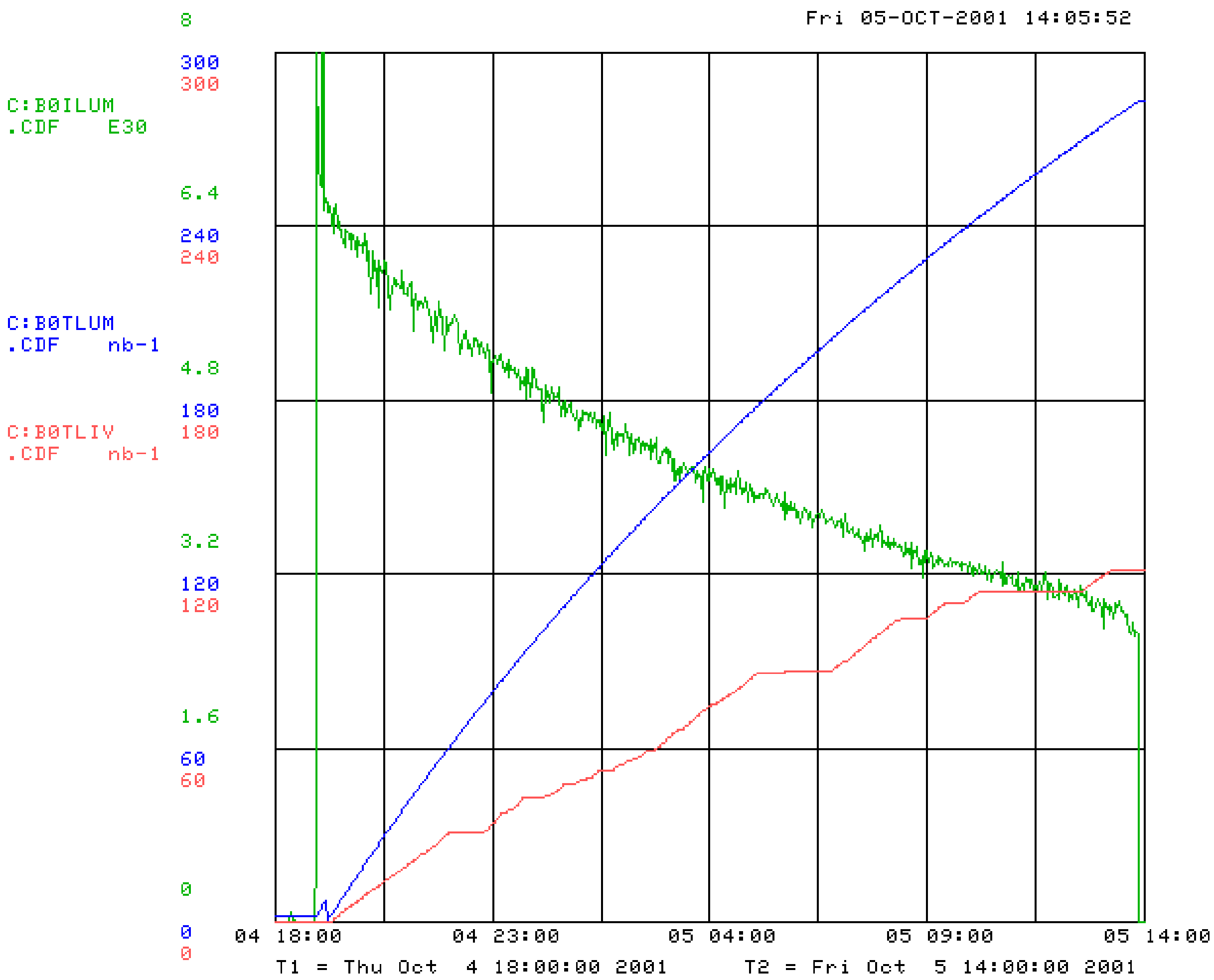
CDF's Luminosity for Aug-Oct 2001

(and beyond)

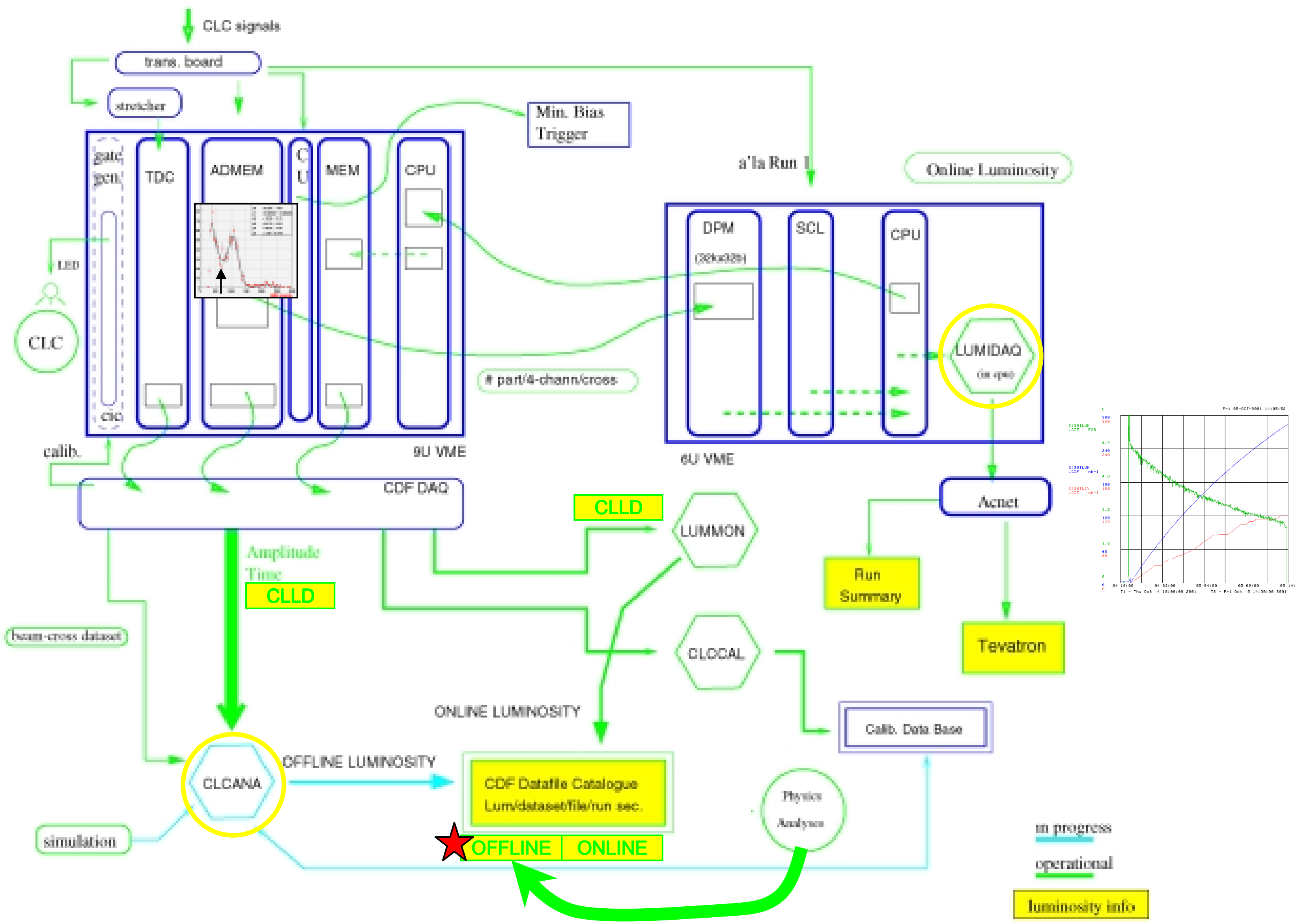


- **Lum. Information**
  - o Accessing it
- **Measurements**
  - o Uncertainties
  - o Cross-checks
- **Plans**

- Luminosity Group
  - D. Acosta
  - S. Klimenko
  - J. Konigsberg
  - A. Pronko
  - A. Sukhanov
  - D. Tsybychev
  - S.M. Wang
  - + …

J. Konigsberg
Ops. meet 12/13/01

Luminosity Information



Official Luminosity in the Datafile Catalog

http://cdfsga.fnal.gov/upgrades/computing/projects/dfcatalog/dfcatalog.html

- Runs are divided up into **runsections** (~30 sec of online run time) and the integrated luminosity is calculated by runsection by the Luminosity Group:
  - The online information is filled by LumMon
  - The offline information is filled after offline analysis → this is the official Lum
    - →recently done for Aug 8th to Oct 6th
- "To obtain the total integrated luminosity for a given data sample one should know the exact list of runsections contributing to the sample" (Data Handling group)

Data Sample Luminosity Sum (LumSum)

- When the luminosity for a secondary dataset is calculated, all runsections from which the primary dataset was obtained should be taken into account.
  - **When events are filtered out in a secondary dataset and no events are left from a given runsection the DH keeps an empty runsection record (ERS).**
  - **!!!Warning: Cutting out runs in a secondary dataset (low lum or “bad”) keeps the ERS’s for those runs: lum is overestimated… a solution in the works (DH)**

- Determination of the luminosity for a dataset is thus a <u>two-step procedure</u>:

1. Use DHInput “talk to”: setInput log=<log-file-name> command
   - A list of all contributing runs/runsections will be written into the log file.
2. Process log file with stand alone utility program LumSum which retrieves the necessary information from the database and integrates it.

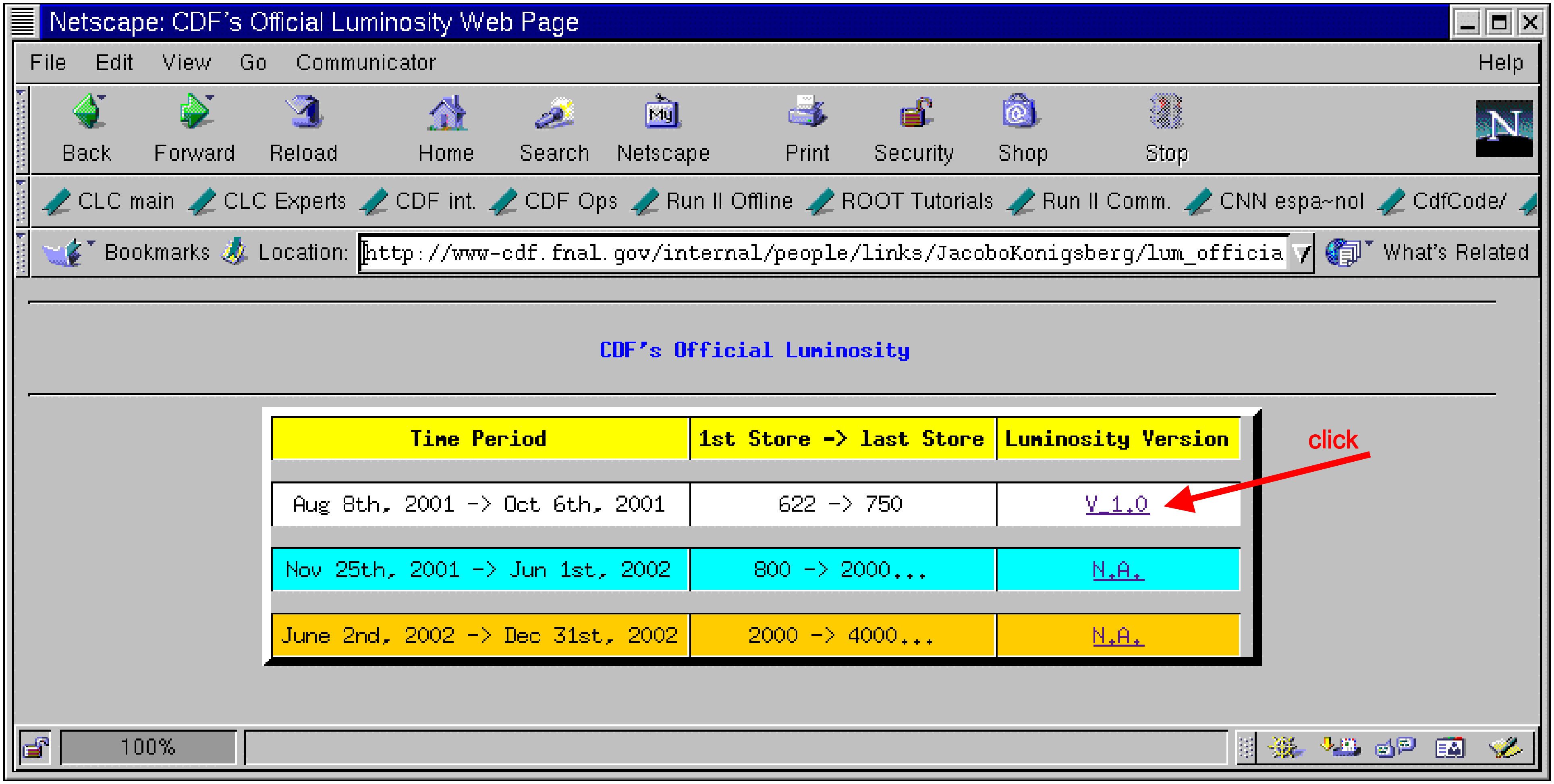
- LumSum utility is hereby released (Valentin Necula: allan@phys.ufl.edu)

LumSum Example

- # Data processing log for the process PID 59925341 generated by DHLogger
- OIF /cdf/data05/s7/data_val/HighPtElectrons/ElectronSample_4238.dat
- R 126998
- S 0 38
- R 126999
- S 0 0
- S 8 112
- R 127016
- S 0 11
- R 127017
- S 0 10
- S 13 13
- S 15 19
- S 24 25
- .
- .
- .
- CIF /cdf/data05/s7/data_val/HighPtElectrons/ElectronSample_4238.dat
- OIF /cdf/data05/s7/data_val/HighPtElectrons/ElectronSample_4238.dat_1
- R 127023
- S 24 24
- .
- .
- .
- OIF /cdf/data05/s7/data_val/HighPtElectrons/ElectronSample_4238.dat_1
- .
- .
- .
- CIF /cdf/data06/s2/top/HighPtElectrons/ElectronSample_4295.dat_1

- LumSum log-file-name
- Output for inclusive high-pt electron dataset:
  - ***Integrated Luminosity: 3.279 pb-1***
- Too high due to ERS from filtered runs
- In reality: ~ 2.2 pb-1
  - ***From assuming at least one event/run***
  - ***Made new log file and integrated over those runs…***

Luminosity Version 1.0



CDF's Official Luminosity

Time Period	1st Store -> last Store	Luminosity Version
Aug 8th, 2001 -> Oct 6th, 2001	622 -> 750	V_1.0
Nov 25th, 2001 -> Jun 1st, 2002	800 -> 2000...	N.A.
June 2nd, 2002 -> Dec 31st, 2002	2000 -> 4000...	N.A.

Luminosity V_1.0

- **Procedure:**
  - Based on the Online "hit counting" measurements done in the standalone CLC 6U crate which are read out into the CLLD bank
  - Lummon looks at the CLLD bank for events within 1 run section and takes the difference in live integrated luminosity between the 1st and last event to calculate the total integrated luminosity per run section. This value is then entered into the Online Luminosity column in the CDF II Datafile Catalogue.
  - We apply corrections to the Datafile Catalogue Online values, as described below, and fill the Datafile Catalogue Offline values.

    --> These Offline values are what users should access to calculate their dataset luminosity
  - We estimate the uncertainty in the total integrated luminosity for this version to be +/- 10% dominated by the absolute nromalization. This will be reduced in future versions with better MC simulation and further data studies.

- **Details on the Online "hit counting method" :**
  - Used the two CLC outer layers
  - Used Xilinx code with 500 ADC counts as the hit counting threshold
  - Required at least one hit per CLC module (East/West) in coincidence before counting
  - Used the following calculation: Lum = (f / Sigma_clc) * (Nhit / <Nhit>1)
  - f = tevatron's frequency = 36/(159*132 ns) = 1.715 MHz
  - Nhit = measured number of hits in a time period of ?????seconds/periods???
  - Sigma_clc = effective CLC cross section for an East-West coincidence (500 ADC counts)
  - <Nhit>1 = Avg. number of hits (East+West) in a single p=pbar interaction
  - We used the following values for Sigma_clc and <Nhit>1:
    - For 122255 < run < 126686 :

      <Nhit>1= 13.8 and Sigma_clc = 36.5 mb
    - For run .ge. 126686 :

      <Nhit>1 = 16 and Sigma_clc = 37.78 mb

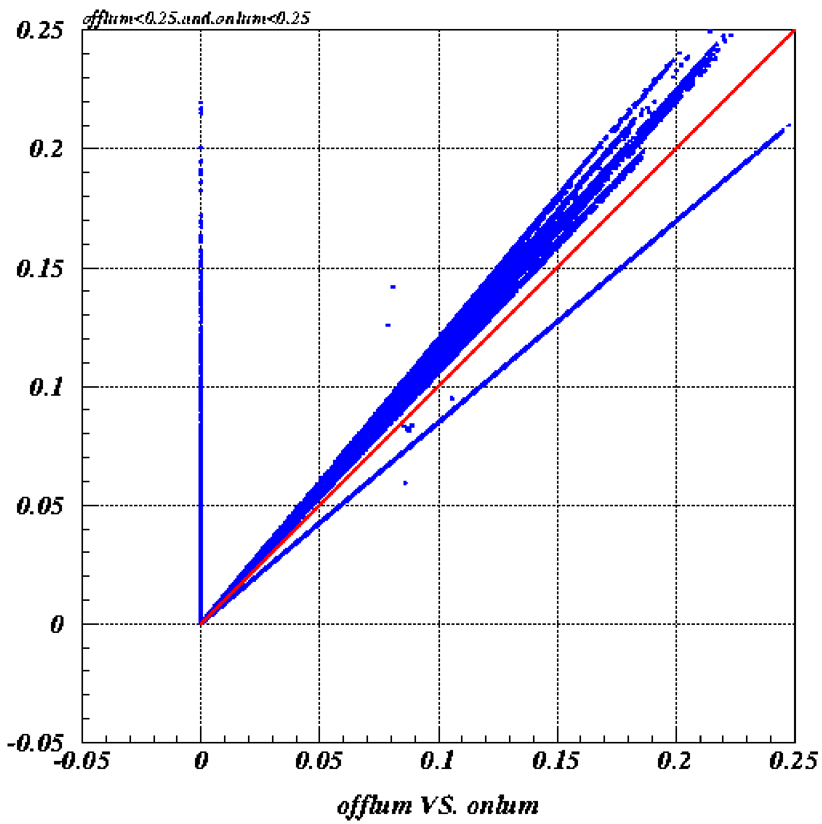
100%

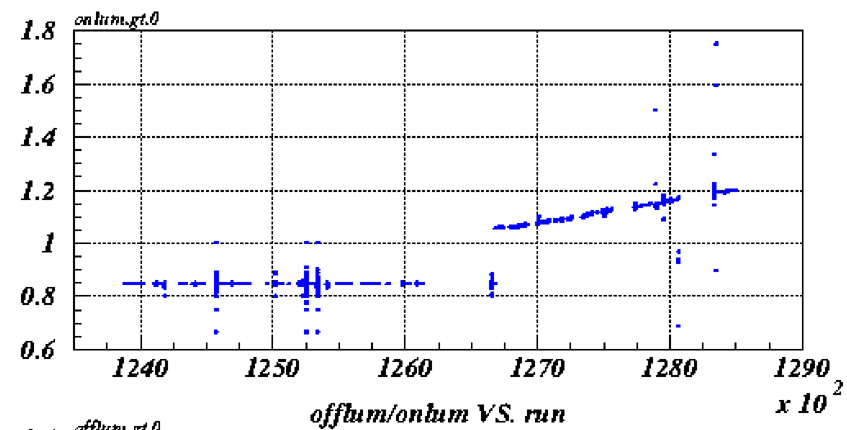
Version 1.0 corrections

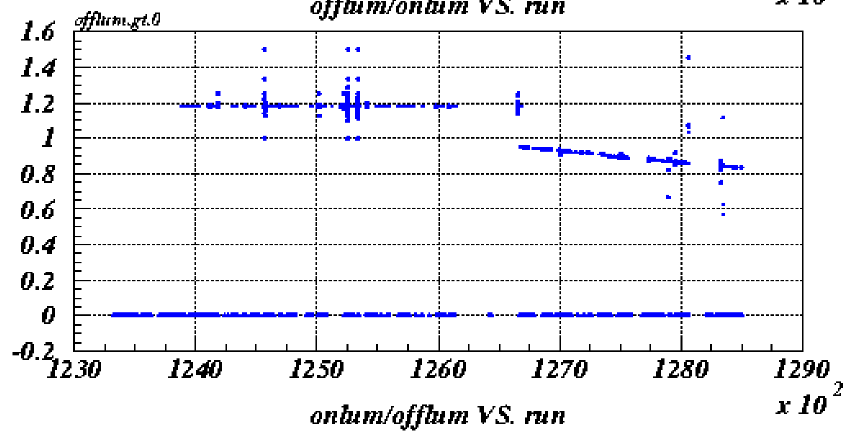
- **Corrections to the Online measurement:**
  - Filled gaps for run sections with zero Online luminosity due to Lummon failure
    - If for a given run more than 10% of the runsections in the Online Datafile Catalogue were zero then the Offline value of these runsections is set such that the total run luminosity is in agreement with the ACNET value (taken from the Run Configuration database). This happened for 25% of the runs that had a luminosity greater than 1 nb in ACNET.
    - If less than 10% of the runsections are zero we used a linear interpolation from adjacent non-zero runsections to compute the Offline luminosity for these runsections. If the run starts(ends) with runsections having zero luminosity then these are set to the value of the first(last) non-zero runsection.
  - For runs between 122255 and 126686 (between July 31st, 2001 and Sept 14th, 2001) we had an effective cross section such that the Online luminosity was measured 20% higher than it should have been.
    - We multiplied the Online Data catalogue values by 0.83 for these runs
  - Correction due to CSL not sending all events to Lummon
    - Lummon needs the first and last event of a runsection to calculate the full integrated luminosity. The CSL in many cases does not send these events and on average Lummon underestimates the luminosity by 2%.
  - Correction due to PMT gain drift between Sept 14, 2001, and Oct 6, 2001
    - The effective CLC cross-section and the number of hits per single interaction change if the PMT gain changes (due to the fixed Xilinx thresholds in the Online measurement). Offline corrected for this by looking at the single particle peak and applying thresholds relative to these peaks. We find a correction in the form of: L_offline = (1.035 + 0.0062 * t [days]) * L_online

100%

By runsection: Offline vs Online







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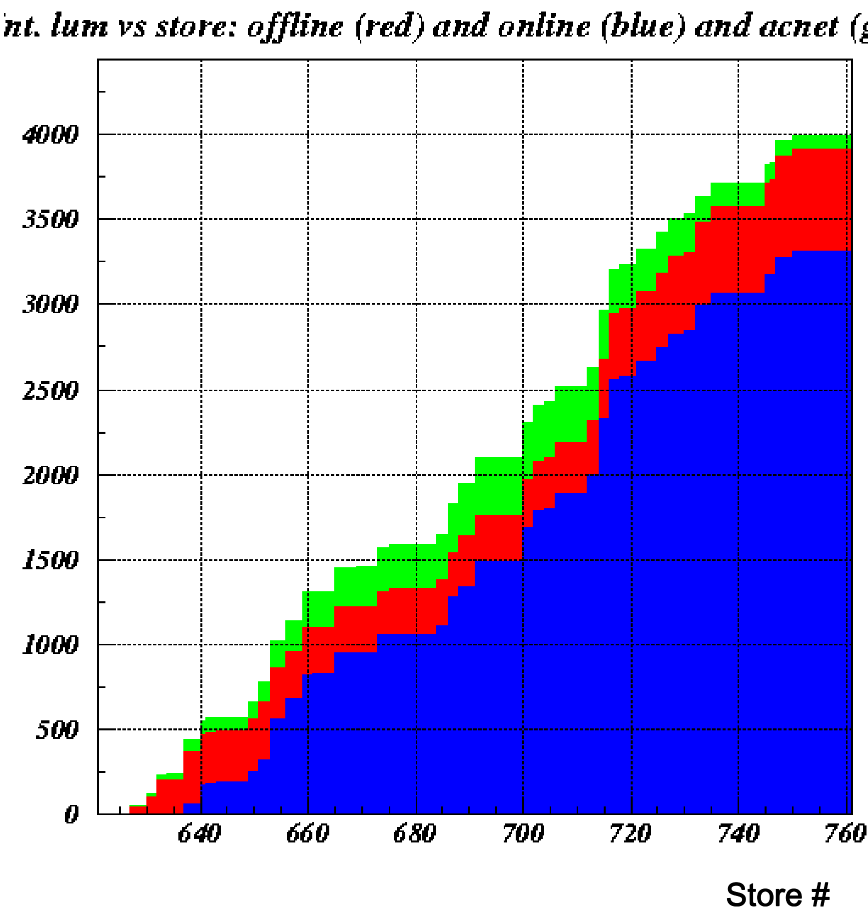
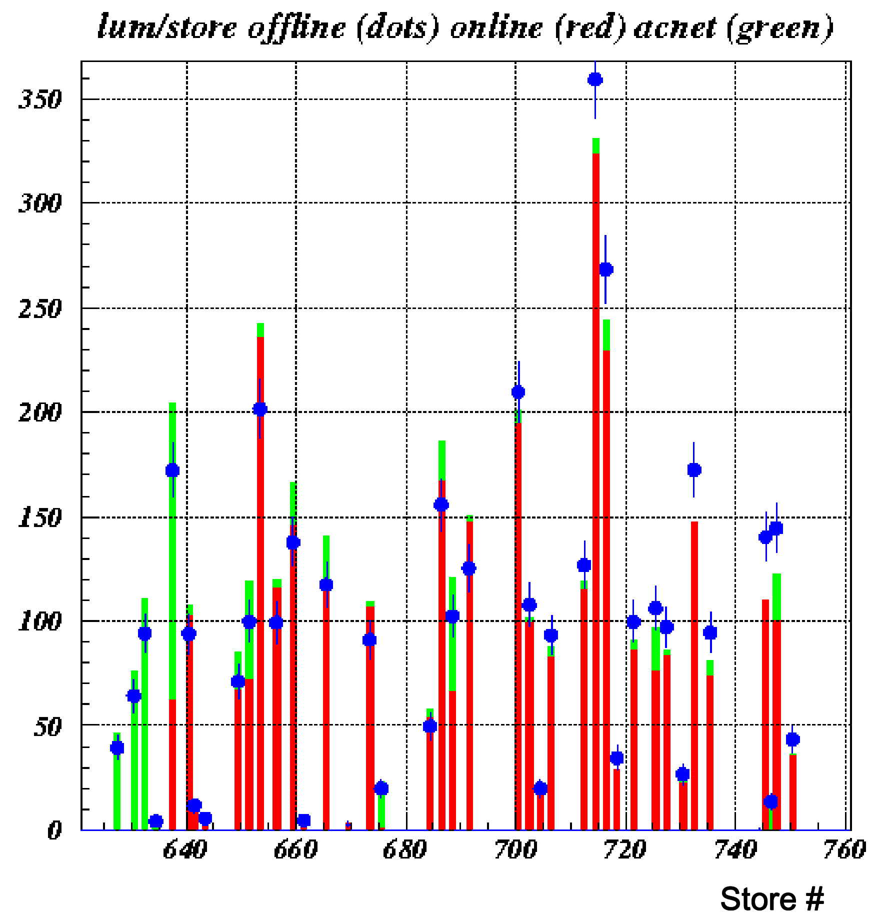
Integrated: Offline vs Acnet vs Online





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Lum Measurements Methods

- For any luminosity measurement method w/CLC
  - *For a defined selection criteria* $\{\alpha\}$ *for a p-pbar interaction to be registered in the CLC :*

$$\tilde{\mu}_\alpha \cdot f_{BC} = \sigma_{tot} \cdot \varepsilon_\alpha^{clc} \cdot L$$

$\tilde{\mu}_\alpha$ = avg. # of int. $\{\alpha\}$/ bunch crossing

f_{BC} = bunch crossing frequency

L = inst. luminosity

$\sigma_\alpha^{clc} \equiv \sigma_{tot} \cdot \varepsilon_\alpha^{clc}$ (effective σ)

- Define a collision $\{\alpha\}$
  - *{ >0 hits in E} .and. { > 0 hits in W} with amplitude > A_o*
    - *Online has fixed thresholds*
    - *Offline we can normalize to single particle peak (spp)*
  - *require hits to be in-time*
    - *Online can have gates*
    - *Offline can cut tighter*

Lum Absolute normalization

$$L = \frac{f_{BC}}{\sigma_{tot} \cdot \varepsilon_\alpha} \cdot \frac{< N_H >_\alpha}{< N_H^1 >_\alpha}$$

$< N_H^1 >_\alpha$ = avg. # hits for a single p-pbar interaction.

Measured at low luminosity from 0-bias data

$< N_H >_\alpha$ = measured avg. # hits/bunch crossing

- We still need to estimate ε_α
- From simulations
  - *Need all material*
    - →**Previously: data had 50% more hits…**
    - →**Added more Si related material**
    - → **Revised beam-pipe implementation**
  - *Need "correct" generator…*
- From real data
  - *CLC vs. calorimeters / trackers*
  - *W's (started !)*
- Have preliminary estimates

CLC Effective Cross Section

$$\sigma_{tot} \sim 81.9 \pm 2.3\,\text{mb} \nearrow \sigma_{inel} \sim 60.4 \pm 1.4\,\text{mb}$$

$\rightarrow \sigma_h \sim 44.4 \pm 1.3\,\text{mb}$ hard core

$\rightarrow \sigma_d \sim 10.3 \pm 0.5\,\text{mb}$ diffractive

$\rightarrow \sigma_{dd} \sim 7.0 \pm 0.5\,\text{mb}$ double diffractive

$$\searrow \sigma_{el} \sim 18.4\,\text{mb}$$ (0 acceptance)

- Acceptance: $$\varepsilon = \frac{\varepsilon^h \cdot \sigma_h + \varepsilon^d \cdot \sigma_d + \varepsilon^{dd} \cdot \sigma_{dd}}{\sigma_{inel}}$$

CLC effective inelastic x-section

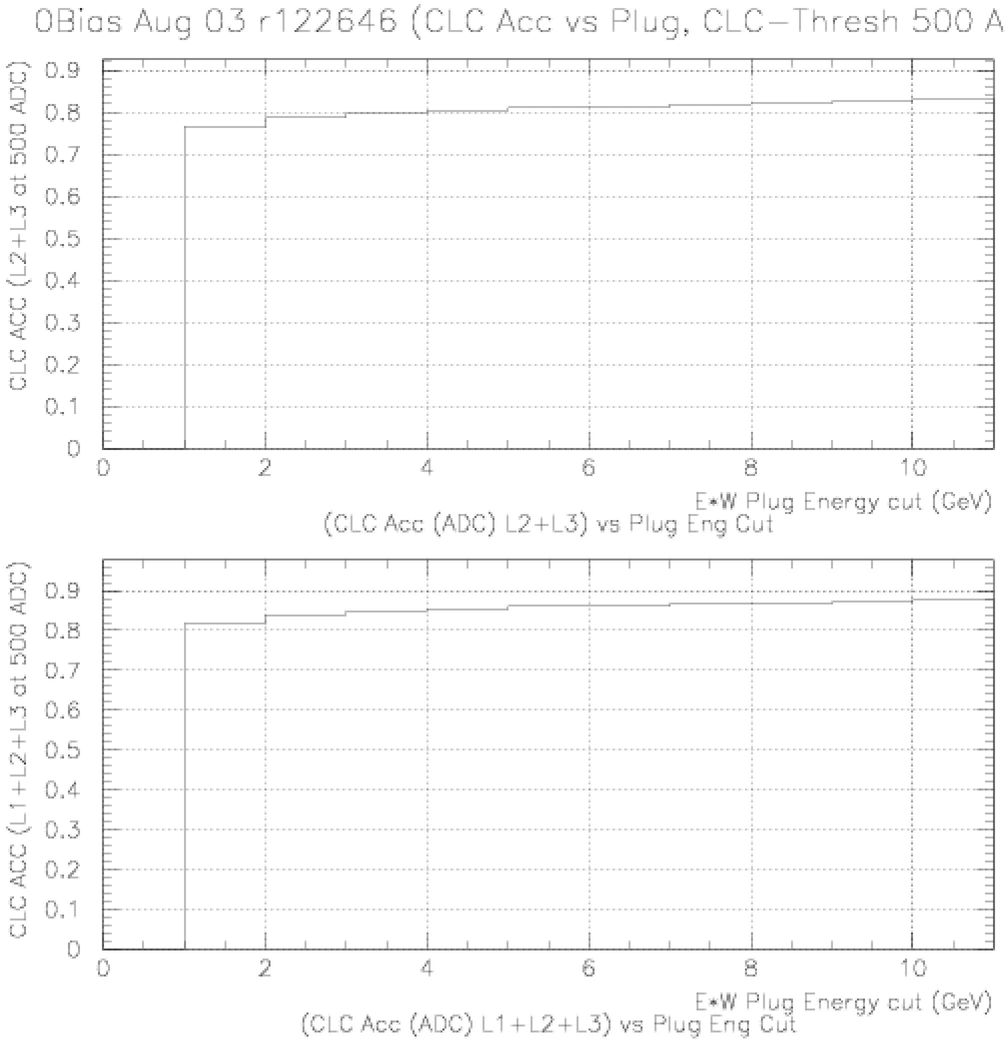
Method	CLC X-sec (mb) 2 layers	CLC X-sec (mb) 3 layers
Old simulation MBR + 3 Xo Straight acceptance	36.9	
Old simulation MBR+3 Xo CLC/(CLC+plug)	35.2	38.6
Data (CLC+plug accept from old sim.) CLC/(CLC+plug)	35.8	38.3
New Simulation Straight acceptance	38.2	42.4

- Used 500 ADC thresholds in CLC
- Used 3 GeV threshold in plug
- East and West coincidence in both
- CLC+ plug acceptance in MC = 94%

Notes:

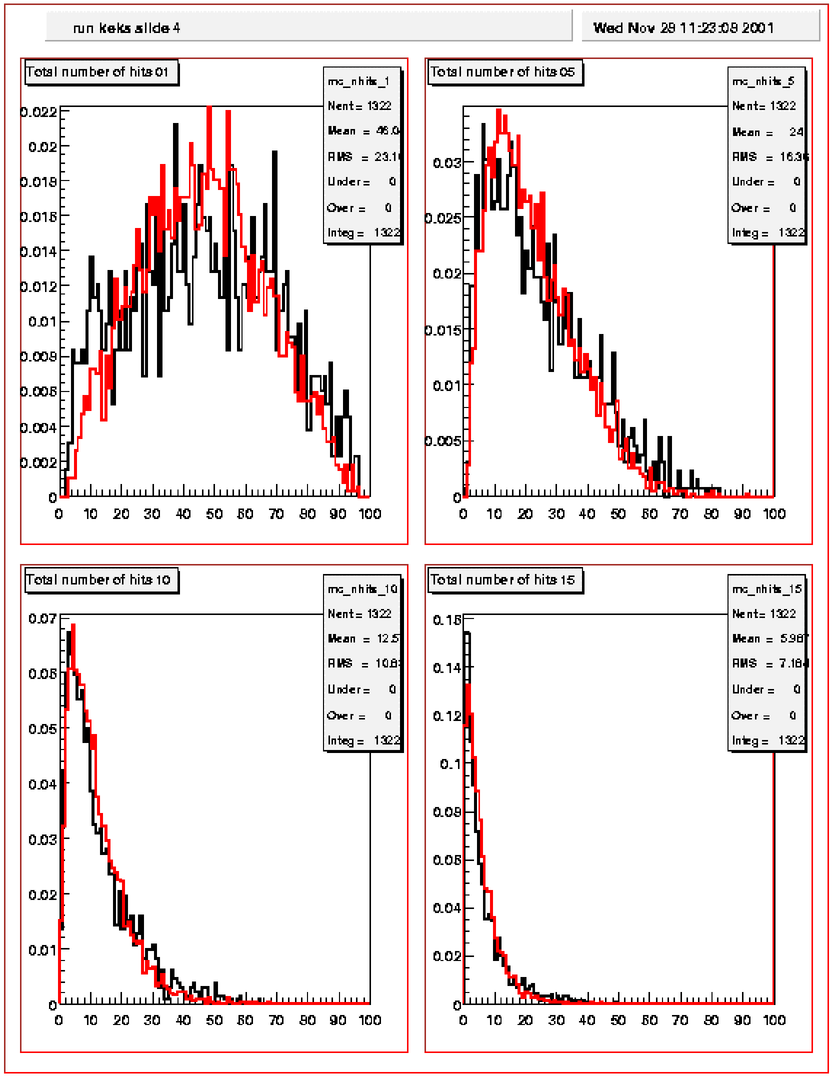
- Span in x-sec is 10%
- So maybe error is ~ +-5 % ?
- Needs more time to settle and to decide what's "more correct"
- MBR inelastic is 44.4 mb ~ measured by CDF
- Pythia gives ~9% smaller
- CLC acceptance for hard-core (@500 ADC) is ~90%. Is ~95% for lower threshold.
- Need to match simulation with data as well as possible & find the right mix →

CLC accept. Vs. (CLC + Plug)

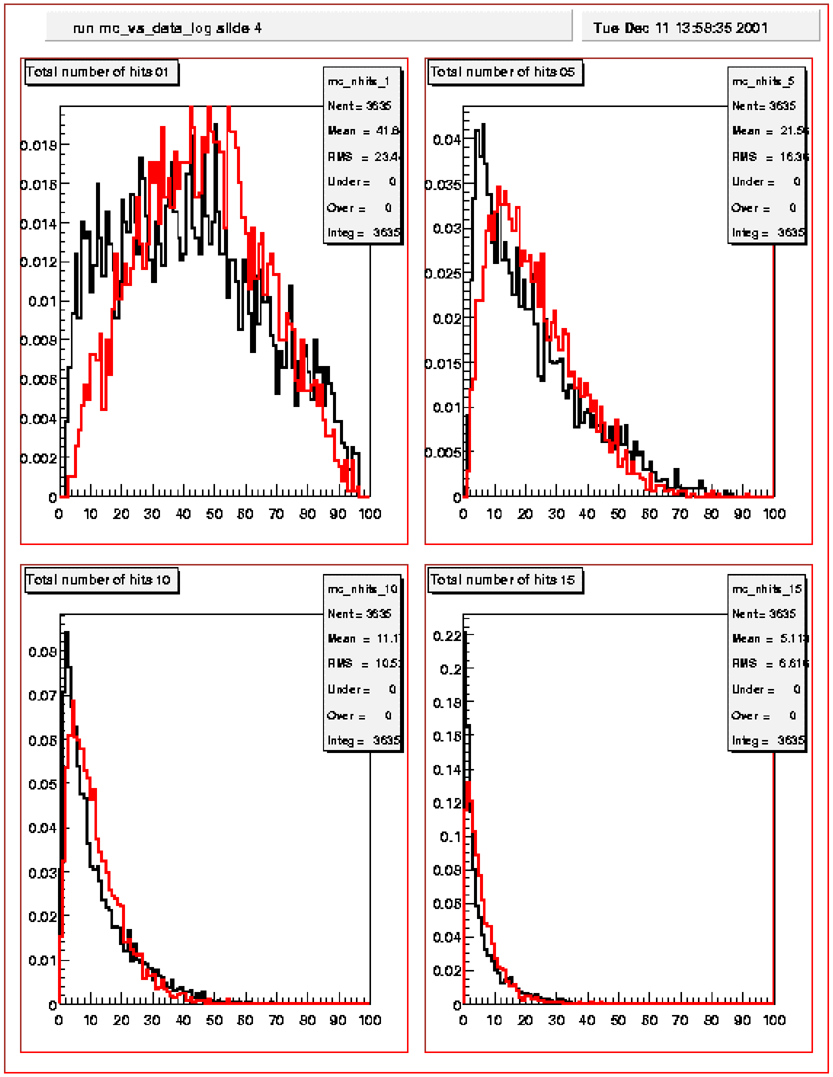


Nhit distributions (vs. threshold) from New Simulation

MBR hard core only

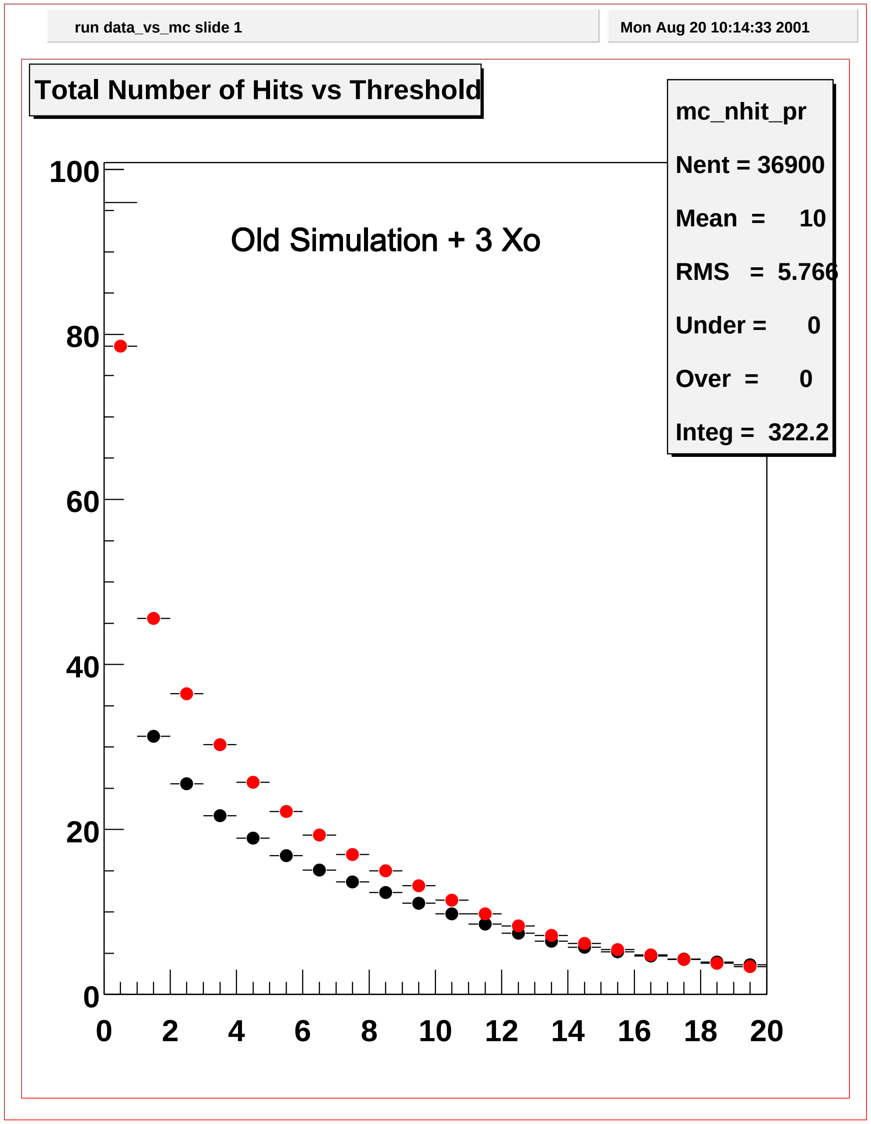


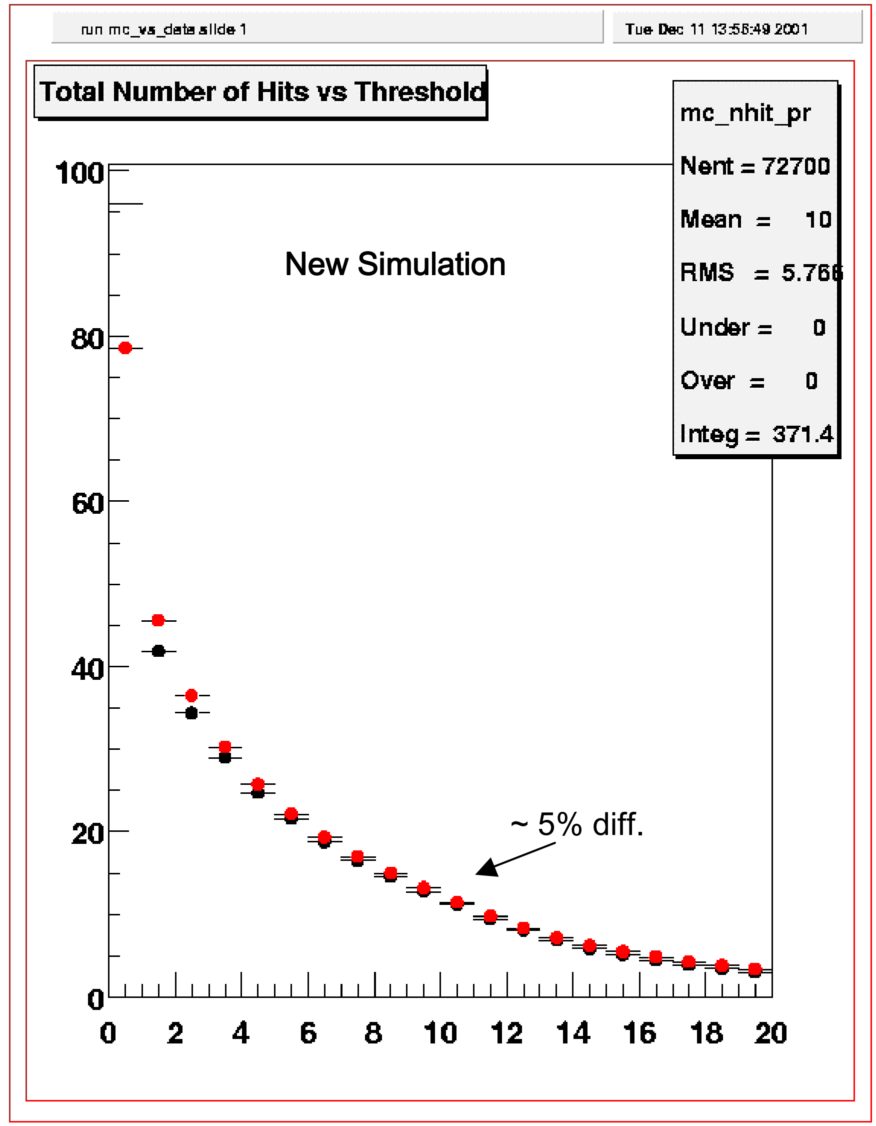
MBR full inelastic



<Nhit> vs. threshold (all layers)

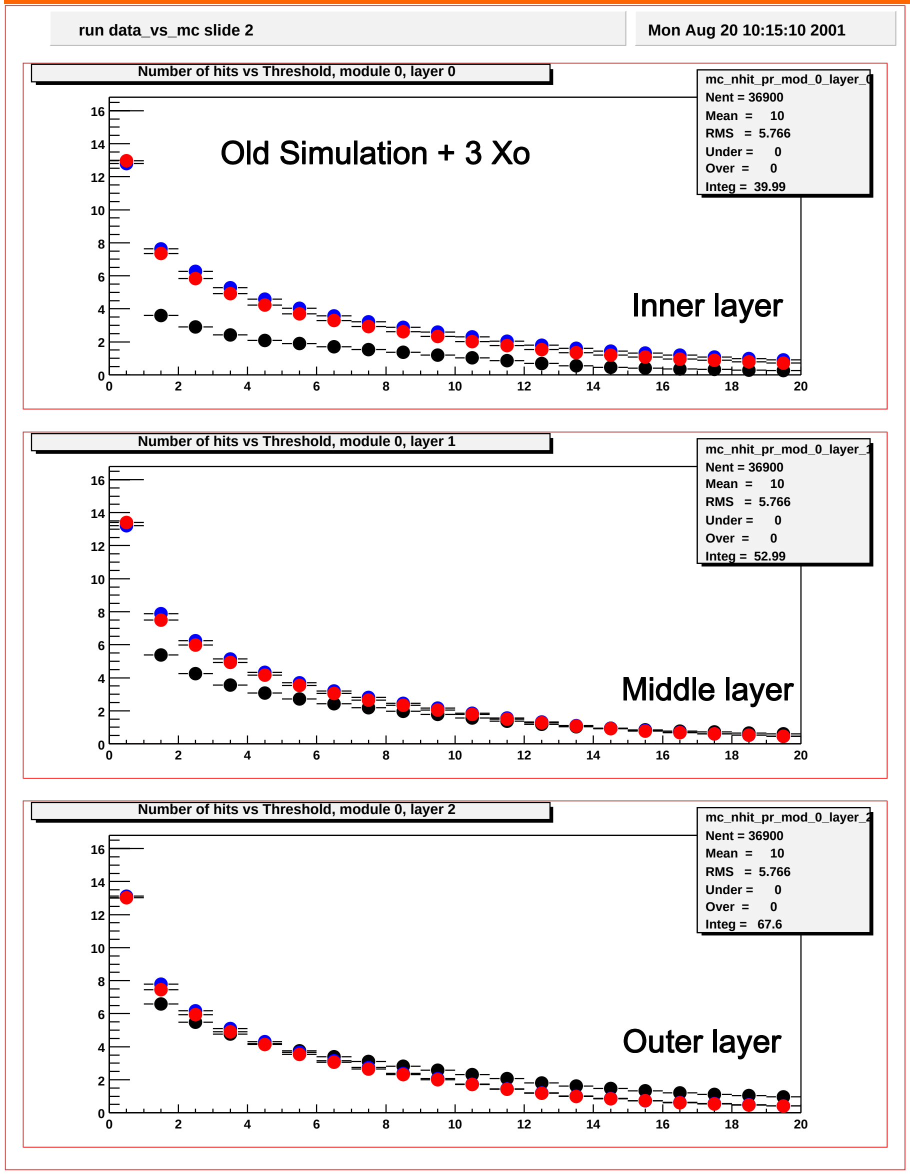
Data (color) vs. Simulation (black)

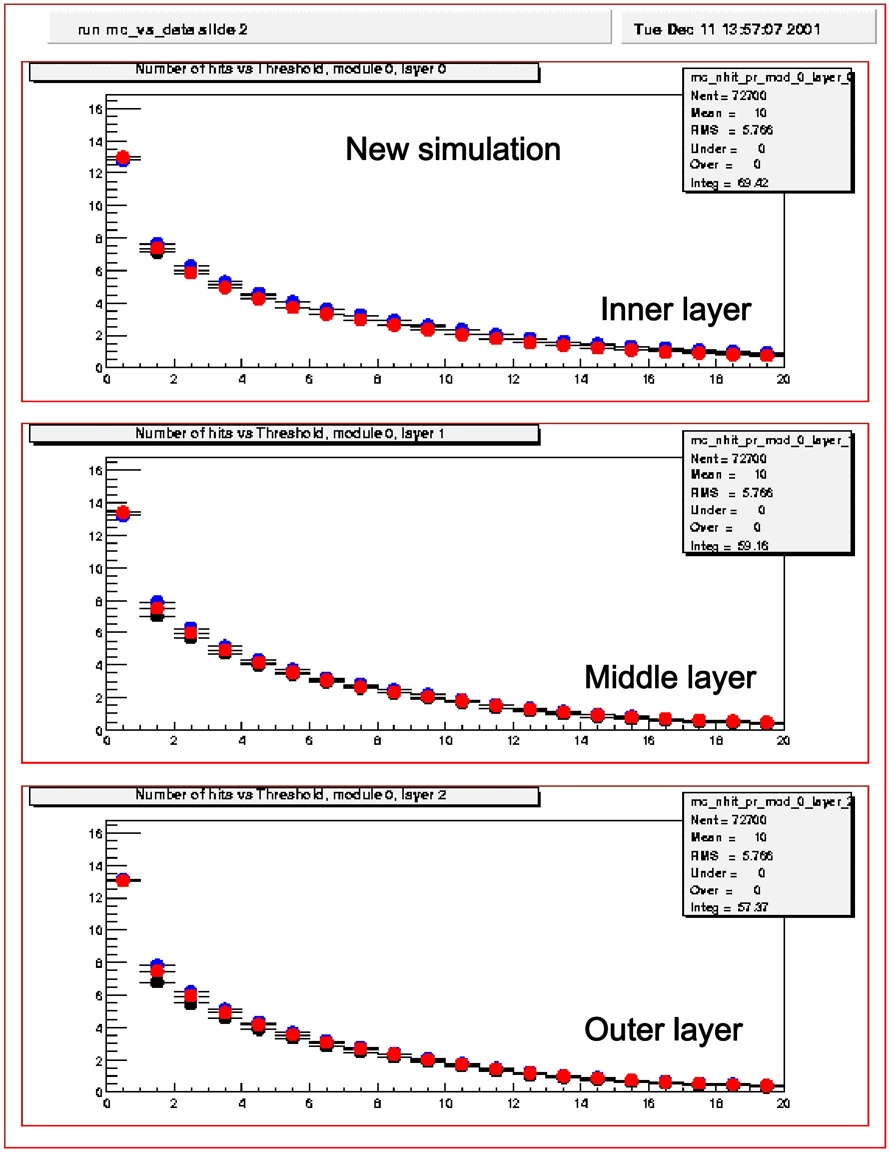




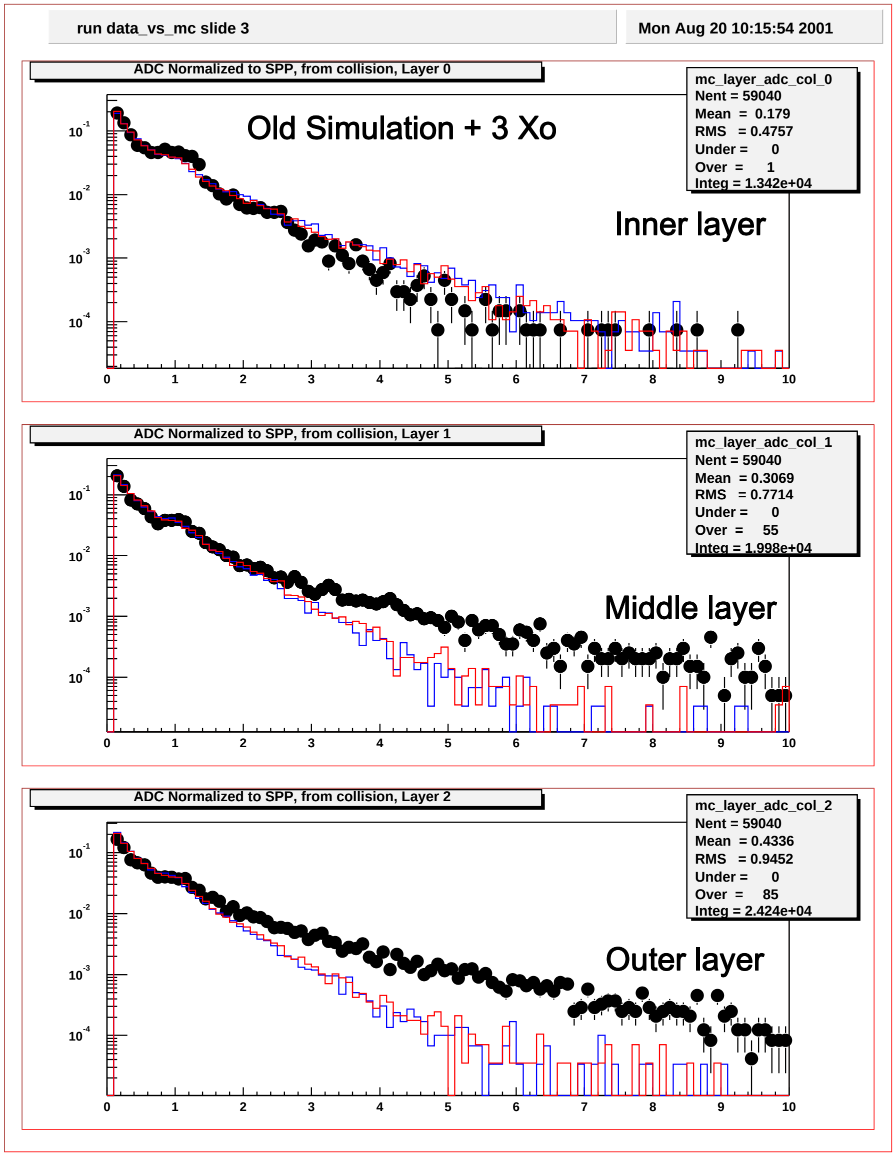
<Nhit> vs. threshold vs. layer

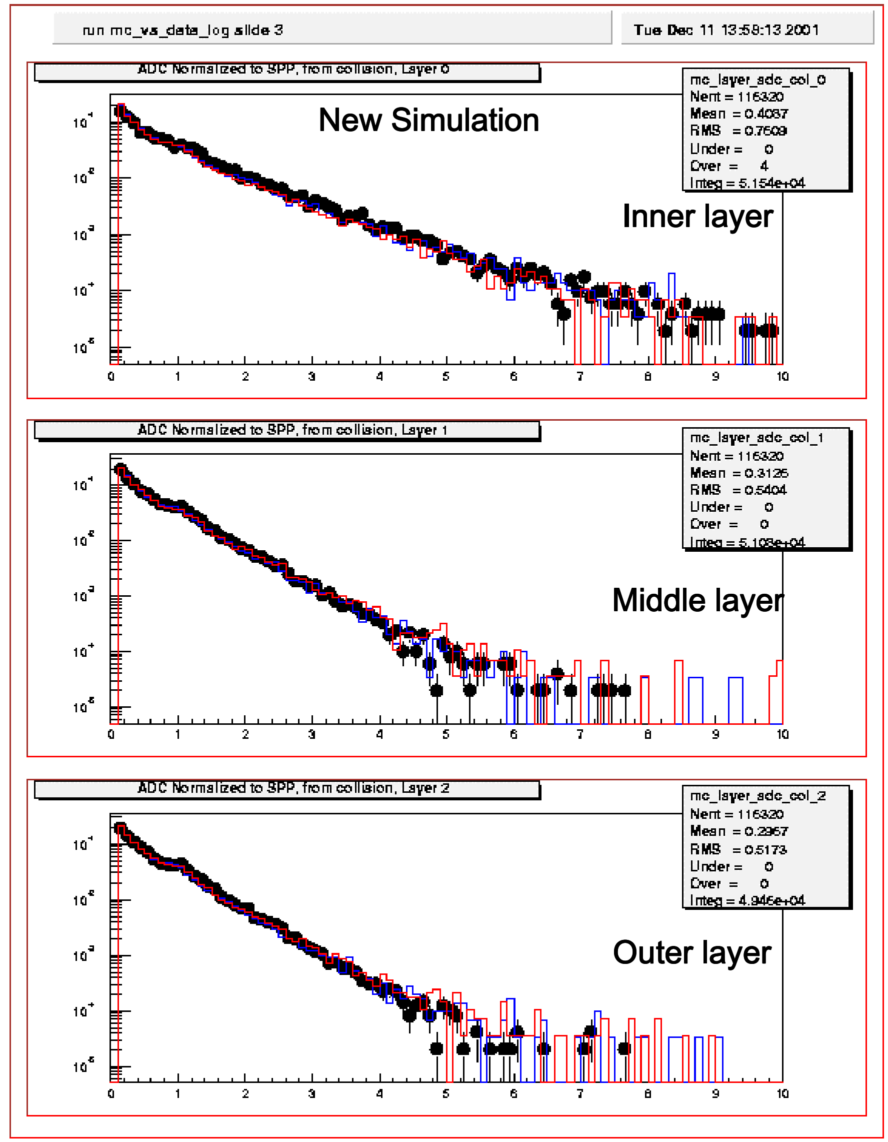
Data (color) vs. Simulation (black)



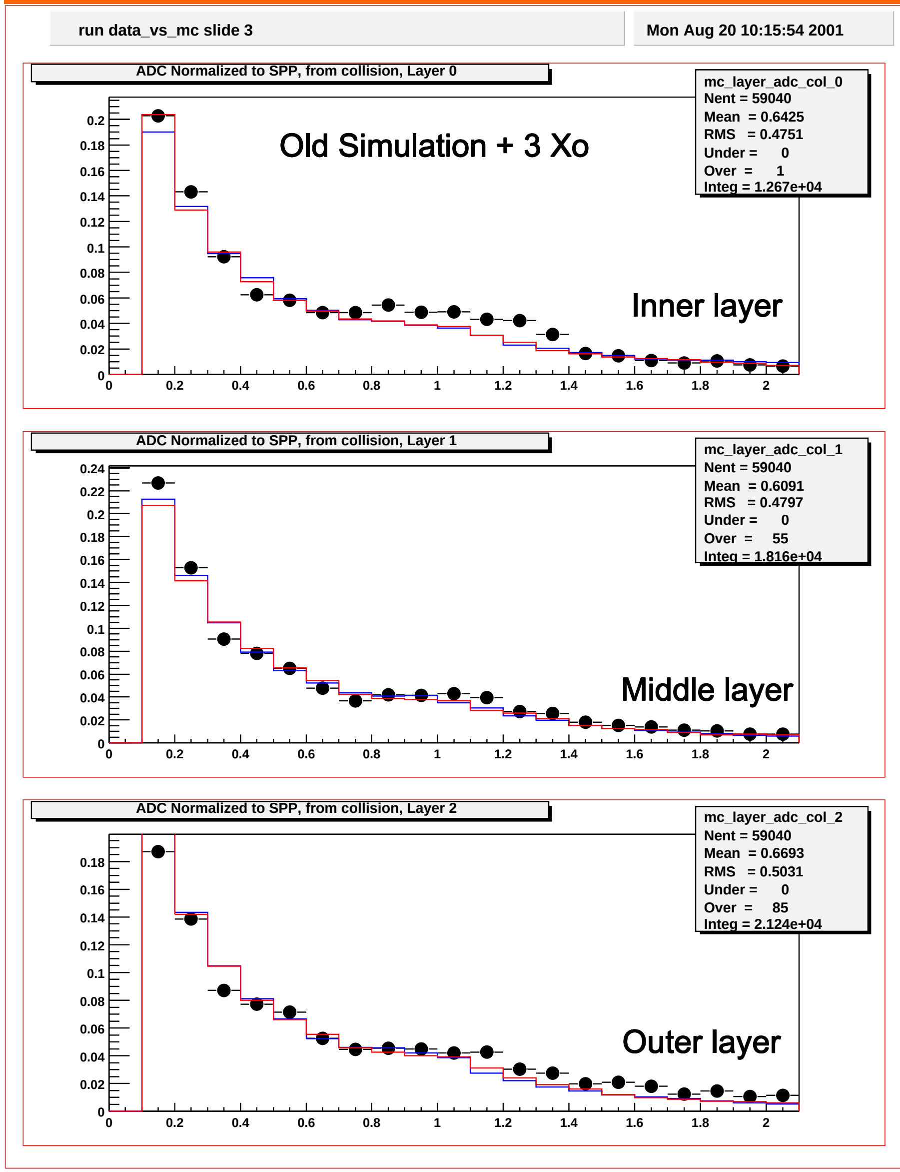


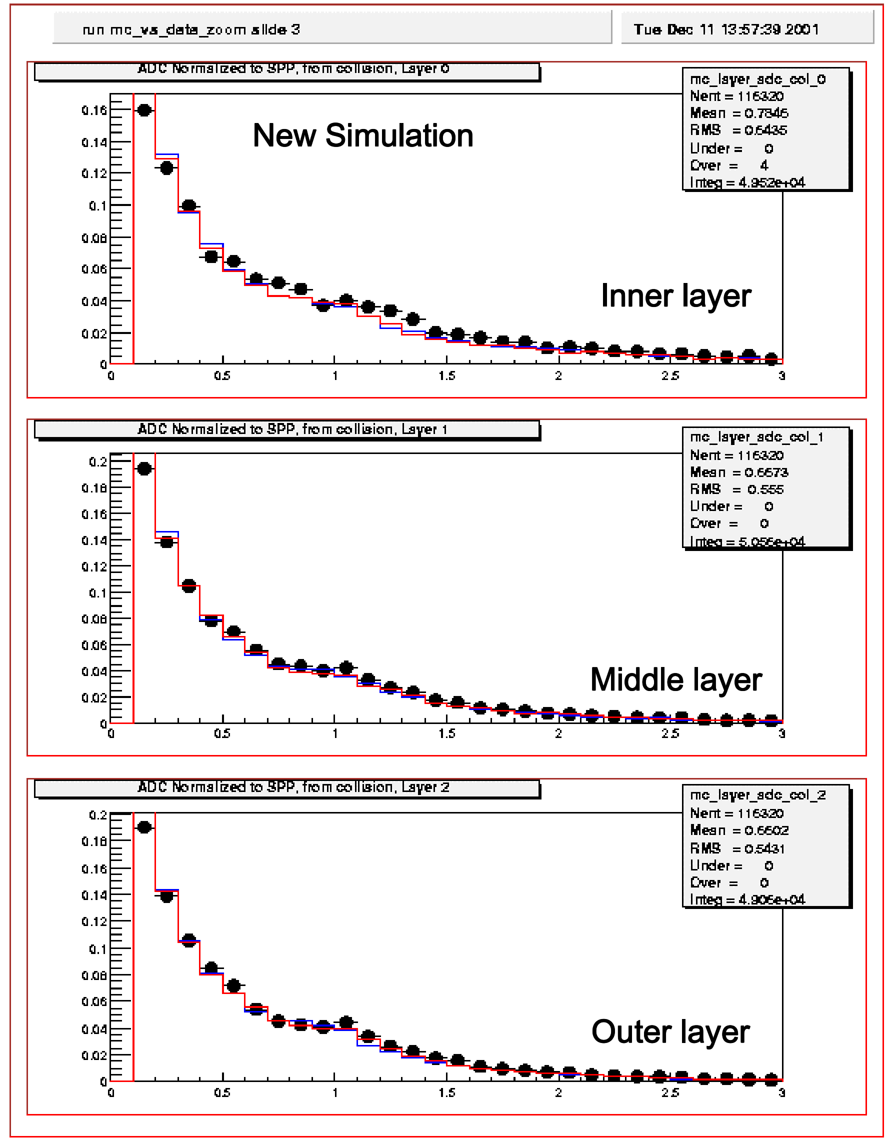
Amplitude distribution → data vs. sim.





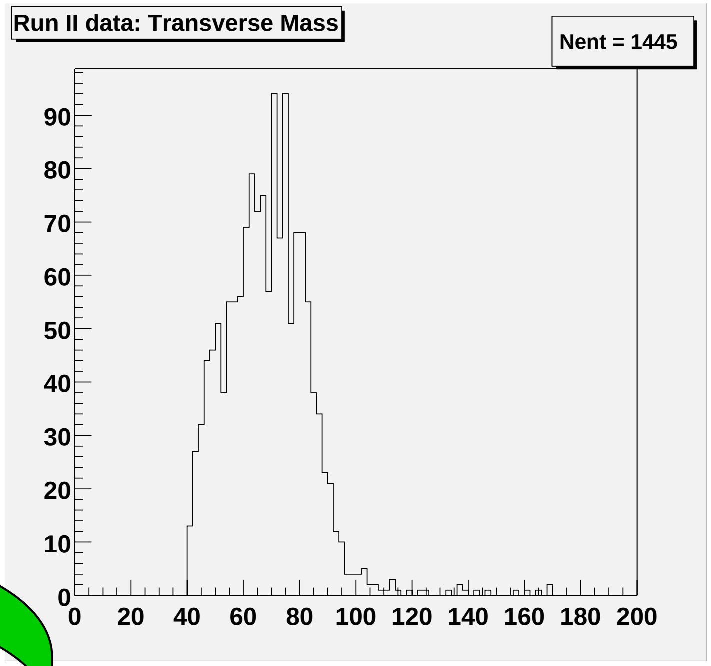
Amplitude distribution → data vs. sim.





Luminosity with W's

- Process: $W \rightarrow e\nu + X$
- First results:
  - Data Aug-Oct 2001: 2.2pb^{-1}
  - Selection criteria:
    - → *Et electron > 25 GeV*
    - → *Met > 25 GeV*
    - → *~Standard electron ID*
    - → *~Delta-phi cut*
  - Pythia total accept ~ 25 %
  - Correct down MC e-id by 20% (from Z's)
  - Expected number of W = 1120 +- ~170
    - → *10% from event selection) & 10% from Lum*
  - Observed number of W = 1292
  - Correct down by ~10% background
  - → Found number of W's = 1163



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W→e nu cross-check

W->e nu Analysis Results from Phytia Monte Carlo and Luminosity Estimation

Selection criterion	Selection criteria	Acceptance (%)	Overall Acceptance (%)
mEt + central electron (cluster with track)	mEt > 20 GeV	37.22	37.22
electron Eta	-1.0 < Eta < 1.0	98.20	36.55
electron Et (cluster)	Et > 20 GeV	85.36	31.20
electron Pt (track)	Pt > 10 GeV	97.37	30.38
Energy over Momentum	E/P < 2.0	97.66	29.67
CEM Isolation	EIso < 0.06	97.67	28.98
CHA Isolation	HIso < 0.04	99.07	28.71
CHA E over CEM E	HoverE < 0.1	98.54	28.29
Lateral shower profile	Lshr < 0.2	97.77	27.66
Delta Z	-2.0 < Dz < 2.0	99.57	27.54
CES Chi squared	Chi2 < 4.	97.28	26.79
Delta X	-1.5 < Dx < 1.5	98.73	26.49
angle between mEt and electron (transvers plane)	-0.6 < DPhi < 0.6	96.33	***25.48***

“Empty crossings” method (low lum)

- Let μ be the average number of interactions per bunch crossing
- Assuming that the number of collisions per bunch crossing follows Poisson distribution we want to find the empty crossing probability (and therefore μ).
- Empty crossing = bunch crossing in which the CLC doesn’t record hits in both sides.
- α the probability that an interaction doesn’t hit either side,
- β the probability that an interaction hits West but doesn’t hit East (equal to probability of hitting East but not hitting West).
- we can compute P(0;k), the empty crossing probability for k interactions

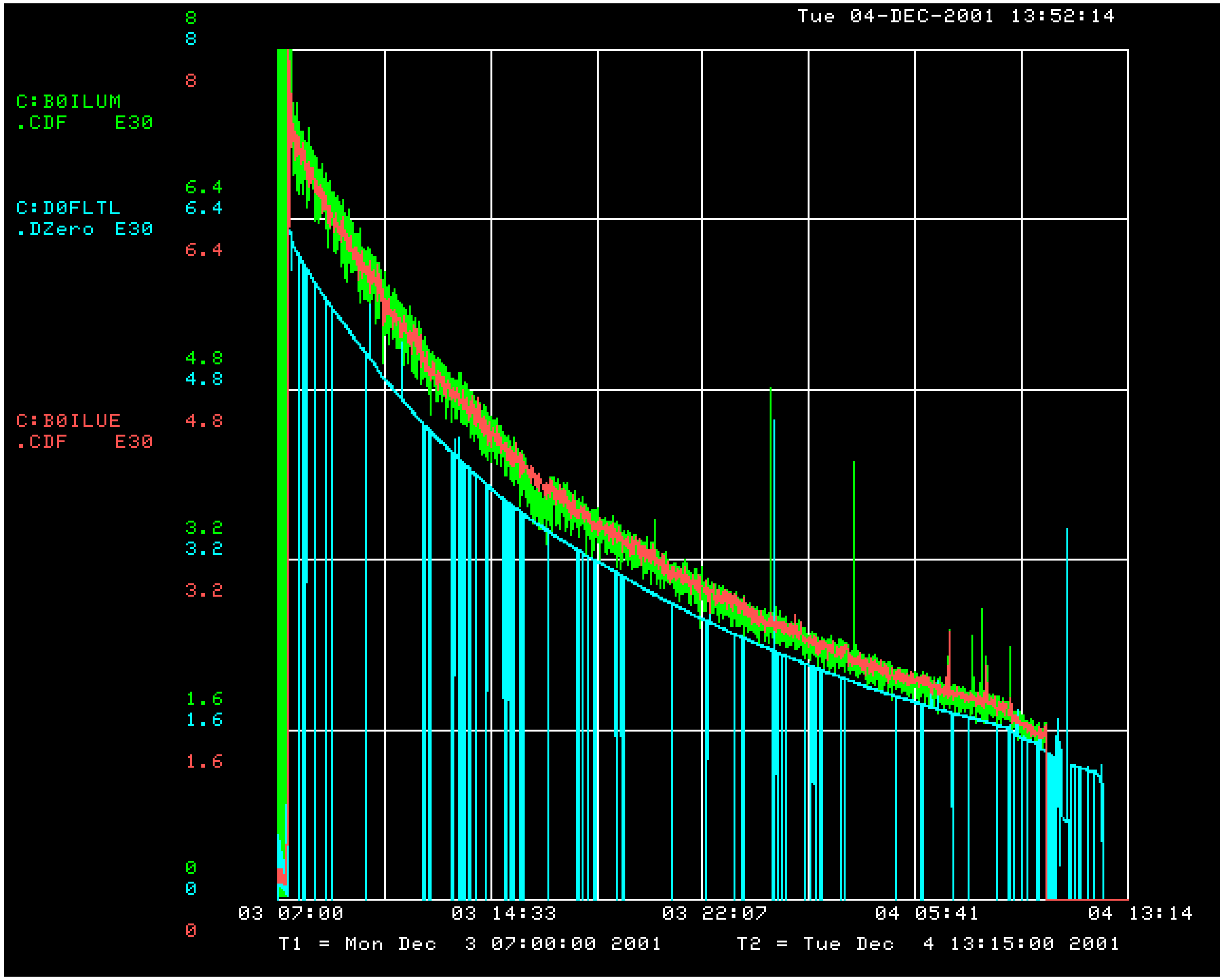
$$P(0;k) = 2*(\alpha + \beta)^k - \alpha^k$$

- Then P(0), the probability of measuring an empty crossing can be obtained from summingup the Poisson distribution with appropriate weigth

$$P_\mu(0) = \sum_k Poisson(\mu \mid k) \cdot P(0;k) = e^{-\mu(1-\alpha)}(2e^{\mu\beta} - 1)$$

- In the low luminosity approximation (when $\mu*\beta << 1$) the above formula is well approximated by $e^{-\mu\varepsilon}$ where $\varepsilon = 1-\alpha-2*\beta$ is the detection efficiency per interaction (probability that the interaction is measured as “non-empty”).

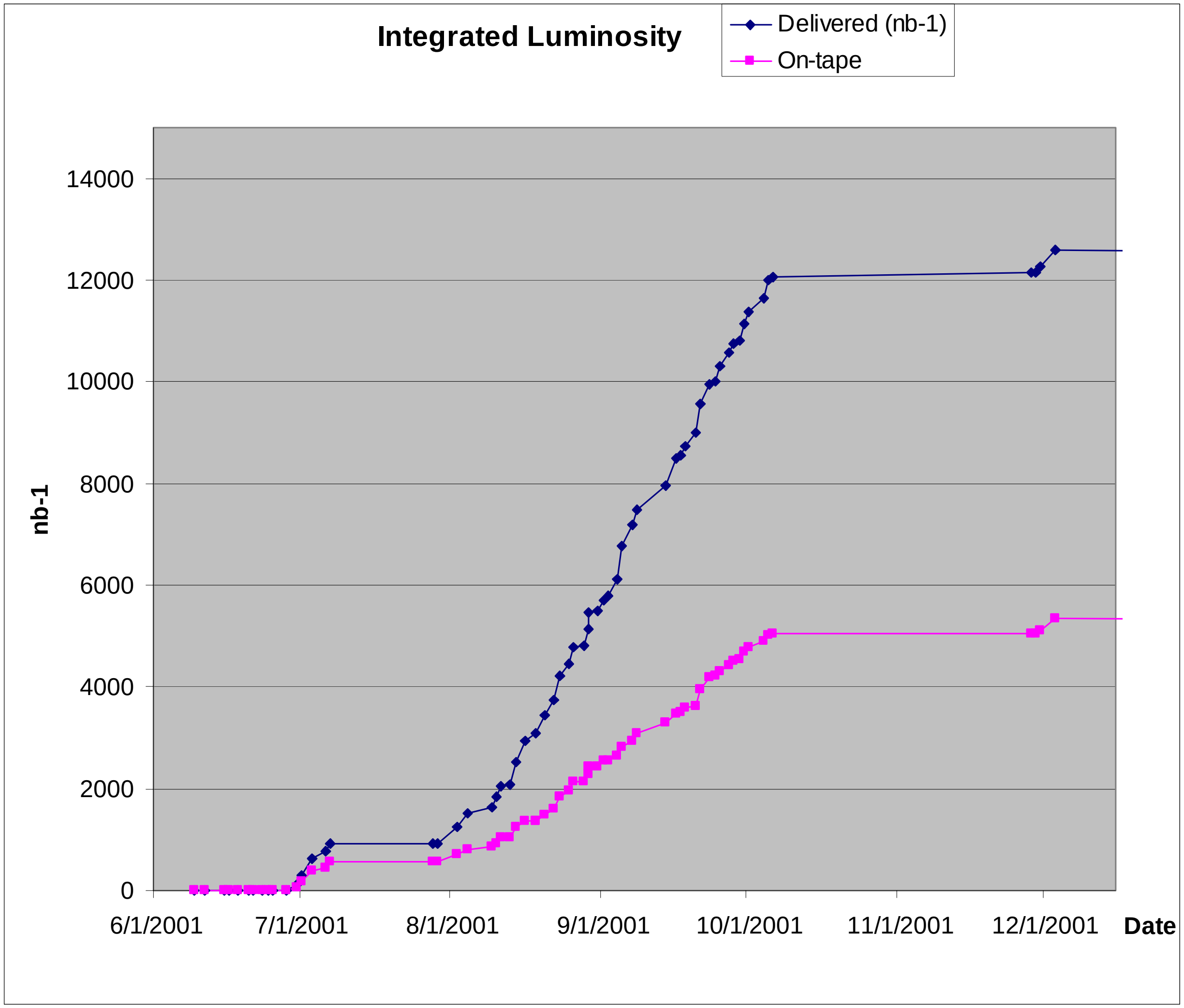
Empty crossing method



Summary and plans

- Established all Lum measurements and accounting
- Official Lum for Aug-Oct released (+- 10%)
- Working on absolute normalization systematics
  - *Generator, Simulation, material, thresholds, pressure etc. etc.*
- Harder with changing gains
  - *Strong effort in calibrations and operations*
- Tested more robust method, ok for luminosity < ????
- Considering changing to this for the time being
- Working with Hamamatsu to solve PMT gain question
- New simulation will allow faster feedback
- Looking a W's for cross-checks
- Expect absolute normalization uncertainty below 5% in next release
- Implement and test high lum algorithms later on
  - *Particle counting*
  - *Time clusters*

Luminosity so far...



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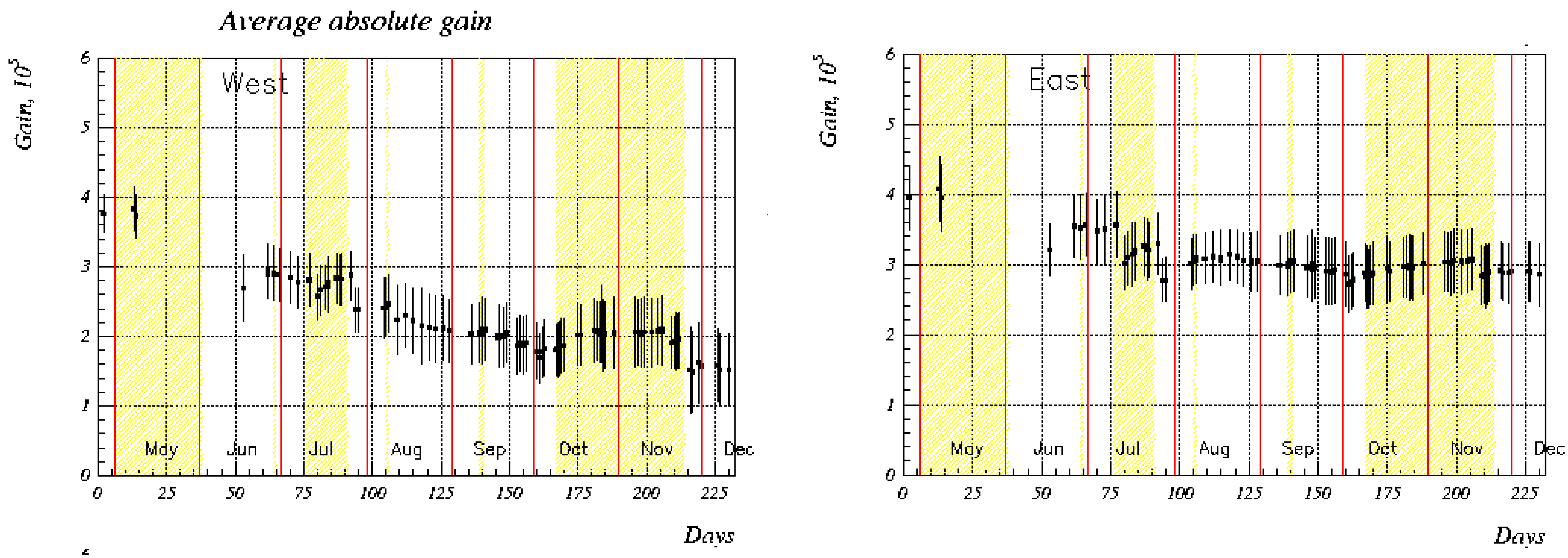
PMT gain over time



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