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200 MeV INJECTOR FOR THE CERN-PS

1. Project description

1.1 Introduction

This preliminary study has been based on the assumption that theoretical and experimental studies of the P.S. will point to a higher injection energy as the best means of achieving P.S. beam intensities in the high 10^{12} range per pulse. We have assumed an energy of 200 MeV, injecting 100 mA for several turns.

In order to extend the flexibility of the P.S. as a nuclear physics tool, the possibility of accelerating deuterons has also been included in the proposal ; that is acceleration in the $4\,\Pi$ mode through the Linac, yielding 14 GeV/c per nucleon from the P.S.

1.2 General planning

The overall aim must be a smooth rise in the P.S. intensity, with the minimum possible dislocation of the experimental programme before and after the change-over, and the minimum possible time occupied by the change-over itself. By "dislocation" one implies for example an imprudent diversion of effort from the present injector resulting in unsatisfactory operation, or unreliable and unstable running of the new machine, which would have a nuisance value apart from the nominal loss of experimental time. We can imagine the following general planning based on the above aims.

Phase I - Design and construction (4 years)

Construction of 200 MeV Linac and beam transport tunnel up to the limit of radiation safety at Octagonal Pt. 4. Tapering off of work on 50 MeV injector.

Phase II - Junction (shut-down plus several months)

Internal shielding at Octagonal Pt. 4 to permit completion of beam transport tunnel and junction with ring tunnel. Installation and tests of inflector tank and bending magnets. 50 MeV Linac continues to inject.

Phase III - Ring penetration (shut-down)

Piercing of ring tunnel and removal of shielding. Junction of beam transport.

Phase IV - Compatible operation (several months)

50 MeV Linac continues to inject.
200 MeV injection and acceleration tests.
"Debugging" of new equipment - 200 MeV Linac and inflector, timing, controls, R.F., securities.
200 MeV injection time gradually increased and radiation surveys evaluated.

Phase V - 200 MeV Operation

50 MeV machine shut-down.
P.S. intensity raised as performance or radiation permits.
Deuteron tests.
200 MeV controls installed in M.C.R.

Layout planning has been carried out in sufficient detail to establish that the 200 MeV machine could be integrated with the site planning west of the P.S.

1.3 General Implications on P.S.

It is evident that a change in the P.S. injection energy would require some changes in the R.F. accelerating system *, injection timing, etc... What are more difficult to assess however are the implications of higher intensity. The development of the P.S. during its 4 years of operation has involved, besides the steady rise in intensity to a figure some 70 times the design figure, the finding of ways to operate satisfactorily at this level. Further increases would demand, for example, further efforts towards the simplification of elements which have to be frequently serviced or removed from the ring, the restricted use of remote handling methods, the addition of further shielding, a judicious choice of materials and perhaps the replacement of some major items such as the vacuum chamber, shorter periods in the ring for personnel, and further ingenuity in reducing or localising beam loss, the latter aspect being strongly coupled to the evolution of the experimental programme.

Provided that these efforts can keep pace with intensity increases ** we can avoid the cost and disruption of a drastic re-build. This point will have to be carefully studied.

1.4 Effects on P.S. Performance

The peak intensity reached by the P.S. to date is 9.5×10^{11} protons per pulse. Taking the conservative view that this represents the transverse space charge limit, then extending the injection energy from 50 to 200 MeV should raise this limit by a factor of about 5, i.e. to about 5×10^{12} protons per pulse. This factor of 5 has been estimated by Hereward

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* One could profit from the reduced R.F. swing to gain some long straight sections if a reduced swing could be kept consistent with deuteron acceleration.

** Note that here we are interested in particles per second and that an increase in repetition rate is relevant.

in the paper "Long-term injector developments for the CPS" attached, and also by Resegotti (Intensity limitations by transverse space charge effects in present and planned CERN machines - AR/Int. SG 64-1) in which he takes into account the image forces analysed by Laslett and arrives at factors of 4.55 and 5.5 for the cases of coherent vertical displacement and single particle stability respectively.

The optimistic view is that the P.S. with 50 MeV injection should go up to at least 2×10^{12} p/p, in which case 200 MeV injection should take us to 10^{13} p/p.

2. Influence on Experimental Programme

In the early stages, it will be difficult to distinguish between, for example, tests carried out on the present Linac with the object of improving the beam loading compensation, and tests aimed at gathering information for a new design, but later the distinction may become clearer and with the reduction of P.S. maintenance time envisaged it may be necessary to ask for more machine development time specifically for the new machine studies.

Apart from this, the "general planning" outlined above has already placed the accent on a smooth transition with adequate time to ensure the reliability and stability of the 200 MeV machine before placing it in service.

In terms of shut-downs, the transition might require two or three weeks for the placing of shielding in the "junction" phase, followed a few months later by four to five weeks for the "penetration".

3. Budget and Staff

Roughly speaking, the Linac project itself should cost the order of 40 million (code 2 + 3) Swiss Francs and the injector could be designed and built by the combined efforts of the present MPS Linac Group and the Accelerator Research Linac Study Group (with perhaps the collaboration of NIRNS for the structure design), plus 25 more.

3.1 Budget

The budget aspects are summarized in Table I.

Concerning the design study, perhaps one half could be absorbed in present budgets. No attempt has been made to estimate in detail the cost of modifications to the P.S. for the higher energy. At first glance it would appear that such costs would be slight and could be absorbed in the Item 3 for "Commissioning". The budgetary implications of higher intensity are another matter but at this stage we can but guess at a figure of say 5 M.

3.2 Staff

The present development and exploitation of the 50 MeV Linac occupies about 25 people. Because of its increased complexity, mainly of the R.F., the 200 MeV machine might settle down to an exploitation and development figure of 35 people. This could consist of the 25 50 MeV people who had been gradually transferred to full-time occupation on the 200 MeV machine, plus 10 more.

For the later stages of construction, the 50 MeV machine had a group of some 30 people working on it. Let us estimate 50 for the 200 MeV machine, Taking say 15 from the 50 MeV machine one has to find 35, of whom 5 might be workshop personnel since workshop support on the spot would be

essential in such a project. The remaining 30 might comprise the full or part-time efforts of the A.R. Study Group plus scientific and technical personnel. The extent to which A.R. will be occupied on the 300 GeV injector work is unknown, but let us guess that we have to find 25 people of whom 10 will be needed for exploitation eventually.

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TABLE I – BUDGET

(code 2 + 3)

YEAR		1	2	3	4	5	6
1. DESIGN STUDY (MPS, AR)							
R.F. power tubes, vac. pumps, structure models (R.F. and mechanical), etc...		0.5	0.5	- - -	- - -		
Buildings							
2. CONSTRUCTION							
a) Buildings	5 M		2	2	1		
b) Tanks	12 M			6	6		
c) R.F. power	4 M		0.5	1.5	2		
d) Vacuum	5 M		1	2	2		
e) Cooling & ventilation	0.7M			0.5	0.2		
f) Focussing, controls, cabling	5 M			2	2	1	
g) Inflector	1 M			0.5	0.5		
3. COMMISSIONING							
Tests, Junction, Penetration, Compatible operation	5 M					5 (*)	
4. EXPLOITATION							
Annually	2 M						→
TOTALS		0.5	4	14.5	13.7	6	2
Design and construction	33.7M						
Commissioning	5 M						
Exploitation	2 M						
P.S. high intensity	5 M						