Introduction

The accelerator complex of Laboratori Nazionali di Legnaro is made by a super-conducting linac, ALPI, injected either by a Van der Graaf tandem accelerator or PIAVE, where the world's first s-c RFQ is running and regularly accelerates beams. PIAVE and ALPI are working reliably, at present, fulfilling the experimental programme of INFN-LNL prepared with the support of an international Programme Advisory Committee. However, further improvement of these facilities are required (among other upgrades) by the future proposed scenario of the laboratories. The most important challenges that Legnaro is facing are the experimental campaign with EU-detector AGATA in 2009 and the use of PIAVE-ALPI as a RNB accelerator in the SPES facility, which is planned for the near future.

AGATA (Advanced GAmma Tracking Array) is a 4π set of 180, large 36-fold segmented Ge detectors, designed to be operational at European Laboratories offering high intensity stable and unstable beams. Its demonstrator will be commissioned and tested for the first time at LNL with PIAVE-ALPI beams (2008-2010), then at GANIL (France) in an upgraded version (2010-2012) and finally at GSI (Germany) after 2012. The requested beams at LNL are medium-heavy ions accelerated at 20-40% more of the Coulomb barrier, which means $8 \div 10$ MeV/A depending of the ion specie and target.

So as to fulfil the experimental specifications of the AGATA demonstrator, higher heavy ion beam currents and energies are required on PIAVE-ALPI for SPES project. This is a RIB facility based on a fission target (10^{13} fission per second) driven by a 40 MeV proton beam. After the ^{238}U carbide target, the 1+ charged ions are selected by a high resolution mass spectrometer, charge enhanced by a charge breeder and then post-accelerated up to $8 \div 13$ MeV/A.

The required performances for both scenarios are beyond the limits of the present accelerating structures. Hence a complete study of the actual performances of the present machines and their possible upgrades have been performed.

In Chapter 1 ALPI accelerator is described along with its state-of-the-art s-c cavities, which thanks to an intense cavity technology development, have significantly boosted year by year the accelerator performances since 1995. An analysis of the periodic structure of the linac is performed to show how its performances could be extended if some conditions are satisfied. Examples of the customary machine set-up are also shown.

PIAVE injector is described in Chapter 2. Particular attention will be paid to the longitudinal beam emittance measurements recently performed and in general to all the injector characterization, which has brought to a complete definition of the present performances of PIAVE-ALPI complex.

Chapter 3 is dedicated to the ion source of PIAVE. The LNL have bought recently the Supernanogan ECRIS source from the French company Pantechnik. This new source plays a central role to fulfil AGATA energy requirements since very high charge state are required in order to accelerate properly the heaviest ion species. This is the reason why an accurate acceptance test of the ion source was made at Pantechnik site, including current stability tests and emittance measurements.

The first experiences with carbon stripper foils in ALPI are reported in Chapter 4. The foils, installed almost at the accelerator middle point, increase the charge state of the beam impinging on them. Therefore higher final energies could be obtained with the same voltage at the cost of a

lower current. Four beam stripping experiments have been carried out up to now: the analysis of the results perfectly matches the theoretical predictions and two examples of accelerated beams will be described.

Finally, Chapter 5 explains what it is possible to be expected from ALPI in 2009 when AGATA detector will be installed at LNL. The beams either simply accelerated or stripped and then accelerated will satisfy most of the users requests. However that is not enough for the SPES Project: a radical change of PIAVE layout has therefore been studied and as a consequence higher final energies with better beam quality are reached.