Detecting physics beyond the Standard Model with the REDTOP experiment

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Abstract

REDTOP is an experiment, at its proposal stage. It belongs to the High Intensity class of experiments. REDTOP will use a 1.8 GeV continuous proton beam impinging on a fixed target. It is expected to produce about 10^{13} η mesons per year. The main goal of REDTOP is to look for physics beyond the Standard Model by detecting rare η decays. The detector is designed with innovative technologies such that the background events are efficiently rejected. In this poster, the experimental design, the physics program and the running plan of the experiment are presented.

1 Introduction

The particular properties of the η meson are excellent to test the conservation of discrete symmetries, search for new particles and forces, as well as to perform further studies. The REDTOP detector is designed with innovative technologies such that interesting events can be observed and the background events are efficiently rejected; it is based on the detection of prompt Cherenkov light, because the final events of the process of interest contain fast leptons.

2 Why η meson?

The η meson is a special particle in the universe, it is a pseudo Goldstone boson. The η meson is especially useful when looking for symmetry violating decays. It is an eigenstate of the C, P, CP and G operators. The η dynamics is such that all its possible strong decays are forbidden in lowest order by P and CP invariance, G-parity conservation and isospin and charge symmetry invariance. First orden electromagnetic η decays are forbidden as well: $\eta \to \pi^0\gamma$ by conservation of angular momentum, $\eta \to 2\pi^0\gamma$ and $\eta \to 3\pi^0\gamma$ by C invariance. For those reasons, the η decays with leptons in the final state have very small Standard Model backgrounds.

3 The experimental apparatus

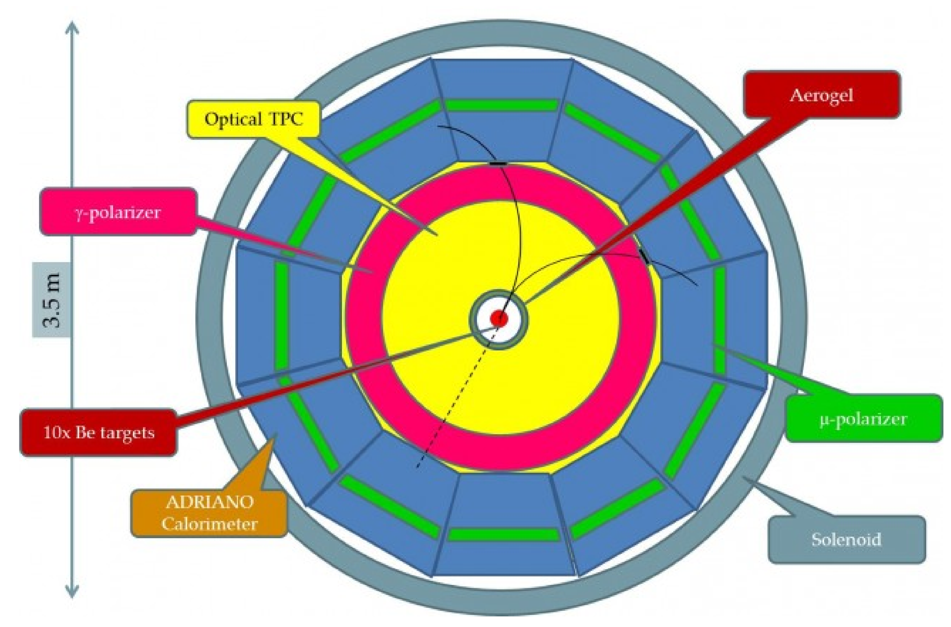

Figure 1: This picture show the main parts of REDTOP detector with its different layers.

The beam and target system

Target system. Ten round foils of beryllium, each about 1/3 mm thick and 1 cm diameter.

The beam

- Monte Carlo simulations indicate that an energy of 1.8 GeV is optimal for the experiment.
- The η mesons will be produced from protons impinging on the target producing about 10^{13} η mesons per year of running.
- A beam delivering 10^{11} proton/sec onto REDTOP targets will produce about 2×10^5 η /sec.

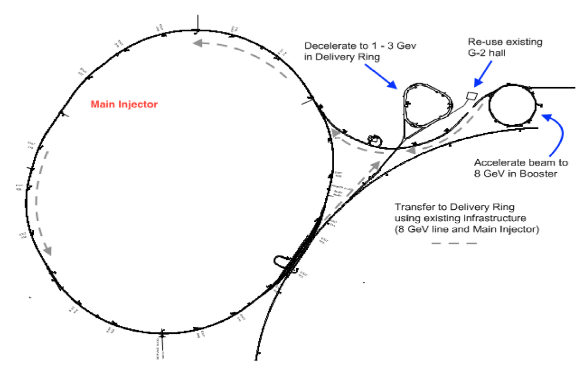

Figure 2: Beam from the Booster is sent through the Main Injector to the Delivery Ring at 8 GeV, before final deceleration to 2 GeV and subsequent slow spill.

The Optical TPC

The OTPC works on the same principles as a conventional TPC, it will measure the momentum and the position of the particles. The OTPC uses the Cherenkov effect to detect particles and will be sensitive only to leptons and fast pions. Two Cerenkov radiators are present; a double aerogel cylinder about 3 cm thick at the inner wall and low-pressure nitrogen gas filling the rest of the volume.

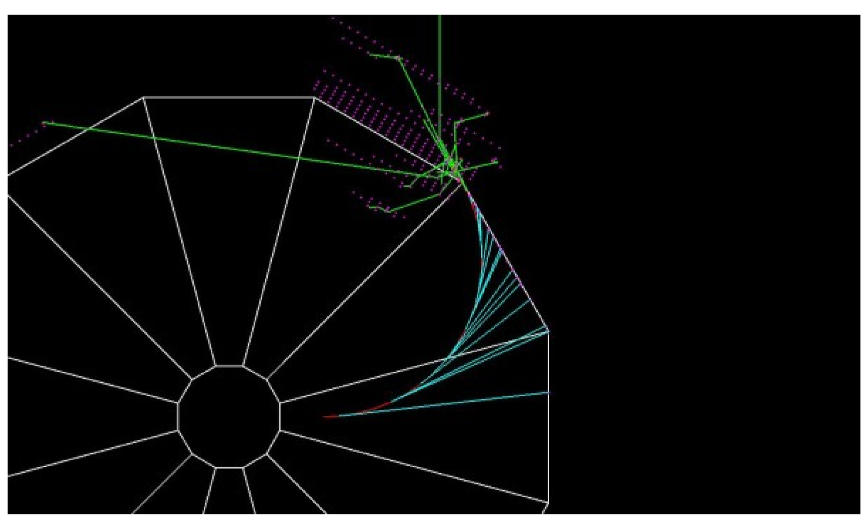

Figure 3: Representation of a 100 MeV electron across the gas with a 0.6 T magnetic field.

The ADRIANO Dual-Readout Calorimeter

The ADRIANO calorimeter is based on two simultaneous measurements of the energy deposited by a hadronic or electromagnetic shower into two media with different properties. The main advantage of using ADRIANO to detect the photons from the η decays is that the background from most neutrons entering the detector could be easily rejected.

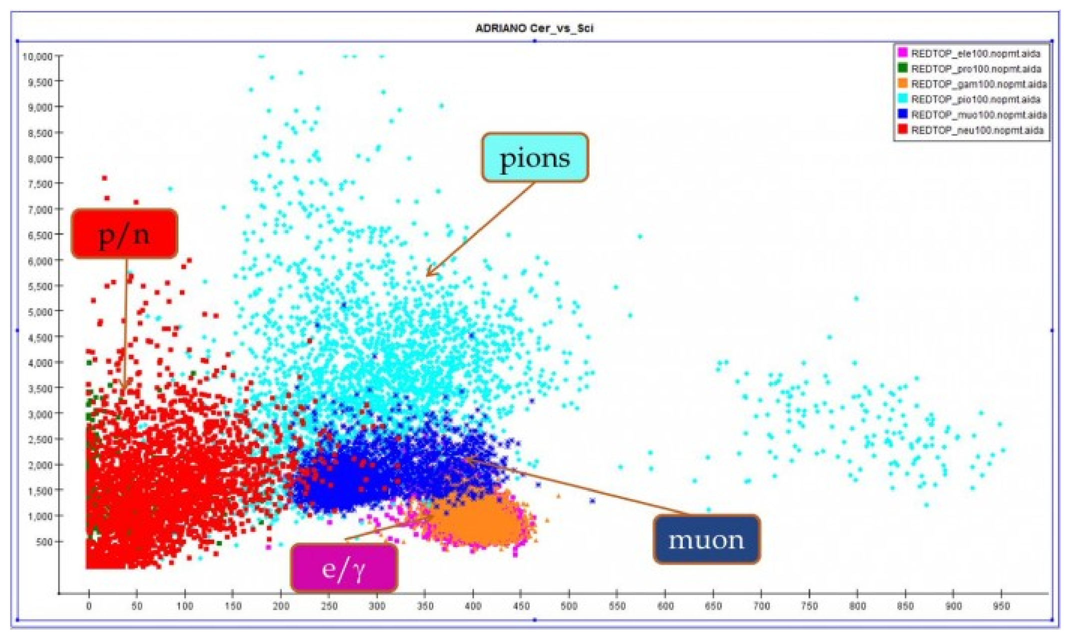

Figure 4: Scintillation vs Cherenkov signals in the ADRIANO calorimeter with E_{kin} = 100 MeV.

4 Polarimeters

The Muon Polarimeter. It is made from a plastic scintillators inserted between the inner and the outer shells of ADRIANO. It will count the number of e^+ and e^- emitted when a muon is stopped inside the polarimeter.

The Photon Polarimeter: It is made of a thick scintillating plate inserted inside the volume of the OTPC. It will count the number of e+ and e- emitted when photon is converted e^+ e^- pair. For both Muon and Photon polarimeter, the asymmetry in the counting will provide an estimate of the polarization of muons and photons.

5 Physics program

Symmetry and conservation violations	CP Violation (Type I and Type II, via the polarization of the muons).		
	CP and C Violation with Dalitz plot studies		
	CT Violation via the polarization of the muons		
	CPT Violation (with non-hermitian lagrangians)		
	Single and double lepton flavor violations.		
Searches for new particles and forces	True muonium	Low and intermediate energy studies	Test of nuclear models
	Dark photons		Non-perturbative QCD
	Lepto-quarks		Chiral perturbation theory
	New scalar particles		Test of nuclear models
	New baryonic forces		$\pi\pi$ interactions

6 Running plan

Run I -η factory	Production of η mesons using a proton beam of 1.8 GeV of energy, with the purpose of collect an excess of 10^{13} η mesons.
Run II -η' factoy	Production of η' mesons using a proton beam with an energy of 3.5 - 4.9 GeV, aiming to collect 10^{11} η mesons.
Run III - μ scattering experiment	The beam required is composed of muons with an energy between 0.2 and 0.8 GeV, aiming to collect of the order of 10^{12} muons scattering events.
Run IV - Rare K decay experiment	The main physics topic will be the study of the CP violating process $K^+ \to \pi + \nu\nu$.

7 Conclusions

The η meson is useful for exploring physics beyond the Standard Model, REDTOP is designed to produce an excess of 10^{13} of such particles and detect its rare decays using novel detector technologies which are highly sensitive to processes from new physics.

References

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