Proposal to Upgrade the MIPP Experiment-P960

Rajendran Raja

Nov 4-2010

- Format of talk
  - » Description of Experiment
    - Motivation
  - » Upgrade proposal
    - Why it is essential to do
  - » Analysis of MIPP data taken so far
  - » Upgrade proposal in detail
  - » Conclusions

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MIPP Upgrade collaboration list

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18 new institutions have joined. 6 from India.
New Collaborators in color cyan

Brief Description of Experiment

- Approved November 2001
- Situated in Meson Center 7
- Uses 120GeV Main Injector Primary protons to produce secondary beams of $\pi^{\pm}$ $K^{\pm}$ $p^{\pm}$ from 5 GeV/c to 85 GeV/c to measure particle production cross sections of various nuclei including hydrogen.
- Using a TPC we measure momenta of ~all charged particles produced in the interaction and identify the charged particles in the final state using a combination of dE/dx, ToF, MultiCell Cherenkov and RICH technologies.
- Open Geometry- Lower systematics. TPC gives high statistics 3D track reconstruction.
- First Physics run- 18 million events 2005. Ended Feb 2006. We will present briefly the results.
  - » Forward neutron paper sent for publication arXiv:1010.6291v2 [hep-ex]
  - » NuMI Target analysis 95% complete.

Data taken so far (20Hz)

Data Summary 27 February 2006			Acquired Data by Target and Beam Energy Number of events, x 10^6									
Target			E									Total
Z	Element	Trigger Mix	5	20	35	40	55	60	65	85	120	
0	Empty	Normal		*0.10*	*0.14*			*0.52*			*0.25*	*1.01*
	K Mass	No Int.				*5.48*	*0.50*	*7.39*	*0.96*			*14.33*
	Empty LH	Normal		*0.30*				*0.61*		*0.31*		**7.08**
1	LH	Normal	0.21	**1.94**				**1.98**		**1.73**		
4	Be	*p* only									1.08	**1.75**
		Normal			0.10			0.56				
6	C	Mixed						**0.21**				**1.33**
	C 2%	Mixed		**0.39**				**0.26**			**0.47**	
	NuMI	*p* only									**1.78**	**1.78**
13	Al	Normal			*0.10*							*0.10*
83	Bi	*p* only									1.05	**2.83**
		Normal			0.52			1.26				
92	U	Normal						1.18				**1.18**
Total			**0.21**	**2.73**	**0.86**	**5.48**	**0.50**	**13.97**	**0.96**	**2.04**	**4.63**	**31.38**

Why MIPP?

- Why study the strong interaction? Answer:- We do not know how to calculate a single cross section in non-perturbative QCD! This is >99% of the total QCD cross section. Perturbative QCD has made impressive progress. But it relies on structure functions for its calculations, which are non-perturbative and derived from data.
- If the Higgs does not exist and electroweak symmetry breaking occurs through strong W interactions, then we need to understand non-perturbative interactions. Low energy strong interactions are a good place to start.
- All Scaling laws (Feynman scaling, KNO scaling, rapidity plateaus) are violated.
- Most existing data are old, low statistics with poor particle id.
- Most models tuned on a variety of old data on single particle inclusives. They manage to get the longitudinal profiles of hadronic showers correct. Transverse profiles requires understanding and modelling of particle correlations (i.e full non-perturbative QCD dynamics). Data not available. One is at the mercy of a large number of models that are not consistent with each other. A lot of manpower is invested in "tuning and validating" models, that are inadequate to answer the detailed questions precision experiments are asking today.
- Technology has improved since the bubble chamber and today we are in a position to acquire high quality production data that can completely revolutionize our ability to predict hadronic showers. This will greatly increase our understanding of systematics in a series of experiments, fixed target neutrino experiments being a significant beneficiary.
- With the upgraded MIPP, we will be able to build up a database of events from 30 nuclei that can be used directly in simulators or as a queriable database to plot cross sections, inclusive distributions etc.

Service measurements

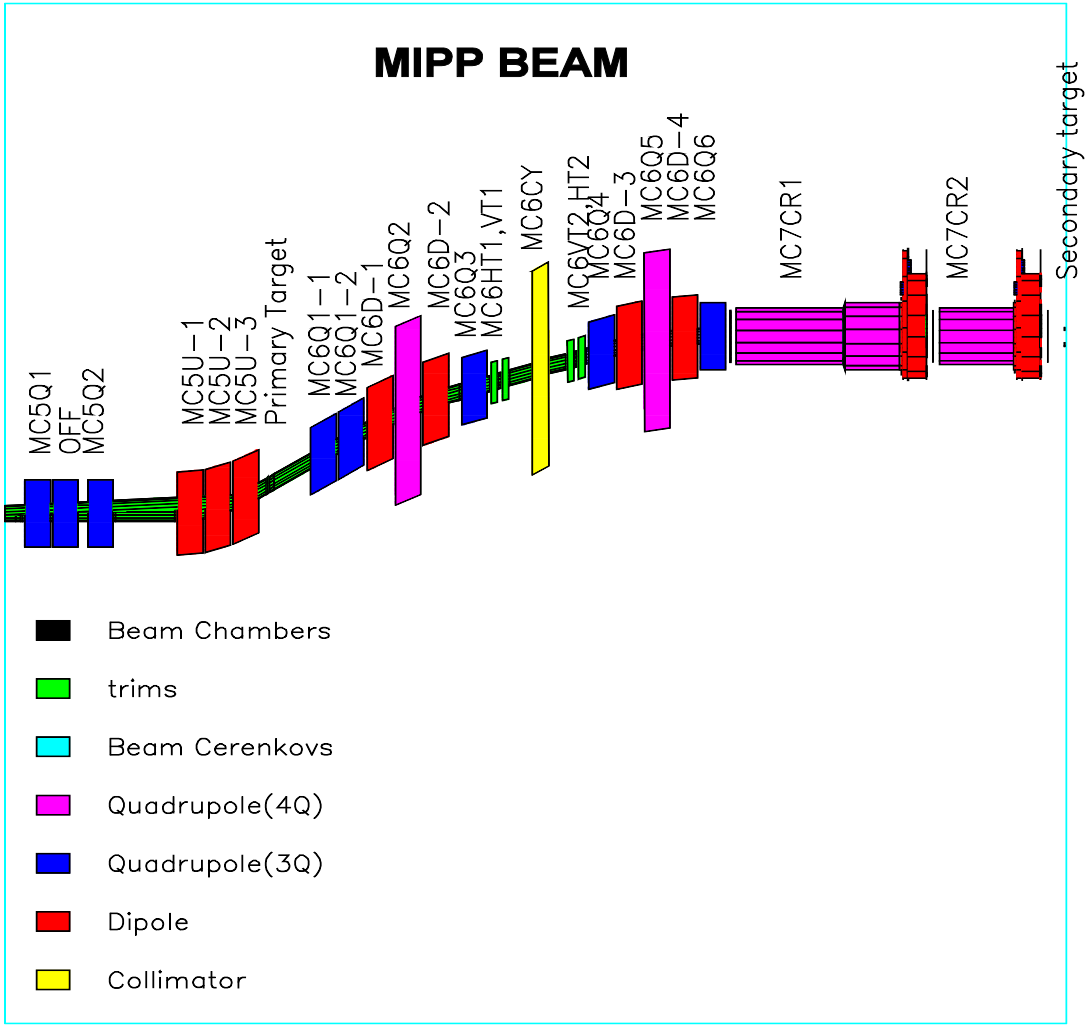
- Nova/ Minerva medium energy target measurement.-15 million events in 3 days
- Measurement of particle production on materials in the beamline (He, Cu, Fe etc)
- Improve shower simulators (MARS, Geant4..). Plastic ball recoil detector will detect recoil neutrons from nuclei. Important for calorimeter compensation mechanisms.
- Measurement of production on nitrogen for cosmic ray + atmospheric neutrino experiments.
- Measure pbar-p cross sections (GSI, FAIR)
- Tagged neutral beams
- Measure mercury target for Muon Collider/neutrino factory studies

Physics of the strong interaction

- Scaling laws of inclusive particle production-non-perturbative in their very nature
- Missing baryon resonances.
- Nuclear physics.
- Will not be able to cover all of these in detail in this talk. But one upgraded apparatus (DAQ faster by 150) will enable all these topics to be done well.
- Not on the Intensity, Cosmic, or energy frontiers. However, we are on the knowledge frontier.

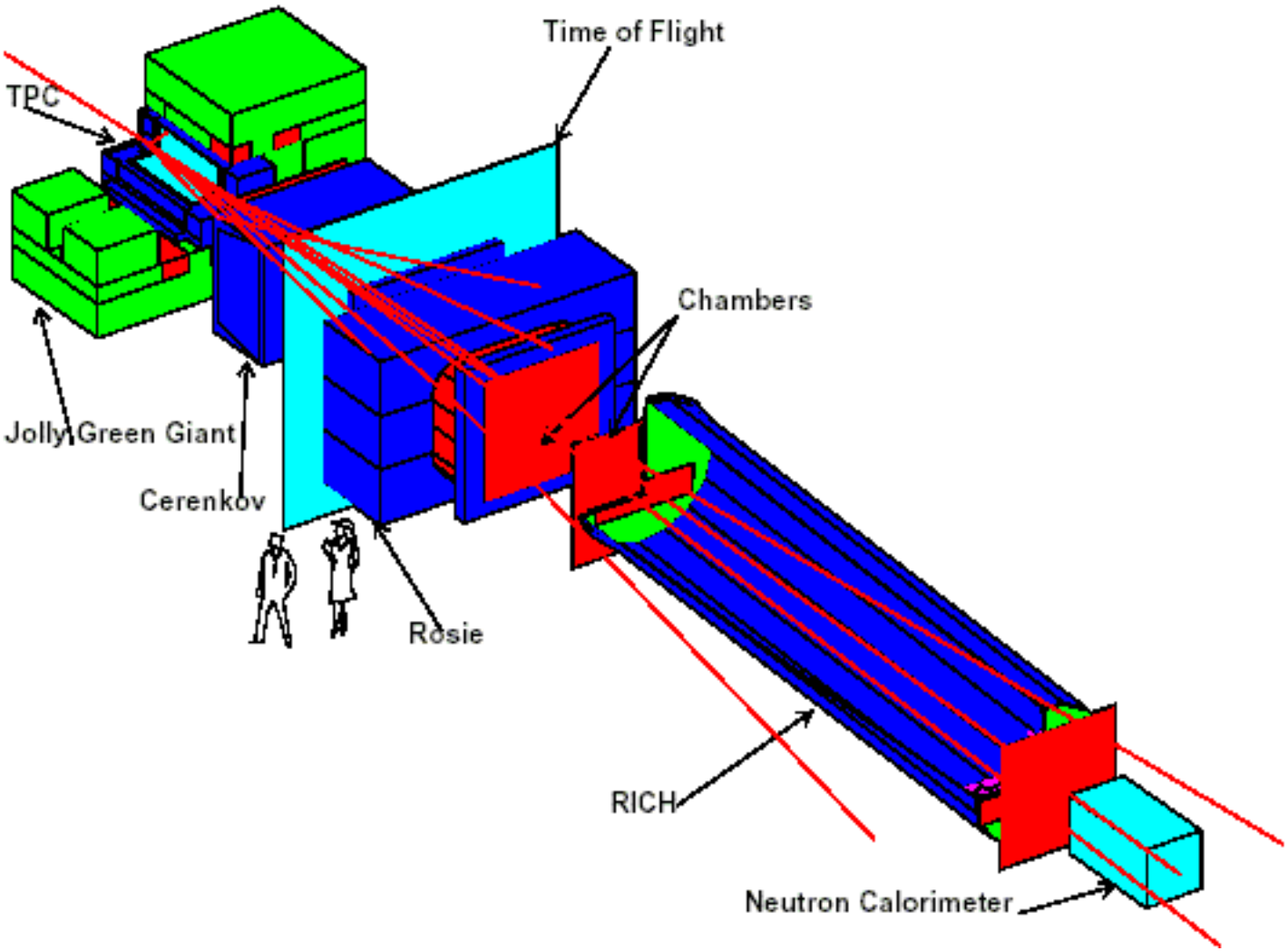
MIPP Secondary Beam

Installed in 2003. Excellent performance. Ran it successfully in MIPP from 5-85 GeV/c secondaries and 120 GeV/c primary protons. Excellent particle ID capabilities using 2 Beam Cerenkovs. 6 beam species ($\pi^{\pm}$,$K^{\pm}$,$p^{\pm}$) in the momentum range ~1-120 GeV/c



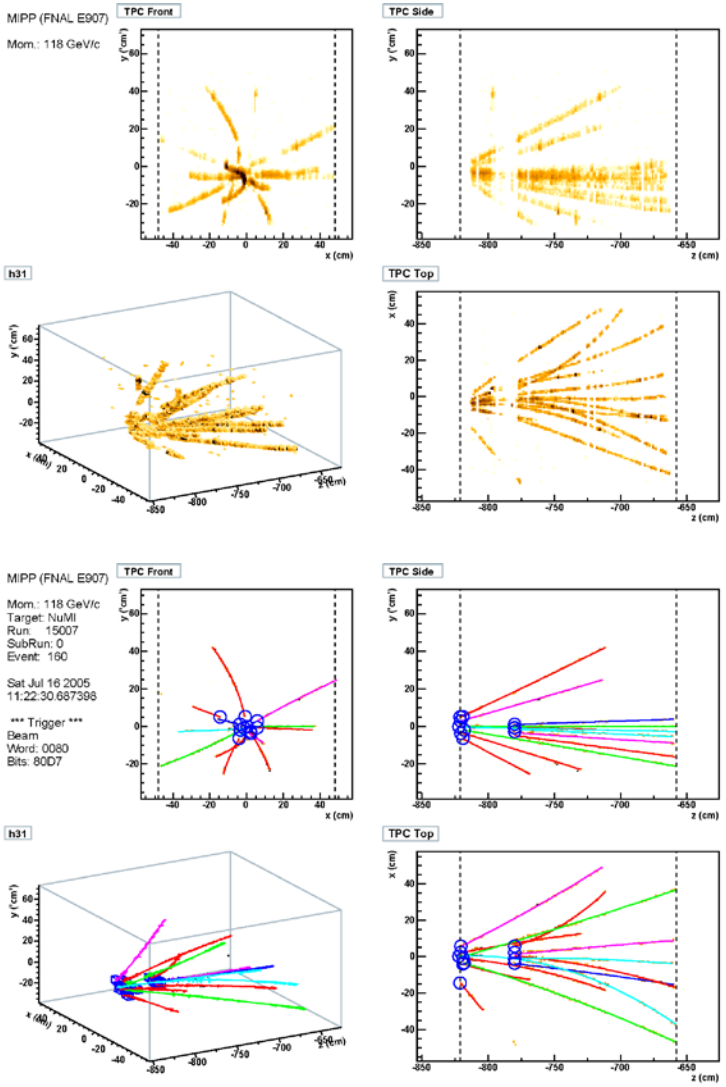
MIPP

Main Injector Particle Production Experiment (FNAL-E907)

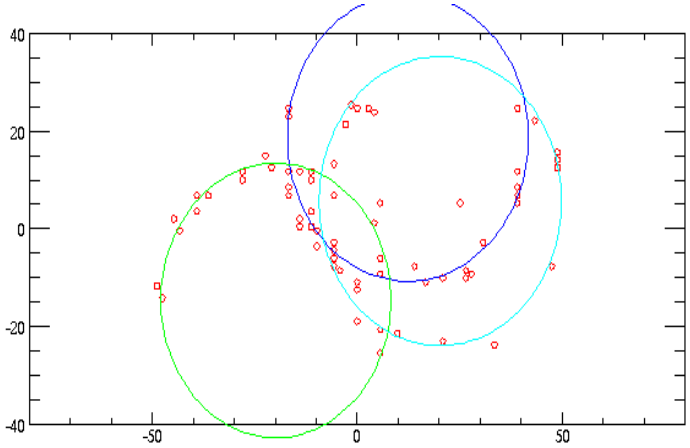


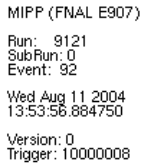
MIPP-I Installation in progress- ~2003

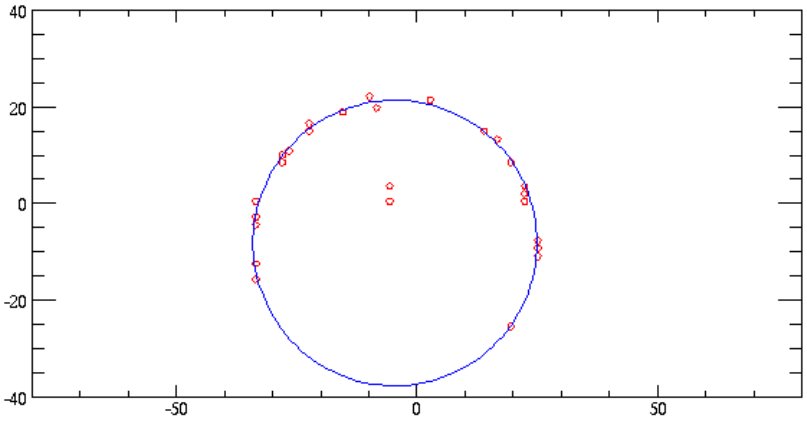
MIPP TPC

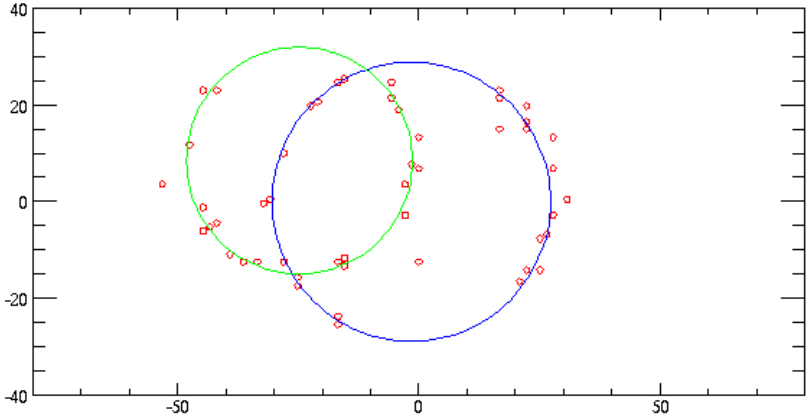

MIPP (FNAL E907)
Mom.: 118 GeV/c
TPC Front
TPC Side
h31
TPC Top
MIPP (FNAL E907)
Mom.: 118 GeV/c
Target: NuMI
Run: 15007
SubRun: 0
Event: 160
Sat Jul 16 2005
11:22:30.687398
*** Trigger ***
Beam
Word: 0080
Bits: 80D7
TPC Front
TPC Side
h31
TPC Top

RICH rings pattern recognized









The MIPP Upgrade Proposal in a nutshell

- MIPP -I took data at ~20Hz. The limitation was the TPC electronics which are 1990's vintage. We plan to speed this rate up to 3000Hz (~150 times faster) using ALTRO/PASA chips developed for the ALICE collaboration.
- Beam delivery rate– We assume the delivery of a single 4 second spill every two minutes from the Main Injector. We assume a 42% downtime of the Main Injector for beam manipulation etc. This is conservative. Using these figures, we can acquire 5 million events per day.
- Jolly Green Giant Coil Replacement- Towards the end of our run, the bottom two coils of the JGG burned out. We decided to replace both the top and bottom coils with newly designed aluminum coils that have better field characteristics for the TPC drift. The coils have been installed.
- Beamline upgrade- The MIPP secondary beamline ran satisfactorily from 5 5GeV/c-85GeV/c. We plan to run it from ~1 GeV/c to 85 GeV/c. The low momentum running will be performed using low current power supplies that regulate better. Hall probes in magnets will eliminate hysteresis effects.
- TPC Readout Upgrade-We have ordered 1100 ALTRO/PASA chips from CERN ($80K). Chips have been delivered and first prototype boards have been made.

The MIPP Upgrade Proposal in a nutshell

- MIPP- Recoil detector- GSI- Darmstadt / KVI Groningen have joined us. They will bring the plastic ball detector (a hemisphere of it) which will serve to identify recoil (wide angle) neutrons, protons and gammas from our targets.
- Triggering system- We propose to replace the MIPP interaction trigger (scintillator/wire chamber) with 3 planes of silicon pixels based on the B-TeV design. Will enable us to trigger more efficiently on low multiplicity events.
- Drift Chamber/ PWC electronics- We will replace both systems with a new design that utilizes some of the infrastructure we developed for the RICH readout.
- ToF/CKOV readout- new readout designed.
- Will use the VME readout cards in common with RICH, TPC
- RICH detector and the Beam Cerenkovs will work as is.
- Calorimeter Readout- Switch to readout similar to Plastic ball.
- DAQ software upgrade- Front end DAQ software needs to be developed. The MIPP DAQ control software+ Data base can be kept as is.
- Plan is to store one spill's worth of data (12,000 events) on each detector and read out the whole lot at end of spill.

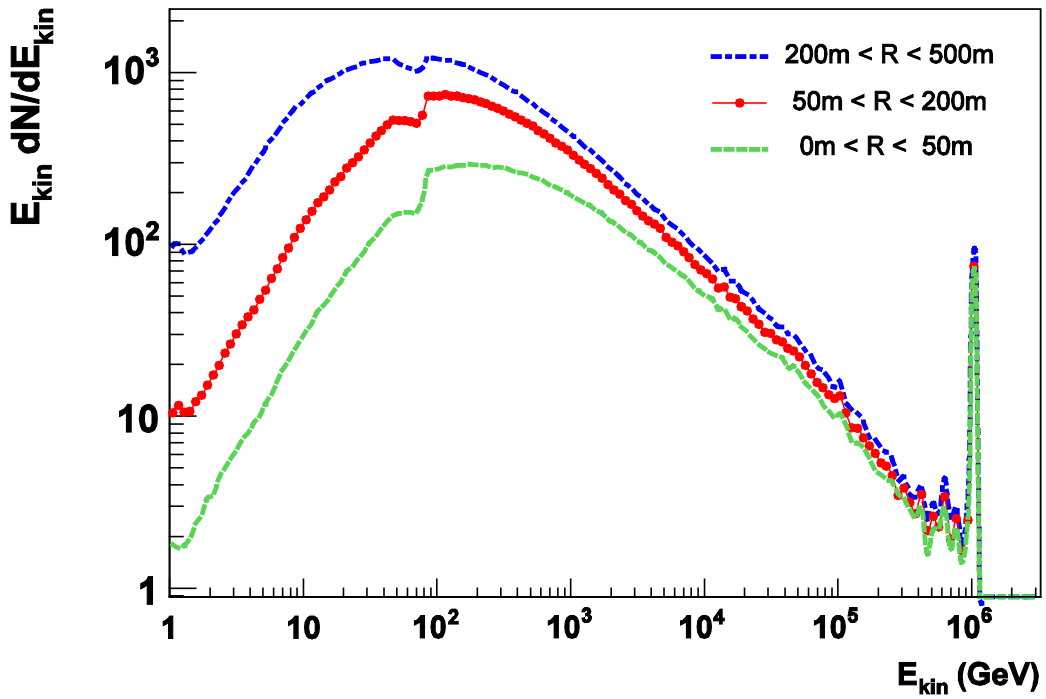
Nuclei of interest- 1st pass list

- The A-List
- H_2,D_2,Li,Be,B,C,N_2,O_2,Mg,Al,Si,P,S,Ar,K,Ca,,Fe,Ni,Cu,Zn,Nb,Ag,Sn,W,Pt,Au,Hg,Pb,Bi,U
-
- On each nucleus, we can acquire 5 million events/day with one 4sec beam spill every 2 mins and a 42% downtime.
- We plan to run several different momenta (1-85 geV/c) and both charges. For neutrinos we will also have p=120GeV on thick and thin targets.
- The libraries of events thus produced will be fed into shower generator programs which currently have 30 year old single arm spectrometer data with high systematics

HSSW06 programs and models used by them

Program	Event Generator Models	Nuclear Break up models
Fluka05	Isobar model (below few GeV) own version of DPM + hadronization	PEANUT (Includes GINC) Generalized InterNuclear Cascade
Geant4	QGS + Fritiof String model $> 20GeV$ Bertini Cascade Model $< 10GeV$ Binary Cascade model Low Energy Parametrized Models & High Energy Parametrized Models (GHEISHA origin)	Geant4 Pre-compound model Bertini evaporation model Chiral Invariant Phase Space model (CHIPS) $< 20MeV$ Nuclear break-up libraries
MARS15	Inclusive event generator CEM03, LAQGSM03 Quark-Gluon String model	Generalized intra-nuclear cascade evaporation and fission models
PHITS	Jet AA Microscopic Transport Model (JAM) $> 20MeV$ Jaeri Quantum Molecular Dynamics model JQMD	Neutrons done as in MCNP JQMD
MCNPX	Fluka79 or LAQGSM	Intra Nuclear Cascade models Bertini, ISABEL, CEM, INCL4..

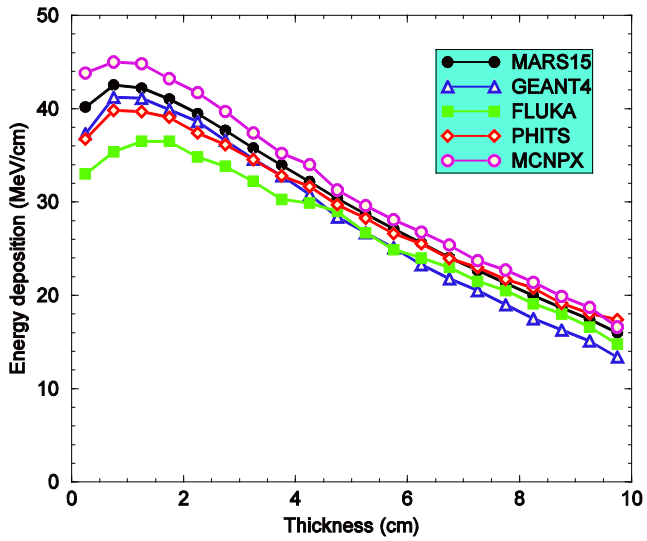
Meurer et al –Cosmic ray showers Discontinuity- Gheisha at low energies and QGSJET at higher energies- Simulation of air showers. This problem cannot be solved by measuring a nitrogen target at one or two energies.



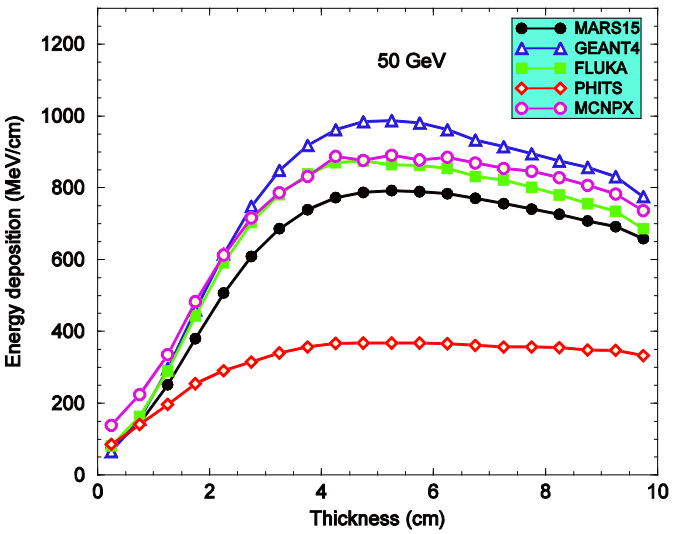
Nitrogen measurements by MIPP will fix this. Francis Halzen, Pierre Sokolsky, Indian Groups (INO) interested

Benchmark example from HSSW06- (N. Mokhov, S. Striganov, D. Wright et al)

- Energy deposit profile as a function longitudinal depth in a tungsten rod of 1cm radius—Challenges to get longitudinal and transverse distributions correctly simultaneously.



1 GeV/c protons



50 GeV/c protons

Summary of simulator problem

- Large variations in models predicting longitudinal energy deposition in thick targets.
- Models/data are off ~500% in 67-GeV p-Al (Thick target data) from Protvino.
- x_F-vs-p_T distribution of π/K production are 30 years old and are sparse.
- Thin target data (where avaliable) and models do not agree
- Particle correlations are important for transverse shapes (and thus also for neutrino spectra for thick targets whose transverse size is less than hadronic shower). Little correlation data available. So large model variations.

Can we reduce our dependence on models?

- Answer- Yes- With the MIPP Upgrade experiment, one can acquire 5 million events per day on various nuclei with six beam species (π ,K ,p) with beam momenta ranging from 1 GeV/c-90 GeV/c. Full acceptance over phase space, including info on nuclear fragmentation
- This permits one to consider random access event libraries that can be used to generate the interactions in the shower.

Random Access Data Libraries

- Typical storage needed

Nuclei	beam species	momentum bins	events/bin	tracks/event	words/track
30	6	10	100000	10	5
	Number of events		1.80E+08	Number of days	36
	Total number of words		9.00E+09	to take data	
		Bytes	3.60E+10		

- Mean multiplicities and total and elastic cross section curves are parametrized as a function of s.
- Events contain correlations!
- 36 GBytes of disk needed to house this database!

The recoil detector-Important for calorimetric simulations and nuclear physics

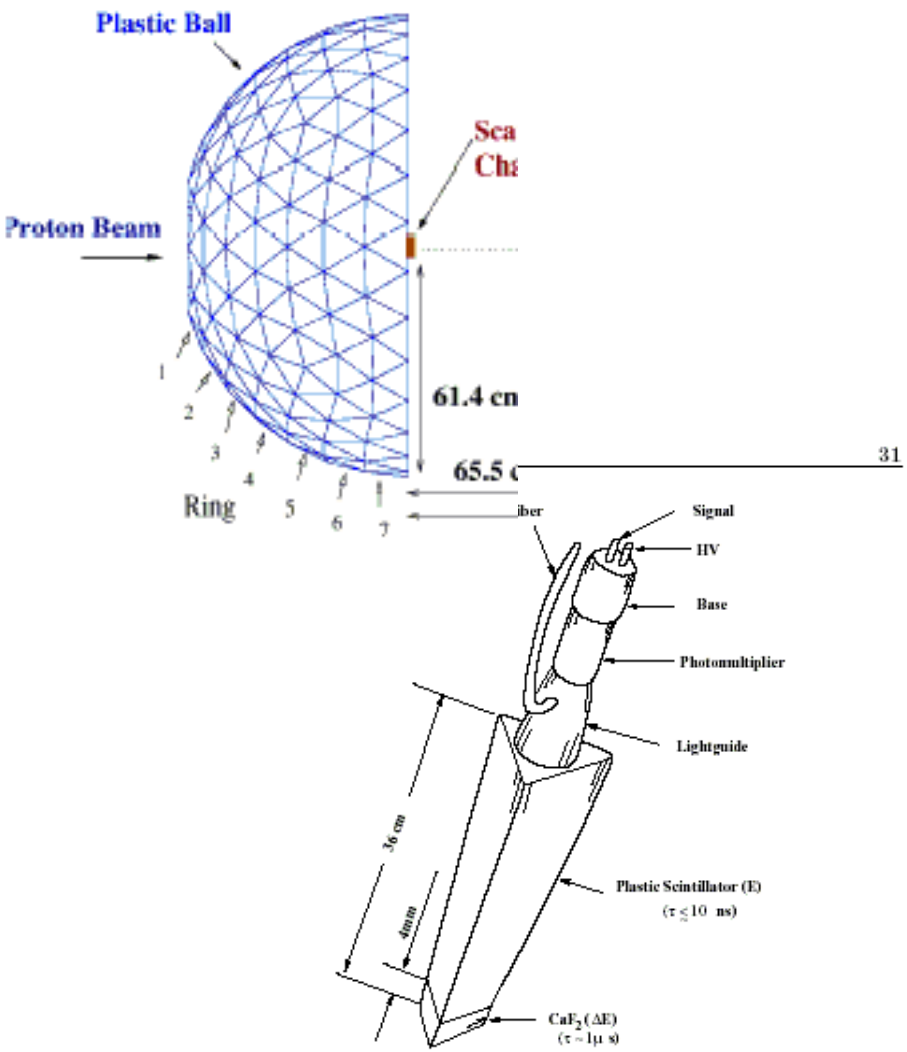
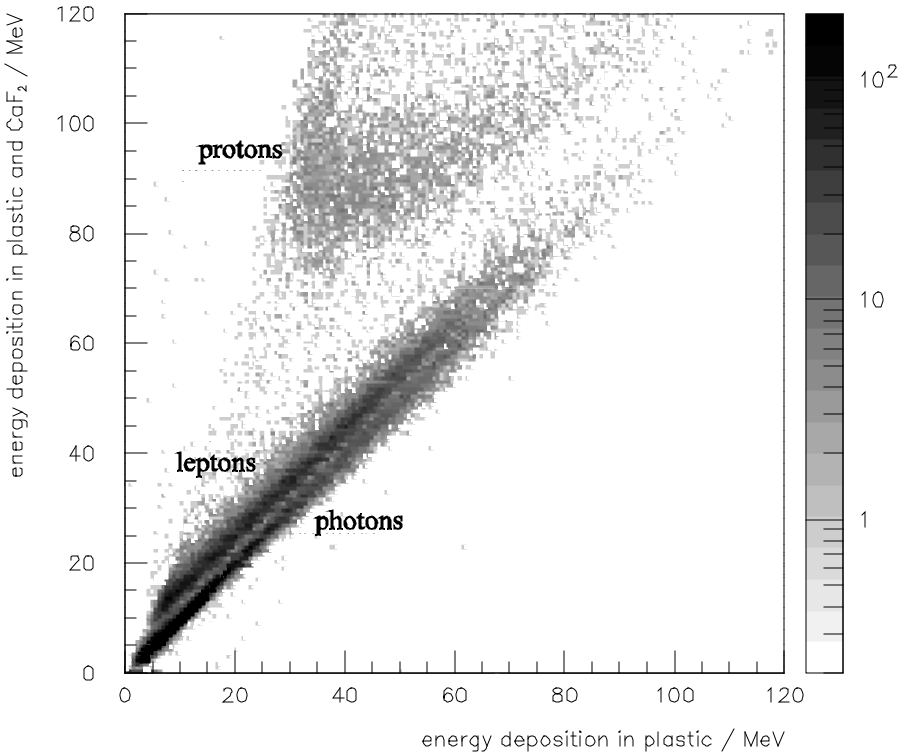


Figure 3.5: Schematic drawing of an individual Plastic-Ball detector.



Detect recoil protons, neutrons, photons and charged pions, kaons

Interest in MIPP Upgrade data

January 10, 2008

Dr. R. Raja
Fermilab

Re: Interest in data provided by the upgraded MIPP experiment at Fermilab

Dear Raja:

We would like to express our keen interest in utilizing the data provided by the upgraded MIPP experiment at Fermilab in improving the predictive power of hadronic shower simulation codes. The upgraded MIPP experiment will provide high quality data with final state particle identification on 30 nuclei using six beam species with momentum ranging from 1 to 90 GeV/c. The present codes use models that are tuned on single-particle inclusive data taken over many years and not always mutually consistent with each other. The MIPP upgrade data will eliminate a significant portion of the systematic uncertainties involved in hadronic shower simulations. Improved codes will benefit diverse fields within the HEP community, such as the fixed target neutrino and kaon programs, the atmospheric neutrino program, cosmic rays, calorimetry simulations in hadron collider experiments, as well as outside HEP such as studies to design radiation safe spacecraft environments. Improved codes will also help planning and calorimeter design studies for the International Linear Collider and a Muon Collider.

Sincerely,

John Apostolakis (CERN), Dennis Wright (SLAC), on behalf of the GEANT4 team

Nikolai Mokhov (Fermilab) on behalf of the MARS team

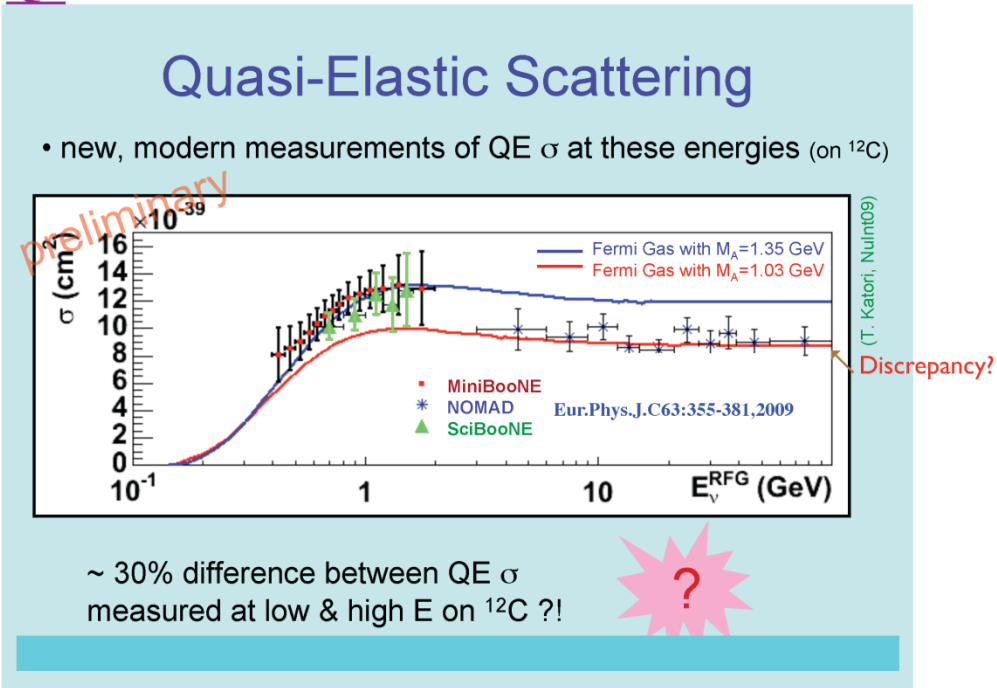
Koji Niita (RIST/JAEA) on behalf of the PHITS team

Laurie Waters (LANL) on behalf of the MCNPX team

Flux measurements for NuMI neutrinos - Nova/Minerva new target

- "Standard candle" reaction of neutrino CC Quasi Elastic reaction may no longer be a valid assumption. Pays to measure flux from first principles. MIPP + MIPP upgrade can do this as well as predict better secondary neutrino production due to downstream material.

QE



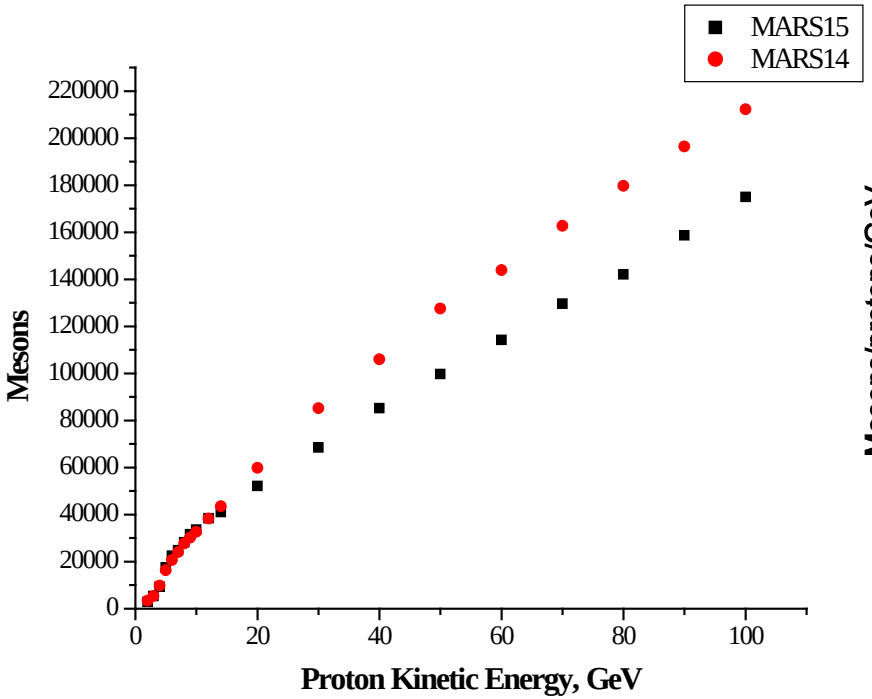
Analysis is ongoing on the above effect. Why not measure the flux using MIPP and measure the CCQE rather than making assumptions based on theory to obtain the flux indirectly?

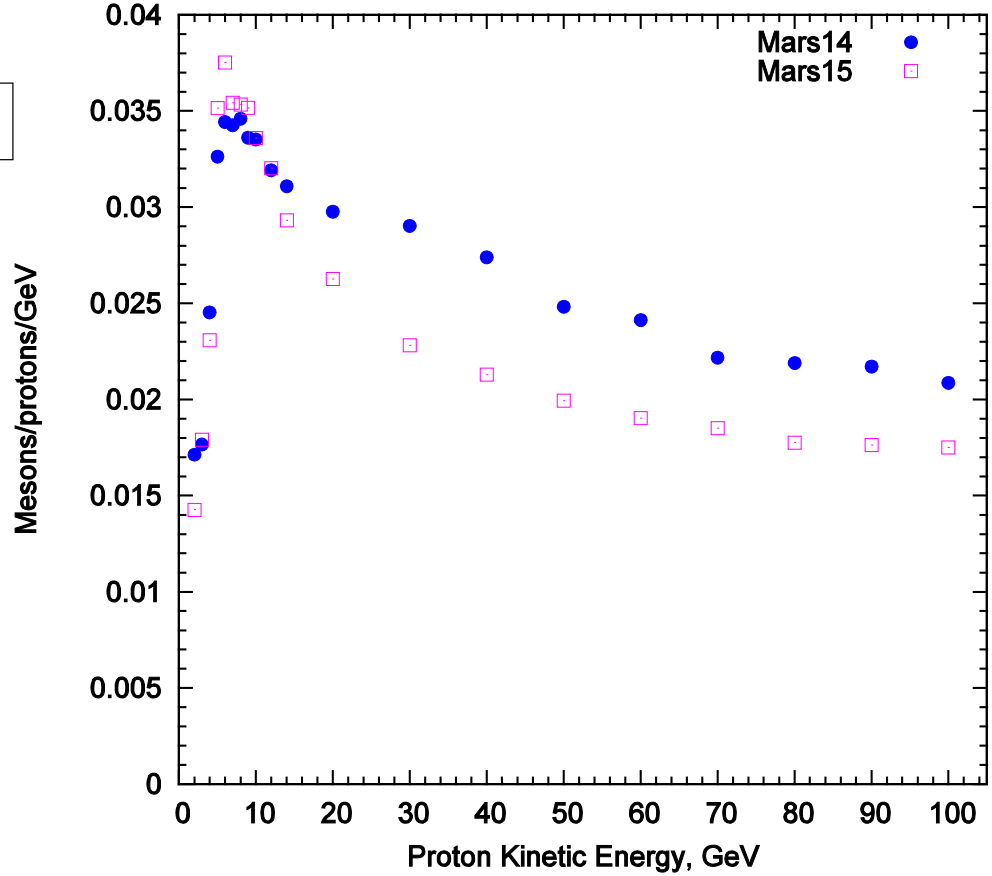
K-Long spectra off thin and thick targets

- MIPP TPC is capable of measuring K-Shorts that decay in its decay volume. This spectrum can be used to predict the K-Long spectrum from the target.
- This spectrum as well as the Charged Kaon and pion spectrum will be available in MIPP –II as well as MIPP-I.
- This will help pin down the electron neutrino background due to K-Long decays.
- Important for LBNE.
- Director's review of M-Center and MIPP concluded
  - » If the MIPP II upgrade can be expedited, its results could be used for design of new experiments such as LBNE, or if not, they can be used later in analysis.

Muon Collider/Neutrino factory needs Mars14 vs Mars15 Comparison

Pions kinetic energy 40 MeV<T<180 MeV → 112MeV/c <p< 287MeV/c

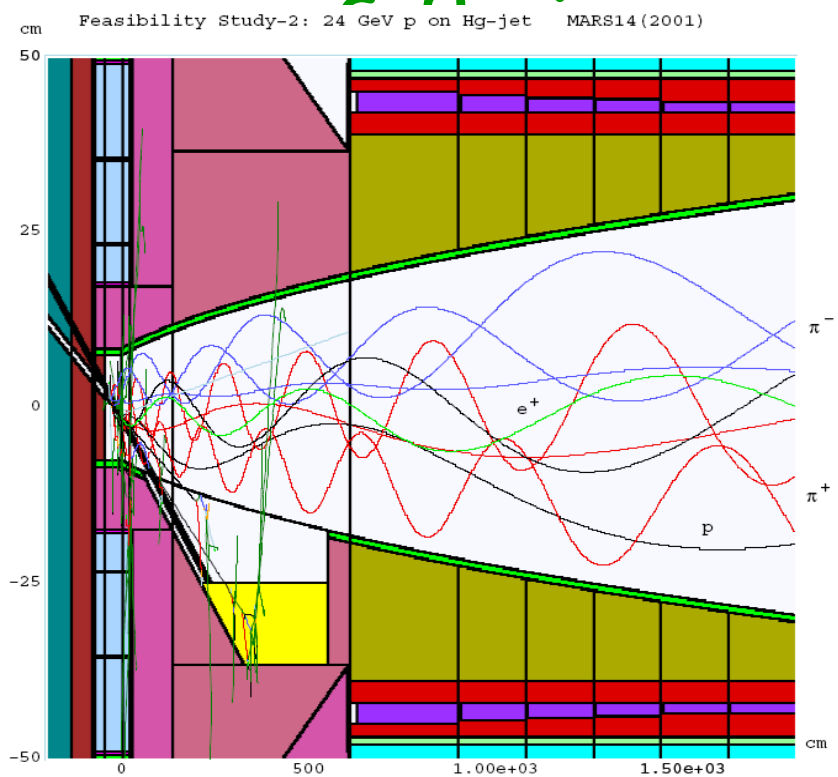


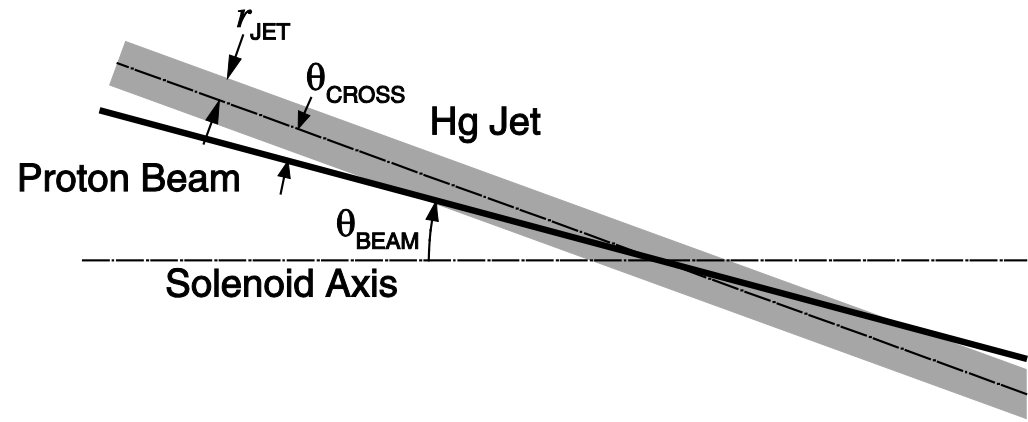


The Muon Collider/Neutrino Factory Target Concept

- **Maximize Pion/Muon Production**

Mock this up in MIPP

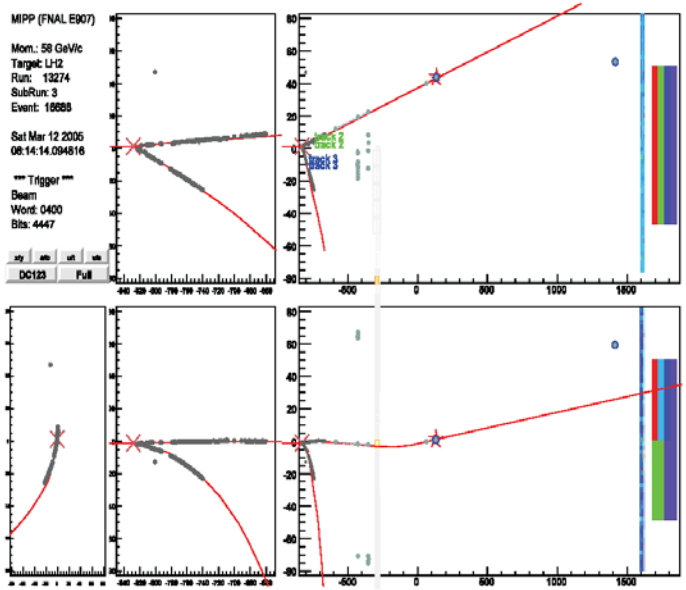


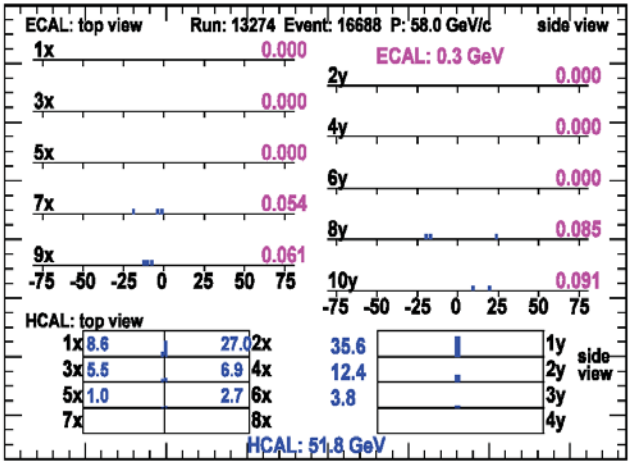


Harold Kirk, Bob Palmer (BNL)
K.Mcdonald (Princeton)
have joined this proposal to work with
Y. Torun (IIT) on this in MIPP.

Tagged Neutron candidates observed

Tagged neutral candidate 2 --58 GeV pp interaction





Tracking Display

Calorimeter display

Beam Momentum GeV/c	Proton Beam n/day	K+ beam K-Long/day	K- beam K-Long/day	Antiproton beam anti-n/day
10	20532	4400	4425	6650
20	52581	9000	9400	11450
30	66511	12375	14175	13500
60	47069	15750	14125	13550
90	37600			

General scaling law of particle fragmentation

- States that the ratio of a semi-inclusive cross section to an inclusive cross section

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

- where 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. PRD18(1978)204.
- Using EHS data, we have tested and verified the law in 12 reactions (DPF92) but only at fixed s.
- MIPP will test this in 36 reactions. MIPP upgrade can extend these scaling relation tests to two particle inclusive reactions which requires more statistics.

Missing baryon Resonances

- Partial wave analyses of πN scattering have yielded some of the most reliable information of masses, total widths and πN branching fractions. In order to determine couplings to other channels, it is necessary to study in elastics such as

$$\pi^- p \to \eta n; \pi^- p \to \pi^+ \pi^- n; \pi^- p \to K^0 \Lambda$$

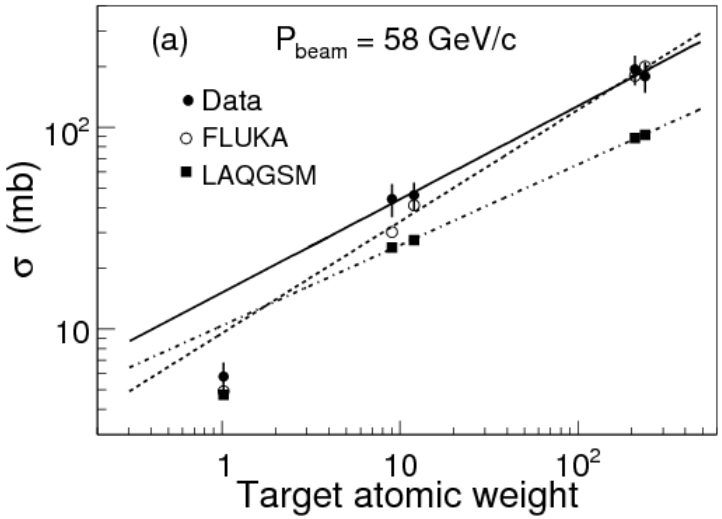
$$\gamma p \to \pi^0 p; \gamma p \to K^+ \Lambda; \gamma p \to \pi^+ \pi^- p$$

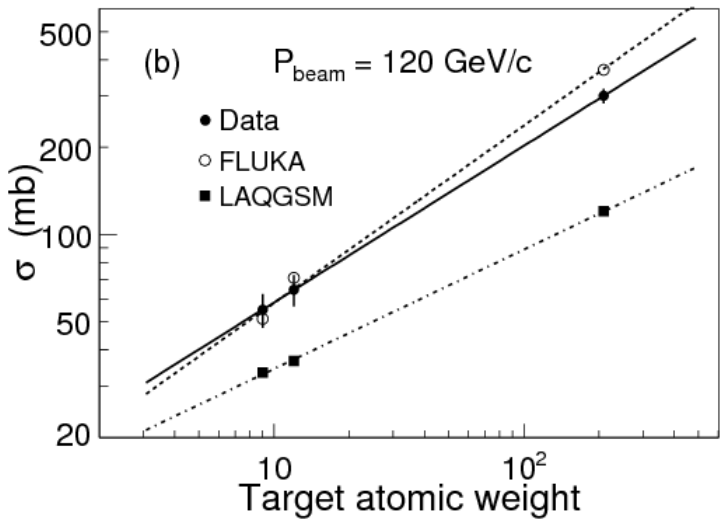
- All of the known baryon resonances can be described by quark-diquark states. Quark models predict a much richer spectrum. Where are the missing resonances? F.Wilczek, A. Selem
- "..this could form the quantitative foundation for an effective theory of hadrons based on flux tubes"– F.Wilczek

Results from Data acquired so far

- Five PhD's awarded
  - Ratio of Pion Kaon Production in Proton Carbon Interactions (A. Lebedev, Harvard)
  - Measurement of Pi-K Ratios from the NuMI Target (S. Seun, Harvard)
  - Measurement of the Charged Kaon Mass with the MIPP RICH (N. Graf, Indiana) (published)
  - Charged pion production cross section using 120 GeV/c proton beam on carbon target (G. Aydin, Iowa)
  - Cross section measurements in the Main Injector Particle Production (FNAL-E907) experiment at 58 GeV/c (Y. Gunaydin, Iowa)
- Publications
  - Kaon mass: NIM A631 (Mar. 2010)- NEW TECHNIQUE TO MEASURE CHARGED KAON MASS OF BOTH CHARGES
  - Calorimeter performance: NIM A598 (Jan. 2009)
- Today I WILL BRIEFLY COVER
  - NuMI target particle yields-95% complete
  - Forward neutron production cross sections- sent for publication
- Soon
  - More analyses in progress on cross sections with particle id on nuclei

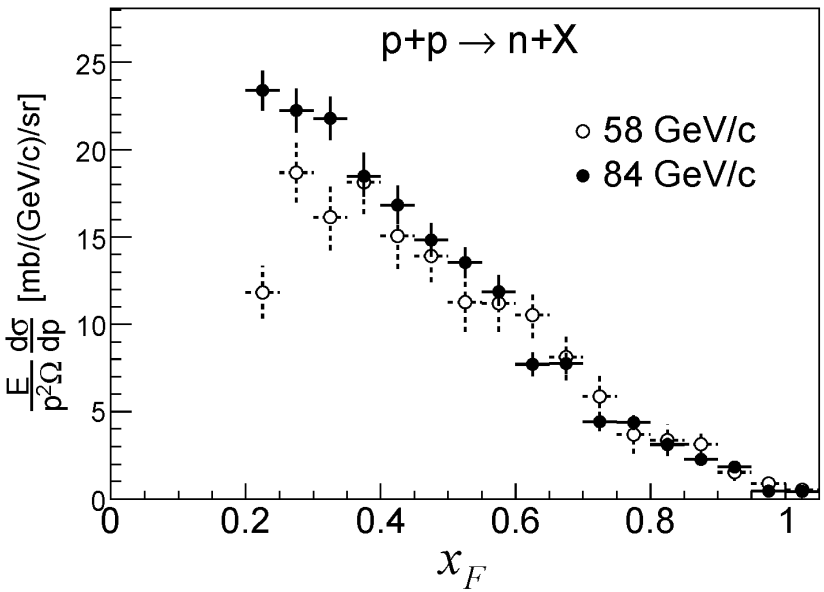
Forward Neutron Cross Section Results- Sent to PRD- arXiv:1010.6291v1 [hep-ex]

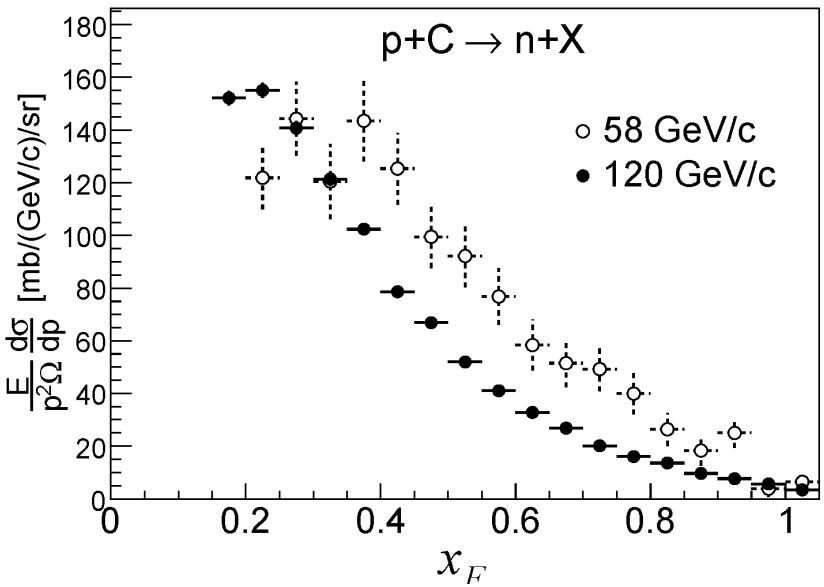


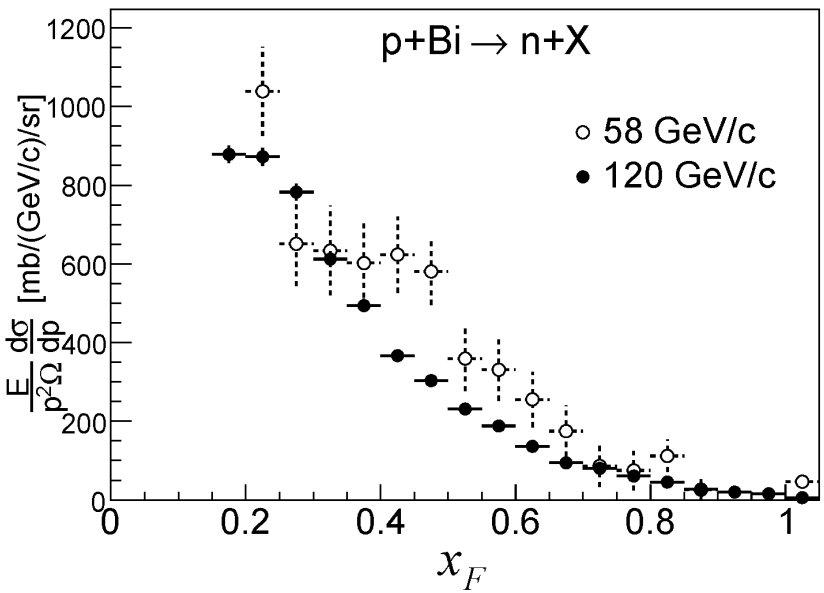


Notice discrepancies between the 2 Monte Carlos and also the data and the Monte Carlos

Forward neutron results-Invariant X section Scaling?

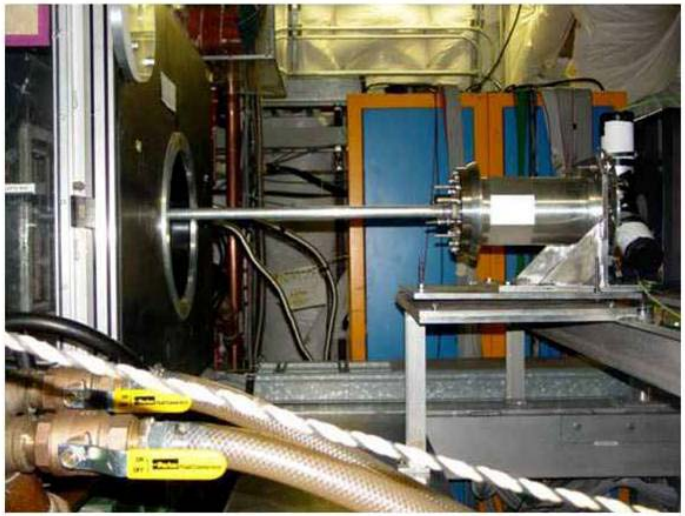


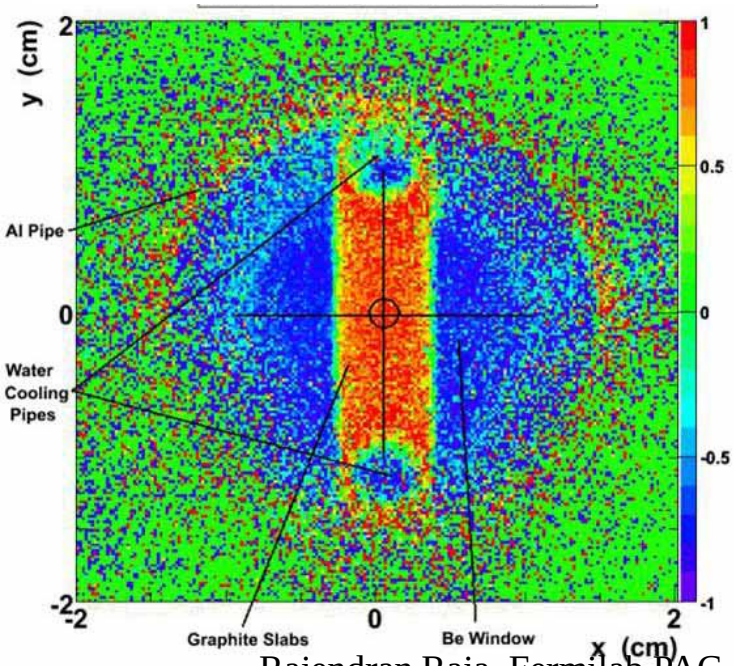




NuMI Target analysis

Actual NuMI target in MIPP upstream of the TPC. This target was then installed in NuMI.

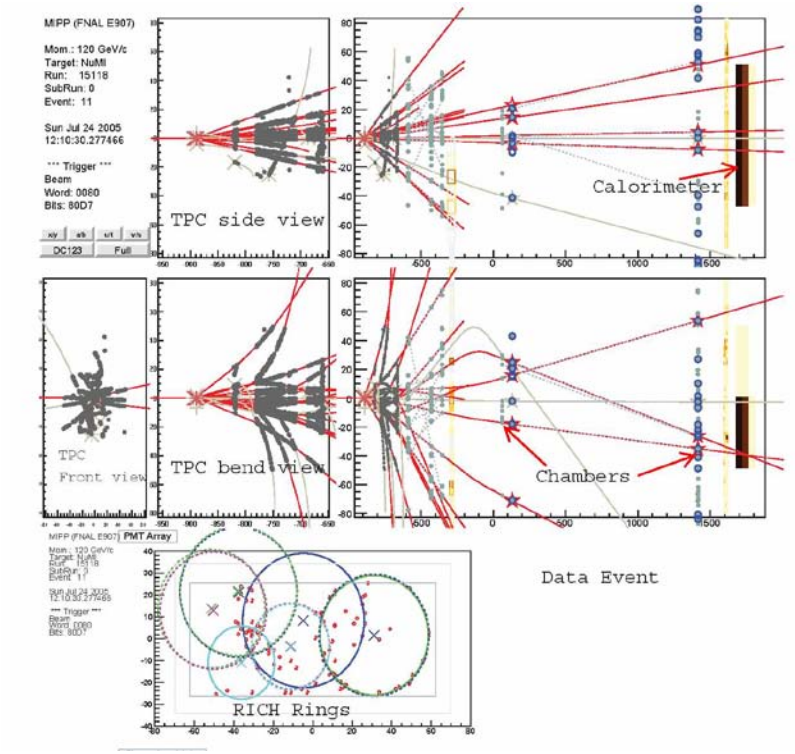




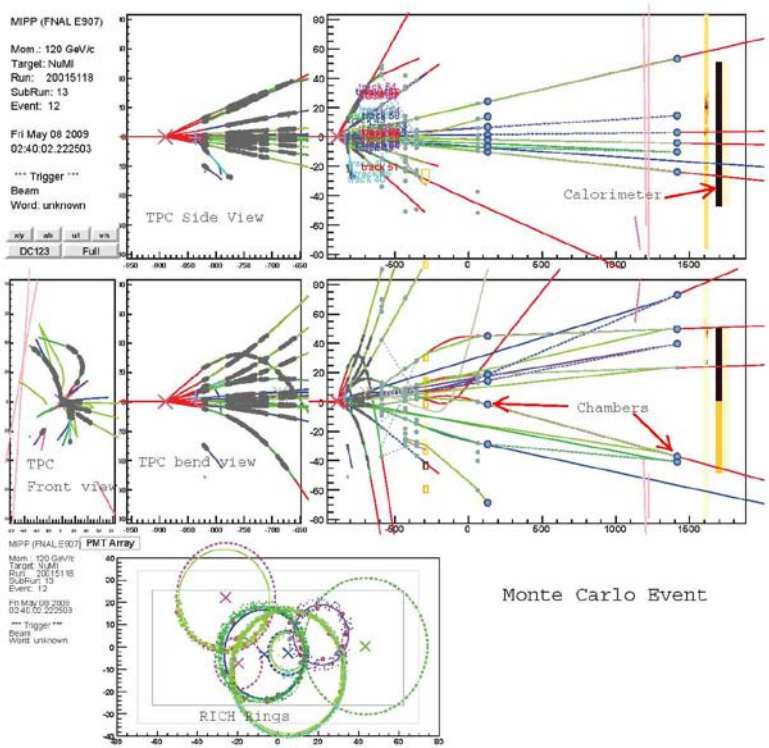
Radiograph of NuMI target in MIPP taken with a defocused 120 GeV/c proton beam

Event Displays

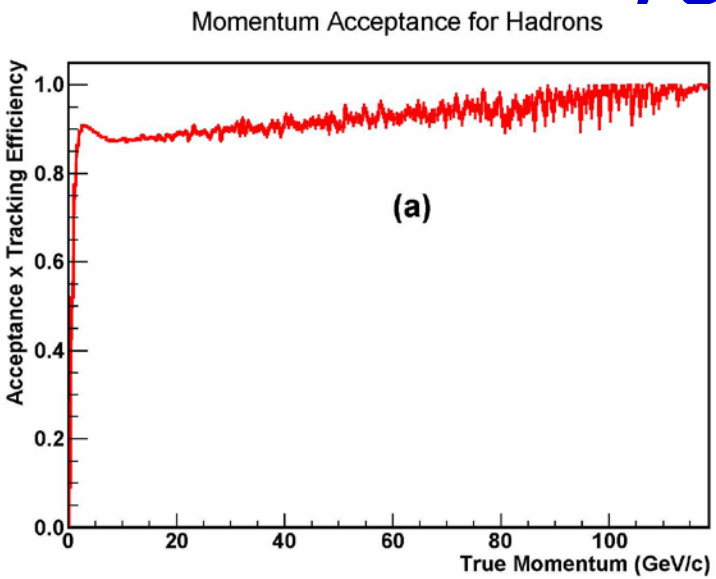
NuMI target data event

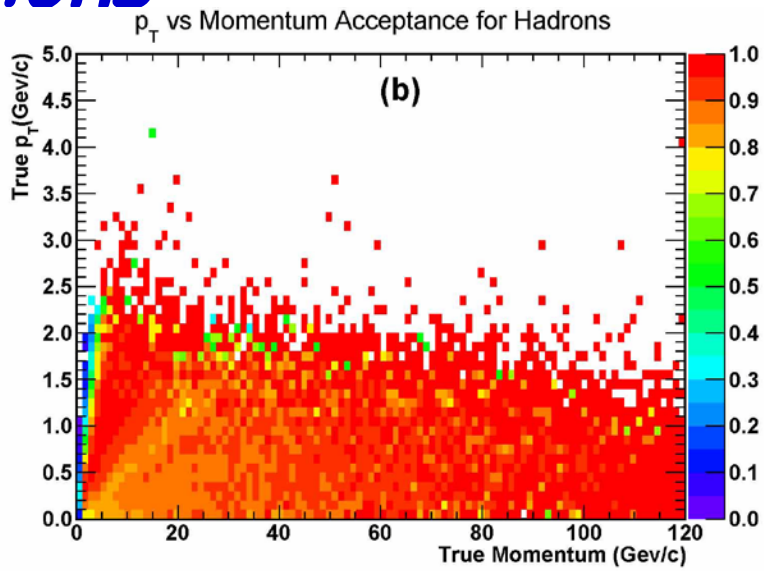


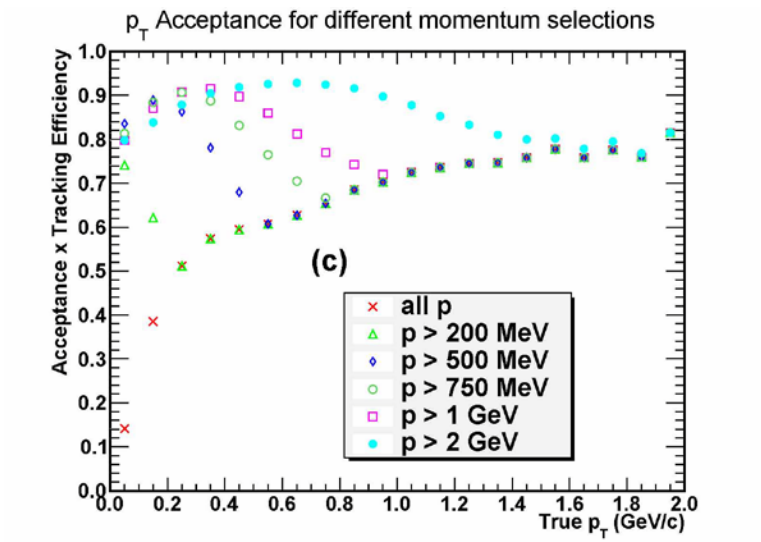
NuMI target Monte Carlo event with run dependent imperfections added

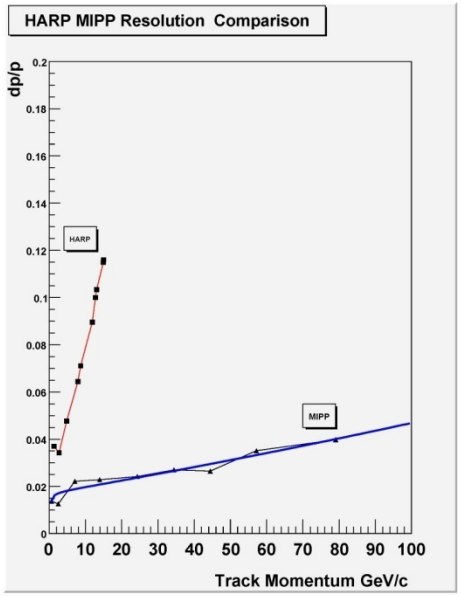


Acceptances and momentum resolutions

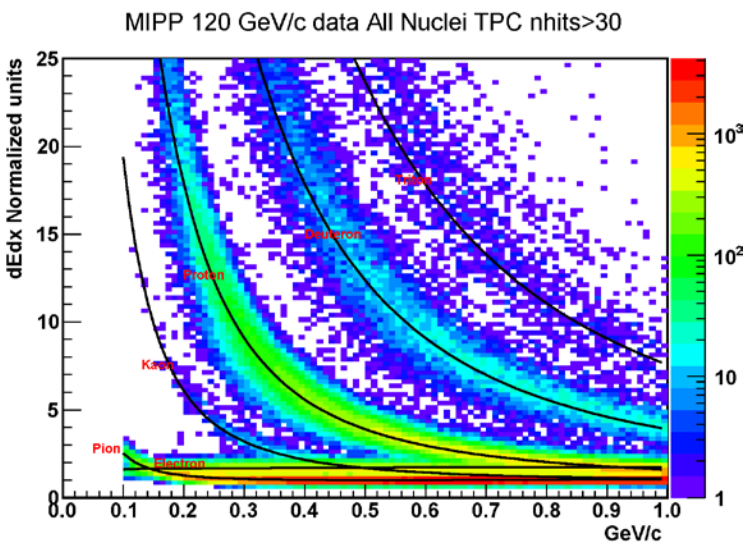


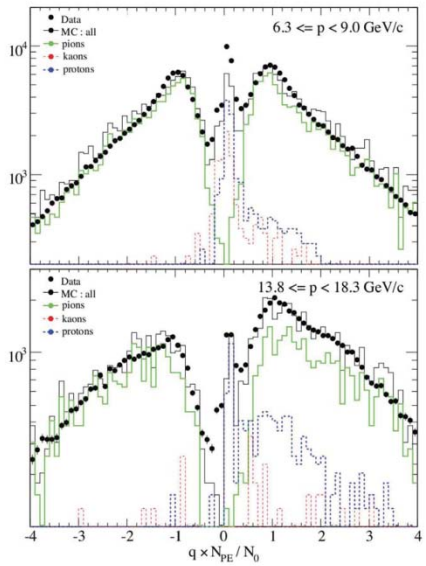


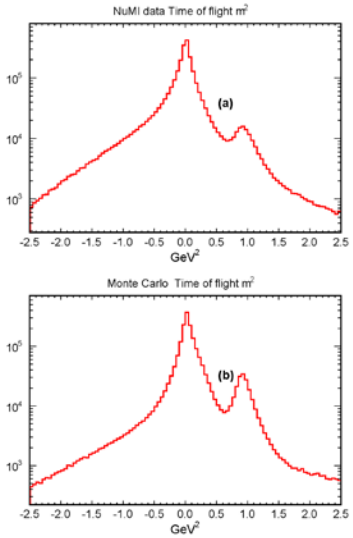


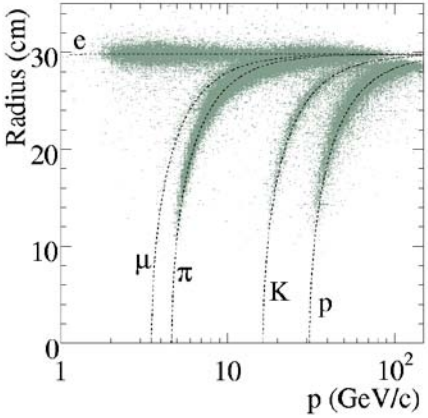


MIPP detector responses



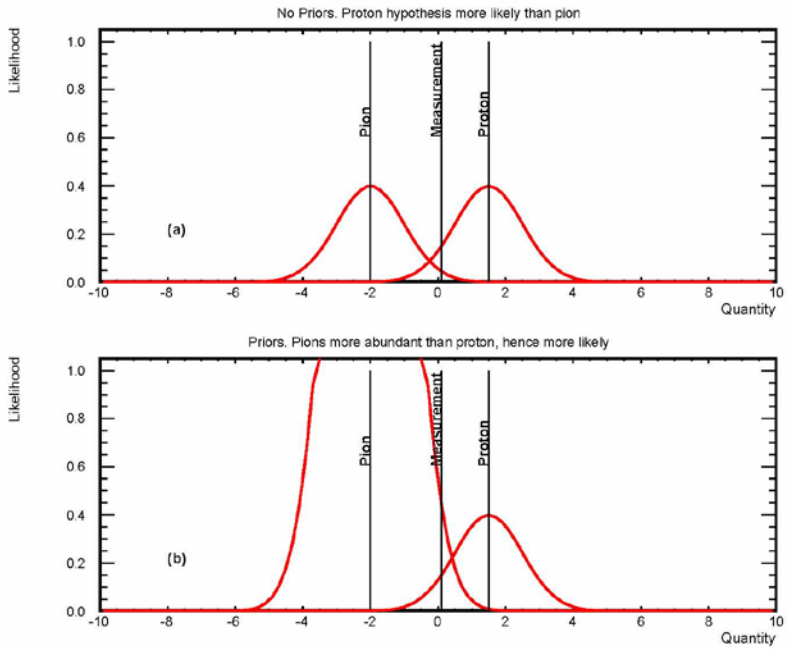


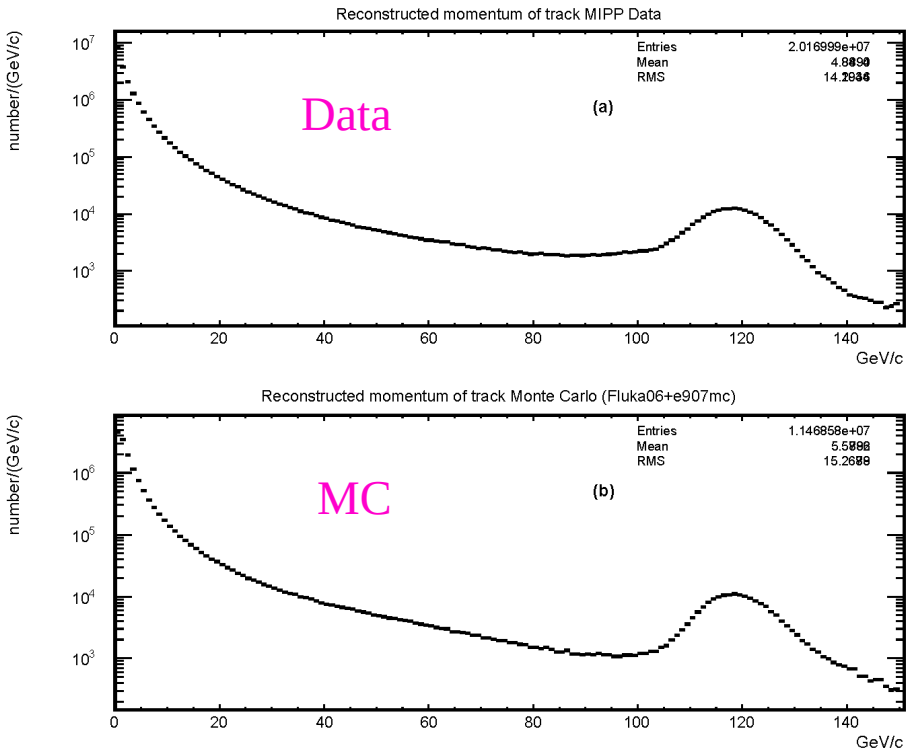




Need to know particle content a priori to calculate likelihoods

- Bayes' Theorem based algorithm





Bayes' theorem – Global PID formalism

- The joint probability P(H,x) can be written as (H = e,π,K,p; x = dE/dx, ToF, r_{RICH},...)

$$P(H,x) = P(x \mid H)P(H)$$

where P(H) is the probability of a particular hypothesis. This is what we are trying to determine. These equations are for a given momentum. We have suppressed the momentum dependence for simplicity.

- By Bayes' theorem

$$P(H,x) = P(H \mid x)P(x)$$

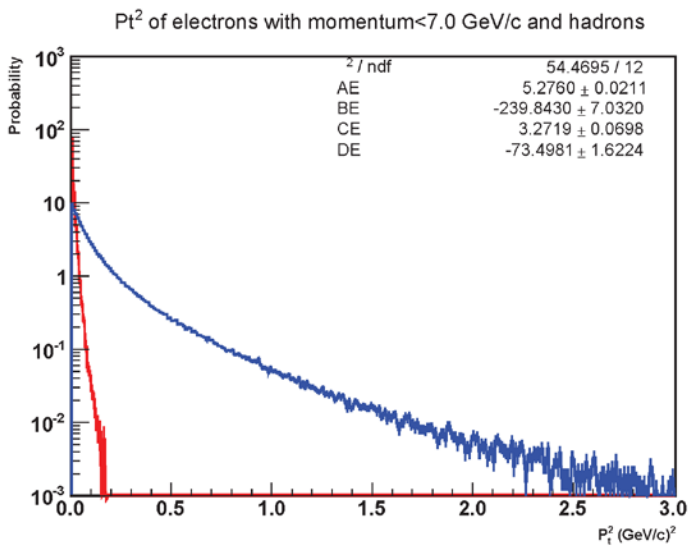
- This leads to

$$P(H \mid x) = \frac{P(x \mid H)P(H)}{\sum_H P(x \mid H)P(H)}$$

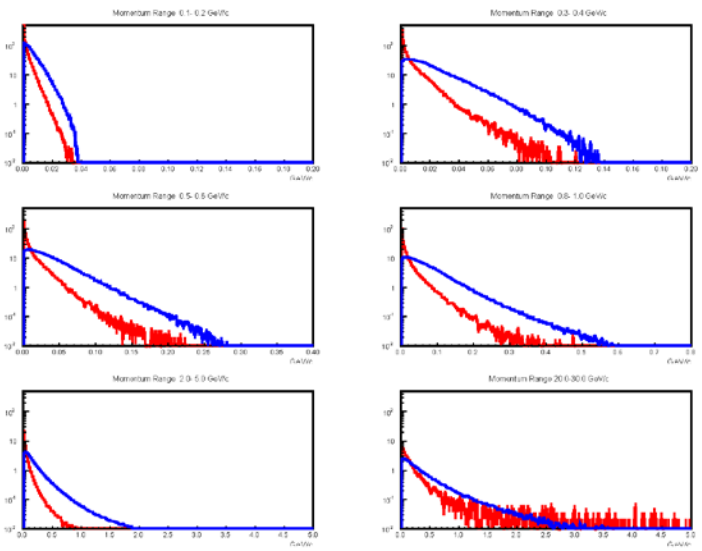
- We determine P(H) iteratively. Assume that all hypotheses are equally likely initially, i.e. P(H) = $\frac{1}{4}$ since there are 4 hypotheses (e/π/K/p). For each track, we then determine the posterior probability P(H|x) which is used to weight the track for each hypothesis.
- $$\sum_H P(H \mid x) = 1; \text{preserves unitarity}$$
- The resulting P(H) is used for the next iteration, till convergence.
- The aim is not to determine whether each particle is definitely one type or the other but to determine the maximum likelihood momentum functions for each hypothesis. Each particle enters all hypotheses plots with its appropriate hypothesis dependent weight.
- We treat MC and data as two separate experiments, each with slightly different behavior. We test the algorithm on the MC, since we know the answer. – (Movie)

Electron Pion separation- Pt^2 discriminant

- Electrons and pions are difficult to separate since they are for most part beta~1 particles. However, electrons (and positrons) for the most part result from the conversion of photons which are the result of π^0 decay. So electrons from this source will have on average $\frac{1}{4}$ pt of the pion. Majority of electrons from this source.

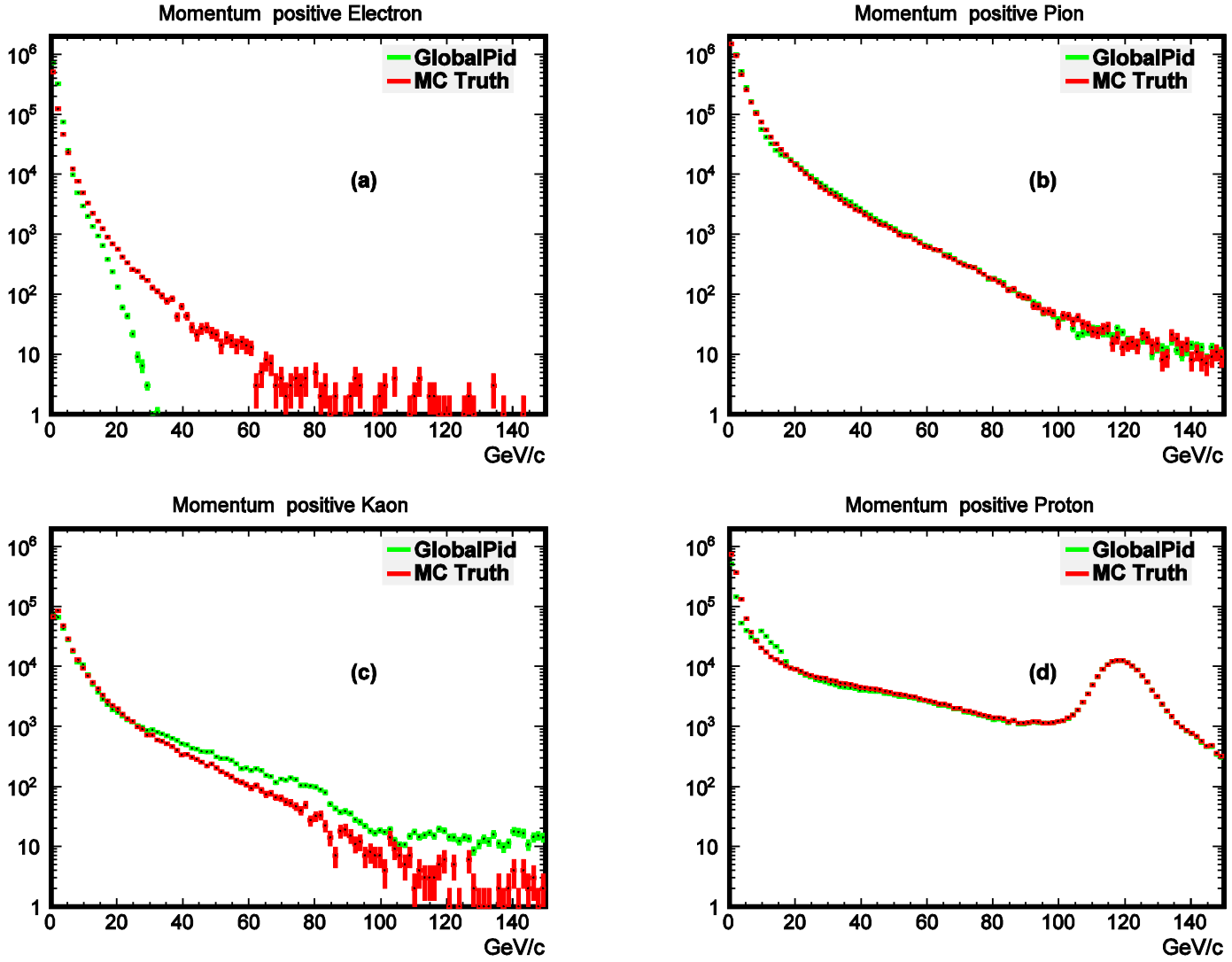


MIPP data RICH electrons (red) pions (blue)

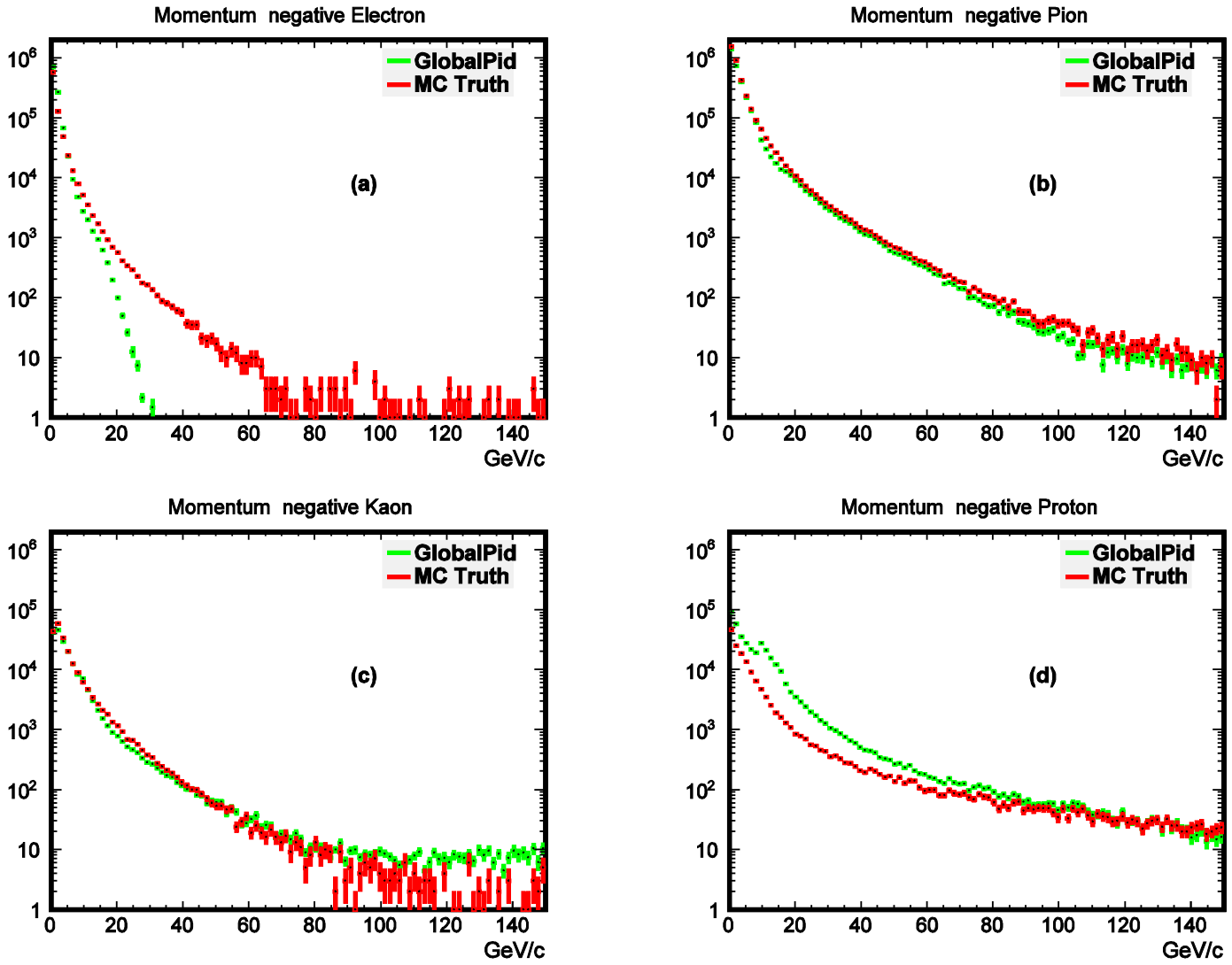


NuMI target Monte Carlo for various momentum ranges

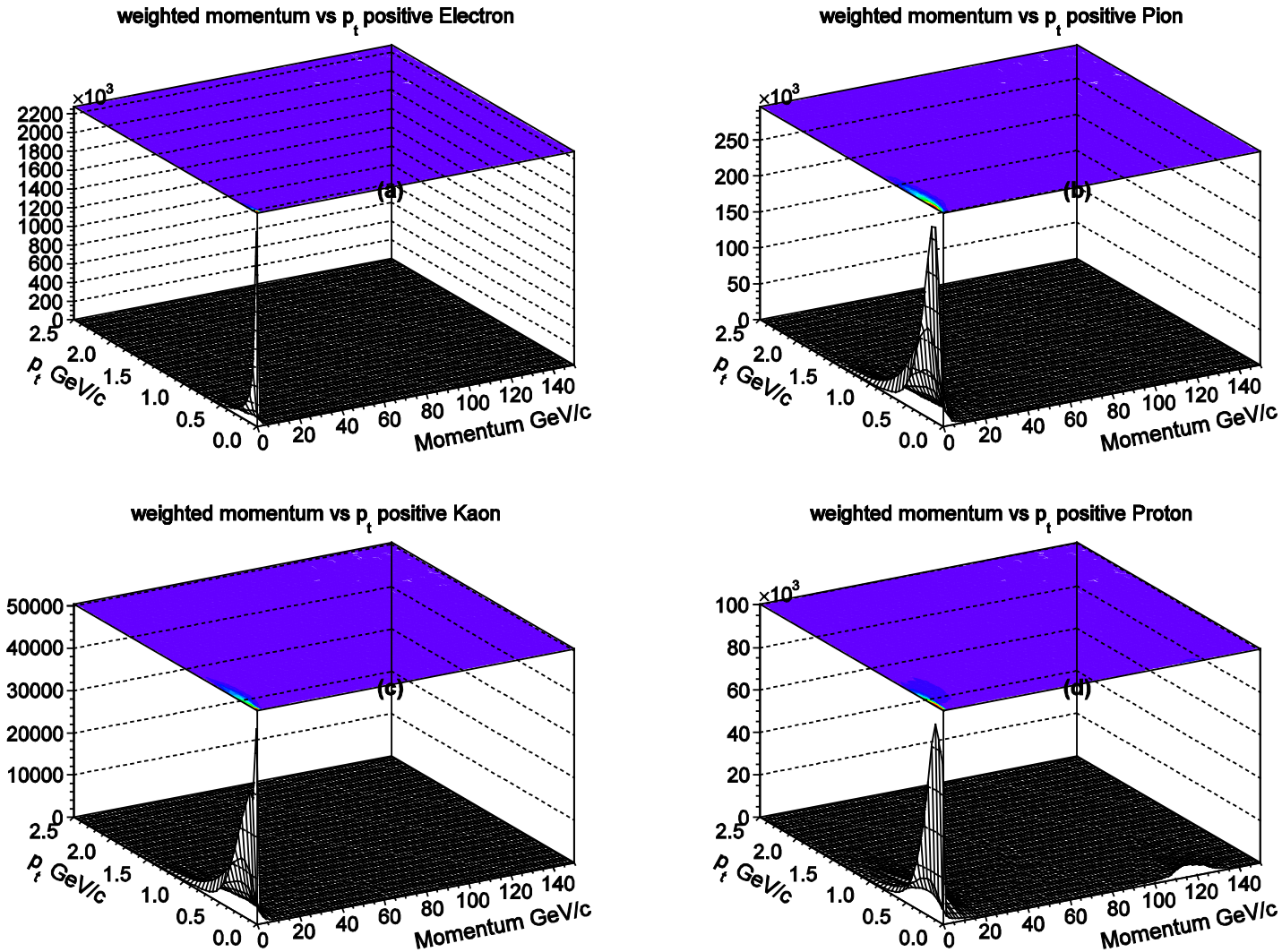
Green GlobalPid. Red MCTRUTH 15 iterations Positive charges



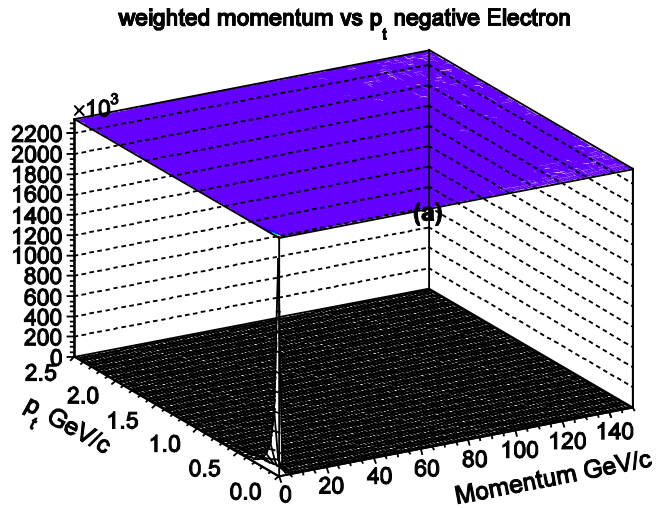
Green GlobalPid. Red MCTRUTH 15 iterations Negative charges

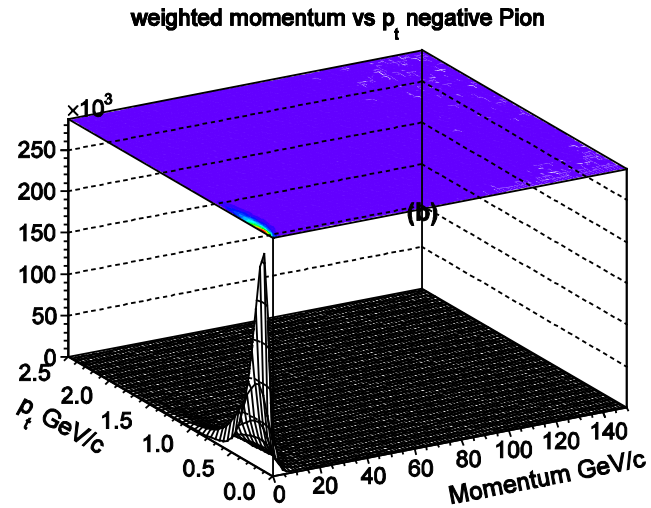


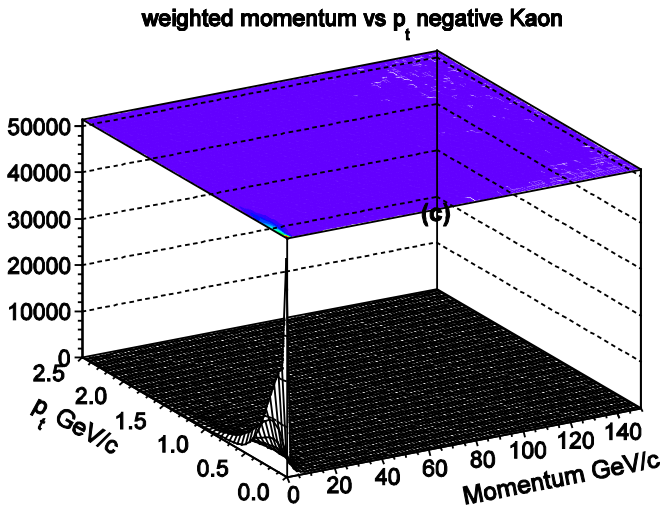
Data p vs pt positives

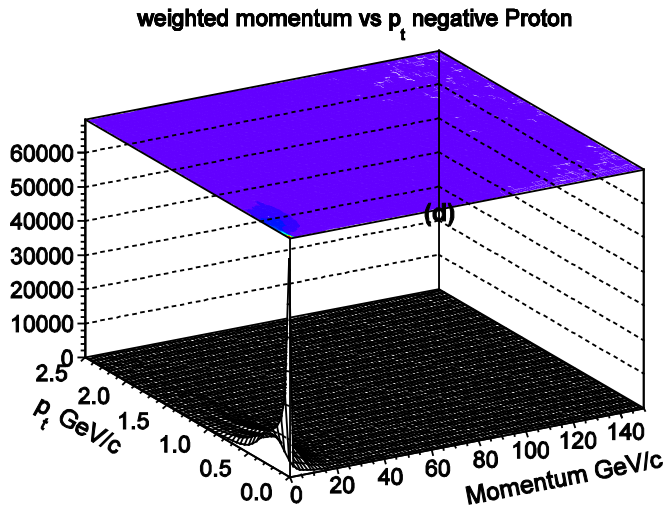


Data p vs pt negatives

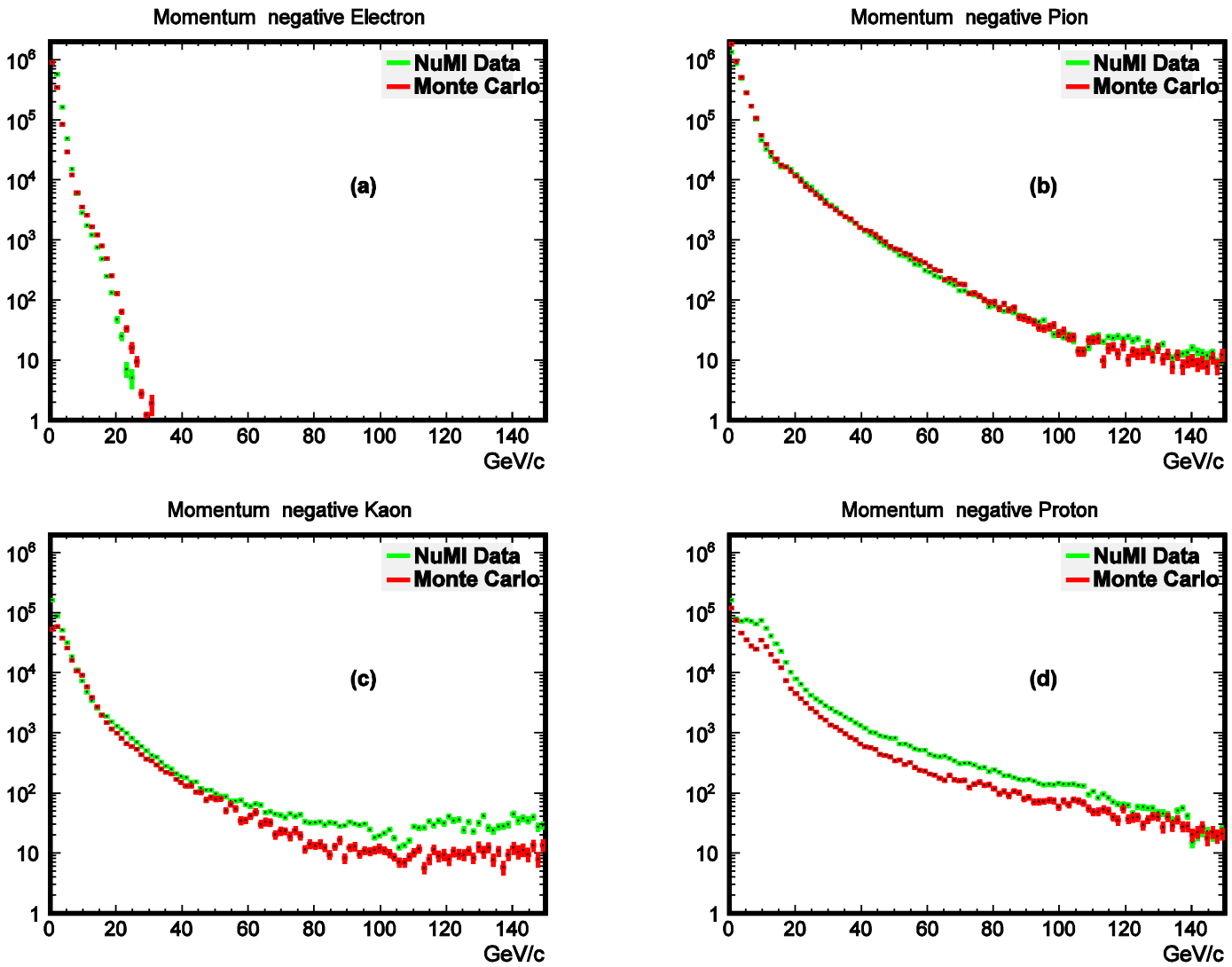




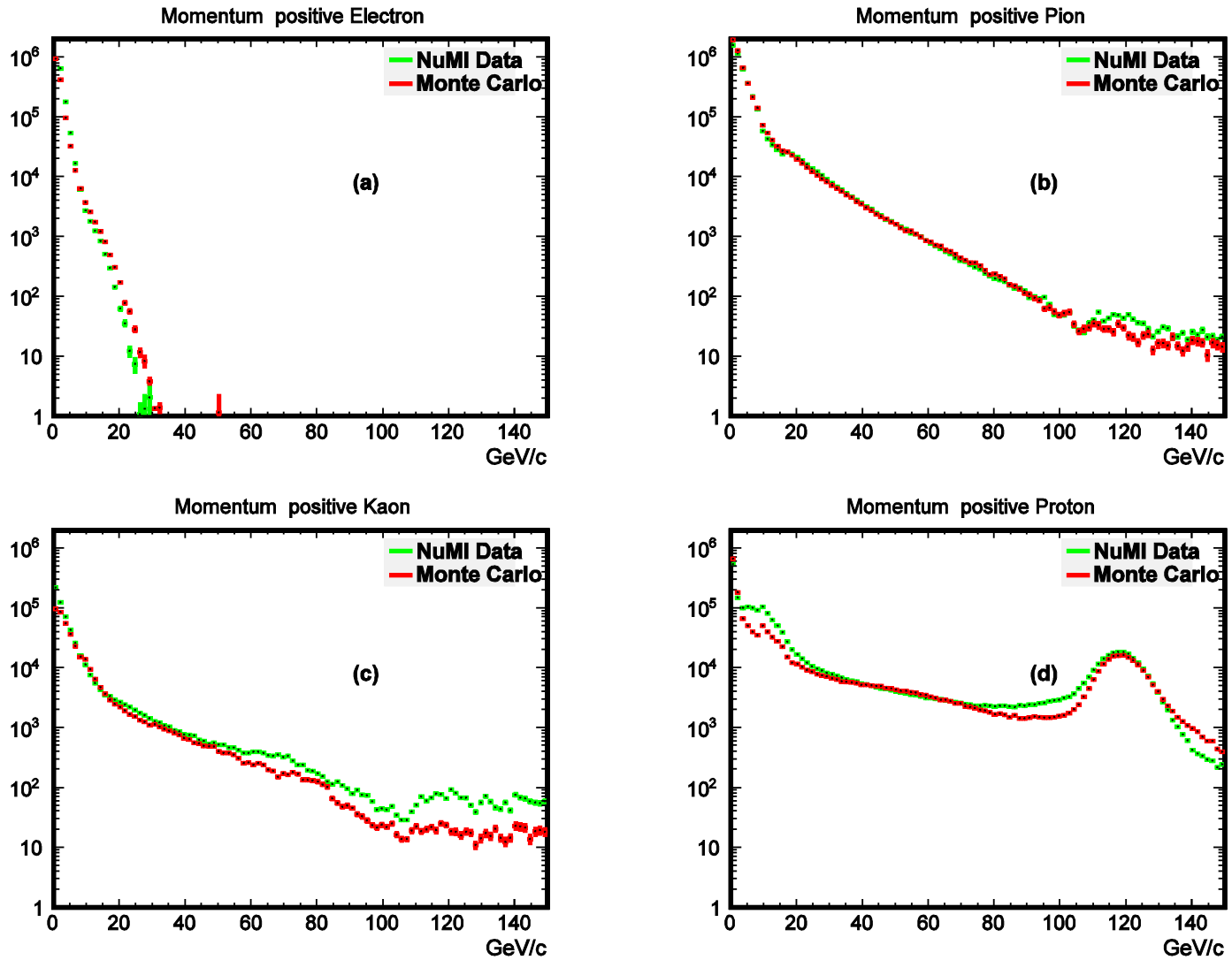




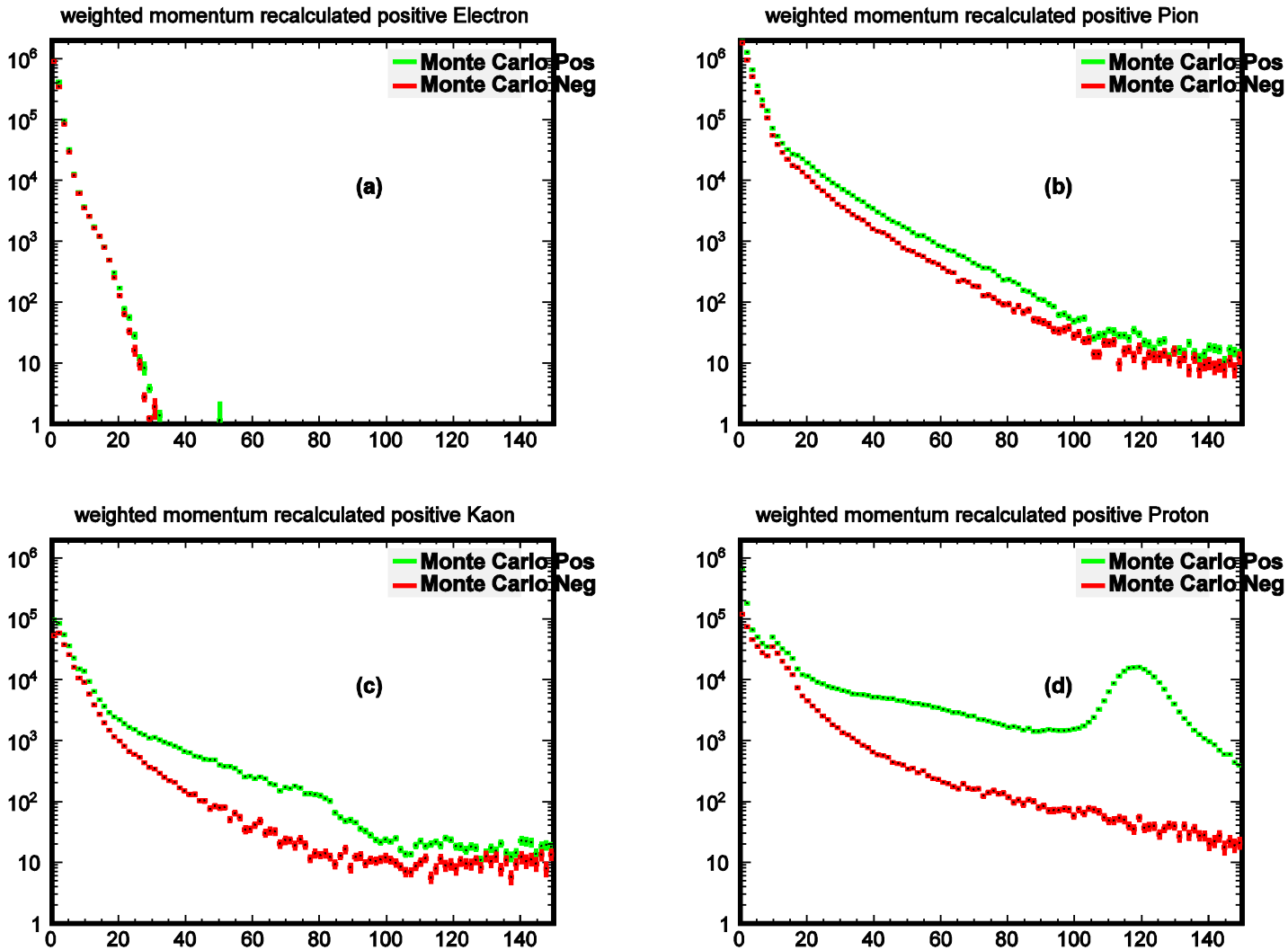
Comparison of Data and MC for negatives



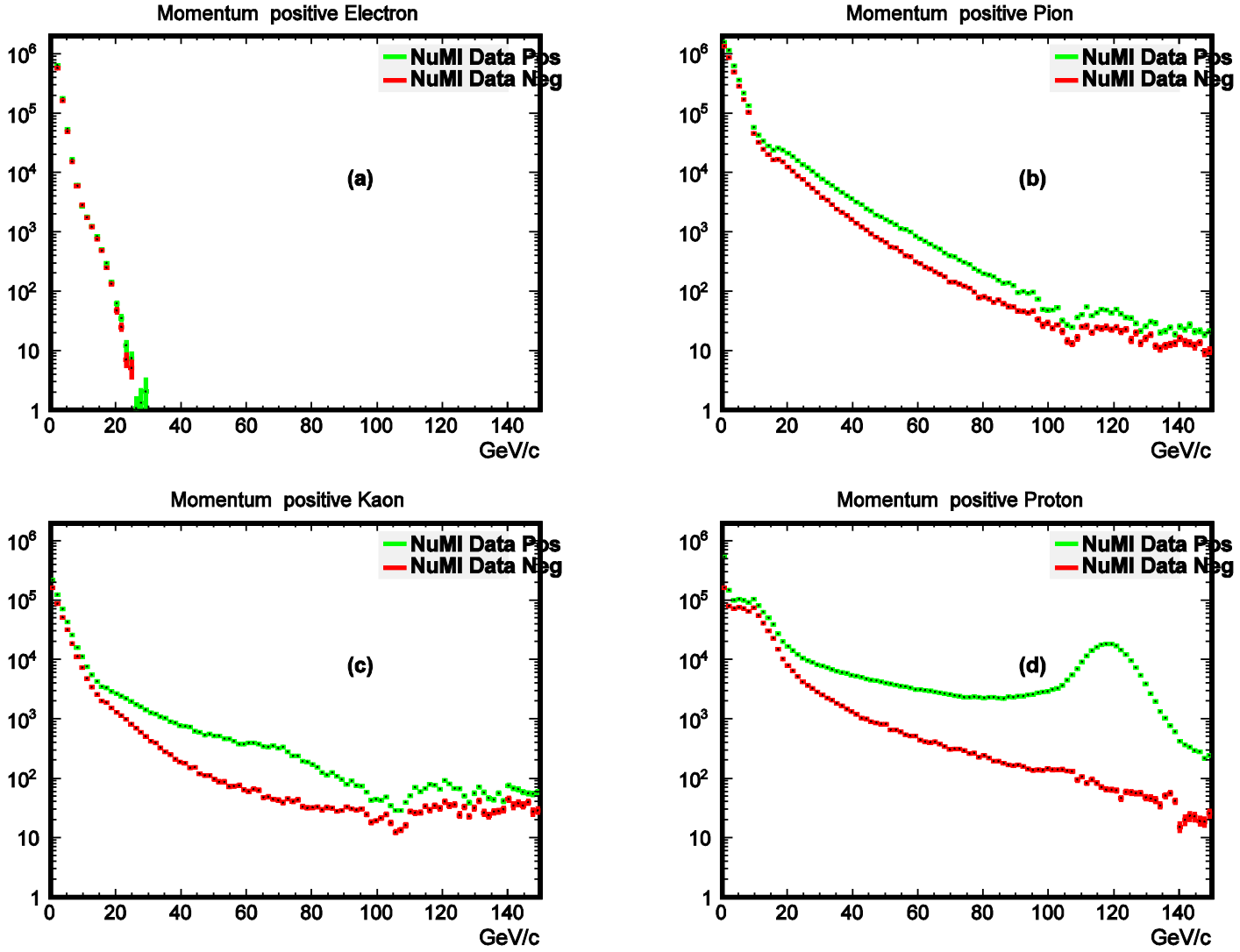
Comparison of Data and MC for Positives



Comparison of Monte Carlo Positive and negative spectra



Comparison of Data Positive and negative spectra



Work left to do

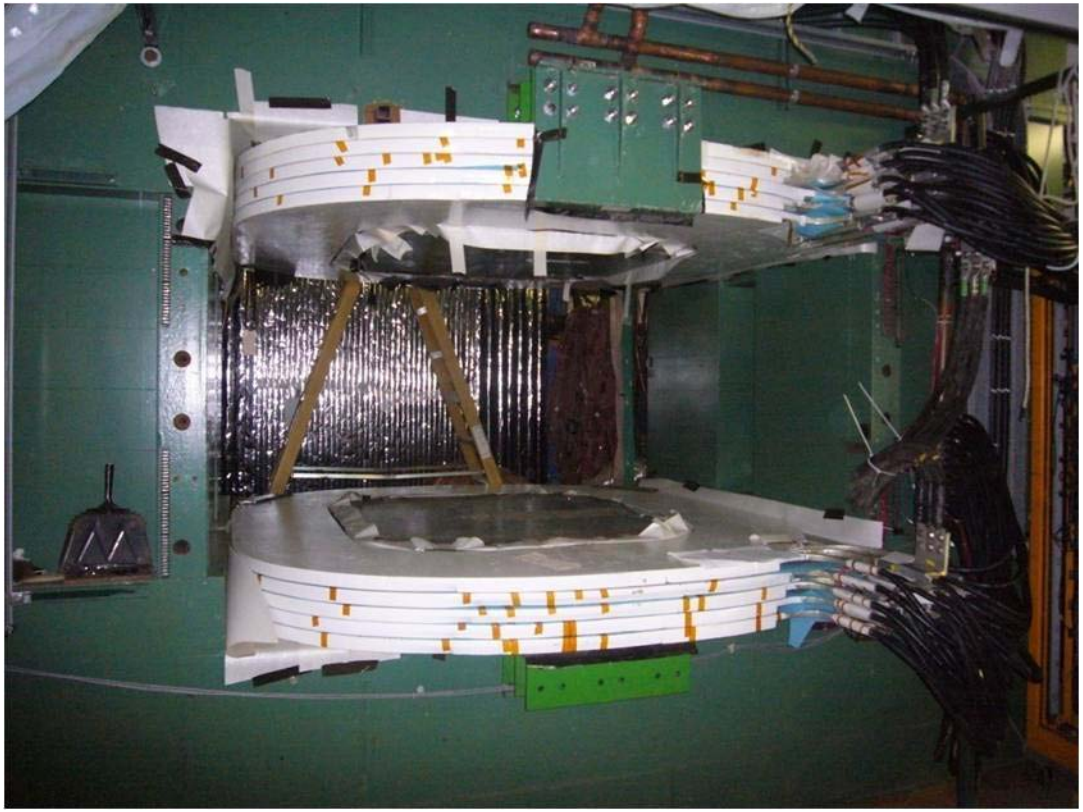
- Acceptance Corrections
- Tweaking CKOV response
- Systematic errors
- Should have a paper out in ~ 2months.

Comparison MIPP Upgrade/ NA61 (Shine)

MIPP Upgrade	NA61-Shine
• DAQ rate- 3000 Hz	• 70Hz
• Beams 6 species 1-120 GeV/c	• 2 species- protons, π^+ mostly 158 GeV/c- Does not cover resonance region. Heavy ion beams
• Tagged neutral beams (n, Klong, nbar)	• Not enough data rate for tagged neutral beams.
• Plastic ball recoil detector. Covers backward hemisphere in lab.	• No such detector

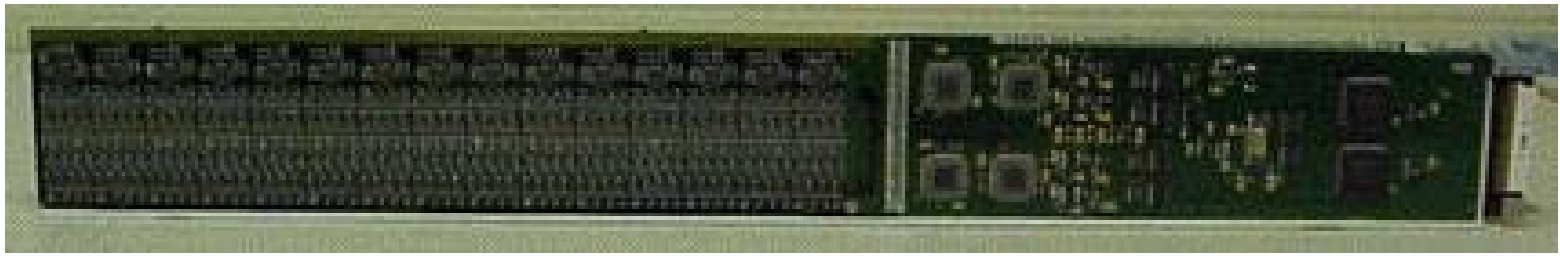
Details of the proposal

New Jolly Green Giant Coils installed.
Aluminum, longer along beam direction.
Less E x B effects



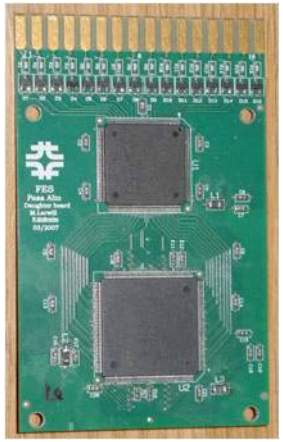
TPC boards- Not to scale

Old Stick



New Stick

Single Altro/Pasa unit

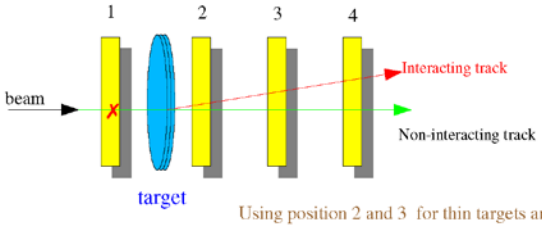


Buffer Board

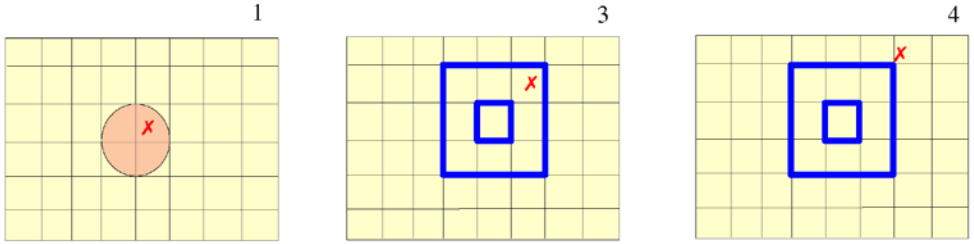
MIPP Upgrade Silicon Pixel trigger

- Beam sizes are large in MIPP due to the "low divergence" condition needed for beam CKOV's.
- Previous trigger of SCINT counter performed satisfactorily for MIPP -I physics but needs improvement at low multiplicities—Landau tails.
- We propose to use silicon pixel counters (developed for B-TEV).
- Use a "Bull's Eye" system to detect absence of beam particle in final state to signal interactions. Also use the multiplicity in the final state as an additional piece of information.

fPix Silicon Detector of 3 planes of 48 fPix 2.1 chips

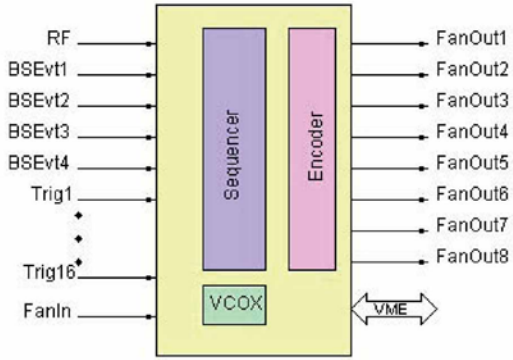


Using position 2 and 3 for thin targets and position 3 and 4 for the thicker cryo targets.



First layer before target tags where beam is and that there was only 1 hit cell. Brown circle represents where 86% of the beam hits the 4 cells in the center.

A bulls eye target, shown in blue, is made around the one cell hit location of plane1.



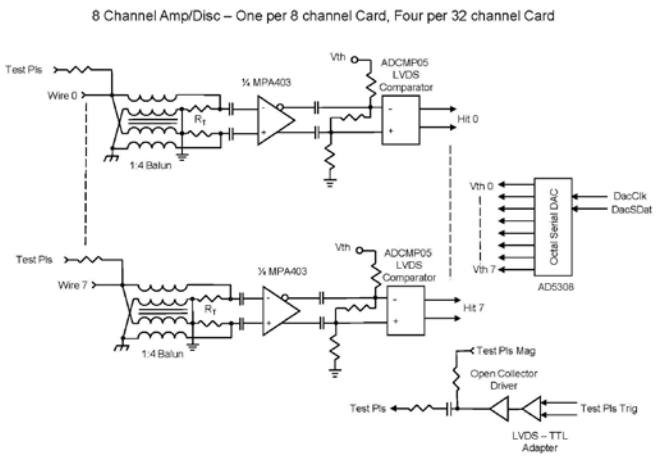
Trigger module block diagram

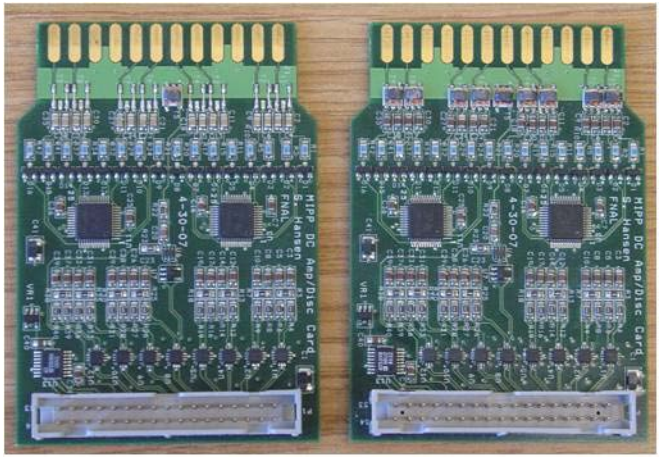
MIPP Trigger Upgrade Details

- Each silicon layer consists of an array of 6x8 fPix chips. The pixels on each chip are 400μmx50μm with finer segmentation in y.
- Permits Bull's Eye implementation with a fat beam.
- 80% of beam will hit 4 chips upstream of the target.
- Additionally, the pixel information will aid in track and vertex reconstruction.
- Trigger readout and trigger board needs to be designed. Trigger logic programmed on FPGA.

Drift Chamber/ PWC readout Upgrade

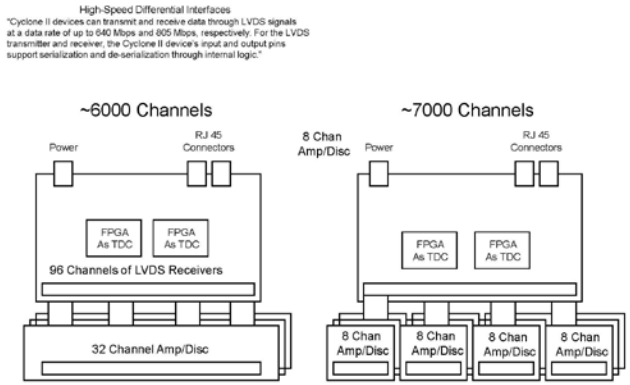
- Large PWC's use old CERN RMH electronics- Needs replacement.
- MIPP proposes a unified scheme for reading out both sets of chambers using a system that modifies the MIPP RICH readout cards by changing the latch to a TDC.
- Preamp cards being replaced Preamp/Discriminator front end cards.
- The RICH cards will store an entire spill's worth of events, which are readout in between spills.

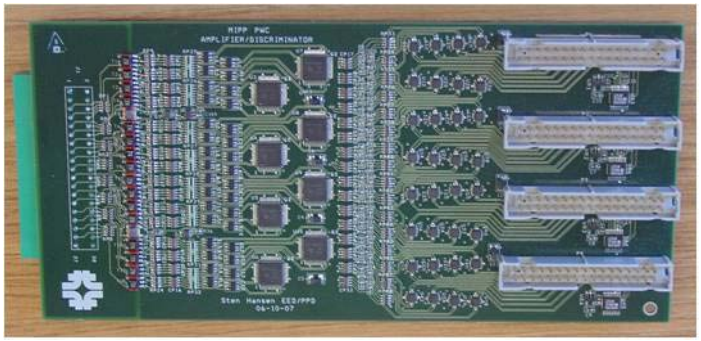




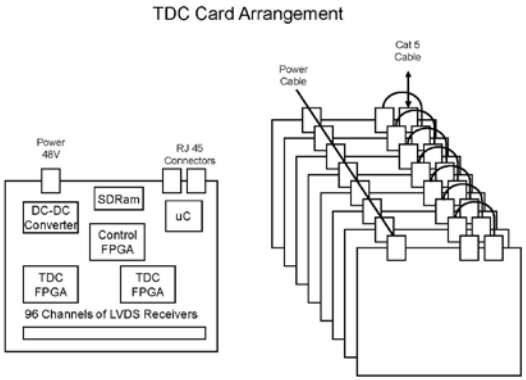
8 Channel amplifier card

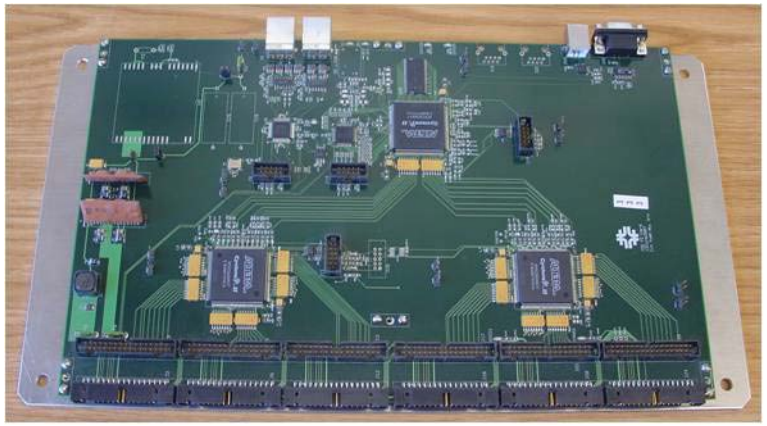
Chamber Card prototypes





32 channel amplifier card





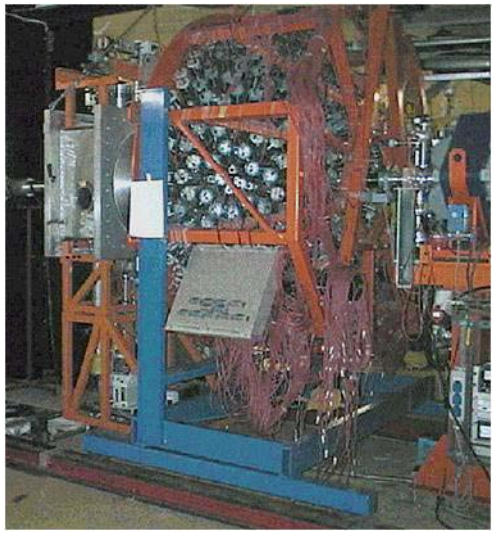
96 channel TDC card

TOF & CKOV readouts

- 106 TOF + 12 T0 +96 Ckov channels
- Plan to use the back end provided by MIPP readout controller.
- Front end likely to be TriP-T chip (also used by MINERvA(ADC)) and a high resolution TDC chip (TDC-GPX from ACAM 30ps resolution). Will buffer an entire spill. Delay cables will be eliminated.

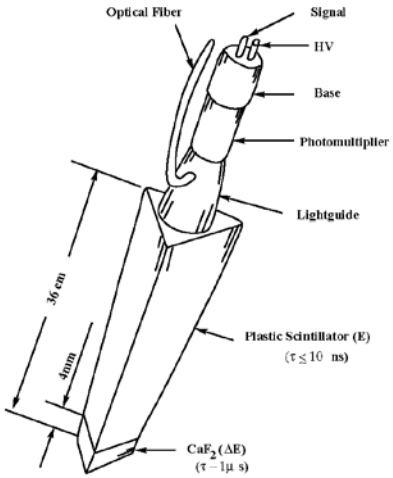
Plastic Ball Recoil detector

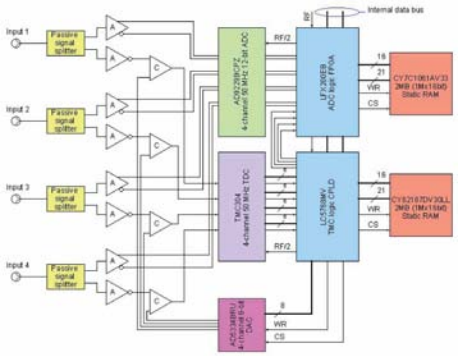
- Plastic ball detector is available. GSI/KVI have joined MIPP. We will install a hemisphere in MIPP. Mounting details to be worked out. Need the ability to remove the detector to repair it and the TPC.
- Transportation to Fermilab.
- GSI/KVI will play a lead role in making this happen
- Detector will help in all aspects of MIPP data including tagged neutral beams, missing baryon resonances and hadronic shower simulation data.



Picture of the full plastic ball at KVI

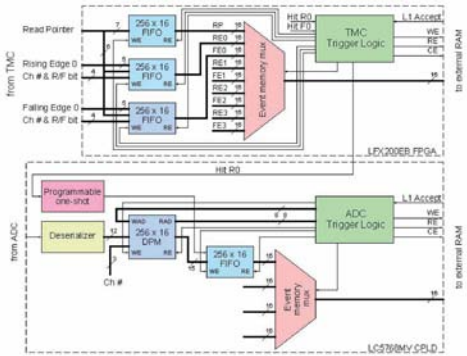
Plastic ball readout



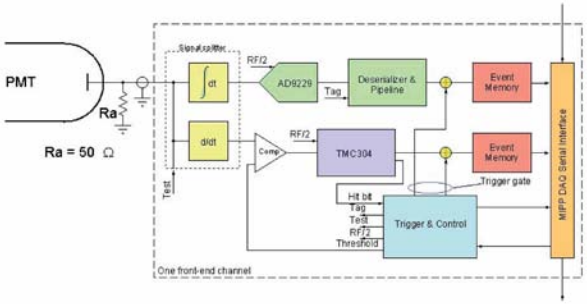


4 channels

Plastic ball front end board

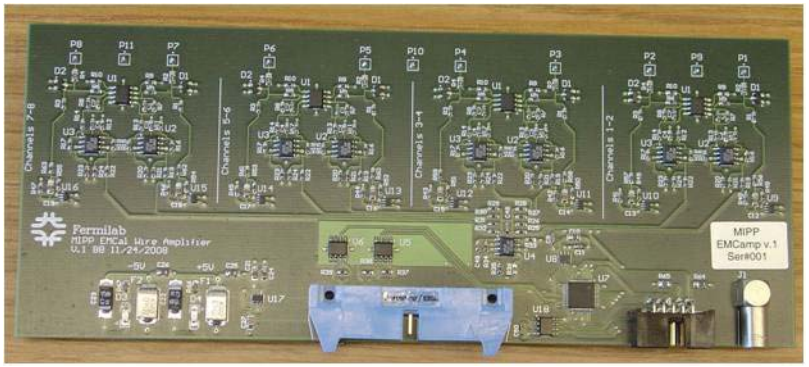


Plastic ball trigger logic

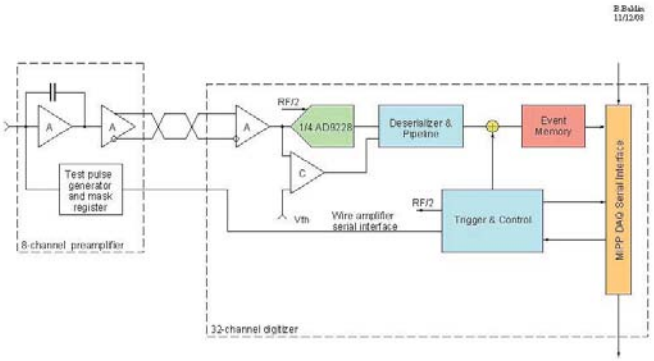


Plastic ball front end board schematic

EM Calorimeter wire amplifier board



EM cal front end 8 channel wire amplifier board



Block diagram of EM cal front end 8 channel wire amplifier board

EM cal front end board

HCAL has currently 8 PMT/ADC channels. We plan to adapt a plastic ball readout module for this.

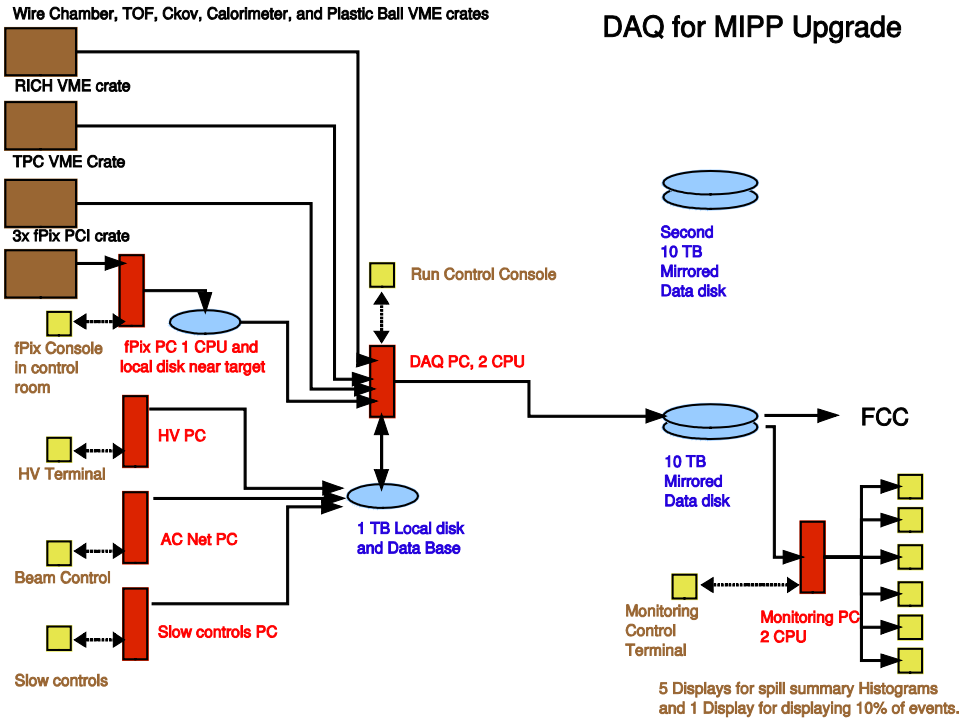
Beamline upgrade

- Add 9 low current power supplies and 2 Hall probes in each magnet to facilitate low momentum running. Return to the same magnetic field each time since hysteresis effects can be significant at low currents.

  WBS task 8 M&S $156K (Power supply cost added)

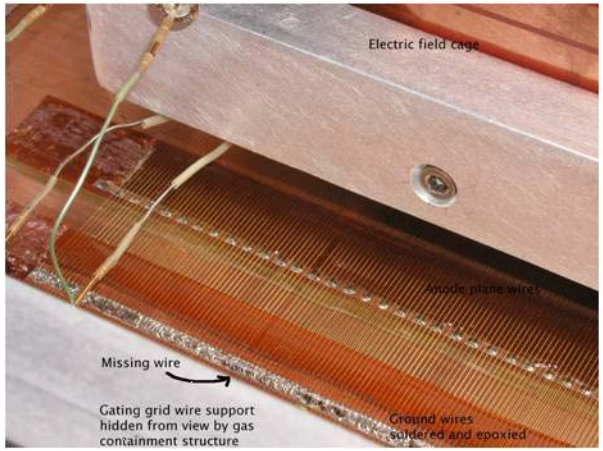
MIPP DAQ System upgrade

- Most of the DAQ upper layer software (Run control, Book keeping, plots) can be kept as is.
- New Power PC 5500's replace 6 existing ones.
- Linux kernel to migrate to it.(10 person weeks)
- Update Event builder(6 weeks)
- Modify DAQ for new TPC(12 weeks),chambers(4wks),CKOV,TOF, Cal(4 weeks)
- Modify event monitor(2 weeks)
- New fPix readout PC, DAQ PC with 1TB disk storage. All PC's will have GBit and 100MBit fast Ethernet ports.
- 100 Kbytes/event. 1.2 GB of data per spill.
- 200Mbits/sec transfer from MC7 to Ptkmp.
- 6 Mbytes/second transfer rate into ENSTORE is needed to transfer 5 million events/day. CDF/D0 do 30-60 Mbytes/sec routinely.



Miscellaneous upgrades

- Beam Veto wall upgrade- Increase veto counter area
  - » Veto Counter fabricated
- Cryogenic target upgrade
  - » Increase diameter of transfer pipe to cut interactions due to beam tails.
  - » Spare cryo-cooler
  - » Operate with Liquid N2 flask.
- Gas system and slow control upgrades
  - » Methylal refrigerator filling to be automated
  - » Automate RICH vessel topping up with CO_2
  - » Upgrade P10 gas system-to be supplied semi trailer rather than bottles.
  - » Upgrade Beam CKOV vacuum instrumentation (failure detection)
  - » More temperature probes in hall.
  - » CKOV gas purification system upgrade. CKOV pressure sensors to be replaced
  - » Additional slow control infra-structure – APACS system
- RICH and CKOV phototubes
  - » 7 CKOV PMT's need replacement (total 96)
  - » 912 PMT's in RICH were lost due to fire. RICH works without them. But upgrading it by more PMT's will help with efficiency near threshold.



TPC rewind needed to get rid of dead wires.

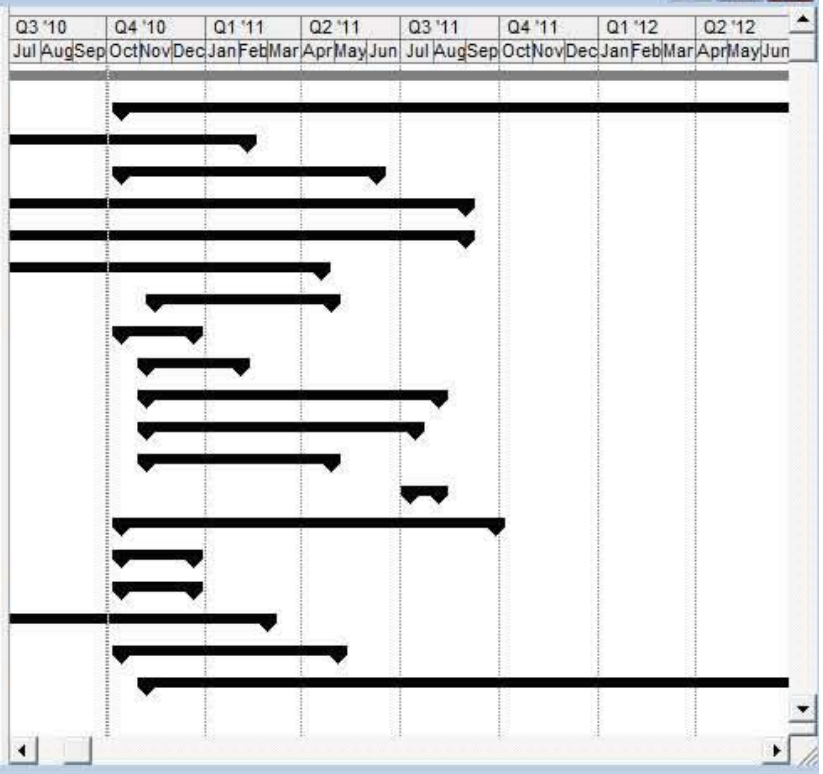
MIPP Upgrade Cost estimate

WBS	Task Name	Fermilab M&S Cost	Fermilab Labor Cost	Total Project Cost	Remaining Cost
0	MIPP	$2,788,830	$615,568	$3,477,158	$3,049,241
1	Project Management	$55,000	$0	$55,000	$55,000
2	Jolly Green Giant Repair	$288,500	$132,384	$438,644	$108,500
2.1	Jolly Green Giant disassembly/assembly	$80,000	$94,380	$192,140	$103,700
2.2	JGG coil design and fabrication	$199,000	$25,524	$224,524	$0
2.3	Ziptrack JGG magnet	$9,500	$12,480	$21,980	$4,800
3	Improvements on detector hardware	$290,600	$114,554	$405,154	$404,767
3.1	Gas System and Slow Controls Upgrade	$51,500	$35,308	$86,808	$86,421
3.1.1	RICH vessel fill automation	$2,500	$5,610	$8,110	$7,981
3.1.2	Methylal bath fill automation	$5,000	$7,228	$12,228	$12,056
3.1.3	P10 supply upgrade	$5,000	$6,664	$11,664	$11,578
3.1.4	TOF wall thermal instrumentation	$2,000	$4,232	$6,232	$6,232
3.1.5	Replacement of CKOV pressure sensors	$2,000	$412	$2,412	$2,412
3.1.6	Ckov gas purification system	$11,000	$5,440	$16,440	$16,440
3.1.7	Beam Ckov vacuum system	$3,000	$1,340	$4,340	$4,340
3.1.8	Calibration and maintenance	$0	$2,952	$2,952	$2,952
3.1.9	Slow Controls infrastructure upgrade	$21,000	$1,430	$22,430	$22,430
3.2	Cryogenic System Upgrade	$68,000	$75,598	$143,598	$143,598
3.2.1	Hydrogen Target transfer line	$13,000	$38,120	$51,120	$51,120
3.2.2	Nitrogen Target	$10,000	$23,260	$33,260	$33,260
3.2.3	Spare Cryocooler	$45,000	$14,218	$59,218	$59,218
3.3	TPC rewind	$10,000	$0	$10,000	$10,000
3.4	Chamber wire repairs	$1,100	$3,648	$4,748	$4,748
3.5	Ckov Photomultiplier tubes	$10,000	$0	$10,000	$10,000
3.6	RICH Photomultiplier tubes	$150,000	$0	$150,000	$150,000
4	Detector Readout Upgrades	$399,920	$240,918	$648,513	$520,002
4.1	TPC Electronics	$225,920	$150,847	$384,442	$273,028
4.2	Drift Chamber/Wire Chamber electronics	$121,250	$28,718	$149,968	$136,219
4.3	ToF + CKOV electronics board design	$15,750	$18,352	$34,102	$34,102
4.4	Calorimeter electronics	$17,000	$1,720	$18,720	$15,372
4.5	large pixel array upstream of TPC	$20,000	$41,280	$61,280	$61,280
5	Trigger System Upgrade	$145,900	$51,400	$208,300	$197,300
5.1	Interaction Trigger Fpix	$137,100	$38,800	$186,900	$175,900
5.2	Interaction Trigger Board	$8,800	$12,600	$21,400	$21,400
5.3	Other Trigger Upgrades	$0	$0	$0	$0
6	DAQ Software and Hardware Upgrade	$32,800	$38,952	$71,752	$71,752
7	Offline farm Upgrade	$0	$0	$0	$0
8	Beam Line Upgrade	$56,000	$0	$56,000	$156,000
9	Enhanced Veto Wall	$20,110	$1,440	$21,550	$0
10	Recoil Detector	$0	$35,920	$90,920	$35,920
11	Visitor Support for collaborators	$1,500,000	$0	$1,500,000	$1,500,000

Schedule

MIPP-II-Project-Oct2010

WBS	Name	Duration	Start	Finish
0	MIPP	429.2 wks?	Thu 7/13/06	Thu 10/2/14
1	Project Management	206.2 wks	Fri 10/15/10	Thu 10/2/14
2	Jolly Green Giant Repair	229.8 wks	Thu 7/13/06	Tue 2/8/11
3	Improvements on detector hardware	33 wks	Fri 10/15/10	Wed 6/8/11
4	Detector Readout Upgrades	253.4 wks?	Mon 8/21/06	Tue 8/30/11
4.1	TPC Electronics	253.4 wks	Mon 8/21/06	Tue 8/30/11
4.2	Drift Chamber/Wire Chamber electron	198.8 wks	Mon 5/7/07	Mon 4/18/11
4.3	ToF + CKOV electronics board design	22.6 wks	Tue 11/16/10	Wed 4/27/11
4.4	Calorimeter migration to common bac	9 wks	Fri 10/15/10	Mon 12/20/10
4.5	large pixel array between plastic ball a	12.8 wks?	Mon 11/8/10	Thu 2/3/11
5	Trigger System Upgrade	38.2 wks	Mon 11/8/10	Fri 8/5/11
5.1	Interaction Trigger Fpix	35.2 wks	Mon 11/8/10	Fri 7/15/11
5.2	Interaction Trigger Board	24.8 wks	Mon 11/8/10	Thu 4/28/11
5.3	Other Trigger Upgrades	4 wks	Mon 7/11/11	Fri 8/5/11
6	DAQ Software and Hardware Upgrade	48.8 wks	Fri 10/15/10	Tue 9/27/11
7	Offline farm Upgrade	9 wks	Fri 10/15/10	Mon 12/20/10
8	Beam Line Upgrade	9 wks	Fri 10/15/10	Mon 12/20/10
9	Enhanced Veto Wall	196.8 wks	Mon 4/2/07	Mon 2/28/11
10	Recoil Detector	28 wks	Fri 10/15/10	Wed 5/4/11
11	Visitor Support for Russian, Indian, other	203.6 wks	Mon 11/8/10	Wed 10/1/14



Run Plan

Phase 1 Run Plan			
Target	Number of Events (Millions)	Running Time (Days)	Physics Need Group
NuMI Low Energy target	10	2	MINOS MINERVA
NuMI Medium Energy Target	10	2	MINERVA NOVA
Liquid Hydrogen	20	4	QCD PANDA DUBNA
Liquid Nitrogen	10	2	ICE CUBE
12 Nuclei			Nuclear Physics
D2 Be C Al Si Hg Fe Ni Cu Zn W Pb	60	12	Hadronic Showers
Total Events	110	22	
Raw Storage	11 TBytes		
Processed Storage	55 TBytes		

Phase 2 Run Plan			
Target	Number of Events (Millions)	Running Time (Days)	Physics Need Group
18 Nuclei			
Li B O2 Mg P S Ar K Ca			Nuclear Physics
Ni Nb Ag Sn Pt Au Pb Bi U	90	18	Hadronic Showers
10 Nuclei B-list			Nuclear Physics
Na Ti V Cr Mn Mo I Cd Cs Ba	50	10	Hadronic Showers
Total Events	140	28	
Raw Storage	14 TBytes		
Processed Storage	70 TBytes		

Phase 3 – Tagged Neutral beams for calorimeter PFA studies 5 million events/day LH2 target

Missing baryon resonance search may request additional running depending on what is found.

Conclusions

- MIPP has proposed a low cost upgrade to the apparatus that will permit high quality, high statistics data on hadronic production to be acquired in a timely fashion.
- Data thus acquired needed by a variety of clientele
- More groups will join the effort once it is approved
- The entire monitoring/reconstruction/analysis package of MIPP-I will go over into MIPP-II. Plastic Ball analysis has to be written.

Backup slides

Why MIPP results have been delayed

- Significant analysis hurdles had to be overcome. MIPP has had to correct large E X B effects in the TPC, temperature and cross talk effects in the ToF, Calibrate the Ckov in presence of lower than expected light yield.
- Lack of support by the DoE who decided not to issue MIPP Universities with any postdoc or graduate student explicit support. Participating Universities had to use existing funds to work on MIPP
- DOE explicitly prevented U Virginia from continuing on MIPP. The MIPP group had to join D0 to get funds!
- Livermore had to drop out of MIPP because of the stoppage of stockpile stewardship funding.
- Situation considerably improved after Pier returned from India in 2009 with a promise to put 6 Indian students on MIPP and MIPP upgrade. Fermilab G&V help provided funding for U of Michigan personnel as well. Many thanks for this.