

Global Muon Trigger

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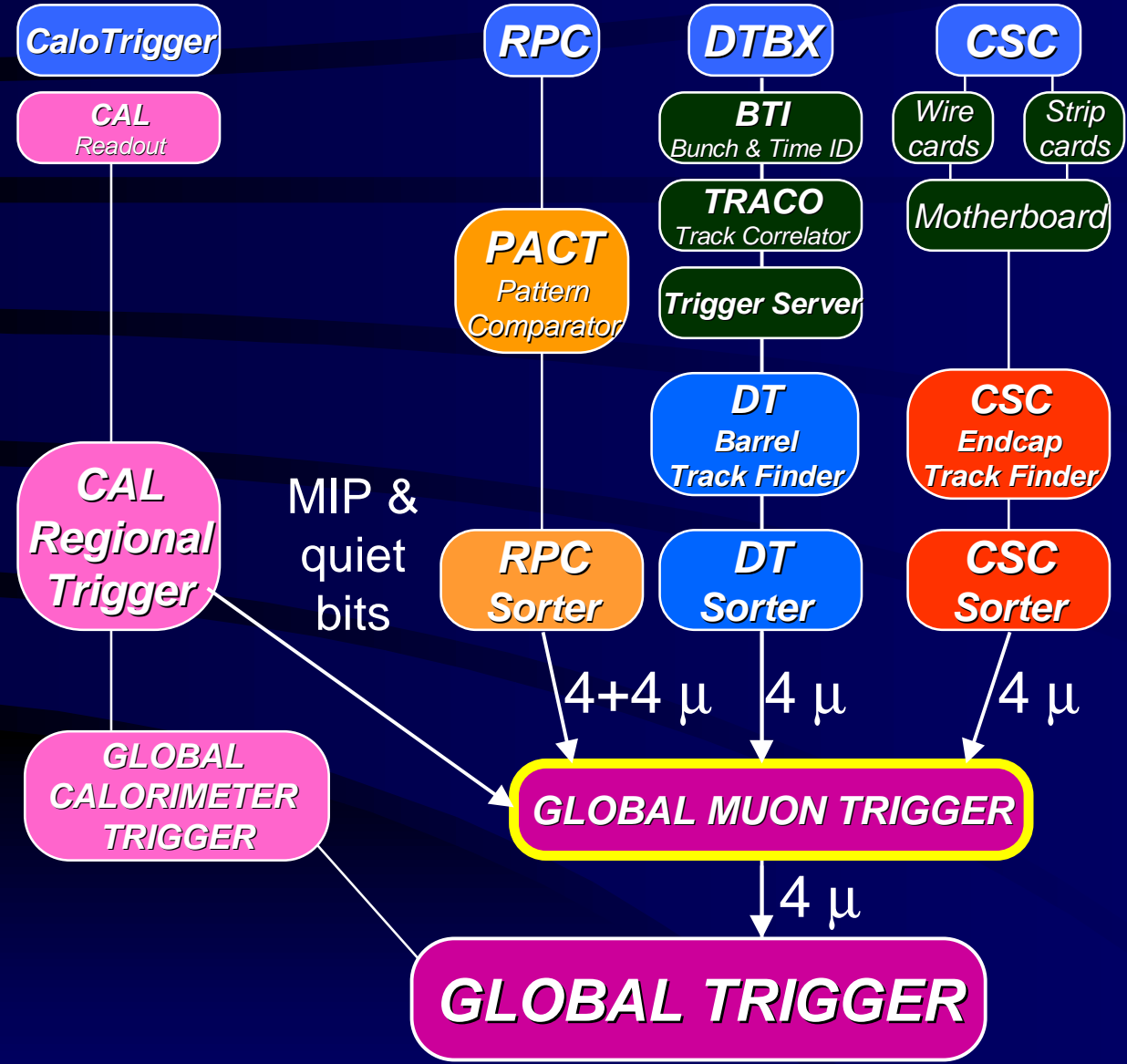
HEPHY Vienna

(* on leave from HEPHY Vienna)

TRIGGER Review, November 9th, 1999



CMS Muon Trigger System

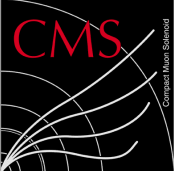




Overview



- Goals & Strategy
- Issues in the overlap region
- New Simulation results for endcap and overlap region &
- Existing Simulation results for barrel
- Plans for R&D in 2000



Goals of GMT



- Make use of the Complementarity of RPC and DT/CSC Trigger
- Increase Efficiency
- Reduce Ghosts

Strategy of GMT

- Attempt to match RPC and DT/CSC candidates
- If match found, forward better muon
- If unmatched RPC muon
 - always forward (low ghost rate) (for $|\eta| < 2.1$)
- If unmatched DT/CSC muon,
 - only forward if high quality (for $|\eta| < 2.1$)
 - always forward (for $|\eta| > 2.1$)

Input & Output

- *From regional Muon Triggers*
 - up to 4 muons each from DT, CSC
 - up to 4 + 4 muons from RPC
 - for each muon: η , ϕ , P_T , muon sign, quality
- *From Calorimeter Trigger*
 - MIP & Quiet Bit for 288 (16x18) regions of $\Delta\eta \times \Delta\phi = 0.35 \times 0.35$
- *To Global Trigger*
 - up to 4 muons with
 - η , ϕ , P_T , muon sign, quality, MIP bit, Quiet bit



Functional Blocks

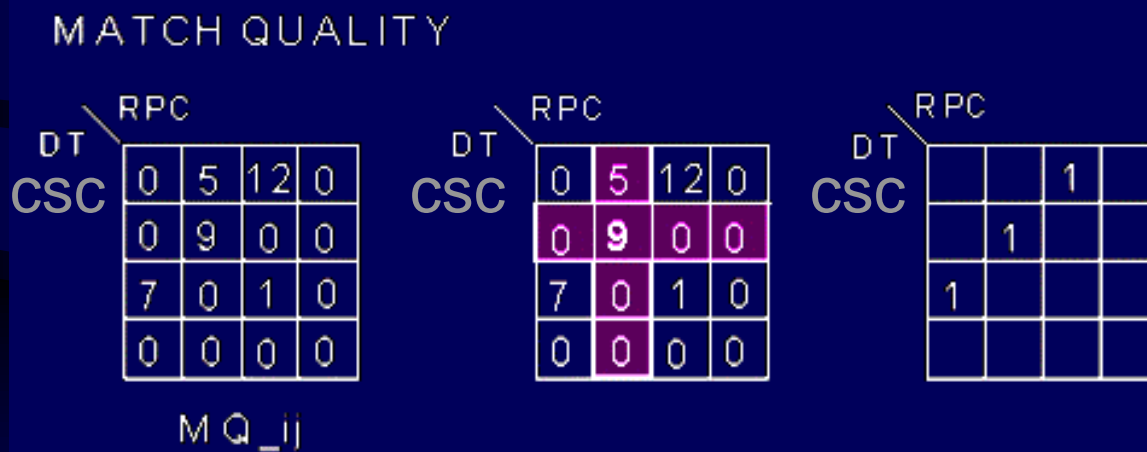


- synchronization
- unit conversion
- muon matching (selection matrix, ...)
- single rank calculation
- rank assignment
- quiet bit + MIP bit logic
- final sorting

Muon Matching

- Calculate function of $\Delta\eta$ and $\Delta\phi$ and define *match quality* (6 bits)

$$match_quality \propto \frac{1}{\sqrt{w_A \cdot (\Delta\eta)^2 + w_B \cdot (\Delta\phi)^2}}$$

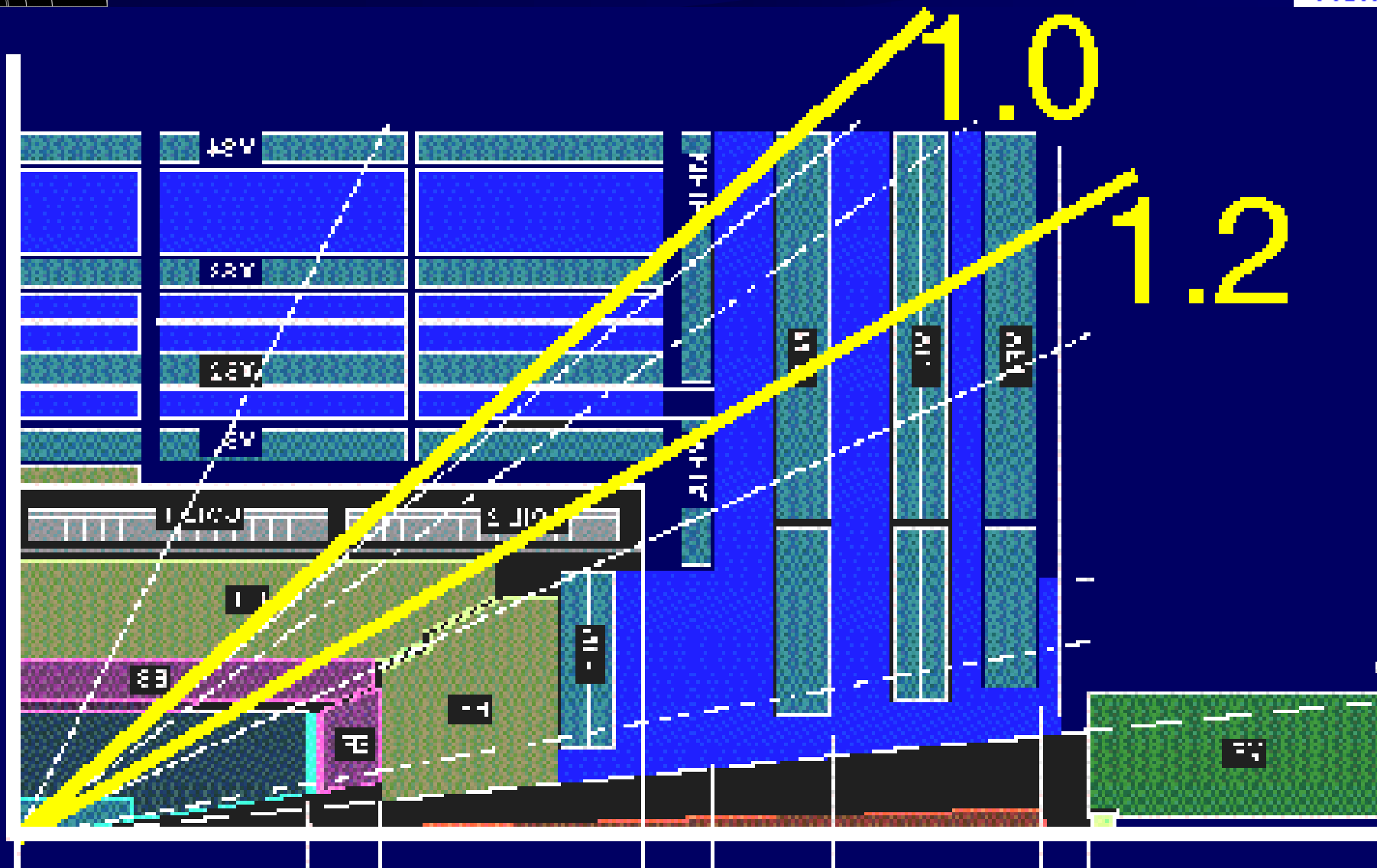


- Find maximum in row and column

Rank Assignment

- After matching assign *PAIR-Quality*
 - winner of match ... *match quality*
 - loser of match ... 0
 - unmatched muon ... 1
- *Single Rank* based on P_T , Quality, η , ϕ
- Compute *RANK*
 - $RANK = PAIR-Quality * Single Rank$
- Sort by *RANK* (cancel out RANK 0 and 1)

Overlap Region Issues



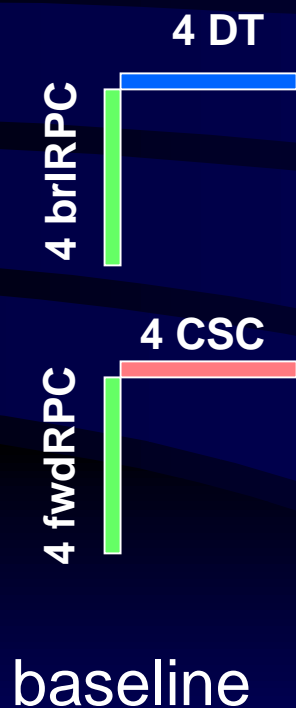
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Overlap Region Issues

- Can a clean and **common** η -boundary be achieved in all 3 muon systems ?

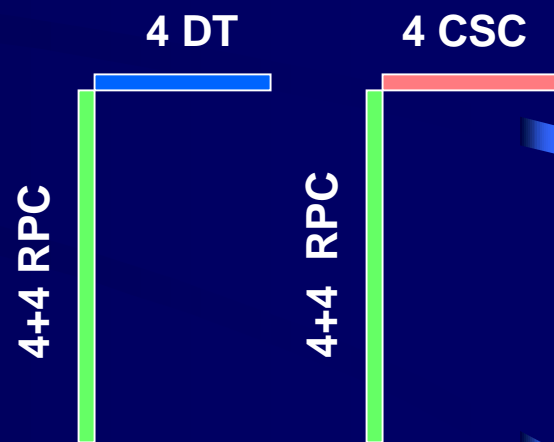


- Requirements

- clean η -boundary in DT/CSC (no muons duplicated)
- clean η -boundary in RPC
- common (exactly same) η -boundary in DT/CSC and RPC
- correct BX-assignment in all 3 systems

Overlap Region Issues

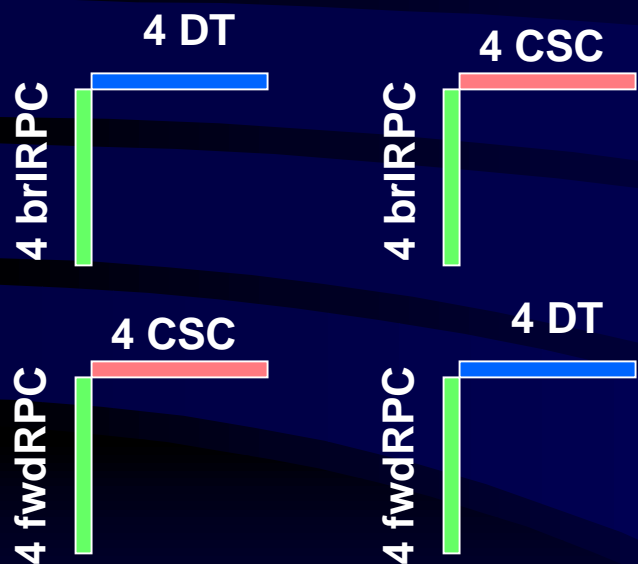
- Can a clean and **common** η -boundary be achieved in all 3 muon systems ?
- Requirements:
 - clean η -boundary in DT/CSC (no muons duplicated)
 - clean η -boundary in RPC
 - common η -boundary **NOT** necessary
 - correct BX-assignment in all 3 systems
- Problems:
 - logic more complex → **more latency ?**



under investigation (A)

Overlap Region Issues

- Can a clean and **common** η -boundary be achieved in all 3 muon systems ?



- Same requirements as before
- 4 matching algorithms in parallel \rightarrow faster
- more complex sorting \rightarrow **also more latency?**

under investigation (B)



Simulation - Endcap



- Done using CMSIM 117
- LCT simulation
(C++/FORTRAN, provided by Benn Tannenbaum)
- Standalone Endcap Track Finder
(FORTRAN, provided by Ming Wang)
- 8 RPC muons from whole detector
- Standalone GMT
(FORTRAN, based on N. Neumeister's code)



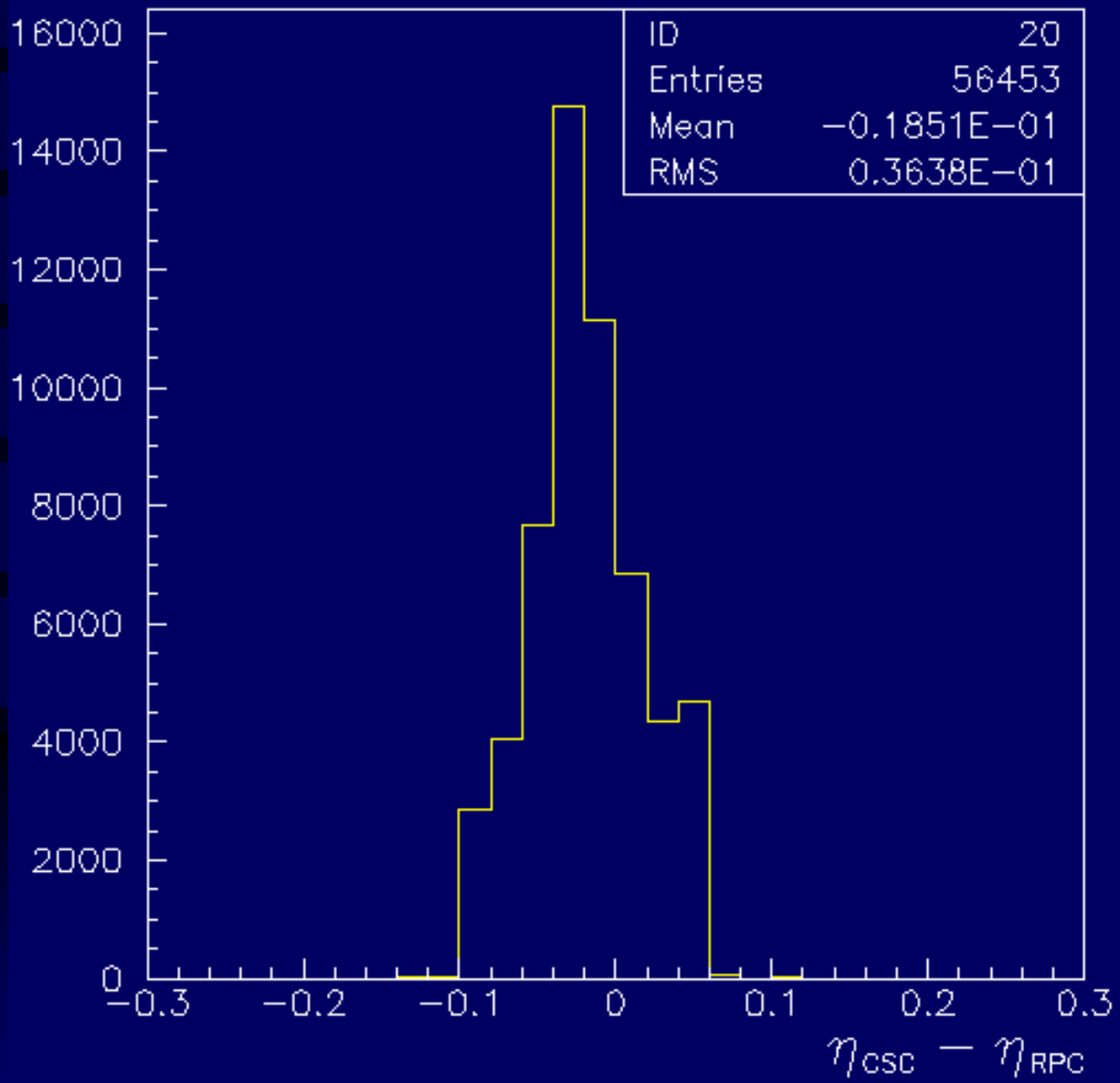
Simulation - Endcap

- 100.000 single muon events generated with CMSIM 117
 - $0.9 < \eta < 2.5$, flat, randomly distributed
 - $0^\circ < \phi < 360^\circ$, flat, randomly distributed
 - $2.5 \text{ GeV} < P_T < 100 \text{ GeV}$, flat, randomly distributed
 - charge randomly distributed

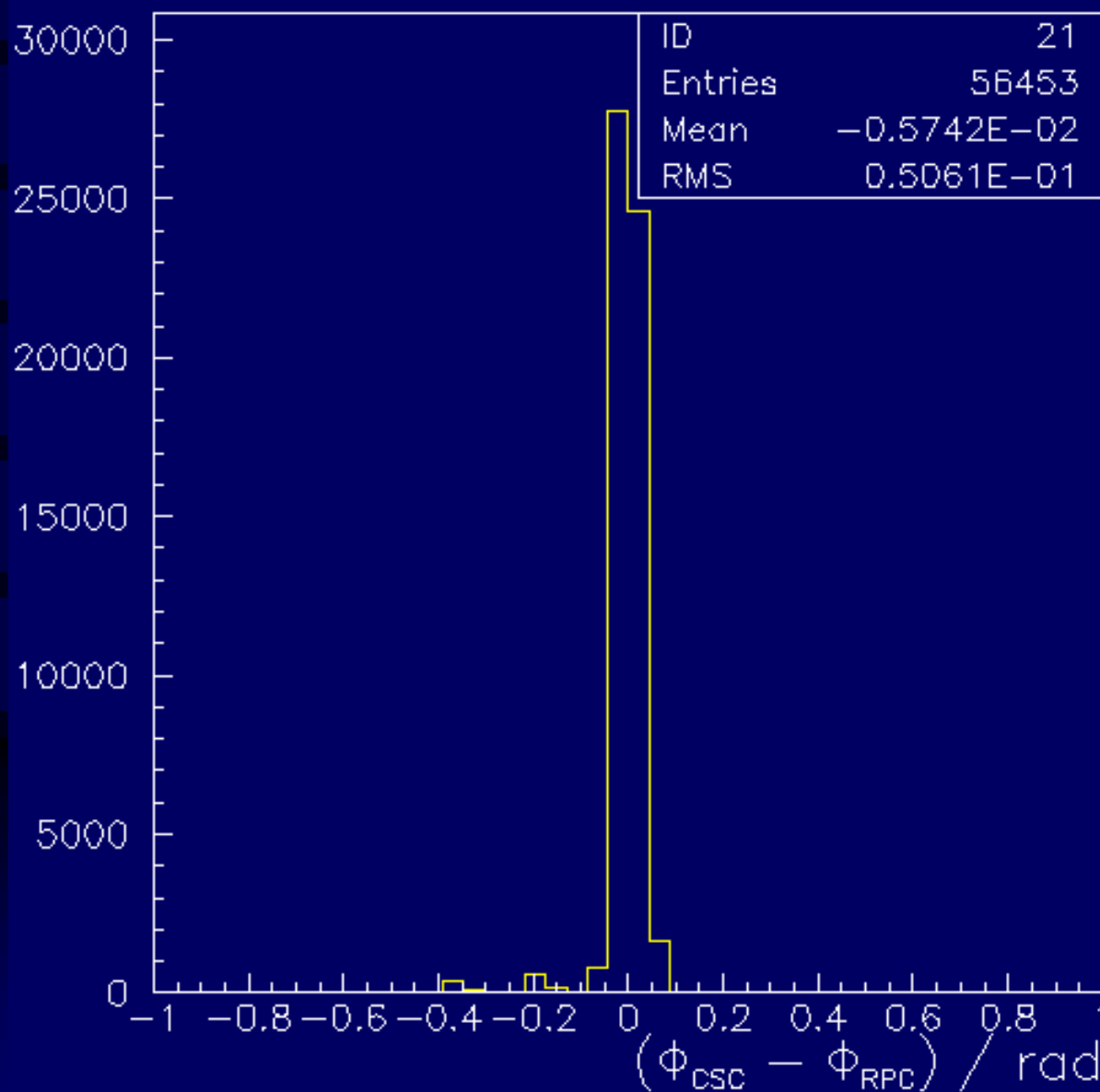
Simulation - Barrel

- 100.000 single muon events generated with old geometry
 - parameters same as above, but
 - $-1 < \eta < 1$ and $5 \text{ GeV} < P_T < 100 \text{ GeV}$

$\eta_{CSC} - \eta_{RPC}$



$\phi_{CSC} - \phi_{RPC}$

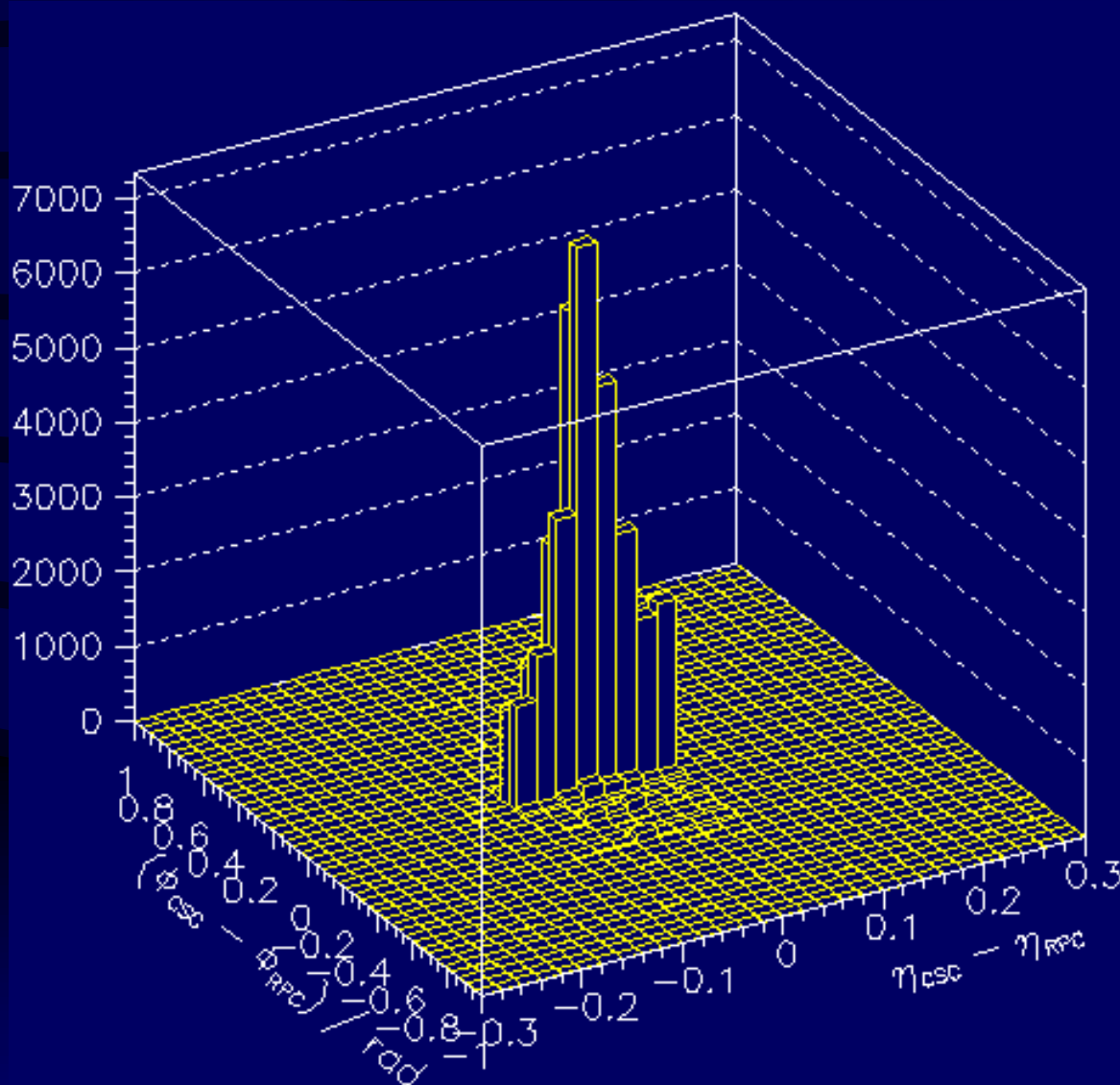


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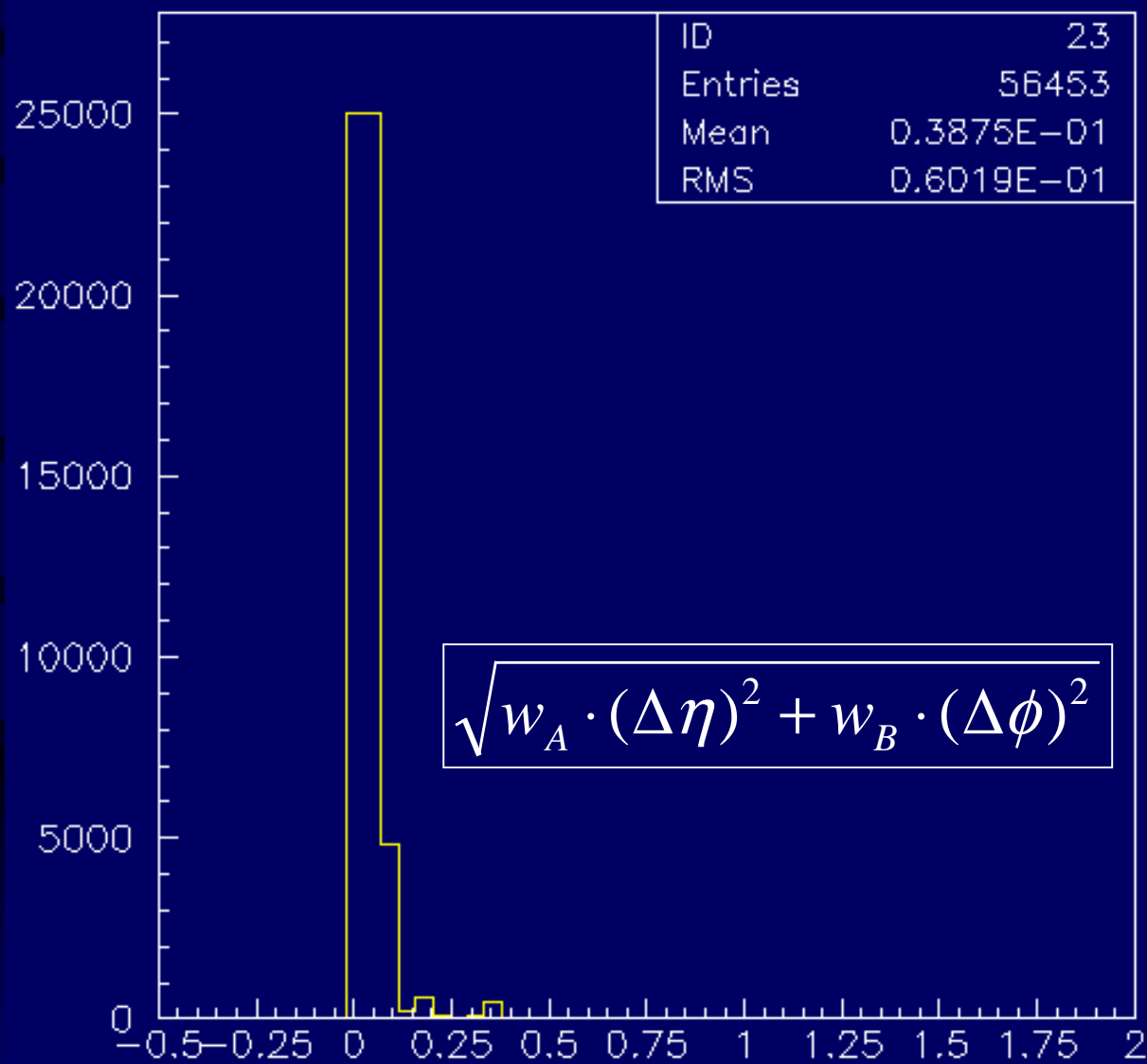
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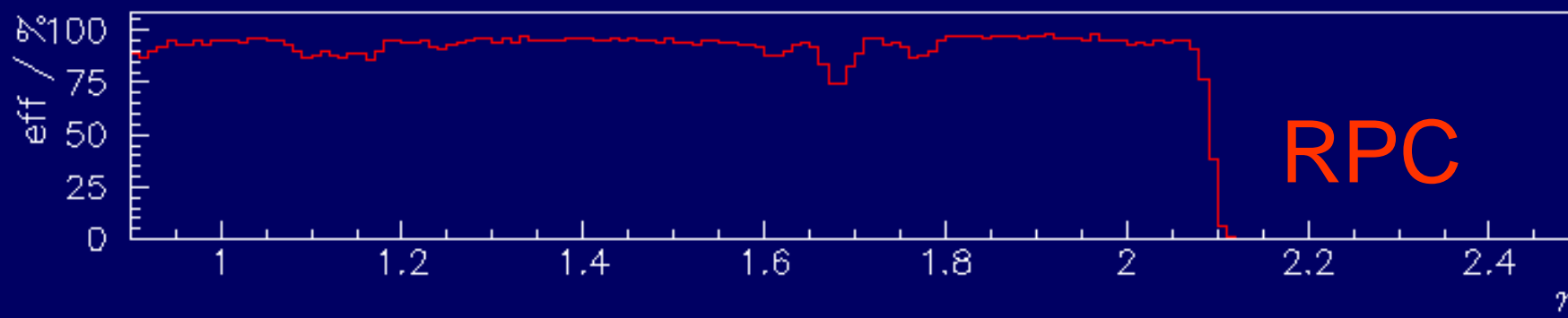
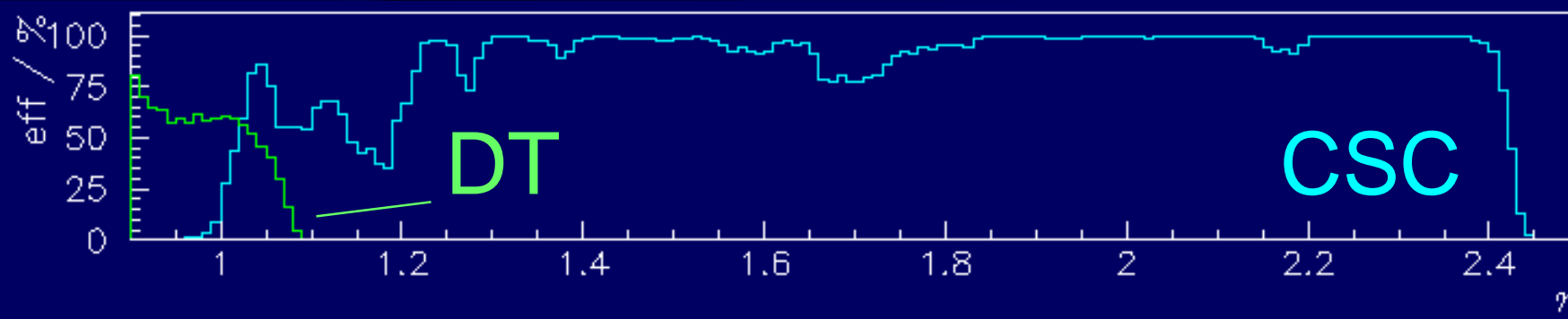
$\eta_{\text{CSC}} - \eta_{\text{RPC}}$ versus $\phi_{\text{CSC}} - \phi_{\text{RPC}}$



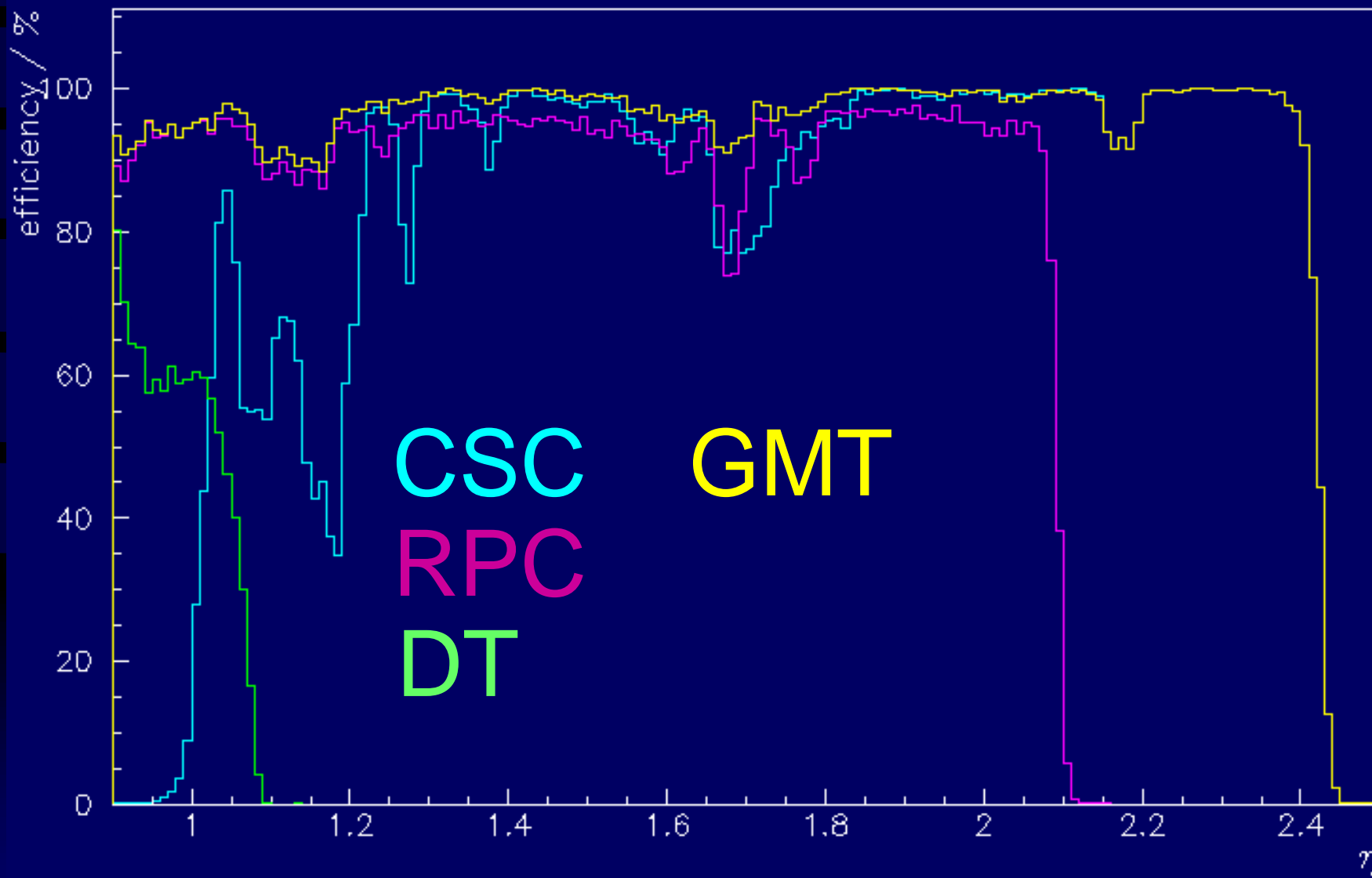
Matching function



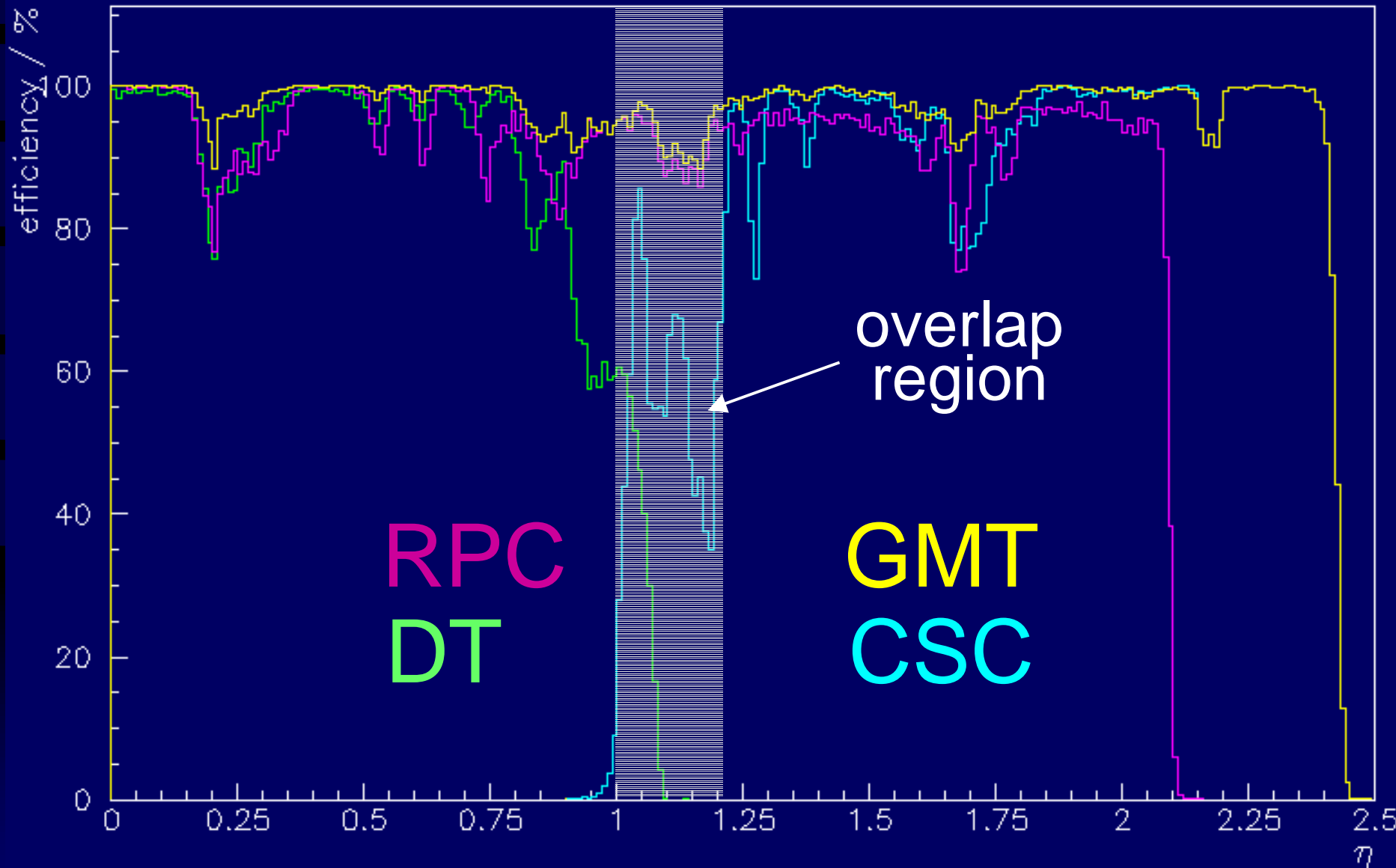
Efficiency vs. η



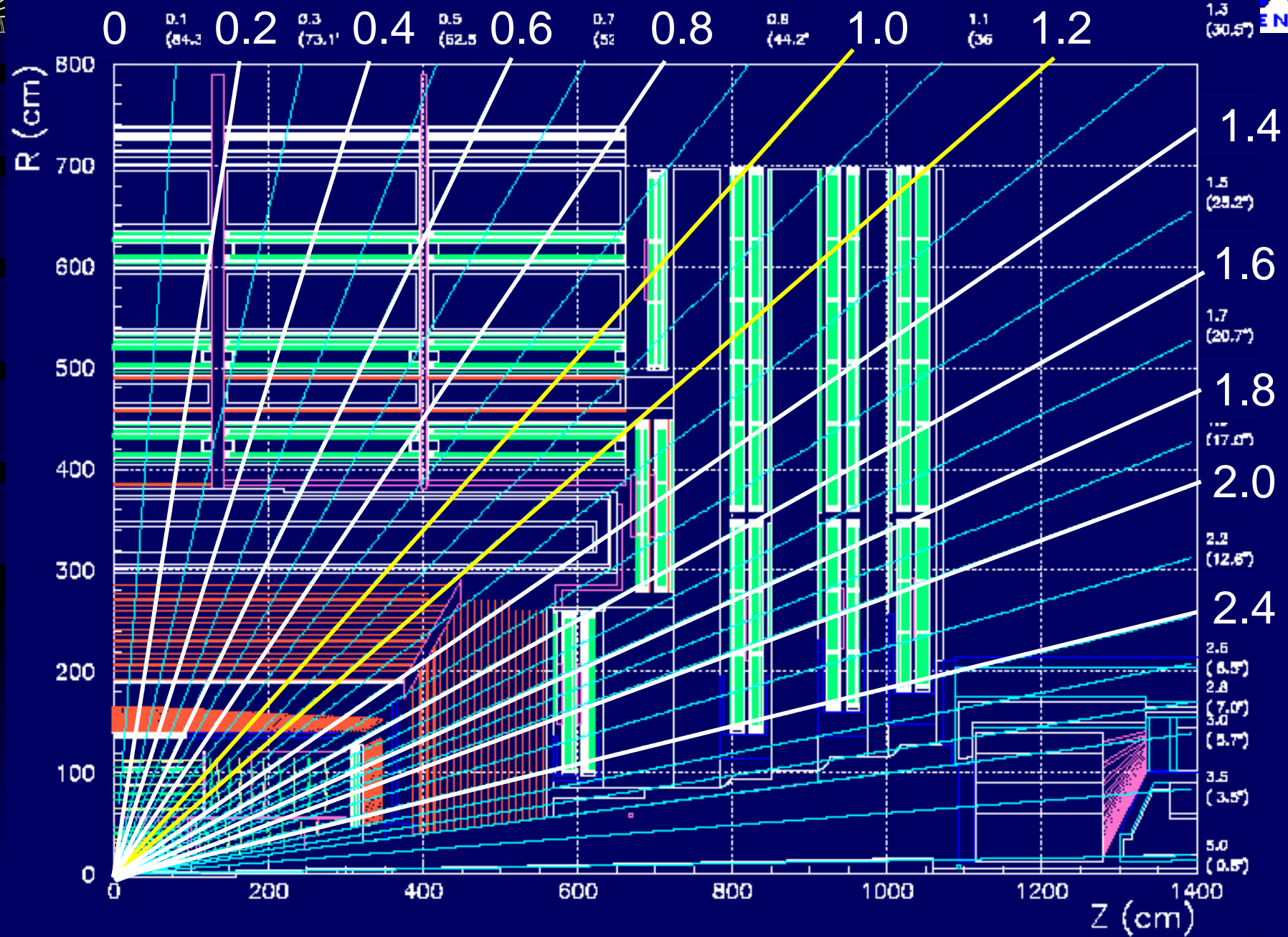
Efficiency vs. η



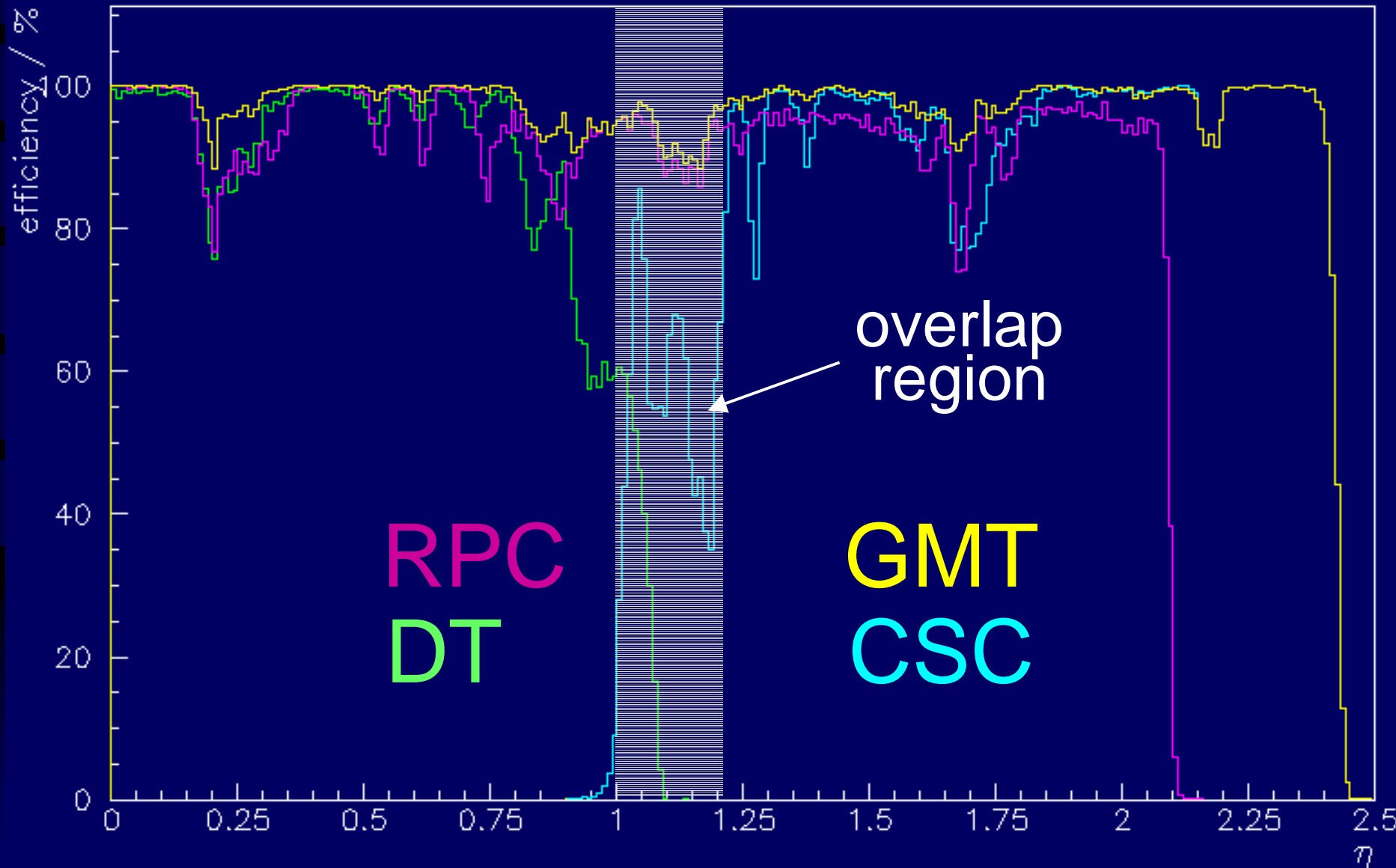
Efficiency vs. η (with barrel)



CMS longitudinal view

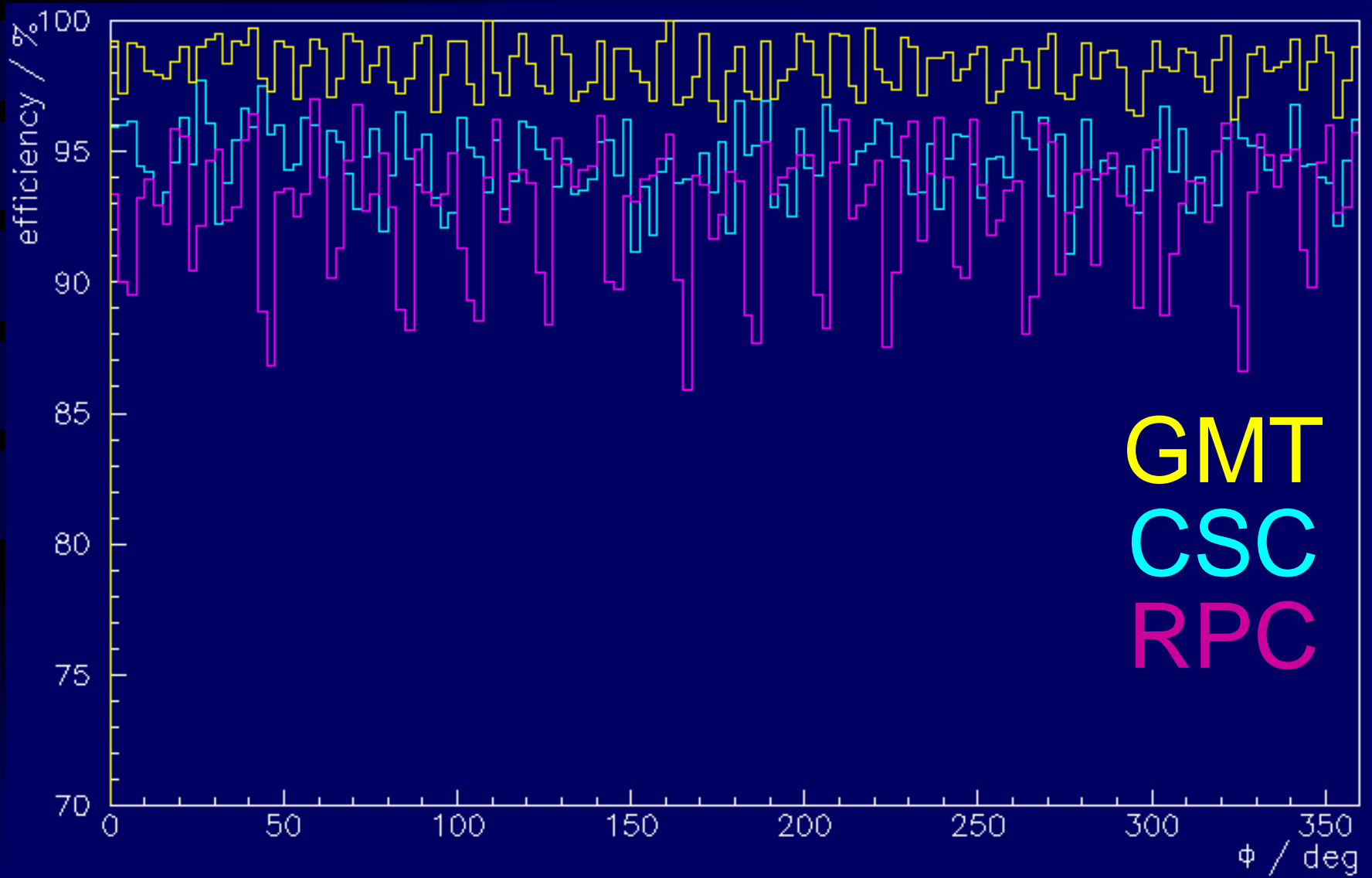


Efficiency vs. η (with barrel)





Efficiency vs. ϕ $1.2 < \eta < 2.1$



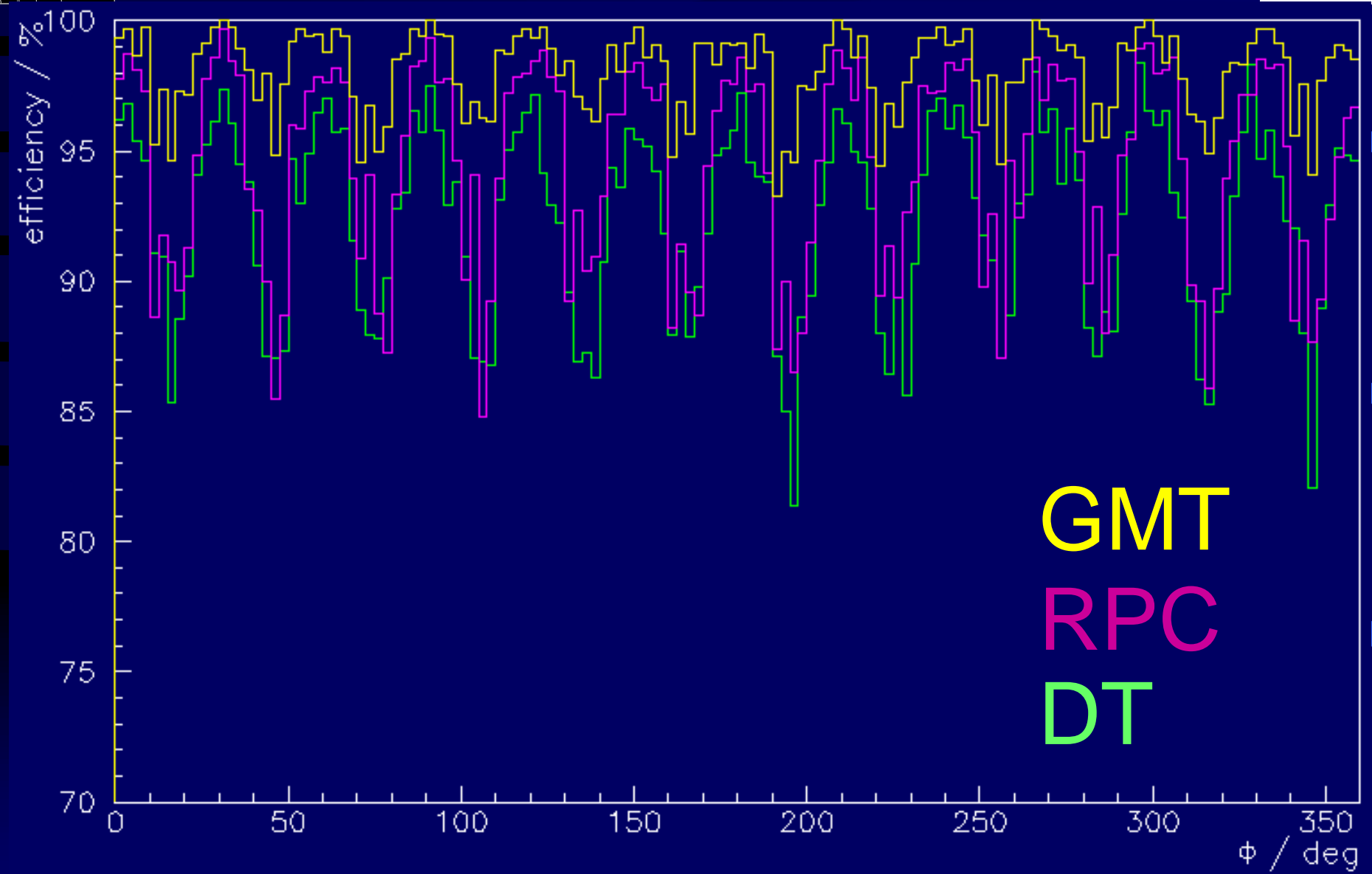
GMT
CSC
RPC

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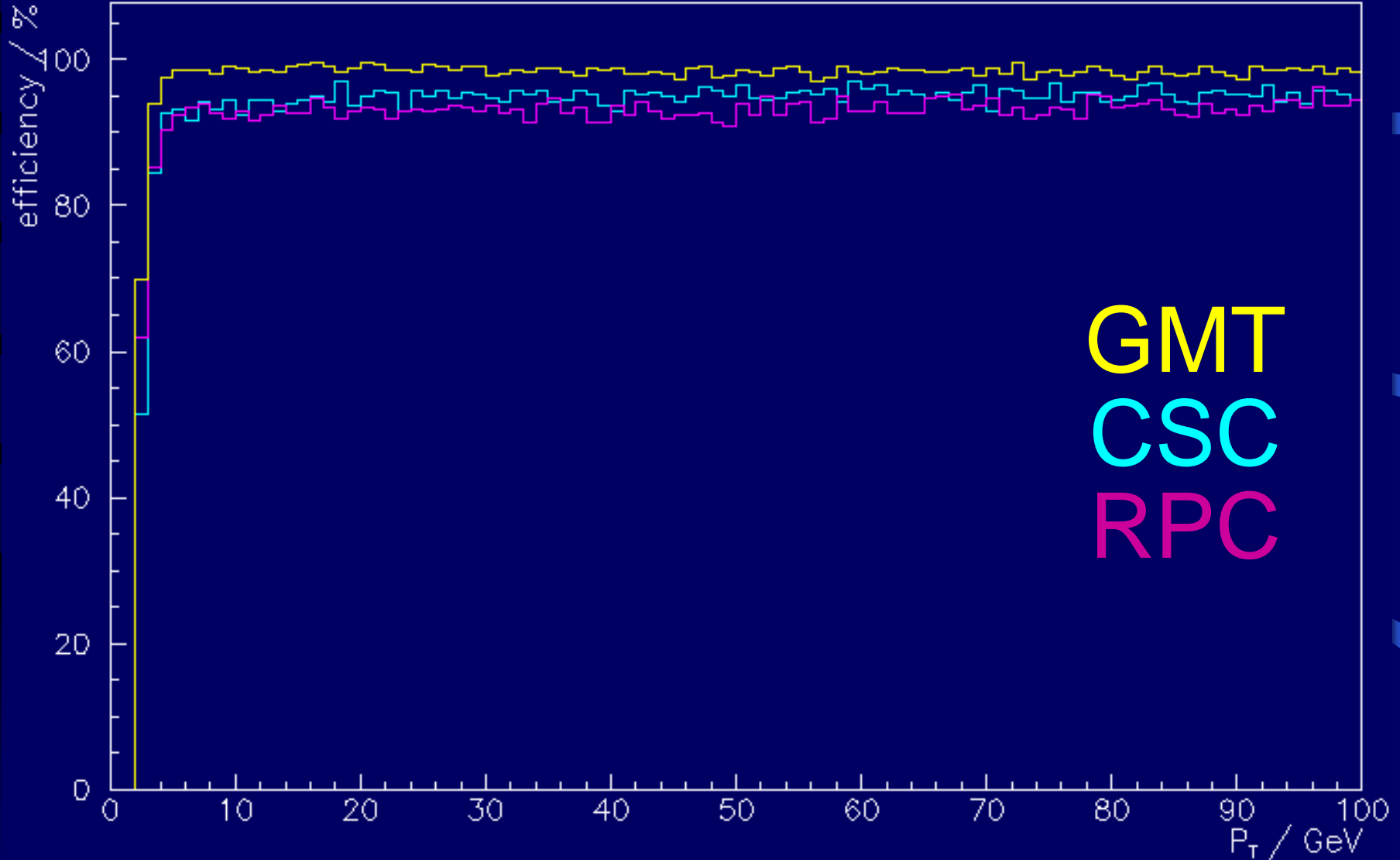
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Efficiency vs. ϕ - barrel $0 < \eta < 1$



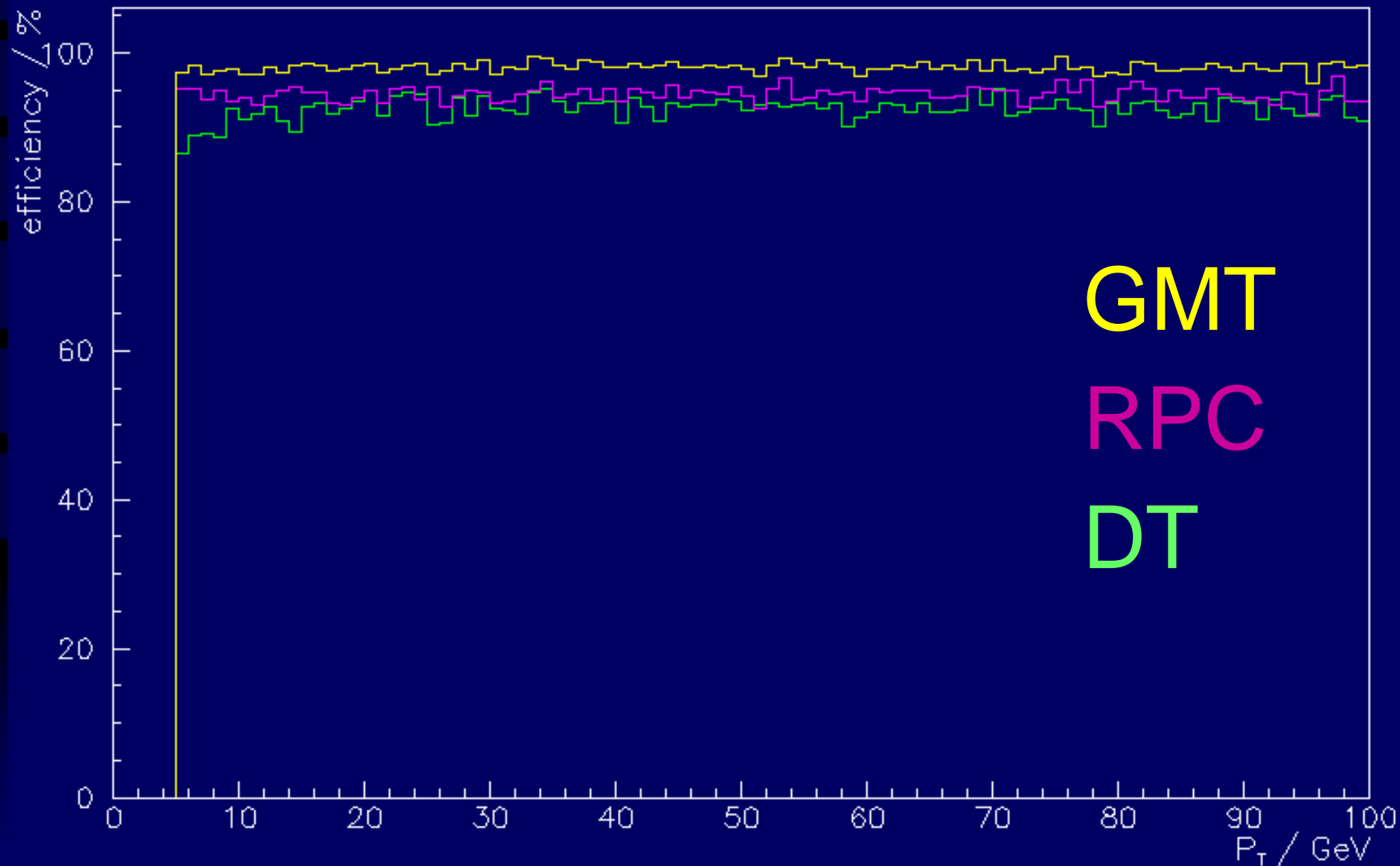
GMT
RPC
DT

Efficiency vs. P_T $1.2 < \eta < 2.1$



GMT
CSC
RPC

Efficiency vs. P_T barrel $0 < \eta < 1$



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Efficiencies (single muons)

- $1.2 < \eta < 2.1$

	no muon found	one muon found	two muons found
RPC	$7.07 \pm 0.12 \%$	$92.88 \pm 0.56 \%$	$0.05 \pm 0.01 \%$
CSC	$5.37 \pm 0.10 \%$	$93.76 \pm 0.57 \%$	$0.87 \pm 0.04 \%$
GMT	$1.76 \pm 0.06 \%$	$97.83 \pm 0.58 \%$	$0.41 \pm 0.03 \%$

- $1.2 < \eta < 2.4$

	no muon found	one muon found	two muons found
RPC	$28.85 \pm 0.23 \%$	$70.11 \pm 0.40 \%$	$0.04 \pm 0.01 \%$
CSC	$4.42 \pm 0.08 \%$	$94.76 \pm 0.50 \%$	$0.82 \pm 0.03 \%$
GMT	$1.71 \pm 0.05 \%$	$97.83 \pm 0.51 \%$	$0.46 \pm 0.02 \%$

Efficiencies (single muons) Barrel

- $-0.8 < \eta < 0.8$

	no muon found	one muon found	two muons found
RPC	$4.49 \pm 0.10 \%$	$95.49 \pm 0.61 \%$	$0.02 \pm 0.01 \%$
DT	$6.08 \pm 0.11 \%$	$93.70 \pm 0.60 \%$	$0.22 \pm 0.02 \%$
GMT	$1.04 \pm 0.05 \%$	$98.78 \pm 0.70 \%$	$0.18 \pm 0.02 \%$

Conclusion

- New Simulation of Endcap ✓
Existing Simulation for Barrel (*N. Neumeister*)
 - ☺ GMT improves efficiency
 - ☺ GMT reduces ghosts
 - ☹ Study of Overlap region not yet possible
 - different schemes under investigation
- Next Steps
 - Move to ORCA, simulate whole detector
 - Decide on final design
 - Build Prototype

Plans for R&D up to end of 2000 (tentative)

- Simulation / Hardware
 - **Dec99** baseline version of overlap region coverage in barrel track finder (DT)
 - **Mar00** Optimized version of barrel track finder overlap region coverage (DT)
 - **Jun00** Detailed study of GMT for whole detector including different schemes for overlap handling
 - **Jun00** final decision on solution for overlap region
 - **Nov00** final conceptual GMT design