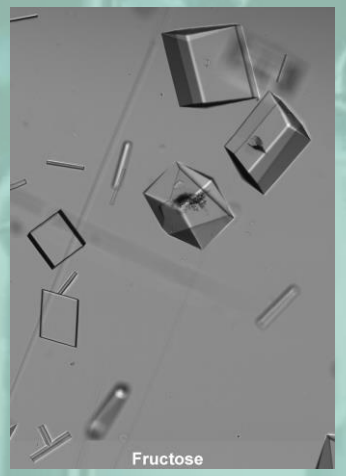
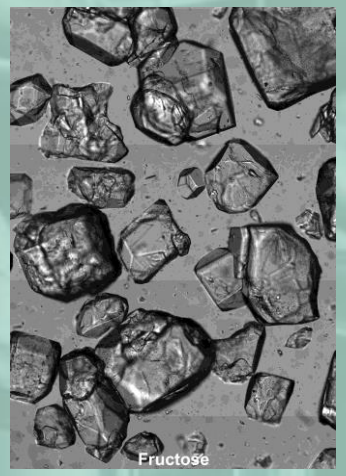
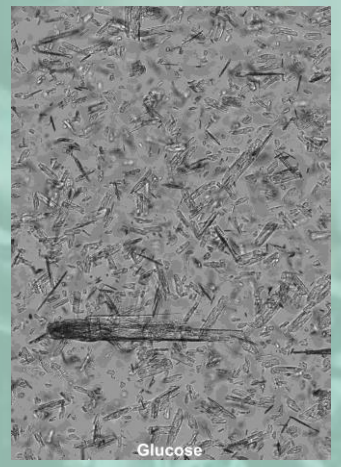




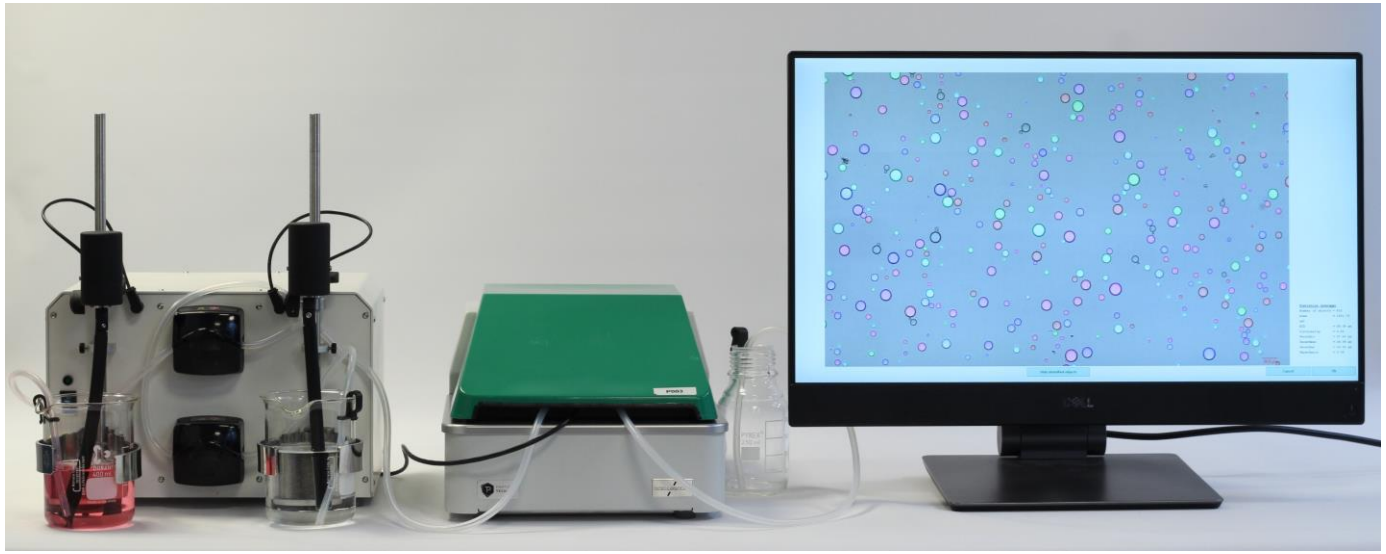


ParticleTech Sugar Analyzer

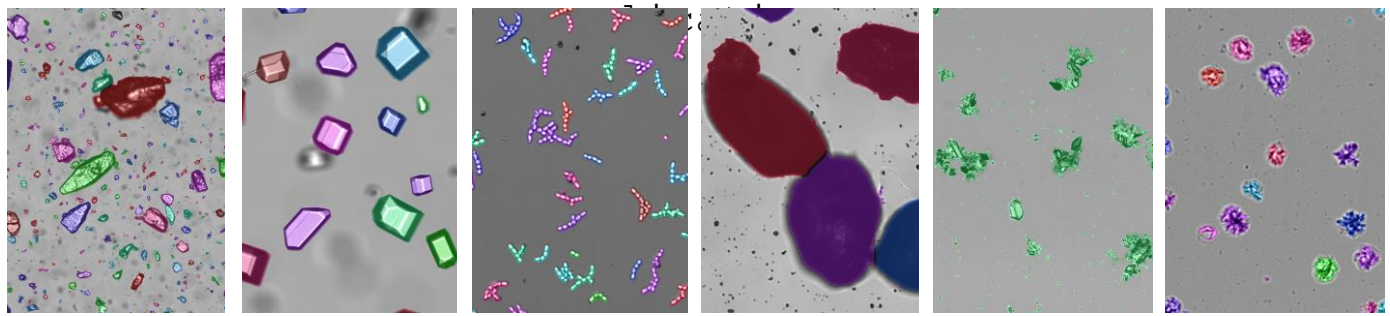
June 2023

PARTICLE TECH

ParticleTech Solution – many applications



Multi-use analysis equipment, suited for various



Crystallization | Sugars | Fermentation | Dry powder | Flocculation | Fats & oils

Key highlights

High quality particle analysis
Image analysis using advanced scanning technology and algorithms based on statistically significant sample sizes.

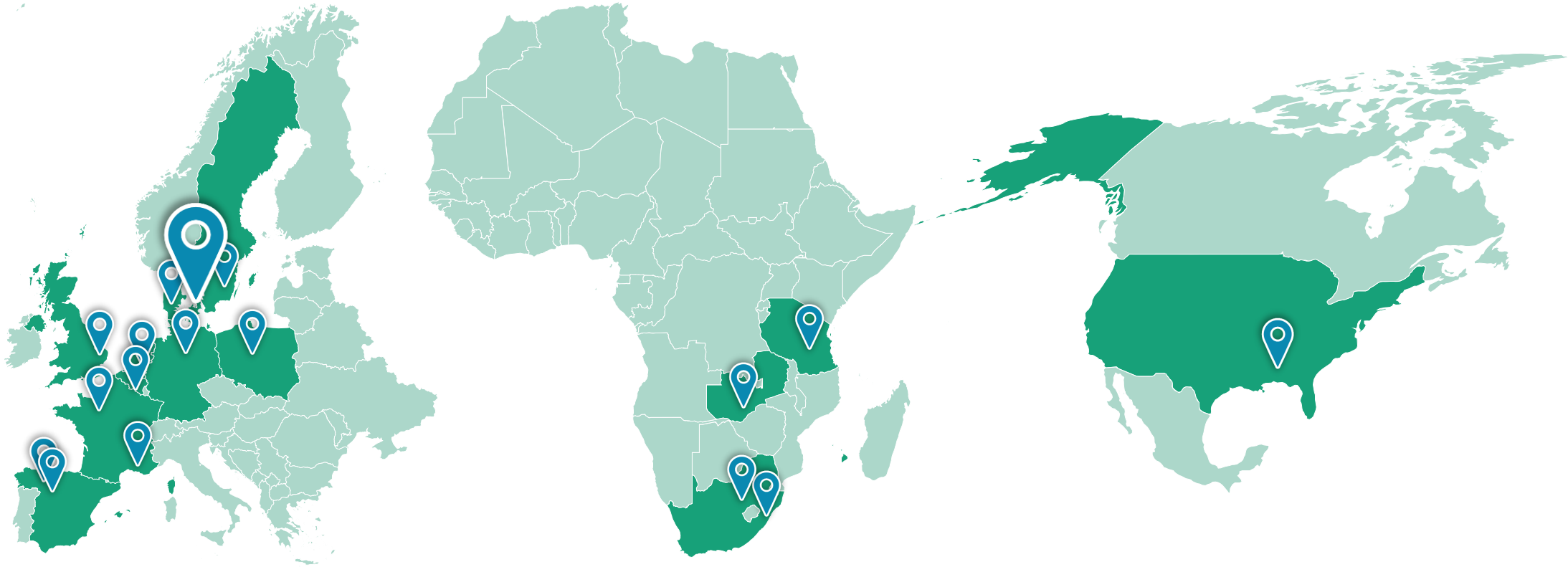
Fast analysis
The solution provides measurements of critical particle properties in less than 60 seconds, including particle shape & size.

Industry 4.0-ready
The solution can be seamlessly integrated into central data-storage- & automation-systems via the standardized OPC-UA protocol.

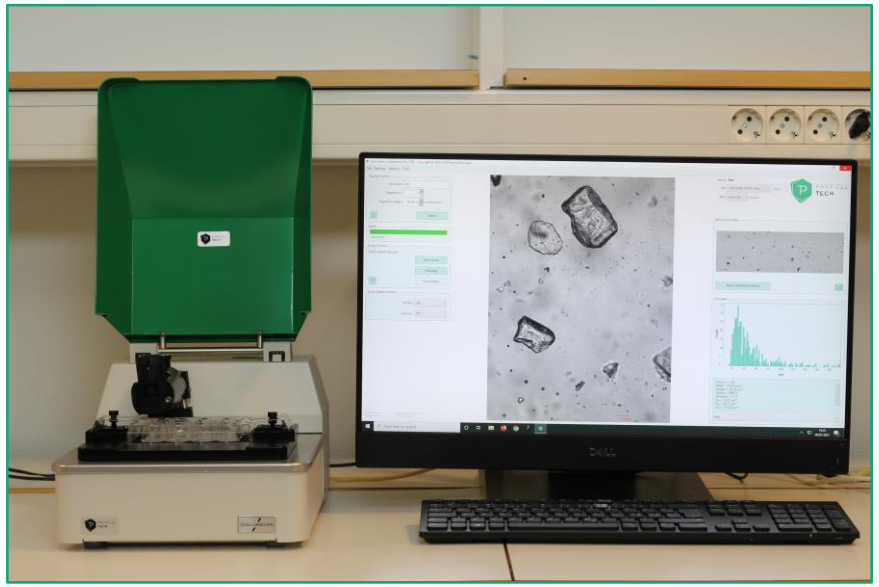
Portable & lightweight
The solution is lightweight and can easily be transported in-between labs and productions in a designated flight-case.

Customers

Customers in food, biotech, pharma, cosmetics, construction, oil & gas and many more

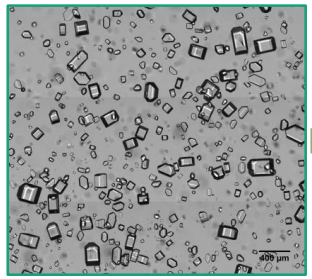


ParticleTech Sugar Analyser

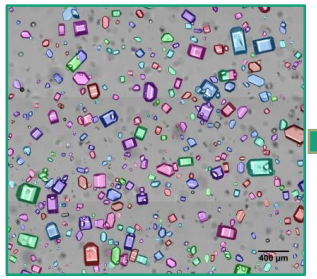


Portable Solution

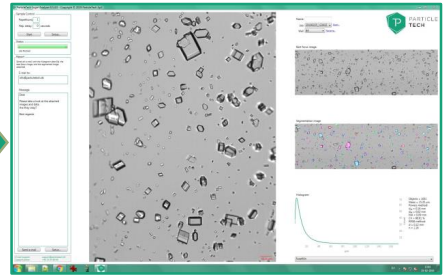
- **Optimization and control**
- **From seed to massecuite C**
- **Crystal size and shape**
- **60 times faster than sieve analysis**
- **ICUMSA Standard Methods**
- **User-friendly software**



Best Focus Image

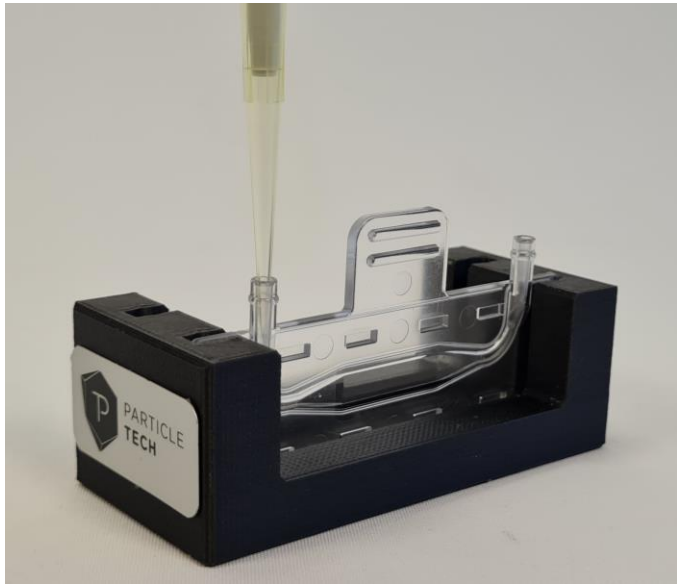


Segmented Image



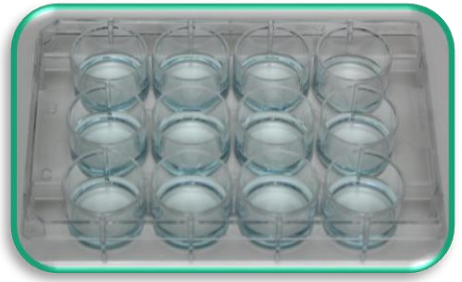
Output shown in PC

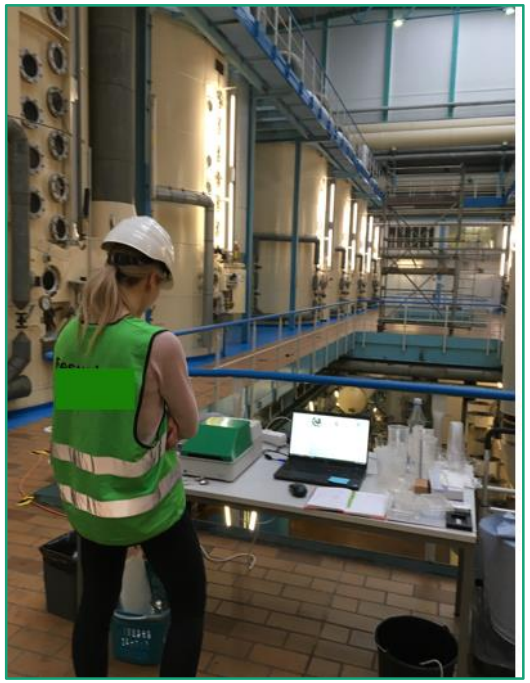
Other sampling methods than Flow System

Dry & wet samples in titer-plate	Wet samples in flow-cell	Dry samples at microscope slide
		
Particle samples are manually transferred to titer-plate and subsequently analyzed in the imaging unit	*Particle samples are manually transferred with pipette to flow-cell and subsequently analyzed in the imaging unit using the flow-cell adapter*	*Particle samples are manually transferred to microscope slide and subsequently analyzed in the imaging unit*

How does it work in Sugar Crystallization

- A sample is taken from the vacuum pan.
- A dilution media is ready and the sample is mixed with dilution.
- With a spoon a small amount is added to a well in a 12 wells titer plate and placed in the ParticleTech oCelloScope.
- The software is started and within 1-2 minutes an analysis is provided including particle size distribution, shape and ICUMSA results (Powers, RRSB, Rens, Butler).

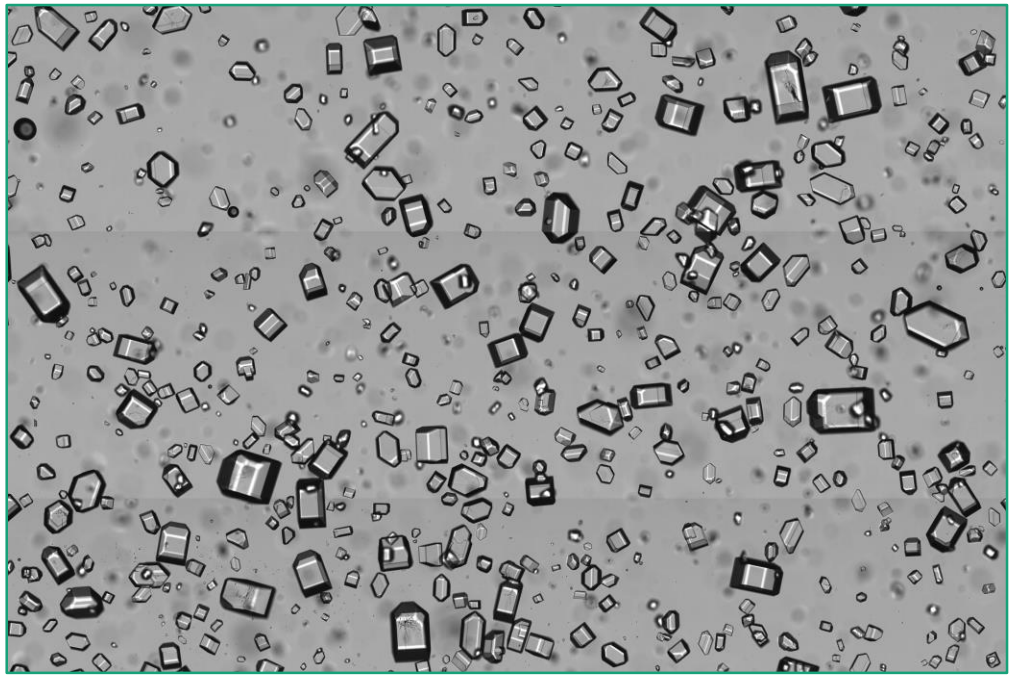




ParticleTech Sugar Analyser can be placed right at the vacuum pans, or in the production laboratories.

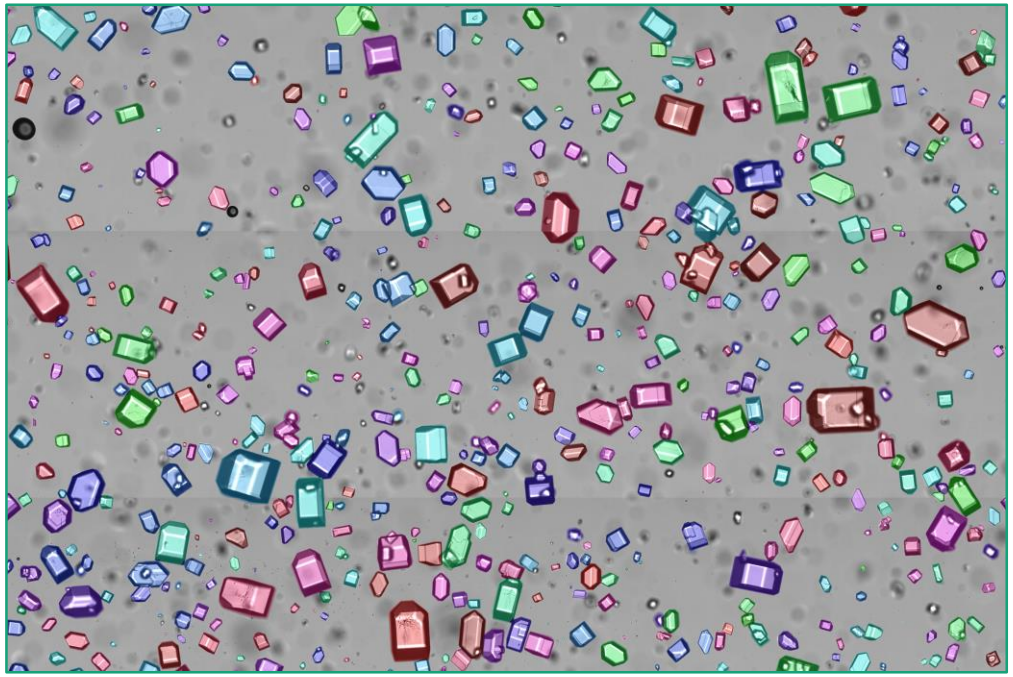
How does it work in Sugar Crystallization?

Best Focus Image



The ParticleTech oCelloScope scans the sample in the titer plate well and an image is provided – *best focus.*

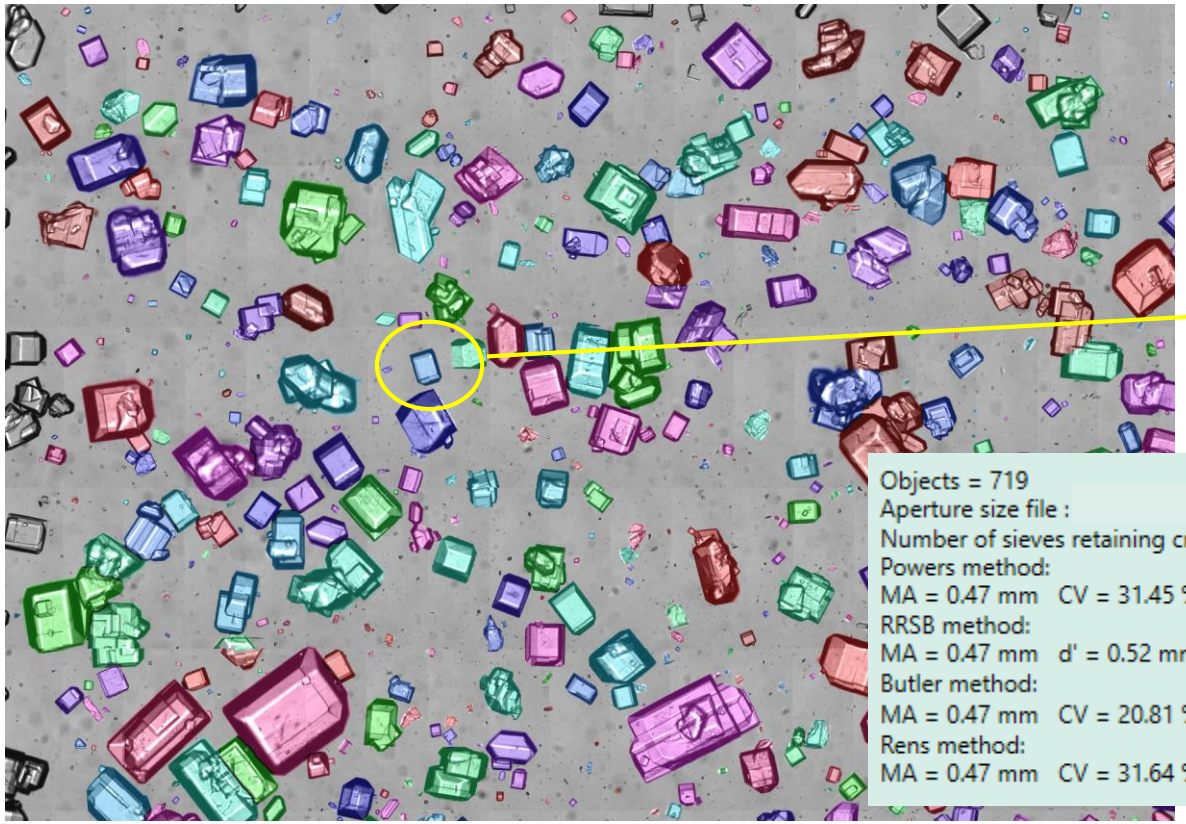
Segmented Image



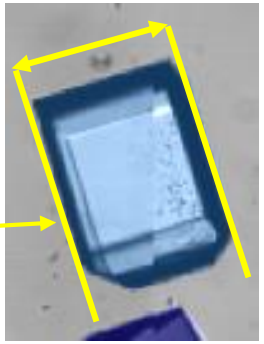
ParticleTech Algorithm is applied and the identified crystals are coloured. The colours can be used to classify crystals – *see slide 13*.

How does it work in Sugar Crystallization?

Based on the segmentation every crystal in the image is measured and the data facilitates analyses of size, size distribution, shape and ICUMSA results.

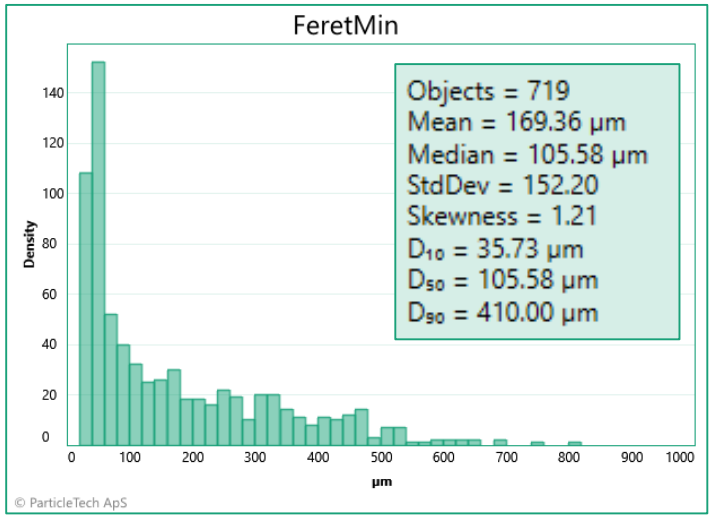


FeretMin

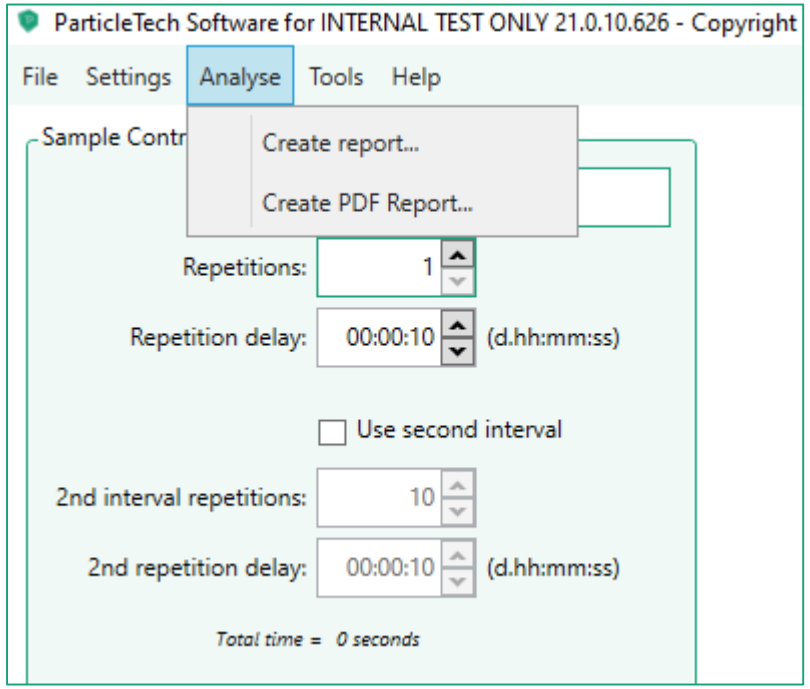


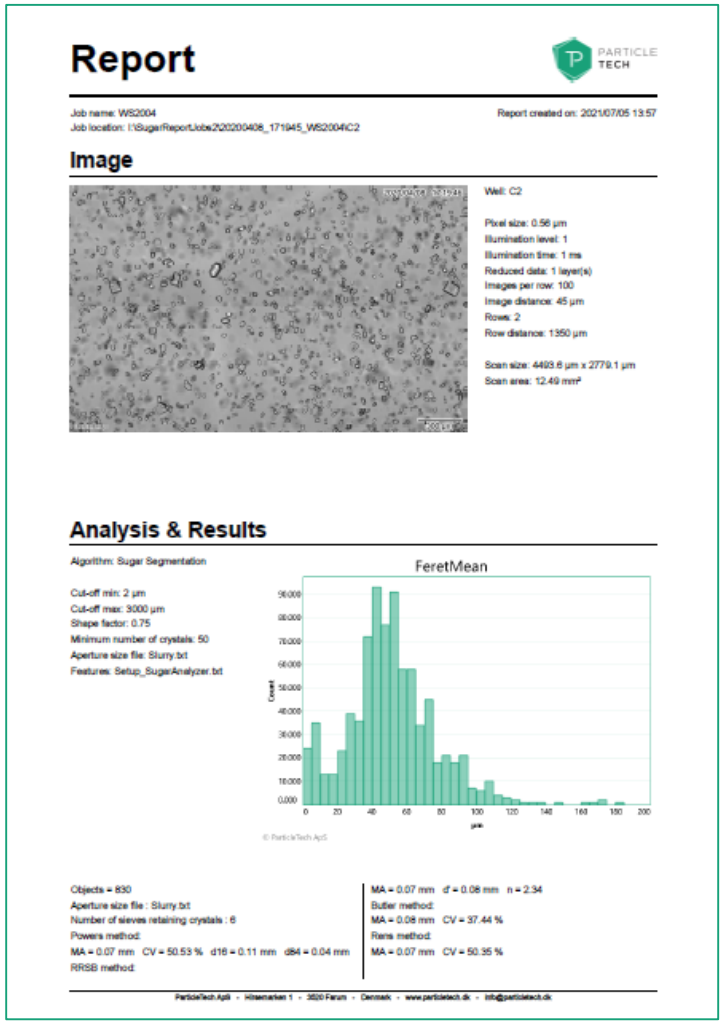
Objects = 719
Aperture size file : :
Number of sieves retaining crystals : 5
Powers method:
MA = 0.47 mm CV = 31.45 % d_{16} = 0.61 mm d_{84} = 0.32 mm
RRSB method:
MA = 0.47 mm d' = 0.52 mm n = 3.65
Butler method:
MA = 0.47 mm CV = 20.81 %
Rens method:
MA = 0.47 mm CV = 31.64 %

ICUMSA results



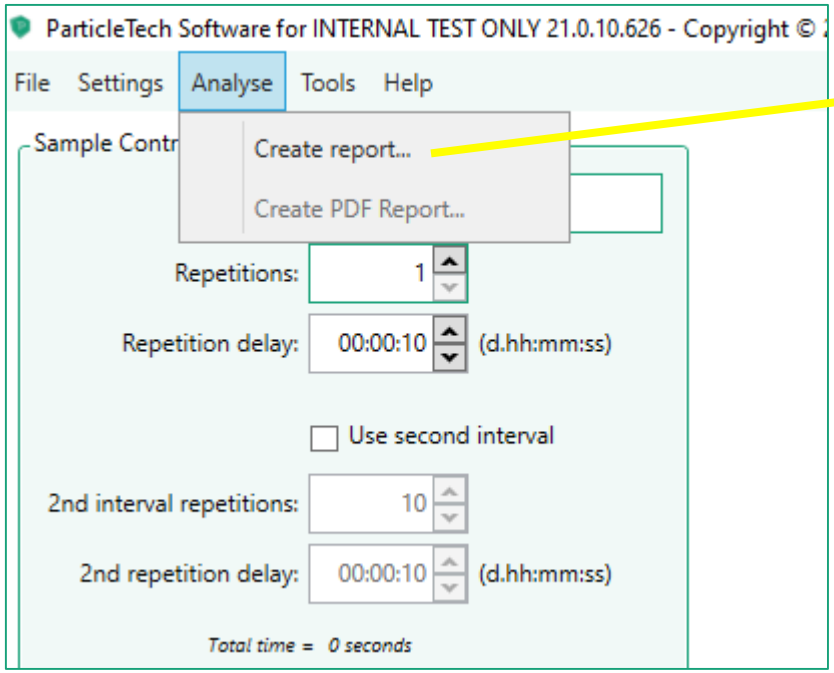
How does it work?
Report and document per job. One-pager PDF.

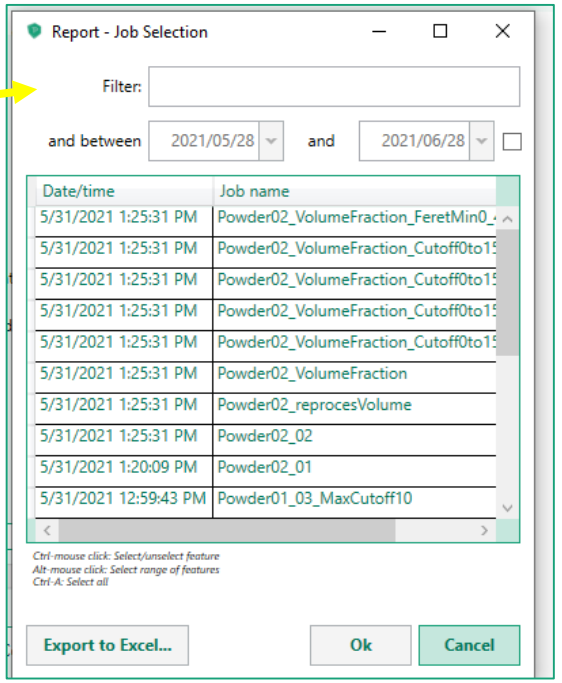




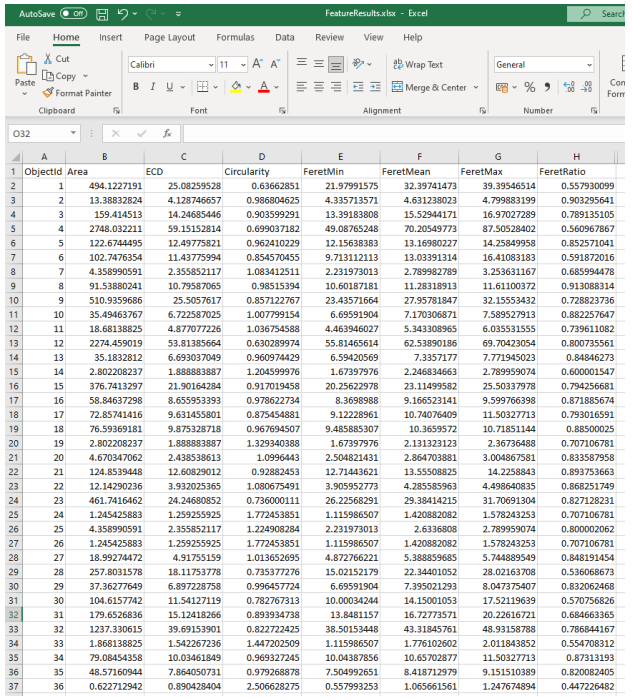
After running a job you choose Create PDF Report and you immediately get the overview and documentation of the specific job.

How does it work?
Reporting Tool: analyse more jobs





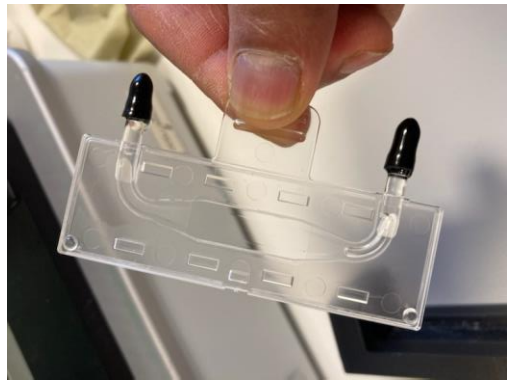
You can filter on batches and specific features like area and mean diameter.

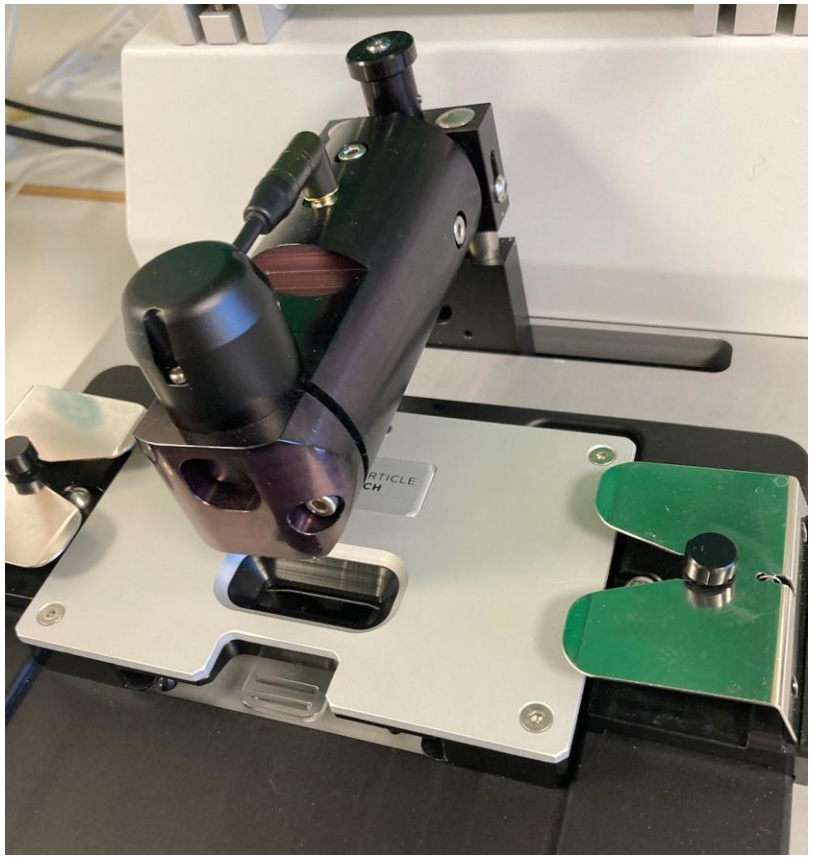


ObjectId	Area	ECD	Circularity	FeretMin	FeretMean	FeretMax	FeretRatio
1	494.1227191	25.08259528	0.63662851	21.97991575	32.39741473	39.39546514	0.557930099
2	13.38832824	4.128746657	0.986804625	4.335713571	4.631238023	4.799883199	0.903295641
3	159.414513	14.24685446	0.903599291	13.39183808	15.52944171	16.97027289	0.789135105
4	2748.032211	59.15152814	0.699037182	49.08765248	70.20549773	87.50528402	0.560967867
5	122.6744495	12.49775821	0.962410229	12.15638383	13.16980227	14.25849958	0.852571041
6	102.7476354	11.43775994	0.854570455	9.713112113	13.03391314	16.41083183	0.591872016
7	4.358990591	2.355852117	1.083412511	2.231973013	2.789982789	3.253631167	0.685994478
8	91.53880241	10.79587065	0.98515394	10.60187181	11.28318913	11.61100372	0.913088314
9	510.9359686	25.5057617	0.857122767	23.43571664	27.95781847	32.15553432	0.728823736
10	35.49463767	6.722587025	1.007799154	6.69591904	7.170306871	7.589527913	0.882257647
11	18.68138825	4.877077226	1.036754588	4.463946027	5.343308965	6.035531555	0.739611082
12	2274.459019	53.81385664	0.630289974	55.81465614	62.53890186	69.70423054	0.800735561
13	35.1832812	6.693037049	0.960974429	6.59420569	7.3357177	7.771945023	0.84846273
14	2.802208237	1.888883887	1.204599976	1.67397976	2.246834663	2.789959074	0.600001547
15	376.7413297	21.90164284	0.917019458	20.25622978	23.11499582	25.50337978	0.794256681
16	58.84637298	8.655953393	0.978622734	8.3698988	9.166523141	9.599766398	0.871885674
17	72.85741416	9.631455801	0.875454881	9.12228961	10.74076409	11.50327713	0.793016591
18	76.59369181	9.875328718	0.967694507	9.485885307	10.3659572	10.71851144	0.88500025
19	2.802208237	1.888883887	1.329340388	1.67397976	2.131323123	2.36736488	0.707106781
20	4.670347062	2.438538613	1.0996443	2.504821431	2.864703881	3.004867581	0.833587958
21	124.8539448	12.60829012	0.92882453	12.71443621	13.55508825	14.2258843	0.893753663
22	12.14290236	3.932025365	1.080675491	3.905952773	4.285585963	4.498640835	0.868251749
23	461.7416462	24.24680852	0.736000111	26.22568291	29.38414215	31.70691304	0.827128231
24	1.245425883	1.259255925	1.772453851	1.115986507	1.420882082	1.578243253	0.707106781
25	4.358990591	2.355852117	1.224908284	2.231973013	2.6336808	2.789959074	0.800002062
26	1.245425883	1.259255925	1.772453851	1.115986507	1.420882082	1.578243253	0.707106781
27	18.99274472	4.91755159	1.013652695	4.872766221	5.388859685	5.744889549	0.848191454
28	257.8031578	18.11753778	0.735377276	15.02152179	22.34401052	28.02163708	0.536068673
29	37.36277649	6.897228758	0.996457724	6.69591904	7.395021293	8.047375407	0.832062468
30	104.6157742	11.54127119	0.782767313	10.00034244	14.15001053	17.52119639	0.570756826
31	179.6526836	15.12418266	0.893934738	13.8481157	16.72773571	20.22616721	0.684663365
32	1237.330615	39.69153901	0.822722425	38.50153448	43.31845761	48.93158788	0.786844167
33	1.868138825	1.542267236	1.447202509	1.115986507	1.776102602	2.011843852	0.554708312
34	79.08454358	10.03461849	0.969327245	10.04387856	10.65702877	11.50327713	0.87313193
35	48.57160944	7.864050731	0.979268878	7.504992651	8.418712979	9.151510389	0.820082405
36	0.622712942	0.890428404	2.506628275	0.557993253	1.065661561	1.247674894	0.447226482

You can measure a batch over time and follow the crystallization by filtering the jobs by batch number. The report tool provides an overview of the specific batch crystallization.

Seed measurement using ParticleTech Flow Cell





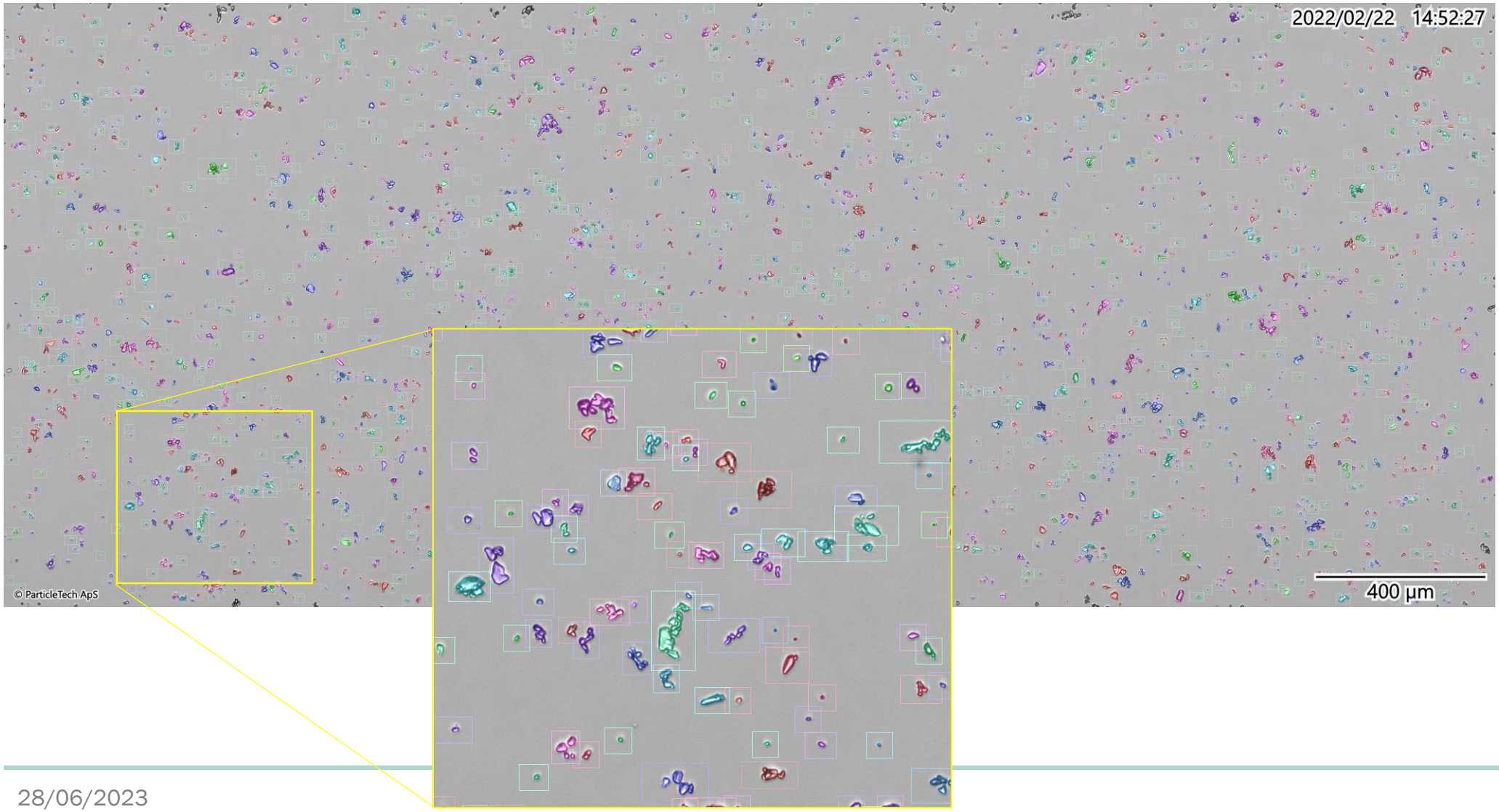
Sampling manually handled in a pipette

1. The flow cell is used with an easy pipette, *or*

2. With the automated pump system in the ParticleTech Sample Unit.

Sampling automatically pumped into flow cell

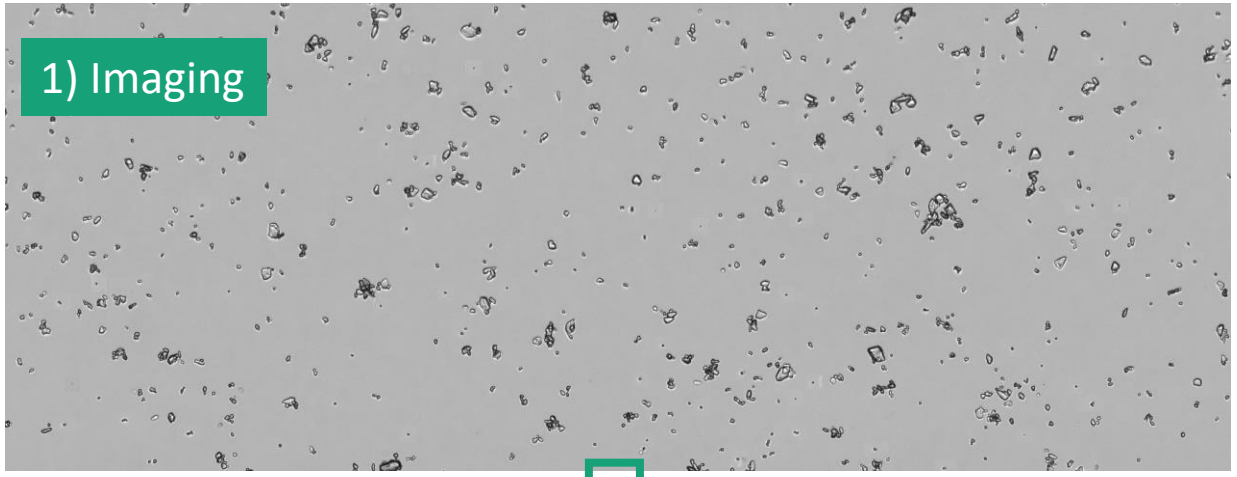
Slurry / Seed measured in a Flow Cell



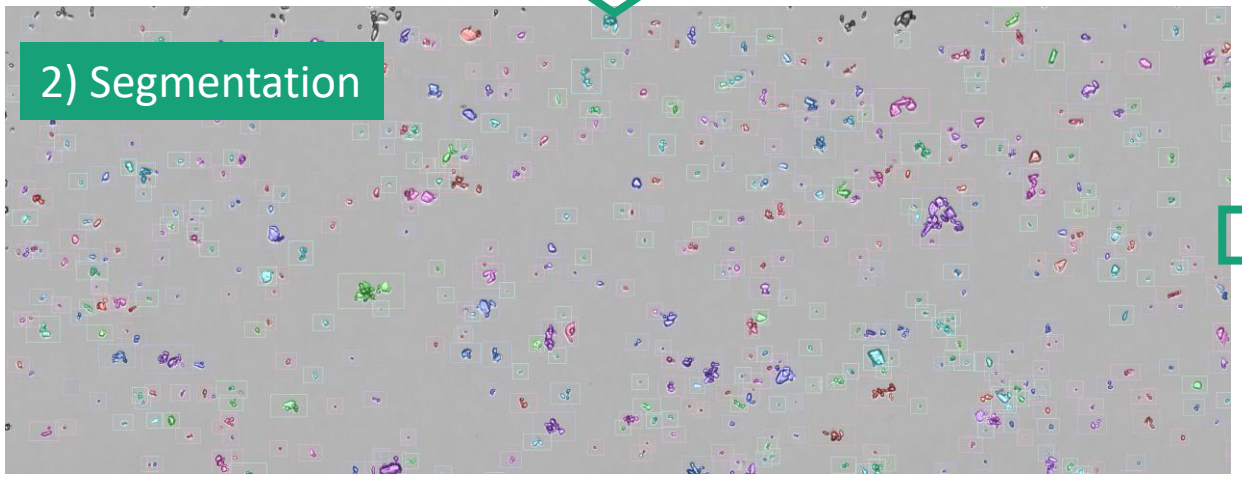
Slurry / Seed measured in a Flow Cell

PARTICLE TECH

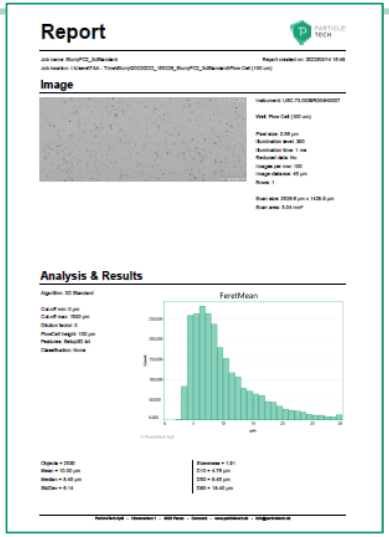
1) Imaging

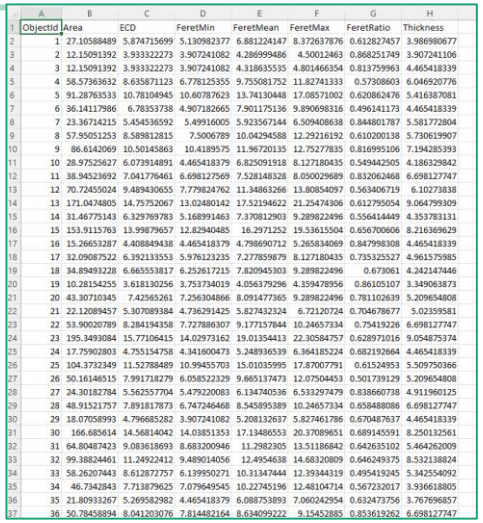


2) Segmentation

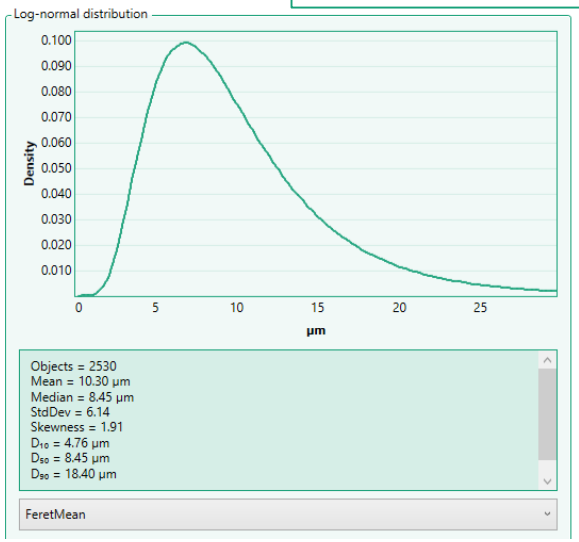


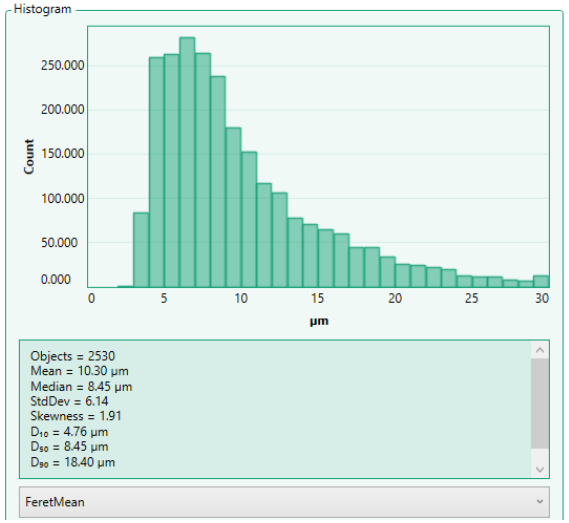
3) Fast output directly in software:





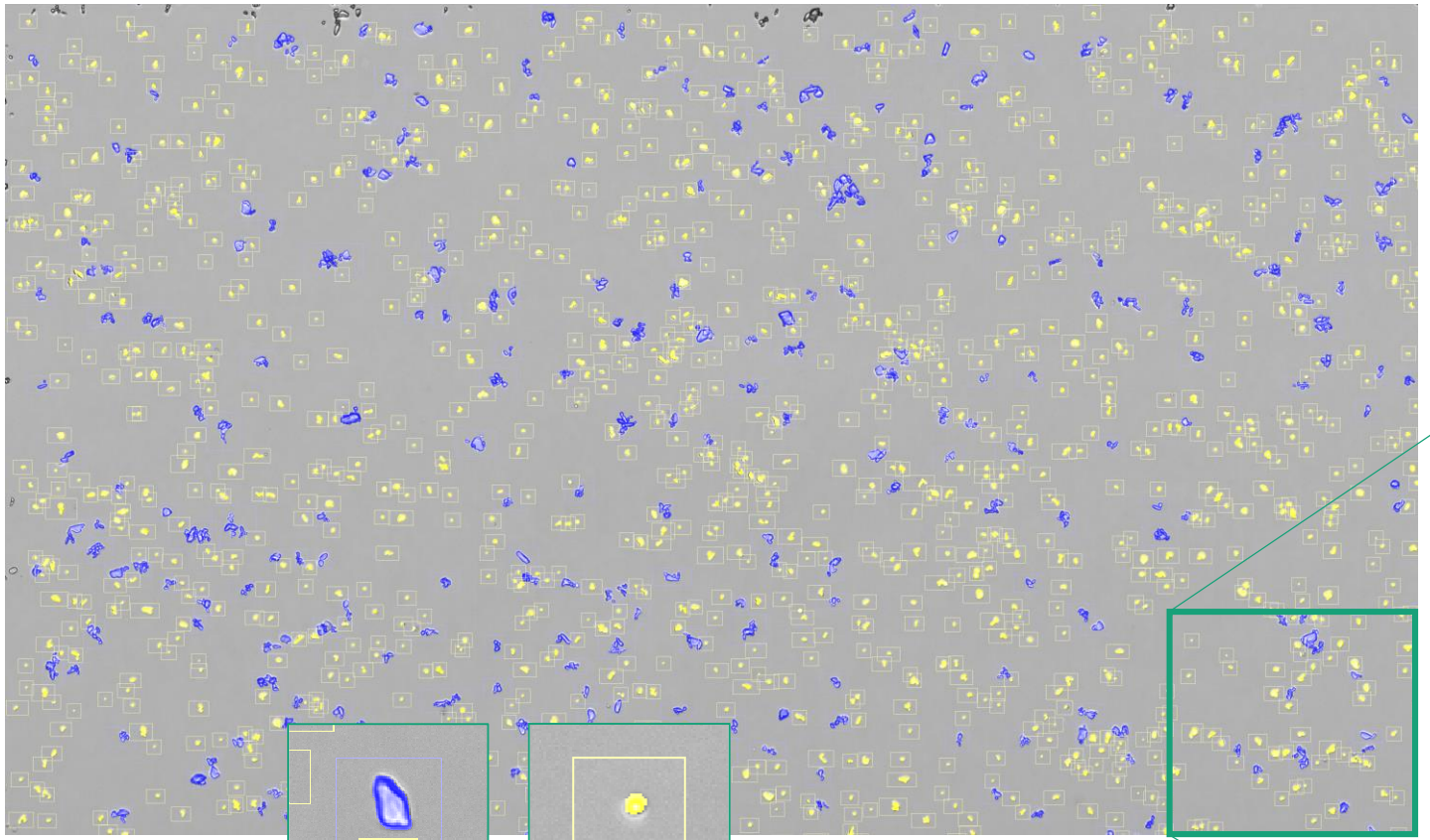
ObjectId	Area	ECD	FeretMin	FeretMean	FeretMax	FeretRatio	Thickness
1	27.10588489	5.874715699	5.130982377	6.881224147	8.372637876	0.612827457	3.986980677
2	12.15091392	3.933322273	3.907241082	4.286999486	4.50012463	0.868251749	3.907241106
3	12.15091392	3.933322273	3.907241082	4.318635535	4.801466354	0.813759963	4.465418339
4	58.57363632	8.635871123	6.778125355	9.755081752	11.82741333	0.57308603	6.046920776
5	91.28763533	10.78104945	10.60787623	13.74130448	17.08571002	0.620862476	5.416387081
6	36.14117986	6.78353738	4.907182665	7.901175136	9.890698316	0.496141173	4.465418339
7	23.36714215	5.454536592	5.49916005	5.923567144	6.509408638	0.844801787	5.581772804
8	57.95051253	8.589812815	7.5006789	10.04294588	12.29216192	0.610200138	5.730619907
9	86.6142069	10.50145863	10.4189575	11.96720135	12.75277835	0.816995106	7.194285393
10	28.97525627	6.073914891	4.465418379	6.825091918	8.127180435	0.549442505	4.186329842
11	38.94523692	7.041776461	6.698127569	7.528148328	8.050029689	0.832062468	6.698127747
12	70.72455024	9.489430655	7.779824762	11.34863266	13.80854097	0.563406719	6.10273838
13	171.0474805	14.75752067	13.02480142	17.52194622	21.25474306	0.612795054	9.064799309
14	31.46775143	6.329769783	5.168991463	7.370812903	9.289822496	0.556414449	4.353783131
15	153.9115763	13.99879657	12.82940485	16.2971252	19.53615504	0.656700606	8.216369629
16	15.26653287	4.408849438	4.465418379	4.798690712	5.265834069	0.847998308	4.465418339
17	32.09087522	6.392133553	5.976123235	7.277859879	8.127180435	0.735325527	4.961575985
18	34.89493228	6.665553817	6.252617215	7.820945303	9.289822496	0.673061	4.242147446
19	10.28154255	3.618130256	3.753734019	4.056379296	4.359478956	0.86105107	3.349063873
20	43.30710345	7.42565261	7.256304866	8.091477365	9.289822496	0.781102639	5.209654808
21	22.12089457	5.307089384	4.736291425	5.827432324	6.72120724	0.704678677	5.02359581
22	53.90020789	8.284194358	7.727886307	9.177157844	10.24657334	0.75419226	6.698127747
23	195.3493084	15.77106415	14.02973162	19.01354413	22.30584757	0.628971016	9.054875374
24	17.75902803	4.755154758	4.341600473	5.248936539	6.364185224	0.682192664	4.465418339
25	104.3732349	11.52788489	10.99455703	15.01035995	17.87007791	0.61524953	5.509750366
26	50.16146515	7.991718279	6.058522329	9.665137473	12.07504453	0.501739129	5.209654808
27	24.30182784	5.562557704	5.479220083	6.134740536	6.533297479	0.838660738	4.911960125
28	48.91521757	7.891817873	6.747246468	8.545895389	10.24657334	0.658488086	6.698127747
29	18.07058993	4.796685282	3.907241082	5.208132637	5.827461786	0.670487637	4.465418339
30	166.685614	14.56814042	14.03851353	17.13486553	20.37089651	0.689145591	8.250132561
31	64.80487423	9.083618693	8.683200946	11.2982305	13.51186842	0.642635102	5.464262009
32	99.38824461	11.24922412	9.489014056	12.4954638	14.68320809	0.646249375	8.532138824
33	58.26207443	8.612872757	6.139950271	10.31347444	12.39344319	0.495419245	5.342554092
34	46.7342843	7.713879625	7.079649545	10.22745196	12.48104714	0.567232017	3.936618805
35	21.80933267	5.269582982	4.465418379	6.088753893	7.060242954	0.632473756	3.767696857
36	50.78458894	8.041203076	7.814482164	8.634099222	9.15452885	0.853619262	6.698127747





Colors used in a smart way to classify Slurry / Seed by size

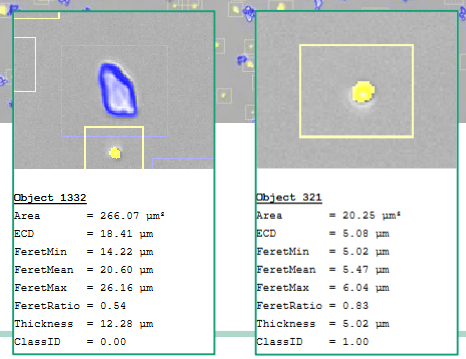
PARTICLE TECH



Objects = 2530
Mean = 10.30 µm
Median = 8.45 µm
StdDev = 6.14
Skewness = 1.91
D_{10} = 4.76 µm
D_{50} = 8.45 µm
D_{90} = 18.40 µm

FeretMean

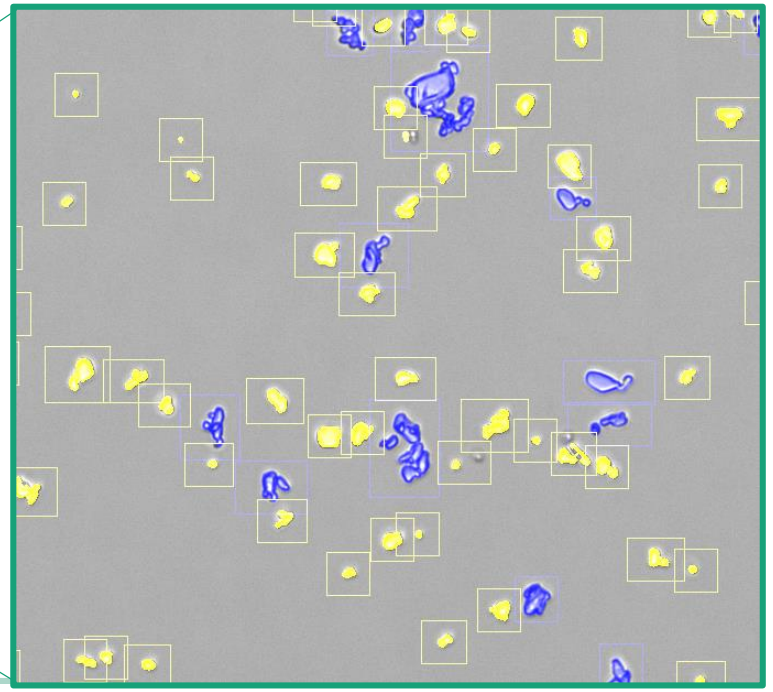
Large = 17.35 %
Small = 82.65 %



Object 1332
Area = 266.07 µm²
ECD = 18.41 µm
FeretMin = 14.22 µm
FeretMean = 20.60 µm
FeretMax = 26.16 µm
FeretRatio = 0.54
Thickness = 12.28 µm
ClassID = 0.00

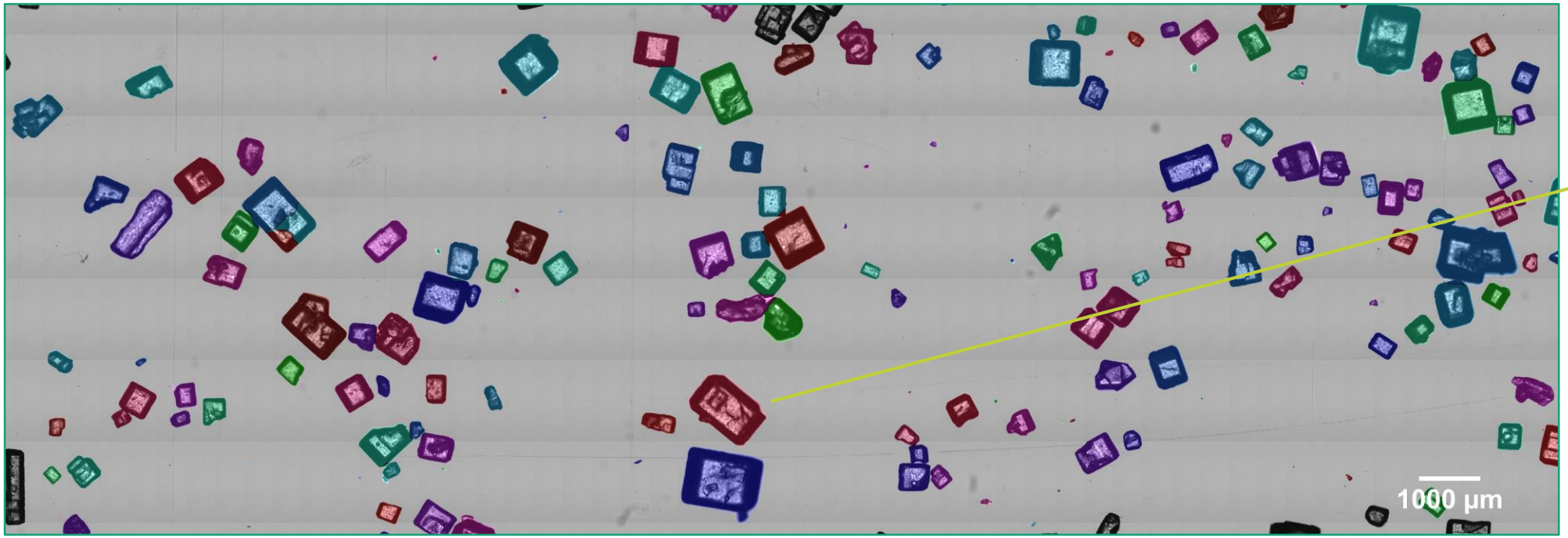
Object 321
Area = 20.25 µm²
ECD = 5.08 µm
FeretMin = 5.02 µm
FeretMean = 5.47 µm
FeretMax = 6.04 µm
FeretRatio = 0.83
Thickness = 5.02 µm
ClassID = 1.00

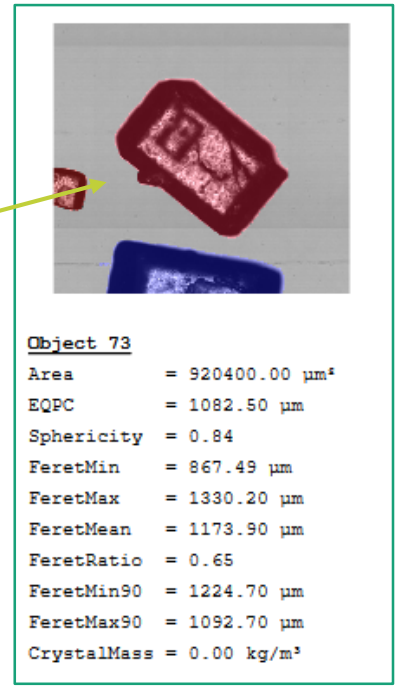
Blue >= 15µm
Yellow < 15µm



Dry sugar results

Using a holder for standard microscope dry sugar can be measured.

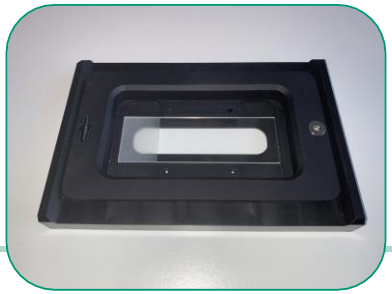




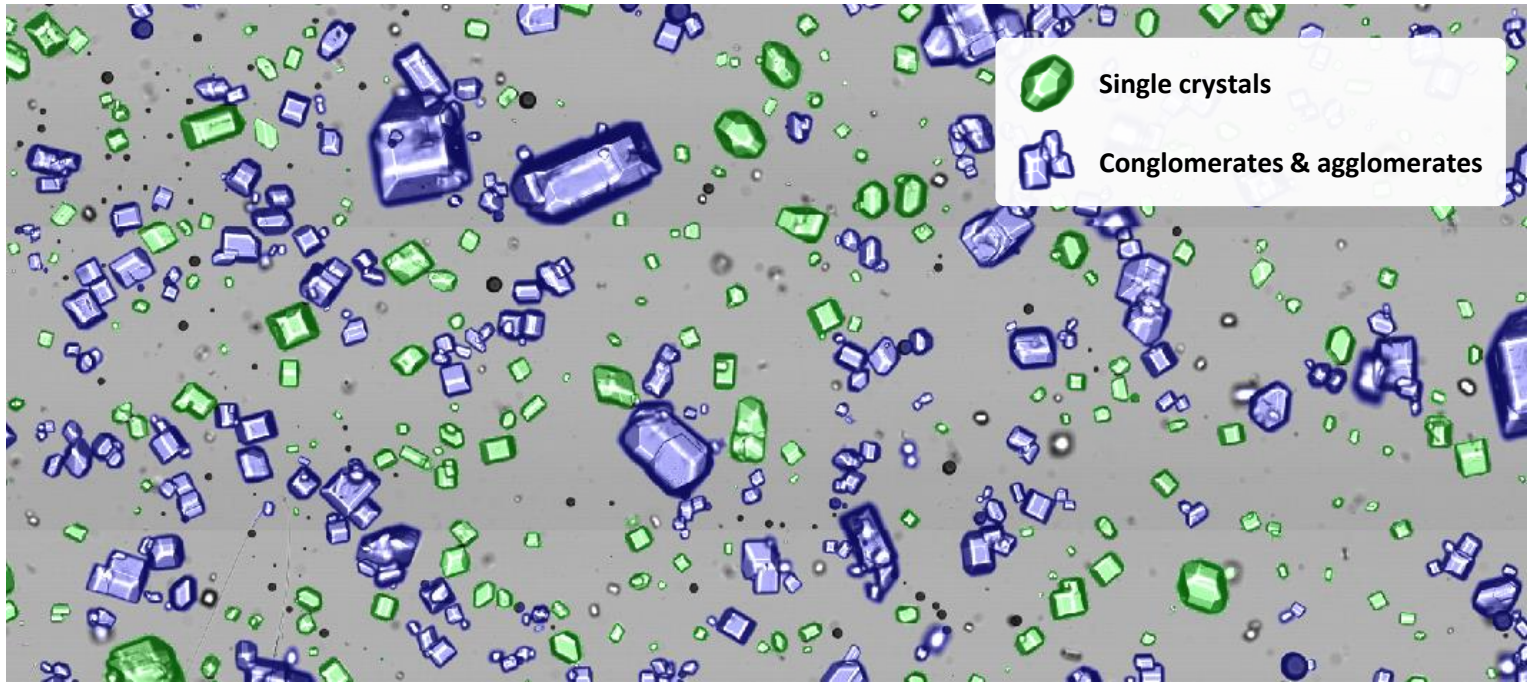
Object 73

Area	=	920400.00 µm²
EQPC	=	1082.50 µm
Sphericity	=	0.84
FeretMin	=	867.49 µm
FeretMax	=	1330.20 µm
FeretMean	=	1173.90 µm
FeretRatio	=	0.65
FeretMin90	=	1224.70 µm
FeretMax90	=	1092.70 µm
CrystalMass	=	0.00 kg/m³

Microscope slide adapter:



ParticleTech Sugar Analyzer



Sieve analog results

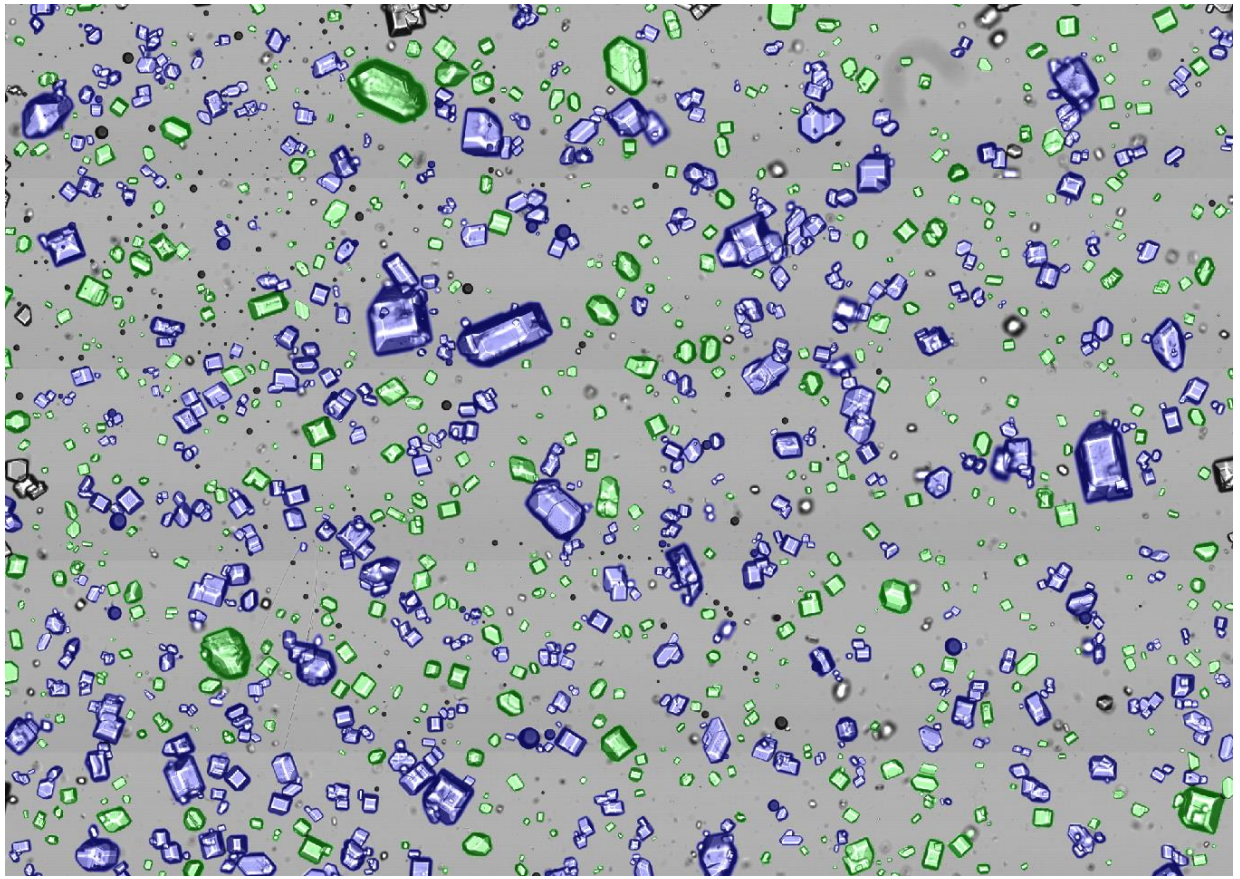
Measurement of crystal size distribution based on ICUMSA standard

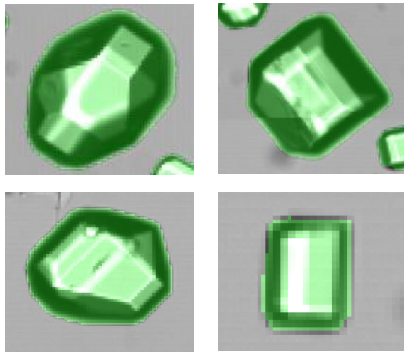
New feature: Crystal classification

Direct quantification of the crystal population quality by measuring the percentage of single crystals and conglomerates

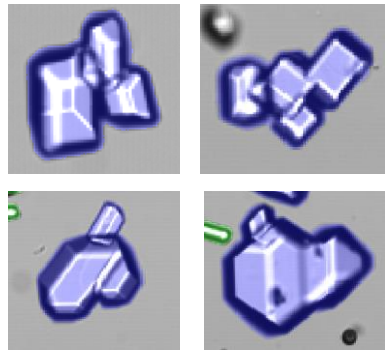
New feature: Sugar crystal classification

Objectively quantify the percentage of agglomerates & conglomerates in any sugar sample





Single crystals



Conglomerate

With the new classification algorithm, the sugar analyzer directly quantifies the crystal population quality by analyzing the shape and morphology of each crystal. Their properties are subsequently used for classifying them into individual crystals and conglomerates.

Benefits of the new classification feature

- Combat conglomerate-related problems
  - Get better control of crystal size
  - Resolve filtering problems
  - Increase product purity
- Classification method makes it possible to
  - Mass percentage of single crystals and conglomerates
  - Clarify if crystal size changes are due to crystal growth rate changes or conglomeration
  - Fast discovery of when and where the conglomerates are formed in the sugar refining process

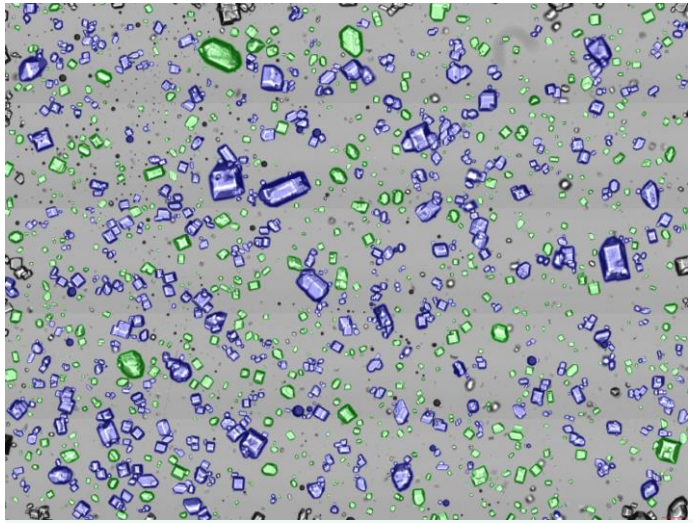
Discovering the origin of conglomerates

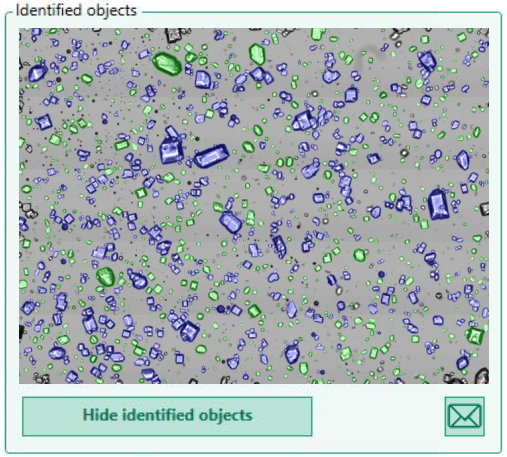
	Seed magma	Seed pan	Product pan 1	Product pan 2
MA	116 µm	361 µm	675 µm	602 µm
CV	50 %	45 %	46 %	57 %
	42 %	56 %	44 %	11 %
	58 %	44 %	56 %	89 %

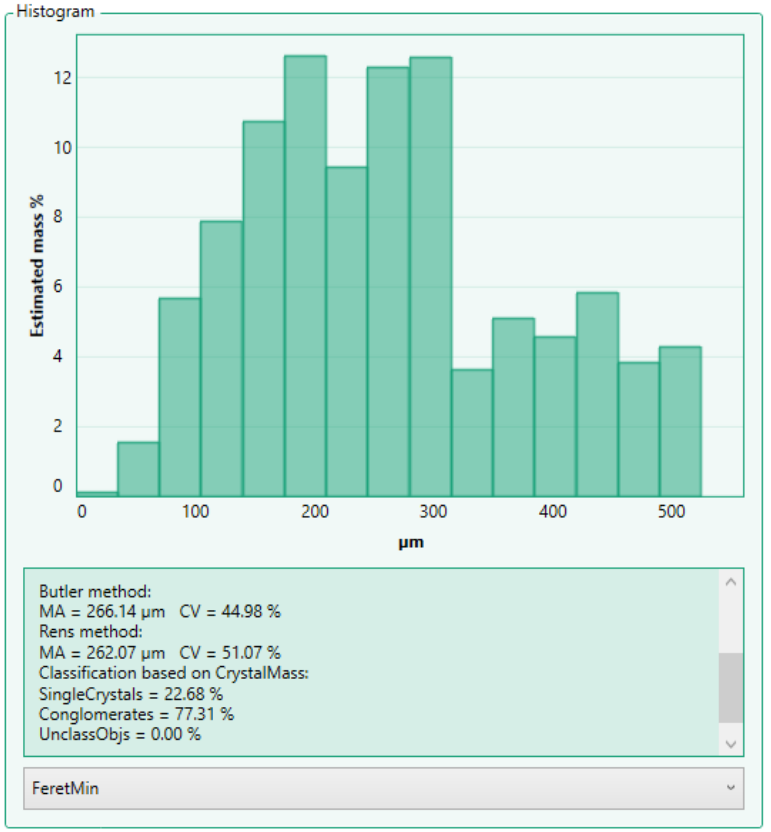
Based on the new classification analysis, it becomes clear that the conglomerates are produced in product pan 2.

Classification is automatically performed

Classifications are automatically presented in software alongside the ICUMSA based measurements







Butler method:
MA = 266.14 µm CV = 44.98 %
Rens method:
MA = 262.07 µm CV = 51.07 %
Classification based on CrystalMass:
SingleCrystals = 22.68 %
Conglomerates = 77.31 %
FeretMin

Collaboration with Nordzucker

New Fast Measuring Method for Process Optimization of Sucrose Crystallization

Introduction and Background

The optical scanning of suspensions and image analysis were tested on magmas and massecuites in all steps of sucrose crystallization at Nordzucker. Image analysis is a fast method for measuring crystal size distribution for the optimization of the mean-crystal size.

Comparison to Sieve Analysis

In comparison to sieve analysis, results from image analysis have been proven to be reliable:

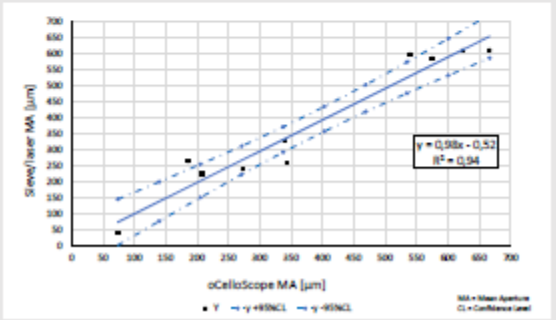
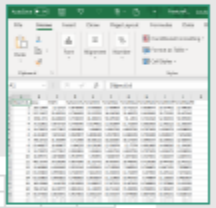
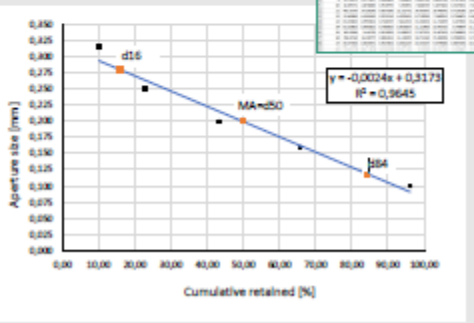


Image Analysis also provides:
Mean Aperture, MA, and Coefficient of Variation, CV%.
These are generated according to ICUMSA standard methods:

- **Powers**
- **Rens**
- **RRSB**
- **Butler**

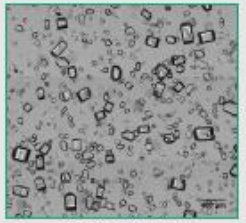


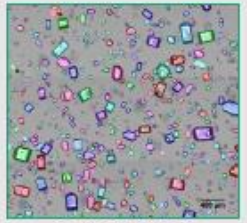
Powers Method:



The ParticleTech Sugar Analyser

This method is about **60 times faster** than the conventional washing, drying, and sieving method. It provides accurate data and results and includes a valuable visual tool as well.

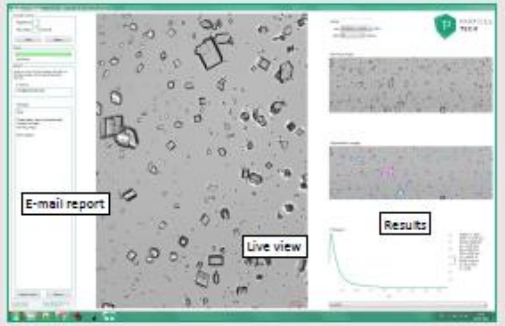

Best focus image


Segmented image

Data generation:

- Measured distributions of: Feret diameters (min, mean, etc.), area, circularity, EQPC, etc.
- The results provided are tailored according to needs.

The user friendly software generates results within **1-3 minutes** after a sample is prepared. The ParticleTech Sugar Analyser can be used on the production floor or in the lab.



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Meet us at ESST booth 43

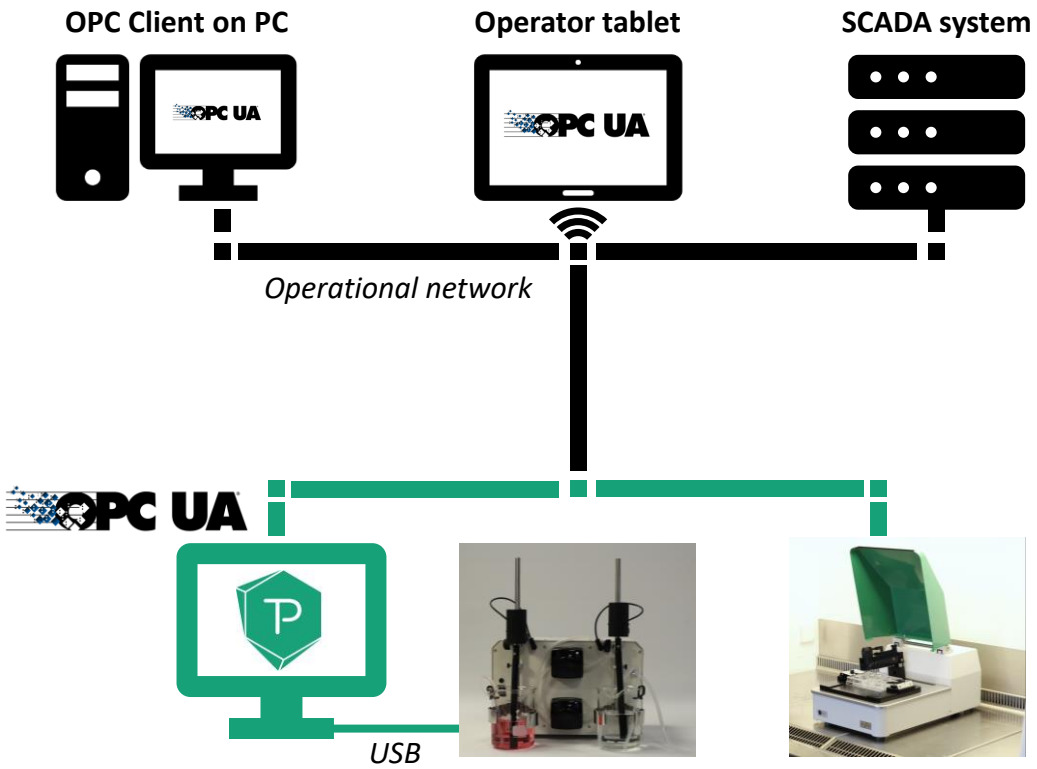
Nordzucker

PARTICLE TECH

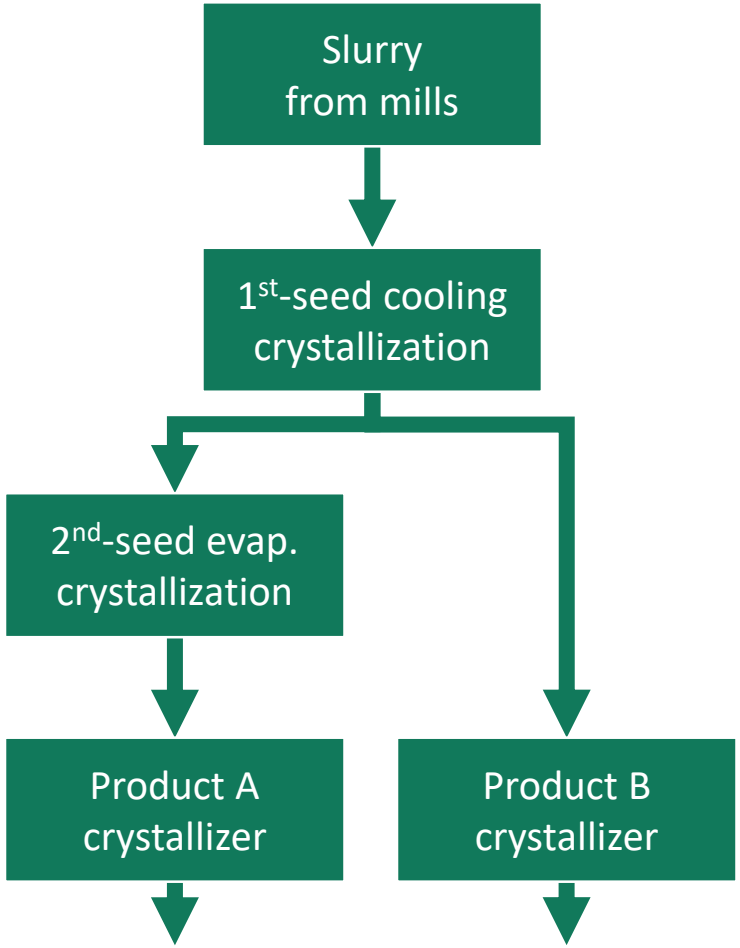
Prepared for Industry 4.0

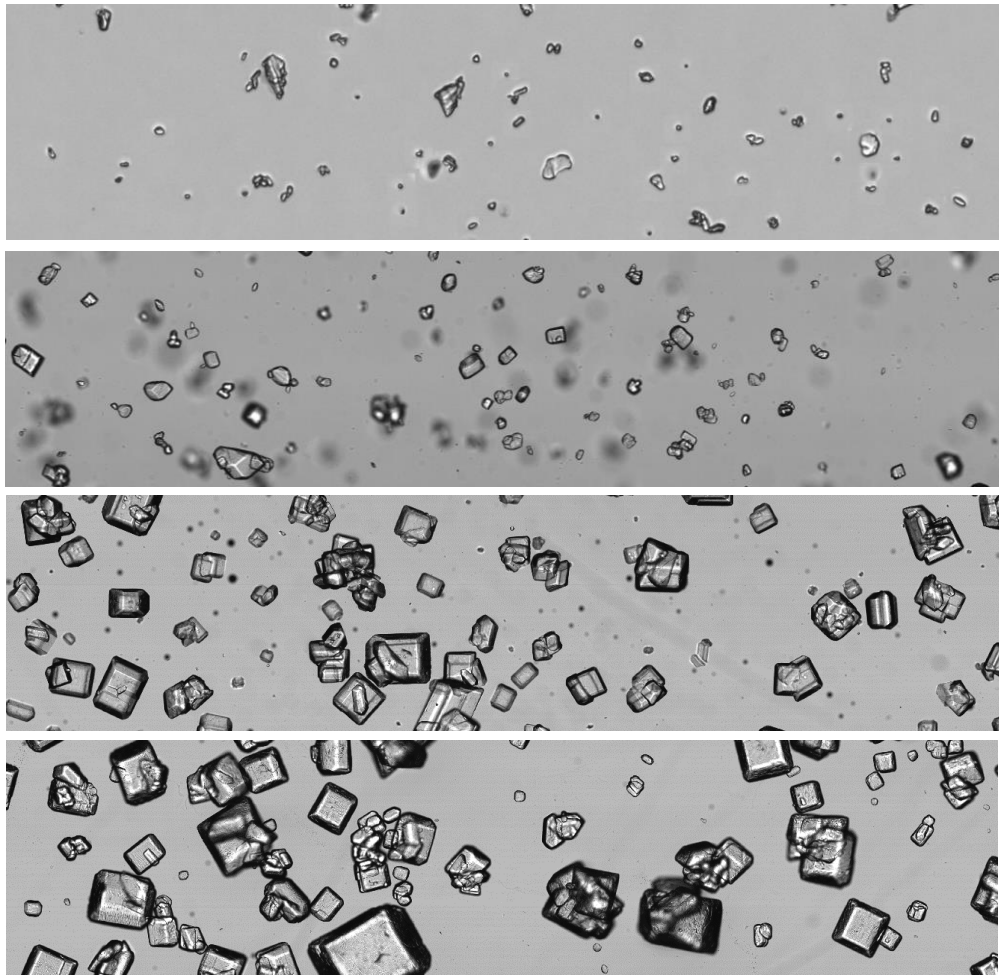
Particle Tech Solution can be seamlessly connected to central data-storage- & automation-systems

- Particle Tech Solution can be interfaced via OPC UA (Open Platform Communications Unified Architecture), a standardized interface for Industry 4.0 communication.
- The interface makes it possible to seamlessly transfer measurement data directly to existing Supervisory Control And Data Acquisition systems (SCADA) and/or Laboratory information management systems.



Sugar refining





Crystal size

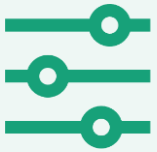
~10 µm

~100 µm

~400 µm

500-600 µm

Sugar refining



Key challenges

Reducing product variations

Ensuring high product purity

Reducing energy consumption

Potential solution

Continuous monitoring of crystal size & shape

BIOSOLUTIONS ZEALAND

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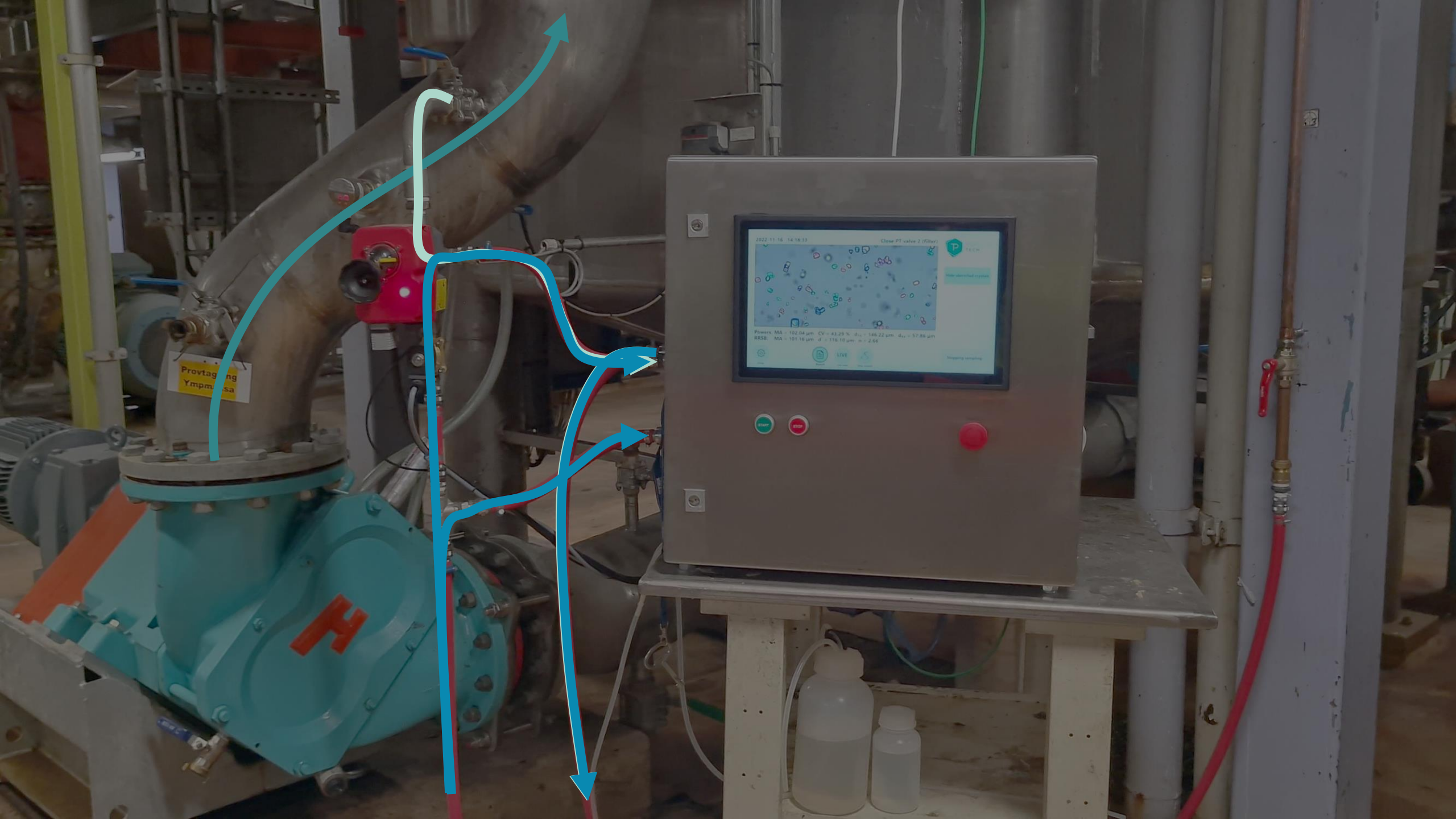
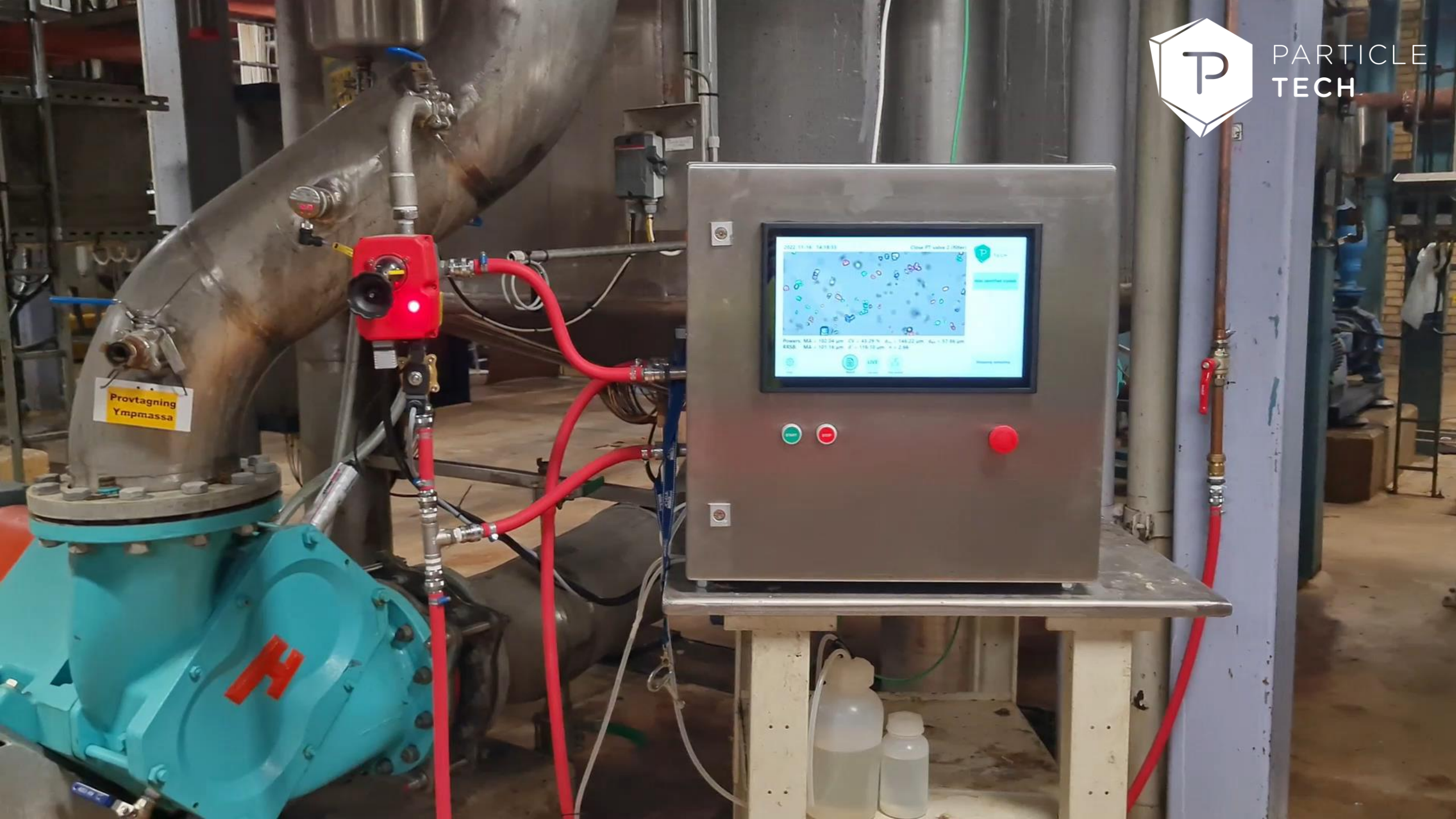
DTU

Nordic Sugar
Member of Nordzucker Group

Sugar refining

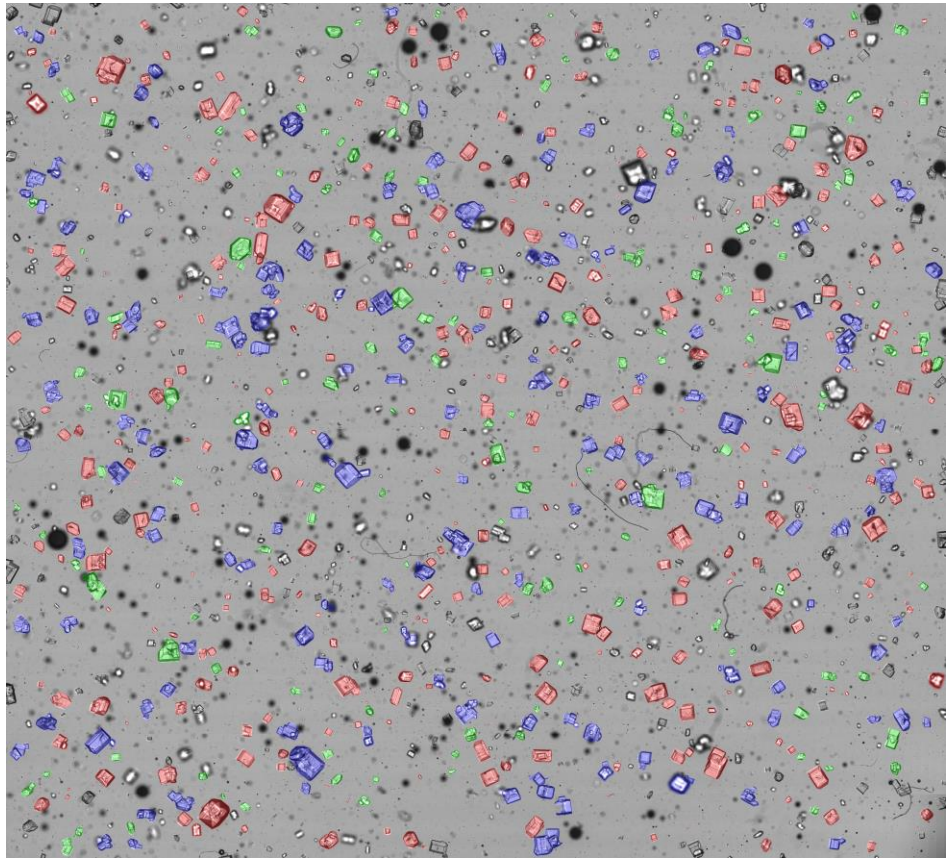


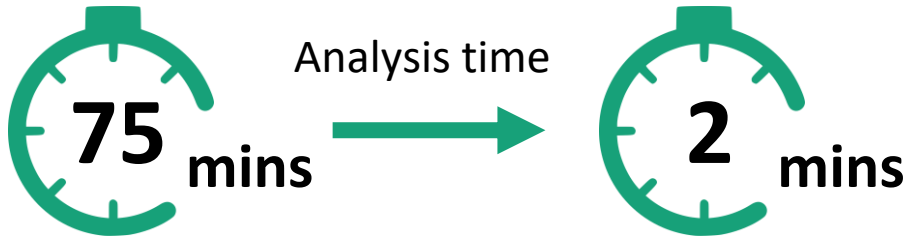


PARTICLE
TECH

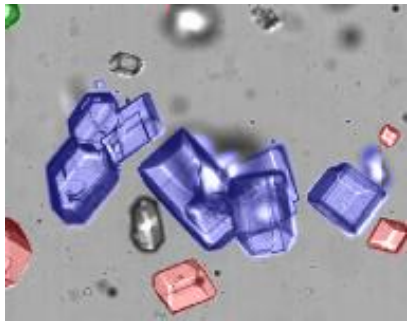
Sugar refining

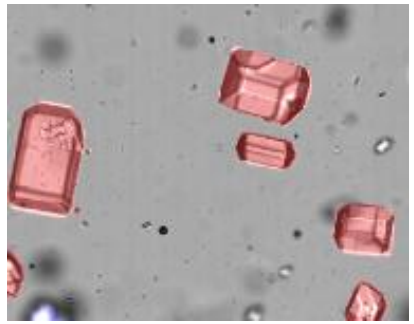
Automated and fast analysis of sugar crystal size and quality based on shape and morphology

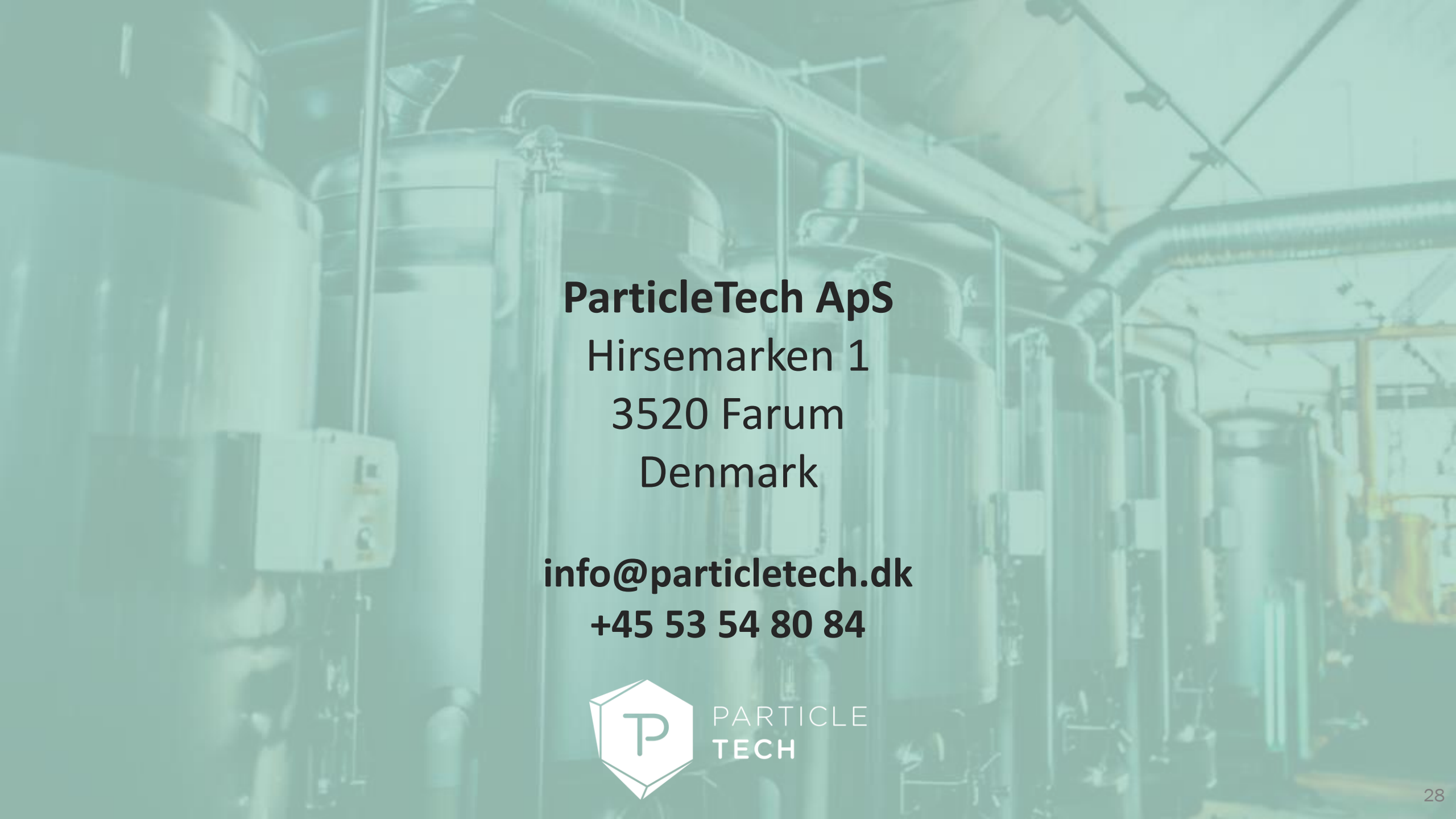




Critical information on agglomerates alongside size and shape parameters







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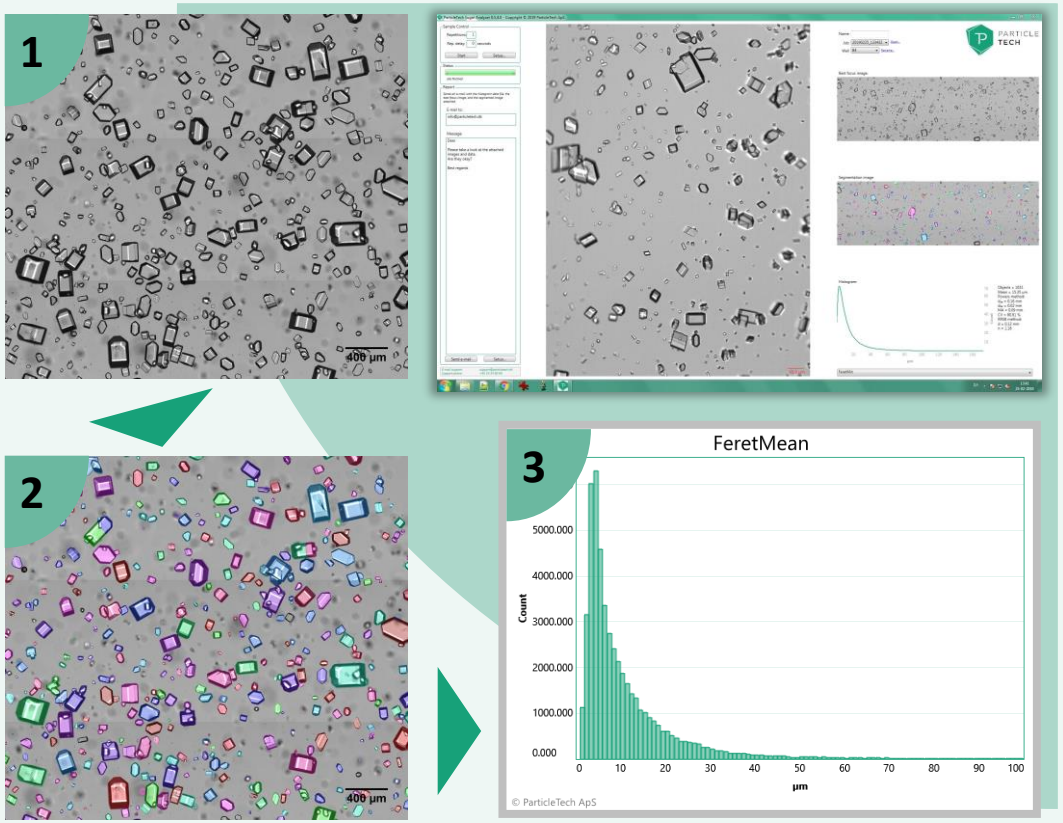
PARTICLE TECH

Core technologies

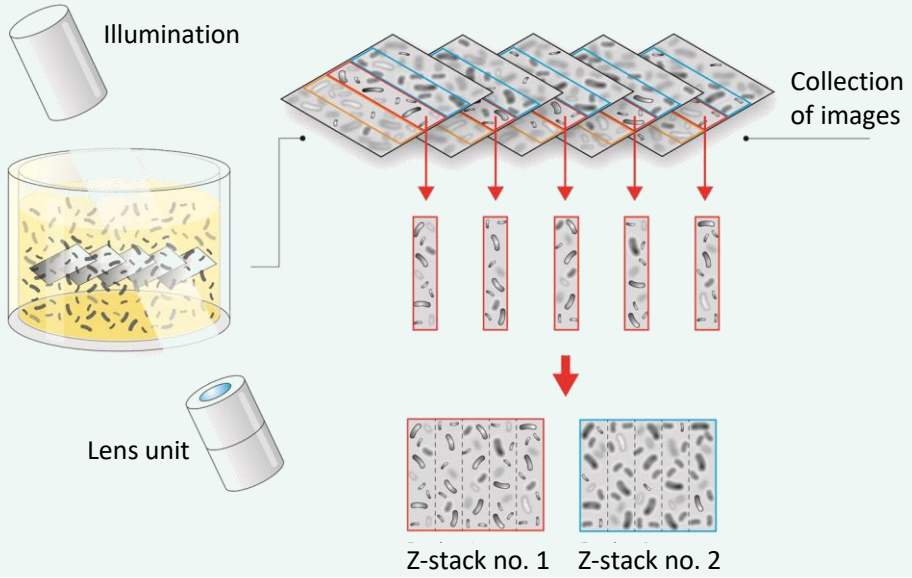
Fully automated image analysis



1) Image aquisition, 2) Segmentation, 3) Particle analysis & statistics

FluidScope™ scanning technology

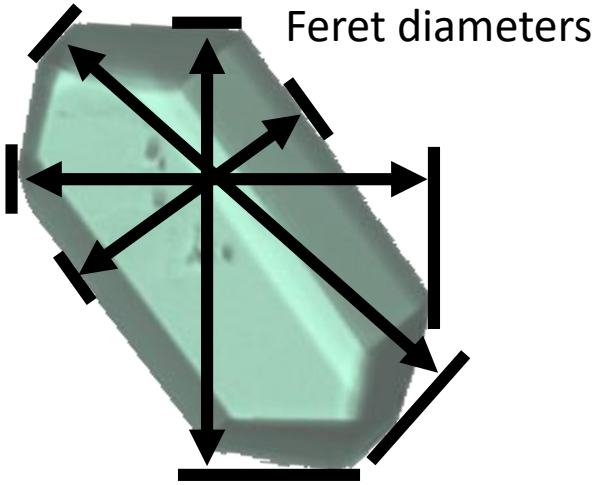
- Samples are scanned using the FluidScope™ technology to generate image Z-stack.
- Provides high quality microscopy images, suitable for image analysis.



Measured particle properties

Particle properties measured based on ISO 9276-6 standard for particle size analysis

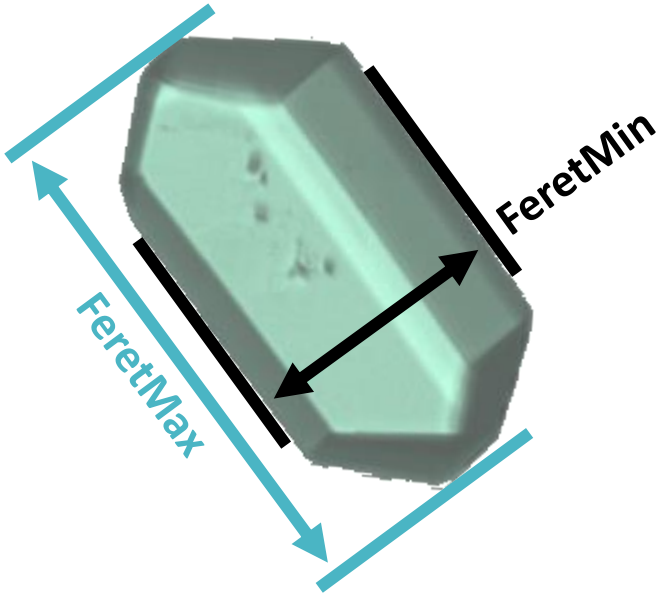
Averaged particle diameter



FeretMean:
Averaged Feret diameters

Serves as an overall average of the particle size

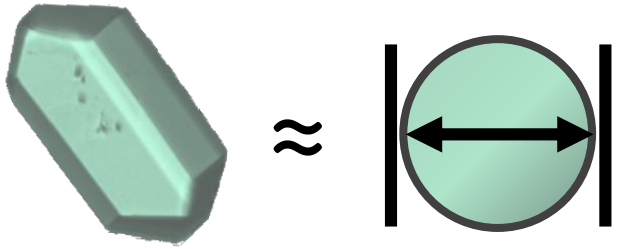
Particle height and width



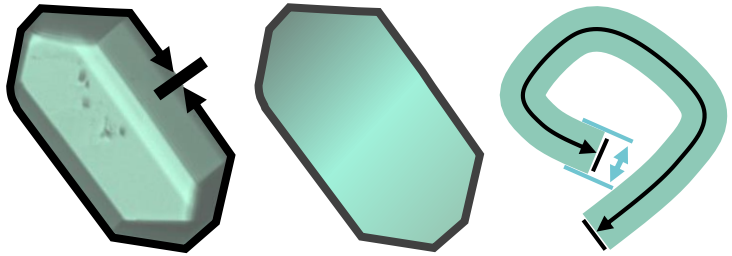
$$\text{FeretRatio} = \frac{\text{FeretMin}}{\text{FeretMax}}$$

And corresponding 90° diameters for FeretMin and FeretMax

Other overall particle properties



Equivalent circle diameter (area based)

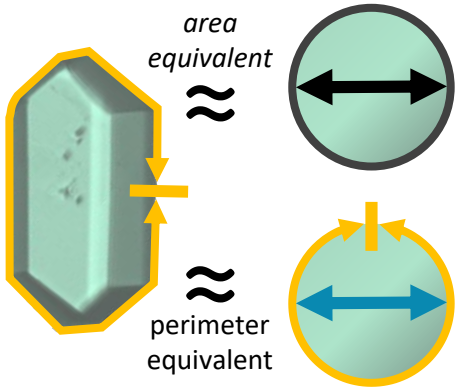


Perimeter **Area** **Fiber length & thickness**

Measured particle properties

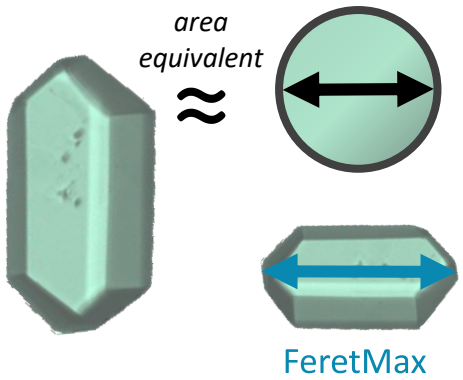
Particle properties measured based on ISO 9276-6 standard for particle size analysis

Circularity



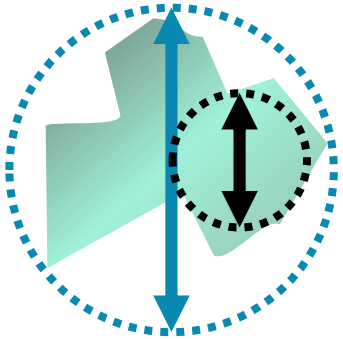
$$\text{Circularity} = \frac{\text{Area eq. diameter}}{\text{Perimeter eq. diameter}}$$

Compactness



$$\text{Compactness} = \frac{\text{Area eq. diameter}}{\text{FeretMax}}$$

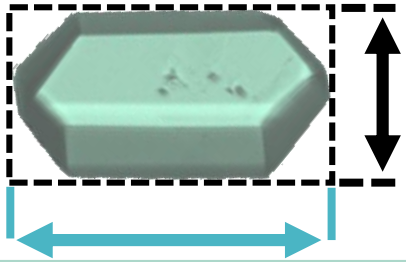
Irregularity



$$\text{Irregularity} = \frac{\text{Min. inscribed circle diameter}}{\text{Min. circumscribed circle diameter}}$$

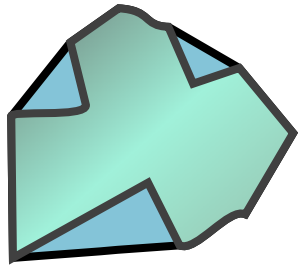
Squareness

Particle contained in minimum bounding box



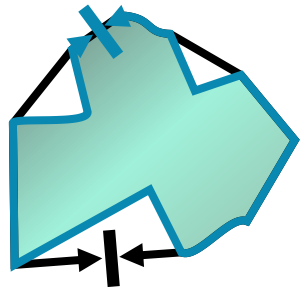
$$\text{Squareness} = \frac{\text{Min. bounding box height}}{\text{Min. bounding box width}}$$

Solidity



$$\text{Solidity} = \frac{\text{Object area}}{\text{Convex area*}}$$

Roughness



$$\text{Roughness} = \frac{\text{Convex perimeter**}}{\text{Object perimeter}}$$

*Convex area = area formed by convex perimeter**
**Convex perimeter = perimeter formed if a rubber band was to surround the particle