Summary of CI simulations

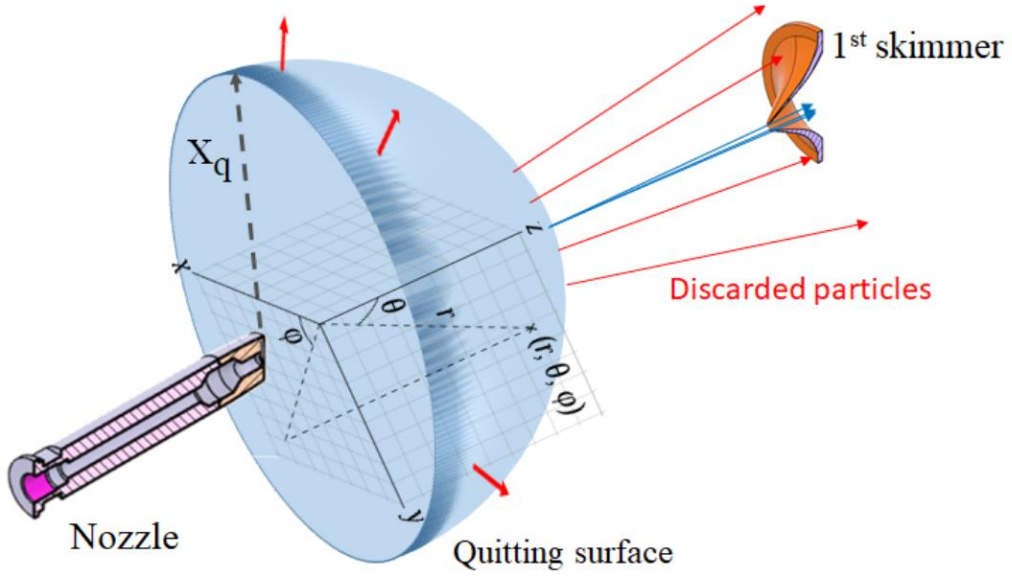
CI team

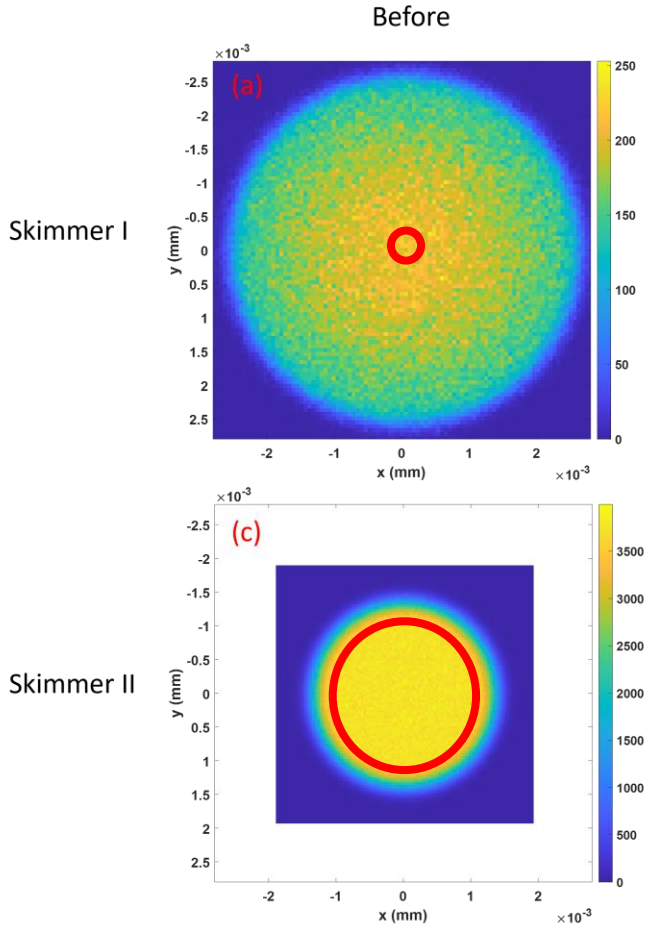
UNIVERSITY OF LIVERPOOL

Contents

- Recap the simulation methods
- Simulated options for v3 modification.
- Optimisation of BGC v4.1 @EBTS
- Optimised options of BGC v4.2 @LHC

Simulation method (TPMC + MOGA)

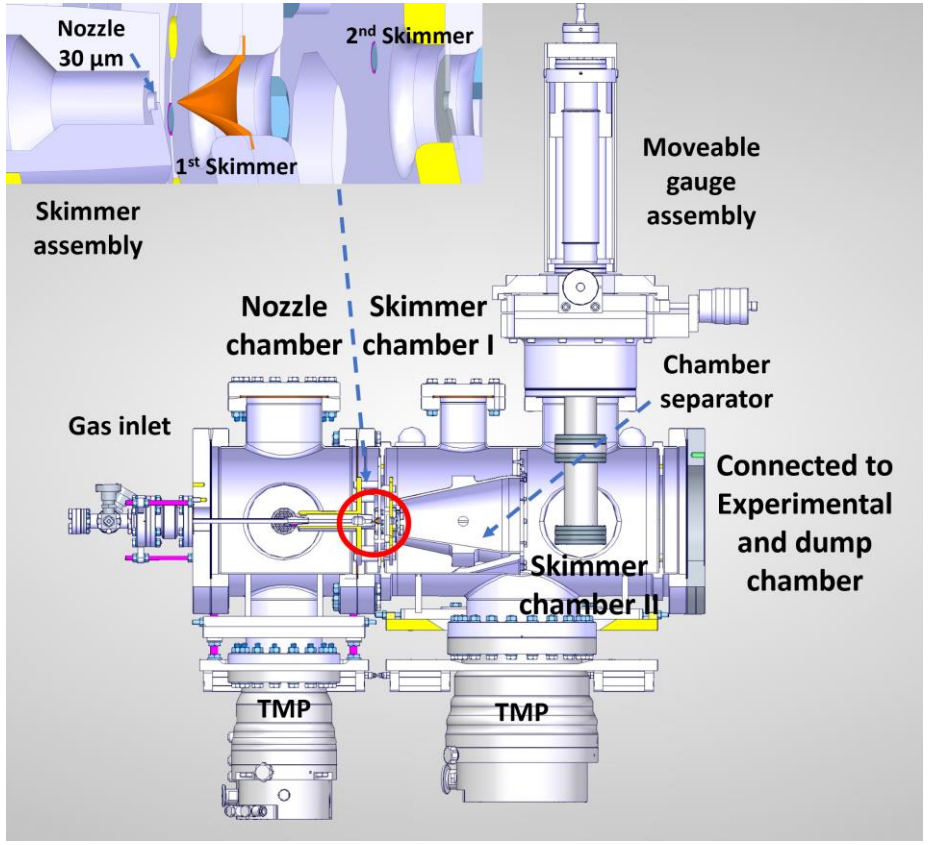




TPMC: Test particle Monte Carlo simulation
Continuum flow + Ray tracing for Molecular flow

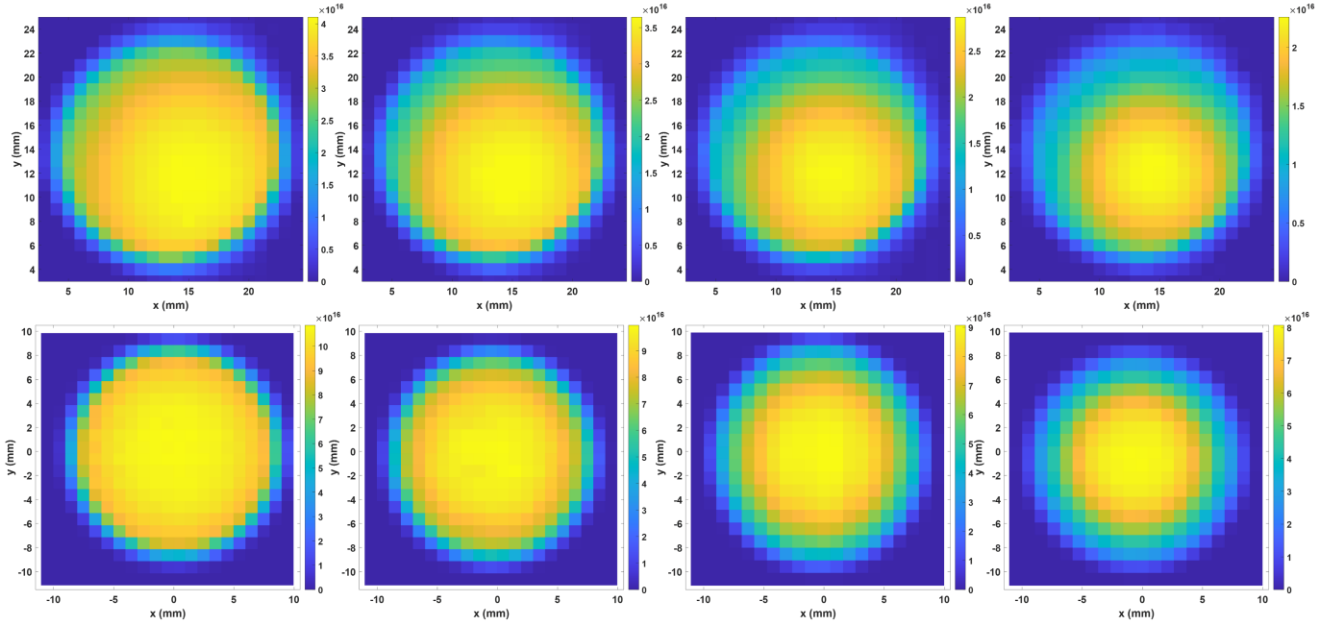
MOGA: Multi-object genetic algorithm for geometry optimisation

Good agreements between simulation and experiments



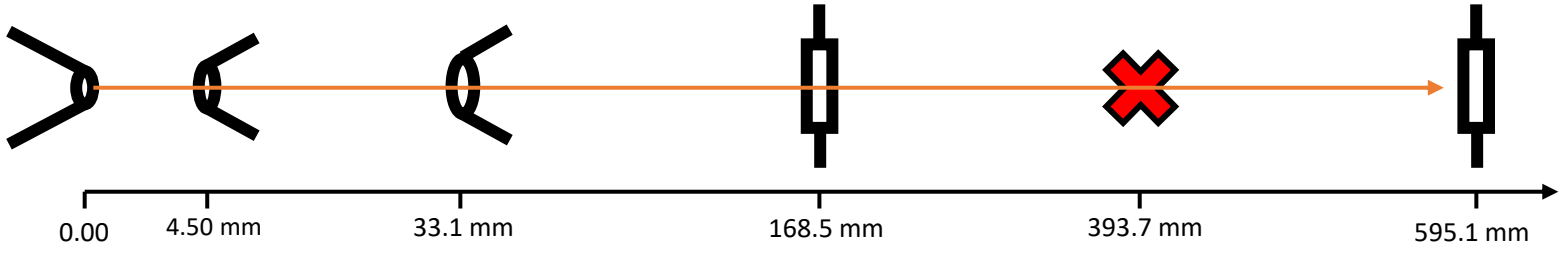
Test on V2 setup

Experiments: N_2 gas, 5bar inlet pressure

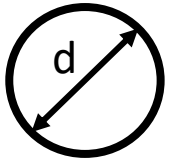


Simulation

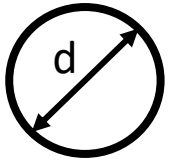
Simulation of V3 modification for YETS



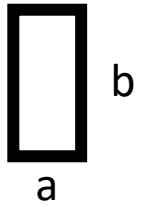
Nozzle | 1st Skimmer | 2nd Skimmer | 3rd Skimmer | IP | 4th Skimmer



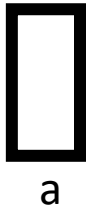
d: 400 µm



d: 2.00 mm

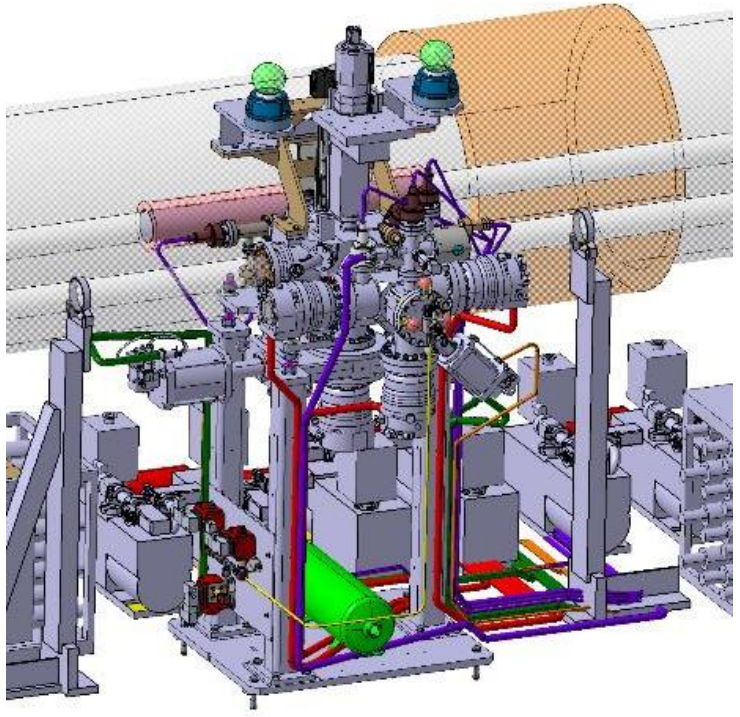


a: 0.3 mm b: 9.0 mm

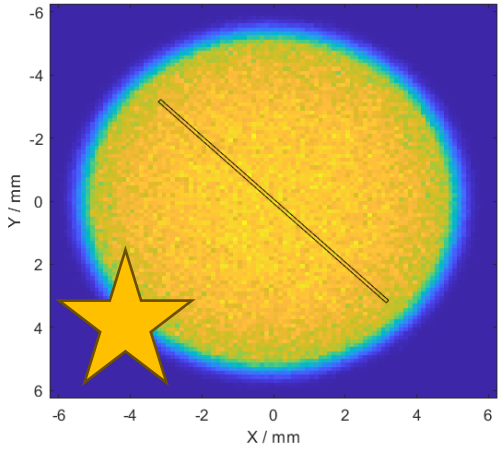


a: 7.0 mm b: 31.0 mm

Modify 3rd and 4th skimmer in YETS

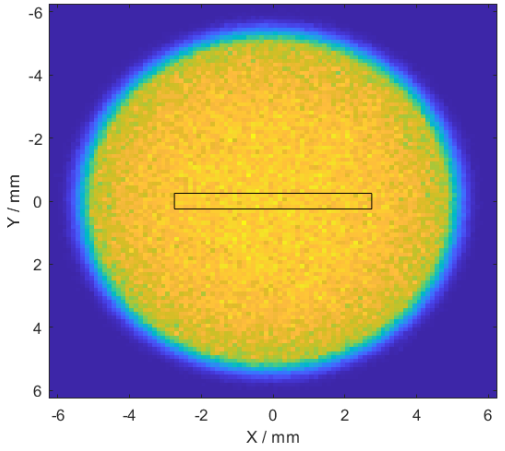


Simulation of V3 modification options for YETS



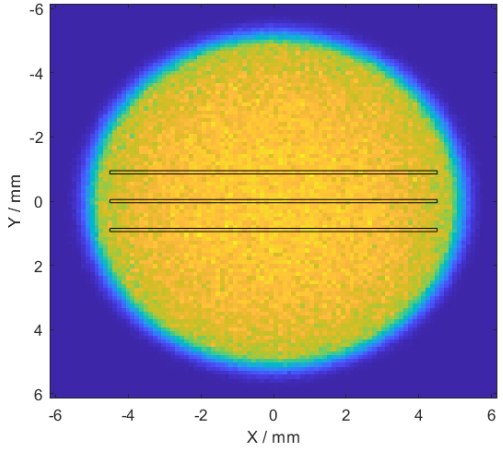
1.1 – Thin Curtain

Reduce thickness smearing for 2D profile



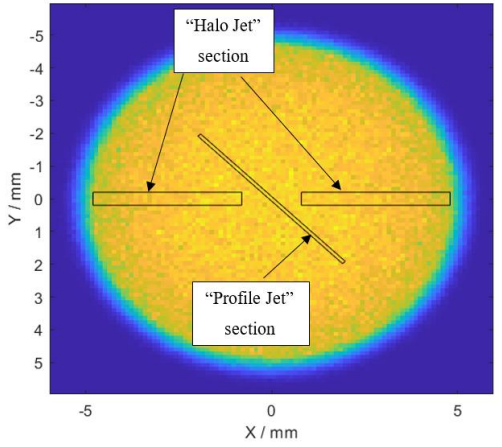
1.2 – Halo Single

Maximise losses for halo detection



1.3 – Halo Multi

Same as 1.2, but reduced chance of misalignment



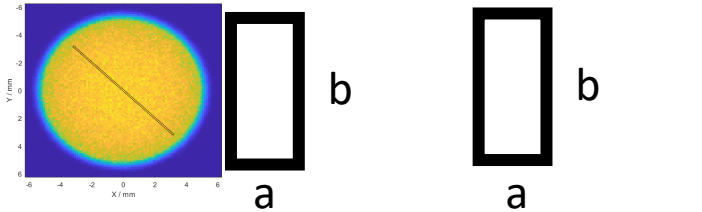
1.4 – Profile & Halo

Combination of 1.1 and 1.2 (shared positives and negatives)

See technical notes: https://indico.cern.ch/event/1461184/

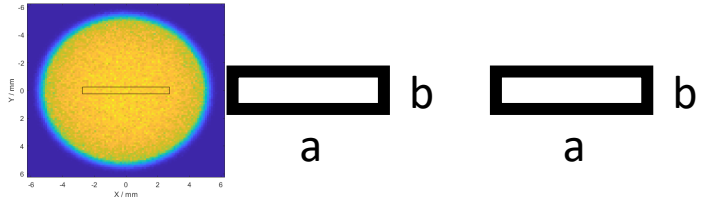
Optimised results for each option

3rd Skimmer 4th Skimmer IP



a: 0.1 mm
b: 7.5 mm

a: 0.8 mm
b: 26.4 mm



a: 7.8 mm
b: 0.7 mm

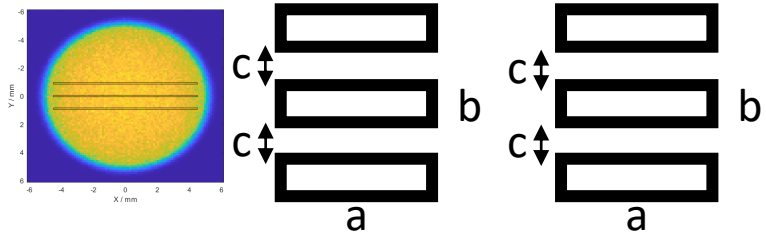
a: 27.0 mm
b: 3.2 mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	BG Pressure / mbar
Thin Curtain	1.01×10^{17}	17.2	0.22	4.8×10^{-9}

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	BG Pressure / mbar
Halo Single Slit	1.01×10^{17}	1.53	18.0	4.4×10^{-8}

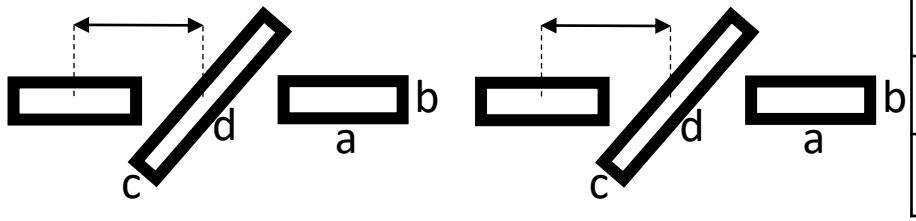
Results for each option

3rd Skimmer 4th Skimmer



a: 8.9 mm
b: 0.08 mm
c: 1.0 mm

a: 31.7 mm
b: 1.0 mm
c: 3.6 mm



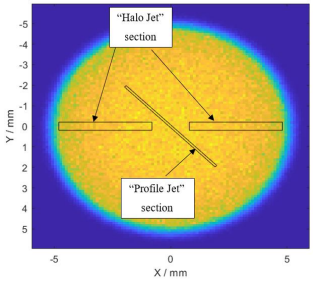
a: 4.0 mm b: 0.4 mm
c: 0.1 mm d: 5.5 mm
e: 2.8 mm

a: 14.4 mm b: 1.7 mm
c: 0.7 mm d: 20.0 mm
e: 10.0 mm

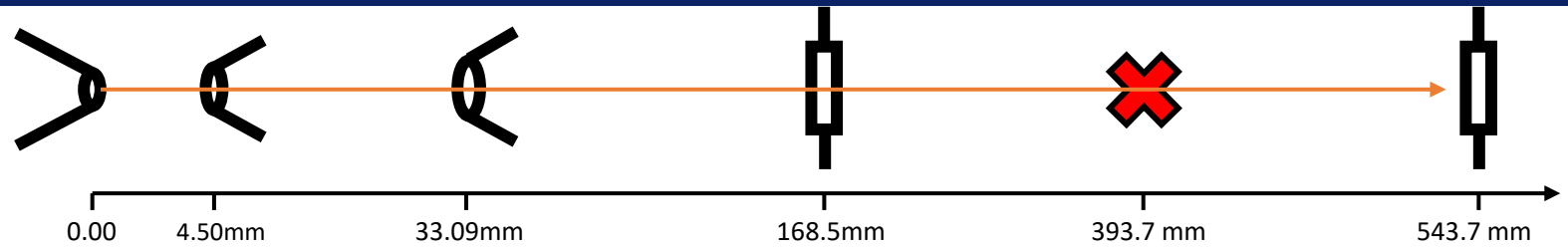
IP

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	BG Pressure / mbar
Halo Multi Slit	1.03×10^{17}	3×0.20	20.5	1.71×10^{-8}

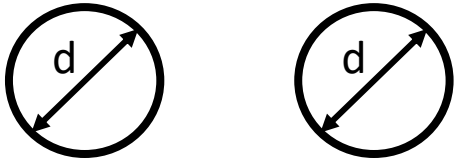
Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	BG Pressure / mbar
Profile	1.18×10^{17}	12.6	0.22	2.7×10^{-8}
Halo	1.20×10^{17}	0.91	2×9.0	2.7×10^{-8}



v4.1 design: nozzle skimmer assembly in simulation

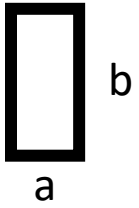


Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**

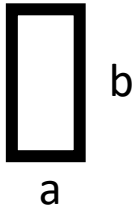


d: 700 µm

d: 5.10 mm



a: 0.10 mm b: 25.9 mm



a: 1.1mm b: 95.2 mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.36×10^{16}	57.85	0.24	1.87	2.93×10^{-8}

Now these are defined as a FWHM value.

v4.1 design: nozzle skimmer assembly

Table 1. On axis distances from nozzle of skimmers and IP

	1st Skim	2nd Skim	3rd Skim	IP
'V4 – EBTS'	4.5 mm	33.09 mm	168.5 mm	393.7 mm
JEREMY	4.5 mm	31.7 mm	183.27 mm	329.85 mm

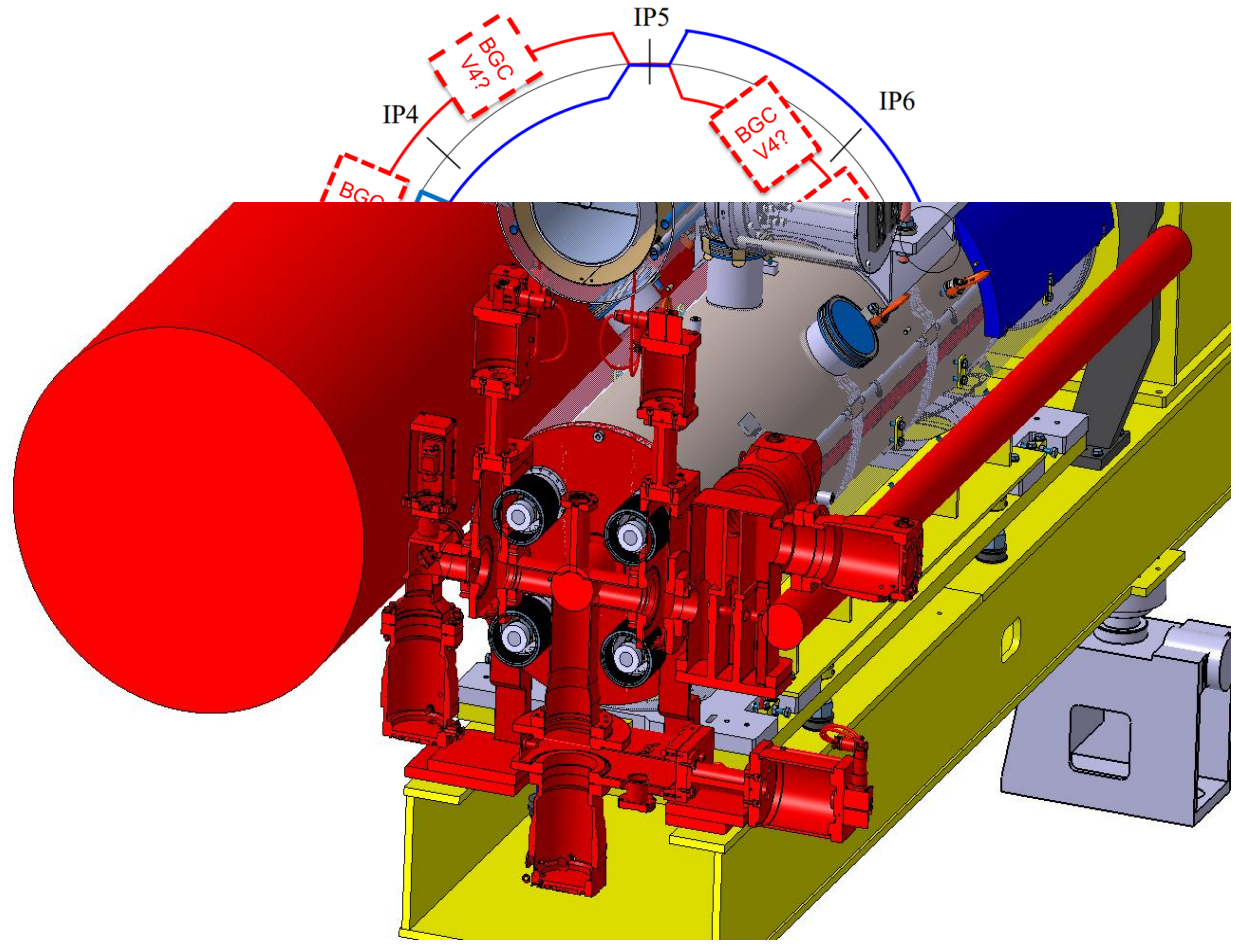
Movable gauge also reduces this by 20mm (new = 309.85 mm)

Table 2. Nozzle and skimmer sizes

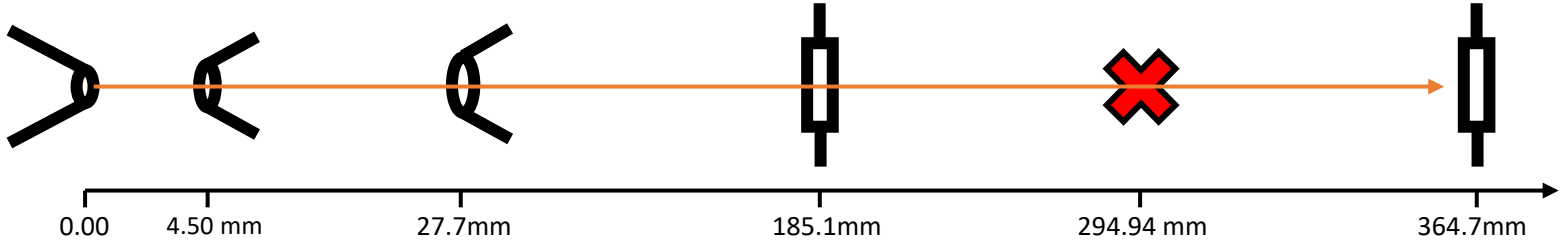
	Nozzle	1st Skim	2nd Skim	3rd Skim
'V4 – EBTS'	30 µm	700 µm	5.1 mm	0.1x25.9 mm
JEREMY	30 µm	700 µm	5.3 mm	0.1x30 mm

V4.2 design consideration

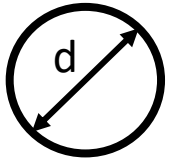
- Point 4:
  - Distance Beam1 – Beam2 axes limit the space of the injection.
  - Space for injection will be reduced with v3 design
- Point 6:
  - Distance Beam1 – Beam2 axes is only 194mm
    - Currently design need to squeeze the dump side from 420 to 194mm.



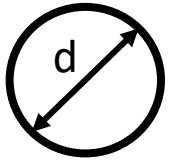
Simulation of v4.2 for point 4 beam 2



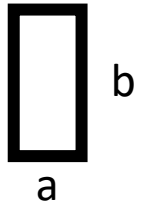
Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**



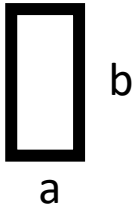
d: 200 µm



d: 1.0 mm



a: 1.8 mm b: 6.7 mm

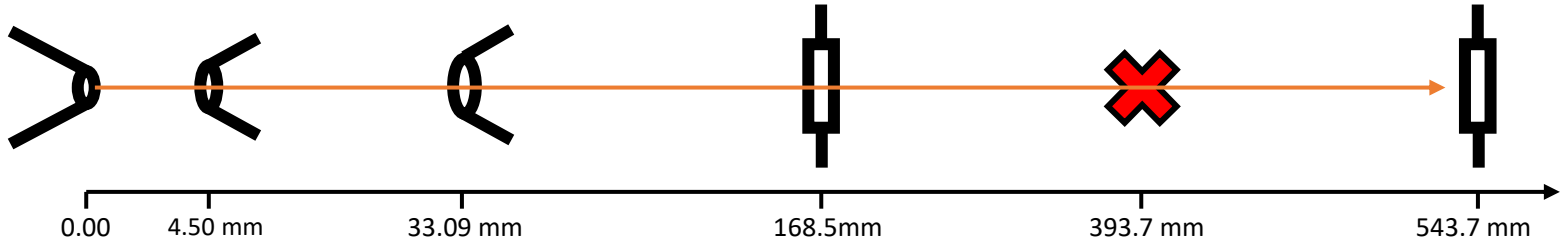


a: 4.4 mm b: 16.7 mm

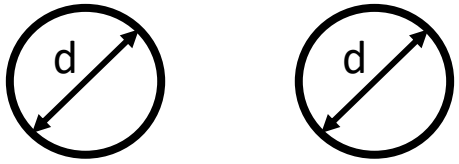
- Optimised for 10 mm curtain Length.
- Maximised the curtain width to increase the signal.

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.86×10^{17}	10.16	2.80	0.94	4.13×10^{-8}

Simulation of v4.2 for point 6 beam 2

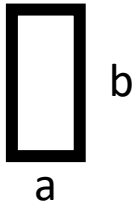


Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**

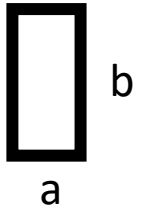


d: 200 µm

d: 800 µm



a: 1.1 mm b: 4.5 mm

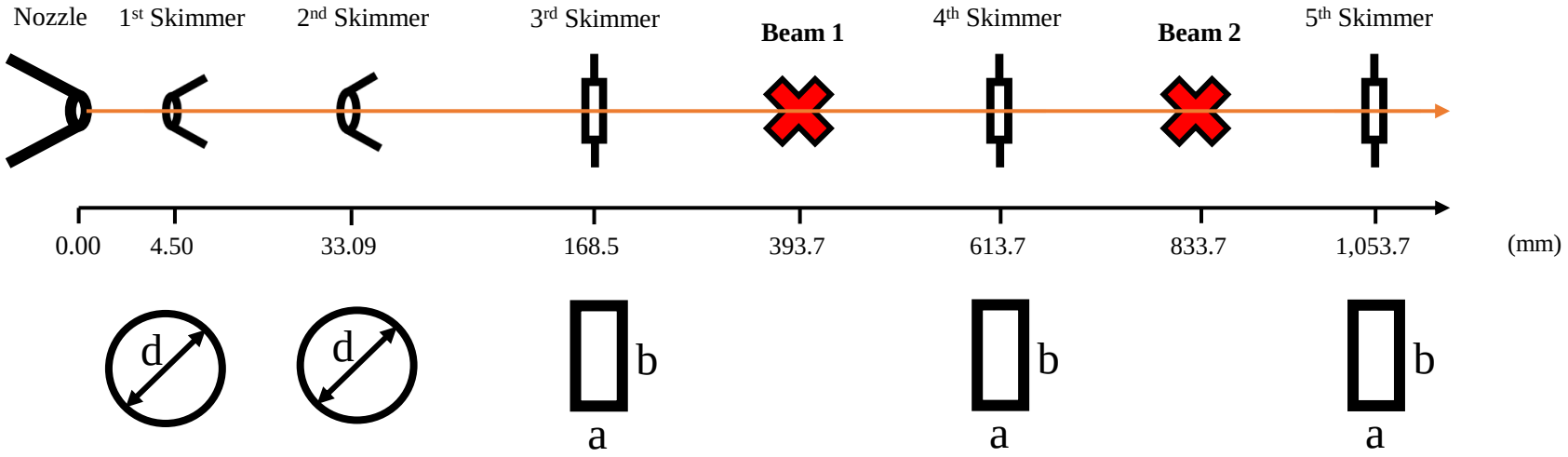


a: 4.8 mm b: 16.6 mm

- Optimised for 10mm curtain Length.
- Maximised the curtain width to increase the signal.

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.03×10^{17}	9.07	2.51	1.06	1.74×10^{-8}

Simulation of v4.2 for point 4 both beam



d: 400 μm

d: 530 μm

a: 1.2 mm
b: 2.0 mm

a: 5.0 mm
b: 8.9 mm

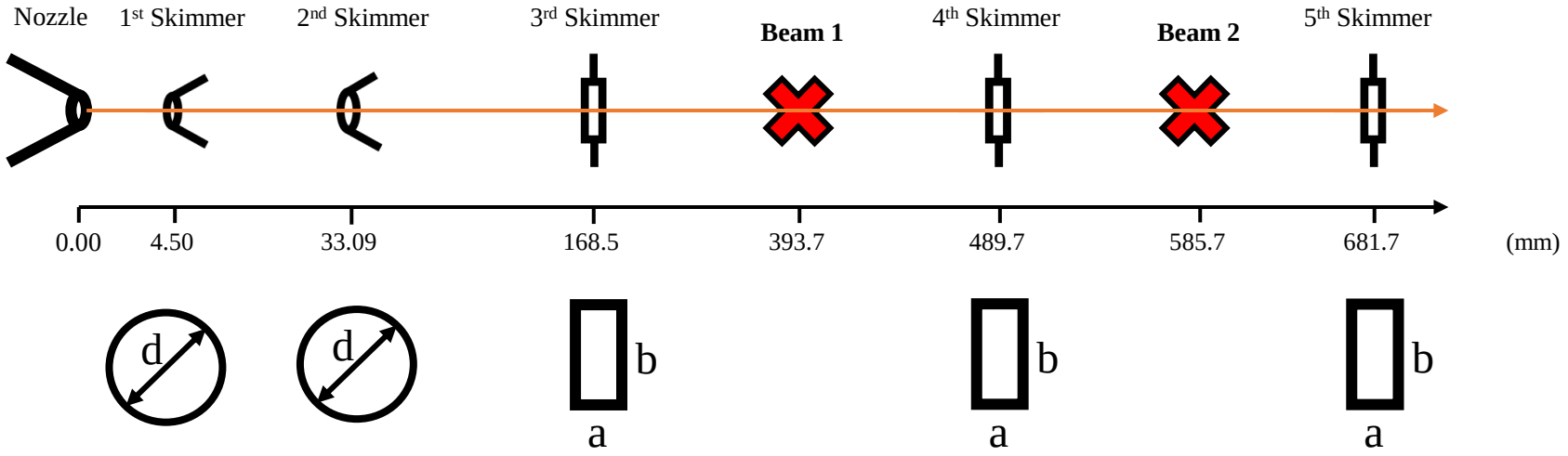
a: 8.0 mm
b: 13.8 mm

Criteria	Density / # m^{-3}	Length / mm	Width / mm	Variation / %	BG Pressure / mbar	Density / # m^{-3}	Length / mm	Width / mm	Variation / %	BG Pressure / mbar
Optimised Value	5.15×10^{16}	4.69	2.69	2.02	1.38×10^{-9}	1.15×10^{16}	9.99	5.68	1.83	1.24×10^{-8}

Beam 1 conditions

Beam 2 conditions

Simulation of v4.2 for point 6 both beam



d: 300 µm

d: 560 µm

a: 1.0 mm
b: 2.8 mm

a: 4.4 mm
b: 8.8 mm

a: 5.2 mm
b: 12.8 mm

Criteria	Density / # m^{-3}	Length / mm	Width / mm	Variation / %	BG Pressure / mbar	Density / # m^{-3}	Length / mm	Width / mm	Variation / %	BG Pressure / mbar
Optimised Value	5.15×10^{16}	6.32	2.27	1.48	1.48×10^{-9}	2.32×10^{16}	9.37	3.37	1.48	8.68×10^{-9}

Beam 1 conditions **Beam 2 conditions**

Conclusion

- Simulation serves the design work very well.
- Lead to creative curtain design.
- Planned publication on the simulation work.