Electron Trigger in PHENIX at RHIC

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for the
PHENIX Collaboration

at APS April Meeting in Long Beach, CA on May 1, 2000

Presentation Outline

- PHENIX Experiment at RHIC
- Electron Identification Devices of PHENIX
- Needs for Electron Trigger in PHENIX
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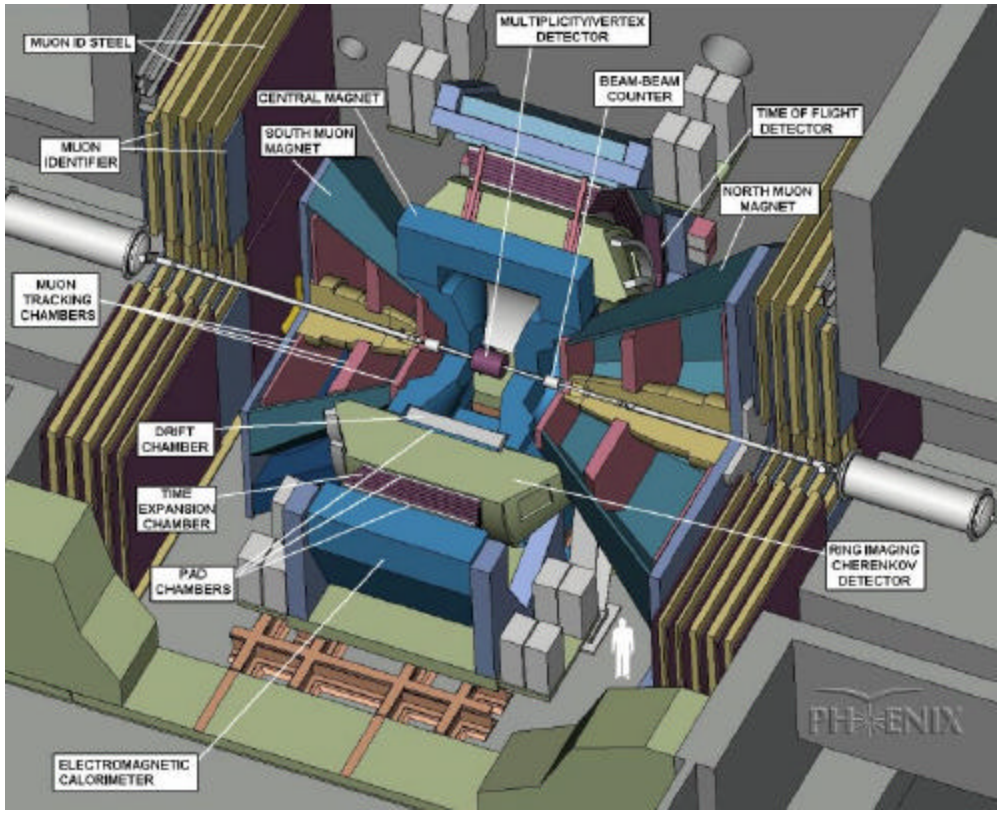
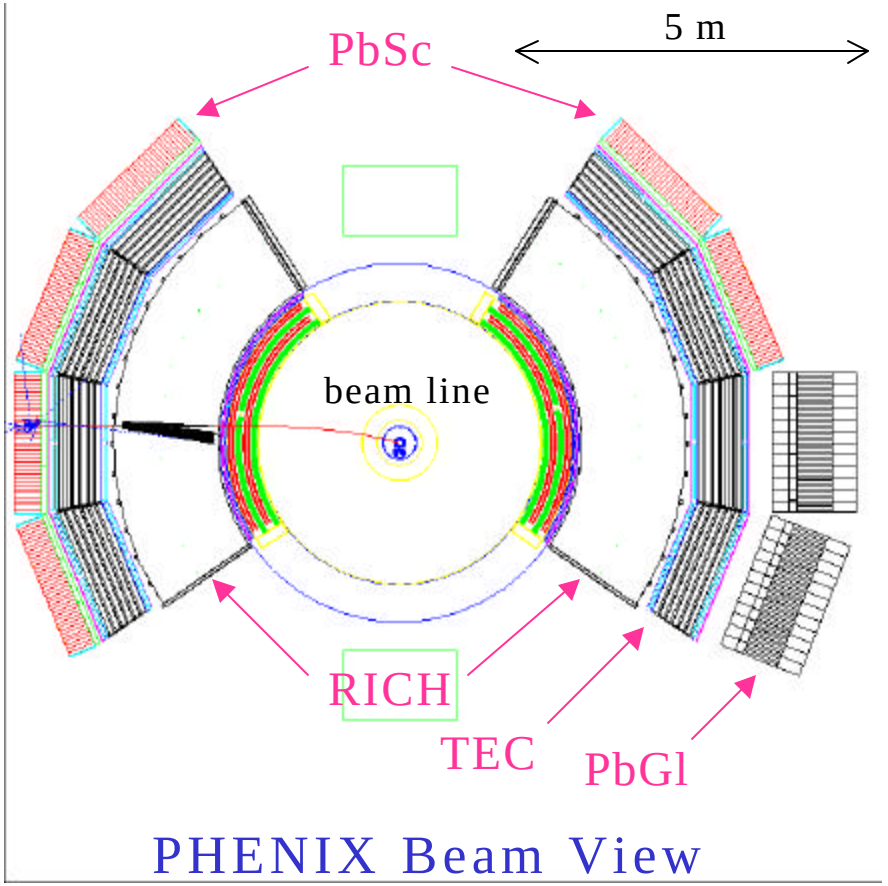
PHENIX Experiment at RHIC

- experimental study of QCD under extreme conditions
  - search for and characterize deconfined QGP phase
- wide variety of probes
  - emphasis on transparent probes
- detector systems
  - 2 central arms for photon, electron, hadron
  - 2 forward arms for muon
  - global detectors for event characterization



Electron ID Devices of PHENIX

- RICH
  - primary eID device
  - $|y| < 0.35$; $d\phi = \pi/2 \times 2$
  - CO_2 / C_2H_6 gaseous radiator
  - 5,120 PMT readout
- EMCal
  - γ / eID with fine granularity
  - PbSc (75% of coverage)
    - 15,552 PMT readout
  - PbGl (25% of coverage)
    - 9,216 PMT readout
- TEC
  - helps PID in mid-p_t region



Needs for Electron Trigger in PHENIX

- reaction rates (w/ RHIC design luminosities)
  - 200 A GeV Au+Au
    - 6 barn $\times$ 2e26 $cm^{-2}sec^{-1}$ = 1.2 kHz
  - 200 GeV p+p
    - 50 mb $\times$ 8e30 $cm^{-2}sec^{-1}$ = 400 kHz (4 MHz later)
  - 500 GeV p+p
    - 60 mb $\times$ 2e31 $cm^{-2}sec^{-1}$ = 1.2 MHz (12 MHz later)
- DAQ capability
  - designed at 25 kHz (6 kHz initially)
- electron trigger in p+p and light A+A for systematic studies of rare physics probes
  - J/Ψ, ϕ, ω, ρ (di-electron)
  - charm (single electron)

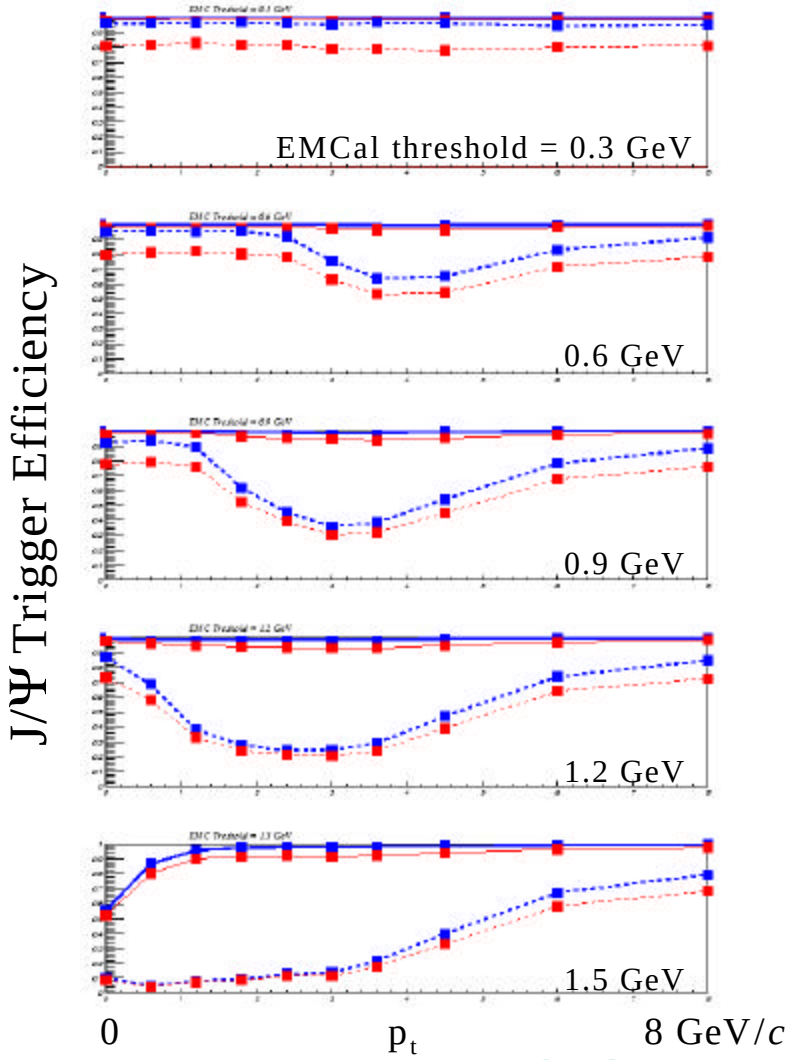
Electron Trigger Scheme

- front-end
  - EMCal level-1 trigger
    - max. 172 bits from overlapping 4x4 PMT sums, 36 tiles OR'ed
  - RICH level-1 trigger
    - max. 256 bits from non-overlapping 4x5 PMT sums
- EMCal-RICH look-up
  - based on EMCal and RICH level-1 information
  - hardware layouts under discussion
- simulation studies ongoing to finalize specifications
  - evaluate trigger performance
  - establish trigger hardware specifications and design
    - segmentation and rejection power
    - look-up scheme and trigger efficiency
    - single / double electron trigger

Simulation Method and Data Sets

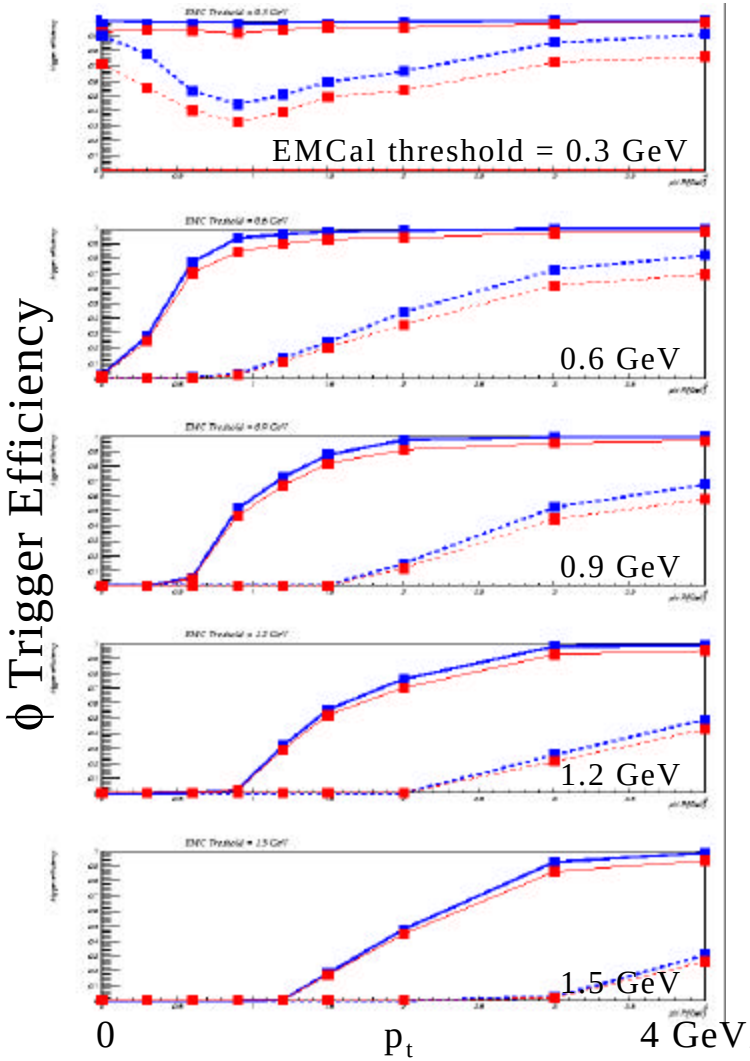
- simulation method
  - PHENIX full simulation chain
  - compare EMCal alone and RICH-EMCal triggers
  - present RICH-EMCal look-up scheme
    - 8 trigger blocks per central arm
    - 1-to-1 AND of 16 bits (RICH) + 16 bits (EMCal)
- vector meson signals
  - 60K single J/Ψ ($0.0 < p_t < 8.0$ GeV/c) $\rightarrow e^+e^-$
  - 54K single ϕ ($0.0 < p_t < 4.0$ GeV/c) $\rightarrow e^+e^-$
  - PHENIX pair acceptance cut
- minimum-bias backgrounds
  - 12K Au+Au, 6K Ag+Ag, 12K Si+Si from HIJING
  - 85K p+p from PYTHIA

Trigger Efficiency for J/Ψ



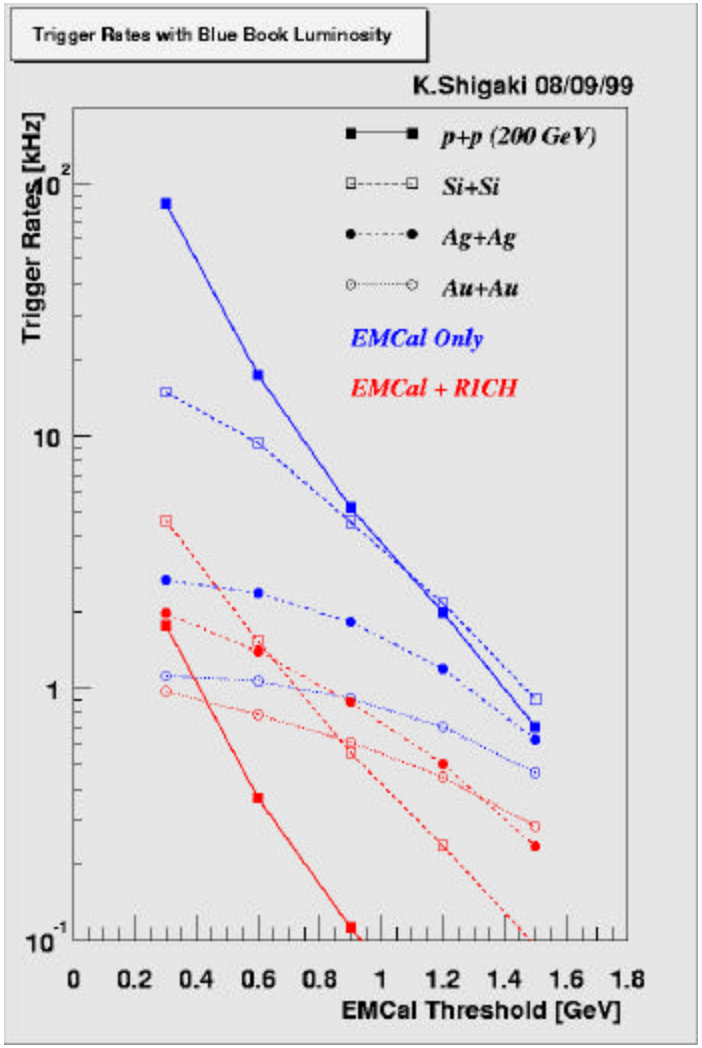
- plot (by T.Matsumoto and KS) :
  - blue: EMCal alone
  - red: RICH-EMCal lookup
  - solid: single electron trigger
  - broken: double electron trigger
- single electron trigger
  - threshold needs to be < 1.2 GeV
- double electron trigger
  - p_t dependent trigger bias

Trigger Efficiency for ϕ



- plot (by T.Matsumoto and KS) :
  - blue: EMCal alone
  - red: RICH-EMCal lookup
  - solid: single electron trigger
  - broken: double electron trigger
- single electron trigger
  - threshold needs to be < 0.6 GeV
  - close to EMCal hardware limit
- double electron trigger
  - low trigger efficiency
  - p_t dependent trigger bias

Electron Trigger Rates



- plots: single electron trigger rates with RHIC design luminosities
- EMCal alone
  - *e.g.* in p+p at 200 GeV
    - 4 kHz at 1.0 GeV threshold
    - 30 kHz at 0.5 GeV threshold
  - marginal for J/Ψ
  - insufficient for ϕ (and maybe c)
- RICH-EMCal
  - *e.g.* in p+p at 200 GeV
    - < 0.1 kHz at 1.0 GeV threshold
    - 0.6 kHz at 0.5 GeV threshold
  - sufficient rejection even with future RHIC upgrade

Summary

- PHENIX level-1 electron trigger under development
  - essential for systematic studies of single- and di-electron channels
    - rare physics probes such as J/Ψ, φ, ω, ρ, charm, ...
    - from p+p, light A+A, to Au+Au
- simple RICH-EMCal look-up proved promising
  - single electron trigger preferred to minimize trigger bias
  - allows electron threshold « 1 GeV
    - required for φ and charm (single electron) trigger
      - triggering on φ might be difficult due to a hardware limitation
  - works at RHIC design luminosity and with future upgrade
- hardware work ongoing
  - level-1 trigger hardware for RICH and EMCal in final design stage
  - RICH-EMCal look-up scheme under study to finalize hardware specifications