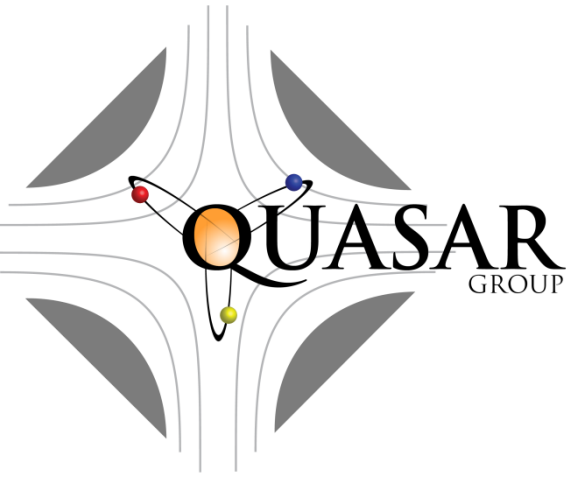


# ALIGNMENT OF A NOZZLE-SKIMMER SYSTEM FOR A NON INVASIVE GAS JET BASED BEAM PROFILE MONITOR

V. Tzoganis \*, C.P. Welsch, Cockcroft Institute and University of Liverpool, UK



## Abstract

A non-invasive gas jet-based beam profile monitor has been developed in the QUASAR Group at the Cockcroft Institute, UK. This shall allow monitoring ultra-low energy, as well as high energy particle beams in a way that causes least disturbance to both, primary beam and accelerator vacuum. In this setup a nozzle-skimmer system is used to generate a thin supersonic curtain-shaped gas jet. However, very small diameters of both, the gas inlet nozzle and subsequent skimmers, required to shape the jet, have caused problems in monitor operation in the past. Here, an image processing based technique is presented which follows after careful manual initial alignment using a laser beam. An algorithm has been implemented in Labview and offers a semi-automated and straightforward solution for all previously encountered alignment issues. The procedure is presented in detail and experimental results are shown.

## Motivation

- Least interceptive instrumentation is highly desirable .
- Established techniques for transverse beam profile monitoring are in many cases invasive.
- Non-invasive techniques such as residual gas monitor take a significant amount of time to acquire a profile.
- A new non-invasive technology applicable across a large range of beam energies is based on the use of a supersonic gas jet.

## Alignment Issues

### Observations

- Alignment is lost when system is under vacuum.
- Elements of the setup move during pump down.

### Solution

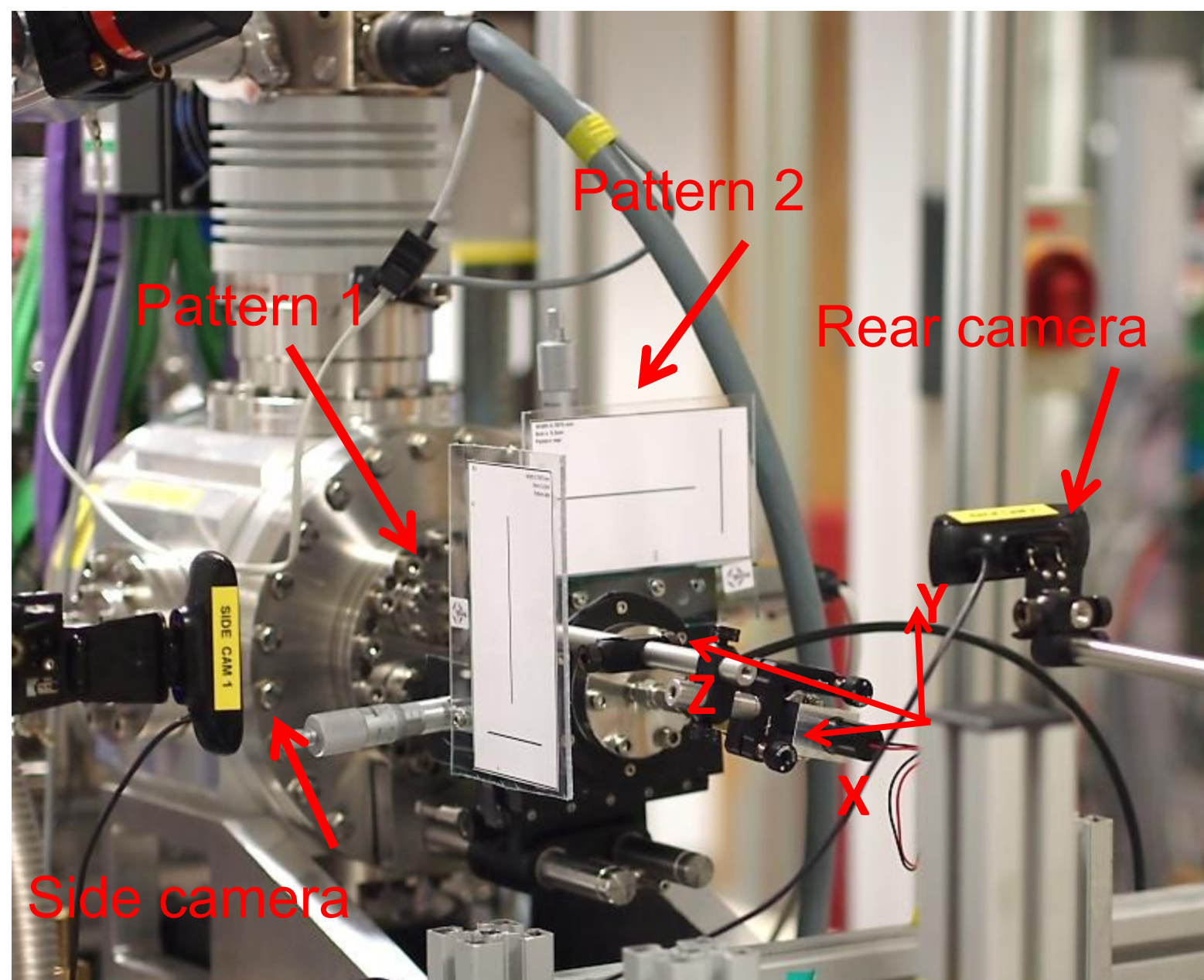
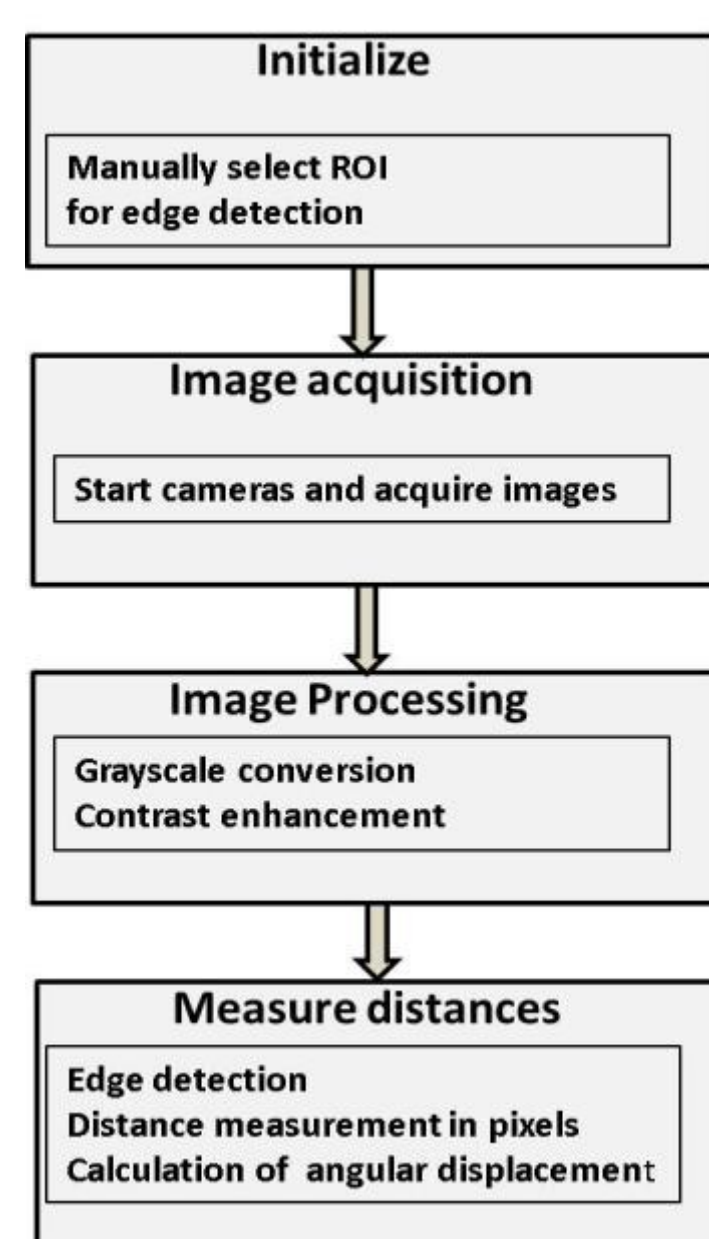
- Dedicated move detection system

### Methodology

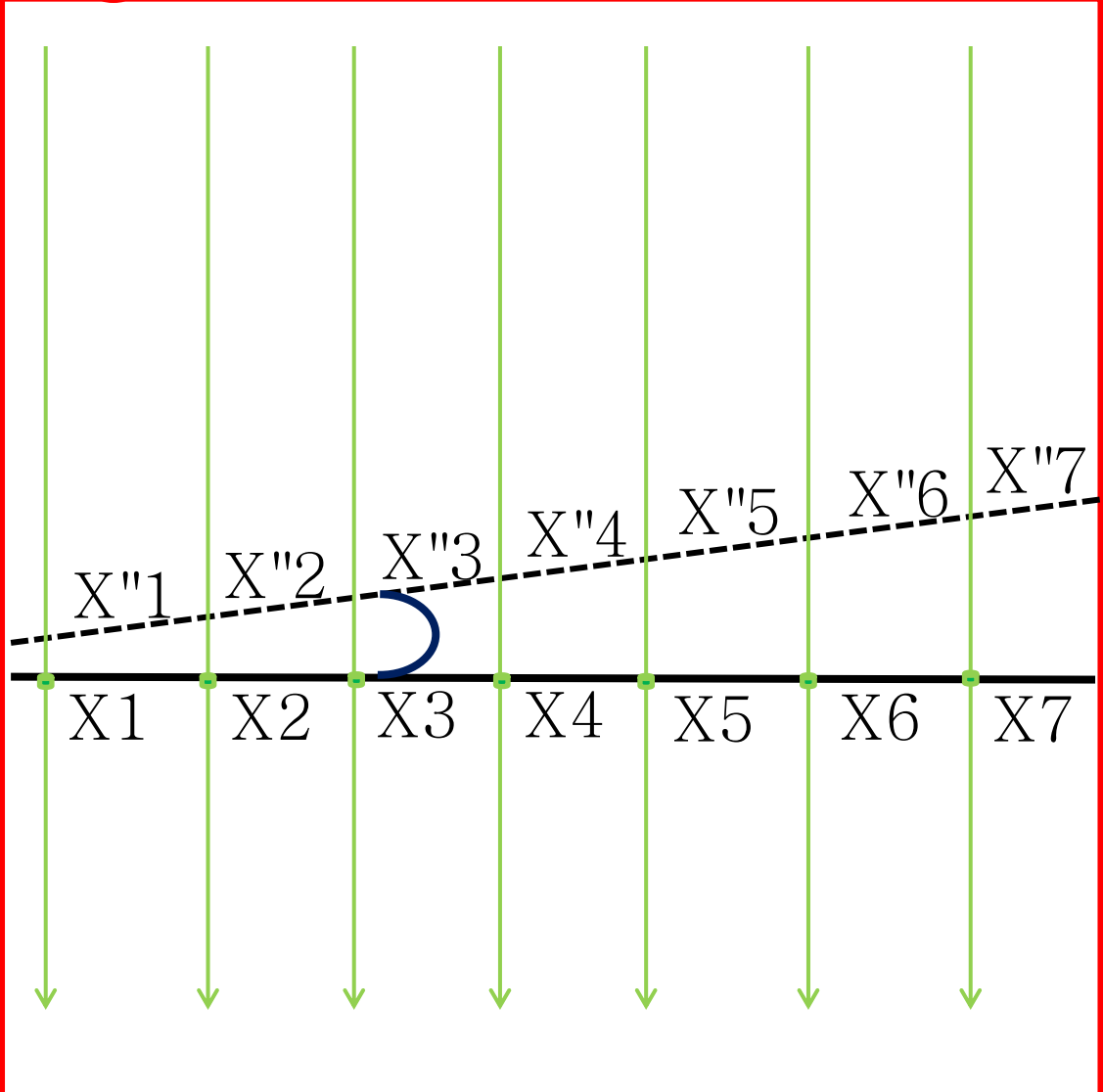
1. Edge detection algorithm in NI Labview.
2. 2 HD Logitech C902 cameras, 2592 x 1944 resolution and 8 bit color depth.
3. 2 patterns consisting of a pair of black lines printed on white background.
4. Very careful manual initial alignment.

1

2



Region of Interest



### Algorithm operation

- Measure distances x1 to x7.
- Log them as reference position.
- Compare x with x''.
- Check for angular displacement comparing (x1-x''1) and (x7-x''7).
- Calculate the linear displacement from x''1 to x''7.

## Conclusions

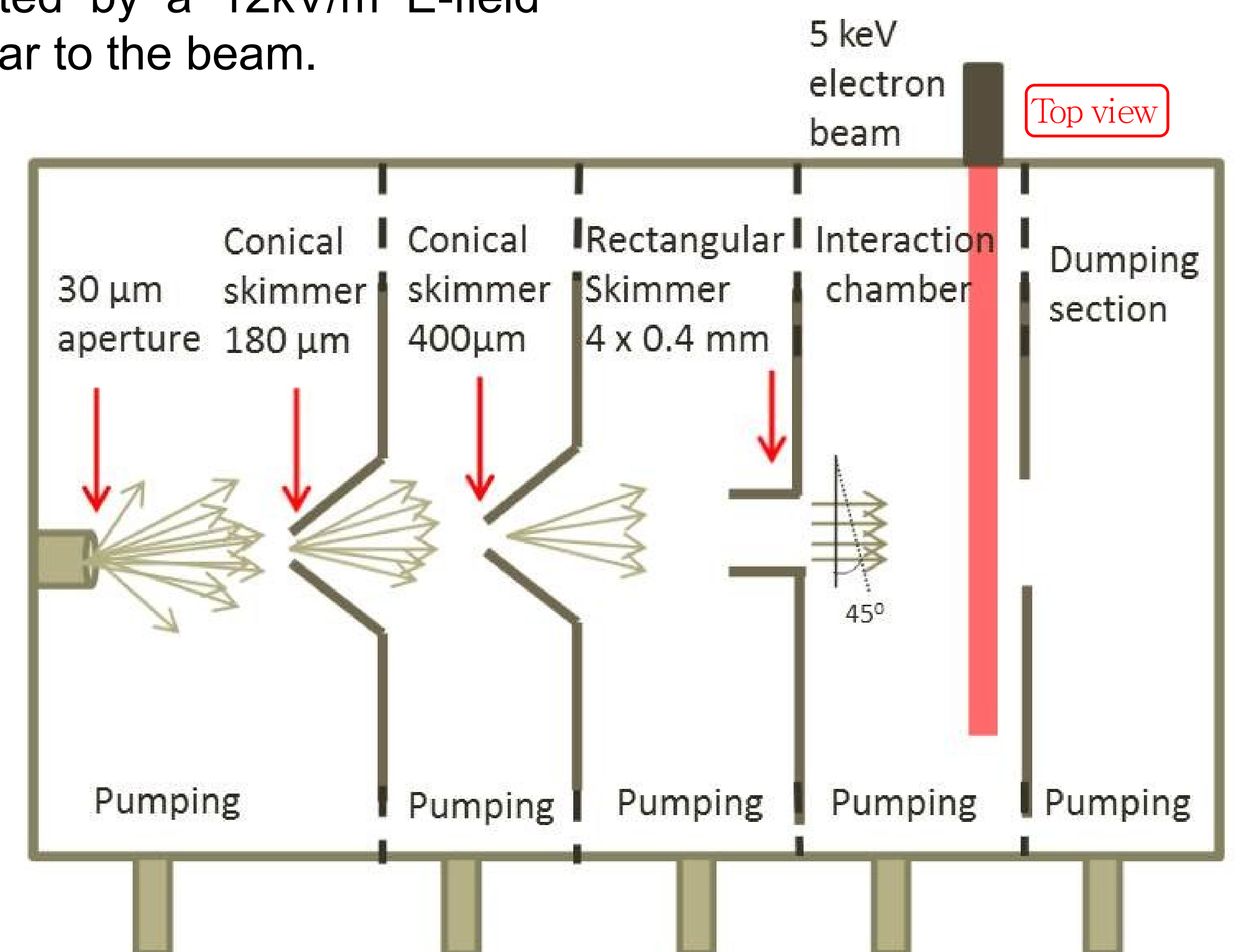
- Gas jet monitor could potentially be used in almost any accelerator, covering different particle types, various beam energies and a very wide vacuum pressure range.
- Careful alignment of all components is crucial.
- The presented procedure offers a fast and accurate solution for movement detection and correction of any displacement as large as ~500  $\mu\text{m}$  .

## Outlook

- One more challenge is related to the absolute position of the jet and in overlapping it with the primary beam.
- Recent results from simulations indicate that a Fresnel Zone Plate could be used as a focusing element.

## Gas Jet monitor operation

- Neutral gas expands in the vacuum
- Skimmed and shaped
- Interaction with 5 keV electron beam
- Ions and electrons production
- Ions extracted by a 12kV/m E-field perpendicular to the beam.
- Directed to the detector scheme
- MCP paired with Phosphor screen
- Light imaged by a CCD camera.
- Gas jet is evacuated after interaction.



## Initial alignment

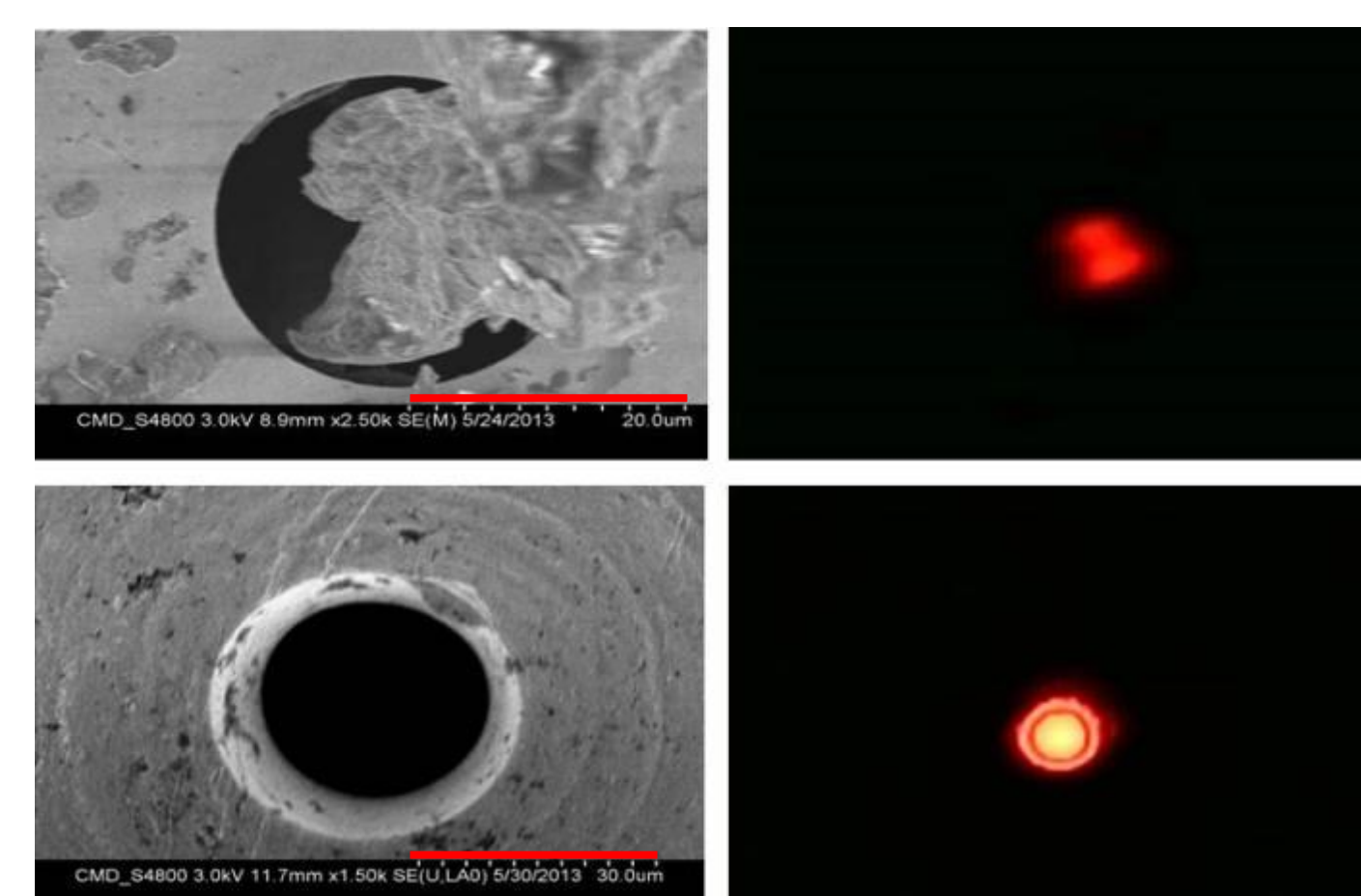
- Highly accurate alignment is required.
- Remove the 30 $\mu\text{m}$  aperture is from the setup.
- Shine a laser through all skimmers.
- Image laser beam from the other side.
- Move the skimmers slightly with fine manipulation
- Until maximum intensity is achieved.

### Second step

- The aperture nozzle mounted on it's tube has to be examined in a different setup
- A laser is shined through and a camera right after the aperture is recording the image.

### Third step

- Aperture's tube returns to the setup.
- Laser is shined through all skimmers and aperture.
- Very fine movement of the nozzle's translating stage lead to precise alignment.



## MECHANICAL UPGRADES

- To allow a laser to be shined along the gas expansion path while the chamber is evacuated.
- T-Connector , glass viewport and a safety valve.



- **Left** :images from SEM, Right: from camera
- **Upper row**: aperture is blocked.
- **Lower row**: the aperture is clean and perfectly circular

**Work supported by** the EU within DITANET under grant agreement 215080, HGF and GSI under contract number VH-NG-328, the STFC Cockcroft Institute Core Grant No. ST/G008248/1, and a RIKEN-Liverpool studentship.

