CMS Luminosity

JTREM IV

Valerie Halyo for Lumi Team

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Lumi team Effort for HF based Lumi

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Talk Outline

- Overview on Luminosity
  - Goals
  - Design strategy
  - Method
- Absolute Lumi normalization
- Lumi dataflow
- User Info
- Conclusions

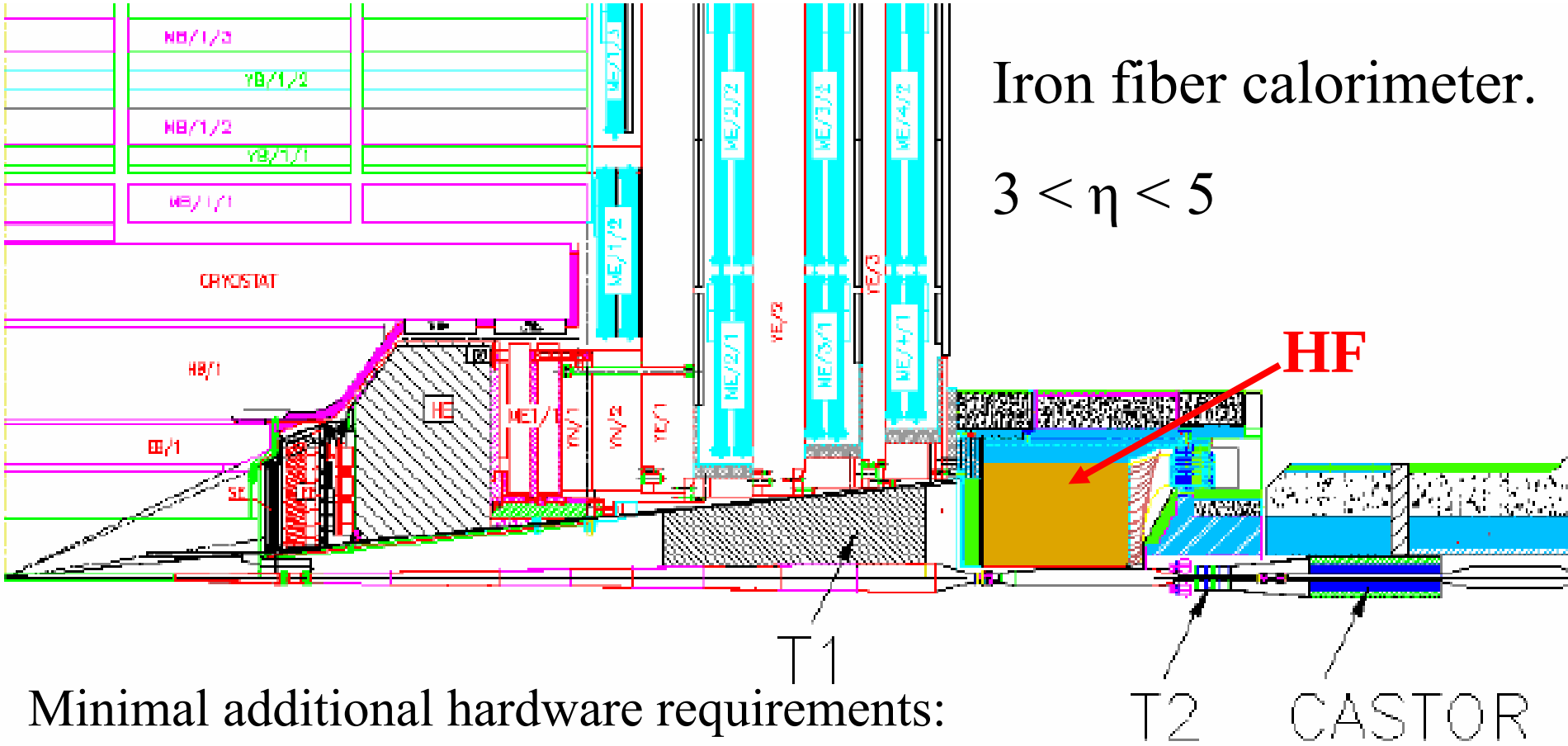
Design Goals: General Desirables

- Absolute calibration, based on a known cross section with a reliably calculated acceptance.
- Temporal stability against gain changes and other drifts: "countable objects" or self calibrating signals (e.g., MIP peak).
- Linearity over a large range of luminosities.
- Real time operation independent of full DAQ.
- Redundancy
  - There is no perfect method
  - Applies to both real time monitoring and to offline absolute normalization

General Strategy

- Use absolute calibration of machine luminosity or TOTEM measurement as a reference point.
- Use real time techniques (HF, Pixel Telescopes, BRAN) to extrapolate/interpolate to design luminosity
- Normalize the luminosity using processes of ~known cross section (e.g., W's and Z's)

Signals From HF



Minimal additional hardware requirements:

- Mezzanine board to tap into HF data stream and forward bits to a server via Ethernet
- Autonomous DAQ system to provide "always on" operation

T1 & T2 are elements of TOTEM

HF Methods

Methods:

- Count “zeroes”
- Use also linear E_T sum, which scales directly with luminosity.

Simulations:

Full GEANT4 with realistic representation of photo statistics, electronic noise and quantization, etc. within the framework of CMSSW

Tower Occupancy Method

The average fraction *f*, of empty towers per bunch crossing is given by:

$$\langle f \rangle = e^{\mu(p-1)} \Rightarrow -\ln\langle f \rangle = (1-p)\mu$$

Where:

p = probability that a given tower is empty after ***single interaction***,

μ= mean number of interactions per bunch crossing.

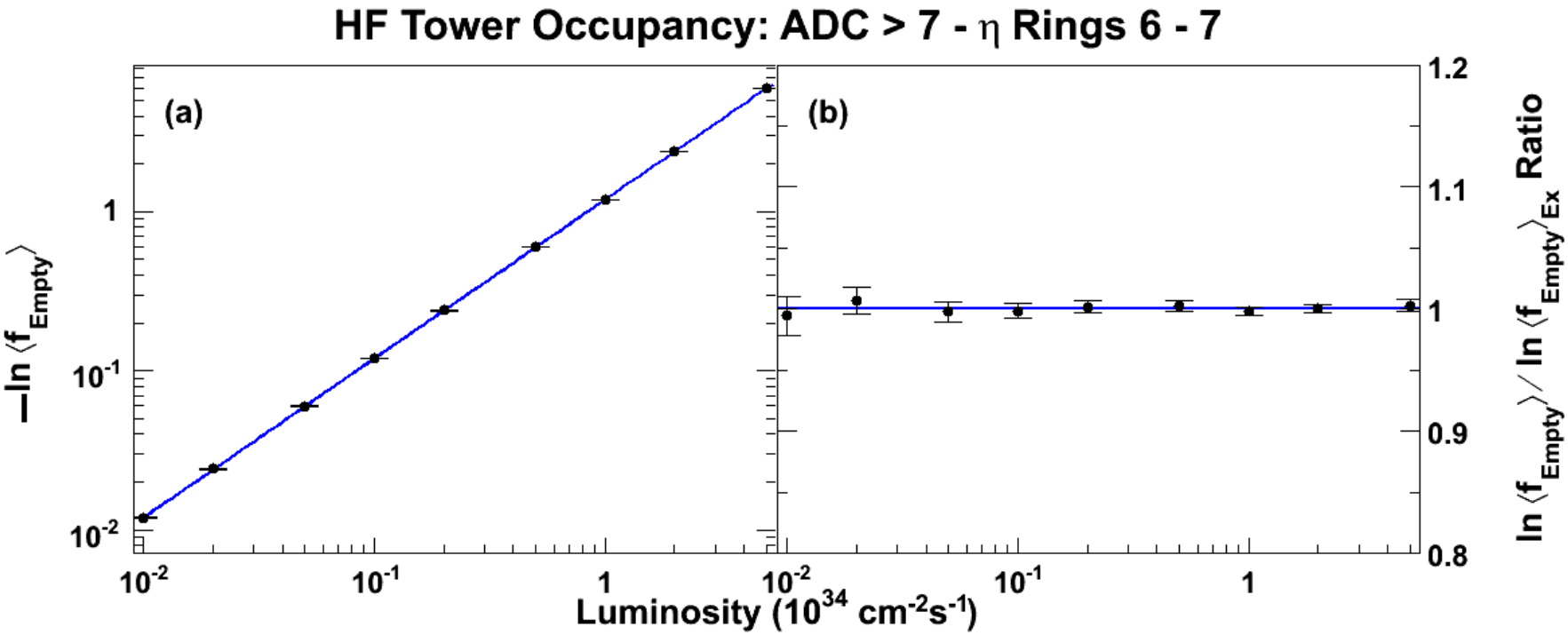
Tower Occupancy Method

In real life in order to decide whether a tower is empty we have to introduce a threshold cut which would cut somewhat into our signal and therefore introduce a correction to our previous result

$$-\ln\langle f \rangle = (1-p)(1-\varepsilon)\mu + \mathrm{N}$$

This term is a measure of the overlap between the signal and noise distribution below the threshold

Tower Occupancy Status



Nadia Adam

we plan to use two sets of two rings.

E_T Sum Method

Average transverse energy per tower per BX

$$\langle E_T \rangle = \nu(1-p)\mu + \mathrm{N}$$

Where:

p = probability that a given tower is empty after ***single interaction***,

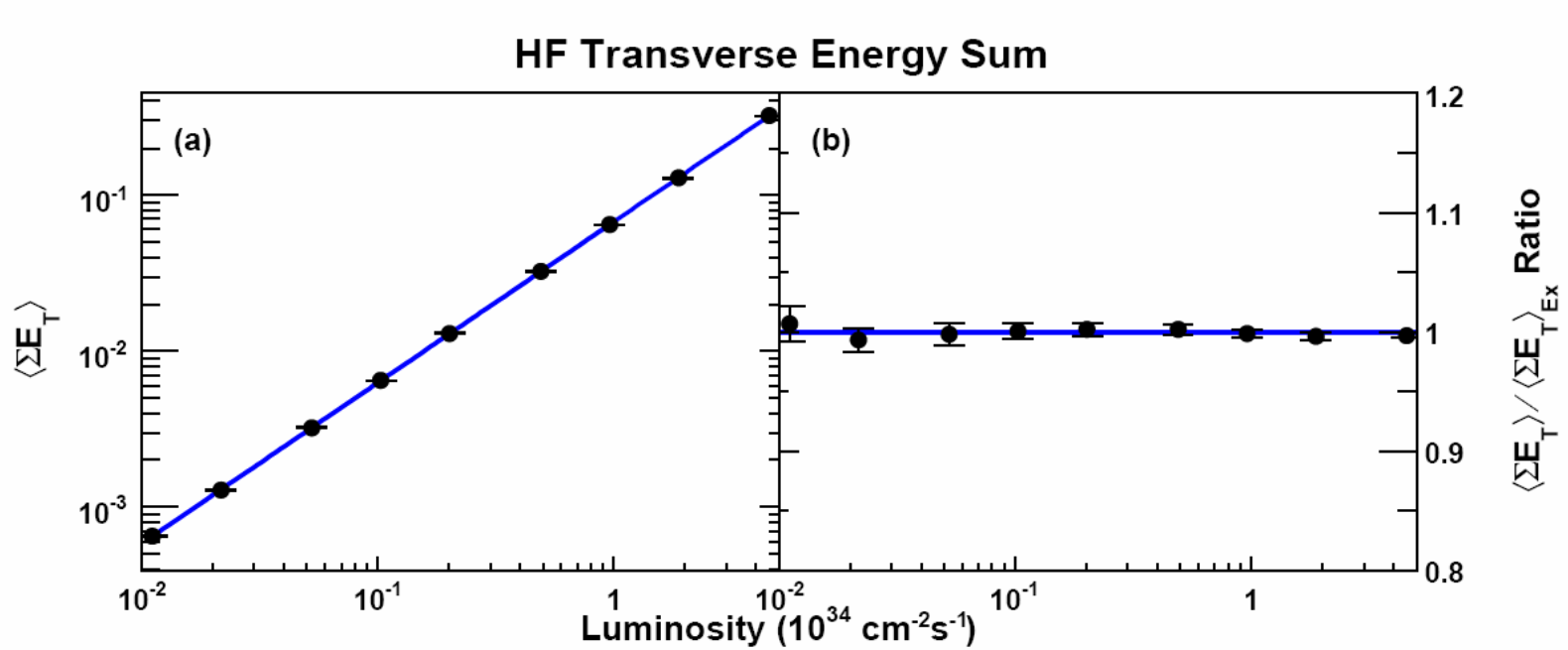
ν= <ET> for a single occupied tower in a single interaction

μ= mean number of interactions per bunch crossing

N= Noise contribution.

E_T Sum Status

The average EtSum is linear over all the expected luminosity dynamic range



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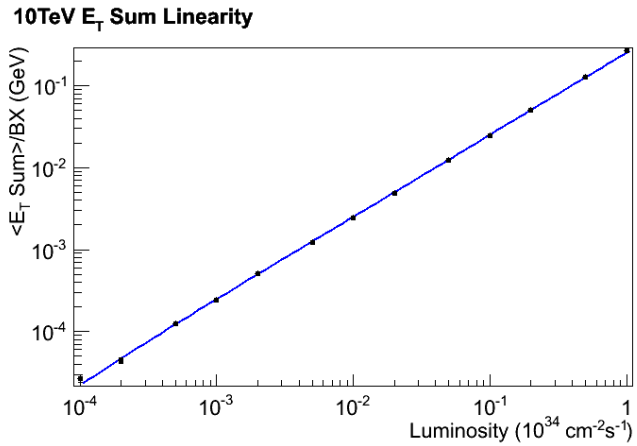
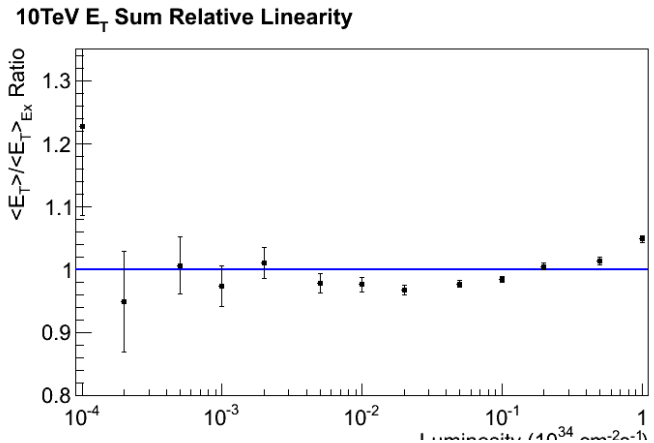
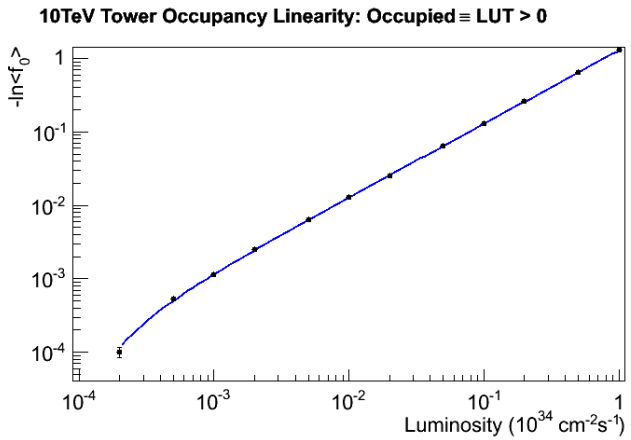
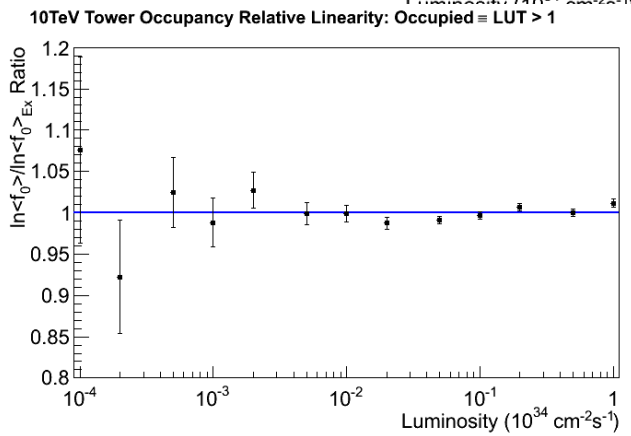
Any noise offset would be calibrated out by using the the Hlx data during the abort gap

Update for 10TeV (3_2_x)









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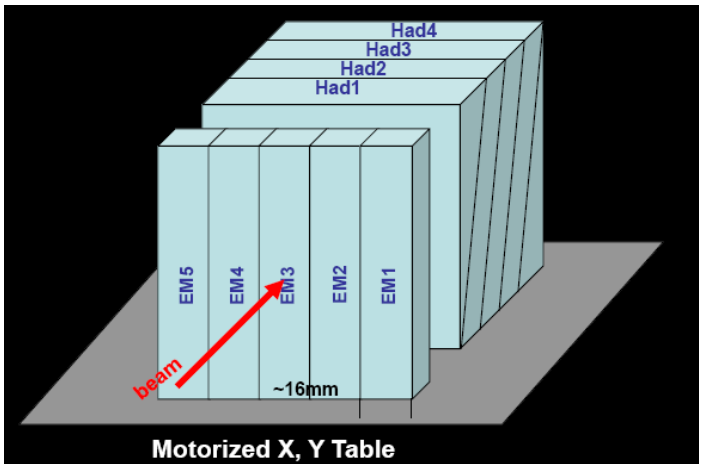
Luminosity Monitors: ZDC,BRAN

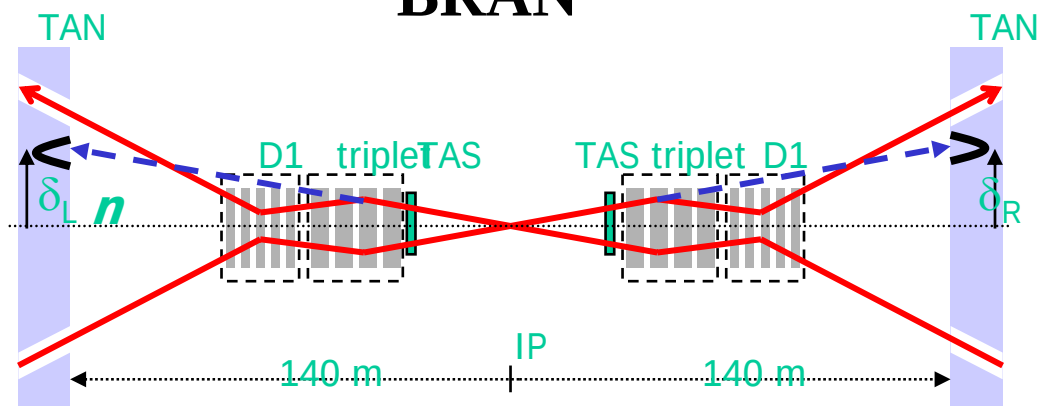


ZDC

The design of each ZDC Includes (EM section) and (HAD section).

The LHC accelerator project incorporated fast ionization counters, in the TAN region, which is ±140m from the IP

BRAN



The Luminosity Calibration

- None of the methods discussed provides an absolute calibration for the luminosity
- Initially determine a luminosity calibration using the luminosity measurement from the LHC's measurement of beam parameters.
- Stick with that normalization until we have had a chance to study
    - CMS measurement of $\sigma_{W/Z.}$ pp->ppμμ
    - Total cross section from TOTEM

Projected Integration Times for VdM

LHC Beam Parameters

Stage	Energy[TeV]	Bunch Configuration	$\beta^*[m]$	Luminosity[$cm^{-2}s^{-1}$]	Event rate/crossing
A	0.9	2×2	11	2.6×10^{27}	0.006058
A'	10	2×2	11	2.9×10^{28}	0.0974
A'	10	2×2	2	1.6×10^{29}	0.5375
A'	10	43×43	2	6.9×10^{30}	1.0780
A'	10	156×156	2	2.49×10^{31}	1.0723
A'	10	156×156	1	1.615×10^{32}	6.9550

Integration Times based on Statistical Errors using EtSum Method

Stage	Luminosity[$cm^{-2}s^{-1}$]	Ave Time [s] 1%	Time [s] 5%	Ave Time [s] 5%	Time [s] 10%	Ave Time [s] 10%
A	2.6×10^{27}	-	-	-	425.6042	227.7675
A'	2.9×10^{28}	20.6513	1.5684	0.8261	0.3921	0.2065
A'	1.6×10^{29}	3.9007	0.3093	0.1560	0.0773	0.0390
A'	6.9×10^{30}	0.1019	0.1466	0.0041	0.0366	0.0010
A'	2.49×10^{31}	0.0407	0.1473	0.0016	0.0368	0.0004
A'	1.615×10^{32}	0.0034	0.0190	0.0001	0.0047	0.00003

Zhiming Shi

Update on Lumi from Z xsec

Our recent study shows the systematic error on the Z cross section to be the following

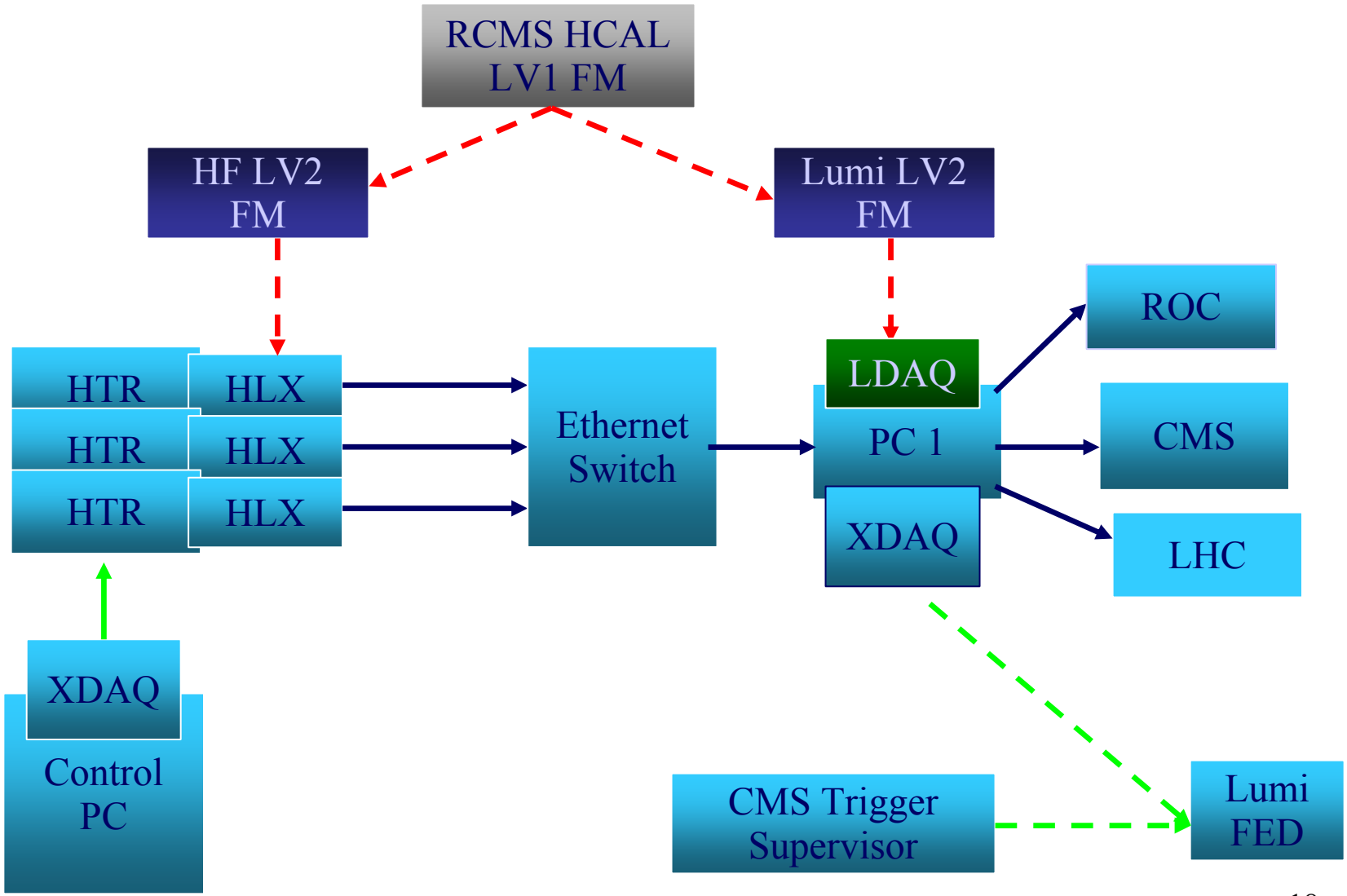
	Z	
Error	$\Delta\sigma$ (%)	ΔA (%)
Higher Order	0.23 ± 1.25	-1.97 ± 1.51
QCD Scale	0.92 ± 0.61	1.58 ± 1.35
PDF	2.75 ± 0.00	1.03 ± 0.00
Total	2.91 ± 0.22	2.73 ± 1.35

Hence the absolute luminosity measurement will be dominated by statistic at startup

CMS AN-2009/088

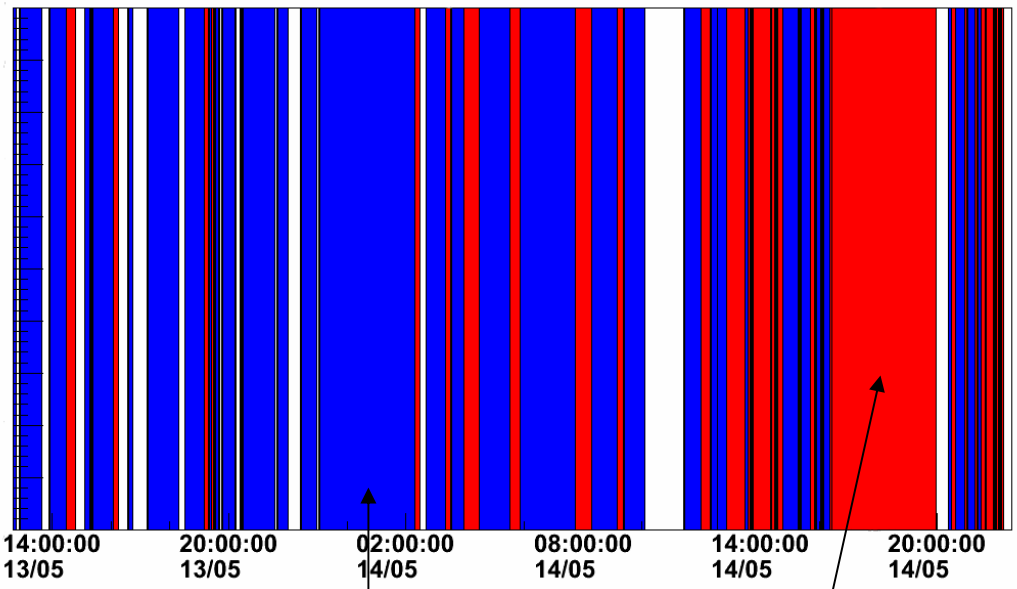
JHEP **09** 2008 133 , *JHEP* **05** (2008) 062

HF Luminosity Readout Path



Lumi Continuous Running Mode

Adam Hunt



Lumi as LV2 FM
Communicates to
HCAL L1FM

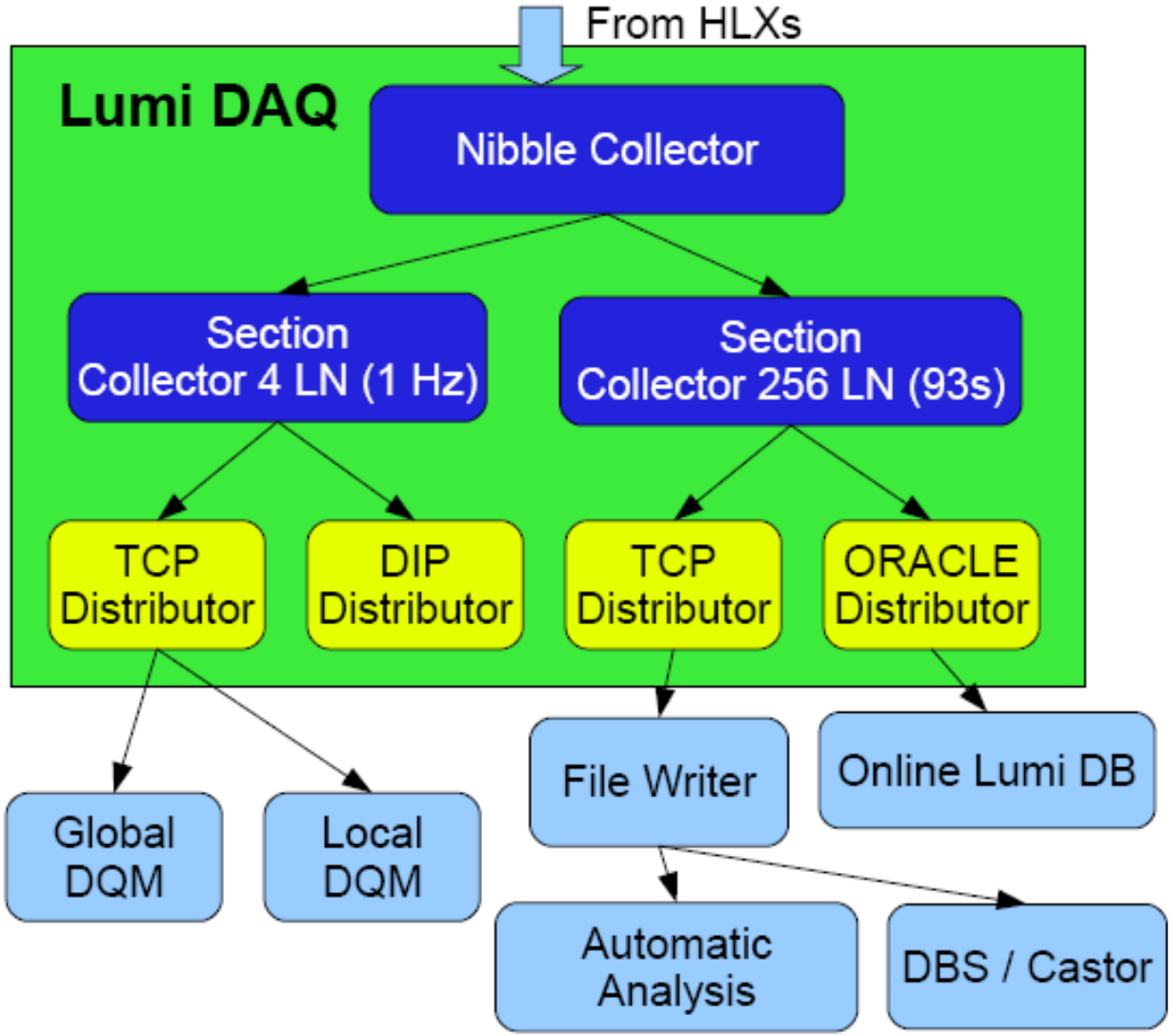
Lumi start with CMS
And continuous until
the next 0C0

Extra Lumi Run

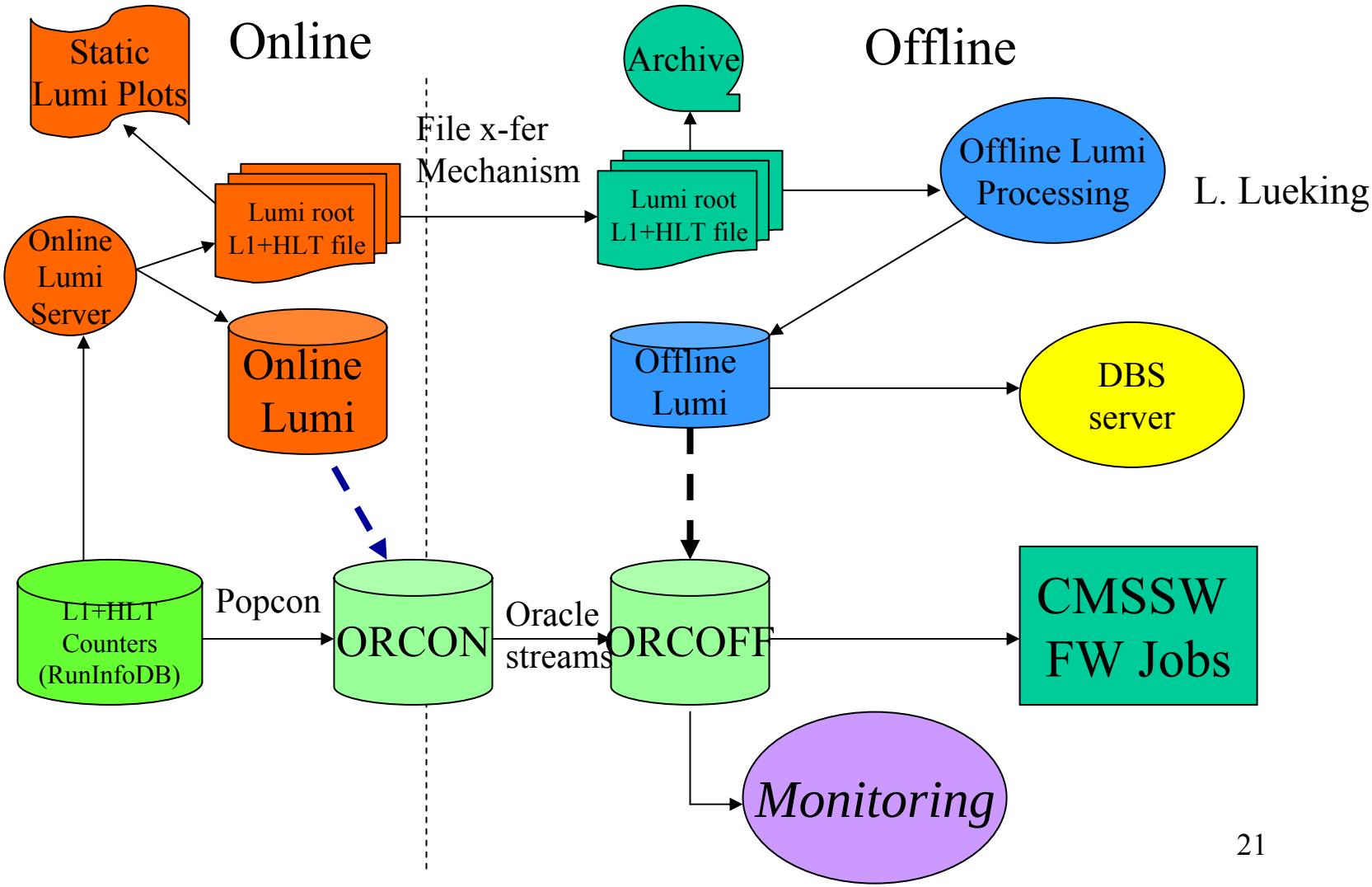
Both HCAL + Lumi run

Lumi run 87% of time
CMS was on 57% of the time

Software Architecture



Schematic diagram of lumi DataFlow



User Info

- Summary and details luminosity data would be loaded into the event during prompt reconstruction.
- The loading happens ~24h from the end of the run
- Lumi data is defined in CMSSW/DataFormat/Luminosity

Lumi Summary	Lumi Details
Inst Lumi/LS	EtSum+Occ
Error Lumi	Bunch by Bunch Lumi
Quality of Lumi	Error on Lumi
Scalers	Lumi Quality
deadTime	

Lumi Data

- Lumi ROOT file is accessible in DBS (Local DBS at the moment)

  - "find file where file like *CMS_LUMI%
  - In DBS Prod Tier0

  - Lumi data structure in ROOT file described in LumiWiki_ROOTFileStruct (update in progress)

Lumi Discovery page

- Once DAS + Lumi integration is complete
- A query page would be available to calculate the lumi for on demand
- The page would interface Lumi+DBS+Quality+Config DB

and allow the user to correlate the different inputs

Lumi Monitoring

- Can be accessed from **LumiWiki_DataQualityMonitoring**
- Online:
  - DQM
  - Static plots from our raw data
  - LHC monitoring accessed from WBM
  - OMDS browser a week of lumi data
- Offline
  - Offline plots of processed lumi data (under development)

New Offline Monitoring Tool

Web CondDB - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

https://cmsweb.cern.ch/conddb/lumi/index

Princeton SPIRES arXiv CDS Wikipedia Gmail PDG CMS Lumi Page Private EVO DiLepton Lumi LumiSystemOperations MyQED IM

https://svn.prince...tion_VH_OJI08.tex | Web CondDB

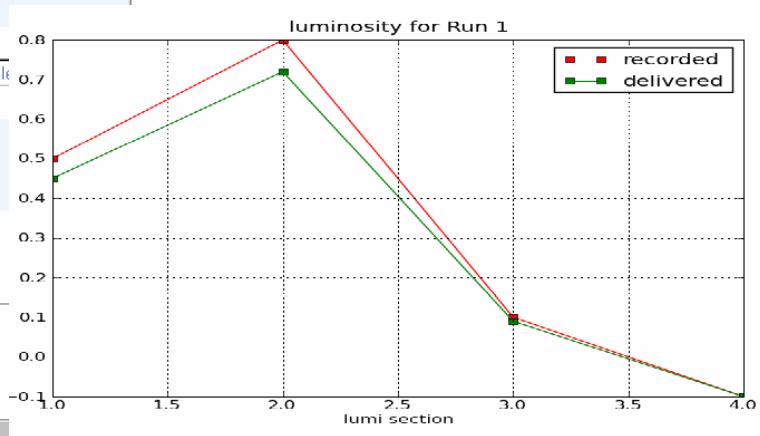
Dashboard DBS Discovery ProdRequest PhEDEx SiteDB CondDB Support valerieh » logout

CondDB Navigation :: Overview - IOV Management - IOVOld - Global Tag - Luminosity

dummy | cms_orcoff_prod

dummy

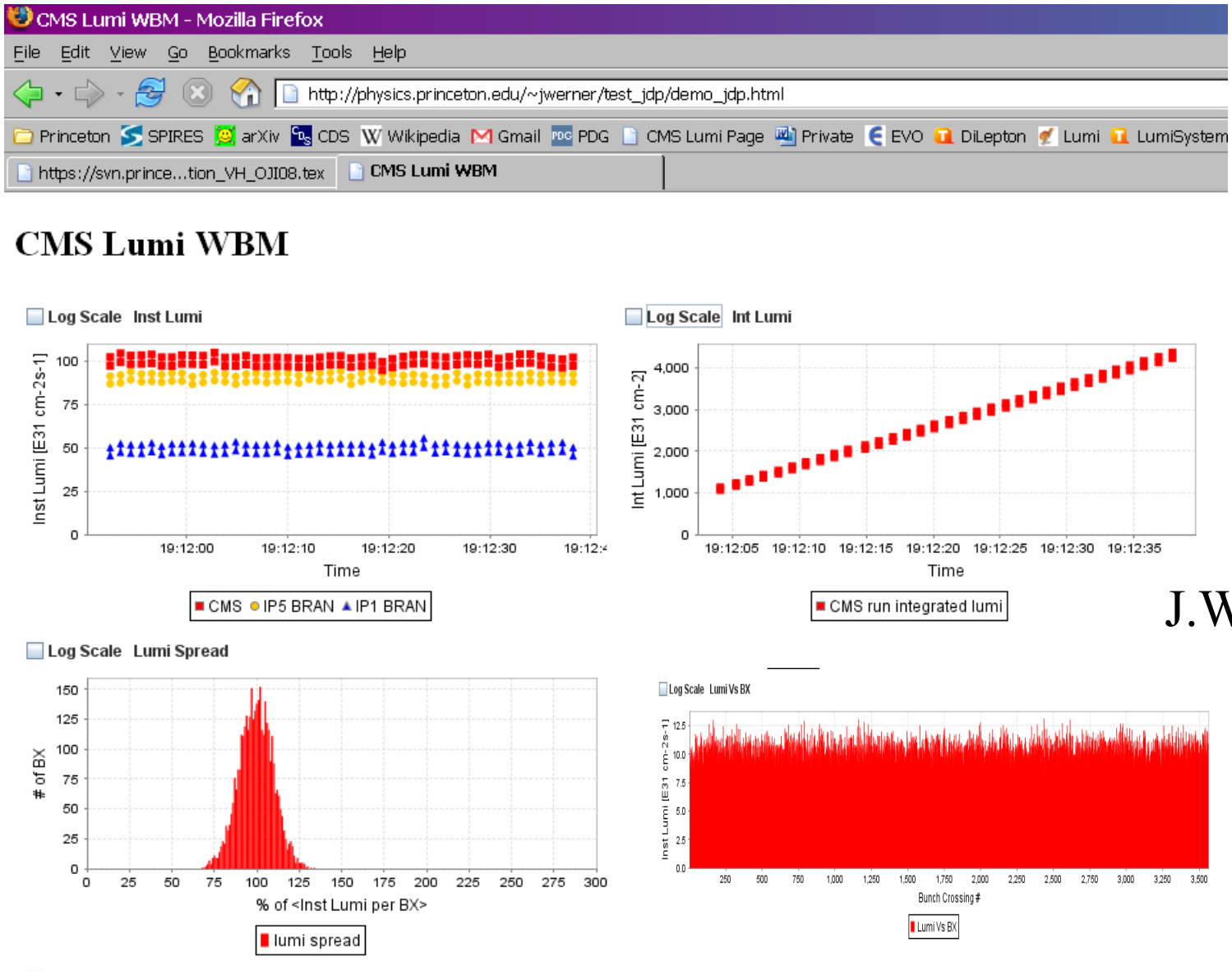
tag name	class/record	start run	end run	revision	operationlog	plot
chi	luminosity	1	4	0	USER=futyand HOSTNAME=srv-C2C04-21 PWD=/nfshome0/futyand/CMSSW_3_1_0_pre9/src	--select a run--
cruzet	luminosity	80	84	0	USER=futyand HOSTNAME=srv-C2C04-21 PWD=/nfshome0/futyand/CMSSW_3_1_0_pre9/src	--select a run--
craft	luminosity	9,080	9,084	0	USER=futyand HOSTNAME=srv-C2C04-21 PWD=/nfshome0/futyand/CMSSW_3_1_0_pre9/src	--sel
crame	hltinfo	9,080	9,090	0	USER=futyand HOSTNAME=srv-C2C04-21 PWD=/nfshome0/futyand/CMSSW_3_1_0_pre9/src	
cream	hltinfo	10	90	0	USER=futyand HOSTNAME=srv-C2C04-21 PWD=/nfshome0/futyand/CMSSW_3_1_0_pre9/src	



Find: rutgers Find Next Find Previous Highlight Match case

Zhen Xie

LHC Monitoring



J.Werner

Conclusions

- CMS will use multiple relative luminosity monitors
- The Calibration procedure is well planed
- Several studies on W/Z and pp->ppmumu to calibrate lumi exist
- Lumi is operating in “Continuous mode”
- Lumi is planned to be loaded into the event during CRAFT
- ROOT files should be accessible via DBS
- Discovery page depends on DAS + lumi integration
  - Estimate (D. Evans) multi variable query capabilities might be accessible