Summary of Hadronic Parallel Session 6A
Hadronic models: development & validation (part I)

Compiled by Krzysztof Genser and Alberto Ribon

Geant4 21st Collaboration Meeting
12-16 September 2016, Ferrara, Italy

Hadronic models: development & validation (part I)

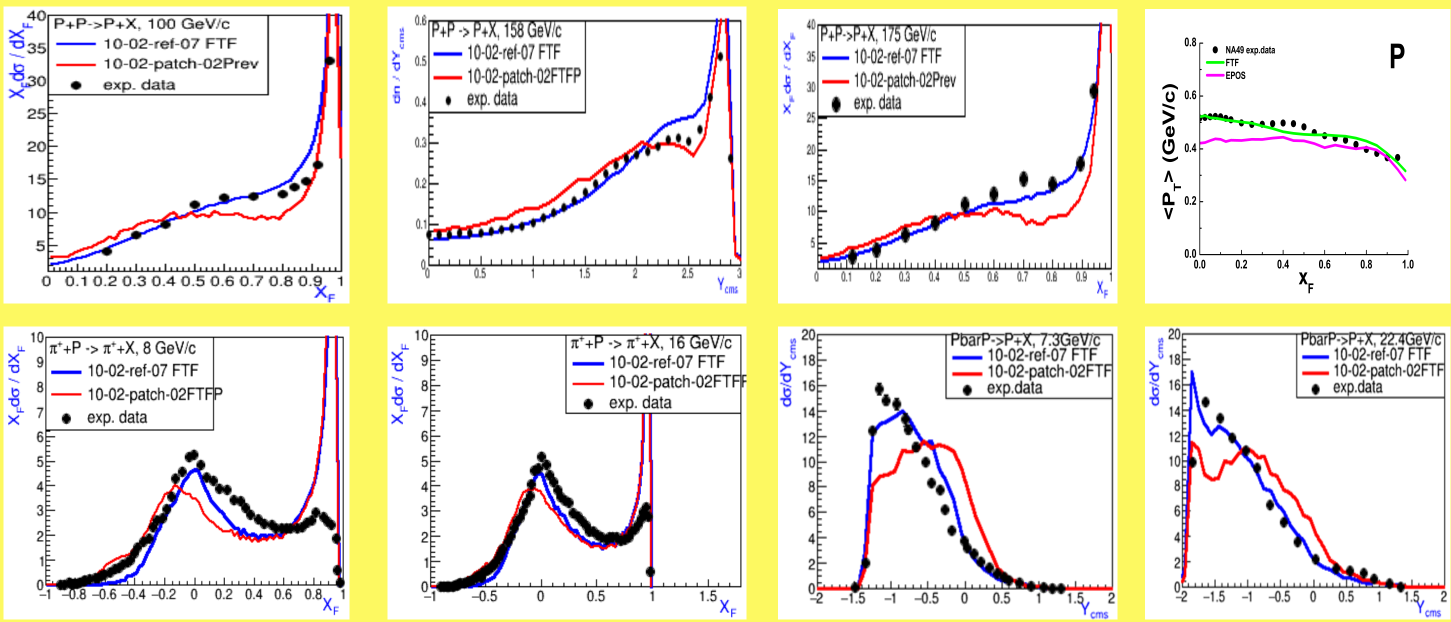
14:00	**Update on hadronic string models**	*UZHINSKY, Vladimir et al.*	*Aula Magna, Ferrara*	14:00 - 14:20
	Update on intra-nuclear cascade models	*DAVID, Jean-Christophe*	*Aula Magna, Ferrara*	14:20 - 14:40
	Update on precompound de-excitation model	*IVANTCHENKO, Vladimir*	*Aula Magna, Ferrara*	14:40 - 15:00
15:00	**Update on Geant4 simulations of n_TOF facility**	*CORTES-GIRALDO, Miguel Antonio*	*Aula Magna, Ferrara*	15:00 - 15:20

V. Uzhinsky Update on hadronic string models

FTF development

1. Fragmentation functions of strings into baryons were chosen as:
   F(z)~xmin + (xmax-xmin) x^(n-1),
   Tuned parameters are: n = 2.5 for B(1/2), and n=0.75 for B(3/2).

2. <Pt> of particles at a string fragmentation are tuned:
   for mesons and baryons (1/2) – 435 MeV/c
   for baryons (3/2) - 1000 MeV/c !!!

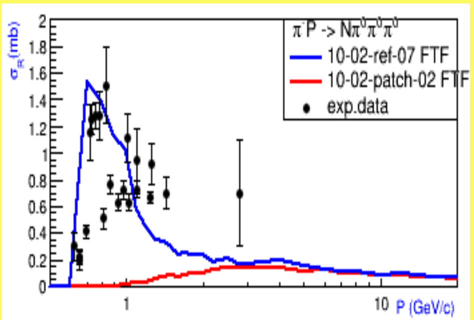


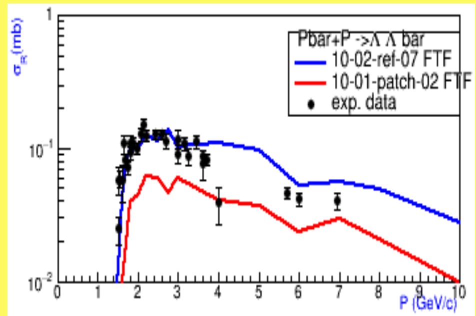
We are not consider hadron-nucleus interactions because there are **TOO** many figures!

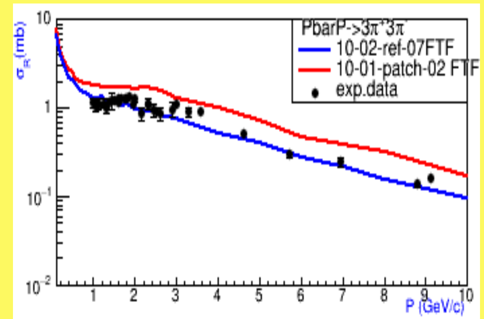
V. Uzhinsky Update on hadronic string models

FTF development

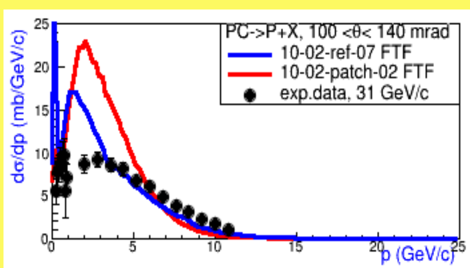
3. Improvement of FTF validation is proposed – accounting of Eta, Eta' decays.
4. Smearing of Delta mass is implemented in quark exchange processes.
5. Antibaryon annihilation was improved.

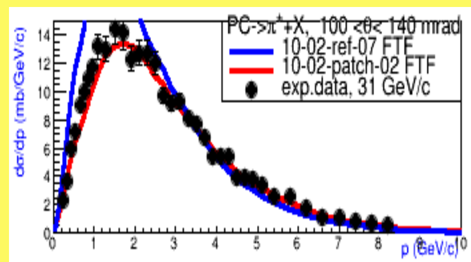


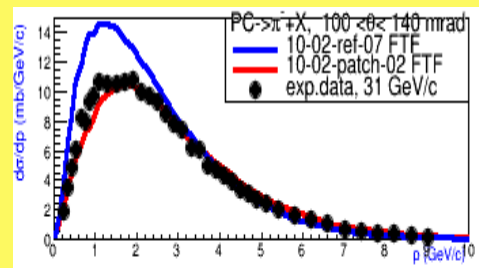




There are some problems with hadron-nucleus interactions







pC->p X   pC->π+ X   pC->π- X

NA61/SHINE Collab. Data on p+C interactions at 31 GeV/c

Description of general features of particles inclusive spectra in PP interactions at 20 – 158 GeV/c is reached!

V. Uzhinsky Update on hadronic string models

Current FTF and G4 10.2.ref03

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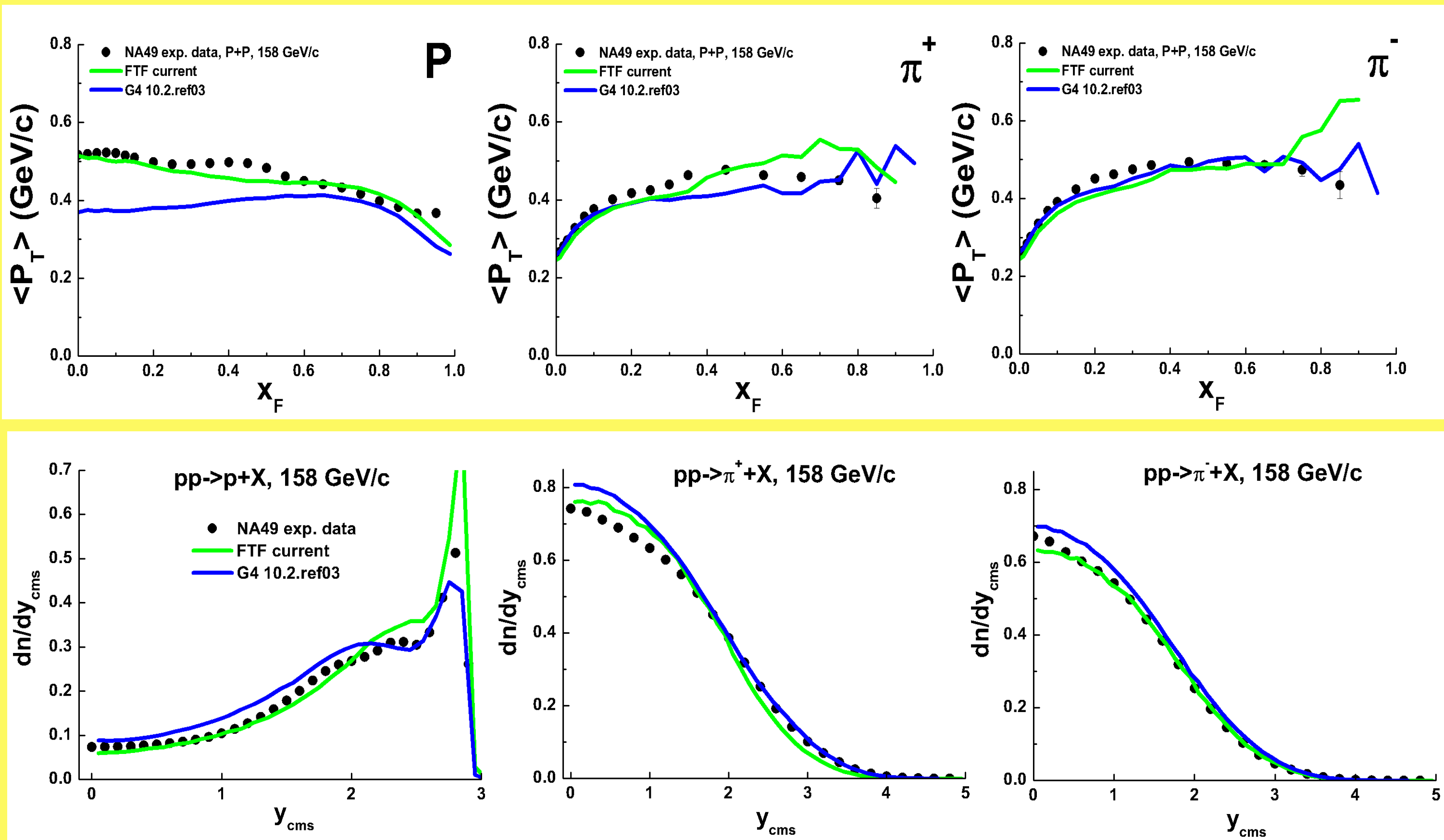
<Pt> at string fragmentation: 435 MeV/c for mesons
435 MeV/c for nucleons
1000 MeV/c for Δ isobar!



Fermilab

V. Uzhinsky Update on hadronic string models

NA49 exp. Data, <Pt> - Xf, 158 GeV/c, FTF and EPOS

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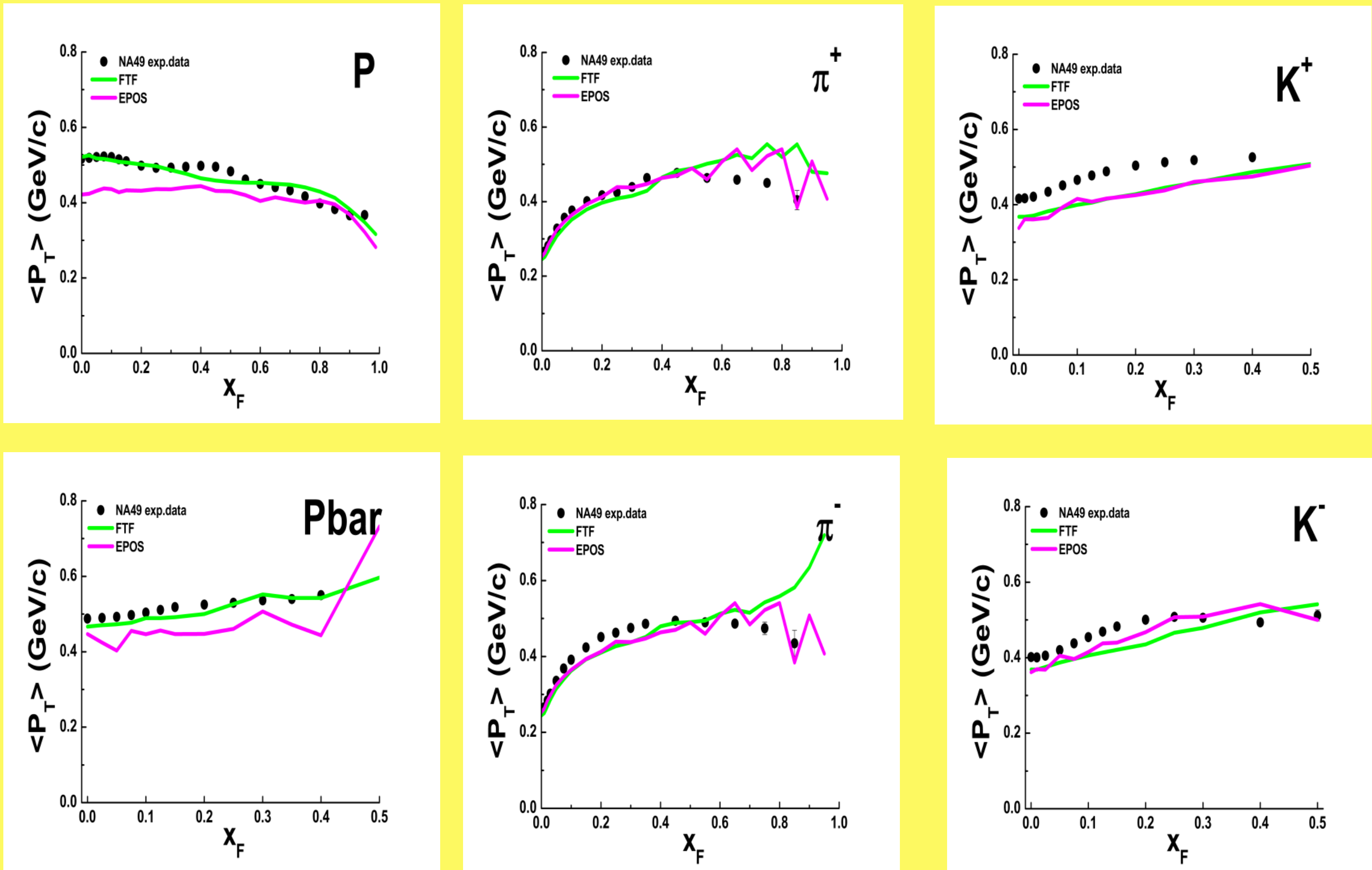


!

!

Results of FTF and EPOS are very closed to each other! Only problem with Pt of protons and antiprotons in EPOS. K+/K- common problem.

V. Uzhinsky Update on hadronic string models

Summary

The main message of us is, Δ isobars must be special treated in ALL string fragmentation model!

1. Fragmentation functions for baryons were chosen:
   F(z)~xmin + (xmax-xmin) x^(n-1), n = 2.5 for B(1/2), and n=0.75 for B(3/2).

2. <Pt> of particles at a string fragmentation are tuned:
   for mesons and baryons (1/2) – 435 MeV/c
   for baryons (3/2) - 1000 MeV/c !!!

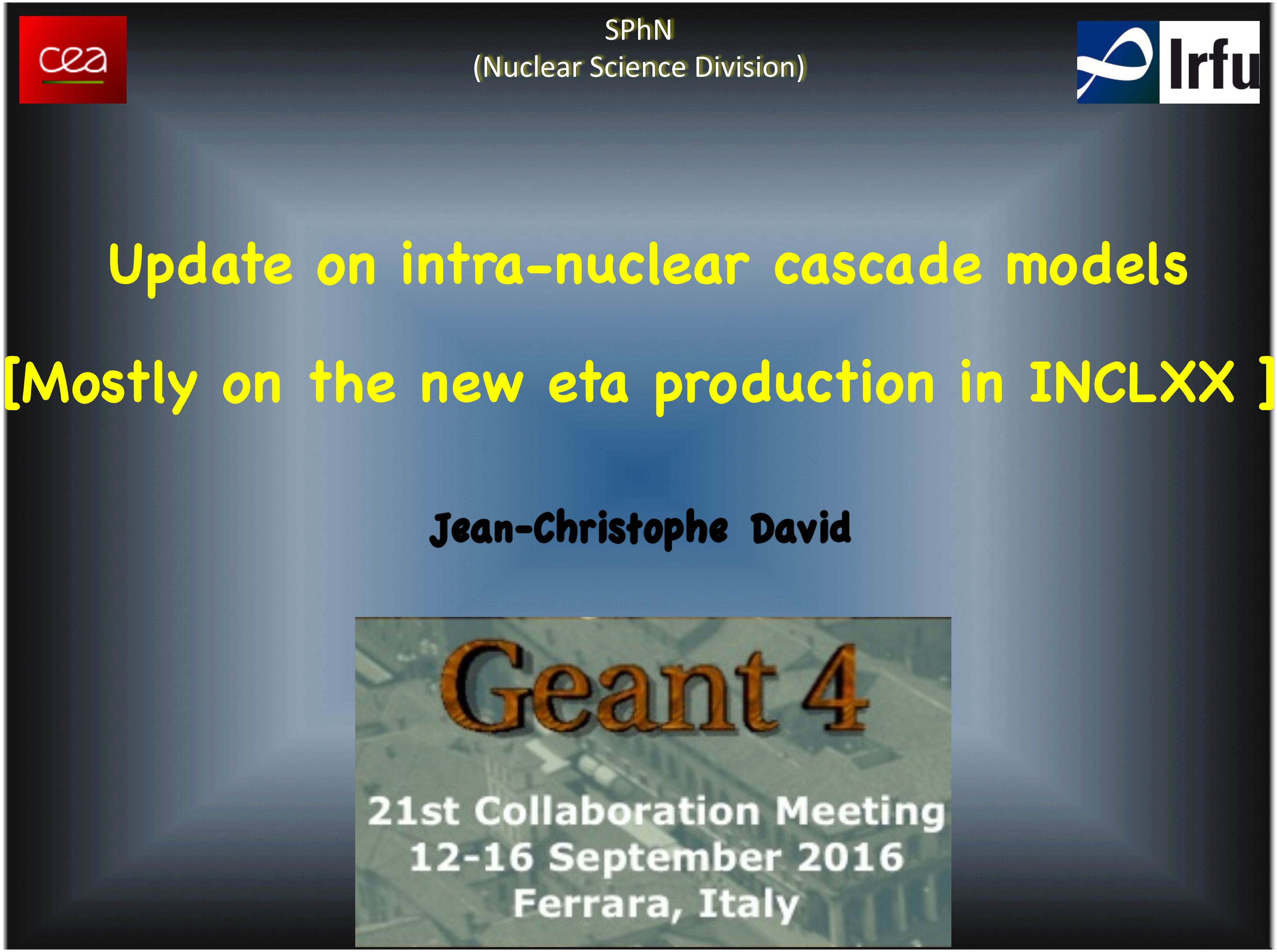
3. Improvement of FTF validation is proposed – accounting of Eta and Eta prime decays.
4. Smearing of Delta mass is implemented in quark exchange processes.
5. Antibaryon annihilation was improved.

FTF model is on the level of other models for pp interactions. What will it be for nucleus-nucleus ones?

The main problem of models, except EPOS, was a description of baryon spectra. It is now solved in part in FTF.

Description of general features of particles inclusive spectra in PP interactions at 20 – 158 GeV/c is reached!
<Pt> - Xf correlations are reproduced!

J-C David Update on intra-nuclear cascade models



J-C David Update on intra-nuclear cascade models

Update on intra-nuclear cascade models
(Mostly on eta in INCL++)

- Short News from Binary Cascade and Bertini Cascade
- η in INCL++

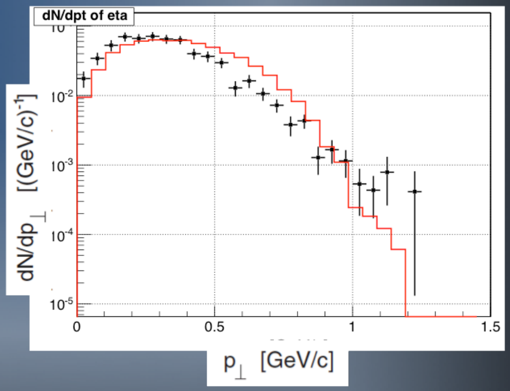
J-C David Update on intra-nuclear cascade models

- Nothing new in Binary Cascade
- Bertini Cascade:
  - K interaction and gamma-nuclear interaction updated

- INCL++ works with n, p, π up to 10-15 GeV
- 2016: η and ω and 2017: K and Y
  → open new physics (rare decay (η), hypernuclei, ...)

- First implementation of η gives rather good results: ex. p(3.5 GeV)+Nb

- η and ω soon in Geant4 10.3



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J-C David Update on intra-nuclear cascade models

Motivations

Why η, ω?

- a necessary step toward K, Y
- what's the role in π production? (decay product)
- source of dileptons (= clean information of nuclear matter)
- to study rare decays violating a conservation law

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Update on intra-nuclear cascade models

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J-C David Update on intra-nuclear cascade models

Conclusions

- η is in INCL++ and gives good results
- A first implementation in Geant4 works
- Some (minor) changes until the *official* version
- ω is almost in INCL++ and soon in Geant4
  (unfortunately no data to test it)
- See you next year for the strangeness (PhD - Jason Hirtz)

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Update on intra-nuclear cascade models

V.Ivanchenko Status of pre-compound model and de-excitation module

Geant 4

Geant4 ASSOCIATES INTERNATIONAL

Experts in Radiation Simulation

Status of pre-compound model and de-excitation module

V. Ivanchenko, CERN & Geant4 Associates International

21th Geant4 Collaboration Workshop
12-16 September 2016
University of Ferrara, Italy

Status of pre-compound model and de-excitation module (V.Ivanchenko)

- Geant4 pre-compound model is responsible for simulation of pre-equilibrium emission of neutrons and light ions
  - When excited nucleus reach the equilibrium the pre-compound model call de-excitation module
  - Any hadronic model may interface pre-compound model or de-excitation models
- Recently a process of review and redesign of pre-compound/de-excitation is started due to following reasons:
  - Provide thread safe and effective code
    - CPU performance and memory consumption of many of hadronic generators are limited by the performance of pre-compound/de-excitation
  - Sub-models use hardcoded nuclear level energies and other parameters
    - not possible guarantee reproducibility
  - There were a lot of duplicated code
  - Memory was used not in an optimal way
    - Overheads in MT mode
  - It was difficult to add new features
    - For example, correlated gamma emission

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V.Ivanchenko Status of pre-compound model and de-excitation module

Status of pre-compound/de-excitation

- Full migration of Pre-compound/de-excitation to G4DeexPrecoParameters
  - Parameters may be changed via C++ interfaces from the master thread only
- Current default evaporation has only 8 decay channels
  - No GEM channels by default
  - Better CPU performance for HEP applications
- Coulomb barrier classes were reviewed and an interface now universal allowing to use them for all sub-models
  - Number of small files in the sub-library is reduced
- A new class G4FermiBreakUpVI is validated and is a current default
  - The old model will be removed soon
  - The new model model is fully based on the nuclear level structure from G4LEVELGAMMADATA
    - no hardcoded energies or other parameters
    - This is important for reproducibility
  - Standard Coulomb barrier implementation is used
- A new class G4GEMChannelVI and the corresponding classes have been committed but not yet validated enough
  - Plan to evaluate it for 10.3
- G4PhotonEvaporation has been fixed and extended, majority of radioactive decay transitions are correct
  - Current bug reports and other questions concern of previous releases
  - A possibility of simulation of correlated gamma is prepared by not yet tested
    - Plan to have this feature working for the release
- CPU/memory performance of the de-excitation module was improved allowing to use it by the Bertini cascade

V.Ivanchenko Status of pre-compound model and de-excitation module

Summary

- A general redesign of the de-excitation module is ongoing
  - The module includes c++11 elements
  - Performance is improved
  - Bertini cascade will have similar CPU performance if use standard pre-compound/de-excitation
- There are several developments for 10.3 which not yet done
  - Adoptation of the new data structure prepared by L.Desorgher
  - Enabling correlated gamma emission
  - Validation and tuning of the new GEM model
  - Enabling of isomere production
- Validation results are stable in general
  - There are some plots with improvemets
  - There are some plots with slight degradation
  - Neutron spectra below 0.5 MeV is strongly supressed in the new model
    - This requires evaluation and further tuning

Miguel A. Cortés-Giraldo et al - Update on Geant4 Simulations of Lead Spallation Target at n_TOF Facility

Update on Geant4 Simulations of Lead Spallation Target at n_TOF Facility

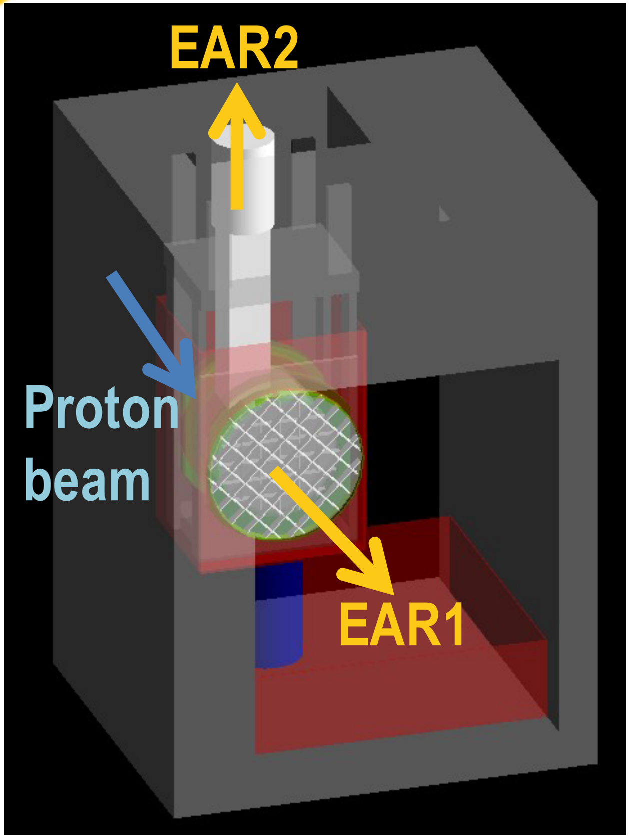
Miguel A. Cortés-Giraldo[1], J. Lerendegui-Marco[1], M. Sabaté-Gilarte[1,2], C. Guerrero[1], J. M. Quesada[1]

1) Universidad de Sevilla (Spain)
2) CERN (Switzerland)

21st Geant4 Collaboration Meeting

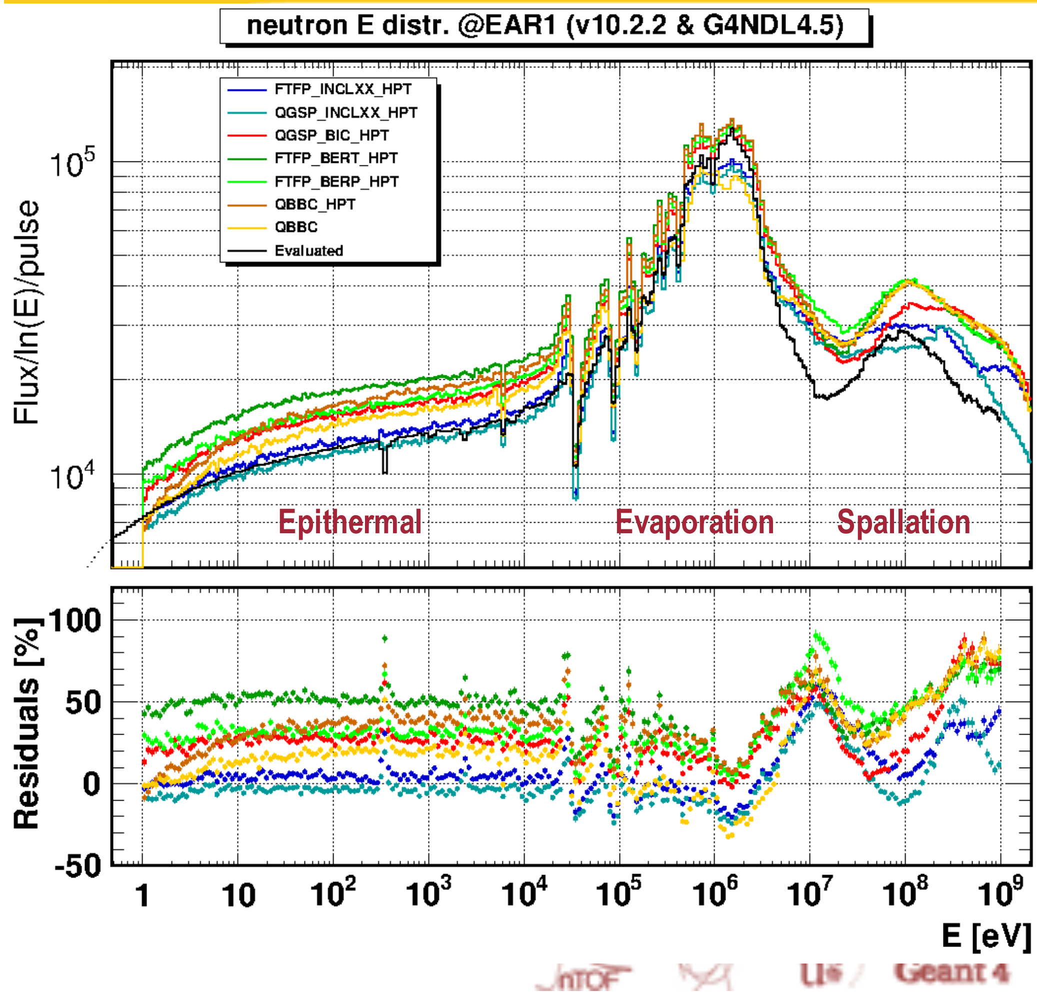
Ferrara (Italy), September 15th, 2016

Full Geometry Model of the Target at n_TOF



- 20 GeV/c protons, with an incidence angle of 10 deg.
- Gaussian profile proton beam (FWHM=3.53cm).
- Precise implementation of the cooling and moderation layers.
- All the components have been implemented **following the technical drawings.**
- **Special care** in the **composition** of the lead target and the surrounding materials is mandatory to reproduce dips in energy spectrum accurately.
  - However, in this work we used simplified material compositions in order to speed up, since it does not affect overall neutron production.

Neutron Energy Distribution @ EAR1 (v10.2.2)



- **More precise collimation data used.**
  - It improves significantly the integral flux calculated.
- **Trends between PLs are similar to those found with v10.1.1**
- Tracking of **neutrons** was **suspended below 1 eV** to shorten simulation time.
- ***_HPT** stands for **NeutronHP** with **ThermalScattering physics** activated (**E_n < 4 eV**)

Neutron Energy Distribution @ EAR1 (v10.2.2)

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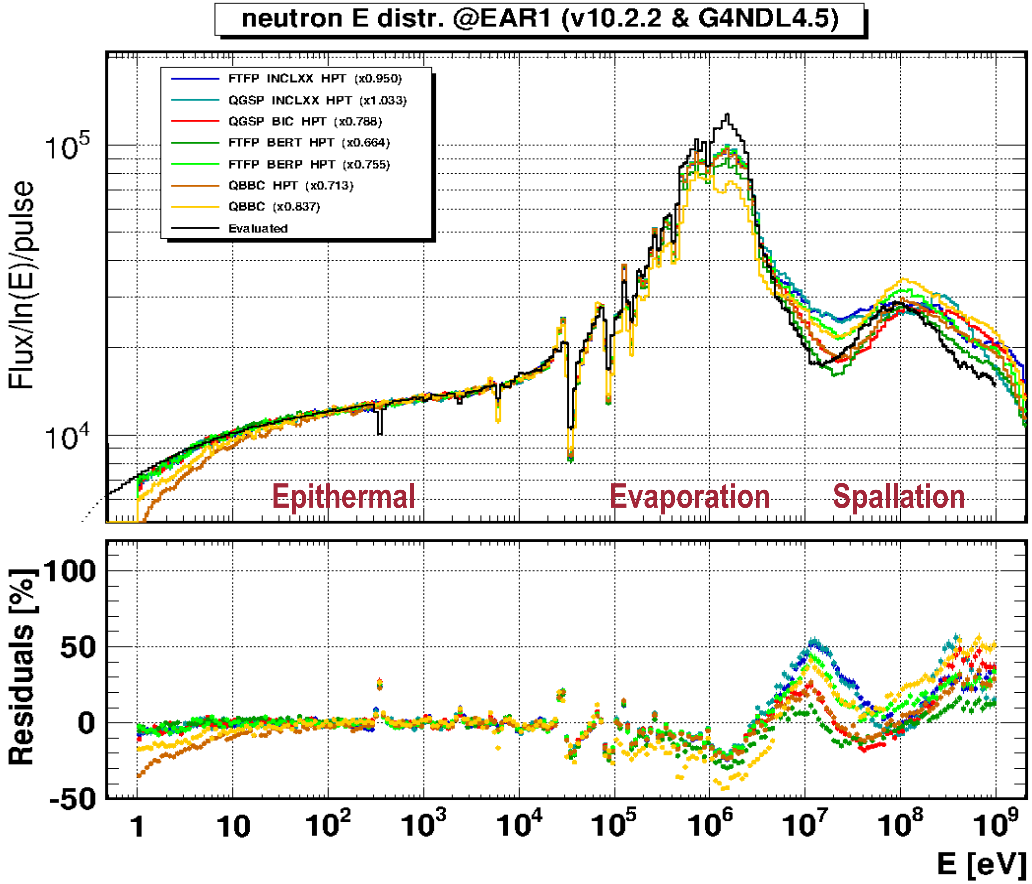

- **Normalization factors** calculated using integral for **1-10 keV**.
- *_INCLXX_HPT physics lists provide better normalization factors.
- FTFP_BERT_HPT follows better the spectrum shape at **spallation** energies, but it still presents the largest deviation w.r.t. to integral flux.

- **Norm factor** varies from **1.033** (QGSP_INCLXX_HPT) to **0.664** (FTFP_BERT_HPT).

Miguel A. Cortés-Giraldo et al - Update on Geant4 Simulations of Lead Spallation Target at n_TOF Facility

Neutron Energy Distribution @ EAR2 (v10.2.2)

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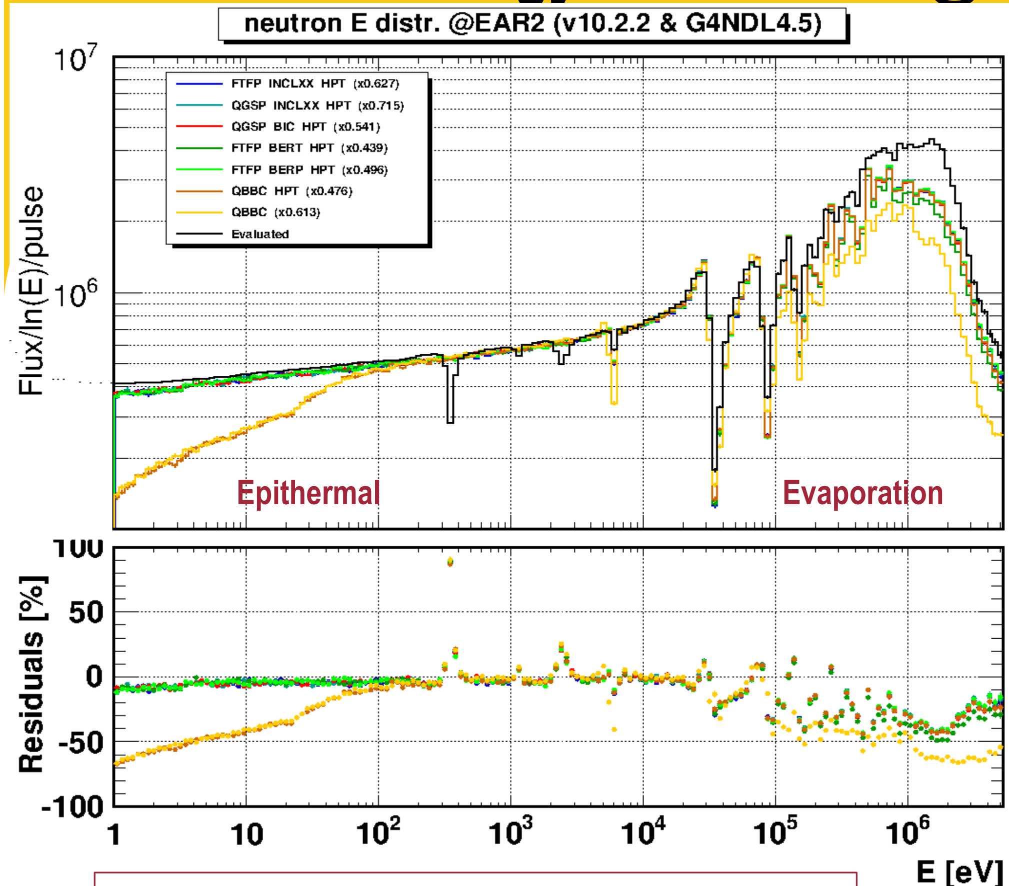

M. Sabaté-Gilarte, M. Barbagallo et al., in preparation
N. Colonna et al., *Nuc. Phys. News* 25: 19-23 (2015)

- **Norm factor** varies from **0.715** (**QGSP_INCLXX_HPT**) to **0.439** (**FTFP_BERT_HPT**).
- **Actual distance from EAR2 ground to target to be accurately determined.**
  - It may improve agreement between calculations and experimental neutron flux
- **Precise quantification of neutrons scattered at collimators might also change the calculated spectrum shape.**
  - Transport through collimators is done "ideally".

Conclusions

- Slightly better agreement as for neutron integral flux calculation @EAR1 thanks to more accurate collimation data.
- Experimental integral flux evaluated @EAR2 still preliminary – need to know accurate total distance.
  - More accurate simulation of collimators closer to EAR2 may be needed.
- Preliminary CPU overhead observed when using NeutronHP (with Thermal Scattering XS). Work in progress to figure out what causes this:
  - Local implementation of NeutronHPThermalScattering?
  - ParticleHP interface?,
  - Other?
- Study on reaction multiplicities ongoing to try to explain differences between PLs.

nTOF CERN US Geant 4