GLOBAL PHYSICS CAPABILITIES OF PHENIX

by

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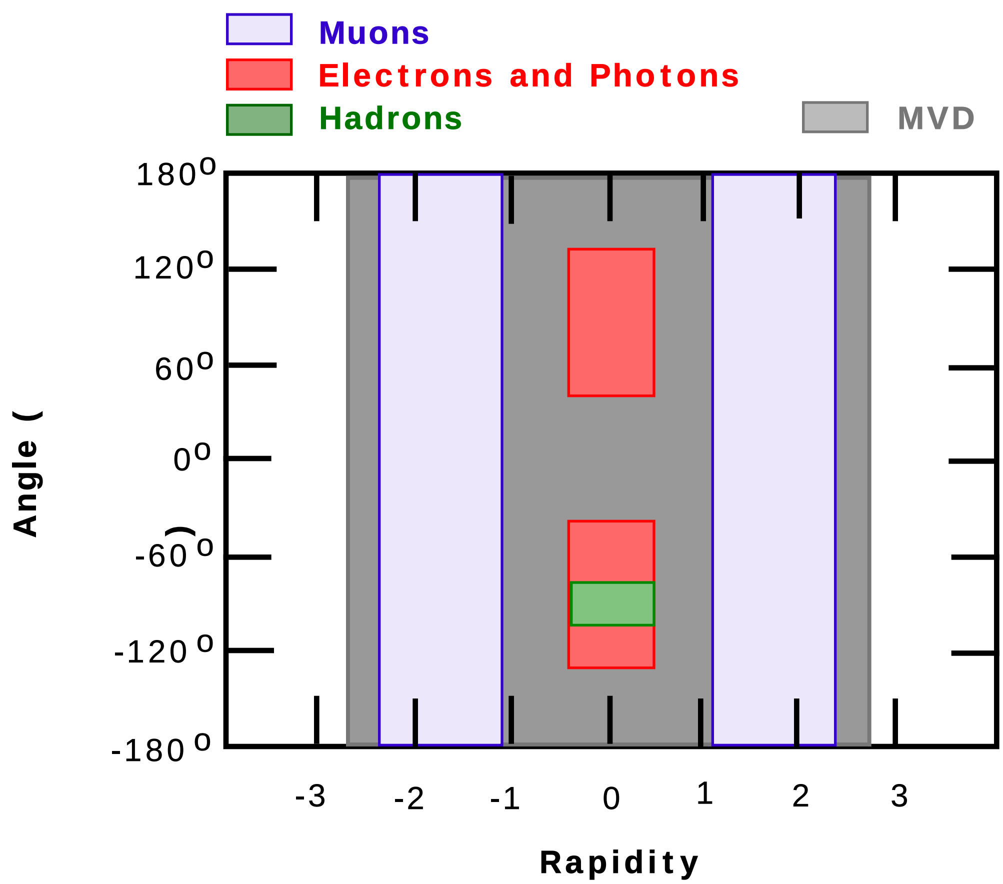
PHENIX Physics Philosophy

Simultaneous measurement of QGP signatures as function of energy density: p+p, p+A, A+A

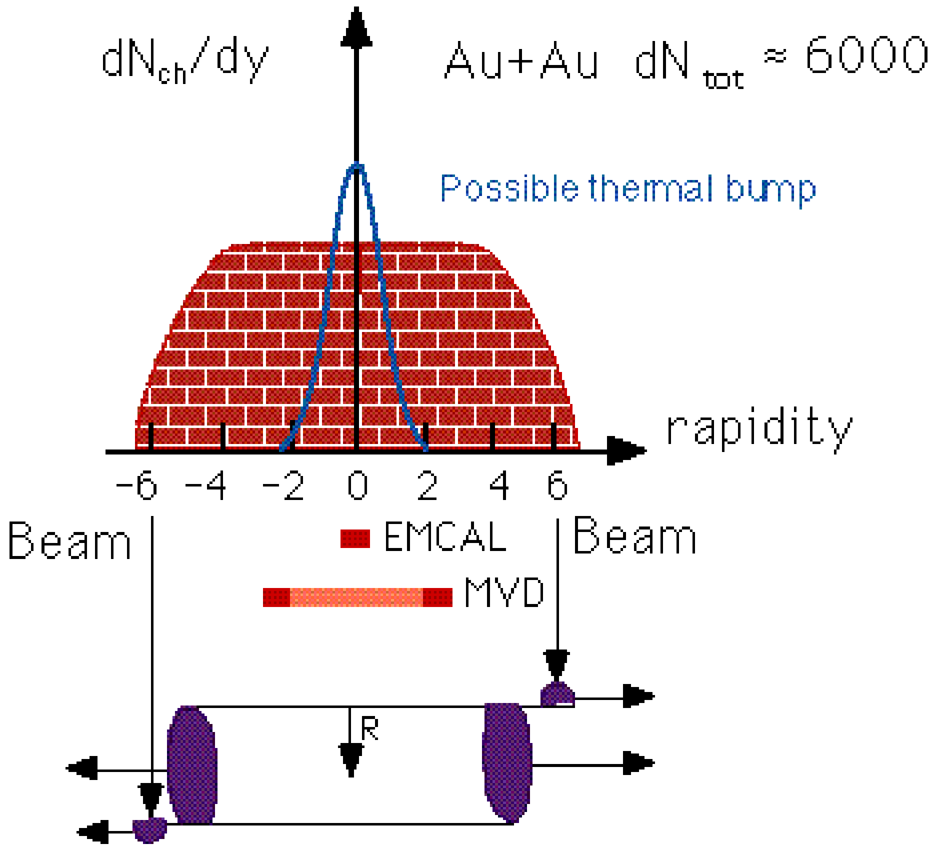
Lepton: Direct probe of plasma
Hadron: Complimentary to leptons, study hadron gas phase



Characterization of Collision Environment

The PHENIX Collaboration will search for the Quark Gluon Plasma through a systematic study of a broad array of potential signatures, as a function of energy density in A+A, p+A, and p+p collisions. Global observables such as $dN/d\eta$ from the Multiplicity Vertex Detector and $dE_T/d\eta$ from the Electromagnetic Calorimeter will be used to characterize the collision environment. The determination of the energy density of the system formed in the heavy-ion collision is the core of the PHENIX physics program.

Global Measurements



$$\varepsilon = \frac{1}{\pi R_T^2} \frac{dE_T}{dy}$$

- MVD defines collision geometry and dN_{ch}/dy
- EMCAL measures $dE_T/d\eta$
- Zero Degree Calorimeter works well in conjunction with MVD to distinguish peripheral from non-peripheral events

MVD Overview

Physics Goals:

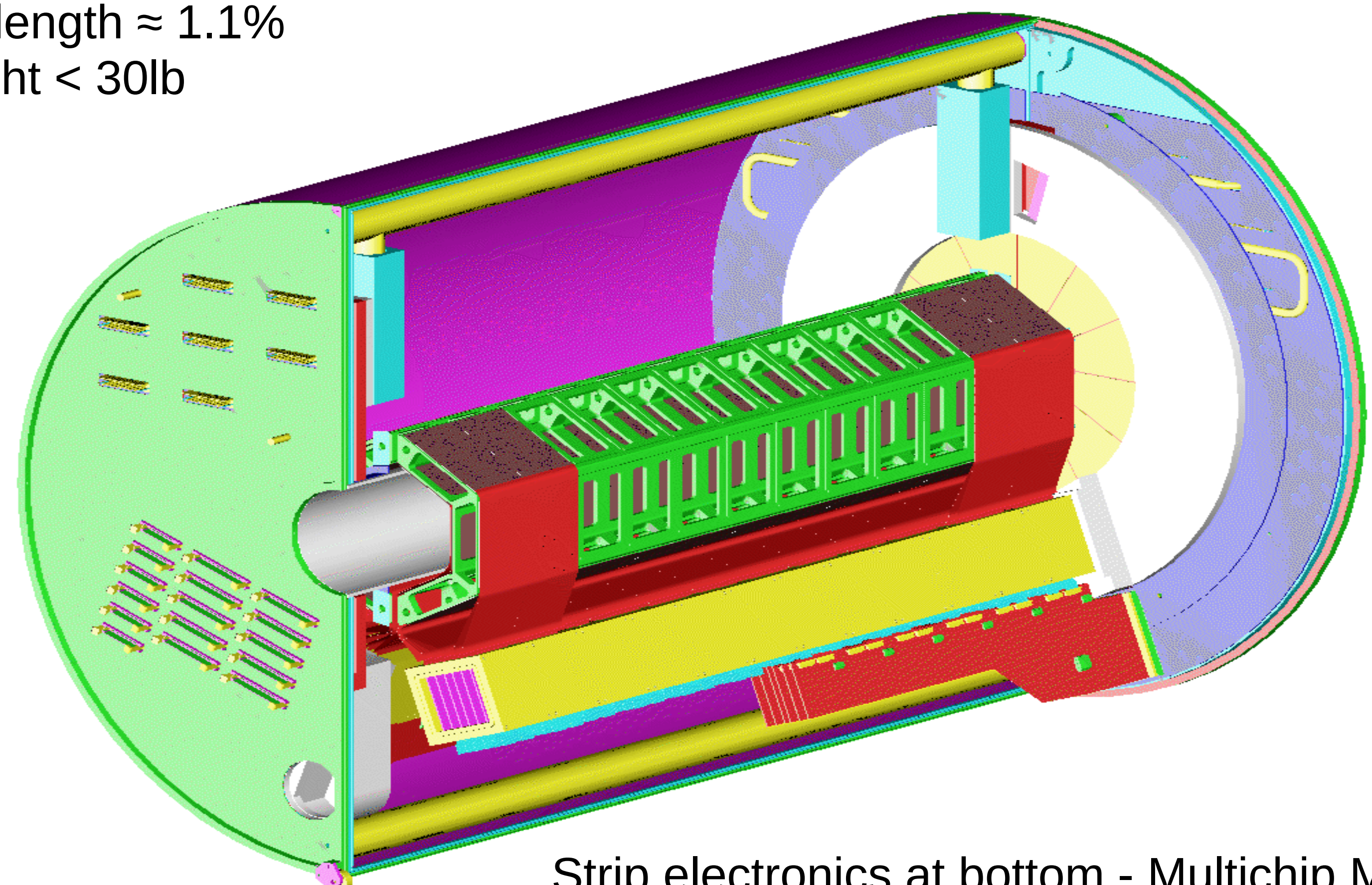
* Charged particle multiplicity
* $d^2N/d\eta d\varphi$
* Centrality trigger at LVL-1
* Collision vertex position ($\sigma < 2mm$)

Design Criteria:

* Large rapidity coverage ($\Delta\eta = 5$)
* Good azimuthal coverage & granularity
* Minimum material in electron arm acceptance

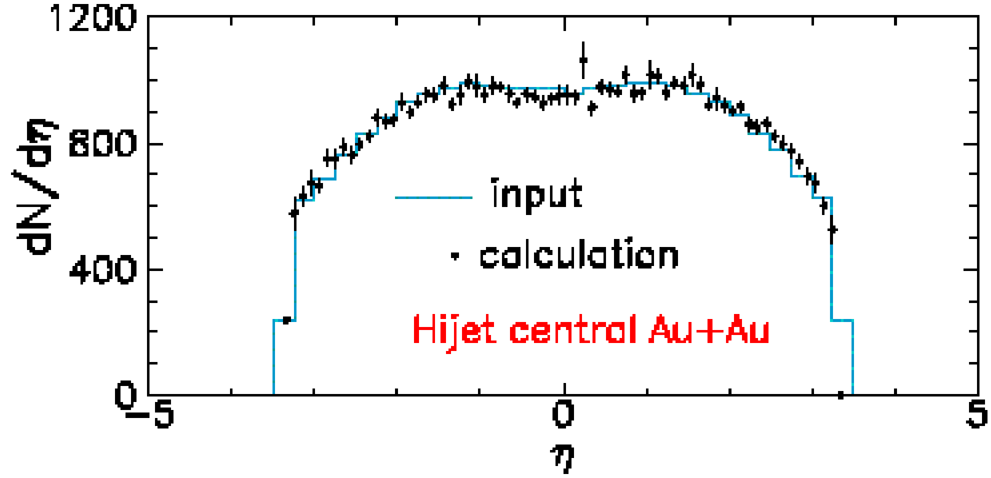
The Multiplicity Vertex Detector

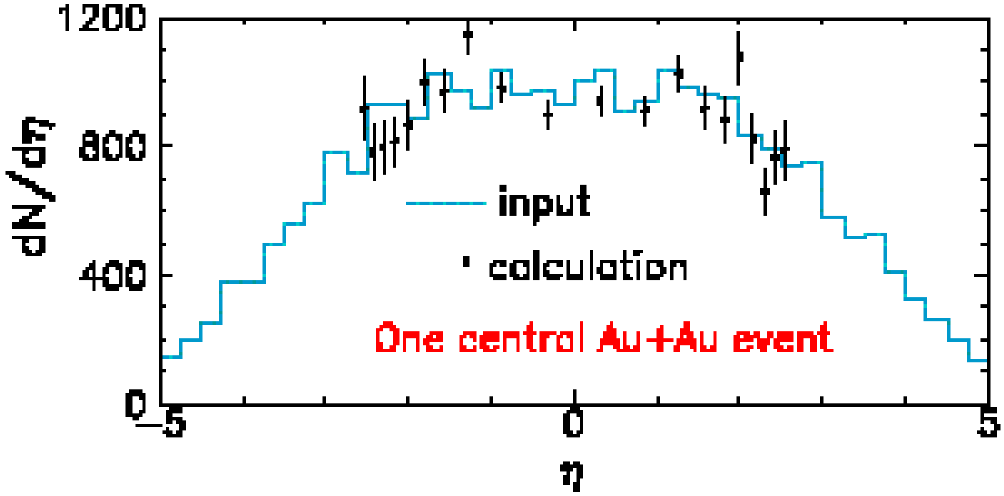
Clamshell design - mounts to magnet pole faces.
Inner and outer barrels of silicon strip detectors, 200µm, 64cm length
Silicon pad endcaps @ +/- 35cm
Rad length ≈ 1.1%
Weight < 30lb



Strip electronics at bottom - Multichip Module
256 channels/detector
Channel count = 34,816

dN/dη Measurements





- FIRST DAY PHYSICS
- Based on 125 Central Au+Au collisions - HIJET
- Blue line is simulation result
- Data points indicate distribution reconstructed from analog sums of signal in Si strip detectors

Some Physics Topics

$dN/d\eta$ vs η has been proposed [1] to study droplet formation due to the QCD phase transition and intermittency [2]. Large scale fluctuations could arise from a second order phase transition from the QGP to the final hadronic state, and are related to the mechanism of hadronic matter formation. Such large fluctuations could exist in the ratio of charged to neutral pions [3,4] upon formation of a disoriented chiral condensate.

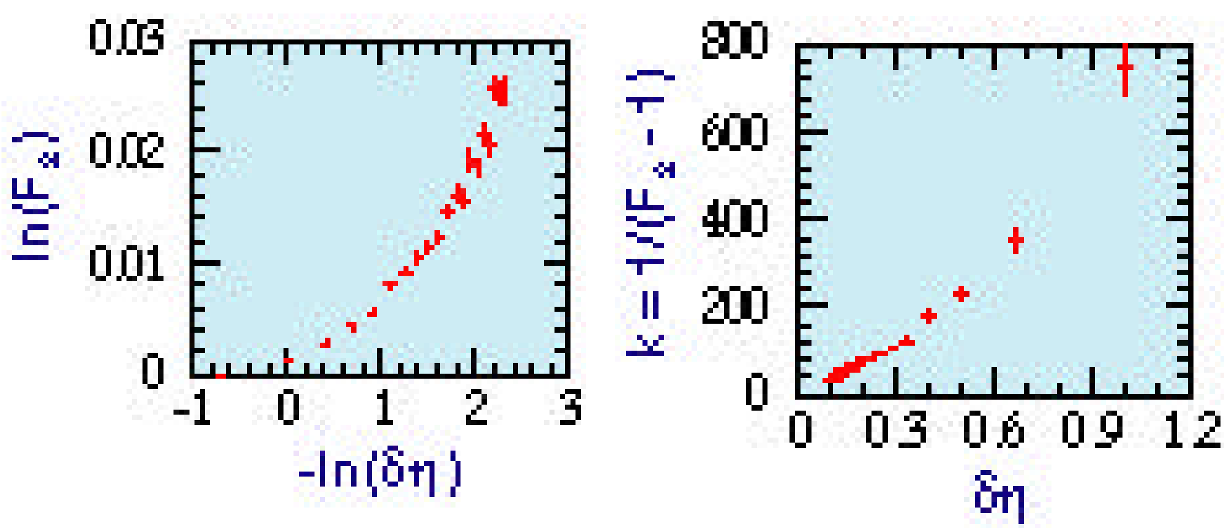
[1] L. Van Hove, Z. Phys. C27, 135 (1985)
[2] A. Bialas and Peschanski, Nucl. Phys. B273, 703(1986);B308, 857 (1988)
[3] J.D. Bjorken, Int. J. Mod. Phys. A7, 4190 (1992)
[4] L. Van Hove, Ann. Phys. 192, 66(1989)

INTERMITTENCY

Intermittent or fractal behavior indicates the absence of a well-defined scale of length. Intermittency can be studied by the method of normalized factorial moments or by the method of negative binomial distributions (NBD).

Ideal detector: In absence of intermittency, the normalized factorial moment of second order, F_2, is an independent function of δη and the k parameter of the NBD is an independent function of dη. Note that $F_2 = 1+1/k$. In presence of intermittency, ln(F_2) is a linear function of -ln(δη), and k is a linear function of δη, respectively, where intermittency occurs if k(0) = 0, in which case, F is obviously divergent.

Multiplicity Vertex Detector: Below we show the effects of the detector acceptance of the MVD on 100 Au+Au Hijet events, which are statistically independent and therefore not intermittent. Iintermittency has to show up in significantly larger slopes compared to the ones which are shown here.



A. Bialas, R. Peschanski, Nucl. Phys. B273 (1986) 703.
A. Bialas, R. Peschanski, Nucl. Phys. B308 (1988) 857.
M.J. Tannenbaum, Mod. Phys. Lett. A9(1994) 89.

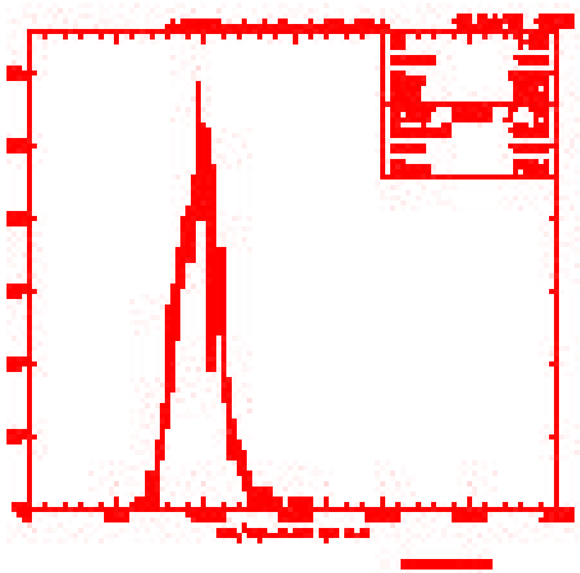
Disoriented Chiral Condensates

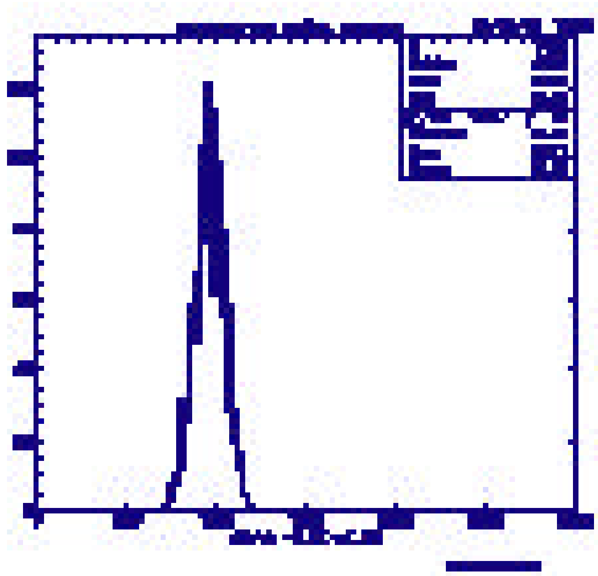
During the QCD phase transition, domains may form in which the quark condensate is misaligned in isospin space (DCC's), resulting in fluctuations in the relative populations of charged and neutral π's, particularly at low p_T [1,2,3].

The MVD can be used to measure fluctuations in the dN/dη spectrum of charged π's. Shown below in blue is the spread in the value of dN/dη over the range $-2.5<\eta<2.5$ using 100 HIJET events. Shown in red is the same distribution, after adding in simulated MVD resolution. The ability of the MVD to recognize a DCC-induced increase in dN/dη will depend on the size of the signal; it has been estimated that a moderately sized domain could form an extra ~50 charged π's over a small η range [2]. In addition, the EMCALcould be sensitive to a DCC-induced increase in low p_T neutral π's [2].

DCC's cont...

A potentially stronger tool is to look directly at variations in the neutral to charged π ratio, using charged π's from tracking and the MVD, and neutral π's from the EMCAL. Efforts are currently underway at LANL to develop a DCC event generator, which will then be used to study this approach.





[1] F. Cooper, Kluger, Mottola, Phys Rev C54, 3298 (1996)
[2] S. Gavin, Nuclear Physics A590, 163c (1995)
[3] F. Wilczek, Nucl. Phys. A566, 123c (1994)