



Electron Trigger in PHENIX

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at

PHENIX Heavy Flavor and Light Vector Meson
Physics Working Group Meeting

on

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Presentation Outline

- Needs for Electron Trigger in PHENIX
 - Trigger Needs for Heavy Ion Physics
- Electron Trigger Scheme
- Simulation Studies
 - Electrons to be Triggered
 - Rejection against Minimum-Bias Events
 - Minimum-Bias Trigger Rates
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- Heavy Ion Physics Gain with Electron Trigger
- Summary

Needs for Electron Trigger in PHENIX

- reaction rates (w/ blue book luminosities)
 - 200 A GeV Au+Au
 - $6 \text{ barn} \times 2e26 \text{ cm}^{-2}\text{sec}^{-1} = 1.2 \text{ kHz}$
 - 200 GeV p+p
 - $50 \text{ mb} \times 8e30 \text{ cm}^{-2}\text{sec}^{-1} = 400 \text{ kHz}$ (4 MHz later)
 - 500 GeV p+p
 - $60 \text{ mb} \times 2e31 \text{ cm}^{-2}\text{sec}^{-1} = 1.2 \text{ MHz}$ (12 MHz later)
- DAQ capability
 - LV1 limit : 25 kHz (6 kHz initially)
 - LV2 limit : 20 Mbyte/sec ~ 100 Hz minimum-bias Au+Au

Trigger Needs for Heavy Ion Physics

- **p+p**
 - essential to understand A+A data
 - **no p+p data** at the RHIC energy
 - only limited data at the ISR energies up to $\sqrt{s} = 63$ GeV
 - **uncertainties in p+p** can easily overshadow new phenomena in A+A
 - true for basically all physics probes (**J/Ψ**, **ϕ**, **ω**, **ρ**, **charm**, ...)
- **light A+A**
 - important systematics
 - Au+Au might be too heavy to show step behavior at RHIC
- **peripheral Au+Au ?**

Electron Trigger Scheme (1)

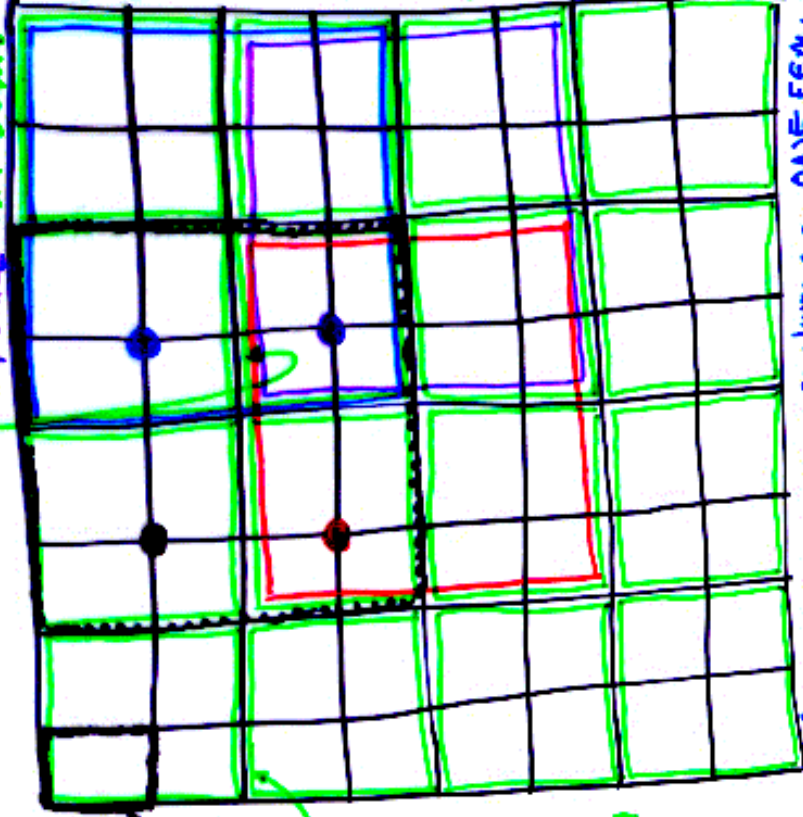
- front-end
 - EMCal Ersatz LV1
 - under development at [ORNL](#)
 - max. **172 bits** from overlapping 4x4 PMT sums, 36 tiles OR'ed
 - *ref.* [G.Young](#) at Trigger Meeting in February '00
 - RICH LV1
 - under development at [CNS Tokyo](#) / [Waseda U.](#) / [NIAS](#)
 - max. **256 bits** from non-overlapping 4x5 PMT sums
 - *ref.* [T.Matsumoto](#) and [K.Oyama](#) at Trigger Meeting in February '00

Towers & Tiles

64 EMCal towers
8x8

1 tower

2x2 sum }
= 1 preamp chip
= "muon" basic element
= sub-tile for 4 overlapped 4x4 sums



This 2x2 tile is part of all four 4x4 tile sums shown. It's preamp ASIC prepares 4 copies of the 2x2 sum, & accumulates the PURGE 4x4 sum. The preamp also

makes 3 copies of the 4x4 sum & compares each to a separate, programmable threshold.

The resultant 3 bits are output.

The 2x2 sum is compared to a 4th 'cosmic' threshold & the resultant bit is output. The 2x2 current sum is also output, for

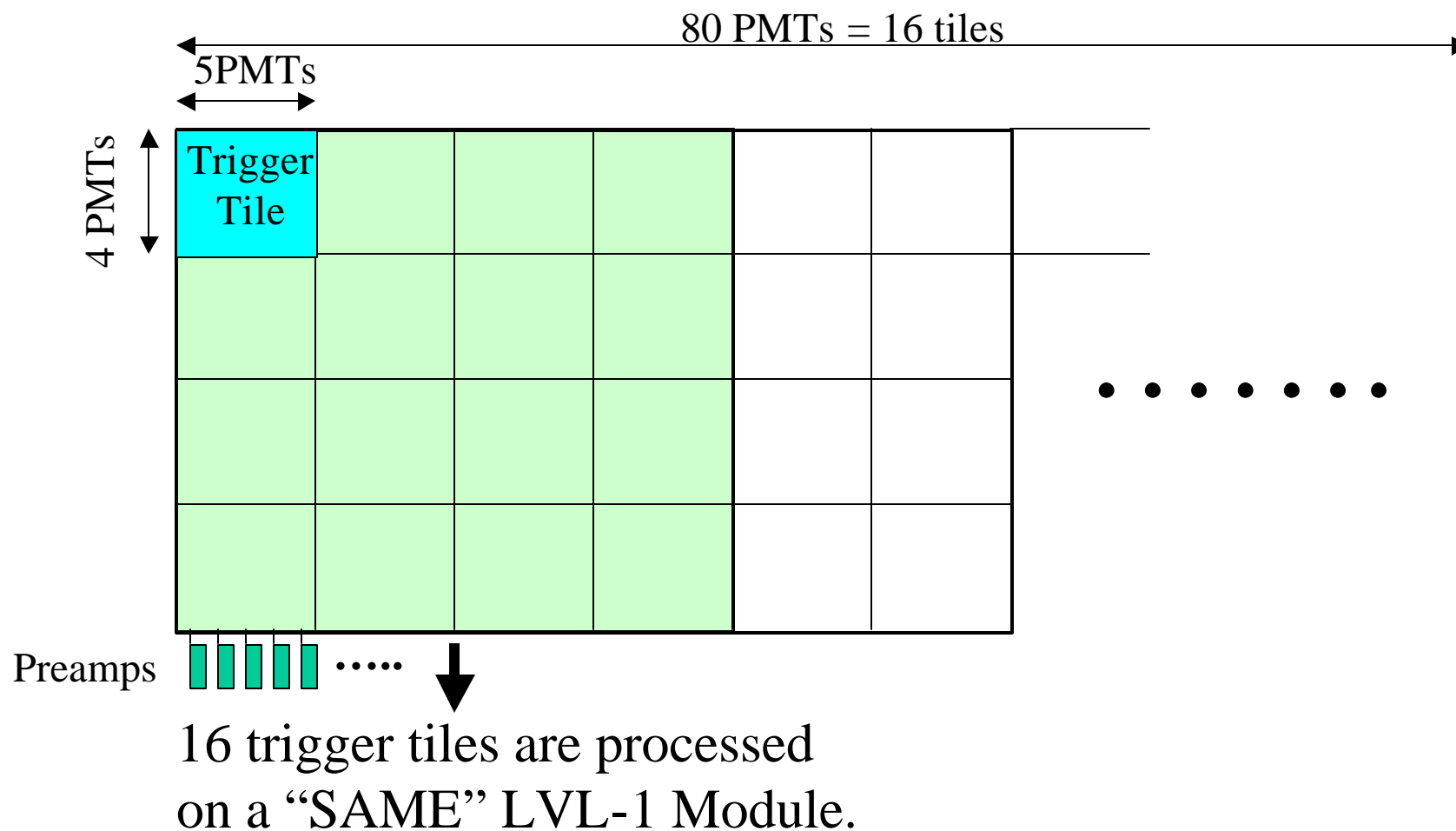
(Note: 2x2 sums are always on OASE FEMs. 4x4 sums may span 1, 2, 3 or 4 FEMs) → E₁ sum usage corners!

- A "FEM" board services 144 towers.
- It has 6 "ASIC" daughter cards, each servicing 24 towers.
- There are 144/(4x4) x 4 = 36 overlapping 4x4 tiles per FEM.
- These produce 3x36 bits 'Yes/No' corresponding to 3 thresholds
- There are 144/(2x2) = 36 'cosmic' files per FEM. These produce 36 bits, which are summed (on trigger daughtercard) & compared to digital threshold, e.g. 5 fixed tiles, to give "cosmic" trigger
- Each ASIC card sums its 6 2x2 tiles to give a local energy sum. These 6 energy sums go to the trigger card, where they may be summed, as this FEM's contribution to a total E₁ (= E₂) sum.

Geometry of Trigger Tile

T.Matsumoto and K.Oyama Feb.11, 2000

- **RICH PMT array of a side (1/4 of entire PHENIX) has 1,280 PMTs (64 non overlapped trigger tiles)**

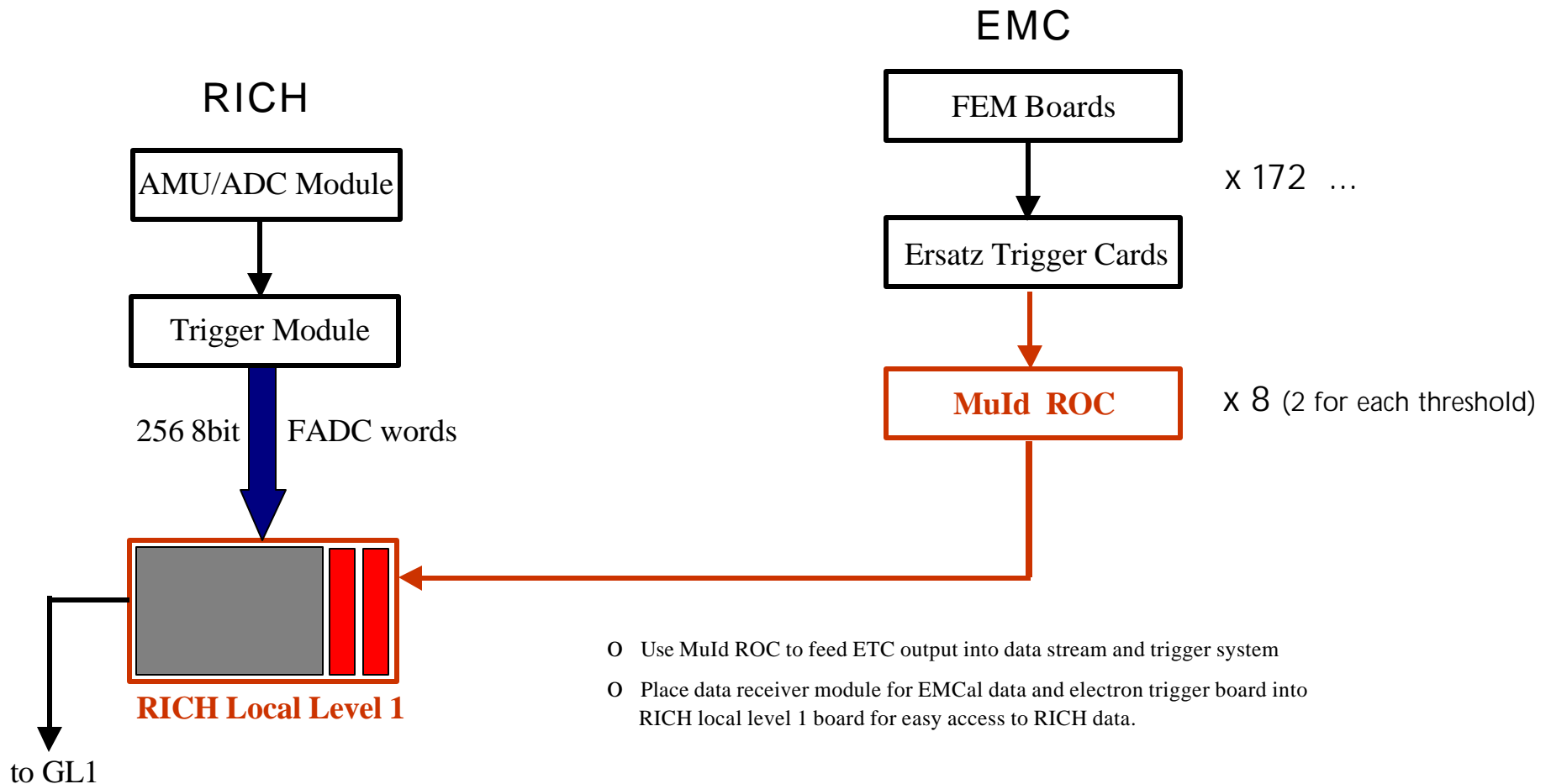


Electron Trigger Scheme (2)

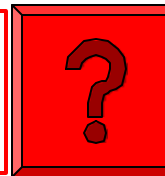
- EMCal-RICH look-up
 - was not in original GL1
 - a really simple scheme: 1/2 sector matching
 - EMCal: 3x3 (PbSc) / 4x4 (PbGl) bits OR'ed
 - RICH: 4x4 bits (= 1 readout FEM) OR'ed
 - look-up: simple 1-to-1 AND of 16 bits + 16 bits
 - *ref. K.Shigaki* at Heavy+Light and Spin PWG's in August '99
 - hardware layouts under discussion
 - studies ongoing to finalize specifications
 - finer segmentation for better rejection power ?
 - overlapping look-up for higher efficiency ?
 - single / double electron trigger ?

RICH/EMCal Layout Option #1

K.Barish Feb.11, 2000

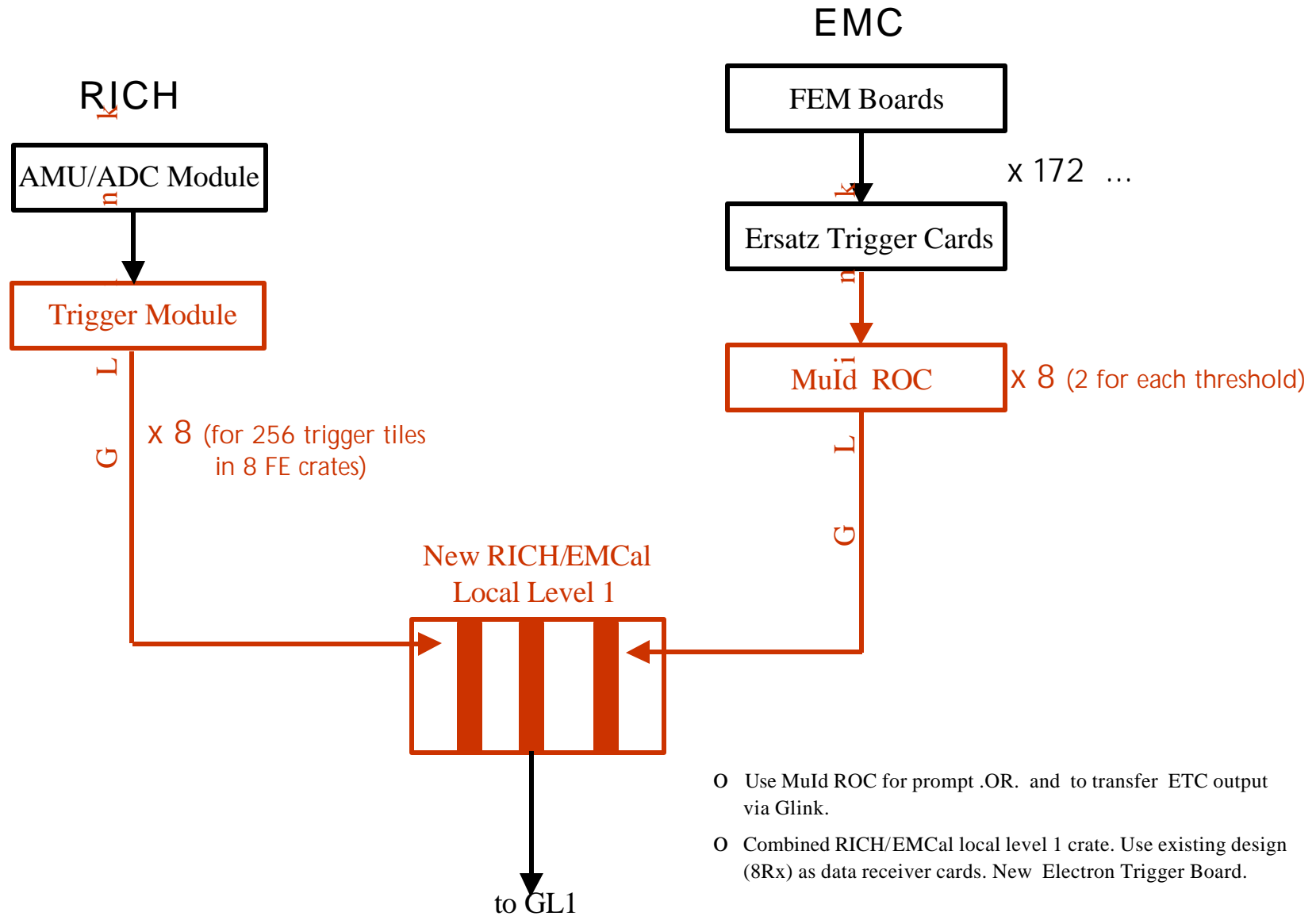


Are RICH primitives (Adjacency check on Tiles, Ring Sums) still required input at Level 2 or can this be generated at level 2 based on increased processing power? If yes, when will the RICH local level 1 be built?



RICH/EMCal Layout Option #2

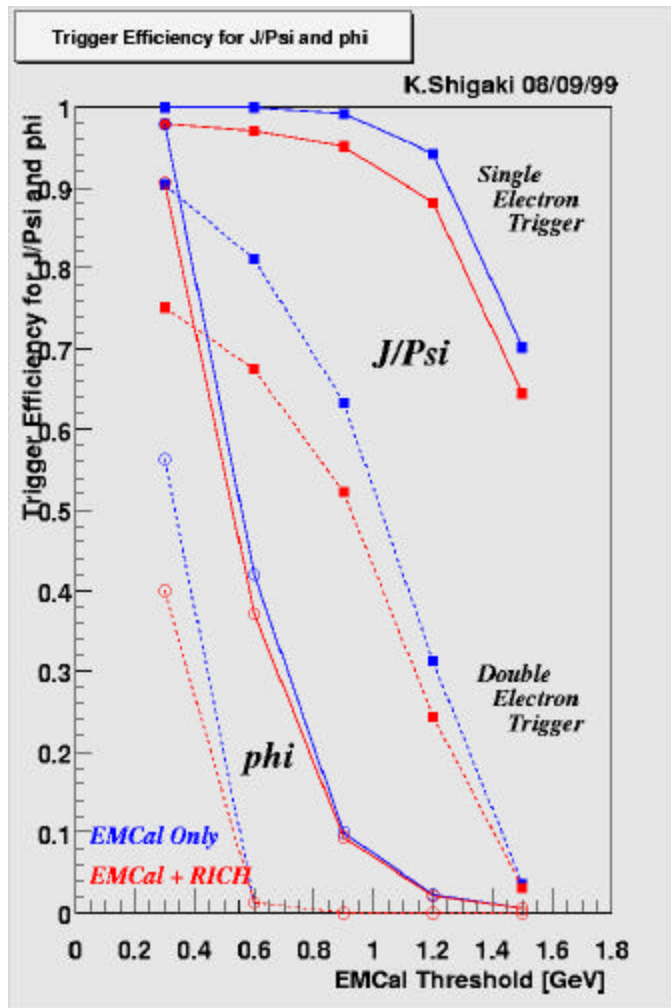
K.Barish Feb.11, 2000



Simulation Studies

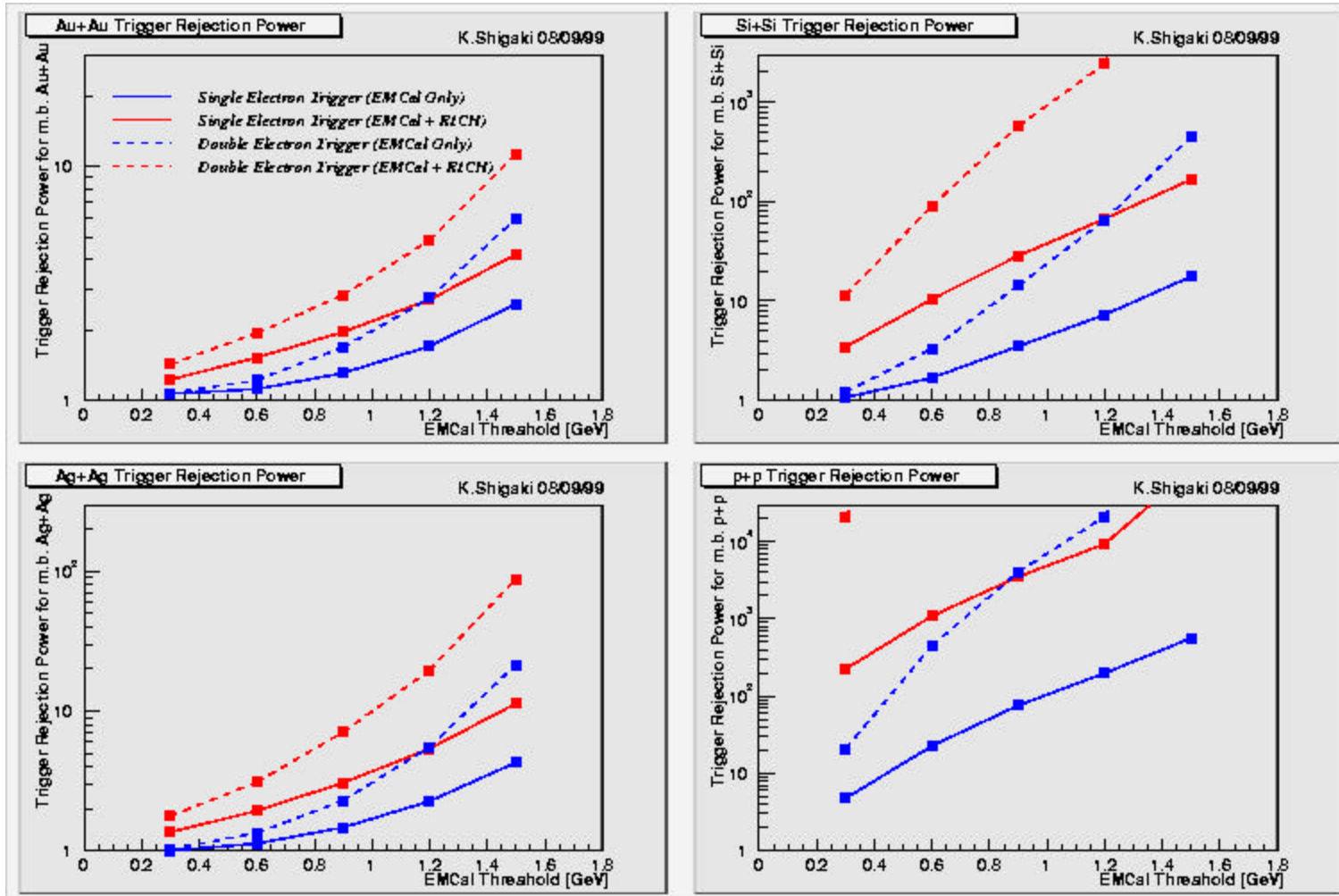
- vector meson signals
 - MDC-2 and its follow-up at RCF
 - requested by M.Rosati and K.Barish; generated by I.Ojha *et al.*
 - 778 J/Ψ , 700 ϕ from RV generator
- minimum-bias backgrounds
 - MDC-J-2 at PHENIX-CC-J
 - requested by K.Shigaki; generated by N.Hayashi *et al.*
 - 12,117 Au+Au, 6,120 Ag+Ag, 12,211 Si+Si, 85,203 p+p
- more vector meson signals for systematic study
 - VRDC at PHENIX-CC-J / RCF
 - requested by K.Shigaki; generated by N.Hayashi *et al.*
 - 60K J/Ψ , 54K ϕ at fixed p_t , Z_{vertex}

Electrons to be Triggered (MDC-2)

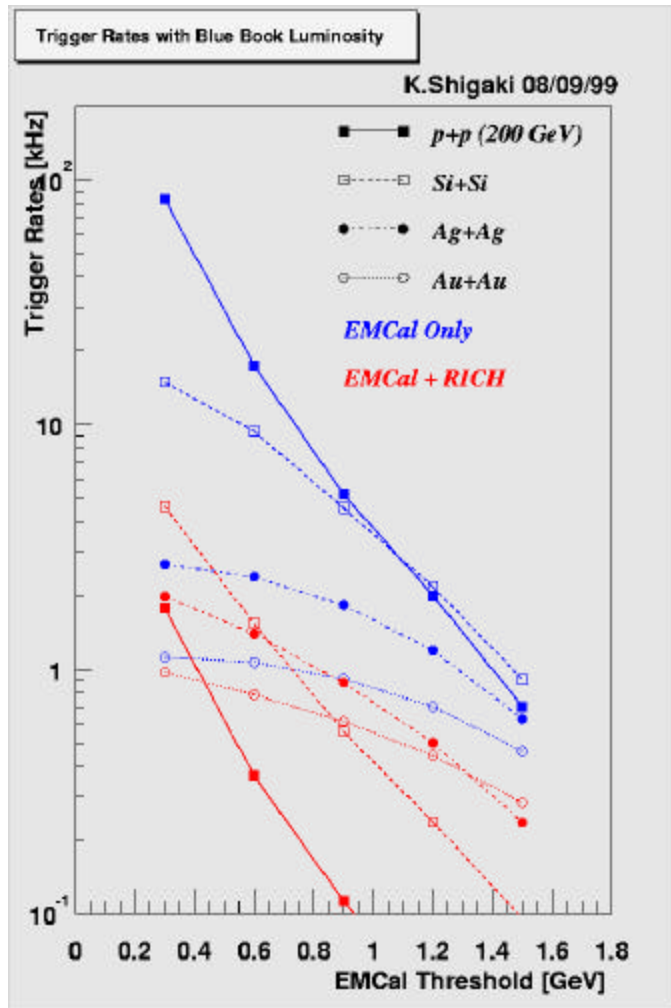


- trigger threshold for J/Ψ
 - needs to be $< 1 \text{ GeV}$
- trigger threshold for ϕ
 - needs to be $< 500 \text{ MeV}$
 - close to EMCal hardware limit
- to be updated in VRDC
 - as a function of p_t , Z_{vertex}
 - geometrical acceptance cut
 - pair reconstruction
 - refined trigger simulation
 - *ref.* report by T. Matsumoto

Rejection against M.B. Events (MDC-J-2)

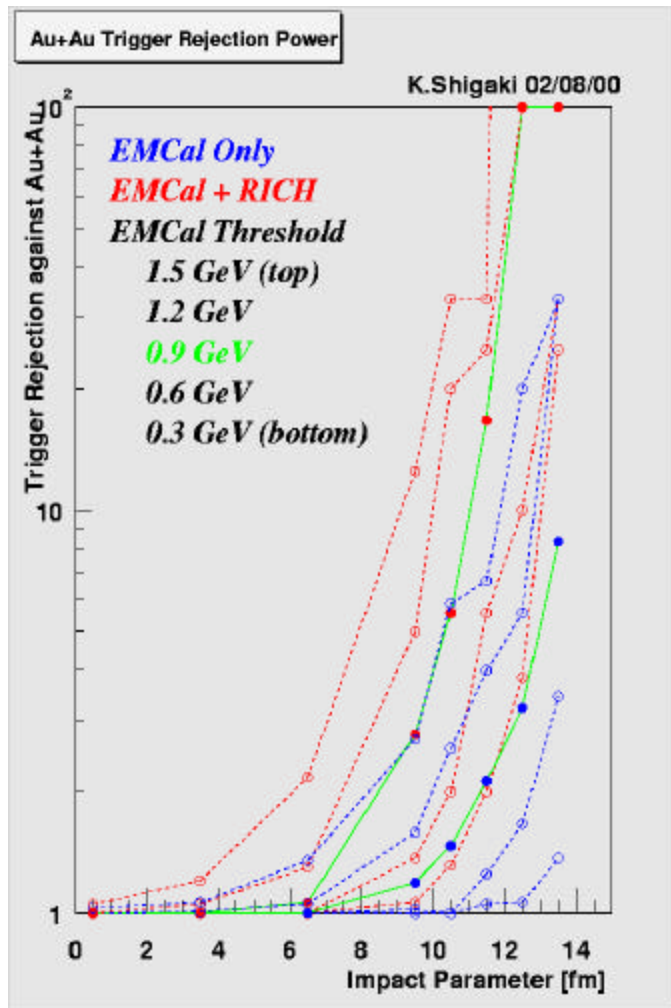


Minimum-Bias Trigger Rates (MDC-J-2)



- plots: single electron trigger rates with blue book luminosities
- EMCal trigger with light collision systems:
 - marginal for J/Ψ
 - insufficient for ϕ (and c ?)
 - does not sustain $\times 10$ luminosity
- EMCal + RICH trigger:
 - significant improvement
 - promising even for ϕ from $\times 10$ luminosity $p+p$

Centrality vs. Rejection in Au+Au



- rejection power exists against peripheral Au+Au
 - might be where the QCD phase transition occurs at RHIC
 - possible use of electron trigger in Au+Au running

HI Physics Gain with Electron Trigger

- high luminosity runs
 - $p+p$ and light $A+A$
 - with blue book luminosities and future RHIC upgrade
- possible use for peripheral $Au+Au$
- low electron threshold
 - can go down $\ll 1$ GeV with EMCAL-RICH lookup
- access to rare probes
 - J/Ψ , ϕ , ω , ρ (di-electron)
 - charm (single electron)
- essential to systematic studies of virtually all single- and di-electron channels

Summary

- electron trigger for heavy ion physics
 - essential for systematic studies with light A+A, p+p
 - can be useful to trigger peripheral Au+Au
- simple EMCAL-RICH look-up covers many physics probes (J/Ψ , ϕ , ω , ρ , charm, ...)
 - allows threshold $\ll 1$ GeV with light collision systems
 - required for ϕ and charm (single electron) trigger
 - sustains $\times 10$ blue book luminosity
 - EMCAL trigger hardware sets lower limit of threshold at ~ 500 MeV
- look-up scheme under study to finalize hardware specifications of level-1 electron trigger