New DØ Luminosity

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All Experimenters Meeting

10/09/2006

DØ Luminosity History

- Beginning of Run II:
  - Used the Run I constant until calibration was complete.
- January 2004:
  - First attempt at Run II constant put online based on best information available.
- October 2005:
  - Began using new readout electronics that drastically increased info available offline.
- October 2006:
  - New determination of the Run II luminosity scale put on line
  - Luminosity at DØ increases by about 12%.

Measurement Principle

- Luminosity determined by counting inelastic interactions and normalizing with respect to the inelastic cross section

$$\mathcal{L} = \frac{1}{\sigma_{p\bar{p},\mathrm{eff}}} \frac{dN}{dt}(p\bar{p})$$

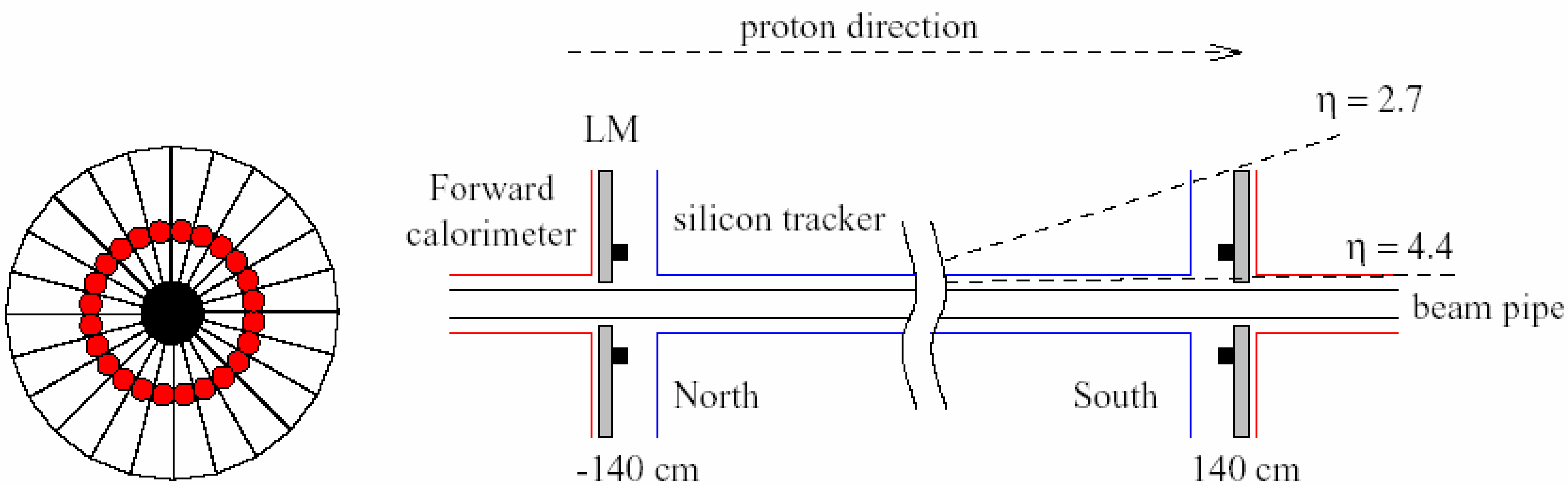
- Avoid difficulties of counting multiple interactions by counting zeros:

$$P(n=0) = e^{-\mu}.$$

Ingredients 0: Inelastic cross section

- Current number is a combination of E811 and CDF measurements at 1.8 TeV scaled to 1.96 TeV
  - S. Klimenko, H. Konigsberg, T. Liss, Fermilab-FN-0741 (2003)
  - $\sigma = 60.7$ +/- 2.4 mb
- Same number used by DØ and CDF

Ingredients I: A good detector



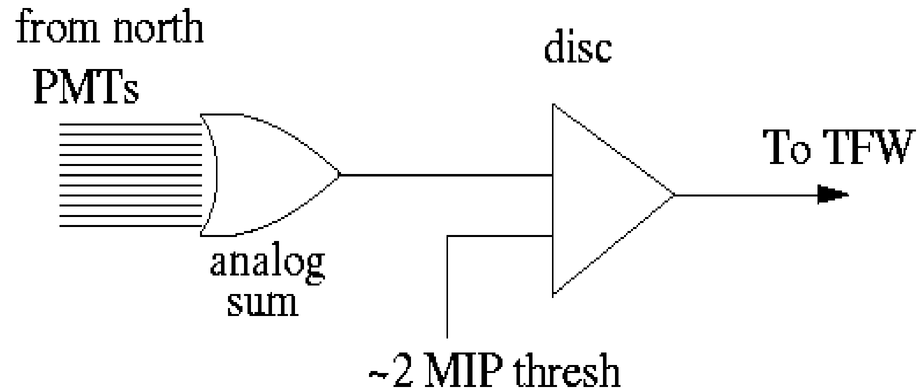
- Two arrays of forward scintillator. 24 wedges per side each read out with FM PMT
- Inelastic collision identified using coincidence of in-time hits in two arrays

Ingredients II: Good Readout

Readout in January 04

1 discriminator per array

Impossible to have high single particle efficiency and not saturate electronics in high mult crossings

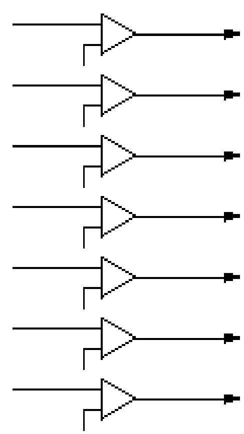


high threshold, fake gaps from deadtime

Readout Now

1 discriminator per channel

Sub MIP thresholds, high single particle efficiency



Each PMT

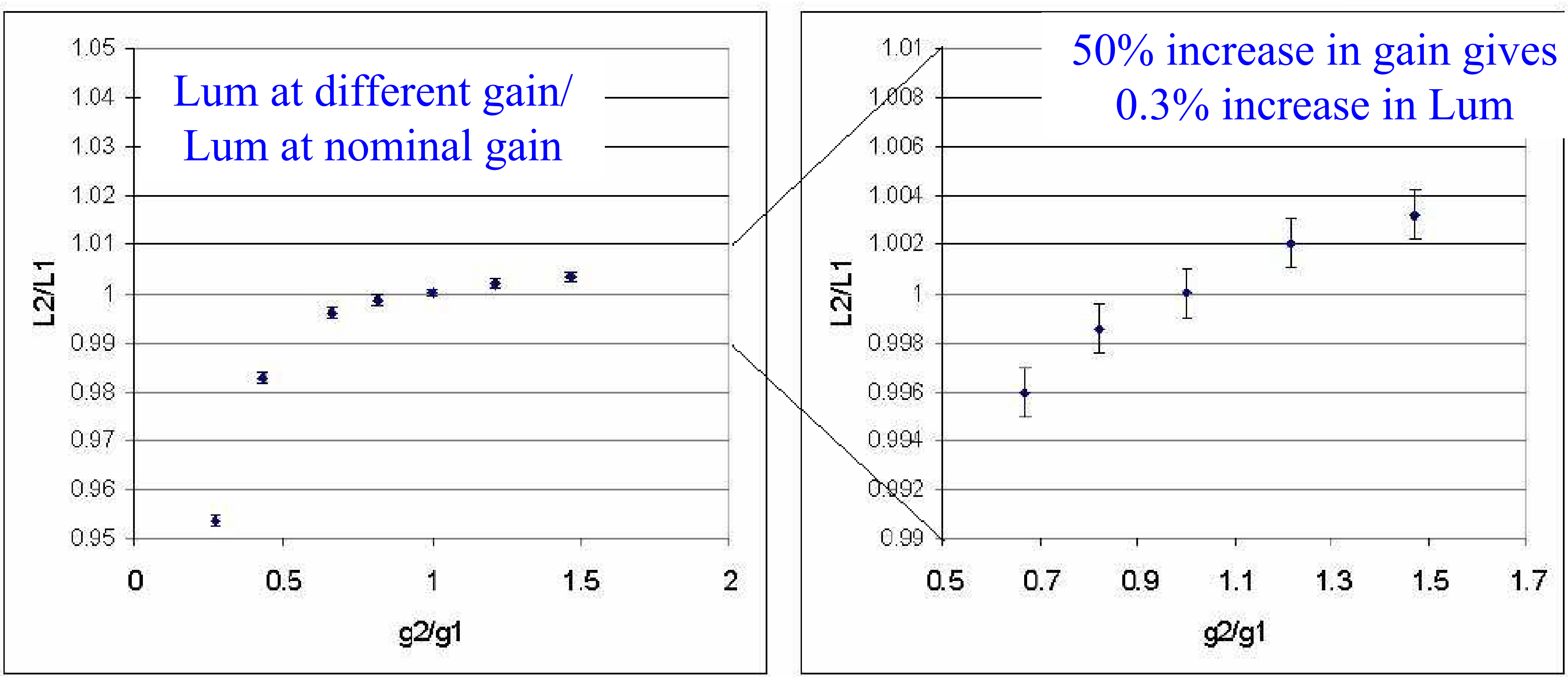
discriminated

with < 1 MIP thresh

T/Q info to L3

low thresholds, almost no deadtime

Ingredients II: Good Readout



Readout Now

PMT gain now set so that counting rate of inelastic collisions is plateaued

Ingredients III: Info to tune MC

Readout in January 2004

One bit for each array

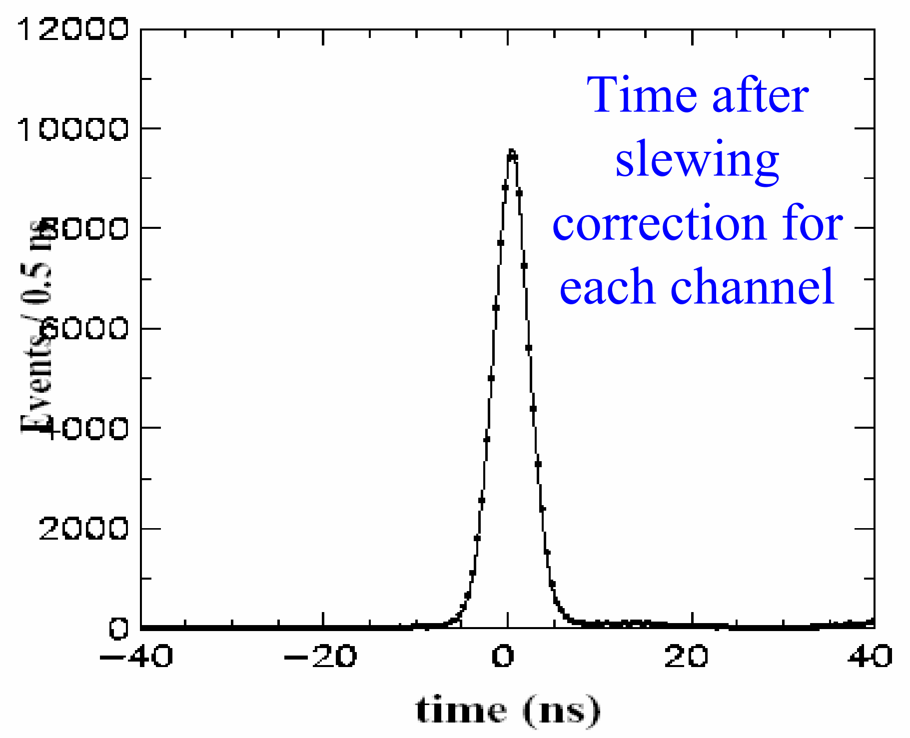
One bit for timing cut

One bit for halo

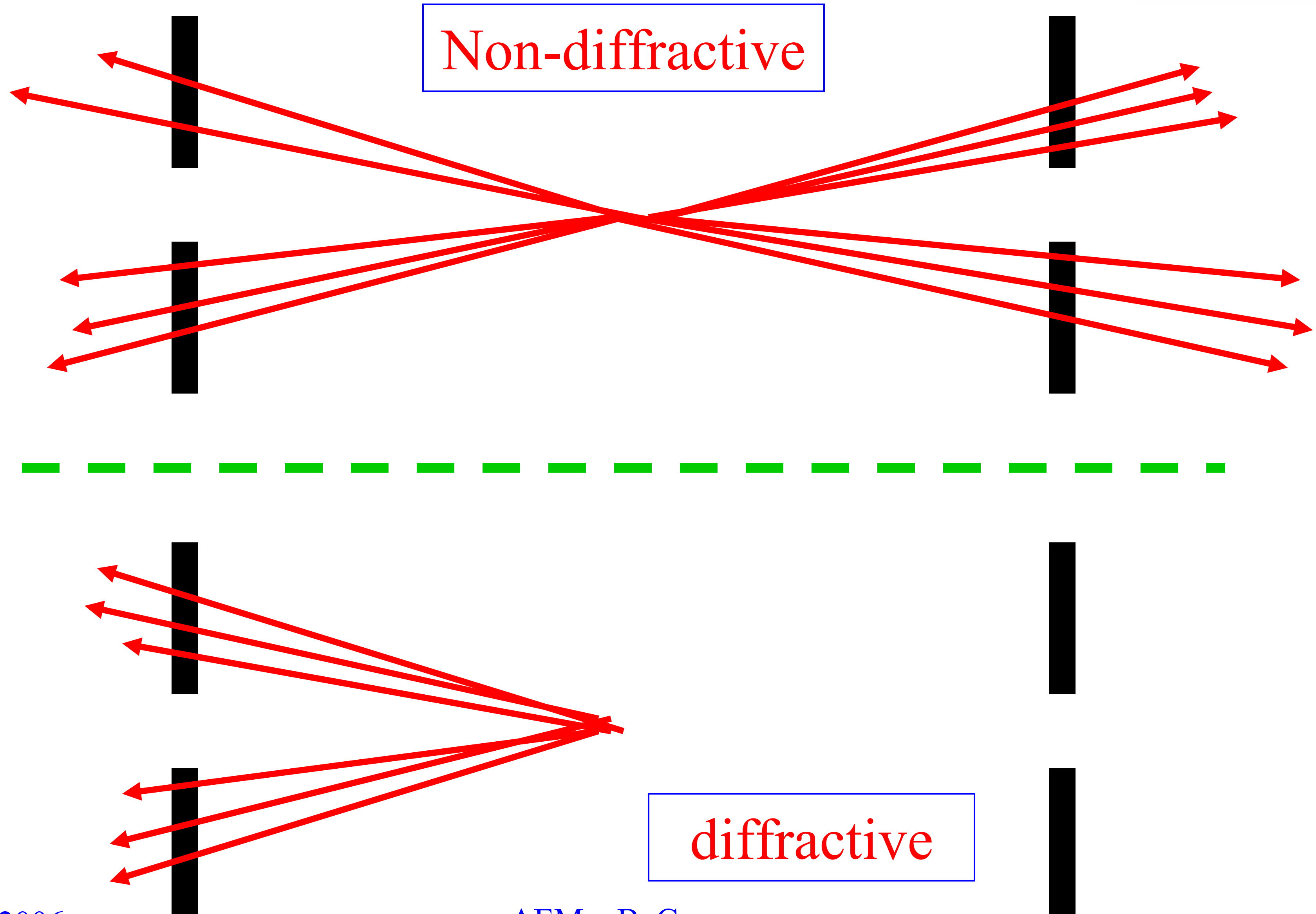
North	0
South	1
Coincidence	0
Proton halo	1
Antiproton halo	0

Readout Now

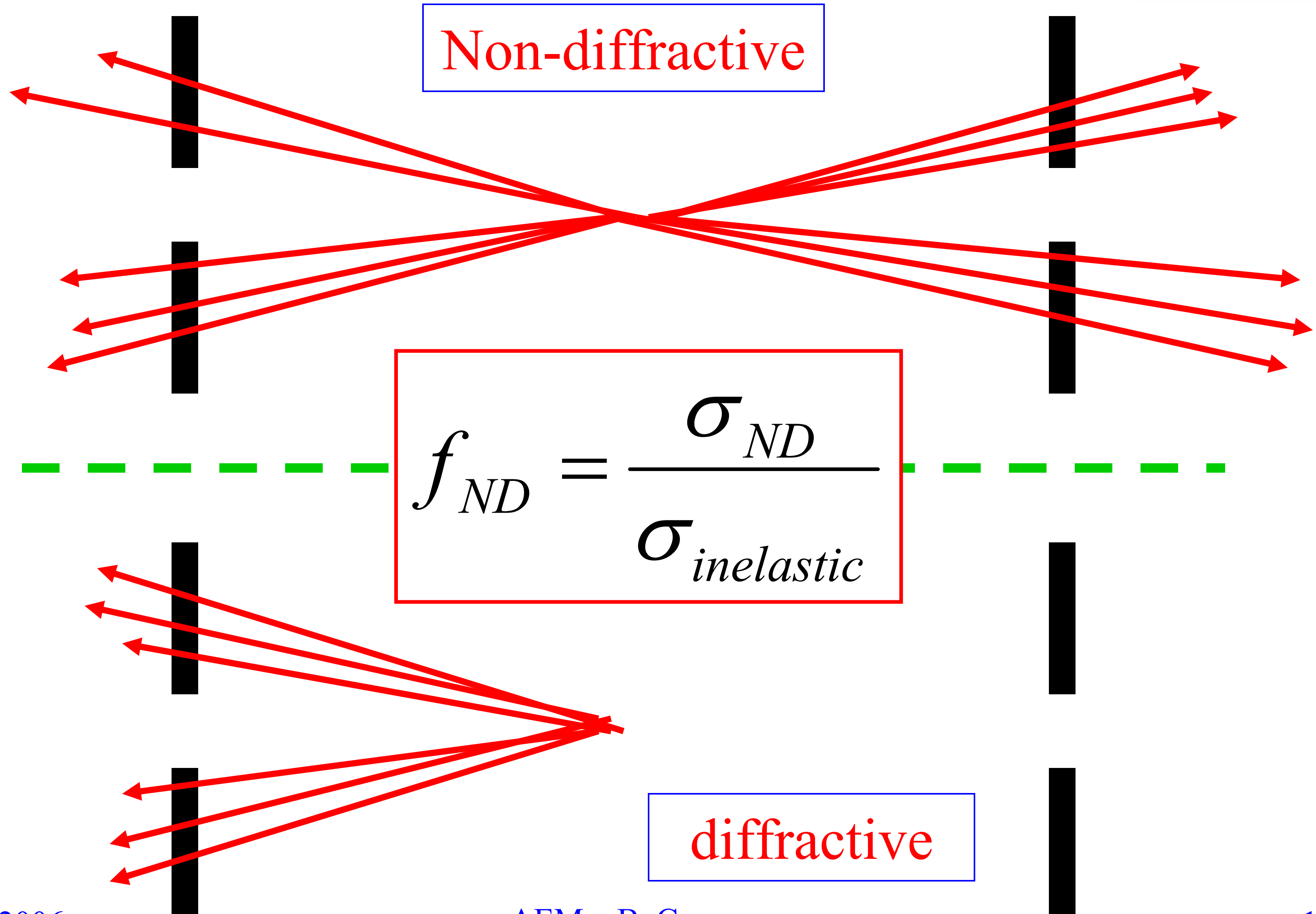
All info for all channels for every event: MIP location, thresholds, timing cuts now all in MC



Ingredients IV: Inelastic acceptance



Ingredients IV: Inelastic acceptance



$$f_{ND} = \frac{\sigma_{ND}}{\sigma_{inelastic}}$$

Ingredients IV: Inelastic acceptance

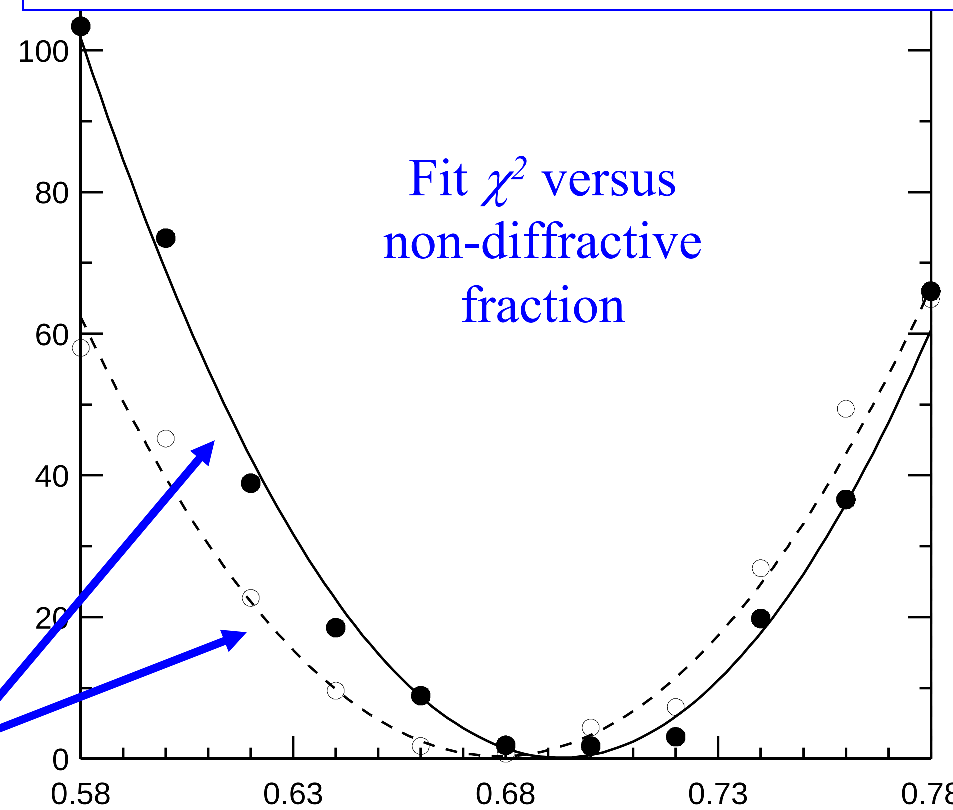
January 2004

MC weighted using measured diffractive cross sections.

No way to verify weighting was appropriate

Now

Weighting determined by fits to the multiplicity in LM detector

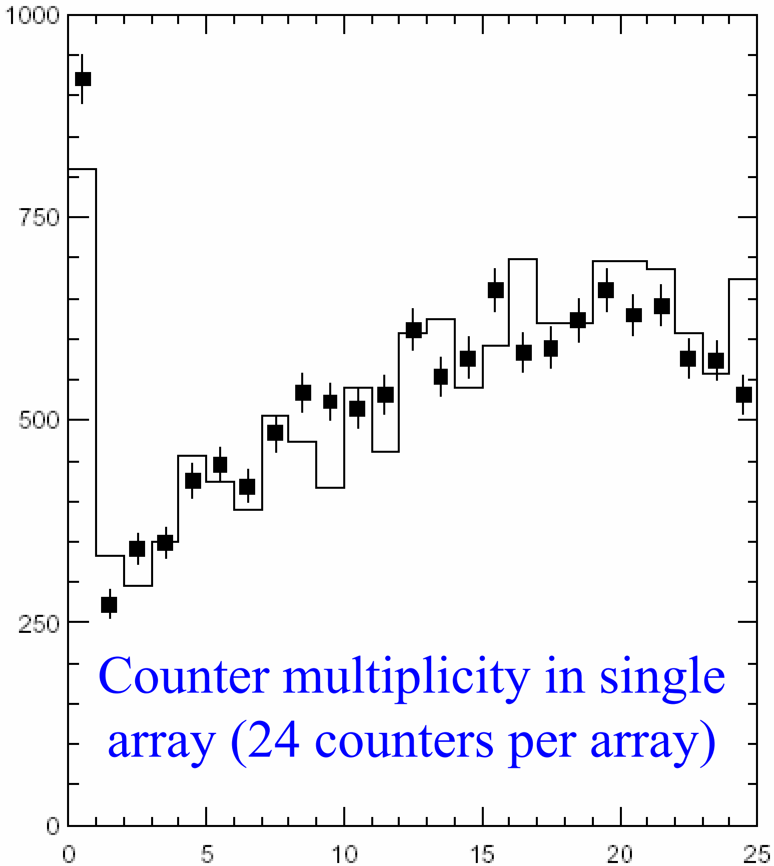


Different assumptions

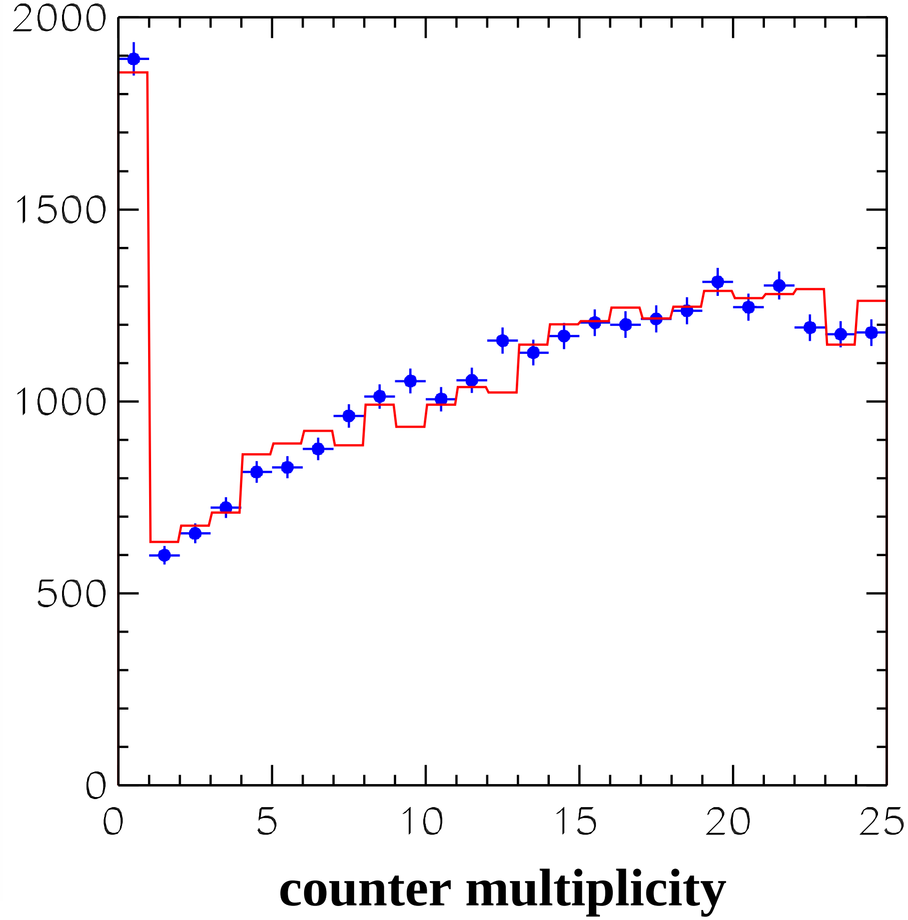
Ingredients IV: Inelastic acceptance

Data versus MC using

Jan 2004 numbers



Data versus MC Now



Cross-checks

Fit parameters	non-diffractive fraction
final	0.687 ± 0.044
12e30 fit, opposite side mult > 0, 2 bin fit	0.695
14e30 fit, opposite side mult > 0, 2 bin fit	0.678
12e30 fit, opposite side mult > 0, 25 bin fit	0.685
12e30 fit, opposite side mult > 1, 25 bin fit	0.690
14e30 fit, opposite side mult > 0, 25 bin fit	0.658
14e30 fit, opposite side mult > 1, 25 bin fit	0.665
43e30 fit, opposite side mult > 0, 25 bin fit	0.693
12e30 fit, opposite side mult > 0, 2 bin fit, $f_{DD} = 0$	0.695
12e30 fit, opposite side mult > 0, 2 bin fit, $f_{SD} = 0$	0.706
12e30 fit, opposite side mult > 0, 2 bin fit, 0.3 X_0 added	0.687
Pythia calculation	0.662
E710, E811, CDF measurements	0.723

Final Numbers

	default	thresholds	in-time	material	MIP location	light-yield modeling
non-diffractive	0.981 ± 0.001	± 0.003	± 0.001	$\pm 0.006(5)$	$\pm 0.004(4)$	± 0.004
single diffractive	0.330 ± 0.004	± 0.007	± 0.001	$\pm 0.022(25)$	$\pm 0.003(11)$	± 0.001
double diffractive	0.436 ± 0.005	± 0.008	± 0.003	$\pm 0.019(30)$	$\pm 0.014(14)$	± 0.005
inelastic	0.784 ± 0.001	± 0.004	± 0.007	$\pm 0.003(7)$	$\pm 0.005(4)$	± 0.003

non-diffractive efficiency	0.981 ± 0.009
single diffractive efficiency	0.330 ± 0.024
double diffractive efficiency	0.436 ± 0.026
f_{ND}	0.687 ± 0.044
$f_{SD}/(f_{SD} + f_{DD})$	0.57 ± 0.21
inelastic efficiency	0.792 ± 0.029
inelastic cross-section	60.7 ± 2.4 mb

48 mb, ~6% uncertainty

lum increases by ~12%

Conclusions

- In October 2005 we completed integration of new readout electronic for the DØ luminosity detector
  - Allowed us to increase PMT gains to plateau
  - Provided necessary info into the data to properly calibrate the detector and MC
- Using the new available information, we have updated the DØ luminosity scale
  - ~12% increase in reported instantaneous luminosity