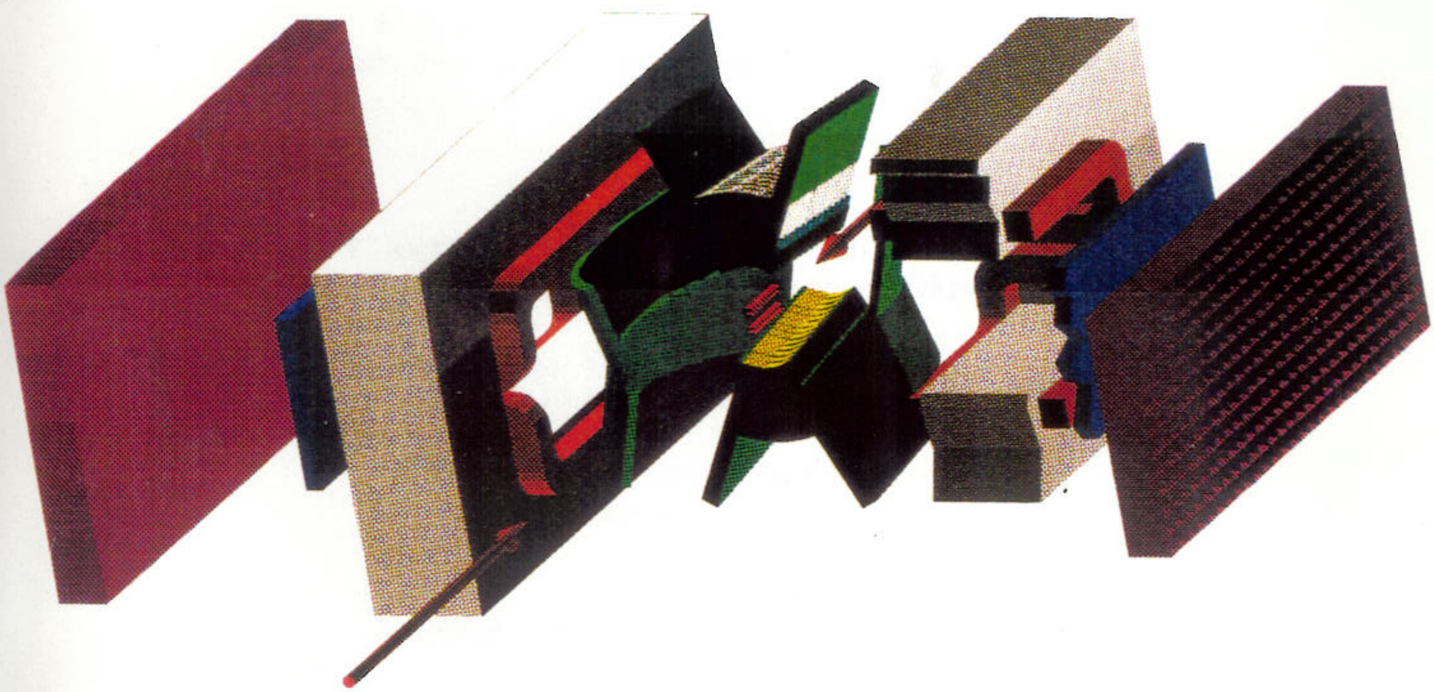
# The TALES/SPARHC EXPERIMENT at RHIC



*Letter of Intent for RHIC Experiment*

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# 1 INTRODUCTION

We propose to build a compact, flexible and versatile apparatus for the investigation of photons, dielectrons, charged particles and jets at one of the intersection regions of RHIC. Our major physics goals are to detect and diagnose the properties[1] of the Quark-Gluon Plasma (QGP). As our main experimental tool for this search, we will use, in conjunction with good event characterization, the measurement of directly emitted penetrating radiation from all phases of a nucleus-nucleus collision.

It is at intermediate values of transverse momentum $p_t$ or transverse mass $m_t$ (0.5 − 4 GeV) where effects from the QGP potentially formed in such collisions should be most clearly visible. Here, dielectrons and photons from the hot initial phase[2] of the QGP should be observable. In the proposed experiment we will place special emphasis on the measurement of this promptly emitted radiation from the plasma which, together with information on produced multiplicity of charged hadrons, will provide direct information on the initial temperature and, indeed, the equation of state of the plasma.

At lower transverse momenta soft processes from the later stages of the collision will dominate[3]. Here, we will focus on the measurement of identified hadrons to a) search for enhanced strangeness or antinucleon production, b) measure the spectral distributions for inclusive hadron production as a function of the centrality of the collision and c) test to what degree the central region is baryon free. The existence of a phase transition may be inferred from such measurements, *e.g.*, by correlating for identified hadrons $< p_t >$, *i.e.*temperature, with charged particle density $dN_c/d\eta$ or transverse energy density $dE_t/d\eta$. Large fluctuations over limited regions of rapidity ($\leq 1$ unit) in these densities could provide evidence for large latent heat stored in the collision. Identical particle interferometry may also be used to estimate the space-time extent of the system while it hadronizes and expands. Furthermore, we will search for the photon radiation emitted if a pion liquid[3] is formed in the collision and measure the rate of low transverse mass dielectron pairs to shed light on this "anomalous" region.

At very high $p_t$ ($p_t \geq 6$ GeV/c), corresponding to very short distance and time scales, hard scattering from the initial phase of the collision will dominate. Barring surprises, these processes should be calculable using QCD perturbation theory if initial-state scattering is taken into account. At RHIC luminosities, direct photons and jets can be studied as a probe of these hard collisions. Jets will be detected by leading particles. We note, however, that high $p_t$ hadrons and jets may be influenced by, and possibly thermalized in, the hadronic/quark-gluon medium surrounding the production point [4, 5]. A comparison of high $p_t$ photon spectra with spectra of identified hadrons is therefore a sensitive tool to investigate whether or not the hadrons are thermalized.

The proposed detector is principally a two-arm spectrometer which combines the geometry and RICH detectors from TALES (in the rotated configuration) with the vertex detector, straw tube tracker and high resolution photon detector from SPARHC.

We plan to develop detectors in which charged particle multiplicity and transverse electromagnetic energy production of dominantly soft particles are measured to determine the event characteristics (degree of centrality, entropy, unusual fluctuations in space/rapidity, as discussed in section 2.3). Ring-imaging Čerenkov (RICH) counters, trackers made from straw tubes, a small time-of-flight wall and high resolution photon detectors will provide the above discussed information on dielectrons, charged particles and photons. The detector concept is unique in that it explicitly incorporates flexibility. The distance from the beams to the magnets, tracking, and photon detectors (as well as the $\eta$ coverage of the spectrometer) can be varied to adapt the setup to unusual event characteristics, should they appear in collisions at RHIC. Since it is important to establish a connection to a region where perturbative QCD can be applied, the experiment will be designed to cover the whole range of projectile-target combinations available, and for the highest luminosities forseeable.

# LOI at a glance

**Physics Goals and Measured Signatures**

| What | | How |
|---|---|---|
| Search for QGP radiation using Penetrating Probes | QGP Photon spectrum<br>$\gamma/\pi$ enhancement<br>virtual photon spectrum | CsI detector<br><br>Dalitz-suppressed $e^+e^-$ |
| Resonance Production | $\rho, \omega, \phi, J/\Psi$<br>yield change, mass shift, melting? | RICH + tracking + EM |
| Inclusive Hadron Spectra | Identified charged hadron<br>Neutral hadron | Tracking+TOF<br>High-resolution EM detector |
| Global Variables | $dE_t/d\eta$<br>$dN_c/d\eta$, $d\sigma/dN_c$ | EM calorimeter<br>Si vertex detector |
| Hard process | Direct photon from QCD scattering<br>photon-jet coincidence<br>Charm | EM calorimeter<br>Tracking + EM calorimeter<br>Dalitz-suppressed $e^-$ spectru |

# LOI at a glance

### Detector Components and Capabilities

| Concept | Versatile double-arm dipoles |
|---|---|
| Single-particle acceptance | $\phi \sim \pm 15°$ |
| | $\eta \sim \pm 0.5$, and $\sim \pm 0.8$ |
| | $p_t$ cut at 100 MeV/c |
| Momentum resolution | $\delta p/p = 1\%$ at 1 GeV/c |
| $e^+e^-$ pair acceptance | 1% at $\phi$ peak |
| | 3% at $J/\Psi$ peak |
| $e^+e^-$ pair-mass resolution | $\delta M/M = 1\%$ at $\phi$ |
| | 1.5% at $J/\Psi$ |
| Tracking | Designed to work for $dN_c/dy > 1500$ |
| | Straw chambers : 4 super-layers / arm |
| | + confirmation pixel chamber / arm |
| | + Si vertex detector |
| Photon detection | Good resolution essential for single-photon and $\gamma/\pi^0$ study |
| | High-resolution CsI in 1 arm |
| | + Lead glass in the other arm |
| Charged hadron identification | TOF slats, $K/\pi$ up to 2 GeV/c |
| Neutral hadron identification | $\pi^0$, $\eta^0$ reconstructed for $p_t > 0.5, 1.5$ GeV/c |
| Electron identification | RICH+tracking+EM cal. |
| $e^+e^-$ pair reconstruction | The use of RICH essential to identify electrons and to reject Dalitz |
| | PMT-based RICH in the central field-free region |
| | Electron identification : RICH + crystal |
| | Dalitz rejection : $e^+e^-$ opening-angle cut of $\leq 15°$ with RICH |
| Global event characterization | Coarse EM calorimeter $2 < \eta < 6$, $2\pi$ |
| | + EM calorimeter $-1 < \eta < 1$, $-30° < \phi < 30° \times 2$ |
| | + mid-rapidity high-resolution EM calorimeter |
| | + Si vertex multiplicity |

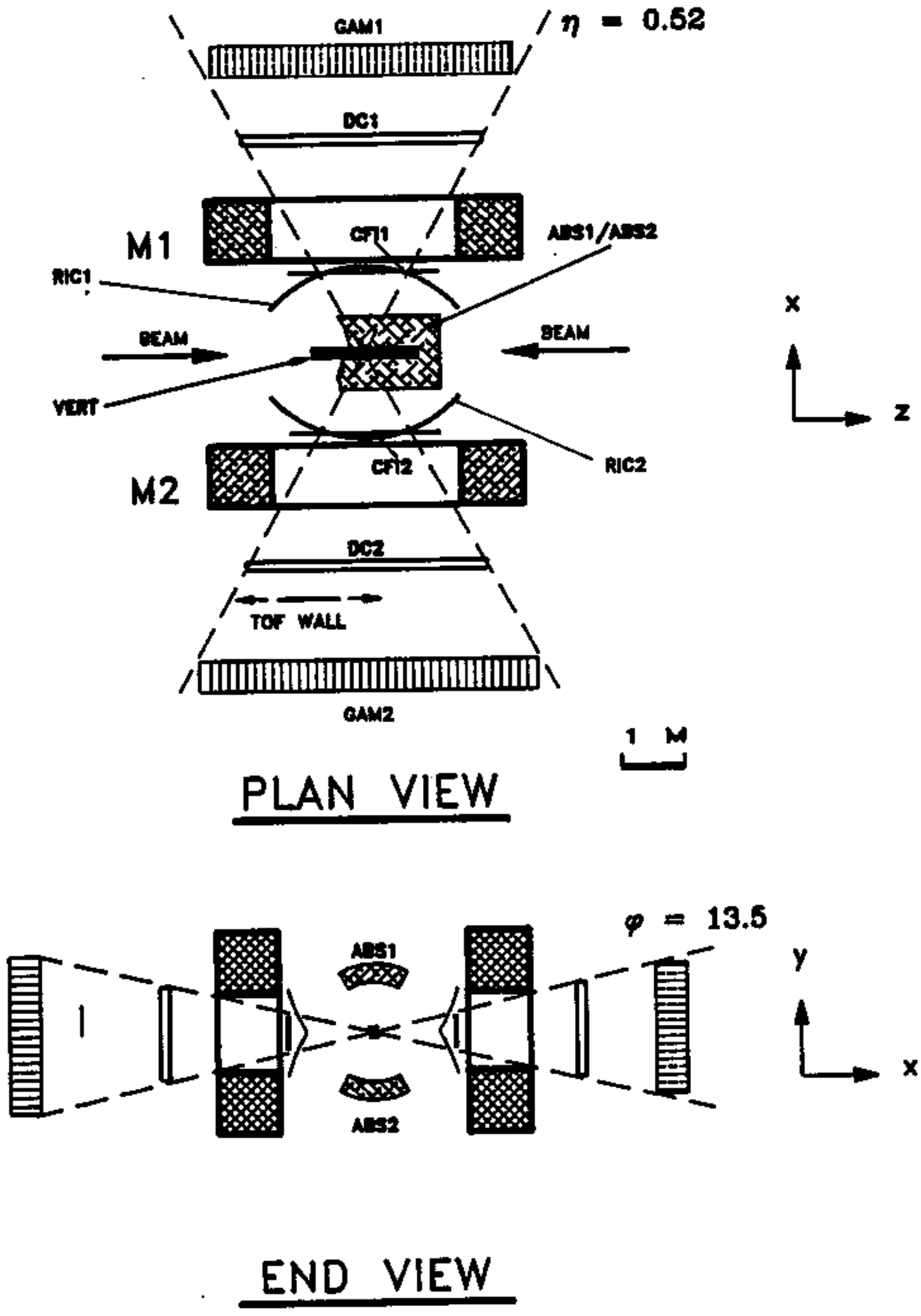


Figure 5: Detector Configuration 2

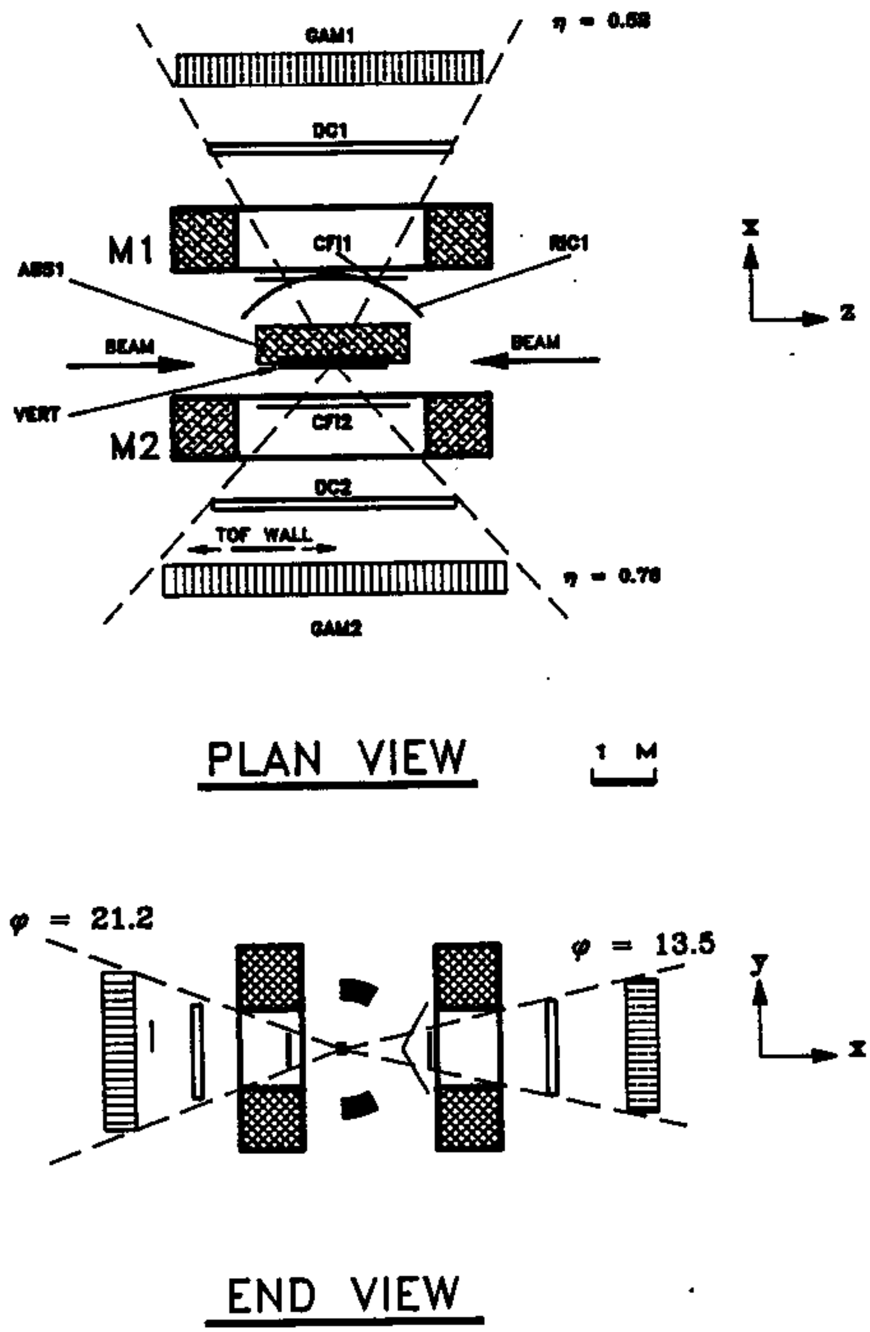


Figure 4: Detector Configuration 1. The detector names are explained in the text.