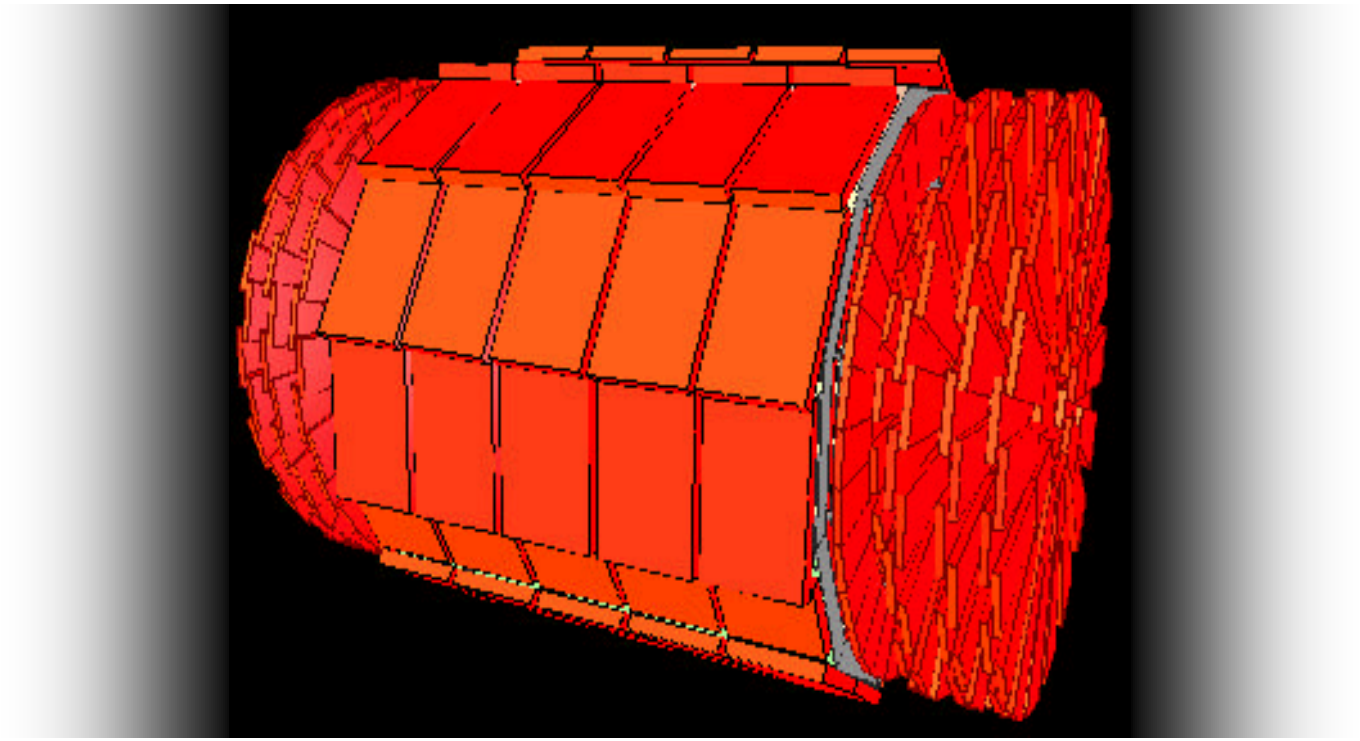
PRS Muon Results & Status



Darin Acosta

PRS/μ report

General Muon meeting, 6/3/02

Recent activity of muon-PRS group (since last Nov.report at Muon General meeting) focused on following milestones (in view of DAQ TDR) :

Determination of calibration methods and constants	March 2002
Data rates, data formats, online clustering	“
CPU analysis for low lumi selection	“

Next step will be:

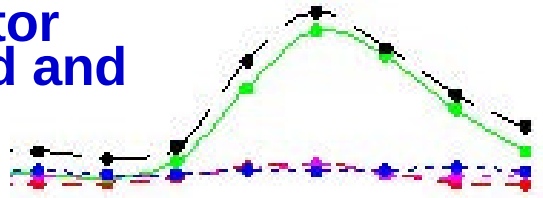
Complete HLT selection for high-lumiscenario	June 2002
CPU analysis for low lumi selection	“
Repeat on line selection for low-lumi	“
HLT results on B physics	“

PRS March Milestones

1. **Determination of calibration methods and samples**
2. **Data rates, data formats, online clustering**
3. **CPU analysis for low-luminosity selection**

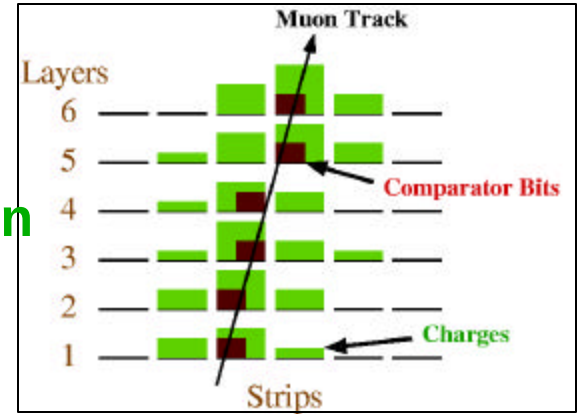
Overview of CSC DAQ

- The pulses from the cathode strips are sampled and stored in an analog memory (switched capacitor array) every 50 ns. They are also discriminated and sent into a comparator network for the trigger



- The pulses from the anode wire groups are discriminated, and the digital information is read out with the trigger data

- Digitization occurs *only* if there is a L1 accept *and* if there was a local charged track (LCT) segment in the chamber
  - LCT is used to select a "region of interest" in order to reduce the DAQ bandwidth
  - 12-bit ADC for digitization (2 byte word)

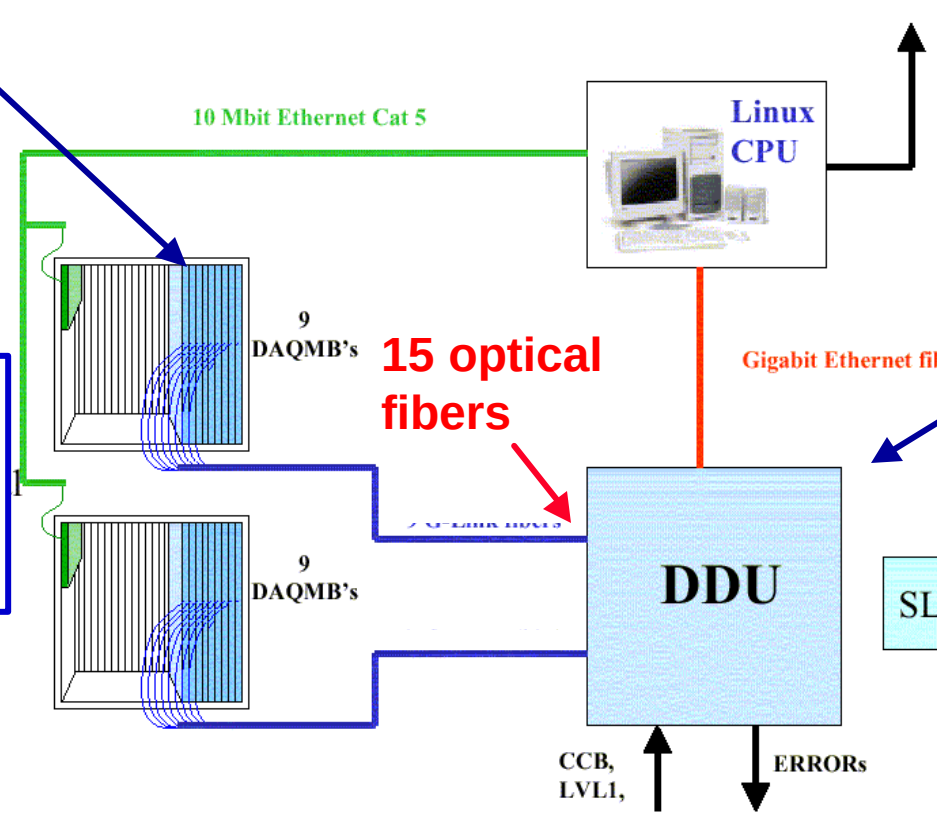


- 8 or 16 time samples are read out over a region 16 strips wide by 6 layers deep (3 kB or 5.4 kB)

CSC DAQ Path

1 DAQMB serves up to 5 CFEBs » 1 CSC

15 DAQMBs grouped into 20° sector (ME1–ME4)



Standalone DAQ ~18 rack-mounted PCs

CSC DDU aka "FED"

Sector Processors send L1 data

6–9 Data Concentrator Cards

Calculation of CSC Rates

J. Gilmore estimated the LCT occupancy per BX using the *L1CSCTrigger* package by UCLA applied to an unweighted min bias sample

Final numbers still need to be updated once the CMS Note on LCT trigger rates, in preparation by UCLA, is released

Web page prepared with CSC Data rates:

- è **http://www.physics.ohio-state.edu/~gilmore/cms/CSC_Occupancy2001.html**

CSC Data Rate Estimates

CSC Occupancy for LCTs per LHC Bunch

Preliminary Results based on 50,000 bunch crossings in full ORCA simulation

- Best-estimate algorithms as of September 2001
- 17 minimum bias events per crossing

L=10^{34}
100 kHz DAQ

- **First possibility: assume that only CLCT coincidence required with L1A** (16-time samples unless noted)

CSC per BX Occupancy for CLCT-only trigger	1 BX only	3 * 1 BX Result: for +/-1 BX	EMU Data Bandwidth	# Readout SLINKs Needed
No Neutrons	0.6	1.8	1070 MB/sec	6
Add Neutrons, all CSCs	1.2	3.6	2040 MB/sec	12
Add Neutrons, but no ME4/2	0.9	2.7	1560 MB/sec	9
Add **3*Neutrons**, all CSCs (imposed safety factor)	2.4	7.2	4000 MB/sec	23 [36]
Add **3*Neutrons**, but no ME4/2 (safety factor)	1.5	4.5	2530 MB/sec	15 [18]

±1 BX window on LCT requirement

Muon Enrichment of L1 Triggers

Average CSC occupancy in min bias BX:

- 0.9 LCT segments for high-lumi (0.7 with ALCT*CLCT)
- 0.9/17.3 = 0.052 per min-bias collision

L1 Trigger content:

- ¼ μ + 2 μ
- ¼ e + 2e
- ¼ jets + Etmiss
- ¼ e μ, e-jet, μ-jet, …

Estimate that half of L1 triggers have a single muon

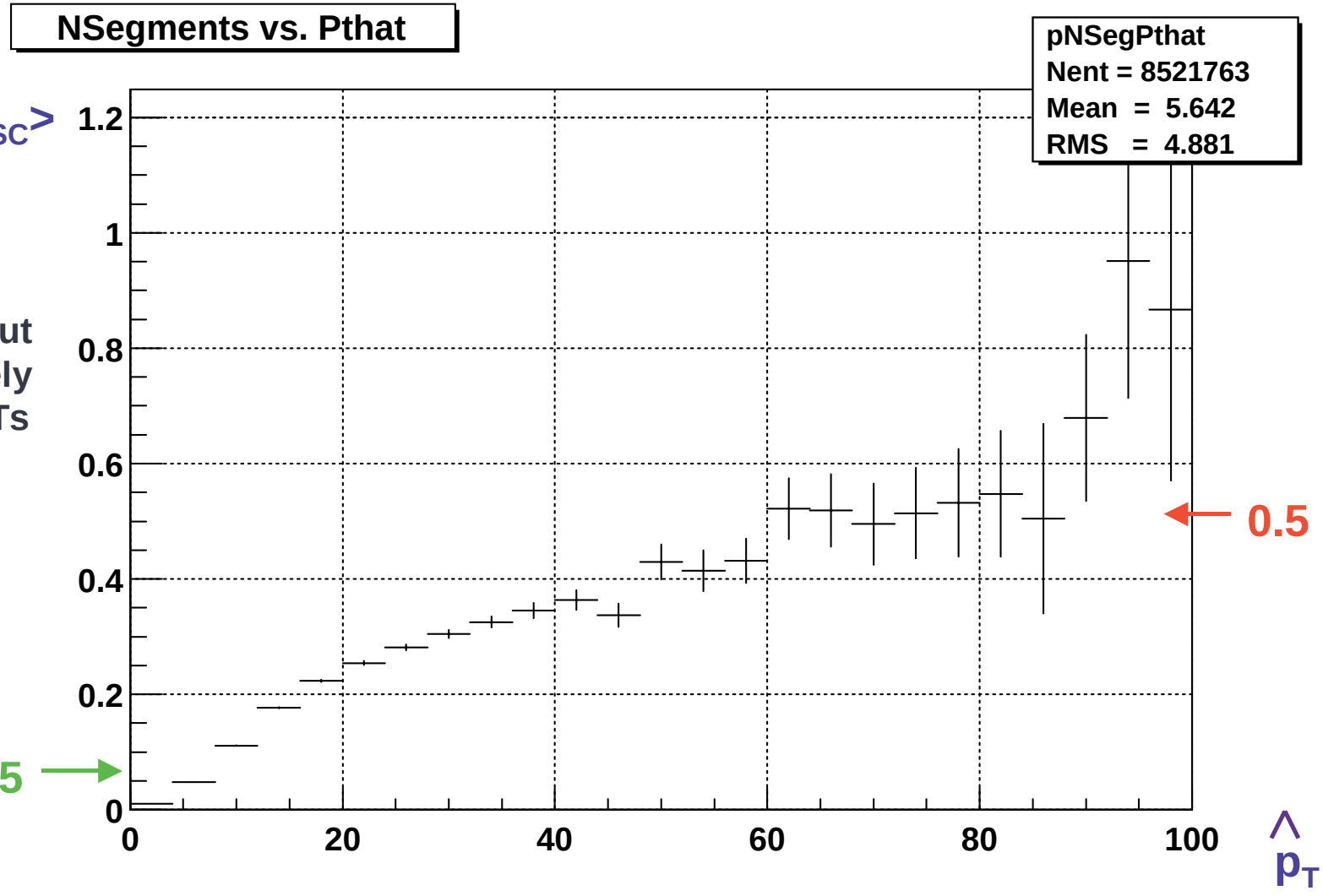
- Of those, half are in endcap and half in barrel
- Single muon has ~4 segments in endcap region
- CSC occupancy for μ triggers is 0.5*4 + pile-up ($0.052*N_{p/u}$)

Other half of L1 triggers come from calorimeter triggers

- Muon occupancy in calorimeter triggers will be higher than pure min-bias because of harder Pt scale of signal event

CSC Occupancy per MB Collision vs. p_T

Single min bias collisions from BigMB production



These are actually L2 segments, but approximately same as LCTs

CSC Occupancy per L1A

CSC readout includes pile-up LCT segments over 3 BX

Pure Min Bias pile-up:

- **High Lumi: $\langle N_{LCT} \rangle$ = 3*0.7 = 2.1 (ALCT*CLCT)**
- **Low Lumi: $\langle N_{LCT} \rangle$ = 3*0.9/5 = 0.54 (CLCT only)**

Signal + pile-up:

Single Muon triggers:

- **High Lumi: 0.5*4 + 2.1 = 4.1**
- **Low Lumi: 0.5*4 + 0.54 = 2.54**

Calorimeter triggers

- **High Lumi: 0.5 + 2.1 = 2.6**
- **Low Lumi: 0.5 + 0.54 = 1.04**

Average CSC occupancy for L1 triggers:

- **High Lumi: 3.4 (1.6X larger than pure min bias)**
- **Low Lumi: 1.8 (3.3X larger than pure min bias)**

Corrected CSC Data Rates

Low Lumi (2×10^{33}):

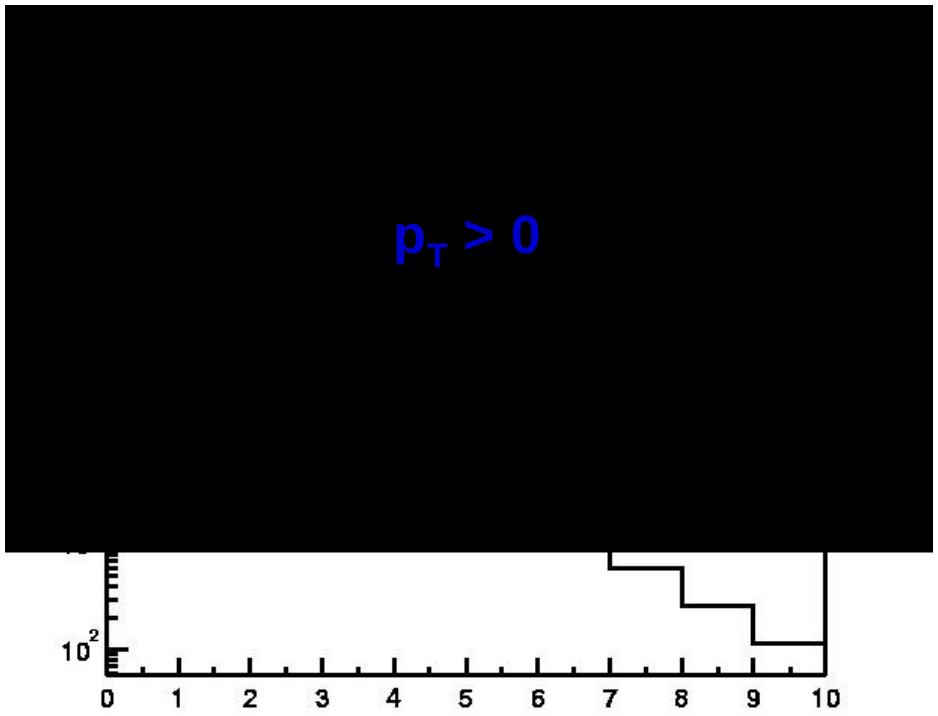
- ➔ 50 kHz DAQ, ME4 staged, 16 time samples, CLCT selection
- ➔ 500 MB/s (600 MB/s with 3´ safety factor on neutrons)
- ➔ Average occupancy is 1.8 segments Þ 10kB/event

High Lumi (10^{34}):

- ➔ 100 kHz DAQ, ME4, 8 time samples, ALCT*CLCT selection
- ➔ 1100 MB/s (1300 MB/s with 3´ safety factor on neutrons)
- ➔ Average occupancy is 3.4 segments Þ 10kB/event (8 time samples)

Fluctuations in Data Size

- In principle, need to sample from one of the following distributions of the number of CSC segments for the appropriate amount of pile-up
- In practice, with a 10 kB average event size, probably not a worry



$p_T > 80$

CSC segments per collision

CSC Calibration

Need to pulse anodes and cathodes:

- ➔ Find dead channels (very quick test)
- ➔ Measure fC-to-ADC count conversion and linearity (cathodes)
- ➔ Measure cross-talk
- ➔ Determine comparator and discriminator thresholds
- ➔ Measure analog and digital noise
- ➔ Determine offsets to comparators (cathode trigger)
- ➔ Inject known patterns to check LCT logic

Calibration Methods

Cathodes

- Inject charge into one channel of each FE board, read out all 96 channels
- Data volume per pulse: 3.5 MB
- Data volume for full calibration: ~300 GB
- Expect a full calibration to take 10–20 minutes
- Can use standalone DAQ system to collect data
- Full calibration constants checked periodically (monthly)
- Tests require no beams

Anodes

- Pulse wire group channels
- Smaller amount of data than cathodes
  - 1 bit versus 2 bytes, since only have discriminator data

CSC Special Triggers

Calibration data is not planned to be taken during normal collision running (i.e. during abort gaps)

Time synchronization necessary during commissioning

- ➔ **Histogram time distribution, look for LHC gap structure**
- ➔ **Significant amount of running during commissioning, but should be fixed once normal operation begins**

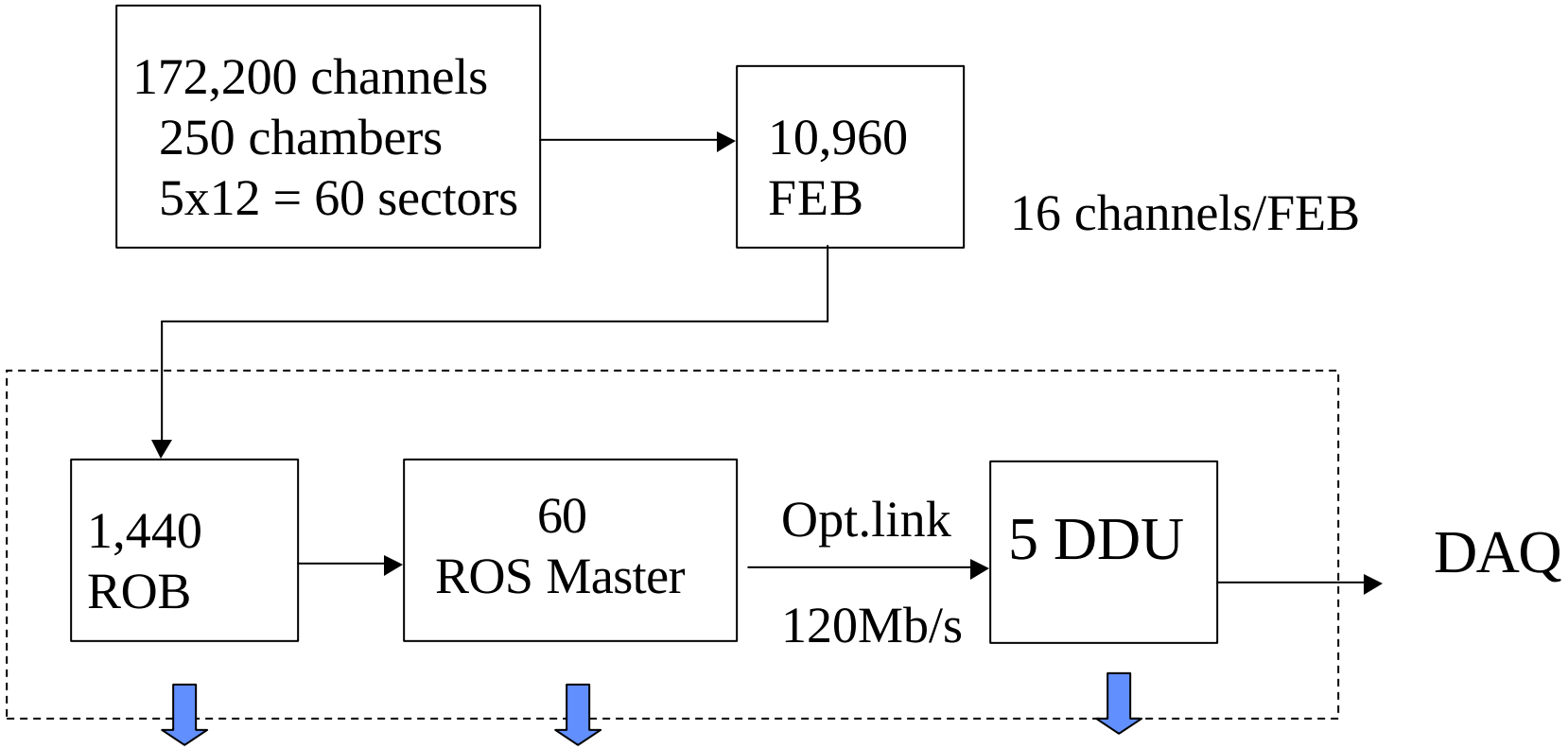
Accelerator muon triggers (i.e. "tunnel" or "halo" muons)

- ➔ **CSC Track-Finder (and GMT) will have the ability to trigger on muons traveling parallel to the beam axis during normal running**
- ➔ **Should be useful for in-situ alignment studies of chambers**
- ➔ **Amount of data needed not known, should not greatly perturb normal data rates**

Special loose triggers (heavily prescaled)

- ➔ **Single station trigger to measure CSC Track-Finder efficiency and to collect sample of collision muons for alignment studies**

DT DAQ Path


172,200 channels
250 chambers
5x12 = 60 sectors
10,960
FEB
16 channels/FEB
1,440
ROB
60
ROS Master
Opt.link
120Mb/s
5 DDU
DAQ
On chamber
"MINICRATE"
In 1 ROB: 4
32-channels TDCs
1 per sector
(4 chambers)
1 per 12 ROSM
(preliminary;
DDU design yet to be finalized)

Data rate & size (II)

➡ Total size: 9 KB/event

(including an estimated 35% overhead in headers-trailers; this is in a specific ROS format proposal; final one yet to be defined)

➡ Small amount of data => all DT data transferred to DAQ @ each L1A

➡ L2 input @ 100 KHz: 900 MB/s to DAQ

=> 900 MB/s / 60 = 120 Mb/s bandwidth on ROS-DDU links

DT Calibration Methods & Runs

Calibration runs currently foreseen:

1) **Threshold run**

2) **t0 calibration**

3) **rates**

4) **extraction gap test**

Event size is not expected to exceed normal event size.

Each calibration should take just several minutes during fill (or taken during run)

5) alignment with real muons

- prompt muons ($p_T > 50$ GeV/c) from GMT
- 0.2 – 1 Hz muon/sector

4 days needed @ L=2 10^{33} to reach 200 μm precision

=> ~ 1 TB dedicated data stored for off-line alignment analysis

(under certain assumptions on DB/B, see eg. T.Rodrigo et al. CMS-TN 96-005)

PRS/μ report

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Complete HLT selection for low-luminosity scenario	Dec.2001
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PRS/μ report

In Dec.'01 CMS week, results of
were presented, using the full simulation+reconstruction chain based on CMSIM+ORCA

≈ 10^6 events simulated (MB background + "signals":
W->μν, Z->μμ, tt ->μX,
H->WW->μνμν, H->4μ , H_{susy}->ττ->μX)

All events fully digitized with pileup at 2 x 10^{33} luminosity
Different DAQ scenarios (100 / 75 / 50 KHz) considered

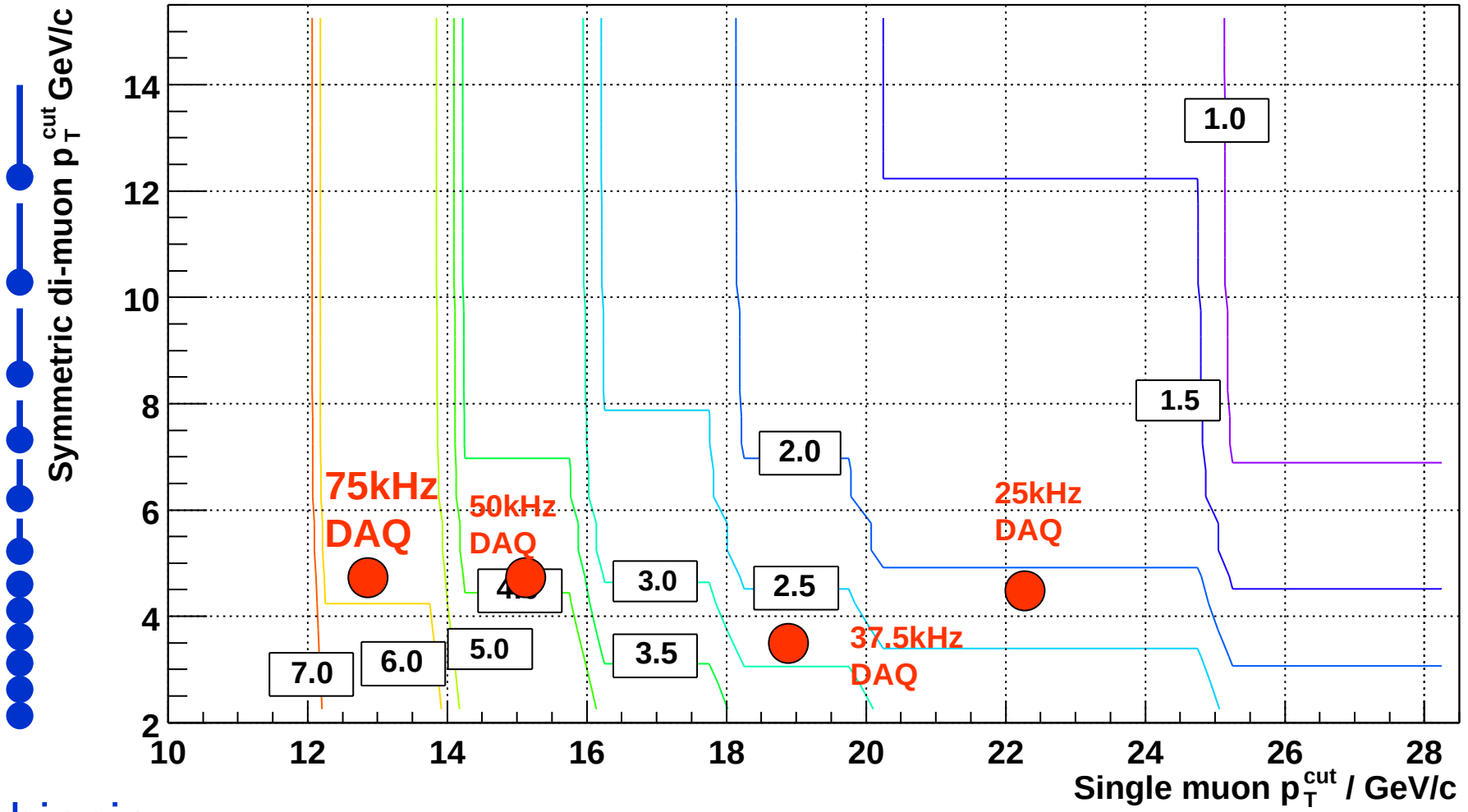
(details on report at general PRS meeting 6/12/01:
http: //cmssun4.pd.infn.it/~ugs/cms/hlt/Report_011206.pdf)

L1 single & di-muon trigger rates

symmetric di-muon cut, GMT Nov 2001 tune

L1 single and di-muon trigger rates

trigger rates in kHz



binning

Single μ stream: summary

	L1	L2	L2+iso	L3	$L3_{Pxiso}$
p_T (GeV)	14.	14.	14.	22.	22.
Rate(Hz)		900.	500(calo)	90.	
			(pixel)		
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

ε

$t \rightarrow Wb \rightarrow \mu\nu X$

efficiencies must be multiplied by geometrical acceptance
(ε_{acc}= 0.57 for $W \rightarrow \mu\nu$, 0.92 for $H \rightarrow \tau\tau$)

L1

L2

L3

A.Fanfani