RADAR ECHO TELESCOPE

A macroscopic model of radar detection for the Radar Echo Telescope

Enrique Huesca Santiago

Vrije Universiteit Brussel

on behalf of the RET Collaboration

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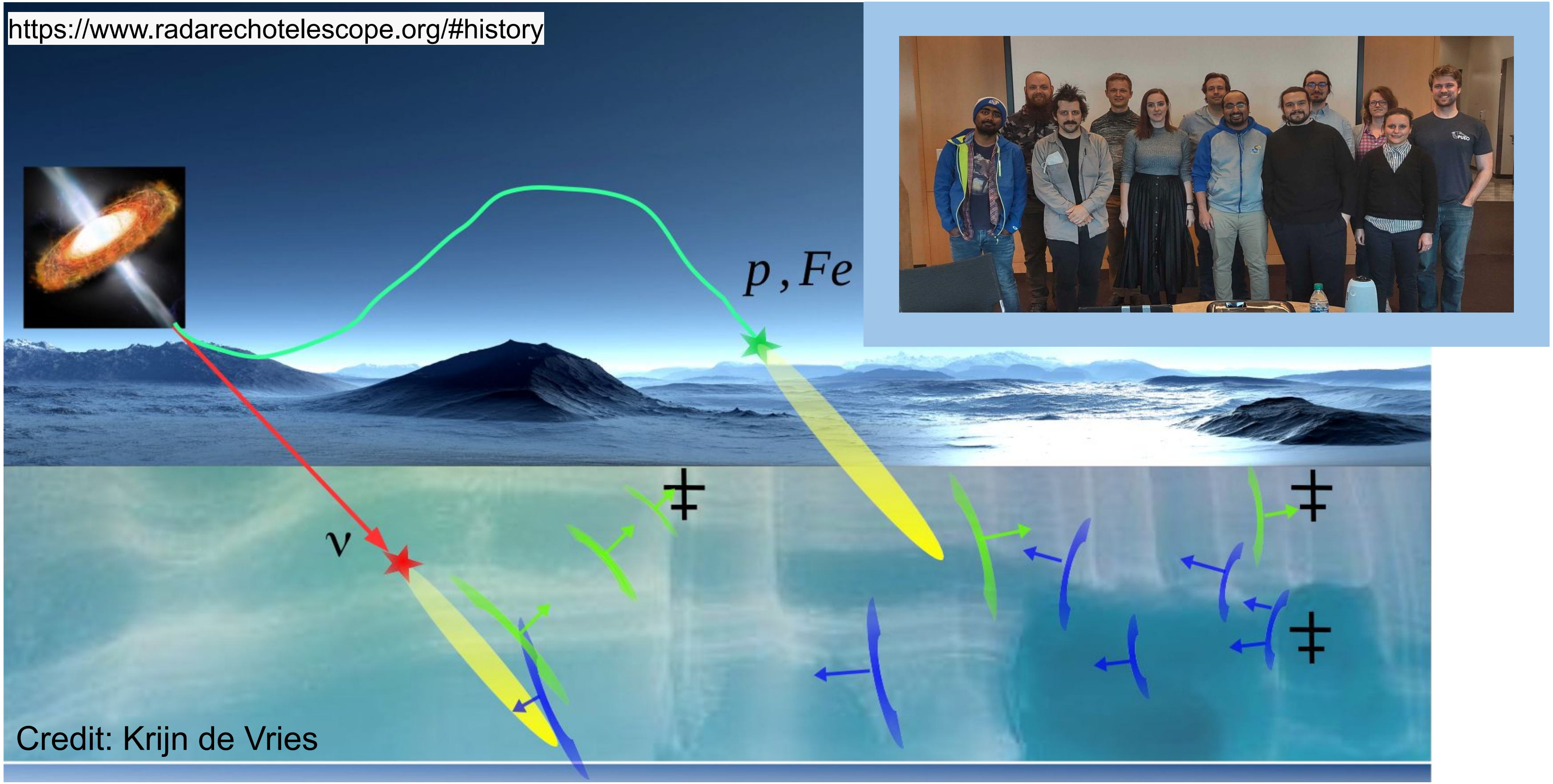
A quick introduction

The Radar Echo Telescope



Macroscopic radar scattering

WHY:

The particle cascade is a *relativistic, non-uniform, non-perfect conductor.*

We want to gain a deeper understanding of the radar scatter from the global cascade properties.

We want a complementary, fast approach to existing Monte Carlo methods.
(arXiv:1710.02883)

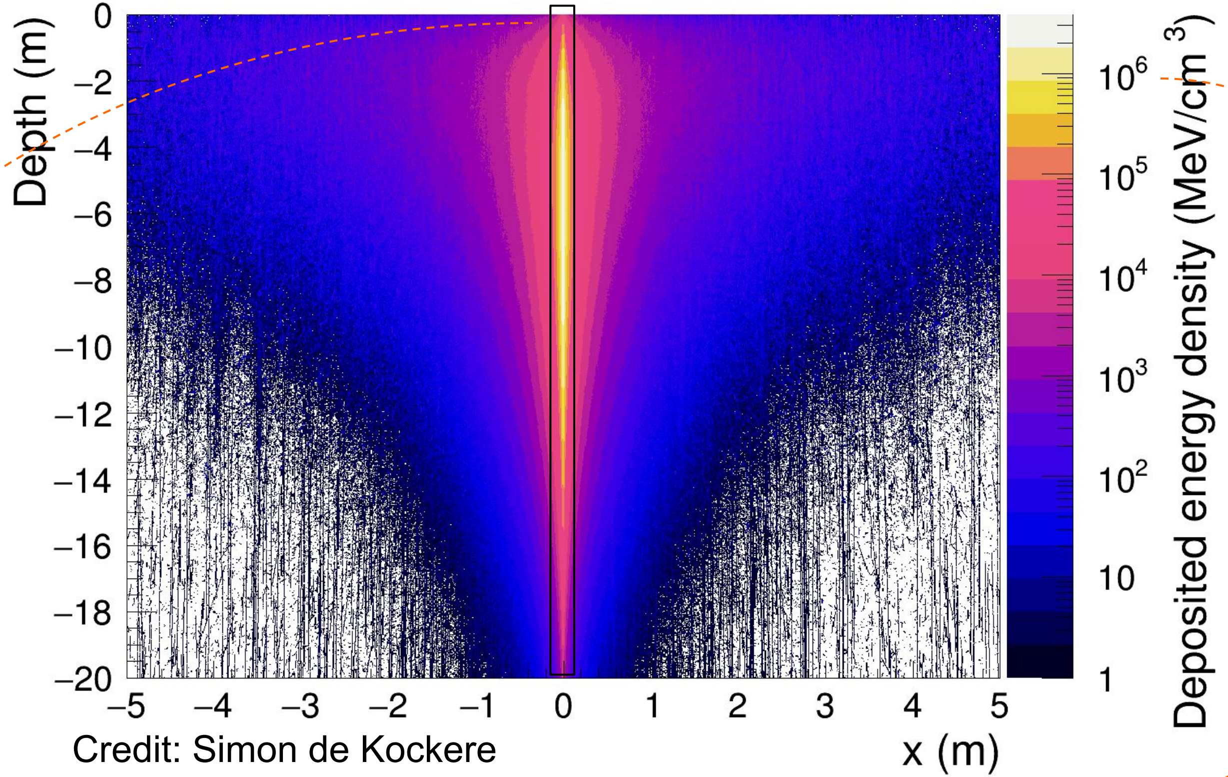
HOW:

We can use parameterisations of the in-ice showers.

- ➔ Nishimura, Kamata & Greisen: In-ice neutrino cascades
  Progr. Theoret. Phys. 6, 93 (1958) & Prog. Cosmic Ray Phys., vol. III (1965)
- ➔ Simon De Kockere, *et al.* 2022: In-ice air shower cores
  (arXiv:2202.09211)

The In-Ice particle cascade

$E_p = 10^8$ GeV

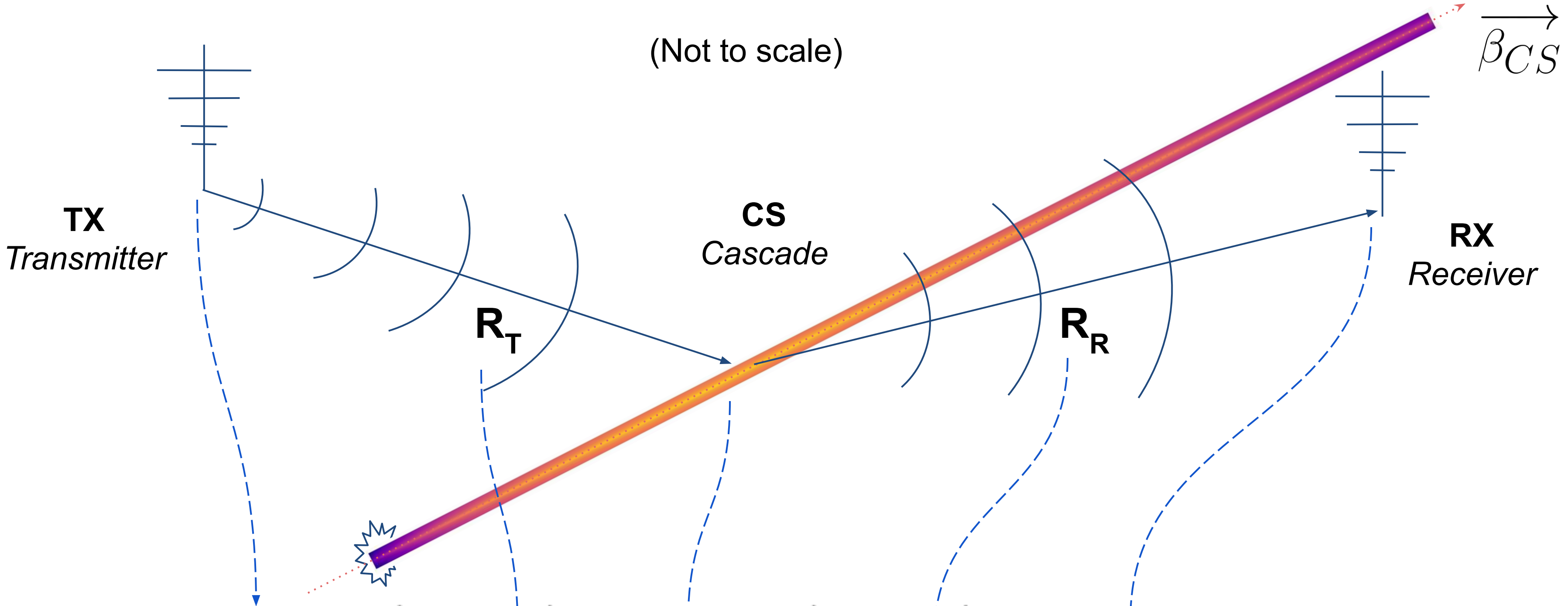


Credit: Simon de Kockere

$$\frac{10^6 \frac{MeV}{cm^3}}{20 \frac{eV}{e^-}} = $$

$$= 10^{11} \frac{e^-}{cm^3}$$

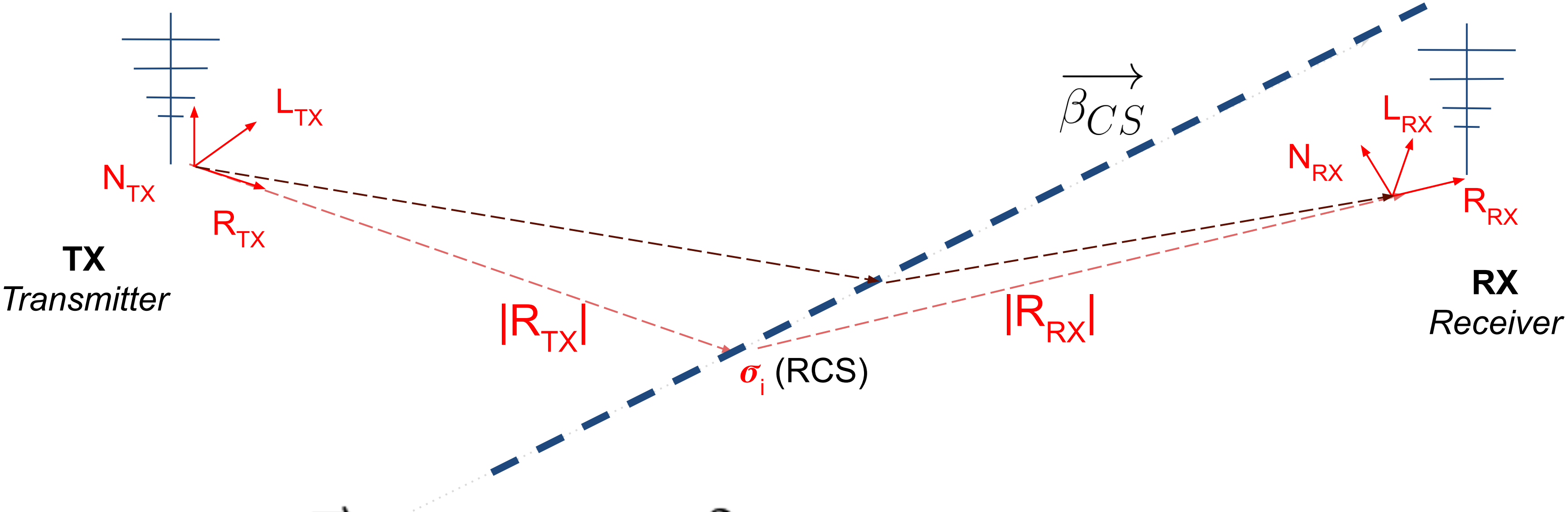
The Radar Scatter Range Equation



$$P_R = P_T \left(\frac{G_T}{4\pi R_T^2} \right) \sigma_{RCS} \left(\frac{1}{4\pi R_R^2} \right) A_{eff,R} [f_{att}][f_{pol}]$$

A little bit of math

Macroscopic Radar Scatter



$$P_{RX} \propto |\vec{E}_{RX}(R,t)|^2 =$$

$$|\sum_{i=1}^{N} E_{sc,i}(R_i,t) * e^{i(kR_i - \omega t|_{RX} + \psi_i)}|^2$$

Strength of the scatter

$$E_{sc,i} = \frac{\sqrt{2ZP_T G_T}}{4\pi R_{T,i} R_{R,i}} \sqrt{\sigma_{RCS,i}}$$

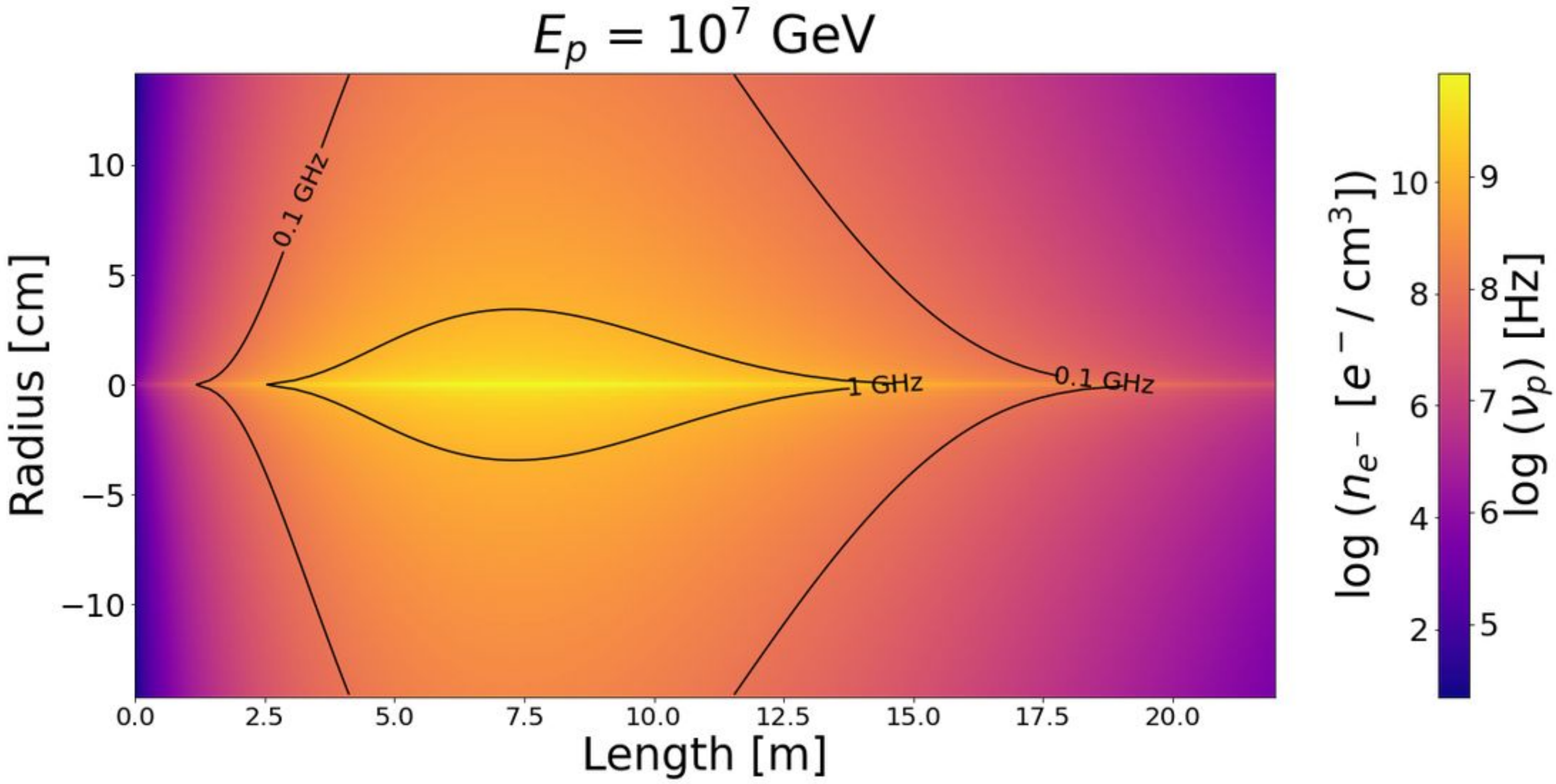
$$\sigma_{RCS,i} = \sigma_{RCS,e^-} \cdot N_e^2 \cdot \mathfrak{T} \cdot [\Theta(t - t_0) e^{-2t/\tau_e}]_{t=t_{ret}}$$

$$\sigma_{RCS,e^-} \simeq \sigma_{Thomson} \cdot \left(\frac{\omega}{\omega_c}\right)^2 \cdot G_{Hertz}$$

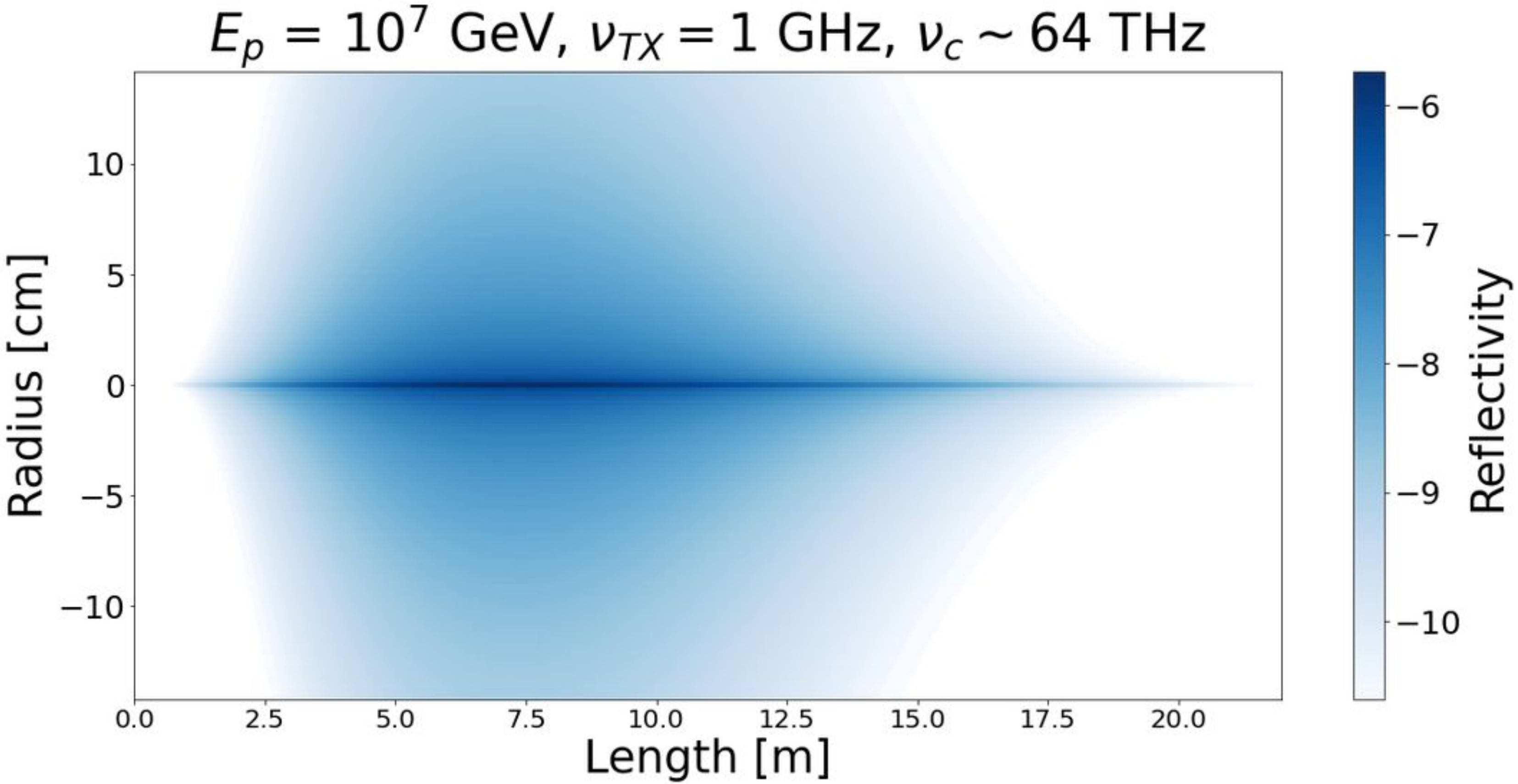
$$6.65 \cdot 10^{-25} cm^2 \qquad \sim 10^{-13} \to 10^{-10} \qquad \frac{3}{2}\sin^2(\theta)$$

How does this look?

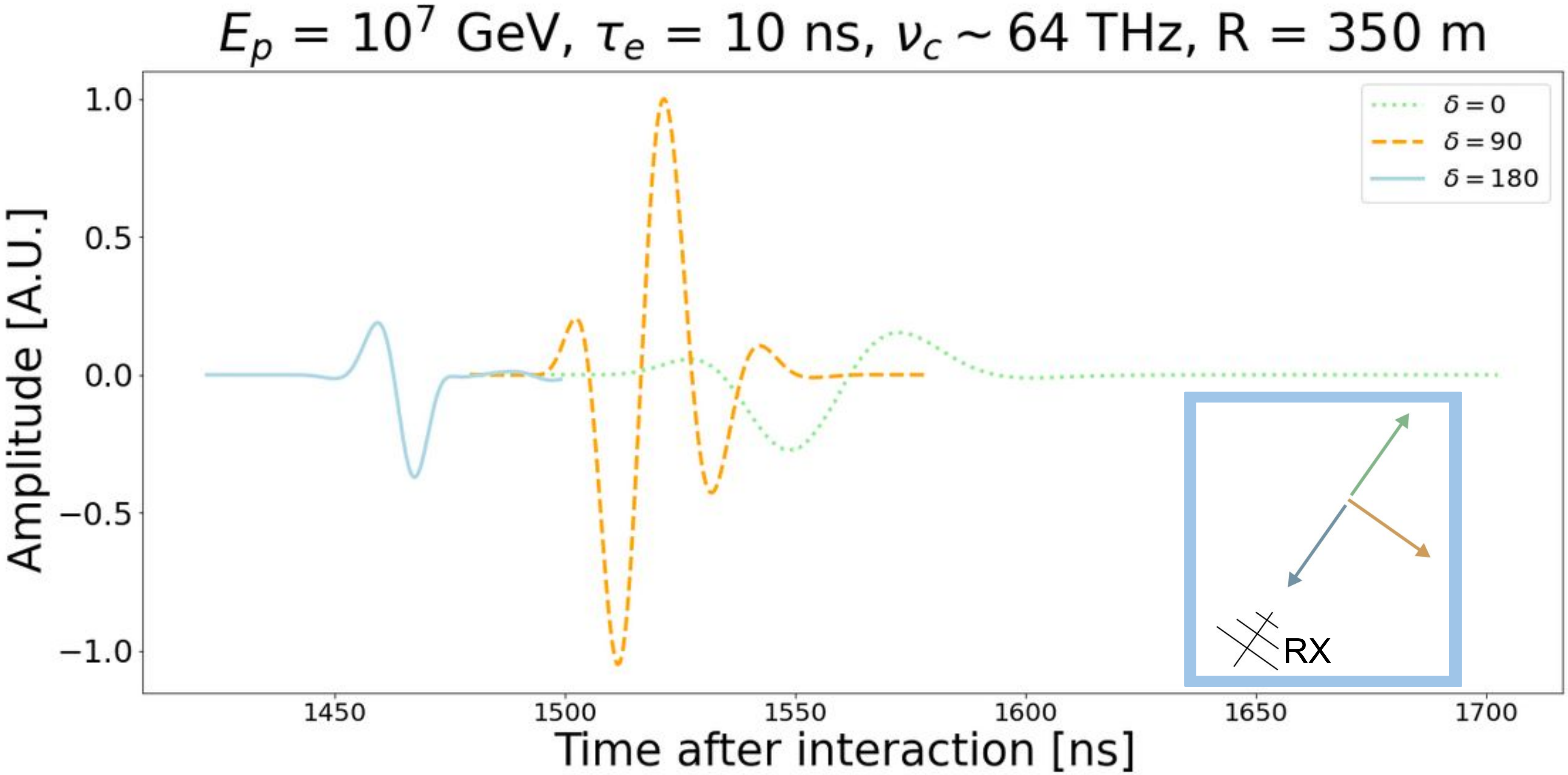
Starting with the cascade again



The reflectivity



The received signal



Outlook

1) The macroscopic model is in its final state.

2) The code implementation is near completion, e.g., finalising antenna implementation.

3) Looking forward to a rigorous cross-check with the SLAC test beam data.

4) Afterwards, there is a planned comparison with the current modelling tools (RadioScatter).

Thank you for your attention!