Deutsches Pflanzen Phänotypisierungs- Netzwerk

DPPN

JÜLICH FORSCHUNGSZENTRUM

Noninvasive 3D Root Imaging

D. Pflugfelder, D. van Dusschoten, J. Kochs, R. Metzner, R. Koller, J. A. Postma, J. Bühler, A. Chlubek, S. Jahnke
IBG-2: Plant Sciences, Forschungszentrum Jülich

Goals:
- Noninvasive imaging of 3D root system architecture (RSA) and function in natural soil
- Identification of structural and functional root system traits
- Monitoring the development of root system traits during plant growth and identifying traits of resource use efficient roots

Magnetic Resonance Imaging (MRI)

Project status
- Dedicated 4.7T plant MRI [1]
- High contrast 3D root images due to suppressed soil signal
- Automated measurements with a prototypic robot system
- MRI data analysis software to:
  - Extract RSA automatically
  - Manually correct obtained RSA
  - Calculate traits from RSA
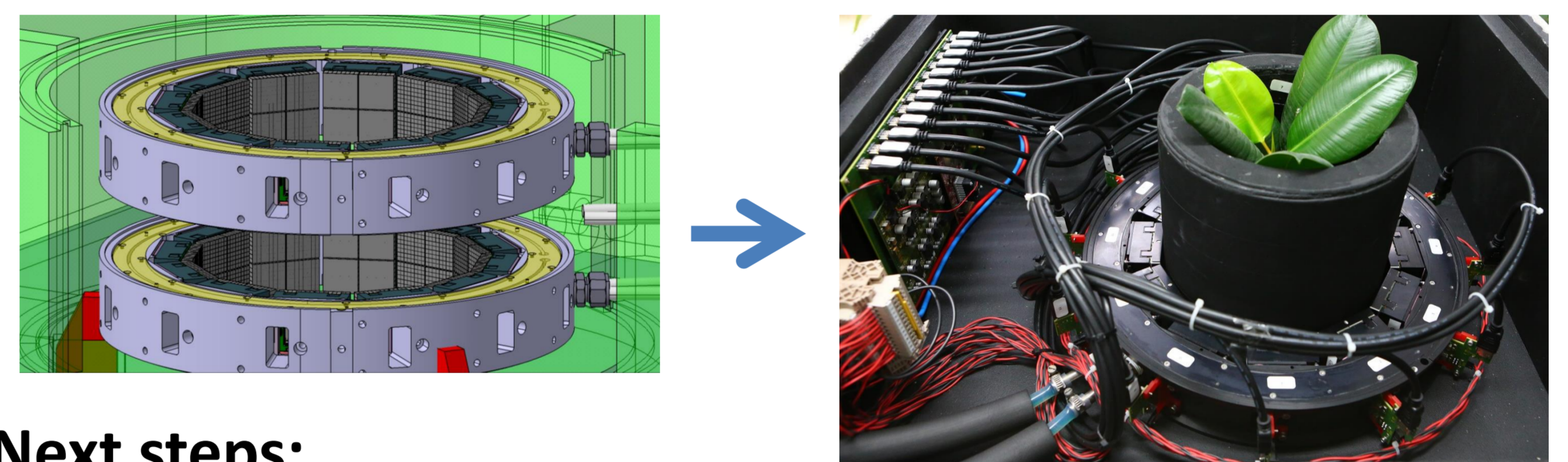
Next steps:
- Measurement series on a variety of species/genotypes/treatments
  → see Poster:
- Improve automated extraction of RSA
- Setup of an image database infrastructure

## Positron Emission Tomography (PET)

Project status
- First tracer experiments with an existing, but rather insensitive PET system (PlanTIS [1])
- New plant dedicated, highly sensitive PET system (*pheno*PET) currently been assembled
- First test measurements acquired

Next steps:
- Finish buildup and testing of *pheno*PET system
- Development of quantitative image reconstruction for improved monitoring of tracer transport parameters
- Development of systems to facilitate automated combined MRI-PET measurements

Results: Data extraction from MRI images

Diameter [mm]
1.50
1.30
1.10
0.900
0.700
0.500
0.300
0.100

30mm

30mm
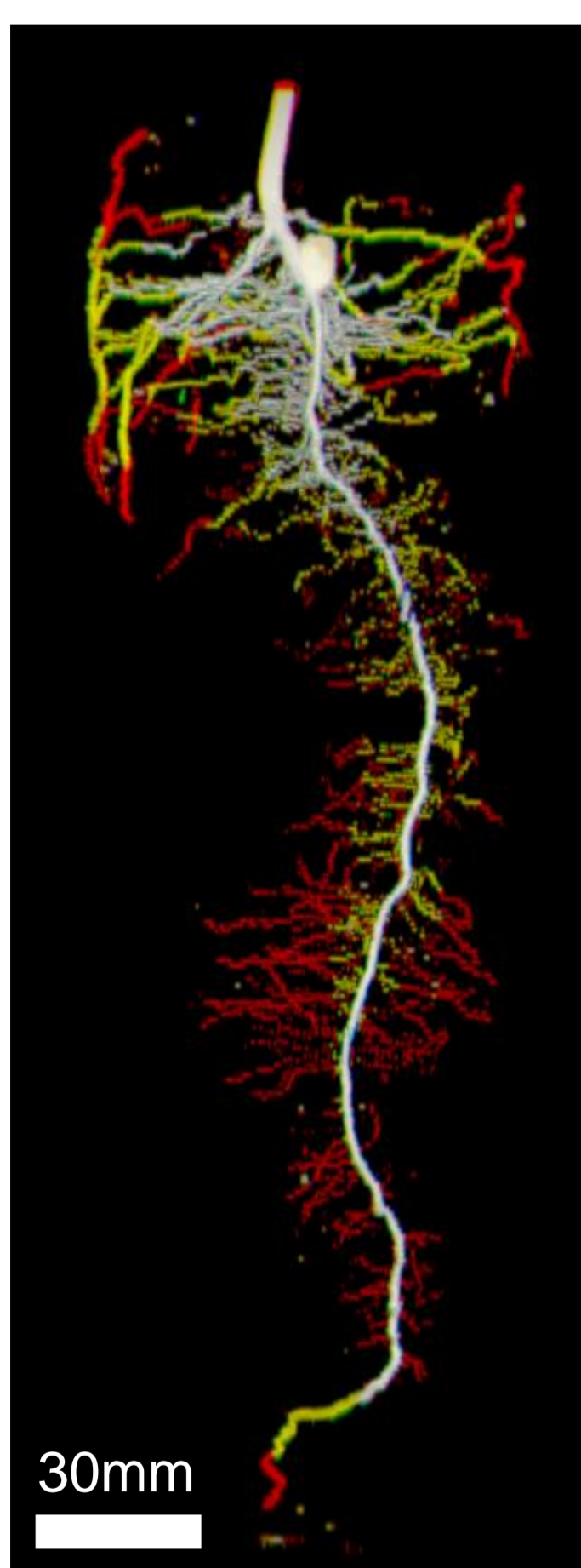
MRI Image of maize root White/yellow/red: 9/12/15 days after sowing (DAS) Image resolution: 0.5x0.5x1.0mm
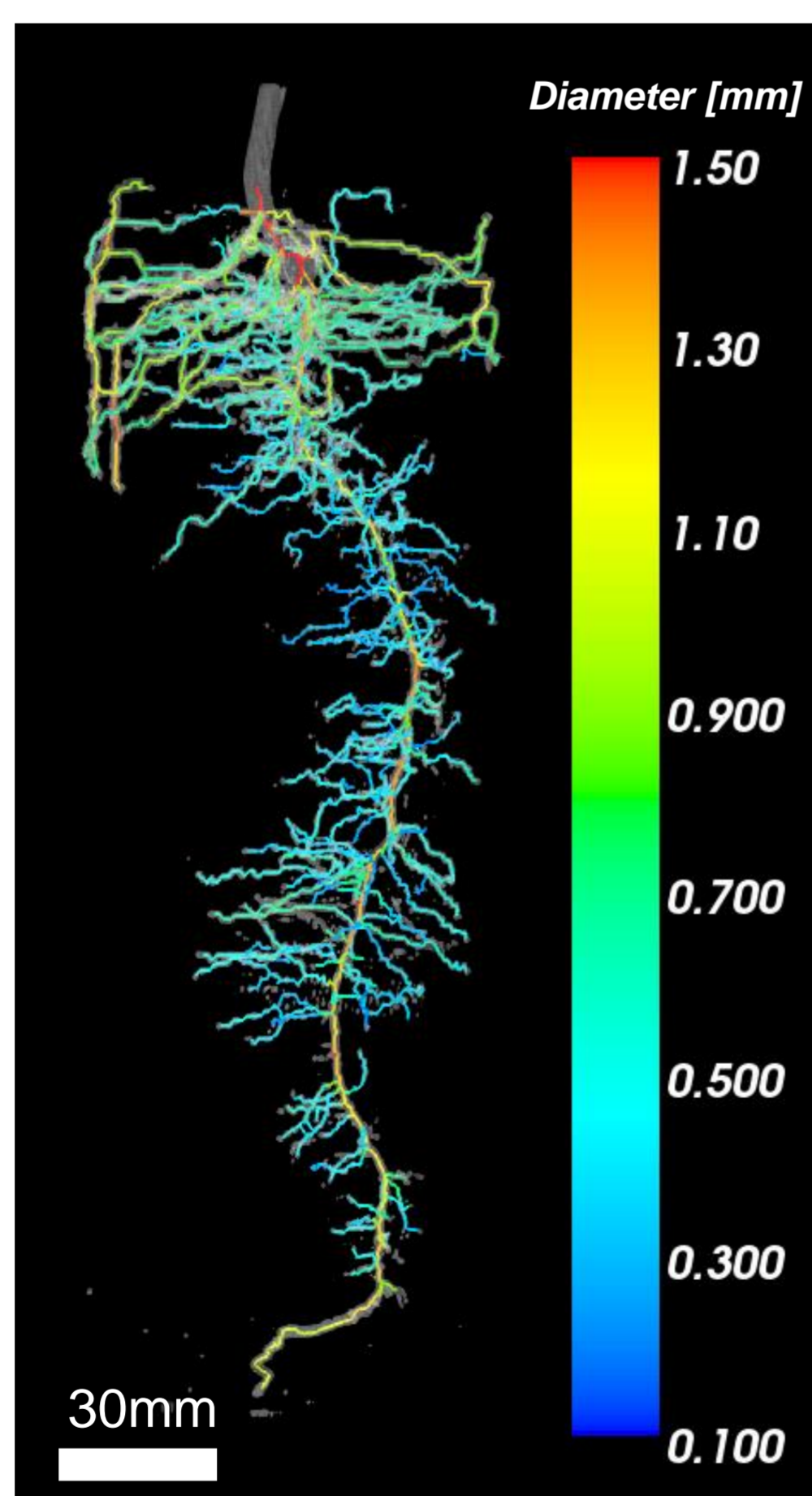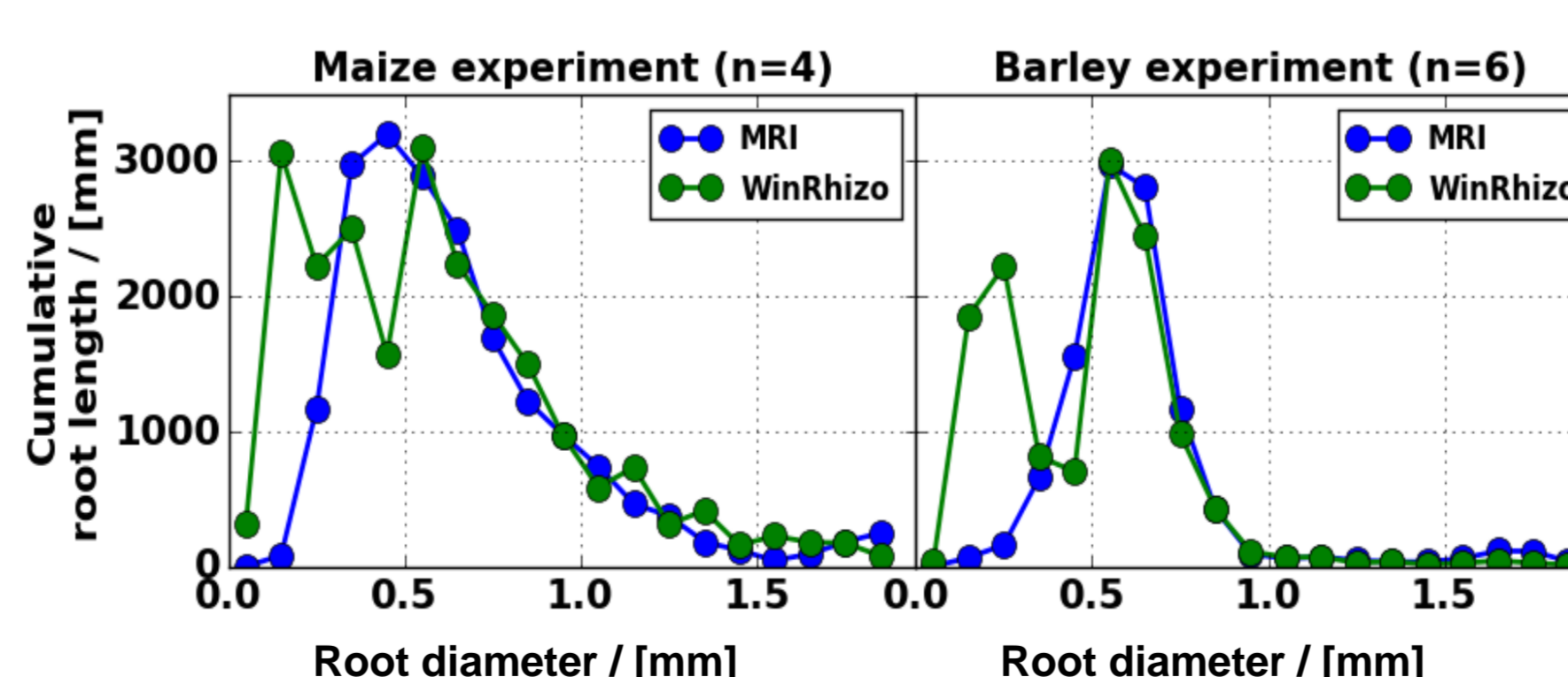
Extracted RSA overlaid on MRI data (15 DAS). MRI signal intensity allows estimation of subvoxel sized root diameters.
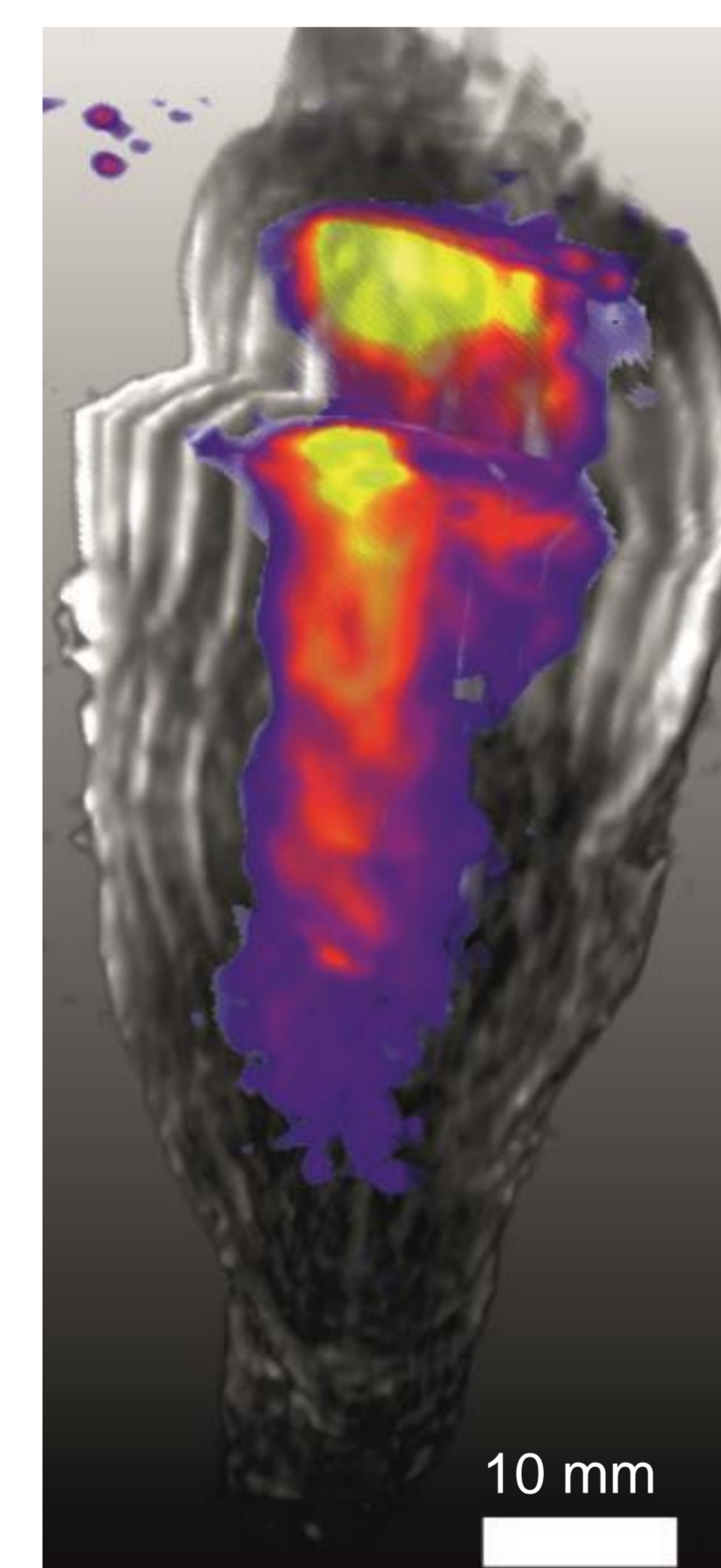
Selective traits obtained from shown MRI data:

Days after sowing	Number of Root tips	Fresh weight [g]	Total Root Length [mm]	Primary root length [mm]	Lateral root length [mm]	Mean lateral length [mm]
6	6	0.22	241	208	33	7.3
9	79	0.49	1380	325	1055	13.9
10	113	0.86	2049	355	1694	15.5
12	186	1.16	3625	412	3213	17.8
13	234	1.36	4619	436	4183	18.3
15	302	1.57	6204	470	5734	19.4

Comparison of root diameter estimates obtained by MRI and WinRhizo:

Maize experiment (n=4) — MRI, WinRhizo
Barley experiment (n=6) — MRI, WinRhizo

Cumulative root length / [mm] (y-axis: 0, 1000, 2000, 3000)
Root diameter / [mm] (x-axis: 0.0, 0.5, 1.0, 1.5)

Results: Fused MRI/PET images

10 mm

15 mm

Sugar beet, 110 DAS   Maize root, 11 DAS

Grayscale: MRI data
Color: PET image showing ^{11}C tracer distribution.
For quantification of tracer transport, see [2]
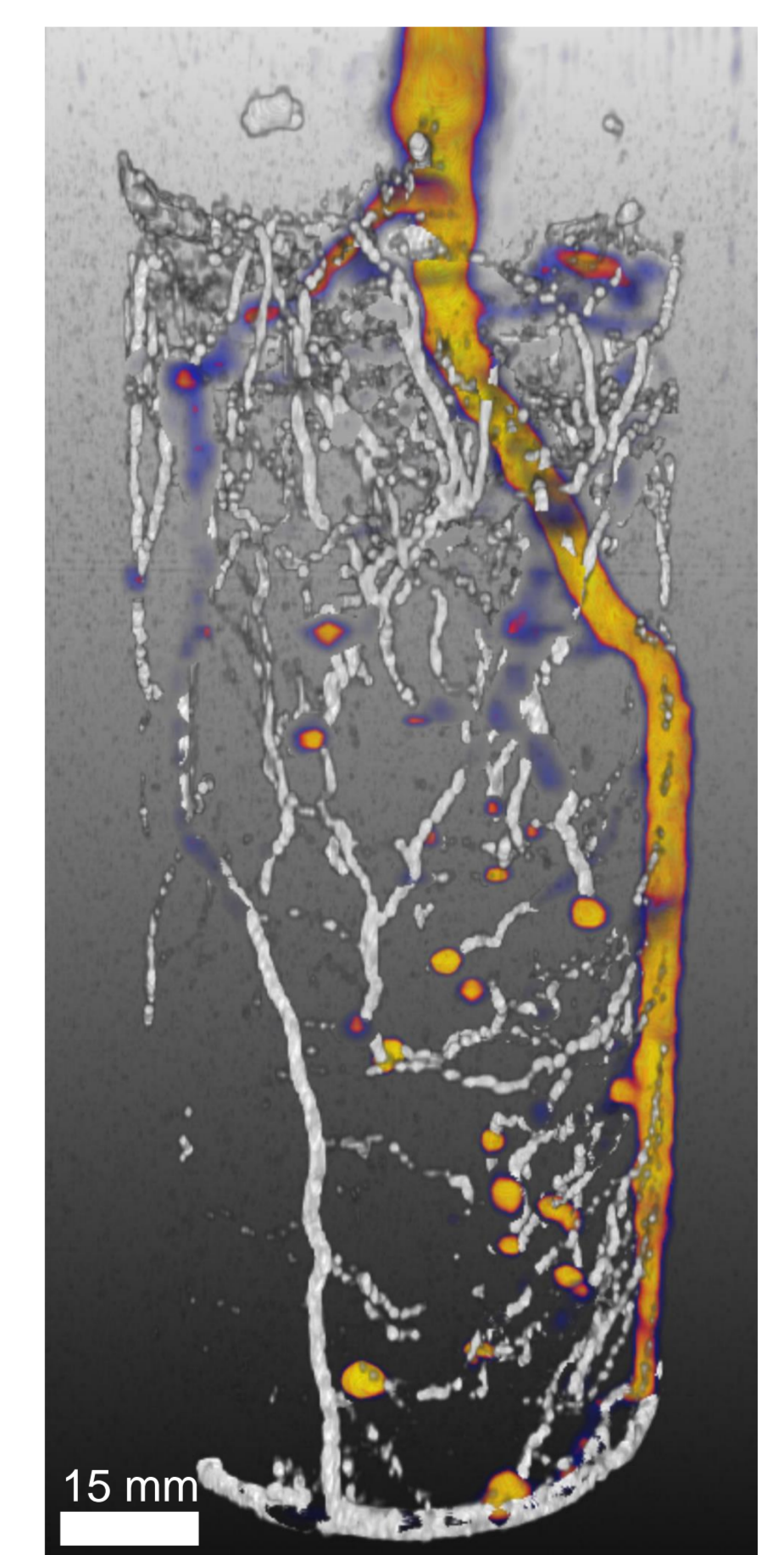
[1] S. Jahnke et al.: Combined MRI-PET dissects dynamic changes in plant structures and functions. The Plant Journal (2009) 59, 634–644
[2] J. Bühler et al: A class of compartment models for long-distance tracer transport in plants. Journal of Theoretical Biology (2014) 341, 131–142

www.dppn.de

Bundesministerium für Bildung und Forschung