Beam Energy Scan Summary

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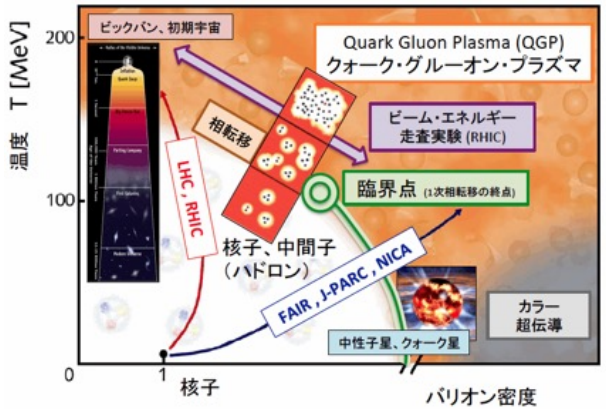
Tomonaga Center for the History of the Universe (TCHoU)

- Experiments at BNL, CERN, GSI
- Beam Energy Scan Phase-II
- Thermal and Chemical Freeze-out
- Temperatures with photon, di-lepton
- Baryon, Meson and Strangeness
- Directed and Elliptic Flow
- Femtoscopy and Source Geometry
- Net-Baryon Higher Order Fluctuation
- Vortical Fluid and Chiral Magnetic Effect



筑波大学
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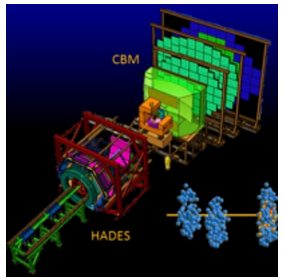
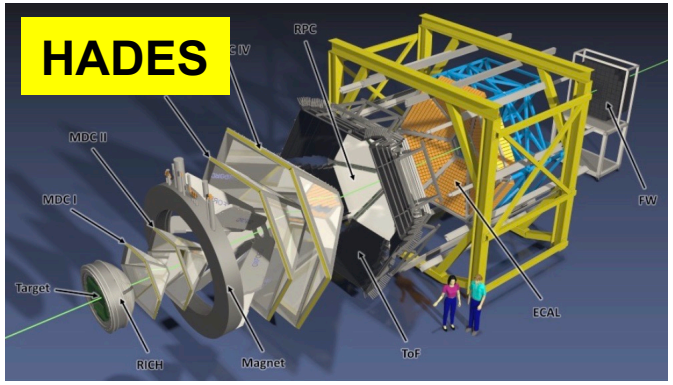
Experiments at BNL, CERN, GSI

CBM

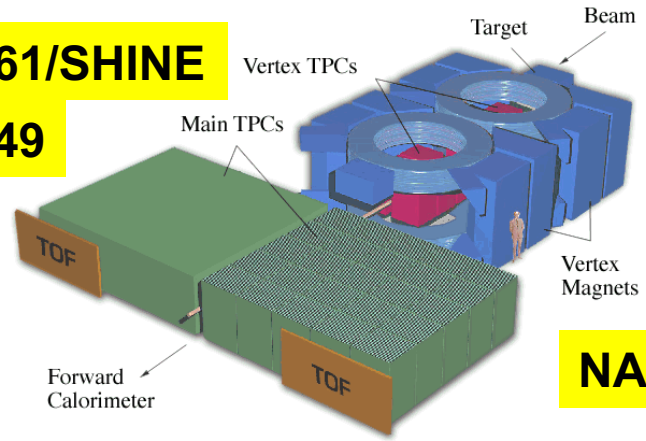


HADES

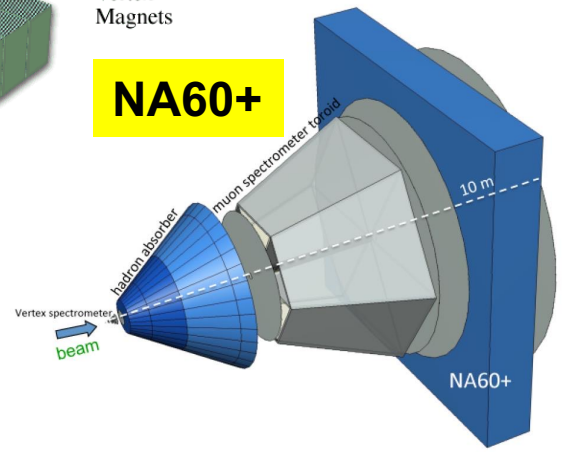


NA61/SHINE

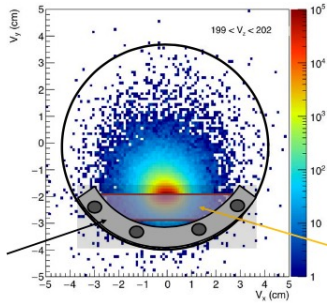
NA49



NA60+



fixed target at STAR



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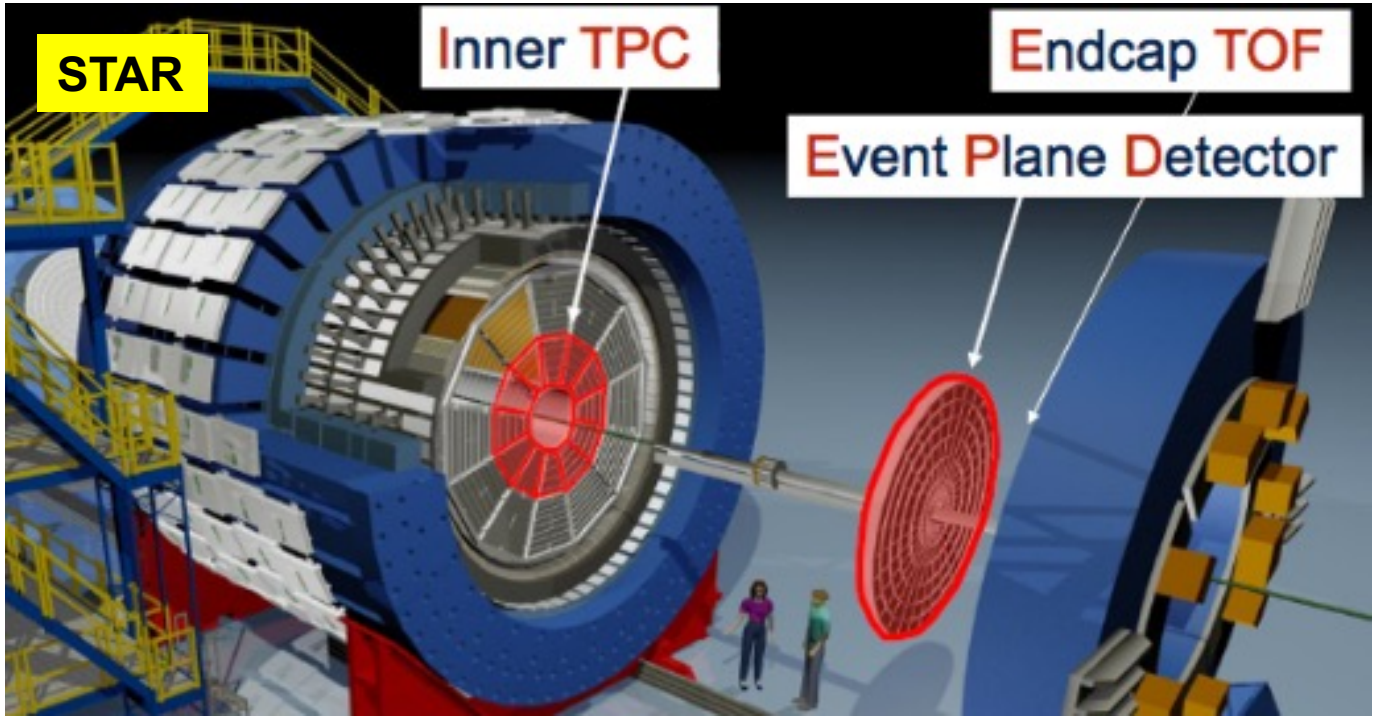
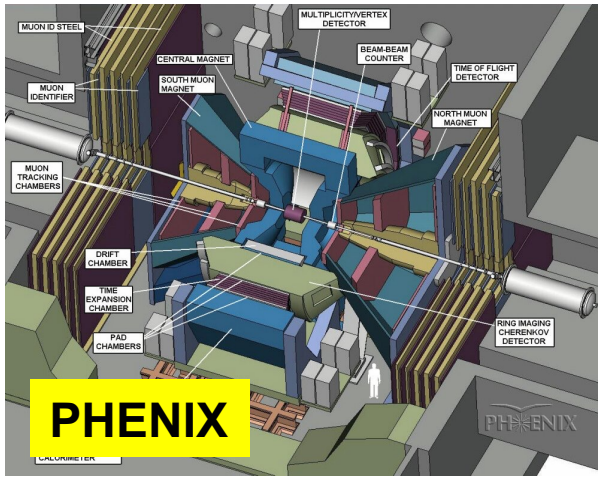
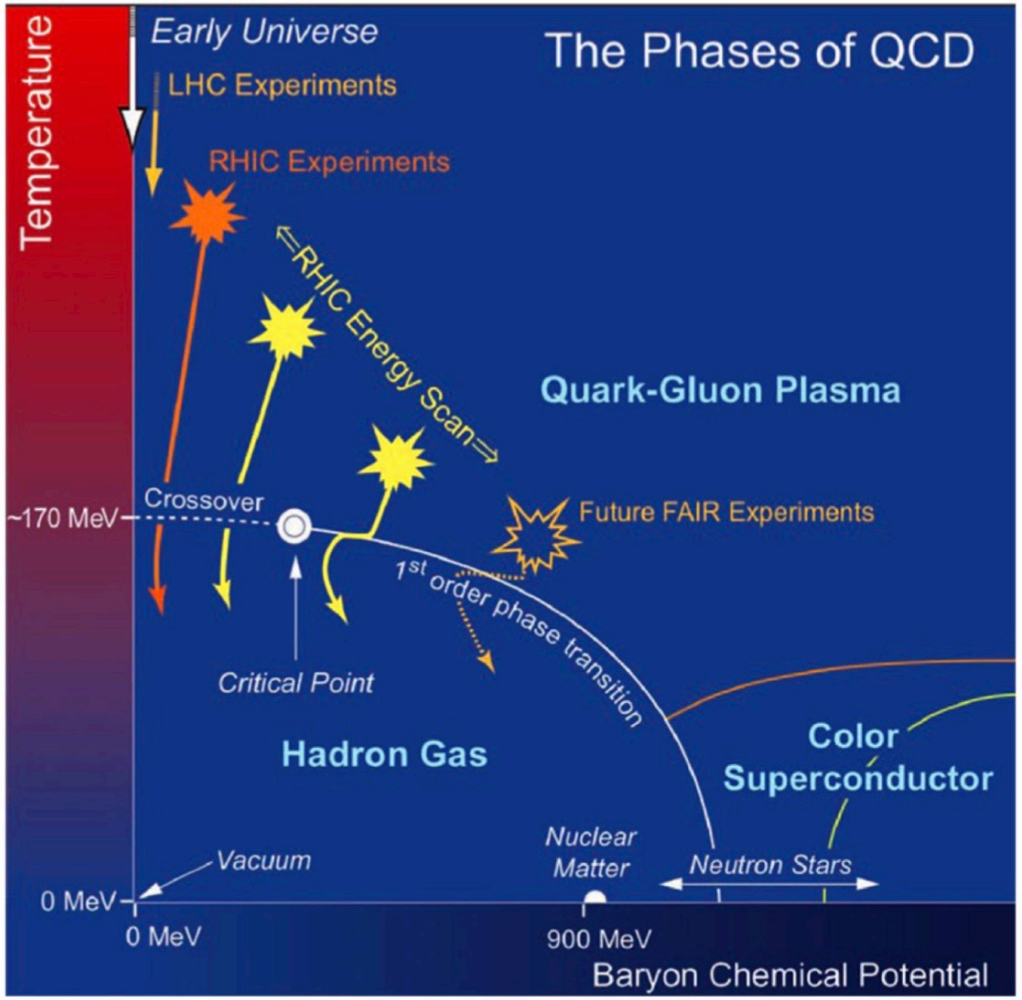
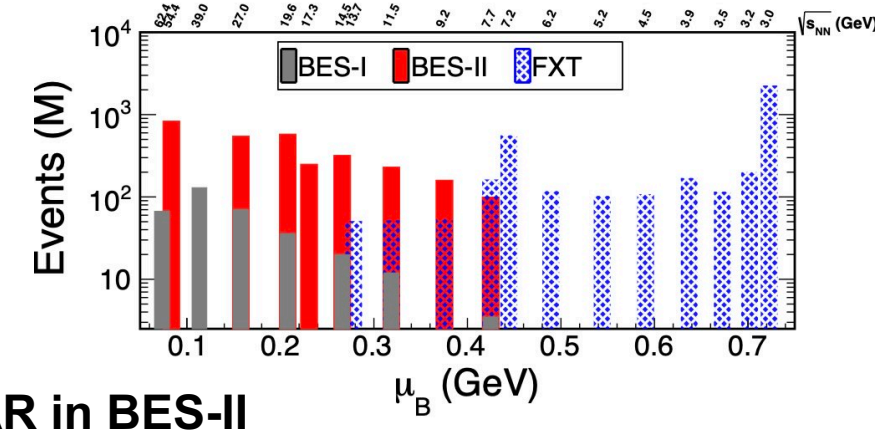




Beam Energy Scan Phase-II at RHIC





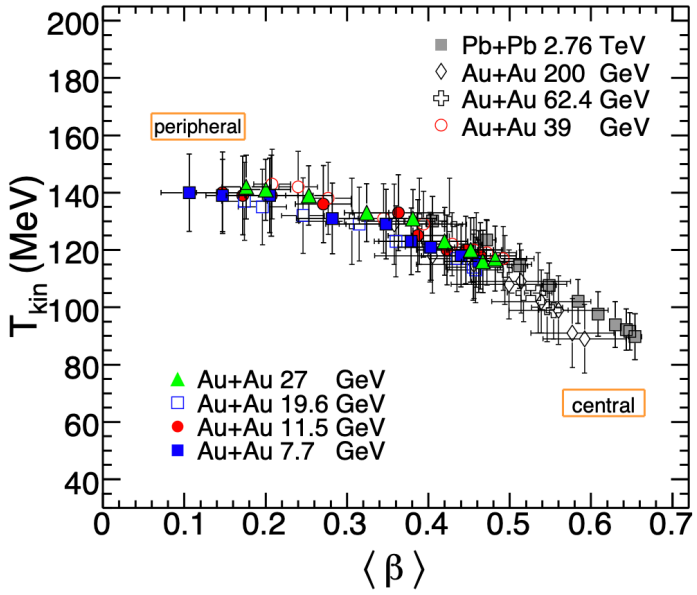
data taken at STAR in BES-II

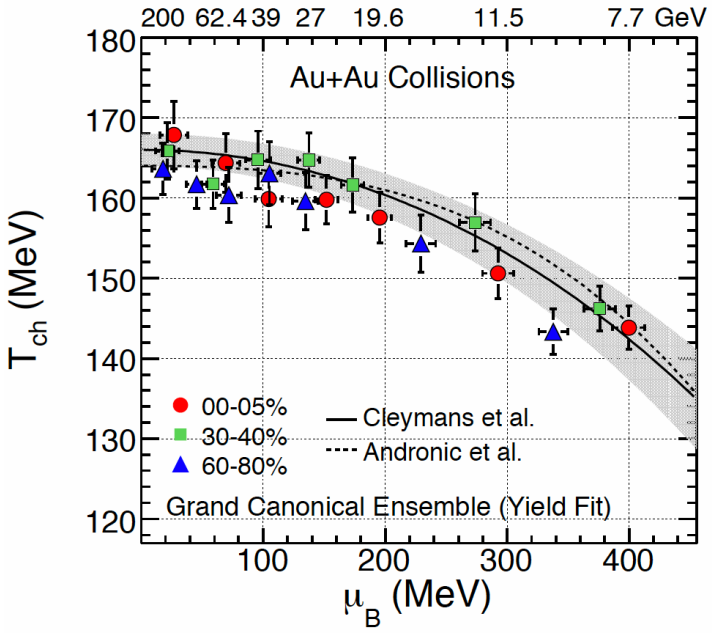
$\sqrt{s_{NN}}$ (GeV)	Beam Energy (GeV/nucleon)	Collider or Fixed Target	$y_{center\ of\ mass}$	μ_B (MeV)	Run Time (days)	No. Events Collected (Request)	Date Collected
200	100	C	0	25	2.0	138 M (140 M)	Run-19
27	13.5	C	0	156	24	555 M (700 M)	Run-18
19.6	9.8	C	0	206	36	582 M (400 M)	Run-19
17.3	8.65	C	0	230	14	256 M (250 M)	Run-21
14.6	7.3	C	0	262	60	324 M (310 M)	Run-19
13.7	100	FXT	2.69	276	0.5	52 M (50 M)	Run-21
11.5	5.75	C	0	316	54	235 M (230 M)	Run-20
11.5	70	FXT	2.51	316	0.5	50 M (50 M)	Run-21
9.2	4.59	C	0	372	102	162 M (160 M)	Run-20+20b
9.2	44.5	FXT	2.28	372	0.5	50 M (50 M)	Run-21
7.7	3.85	C	0	420	90	100 M (100 M)	Run-21
7.7	31.2	FXT	2.10	420	0.5+1.0+ scattered	50 M + 112 M + 100 M (100 M)	Run-19+20+21
7.2	26.5	FXT	2.02	443	2+Parasitic with CEC	155 M + 317 M	Run-18+20
6.2	19.5	FXT	1.87	487	1.4	118 M (100 M)	Run-20
5.2	13.5	FXT	1.68	541	1.0	103 M (100 M)	Run-20
4.5	9.8	FXT	1.52	589	0.9	108 M (100 M)	Run-20
3.9	7.3	FXT	1.37	633	1.1	117 M (100 M)	Run-20
3.5	5.75	FXT	1.25	666	0.9	116 M (100 M)	Run-20
3.2	4.59	FXT	1.13	699	2.0	200 M (200 M)	Run-19
3.0	3.85	FXT	1.05	721	4.6	259 M -> 2B(100 M -> 2B)	Run-18+21

Thermal and Chemical Freeze-out

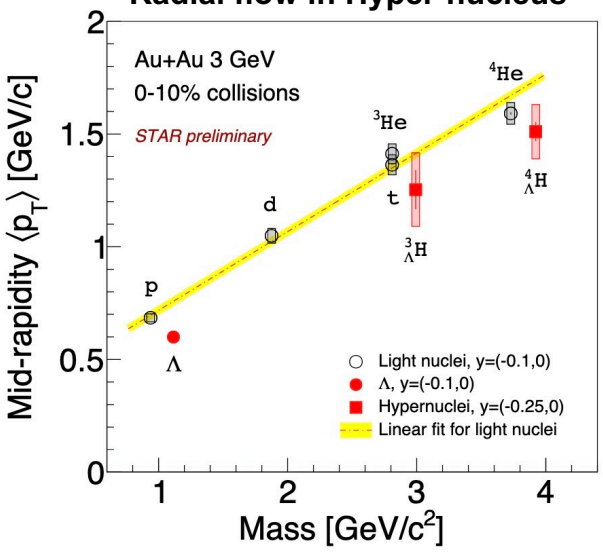
- thermal freeze-out, centrality
- chemical freeze-out, beam energy
- light- and hyper-nuclei freeze-out

PRC 96 (2017) 4, 044904

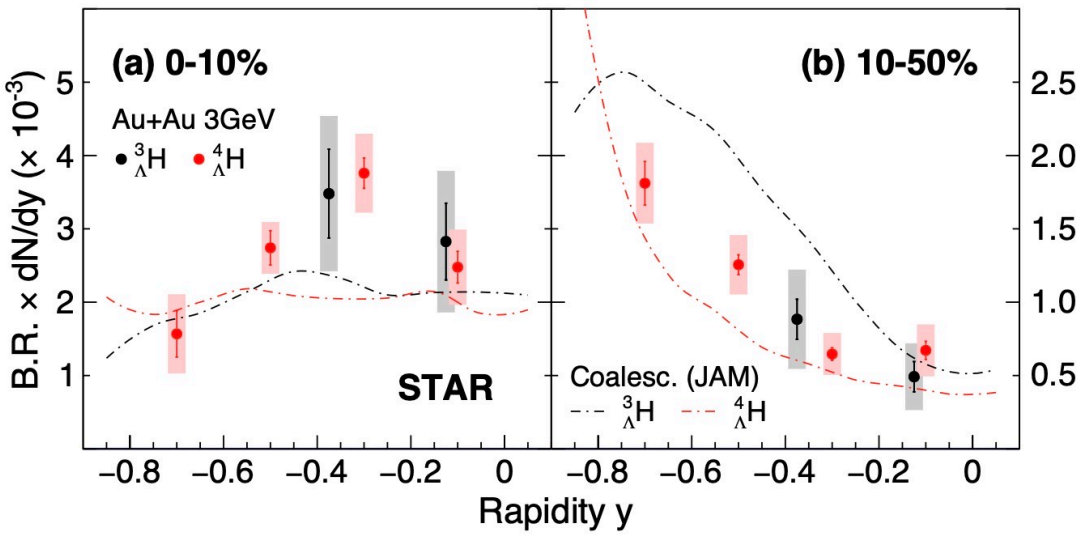




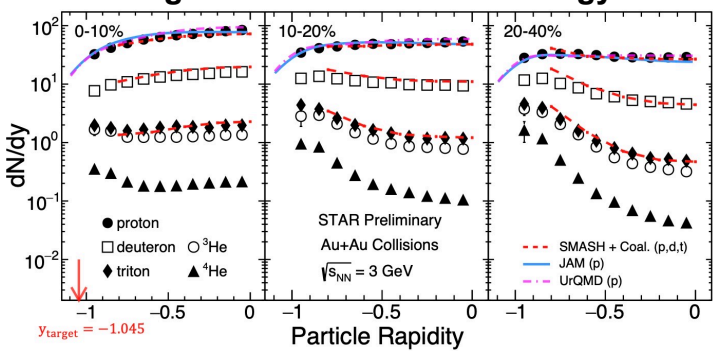
Radial flow in Hyper-nucleus



PRL 128 (2022) 202301

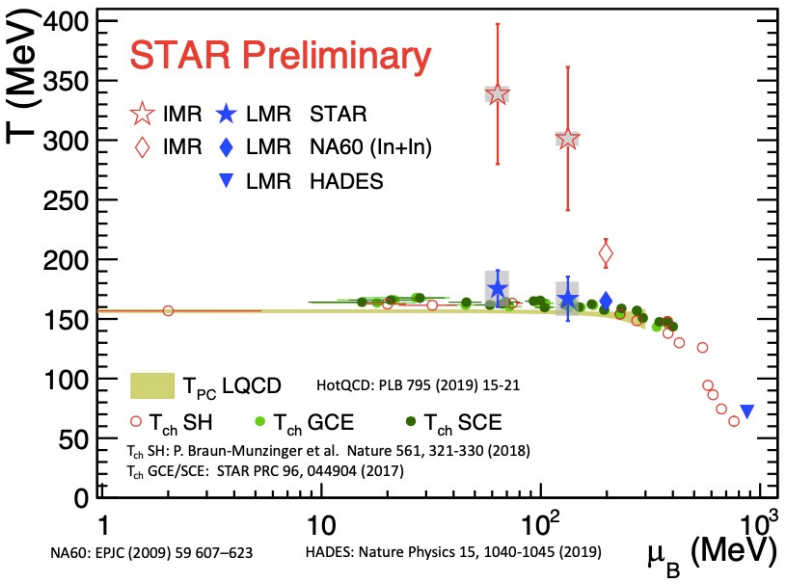


light nuclei at the same energy

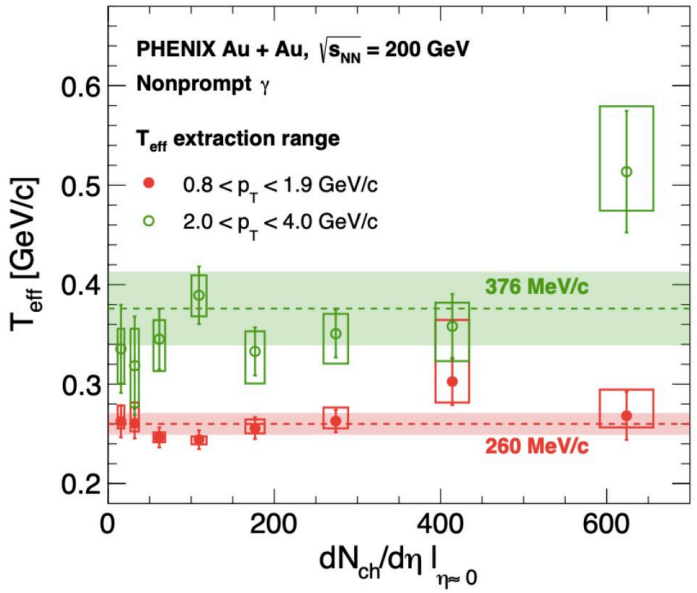


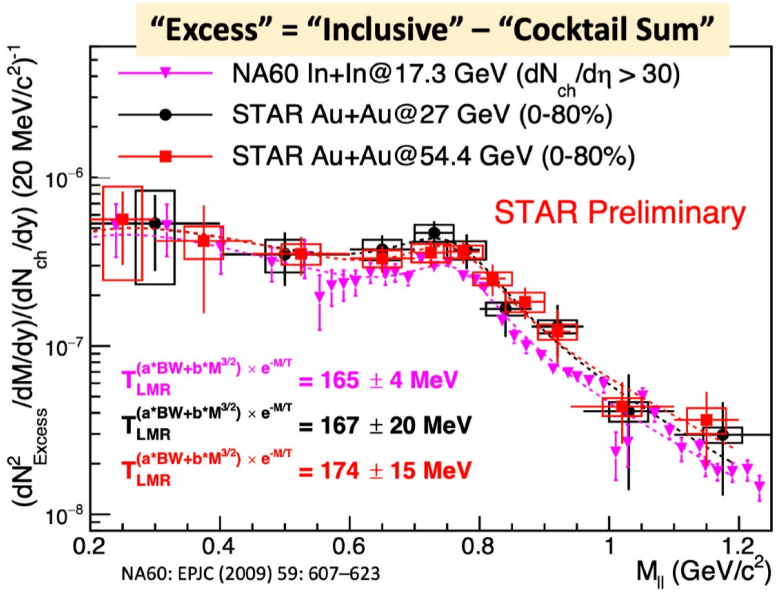
Temperature via photon and di-lepton

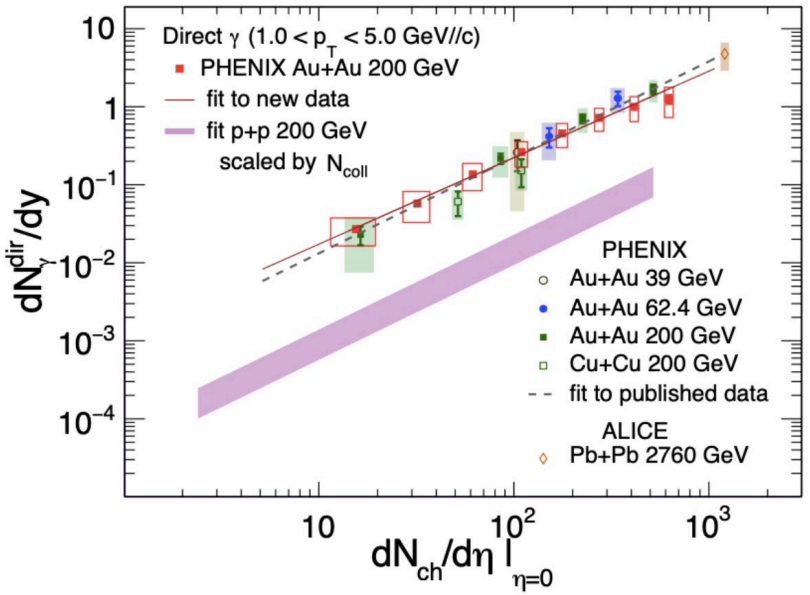
- T_{INIT} from di-lepton mass spectra
- direct photon – QCD prompt γ



Non-prompt direct "thermal" photon



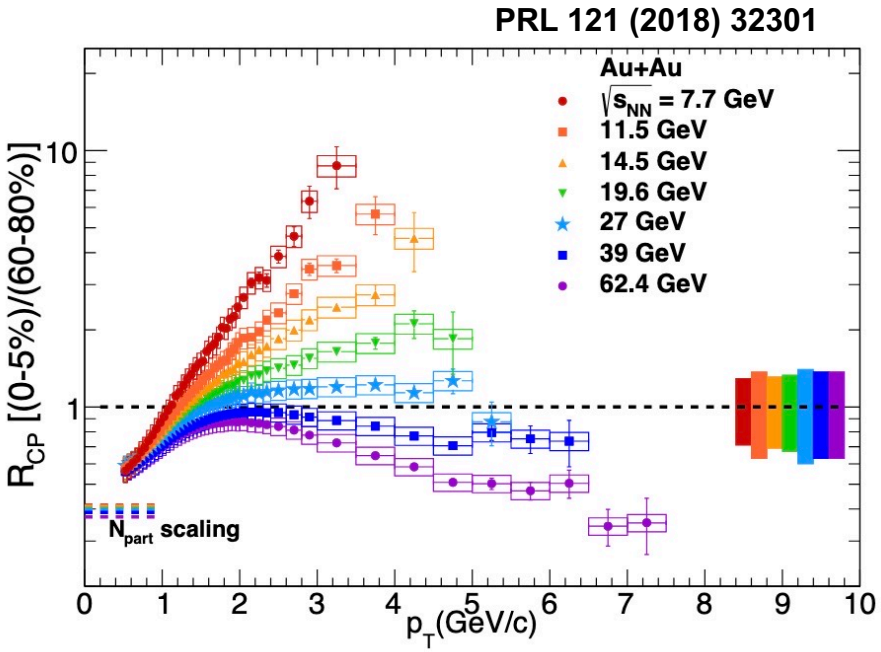


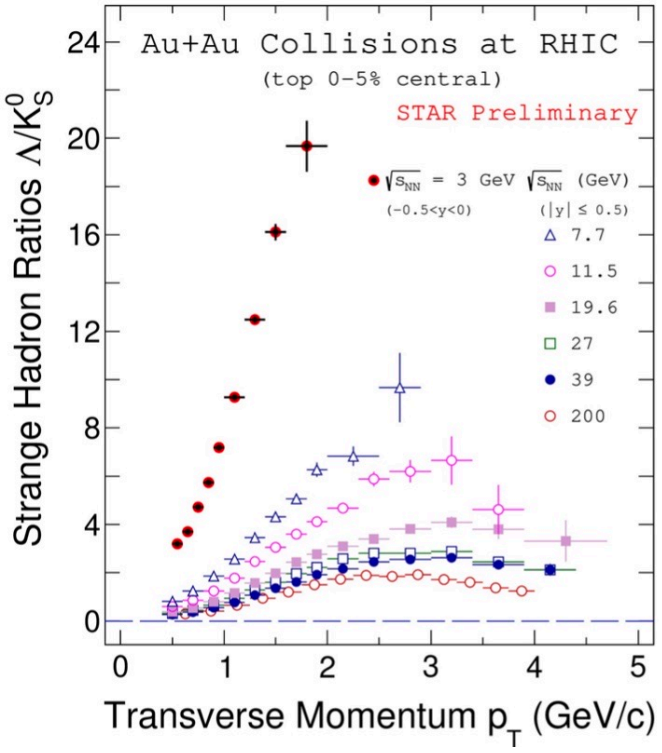


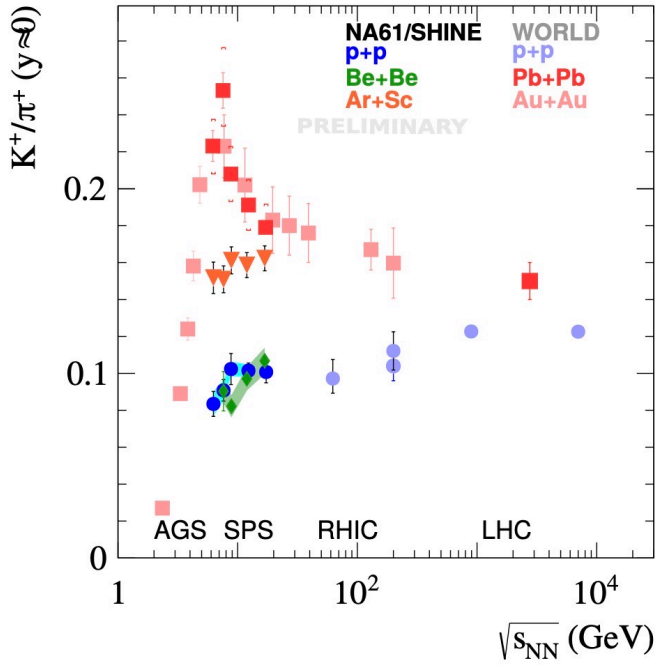
arXiv:2203.17187
PRL 123 (2019) 022301

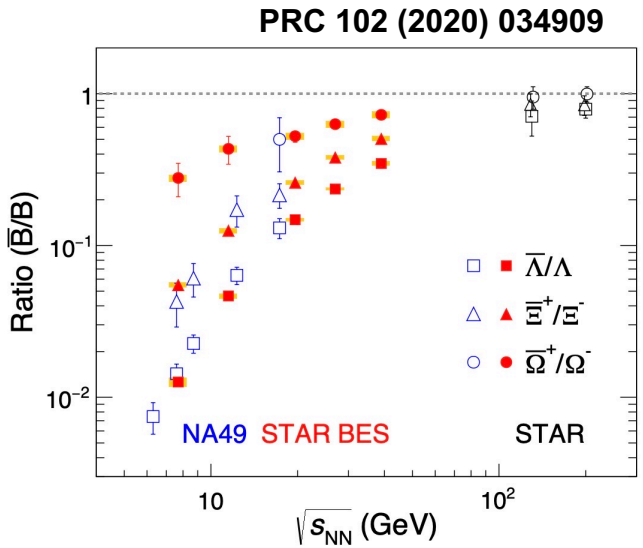
Nuclear Modification, Baryon, Meson and Strangeness

- onset of high p_T suppression, Baryon - meson
- strangeness enhancement, K/pi horn, baryon density
- onset of J/psi suppression, flow of charm quark





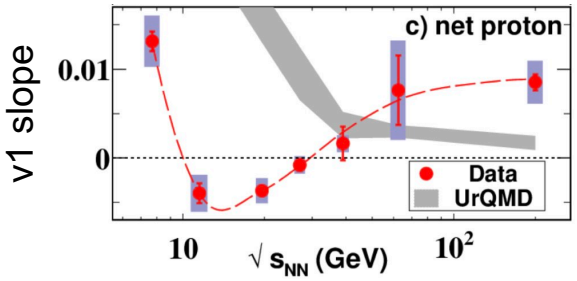




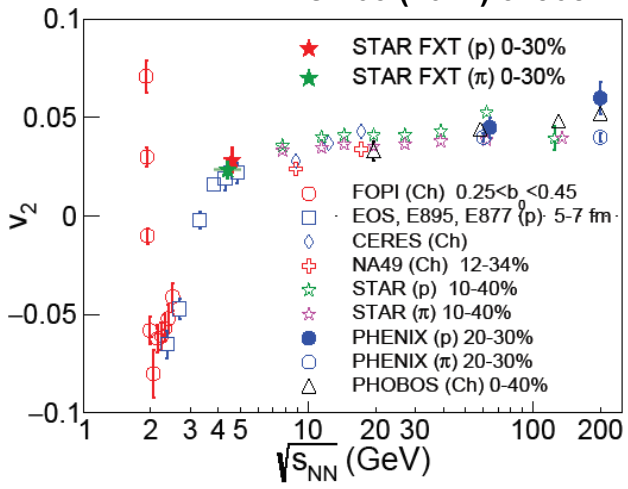
Directed and Elliptic Flow

- v1-slope, EOS, phase transition
- light- and hyper-nuclei
- v2, N_{CQ}-scaling, hadron-parton
- expansion, small system

PRL 112 (2014) 162301

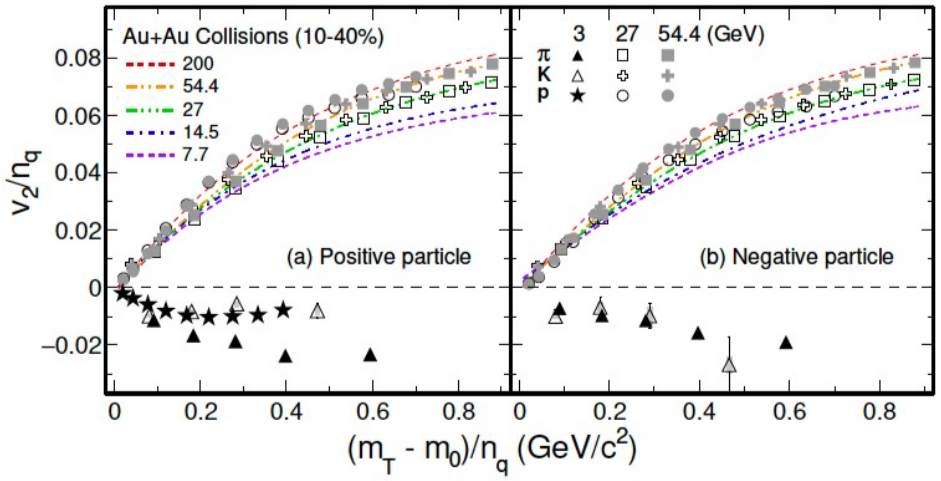


PRC 103 (2021) 34908

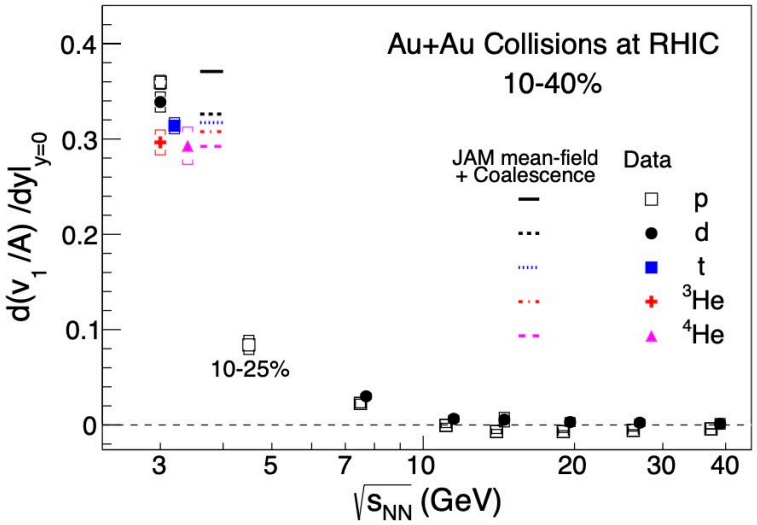


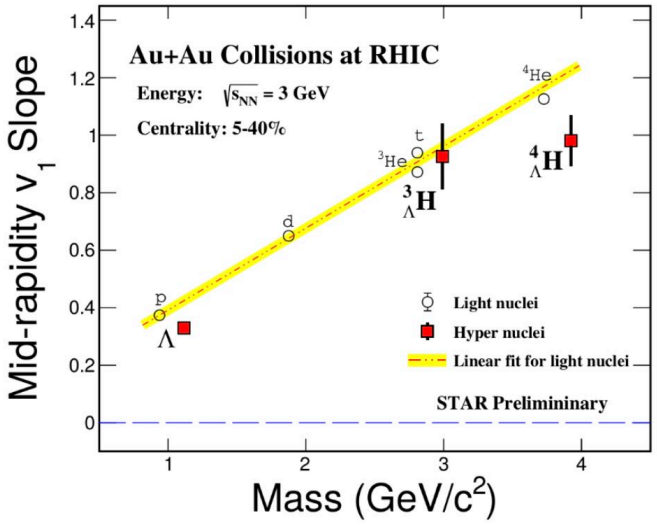
Test of N_{CQ}-scaling of v2

PLB 827 (2022) 137003



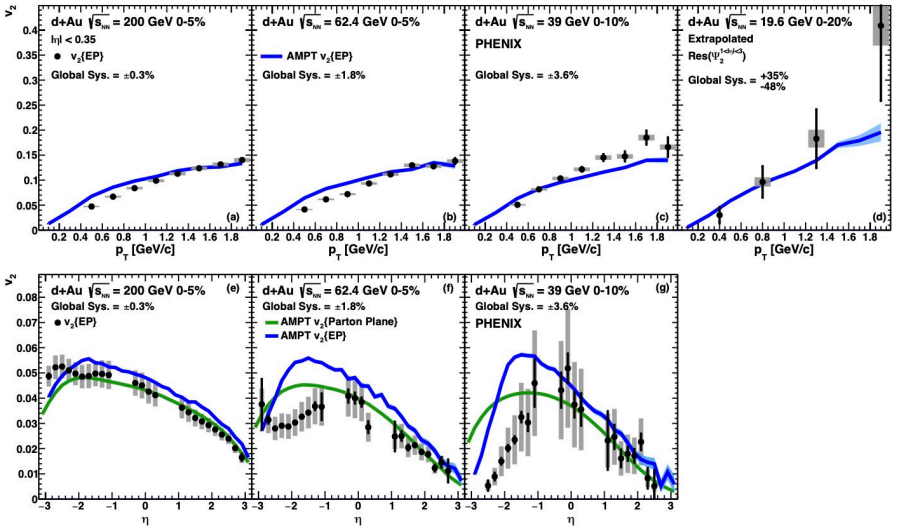
PLB 827 (2022) 136941





Small system flow
(non-flow subtraction needed)

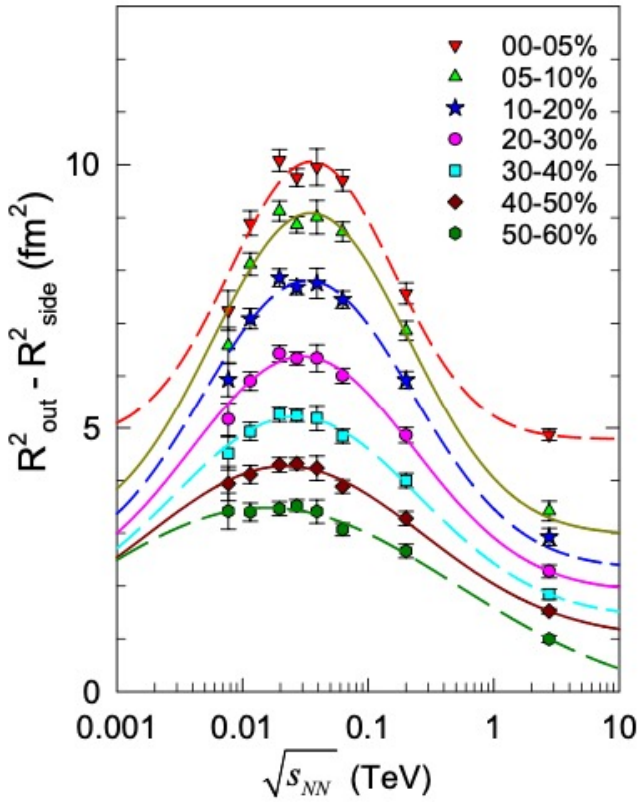
PRC 96 (2017) 064905

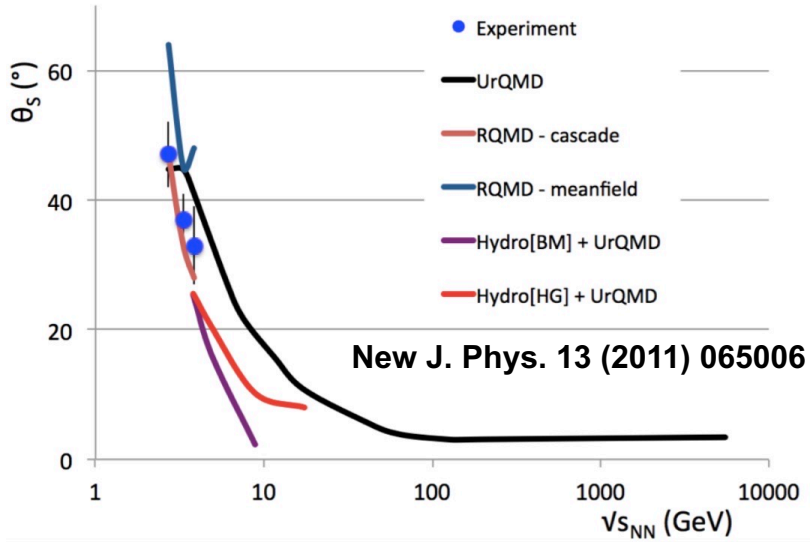


Femtoscopy and Source Geometry

- duration time, size
- source tilt, eccentricity
- dynamical expansion

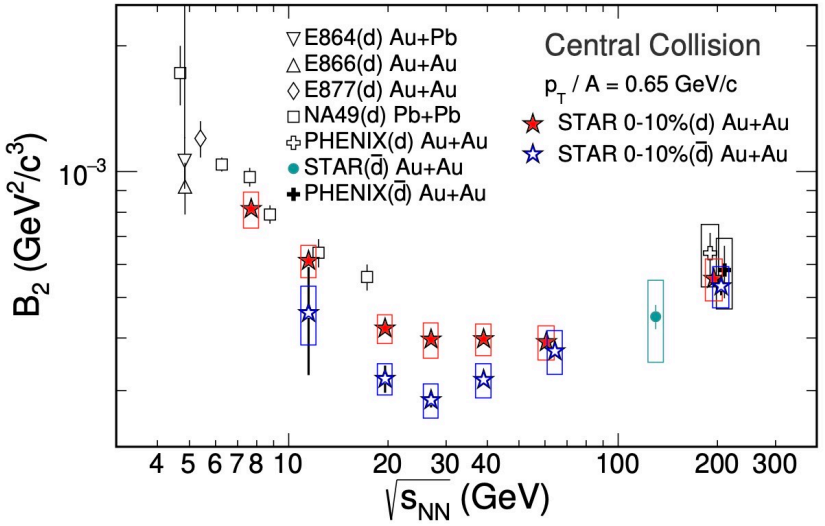
PRL 114 (2015) 142301



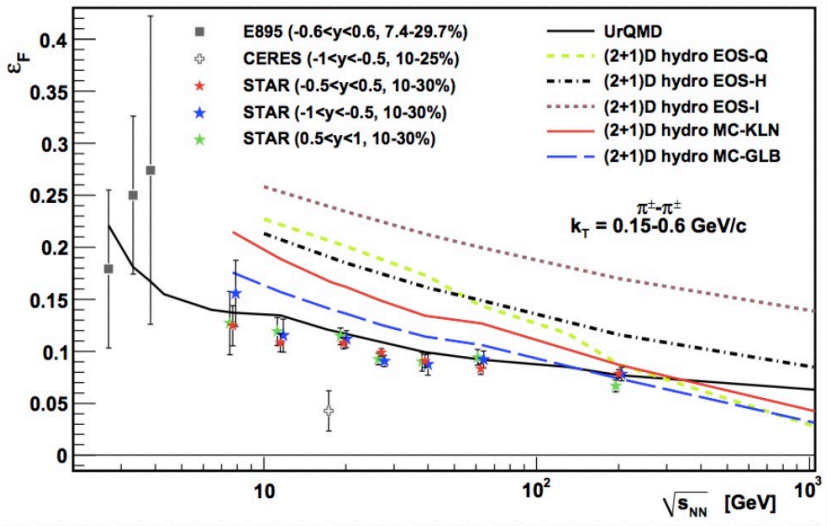


New J. Phys. 13 (2011) 065006

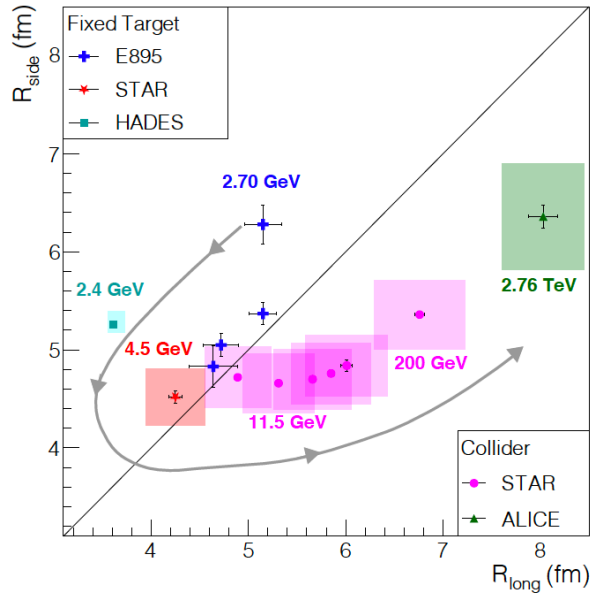
PRC 99 (2019) 064905



PRC 92 (2015) 14904



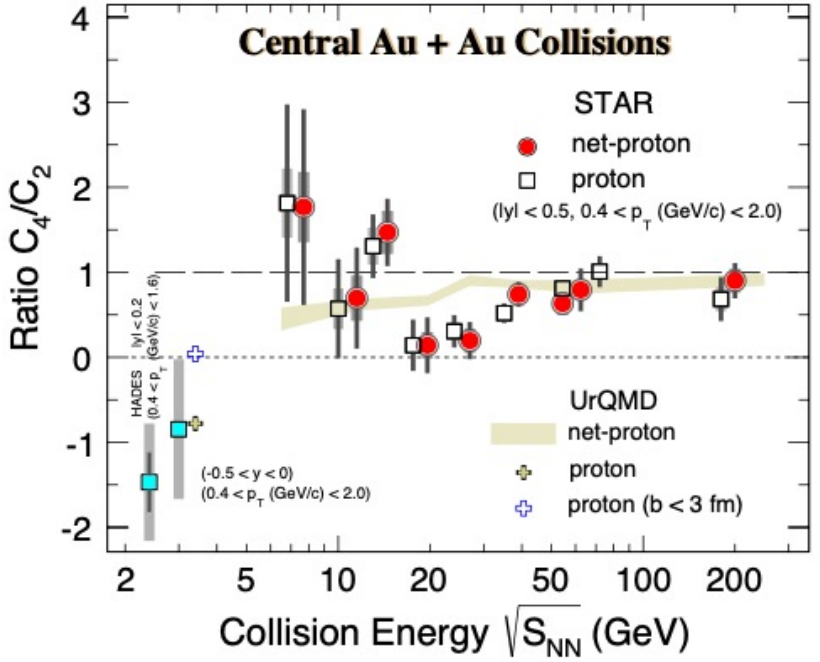
PRC 103 (2021) 34908

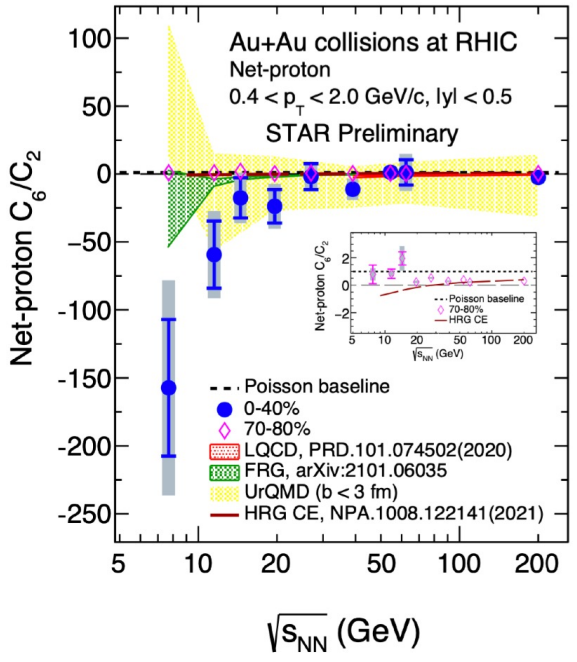


Net-Baryon Higher Order Fluctuation

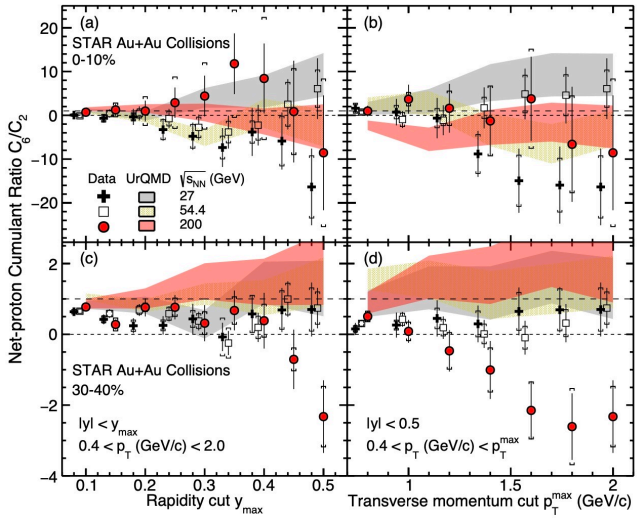
- conserved number fluctuation
- higher order, sensitivity
- CEP, cross-over transition
- baryon conservation baseline
- volume fluctuation, centrality
- rapidity acceptance dependence

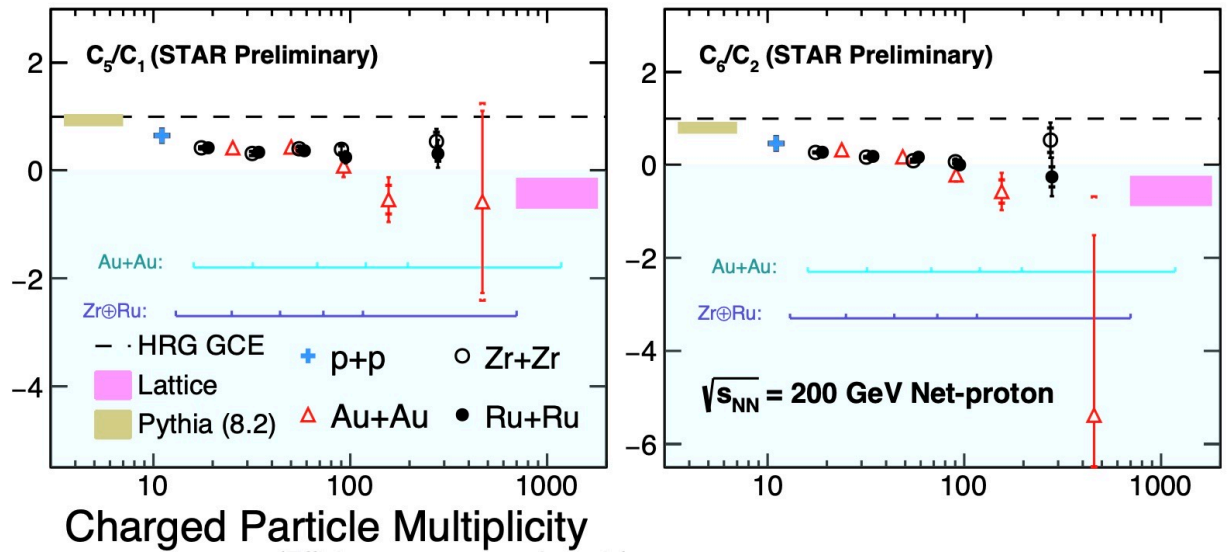
PRL 128 (2022) 202303





PRL 127 (2021) 262301



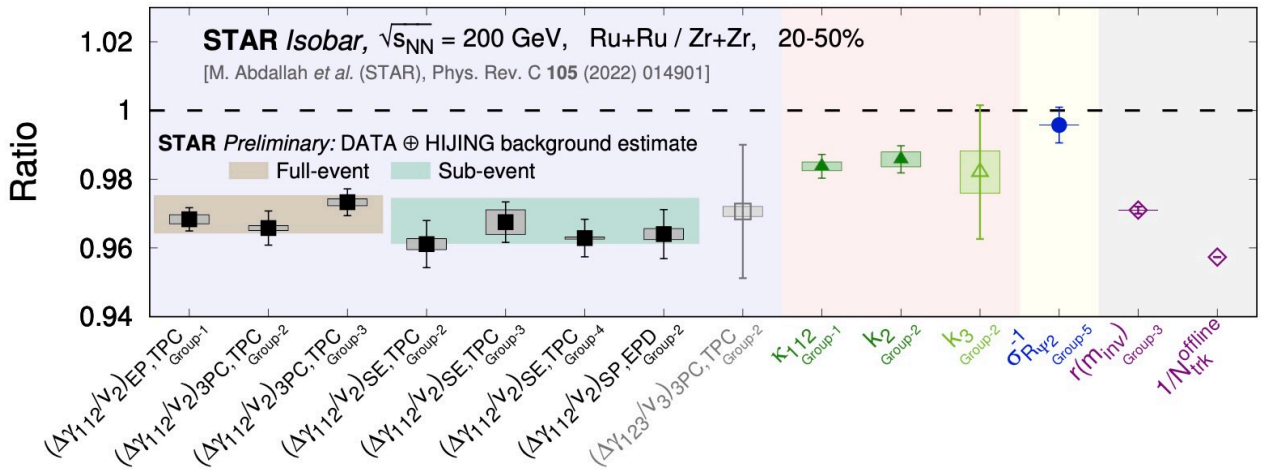


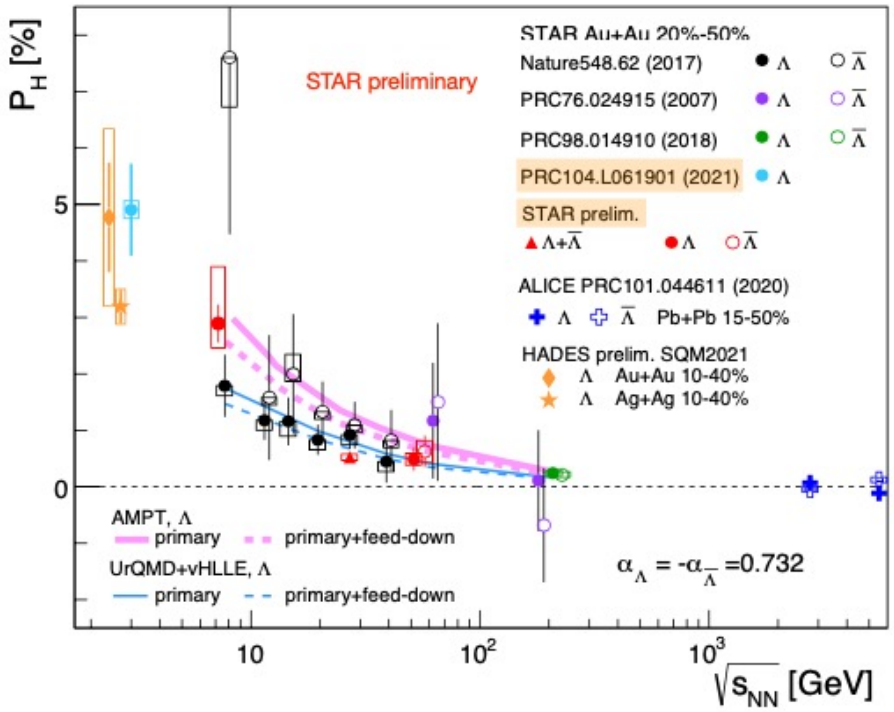
Vortical Fluid and Chiral Magnetic Effect

- global and local polarization, spin alignment
- beam energy and centrality dependence
- lambda anti-lambda difference…
- no visible CME signal in isobar blind analysis
- Δγ, ΔS, pair wise or event wise, Δv1, Δv2,,,

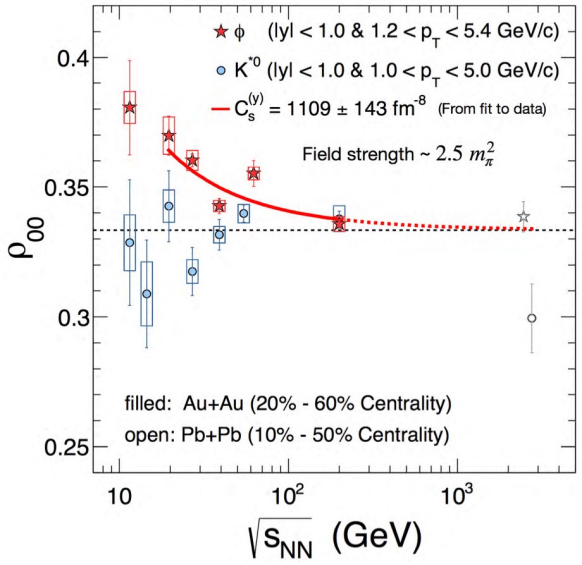
isobar blind analysis completed (no hint of CME at the moment)

PRC 105 (2022) 14901

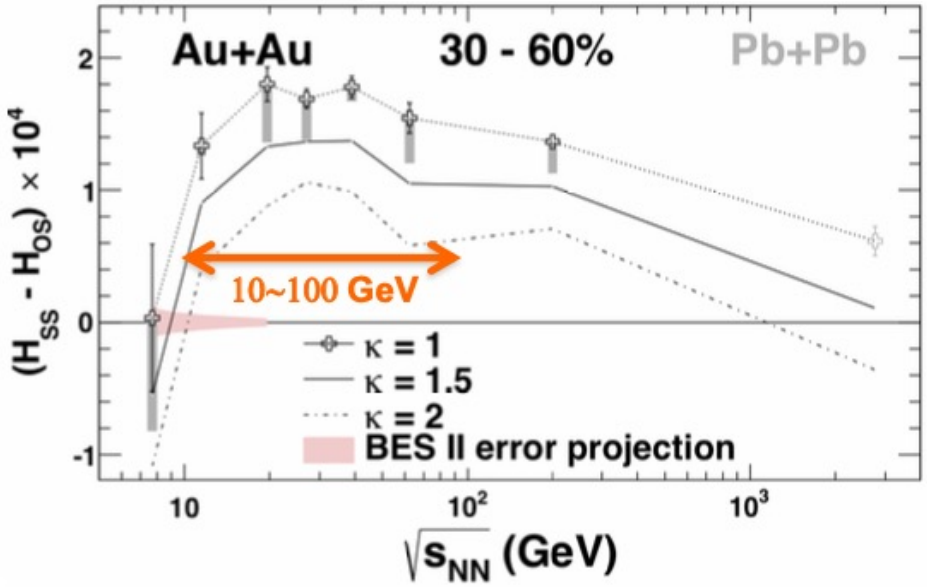




arXiv:2204.02302



PRL 113 (2014) 052302



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Thank you very much, especially for RHIC/BNL staffs, STAR (and other) collaborators, and high-energy heavy-ion group members in Univ. of Tsukuba, and Tomonaga Center for the History of the Universe