Centrality Measurements and other uses for Photons

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- E_T distributions using photons, i.e. EmCal, since E_T is just the sum of $E \sin\theta$ over all the inclusive photons
- π^0, η^0, $\omega \rightarrow \pi^0 + \gamma$, by reconstruction rather than just by inclusive photons. Of course there is a good check from the measured cross section of these 3 neutral decaying particles and the inclusive photon spectrum, and vice versa. Also, the best, if not the only way to measure jets in RHI collisions is by inclusive π^0, which are automatically 'leading' by the so-called trigger-bias effect. For the Phenix detector this is true in all reactions as PHENIX is too small to contain a jet which is usually $\Delta r = \sqrt{\Delta\eta^2 + \Delta\phi^2} \leq 0.6 - 1.0$, where these clearly refer to the 1/2 angles.

I have other issues which relate to your workshop.

1. For inclusive or direct photons, you might want to consider whether in a certain range of p_T these aren't much better measured using low mass e^+e^- pairs from internal and external conversions. At low p_T, where background rather than rate is a problem, the factor of 20-80 you lose from the conversion probability may be made up by the higher momentum resolution and the ability to point to the vertex.
2. I would like to hear the Gabor-Terry debate on what resolution is needed to measure π^0, left over from the days of the HirX vs PbGl. Unfortunately, I have heard that neither of them are

going to the collaboration meeting. Of course, we have been waiting for so long, that we should perhaps schedule this talk for the June 23-28 meeting at BNL.

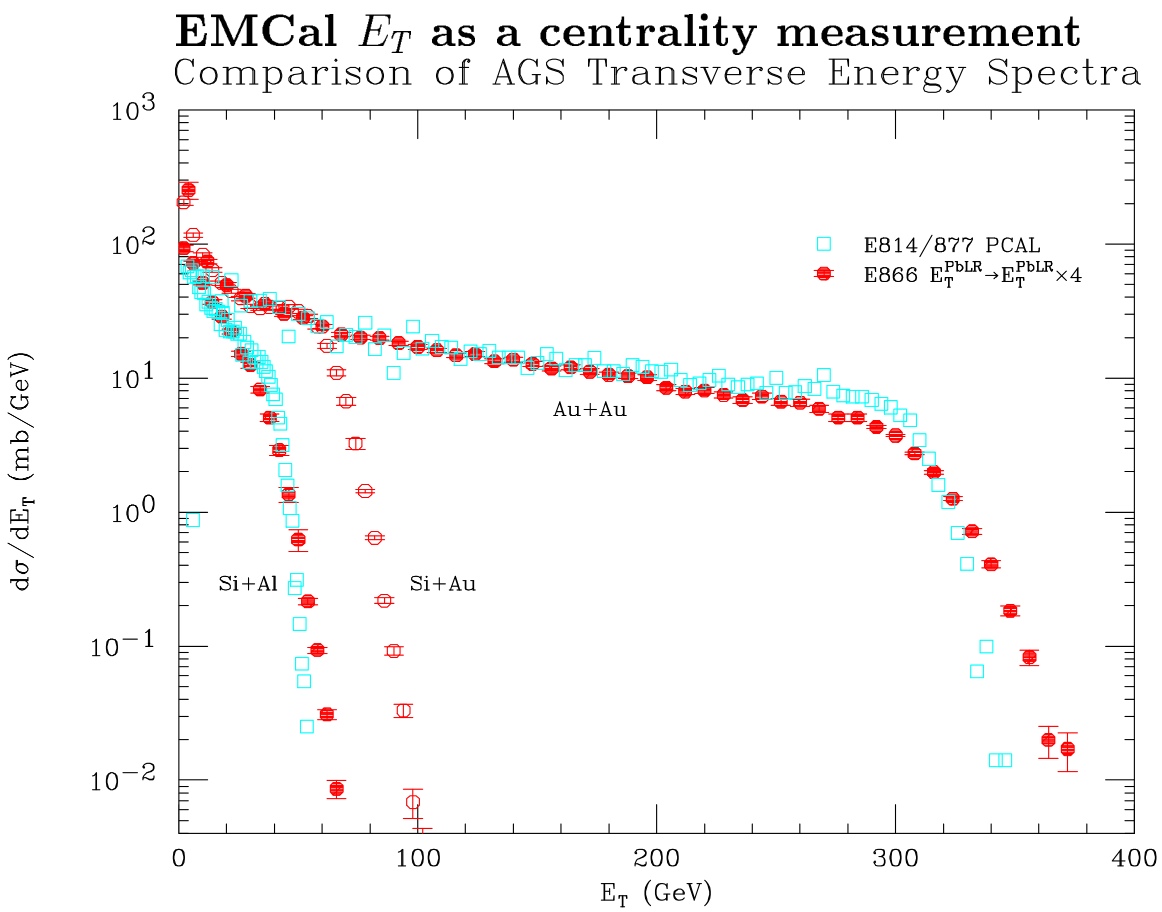
Outline of My my talk:

1. EMCal E_T as a centrality measurement
2. what size $\delta\eta$ is appropriate?
3. What does the MVD add—the issue is what is a BIG fluctuation
4. Why we must measure the inclusive p_T spectrum of π^0 as close to day-1 as possible so as not to MISS the QGP in the unlikely but possible scenario that it hits us over the head i.e. is easy to see in hadrons, particularly if hot matter stops quarks.
5. why leading particles was the way jets were discovered and why leading particles are the only way to see jets in RHI collisions.
6. Besides leading particles where you suffer a loss of $e^{-6} \sim 10^{-3}$ can we get a jet measure in PHENIX—this is more for pp than RHI.

some references on jets by leading particles

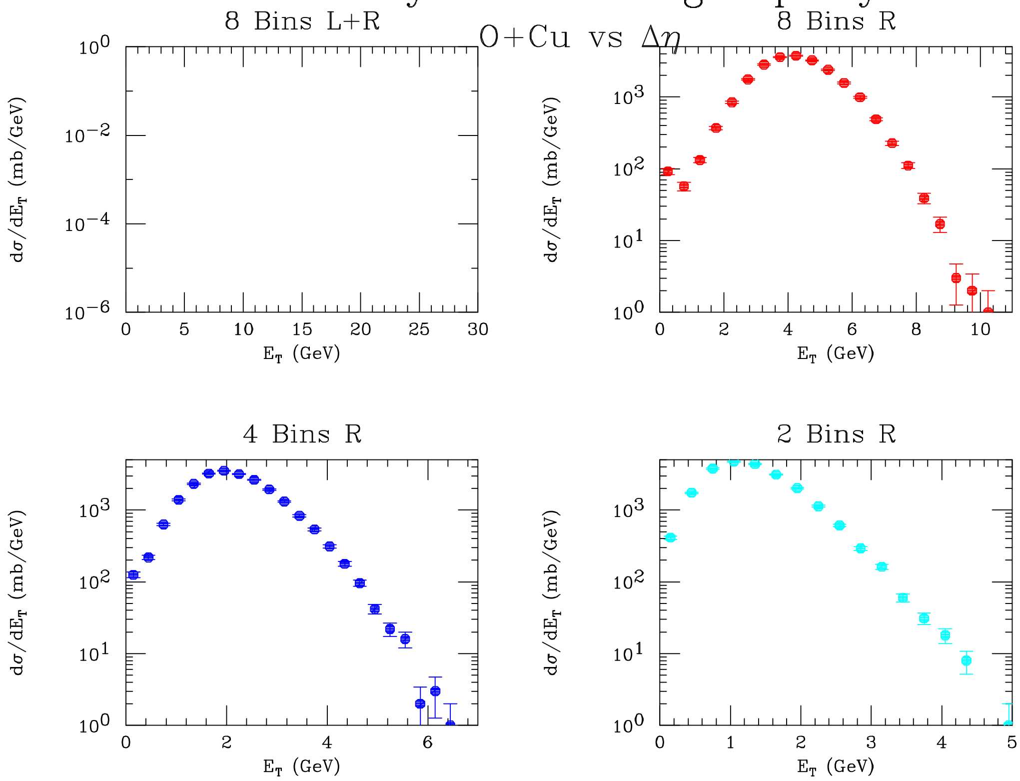
1. Proceedings of the International Workshop on Quark Gluon Plasma Signatures, Strasbourg France Oct 1-4, 1990, ed V. Bernard et al., Editions Frontieres, FRANCE; in particular, see my summary on the subject on page 401 sqq.
2. MJT International Journal of Modern Physics A4, 3377 (1989), where on pp 3377-3405, I explain how to find jets incorrectly and then correctly (in p-p collisions) which is infinitely easier than our present subject, yet took 10 years to sort out.

3. Incredibly, some theorists actally understood this: see Xin-Nian Wang and Miklos Gyulassy QM '91 [no excuse for not having this proceedings] Nucl Phys A544 (1992) 559c, see fig 2. also see Xin-Nian Wang Phys. Rev. D47, 2754 (1993).



What size $\delta\eta$ is appropriate?

This is determined by the short-range rapidity correlation length.

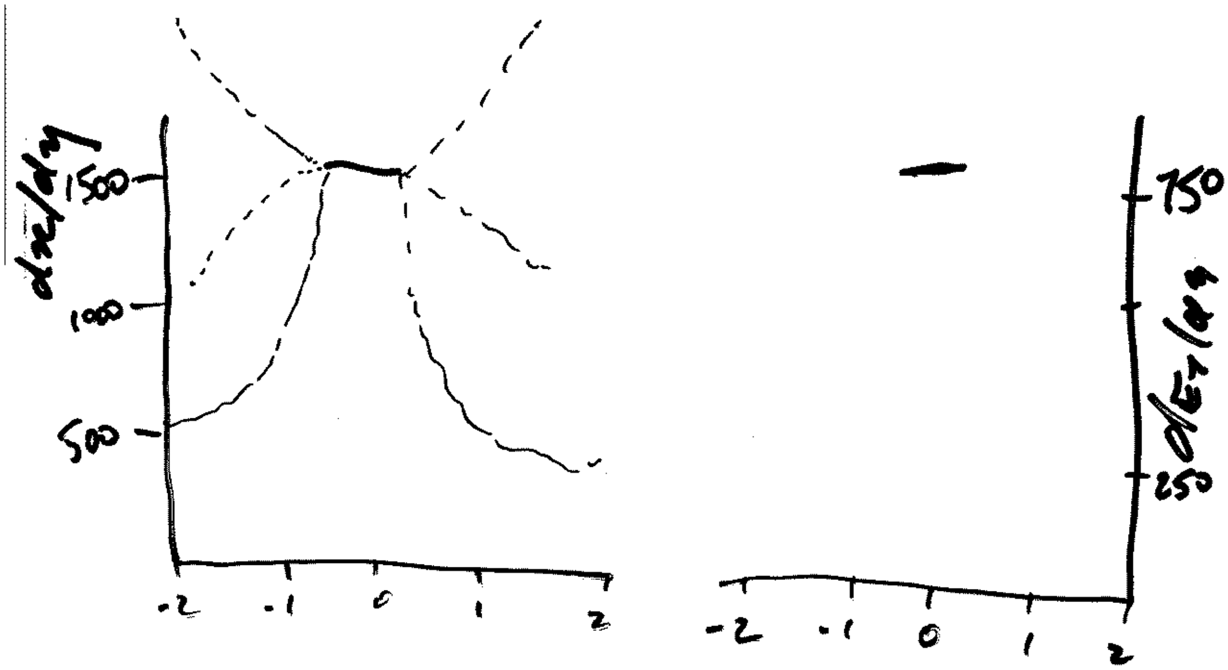


The "shape" of the upper edge (ZCAL) of the E_T distribution changes as the number of "bins" in $\delta\eta$ is reduced—the smaller the $\delta\eta$ interval, the larger the fluctuations about the mean and the more asymmetric the distribution on the high side. For multiplicity distributions, this is known as intermittency. [See http://www.rhic.bnl.gov /phenix /WWW/ proceedings /collab_0196 /wkshp2.html]

This variation is determined by the short-range rapidity correlation length which is $\sim 0.1 - 0.2$ units, thus the PHENIX central spectrometer spans 3.5 to 7 correlation lengths, so is adequate (generous) to measure a true and interesting E_T and multiplicity distribution

MY Use for the MVD
What is a BIG fluctuation?

In my opinion the main use for the MVD with respect to centrality is in the regions $0.35 < |\eta| < 2.5$, where, when we see a "big" fluctuation in the central aperture, we can tell whether it is big over a large region of η or just a "deflagration" (whatever that means) bubble at central rapidity.



MY CHALLENGE TO THE PHENIX SIMULATORS

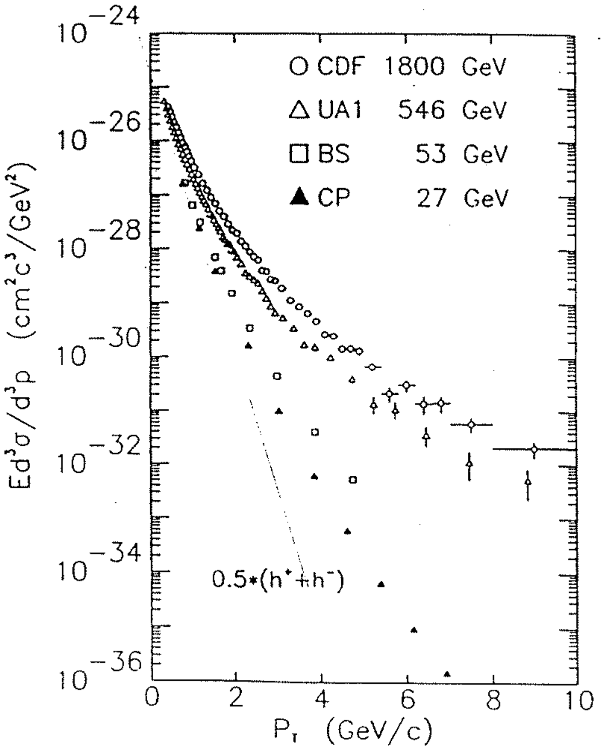
Calorimeters have spreading showers which lead to a correlation length of a certain size. A similar effect exists due to showers or tracks entering non-normal to the face.

Challenge: Fritiof has Poisson distributions:
the NBD parameter $k = \infty$ and $\frac{1}{k} = K_2 = F_2 - 1 = 0$.

- Throw Fritiof at PHENIX
- Calculate E_T WITH and WITHOUT the effect of the detector
- Does the shape of E_T change with $\delta\eta$ in either case?
- DITTO with multiplicity on MVD.

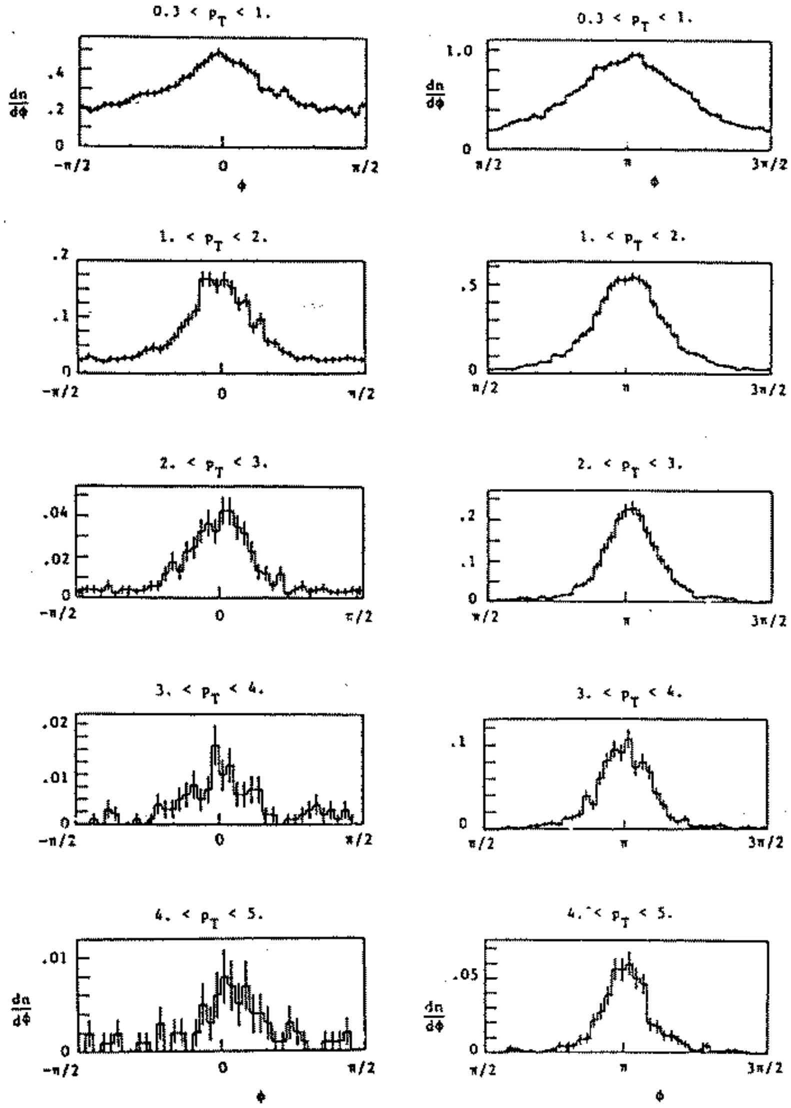
We must measure the semi-inclusive p_T spectrum of π^0 and $\pi^{\pm}$ as close to day-1 as possible so as not to MISS the QGP in the unlikely but POSSIBLE scenario that it is easy to see in hadrons from hard-scattering IF hot matter stops quarks

The discovery of hard-scattering in hadron collisions was made by leading π^0 and $\pi^{\pm}$ individually or in coincidence



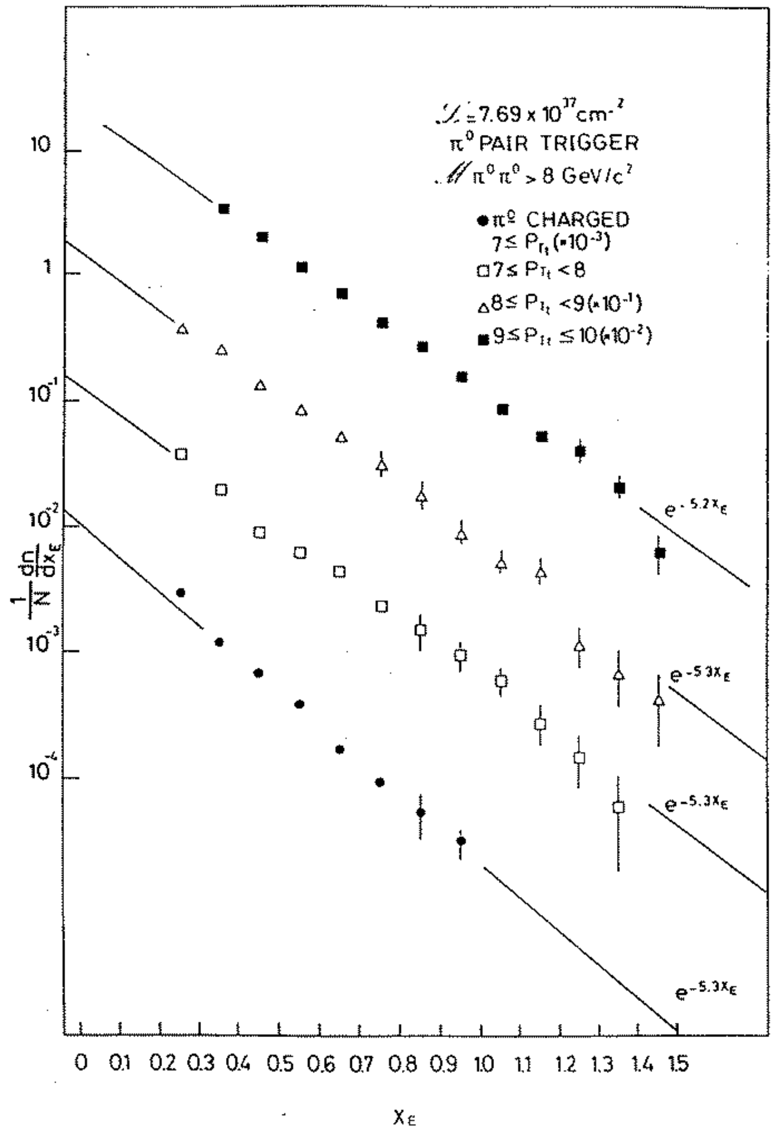
In RHI central collisions, leading particles are the only way to find jets because in one unit of Δr there is $\pi \times \frac{1}{2\pi}\frac{dE_T}{d\eta} \sim 375$ GeV **!!!**.

How Everything You Want To Know about JETS can be done in PHENIX with leading particles in each arm c.f. CCOR



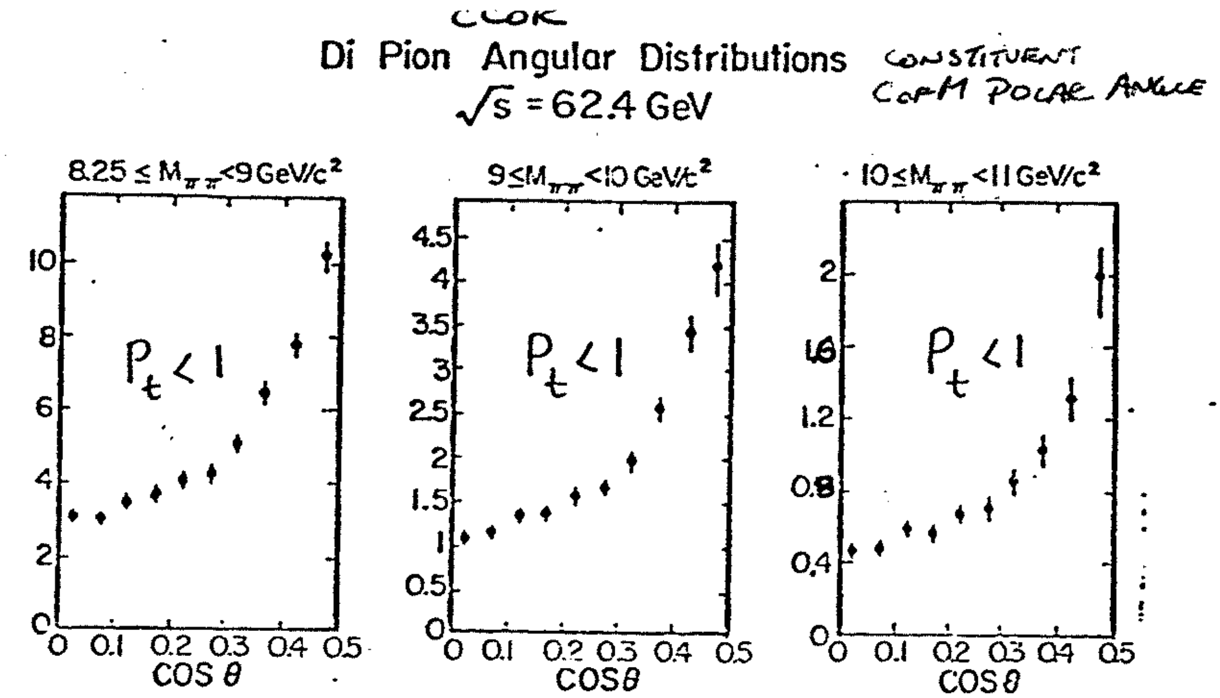
Two particle correlation in azimuth of charged particles relative to a triggering neutral with transverse momentum $p_{Tt} \geq 7.0$ GeV/c which defines the zero of azimuth, $\phi = 0$. Charged particles with $|\eta| < 0.7$ in the same 'arm' as the trigger are on the left and opposite 'arm' to the trigger on the right. As the p_T of the observed charged particle increases, the width of the away side peak (plots on the right) narrows. This effect clearly shows that the jets **are not collinear in azimuth** (they have a net transverse momentum k_T. If there were only fragmentation transverse momentum, then $p_T \times \Delta\phi$ would remain constant which would equal to $< j_T >$, the mean transverse momentum of fragmentation. [See PL 97B (1980) 163 for details]

Measurement of fragmentation function with the same data

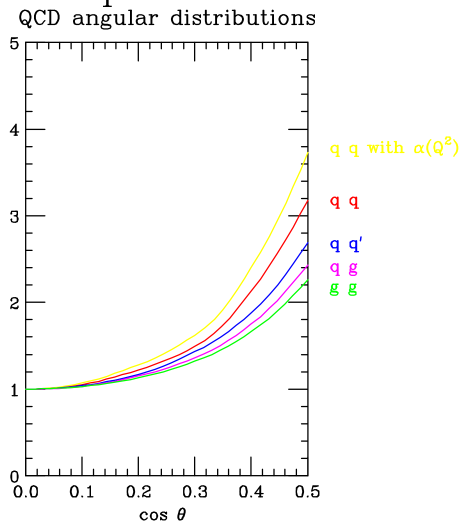


Distribution in x_E for a charged pion (or π^0) observed roughly back-to-back to a triggering π^0 of transverse momentum p_{T_t}, where both pions have $|\eta| < 0.5$ in the c.m. system. x_E is the ratio of the component of the p_T of the second pion, opposite in azimuth to the triggering pion, divided by p_{T_t}. **Exercise for students:** What do you have to know about the leading trigger particle to convert from $e^{-5.3x_E}$ to the jet fragmentation variable z [e^{-6z}].

Rutherford scattering of quarks— First measurement of QCD subprocess angular distributions



QCD Subprocess predictions normalized at 90°



Angular distributions of pairs of nearly back-to-back π^0 as a function of the invariant mass $M_{\pi\pi}$ of the pair. The net P_t of the pion pair is restricted as indicated on the figure and the net rapidity of the di-pion system is restricted to $|Y_{\pi\pi}| < 0.35$. The distribution plotted is the polar angular distribution of the dipion axis in the frame with zero net longitudinal momentum. The important feature of the analysis in these variables, which are more typically used for lepton pairs, is that the di-pion angular distribution at fixed mass corresponds closely to the distribution of scattered partons at fixed $\hat{s}$, thus the data and QCD prediction at the parton level can be directly compared without recourse to a Monte Carlo. [see Nucl Phys **B209** (1982) 284].