EUROPEAN PHYSICAL SOCIETY

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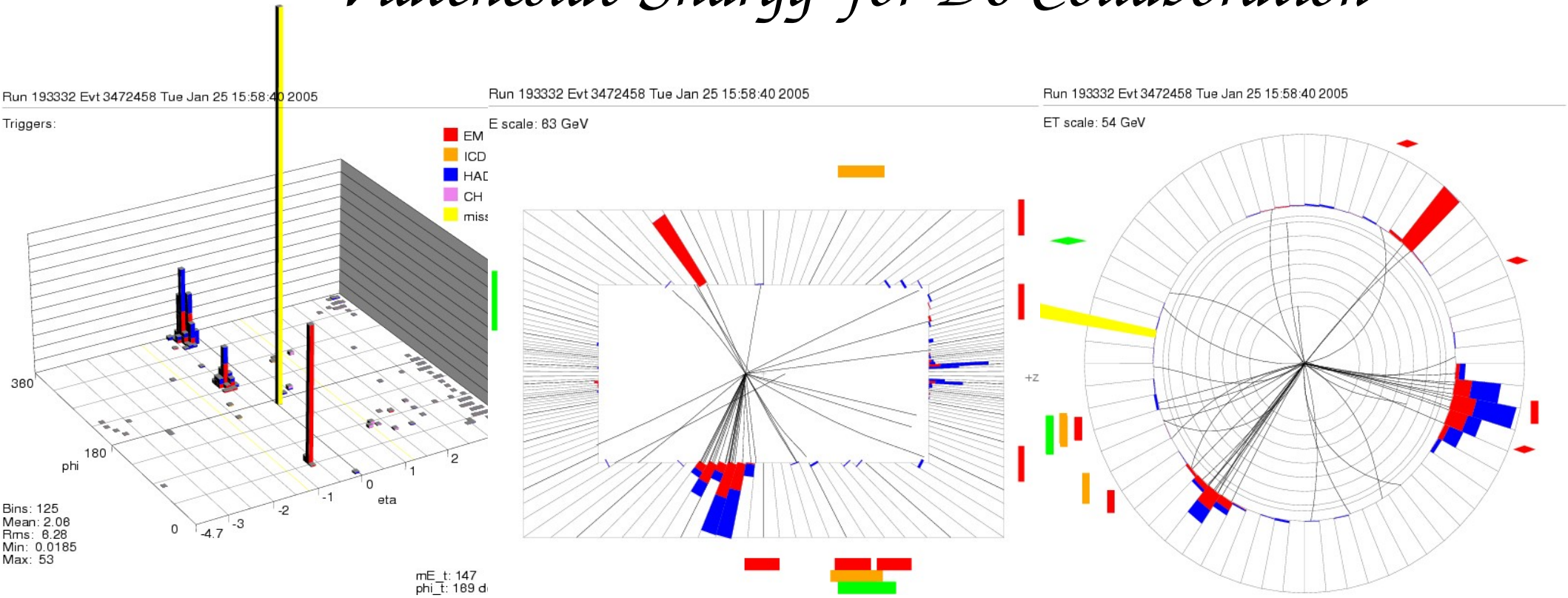
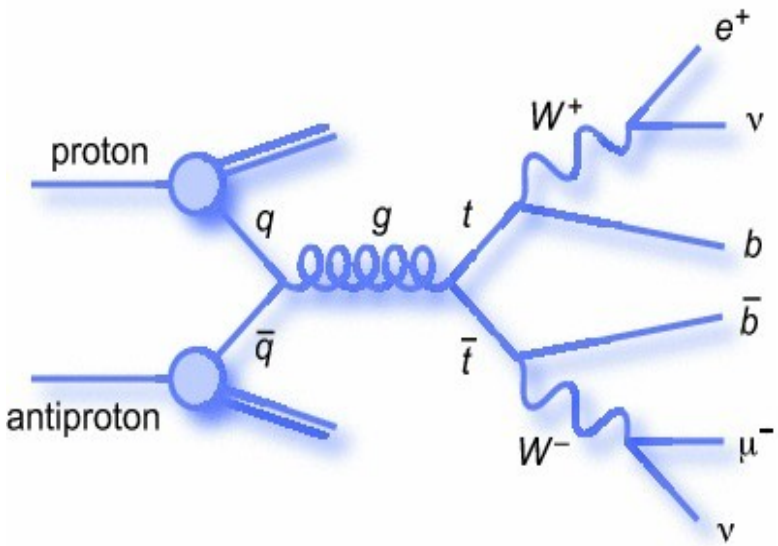
Measurements of the Top Quark Pair Production Cross Section in the Dilepton and All-Jets Final States With D0 Detector

Viatcheslav Sharyy for D0 Collaboration



DILEPTON FINAL STATE

- Signature: 2 b jets; 2 high p_T leptons (electron, muon); large missing E_T.
- The "cleanest" channel for the top production, but small branching ratio (~6%)

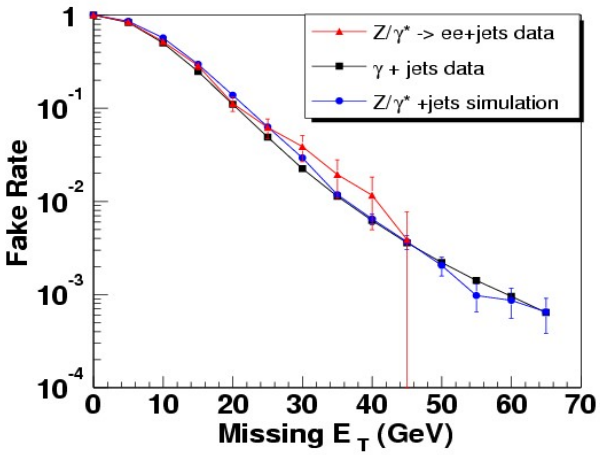


- Main backgrounds:
  - "physics" backgrounds WW, WZ and Z production (ee, μμ, eμ);
  - "fake" electron, muon and missing E_T backgrounds;
- 3 separate analyses: ee (1.6%), μμ (1.6%) and eμ (3.2%). *Branching ratios include τ decays to electron and muon.*

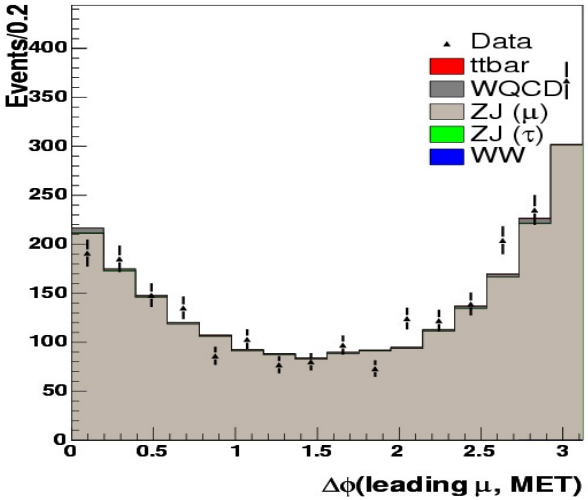
EVENTS SELECTION

- **Electron:** isolated electron-like shower in calorimeter, matched to the track in the tracking system, $p_T > 15$ GeV, $|\eta| < 1.1$ or $1.5 < |\eta| < 2.5$
- **Muon:** track in the muon system matched to the track in the tracking system, isolated both in the calorimeter and in the tracking system, $p_T > 15$ GeV, $|\eta| < 2.0$
- **Jets:** jets-like shower in the calorimeter $p_T > 20$ GeV, $|\eta| < 2.5$
- **Missing E_T:** sum of the calorimeter cell transverse energies, corrected by jet, electron, muon energy depositions. Typical cut value 35 – 40 GeV

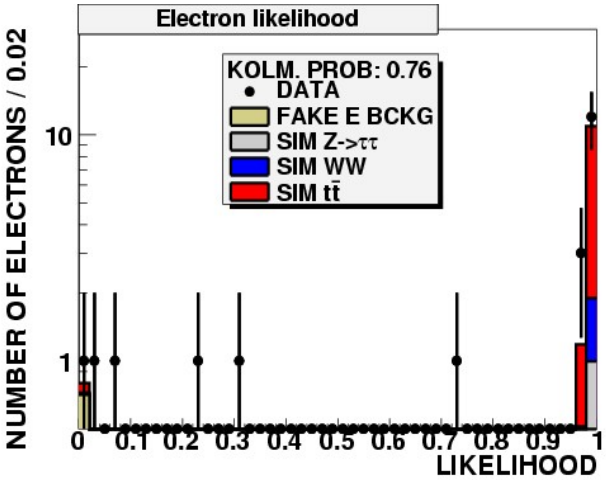
INSTRUMENTAL BACKGROUND



- **Di-electron** channel has a multijet and Z production backgrounds due-to mismeasured missing E_T and misidentified electron. These background estimated from data.



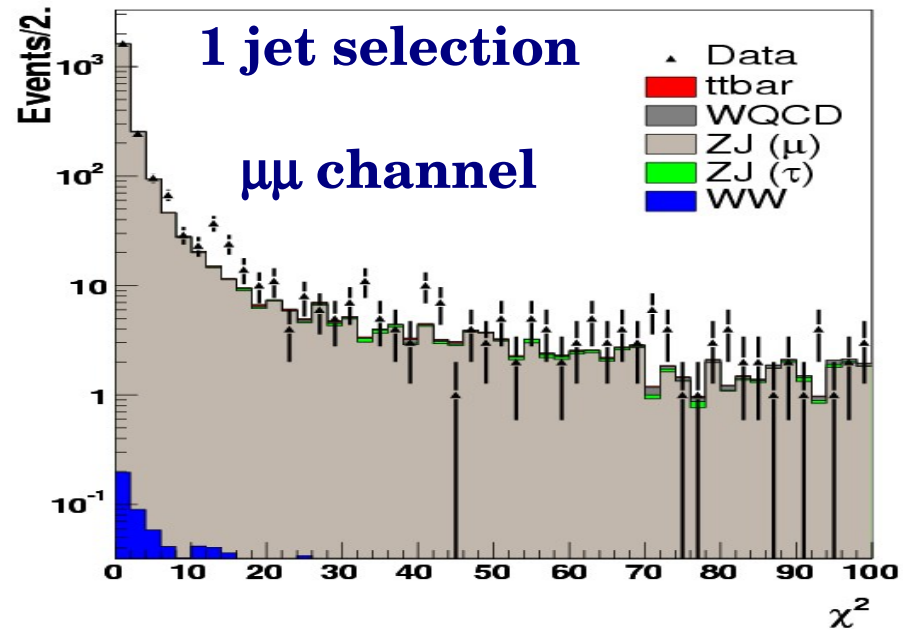
- **Di-muon** channel has a significant contribution from $Z \rightarrow \mu\mu$. It is estimated with simulation corrected by experimental resolutions.

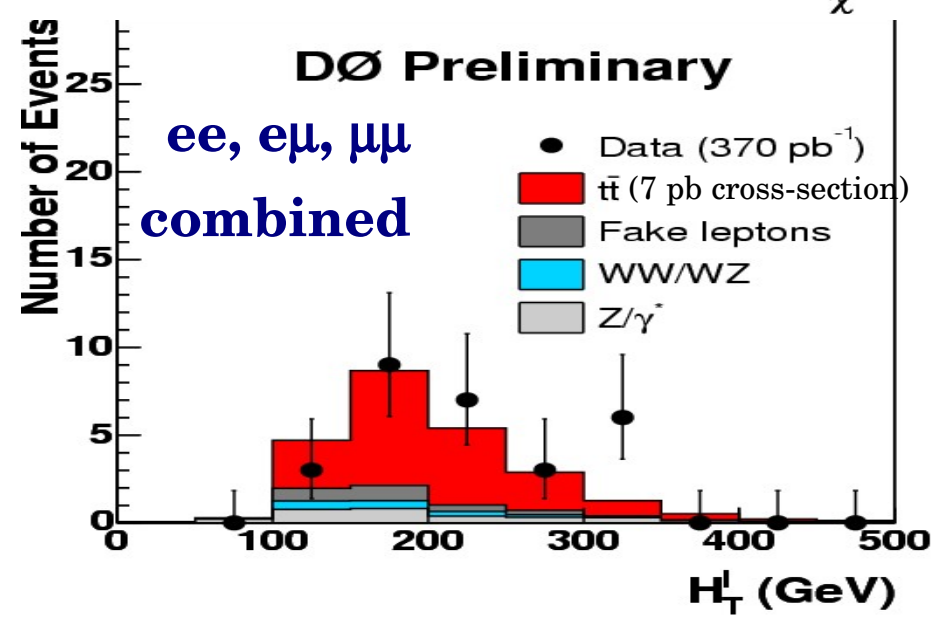


- **Electron-muon** channel has a contribution from multijet production due to the misidentified electron. This contribution is subtracted using the electron likelihood distribution with signal and background shapes measured from data

FINAL SELECTION

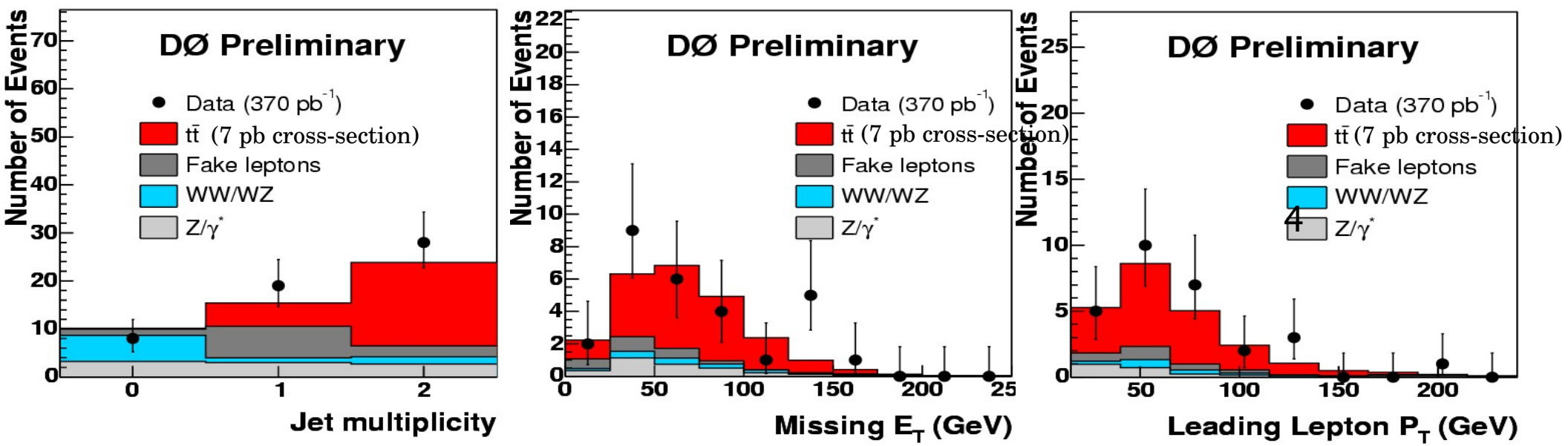
- **Di-electron** channel uses cut on sphericity (sum of 2 leading eigenvalues of a normalized momentum tensor)
- **Di-muon** channel uses cut on the χ^2 value calculated in $Z \rightarrow \mu\mu$ hypothesis ($\chi^2 > 2$)
- **Electron-muon** channel uses cut on the sum of transverse momenta of 2 leading jet and leading lepton ($H^l_T > 122$ GeV)





YIELD

Category	ee	$\mu\mu$	$e\mu$	$\ell\ell$
Integrated luminosity (pb^{-1})	384	363	368	–
Z/γ^*	$0.75^{+0.18}_{-0.21}$	$1.01^{+0.22}_{-0.34}$	$1.22^{+0.33}_{-0.39}$	$2.98^{+0.43}_{-0.55}$
WW/WZ	$0.20^{+0.10}_{-0.14}$	$0.20^{+0.08}_{-0.07}$	$1.13^{+0.45}_{-0.48}$	$1.53^{+0.47}_{-0.50}$
Instrumental leptons	0.09 ± 0.03	0.13 ± 0.04	$2.13^{+2.50}_{-1.66}$	$2.35^{+2.50}_{-1.67}$
Total background	$1.0^{+0.2}_{-0.3}$	$1.3^{+0.3}_{-0.4}$	$4.5^{+2.6}_{-1.8}$	$6.8^{+2.6}_{-1.8}$
Signal efficiency	0.082	0.064	0.139	–
Expected signal	3.5 ± 0.4	2.5 ± 0.3	$11.3^{+1.2}_{-1.4}$	$17.3^{+1.3}_{-1.5}$
Signal + background expectation	$4.5^{+0.4}_{-0.5}$	$3.8^{+0.4}_{-0.5}$	$15.8^{+2.8}_{-2.3}$	$24.1^{+2.9}_{-2.4}$
Selected events	5	2	21	28

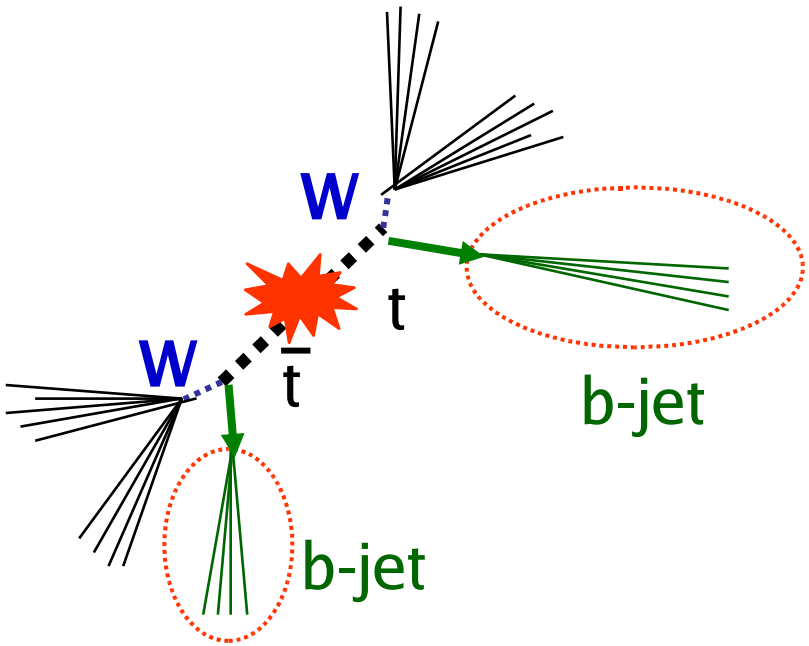


RESULTS

$$\sigma = 8.6\,^{+2.3}_{-2.0}\,(stat)\,^{+1.2}_{-1.0}(syst) \pm 0.6\,(lum)\ \ pb$$

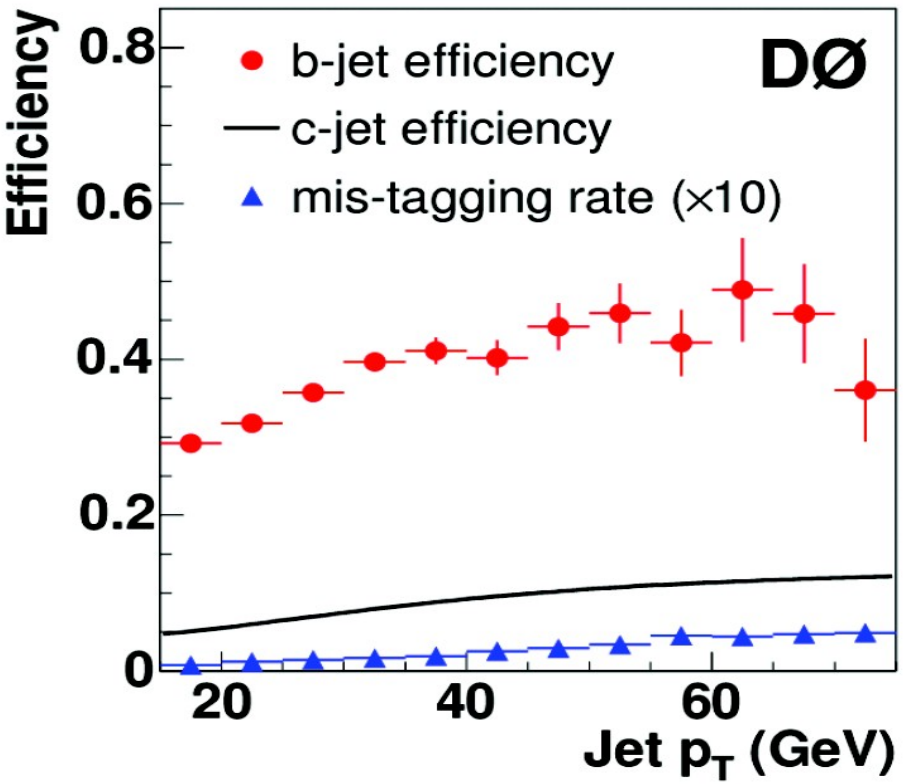
SYSTEMATICS UNCERTAINTY	VALUE, pb	
Jet energy calibration	+0.5	-0.5
Jet identification	+0.5	-0.4
Muon identification	+0.5	-0.4
Electron identification	+0.4	-0.3
Trigger	+0.7	-0.4
Other	+0.4	-0.4

ALL-JETS FINAL STATE



- Final state: at least 6 jets (with 2 b-jets).
- Large branching ratio (46%), but huge QDC background $\sigma_{QCD} > 5000\sigma_{tt}$
- Pre-selection
  - at least 6 jets with $E_T > 15$ GeV, $|\eta| < 2.5$
  - Isolated lepton veto
  - Reject events with multiple hard-scattered vertices

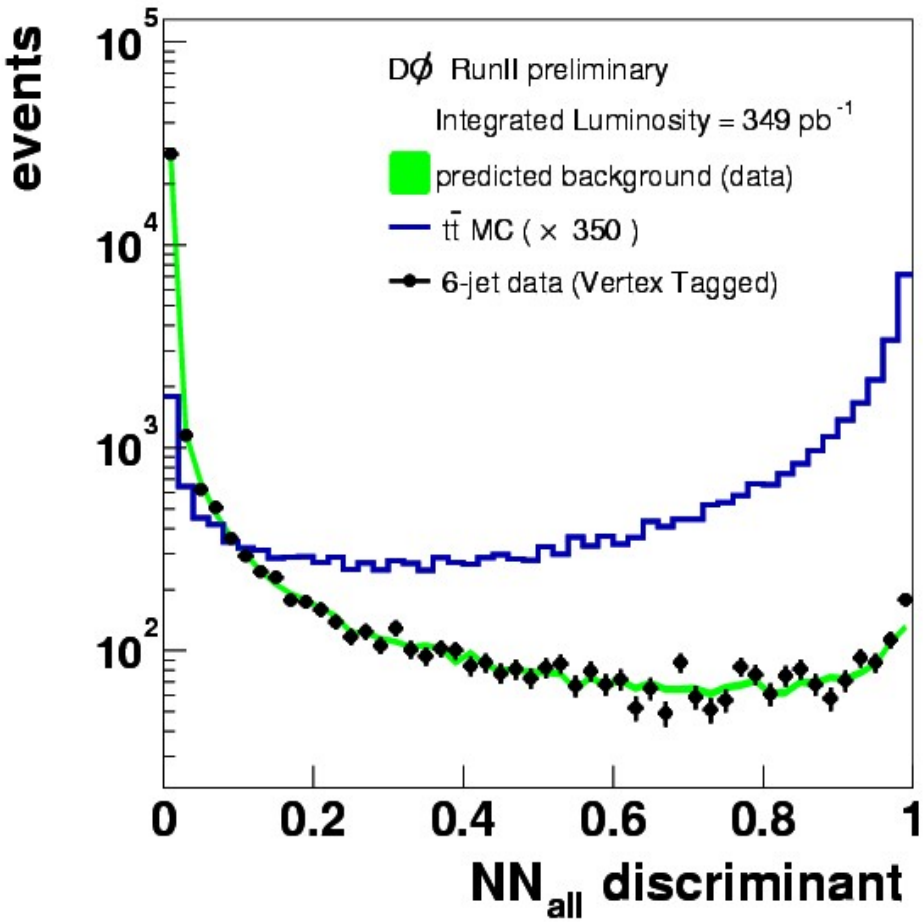
SECONDARY VERTEX TAGGING



- Typical efficiency to have at least one b-tag in a $t\bar{t}$ event is 61%. Use muon-tagged jets to measure data / MC efficiency correction factor and then apply this factor to MC.

- Tag rate in background data events (TRF) is 3%. This includes: b-jets, c-jets, mis-tag rate for light jets. This rate was measured using the pre-selected 6 jet sample and parametrized in η, φ, p_T, z_{pv}, H_T.

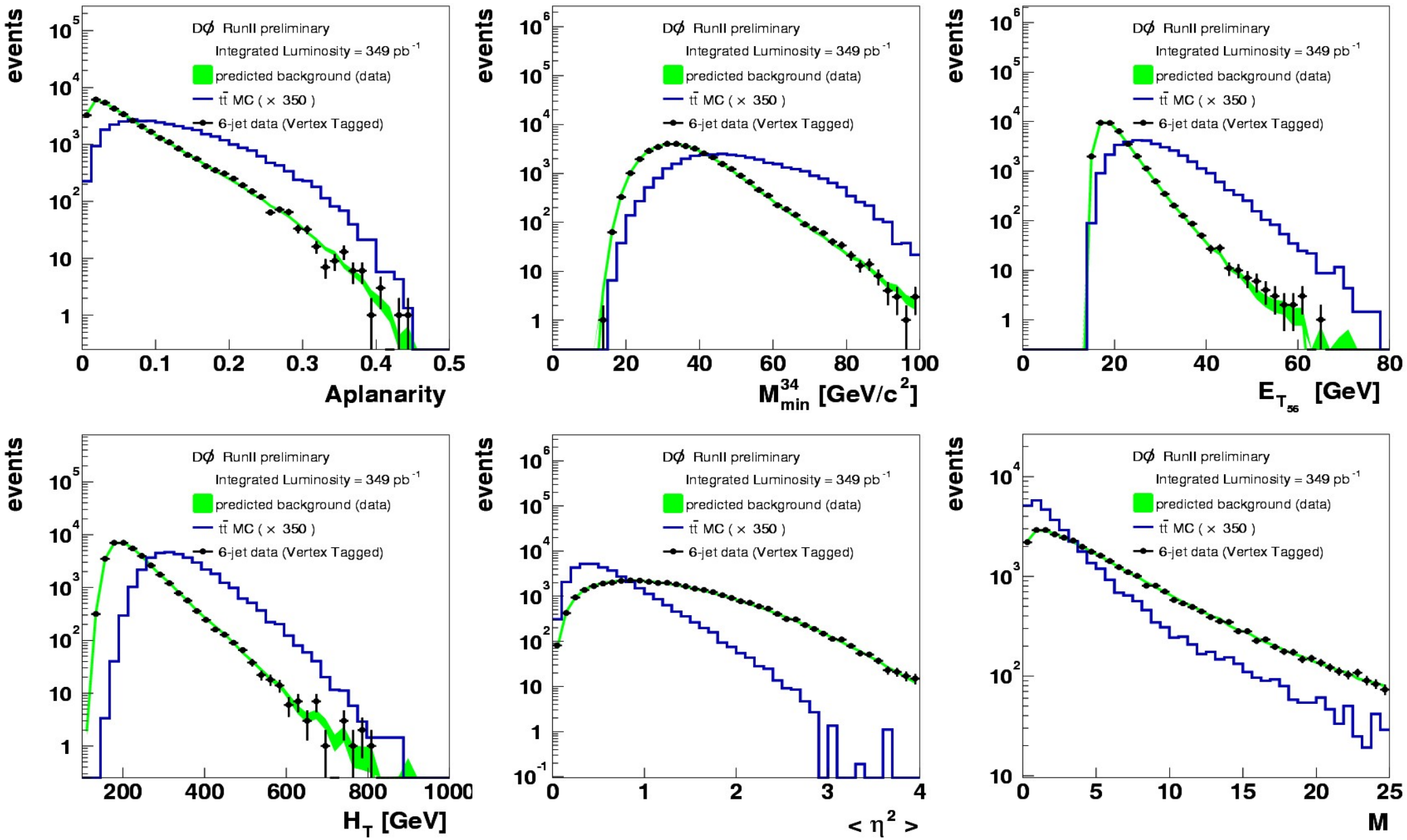
NEURAL NETWORK DISCRIMINANT



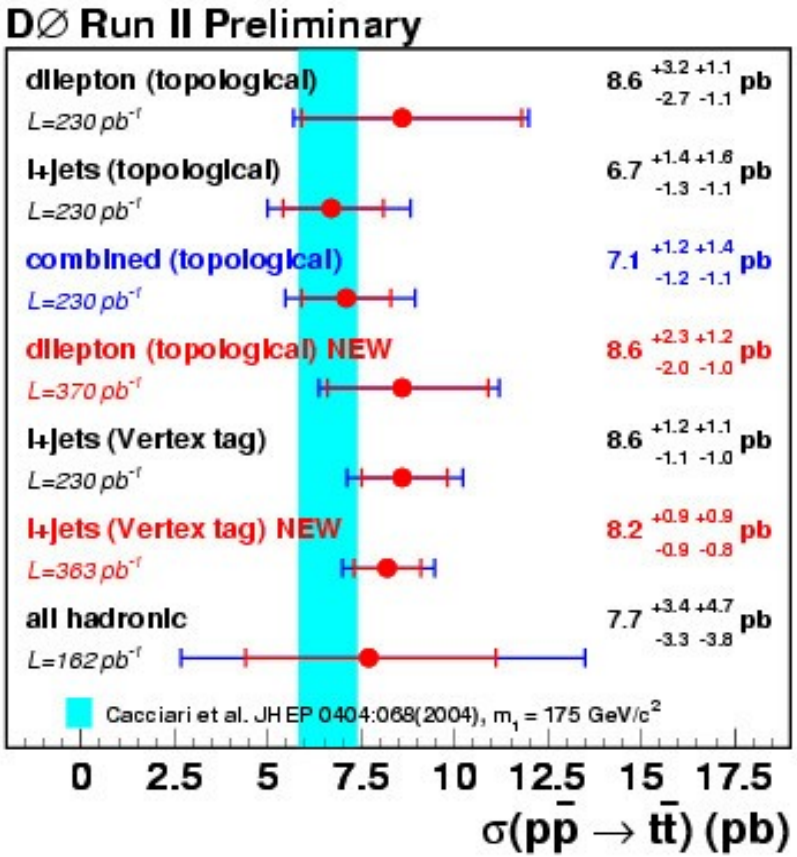
$$M = \frac{(M_{W_1} - M_W)^2}{\sigma_W^2} + \frac{(M_{W_2} - M_W)^2}{\sigma_W^2} + \frac{(m_{t_1} - m_{t_2})^2}{\sigma_t^2}$$

1) Scalar sum of the p_T of four leading jet (H_T)
2) Aplanarity: a linear combination of the eigenvalues of a normalized momentum tensor
3) The geometric mean of the transverse energies of the fifth and six leading jets (E_{T56})
4) The weighted RMS of η of the six leading jets ($<\eta^2>$)
5) The second smallest di-jet mass in the event (M^{34}_{min})
6) The minimal mass likelihood value over all combination (M)

KINEMATIC DISTRIBUTIONS



CONCLUSION



- Precision of the cross-section measurement in dilepton channel is significantly improved.
- The all-jets channel is well advance and one expect significant improvement in both systematics and statistical uncertainties
- More than 800 pb^{-1} are waiting to be analyzed. Entering to the era of the precision top cross-section measurements at Tevatron.
- For the first time the dilepton channel provide a quite large sample for properties analysis. This is a sample with high purity and small jet energy scale systematics.

BACKUP

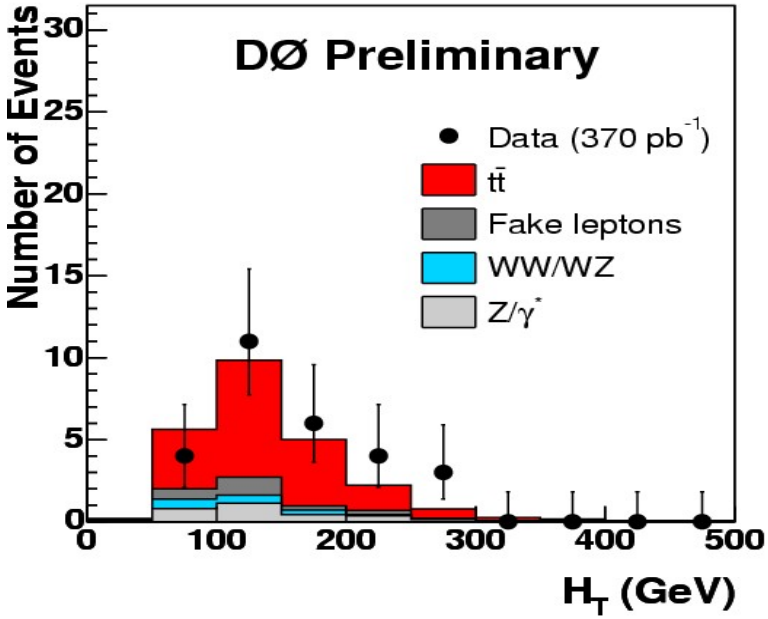
Dilepton cross-sections

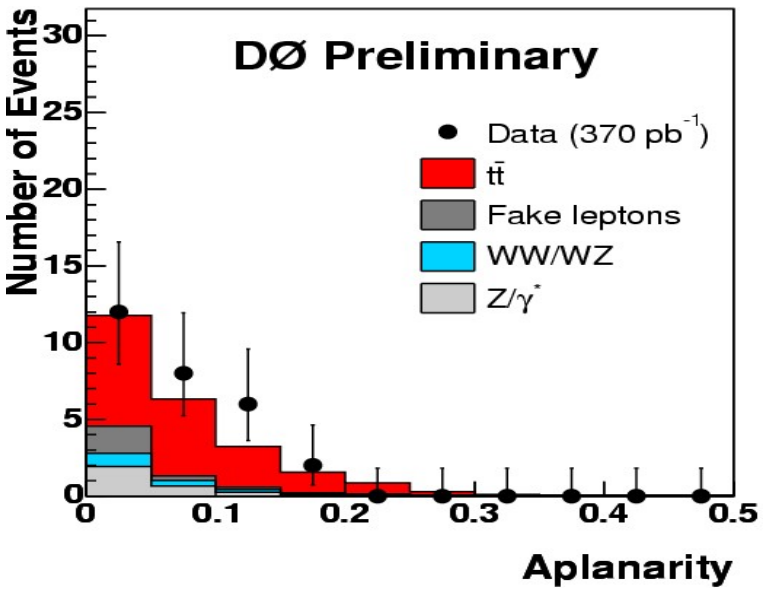
$$\text{ee} \;:\quad \sigma_{t\bar{t}} = 7.9^{+5.2}_{-3.8}\,(\text{stat})\,^{+1.3}_{-1.0}\,(\text{syst})\;\pm 0.5\,(\text{lumi})\,\text{pb}$$

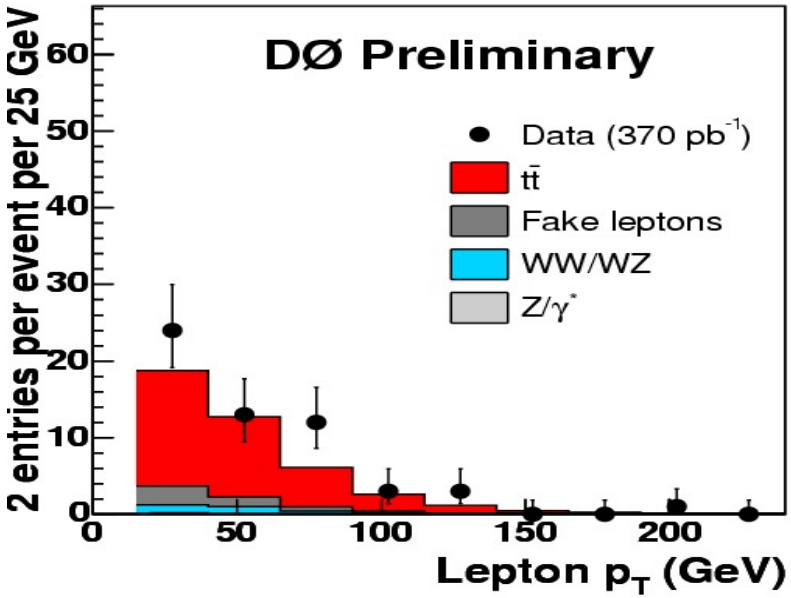
$$\text{e}\mu \;:\quad \sigma_{t\bar{t}} = 10.2^{+3.1}_{-2.6}\,(\text{stat})\,^{+1.6}_{-1.3}\,(\text{syst})\;\pm 0.7\,(\text{lumi})\,\text{pb}$$

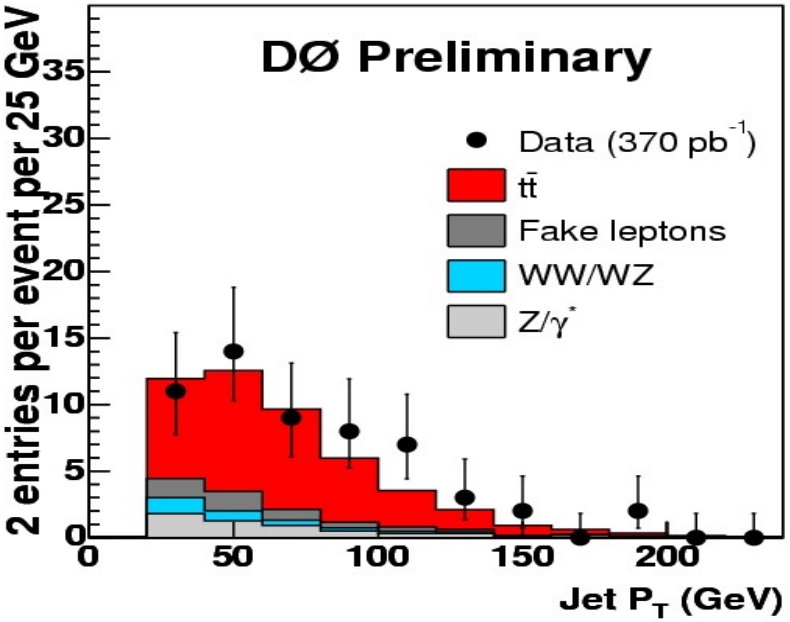
$$\mu\mu \;:\quad \sigma_{t\bar{t}} = 1.8^{+4.8}_{-3.0}\,(\text{stat})\,^{+1.0}_{-1.2}\,(\text{syst})\;\pm 0.1\,(\text{lumi})\,\text{pb}$$

Control plots (dilepton)









Formulas

$$\eta(\theta,\beta)=\frac{1}{2}\frac{\ln(1+\beta\cos\theta)}{\ln(1-\beta\cos\theta)},\qquad \beta=\frac{p}{E}$$

$$dR=\sqrt{(\eta_1-\eta_2)^2+(\varphi_1-\varphi_2)^2}$$