Summary of PRS/Muon Activities

D. Acosta
University of Florida

Review of past results
Ongoing work toward HLT milestones
Analysis environment

CMS

HLT Single Muon Rates

What was shown in December for $L = 2 \times 10^{33}$:

Single μ stream: summary

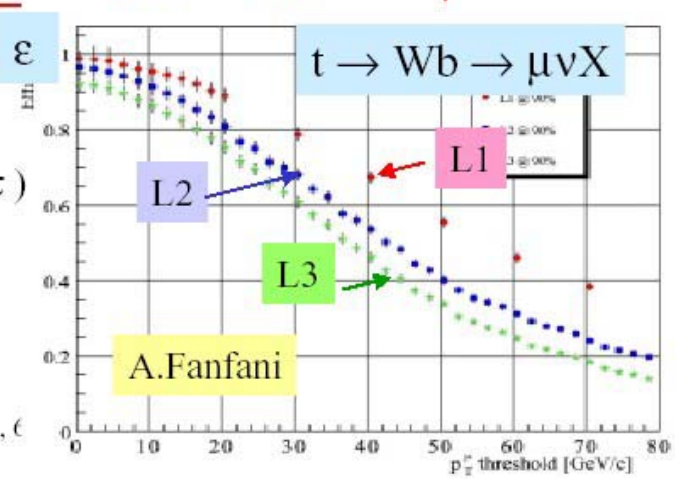
	L1	L2	L2+iso	L3	$L3_{Pxiso}$
p_T (GeV)	14.	14.	14.	22.	22.
Rate(Hz)	3600.	900.	500(calo) 300(pixel)	90.	24.
ε (W ->μν)	0.85	0.78	0.75	0.55	0.50
ε (t->Wb->μνX)	0.93	0.88	0.84	0.73	0.66
ε (H_{200}->ττ->μX)	0.77	0.70	0.67	0.53	0.48
ε (Z->μμ)	0.99	0.98	0.94	0.94	0.93
ε (H_{120}->2μ2ν)	0.96	0.93	0.90	0.76	0.75

W : 11 Hz
Z : 1 Hz
b/c → μ: 10 Hz
K/π→ μ: 2 Hz

p_T threshold set to 22 GeV

efficiencies must be multiplied by geometrical acceptance
(ε_{acc} = 0.57 for W → μν, 0.92 for H → ττ)

** all numbers are preliminary **



U.Gasparini

CMS week, €

Recent Re-Analysis of Single P Rate

M.Konecki

	Standalone muon measurement		With Tracker	With Pixel isolation	Isolation + pixel line
PT	L1	L2	L3	L3IPx	L3IPxC
16	2500.04	717.31	252.97	89.4243	60.1642
17		591.267	195.409	67	42.4445
18	1945.23	525.119	158.483	52.9872	31.0895
19		430.511	127.835	41.6912	22.748
20	1543.63	392.41	107.195	34.7845	17.7768
21		264.101	79.764	24.9658	11.5318
22		**248.638**	**68.4177**	**20.6414**	**8.70907**
23		233.212	61.0832	18.8946	7.25566
24		219.454	53.538	16.7527	5.90529
25	885.173	204.444	47.3989	15.1819	4.64781

A little unclear why there is improvement

What used to be 24 Hz in Dec.

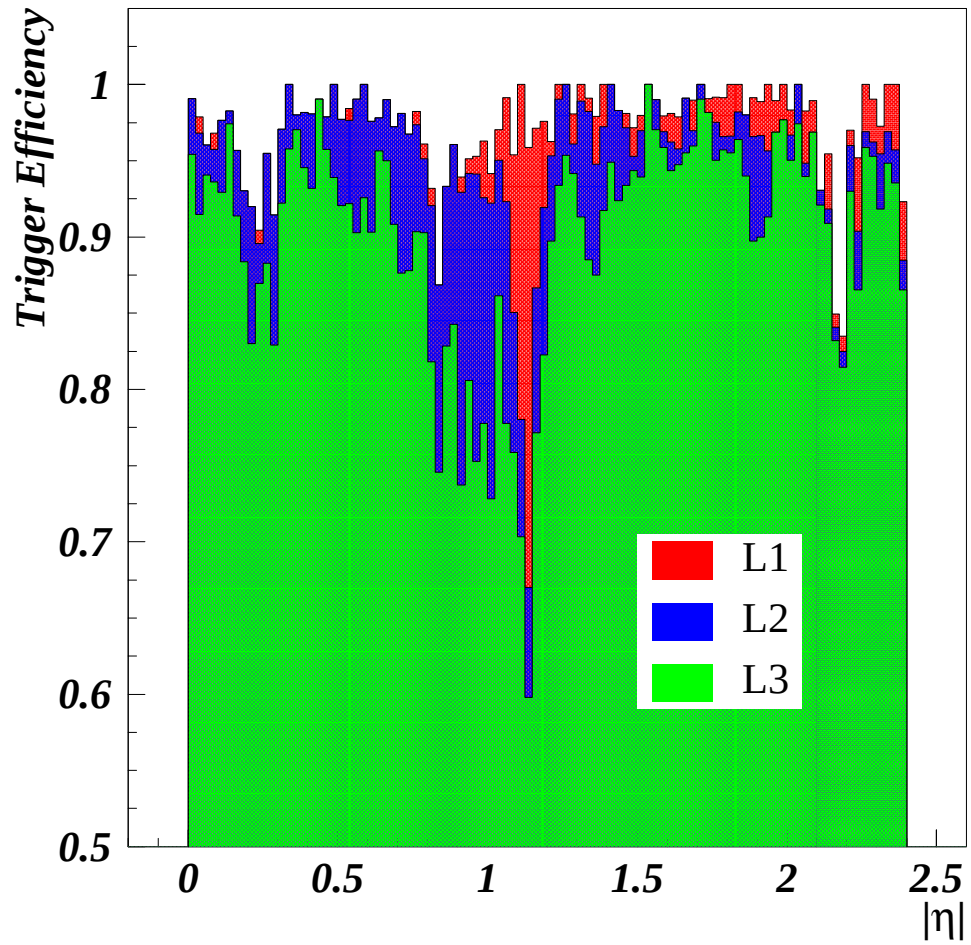
+12 = 21 Hz

Rates only for minbias events – must add about 12 Hz W/Z for total

CMS

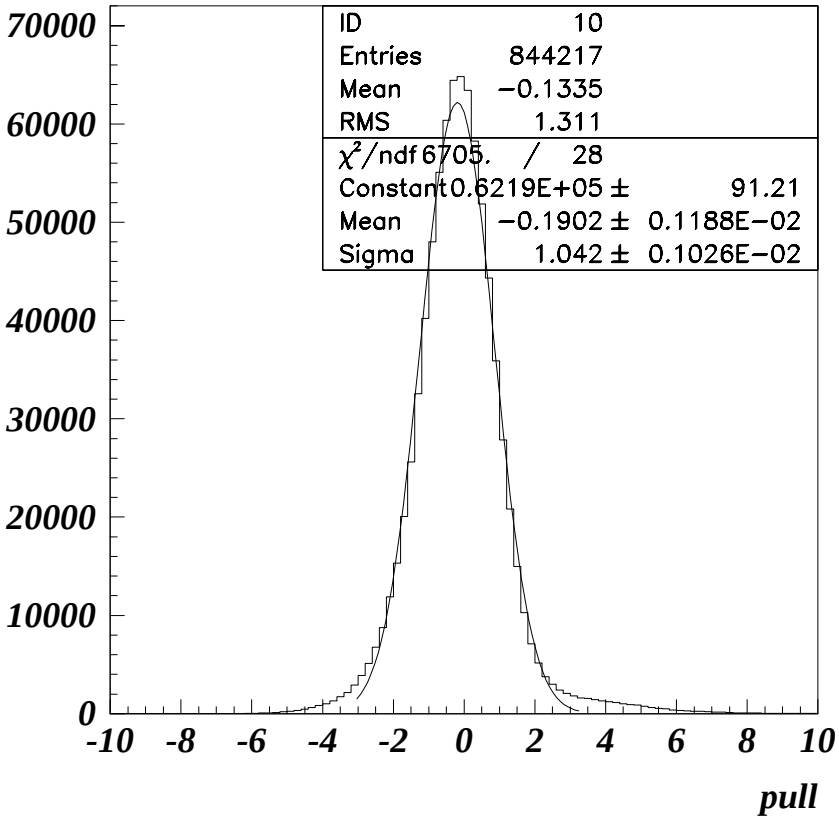
Muon reconstruction efficiency (L2 and L3: only DT+CSC)

ORCA 5 3 4

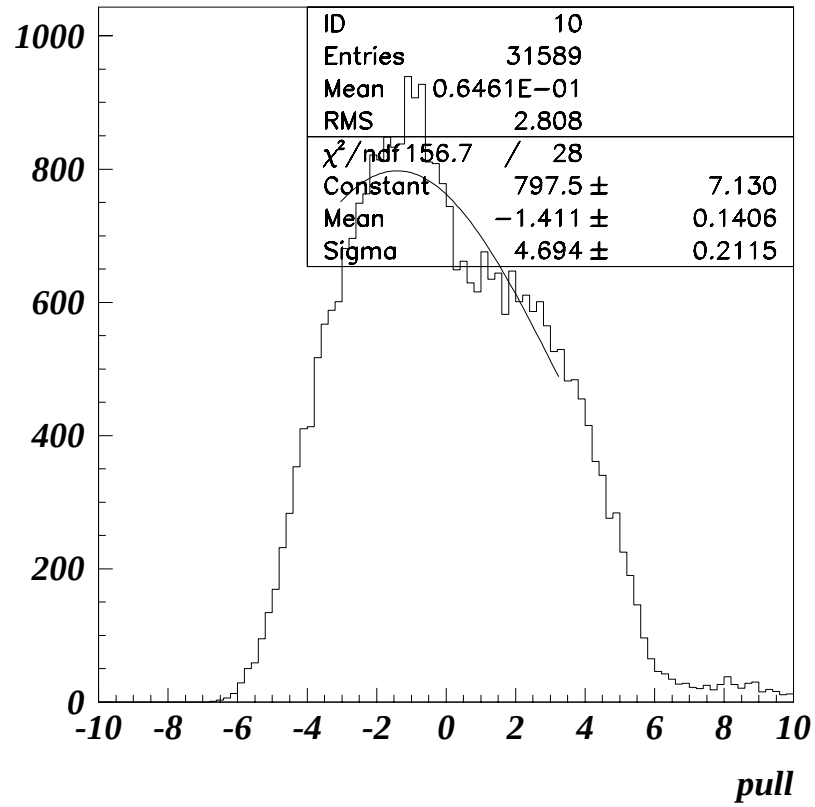


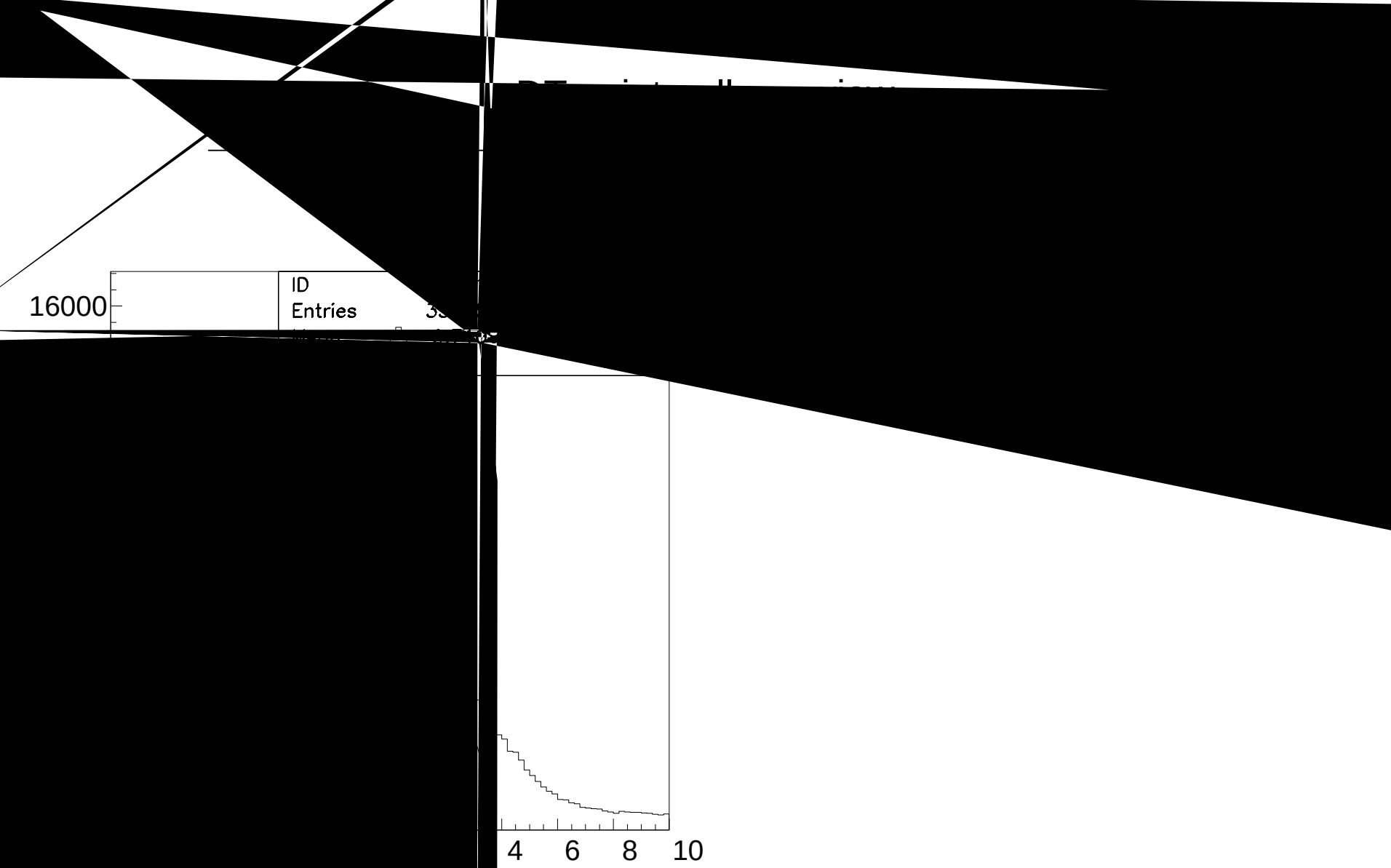
DT point pull: φ view

Total



MB1 -overlap



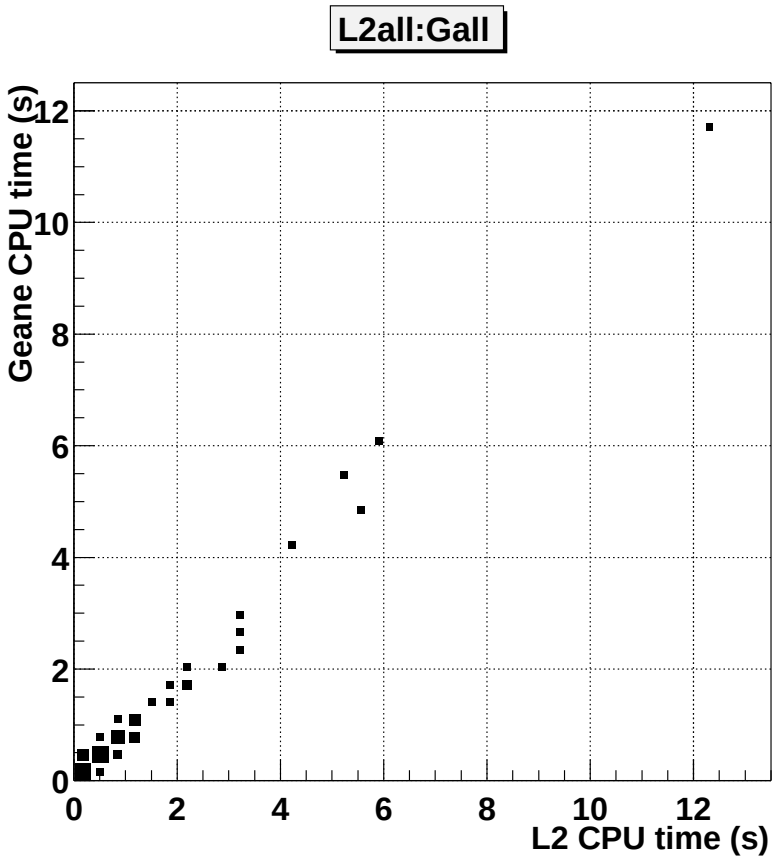

16000
ID
Entries
4
6
8
10

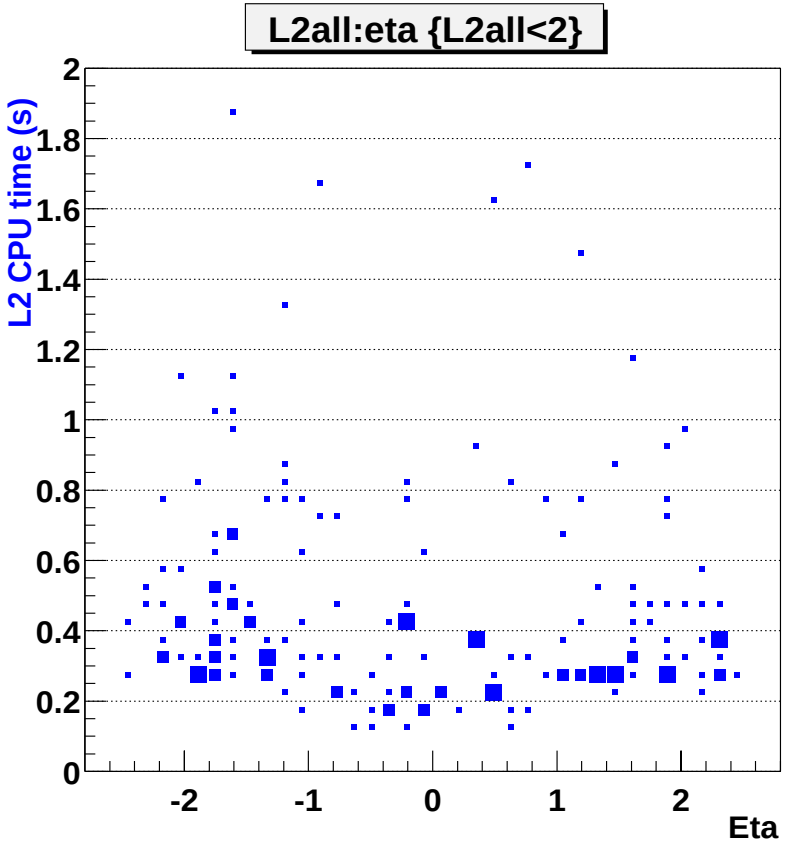
L2 CPU analysis (I):

- L2: ~ 780 ms/ev large fluctutation (see after)
  - Seed generation ~ 25 ms/ev
  - Trajectory builder: ~ 680 ms/ev
  - Vertex constraint ~ 75 ms/ev
- Trajectory builder: ~ 680 ms/ev
  - Forward K. filter (FTSRefiner): ~ 460 ms/ev (bigger initial error)
  - Backward K. filter: ~ 220 ms/ev

    of which:
    - Extrapolation inside DT/CSC chamber: ~ 30 ms/ev
    - Kalman update: ~ 20 ms/ev
    - Segment building: ~ 60 ms/ev

L2 CPU analysis (IV):





all L2 time is spent inside Geane!

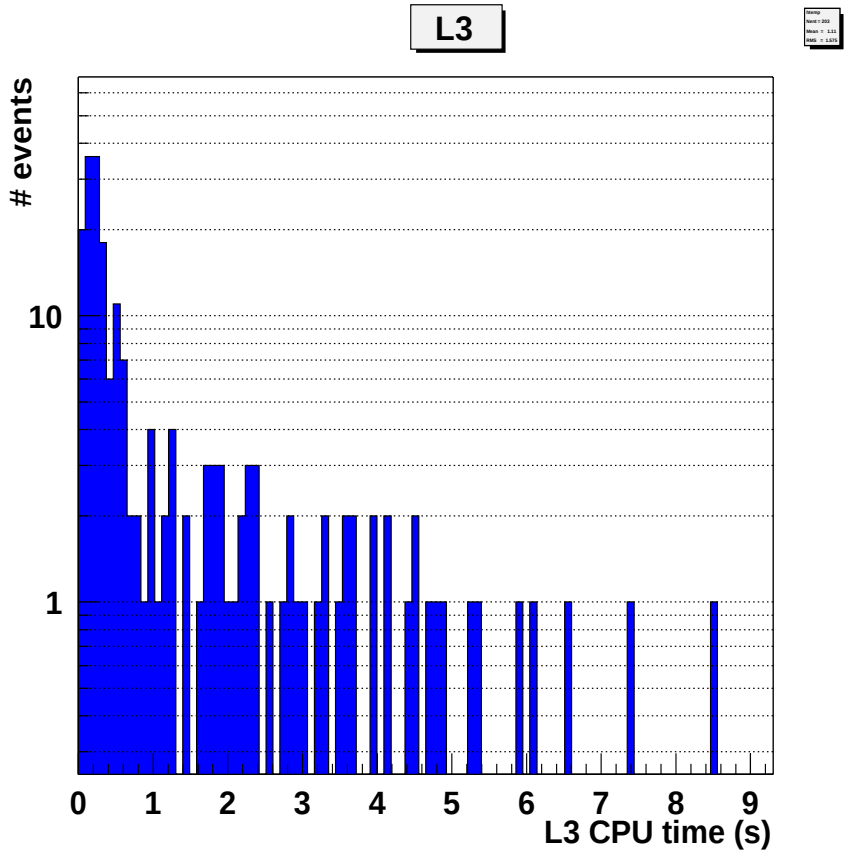
$\sim$ slower in the endcap

L3 CPU analysis:

L3: ~ 1680 ms/ev

large fluctuation (see $\Rightarrow$)

- Seed generation ~ 90 ms/ev
- Trajectory builder: ~ 1580 ms/ev
- Trajectory smoother: ~ 8 ms/ev
- no η correlation, slower for low p_T muons.



Faster L2 Algorithms

Several approaches (from conservative to extreme)

- Replace GEANE with faster propagation method based on parameterizations
  - Possibility first explored by O.Kodolova
  - Needs someone to implement method to propagate through iron in current muon reconstruction package
- Optimize detector layout in ORCA to minimize GEANE calls
  - Under development by N.Amapane to replace detector wheel (ring) with azimuthal sector (rod) →
- Minimize (or eliminate) GEANE calls by optimizing L2 segment selection and parameterize track parameters
  - Recently studied by M.Konecki using L1 information to guide L2 algorithm →
- Use *only* L1 information to swim tracks inward to pick up tracker hits at L3
  - Bypass even L2 segment building by using precision L1 segments stored in DAQ banks
  - Needs a volunteer…

Current L2 Navigation

On average, 270 calls to GEANE propagation per event!

- For each DL, 3 rings are checked
- For each ring 3 DetUnits are checked
- For each of the 9 DetUnit a full propagation thru IRON is made
  - Most of these propagations start from the same FTS and end to the same surface…

- Possible optimizations:
  - Take into account detectors only if they are REALLY compatible with FTS (using errors); as done by Stefano
  - Re-use propagated states

Do not fit in current DetLayer design!

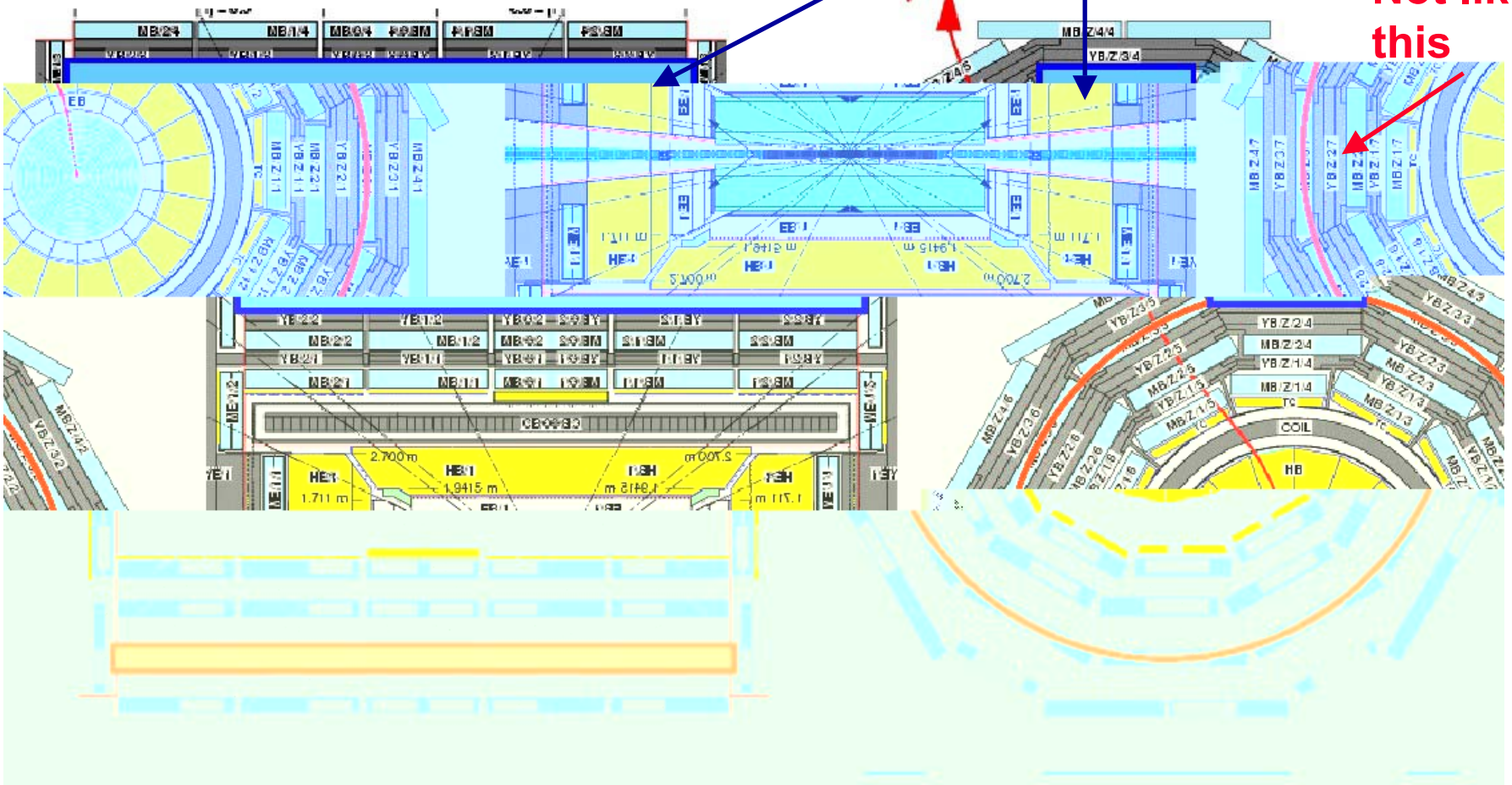
⇒ A different approach investigated

- Re-design the DetLayer layout

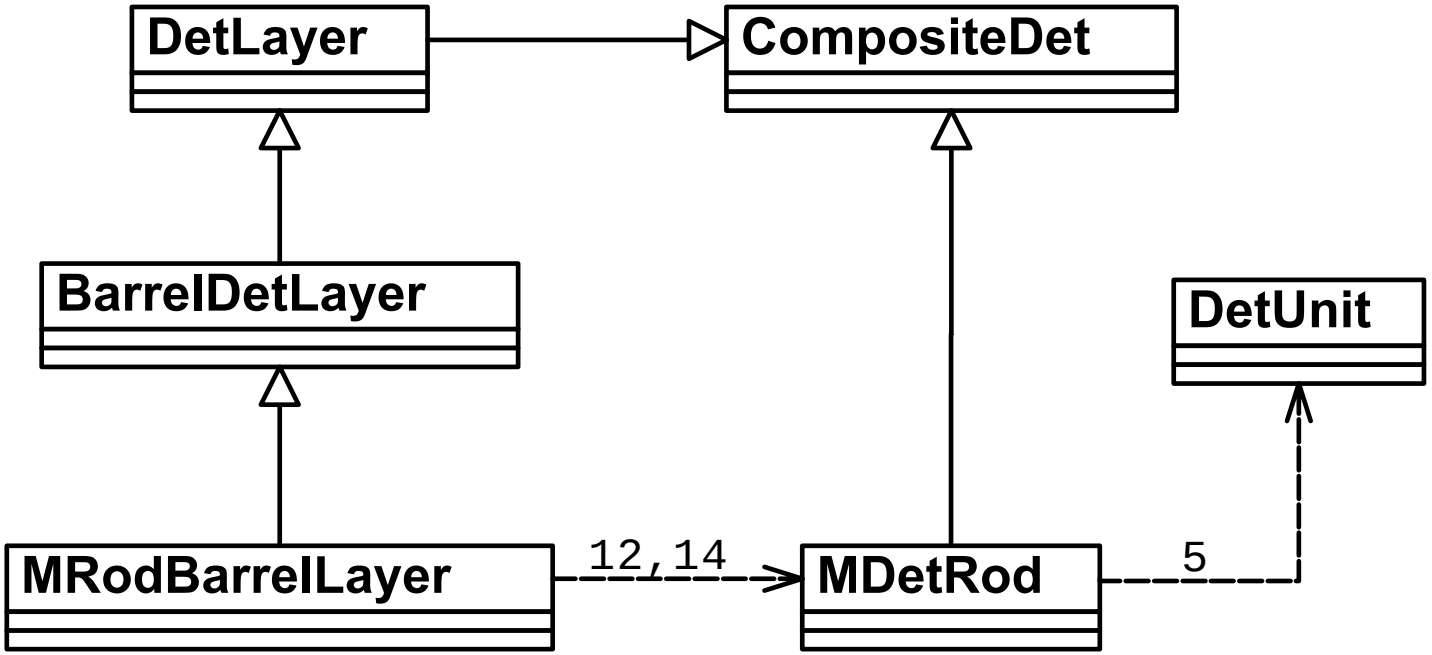
Caveats: Very preliminary results, barrel (DT) only

Composite Detector Organization

- MRodBarrelLayer (12/14 MDetRod)
- MDetRod (5 DetUnits)



Layer composed of Rods



- Implemented following TrackerReco's recent improvements
  - Cfr. TkRingedBarrelLayer
- DetUnits in a rod have the same surface of the DetRod
  - Makes finding compatible dets easier and re-use o propagated states natural

Status

- Very preliminary implementation
  - Still not fully refined, not optimized, mostlty unchecked…
- First Results on 100 single muons (pt100!)

Segment finding efficiency = 100.0%

w.r.t. old layout

Reconstruction with DT only

	Old layout	New layout
Geane calls/ev	68	16
Geane propagation (ms/ev)	935	93
Trajectory building (ms/ev)	980	112

Overall timing improved by a factor 8.5

Much simpler code structure

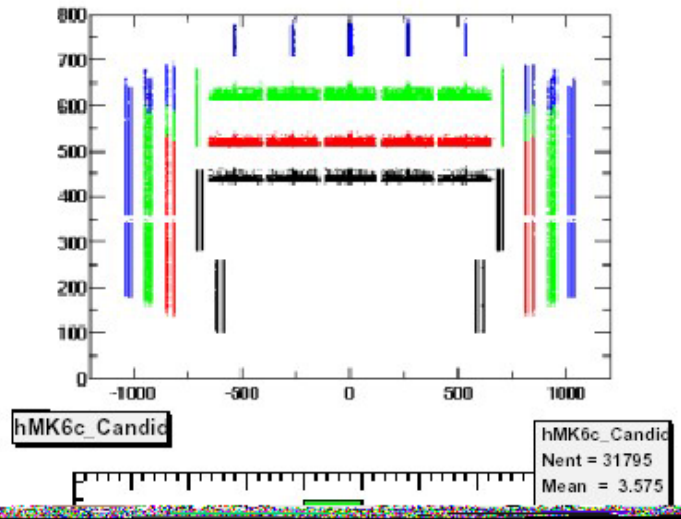
Faster Segment Selection in L2

Selection of L2 segments

The detailed GEANE extrapolations are not necessary to select segment created by muons. One can follow L1 patterns or make use of the fact that segments are almost along straight line

In this analysis:

- Find reference segment as the one closest to



Parameterization of Track Parameters

PHI,CHARGE,PT

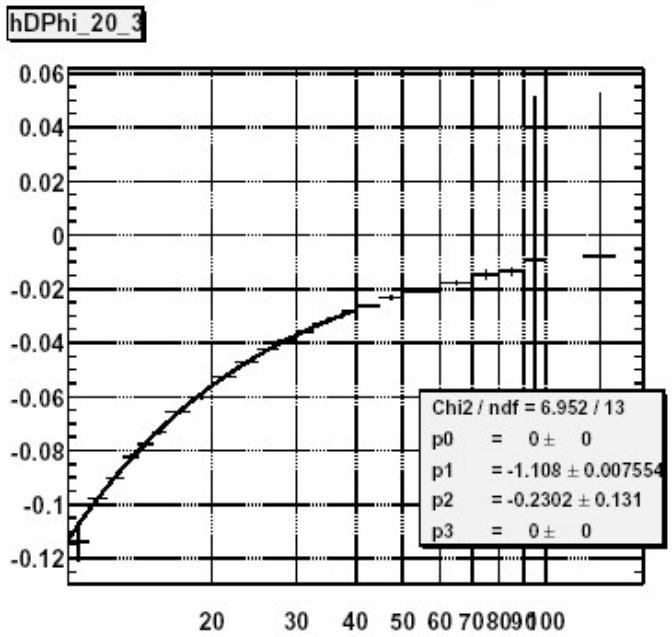
$$f(p_T) = \mathrm{p0} + \mathrm{p1}/p_T + \mathrm{p2}/{p_T}^2 + \mathrm{p3}/{p_T}^3$$

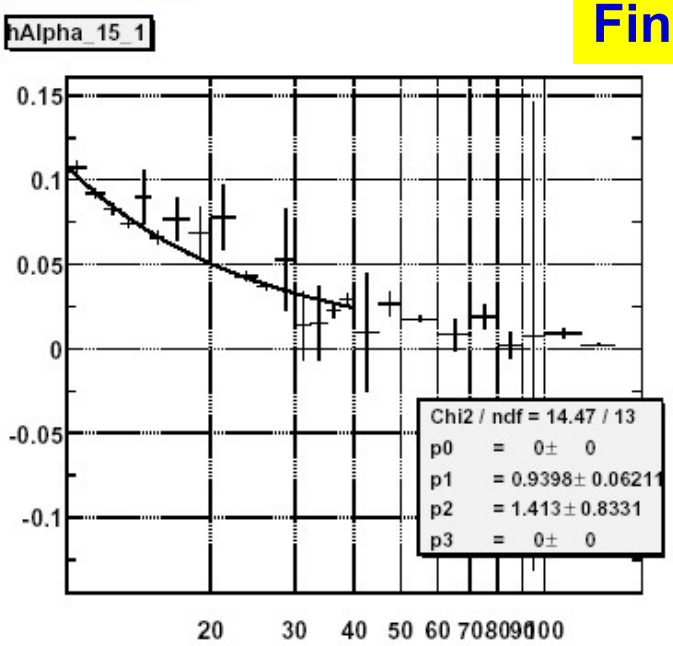
$$\varphi^i = \varphi^0 + f^i(p_T) \qquad \alpha^j = f^j(p_T)$$

$$\chi^2_\varphi = \Sigma_i(\varphi^i - \varphi^0 - \mathrm{charge}\cdot f^i_\varphi(p_T))^2 \qquad \chi^2_\alpha = \Sigma_j(\alpha^j - \mathrm{charge}\cdot f^j_\alpha(p_T))^2$$

look for p_T, charge, φ^0 that gives minimal χ^2_α, χ^2_φ and combined $\chi^2_\alpha + \chi^2_\varphi$ (in p_T range 5-L1)

Fast fit of track parameters to L2 segments (a là L1 Track-Finders)





Fast Seed Selection in Tracker

Possible Scenarios

Clearly there is room to optimize speed and efficiency in L2 and L3 algorithms

Possibilities exist to improve code organization, simplify segment selection and improve propagation procedure

Ultimately we will settle on a choice (or choices) that minimize execution time, maximize efficiency, and minimize backgrounds

CMS

CMS

U.S. PRS/Muon Community

U.S. muon analysis is still CERN-centric

- A couple individuals have even "emigrated" to Europe

But muon chamber construction and testing is U.S.-based

- Some mismatch between where the software developers are and where the people looking at data and writing firmware are

This is okay, but we have to work on communication, and invite people working on hardware to participate more in the PRS/Muon group

Examples of tasks that bridge the two communities:

- Validation of the simulation against cosmic and testbeam data
- Validation of the algorithms with the actual electronic firmware for the L1 trigger and DAQ
- Integration of test-stand code with the CMS DAQ framework (XDAQ) and with ORCA (for storing data)
- Specification of calibration procedures
- CSC event display

CMS