Challenges in Microscope Mode Imaging Mass Spectrometry

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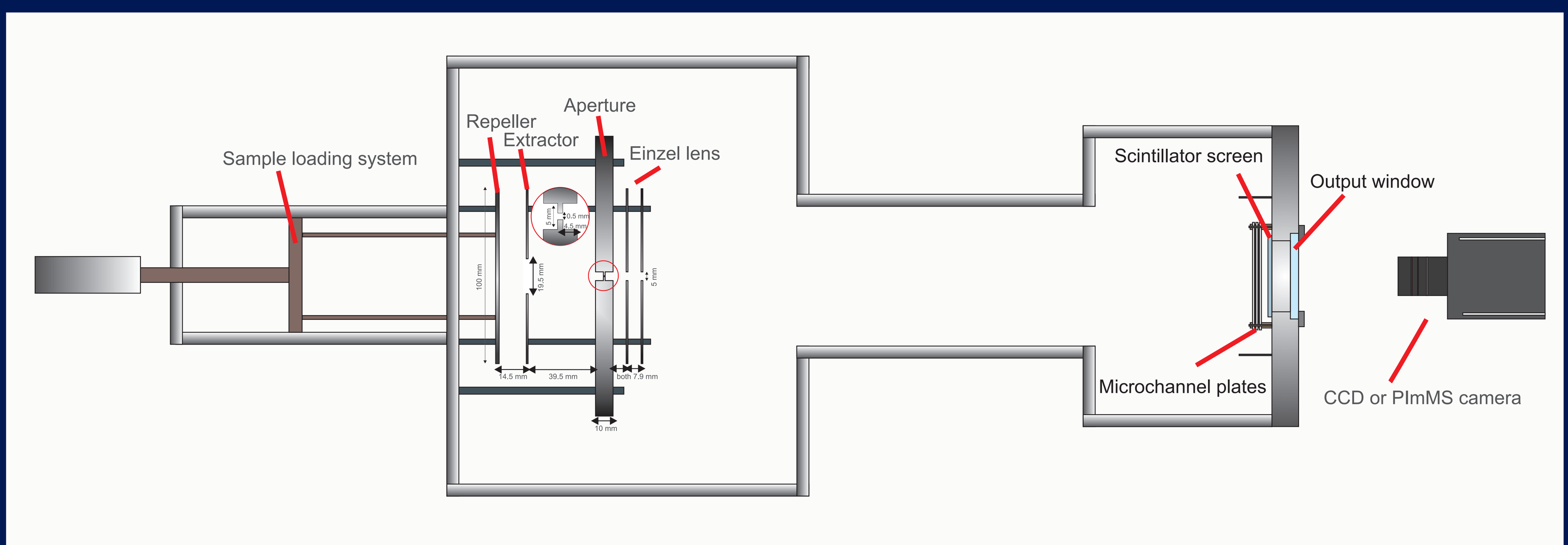
Aims

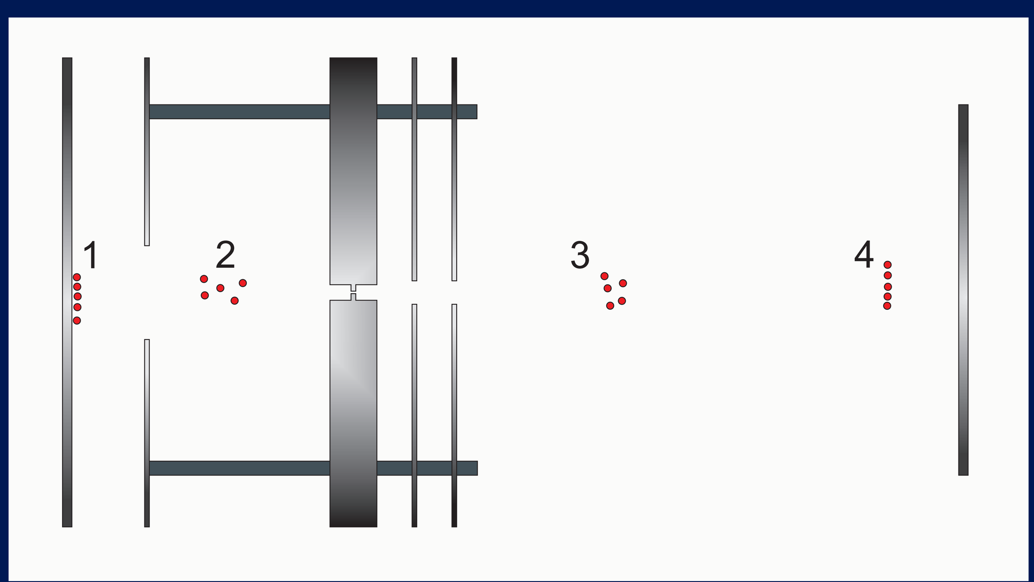
- To construct a linear microscope imaging mass spectrometer
- To apply a post extraction different extraction (PEDA) method to gain an enhanced ToF resolution [1,2]
- To develope a new scintillator based imaging ToF detector

Experimental setup



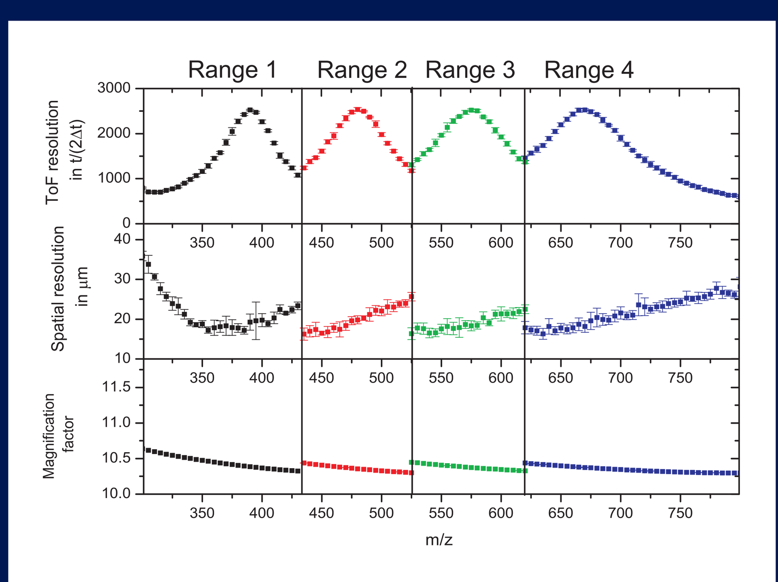
- 4 mm experimental field of view
- MALDI/ LDI ionisation of a large sample section
- Spatial mapping onto a novel scintillator based imaging detector
- Image collection using a CCD or a multi mass imaging PImMS camera [3]

Ion extraction using the PEDA technique

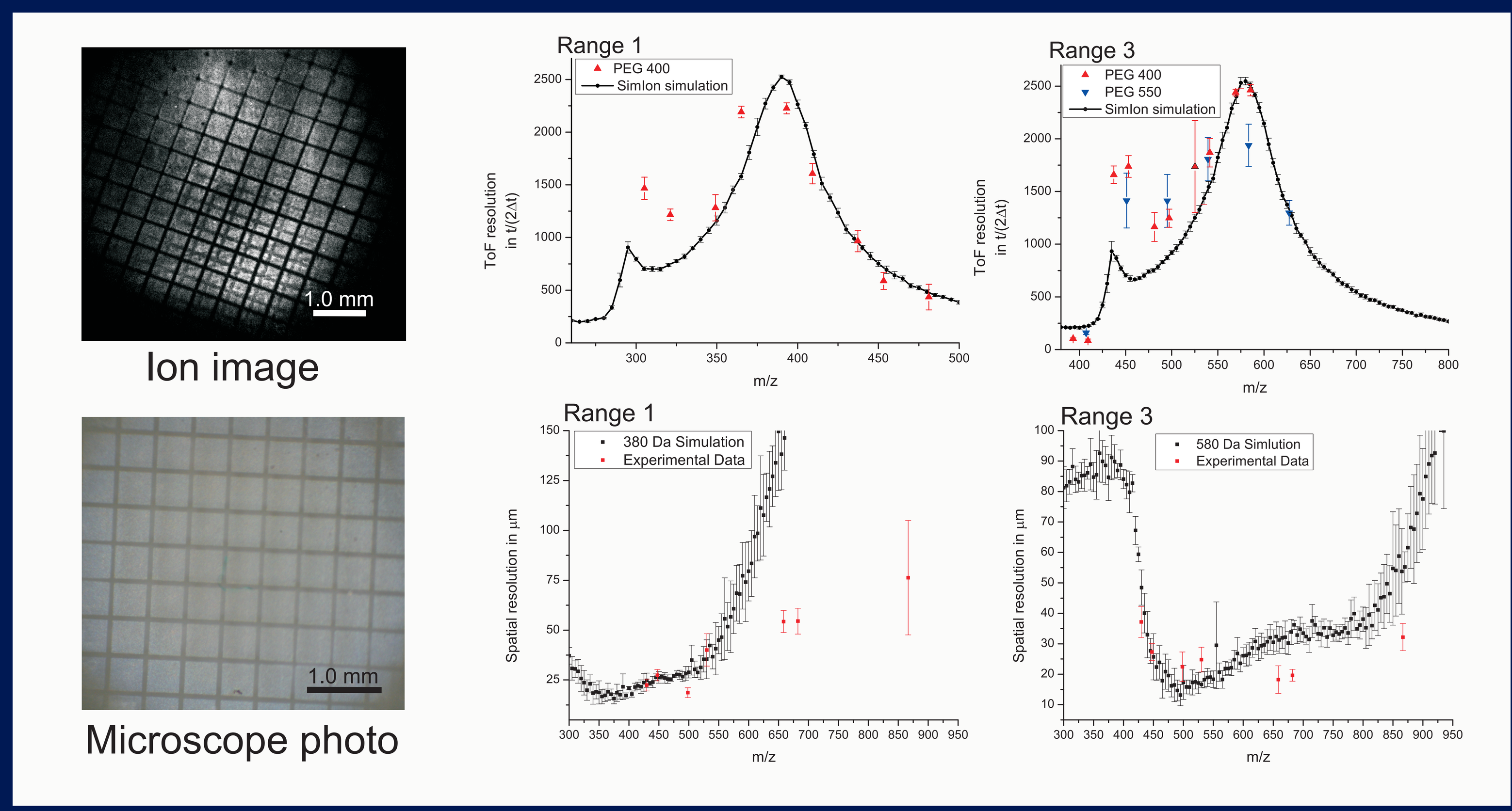


1. Ions are extracted immediately after ionisation using a static electric field formed between the repeller and the extractor electrode.
2. Once the ions of interest are situated between the extractor electrode and the Einzel lens, the extractor is pulsed to a higher acceleration potential.
3. The ions are time/spatially focussed as they traverse the field free region
4. When the time focus plane is coincident with the detector plane, microscope mode imaging with high ToF resolution becomes possible. The inital ion velocity spread can be corrected.

- ToF and spatial resolution, are a result of the mass dependent focussing properties of the ion optics
- For two different particle masses, it is possible to maintain the mapping position by adjusting the applied potentials, but maintaining the voltage ratios between the electrodes
- Multiple mass ranges can be defined in which the spectrometer specifications are maintained.
- Spectrometer can be tuned to any mass range



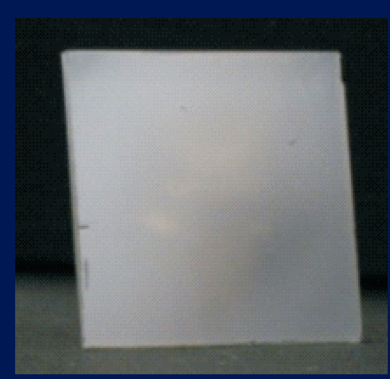
Experimental results



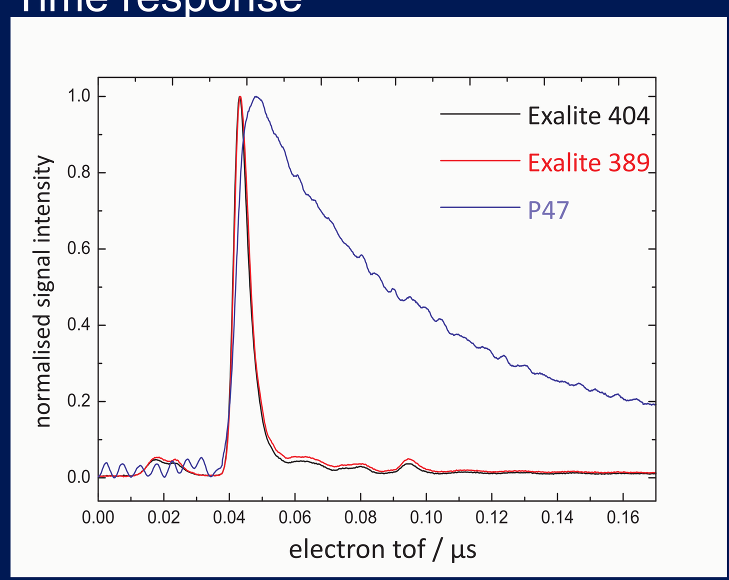
- Microscope mode imaging mass spectrometry was performed with 20 μm spatial resolution
- Experimental field of view of 4 mm
- Time of flight resolutions of t/2Δt=2000
- Optimum spectrometer specification could be tuned to any mass of interest

Developement of an fast scintillation detector

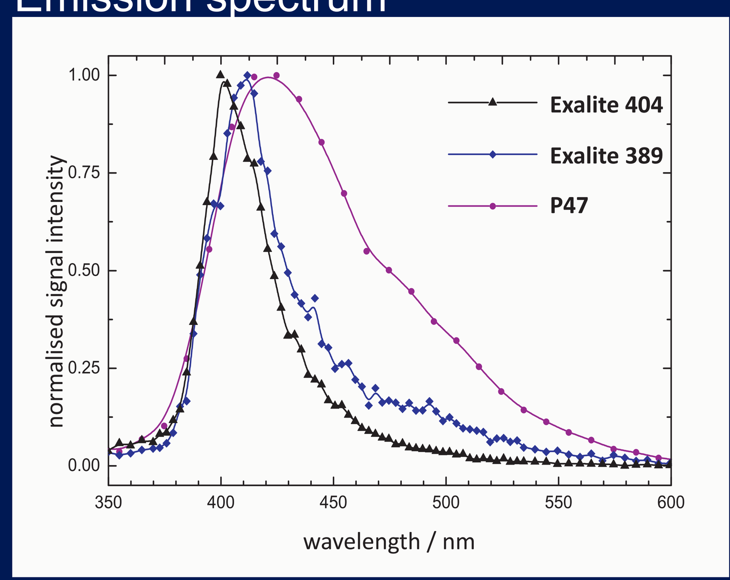
- Imaging mass spectrometry experiments require fast MCP phosphor screen detectors to access a high ToF resolution
- Conventional systems are limited by the fluorescence decay time of P47 phosphor screens (70 ns)
- Here, we present a new, dye based scintillator screen, which allows particle detection with high timing precision
- An enhanced brightness and sensitivity could be determined for the new dye screens in comparison to a P47 phosphor
- The screen was designed to be combined with the PImMS camera, which allows multi-mass imaging with a time precision of sub 12.5 ns.



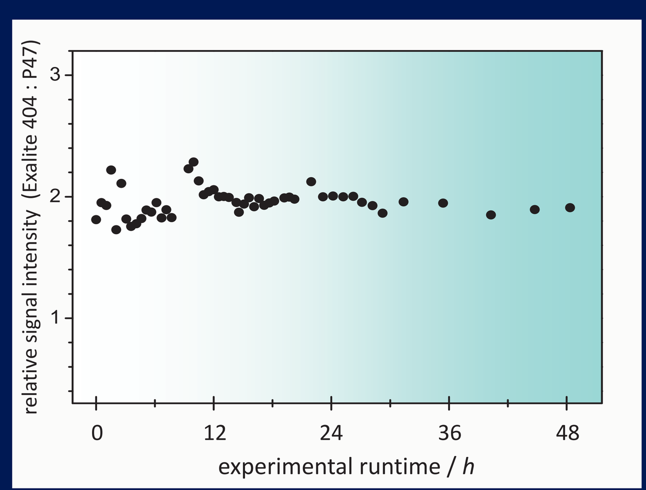
Time response



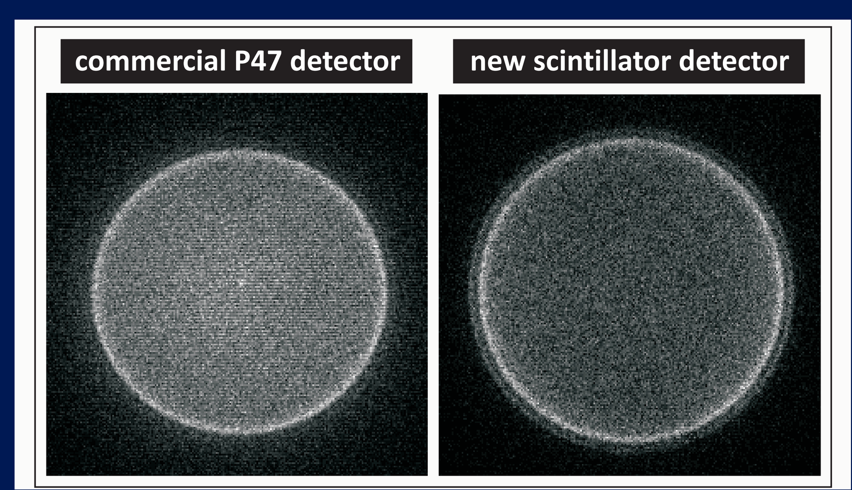
Emission spectrum



Relative brightness and stability



Imaging performance



Scintillator	Type	Emission λ_{max} (nm)	Relative emission efficiency	Decay constant
P43 (YAG)	Inorganic	545	483-725	> 1 ms
P47	Inorganic	**430**	**145-156**	**70 ns**
Anthracene	Organic Crystal	447	100	30 ns
BC-404	Plastic	423	65	2.4 ns

Scintillator	Type	Emission λ_{max} (nm)	Relative emission efficiency	Decay constant
Exalite 389	Organic Dye	404	50-70	< 3 ns
Exalite 404	Organic Dye	**412**	**200-300**	**< 3 ns**
BBOT	Organic Dye	480	~70*	< 3 ns
LYSO	Inorganic Crystal	430	~80*	49 ns

*for direct ion detection only (see Section 5)

This work is subject to a patent application by ISIS Innovations Ltd. (UK patent: 1310476.5). For further details of the PImMS collaboration: **pimms.chem.ox.ac.uk**

[1] J. Aoki, H. Hazama, M. Toyoda J. Mass Spectrom. Soc. Jpn. 59, 57 (2011).
[2] B. Winter, E. Halford, M. Brouard, *Int. Journal of Mass Spectrometry* **356**, 14-23 (2013).
[3] A.T. Clark, B. Winter, R. Turchetta, M. Brouard, A. Nomerotski, C. Vallance et al. , *J. Phys. Chem. A* **116**, 10897, (2012)
[4] B. Winter, S. J. King, C. Vallance, M. Brouard, *Rev Sci Instrum*, in press.