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Experimental investigation of granule size and shape dynamics in twin-screw granulation

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Outline

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- Background
  - Consigma™-1 system
  - Twin-Screw Granulator
  - High shear wet granulation
- Experiments
  - Objective – factors and responses
  - Results
- Conclusions

Consigma™-25 system

(GEA pharma systems, Collette)

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Continuous twin screw granulator

Segmented Fluid bed dryer

Granule conditioning module

Consigma™-1 system

(GEA pharma systems, Collette)

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Continuous twin screw granulator

Segmented fluid bed dryer

Consigma™-1 system

(GEA pharma systems, Collette)

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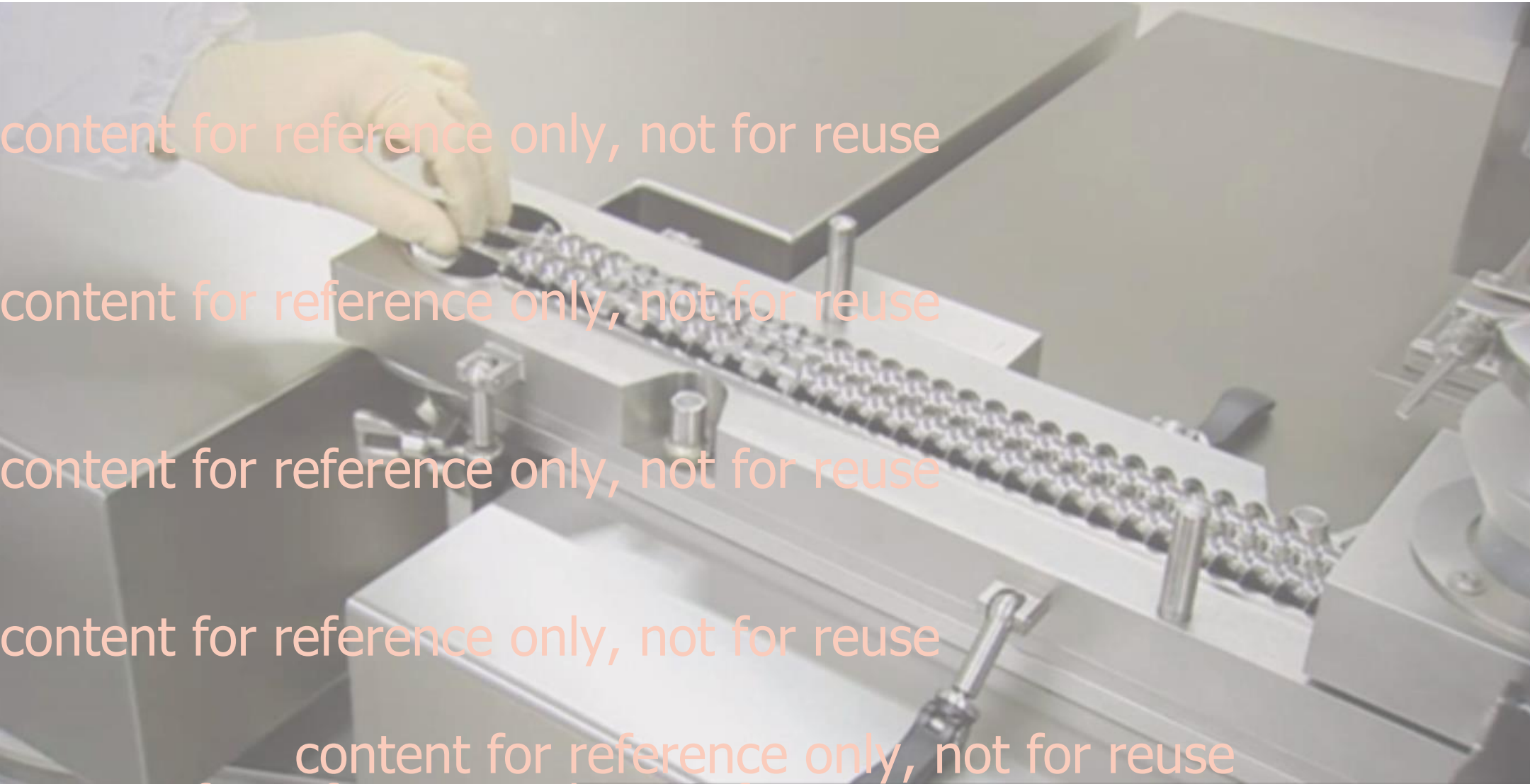
Open barrel of a twin screw granulator



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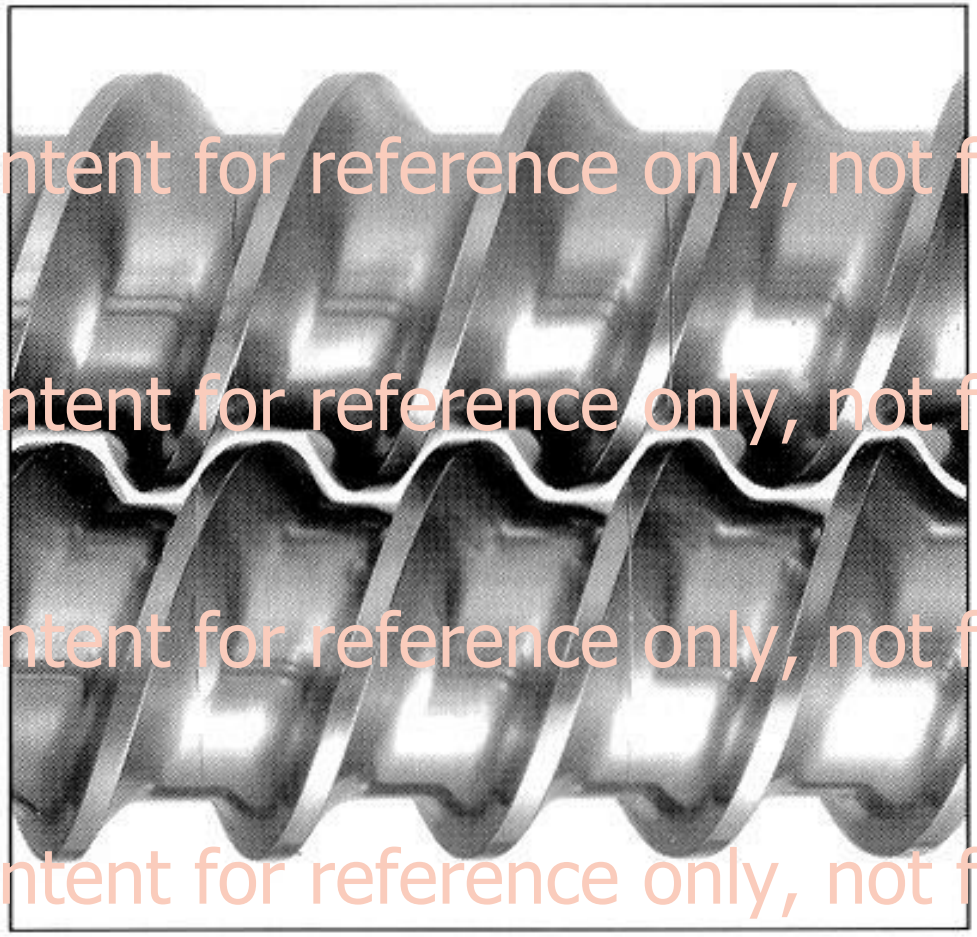
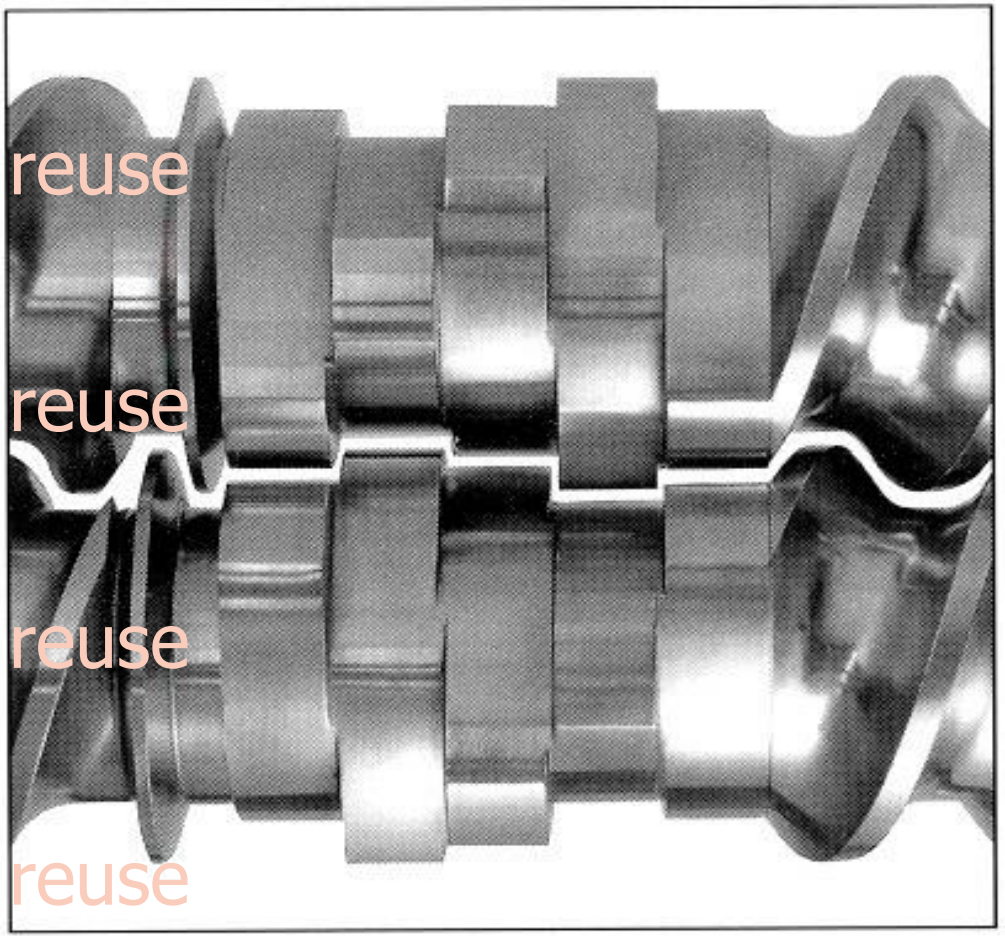
Conveying Elements



Mixing Elements



Twin-Screw Granulation - HSWG

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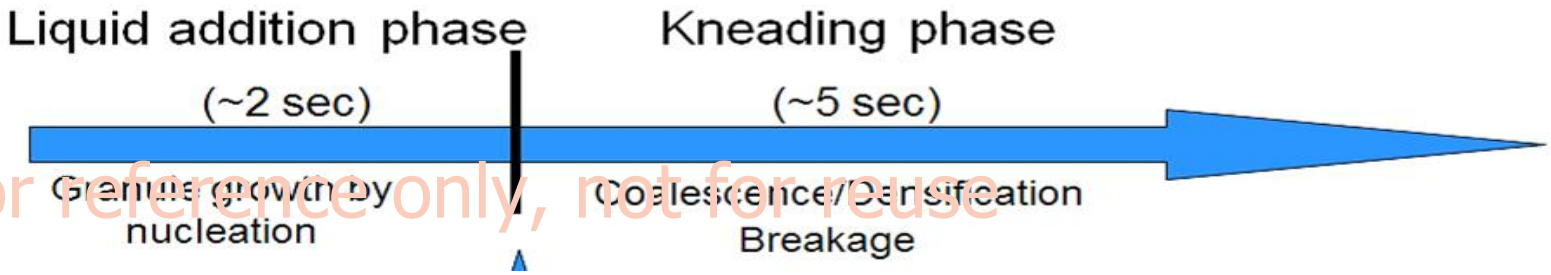
Decreasing Intragranular porosity



Twin-Screw Granulation - HSWG

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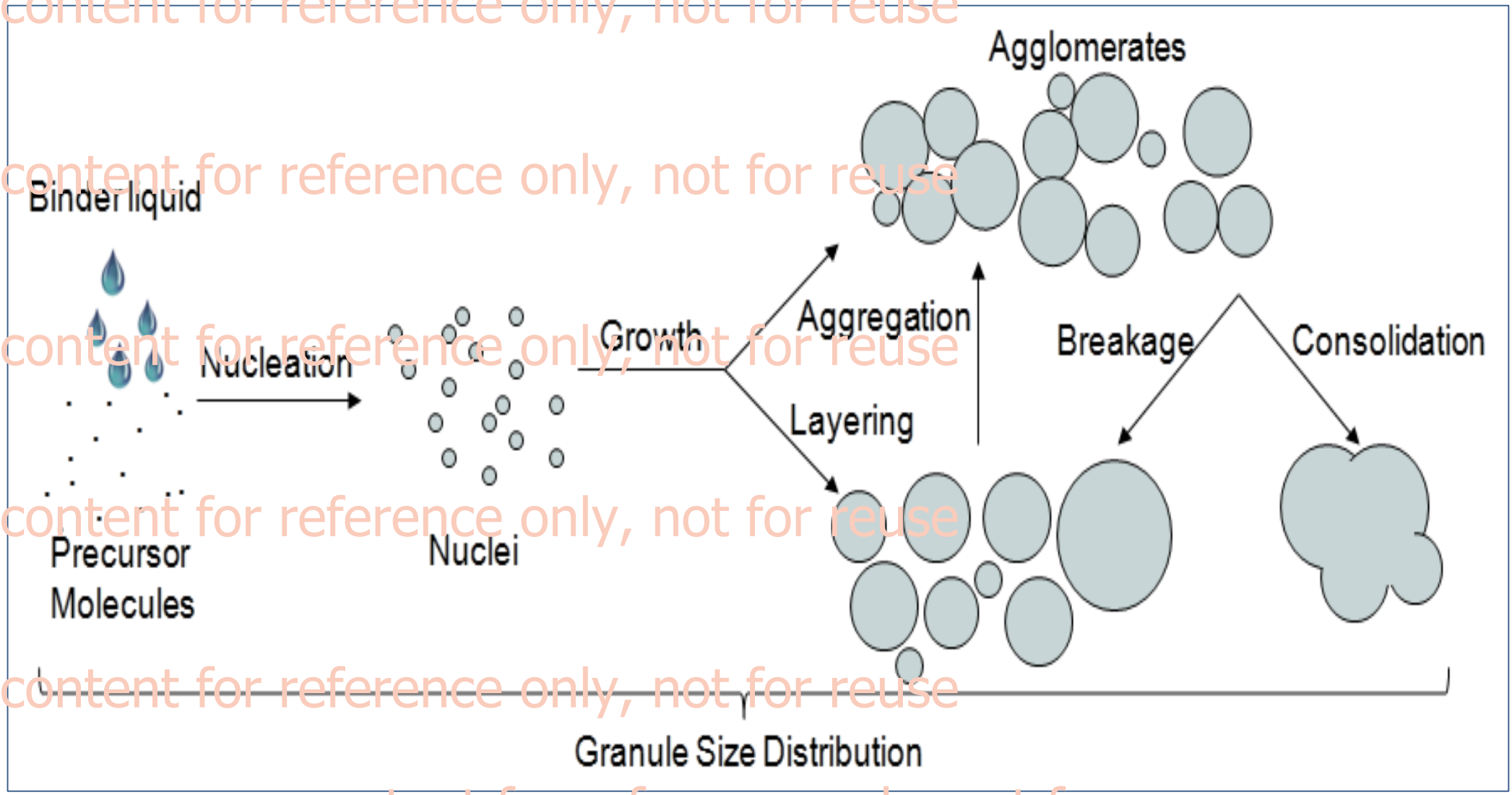

Consigma™-1 system

(GEA pharma systems, Collette)

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Setpoints (logged):

- Powder mass flow (g/min) - powder feeder
- Liquid mass flow (g/min) - liquid addition
- Screw speed (rpm)
- Barrel temperature (°C)

Granulation steady state criterion:

- Torque granulator (N-m)

Consigma - 1 experiments

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Lactose/PVP (97.5/2.5) premix was granulated with distilled water

Factors:

Parameters	Low	High
Throughput	10 Kg/h	25 Kg/h
Liquid-solid ratio	4.58 %	6.52%
Screw speed	500 RPM	900 RPM

1 2 3 4 5

kneading block 1 kneading block 2

Responses: Particle characterization by Laser Obscuration Time technique (Location 1, 3, 5)

Size and shape characterisation

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Average Feret diameter:

$$\frac{F_1 + F_2 + F_3 + F_4 \ldots F_{36}}{36}$$

For a sphere size = diameter

Average Feret diameter (µm)

$$\text{Aspect Ratio} = \frac{[\text{min Feret diam.}]}{[\text{max Feret diam.}]}$$

Aspect ratio

Number density of size and shape

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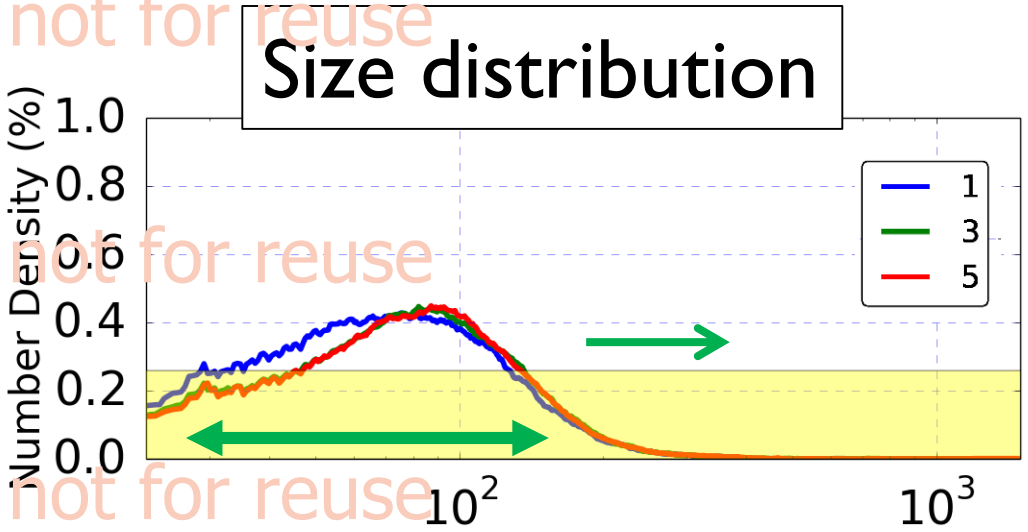
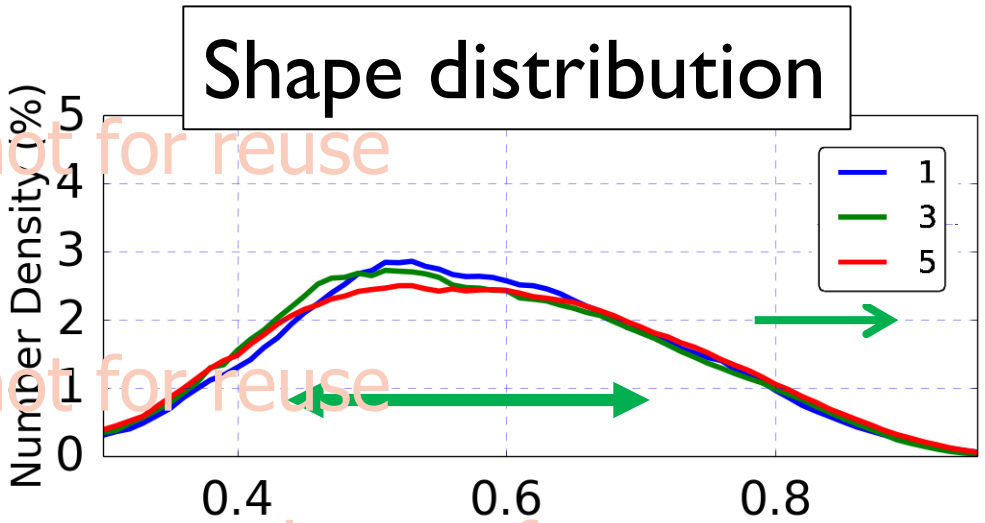
Average Feret diameter (µm)



Aspect ratio



Granule size and shape dynamics

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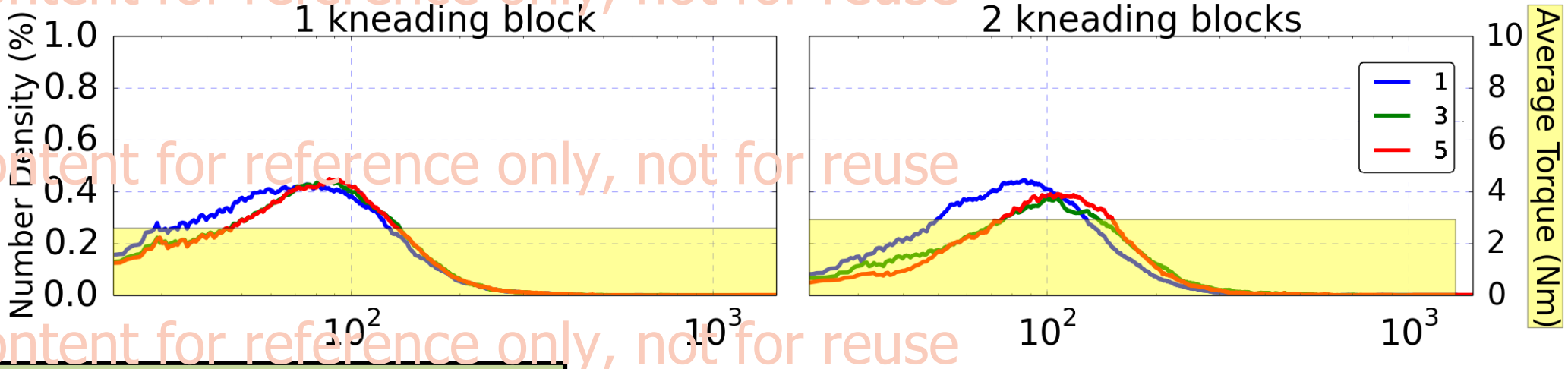
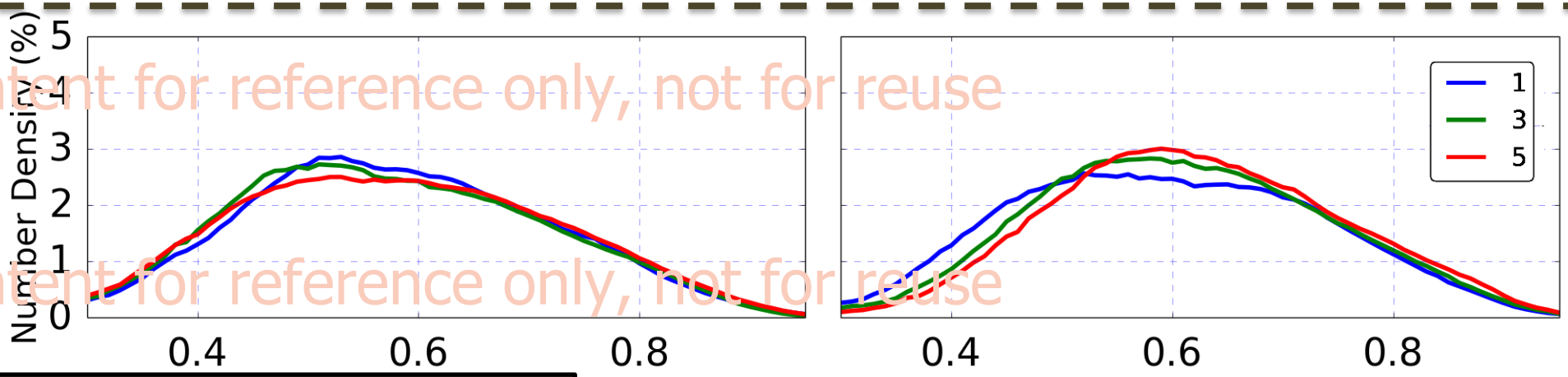
Throughput Low | Liquid-solid ratio Low | Screw speed Low



Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

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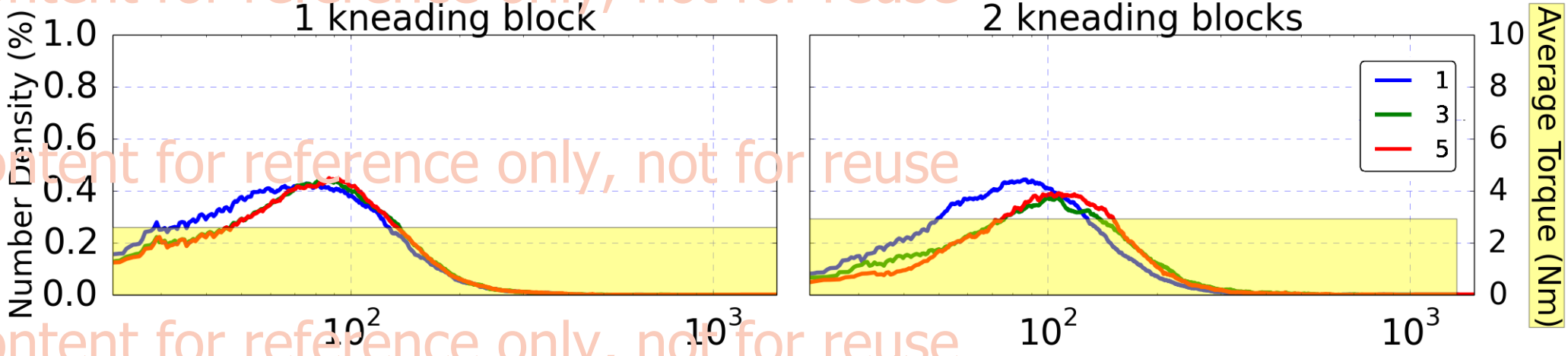
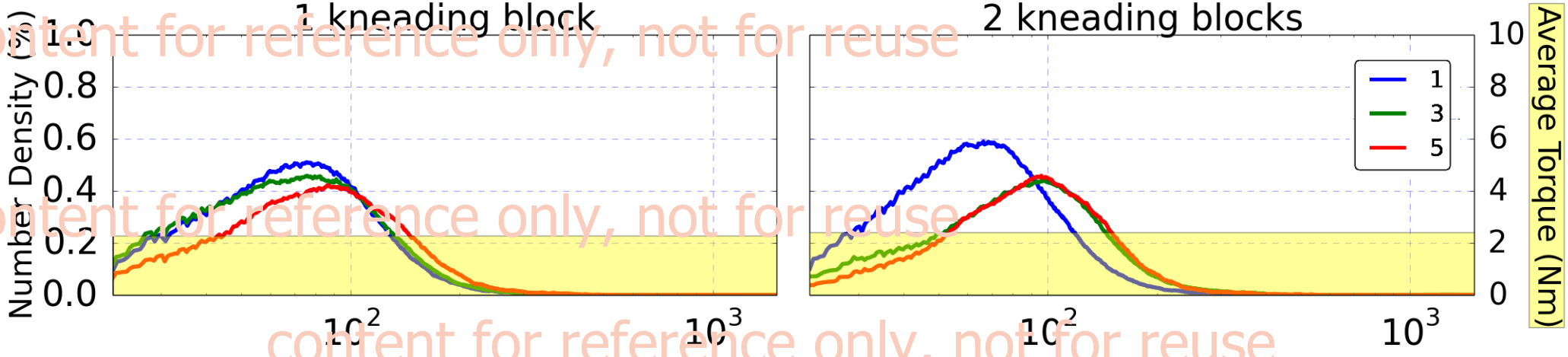
Throughput Low | Liquid-solid ratio Low | Screw speed Low



Throughput High | Liquid-solid ratio Low | Screw speed Low



Granule size and shape dynamics

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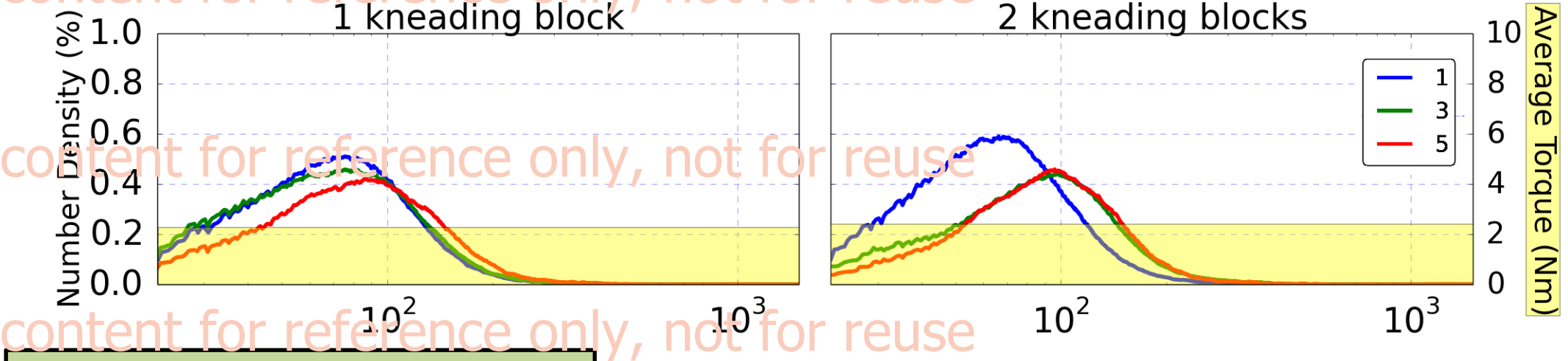
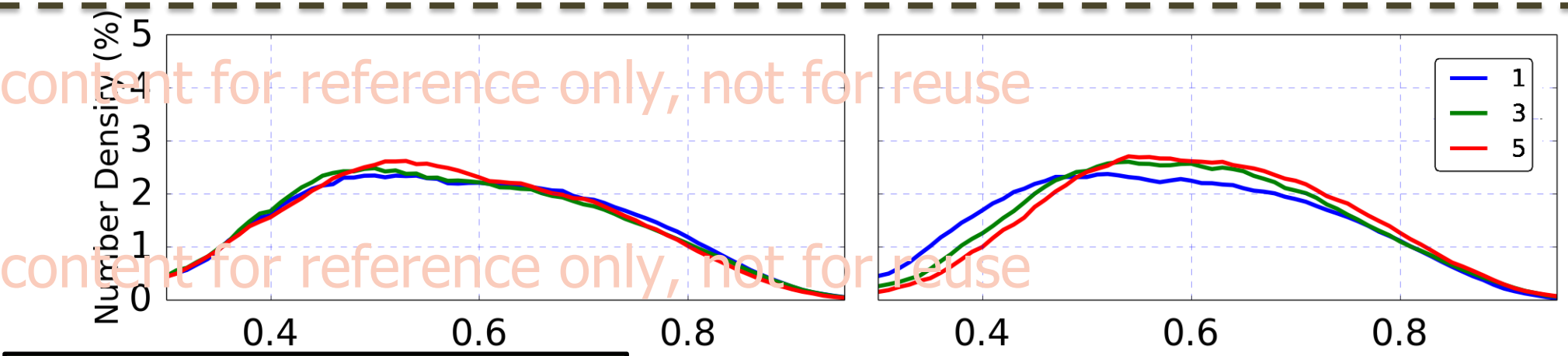


Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

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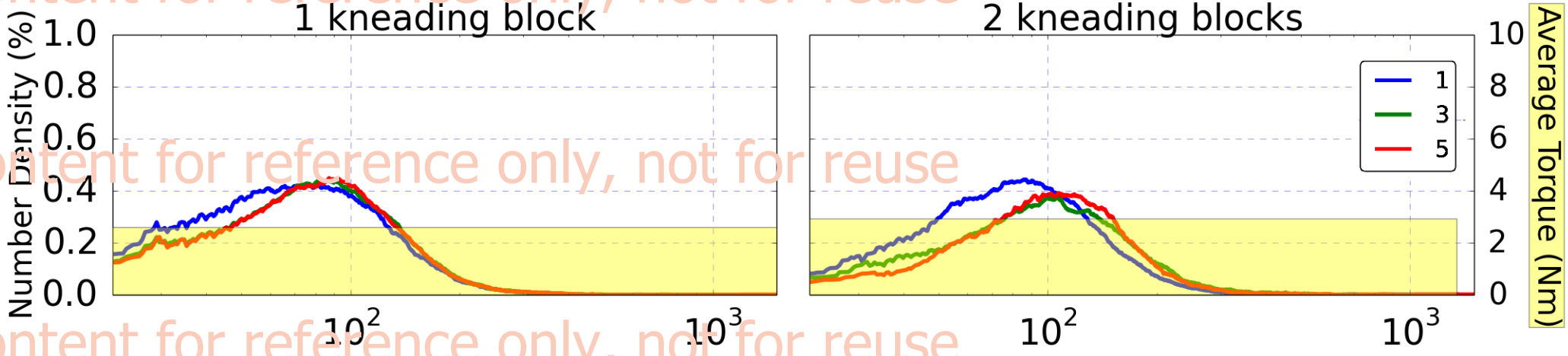
Throughput Low | Liquid-solid ratio Low | Screw speed Low



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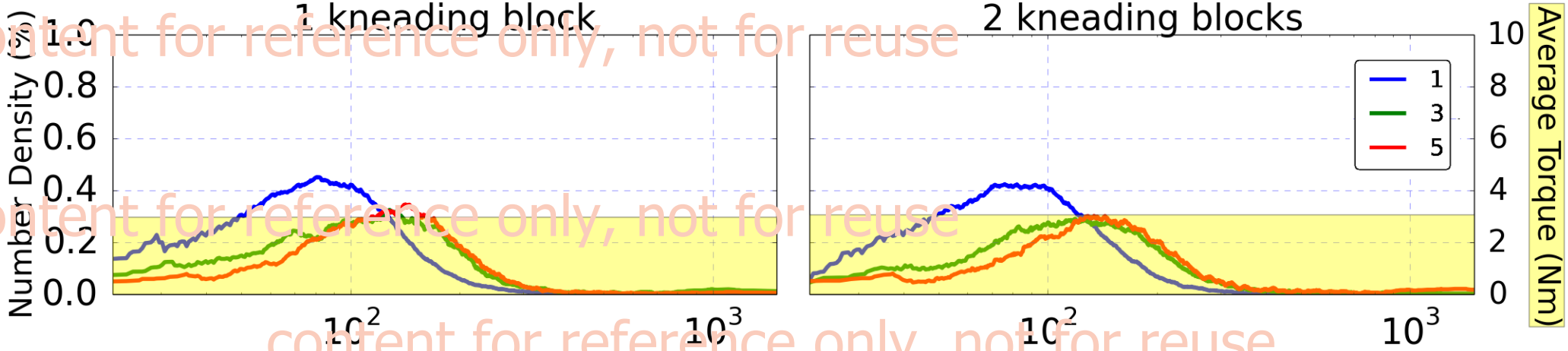

Granule size and shape dynamics

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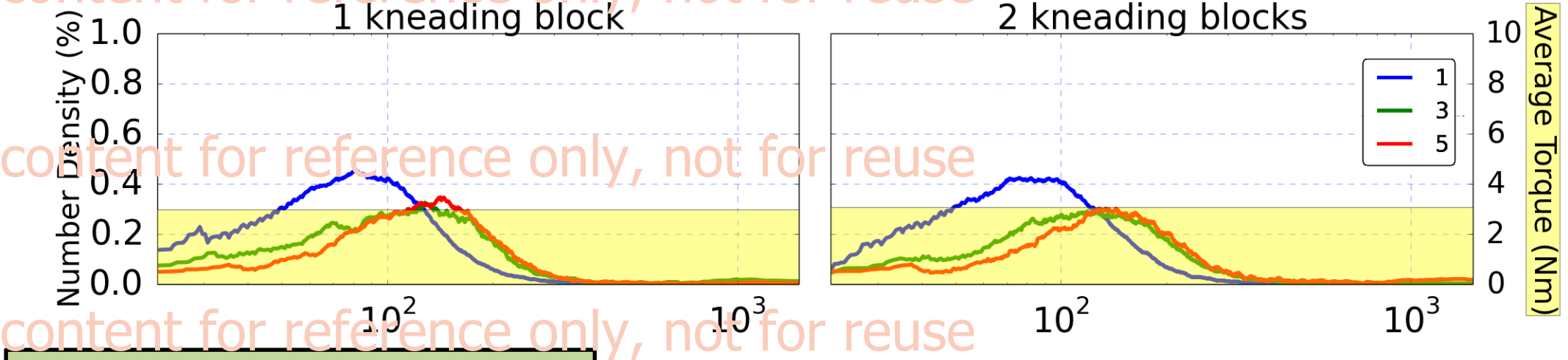
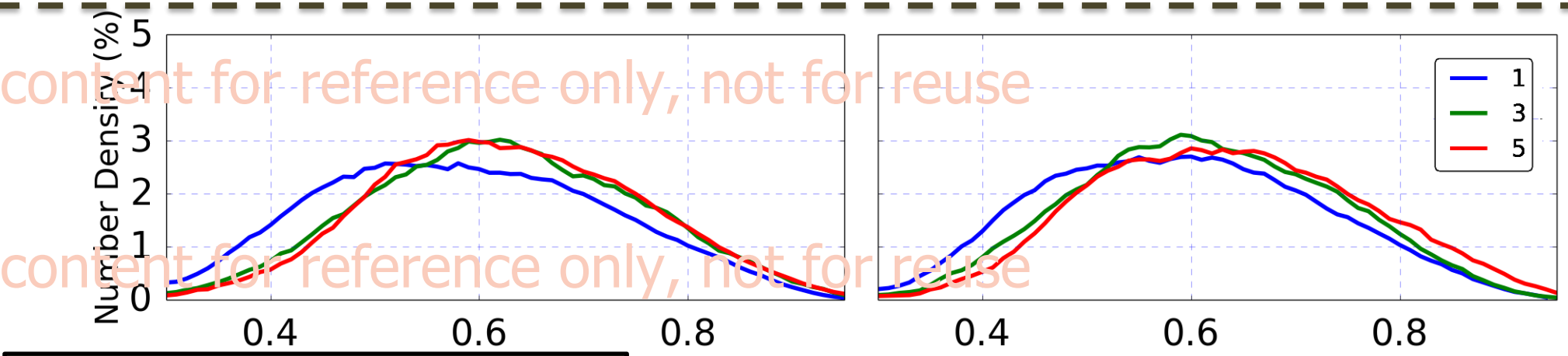
Throughput High | Liquid-solid ratio Low | Screw speed Low



Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

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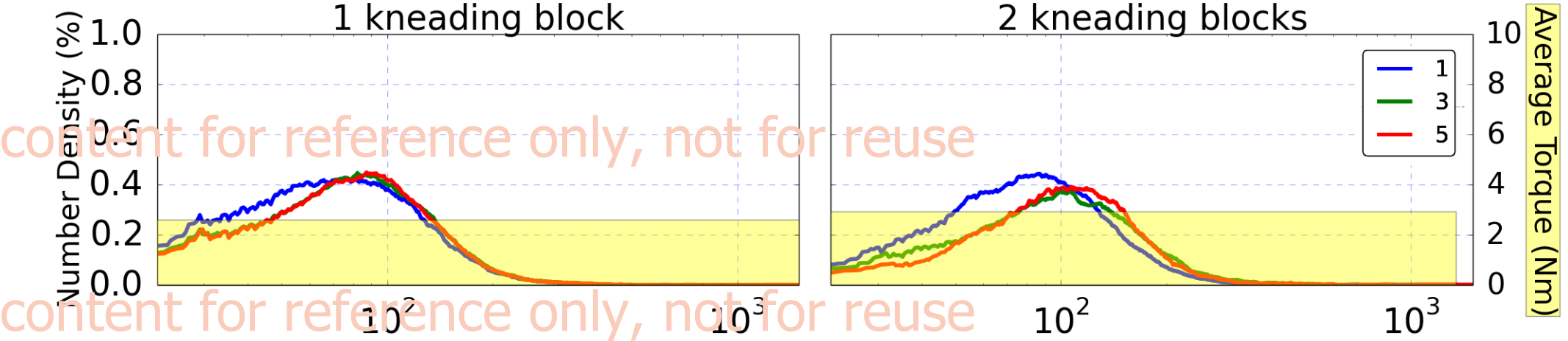
Throughput Low | Liquid-solid ratio Low | Screw speed Low



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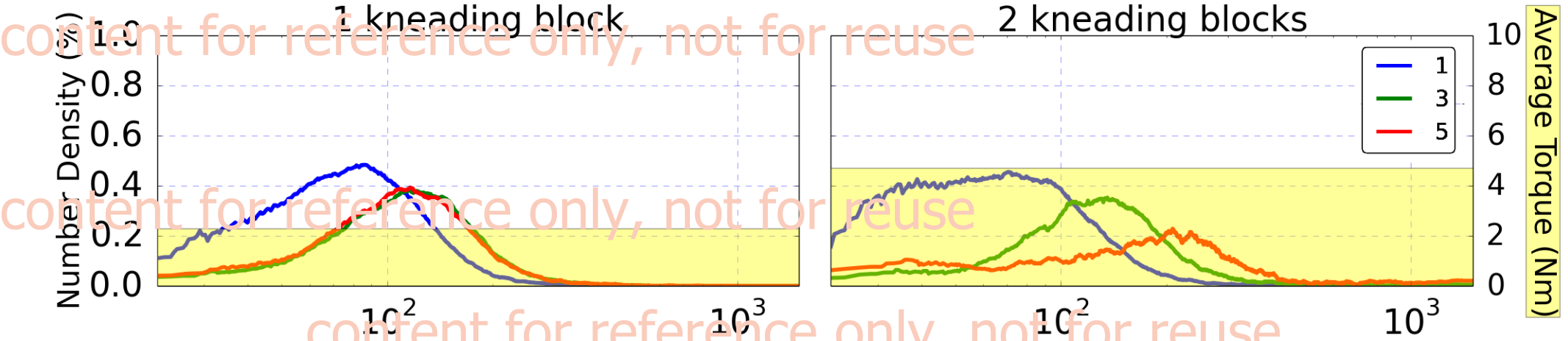

Granule size and shape dynamics

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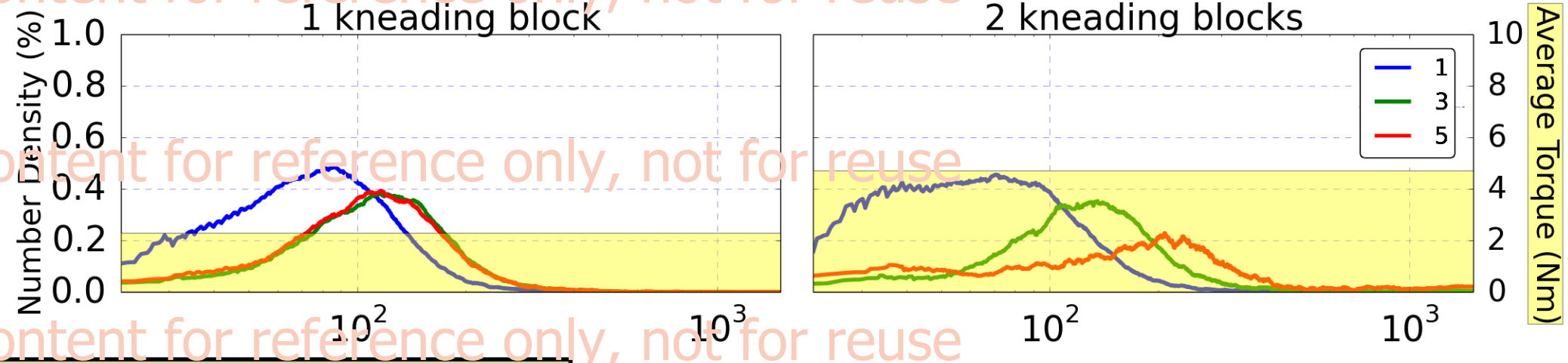
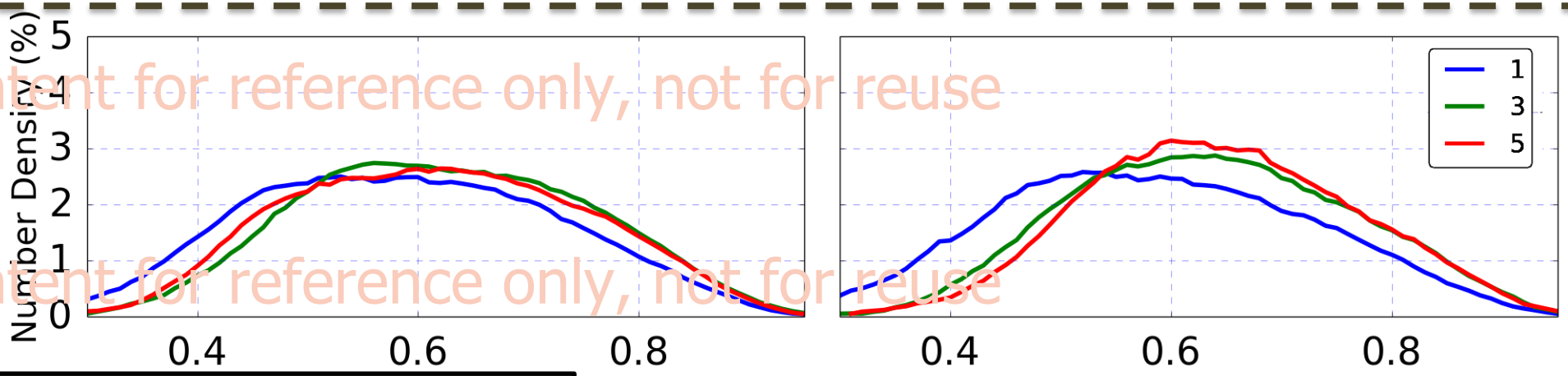
Throughput High | Liquid-solid ratio High | Screw speed Low



Average Feret diameter (µm)



Aspect ratio

Granule size and shape dynamics

Intermediate Summary

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Parameters	Granule size	Elongation (lower aspect ratio)
Increase in number of kneading discs	↑	↓
Increase in L/S	↑	↓
Increase in powder feed rate	↓	↑
Increase in both Throughput and L/S ratio	↑	↓

Comparing average Feret diameter

At low throughput and L/S

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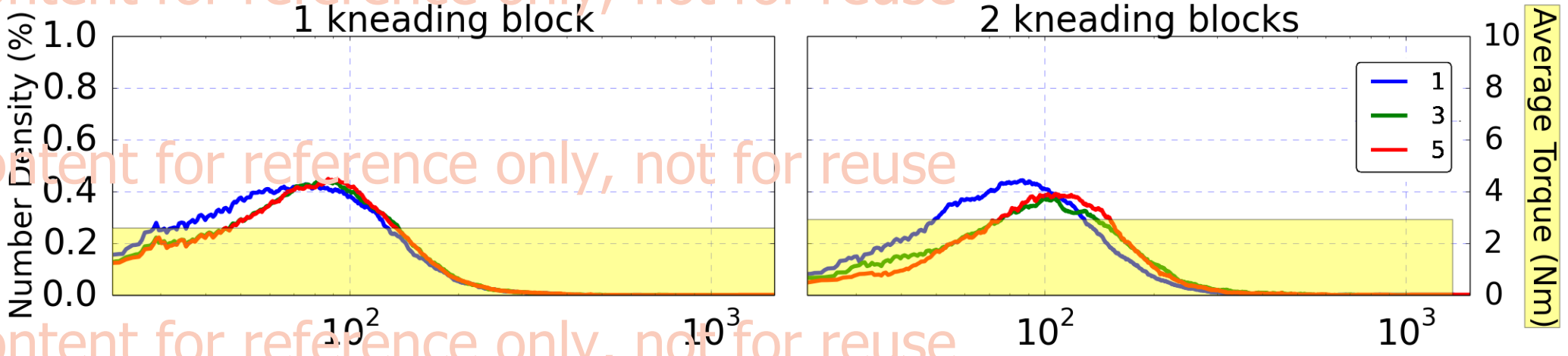
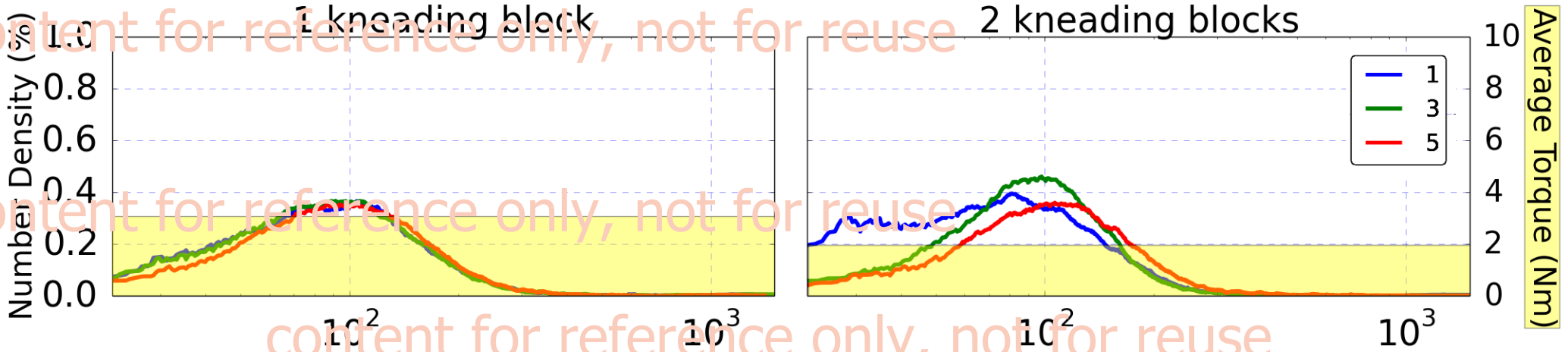
Throughput Low | Liquid-solid ratio Low | Screw speed Low



Throughput Low | Liquid-solid ratio Low | Screw speed High



Granule size and shape dynamics

At low Throughput and L/S

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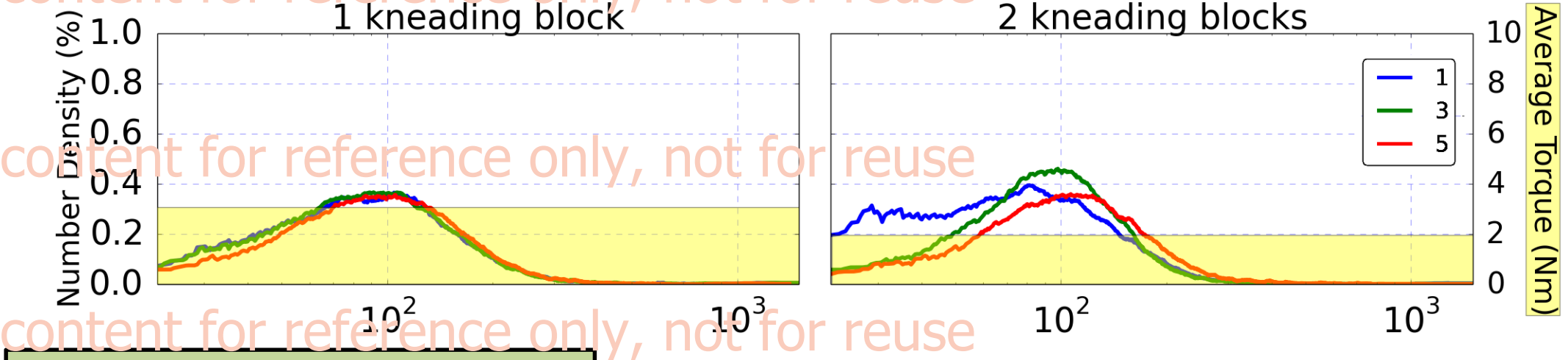
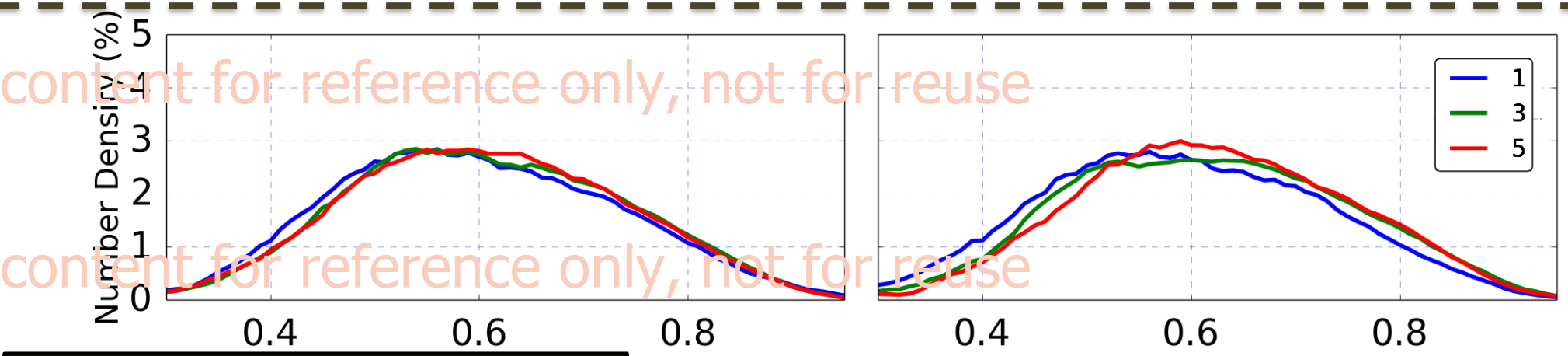
Throughput Low | Liquid-solid ratio Low | Screw speed High



Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

At low Throughput and high L/S

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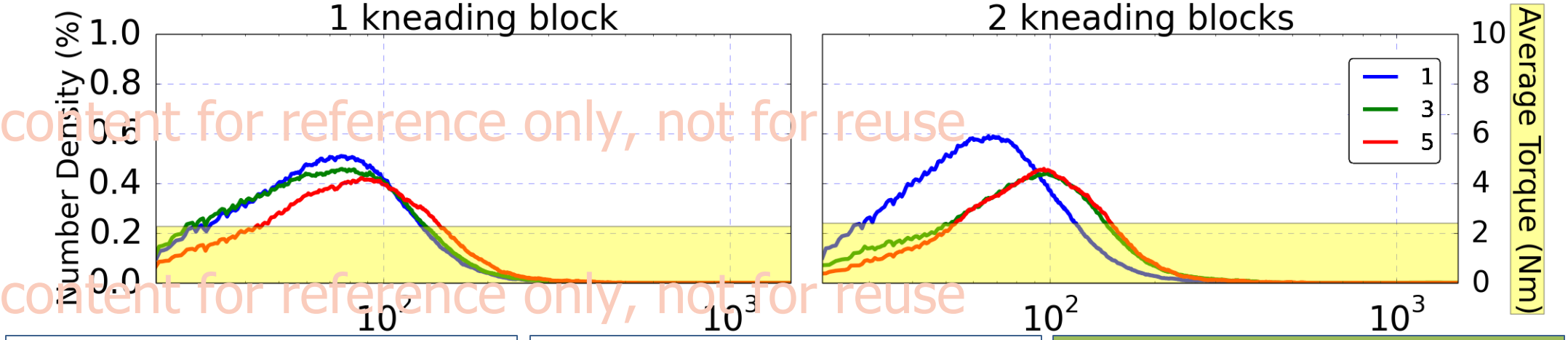
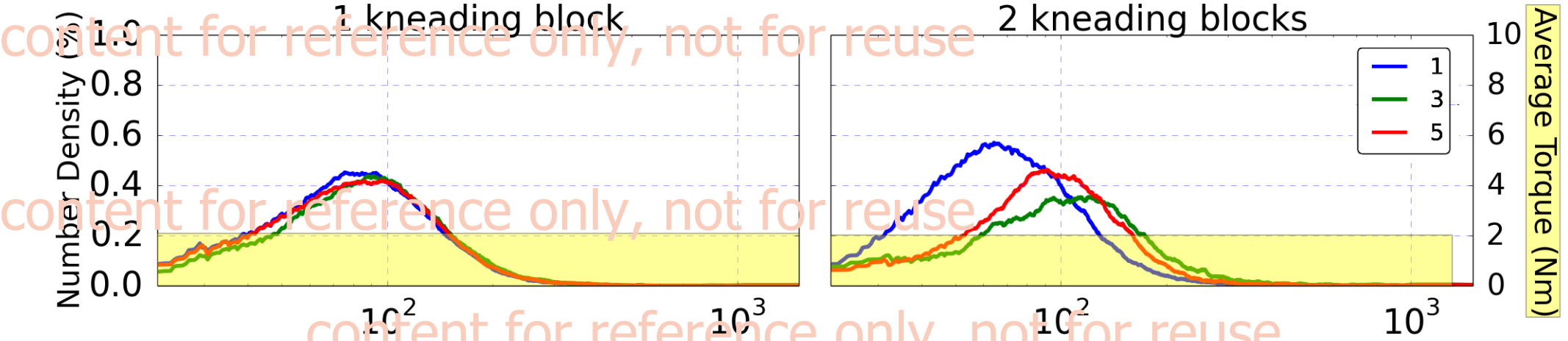
Throughput High | Liquid-solid ratio Low | Screw speed Low



Throughput High | Liquid-solid ratio Low | Screw speed High



Granule size and shape dynamics

At low Throughput and high L/S

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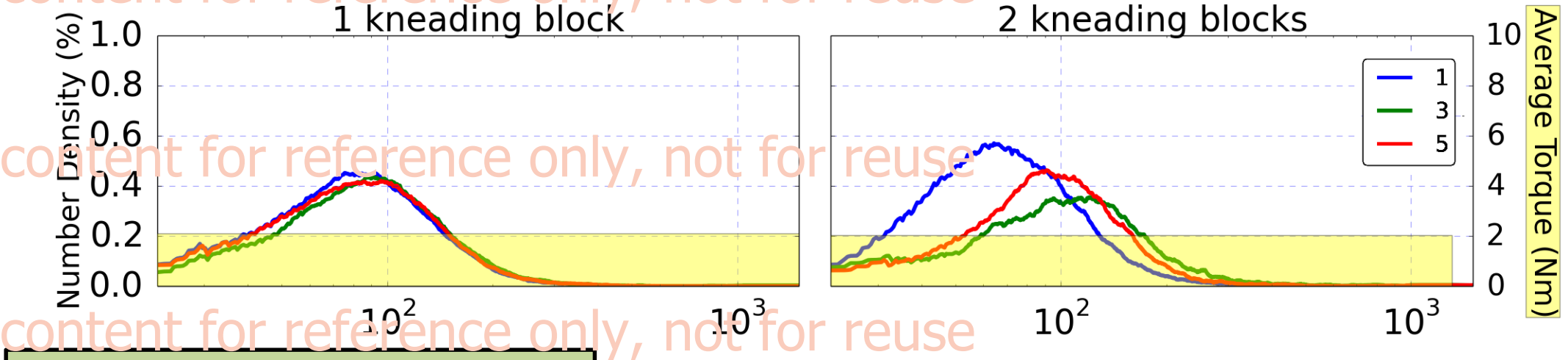
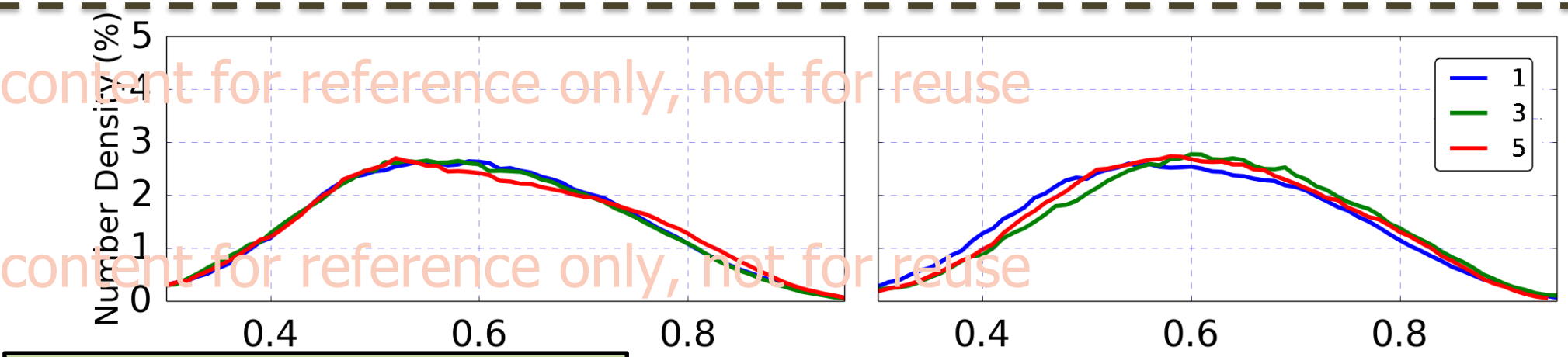
Throughput High | Liquid-solid ratio Low | Screw speed High



Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

At high Throughput and low L/S

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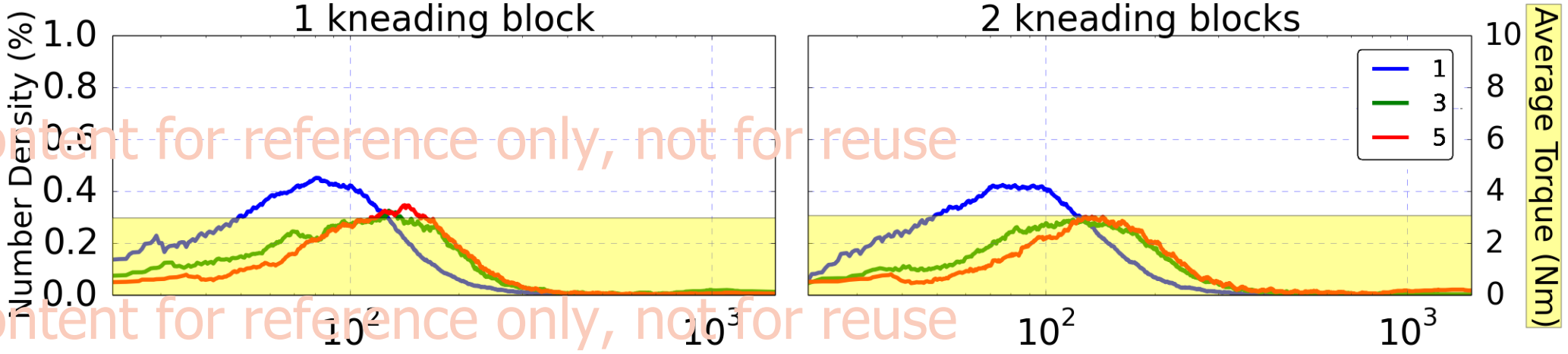
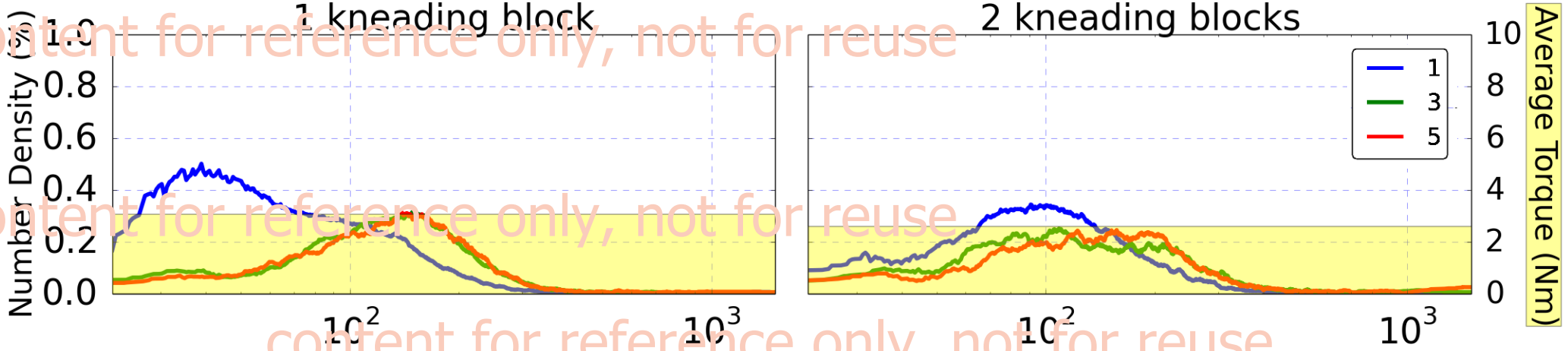
Throughput Low | Liquid-solid ratio High | Screw speed Low



Throughput Low | Liquid-solid ratio High | Screw speed High



Granule size and shape dynamics

At high Throughput and low L/S

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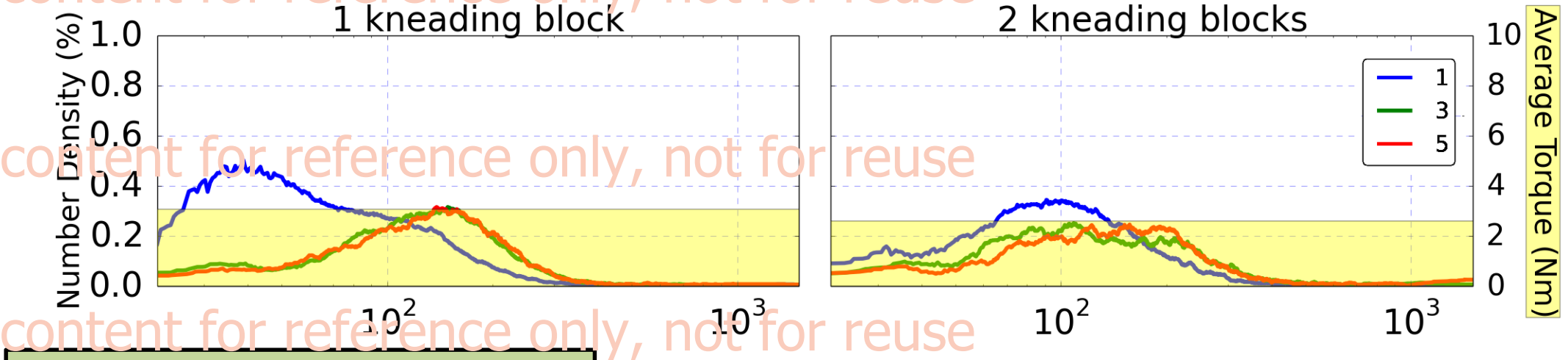
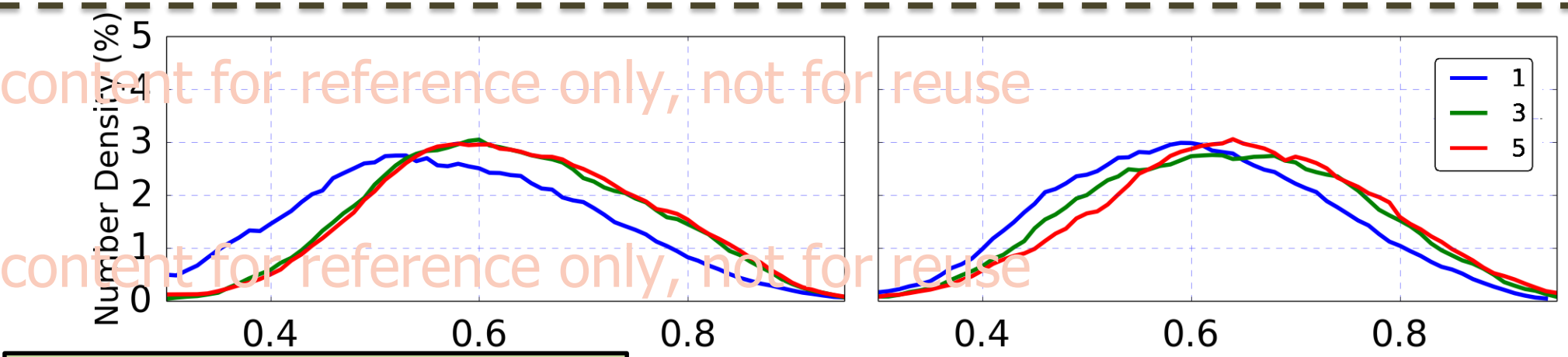
Throughput Low | Liquid-solid ratio High | Screw speed High



Average Feret diameter (µm)



Aspect ratio

Comparing average Feret diameter

At high Throughput and L/S

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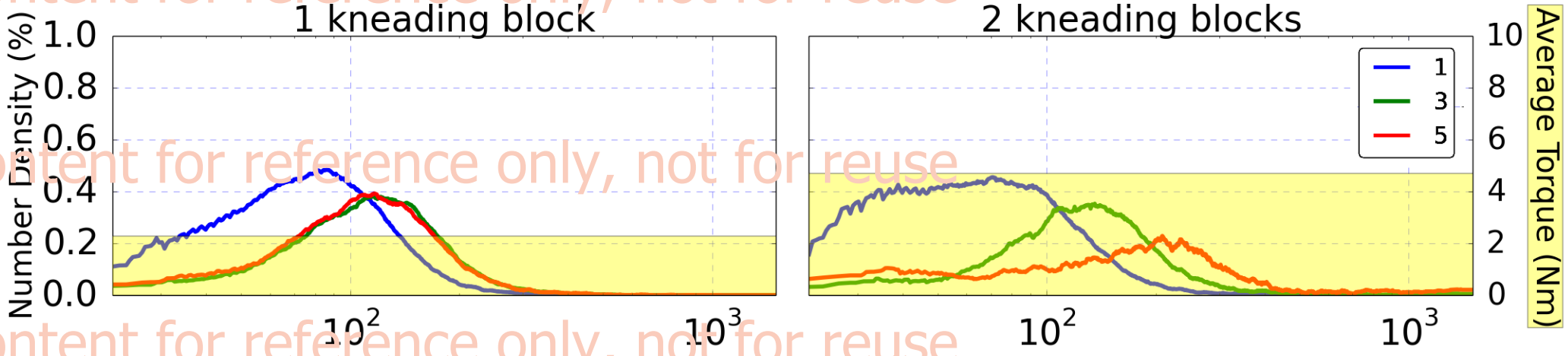
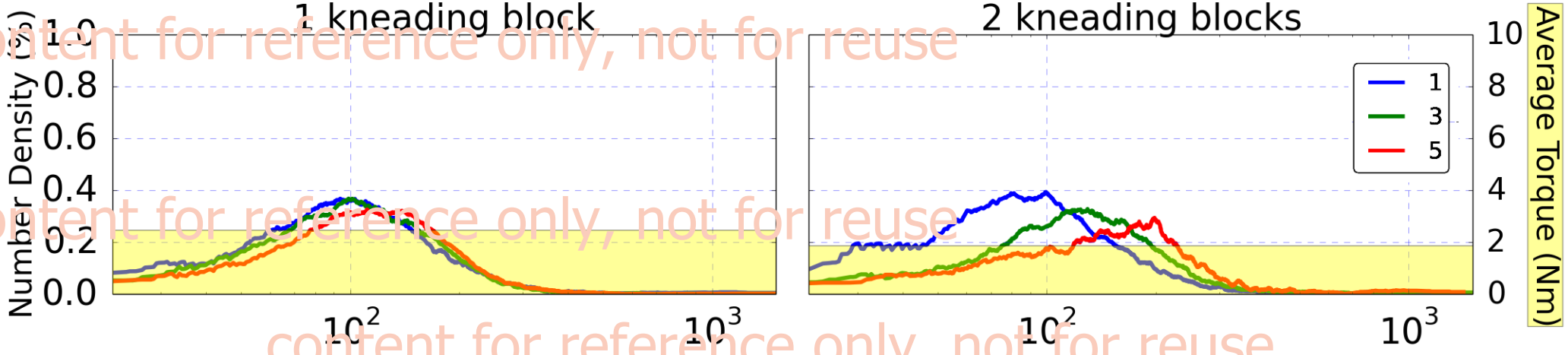
Throughput High | Liquid-solid ratio High | Screw speed Low



Throughput High | Liquid-solid ratio High | Screw speed High



Granule size and shape dynamics

At high Throughput and L/S

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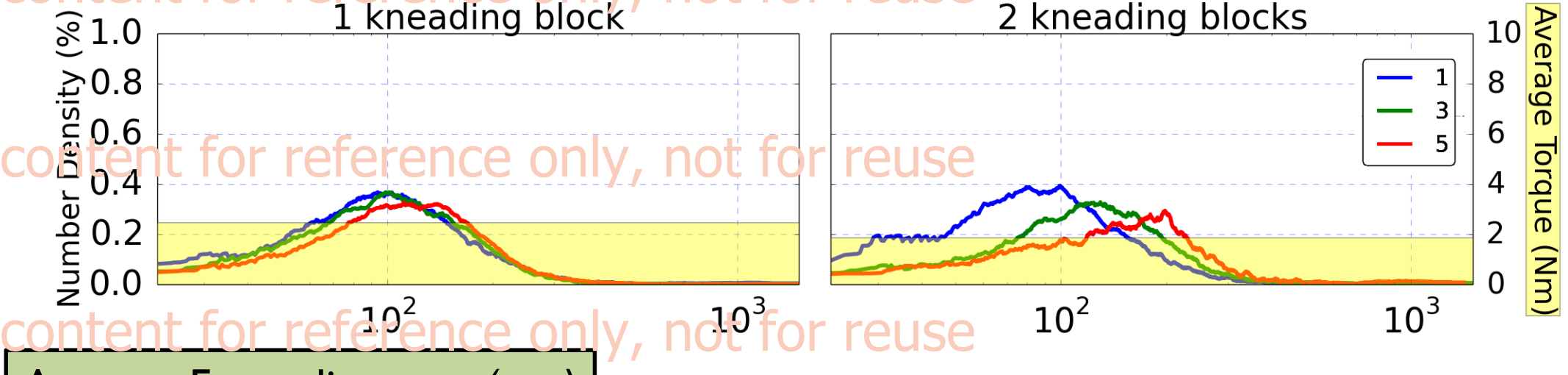
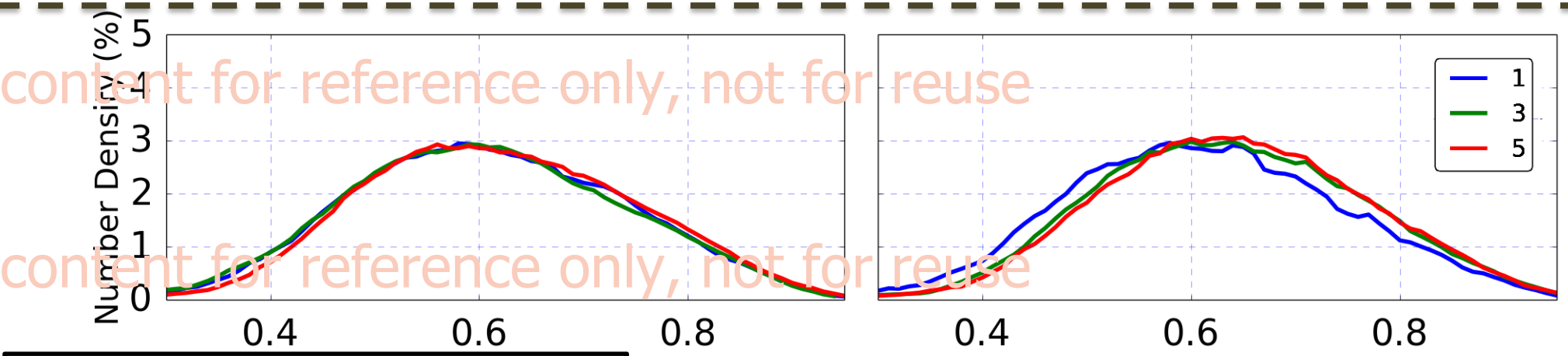
Throughput High | Liquid-solid ratio High | Screw speed High

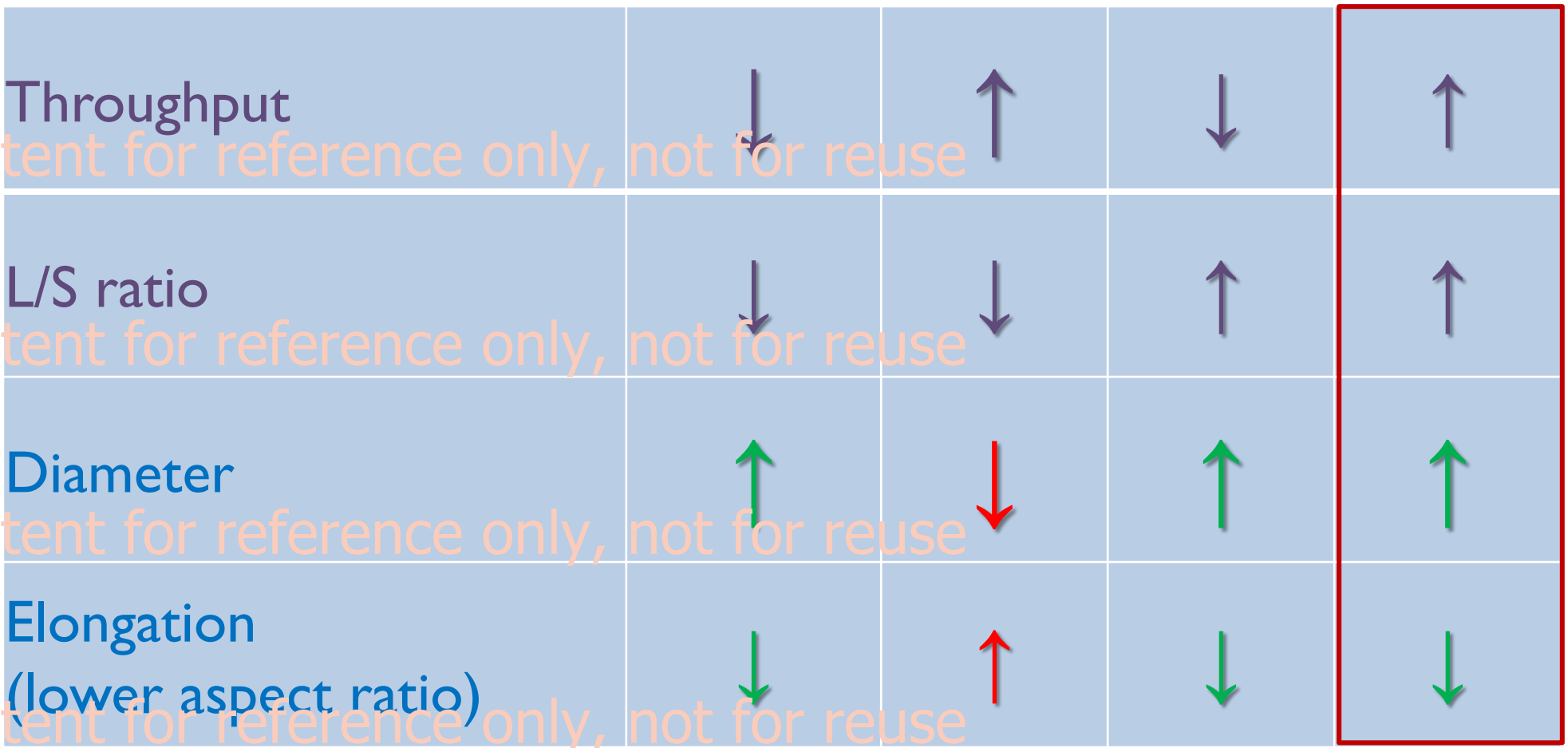


Average Feret diameter (µm)



Aspect ratio

Granule size and shape dynamics
Effect of screw speed



Conclusions

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- The fill ratio in the TSG is an important parameter in shaping the granule characteristics.
- High throughput can easily be achieved by simultaneously increasing the feed rate and screw speed.
- Increase in both Throughput and L/S ratio is another criterion for switching on and off specific rate processes.

So what next...

- Investigate material properties influence.
- Use the results obtained to form the basis for modeling of the granulation process in TSG.

Aknowledgements

Jurgen Vercruysse

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Ingmar Nopens

Kris Schoeters

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Q&A

Granule size and shape dynamics