A simulation about electron diverter on board *HiZ-GUNDAM*

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Abstract

Gamma-ray bursts (GRBs) are transient phenomena that release the radiation energy on the order of 10^{51}-10^{54} ergs and known as the brightest explosion in the universe. *HiZ-GUNDAM* observes GRBs within multi-wave length. However, there is a risk of false detections by cosmic electrons. So, we will reduce the electron's incidents with magnetic field. To develop enough electron divertor, we should find problematic electron and suitable magnetic field. This poster reports on the progress of simulations with Geant4 to consider the effective electron diverter.

1. Introduction

I. Gamma ray bursts (GRBs)

- GRBs are transient phenomena that release the radiation energy on the order of 10^{51}-10^{54}.
- They are known as the brightest explosion in the universe.

Using the bright emission GRBs at high redshift (z >7), We can prove physical condition.

Credit: NASA Goddard Space Flight Center

II. *HiZ-GUNDAM* project

- Main mission
  (1) observe multi messenger sources in the early universe within multi-wave length.
  (2) Exploration of the early universe.

- Science goal
  (1) Combine data of GW & Ultra High-Energy Neutrino.
  (2) Confirmation of existence of relativistic jet.
  (3) Understand formation process of BH using energy transition.

- *HiZ-GUNDAM* will enter the sun-synchronous dawn-dusk orbit. Then, many electrons are present.
  →We have to reduce the electron.

III. *HiZ-GUNDAM*'s sensor

- Energy band : 0.4-4 keV
- Pixel size : 75 –100 μm²

If electron deposits energy of 0.4-4 keV some pixels, sensor can't distinguish between electrons and photons.

Call such electron "confusing" electron in this poster.

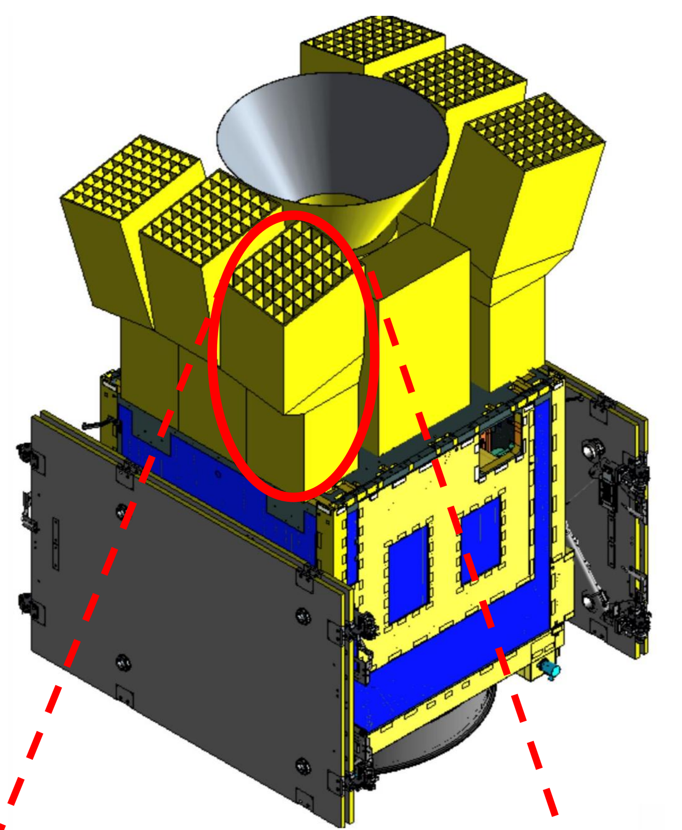


Fig 1 : schematic drawings of HiZ-GUNDAM

IV. Electron diverter

To prevent false detections by "confusing" electrons, we will install an electron diverter with magnetic field.

Should research
(1)find how electron is "confusing" electron.
(2)find magnetic field can deflect electrons of (1).
→Simulate with Geant4

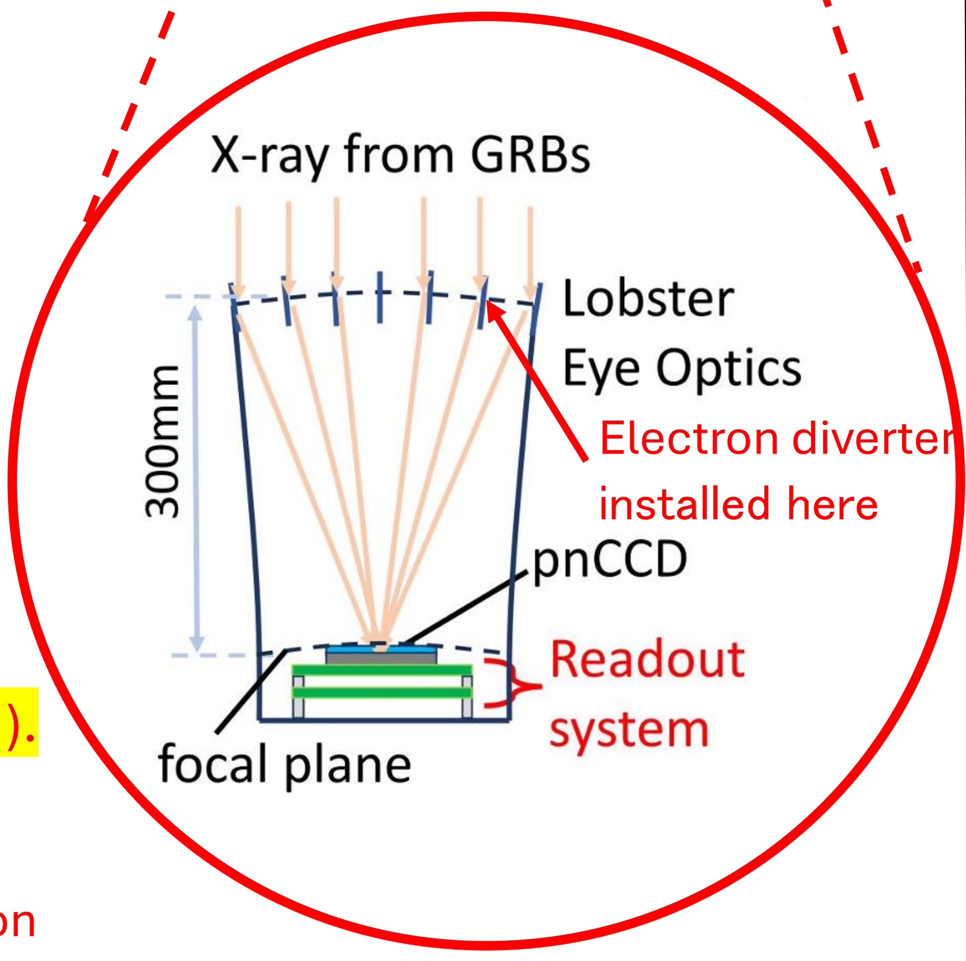
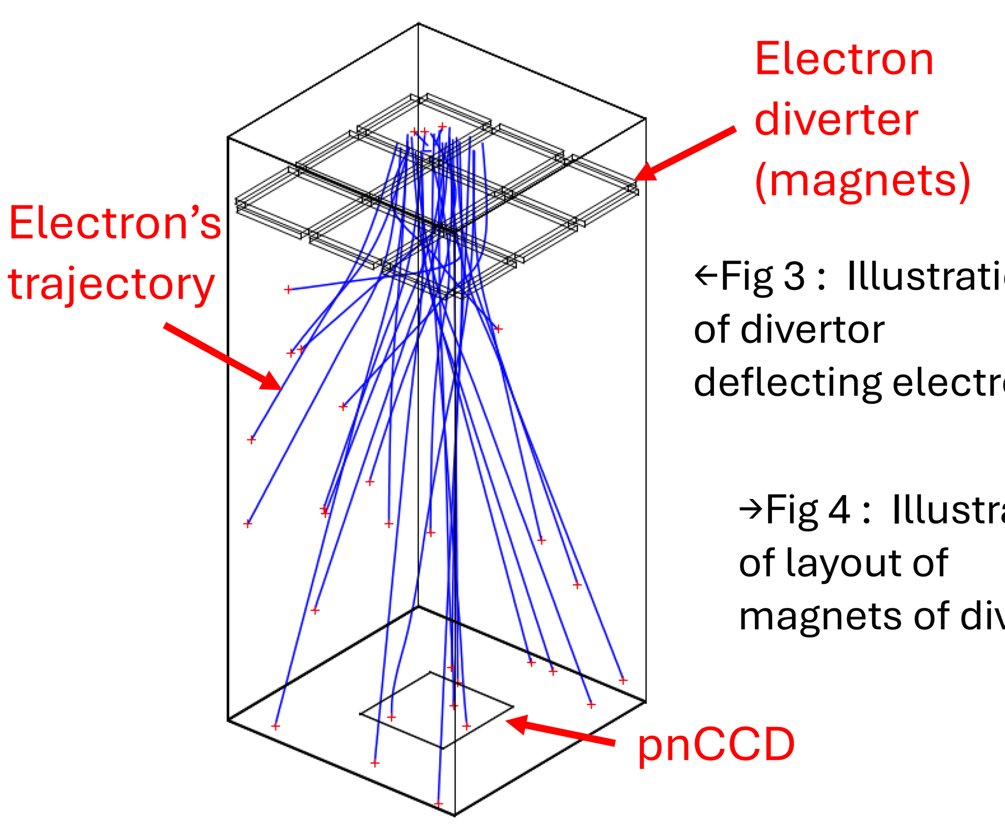
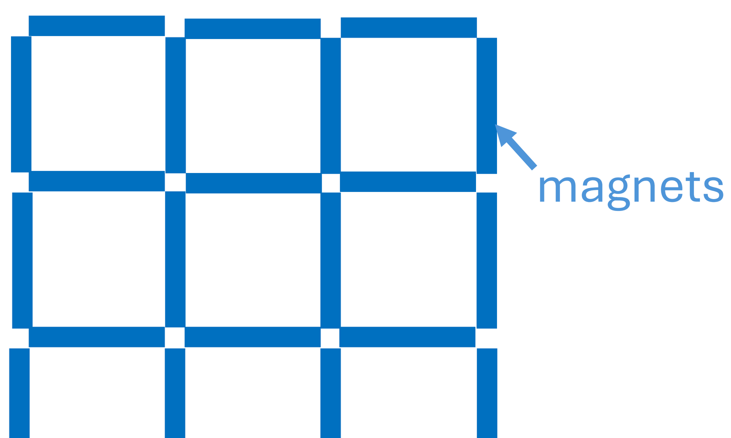


Fig 2 : rough drawings of focal detector



←Fig 3 : Illustration of divertor deflecting electron



→Fig 4 : Illustration of layout of magnets of divertor

2. Define "confusing" electron

- Situation: electron has certain energy(E_e) incidents in center of sensor vertically, 10000 times.
- Definition of "confusing" electron is deposits energy less than 10 keV within a single pixel of 100 μm × 100 μm.

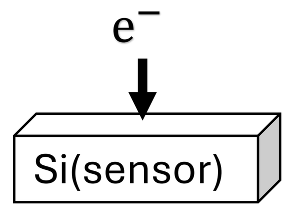


Fig 5 : Illustration of situation

About fig 6
- Almost all electron has E_e <10 keV is "confusing" electron.
- About 10-20% of electron 10 keV< E_e<30 keV will be "confusing" electron
- So, we should be careful about electron E_e≦30 keV.

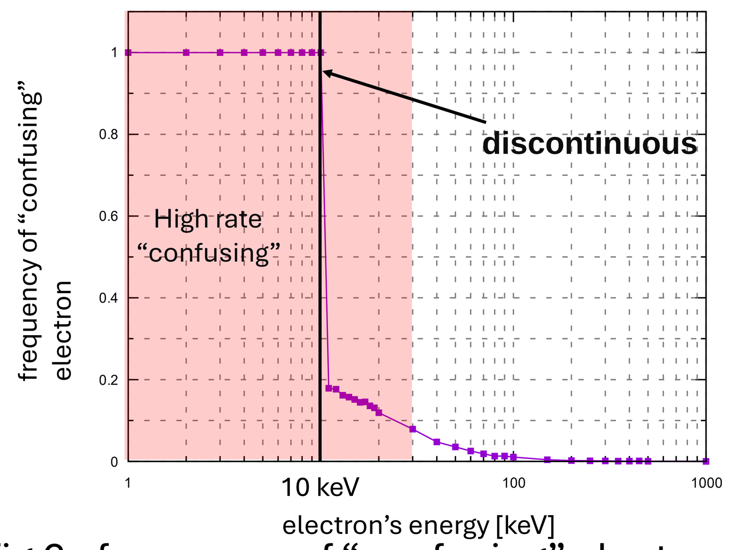
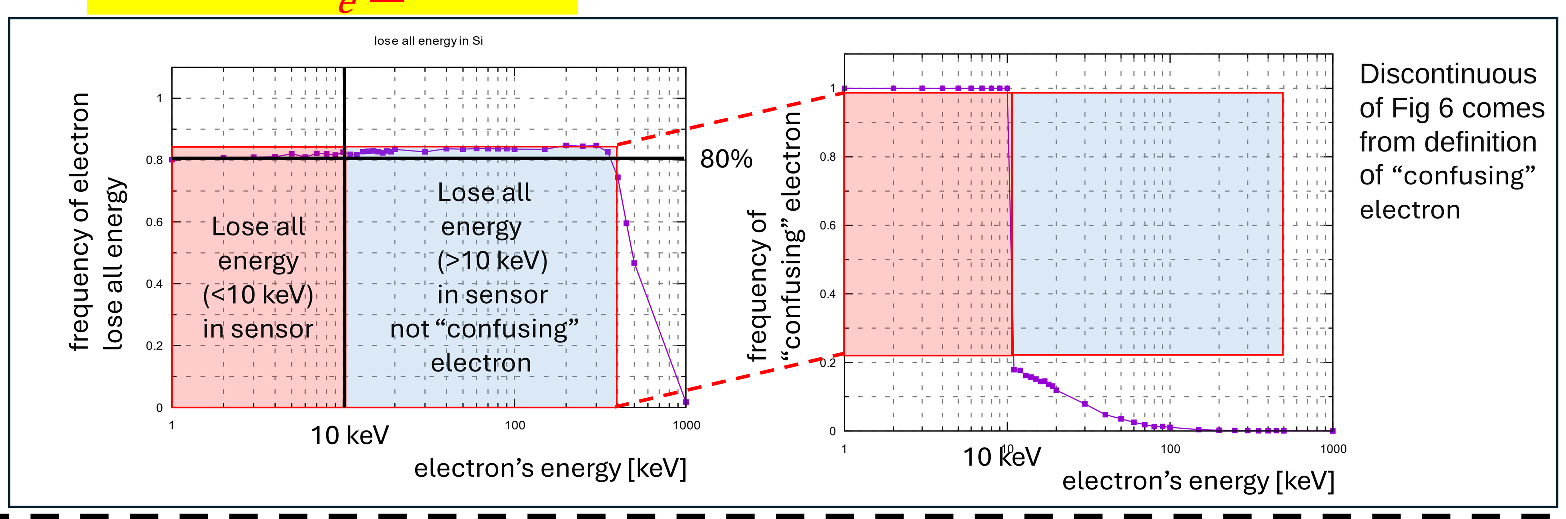


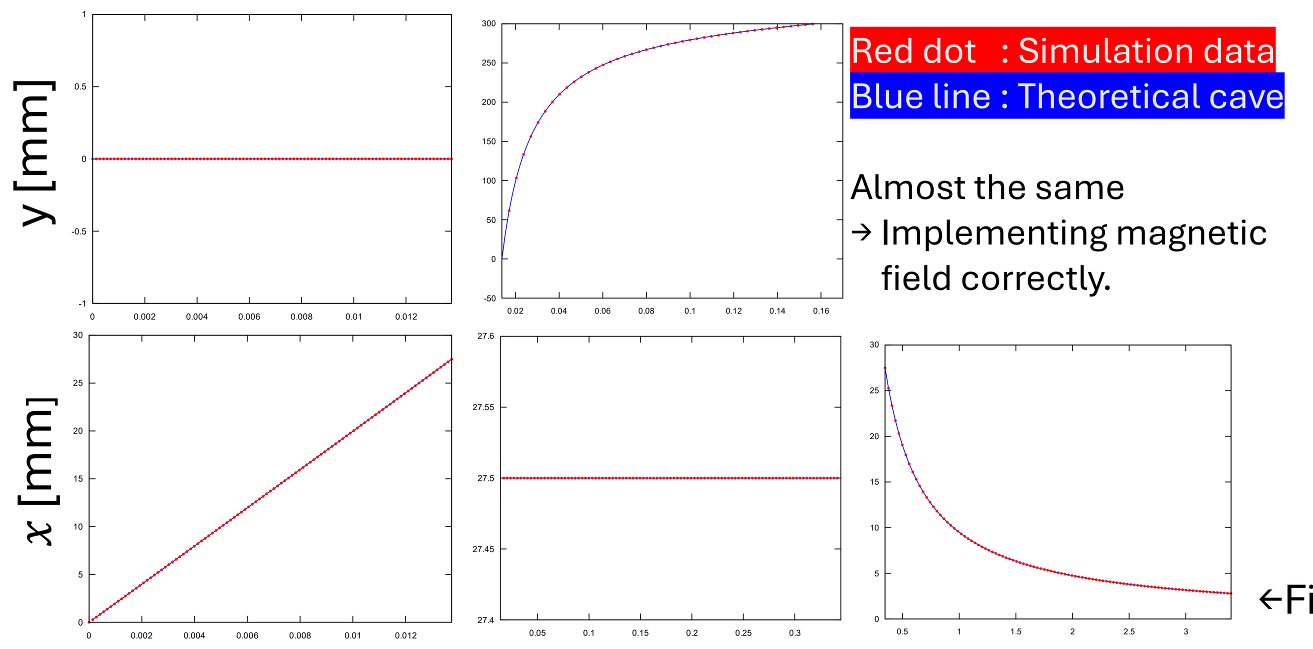
Fig 6 : frequency of "confusing" electron
This graph is discontinuous in E_e =10 keV



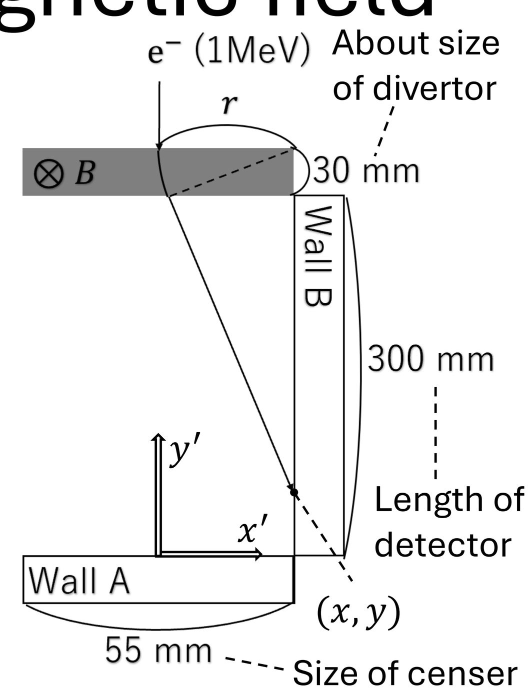
←Fig 7 : Exploration discontinuous of Fig 6

3. Check implementation of magnetic field

- Situation: Incident electron (E_e = 1 MeV) in uniform magnetic field to check implementation of magnetic field with relativistic electron (like Fig 8).



←Fig 9 : Result of simulation



↑Fig 8 : Illustration of situation

4. Calculate formula of magnetic field

- Think magnet as box filled by magnetic dipole. Concretely, calculate this integration.

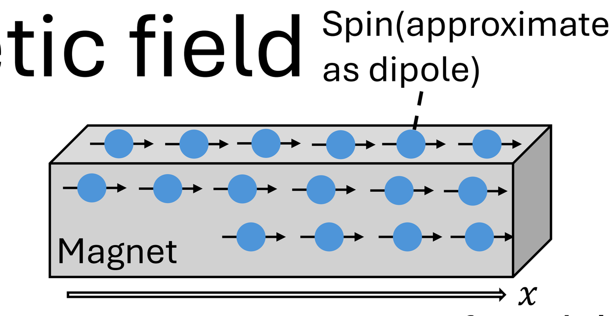
$$\int_{Volume\ of\ magnets}\left[\frac{\mu_0}{4\pi}\left\{\frac{3r(\boldsymbol{m}\cdot\boldsymbol{r})}{r^5}-\frac{\boldsymbol{m}}{r^3}\right\}\right]dV$$

where $\boldsymbol{m}=(m_x,0,0), \boldsymbol{r}=(x,y,z), r=|\boldsymbol{r}|$

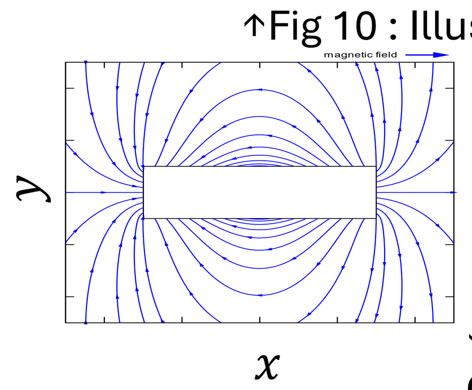
Thus, we get formula of magnetic field

$$B_x=\frac{\mu_0 m_x}{4\pi}\mathrm{atan}\left[\frac{yz}{xr}\right], B_y=\frac{\mu_0 m_x}{4\pi}\log\left|\frac{1-\frac{z}{r}}{1+\frac{z}{r}}\right|$$

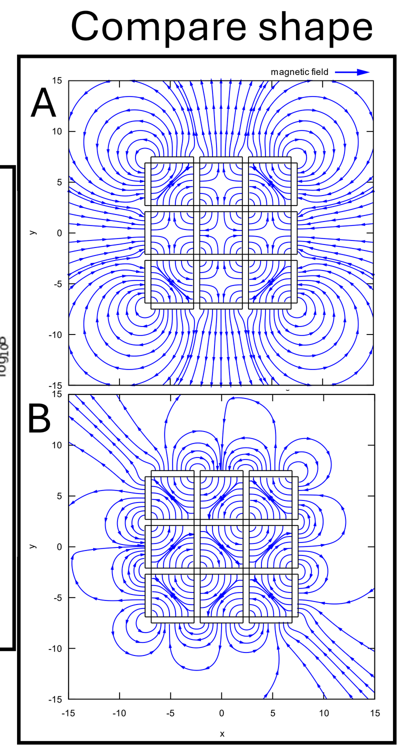
B_z is got by replacing z with y in B_y (as indefinite integral.)



↑Fig 10 : Illustration of model of magnet

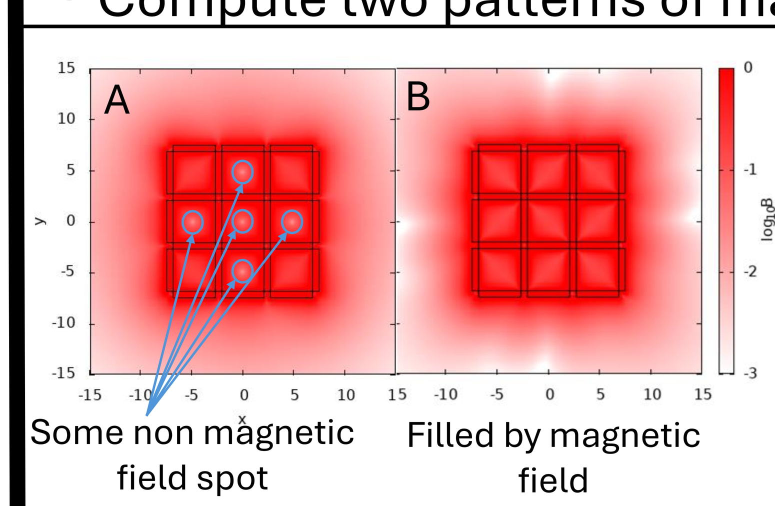


←Fig 11 : Plot of magnetic field

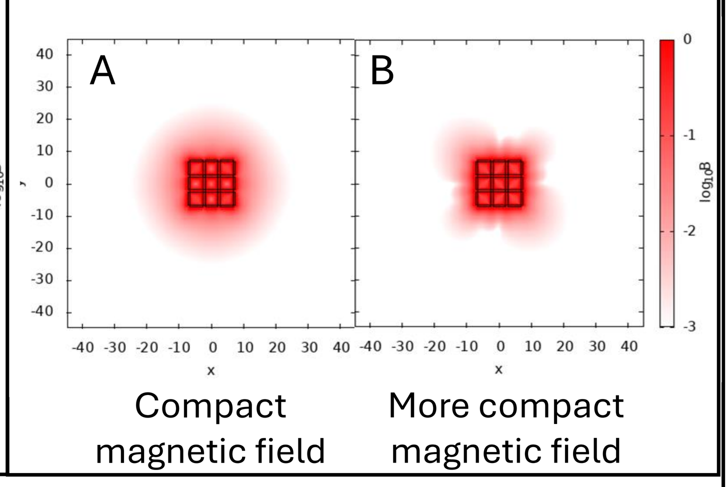


↓Fig 14 : Compare shape

- Compute two patterns of magnetic field A and B



↑Fig 12 : Compare map locally



↑Fig 13 : Compare map globally

- B looks better than A for electron divertor but shape of B is similar to magnet's magnetic field → More significant effects the attitude.

5. Future task

Simulate with real geometry and consider electron divertor can remove "confusing" electron.
- Estimate effect for other device by electron divertor.