Computing Session

HELMHOLTZ ASSOCIATION

Helmholtz Institute Mainz

DPM improvements: A proposal/request

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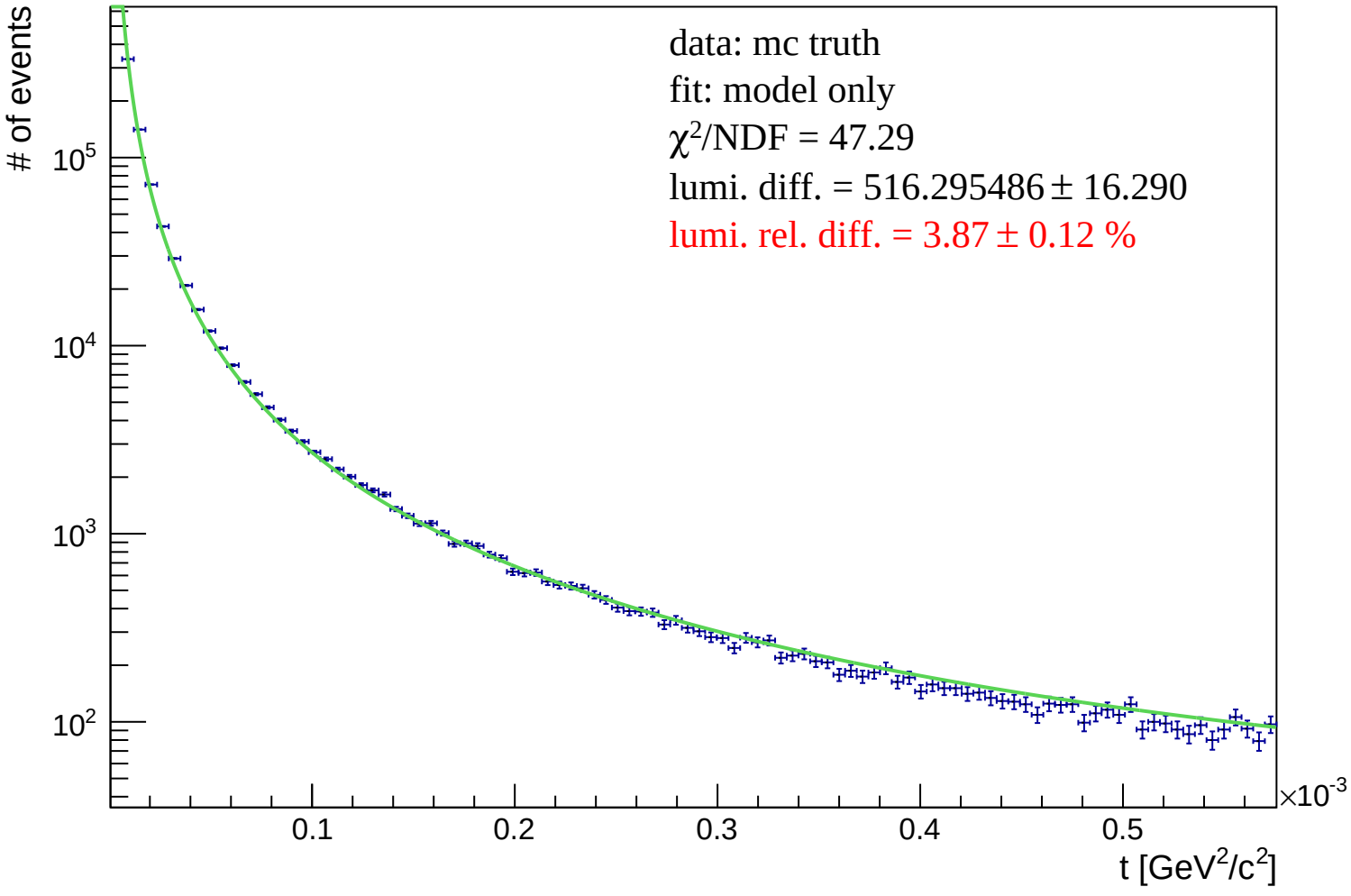
DPM Elastic Only + Fit at $P_{lab} = 1.5\,\mathrm{GeV}$



$\rightarrow$ Traced problem back to DPM!

Problem + Proposal

Current DPM

- only floats and ints (4 bytes)
  - discretization of random numbers is visible
  - larger machine imprecision $\rightarrow$ prone to numerical instabilities
- simple trapezoidal integration of elastic cross sections
  (e.g. for 1.5 GeV : $\Delta t \approx 0.2 \times 10^{-4}\,\mathrm{MeV}^2/c^2$ division width)

$\rightarrow$ luminosity error of 4% (design goal $\leq$ 3%)

Proposal

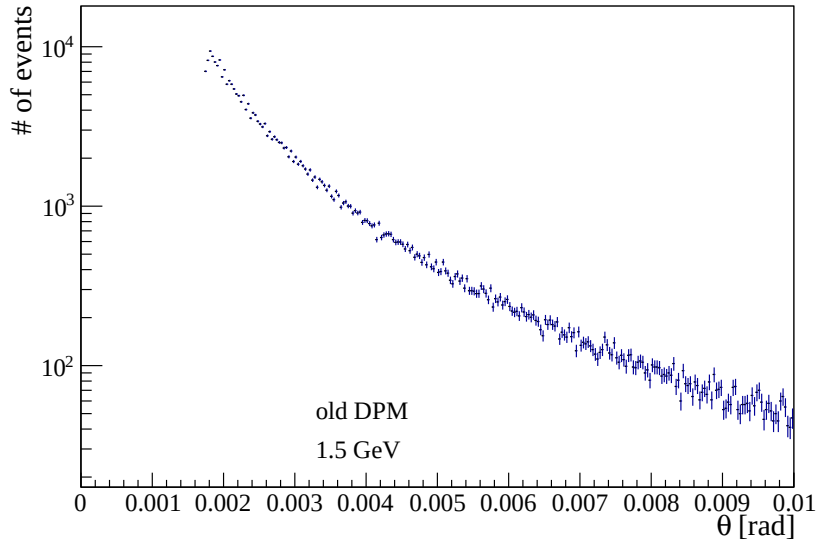
- use doubles and long ints (8 bytes)
- non equidistant sampling and simpsons rule integration

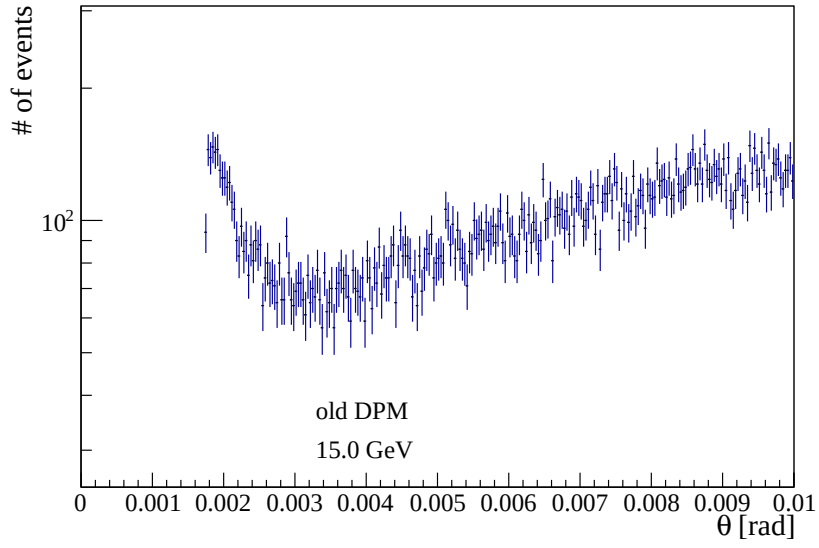
Informations

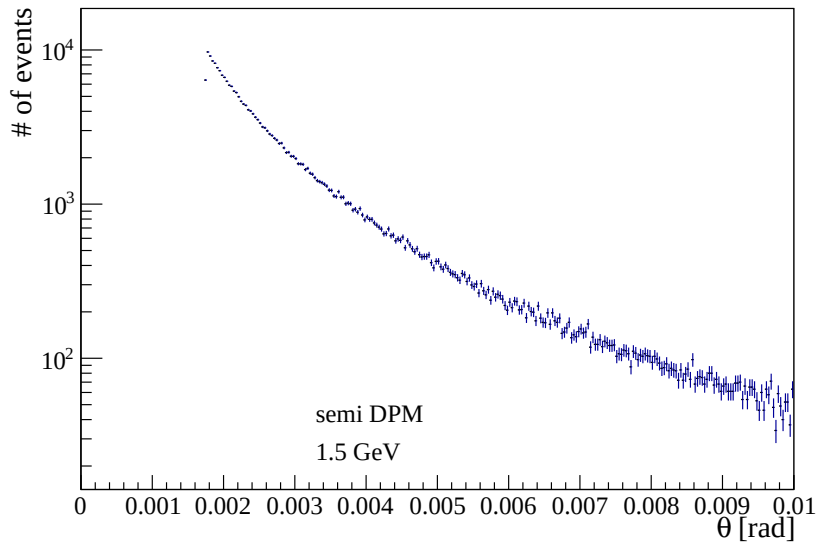
Specs of following plots

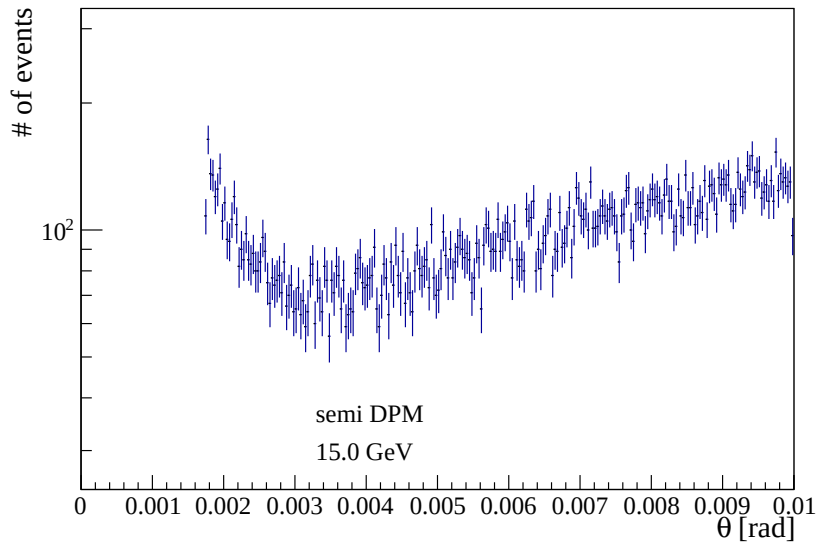
- generated both elastic and inelastic events
- $\theta_{min} = 0.1^\circ \approx 1.75\,\text{mrad}$ lower acceptance bound of LMD
- distributions show all generated particles

Switching to Double Precision

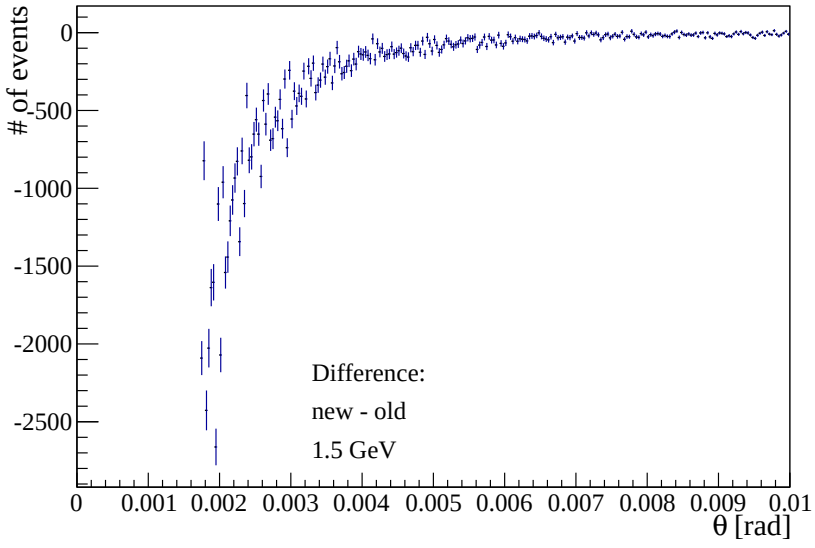


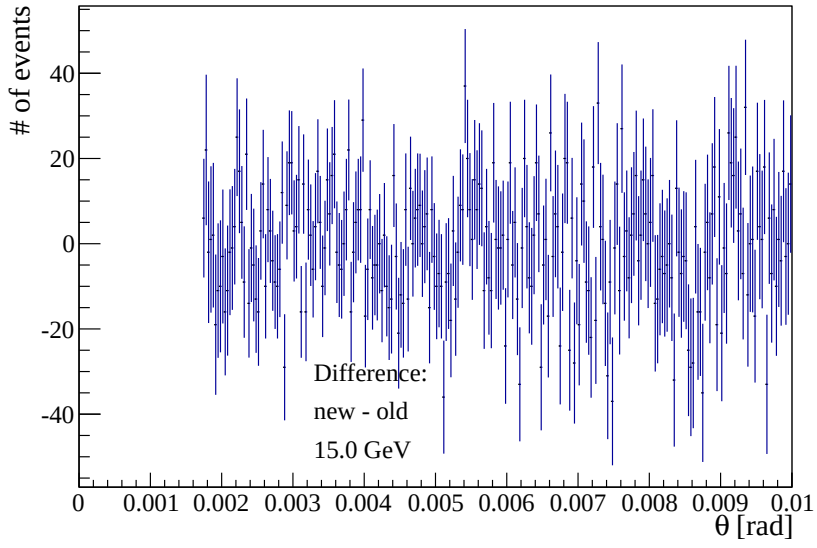


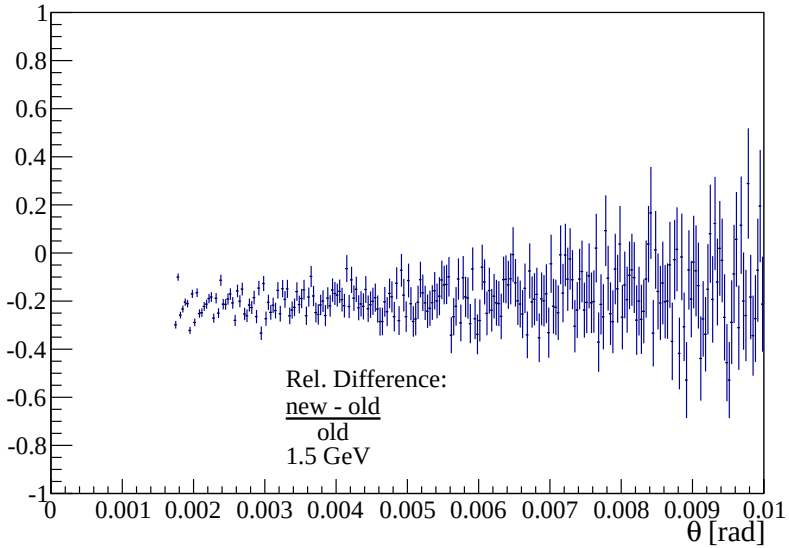


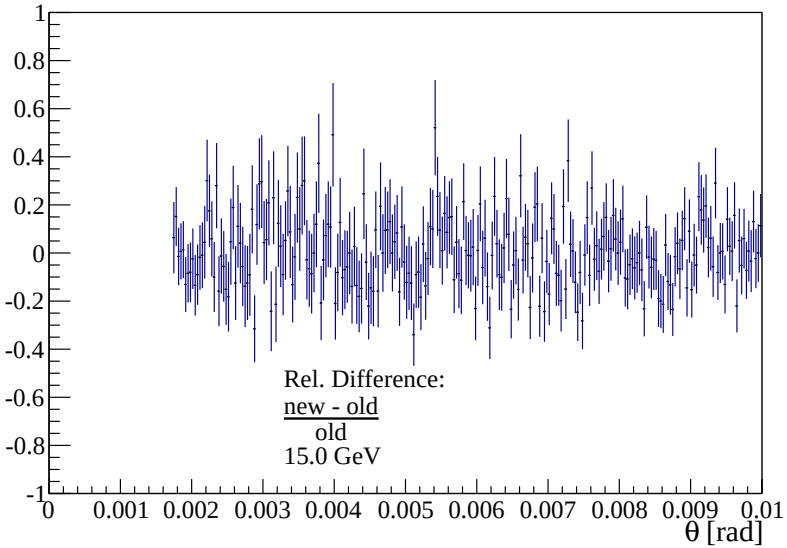


Comparison at LMD Range: Old vs. New

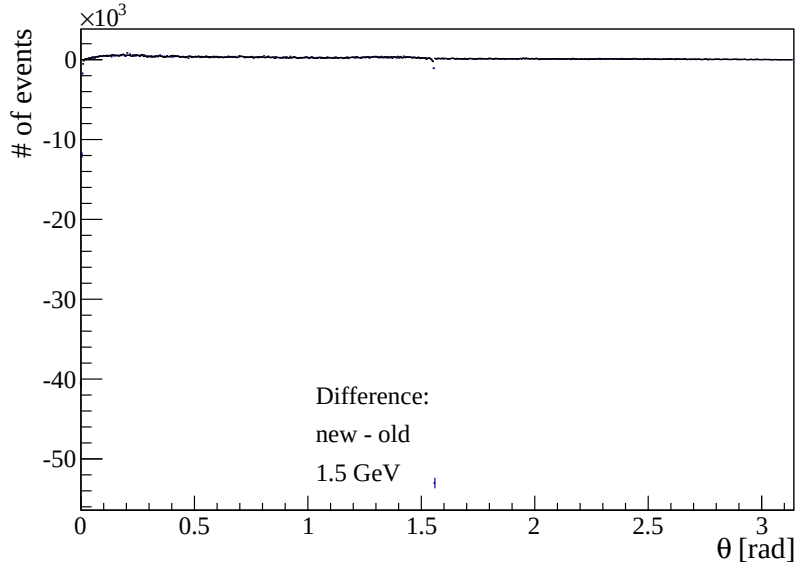


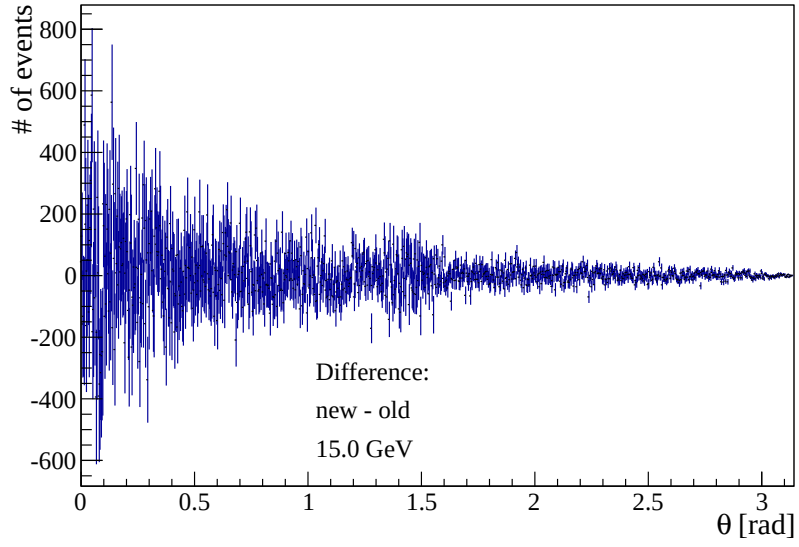


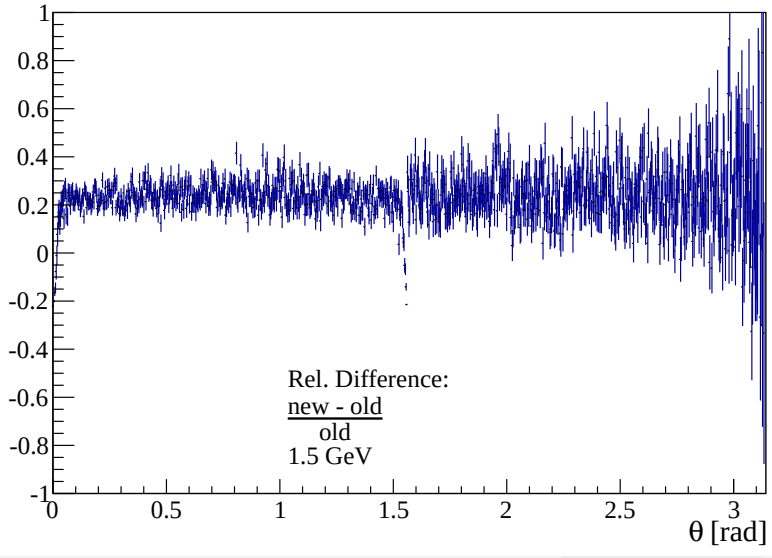


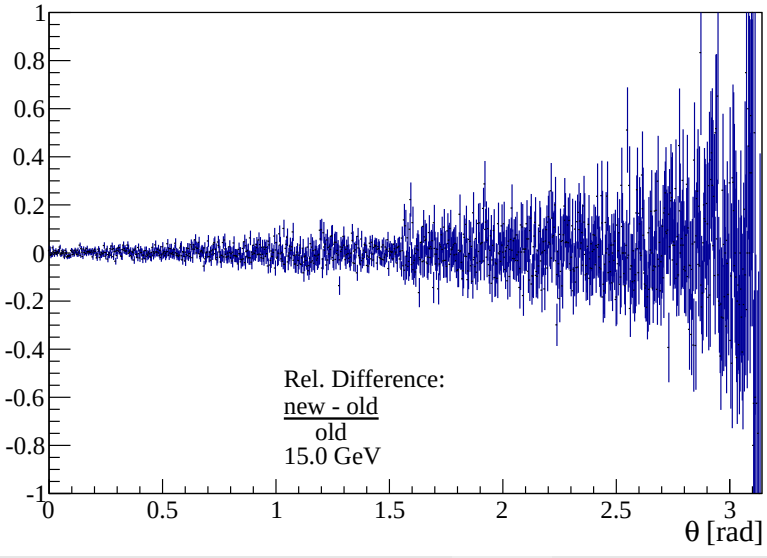


Comparison at Full θ Range: Old vs. New

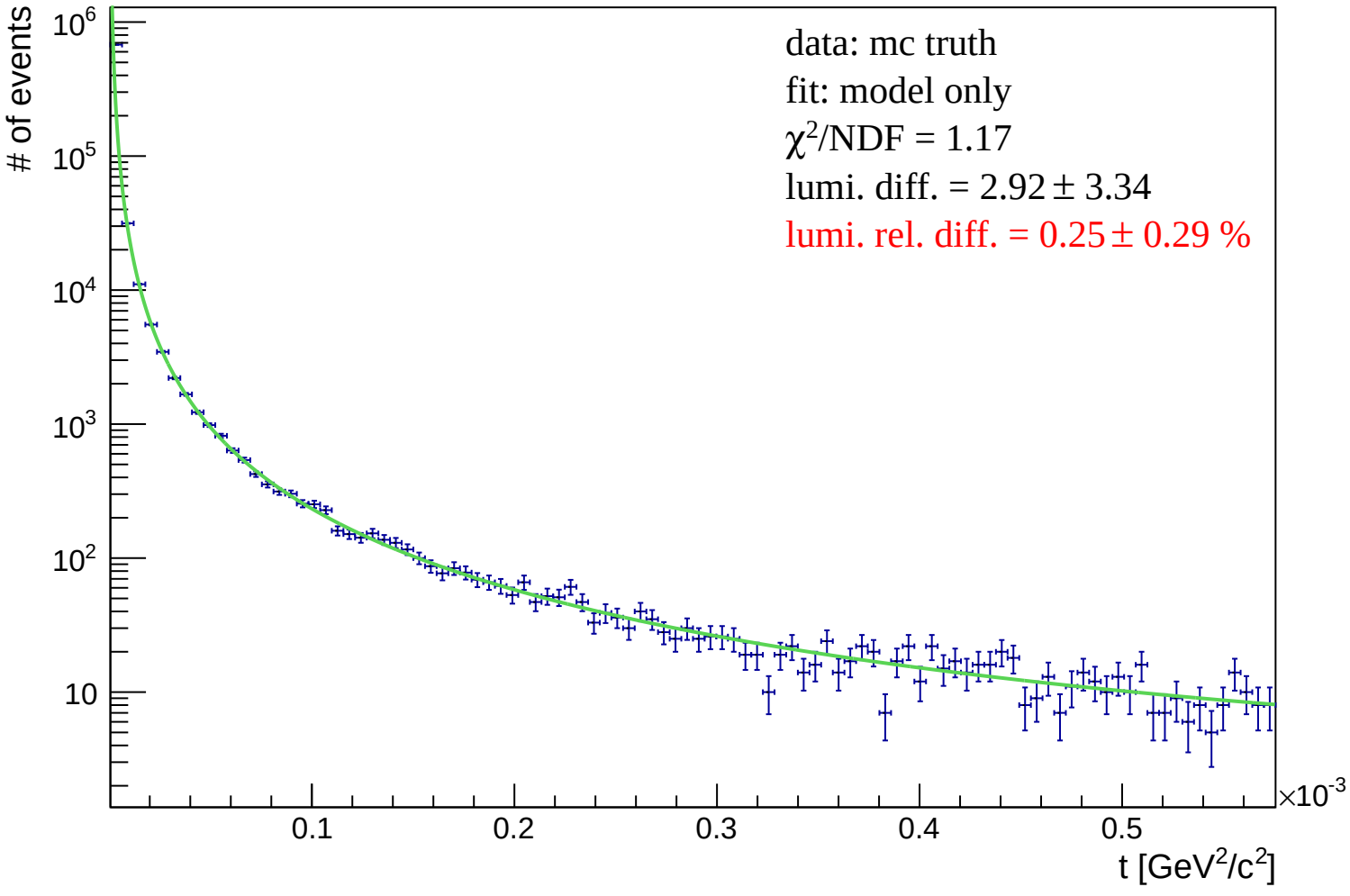








New DPM Elastic Only + Fit at $P_{lab} = 1.5\,\mathrm{GeV}$



Changes in Numbers

	1.5 GeV				15.0 GeV			
θ_{min} [°]	$\sigma_{\text{col}}^{\text{old}}$ [mb]	$\sigma_{\text{col}}^{\text{new}}$ [mb]	diff [mb]	rel. diff. [%]	$\sigma_{\text{col}}^{\text{old}}$ [mb]	$\sigma_{\text{col}}^{\text{new}}$ [mb]	diff [mb]	rel. diff. [%]
0.1	83.06	52.84	30.21	57.17	0.37	0.36	$9.16 \cdot 10^{-3}$	2.50
0.2	13.86	13.187	0.673	5.10	$8.41 \cdot 10^{-2}$	$8.40 \cdot 10^{-2}$	$1.44 \cdot 10^{-4}$	0.17
0.3	5.90	5.845	0.061	1.04	$3.33 \cdot 10^{-2}$	$3.33 \cdot 10^{-2}$	$1.19 \cdot 10^{-5}$	0.03
0.4	3.28	3.276	0.010	0.30	$1.64 \cdot 10^{-2}$	$1.64 \cdot 10^{-2}$	$1.85 \cdot 10^{-6}$	0.01
0.5	2.09	2.088	0.002	0.09	$9.04 \cdot 10^{-3}$	$9.04 \cdot 10^{-3}$	$3.79 \cdot 10^{-7}$	$4.19 \cdot 10^{-3}$
0.6	1.44	1.443	$8.24 \cdot 10^{-4}$	0.05	$5.32 \cdot 10^{-3}$	$5.32 \cdot 10^{-3}$	$8.21 \cdot 10^{-8}$	$1.54 \cdot 10^{-3}$
0.7	1.05	1.05	$2.37 \cdot 10^{-4}$	0.02	$3.27 \cdot 10^{-3}$	$3.27 \cdot 10^{-3}$	$1.36 \cdot 10^{-8}$	$4.15 \cdot 10^{-4}$
0.8	0.803	0.803	$8.96 \cdot 10^{-5}$	0.01	$2.07 \cdot 10^{-3}$	$2.07 \cdot 10^{-3}$	$-2.12 \cdot 10^{-8}$	$-1.02 \cdot 10^{-3}$
0.9	0.630	0.630	$2.26 \cdot 10^{-6}$	$0.35 \cdot 10^{-3}$	$1.34 \cdot 10^{-3}$	$1.34 \cdot 10^{-3}$	$-1.48 \cdot 10^{-8}$	$-1.10 \cdot 10^{-3}$
1.0	0.507	0.507	$3.85 \cdot 10^{-5}$	$7.59 \cdot 10^{-3}$	$8.83 \cdot 10^{-4}$	$8.83 \cdot 10^{-4}$	$-7.89 \cdot 10^{-9}$	$-8.84 \cdot 10^{-4}$

- simulations with $p_{\text{lab}} = 1.5\,\text{GeV/c}$ not effected for $\theta_{\text{min}} > 0.3°$
- simulations with $p_{\text{lab}} = 15\,\text{GeV/c}$ not effected for $\theta_{\text{min}} > 0.1°$

Conclusions

Summary

- DPM improvements $\rightarrow$ systematic uncertainty reduced by 4%
- no numerical oscillations and more stable integral calculations
- all other PANDA groups: $p_{\mathrm{p}} \approx 100\,\mathrm{MeV}/c$
  - $1.5\,\mathrm{GeV} : \theta_{\mathrm{min}} \approx 4^{\circ}$
  - $15\,\mathrm{GeV} : \theta_{\mathrm{min}} \approx 0.4^{\circ}$
  - well above previous thresholds $\rightarrow$ NO changes!

Conclusions

Request

- implement both of the proposed changes/improvements
  - switch to double precision:
    new (8 byte) random gen. and compilation flags

    ```
    -fdefault-real-8 -fdefault-double-8 -fdefault-integer-8
    ```
  - implement more accurate integrals algorithms (Aida semi-fixed this)

End

Thanks for Your Attention!

Elastic Cross Section

$$\frac{d\sigma}{dt} = \frac{d\sigma_C}{dt} + \frac{d\sigma_{int}}{dt} + \frac{d\sigma_H}{dt}$$

with

$$\frac{d\sigma_C}{dt} = \frac{4\pi\alpha_{EM}^2 G^4(t)}{\beta^2 t^2}$$

$$\frac{d\sigma_{int}}{dt} = \frac{\alpha_{EM}\sigma_{Total}}{\beta|t|} G^2(t) e^{\frac{1}{2}Bt}(\rho cos(\delta) + sin(\delta))$$

$$\frac{d\sigma_H}{dt} = A_1 \cdot \left[e^{t/2t_1} - A_2 \cdot e^{t/2t_2}\right]^2 + A_3 \cdot e^{t/t_2}$$