Summary of CI Simulations

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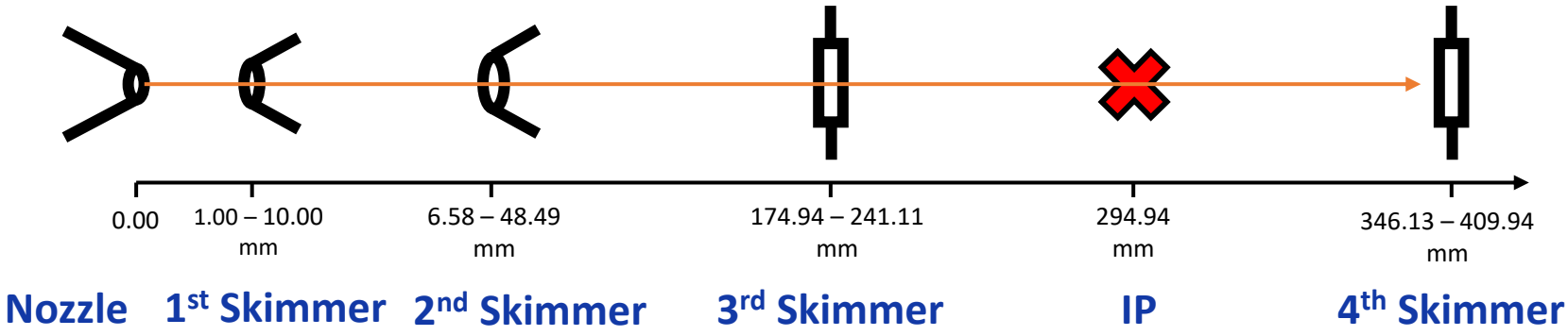
Contents

- **Test Particle Monte Carlo** simulation introduction
- **Multi-Objective Genetic Algorithm** summary
- Optimised geometries
  - **EBTS** – 60mm curtain
  - **LHC** – Hadron only beam

Test Particle Monte Carlo Simulation



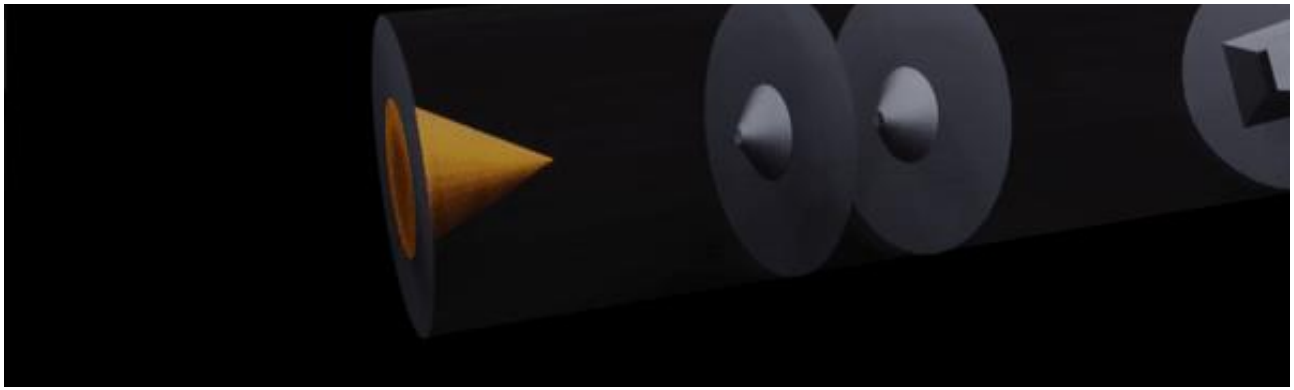


Figure 2: Animation of the Test Particle Monte-Carlo gas jet principal.

Injection Optimisation

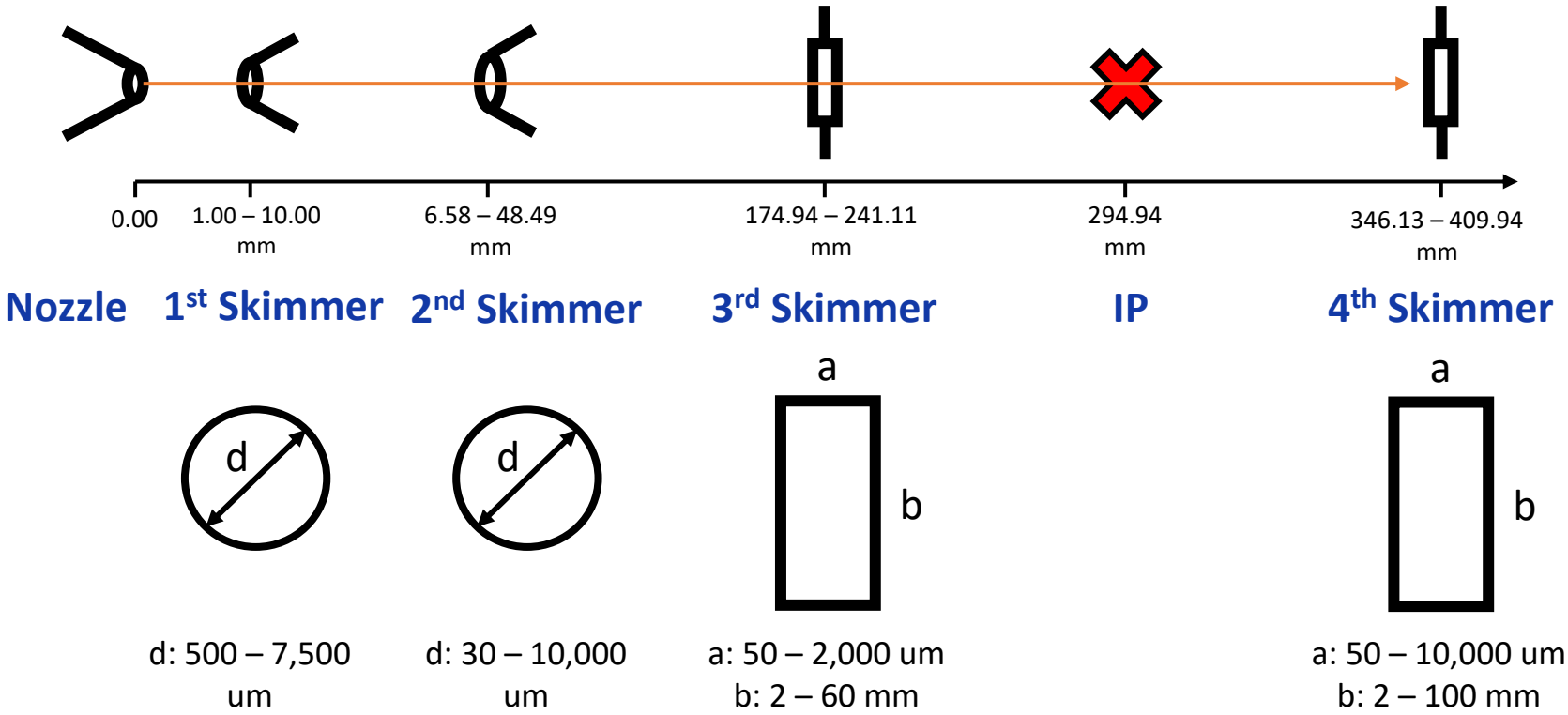


Figure 3: Schematic of the injection parameter space used for the optimisation study.

Objective Space

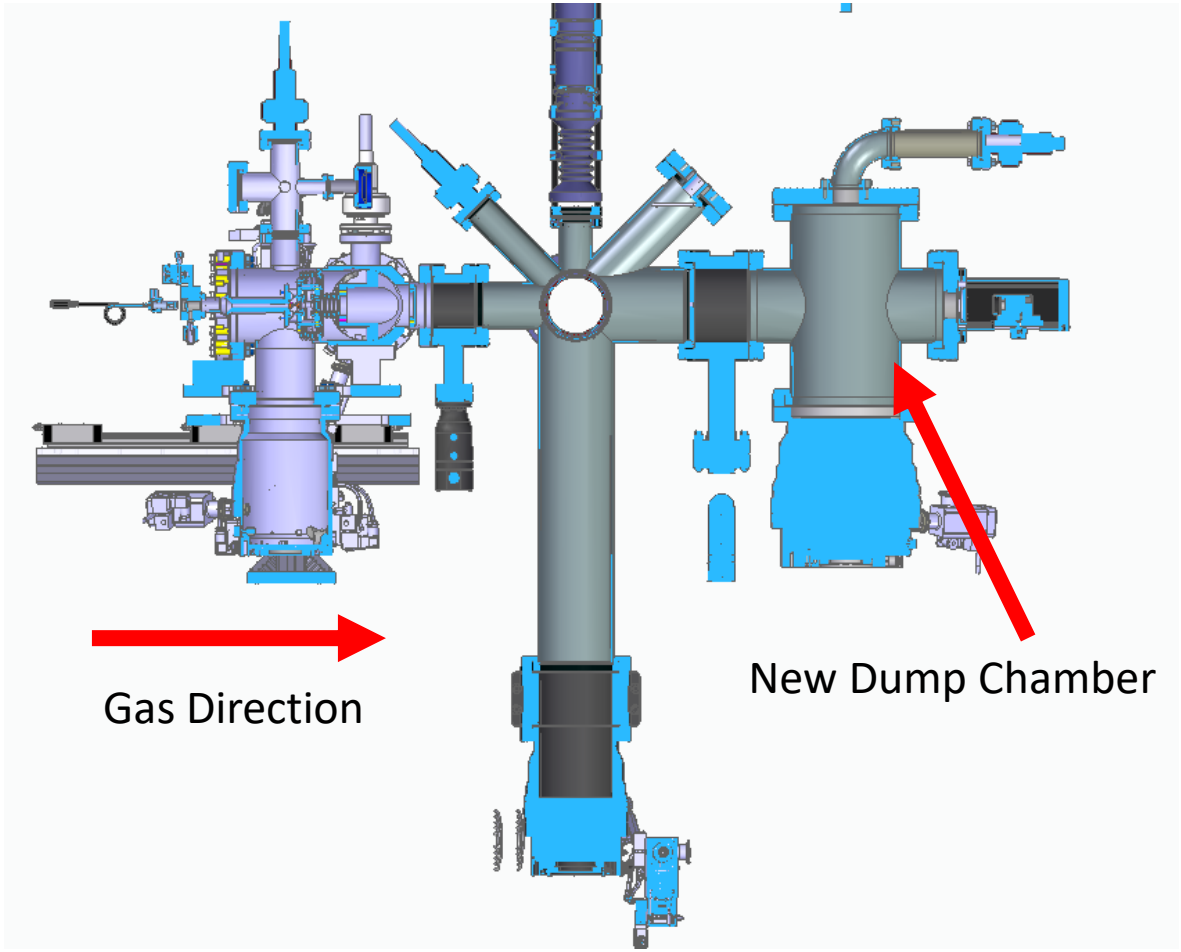
Objective Parameter		Justification	Target
Number density	-	Proportional to **signal received**	$> 2 \times 10^{16}\ \#m^{-3}$
Length of jet	-	Maximum **beam profile size**	$> 20\ mm$
Width of jet	-	Determines **spatial resolution**, **signal** yield and **beam losses**	$< 1.5\ mm$
Density variation	-	**Uniform** profile measurement	$< 20\ \%$
Background Pressure	-	Minimise **beam losses**	$< 5 \times 10^{-8}\ mbar$

MOGA Summary

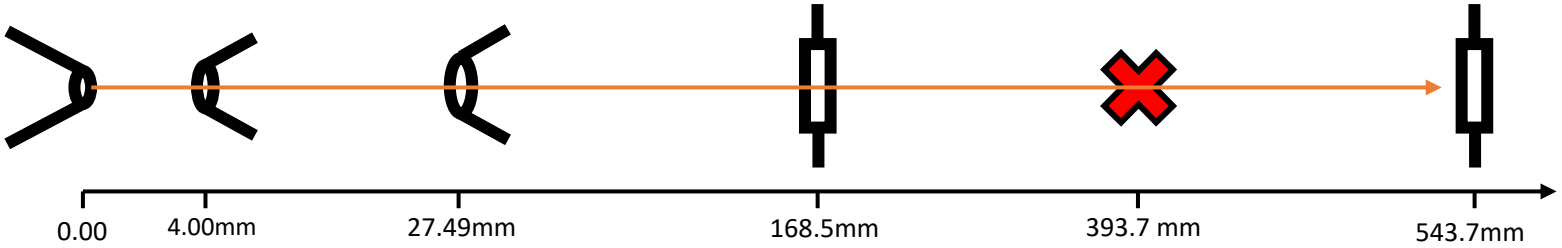
- Some **26 million simulations** ran over past 6 months
- Undergone several iterations of code
- **Statistical error** has been **characterised**
- **Successful** confidence testing for **local optimum**
- Started **writing up** MOGA work
- **Most relevant** two simulations presented

BGC V4 – EBTS Device

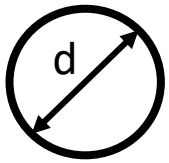
- BGC made for permanent use on the EBTS
- 60mm curtain, 5E-8mbar background, N2 gas, different size constraints.



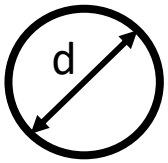
Results – 60mm New Dump



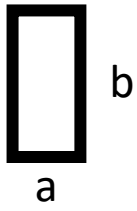
Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**



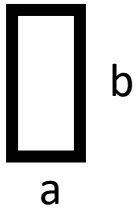
d: 700um



d: 4.49mm



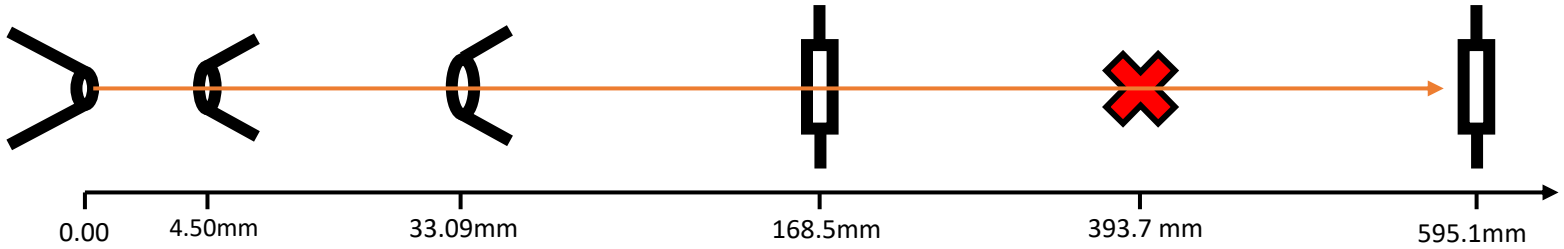
a: 0.11mm b: 26.4 mm



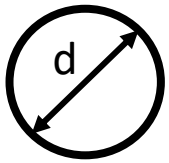
a: 0.91mm b: 85.6mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.38×10^{16}	60.28	0.24	3.89	3.86×10^{-8}

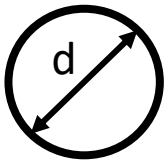
LHC – Hadron Only Beam (Ne gas)



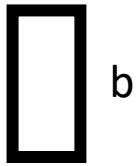
Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**



d: 200um

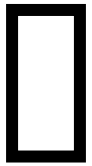


d: 1.65mm



a: 0.65mm b: 2.37 mm

Option for thicker curtain, increased signal at cost of 1D resolution



a: 2.38mm b: 8.47mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	3.23×10^{16}	5.46	1.40	5.58	5.65×10^{-9}

Projected ~ 4mm

Special Thanks

A. Jury, C. Swain, A. Pollard, N. Kumar

Monte-Carlo Statistical Error

- MC inherently a random simulation, statistically improved by more test particles, costing more computational power/time.
- Single solution (2bn particles generated), repeated 150 times from scratch with each final values recorded to determine the standard deviation

	Density / # m-3	Length / mm	Width / mm	Density variation / %	Background Pressure / mbar
SD	2.00×10^{14}	0.41	0.0059	0.94	1.98×10^{-11}
SD as % of mean	1.81%	0.72%	2.76%	18.18%	0.08%

Confidence Testing

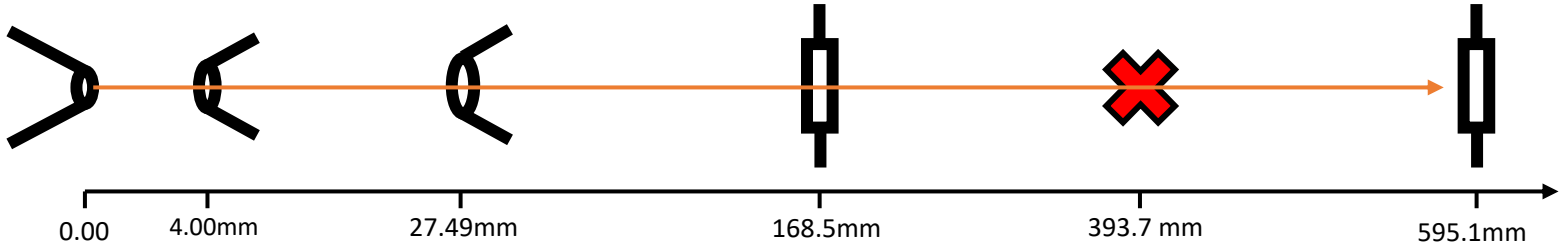
- Take optimum solution
- Manually vary each size individually by some small value (delta << current size)
- Compare final score and include a consistency check with S.D. of Monte Carlo error

Solution	Initial Score	Best manual Score	S.D of initial score	Conditions at Best Manual
60mm	3.44	3.53	0.16	Skim 3 length + 0.6mm
60mm, DN63	3.07	3.23	0.24	Skim 3 length - 0.6mm

Within 1σ of initial score

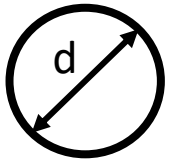
Results – V3 (Benchmark)

Out of Date skimmer values (i.e tunnel is different), but still used for benchmark other sims



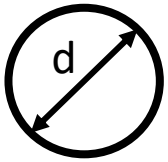
Nozzle

1st Skimmer



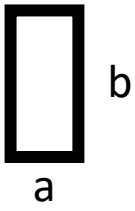
d: 400um

2nd Skimmer



d: 2.00mm

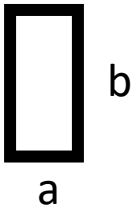
3rd Skimmer



a: 0.3mm b: 9.0 mm

IP

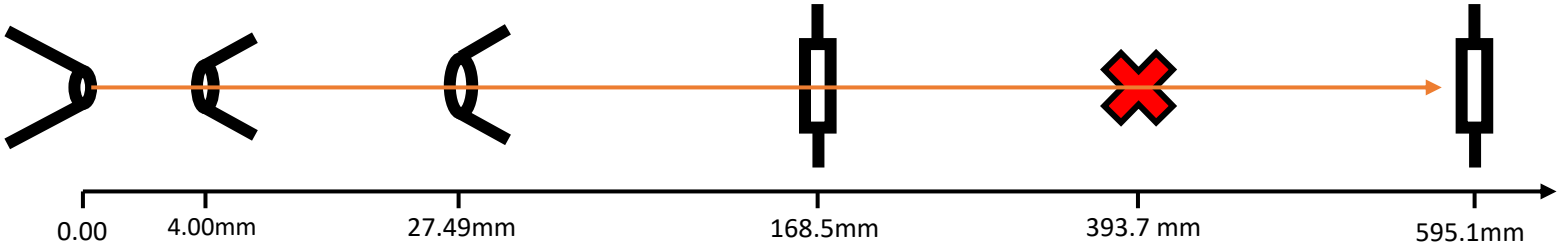
4th Skimmer



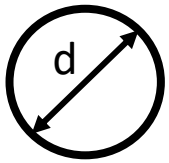
a: 7.0mm b: 31.0mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.81×10^{16}	20.8	0.52	5.73	2.10×10^{-8}

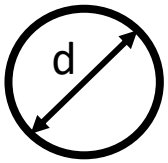
Results – 60mm



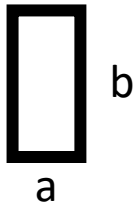
Nozzle **1st Skimmer** **2nd Skimmer** **3rd Skimmer** **IP** **4th Skimmer**



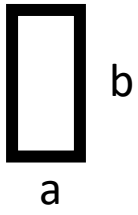
d: 700um



d: 4.49mm



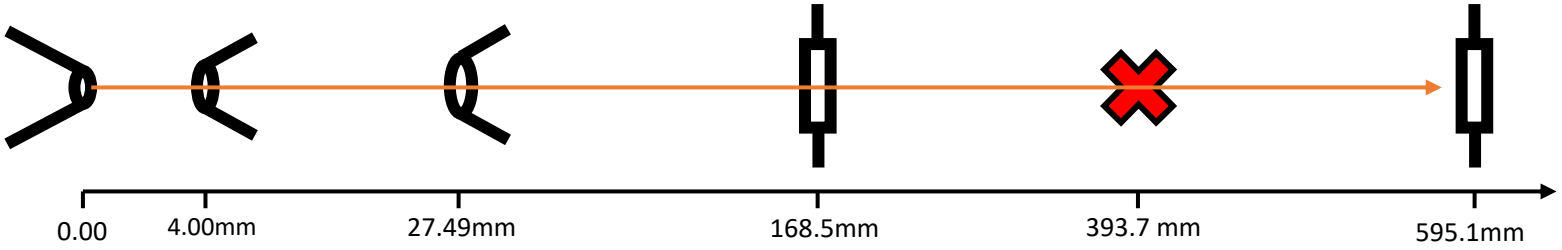
a: 0.11mm b: 26.4 mm



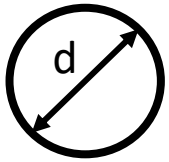
a: 1.12mm b: 103.4mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.34×10^{16}	60.89	0.23	3.23	3.93×10^{-8}

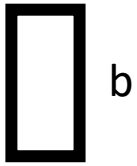
Results – Rectangular 2nd Skimmer



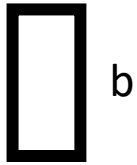
Nozzle | 1st Skimmer | 2nd Skimmer | 3rd Skimmer | IP | 4th Skimmer



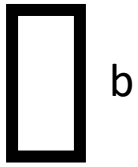
d: 700um



a: 0.4mm b: 4.4 mm



a: 0.10mm b: 25.5 mm



a: 1.2mm b: 52.9mm

Criteria	Density / # m^{-3}	Curtain Length / mm	Curtain Width / mm	Variation in centre / %	BG Pressure / mbar
Optimised Value	1.36×10^{16}	59.31	0.23	3.43	4.84×10^{-8}

Chamber Pressure Profiles

All Pressures as BG chamber pressure, calculated with MC simulation – in mbar

	Nozzle	Skimmer 1	Skimmer 2	Interaction	Dump
V3	1.00×10^{-3}	4.82×10^{-6}	4.66×10^{-6}	2.09×10^{-8}	1.00×10^{-7}
60mm	9.95×10^{-4}	5.68×10^{-6}	2.34×10^{-5}	4.04×10^{-8}	1.14×10^{-7}
60mm, DN63	1.00×10^{-3}	3.65×10^{-6}	1.77×10^{-5}	6.08×10^{-8}	7.25×10^{-8}

Largest discrepancy between calculated and true measured value of BG in nozzle chamber, where transitional flow occurs.
Converges to similar value at lower pressures.