08/03/2017

Feasibility of the implementation of the MICE cooling demonstration at NRC KI IHEP

Here is a feasibility study of the MICE cooling demonstration at the 70-GeV machine at IHEP. In this analysis, the materials presented in Dr. K. Long's letter of 6 February 2017 and in the publications indicated in this letter are used. All findings are preliminary.

1. Layout

Experimental hall serving to place the installation, shown in Figure 1.

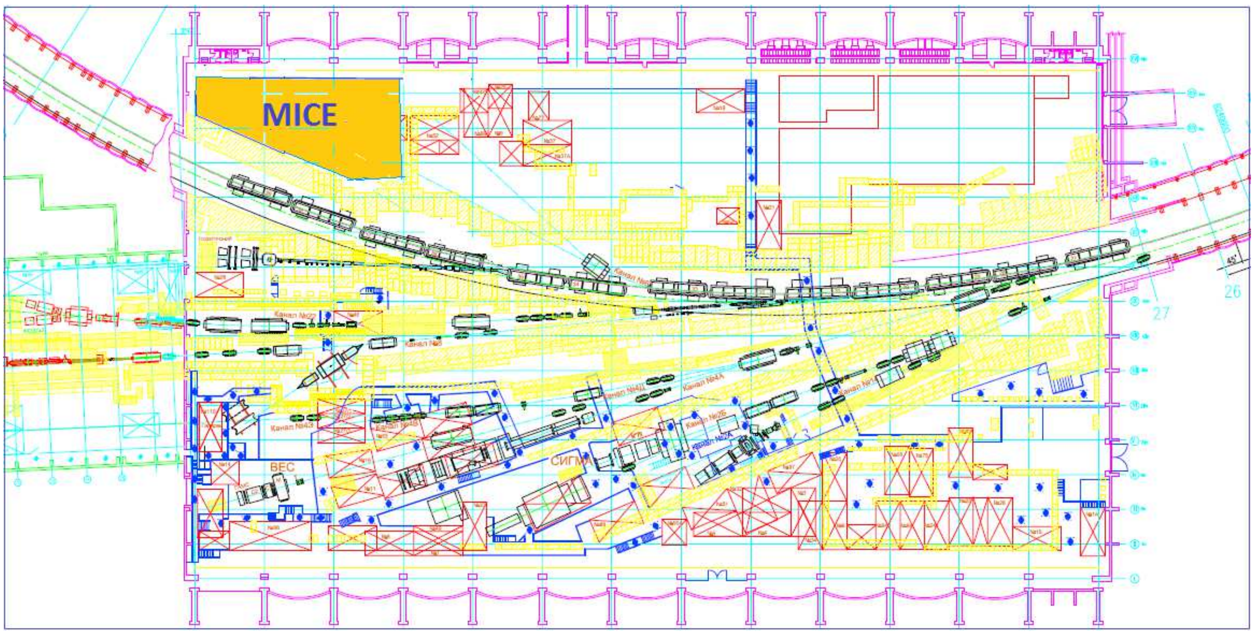

Fig. 1 Experimental hall

The area of the hall is $156 \cdot 90\ m^2$. The accelerator crosses this hall. The accelerator is covered with thick concrete shielding (light yellow in Fig.1).
In the southern part of the hall there are channels of secondary particles from internal targets, channels for extracted proton beams, as well as part of experimental facilities. In the northern part there are two low energy channels.

The accelerator usually runs three months a year, one month in March-April and two months in October-December, providing following proton beam:

- Energy: 50 GeV
- Intensity $8 \cdot 10^{12}$ p/cycle
- Cycle 9.5 s
- Flat top 3 s

The installation is proposed to be placed in the northwestern part of the hall. This choice is driven by following arguments:

- this area is sufficient to accommodate the MICE facility
- it is convenient here to construct a low-energy muon channel
- the internal target can work in “shadow” mode providing the beam in most operating modes of the accelerator
- this area is “background free”
- currently, there is a moderate installation in this zone, which can be dismantled if necessary

2. Infrastructure

2.1 Electrical power

Required electrical power of 1.5 MW can be provided by existing electrical network. The compatibility of the power supply standards has to be verified.

2.2 Gases

Helium and nitrogen are routinely in use at the IHEP. We do not expect any problems with these gases. As for hydrogen, we will need to update the system of safe operation with large (>1 liter) volumes of liquid hydrogen, since in recent years we have worked with volumes significantly less than a liter, which do not require special safety measures.

2.3 Cran

In the hall there is a crane with a carrying capacity of 40 tons. It can serve almost the entire installation area (highlighted in dark yellow in Fig.2). In the peripheral parts, lifting operations are performed using a forklift truck.

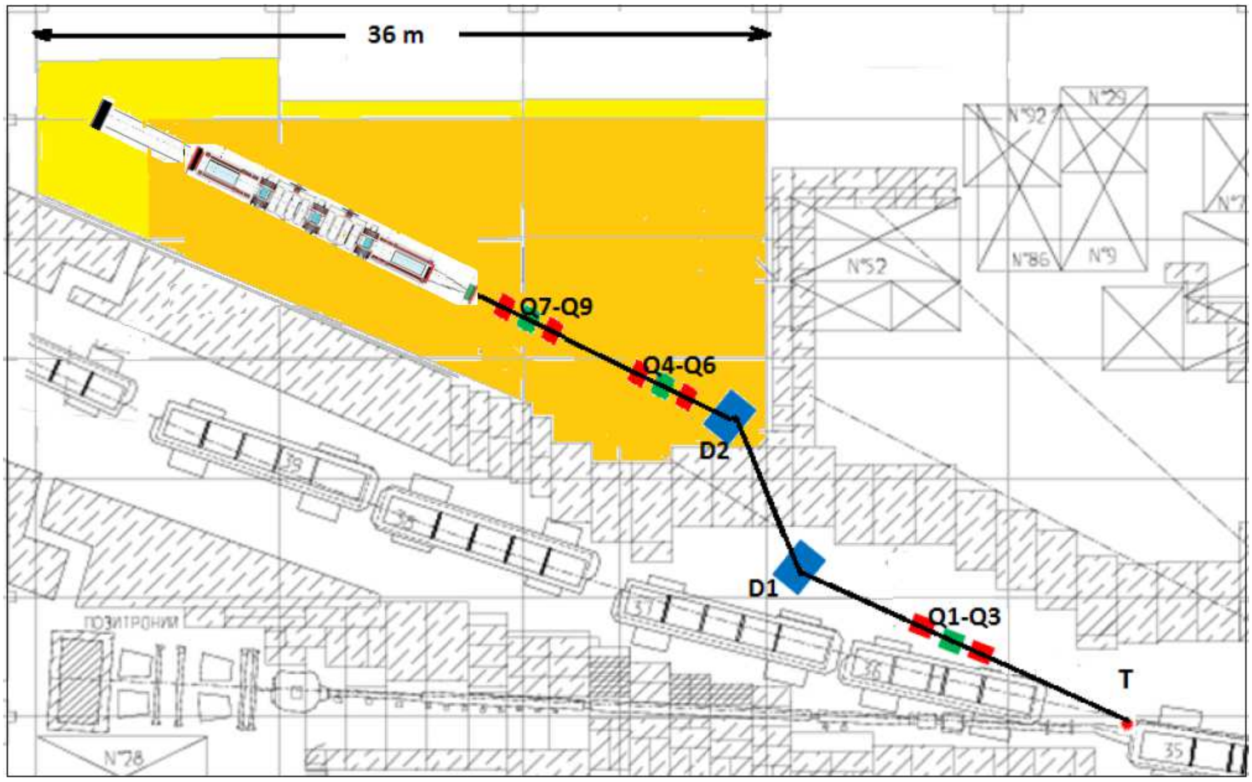

Fig. 2 The channel and facility layout

3. Characteristics of the muon channel

The channel scheme is shown in Figure 2:

- T : internal target,
- direction of the channel axis: 15^o
- Q1-Q3, Q4-Q9, D1, D2: equipment of the present MICE channel
- Rotation angles in D1 and D2: 45^0

- Distances: T -> D1 = 18.4 м, D1 -> D2 = 8.5 м, D2 -> EXP = 18 .1 м, T -> EXP = 45.0 м.
- The solenoid is not used due to the complexity of its placement inside the thick shield

To calculate the spectra of secondary particles, we used the RTS&T-2004 code *([Simulation of relativistic hadronic interactions in the framework of the RTS&T-2004 code, I.I. Degtyarev et al. Oct 2004. Prepared for Conference: C04-10-04.1, p.480-482]*).
For $p_\pi = 410$ MeV/c , $\theta = 15^0$ it gives:

$$\frac{d^2N\left(\pi^+\right)}{dpd\Omega} = 7\times10^{-10}(\text{MeV/c})^{-1}\mu\text{sr}^{-1}(\text{int.proton})^{-1}$$

The result of calculations of the muon spectrum in the setup is shown in Fig.3

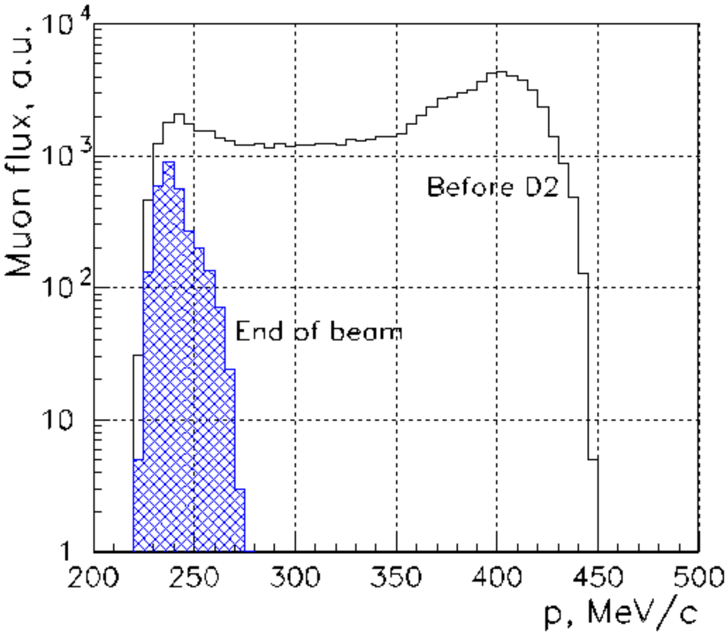

Fig. 3 The muon spectrum

Parameters of a muon beam:

$p_\pi = 410$ MeV/c

$p_\mu = 240$ MeV/c, r.ms. = 8.4 MeV/c

$I_{\mu+} = 1.2\times10^{-8}$ μ/interacting proton

It leads to following intensity:

$I_{\mu+} = 5\times10^3$ μ/cycle in "active" mode

$I_{\mu+} = 1\times10^3$ μ/cycle in "shadow" mode

Conclusion

Preliminary feasibility study leads to following conclusions:

- In the main experimental hall there is a suitable area for placing the installation
- Basic infrastructure parameters satisfy the requirements of the experiment
- The parameters of the muon beam satisfy the experimental requirements
- To reach certain conclusions, additional research is needed