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MOSCOW MESON FACTORY LINAC STATUS REPORT

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Abstract

This paper discusses the recent results of the Moscow Meson Factory Linac commissioning using a proton beam. The results of the accelerator longitudinal tuning are presented. The description of the realized and outlined improvements of some accelerator systems is given.

Introduction

The main results of the technical and scientific activities connected with construction of the 600-MeV linear accelerator of the Moscow Meson Factory (MMF) gained during 1992 are discussed in this paper. Some plans for the facility upgrade, aiming at better reliability are briefly presented. The MMF linac is designed to accelerate 50 mA of protons and H^- pulse current at the repetition rate of 100 Hz and a pulse length of 100 μs. The main tasks being reported during this period are:
1.Conducting the first experiment at the beam energy of 160 MeV and a repetition rate of 50 Hz; and
2.Acceleration of the protons in nine disk and washer structure (DAW) modules consisting of four sections each up to the energy of 250 MeV at the repetition rate of 1 Hz using a modified Δt-procedure.

Providing Beam for the First Experiment

MMF linac has an interruption in the regular DAW structure to extract the beam at the intermediate energy of 160 MeV. Beam extraction is done using a 26° bending magnet downstream of the fourth DAW module. In March and April, 1992, 160-MeV beam, with a very low current, was used for conducting the first particle experiment "π^0 production near threshold". It was for the first time that the proton injector, five drift tube (DT) tanks and four DAW modules have undergone long term simultaneous high average power tests at the repetition rate of 50 Hz.

The most serious problem occurs with the resonant frequency stabilization of the accelerating cavities. Temperature difference between the inside surface of the cavity and water flow from the DT was 1°C (tank#1) to 7°C (tank#5). In the DAW linac the temperature difference was about 1.5-2.0°C.In such circumstances occasional cavity shut down leads to quick (about 1 min) cavity mistuning and subsequent long restoration of the nominal field in the cavity.

To overcome this difficulty a special program was developed for the stepped cavity excitation using rf-heating of the cavity walls.

The stability of the beam parameters has been provided by the phase and amplitude control system which keeps the slow drift of the phase and amplitude better then 0.5° and 0.3%.The change of the phase and amplitude during the macropulse were found to be 0.4° and 0.4%. The detail description of the amplitude and phase control is given in the paper at this conference [1].

For automatic control of the phase of the DAWL relatively to the DTL a cavity operating on the fifth harmonic of the fundamental frequency 198.2 MHz has been used. This cavity has been installed at the output of the DT tank #5. The rf signal from the measuring loop of this cavity is compared with the signal taken from the reference line of the DAWL using a phase detector.The reference signal is used to adjust the phase of the driver amplifiers of the DAWL.

As a result of the operation mentioned above, π^0 -production cross sections have been measured for carbon, calcium, aluminum and lead targets [2]. This experiment took 85 hours of the stable operation of the linac at 50-Hz repetition rate.

250-MeV Beam Energy

During commissioning of the 160-MeV part of the MMF linac, longitudinal tuning has been done with the help of the magnetic spectrometer and cavity monitors operating on the third harmonic of the fundamental frequency. Downstream of the fourth DAW module (160 MeV) a matching two-section DAW cavity was made providing compensation for the debunching process in the extraction part that consist of several drift lengths. The dependence of the phase difference from a beam harmonic monitors vs the rf-field phase in the matching cavity was used to find the necessary values of the amplitudes and phase (Fig.1).

The longitudinal tuning procedure of the multi-tank linac usually consists of two stages [3]:
1.) Finding the rough (about 5% and 5°) values of the amplitude and phase of the field in a cavity;

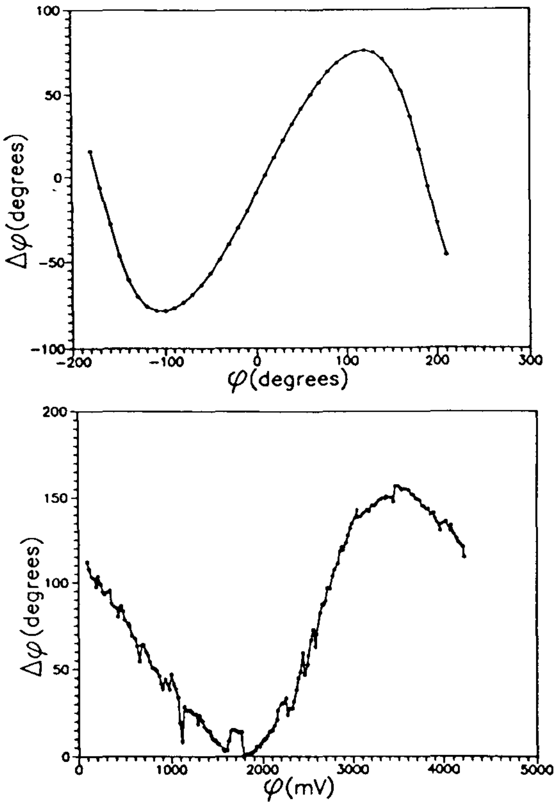

Figure 1: The phase difference from beam harmonic monitors vs the rf field phase in the matching cavity.

2.) **Precise adjustment of the amplitude and phase using the classical Δt-procedure [4] or its modifications.**

For beam accelerated from 160 MeV to 250 MeV, five DAW modules have been used each consisting of four sections. Preliminary amplitude and phase setting in this modules has been done using time of flight measurements from two the third harmonic cavity monitors placed about 1 m apart. Fig.2 shows the calculated and experimental phase difference from the beam harmonic monitors signals vs the phase of the rf-field in the DAW module #9. The precise amplitude and phase adjustment of the field in all DAW modules up to 250 MeV has been done using the Δt-procedure. Detail description of this method is given in [5]. It was found after the Δt-procedure the mean energy of the particles at the output of each module differs not more than .1% from the design value.

At the synchronous phase the maximum flux of neutrons from the beam dump was detected for each module. The dependence of the neutron flux vs beam energy was found (Fig.3).

In conclusion, the operation of the DAW accelerating structure proved to be stable and efficient providing precise parameters for the proton beam.

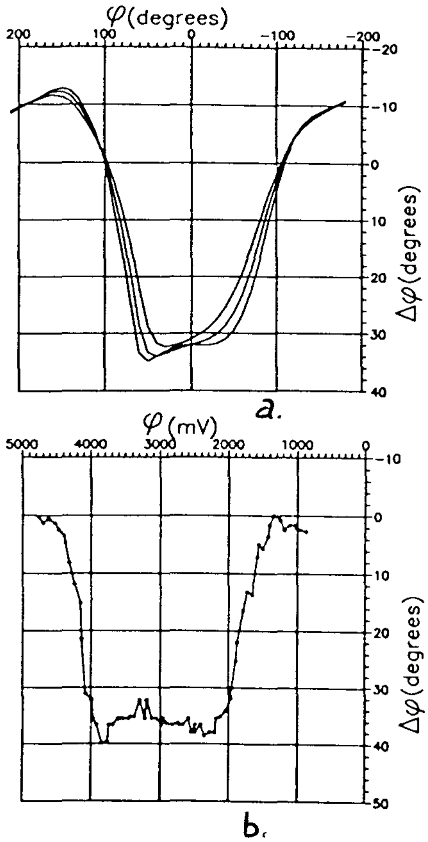

Figure 2: The phase difference from beam harmonic monitors vs the rf field phase in the DAW module #9. a) calculated at 3 rf field levels, b) experiment.

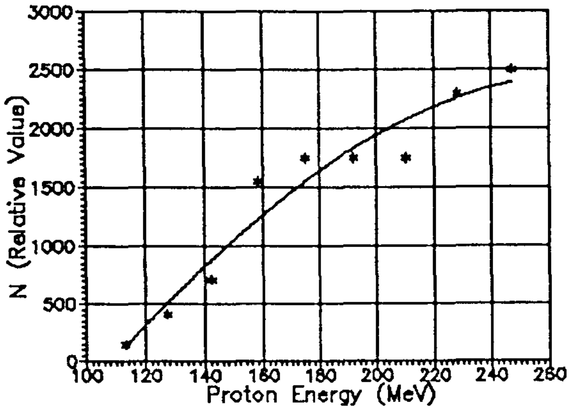

Figure 3: The neutron flux vs the beam energy.

Accelerator System Improvements

Long term operation has shown a number of weak points having significant influence on the accelerator reliability:

1.) In order to have the margin of electrical strength for a reliable beam loading compensation the new modulating tube for DTL having a maximum anode voltage of 120 kV was developed and is undergoing full power tests.

2.) 76 kV applied to the 991-MHz klystron anode requires higher electrical strength for all the high voltage elements. To increase their life-time we have been forced to develop an optimized output cavity for the 4.75 MW klystron. As a result the klystron anode voltage was lowered to 67 kV at the same output power. It has made the modulator operation much easier.

3.) A completely new 42-beam 991-MHz klystron is now under development. It will have an average power of 120 kW, a peak power of 4.75 MW and 60% efficiency. The first working prototype is nearly complete and ready for testing. This klystron must handle the increased duty factor while lengthening the macropulse from 100 μs to 200 μs without increase the net power consumption.

4.) The 750-kV pulsed transformer and accelerating tube of the proton injector proved not to be very reliable at full power and high repetition rate. It can not operate safely higher than 50 Hz repetition rate. Therefore the decision was made to develop an RFQ booster section from 400 keV to 750 keV that will be used for acceleration of protons and H ions. Lowering the injector voltage to 400 kV will make this operation simpler and will permit pulse length to 200 μs without saturation of the iron in the pulse transformer.

5.) Another RFQ has been completed recently. It is to be used in the polarized proton injector to accelerate 30-keV polarized protons to the energy of 750 keV. An atomic beam polarized proton source developing 10-mA peak current is now operational.

6.) The H^- low energy beam transport line fabrication is under way. The installation will be completed in 1993. In 1994, H^- beam will be available.

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