Comment from applied cosmic ray physicist

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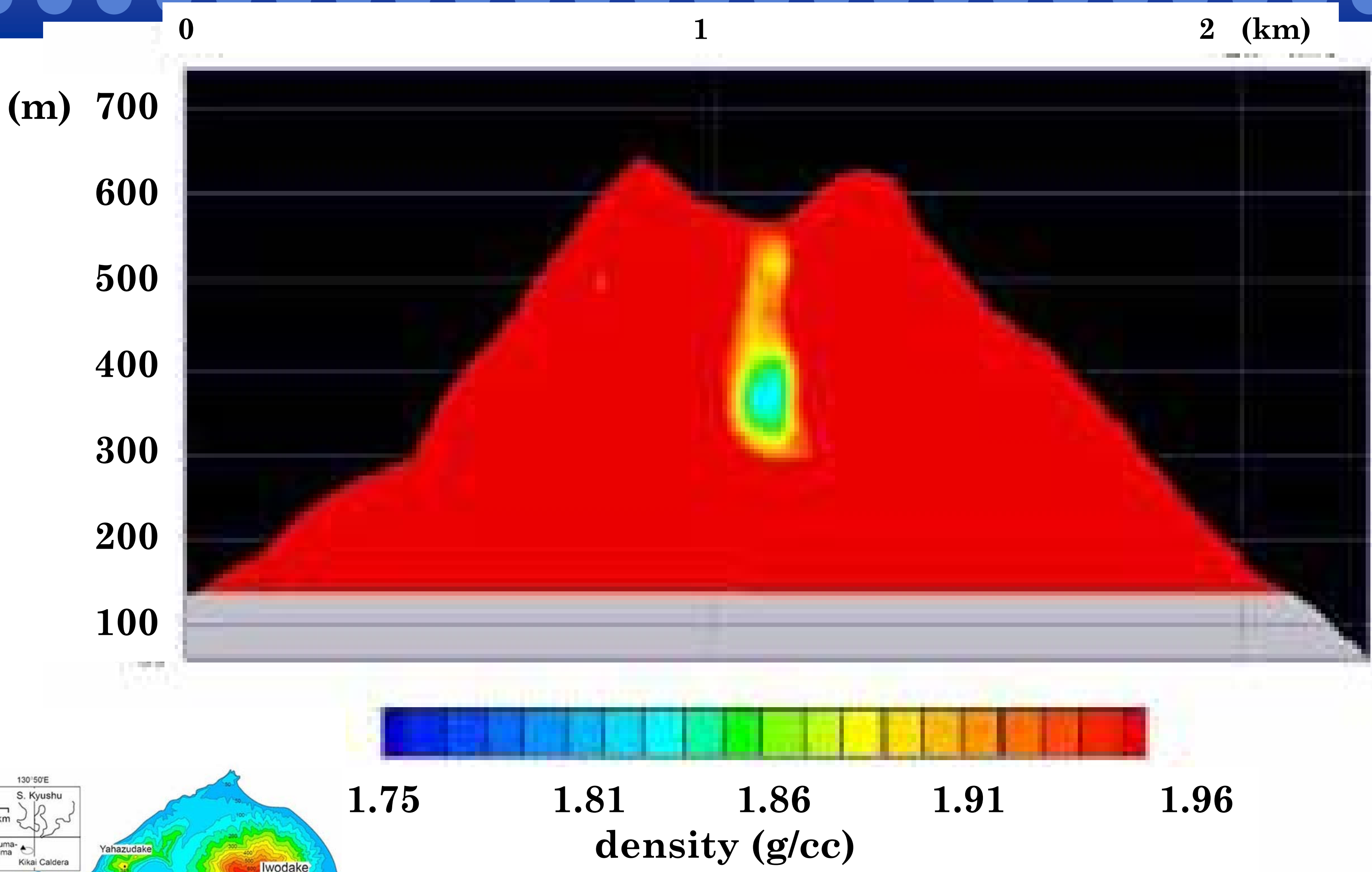
confidential

Mt. Satsuma Iwo Jima (taken by muon)



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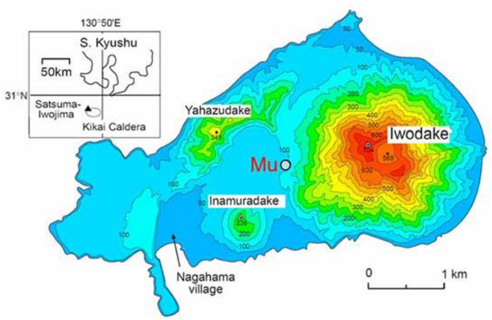
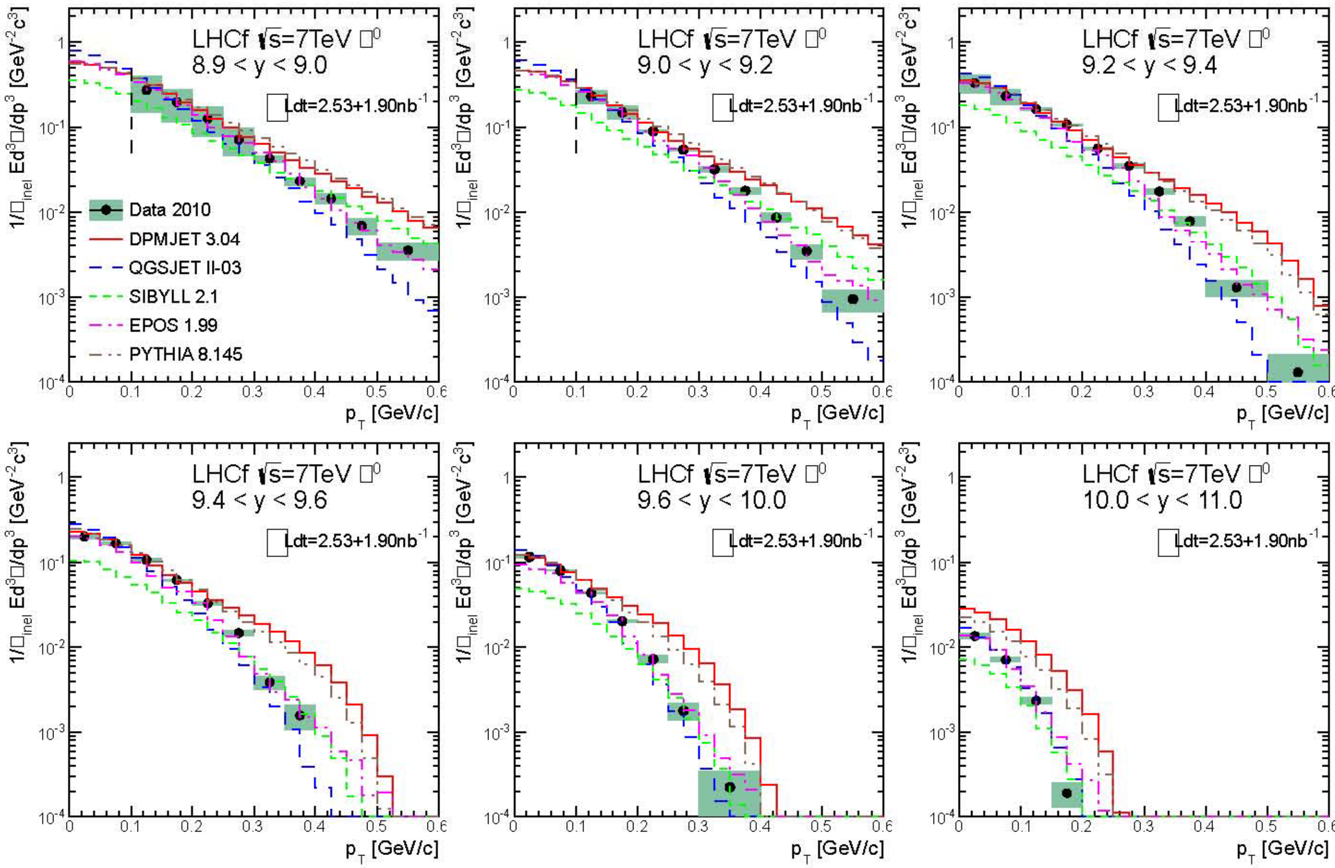


Comparison of π^0 data at $\sqrt{s} = 7\text{TeV}$ w/ hadronic interaction models

11



"$\sqrt{s} = 7\text{TeV}$" → CR energy of 2.6x10^16eV

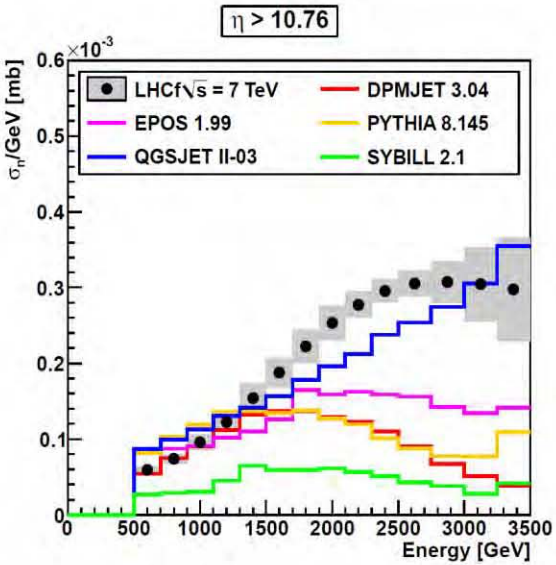
FIG. 7: (color online) Combined p_T spectra of the Arm1 and Arm2 detectors (black dots) and the total uncertainties (shaded triangles) compared with the predicted spectra by hadronic interaction models.

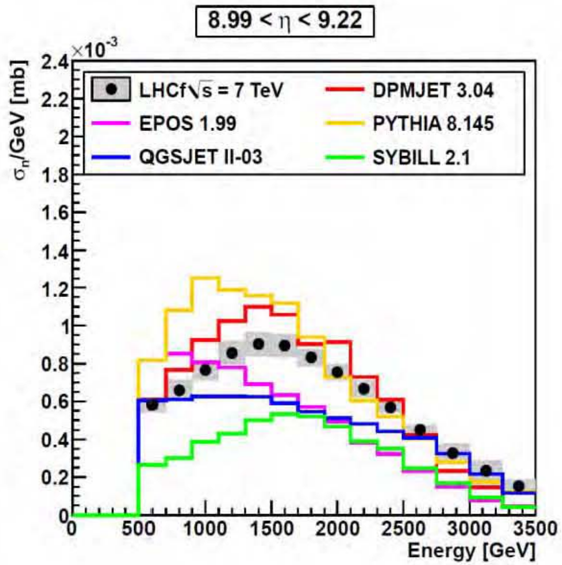
- **EPOS1.99** show the best agreement with data in the models.
- **DPMJET** and **PYTHIA** have harder spectra than data ("popcorn model")
- **QGSJET** has softer spectrum than data (only one quark exchange is allowed)

The values of p_T obtained in Table II and Table III are in reasonable agreement. When a specific value of

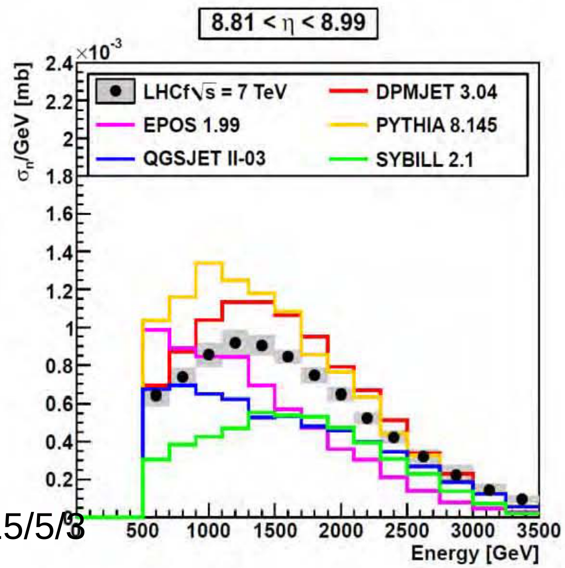
Rapidity	p_T^{upper} [GeV/c]	p_T [MeV/c]	Total uncertainty [MeV/c]
[9.2, 9.4]	0.6	167.1	4.3

Comparison of n data at $\sqrt{s} = 7\mathrm{TeV}$ w/ hadronic interaction models.



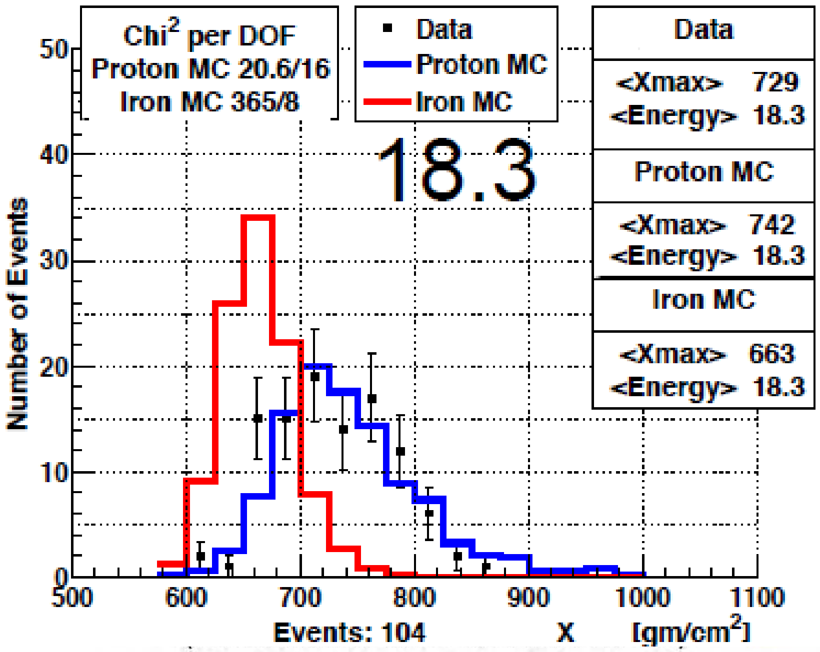


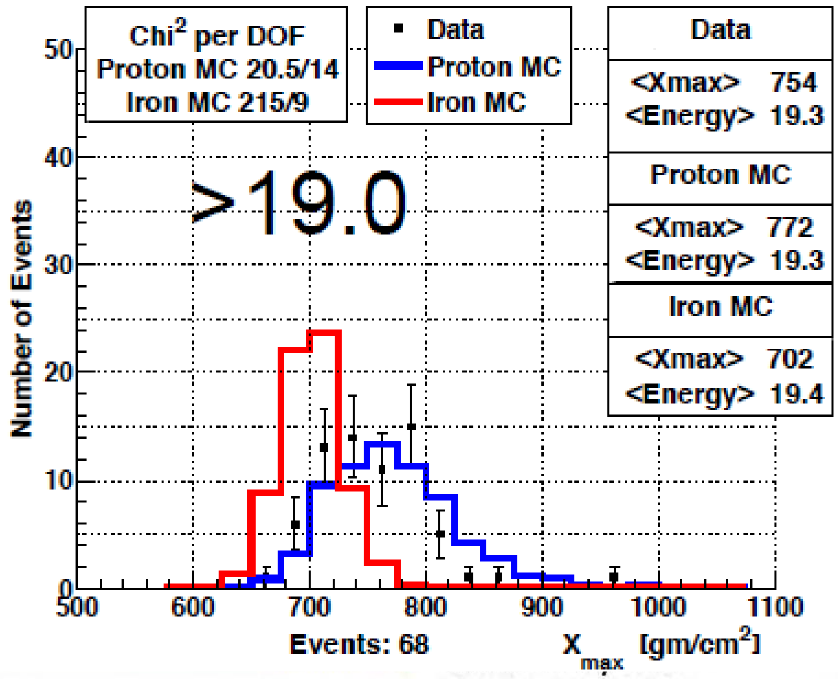
“$\sqrt{s} = 7\mathrm{TeV}$“→ CR energy of 2.6x10^16eV



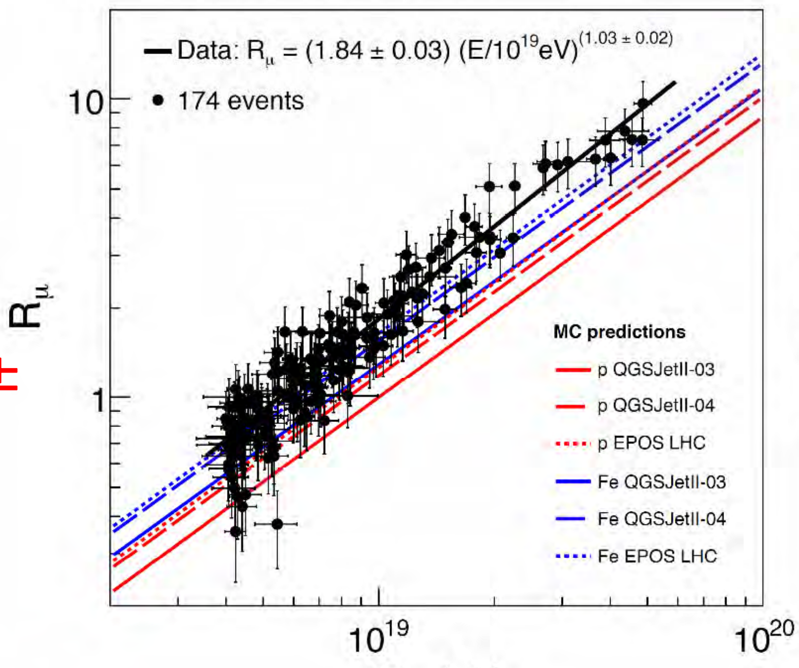
- **QGSJET-II-03** predicts a high neutron production at the highest pseudo-rapidity region.
- **DPMJET3** is similar with data at the lower pseudo-rapidity region.
- No model completely explains the experiment results.

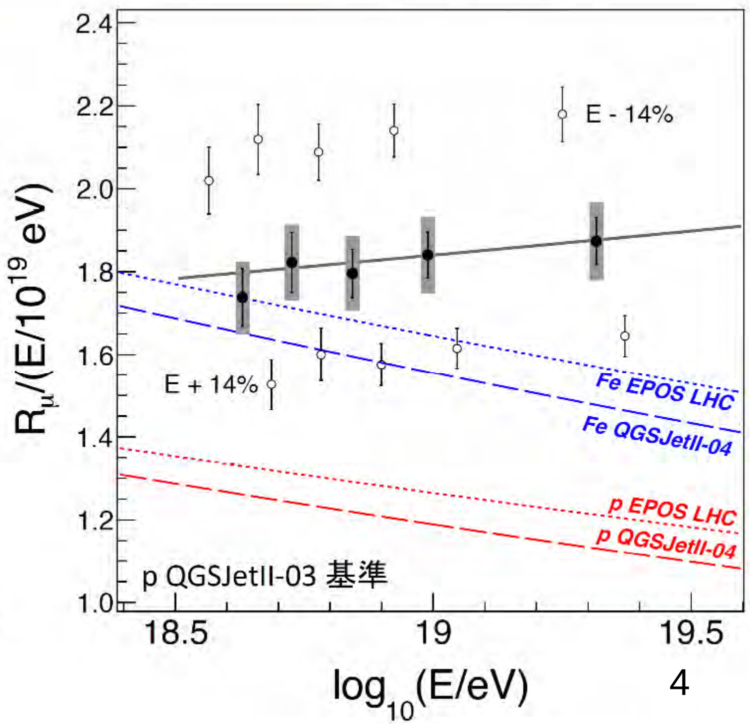
EM
$\sim\pi^0$



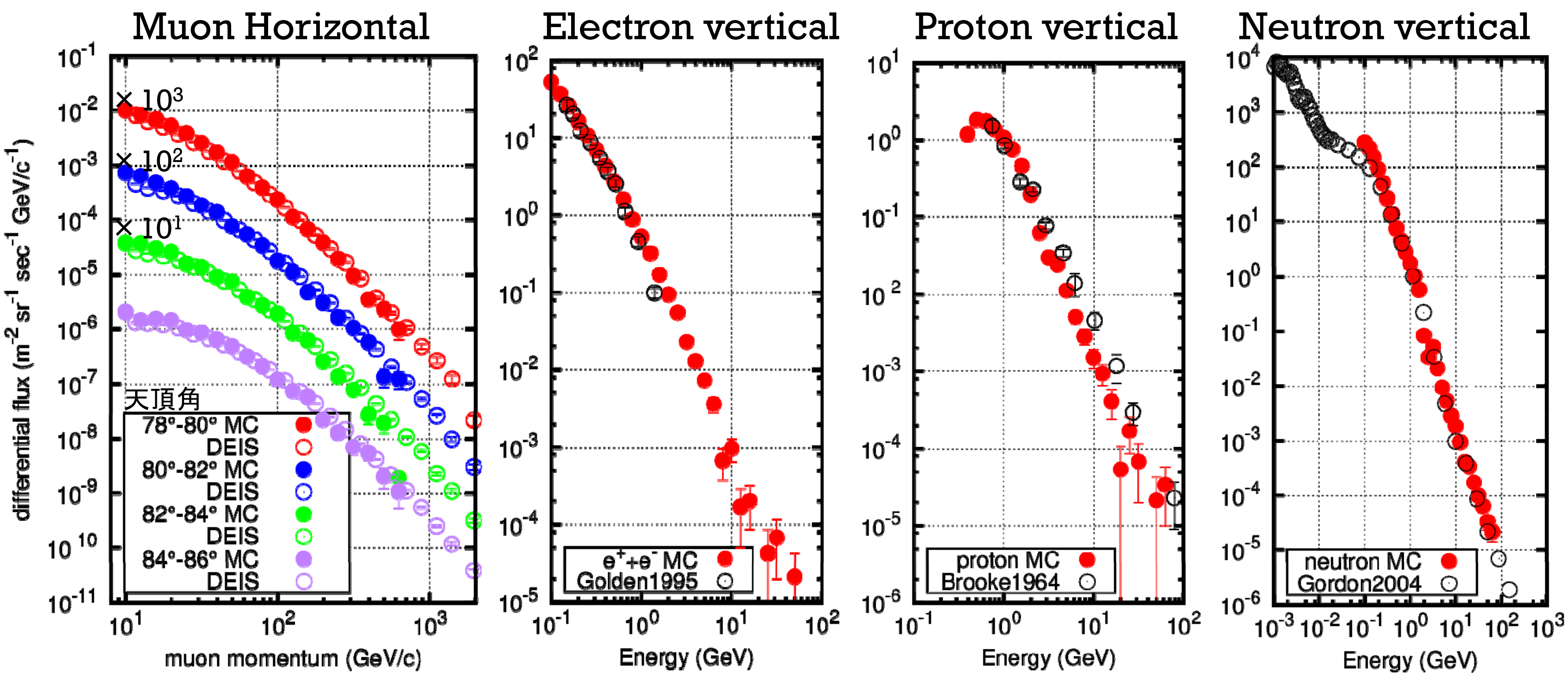


μ
$\sim\pi^{\pm} + K^{\pm}$





On the other hand… (COSMOS ASMC)



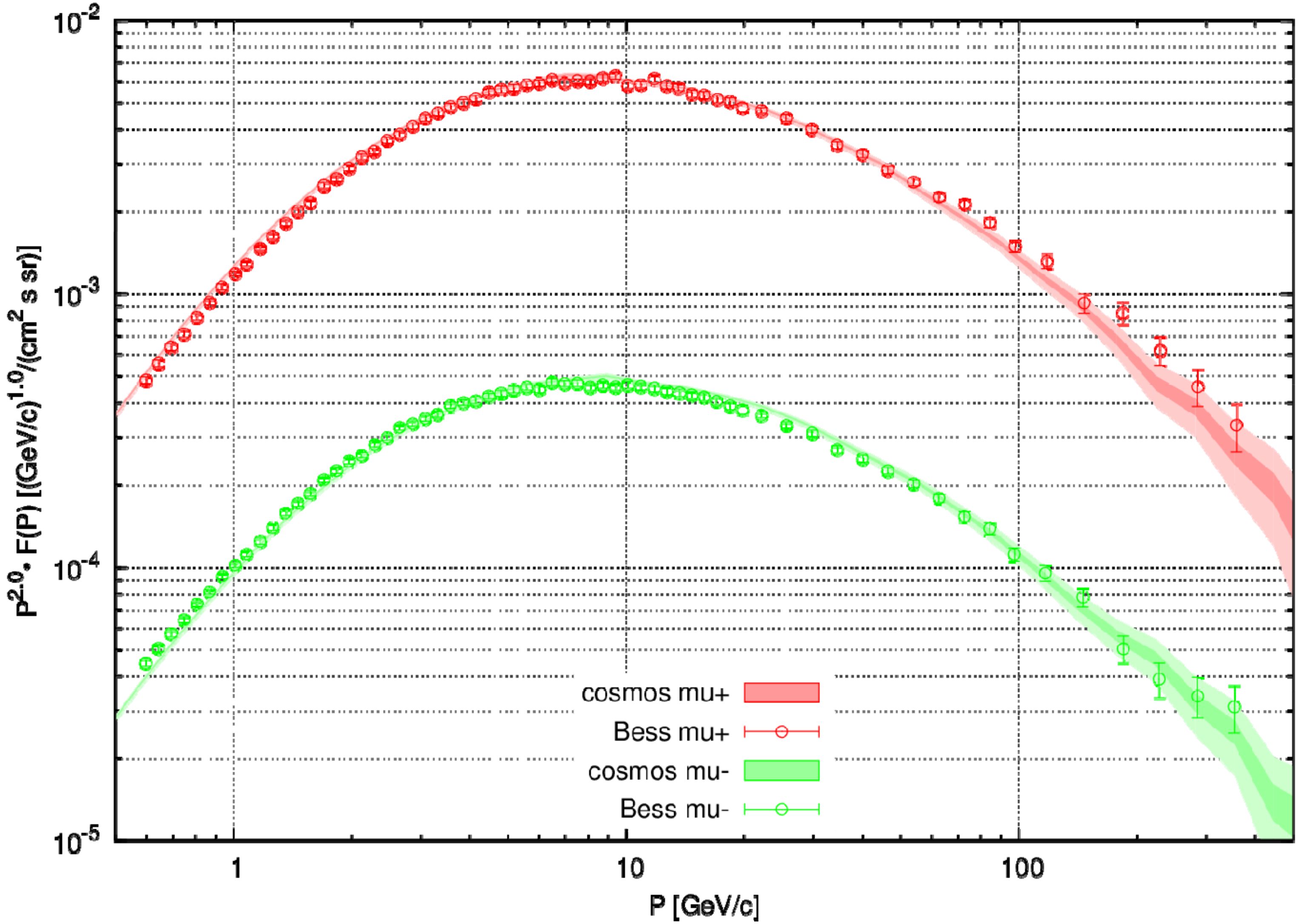
Alkofer et al. (1985) Golden et al. (1995) Brooke et al. (1964) Gordon et al. (2004)

$\pi^{\pm}$ + $K^{\pm}$ (icecube)

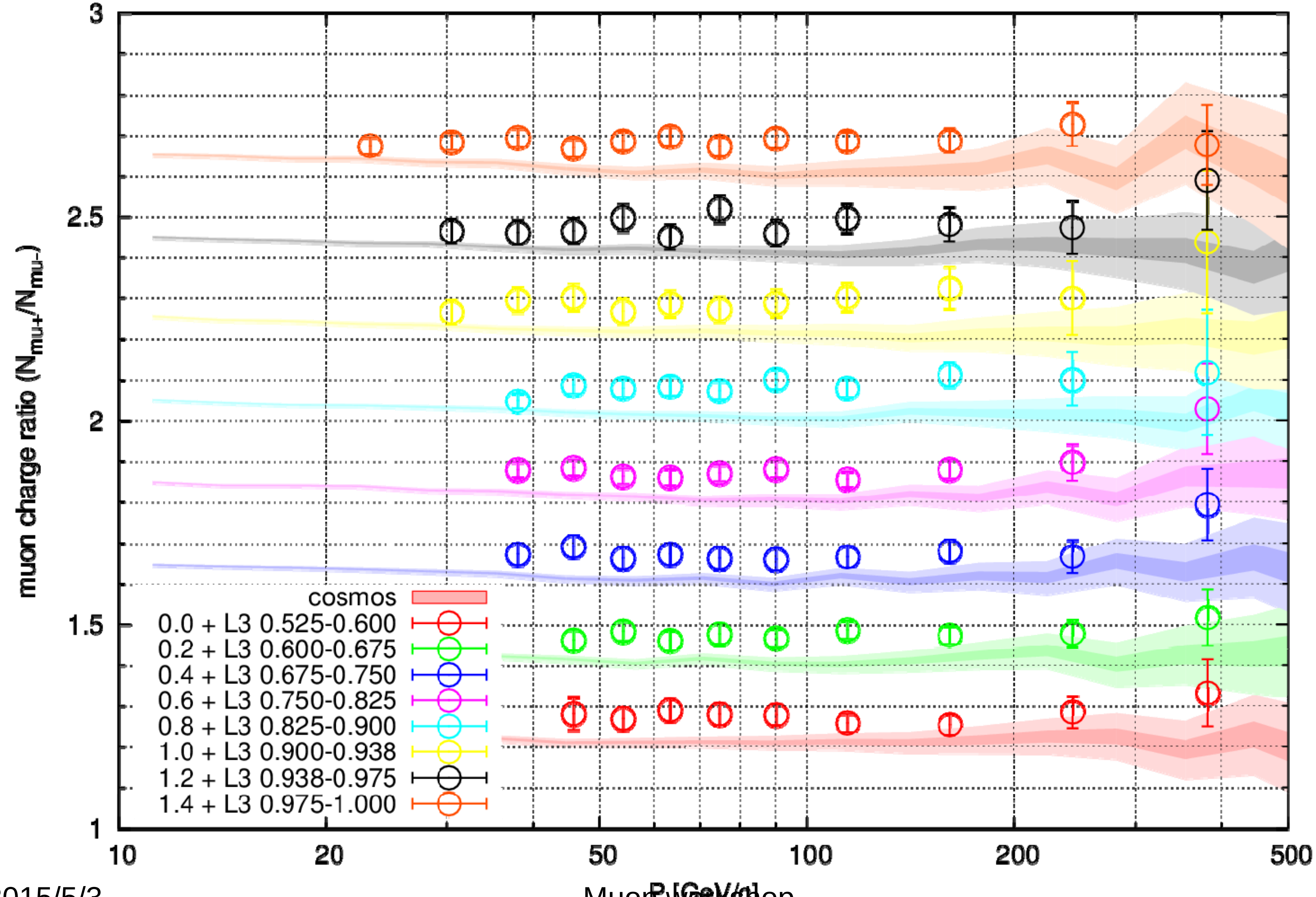
π^0 (icetop)

QGSJET-II-03 (> 100 GeV)
DPMJET-III (2-100 GeV)
PHITS (< 2 GeV)

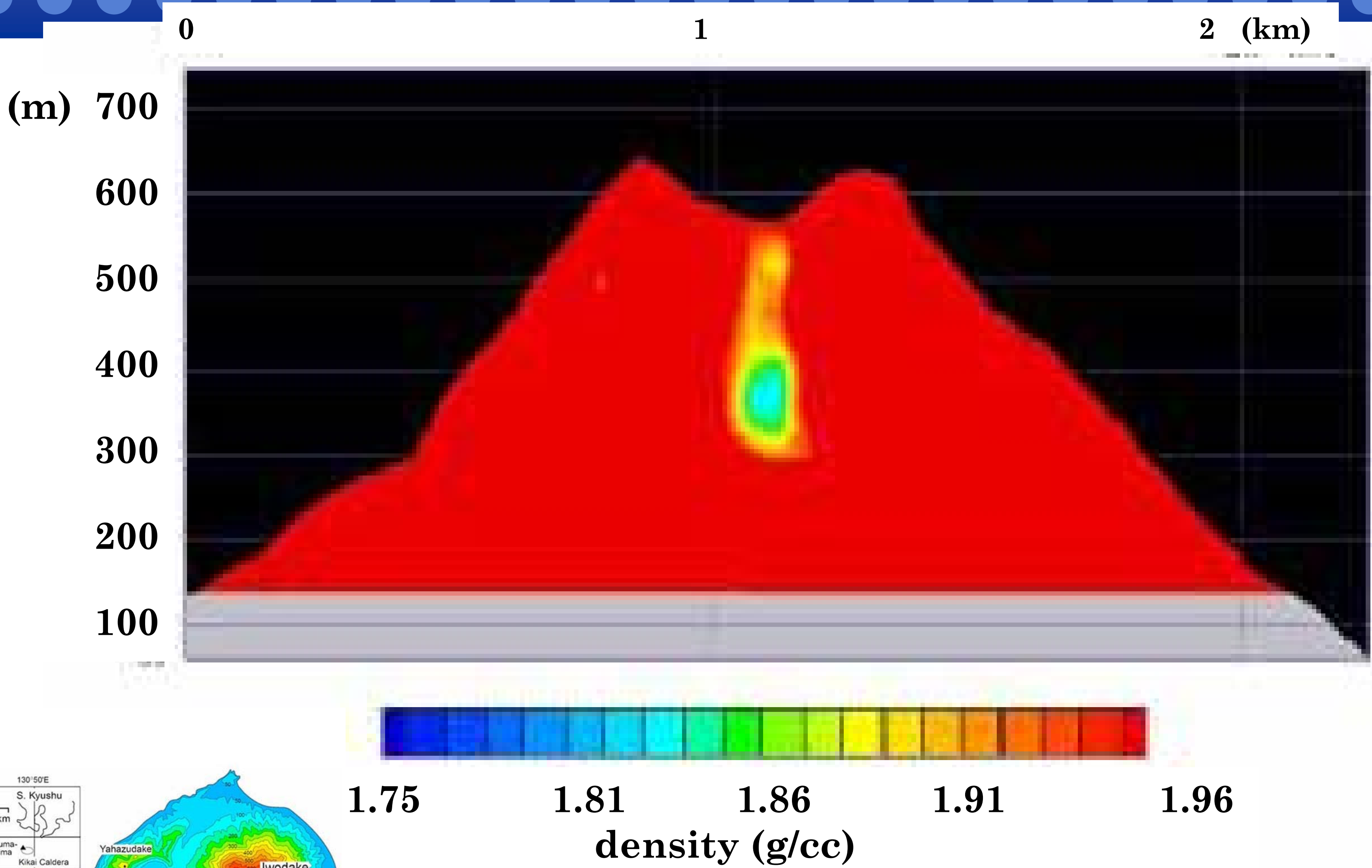
Vertical muon flux (Bess VS COSMOS ASMC)

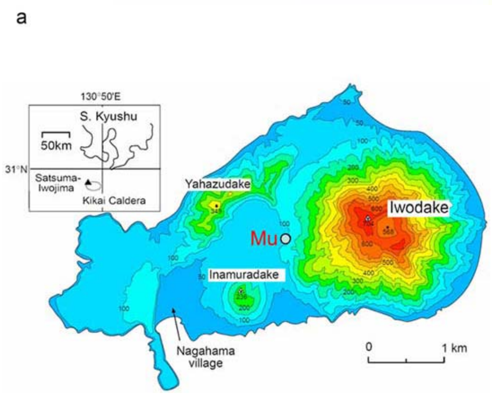


Charge ratio (L3 VS COSMOS ASMC)

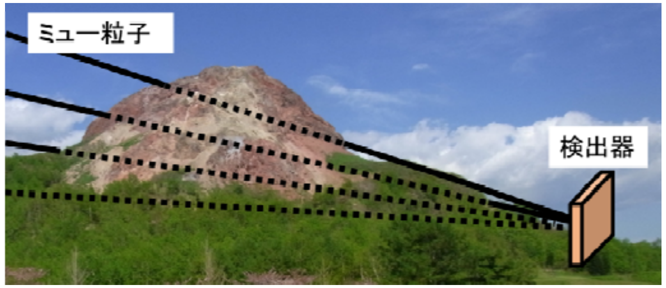


Mt. Satsuma Iwo Jima

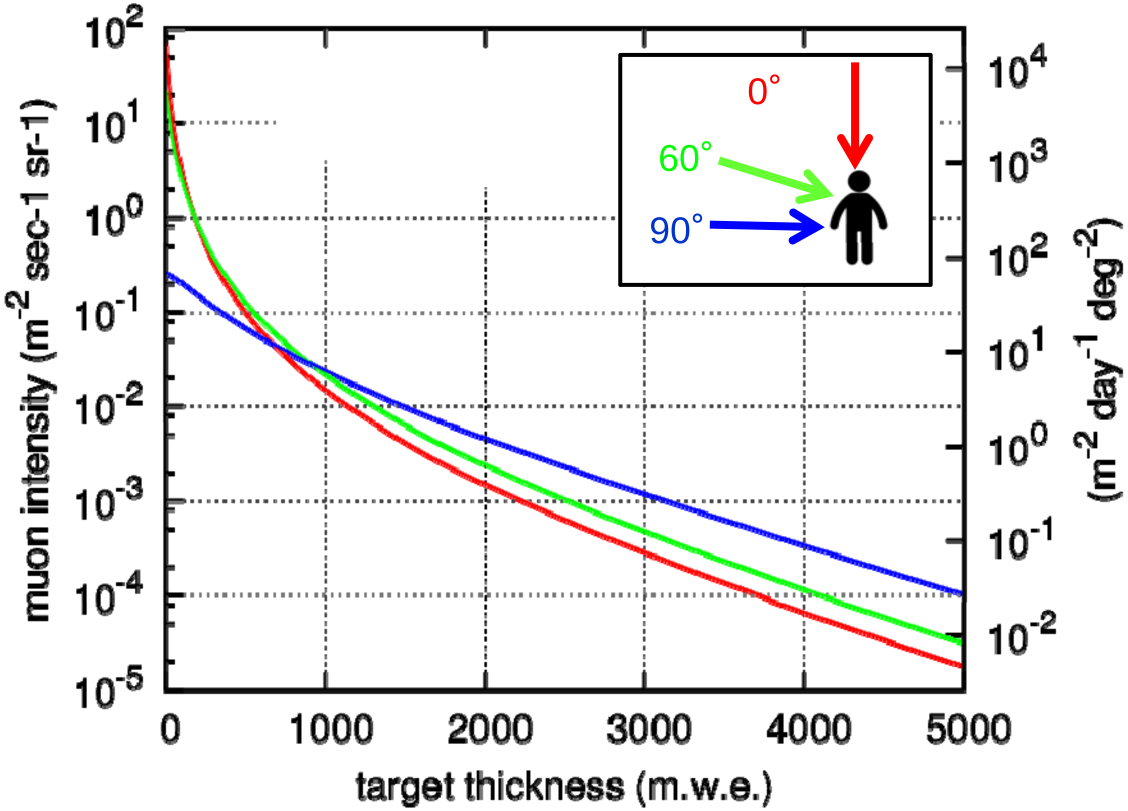




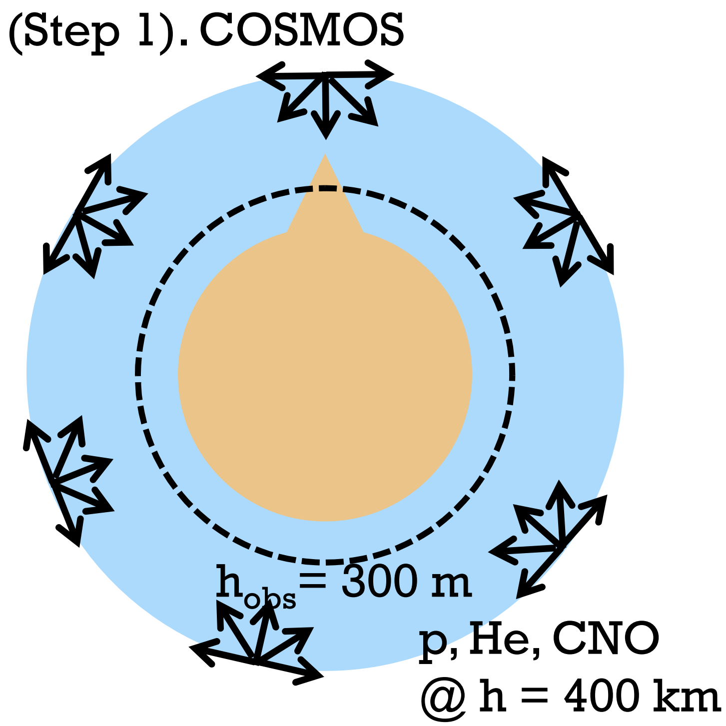
MC for muon radiography

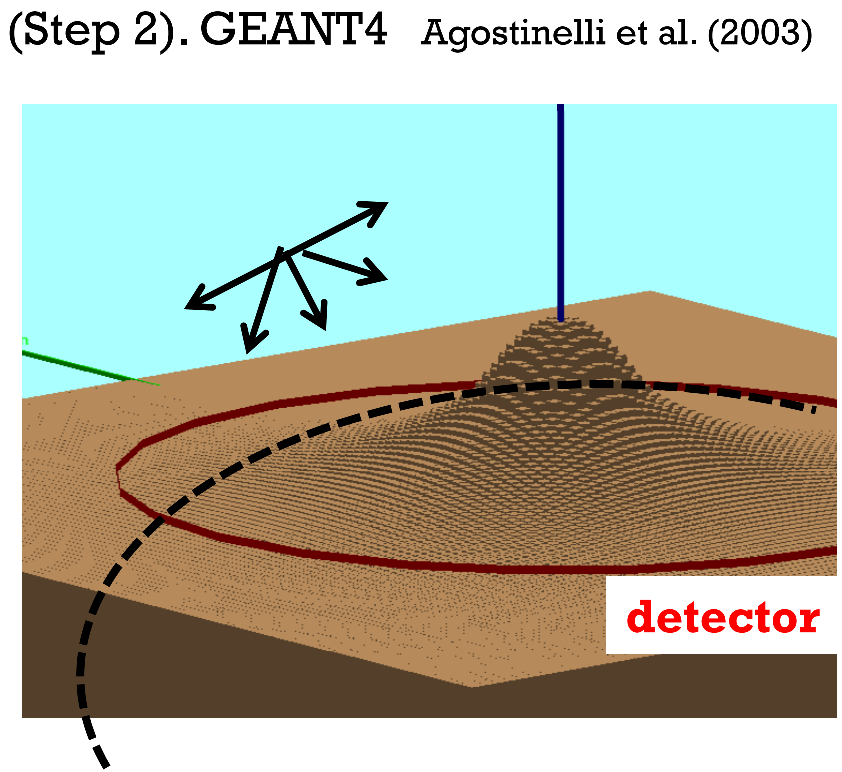


$$I_{obs} = \frac{\epsilon^{-1} N_{obs}}{S\,\Omega\,T}$$



MC framework

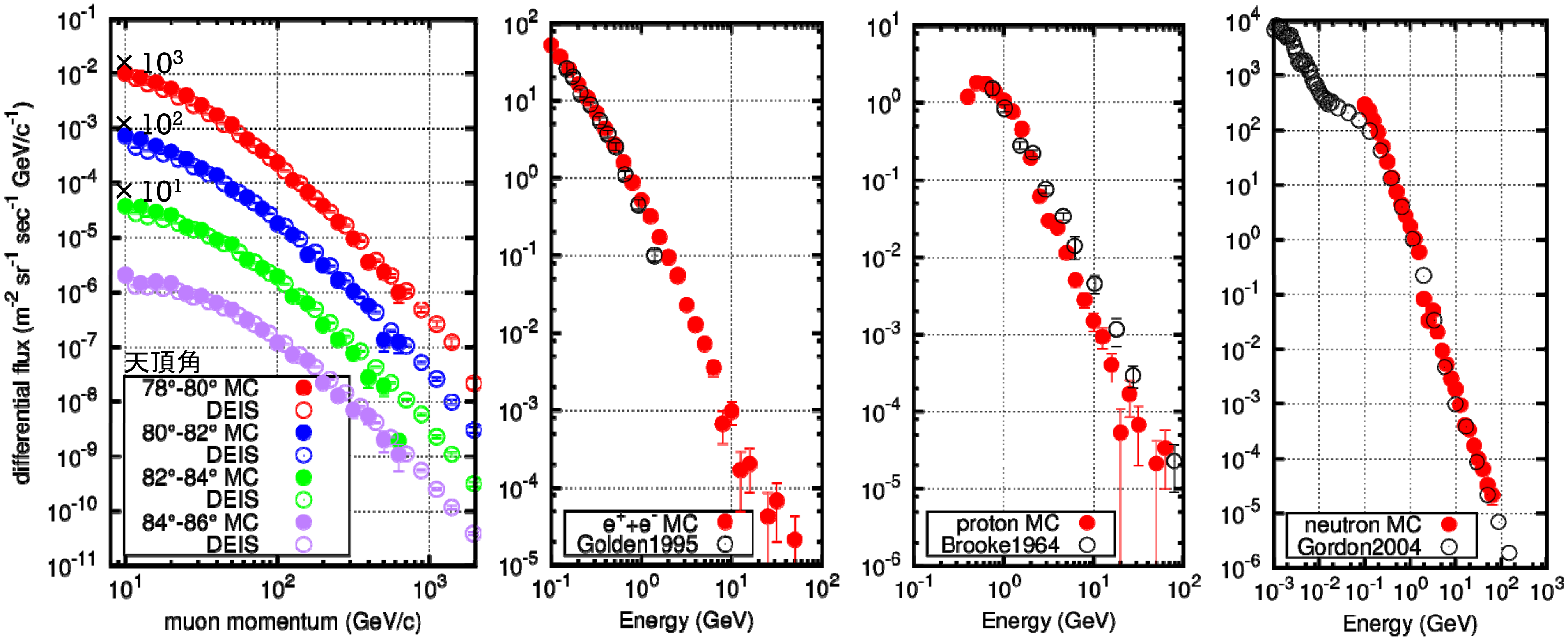




- primary: BESS1998 (Sanuki et al., 2000)
- interaction model: PHITS (< 2 GeV)
  DPMJET-III (2 – 100 GeV)
  QGSJET-II-03 (> 100 GeV)
- US Standard Atmoshpere (1976)

Step1: COSMOS VS experimental result

Muon Horizontal | Electron vertical | Proton vertical | Neutron vertical



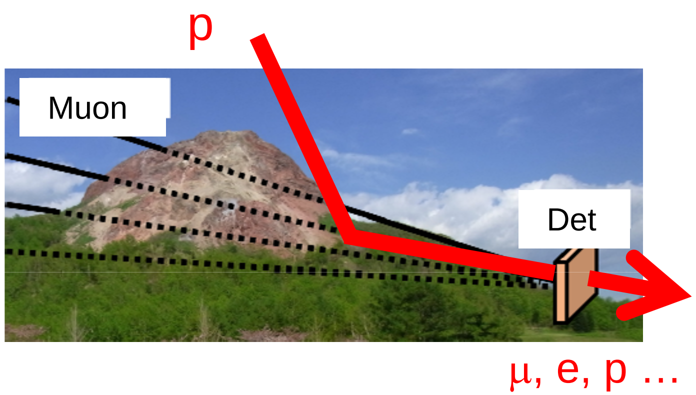
Alkofer et al. (1985) | Golden et al. (1995) | Brooke et al. (1964) | Gordon et al. (2004)

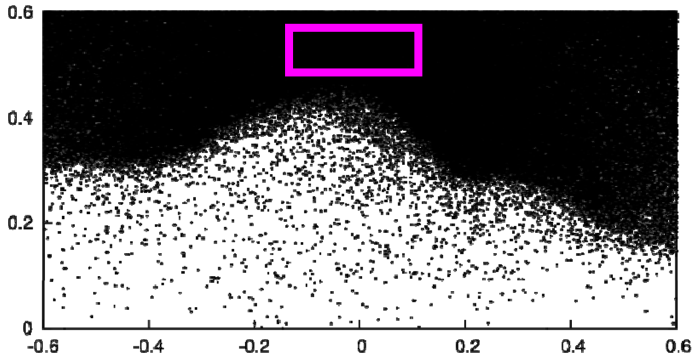
$\pi^{\pm}$ + $K^{\pm}$ (icecube)

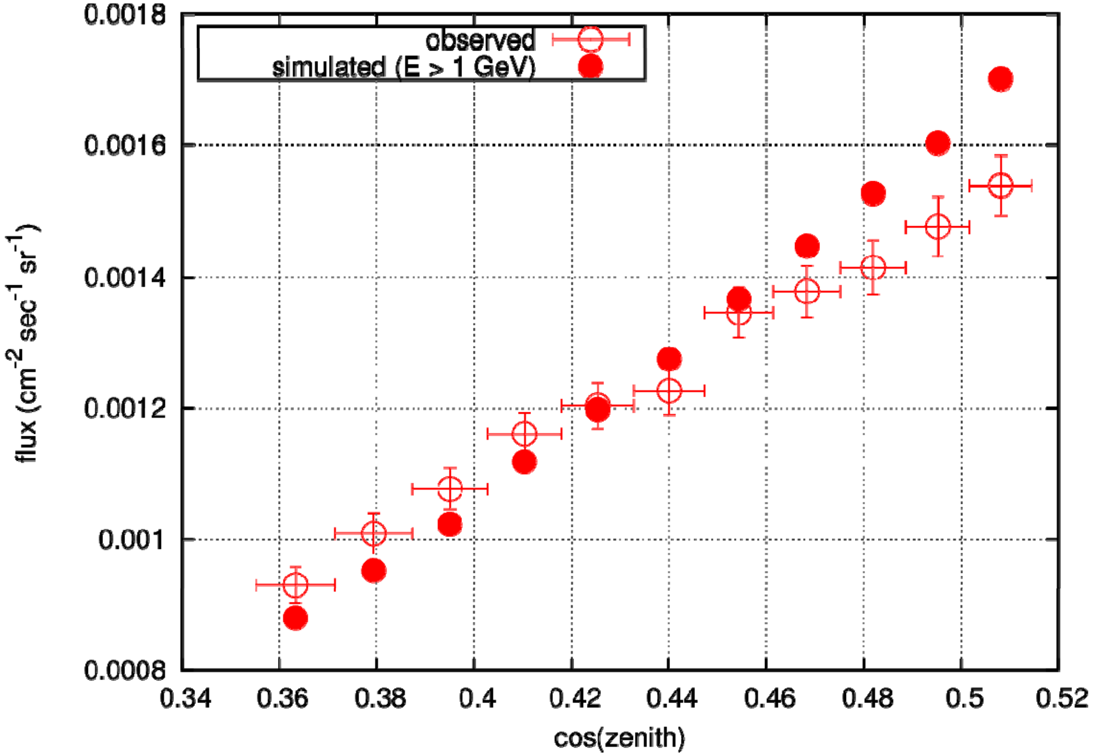
π^0 (icetop)

QGSJET-II-03 (> 100 GeV)
DPMJET-III (2-100 GeV)
PHITS (< 2 GeV)

Free sky muon flux (measured by emulsion cloud chamber)

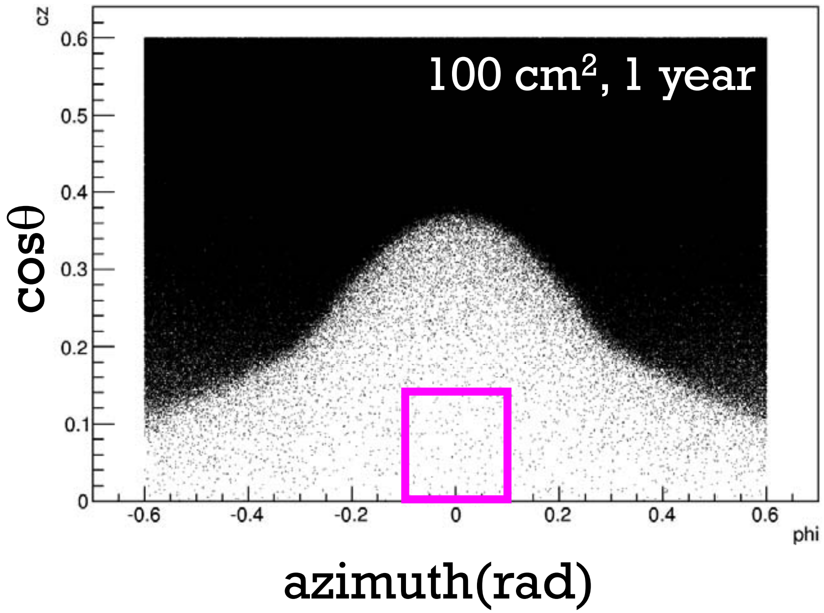




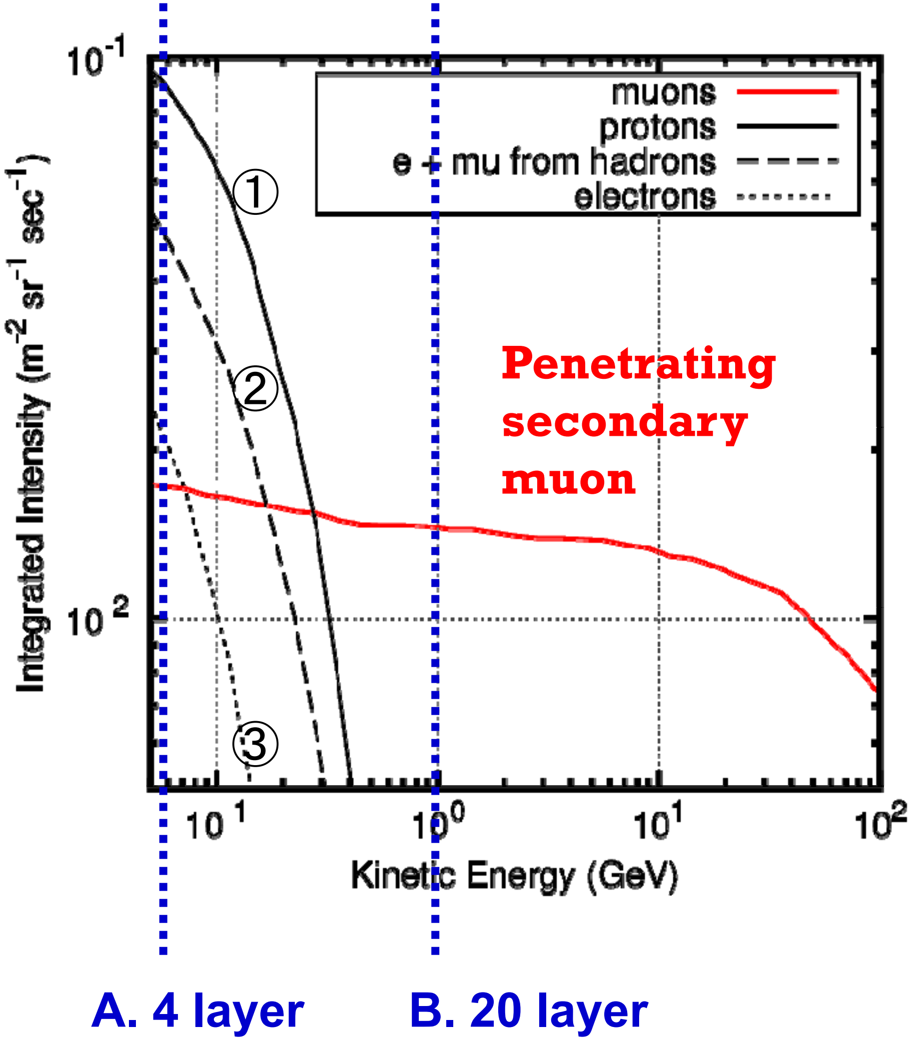


Incident angle dependence of detector is neglected

BG estimation by COSMOS+GEANT4

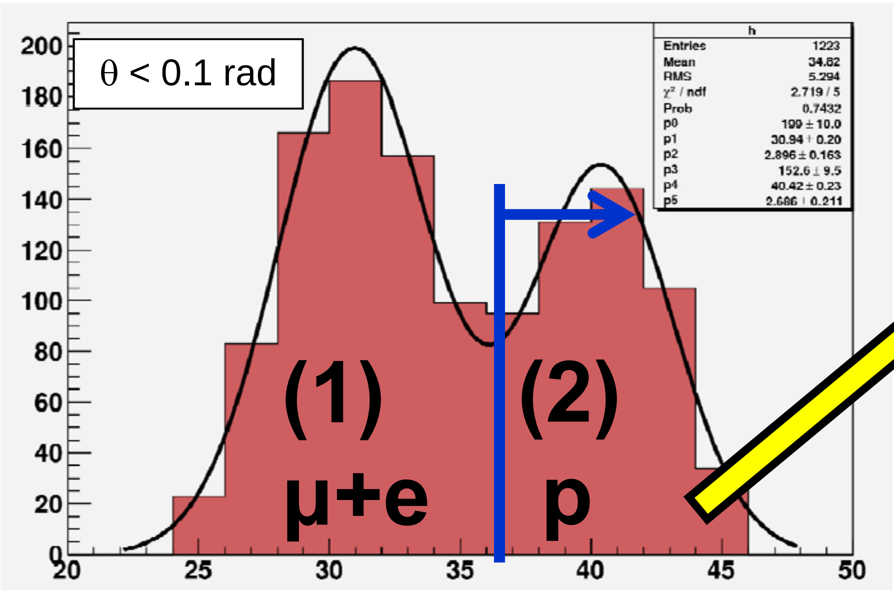


① tertiary proton
② tertiary muon from p, n, etc
③ upward electron from behind

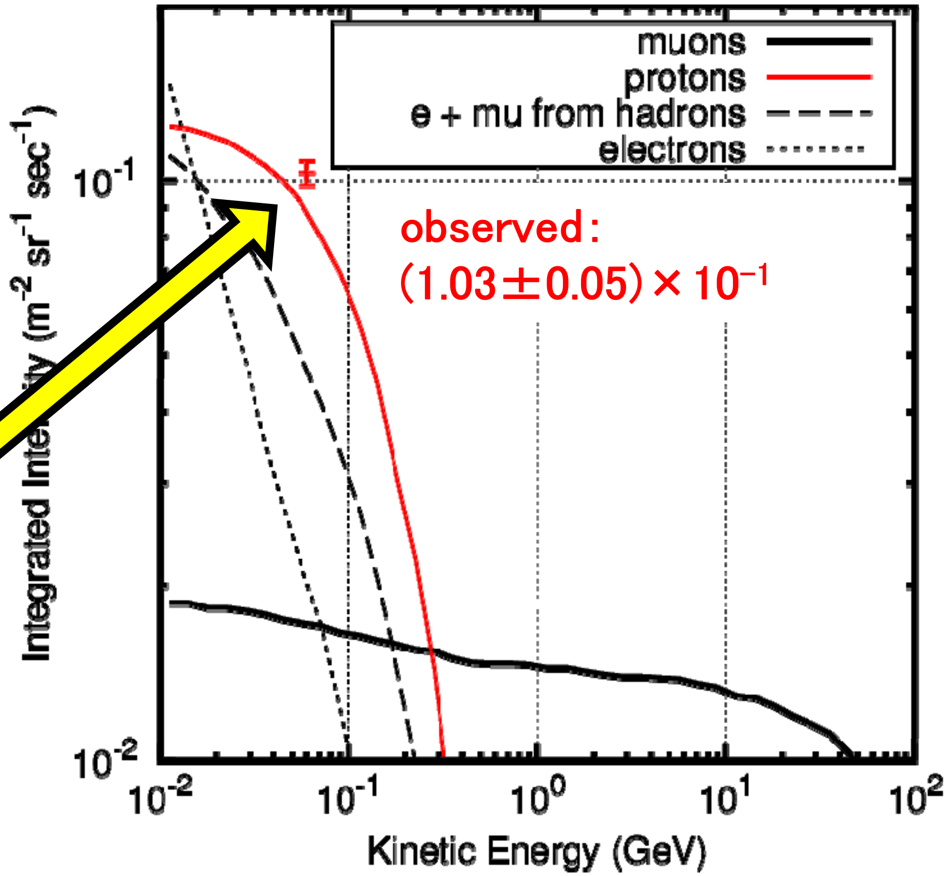


Tertiary proton flux (measured by emulsion cloud chamber)

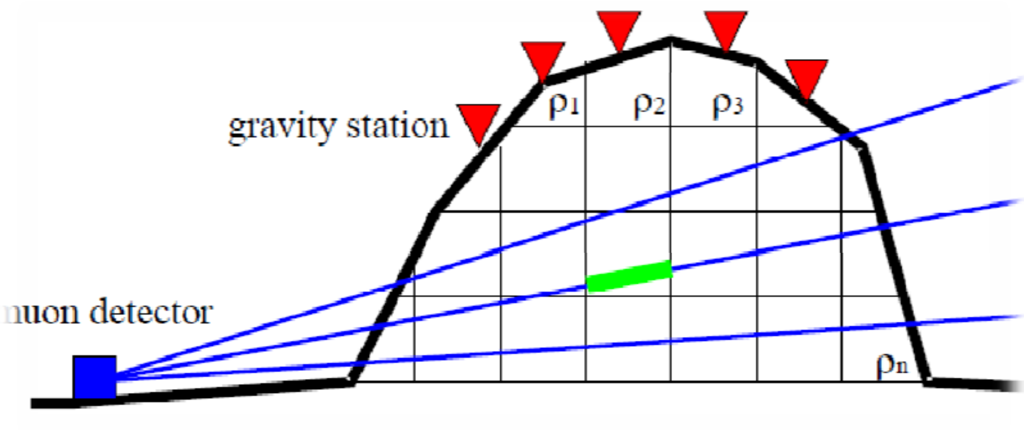
Grain density（4 layer）

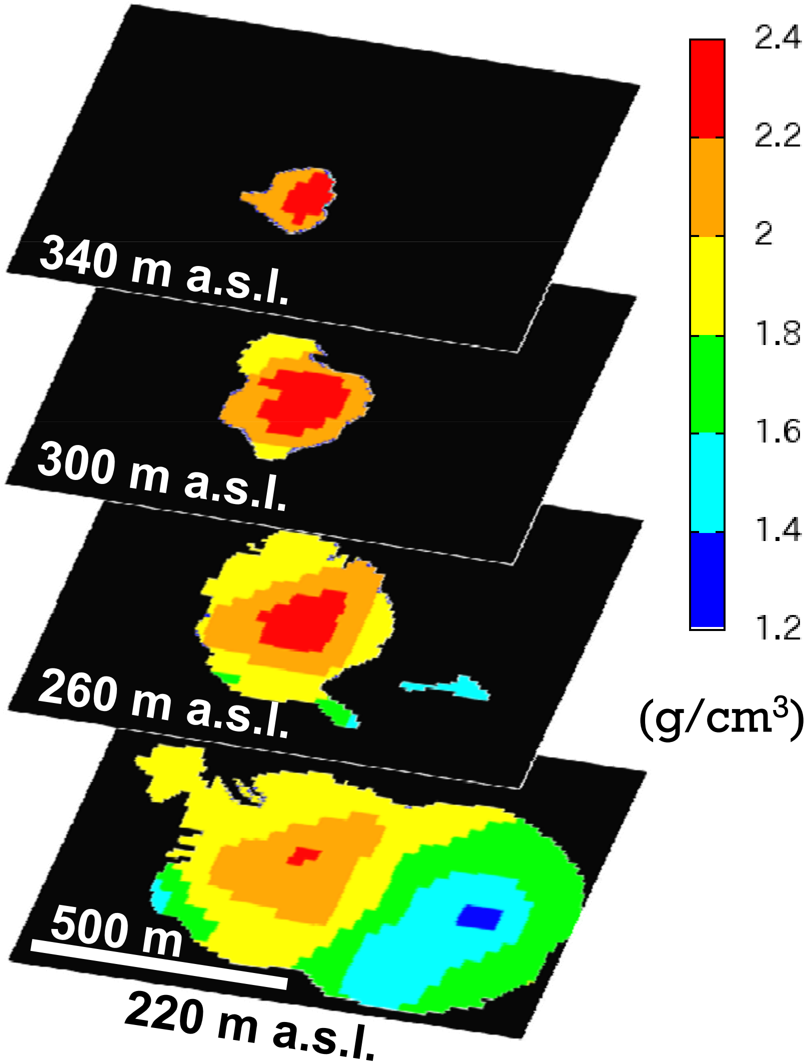


# of grain/100 μm ~ dE/dx

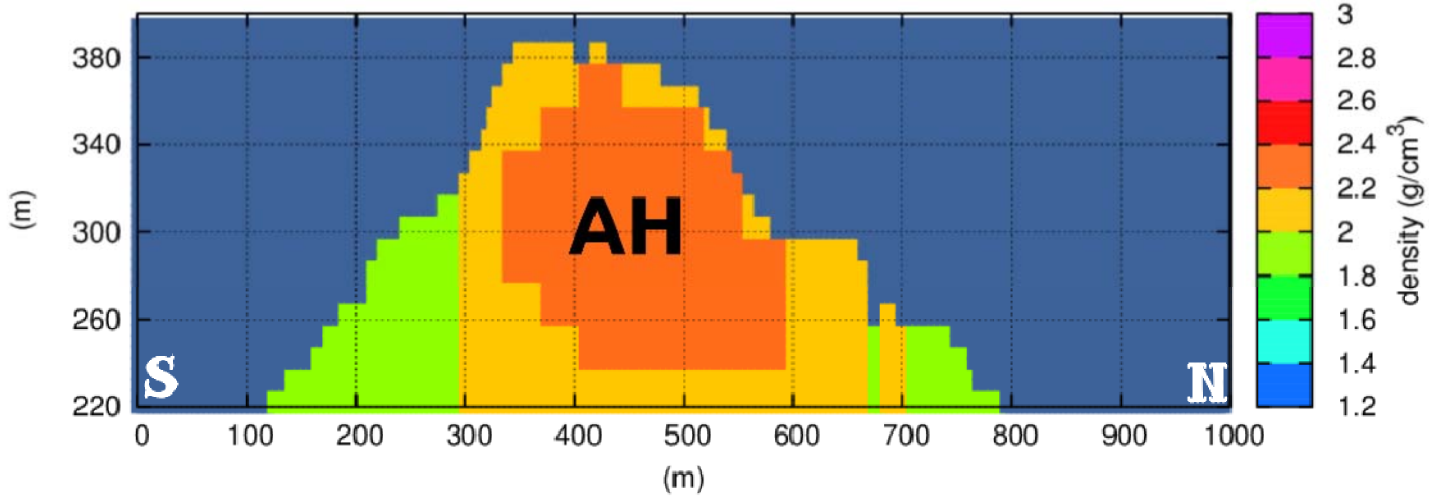


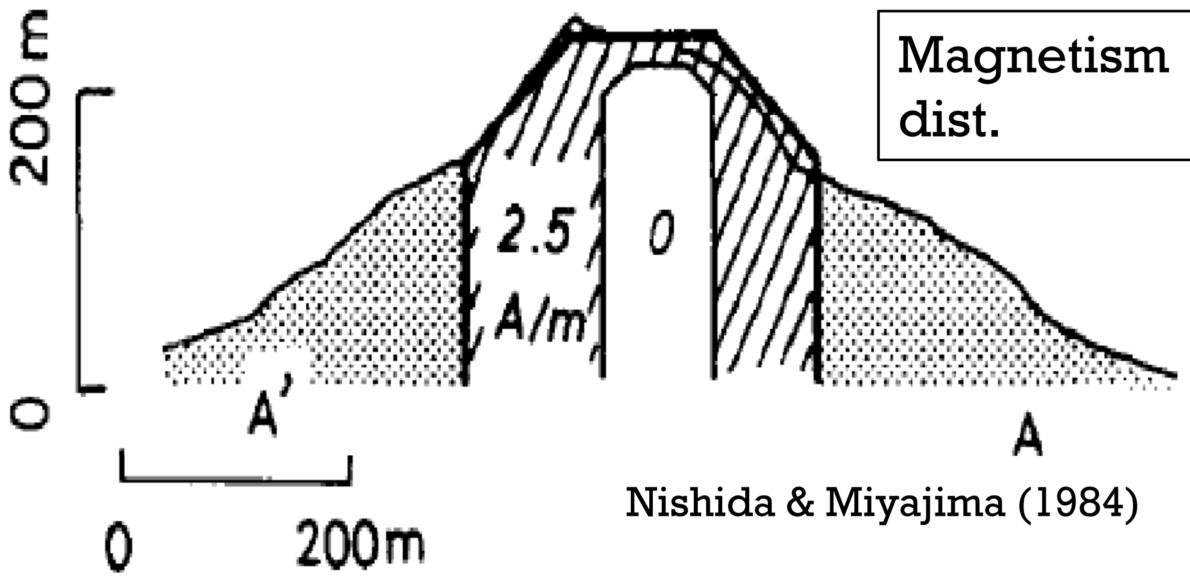
Joint inversion (muon + gravity)





Comparison with other experiment





Nishida & Miyajima (1984)