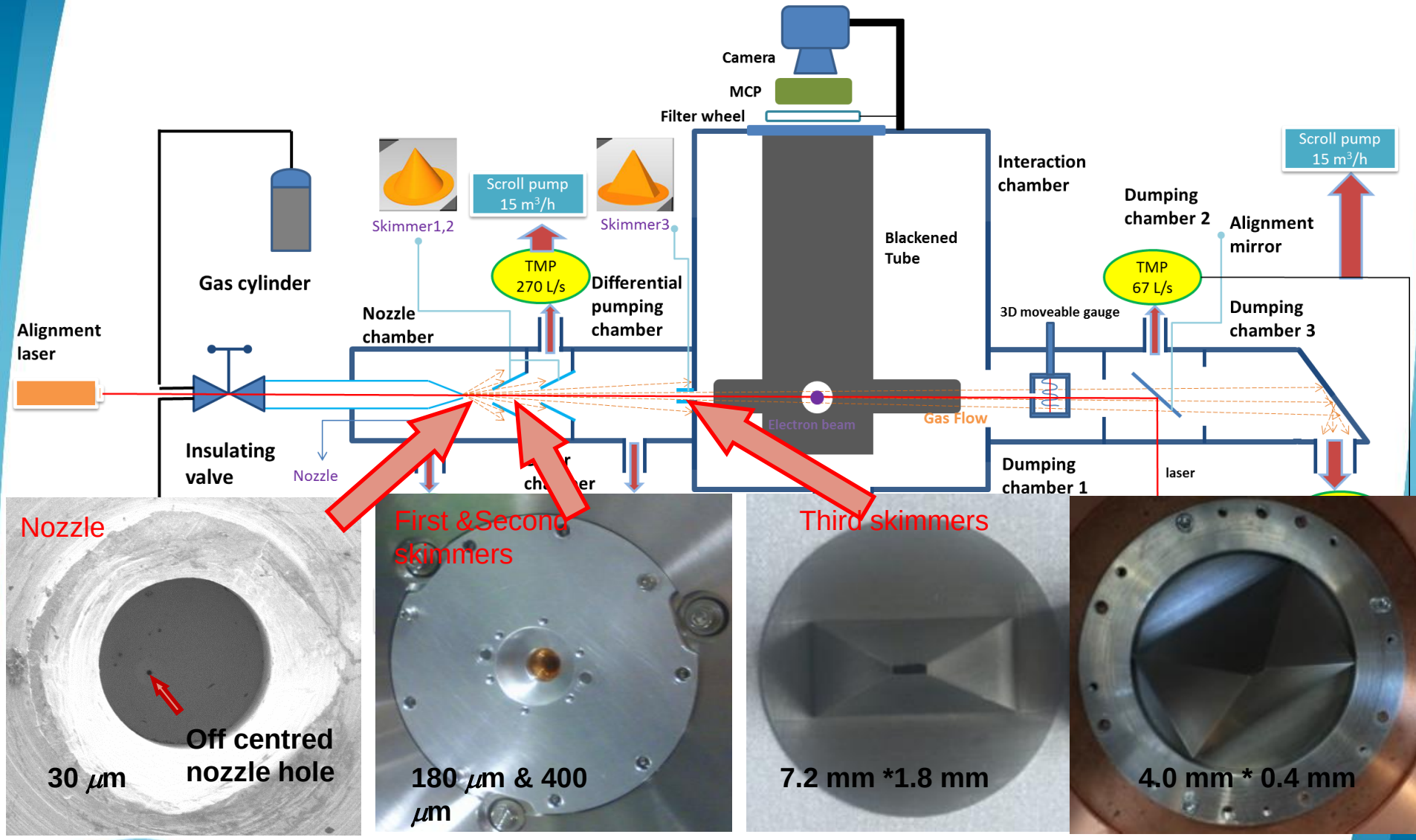
Experiment program at CI

Hao Zhang (Cockcroft Institute)

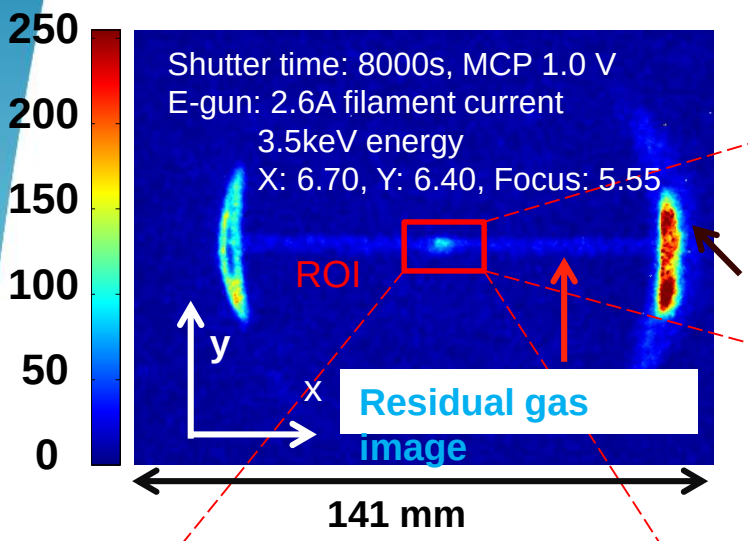
Outline

- Progress with gas jet testing
  - Experimental setup
  - Measurement using BIF mode with gas jet
  - Characterization of the jet density
  - Residual gas test with Nitrogen and Neon
- Development of second gas jet prototype (version 2)
  - Improvement
  - Progress of the production
  - Initial tests

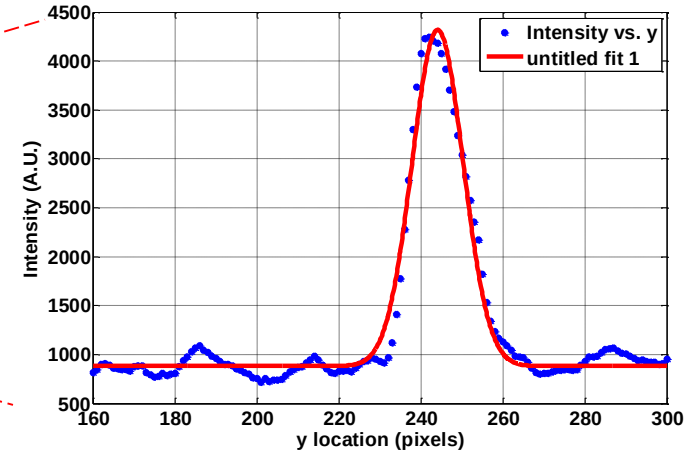
Modified monitor (version1) for beam induced fluorescence test

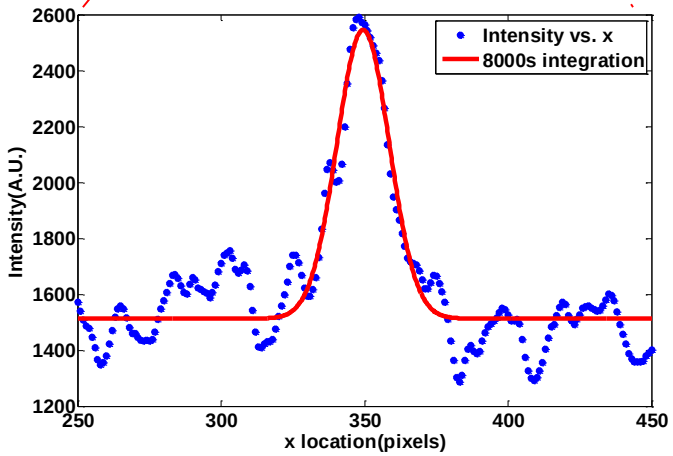


Gas jet image from fluorescent



Reflection of the hot cathode or E-beam on the tube joint





Axis	BIF	IPM
Xrms	1.96 mm	1.2 ± 0.2 mm
Yrms	1.33 mm	0.4 ± 0.2 mm

1pixel = 0.215 mm

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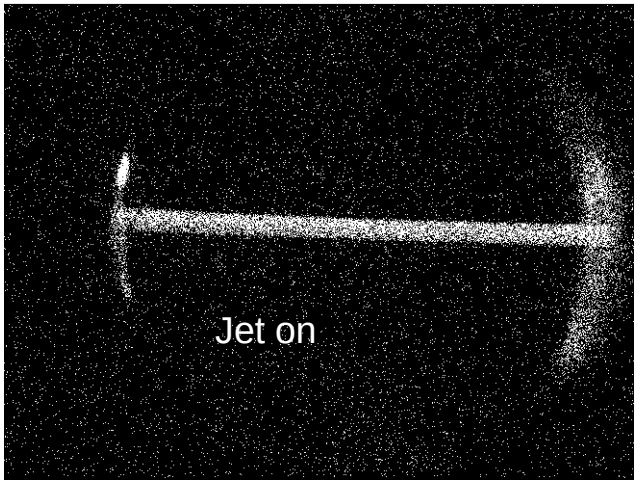
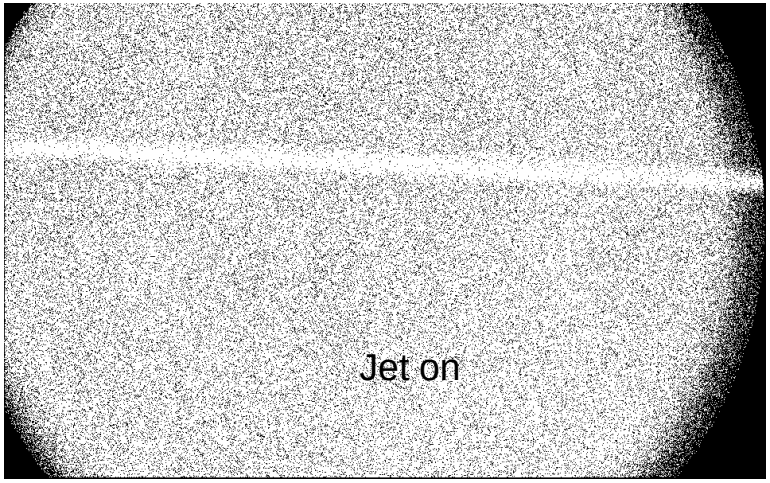
haozhang@cockcroft.ac.uk

Updates from last report

- New optical system
- A higher current electron gun (~80 microA)
- New data analysis (single photon counting)

Comparison of optical systems





Pressure at the interaction chamber

1.6e-7mbar

As discussed before, the new optical system is designed for much higher signal, where the ratio between the signal (no matter it is the image from residual gas or gas jet) and noise is much higher. (5A electron compared to current ~50 uA electron)

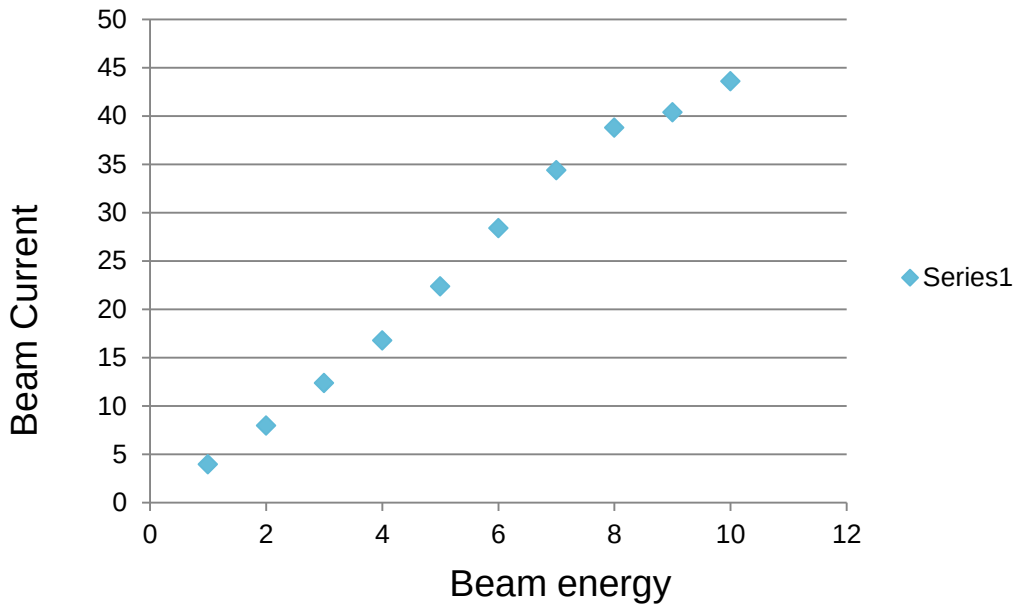
Electron gun

VARIAN Products

10 keV RHEED Gun 450 and Control

- Higher current ~80microA (previous 10microA)
- The steering of the beam is hard (indicator is not accurate)

Measurement of E-gun



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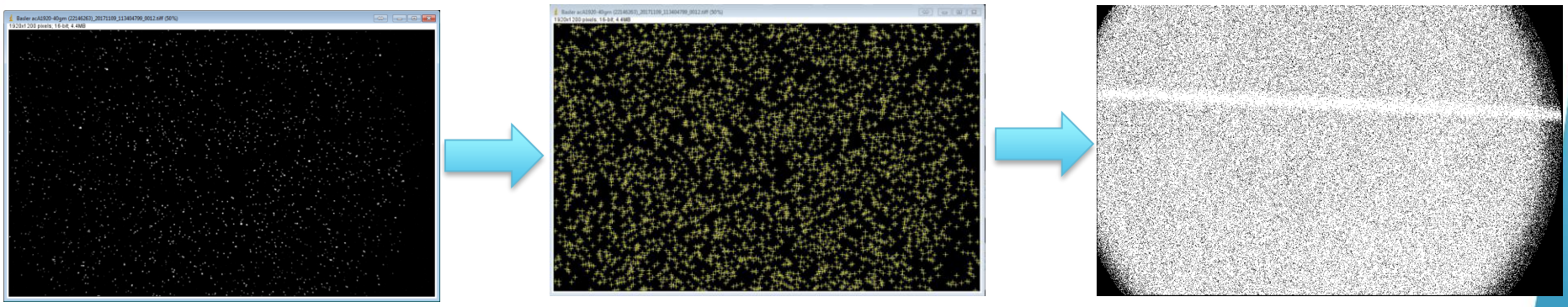
haozhang@cockcroft.ac.uk

New data analysis: Single photon counting

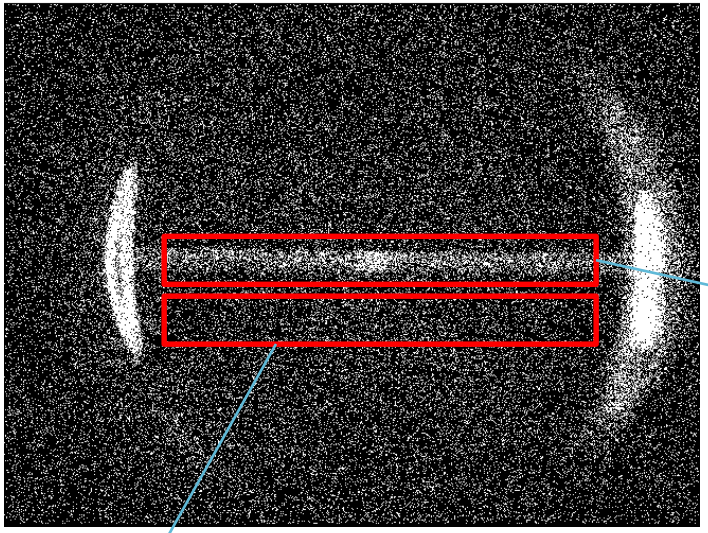
- For each photos with 2s integration time
  - Set a threshold to remove the background
  - Find the coordinates of the local maximums (photon)
- Sum up all the photos
  - Total integration time will be the 2s * number of photos
  - The final pixel value will be the total photon number in that pixel.

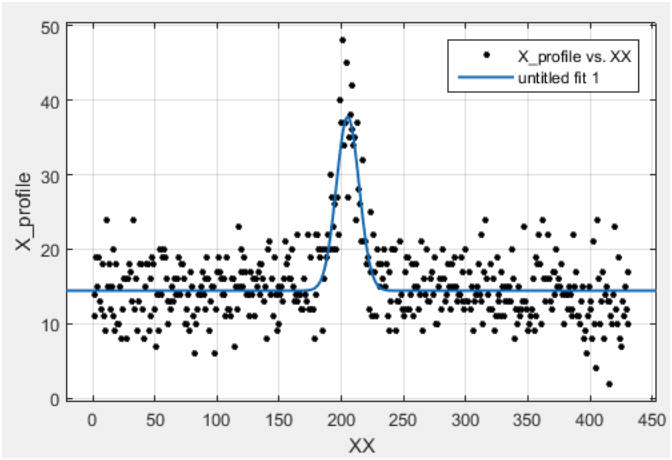


Single photon counting

Data from last year, 8000s integration time

Old E-gun Pressure at 4e-8mbar





$$f(x) = 23.52 * \exp\left(-\frac{1}{2}\left(\frac{x - 203.8}{8.885}\right)^2\right) + 13.83$$

Total photos for the gas jet region ~ 524
Not include the dark count and residual gas photon

$$f(x) = 6.955$$

In 3 sigma area, 3*9.156=55 vertical line, dark count = 6.955 per line
So the residual gas photon = 6.875 per line
Photon from residual gas in 3 sigma area = 55*6.875 = 378

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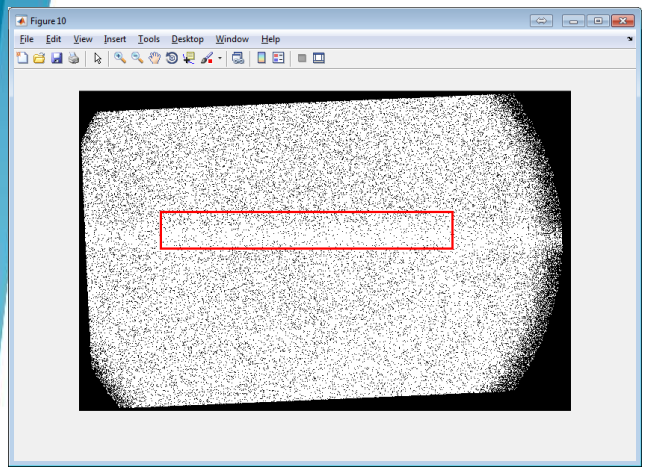
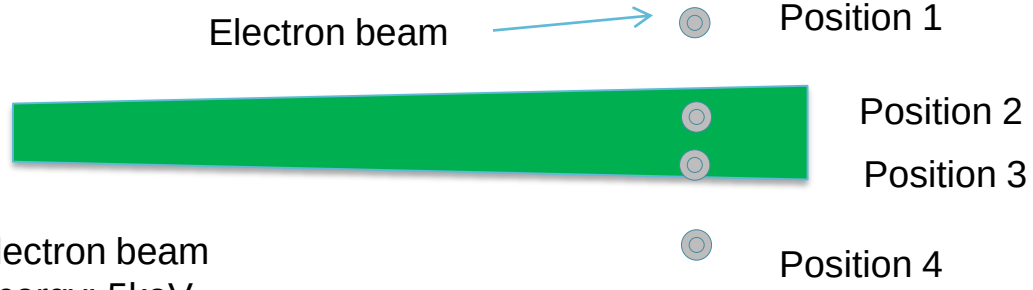
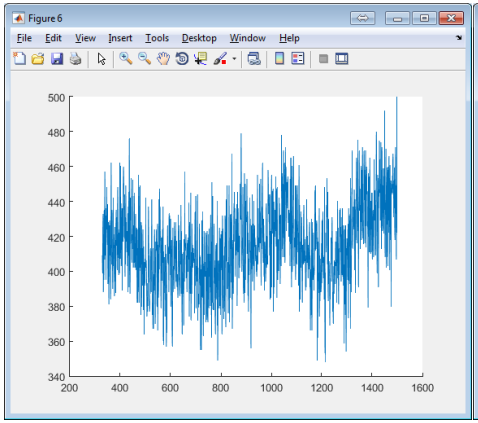
haozhang@cockcroft.ac.uk

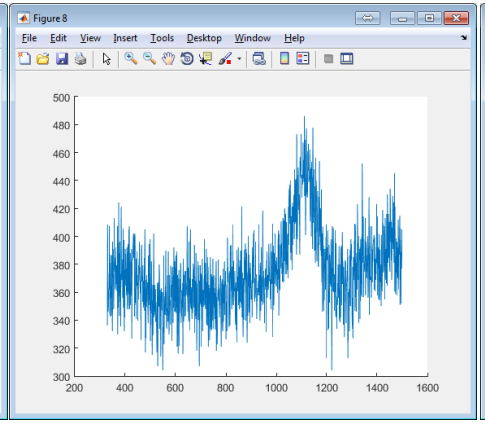
Measurements after upgrades

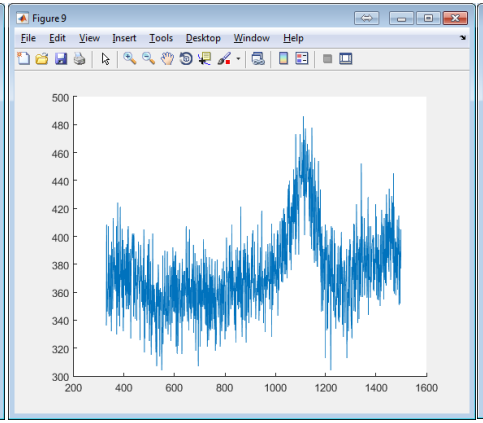


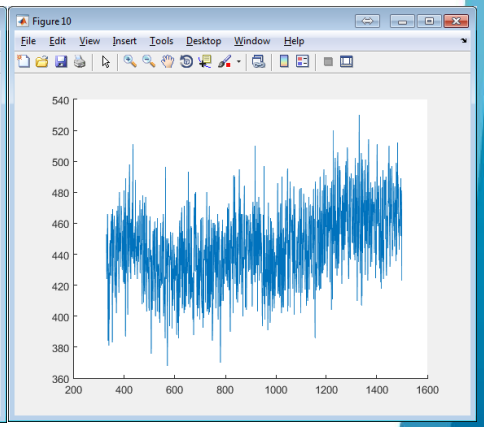


Electron beam
Energy: 5keV
Current: ~30uA
Inlet pressure increased to 8 bar
Pressure: ~6*10^{-8} mbar
4000 s integration time









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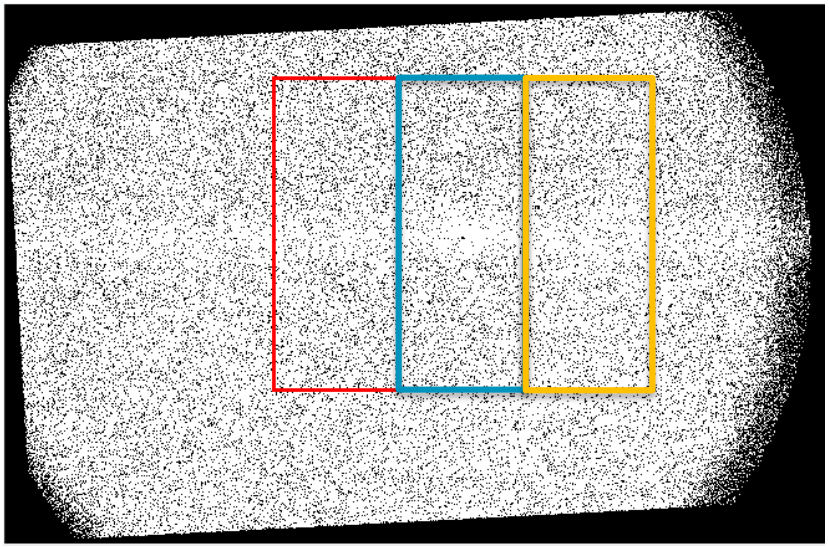
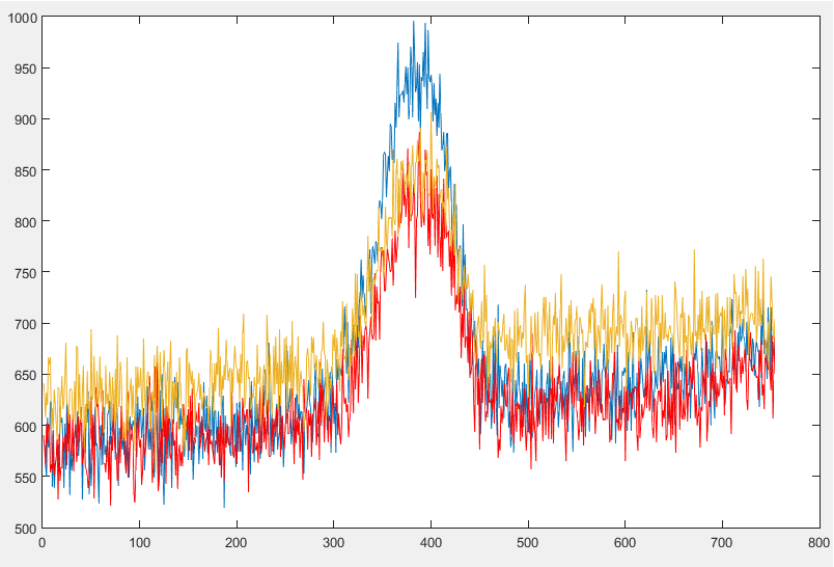
haozhang@cockcroft.ac.uk

Measurement

Electron beam Energy: 5keV, Current: ~30uA



Pressure: ~6*10^{-8} mbar 4000 s integration time



Fitting curve f(x) = a*exp(-(x-b)^2/2/c^2)+d*x+e

d*x+e represent the background
a*exp(-(x-b)^2/2/c^2) is Gaussian distribution for the beam profile

Blue one is from the image of the jet plus the residual gas

Total photon number = A*sqrt(2*pi*C^2)

Photon from jet is about 9521

	Red	Blue	Yellow
A	222.20	337.30	193.00
B	386.10	383.30	386.00
C	34.99	34.31	34.49
D	0.08635	0.1096	0.1171
E	574.90	577.90	620.7
Photon	19488	29009	16686

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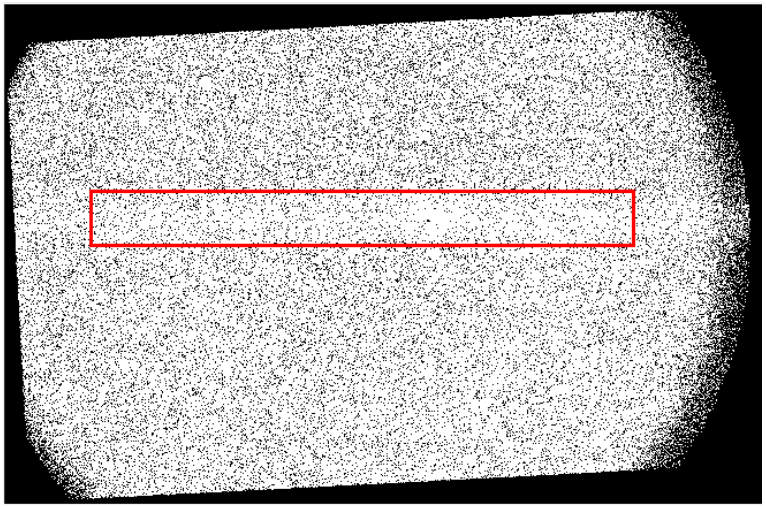
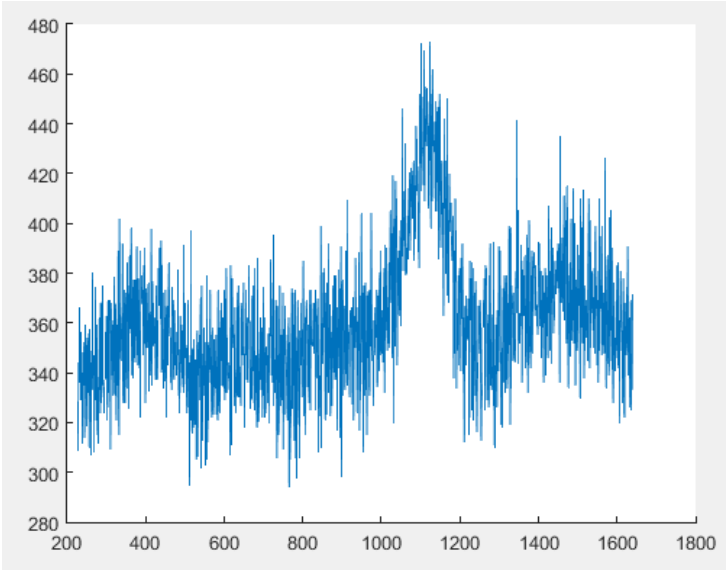
haozhang@cockcroft.ac.uk

Horizontal fitting



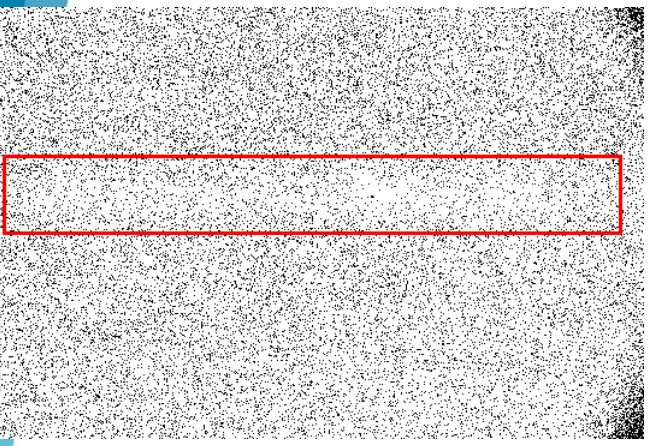


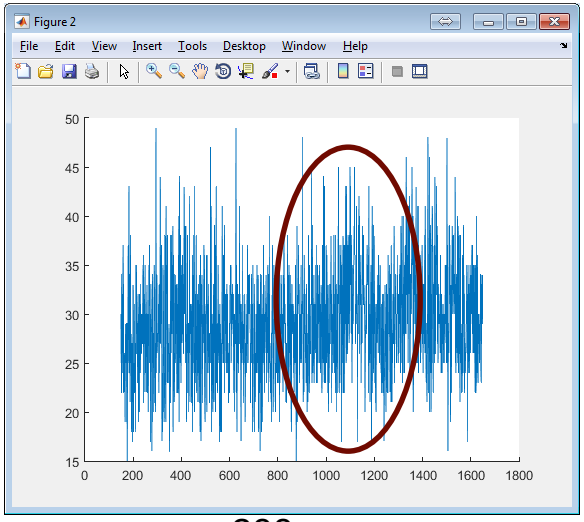
Photon from jet is about 9908

More photon than last year.
- Electron beam current
- Better optical transmission rate
- Higher inlet pressure

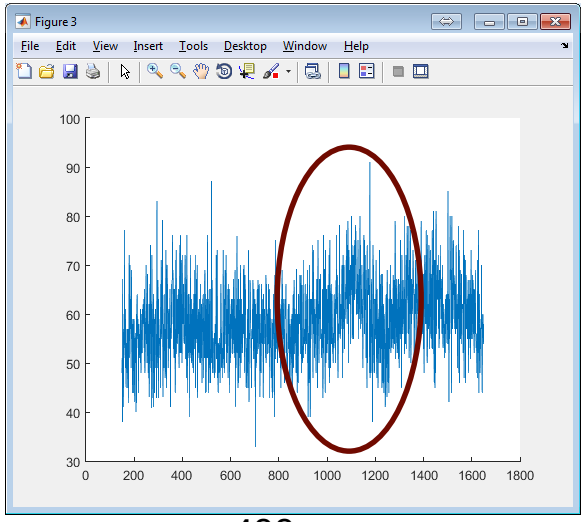
A	81.07
B	289.8
C	48.76
D	0.007226
E	354.6
Photon	9908

Different integration time

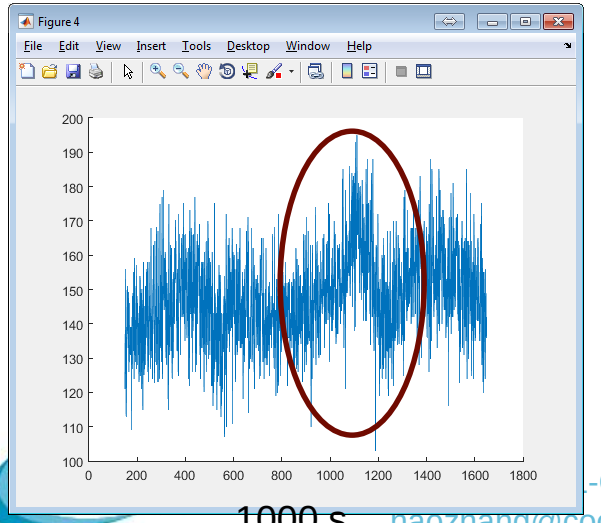




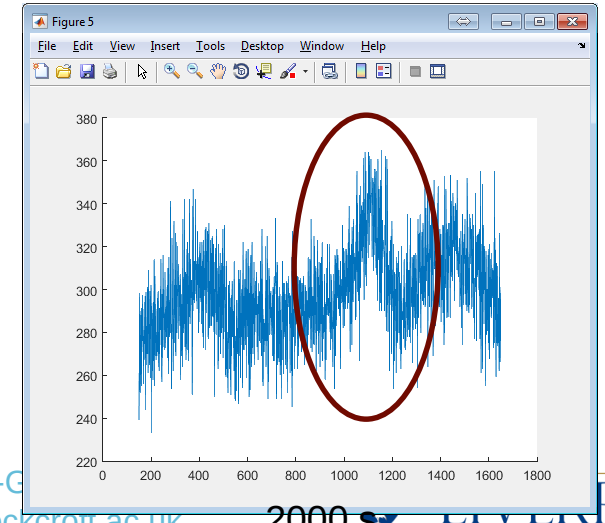
200 s



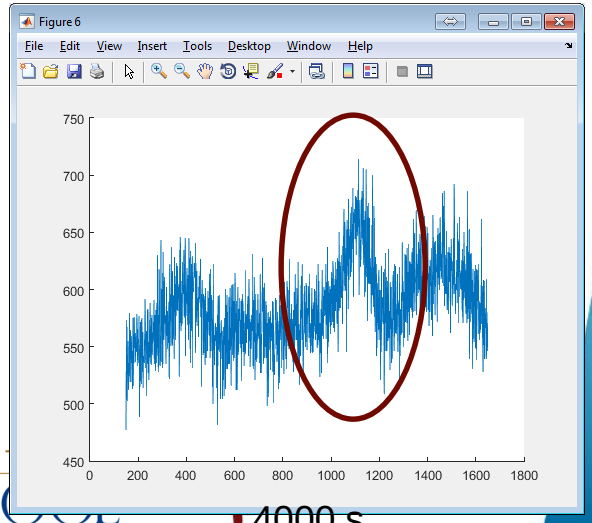
400 s



1000 s



2000 s

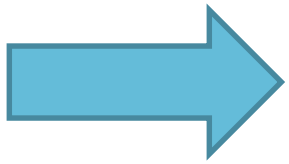


4000 s

Density calculation based on jet image

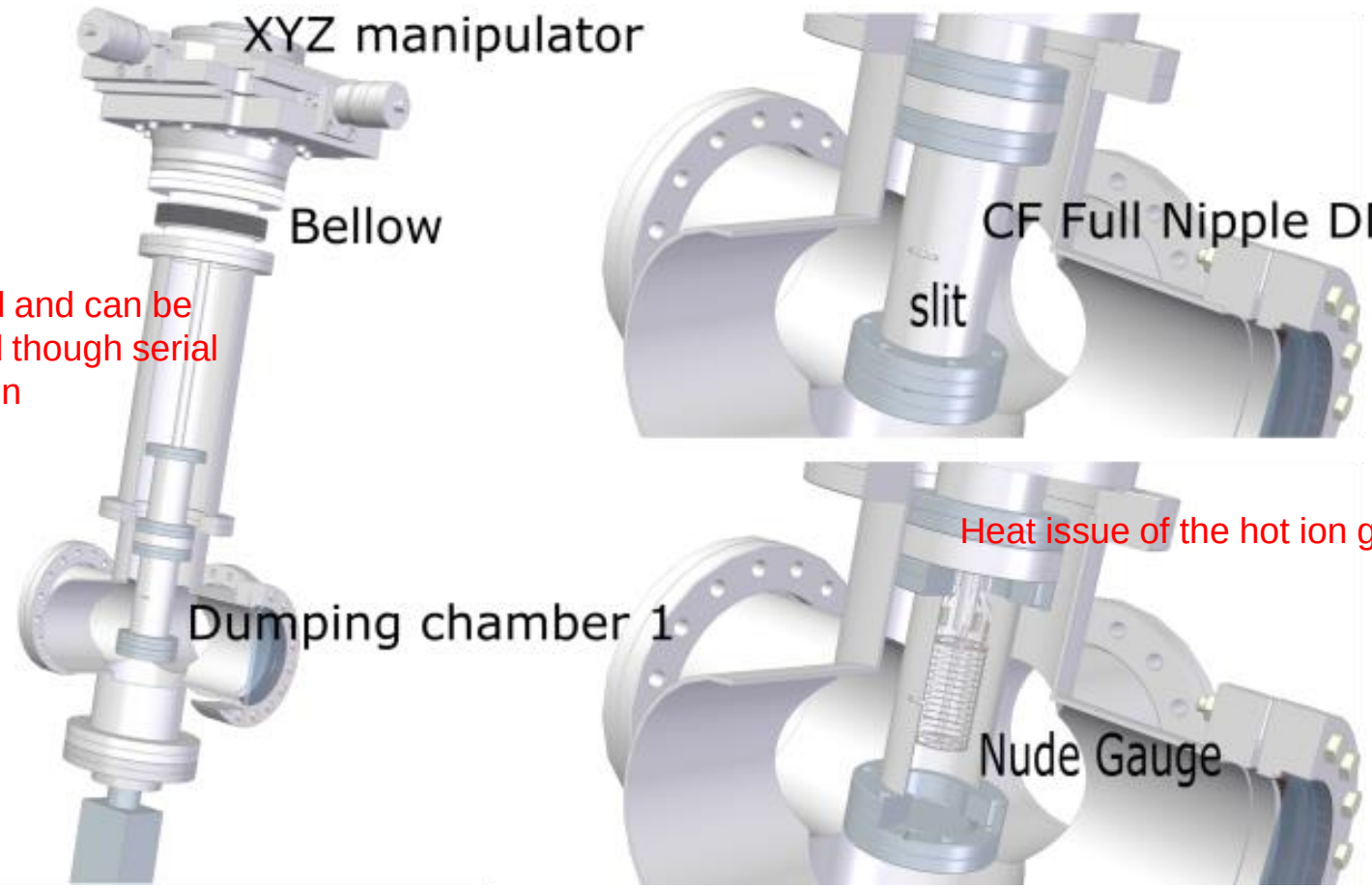
$$N_\gamma = \sigma \cdot \frac{I \cdot \Delta t}{e} \cdot n \cdot d \cdot \frac{\Omega}{4\pi} \cdot T \cdot T_f \cdot \eta_{pc} \cdot \eta_{MCP}$$

E = 5 keV
Sigma = 1.66e-18 cm^{-2}
I = 30 uA
Delta_t = 4000 s
d = 2.8 mm
Omega = Pi*4e-4 sr
T = 0.7
T_f = 0.3
Mu_pc = 0.3
Mu_MCP = 0.5
N ~ 10000
e = 1.6e-19 C



n ~ 9.0e15 m^{-3}

Density measurement using scanning gauge



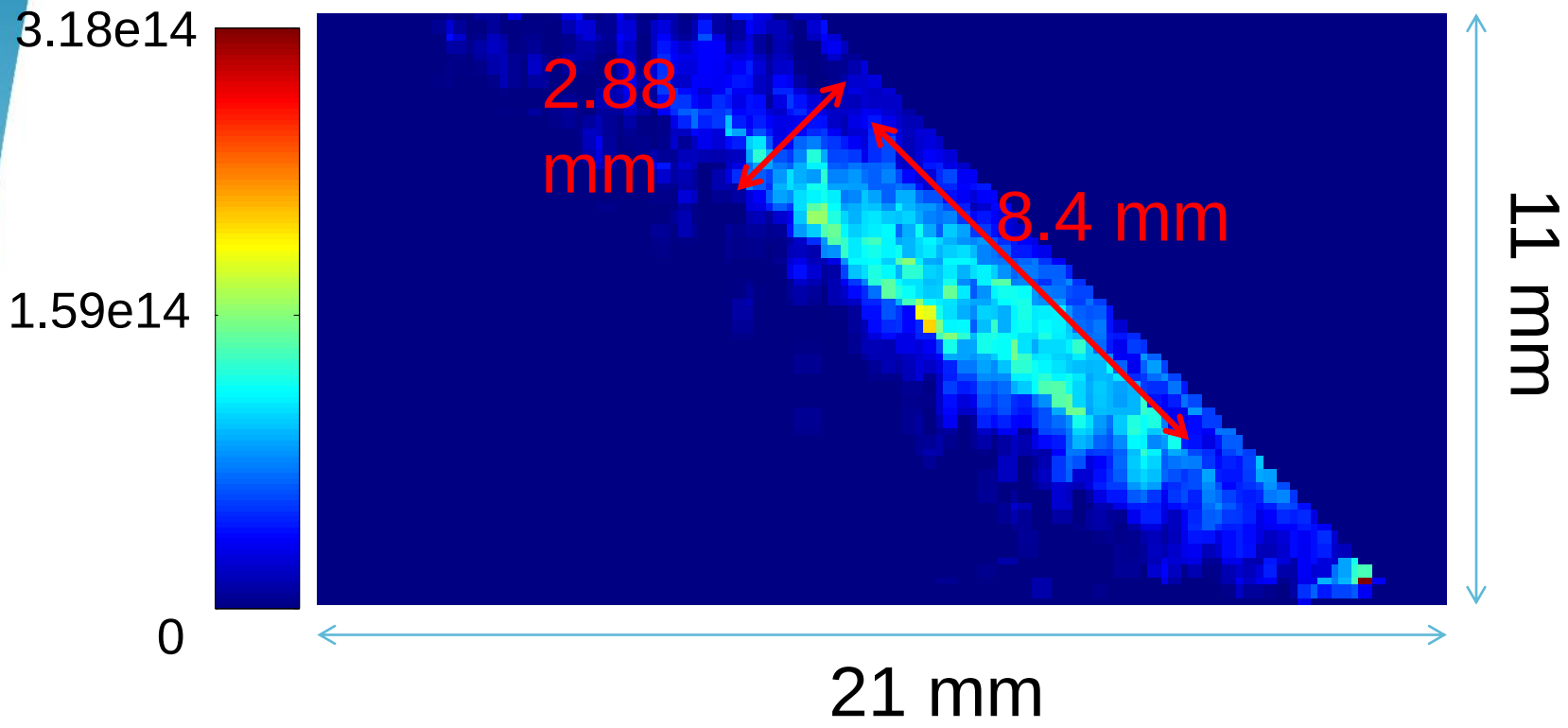
Motorized and can be controlled though serial connection

Heat issue of the hot ion gauge

Gauge signal is amplified by pico-ampere meter and record by scope.

Details at meeting 01/19/2018

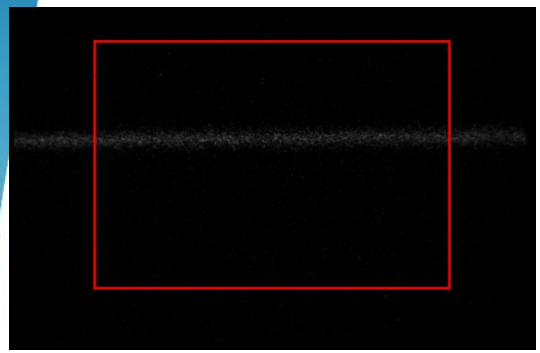
Density scan



Lower jet density measured.
- Pulsing mode used
- Out-gassing of the Gauge

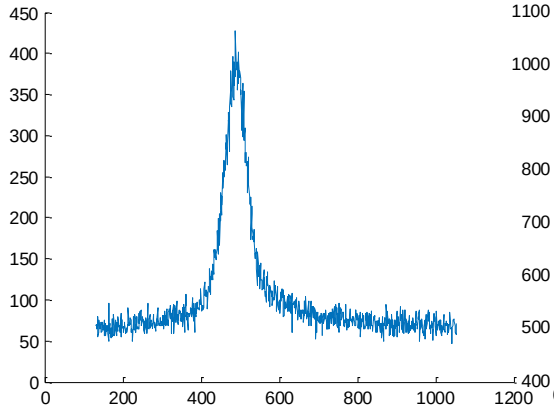
This method is good for characterize the jet shape

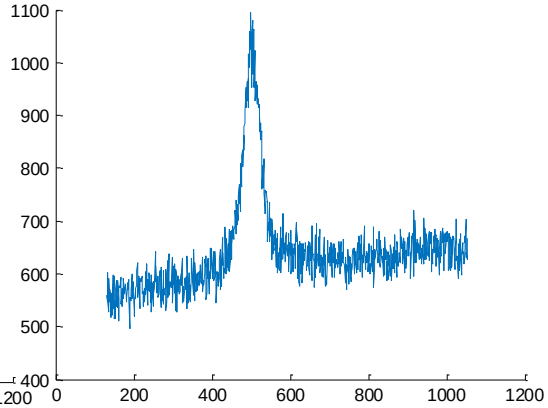
Neon test

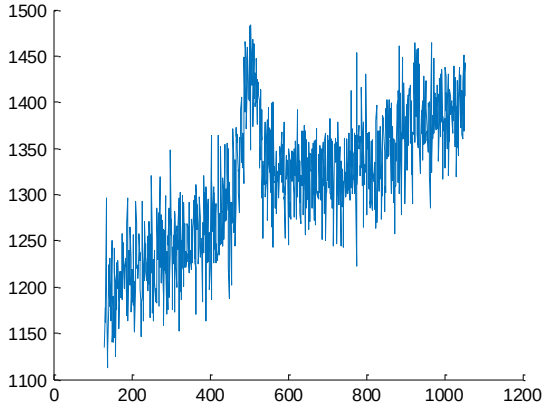


E-gun:

7keV
3.2A filament current
600 Anode current indicator,~80uA







9.8e-6mbar ~1.0e-5 mbar
100 s integration time

9.8e-7mbar ~1.0e-6 mbar
1000 s integration time

2.1e-7mbar
2000 s integration time

Photon number

21754

11792

8327

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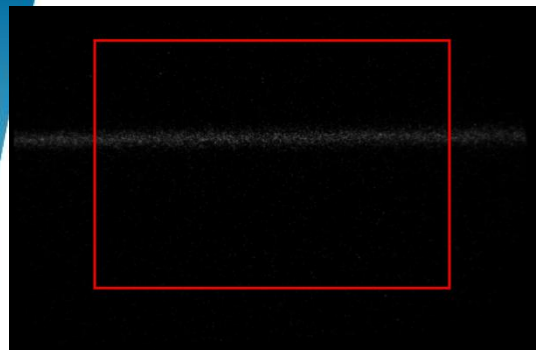
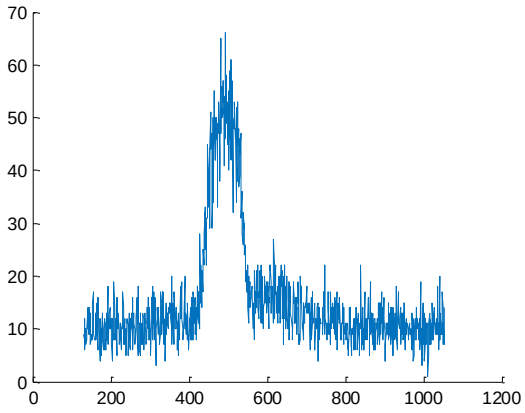
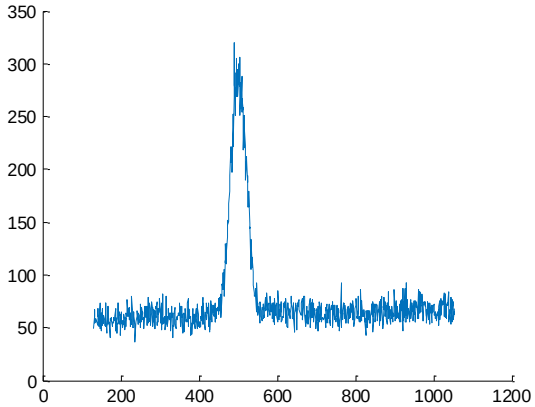
haozhang@cockcroft.ac.uk

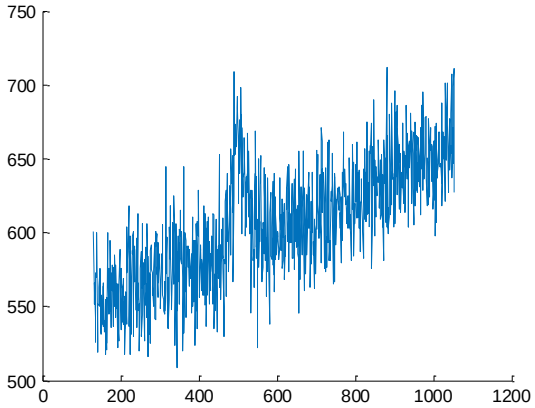
Nitrogen test



E-gun: the same with Neon







1.0e-5 mbar
2 s integration time (already saturated)

9.8e-7 mbar
100 s integration time

1.4e-7mbar
1000 s integration time

Photon number

23244.61

3149.78

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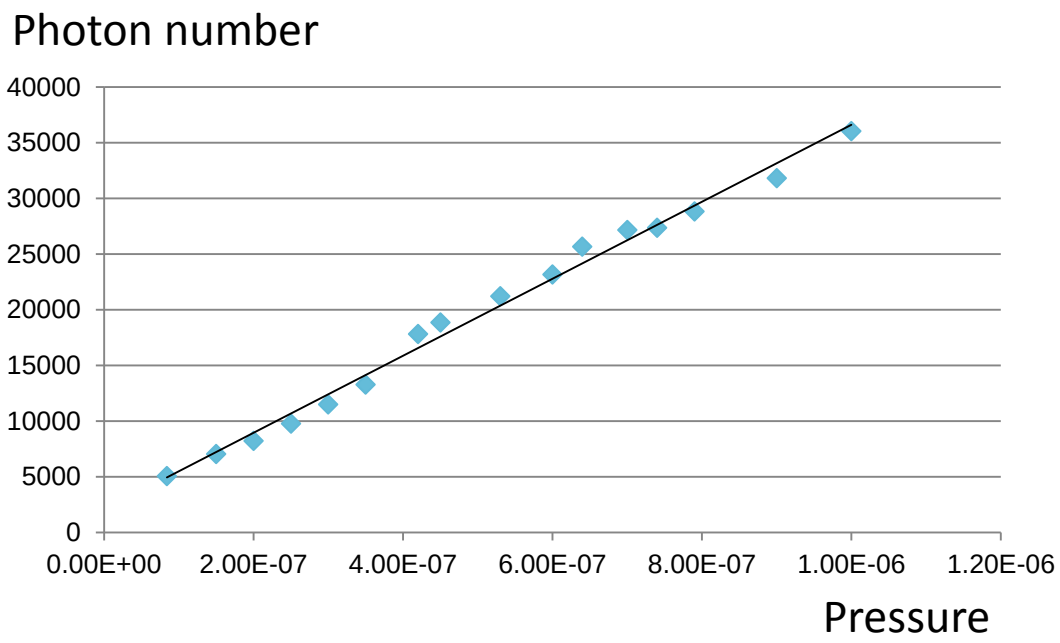
haozhang@cockcroft.ac.uk

More from Nitrogen residual gas image



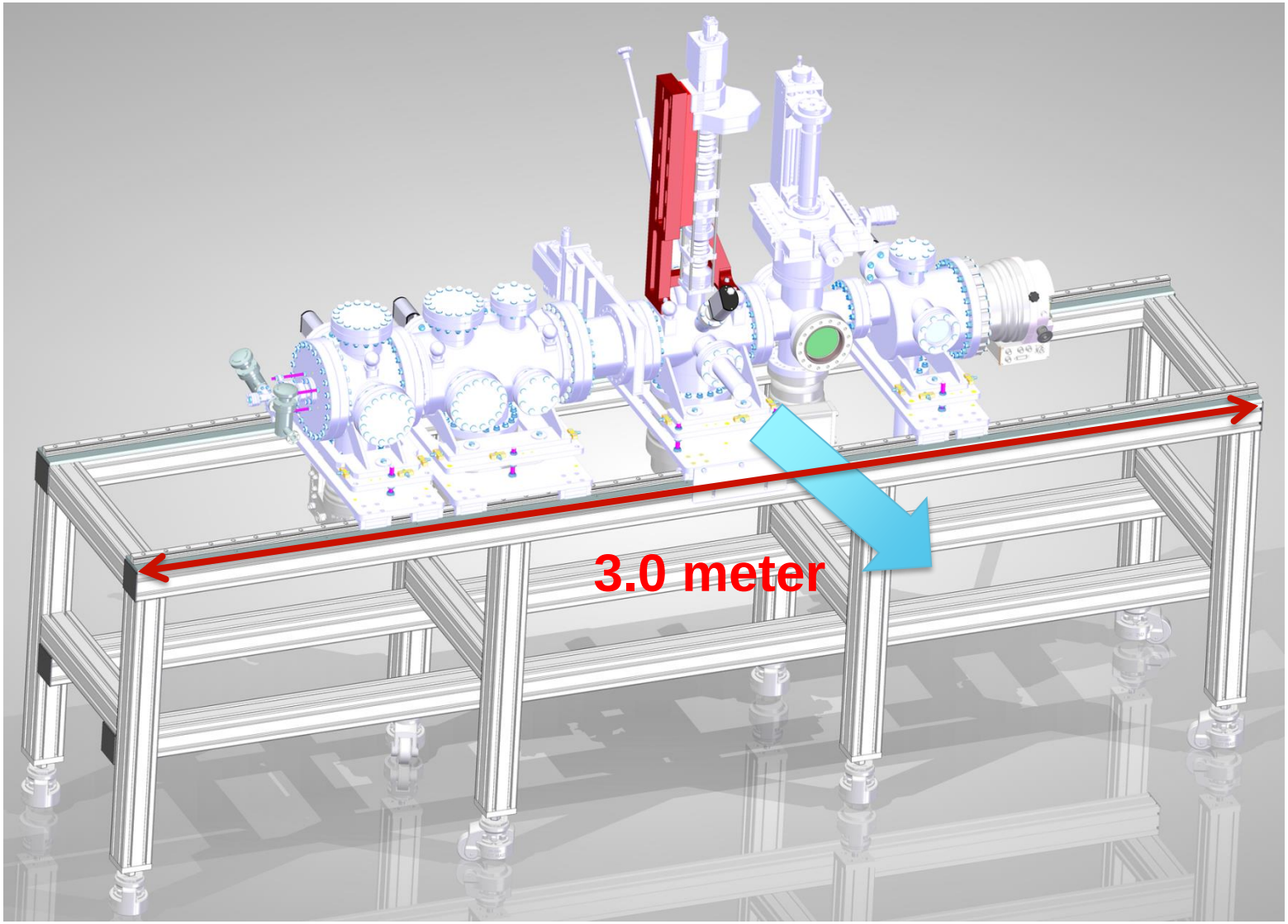
E-gun:

5 keV
3.2A filament current
~60uA

The measurement is rely on
- The accuracy of the gauge
- Known pressure relationship between gauge position and interaction

If the pressure relationship is known, this could be used to measure the gas jet density as well.

Progress of the new gas jet



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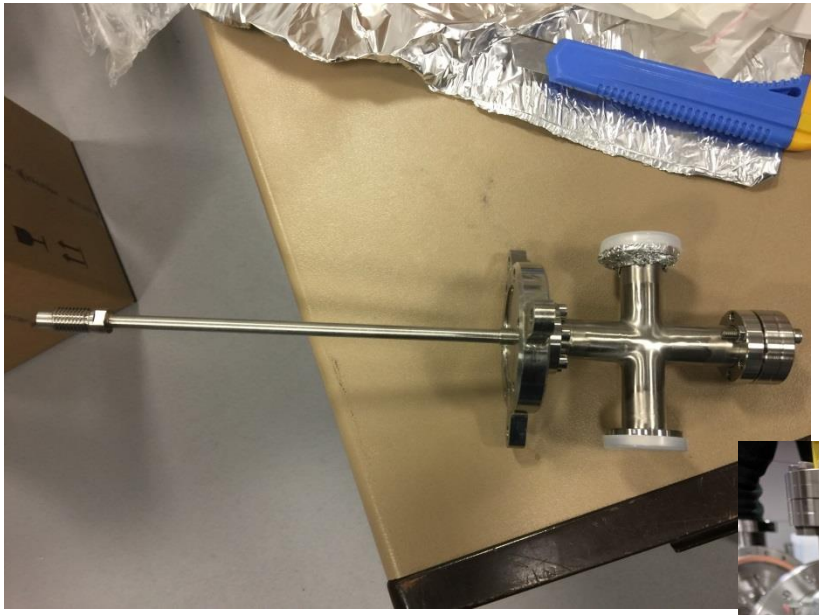
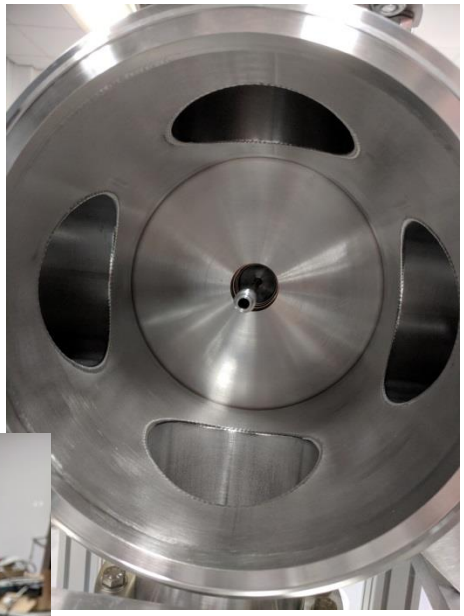
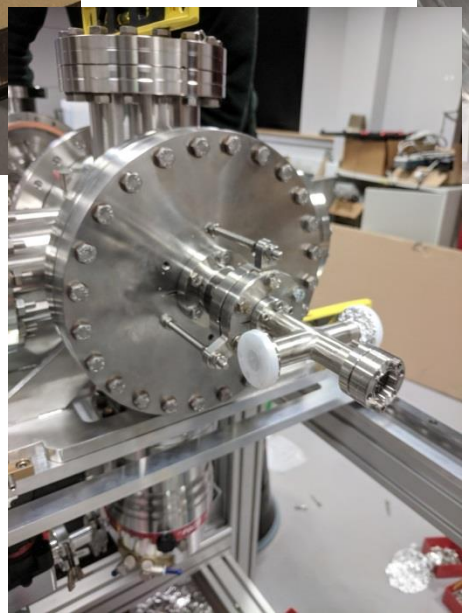
haozhang@cockcroft.ac.uk

Injector







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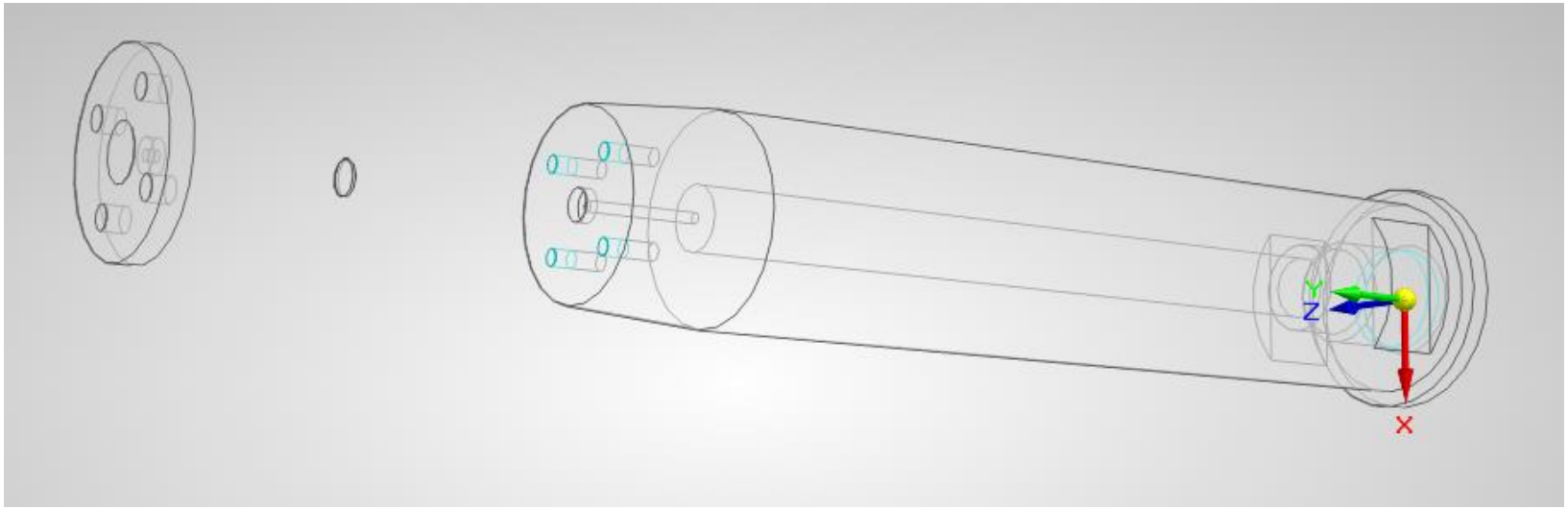
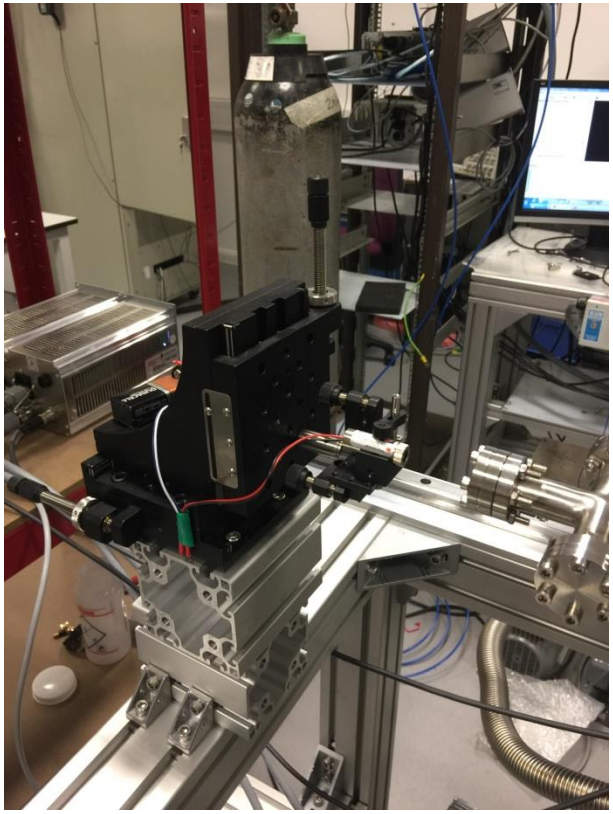
haozhang@cockcroft.ac.uk

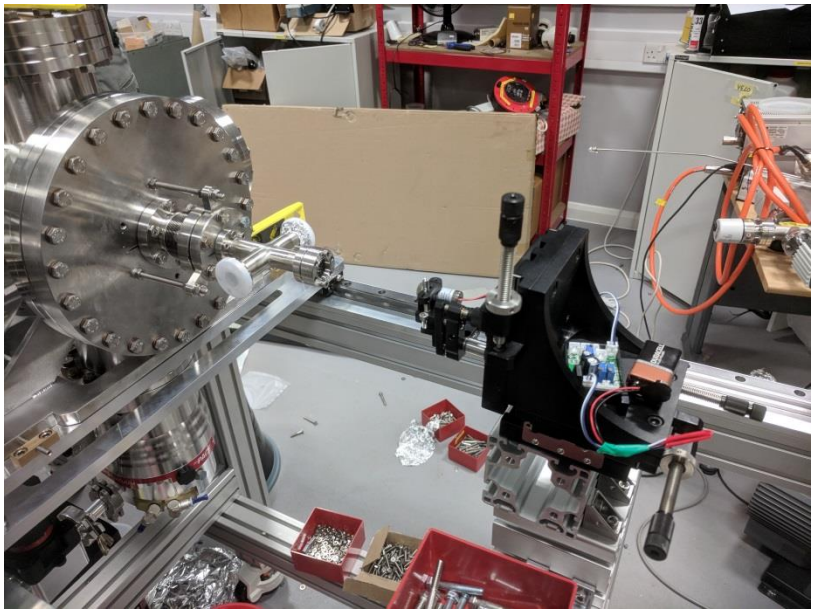
New nozzle design



- Will be ready in 3 weeks

Alignment laser system





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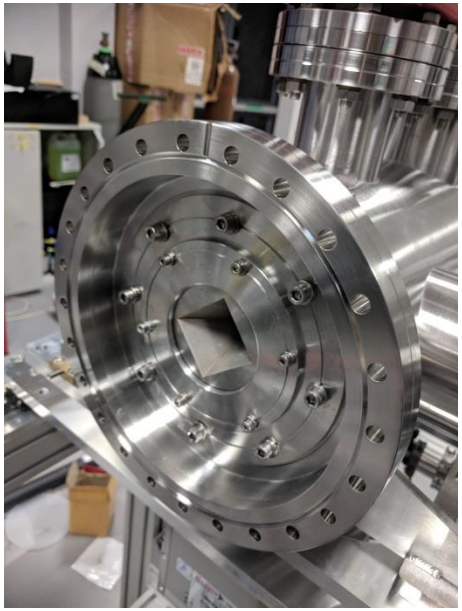
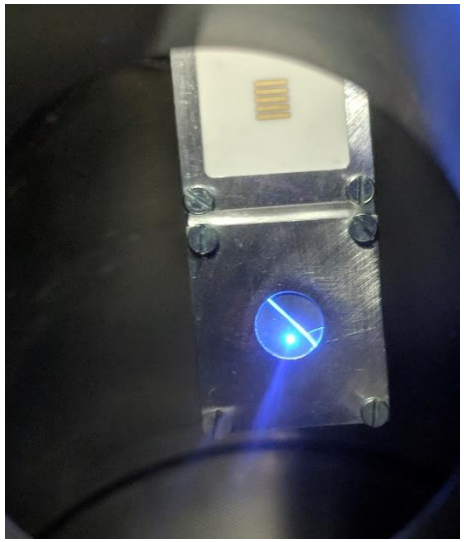
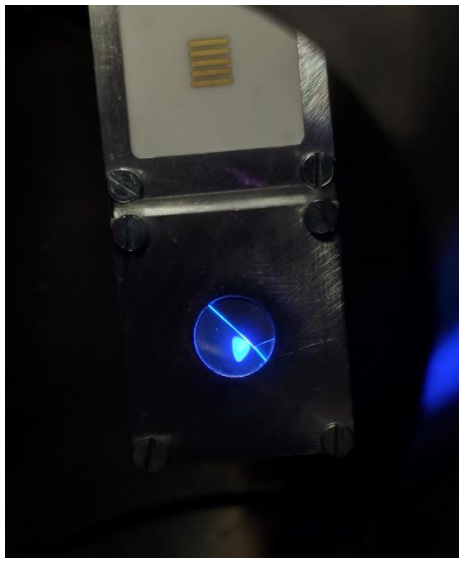
Skimmer assemblies



Screen & Target

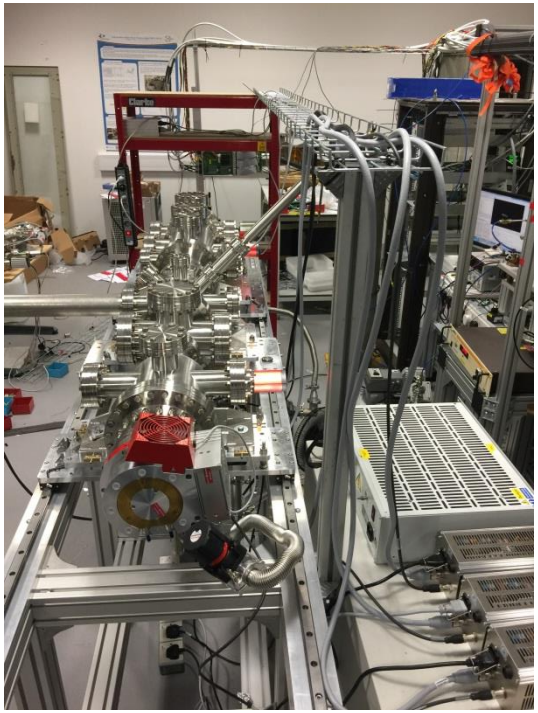




E-beam: 3keV, ~7uA

Hao Zhang-HL-GSI 19/03/18
haozhang@cockcroft.ac.uk

Setup as a whole



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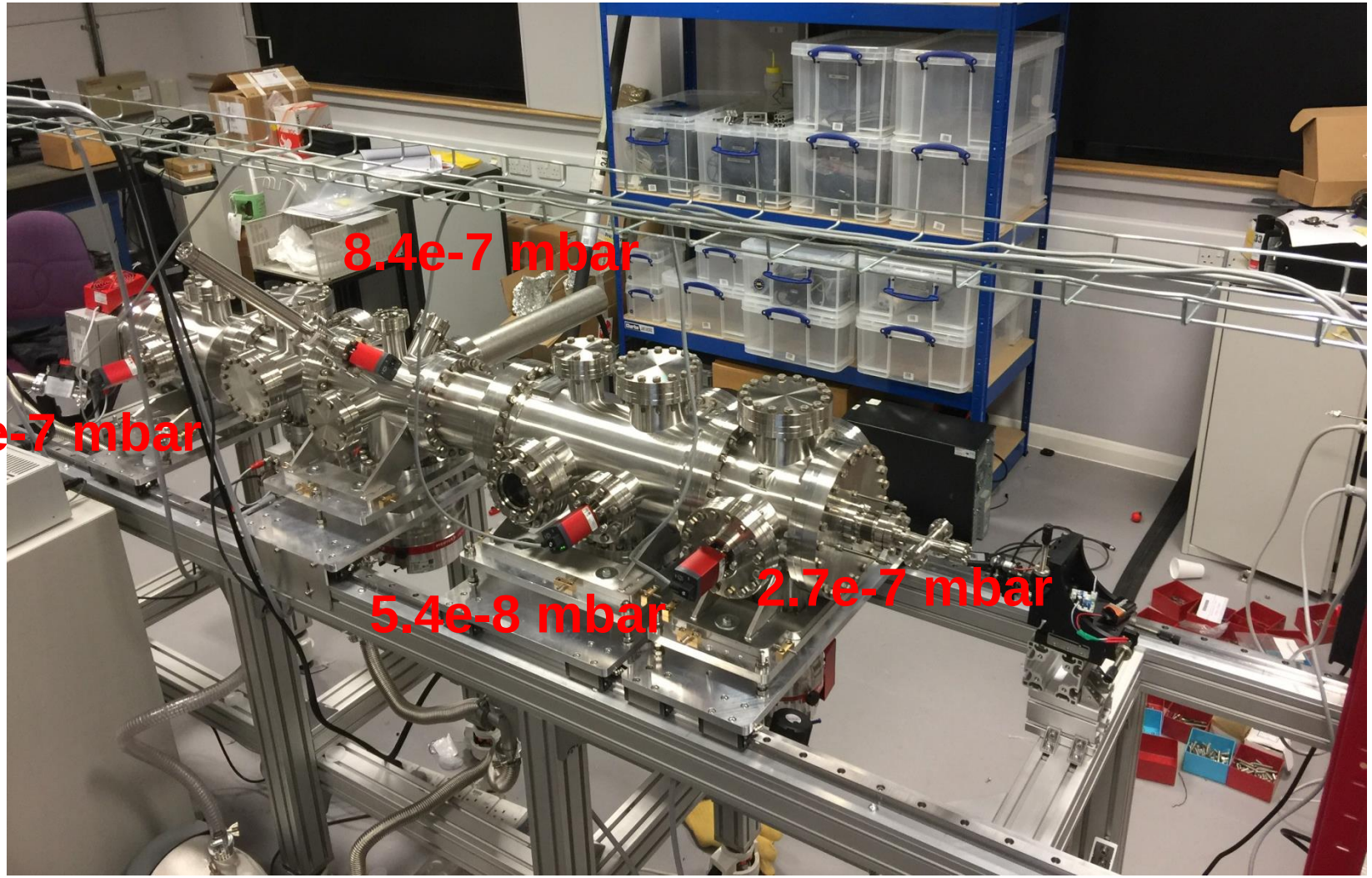
haozhang@cockcroft.ac.uk

Pumping test



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Leaking test failed

There might be a welding error here.

Other test
When mounting separately, the chamber can reach 10-8 mbar in one hour. 10-9 mbar over night.

New Electron Gun

- Will be shipped out at end of this month.
- Higher current (1uA-10mA)
- More accurate to steer the beam

Plans for 2018

- Install new gun in the old setup to further decrease the integration time (in seconds or less)
- Scanning gauge working in continuous jet mode
- Finish commissioning of the second gas jet setup
  - Nozzle and skimmers alignment
  - Chamber blackening
  - Pumping test
  - Bake-out
- Experiment tasks for the second gas jet
  - Jet image of e-beam, integration time and resolution
  - Different gas species, Nitrogen, Neon, Argon
  - Nozzle sizes (20um, 30um, 50um) and shape (regular or naval nozzle)
  - Jet density measurement
  - Nozzle, skimmer distance

Thanks for your attention

Hao Zhang-HL-GSI 19/03/18
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