momentum distribution
- Scaling is verified in *ep* scattering and low energy hadron beams at KEK E352 experiment



Scaling function F(y) for Fe. The Q^2 values are given for Bjorken x = 1



Change in rapidity of 18 GeV/c protons as a function of the number of recoil nucleons (BNL E910 experiment)



Data from the SPS experiment WA97 showing various strange baryon yields per participant relative to *pBe* collisions

Fermilab

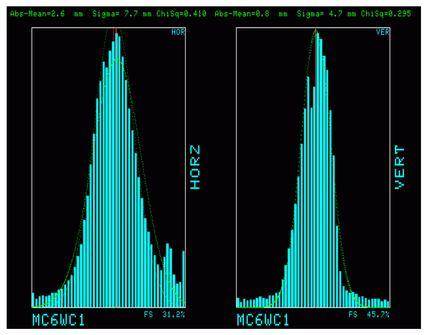
Main Injector Particle Production Experiment (FNAL-E907)

MIPP Progress

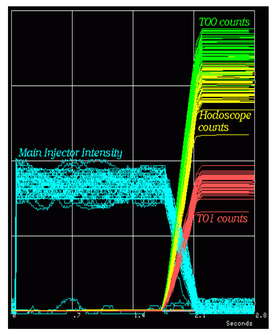
- Commissioning is going at full speed
  - » Thanks to tremendous progress made with slow extraction from Main Injector
- DAQ is operational
- First beam observed with beam chambers, beam devices, TPC, RICH, and calorimeters
  - » Almost all detectors are online, need debugging
- offline software is not too far behind
- Physics quality data expected within the next couple of months

Slow-Extracted Main Injector Beam

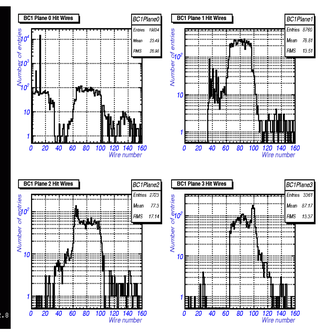
- 1-2 shots per minute
  - » We need 1 per 3-6 seconds to fully realize our potential
- 40 GeV/c positive particles
- Emittance is too high
- Beam tuning is in progress



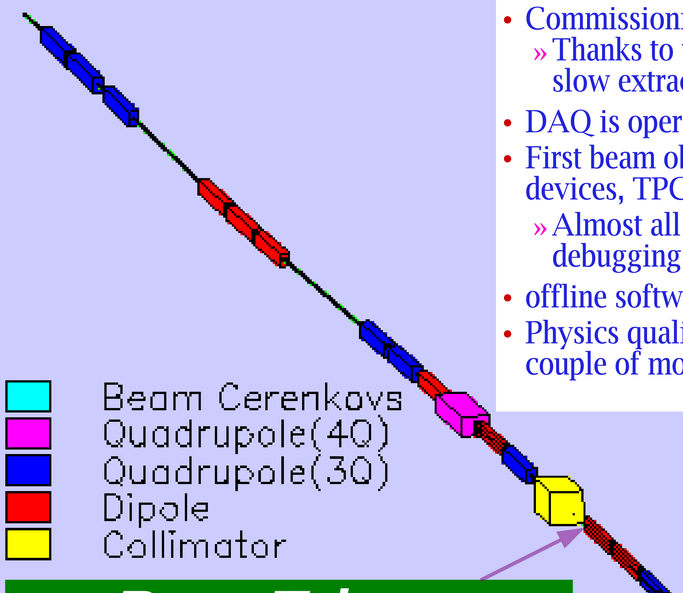
Beam profile before the primary target: primary beam needs to be focused better



Beam at the MIPP target: secondary beam is not tuned



Wire profiles of Beam Chamber 1



Beam Cherenkovs

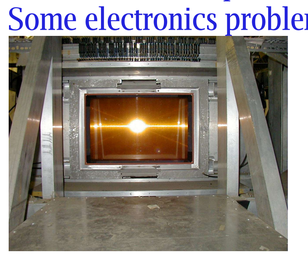
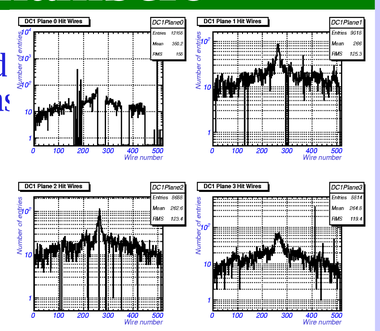
- Fully operational, need well focused beam to calibrate beam particle ID efficiency

Beam Chambers

- All three working
- Gas is not yet optimized
- Minor problems with electronics

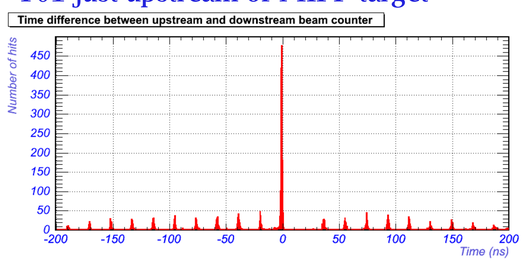
Drift Chambers

- All four operational
- Gas needs to be optimized
- Some electronics problems

Beam Trigger

- Identical fast scintillator+PMT counters: T00 is just downstream of the collimator, T01 just upstream of MIPP target



Magnets

- Magnetic field is mapped with Ziptrack
- Fully operational

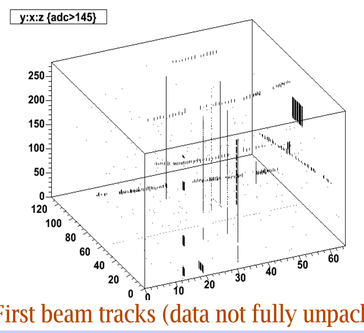
Time of Flight Wall

- Fully assembled
- Problems with readout are being addressed

Time Projection Chamber

- Holds high voltage (10 kV) when filled with P10 gas
- Needs minor online code changes to speed up readout
- 10 sticks need to be repaired


TPC on rails in MC7



First beam tracks (data not fully unpacked)

Multi-cell Cherenkov

- To be filled with C_4F_{10} soon
- PMT's are working
- Readout is complete

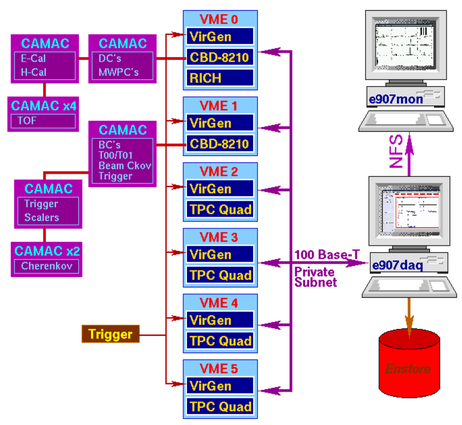

PMT's seen through mirrors

Proportional Chambers

- » Chamber 5 is working,
  - High voltage is plateaued
- » Chamber 6 has HV problems
- » Readout issues to be worked out

Data Acquisition System

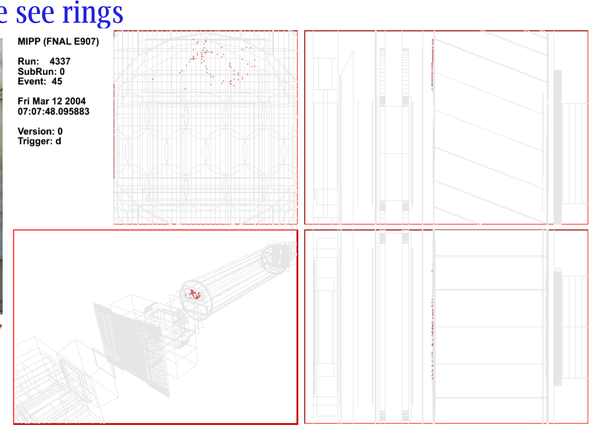
- Readout is based on VME Power PC's
- Almost all electronics is recycled
- All essential code is written, needs more bells and whistles
- CAMAC readout being debugged



Ring Imaging Cherenkov

- Filled with CO_2, we see rings


Looking upstream in MC7



Calorimeters

- Both electromagnetic and hadronic calorimeters are working
- Calibration studies with beam are in progress

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