Major parameters of $pp$ interactions at $\sqrt{s} = 40 \div 800 \text{TeV}$

D. Denisov  
Fermilab

1. Total and elastic cross sections
2. Multiplicity distributions
3. Charged tracks rapidity distribution
4. Radiation doses
5. Summary

Snowmass 2001, July 9 2001
Parameters of pp Interactions

- Most results are for 100TeV and luminosity $10^{34}\text{cm}^{-2}\text{s}^{-1}$

We will start from properties of individual interactions

Total and inelastic cross sections
Charged Particles Multiplicity: min_bias events

Average number of charged tracks

![Graph showing charged multiplicity vs. centre of mass energy.]

Multiplicity distribution

![Histogram showing multiplicity distribution with mean and RMS values.

Particles p_t distribution

![Graph showing p_t distribution with entries, mean, and RMS values.]
Radiation doses

- Materials change their properties under irradiation. Mostly affected areas are:
  - Central tracking detector
  - Calorimetry in shower maximum

Typical dose rates for central region and calorimetry

1. Dose in central region increase slowly with energy, but linearly with luminosity
2. Beam losses is another source of irradiation
3. Radiation dose not depend upon luminosity “structure”
Rapidity plateau

Pseudorapidity distributions for stable hadrons in minimum bias proton-proton interactions at $\sqrt{s} = 200\,\text{TeV}$ (solid line), and at $\sqrt{s} = 16\,\text{TeV}$ (points).

- Average number of particles per unit of rapidity is $\sim 5$

*Energy flow, 100 TeV, 1 event*

- Almost all energy is in the forward region
Example: * of tracker elements

For $\sqrt{s} = 200$ TeV, * of tracks per event:

$$N_{\text{tracks}} = 50 \times 100 = 5 \times 10^3 \text{ tracks/event}$$

* of interactions per crossing

For reasonable reconstruction/triggering occupancy below 1% is needed:

$$N_{\text{elem.}} = 5 \times 10^3 \times 100 = 5 \times 10^5 \text{ elements/layer}$$

Number of layers $\geq 20$ is needed:

$$N_{\text{tot}} = 5 \times 10^5 \times 2 \times 10 = 10^7 \text{ number of tracker "elements"}$$
Conclusions

1. Cross sections and multiplicities changing with energy increase very slowly.

2. Multiplicity distributions have long non-Gaussian tails.

3. Radiation dose in the central region is function of luminosity, "not" $\sqrt{s}$.

4. Most of charged tracks are low momentum $\langle p_T \rangle \approx 0.6 \text{ GeV}$

5. All parameters discussed are based on "extrapolation": we could see surprises at very high energy!