

One Year and Onwards with the Fully-automated LemnaTec Phenocenter



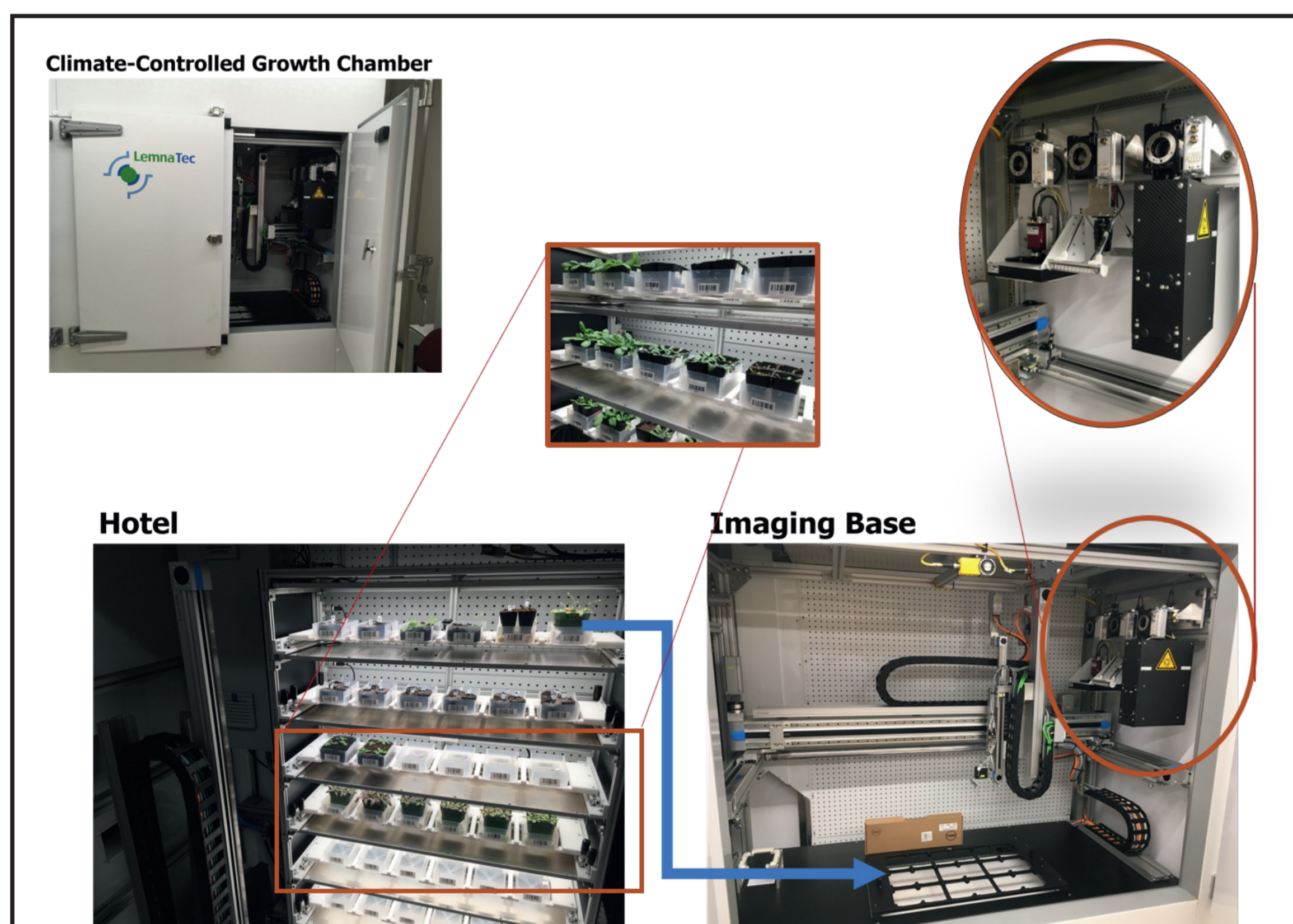
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High-throughput phenotypic screening for small plants and larger-crop plant seedlings in a climate-controlled growth chamber

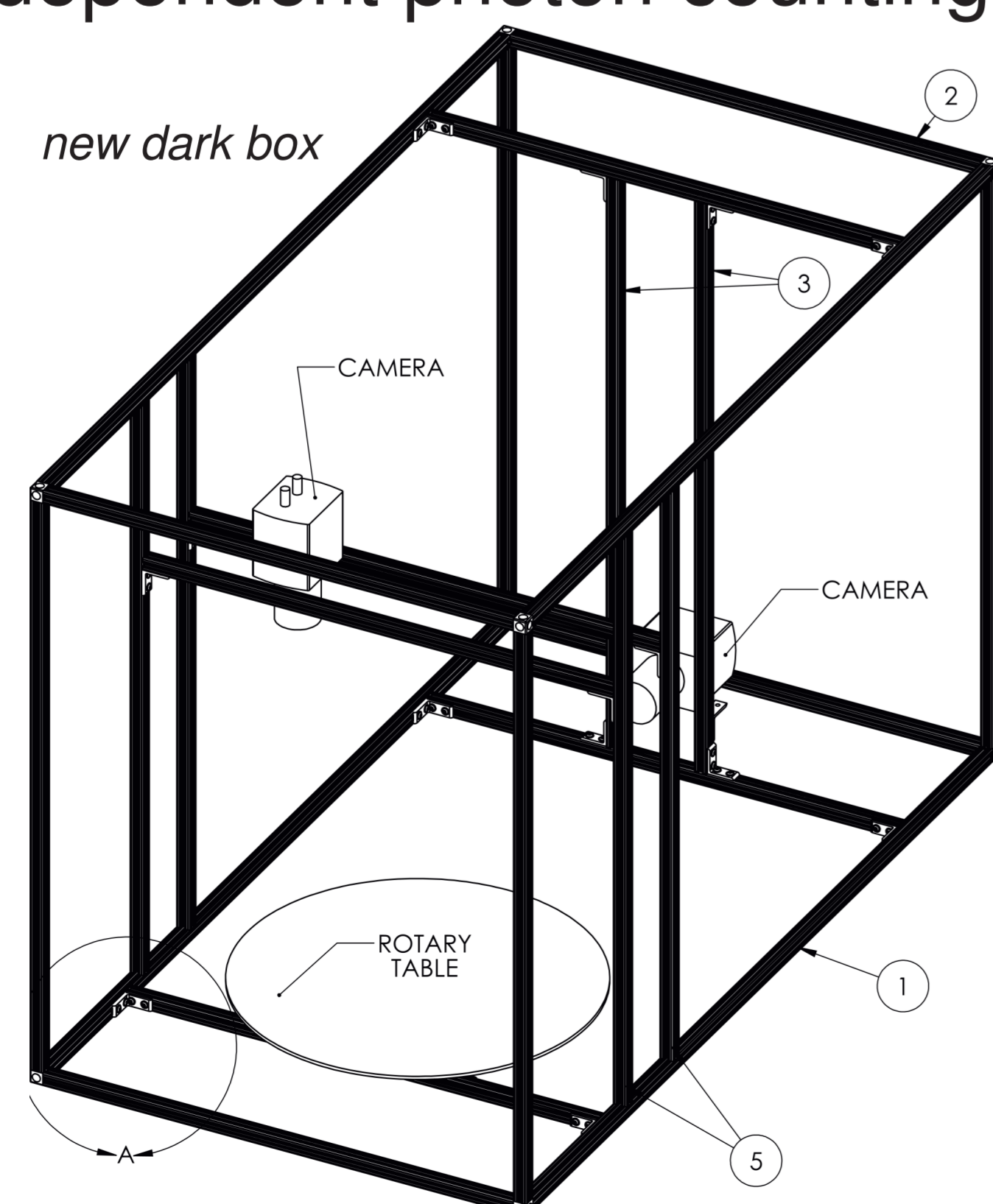
<https://phenomics.cahnrs.wsu.edu>
<https://github.com/CougPhenomics>
 Community resource - email Dominik!



- Capture plant physiology every hour!
- RGB photography for growth rate and necrosis detection
- 3D scanning for biomass quantification
- Chlorophyll Fluorescence for plant stress quantification
- Photon Counting for luciferase, Aequorin assays
- SWIR for water content detection

Ongoing Challenges

- Windspeed from climate control causes plant movement and blur at slow exposure speeds
- Low illumination when optimizing for depth of field
- Developing independent photon counting system with both top and side imaging capabilities due to issues with condensation inside growth chamber



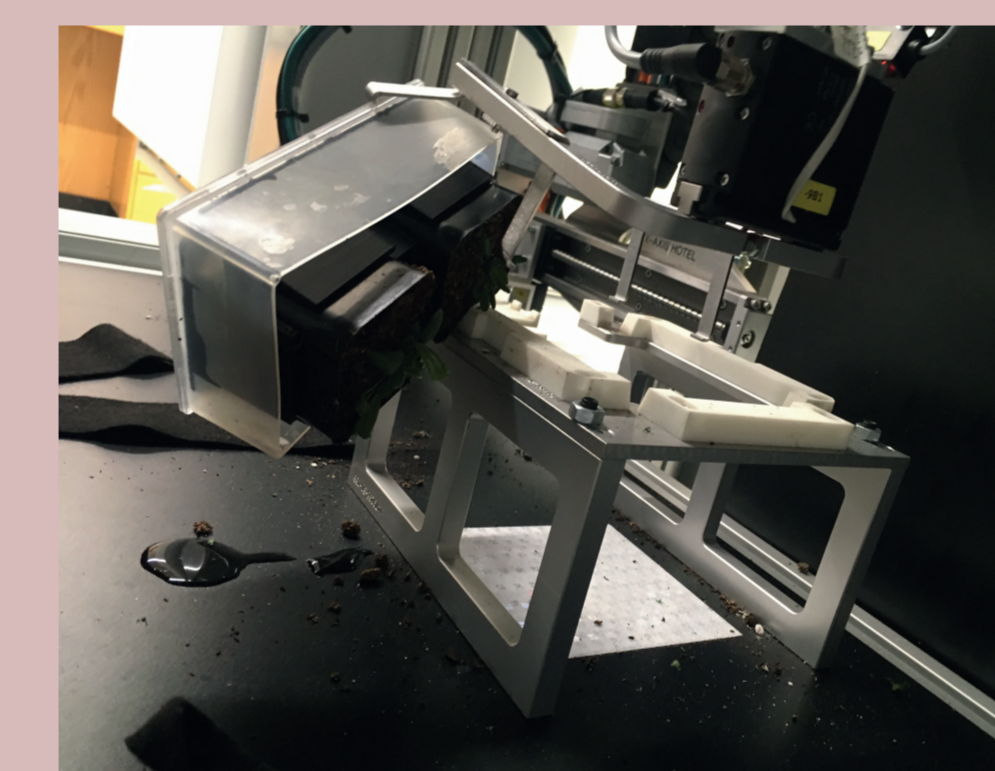
Best Practice Discoveries

- Approach phenomics with a clear, testable hypothesis rather than a fishing experiment
- Include WT and known phenotype controls under treatment
- Sample preparation and imaging setup is critical for downstream success
- Monitor plant condition even with automatic watering
- Soil matters for water retention and image background



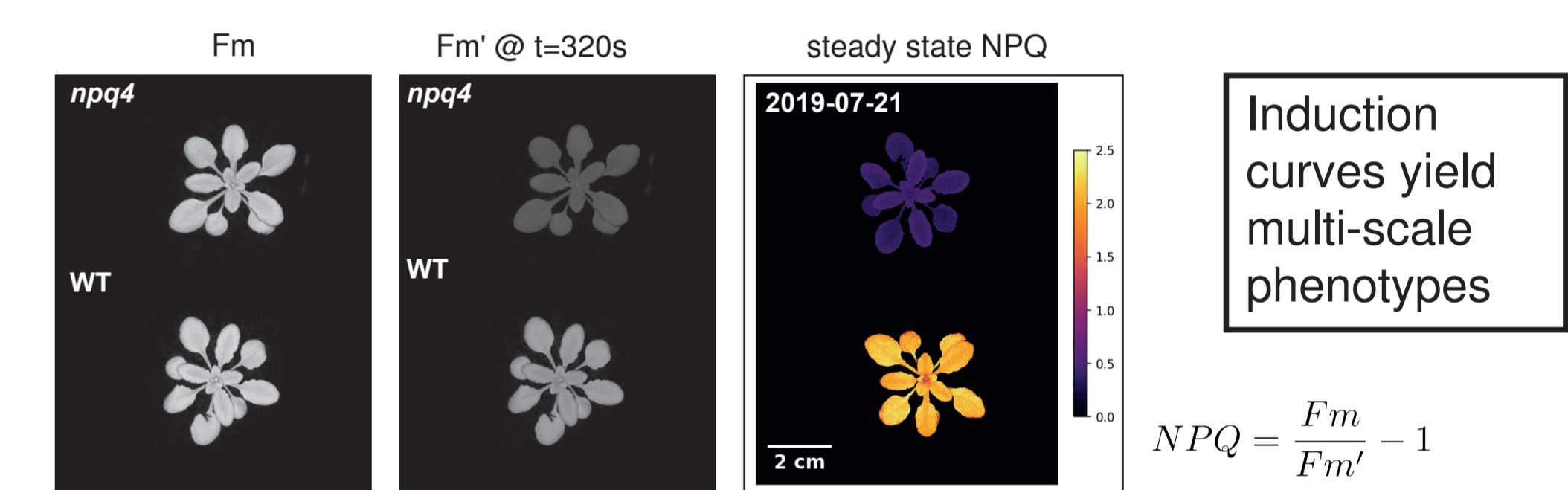
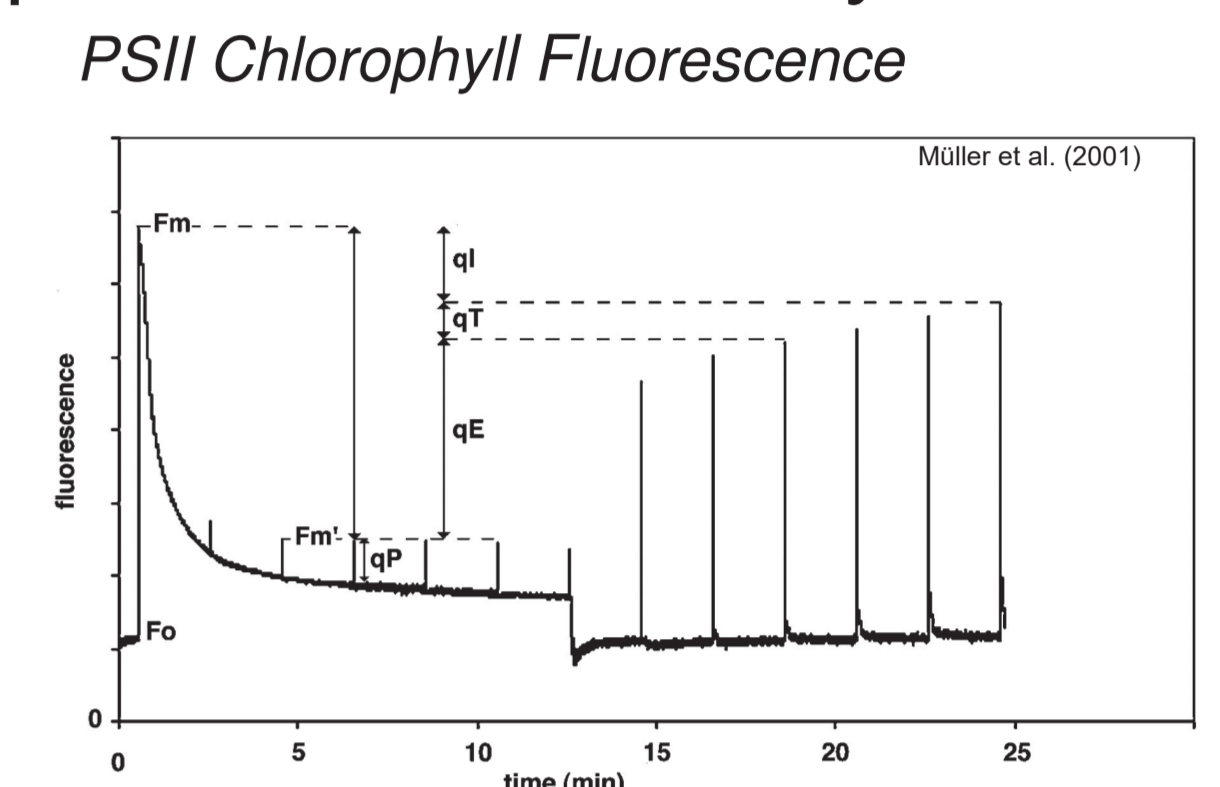
Technical Solutions

- 3D printing and machine shop for custom parts including pot holders and part hacking
- Black non-reflective spray paint
- Move to open source workflow enables flexibility and versioning
- Deliver both quantitative data and visuals with basic post processing. Presentation tools include an automated RMarkdown report and gif generation script.



Sample Dataset

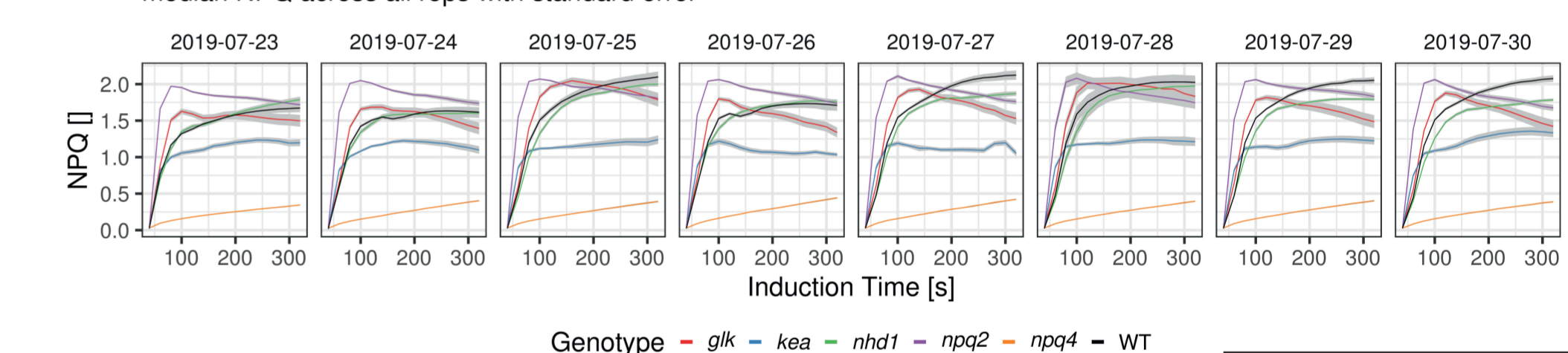
- Goal to quantify reps needed to identify known phenotypes
- 4 photosynthesis mutants + WT
- PSII monitoring with corresponding visible images



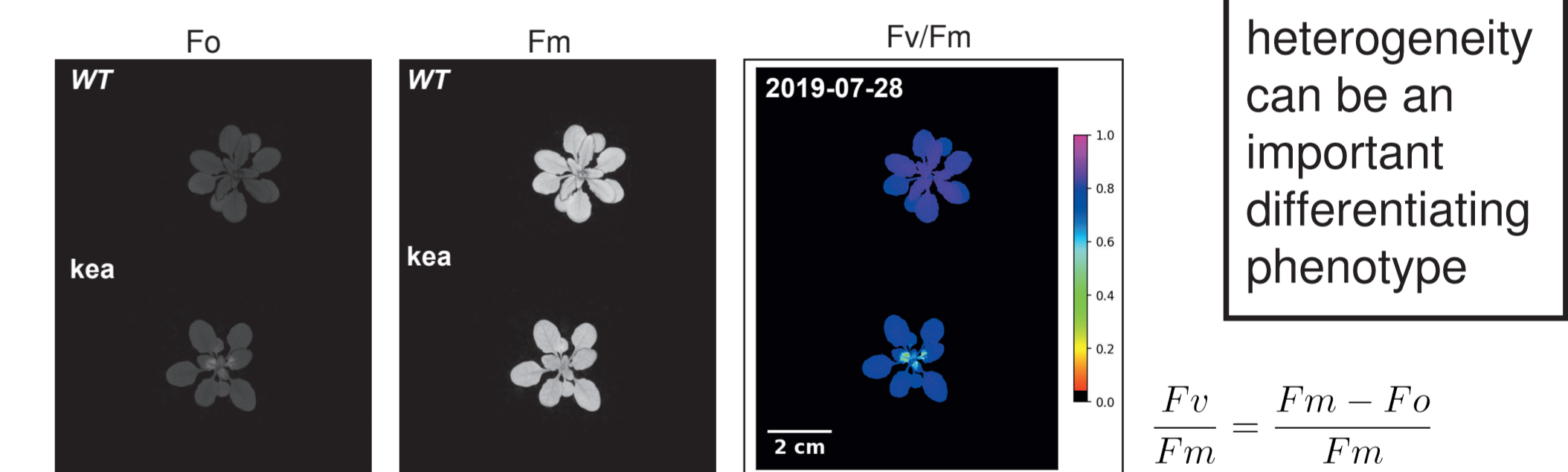
Induction curves yield multi-scale phenotypes

$$NPQ = \frac{F_m}{F_m'} - 1$$

Non-Photochemical Quenching (NPQ) over a Week
 median NPQ across all reps with standard error

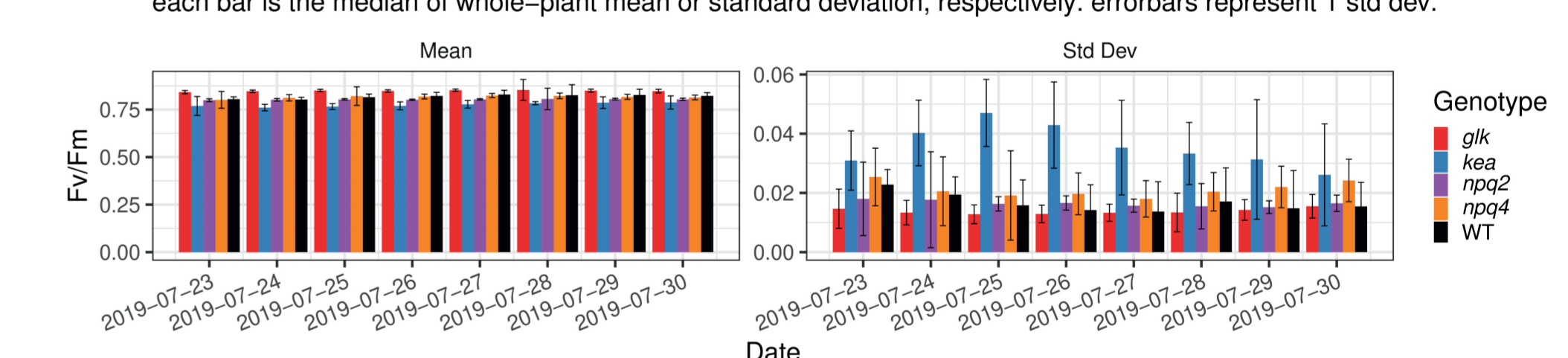


Plant heterogeneity can be an important differentiating phenotype



$$\frac{F_v}{F_m} = \frac{F_m - F_0}{F_m}$$

Max Photosynthetic Efficiency over a Week
 each bar is the median of whole-plant mean or standard deviation, respectively. errorbars represent 1 std dev.



Established workflow to convert ideas to phenotypic data

proposal + experimental design

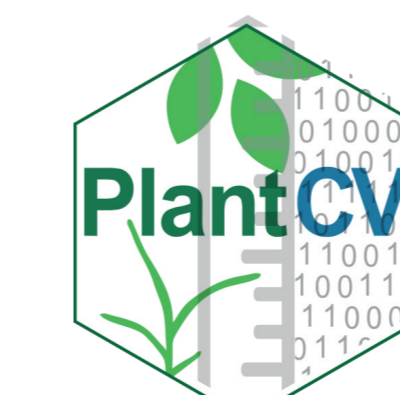
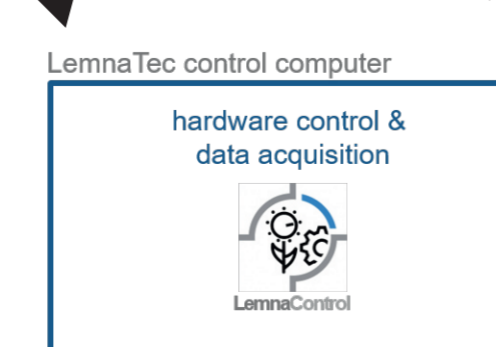


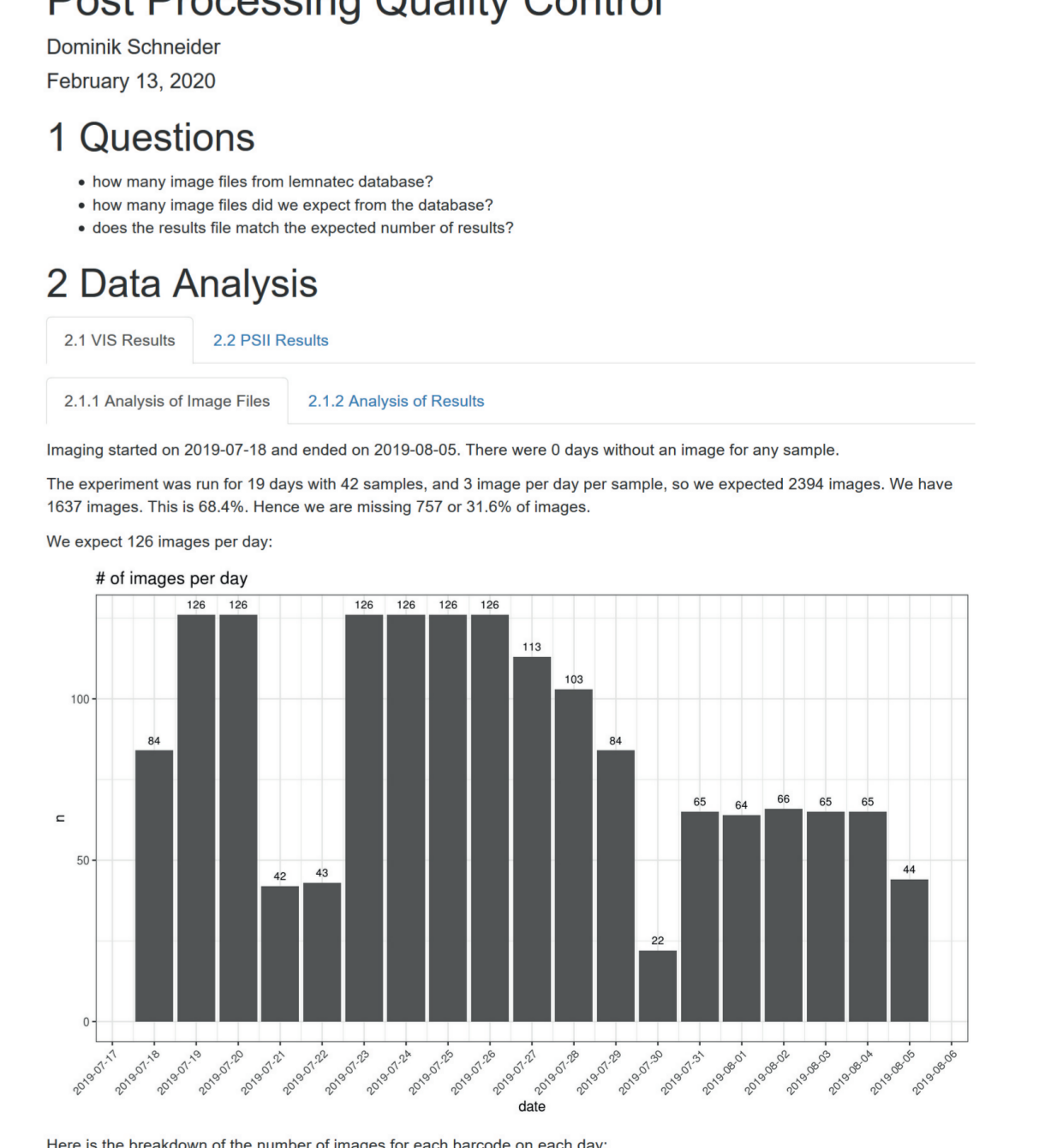
image segmentation and feature extraction

timelapse gifs



RMarkdown report to quantify experiment output

Post Processing Quality Control



Schneider, D., Lopez, L.S., Li, M., Crawford, J.D., Kirchhoff, H., and Kunz, H.-H. (2019). Fluctuating light experiments and semi-automated plant phenotyping enabled by self-built growth racks and simple upgrades to the IMAGING-PAM. *Plant Methods* 15, 156.