The goal of our project was to familiarize with the key parameters of a collider. As well as overall project management, teamwork and finally identity and address the limitations of the project due to current (and future) technologies.

**Future Technologies**

For this project it would be crucial to have certain technologies in the future which are currently being researched. The most important one would be nuclear fusion (NF) as a power source. Currently centers such as CERN synchrotron power from the electricity grid, which would be impossible in space. We would therefore require power plants attached to the collider, and the most powerful and efficient method would be through the use of NF. Thus, we have designed HECTOR with two fusion centers to power the beam. Known technology, such as the solar panels currently in use on the ISS, will be used to power the manned bases. NF will also be used to power the large fleet of reusable rockets, such as the ones being designed by Space X and Virgin Galactic, which will be required to transport the thousands of tons of material into orbit.

Due to the high quantity of data which will be collected by the detectors analyzing the collisions on HECTOR, we are also taking into consideration that quantum computers will be developed. Access to such computing power both on the manned stations and back on Earth will allow physicists to analyze and store a much greater amount of information than is currently possible.

**Parameters**

- **Circumference (km)**: 26.7, 100, 44000
- **Straight sections**: 8, 12, 2200
- **Average straight section length (km)**: 0.528, 1.4, 20
- **Number of IP’s**: 4, 2 + 2, 4
- **Number of man bases**: 2 large ones (+1 for each detector)
- **Number of fusion power plants**: 2

**Beam**

- **Number of bunches (25 ns)**: 2,808, 10,600, 6,285,000
- **Bunch population**: 1.15, 1.00, 1.00
- **Nominal transverse Normalized emittance (mm)**: 3.75, 2.20, 2.50
- **CM energy [TeV]**: 14, 100, 1560
- **Peak Luminosity** $10^{33}$-cm$^{-2}$s$^{-1}$: 1.00, 5.00, 947.35
- **Synchrotron radiation power per proton** 10$^{-11}$ W: 1.93, 45, 45
- **Dipole field [T]**: 8.33, 16, 0.332
- **Beta function at IP**: 0.55, 1.10, 0.15

**Human bases & maintenance**

Maintenance is a crucial part of every structure, especially mega structures laid out in space. HECTOR will be built using the most advanced technologies we can imagine, yet constant bombardment of cosmic rays, solar winds, space scrapes and more will require frequent maintenance. Most of the work will be conducted by robots, yet we believe that in a 100 years from now human presence will still be necessary. Therefore, HECTOR will have two main human bases, each located in between of the different detectors. The bases will contain life support system, tools, supplies, and will be connected to the power plants and the detectors via network of trains, attached externally to HECTOR’s main structure. The human bases can also be used as a stage for space research - similarly to the ISS, but on a much larger scale.

**Synchrotron radiation power per proton**

$$ P = \frac{2}{3} \frac{e^2 c^4 \gamma^4}{4 \pi \varepsilon_0 p^2} $$

**The area of the proton bunch**

$$ \sigma = \sqrt{\varepsilon \beta} $$

**EQUATIONS**

**Luminosity**

$$ \mathcal{L} = \frac{N_p n_b f_{rev}}{4 \pi \sigma_x \sigma_y} $$

**Accelerator momentum formula**

$$ B \rho = 3.3 \rho_{[GeV]} $$

**SOURCES**

Particle physics:

- P. Jones: “Physics at Future Colliders”. CERN Summer School 2016: Lecture 1, Lecture 2, Lecture 3, Lecture 4
- Accelerator physics:
  - T. Zimmermann: “Collider beam physics”
  - C. Schmit: “Future Collider Technologies”

CERN design reports:

- FCC Study report. Volume 1, Volume 2, Volume 3

**High Energy Litter Liquidator (HELL)**

Instead of using a beam dump such as the one used at the LHC, at the end of an experiment, our collider would simply eject the beams into space.

**Fusion Reactors**

The reaction which occurs between the protons and neutrons of atomic nuclei at close proximity to one another. The threshold proximity is defined at the point where protons and neutrons from both nuclei in question react with each other. When fusion between 2 hydrogen atoms occurs (D + T), the amount of energy released is 17.6 MeV.

Using this value we can calculate how much hydrogen is required to power different collider facilities (using the hydrogen that can be extracted from water molecules):

- LHC stored beam energy 392 MJ
- FCC stored beam energy 4.6 MJ
- HECTOR stored beam energy 4,235 MJ
- 567 EJ

The word energy consumption (2015): 0.9 T/EJ = 600 Tons of water per 2.4 Olympic swimming pools.

**Enormous Analytical Space Yard (EASY)**

Another possible future detector