The new gas injection system for the LINAC4 accelerator at CERN

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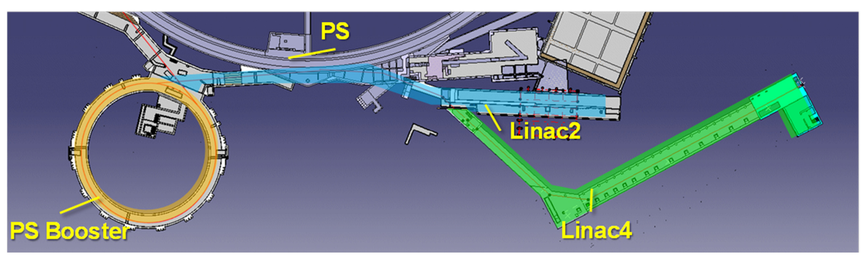
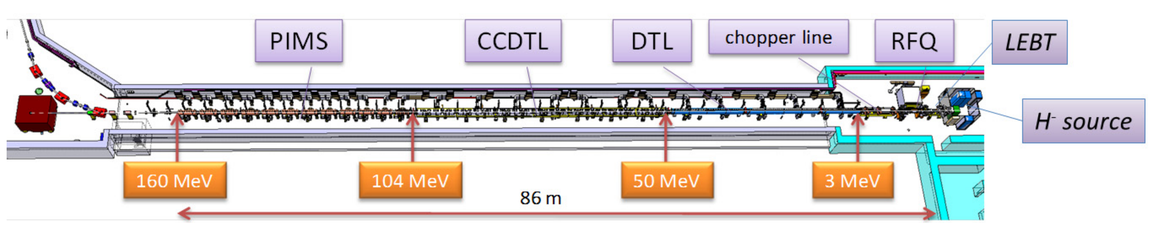
Introduction

The linear accelerator is the first stage of LHC injector complex.

- The reliability of the Linac has to be the highest of the entire accelerator complex: a fault of the heavy ion or proton ion source stops all experiments.
- The currently used proton Linac (Linac2) is in operation since 1978 has reached an excellent reliability (> 98%) over the last 5 years.
- The present configuration of CERN injectors for the LHC (years 1995-2000) allowed reaching the LHC goals.

➢ The Linac4 is an H^- linear accelerator, intended to replace Linac2 as injector to the PS Booster (PSB):
- Higher energy and charge exchange during injection shall improve brightness and reduces losses.
- It is 90 m long and will accelerate H^- ions up to 160 MeV.





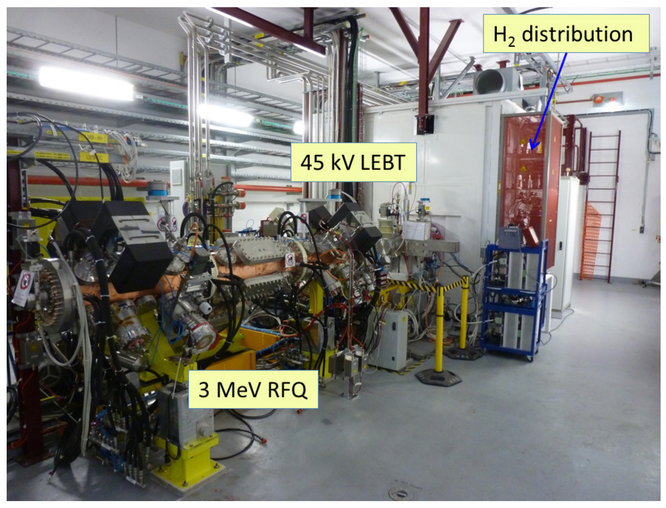
The Linac4 basic architecture

Upgrade of the LHC injector chain:
- 50 MeV p Linac2
- 160 MeV H^- Linac4

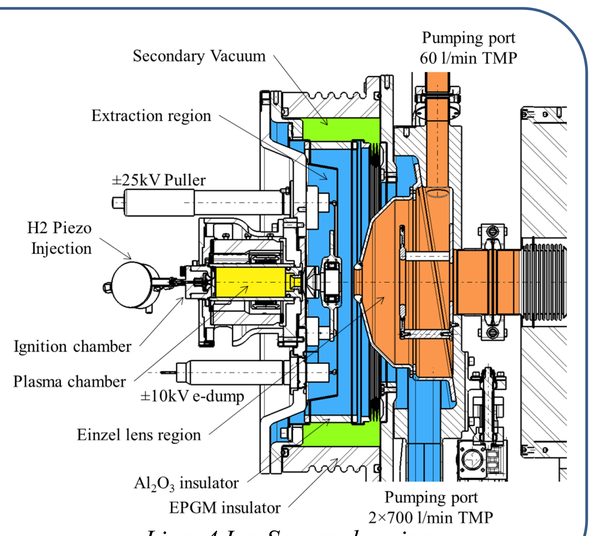
Ion Source and LEBT

The Linac4 H^- source is being developed, RF volume type, based on the design of the DESY HERA source (for commissioning), Cesiated surface H^- sources derived from the SNS source and Magnetron are considered for operation.
H^- ions are used in Linac accelerators because of the charge exchange injection process that improved the filling into circular accelerators.

The Linac4 Low-Energy Beam-Transport (LEBT) is based on a two-solenoid focusing system. LEBT systems for ion sources have to perform multiple tasks. Its main function is to match the extracted H^- beam into the subsequent accelerator structure (RFQ), giving the beam the desired radial size and angle.
The rest gas density in the LEBT can be controlled by a gas injection system, in order to compensated the beam space charge by rest gas ions. Eventually, the beam current and size can be measured via faraday cup and grids.



View of the Faraday cage in the Linac4 tunnel



Linac4 Ion Source drawing

Gas injection system for Ion Source and LEBT

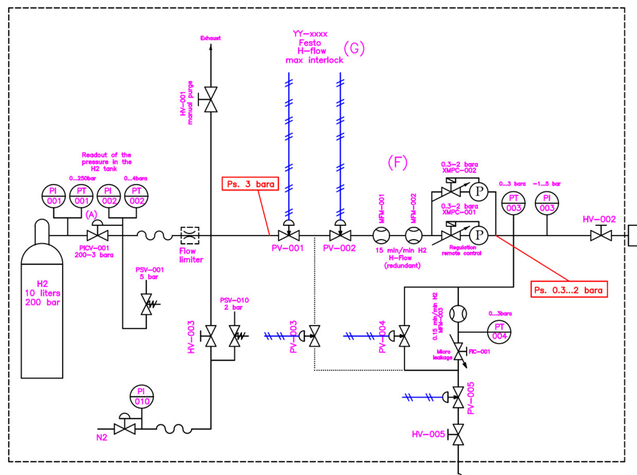
The gas injection system is providing a stable and constant H2 density in the range between 400 and 2800 mbara at 25 °C for reliable operation. It is separated from the 45 kV high-voltage platform of the ion source using a 50 cm long Al2O3 tube.

H_2 gas pulses, between 200 and 500 µs long, are injected into the source using a standard piezo-valve, which is operated with a repetition rate of 1-2 Hz.

Emphasis was given to safety, high leak-tightness, and cleanliness by using metal seals wherever possible and redundancy for maximum reliability.

Bronkhorst pressure regulators (XMPCs) are used to control the H_2 pressure. The total hydrogen consumption is monitored by means of thermic mass-flow meters (MFMs) and recording the pressure in the storage cylinders. In case an abnormal consumption, the gas system control immediately closes the hydrogen supply, and send alarms to the persons on-shift.

A prototype gas system was tested at LINAC4 3 MeV Test Stand setup from August 2012. The final unit was installed during summer in the new Linac4 tunnel at Bldg400 and first beam was obtained on September 2nd, 2013.



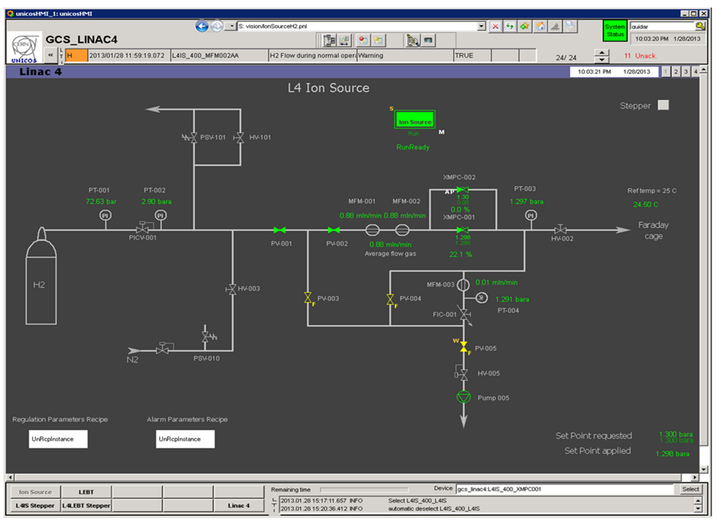
Linac4: Ion Source: P&I drawing

Ion Source and LEBT gas injection rack in the Linac4 tunnel

Linac4 H_2 gas cylinder

Control system for Ion Source and LEBT

The Ion source and LEBT gas systems are controlled by means of software running on an industrial PLC. A PVSS interface is used to monitor and control the process.



User interface for the control system

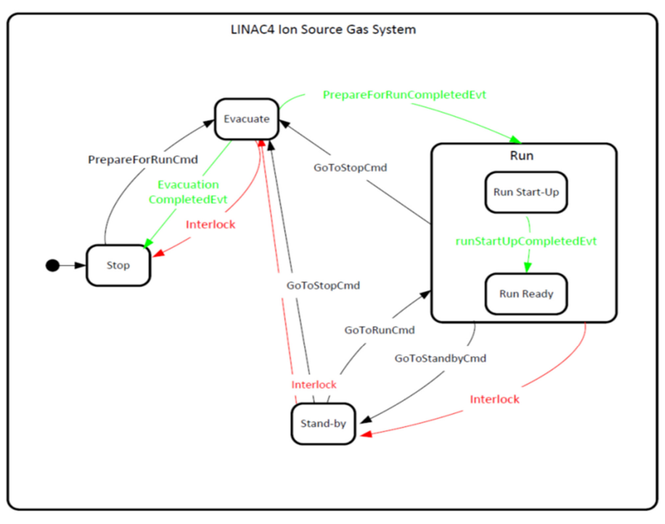
Gas system controls: Operational States

Stop – (maintenance, modifications)–all the actuators in their fail-safe positions. H2 has been evacuated from the system.

Stand-by – (allows interventions on other systems) –The gas system is stopped with all the actuators in their fail-safe positions, H_2 has not been evacuated.

Evacuate – (improve gas purity at H_2 filling) – H_2 is evacuated from the gas system until a certain pressure threshold is reached.

Run – (It is the normal gas system operational state):
Run Start Up: All devices are put is the Run mode state, but the warning limits are increased for a few minutes.
Run Ready: The gas system is running and all the parameters are stable and within the defined limits for this operational state.

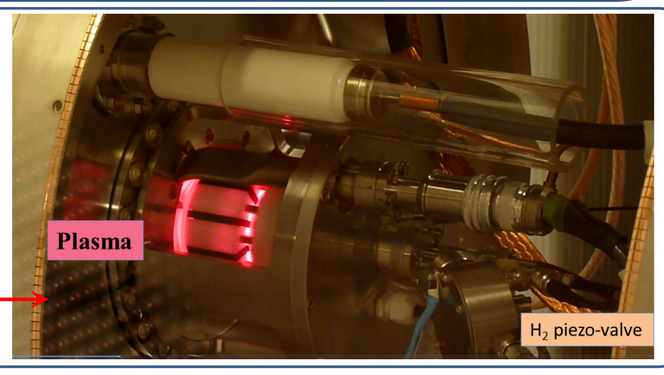


Operational states and transitions

A new gas injection system for the LINAC4 Ion Source and LEBT has been developed and fully tested first at the 3 MeV Test Stand and is now operational in the Lina4 accelerator tunnel.

The gas system is fully automated, controlled by an industrial PLC and remotely accessible through a PVSS interface.

The supply pressure is corrected according to the environmental temperature and the achieved density stability is better than 0.5 mbara 25 °C



Plasma formation in the Ion Source chamber during the first beam on September 2nd

[1] Linac4 Technical Design Report, CERN-AB-2006-084 ABP/RF.
[2] Status of Linac4 construction at CERN, M. Vretenar, 26th International Linear Accelerator Conference, *LINAC12,* Tel Aviv
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