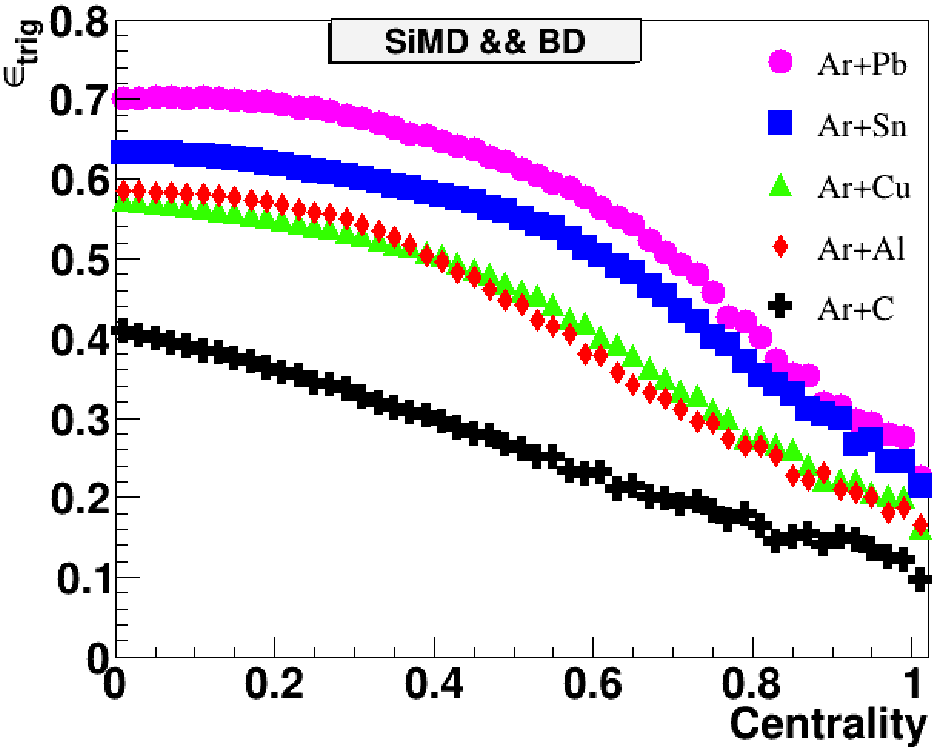
It's important to acknowledge that achieving 100% centrality may not be possible due to some physical effects.



On these histograms, you can see the dependence of the trigger efficiency on centrality for different targets. We observe that the trigger efficiency smoothly decreases with an increase of the centrality and decrease of the atomic number of the target. As you can see, there is no drop in the efficiency between 80% and 100% centrality. The distribution shows that the trigger detectors are sensitive between 80-100% centrality. We have no reason why we should select   events with centrality from 40% to 80%.

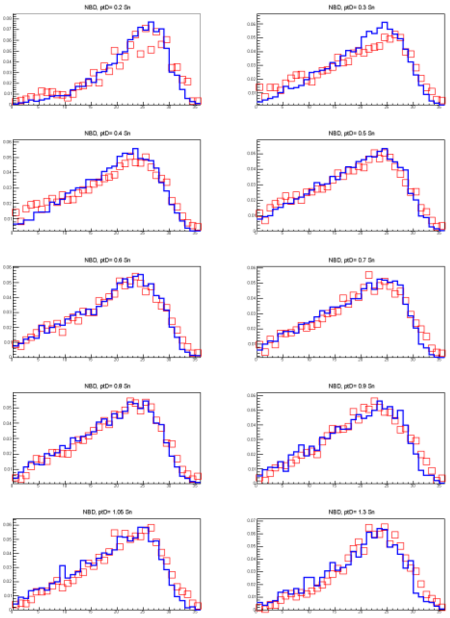
Are we sure that in other models we will not obtain different centrality values?

A lot of work has been done to adjust results of simulation based on the DCM-SMM model to describe the data well. Various physical effects and detector efficiencies have been included to ensure that the differences between Data and Monte Carlo simulation are minimized. In the analysis note we showed many control plots. To define two classes of centrality in data and MC, multiplicity distributions of hits in the barrel detector (NBD) and tracks (Ntr) are used.

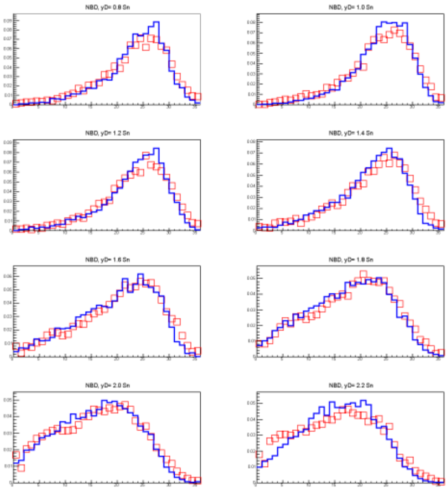
Plots below show the level of agreement between Data and Monte Carlo in the multiplicity distributions of NBD (upper plots) and Ntr (lower plots) in bins of pT (left plots) and rapidity y (right plots). Systematic errors of the p,d,t yields in the two centrality bins are evaluated from the remaining difference of the NBD and Ntr spectra in Data and MC. It means that the centrality classes are defined from the multiplicity distributions in MC which are in agreement with the multiplicity distributions in Data.

We are satisfied with the level of agreement between Data and MC and the resulting systematic errors. If we switch to a different model, we have to adjust MC distributions to Data and evaluate a new set of systematic errors which will cover the difference between the model and data spectra.

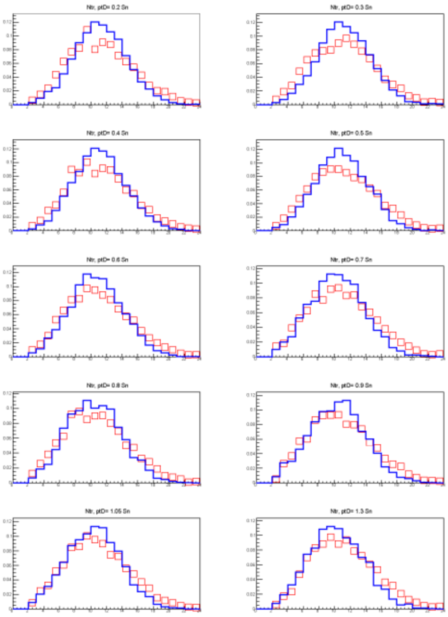
NBD (pT bins)



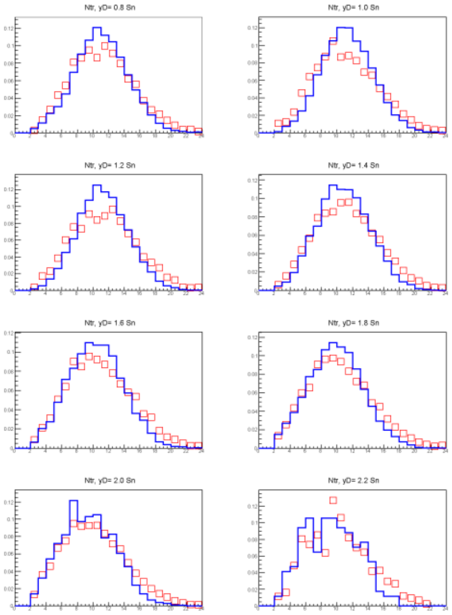
NBD(y bins)



Ntr (pT bins)



Ntr (y bins)



Show the impact of centrality analysis on your overall results and comparisons with other experiments. Consider how variations in centrality ranges might affect your conclusions and interpretations.

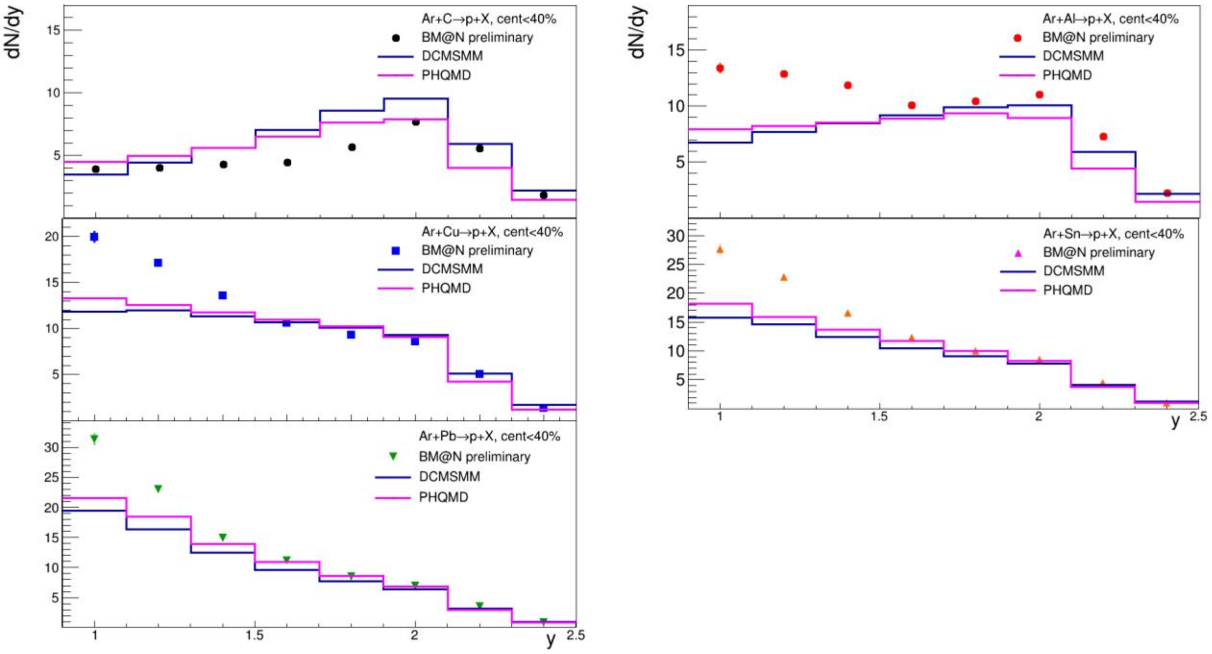
Our analysis aims to separate more central from more peripheral events. While the centrality analysis may not be extremely precise, it categorizes the data into just two classes. We think that for this type of analysis, it's not so important if the selected centrality ranges deviate by 10% in one direction or the other. These deviations are not significant to the final results when compared to heavy ion experiments. The results we've obtained are found in line with main trends observed in other experiments for transverse mass dependence on the atomic number, ratios of triton and deuteron to proton yields, coalescence parameters for deuteron and triton production.

Using formulas to calculate parameters like B2 and B3 may resemble the coalescence model, but doesn't always strictly adhere to it. Caution is needed when drawing conclusions about agreement or disagreement with this model, considering the differences between calculations and actual coalescence processes.

In the coalescence model nucleons originate from a small volume in the 3-momentum space to form cluster (nuclear fragment). In real experimental conditions this requirement is resulted in a low purity of data samples in the 3-momentum space. In the experiment we have to average the measurement of coalescence factors B2 and B3 over wider kinematical range, in particular over 2*pi azimuthal angle and rapidity bins. We compare our results with the measurements of other experiments which use similar methods to average the results over wider kinematical range to improve purity of the measurements.

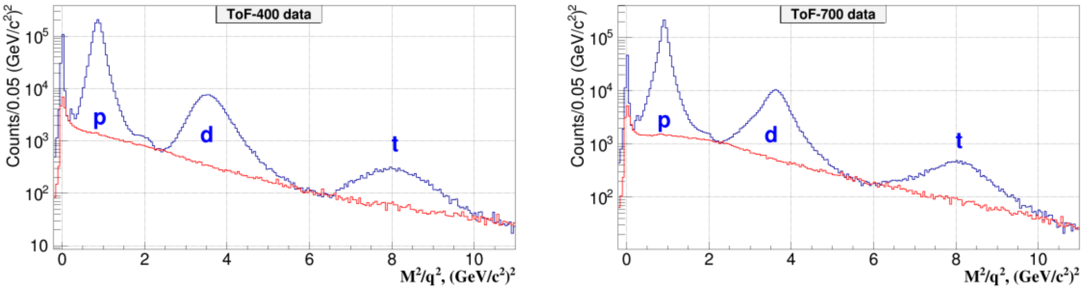
Explanation for the unexpected behavior in the data rapidity spectra dN/dy of protons produced in Ar+Al interactions. There is an expectation that in asymmetric collisions the yield is larger for heavier nuclei.

We observe excess of deuterons and tritons in the beam fragmentation range relative to the central rapidity range in Ar + Al reaction in more central and peripheral collisions. The measured yields of protons produced in Ar+Al collisions are higher in the central rapidity range relative to the beam fragmentation range. We assume that in data compared to the model a larger fraction of protons originates from inelastic interactions compared to spectator and elastically scattered protons (in reactions n+p -> p + n, n+p -> p + p + pi- , etc)



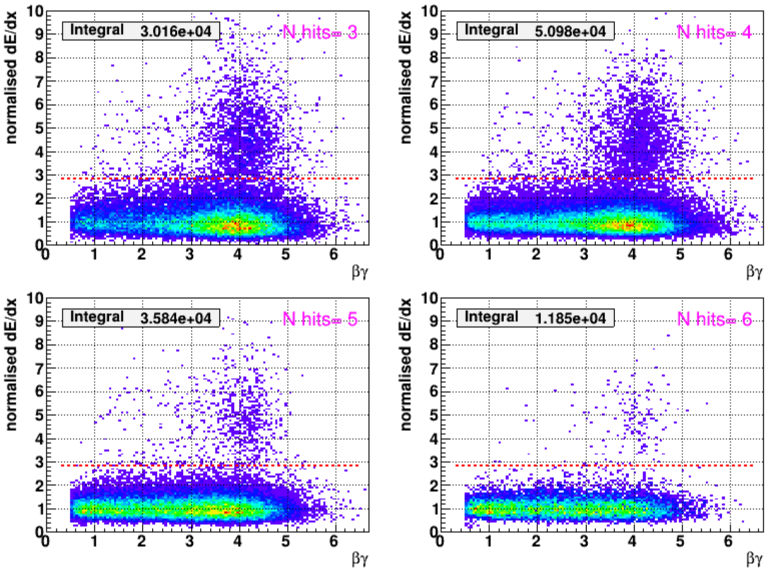
Background shape from the mixed event should be shown and overlaid on slide for argon-nucleus interactions.

The red lines show the background estimated from "mixed events." The main peak under pions is due to the detector electronics, which detect the fastest particles first and apply momentum-dependent criteria. The “mixed event” spectra are normalized to the integral of the data spectra in the ranges below and above the proton peak. As you can see, the mixed events method describes the background under the particles' peaks well. The background integral under the p, d, t mass-squared windows taken from "mixed events" and from the fitting of the m^2 spectra by a linear function is calculated as systematic uncertainty and is under 5%.



dE/dx distribution and the cut applied to eliminate helium-4 contribution should be visualized.

On this slide, you can see the distribution of normalized dE/dx vs beta gamma. Here we use identified tracks in TOF 700 with the mass^2 greater than 2.3 GeV^2 and βγ=p/m less than 5. Using the product of beta and gamma allows us to analyze energy losses independently of particle type. To separate helium-4 from deuterium, we use a criterion of a minimum of 3 median units of dE/dx for deuterons.



The overall efficiency shown on slide 8 seems low, so it would be beneficial to discuss the contributions from geometry and reconstruction.

In MC simulation, efficiencies of central tracking detectors, outer tracker and ToF detectors are adjusted (scaled down) to describe efficiencies in Data. The final reconstruction efficiency takes into account selection cuts, matching corridors for tracks in outer detectors dependent on particle momentum. That is why there is no reason to separate acceptance, track searching efficiency, matching efficiency to outer detectors, vertex selection efficiency. But we will provide the acceptance plots for detection of protons (deuterons) in ToF-400 and ToF-700 in the next version of this answer note.

Slide 20 shows values of the temperature parameter derived from plots. It's suggested to compare these values with those obtained from momentum distribution fits on slide 13.

Slide 20 shows values of the mean transverse mass <mT>-m (but not the temperature slope T0). The mean transverse mass is related to the inverse slope derived from fits on slide 13 by the relation:

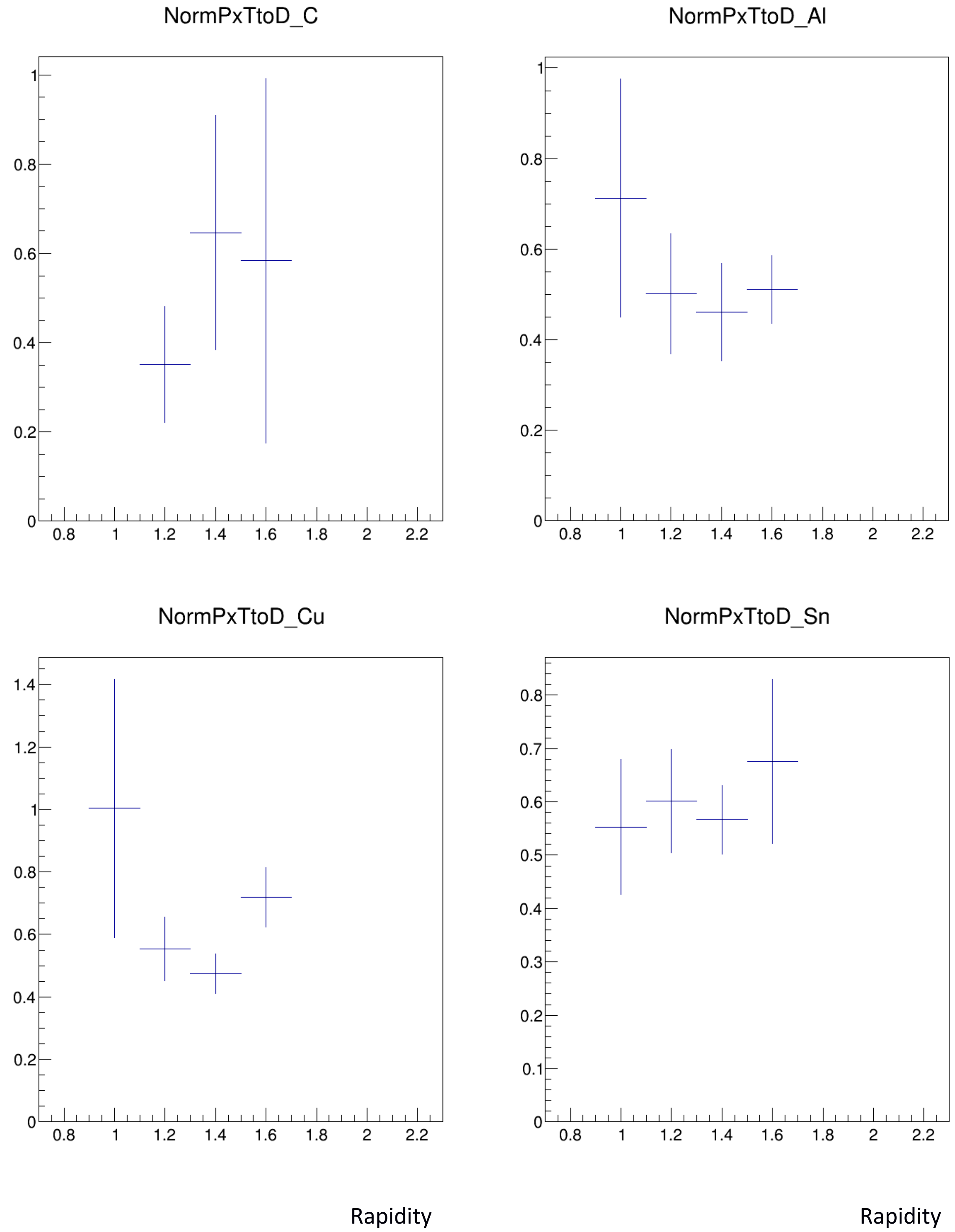
⟨mT ⟩ − m = T0 + T0^2 / (T0 + m).

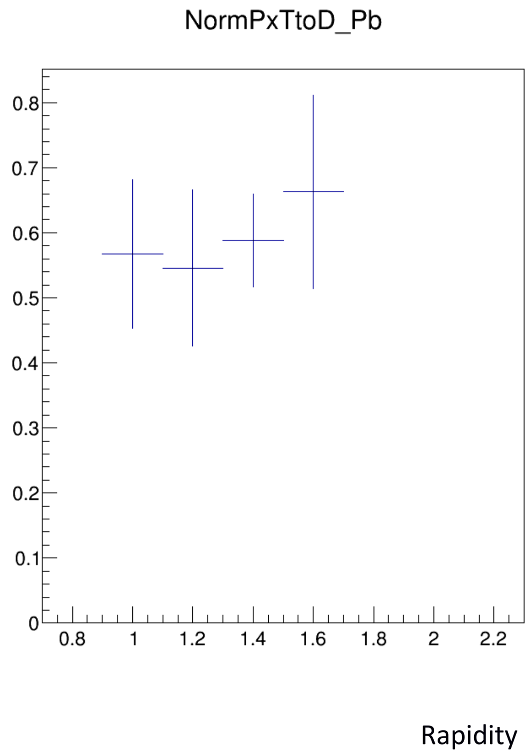
If fragment **mass >> T0** (for p,d,t) , **<mT>-m --> T0**, for light particles **<mT>-m --> 2*T0**

It means that **<mT>-m** and **T0** values are not equivalent. We analyze the dependence of the transverse kinetic energy on the fragment mass number. It is more appropriate than to analyze the inverse slope of the transverse mass distribution.

Could you present the rapidity dependence of the Nt *Np / Nd2 ratio?

Double ratio of the dN/dy values for protons, tritons and deuterons: Nt *Np / Nd2 shows no strong dependence on rapidity. Fit of the rapidity distributions shown below with a linear function gives the slope consistent with zero within 1 sigma of its uncertainty.

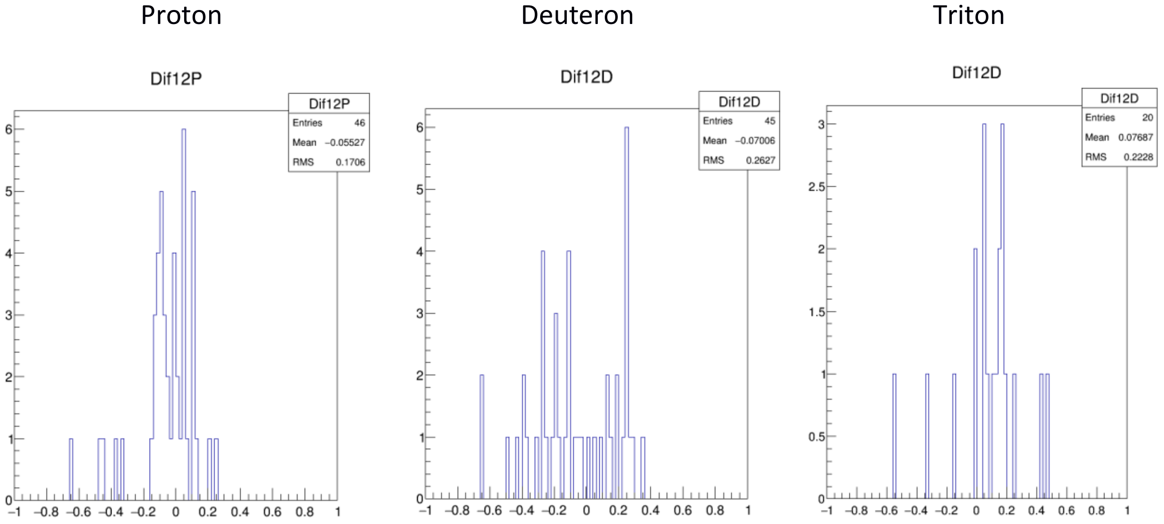




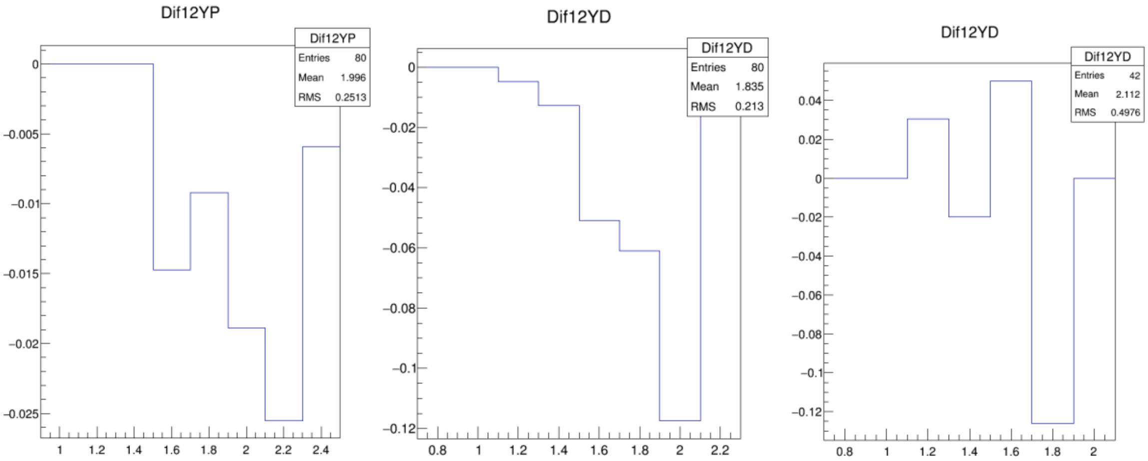
Double ratio of the dN/dy values for protons, tritons and deuterons: Nt *Np / Nd^2 shown as a function of rapidity, calculated for Ar+C,Al,Cu,Sn,Pb interactions with centrality of 0-40%.

If there's overlap between different data sets (e.g., top 400 and top 700), verify if the values of efficiency-corrected yield are consistent between them and request a plot showing how different they are. Request to provide graphs or visualizations that demonstrate differences and uncertainties due to systematic errors for better understanding.

The yields are calculated as weighted average of the results obtained with ToF-400 and ToF-700 in bins of pT and y. The systematic error of the combined result of the ToF-400 and ToF-700 measurements is calculated as half of the difference of the p, d, t yields measured in bins of rapidity y in the ToF-400 and ToF-700 detectors. The relative difference of yields of protons, deuterons and tritons measured in ToF-400 and ToF-700


Proton Deuteron Triton

Ar+Sn: Difference in yields calculated in ToF-400 and ToF-700 and normalized to the mean value of yields in bins of (y,pT). Centrality range 0-40%. Statistical fluctuations in (y,pT) bins contribute to the spread.

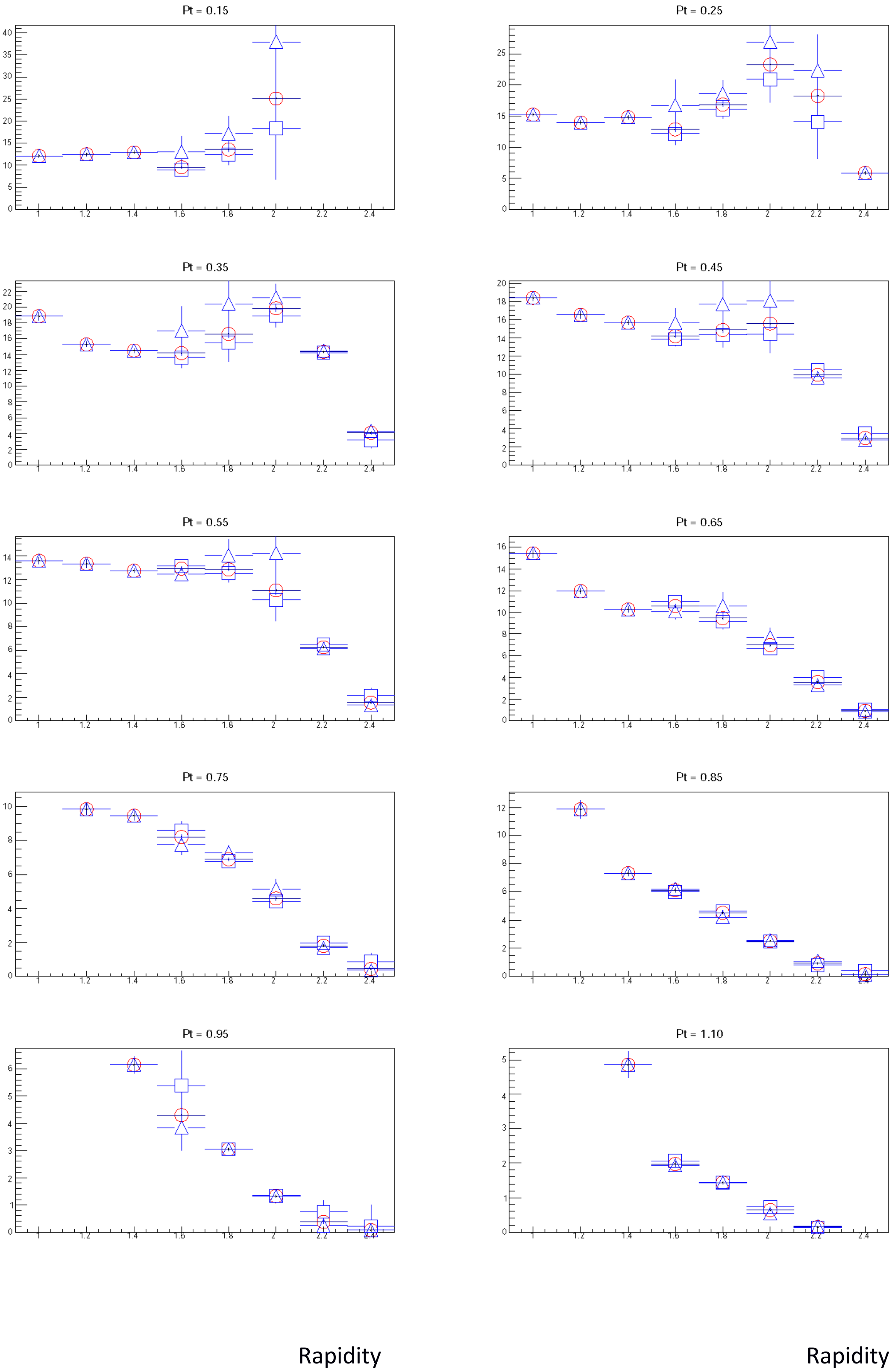


Proton Deuteron Triton

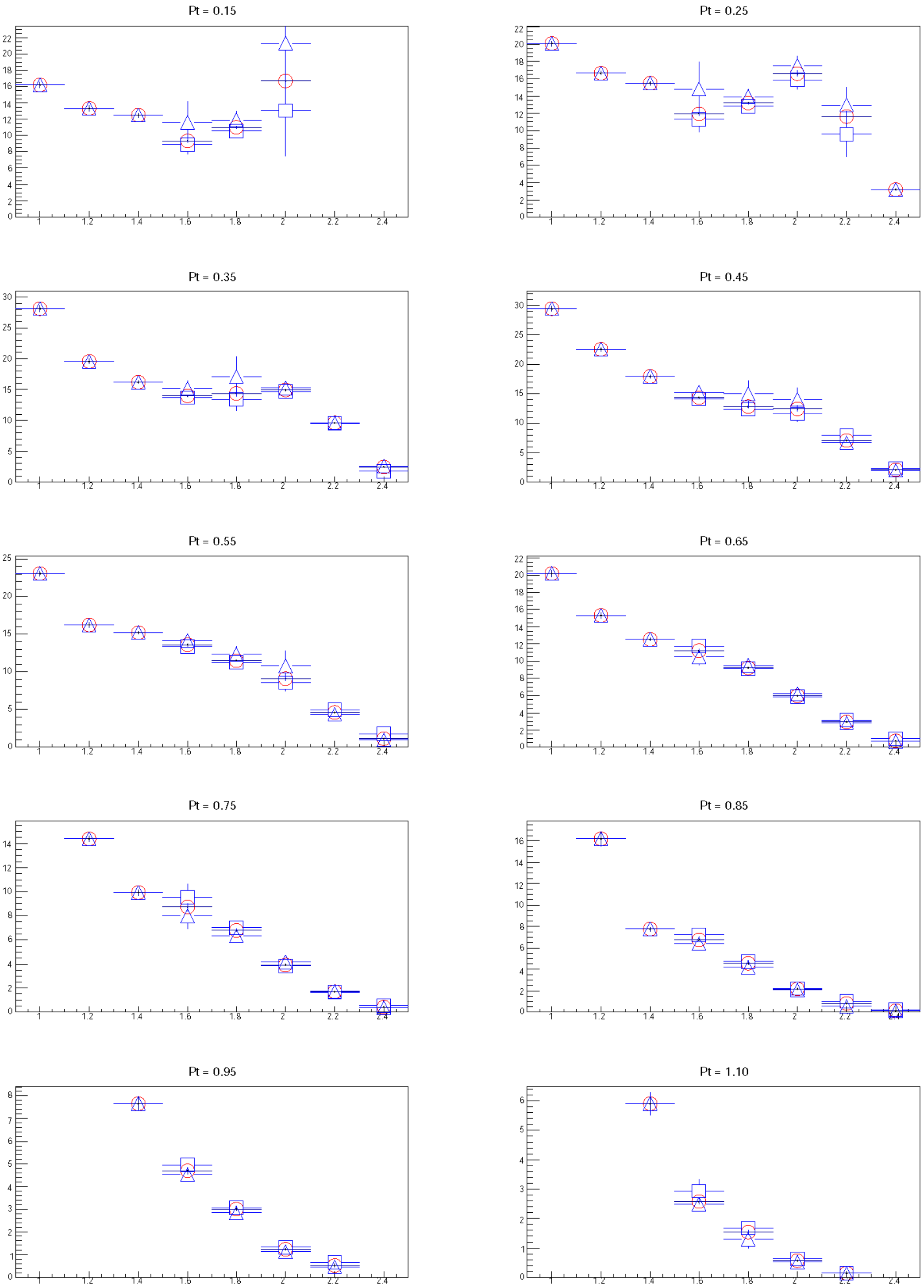
Rapidity Rapidity Rapidity

Ar+Sn: Difference in yields calculated in ToF-400 and ToF-700 and normalized to the mean value of yields (vertical axis) in bins of y (horizontal axis). Centrality range 0-40%. These values are taken as the systematic uncertainty.

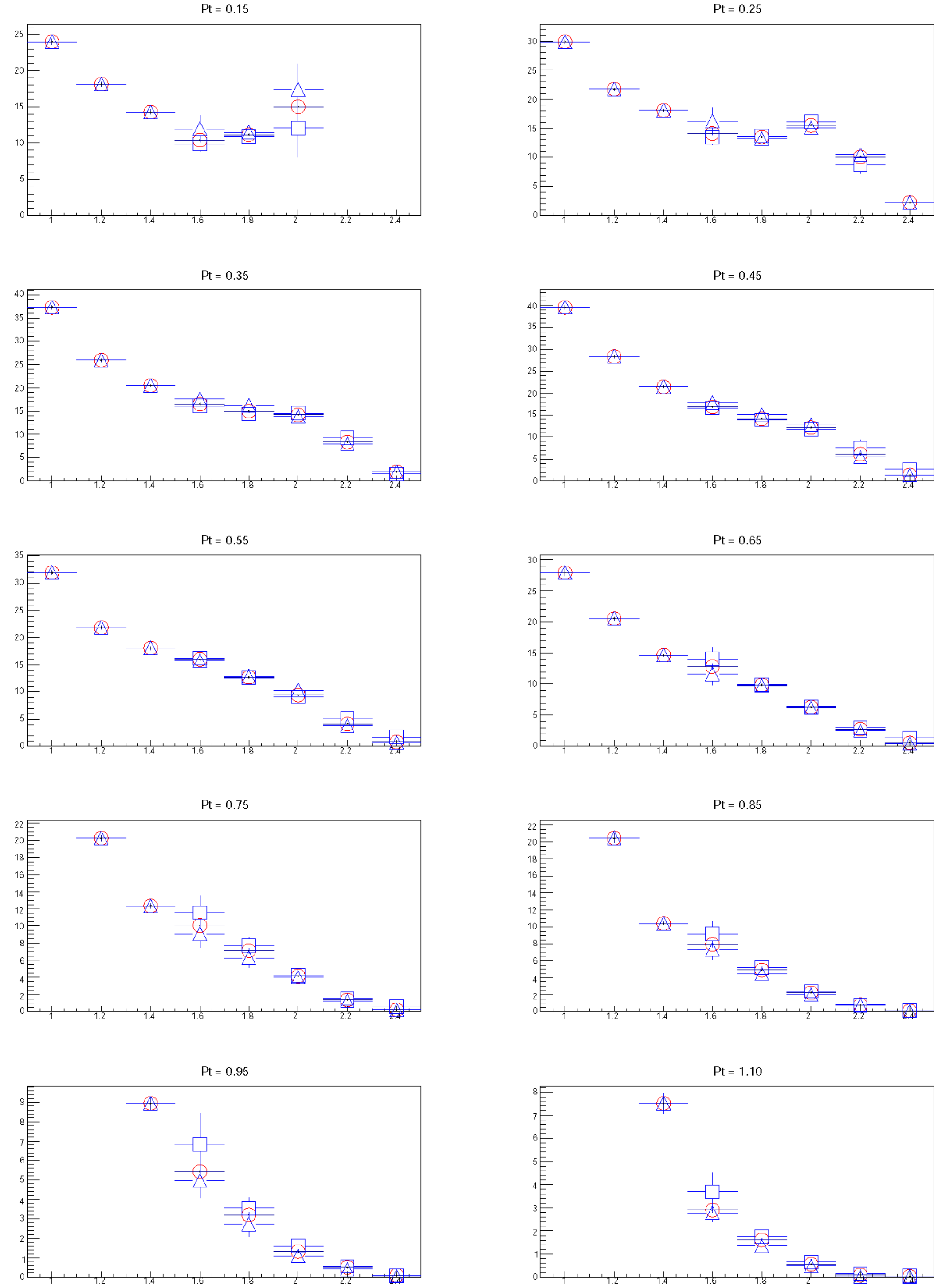
Distributions below show yields of protons, deuteron produced in Ar + Al, Cu, Sn, Pb, C interactions and and tritons produced in Ar + Al, Cu, Sn, Pb interactions given as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data.



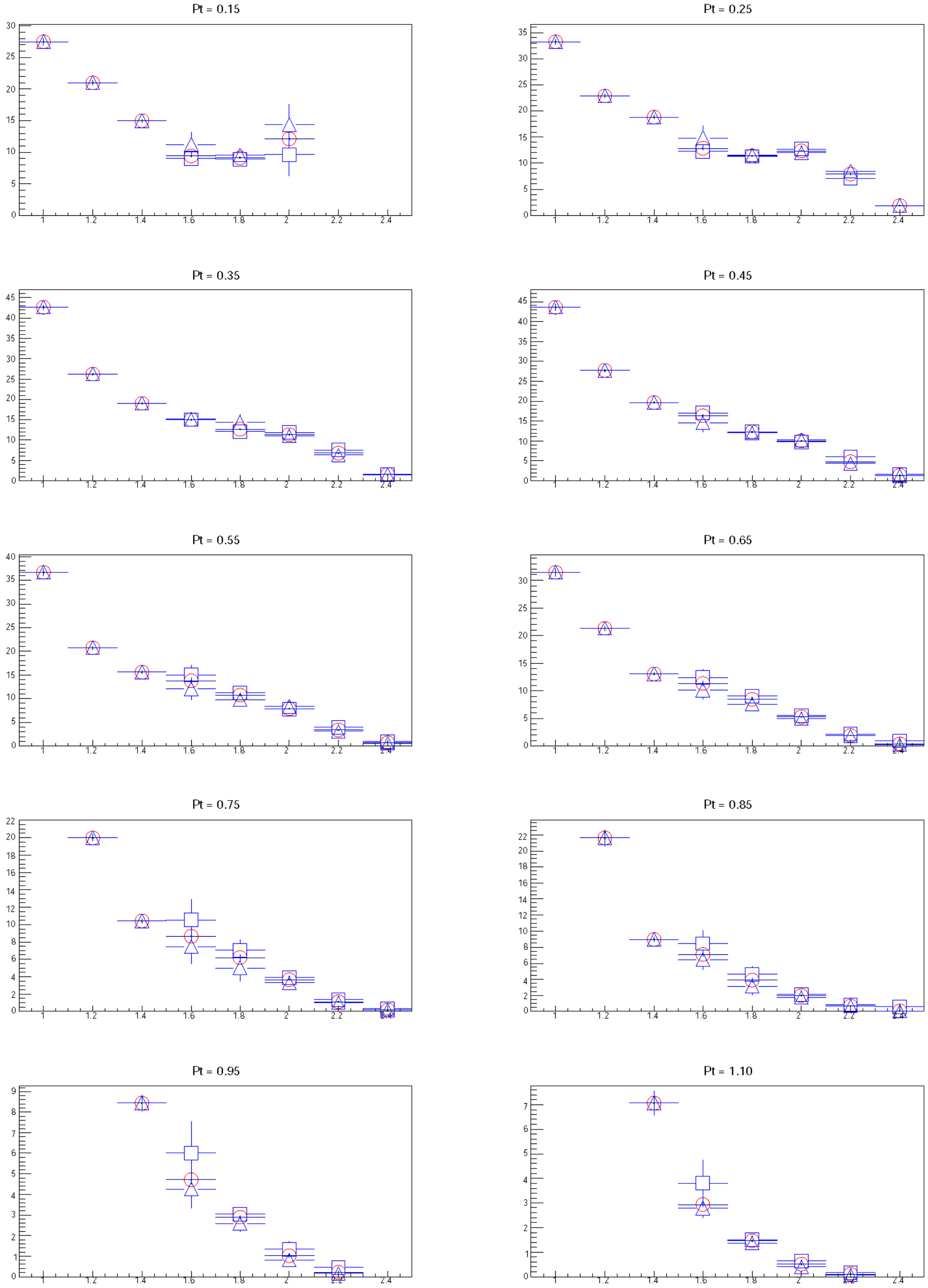
Protons in Ar + Al: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



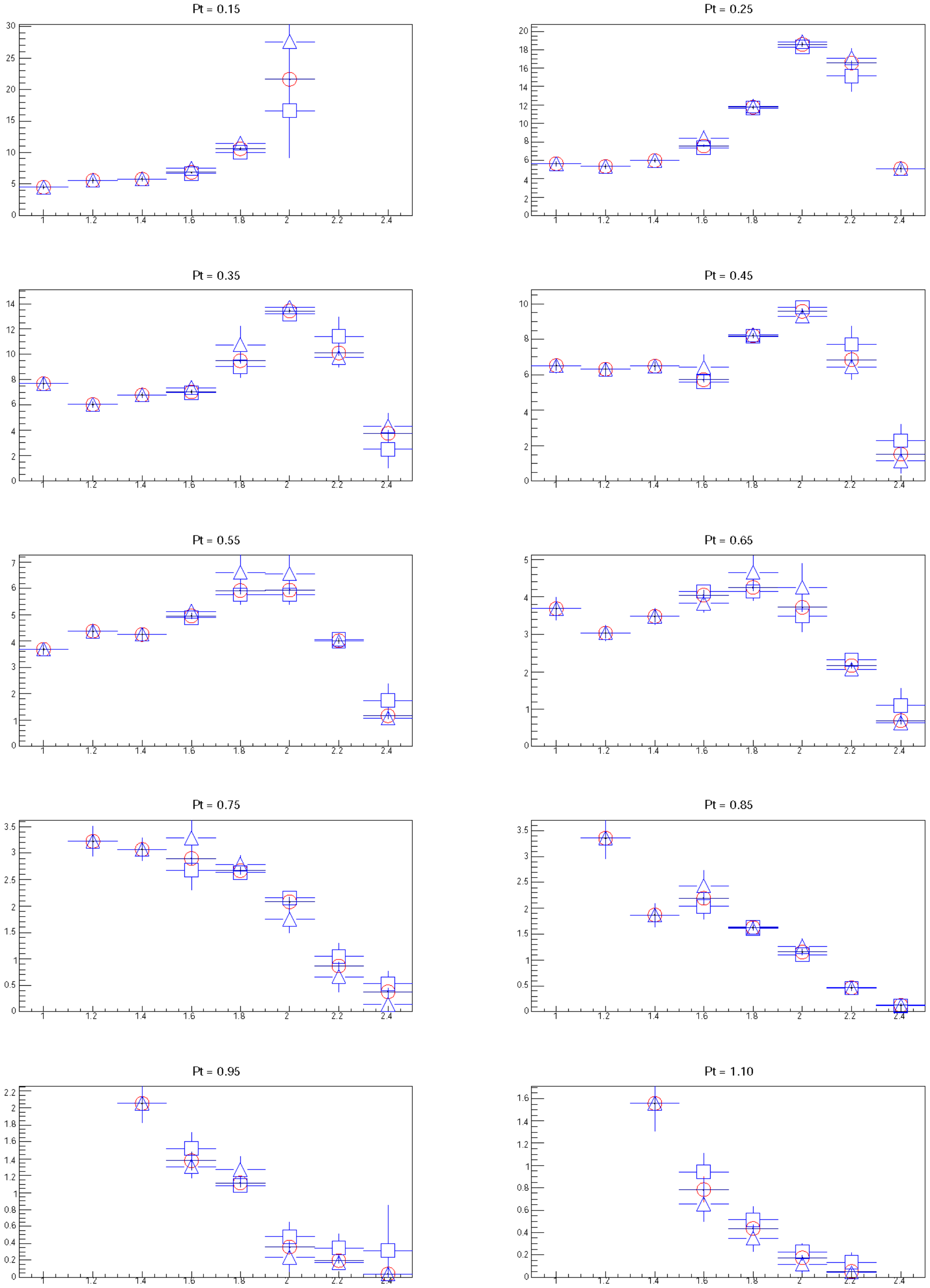
Protons in Ar + Cu: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



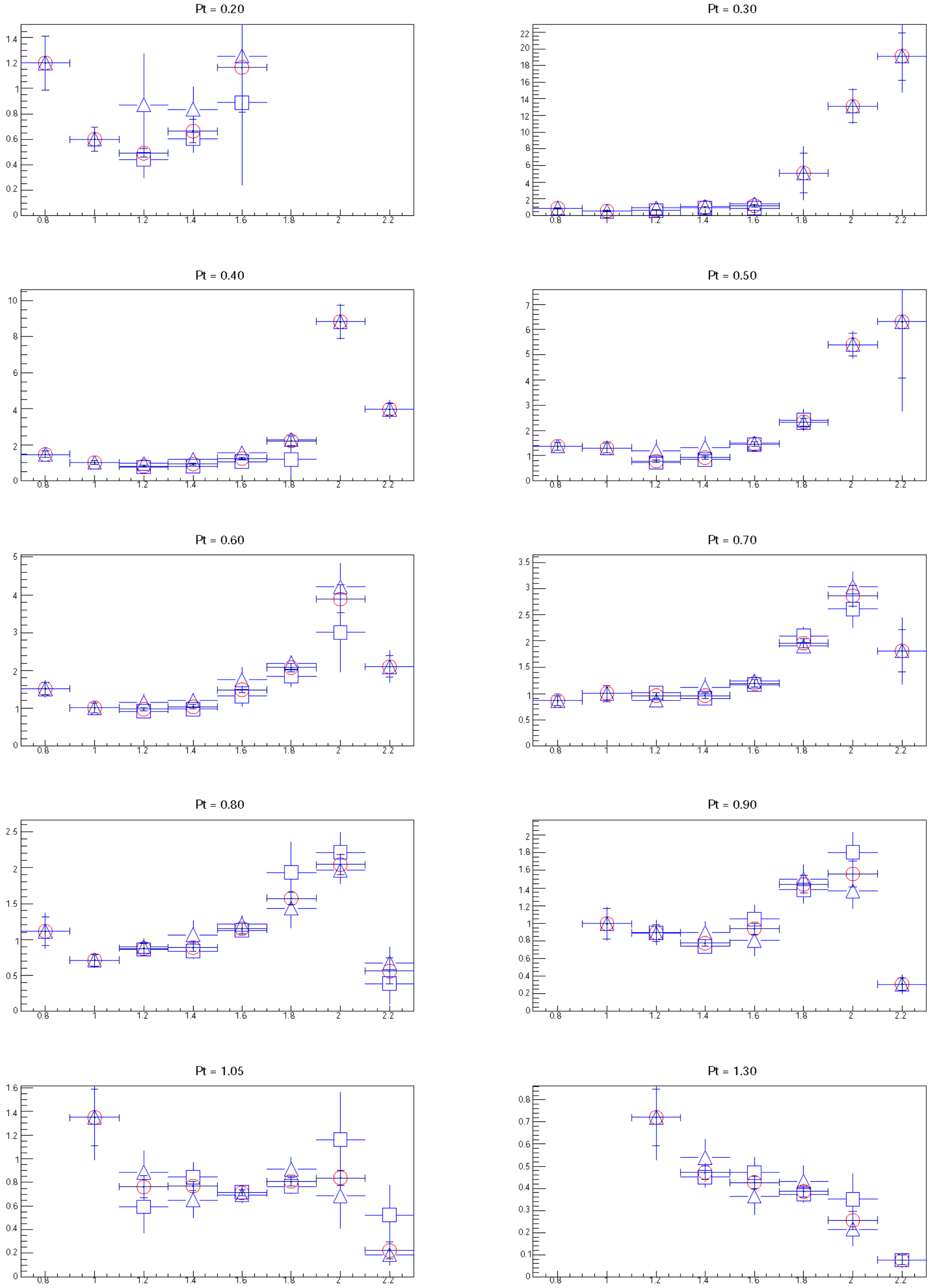
Protons in Ar + Sn: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



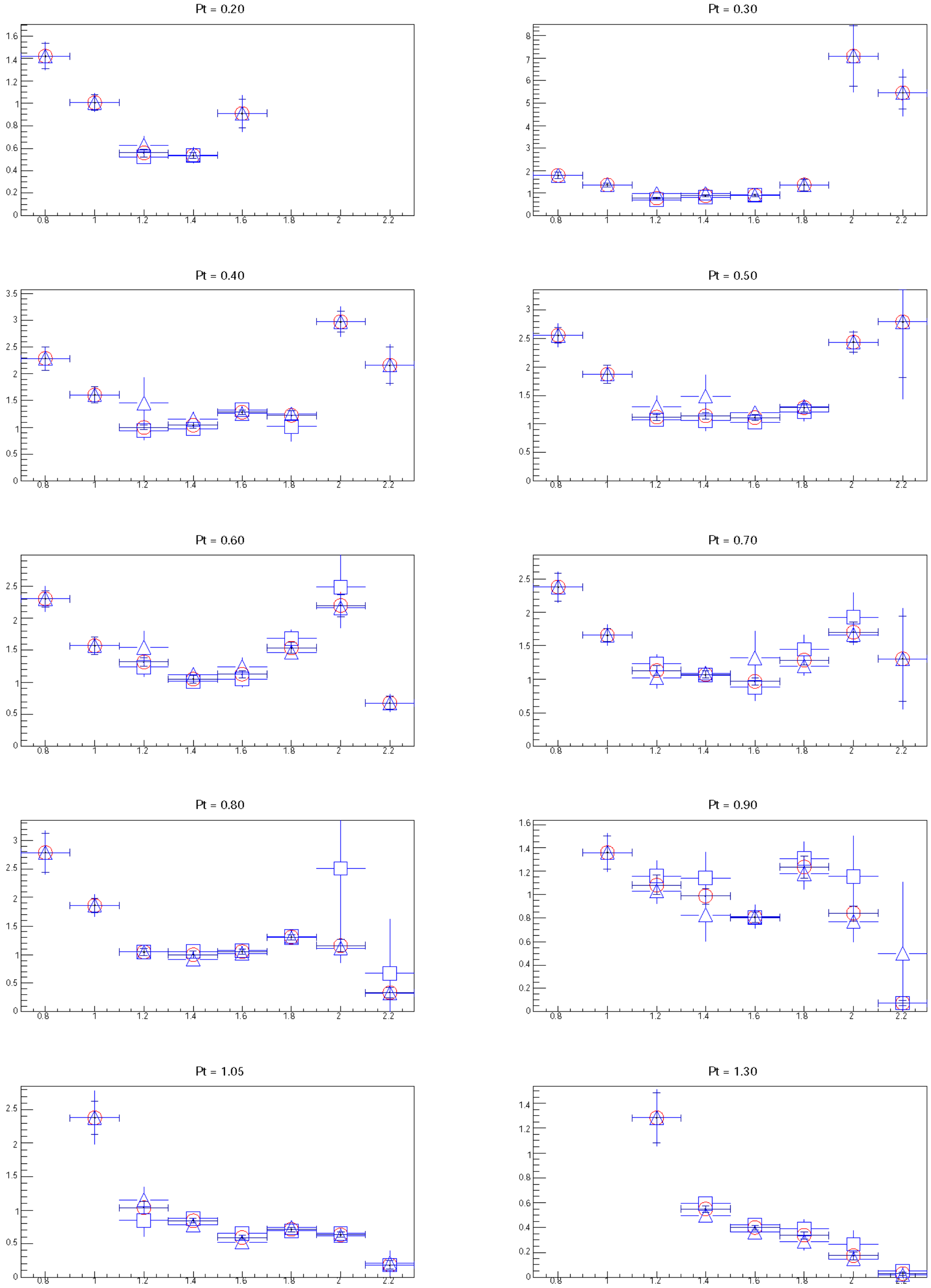
Protons in Ar + Pb: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



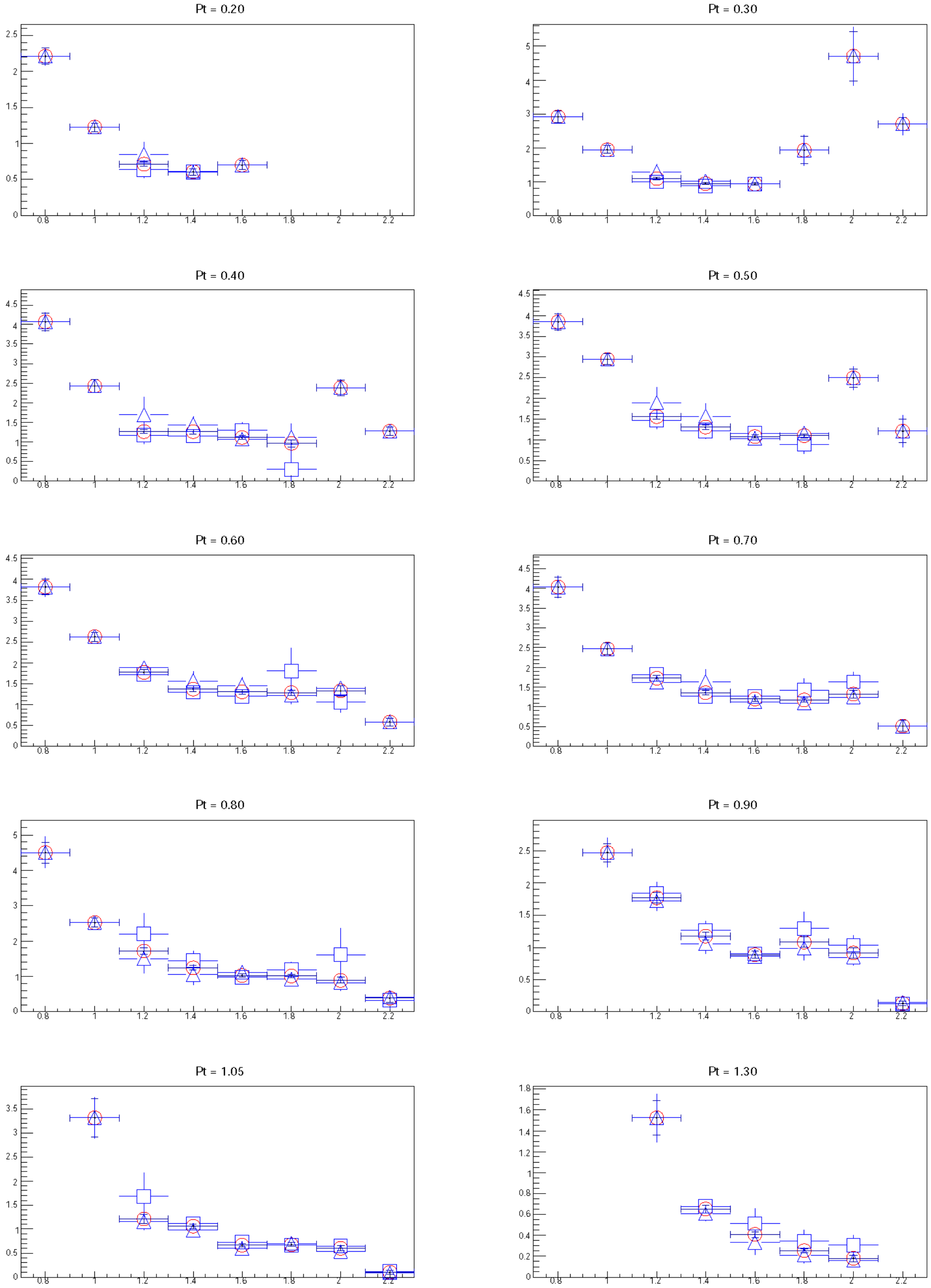
Protons in Ar + C: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



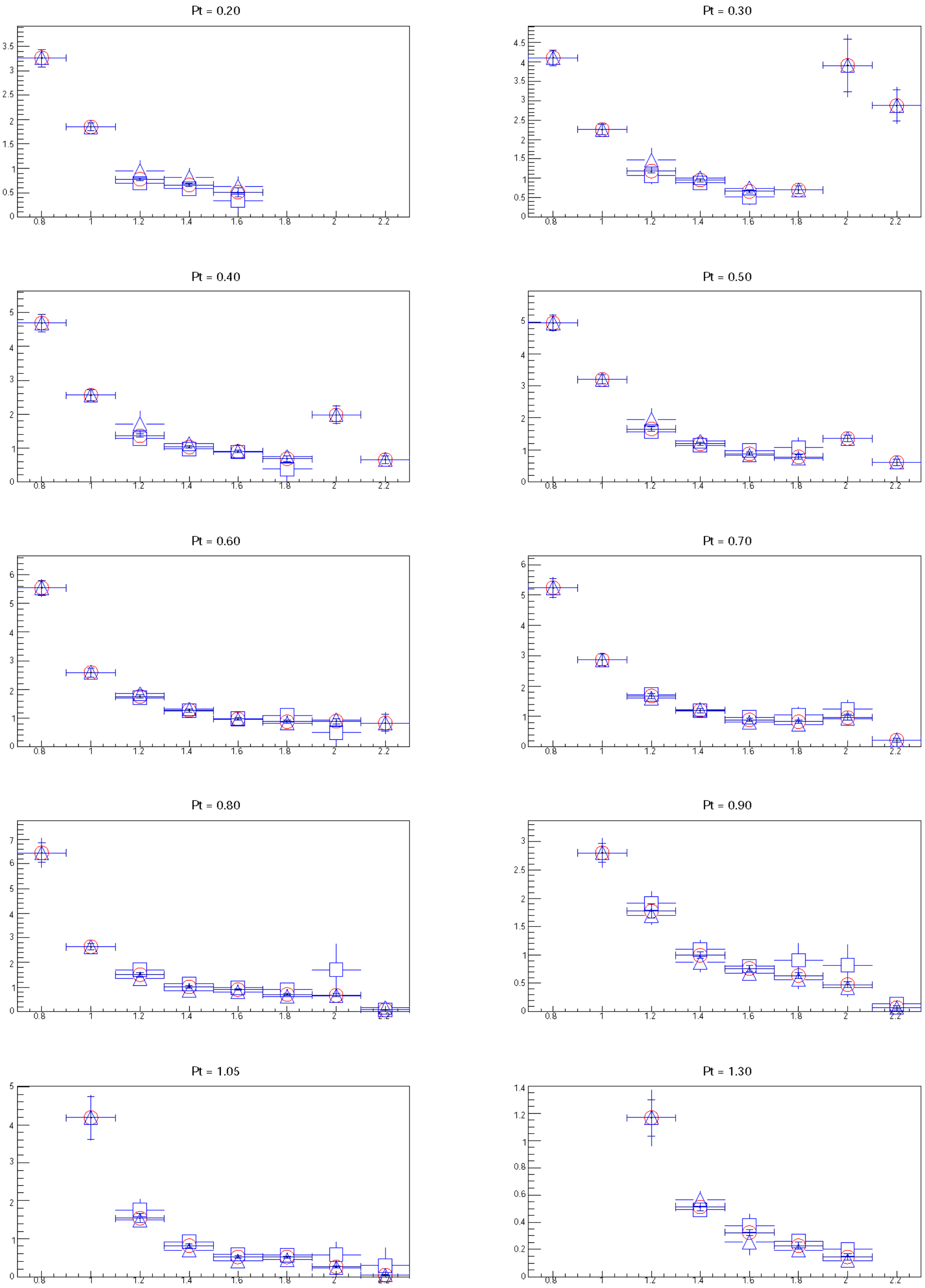
Deuterons in Ar + Al: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



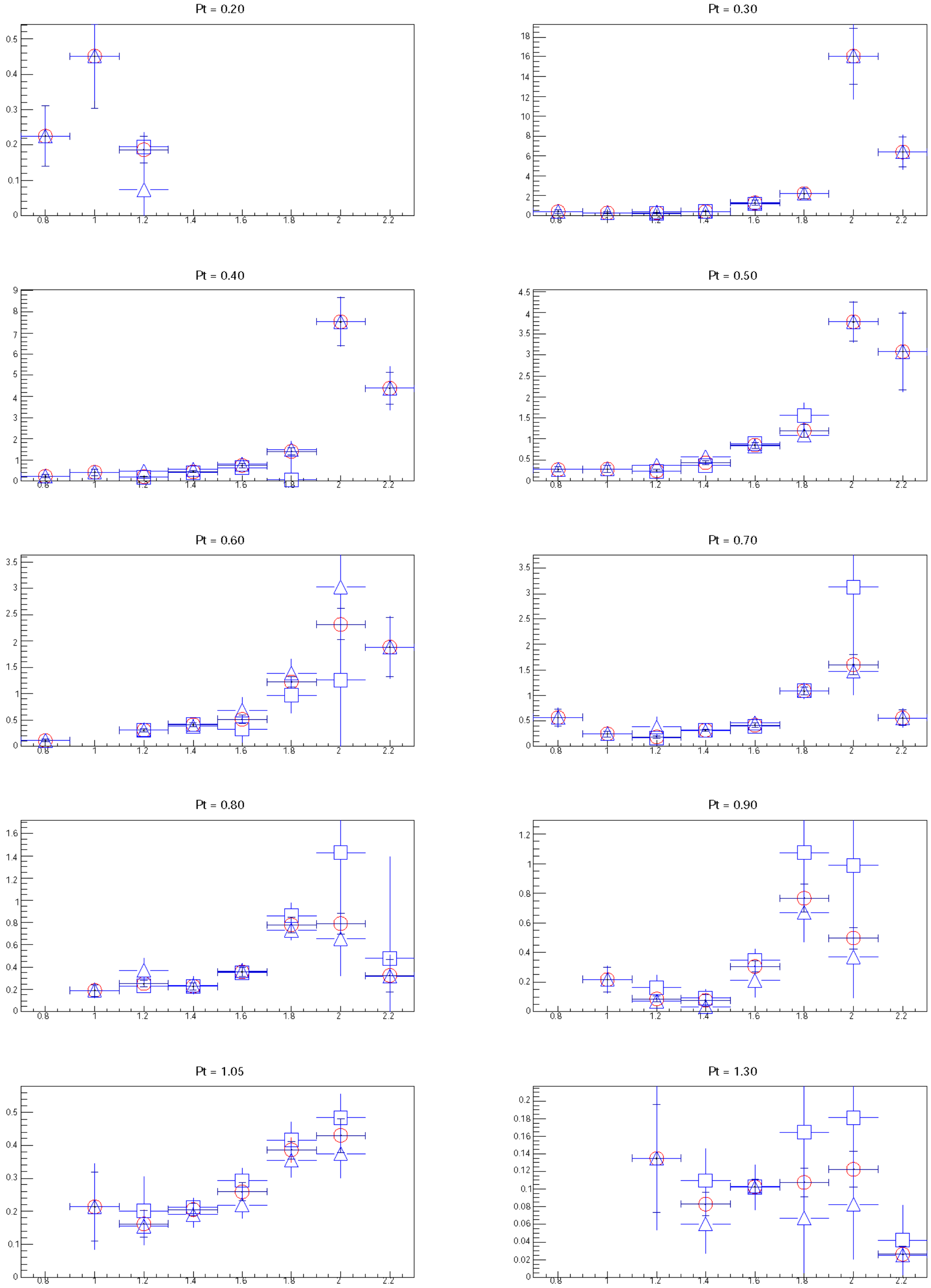
Deuterons in Ar + Cu: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



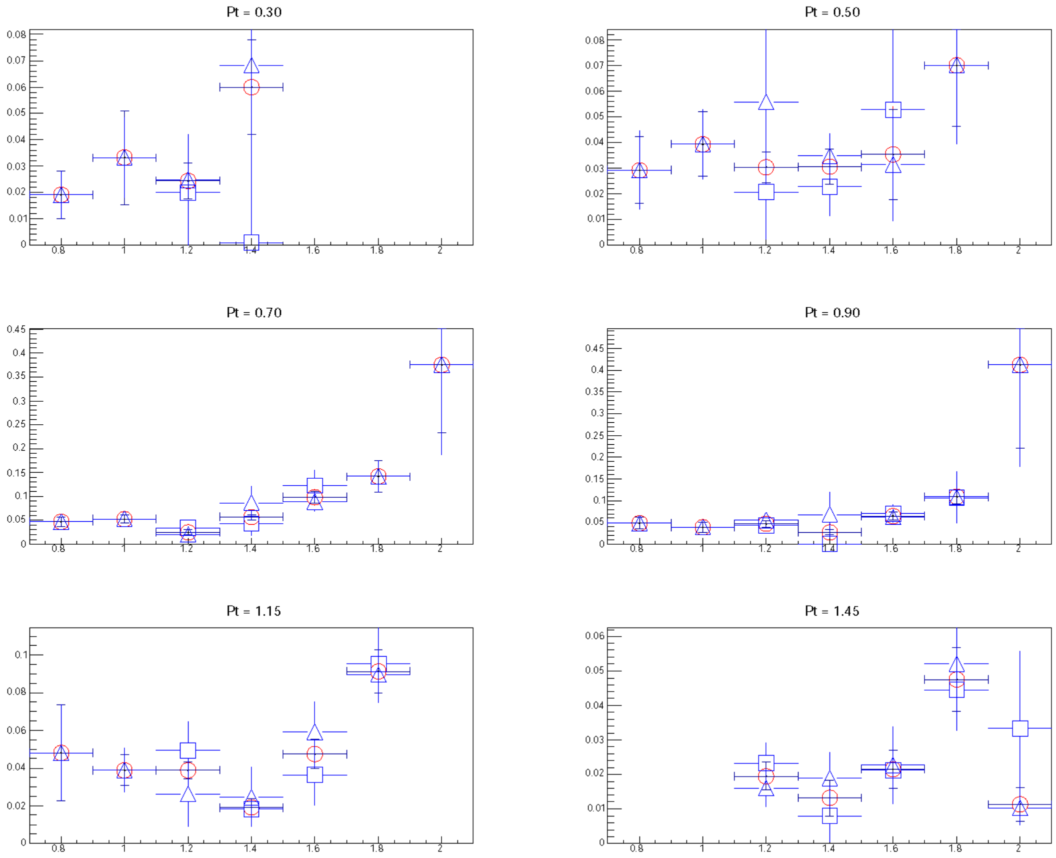
Deuterons in Ar + Sn: Yield as a function of rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



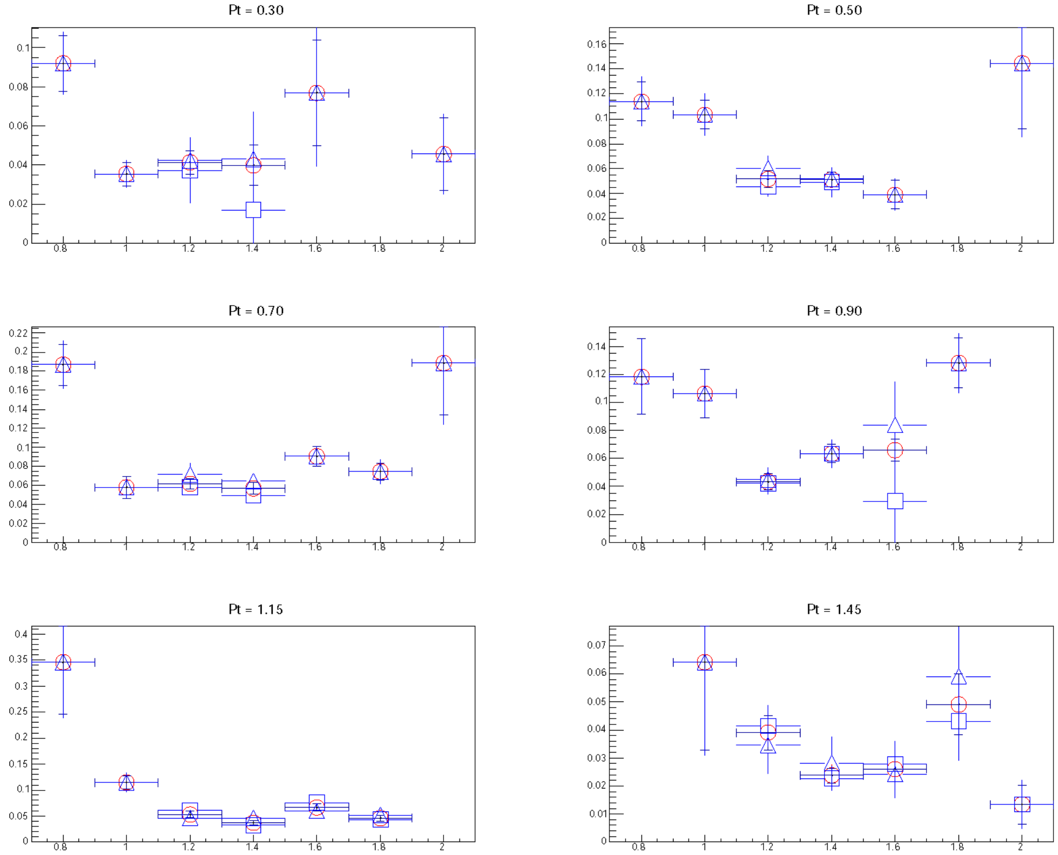
Deuterons in Ar + Pb: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



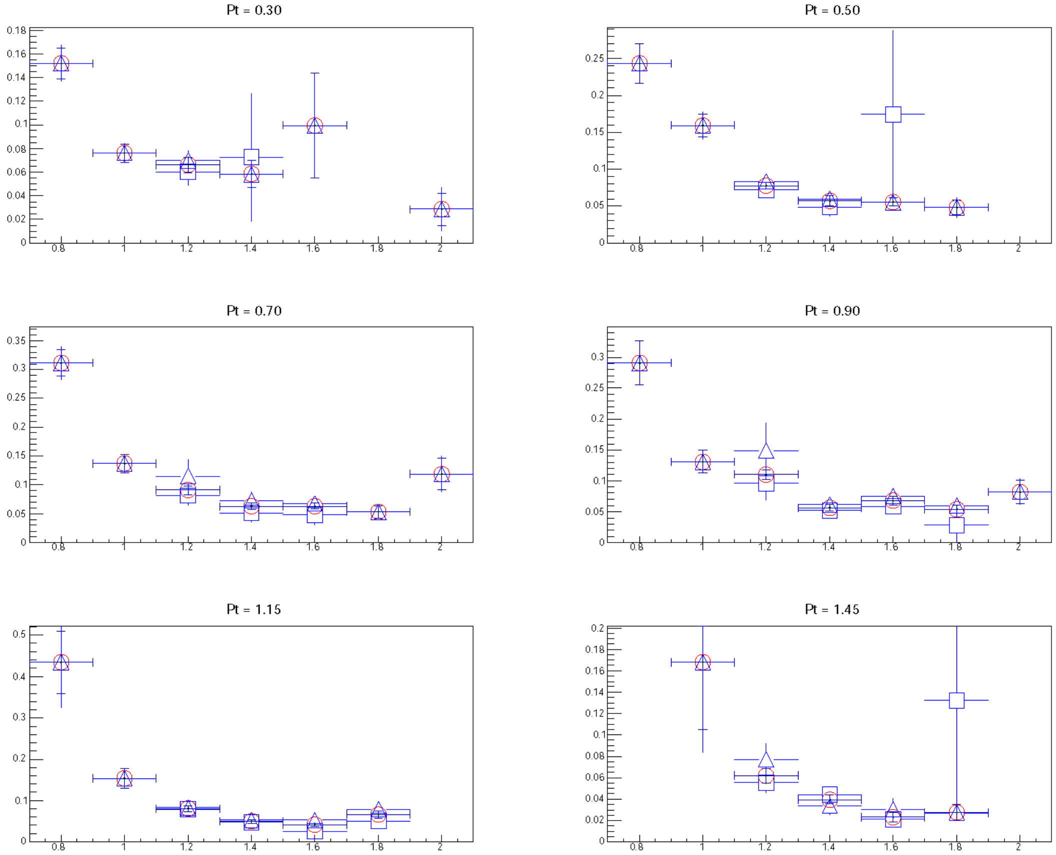
Deuterons in Ar + C: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



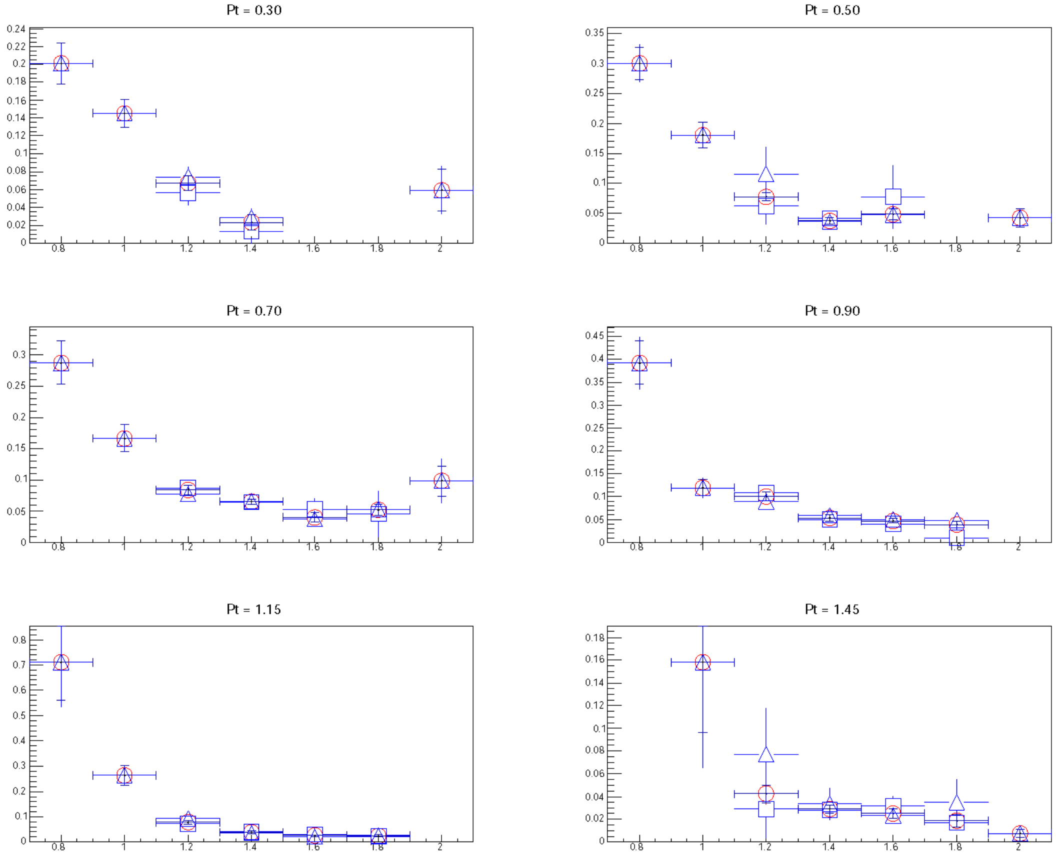
Tritons in Ar + Al: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



Tritons in Ar + Cu: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



Tritons in Ar + Sn: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data



Tritons in Ar + Pb: Yield as a function of the lab rapidity in bins of pT. Blue rectangles – ToF-400 data, blue triangles – ToF-700 data, red circles – weighed averaged values of ToF-400 and ToF-700 data