Peter Pauli

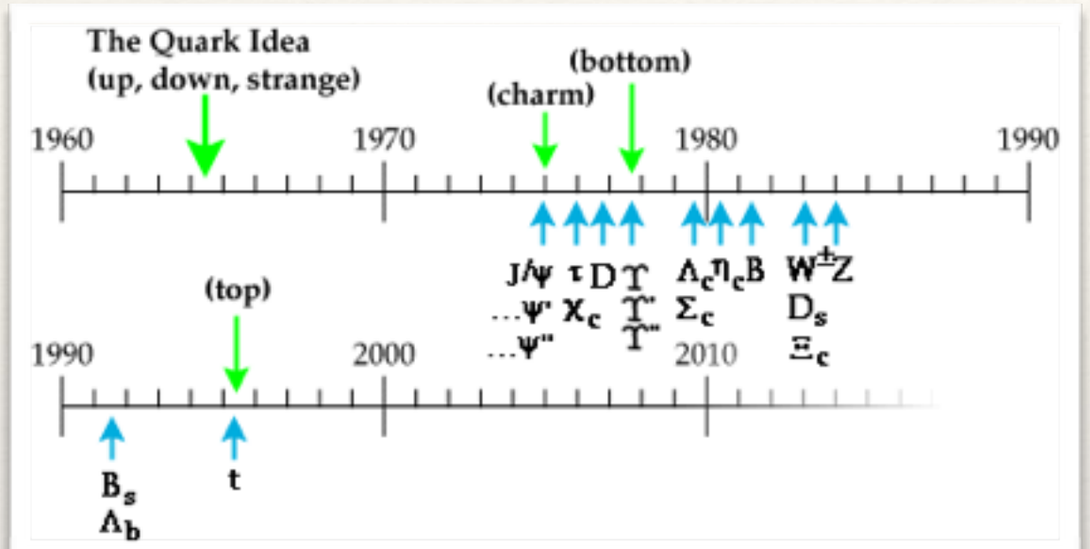
Observation of the Top Quark

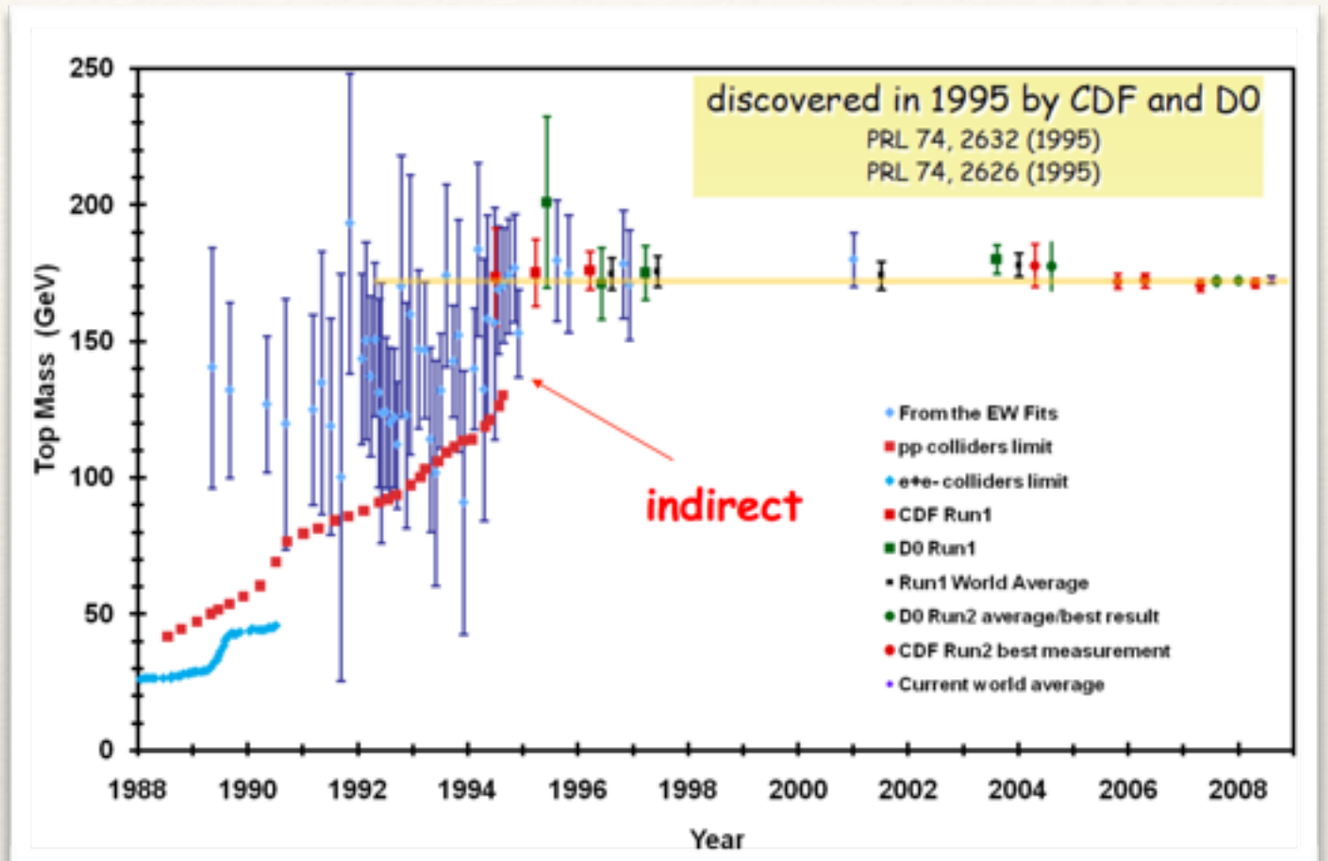
DØ Collaboration
arXiv:hep-ex/9503003v1
3 Mar 1995

Outline

- Pre top quark era
- The D0 experiment
- Analysis techniques
- Results
- Implications on SM

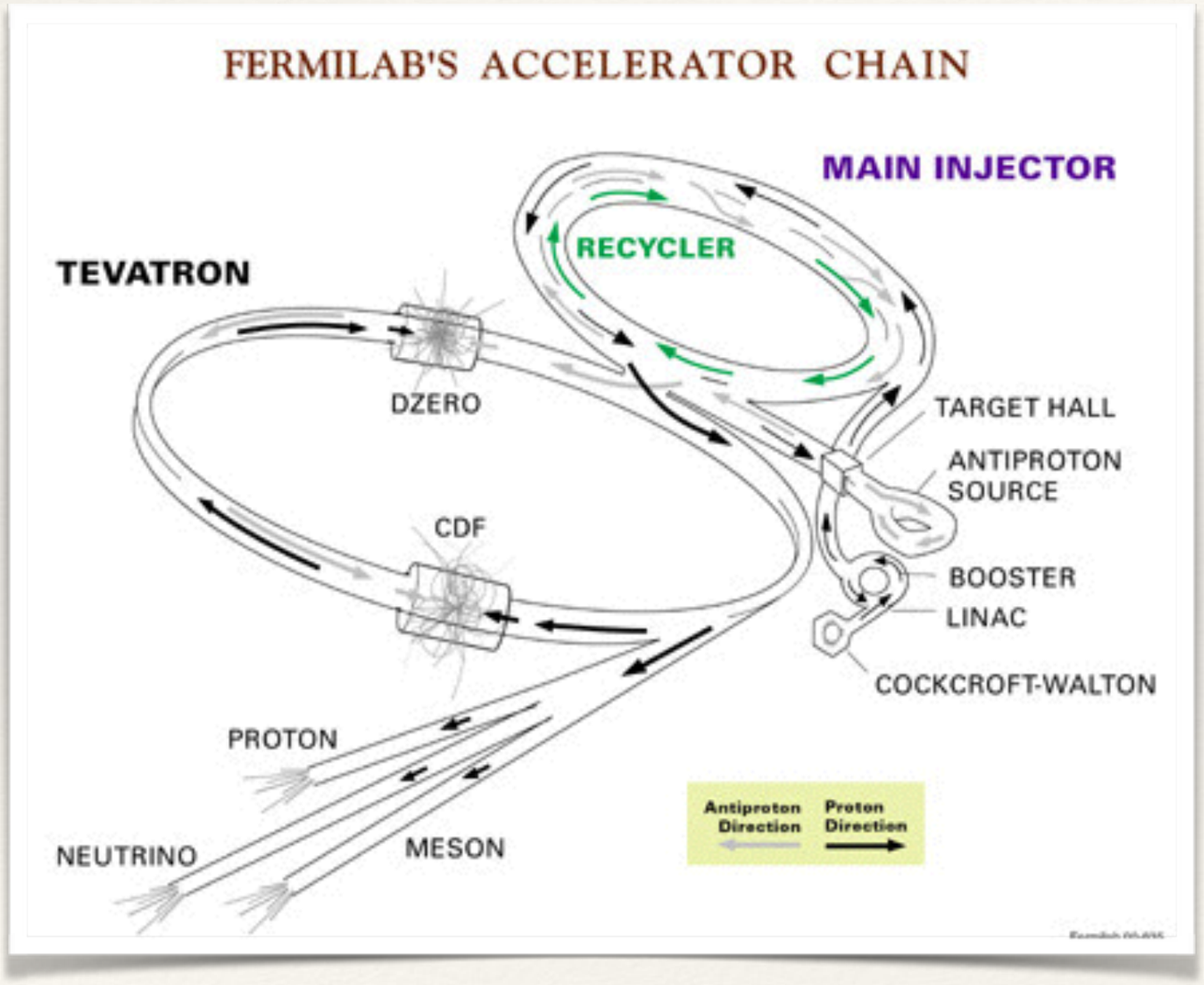
Pre Top Quark era





- several lower mass limits for the top quark by UA1/2, e^+e^-collider, W/Z measurements and other EW measurements
- upper limits from consistency with W/Z masses

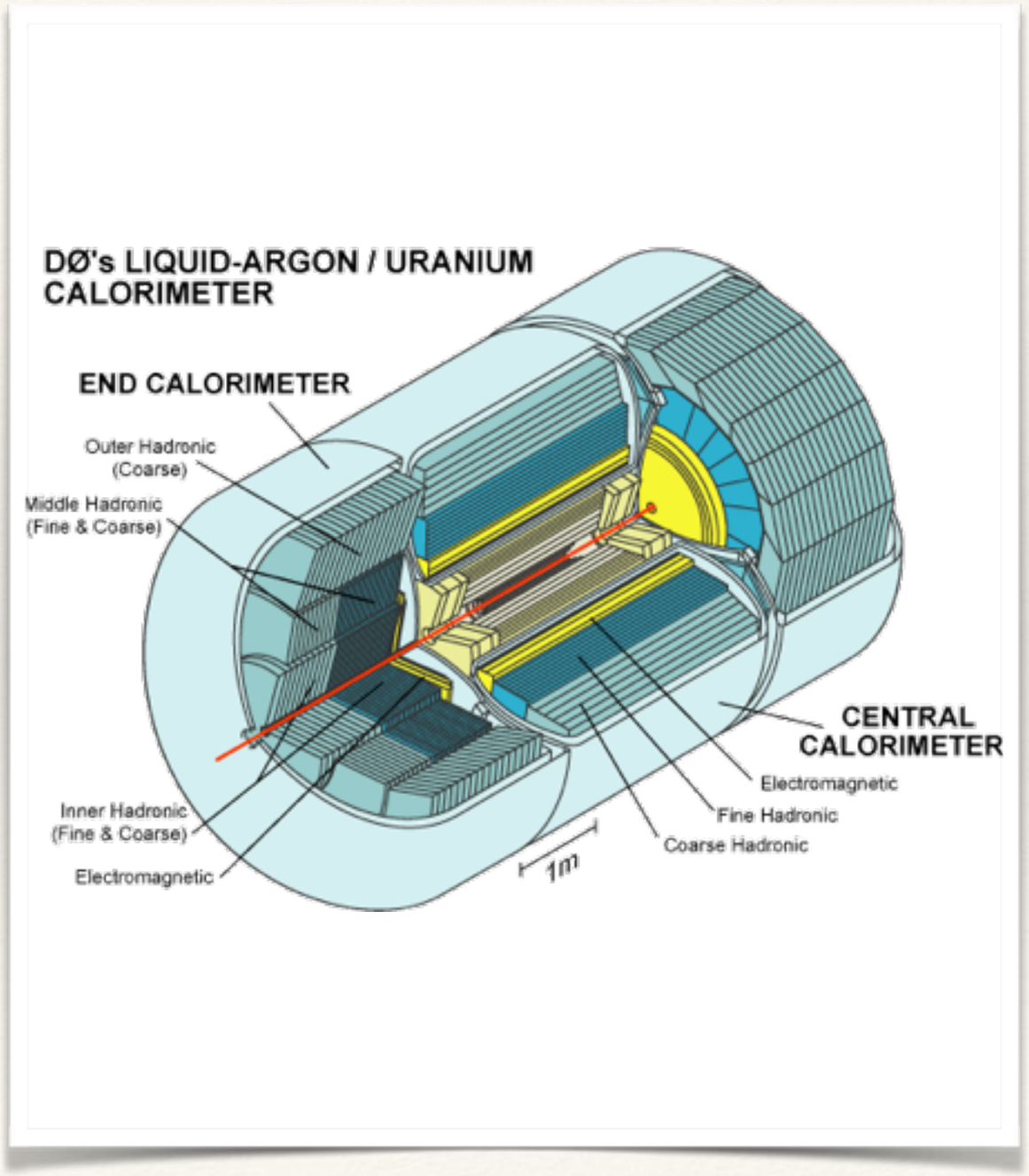
Tevatron



- Running time 1983-2011
- 6km circumference
- proton anti-proton collider
- 1.96 TeV centre of mass energy

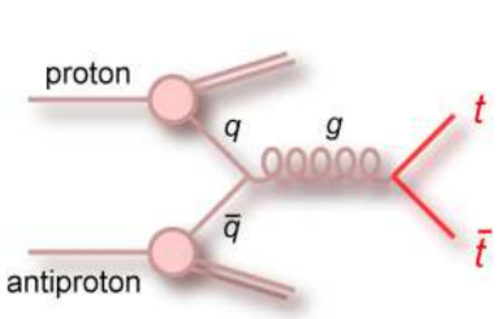
D0 @ Tevatron

- inner tracking detectors
- calorimeters
- outside muon chambers

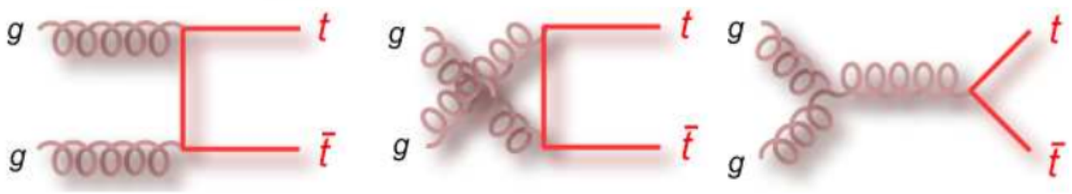


Top Production

Strong top production

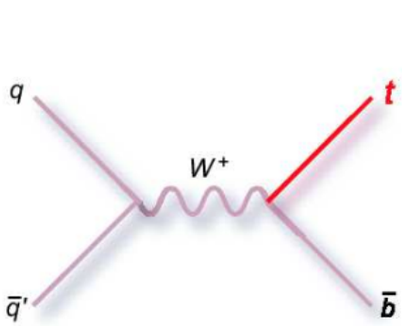


$$85\% \quad q\bar{q} \to t\bar{t}$$
$$15\% \quad gg \to t\bar{t}$$



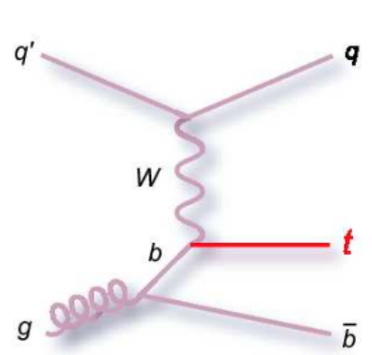
$\sigma(t\bar{t}) \simeq 7.46\text{pb}$

Weak top production



Drell-Yan

s-channel



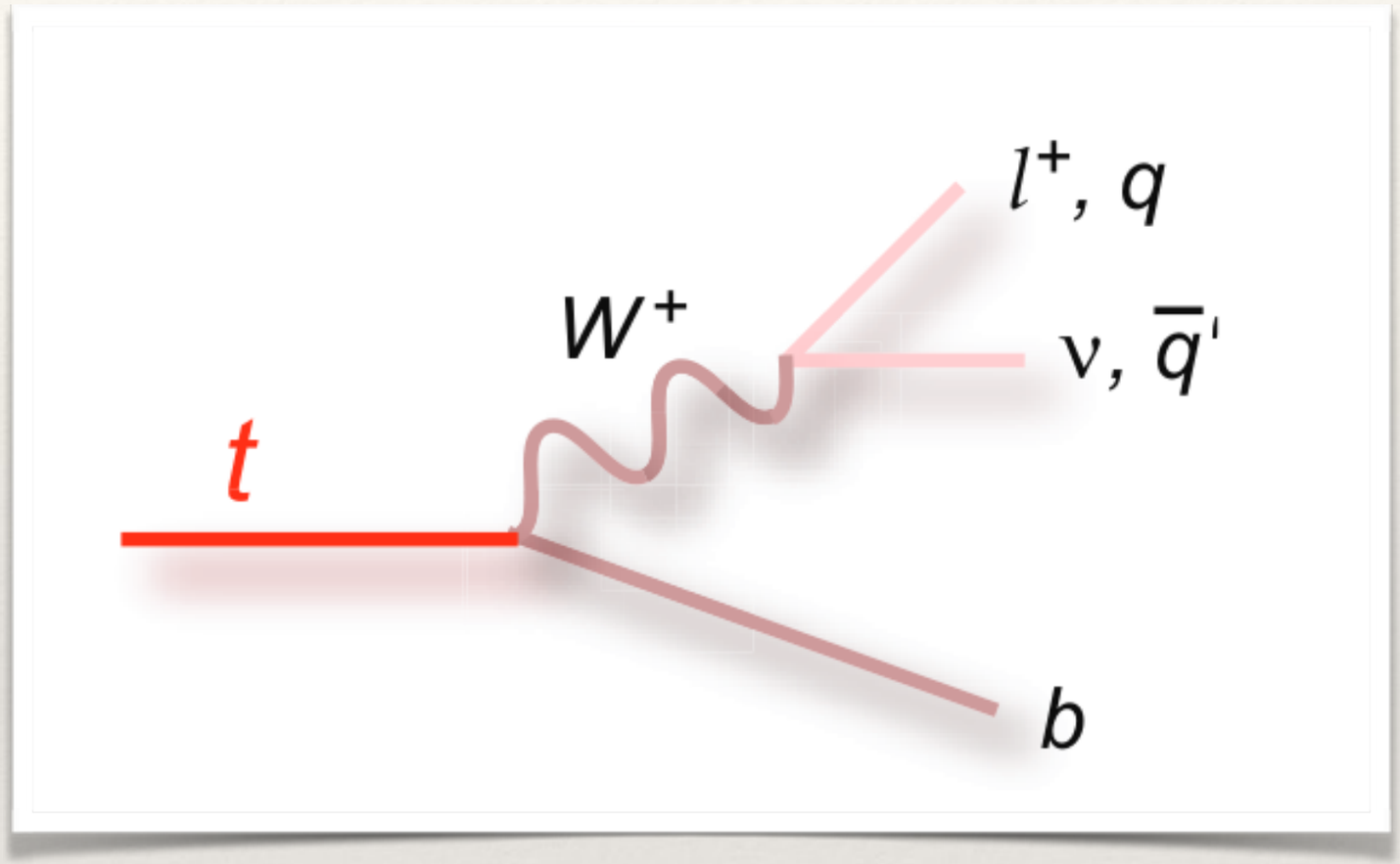
W-g fusion

t-channel

$\sigma(t) = 3.46\text{pb} = 1.12\text{pb} + 2.34\text{pb}$

Top Decay

- Di-lepton:
  e μ + jets
  e e + jets
  μ μ + jets
- Single-lepton
  e + jets
  μ + jets
- Single-lepton b-tagged
  e + jets / μ
  μ + jets / μ



$$b \rightarrow \mu + X$$

Kinematic Requirements

Channel	Leptons		Jets		$\not\!\!E_T$	H_T	$\mathcal{A}$
	$E_T(e)$	$p_T(\mu)$	N_{jet}	E_T			
$e\mu$ + jets	15	12	2	15	20	120	-
ee + jets	20		2	15	25	120	-
$\mu\mu$ + jets		15	2	15	-	100	-
e + jets	20		4	15	25	200	0.05
μ + jets		15	4	15	20	200	0.05
e + jets/μ	20		3	20	20	140	-
μ + jets/μ		15	3	20	20	140	-

- tagged muon minimum $p_T = 4\text{GeV}/c$
- for last 70% of data muons restricted to $|\eta| < 1$
- $\mu\mu$+jets and μ+jets/μ inconsistent with Z + jets (kin. fit)

H_T Cuts

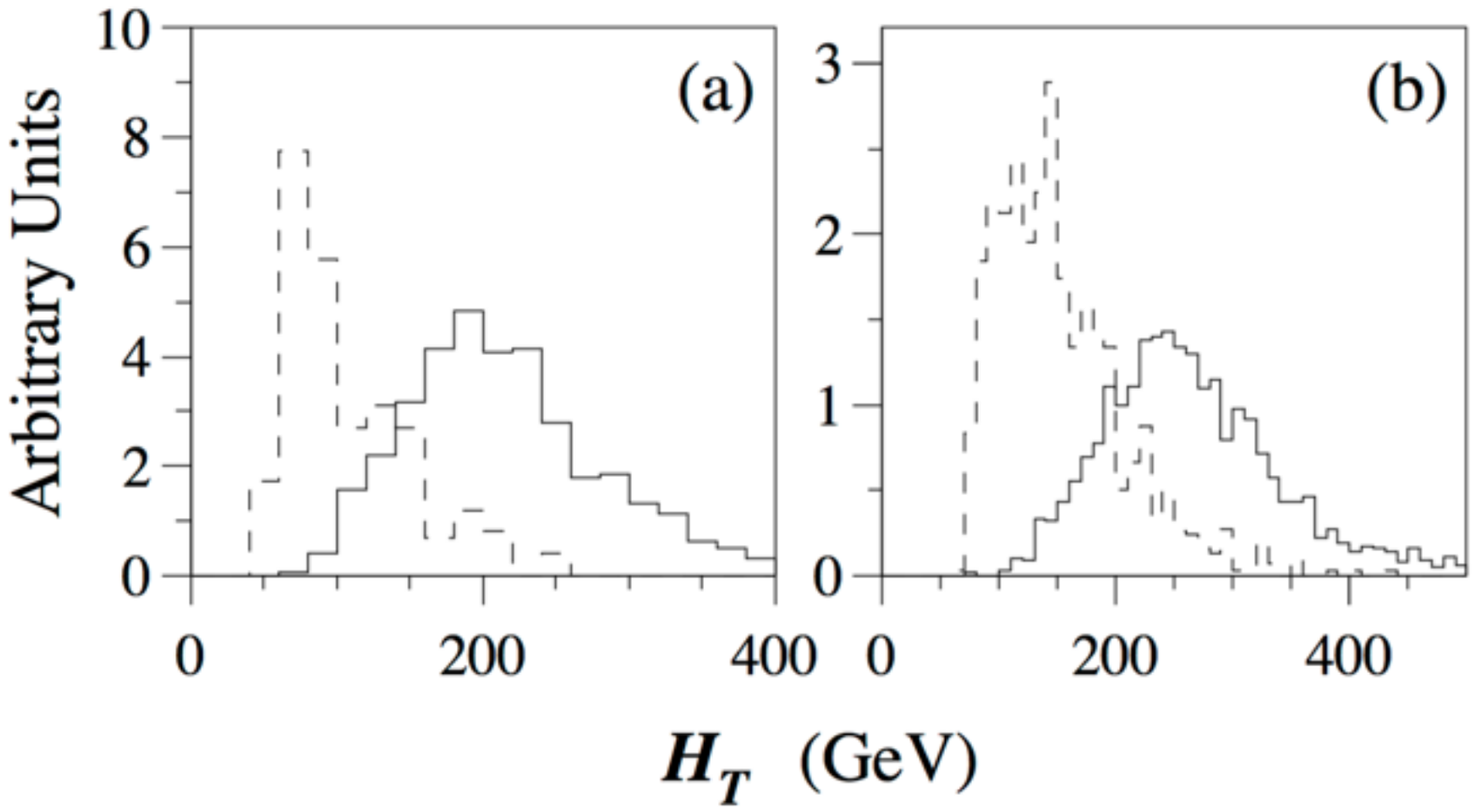


FIG. 1. Shape of H_T distributions expected for the principal backgrounds (dashed line) and 200 GeV/c^2 top quarks (solid line) for (a) $e\mu$ + jets and (b) untagged single-lepton + jets.

A vs H_T Cuts

- Event shape criteria
  - ideal spherical: A=1/2
  - plane circular or linear: A=0

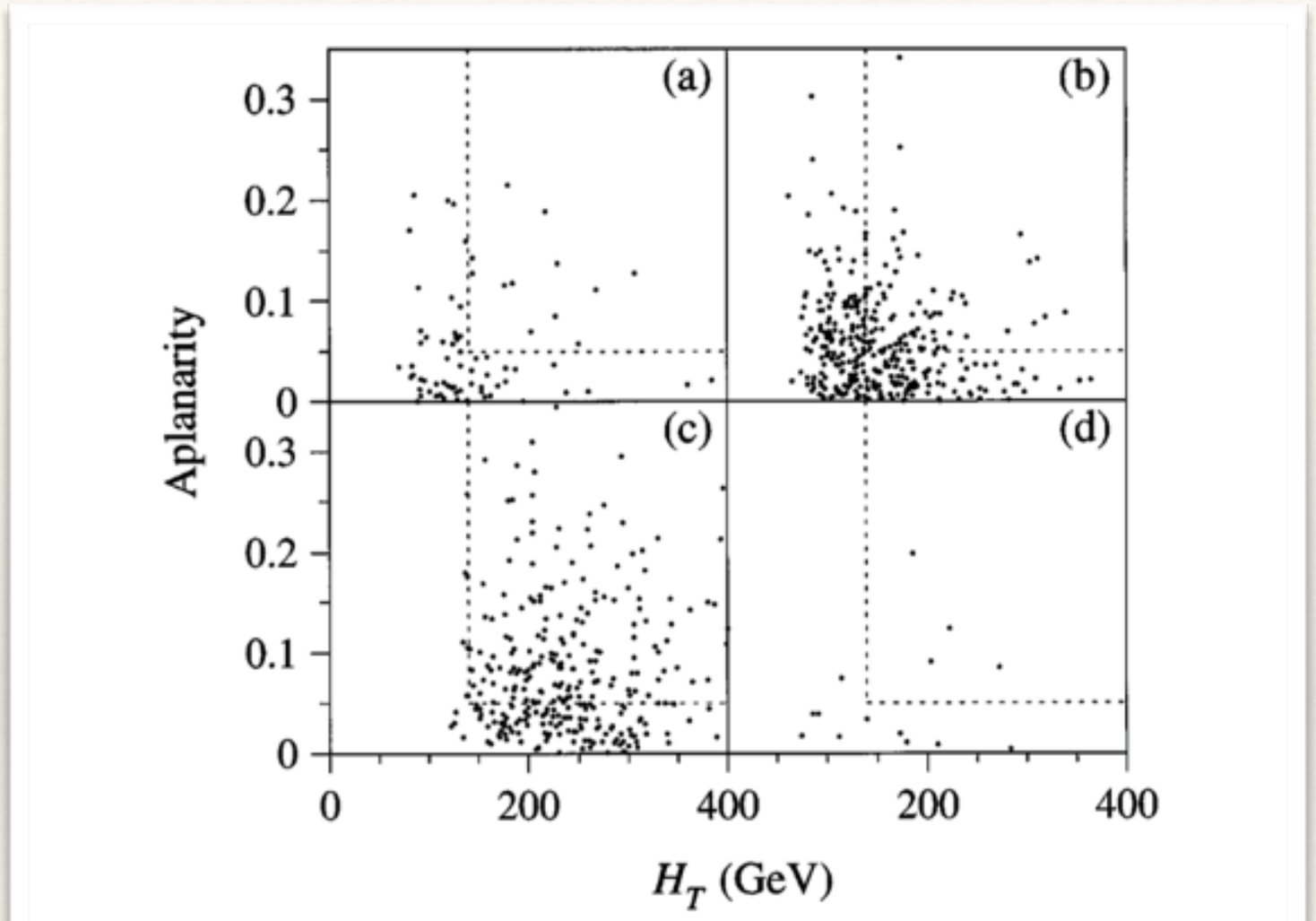
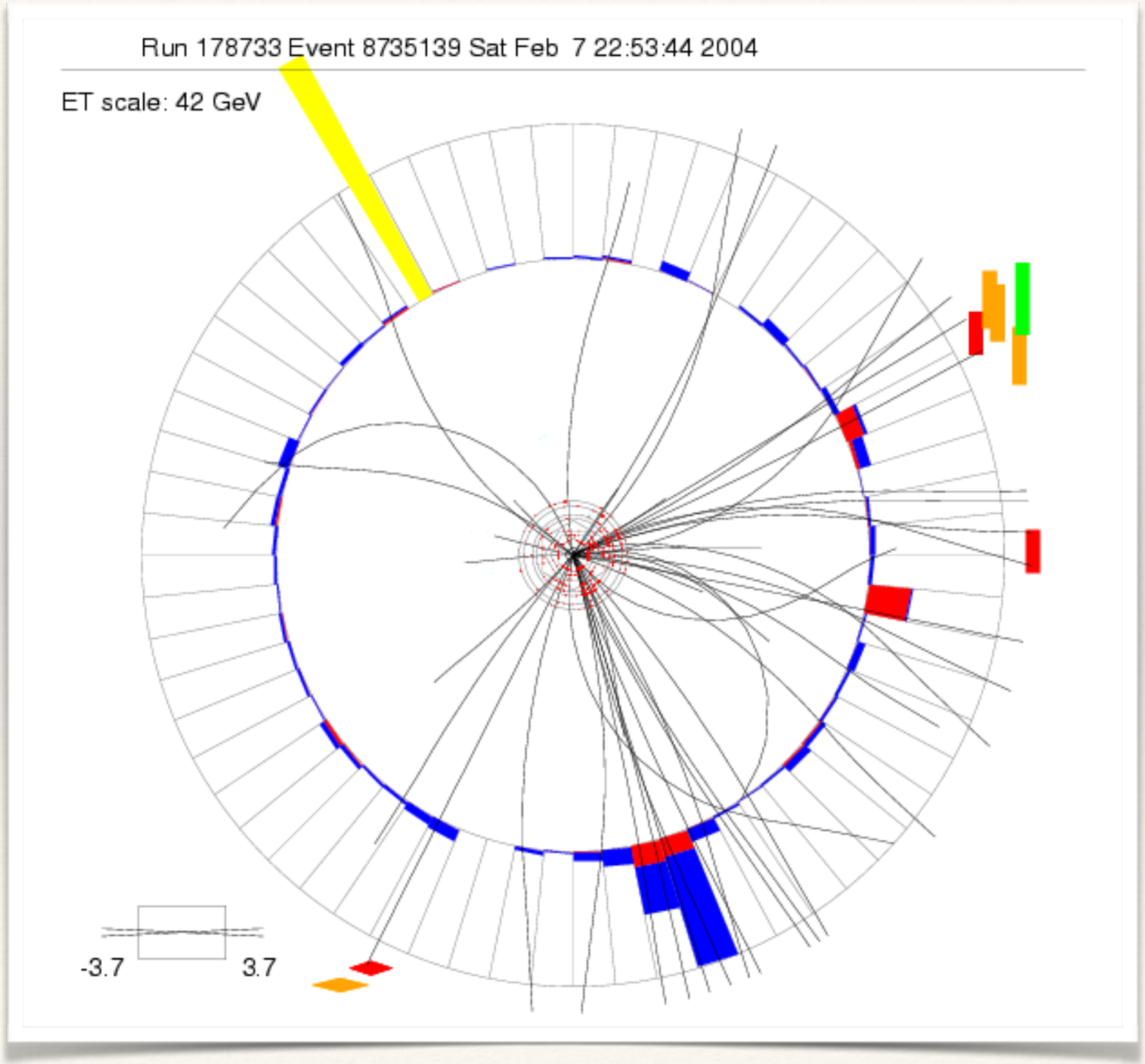


FIG. 2. $\mathcal{A}$ vs H_T for single-lepton events for (a) multijet background from data (effective luminosity = 60 × data luminosity), (b) background from W + 4 jet VECBOS Monte Carlo simulation (580 pb^{-1}), (c) 180 GeV/c^2 top ISAJET Monte Carlo simulation (2200 pb^{-1}), and (d) data (13.5 pb^{-1}). The dotted lines represent the event shape cuts used in the analysis.

Event Display



Results

- 17 events with expected background of 3.8
- 11 were used in kinematic fit to determine the top quark mass
- mass:
  199(+19 -21)(± 22)GeV
- production cross-section:
  6.4 ± 2.2pb

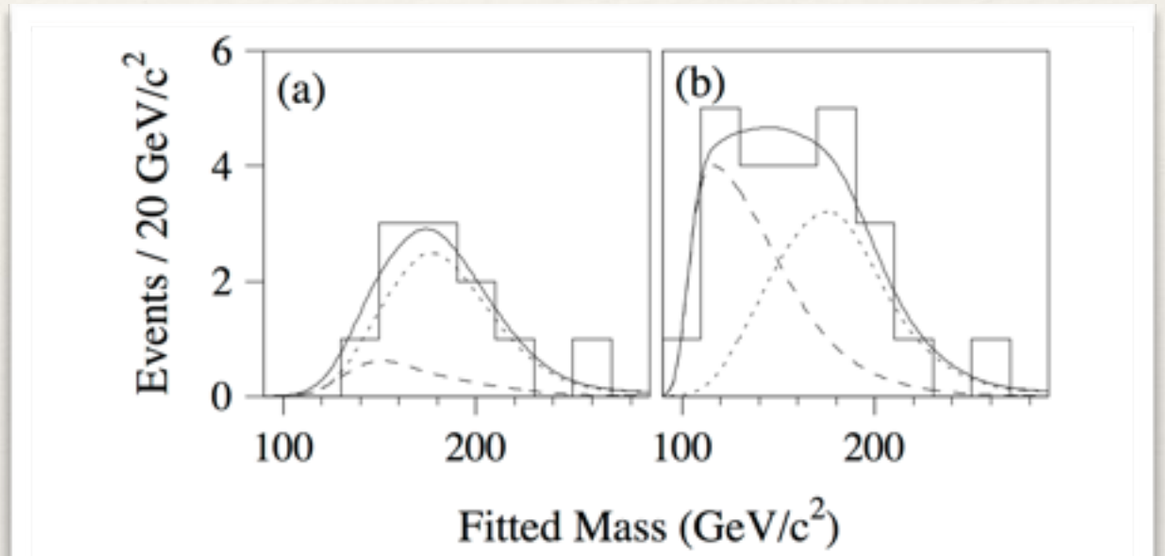
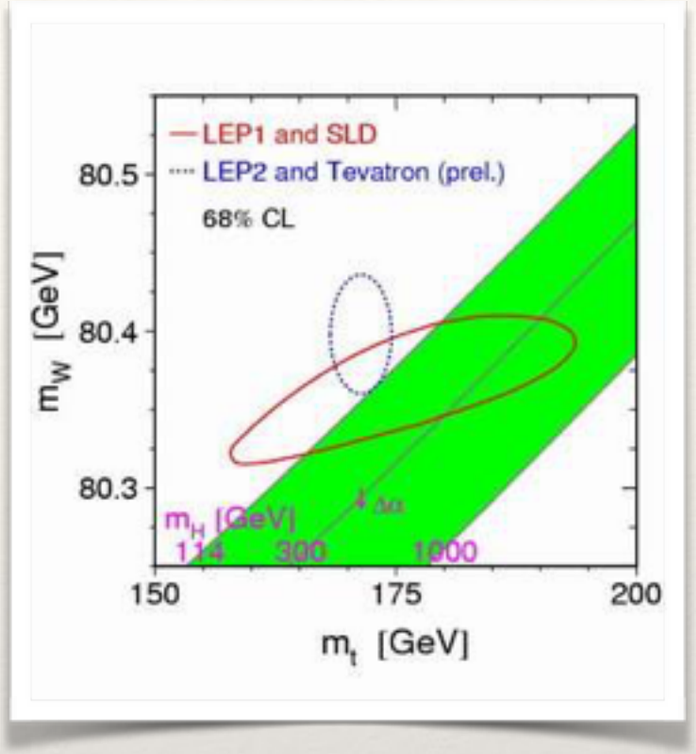
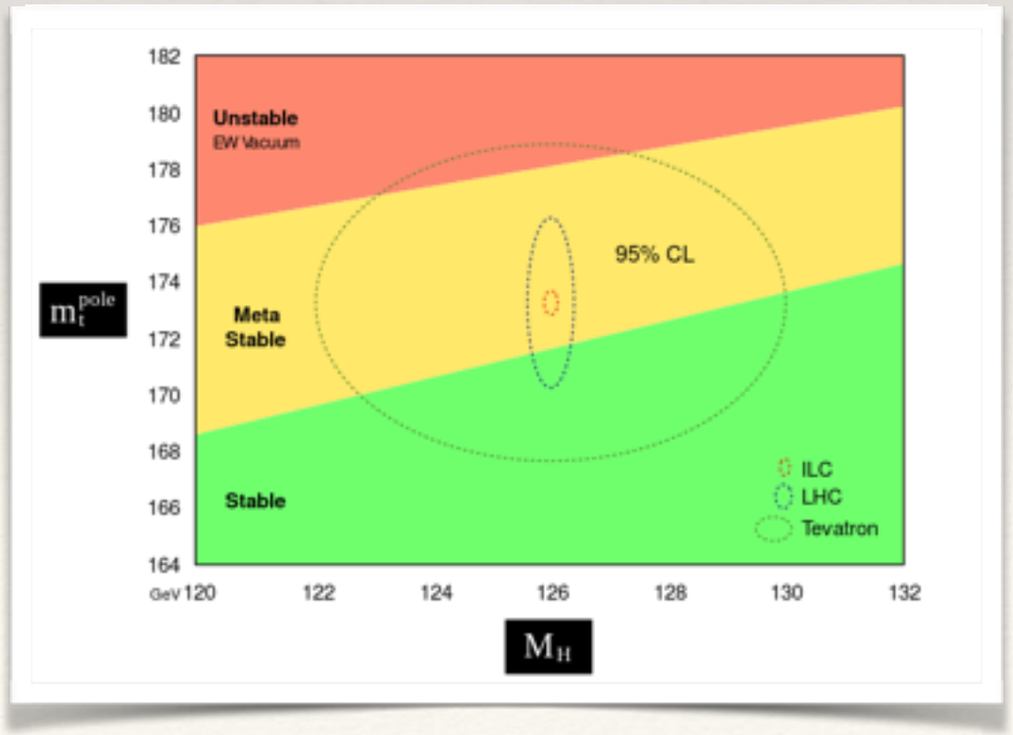


FIG. 5. Fitted mass distribution for candidate events (histogram) with the expected mass distribution for 199 GeV/c^2 top quark events (dotted curve), background (dashed curve), and the sum of top and background (solid curve) for (a) standard and (b) loose event selection.

Implications

- constrained Higgs Mass
- top quark is the heaviest elementary particle known… why so heavy?
- top decays before it hadronizes: unique opportunity to study a „bare“ quark
- (Yukawa) coupling to the Higgs field is close to 1:
  special roll in EW symmetry breaking?
- maybe sensitive to new couplings?
- stability of the universe





Thank You

Papers:

- Observation of the Top Quark, Phys. Rev. Letters {74} 2632 (1995)
- Search for High Mass Top Quark Production in pbarp Collisions at sqrt s = 1.8TeV, Phys. Rev. Letters {74} 2422 (1995)
- The D0 Detector, Nucl. Instr. and Methods, A338, 185 (1994)

Backup: H_T Data

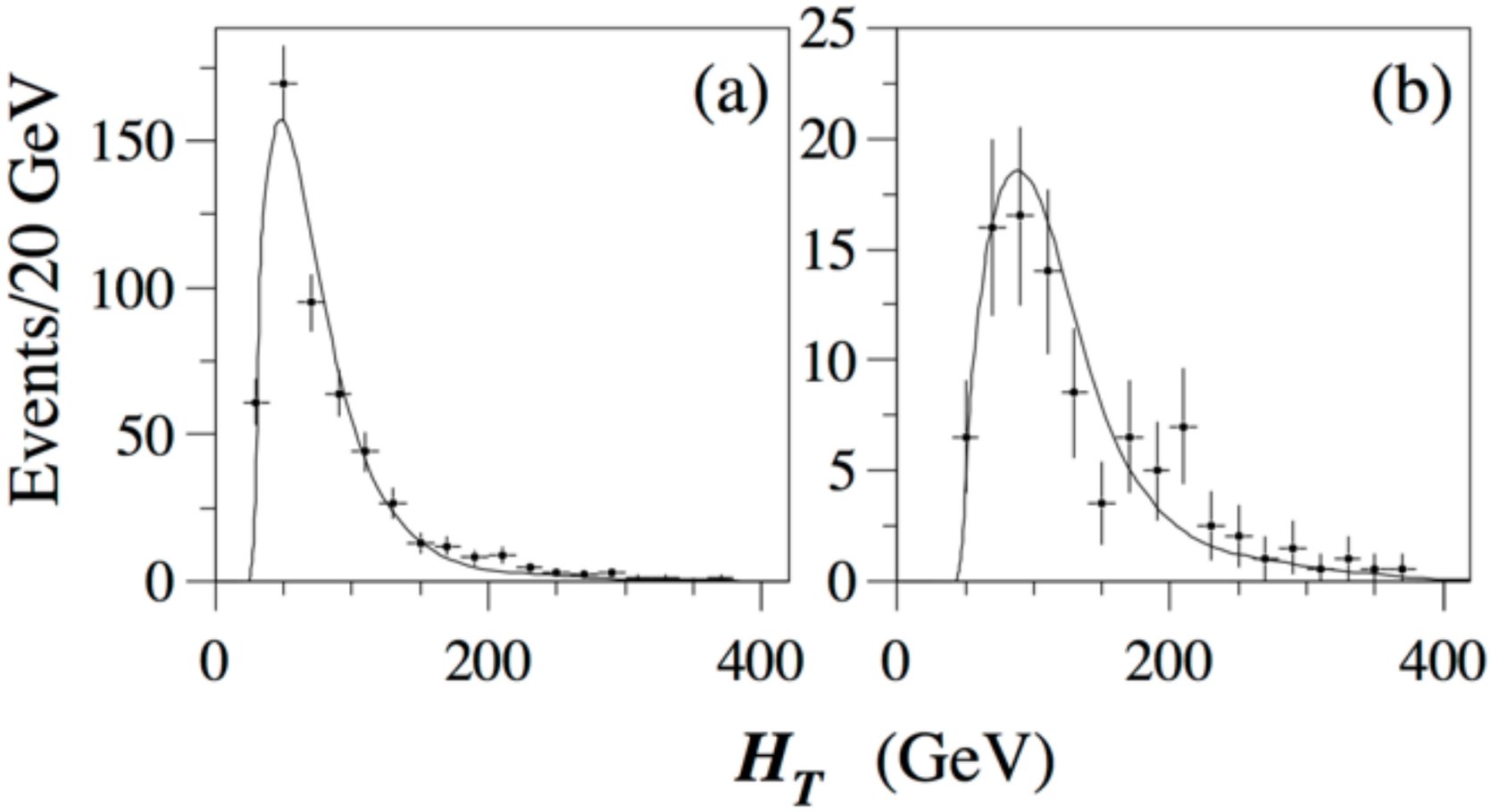


FIG. 2. Observed H_T distributions (points) compared to the distributions expected from background (line) for $\not\!\!E_T > 25$ GeV/c and (a) $e + \geq 2$ jets and (b) $e + \geq 3$ jets.