Muon triggers issues

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Reporting considerations from several sources

Thanks to D.Acosta, M.Dallavalle, J. Hauser, A. Montanari, W. Smith and many others

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Muon rates at 10^{35} cm^2s^{-1}

The muon trigger rates at the LHC p_T thresholds will largely exceed the reserved 12.5 kHz rate bandwidth.

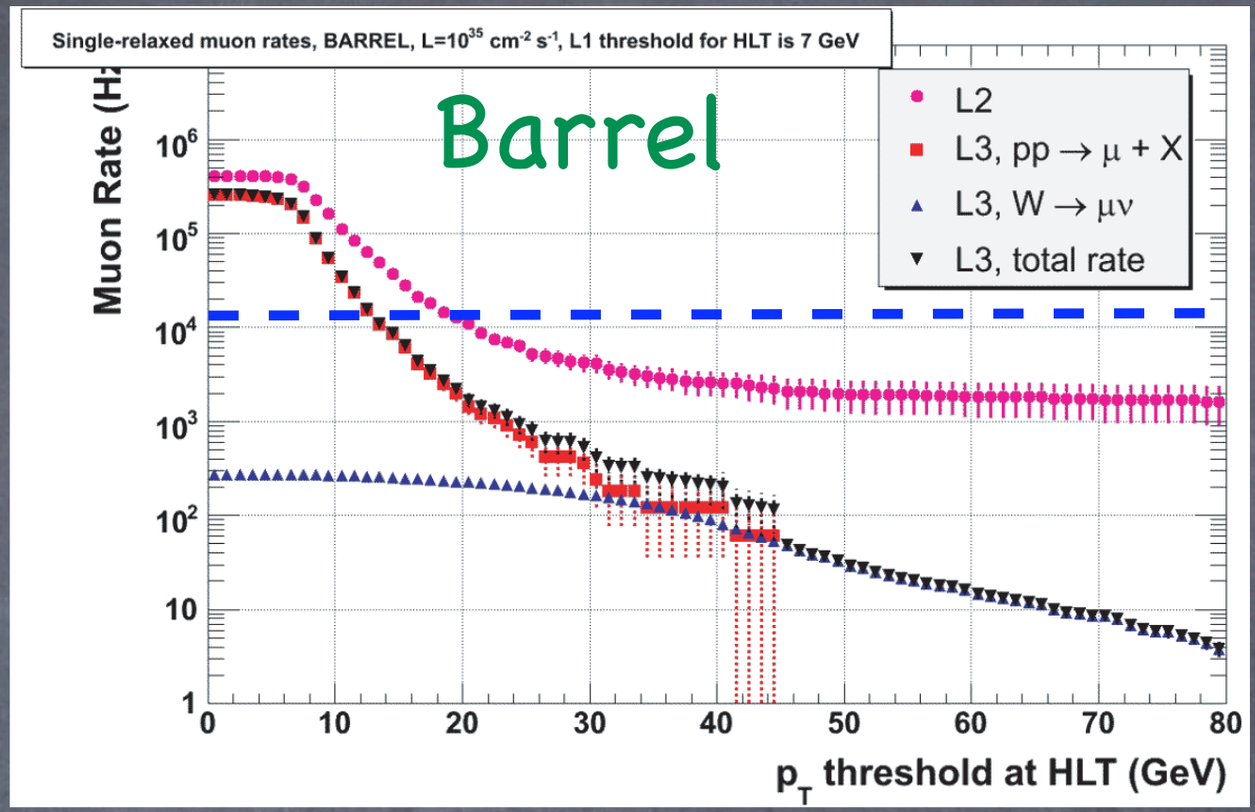
This is not due to the true muon rate, but rather to insufficient p_T resolution allowing high p_T assignment of low energy muons

The solutions are an increase of the threshold or a resolution improvement.

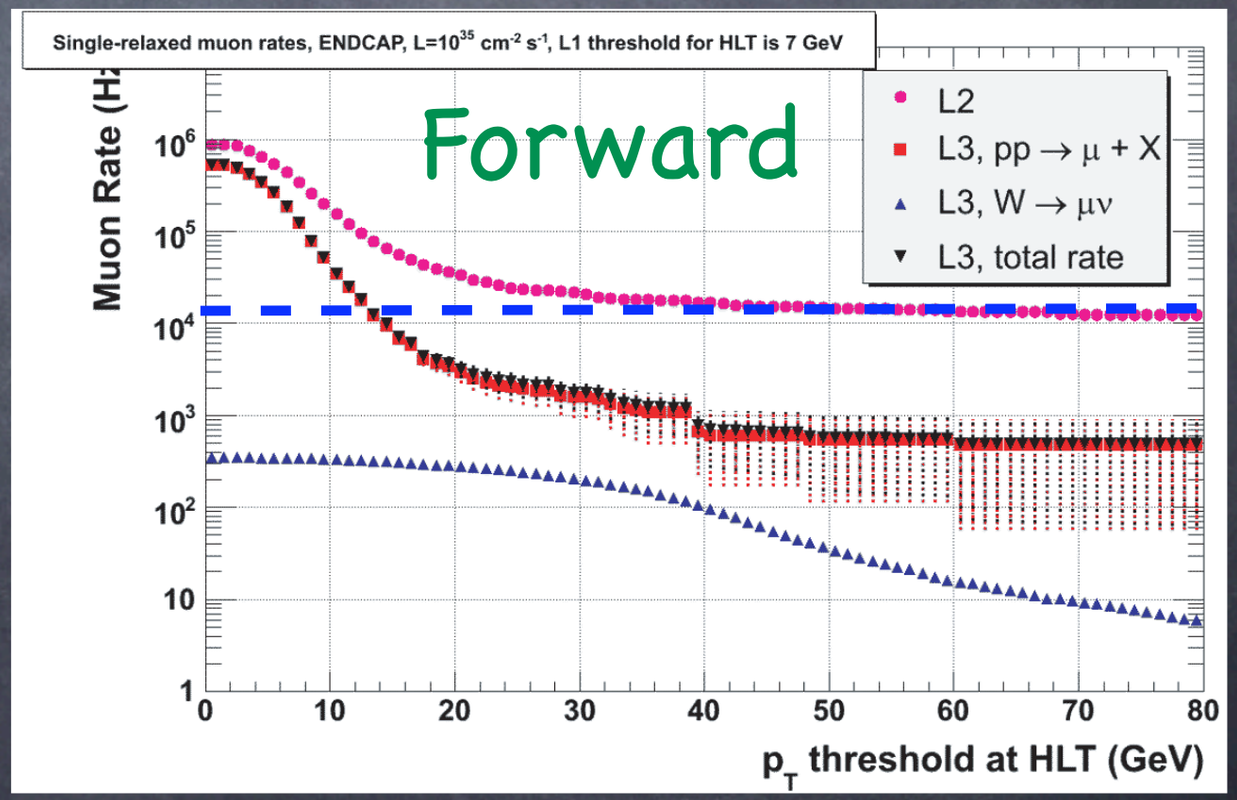
Increasing thresholds is unacceptable.

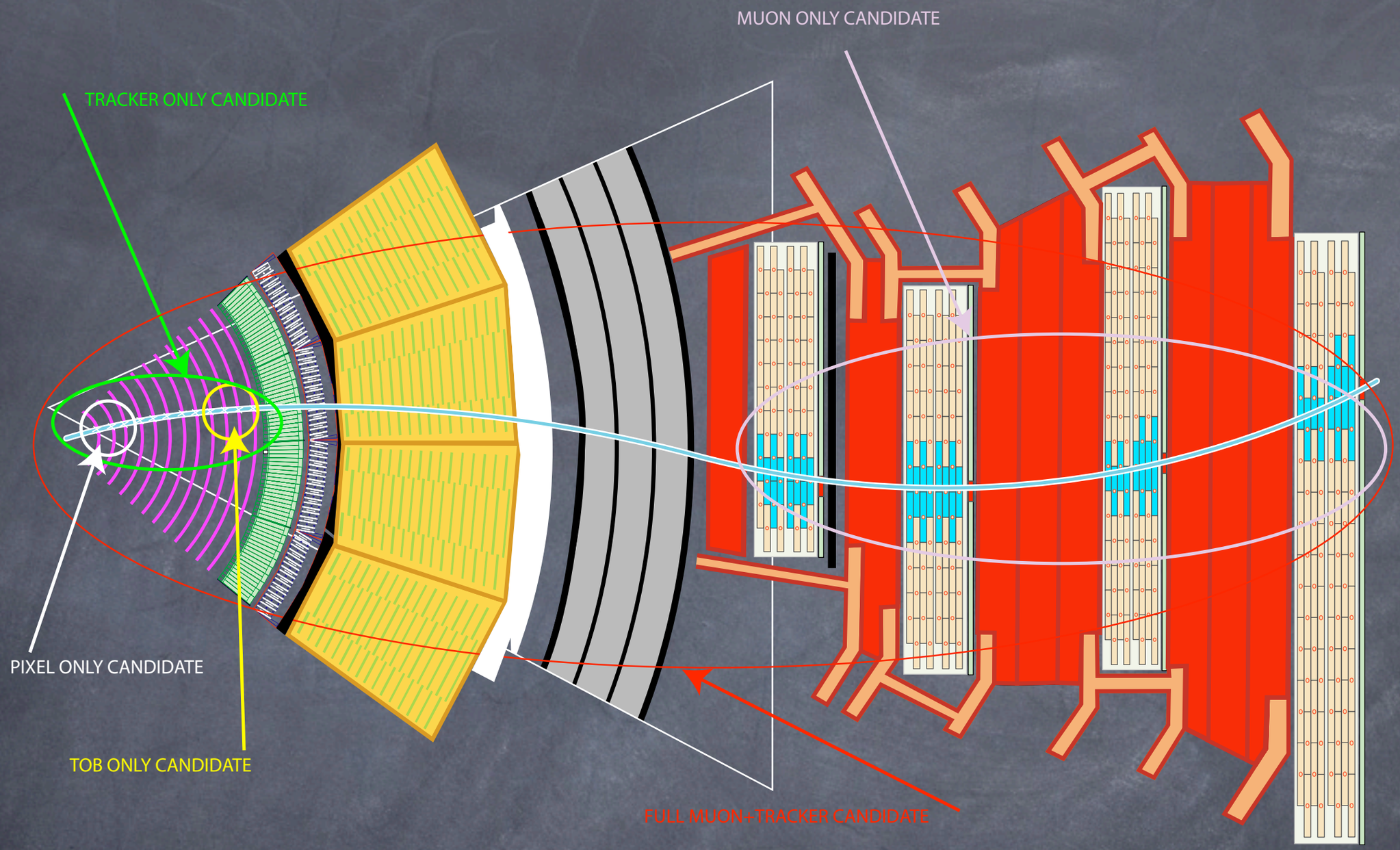
Simulation of HLT trigger algorithms at SLHC luminosity shows that even using the full detector resolution will be barely sufficient for the barrel and still insufficient for the forward detectors.

Hence the only possibility for a sensible resolution improvement is providing access to the Tracker hits



FROM J. ALCARAZ





Muon trigger candidates can be reconstructed using

- Full information
- Only muon information
- Only inner tracker information
- Few selected tracker layers (e.g. pixels only in Phase 1)

but of course with different resolutions ...

MUON DETECTOR ONLY TRIGGERS

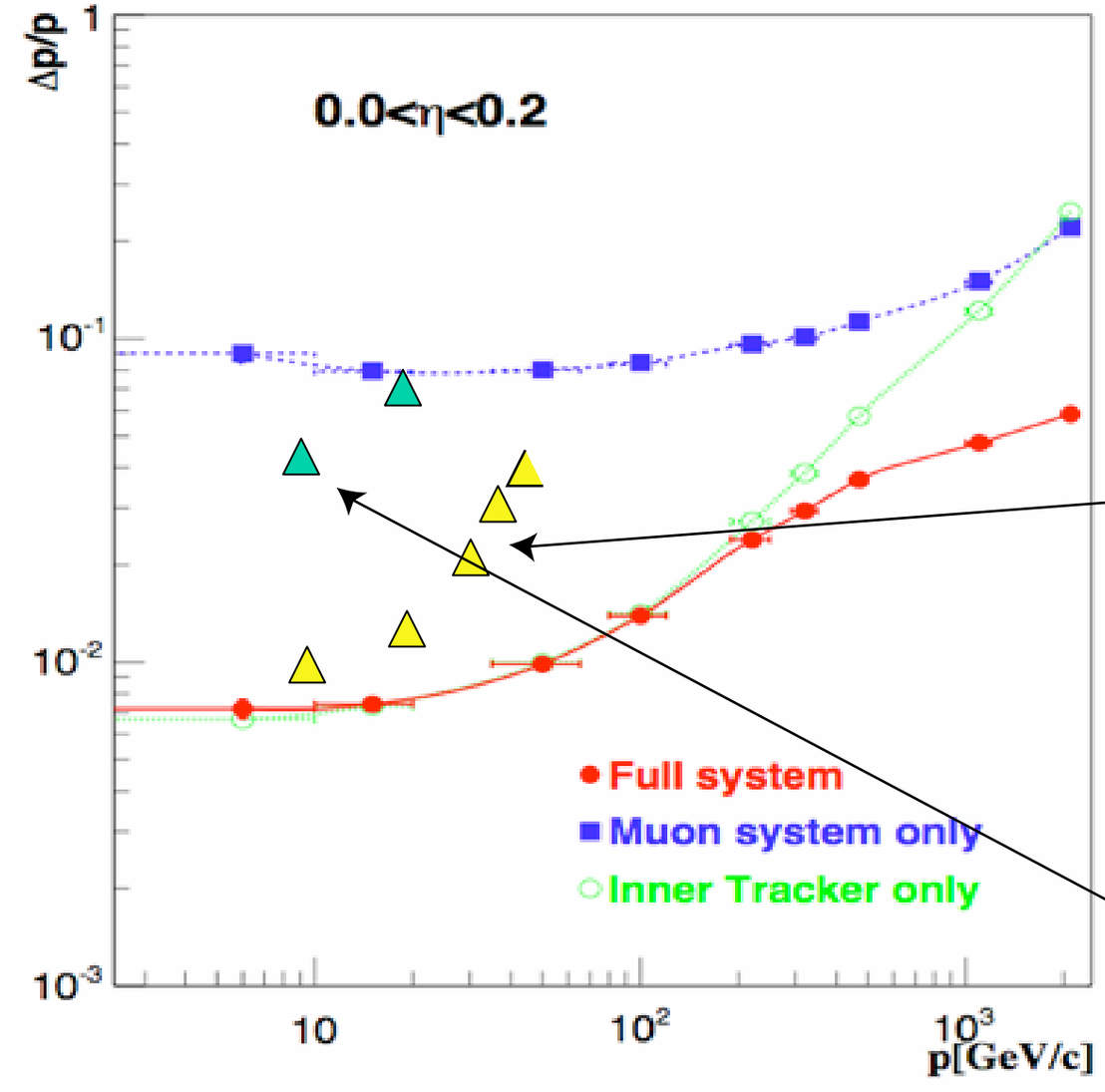
The definition of the muon trigger candidates within the muon detector is rather complicated: we have an hardware implementation of offline algorithms

- main concept is “redundancy”
- based on three different detectors with rather different techniques
- for DTs an CSCs it is defined by a multistage approach based on algorithmic search while for RPCs it is based on firing of predefined patterns: superposition between the two approaches is total
- the candidates must then be compared and decision must be taken making use of “quality flags”

Our choice implies a large built-in flexibility

- several cuts can be applied at several stages during processing
- big efficiency due to superposition
- muons are classified in a quality hierarchy

Achievable resolutions



fit of 2 points (in two TOB layers) and the vertex constraint, strip pitch of 200 μm

Radius (cm) of two layers	Δ Pt / Pt (%) for different Pt (GeV/c)				
	10	20	30	40	50
61.0-108.0	0.8	1.1	1.6	2.1	2.6
61.0-86.8	1.1	1.8	2.8	3.5	4.4
86.8-108.0	0.9	1.5	2.3	3.0	4.0

Radius (cm) of 3 layers:4.4, 10.2, 25.0

No vertex constraint

Pixel pitch	Δ Pt / Pt (%) for different Pt (GeV/c)	
	10	20
100 μm	7.5	14.5
50 μm	4.3	7.2
20 μm	2.7	3.2

No background simulated

Partial Tracker information (even only pixels)could provide a rate reduction
Another possibility is partial tracker information (two layers: one outer and one inner) to be combined with the muon primitives.

FROM BOLOGNA GROUP: G. ABBIENDI, C. BATTILANA, A. MONTANARI, A. PERROTTA

Facing a rather complex scenario

- LHC upgrade proceeding in small steps
- Large systems to be upgraded
- Detectors will not be changed
- Too many possible tracker options
- Need of strict correlation among detectors

Flexible upgrade strategy required

TRACKER PERFORMANCE OPTIONS
AND
RELATED MUON SYSTEM ACTIONS

- NO PREPROCESSING
  - START TRACKER SELECTIVE READOUT OF HITS/TRACKS
- SOME PREPROCESSING
  - MINIMAL: JUST COUNTING TRACKS WITH P_T OVER THRESHOLD
    - MATCH TRACKER AND DT/CSC PRIMITIVES COMPUTING P_T
  - MAXIMAL: MOMENTUM MEASUREMENT DONE
    - MATCH TRACKER AND MUON TRACK FINDERS CANDIDATES
  - IT WOULD BE NICE IF THE CONCEPT OF QUALITY COULD BE USED

COMBINED MUON/TRACKER MEASUREMENT

ACTION IF THE TRACKER PERFORMS FULL TRACK MEASUREMENT

◇ MATCH TRACKER CANDIDATE AND MUON CANDIDATE AFTER MUON TRACK FINDER

- PLAIN TAGGING OF MUON CANDIDATE AMONG TRACKER CANDIDATES

POSSIBLE ACTIONS IF THE TRACKER CANNOT PERFORM FULL TRACK MEASUREMENT

◇ BUILD TRACK USING TRACKER HITS/TRACKS ONLY IN FEW SELECTED LAYERS WITH VERTEX CONSTRAINT AND MATCH TO MUON TRACK FINDERS OUTPUT

- LOWER MULTIPLE SCATTERING BUT SHORTER LEVER ARM
- MATCHING MUST BE DONE AFTER AN EXTRAPOLATION

◇ BUILD TRACK USING TRACKER HITS/TRACKS AND DT/CSC PRIMITIVES AT 1ST/2ND STATION WITH/WITHOUT VERTEX CONSTRAINT AND MATCH TO MUON TRACK FINDERS OUTPUT

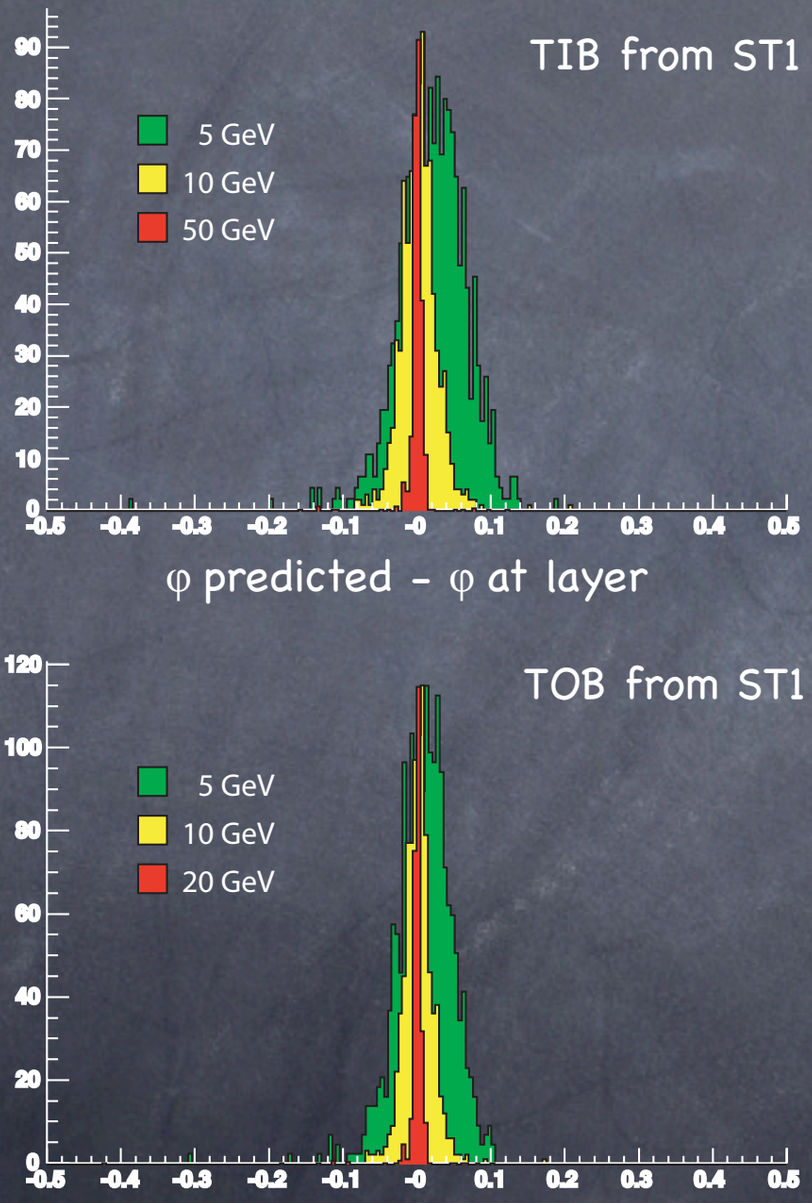
- HIGHER MULTIPLE SCATTERING BUT LONGER LEVER ARM
- EASIER MATCHING DUE TO COMMON MUON PRIMITIVE

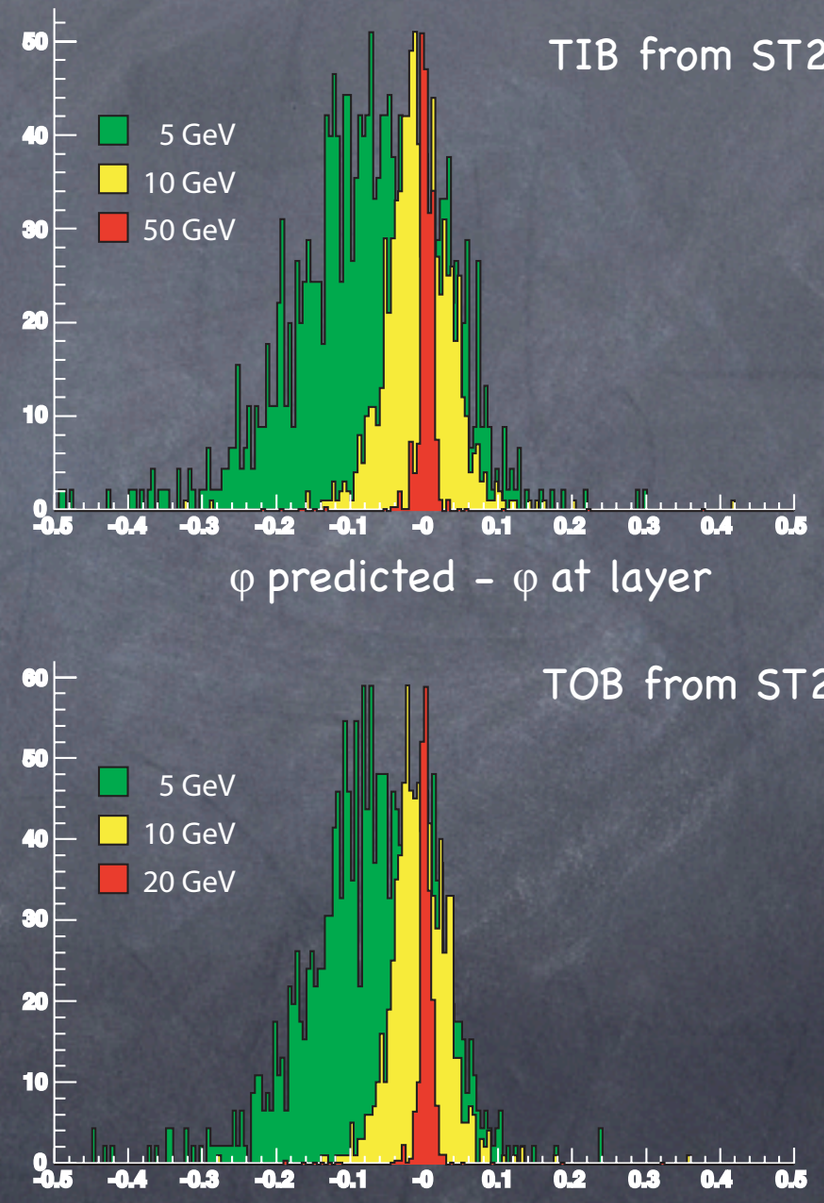
◇ BUILD COMBINED TRACK USING HITS/TRACKS ONLY IN FEW SELECTED TRACKER LAYERS AND DT/CSC PRIMITIVES WITH/WITHOUT VERTEX CONSTRAINT

- COMPLICATED DUE TO REVERSE BENDING AFTER MAGNET AND HIGH MULTIPLE SCATTERING
- NO NEED FOR MATCHING

Extrapolation to tracker layers

last TIB layer (R ≈ 50 cm) and last TOB layer (R ≈ 110 cm)



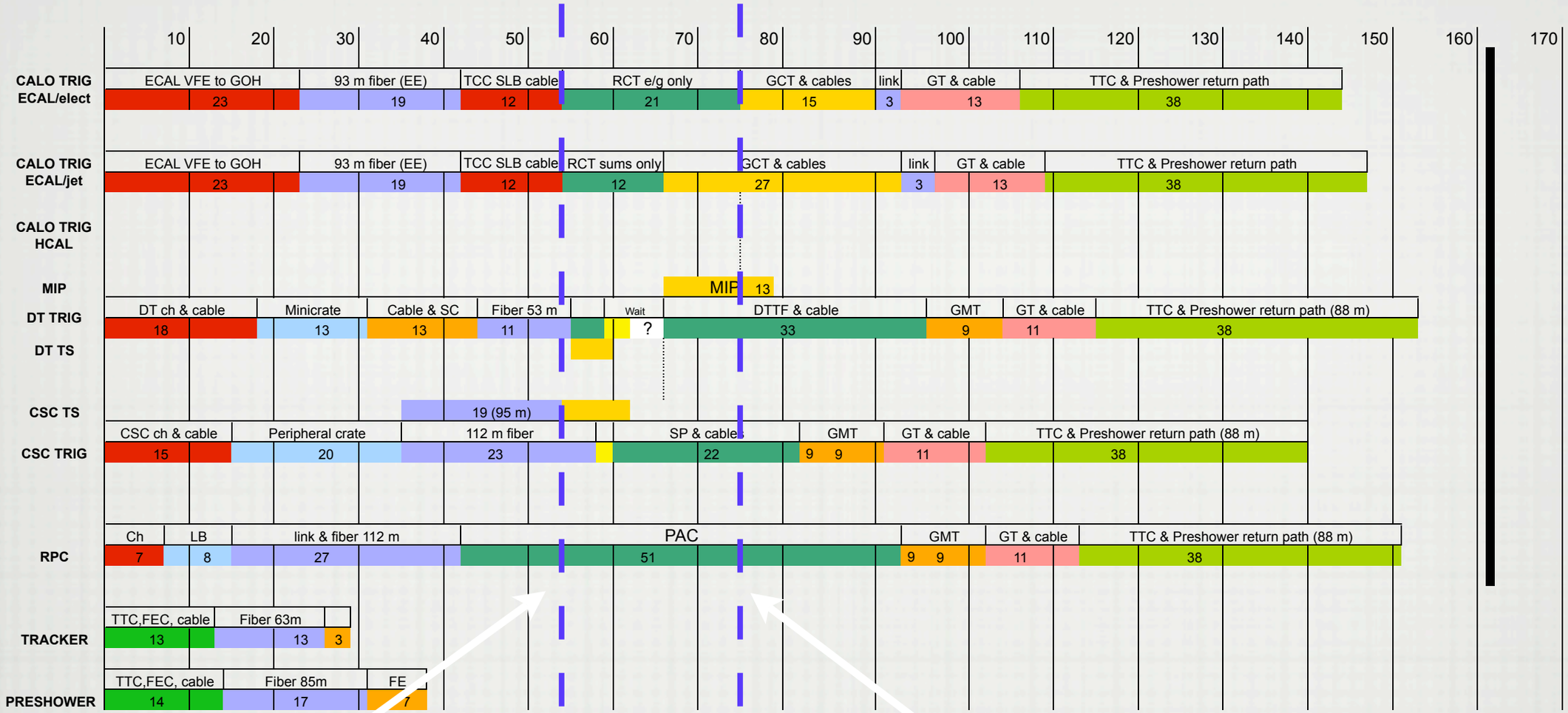


SOME CONSIDERATIONS

- In case we go for a selective readout to avoid a messy situation we must find an agreement among detectors (DTs, CSCs, Calorimeters) on the time the tracker is addressed to avoid individual addressing of each detector
- The number of regions in the tracker that can be addressed at the same time will be limited
- All primitives (muons, electrons/gammas, jets) should be input to a matching box which will be actually addressing the tracker after sorting them in a priority order using associated quality flags

- In case the tracker is already providing its own primitives we need to associate a quality flag to tracker primitives
- In case the tracker preproccessing is limited we can then think about several matchboxes matching each detector and the tracker primitives between them in order to send updated muons/electrons/taus/jets to the Global Trigger
- In case the tracker provides full information the actual matchbox is very likely the Global Trigger

MINIMAL LATENCY TO START ANY COMBINED ACTION



55 BXs = 1.375 μs

75 BXs = 1.875 μs

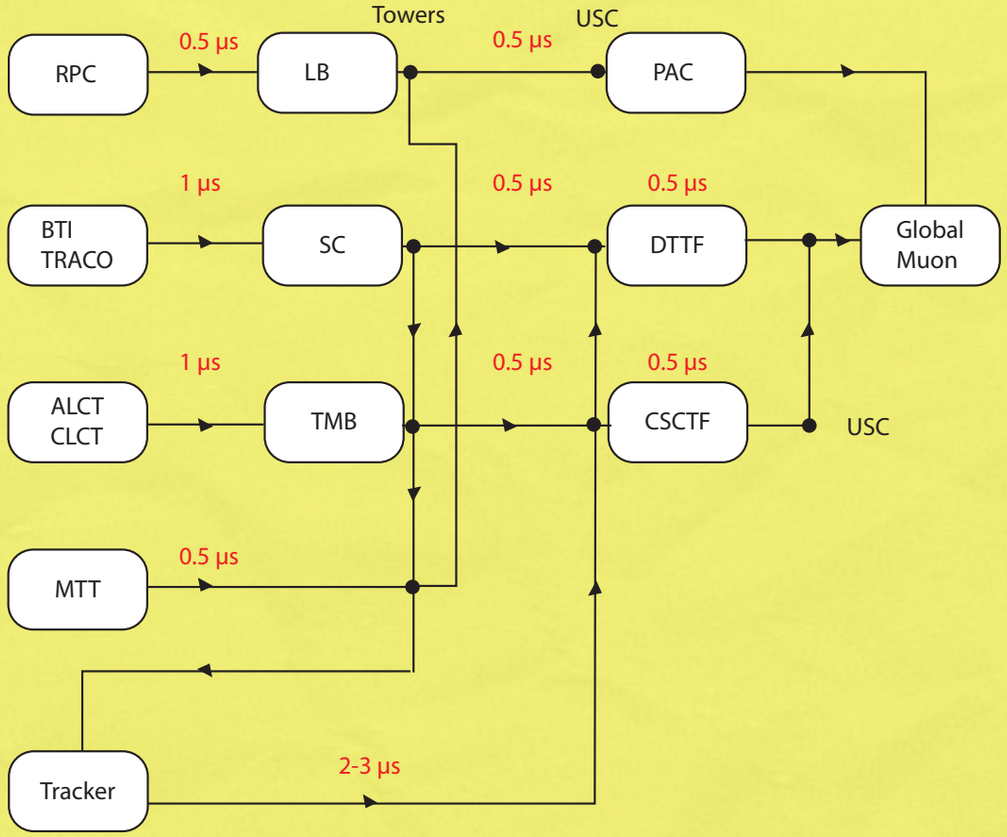
Reasonably the addressing cannot be done before the ECAL trigger primitives are available. Hence the earliest time is between 55 and 75 BXs (fixed by the gain in processing time of the new RCT). Addressing after the TFs is not excluded assuming a tracker L1 data latency better than 2 μs.

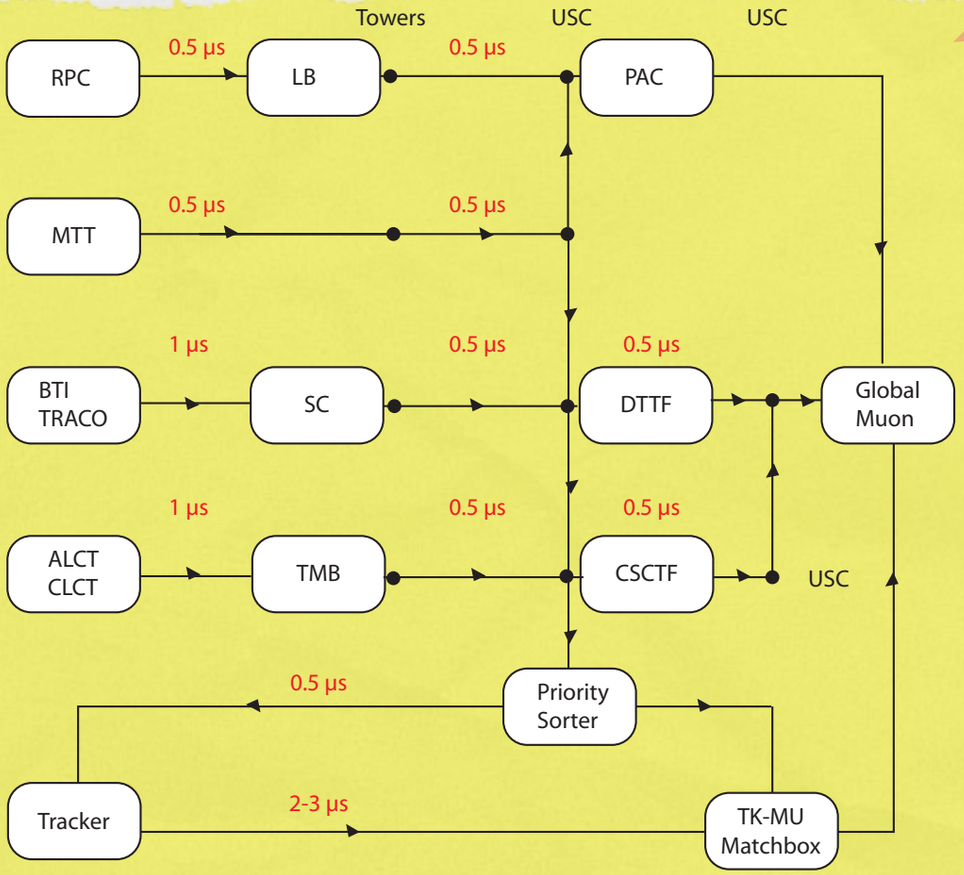
Architectures

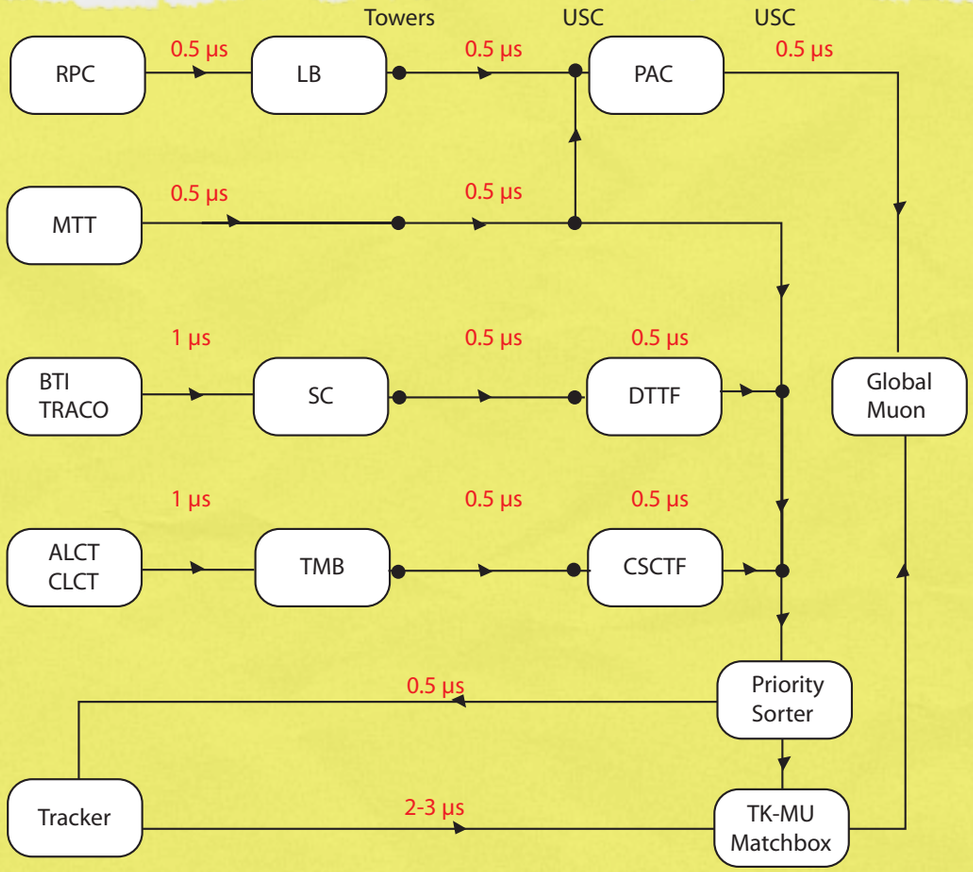
Tracker addressing from towers

Tracker addressing from USC before the TFs

Tracker addressing from USC after the TFs







CONCLUSIONS

- General consensus on need for tracker data
- Several possible upgrade architectures depending on actual tracker choices
- Prefer flexible choices in order to be ready to switch fast among different scenarios
- Seriously consider any sensible proposal
- Need of strict collaboration among all trigger detectors to guarantee shared choices