DEVELOPMENT OF NON-INVASIVE TRANSVERSE PROFILE MONITORS FOR THE ESS LINAC

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The European Spallation Source (ESS) consists of a partly superconducting linac which will deliver a **2 GeV, 5MW proton beam** to a rotating tungsten target. This linac will produce a **beam of 62.5mA with a pulse of 2.82 ms and 14Hz**. Beam transverse profile monitors are an important tool in proton beam diagnostic as they insure that the lattice parameters are set and the beam emittance is matched. In the ESS linac, the beam transverse profile measurement will be performed by two different kinds of device[1][2], an invasive and a non-invasive one, located in the same module. The invasive device, used during the commissioning at low current and short pulse, will be a wire scanner[3]. The development of a non-invasive device appears necessary as the wire scanner will be damaged at full beam power and as non-disturbing measurements of the beam profile are required during normal operations.

NON-INVASIVE PROFILE MONITORS

The ESS Non-invasive transverse Profile Monitors (NPM) are based on the **interaction processes between the proton beam and the vacuum chamber residual gas**. The residual gas in the beam pipe is expected to be primarily **composed of H_2 (65-80%)** with the rest being a mixture of CO, CO_2, CH_4, Ar and H_2O.

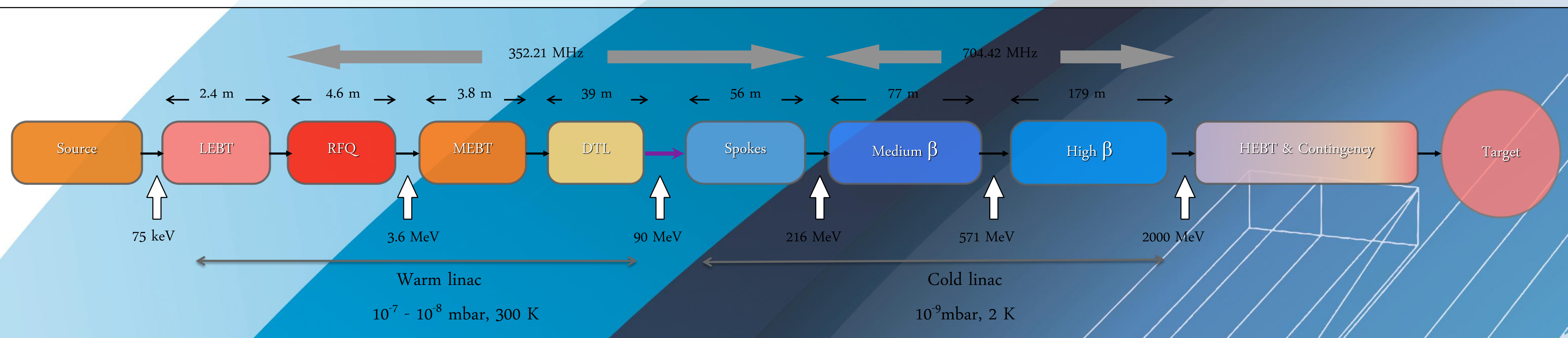

Figure 1: ESS linac.

BEAM INDUCE FLUORESCENCE PROFILE MONITOR [4][5][6]

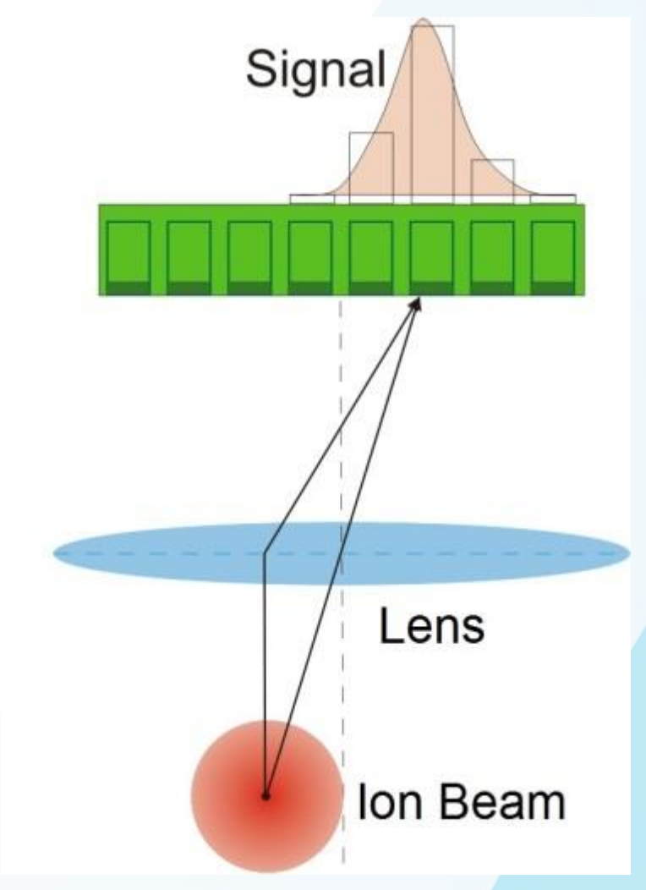

Figure 2: BIF principle.

The BIF monitor is based on the **fluorescence emission of the excited residual gas** (H molecule).

In the current ESS linac layout, **4 BIF** will be used in the **warm linac** section and **4** in the **HEBT** part.

One of its advantages is that it allows to use a **simple optical design**, which can be **easily changed** since all the device components, except for the beam pipe viewport, are outside the beam pipe. The other advantage of the BIF is that measurements can be performed for both **horizontal and vertical profiles at the same place**. This last point fits well to the constraint on the **available space** for the NPM in the warm linac, which is about **10 cm**.

IONIZATION PROFILE MONITOR [7][8][9]

The IPM monitor uses the **charged particles, produced during the interaction of the beam with the residual gas**, to obtain the profile of the beam.

In the current ESS linac layout, **5 IPM** will be used in the **cold linac** section.

The current ESS IPM design produces **a 600 kV/m**[2] via 2 symmetric plane electrodes on which a voltage of 30 kV is applied. This electric field accelerates the secondary ions produced at the IPM center to a scintillator screen in **42 ns**. It also **decreases the space charge effect** of the beam which would disturb the ions trajectory and distort the profile.

Due to the dose rate[10] in the cold linac section, a **scintillator screen** is preferred to collect the secondary ions.

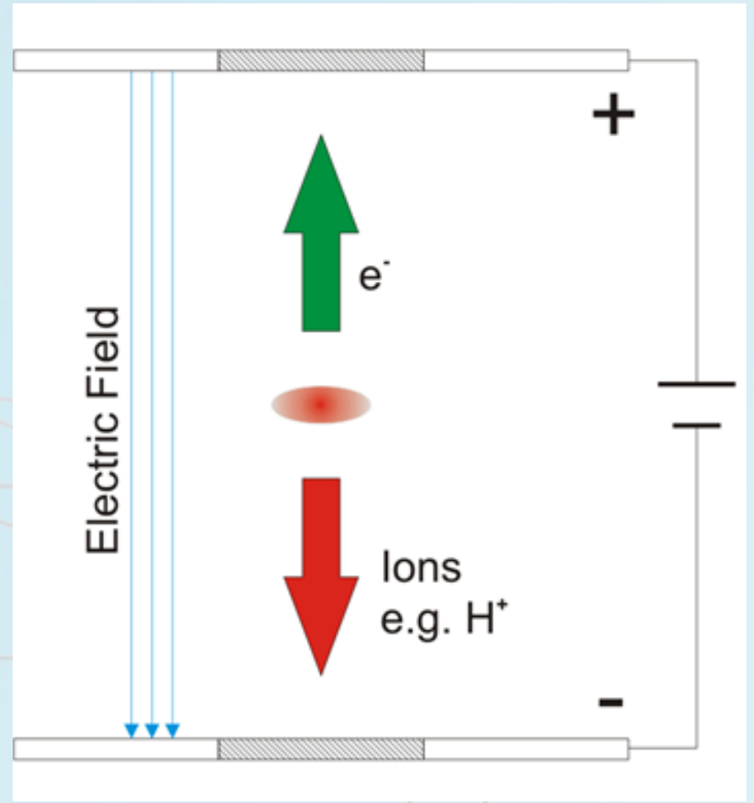

Figure 3: IPM principle.

EFFICIENCY TESTS OF SCINTILLATOR SCREENS

The experiments to test scintillator screens for the IPM have been conducted at the DESIREE facility of the Stockholm University.

The accelerator was delivering a **proton beam of 20 nA** and 4 energies: **10, 20, 30 and 40 kV**.

4 scintillator screens have been tested:

- a P47 screen with a ITO layer (emission wavelength = 420 nm),
- a P47 screen with an Al layer (emission wavelength = 420 nm),
- a YAG:Ce screen with a conductive layer (emission wavelength = 550 nm),
- a CaF2:Eu screen with a conductive layer (emission wavelength = 435 nm).

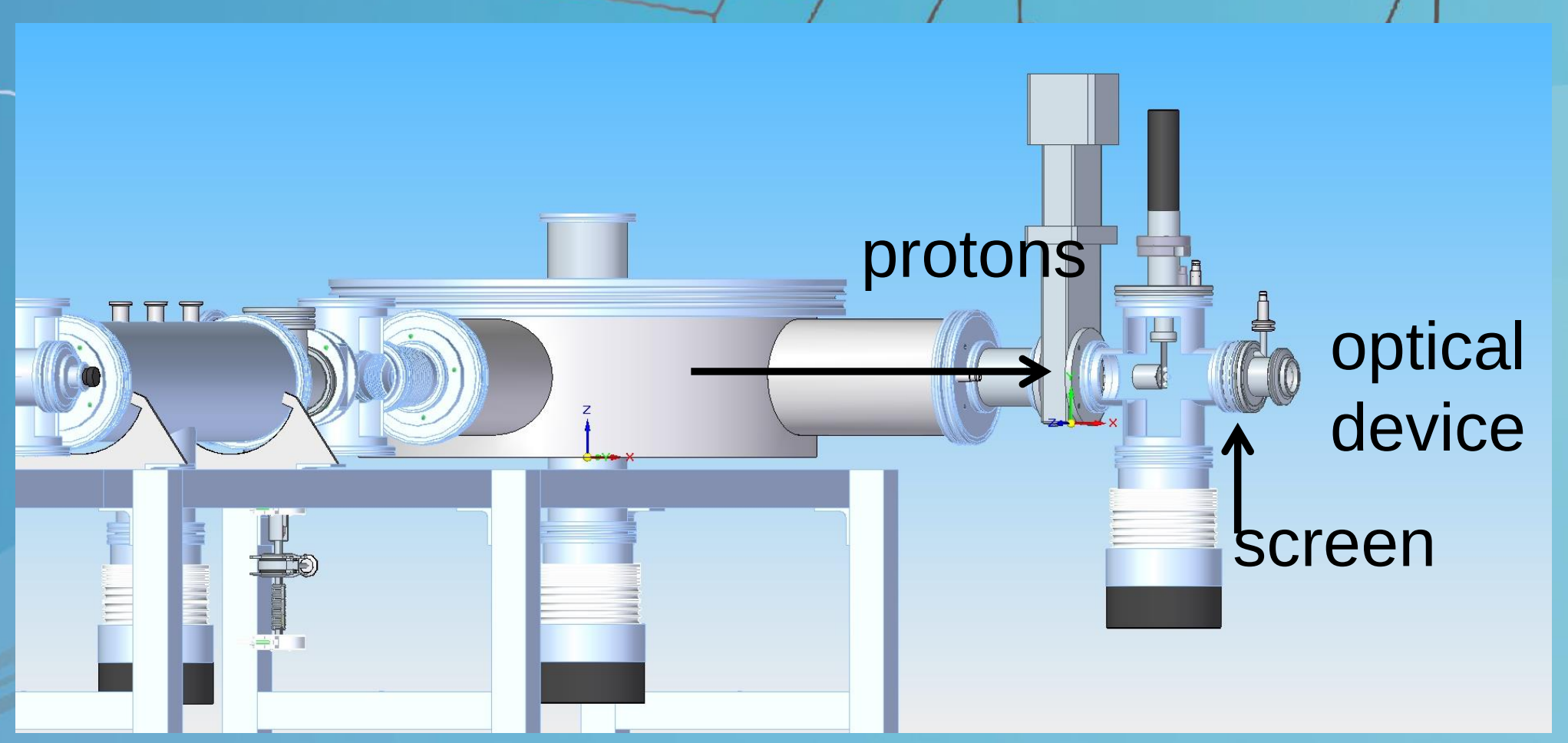

Figure 1: Setup of the experiment.

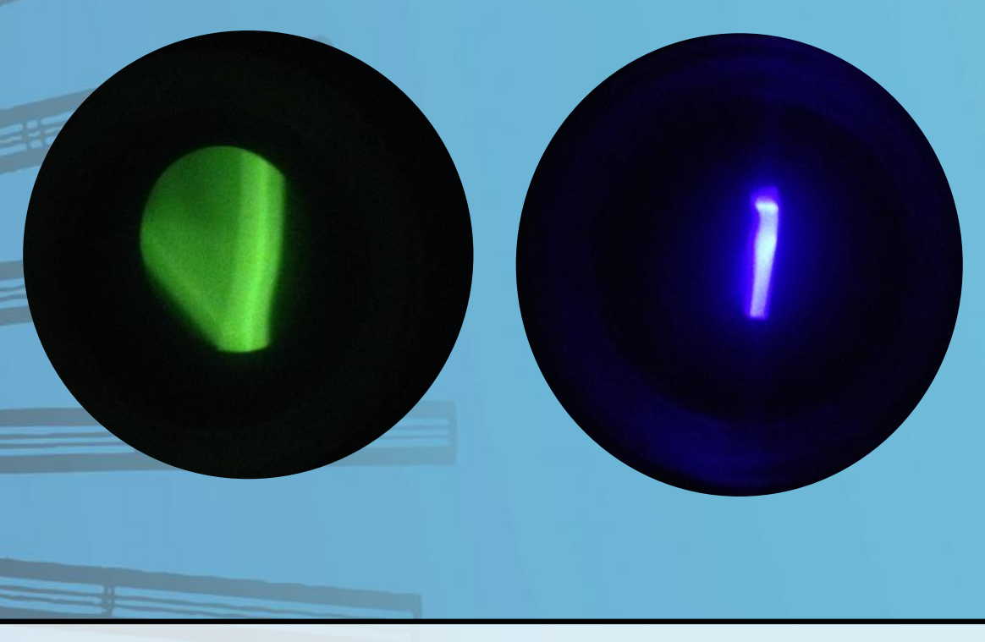

Figure 2: Light produced by the YAG:Ce and CAF2:Eu screens.

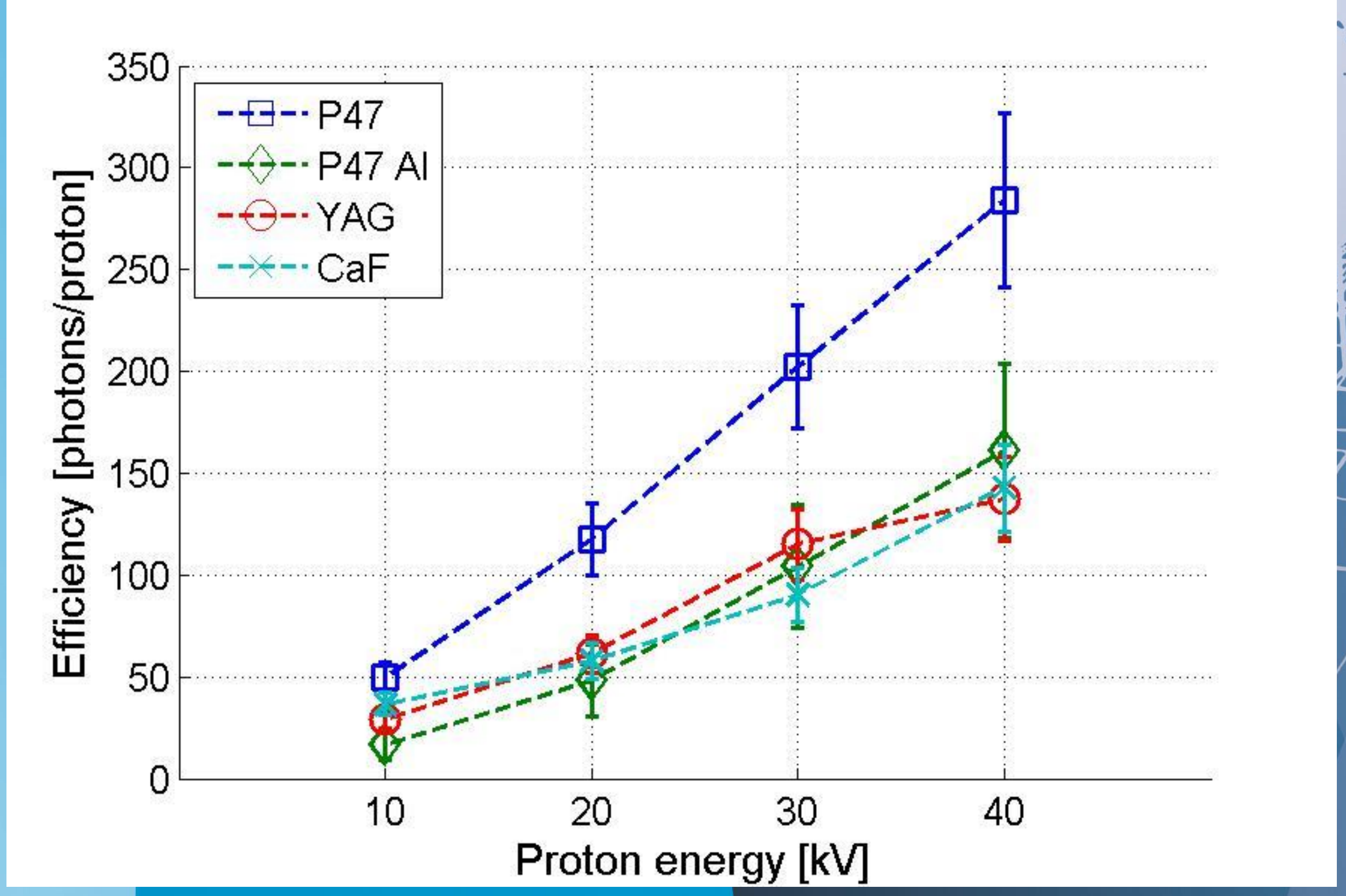

Figure : Screens efficiency in terms of number of photons per proton.

The **results** shows that **the efficiency of the P47 screen is two times higher compared to the others**. The relative uncertainty is about 15% and is due to the beam current fluctuations. For the efficiency parameter, the P47 screen with a ITO layer is the preferred choice for the IPM.

However this choice depends on the screen **radiation hardness** as well. Tests will have to be performed in order to be able to answer the question concerning the screens efficiency and its radiation hardness.

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