Status of the MicroBooNE BEAM MC upgrade to Geant4, v4.10x

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With contributions from Elena Gramellini and Zarko Pavlovic, and productive discussions with Alberto Marchionni Steve Brice.

Outline

- Motivation to move from G4 v4p8 to v4p9, to v410px.
- Scope: Old and new capabilities.
  - What has been kept, what is no longer supported...
- Methodology:
  - The FermiRedMine development environment
  - Code management: git
  - Testing
  - Checks & Comparisons
- Status:
  - Based on V4.10 with 2 major options, regarding the use (or not) of the HARP data on pion production from 8 GeV proton on Be target.

Motivation

- Motivation to move from G4 v4p8 to v4p9, to v410px.

  They are obvious:

  - Updating the Computing environment (compiler, libraries...) will allow you take advantage of the large amount of compute power available on Fermi-Grid.
  - Older versions (v4.9.6, and prior to) of G4 no longer supported. (if problem occurs, little sympathy for the users that stay behind.)
  - New capabilities of G4 (graphics, most importantly, hadronic models)
  - Interface to current Neutrino Physics libraries (Dk2Nu, and from there, GENIE, etc..)

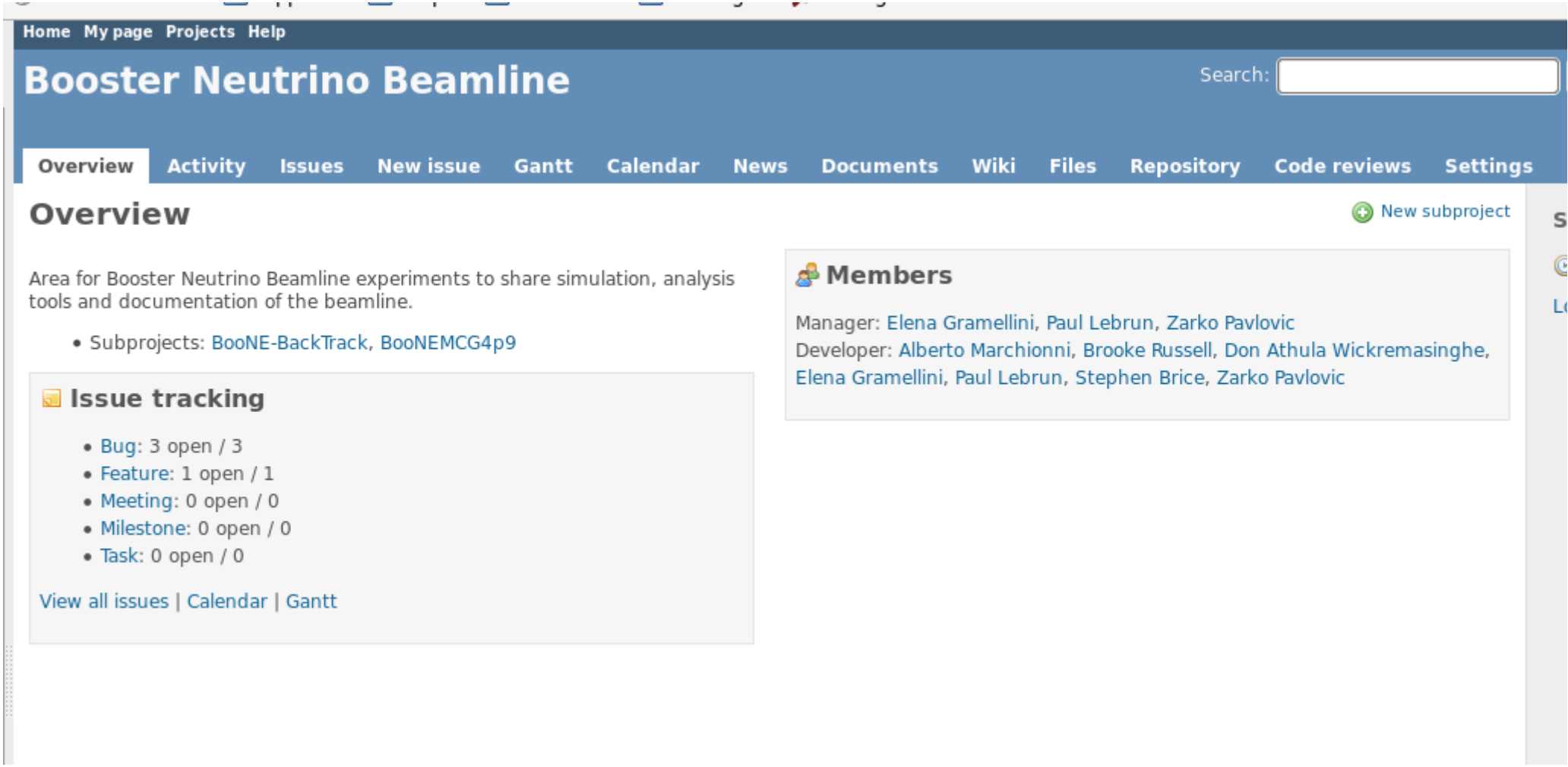
Scope

- Same capabilities as before.. Except
  - No longer support the old HBOOK data format and related tools.
  - Some of the modifications to the Geant 4.8.1 Hadronic models have been lost.
    - Because the G4 “Physics lists” has been re-vamped.
    - However...
  - The MiniBooNE pions/kaons production model for 8 GeV proton on Be target based on a Sanford-Wang (S-W) parameterization of the inclusive cross-section can, and should be used...
  - Same geometry as in MiniBooNE, however, one can of-course could implement new volumes..
  - Output: DK2Nu and ASCII Ntuples for debugging.

Methodology

- Fermilab Scientific CD made available a customized version of the RedHat software management tool set.
  - Consistent with other projects (SBND, etc...)

https://cdcvs.fnal.gov/redmine/projects/booster-neutrino-beamline?jump=welcome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Overview
New subproject
Area for Booster Neutrino Beamline experiments to share simulation, analysis tools and documentation of the beamline.
Subprojects: BooNE-BackTrack, BooNEMCG4p9
Issue tracking
Bug: 3 open / 3
Feature: 1 open / 1
Meeting: 0 open / 0
Milestone: 0 open / 0
Task: 0 open / 0
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Members
Manager: Elena Gramellini, Paul Lebrun, Zarko Pavlovic
Developer: Alberto Marchionni, Brooke Russell, Don Athula Wickremasinghe, Elena Gramellini, Paul Lebrun, Stephen Brice, Zarko Pavlovic

Booster Neutrino Beam Simulation project

- About this redmine
- Mailing List
- Computing Access

The G4BNB Software

Downloading the G4BNB code

G4BNB software is maintained in a git repository:https://cdcvs.fnal.gov/redmine/projects/booster-neutrino-beamline/repository associated with this redmine project. You may clone this repository anonymously and without authentication and in order to push commits back you must be authenticated. See About this redmine for details on authentication.

Authenticated clone (i.e., allows to modify the software and upload your modification on this site, via git push):

```
$ git clone ssh://p-booster-neutrino-beamline@cdcvs.fnal.gov/cvs/projects/booster-neutrino-beamline
```

Anonymous clone (no push):

```
$ git clone http://cdcvs.fnal.gov/projects/booster-neutrino-beamline/
```

For help with git see Git Help. To check out a fixed release of g4lbnb (which is recommended for large production runs) into a directory with the name of the tag, you can do:

```
$ git clone ssh://p-booster-neutrino-beamline@cdcvs.fnal.gov/cvs/projects/booster-neutrino-beamline/ <tag_name>
$ cd <tag_name>
$ git checkout <tag_name>
```

You can see a list of available tags by doing:

Methodology

- Fermilab Scientific CD made available a customized version of the RedHat software management tool set.
- Code management & book-keeping:
  - History of the migration from v4.8.1 to v4.9.6 kept..
    - Including the necessary bug fix in array overwrite in setting one S-W parameter set.
  - However, the old (ancient) history of MiniBooNE, based on CVS, has been discarded.
- Talk to me or Zarko P. you need “developper” access...

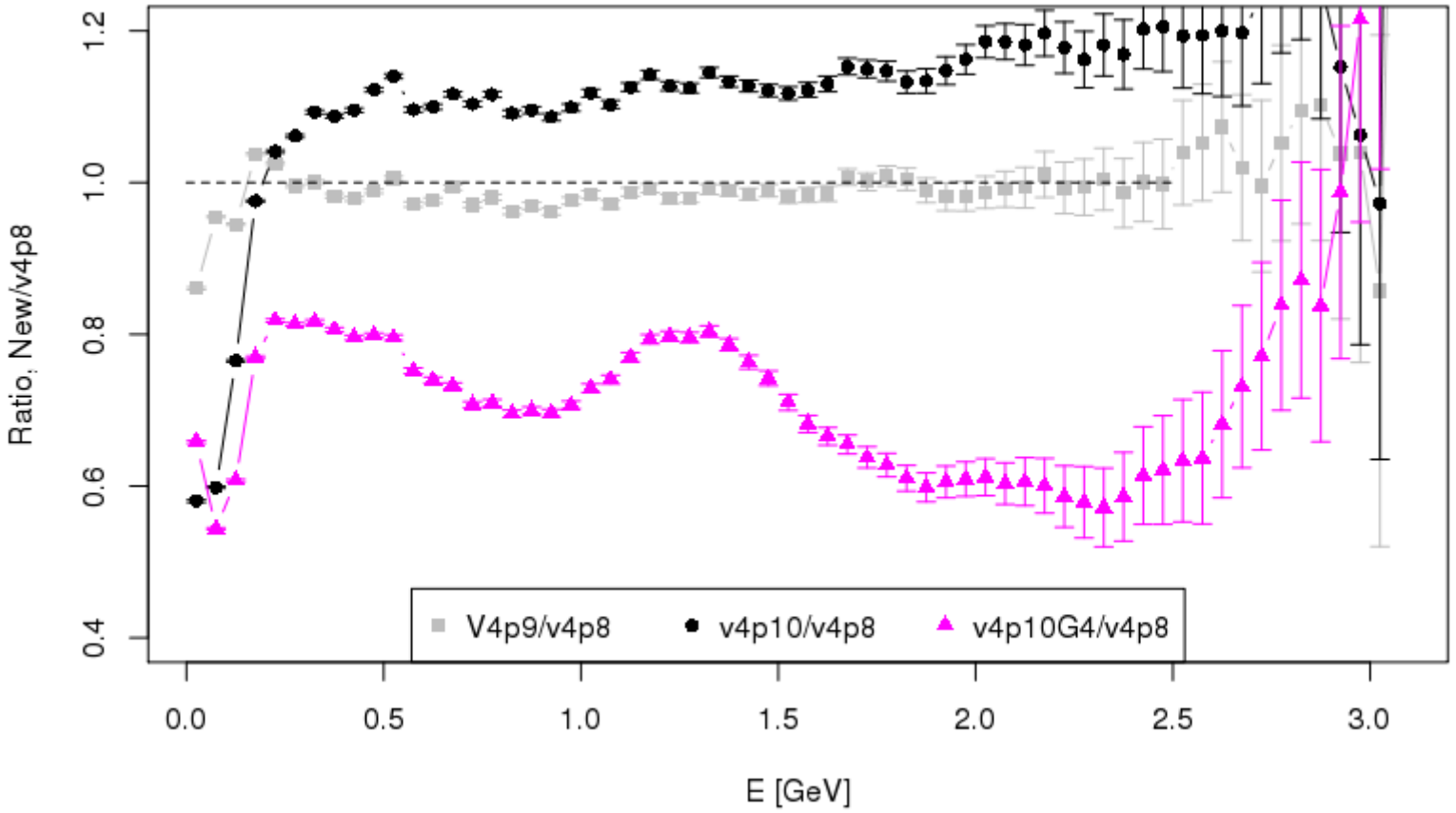
Supported Platform

- Scientific Linux 6.x Preferred choice. Was developed on dunegpvm0x machine.
- Probably available on MAC-OS. Do we want/need on Ubuntu? It should be possible.. (G4 & ROOT strongly supported on Ubuntu, I would think...)
-

Status

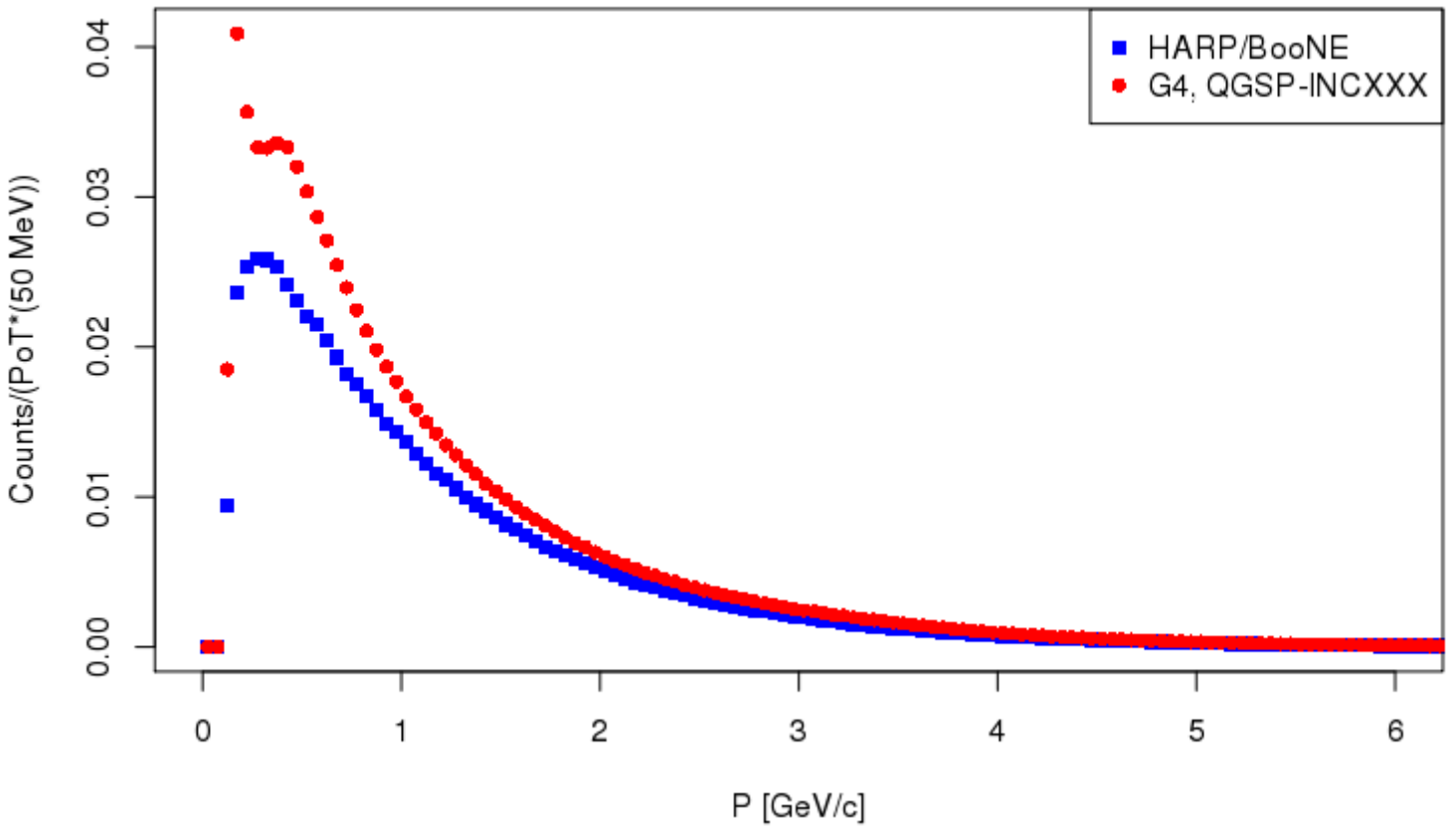
- ***Available !!!***
- Need users! Tell me what's missing, what's wrong!.
- Yet, there is more to do... more on this later...
- Here are some slides prepared on April 29 2016 for a meeting between Alberto, Steve and myself.

Neutrino flux, from $\pi^+ \rightarrow \mu^+ \nu_\mu$



The inelastic production of pions, proton on Be, seems quite a bit different, HARP/BooNE vs QSGSP_INCXX physics list.

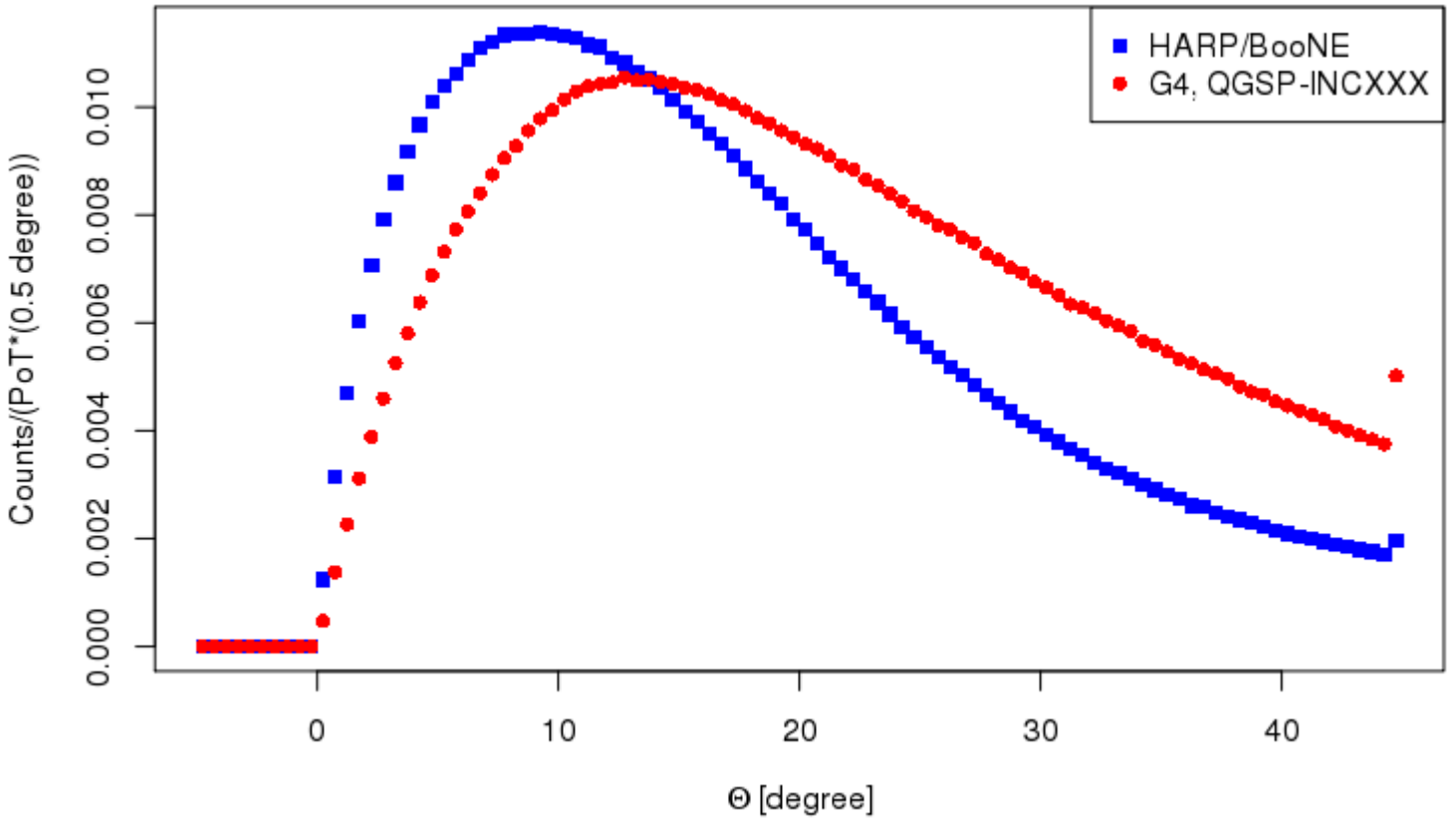
π^+ From p → Be



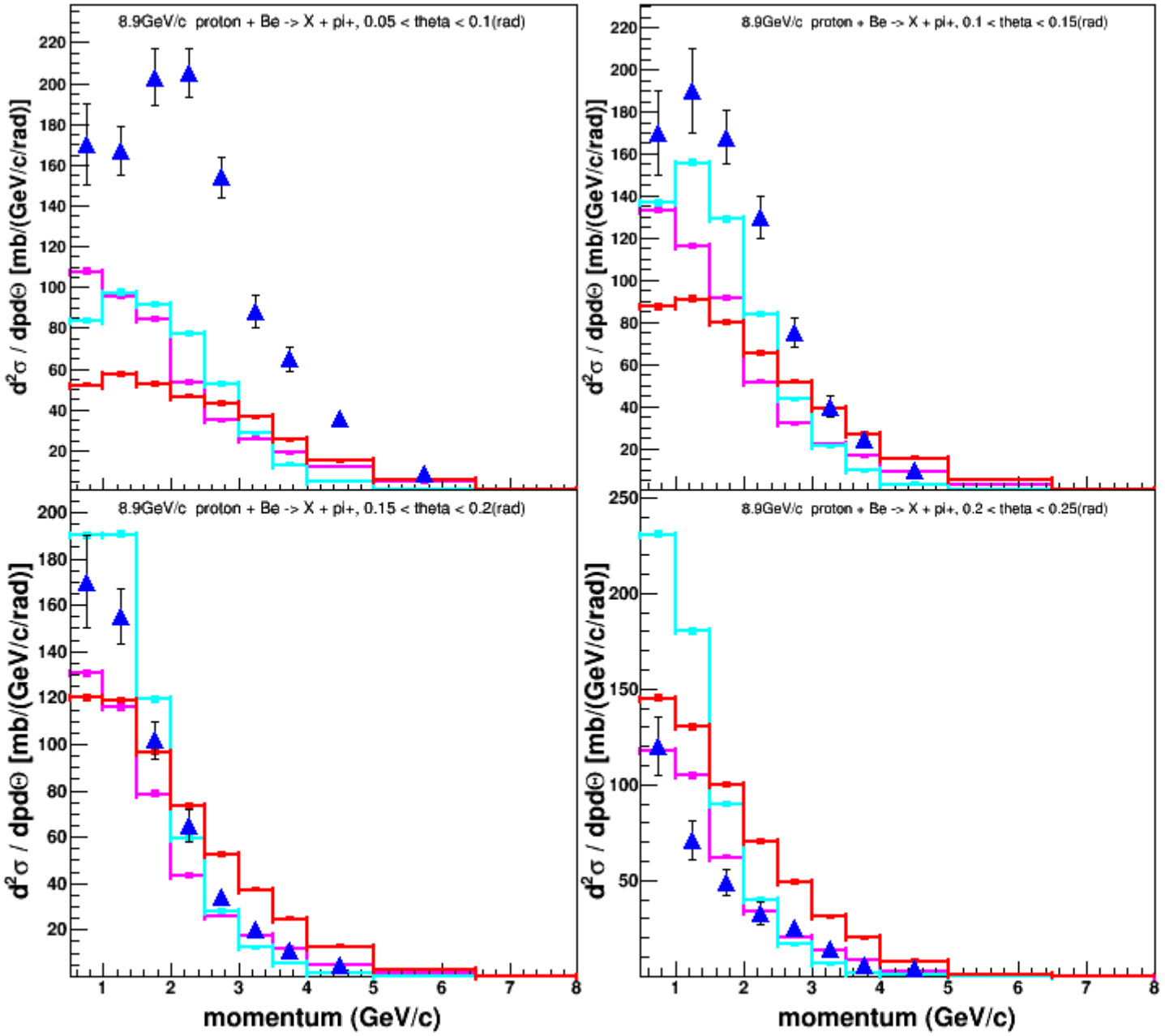
Geant4 GQSP-INCXX (recommended, Hand W. et al) produced a lot more soft pions
So why do we have a deficit of neutrinos ?

Note: This is a bit disappointing.. I would have expected a better agreement...

π^+ From p → Be



The angular distribution differ even more.. Pions produced at large angle may be not be focused enough to go through the collimator.. And we have a serious deficit (almost a factor 2 at ~ 5 degrees) of pions in QGSP-INCXXX .



Received from Julia Yarba,April 14 2016.

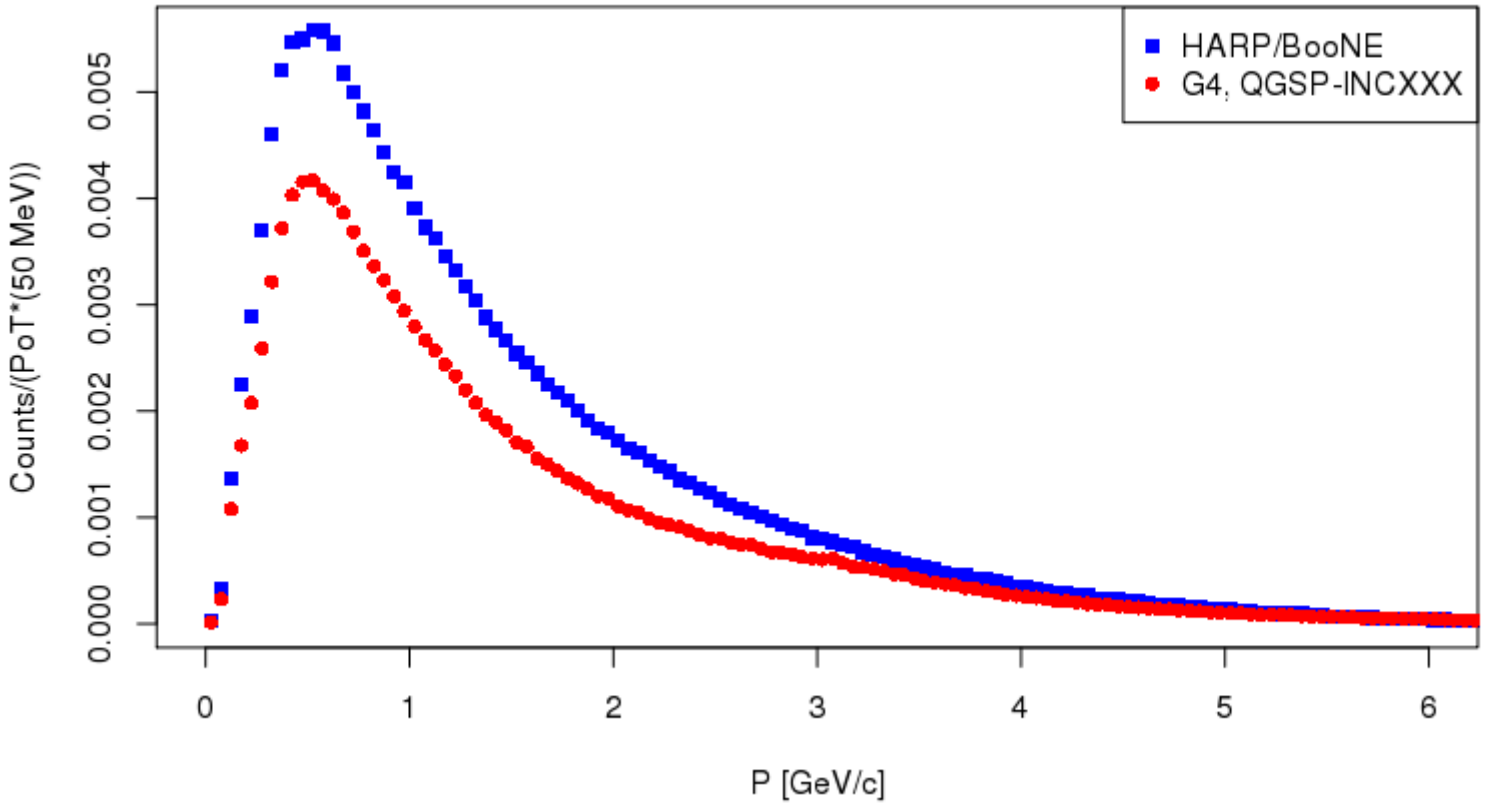
She ran the same G4 version..

Note that the comparison starts at 50 mRad.

And the G4 MC deficit (for all physics list do show a severe deficiency.

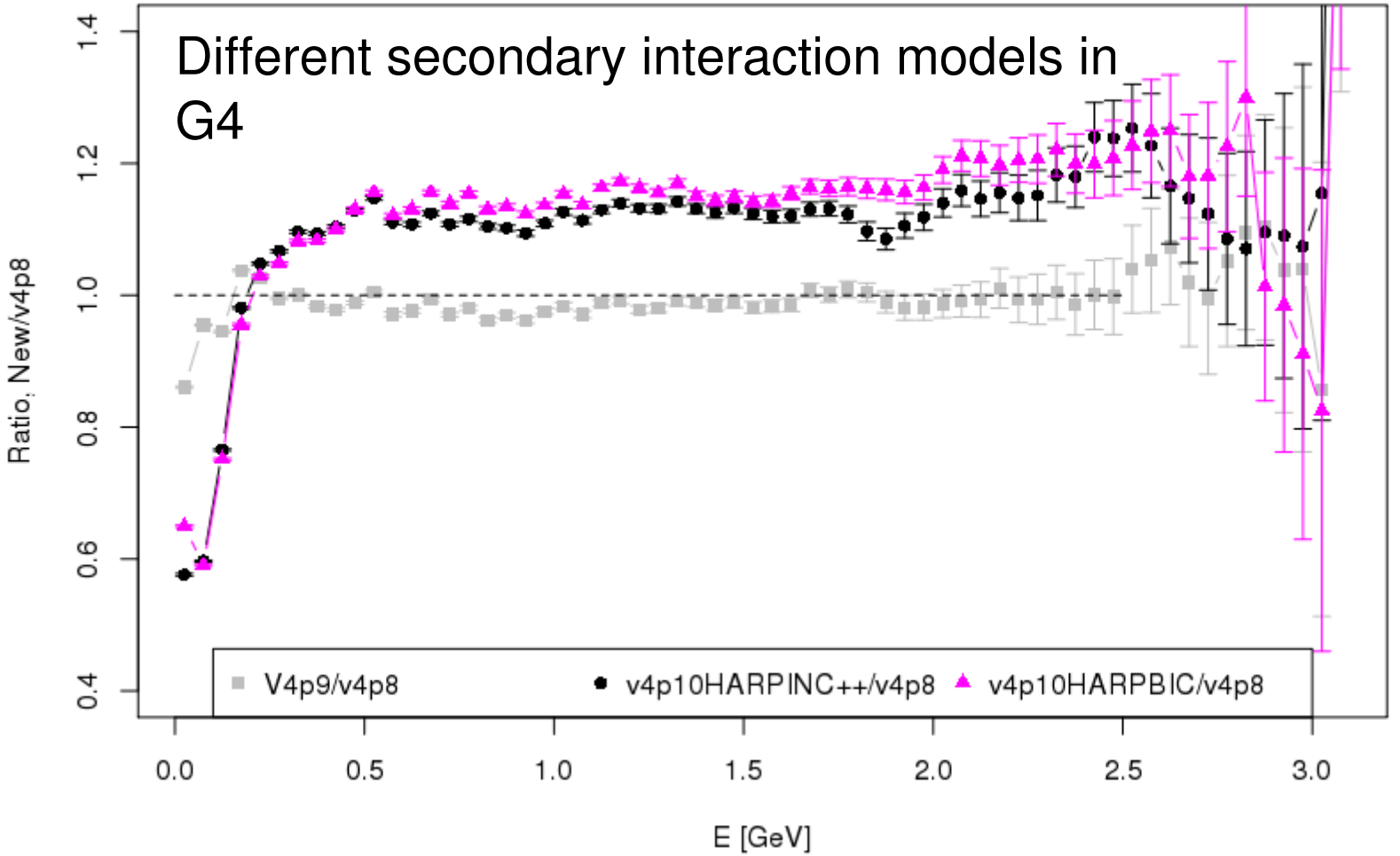
Consistent with the previous slides.

π^+ Yield After the Collimator...



Consequently, we have a serious deficit of pion filtering through the collimator...

Neutrino flux, from $\pi^+ \rightarrow \mu^+ \nu_\mu$



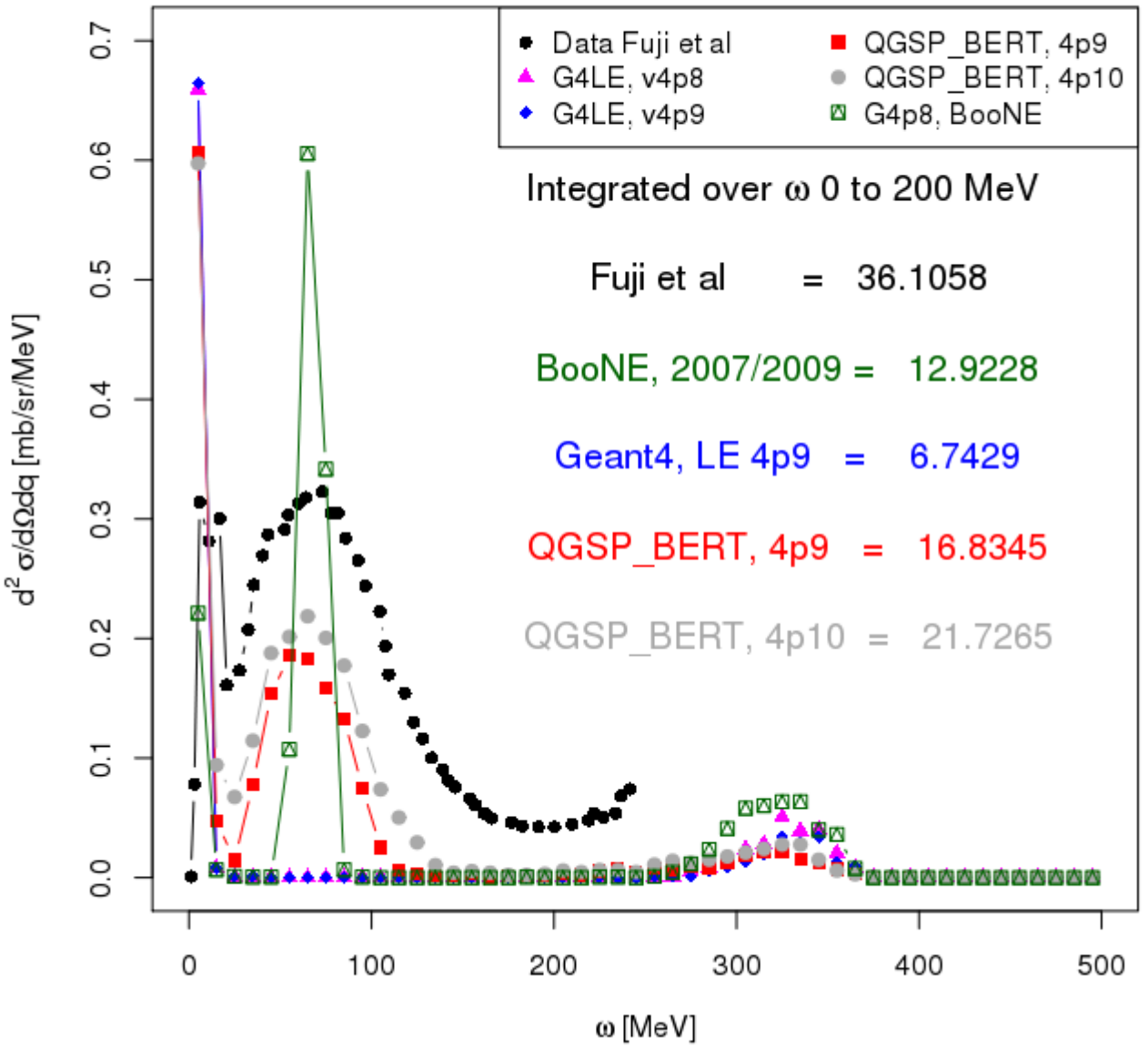
In all three cases, the S_W HARP/BooNE inclusive production model is used,
But we have different scattering models for proton on Be, and pion on Be, Al, Steel, etc...

What's next?

- Need users! Tell me what's missing, what's wrong!.
- Further checks (not done by me!) to be done:
  - Running with shorter target, and/or no material in the horn and in the collimator. Verify, when the S-W model is used at the primary vertex is used..., that the agreement with v4.8.1 improves.
  - Studying, “adding” proton/neutron flux from 8 GeV proton-Be interactions... When using the S-W model... (Athula W. volunteered.)
  - More studies of “effective absortion” of pions in the collimator. This is possible now,
    - with the new Dk2Nu Ntuples, where the complete history of a neutrino is recorded, including elastic and quasi elastic scattering.
    - ASCII Ntuples before/after Collimator.

What's next: Long term upgrades.

- Work in collaboration with the Hadronic Generator group of the Geant4 collaboration to improve the simulation of pions (kaons is much harder..) elastic and quasi-elastic scattering process..



Summary plot for the study on pion-Carbon scattering Quasi Elastic scattering.

Large difference between models and data..

In this context, seeing 5~10% in difference in neutrino flux between v4p8 and v4p10, using the same HARP model to generate pions, is not surprising....