"Summary" talk:
Outlook and future of heavy-ion physics

Constantin Loizides
(ORNL)

09 Nov 2019

Link to agenda

The most unexpected result

Eintracht Frankfurt winning 5:1 against Bayern Muenchen after ~9 years of not beating them in the Bundesliga

The most important point

Long-Gang Pang's summary of the "Machine learning in HI physics" talk

Summary

- PCA, Bayesian analysis and deep learning have been used to find patterns for nuclear structure, QCD EoS, QGP property, jet flavor classification.
- Machine learning is also the hero behind scenes for experimental data processing, such as track reconstruction, background removal, detector simulation ...

- Many challenges
  - Fast models to accumulate data in HIC
  - Good models for supervised learning (e.g., how to encode the critical fluctuations?)
  - Model uncertainty and detector efficiency
  - Interpretation is crucial

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In fact should be or is the motto of our field

Outline

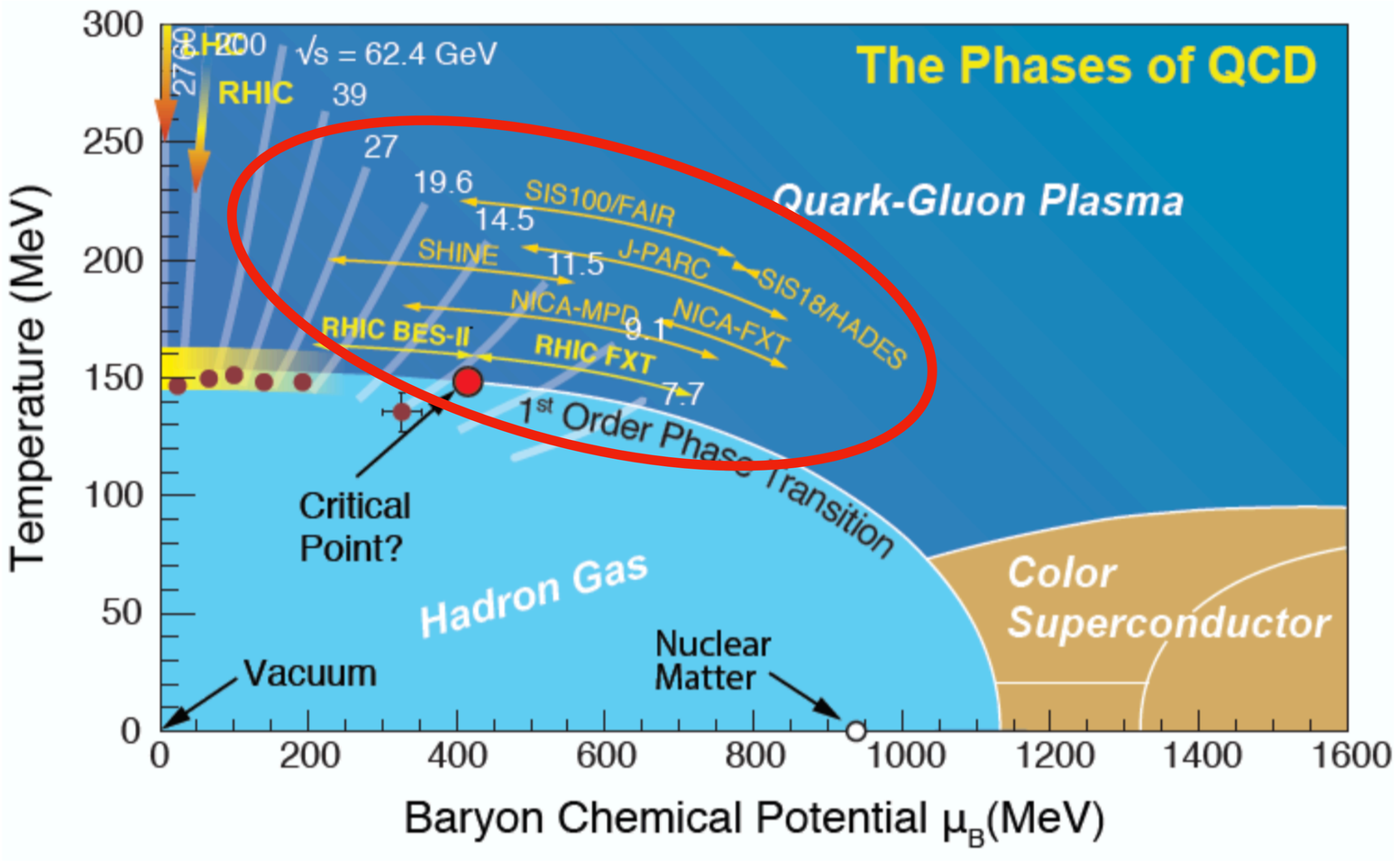
The task given to me:

[...] to give the **"Summary" talk: Outlook and future of Heavy-ion Physics**. [...] Instead, we would like you to give your view on the Outlook and future of heavy-ion physics. Given what we know so far, especially what have been presented in this conference, what kind of problems and challenges we will face, and how we will meet these challenges in the future. [...]

After "interpreting", what I will talk about:

I'll go through some of the results that got my attention,
and will give you my take on what they mean or what we should do next.
I'll mention all future experiments and upgrades, but only briefly
since they were covered by A.Dainese this morning.

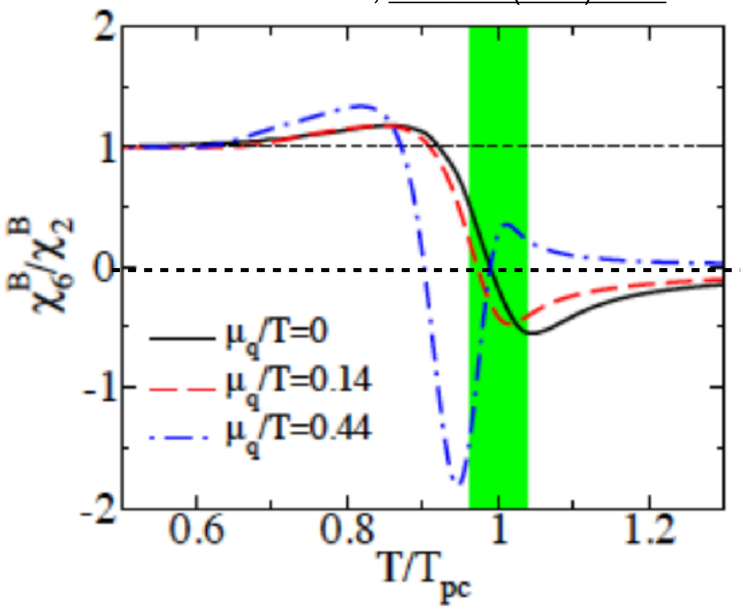
The high-density frontier



New BES results from STAR: C_6/C_2

Ashish Pandav [739]
Poster by Toshihiro Nonaka [586]

B. Friman et al., EPJC 71 (2011) 1694



Above $\sqrt{s_{NN}}$>60 GeV, predicted $C_6/C_2 < 0$ for B (and Q)

- The C_6/C_2 of net-proton and net-charge distributions for central Au+Au collisions at 54.4 GeV are positive while that for 200 GeV, C_6/C_2 of net-proton distribution is negative (most central).
  - Consistent with Lattice calculations
  - Could be experimental support for the O(4) criticality in the cross-over region
  - However, more experimental studies needed, stay tuned

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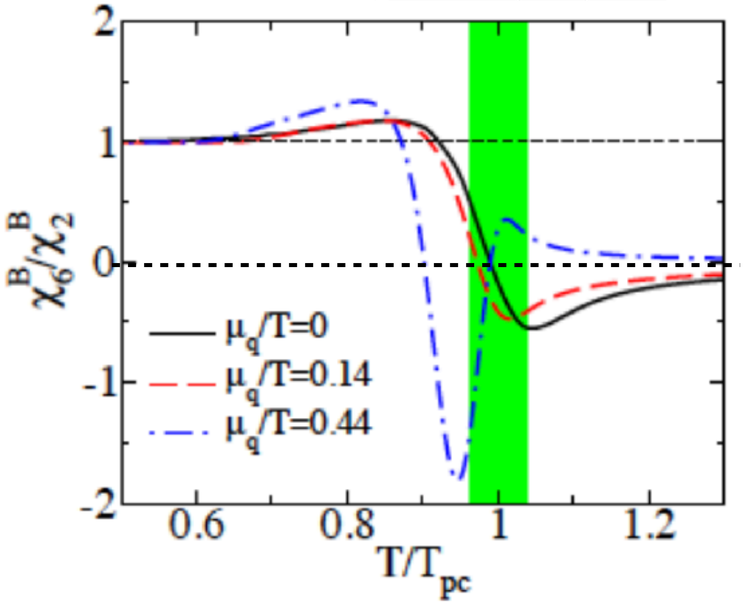

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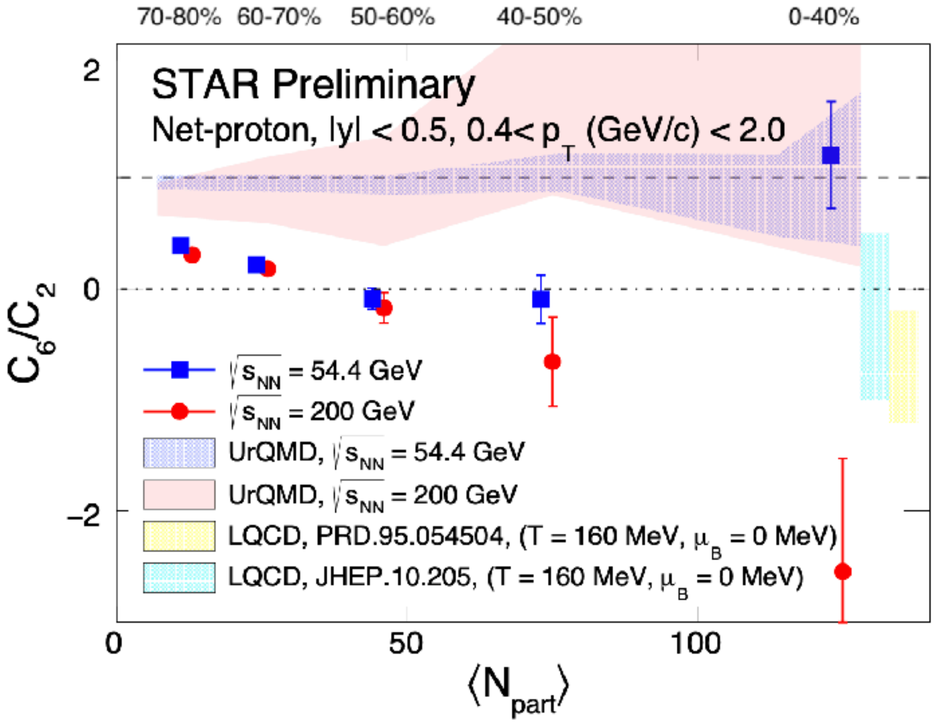

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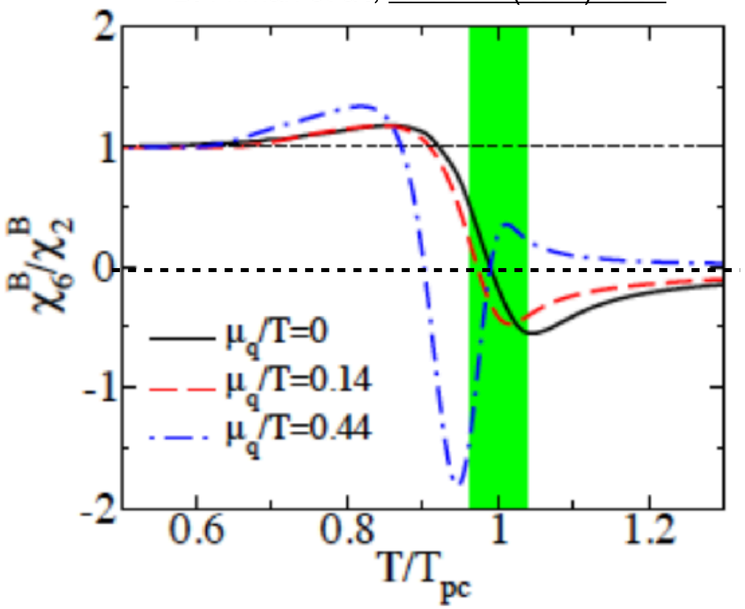

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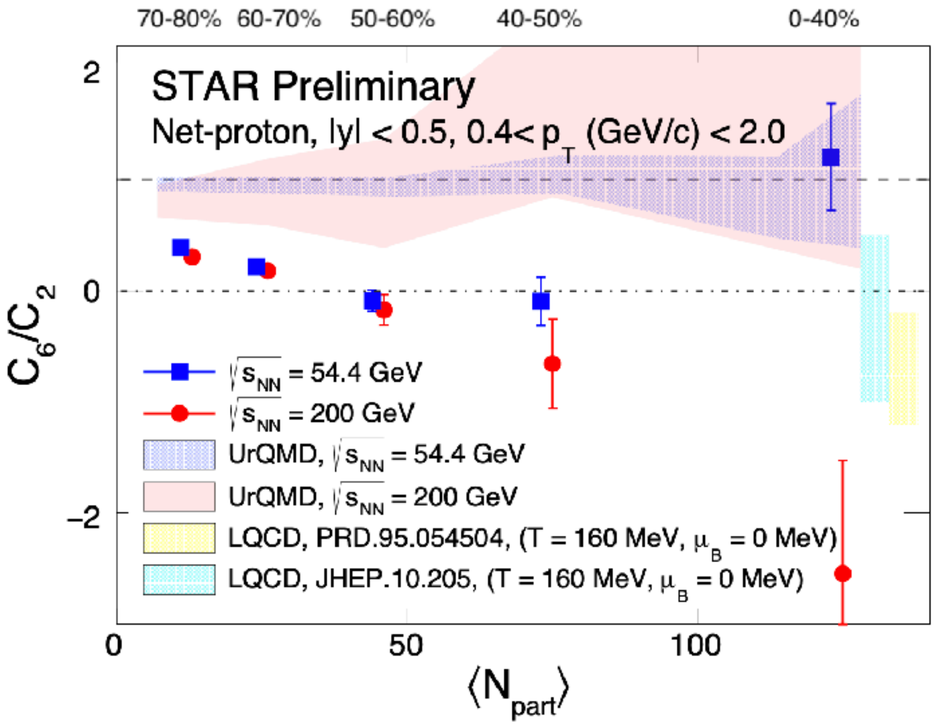

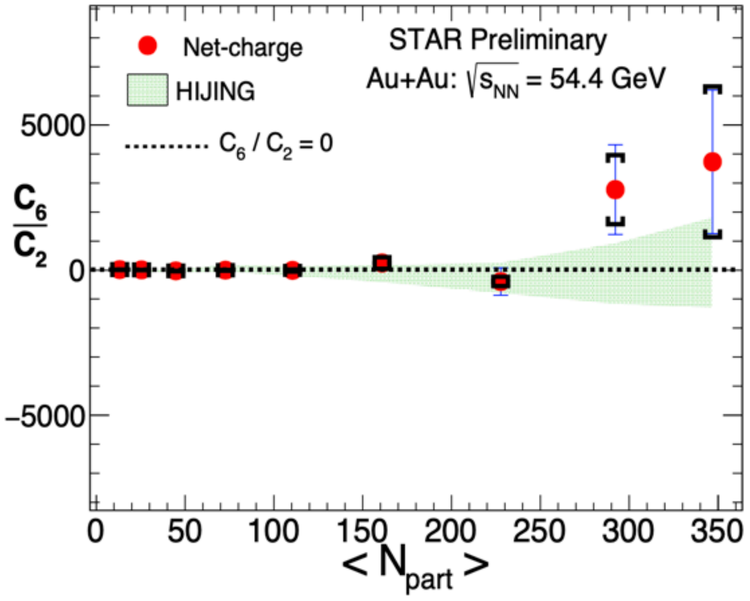

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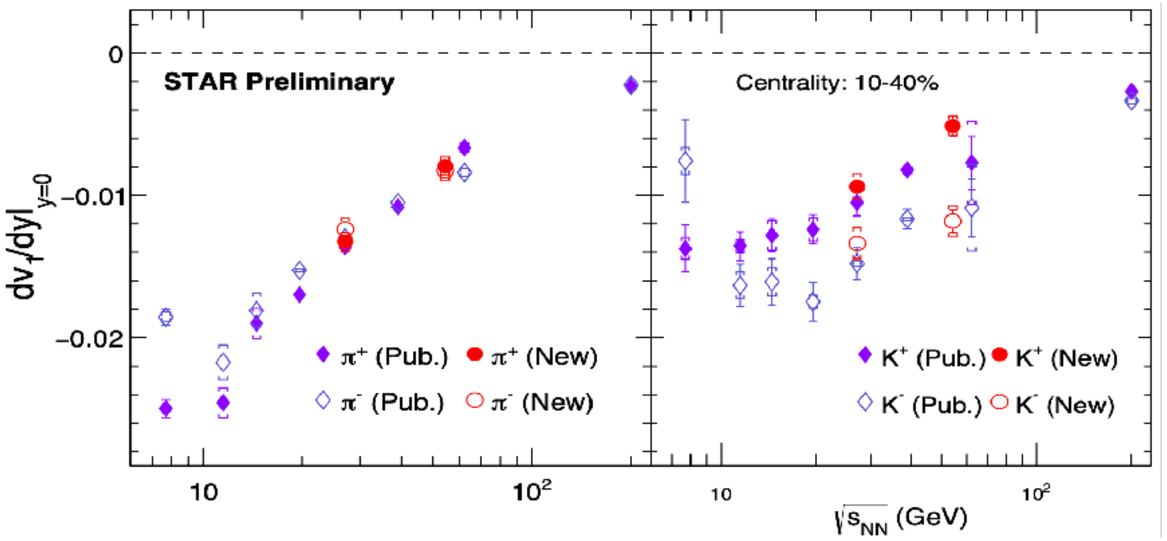
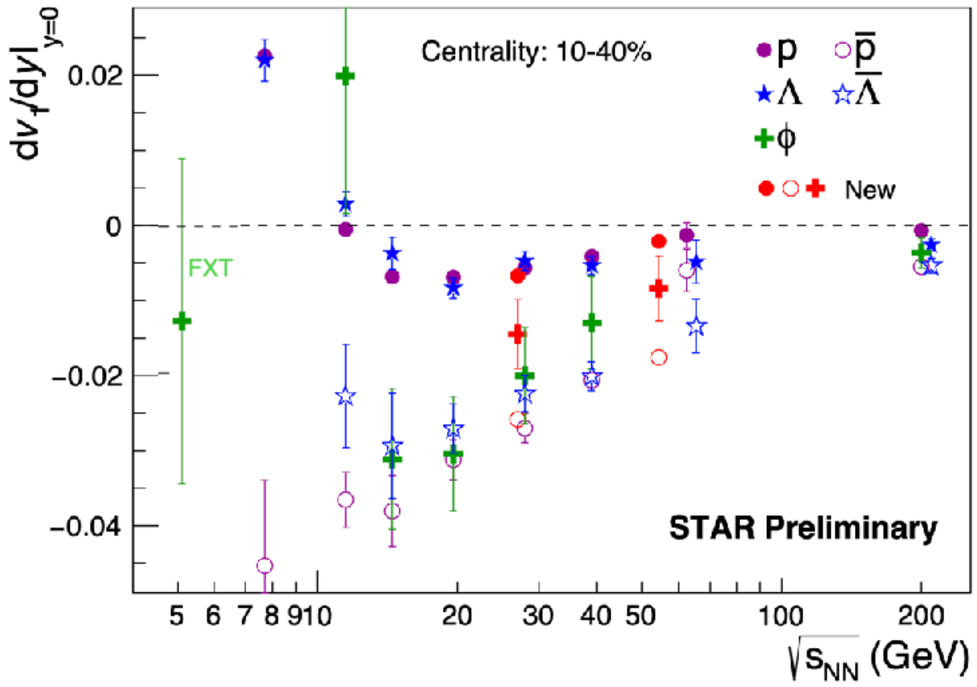
New BES results from STAR: v_1

Kishora Nayak [736]





- Mesons and anti-baryons have negative slope, while baryons have positive slope
- Situation for ϕ-meson below $\sqrt{s_{NN}}$=14.5 GeV not clear, need more statistics
- Need to disentangle contributions from baryon stopping
  - Calculation from BEST is really needed!
- Also waiting for data in fix-target mode!

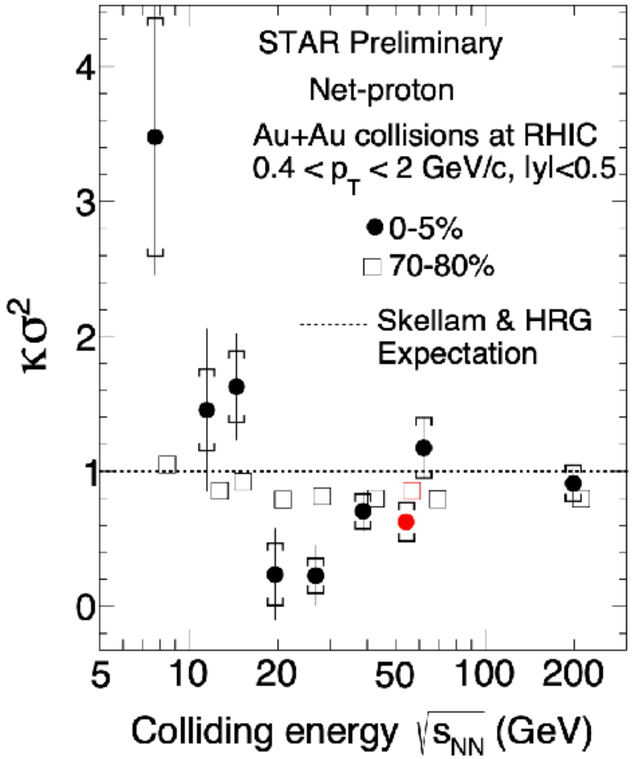
PRL 112 (2014) 162301 (2014); PRL120 (2018) 062301

New BES results from STAR: C_4/C_2

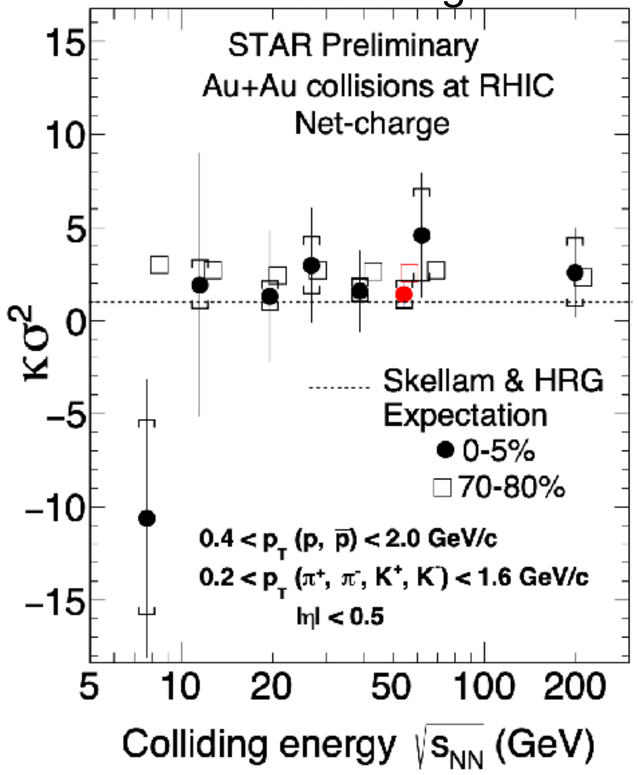
Ashish Pandav [739]

$C_4/C_2 = \kappa\sigma^2$

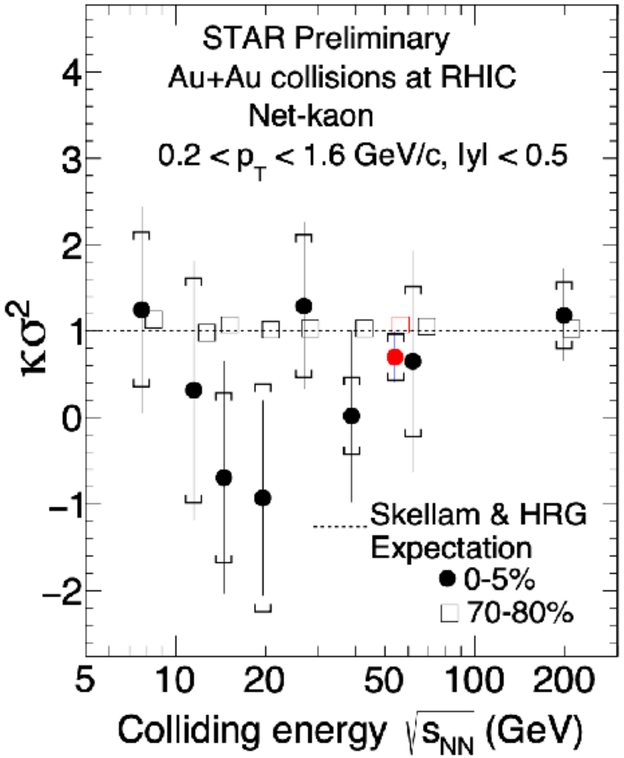
Net-proton



Net-charge



Net-kaon

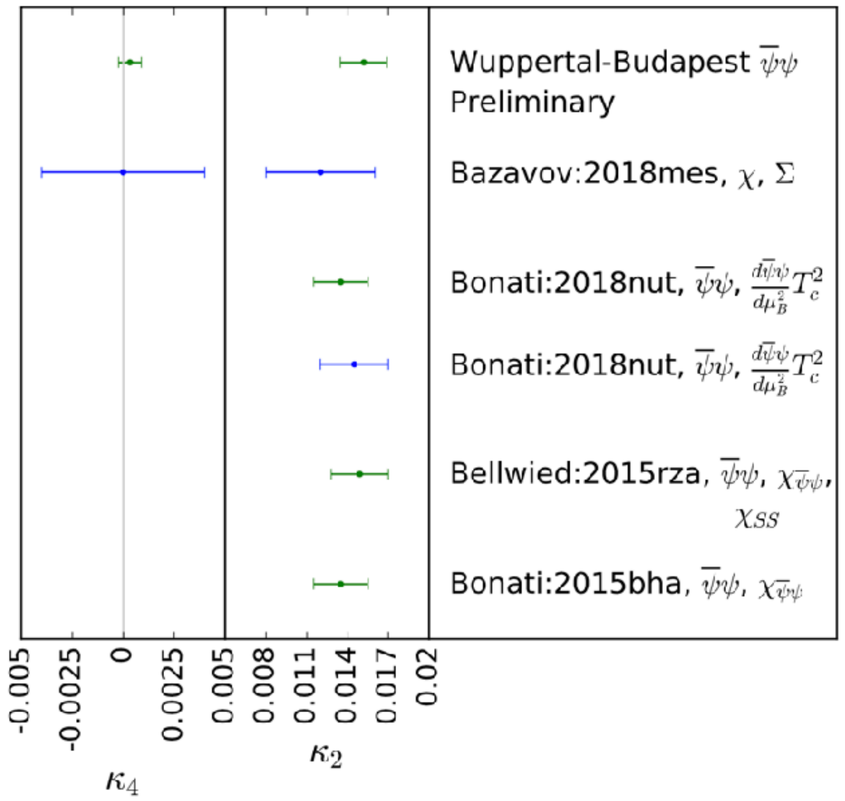


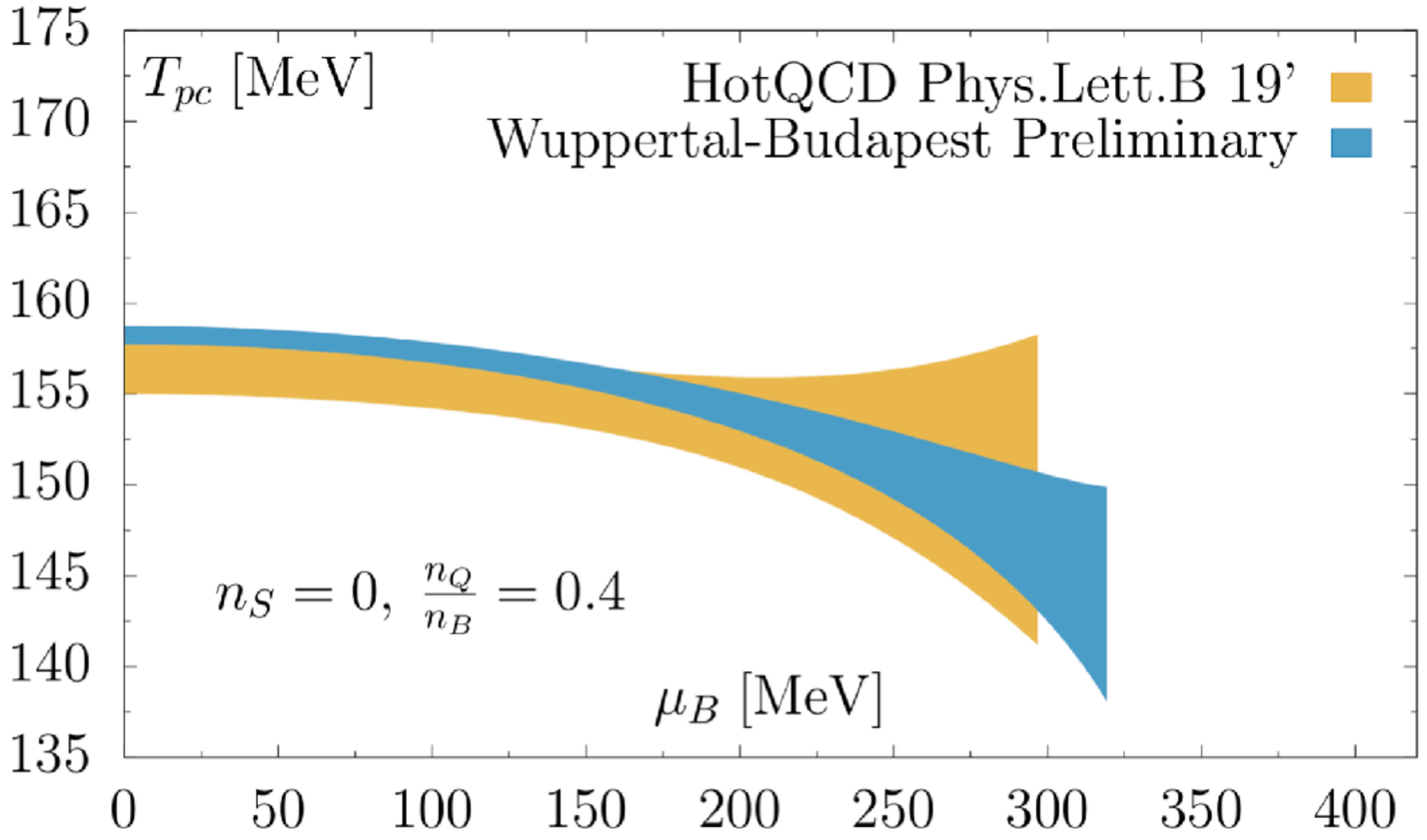
- New data for 54.4 GeV shows great potential of BESII statistics
- Eagerly waiting for BES2 data in the low energy region!

Latest news from the lattice

Jana Guenter [587]

$$\frac{T_c(\mu_B)}{T_c(0)} = 1 - \kappa_2 \left(\frac{\mu_B}{T_c}\right)^2 - \kappa_4 \left(\frac{\mu_B}{T_c}\right)^4 + \mathcal{O}(\mu_B^6)$$





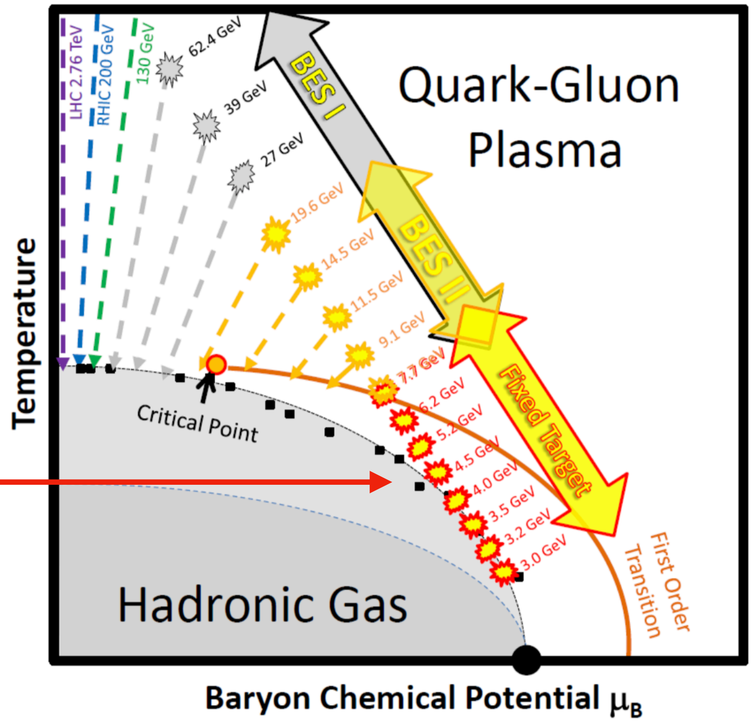
- New results from the WB collaboration from the imaginary chemical potential pushes the region for the expected CP to $\mu_B \gtrsim 300$ GeV
  - Smaller uncertainties, consistent with previous HotQCD results

The high-density frontier: Future

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040	2050
BESII	BM@N	MPD LHCb-ft	NA62	CEE		CBM/NA60+/J-PARC-HI							

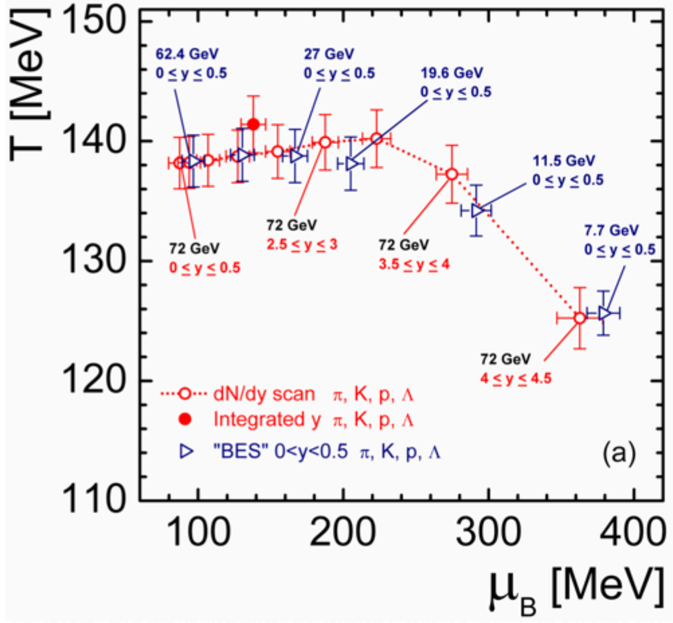
Key region for CP search

$2.5 < \sqrt{s_{NN}} < 8\,\mathrm{GeV}$



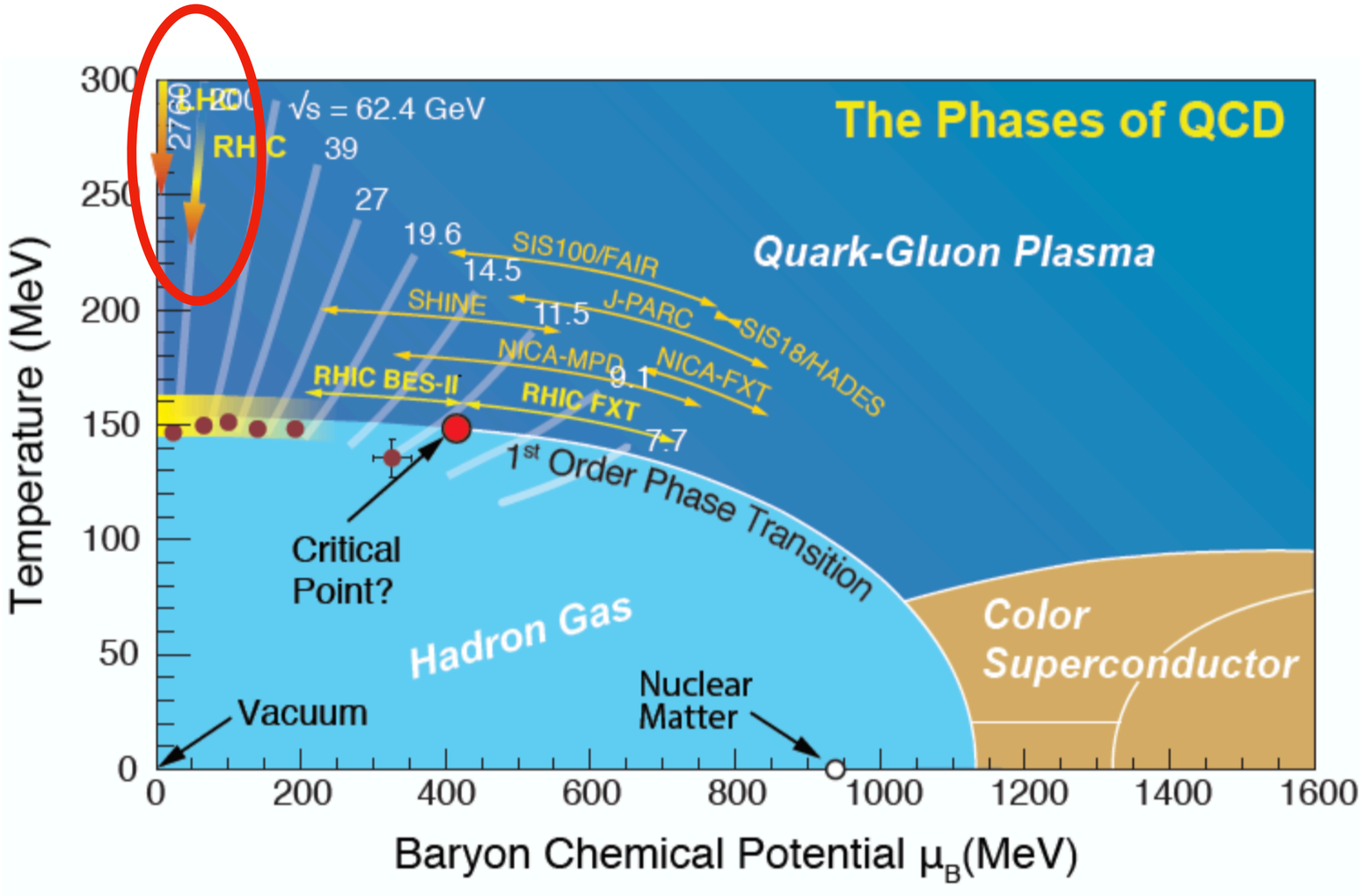
Facilities:
BNL/RHIC
CERN/SPS
FAIR/SIS
JINR/NICA
J-PARC
HIAF

LHCb-ft (SMOG)



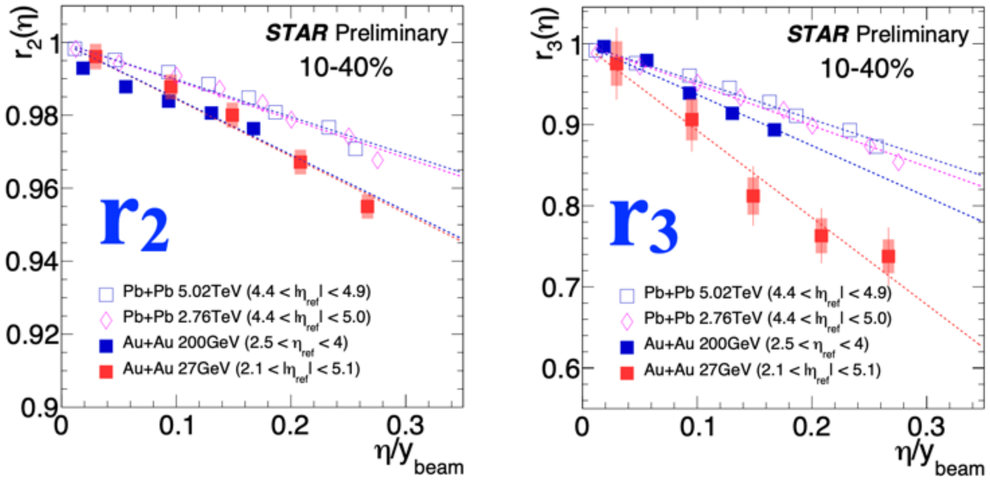
Systematic exploration of high μ_B region

The high-energy frontier



Ever increasing precision in measuring bulk properties

Maowu Nie [671]



Wealth of "higher" order data constraining models and allow extraction of bulk properties

Ever increasing precision in measuring bulk properties

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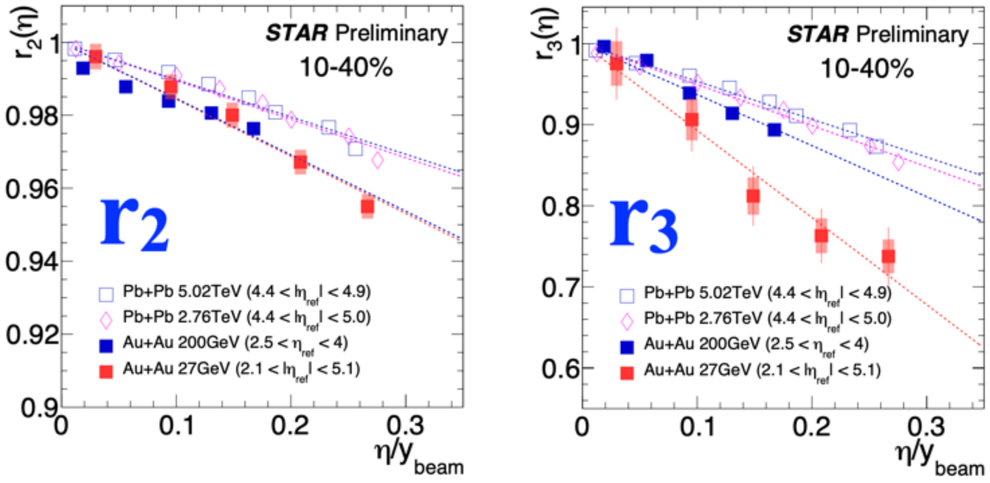
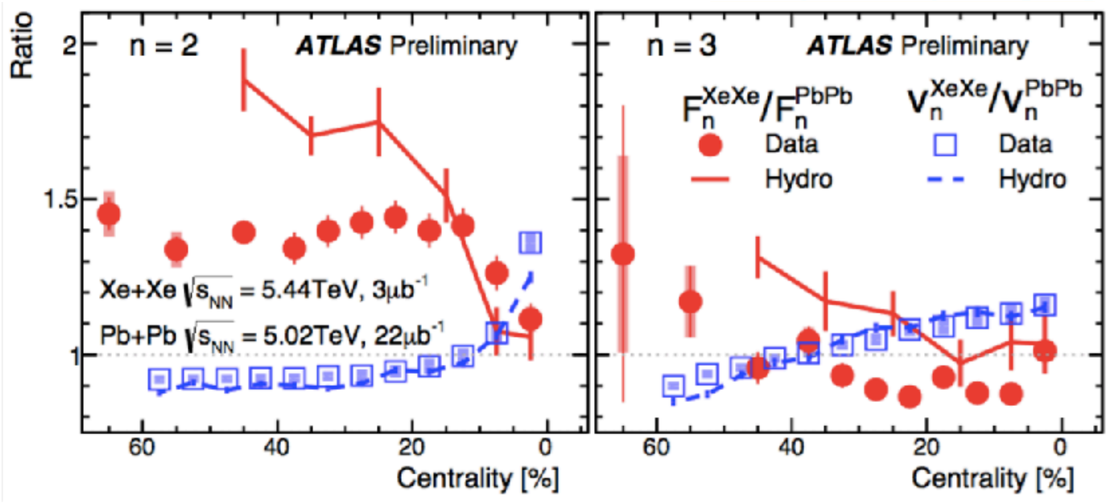


Soumya Mohapatra [127]



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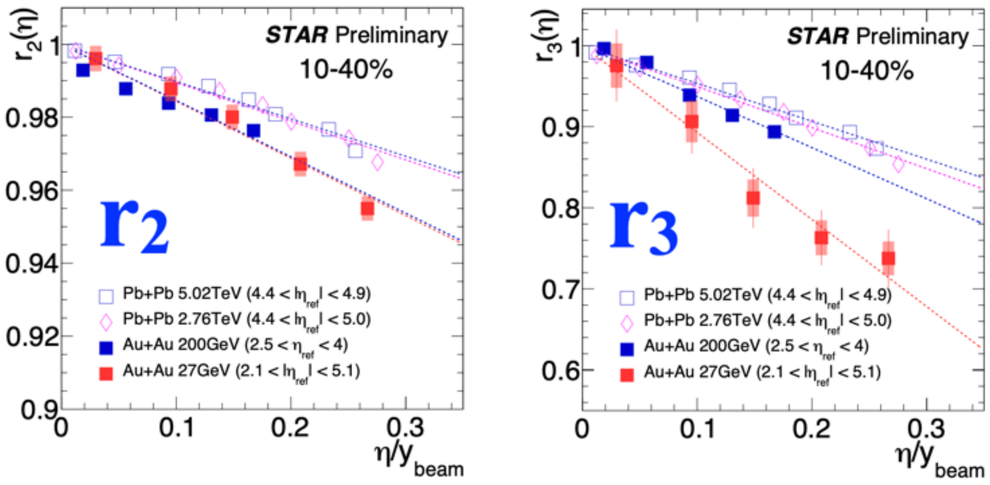

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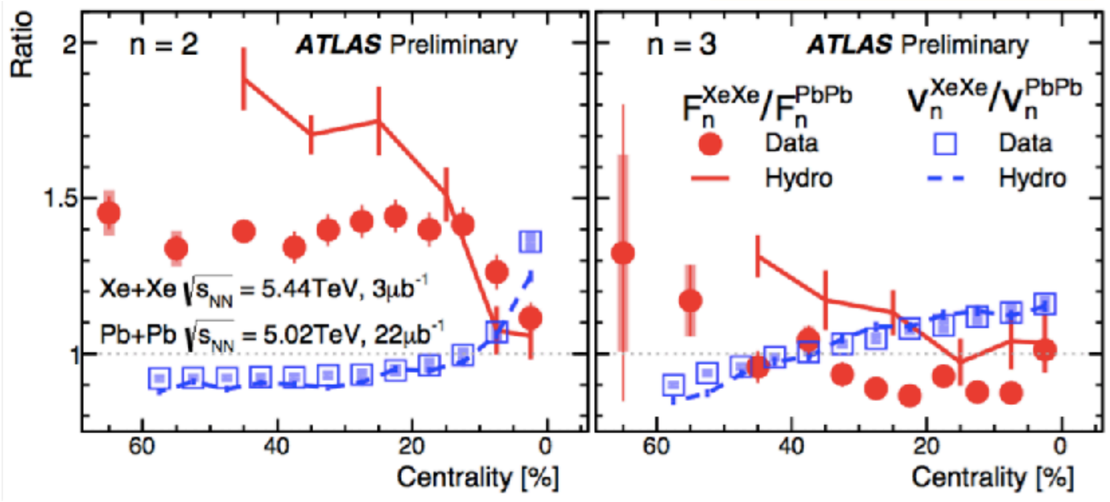

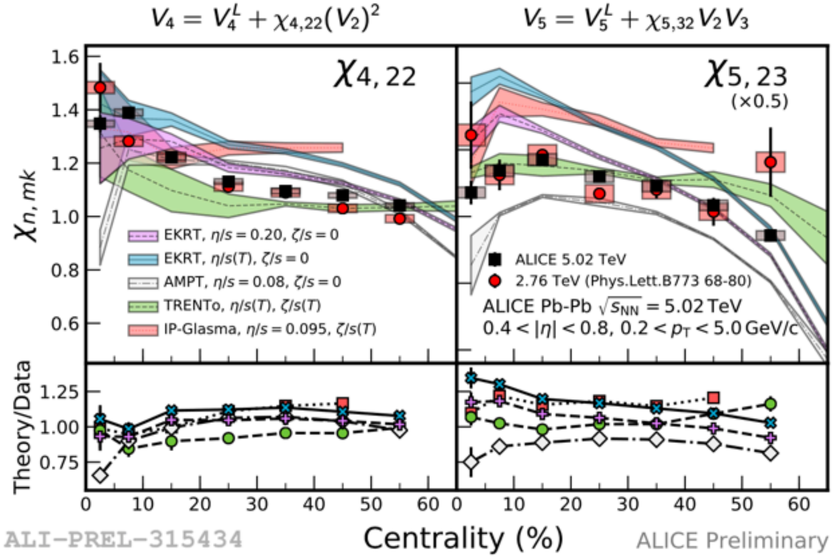

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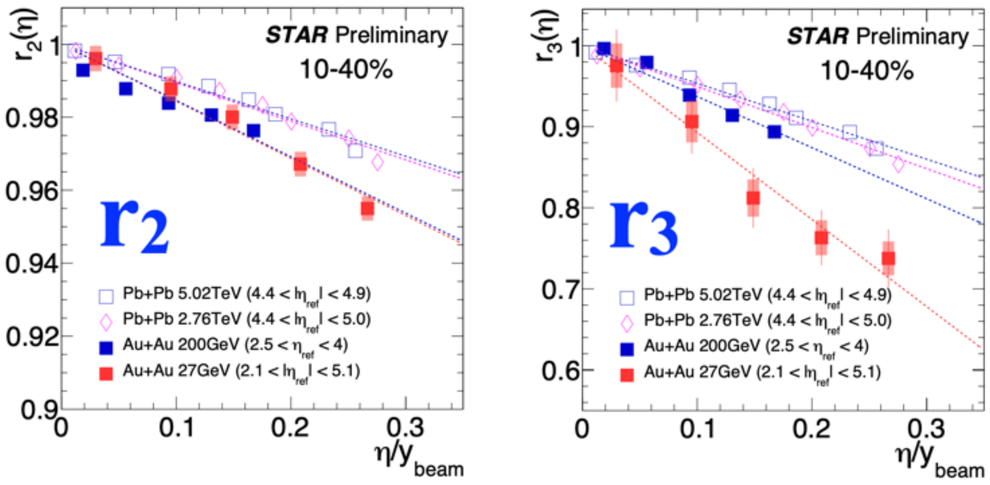

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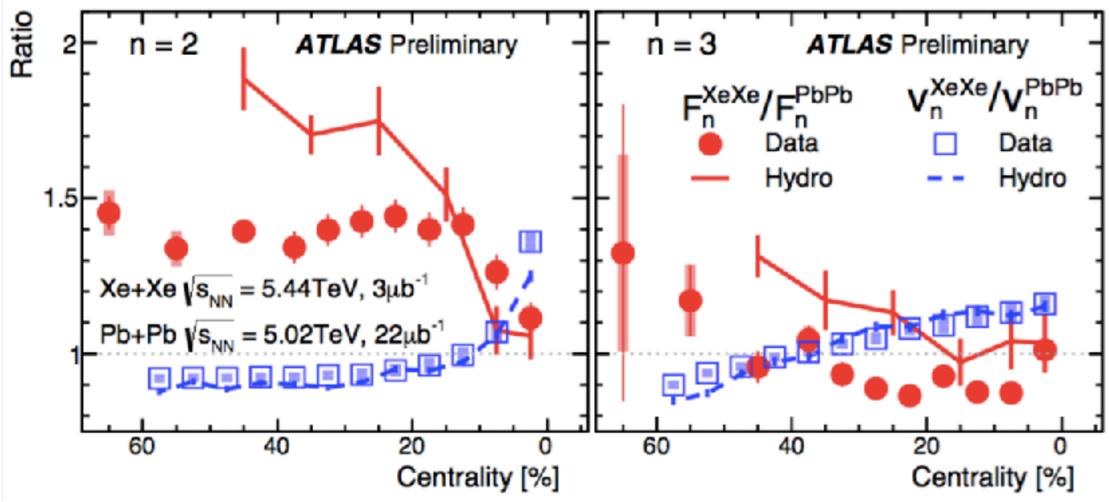

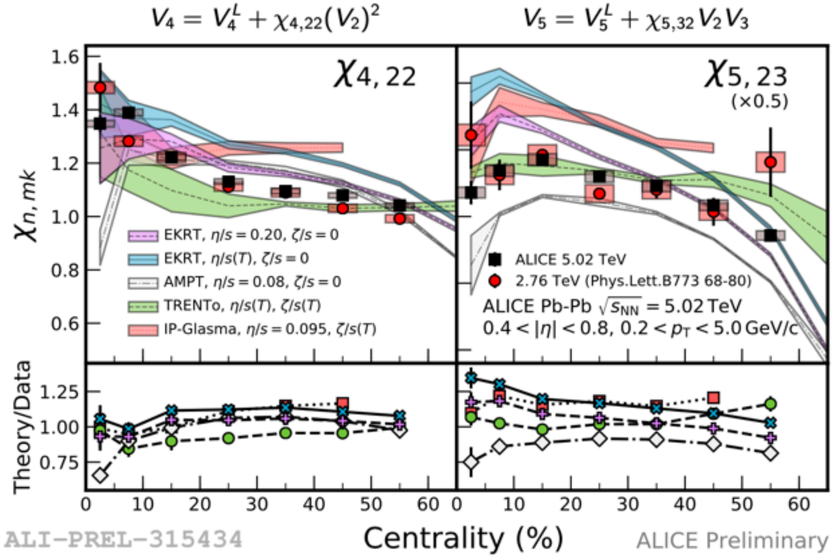

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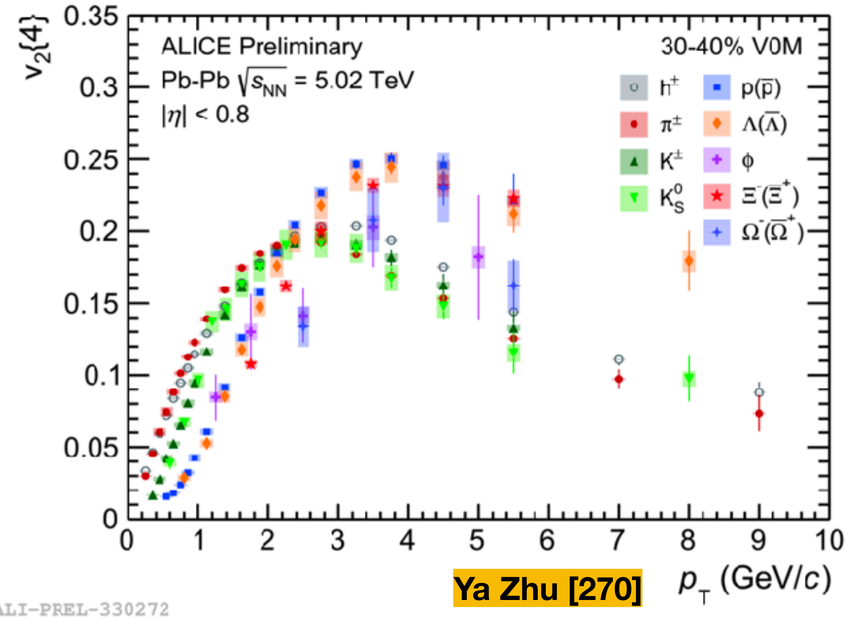


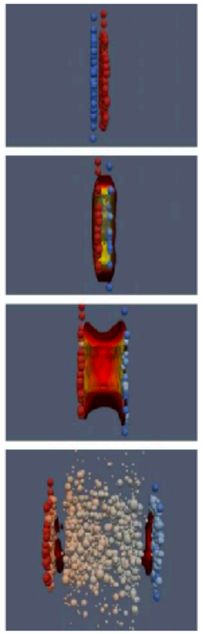
Ya Zhu [270]

Wealth of "higher" order data constraining models and allow extraction of bulk properties

Bayesian extraction of bulk properties

Jean-Francois Paquet [446]

JETSCAPE



$\tau = "0^+"$: Nuclei collide

- Trento ansatz used to parametrize the energy deposition
- 5 parameters: (i-iii) nucleon width, fluctuation & minimum distance, (iv) transparency parameter, (v) normalization

$\tau \sim 0.1$ fm: "Pre-equilibrium phase"

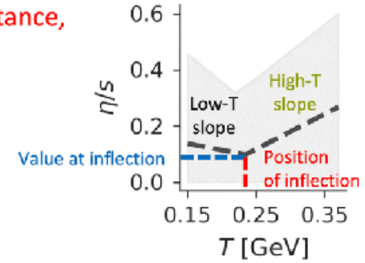
- Free-streaming
- Free-streaming time is a parameter

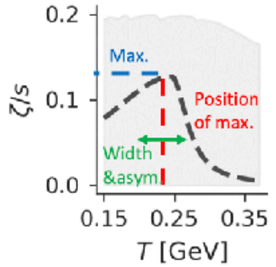
$\tau \sim 1$ fm: Beginning of "hydrodynamic phase"

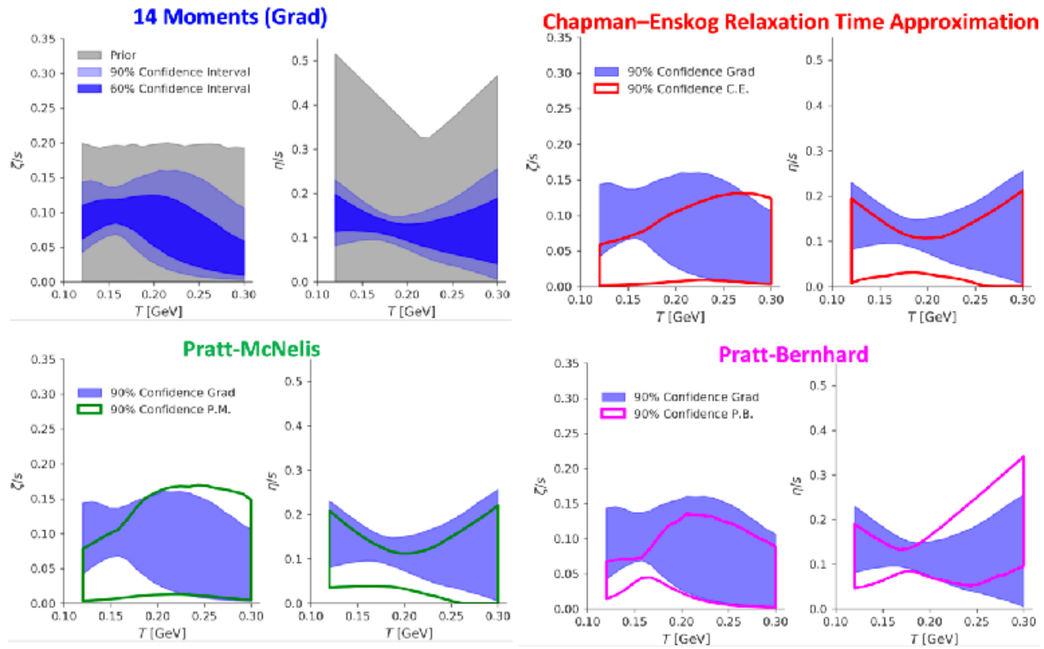
- 2+1D relativistic viscous hydrodynamics [MUSIC]
- Equation of state: hadron resonance gas + lattice QCD [HotQCD]
- Shear and bulk viscosity: $\frac{\eta}{s}(T)$ and $\frac{\zeta}{s}(T)$ parametrized

$\tau \sim 10$ fm: End of "hydrodynamic phase"

- Fluid converted to hadrons [iS3D]: Cooper-Frye at temperature T_{sw}
- Viscous corrections in Cooper-Frye: 4 different models
- Hadronic interactions with SMASH hadronic transport



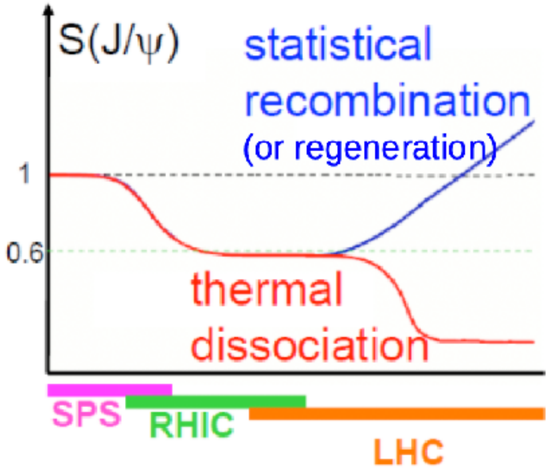




- RHIC data complement LHC data in Bayesian extraction of bulk properties
- Non-negligible uncertainties from hydrodynamics to particle transition ("viscous corrections")
- Importance of "plug and play" approach and open source code

Quarkonia: J/ψ, a true success story

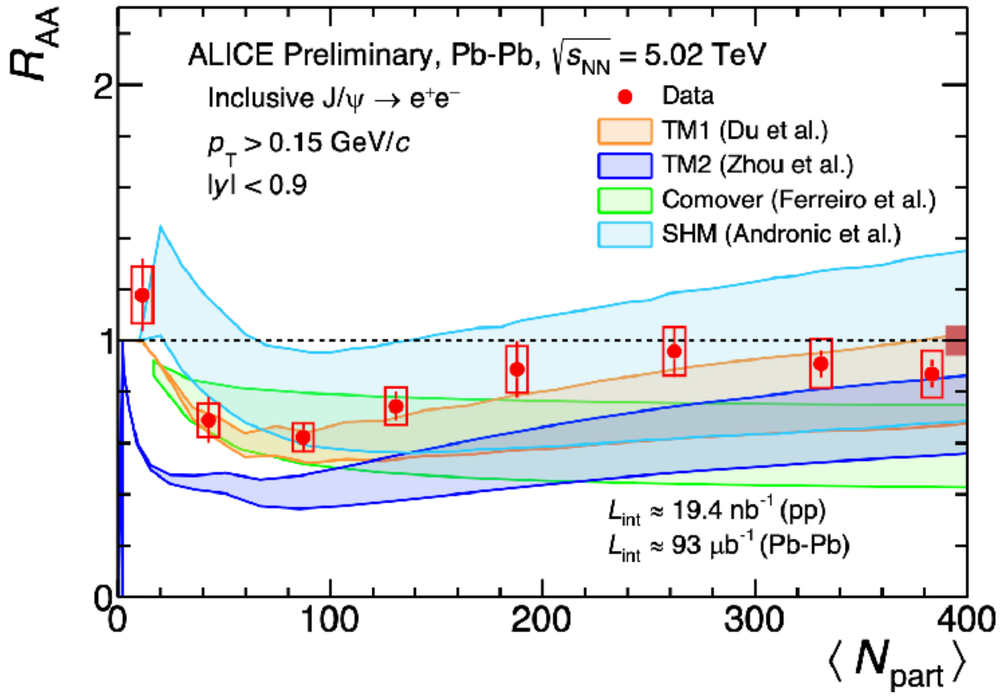
Xiaozhi Bai [189]



M.Gazdzicki et al., PRL 83 (1999) 4009

R.Threws et al., PRC 63 (2001) 054905

A.Andronic et al., PLB 571 (2003) 36



- Precision reached in the mid-rapidity ALICE data to clearly see predicted behavior
- Consequently large flow due to "approximately thermalized" charm at low p_T
- Total charm cross section needed to reduce model uncertainties

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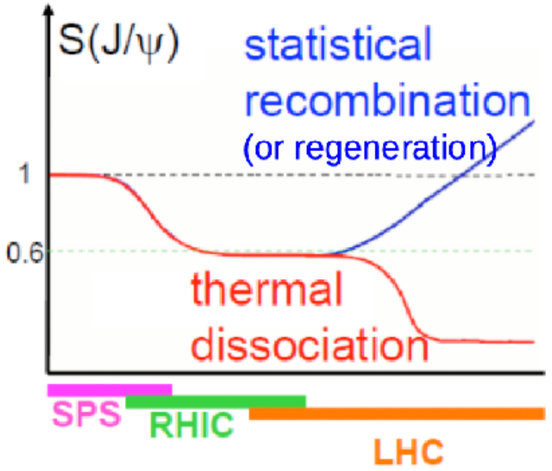

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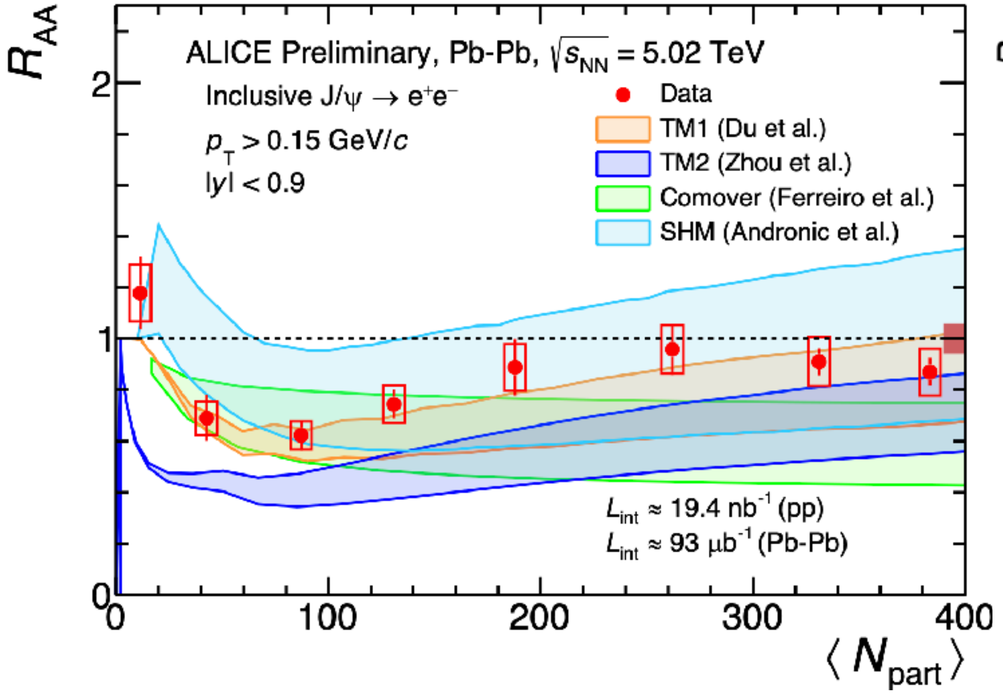

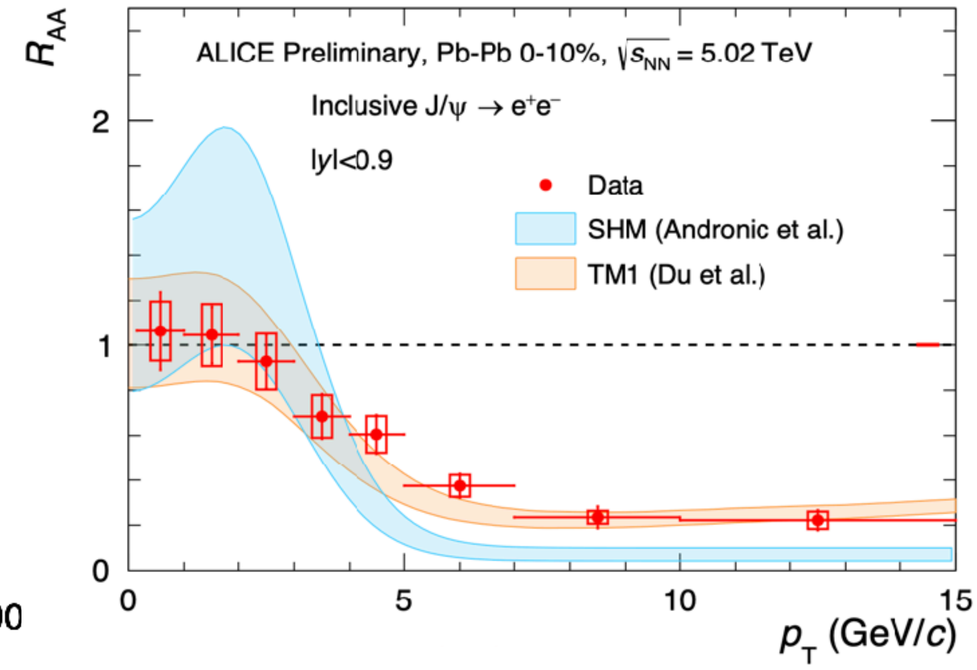

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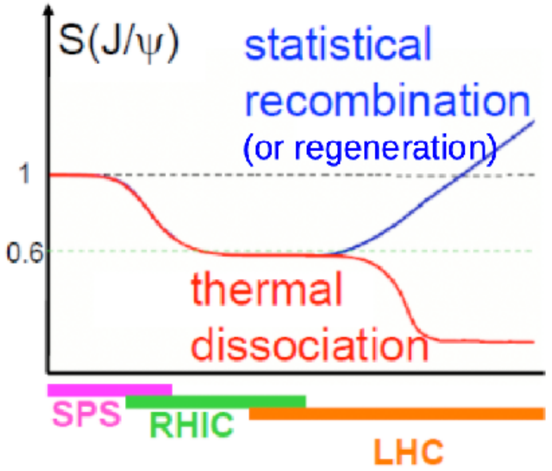

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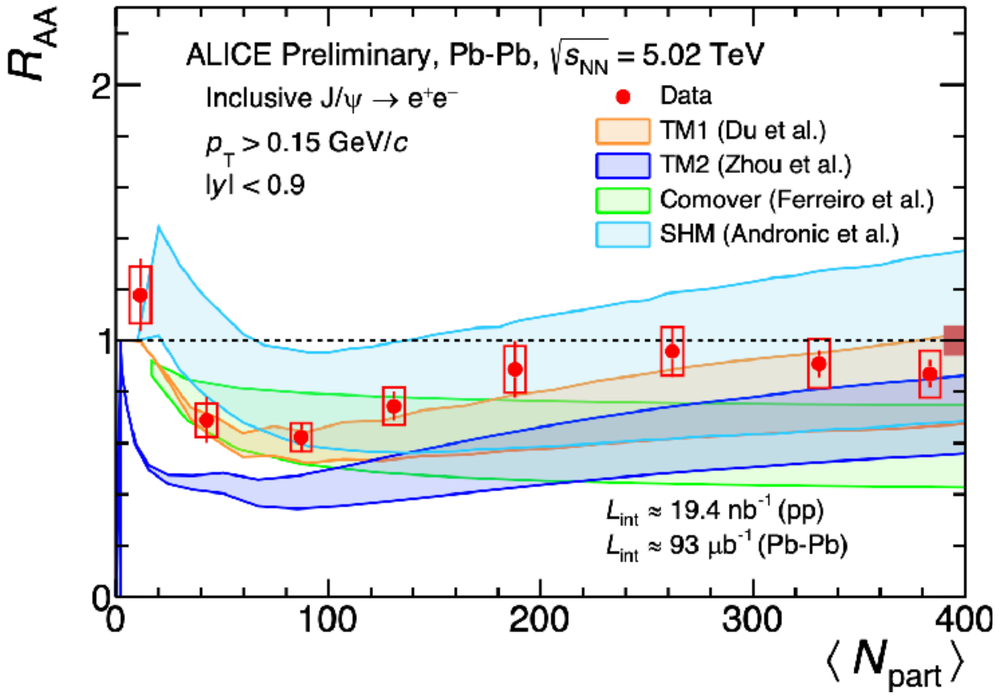

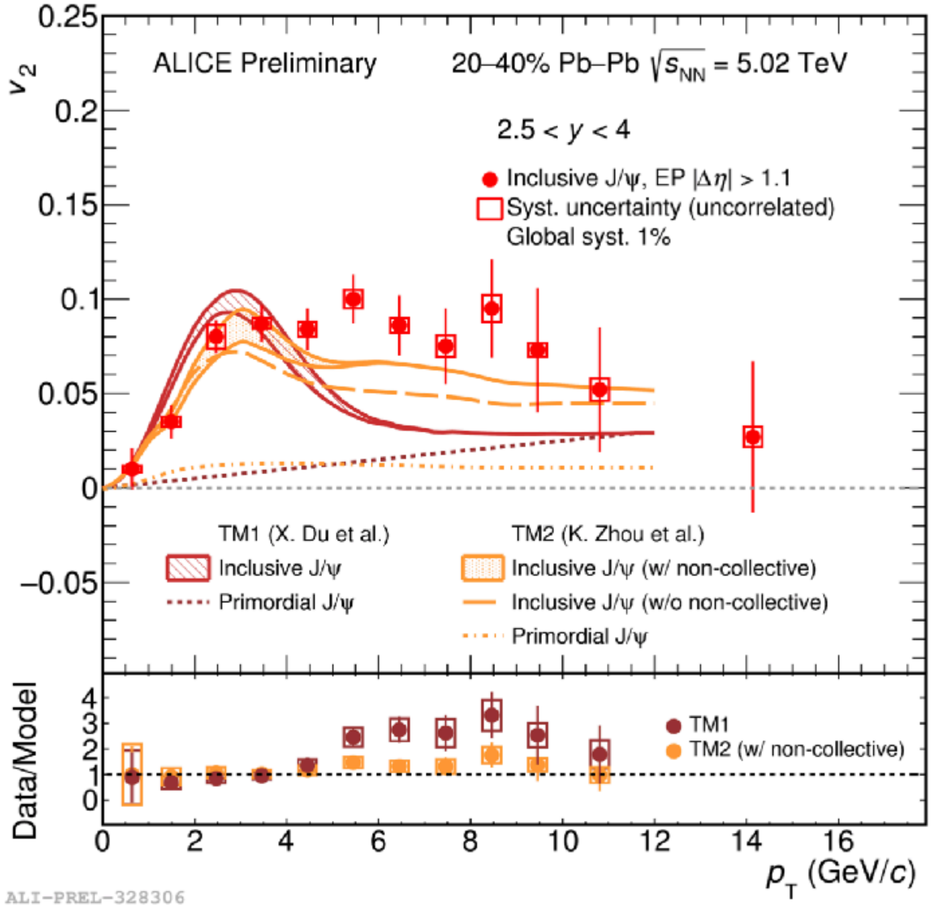

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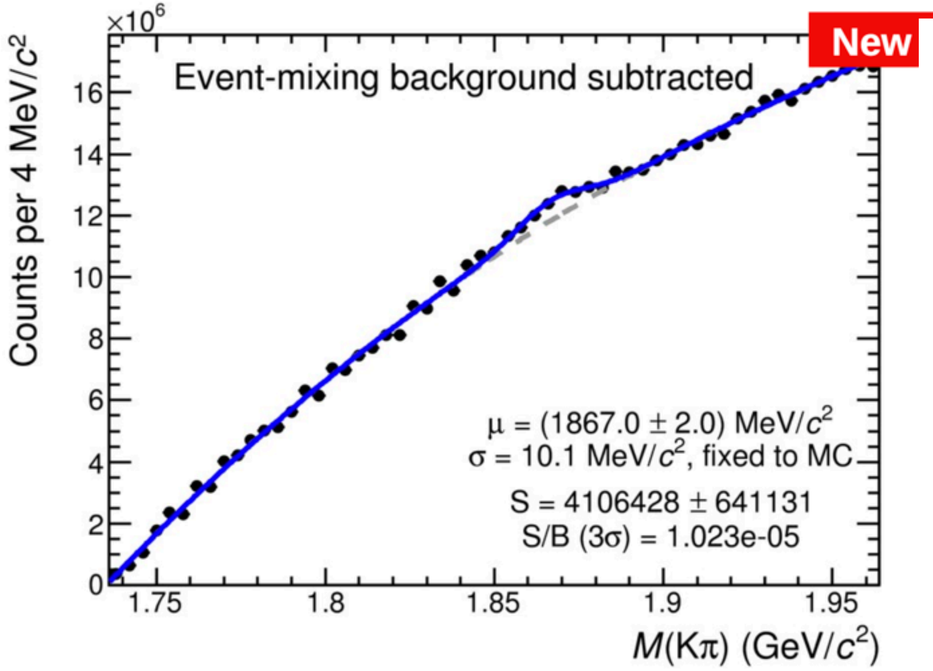
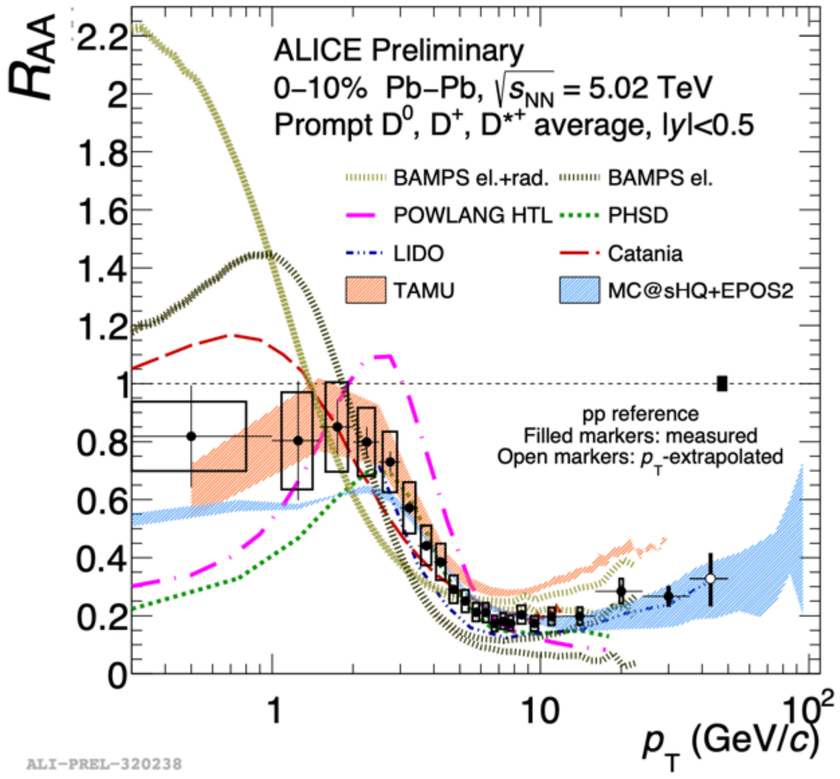
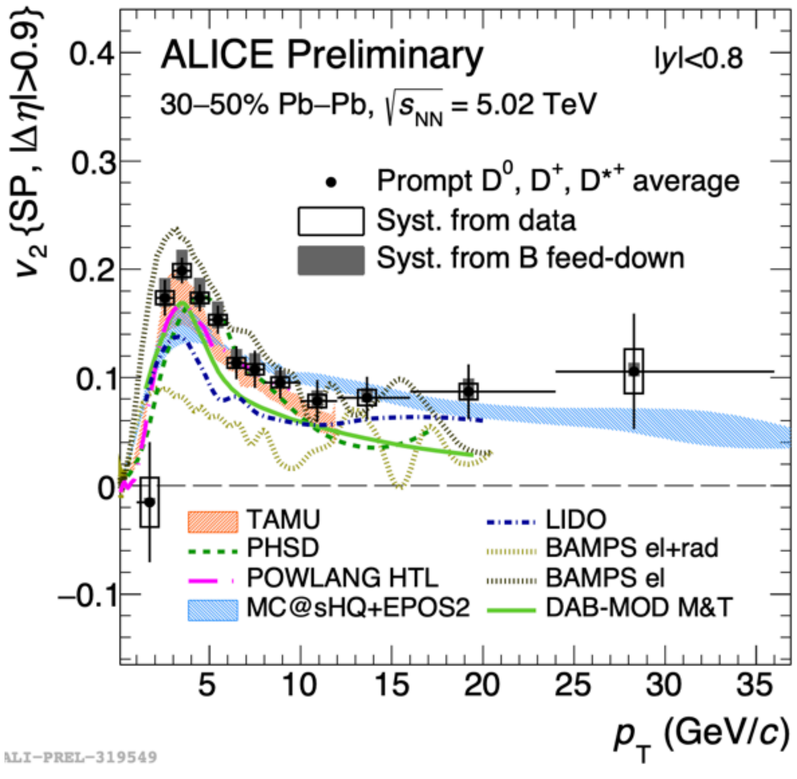
First measurement of D^0 down to zero p_T

Gian-Michele Innocenti [172]

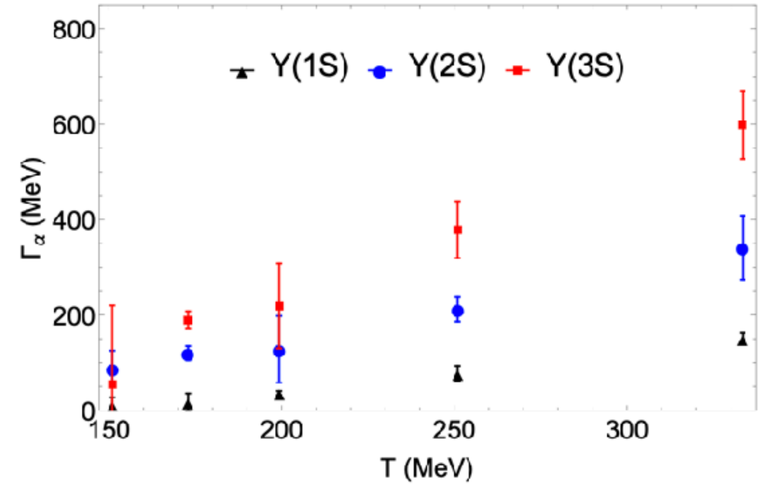


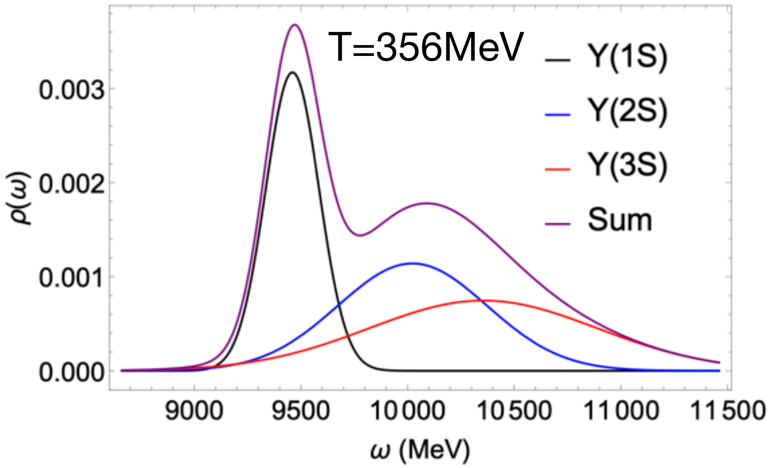




- "Brute-force extraction" of lowest p_T bin for first constrains of the total charm cross section in PbPb
- Critical for constraining shadowing effects and natural normalization for J/ψ measurements
- Better performance and more statistics after ALICE upgrade

Quarkonia: Upsilon family



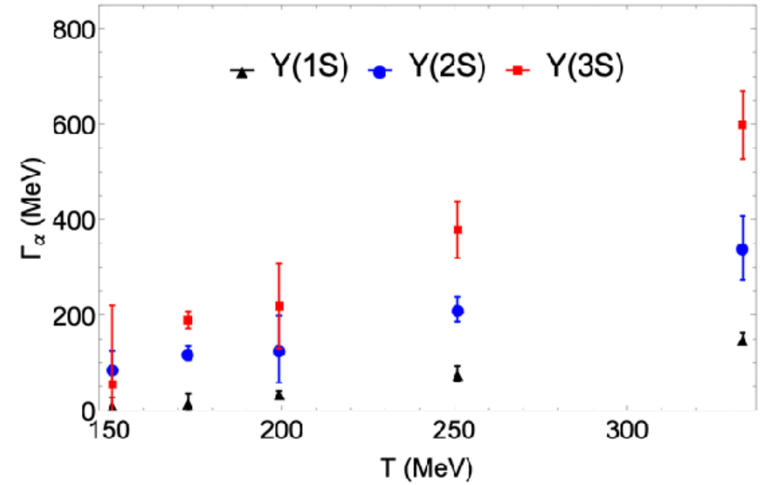


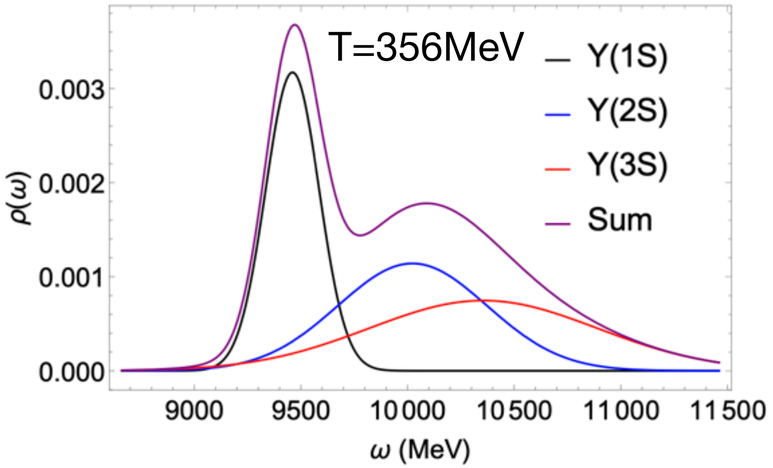
- Broadening of spectral widths vs T on the lattice compatible with sequential dissociation picture
- Suppression of Upsilon family follows sequential suppression, and stronger in PbPb than pPb
  - Suppression in pPb typically attributed to comovers, could partially be from screening, hard to disentangle
- Elliptic flow consistent with zero
  - From BW fits to existing data, one expects significant v_2 only $\gtrsim$ 10 GeV
    (K.Reygers et al., arXiv:1910.14618)

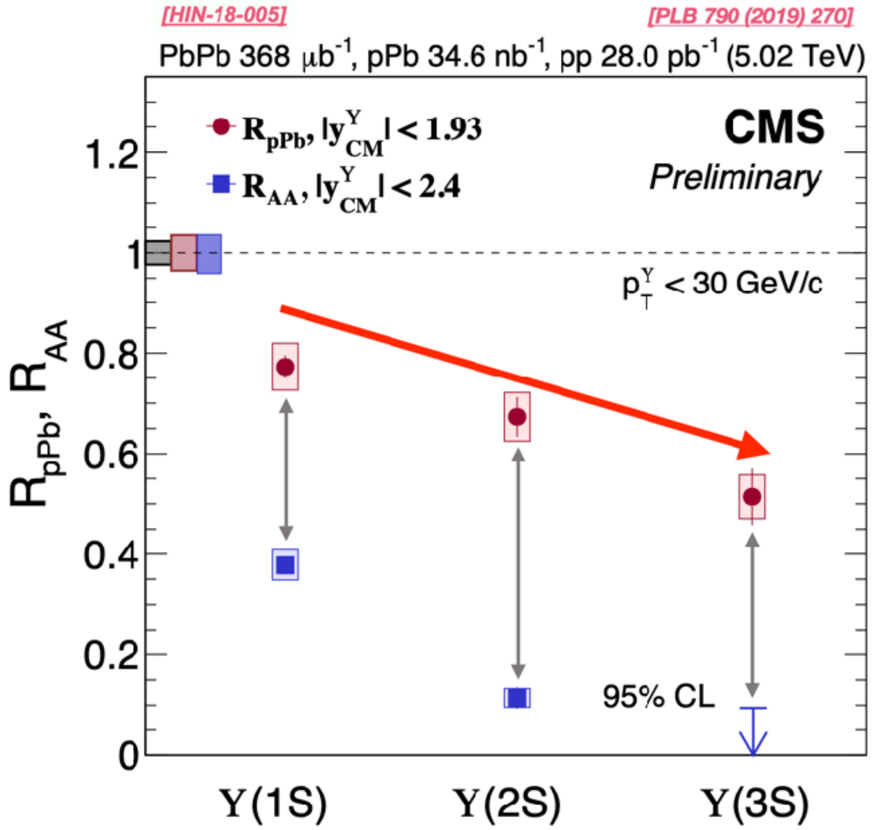
Quarkonia: Upsilon family

Rasmus Larsen [116]

Jaebeom Park [494]







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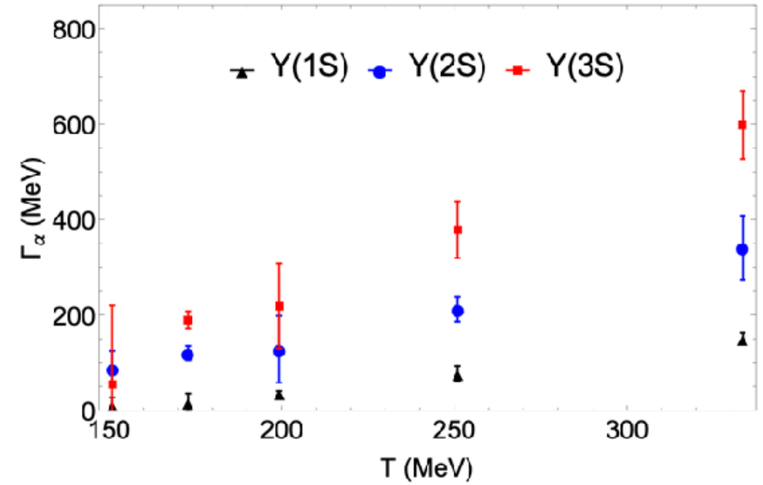

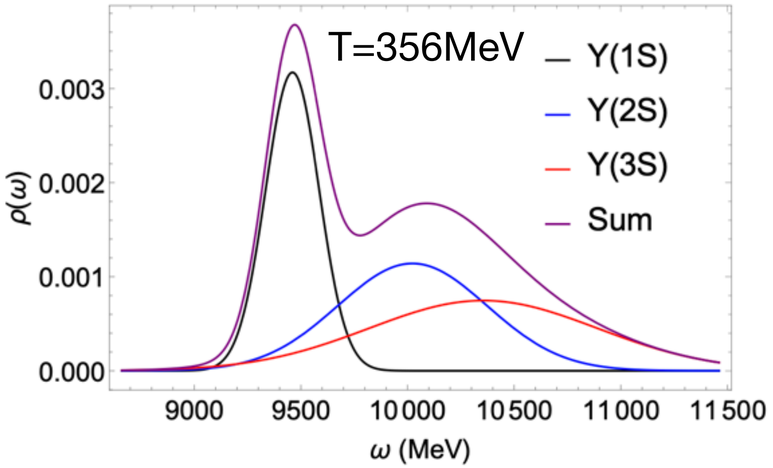

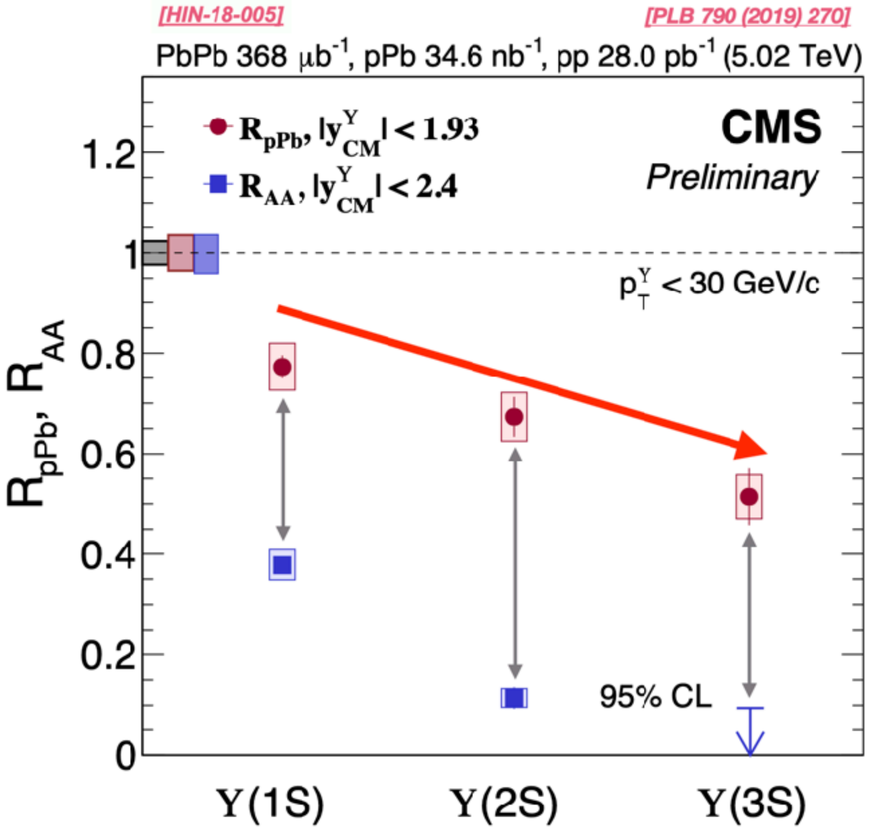

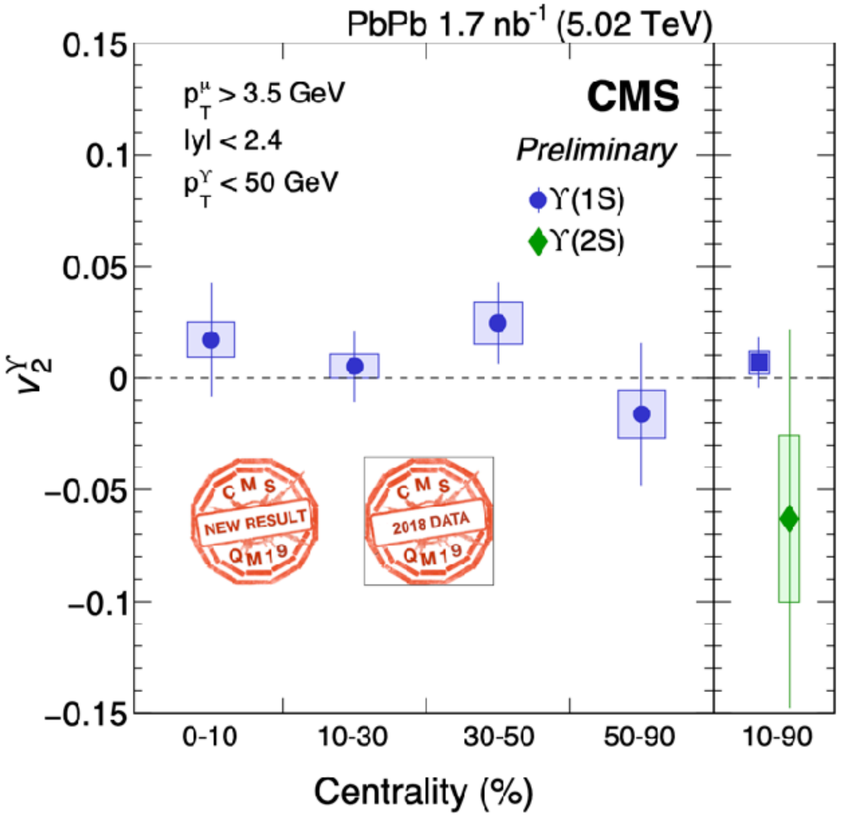

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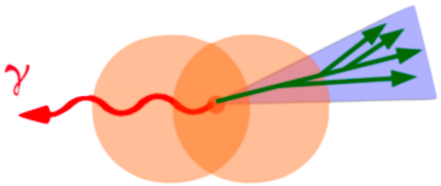
Modification of fragmentation function

PRL 121 (2018) 242301

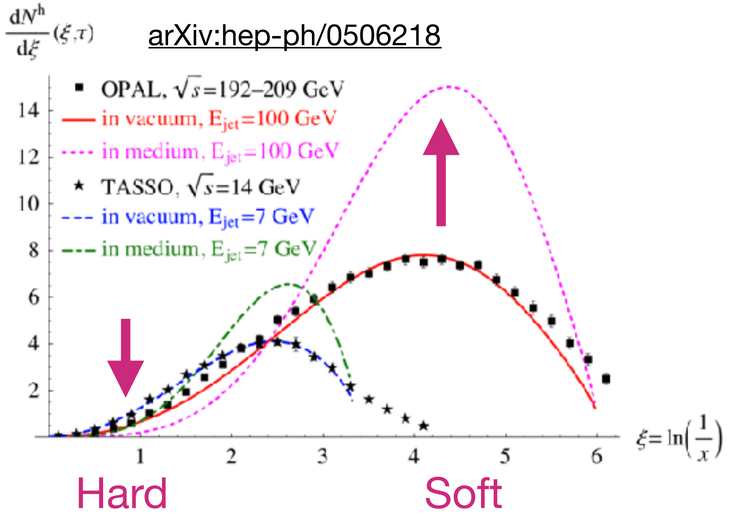
Photon-tagged jets

$$\xi_{\mathrm{T}}^{\gamma} = -\ln(p_{\mathrm{T}}^{\mathrm{h}}/E_{\gamma})$$



Expected longitudinal distribution inside jet:

arXiv:hep-ph/0506218



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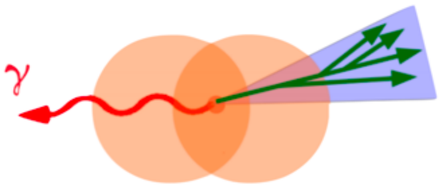

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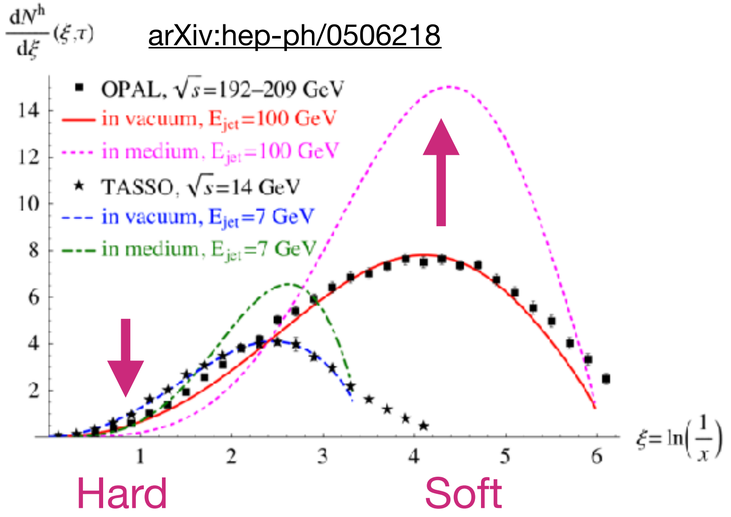
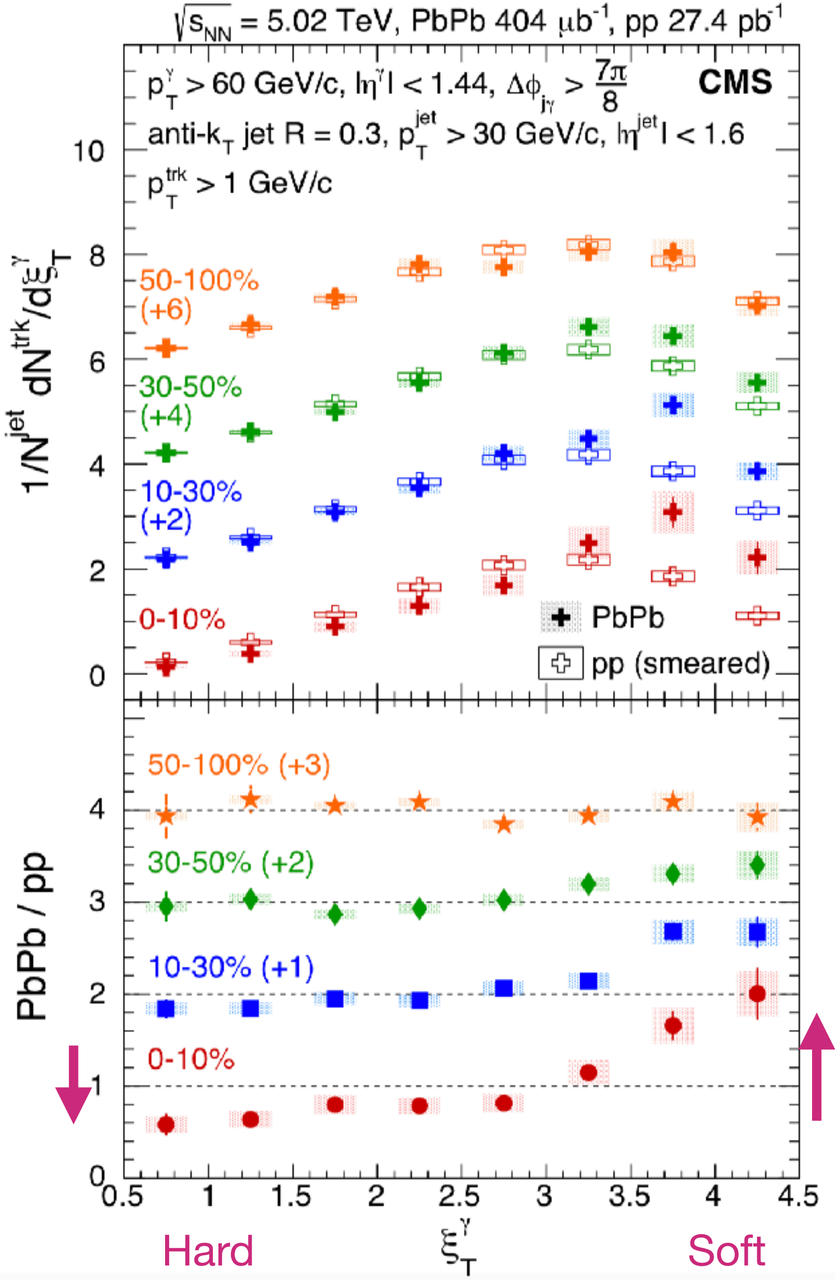


PRL 121 (2018) 242301

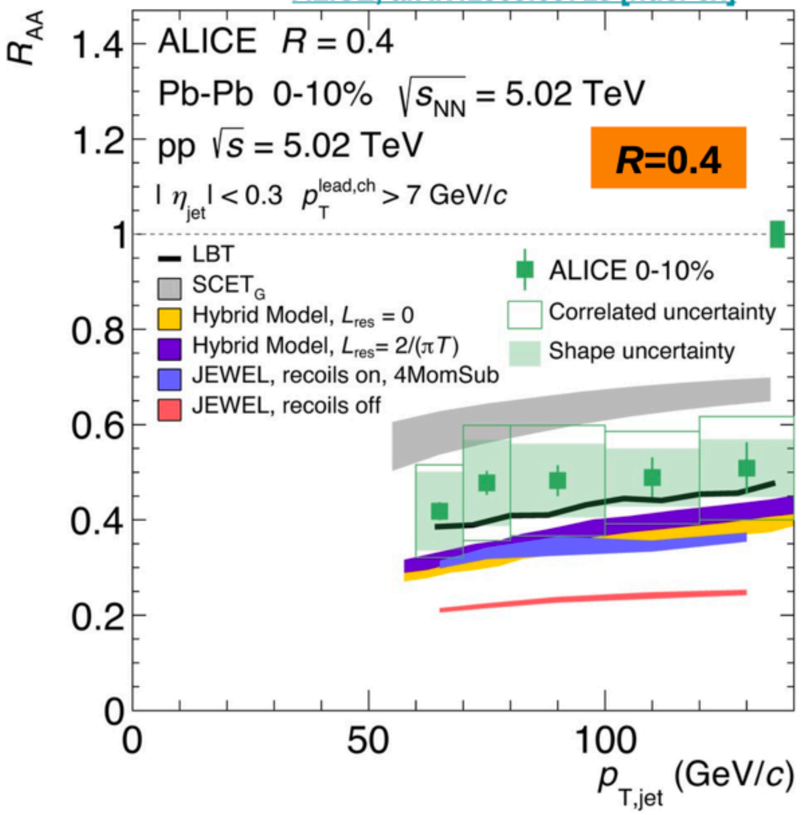


"Text book" result:
Predicted modification of fragmentation function found,
soft (low-z) particles enhanced, while hard (high-z) suppressed

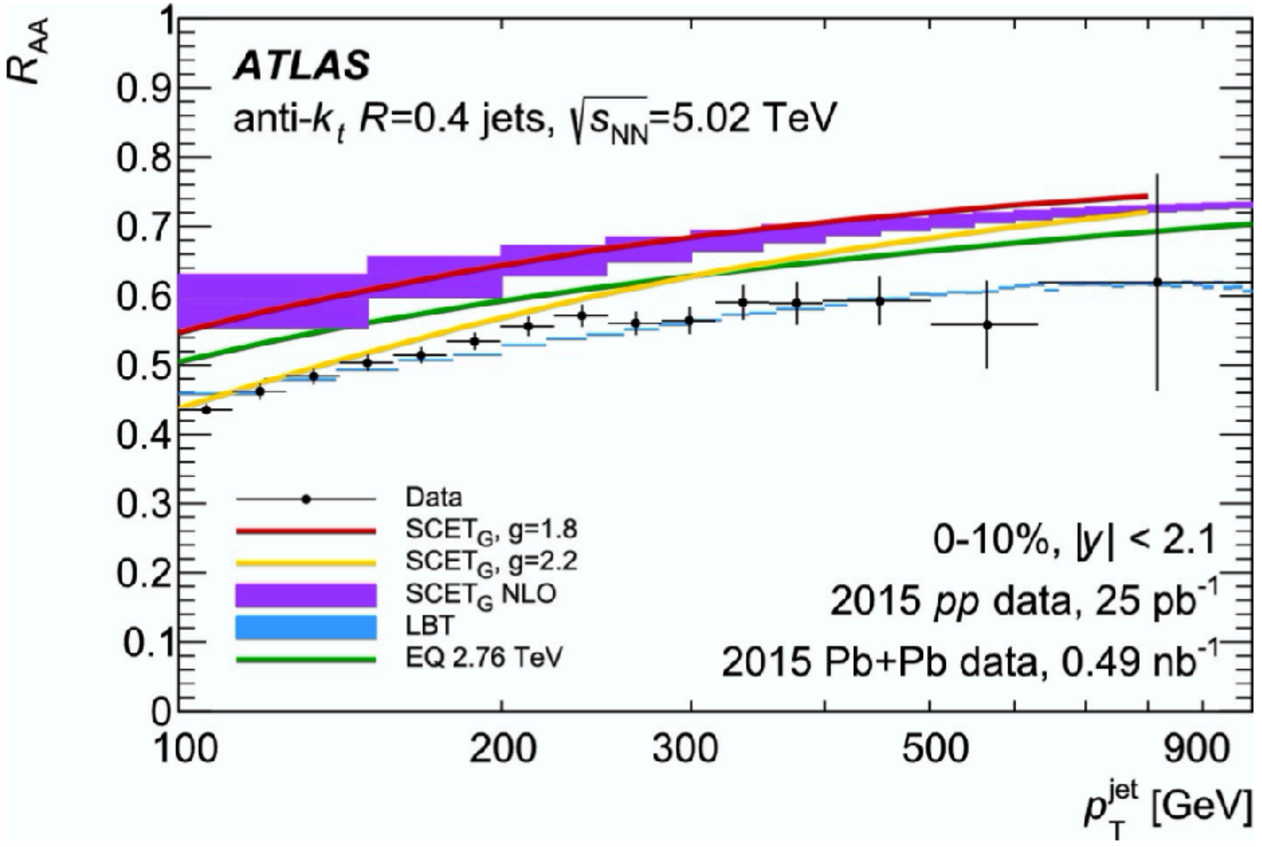
Will play a key role for precision measurements
in Run-3/4 and in sPHENIX era

Jet nuclear modification factor for R=0.4

ALICE, arXiv:1909.09718 [nucl-ex]



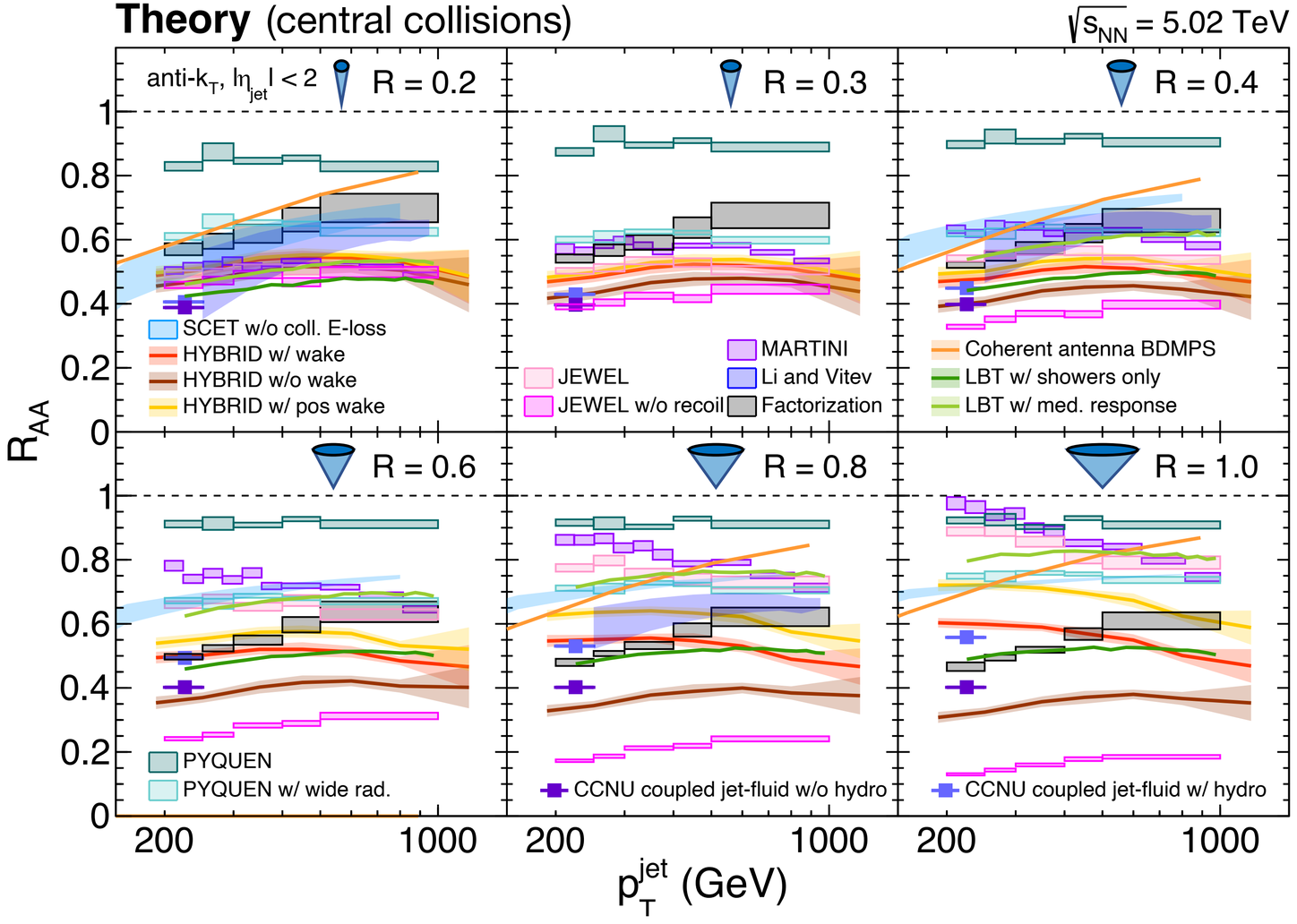
Phys. Rev. B 790 (2019) 108



Good description of R_{AA} for various models for R=0.4 over large range in p_T

Large-R model predictions for jet R_{AA} prior QM19

Molly Taylor [514]



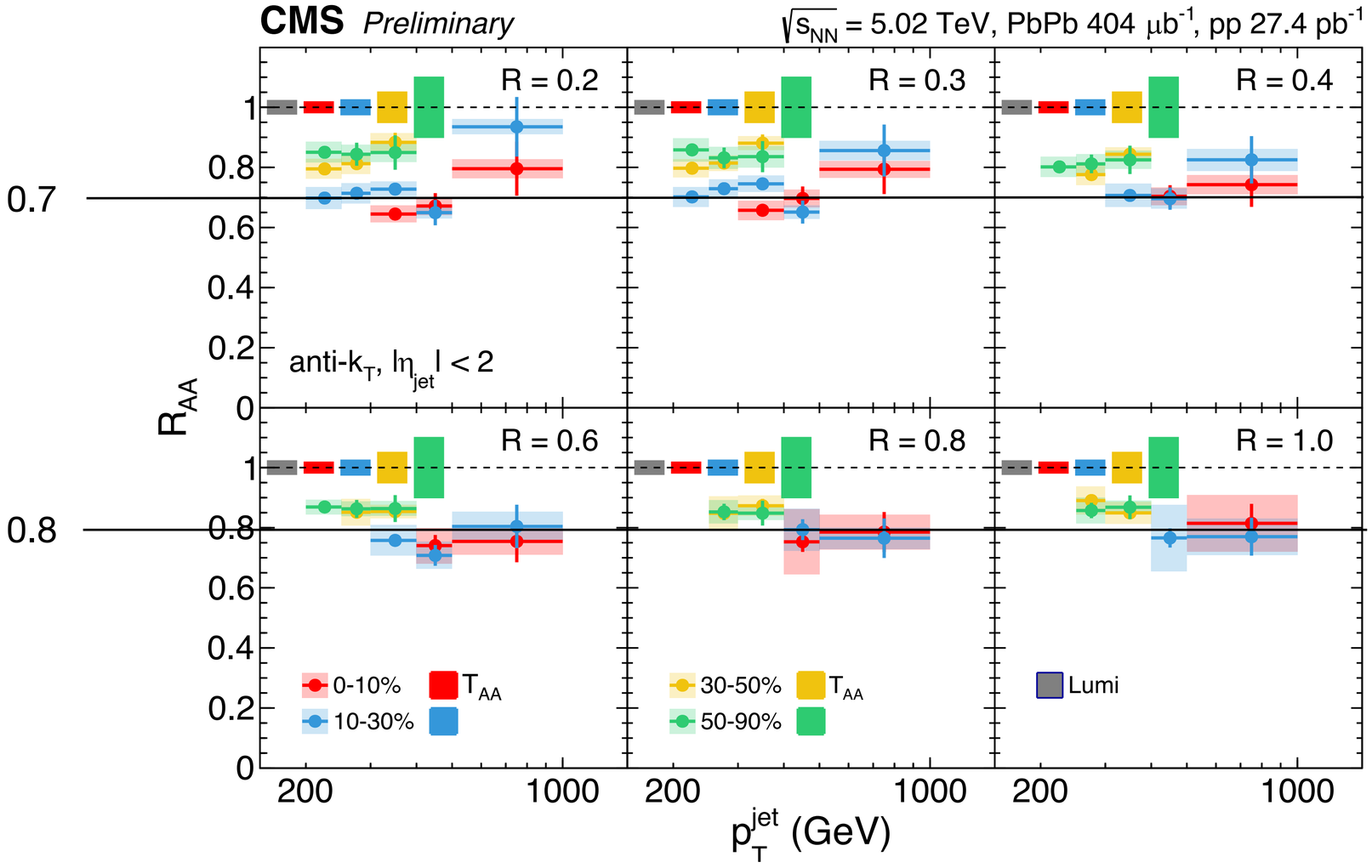
Phase space since ~10 years

New phase space

- Providing measurements in limited phase space over past years, "attracted" calculations
- Define set of reference measurements (accord) that a jet model has to be benchmarked against?

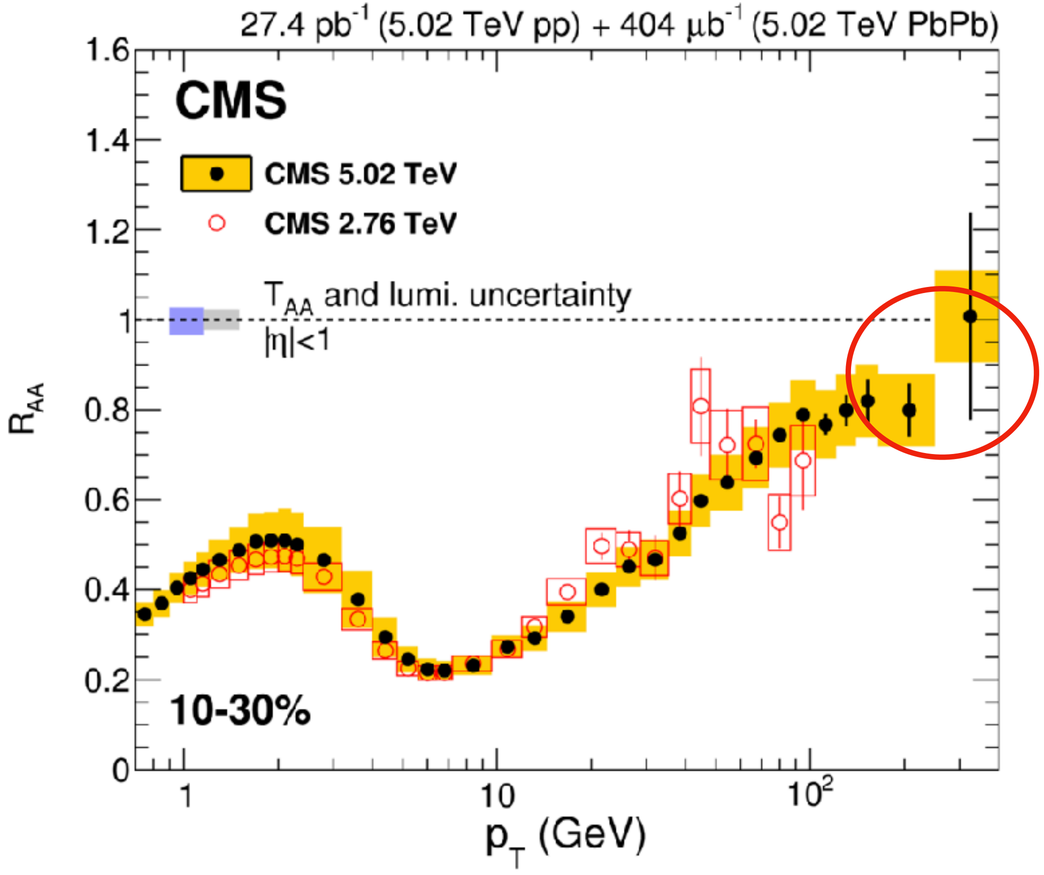
Large-R results for jet R_{AA} prior QM19

Molly Taylor [514]



- Finite suppression (with trend to decrease with p_T) in central collisions even for R=1.0
  - Suppression decreases with increasing R
  - Most peripheral collisions consistent with 1
- Wishlist: Where possible measure also to lower jet p_T; (and to even higher p_T in Run-3/4)

One of my puzzles over the past years "solved"



~0.8-1?

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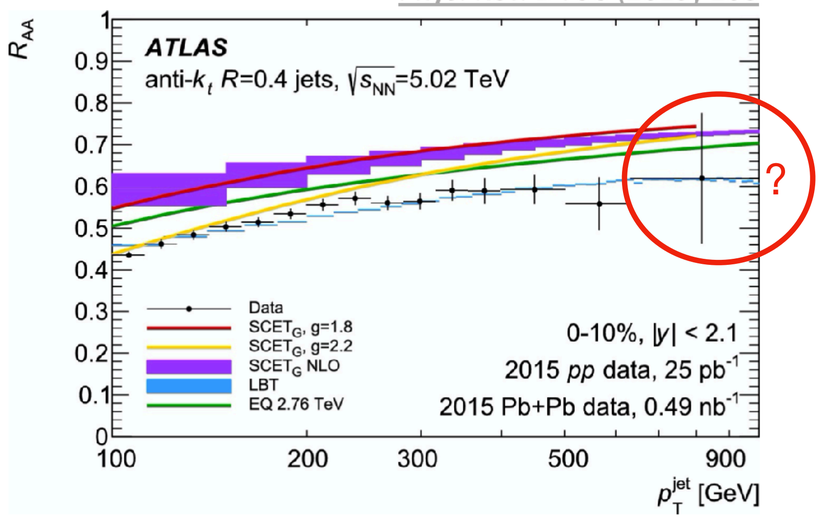
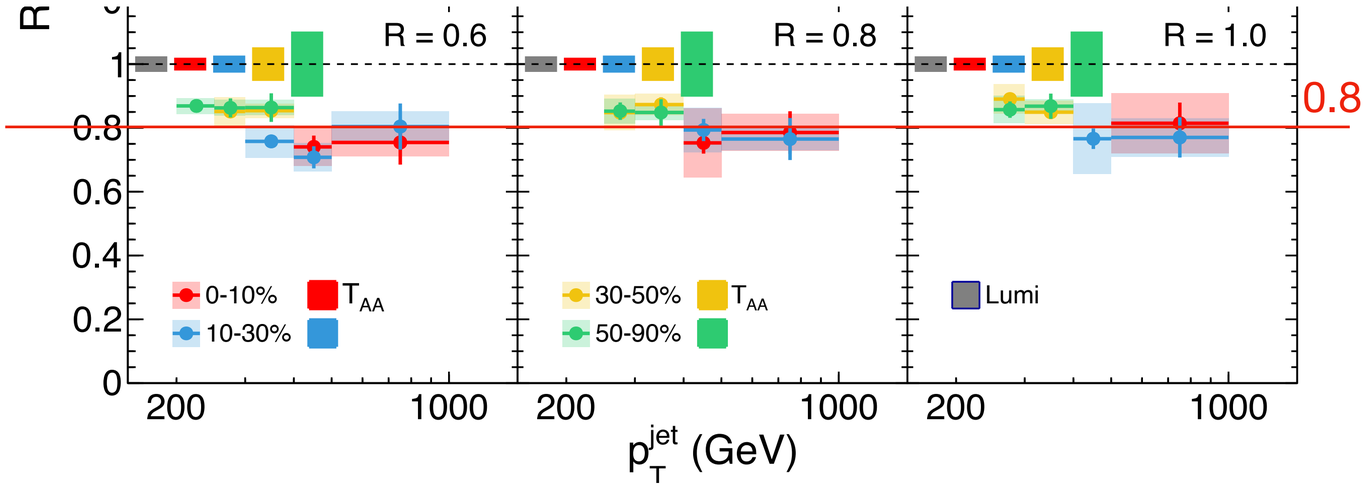
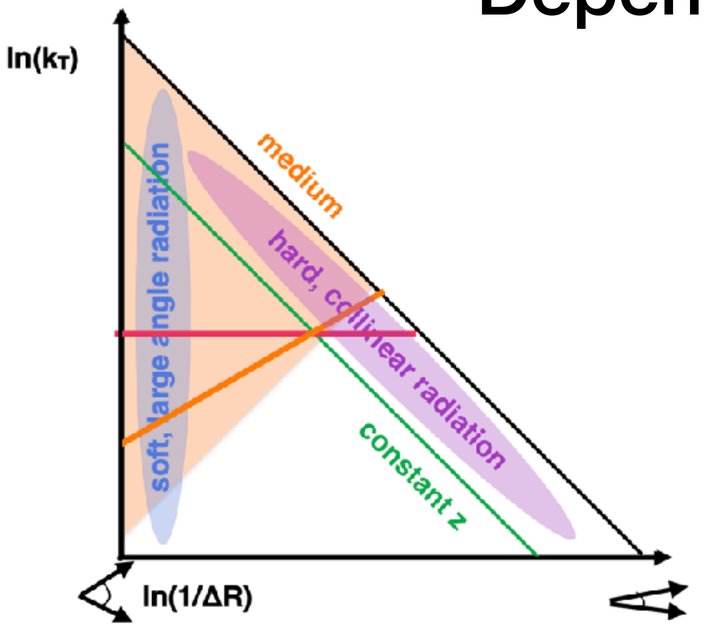




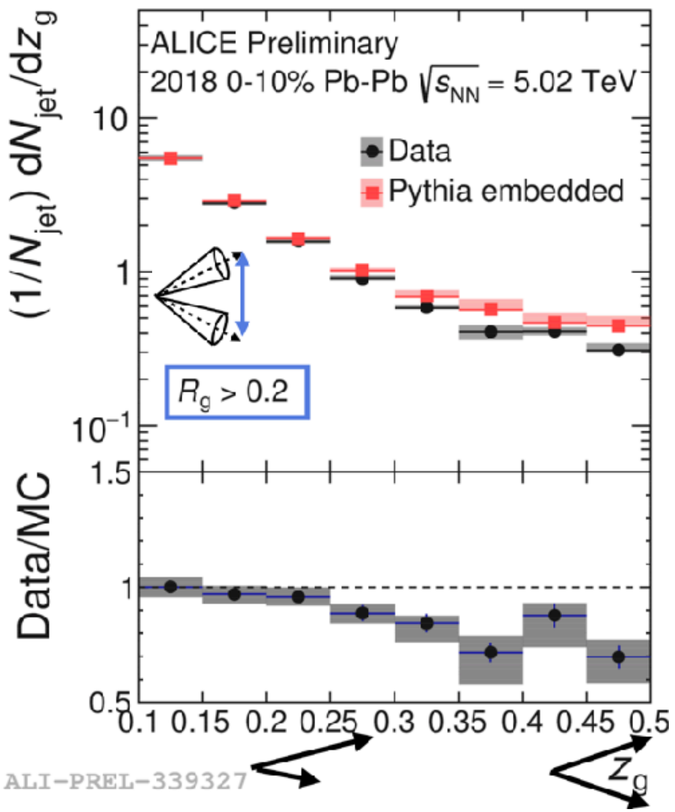
0.8

Wishlist: Measure the charged particle R_{AA} to higher p_T with the 2018 data:-)

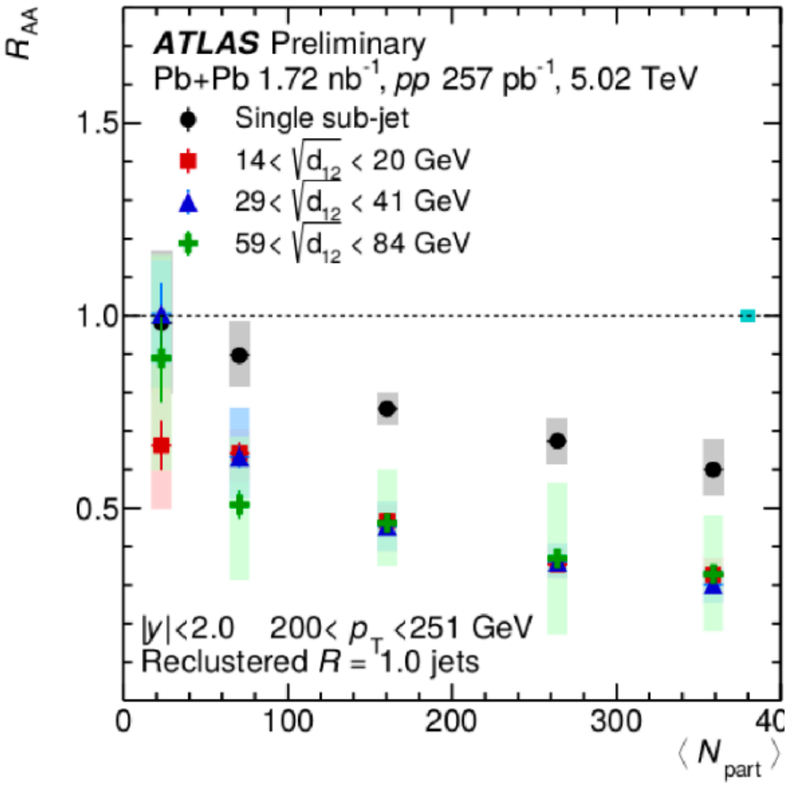
Dependence of suppression on jet structure



Laura Havener [242]



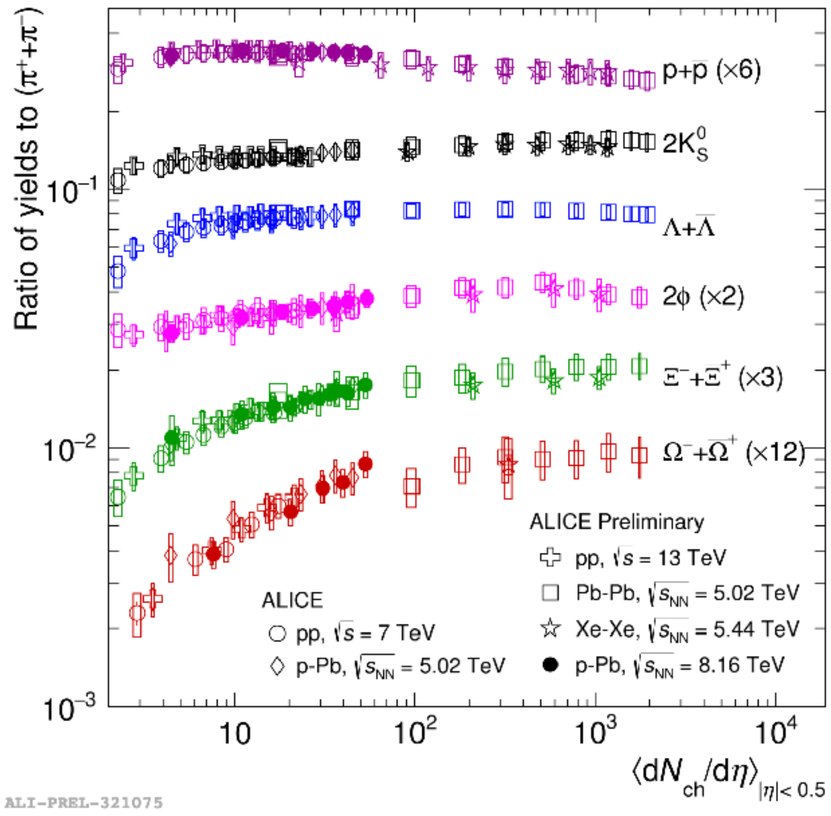
Martin Rybar [134]



- Substructure and reclustering techniques are extremely promising window to access the partonic structure of the shower
- Already at this QM, new evidence for coherent/wide angle energy loss picture:
  - Symmetric splittings for wide-angles suppressed relative to vacuum
  - Single sub-jets less suppression, than jets with multiple subjets

Strangeness enhancement with multiplicity

Silvia Pisano [167]



- Yields vary with multiplicity, rather independent of collision species and energy
- Rapid rise at low M plus QGP signals in pp collisions lead the idea of core/corona models
  - Good description of data across systems with universal approach (similar to EPOS)
- Experimental check in Run-3/4

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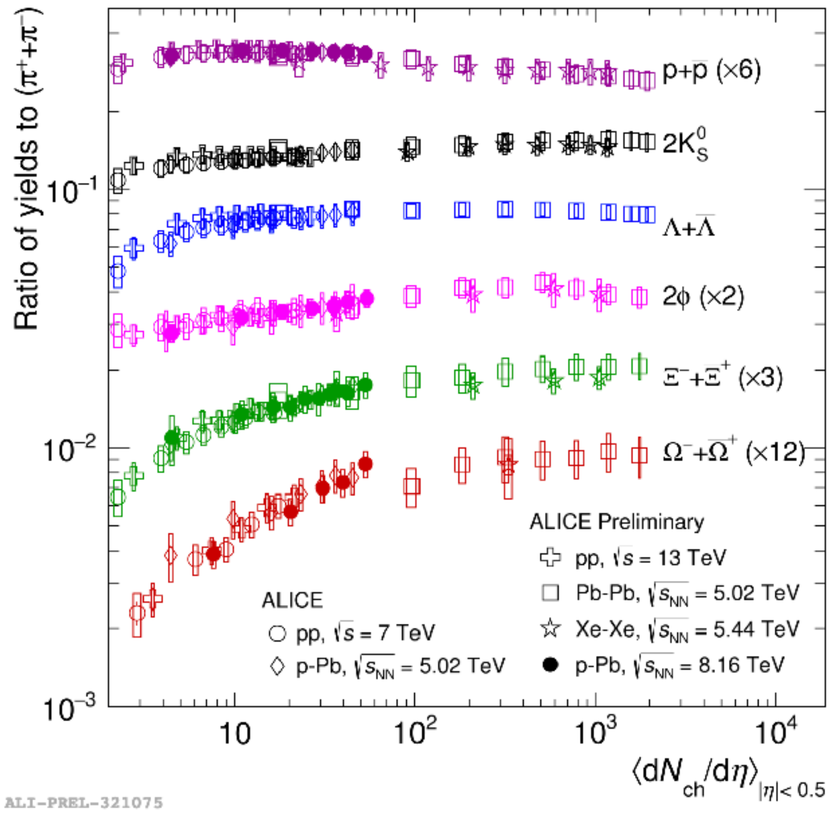

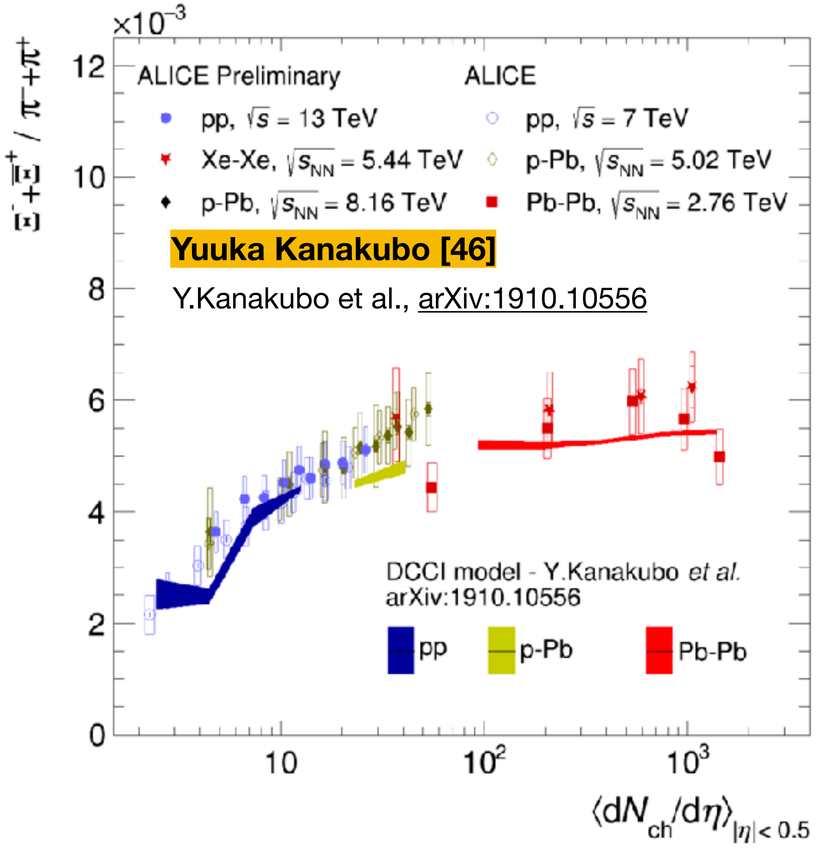

Yuuka Kanakubo [46]

Y.Kanakubo et al., arXiv:1910.10556

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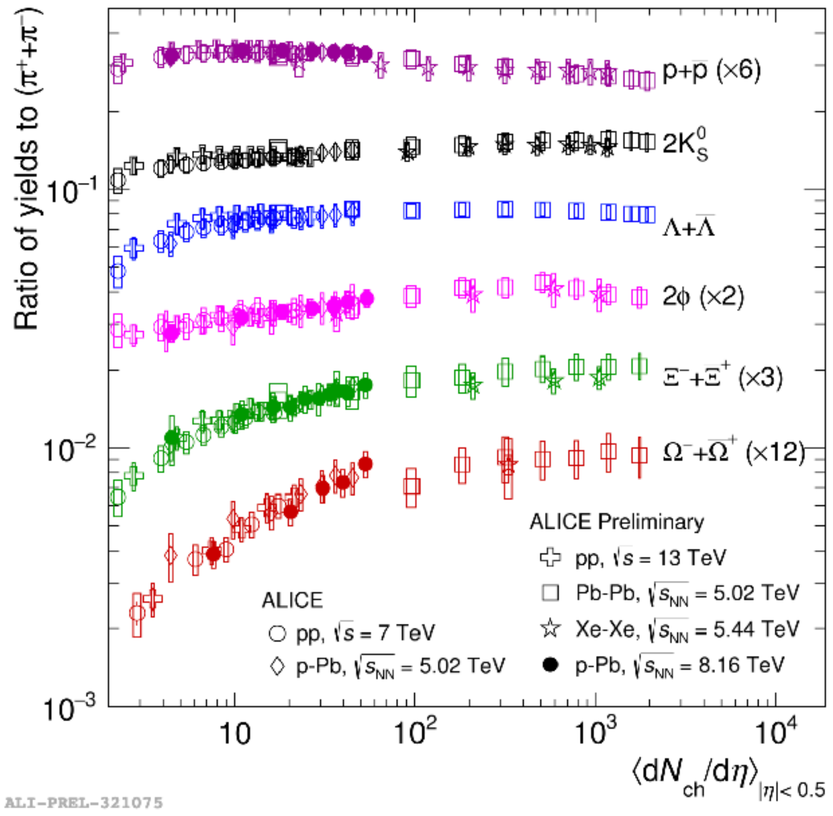
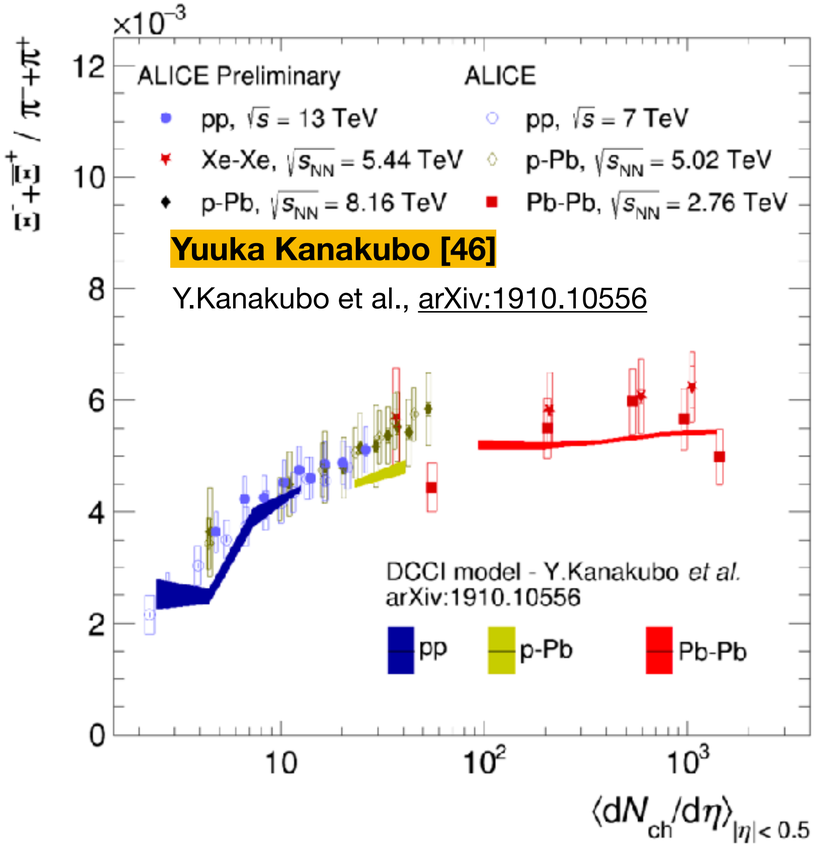
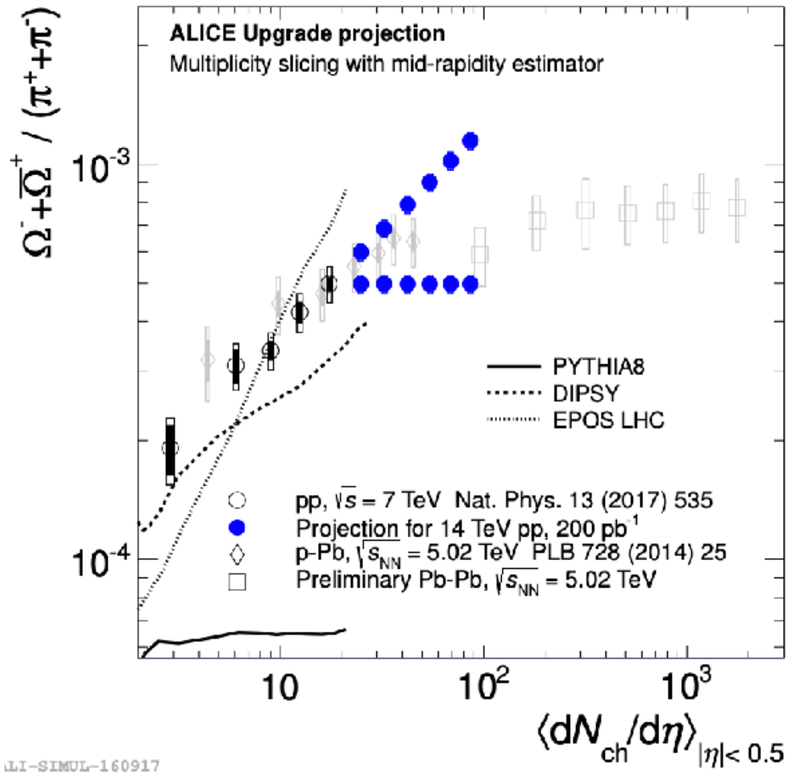




200/pb minbias pp program



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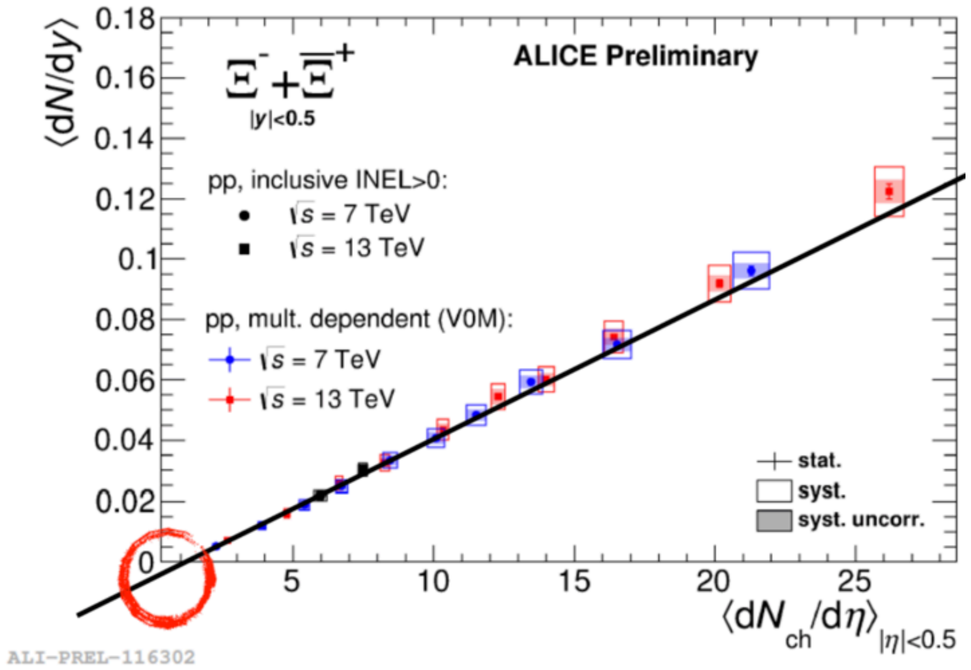
Alternatively, effect driven by soft/hard particle correlation?

☞A.Morsch, LightUp workshop 2018



- Offset in particle production can be parameterized with $y = a\left(1 - \frac{n_0}{\langle N \rangle}\right)$
- Interpretation:
  - Min. associated M to multi-strange production and/or different scaling of soft and (semi-)hard processes vs b
    - Induces suppression at low M (generally for all hard processes)
    - Not seen in PYTHIA because strangeness much softer than in data (effect there in PYTHIA for charm)
- First analyses presented at the conference trying to differentiate pictures
  - Yield in/outside jets, vs multiplicity in transverse region, Ξ-π and Ξ-K particle correlations
  - Not yet crispy/conclusive... but stay tuned

Posters: J. Adolfsson, O.Matonoha, A.Nassirpour

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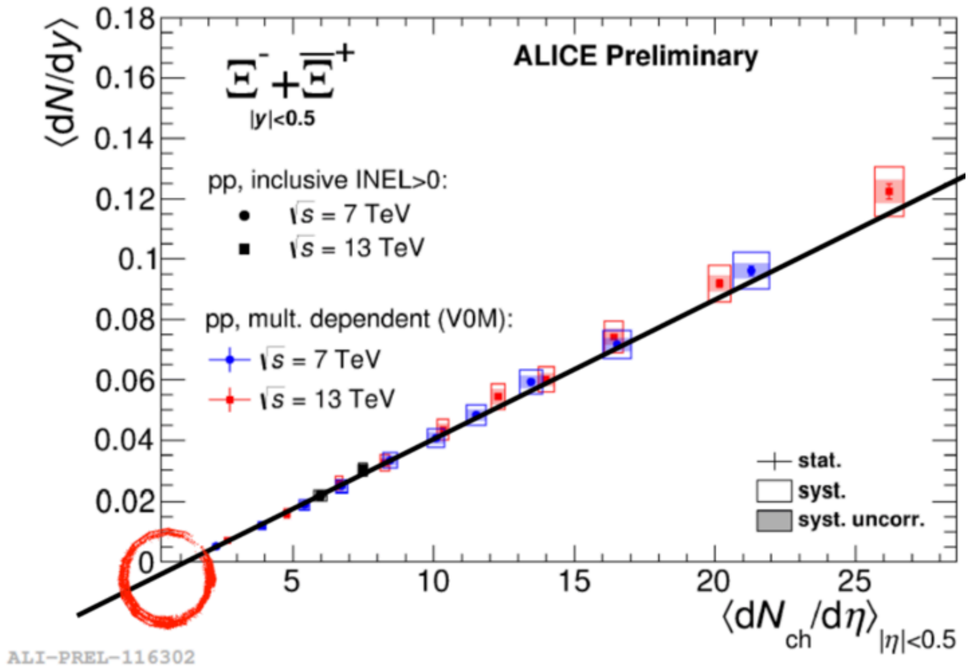

Ξ/π

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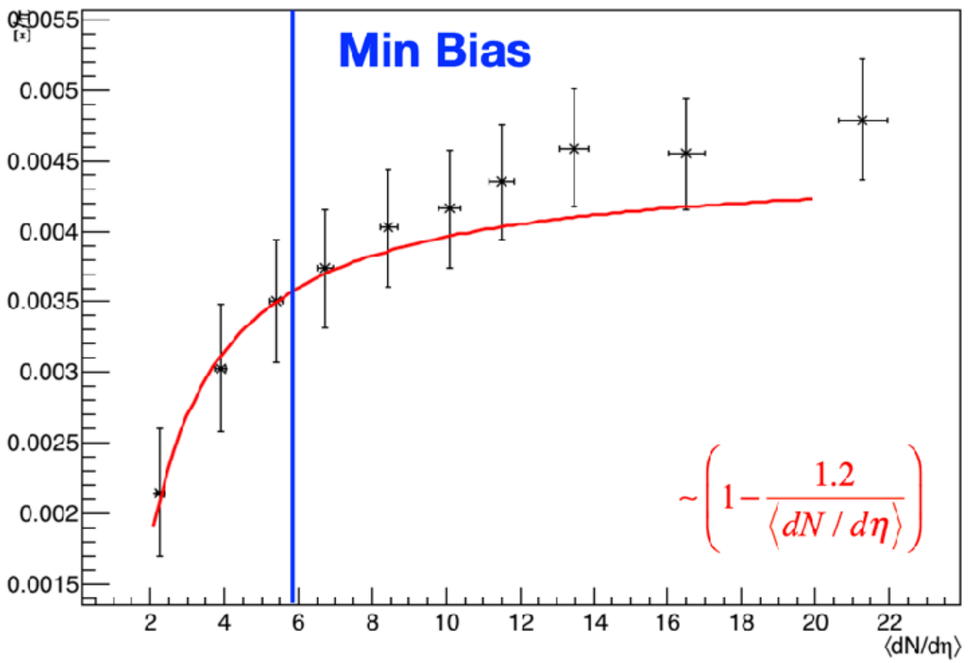

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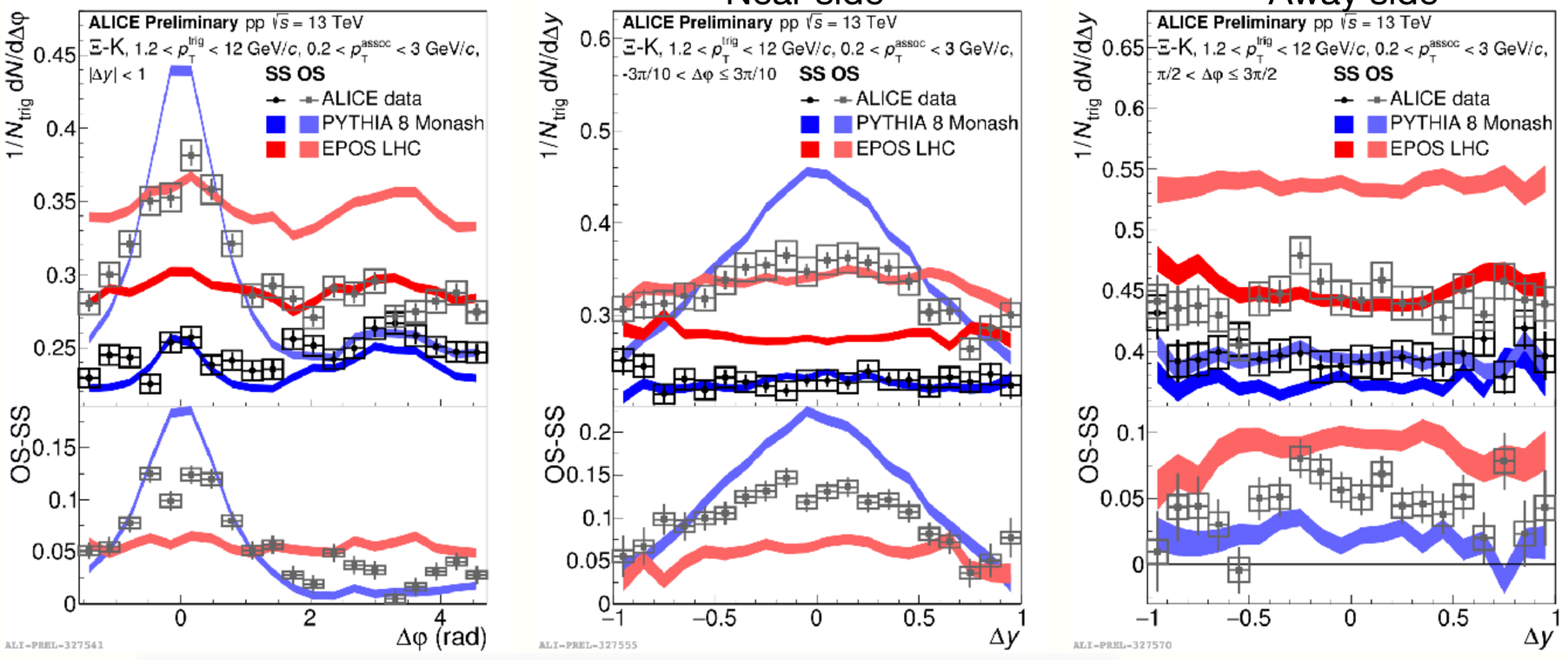
Alternatively, effect driven by soft/hard particle correlation?

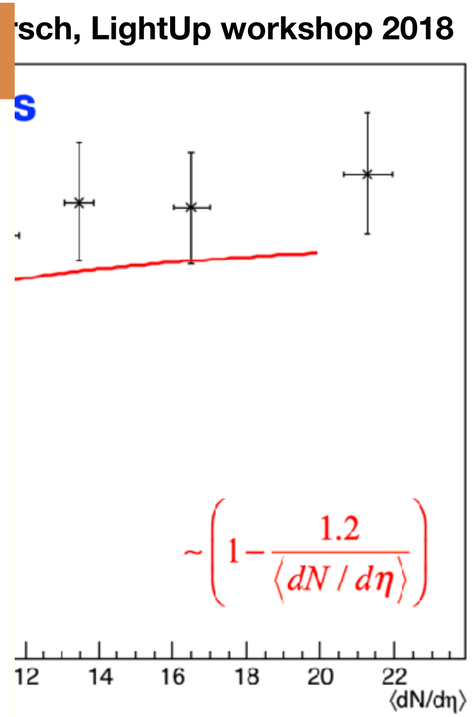
Ξ – K correlation results

Poster: J. Adolfsson

Near side

Away side





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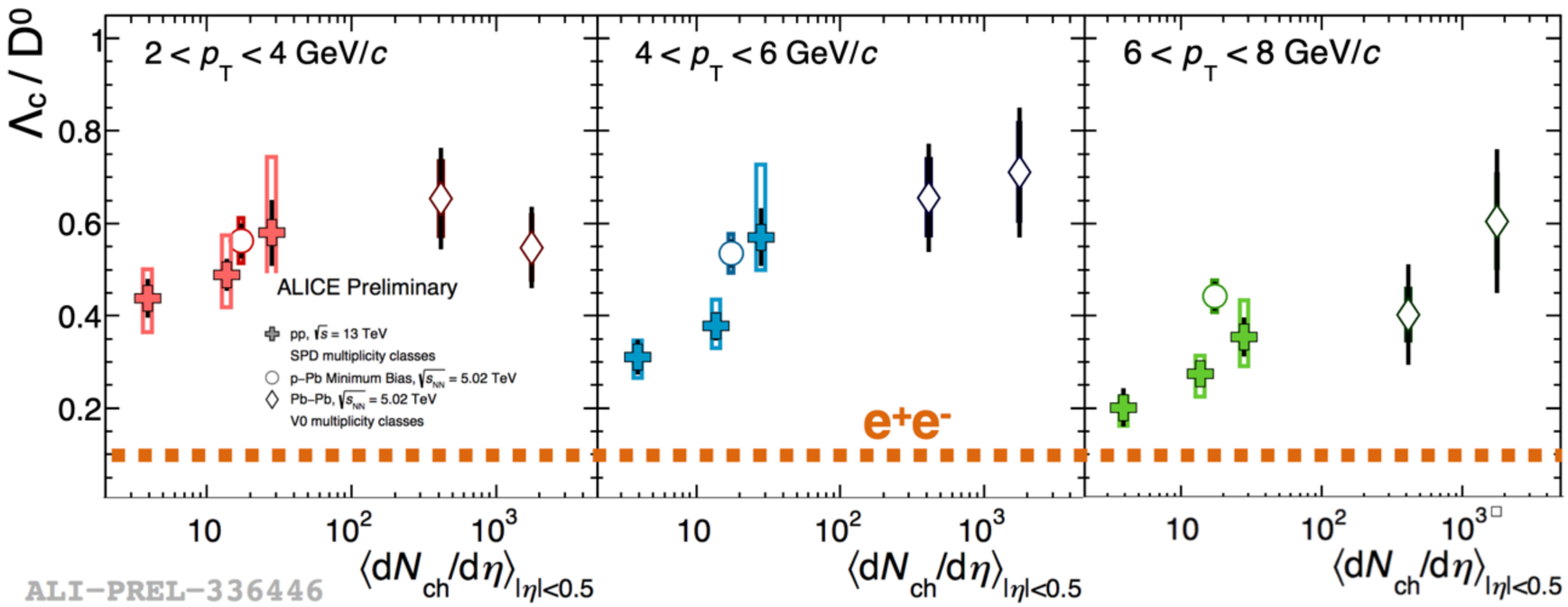
Posters: J. Adolfsson, O.Matonoha, A.Nassirpour

The Λ_c/D^0 surprise

Gian Michele Innocenti [172]

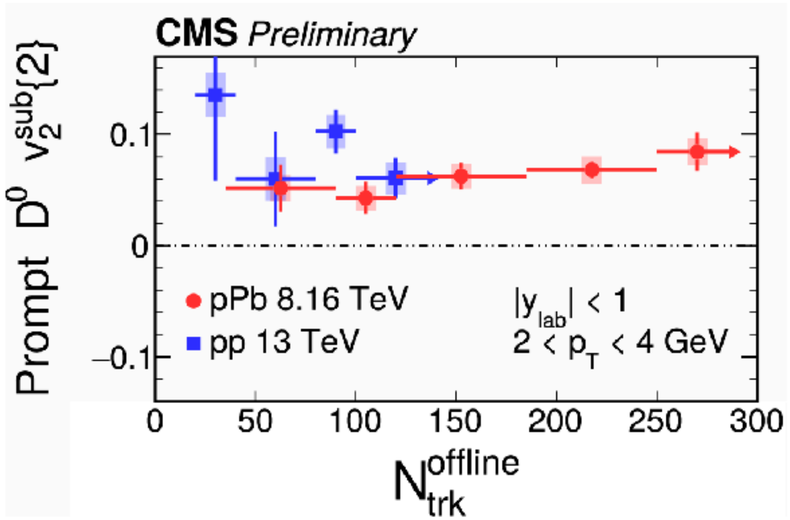


- Smooth increase of ratio with multiplicity
  - Lowest pp point (below pp average) already significant higher than e+e-
  - Highest pp point approaches values in PbPb
- Qualitative agreement with "recombination" hypothesis saturating already few times mean pp mult (~6)
- Recombination would require notion of local space-time density
- Alternative mechanism in PYTHIA (color reconnection) can describe the data (but is not universal)
- Opens up research on hadronization at pp and future ep,eA colliders

Brian Cole [132]

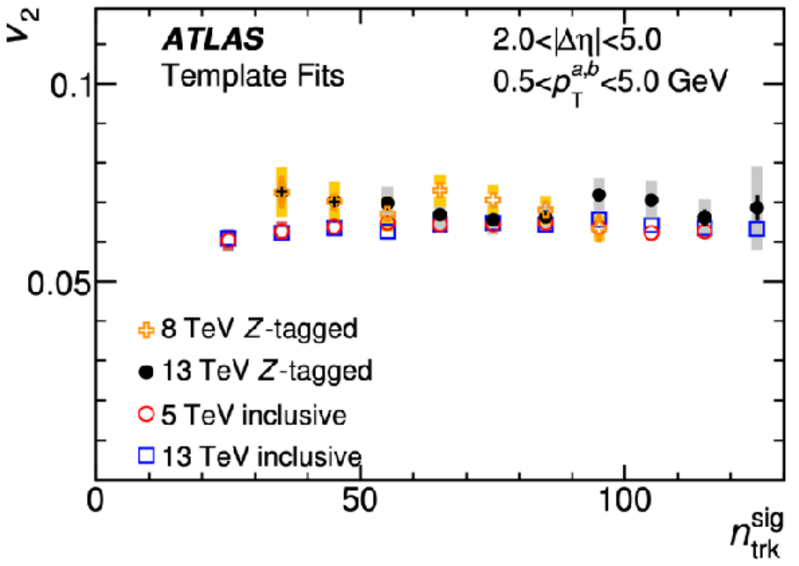
"Geometry" scan at LHC

Austin Baty [500]

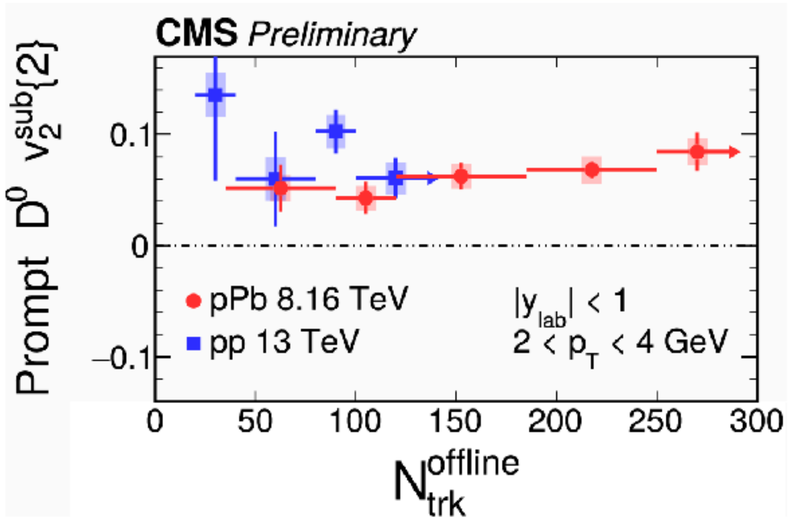


- In pp events, heavier particles up to D^0-mesons show v_2 , B-mesons do not show v_2
- "Engineered events"
  - Finite v_2 in UPC and Z-triggered events
    - To my ATLAS colleagues: When do you have enough stats to measure the v_2 in Higgs events?
  - Absence in e+e- (and ep events, statistically limited)
  - Wishlist: Measure yield ratios vs p_T, or even just mean p_T, particle spectra
- Calculations suggest dominance of final state beyond dN/dη>~10
  (B.Schenke et al., arXiv:1908.06212)

"Geometry" scan at LHC



Austin Baty [500]



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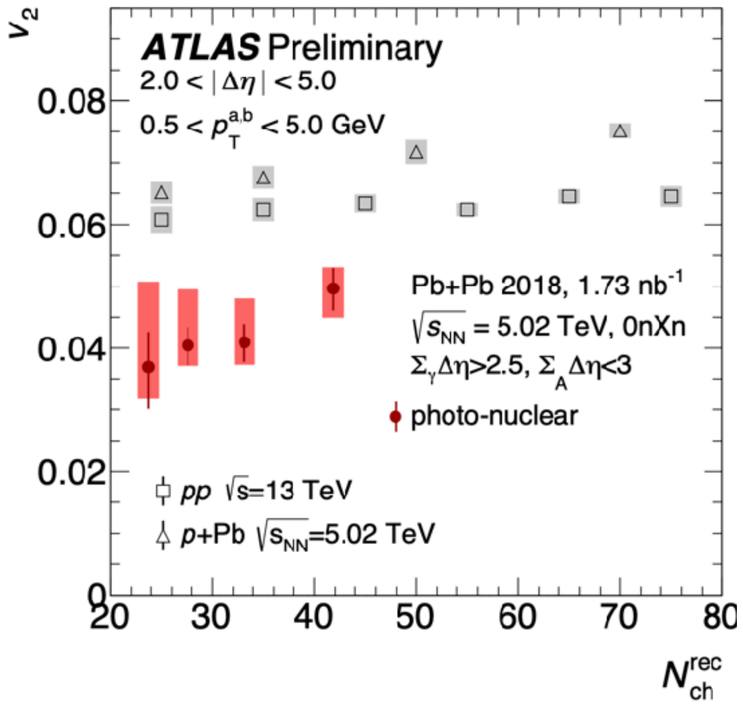

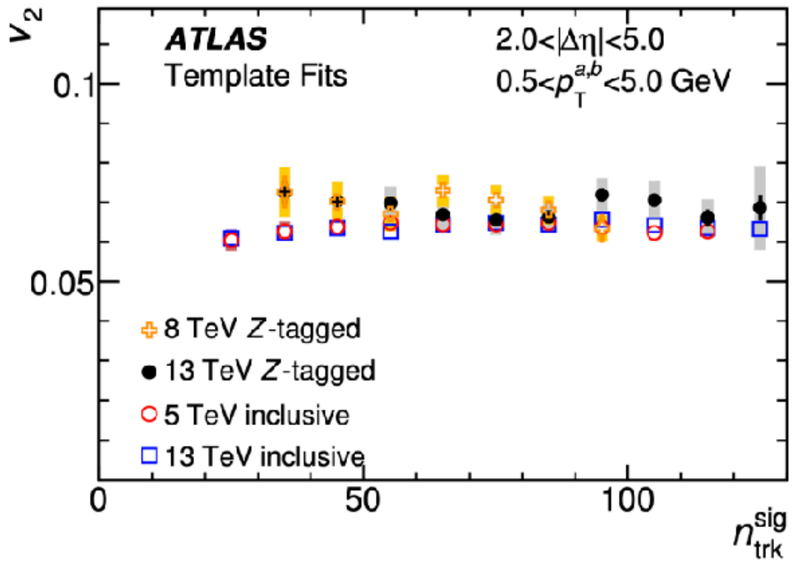

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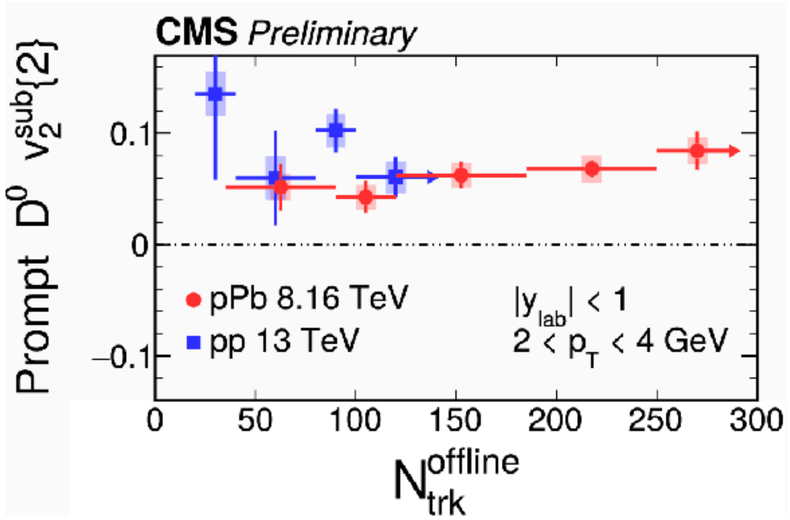

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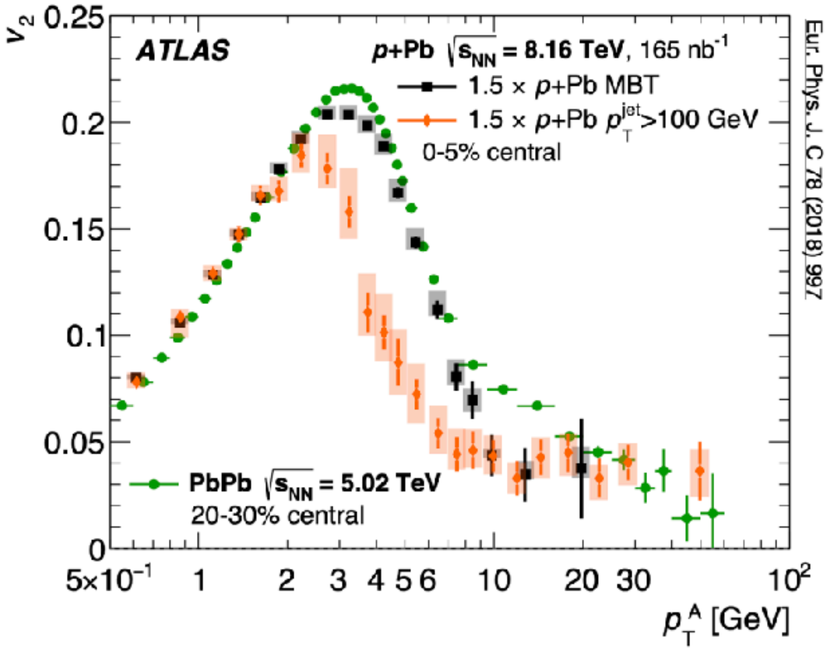
The "high-p_T v_2" puzzle

Kurt Hill [129]



- Significant v_2 values up to high p_T measured in pPb using the template fit method
- Can not consistently be interpreted due to parton energy loss as it implied strongly suppressed R_{pPB}
- The similarity of the shape to PbPb asks whether there is a yet unknown source of v_2 in both systems?
- Remember: The measured fact is that
  "there is a long-range correlation between hard and soft particles on the level of 2% in the 0-50% centrality"
  - Could it be from remnants of the dijet?
    - Perform measurement in subsample where one jet is constrained into the calorimeter
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- For calculations: Jet energy loss in HRG seems sizable ($\hat{q} = 0.4\,\mathrm{GeV}^2/\mathrm{fm}$); should be included (in general!)
  (P. Dorau et al., arXiv:1910.07027)

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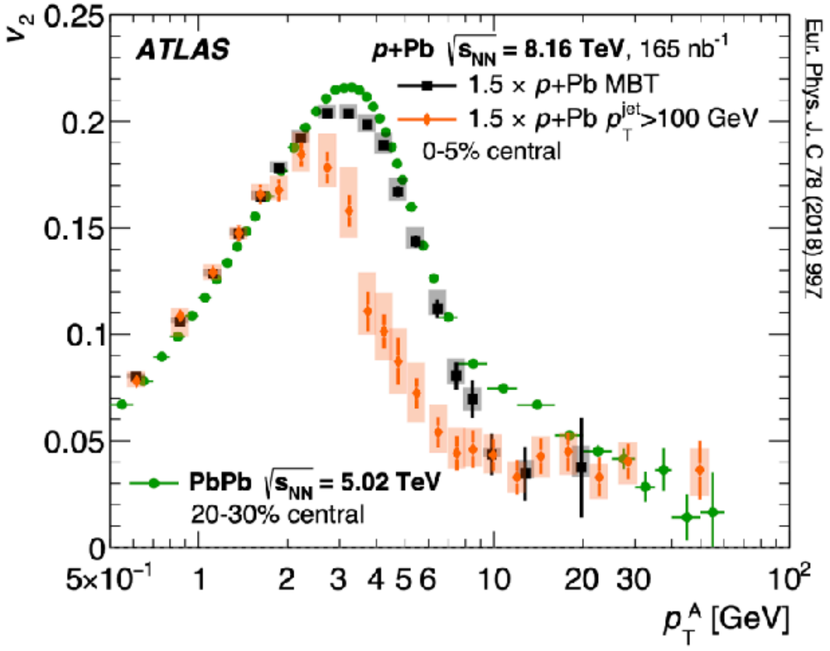

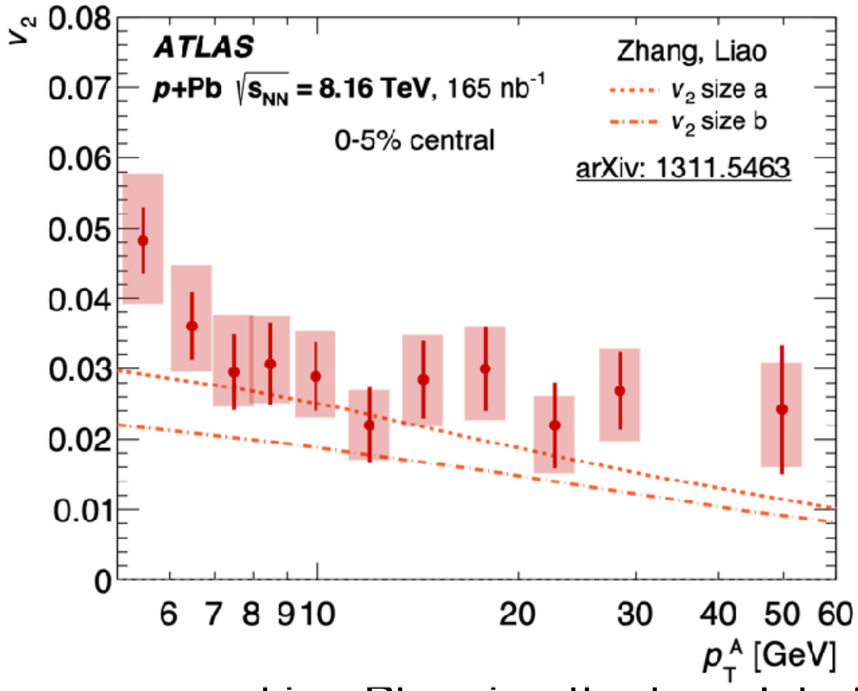

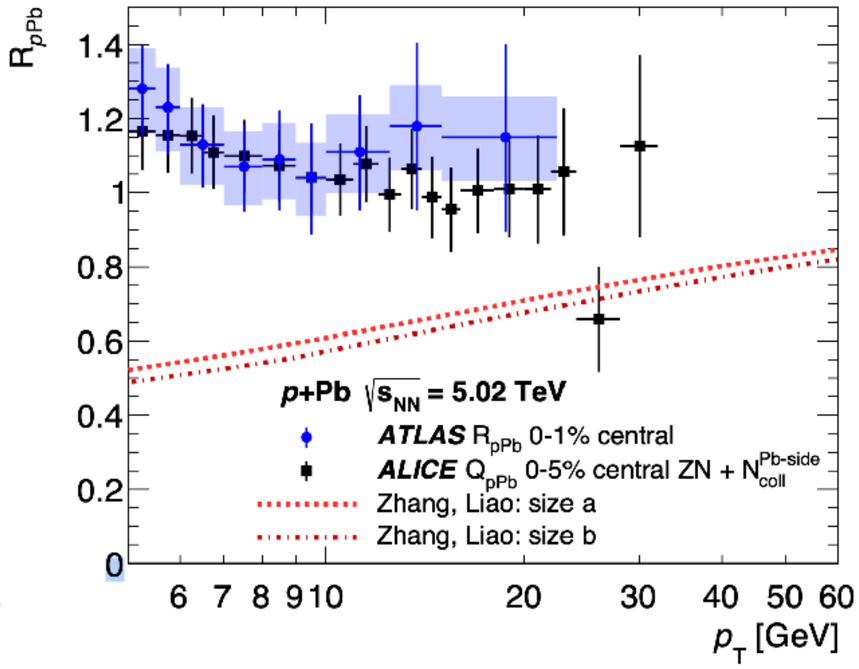

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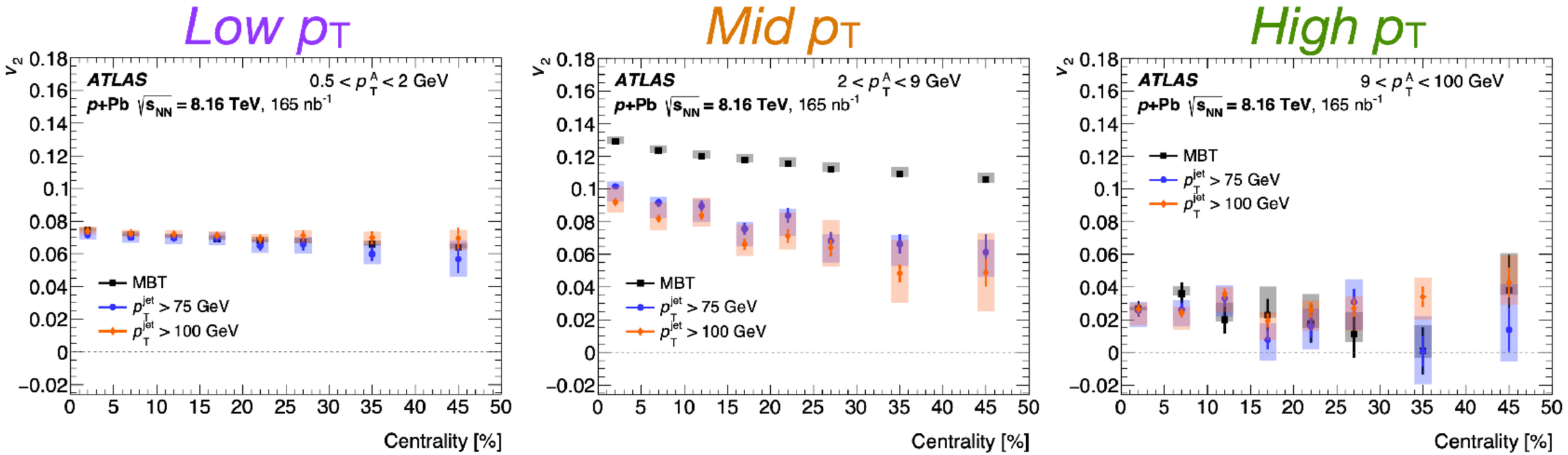

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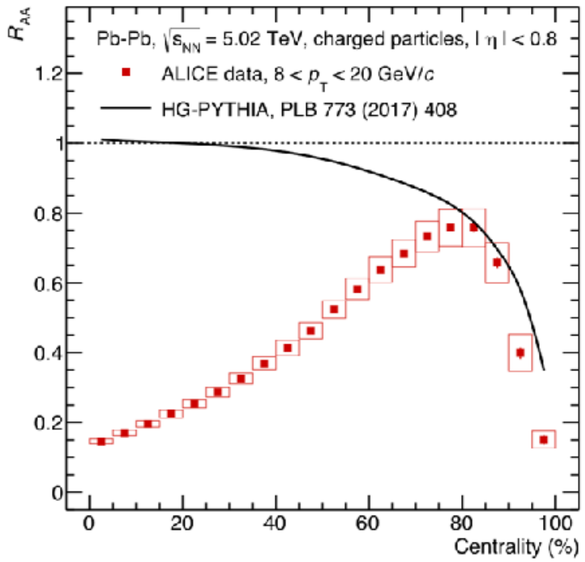
Onset of jet quenching



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- Idea to study onset at LHC with OO collisions
  - Unlike it pp or pPb have centrality plateaux for Ncoll normalization
  - Expected effects will be small (max ~20% estimated from XeXe)
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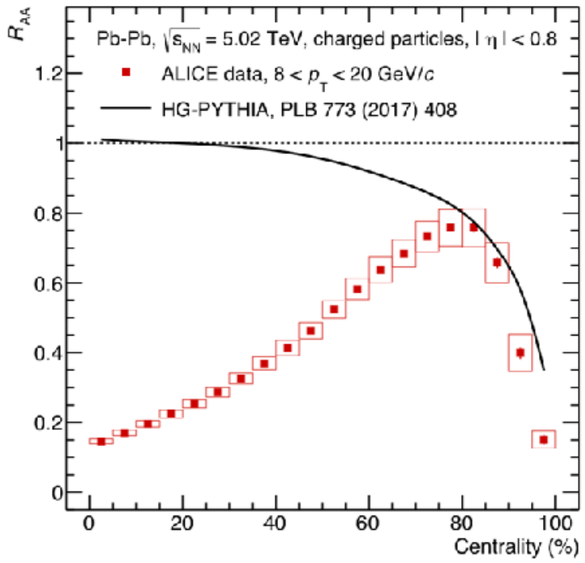

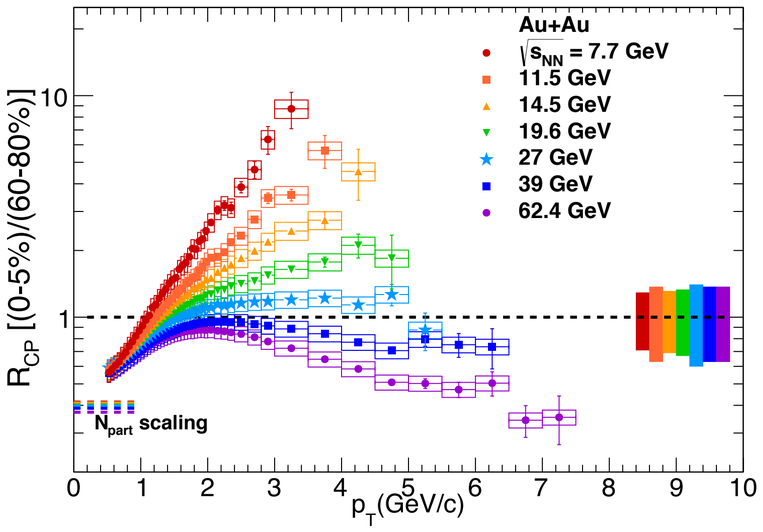

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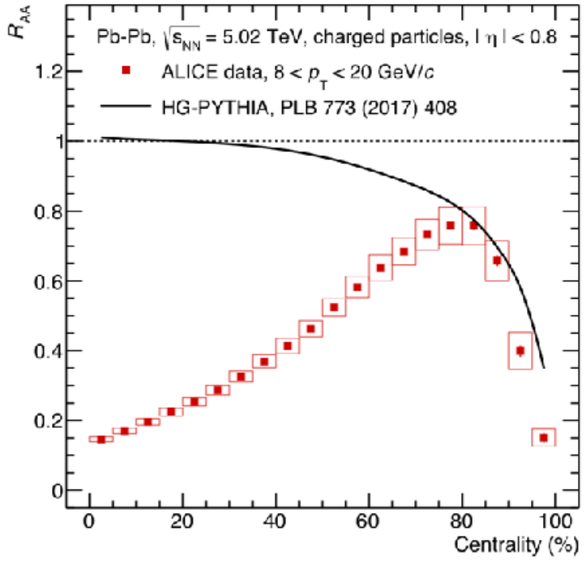

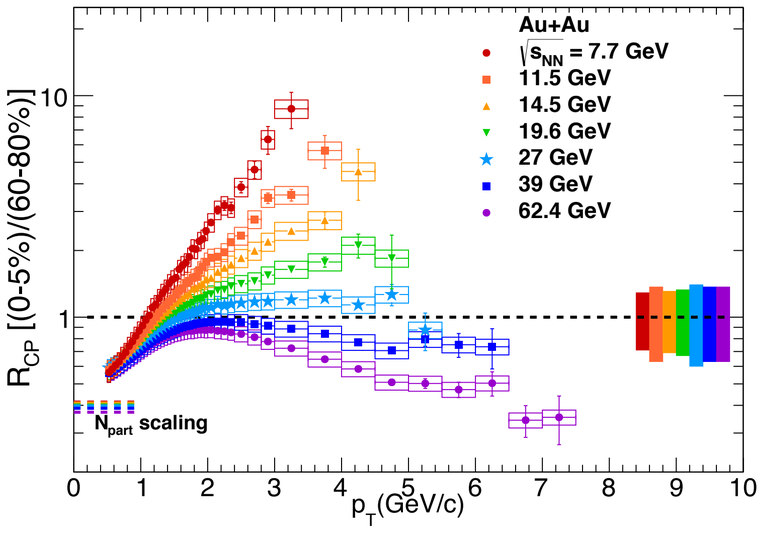

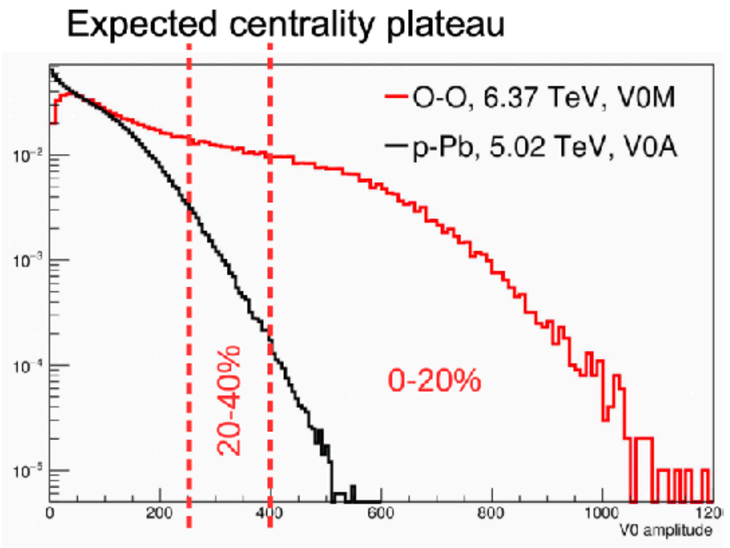

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From my QM 2015 talk (arXiv:1602.09138)

- Hypothesis:
  The Physics underlying the observed collectivity is the same
  - sQGP: thermo and hydrodynamics (maybe "at the edge") (→ Piotr)
    - Inconsistent with large v_2 and without direct evidence of jet quenching?
  - sMOG(*): non-equilibrium parton dynamics (maybe can drive the system from weak to strong collectivity?) (→ Paul)
  - CGC + "evolution model" (→ Soeren)

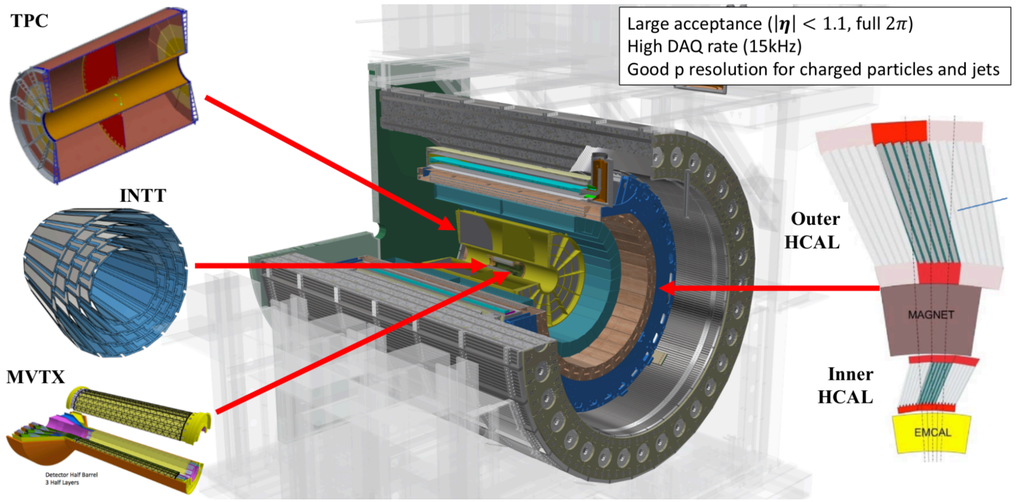
Maybe still a possibility, but needs consistent approach

- Four years later, I am now convinced that we indeed likely see the sQGP properties shining through even down to multiplicities just above that of minbias pp collisions at LHC energies
  - Note that "flow without jet quenching" does not rule out a QGP
- Focus rather now on the "how" and "why", and "there implications", rather than on "if"

The high-energy frontier: Future

2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2040	2050
BESII	BM@N	MPD LHCb-ft	NA62	CEE sPHENIX		CBM/NA60+/J-PARC-HI							

sPHENIX



Systematic exploitation of hard probes at RHIC
to explore the inner-working of the QGP

The high-energy frontier: Future

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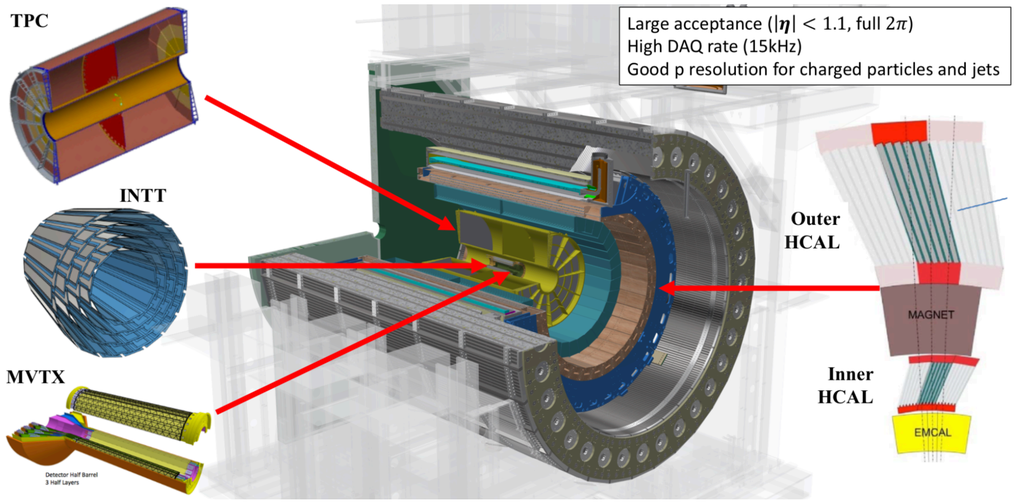
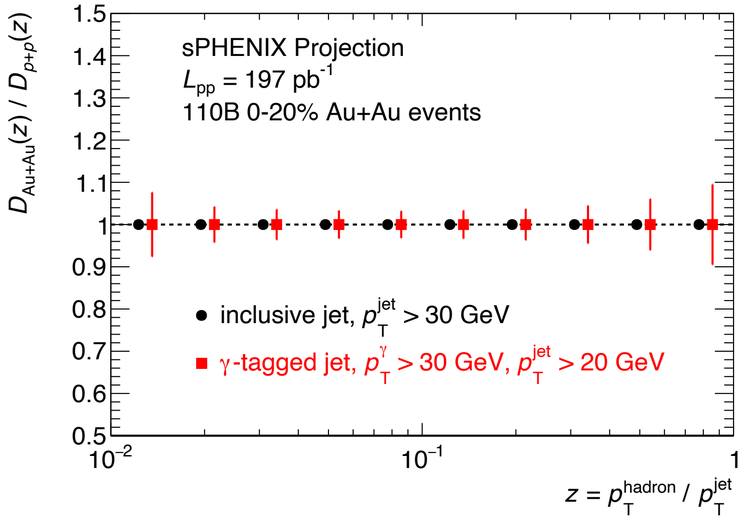
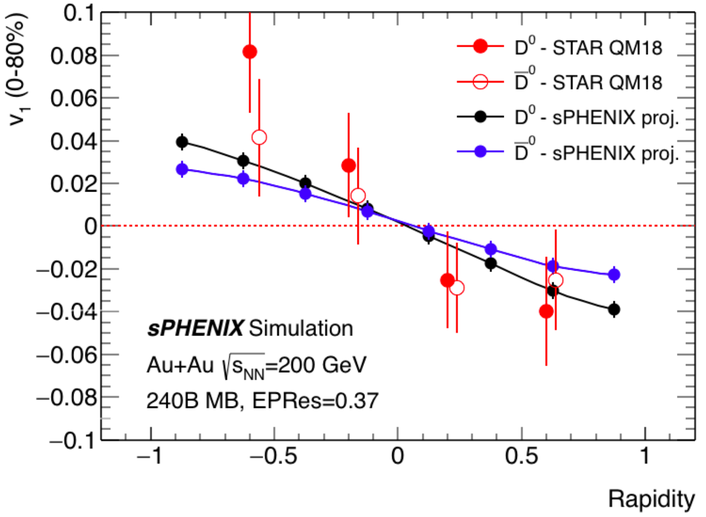
LHCb-ft | sPHENIX

sPHENIX







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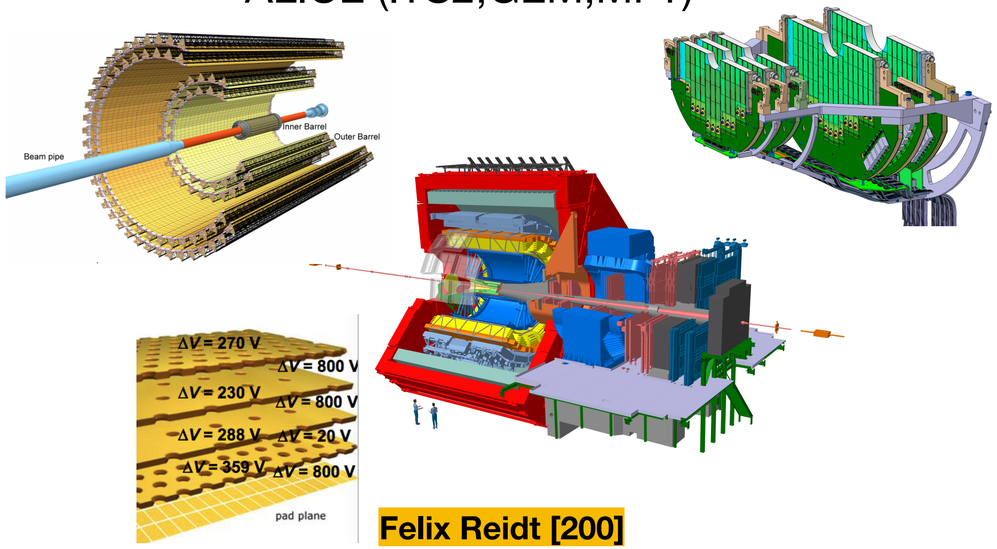
ALICE/LHCb (LS2 upgrades)

CMS/ATLAS LS3

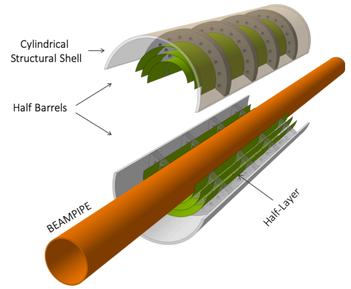
ALICE ITS3

ALICE (ITS2,GEM,MFT)

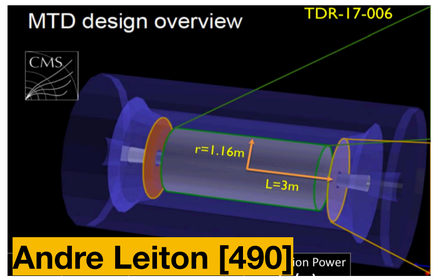


Felix Reidt [200]

ALICE ITS3

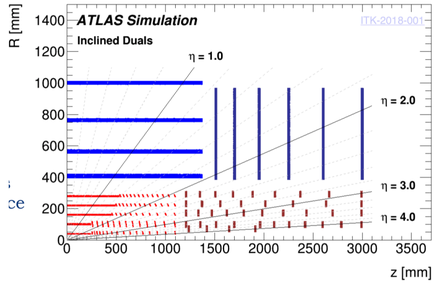


CMS MTD



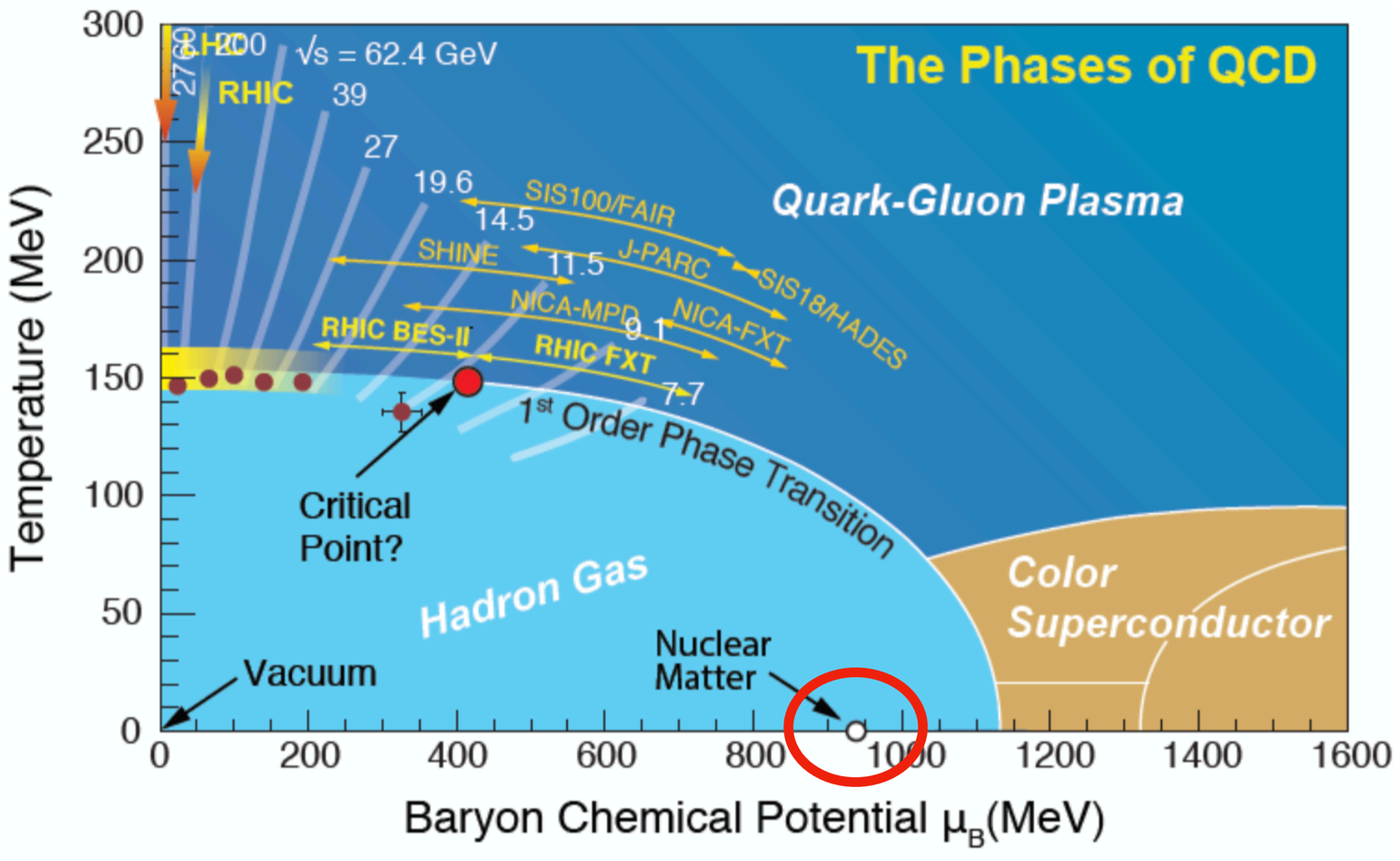
Andre Leiton [490]

ATLAS ITK

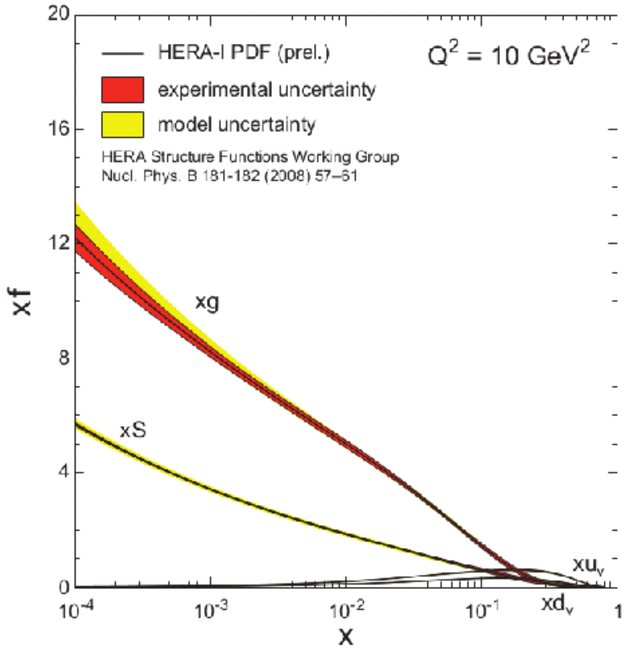


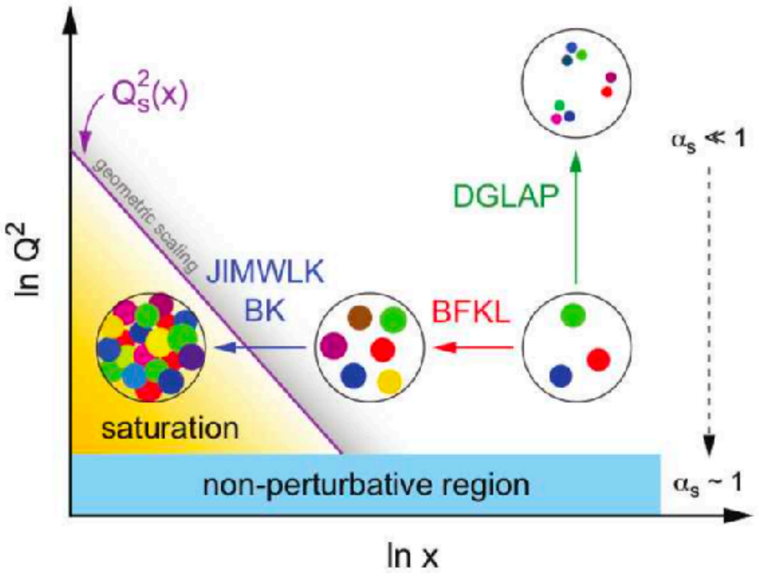
Complementary to upgrades at LHC exploiting hard probes at low+high p_T

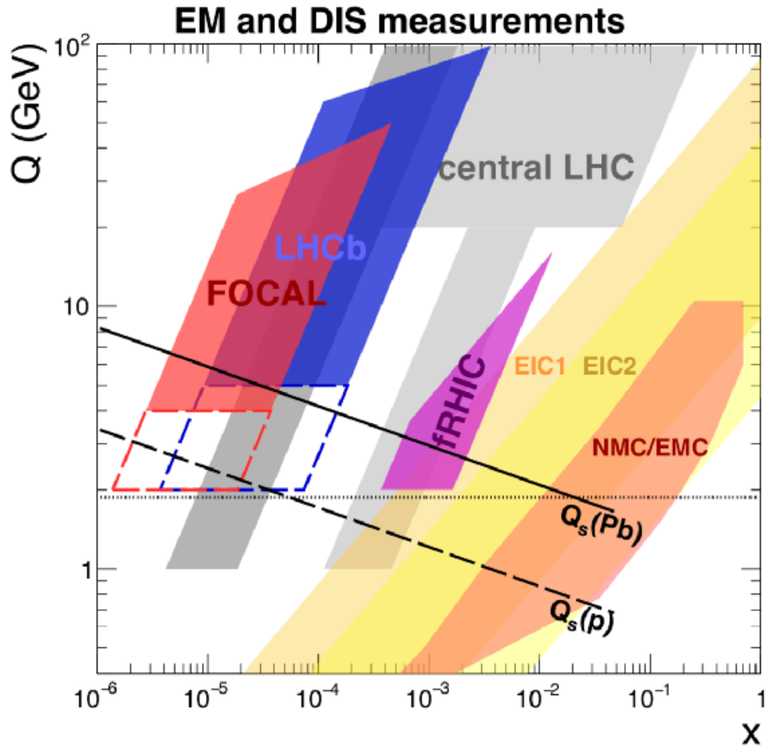
Cold nuclear matter



Accessing PDFs at small-x







- Main goal
  - Constrain nuclear PDFs at small x
  - Explore non-linear QCD evolution
- Logarithmic dep. of QCD evolution on x and Q
  - Requires many measurements over largest possible range to find change from linear evolution

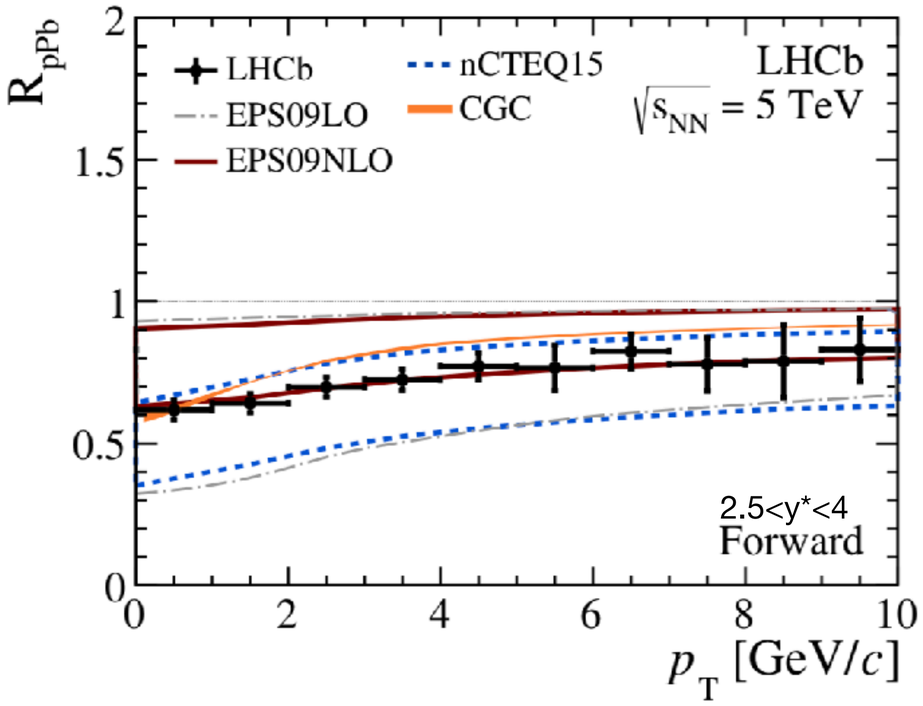
Current/future small-x program at RHIC+LHC

- Various experiments/measurements: direct γ, DY, open charm + UPC
- Important to test factorization/universality
- Synergy with fRHIC (+ EIC)

Forward open charm by LHCb

Petja Paakkinen [115]

LHCb, arXiv:1707.02750



Eskola et al., arXiv:1906.02512

- Forward D^0 suppression observed by LHCb
- Consistent description with nuclear PDFs, with a large contribution from high x from fragmentation
- Data constrain nPDF uncertainties by ~factor 2
  - Final state effects ignored
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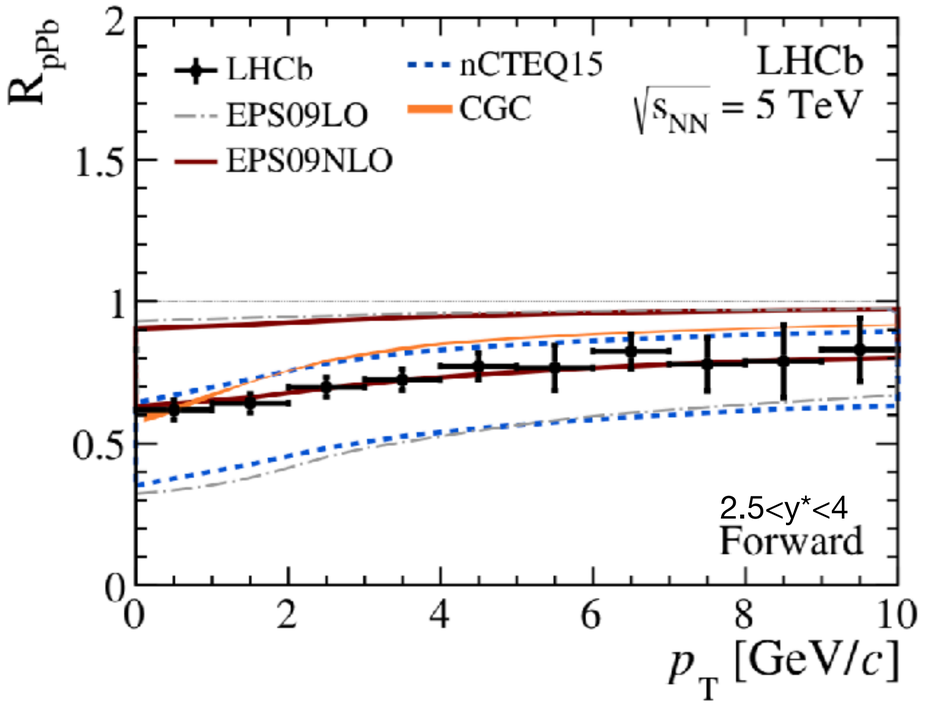

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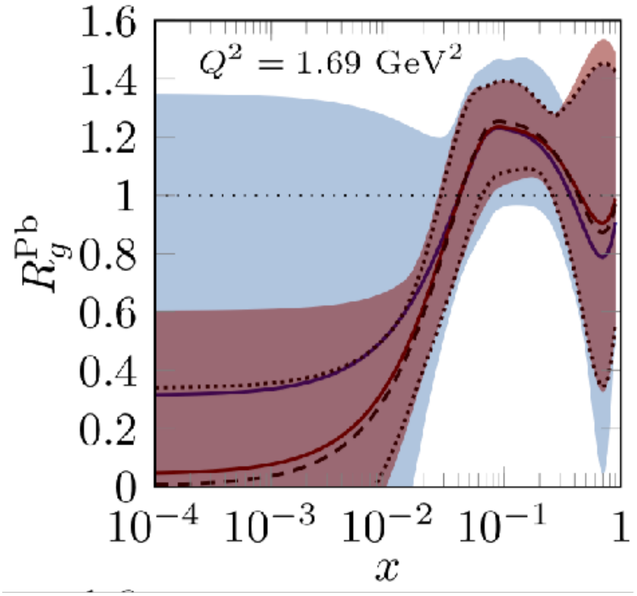

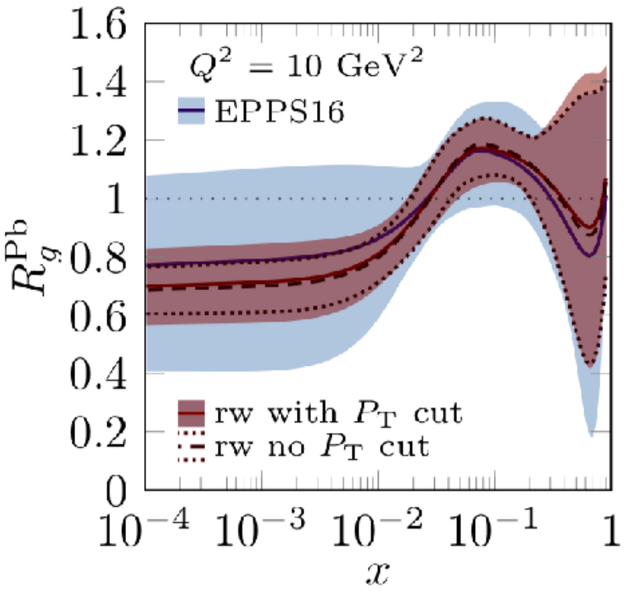

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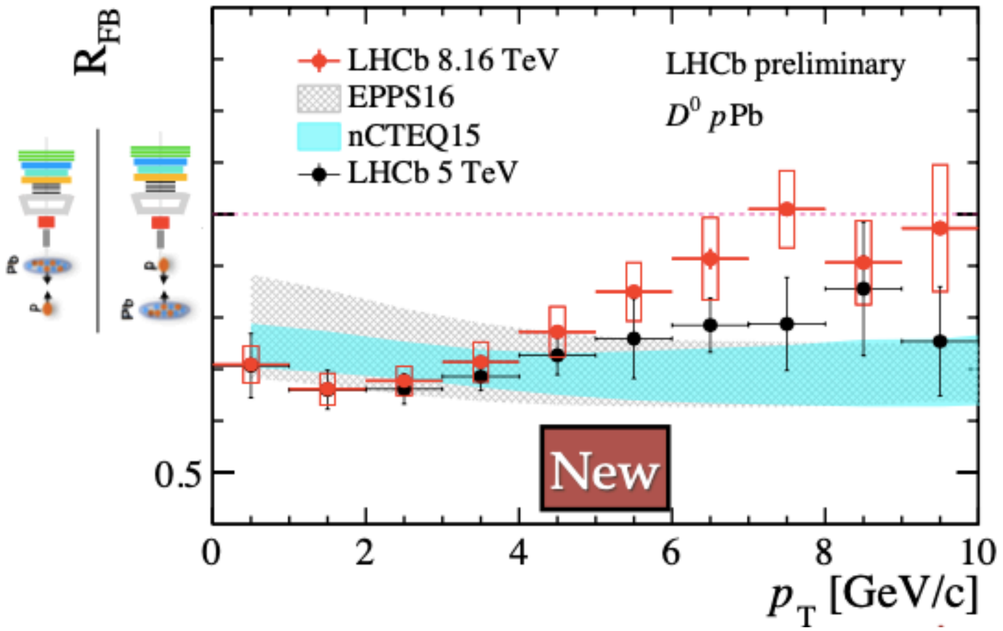
Cold(?) nuclear matter effects

Shanzhen Chen [228]

- Few measurements shown at this conference exhibit need to go beyond just nuclear PDFs
- Measurements with photons should not be affected by final state effects



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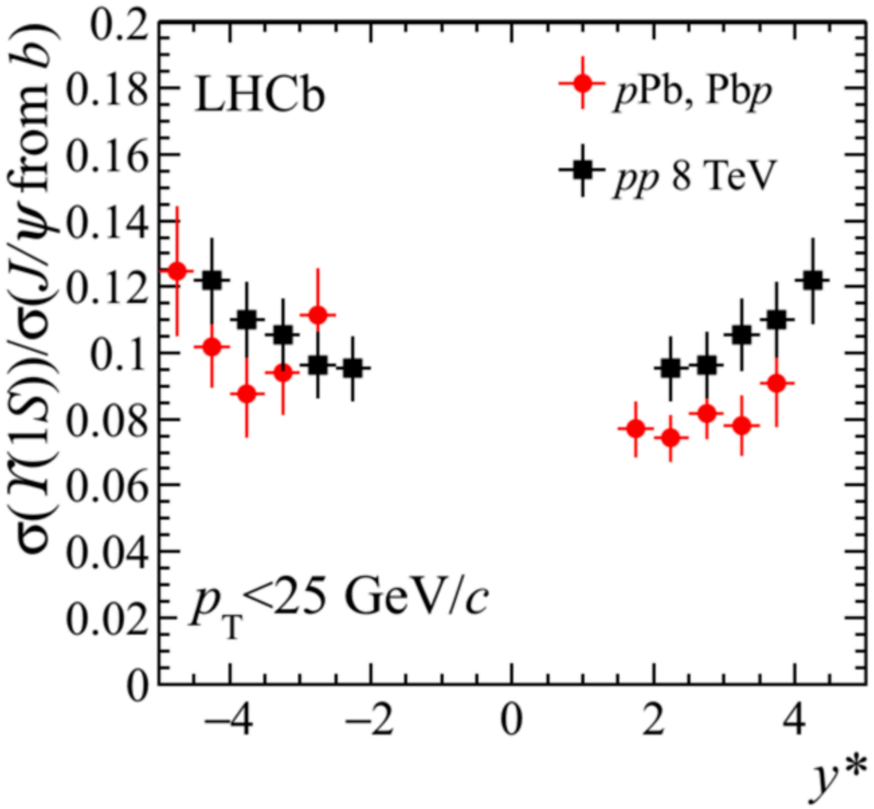

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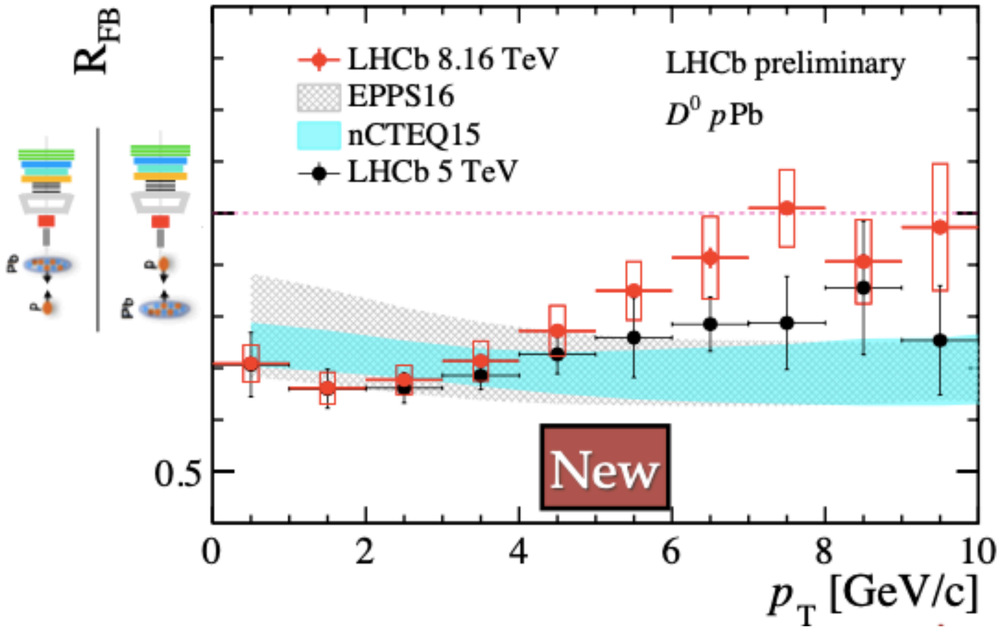

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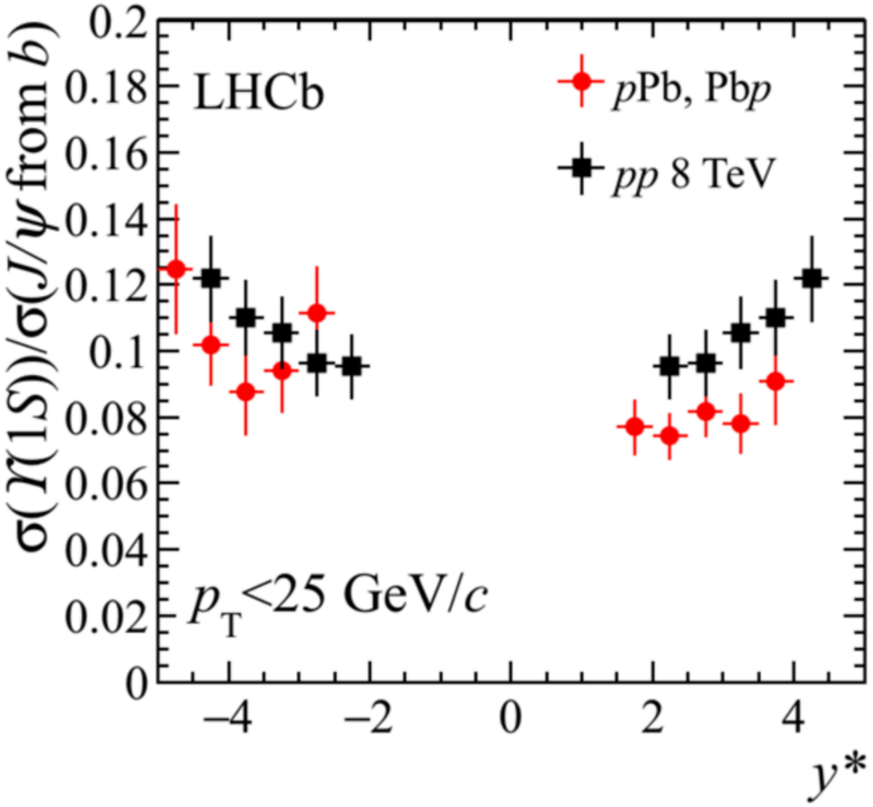

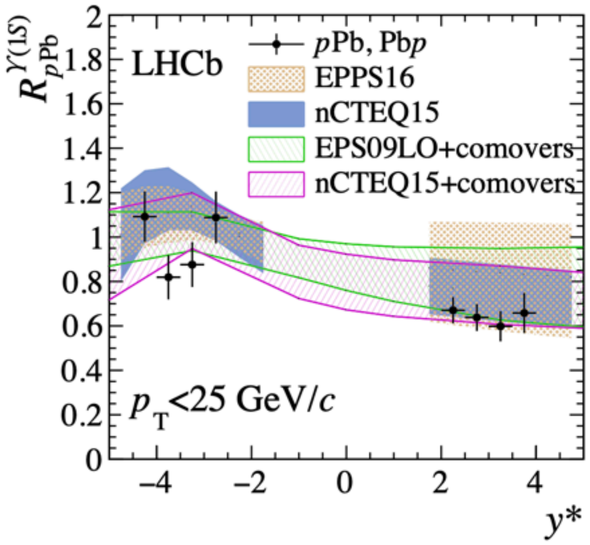

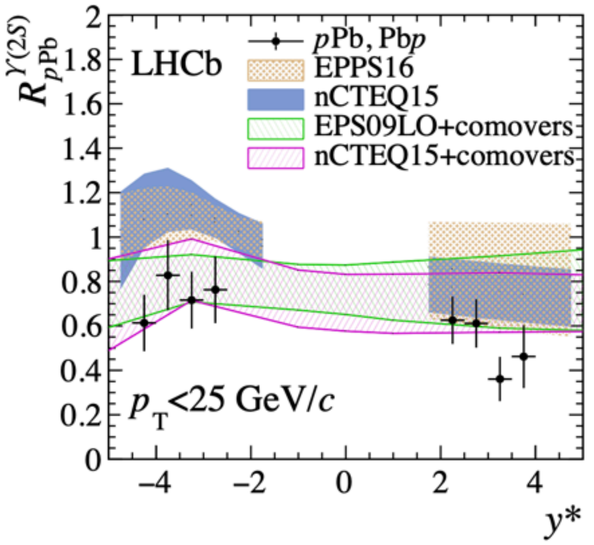

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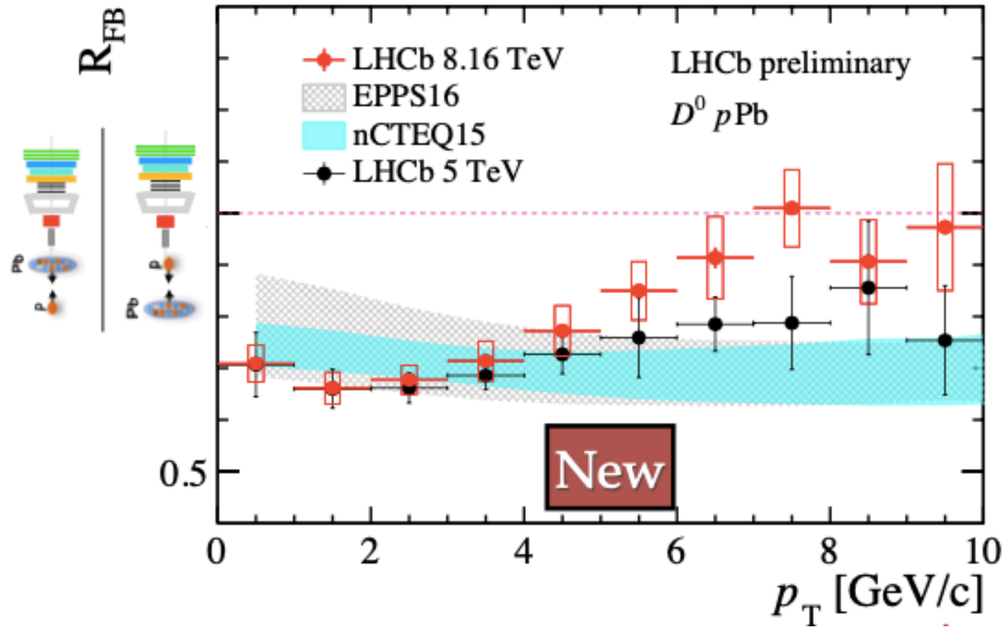
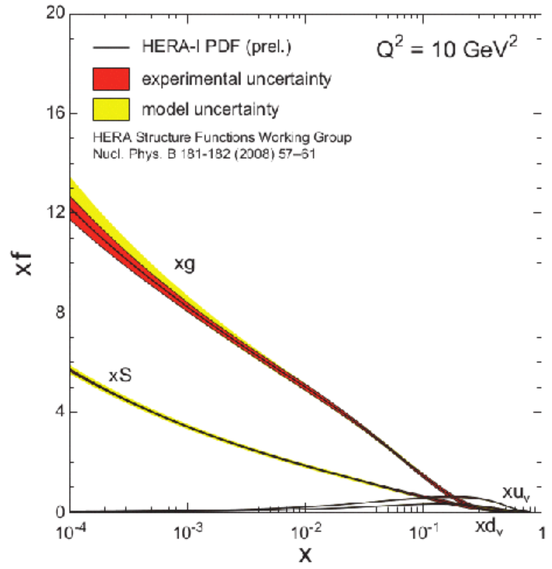
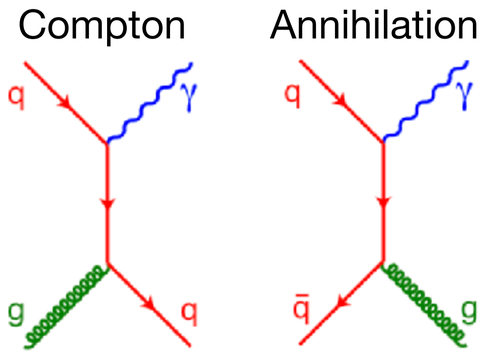
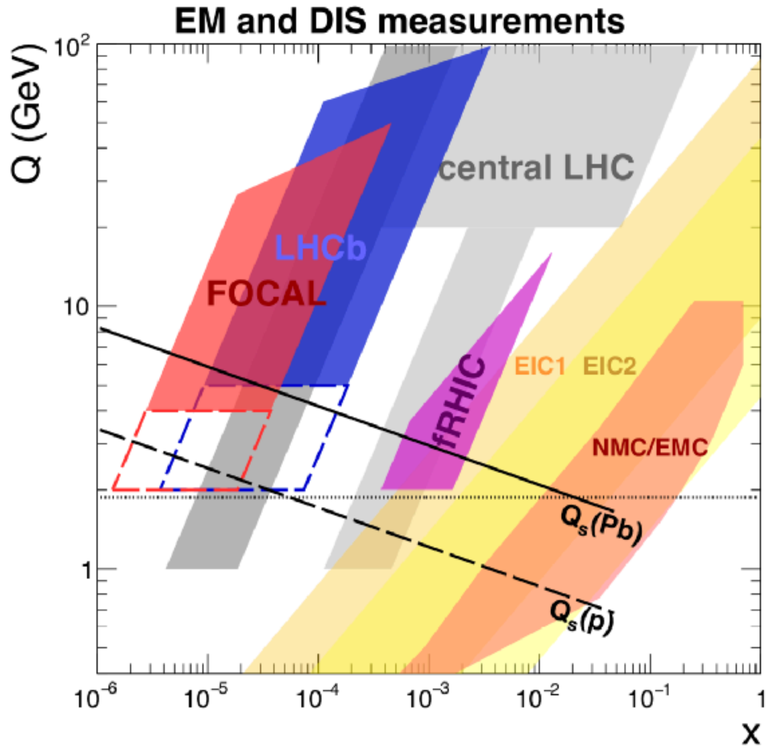


Accessing small-x with isolated photons at forward rapidity







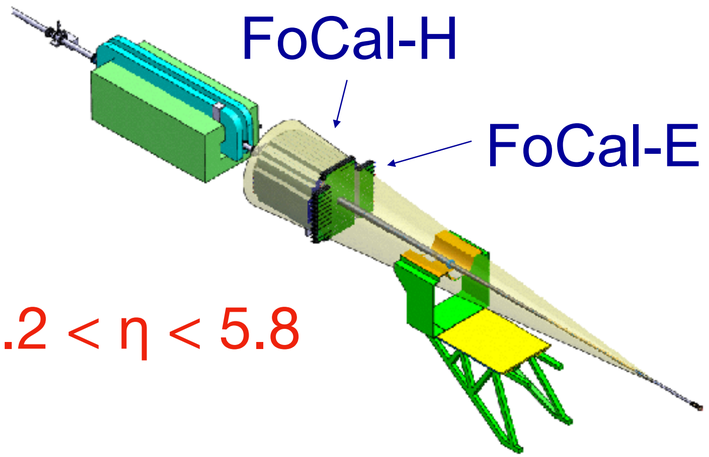
- Measure isolated photons forward
  - At LO more than 70% from Compton with direct sensitivity to gluon density
  - Not affected by final state effects nor hadronization
  - Uniquely small-x coverage at LHC (similar to LHeC)
  - Accessible by LHCb reconstructing electron/positron conversions
  - Dedicated forward calorimeter being proposed for ALICE for Run-4

Current/future small-x program at RHIC+LHC

- Various experiments/measurements: direct γ, DY, open charm (*) + UPC
- Important to test factorization/universality
- Synergy with fRHIC (+ EIC/LHeC)

(*) No longer sure we can safely use charm at all

FoCal: Proposed ALICE upgrade for Run-4



FoCal-E: high-granularity Si-W sampling calorimeter for photons and π^0
FoCal-H: conventional Cu-Sc sampling calorimeter for photon isolation and jets

Other observables:

- Neutral mesons
- Jets (and di-jets)
- J/ψ (Y) in UPC
- W, Z maybe possible
- Event plane and centrality

ALICE-PUBLIC-2019-005

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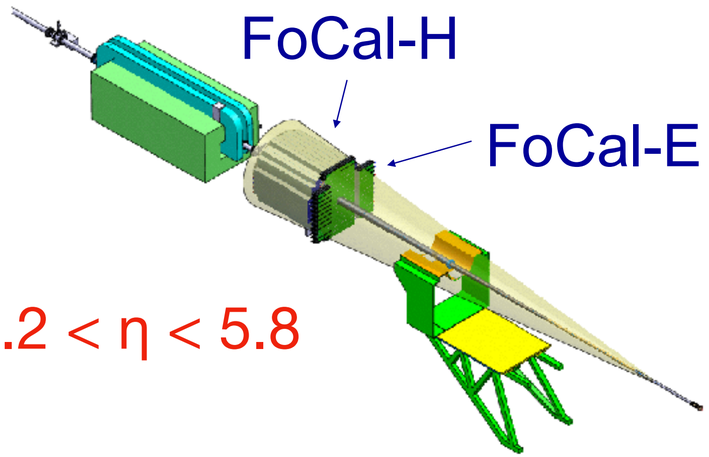

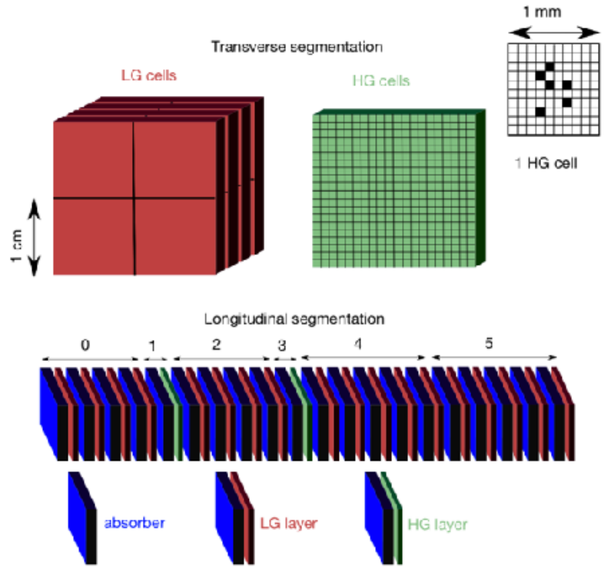

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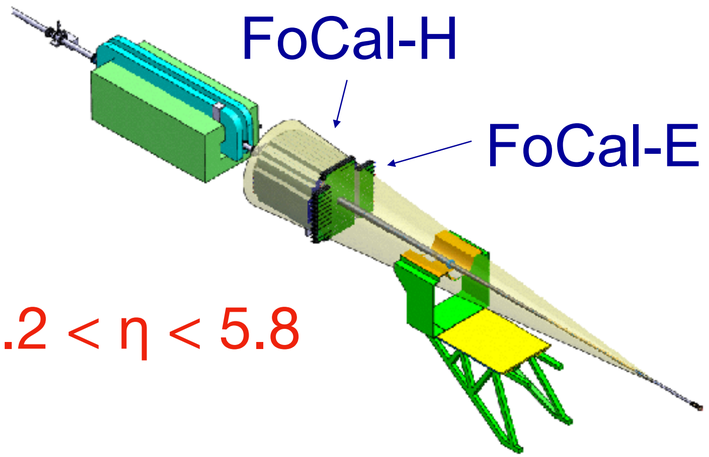
Key feature: Separate γ/π^0 at high energy

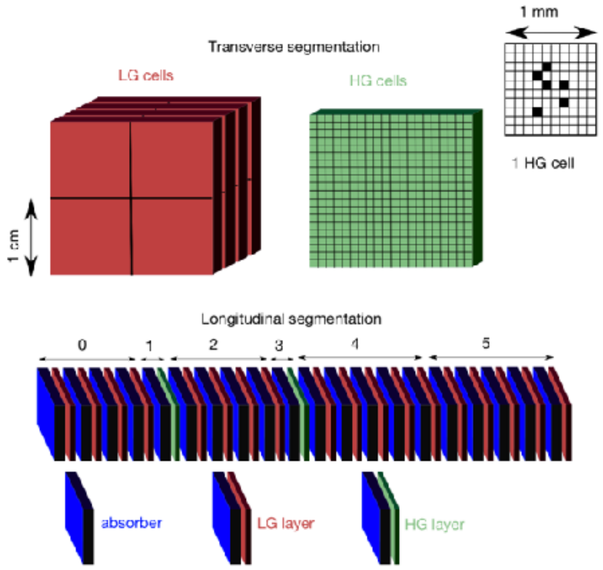
- Two photon separation from π^0 decay (10 GeV, η=4.5) ~2mm
- Small Molière radius and high granularity readout
- Si-W calorimeter 18 silicon-pad layers (1x1cm^2) and 2 silicon-pixel layers with effective granularity ≈ 1mm^2

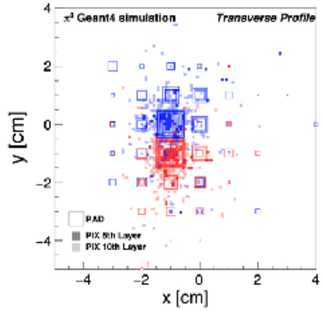
ALICE-PUBLIC-2019-005

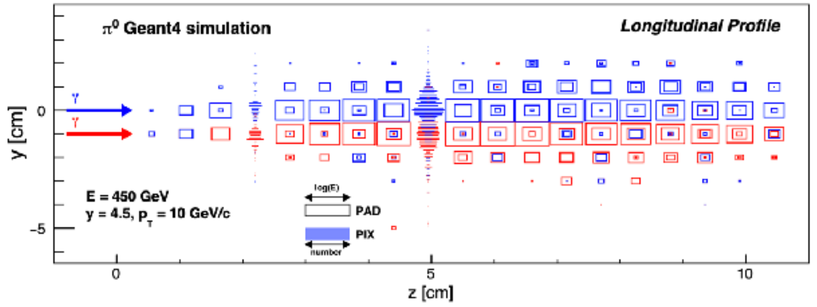
FoCal: Proposed ALICE upgrade for Run-4



$3.2 < \eta < 5.8$







FoCal-E: high-granularity Si-W sampling calorimeter for photons and π^0
FoCal-H: conventional Cu-Sc sampling calorimeter for photon isolation and jets

Other observables:

- Neutral mesons
- Jets (and di-jets)
- J/ψ (Y) in UPC
- W, Z maybe possible
- Event plane and centrality

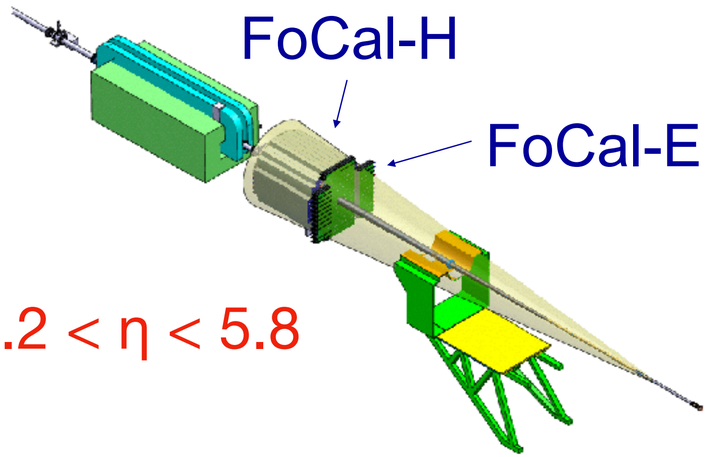
Key feature: Separate γ/π^0 at high energy

- Two photon separation from π^0 decay (10 GeV, η=4.5) ~2mm
- Small Molière radius and high granularity readout
- Si-W calorimeter 18 silicon-pad layers (1x1cm^2) and 2 silicon-pixel layers with effective granularity ≈ 1mm^2

Essentially take 3D image of EM shower(s)

ALICE-PUBLIC-2019-005

FoCal: Proposed ALICE upgrade for Run-4



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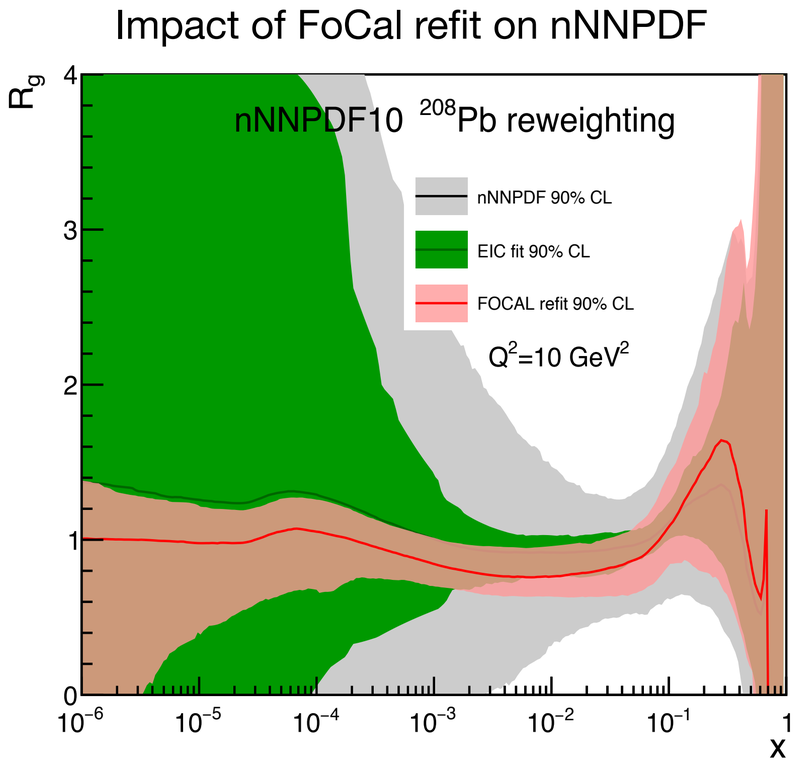


Significantly constraining nNNPDF (obtained from DIS data with minimal theoretical assumptions)

ALICE-PUBLIC-2019-005

The cold-nuclear matter frontier: Future

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2040 | 2050

BESII BM@N MPD NA62 CEE CBM/NA60+/J-PARC-HI

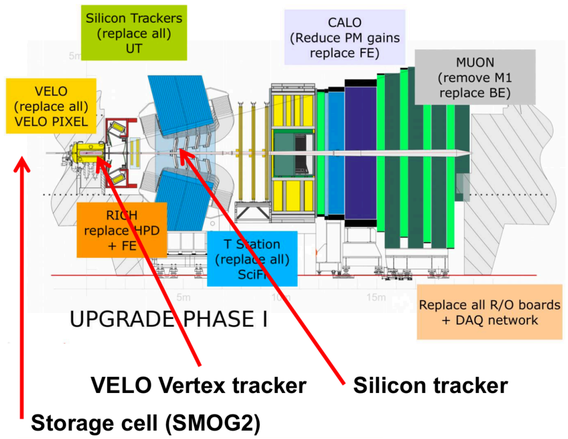
LHCb-ft fsPHENIX/forward STAR

ALICE/LHCb (LS2 upgrades)

CMS/ATLAS LS3

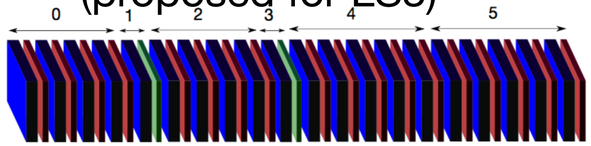
ALICE ITS3+FoCal

LHCb (LS2)

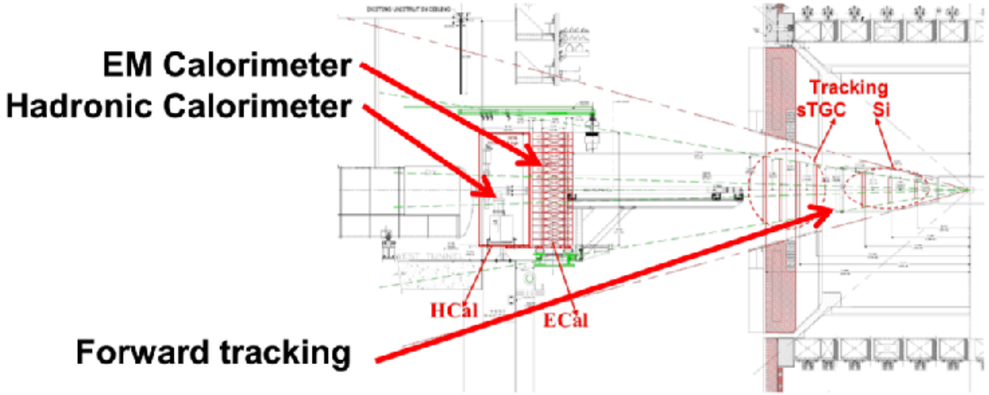


Pasquale di Nezza [234]

ALICE FoCal 3.2<η<5.8 (proposed for LS3)



Forward STAR (similar for fsPHENIX)



Yi Yang[388]

Very small-x (~10^{-6}) program at LHC

complemented by forward upgrades for RHIC cold nuclear physics program

Ultra-precision QCD: Future

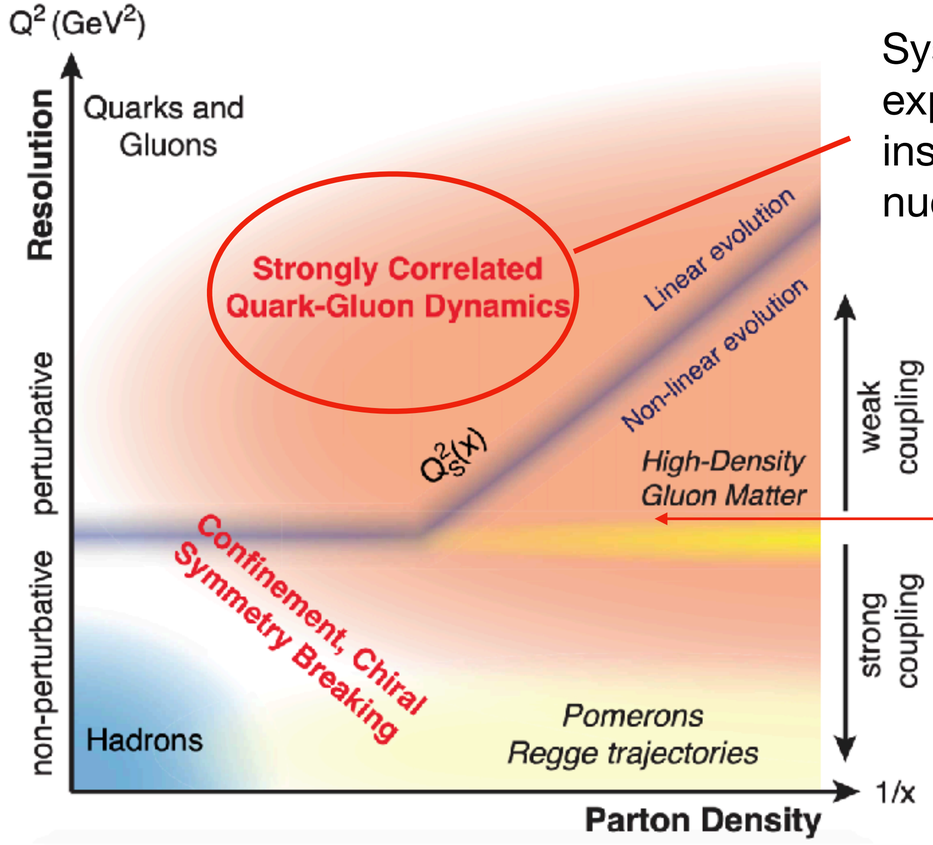
2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2040 | 2050

BESII BM@N MPD NA62 CEE CBM/NA60+/J-PARC-HI

LHCb-ft fsPHENIX/forward STAR EIC LHCb FCC

ALICE/LHCb CMS/ATLAS LS3 NGHI SppC

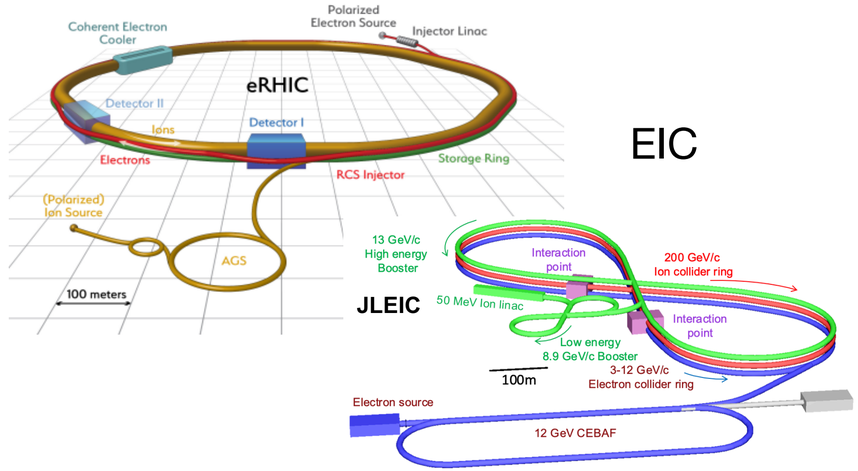
(LS2 upgrades) ALICE ITS3+FoCal



Systematically explore correlations inside protons and nuclei

A possibility?:
Study new regime in QCD of weakly coupled high density matter

Very importantly:
Study hadronization



Precision cold nuclear physics program

Ultra-precision QCD: Future

2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2040 | 2050

BESII BM@N MPD NA62 CEE CBM/NA60+/J-PARC-HI

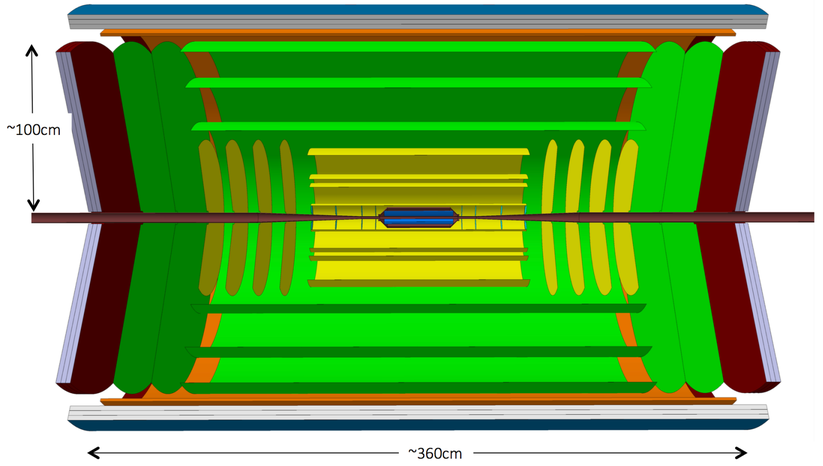
LHCb-ft fsPHENIX/forward STAR EIC LHCb FCC

ALICE/LHCb CMS/ATLAS LS3 NGHI SppC

(LS2 upgrades) ALICE ITS3+FoCal

- Fast, ultra-thin detector with precise tracking and timing,
- Ultimate performance for (multi-)HF, soft hadron and thermal radiation
- Maybe add forward tracking/PID to access the high net-baryons and/or fwd calorimeter for ultra small-x photons

Next-generation heavy-ion experiment



Also LHCb will be fully operational in PbPb collisions, as well as CMS/ATLAS, providing a rich high-energy QCD/HI programme in parallel to the EIC

We are truly entering the golden age of heavy-ion/high density QCD physics!

2019 — 2020 — 2021 — 2022 — 2023 — 2024 — 2025 — 2026 — 2027 — 2028 — 2029 — 2030 — 2040 — 2050

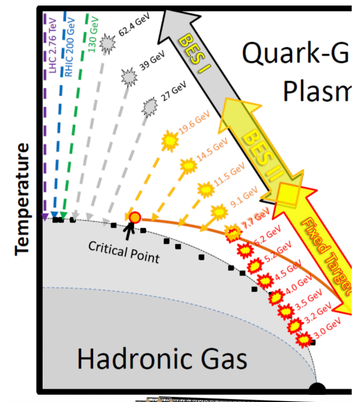
BESII BM@N MPD NA62 CEE CBM/NA60+/J-PARC-HI

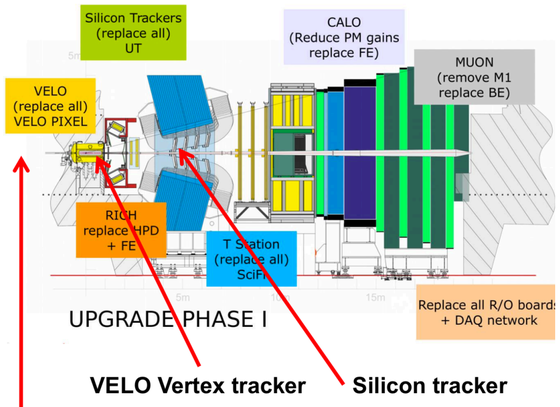
LHCb-ft fsPHENIX/forward STAR EIC LHCb FCC

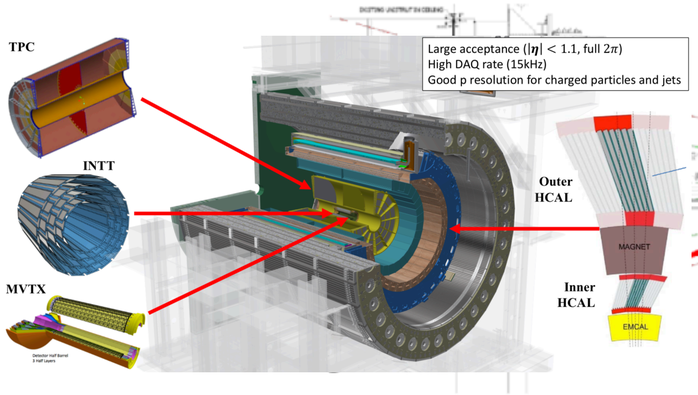
ALICE/LHCb NGHI SppC

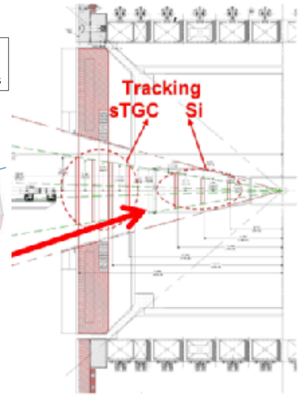
(LS2 upgrades) CMS/ATLAS LS3

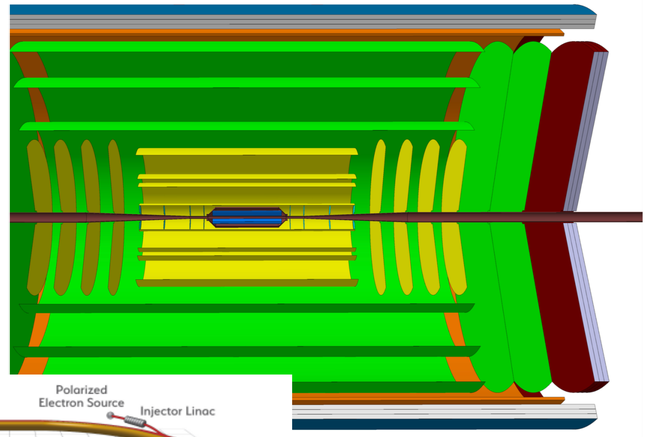
ALICE ITS3+FoCal

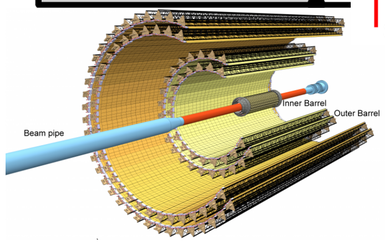


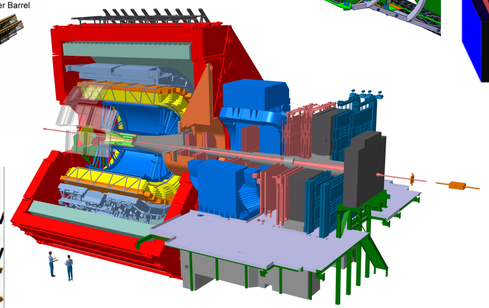


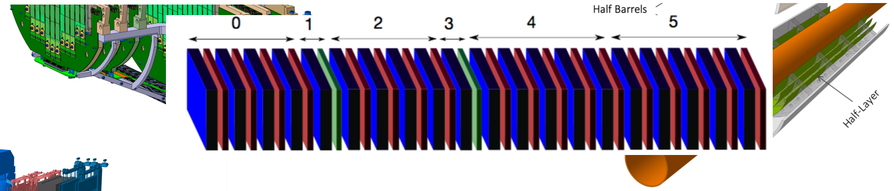


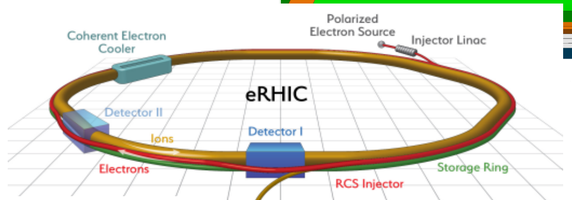




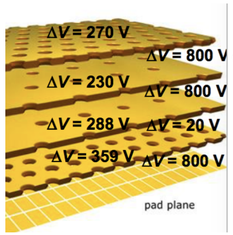


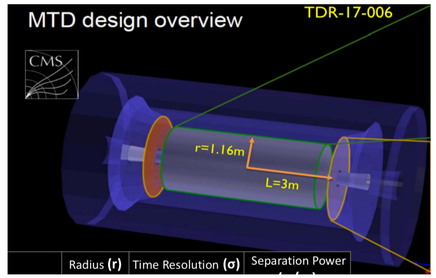


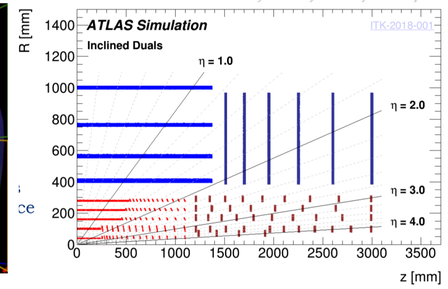


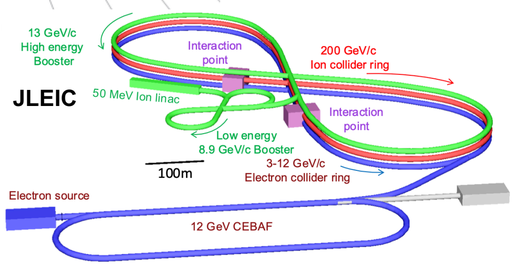


EIC









Thanks to the conference organizers for their endless work to make the conference happen and being so extra-ordinary hosts