Optimizing Physics Output from Run-10 Beam Energy Scan

Stefan Bathe

for PHENIX

Steve's Current Run-10 Plan

$\sqrt{s_{NN}}$ (GeV) for Au+Au	# weeks in 25-cryoweek scenario	# weeks in 30-cryoweek scenario
200	10	10
62.4	4	4
39	1.0	1.5
27	2.5	4.5
18	0	1.5
11.5	1.5	2.5
7.7	1.0	1.0

Confirmed

Today's discussion

Steve Vigdor's RHIC Run 10 Plan , 8/7, 2009

PHENIX BUP Run-10

- 1st priority: Au+Au @ 200 GeV
  - NA 60 type measurement utilizing HBD
  - 1.4 nb^{-1} (or 10 weeks) → 9 x Run-4 significance
- 2nd priority: beam energy scan focusing first between full and injection energy
  - Can measure many more physics observables at higher energies
    - Excitation function of low-mass enhancement
    - Onset of jet quenching
    - v_2 saturation
  - Additional reasons for not running below injection energy:
    - collision rates below injection energy become extraordinarily low
    - operation at 1 Hz or less is poorly matched to the PHENIX optimization for rare probes
  - Au+Au @ 62.4 GeV: 350 M events, 3.5 weeks
  - (PAC recommendation: 4 weeks)
  - Au+Au @ 39 GeV: 50 M events, 1.6 weeks
  - Au+Au @ 27 GeV: 25 M events
  - Au+Au < 22 GeV: move to later

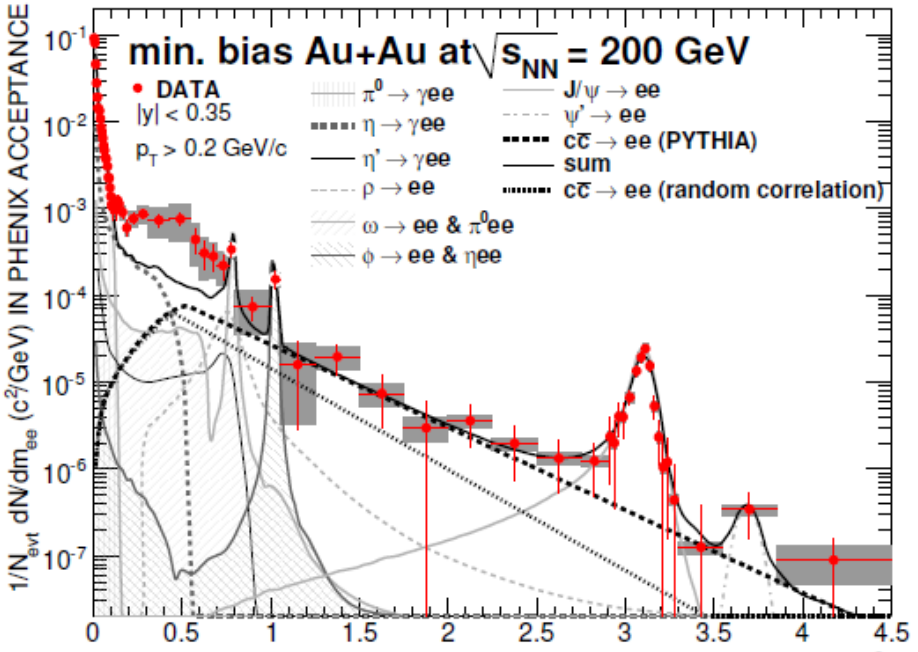
PHENIX Beam Use Proposal for RHIC Run-10 and Run-11, June 2, 2009

Dilepton physics at 62 GeV

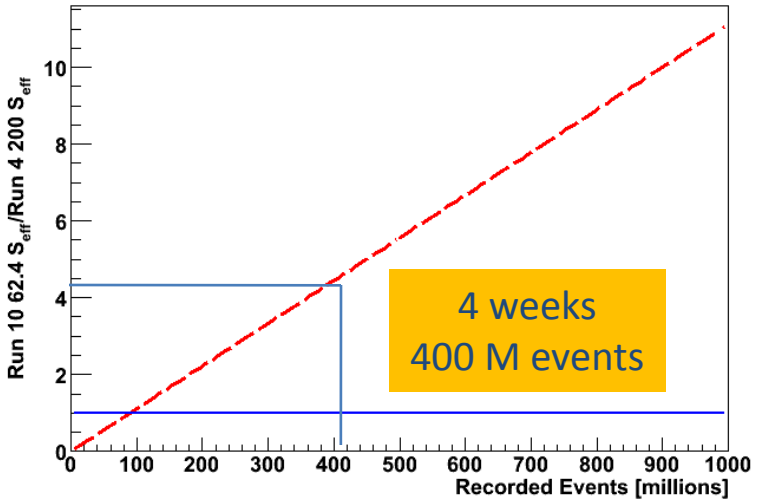
With 400 million recorded AuAu @ 62 GeV minimum bias events in PHENIX,
if we assume a similar low mass enhancement to our published Run-04 AuAu @ 200 GeV result, we will have
an increase in the statistical significance of 2.

The Run-04 @ 200 GeV low mass enhancement is a 2.6 sigma effect.

Thus, the Run-10 @ 62 GeV result would be a 5.2 sigma effect.

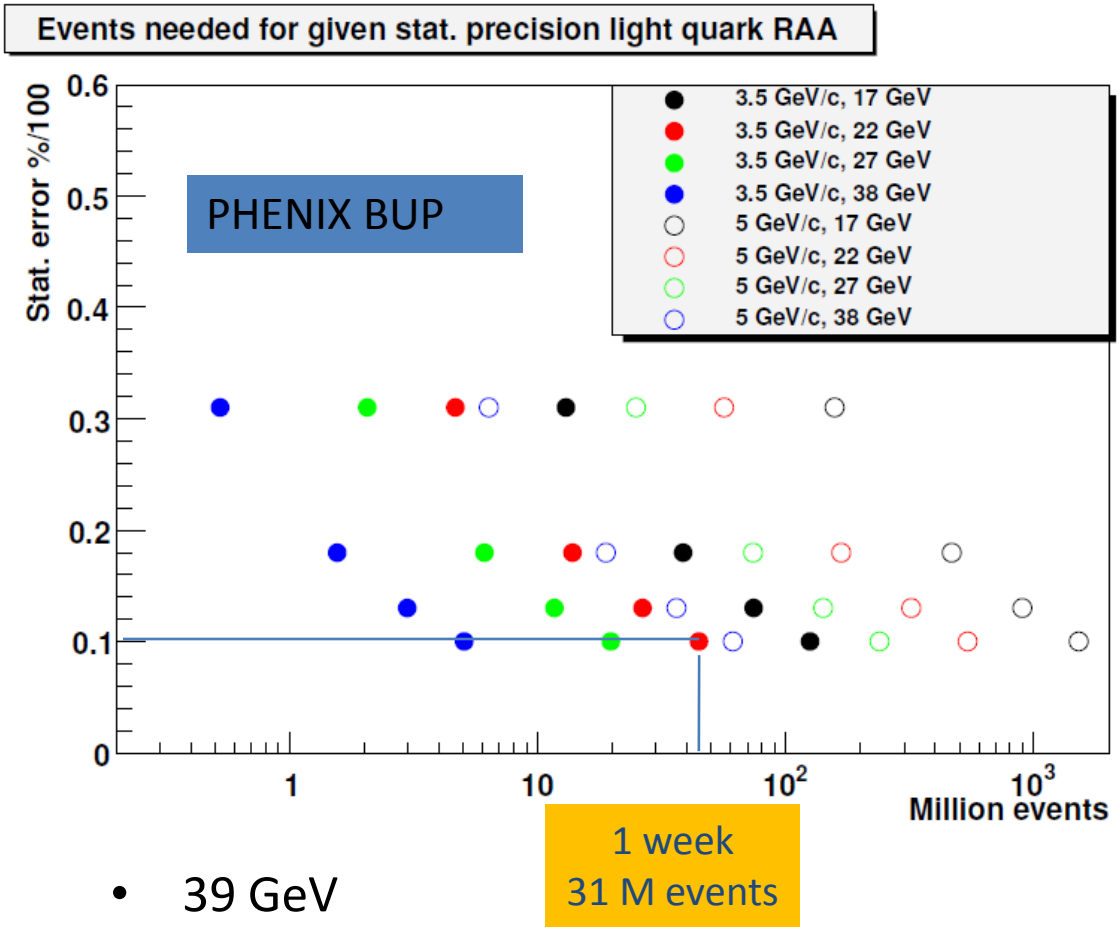


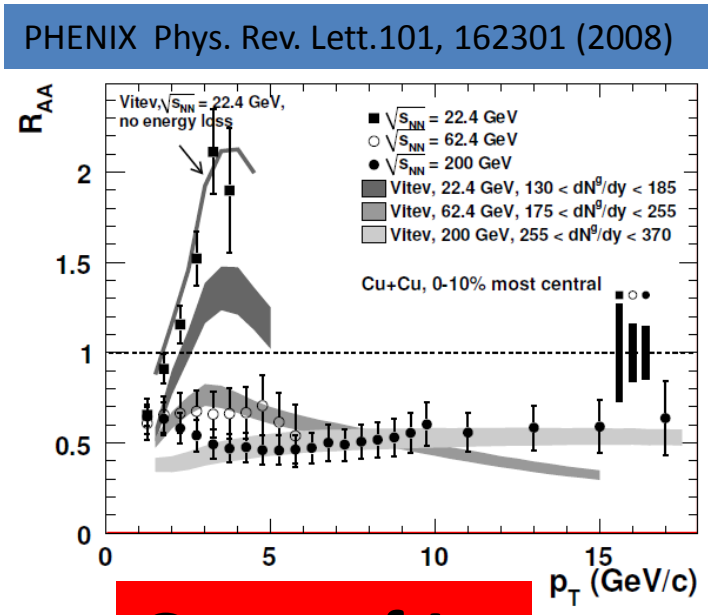
PHENIX Run-04 AuAu 200 GeV arXiv:0706.3034



62.4 GeV improvement factor w.r.t. Run-4@200GeV as function of # of events

Light Quark R_{AA} @ 39 GeV

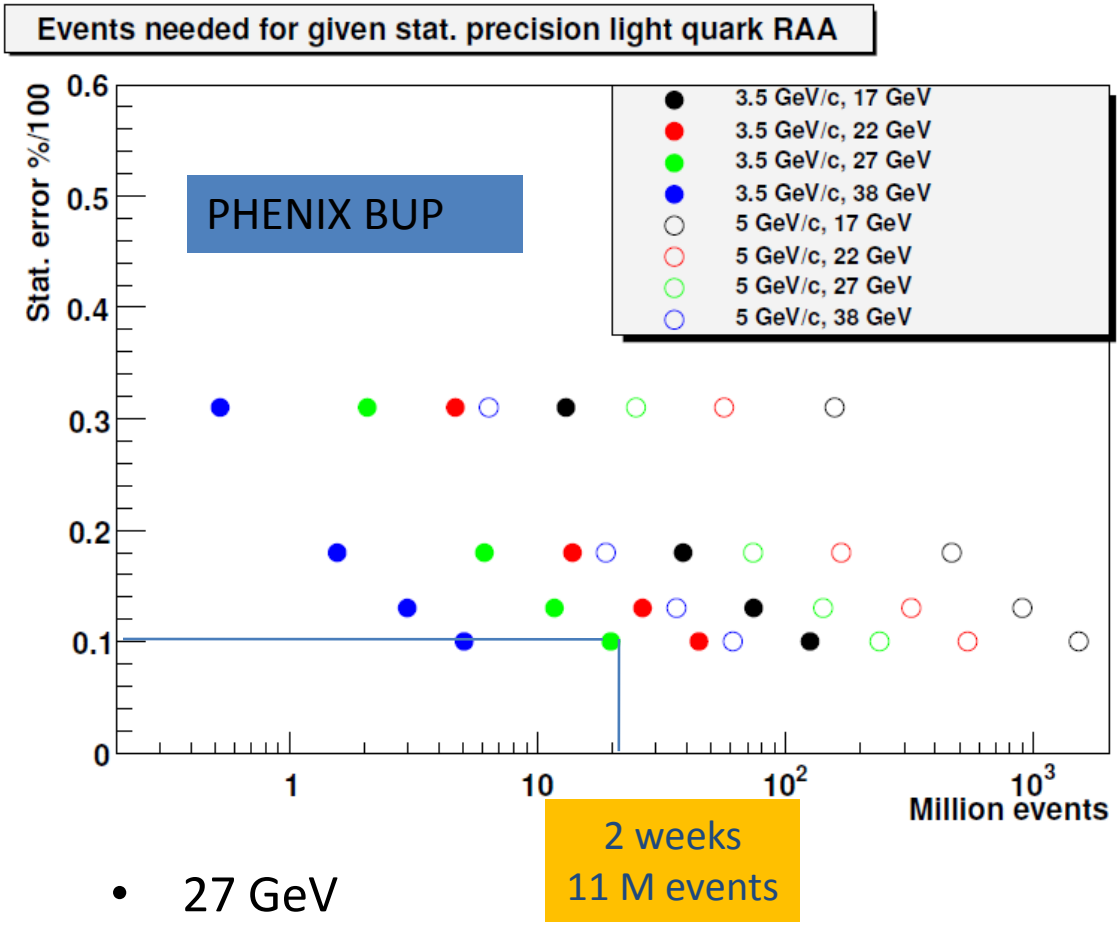


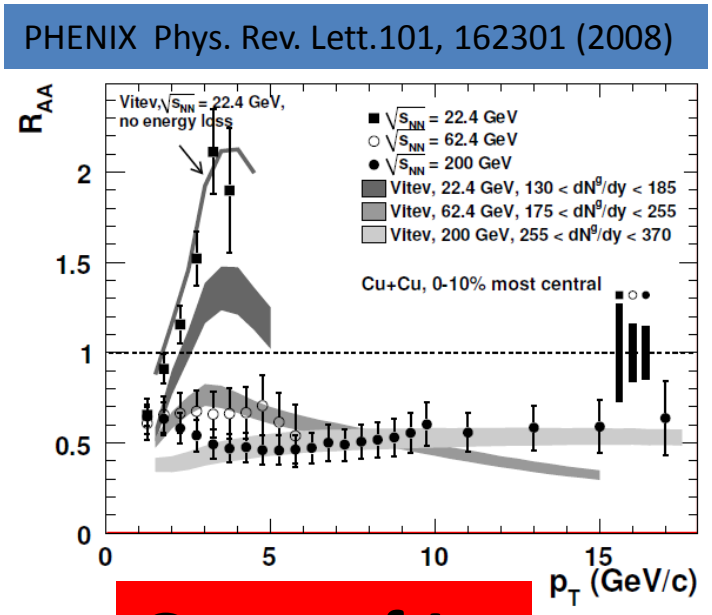


Onset of Jet Quenching

- 39 GeV
  - asked for 1.6 weeks, 50 M events
    - to achieve 10% statistical uncertainty
    - pion R_AA at 5 GeV/c pT
  - Down to 1 week, 31 M events, in 25-week scenario (1.5 w. in 30-week sc.)
    - Increases uncertainty to 15% (assuming 3-day change-over is in addition to 1 week)

Light Quark R_{AA} @ 27 GeV





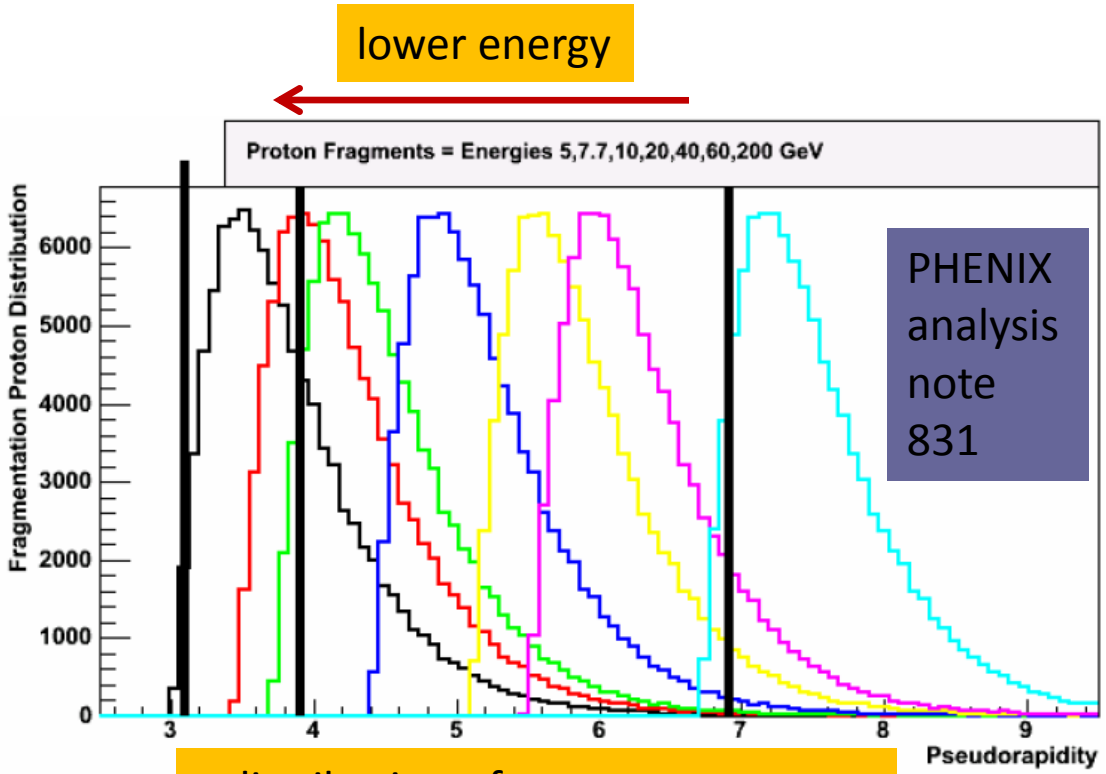
- 27 GeV
  - asked for 4.5 weeks, 25 M events
    - to achieve 10% statistical uncertainty at 3.5 GeV/c pT
  - Down to 2 weeks, 11 M events, in 25-week scenario (4.5 w. in 30-week sc.)
    - Increases uncertainty to 18%

Suggestion

- existing ISR data and interpolated ISR and RHIC p+p data will allow publication of 39 and 27 GeV R_AA results immediately, without need to wait for further running
- PHENIX is excited about the greater physics impact of the 27 GeV R_AA and v_2 measurements by adding weeks beyond 25 weeks to this run. However, we recognize the strong interest in collecting a data set at 7.7 GeV. Consequently, we propose adding the additional two weeks to 7.7 GeV and will participate in this running.

What has changed since the PAC meeting?

- We determined--after significant additional detailed studies--we can trigger on sub-injection-energy collisions with high efficiency (ca. 70%)
  - Fermi motion sends spectator fragments into BBC acceptance
  - tight timing cut on BBC coincidence removes most beam-gas and beam-Be background
  - URQMD simulation and re-analysis of 9.2 GeV data as documented in 2 PHENIX-internal analysis notes
  - see also arXiv:0910.3205



ηdistribution of spectator protons as function of beam energy

What has not changed?

- collision rates below injection energy become extraordinarily low
- operation at 1 Hz or less is poorly matched to the PHENIX optimization for rare probes
- New silicon detector in Run-11
  - background reduction (off-axis events: beam-gas, beam-scrape)
    - Can also be done with BBC timing cut
  - acceptance enhancement
    - measure low p_T particles
    - expand acceptance for multiplicity and flow measurements
    - But only for unidentified charged hadrons
    - And with reduced momentum resolution
  - reduces PHENIX z_{vertex} acceptance
    - +/- 30 cm $\rightarrow$ +/- 10 cm
    - factor 3 reduction in collision rate

Rates at 7.7 GeV

- For 7.7 GeV running, the rate from Wolfram is 2.7 Hz. Thus, if we only get ~ (30/150) in the zvertex cut, and the PHENIX and RHIC combined uptime at (0.65*0.6) = 0.39, then in one week of running we get:

  (7 days) x (24 hours/day) x (60 minutes/hour) x (60 seconds/minute) x
  (2.7 Hz) x (30/150) x (0.39)

  == 1.3 x 10^5 events

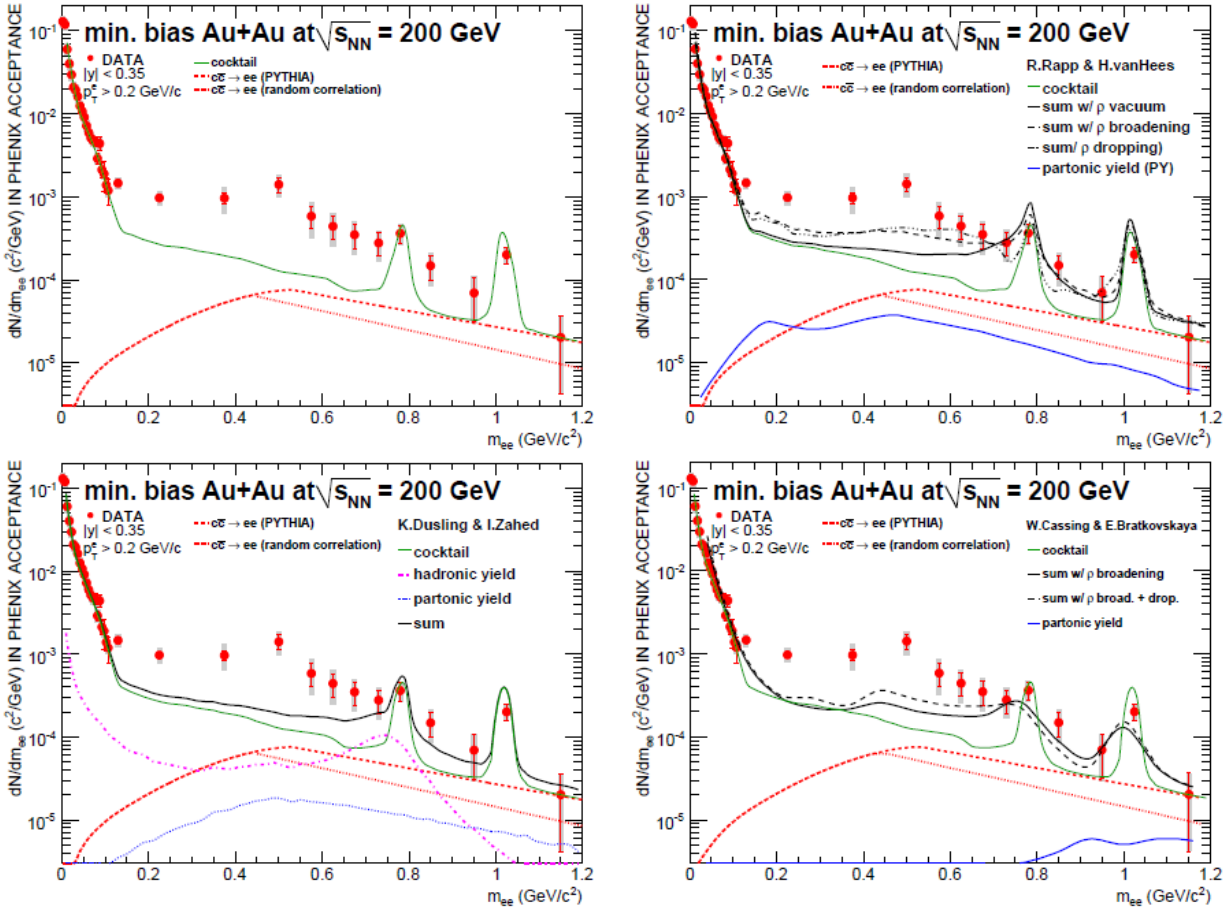
  So assuming we can trigger on something like 70% of the inelastic interaction cross section, we would record ~ 100,000 events in one week.
- With this small sample, PHENIX can measure only identified hadron ratios, spectra, and fluctuation in <N> and <pT>.

Radiation damage to VTX?

- Steve brought up potential issue of radiation damage to PHENIX VTX detector at sub-injection energy running
- This was suggested by STAR
  - STAR saw many beam-pipe collisions
- We did not consider this a danger because:
  - CA-D adviced this is not an issue when asked about implications of new beam pipe for VTX detector
  - Collision rate
    - p+p @ 500 GeV is: ~ 1 MHz
    - Au+Au @ 7.7 GeV: ~ 1 Hz
    - Can background at 7.7 GeV really be higher than the collision rate at 500 GeV?
    - If so, background at 7.7 GeV would be overwhelming and making 7.7 running useless
- Confirm in Run-10
  - measurements using dosimeters
  - What measurements can CAD do to confirm? Orbit data?

BACK-UP SLIDES

Dilepton enhancement at 62.4 GeV: p_T dependence



PHENIX: Detailed measurement of the e+e- pair continuum in p + p and Au+Au collisions at 200 GeV and implications for direct photon production , to be submitted for publication

- Run-4 statistical significance makes measurement of double differential mass and p_T dependence marginal
- We must plan for success and take enough data.

Dilepton physics at 62 GeV

- S_{eff}: corresponding signal in background-free environment
- Significance: $S/\varepsilon(S) = \sqrt{S_{eff}}$
- Run-4: 1.5 G recorded events
- HBD increases S_{eff} by factor ~15 due to improved S/B
- 400 M AuAu@62.4 GeV events in Run-10 will yield
  - 4 x S_{eff}(Run4@200 GeV)
  - 2 x 200 GeV significance (Run-4@200 GeV)