An Experimental Program for demonstrating precision jet energy measurement at the ILC

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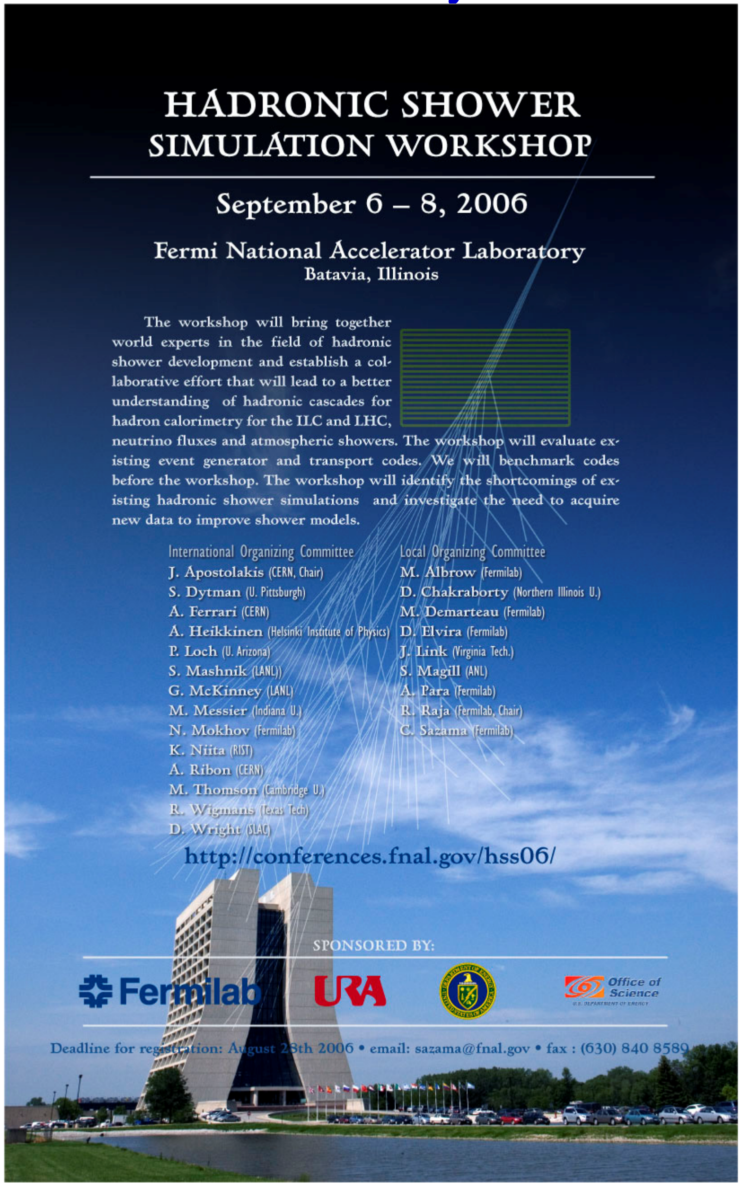
- Contents described in white paper arxiv:0709.0927
- Describe the present state of Hadronic Shower Simulators—HSSW06
- Motivate a two pronged approach
  - » Thin target cross section measurements to improve simulators
  - » Test beam program for calorimeters
- Possibilities for getting excellent thin target data—MIPP Upgrade
- Tagged neutral beams
  - » Why np cross sections cannot be deduced via isospin arguments below ~ 20 GeV
  - » MIPP Upgrade and tagged neutral beams
- Compensation vs PFA
  - » Non-linearity and resolution issues for uncompensated calorimetry
  - » Case for longitudinal segmentation
  - » A compensated highly segmented approach to calorimetry using liquid argon TPC with plates that can also be used with PFA.
- Conclusions

Hadronic Shower Simulation Workshop HSSW06

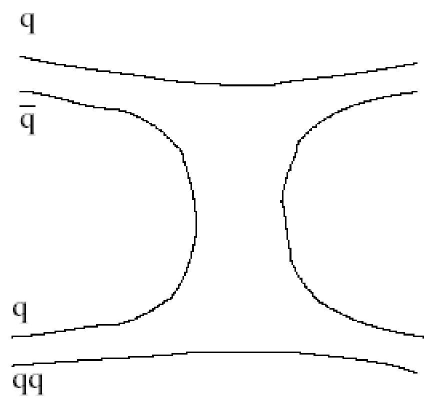
- Venue—Fermilab September 6-8, 2006
- Experts from GEANT4, FLUKA, MARS, MCNPX, and PHITS attended as well users from Neutrino, ILC, Atlas, CMS communities. Goal was to reduce systematics between various models and arrive at a suite of programs that can be relied on.
- Major conclusion—too many models-new particle production data on thin targets needed to improve models.



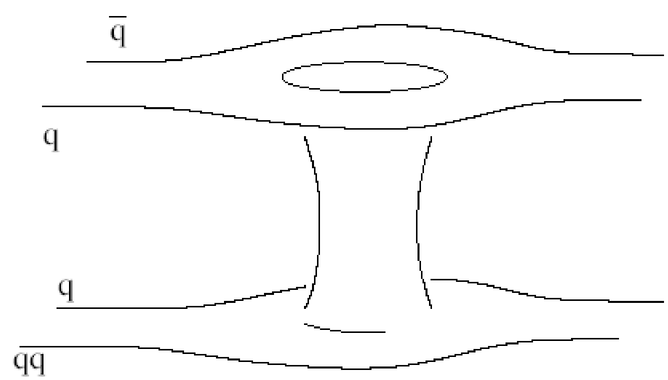
Describe a widely used model—

There exists no workable theory of the strong interaction in the non-perturbative regime. No cross section (elastic, diffractive, central) can be calculated from first principles. People resort to models with tunable parameters and arbtraty assumptions. To illustrate- let us review briefly DPMJET (Dual Parton Jet) concepts similar to QGSJET. Used in Fluka as well as by itself similar to QGSJET in Geant4.

Reggeon exchange. Can either be thought of as a sum of t channel exchanges or as a sum of s channel resonances- Hence Dual.

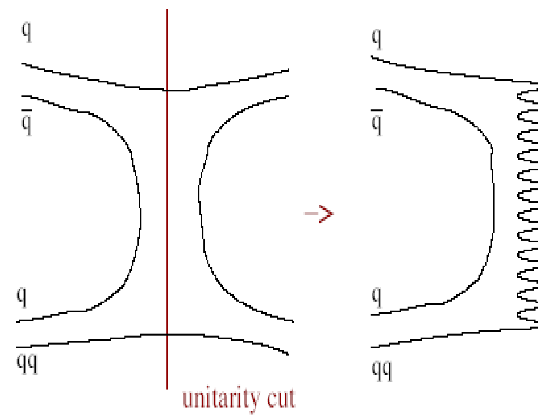


Pomeron exchange Does not depend on flavor of scattering particles.

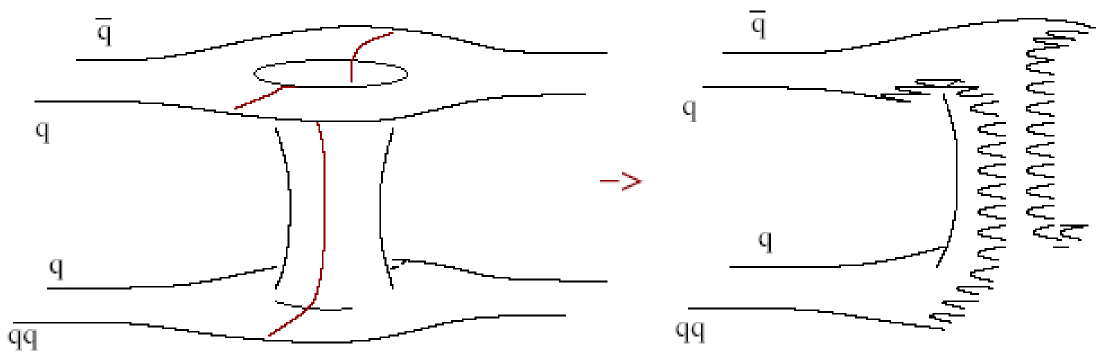


Dual Parton Model- Concepts-Optical theorem

Reggeon Exchange-Single string of hadrons

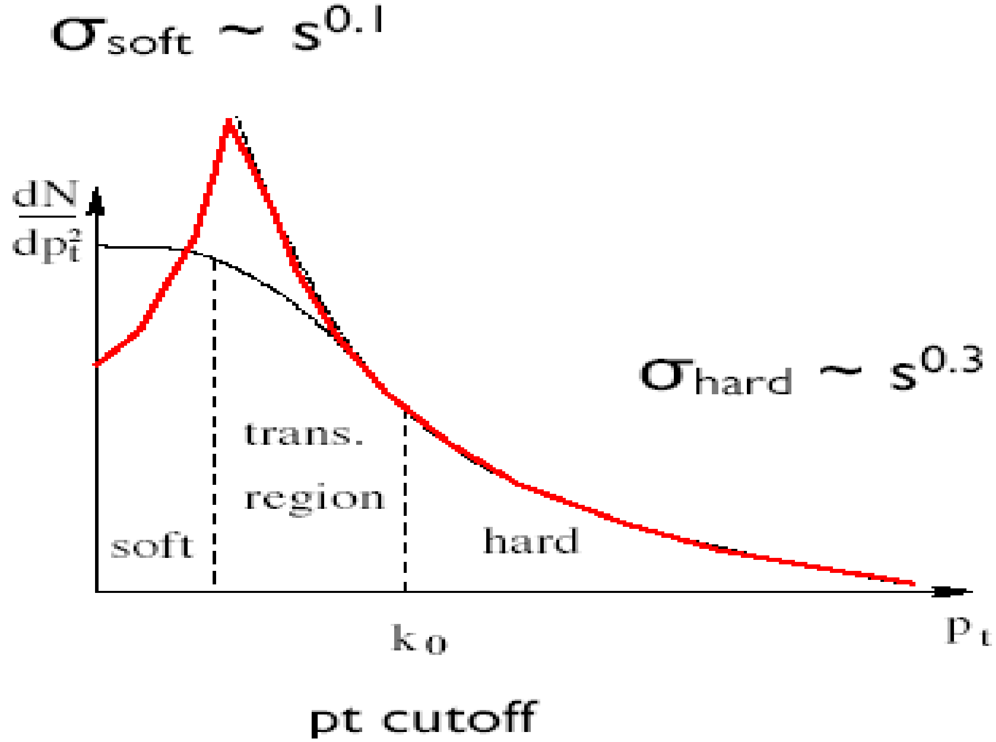


Pomeron Exchange-Two strings of hadrons



Conceptual problem- Matching soft and hard processes.

This is done by tuning the transition region carefully! And arbitrarily

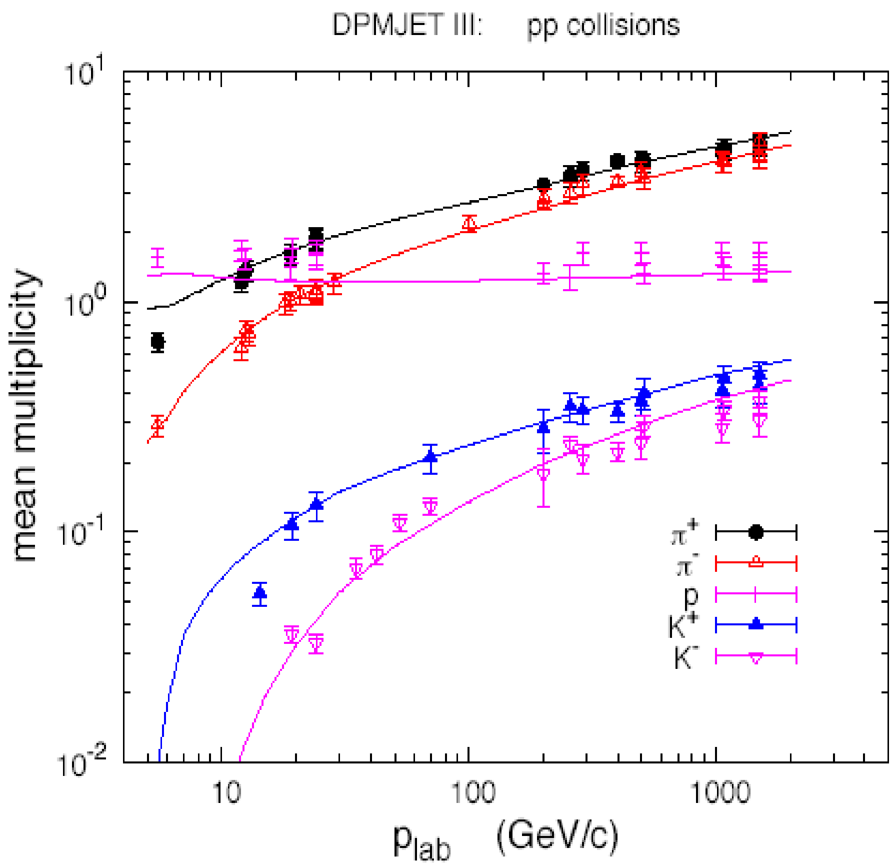


DPMJET-Multiplicities-Slides from R.Engel

DPMJET in p-p mode:
simulation of particle production from energy threshold on

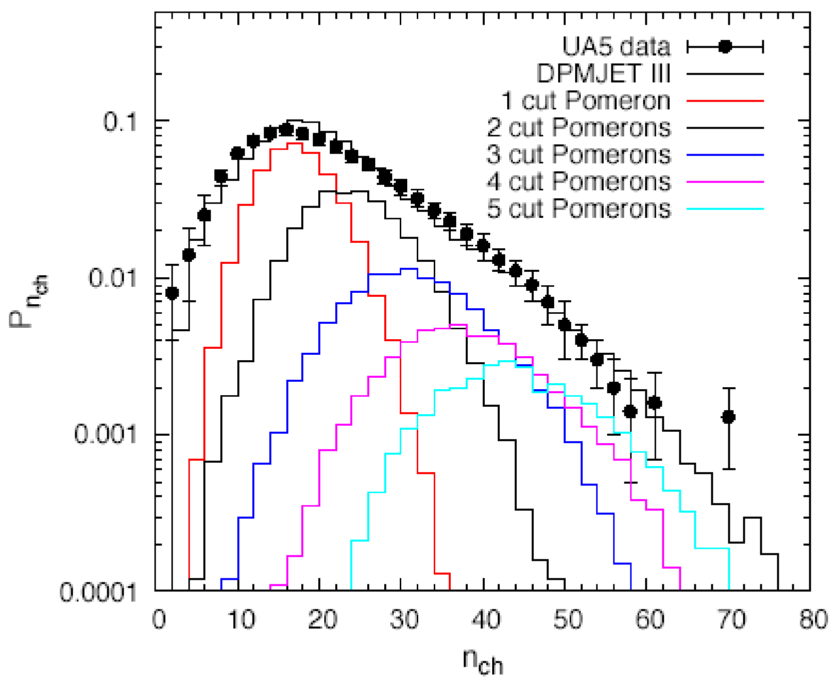
proton - proton, E_{lab} = 200GeV

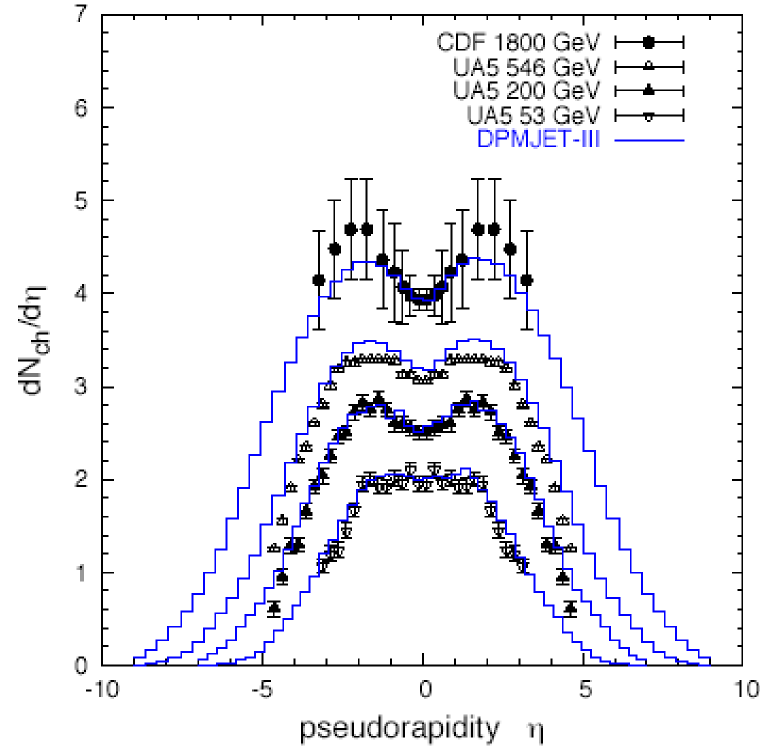
	Exp.	DPMJET-III
charged	7.69 ± 0.06	7.64
neg.	2.85 ± 0.03	2.82
p	1.34 ± 0.15	1.26
n	0.61 ± 0.30	0.66
π^+	3.22 ± 0.12	3.20
π^-	2.62 ± 0.06	2.55
K^+	0.28 ± 0.06	0.30
K^-	0.18 ± 0.05	0.20
Λ	0.096 ± 0.01	0.10
$\bar{\Lambda}$	0.0136 ± 0.004	0.0105



DPMJET- Collider distributions (R.Engel)

Charged particle multiplicity distribution at 200 GeV cms.





Charged particle pseudorapidity distributions

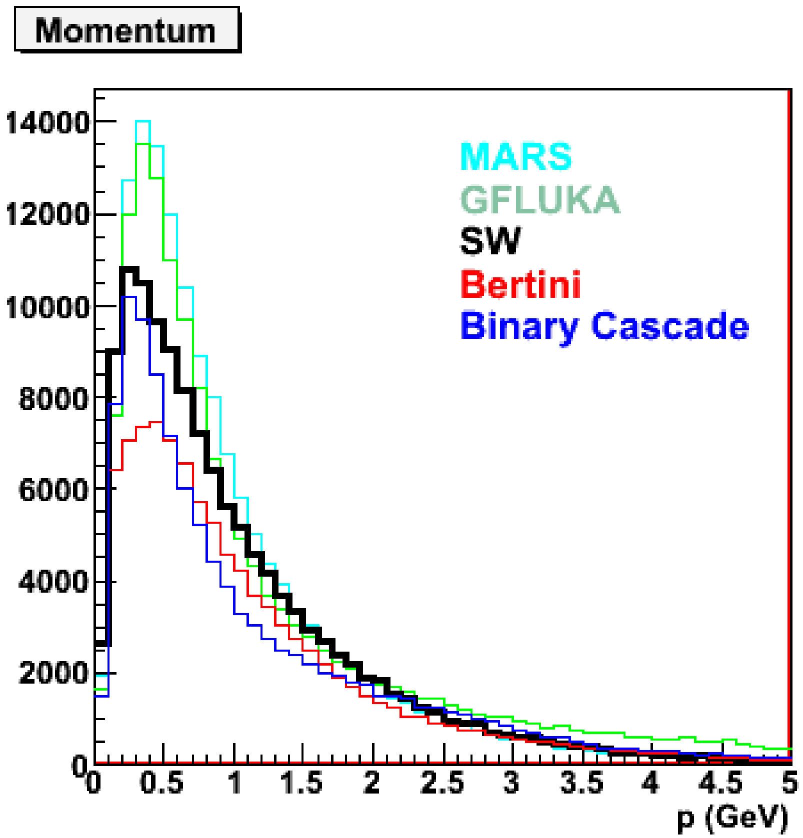
HSSW06 programs and models used by them

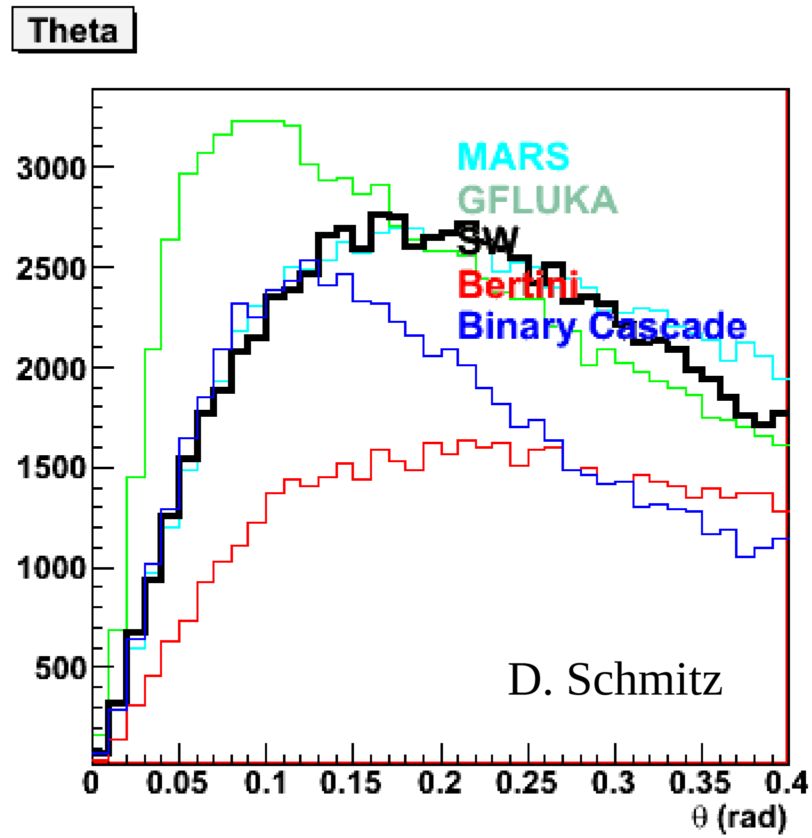
Program	Event Generator Models	Nuclear Break up models
Fluka05	Isobar model (below few GeV) own version of DPM + hadronization	PEANUT (Includes GINC) Generalized InterNuclear Cascade
Geant4	QGS + Fritiof String model $> 20GeV$ Bertini Cascade Model $< 10GeV$ Binary Cascade model Low Energy Parametrized 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..

Models Fit to data where they have been tuned

- Tuning done in single inclusive variable –egFeynman x or multiplicity.
- Errors in models multiply when applied to the calorimeter problem. Repeated showering causes systematics to be enlarged.
- In order to get longitudinal and transverse shapes correctly, one needs to not only single particle inclusive cross sections but also multiparticle correlations.
- To do this we need new data.
- To illustrate—Neutrino targets (many interaction lengths) and transverse size of target restricted.

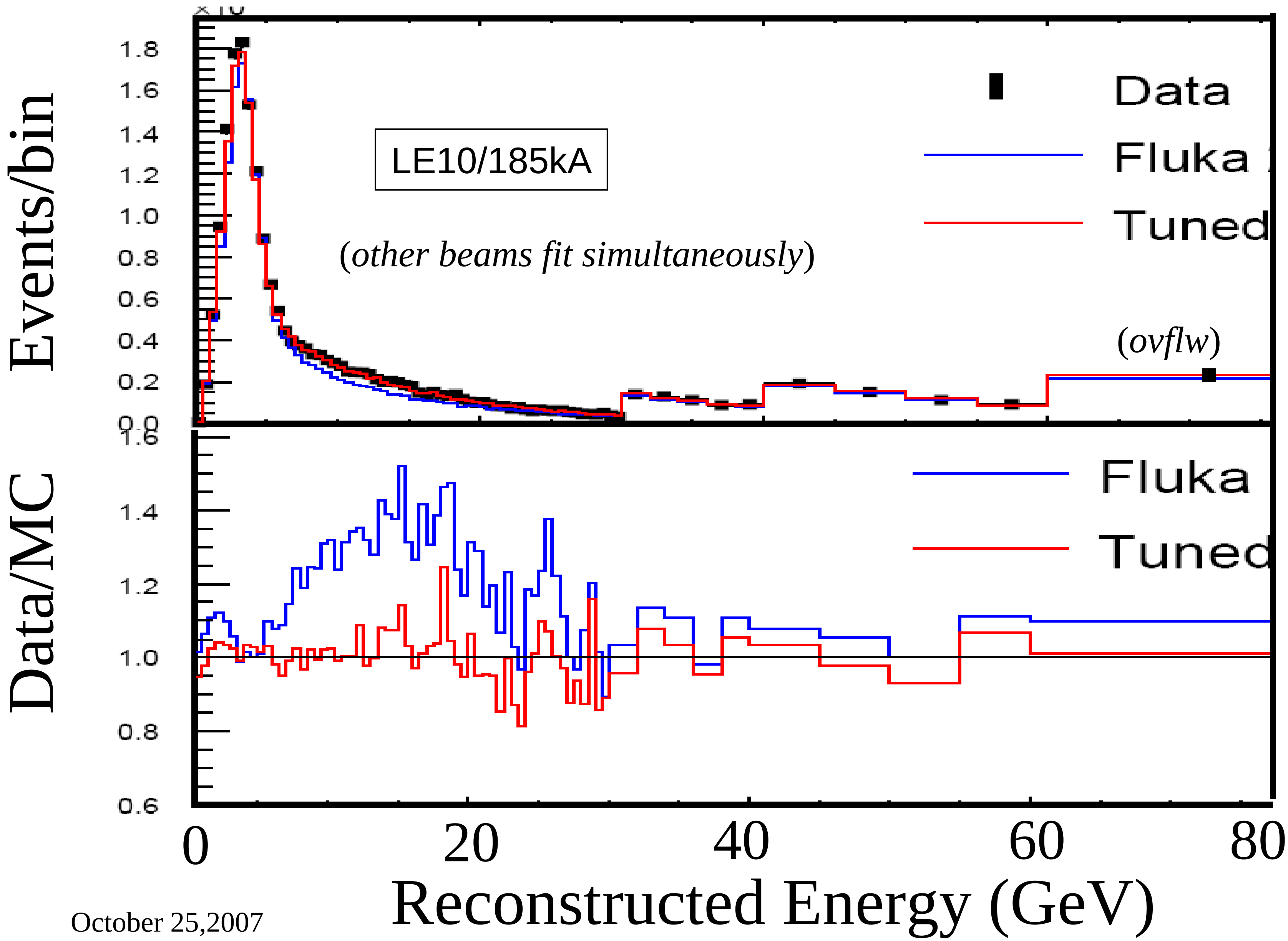
Miniboone-Sanford-Wang (SW) parametrizaion of E910 and HARP compared to other models



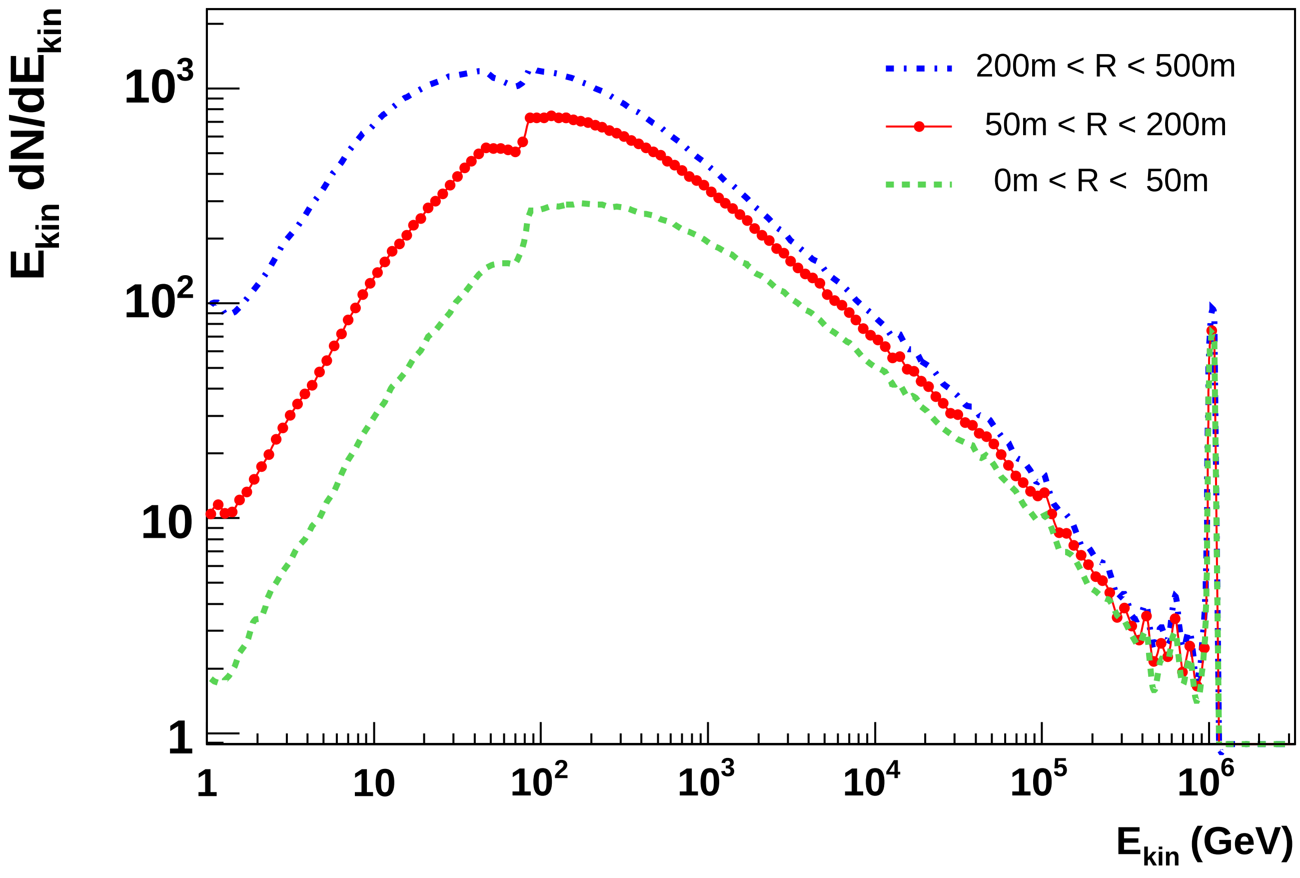


The differences are dramatic in the between models! But the E910 and HARP cross sections determine the correct model, which is very close to MARS.—Does this mean MARS is now the correct simulator to use?

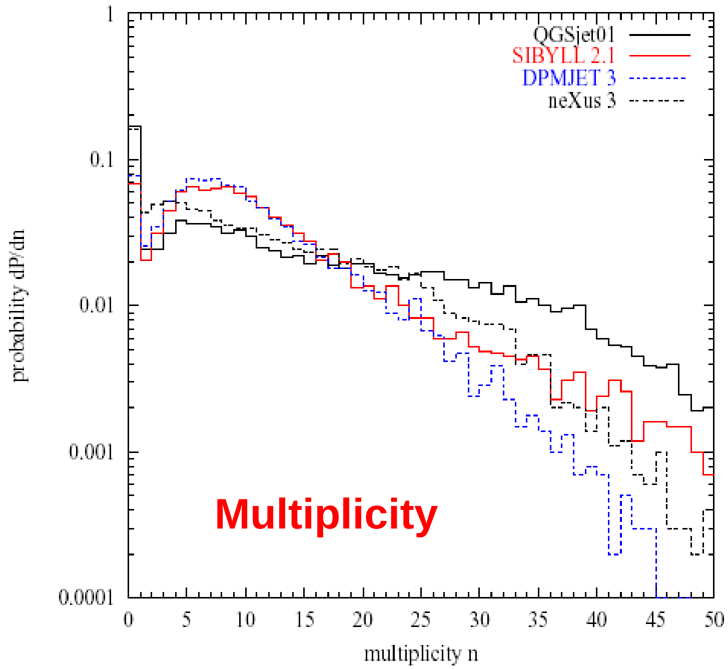
MINOS problem- (from S.Kopp)



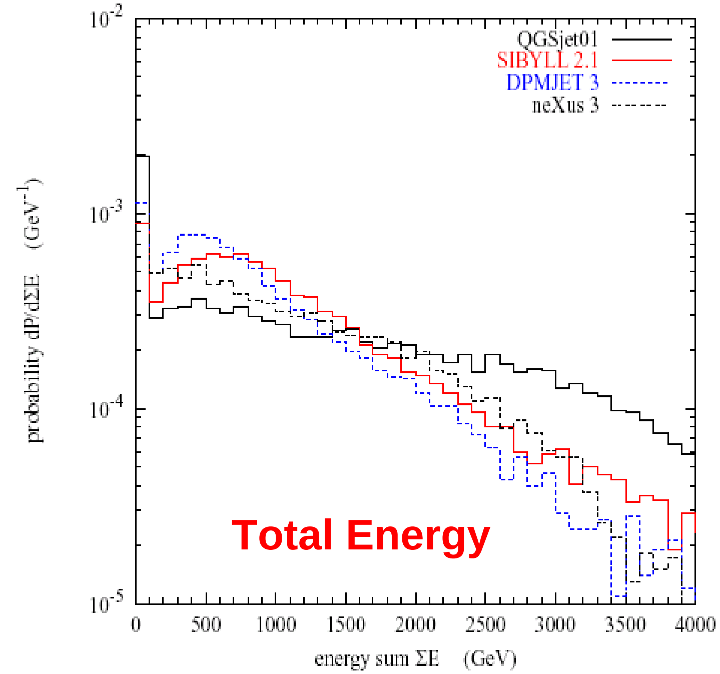
Meurer et al –Cosmic ray showers Discontinuity-Gheisha at low energies and QGSJET at higher energies-Simulation of air showers



Model Predictions: proton-proton at the LHC -Totem Expt- S.Lami



total multiplicity in forward detector
$(5 \leq \eta \leq 7)$



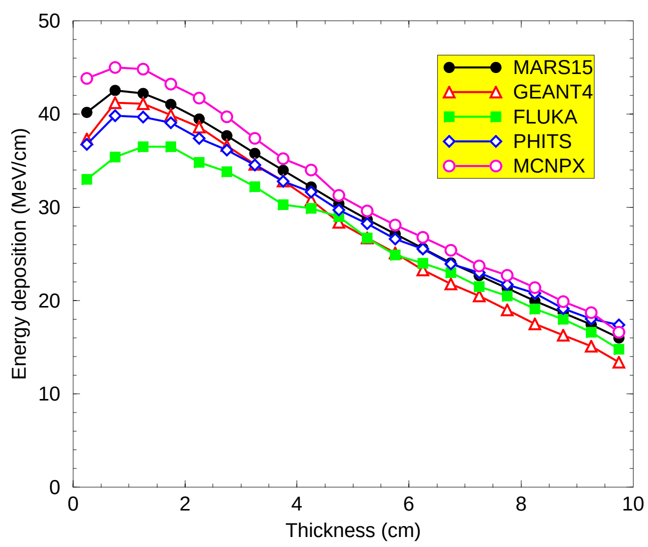
total energy in forward detector
$(5 \leq \eta \leq 7)$

Predictions in the forward region within the CMS/TOTEM acceptance

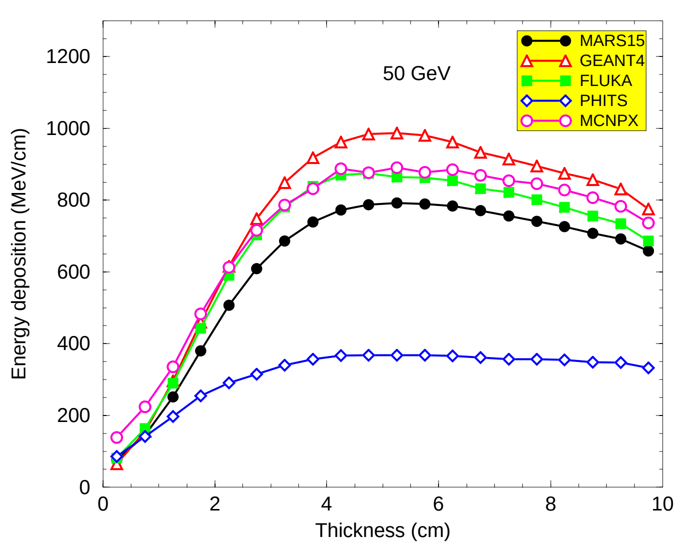
(T1 + T2 + CASTOR)

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

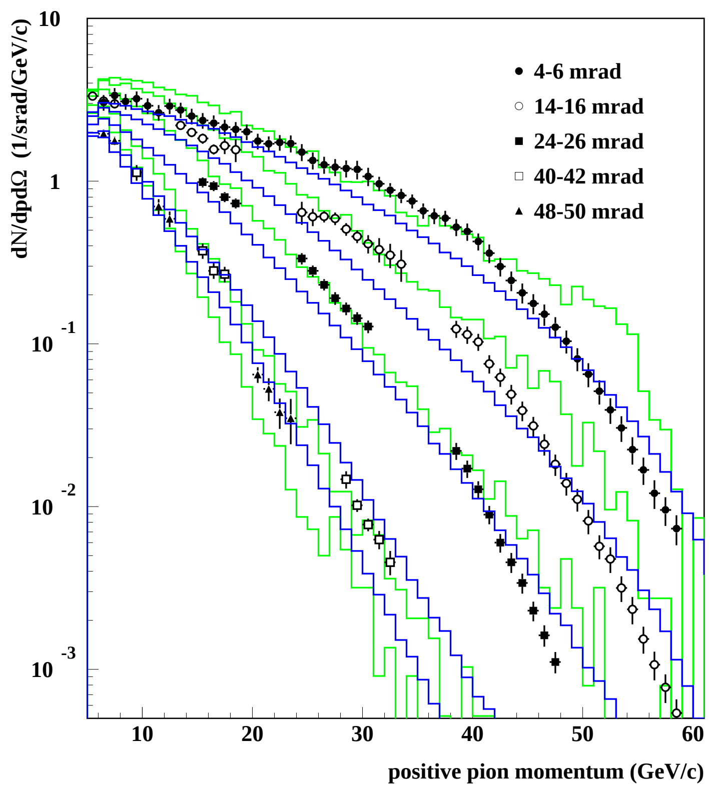


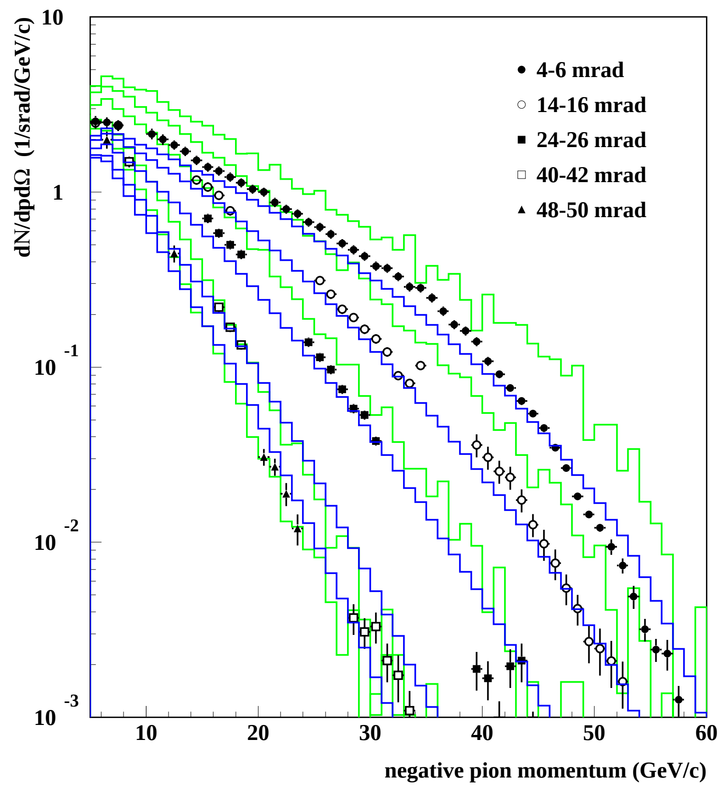
50 GeV/c protons

HSSW06 benchmark test 60cm Al target- Data from Protvino

Pion data. Blue curve MARS. Green curve PHITS.

Monte Carlos (including MARS) disagree with each other and the data!

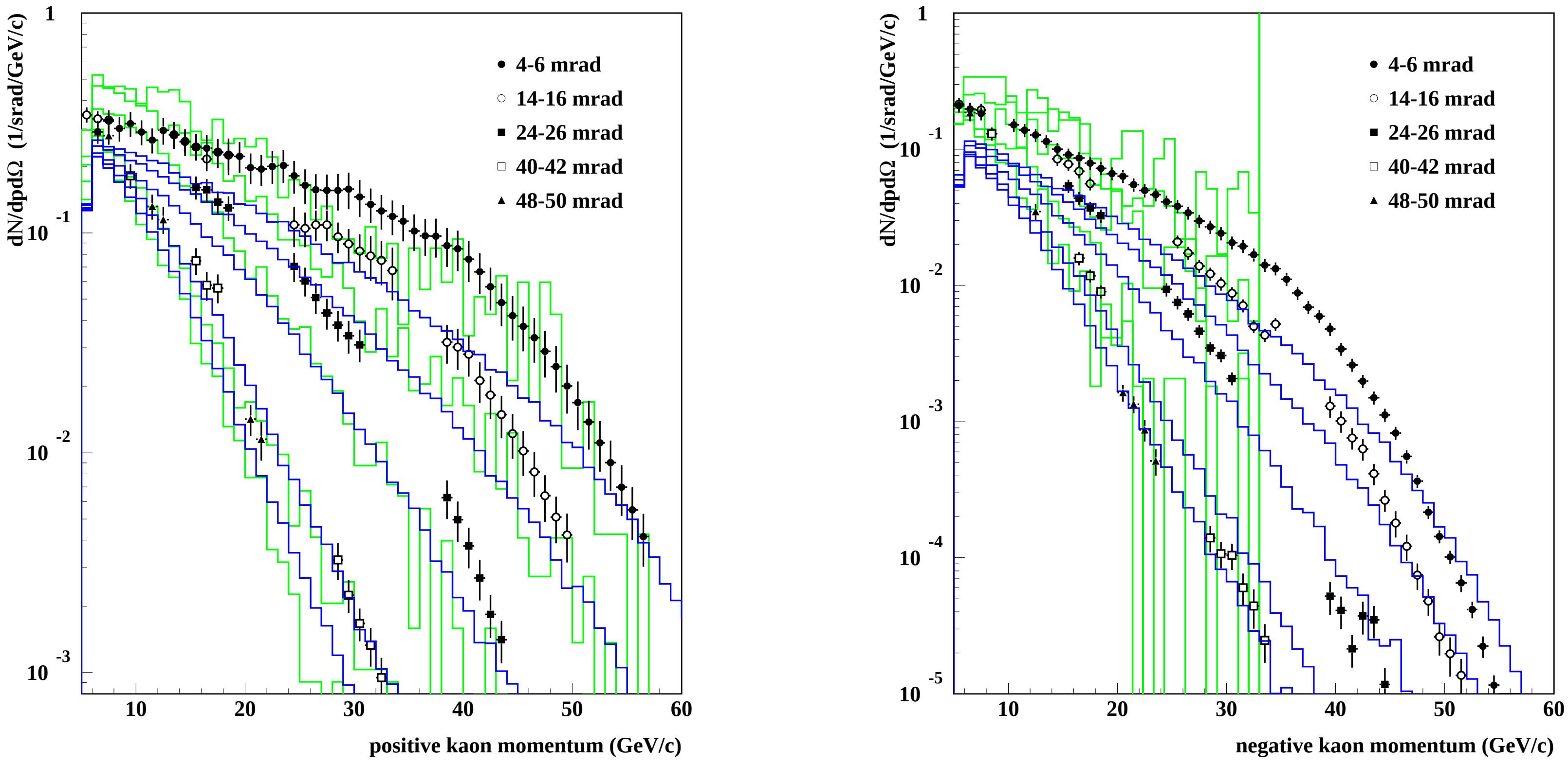




HSSW06 benchmark test 60cm Al target- Data from Protvino

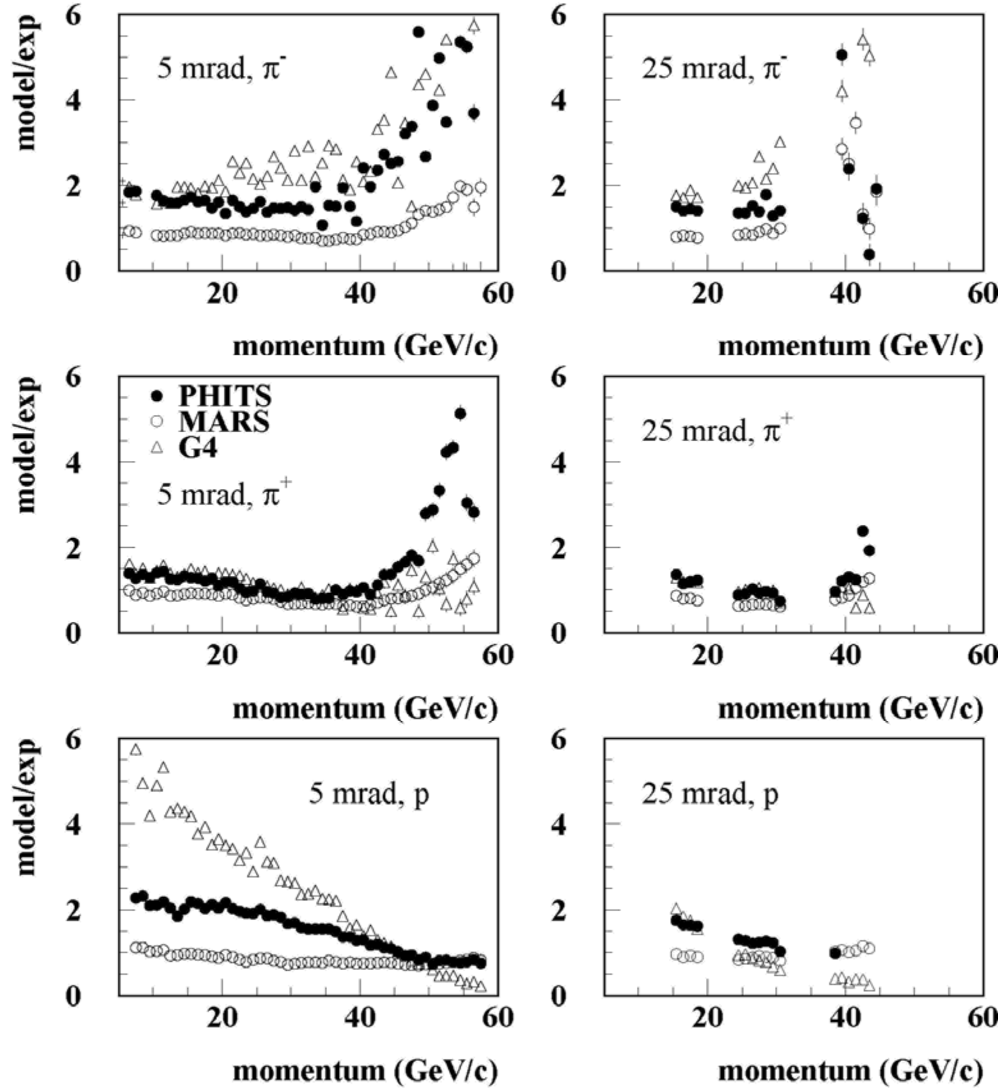
Kaon data. Blue curve MARS. Green curve PHITS.

Monte Carlos disagree with each other and the data!

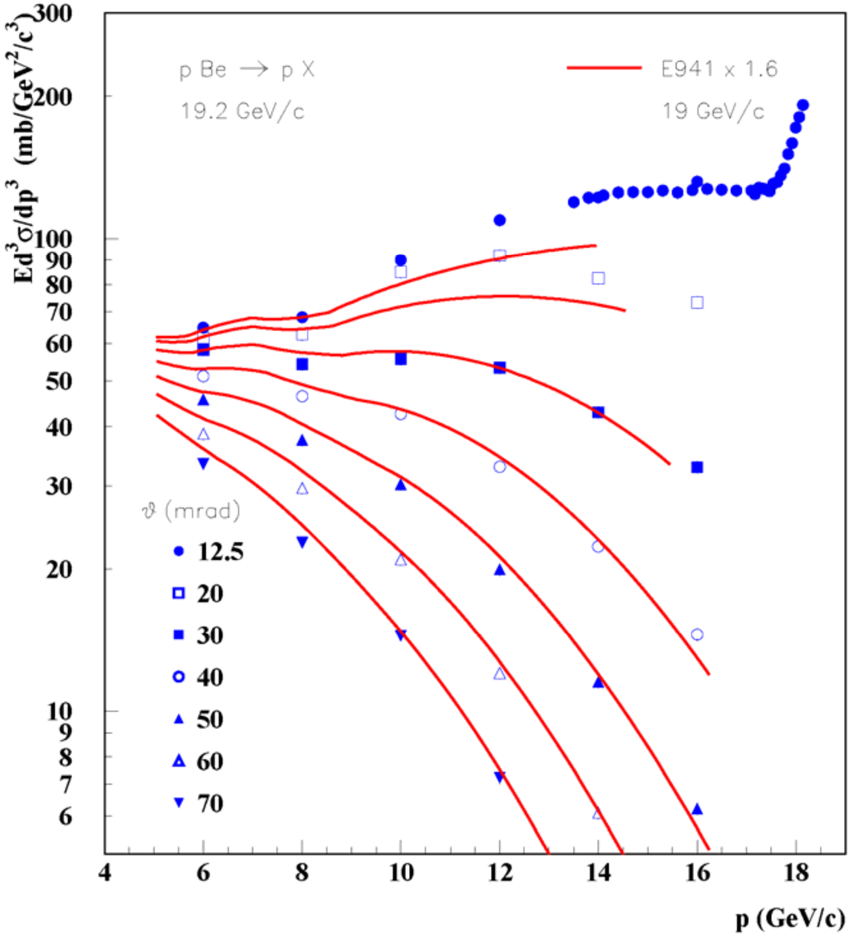


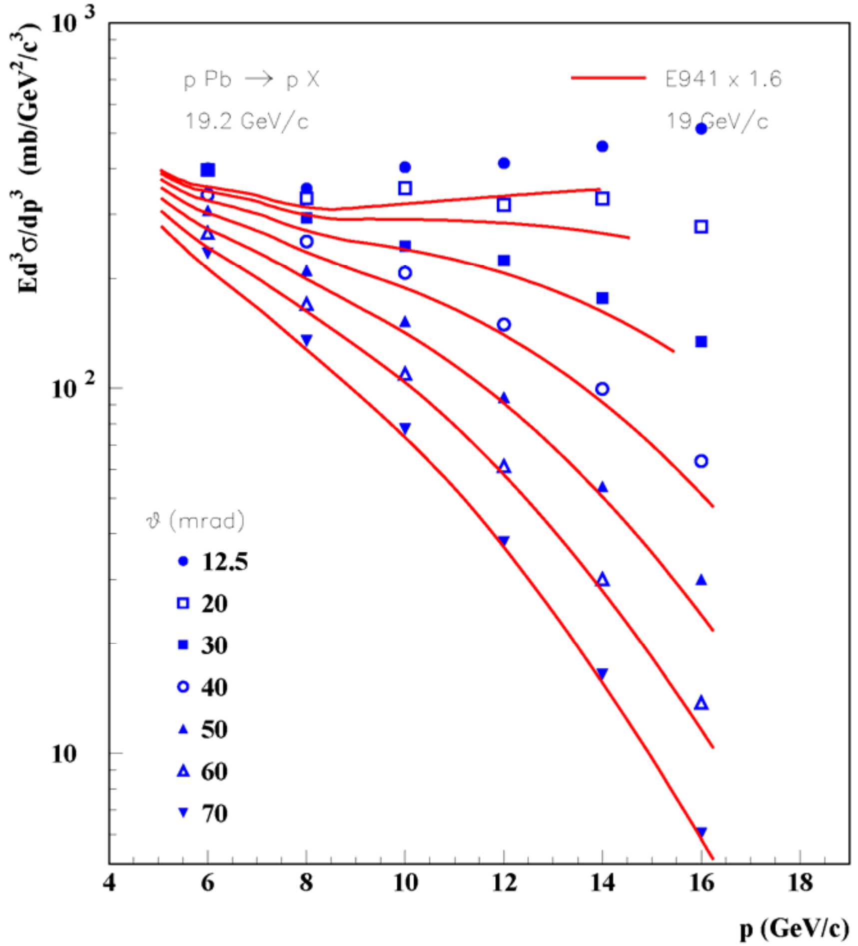
Models plotted as a function of ratio to data.

- Plotted on right are the ratios of model/data for various final state particles for 67 GeV/c protons on a thick aluminum target at protvino. Discrepancies of order 5-6 are evident between model and data. Models disagree amongst themselves.



Model Input data unreliable-some over 30 yrs old a recent example 60% normalization error between 2 experiments.





Present ILC calorimetry strategy

- The present strategy of building calorimeter modules and exposing them to charged test beams will only verify
  - » The modules + DAQ work
  - » Measure resolutions etc. All worthwhile
- However, the DESY ILC Calorimeter R&D review May 31-June 4 2007 states

Relevant studies are under way by the CALICE collaboration, taking data on showers induced by identified electrons and charged hadrons ($p^{\pm}$, $p^{\pm}$) incident on realistic 'physics prototypes' of large scale ECAL/HCAL assemblies. While it would not be possible to undertake ILC physics studies on the basis of shower libraries of all the particles in each jet, these data will be extremely important in selecting the shower simulation model(s) which best fit the data, and possibly tuning the model parameters to refine the fits.

Geant4 response by Dennis Wright

Our (Geant4) position is that only thin-target data should be used to tune the hadronic models. Full setups, calorimeter test beams and shower shape measurements definitely help in deciding which models to use and how to connect one to another, but they do not sufficiently isolate models.

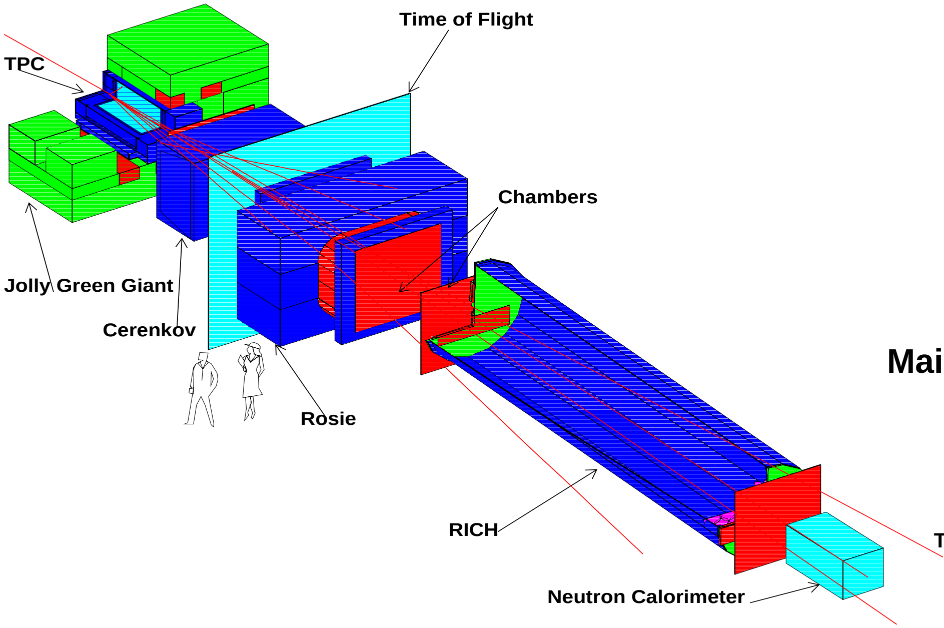
- If you want to improve simulators, obtain better thin target particle production data with correlations and particle id.
- Just as MARS worked for MINIBoone but failed to describe Protvino data, you cannot even pick the correct simulator model using calorimeter data. This assumes such a model exists! Since these models are based on old single particle inclusive data, chances are highly likely that while they may succeed in one case, they may fail in another case.
- The present ILC test beam strategy is one pronged—One needs a two pronged approach and improve simulators if one wants this program to optimize hadronic calorimeter design.
- It assumes the perfect model exists to be found by experimentation!

Possibilities of new data

- MIPP Upgrade—Proposal deferred till we publish on data already acquired.
- Will speed up existing MIPP apparatus by a factor 100 in DAQ.
- Will enable the acquisition of 5 million events per day and will measure particle production (multiplicities, particle id, correlations) on over 30 nuclei.
- Will feature a new detector- Te plastic ball which will measure nuclear breakup products.
- Will solve the hadronic shower simulation problem once and for all.
- Will provide tagged neutral beams of $n, \bar{n}, K_L^0, \pi^0$
- Can study calorimeter response to multiparticle "jets" while doing the tagged neutral study.

MIPP

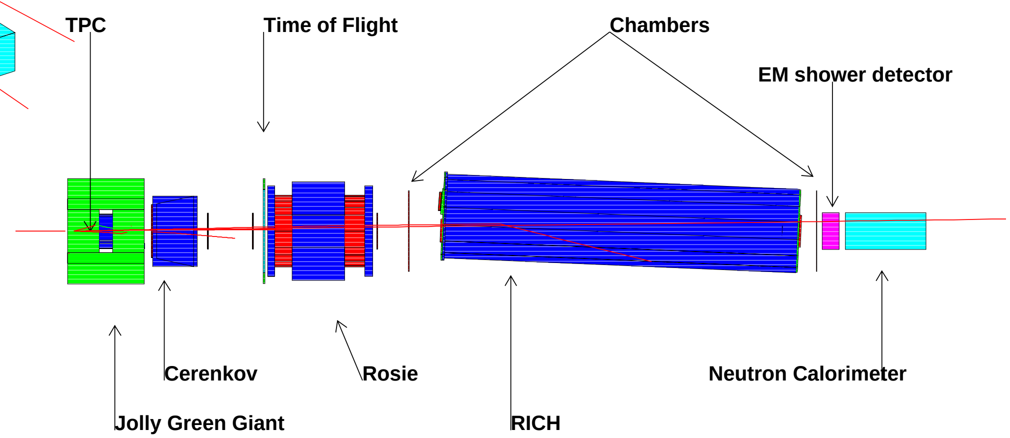
Main Injector Particle Production Experiment (FNAL-E907)

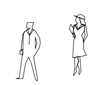


MIPP

Main Injector Particle Production Experiment (FNAL-E907)

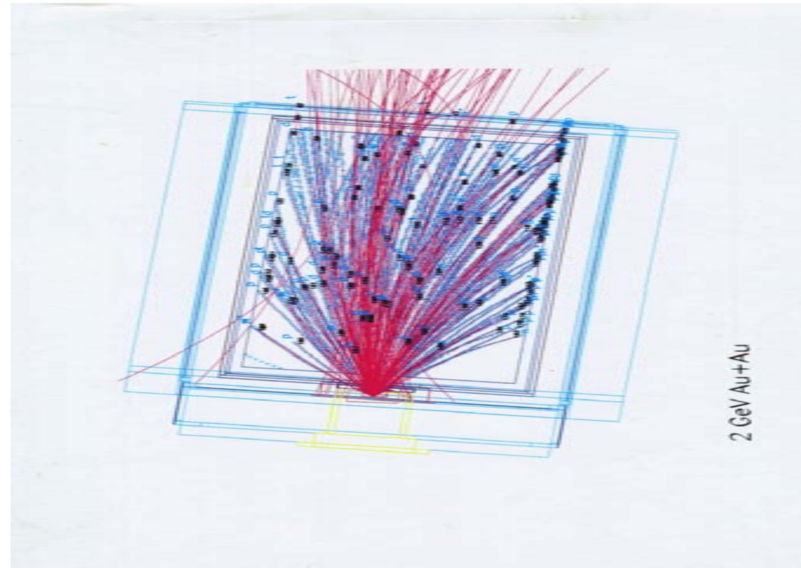
Vertical cut plane

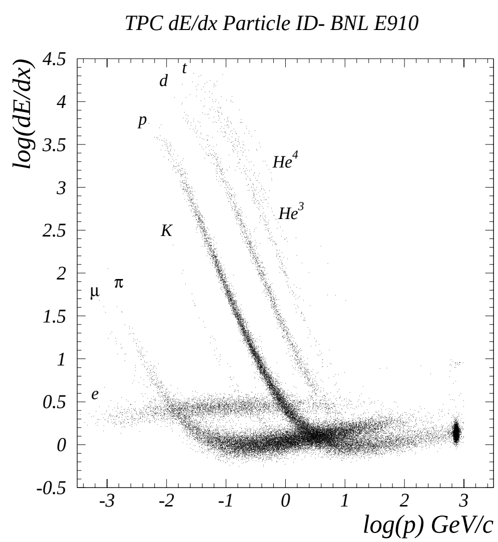




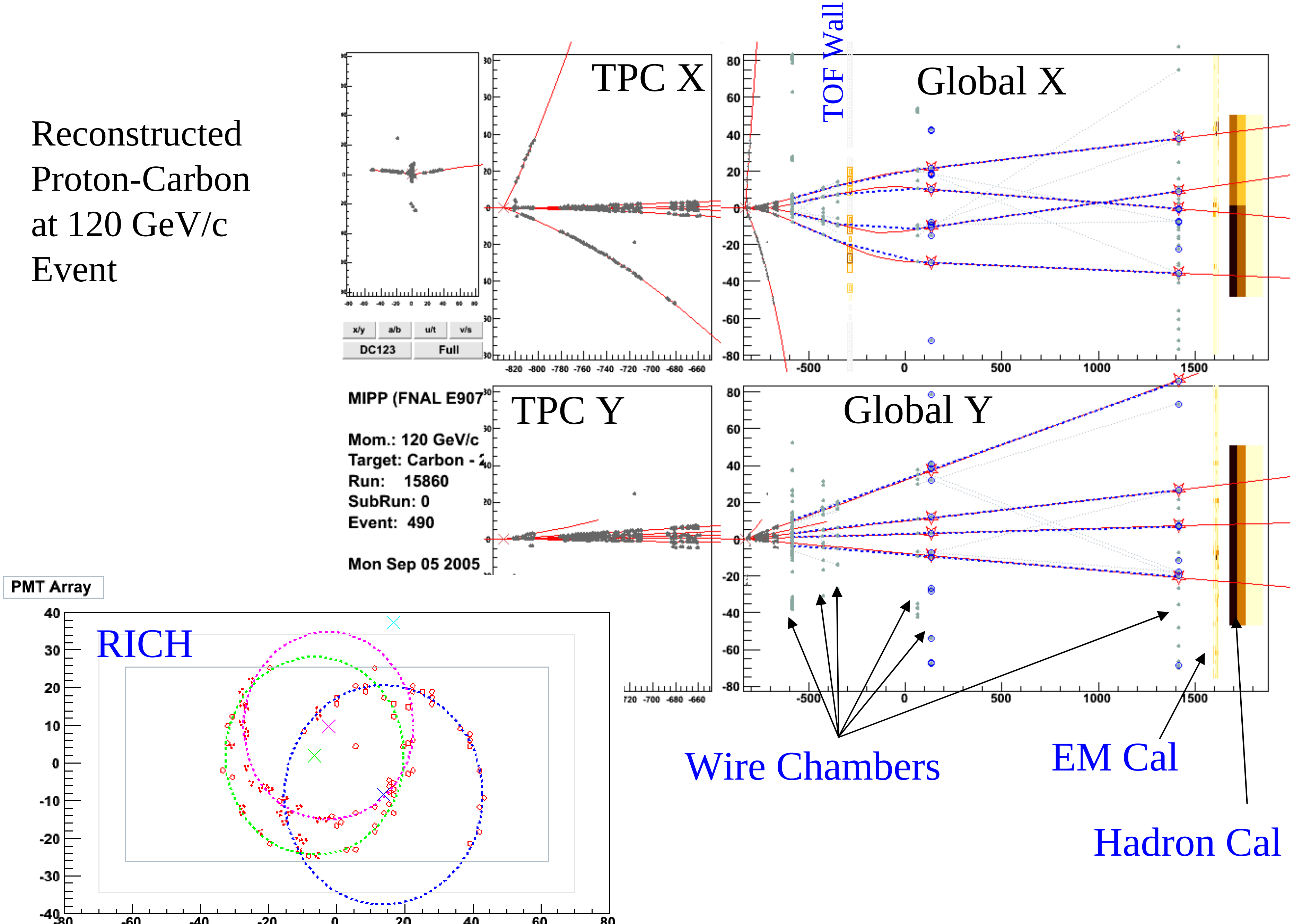
TPC

•


2 GeV Au+Au


TPC dE/dx Particle ID- BNL E910
log(dE/dx)
log(p) GeV/c
d
t
p
He4
He3
K
μ
π
e

Reconstructed Proton-Carbon at 120 GeV/c Event



MIPP Upgrade collaboration list

D.Isenhower,M.Sadler,R.Towell,S.Watson
Abilene Christian University
R.J.Peterson
University of Colorado, Boulder
W.Baker,B.Baldin,D.Carey, D.Christian,M.Demarteau,D.Jensen,C.Johnstone,H.Meyer, R.Raja,A.Ronzhin,N.Solomey,W.Wester,J-Y Wu
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Bill Briscoe, Igor Strakovsky, Ron Workman
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Illinois Institute of Technology
M. Messier,J.Paley
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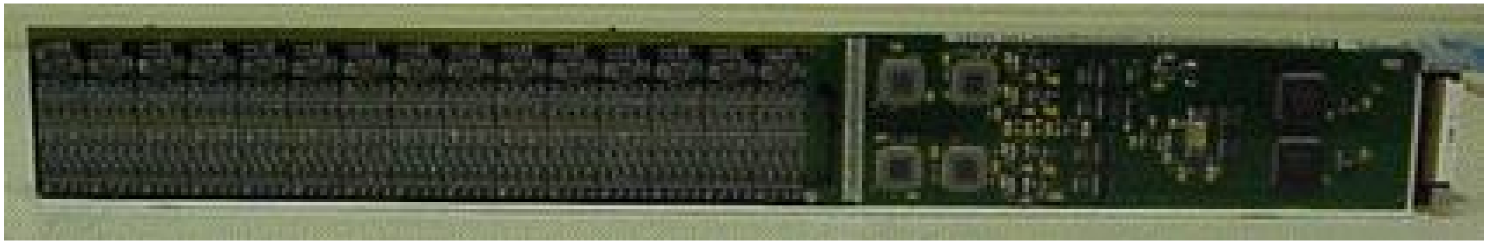
C.Dukes,C.Materniak,K.Nelson,A.Norman
University of Virginia
P.Desiati, F.Halzen, T.Montaruli,
University of Wisconsin, Madison
P.Sokolsky, W.Springer
University of Utah

Bigger then MIPP I. Previous collaboration built MIPP up from ground level. Less to do this time round. More data.

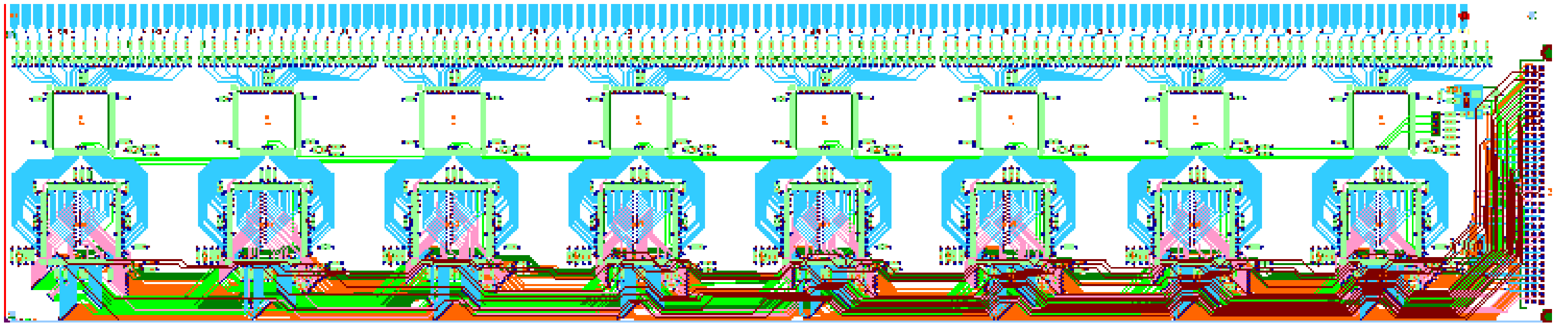
Finished Coils Delivered October 07

TPC electronics upgrade

- Old MIPP TPC "Stick" – 120 of these.

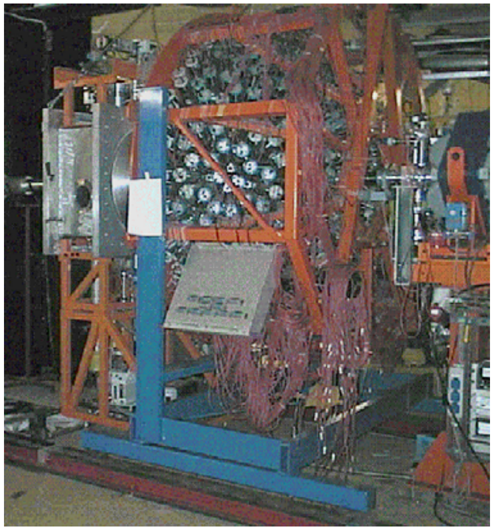


- New MIPP TPC "stick" layout using ALTRO/PASA chips. $80K worth of chips delivered. All boards in prototype. We have new calorimeter readoutwith pipeline designed.



Plastic Ball Recoil detector

- Plastic ball detector is avaliable. 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

WBS task 10 Fermi M&s $0

Labor $25.9K, In Kind $55K

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
- The B-List
- Na, Ti,V, Cr,Mn,Mo,I, Cd, Cs, Ba
- 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 and both charges.
- 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

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 ($\pi^{\pm}$,$K^{\pm}$,$p^{\pm}$) 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 parametrised as a function of s.
- Neutral particle algorithm
- Particle correlations taken care of.

Why np cross sections cannot be deduced from pp cross sections below 20 GeV

- Isospin (Charge Symmetry to be exact) states that pp differential and total cross sections are equal to nn differential and total cross sections (ignoring electromagnetic interactions). For example

$$pp \rightarrow n\pi^{+}p$$

$$nn \rightarrow p\pi^{-}n$$

are conjugates of each other by isospin reflection. Knowing the pp reaction, one can obtain the nn reaction.

- It is however not the case for np reactions. They cannot be deduced from pp reactions till we get to over 20 GeV incident momentum when pomeron exchange(limiting fragmentaition) dominates.

Argument in R. Raja Ph.D Thesis (1975)

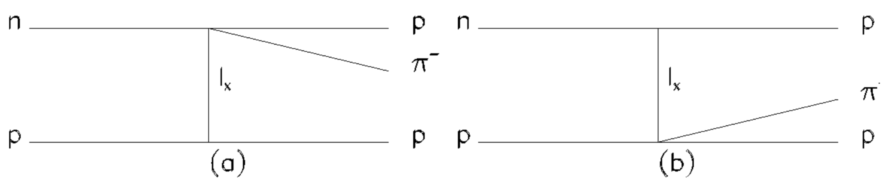
- Characterize amplitudes for reactions by $M^{I_x}{}_I$ where I_x is the isospin of the exchanged object and I the isospin of the Np combination.
- You can express all reaction cross sections in terms of 3 amplitudes which are fitted as a function of momentum Kp^{-n} yields

$$pp \to pp\pi^0$$

$$pp \to pn\pi^+$$

$$pn \to pp\pi^-$$

Cross section due to amplitude	n
$M^0{}_{1/2}$	-0.33
$M^1{}_{1/2}$	-1.37
$M^1{}_{3/2}$	-1.84



Pomeron Exchange dominance

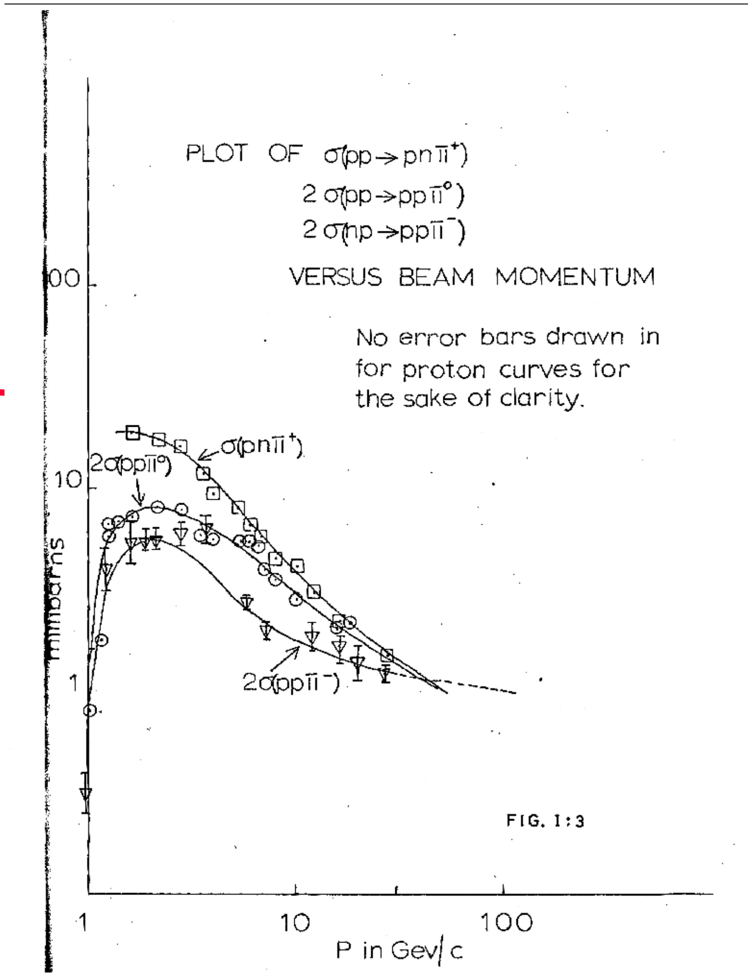
- When Pomeron exchange ($M^0_{1/2}$) amplitude dominates, one can show

$$\sigma(pp \rightarrow pp\pi^0) = \sigma(np \rightarrow pp\pi^-) = \frac{1}{2}\sigma(pp \rightarrow pn\pi^+)$$

- Thus below 20 GeV, np cannot be deduced from pp.

np is poorly known.

If the target nucleus is not isoscalar, a proton will see different pn interactions than a neutron hitting the target.



Np cross sections contd

- In order to describe a simple cross section such as np->ppp$^-$, one needs to reggeise the pion in the Treiman Yang angle, introduce pp elastic scattering phase shifts etc as in Reggeised One pion exchange). The transverse size of a shower induced by a neutron interacting on a proton will be influnced by the first single pion production reaction. There is no guarantee that any of the shower generators describe these reactions.
- Eg DPMJET gets the cross section for pp->pnp$^+$ wrong by a factor of 4.8 at 20 GeV. Since the total inelastic cross section is correct, it must gets other cross sections wrong as well to compensate.
- So it may behoove the ILC calorimeter effort to measure these shower shapes using tagged neutral beams.
- The 128 measurements made by the TPC in 3D + the recoil detector are very important for getting clean tagged neural beams. Non trivial. Tagged neutral cross section is 1% of the total cross section. If it is contaminated by 0.5% of the total cross section, this is a 50% contamination! TPC + particle ID + recoil detector very important.

Tagged neutron K-long and π^0 beams in MIPP

- MIPP Spectrometer permits a high statistics neutron and K-long beams generated on the LH2 target that can be tagged by constrained fitting. The neutral momenta can be known to better than 2% event by event by the 3-C fit. The energy of the neutron (K-long) can be varied by changing the incoming proton(K^+) momentum. The reactions involved are

$$pp \rightarrow pn\pi^+$$

$$K^\pm p \rightarrow pK_L^0\pi^\pm$$

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

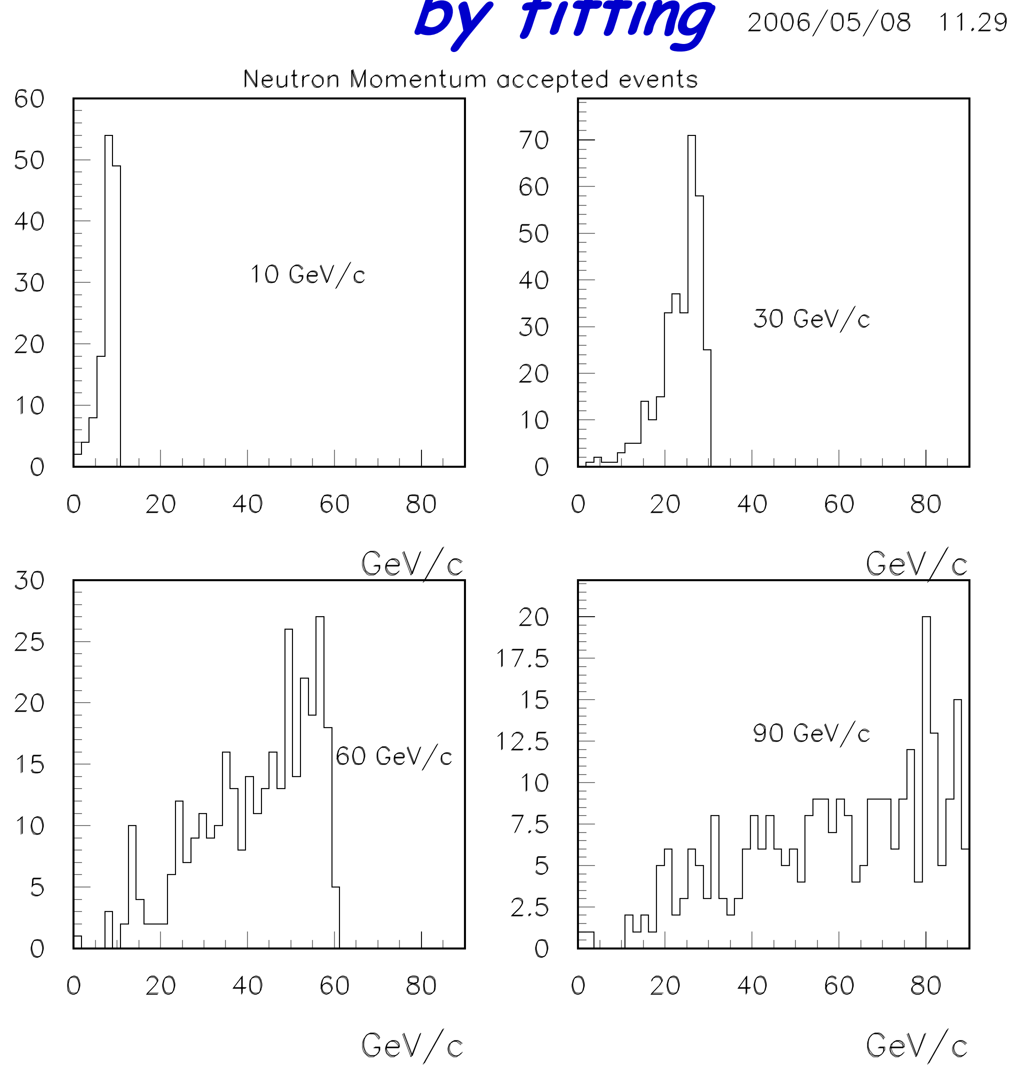
$$\pi^\pm p \rightarrow \pi^\pm\pi^0 p$$

See R.Raja-MIPP Note 130

hep-ex/0701043

~50K tagged neutrons per day

Neutron spectra for various beam momenta. Each individual momentum known to 2% or better by fitting



Expected tagged neutral beam rates

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			

Expect a neutron background of 30 times the tagged rate from events with missing pizeros. MIPP will record 12,000 events in 4 seconds. Of which a large number will have multiple charged tracks hitting the calorimeter with particle id which can be used to study jet systematics.

Triggering the Calorimeter

- MIPP Upgrade DAQ is massively pipelined. Every sub-detector can store 12,000 events acquired over a 4 second spill delivered every 2 minutes. These events all have a trigger time stamp which is used to event build offline reading out the data in ~30secs.
- In the absence of a pipeline, next best solution is for ILC calorimeter to generate its own trigger. It must veto against 300KiloHZ of uninteracted beam hitting it (this can be steered away using the magnet Rosie if needed). It should then form an energy sum trigger with a event serial number which it can communicate to the MIPP DAQ.
- If neither of these can be made to work, MIPP may be able to get its interaction trigger on a 0.9c fast line over to the calorimeter to trigger it. This needs study.
- To my mind, putting the DAQ difficulties up front is like putting the cart before the horse. One needs to ask, how important is it to measure the neutral particle respnse using a tagged neutral beam? Then design the DAQ around it.

PFA and Compensation

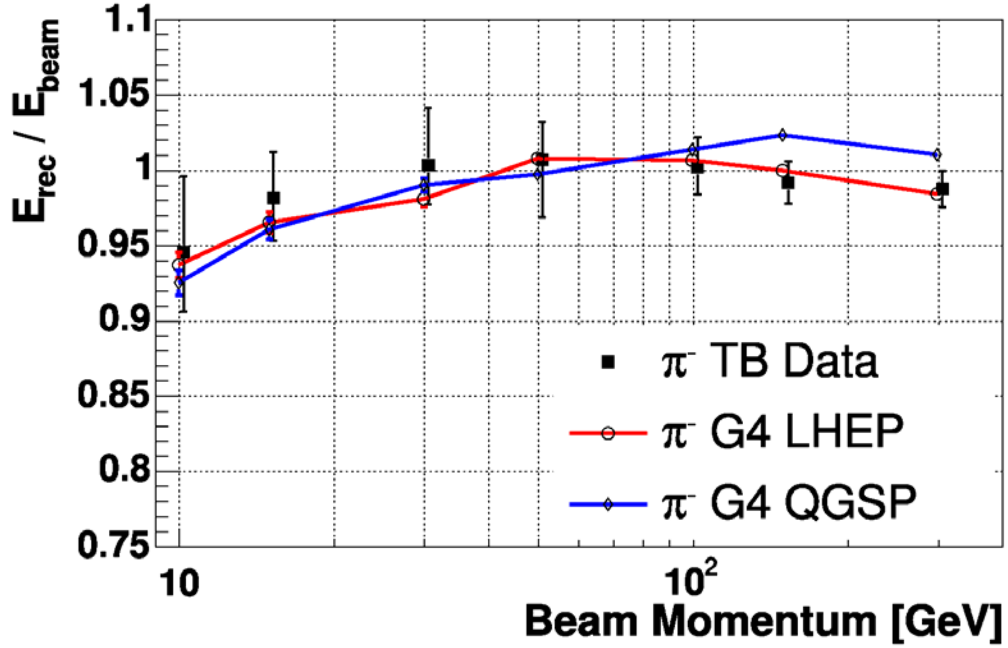
- To my mind good performance of PFA is enhanced if one has a compensated calorimeter. Matching calorimeter deposits to charged hadrons becomes easier if
  - » Calorimeter has good resolution
  - » Calorimeter is linear
- Lack of compensation produces bad resolution as well as non-linearity.

$$\frac{\sigma}{E} = \frac{\sigma}{E}(ideal) \oplus \sigma_\lambda \left\langle \frac{(1-f)}{1-\lambda(1-f)} \right\rangle$$

Where the ideal resolution goes as 1/root(E); f is the e/h ratio and λ is the fraction of hadronic shower in hadrons. The constant term is resolution killer and is zero only if f=1.

CMS Data Linearity test HCAL only

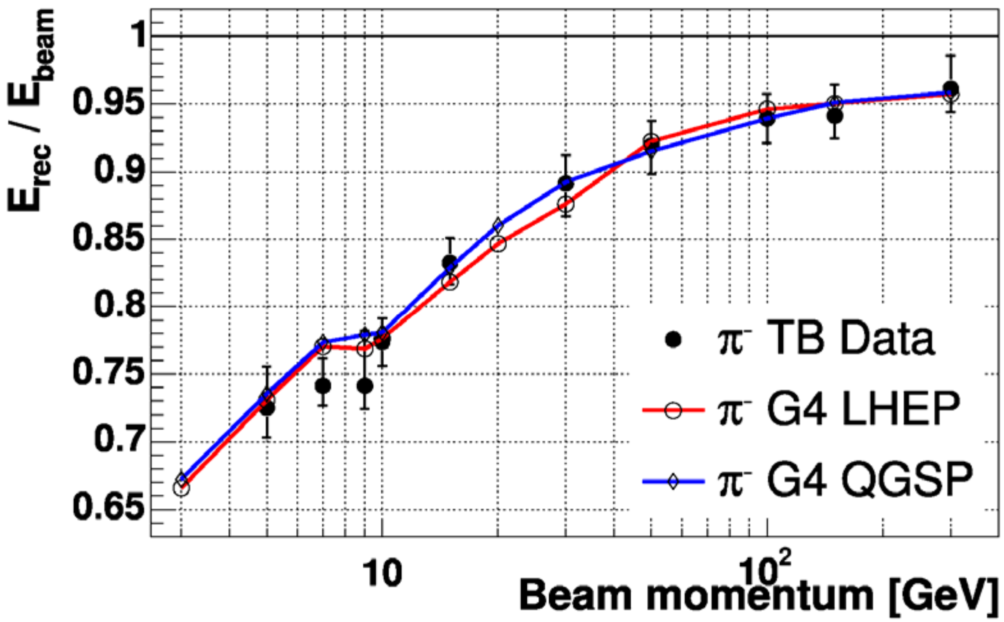
- S.Piperov-HSSW06
- Lack of compensation also produces non-linearities in hadronic energy measurements. This is because the fraction of EM energy in a shower increases with increased energy.



$$\lambda = \left(\frac{E}{E_0}\right)^{m-1}; E_0 \approx 1\,\text{GeV}; \text{m} \approx 0.82$$

CMS Data HCAL + EMCAL

- Moral—Avoid having different technologies for AM and HCAL. A hadron does not know that it should not interact in EMCAL.
- Non-compensation implies non-linearity and bad resolution.



The case for longitudinal segmentation A.Peryshkin, R.Raja D0Note 1215

- There are 2 different ways to calibrate calorimeters
  - Method I--Inverse Sampling fractions μ_k
  - D_k is the Deposited energy and L_k is the Live
  - energy in layer k.

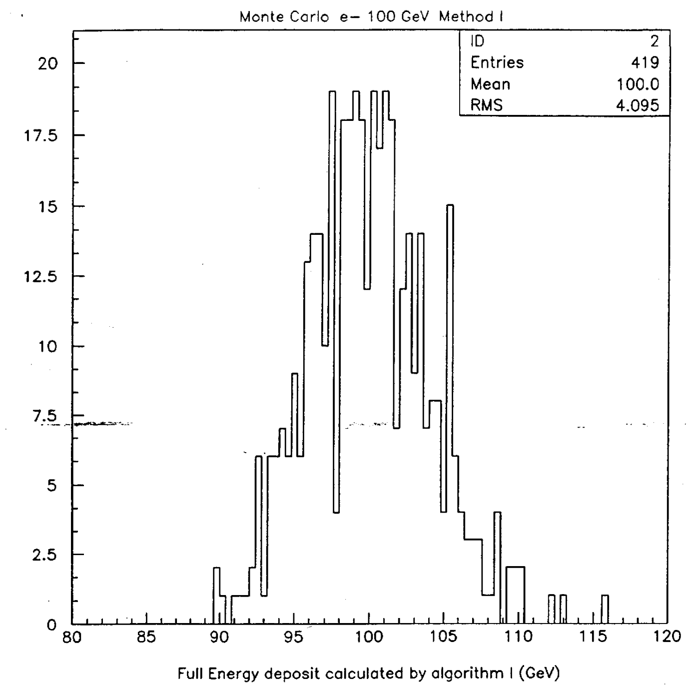
  - Method II-
  - Weights w_k obtained by minimizing resolution as in a test beam.
- Method 1 gives worse resolution than Method 2.
- Method 2 weights are intrinsic non-local quantities that depend on shower correlations and energies observed in all layers.

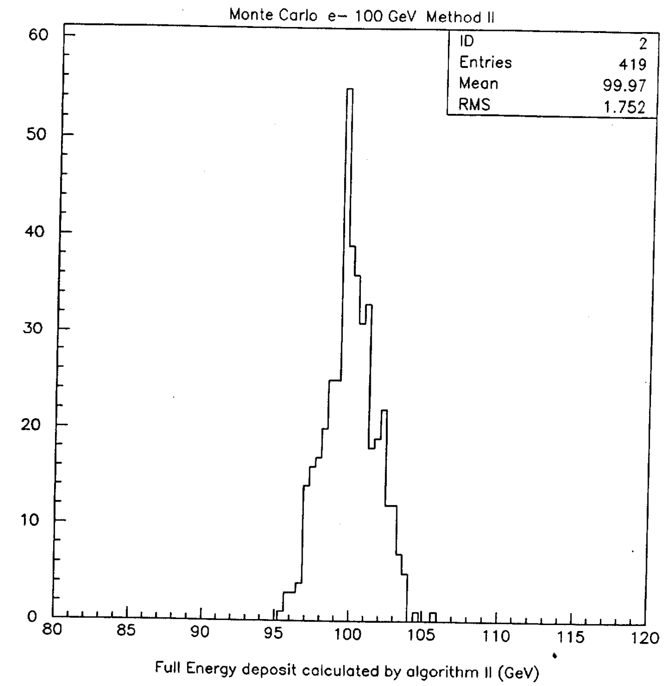
$$D_k = \mu_k L_k ; \mu_k = \left\langle \frac{D_k}{L_k} \right\rangle$$

$$D_i = \sum_j \lambda_{ij} L_j$$

$$w_k = \sum_i \lambda_{ij}$$

The tensor λ involves all layers and utilizes shower correlations to provide best resolution.





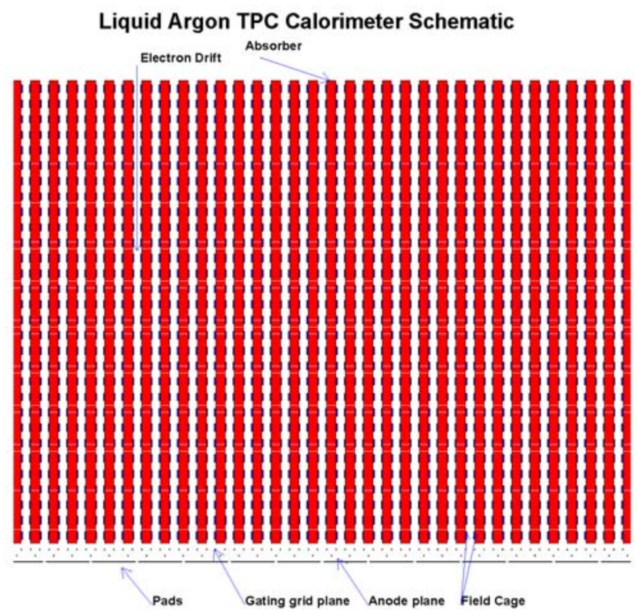
100 GeV electrons
Method I

Using Method II

Applies equally well to hadrons. Argues for longitudinal segmentation. Also pattern recognition arguments.

A liquid argon TPC calorimeter with plates.

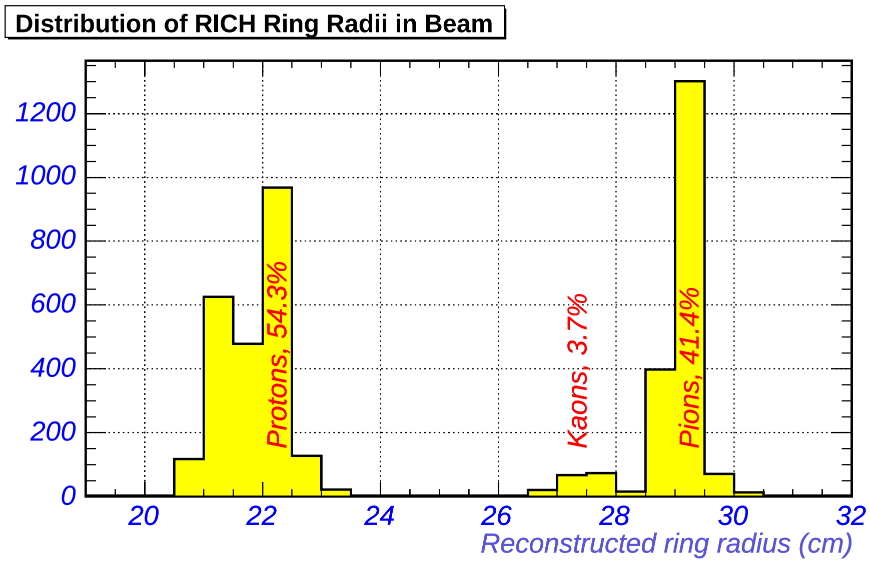
- Liquid argon TPC with plates
  - » 75 cm in 0.5ms
  - » Electric field 500V/cm
  - » Charge diffusion ~1.3mm after 3 ms.
- High segmentation in time direction
- Software compensation by telling EM deposit apart from hadronic deposit.
- 3mm argon gap. 5mm absorber. Each gap has field cage.
- Can be used with PFA. Also good as a compact neutrino detector with magnetic field.
- Time dimension is 75cm long.
- Longitudinal segmentation by pads.
- EM + CAL same unit.
- Aluminum Cryostat with massless gap
- Small R&D effort at FNAL.



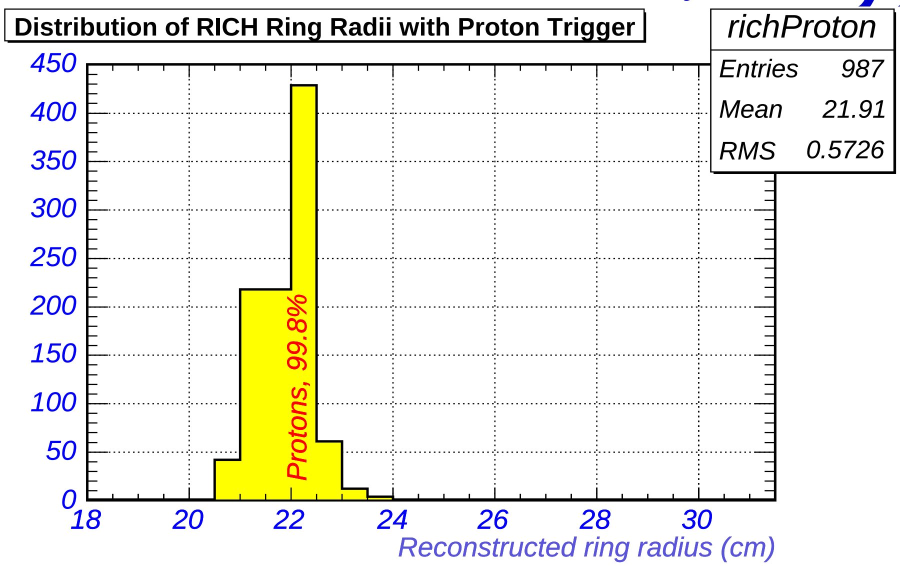
Conclusions

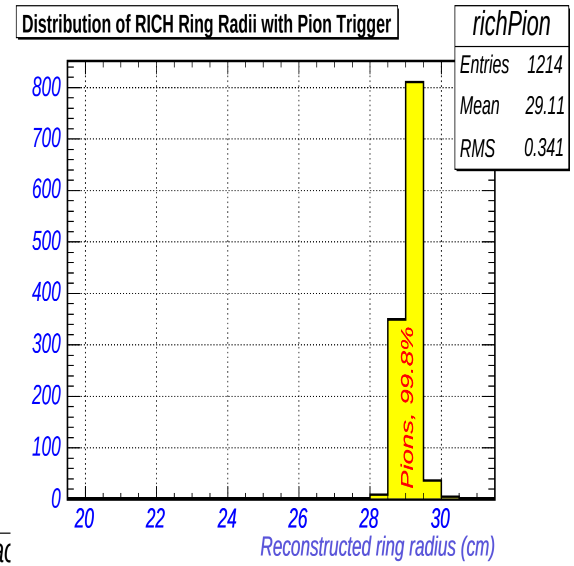
- Propose a 2 pronged approach that attacks the problem from both the simulation and the data ends.
- MIPP Upgrade will provide high quality data that can eliminate many uncertainties in simulation programs- As such its utility extends beyond ILC to netrino physics and cosmic ray physics. It is a great resource to train students.
- We have motivated the need to make tagged neutral measurements.
- We have argued for compensating calorimetry to be used with PFA's and suggest avenues for further R&D.

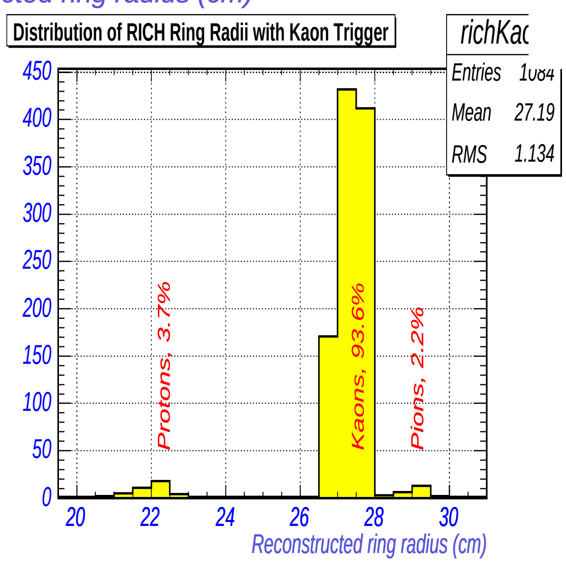
RICH radii for + 40 GeV beam triggers



Comparing Beam Cherenkov to RICH for +40 GeV beam triggers-No additional cuts!

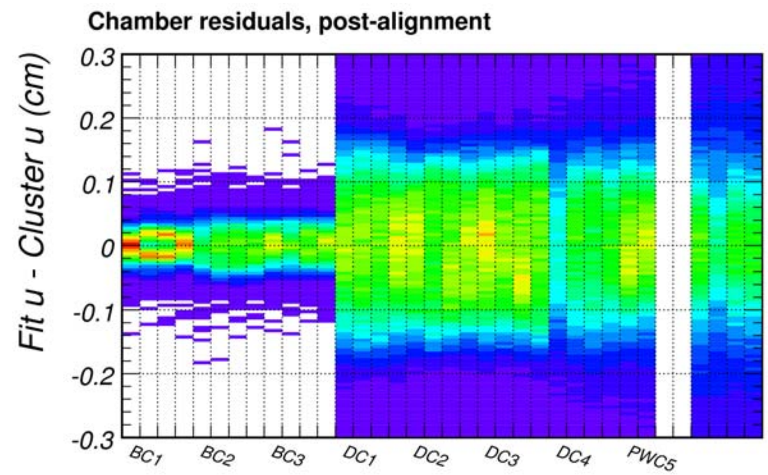


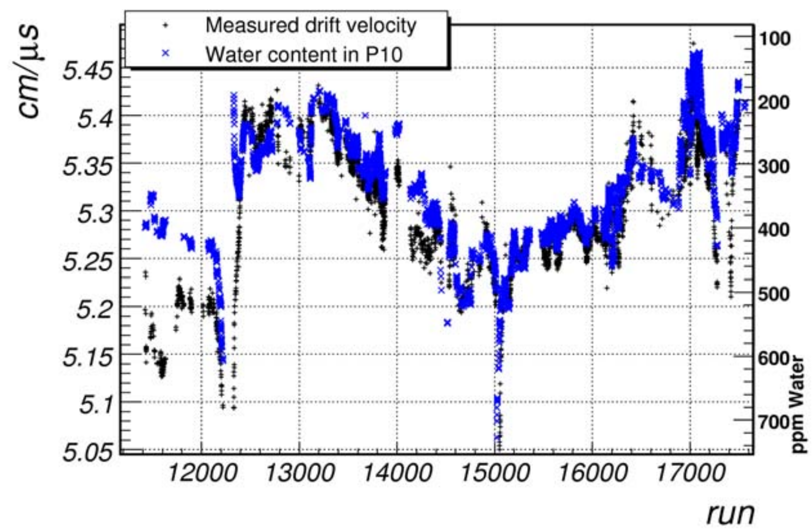




Ongoing analysis-Spectrometer Calibration

- Chamber alignment done for every run
  - » Helped to find bugs in geometry description and refine magnetic field maps
- TPC electron drift velocity measured for every run
  - » Strong correlation with water vapor contamination

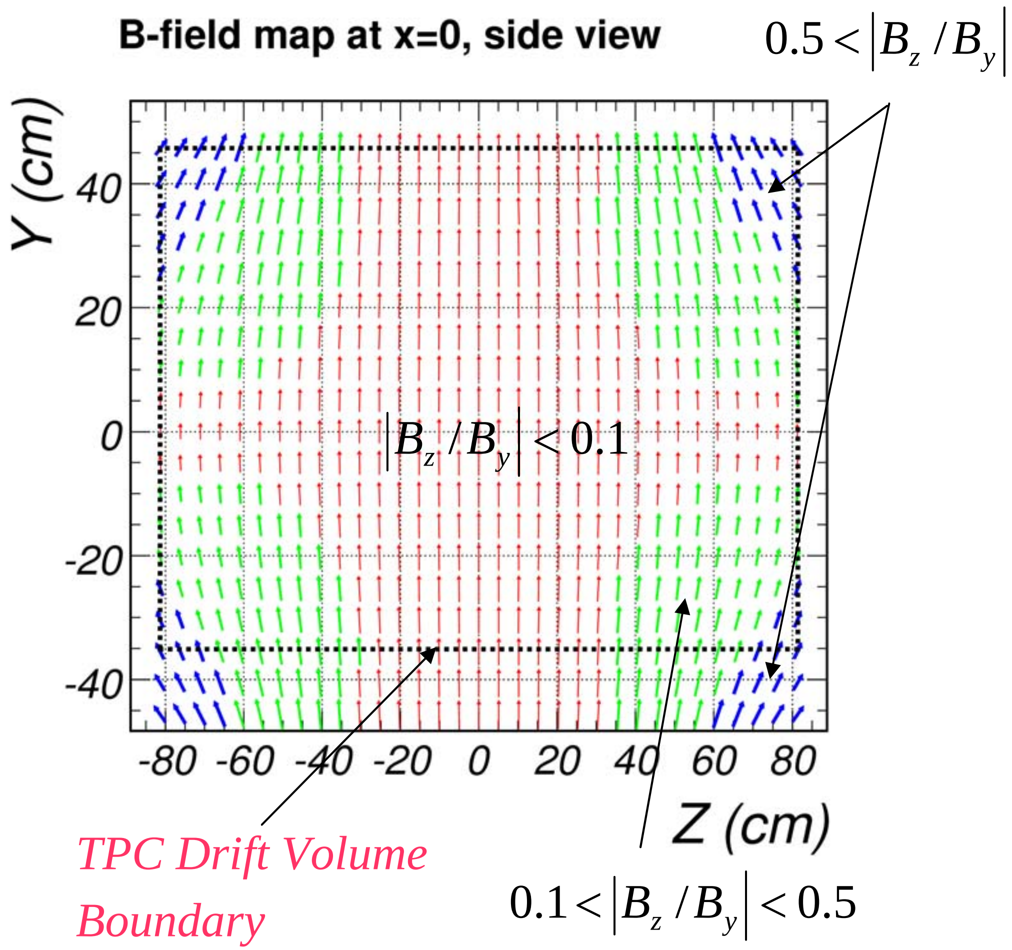




TPC Hit Reconstruction

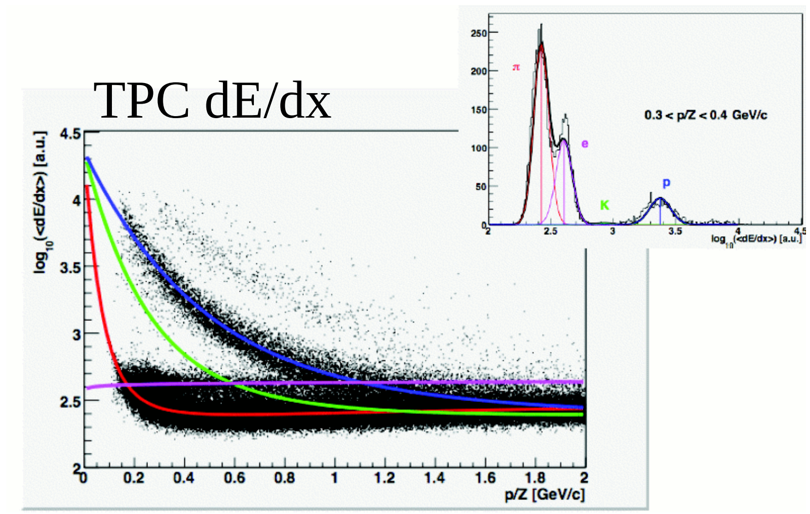
- JGG field is non-uniform
  - » Enormous effect on electron drift in Ar/CH_4
- Previous experiments applied corrections based on steady state solution to linear model

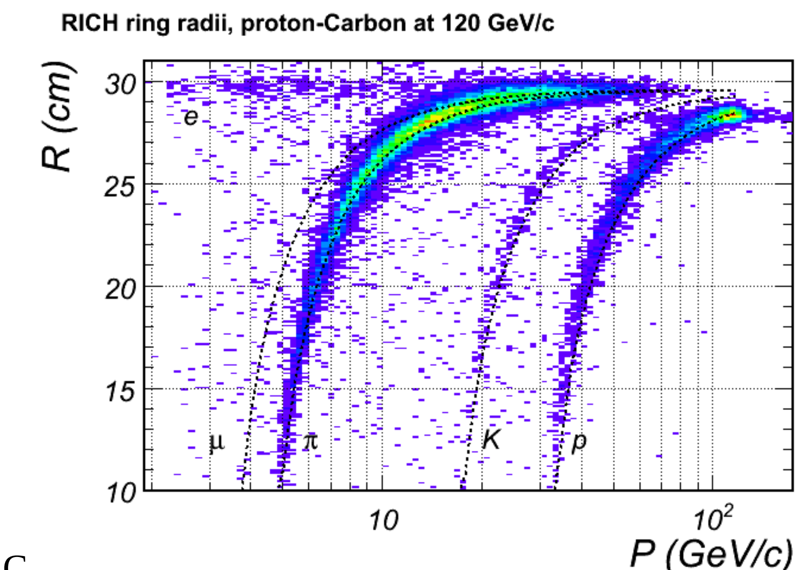
$$m\frac{d\vec{v}}{dt} = e\vec{E} + e\vec{v}\times\vec{B} - \frac{1}{\tau}\vec{v}$$



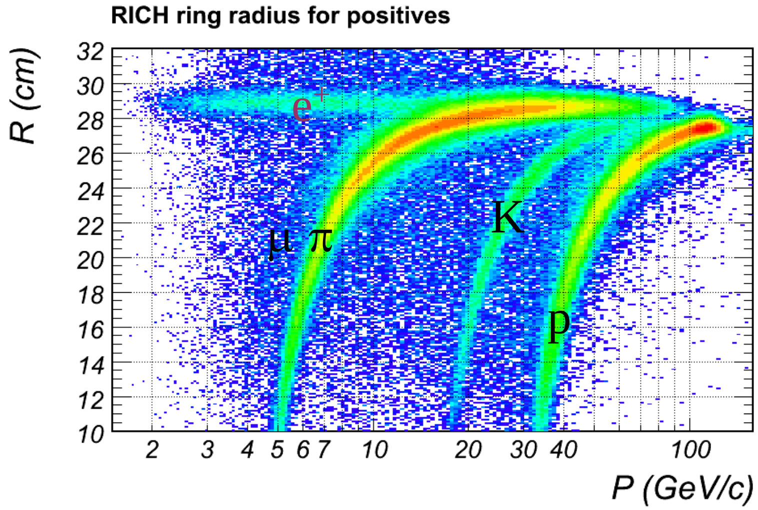
Particle ID status

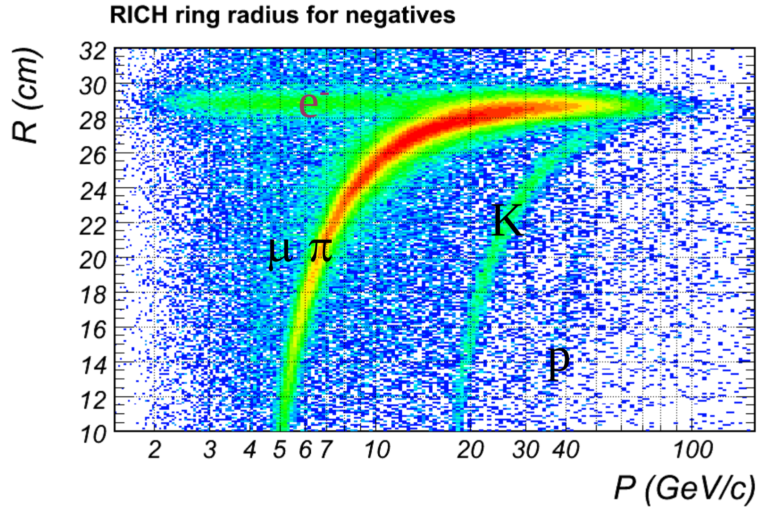
- TPC dE/dx calibration is in progress,
  - » Results to-date are promising
- TOF cable delays to be determined soon
- Cherenkov light calibration is largely done
- RICH calibration and likelihood calculation are nearly complete





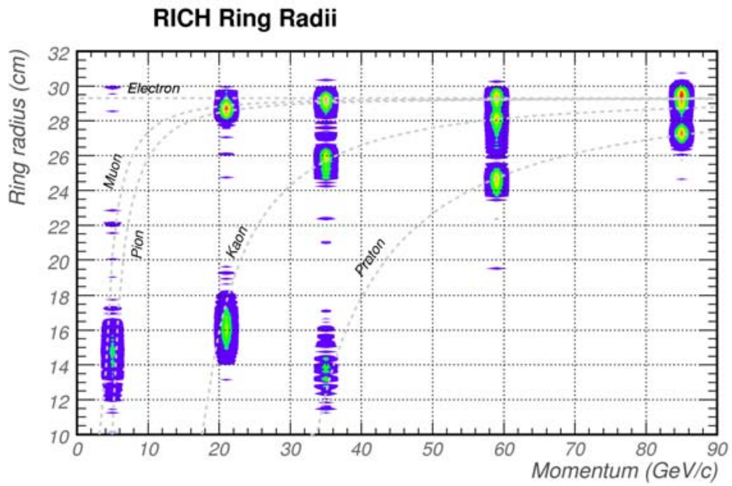
Particle ID (cont.)

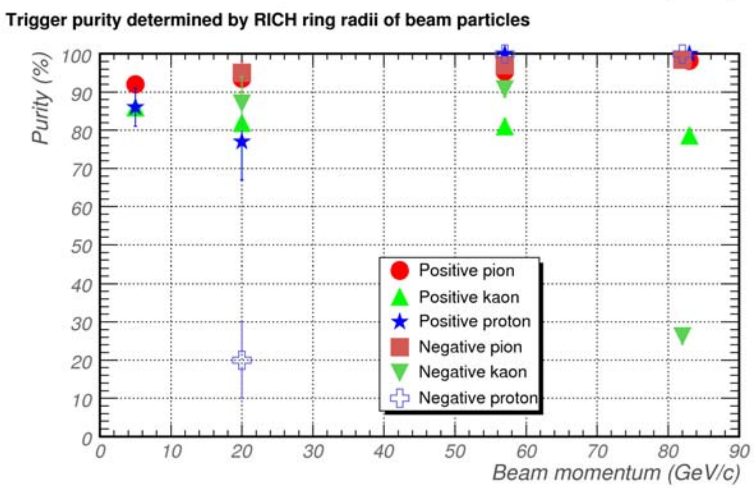




- RICH ring radius gives very good particle ID within acceptance
  - » e/μ/π to 12 GeV/c
  - ≈ π/K/p to 100 GeV/c
- Detector is calibrated and well understood

Secondary Beam Particle ID

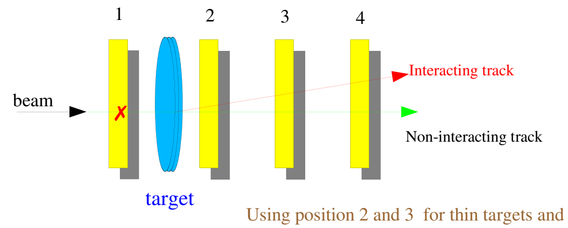


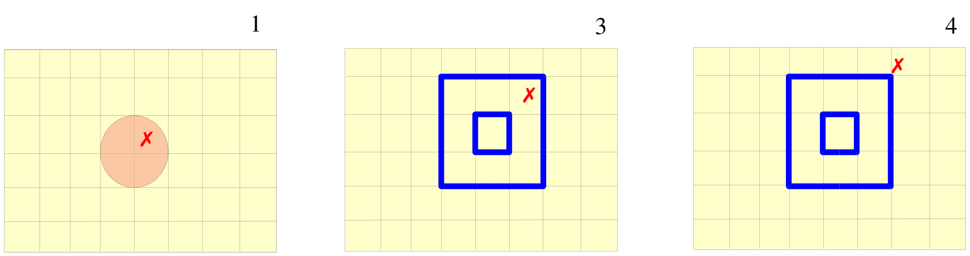


- 2 beam Cherenkov threshold counters separate π/K/p from 20 to 90 GeV/c
  - » N_2 for momenta above 30 GeV/c
  - » C_4F_8O for proton at 20 GeV/c
- Trigger purity measured with the RICH is typically above 80% for minority particle

MIPP Trigger Upgrade

- Beam sizes are large in MIPP due to the "low divergence" condition needed for beam CKOV's.
- Previous trigger of SCINT counter + 1st drift chamber wire signals performed satisfactorily for MIPP -I physics but needs improvement at low multiplicities—Landau tails.
- We propose to use silicon pixel counters (B-TEV, Phenix).
- 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.





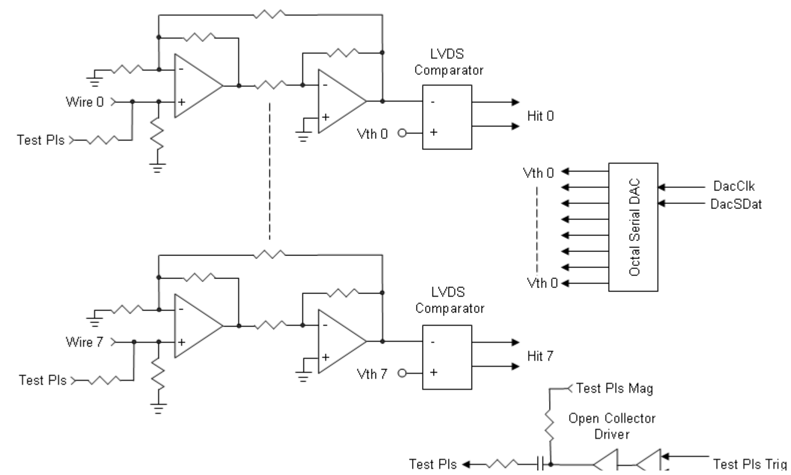
First layer before target tags where beam is and that there was only 1 hit cell. Brown circle represents where 86% of the beam hits the 4 cells in the center.

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

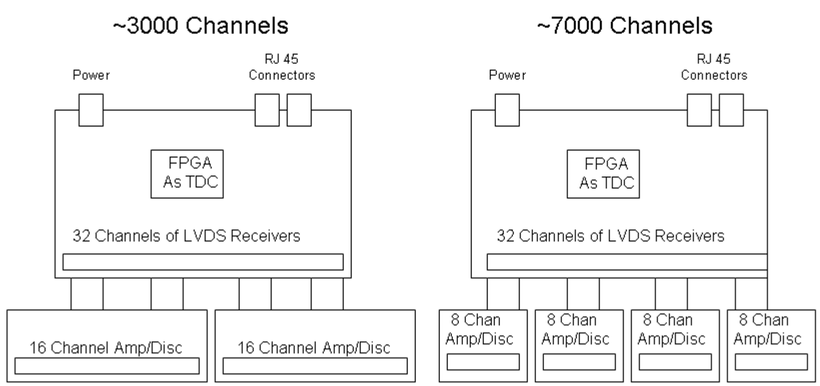
Drift Chamber/ PWC readout Upgrade

- Large PWC's use old CERN RMH electronics- Needs replacement.
- E690 electronics will work at these speed, if CAMAC DMA is implemented. The electronics are also aging and also put out a lot of heat.
- 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.
- WBS task 4.2 M&S $121.2K, Labor $28.7K. Newest of the design efforts. Probably need to add 50% contingency.

8 Channel Amp/Disc – One per 8 channel Card, Two per 16 channel Card



High-Speed Differential Interfaces
"Cyclone II devices can transmit and receive data through LVDS signals at a data rate of up to 640 Mbps and 805 Mbps, respectively. For the LVDS transmitter and receiver, the Cyclone II device's input and output pins support serialization and deserialization through internal logic."



Data Taken In current run

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[1]	Normal		*0.10*	*0.14*			*0.52*			*0.25*	***1.01***
	K Mass[2]	No Int.				*5.48*	*0.50*	*7.39*	*0.96*			***14.33***
	Empty LH[1]	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**

Spallation products

- Such a recoil detector coupled with the TPC can detect spallation products such as "grey" and "Black" protons, and neutrons as well as nuclear fragments.
- Table from Textbook on Calorimetry by Wigmans

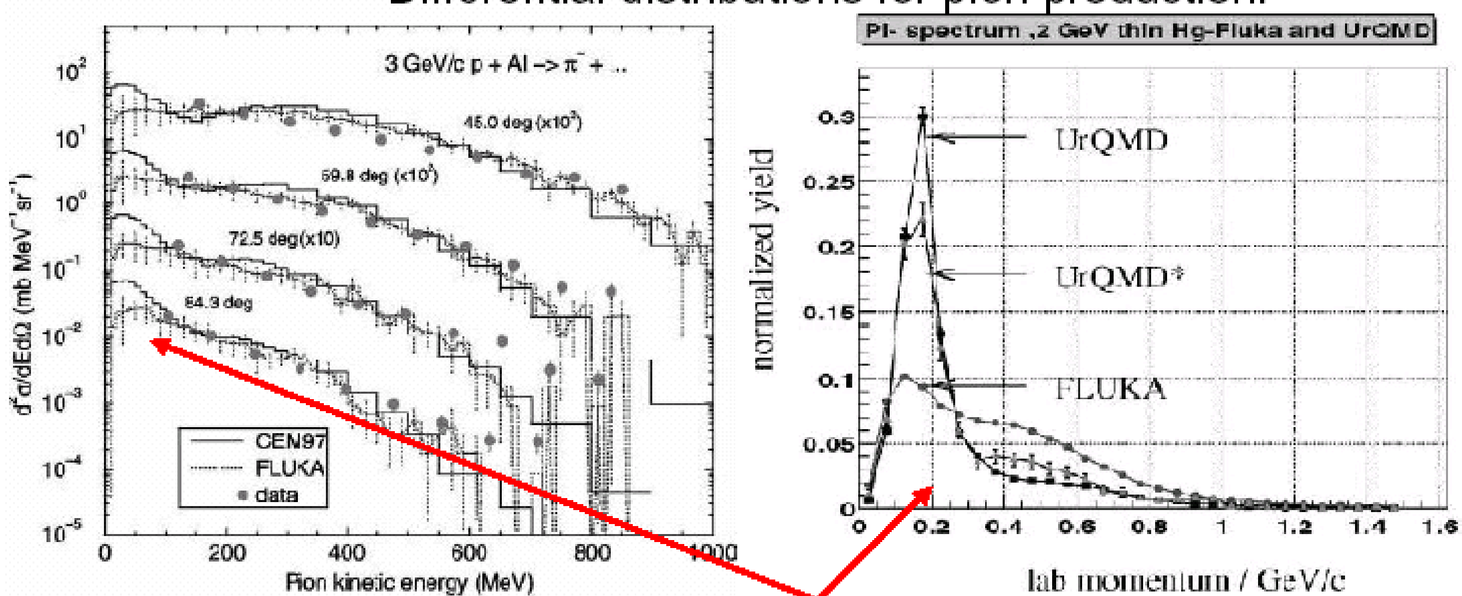
	Binding Energy	Evaportion n (# neutrons)	Cascade n (# neutrons)	Ionization (#cascade p)	Target recoil
Before first reaction				(250)(π_{in})	
First reaction	126	27(9)	519 (4.2)	350(2.8)	28
Generation 2	187	63(21)	161(1.7)	105(1.1)	3
Generation 3	77	24(8)	36(1.1)	23 (0.7)	1
Generation 4	24	12(3)			
Total	414	126(41)		478(4.6)	32

TABLE I: Destination of 1.3 GeV total energy carried by an average pion produced in hadronic shower development in lead. Energies are in MeV.

Discrepancies between hadronic generators

Lack of experimental data and large uncertainties in the calculations,
in particular for thick and high Z target materials

Differential distributions for pion production:



NIMA451(2000)327

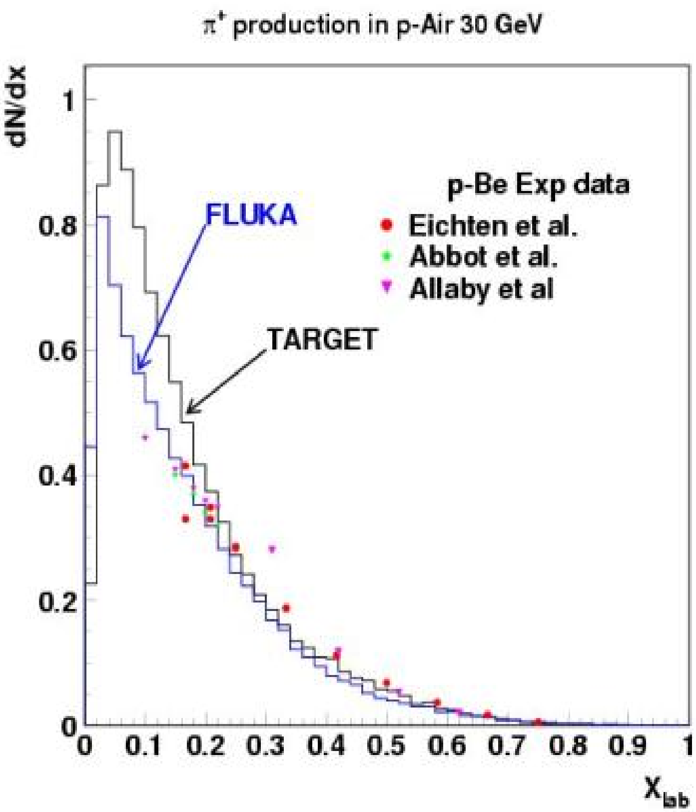
NIMA472(2001)5

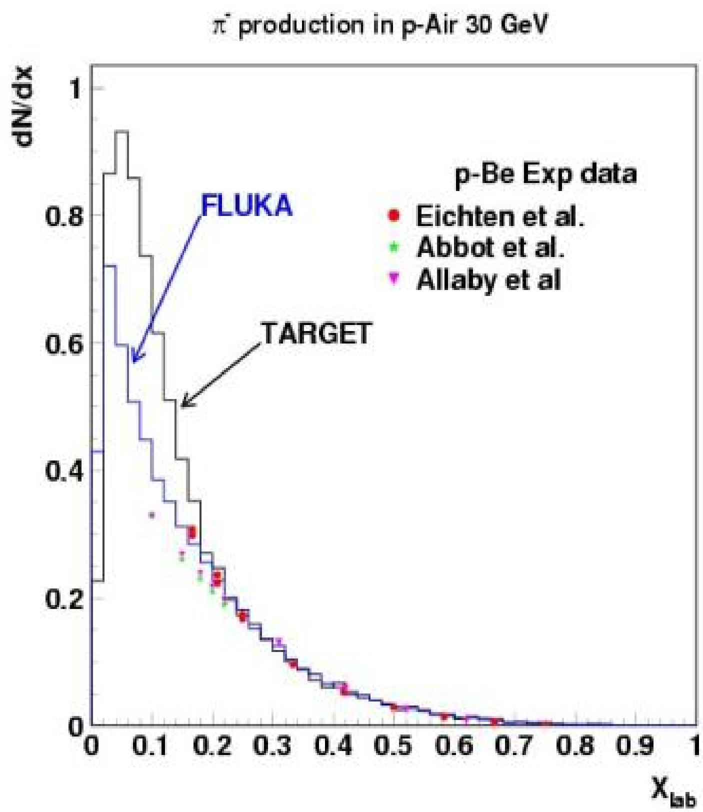
NO DATA !

➔ Thin and thick targets, scan in Z

Discrepancies between hadronic generators- Testing particle production off nitrogen(Be extrapolated)

27





G.Battistoni

The 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- These electronics (E690/RMH) worked well for the first run. They are old (1990's). RMH will not do 3kHz. We will replace both systems with a new design that utilizes some of the infrastructure we developed for the RICH readout.
- ToF/CKOV readout-Plan to build new readout based on TripT chip (Used by Minerva) and a high resolution TDC chip. 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 FERA ADC's (PREP).
- 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 on each detector and read out the whole lot at end of spill.

The Proposal in a nutshell

- MIPP one can take data at ~30Hz. The limitation is the TPC electronics which are 1990's vintage. We plan to speed this rate up to 3000Hz 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 have decided to replace both the top and bottom coils with newly designed aluminum coils that have better field characteristics for the TPC drift. The coil order has been placed ($200K).
- 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). The order had to go in with a bigger STAR collaboration order to reduce overhead. We expect delivery in the new year of tested chipsets.