A Low mass electron pair trigger.

Richard Seto with help from Wei, Tom, Jason et al.

v1.0

Summary: We request that 40% of the band width be allocated to minimum bias triggers and a special emcal-rich level 2 trigger be used to trigger on peripheral di-electron events with a di-electron mass > 500 MeV. In addition we will attempt to use the muon triggers to enhance the central sample because of the natural centrality bias of the muon triggers. This should give us a sample of phi mesons to di-electrons in which a good measurement of the yield vs centrality and pt, as well as a measurement of the overall rate to di-electrons which will then be compared to the rate to KK. Finally, this should give us a first look at the spectral shape of the phi to ee as a function of pt and centrality.

Assumptions:

An estimate was listed in the initial run plan by Tony for 50M min bias events during this next run, which assumed 20 MB/sec, with 20% of the band width for minimum bias.

A reminder -this is taken from Tony's message:
http://www.phenix.bnl.gov/phenix/WWW/run02/runplan_march1.html

- 10 weeks at 25% duty cycle gives 1.5M secs. Min Bias event size: 100Kbytes/event This then gives
- 20Mbytes/sec / 100Kbytes/event = 200 events/sec * .2 (20% band width allocation to Min bias) =40 Min Bias events/sec.
- Finally 40 Min Bias Events/sec * 1.5M sec = 60M events.

This is similar to what Steve posted earlier
http://www.phenix.bnl.gov/phenix/WWW/p/lists/phenix-trigger-l/msg00246.html

which has slightly different assumptions. I.e. 50% duty cycle with 250KB/event for min bias. In any case the number is something like 60M min bias events.

We will assume a more optimistic estimate of 40 MB/sec with 40% of the BW for min bias giving a MB sample of 240M events.

This assumes that we are able to take data at twice the speed. Our average writing speed to RCF will still be 20 MB/sec which we will do with 100% duty cycle. See for example
http://www.phenix.bnl.gov/phenix/WWW/p/lists/phenix-trigger-l/msg00379.html

I note that we should have the ability to write at ~40MB/sec with a second fiber to RCF. The calculation then is

- 40 MB/sec /100 KB/minbiasevent * 0.4(fraction of bandwidth)=160 min bias/sec

- 160 min bias/sec *1.5M sec=240M events

At full luminosity this will require a scale down of about 8.

The general scheme that will be used here is as follows. The minimum bias data will be our primary data set. In addition we will request that level-2 triggers be used to enhance the peripheral data sample where the trigger works well. For central events the rejection factor is poor. One might then ask whether we should request a simple central trigger. Tony has done a calculation (http://www.phenix.bnl.gov/phenix/WWW/p/lists/phenix-triggerl/msg00397.html) showing the enhancement using a straight centrality trigger to get central events is not much better than taking min-bias – hence our request for a large number of minimum bias events which would be beneficial for a lot of other physics. A reasonable split for the remaining 60% of the bandwidth is 30% for central arm triggers and 30% for muon arm triggers.

Yields for min bias.

Using the rate calculations used by the light vector meson group in their original rate calculations we get in the min bias sample:

- ~ 6240 omega to ee, 2900 phi to ee (exodus: 8900,1600)
  - Cent relative yield going to phi
  - 0-5% 18%=520
  - 5-10 14%=405
  - 10-20 25%=725
  - 20-30 13%=380
  - 30-40 10%=290
  - 40-100 20%=580

Reminder: In the light vector meson group we had an agreed upon way to throw the vector mesons. We assumed a flat distribution in y, mt scaling with a slope of 220 MeV and rho/pi0=0.16 omega/pi0=.16 phi/pi0=0.015. At the time we assumed dN/dy for pi0=500 for central events and 150 for min-bias. I use dN/dy for pi0=300 in central events and 90 for min-bias in these calculations. The acceptance for the phi to ee where the phi is thrown from –0.5 to 0.5 in y is 0.028. For the omega it is 0.026.

Exodus uses a thermal model and the acceptance includes dalitz decays. Note that I only consider the phi in this note.

A sample calculation

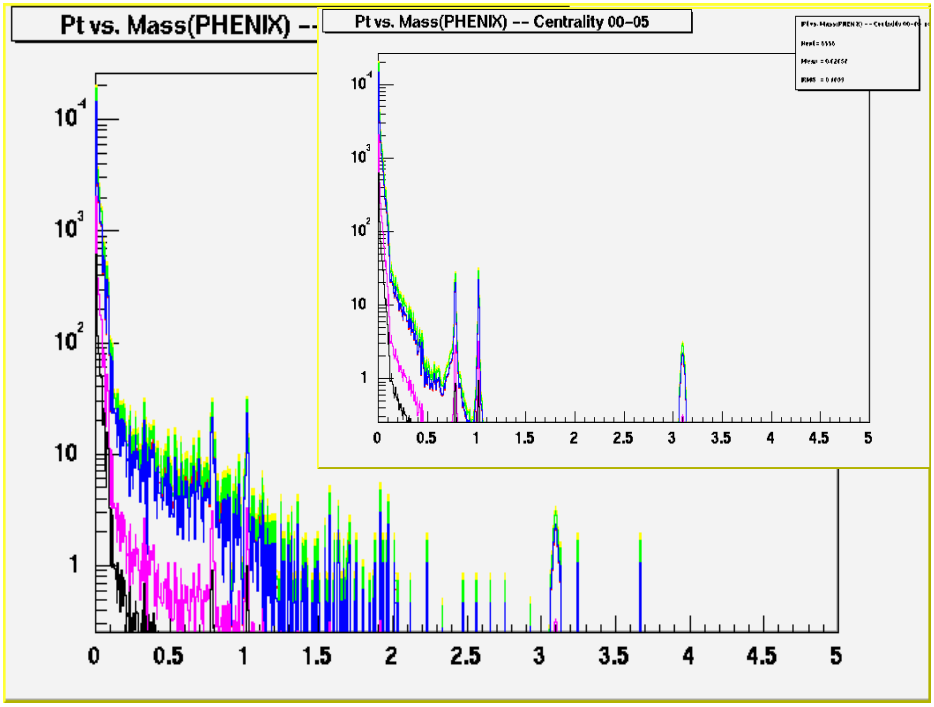
(phi/pi) (dN/dy-pi0) (BR to ee) (Acc) (num Min bias)= Total

(0.16) (90) (3e-4) (0.028) (240M) = 2900

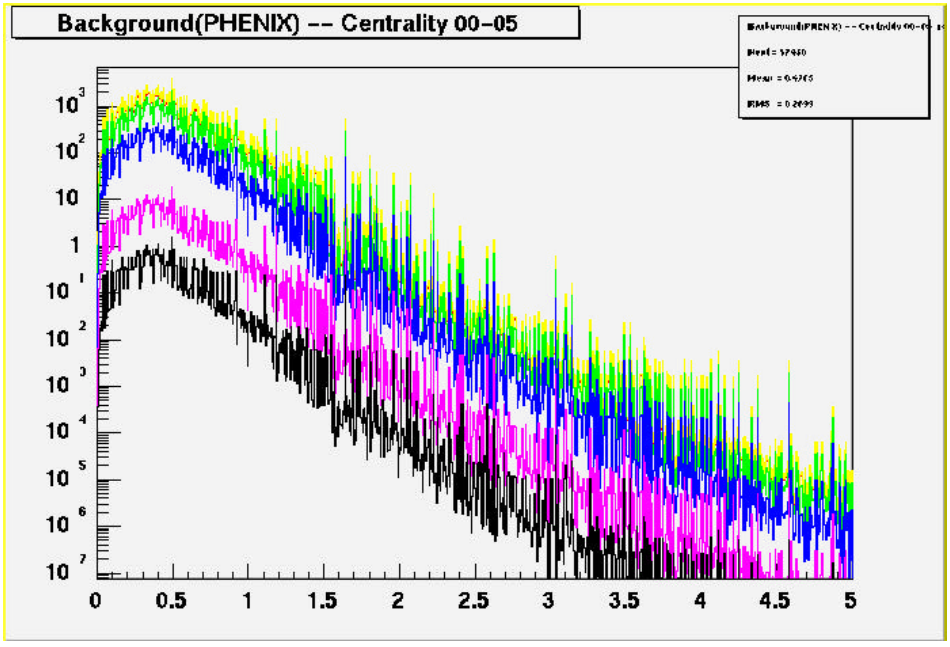
Signal pairs over all centralities

- Integrating the yield over all p_T, we see the following yields per bin in various centrality classes. Charm is included. The inset is without the charm contribution .
- Remember that PHENIX scales the widths of its centrality classes inversely to the multiplicity so for many classes the physical statistics is roughly the same.

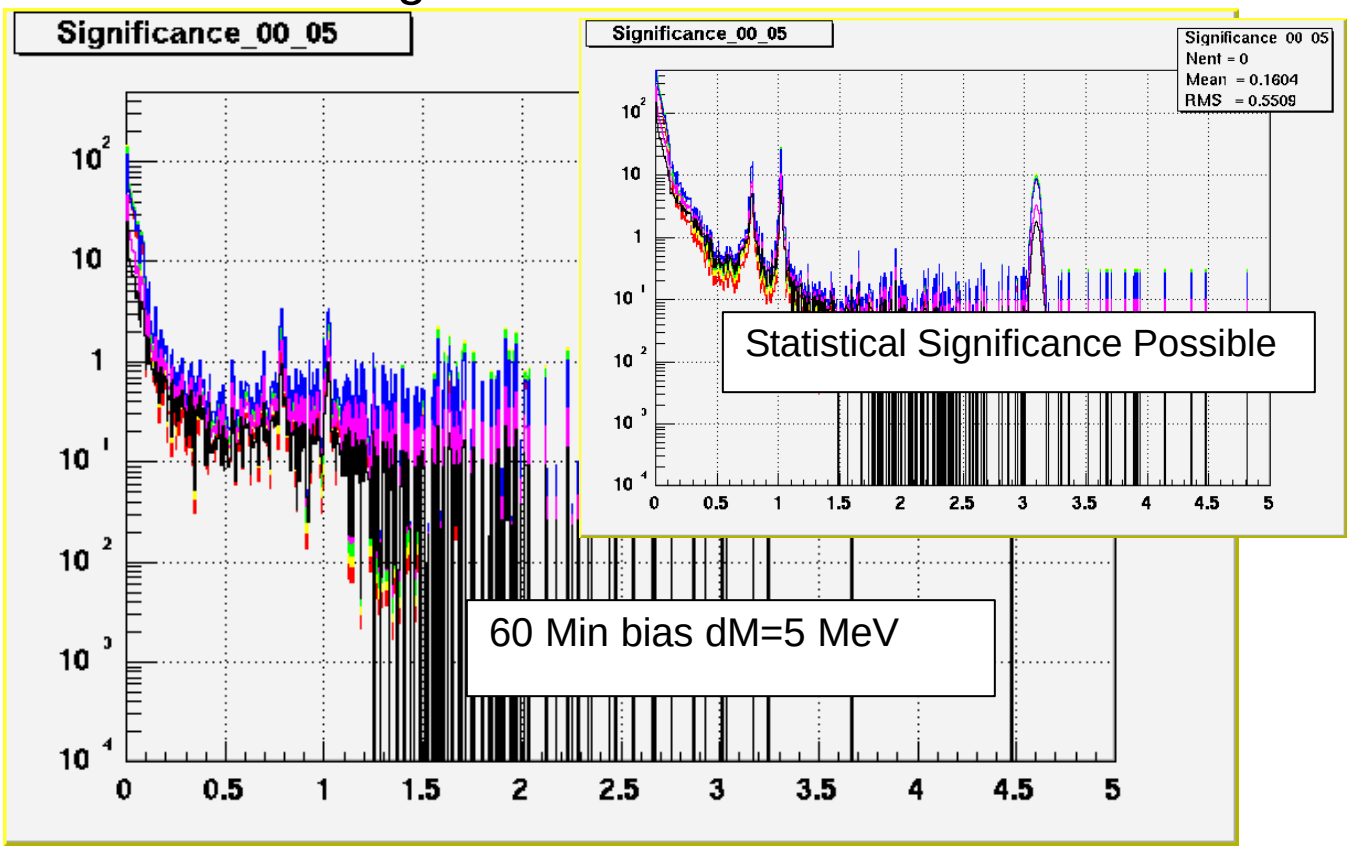
0-5% 5-15% 15-30% 30-60% 60-80%

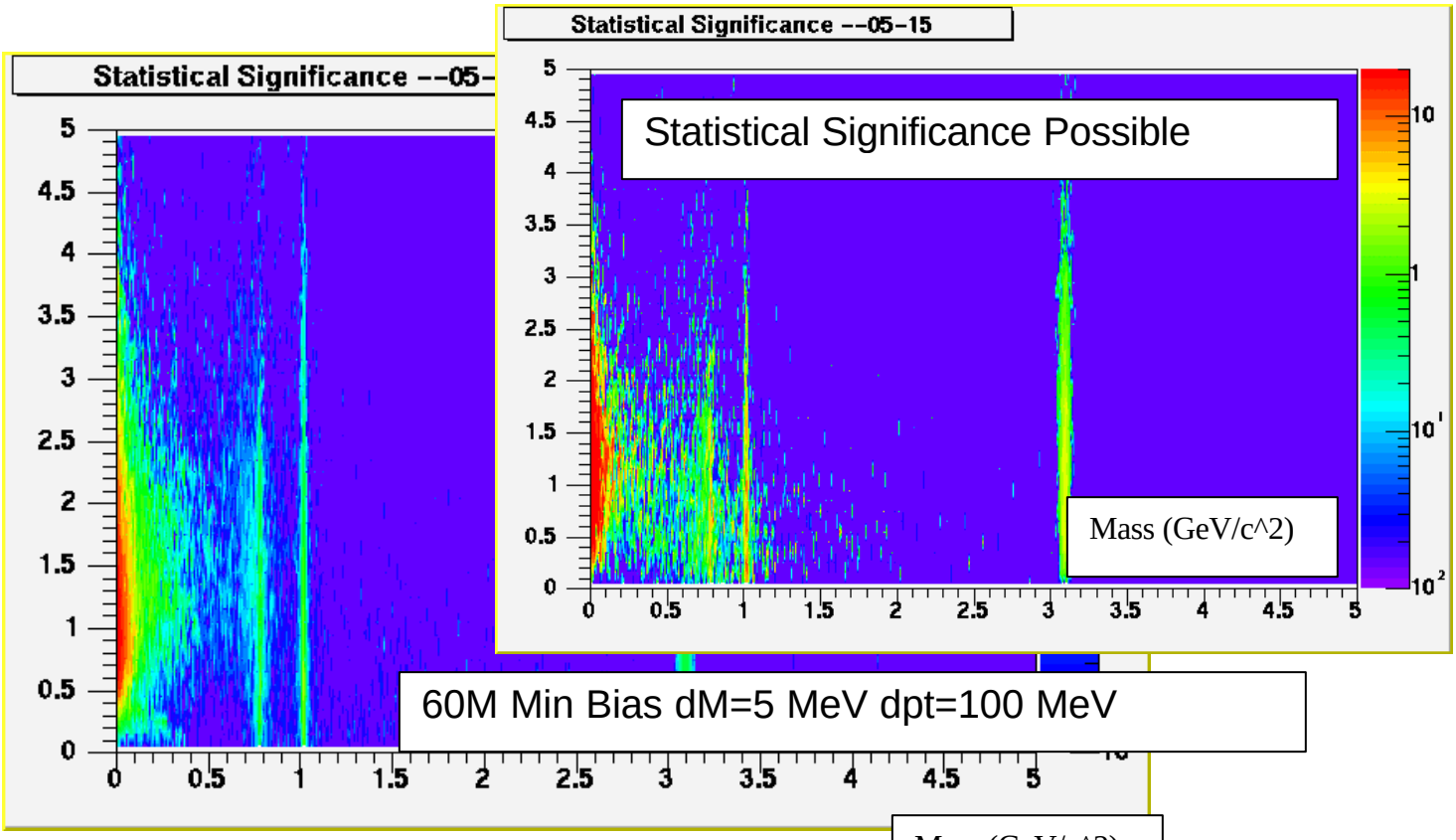


Background Pairs



Statistical Significance





What would we like? (from Tom's stuff)

Tom has chosem dM=5 MeV/c^2, dpt=100 MeV./c. He has done his calculations for 60M min-bias events. We will assume a factor of 4 more statistics,larger bin in pt and somewhat larger bins in centrality.

- With min bias data for the 0-5% centrality bin, we get ~4*30=120 signal, 4x100=400 bkgd

  Defining

$$Significance = \frac{N_{sig}}{\sqrt{N_{sig} + N_{Background}}}$$

- S=120/sqrt(420)=5.8 … not bad

Really we would like to bin in pt and centrality. Looking at the plot we see that the significance as a function of pt is rather flat. In other words any increase in overall significance will affect all pt bins equally. As not to be too greedy I pick a centrality bin of 0-15 % and 7 pt bins of 250 MeV (from 0.5-2.25 GeV/c) so I really have 2/7 of the statistics mentioned above in each bin. This gives me a 3.1 sigma effect in each bin. Increasing this to a 5 sigma measurement requires an increase in statistics of (5/3.1)**2 =2.6 ~3.

- We need an enrichment factor of 3
- I.e. look for a rejection factor in a trigger

The Level 2 trigger

Wei et al have put together a RICH EMCAL electron trigger which can be used in conjunction with Ramila's centrality trigger. The RICH-EMCAL trigger is capable of identifying electrons and making a rough invariant mass measurement for electron pairs. We will use an emcal threshold of 380 MeV (?) and a mass cut of 700 MeV. The rejection factors and efficiency are listed below.

The efficiency of ~ 80% for the phi includes many factors which would probably not be obtainable even with full offline reconstruction. Also, a plan in being tested including a improved algorithm for PC3 matching which may improve the rejection factor.

Rejection factors for the phi (from Wei)

centrality	RF	% BW	prescale
0-5%	1		x
5-20%	1		x
20-30%	1.3		x
30-40%	2.	7%	?
40-100%	35	3%	?

- We will use 10% of the "designated" central arm trigger BW – to go after the phi
  - Assume Min bias event size100 kB, central event 300 Kb, periph-80kB, 30-40%-120kB
  - 3% of BW goes to 40-100% rf ~35
  - 7% of BW goes to 30-40% rf ~ 2
    - Note – eff for phi is ~80%

To get enrichment factors

- 40-100%
  - 40MB/sec*0.03(frac of Band width) /80kB/event*35(rf)/0.6(centrality)* = 870 events/sec
  - So we have enriched the 40-100% piece by a factor of 870/160=5.4 (we wanted 3)
- 30-40%
  - 40MB/sec*0.07(frac of Band width) /120kB/event*2(rf)/0.1(centrality)* = 470 events/sec
  - So we have enriched the 30-14% piece by a factor of 470/160=2.9
- 0-30%
  - We use the muon triggers here

Muon triggers as “min bias”

- We will be able to use the muon triggers as a way to increase “min bias triggers”. The argument goes as follows:
  - The majority of these triggers come from the random decay of pions. In addition the rapidity difference between the muon arms and the central arm is large enough that stuff happening in one is largely independent of the other, save for dependence on centrality. Hence these triggers will be biased toward central events. (One thing we must be careful of is mu-e events from charm. I will talk about this later)

A summary of deep-deep muon triggers (Jason)

%	rf	frac of events	event size
0-5	6	.40	300KB
5-15	14	.30	200
15-30	30	.22	150
30-60	300	.04	100
60-100	300	.04	
Total	50		
eff j/psi	.70		

Enhancement factors

- To get enhancement factor
  - X0.75 (since 30% of BW instead of 40%)
  - X “fraction of events”
  - /centrality
  - But I can take less events because average event size is larger e.g. for 0-5% ~ 100/300 ~ .33
- 0-5% enhancement factor = .75*0.4/.05 *100/300 = 2
- 5-15% =.75*.3/.1*100/200=1.1
- 15-30% =.75*.22/.15*100/150=.7
- 30-60% =.75*.04/.3*100/100<0.1

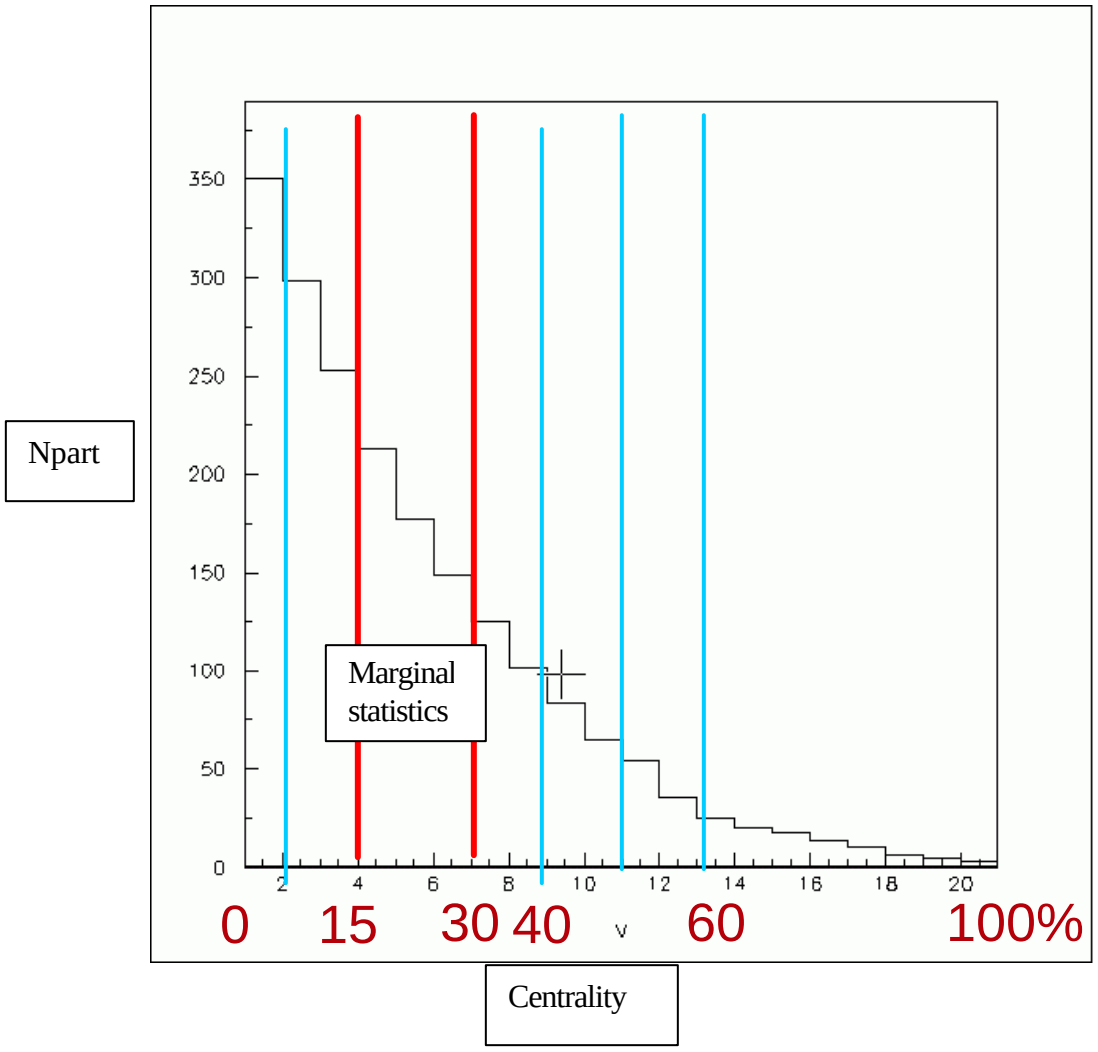
Total Enhancement factors (wanted 3)

- 0-5% 3
- 5-15% 2.1
- 15-30% 1.7
- 30-40% * 4
- 40-100% 6.4

*Wei gives me rejection factors from 30-40-100 instead of 30-60-80-92

Nparticipant vs centrality – What coverage do we get?

- We cover most bins of Npart except for 125-225.



Conclusions/work

- I can trigger on peripherals
- Is triggering on the muons really OK?
  - Any homework?

Summary:

- Want
  - Assume 40MB/second average with 50% duty factor for 10 weeks
  - 40% Min Bias , 30% electron arms, 30% muon arms
  - Need 10% electron arm Band Width
    - 3% - 40-100%
    - 7% - 30-40%
- We Get
  - Gives reasonable coverage of Npart in which we will be able to measure
  - BR to ee – vs pt, centrality
  - Mt slope vs centrality
  - Yield at mid-rapidity vs centrality
  - First look at line shape vs centrality and pt

Looking at mu e contamination from muon triggers-

■ Acceptance for mu-e 90/100K

Aprox probablility ccbar to e- mu 0.1x0.1=0.01

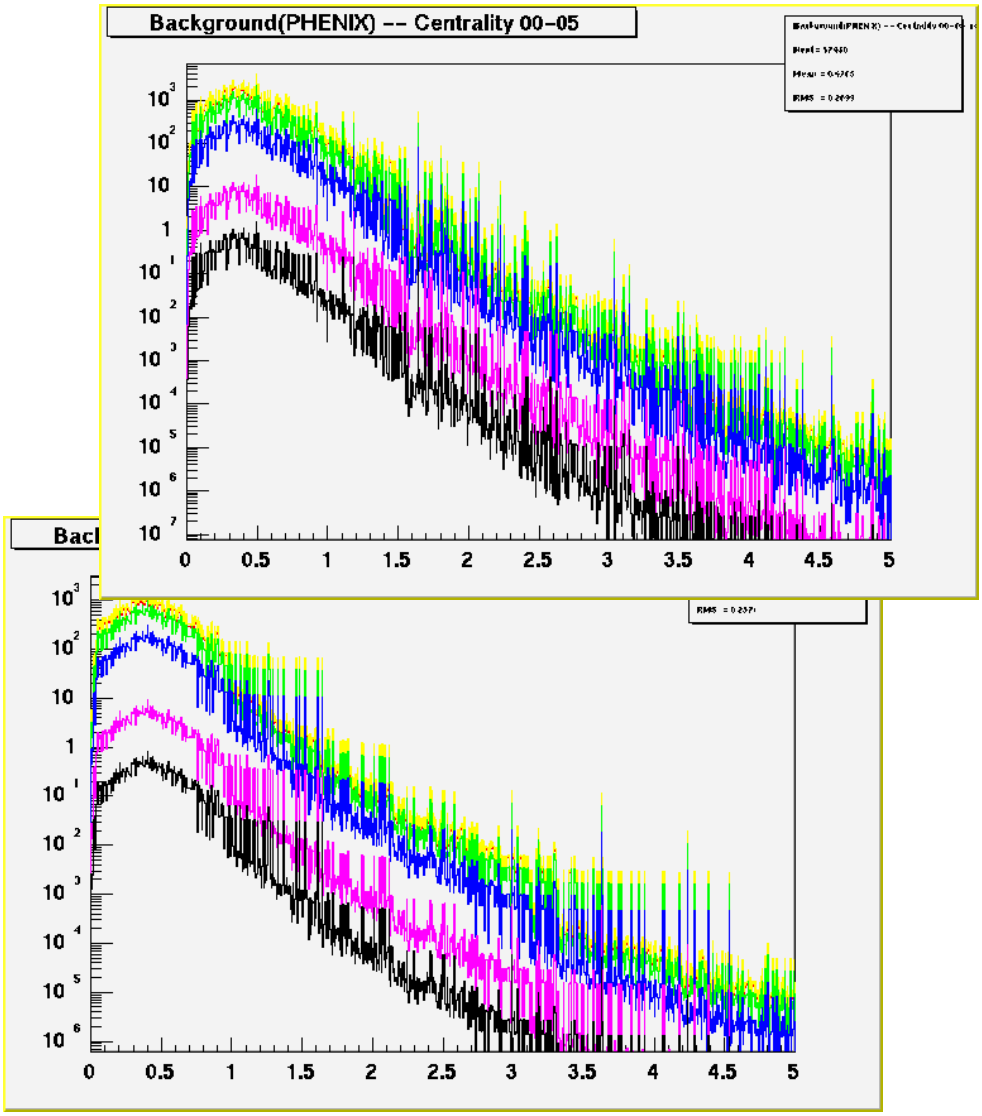
Charm Production in Au-Au (from Trigger proposal for Heavy Flavor PWG)

Centrality	Nbin	prob of ccbar/event	emu accepted	total in 240M mb
0-5%	946	8.3	7.5e-5	900
5-10	749	6.6	6e-5	720
10-15	596	5.2	4.7e-5	564
60-80	20	0.2	1.8e-6	22
min bias	213	1.9	1.7e-5	4104

This contributes to the background.. Futher studies will have to be done in order to understand its significance. We may wish to form a separate background for events triggered in the muon arm using the event mixing technique.

A summary of muon triggers

%	b	dd-rf	frac	ds-rf	frac	ss-rf1d-rf
0-5 (5)	1.6	5.5479	.9(.4)	2.9688	1.7(.34)	1.92572.2246
5-15 (10)	4.5	14.172	.7(.3)	5.2873	1.9(.38)	3.59863.1909
15-30 (15)	7.0	30.594	.5(.22)	11.692	1.2(.24)	8.34975.2873
30-60 (30)	10.	~300	.1(.04)	~300	0.1(.02)	300.47 76.297
60-100(40)	12.5	~300	.1(.04)	~300	0.1(.02)	300 66.046
Total		50		30?(20)		14
eff j/psi		.70		.88		.88


Background(PHENIX) -- Centrality 00-05
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5