Global Muon Trigger

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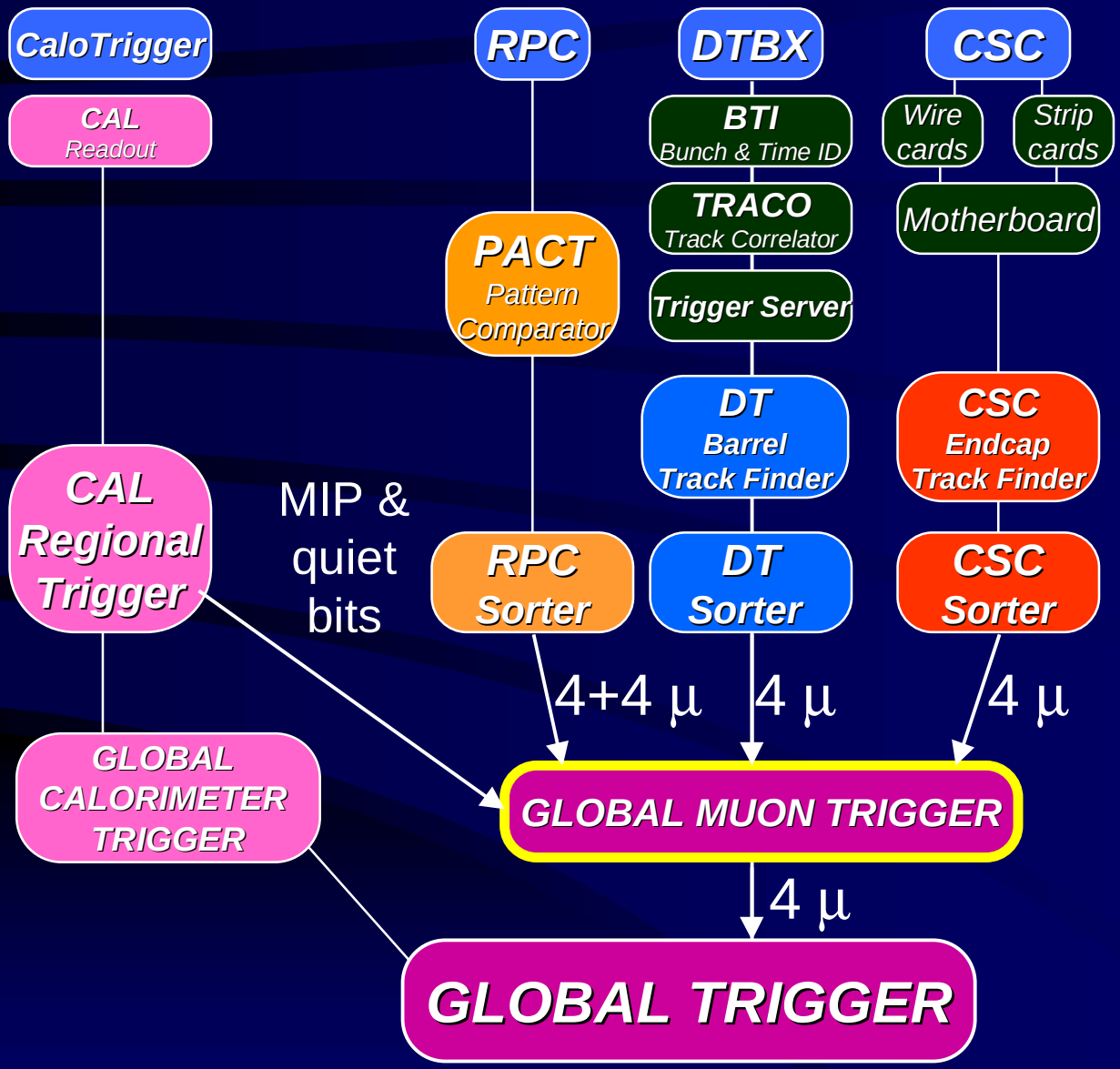
TRIDAS meeting, November 8th, 1999

CMS Muon Trigger System



Overview

- Goals & Strategy
- Hardware design status
- Issues in the overlap region
- New Simulation results for Endcap and Overlap Region
- Plans for R&D in 2000

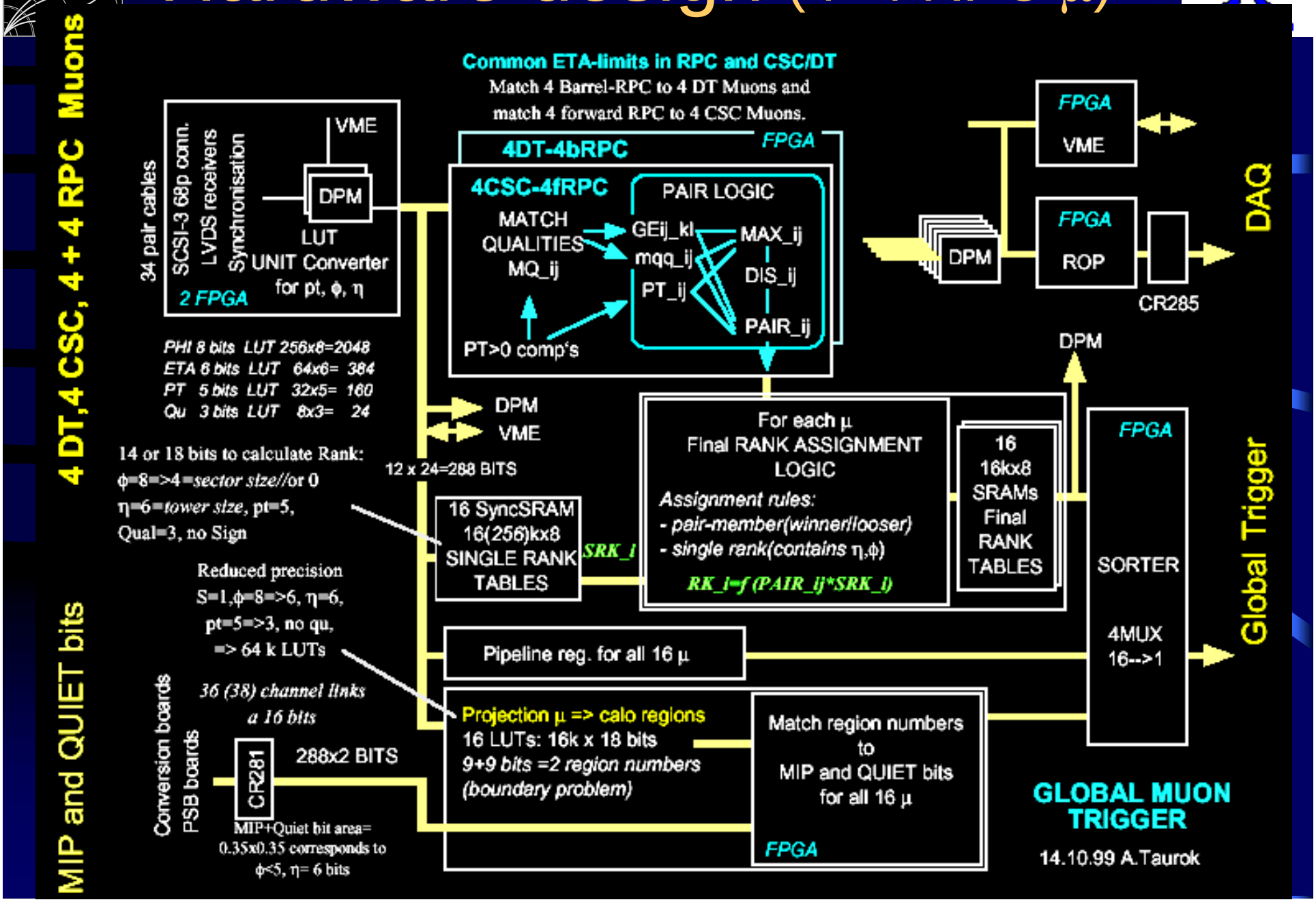
Goals of GMT

- 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 $|\eta|>2.1$)

Hardware design (4+4 RPC μ)



Interface - Input bit counts

- From regional Muon Triggers (per Muon)

	From Barrel TF (DT)		From Endcap TF (CSC)		From RPC Trigger	
Variable	**Bits**	**Precision&range**	**Bits**	**Precision&range**	**Bits**	**Precision&range**
η	**6**	0.5 .. 0.05 units ± 1.2	**5+1**	~0.05 units nonlinear scale ± (0.9 .. 2.4)	**6**	~0.1 units nonlinear scale ± 2.1
ϕ	**8**	2.5 deg 0-360 deg	**8**	2.5 deg 0-360 deg	**8**	2.5 deg 0-360 deg
Muon sign	**1**	-	**1**	-	**1**	-
P_T	**5**	Nonlinear scale 2-140 GeV	**5**	Nonlinear scale 2-140 GeV	**5**	Nonlinear scale 1-100 GeV
quality	**3**	P_T assignment, #TS	**2 ?**	to be defined	**1 ?**	4/3 layers hit
SUM	**23**		**22**		**21**	

- From Calorimeter Trigger

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MIP & Quiet Bit for 288 (16x18) regions of $\Delta\eta\times\Delta\phi = 0.35\times0.35$

Interface - Output bit count

- From GMT to Global Trigger (per Muon)

Variable	Bits	Precision & range
η	**6**	0.5 .. 0.1 units ± 2.4
Φ	**8**	2.5 deg 0-360 deg
Muon sign	**1**	-
P_T	**5**	Nonlinear scale 2-140 GeV
quality	**3**	To be defined
Isolation	**1**	-
MIP	**1**	-
SUM	**25**	

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Interface Technology

Link	Technology	Status
From DT TF	Proposed: 40 MHz parallel, LVDS, 1 cable per Muon, 68pin connectors	Common agreement in progress (almost finished)
From CSC TF		
From RPC		
Form CALO	40 MHz, parallel, differential ECL 18 cables, 68pin connectors	Agreed (except pin numbering)
To Global	Parallel data via backplane	Internal

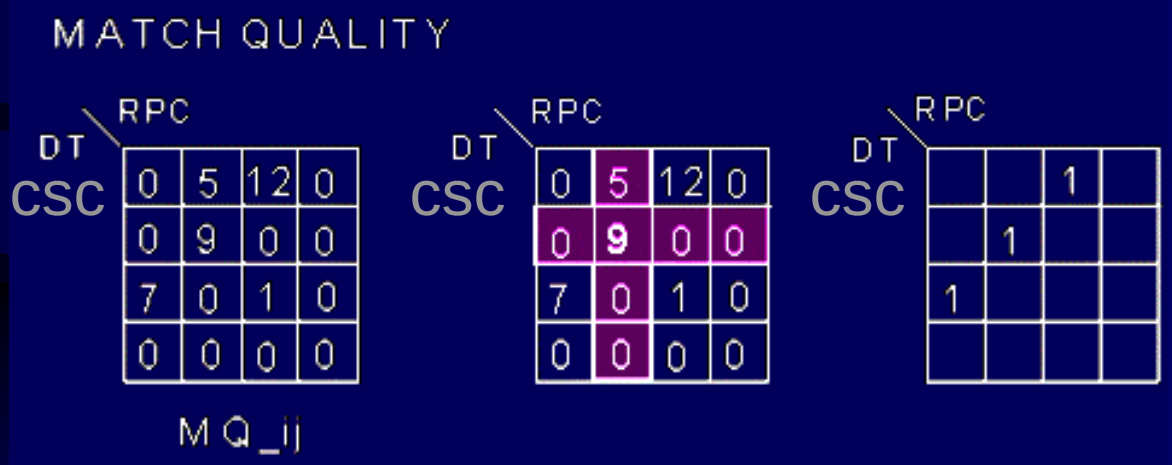
Functional Blocks

- 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)

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



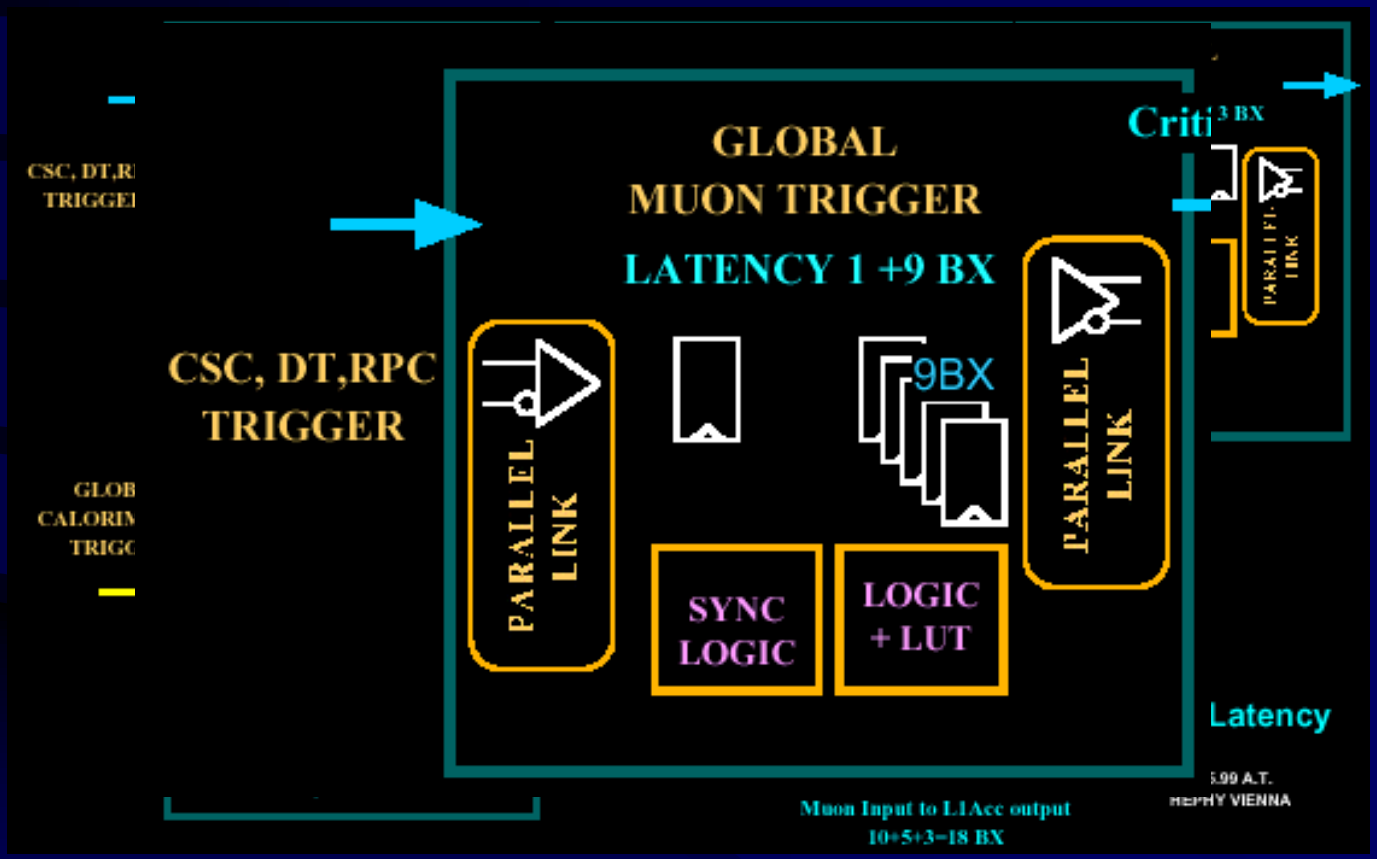
- Find maximum in row and column

Rank Assignment

- After matching assign *PAIR-Quality*
  - winner of match … *match quality*
  - looser 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

Latency Calculation

- Included in Global Trigger (GMT: 1+9 BX)



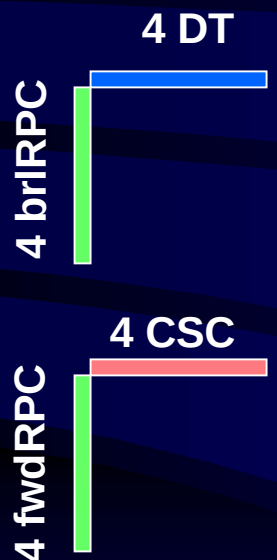
- Dependant on final scheme! → **Uncertainty !**

Configuration & Control

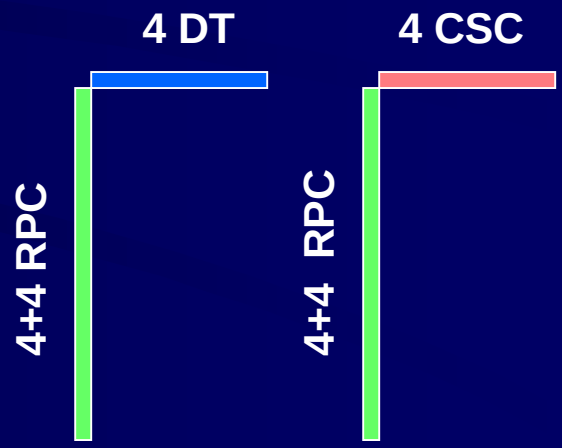
- Integrated into Global Trigger Hardware
- Configuration
  - many LUTs to load
  - small LUTs will be static (loaded during FPGA configuration)
  - large LUTs will be loaded via VME
- No plans for software, yet

Overlap Region Issues

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



baseline



under investigation

Overlap Region Issues

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

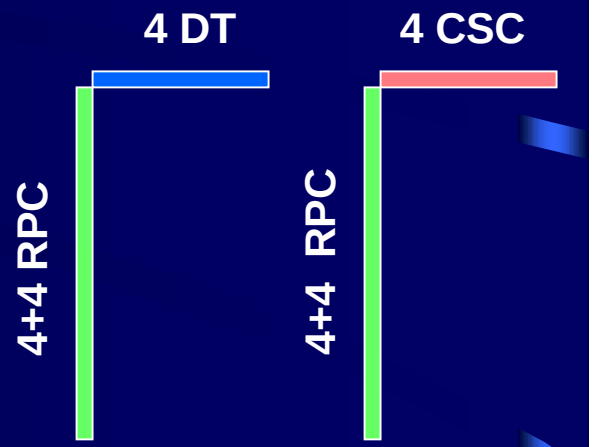
baseline

- 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

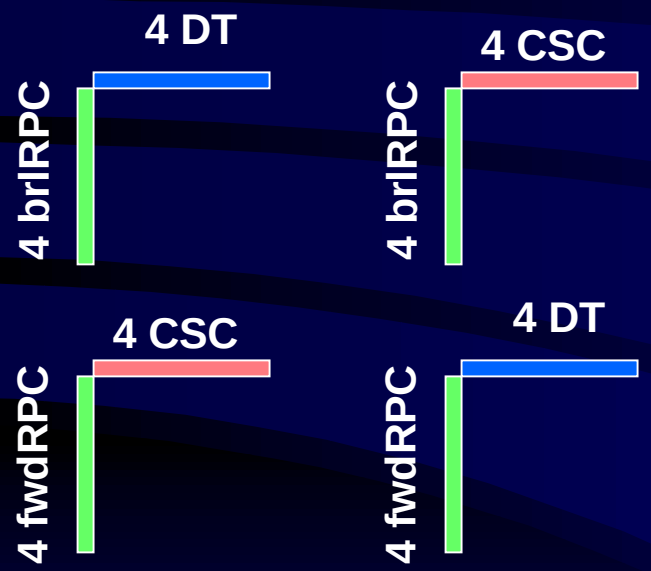


- Problems:
  - logic more complex → more latency ?

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 → faster
- more complex sorting

  → also more latency?

under investigation (B)

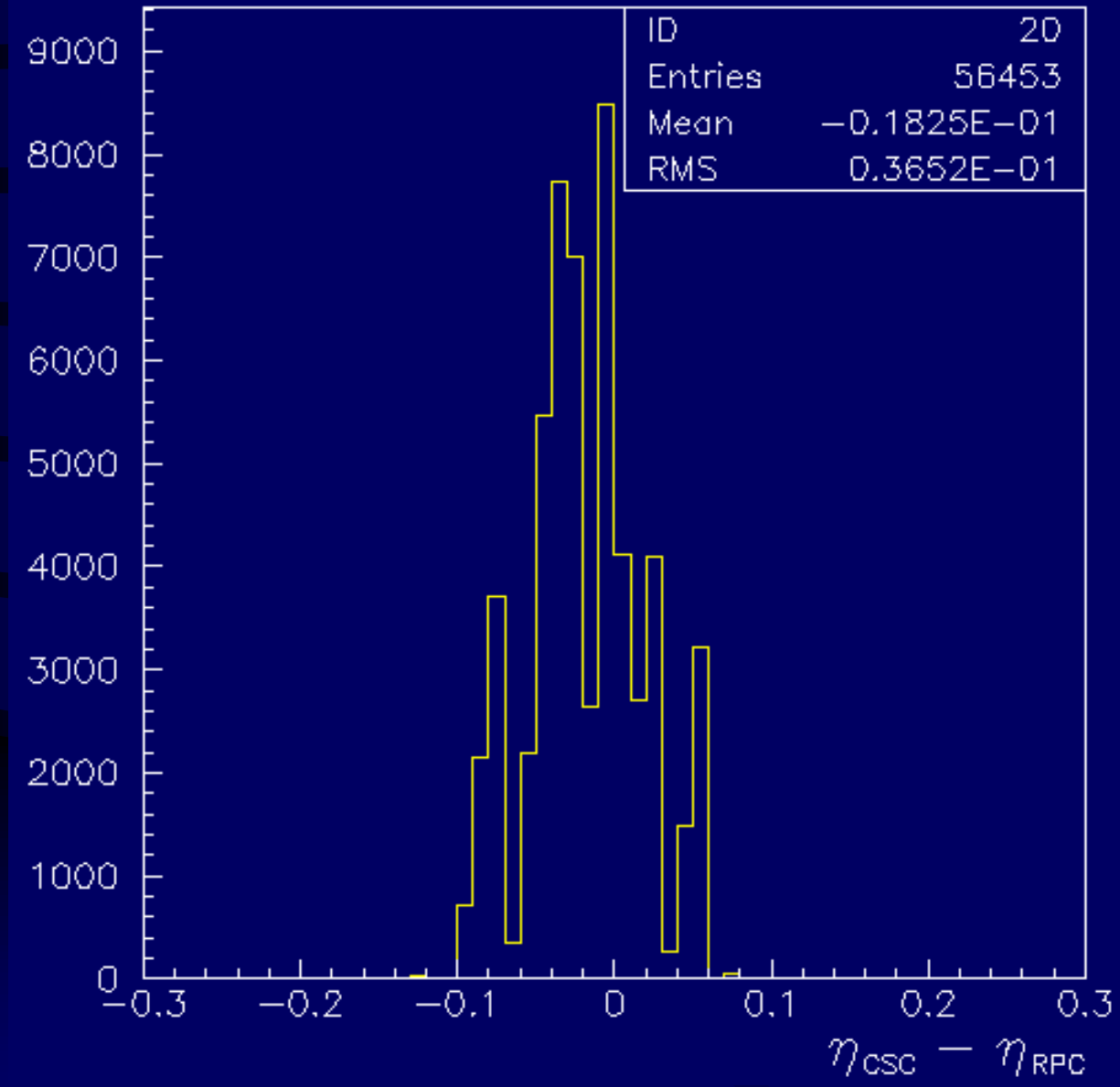
Simulation - Endcap

- 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)

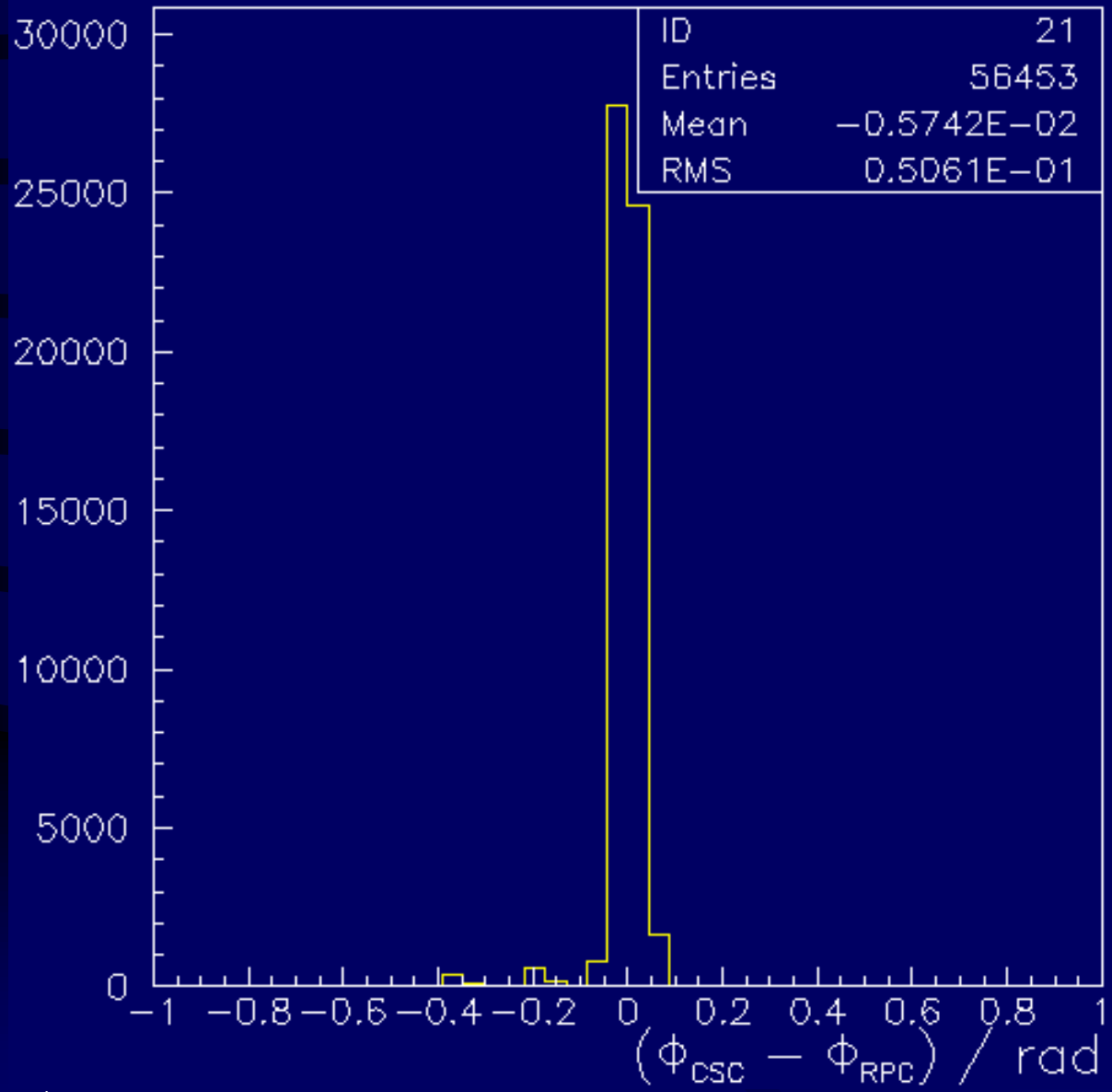
Simulation - Endcap

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

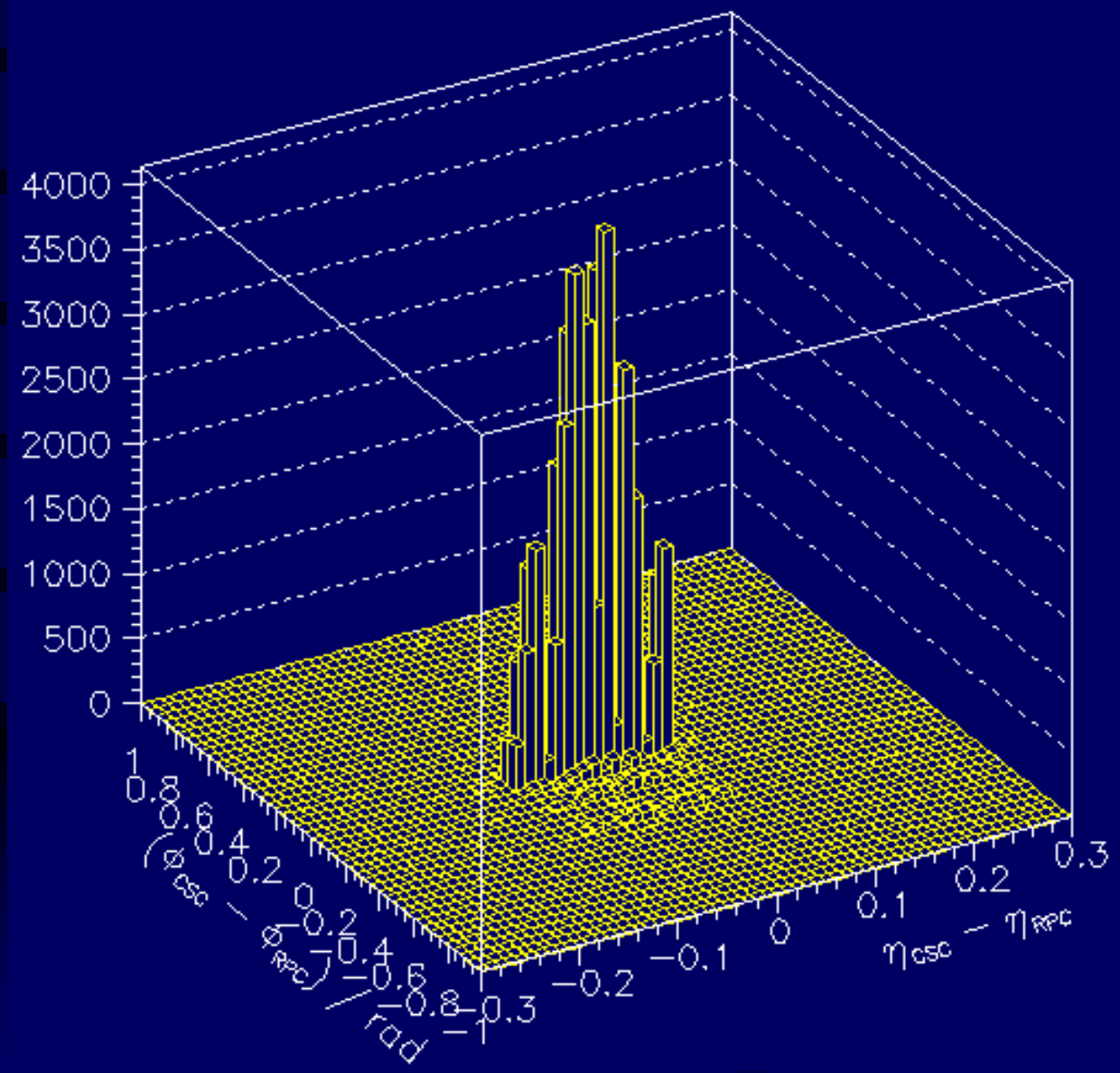
$\eta_{CSC} - \eta_{RPC}$



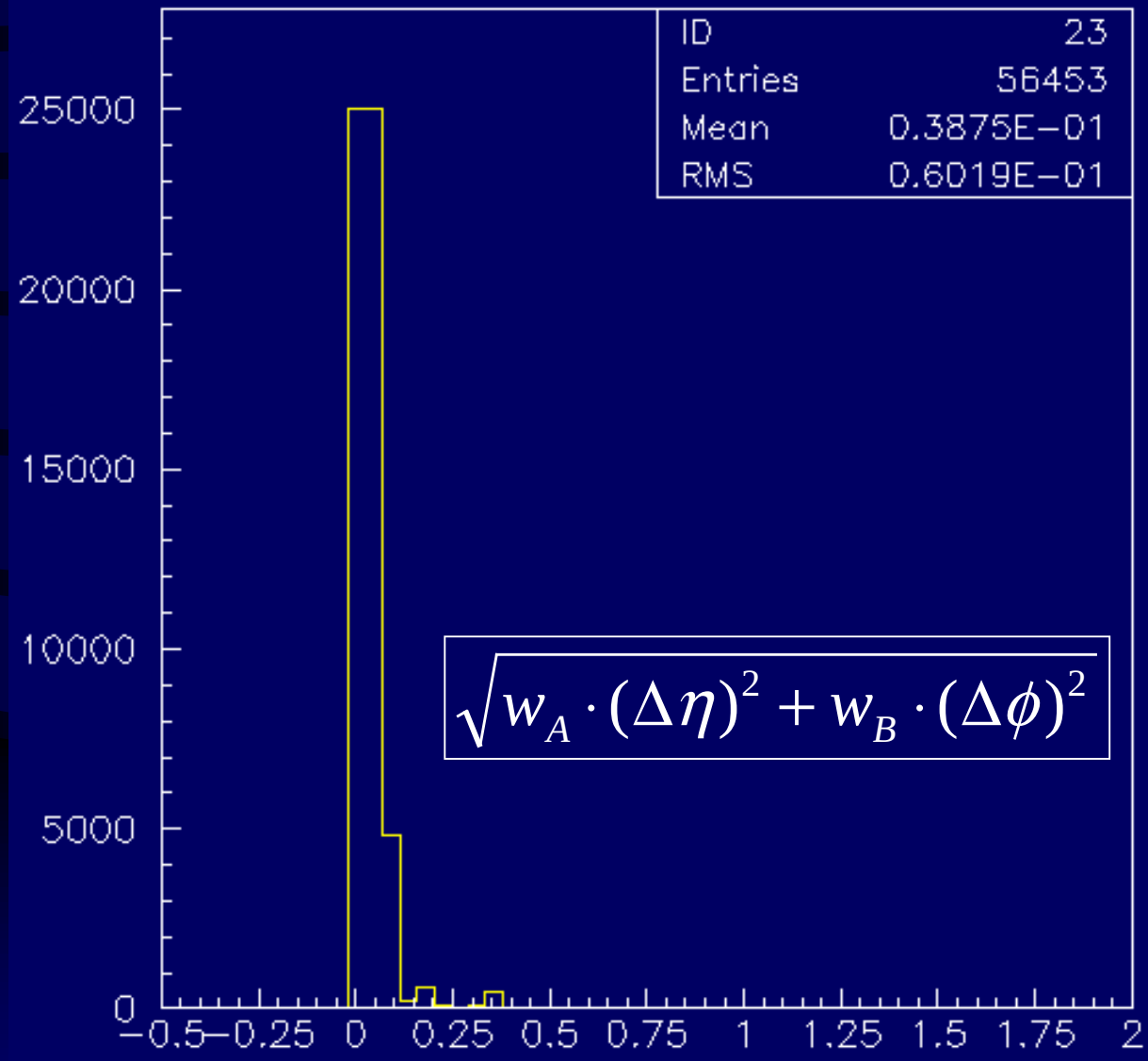
ϕ_{CSC} - ϕ_{RPC}



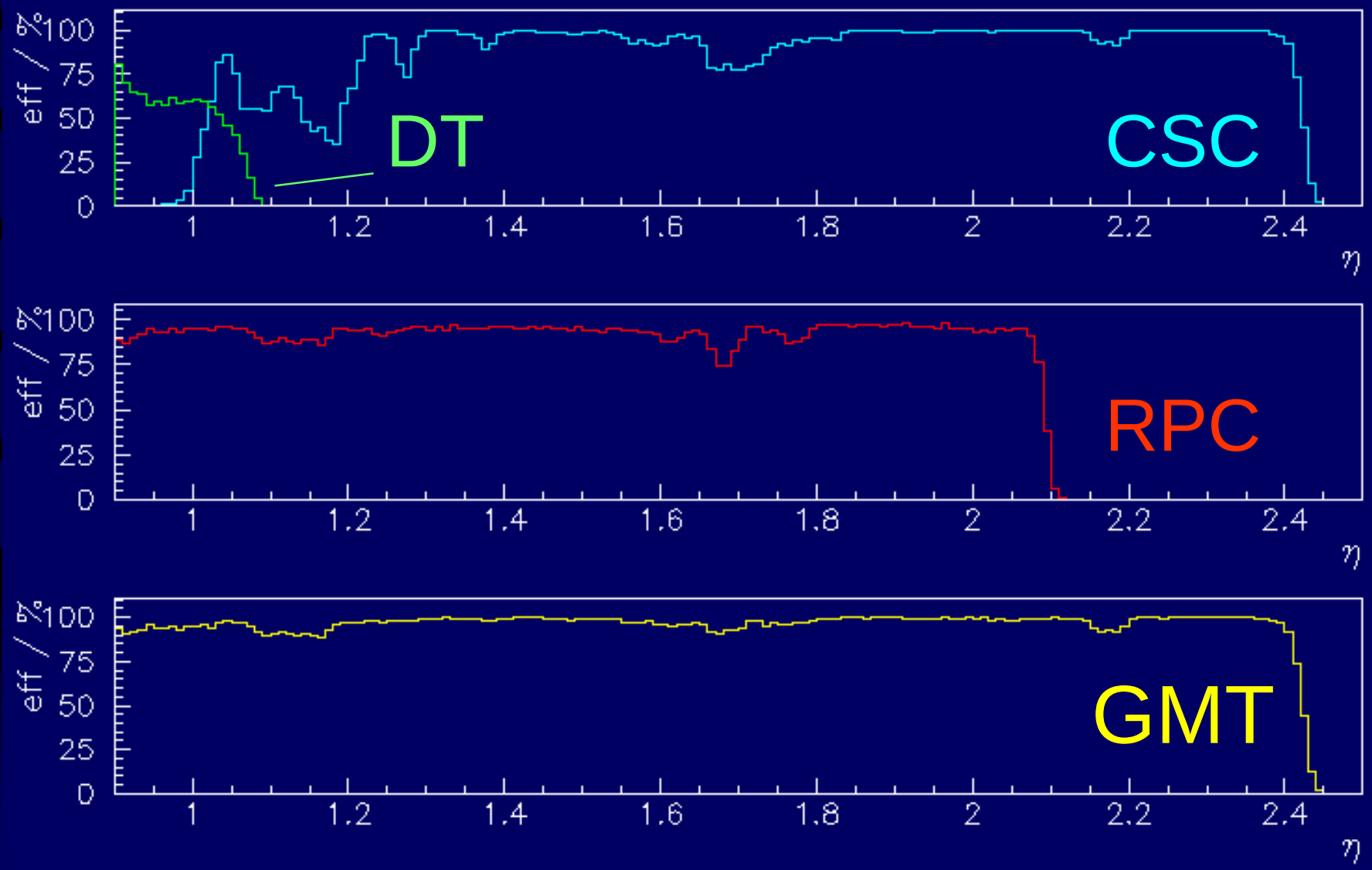
$\eta_{CSC} - \eta_{RPC}$ versus $\phi_{CSC} - \phi_{RPC}$



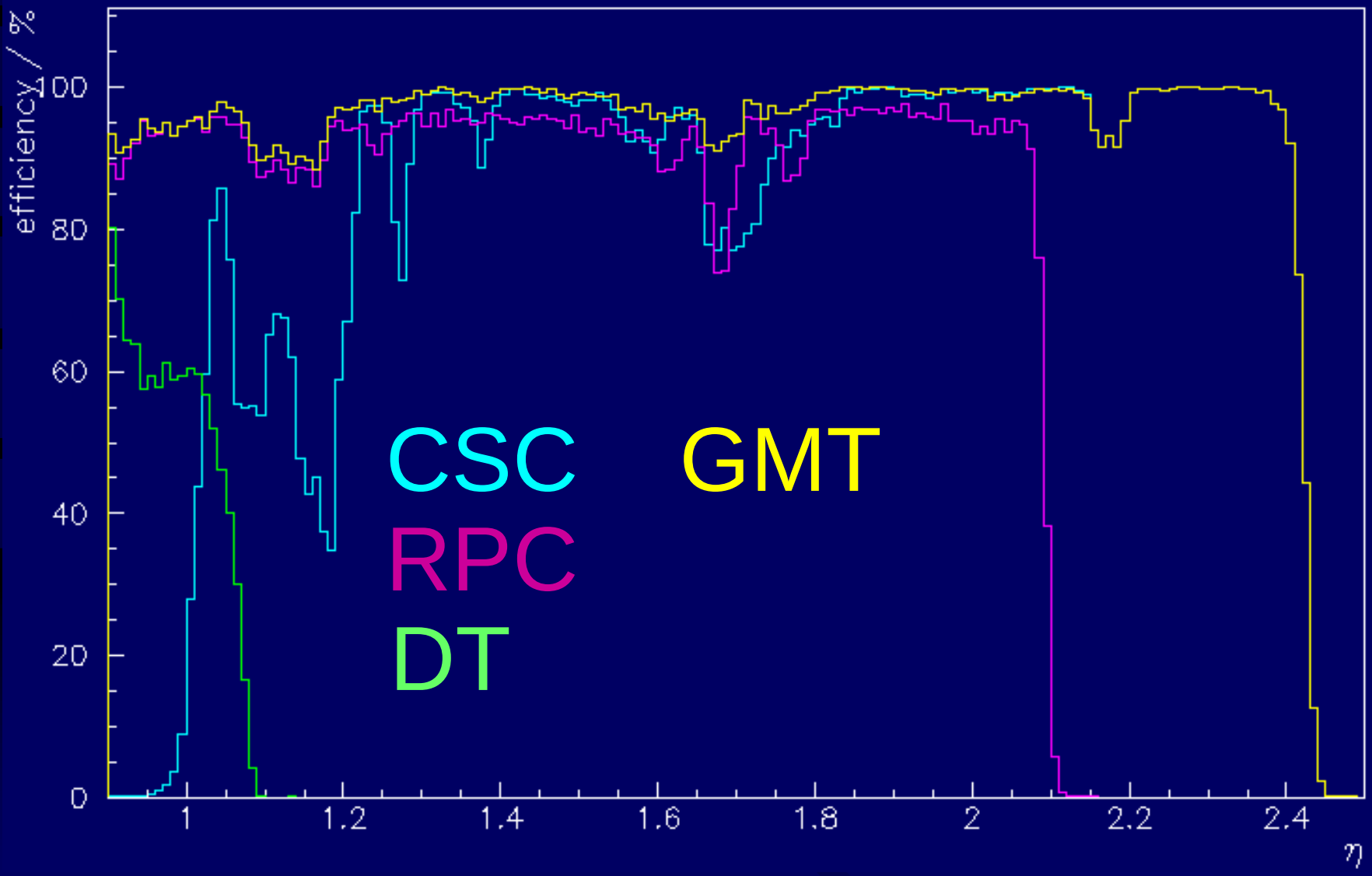
Matching function



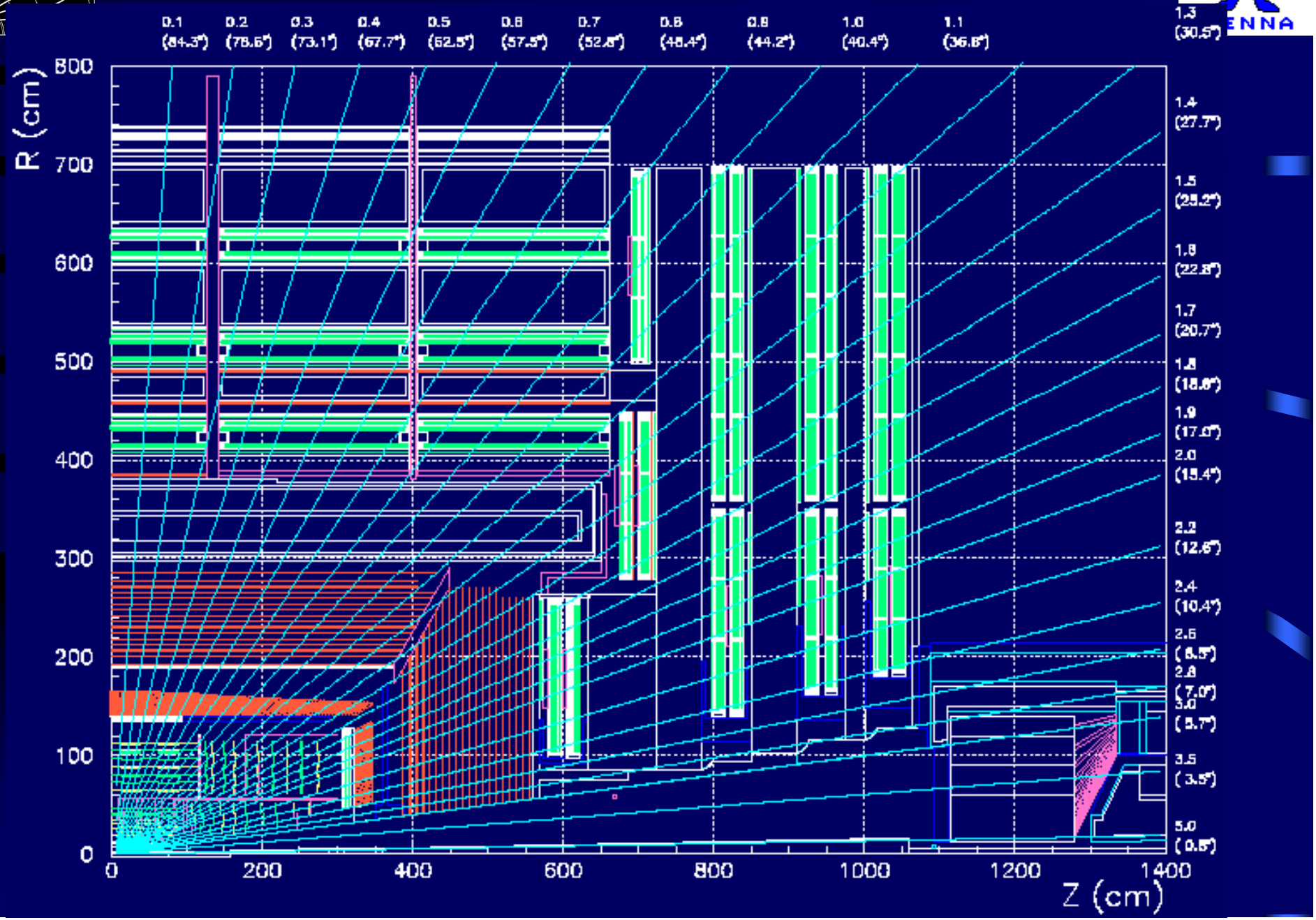
Efficiency vs. η



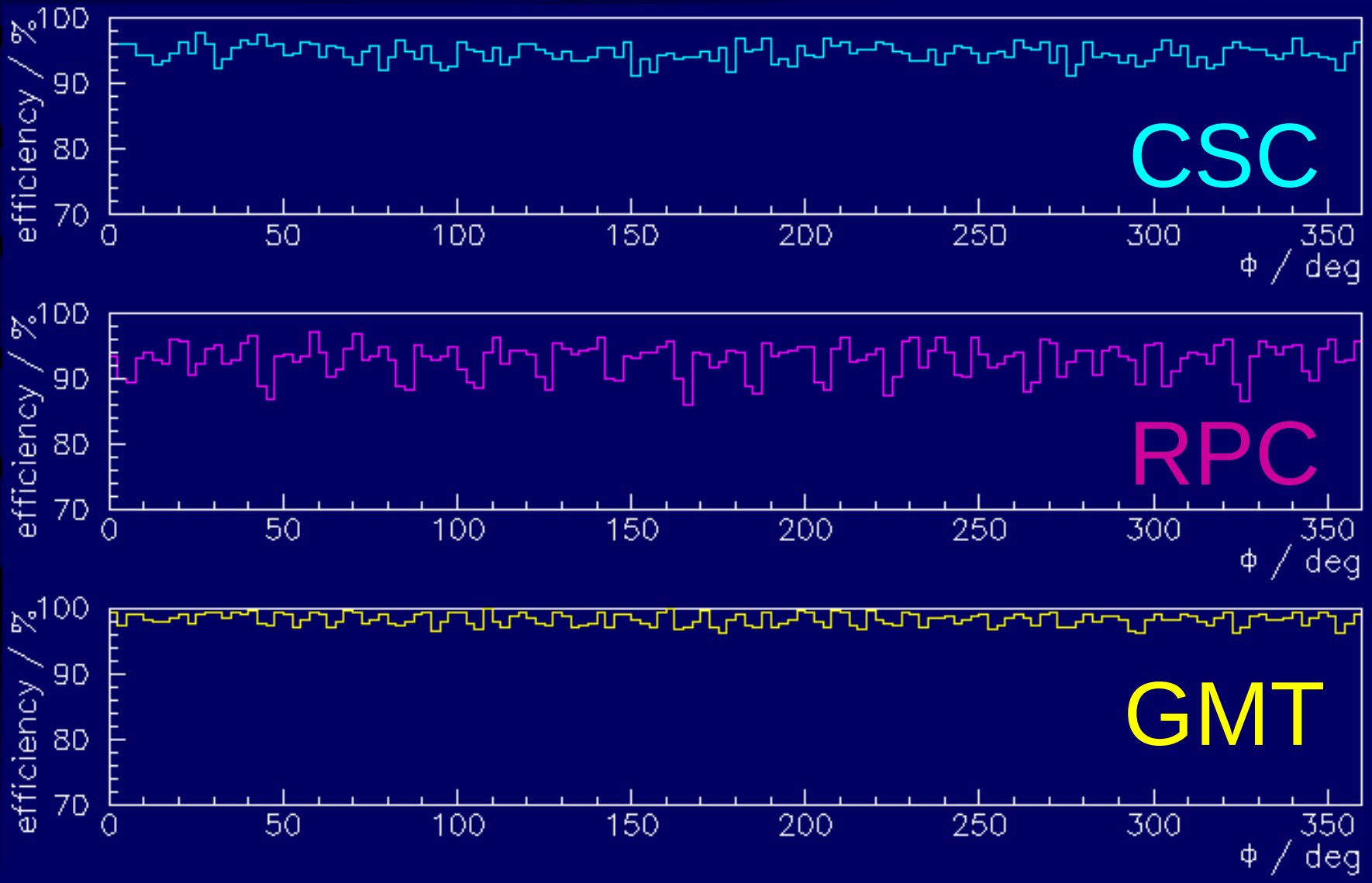
Efficiency vs. η



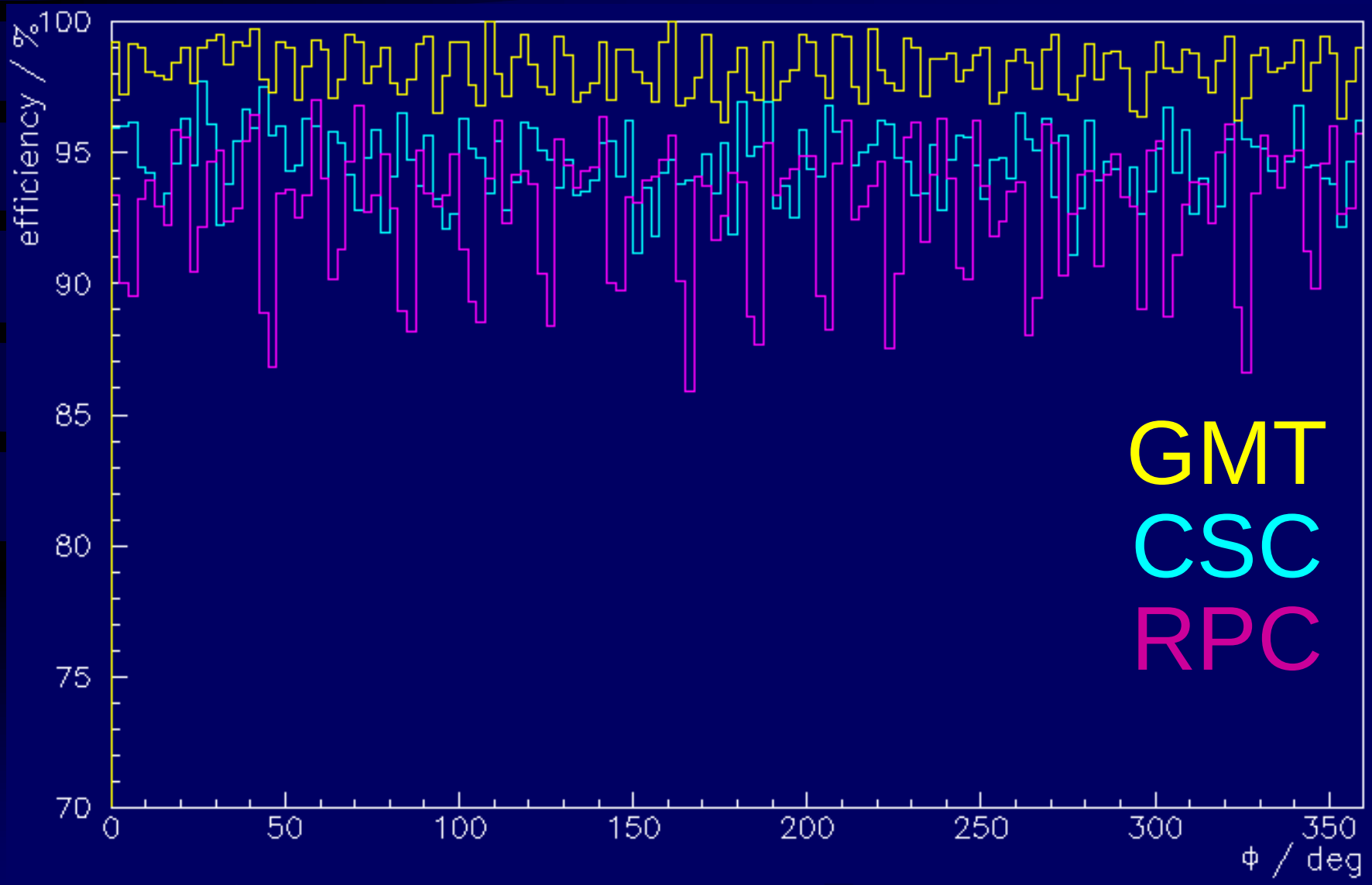
CMS longitudinal view



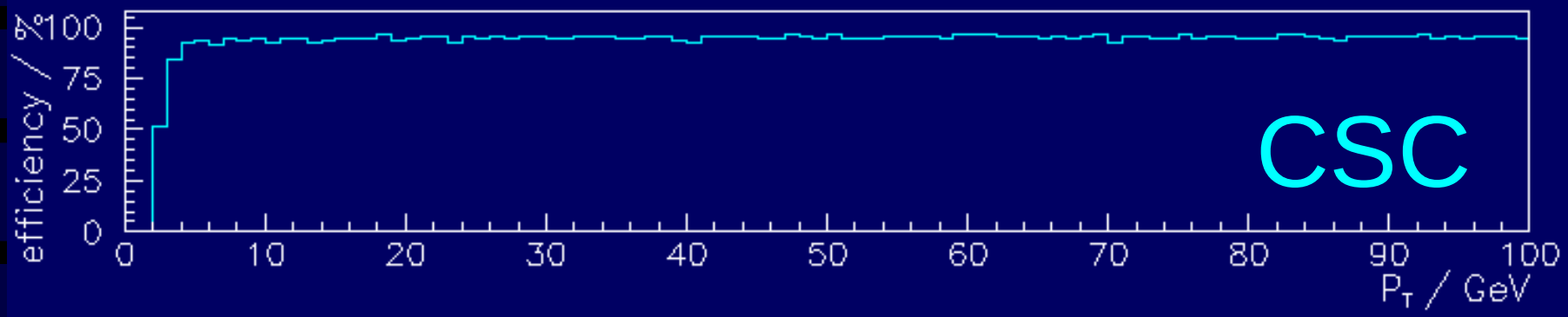
Efficiency vs. ϕ $1.2<\eta<2.1$

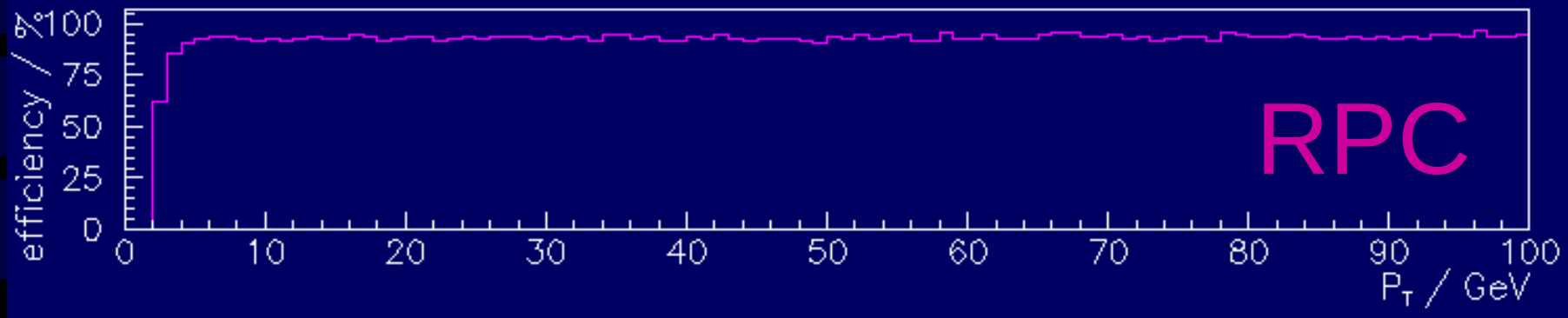


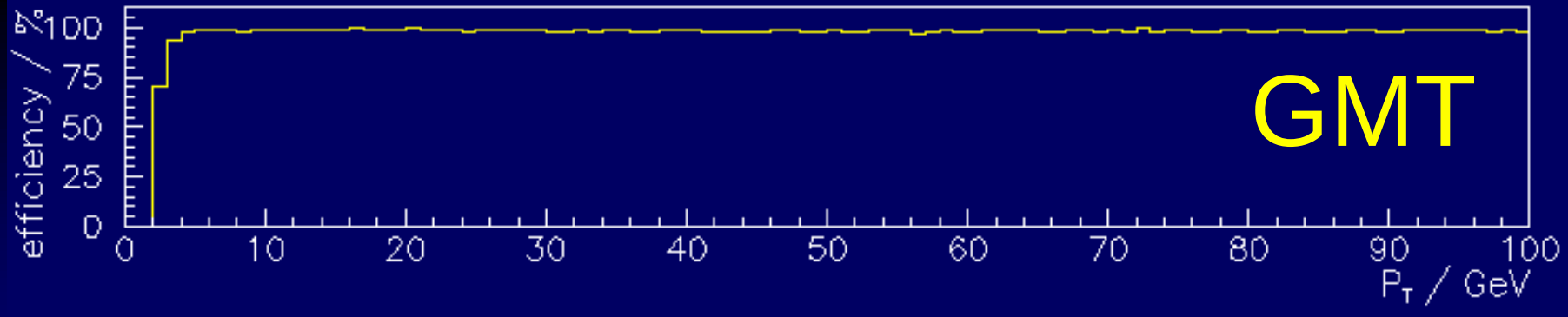
Efficiency vs. ϕ $1.2<\eta<2.1$



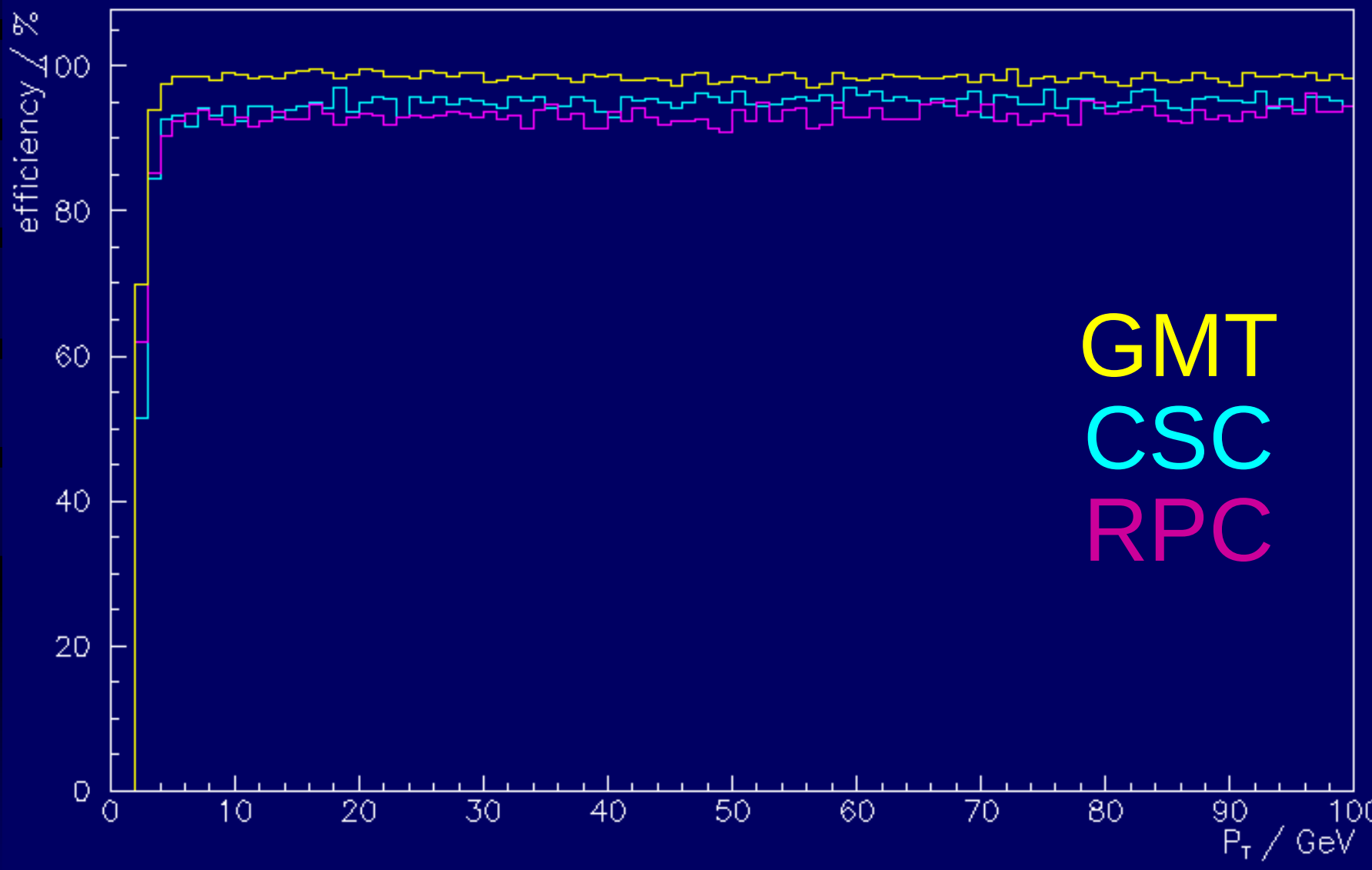
Efficiency vs. P_T $1.2<\eta<2.1$







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



Efficiencies (single muons)

- $1.2<\eta<2.1$

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

- $1.2<\eta<2.4$

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

Conclusion

- Modified design (4+4 RPC muons)✓
- New Simulation of Endcap ✓
  - ☺ 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** Optimzed 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

Milestones 2000-2004

- Integrated into Global Trigger milestones
- see next talk ...