PERFORMANCE AND OPERATIONAL EXPERIENCE OF THE CNGS FACILITY

EDDA GSCHWENDTNER, KAREL CORNELIS, ILIAS EFTHYMIOPOULOS, ALFREDO FERRARI, ANS PARDONS, HEINZ VINCKE, JOERG WENNINGER

CERN, 1211 Geneva 23, Switzerland

DARIO AUTIERO

IPNL Lyon, Lyon, France

PAOLA SALA

INFN Sez. Milano, Milano, Italy

ALBERTO GUGLIELMI

INFN Sez. Padova, Padova, Italy

The CNGS facility (CERN Neutrinos to Gran Sasso) aims at directly detecting muon to tau neutrino oscillations. An intense muon-neutrino beam (1E17 muon neutrinos/day) is generated at CERN and directed over 732 km towards the Gran Sasso National Laboratory, LNGS, in Italy, where two large and complex detectors, OPERA and ICARUS, are located. CNGS is the first long-baseline neutrino facility in which the measurement of the oscillation parameters is performed by observation of tau-neutrino appearance. In this paper, an overview of the CNGS facility is presented. Highlights on CNGS beam performance since during physics run in 2008 and 2009 are given.

1. Introduction

The CNGS facility was first operational in July 2006 for an approved physics program of five years with a total of 22.5E19 protons on target (4.5E19 protons/year). The 400GeV/c CNGS beam is fast extracted from the CERN SPS accelerator. The nominal intensity is 2.4E13 protons on target per 10.5μs extraction. During the 6s cycle, there are two extractions separated by 50ms. The beam is sent down an 840m long proton beam line with a slope of 5.6% onto a carbon target producing kaons and pions, corresponding to an average power at the target of 510kW. The positively charged pions and kaons are energy-selected and guided with two focusing lenses, the so-called horn and reflector, in the direction towards Gran Sasso. These particles decay in a 1000m long, 2.5m diameter decay vacuum tube into muon-neutrinos and muons. All the hadrons, i.e. protons that have not interacted in the target, pions and kaons that have not decayed in flight, are absorbed in a hadron stopper. Only neutrinos and muons can traverse this 18m long block of graphite and iron. The muons, which are ultimately absorbed downstream in around 500m of rock, are measured in two muon detector stations. They are arranged in a cross-shaped array, measure the muon intensity and the vertical and horizontal muon profiles which allows concluding on the quality and intensity of the neutrino beam produced and on the beam profile. A schematic overview of the CNGS neutrino beam facility at CERN is shown in Fig. 1.

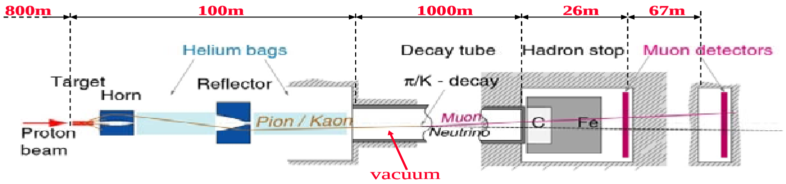

Figure 1: Main components of the CNGS facility.

2. CNGS Operation

CNGS was commissioned successfully in 2006 [1]. During 2007 CNGS was running for 6 weeks. After the completion of the OPERA detector [2] and finishing successfully some initial issues that occurred in the facility, CNGS had its first complete year of physics in 2008 with 1.78E19 protons on target. In 2009 in total 3.52E19 have been cumulated and OPERA has collected more than 21400 on-time events and more than 3700 candidate interactions in the bricks.

Table 1: Cumulated protons on target for CNGS to date.

	protons on target
2006	7.56 E17
2007	6.13 E17
2008	1.78 E19
2009	3.52 E19
Total	**5.44 E19**

3. Start-up Issues

Physics requirements have been pushing the needed power of the proton beam on target to values around and above 500 kW. The CNGS secondary beam line, starting with the target, has to cope with this situation, which pushes the beam line equipment and instrumentation to the limits of radiation hardness and mechanical stresses during the CNGS operation. The choice of materials, shielding configurations, remote handling capabilities for maintenance and exchange of equipment were carefully designed and optimized. However, the startup issues faced demonstrate the difficulty in the design and operation of such high intensity facilities. Details of major technical issues and their improvements are summarized in [3].

4. CNGS Performance

During the first complete CNGS physics run in 2008 in total 1.78E19 protons on target were cumulated. Detailed results can be found in [4] and [5].
The CNGS physics run in 2009 started on 1st June 2009 and was scheduled until 23rd November 2009. The overall efficiency of the accelerator complex was very good, i.e. 74%, resulting to 3.52E19 integrated number of protons on target which is 10% higher than expected (3.2E19), (see Fig. 3).
For most of the time the facility operated with 2E13 pot/extraction. The overall beam performance and stability of the primary proton beam line was excellent throughout the run: 110μm r.m.s in the horizontal plane and 50μm r.m.s in the vertical plane; no active position feedback is necessary.

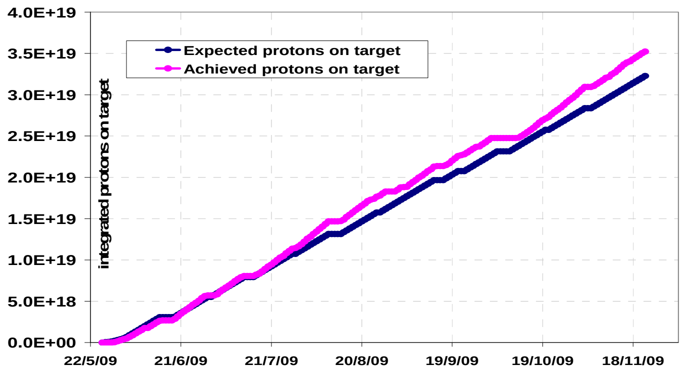

Figure 3: Expected and achieved integrated protons on target for 2009.

The muon detector [6] stations are very sensitive to any misalignment between the proton beam, the target and the horn; for example an 80μm parallel beam shift on the target corresponds to a 5cm shift of the muon profile centroid. This allows to precisely optimizing on-line the secondary particle and neutrino production.
Comparison between the muon profiles measurements and FLUKA [7] simulations shows very good agreement (see Fig. 4). This proves that the CNGS facility is very well understood and special features of the facility are considered: e.g. in the horizontal muon profiles an asymmetry between operating in neutrino mode (focusing of mesons with positive charge) and anti-neutrino mode (mesons with negative charge) has been observed. This can be

explained due to the earth magnetic field in the 1000m long decay tube which results in the profile shifts of the observed magnitude [8].

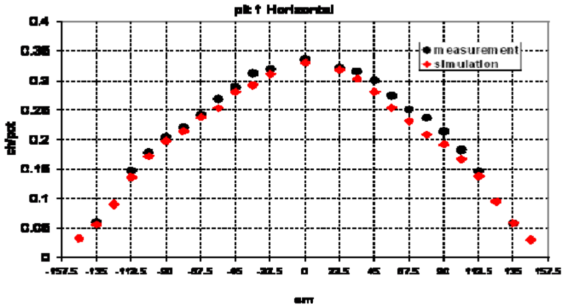

Figure 4: Measured (black circles) and simulated (red rectangles) horizontal muon profile in the first muon detector station. Each point corresponds to one ionization chamber readout.

The observation of horizontal muon detector signals in 2007 non-linear w.r.t. the intensity was attributed to the wire topology of the readout cables. The remedy was to increase the capacitance of all wires to a fixed value [6].

5. Summary

After successfully resolving of the start-up issues since the beam commissioning in 2006, CNGS has started smoothly the physics run in 2008. Since then 5.44E19 protons on target have been cumulated. With the present statistics first tau-neutrino events are expected.

References

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