Towards fixed-target light-flavor hadron production measurements with STAR from $\sqrt{s_{NN}}$ = 3.2 – 7.7 GeV

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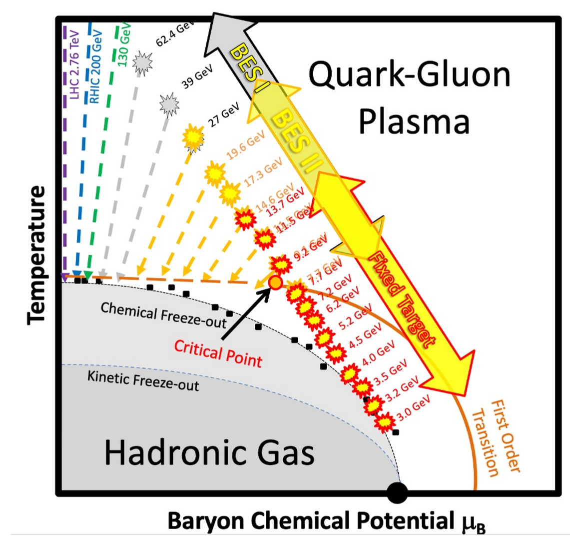
Fixed-Target Program at STAR and the Beam-Energy Scan

Beam-Energy Scan (BES)

- Designed to study the properties of QCD matter around the critical point
- Search for 1[st]-order and crossover phase transitions, and critical point
- BES-I energy range: $\sqrt{s_{NN}} = 7.7 - 62.4$ GeV
- BES-II extended the low end of the energy range to $\sqrt{s_{NN}} = 3.0$ GeV ($\mu_B = 720$ MeV)

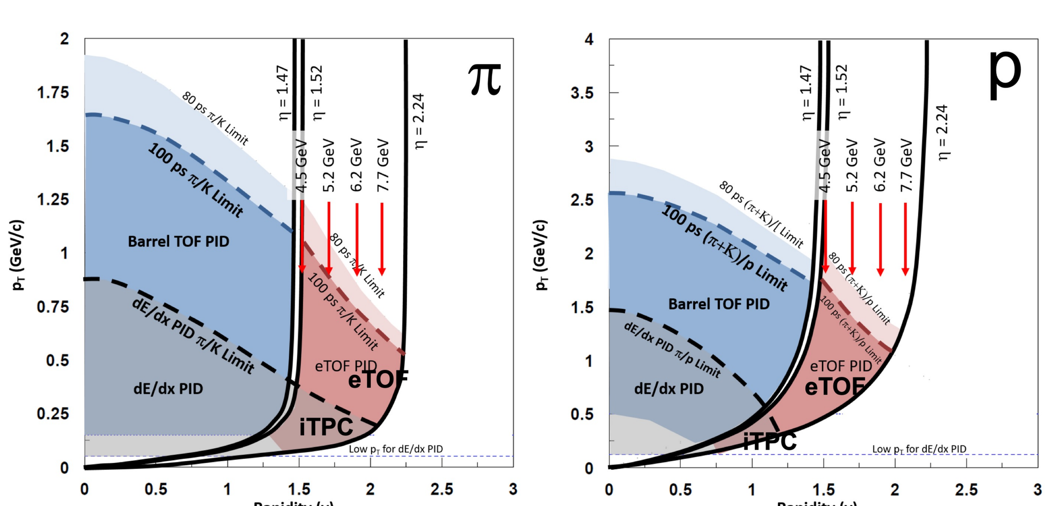


Fixed Target Program (FXT)

- Implemented to extend energy reach of BES-II
- Allows for more extensive scanning of QCD phase diagram
- Turns STAR into a fixed-target experiment with a gold foil target at the west end of the detector

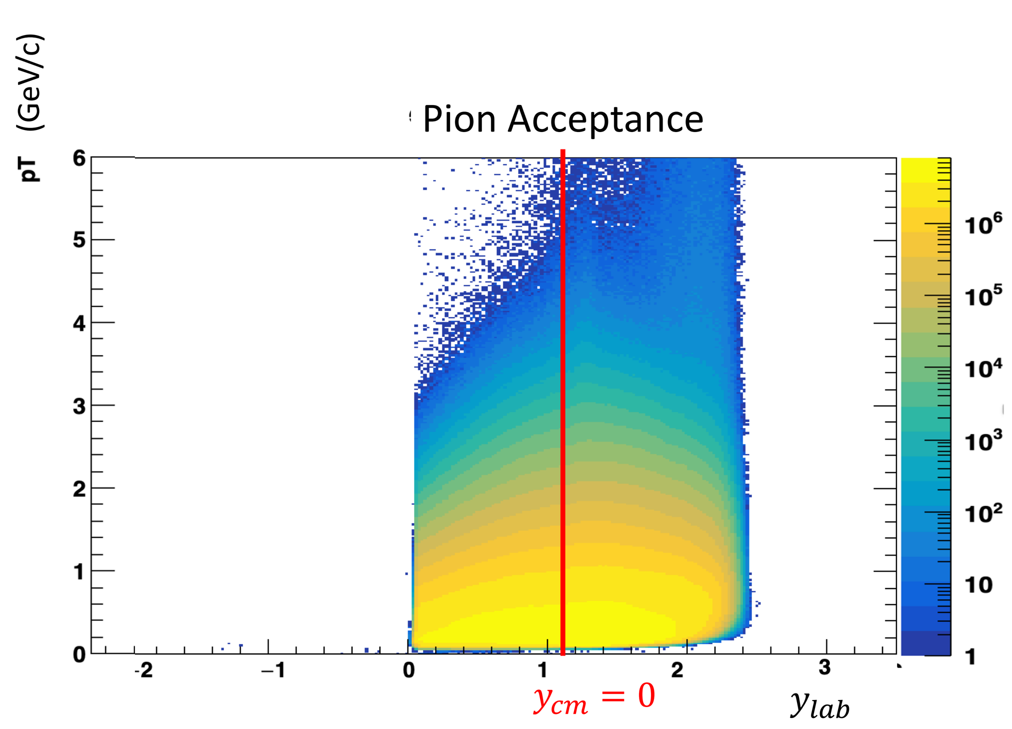
FXT Energy $\sqrt{s_{NN}}$	Single Beam E_T (GeV)	Single beam E_k (AGeV)	Center-of-mass Rapidity	Chemical Potential μ_B (MeV)	Year of Data Taking
3.0	3.85	2.9	1.05	721	2018
3.2	4.59	3.6	1.13	699	2019
3.5	5.75	4.8	1.25	666	2020
3.9	7.3	6.3	1.37	633	2020
4.5	9.8	8.9	1.52	589	2020
5.2	13.5	12.6	1.68	541	2020
6.2	19.5	18.6	1.87	487	2020
7.2	26.5	25.6	2.02	443	2018
7.7	31.2	30.3	2.10	420	2020
9.1	44.5	43.6	2.28	372	2021
11.5	70	69.1	2.51	316	2021
13.7	100	99.1	2.69	276	2021

Detector Acceptance



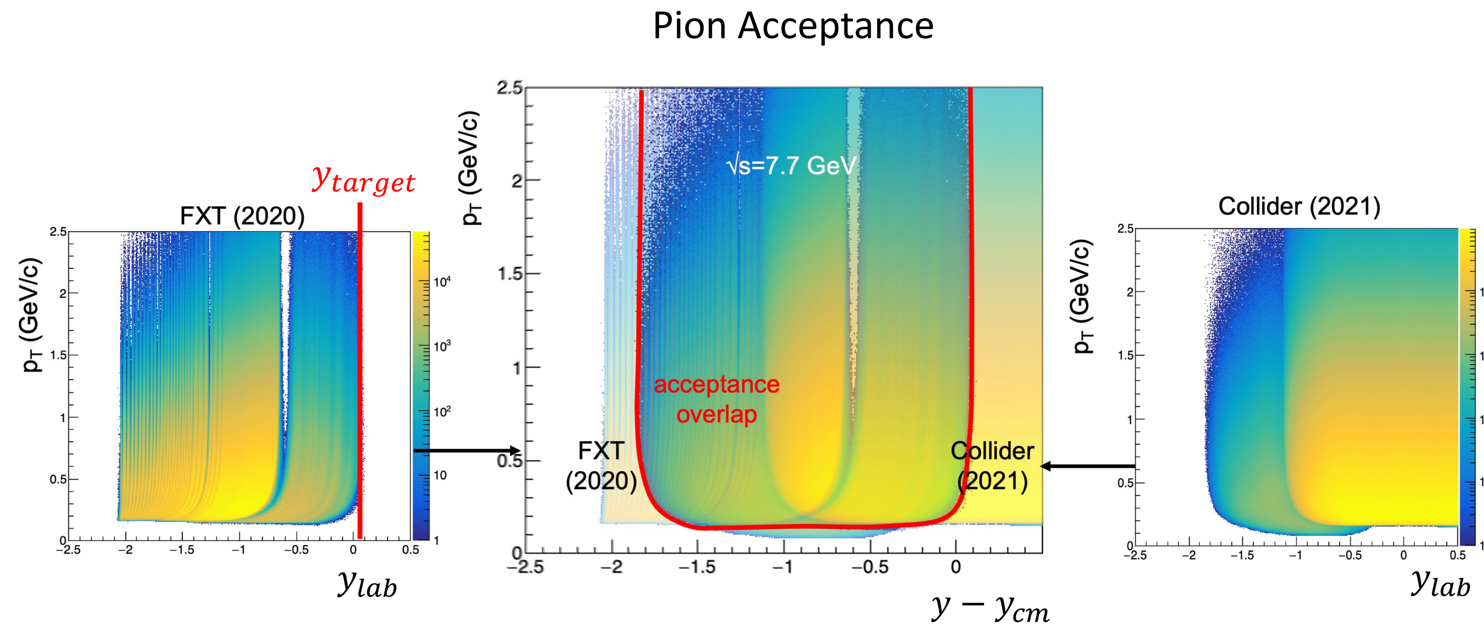
Phase-Space Coverage of STAR Detectors in FXT Configuration

- eTOF extends the phase space available for study
- Center-of-mass rapidity moves into eTOF with higher energy



3.2 GeV Symmetry Check

- 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



7.7 GeV overlap

- 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
- Allows for direct comparison to collider configuration
- Provides an important cross check between collider and FXT configurations

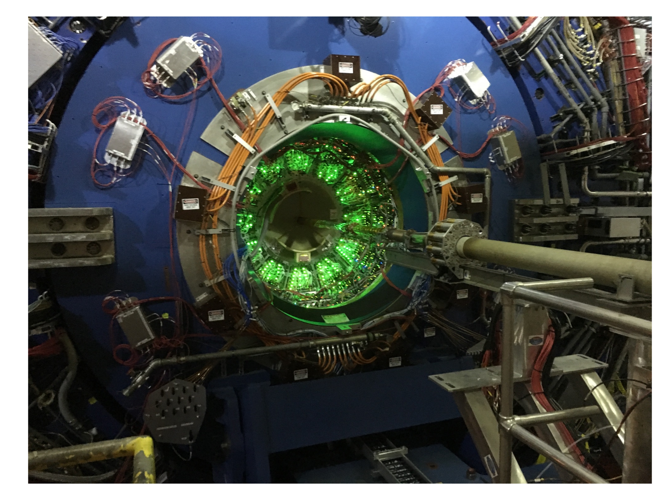
Light-flavor hadron production at STAR

- 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 of QCD matter
- Proton spectra provides important insights into baryon stopping
- Gives unique opportunity to test efficiency methodology applied to STAR analyses

New and upgraded detectors

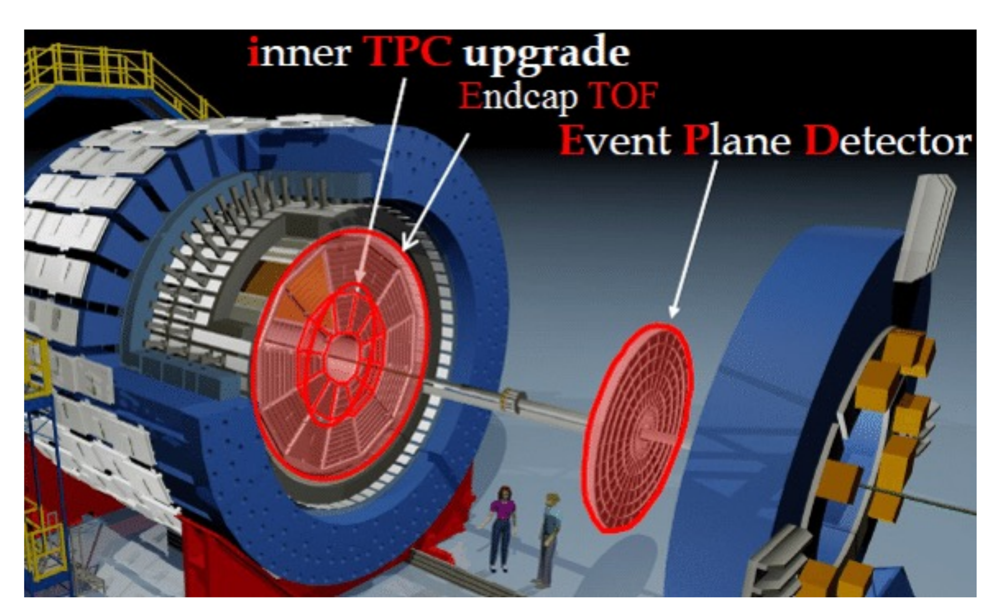
Time Projection Chamber (TPC)

- Recently upgraded (iTPC upgrade)
- Replaced inner pad rows
- Better dE/dx and momentum resolution.
- Extends rapidity reach by roughly 0.5 units.
- For FXT, $0 < \eta < 2.24$



Endcap Time of Flight (eTOF)

- $-2.24 < \eta < -1.52$
- New detector for BES-II
- Extends available phase-space for STAR analyses
- Calibrations ongoing
- 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 at higher FXT energies



Perspectives

- Measurements of [π, k p] spectra is ongoing for the produced fixed target energies: $\sqrt{s_{NN}}$ = 3.2, 3.5, 3.9, 4.5, 5.2, 6.2, 7.2, 7.7 GeV
- New detector geometry and upgraded iTPC improve particle PID and acceptance, but a validation of our new efficiency calculations are needed
- eTOF expands the phase space available to STAR analyses, and will provide more overlap rapidities with collider at 7.7 GeV, and further checks around mid-rapidity at 3.2 GeV
- eTOF critical in FXT analyses, since center-of-mass rapidities move into the endcap with rising energy
- eTOF calibrations recently completed for few FXT datasets, further analysis in progress

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