FTF Configuration Interface

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General Information (I)

- Motivation - experience from HAD validation activity
  - From time to time we see that what we consider as a model improvement gives good MC-data agreement in one area but then turns out to be a degradation in some other areas
  - For at least 2 past releases we had to roll back FTF developments (better agreement with thin target data) because it was “giving bad showers”
- The idea of trying to solve the dilemma by possibly applying fitting techniques, e.g. Professor (http://professor.hepforge.org), has been in the air for a while
- We had several discussion on this topic, e.g.
  - At the collaboration meeting 2017 https://indico.cern.ch/event/647154/contributions/2734925/attachments/1530603/2398365/G4-HAD-Models-Param-Study-G4Wkshop2017.pdf
  - At the Hadronic group meeting this past July https://indico.cern.ch/event/742744/contributions/3085636/attachments/1693204/2724731/G4HAD-July25-2018.pdf
  - **Robert H.** pioneered the activity (w/Bertini) – **see his talk in 4A**

General Information (II)

- However, application of a fitting technique(s) would typically require running multiple different configurations of a model…
- … which is not so simple with model parameters being hardcoded
- Recently expanded model configurability allows more flexibility and paves ways for applying fitting techniques, in a hope to be able to give developers a bit more quantitative feedback than “works in one corner, jams in two others”
  - Not that it makes the fitting “trivial” but it definitely simplifies the process

FTF Configuration Interface

- Initial version released in 10.4-series: http://geant4-userdoc.web.cern.ch/geant4-userdoc/UsersGuides/ForToolkitDeveloper/html/GuideToExtendFunctionality/HadronicPhysics/hadronics.html#changing-internal-parameters-of-an-existing-hadronic-model
- A group of configurable parameters/switches involved in modeling diffractive processes and nuclear destruction for baryon projectile
  - Set/Get methods only, no G4UI interface
- Based on G4HadronicDeveloperParameters (by the SLAC team)
  - Allows to impose range (limits) on parameter's value
  - Produces a message when parameter's setting changes from default value
  - (Unlike Bertini) Does not allow to change parameter's setting from its default value more than once per job, per parameter
    - Prevents having multiple configurations of FTF in the same physics lists
- Overall, greatly simplifies studying the effect of varying model parameters on various simulated physics observables

“First Fruit”: FTF-Professor Exercise

- Small group of FTF parameters (3 + 1 switch out of 18 + 4)
  - All these parameters are involved in modeling target nuclear destruction
  - 2 out of them seem to be “sensitive” (based on last year’s study)
  - (At least) 1 of them is believed to be “problematic” in the “thin target vs hadronic showers story”
- Small number of “point” in the multi-parameter space (i.e. groups of parameters settings)
- Small group of datasets - yet covering light and heavy targets, intermediate and high energies
- For details, see https://indico.cern.ch/event/742744/contributions/3085636/attachments/1693204/2724731/G4HAD-July25-2018.pdf
- Of course, Professor is not a “Magician”, and can not always guarantee a 100% perfect MC-to-data agreement in every possible or impossible corner of the phase space but…

3GeV proton on Pb → neutron + X

Data: Ishibashi et al., J.Nucl.Sci.Tech. Vol.34 N.6, p.529-537 (1997)

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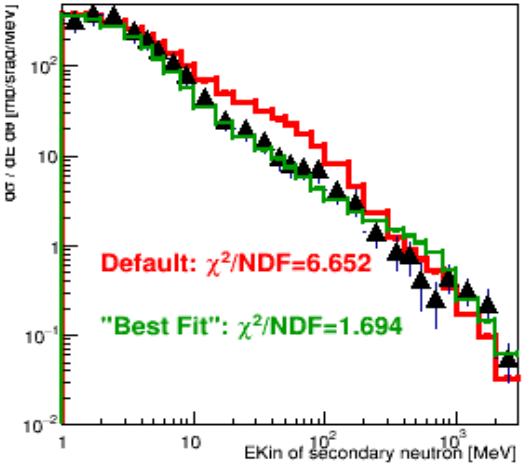

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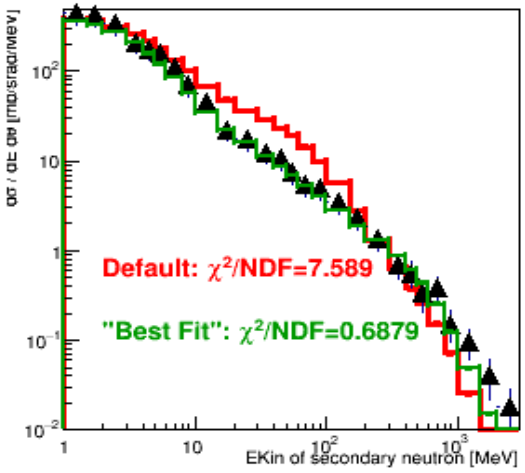

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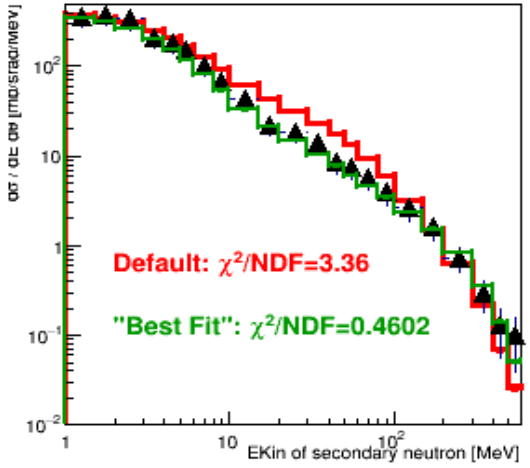

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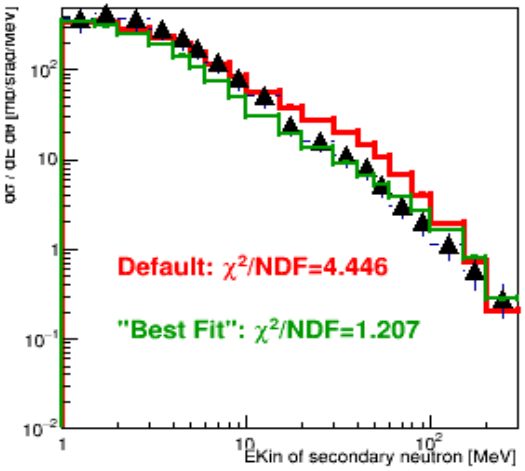

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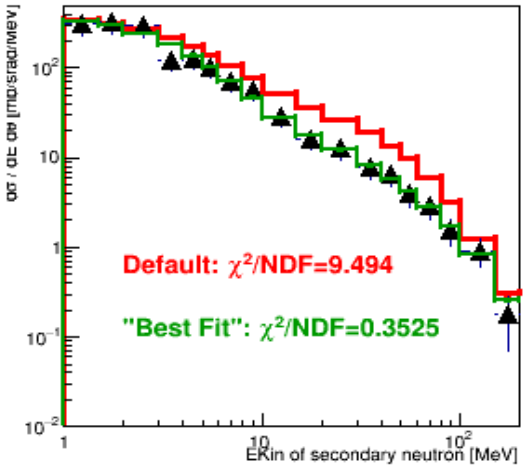

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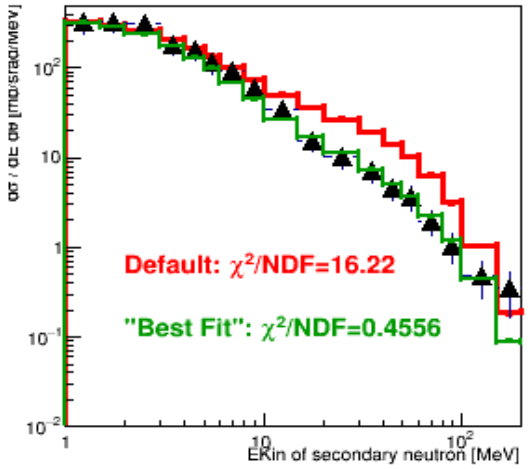


Default FTF Parameters:

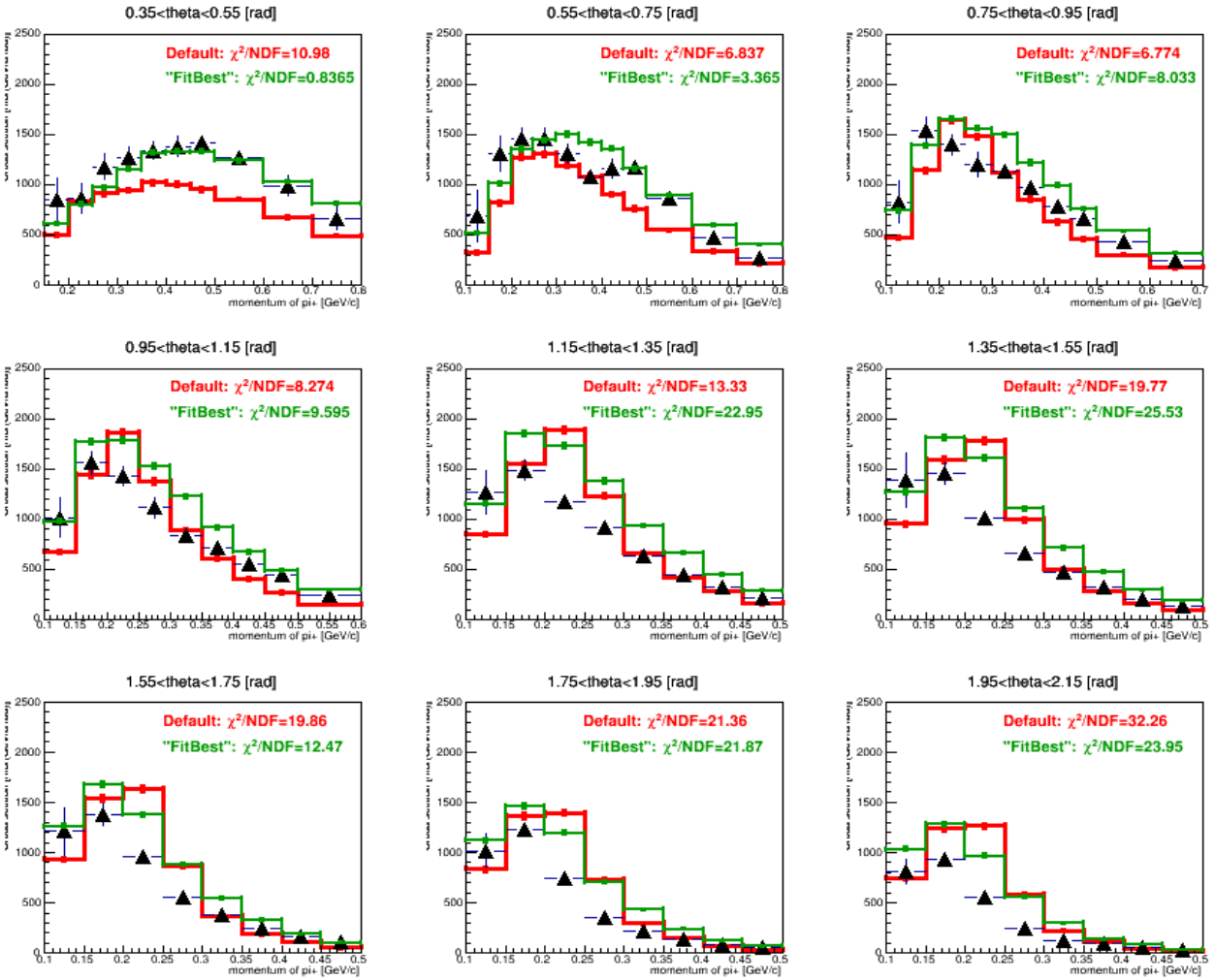
FTF_NUCDESTR_P1_TGT = 1.
FTF_NUCDESTR_P1_ADEP_TGT = false
FTF_NUCDESTR_P2_TGT = 4.
FTF_NUCDESTR_P3_TGT = 2.1
Integral χ^2/NDF=7.678

"Best Fit" FTF Parameters:

FTF_NUCDESTR_P1_TGT = 0.0026 * A(target)
FTF_NUCDESTR_P1_ADEP_TGT = true
FTF_NUCDESTR_P2_TGT = 2.919
FTF_NUCDESTR_P3_TGT = 2.996
Integral χ^2/NDF=0.8544

5GeV/c proton on Pb → π^+ + X (LA)

Data: HARP (various publications)



Default FTF Parameters:

FTF_NUCDESTR_P1_TGT = 1.
FTF_NUCDESTR_P1_ADEP_TGT = false
FTF_NUCDESTR_P2_TGT = 4.
FTF_NUCDESTR_P3_TGT = 2.1

Default (LA): χ^2/NDF=14.7489
Default (FW+LA): χ^2/NDF=12.02

"Best Fit" FTF Parameters:

FTF_NUCDESTR_P1_TGT = 0.0026 * A(target)
FTF_NUCDESTR_P1_ADEP_TGT = true
FTF_NUCDESTR_P2_TGT = 2.919
FTF_NUCDESTR_P3_TGT = 2.996

"Best Fit": (LA): χ^2/NDF=13.33
"Best Fit" (FW+LA): χ^2/NDF=10.89

Current Efforts

- Getting more parameters and more datasets into the study
  - For more extensive study/results, see talk by Robert H. in 4A
- Per advice of Vladimir U., extending configuration interface on other types of projectile
  - Pion projectile
  - For fit: HARP and ITEP771 data on hadron production in p+/pi- on C, Cu, Pb at 3, 5, 8GeV/c (high energy data will be included in the next step)
  - As of now, focus on the target nuclear destruction
  - One of the interesting questions: can modeling of target nuclear destruction be described with the same set of parameters for all types of projectile, or do we need need different groups of parameters for baryons, mesons, etc. ?
  - The assumption is that there should be just one set of parameters for all types of projectile…
  - … but currently at least one of such parameters is different for mesons or (anti)baryons

FTF-Professor Fitting Exercise for Pion Projectile Very Preliminary Outcome (I)

- Study based on limited number of "points" in the multi-parameter space
- Same group of parameters involved in modeling target nuclear destruction
  - **Default settings for pion projectile**
    - **FTF_NUCDESTR_P1_TGT=0.0048*A**
    - **FTFP_NUCDESTR_P2_TGT=4.**
    - **FTFP_NUCDESTR_P3_TGT=2.1**
  - **"Pion Best Fit" (pion beam, both pi+ or pi-)**
    - **FTF_NUCDESTR_P1_TGT=0.0019*A**
    - **FTF_NUCDESTR_P2_TGT=14.09**
    - **FTF_NUCDESTR_P3_TGT=2.67**
  - **"Proton Best Fit" (proton beam, preliminary study from July 2018)**
    - **FTF_NUCDESTR_P1_TGT=0.0026*A**
    - **FTF_NUCDESTR_P2_TGT=2.919**
    - **FTF_NUCDESTR_P3_TGT=2.996**
- NOTE-1: from preliminary study of last year, it looked like the P2 parameter is not a "sensitive" one, at least for the proton beam
- NOTE-2: Separate fits of MC results for pi+ or pi- beam give results that are somewhat different from results of the "combined" fit (both pi- and pi+)

5GeV/c π^- on Pb $\rightarrow$ proton + X

Data: Yu.D.Bayukov et al, Preprint ITEP-148-1983; Sov.J.Nucl.Phys. 42 116, 1985

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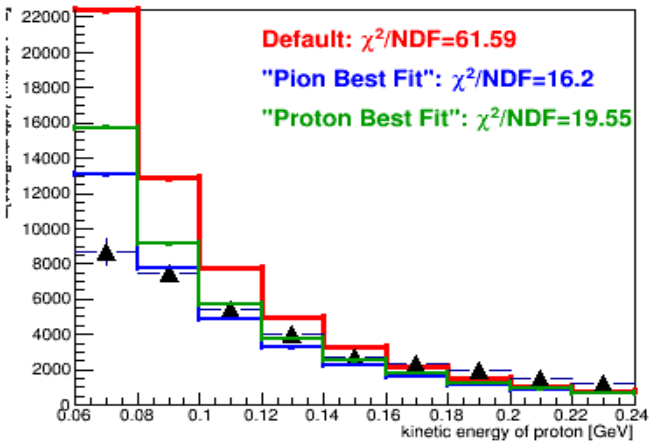

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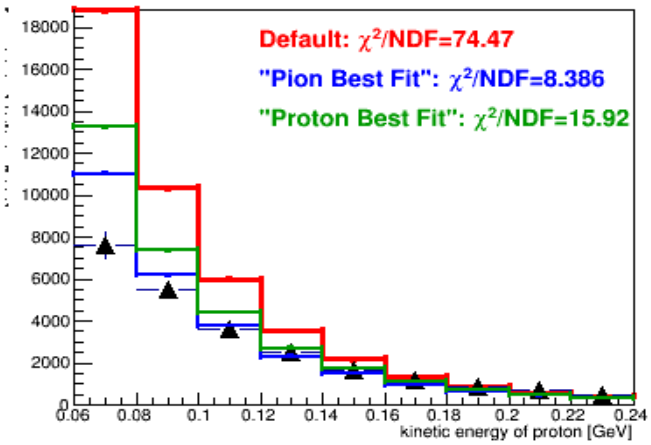

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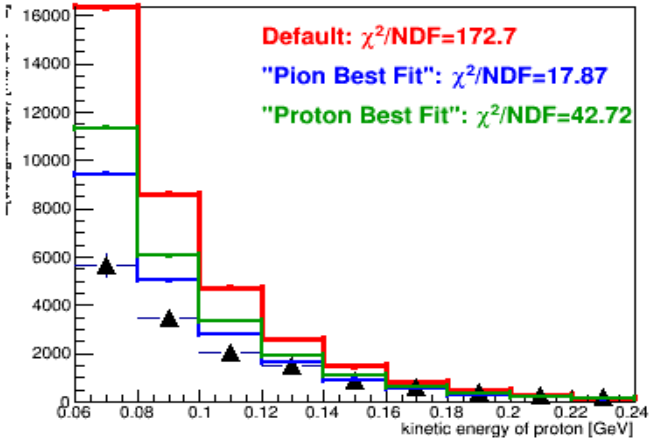

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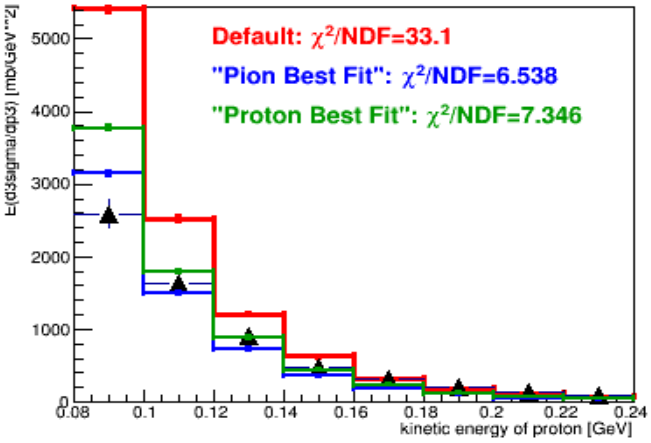
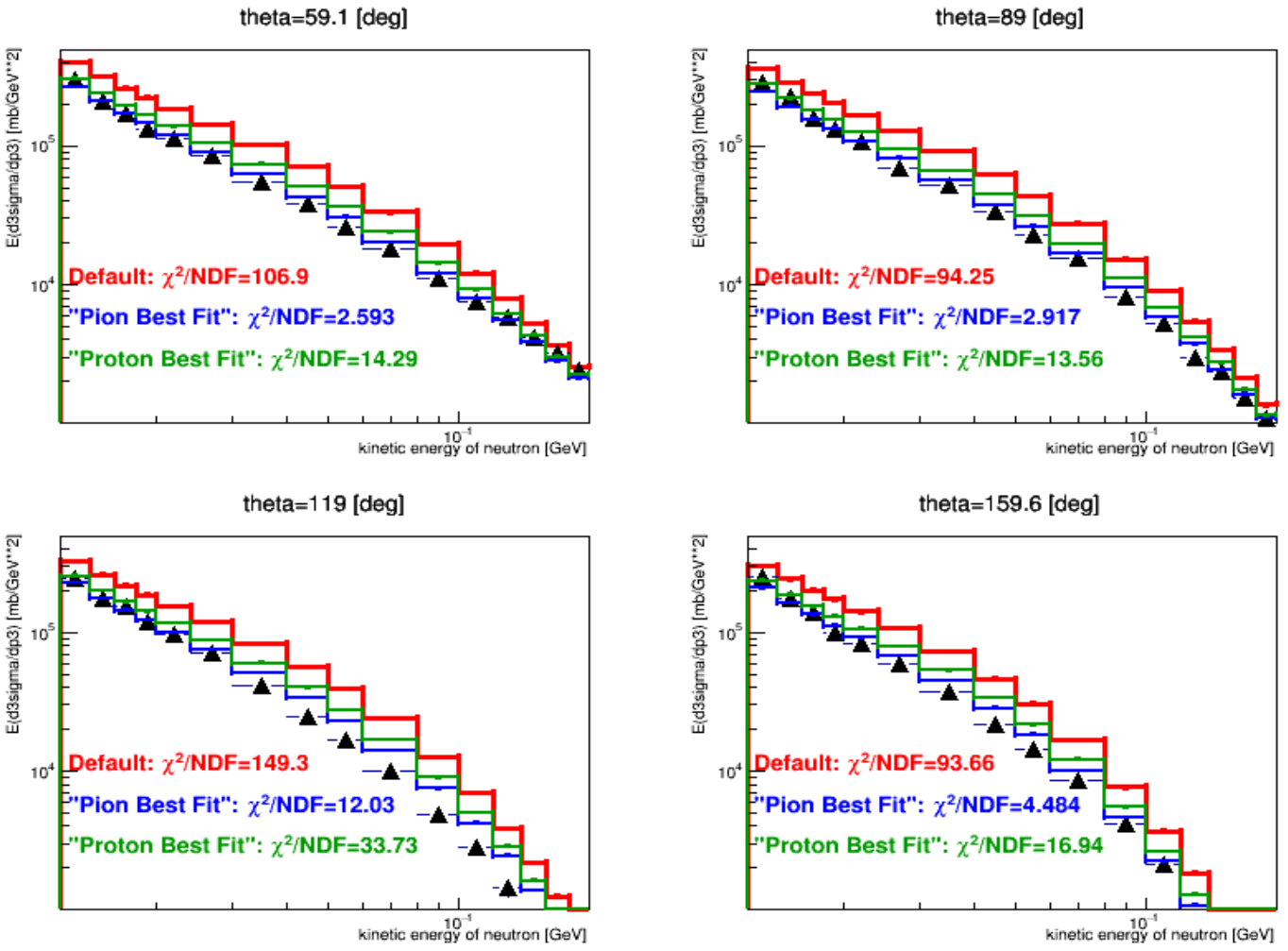


Default: Integral χ^2/NDF=86.95
"Pion Best Fit": Integral χ^2/NDF=12.41
"Proton Best Fit": Integral χ^2/NDF=21.78

5GeV/c π^- on Pb $\rightarrow$ neutron + X

Data: Yu.D.Bayukov et al, Preprint ITEP-148-1983; Sov.J.Nucl.Phys. 42 116, 1985



Default: Integral χ^2/NDF=111

"Pion Best Fit": Integral χ^2/NDF=5.506

"Proton Best Fit": Integral χ^2/NDF=19.63

FTF-Professor Fitting Exercise for Pion Projectile Very Preliminary Outcome (II)

- Current observations do not (yet) prove or disprove the idea that the group of parameters in question should be the same for all types of beam
- They illustrate that making more parameters configurable allows to apply fitting techniques in different corners of the phase space, and to provide certain quantitative feedback to the developers
- More detailed study and discussions with Vladimir U. and Alberto R. are planned in the near future

- NOTE: results obtained with geant4-10-04-ref-06 outfitted with custom modifications to FTF/diffraction (G4FTFParameters), to introduce configurable parameters for the pion projectile

Some Thoughts for the Future (Possibly…)

- Of course, this is a non-trivial matter; more studies/discussions needed
- Assuming that more detailed studies will deliver reasonable output, we might consider extending the scenario
  - Opening more parameters of FTF
    - At least, for internal studies
  - QGS re-tuning
  - Full-scale Geant4 applications, in an attempt/hope to optimize physics list(s) composition and/or overlap region(s)
- Of course, such approach (if justified/accepted) will require certain coding work, CPU and manpower for analysis (nothing is “free”)
- However, introducing configurable parameters opens way to evaluate model-data agreement through fitting techniques, which is likely to benefit Geant4 in general
- Any such decision to be taken by the collaboration, of course

Summary

- Initial version of the FTF configuration interface has been released in Geant4 10.4 series (for the baryon projectile)
- It has paved the way for applying a fitting technique in the multi-parameters space, e.g. Professor, and for providing the feedback to the developers in a more numeric form than “doesn’t work”
- Under the guidance of the FTF developers, we are currently exploring if fitting techniques in the FTF parameters space can be applied to the case of pion projectile
- If further Professor-based studies prove to be successful, we might consider extending the scenario
  - Make more FTF parameters configurable
  - Include other models, e.g. QGS
  - Attempts to optimize physics list(s) composition