Update on Di-Muon trigger study

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Introduction: Goals

- Goals:
  - Increase the Level-1 di-muon trigger efficiency
  - Increase the η acceptance
  - Check efficiency of the track finder algorithm
  - Study possible ways to suppress ghosts from single-muon events

- From previous reports:
  - Study the difference between outputs for default .orcarc parameters and parameters that reflect
    - Reality: staged ME1/1a, descoped
      - default for L1
      - Muon:Endcap:ORedME1A=1, should be used for HLT
    - Dreams: ME 1/1a readout , rescoped
      - for L1: CSCTrigger:twentyDegreeSubSectors=1
      - default for HLT
  - Check consequences of the broader acceptance window in the Extrapolation Unit algorithm

Introduction: task

- Methods (efficiency and eta-coverage increase):
  - accept low quality muons
    - no hits in ME1 are required, 2 or more hits in other stations
    - CSCTrackFinder:lowQualityFlag=4
  - check the influence of other mentioned parameters

- Technical details:
  - CMSIM 133 →
  - ORCA 7_3_0 →
  - hits in ROOT DB →
  - Trigger/L1CSCTrackFinder → *.hbook → *.root

- Cons:
  - L1 di-muon trigger rate increase due to ghosts for single μ-events

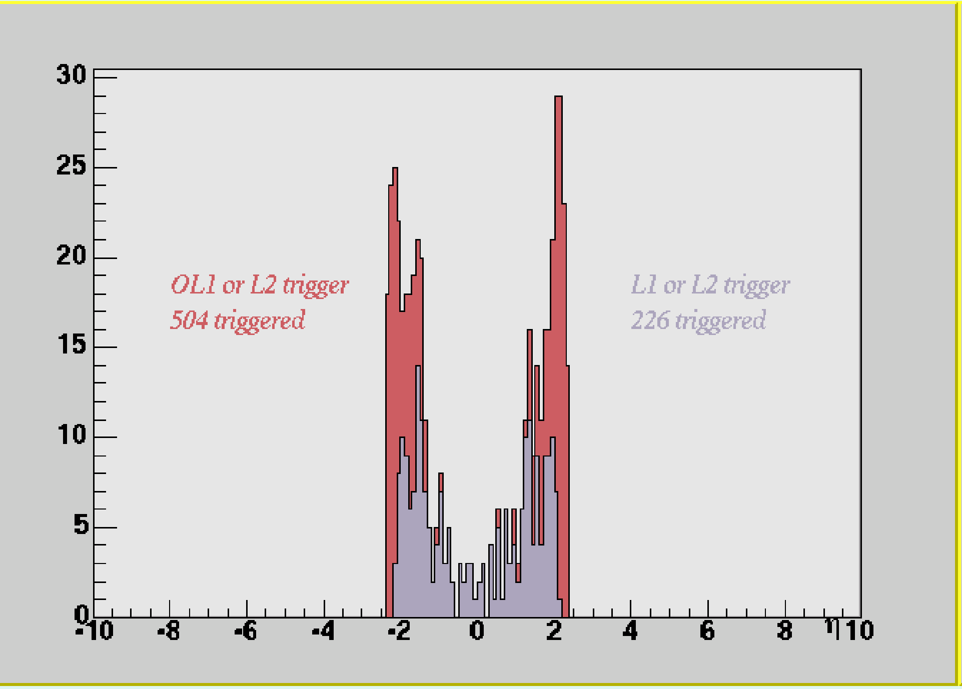
Motivation

- The closer the efficiency is to 100% …
  - the smaller error in measurements, uncertainty
  - the larger statistics
- Increase η coverage → statistics increase
  - CMS Note 1998/020, "Impact of Muon Trigger coverage on physics"
  - Heavy Ions: J/Psi acceptance raise
    - Also see: Analysis Note draft, AN 2003-002
  - B-physics studies at LHC
- Recommendations to use .orcarc parameters that describe realistic detector performance

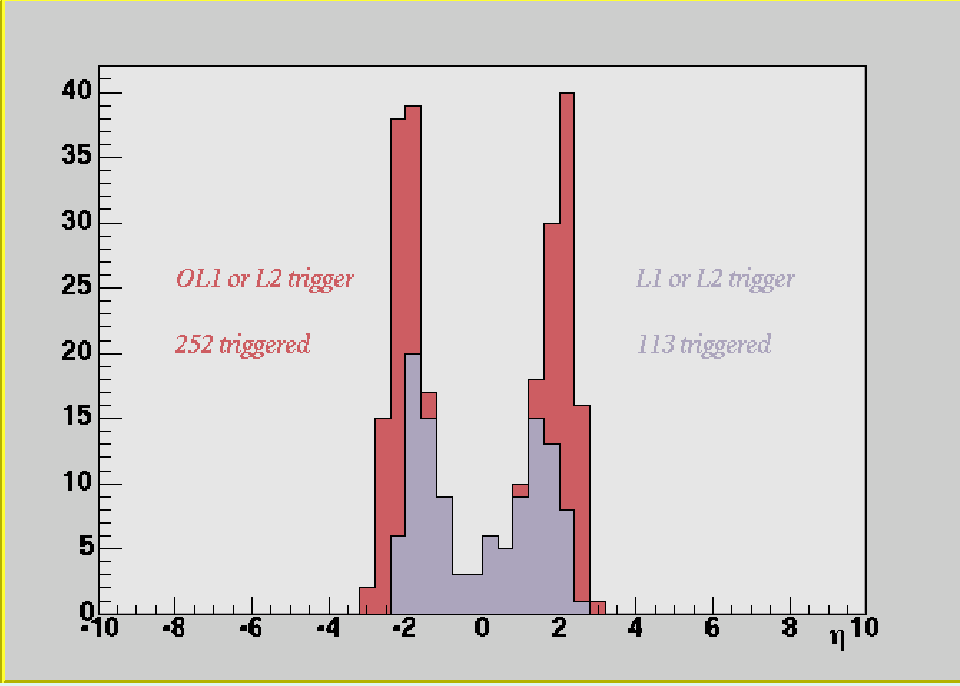
- Illustration:
  - acceptance
    |η| < 2.1 → 2.4
  - up to 10% gain in acceptance
    - Note (!): Applied thresholds on Pt in most of the shown channels were between 7 and 15 GeV

		η^{μ}_{trig}	2.1	1.6	1.2	0.8
$H \to ZZ^{(*)} \to 4\mu$			100	96	88	60
	m_A	$\tan\beta$				
$A^0 \to \tau\tau \to 1\mu$+jet	140	20	94	76	59	41
$A^0 \to \tau\tau \to 1\mu + 1e$	140	20	94	76	59	41
$gg \to A^0 \to 2\mu$	120	30	97	89	78	59
$gg \to A^0 b\bar{b} \to 2\mu$	120	30	100	97	90	78
	m_0	$m_{1/2}$				
$\mathrm{SUSY}_1 \to 1\mu$	80	180	97	90	80	67
$\mathrm{SUSY}_2 \to 1\mu$	500	150	98	92	82	67
$\mathrm{SUSY}_3 \to 1\mu$	200	150	99	96	90	81
$\mathrm{SUSY}_4 \to 2\mu$	105	181	98	94	82	65
$\mathrm{SUSY}_5 \to 2\mu$	150	400	99	96	88	70
$\mathrm{SUSY}_6 \to 2\mu$	50	125	98	90	81	64
$\mathrm{SUSY}_6 \to 3\mu$	50	125	98	92	78	59
$t\bar{t} \to 1\mu$			93	78	62	44
$t\bar{t} \to 1\mu + H^{\pm \to \tau-\mathrm{jet}}$			93	78	62	44
$Wtb \to 1\mu$			93	80	62	40
$t\bar{t} \to 2\mu$			99	95	84	69
$Wtb \to 1\mu$			99	93	82	69
$B \to J/\psi K^0_s \to 3\mu$			100	90	73	56
$B \to J/\psi \to 2\mu$ (incl.)			91	69	52	35
$B \to 2\mu$			91	70	53	35
$b\bar{b} \to 2\mu$ (incl.)			91	72	52	35
$B \to \pi\pi + 1\mu$			89	73	53	39
$B \to \pi\pi KK + 1\mu$ (oscillations)			89	73	53	39

Heavy Ions (Thanks to Olga Kodolova)



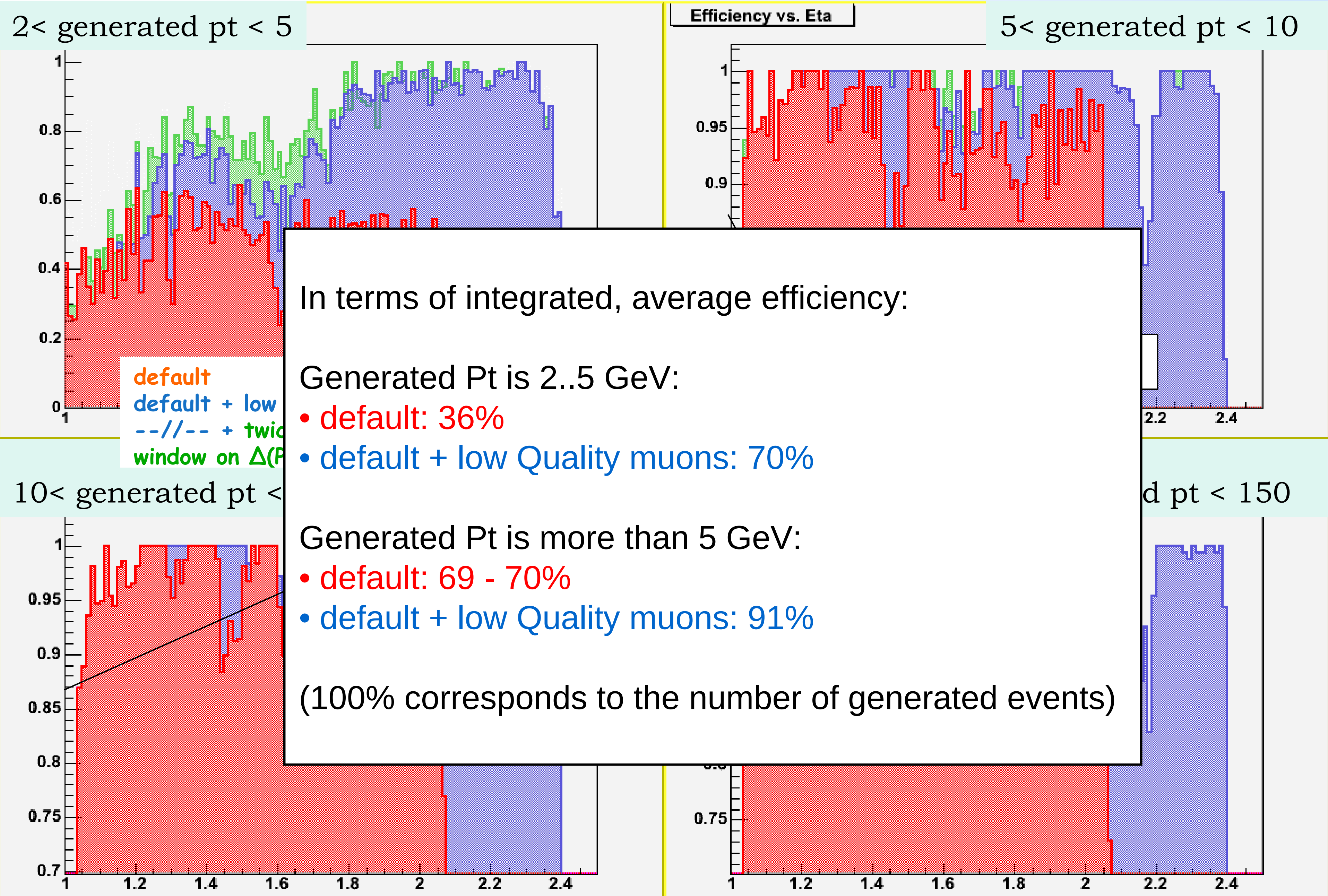
muons from J/Psi



J/Psi

- Muons from J/Psi, |η|<2.4
- Blue – high Quality muons, red – low Quality muons allowed
- Difference for J/Psi acceptance is 123%
  - looks too good (?) → need to check if implementation in simulation software reflects reality…

Pros: L1 μ reconstruction efficiency for single muons



In terms of integrated, average efficiency:

Generated Pt is 2..5 GeV:
- default: 36%
- default + low Quality muons: 70%

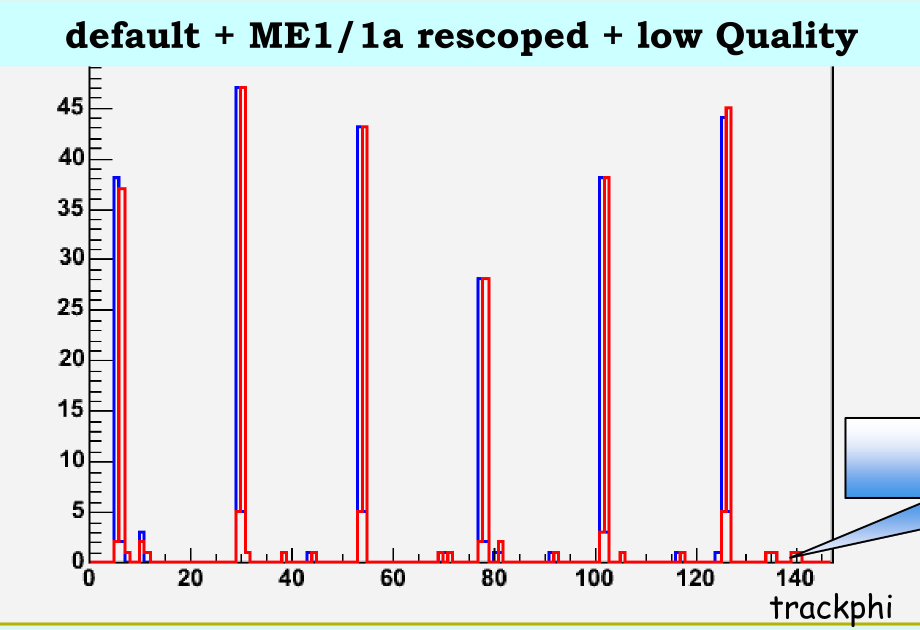
Generated Pt is more than 5 GeV:
- default: 69 - 70%
- default + low Quality muons: 91%

(100% corresponds to the number of generated events)

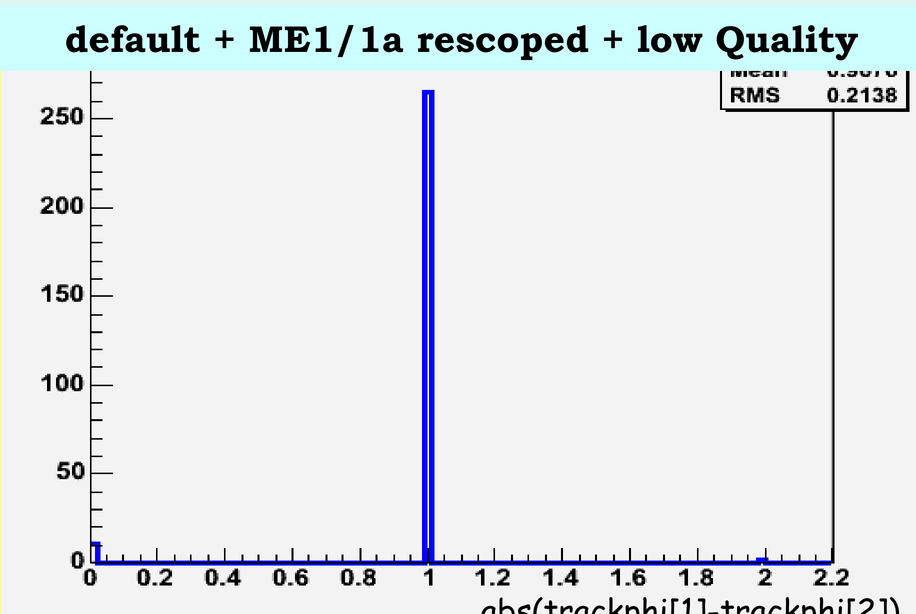
Cons: increase di-muon trigger rate due to ghosts

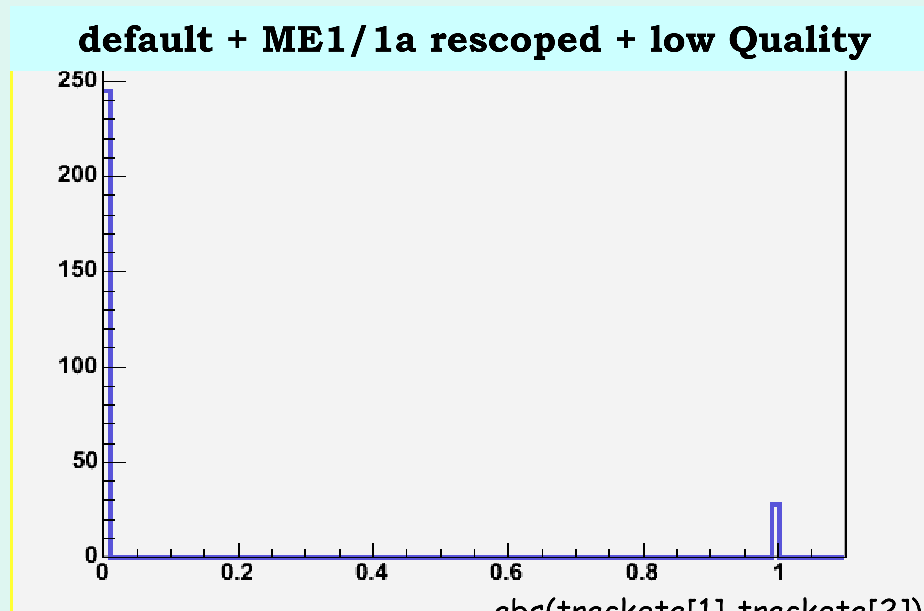
- Estimation mechanism:
  - 320,000 muons were generated (both signs)
  - flat pt distribution
  - pt generated = 2..150 GeV
    - 160,000 events for 2<pt<15 (80,000 of each sign)
    - 160,000 events for 15<pt<150 (80,000 of each sign)
  - 0.9 < generated η < 2.4
  - weighting procedure was applied to simulate min-bias spectrum (falling pt spectrum)
    - formula from CMS Note 1997/096 for min-bias events from b,c hadrons for each muon, defined for:
      - high luminosity: 10^{34} $cm^{-2}s^{-1}$
      - $|\eta| < 2.1$
    - Rate was scaled up to equal total muon rate
      - Clear overestimation because EMU is a part of the total Muon System
  - weighting was used as an alternative to min-bias generation

The way out… Illustrations: reconstructed φ, Δφ, Δη



Note: 1 unit = 2.5°





Is there a way out? (logic)

- Di-muon L1 rate increase reason
  - CSC chambers overlap
  - LCTs are found in both neighbor sectors
  - Current L1 CSC trigger doesn't share information across sector boundaries
- Possible ways to kill ghosts:
  - Changing CSC Muon Sorter logic
  - Changing TMB logic
  - Changing Sector Processor logic

Changing CSC Muon Sorter logic…

Di-muon L1 trigger rate for different .orcarc parameters.
Default here coincide with reality, staged ME1/1a
(Muon:Endcap:ORedME1A=1 doesn't affect L1).

	rate (Hz)	cut1, rate (Hz)	cut1+cut2, rate (Hz)	cut2 only, rate (Hz)
default	620	260	0	0
default + low Quality	20100	3310	0	0
default + ME1/1a resco				0
default + ME1/1a resco				0

- Main cuts
  - Cut1: if m … (trackphi[1]-trackphi[2
  - Cut2: if ab …])<=1 → take away
    - Doesn'
    - This cu … a box (Δφ;Δη
- Additional
  - No additi
- Note: DAQ
  - Total di-muon rate = 1.7 kHz
    - For 5 GeV symmetric thresholds

This was in a previous report (with more details).

Plus of this approach is that cut2 kills ALL ghosts.

Problem is that there should be implemented additional complicated logic into Muon Sorter firmware
- it may not fit into the chip
- it may be to slow…

…but if it is successfully implemented it will be probably the best choice

TMB logic, Sector Processor logic…

- TMB
  - deleting overlaps
    - last 10 half-strips or 3 di-strips (depending on CSC type)
  - BUT
    - ghost rate is still too high
    - furt… …ns as well, intro…

Ghost rates:

Default: 0.9 Hz
TMB, deleting overlaps: 6.0 kHz
SP, deleting low Quality muons on boundaries: 1.8 kHz

(no cuts on reconstructed muon PTs were applied)

- Sector P…
  - deleting… …vel if it is on the bou…
    - if it…
    - X1, X2 … optimization parameters
    - by choosing X1 = 120, X2=3976 more than 90% of ghosts introduced by low Quality tracks acceptance were deleted
  - simple logic (checking 7 bits of tstubphi, low Quality flag)
    - will fit into Sector Processor logic
    - no additional delays

Summary and Plans

- Low Quality flag provides, cons:
  - Increased ghosts rate in di-muon L1 trigger
- ...pros:
  - About 100% efficiency for muon tracks with genpt > 5 GeV
  - η coverage up to 2.4
  - Most (all) of the additional ghost events could be killed by CSC Muon Sorter or Sector Processor
- Ghost suppression:
  - ALL ghost can be killed with cut#2 with Muon Sorter logic, but…
    - complicated logic: size, slowness
  - TMB logic: deleting overlapping strips is not a solution
    - either inefficiency or too high ghost rate
  - Sector Processor logic seems to be a possible solution

Summary and Plans

- Plans
  - Implementation of the new algorithm for Sector Processor into CMS software (ORCA)
    - verification/debugging
    - full checking with min-bias + pile-up samples (DC04 samples)
  - Corresponding Firmware changes in Sector Processor logic
  - Verify the L2/L3 offline can benefit from the low Quality muons with poor pt assignment
    - Still possible to find the right track in the tracker?
      - → verified, preliminary results show some gain in efficiency

- Thanks…
  - UF HEP group
  - UCLA HEP group (Jay Hauser, Jason Mumford)