Experimental and simulated energy loss in magnetized plasmas

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Abstract and motivations

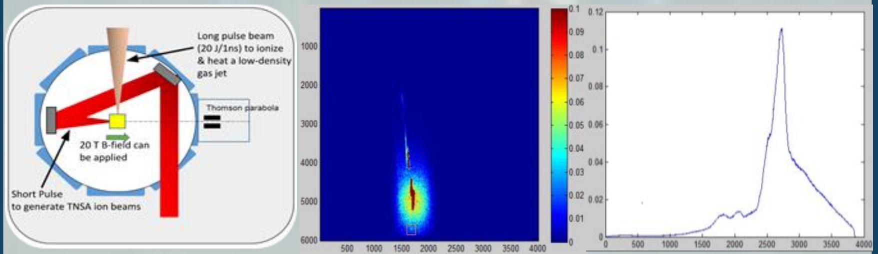
- Energy deposition of the ion beams used, as an example, in **Inertial Confinement Fusion** (ICF) is due to the **stopping power** (Sp) **of the plasma** [1]. The influence of **external magnetic fields** is important to consider [2-6], as they can modify the **trajectory and energy** of the projectiles.
- Theoretical models to calculate **Sp of plasmas** exist, specially considering **totally ionized** ones [1], but not many consider magnetic fields [5-8].
- Based on these models, this magnetic fields are **considered in our calculations and simulation codes**.

Introduction

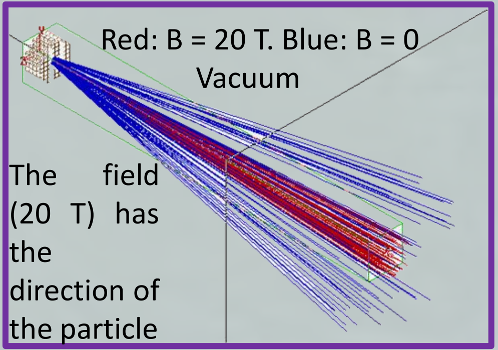
- **Experiments** related to ion interaction with **magnetized plasmas** have been performed in facilities like ELFIE, TITAN, or PEARL [9]. Different Sp data were gathered depending on the ion energy, the **inclusion or not of a magnetic field**, and shots made in vacuum, gas or **plasma**.
- An experiment where **protons accelerated by TNSA** (generated by a short-pulse laser) were ion beams shot against a **neon gas jet or plasma** (generated by a long-pulse laser) **considering, or not, a B_k =20 T** field.
- With our **calculations and simulation codes**, we can attempt to **reproduce** experimental-like results in similar conditions so **energy loss differences between magnetized and no-magnetized plasmas** could be observed.

Experimental data analysis

- The focus of this work is the treatment of **plasma data** from the **experiments**. The experimental set-up is shown in the picture at the right [9].
- Using data from **Thomson parabolas** (left), an **intensity spectra** can be obtained (center) and then, the **experimental number of particles per energy.**



- With a simulation software like SIMION® [10], **trajectories of charged particles** can be obtained **inside a magnetic field**.



- A first simulation shows that charged particles inside a **B field** could have **less dispersion**.
- If the detector is positioned at 0°, it should **detect more particles in a B field**.

- The initial beam dispersion, the energy straggling, the nuclear scattering and the magnetic field will **affect** the **final beam dispersion**.

First simulation results

➢Energy distribution:

- B_k component does not affect the particle energy.
- B_i or B_j suppose the same energy gain.
- B_{ij} supposses an energy gain greater than B_i or B_j.
- B_{ijk} results the same energy gain as B_{ij}.

➢Angle distribution:

- B_k component does not affect the beam dispersion.
- B_i or B_j suppose the same angle dispersion.
- B_{ij} supposses greater dispersion than B_i or B_j.
- B_{ijk} results the same dispersion as B_{ij}.

Conclusions

- **Greater plasma length** increases **dispersion** and **energy loss. Nuclear scattering** affects specially at **low velocities**.
- As B_k does not affect the stopping power, the **energy gain** or **loss depends on** the **other two components** B_i or B_j.
- For experimental-like conditions, the **plasma barely stops** the projectiles as it has very low densities. The inclusion of a $\vec{B}$ **field** does **not** show a great **Sp change**

Future work

- Introduction of **higher densities** and other **initial energy distributions**.
- Inclusion of the Sp of **bound electrons** for **partially ionized plasmas**.
- **Enhancement of** our **simulation code** and **analytical Sp calculation methods.**

THANKS FOR YOUR ATTENTION

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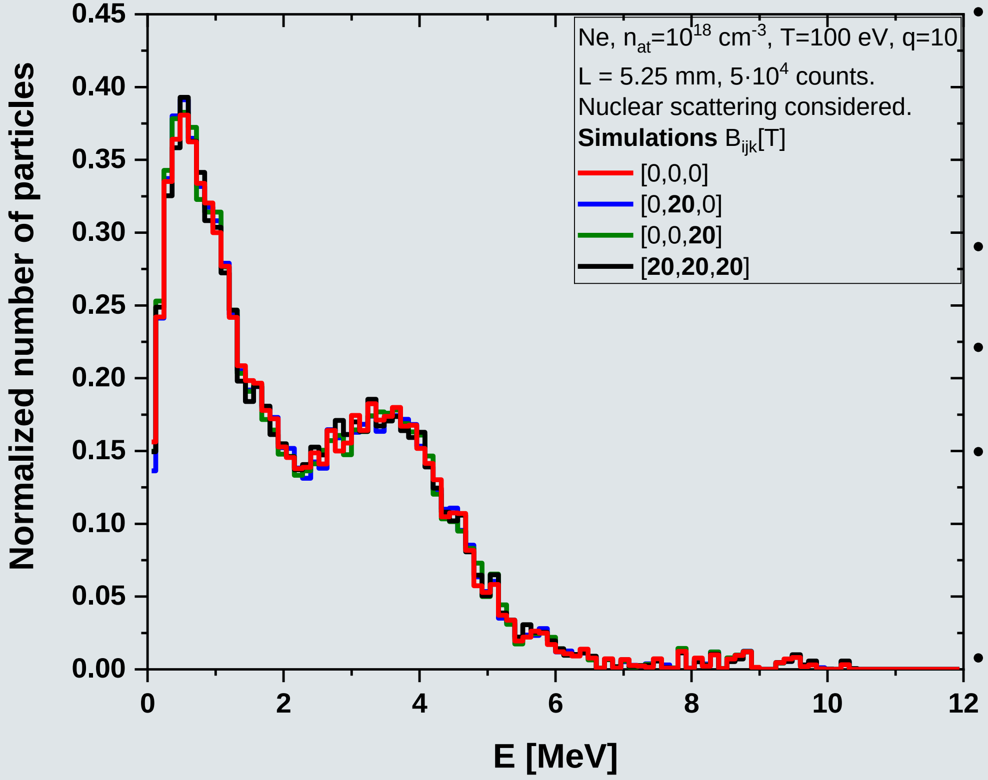
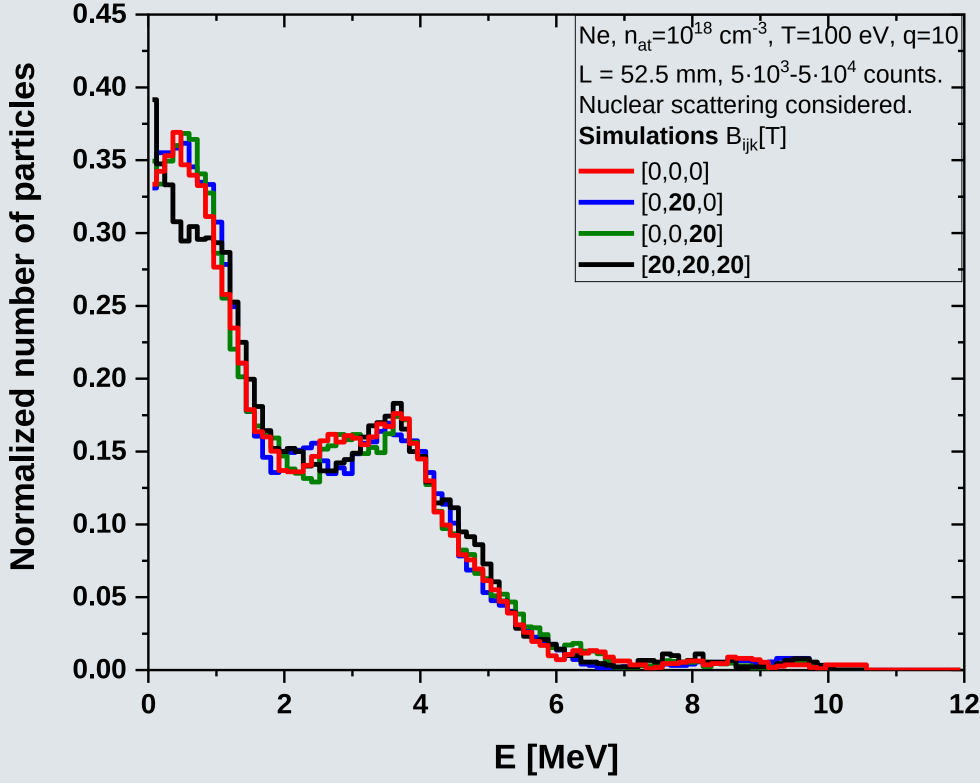
Energy distribution

Length = 5.25 mm



- **Plasma's length** is important to consider. For 5.25 mm, there is no much energy loss, but for 52.5 mm more **differences** are observed.
- B_k component does **not affect** the energy.
- B_i **or** B_j produces **equal energy** gain.
- B_{ij} produces **greater energy** gain than B_i and B_j. As B_k component does not affect, B_{ij} produces the **same results as** B_{ijk}.
- For a magnetic field in the **opposite direction**, the curves are **equal**.

Length = 52.5 mm



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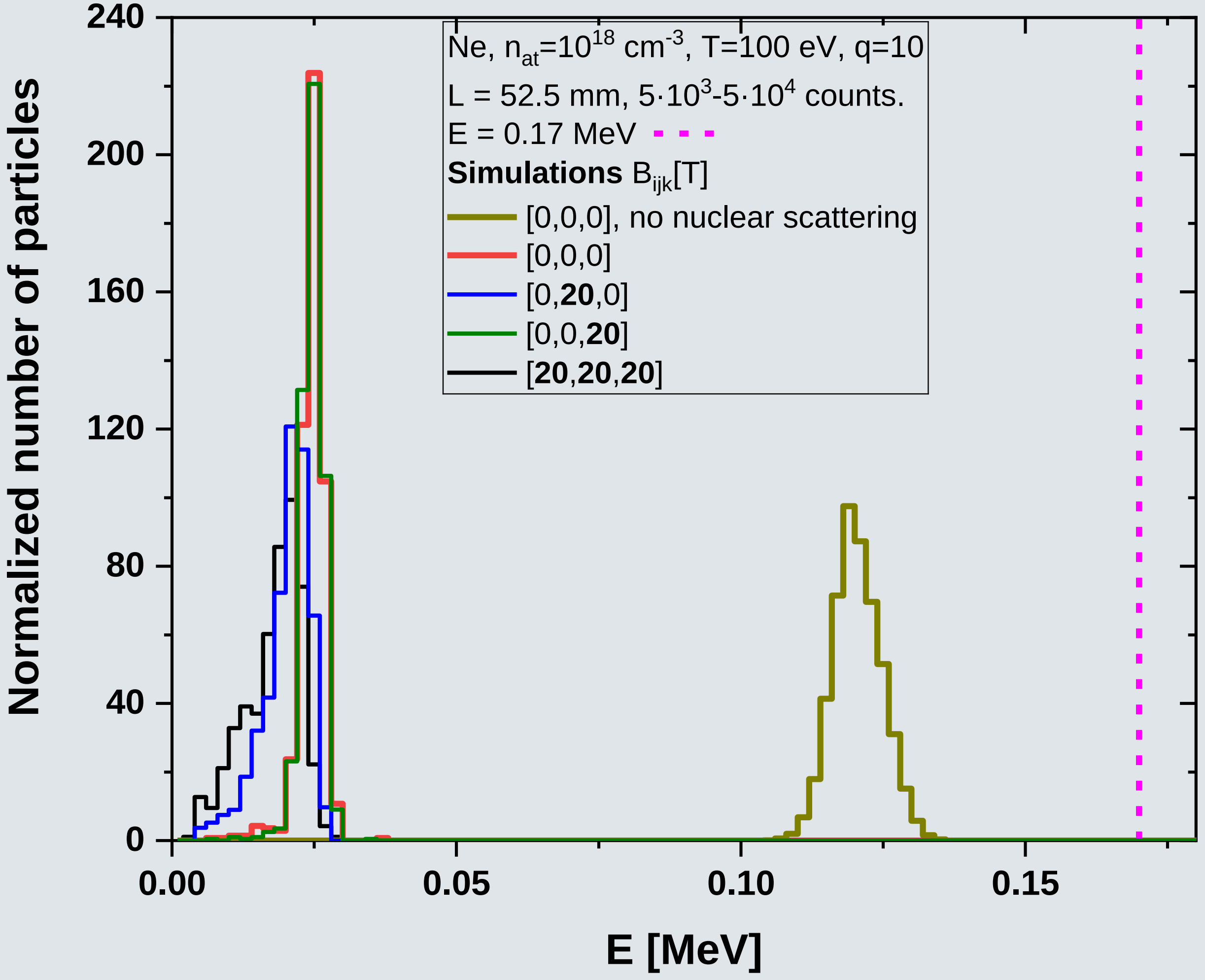
Monoenergetic beam



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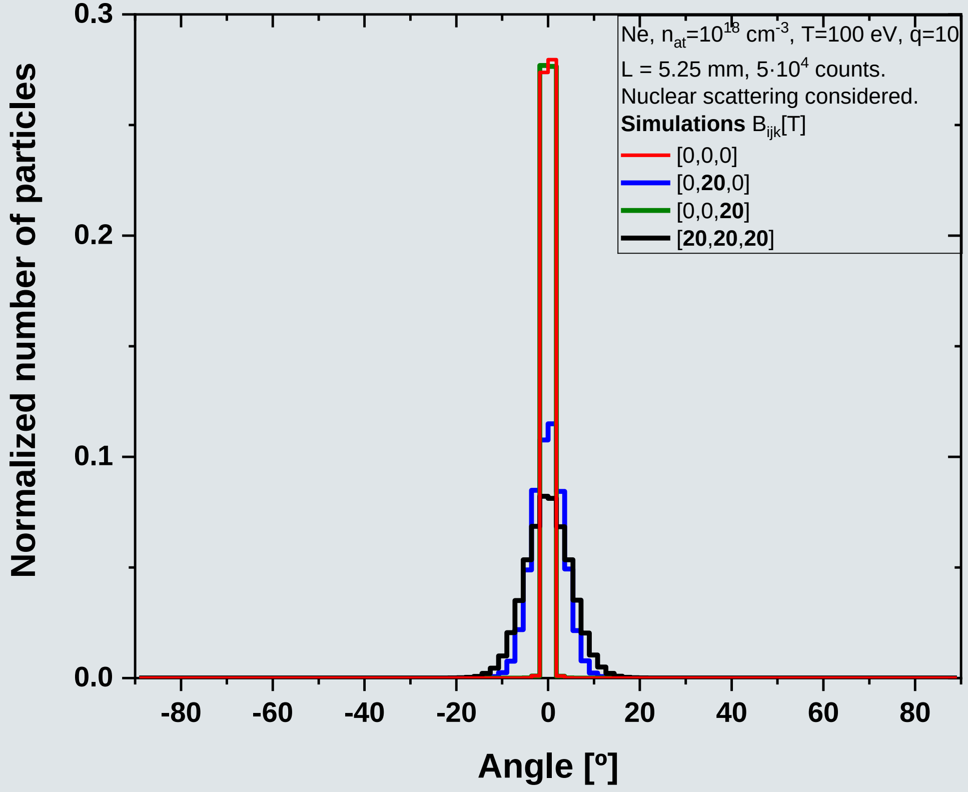
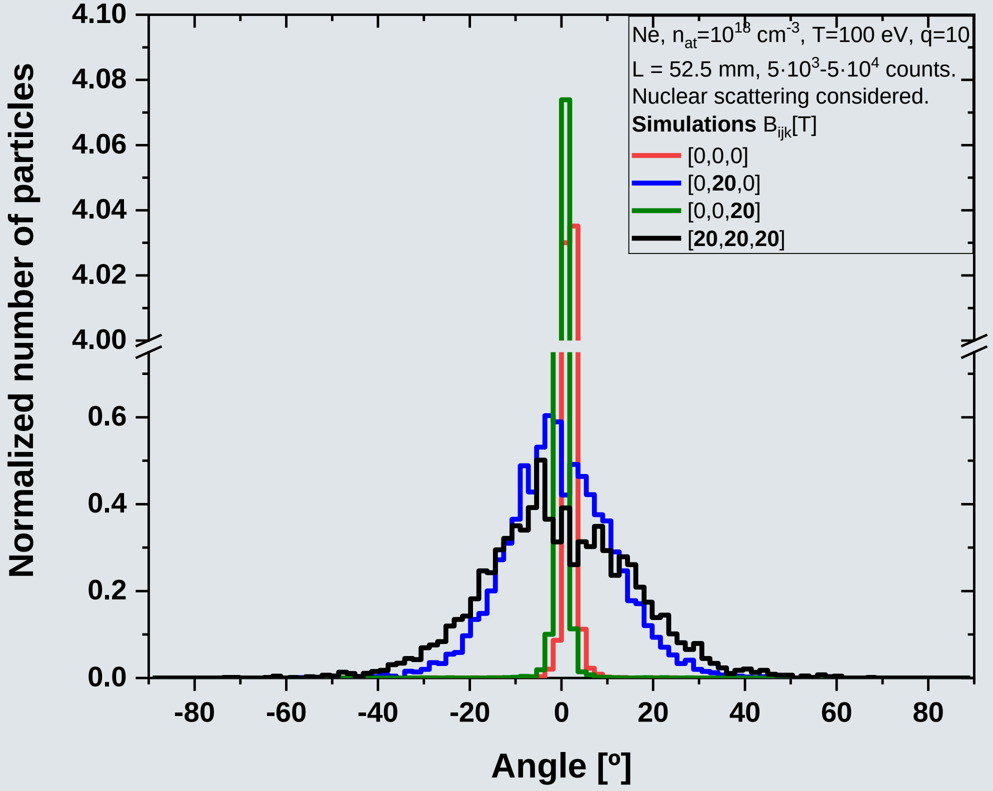
Angle distribution

Length = 5.25 mm



- Cylindrical **symmetry**.
- Greater **plasma length** increases the projectile's **dispersion**.
- B_k magnetic field component does **not affect** the beam, so the **dispersion** is the same as with no field.
- B_i, or B_j, component produces a **significant dispersion**.
- B_{ij} produces **greater** dispersion than B_i **and** B_j.
- As the B_k component does **not affect**, B_{ij} produces the **same** results as B_{ijk}.

Length = 52.5 mm



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