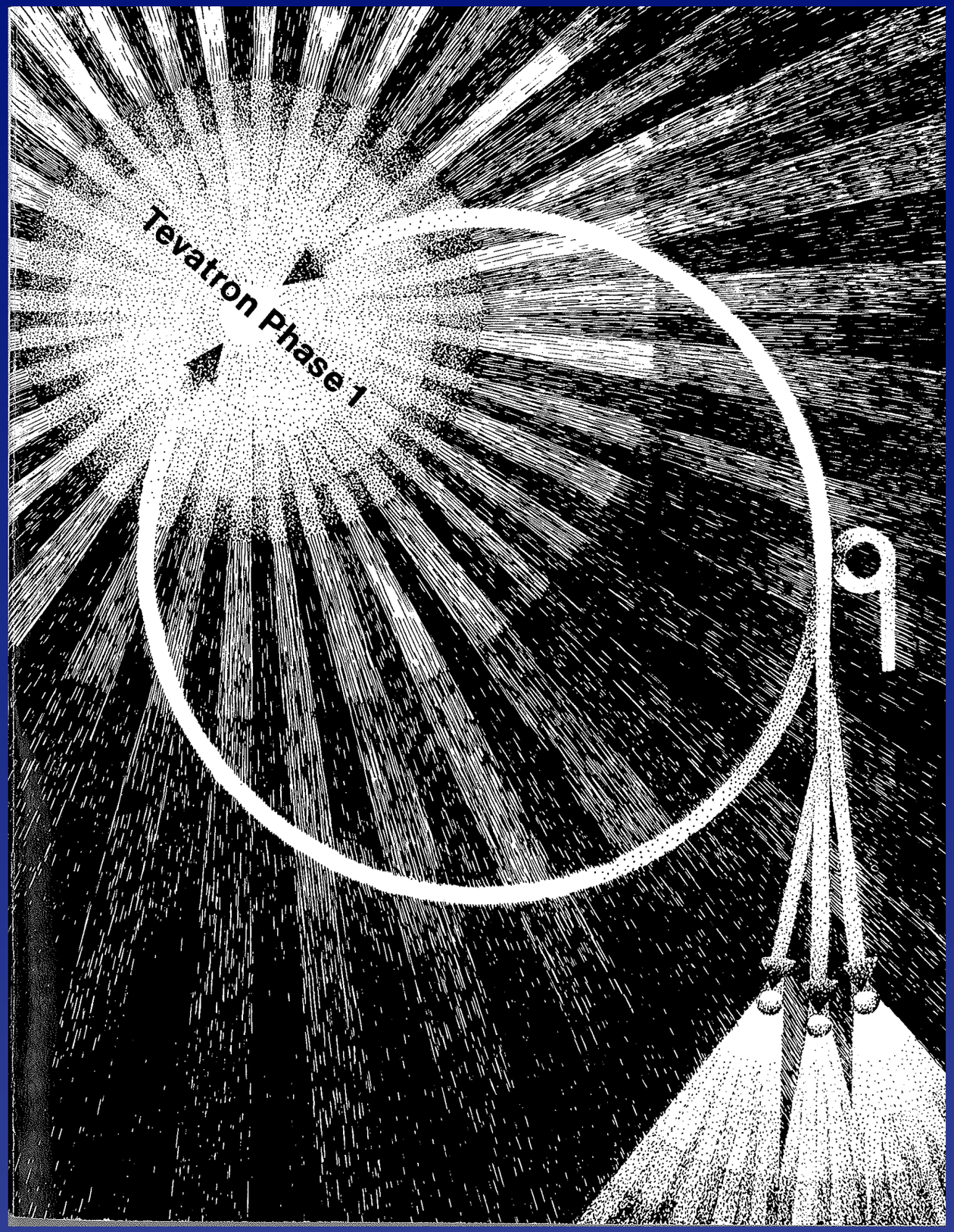
The Tevatron's Impact on Particle Physics

Chris Quigg · Fermilab

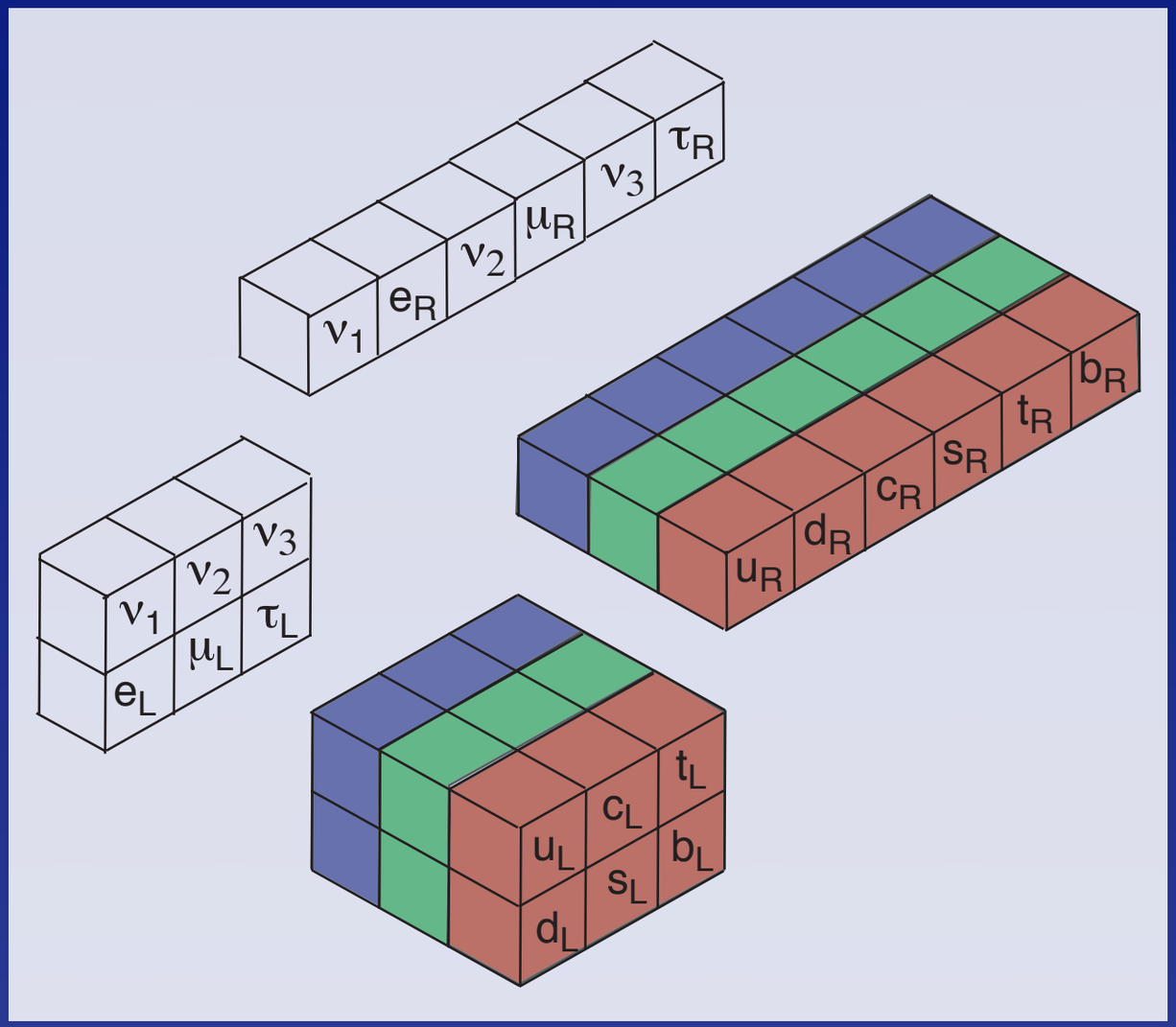


Hundreds of articles

Tevatron Ph.D.s
461 fixed-target
18 small-collider
965 CDF & D0

Two New Laws of Nature +

Pointlike ($r \leq 10^{-18}$ m) *quarks* and *leptons*



Symmetries dictate strong, weak, electromagnetic interactions

CDF & D0 Highlights

Top quark discovery · Higgs-boson search
Exacting measurements: m_t, M_W, B_s oscillations
Heavy-flavor physics
Search for new particles and forces
Testing elements of the "standard model"

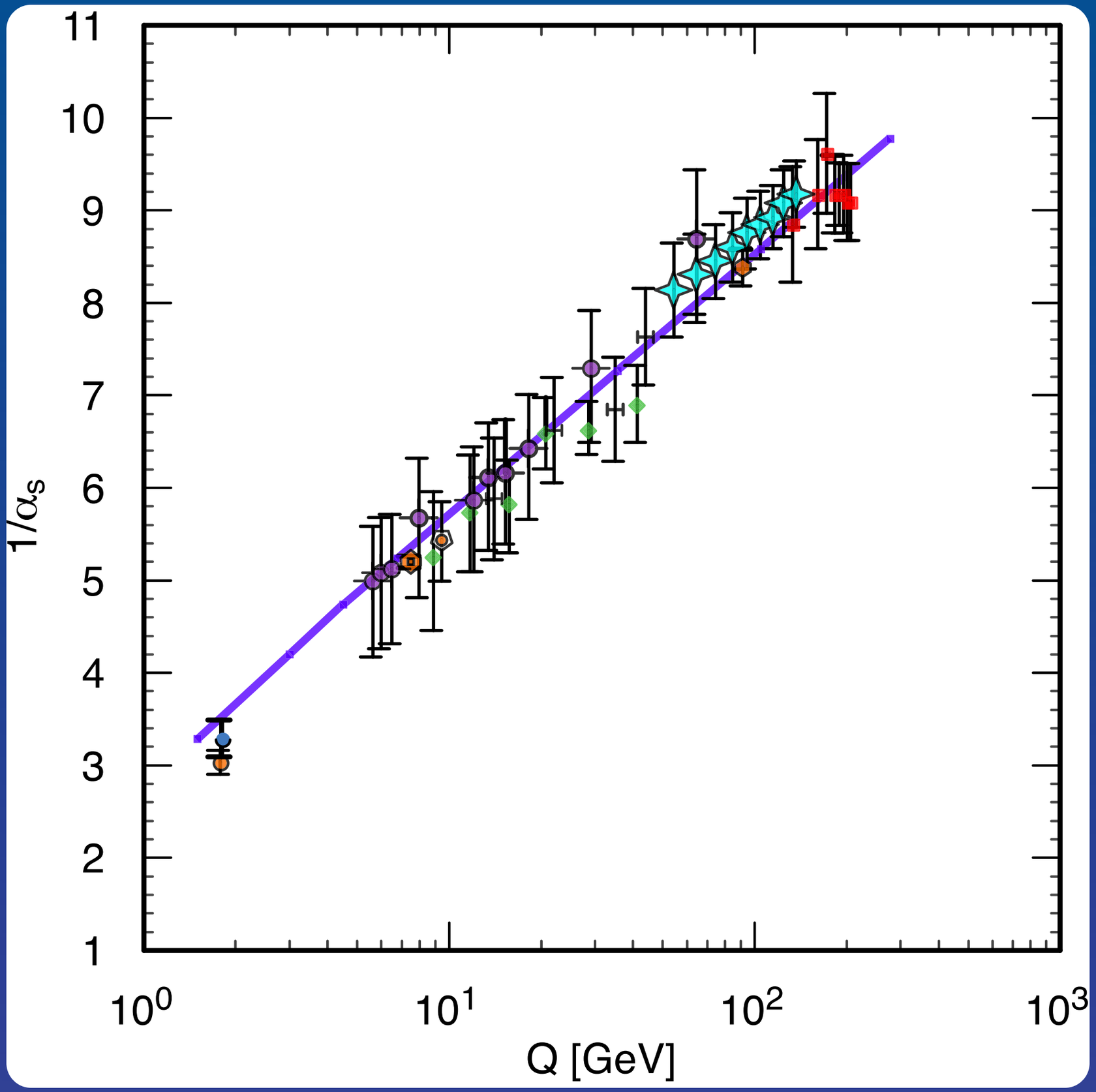
Scientific interests and capabilities expand and deepen
respond to new opportunities
deliver a harvest of results not imagined at the start

Strong Interactions: Quantum Chromodynamics

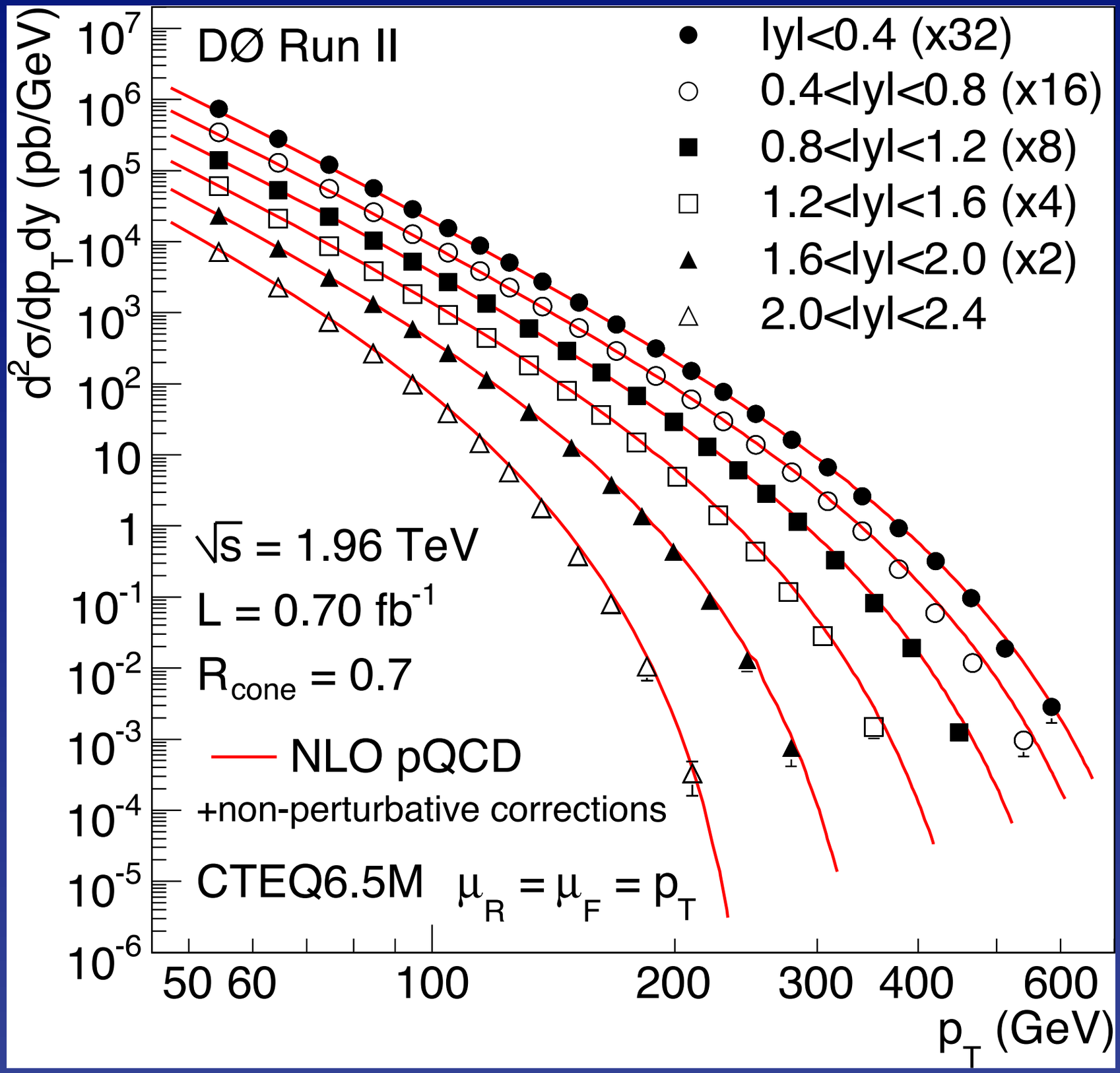
Conundrum:

Protons are made of quarks that seem independent, but quarks can't be liberated.

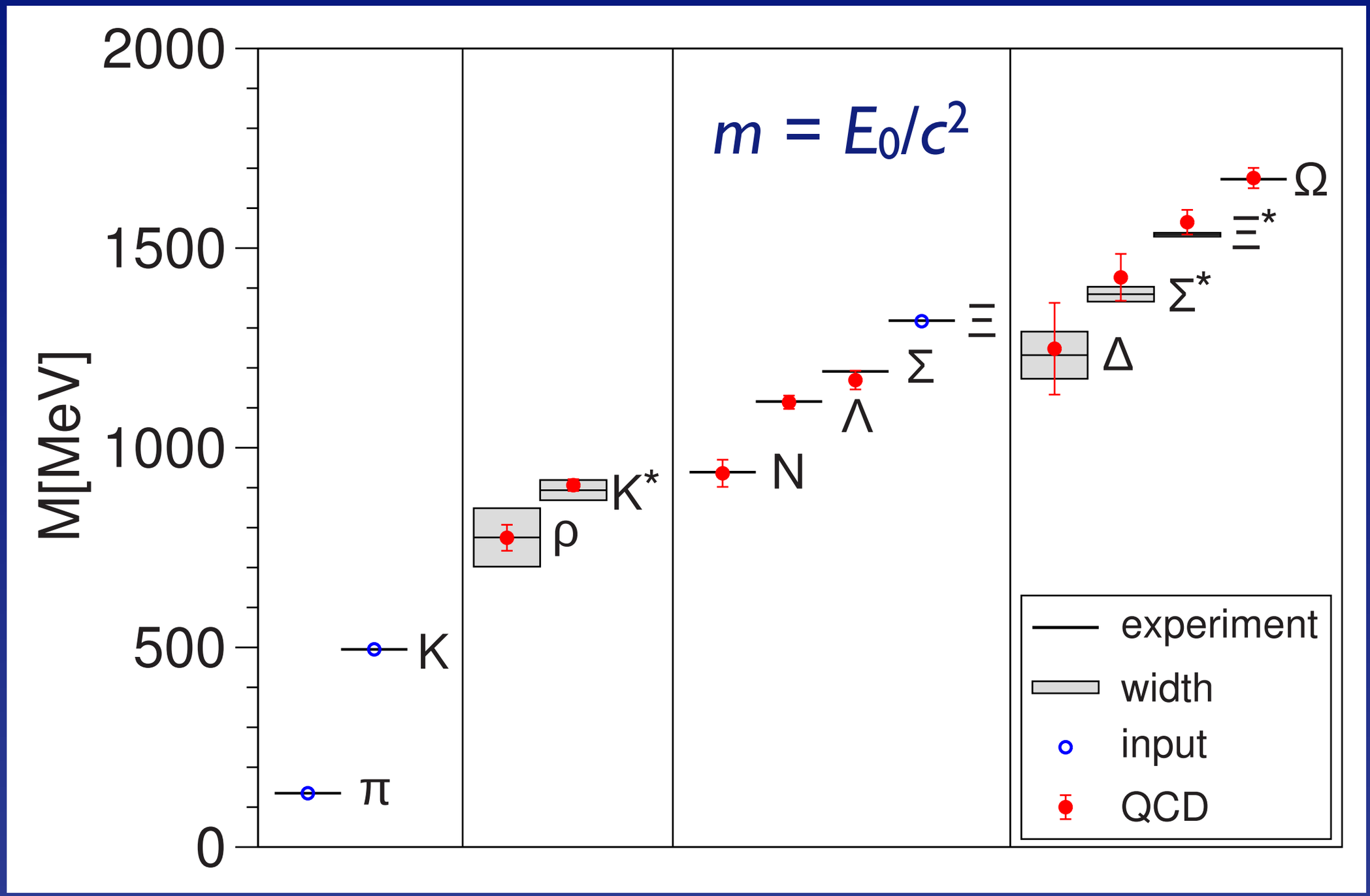
Evolution of the strong coupling



Quantum Chromodynamics



Light hadron spectrum with dynamical fermions



Heavy flavors

Production and decay of quarkonium states

Measurements of *b*- and *t*-quark production

B_c mass and lifetime

Masses and lifetimes of *B* mesons and baryons

Unique source of information on many *B*-baryons

Orbitally excited *B* and B_s mesons

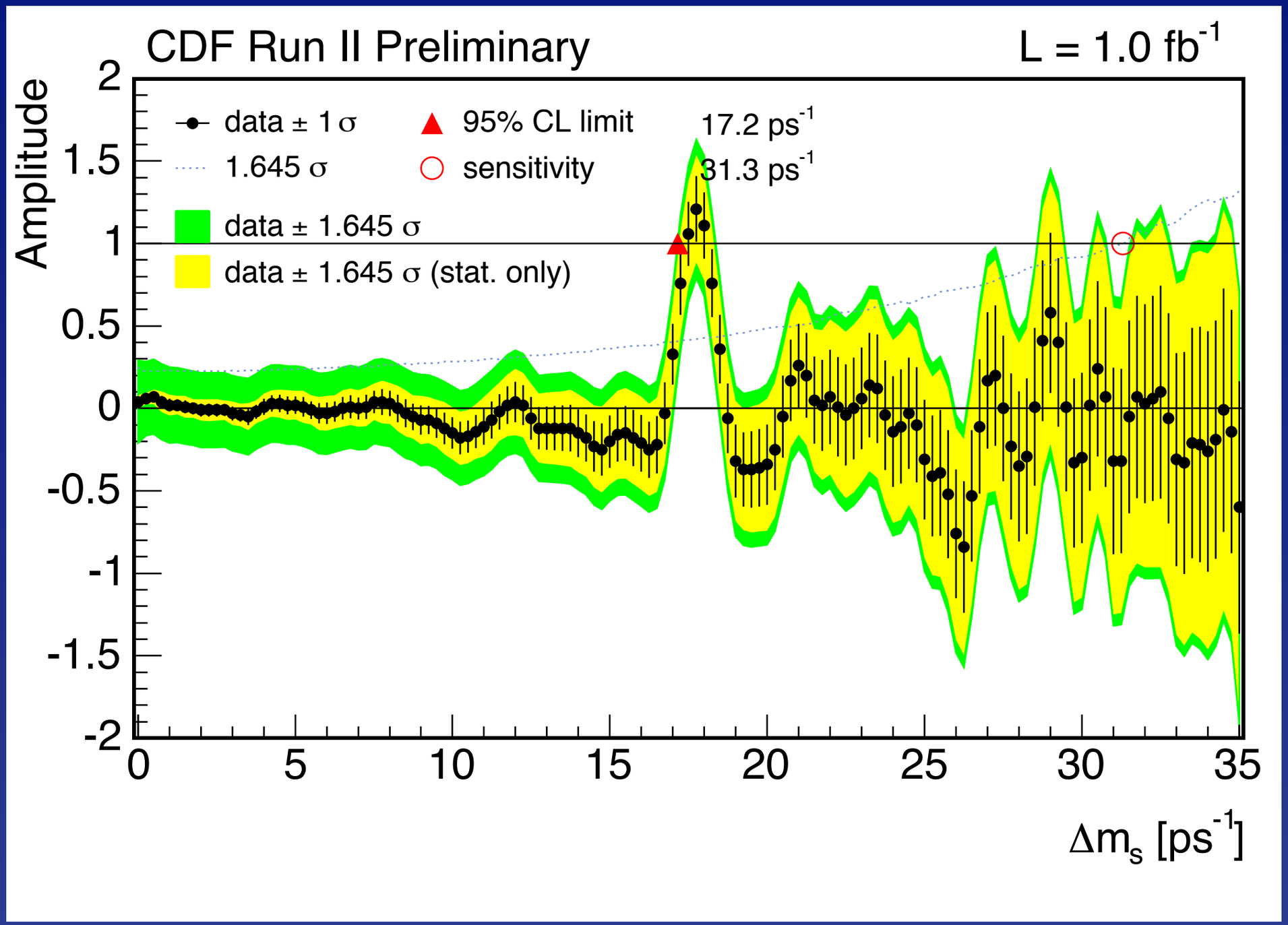
X(3872) mass and quantum numbers

Important evidence on D^0 mixing

Precise CP asymmetries for $D^0 \to \pi^+\pi^-$, $B^+ \to J/\psi K^+$

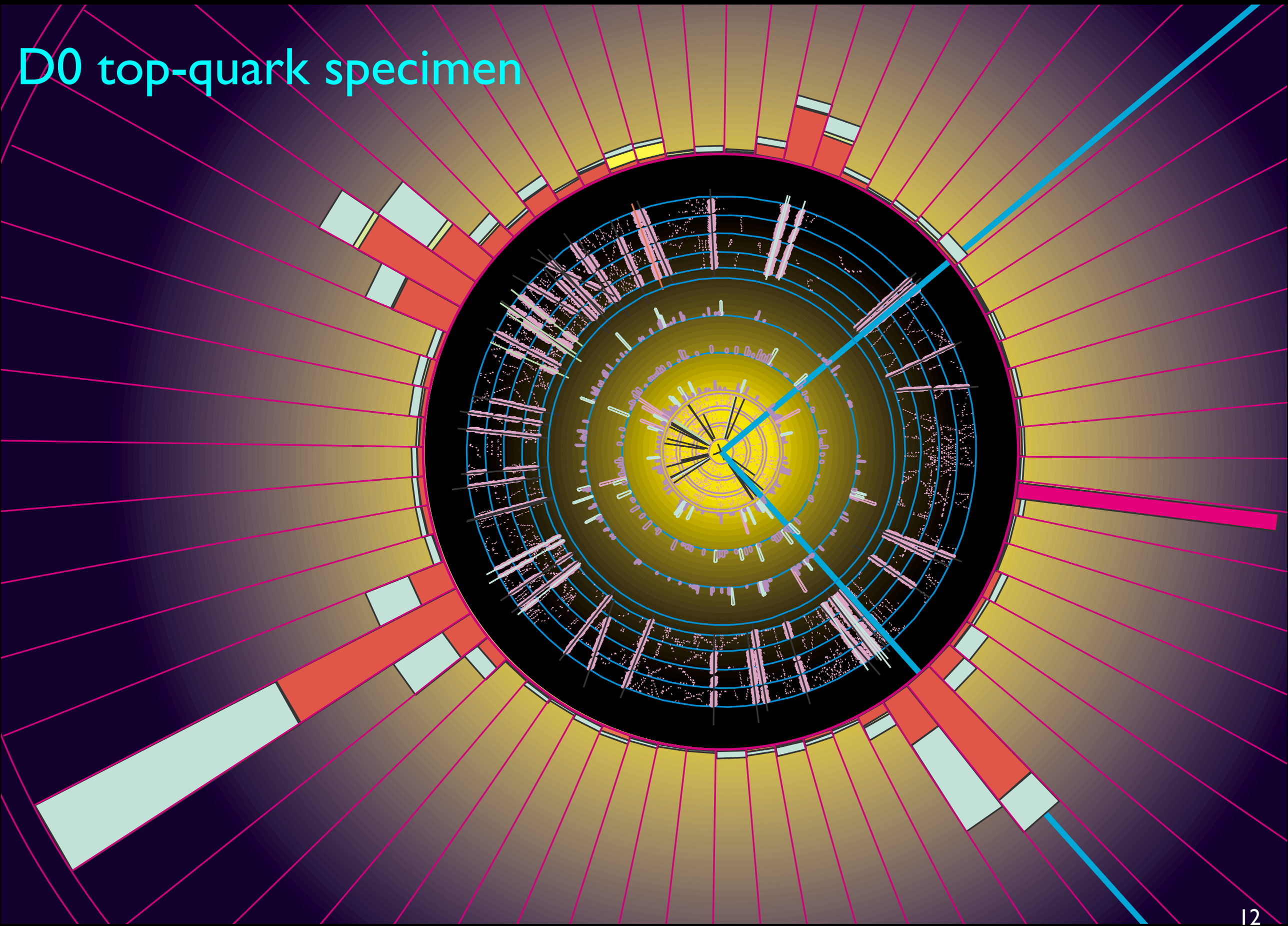
High-sensitivity searches for rare dimuon decays

Frequency of B_s oscillations

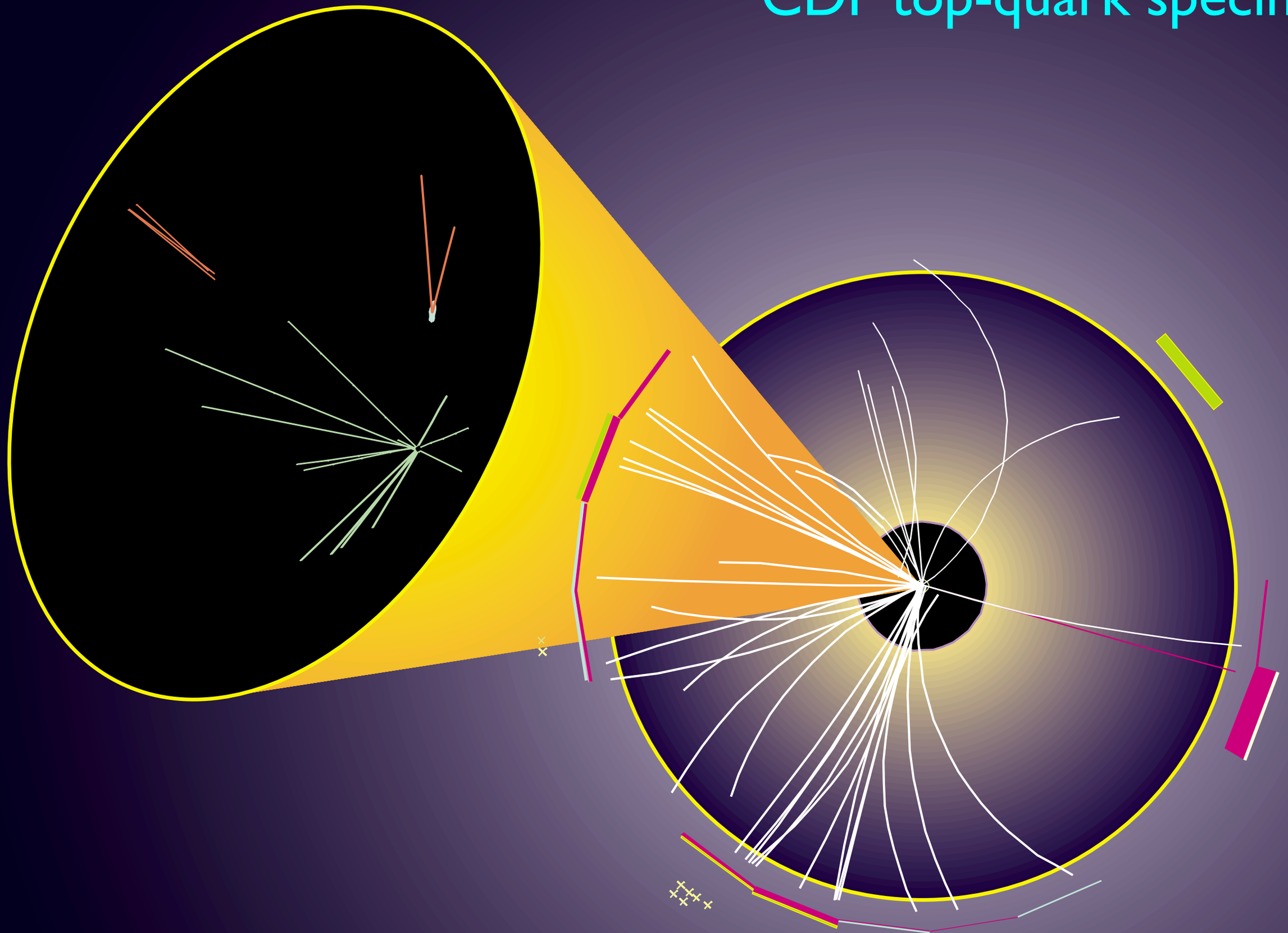


$\Delta m_s = 17.77 \pm 0.13\ \text{ps}^{-1}$

D0 top-quark specimen

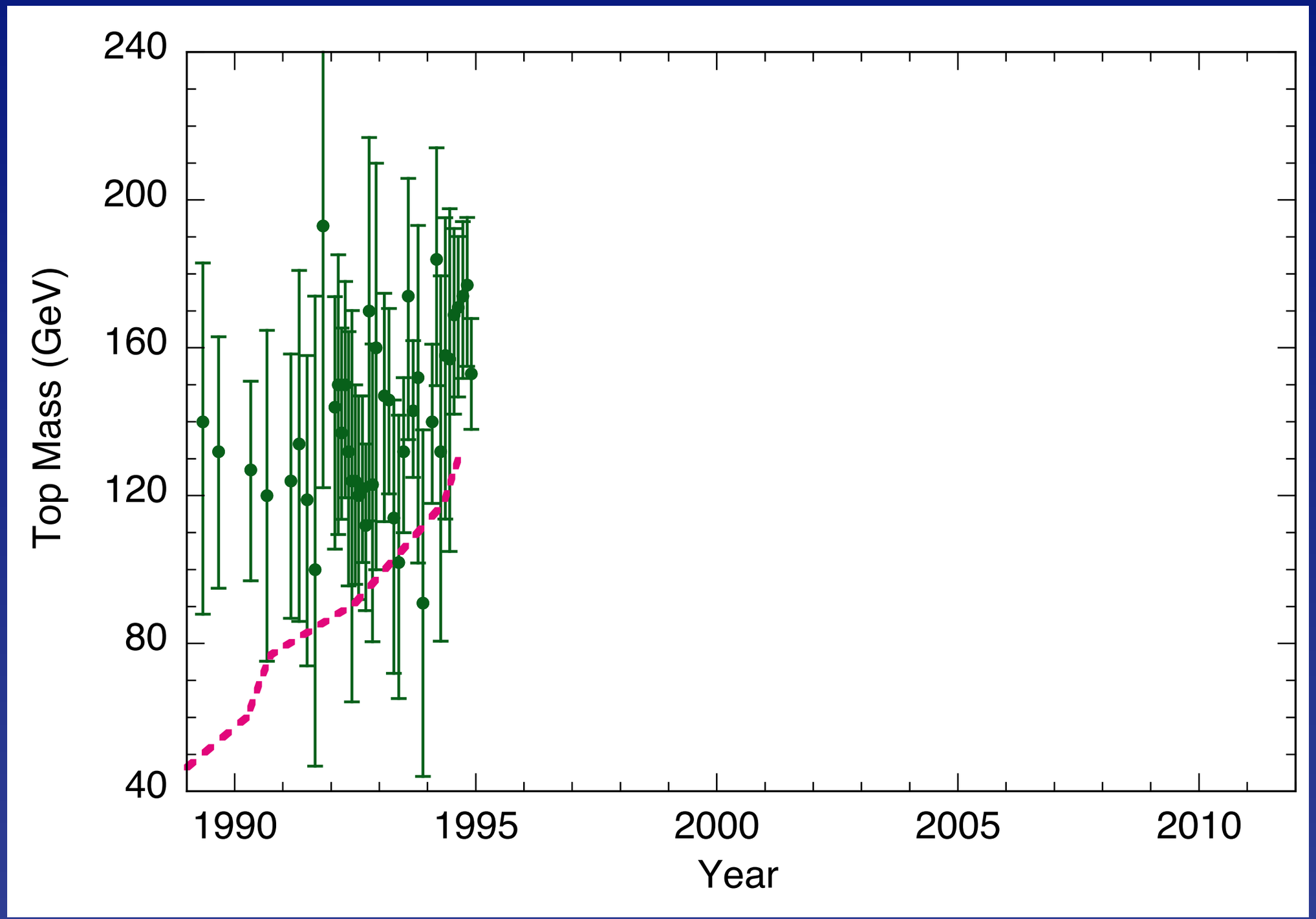


CDF top-quark specimen

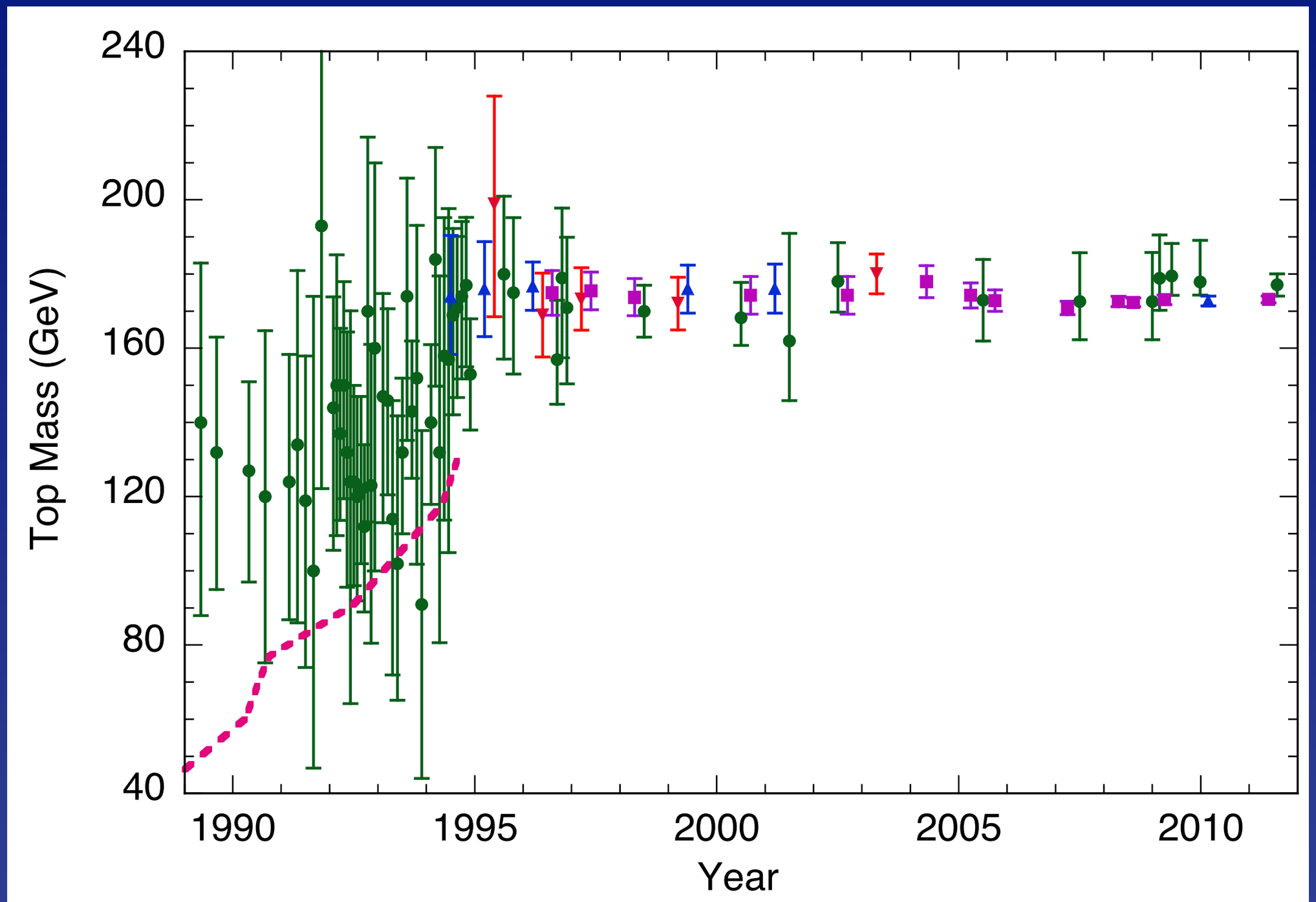


Electroweak theory joins electromagnetism and weak interactions (radioactivity)

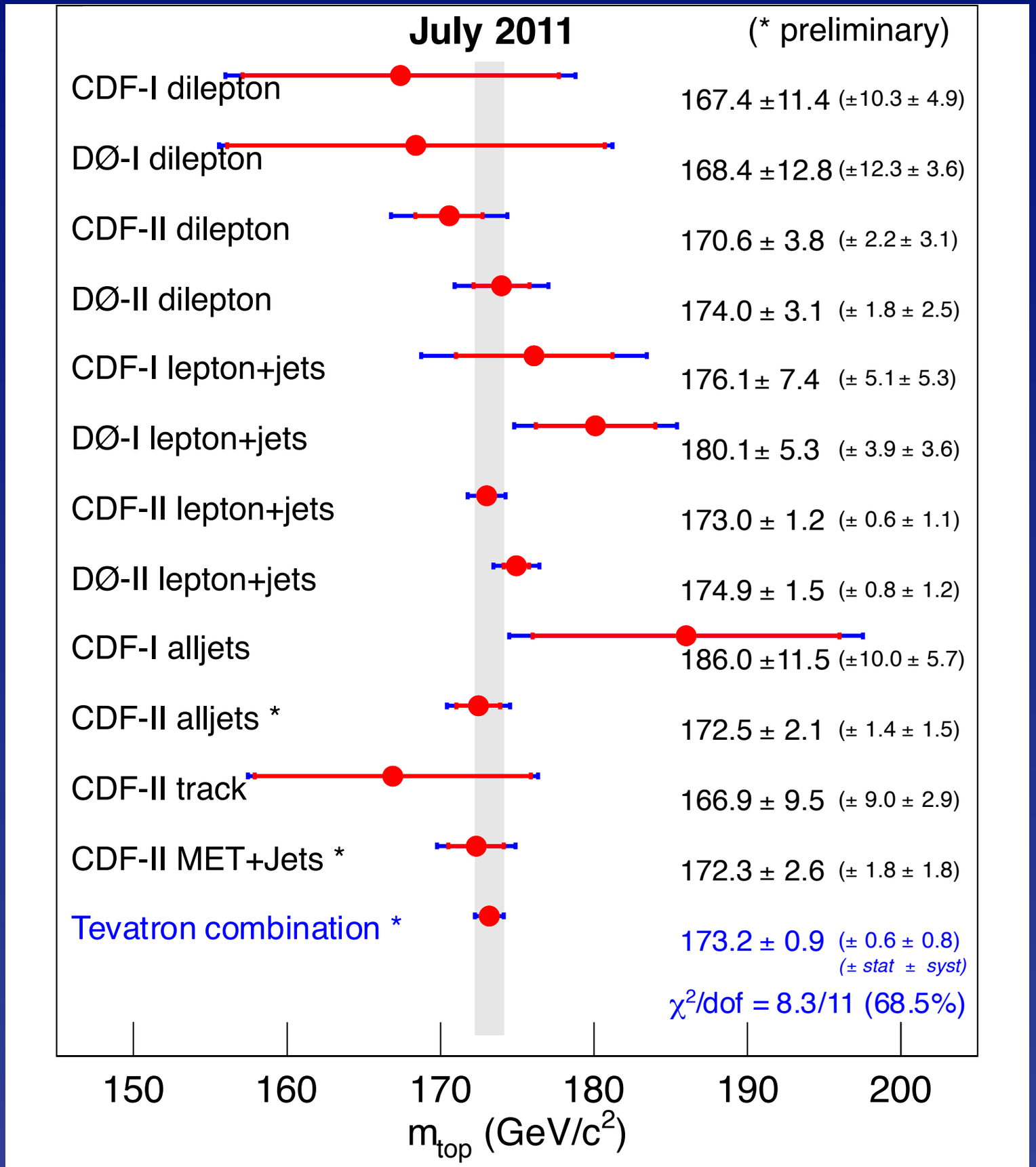
Top mass in the electroweak theory



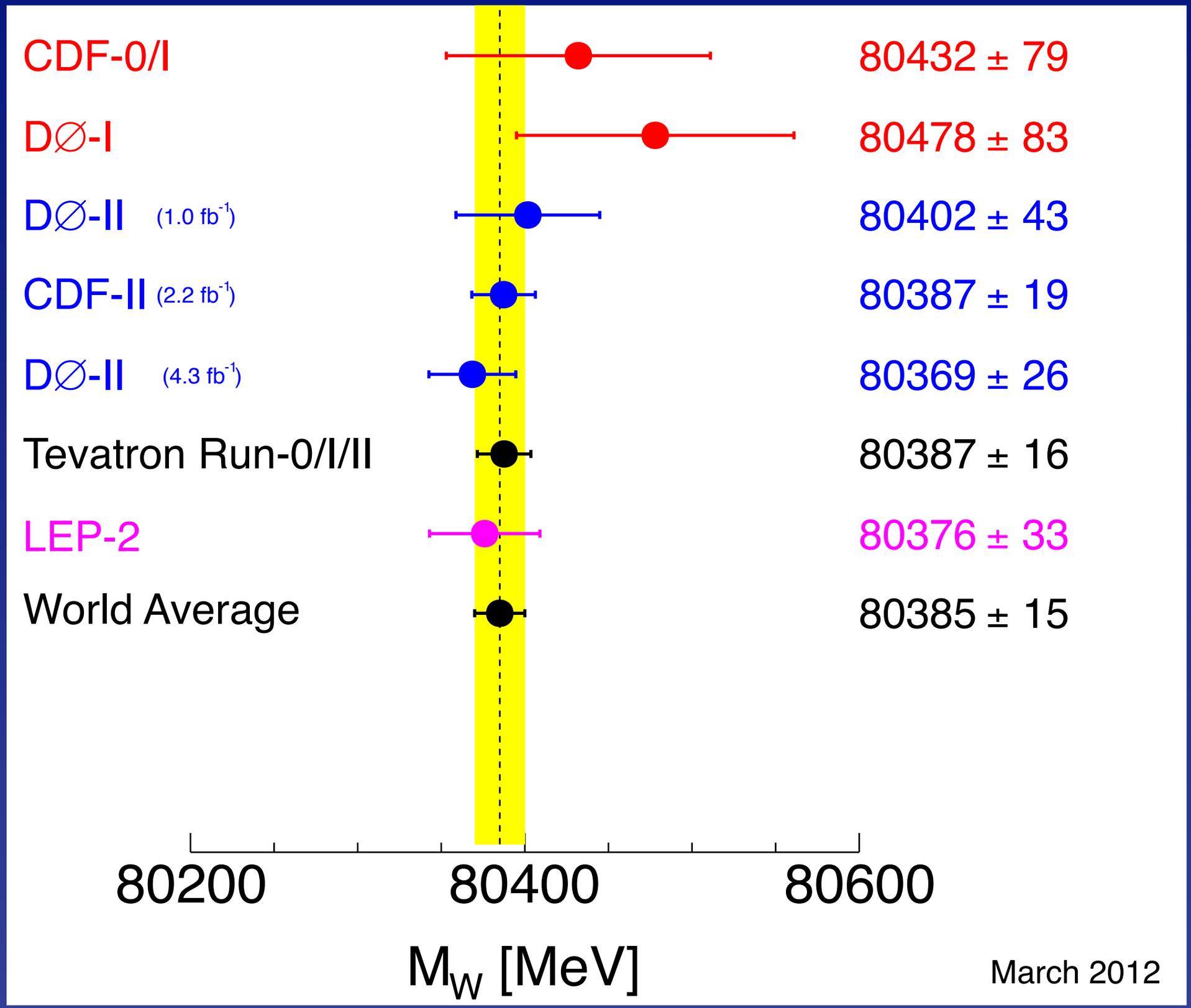
Top mass in the electroweak theory



Top-quark mass



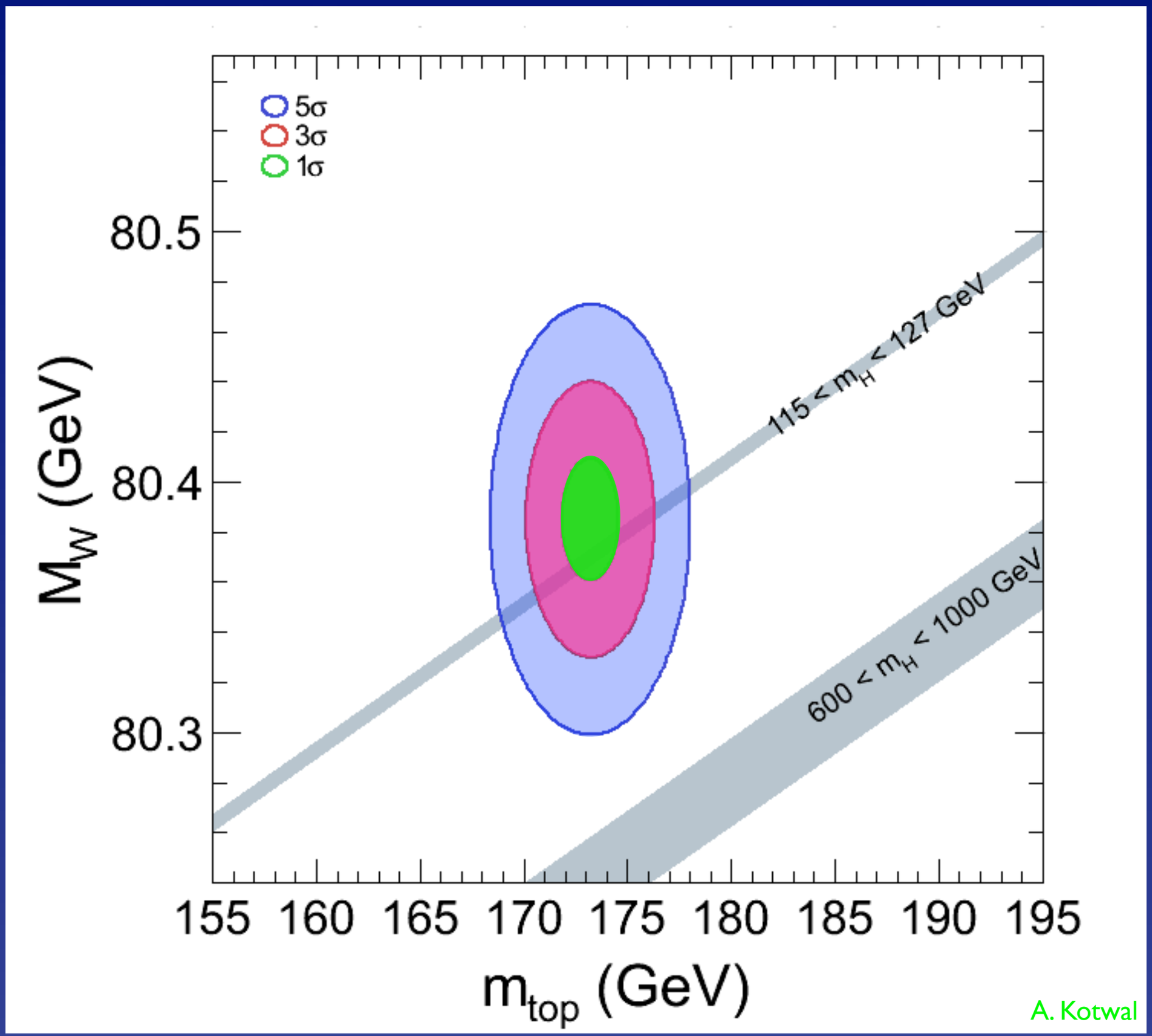
W mass


CDF-0/I
80432 ± 79
DØ-I
80478 ± 83
DØ-II (1.0 fb-1)
80402 ± 43
CDF-II (2.2 fb-1)
80387 ± 19
DØ-II (4.3 fb-1)
80369 ± 26
Tevatron Run-0/I/II
80387 ± 16
LEP-2
80376 ± 33
World Average
80385 ± 15
80200
80400
80600
MW [MeV]
March 2012

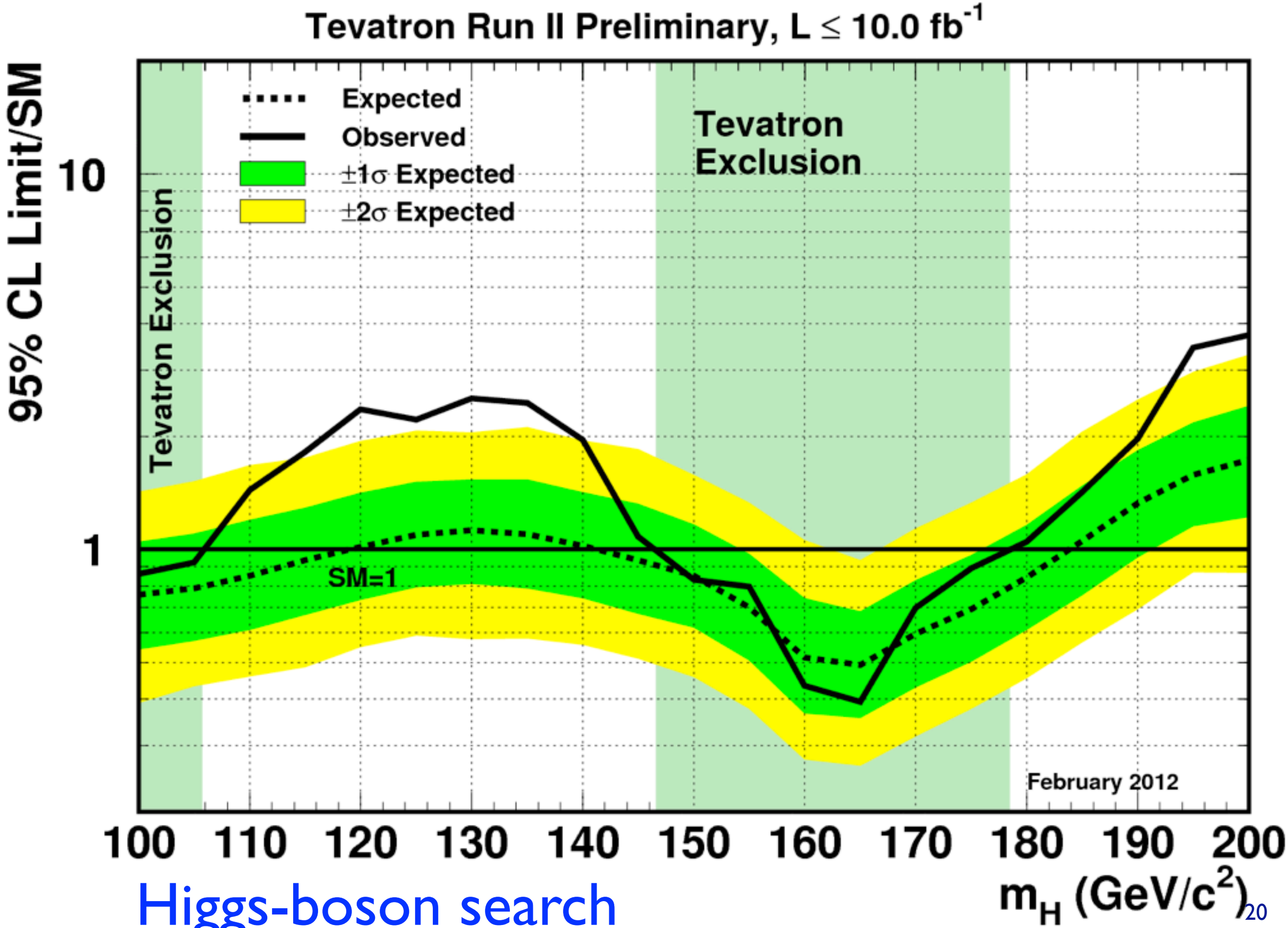
Missing link: the agent that
Differentiates weak, EM interactions
Gives masses to the weak force particles
Sets masses & family patterns of quarks & leptons

Textbook hypothesis: Higgs boson

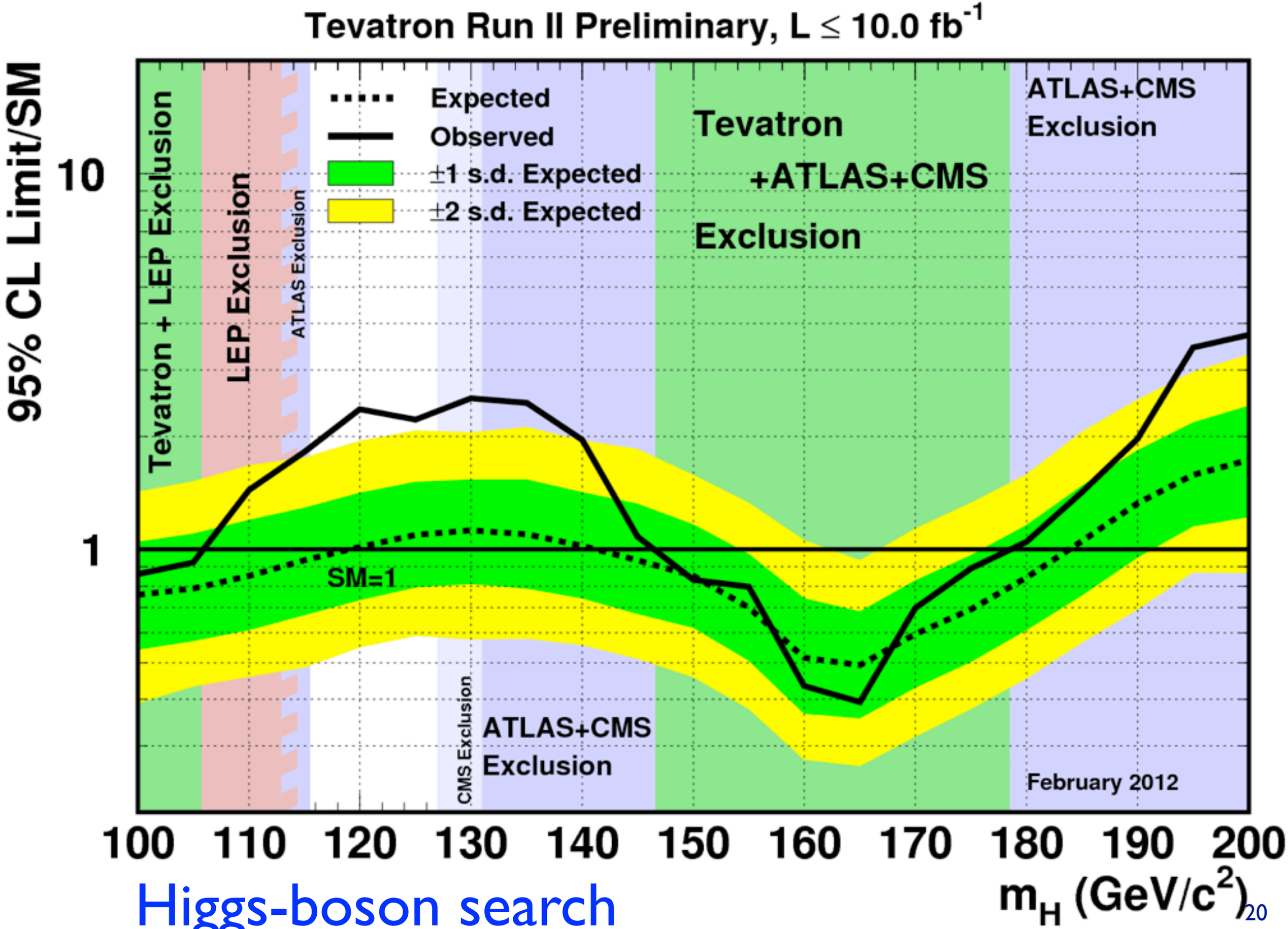
Top quark, W, and the Higgs boson



A. Kotwal



Higgs-boson search



Higgs-boson search

Diverse searches for new phenomena

Limits on

supersymmetric particles

extra spatial dimensions

signs of new strong dynamics

leptoquarks

new gauge bosons

magnetic monopoles

…

Tevatron experiments did not find
what is not there

(A few observations do not match expectations)

Puzzle #1: Expect *New Physics* on TeV scale,
but no sign of flavor-changing neutral currents.

Great interest in searches for
forbidden or suppressed processes

Puzzle #2: Expect *New Physics* on TeV scale,
but no quantitative failures of EW theory

The unreasonable effectiveness of the standard model

Thanks to the dreamers and builders!

Thanks to Tevatron experimenters!

Thanks to all who made the
Tevatron run so beautifully!

Thanks to our patrons!

Continued success to the LHC!

Onward to Fermilab's next great instrument!

Early Tevatron history: H. Edwards, *Ann. Rev. Nucl. Part. Sci.* 35, 605 (1985).

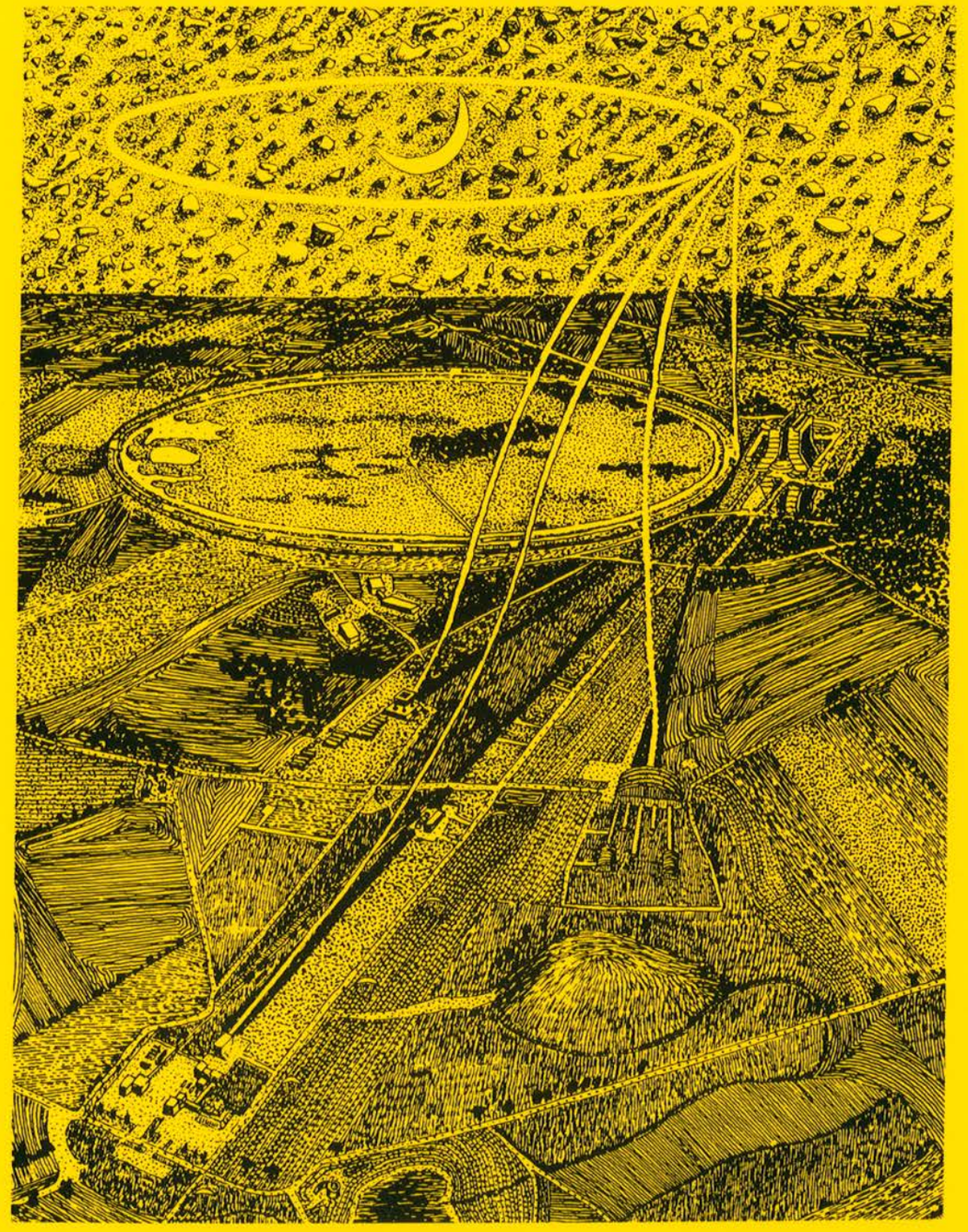
Recent overview: S. Holmes, R. S. Moore, and V. Shiltsev, *JINST* 6, T08001 (2011).

CERN *Courier*: CQ, "Long Live the Tevatron," R. Dixon, "Farewell to the Tevatron"

Anecdotal accounts: V. Shiltsev, "Accelerator Breakthroughs, Achievements and Lessons from the Tevatron Collider," 2010 John Adams Lecture; J. Peoples, Wilson Prize Lecture, "The Tevatron Collider: A Thirty Year Campaign" S. Holmes, DPF 2011 Lecture, "Celebrating the Tevatron: the Machine(s)"

Symposium in Celebration of the

Fixed Target Program with the Tevatron



Fermi National Accelerator Laboratory

June 2, 2000