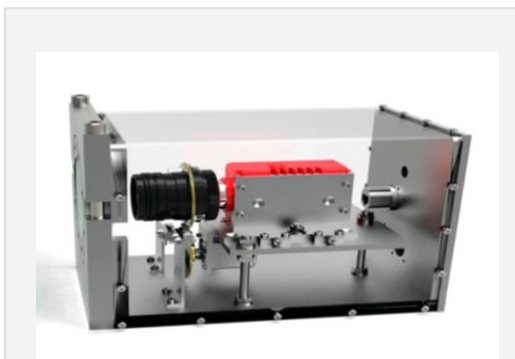


# Technology Transfer Opportunity

## Non-Invasive Beam Profile Monitor

New approaches are required for high energy and intensity accelerators. The established techniques to transverse beam profile monitoring are currently not able to handle the high power stored in their beam. The conventional diagnostic is no longer suitable for high energy/high intensity accelerators. Ideal for many applications would be a slightest invasive beam profile measurement technique that allows continuous operation of an accelerator whilst providing comprehensive data about the particle beam. The Non-invasive Profile Monitors in the ESS has been design to be primarily beam position monitors, where conventional RF based techniques do not apply. The innovative instrument measures the transverse beam profile by imaging the fluorescent gas induced by the accelerated proton beam. The NPM instrument is capable of measuring the beam centroid, its angle and the transverse size. The NPM include two systems, Fluorescence-based Profile Monitor (FPM) and Ionization-based Profile Monitors (IPM). This report will focus on the first system type, FPM, which depend upon the detection of the light produced from the excited residual gas.



### The NPM Features

Single shot capability  
Beam Position:  $\pm 50\mu\text{m}$  accuracy  
Beam angle:  $< 0.2\ \mu\text{rad}$   
Beam size:  $< 5\%$  precision  
Beam profile: 1% linearity  
Emittance: 1% precision

“With ESS, we are developing the NPM instrument to go beyond only measuring the beam profile, to also measure the beam position, angle, and within some condition the beam emittance. “

- **Cyrille Thomas**,  
Beam Diagnostics physicist  
European Spallation Source



### The Issue & Solution

Non-invasive Profile Monitor (NPM) have been designed at European Spallation Source for the measurement of the beam profile at high power. NPM has been designed to monitor the position of non-RF structured beam with  $100\ \mu\text{m}$  accuracy or better, and in addition enable beam profile and size measurement. The ESS Non-invasive Profile Monitor is a complex and innovative diagnostic tool. It is used for high beam currents without disturbing the beam, hence the name non-invasive monitor. NPM can be used when the machine is running at full power, addressing two complex issues;

1. NPM may have to image the beam in a single photon counting mode, where the light intensity is very low.
2. The camera may have to be placed in a shielded area that could be far away from the beam, due to the high-level radiation.

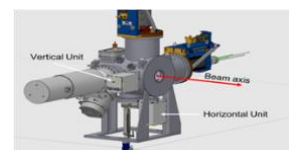
The NPMs system images the fluorescent light induced by the beam onto a camera sensor. For low light conditions, an image intensifier may be used. In all cases a properly selected lens a camera may be used.

### Application

Beam diagnostics for accelerators, in particular it can be used as a beam position monitor in accelerator where the beam is not bunched by an RF structure. Use at ESS in the Low Energy Beam Transport (LEBT) and in higher energy sections.

### Operating principal

Fluorescence imaging of the vacuum gas excited by the beam of particles. The imaging device is fiducialized to support beam position performance and required precision and accuracy on other measurements.



### The Market

The market for the NPM diagnostics equipment is accelerator facilities around the world. Non-Invasive Profile Monitors are highly desirable for all particle beam. The invention is valuable in applications where real time monitoring of the beam properties is required while beam preservation and minimal influence on the vacuum are of the greatest importance. The NPM makes it possible to measure the transverse beam profile non-invasively. The Non-invasive Profile Monitor can reveal the beam's properties and helps in determining the behavior for high beam currents, where the beam's properties are difficult to measure.

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