Light-Flavour Hadron Production at Fixed-Target Energies with STAR

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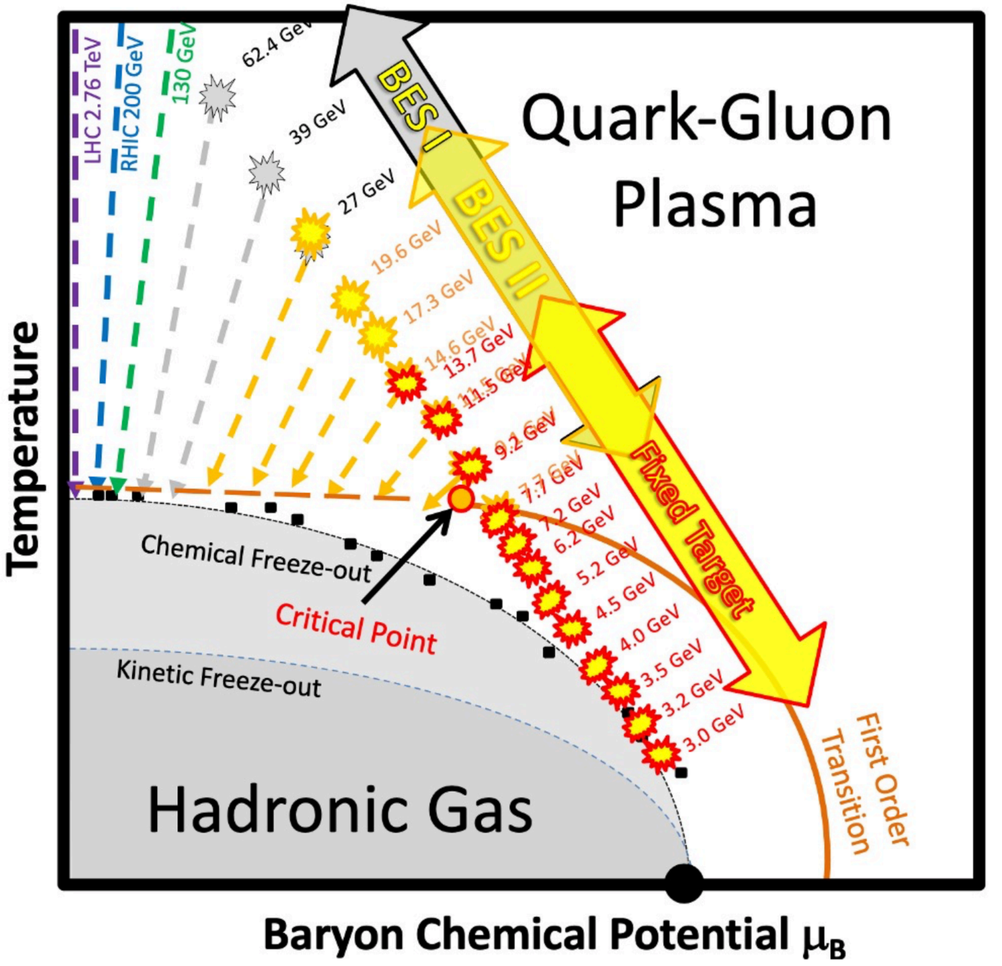
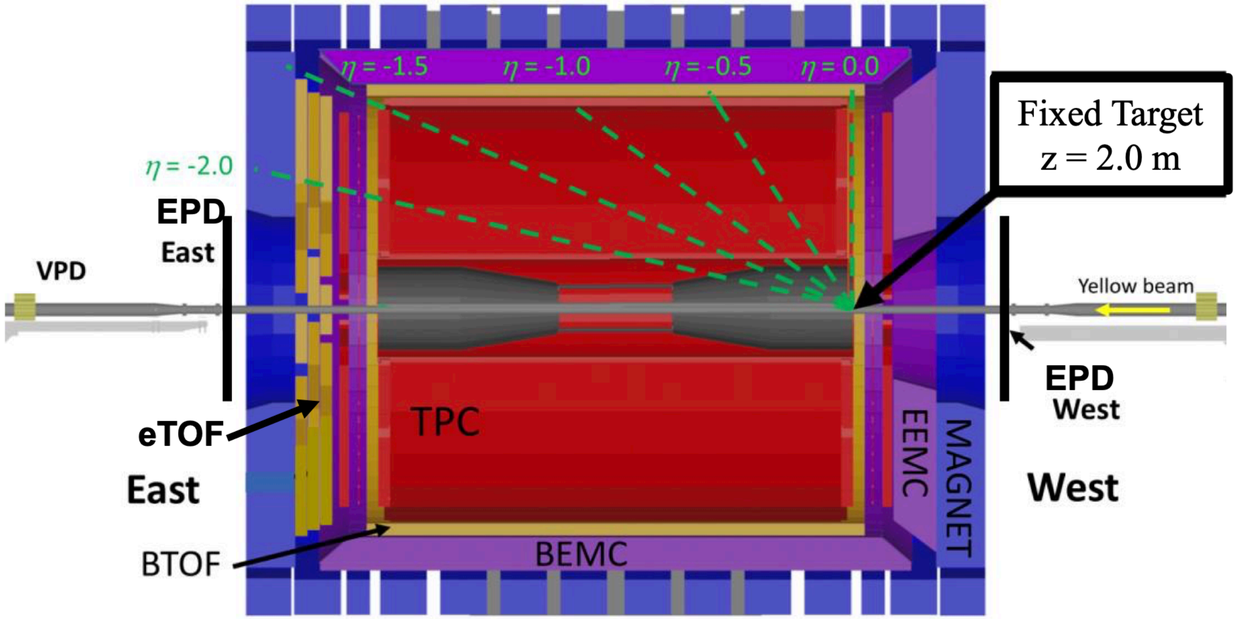
Light-flavour hadron production at STAR

- Hadron production is a key measurement in the search for a change of the QCD equation of state
- Light-flavor hadron [π,K,p] production measurements provide constraints to theoretical models
- This measurement gives unique a opportunity to test methodology of efficiency determination used in STAR



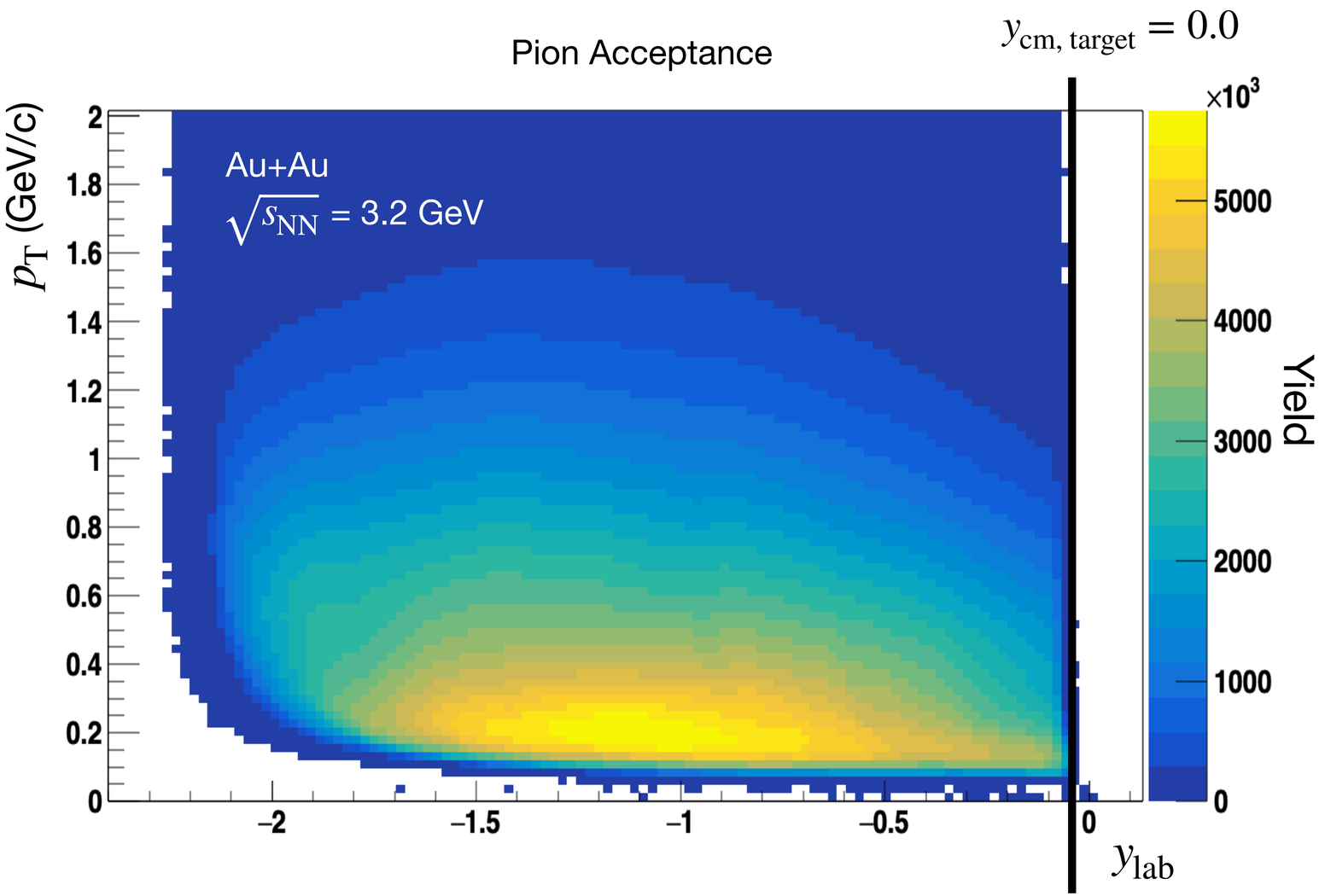
Fixed-target program (FXT)

- Program was implemented to extend energy reach of BES-II
- Run STAR in fixed-target mode with a gold foil target at the entrance to the TPC
- As energy increases, Center of mass rapidity (y_{cm}) is shifted to higher η; eTOF becomes *critical*



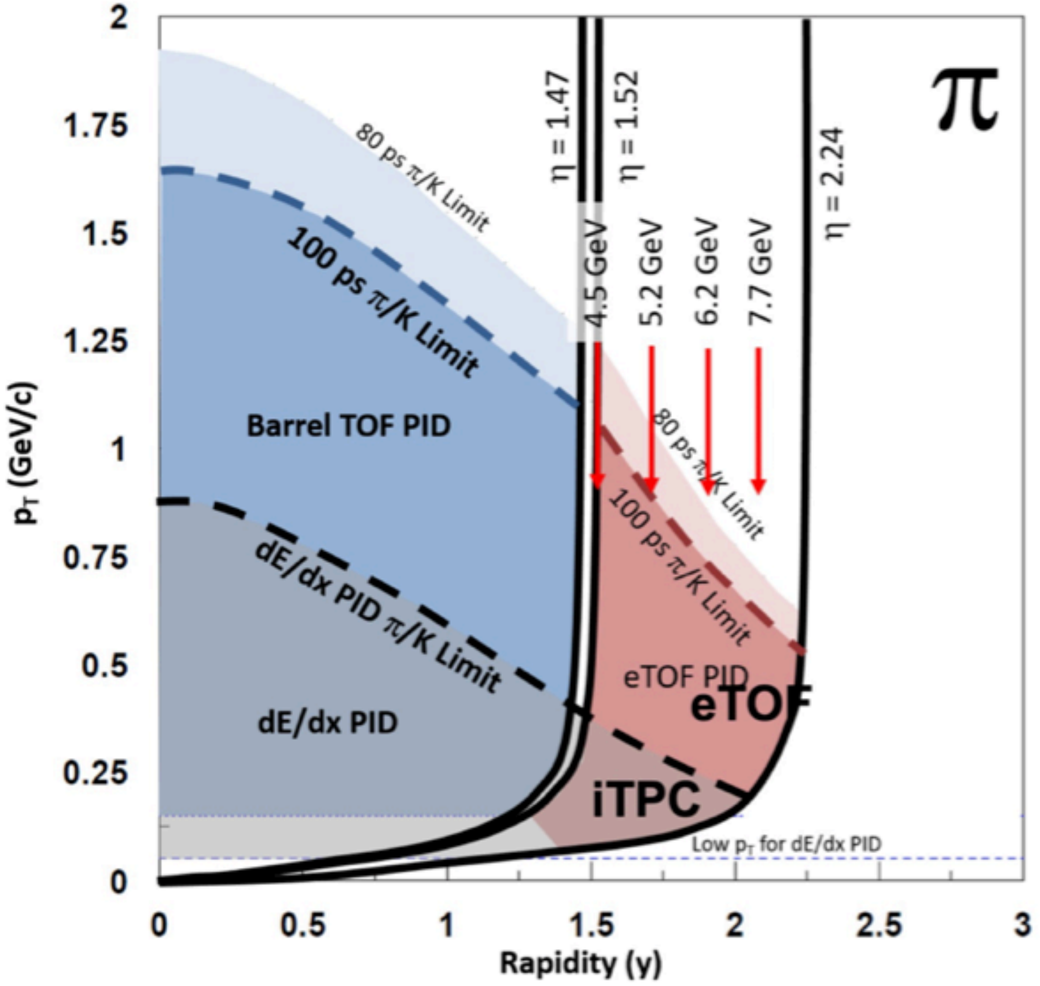
Time Projection Chamber (TPC)

- Recently upgraded TPC (iTPC upgrade, 2019)
  - Replaced inner pad rows (higher density of pad rows than before)
- Better dE/dx and momentum resolution.
- For FXT, $-2.24 < \eta < 0$
- With iTPC upgrade, a validation of the efficiency calculations is needed



Endcap Time-of-Flight (eTOF)

- New detector for BES-II, implemented in 2019
- Psuedorapidity coverage of: $-2.24 < \eta < -1.52$
- Extends PID coverage for STAR analyses
- When combined with collider data, will allow for large rapidity reach beyond center-of-mass rapidity, and extensive comparisons with collider data
- Center-of-mass rapidity moves into eTOF acceptance at higher FXT energies



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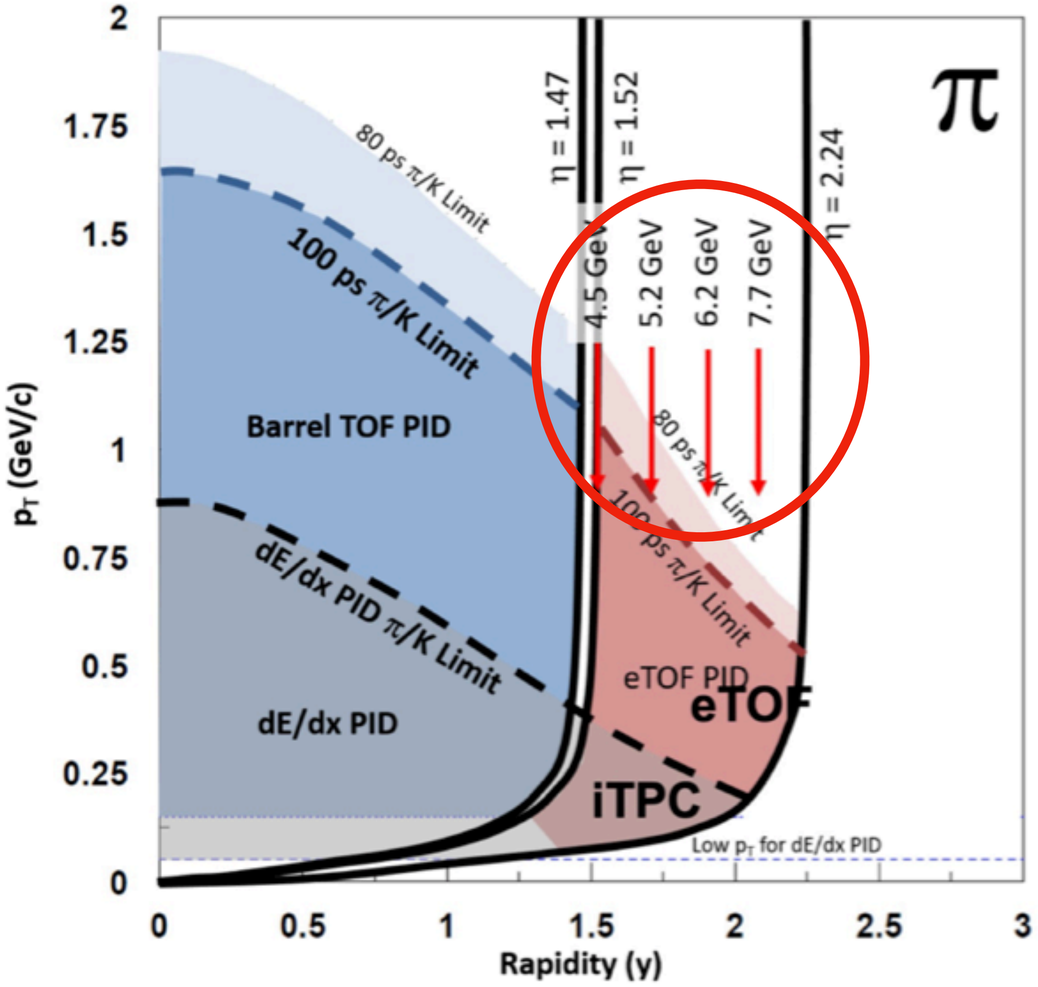
- New detector for BES-II, implemented in 2019
- Extends available phase-space for STAR analyses
- When combined with collider data, will allow for large rapidity reach beyond center-of-mass rapidity, and extensive comparisons with collider data
- Center-of-mass rapidity moves out of bTOF and into eTOF acceptance at higher FXT energies

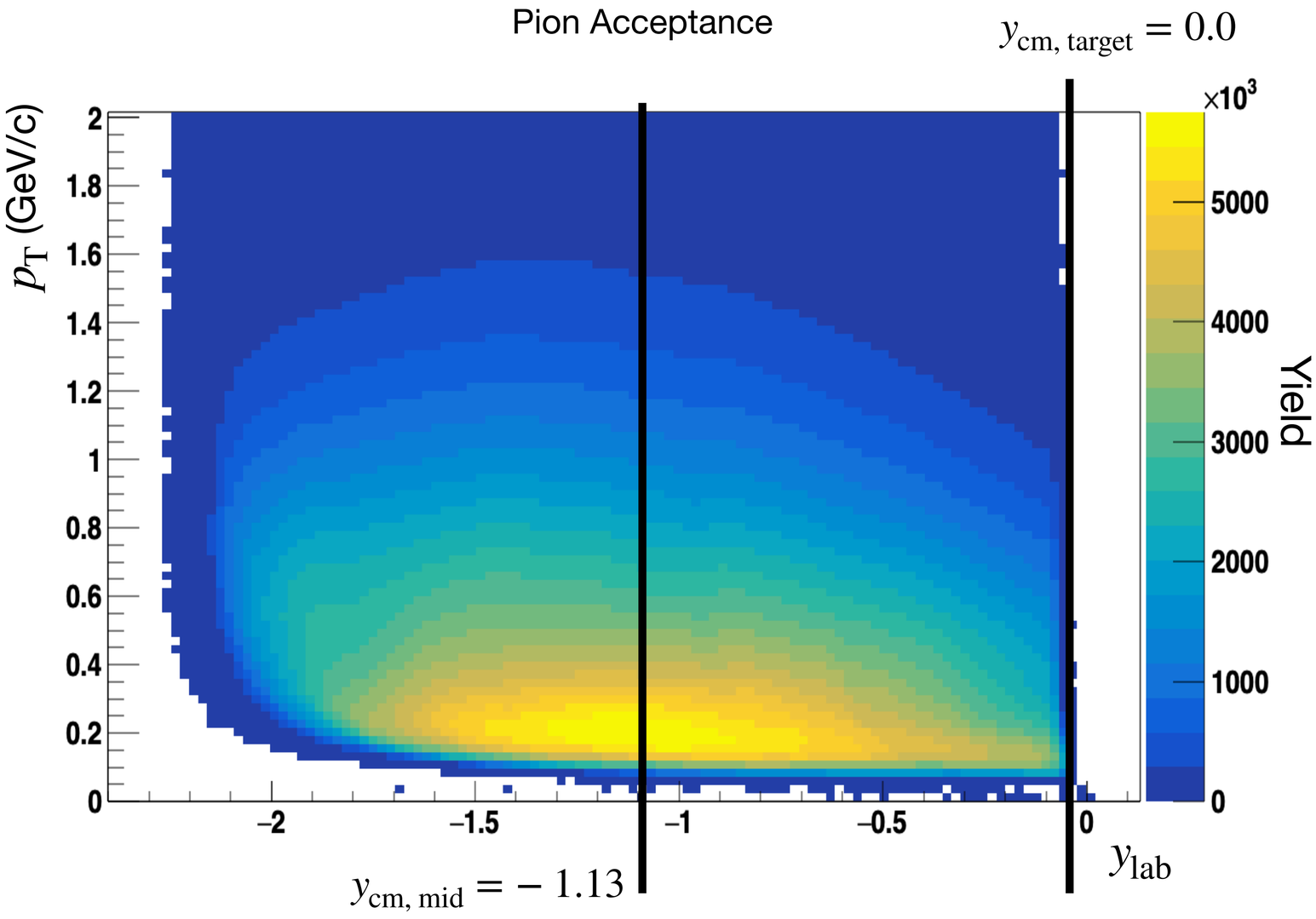


Key energy for validation: 3.2 GeV

- 3.2 GeV rapidity range reaches forward and backwards of center-of-mass rapidity

- Particle yields should be symmetric around mid-rapidity

- Provides a useful check of FXT spectra measurement methodology



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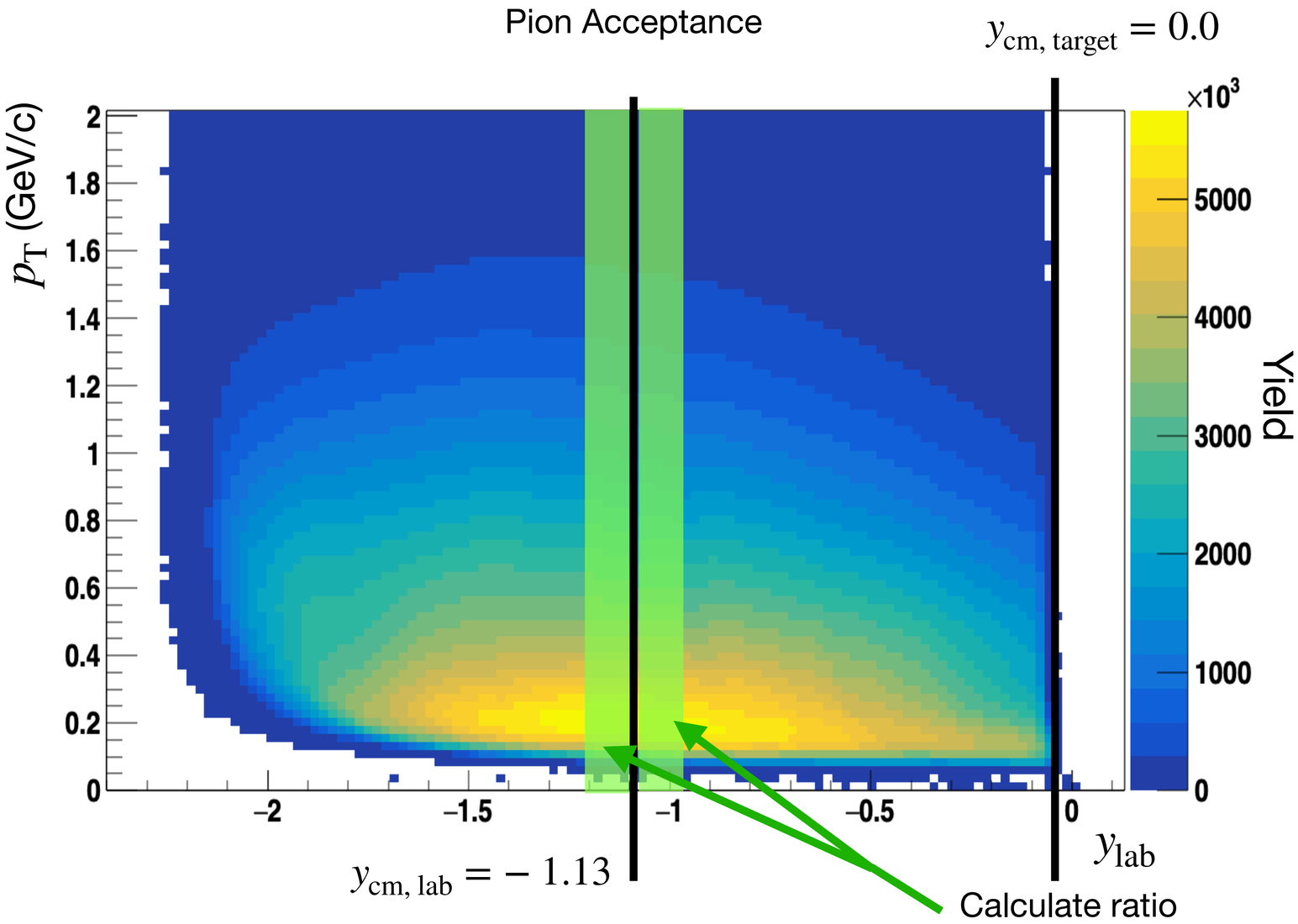

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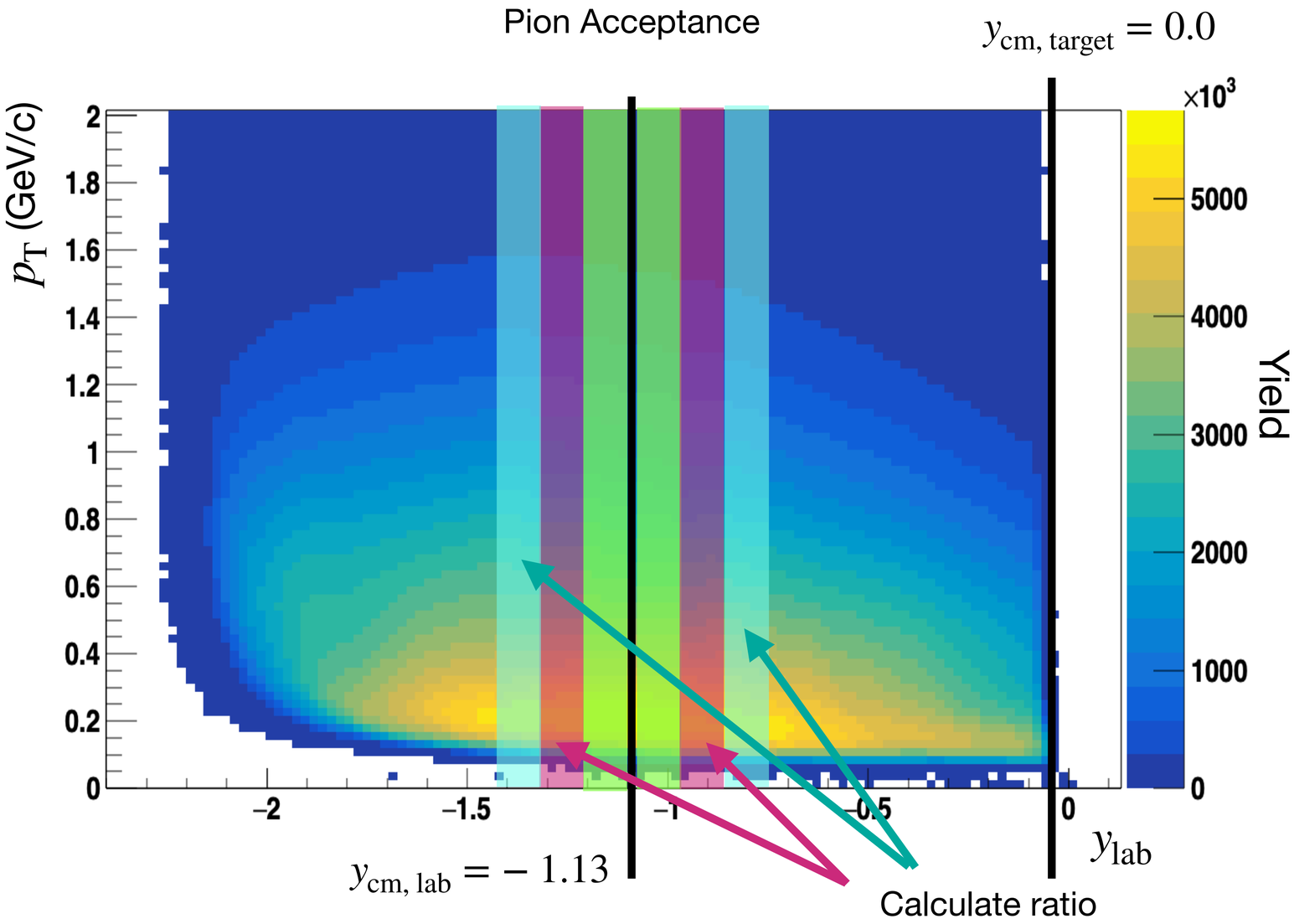

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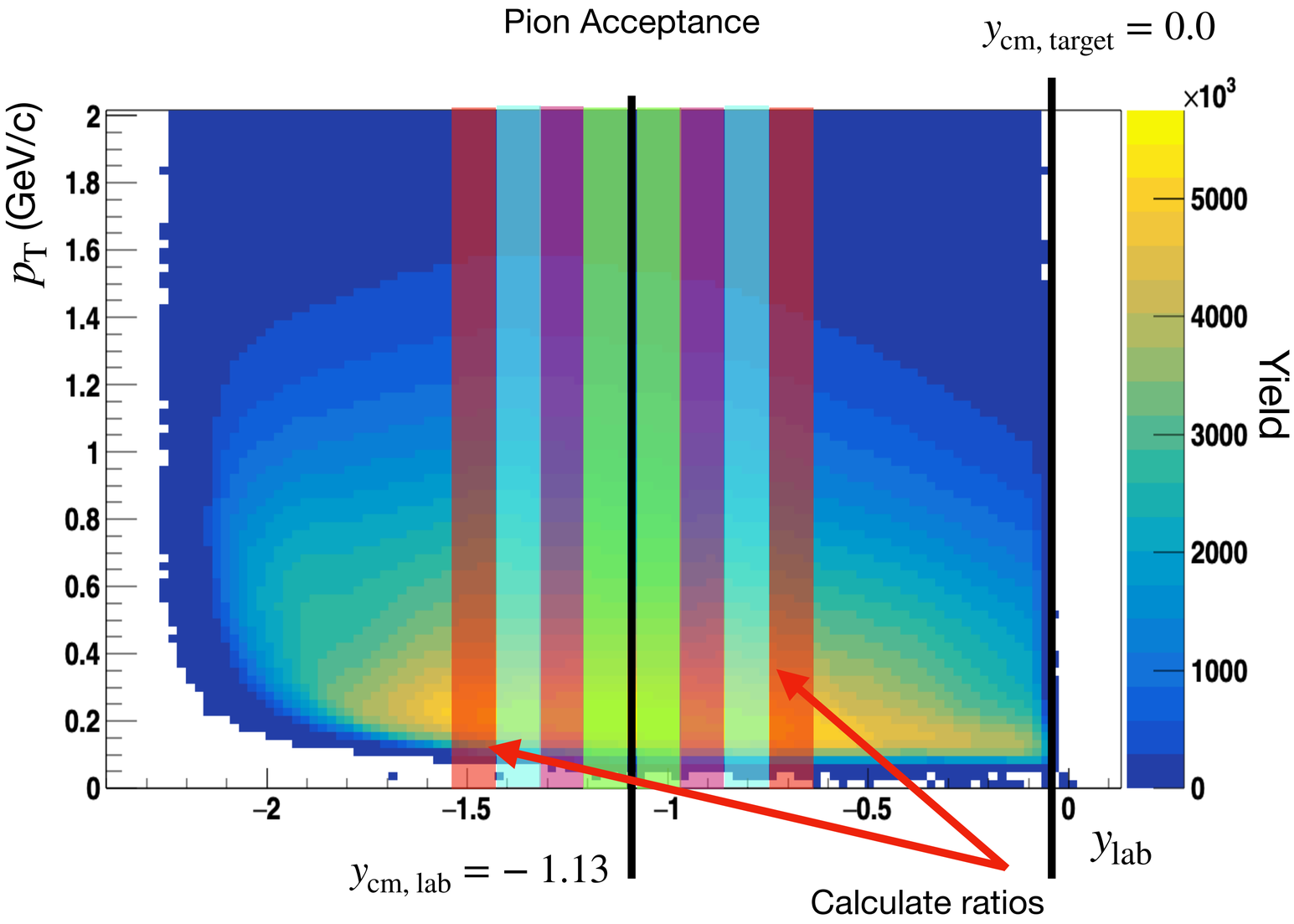
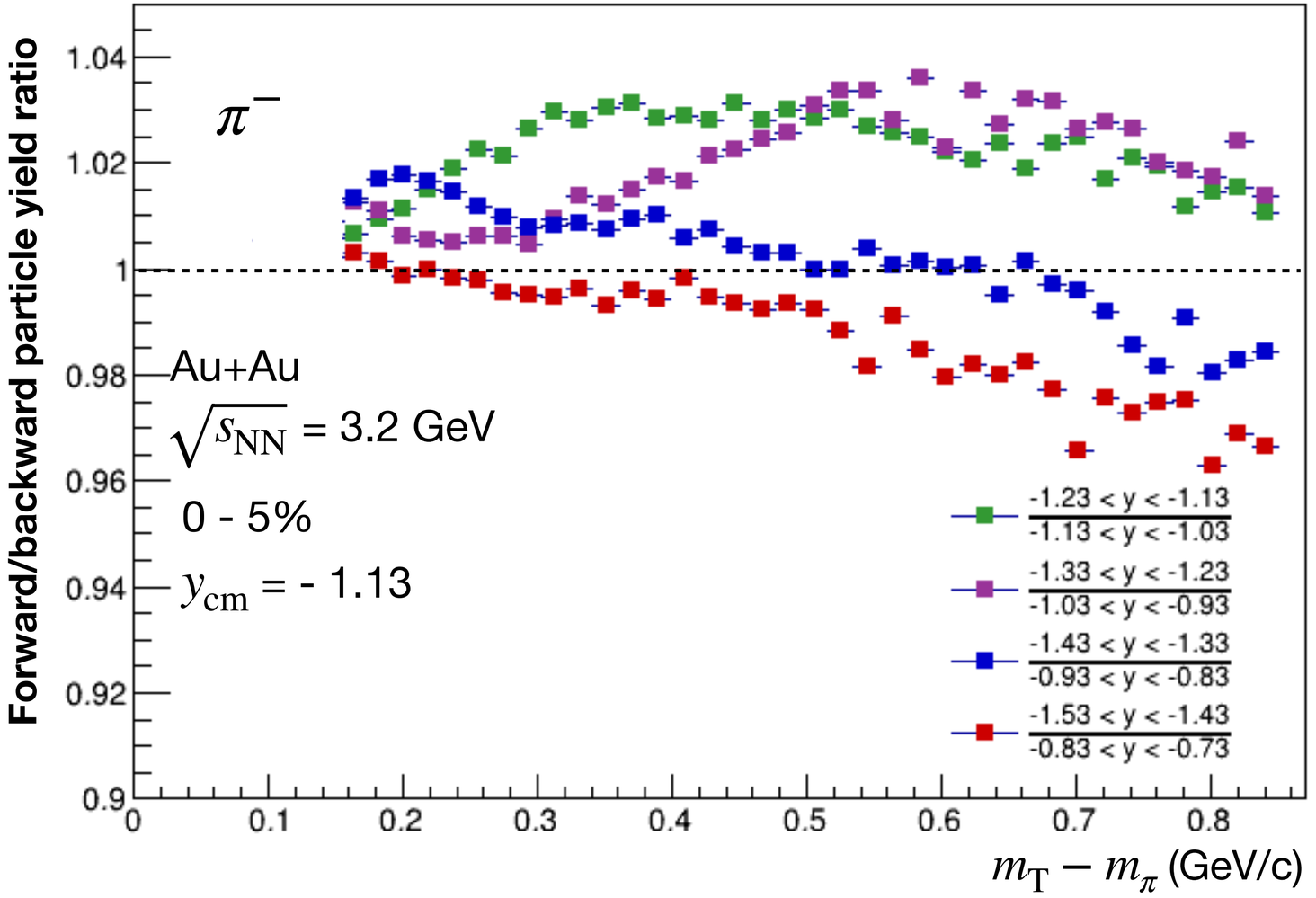


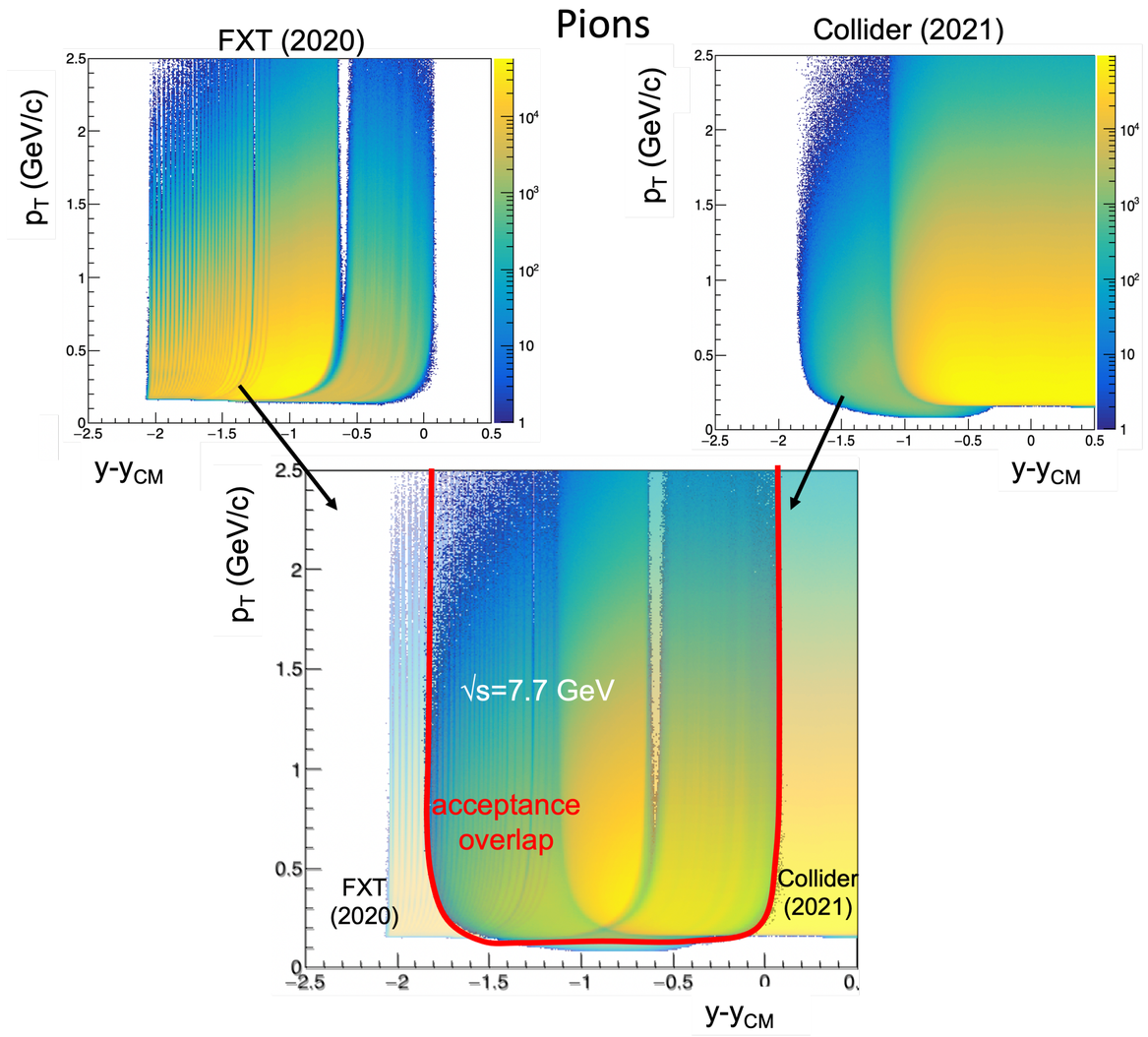
Forward/backward ratios at 3.2 GeV

- Tracks measured by TPC only
- Ratios show deviation from unity up to 4%
- Differences in central value under investigation
- Can be used to empirically correct efficiency calculation, since this is the only correction applied to the measurement
- Further rapidity checks in other bins ongoing
- No systematic errors included



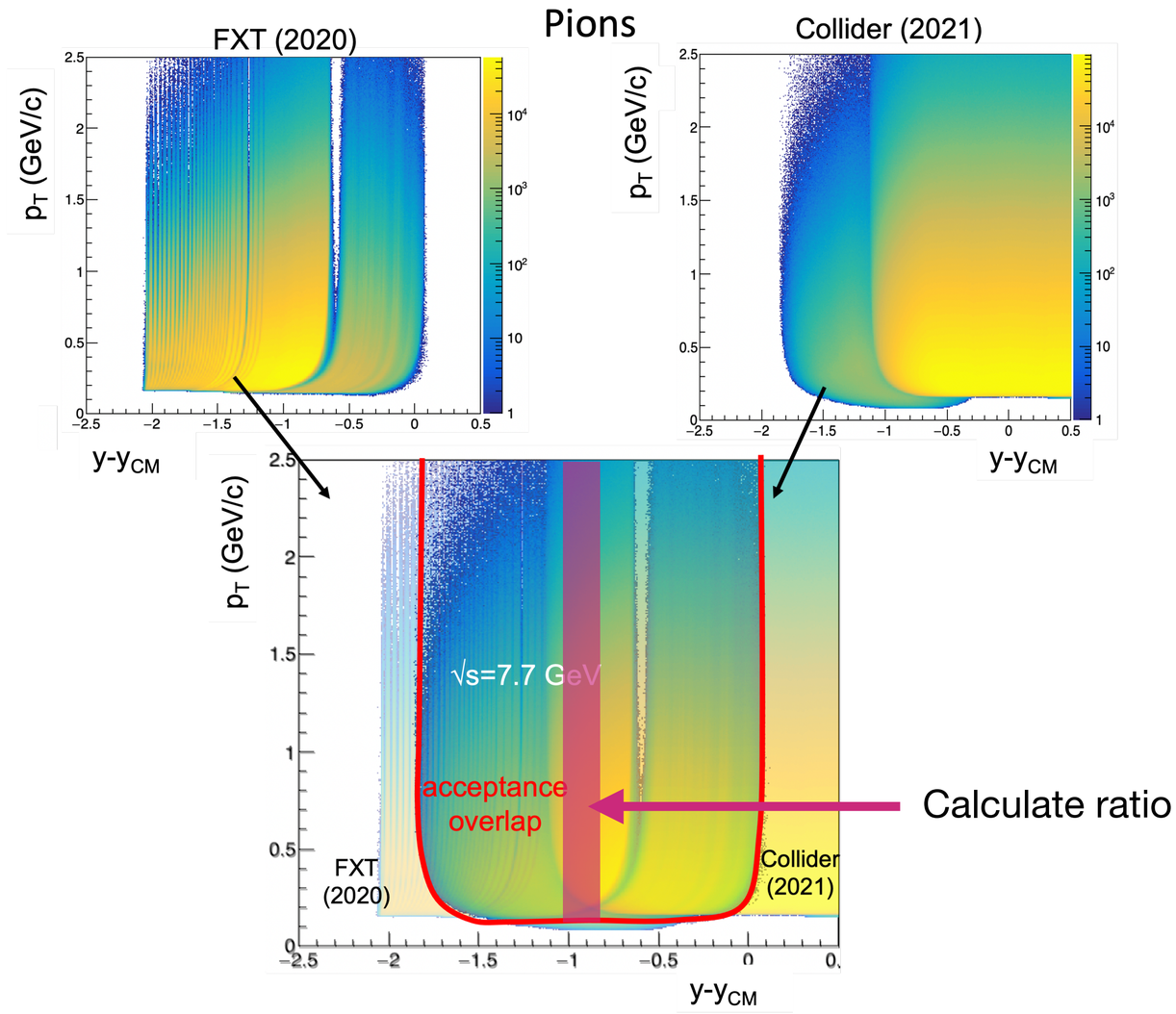
Key energy for validation: 7.7 GeV

- 7.7 GeV – Data available in FXT and collider mode
- Allows for direct comparison of spectra
- Most significant overlap in phase space at 7.7 GeV is with pions



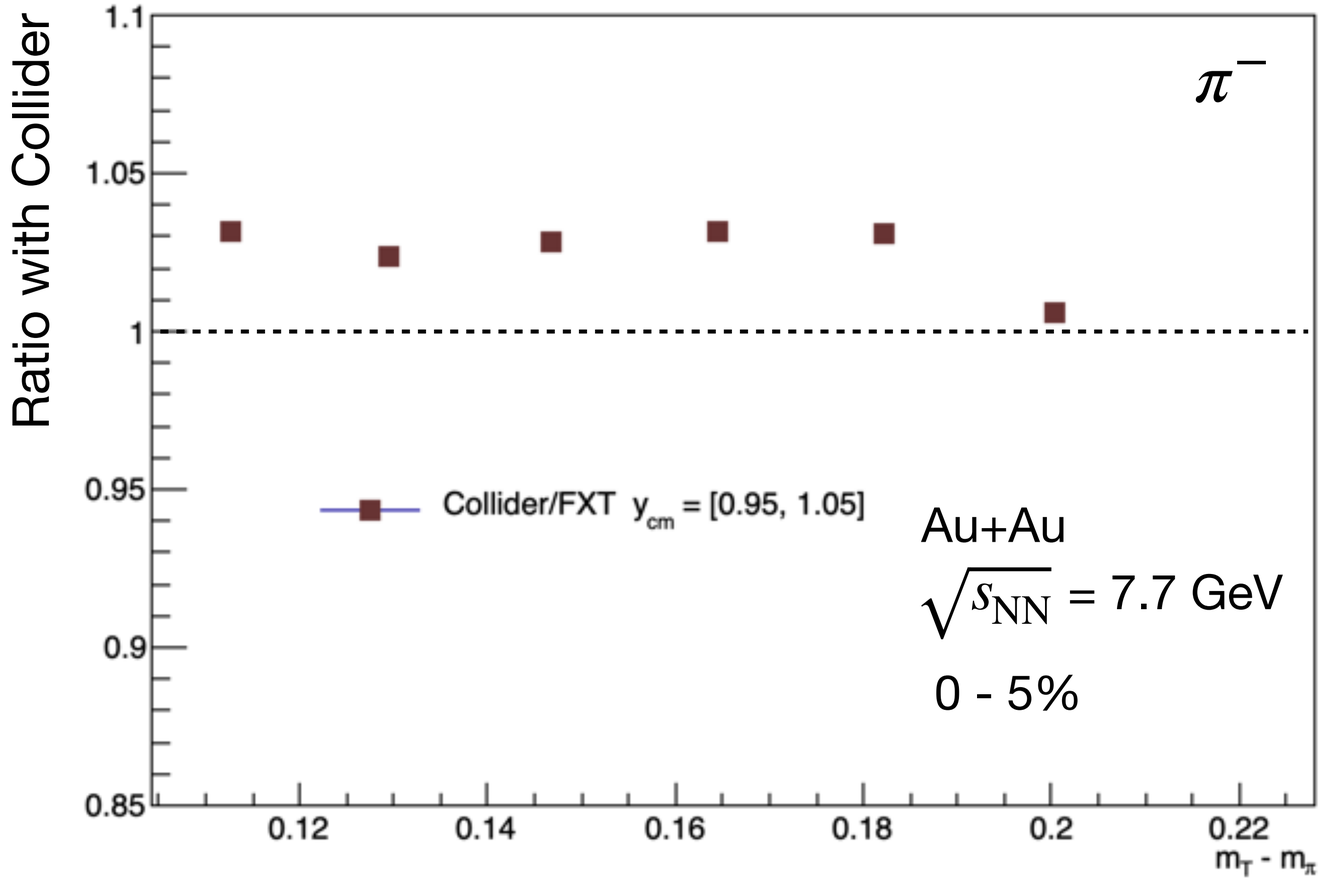
Key energy for validation: 7.7 GeV

- 7.7 GeV – Overlap energy with collider mode.
- Allows for direct comparison of spectra to collider data
- Most significant overlap in phase space at 7.7 GeV is with pions
- Important cross check between collider and FXT configurations
- No systematic errors included



Comparison to collider at 7.7 GeV

- Points measured by TPC only
- Although same rapidity, particles are produced in different regions of the detector
- Systematic difference in central value up to 3%
- Further rapidity checks ongoing



Summary

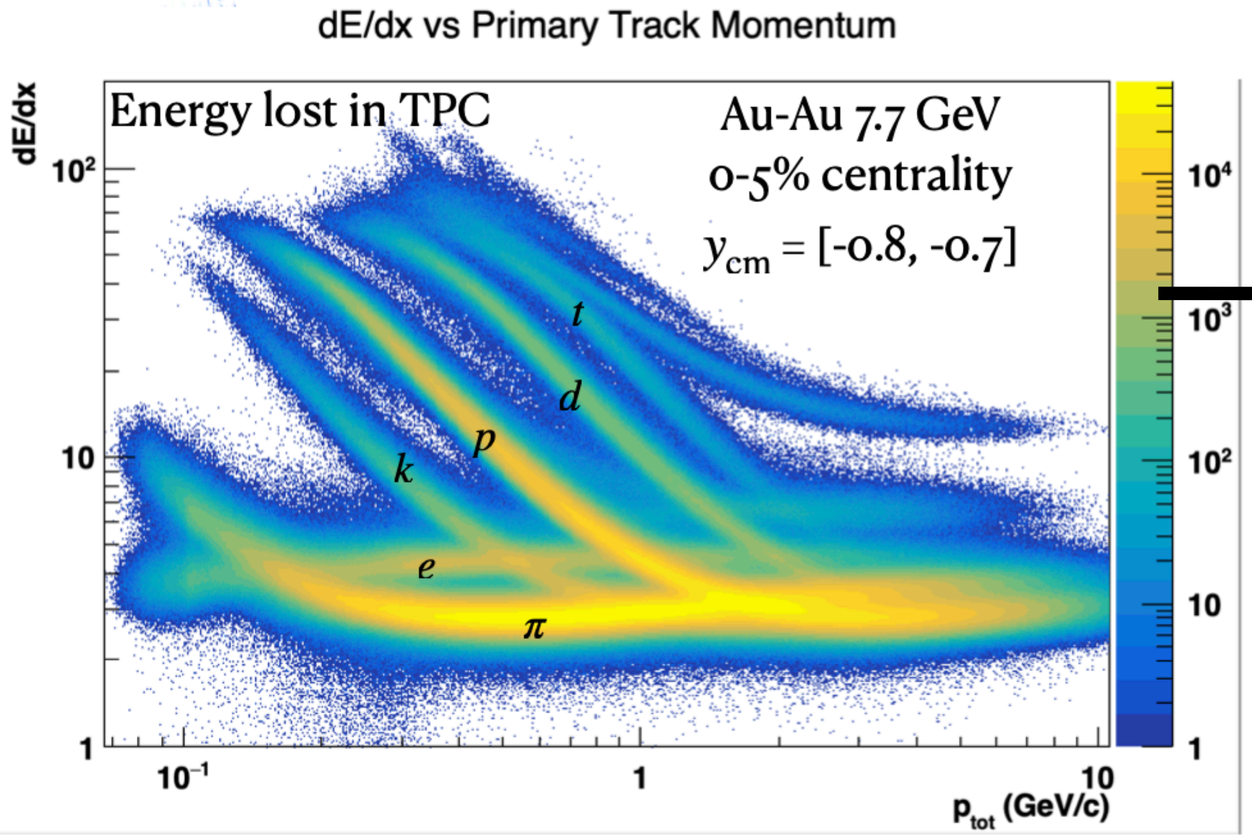
- Measurements of π, k, p spectra is ongoing for the fixed target energies:
  $\sqrt{s_{\mathrm{NN}}} =$ 3.2, 3.5, 3.9, 4.5, 5.2, 6.2, 7.2, 7.7 GeV

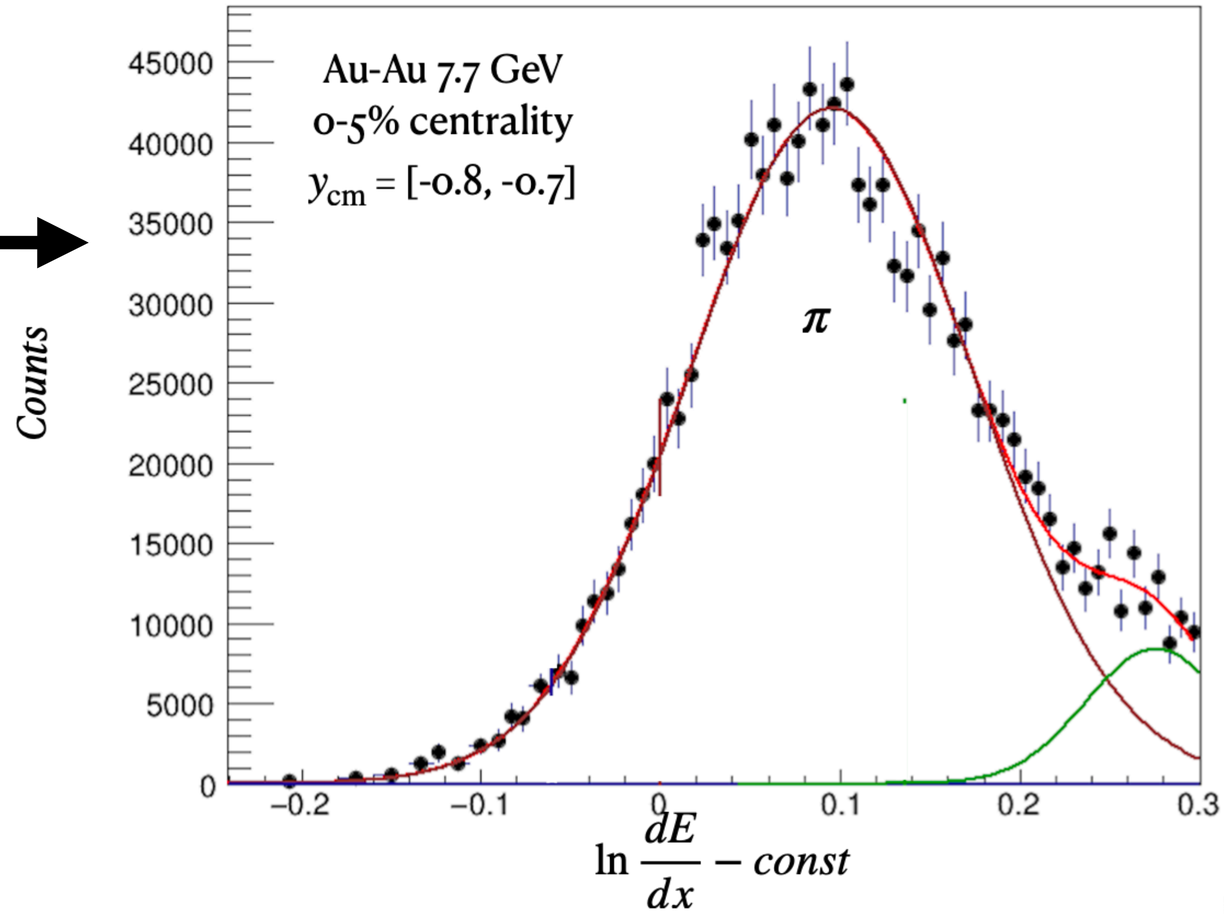
- Upgraded TPC (iTPC) improved particle PID, but a validation of our new efficiency calculations is needed

- eTOF expands the phase-space of identified particles for STAR analyses
- eTOF allows for cross checks at 7.7 GeV, between FXT and collider modes and further checks around mid-rapidity at 3.2 GeV
- Ratios forward and backward of mid-rapidity allow us to empirically evaluate the STAR efficiency
- Ratios shown for rapidity bins of 0.1 around $y_{\mathrm{cm}} \pm 0.4$, where a discrepancy of up to 4% is investigated
- Cross-checks between FXT and collider data at $\sqrt{s_{\mathrm{NN}}} = 7.7$ GeV show a deviation in central value up to 3%

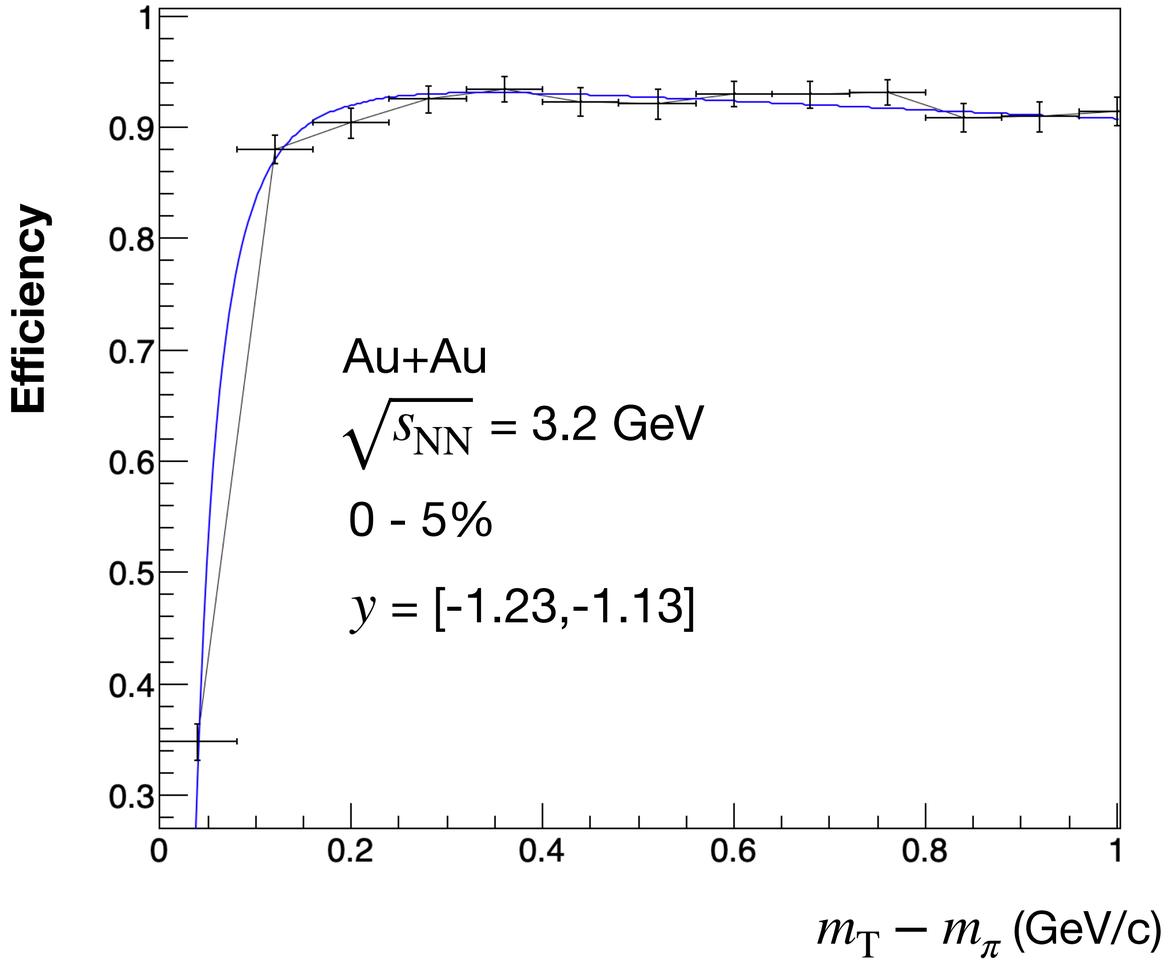
Backup

Methodology





Efficiency


Efficiency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
0.2
0.4
0.6
0.8
1
Au+Au
$\sqrt{s_{\mathrm{NN}}}$ = 3.2 GeV
0 - 5%
y = [-1.23,-1.13]
$m_{\mathrm{T}} - m_{\pi}$ (GeV/c)