Homework

- Calculate the elastic scattering kinematics (use relativistic kinematics)
  - Known : incident electrons (E_{inc}, $\mathbf{P}_{inc}$), scattering angle (Θ)
  - Unknown : outgoing electrons (E_{out}, $\mathbf{P}_{out}$)
- Assuming a homogenous sphere of radius R
  - Known density

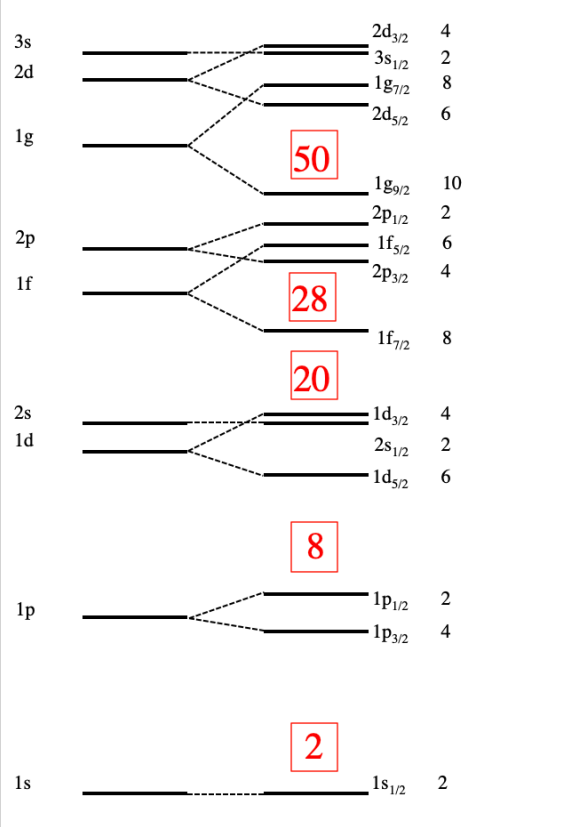
$$\rho(r) = \begin{cases} \frac{3}{4}\pi R^3 & \text{for } r \leq R \\ 0 & \text{for } r > R \end{cases}$$

  - Replacing the density $\rho(r)$ to show that the form factor $F(\mathbf{q}^2)$ is

$$F(\mathbf{q}^2) = 4\pi \int \rho(r) \frac{\sin(|\mathbf{q}|r/\hbar)}{|\mathbf{q}|r/\hbar} r^2 dr = \frac{3}{\alpha^3}(\sin\alpha - \alpha\cos\alpha)\ ; \alpha = |\mathbf{q}|R/\hbar$$

NuPEERS Rare Isotopes HOMEWORK

1) We want to study the clustering in ^{24}Mg:
    a. How many protons and neutrons does this nucleus have?
    b. How many alpha particles would this be?
    c. Show the shell structure of the protons and neutrons in ^{24}Mg with the diagram below, for its ground state. Does it have any closed shells?



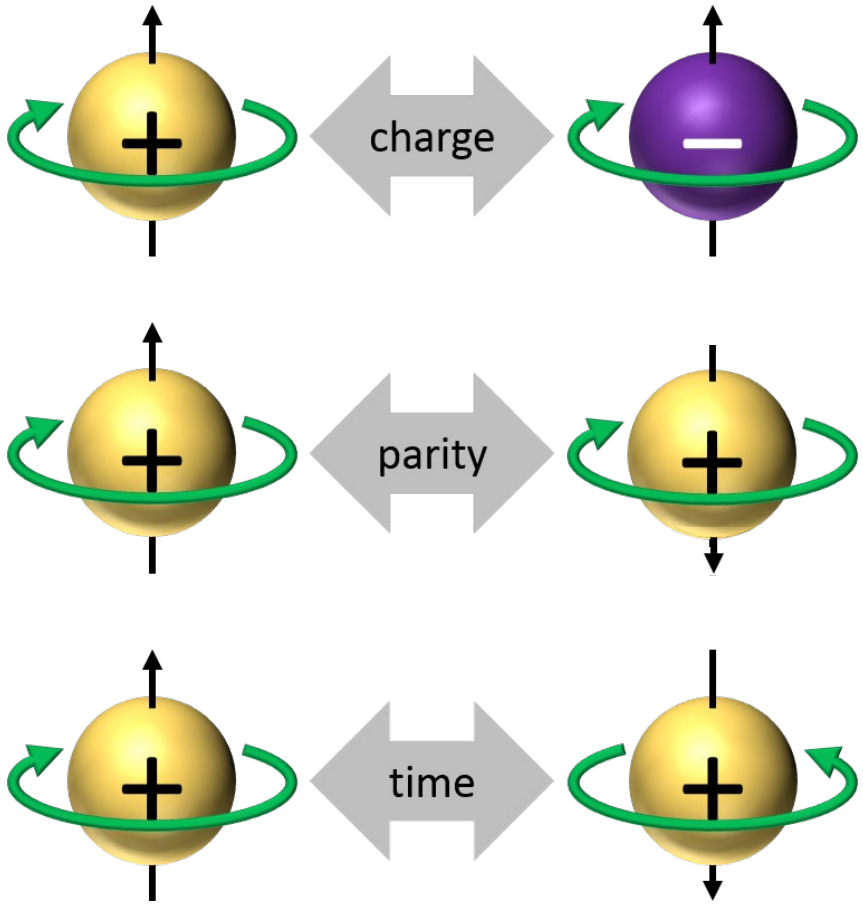
2) We are performing an experiment to understand the structure of ^{12}Be, using the following reaction:

$$^{13}\text{B} + \text{d} \rightarrow {}^{3}\text{He} + {}^{12}\text{Be}$$

We are using a beam of ^{13}B at 30 MeV/u and a gas detector filled with deuterium (D_2) with density $\rho(D_2) = 0.171\ kg/m^3$ at 1 atmosphere
    a. How many protons and neutrons does our beam and product nucleus have?
    b. What are the half-lives of ^{13}B and ^{12}Be?
    c. How many nucleons are transferred in the reaction?
    d. What type of nuclear reaction is this?
    e. Show the shell structure of the protons and neutrons in ^{12}Be with the diagram above, for its ground state. Does it have any closed shells?

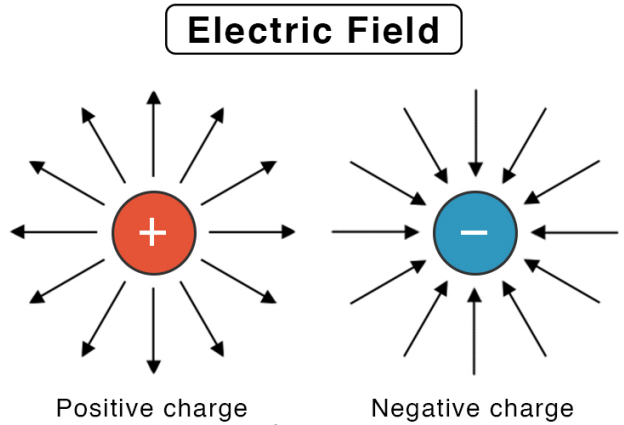
The Discrete Fundamental Symmetries

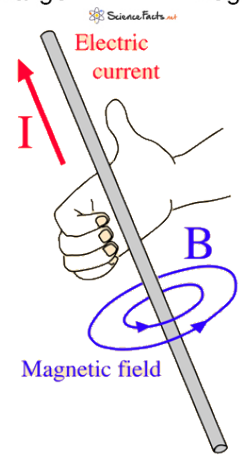
- Charge-conjugation (C): replace matter with antimatter
  - Charge changes sign. Polar vectors (e.g. momentum) and axial-vectors (e.g. spin) are unchanged.
- Parity (P): spatial reflection
  - Polar vectors change sign. Charge and axial-vectors are unchanged.
- Time (T): direction of the clock
  - Axial-vectors change sign. Charge and polar vectors are unchanged.

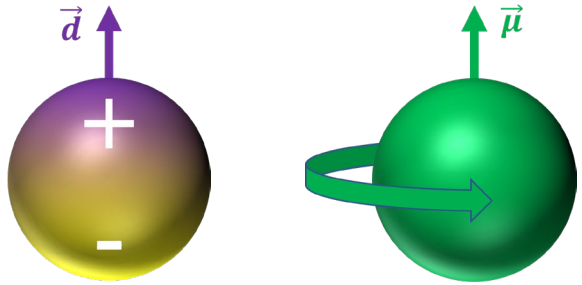


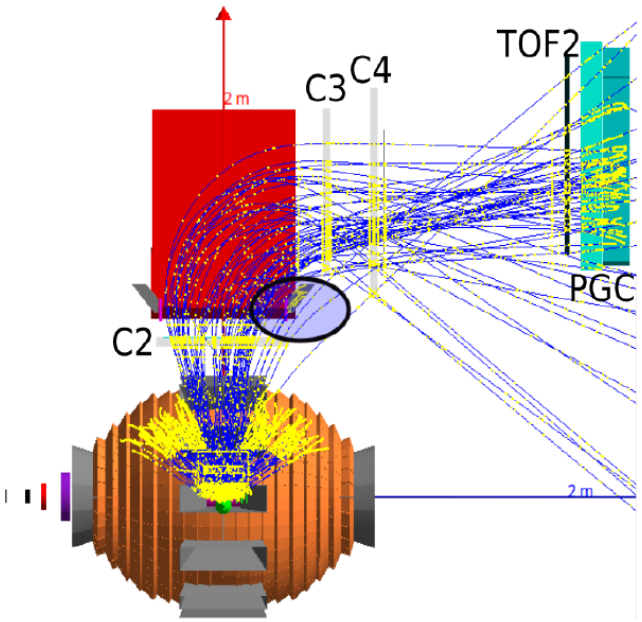
Homework

- Review the definition of polar vectors and axial vectors. Is an electric field a polar vector or axial vector? Which is the magnetic field? How do these transform under C-symmetry, P-symmetry, and T-symmetry?
- A magnetic dipole moment $\vec{\mu}$ can be thought of as the strength of a current loop. How does it transform under C-symmetry, P-symmetry, and T-symmetry? Consider a particle with both a spin and a magnetic dipole moment. Does the initial state look like the final state after a T transformation? That is, does the magnetic dipole moment violate T symmetry?
- An electric dipole moment $\vec{d}$ measures a separation of charge, and points from negative to positive. How does it transform under C-symmetry, P-symmetry, and T-symmetry? Consider a particle with both a spin and an electric dipole moment. Does the initial state look like the final state after a T transformation? That is, does the electric dipole moment violate T symmetry?





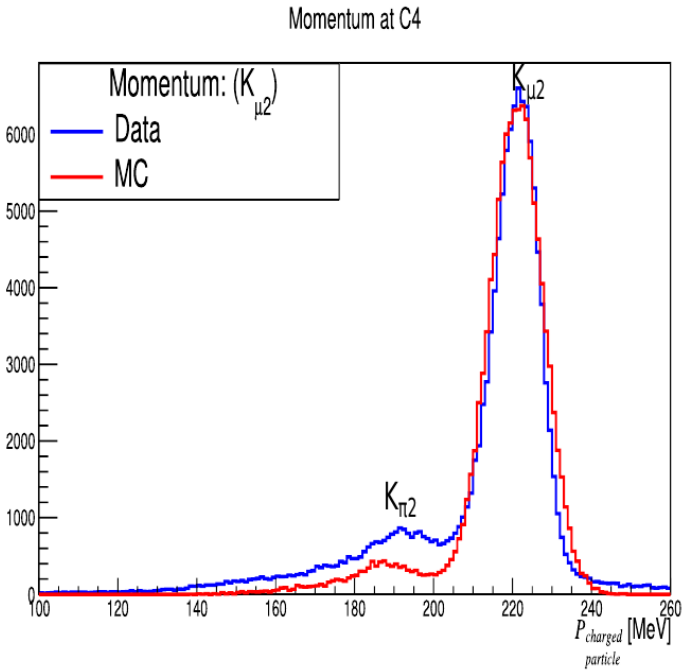




Terminology:

- $K_{\mu 2} : K^+ \rightarrow \mu^+ \nu$
- $K_{\pi 2} : K^+ \rightarrow \pi^+ \pi^0$

- Momentum distribution of at C4
- E_{loss} and material budget well described



Homework Problem:

- The **K – meson** decays at rest as shown in the left box. Please calculate the momentum of the daughter particles μ^+, π^+
- Explain why the momentum is seen to have "*shifted*"

Things to keep in mind:

- Mass of K^+: 493.677 MeV/c^2
- Mass of μ^+: 105.658 MeV/c^2
- Mass of π^+: 139.570 MeV/c^2
- Mass of π^0: 134.977 MeV/c^2
- **You can treat the neutrino as massless**