

FIRST INSIGHTS FROM ^{11}C -PET MEASUREMENTS IN CASSAVA

IMAGING FLOW AND 3D-ALLOCATION OF CARBON NON-INVASIVELY

09.04.2024 | R. METZNER, D. PFLUGFELDER, G. HUBER, A. CHLUBEK, E. BREUER, M. DAUTZENBERG
AND R. KOLLER

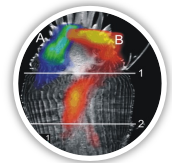
INSTITUTE OF BIO- AND GEOSCIENCES (IBG) 2: PLANT SCIENCES

ENABLING TECHNOLOGIES GROUP

Technology development for sustainable
and innovative plant production



NMR and MRI



Radiotracers
and PET

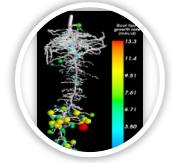
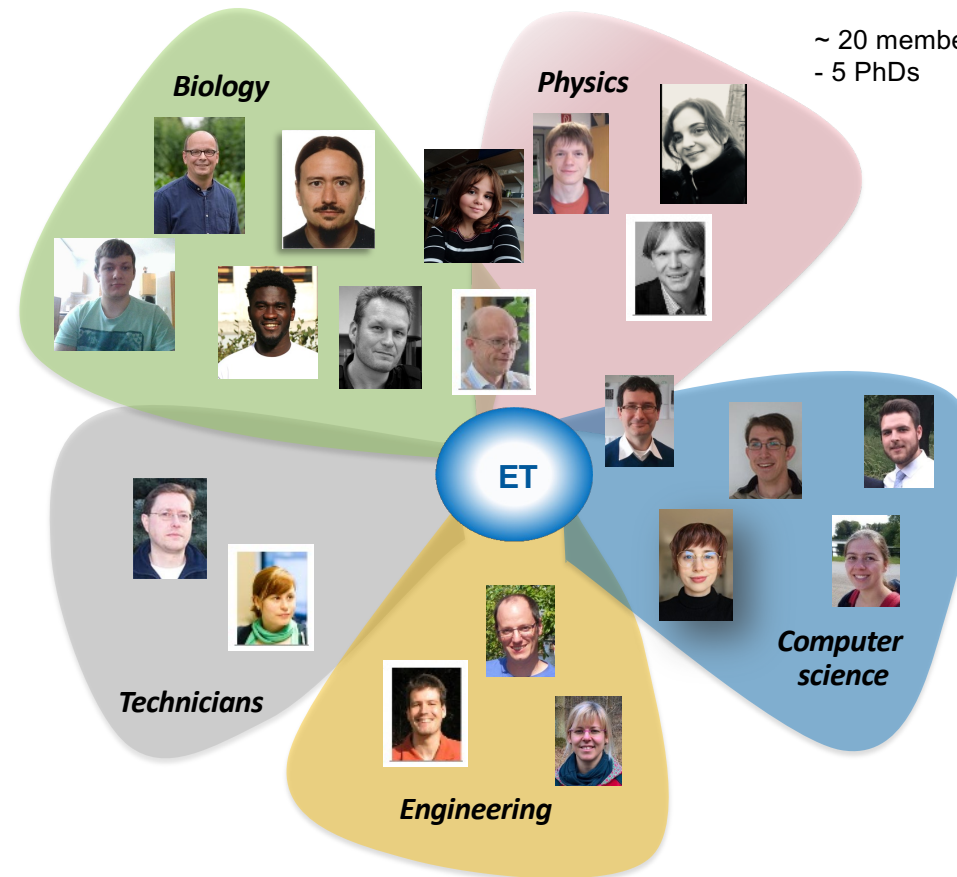


Image
Analysis

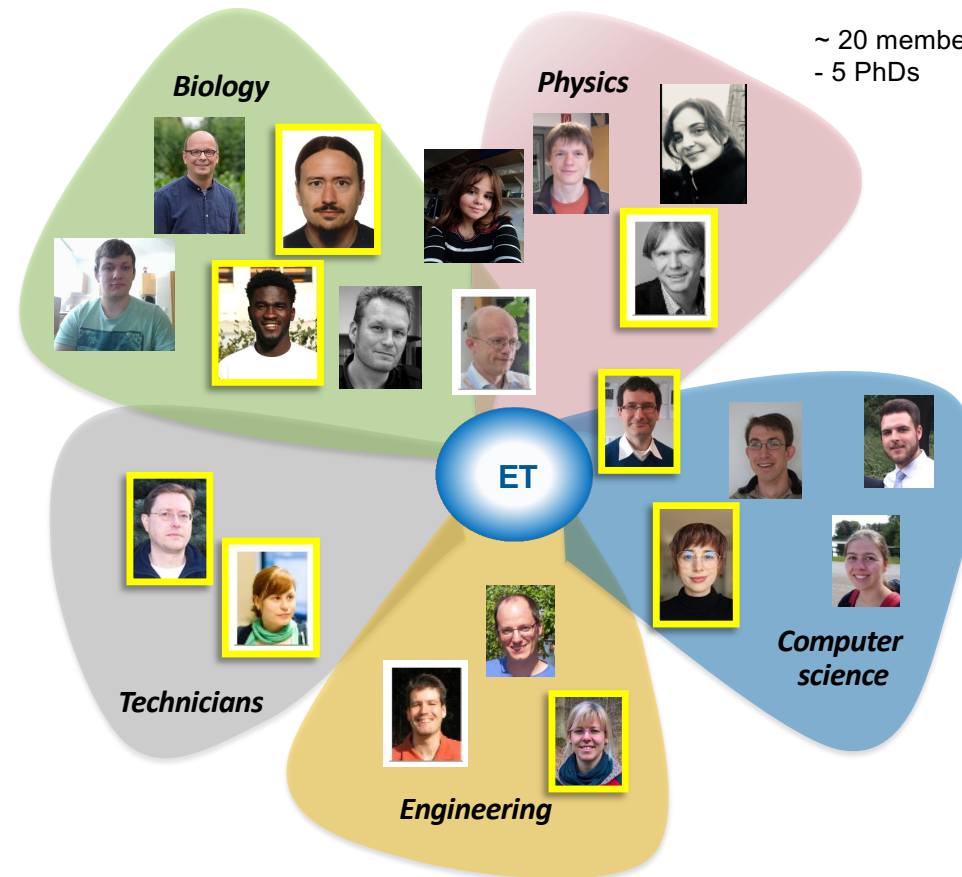
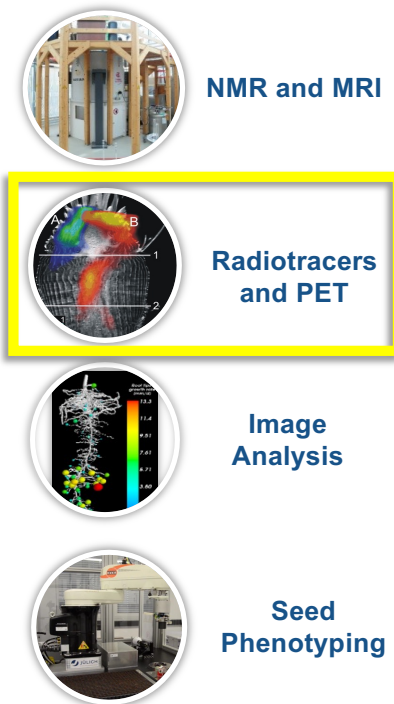


Seed
Phenotyping



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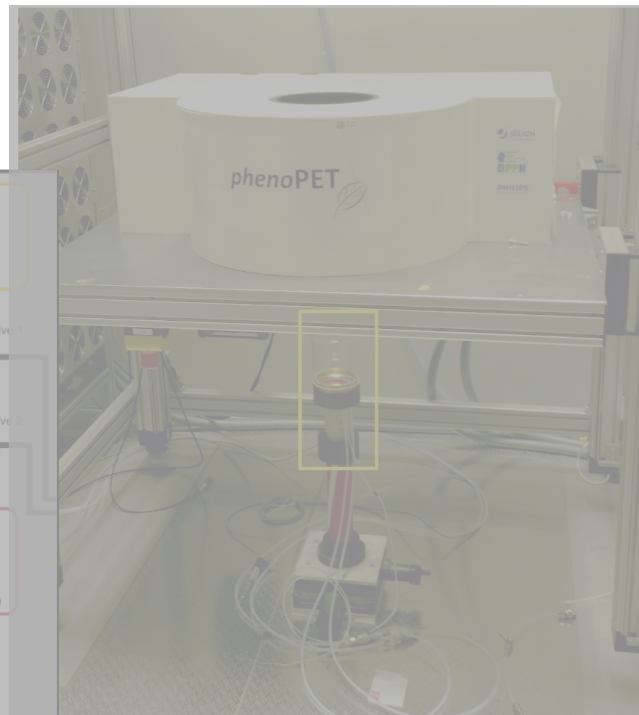
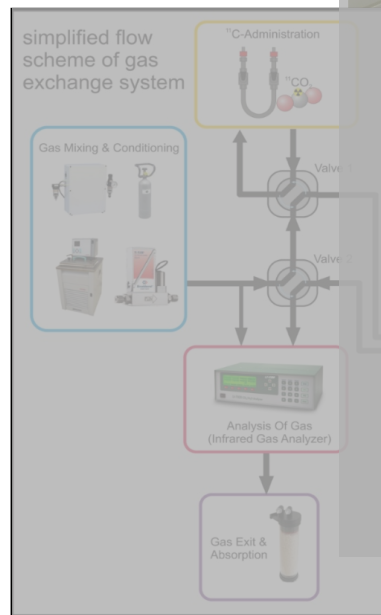
SHORT-LIVED ^{11}C FOR CARBON TRACING IN PLANTS

Carbon Isotopes for tracer studies in plant sciences: ^{11}C , ^{12}C , ^{13}C , ^{14}C

- Administered non-invasively as $^{11}\text{CO}_2$ to the leaves
- Can be detected from outside of the plant / pot and short half life (20 min) of tracer
 - Dynamic studies on allocation and transport by repeated measurements (~every 2-3h)
 - Complementary measurements (MRI, Proteomics...) and final harvest of non-radioactive plant
- 3D detection possible with Positron Emission Tomography (PET)
- On-site production required

^{11}C -PET EXPERIMENTAL PIPELINE

Plant leaf in
Cuvette Setup



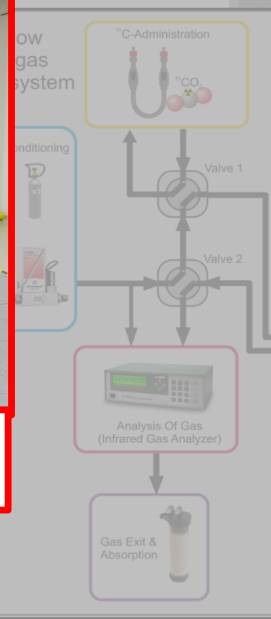
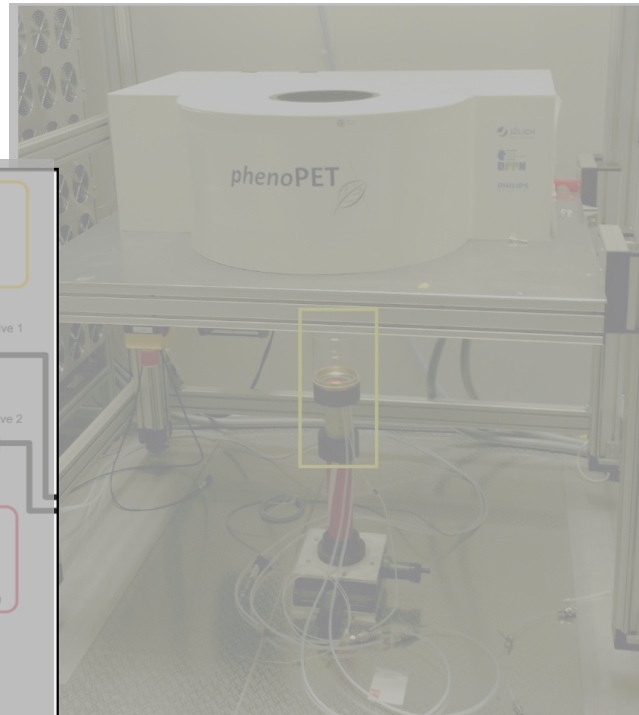
^{11}C -PET EXPERIMENTAL PIPELINE

Plant leaf in
Cuvette Setup

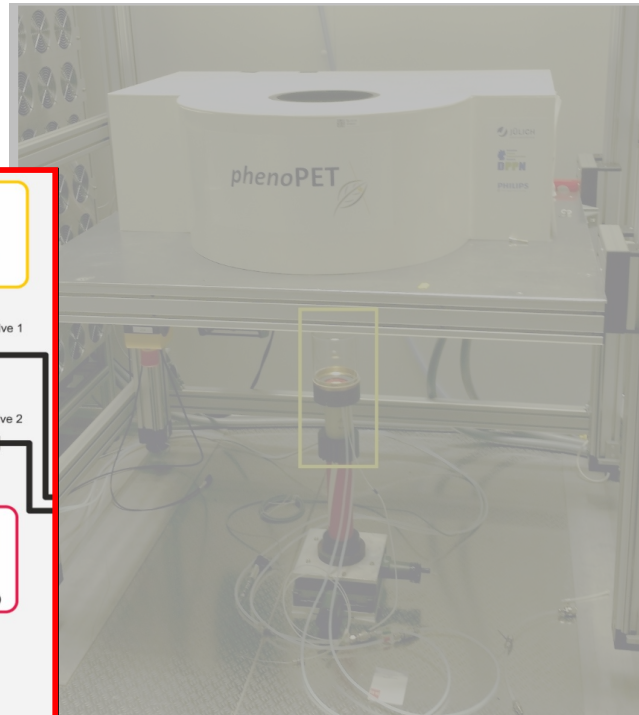
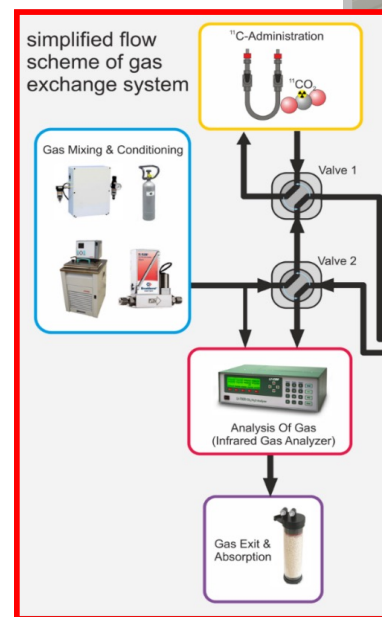
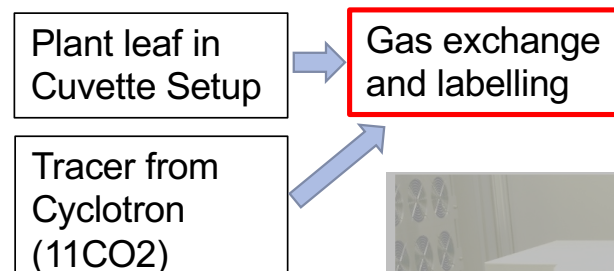
Tracer from
Cyclotron
($^{11}\text{CO}_2$)



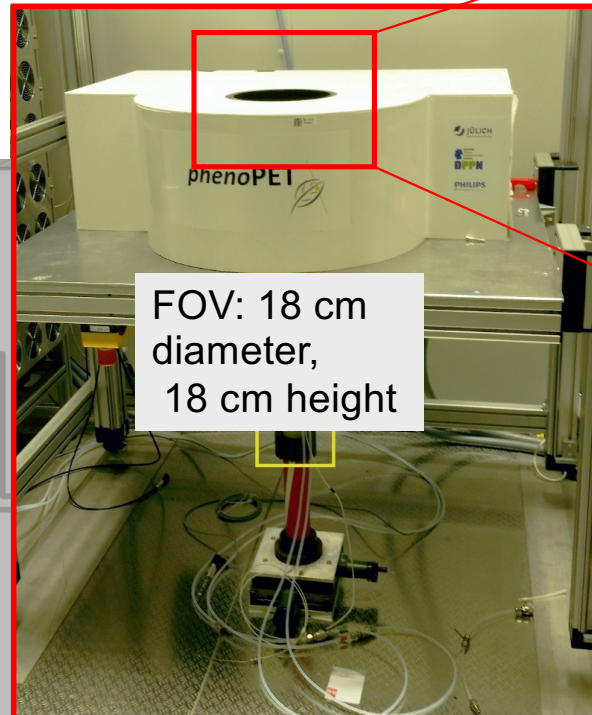
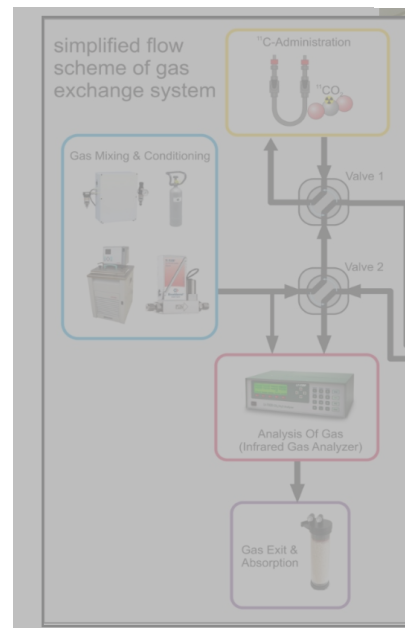
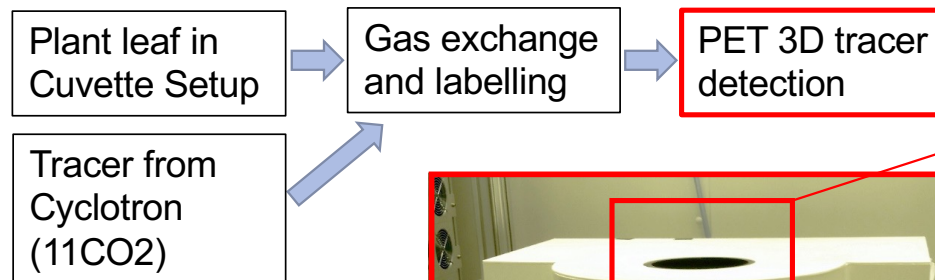
Cyclotron for Plant
Research CYPRES



^{11}C -PET EXPERIMENTAL PIPELINE



^{11}C -PET EXPERIMENTAL PIPELINE

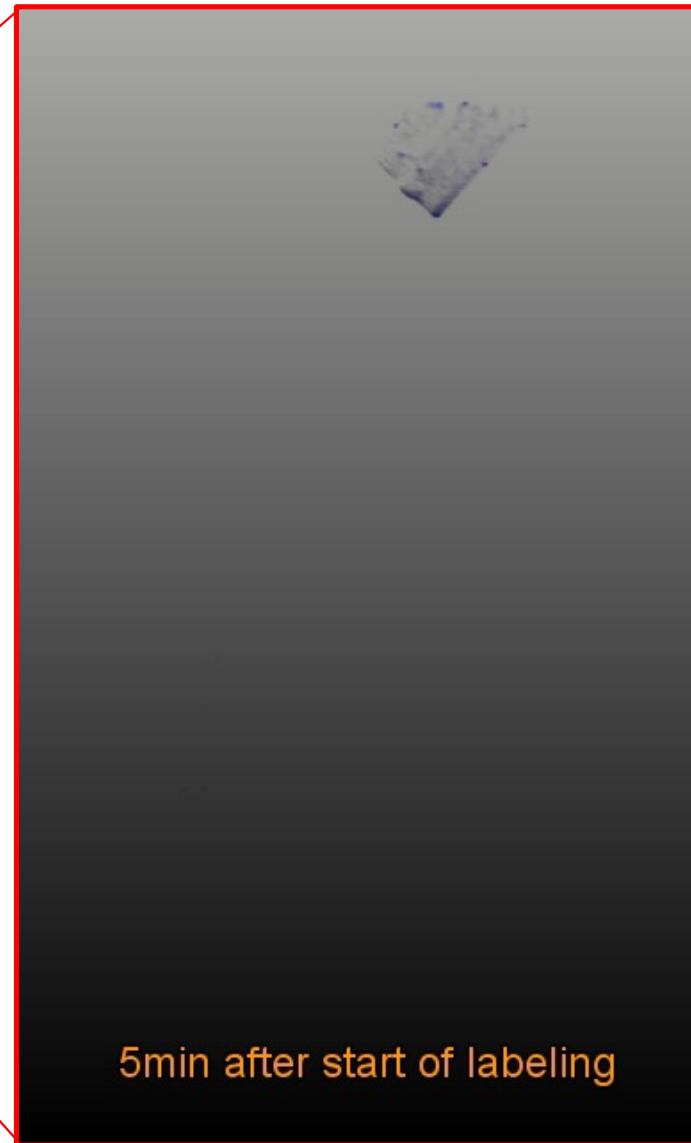


LEAF LABELLING IN CASSAVA



Member of the Helmholtz Association

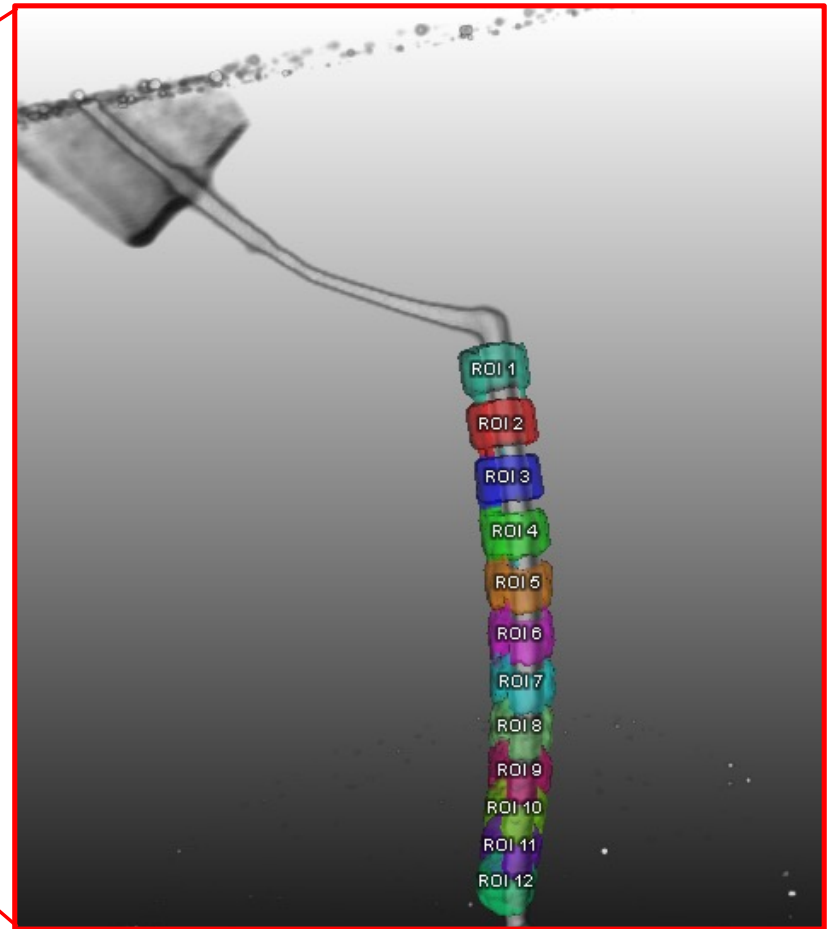
LEAF LABELLING IN CASSAVA



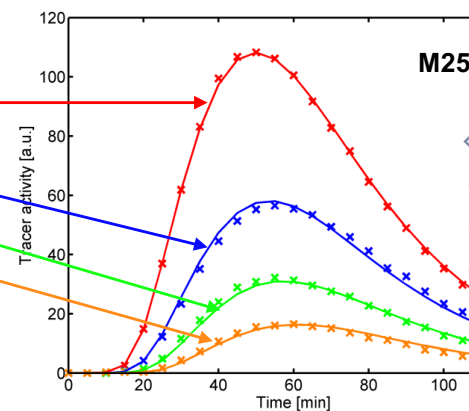
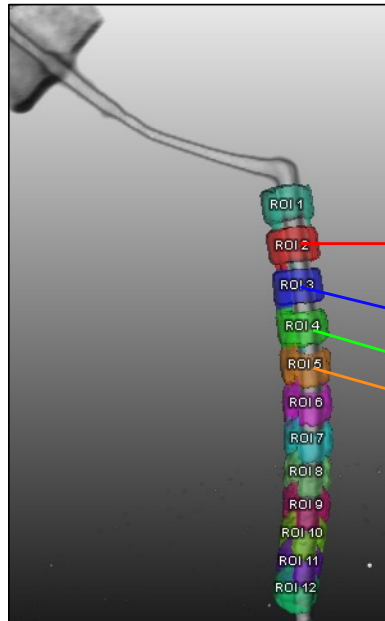
Gray: MRI
Color: PET

5min after start of labeling

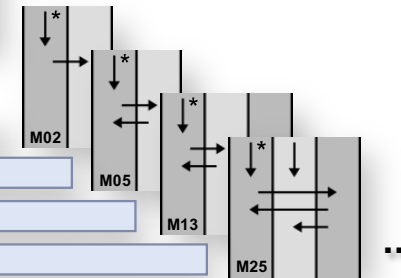
LEAF LABELLING IN CASSAVA



MODEL-BASED TRACER FLOW ANALYSIS



Fitting of compartmental models



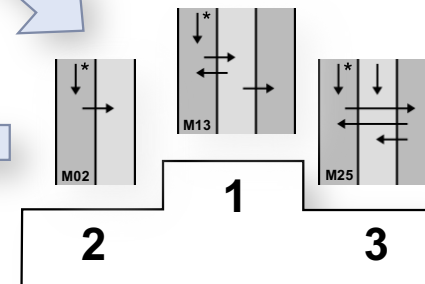
- Fit quality
- Number of parameters
- Stability of parameters

Output of "best" fitting model

Parameter	Parameter estimate	C.I.
Flow velocity	10.3 mm min ⁻¹	18.2%
Lateral loss*	22.0 % cm ⁻¹	1.52%

* Loss available for models with storage compartment

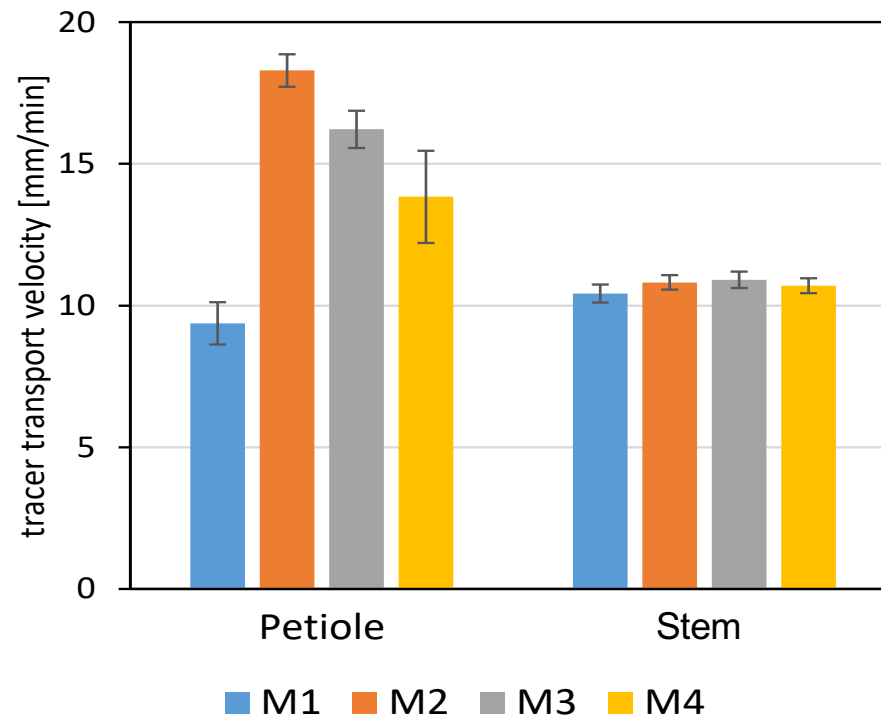
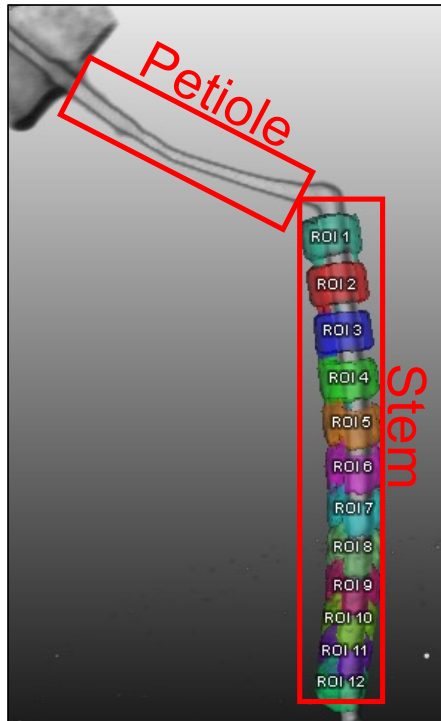
C.I. = Confidence Interval



Model ranking
(AIC)

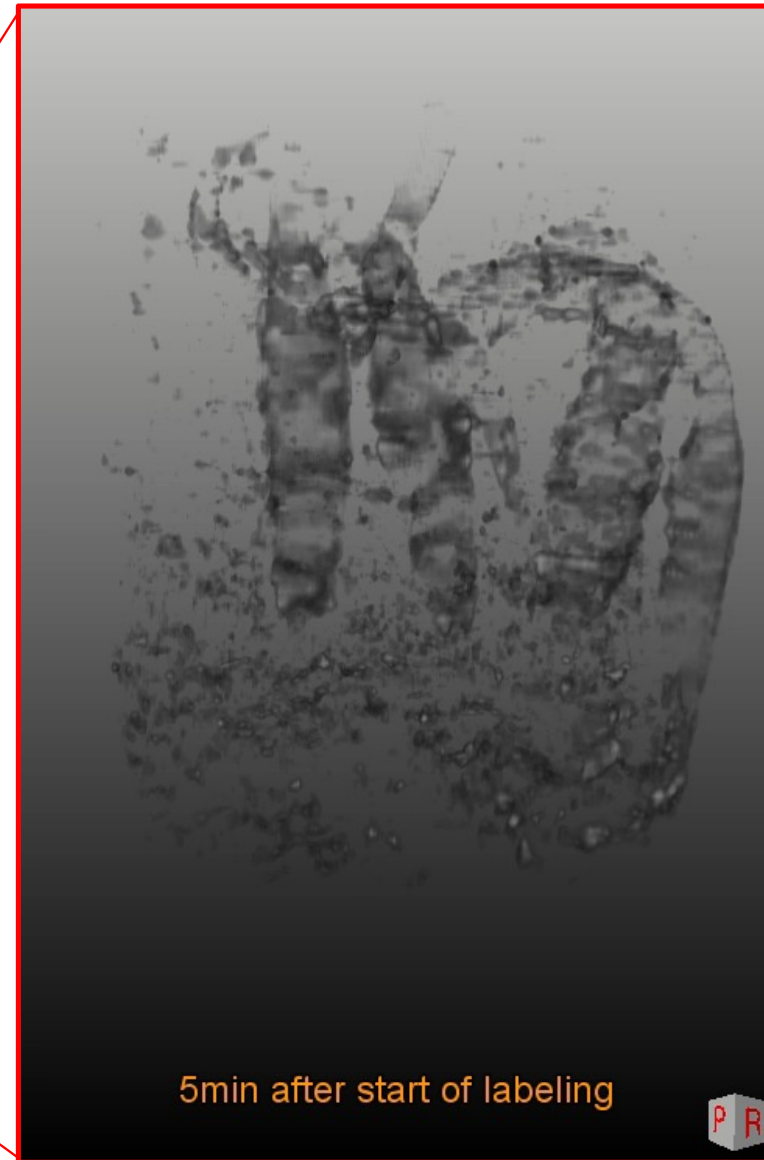
Bühler et al. (2011); Bühler, von Lieres & Huber (2013); Metzner, Bühler et al., unpublished

LOW VARIABILITY IN TRANSPORT VELOCITY IN THE STEM FROM DIFFERENT MEASUREMENTS



M= Measurement #

TRACER FLOW IN ROOTS



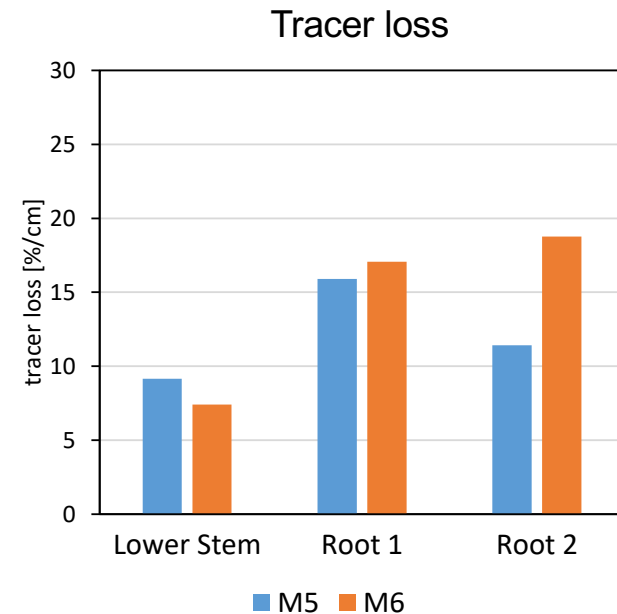
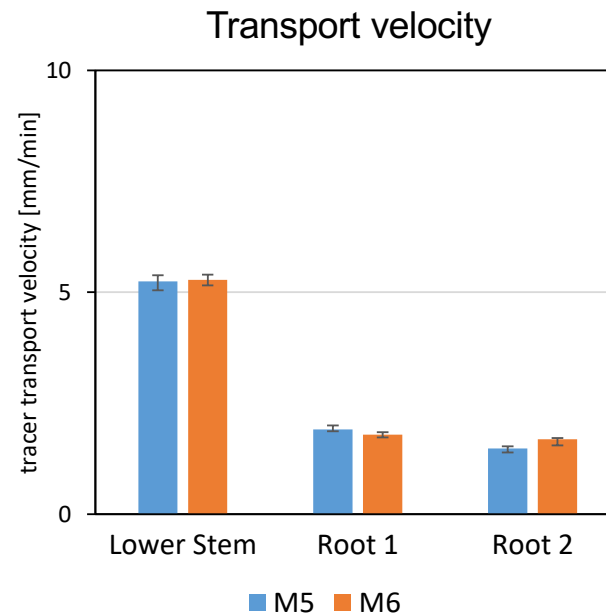
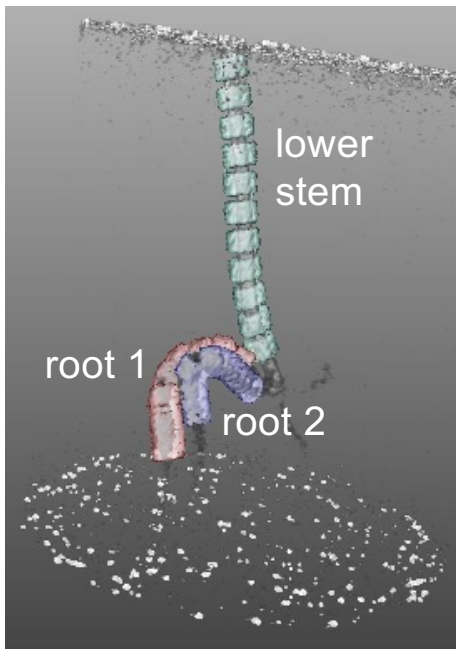
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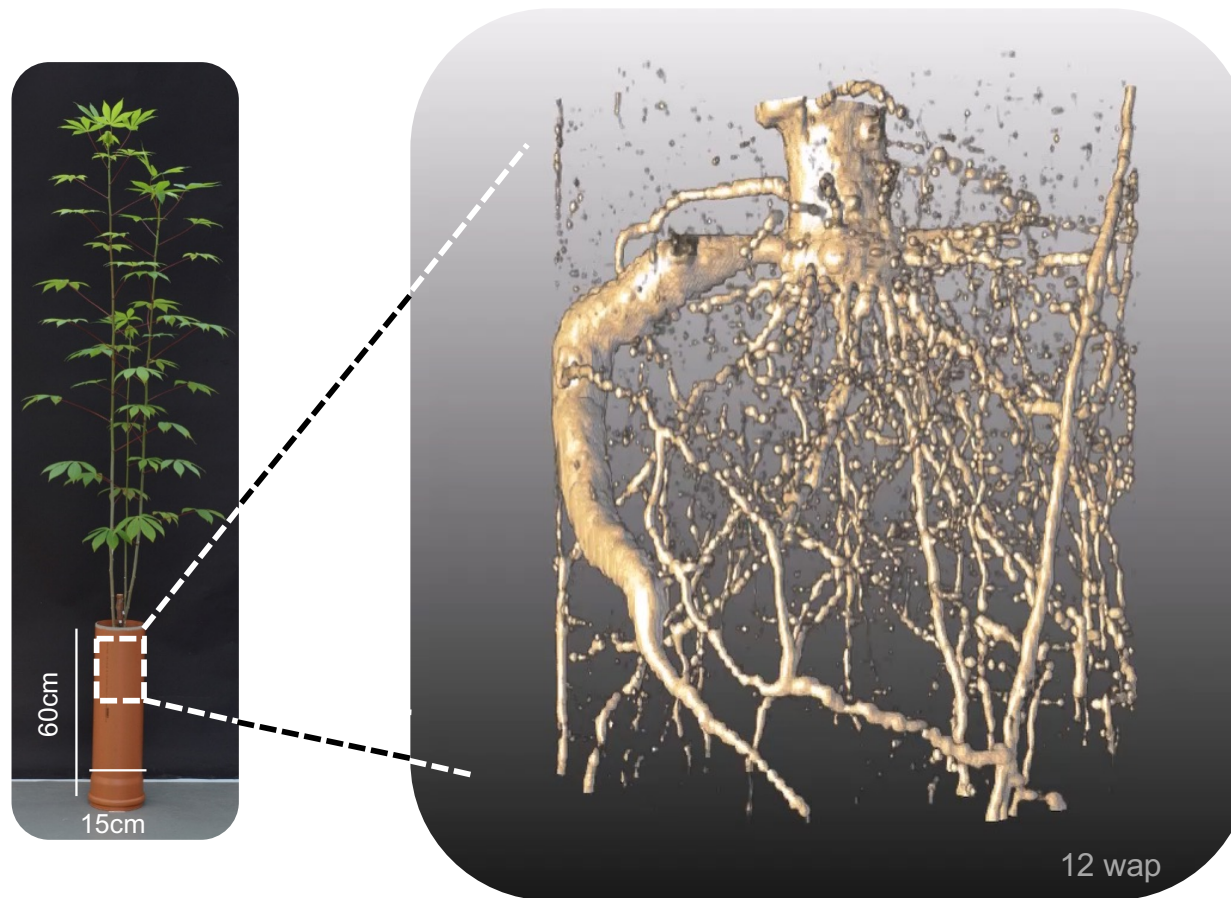
JÜLICH
Forschungszentrum

TRACER FLOW AND LOSS IN LOWER STEM AND ROOTS ALSO SHOW LOW VARIABILITY



M= Measurement #

EXAMPLE OF MRI IN LARGER STORAGE ROOTS (MEASUREMENTS DONE OUTSIDE OF CASS III)



Cassava root

POTENTIAL AND CHALLENGES FOR ^{11}C -PET IN CASSAVA

- Preliminary data from 5 plants and ~30 measurements
- Tracer allocation in the stem and root can be imaged
- Flow velocity from different leaves can be reliably determined in stem and root
- Loss can be estimated currently for the root and part of the stem

- Older leaves and plants under stress conditions can be difficult to measure (Tracer uptake, transport)
- Number of measurements per day limited to ~three
- Auxiliary MRI difficult with potting substrate

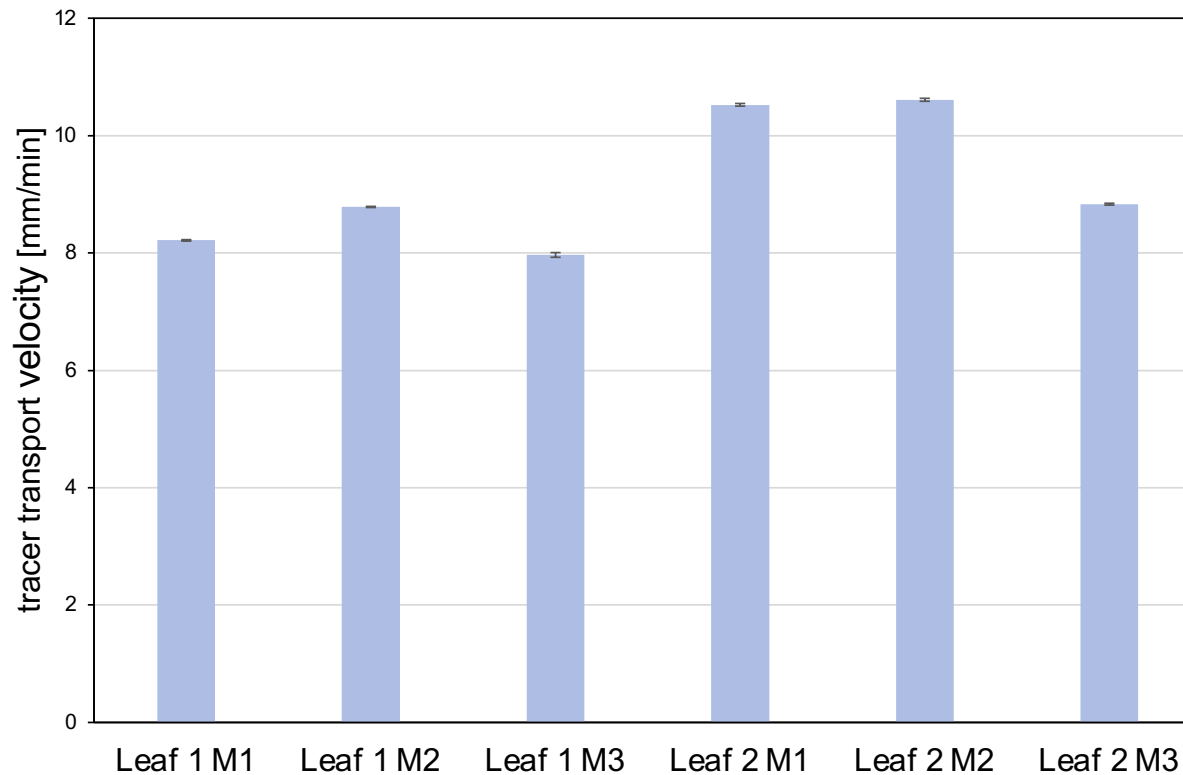


**THANK YOU FOR YOUR
ATTENTION**

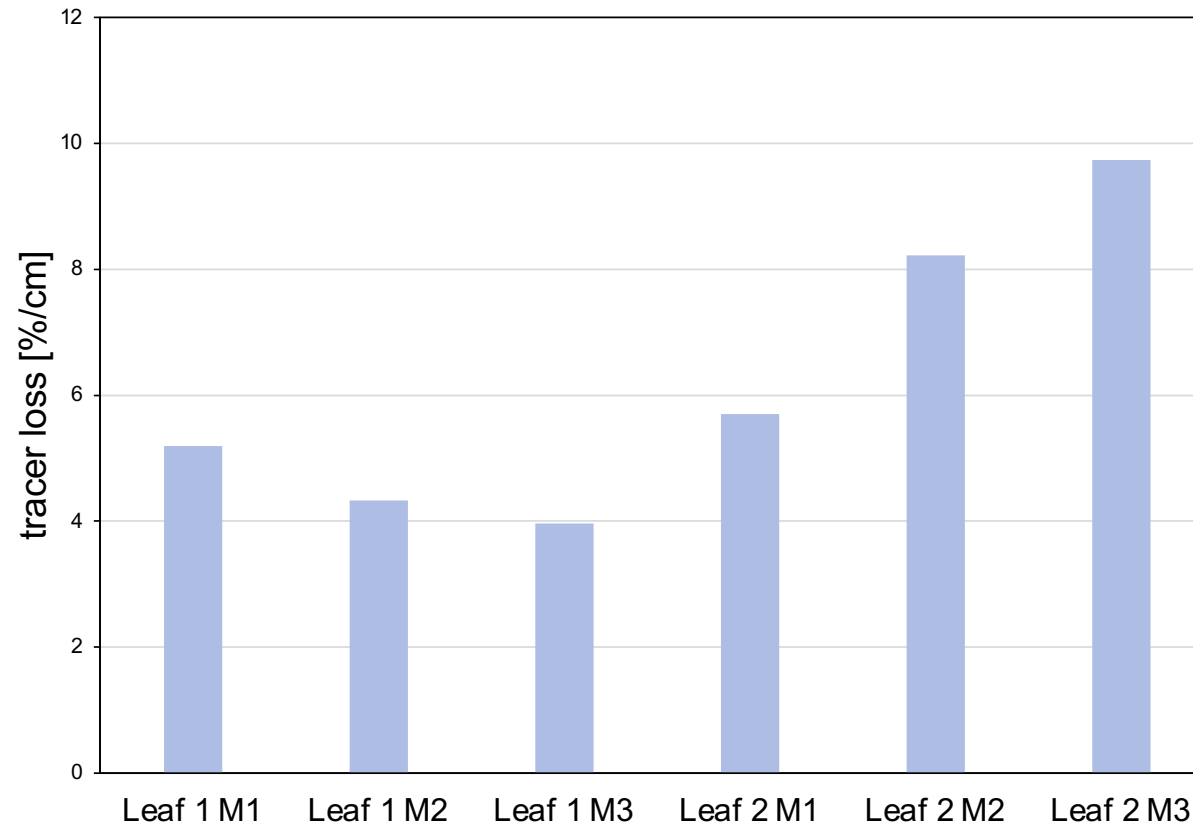
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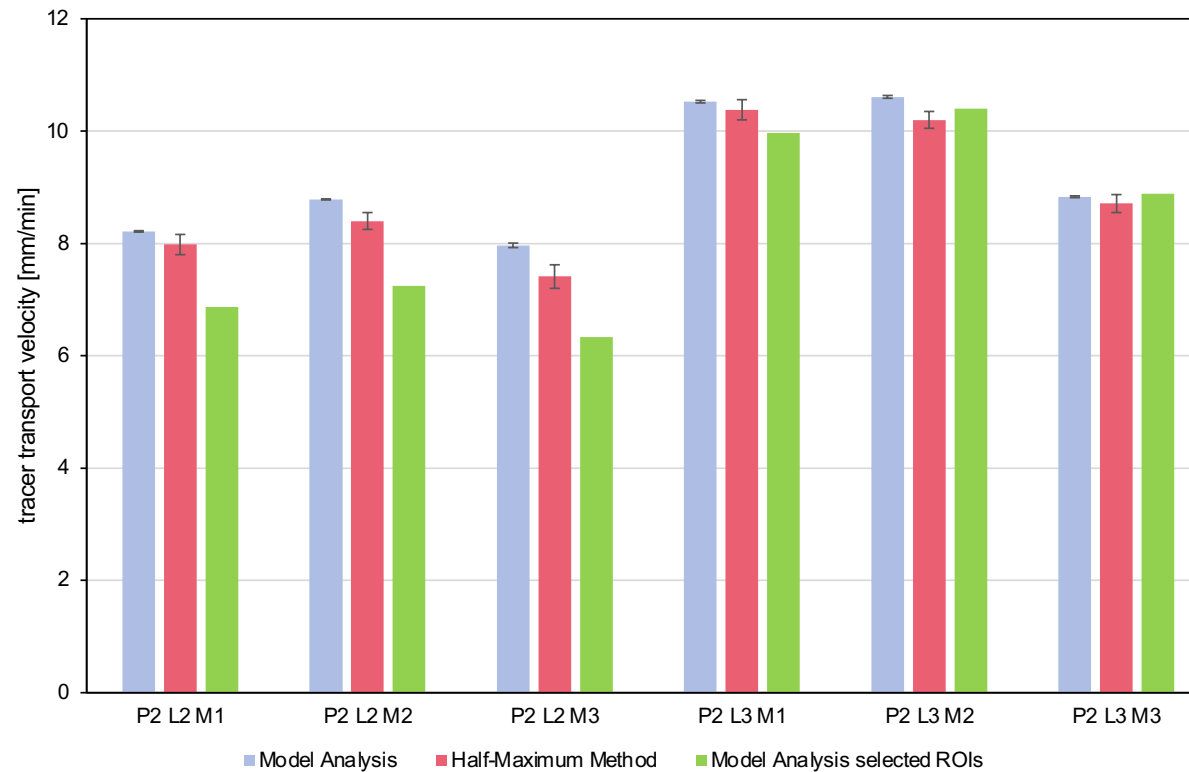
LOW VARIABILITY IN TRANSPORT VELOCITY IN THE STEM FROM DIFFERENT LABELLED LEAVES

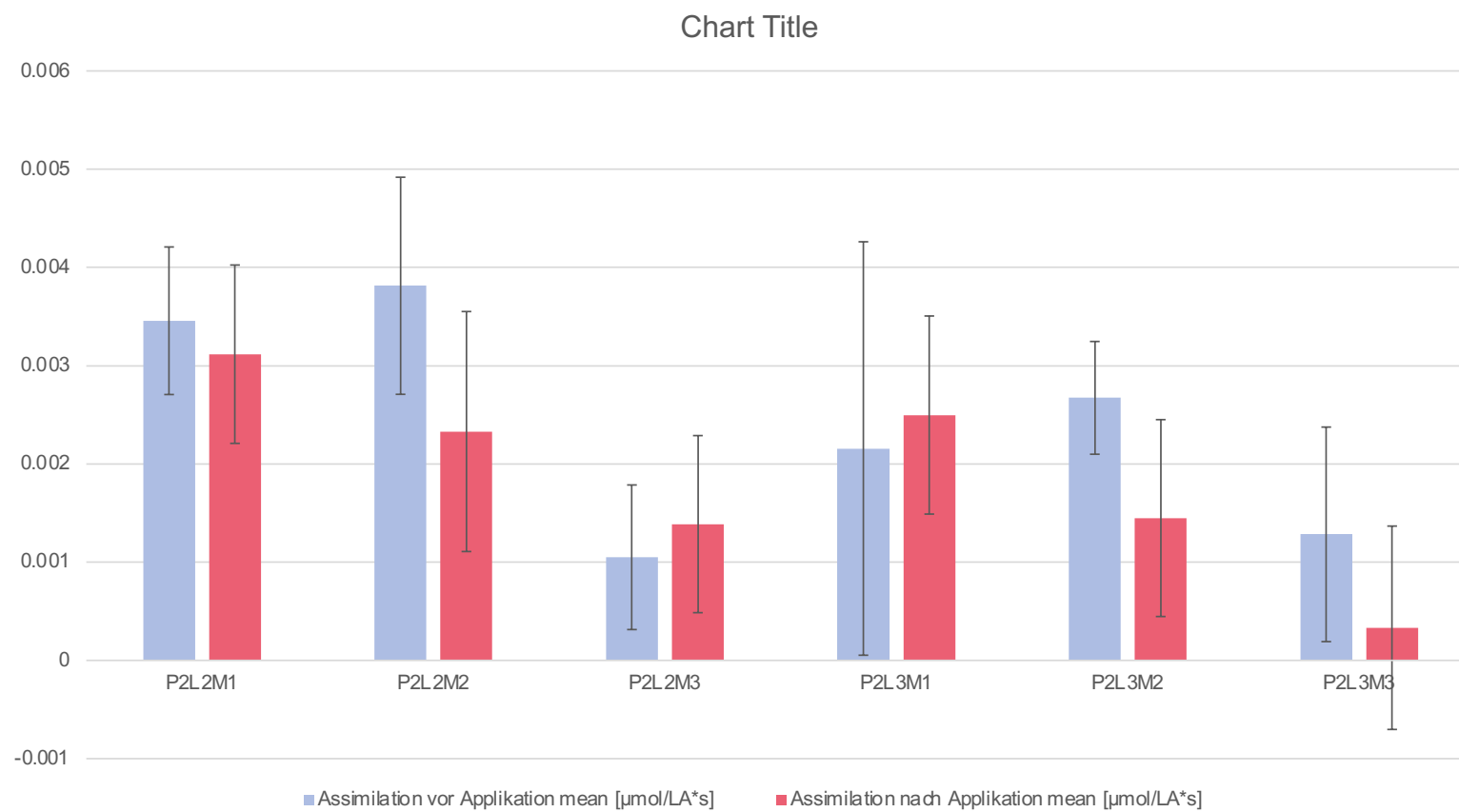


LATERAL LOSS IN CASSAVA SHOOT FROM DIFFERENT LABELLED LEAVES

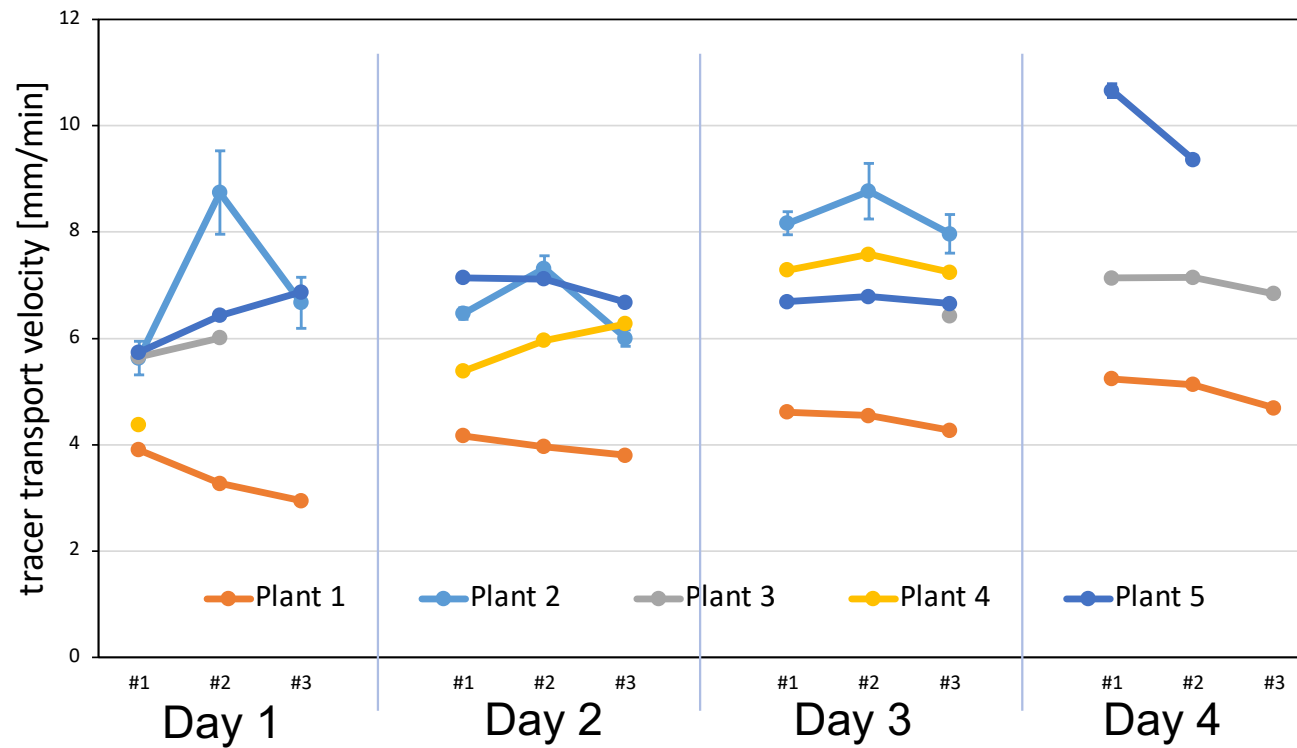


TRACER VELOCITY IN BEAN SHOOTS





TRACER VELOCITY IN BEAN SHOOTS



RADIOTRACER TEAM

Partners @ Forschungszentrum Jülich



IBG-2/Enabling Technologies

