Possible QCDiscoveries at LHC
and the future of TOTEM

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Inspiring quotes
Missing protons in ALICE
Multiplicity, PID, pt and ϕ range
CMS/TOTEM opportunities
TOTEM opportunity
QCD Fullerenes, soft diffraction
Mass range, yield estimate
Bonus: CGC at forward rapidities at RHIC

Inspiring quotes

E-mail from G. Torrieri, Oct 6, 2011:

- **I think TOTEM can be really the optimal experiment to test the issues which I talked about at the HCBM workshop last year, http://arxiv.org/abs/arXiv:1012.2790 and also the validity of models such as Buda-Lund.**
- **Limiting fragmentation in v2 is a VERY weird thing, that as far as I know NO hydrodynamic model can really describe correctly. The fact that dN/dy logarithmic scaling breaks at the LHC, but v2 logarithmic scaling approximately holds, is very interesting, and one could test if the break is accompanied by a break limiting fragmentation. But one would have to go at high rapidity.**

Comment from J. Cleymans, December 2011: The Thermal model at LHC

- **http://indico.cern.ch/conferenceOtherViews.py?confId=163821**
- **Perfect agreement between thermal model predictions and particle yields containing strangeness at LHC**
- **Measured proton yield below expectations of the Thermal Model**
  - **Perhaps protons are shifted forward, out from ALICE acceptance?**
  - **Need PID capabilities in T1 and T2 range to measure dn/dη of p and $\bar{p}$**

Limiting fragmentation, dn/dη and v2

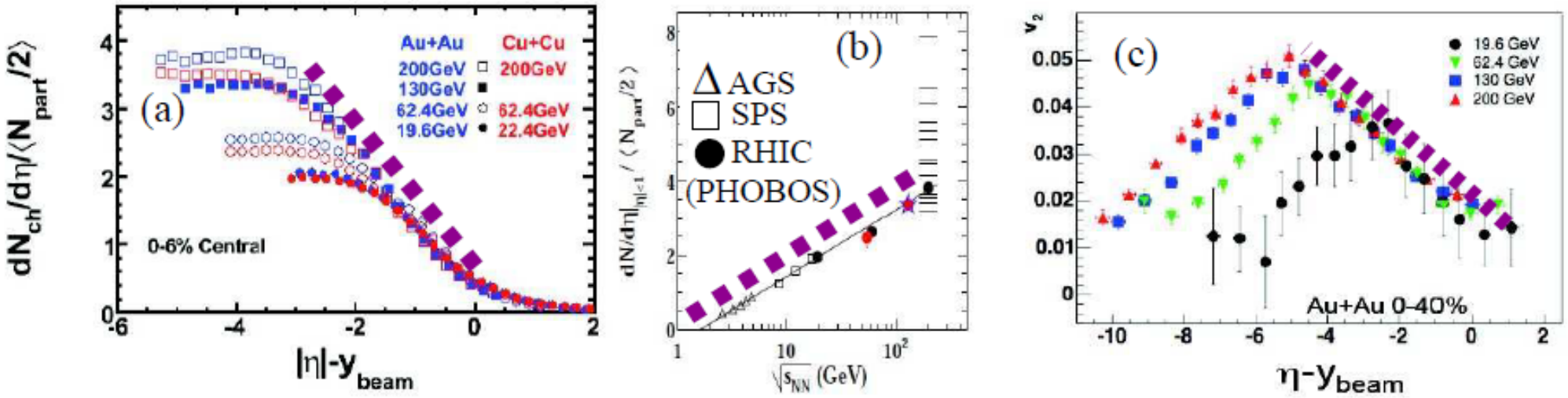

Fig. 1. Scalings of multiplicity and flow between SPS and top RHIC energies. Left panel shows limiting fragmentation, middle panel the logarithmic dependence of multiplicity with energy, and right panel limiting fragmentation of elliptic flow. Experimental data taken from [20]

In the η range of T1, T2: limiting fragmentation in p+p in dn/dη
check it for PID, and also for Pb+Pb

similar scaling: v2 (elliptic flow, event anisotrophy in φ ,)
known to depend also on η - check it with T1 and T2

„Missing protons" at ALICE

Thermal fits: PbPb @ 2.76 TeV (A)

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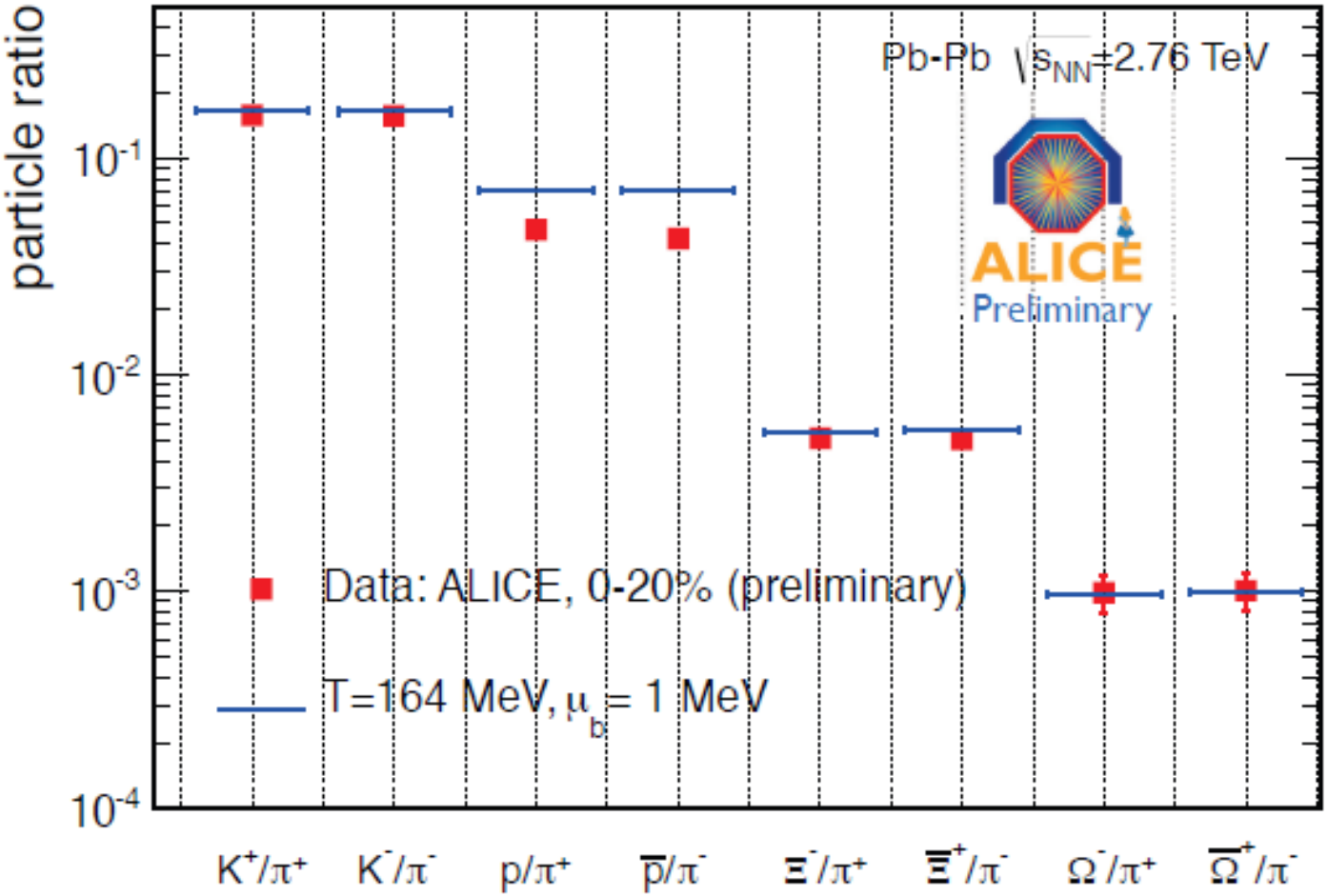

- Perfect agreement between thermal model and all particles containing strangeness: Kaons and Hyperons.
- Measured proton yield below the expectation from the thermal model.

Model: A. Andronic et al., Phys. Lett. B 673:142-145,2009

„Missing protons" at ALICE

Thermal fits: PbPb @ 2.76 TeV (B)

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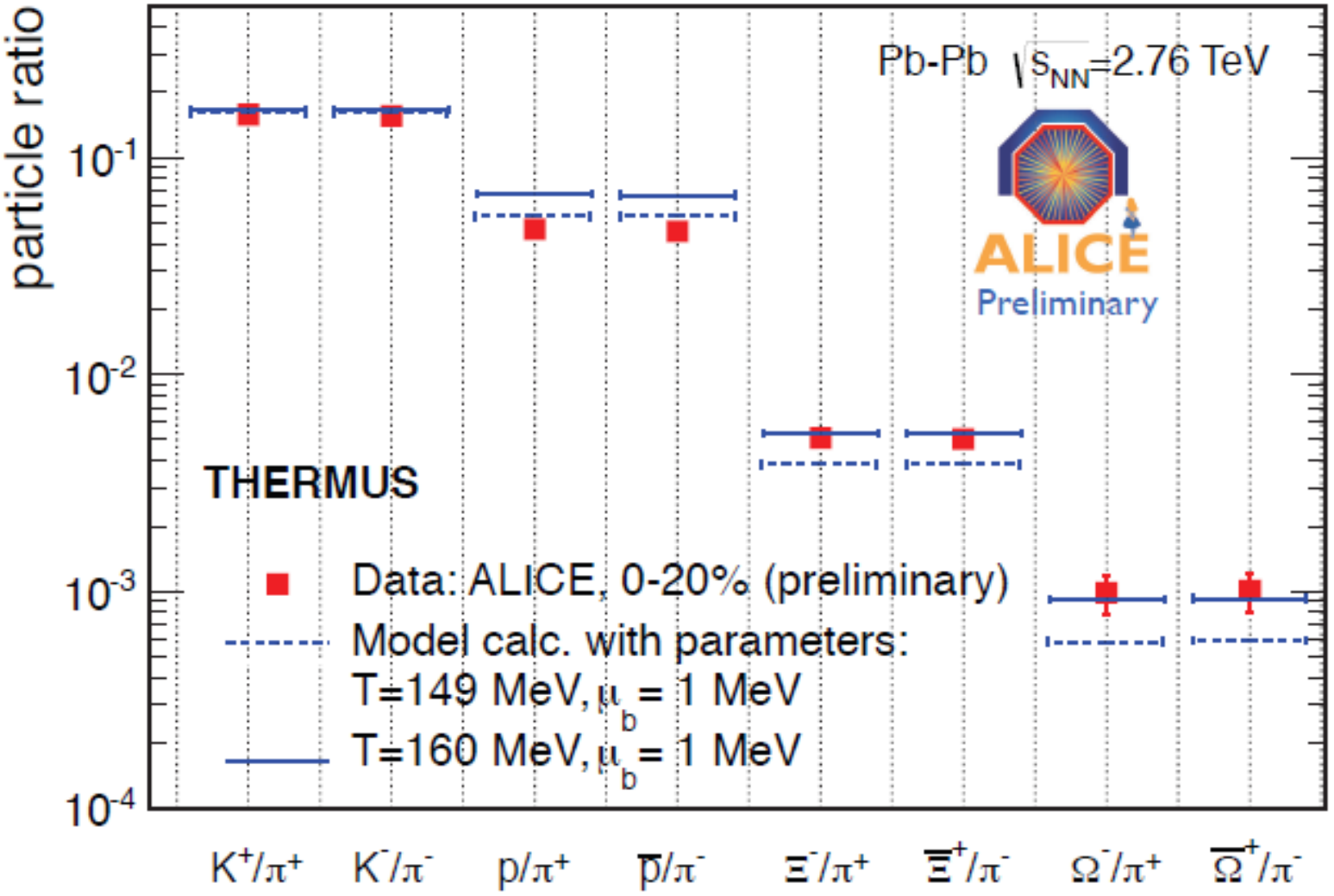
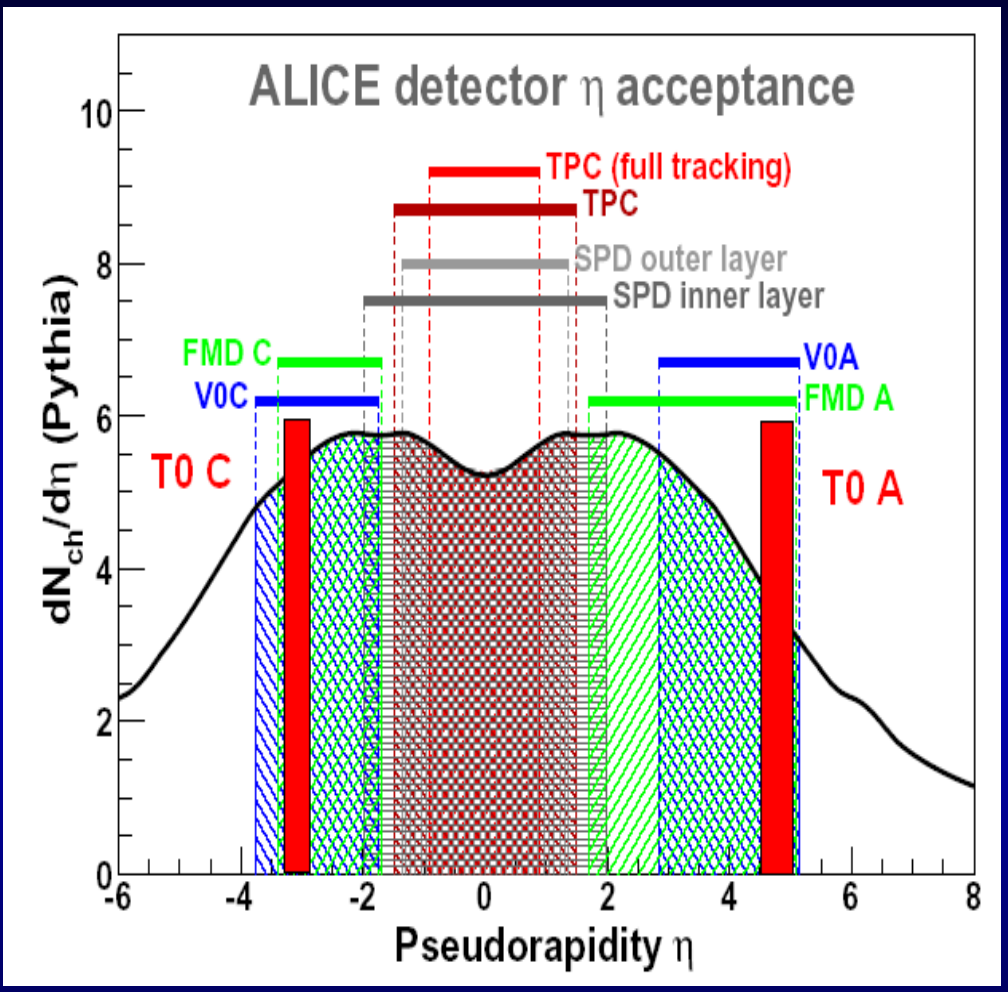
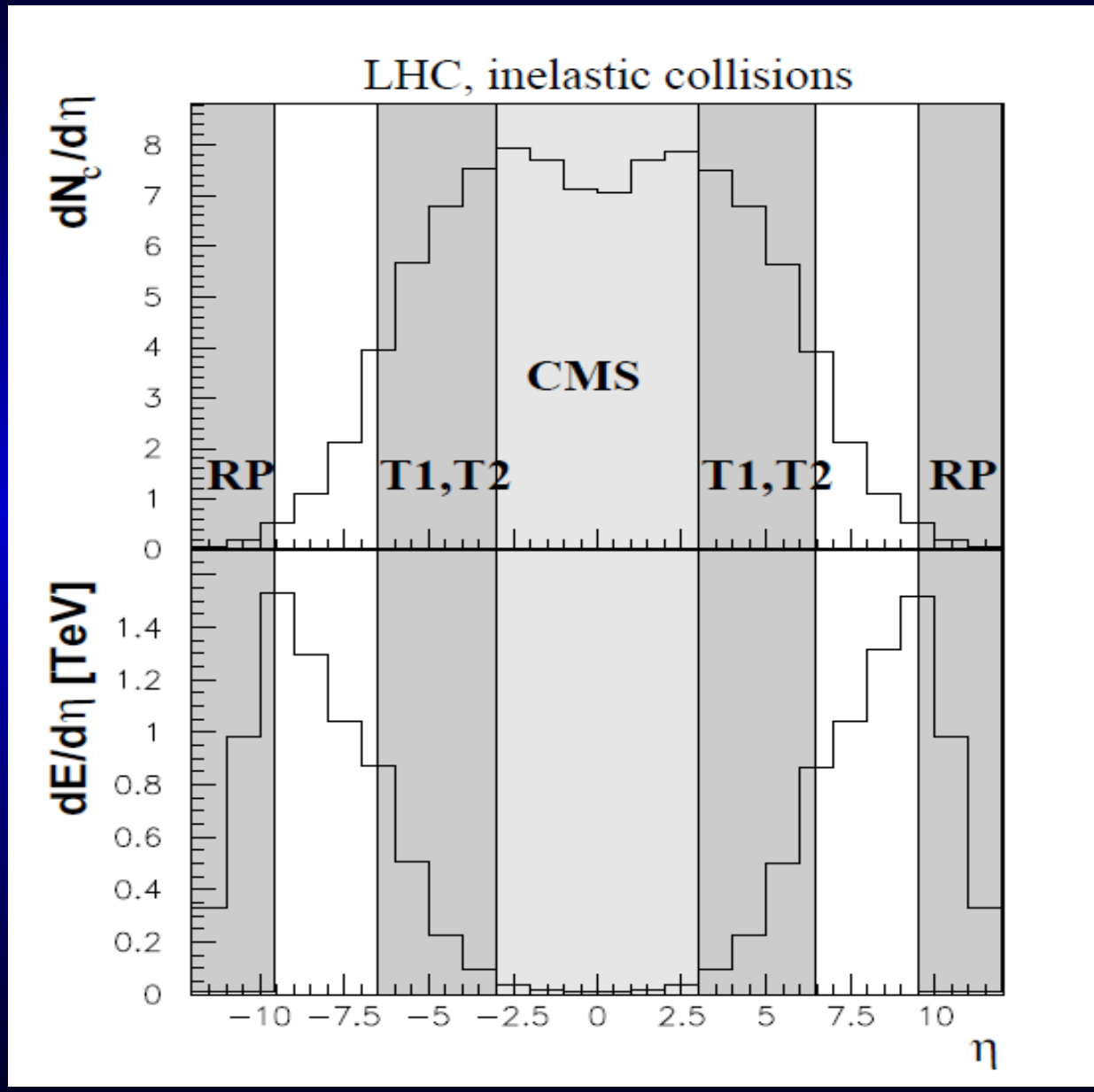


- Similar picture with THERMUS.
- This effect is independent of the specific thermal model used.

S. Wheaton, J. Cleymans and M. Hauer, Comput. Phys. Commun. 180 (2009) 84-106

Acceptance of ALICE vs TOTEM





Only ALICE can PID protons
at LHC, but only at mid-rapidity
Check if protons leak to forward directions?
→ needs to measure PbPb + PID in T1/T2
e.g. tracking + timing + radhard T1', T2', +energy with CMS calorimeters

„Monkey business”

I cannot play these videos - officially.

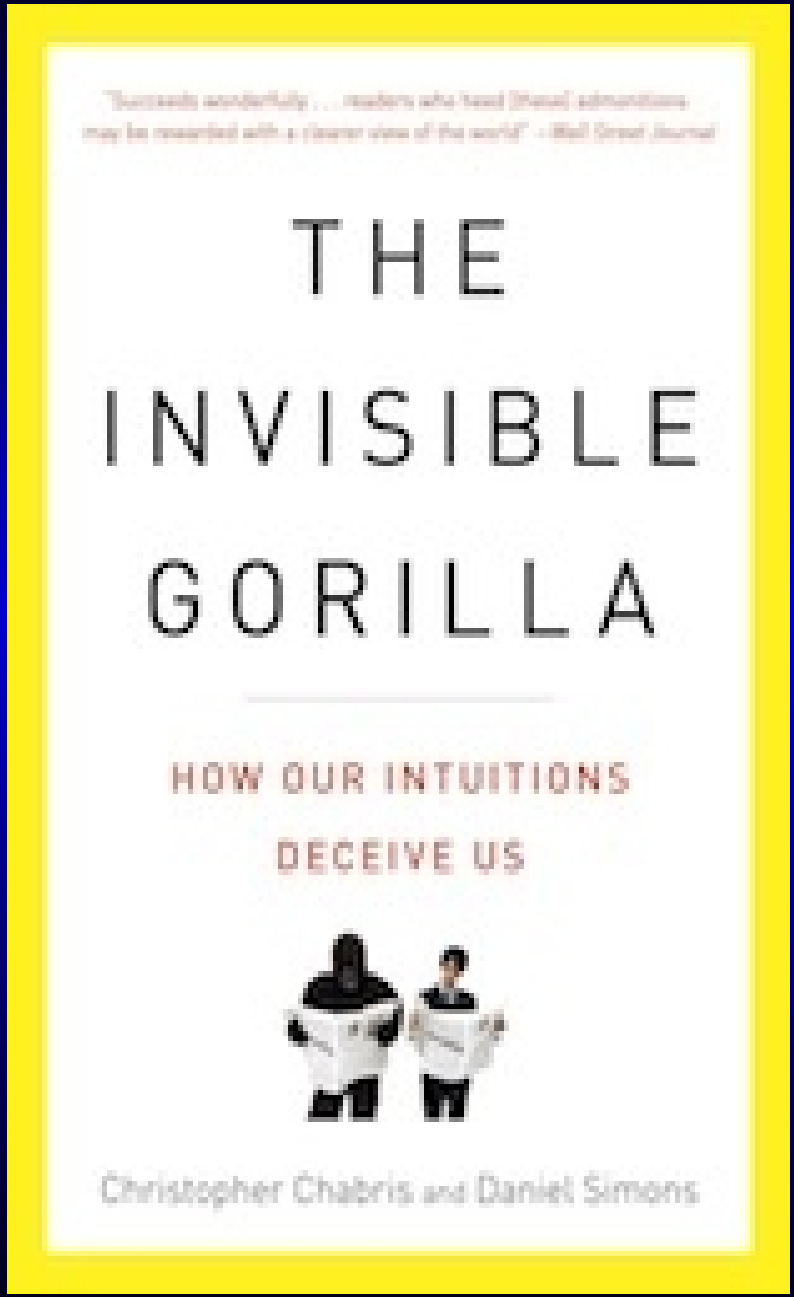
You can privately view them at
http://www.invisiblegorilla.com/videos.html

Check out at least the first two.

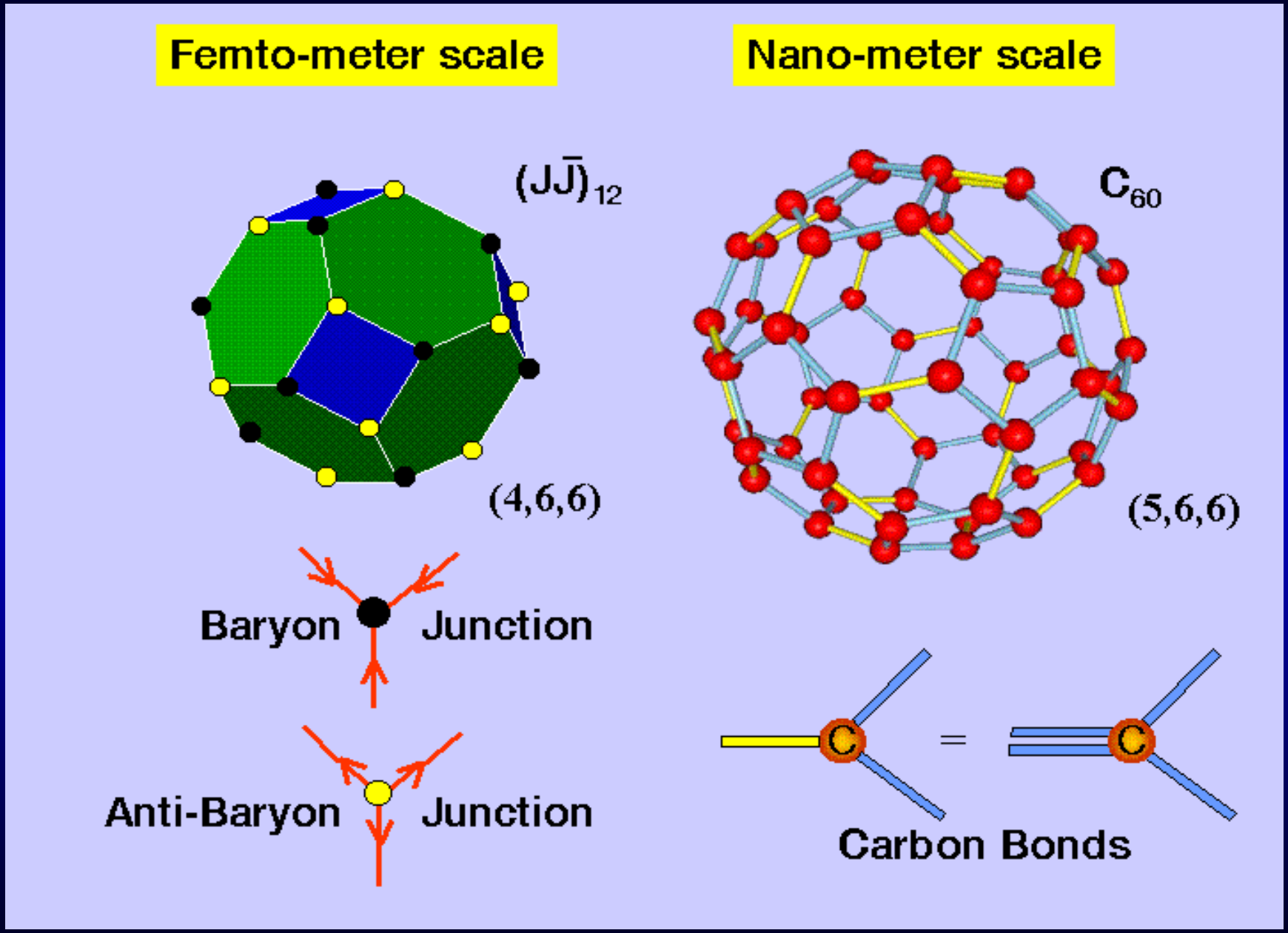
The Invisible Gorilla:
How our intuitions often deceive us
by C. Chabris and D. Simons
(Crown Publishers, NY, 2011)

several case studies, typically outside the domain of science.

are we scientists more aware ?



Possible QCDiscovery: Fullerenes at LHC



T. Cs, M. Gyulassy, D. Kharzeev, J.Phys.G G30 (2004) L17-L25

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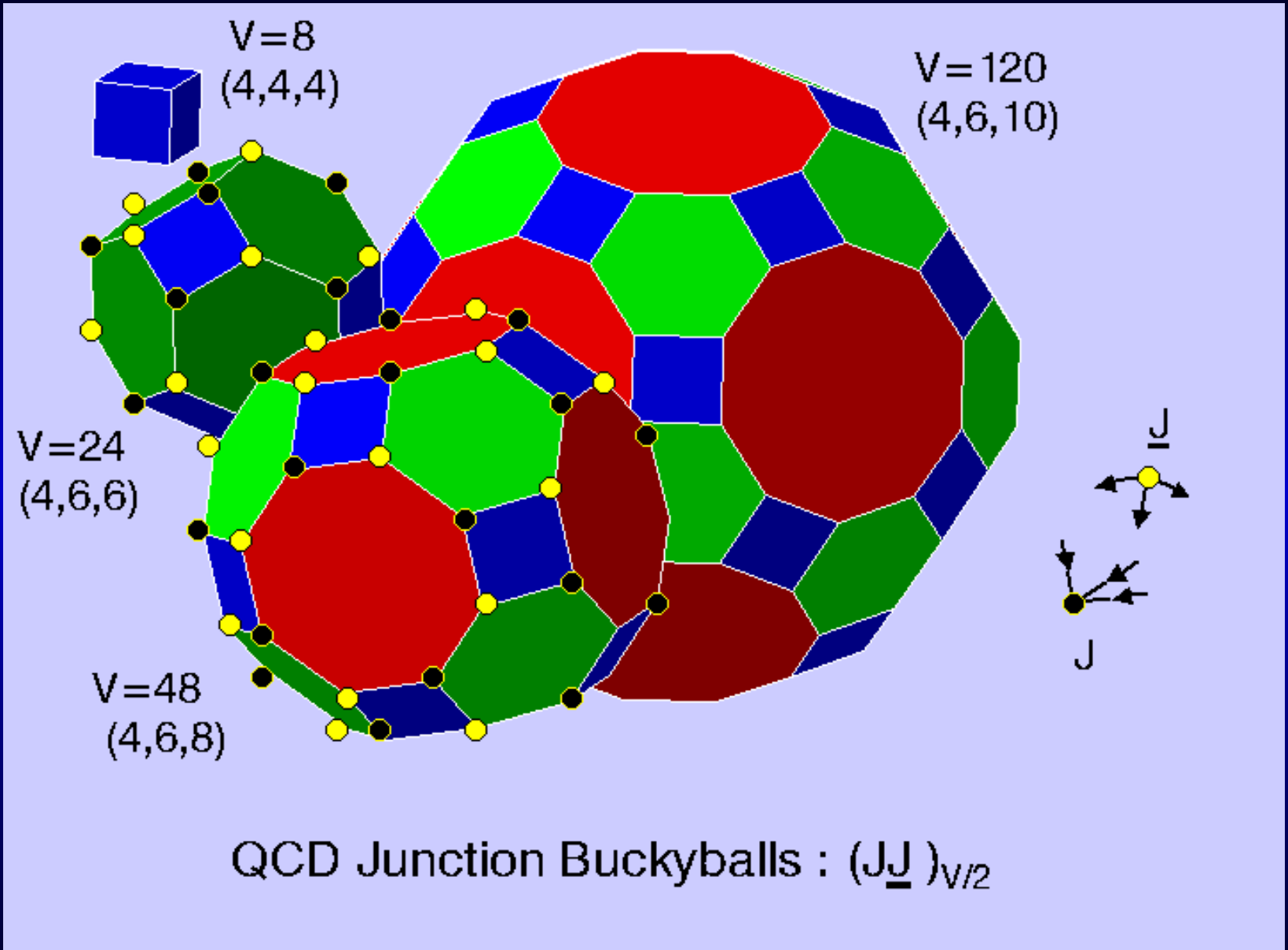


Most symmetric (stable) configurations: baryon-antibaryon clusters: B+antiB = 24,48,120

→ PID in T1, T2, or dn/dM, or soft diffraction with CMS at mid-rapidity

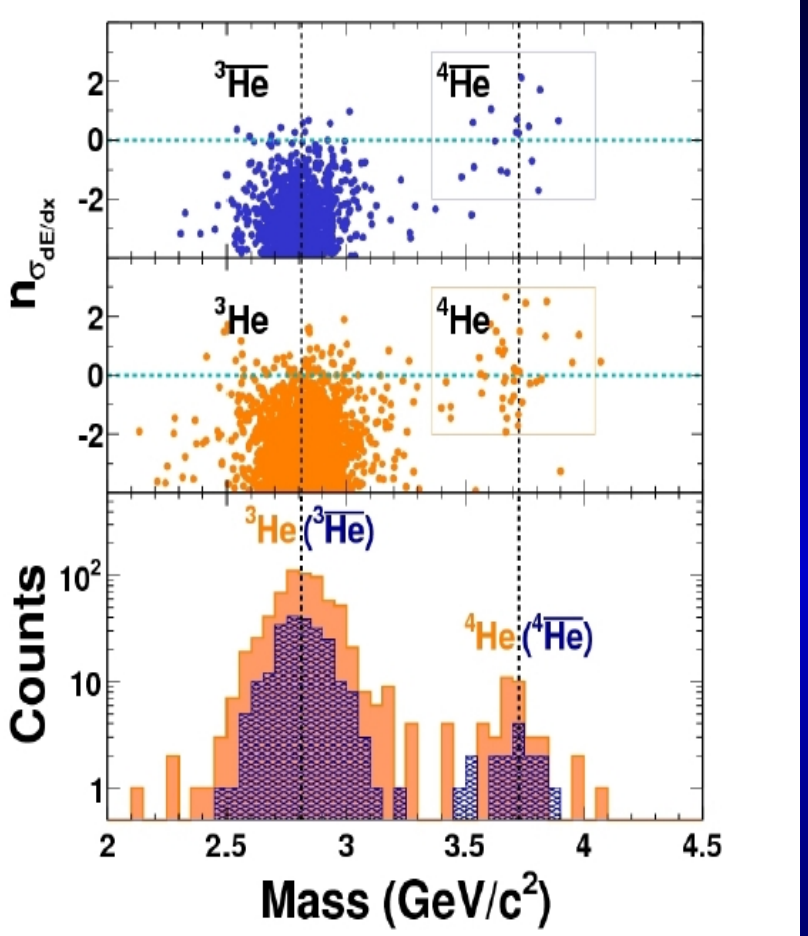
Discovery potential: mass range

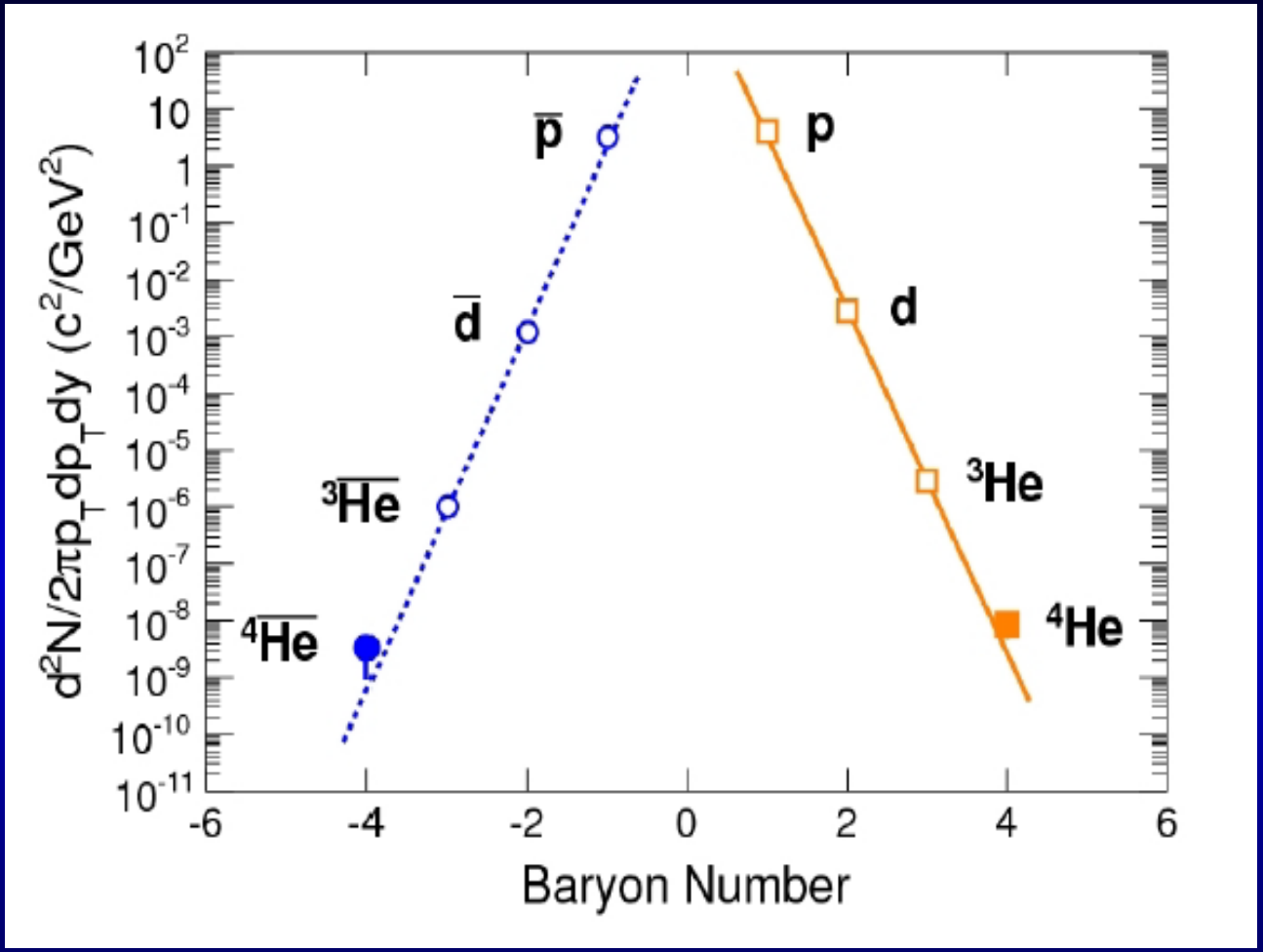
V	(n_1, n_2, n_3)	$\delta h/\gamma$	$M_{\rm min}$ (GeV)	$M_{\rm max}$ (GeV)	$M_{\rm crit}$ (GeV)	d (fm)
8	(4,4,4)	0	9.4	9.4	7.5	1.3
24	(4,6,6)	-1	9.4	28.3	22.6	2.5
48	(4,6,8)	$-\frac{1+\sqrt{2}}{2}$	11.1	56.7	45.1	3.6
120	(4,6,10)	$-\frac{3+\sqrt{5}}{4}$	18.0	141.7	112.8	6.0

Table 1
Estimated mass range for various QCD Fullerenes. V stands for the number of vertexes, (n_1, n_2, n_3) for the face structure at a vertex, $M_{\rm min}$ and $M_{\rm max}$ are the estimated lower and upper limits for the mass of the QCD Fullerene, together with the critical mass of stability $M_{\rm crit}$. The diameter of the circumscribed sphere, d was estimated from $l \approx 0.79$ fm and the geometrical structure.

In the mass range estimated yesterday for diffractive production, p_t range about hbar/d ~ 30 - 150 MeV: extremely soft diffraction

But rates will be extremely low





STAR recently discovered anti-4He in Au+Au at RHIC, http://arxiv.org/abs/1103.3312

About a factor of 1000 suppression for each additional baryon.

Summary: What we need

PID capabilities in T1 and T2 range

measuring p, pbar, n, nbar and their clusters,
huge statistics or triggers on such clusters

PID also for elliptic flow measurements in T1 and T2

tracking + timing + E from CMS calorimeters

Monte Carlo, feasibility studies asap needed for

(very soft, 30 < pt < 200 MeV diffractive production of large baryon+antibaryon clusters up to B+Bbar = 120, mass range of 9 – 150 GeV)

Bonus: forward physics from RHIC

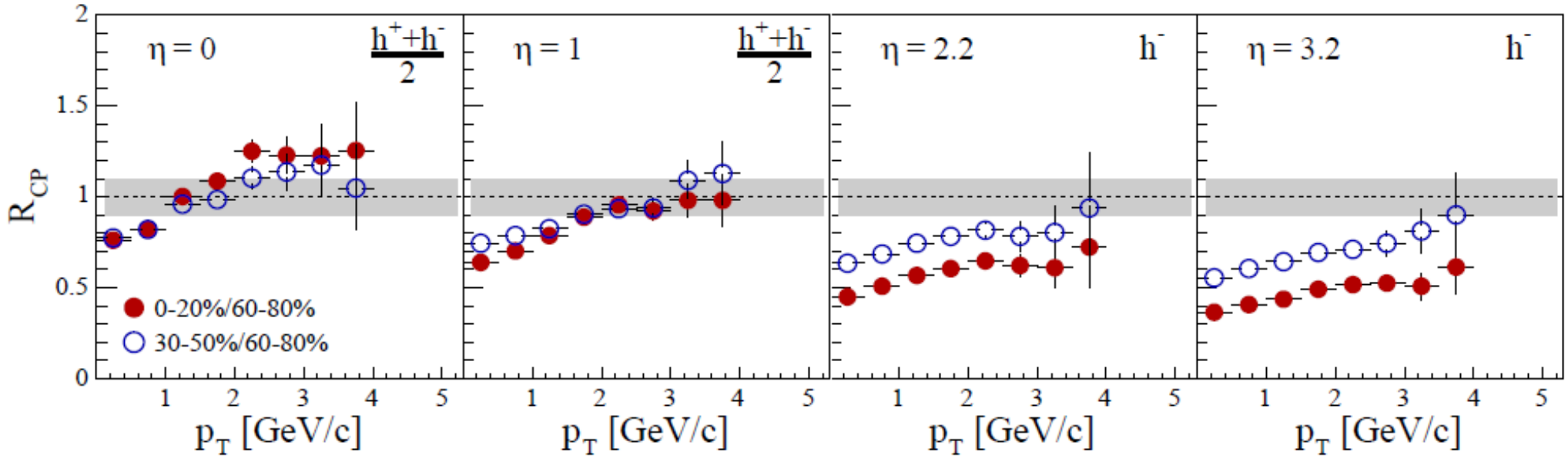


FIG. 3: Central (full points) and semi-central (open points) R_{cp} ratios (see text for details) at pseudorapidities $\eta = 0, 1.0, 2.2, 3.2$. Systematic errors ($\sim 5\%$) are smaller than the symbols.

BRAHMS measurement of a pseudorap dependent nuclear modification factor in d+Au at RHIC at sqrt(s_{NN}) = 200 GeV

http://arxiv.org/abs/nucl-ex/0403005

BRAHMS, STAR and PHENIX in d+Au at RHIC at sqrt(s_{NN}) = 200 GeV

all observe a difference in midrapidity-forward and forward-forward correlations. Interpetation: low-x gluon saturation, consistent with Qsat from HERA

STAR: gluon sat in Au at η = 2-4

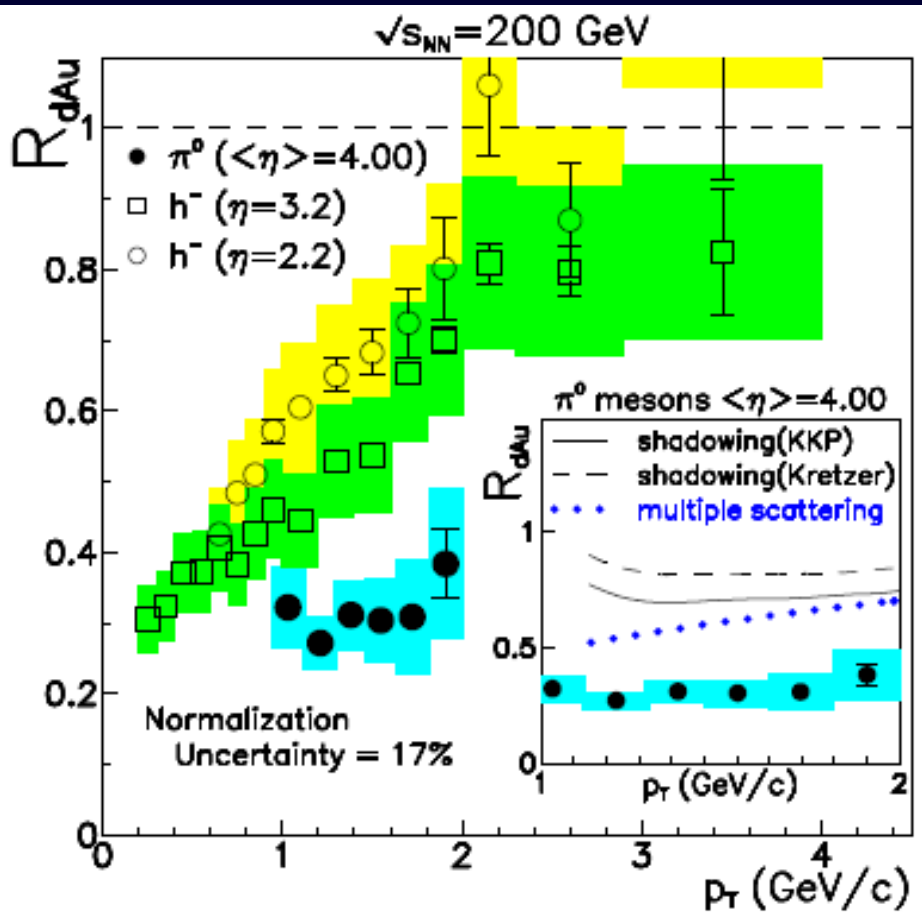


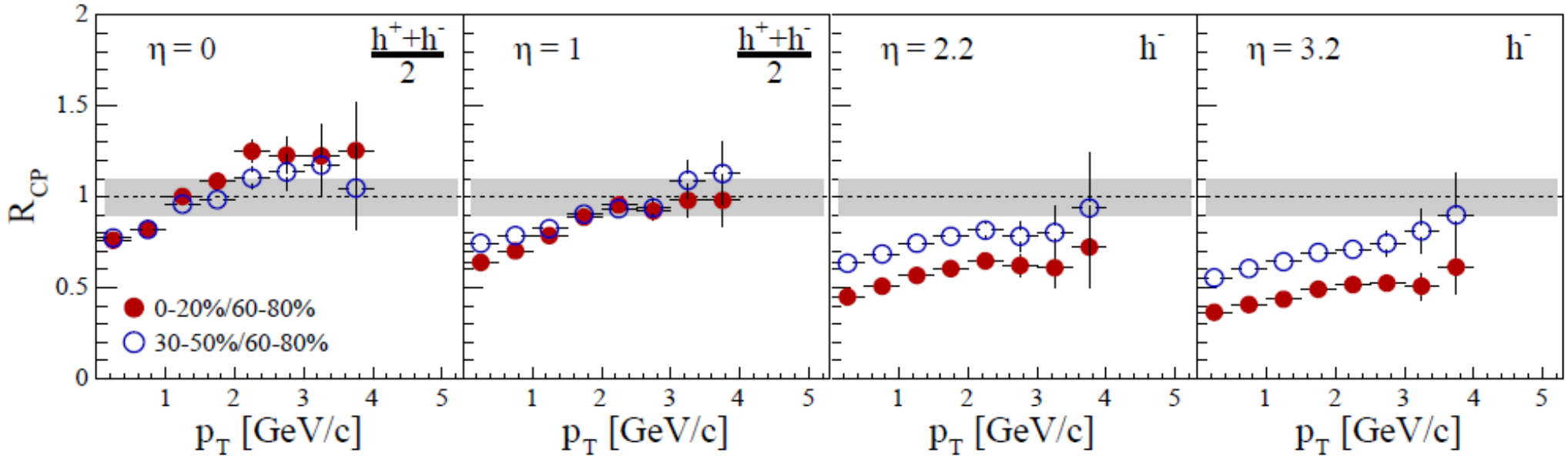
FIG. 3: Nuclear modification factor (R_{dAu}) for minimum-bias d+Au collisions versus transverse momentum (p_T). The solid circles are for π^0 mesons. The open circles and boxes are for negative hadrons [10]. The error bars are statistical, while the shaded boxes are point-to-point systematic errors.

In conclusion, the inclusive yields of forward π^0 mesons from p+p collisions at $\sqrt{s} = 200$ GeV generally agree with NLO pQCD calculations. However, by $\langle\eta\rangle = 4.00$, the spectrum is found to be harder than NLO pQCD, becoming suppressed with decreasing p_T. In d+Au collisions, the yield per binary collision is suppressed with increasing η, decreasing to $\sim 30\%$ of the p+p yield at $\langle\eta\rangle = 4.00$, well below shadowing and multiple scattering expectations, as well as exhibiting isospin effects at these kinematics. The p_T dependence of the d+Au yield is consistent with a model which treats the Au nucleus as a CGC. Exploratory measurements of azimuthal correlations of the forward π^0 with charged hadrons at midrapidity show a recoil peak in p+p collisions that is suppressed in d+Au at low E_π, as would be expected for monojet production. These effects are qualitatively consistent with a gluon saturation picture of the Au nucleus, but cannot definitively rule out other interpretations. A

STAR: Signature of mid-rapidity mono-jet production correlated with forward production in d+Au at RHIC at sqrt(s_{NN}) = 200 GeV

http://arxiv.org/abs/nucl-ex/0602011

Bonus: forward physics from RHIC



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Forward physics from PHENIX at RHIC

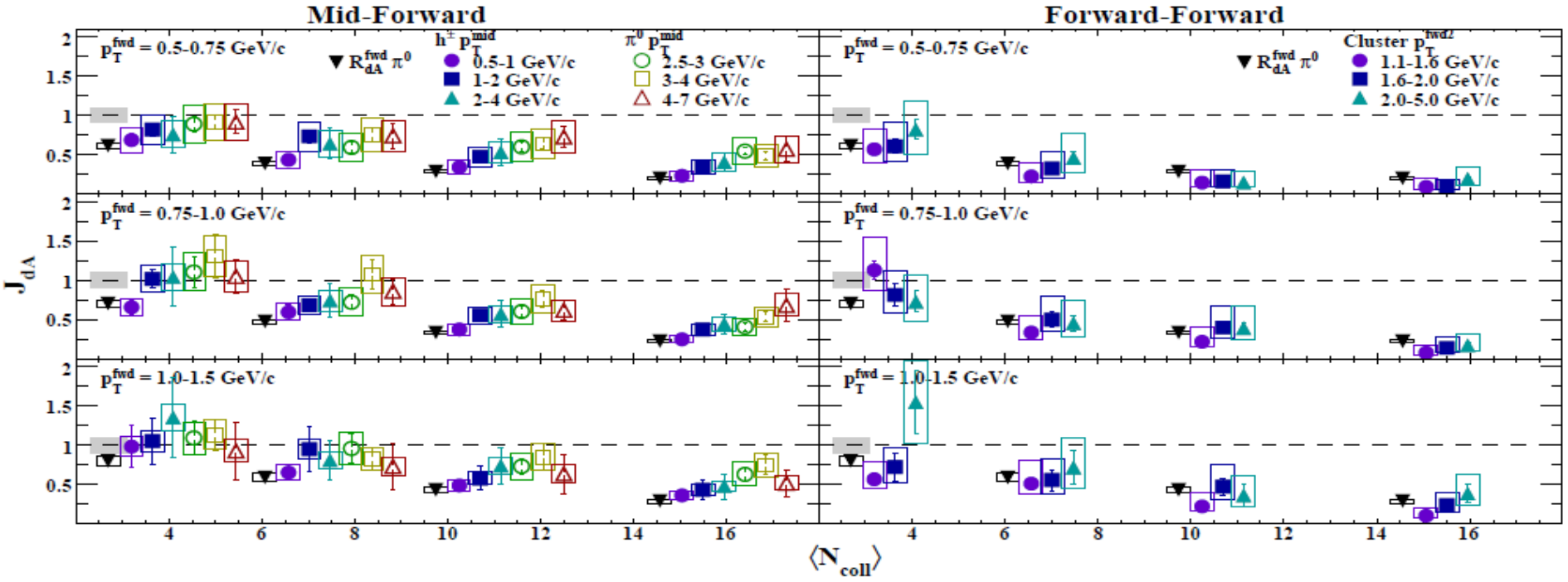

FIG. 3: (color online). Relative yield J_{dA} versus $\langle N_{\rm coll} \rangle$ for forward-rapidity ($3.0 < \eta < 3.8$) π^0's paired with (left) midrapidity ($|\eta| < 0.35$) hadrons and π^0's and (right) forward-rapidity ($3.0 < \eta < 3.8$) cluster-π^0 pairs for the indicated combinations of p_T ranges. Also plotted as inverted solid triangles are the values of the forward π^0 R_{dA}. Around each data point the vertical bars indicate statistical uncertainties and the open boxes indicate point-to-point systematic uncertainties. The gray bar at the left in each panel represents a global systematic scale uncertainty of 9.7%. Additional centrality dependent systematic uncertainties of 7.5%, 5.1%, 4.1%, and 4.8% for the peripheral to central bins, respectively, are not shown. The $\langle N_{\rm coll} \rangle$ values within a centrality selection are offset from their actual values for visual clarity (see text for actual $\langle N_{\rm coll} \rangle$ values).

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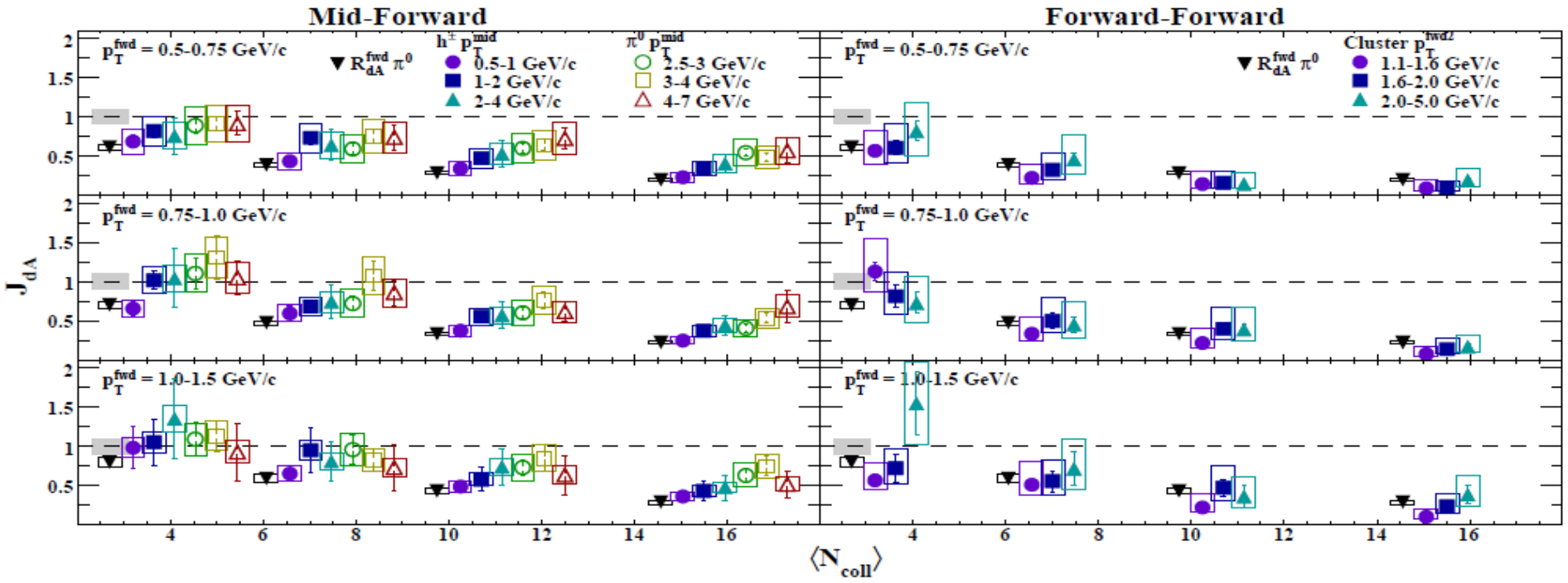

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