Probing fundamental interactions at the LHC

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Outline:
- Intro to HEP
- E.g. measurements with current data
- The LHC
Parton collider

MRST2001

\( Q^2 = 10 \text{ GeV}^2 \)

\[ x f(x, Q^2) \]

\[ x \quad \text{Martin, Roberts, S, Thorne} \]
Strong Interactions: “Observing” quarks

\[ m^2 = (p_q + p_{\bar{q}})^2 \]
Probing QCD: dijets

CDF RunI data

$\sigma/dM_{q\bar{q}}$ [pb/(GeV/c$^2$)]

quark-antiquark invariant mass (GeV/c$^2$)

$X \rightarrow q\bar{q}$

compositeness

$|\eta| < 2$

$|\cos \theta| < 2/3$
Search for high mass di-leptons
Search for high mass di-leptons

![Graph showing dielectron mass distribution with legend for Drell-Yan, QCD background, and tau, WW, WZ, tt events.]

![Diagram showing Feynman diagram for photon or Z boson production.]
Search for high mass di-leptons
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CDF Run II Preliminary (200 pb⁻¹)

- Data
- Drell - Yan
- QCD Background
- ττ, WW, WZ, tt

Central - Central

Dielectron Mass (GeV/c²)

Events / 5 (GeV/c²)

10⁴

10³

10²

10¹

10⁻¹
Search for Supersymmetry

$\Rightarrow Z+\text{jets}$
Standard Model backgrounds to $Z+\text{jets}$

\[ \bar{q} \rightarrow e^+ \bar{q} \rightarrow \gamma^*/Z^0 \rightarrow e^+e^- \]
Standard Model backgrounds to $Z$+jets
Standard Model backgrounds to Z+jets
Number of jets in events with a Z
Can determine QCD effects directly from data
Total energy in the collision is sensitive to the produced mass
Total energy in the collision is sensitive to the produced mass e.g. here is top quark production on top of W+jets
How can we probe higher mass?

More data
or
More energy
CERN Large Hadron Collider
Total Weight : 14,500 t.
Overall diameter: 14.60 m
Overall length : 21.60 m
Magnetic field : 4 Tesla
open -a firefox ~/Lgbk/data/E19630.gif
2.4 m

5.4 m

volume 24.4 m³
running temperature - 20 °C

10 Million Si Strips! 26 Million Wire connections!
$H (150 \text{ GeV}) \rightarrow Z^0 Z^{0*} \rightarrow 4\mu$
5.4 m
2.4 m

volume 24.4 m$^3$
running temperature - 20 °C

10 Million Si Strips! 26 Million Wire connections!
Can then search for high mass dileptons

![Graph showing dielectron mass distribution](image)

![Diagram illustrating the process](image)
...or $X \rightarrow Z + \text{jets}$
...or Higgs to ZZ
Summary

I tried to give you an overview of the goals and techniques of experimental particle physics.

Impending data from LHC will allow many different measurements of known phenomena, and perhaps new phenomena.