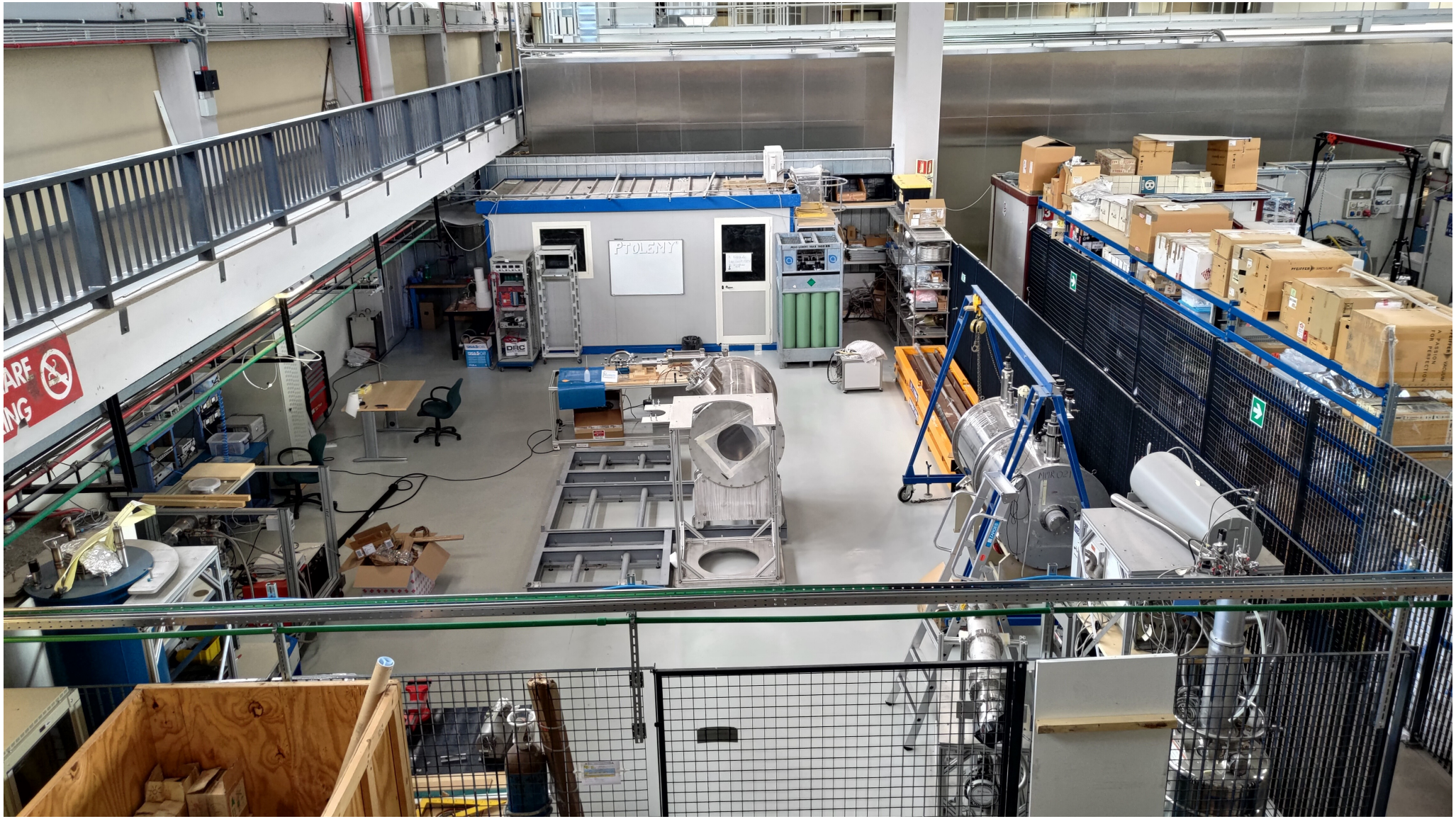
# PTOLEMY General Meeting

summary talk at NYU, NYC, Nov. 8th 2023

# The LNGS activities

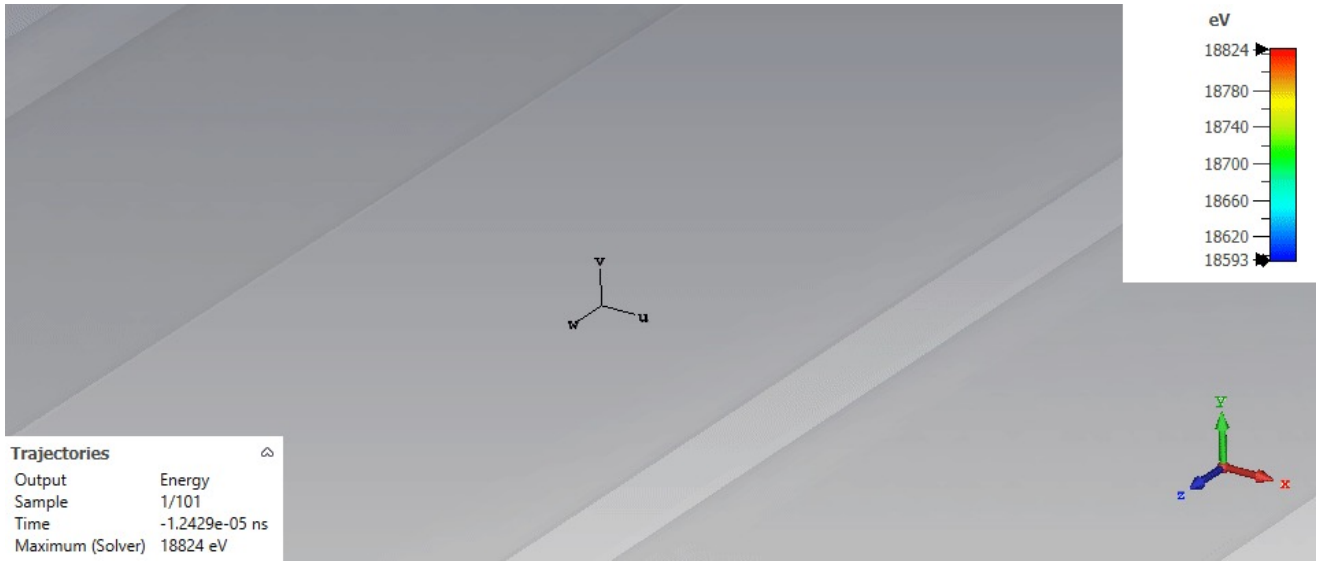
- RF detection of single electron and study of kinematical variables vs FFT
- Simulation of packing geometry for large mass T target.
- Efficiency studies in collaboration with Milano Bicocca University
- Demonstrator magnet at LNGS

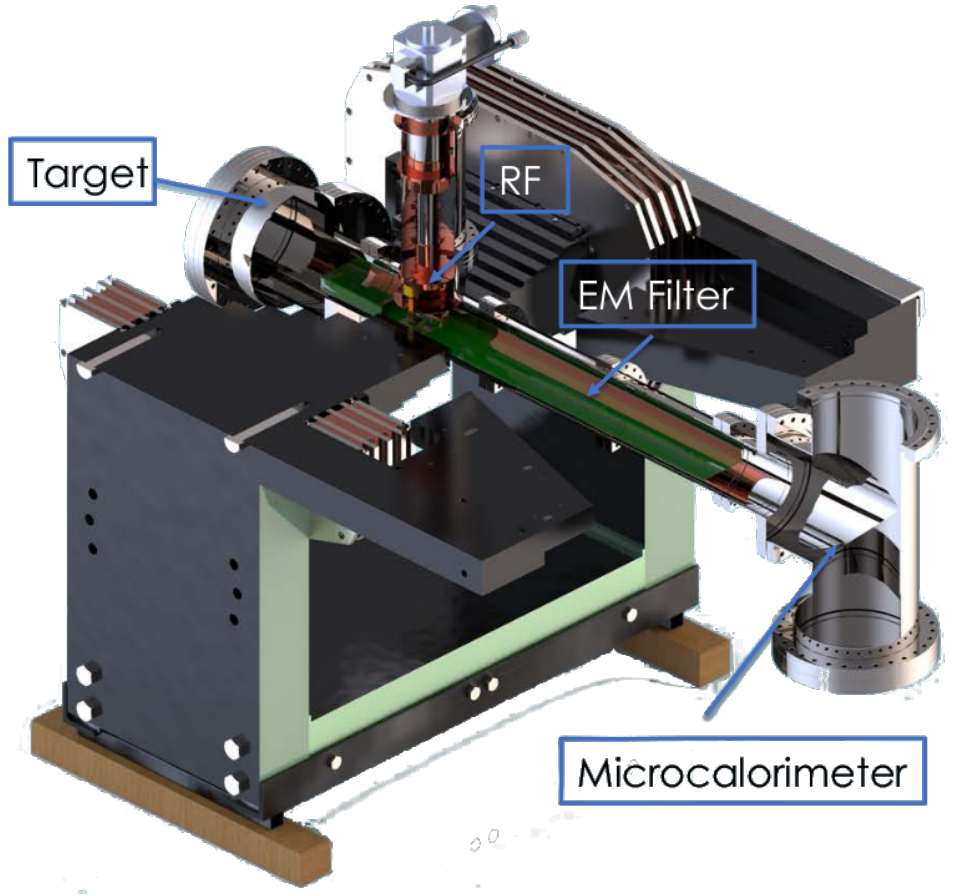
# Experimental area under transformation



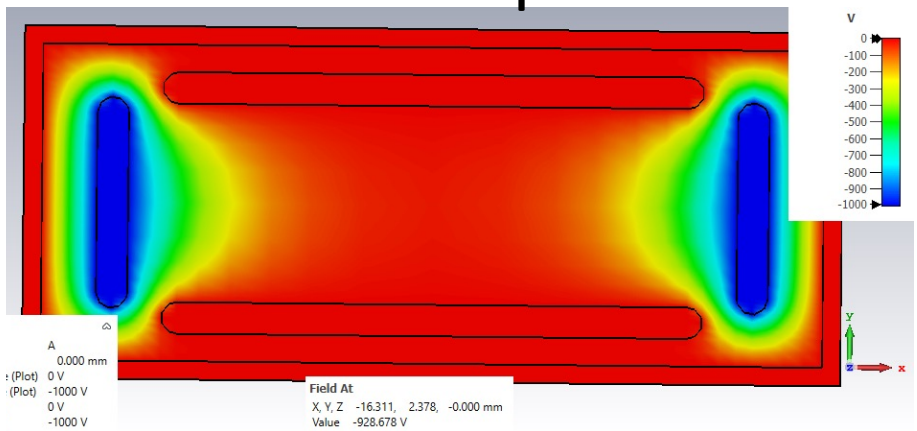
# Introduction: Why electron trap test?

- We want to study the measurement of K, KL in PTOLEMY's antenna region
- Bouncing geometry
- Electron in rectangular waveguide



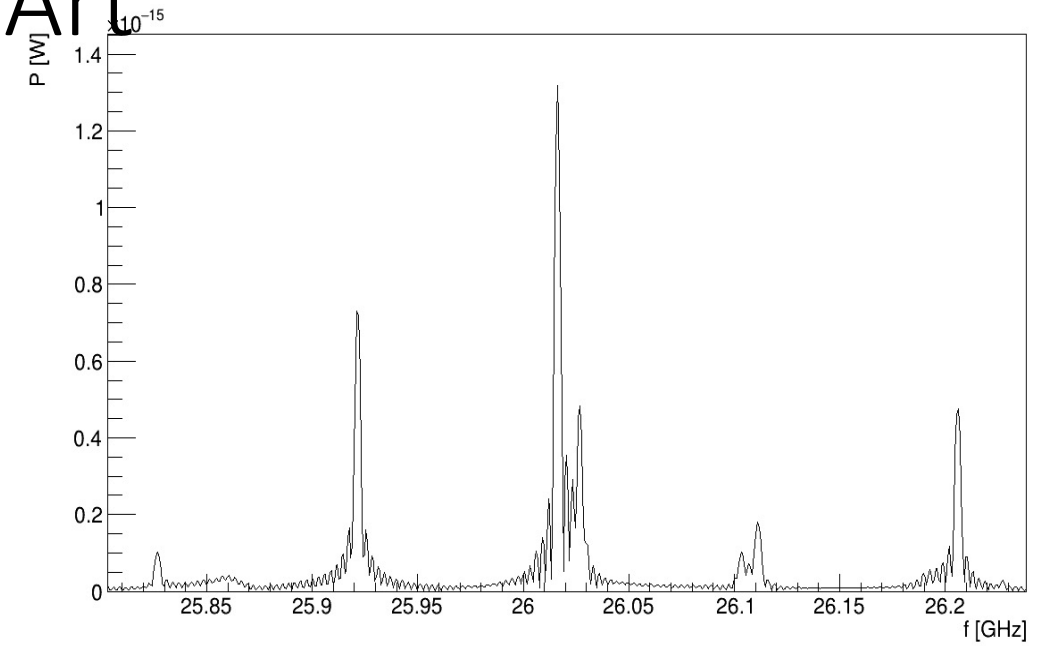
# Electron Trap:State of Art

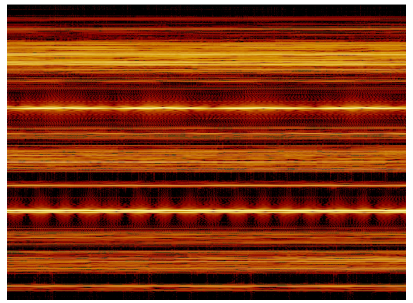



Naples meeting

1. Electron trap design
2. Electron trap simulation
3. Studies about kinematical variables reconstruction(=antenna region)
4. Design of Test Setup
5. Assembly of electron trap test setup
6. Data run

LNGS meeting 26/6/23



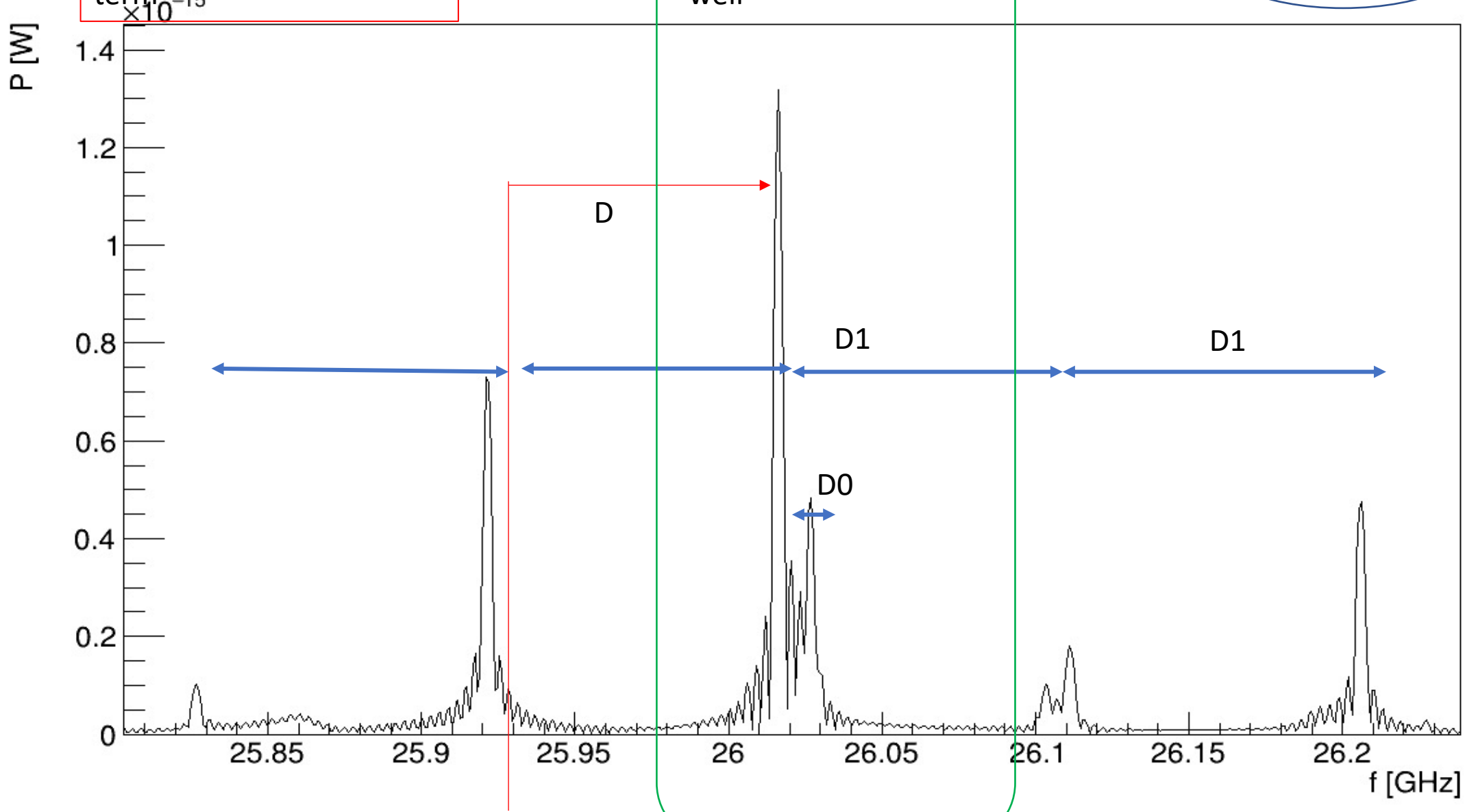
We are starting this phase with a Room temperature setup

# 5)CST simulation

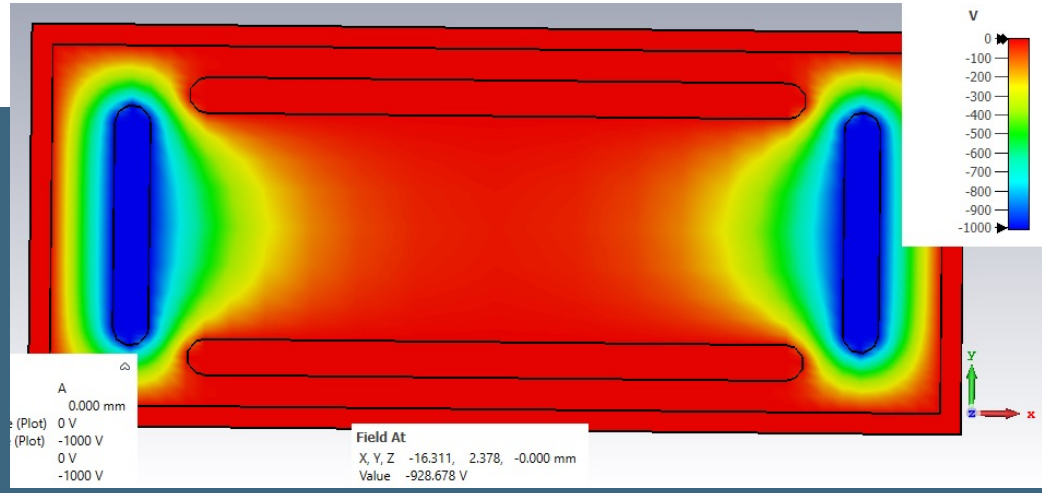
Right Shift from cos(Δω*t) term

Carrier modulation in frequency from K in pot. well

Armonics from FM



# Cryogenic and magnet setup




RF out

PBF

LNA

LNA bias

GM cold head
(11.7K)

WR42

magnet

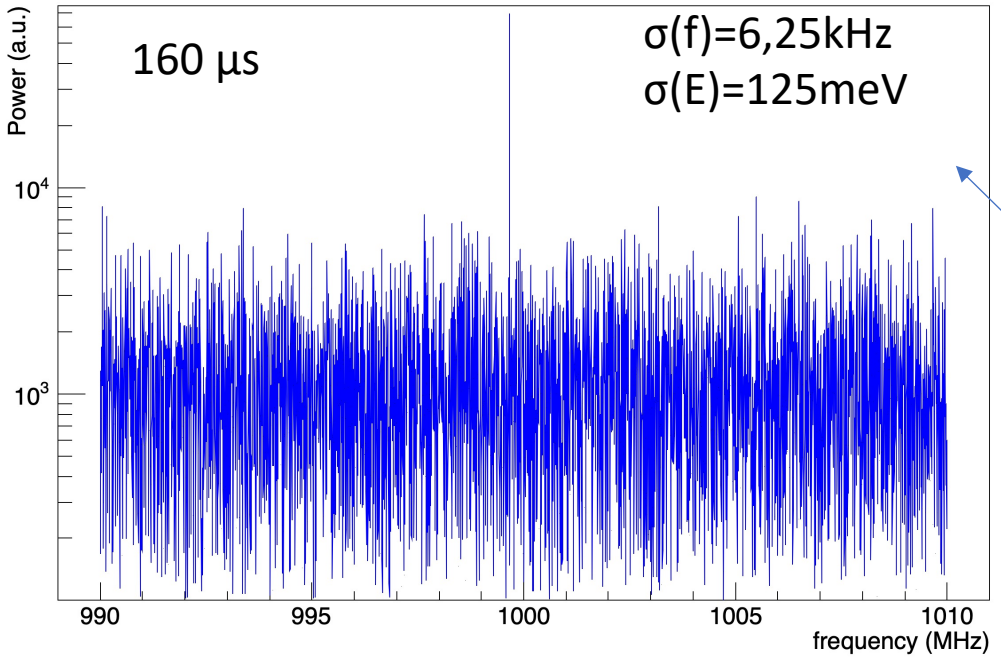
e- trap

source

HV

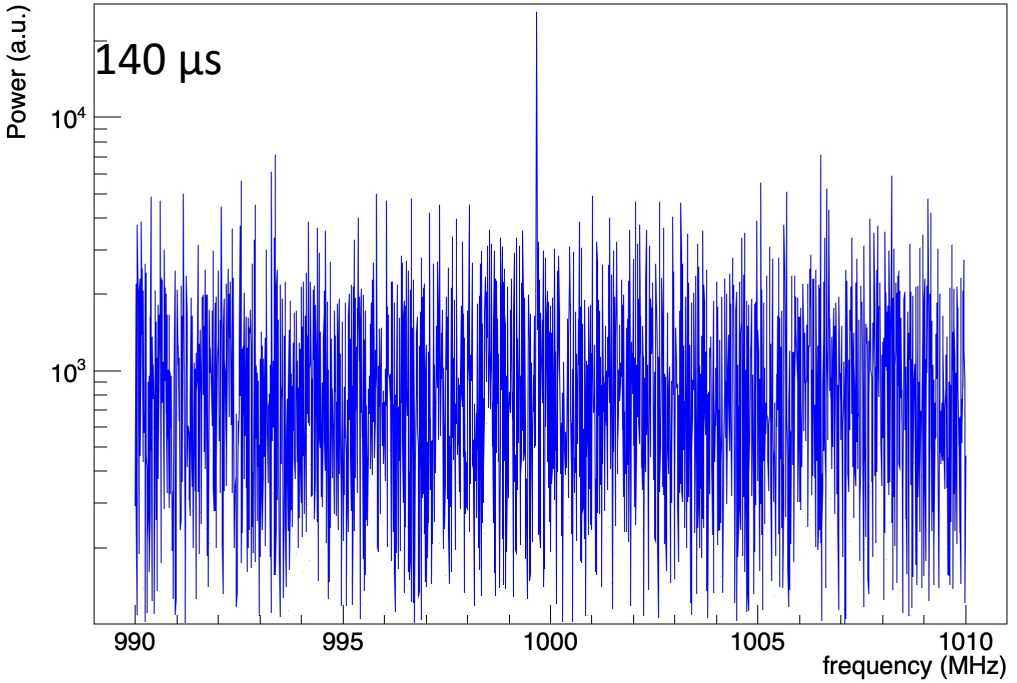
MCP

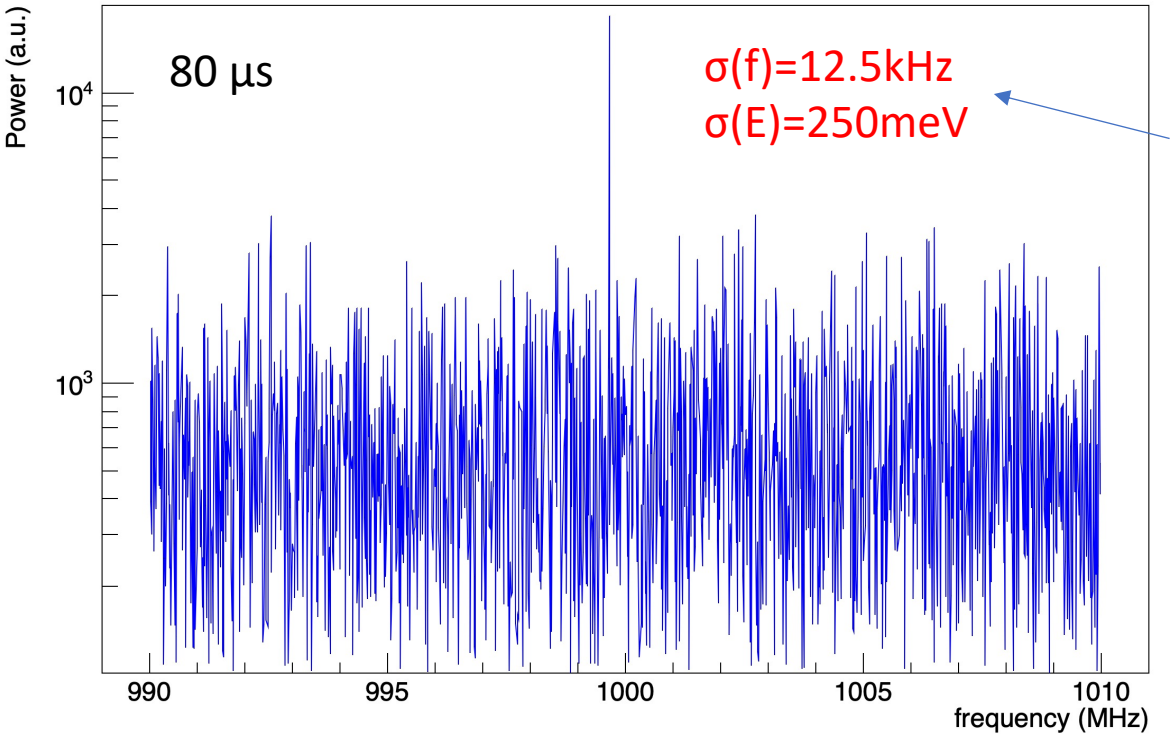
Turbo
pump



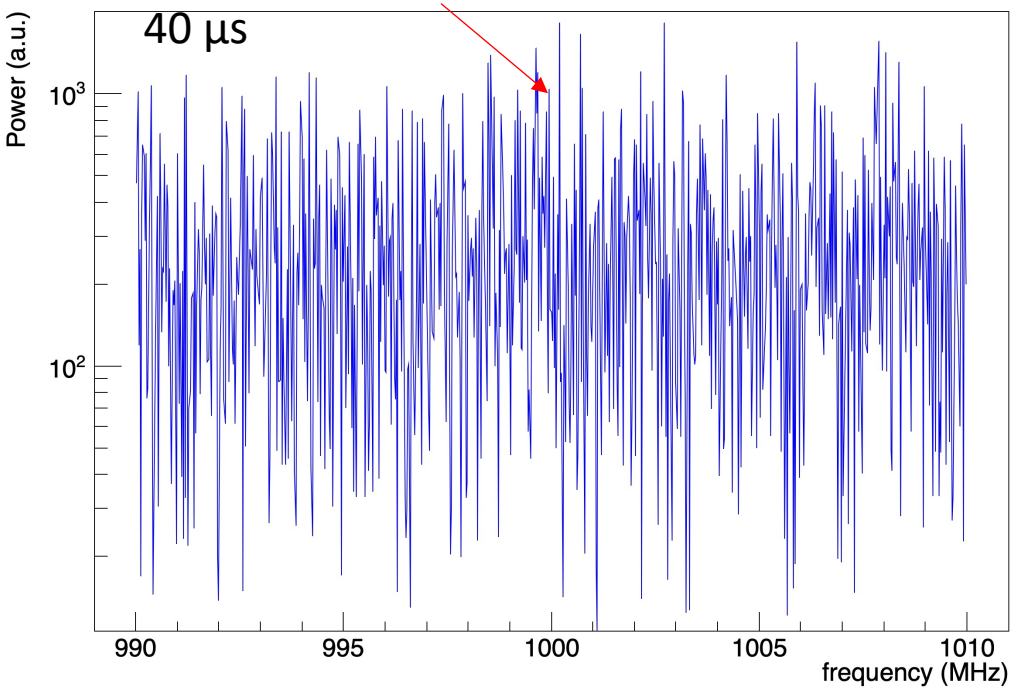

T=300K

High energy loss for tritium electron

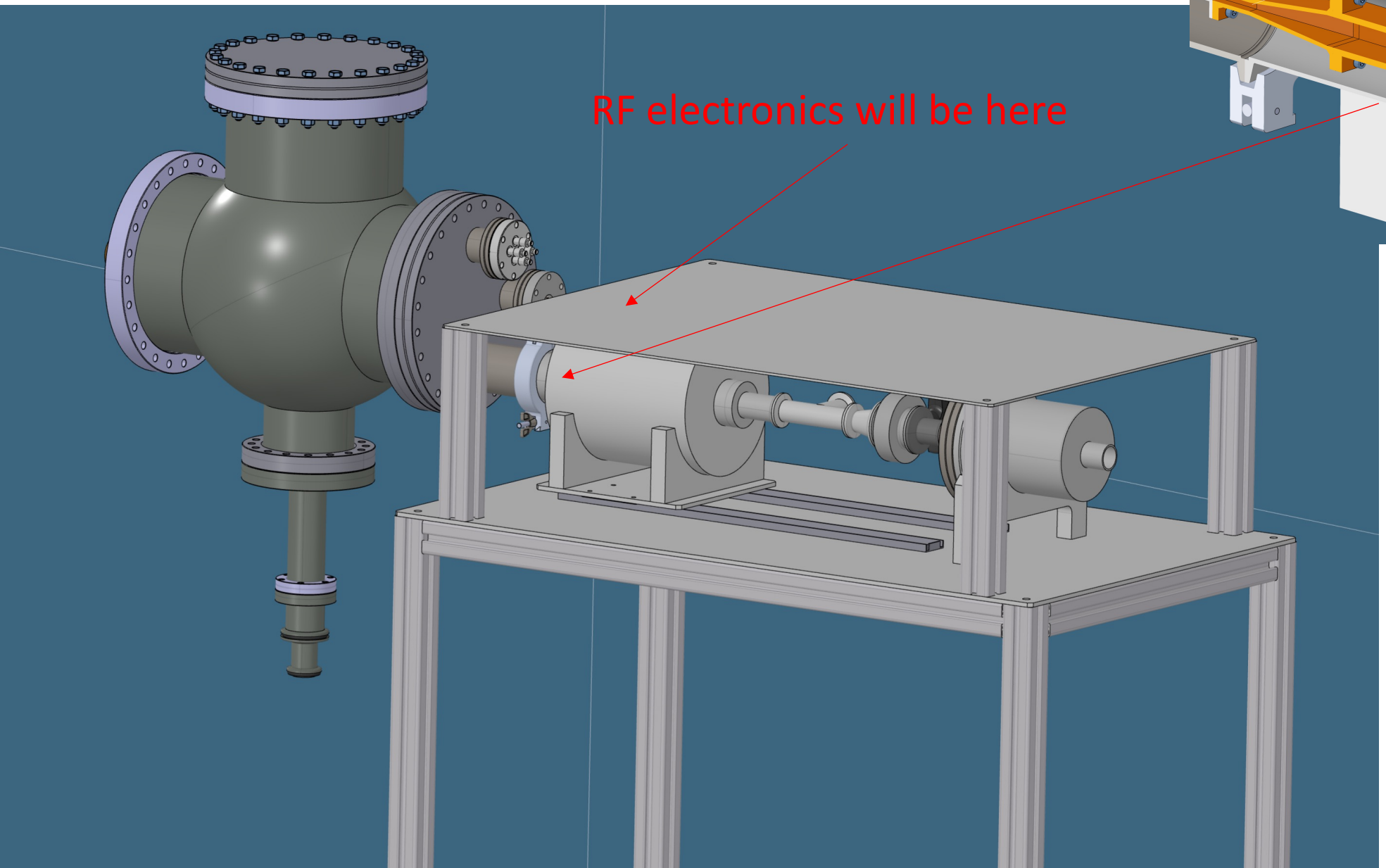


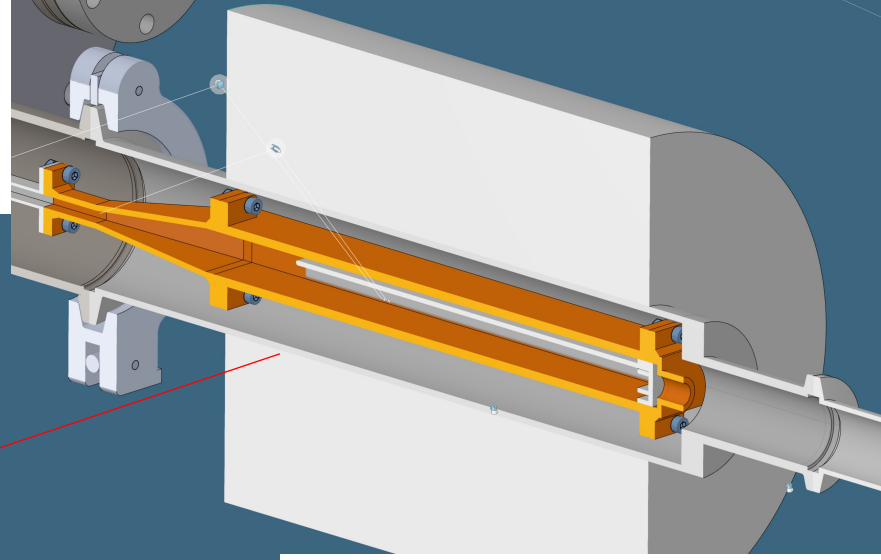




Just 2 bins of energy loss



# Electron trap cryogenic system



# Room temperature Electron trap

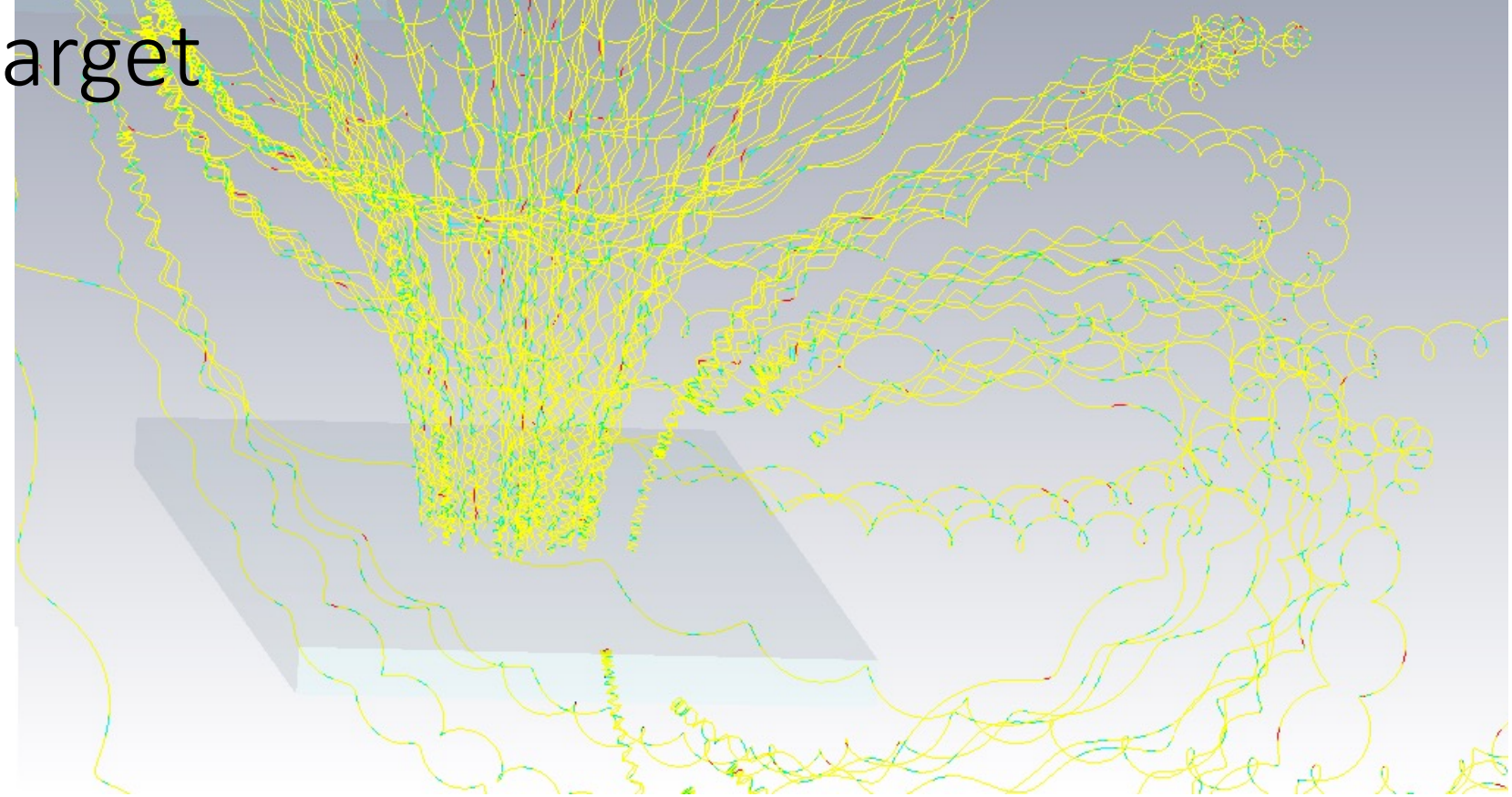
- We are using the old trap
- Same electrodes configuration
- Larger (too much for cold measurements)

HV

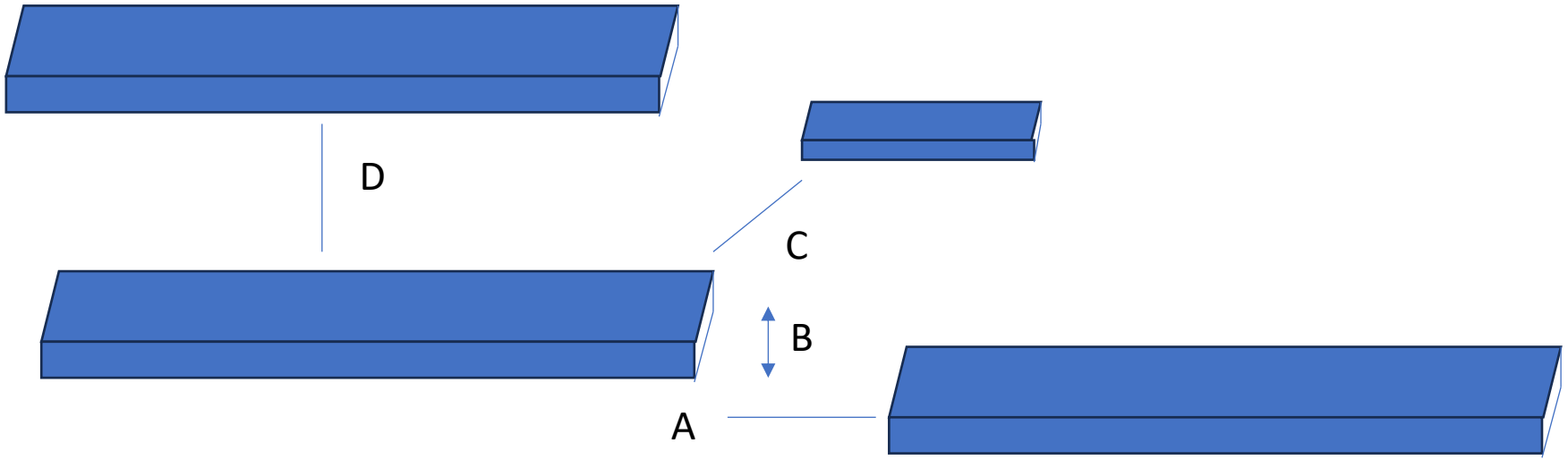
Source

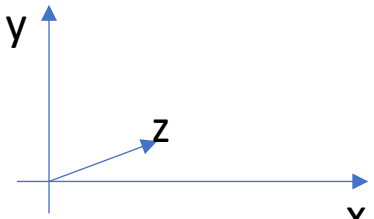
# Permanent magnet target

- We have done several simulation by varying ABCD parameters
- Electrons emitted with random pitch angle
- V_fid= (magnet_x+A)*(magnet_y+D)* (magnet_z+C) , B=0



B_ext



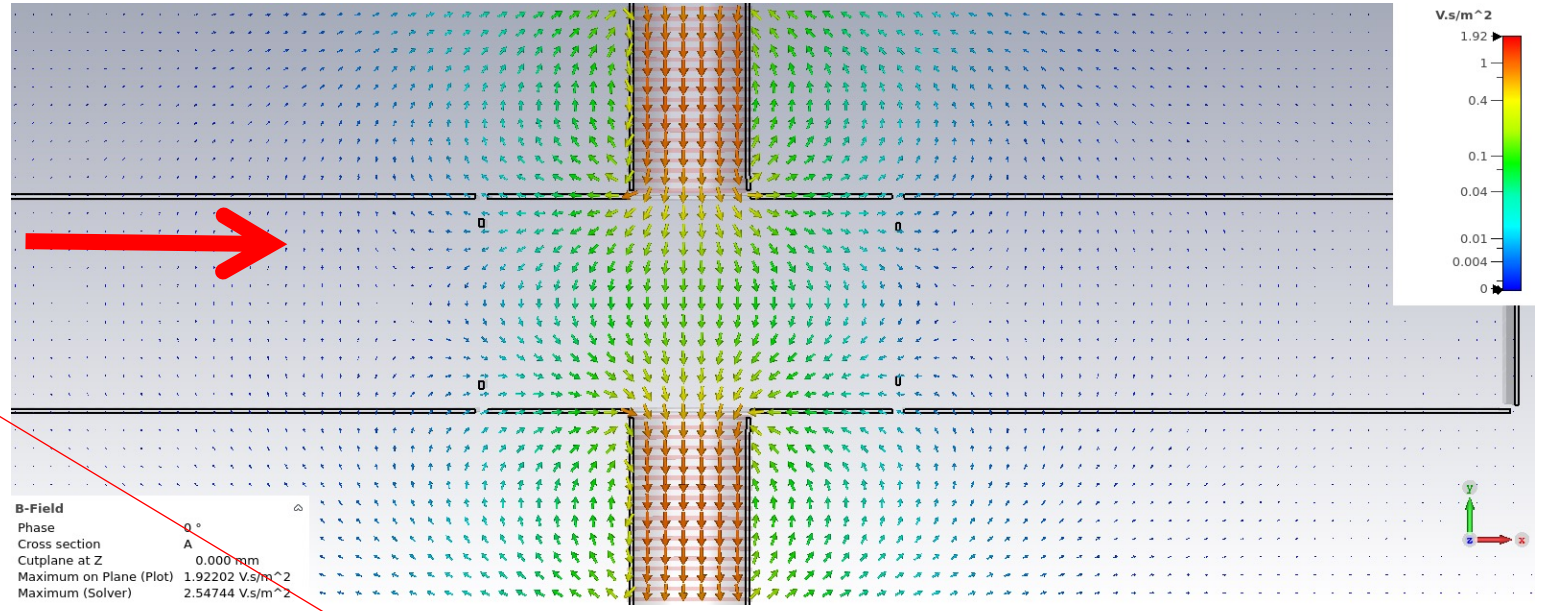



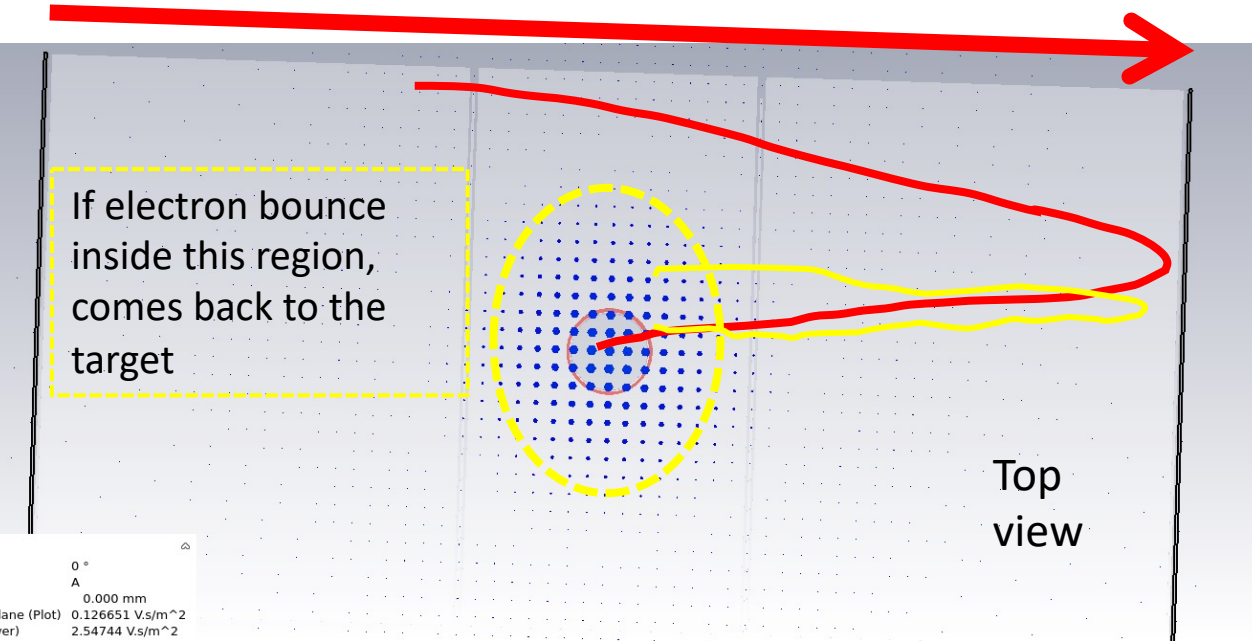
# Electron injection in bouncing geometry: B field

PRELIMINARY

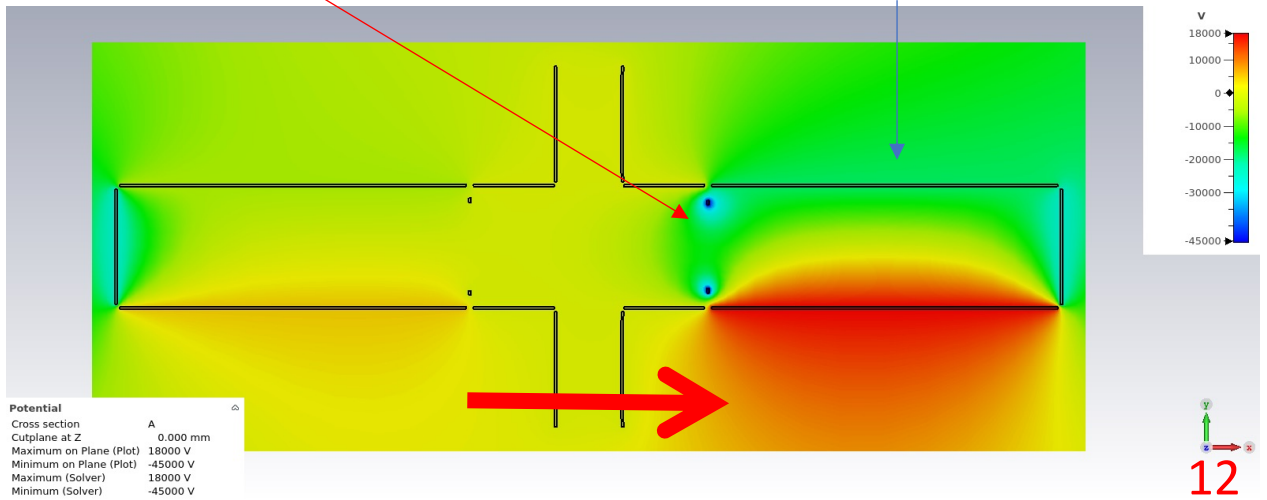
- Need high bouncing potentials
- Need high Z drift
- 3 channel helps to reduce longitudinal kinetic energy

- The wires on the left are not important
- Need this 3 channel geometry just to surpass the B_solenoid



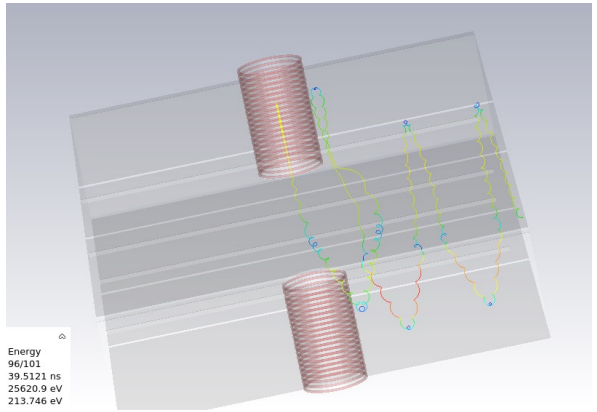

High ExB zone

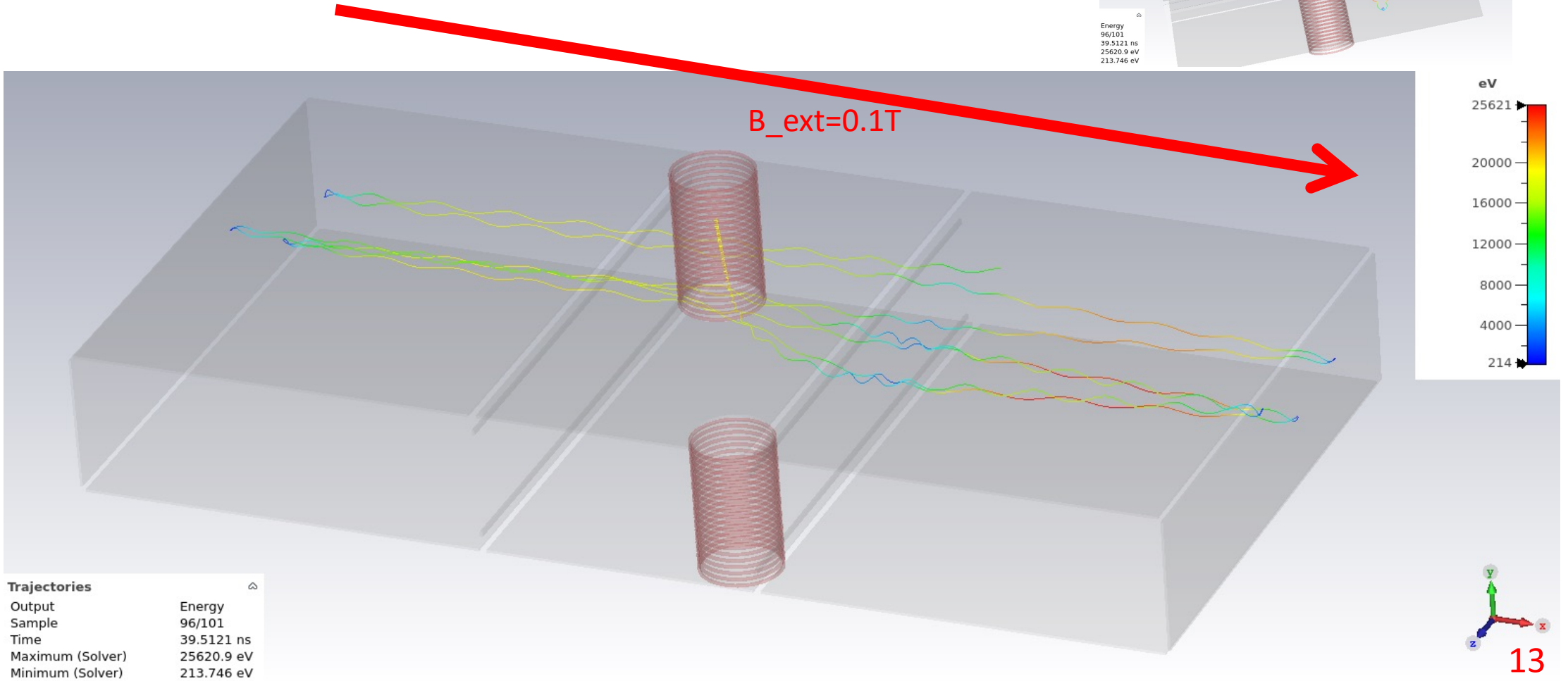


# Electron injection in bouncing geometry

PRELIMINARY

new preliminary simulation
with uniform global B field



# Neutrino mass

$$m_{\mathrm{eff}}^2 = \sum_i |U_{ei}|^2 m_i^2 \lesssim 800 \text{ meV}$$ **KATRIN**

$$\sum_i m_i \lesssim 100 \text{ meV}$$ **Cosmology**

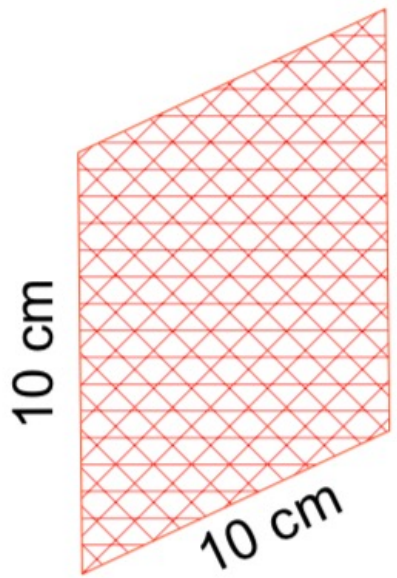
$$m_{\beta\beta} = \left| \sum_i U_{ei}^2 m_i \right| \lesssim 100 - 300 \text{ eV}$$ **ββ0ν ($^{76}$Ge, $^{130}$Te, $^{136}$Xe)**

(If Majorana)

# Reference source

$$N_{dec} = \frac{1}{2}\left(\frac{m_S \mathcal{N}_A}{A_{(^3H)}}(1 - e^{-t/\tau})\right) \simeq 1.1 \times 10^{16}$$

(50% Efficiency for total events)




(x 1 year)

ρ = 0.2 mg/m²
(full loading)

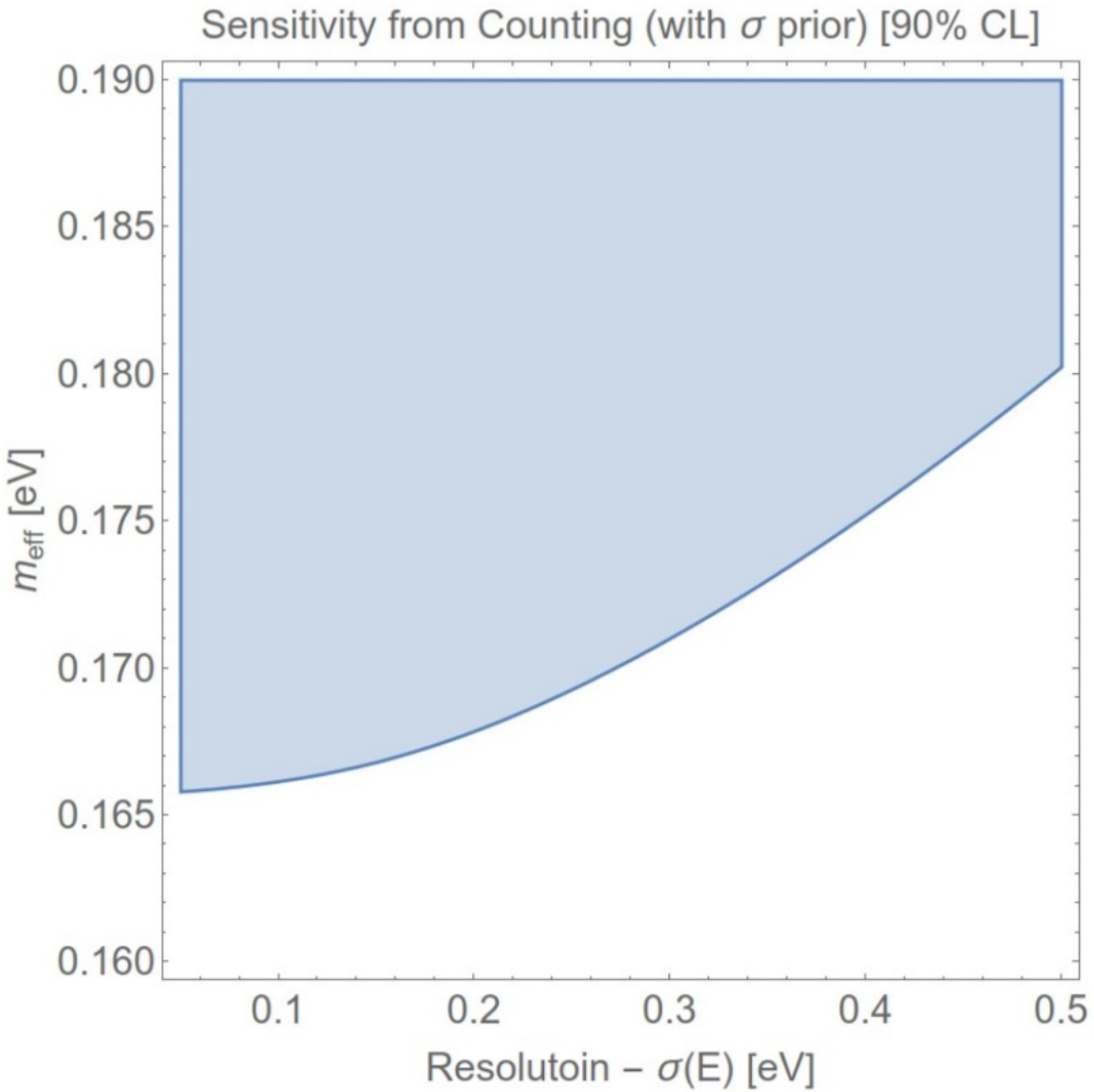
→ 2 μg

716 MBq
(19.3 mCi)

# Sensitivity from counting analysis

**Narrow prior on resolution:**

- Esperimental resolution
- Uncentainty principle smearing (Δ)



Ref. ASG/23.080 /AP

**Attn. to: Dr. Christopher Tully**

**Email**: cgtully@princeton.edu

Date: October 30th, 2023

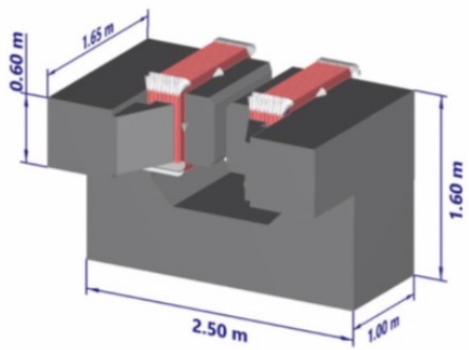
Subject: Design and supply of PTOLEMY LNGS SC Magnet, based in an MgB2 Solution.
ASG Offer 23013 Rev.00

Dear Chris,

Following our discussions please find here below our quotation for the design, manufacturing and testing of a $MgB_2$ magnet solution for PTOLEMY LNGS SC Magnet (this latter referred to as the "**PTOLEMY LNGS Magnet**") for the University of Princeton (herein after the "**Customer**") as better described in the following.

## 1) Introduction

The PTOLEMY LNGS Magnet is designed to be a C-type dipole with extension arms to one side of the pole faces for shaping the fringe field (the "**Horns**") and achieve a constant and uniform 1 T field in the airgap. The resistive version is shown in the Figure 1. The purpose of this offer is to provide cryogen-free superconducting coils to optimize performance and energy efficiency.




## 2) Scope of Supply

The scope of work consists in the design, manufacturing and supply of a $MgB_2$ superconducting Magnet and delivery to CERN, Geneva, Switzerland (CH) (the "**Scope of Supply**" or the "**Supply**").

The Scope of Supply covers the following parts and activities:

- Detail design of the MgB2 coils, cryostats and iron yoke.
- Manufacturing design (drawings and design verifications where request by Customer) of each component.
- Construction and assembling design of all the components and assembled magnet.
- For the sake of clarity:
  - (i) ASG shall supply the PTOLEMY LNGS Magnet yoke without Horns
  - (ii) ASG shall use the draft design of the Horns provided by the Customer by the date of this offer in order to design the yoke and to verify that Horns have no impact on coils and mechanical stability.
  - (iii) the magnetic field in the air gap region as set forth in the items n. 4 for the acceptance at the FAT will be measured without the Horns
  - (iv) the Customer shall be free to modify the Horns design after acceptance of the PTOLEMY LNGS Magnet without ASG being in any way responsible of the possible modification of the magnetic field intensive and homogeneity.
- Procurement of the iron yoke.
- Tests according to QCP (Quality Control Plan).
- Assembly of the whole system, including the ancillary equipment, at ASG's factory in Genoa.
- Acceptance Test at ASG's factory in Genoa. This shall constitute the final acceptance event for the Customer.
- Redaction of the final documentation of the coil system.
- The parties shall agree immediately after contract signature about the content of a quality control plan (QCP) to be provided by ASG.
- The transport and the delivery of the Supply will be at the European Organization for Nuclear Research (CERN), in Meyrin (Cantone of Geneve), Switzerland (CH) according to CIP (Incoterms 2020). Upon arrival to CERN the Scope of Supply shall enter the ownership of the Customer.

Not included in the supply are:

1. Any and all Civil works at Customer premises and /or CERN site.
2. Power supply: ASG shall specify the power supply and provide guidance to the Customer for the relevant procurement.
3. Vacuum pumps.
4. Water cooling system for the cryocooler helium compressor.
5. The design, manufacture, assembly, and testing of the ferromagnetic extensions referred to as Horn will not be part of the Scope of Supply.

# Progress
## First mechanic design