Comments on CDF luminosity measurement

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Joint Luminosity meeting 7/13/04

Luminosity with zero counting method

$$L = \frac{f_{BC} \cdot \mu}{\sigma}$$

$$P_0(\mu, \varepsilon_0, \varepsilon_E, \varepsilon_W) = e^{-(1-\varepsilon_0)\mu}\left[e^{\varepsilon_E \mu} + e^{\varepsilon_W \mu} - 1\right]$$

ε_0 = probability of NO hits on both modules

ε_E = probability of hits only on East module

ε_W = probability of hits only on West module

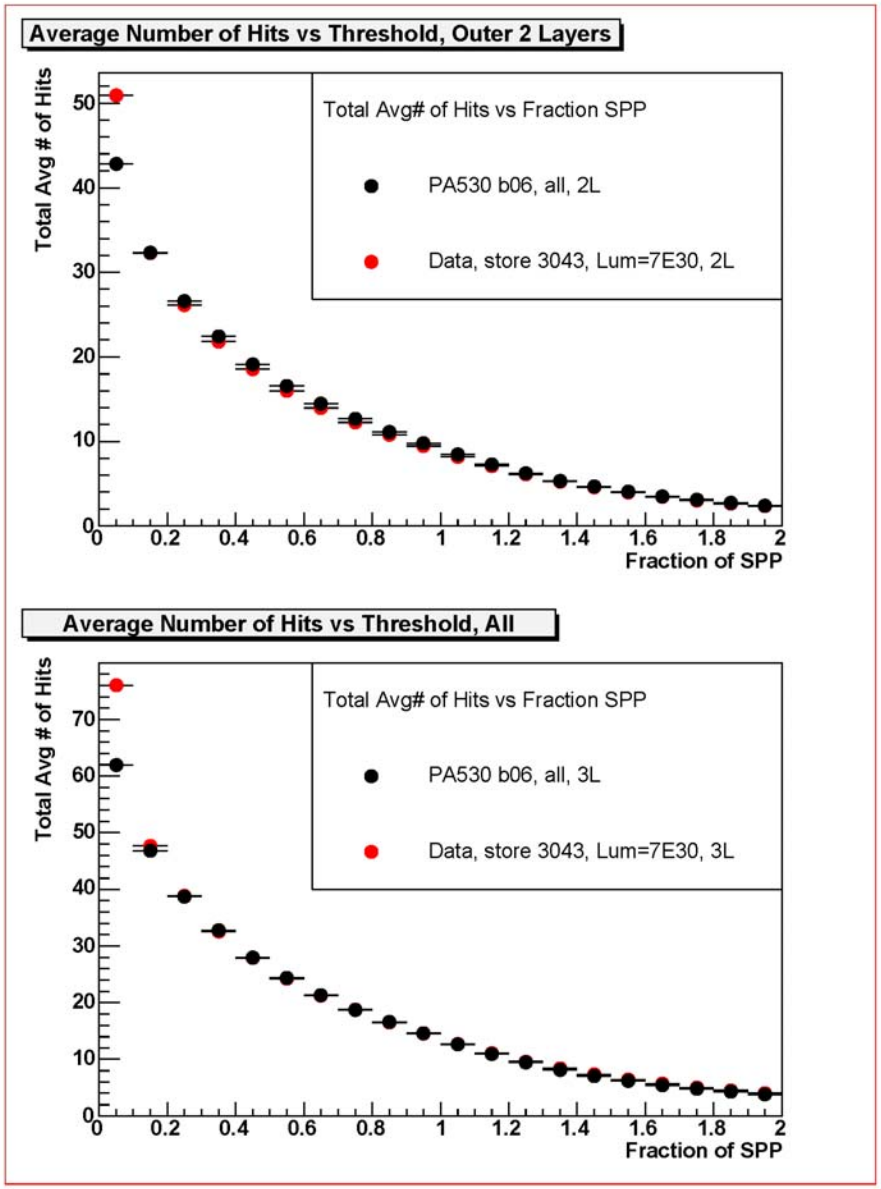
$$L \propto \mu$$

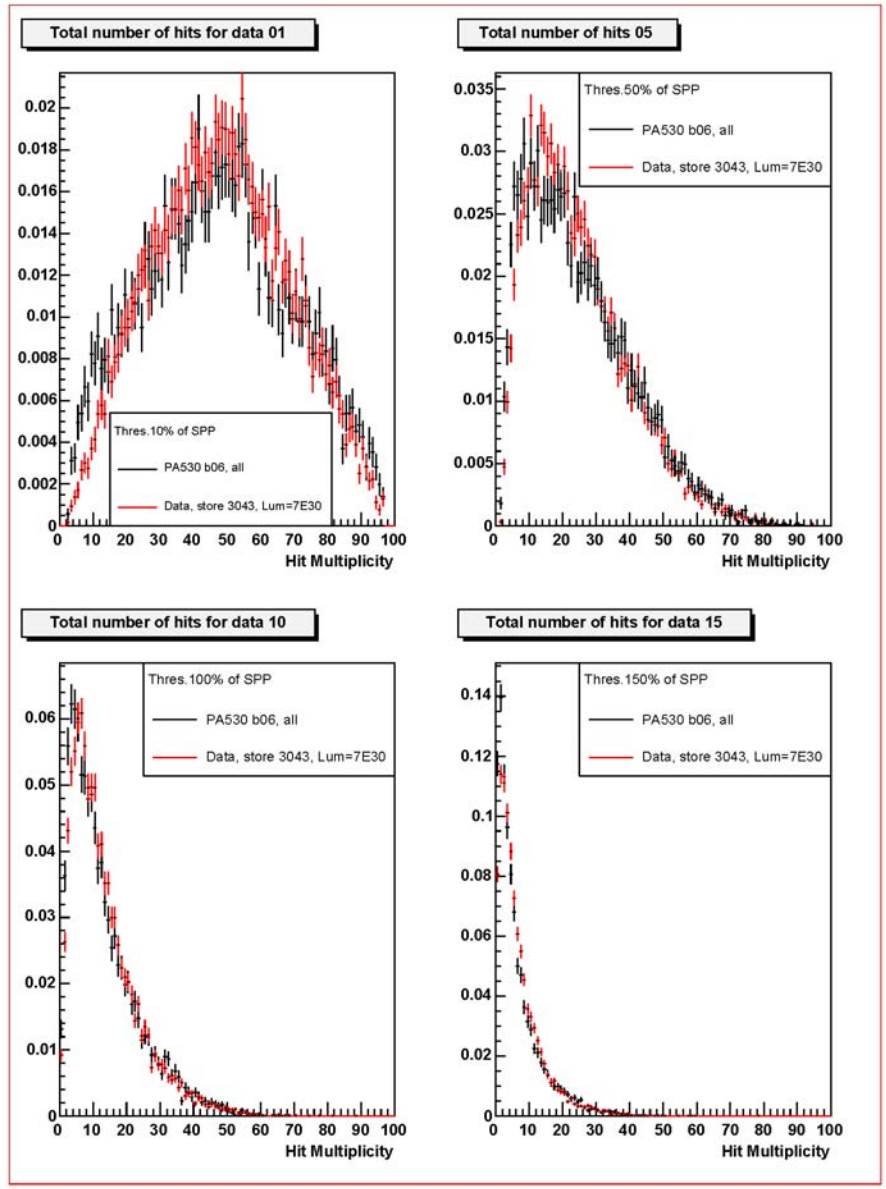
$$\mu = 1.8 \leftrightarrow L \sim 5 \cdot 10^{31}$$

$$\mu = 3.5 \leftrightarrow L \sim 10^{32}$$

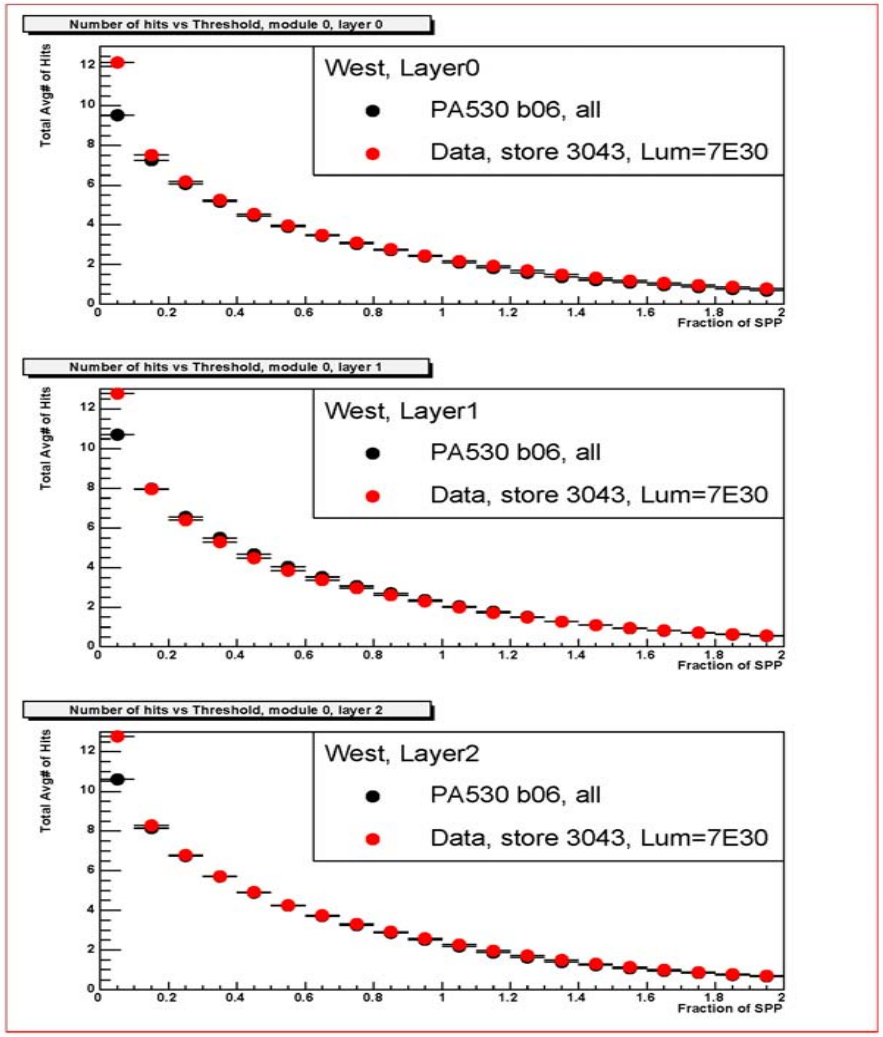
$$\mu = 7.1 \leftrightarrow L \sim 2 \cdot 10^{32}$$

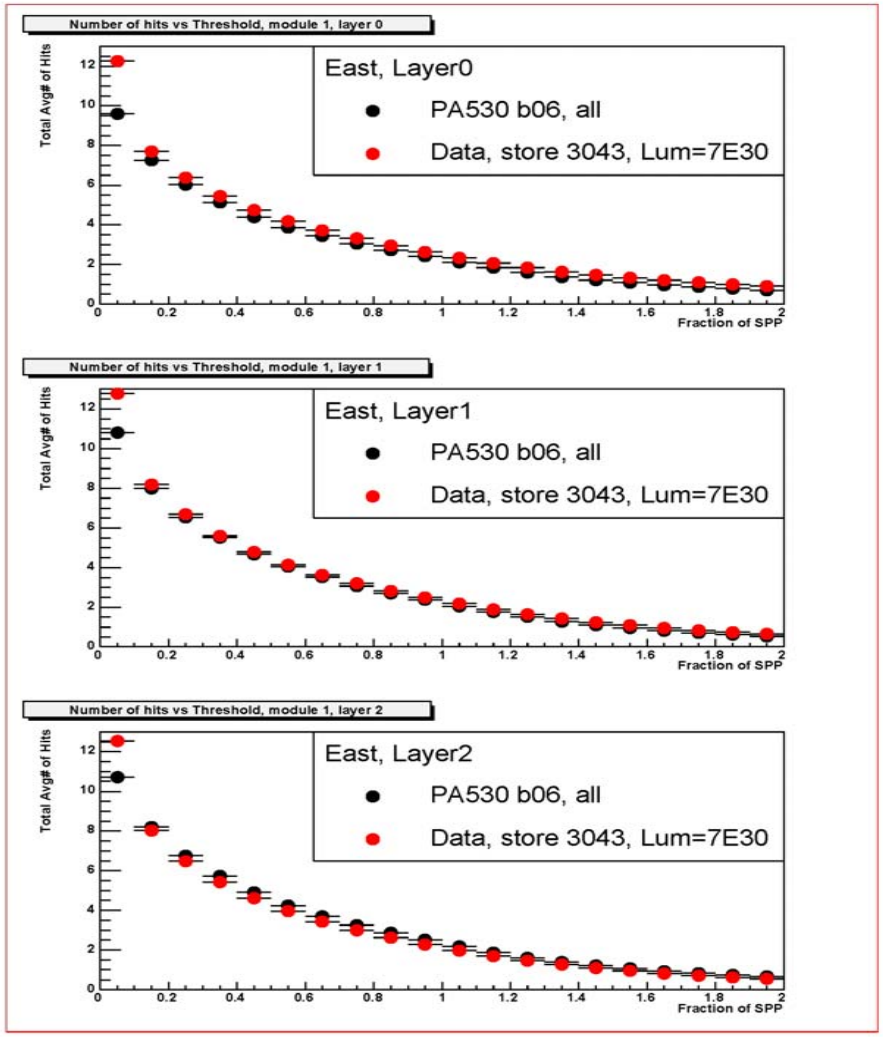
MonteCarlo VS data





MonteCarlo VS data





MC provides the set of "acceptances" (ε_0, ε_E, ε_W) used in online luminosity calculations.

Systematics on these parameters due to detector simulation have been evaluated to be **~ 3%**.

Evaluation of systematics

Given a "baseline" set of ($\varepsilon_0, \varepsilon_E, \varepsilon_W$)

and a new set of ($\varepsilon'_0, \varepsilon'_E, \varepsilon'_W$) both evaluated from MC

Solving

$$P_0(\mu, \varepsilon_0, \varepsilon_E, \varepsilon_W) = P_0(\mu', \varepsilon'_0, \varepsilon'_E, \varepsilon'_W)$$

for μ' we get the sys on L

$$\frac{\mu - \mu'}{\mu} = \frac{L - L'}{L}$$

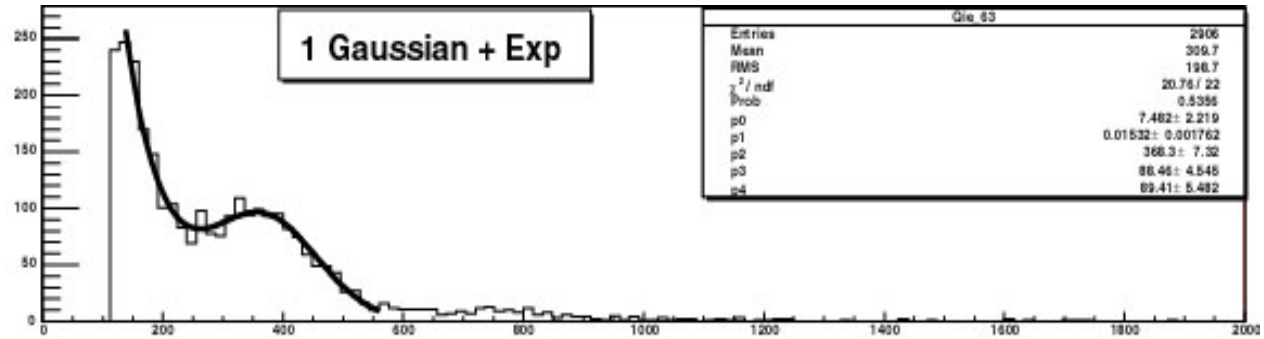
CLC in situ calibration

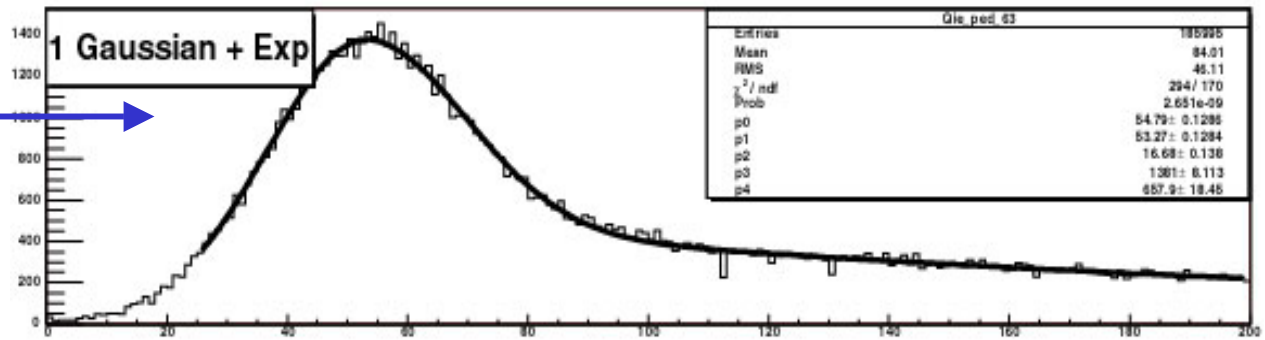
Store 3530 (May 25)

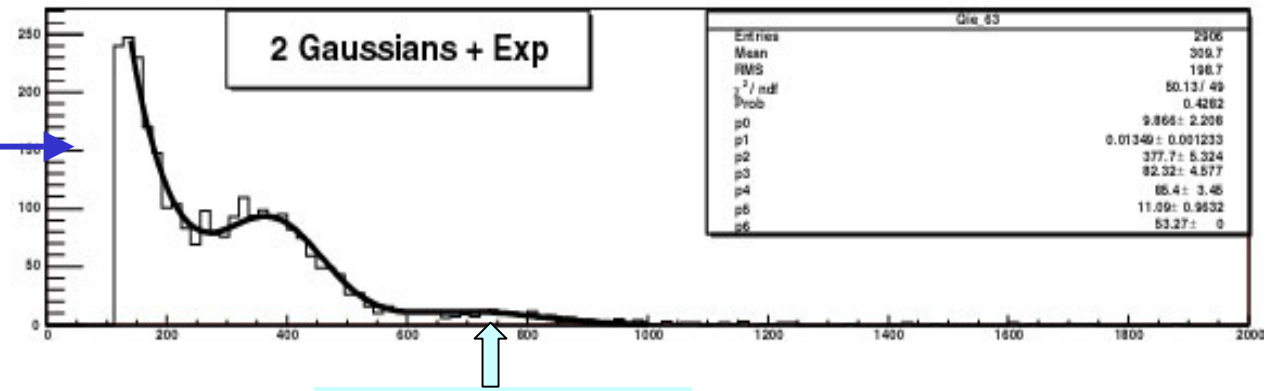
Init. Lum=68.4*10^{30}

Pedestal fit

Single Particle Peak default fit







Two particle peak

CLC *in situ* calibration: systematics study

- **Sources of systematics:**

  → **ISO cut**

  vary ISO cut

  → **Luminosity dependence**

  break store in pieces of ~30K events, compare the first set with the last one

  → **Fit method**

  2 Gaussians+Exp **vs.** *1 Gaussian+Exp*, vary range of fit, vary initial parameters

  → **Systematics of PED fit**

  Gaussian+Exp **vs.** *Gaussian*

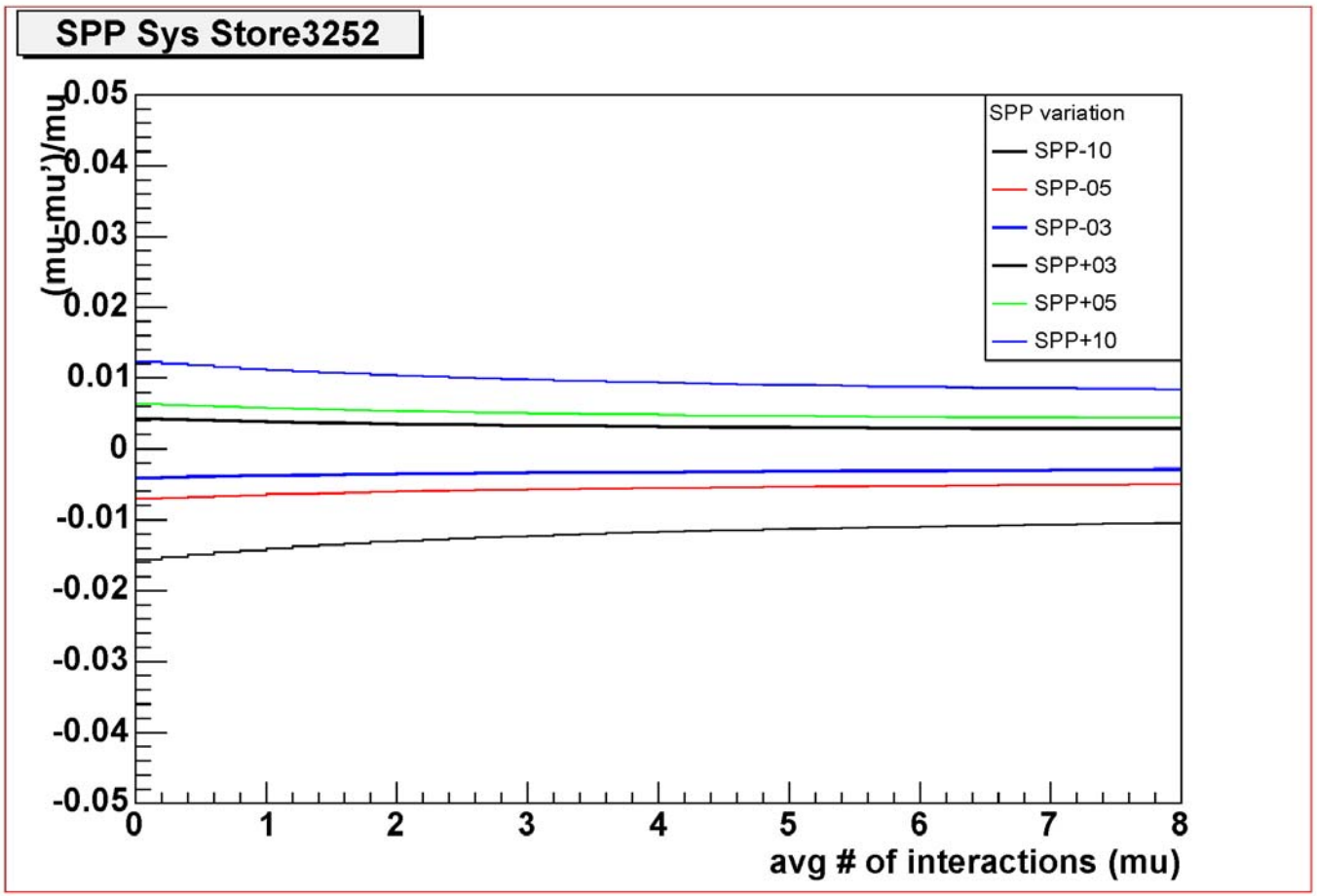
	ISO cut	Lum dep.	Fit meth.	PED syst.
Systematics	**2.1%**	**1.2%**	**1.3%**	**1.5%**

Total syst.: 3%

Systematics from SPP

Given a SPP calibration, we change ALL the SPP values by ±3% (±5%, ±10%) and plot VS μ

This is an <u>OVERESTIMATION</u> of systematics



Systematics from Beam Position

We change the beam position according to the real position splitting the entire RunII into 7 periods.

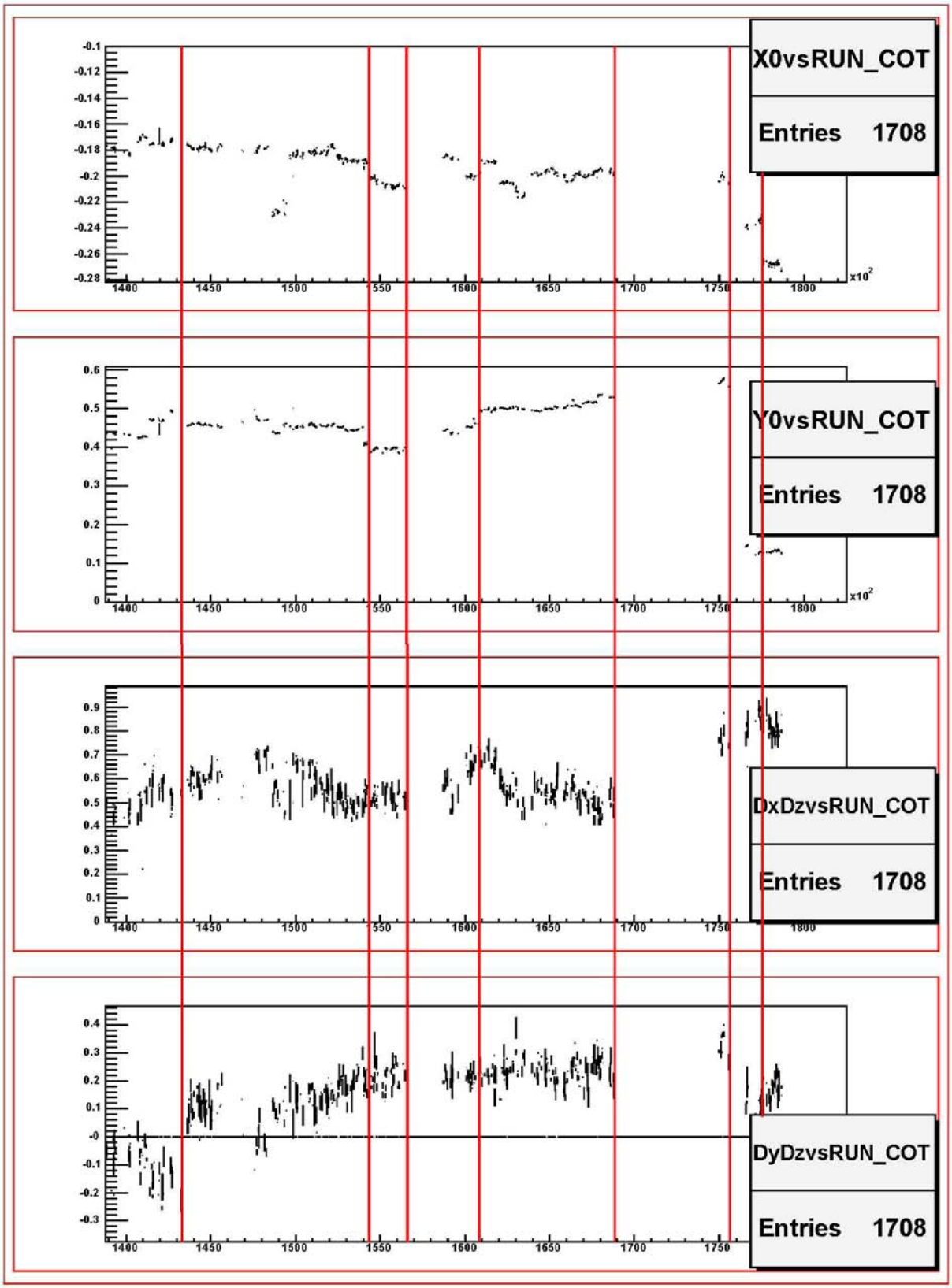
Run	Range	X0	Y0	Z0	DxDz	DyDz	SigmaZ	Lum	Lum%
138808	143299	-0.1756	0.4523	3.5	0.5209	-0.1102	26.59	9.24	3.32%
143299	154230	-0.187	0.4491	1.874	0.5605	0.1433	27.3	64.93	23.35%
154230	156487	-0.2056	0.3942	1.314	0.5234	0.2191	27.67	35.37	12.72%
158640	160823	-0.1944	0.4511	1.651	0.6126	0.2141	27.77	19.4	6.98%
160823	168932	-0.1993	0.5068	3.238	0.5464	0.2331	28.92	117.16	42.14%
174990	175648	-0.201	0.5692	3.241	0.7564	0.3279	30.34	2.3	0.83%
175648	177526	-0.2344	0.1304	-1.399	0.8738	0.08624	29.08	13.29	4.78%
177526	182514	-0.2678	0.13	-1.572	0.8115	0.1732	28.77	16.33	5.87%
								278.02	
Baseline									
		X0	Y0	Z0	DxDz	DyDz	SigmaZ		
		-0.16	0.4	0	0	0	30		

Compute the effect on luminosity by comparing to the baseline MC configuration:

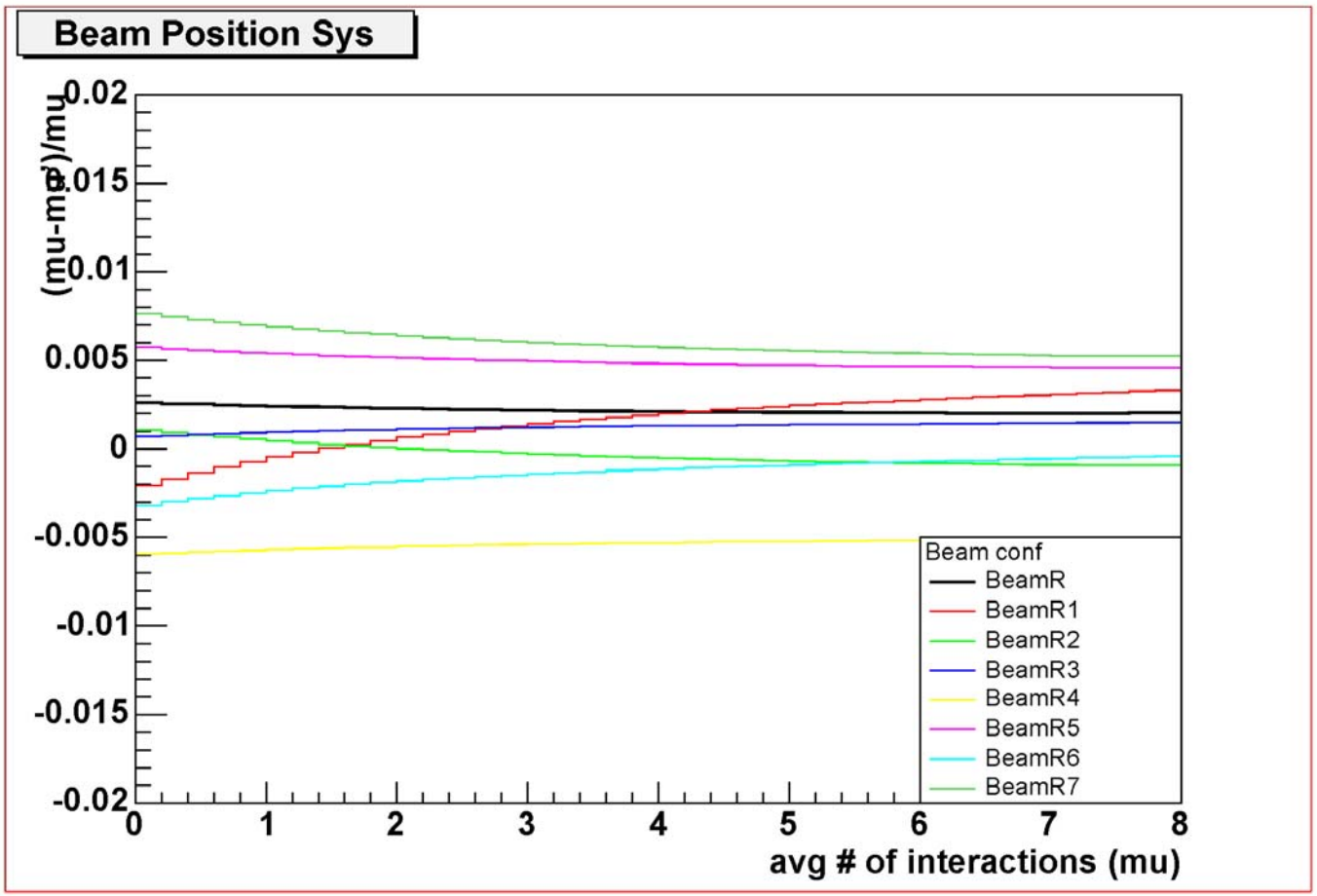
X0 = -0.16 cm

Y0 = 0.4 cm

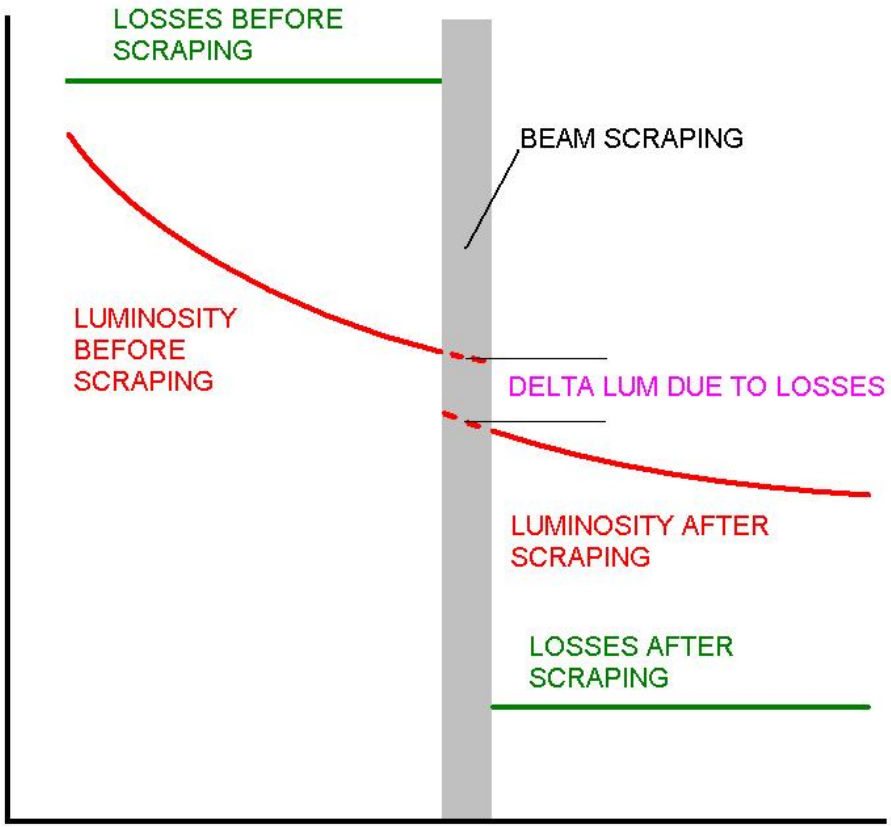
No slopes


X0vsRUN_COT
Entries 1708
Y0vsRUN_COT
Entries 1708
DxDzvsRUN_COT
Entries 1708
DyDzvsRUN_COT
Entries 1708

Systematics from Beam Position



Contribution due to losses

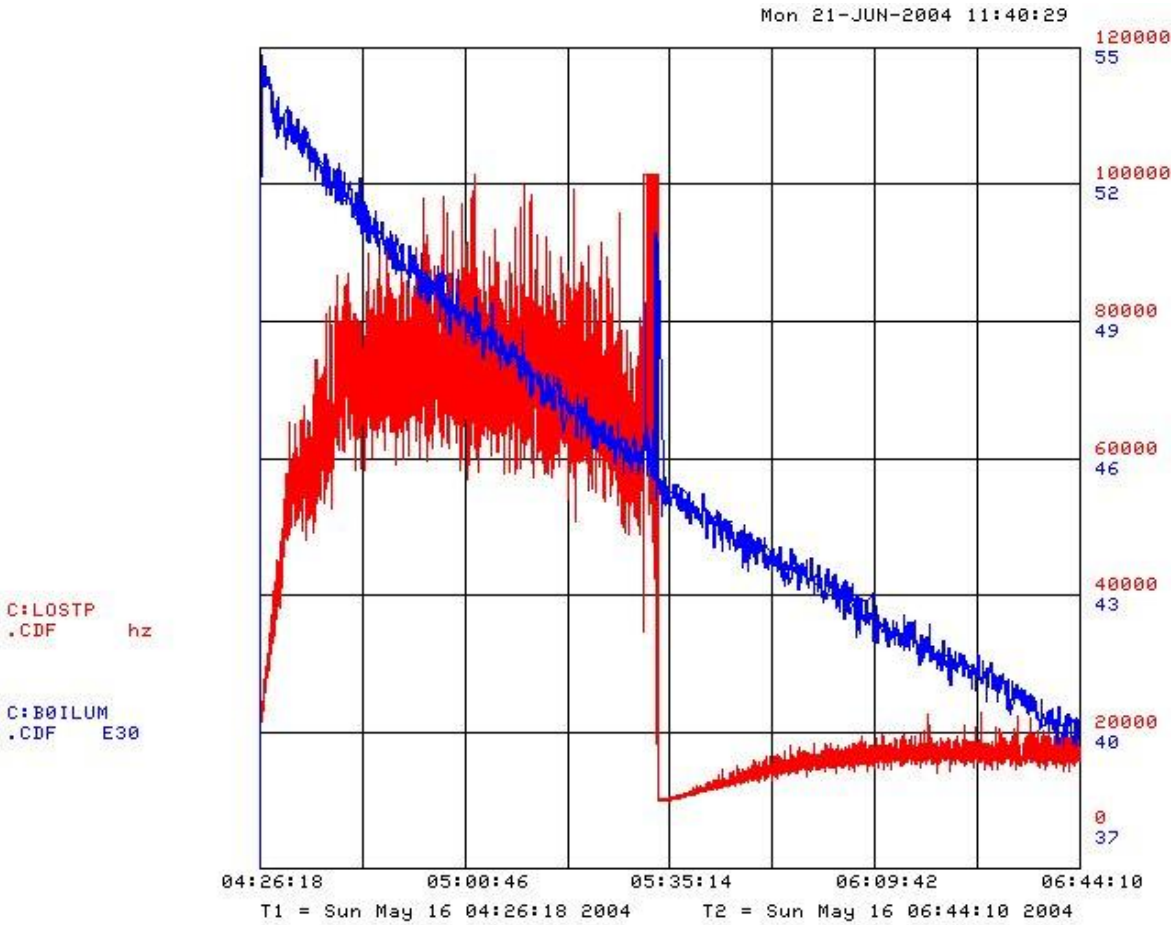


We consider one store with large variation of proton losses, due to a rescraping during the store itself.

We fit the online luminosity measurement in the two regions and calculate the JUMP before and after rescraping.

Delta luminosity is an overestimation of the beam losses contribution (luminosity NEVER increases during rescraping).

May 16, store 3500

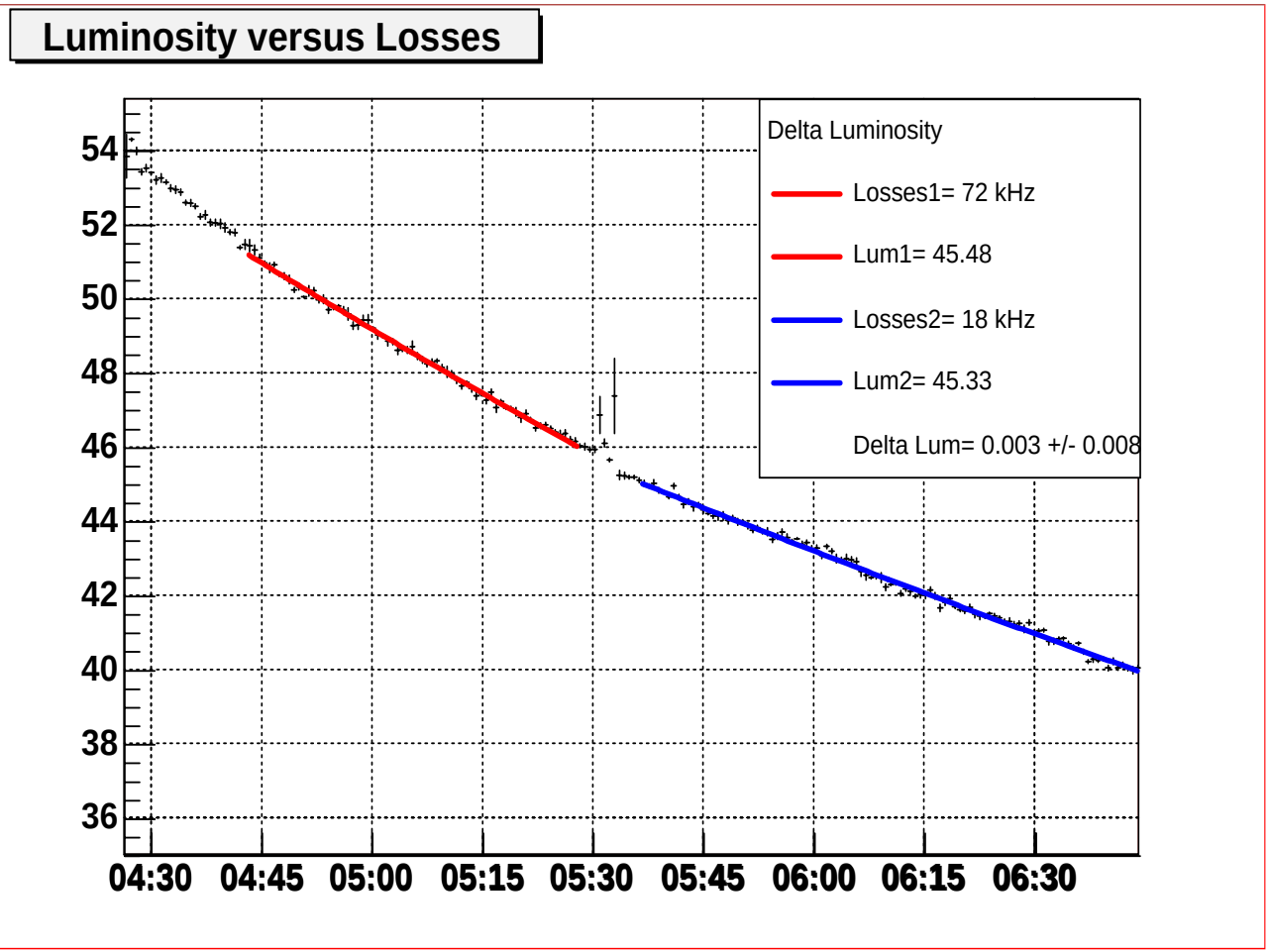


Between 04:45 and 05:30 proton losses had been permanently above 70kHz.

Beam rescraping at 05:33

After rescraping, losses where below 20kHz.

May 16, store 3500



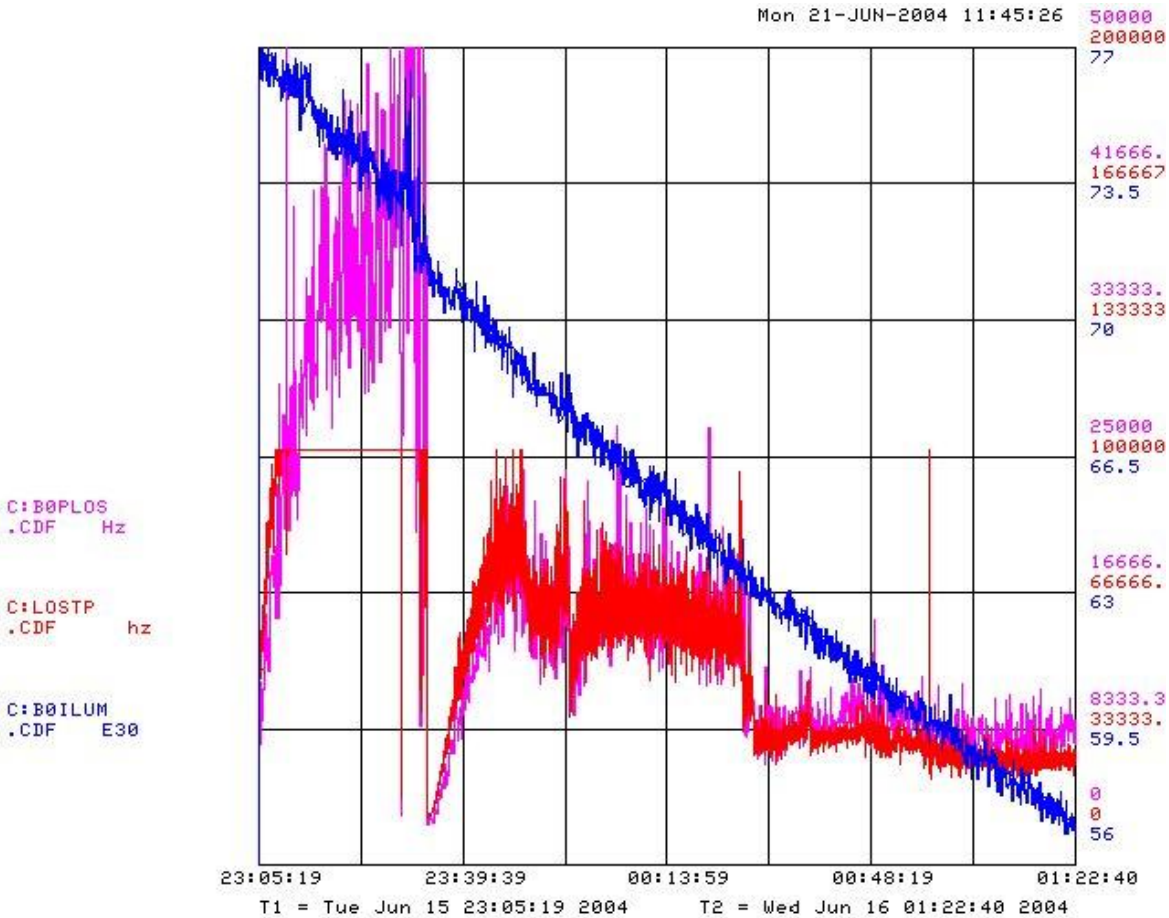
Losses changed by a factor 4 before and after beam rescraping.

Relative change in luminosity is compatible with 0.

Maximum level of losses for good silicon data is 20kHz.

$$DeltaLum = \frac{Lum1 - Lum2}{Lum2} = \frac{45.48 - 45.33}{45.33} = 0.3\% \pm 0.8\%$$

Jun 15, store 3576



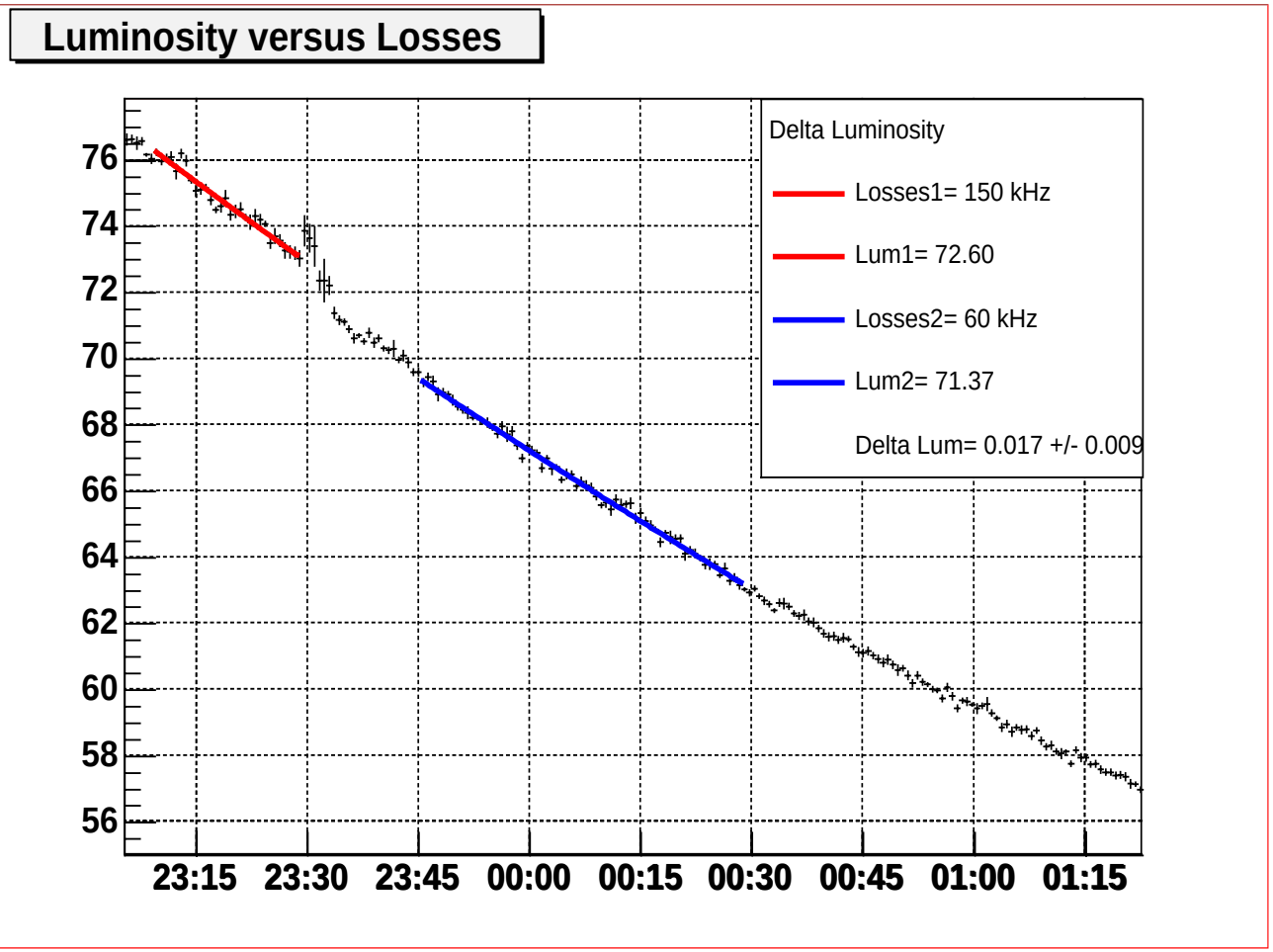
Between 23:10 and 23:28 proton losses had been around 150kHz.

Beam rescraping at 23:30

After rescraping, losses increased again to 60kHz (23:45 – 00:28).

After further tuning at 00:30 losses decreased to 30kHz.

Jun 15, store 3576

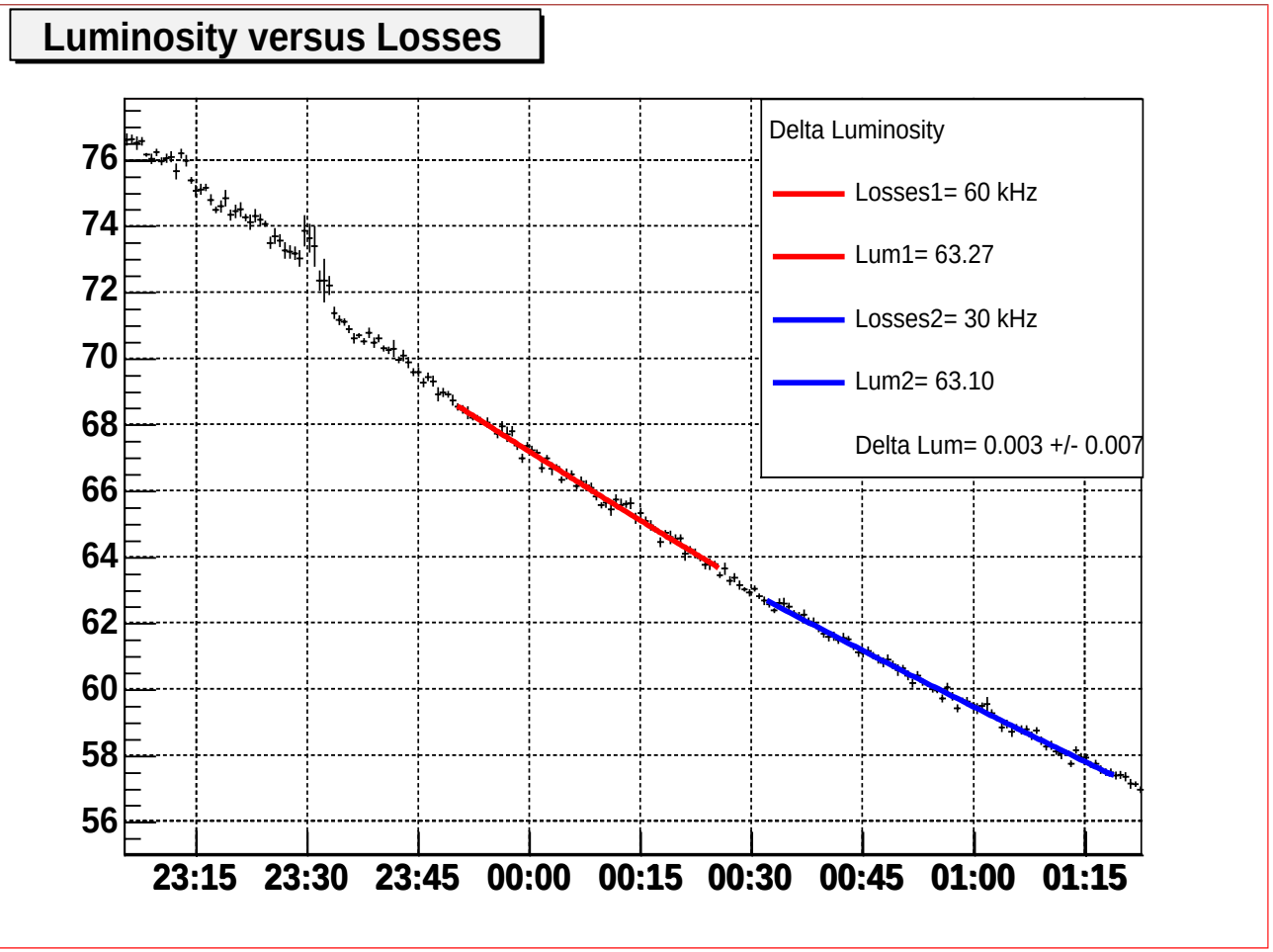


In the transition from 150kHz to 60kHz we observe a contribution to luminosity measurement about 1.7%.

Maximum level of losses for good silicon data is 20kHz.

$$DeltaLum = \frac{Lum1 - Lum2}{Lum2} = \frac{72.60 - 71.37}{71.37} = 1.7\% \pm 0.9\%$$

Jun 15, store 3576

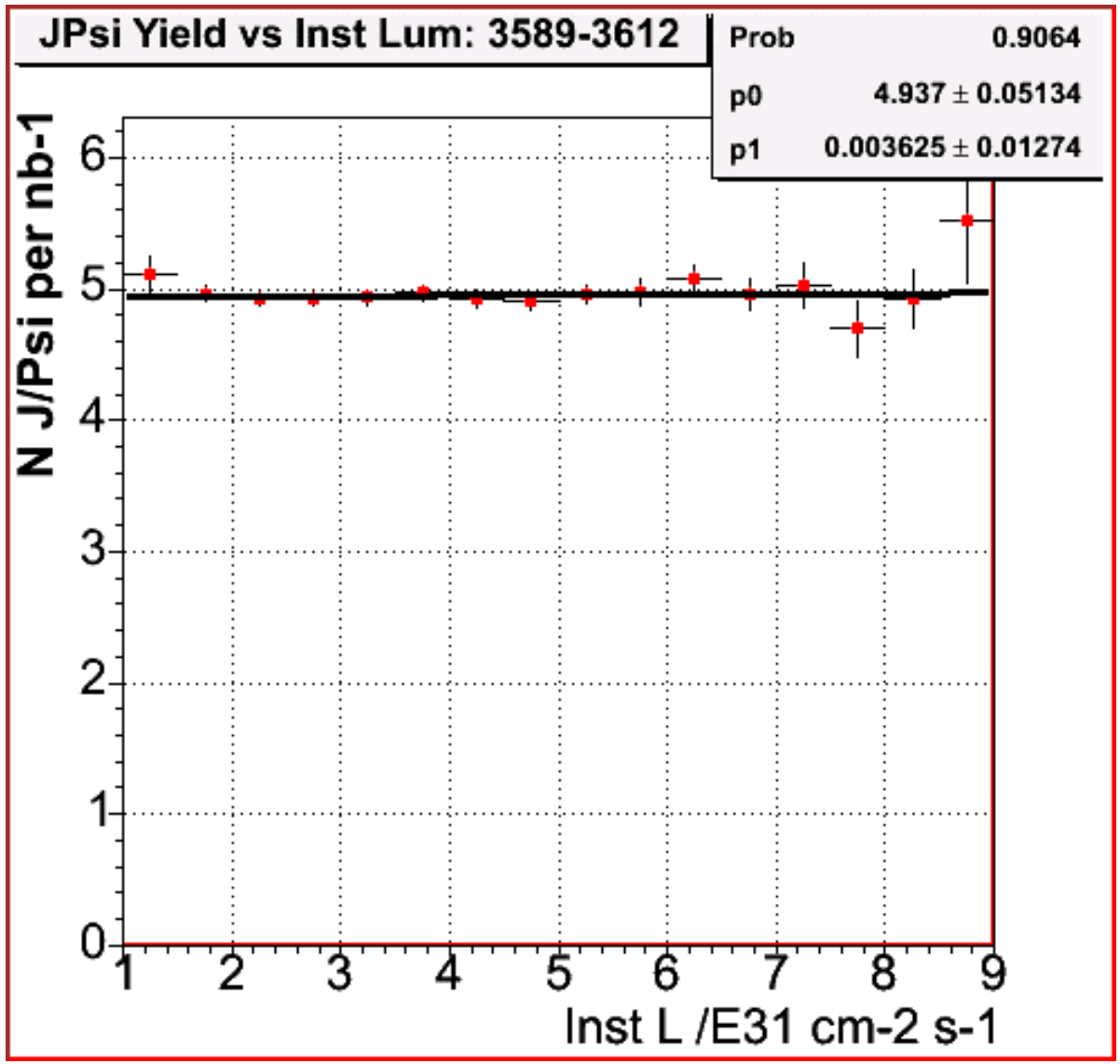


In the transition from 60kHz to 30kHz we observe a NO contribution to luminosity measurement.

Maximum level of losses for good silicon data is 20kHz.

$$DeltaLum = \frac{Lum1 - Lum2}{Lum2} = \frac{63.27 - 63.10}{63.10} = 0.3\% \pm 0.7\%$$

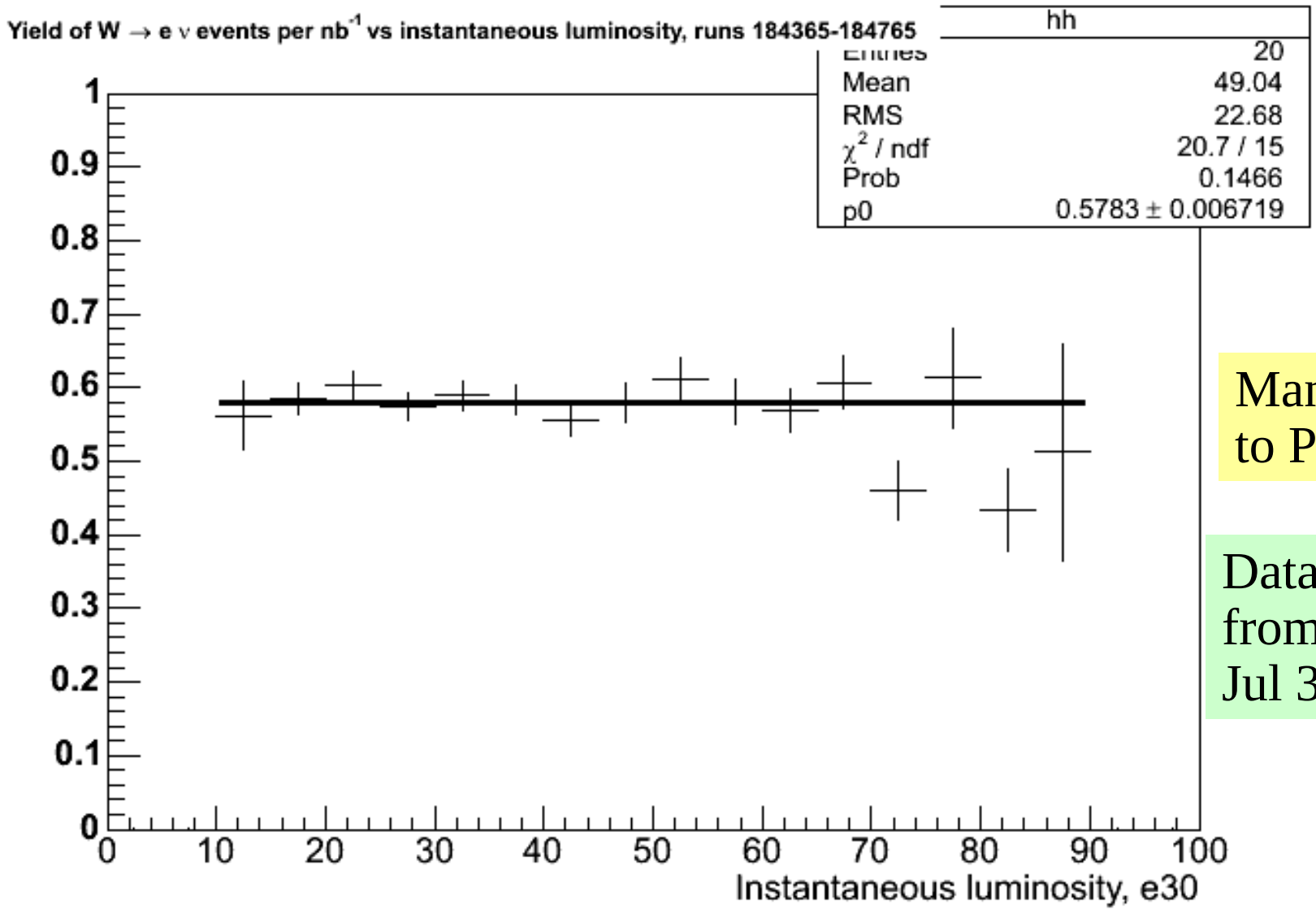
J/ψ →μμ yield versus luminosity



Many thanks to M. Herndon

Data collected from Jun 23 to Jul 3 2004

W→eν yield versus luminosity



Many thanks to P. Murat

Data collected from Jun 23 to Jul 3 2004

Conclusions

	Sys
MC	~3%
Losses	<1%
SPP	<1%
Beam Position	<1%

Flat yield VS luminosity!

Backup

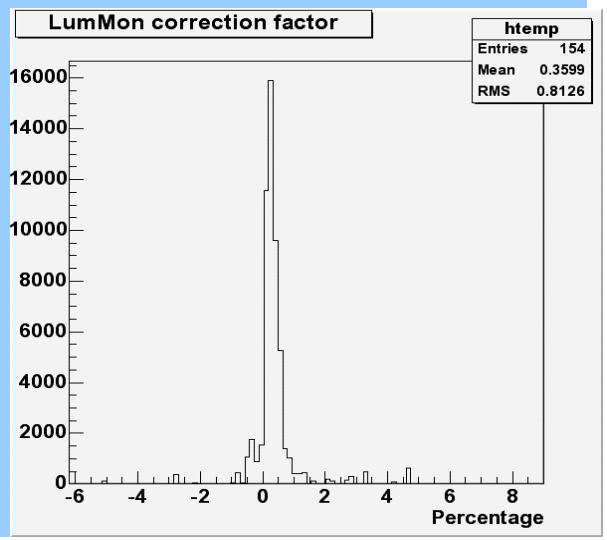
Stability and accounting systematics

Operational Review

- Luminosity is computed and:
  - It is stored directly in the ACNET system
  - It is written in the CLLD bank of each event.
- Online DFC
  - LumMon receives events via CSL and computes the RS
  - LumMon never receives the real first and last event
  - The number is written in the online DFC

Accounting Systematic

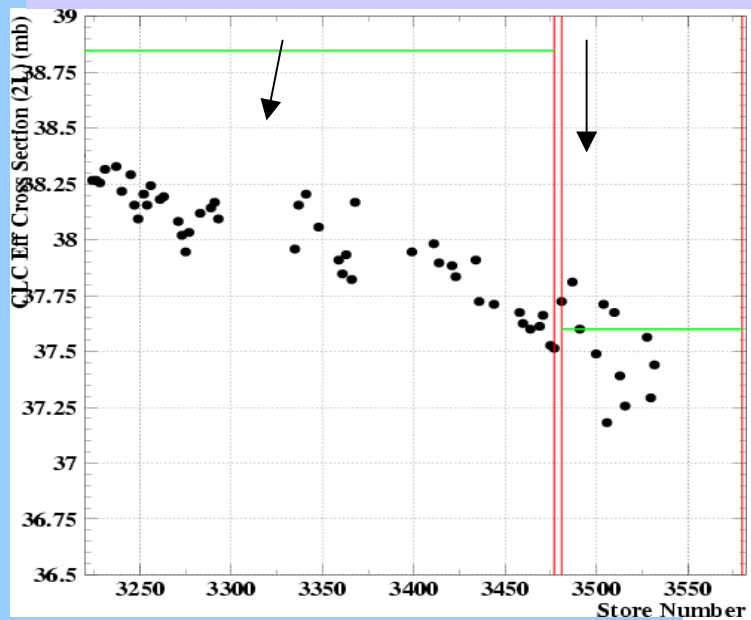
- Sources
  - By virtue of not receiving all events LumMon slightly underestimates the RS value
  - LumMon crashes, DB problems or other failures in filling the online DFC
    - Empty RS are filled either by interpolation or with a flat value when many missing
    - Not perfect → new systematic
- Correction procedure
  - True Lumi per Run known from ACNET, allows for calculation of a correction factor (per set of runs)
- Systematic : negligible (~0.1%)



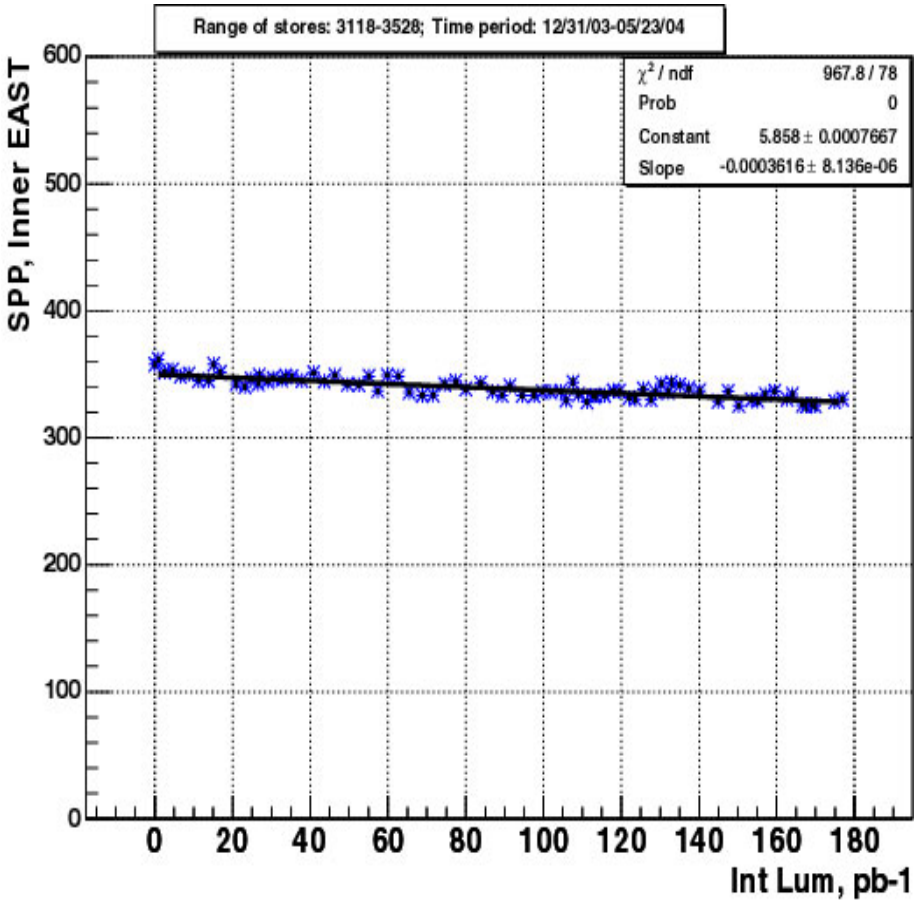
Stability Systematic

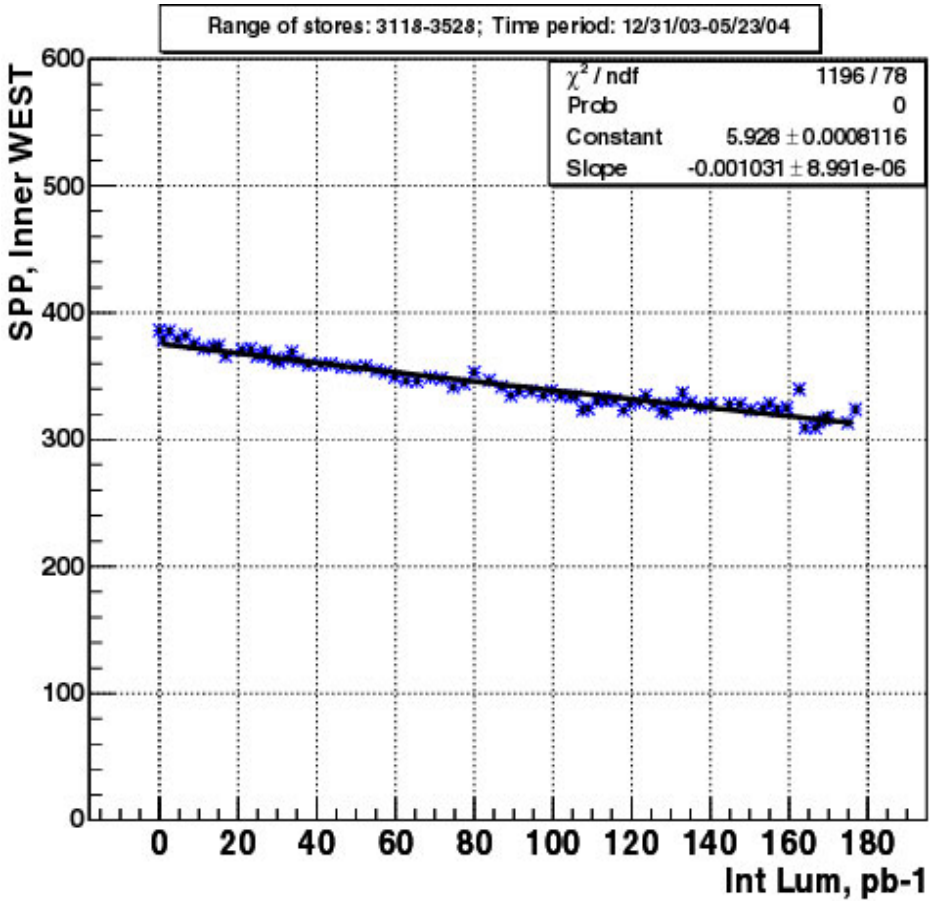
- Source : acceptance varies with time, online code uses same effective x-sec over some period → inexact values
- Correction algo
  - Compute the effective x-sec by store
  - Get AVERAGE effective x-sec per store range
  - Correct the online numbers accordingly
- Systematic comes from the averaging process
  - Ranges choosen such that syst. < 1%

Store ranges for averaging



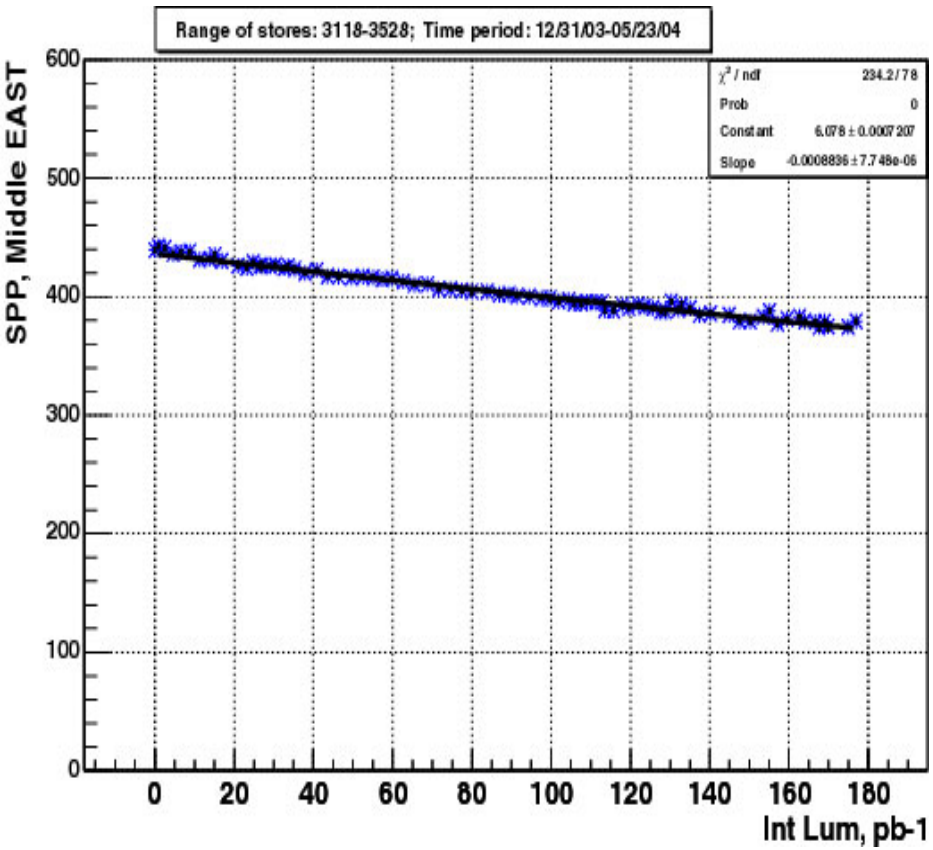
CLC stability after Fall2003 Shutdown: *inner layer*

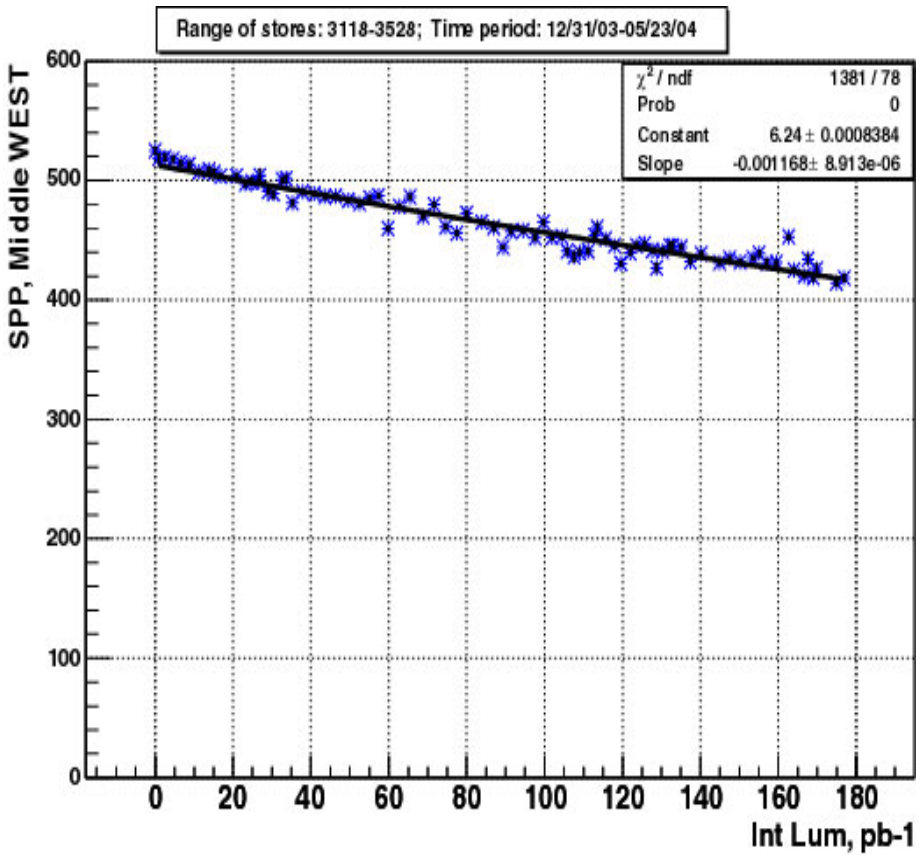




- **EAST:** PMT's were installed during Fall2003 shutdown
- **WEST**: PMT's were installed during 05/25/03-06/02/03 shutdown

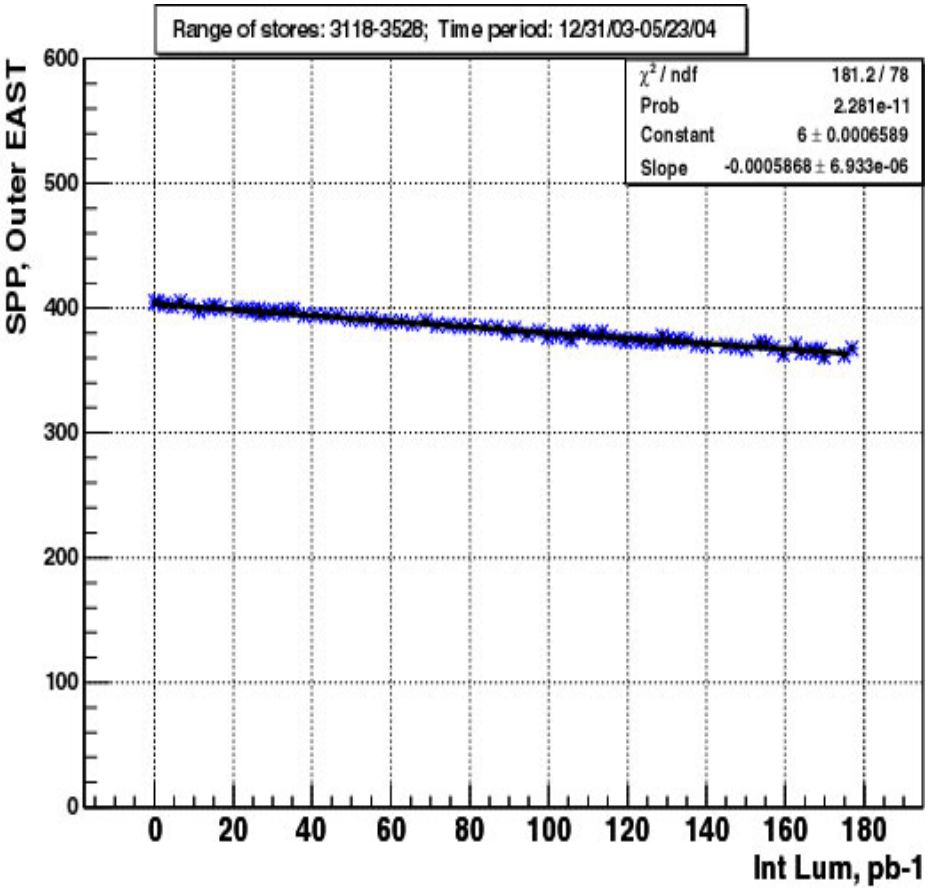
CLC stability after Fall2003 Shutdown: *middle layer*

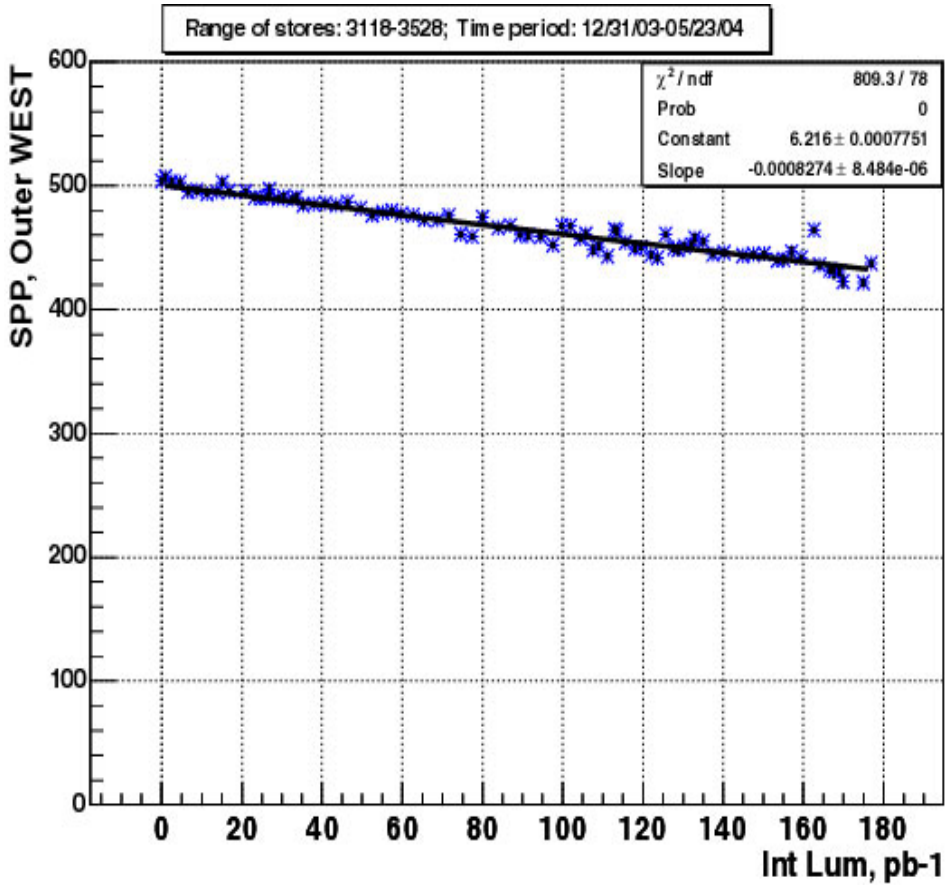




- **EAST:** PMT's were installed during Fall2003 shutdown
- **WEST**: PMT's were installed during 05/25/03-06/02/03 shutdown

CLC stability after Fall2003 Shutdown: *outer layer*





- **EAST:** PMT's were installed during Fall2003 shutdown
- **WEST**: PMT's were installed during 03/01/03-03/12/03 shutdown