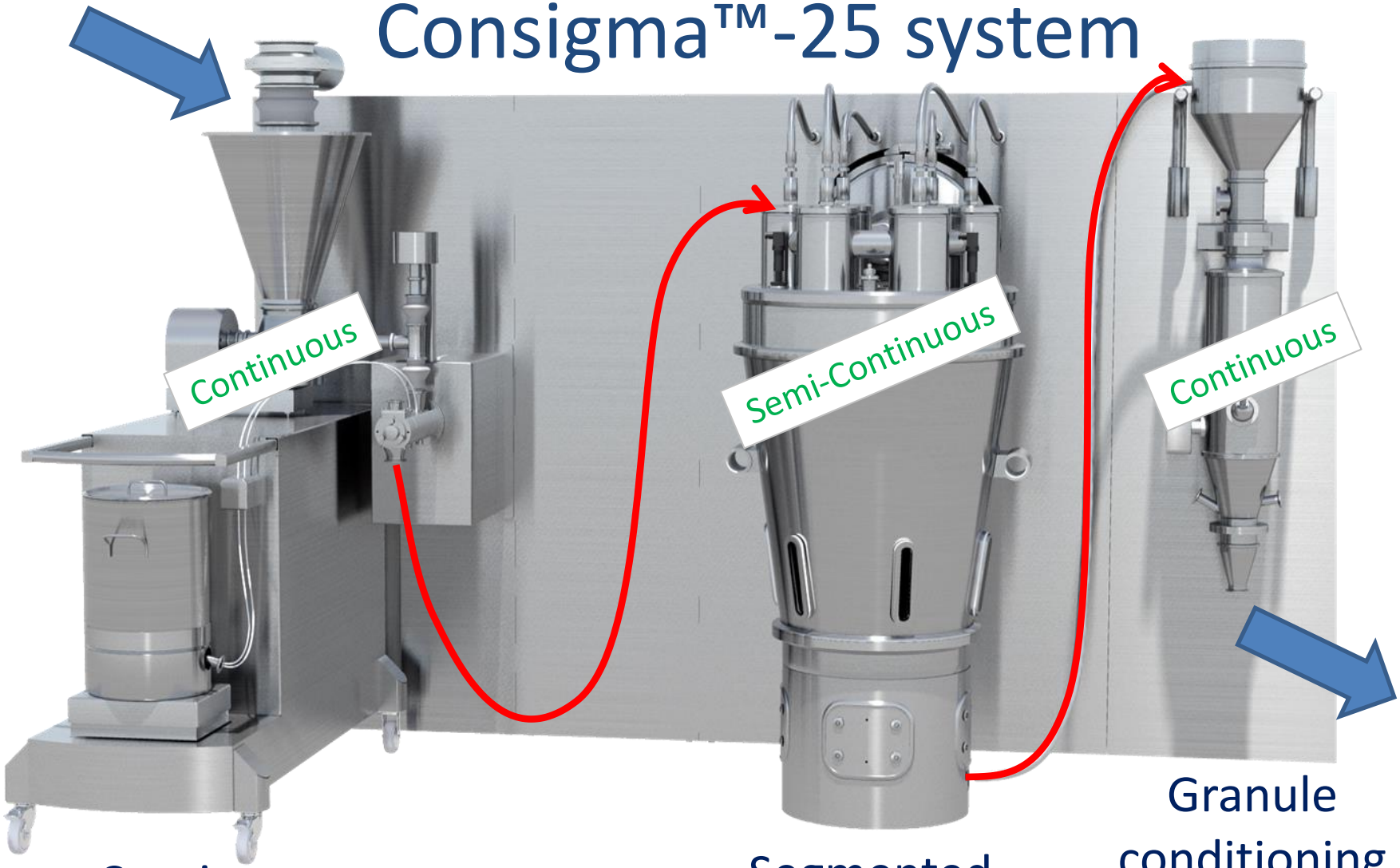
Experimental and model-based investigation of twin screw granulation

Ashish Kumar

Kuopio Summer School, 19 October, 2015

LABORATORY OF PHARMACEUTICAL PROCESS ANALYTICAL TECHNOLOGY
FACULTY OF PHARMACEUTICAL SCIENCES
BIOMATH, DEPARTMENT OF MATHEMATICAL MODELLING, STATISTICS AND BIOINFORMATICS
FACULTY OF BIOSCIENCE ENGINEERING

Continuous manufacturing line Consigma™-25 system

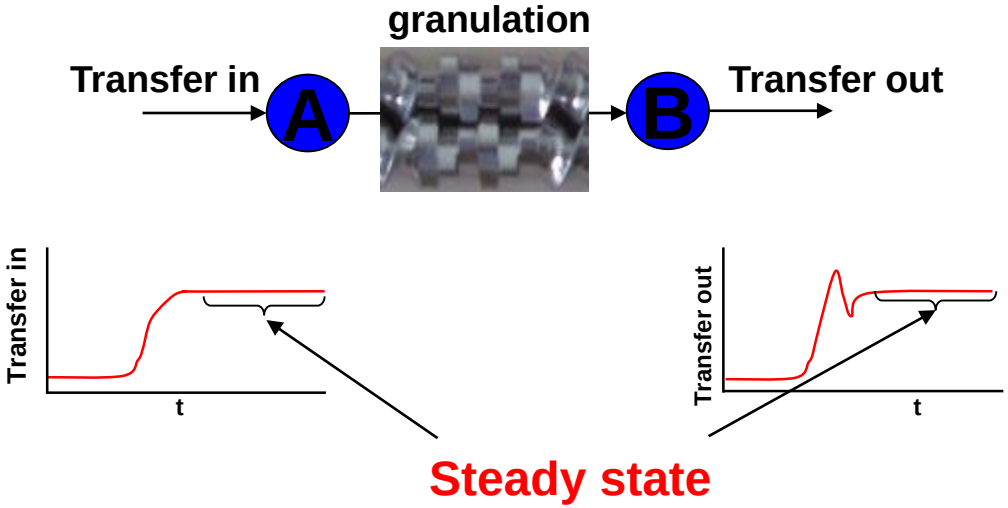


Continuous twin-screw granulator

Segmented Fluid bed dryer

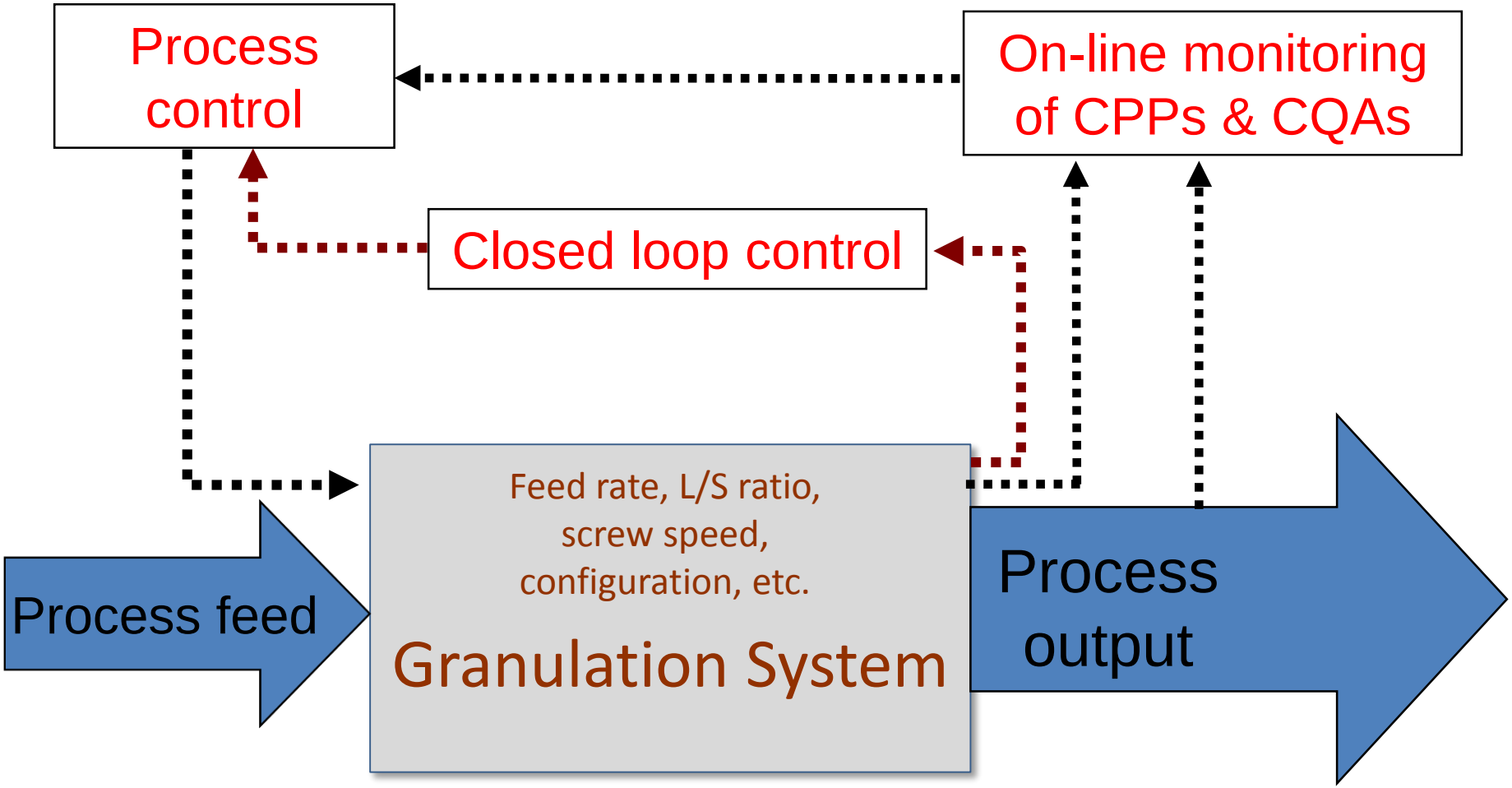
Granule conditioning module

At appropriate time-scales and conditions, granulation is in steady state

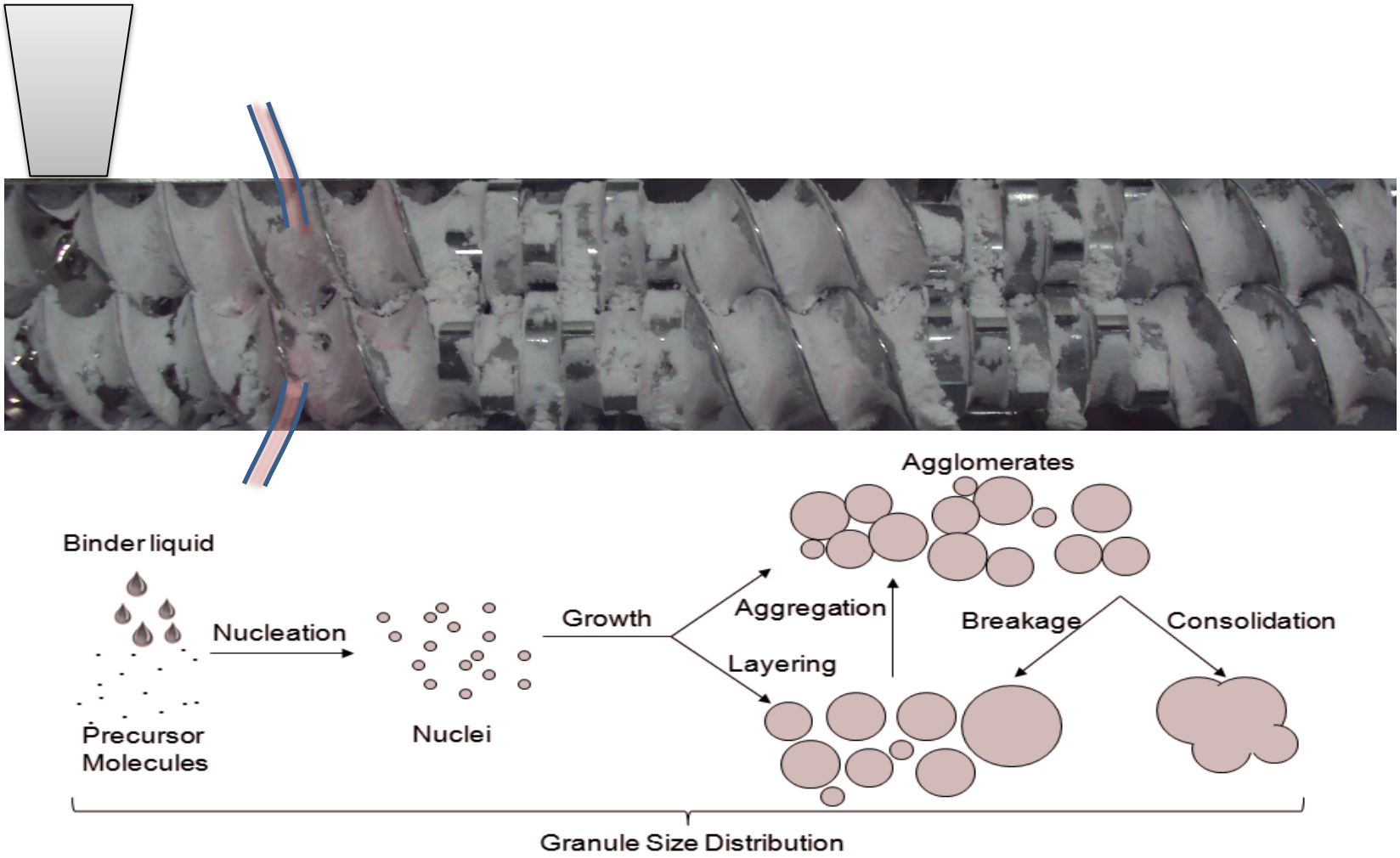


Two key implications

1. Fluxes are roughly constant (Dynamics are transient)
2. If feed is constant, product quality is consistent!


Process control
On-line monitoring of CPPs & CQAs
Closed loop control
Process feed
Feed rate, L/S ratio,
screw speed,
configuration, etc.
Granulation System
Process output

Twin-Screw Granulator applies High Shear Wet Granulation

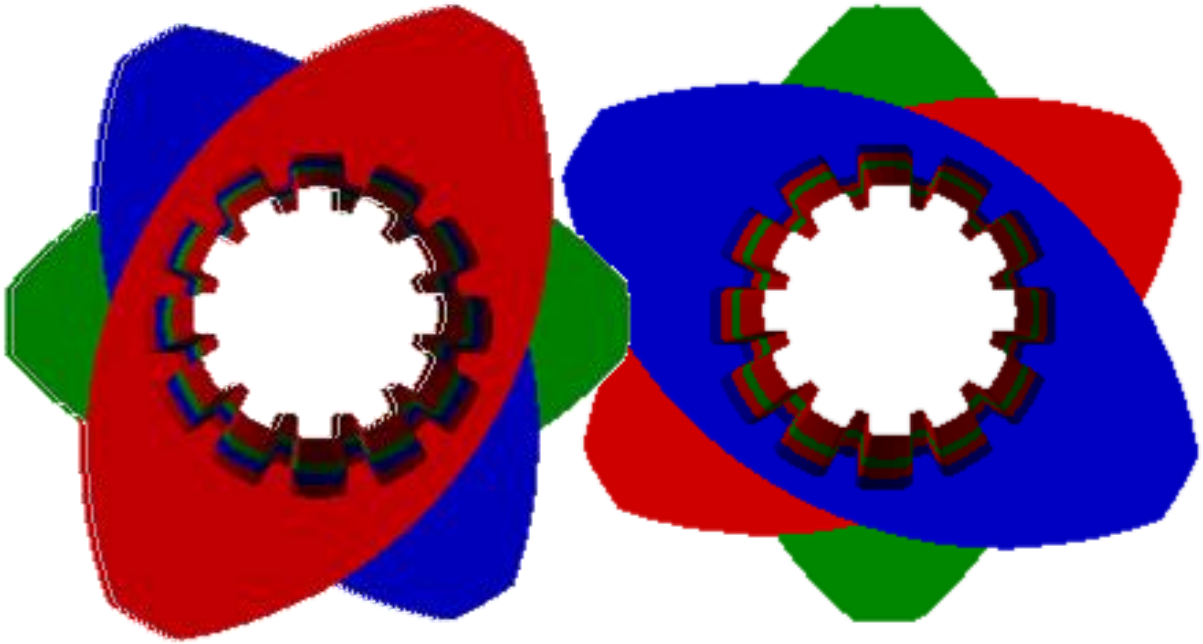


Twin-screw granulation process development

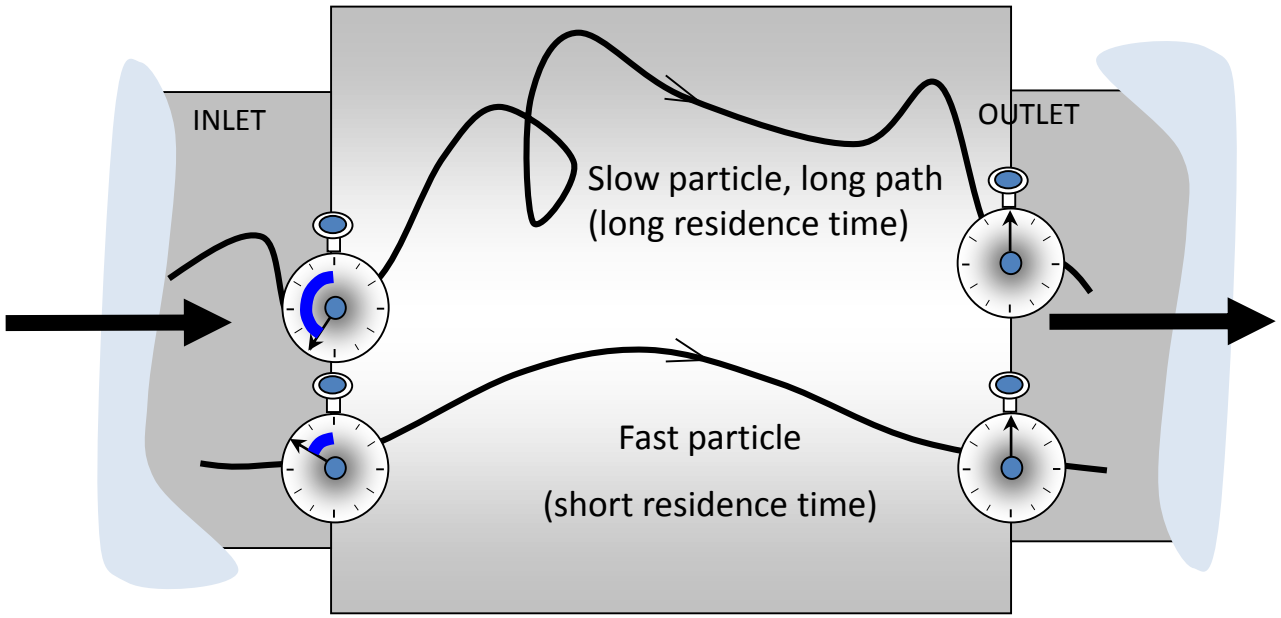
Areas under study:

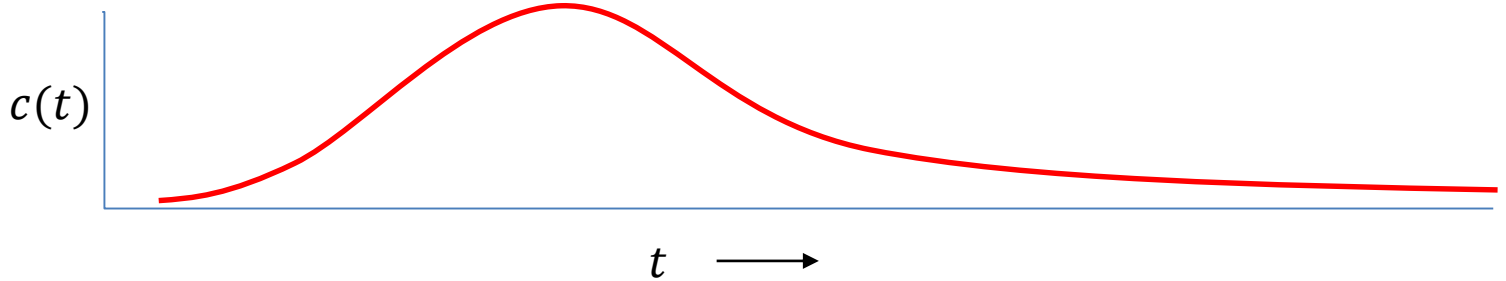
- Granulation time and mixing.
- Aggregation and breakage rates.

Twin-screw granulation process development



Residence time distribution to know the granulation time and mixing

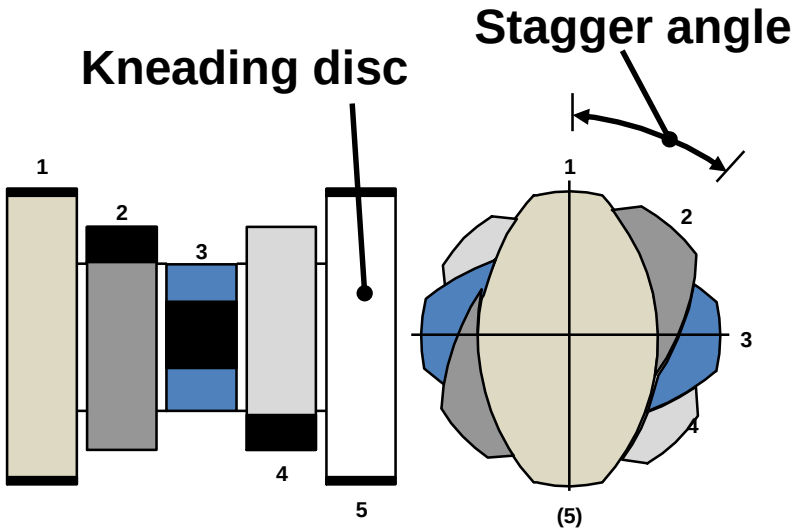




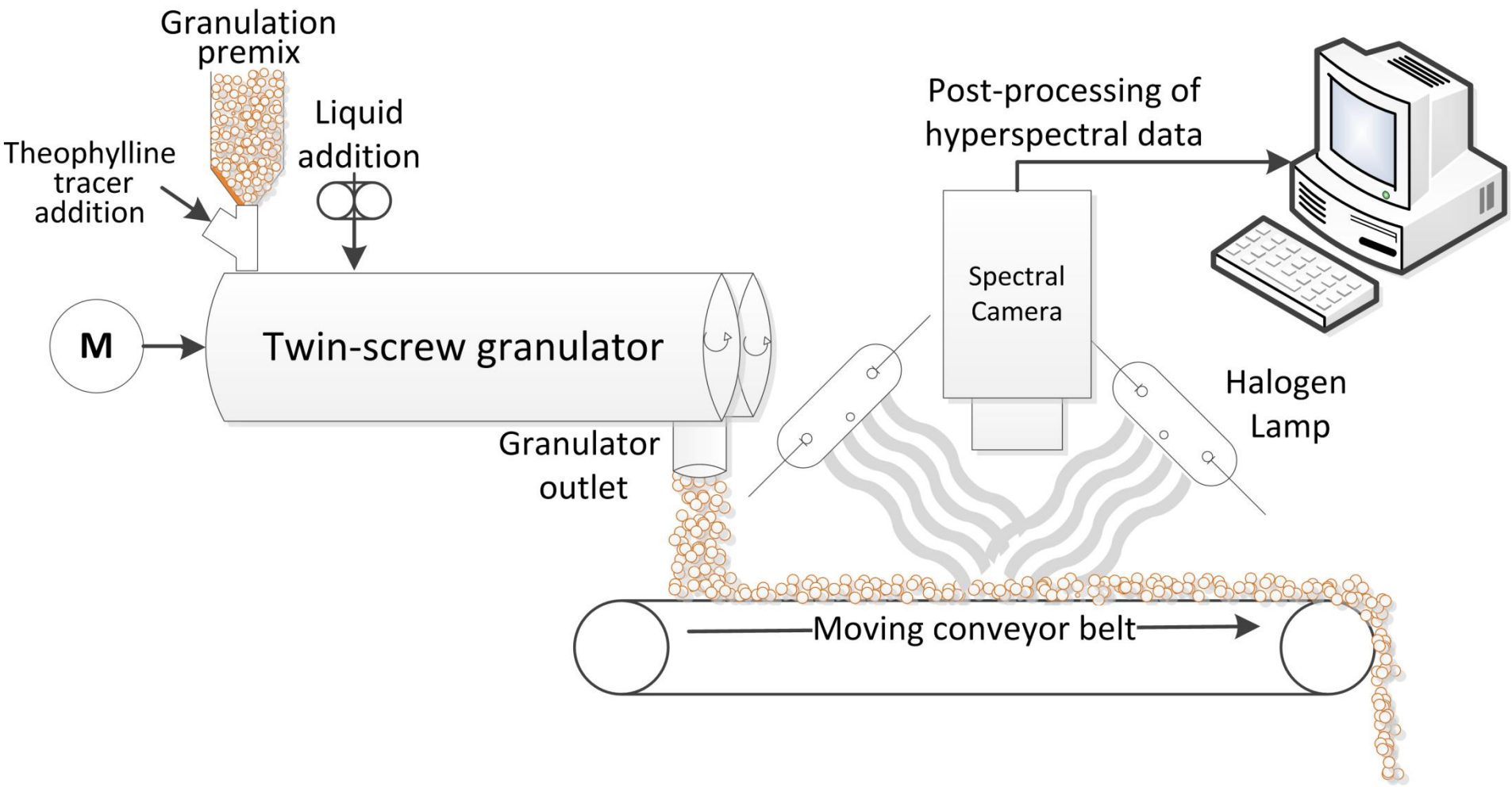
Parameters under study

Screw Configuration
- Number of kneading discs
- Stagger angle

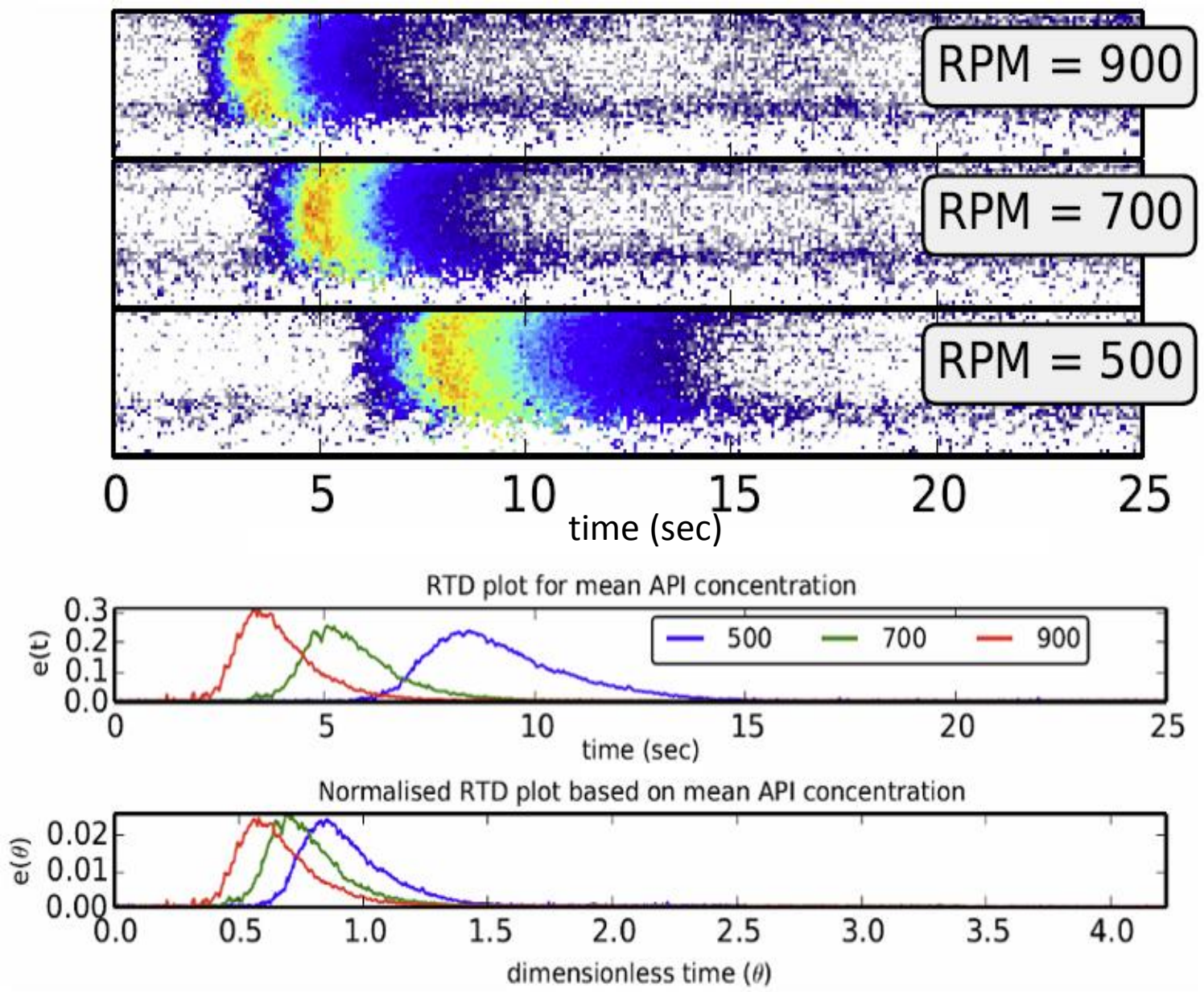
Process settings
- Material throughput
- Screw speed



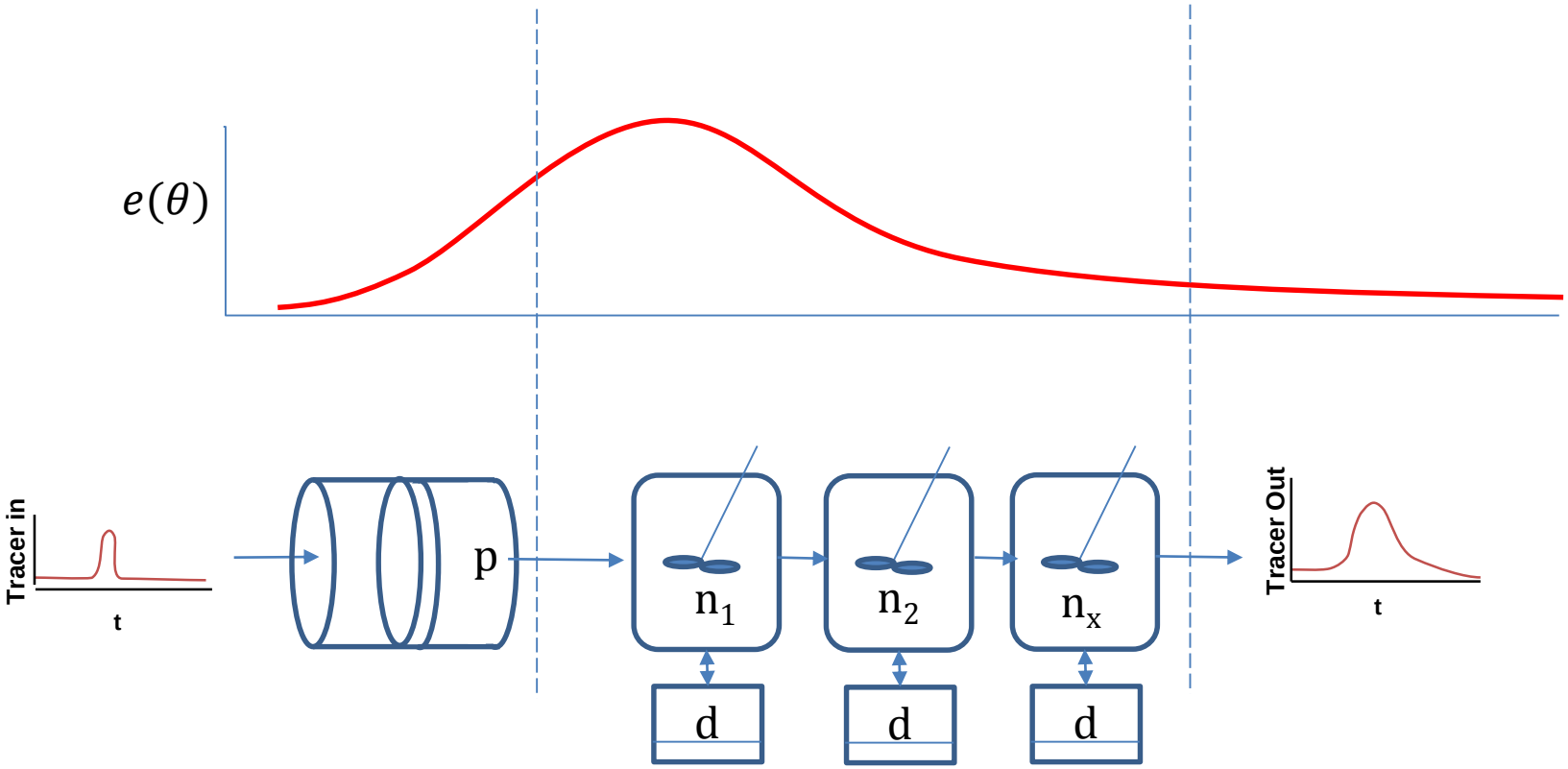
Tracer concentration in granules produced was measured using NIR chemical imaging



API Map was used to measure RTD



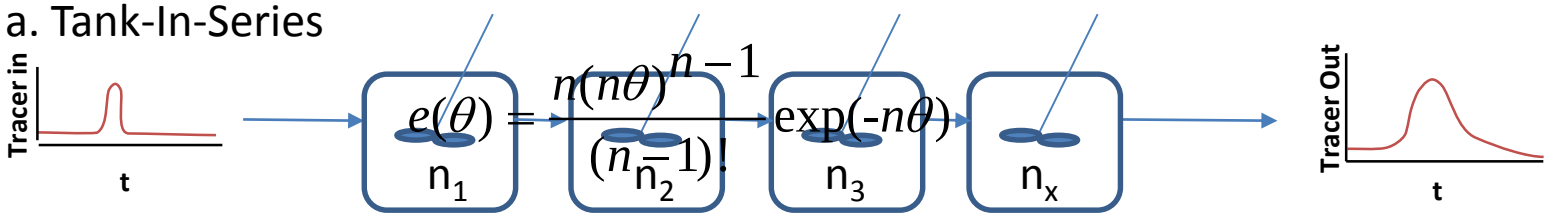
Conceptual modelling for detailed understanding of RTD



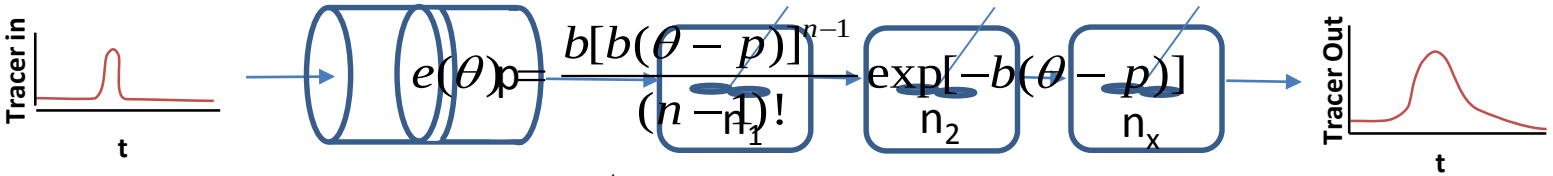
Tank-in-Series model

Conceptual model to include three main components of RTD

a. Tank-In-Series

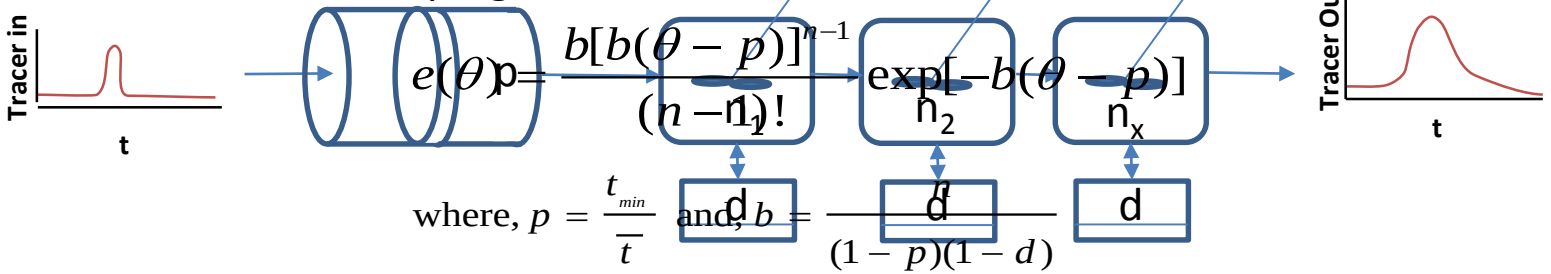


b. Tank-In-Series with plug-flow fraction



where, $p = \frac{t_{min}}{\overline{t}}$ and, $b = \frac{n}{1-p}$

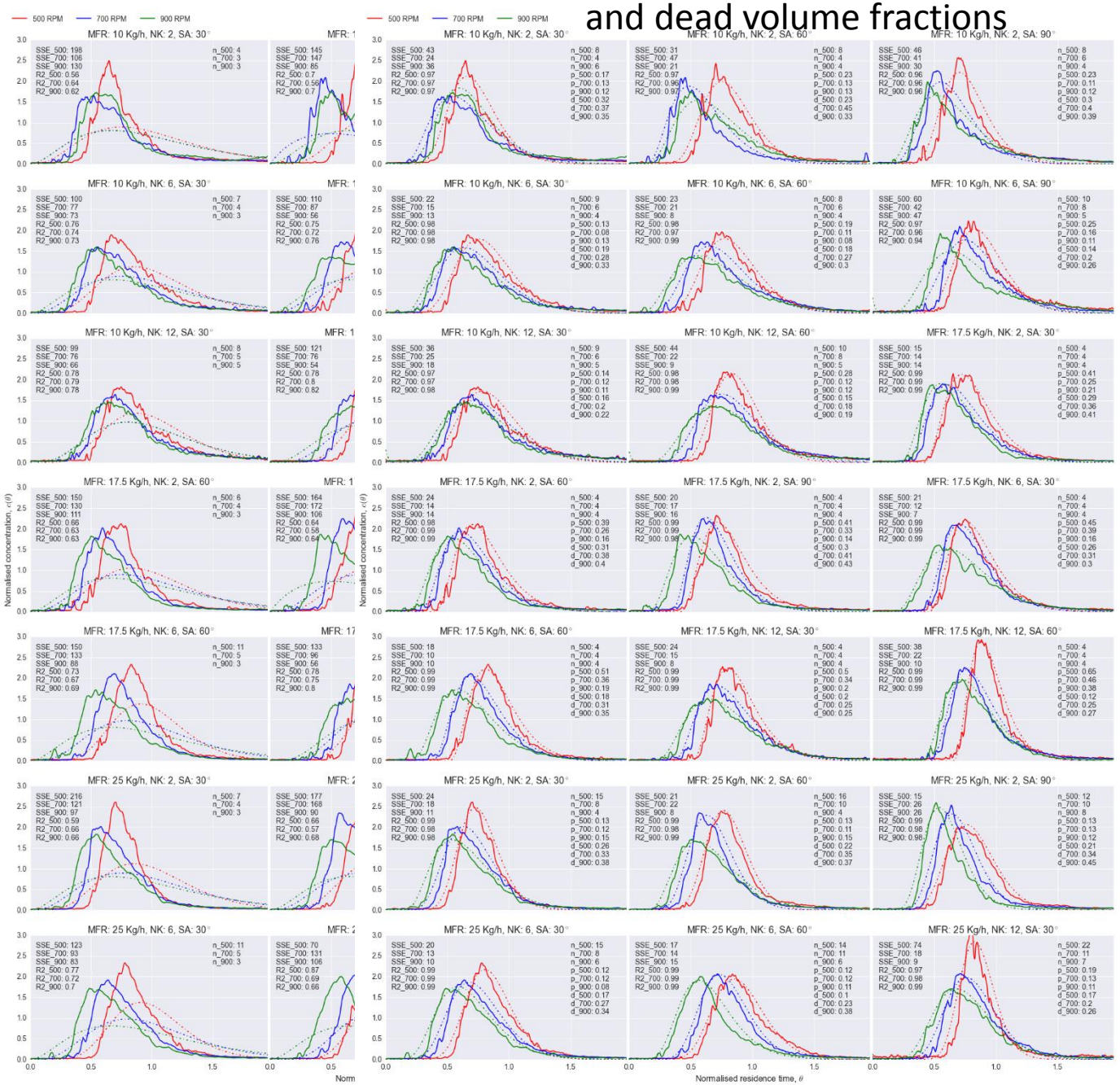
c. Tank-In-Series with plug-flow and dead volume fractions



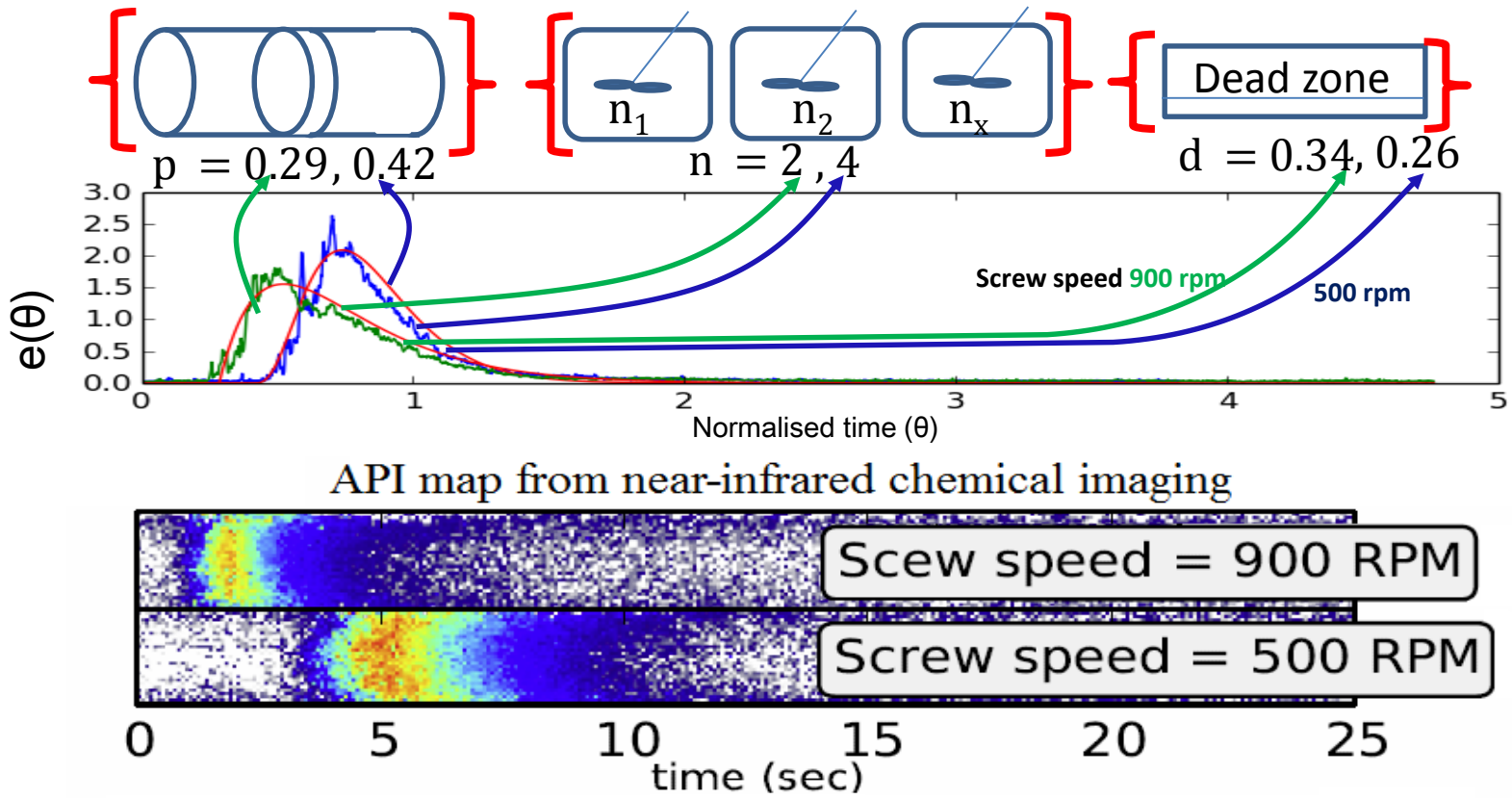
where, $p = \frac{t_{min}}{\overline{t}}$ and, $b = \frac{d}{(1-p)(1-d)}$

Tank-In-Series

Tank-In-Series with plug flow fraction and dead volume fractions



Parameters estimated by the model used for system analysis



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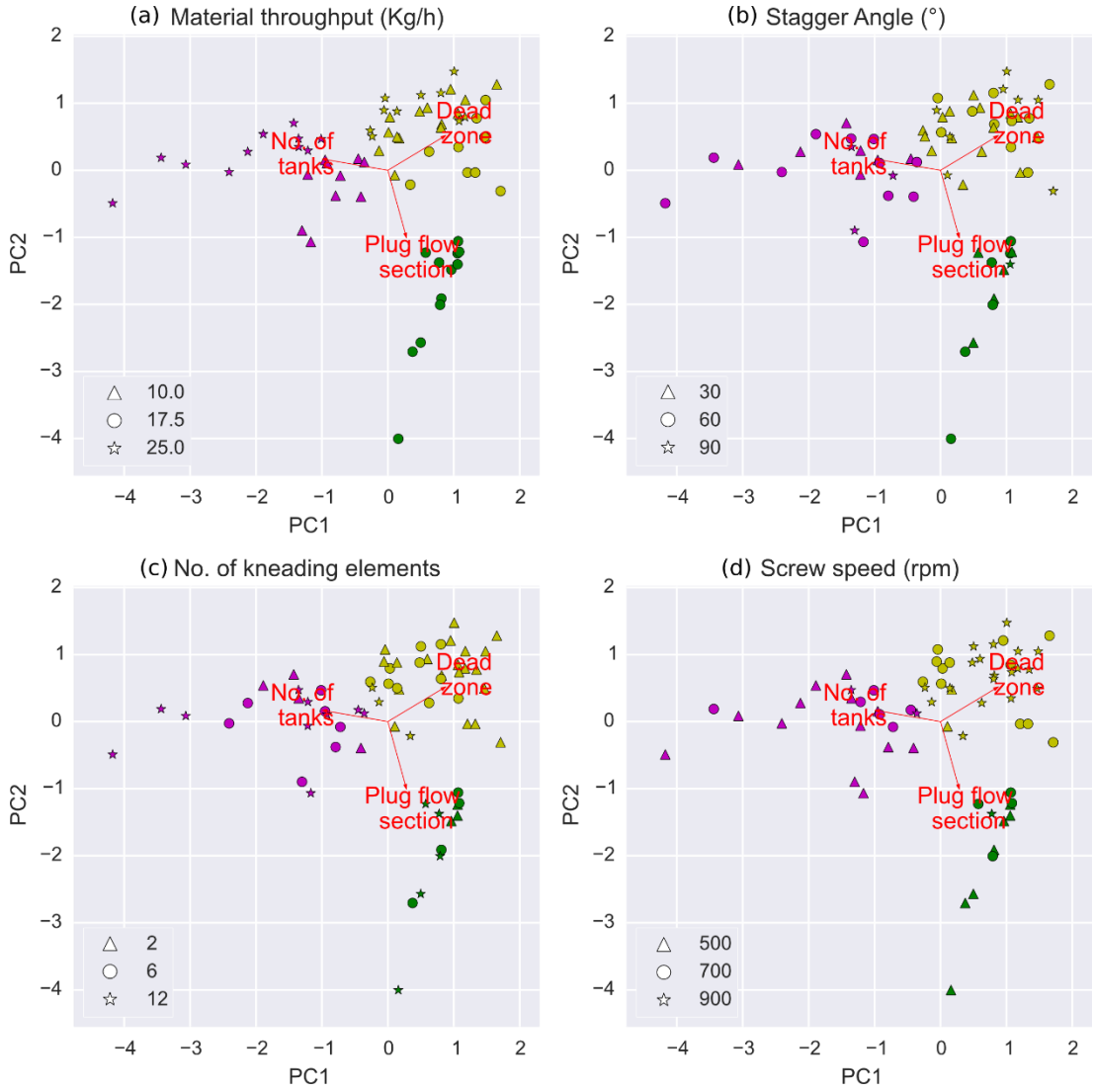
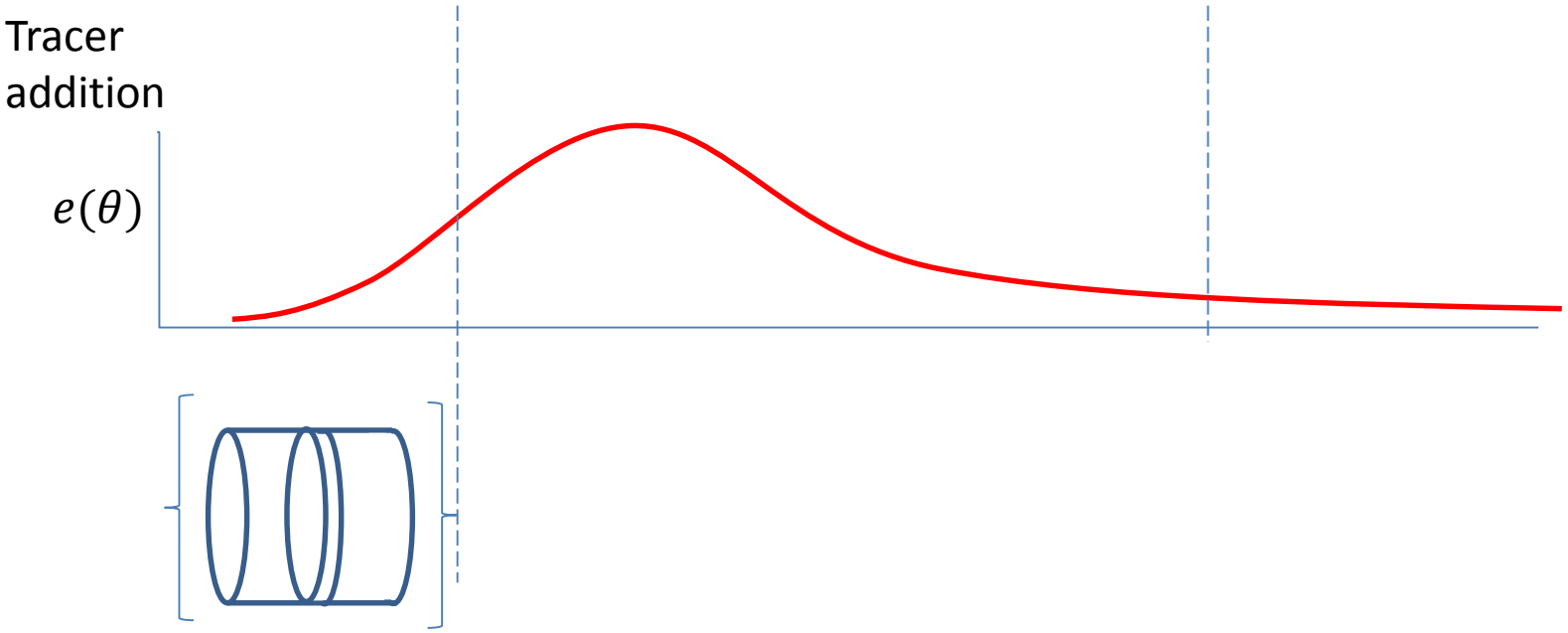
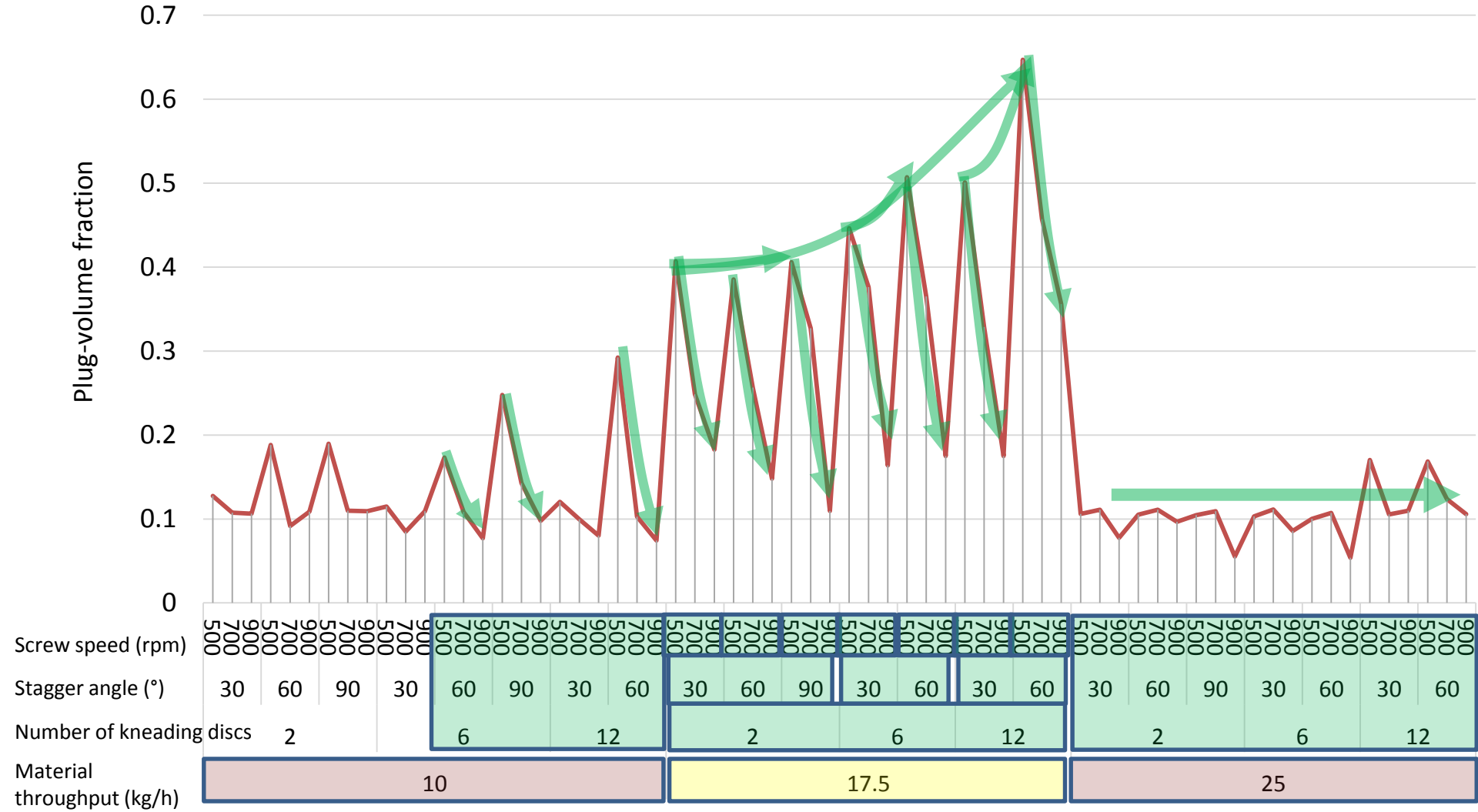


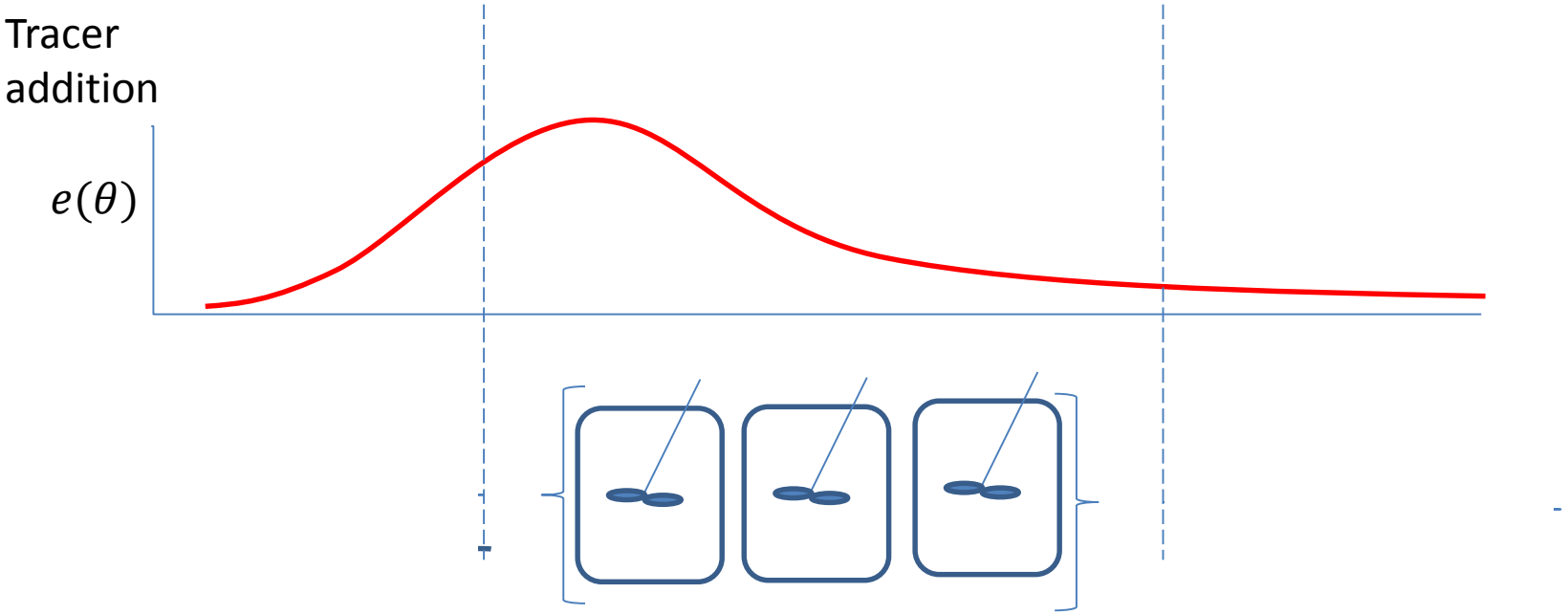
Plug flow component of the RTD



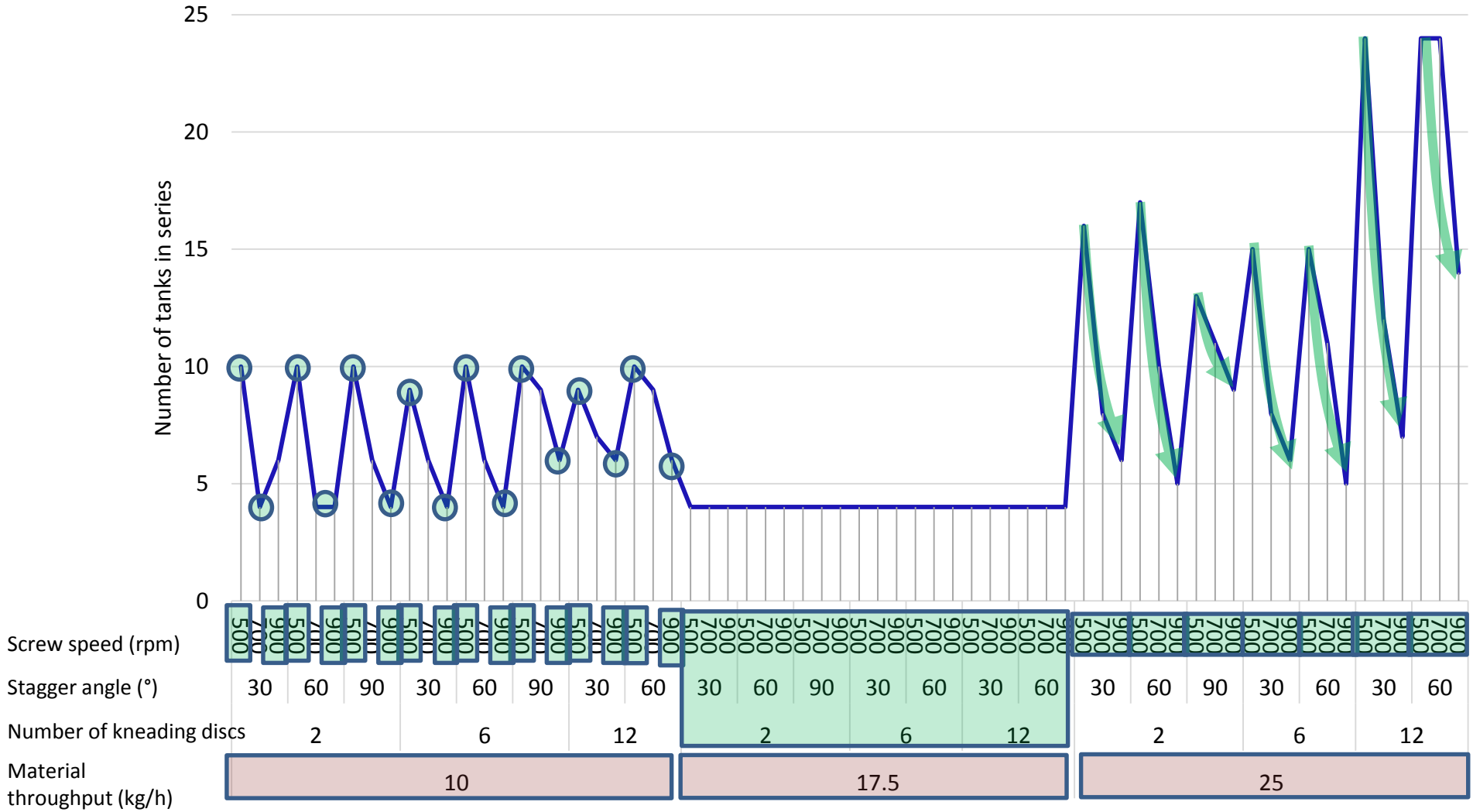
Plug flow fraction decreases with increase in screw speed



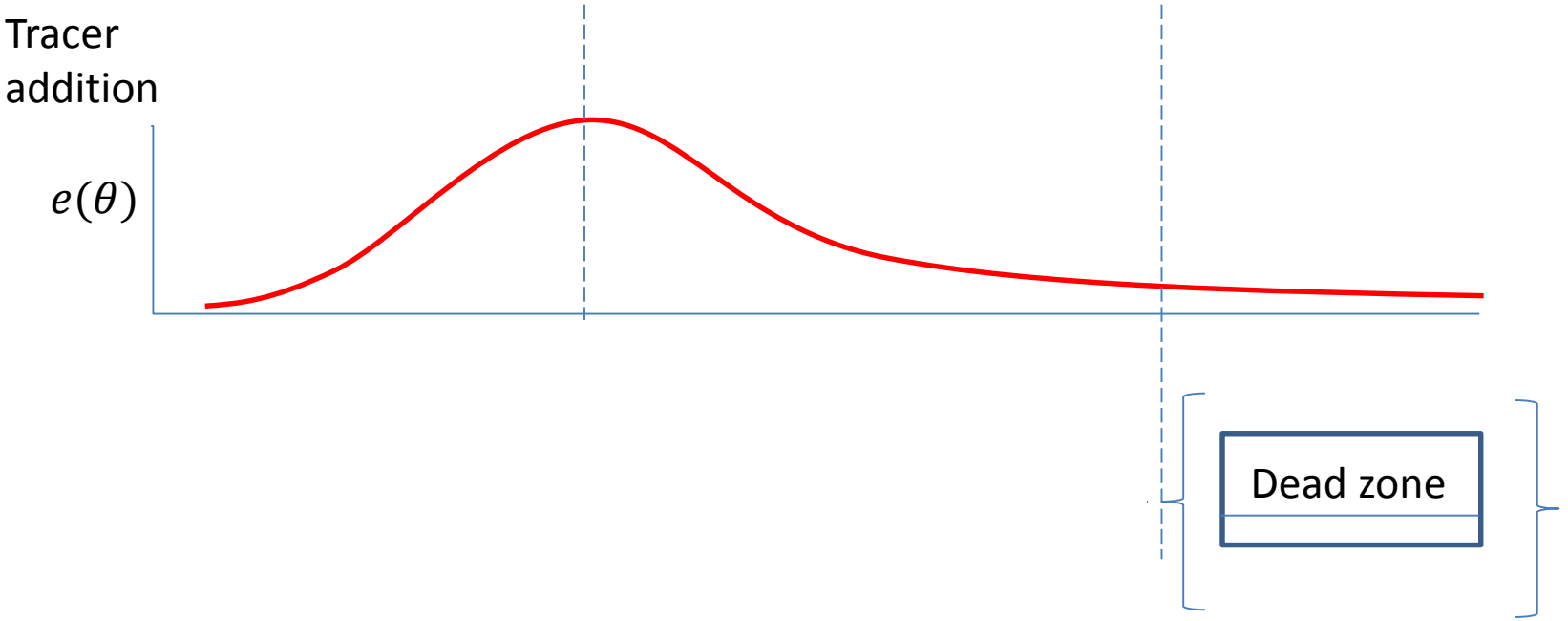
Mixed flow component of the RTD



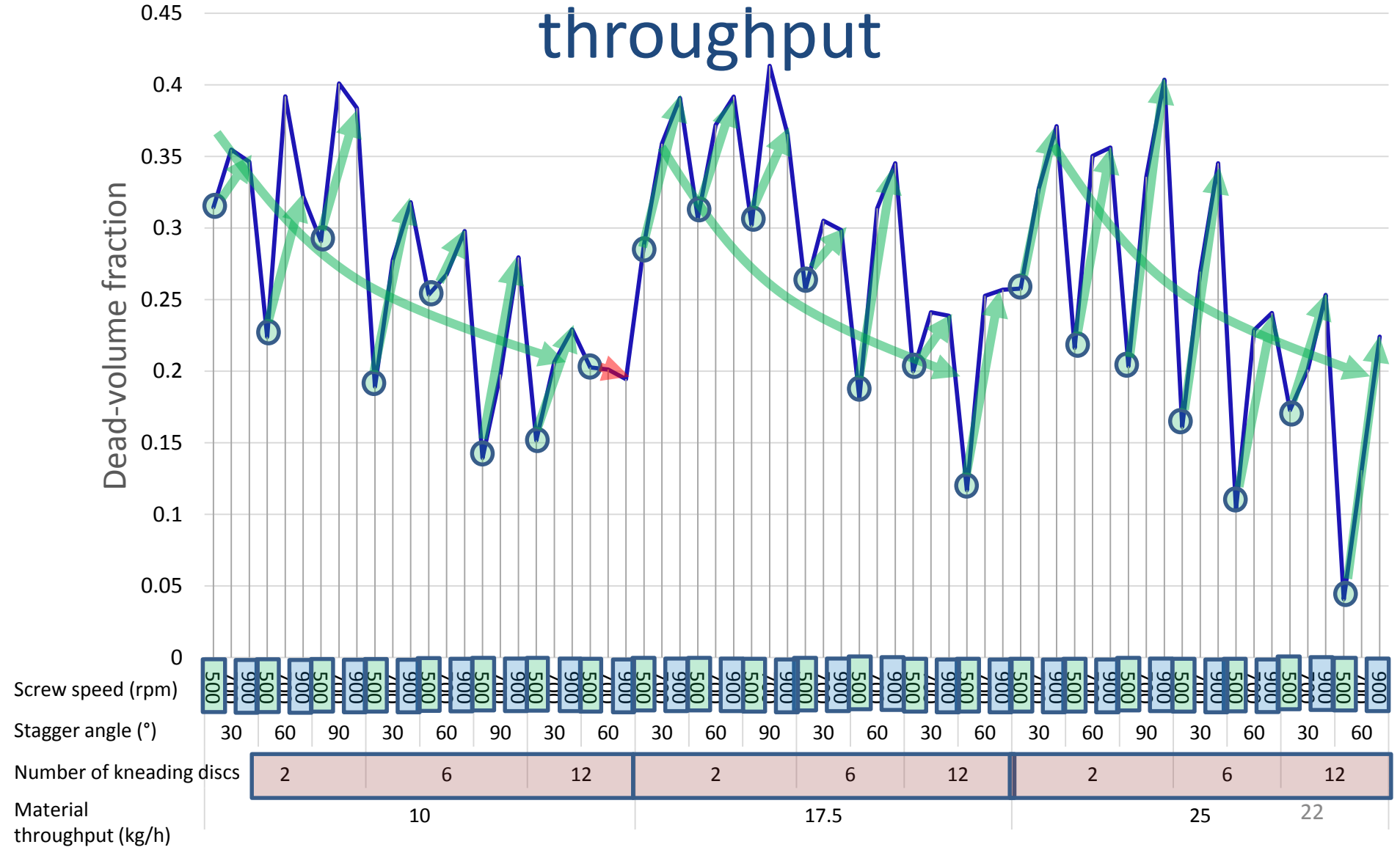
Material throughput controls mixing regime, increase in screw speed increases mixing



Dead-volume component of the RTD



Dead zone increases with screw speed, and reduces with increase in kneading discs and throughput



Summary and Outlook

Along with experimental study, an improved insight can be obtained by model-based analysis.

A balance between conveying rate and throughput force is required for good axial mixing.

Kneading block primarily act as plug-flow zones so it also prevent excessive back mixing in the granulator.

Together with a granule size distribution study it will be confirmed which mixing regime is most desirable.

Aknowledgements

Thomas De Beer
Ingmar Nopens
Krist V. Gernaey

Jurgen Vercruysse
Valérie Vanhoorne

Maunu Toiviainen
Panouillot Pierre-Emmanuel
Mikko Juuti

Kris Schoeters

Ashish.Kumar@UGent.be