NDOF (effective)

R. Seto

May 29

(fixed using mike T's answer)

dEt/dy~1.25dEt/deta

add calculation using s/T^3

Plan

- use dEt/dy to get energy density
- use dN/dy to get entropy density (see lines of thought from muller/Rajagopal (hep-ph/0502174v1 and Enterria/Peressounko nucl-th/0503054v3)
- use Tmeas(photons)~ 245 MeV
- fit models of Tinit using Tmeas as a function of τ
  - this fit allows us to eliminate some sensitivity to T
- get the values for ε/T^4, $3s/4T^3$ and compare to lattice values (multiply by $30/\pi^2$ to get an effective ndof)
- Now in a sQGP I am not sure a dof is well defined, but the ε, s, and T are. I just think of them as effective DOF.
- Maybe a model of resonances can approximate the DOF in an sQGP?
- Hope – look for consistency with the lattice and some lower limit on NDof

Comments

- This is a quintessentially PHENIX measurement – we wanted to measure low mass photons and dileptons, and ET (and dN/dy). We now have them – lets make use of them
- Statements from Muller Rajagopal hep-ph/0502174v1 (2005)
  - The challenge of demonstrating that the matter produced in heavy ion collisions is a deconfined quark-gluon plasma, as predicted by lattice QCD calculations, is the challenge of measuring the number of thermodynamic degrees of freedom $\nu \sim \varepsilon/T^4$ at the time t_0 at which the matter comes into approximate local thermal equilibrium and begins to behave like a hydrodynamic fluid. Data from experiments done at the Relativistic Heavy Ion Collider have been used to estimate t_0 and to put a lower bound on the energy density $\varepsilon(t_0)$. However, measuring ν has seemed out of reach, because no current data serve even as qualitative proxies for the temperature $T(t_0)$.
  - an experimental demonstration of deconfinement cannot be seen as the answer to some “yes/no” question, but must instead involve the measurement of some physical property of the matter created in heavy ion collisions that can also be predicted by controlled theoretical calculations, and which takes on quite different values below and above the crossover between a hadron gas and a quark-gluon plasma.
  - A measurement of the temperatures of the quark-gluon plasma presumed to be present at early times is one of the goals of studies of direct photon and dilepton emission in heavy ion collisions but, so far, no evidence for thermal photon or dilepton radiation has been observed at RHIC.

Preliminaries

theory you know

and

phenix data

a first guess: Degrees of Freedom

Can we melt the hadrons and liberate quark and gluon degrees of freedom?

$$\varepsilon_{SB} = \begin{cases} \{2_f \cdot 2_s \cdot 2_q \cdot 3_c \frac{7}{8} + 2_s \cdot 8_c\} \frac{\pi^2}{30} T^4 = 37 \frac{\pi^2}{30} T^4, \\ \{3_f \cdot 2_s \cdot 2_q \cdot 3_c \frac{7}{8} + 2_s \cdot 8_c\} \frac{\pi^2}{30} T^4 = 47.5 \frac{\pi^2}{30} T^4 \end{cases}$$

$$\varepsilon = g \frac{\pi^2}{30} T^4$$

Energy density for "g" massless d.o.f. (bosons)

$$\varepsilon_g = \frac{1}{2\pi^2} \int \frac{p^3 dp}{e^{\beta p} - 1} \qquad \Rightarrow \varepsilon_g = \frac{\pi^2 T^4}{30}$$

$$\varepsilon_q = \frac{1}{2\pi^2} \int \frac{p^3 dp}{e^{\beta(p+\mu)} + 1} \qquad \Rightarrow \varepsilon_q + \varepsilon_{\bar{q}} = \frac{7\pi^2 T^4}{120} + \frac{\mu^2 T^2}{4} + \frac{\mu^4}{8\pi^2}$$

$$\varepsilon = 3 \cdot \frac{\pi^2}{30} T^4$$

Hadronic Matter: quarks and gluons confined
For T ~ 200 MeV, **3** pions with spin=0

$$\varepsilon = \left\{ 2_s \cdot 8_g + \frac{7}{8} \cdot 2_s \cdot 2_a \cdot 2_f(3) \cdot 3_c \right\} \frac{\pi^2}{30} T^4$$

Quark Gluon Matter:
8 gluons;
2(3) quark flavors,
antiquarks,
2 spins, 3 colors

$$\varepsilon = 37(48) \cdot \frac{\pi^2}{30} T^4$$

37 (48) !

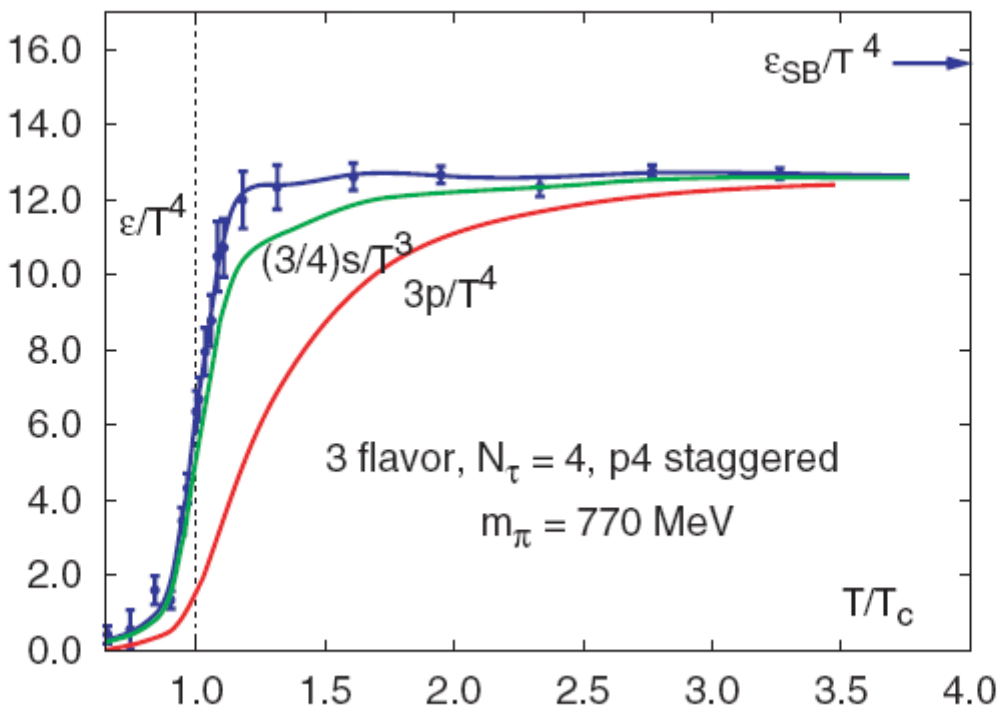
The Critical temperature

$$\varepsilon == g\frac{\pi^2}{30}T^4$$

$$P = \frac{1}{3}\varepsilon$$

$$s(T) = \frac{2\pi^2}{45}T^3$$

- Lattice: T_C~190 MeV (ε_C ~ 1 GeV/fm^3)
  - Phase transition- fast cross over
  - to experimentalist: 1st order



difference between S-B and lattice

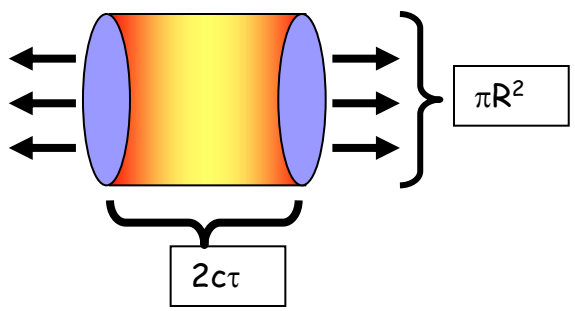
interactions (in hindsight)

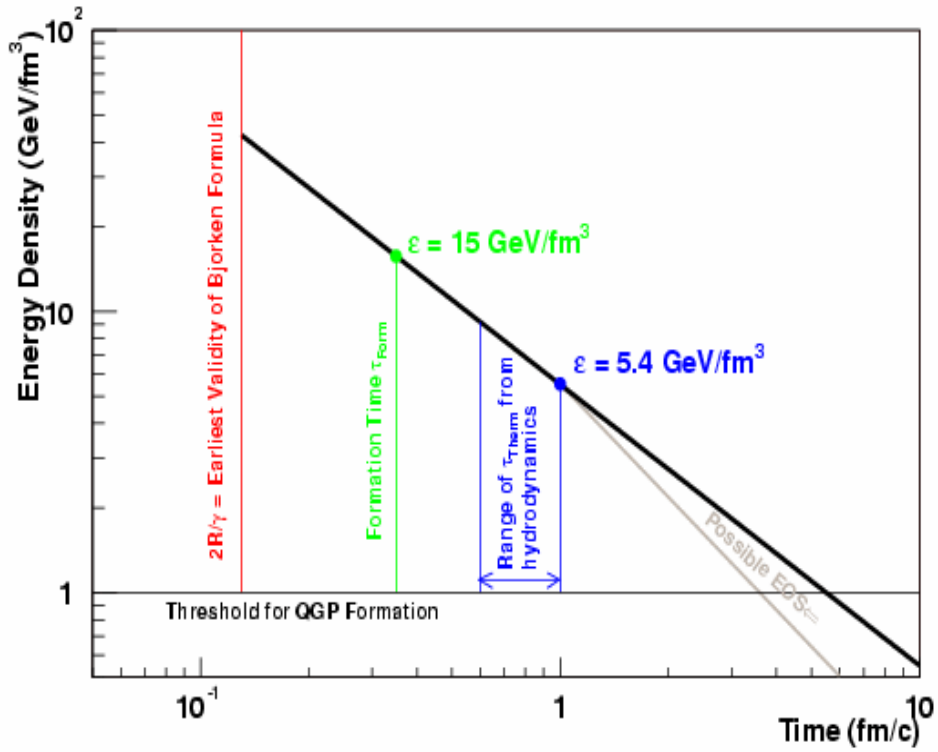
Energy Density

Energy density far above transition value predicted by lattice.

$$\varepsilon_{Bj} = \frac{1}{\pi R^2}\frac{1}{2c\tau}\left(2\frac{dE_T}{dy}\right)$$

R~5.5fm





PHENIX: Central Au-Au yields

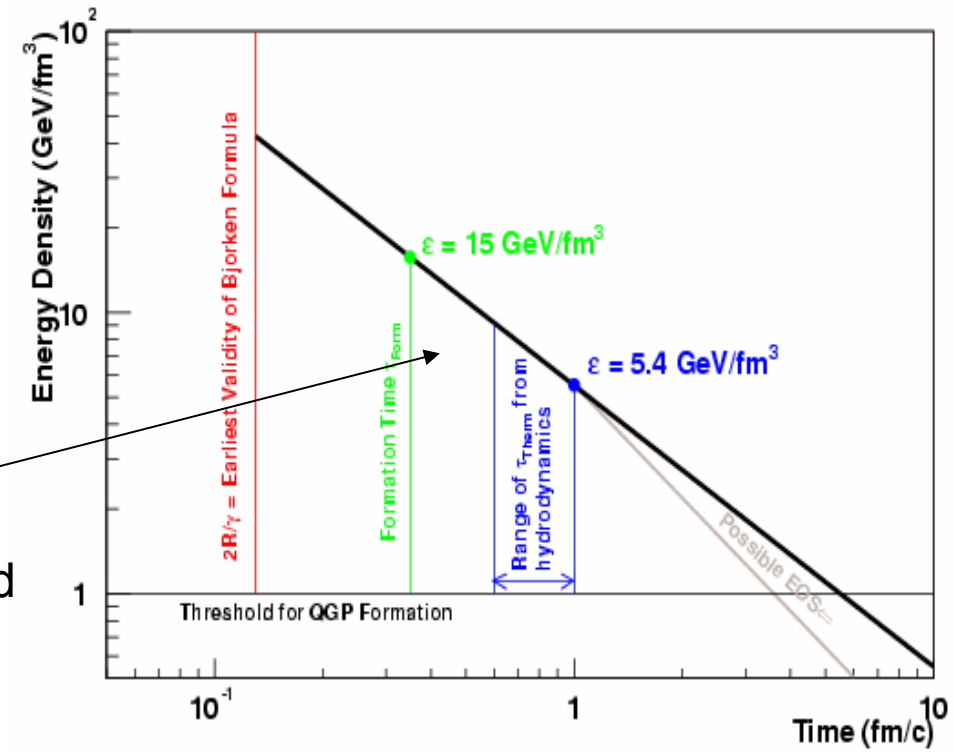
$$\left\langle \frac{dE_T}{d\eta} \right\rangle_{\eta=0} = 503 \pm 2\,GeV$$

$$\varepsilon \sim 15\,\frac{GeV}{fm^3} \quad @\,\tau = 0.35\,fm/c$$

where did this number come from?

Question

$$\varepsilon_{Bj} = \frac{1}{\pi R^2}\frac{1}{2c\tau}\left(2\frac{dE_T}{dy}\right)$$

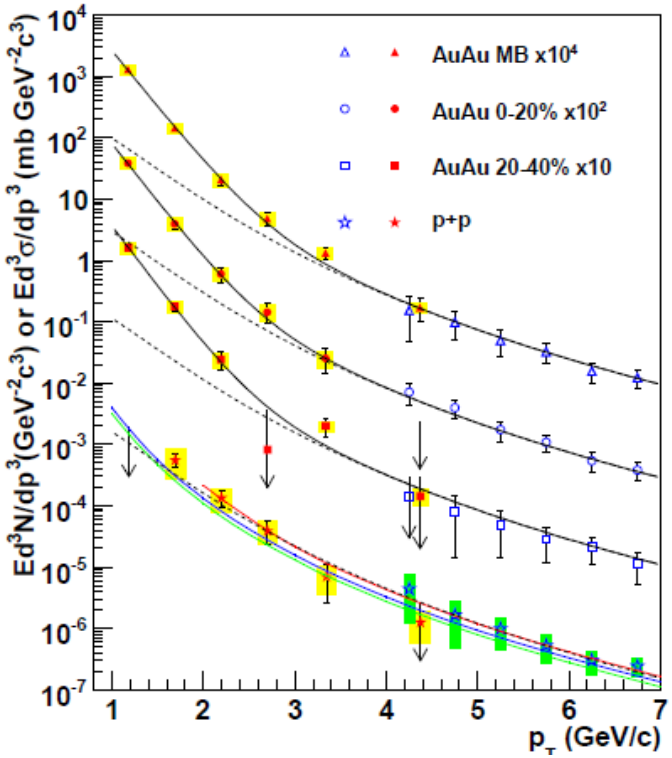


How were these values derived
if I use dEt/deta=600 GeV
R=6.8 and Tau=.35
I get ε=12 GeV/fm^3 (not 15)
I need an R~6fm to get 15

ANSWER from mike
dEt/dy=1.25*dEt/deta
I fixed this and I get this plot

Note: to go from dN/deta to s(entropy)
there is a factor of ~7.9=1.1*7.25/1.04
see Mueller, Rajagopal
hep-ph/0502174v1

Initial State & Temperature - Photons

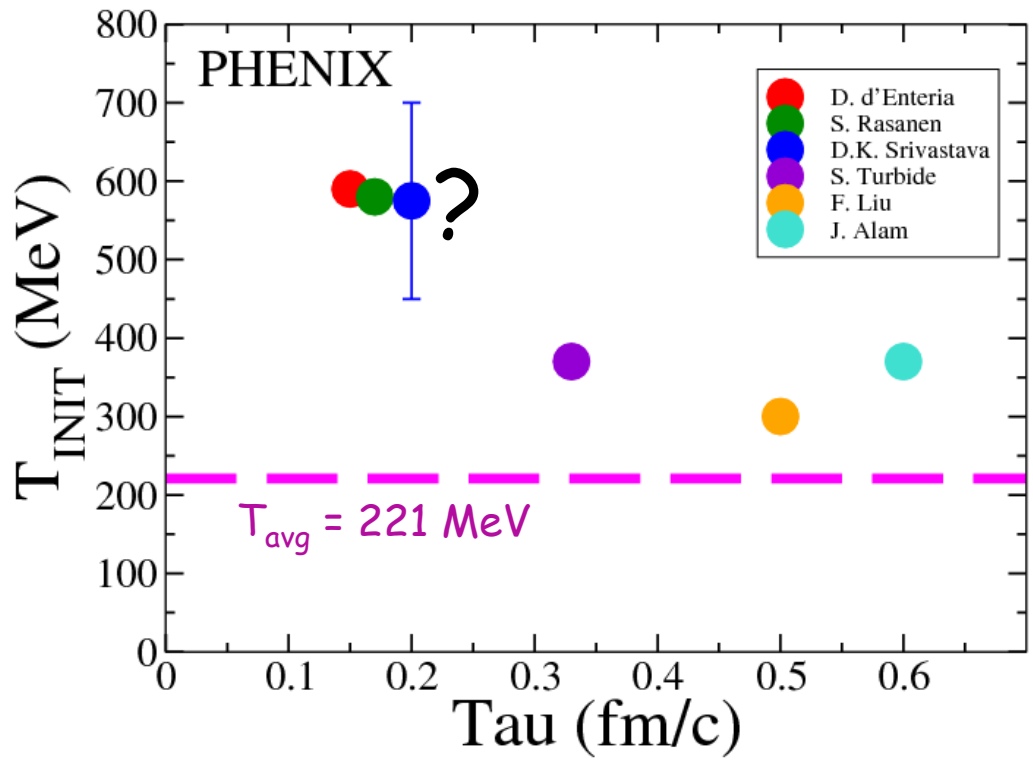


arXiv:0804.4168v1 [nucl-ex]

Nearly real photons extracted from shape of low-mass e^+e^- spectrum

Shows large enhancement above scaled p+p in low-p_T "thermal" region

Talk: Y. Yamaguchi (4C, Thu)



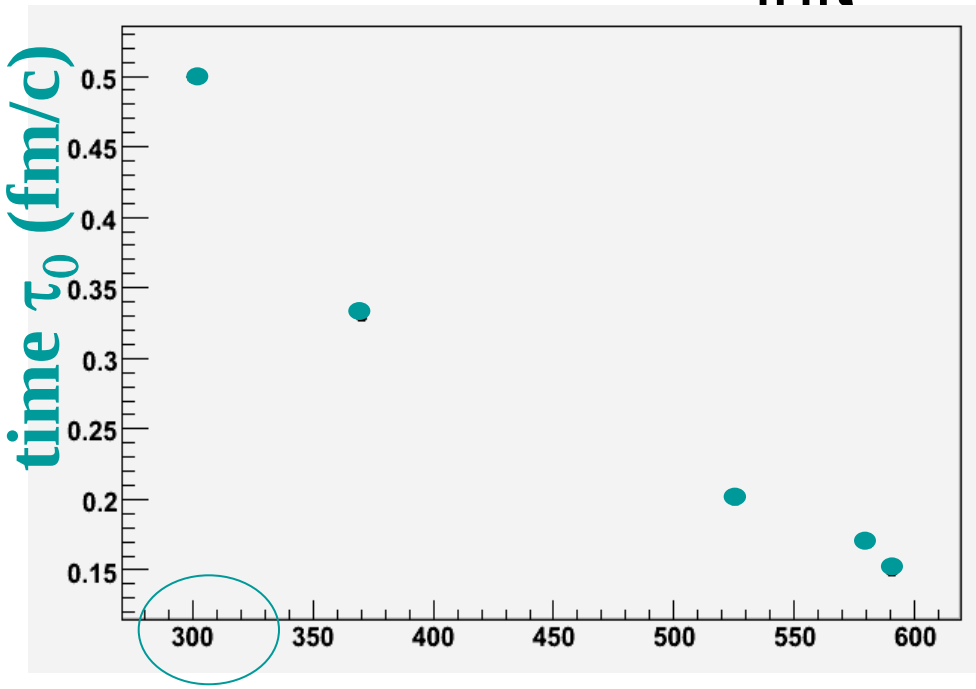
- Fit to the p_T slope in central collisions yields

  T_{avg} = 221 ±23 ±18 MeV
- Using models for the expansion

  T_{avg} = 221 → T_{init} > 300 MeV

G. David

$T_{init} > T_c$!

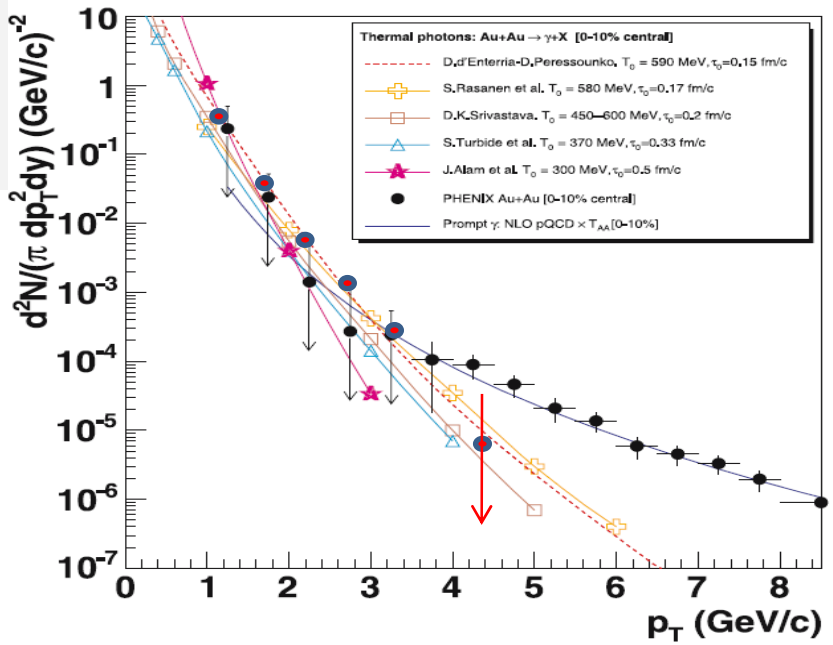


T_{init} (MeV)

To unfold hydro evolution:

Compare to photon spectrum from hydro models

D'Enterria & Peressounko, EPJ C46 (2006) 451



T decreasing with time

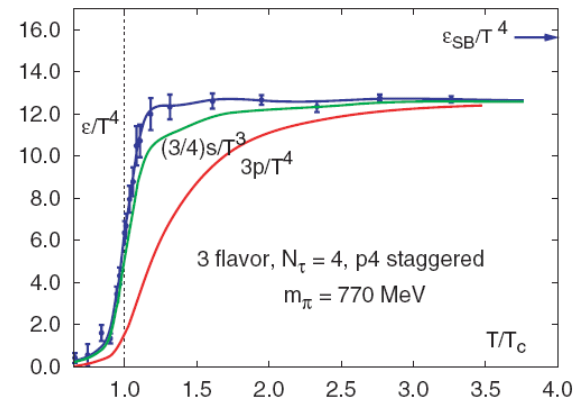
T_{init} ~ 300-600 MeV

T_c ~ 170 MeV

NDOF? a Sanity check

$$\varepsilon = 15 \frac{GeV}{fm^3}$$

$$\varepsilon = 3 \cdot \frac{\pi^2}{30} T^4$$



hadron gas

choose τ_0 ~0.5-0. 6 fm/c

$\Rightarrow T_{initial} \sim 0.300\ GeV$

$$\varepsilon = 37(48) \cdot \frac{\pi^2}{30} T^4$$

"QGP"

$$NDOF = \varepsilon \cdot \frac{30}{\pi^2 T^4} = 15 \frac{GeV}{fm^3} \frac{30\,(0.197\ GeV\ \ fm)^3}{\pi^2 (0.3\ GeV)^4} = 43$$

good...

Now do it more carefully

what do we expect?

for 2 flavors

12 (ndof=36)

9.5 (ndof=29)

7.5 (ndof=23)

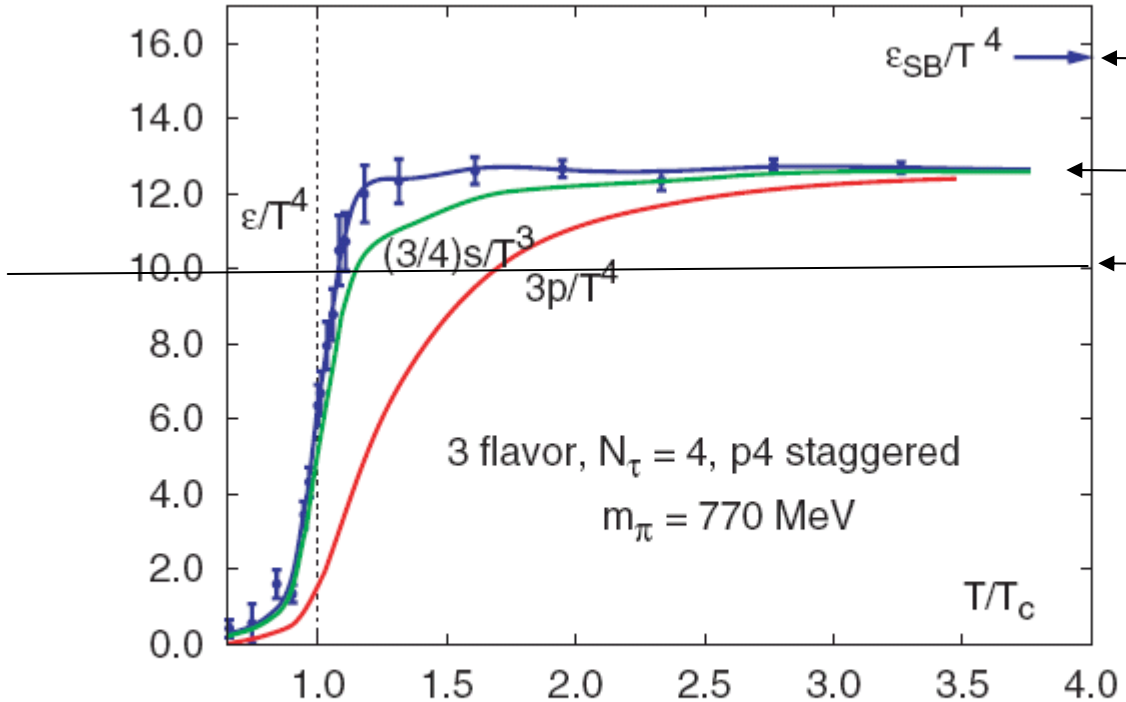
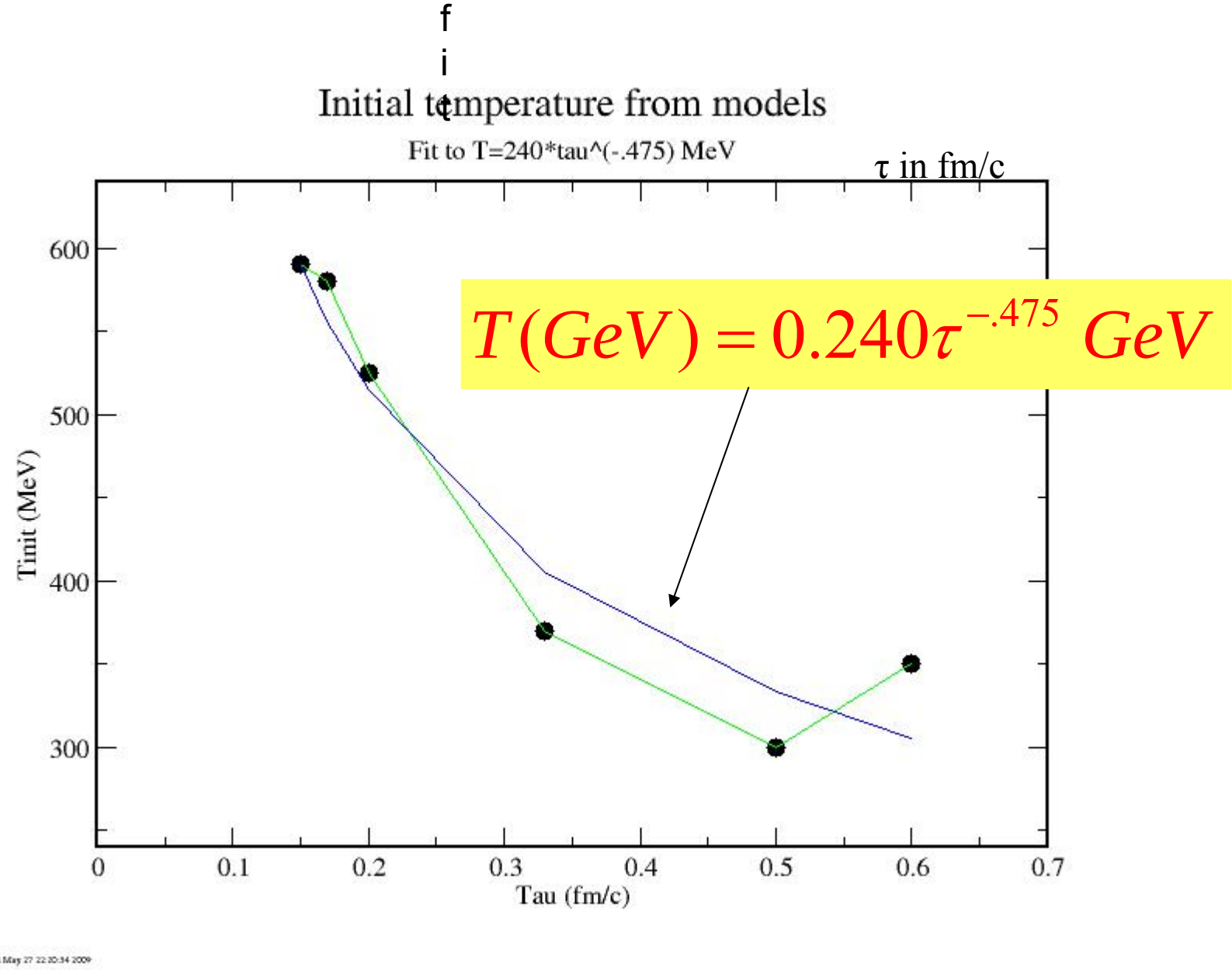


Figure 1 $\varepsilon(T)/T^4$, $P(T)/T^4$, and $s(T)/T^3$ for three light flavors of quarks on the lattice. SB, massless Bose field.

$$9.5\frac{30}{\pi^2} = 29 = ndof\,(effective)$$

37=ndof(effective 3 flavor)

Expectaions								
	ndof(sb)	e/T^4(s	3s/4T^3(sb)	e/T^4(la	3s/4T^3(	ndof(effective)	3s/4T^3(near T	ndof(effective)
3 flavor	48	16.00	16	12.5	12.5	38.0	10.00	30.4
2 flavor	37	12.00	12	9.5	9.5	28.9	7.50	22.8


Initial temperature from models
Fit to T=240*tau^(-.475) MeV
τ in fm/c
$T(GeV) = 0.240\tau^{-.475}\ GeV$
Tinit (MeV)
600
500
400
300
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Tau (fm/c)
Wed May 27 22:20:34 2009

NDOF using ε/T^4

$$\varepsilon = NDOF \cdot \frac{\pi^2}{30} T^4$$

$$NDOF = \varepsilon \cdot \frac{30}{\pi^2 T^4}$$

$$\varepsilon_{Bj} = \frac{1}{\pi R^2} \frac{1}{2c\tau} \left(2 \frac{dE_T}{dy} \right)$$

$$T(GeV) = 0.240\tau^{-.475}\ GeV$$

$$\left\langle \frac{dE_T}{d\eta} \right\rangle_{\eta=0} = 606 GeV \qquad \left\langle \frac{dE_T}{dy} \right\rangle_{\eta=0} = \left\langle \frac{dE_T}{d\eta} \right\rangle_{\eta=0} * 1.25 = 758\ GeV$$

$$NDOF = \varepsilon \cdot \frac{30}{\pi^2 T^4} = \frac{1}{\pi R^2} \frac{1}{c\tau} \left(\frac{dE_T}{dy} \right) \frac{30(\hbar c)^3}{\pi^2 T^4} = \frac{1}{\pi (6.6\ fm)^2} \frac{1}{\tau(\ fm)} (758 GeV) \frac{30\,(0.197\ GeV\ \ fm)^3}{\pi^2 (0.240\tau^{-.475}\ GeV)^4} = C\tau^{0.9}$$

$$NDOF = 39\tau^{0.9} \qquad dEt/dy = 758 \quad R = 6.6 = 1.18 * (351/2)^{1/3}$$

e.g NDOF= $39(0.6)^{0.9}$= 25

NDOF using s/T^3

$$s = ndof\,\frac{2\pi^2}{45}T^3$$

$$\varepsilon = NDOF \cdot \frac{\pi^2}{30}T^4$$

$$NDOF = s \cdot \frac{45}{2\pi^2 T^3}$$

$$NDOF = \varepsilon \cdot \frac{30}{\pi^2 T^4}$$

$$s = \frac{7.9}{\pi R^2}\frac{1}{c\tau}\left(\frac{dN_{ch}}{d\eta}\right)$$

from 1.1*7.25/1.04

$$T(GeV) = 0.240\tau^{-.475}\ GeV$$

$$\frac{dN_{ch}}{d\eta} = 665$$

$$NDOF = s\frac{45}{2\pi^2 T^3} = \frac{7.9}{\pi R^2}\frac{1}{c\tau}\left(\frac{dN_{ch}}{d\eta}\right)\frac{45\,(0.197\ GeV\ \ fm)^3}{2^2\pi^2(0.3\ GeV)^3} = \frac{7.9}{\pi R^2}\frac{1}{c\tau}\left(\frac{dN_{ch}}{d\eta}\right)\frac{45\,(0.197\ GeV\ \ fm)^3}{2^2\pi^2(0.240\tau^{-.475}\ GeV)^3} = C^{0.425}$$

$$NDOF = 39\tau^{0.425} \qquad dEt/dy = 758 \quad R = 6.6 = 1.18*(350/2)^{1/3}$$

e.g NDOF= $22(0.6)^{0.425}$= 18

fits for a range of values

tau	T
0.15	590
0.17	580
0.2	525
0.33	370
0.5	300
0.6	350

Temps from models

NDOF for reasonable values of tau

0-5% central

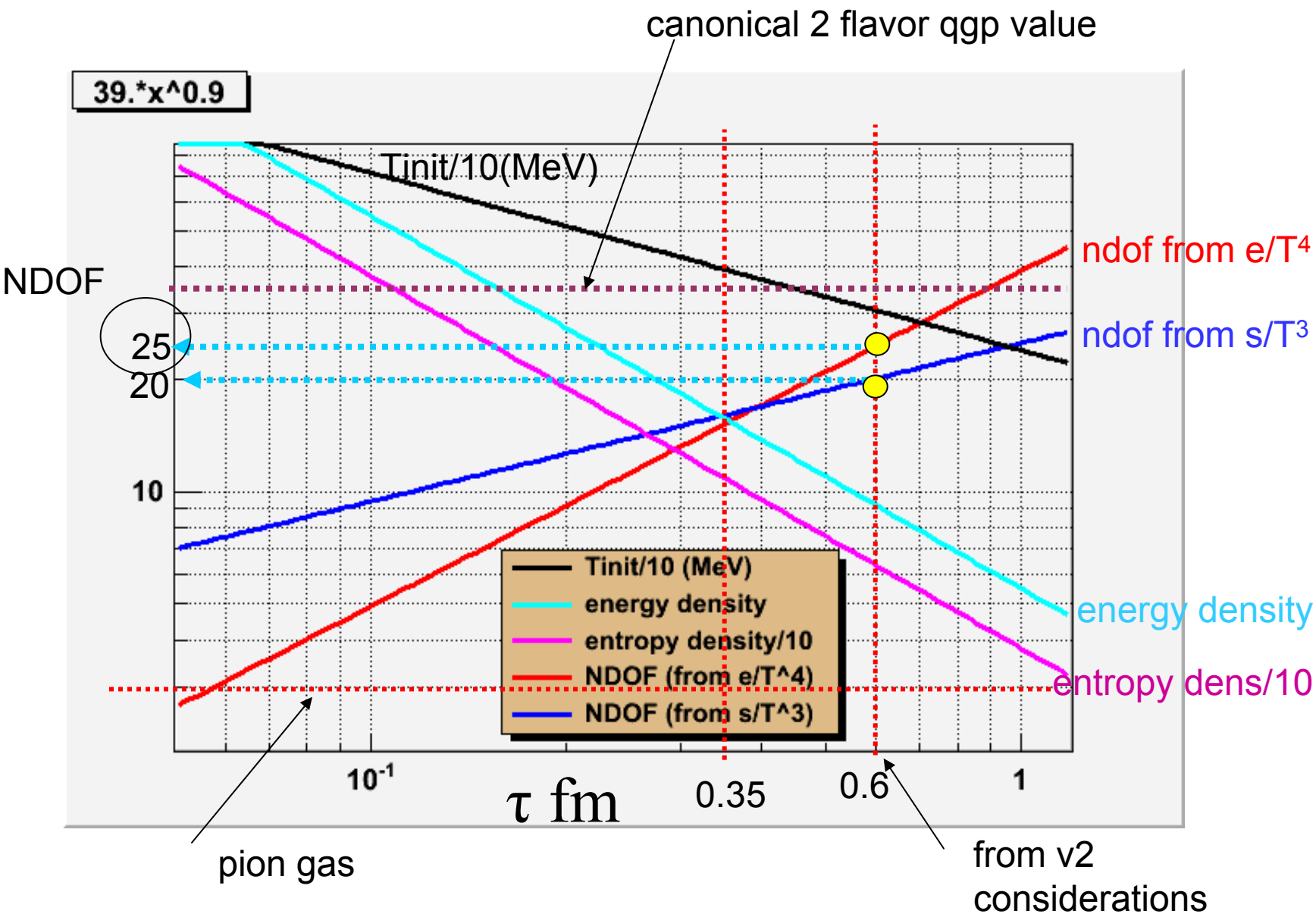
$1.18(npart/2)^{1/3}$

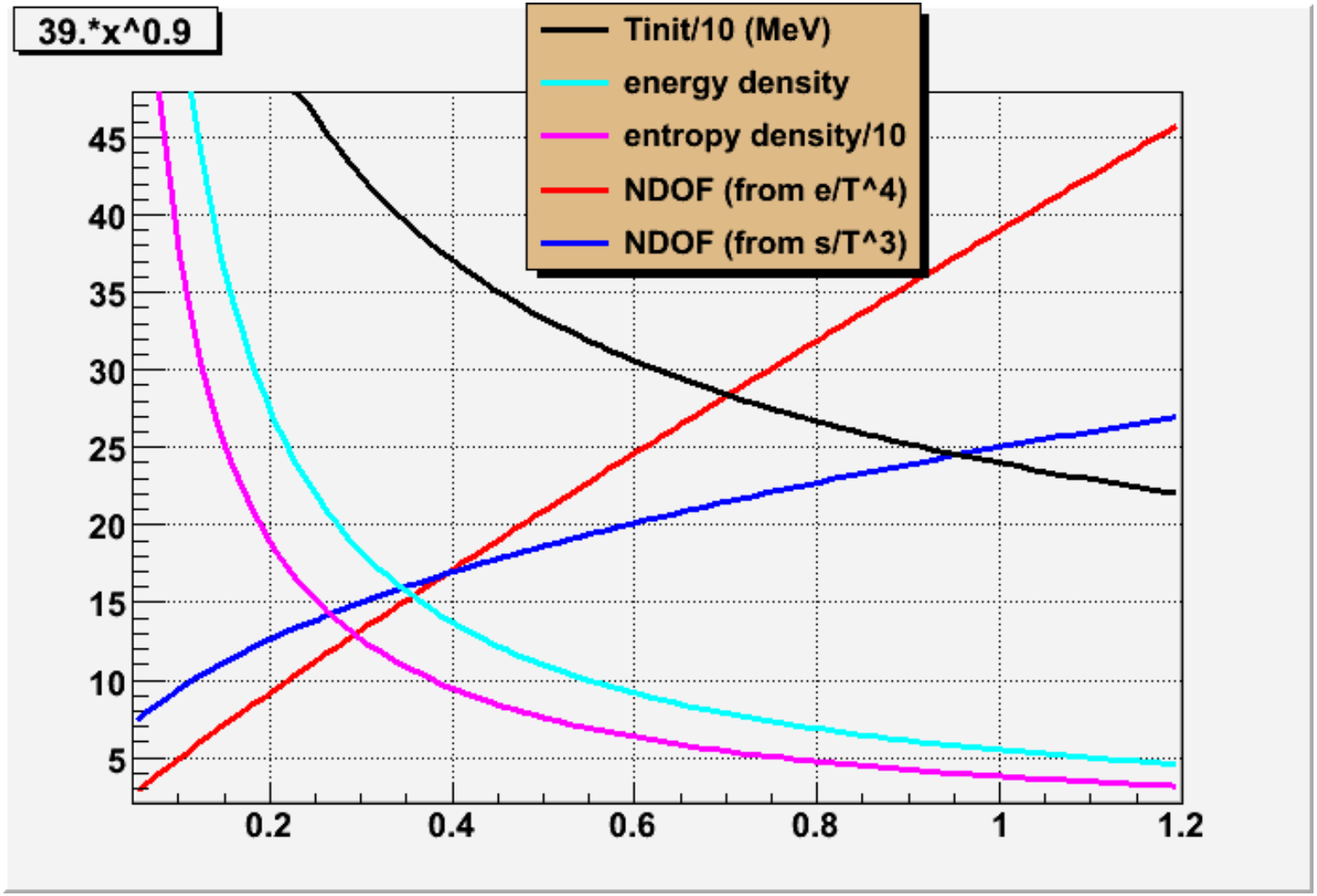
dEt/dy=dEt/deta*1.25 from mike

using ndof=e/T^4									Tinit(	0.821	0.716	0.395	0.306	0.240
cent	Npart	R	dET/deta	dET/dy	e*tau	etau/.35	etau/.6	NDOF/tau^0.9	tau	0.075	0.10	0.35	0.60	1.00
0-5	351.4	6.61	606	758	5.52	15.77	9.20	38.67		3.76	4.87	15.03	24.42	38.67
0-10	325.2	6.44	549.5	687	5.27	15.06	8.78	36.92		3.59	4.65	14.35	23.31	36.92
0-20	279.9	6.13	457.25	572	4.85	13.85	8.08	33.95		3.30	4.27	13.20	21.44	33.95

using ndof=s/T^3									Tinit(	0.821	0.716	0.395	0.306	0.240
cent	Npart	R	dN/deta	ds/dy	s*tau	stau/.35	stau/.6	NDOF/tau^0.42	tau	0.075	0.10	0.35	0.60	1.00
0-5	351.4	6.61	687	5427	39.55	113.00	65.92	24.93		8.29	9.37	15.96	20.07	24.93
0-10	325.2	6.44	624	4930	37.83	108.08	63.05	23.85		7.93	8.96	15.26	19.19	23.85
0-20	279.9	6.13	519	4100	34.77	99.35	57.95	21.92		7.29	8.24	14.03	17.64	21.92

Ndof(tau)


canonical 2 flavor qgp value
39.*x^0.9
Tinit/10(MeV)
NDOF
25
20
10
ndof from e/T4
ndof from s/T3
energy density
entropy dens/10
Tinit/10 (MeV)
energy density
entropy density/10
NDOF (from e/T^4)
NDOF (from s/T^3)
10-1
τ fm
0.35
0.6
1
pion gas
from v2
considerations


39.*x^0.9
Tinit/10 (MeV)
energy density
entropy density/10
NDOF (from e/T^4)
NDOF (from s/T^3)
45
40
35
30
25
20
15
10
5
0.2
0.4
0.6
0.8
1
1.2

Comments

- Pretty hard to get NDOF=3 (i.e. need tau<0.1 fm
- For reasonable tau ~0.35 to 1 fm (0.6 from v2 considerations) get NDOF= 25 using the energy density and 20 using the entropy
- a wQGP predicts ndof=37. If you use the lattice we see a value of 29 using the energy density. The entropy rises slower so right at Tc it would start out at about 23
- pushing it further, it seems to be less than the canonical value of 37 for a ideal massless gas – is this another sign of interactions – i.e. the same thing we see on the lattice where the ε/T^4 does not reach the SB value

- So what I would like to say is that
  - a) we see a e/T^4 and s/T^3 consistent with the lattice
  - b) this would imply then that the ndof ~ lattice
  - c) its much greater than 3

more comments/caveats

- If you look at p 3 of the Mueller/Raj article they point out to exclude the resonance gas we need to exclude Ndof~10 (I don't clearly understand this statement when I look at the figure). I am not sure we know that yet. It seems to be, but I would still like to understand the errors better.
- the energy density is a average of the transverse dimension, where the T is the max. but that implies that the real energy density is higher so that would drive ndof higher
- All the models used to extrapolate back to Tinit are hydro models with a QGP EOS. (note that some of them have a first order transition. I would like to understand if the system sits at Tc in a mixed phase) So the argument is a bit circular. On the other hand you can just use Tmeasured and you still get a large ndof. What you would need is for the Tinit to be much larger (>1 GeV), i.e. to have a much steeper time dependence. That does not seem reasonable to me.
- this does not actually tell you WHAT the DOF are. (again, the DOF may not be well defined in an sQGP) For all we know, perhaps they are some variant of resonances. We already know some modified J/psi continues to live at above Tc, so maybe that is the same of other particles.

- If its OK with the collaboration, I would like to say something like what I have presented here at the AGS/Users meeting where I have to give a talk. However, if its decided that I cannot – I can live with it.

excel

tau	T														
0.15	590														
0.17	580														
0.2	525														
0.33	370														
0.5	300														
0.6	350														
using ndof=e/T^4										Tinit(ta	0.821	0.716	0.395	0.306	0.240
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cent	Npart	R	dN/deta	ds/dy	s*tau	stau/.35	stau/.6		NDOF/tau^0.42	tau	0.075	0.10	0.35	0.60	1.00
0-5	351.4	6.61	687	5427	39.55	113.00	65.92		24.93		8.29	9.37	15.96	20.07	24.93
0-10	325.2	6.44	624	4930	37.83	108.08	63.05		23.85		7.93	8.96	15.26	19.19	23.85
0-20	279.9	6.13	519	4100	34.77	99.35	57.95		21.92		7.29	8.24	14.03	17.64	21.92
Expectaions															
	ndof(sb)	e/T^4(s	3s/4T^3(sb)		e/T^4(lat	3s/4T^3(l	ndof(effective)		3s/4T^3(near Tc	ndof(effective)					
3 flavor	48	16.00	16		12.5	12.5	38.0		10.00	30.4					
2 flavor	37	12.00	12		9.5	9.5	28.9		7.50	22.8					

from dET/dy paper 200 GeV AuAu

TABLE XIII: Results of the measurements by PHENIX at $\sqrt{s_{NN}}$ =200 GeV. Errors have the same dimension as preceding value. Results are plotted in Figs. 5, 7 and 8.

bin [%]	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70
N_p	353.	300.	254.	215.	181.	151.	125.	103.	83.3	66.7	52.5	40.2	30.2	22.0
syst. error	10.	9.0	8.1	7.3	6.6	6.0	5.5	5.1	4.7	4.3	4.1	3.8	3.6	3.4
$A_\perp$[fm^2]	140.	125.	112.	100.	90.8	82.2	73.9	66.8	60.0	54.3	49.3	45.1	40.9	37.5
syst. error	11.	10.	9.1	8.2	7.4	6.8	6.2	5.7	5.2	4.8	4.6	4.5	4.5	4.9
$dE_T/d\eta$ [GeV]	606.	493.	402.	328.	266.	216.	173.	137.	107.	81.8	60.4	43.9	31.1	21.1
stat. error	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
bending syst. error	2.4	5.1	7.0	7.6	8.2	8.5	8.2	8.1	7.6	6.9	6.4	5.5	4.6	3.9
full syst. error	32.	27.	22.	19.	16.	14.	12.	11.	9.5	8.1	7.2	5.9	4.9	4.0
$\varepsilon_{Bj}\tau$ [GeV fm^{-2} c^{-1}]	5.4	4.9	4.5	4.1	3.7	3.3	2.9	2.6	2.2	1.9	1.5	1.2	1.0	0.7
full syst. error	0.6	0.5	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.2	0.2
$dE_T/d\eta/(0.5N_p)$ [GeV]	3.43	3.28	3.16	3.05	2.94	2.86	2.76	2.66	2.57	2.45	2.30	2.18	2.06	1.92
bending syst. error	0.01	0.03	0.05	0.07	0.09	0.12	0.14	0.17	0.19	0.22	0.27	0.31	0.36	0.43
full syst. error	0.21	0.20	0.20	0.20	0.21	0.22	0.23	0.25	0.27	0.29	0.33	0.36	0.41	0.47
$dN_{ch}/d\eta$	687.	560.	457.	372.	302.	246.	197.	156.	124.	95.3	70.9	52.2	37.5	25.6
stat. error	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
bending syst. error	25.	17.	14.	11.	10.	9.9	9.4	9.0	8.2	7.8	7.1	6.1	5.2	4.4
full syst. error	37.	28.	22.	18.	16.	14.	12.	11.	9.6	8.6	7.6	6.5	5.4	4.5
$dN_{ch}/d\eta/(0.5N_p)$	3.89	3.73	3.59	3.45	3.34	3.25	3.15	3.05	2.96	2.86	2.70	2.60	2.48	2.33
bending syst. error	0.14	0.12	0.11	0.10	0.12	0.14	0.16	0.19	0.21	0.25	0.30	0.35	0.41	0.49
full syst. error	0.23	0.22	0.21	0.21	0.21	0.22	0.24	0.26	0.28	0.32	0.36	0.41	0.46	0.55
E_T/N_{ch} [GeV]	0.881	0.879	0.881	0.882	0.881	0.880	0.875	0.874	0.866	0.858	0.851	0.840	0.828	0.823
bending syst. error	0.032	0.026	0.021	0.017	0.015	0.012	0.011	0.010	0.011	0.013	0.017	0.023	0.032	0.047
full syst. error	0.071	0.069	0.067	0.066	0.065	0.065	0.064	0.064	0.064	0.064	0.064	0.065	0.068	0.076

centrality table for AuAu Reygers

class	$\langle N_{part} \rangle$	sys. err.	$\langle N_{coll} \rangle$	sys. err.	T_{AB} (mb^{-1})	sys. err.	$\langle b \rangle$ (fm)	sys. err.	ε	sys. err.
0- 5%	351.4	2.9	1065.4	105.3	25.37	1.77	2.3	0.1	0.027	0.007
5- 10%	299.0	3.8	845.4	82.1	20.13	1.36	4.1	0.2	0.086	0.011
10- 15%	253.9	4.3	672.4	66.8	16.01	1.15	5.2	0.3	0.140	0.023
15- 20%	215.3	5.3	532.7	52.1	12.68	0.86	6.2	0.2	0.182	0.020
20- 25%	181.6	5.6	421.8	46.8	10.04	0.85	7.0	0.4	0.224	0.031
25- 30%	151.5	4.9	325.6	32.4	7.75	0.58	7.8	0.3	0.257	0.022
30- 35%	125.7	4.9	251.0	25.9	5.98	0.48	8.4	0.4	0.287	0.025
35- 40%	102.7	4.3	188.6	20.6	4.49	0.43	9.1	0.4	0.315	0.032
40- 45%	82.9	4.3	139.4	15.4	3.32	0.31	9.7	0.4	0.337	0.039
45- 50%	65.9	3.4	101.3	12.1	2.41	0.25	10.2	0.4	0.360	0.046
50- 55%	51.6	3.2	72.1	10.5	1.72	0.23	10.7	0.4	0.372	0.048
55- 60%	39.4	3.5	49.9	9.6	1.19	0.23	11.2	0.4	0.383	0.069
60- 65%	29.8	4.1	34.4	8.7	0.82	0.21	11.7	0.5	0.397	0.052
65- 70%	21.5	3.8	22.6	6.6	0.54	0.16	12.1	0.5	0.399	0.054
70- 75%	15.5	3.4	14.8	5.1	0.35	0.12	12.6	0.5	0.392	0.075
75- 80%	11.3	2.6	9.9	3.3	0.24	0.08	13.0	0.6	0.381	0.115
80- 92.2%	6.3	1.2	4.9	1.2	0.12	0.03	14.1	0.6	0.261	0.082
0- 10%	325.2	3.3	955.4	93.6	22.75	1.56	3.2	0.2	0.057	0.008
10- 20%	234.6	4.7	602.6	59.3	14.35	1.00	5.7	0.3	0.161	0.021
20- 30%	166.6	5.4	373.8	39.6	8.90	0.72	7.4	0.3	0.241	0.026
30- 40%	114.2	4.4	219.8	22.6	5.23	0.44	8.7	0.4	0.301	0.028
40- 50%	74.4	3.8	120.3	13.7	2.86	0.28	9.9	0.4	0.348	0.042
50- 60%	45.5	3.3	61.0	9.9	1.45	0.23	11.0	0.4	0.377	0.058
60- 70%	25.7	3.8	28.5	7.6	0.68	0.18	11.9	0.5	0.398	0.053
70- 92.2%	9.5	1.9	8.3	2.4	0.20	0.06	13.5	0.5	0.317	0.084
00- 15%	301.5	3.7	861.1	83.4	20.50	1.40	3.9	0.2	0.085	0.013
15- 60%	112.9	3.4	231.3	22.0	5.51	0.40	8.9	0.4	0.302	0.036
60- 80%	19.5	3.3	20.4	5.9	0.49	0.14	12.3	0.5	0.392	0.072
80- 92.2%	6.3	1.2	4.9	1.2	0.12	0.03	14.1	0.6	0.261	0.082
0- 20%	279.9	4.0	779.0	75.2	18.55	1.27	4.4	0.2	0.109	0.014
20- 60%	100.2	3.4	193.7	19.1	4.61	0.36	9.3	0.4	0.317	0.038
60- 92.2%	14.5	2.5	14.5	4.0	0.35	0.10	13.0	0.5	0.342	0.074
00- 30%	242.1	4.2	644.0	62.9	15.33	1.06	5.4	0.3	0.153	0.018
30- 60%	78.0	3.4	133.7	14.0	3.18	0.28	9.9	0.4	0.342	0.042
60- 70%	25.7	3.8	28.5	7.6	0.68	0.18	11.9	0.5	0.398	0.053
70- 80%	13.4	3.0	12.4	4.2	0.30	0.10	12.8	0.5	0.387	0.092
80- 92.2%	6.3	1.2	4.9	1.2	0.12	0.03	14.1	0.6	0.261	0.082
0- 92.2%	109.1	4.1	257.8	25.4	6.14	0.45	9.5	0.4	0.281	0.045