BG merging and reconstruction efficiency

Task-force report

S. Stepanyan (JLAB)

CLAS Collaboration meeting, July 21-24

Goal

Develop and validate GEMC based software for beam background merging with MC event to properly account for track/particle reconstruction efficiency and accuracy in CLAS12.

Charge

- ✓ Develop a software for merging hits in fADCs and TDCs in CLAS12 detectors associated with physics (GEMC or exp. data) and the beam background (from the random trigger) events
- ✓ Develop software for filtering out hits in fADCs and TDC associated with beam background using random trigger events
- ✓ study the dependence of a particle detection efficiency and 3-momentum accuracy on the kinematics of particles and topology of physics events using experimental data with different luminosities (normalized yields, invariant and missing mass distributions)
- ○ validate background merging procedure by comparing above dependencies with results obtained from merged samples of MC and low luminosity data
- ○ document the work

Members

- S. Stepanyan (PI)
- M. Ungaro (core)
- V. Ziegler (core)
- H. Avagyan (core)
- N. Markov (external)
- V. Burkert (external)
- R. De Vita (external)

Documentation

- Update at the Hall-B task-force meeting, May 22, 2020 [54]
- Background files and software tools

Old studies

- Summary of Spring 2019 studies of luminosity scan runs (Stepan)
- Old studies with 2 nA data merged with 50 nA BG (Stepan)
- Background Merging Validation (Joseph)

Meetings on Thursdays at 3 pm. The bluejeans Meeting ID: 149 758 290

https://clasweb.jlab.org/wiki/index.php/Hall-B_Task_Forces_2020#tab=BG_Merging__26_Efficiency

Where we are

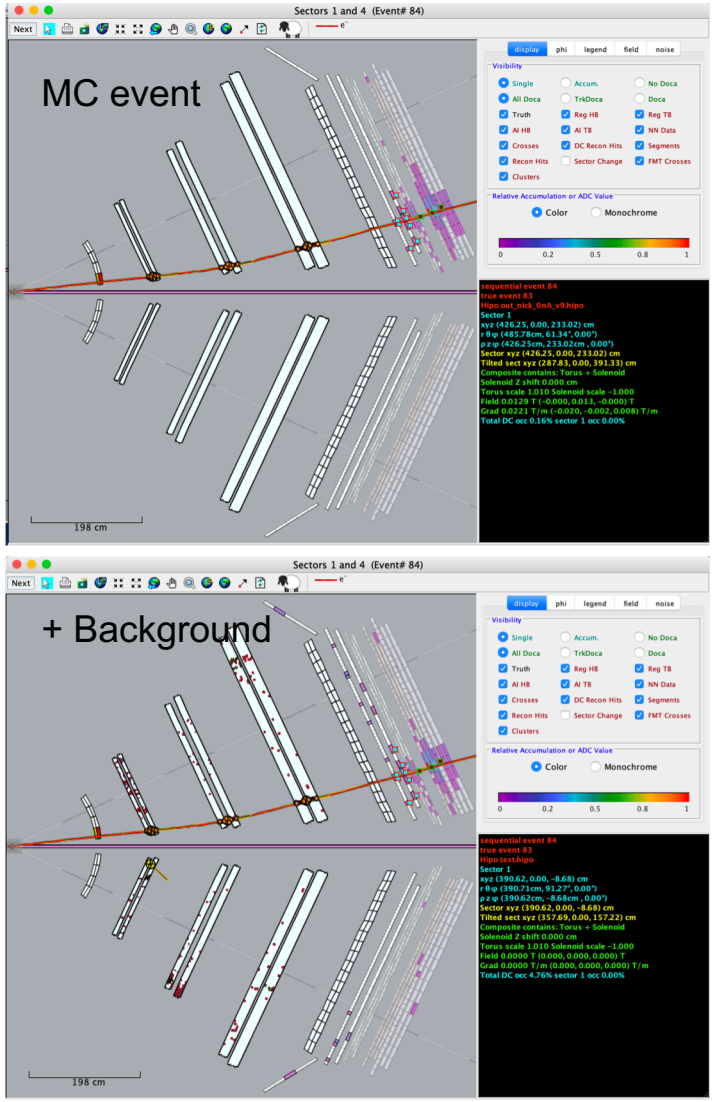
- Software packages for event merging and to filter random/FC trigger events from the production data are ready
- Final steps in GEMC changes and CCDB constants are in progress

Raffaella, Veronique, Maurizio

- Validation of the beam background merging in data is complete – low luminosity data merged with a high luminosity background reproduces dependences of the efficiency and the resolutions (MM and invM) of the high luminosity data
- Validation of the background with the MC event is still ongoing, some discrepancies between different MC studies and a not-fully accounting for inefficiencies in MC+BG samples must be understood
- Started drafting a report

Background merging

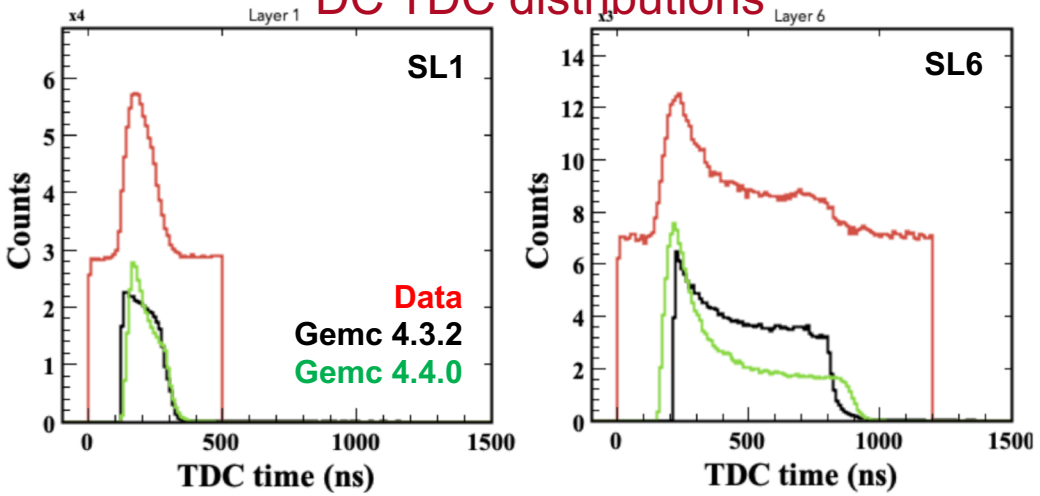
- Tools to filter and merge background from real events with real or simulated events included in coatjava
- Filter tool:
  - Selects events from a specific trigger bit applying a threshold on the beam current
  - Runs on hipo files
- Merging tool:
  - Merges raw banks (adc and tdc) of the primary event and the background event
  - Accounts for readout electronics behavior (multiple hit suppression, tdc jitter, FC time delay)
- Status:
  - Chain fully exercised on both data (low luminosity) and MC
  - Validation completed on data, in final stage for MC
  - Will be included in next release



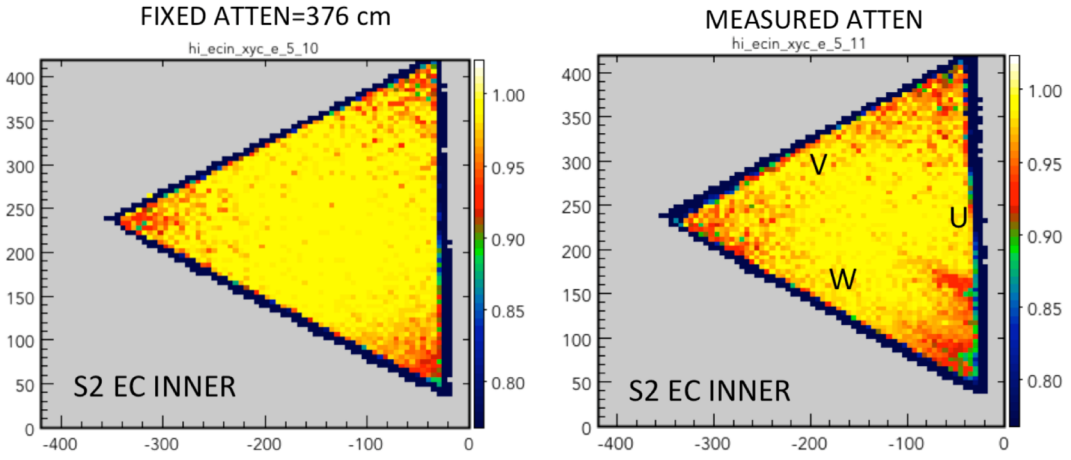
Detector response tuning

- Tuning of detector detector response to reproduce actual performance from data:
  - TOF resolution from calibration results
  - DC intrinsic efficiency and resolution
  - ECAL attenuation length and photoelectron statistics
  - HTCC response in terms of number of photoelectrons
- TOF resolution already available in 4.3.2, others coming with 4.4.0

DC TDC distributions



EC distributions



BG merging validation with data using track multiplicity

- Runs: 5443 (5 nA), 5444 (20 nA), 5453 (40 nA), 5543 (50 nA), 5595 (70 nA) – filled symbols
- Electron events ($p_e \geq 2.5\ GeV/c$) with charged hadrons of $p_h \geq 0.4\ GeV/c$ and $\chi^2{}_{PID} < 5$ in different sector than the electron

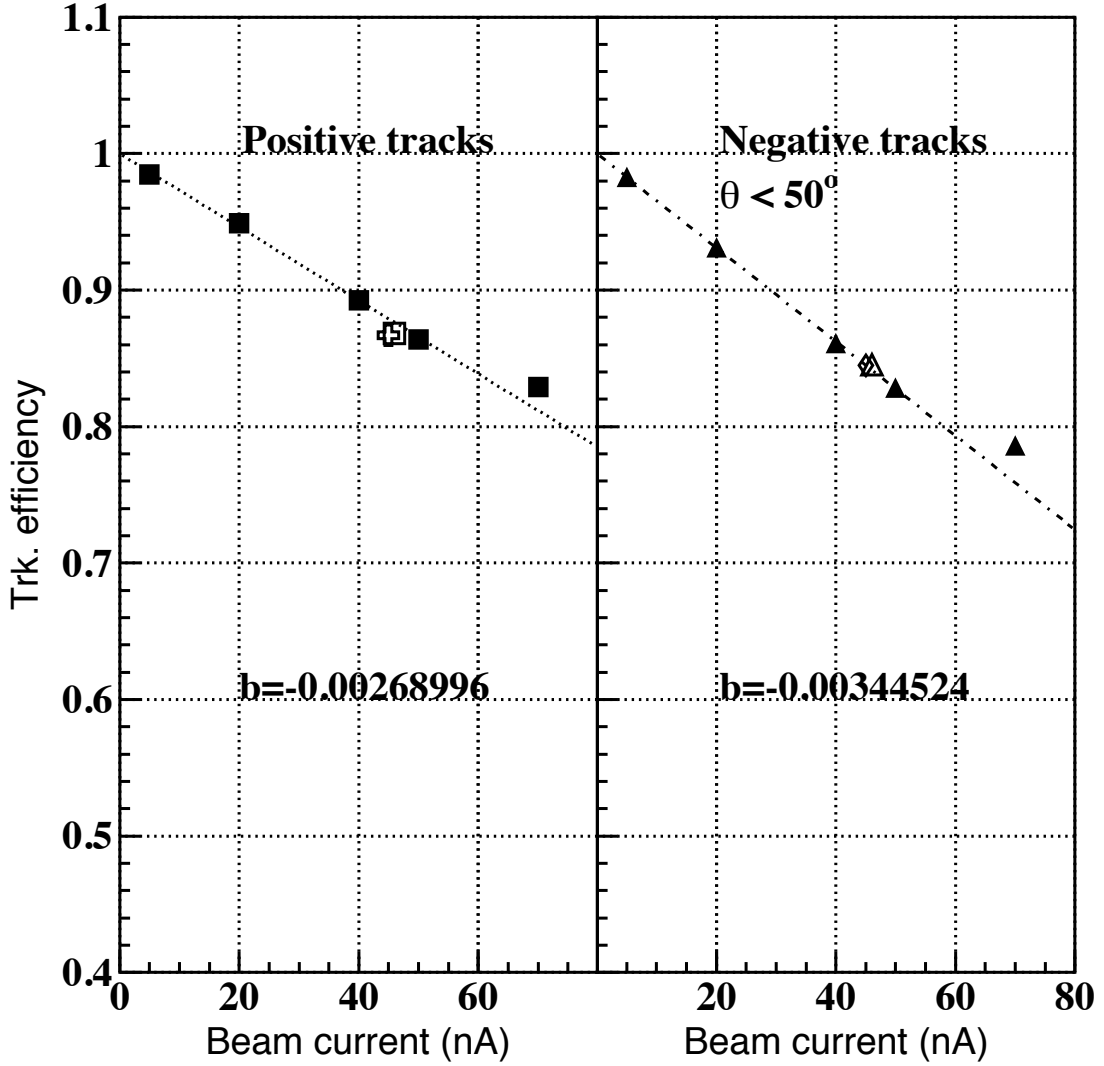
$$n_i = \frac{N_i}{N_e};$$

$$n_i(I) = a + b \times I;$$

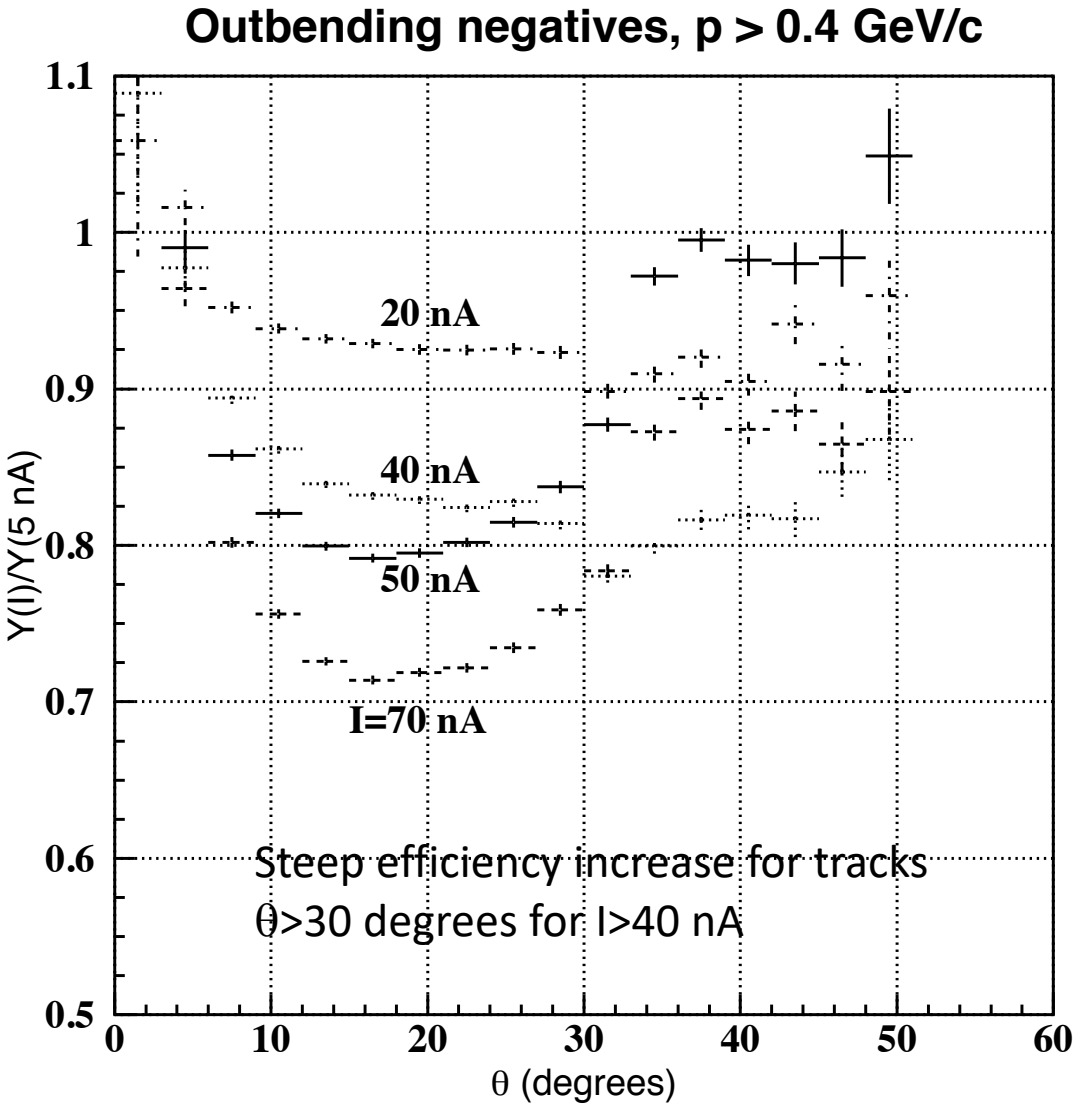
$$Trk.efficiency = \frac{n_i}{a};$$

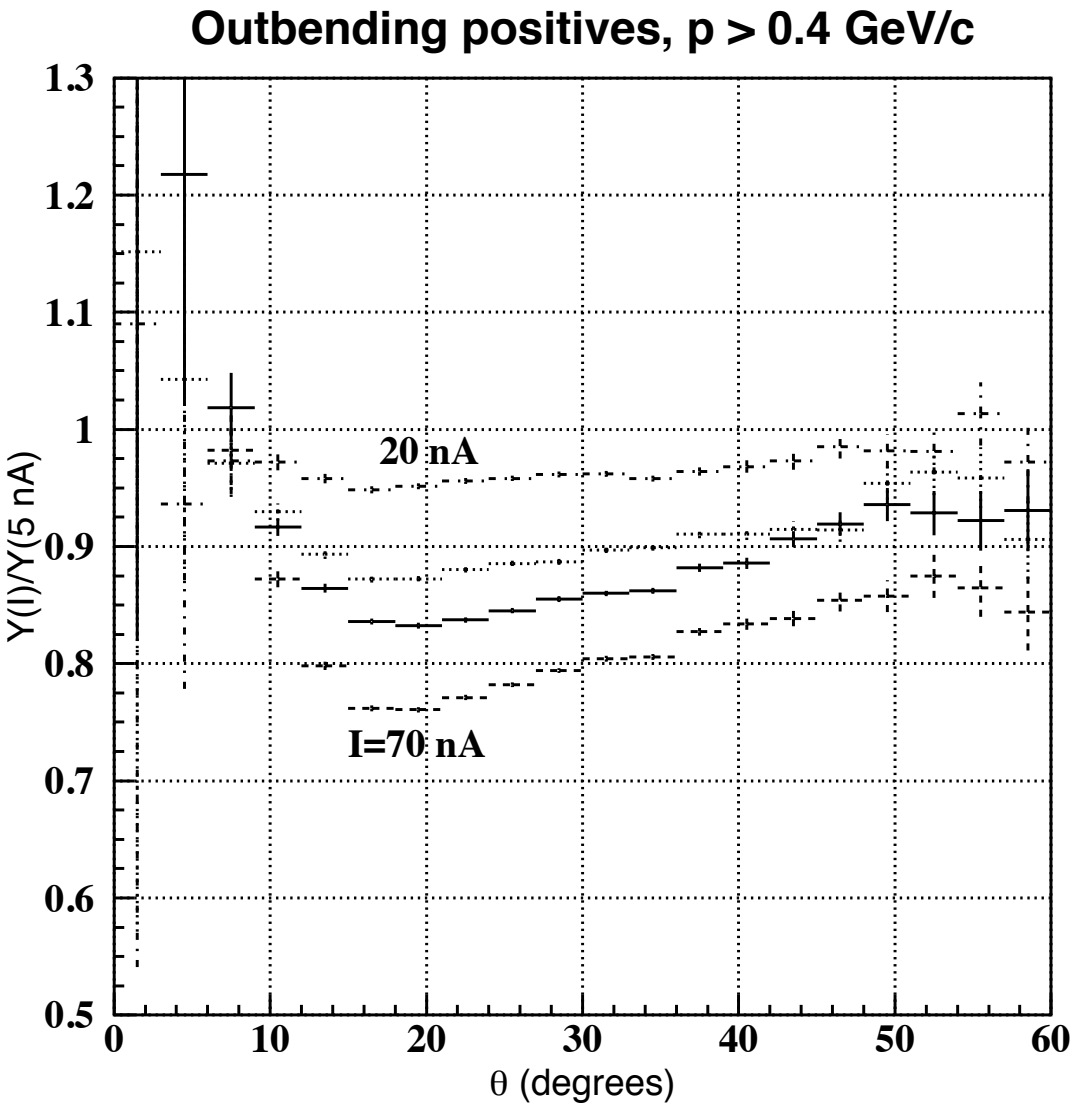
- Nice linear behaver for charged track efficiency as a function of the beam current
- 5 nA data merged with 40 nA BG reproduces the efficiency (open symbols):
  - v8 with correct DC TDC dead time (fix dead time for the whole R2),
  - v9 with variable dead time in R2 per hardware setup

No track in CD or a negatively charged track match with FTOF2



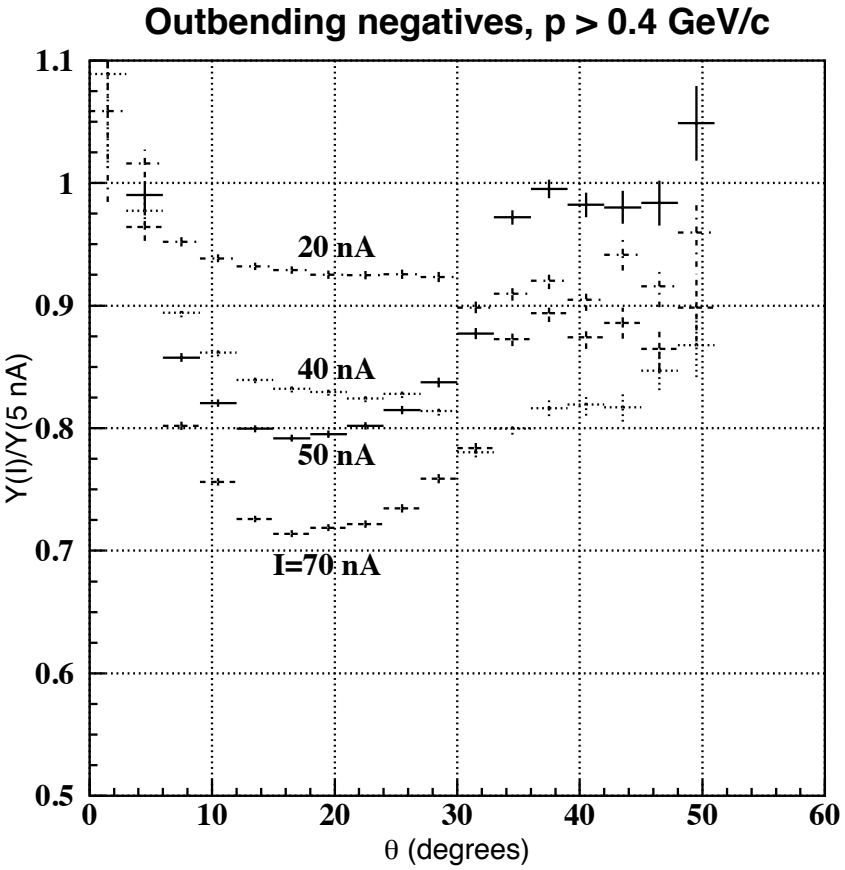
Angular dependences

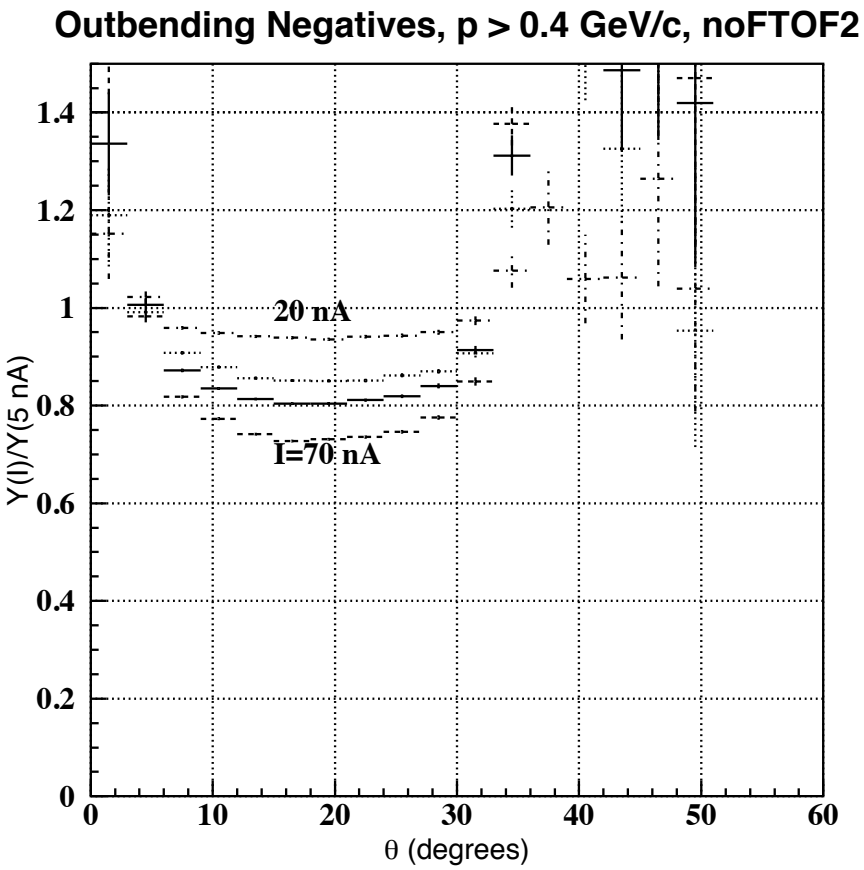


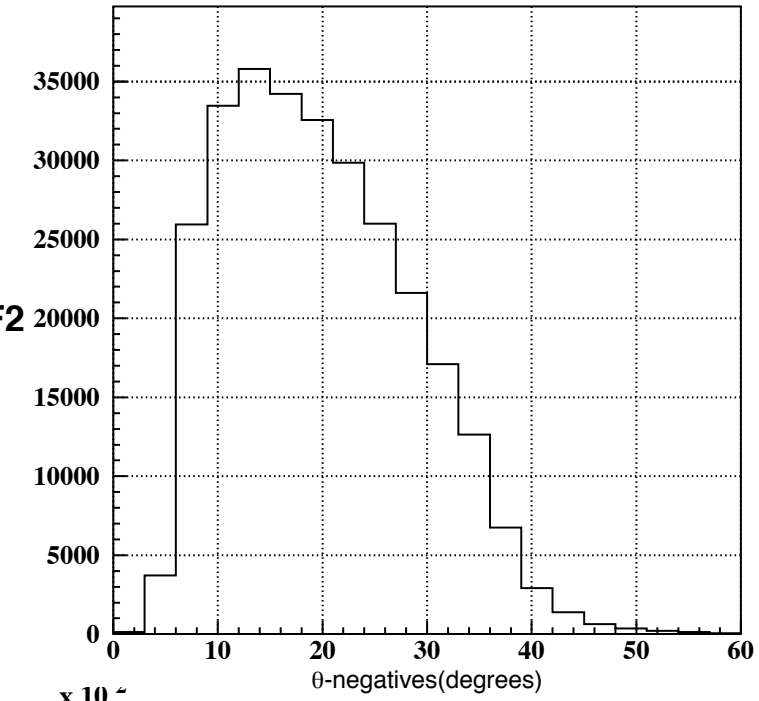


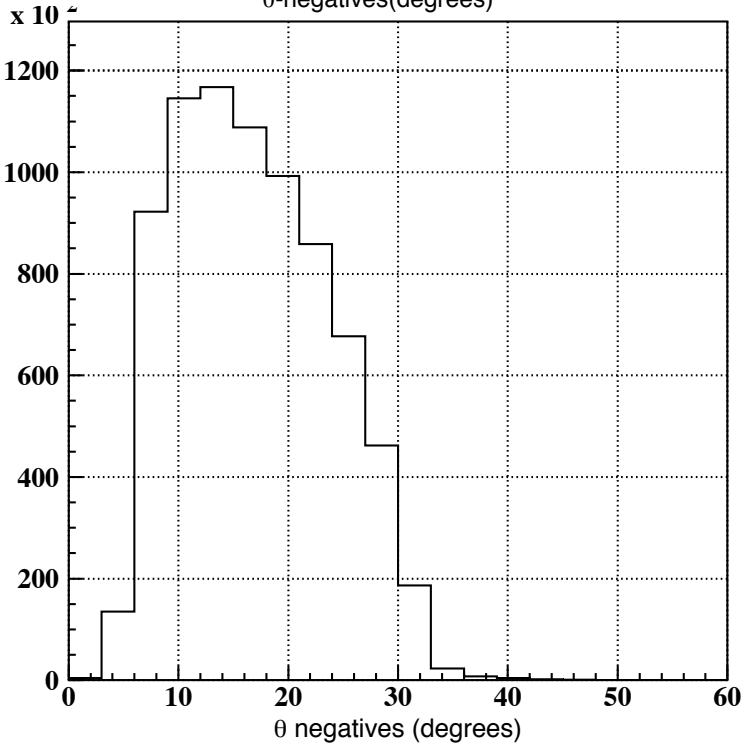
This has been observed in SIDIS events by Harut

Angular dependences









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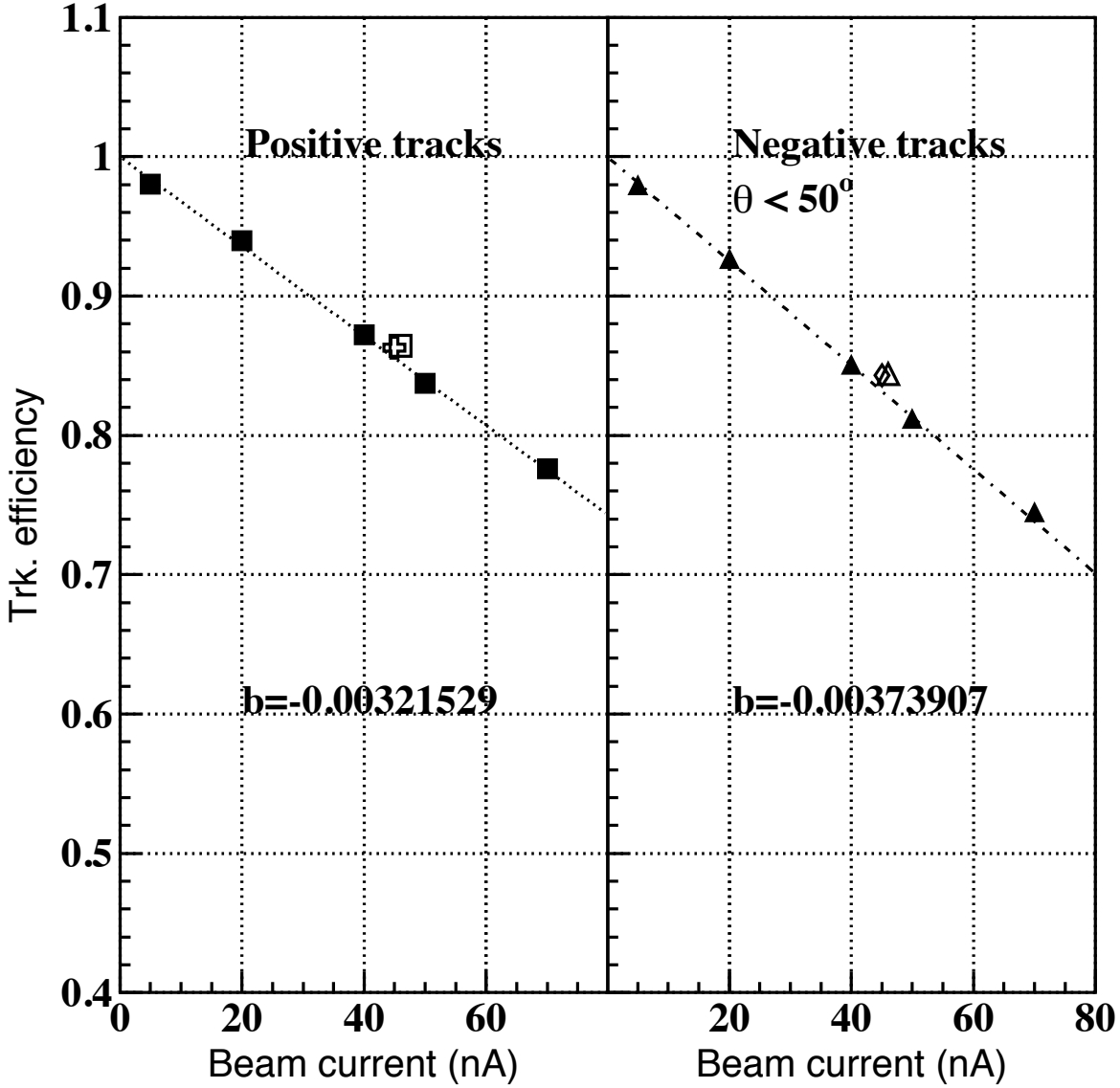
No negatively charged tracks match with FTOF2



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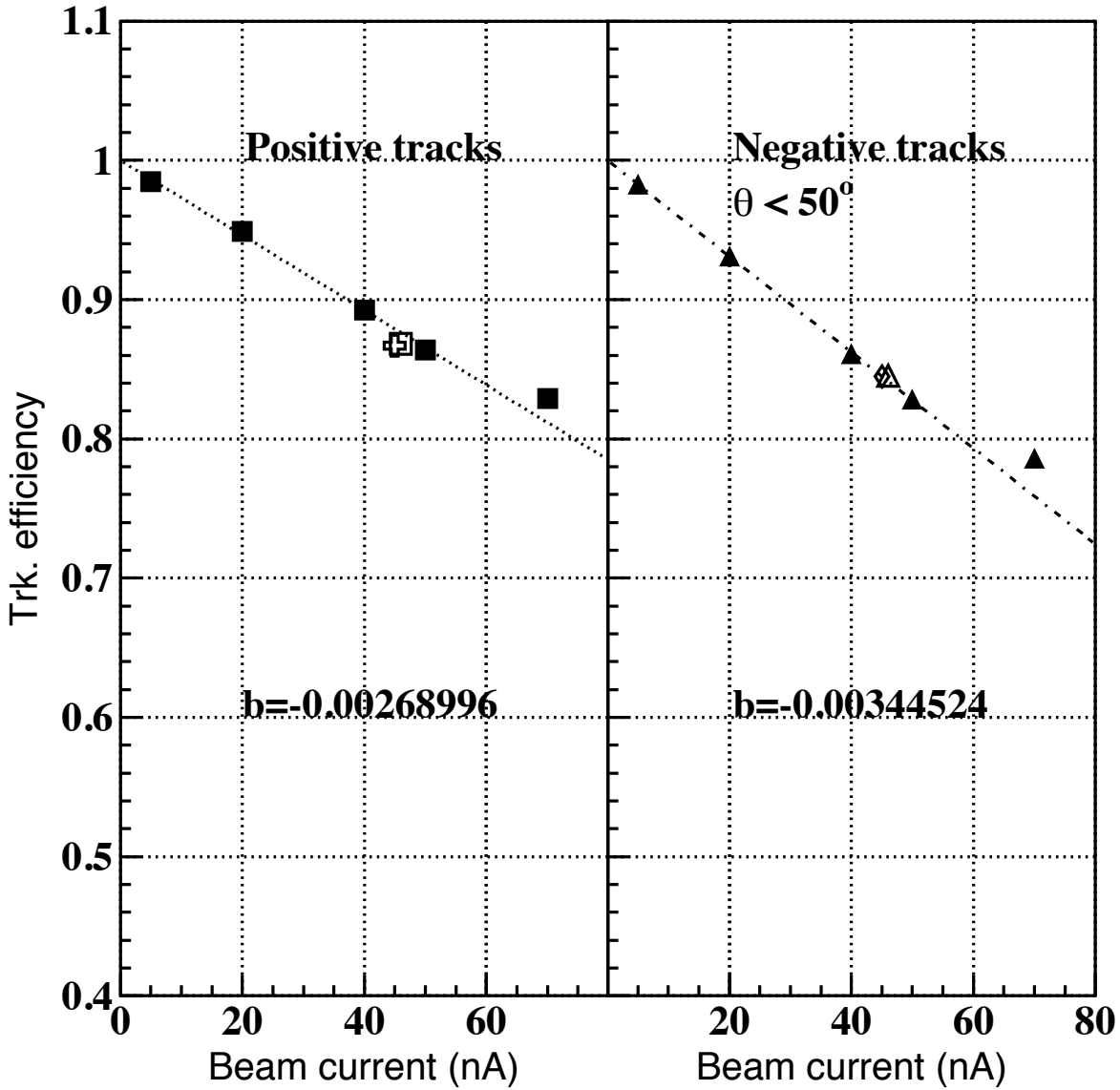
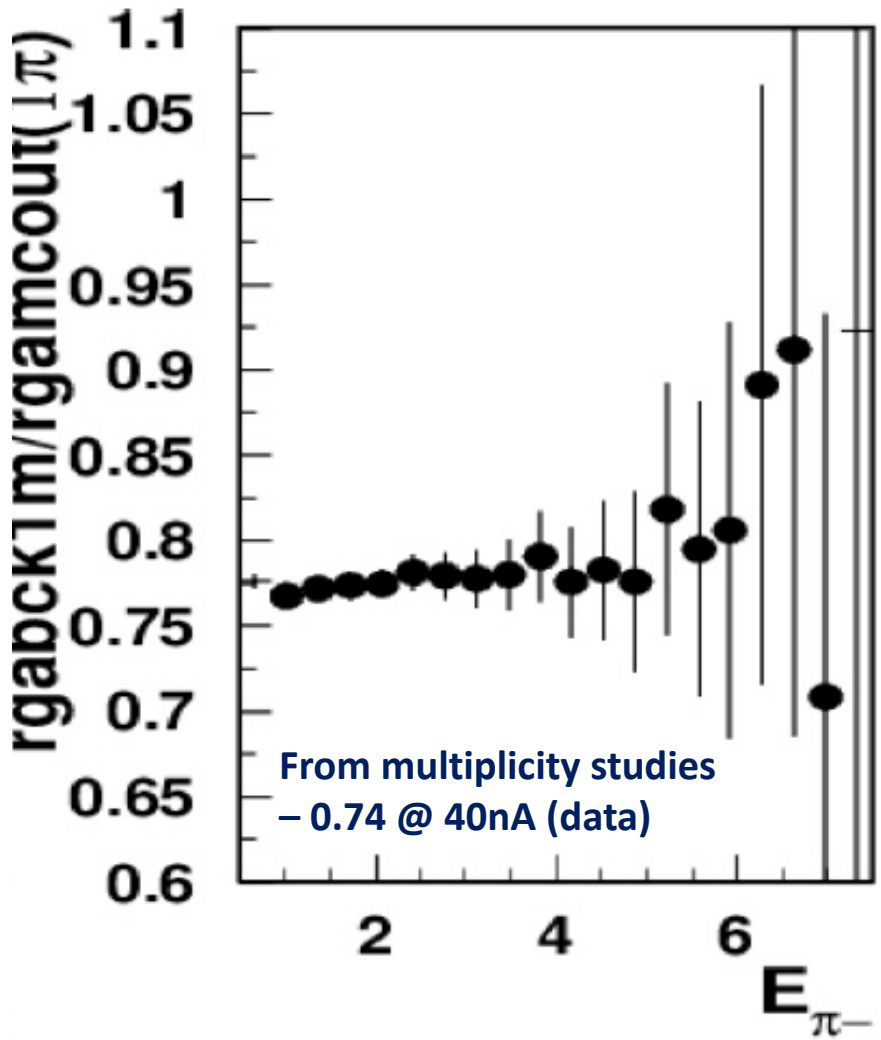
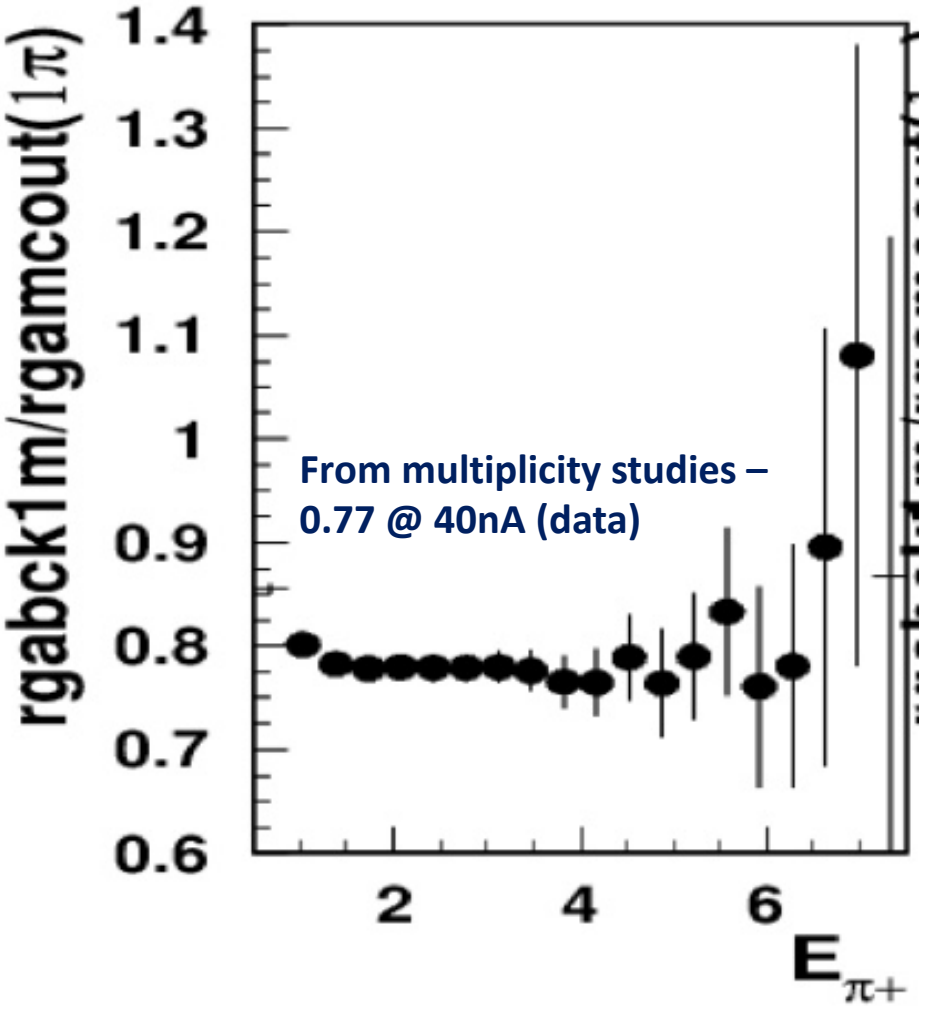


Outbending MC vs. MC_BG, SIDIS single pion (Harut)

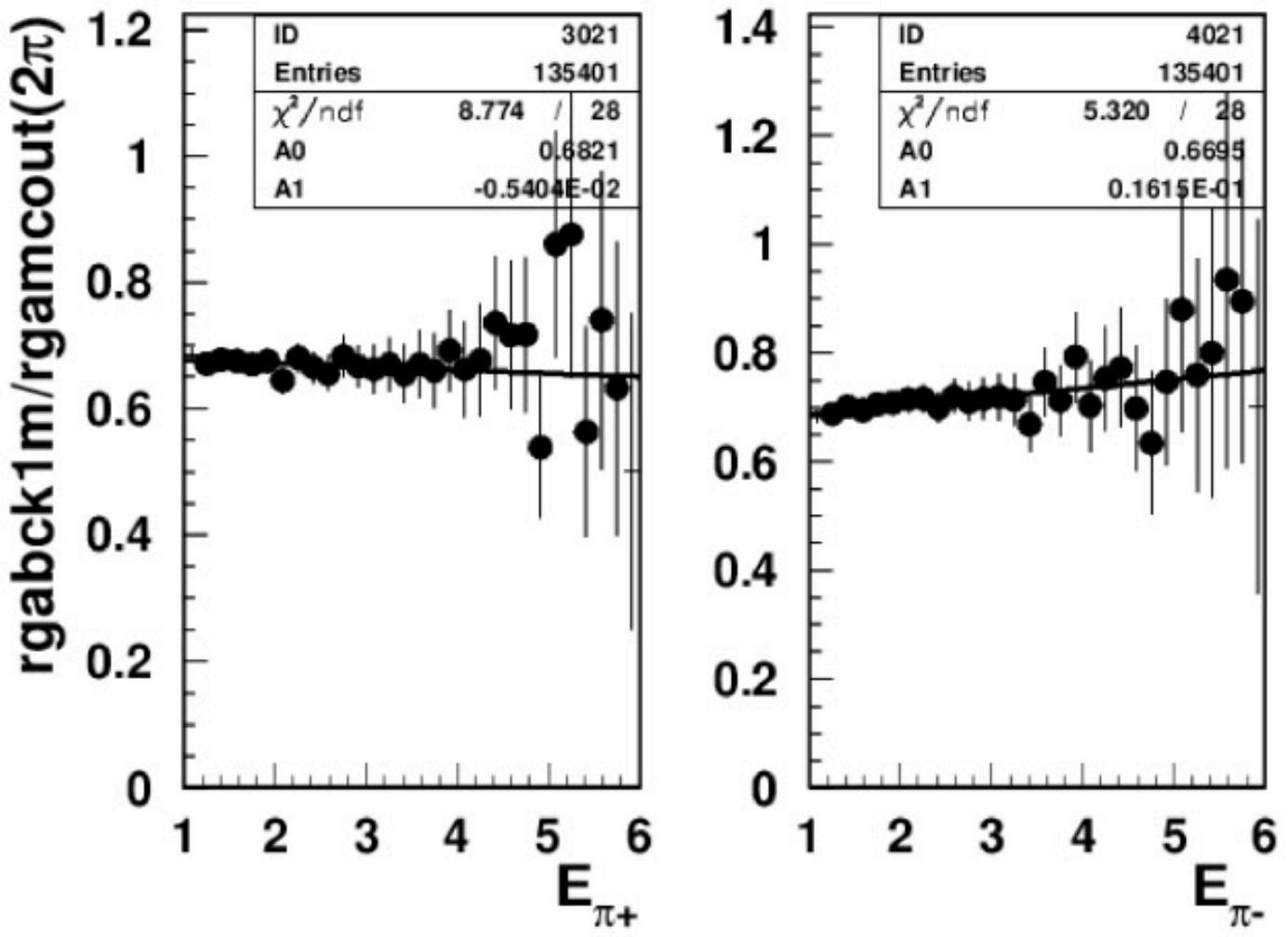




Overall loss of electrons ~13% for Ee>3GeV and theta>10 degrees

The efficiency tend to increase at mall angles

Outbending MC vs. MC_BG, SIDIS two pion (Harut)



From multiplicity studies – 0.66 @ 40nA (data)

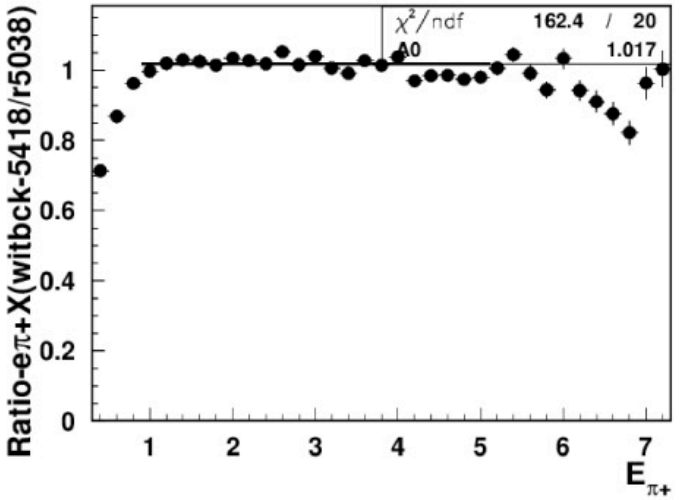
Reconstruction eff ~70%

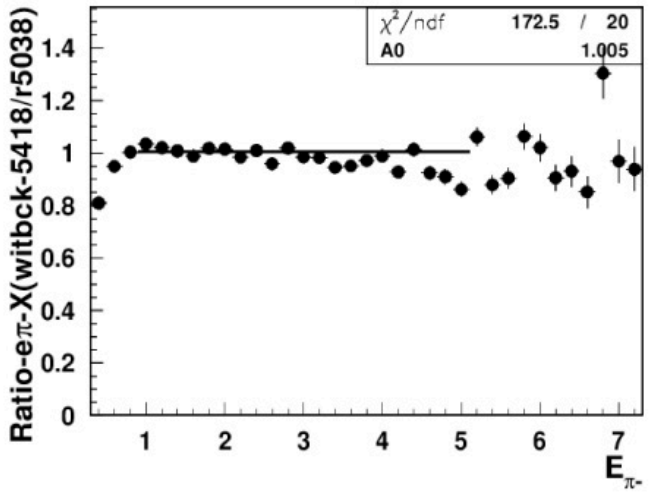
No major kinematical dependence on energy of pions for 2pion events

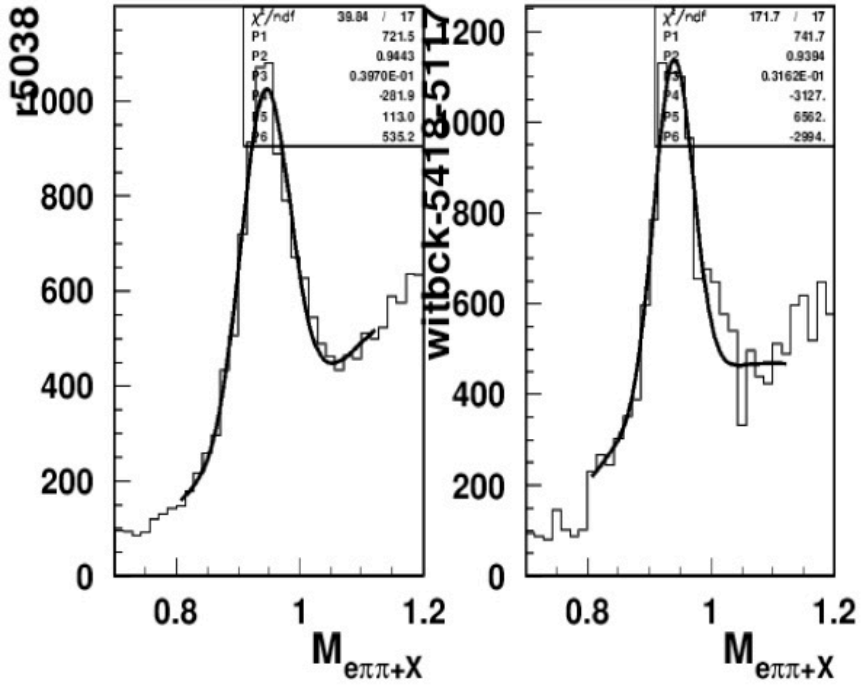
Single and double pion electroproduction

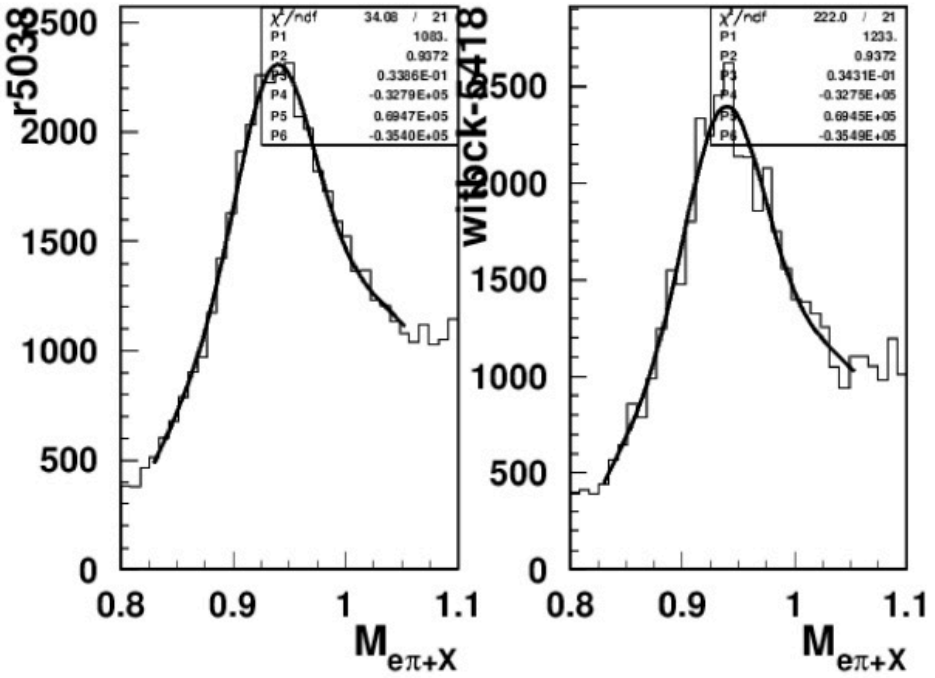
Harut A.

- Comparison of 5 nA data with 40 nA merged BG (5418) with a 45 nA data (run 5038)
- Efficiency and the missing mass resolution of eπ and eππ final state
- Good agreement in the resolution the energy dependence of the efficiency has some issues at low pion momenta (< 1 GeV)

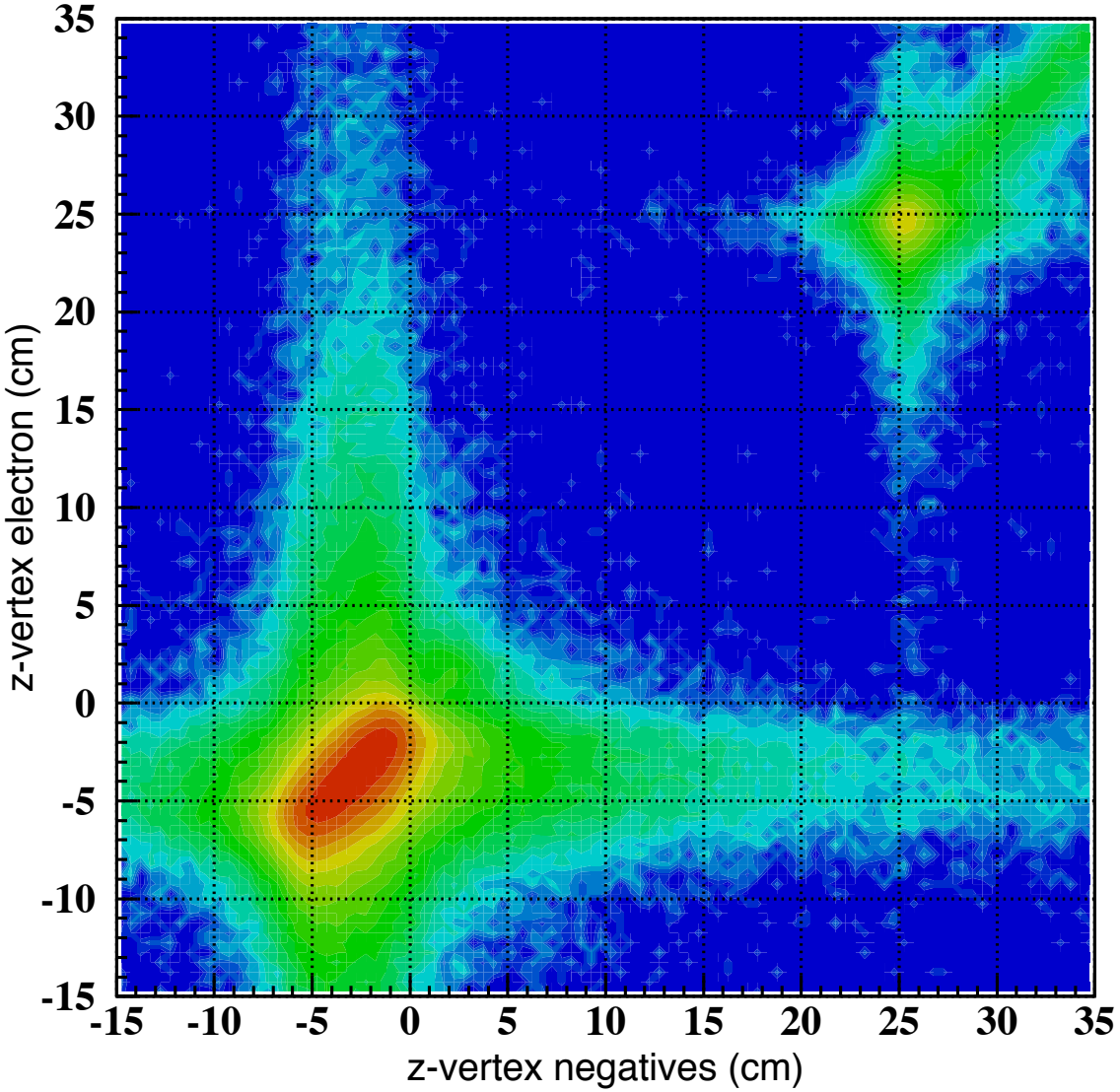


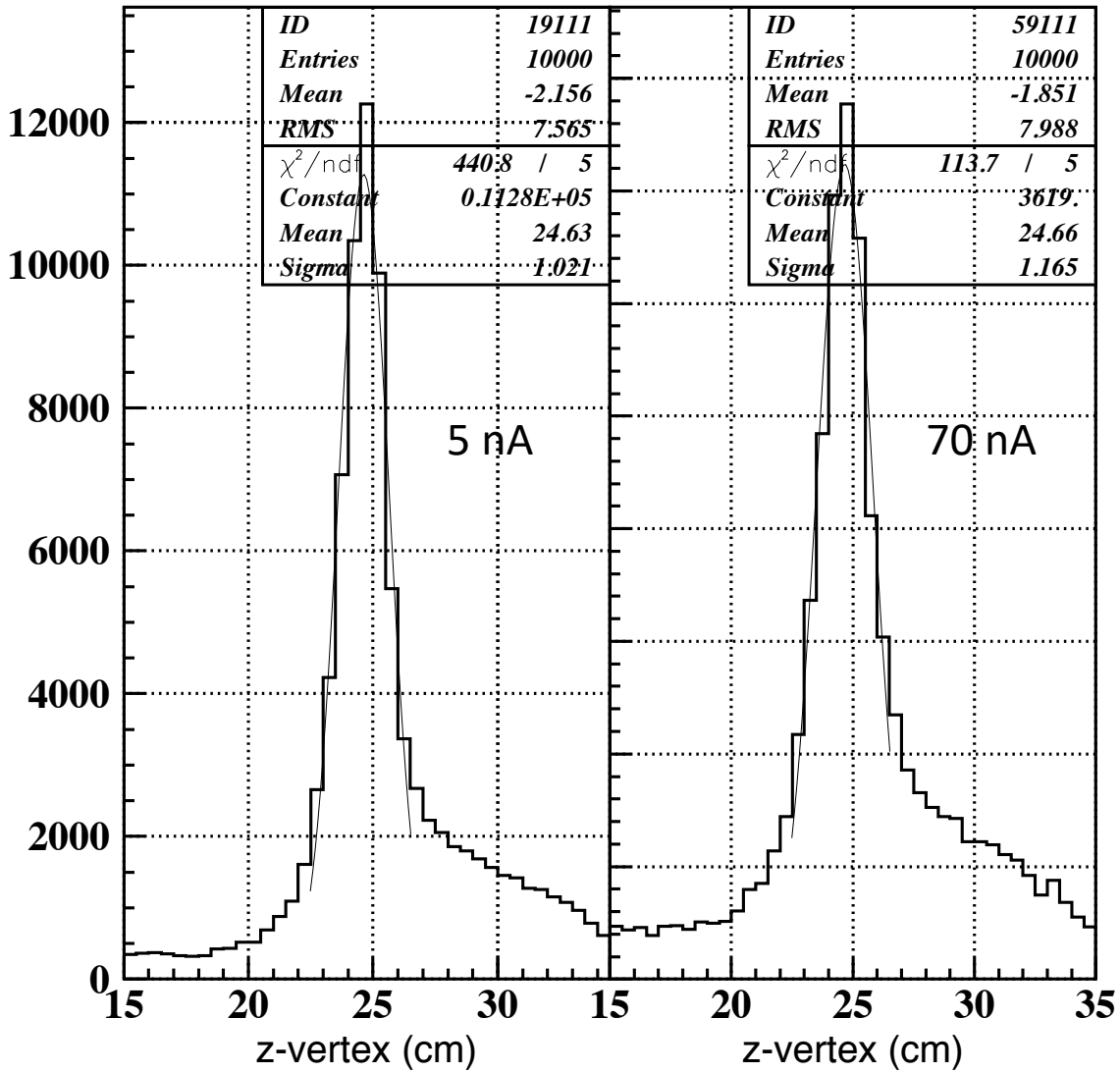






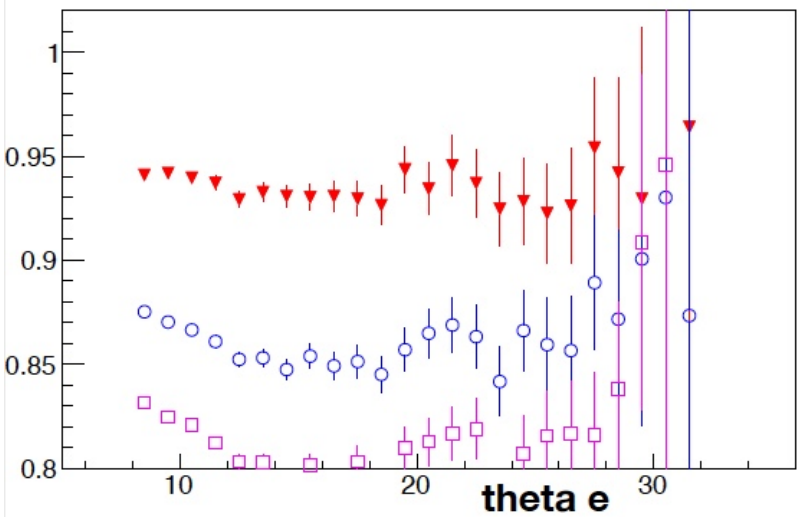
Vertex resolution

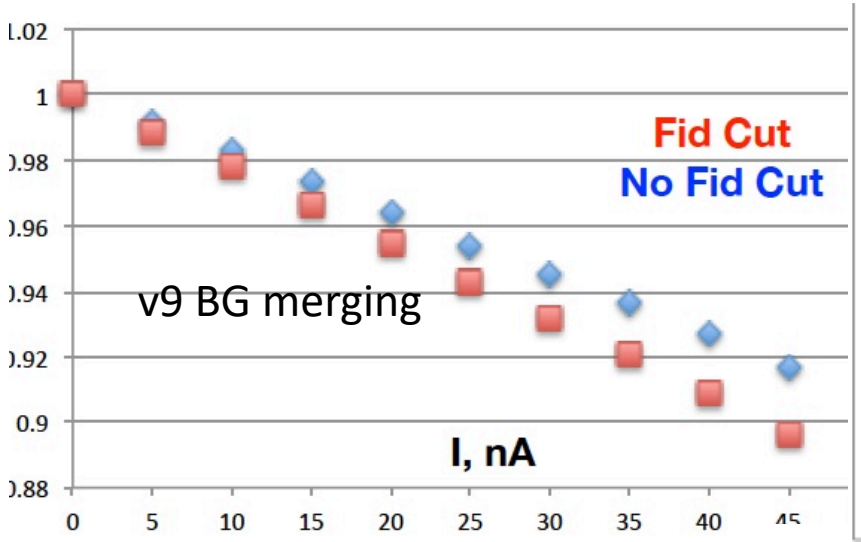


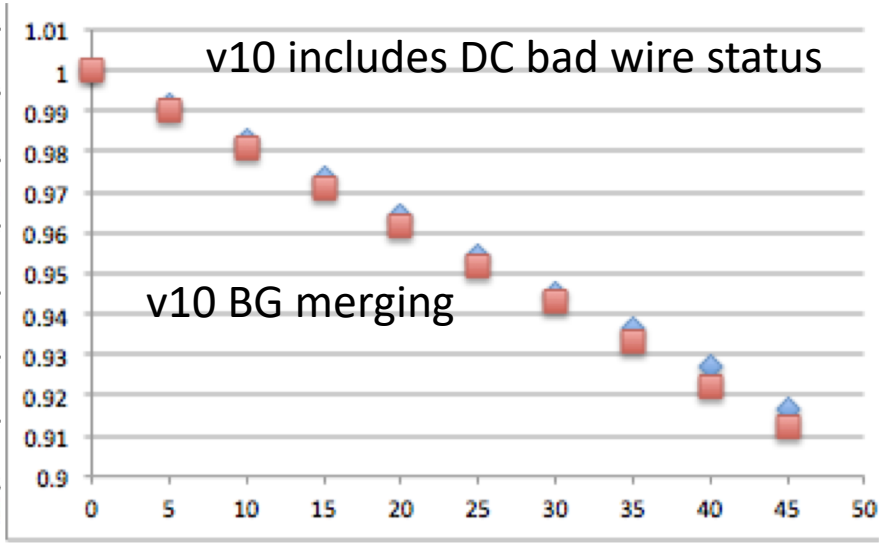


Inclusive electrons (Nick)

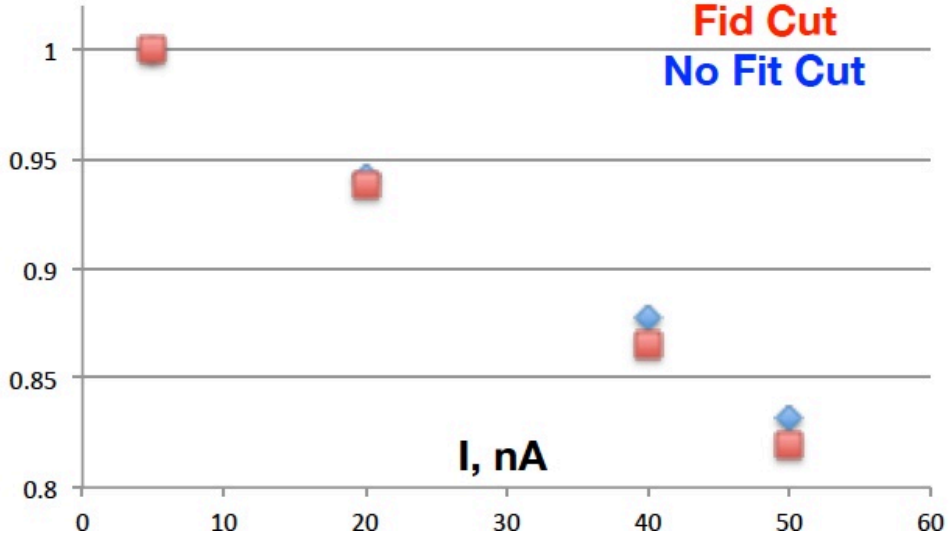
Basic features of the efficiency dependence on the kinematic variables are reproducible with the BG merging but not the average inefficiency. The efficiency in MC+BG is higher by ~5% at 40 nA compared to data





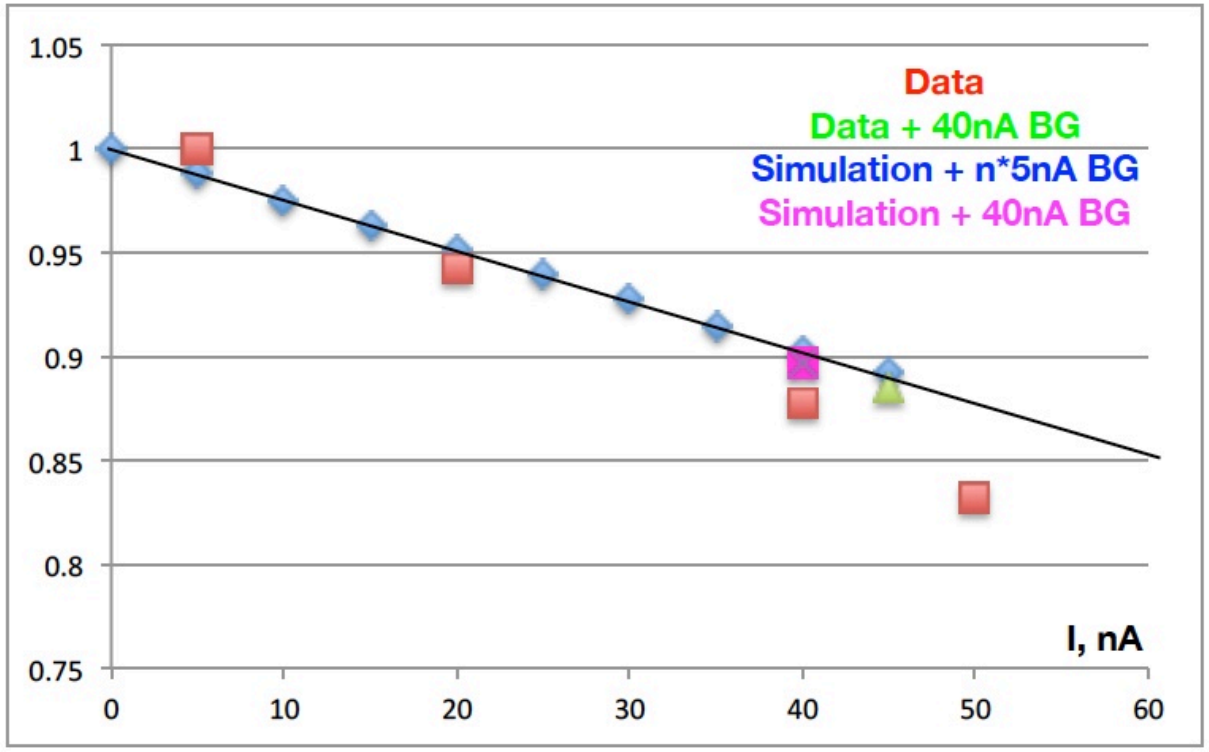


Considering the difference in the FD reconstruction efficiency with and without CD tracks in the event, a single electron event generator may not be a good idea. Other particles in the event and their interactions in the detector will generate hits in the detector

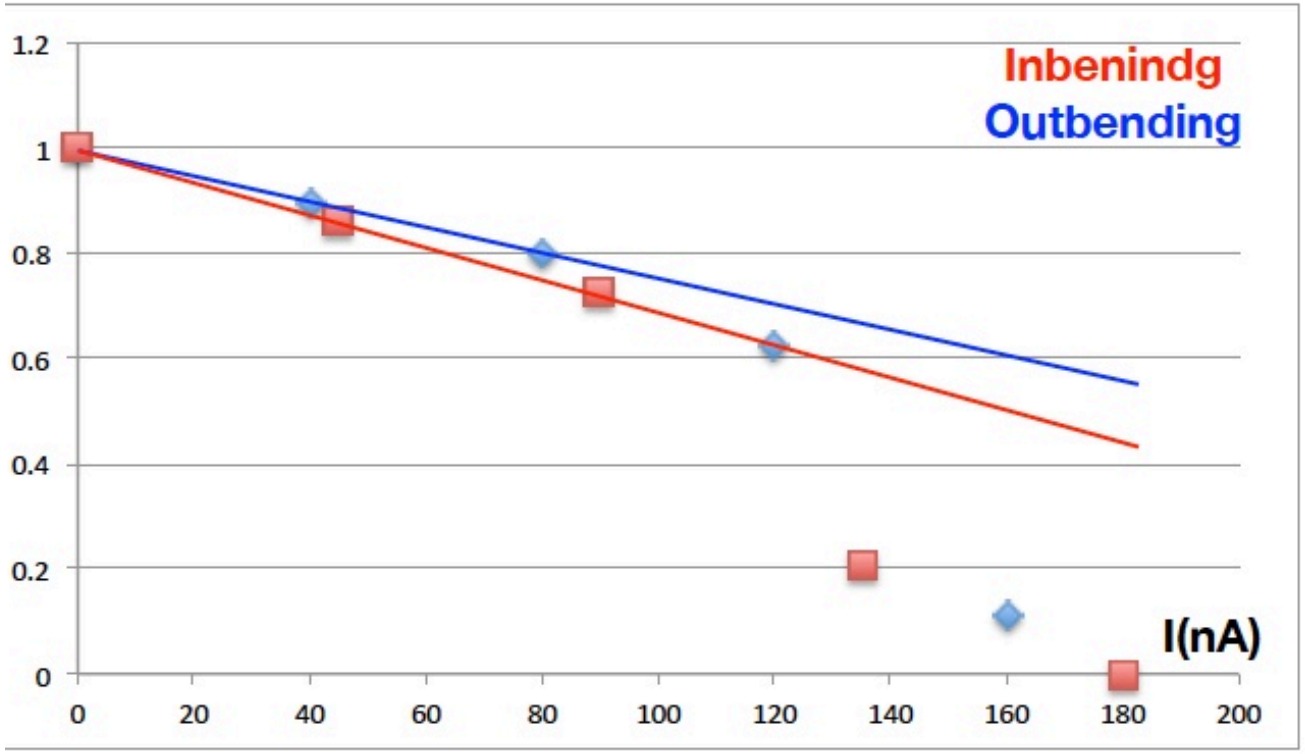


Other studies with inclusive e-: GEMC 4.4.0

5nA simulation with DC, FTOF, EC HTCC overlaid up to 1, 2…9 times on top of simulation



45nA simulation with DC, FTOF, EC HTCC overlaid up to 1, 2…4 times on top of simulation



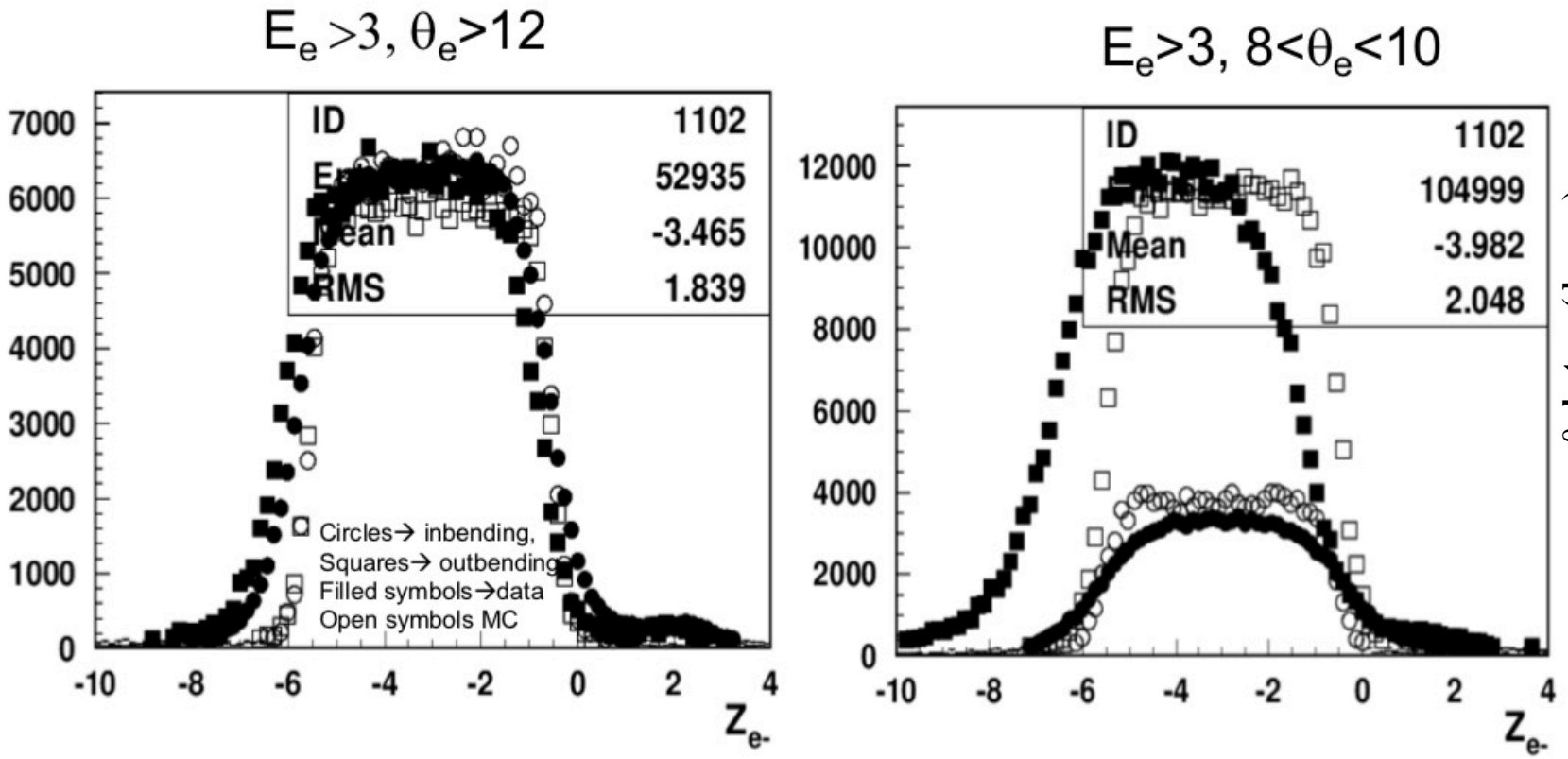
What next

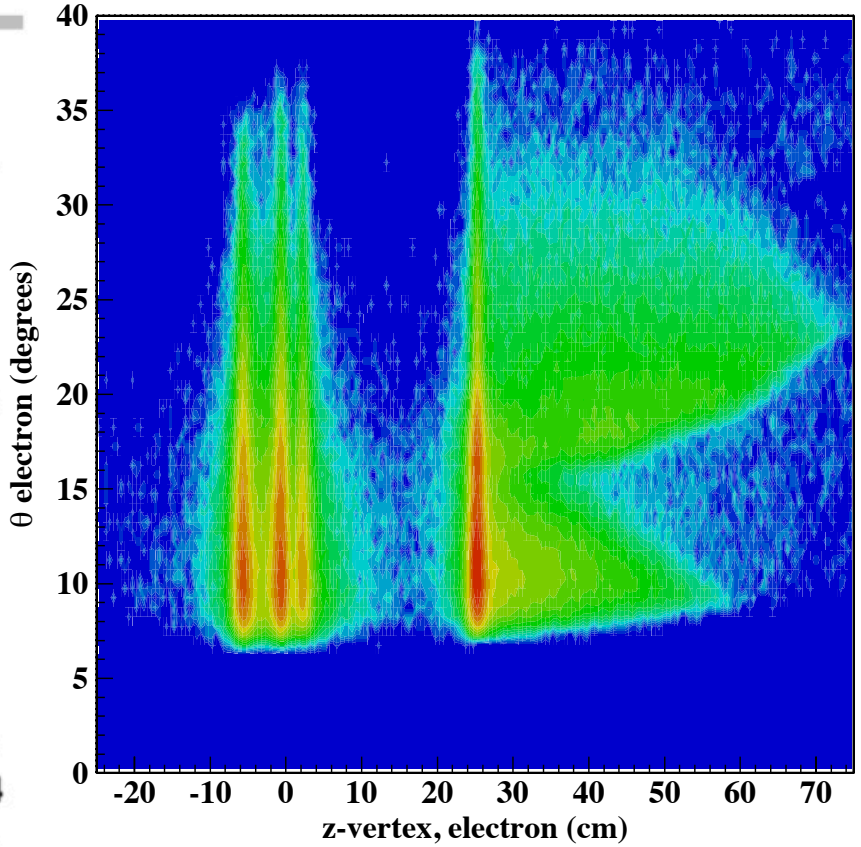
- Finalize MC+BG merging – GEMC 4.4.0, and CCDB for parametrization constants and the malfunctioning elements
- Do comparison of MC and data for few physics reactions (inclusive, SIDIS, J/psi…) – efficiency is topology dependent, event generator will matter
- Provide users with the whole framework, BG merging software and BG events from the production data for physics simulations
- Write a note

Time frame – a week or two

Sidetracked – not related to BG merging

Vertex studies: electrons





Above 10 degrees electron vertexes consistent Zvertexes
At smaller angles data slides to negative z, while MC stays