



*pheno*Seeder

automated phenotyping and sowing of individual seeds of different sizes

28.06.2024 | VIKTOR SYDORUK, ANDREAS FISCHBACH, GREGOR HUBER, JOHANNES KOCHS,
DANIEL KLASSEN, DANIEL PFLUGFELDER, TOMAS HOMBACH, ROBERT KOLLER

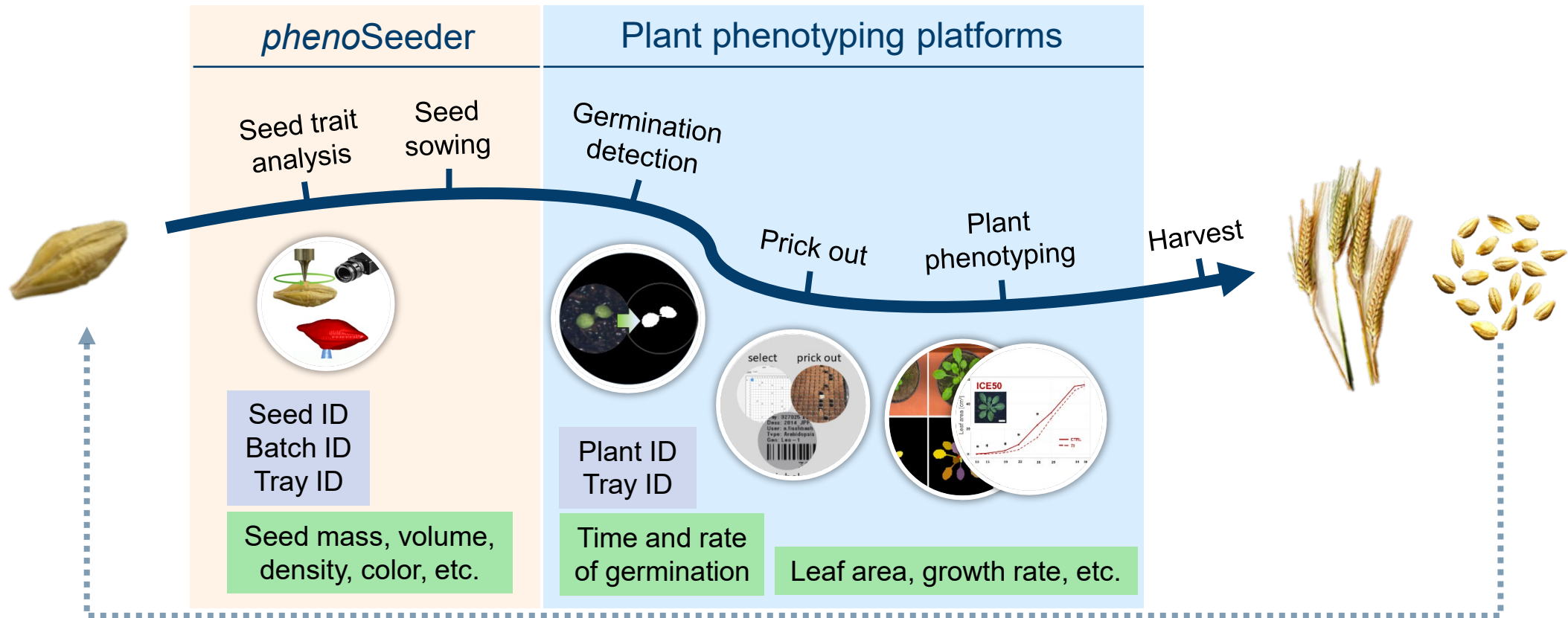
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WHY SEED PHENOTYPING?

- Optimizing the phenotyping pipelines
 - Reducing statistical variance in starting material (seed batches)
 - Characterizing the harvest
- Seed physiology
 - Seeds properties
 - Germination
- Characterising germplasm
 - Quantify seed characteristics in seed banks (?)
- Seed testing for seed industry
 - Quality of seed progeny in commercial environment

SEED TO PLANT TRACKING

Automated phenotyping and tracking of individual seeds and corresponding plants



IDs and trait values are automatically stored into database

PHENOSEEDER

SeedCT (μ CT scanner)

Weighing stations

Seed placement station
(sowing or sorting)



Kuka robotic arm

2D imaging stations (picking up seeds)

3D imaging stations (volume carving)

Acoustic volumeter

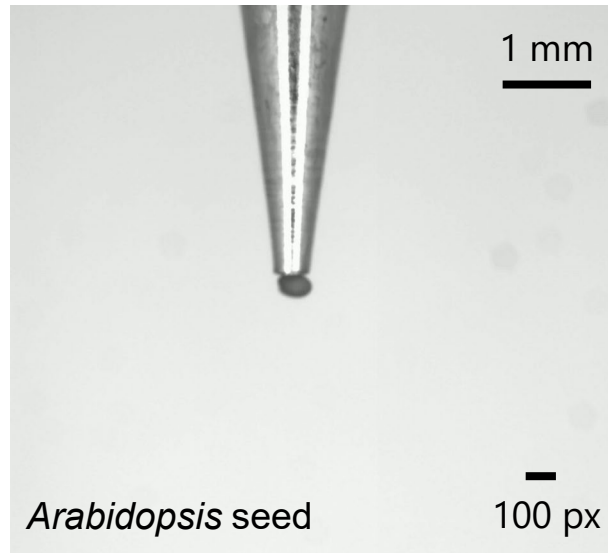
3D RECONSTRUCTION OF SEEDS

Using newly developed Volume carving

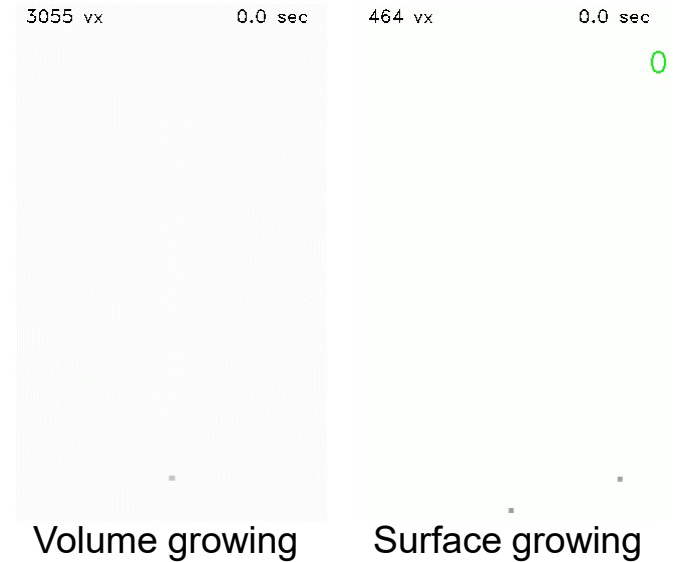
3D Imaging station



Photos from different angles



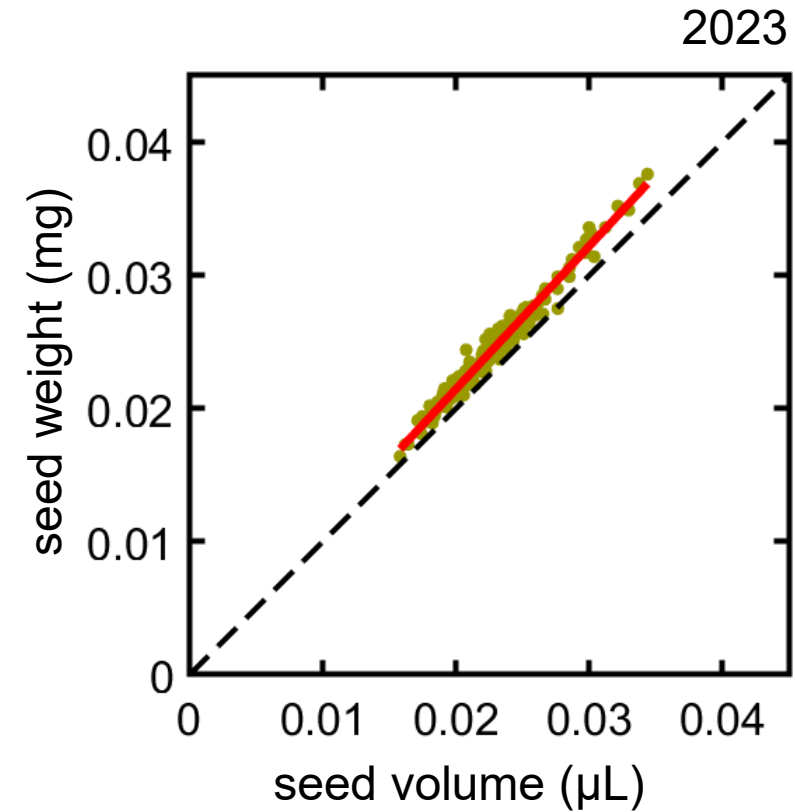
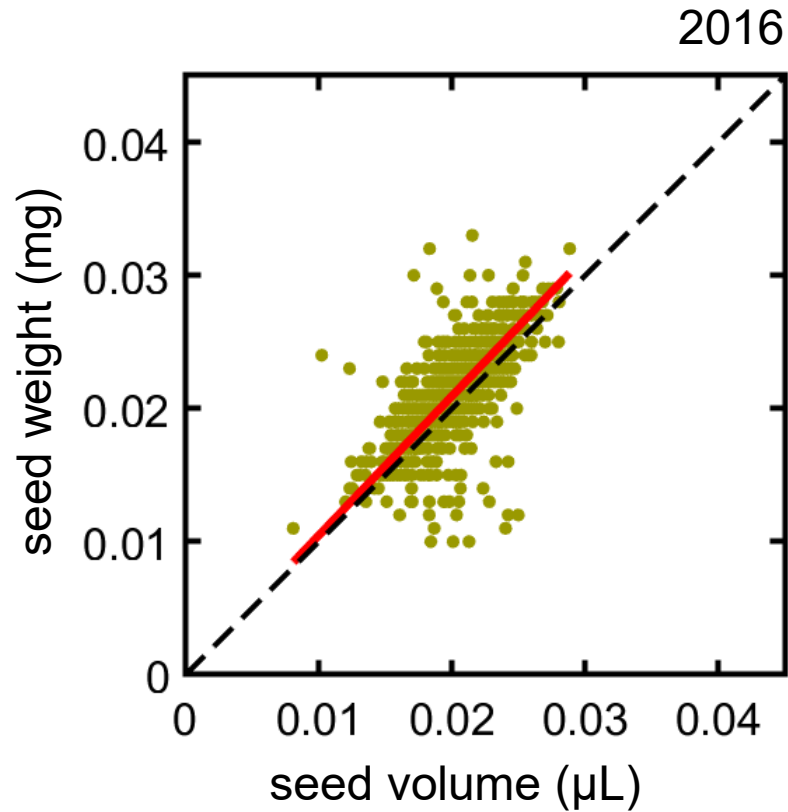
3D reconstruction methods



Old methods: Roussel J., et al. *Frontiers in Plant Science* 2016
New methods: not published yet

VOLUME CARVING

Performance improvement



Much better correlation between seed weight and its envelope volume (*Arabidopsis Col-0* example)

VOLUME CARVING

Delivered traits

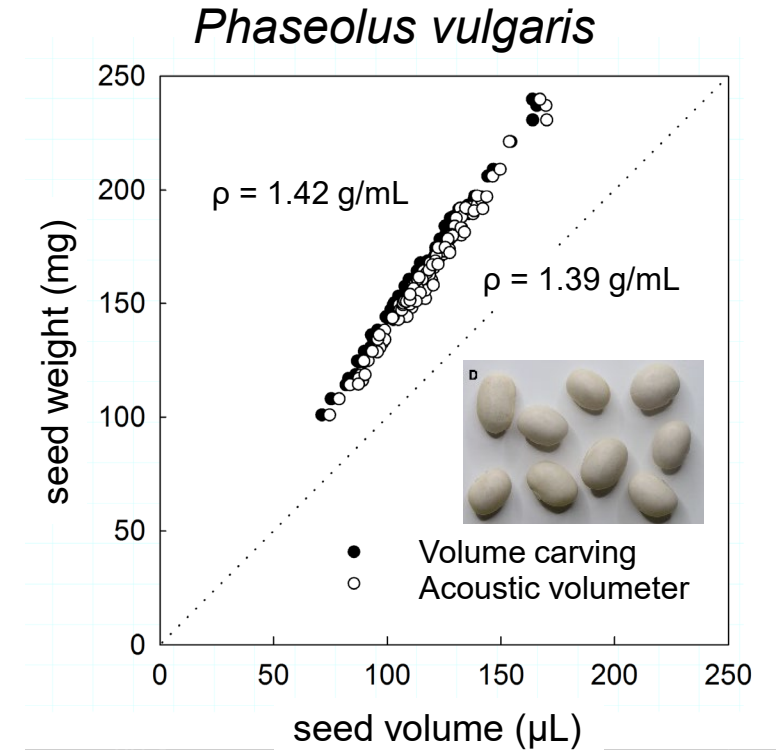
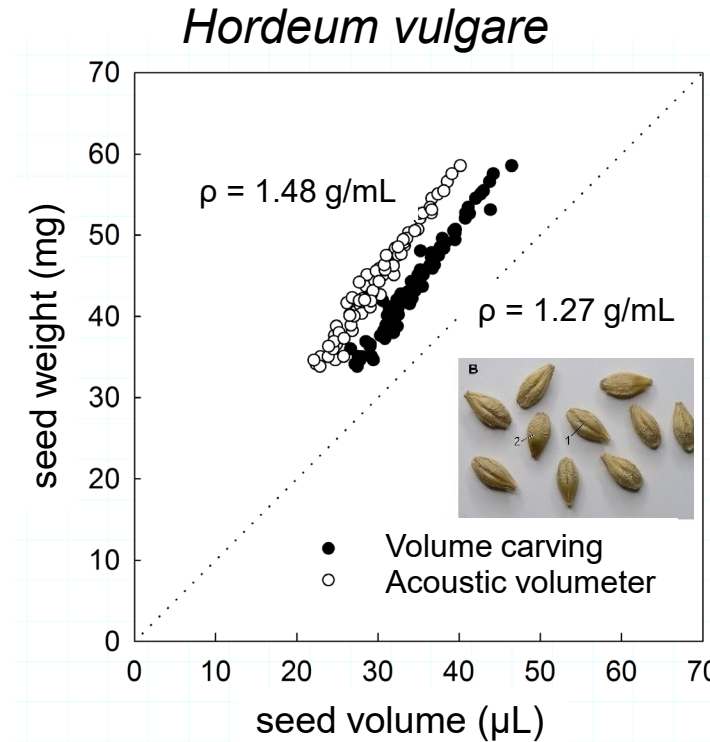
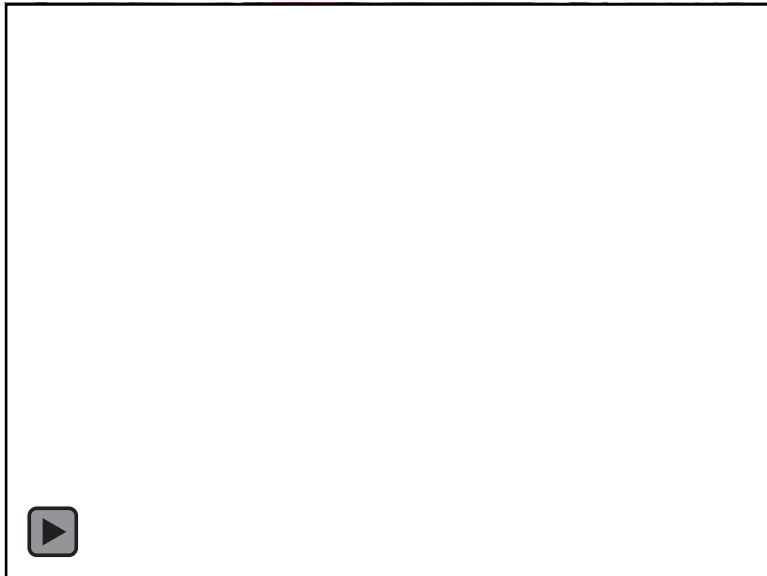


- 3D model of each seed
 - Envelope volume, Convex hull volume
 - Surface area
 - Length, Width, Height
 - Sphericity
 - Luminosity
 - Color information (near future)
- + Reconstruction quality check

A proper volume reconstruction is one of the main keys to estimate seed precise envelope/effective density.

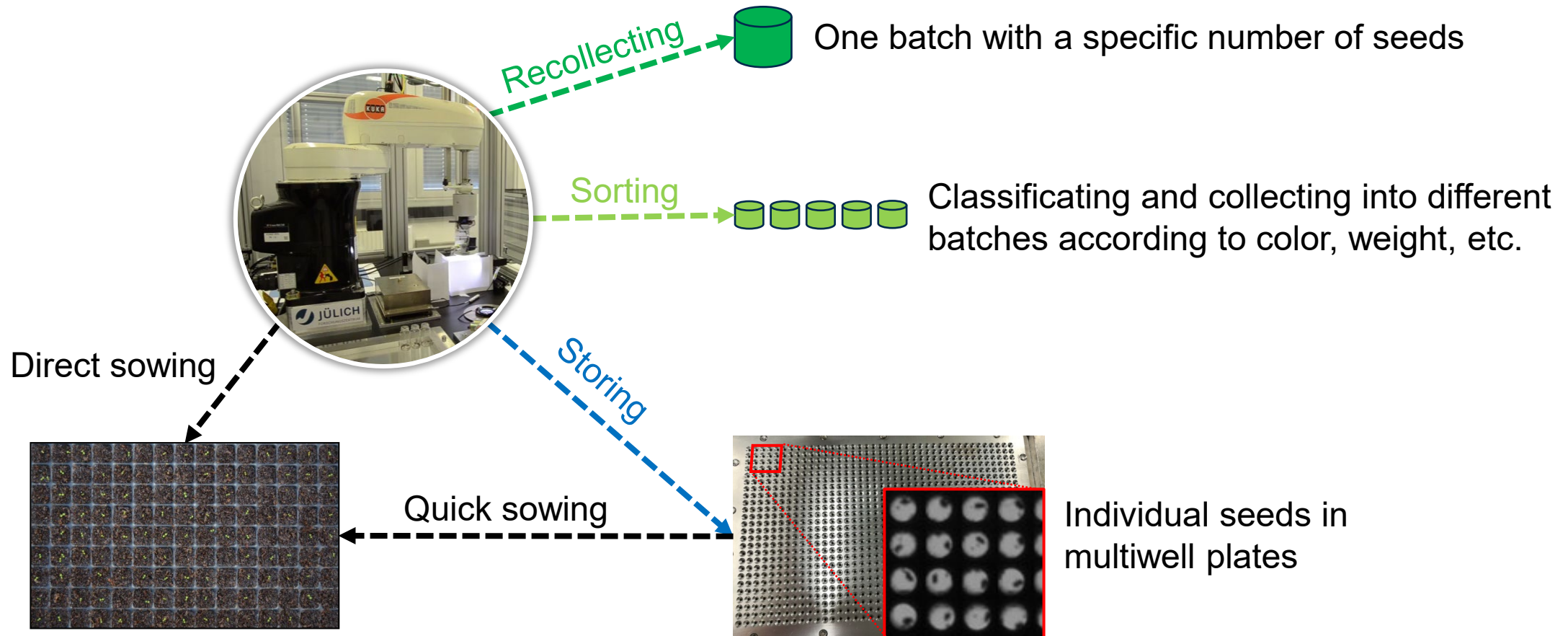
ACOUSTIC VOLUMETER

Method to obtain skeletal volume



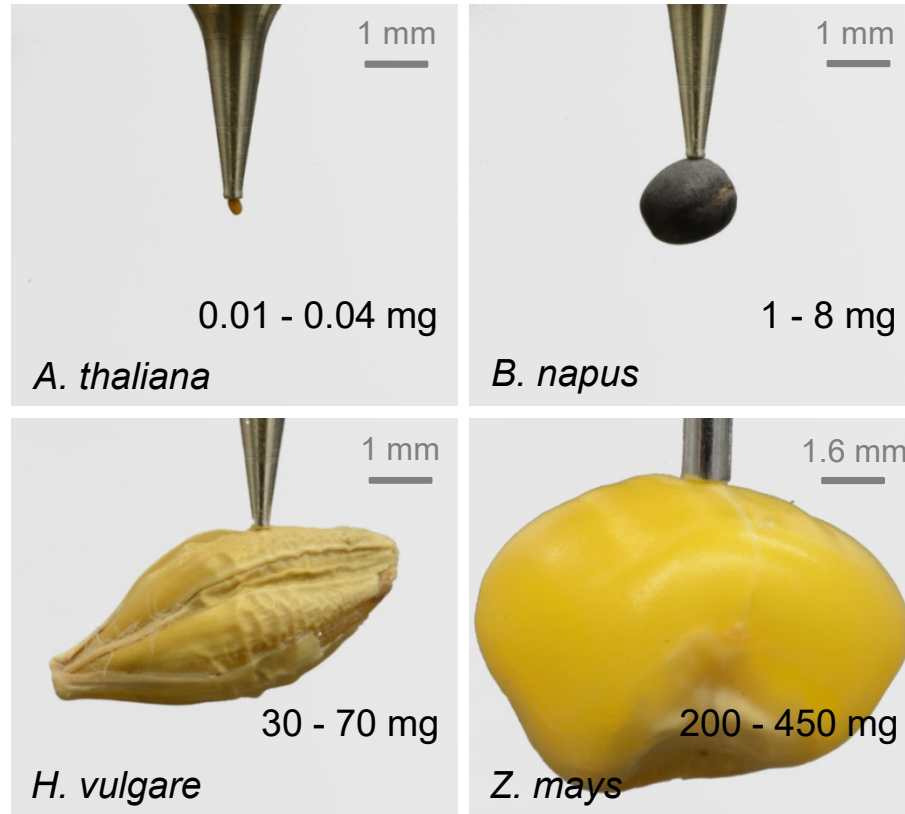
SEED PLACEMENT STATION

Seeds can be processed in different ways after phenotyping



SEED CHARACTERISATION

More than 500 000 individual seeds have already been passed through *phenoSeeder*



Arabidopsis thaliana (~ 700 ≠ genotypes)

Zea mays

Hordeum vulgare

Triticum aestivum

Phaseolus lunatus

Sorghum bicolor

Oryza sativa

Cardamine chenopadifolia

Solanum quitoense

Brassica napus

Nicotiana tabaccum

Boechera spatifolia,

B. stricta, *B. pallidifolia*, *B. polyantha*

B. divaricarpa

Sida hermaphrodita

Cardamine chenopodifolia

Arabis alpina, *A. hirsuta*, *A. ciliata*

...

Paczesniak D., et al. *Frontiers in Plant Science* 2022

Han Y., et al. *Frontiers in Plant Science* 2023

SEEDCT

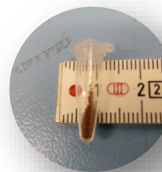
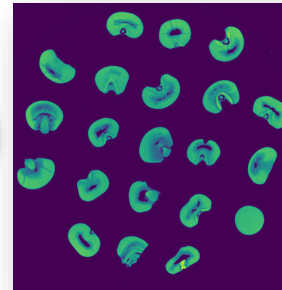
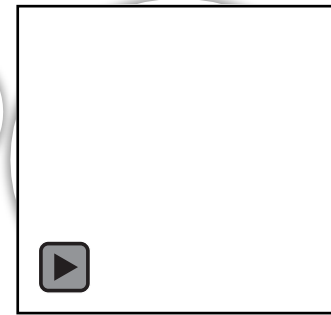
μ CT scanner for internal seed structures



Resolution: 4 .. 40 μ m
FOV: 4 x 9 x 9mm³ .. 40 x 90 x 90mm³
Acquisition time: >15 min

Individual

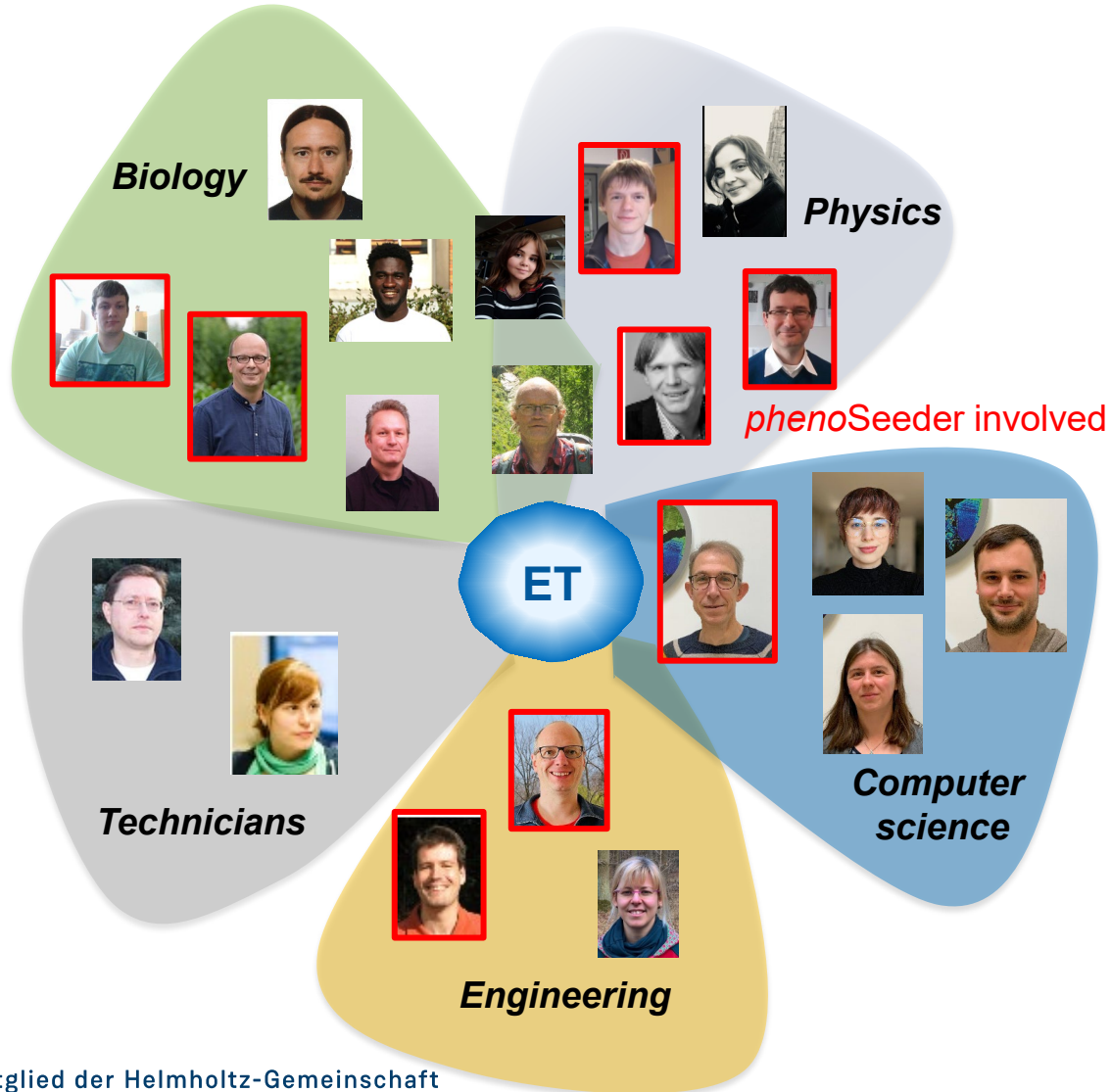
Batch analysis



- Size of embryo, cotyledon
- Volume, closed pores volume, weight
- Mean seed volume, mean mass, mean density

ACKNOWLEDGMENTS

Enabling Technologies Group



Mitglied der Helmholtz-Gemeinschaft

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THANK YOU FOR YOUR ATTENTION!!!