L16

Monday, March 30, 2020 3:00 PM

Natural Units

$\hbar = 1.05457 \cdot 10^{-34} \frac{m^2 \cdot kg}{s}$ $\quad m_e = 9.1 \times 10^{-31} kg$

$c = 299792458 \frac{m}{s}$ $\quad m_e = 0.511\ MeV$

$\varepsilon_0 = 8.854187 \cdot 10^{-12} \frac{C^2}{N \cdot m^2}$

$1J = 6.24 \times 10^{18} eV$

$1eV = 1.6 \times 10^{-19} J$ $\quad 1J = kg \cdot \frac{m^2}{s^2}$

$\hbar = 1$

$c = 1$

$c = 3 \times 10^8 \frac{m}{s} = 1 \quad m = \frac{1}{3 \times 10^8} s$

$s = 3 \times 10^8 m$

$\hbar = 1.05 \times 10^{-34} \frac{m^2 kg}{s^2} \cdot s = 1.05 \cdot 10^{-34} J \cdot s$

$\hbar = 1.05 \times 10^{-34} J \cdot s = \frac{1.05 \cdot 10^{-34}}{1.6 \cdot 10^{-19}} eV \cdot s$

$MeV = 10^6 eV$

$\hbar = \frac{1.05\ 10^{-34}}{1.6\ 10^{-19} \cdot 10^{-6}} MeV \cdot s$

$\hbar = Number \cdot MeV \cdot s = 1$

$1m = \frac{1}{3 \times 10^8} s = \frac{1}{Number \cdot 3 \times 10^8} MeV^{-1}$

$1s = \frac{1}{Number} MeV^{-1}$

$[1m] = MeV^{-1}$

$[1s] = MeV^{-1}$

$[Energy] = MeV$

$1kg = 1kg \cdot \frac{m^2}{s^2} \cdot \frac{s^3}{m^2} =$

$1J \cdot \frac{s^2}{m^2} = \frac{1}{1.6 \cdot 10^{19}} eV \cdot \left(\frac{s}{m}\right)^2 = Number \cdot MeV$

$1s = \frac{1}{Number} MeV^{-1}$

$\hbar = Number \cdot MeV \cdot s$

- Experimental verification of QM calculation is measuring Atomic spectra and transitions

- Completely new way of exploring the structure of matter is the scattering processes

- Scattering becomes possible with discovery of Radioactivity in which case Atoms will radiate particles: alpha particles ( ), electrons ( )

- Later the Bremsstrahlung Radiation was used to scatter photons

- Biggest technical issue was how to focus the ray of these particles into the target that is being explored

- And then how to measure the particles scattered from the target

- Geiger-Marsden- Experiments 1908-1909 University of Manchester

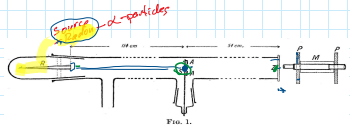
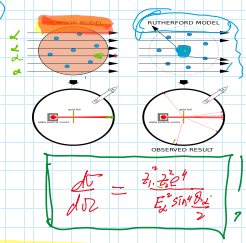


FIG. 1.

- Rutherford- Geiger-Marsden - Experiment 1913 - 1915

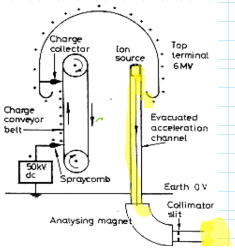
$E_{kin} \sim 7.7\ MeV$

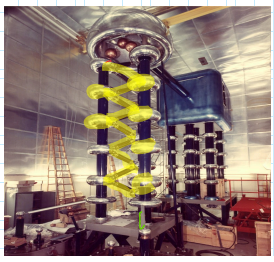
$\alpha \sim 8000$ mass.e



$\frac{d\sigma}{d\Omega} = \frac{z_1^2 z_2^2 e^4}{E_{kin}^2 \sin^4 \theta_{Lab}}$

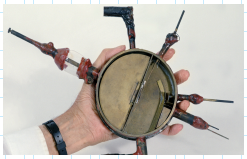
- How to get higher energy particles?
  ~~Cockcroft~~-Walton Generator (Van de Graaf Generator)

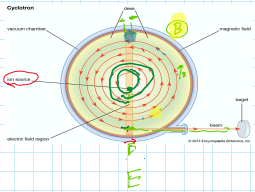




protons, few hundred KeV

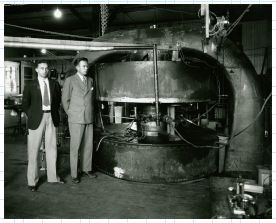
- Cyclotron: Ernest Lawrence 1929-1930 - Berkley

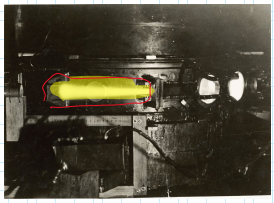




$r = \frac{mv}{qB}$

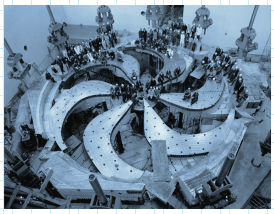
- Cyclotron: 1932 - protons and Ions: Berkeley



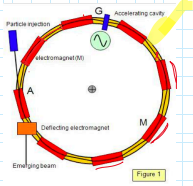


184 inch - 1942 protons and Ions

- Largest Cyclotron: 1974 Triumf - Vancouver Canada, 500 MeV Protons



- Synchrotron: Idea-1944 Vladimir Veksler:
  First realization 1945 - Edwin McMillan 300 MeV electrons

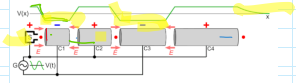


First realization 1949 - Edwin McMillan 300 MeV electrons, University of Michigan

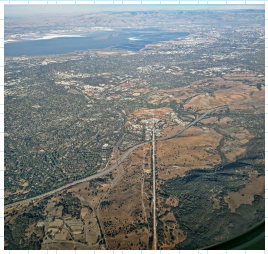
Bevatron Berkeley, 6.2 GeV, 1954, protons

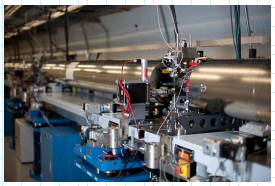
- Yerevan Physics Institute: Armenia, 1967, 4500Mev - 4.5GeV - electrons

- Linear Accelerator Gustav Ising 1924
  Build by Rolf Wideroe 1928

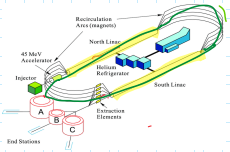


- SLAC: 1962 - 3.2km, 20GeV electron

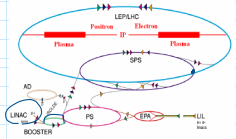




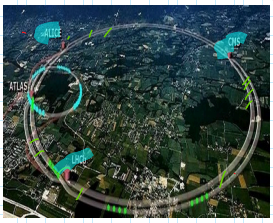
- Jefferson Lab: 1984 4, 6, 12 GeV

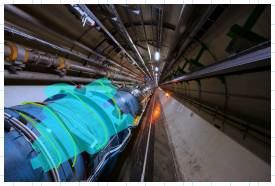


Colliders: Proposal 1961 50 MeV protons prototype

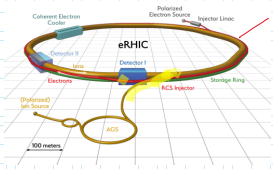


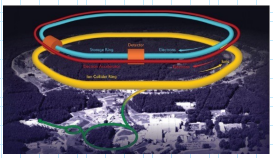
Large Hadron Collider: 2008 13000GeV





Electron Ion Collider: 2028? USA 18 GeV - e 275 GeV - Protons



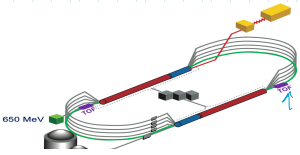


2.5-3B Project

Jefferson Lab Energy Upgrade to 22 GeV

New 650 MeV recirculating injector

Remove the highest recirculation pass (Arc 9 & A) and replace them with two FFA arcs including time-of-flight



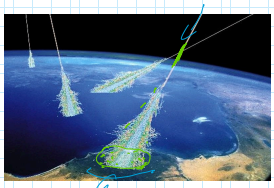
chicanes

Recirculate 4.5 + 6 times to get to **22 GeV**

500M Project

- Spectra and structure of heavy and light hadrons as probes of QCD
  - Ralf Gothe (wgothe@gmail.com)
  - Matt Shepherd (shephest@jlab.org)
- Sea and valence partonic structure and spin
  - Jian-Ping Chen (jpchen@jlab.org)
  - Ioana Niculescu (ioanai@jlab.org)
  - Nobuo Sato (nsato@jlab.org)
- Form Factors, Generalized Parton Distributions and Energy-Momentum Tensor
  - Latifa Elouadrhiri (latifa@jlab.org)
  - Garth Huber (Garth.Huber@uregina.ca)
  - Christian Weiss (weiss@jlab.org)
- Fragmentation, Transverse Momentum and Parton correlations
  - Harut Avagyan (avakian@jlab.org)
  - Dave Gaskell (gaskell@jlab.org)
  - Nobuo Sato (nsato@jlab.org)
- Hadron-quark transition and nuclear dynamics at extreme conditions
  - Lamiaa El Fassi (elfassi@jlab.org)
  - Misak Sargsian (sargsian@fiu.edu)
- Low-energy tests of the Standard Model and Fundamental Symmetries
  - Liping Gan (gan@uncw.edu)
  - Kent Paschke (paschke@jlab.org)

Cosmic Rays:



Space Based Accelerators:

Quantum Mechanical Scattering Theory.