Status and Plans for the Geant4 Bertini Cascade

Geant4 Collaboration Meeting
Parallel Session 3A
28 August 2018
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Outline

- Multi-body final state extension
- Pion absorption by quasi-deuterons
- Gamma-nuclear developments
- Plans

Kaons and Hyperons in 6, 7, 8 and 9-body Final States

- Until recently strange particles were not included in Bertini final states with more than 5 particles
  - partial cross sections within Bertini were affected due to re-scaling to the total cross section
  - not correct above ~10 GeV
- Hundreds of strange particle production channels added for nucleon-nucleon, pion-nucleon and kaon-nucleon interactions
- Inclusion of new channels made slight improvement
  - more kaons and hyperons above 10 GeV
  - fewer nucleons and pions
  - no significant CPU slow-down due to greater number of sampled states

Pion Absorption on Quasi-deuterons

- Prior to 10.4 ref04, Bertini pion absorption did not respect incident particle charge
  - → charge non-conservation

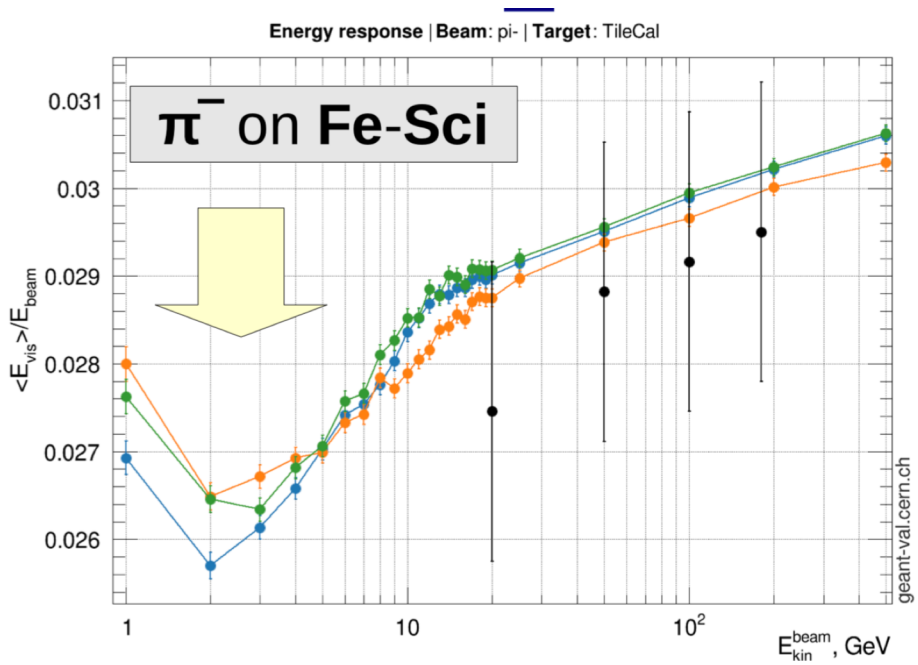
- Fixed in ref05
  - More neutrons produced when π^- absorbed
  - Fewer neutrons produced when π^+ absorbed

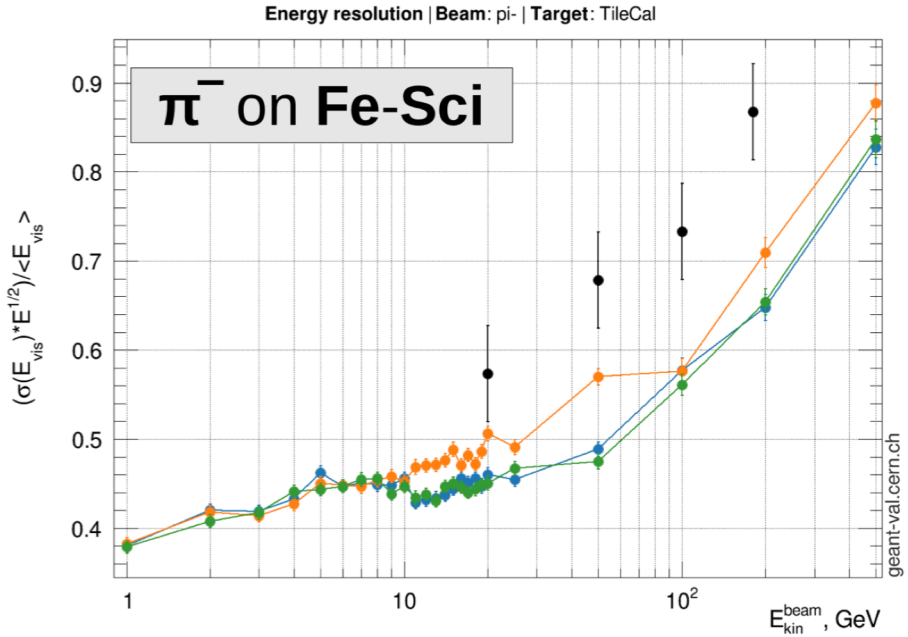
- Slight improvement in showers
  - Lower energy response for π^- (toward data)
  - Resolution for π^- also moves toward data
  - Lower energy response for π^+
  - Resolution not much changed for π^+

Effect of QD Absorption in FTFP_BERT

Blue: ref05

Green: ref04

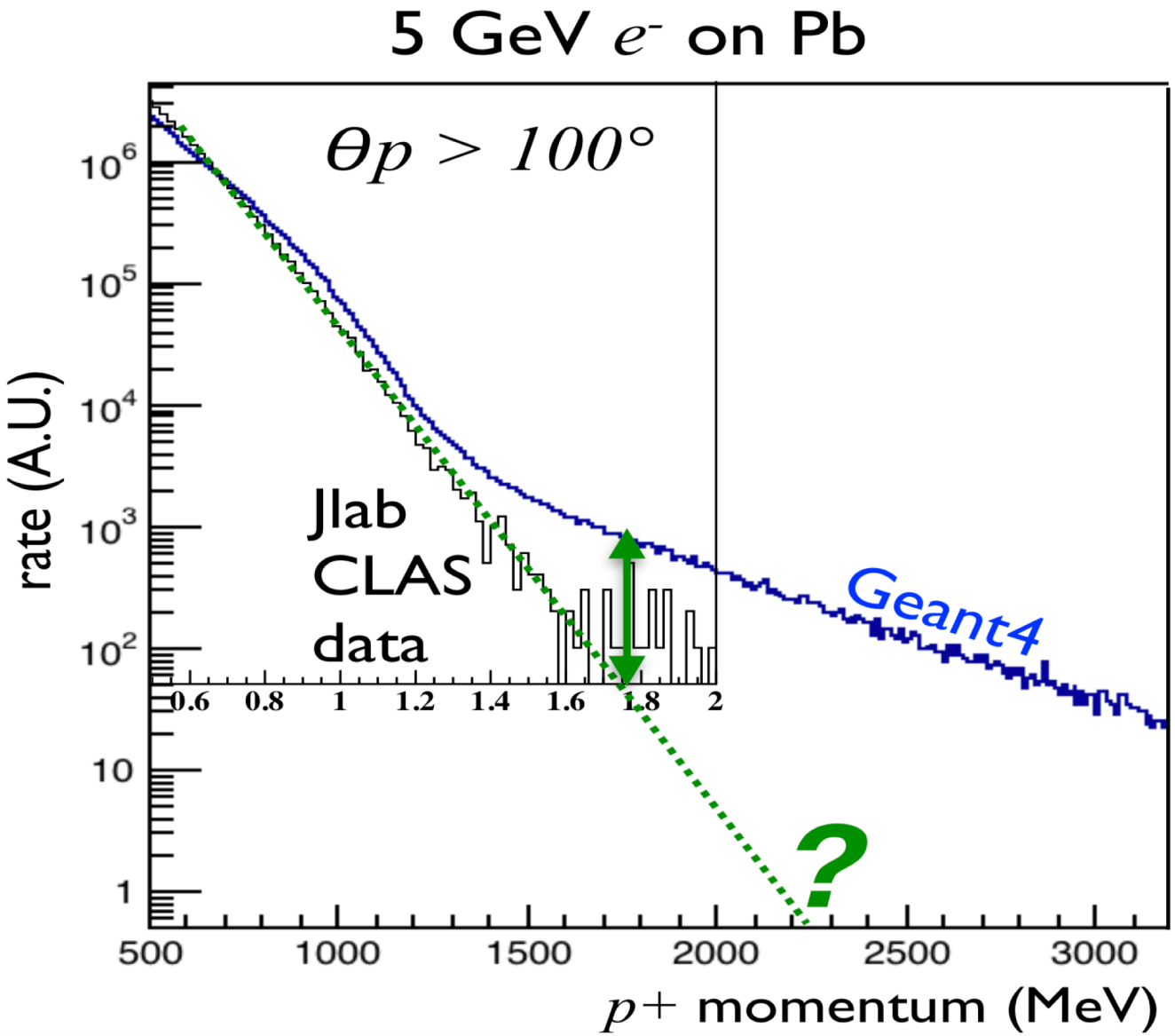




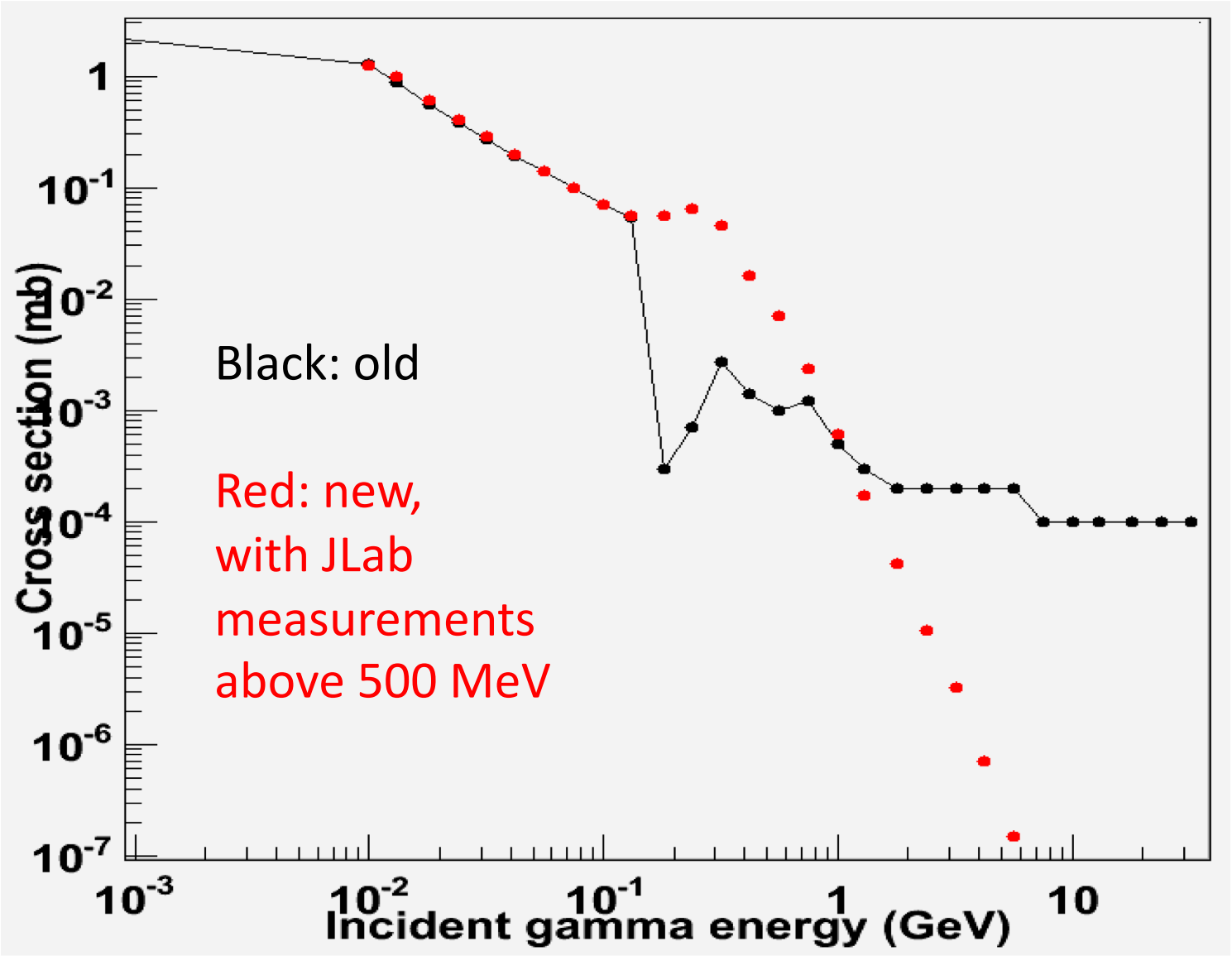
Recent Work in Electro- and Gamma-nuclear

- Working with Natalia Toro (SLAC) on LDMX
  - several problems uncovered in way Bertini handles incident e^- and γ reactions
  - improvements underway
- Problems:
  - electro-nuclear final states have large tails above a few GeV
  - quasi-deuteron cross section incorrect above 150 MeV
  - dinucleon targets in nucleus account for 40% of gamma absorption -- should be only 6%
  - sampled γ MFP too large compared to hadron MFPs → incorrect forcing of interaction
  - incorrect ordering of final state hadrons after gamma absorption on nucleons

Electro-nuclear Problem in Geant4



Improved Quasi-deuteron Photo-disintegration Cross Section



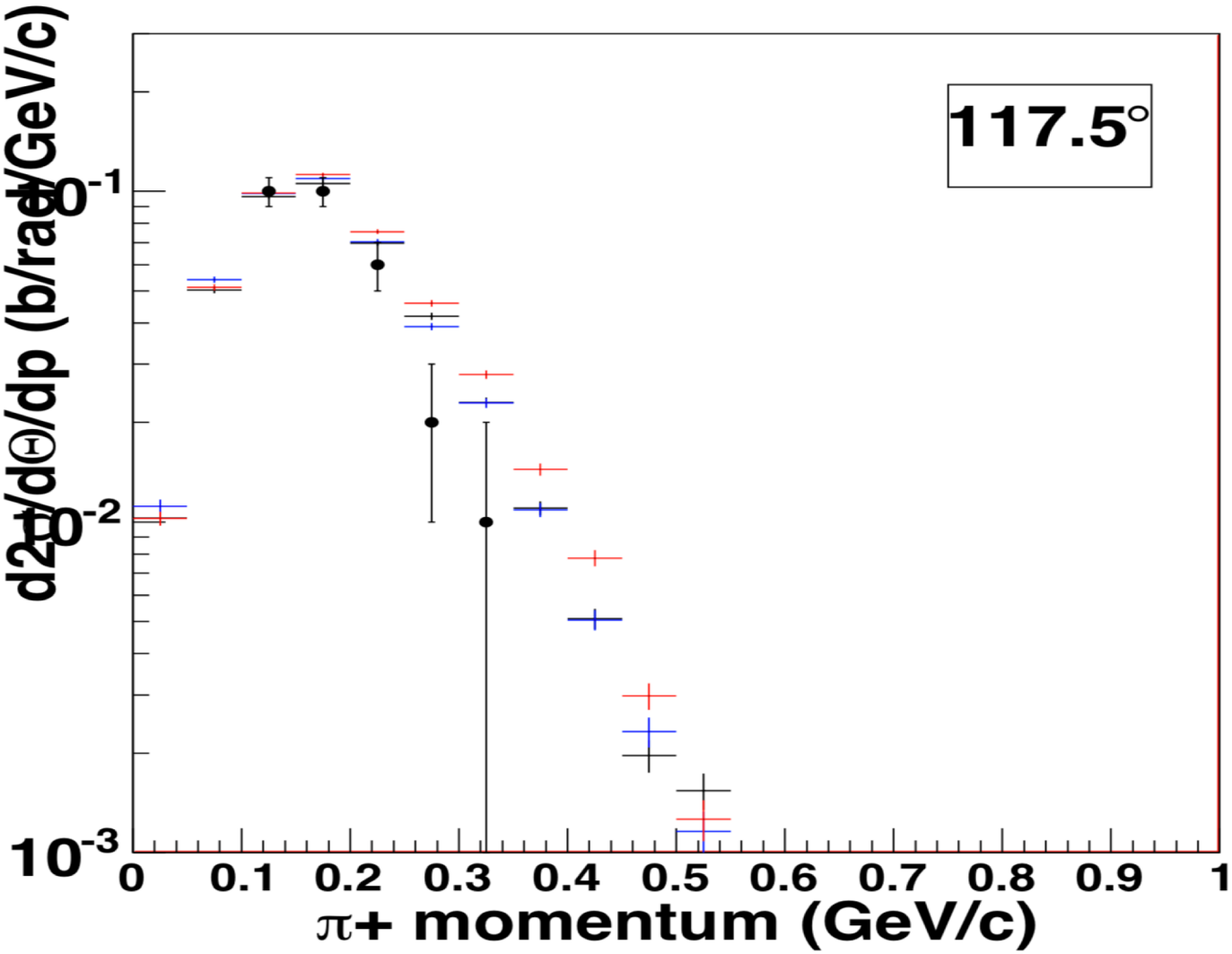
Recent γ-nuclear Improvements

- To fix overestimate of MFP:
  - Calculate total MFP including both scatter and absorption cases
  - Select a target within nucleus (p, n, QD) with probability equal to that target's fractional contribution to MFP

- Improve interaction lengths by:
  - Using Local Density Approximation to get better estimate of dinucleon density in nucleus

- Improve final state angular distributions by:
  - Using correct ordering of hadrons in γ–nucleon final state
  - Better treatment of transmission of high energy, glancing incident hadrons at zone boundaries in nucleus (avoiding trapped particles)

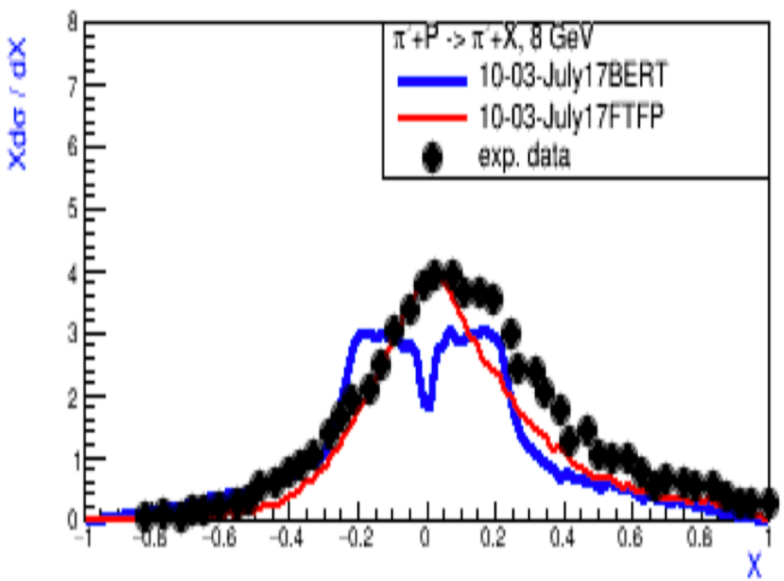
Effect of Code Changes on Final State Angular Distribution for ^{12}C (p, π^+) X

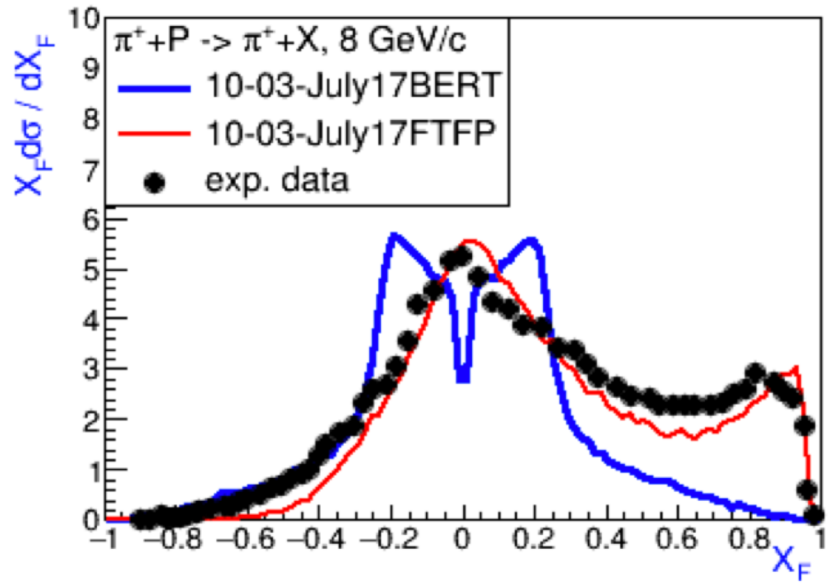


Plans

Anomalous X_F for π p elastic (V. Uzhinsky)

π^- p → π^- X @ 8 GeV/c





π^+ p → π^+ X @ 8 GeV/c

Validation of G4LENDorBERTModel

- T. Koi developed model which uses GND database (LEND) for gamma-induced reactions below 20 MeV
  - Bertini used when no data
- Expected to do much better than Bertini alone
- However, not well validated. Need to:
  - collect data
  - set up tests
  - do thorough validation
  - Q4 of 2018

Re-examine Nucleon-nucleon Cross Section

- p p and p n internal cross sections below 500 MeV are not close to free space cross sections
  - left over from original INUCL code which changed these cross sections to fit data
- Changing them back to measured free-space values improved thin-target data, but made thick target worse
  - so we kept original INUCL values
- May be useful to set up a boolean parameter which allows a change in these cross sections
  - add to current parameter study?

Start to Look at Quasi-elastic Scattering

- Group together all reactions in which the final state is a single hadron and a residual nucleus
  - treat separately from all other reactions in Bertini

- Several advantages:
  - simple, fast kinematic treatment
  - would solve Bertini recoil problem for some fraction of events
  - might solve some double differential cross section discrepancies at energy endpoints of distributions
  - data exist for validation