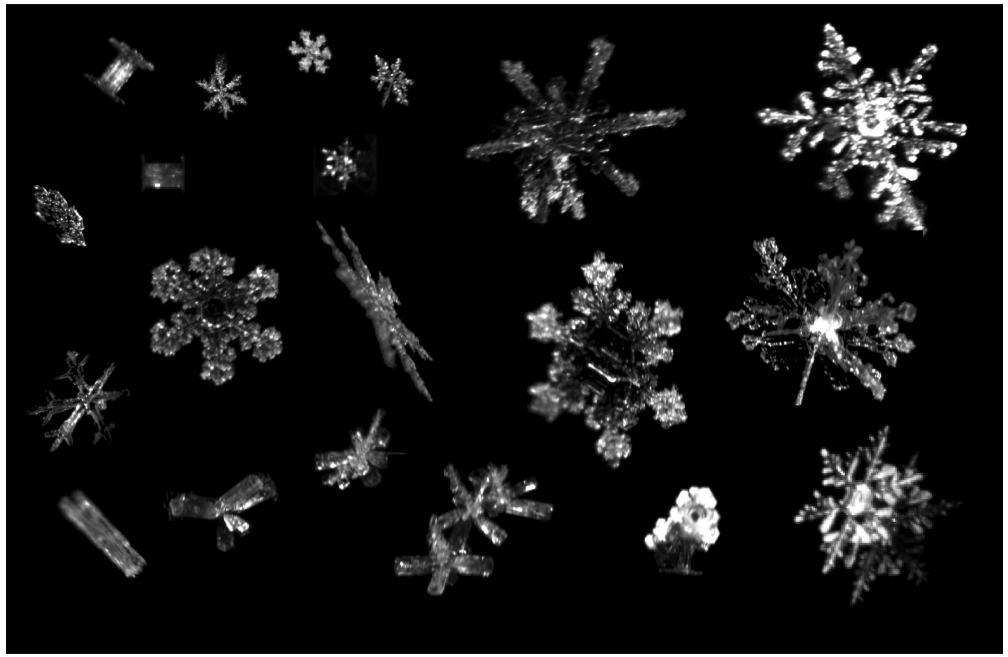
Predicting Realistic Snow Shape for Improved Polarimetric Radar Simulations



PrePEP 2025 Bonn

Soumi Dutta, Davide Ori (PRISTINE, UoC)

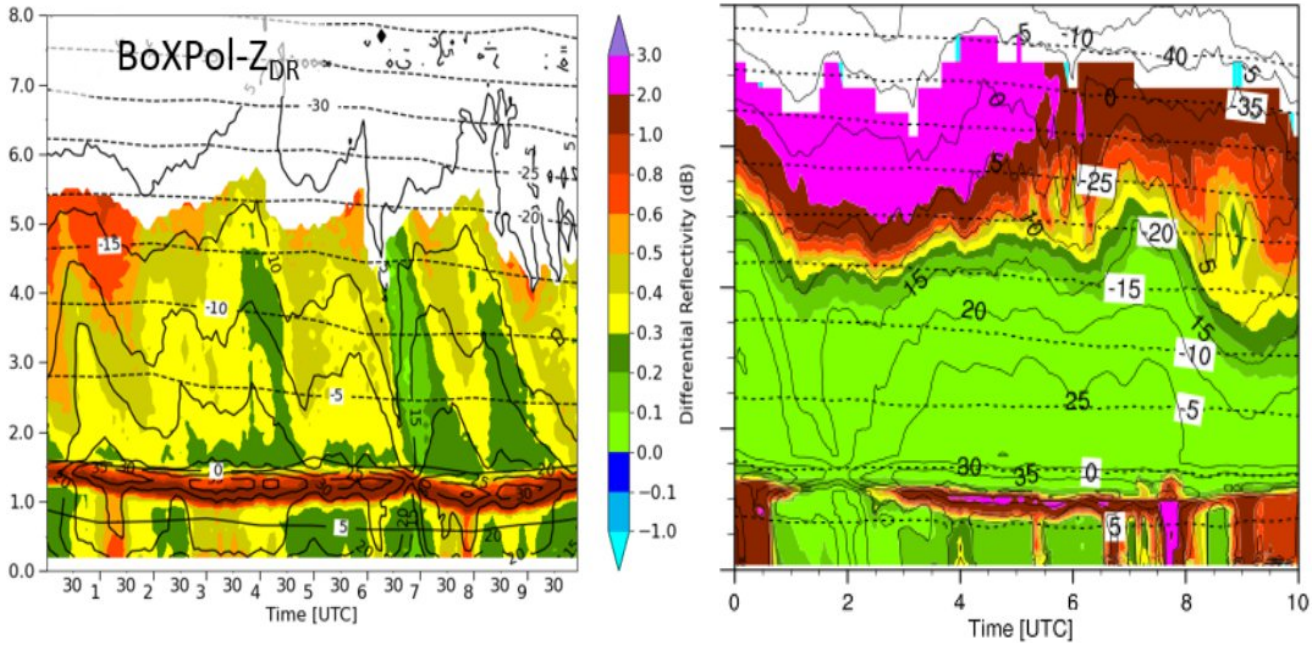
Jana Mendrok, Ulrich Blahak (PRISTINE, DWD)
Christoph Siewert, Axel Seifert (DWD)
Leonie Von Terzi, Stefan Kneifel (LMU)

- EMVORADO is a Polarimetric Radar Forward Operator (RFO) associated with ICON.
- It uses polarimetric scattering calculations based on T-matrix method.

Biases in T-Matrix polarimetric calcuations

Observation

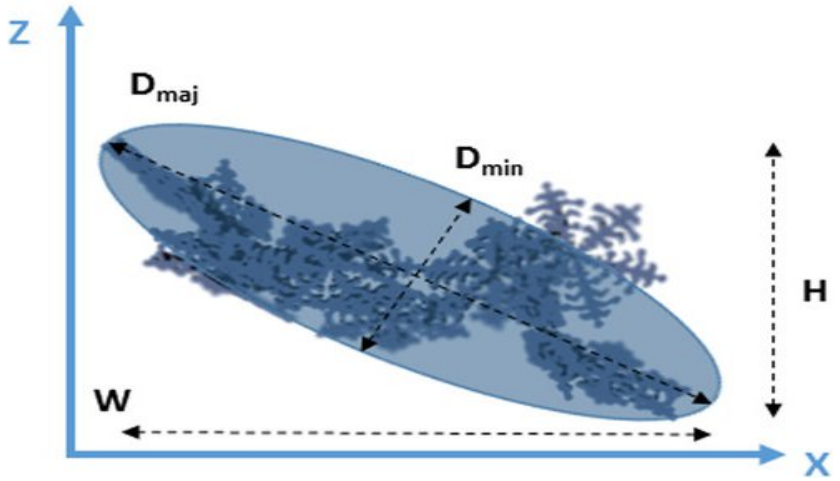
Model+PFO



Shrestha et al., 2021

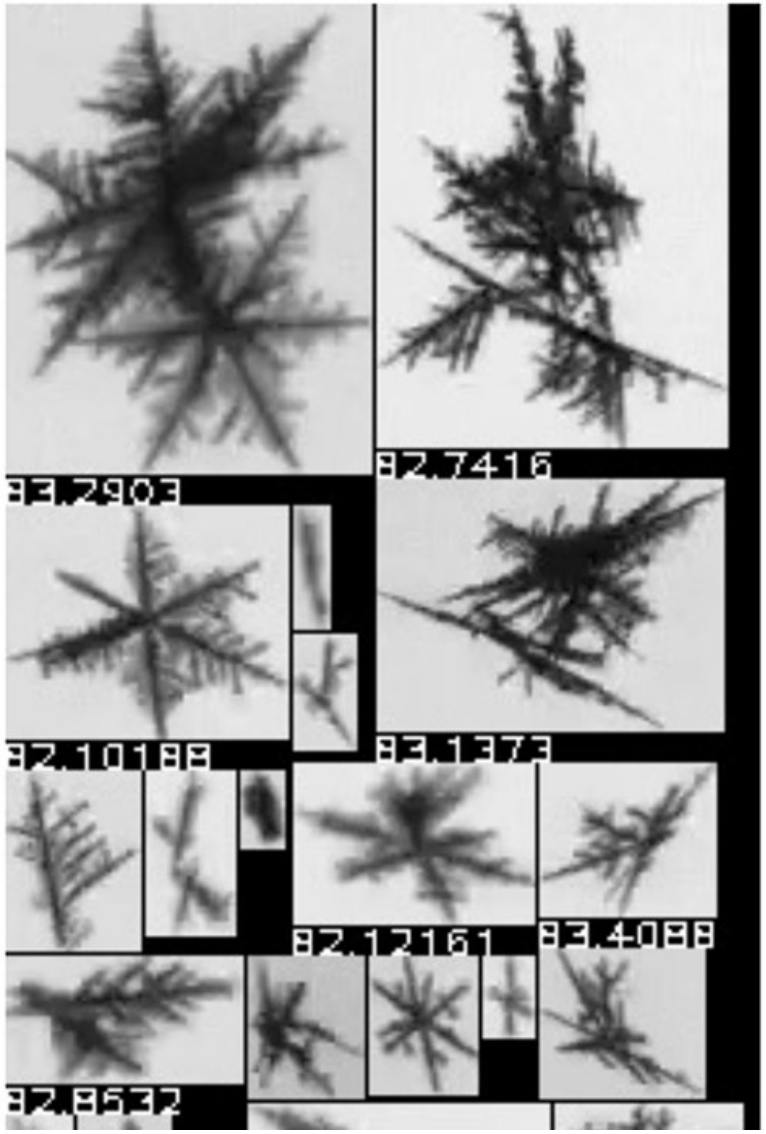
Spheroidal scattering model as a major source of uncertainty (Schrom and Kumiljan, 2018)

T-Matrix based simulations show a **consistent deficit** in terms of **polarimetric response** in the dendritic growth layer where large, “fluffy” particles prevail



Von Lerber et al., 2017

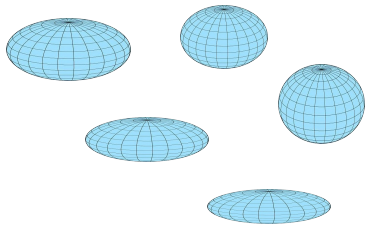
How can we substitute spheroids with realistic shapes?

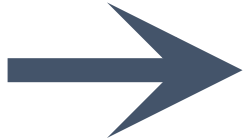


Source: VISSS camera

There are scattering databases available with prescribed shapes of ice crystals and snowflakes

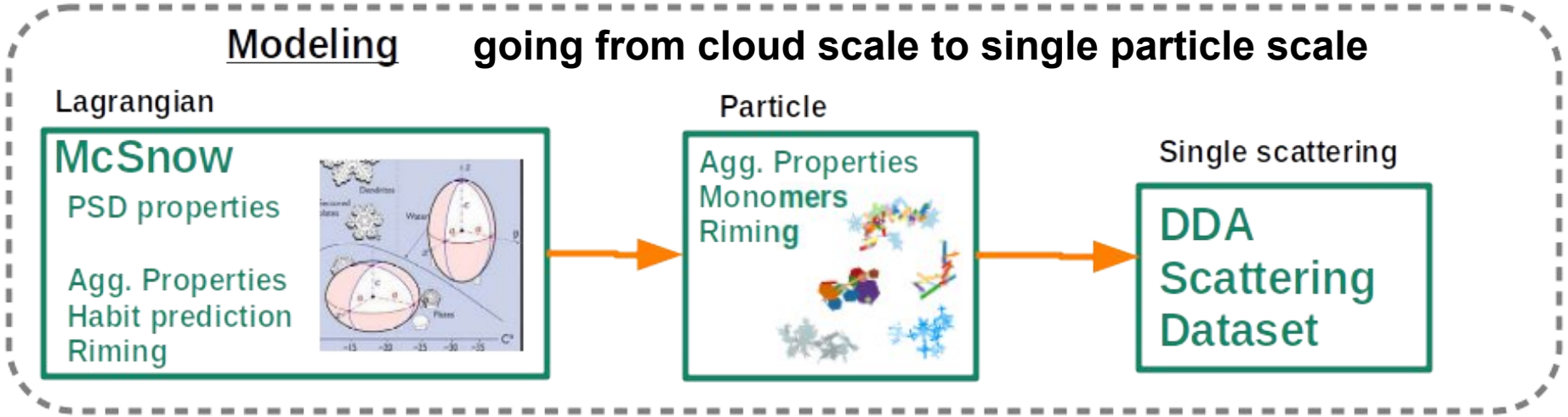
But, we want to get the shapes of ice crystals and snowflakes present in natural variability



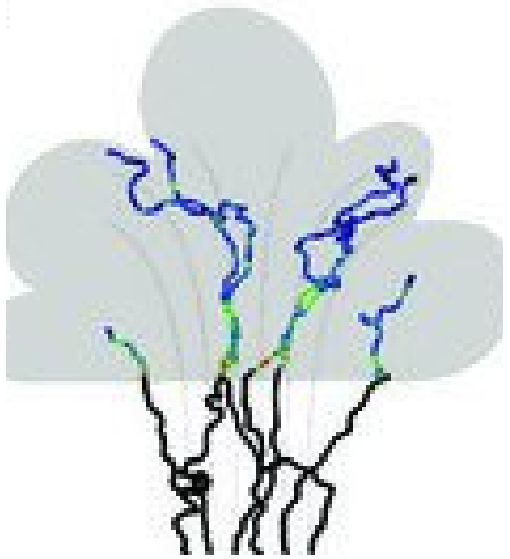


Which one?

Avoid arbitrary particle selection

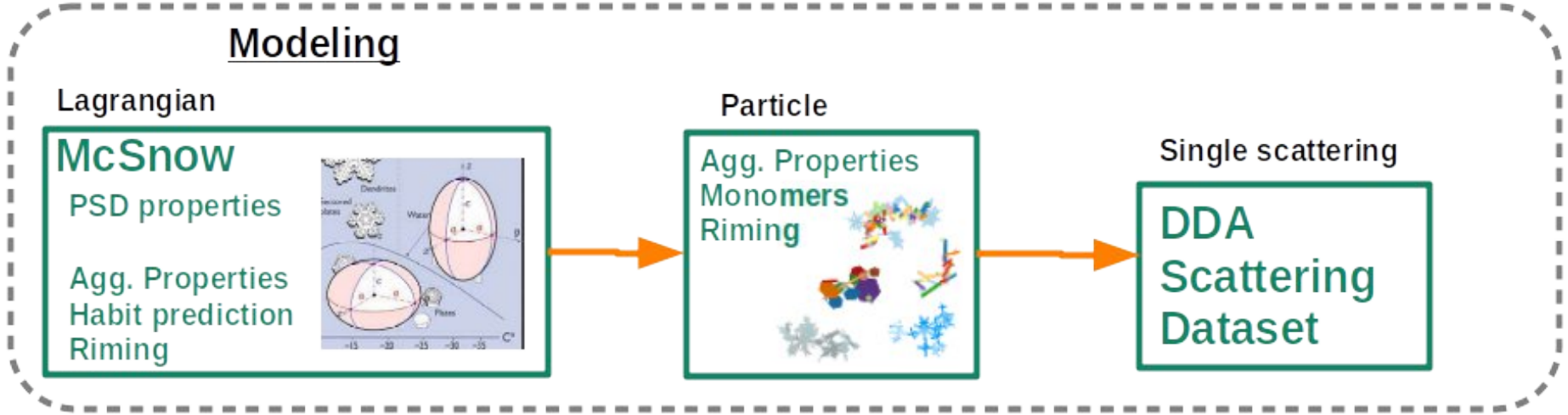


McSnow

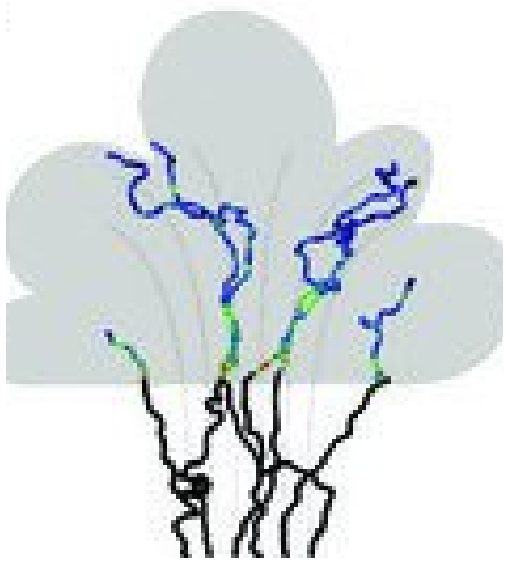


Semi-Lagrangian 1D (single column) cloud model (Brdar and Seifert, 2018)
follows cloud particle trajectories
can predict the shapes

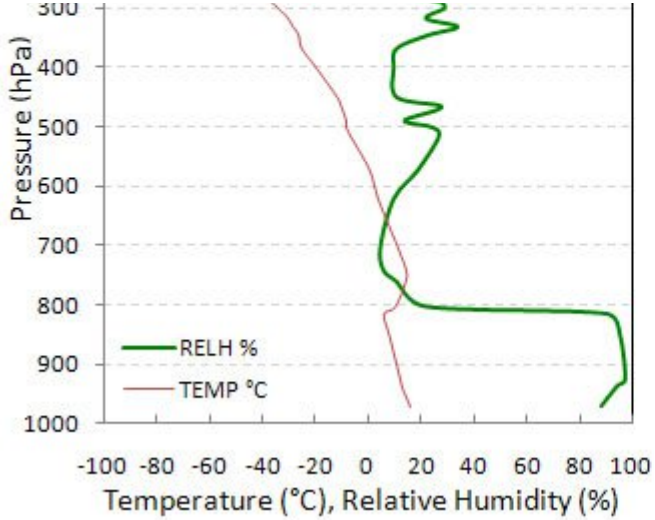
Avoid arbitrary particle selection



McSnow



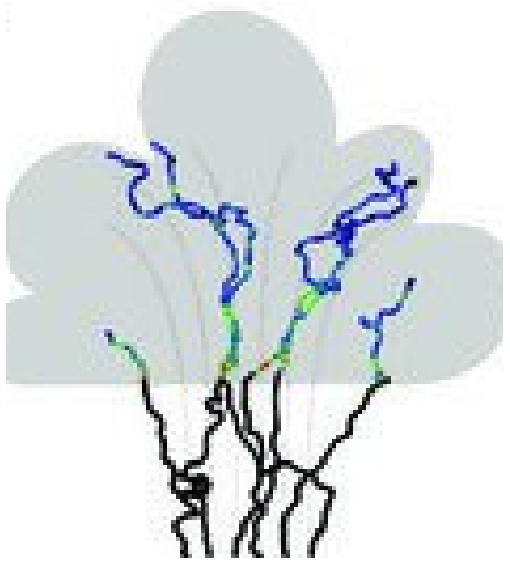
Semi-Lagrangian 1D model (Brdar and Seifert, 2018) follows cloud particle trajectories



1 - Thermodynamic profile from ICON

Avoid arbitrary particle selection

McSnow



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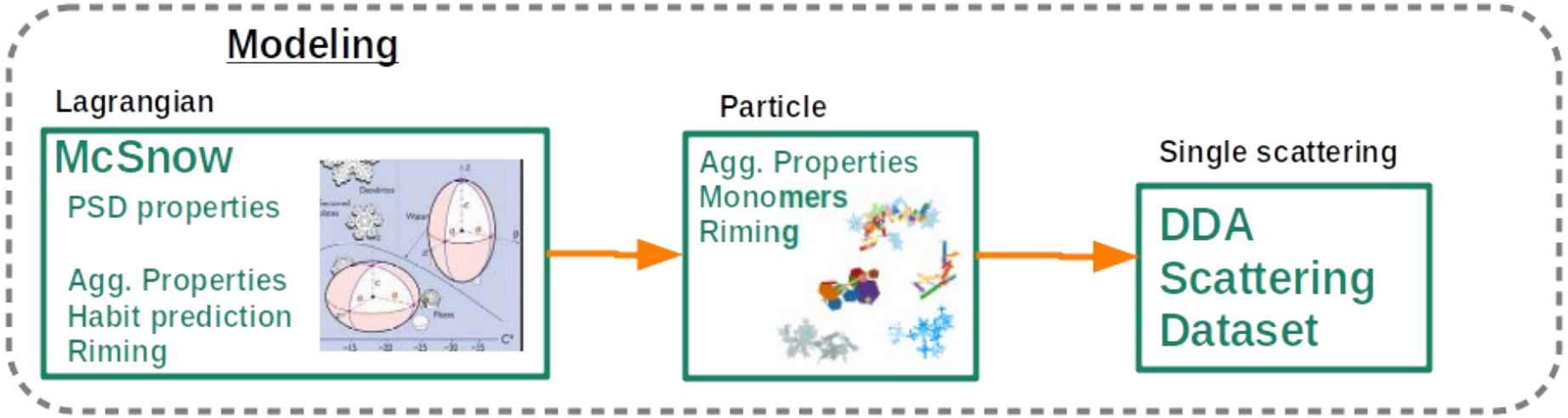

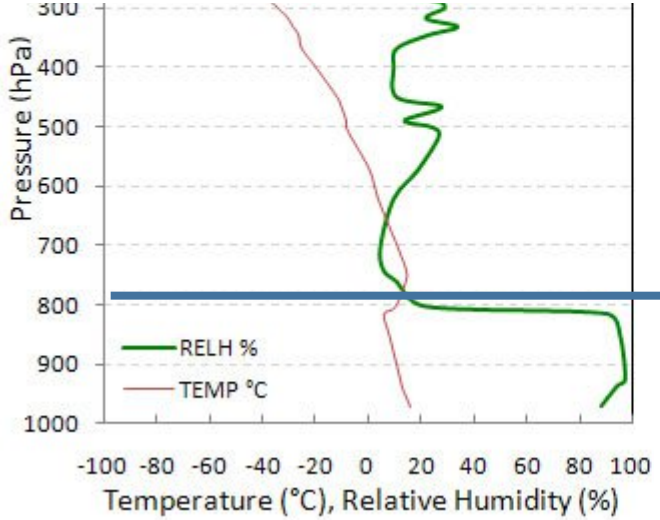

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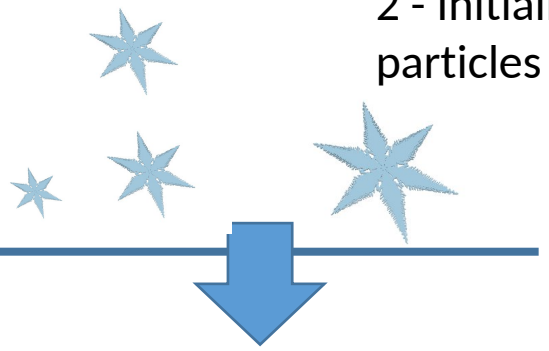
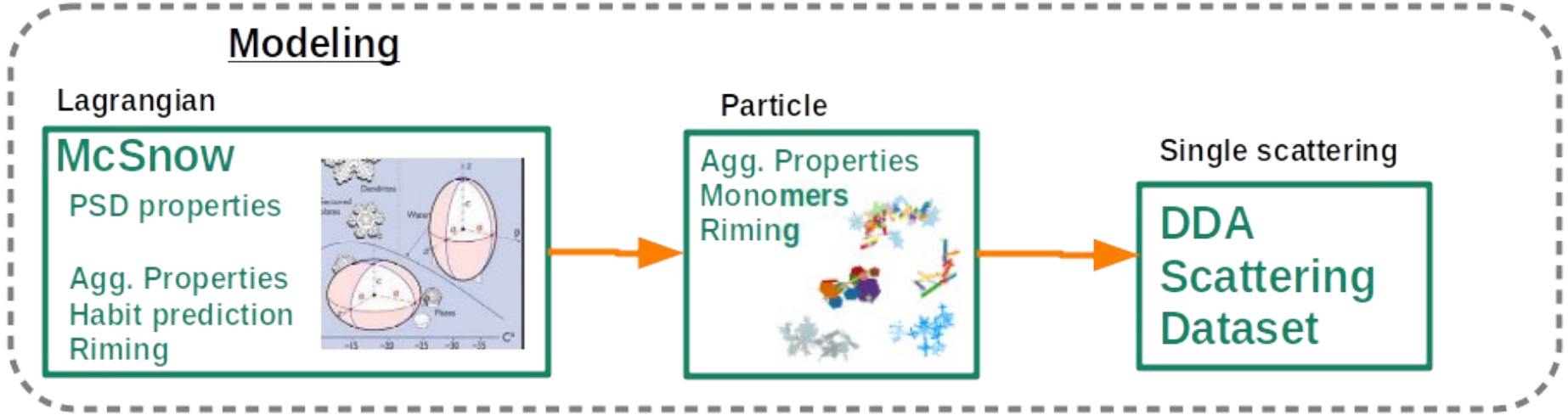
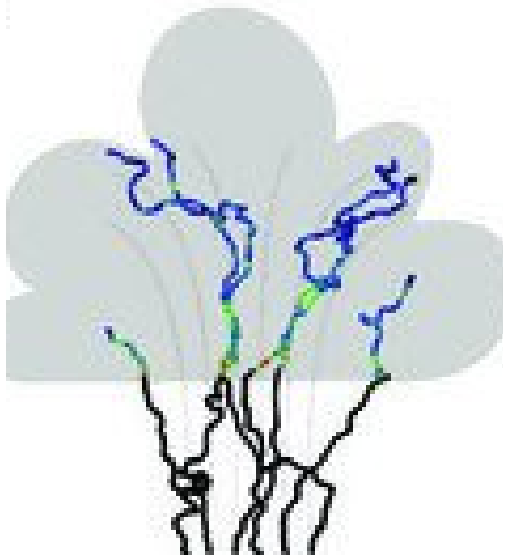


2 - Initialization layer - constant flux of particles with size distribution

Avoid arbitrary particle selection



McSnow



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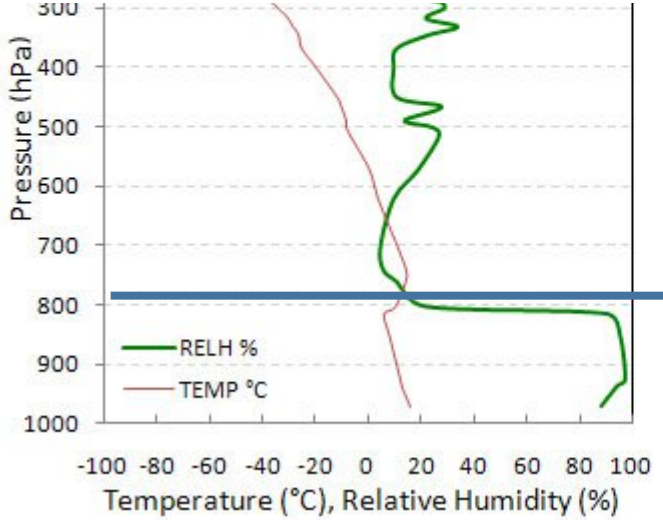

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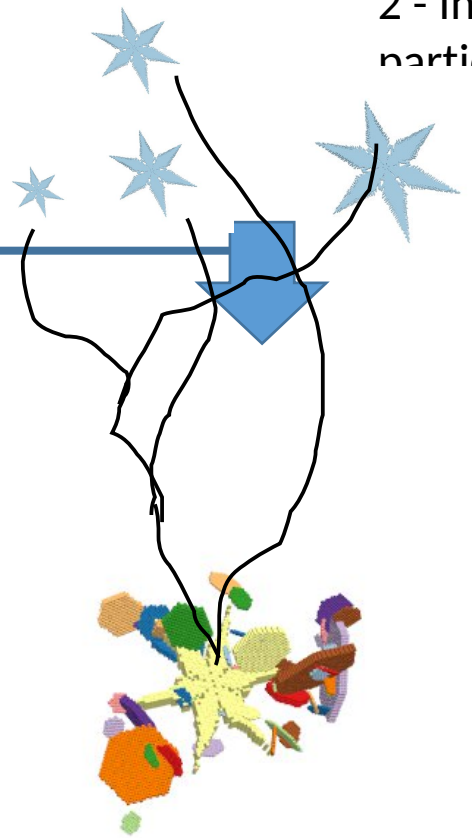
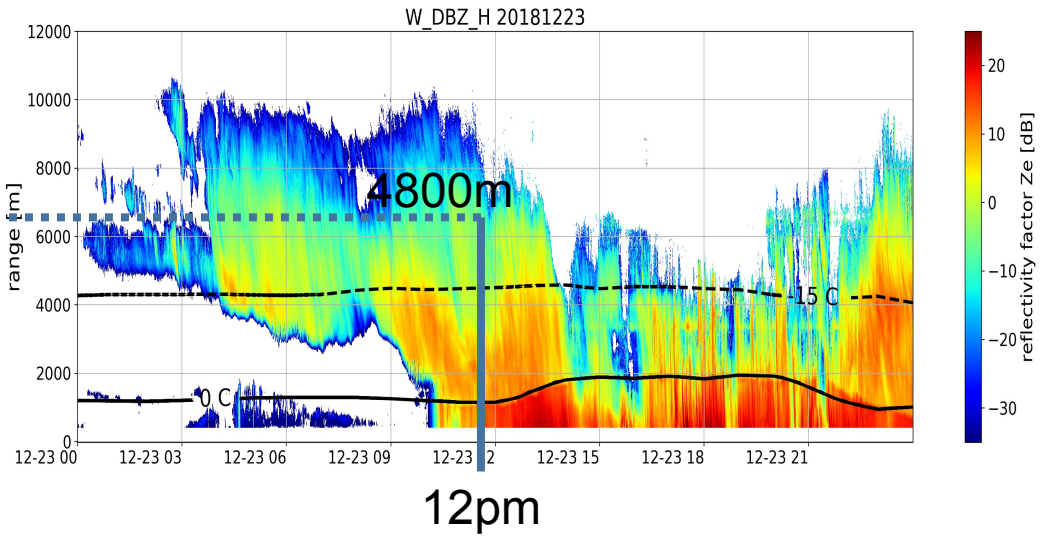
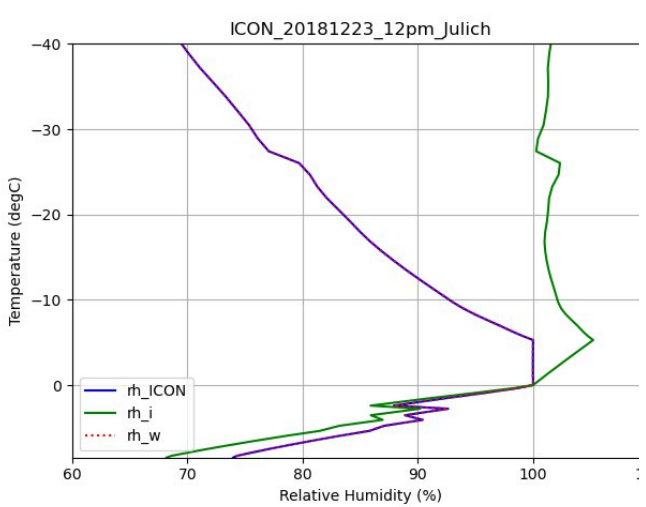


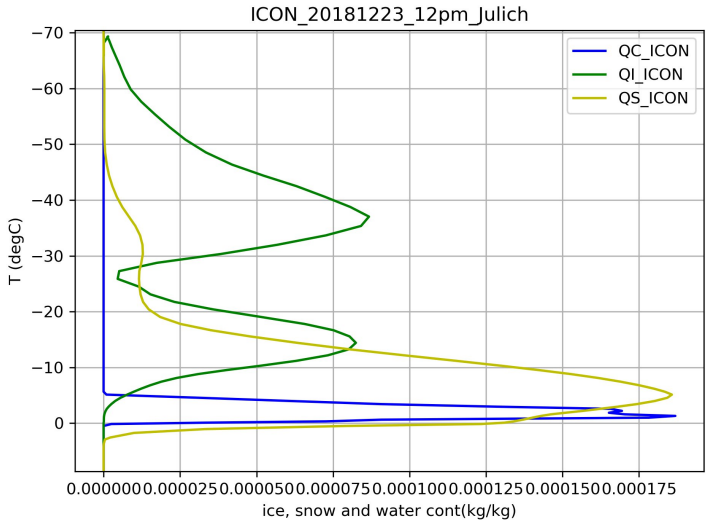
2 - Initialization layer - constant flux of particles with size distribution

3 - Lagrangian Microphysics
Sedimentation
Depositional growth
Aggregation
Riming
Melting
sublimation

Event Selection – TRIPEx-Pol 2018 campaign (Jülich) 23.12.23





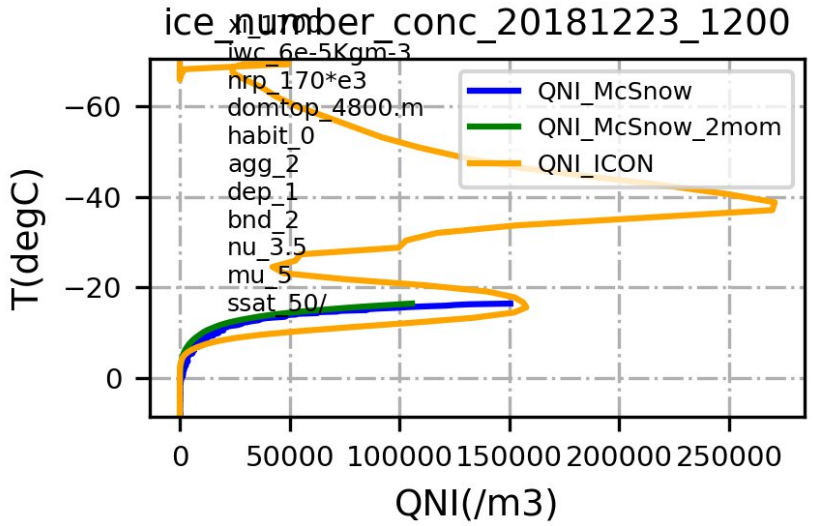


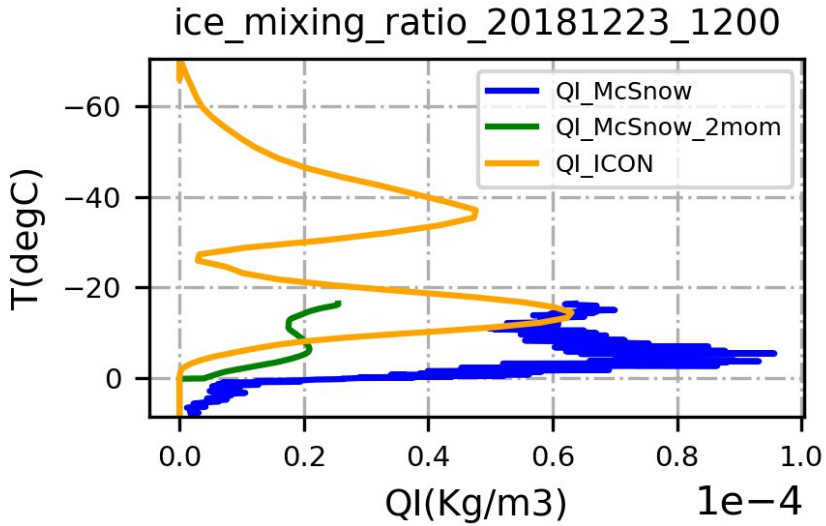
Important to check McSnow's performance for real physical cases

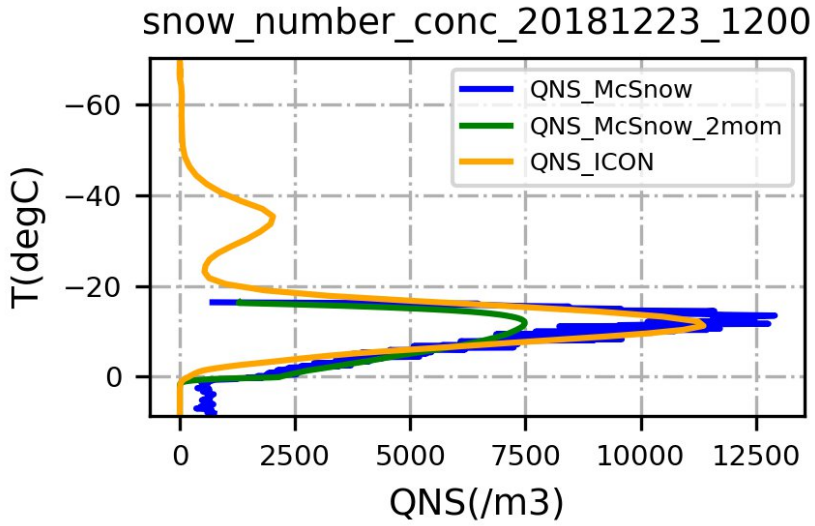
Selection of events where we find stratiform occurance of clouds

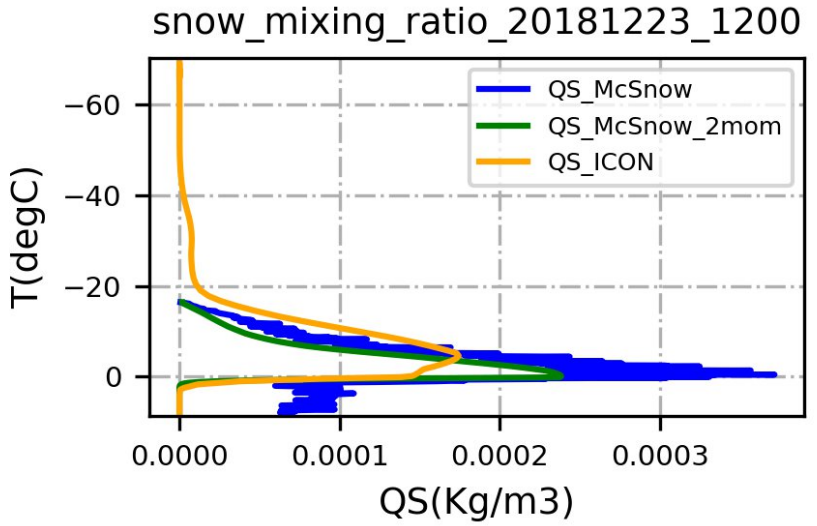
Also, to compare and check how the McSnow 1D microphysics does compare with ICON 3D microphysics

Event Selection – TRIPEx-Pol 2018 campaign (Jülich) 23.12.23



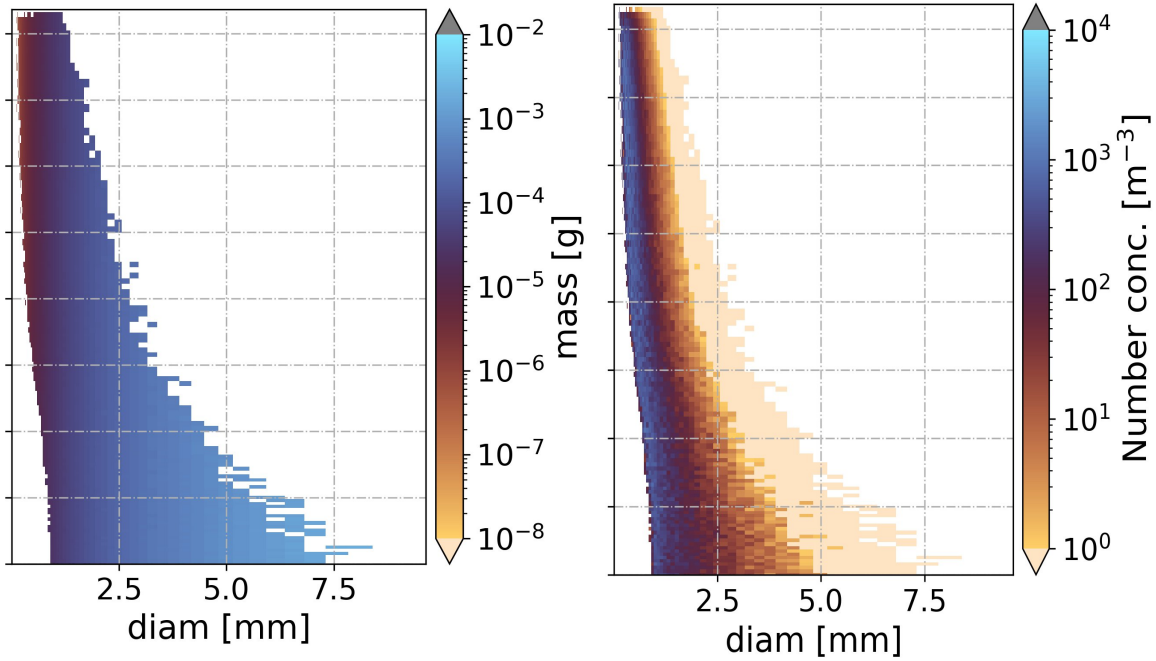


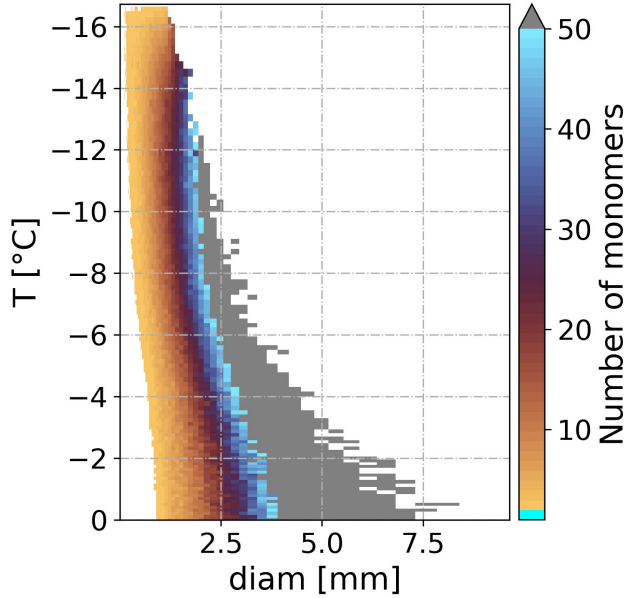




reseonable match with ICON 3D parameters we get

Detailed Aggregate properties

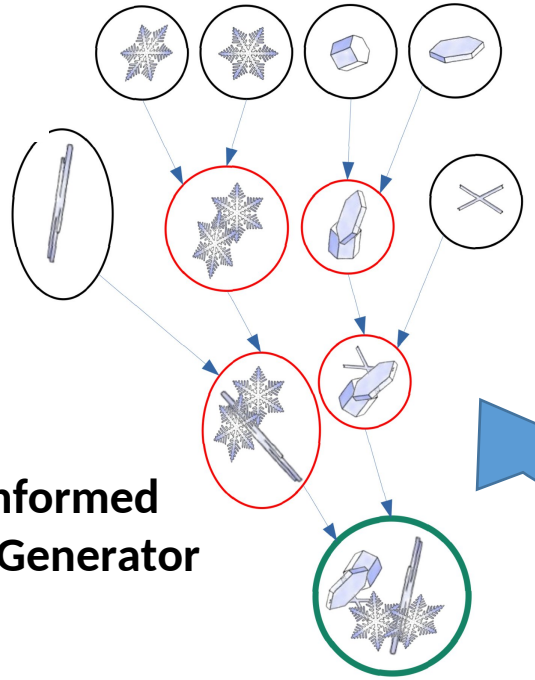




<u>Bulk properties</u>

Average mass-size relation

Size Distribution



Detailed model-informed Particle Generator

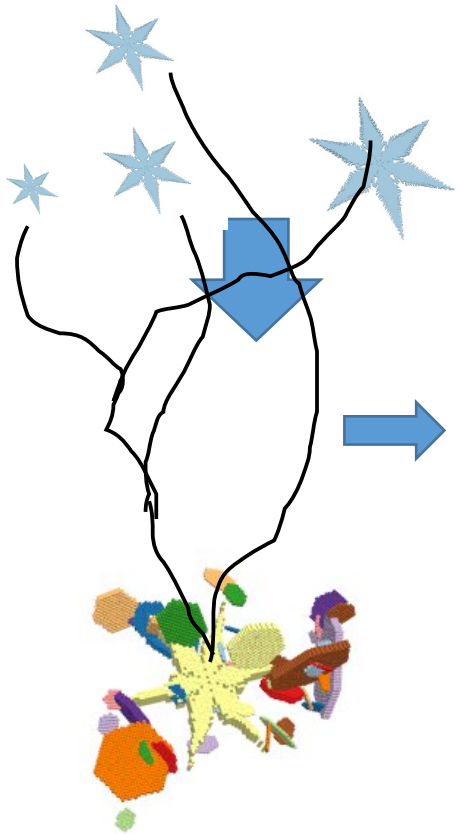
<u>Per Particle:</u>

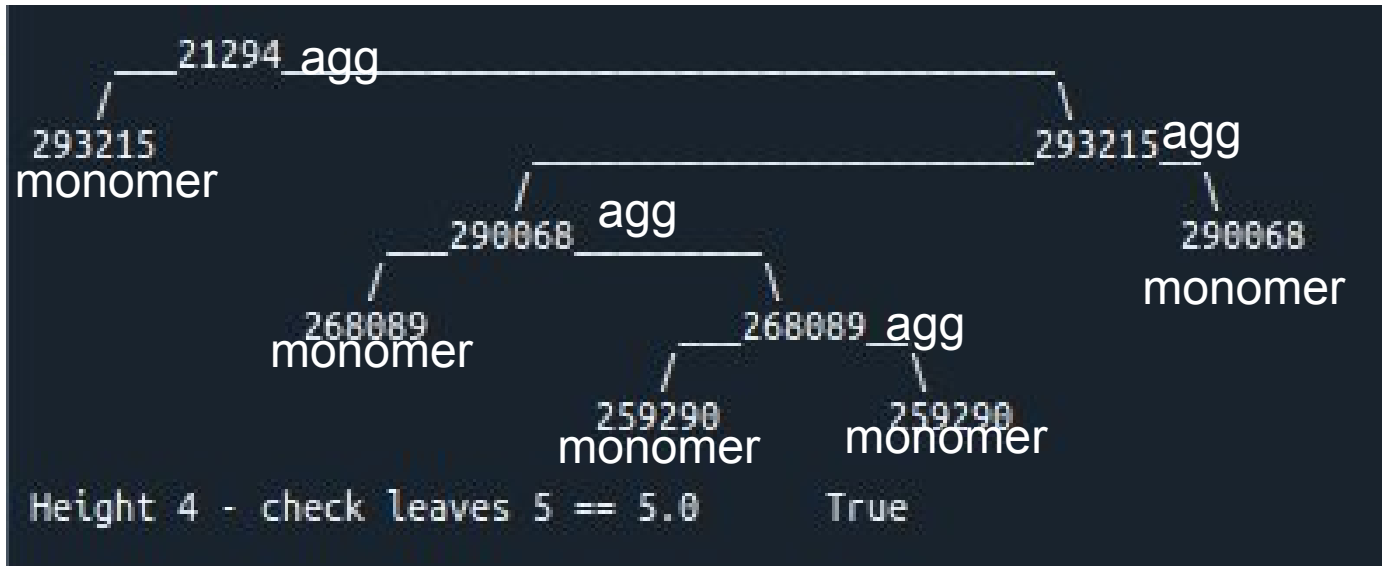
Number of monomers

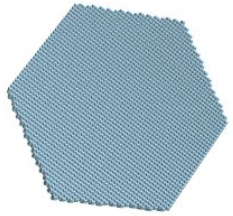
monomer mass distribution

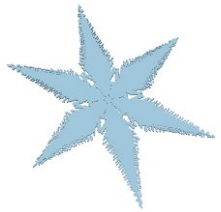
shape information

Forming Aggregates in conjunction of McSnow Simulation and aggregation model







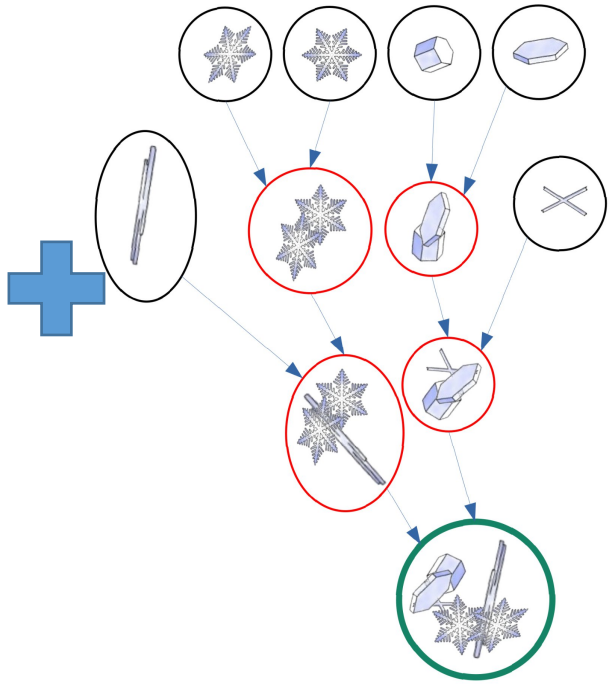


Monomers generated

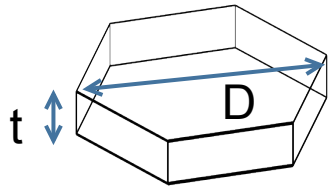
Hexprism Algorithm Reiter's Algorithm

Parameters we get from McSnow to generate monomers

- ✓ Size
- ✓ density
- ✓ Aspect Ratio

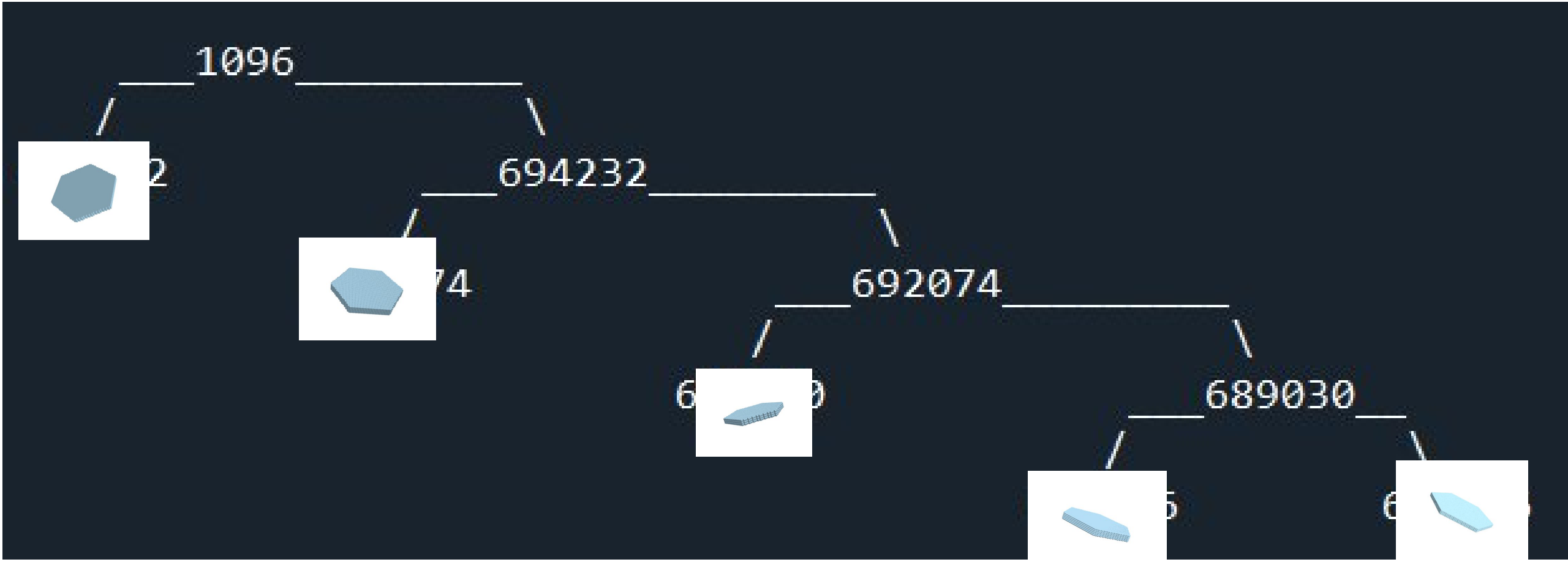


Schematic Diagram of the aggregation process



aspect ratio ar= t/D

How a realistic shape of snowflake generated?



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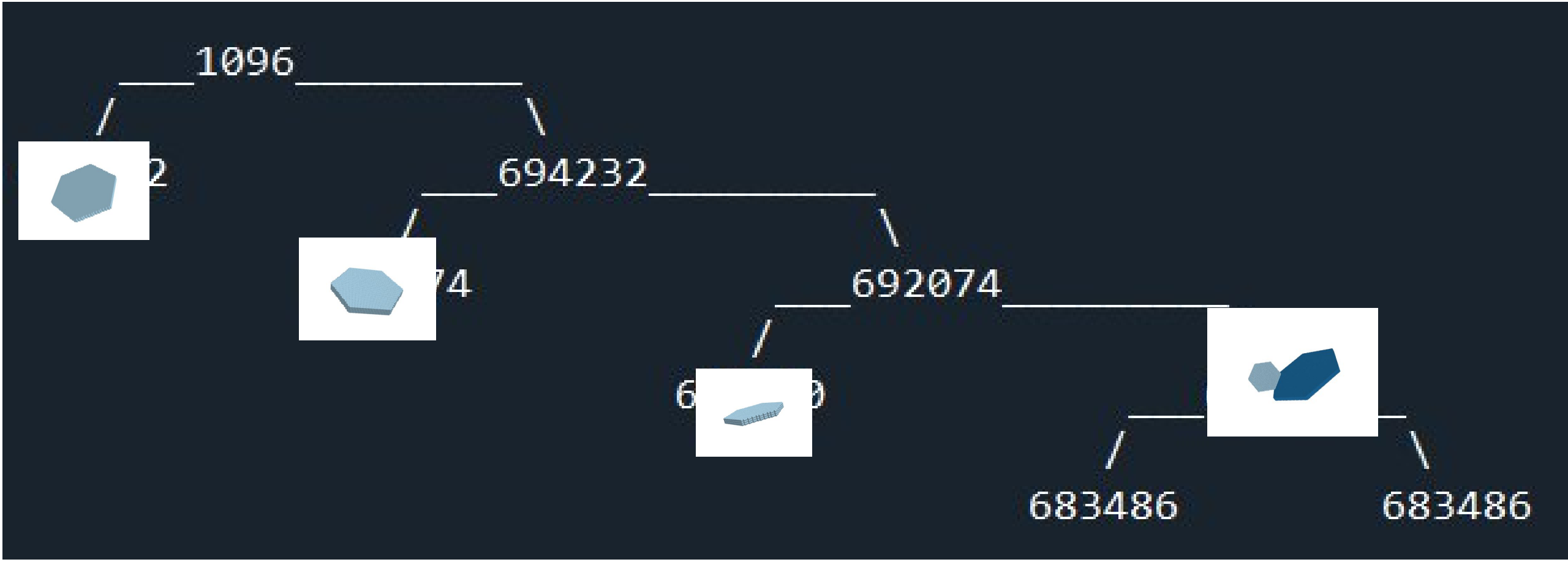

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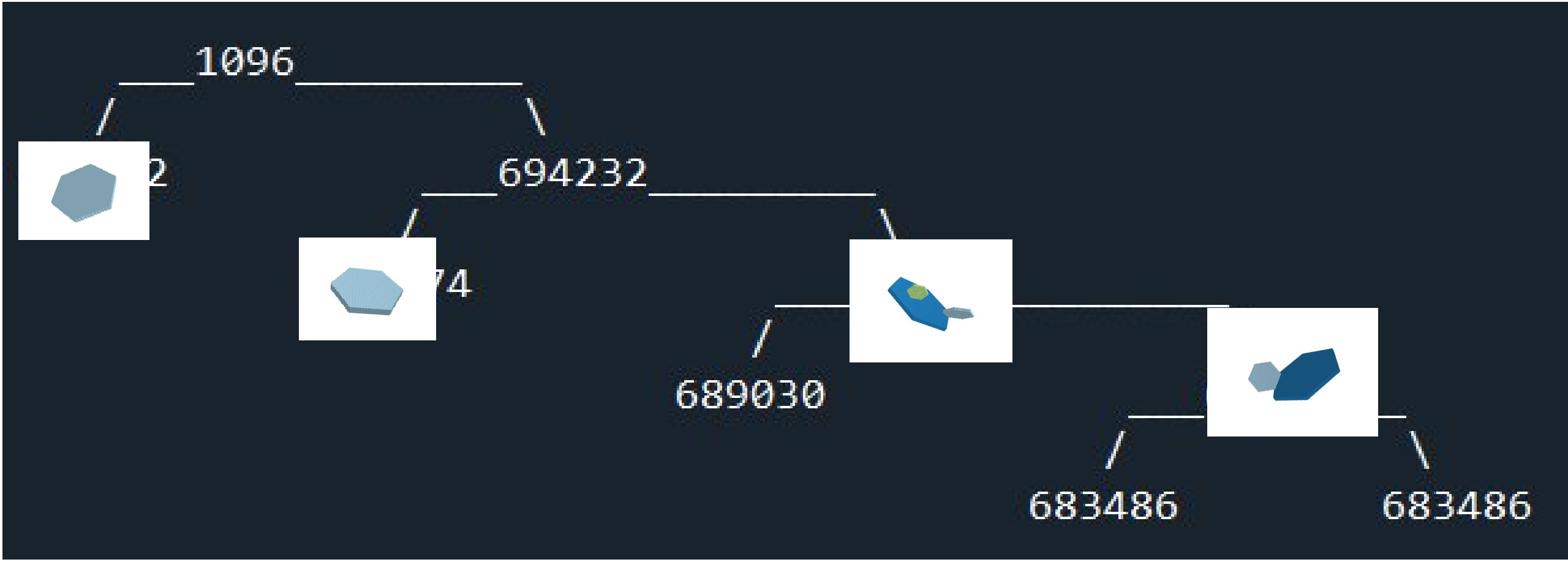

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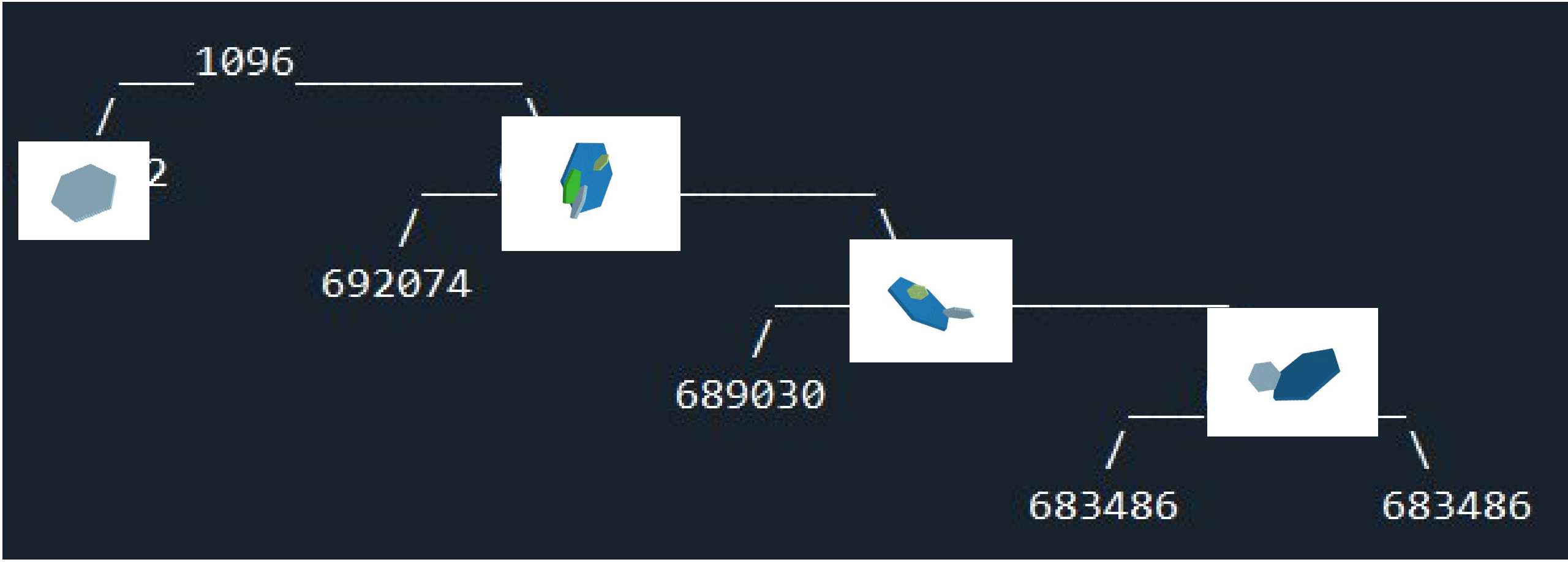

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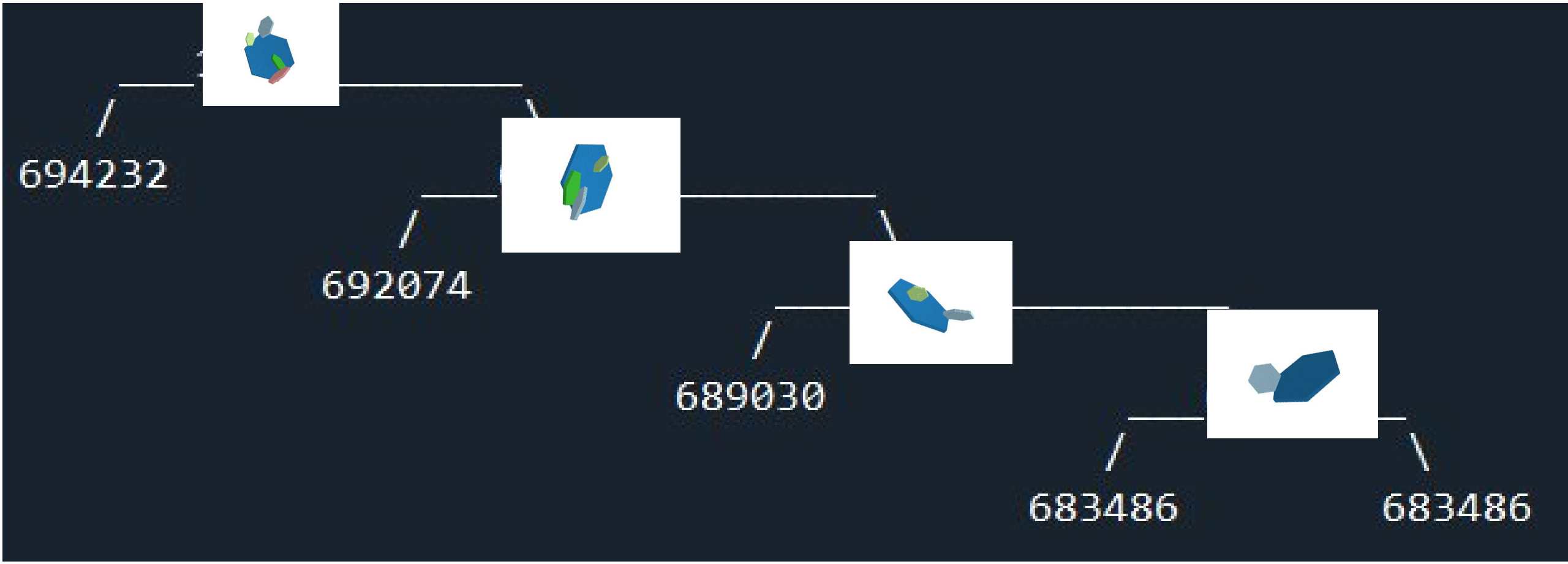

- Shape of the aggregates are further provided to DDA (Discrete Dipole Approximation) for the scattering calculation
- The scattering properties generated from realistic shapes are further used to simulate radar properties from EMVORADO and compared with T-matrix simulation.