FACULTY OF SCIENCES

# Radio detection of high energy neutrinos in the Greenland icecap


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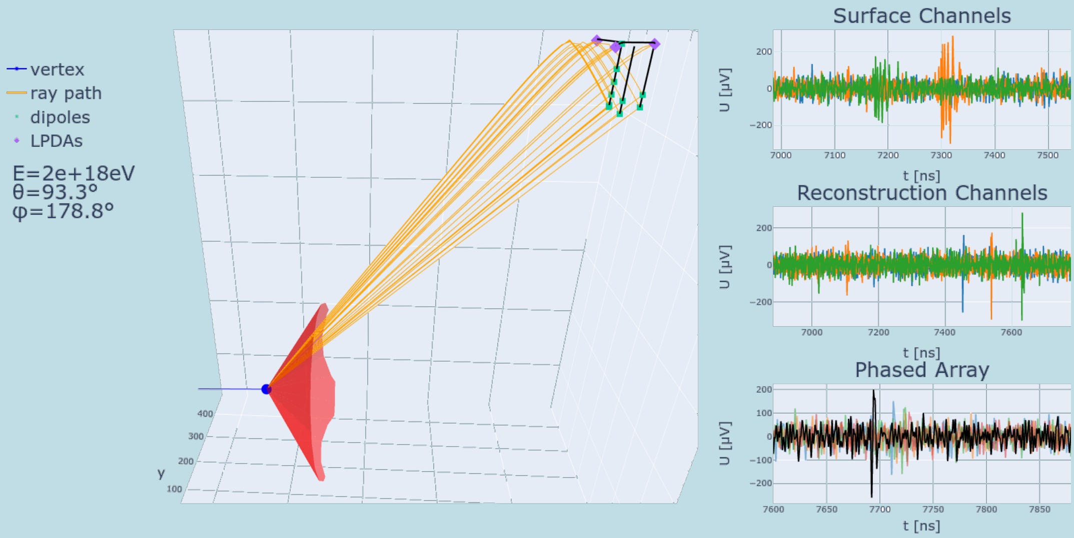



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## 1.1 Discovery

## 1.2 Standard model

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### 1.3.1 Cosmic neutrinos

To estimate the temperature of the neutrinos who decoupled at the start of the universe, we can take a look at conservation of entropy [1] (...) The entropy before and after decoupling are:

$$s(a_1) = \frac{2\pi^2}{45}(2 + \frac{7}{8}(2 + 2 + 3 + 3))T_1^3 \tag{1.1}$$

$$= \frac{2\pi^2}{45}\frac{86}{8}T_1^3 \tag{1.2}$$

$$s(a_2) = \frac{2\pi^2}{45}(2T_\gamma^3 + \frac{7}{8}(6)T_\nu^3) \tag{1.3}$$

$$\tag{1.4}$$

Conservation of entropy:

$$s(a_1)a_1^3 = s(a_2)a_2^3 \tag{1.5}$$

$$\frac{86}{8}(T_1 a_1)^3 = \left(2\left(\frac{T_\gamma}{T_\nu}\right)^3 + \frac{42}{8}\right)(T_\nu a_2)^3 \tag{1.6}$$

$$\frac{86}{8} = 2\left(\frac{T_\gamma}{T_\nu}\right)^3 + \frac{42}{8} \tag{1.7}$$

$$\frac{44}{16} = \left(\frac{T_\gamma}{T_\nu}\right)^3 \tag{1.8}$$

$$\left(\frac{T_\gamma}{T_\nu}\right) = \left(\frac{11}{4}\right)^{1/3} \tag{1.9}$$

i.e

$$T_\nu = \left(\frac{4}{11}\right)^{1/3} T_\gamma \tag{1.10}$$

$\Phi$

### 1.3.2 Oscillations

### 1.3.3 Majorana

CHAPTER

# 2

# RADIO DETECTION

# BIBLIOGRAPHY

[1] Scott Dodelson. Modern Cosmology. Academic Press, Amsterdam, 2003.