MINERvA detector: description and performance

Bari Osmanov

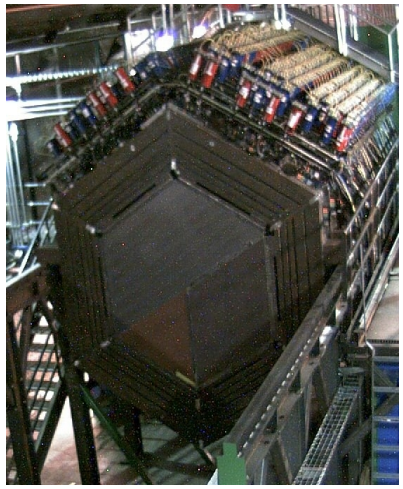
University of Florida
(on behalf of MINERvA collaboration)

OUTLINE

- Experiment overview
- Neutrino flux
- Detector description
- Nuclear targets
- Analysis chain and preliminary results
- Future plans

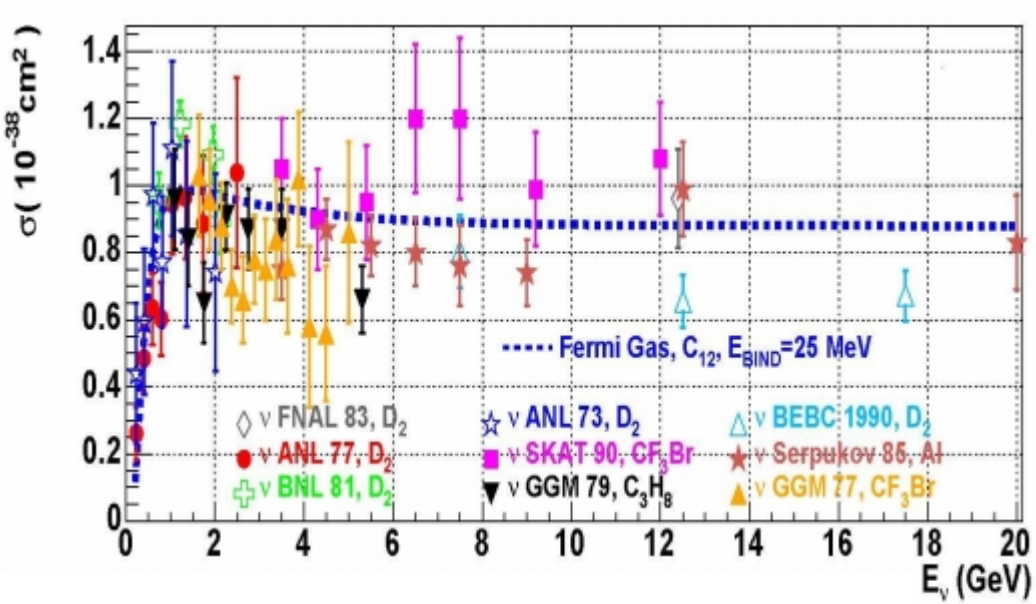
Experiment overview

Detector: finely-segmented scintillator with electromagnetic and hadron calorimetry regions as well as nuclear targets

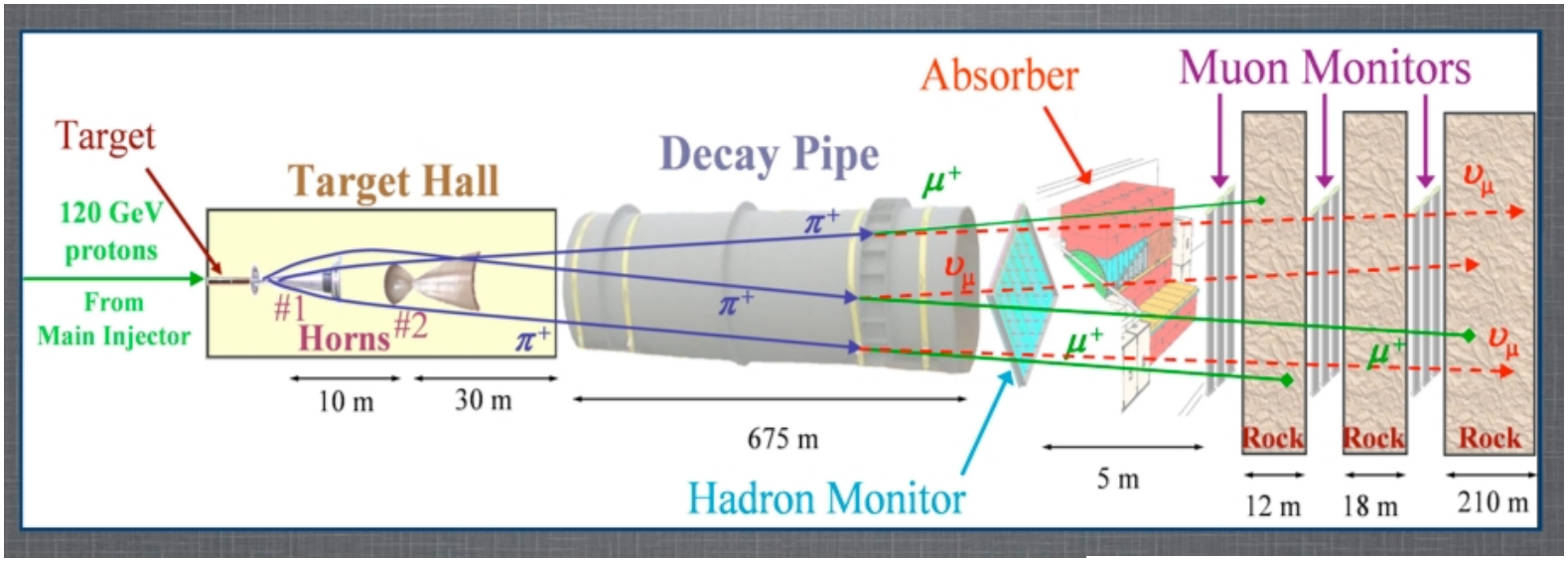


Location: Fermilab, 330 ft underground

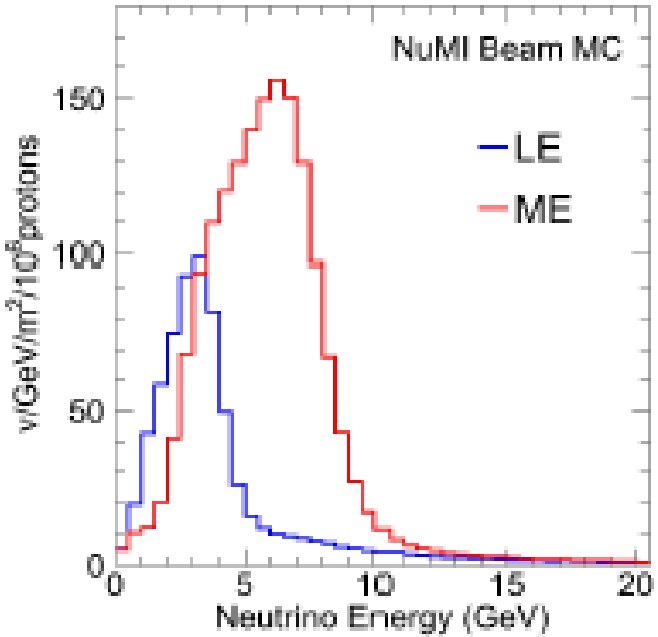
Goals: precise measurements of neutrino-interaction cross-sections for various channels; study of nuclear effects in neutrino interactions



Neutrino flux (I)



- variable beam mode (ν_μ or $\bar{\nu}_\mu$) through changing horn polarity
- variable energy beam through changing horn current and target position
- source-detector distance is ~ 1 km
- monitors for proton, hadron and muon beams



Neutrino flux (II)

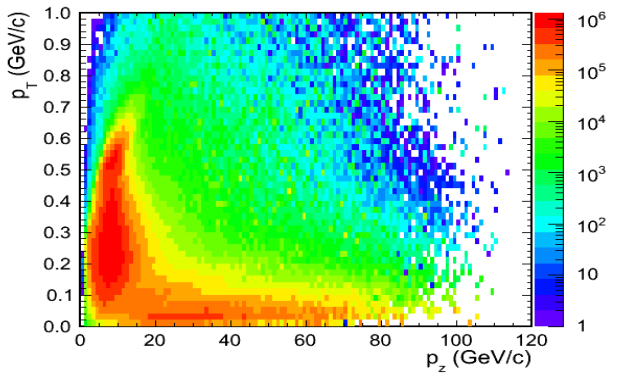
"Low" Energy

π^+ p_T=300 MeV/c and:

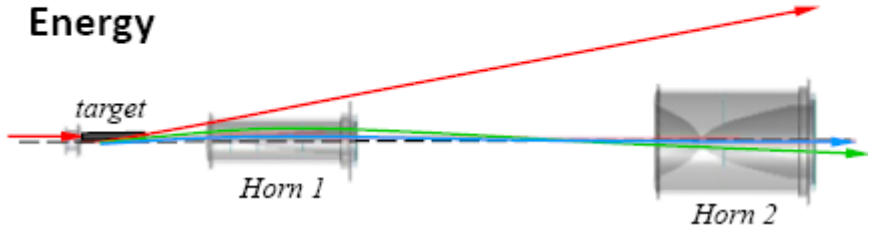
p=5 GeV/*c*

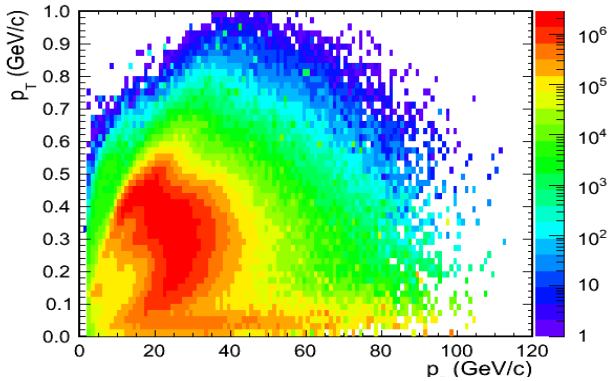
p=10 GeV/*c*

p=20 GeV/*c*

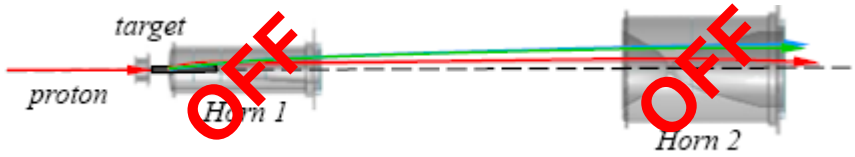


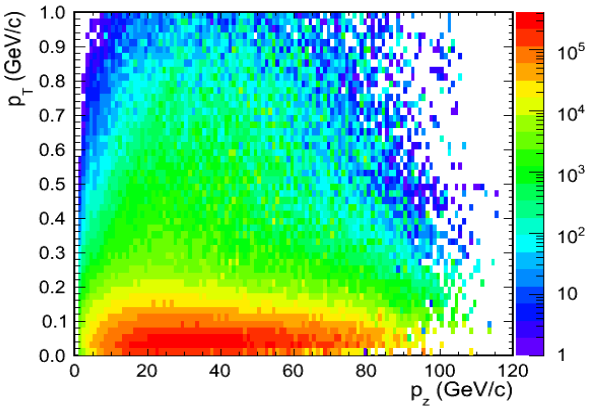
"High" Energy





"Horn off"

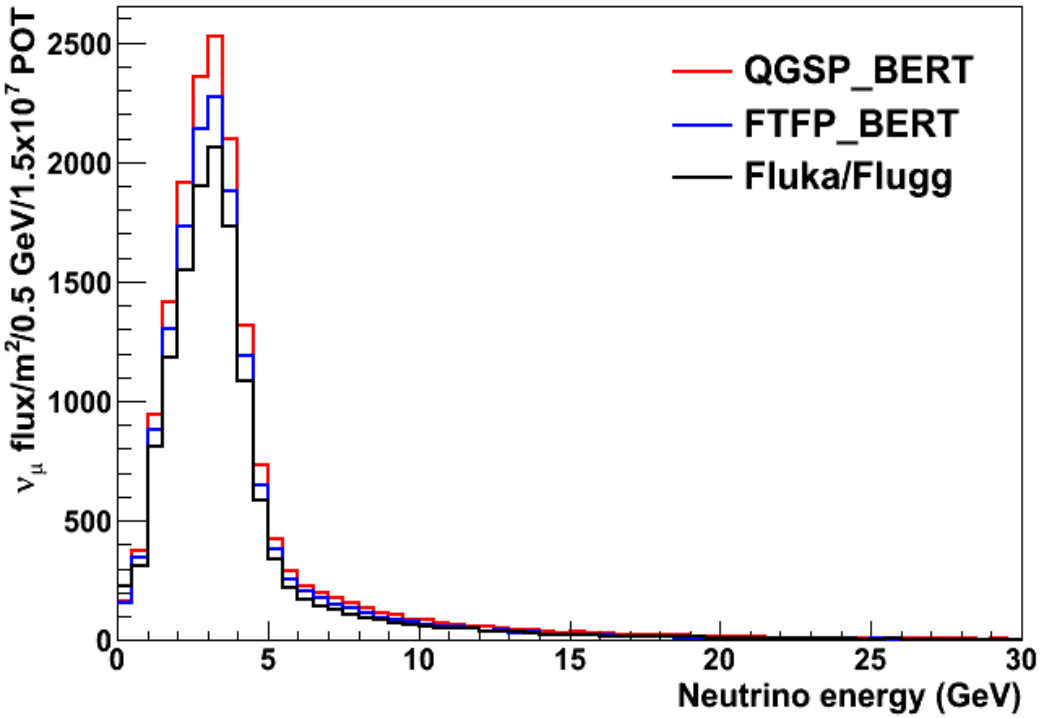




Neutrino flux (III)

Special runs

Aim: to reduce the flux uncertainties that come from hadron production at the target



Geant4 LE beam simulation with the same geometry but different hadron production models

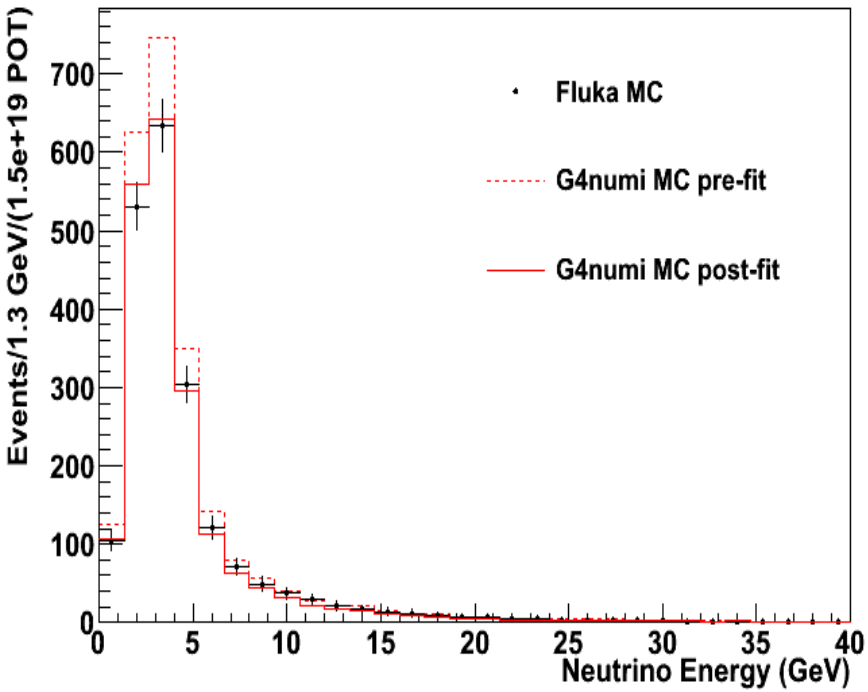
Results in ~ 10% spread

Neutrino flux (IV)

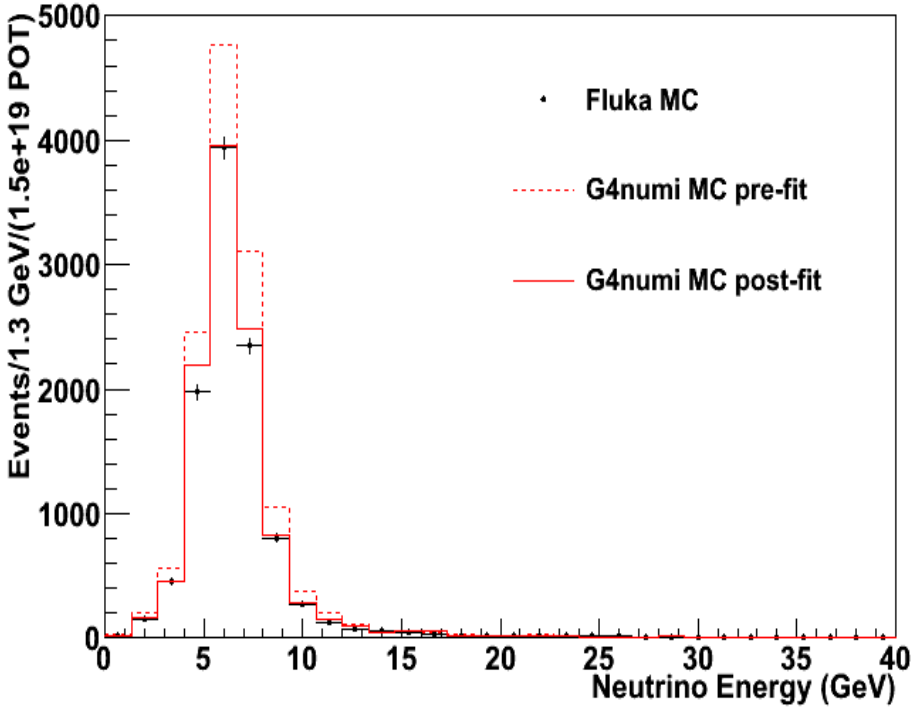
Special runs

Approach: take a series of beam runs with varying target position and horn current and then tune hadron production in MC to match the observed spectra in data

LE, target at 10 cm, horn current 185 kA

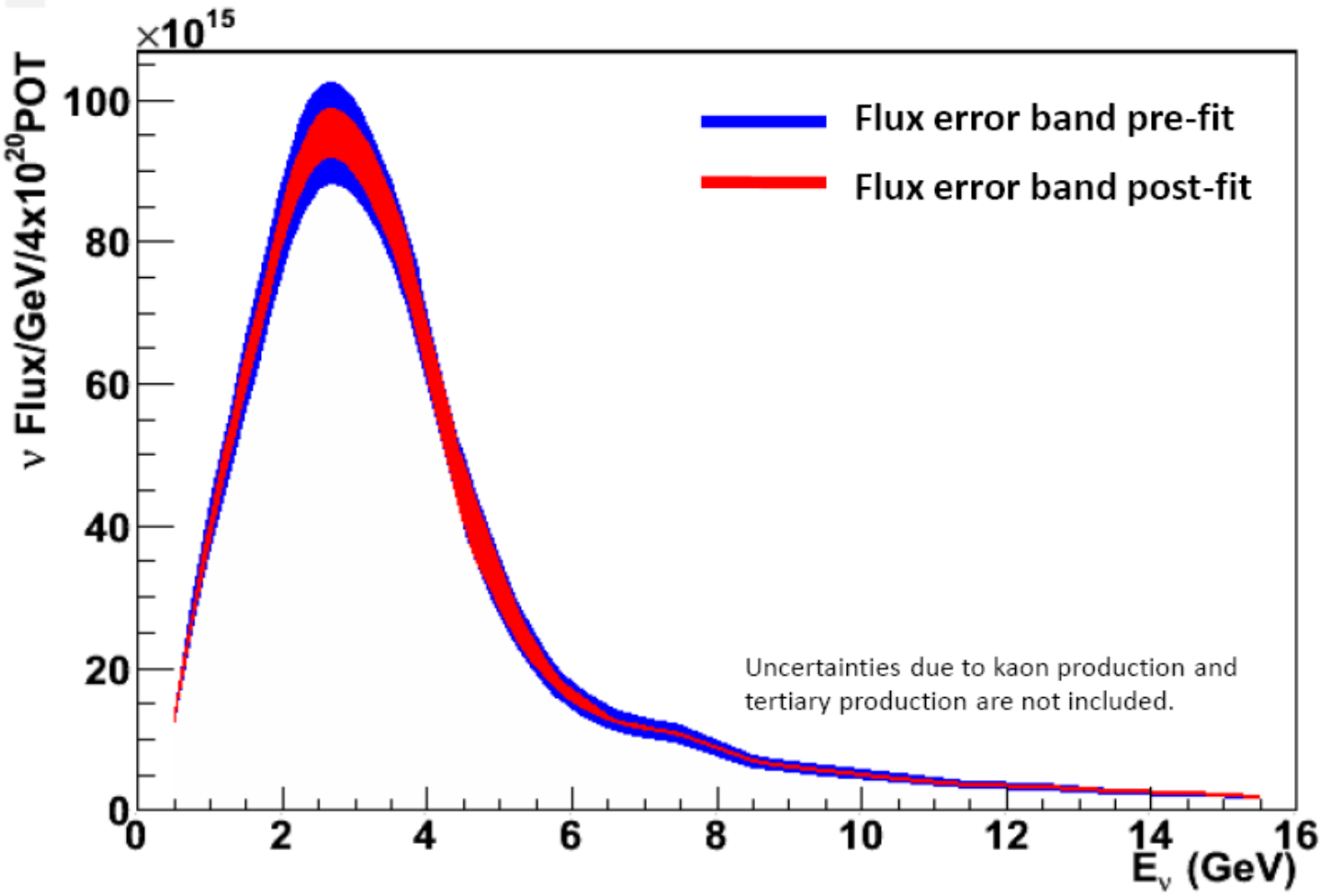


LE, target at 100 cm, horn current 200 kA



Neutrino flux (V)

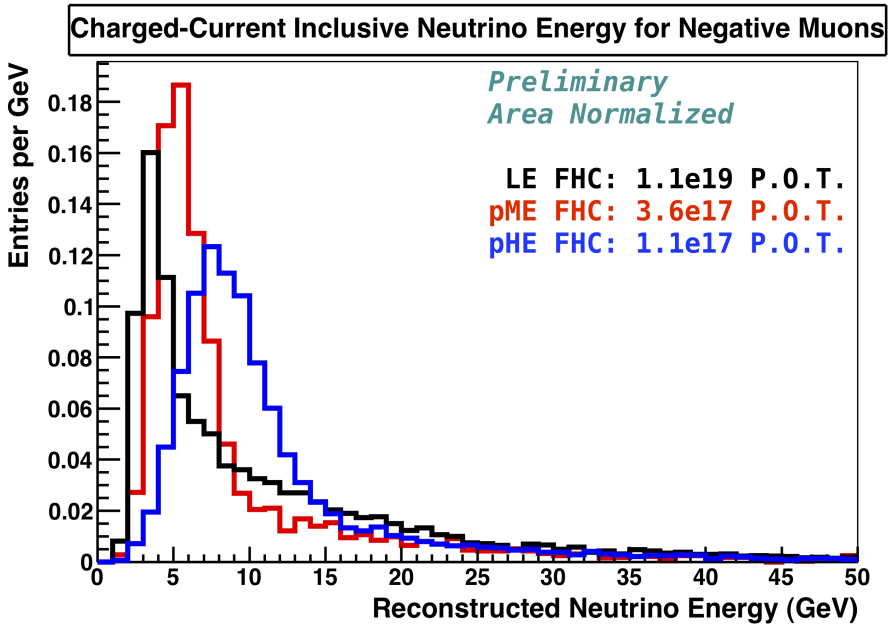
Resulting reduction of errors



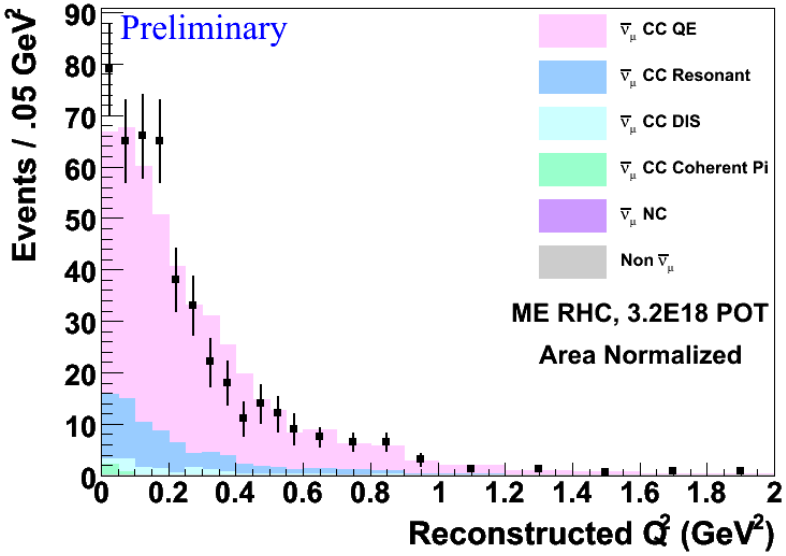
Neutrino flux (VI)

Preliminary results from special runs data (analysis in progress)

Reconstructed neutrino energy of CC inclusive candidates in standard running and special runs (data only)

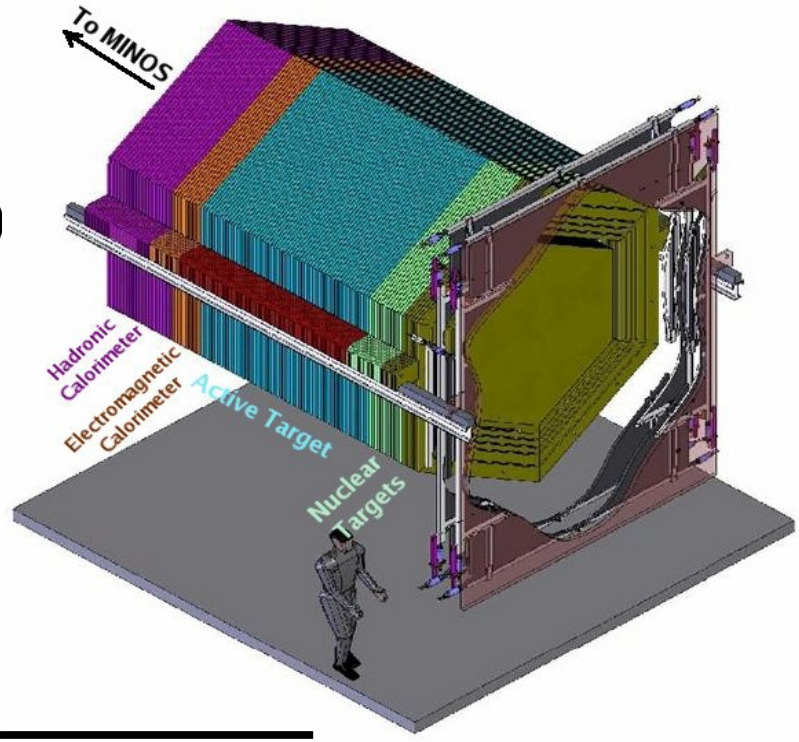


Reconstructed Q^2 of CC quasi-elastic candidates in anti-neutrino special run (data and MC)

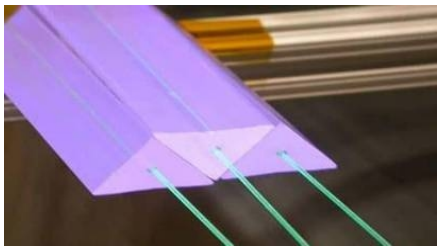
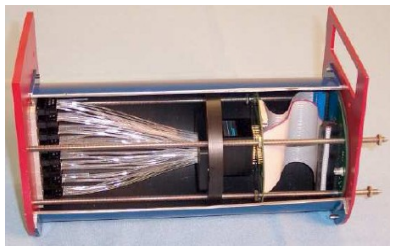


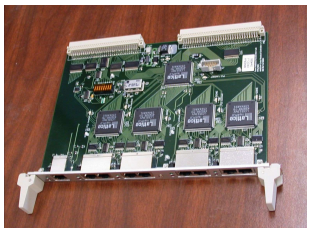
Detector description

- 30K scintillator channels grouped into inner and outer detectors
- Electromagnetic (lead) and hadronic (iron) calorimetry regions
- Nuclear targets (^{4}He, C, Fe, Pb, H_2O)
- Veto wall in front of the detector
- MINOS near detector as muon catcher



scintillator light
WLS fiber
clear fiber → PMT → front-end board → crate → storage

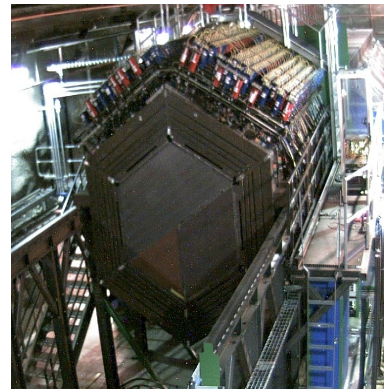






Nuclear targets (I)

- One of the physics goals of MINERvA experiment is to study nuclear effects in neutrino interactions

- Several nuclear targets inside and in front of detector
- Active scintillator (6.43 tons) as a plastic (CH) target

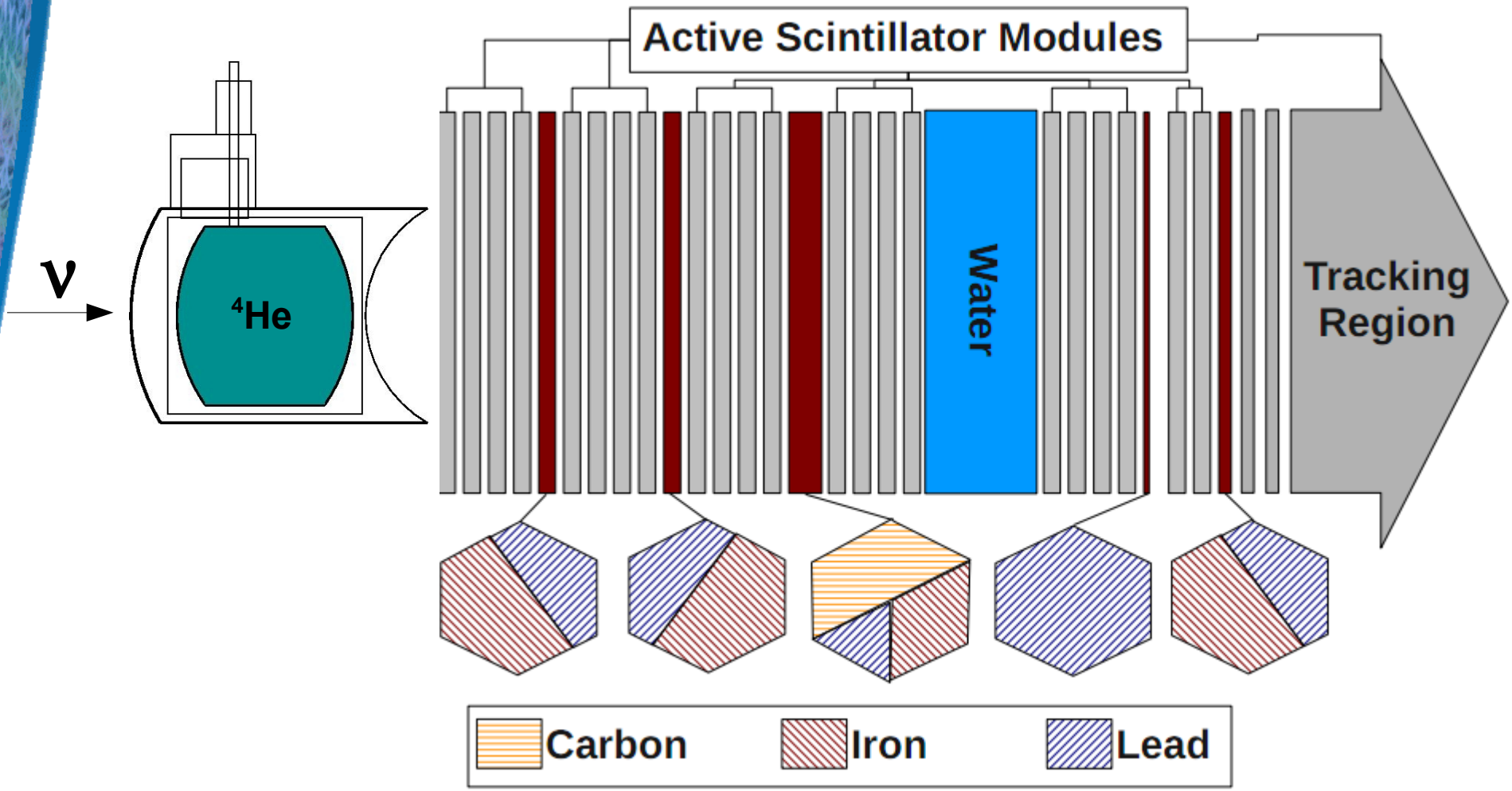


- ^{4}He (0.25 tons) in front of the detector
- C (0.17 tons), Fe (0.97 tons) and Pb (0.98 tons) inside the detector

- H_2O (0.39 tons) target under construction

Nuclear targets (II)

Location of targets in the detector



Event rates

- **Approved for 4.9E20 POT in low-energy and 12E20 POT in medium-energy beam configuration**

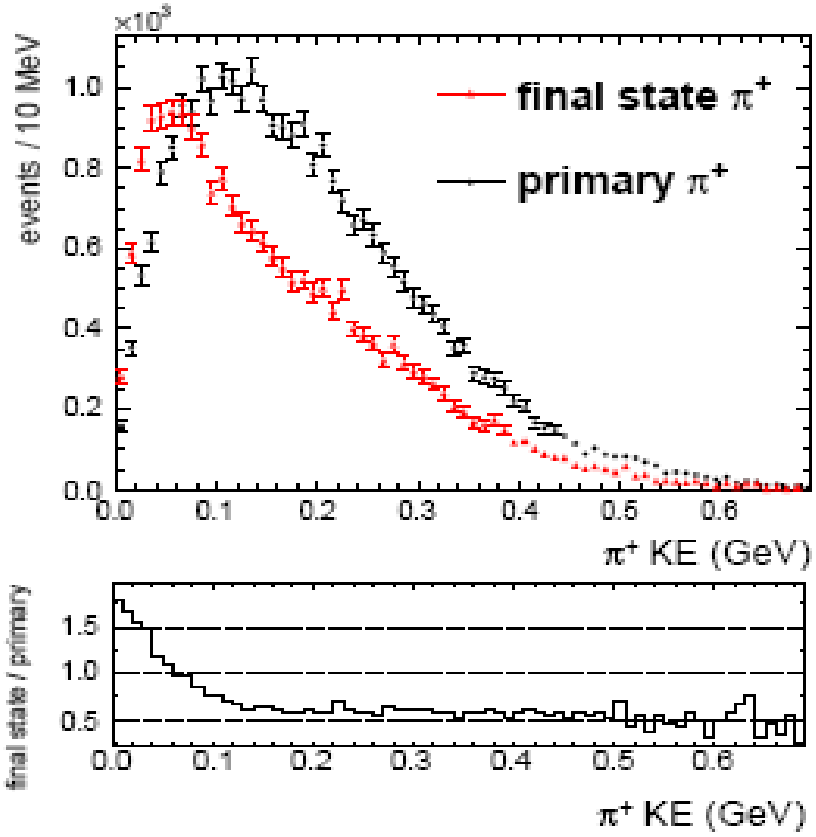
- **So far: 1.5E20 POT for LE neutrino and 1.3E20 POT for LE antineutrino (full detector geometry)**

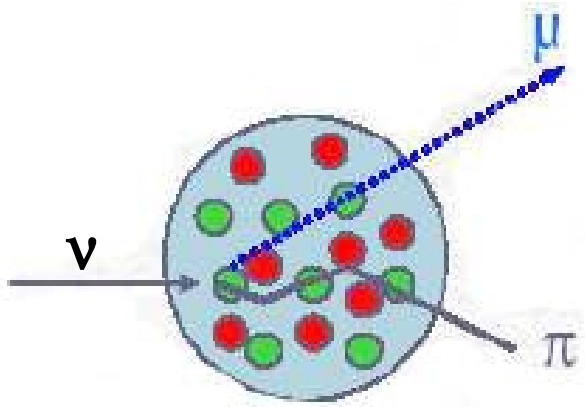
Target	Fiducial Mass	ν_μ CC Events in 1.2e20 P.O.T.
Plastic	6.43 tons	409k
Helium	0.25 tons	16.8k
Carbon	0.17 tons	10.8k
Water	0.39 tons	24.4k
Iron	0.97 tons	64.5k
Lead	0.98 tons	68.4k

(interaction rates from Genie 2.6.2. event generator)

Physics goals (I)

- **Final state interactions (e.g. pion absorption in the nucleus)**

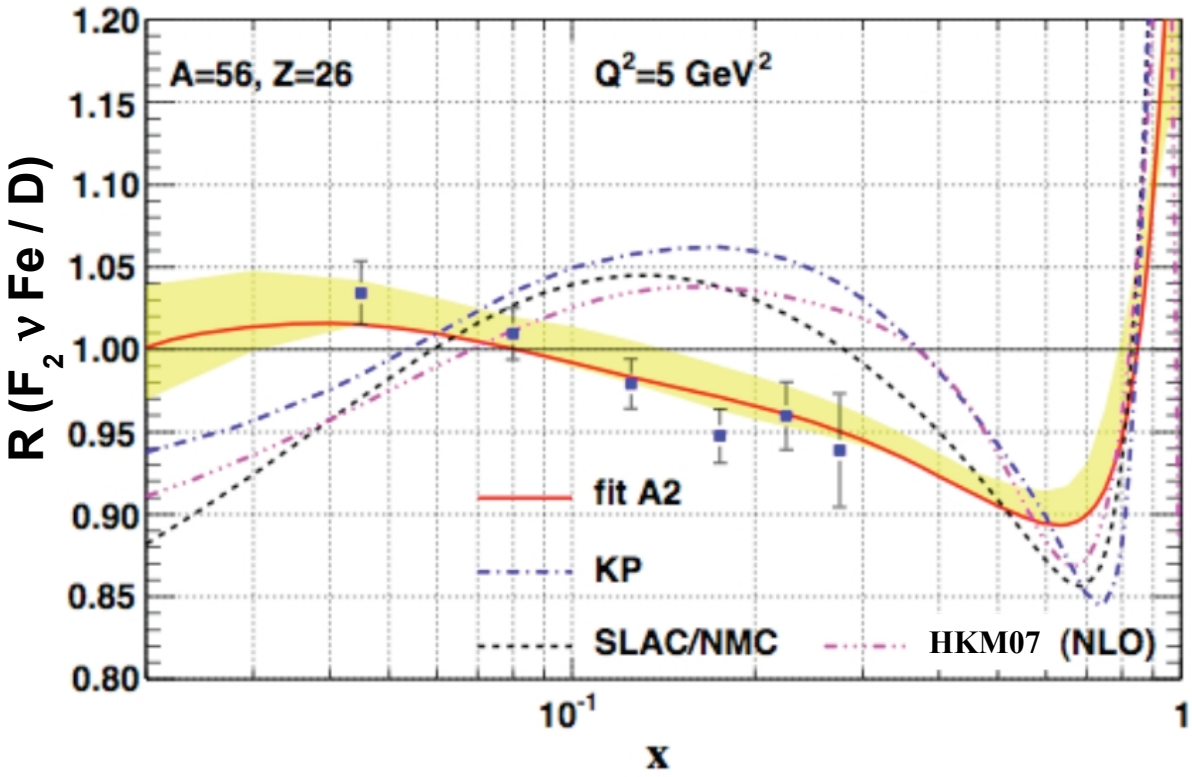




Kinetic energy spectrum of final state and primary π+ from ν + Fe^{56} interactions at 1 GeV (from GENIE manual at http://projects.hepforge.org/genie)

Physics goals (II)

- x-dependence of nuclear effects



A2 – CTEQ fit to NuTeV data on iron (blue points) with free nucleon PDFs for deuterium

KP – Kulagin-Petti nuclear model

SLAC/NMC – charged-lepton nucleus scattering

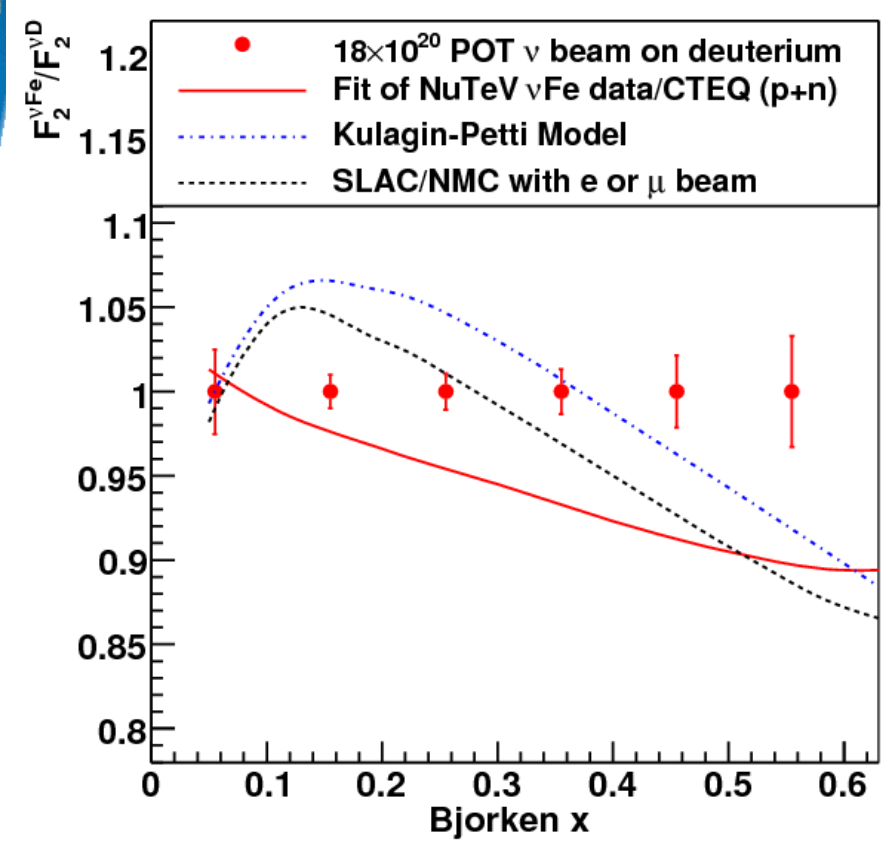
HKM07 – KEK theory center nuclear pdf analysis

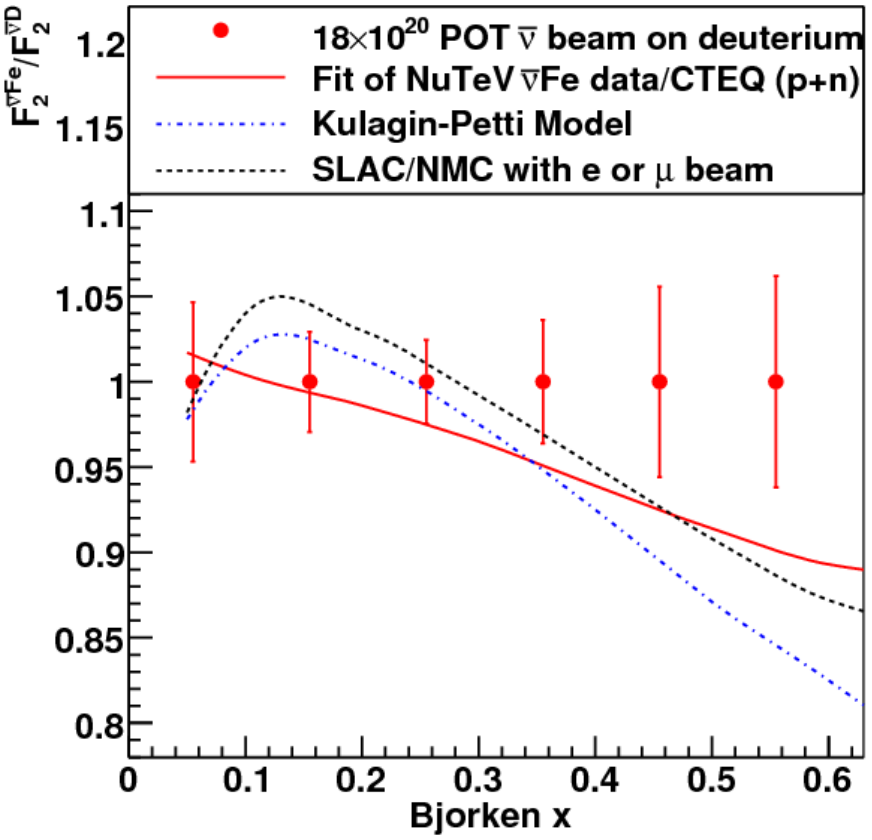
Modification of F2 in comparison with charged-lepton scattering and other analyses

Physics goals (III)

Proposal to fill the cryotarget with deuterium

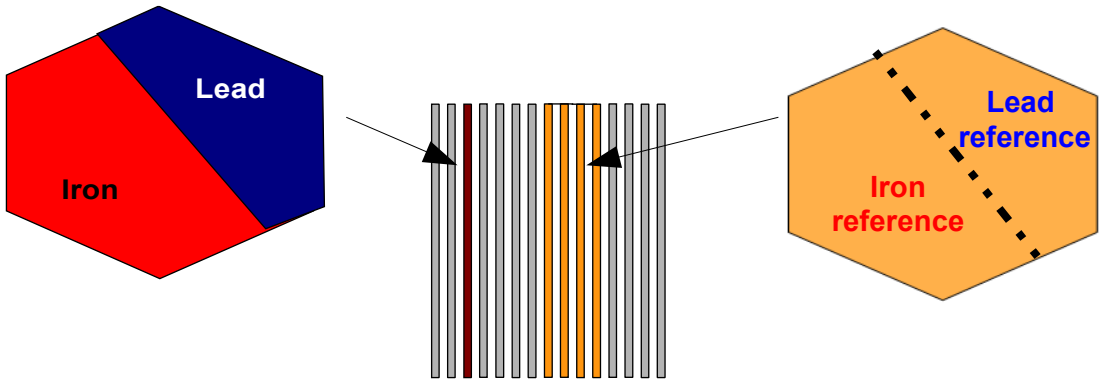
High-precision nuclear-to-D (A/D) ratio measurements





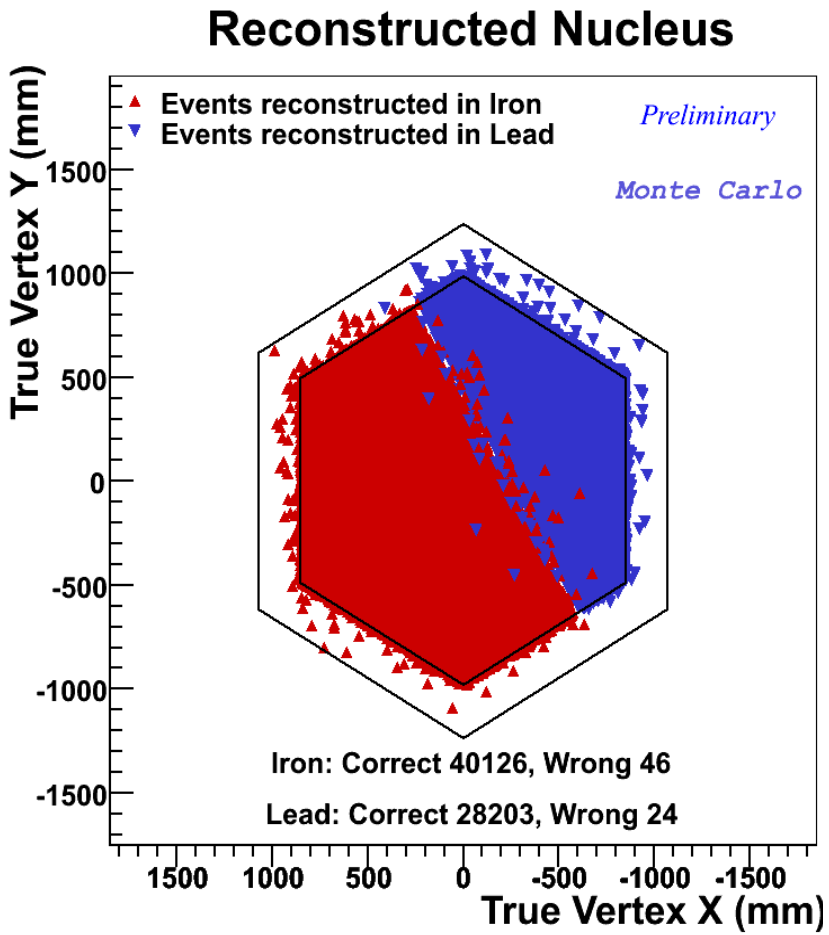
Analysis chain

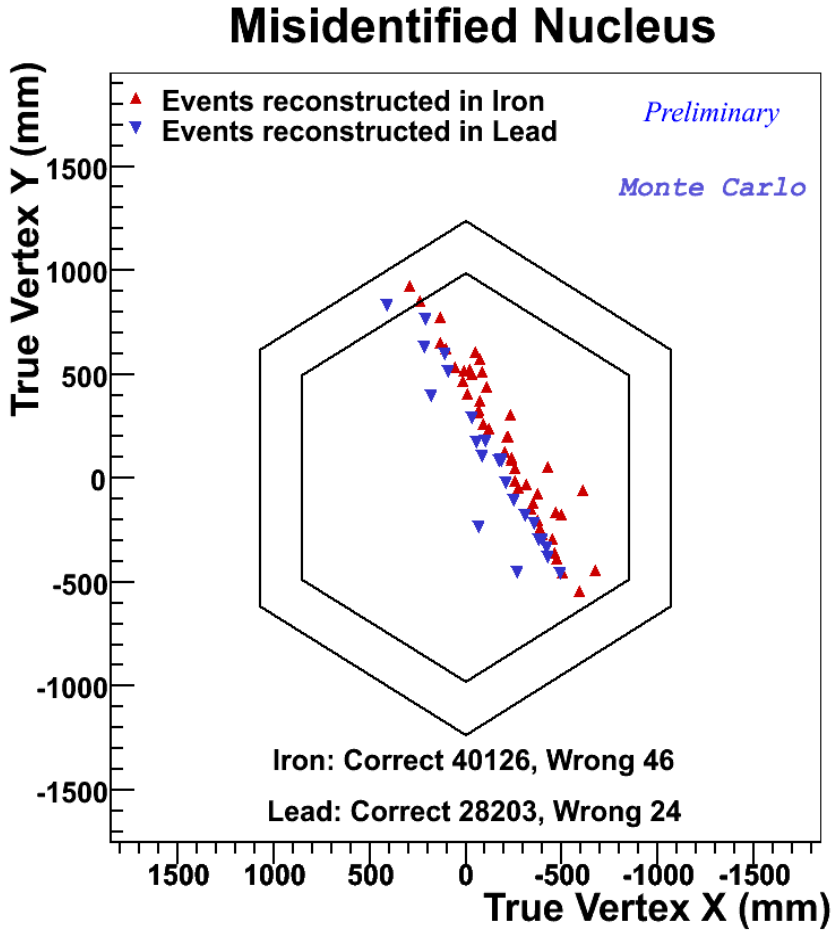
- studying the most downstream target (Fe/Pb)
- CC vμ events in lead, iron and plastic
- one muon track matched to MINOS with reconstructed energy and charge(-)
- fiducial volume – 85 cm hexagon
- z position of muon vertex in nuclear target or the first module downstream
- data sample: 0.9E20 POT LE neutrino mode
- MC sample: 11.2E20 POT LE neutrino mode
- statistical + flux errors
- Plastic reference target with the same divide as the real target (with the aim to compare CH to Fe and Pb)



Preliminary results (I)

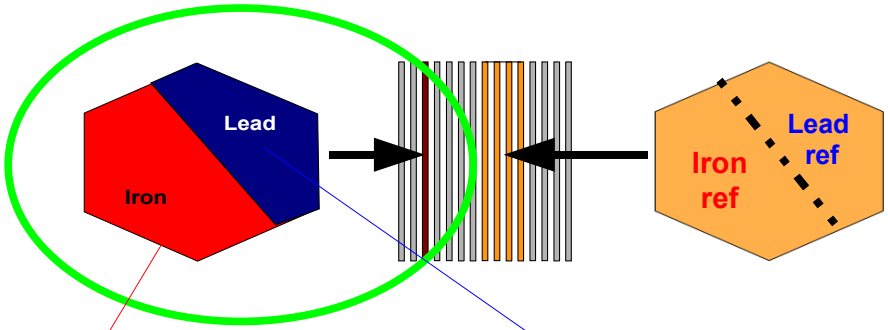
Event misidentification (MC)



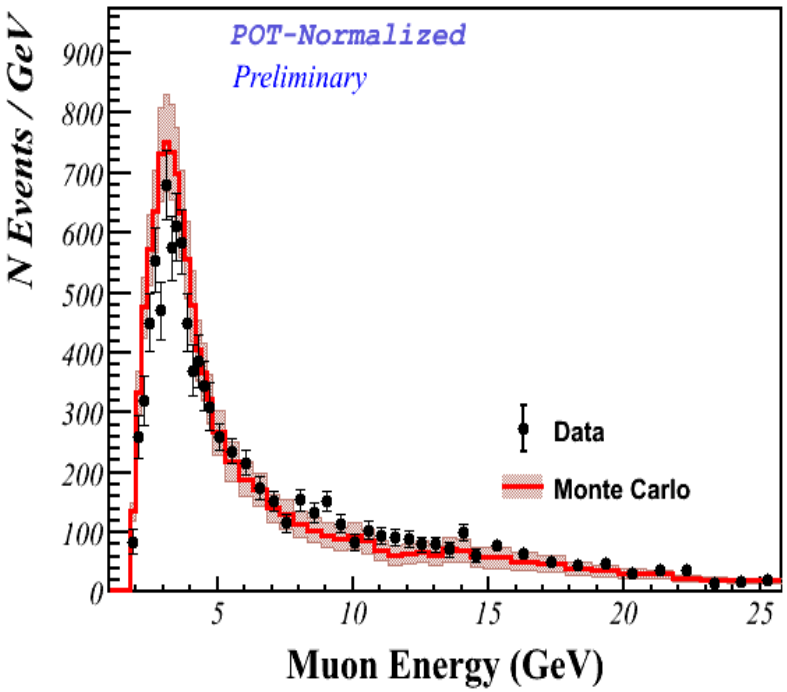


Preliminary results (II)

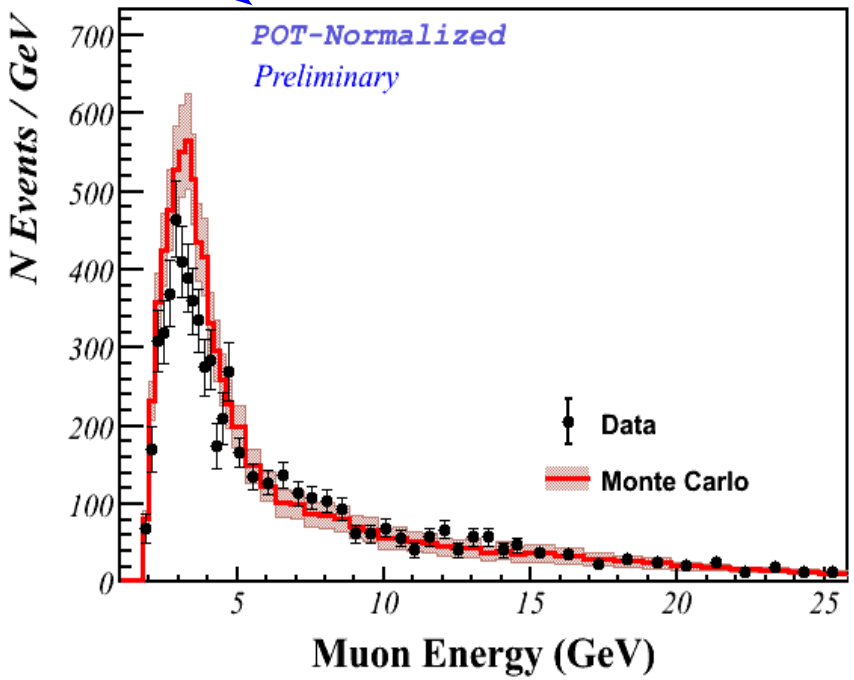
Reconstructed muon energy CC numu (data/MC)



Iron-Enriched Sample

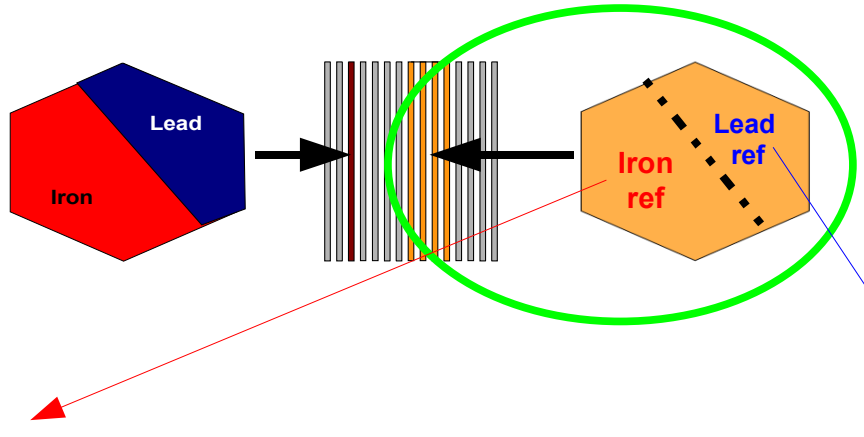


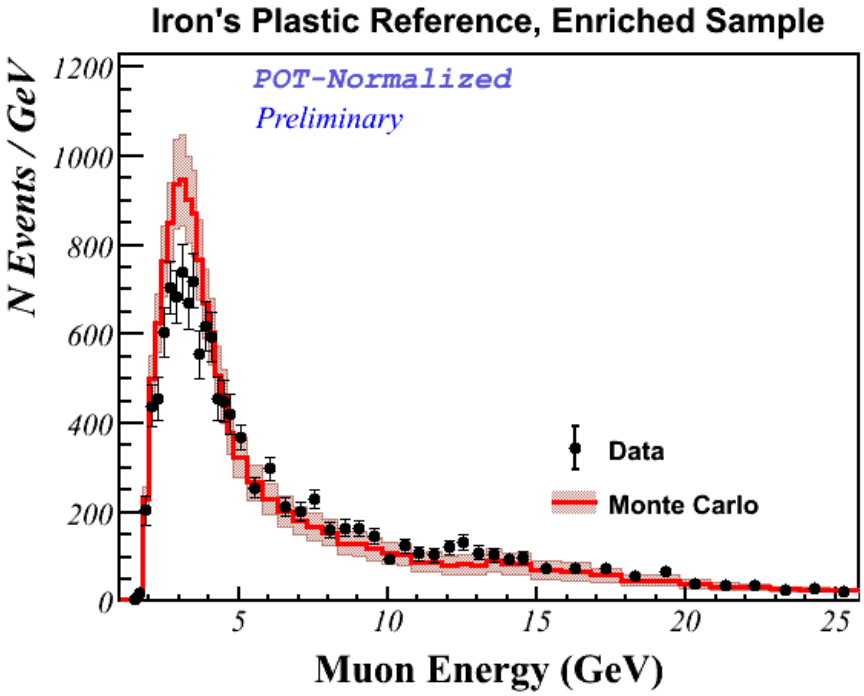
Lead-Enriched Sample

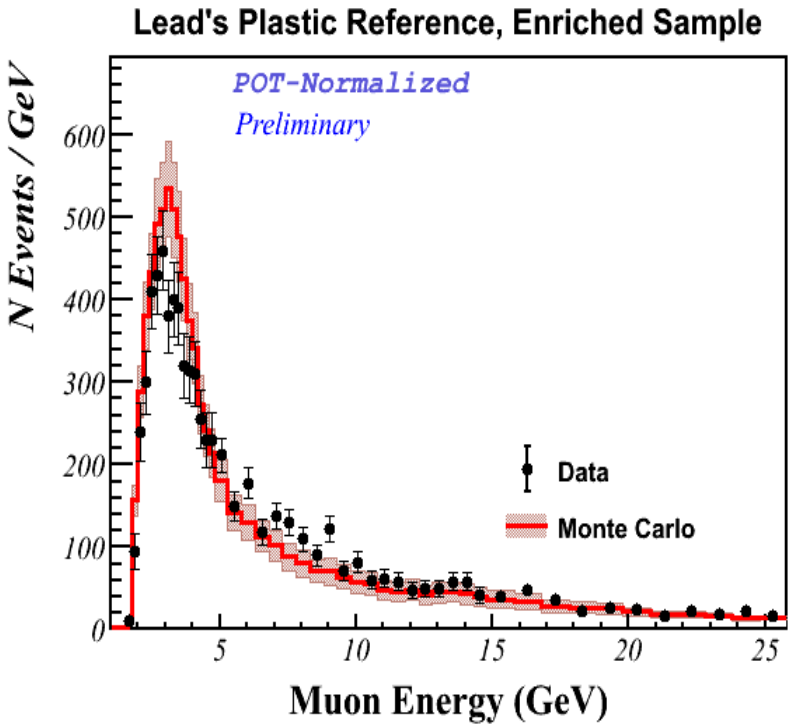


Preliminary results (III)

Reconstructed muon energy CC numu (data/MC)

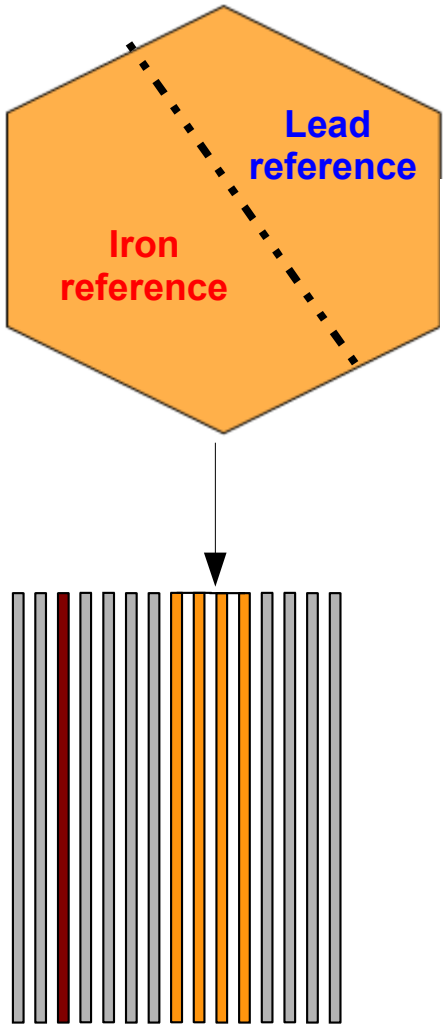






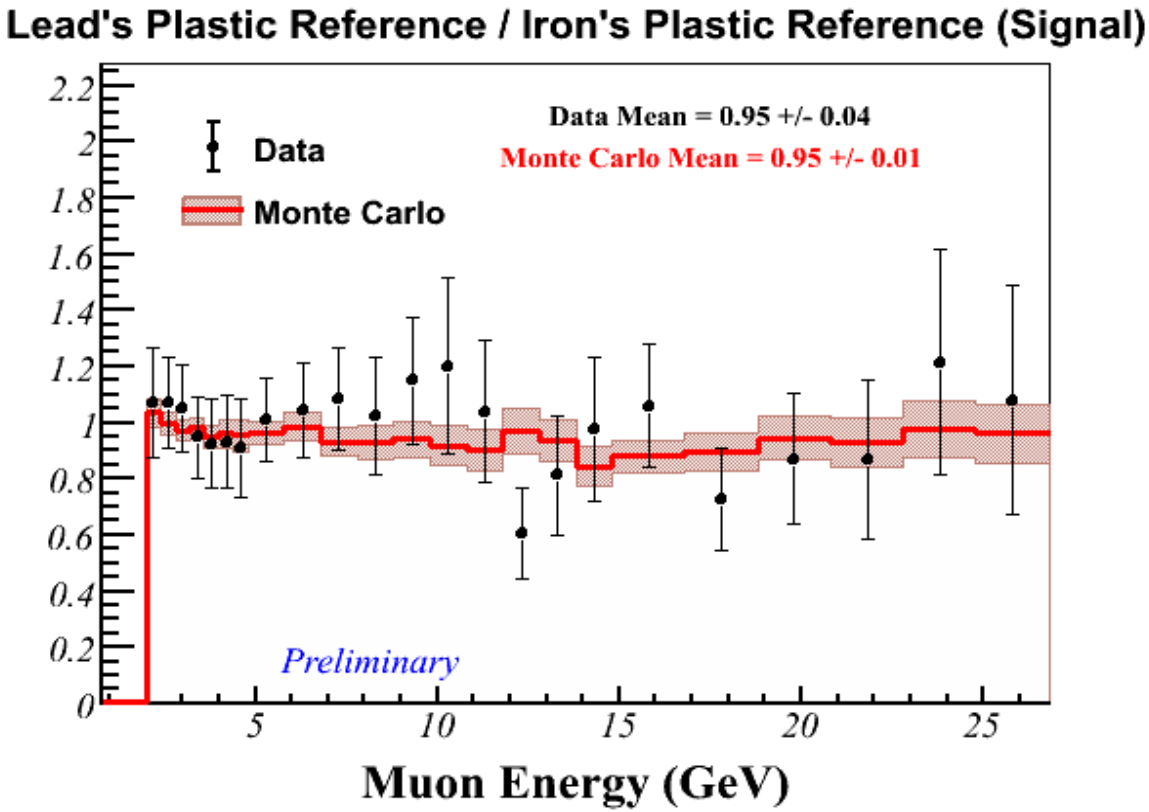
Preliminary results (IV)

Plastic to plastic comparison (data/MC)



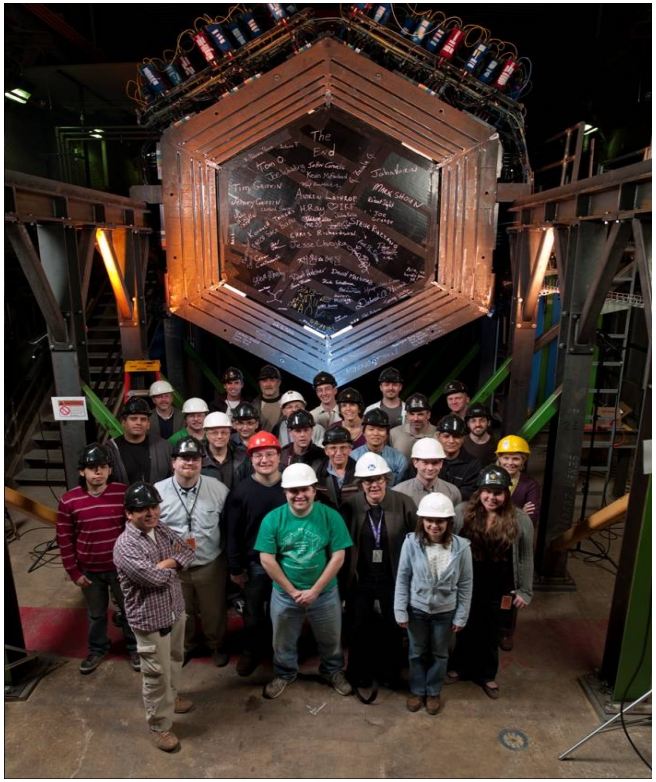
Data: 0.9E20 POT LE neutrino mode

MC: 11.2E20 POT LE neutrino mode



Future plans

- Detector is up and running and taking a data
- Work in progress on reconstruction and various analysis channels
- For nuclear targets we will have 4x more POT and 4x more mass for final analysis – very precise measurement
- Ratio plots among nuclear targets and CH are coming very soon
- Stay tuned



THANK YOU

G. Tzanakos
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Fermilab

J. Felix, A. Higuera, Z. Urrutia, G. Zavala
Universidad de Guanajuato

M.E. Christy, C. Keppel, P. Monagham, T. Walton, L. Y. Zhu
Hampton University

A. Butkevich, S.A. Kulagin
Inst. Nucl. Reas. Moscow

G. Niculescu, I. Niculescu
James Madison University

E. Maher
Mass. Col. Lib. Arts

L. Fields, B. Gobbi, L. Patrick, H. Schellman
Northwestern University

N. Tagg
Otterbein College

S. Boyd, I. Danko, S.A. Dytman, B. Eberly, Z. Isvan, D. Naples, V. Paolone
University of Pittsburgh

A. M. Gago, N. Ochoa, J.P. Velasquez
Pontificia Universidad Catolica del Peru

S. Avvakumov, A. Bodek, R. Bradford, H. Budd, J. Chvojka, M. Day, H. Lee, S. Manly, C. Marshall, K.S. McFarland, A. M. McGowan, A. Mislivec, J. Park, G. Perdue, J. Wolcott
University of Rochester

G. J. Kumbartzki, T. Le, R. D. Ransome, E. C. Schulte, B. G. Tice
Rutgers University

H. Gallagher, T. Kafka, W.A. Mann, W. P. Oliver
Tufts University

C. Simon, B. Ziemer
University of California at Irvine

R. Gran, M. Lanari
University of Minnesota at Duluth

M. Alania, A. Chamorro, K. Hurtado, C. J. Solano Salinas
Universidad Nacional de Ingeniera

W. K. Brooks, E. Carquin, G. Maggi, C. Pea, I.K. Potashnikova, F. Prokoshin
Universidad Tcnica Federico Santa Mara

L. Aliaga, J. Devan, M. Kordosky, J.K. Nelson, J. Walding, D. Zhang
College of William and Mary