

# Diagnosics for RAL's H<sup>-</sup> Ion Beam Front End Test Stand (FETS)

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and many more from the  
FETS team

STFC, RAL, Isis, ASTeC,  
Imperial College

**Christoph Gabor**

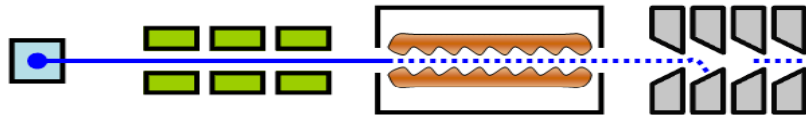
STFC (ASTeC, RAL)

1<sup>st</sup> April 2009



**Experimental Hall R8**

The talk gives an overview which various types of diagnostics are intended to use at the high power front end

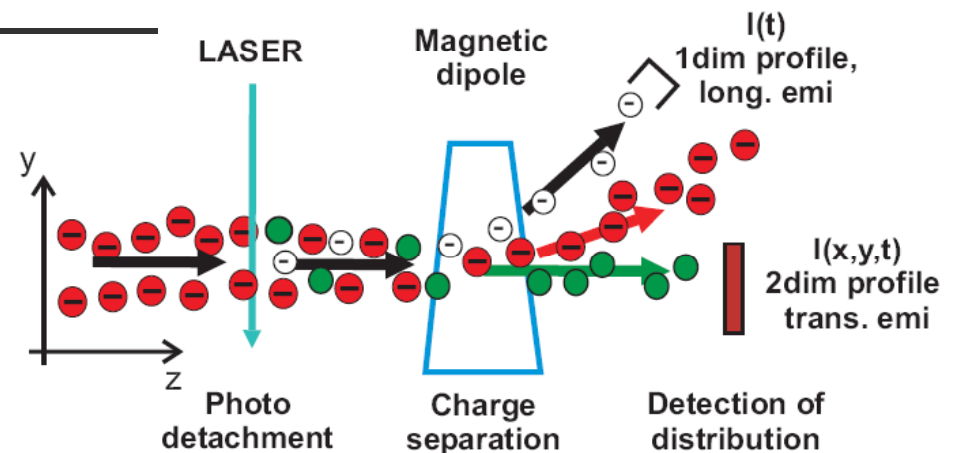


Future High Power Proton Accelerators base on H- and demand a specific low energy injector providing a fast chopped ion beam.

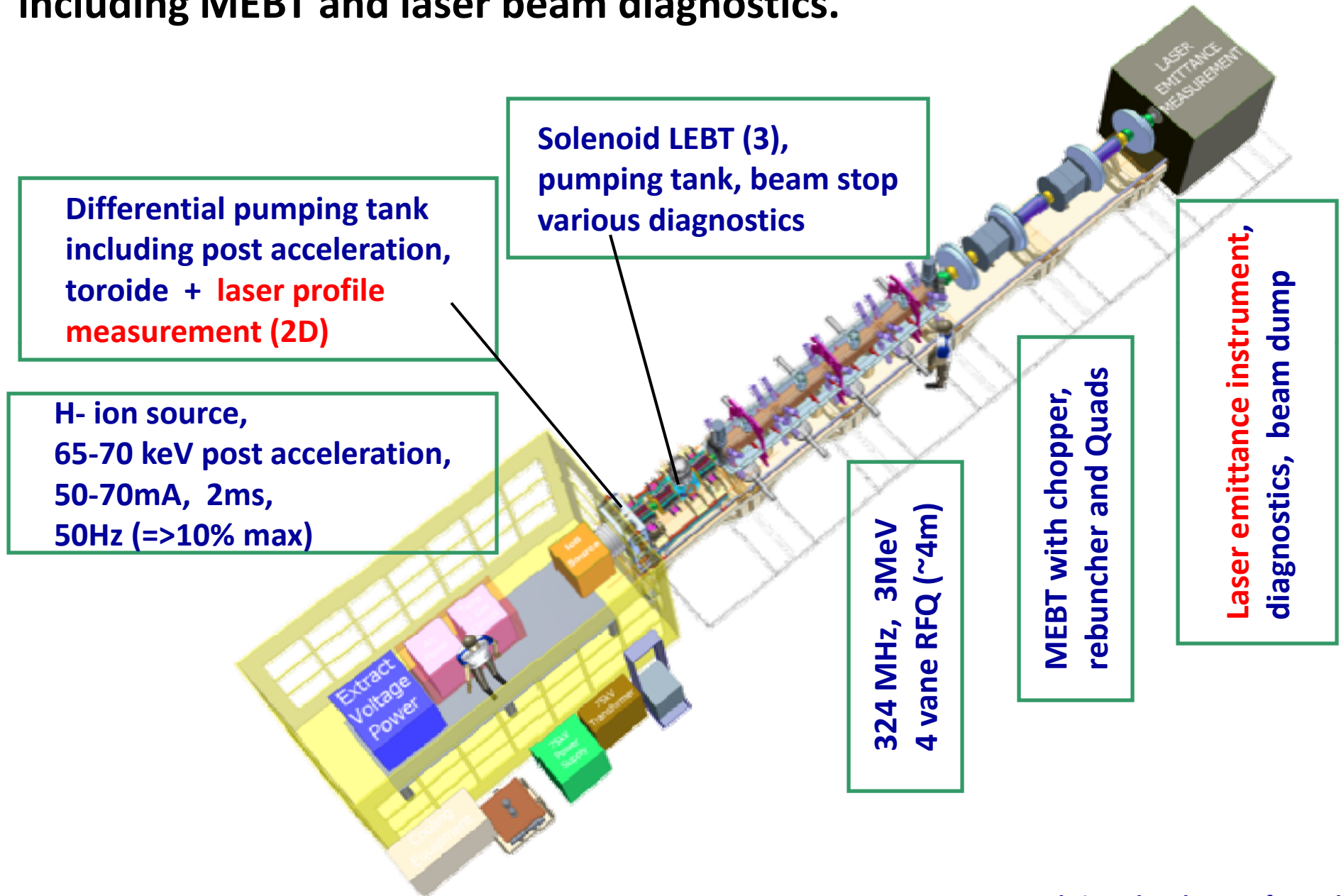


The “bread and butter” diagnostics has to be reliably and is important for commissioning and daily routine operation. Very often destructive methods.

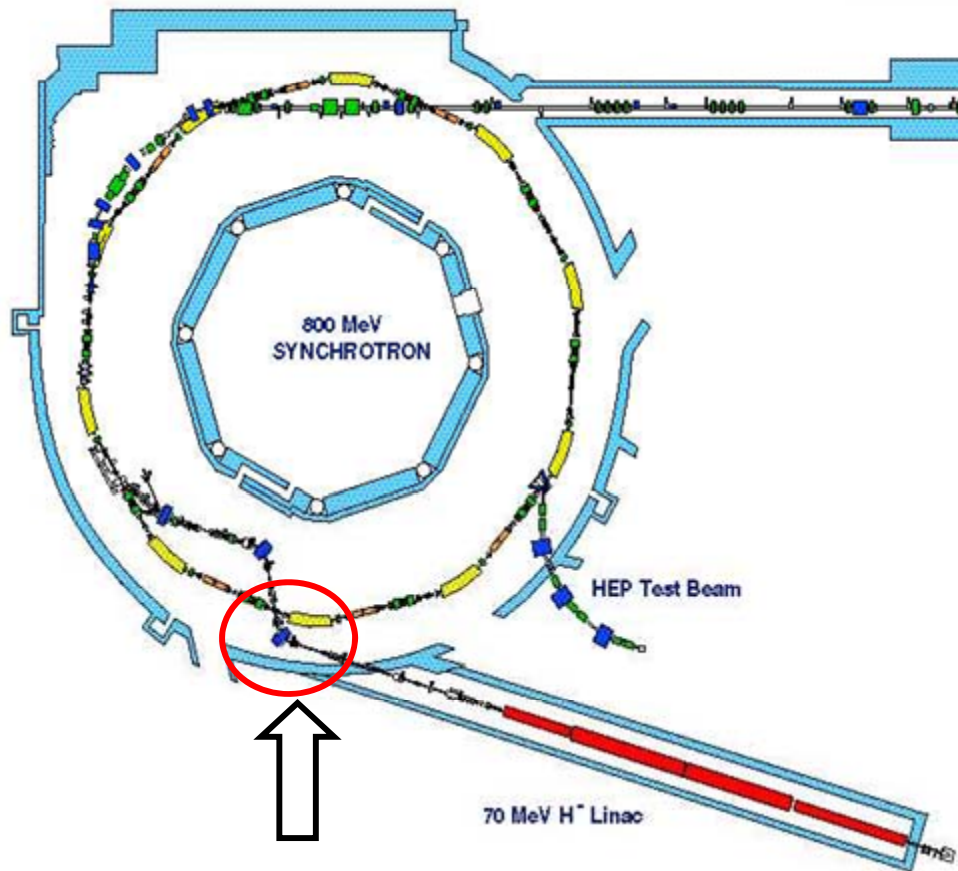
For H- non—interceptive techniques are possible by replacing mechanical equipment by a laser to detect detached electrons or neutrals.



The front end FETS means all parts of the accelerator up to 3MeV including MEBT and laser beam diagnostics.

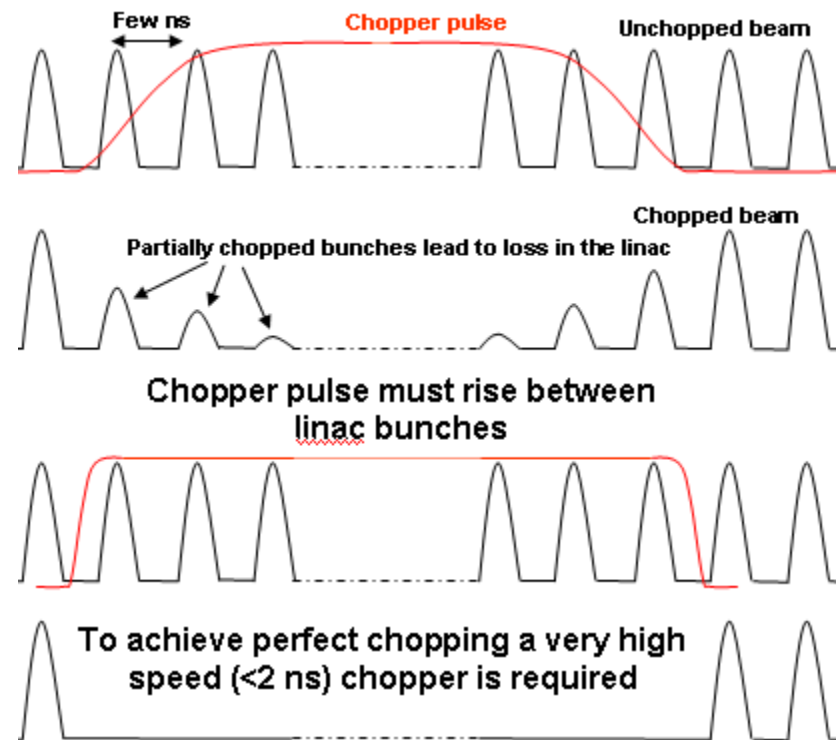


# Motivation and necessity of a front end with a fast chopper



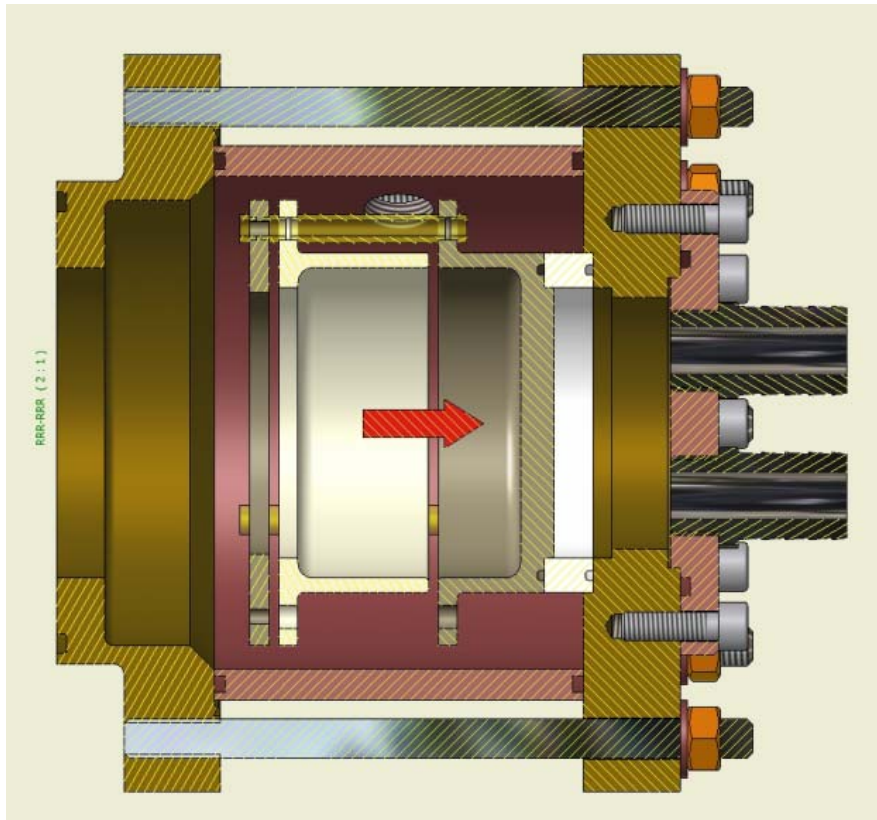
Due to H<sup>-</sup> in the injector LINAC a significant higher luminosity in the synchrotron is possible (non Liouville stacking).

"Ideal chopping" is an important issue for future projects to avoid long. losses caused by partially chopped beams (activation!).



... has to be demonstrated on highest current level and full duty cycle

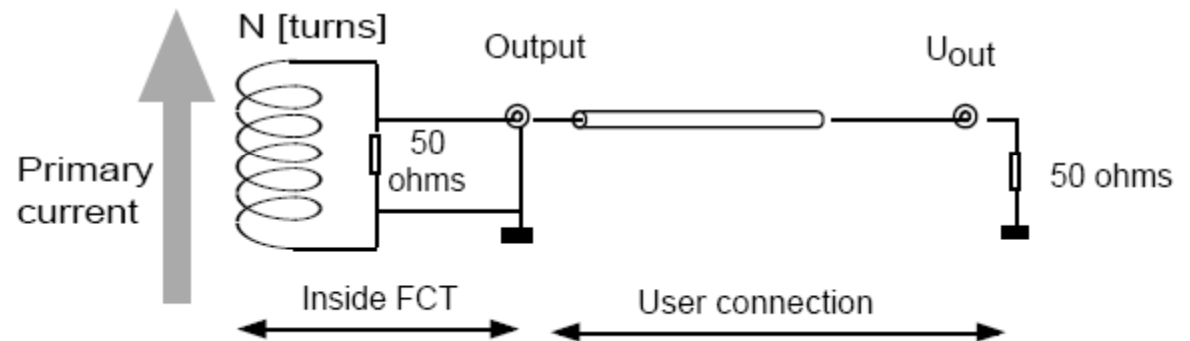
# Intensity measurements based on FDC and CT



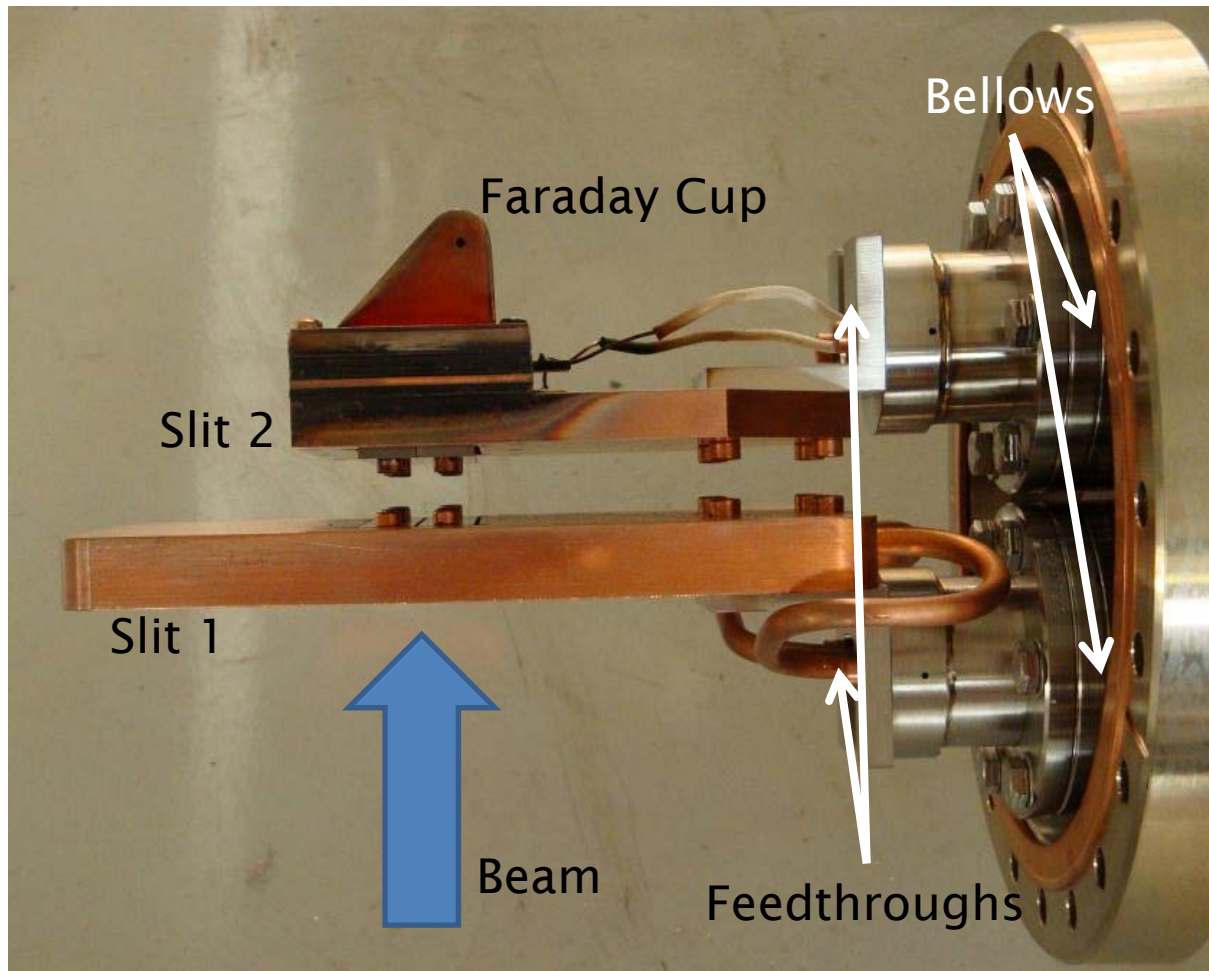
(Fast)  
Current  
transformer  
frequency +  
band width in  
coexistence  
with small  
pulse length  
droop can be  
challenging



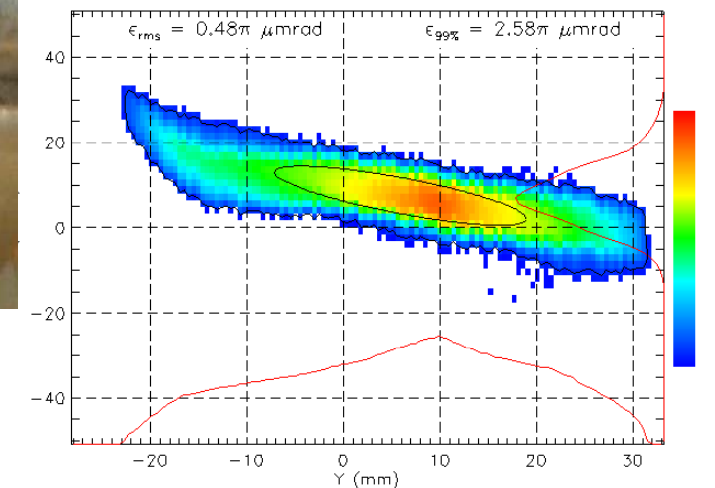
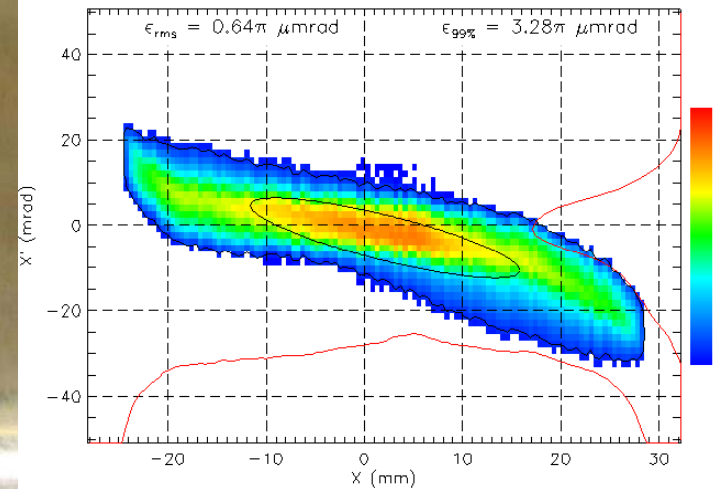
< 70keV  
Faraday Cup (FDC) with  
secondary electron  
suppression (fixed/  
movable versions)



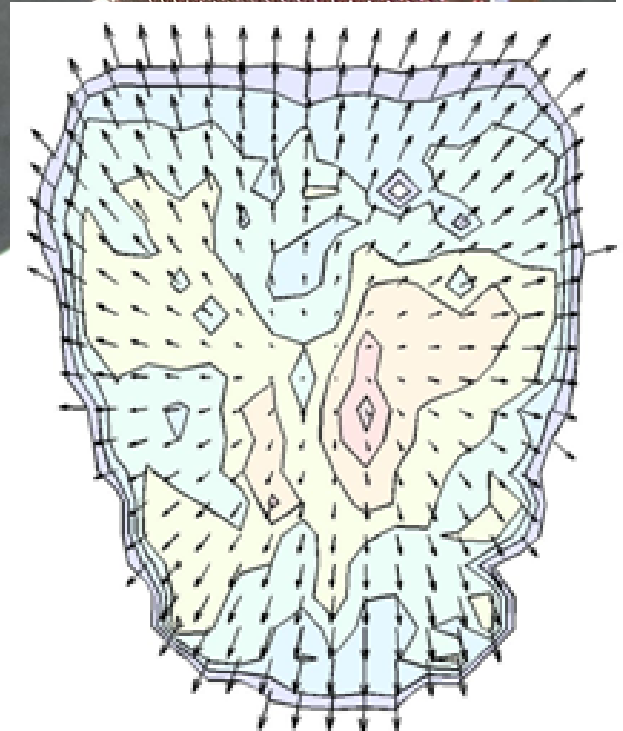
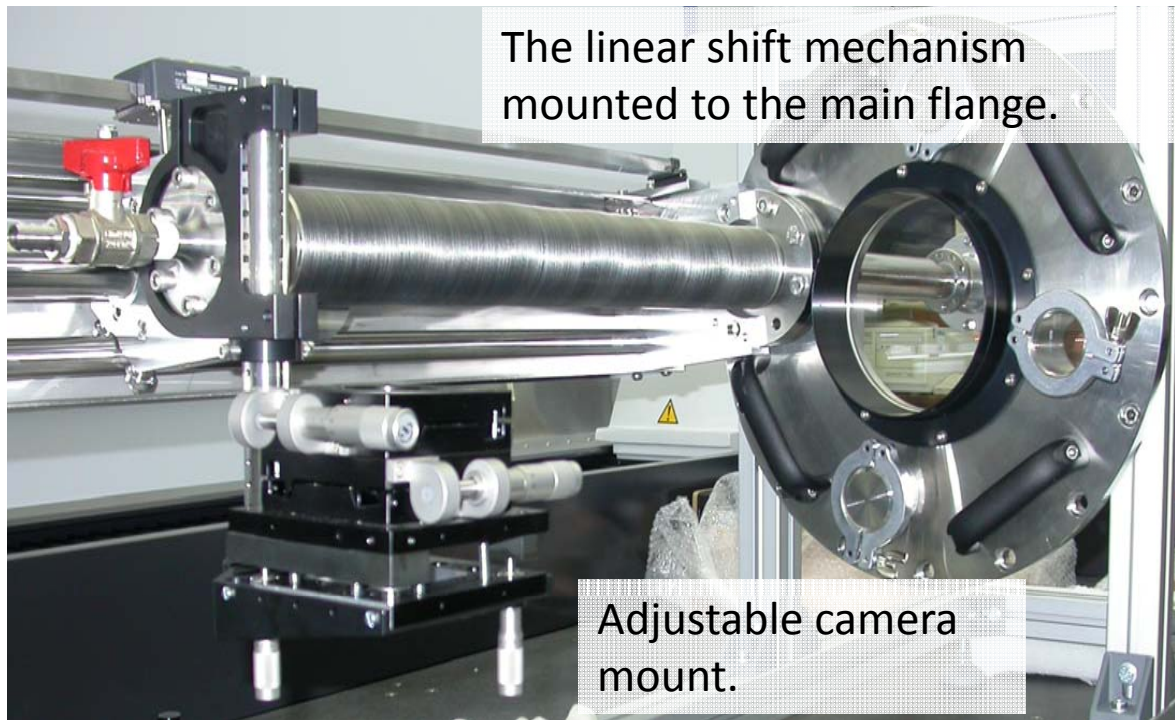
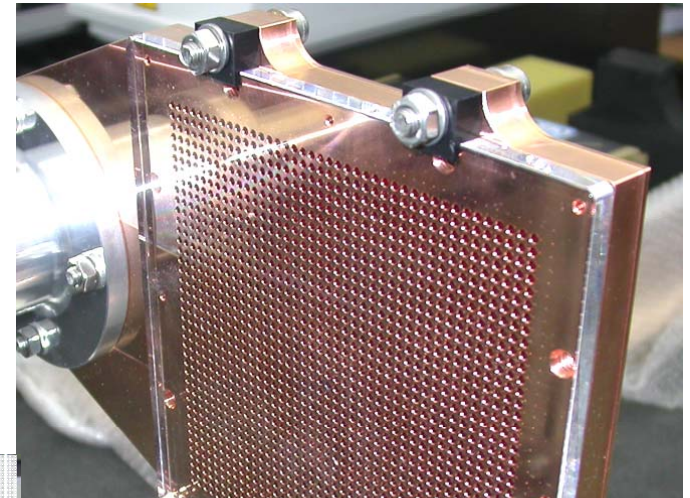
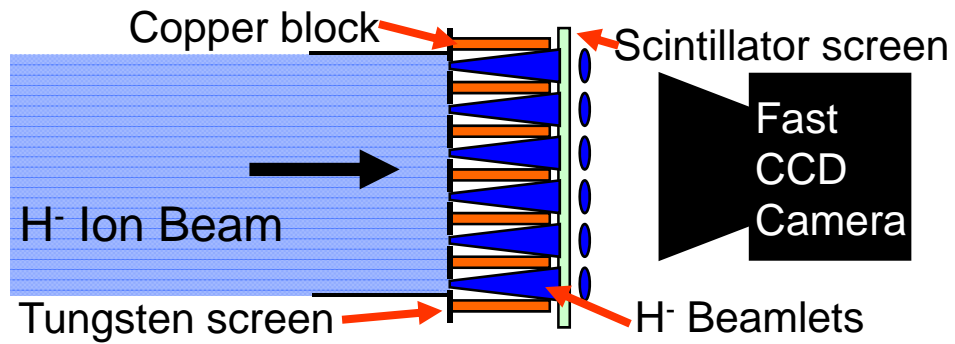
Transverse emittance instruments typically measure only in one plane, i.e. 2D equivalent to information loss



Post processed data

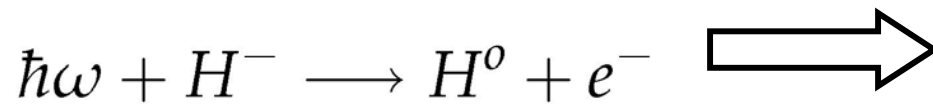


# Principle and technical set up of the pepper pot emittance instrument.

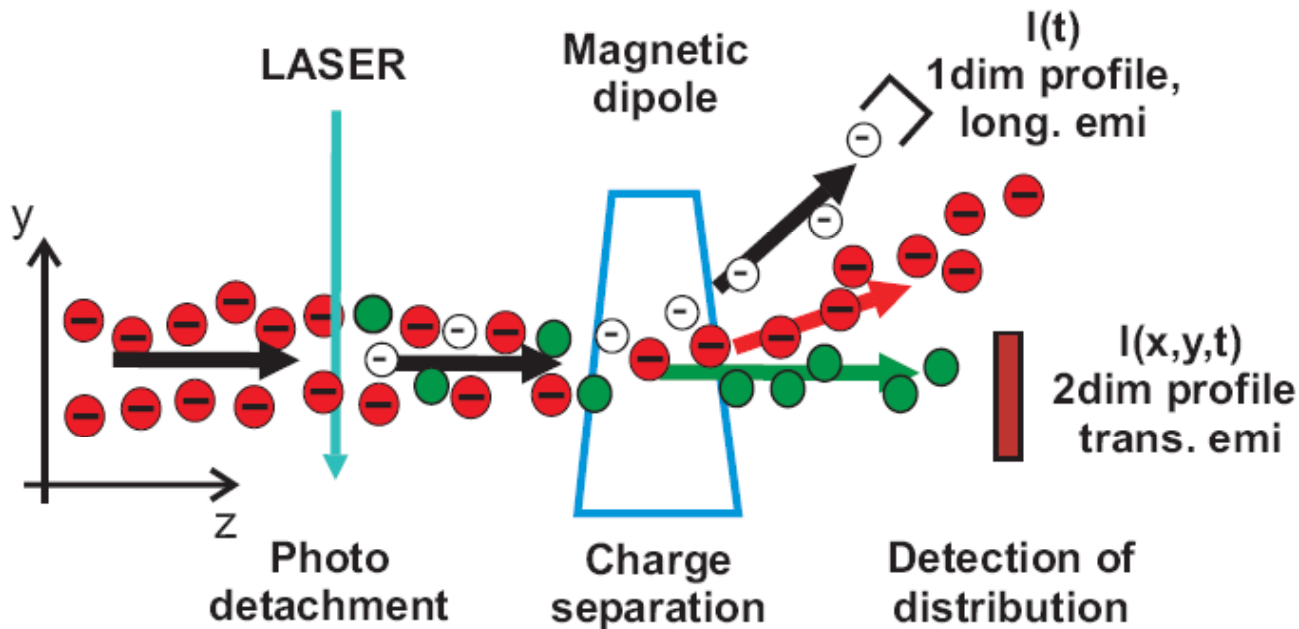
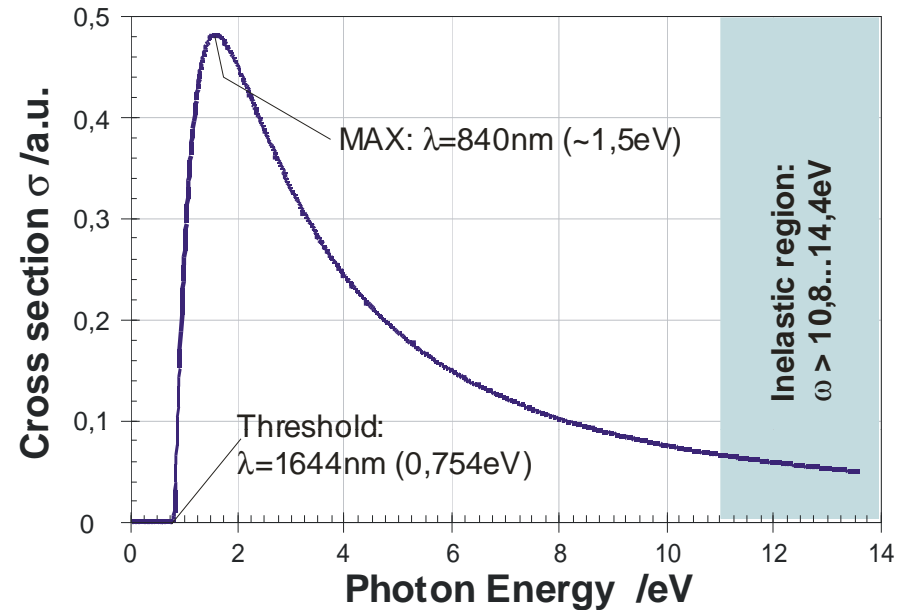


The binding energy of the additional electron of H<sup>-</sup> is very low and accessible by laser photon energies.

Photo—detachment Process



Mechanical parts are replaced by laser beam

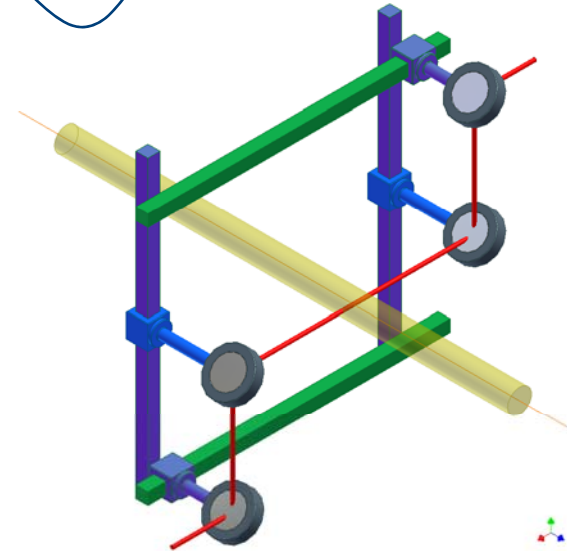
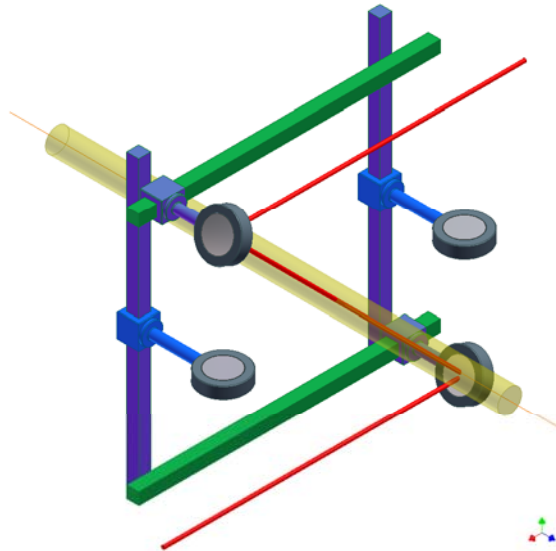
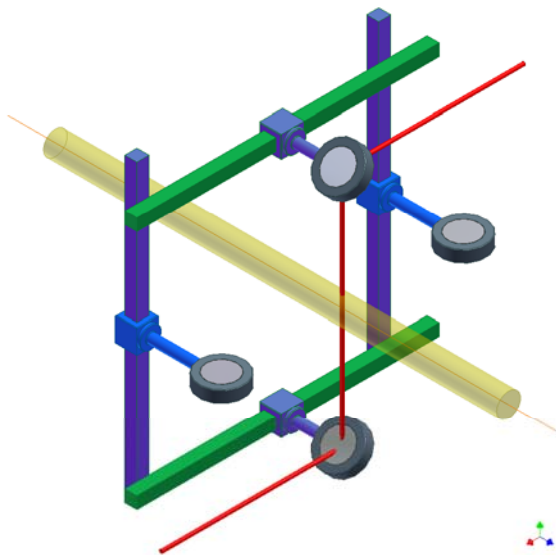
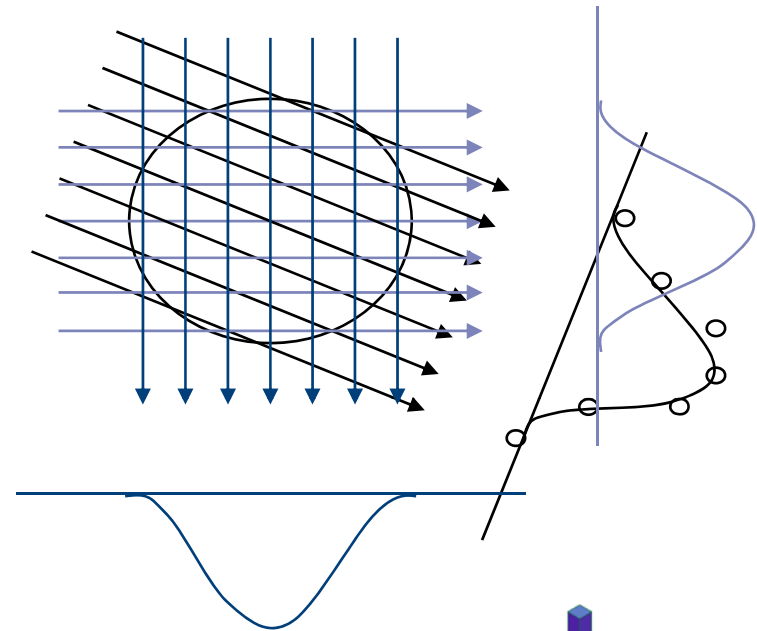


Diagnostics carried out either on detached electrons or neutrals

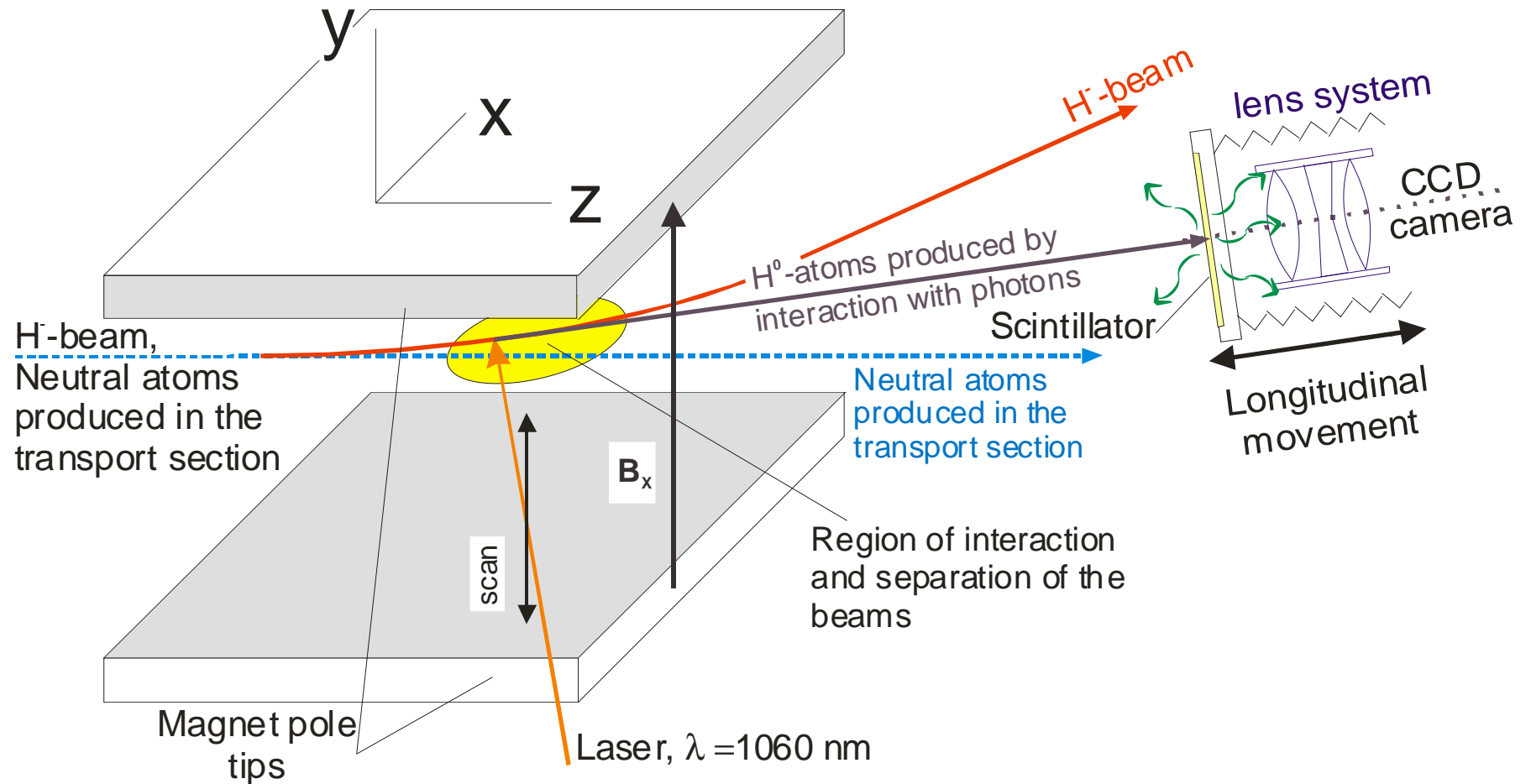


**Transverse beam particle distribution will be determined by the use of a laser wire profile device (tomography).**

Multiple profile measurements under different angles allow investigation of the spatial beam ion density distribution utilizing tomographic methods.



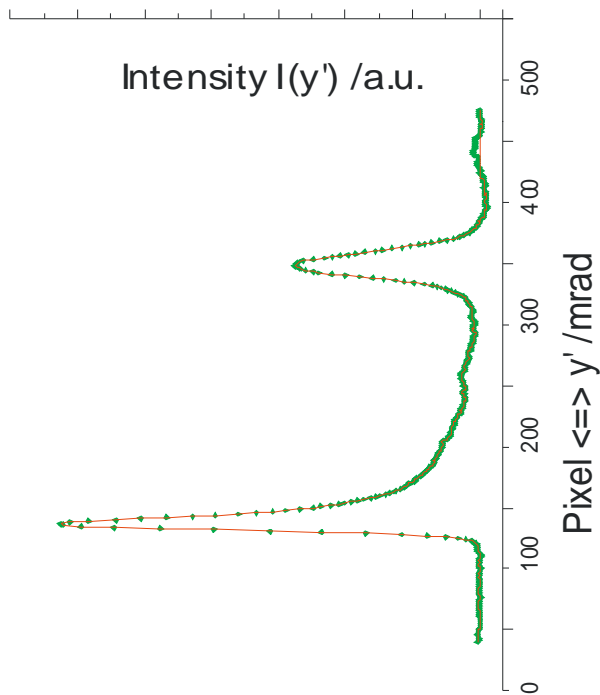
# Emittance measurement instrument based on photo detachment



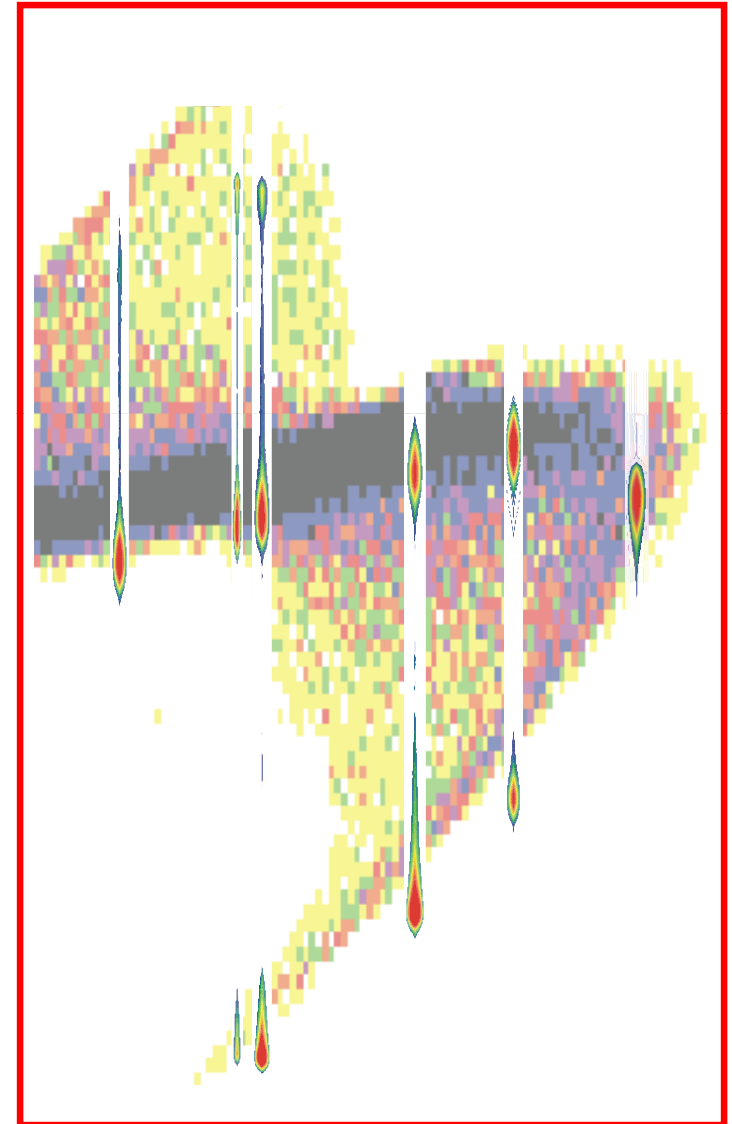
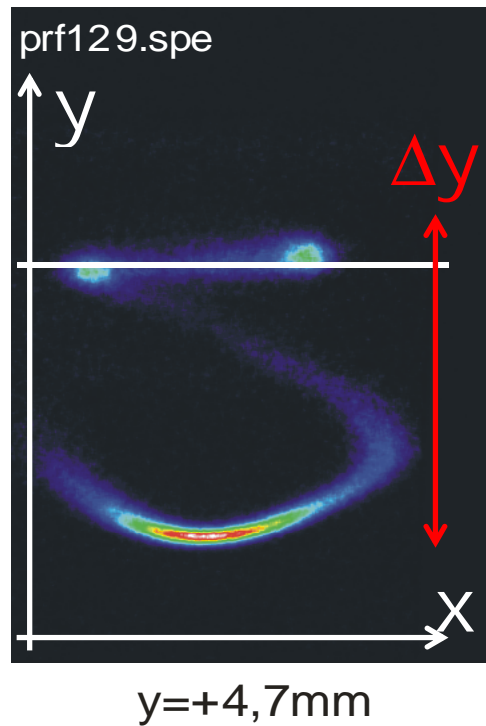
The design has to be adapted to beam parameters and other technical constraints, thus less flexible than a slit scanner. Also higher costs but non-destructive and "online measurements" possible.

# A "proof of principle" experiment as an example of this technique

Result of a "proof of principle" of principle"



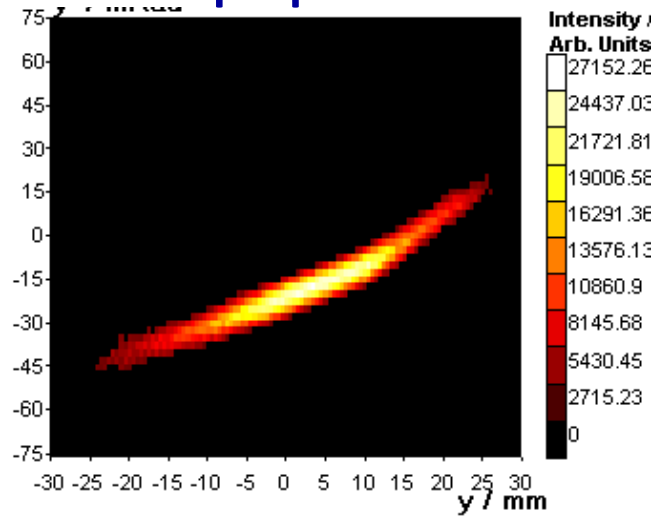
Result of a "proof of principle" of principle"



$$\int dx I(x, y) \mapsto I(y)$$

The front end should deliver first beam (running ion source) within the next 4 (four) weeks. Hopefully!

More traditional diagnostics will be used for general purpose



current transformer,  
slit slit emittance scanner,  
pepperpot,  
beam profile screens,  
Faraday cup (fixed/  
movable)

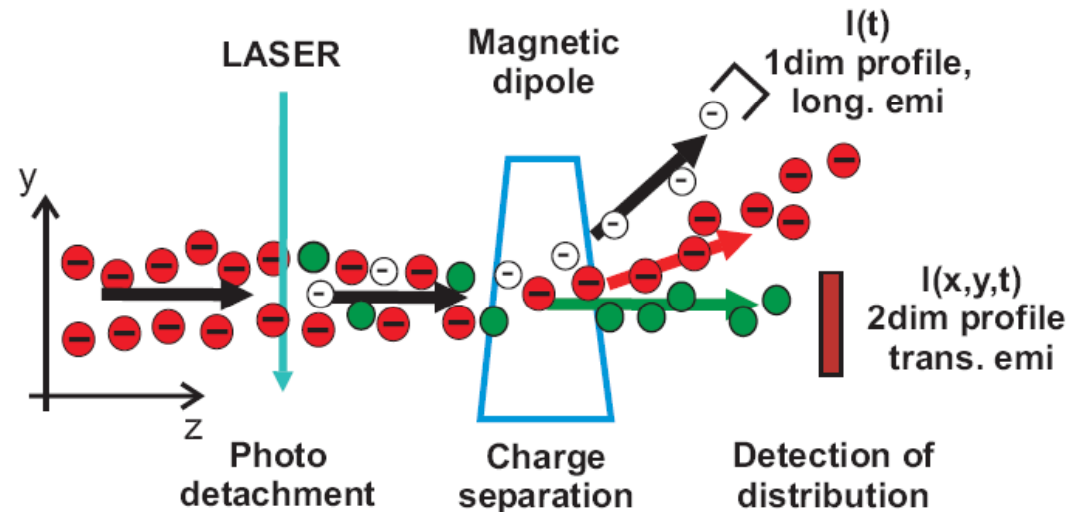
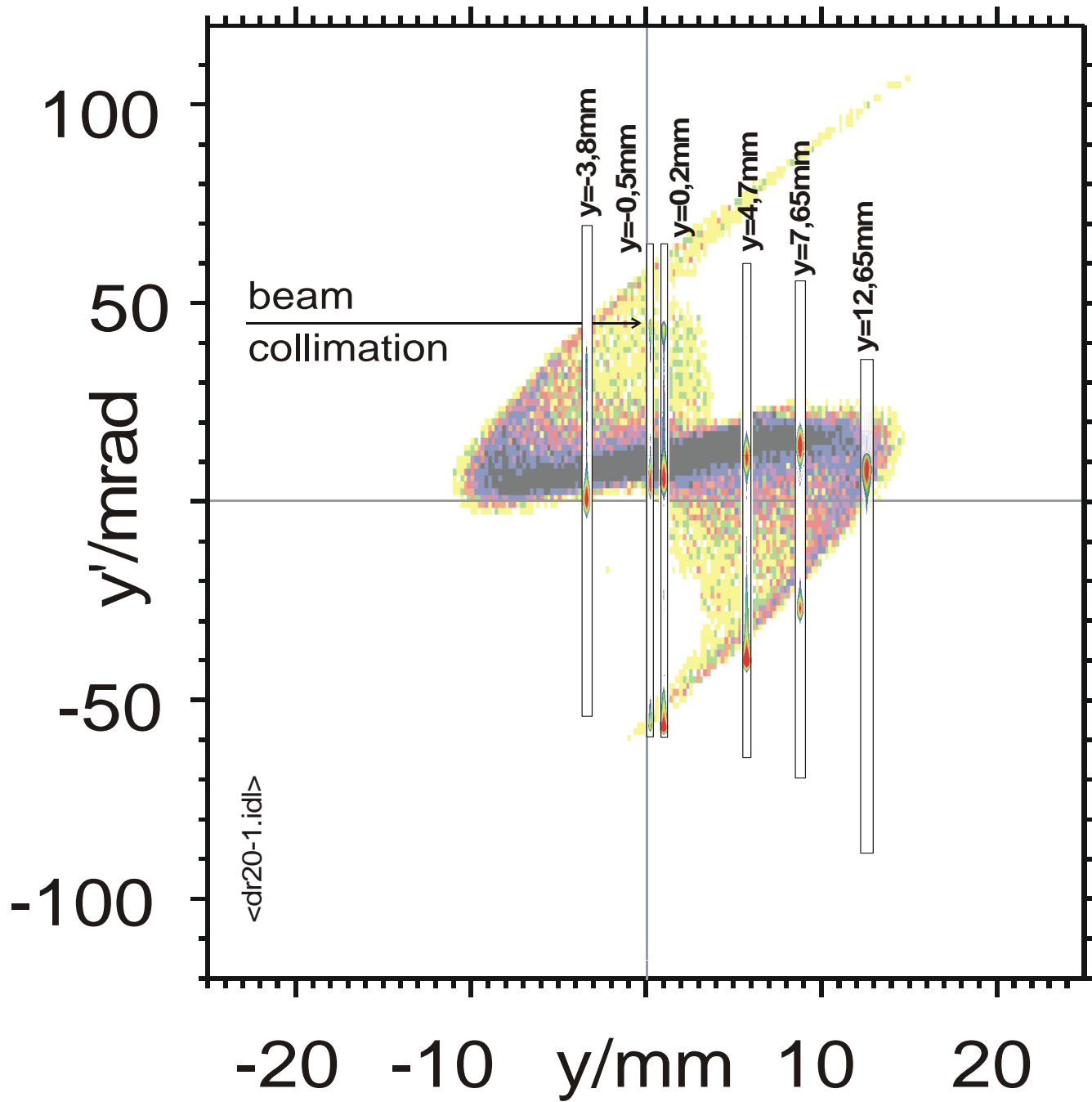
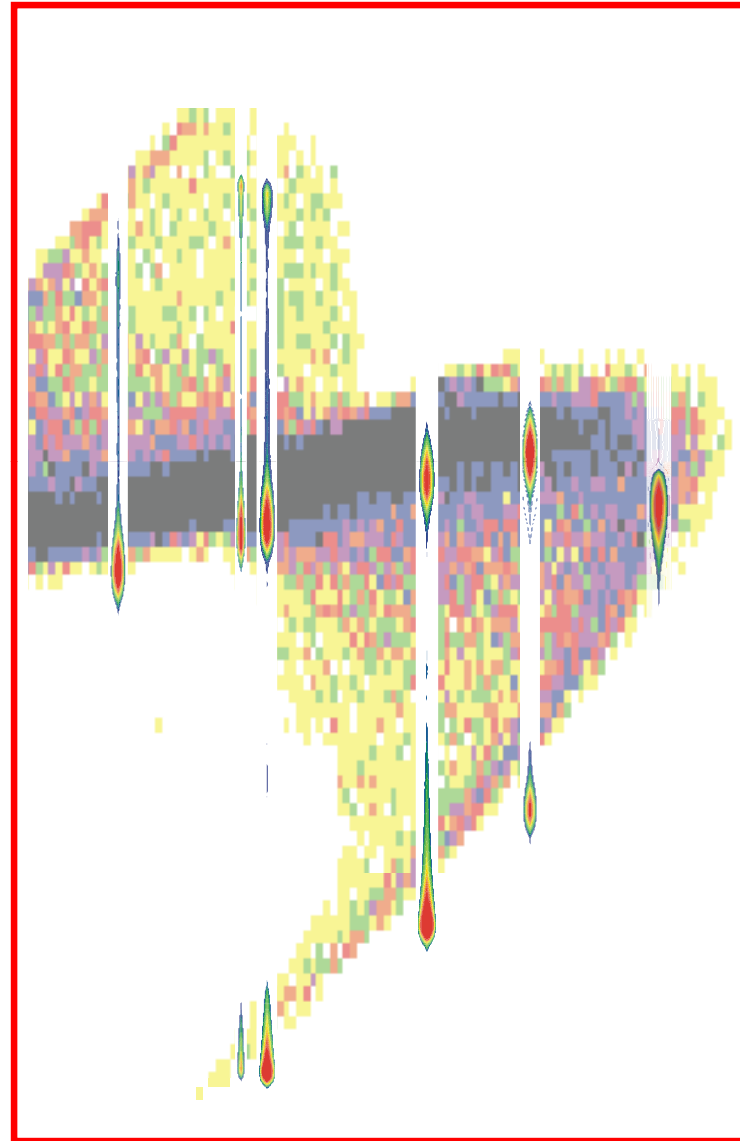
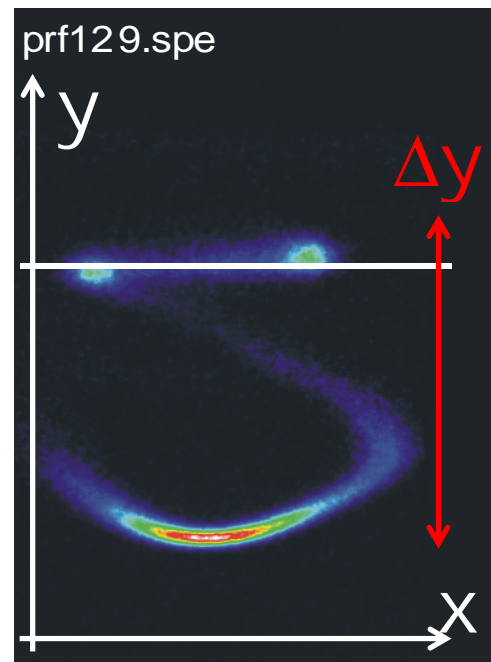
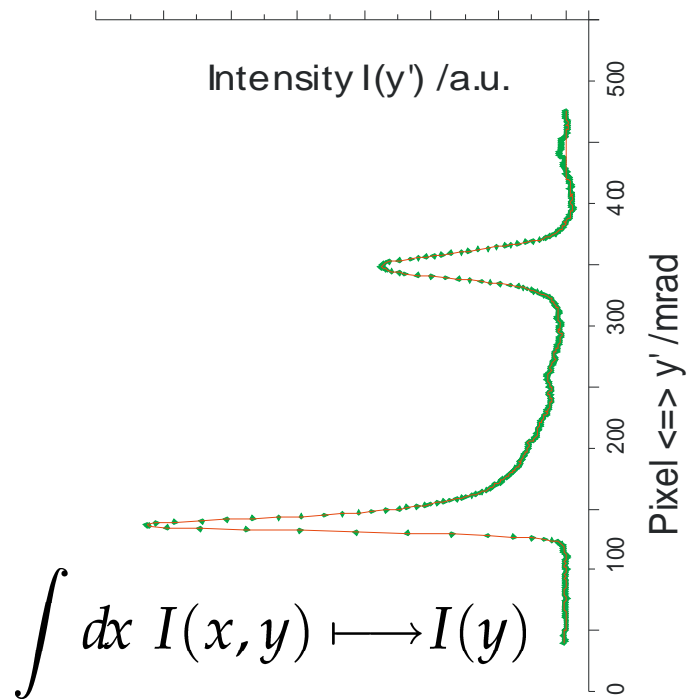


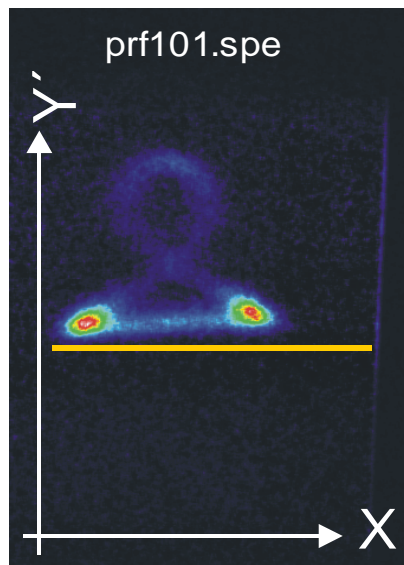
Photo detachment is THE preferable diagnostic for tool for H- if you simultaneously want to measure non destructive & online gathering with good coverage (resolution) of phase space.



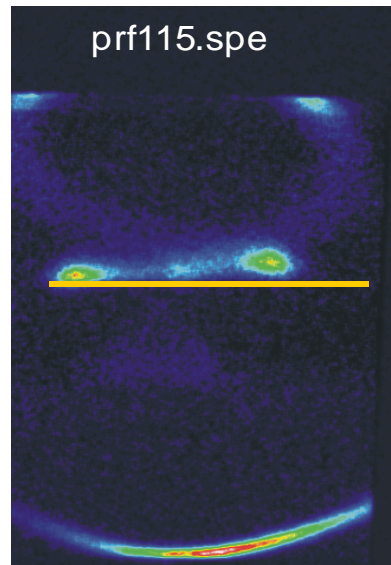




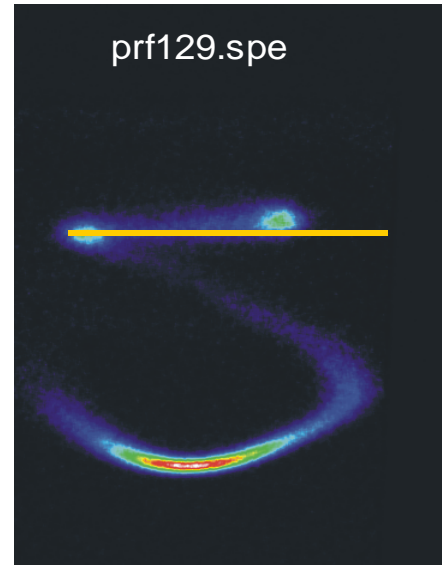
$y=+4,7\text{mm}$



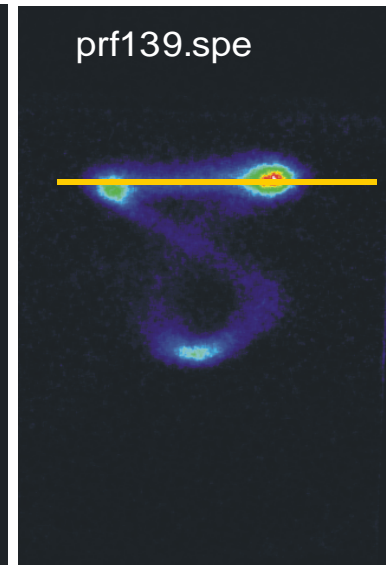
$y=-3,8\text{mm}$



$y=+0,2\text{mm}$



$y=+4,7\text{mm}$



$y=+8,4\text{mm}$

The aims of FETS is to demonstrate key technology for HPPA as well build up skills in accelerator technology in UK

THE UNIVERSITY OF  
WARWICK

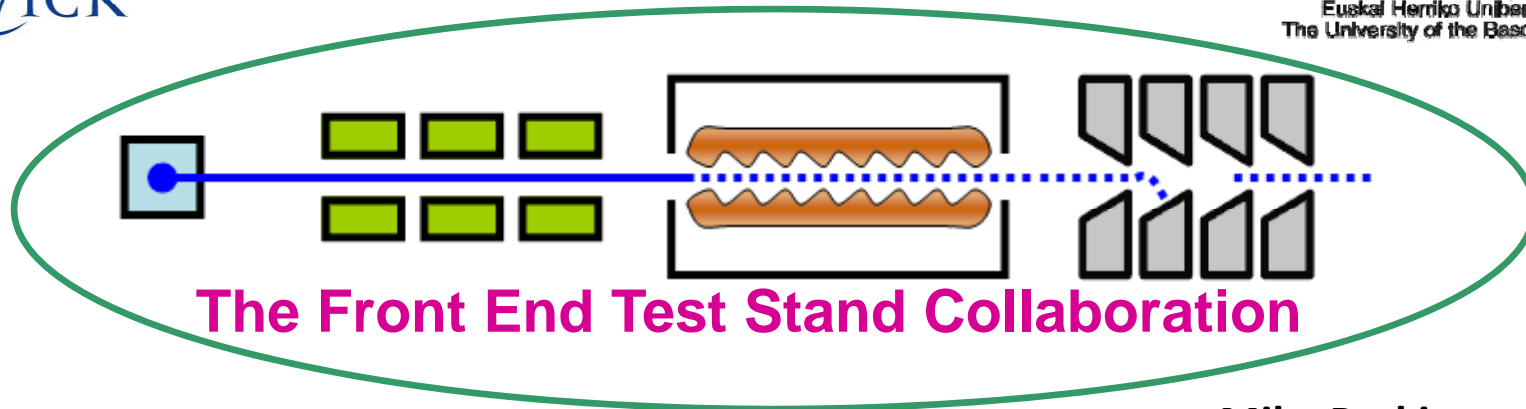
Imperial College  
London

ASTeC

ISIS



Universidad del País Vasco  
Euskal Herriko Unibertsitatea  
The University of the Basque Country



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David Lee  
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Jürgen Pozimski  
Peter Savage  
Christoph Gabor  
Mark Whitehead  
Trevor Woods

Companies:  
Tekniker, Jema, Elyt  
Diversified Technology  
Toshiba

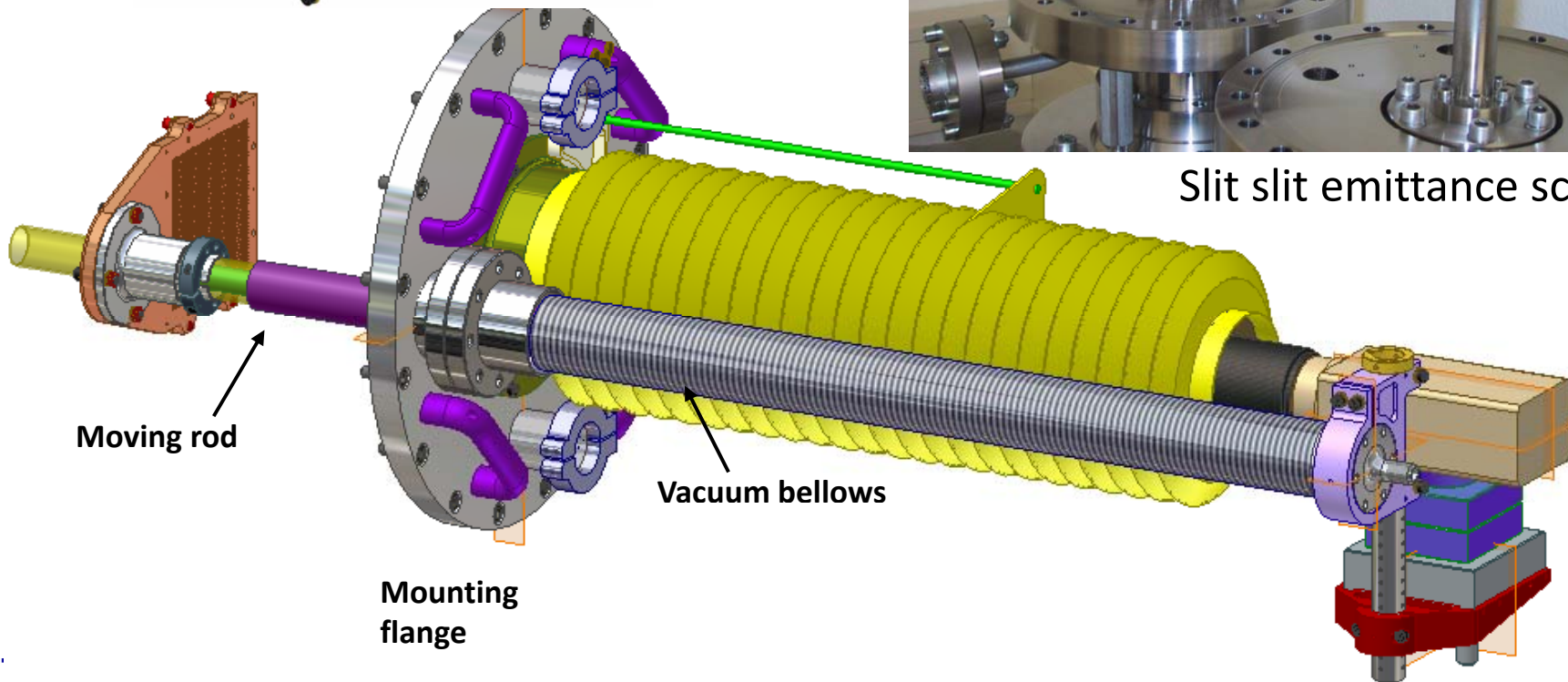
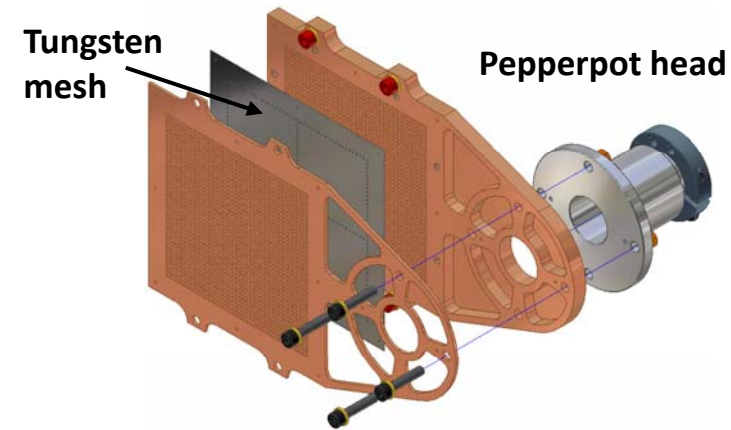
Further collaboration:  
CERN  
IHEP (China)  
John Adams Institute,  
(Oxford)

Mike Perkins  
John Back  
Ajit Kurup  
Ciprian Plostinar  
Mike Clarke-Gayther  
Phil Wise  
Javier Bermejo  
Julio Lucas  
Jesus Alonso  
Rafael Enparantza

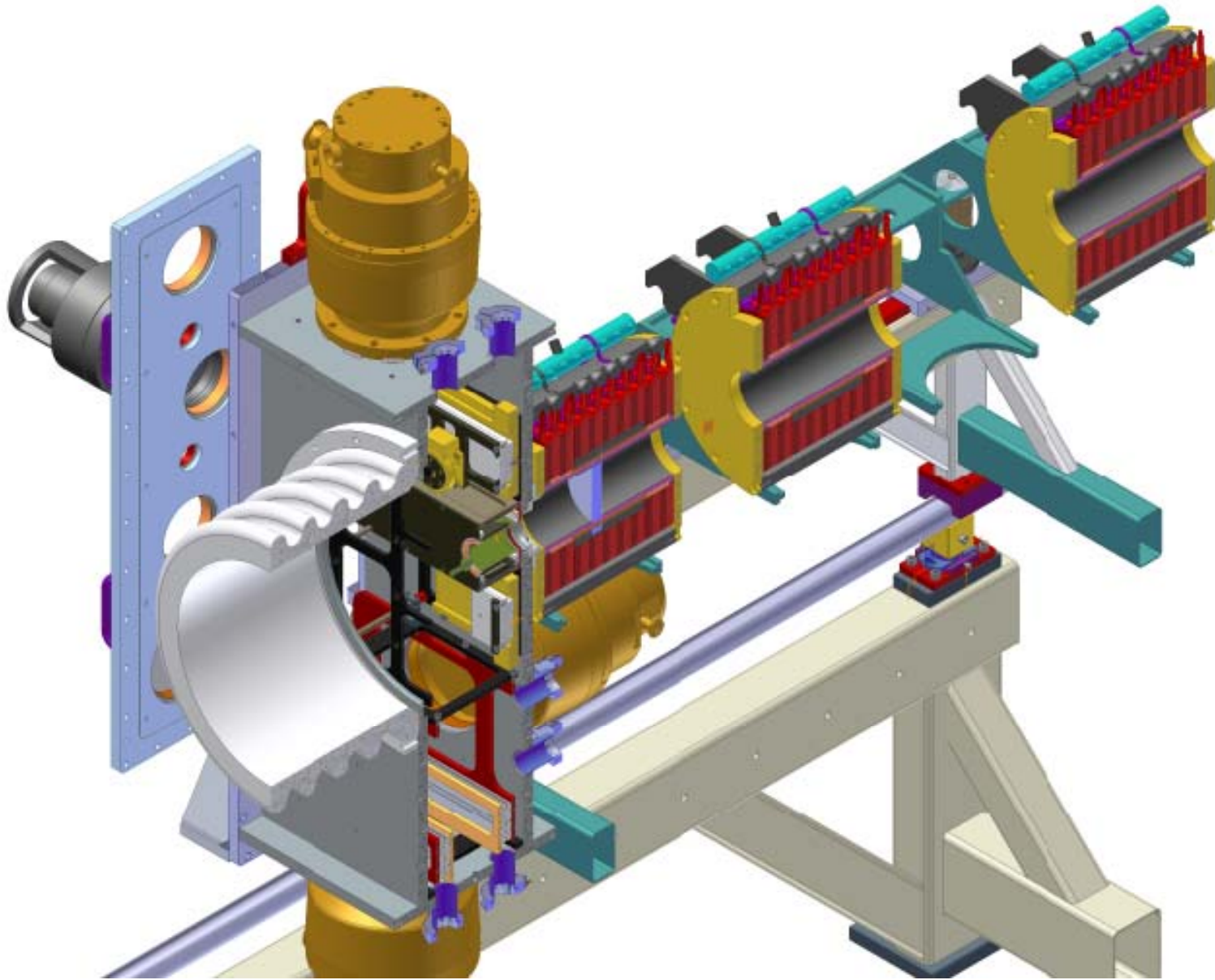
[christoph.gabor@stfc.ac.uk](mailto:christoph.gabor@stfc.ac.uk)



An emittance scanner can be based on various principle, here slit--slit (2D) and pepperpot (4D) are shown.



# LEBT and differential pumping tank





# Empty slide

Extraction geometry

Transport through the analyse dipole (cold box)

Post acceleration

**Dan Faircloth**

# Empty slide

Extraction geometry

Transport through the analyse dipole (cold box)

Post acceleration