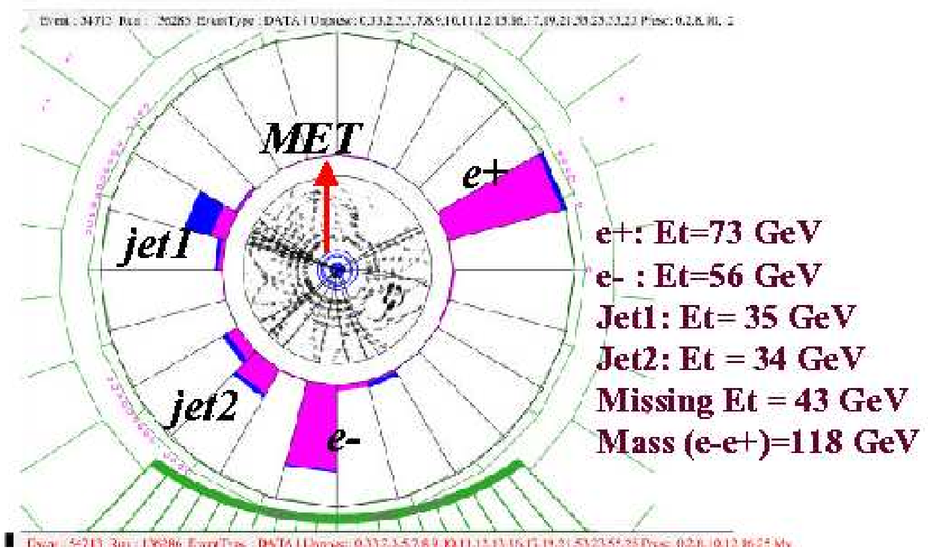
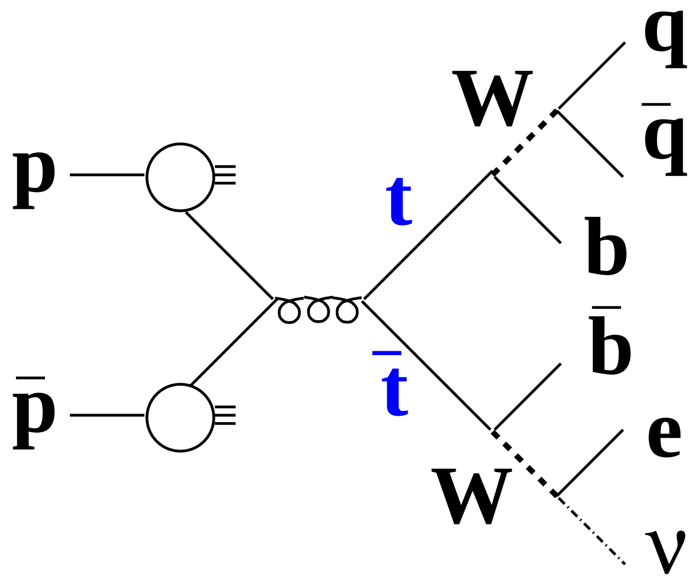
Analysis techniques for top physics



$\stackrel{?}{=}$

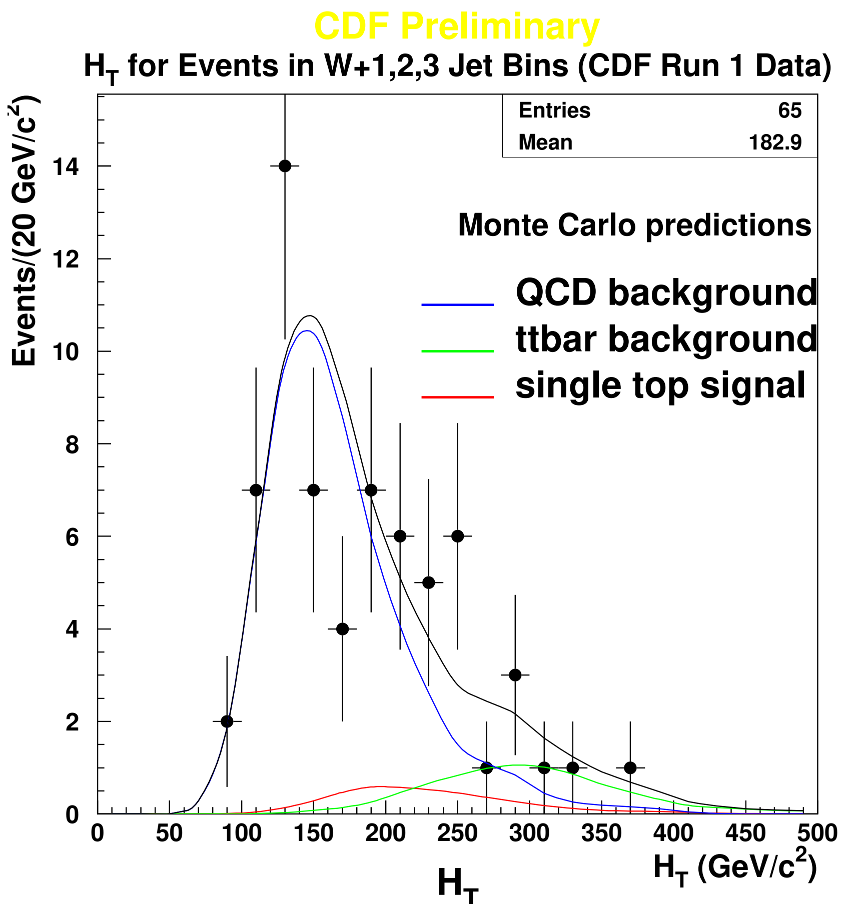
Physics?
Software?



Yves Kemp IEKP Karlsruhe

RTN Rome 12/18/2002

Why top physics?



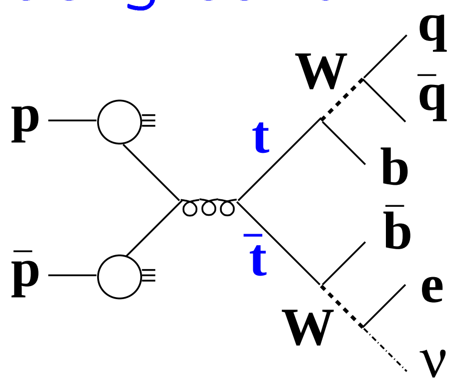
- top coupling to Higgs
  $y = \sqrt{2} m_{\mathrm{top}} / v \approx 1$
- measurment of v_{tb}:
  3 generations?
- anomalous top production?
- test of SM with
  electro-weak top-production

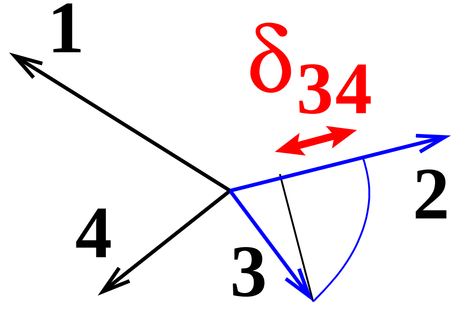
$\Rightarrow$ top physics is Higgs physics

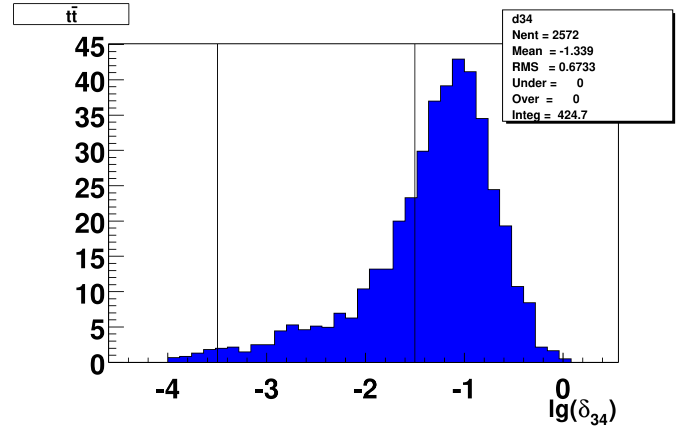
"Jet Counting": Event shape observables

(simulation using kt-jet algorithm)

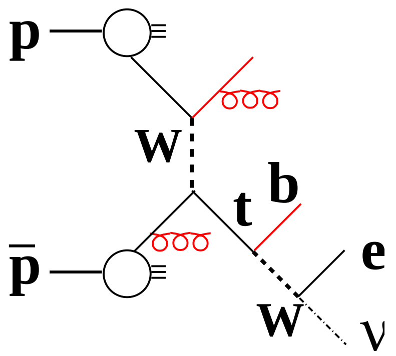
$t\bar{t}$ background

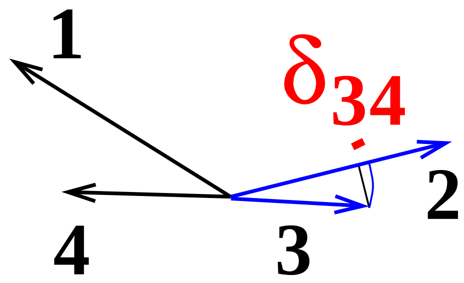


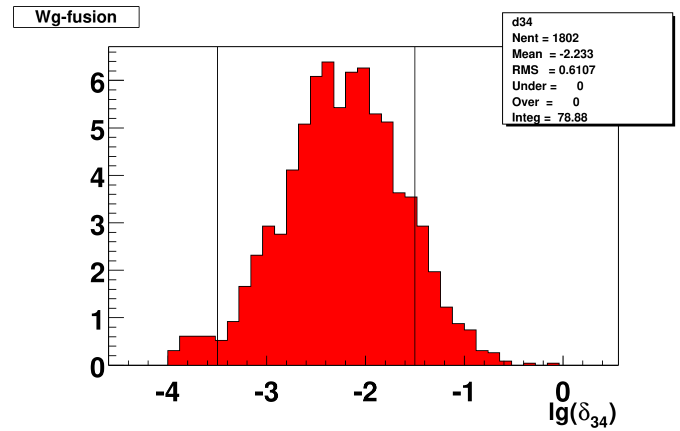




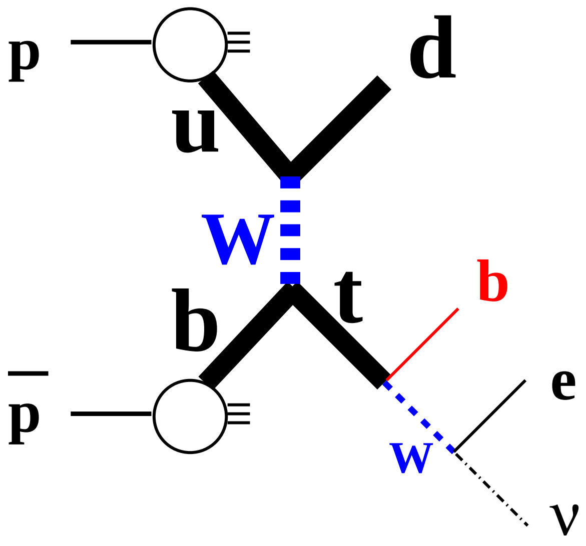
electroweak top quark production

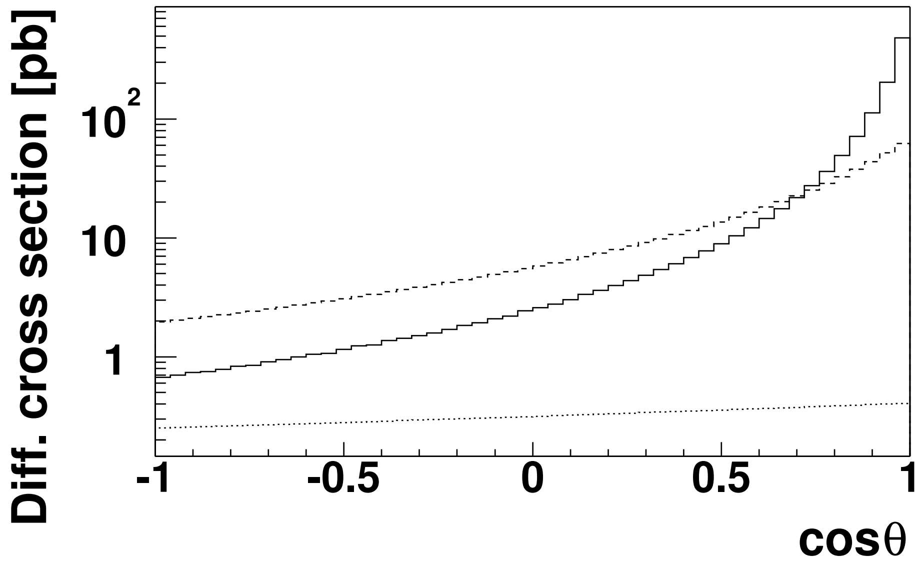






Kinematics of the hard process: Δy





Rapidity: $y = \frac{1}{2} \ln \frac{E+P_z}{E-P_z}$

$$\Delta y = y_{\text{top}} - y_{\text{d}}$$

$$= \tanh^{-1} \left[\frac{\cos \hat{\theta}}{\sqrt{1+\frac{4m_t^2}{\hat{s}}}} \right] + \tanh^{-1} \left[\cos \hat{\theta} \right]$$

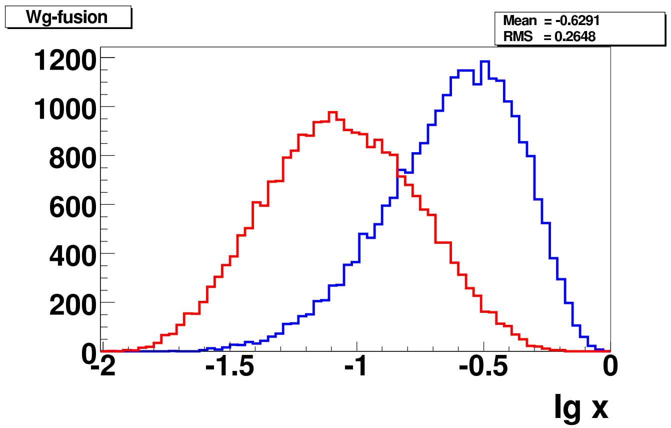
→ "Rutherford scattering"

→ forward scattering dominates

For large $\hat{s}$: $\tanh \frac{\Delta y}{2} = \cos \hat{\theta}$

Kinematics of the hard process: Σy (boost)

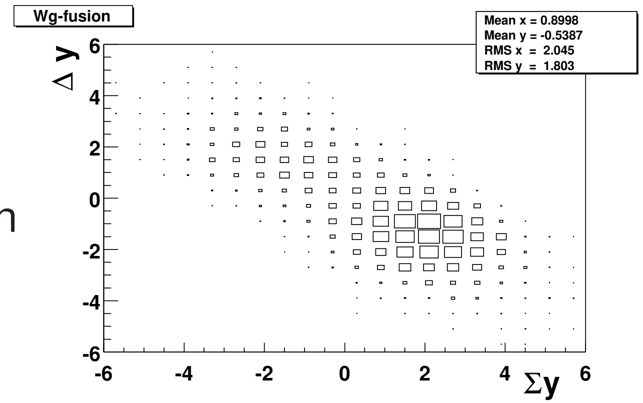
Fractional momenta of the
incoming light quark –
incoming b-quark –



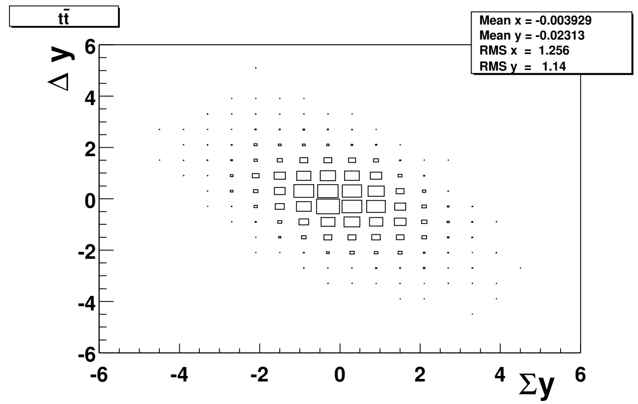
boost of the partonic system:
$y_{\text{boost}} = \frac{\Sigma y}{2} = \frac{y_t + y_l}{2}$

combining Σy with Δy :

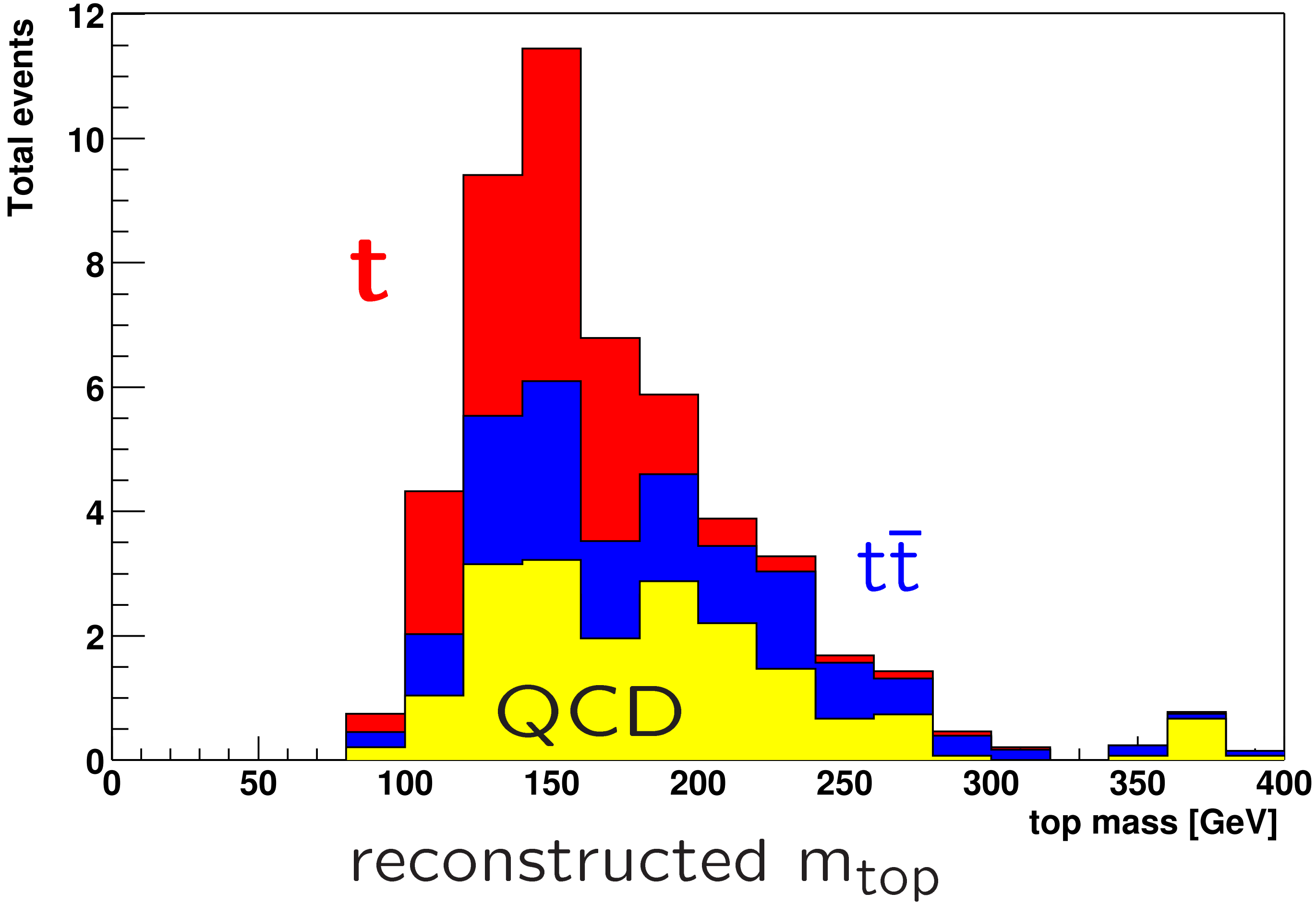
W-gluon-Fusion:
largest population away from
$\hat{\theta} = 90°(\Delta y > 0)$



$t\bar{t}$-Production:
largest population:
$\hat{\theta} \approx 90°(\Delta y \approx 0)$
Incoming PDF x symmetric



Neural Network: simulation of electroweak top production analysis



$\Rightarrow$ **expect 3 std.dev. signal in 500 pb^{-1}**

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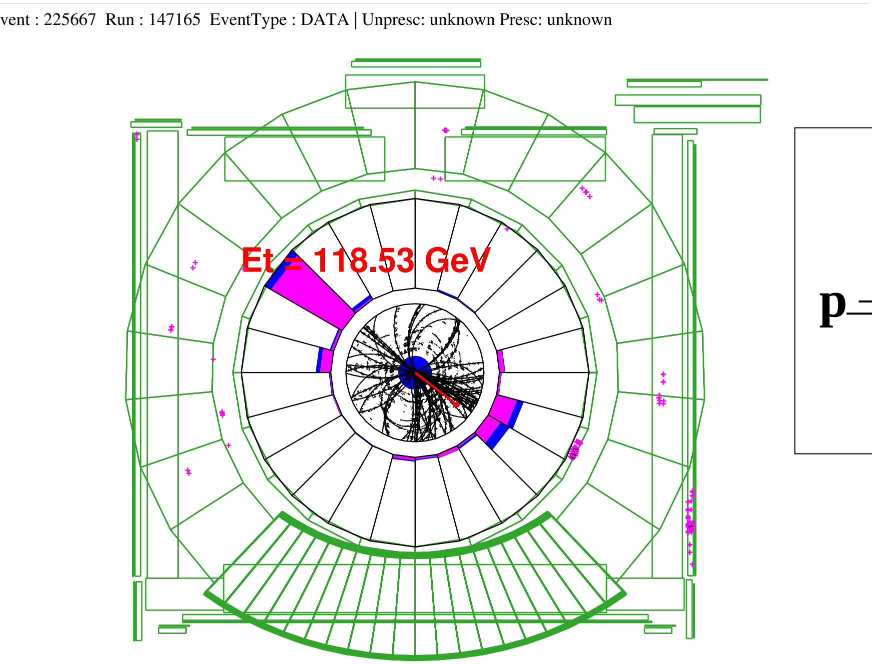
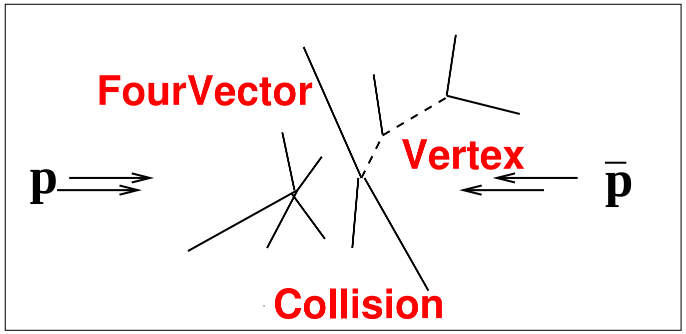
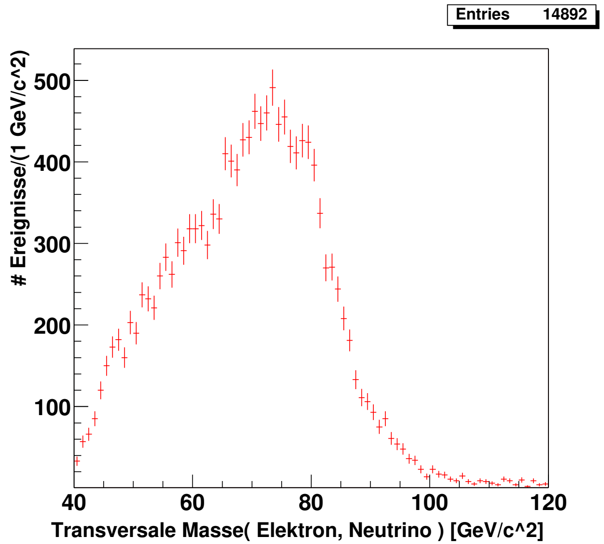
Physics Analysis eXpert (PAX)







for all collider experiments

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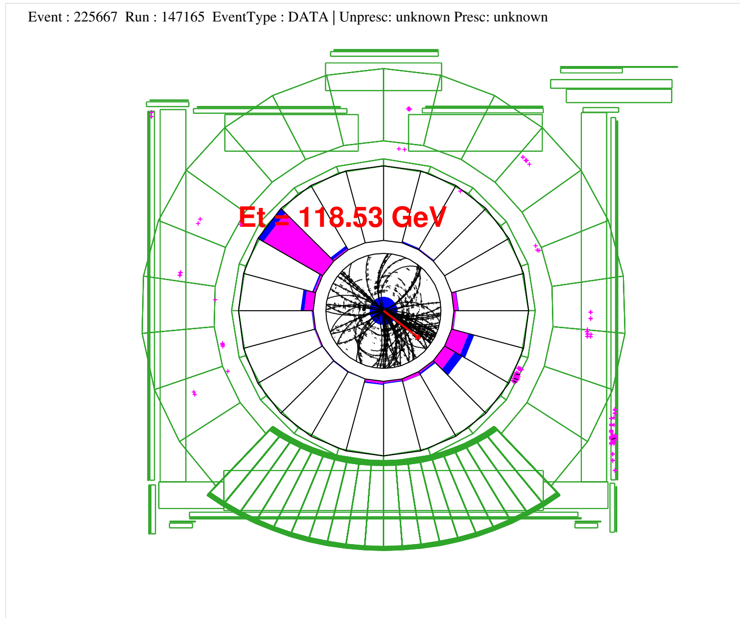
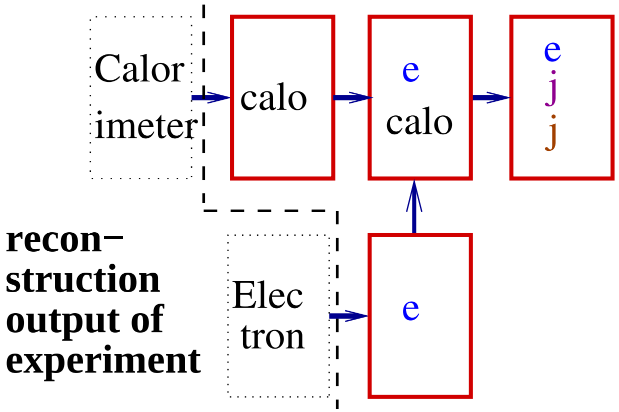
Physics Analysis Expert (PAX)

Making combined objects: An example

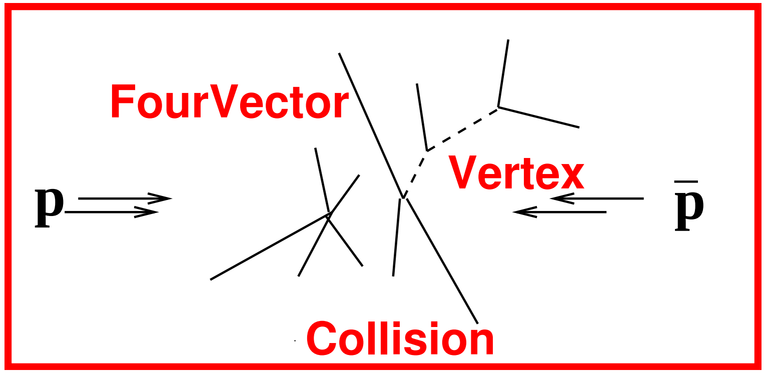


event interpretations



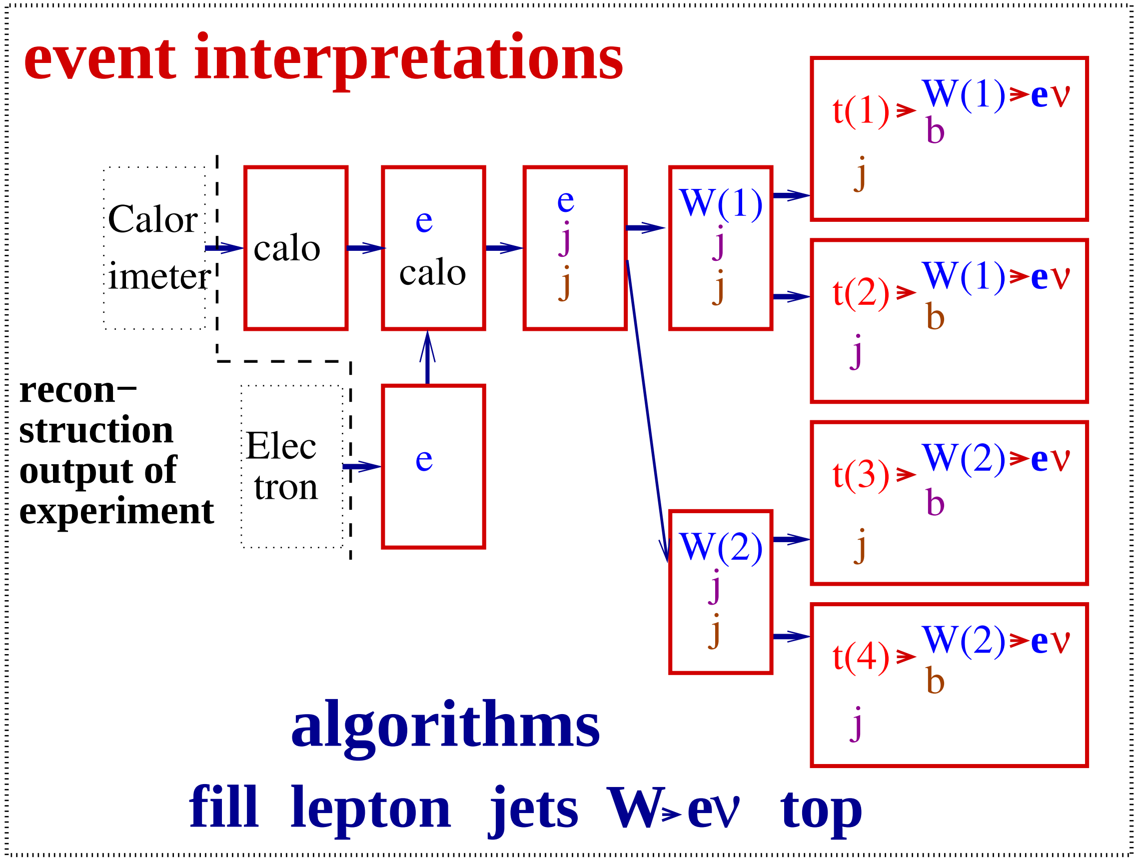
algorithms

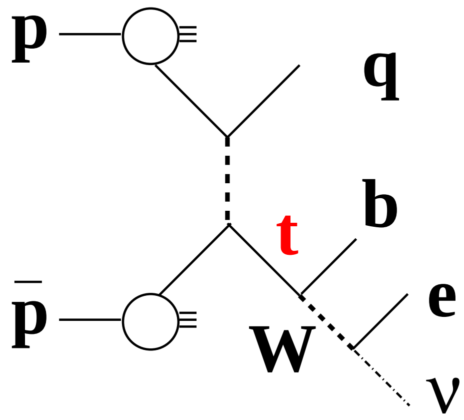
fill lepton jets W→eν top



Physics Analysis Expert (PAX)

Different interpretations of one event: An example

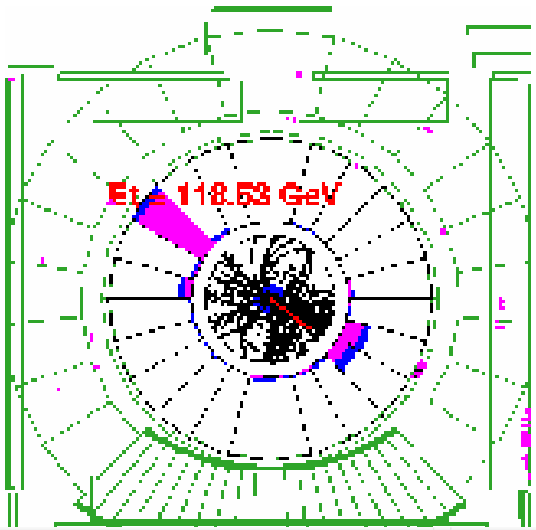




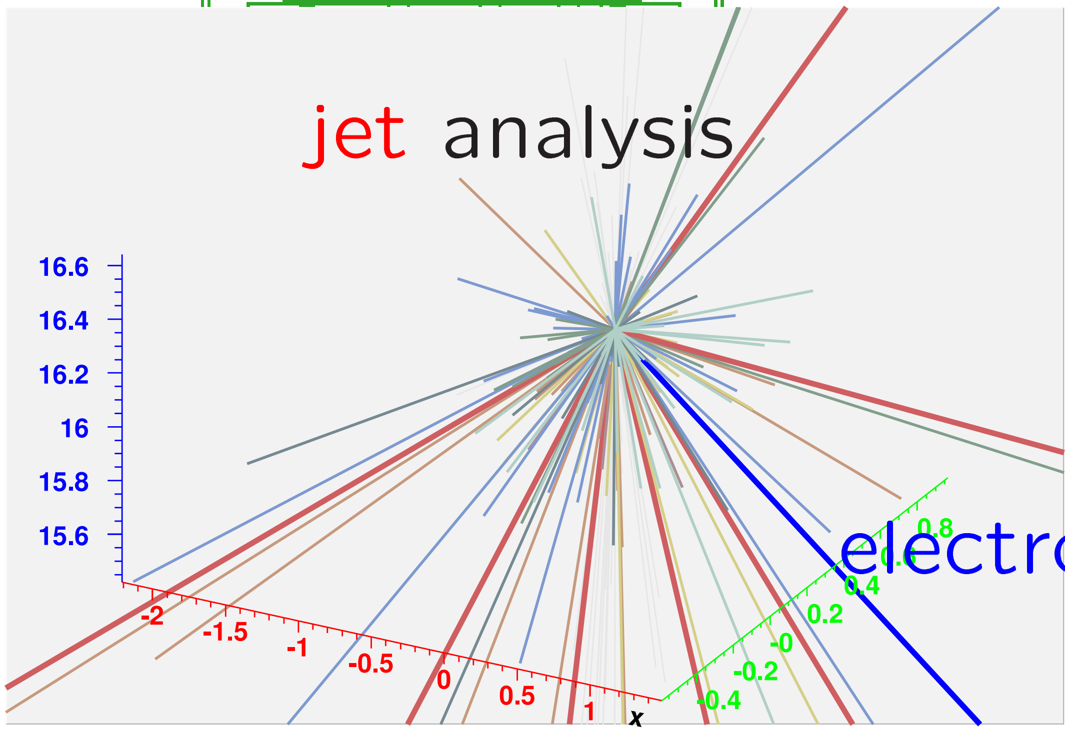
Ambiguities:

- ν_{P_z}
- b-jet
- light-jet
- different cuts
- ...

RUN II: Top-Antitop Pair Production Analysis

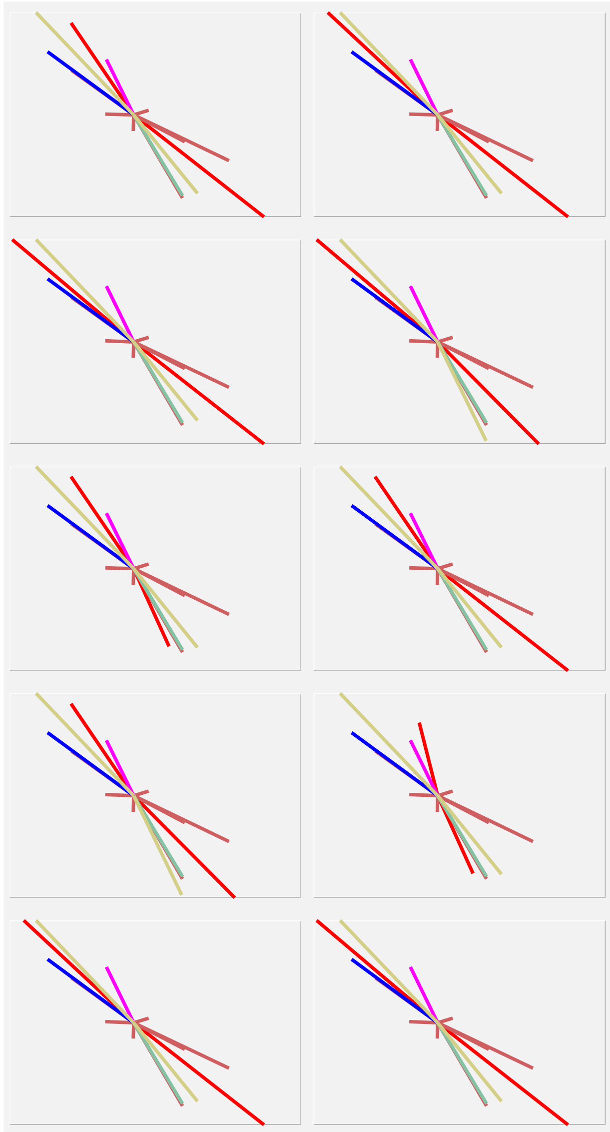


jet analysis



electron

$t\bar{t}$ analysis



best

Conclusion and Outlook

- observables related to parton scattering process:
  - $\Sigma y \leftrightarrow$ boost of parton–parton system
  - $\Delta y \leftrightarrow$ parton scattering angle
  - $\delta_{i,j} \leftrightarrow$ parton counting

$\Rightarrow$ have an excellent potential for top physics using Neural Network techniques.

- Physics Analysis eXpert (PAX)
  - Developed in Karlsruhe for CDF and CMS
    Usable in every collider experiment with C++ software
  - intended to ease starting a CDF analysis
  - support expert teams in mastering most challenging projects