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Helium Ion Microscopy studies of biological/biomedical samples, elemental identification and atomic size defects

Viacheslav Manichev, Leonard C. Feldman and Torgny Gustafsson

Summary

1. Imaging Rat Kidneys

2. Calcification Centers of Corals

3. Elemental Identification in HIM

4. STEM Imaging of Ion-Beam induced Defects in MoS_2 monolayers

e New York Times

ASING IMMORTALITY

Test Drug Aimed at Humans' Biggest Killer: Age

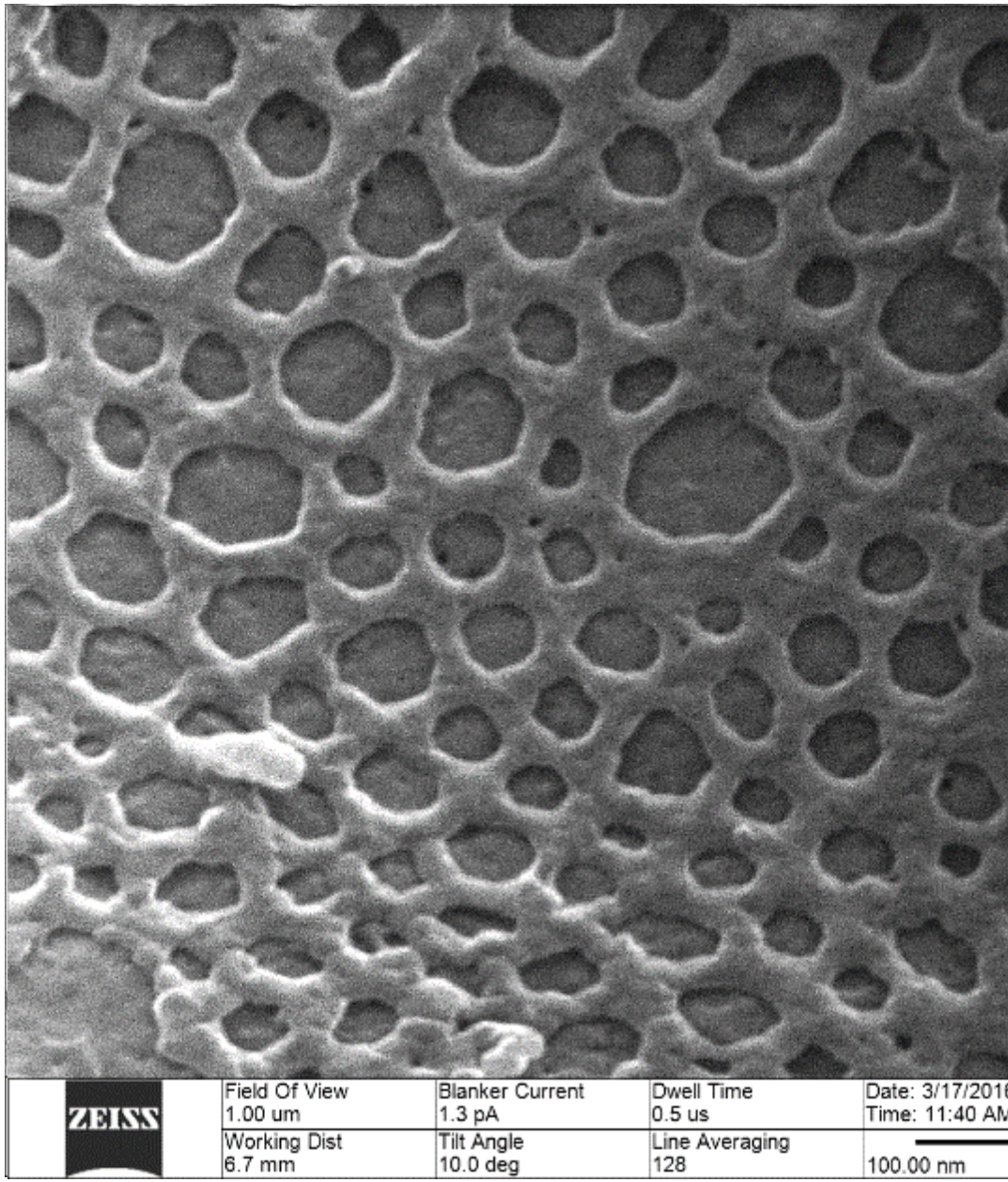
ON MAY 16, 2016

her dog, Bela, at a park near their home in Seattle. Bela has participated in a trial of at has lengthened the lives of laboratory mice. Ruth Fremson/The New York Times

Rat Kidney

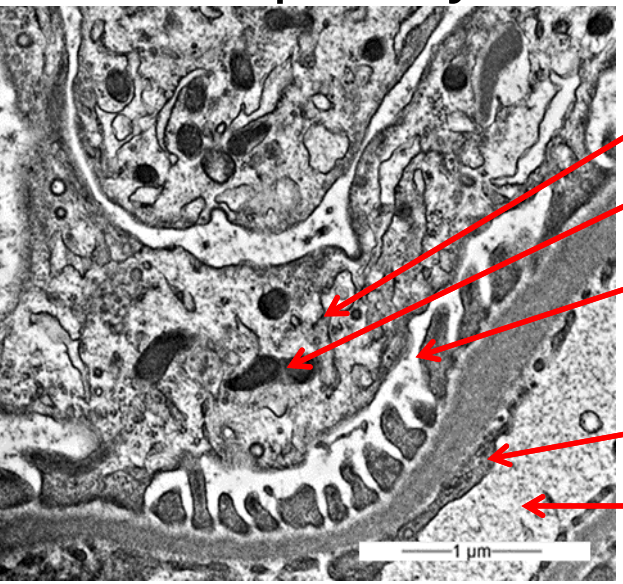
omeruli located in kidneys
e responsible for the first
age filtration of blood. We
udy age and disease related
amage of podocytes (feet like
ructures).

ork done with H. Szeto, L.
hen-Gould et al, Weill-Cornell
edical Center, NYC



Normal podocytes

Kidney samples obta
from young rat



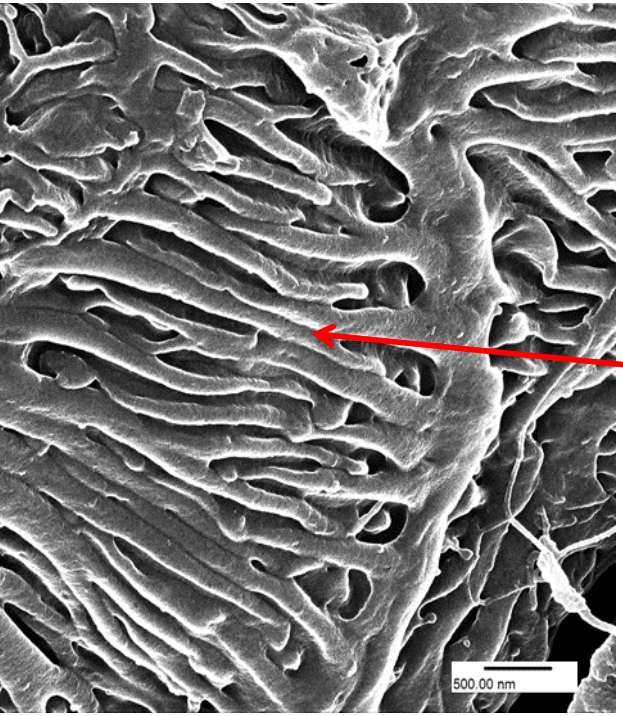
Podocyte

Podocyte mitochondria

Podocyte foot processes

Endothelial cell fenestration lining capillary

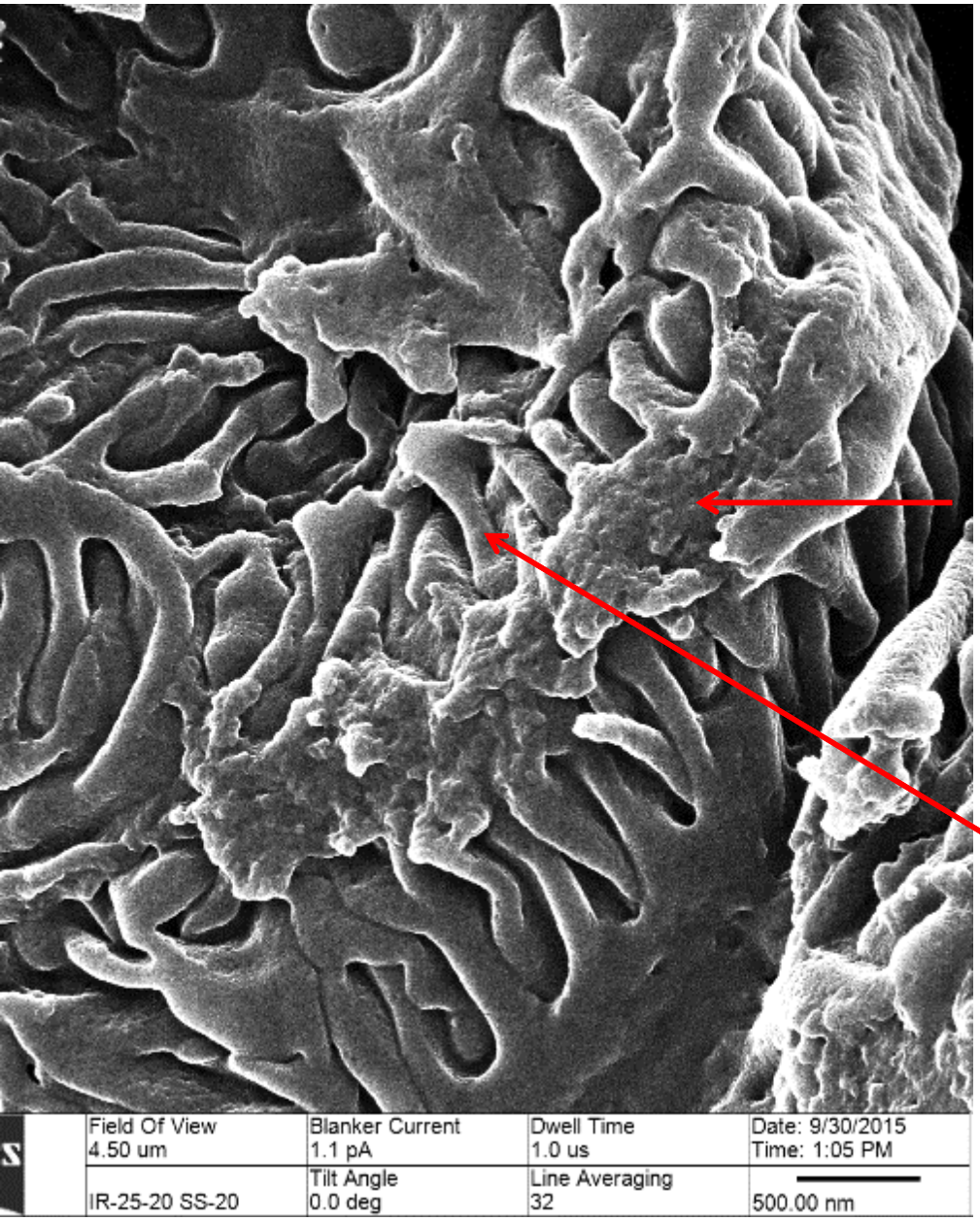
Capillary



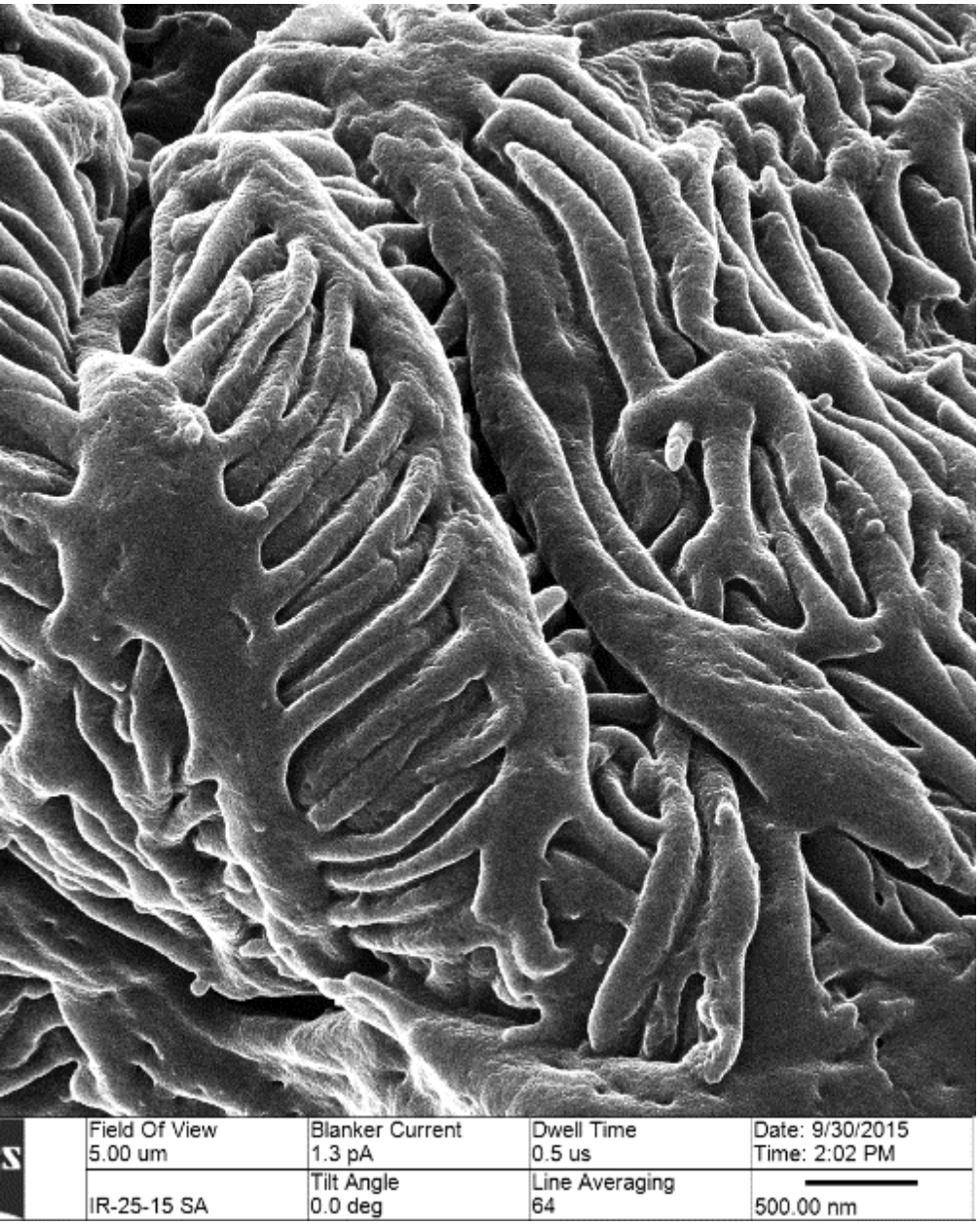
Podocyte foot processes interdigitating
over the surface of a capillary

4 weeks after ischemia

Kidney sample obt
34 weeks after acu
of blood flow for 45



20 treated after ischemia



Kidney sample obt
34 weeks after acu
of blood flow for 45
Rat was treated wi
20 from week 4 to
10 after acute isch

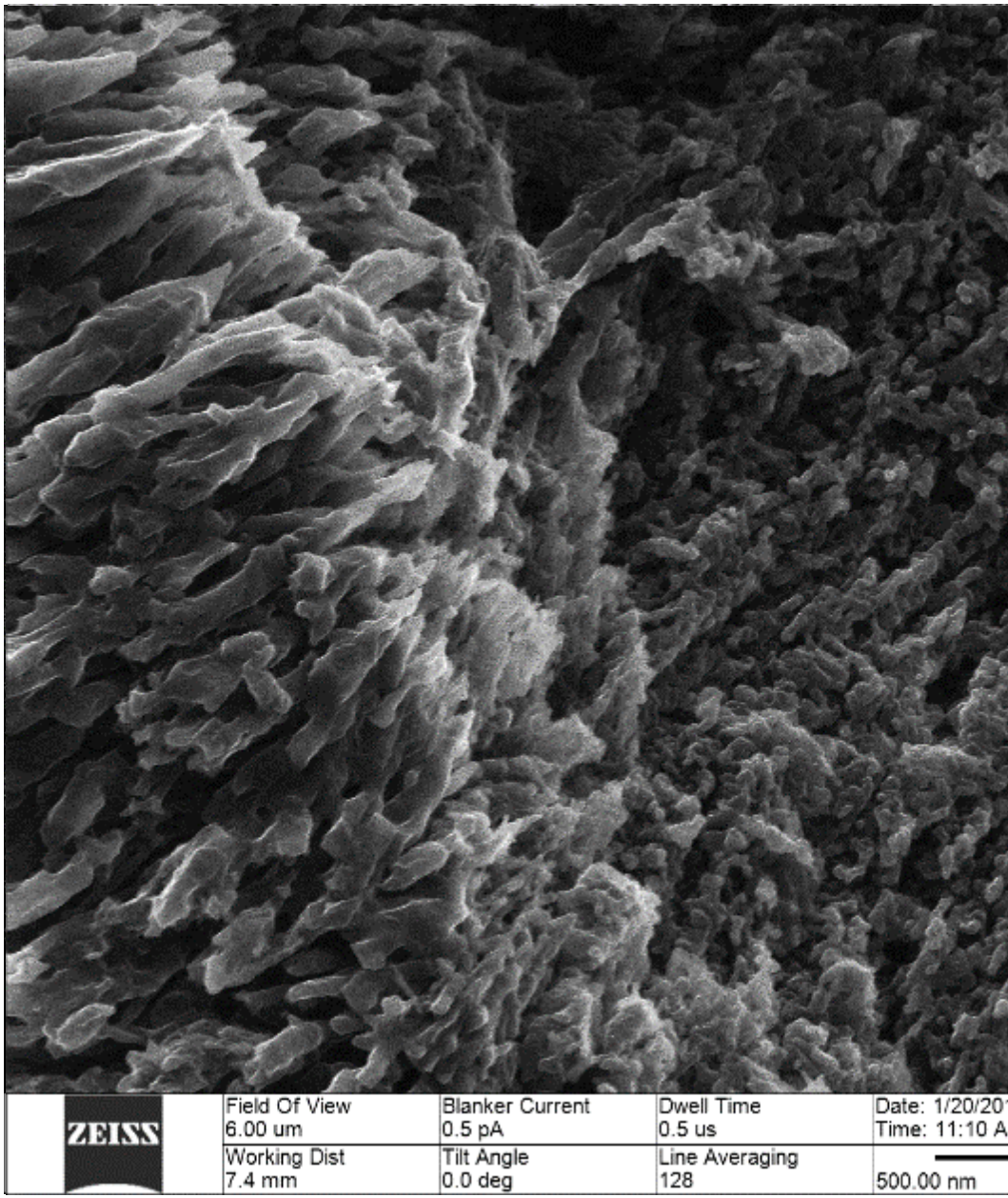
Treatment with SS-20 restored podocyte health – normal cytoplasmic density and mitochondria. Foot processes are long and narrow over capillary

HIM shows podocytes are not swollen and good interdigitation

Calcification Centers of Corals

oday our understanding of the lcification process in the coral very limited. A quarter of the orld's coral species may go tinct by 2050 due to climate hange and rapid rise in ocean cidity.

ork done with S. V. Euw, P. G. lkowski et al, Rutgers



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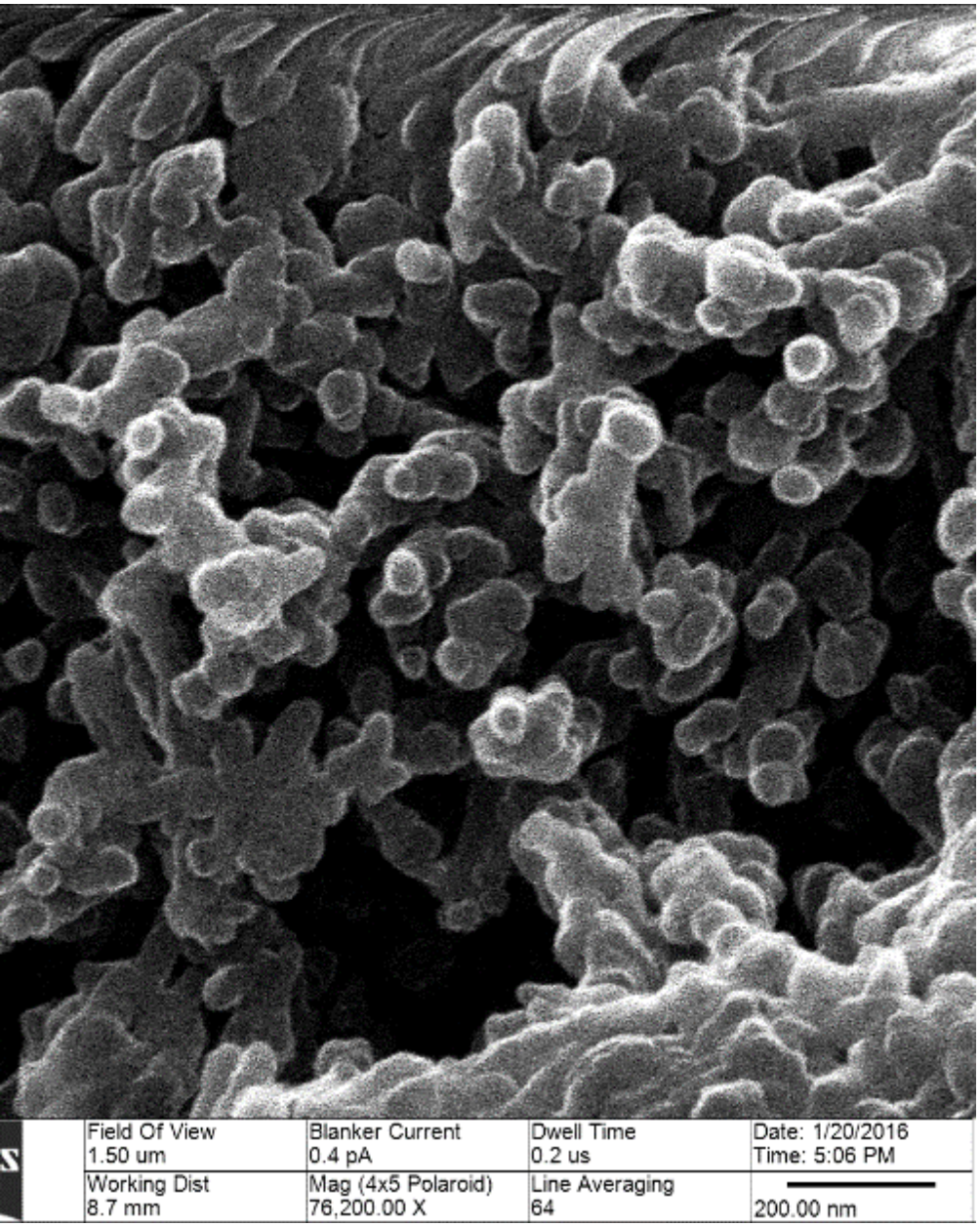
Field Of View
1.50 um
Blanker Current
0.4 pA
Dwell Time
0.2 us
Date: 1/20/2016
Time: 5:06 PM
Working Dist
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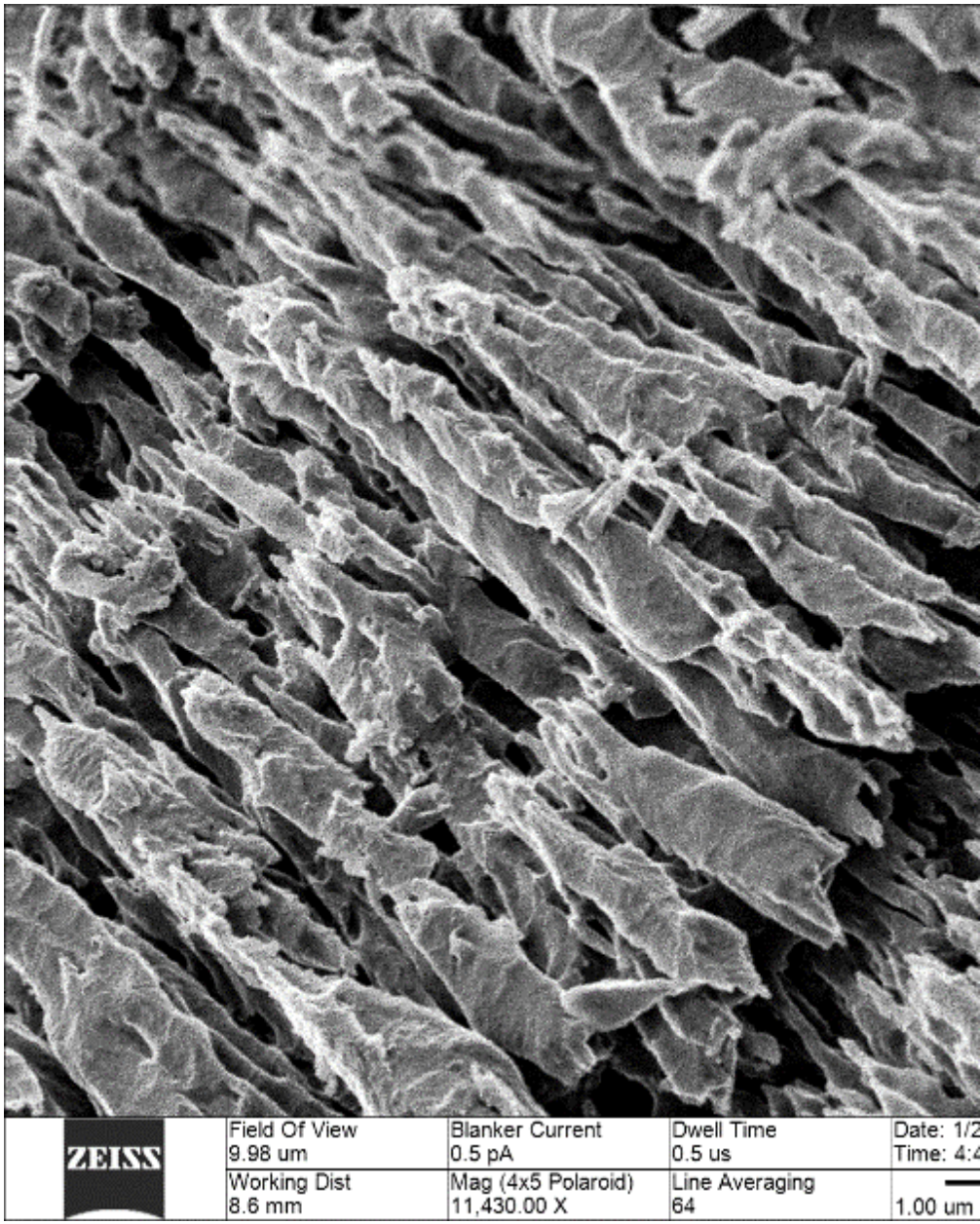
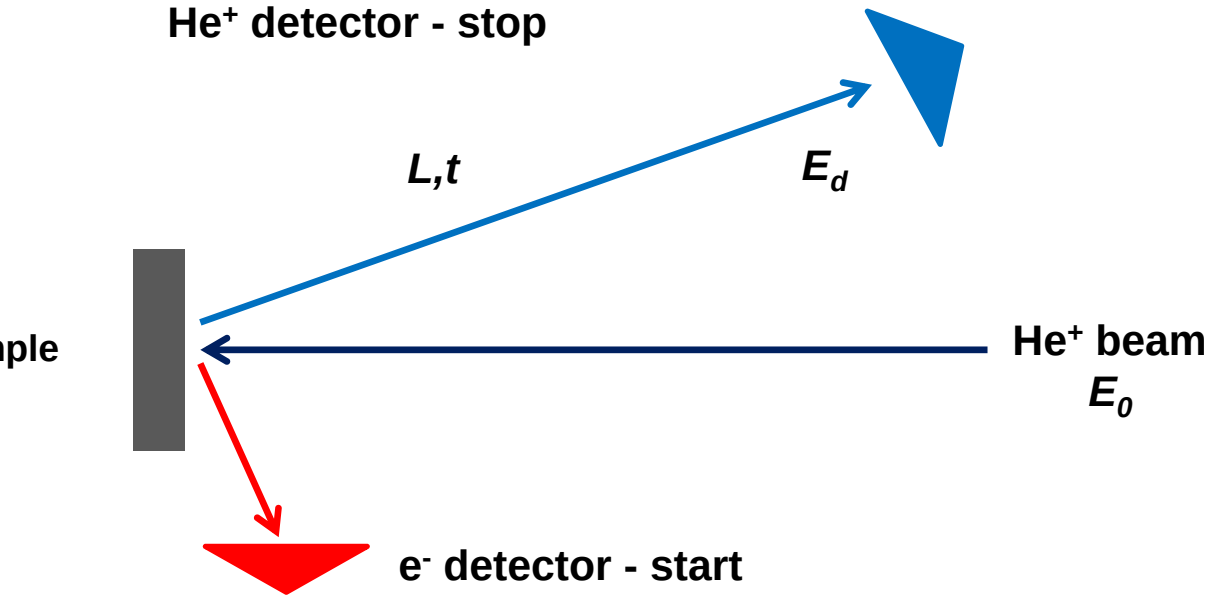
Mag (4x5 Polaroid)
76,200.00 X
Line Averaging
64
200.00 nm


ZEISS
Field Of View
9.98 um
Blanker Current
0.5 pA
Dwell Time
0.5 us
Working Dist
8.6 mm
Mag (4x5 Polaroid)
11,430.00 X
Line Averaging
64
1.00 um

Chemical Identification in HIM

In collaboration with
Albert J. Schultz – Ionwerks, Inc.

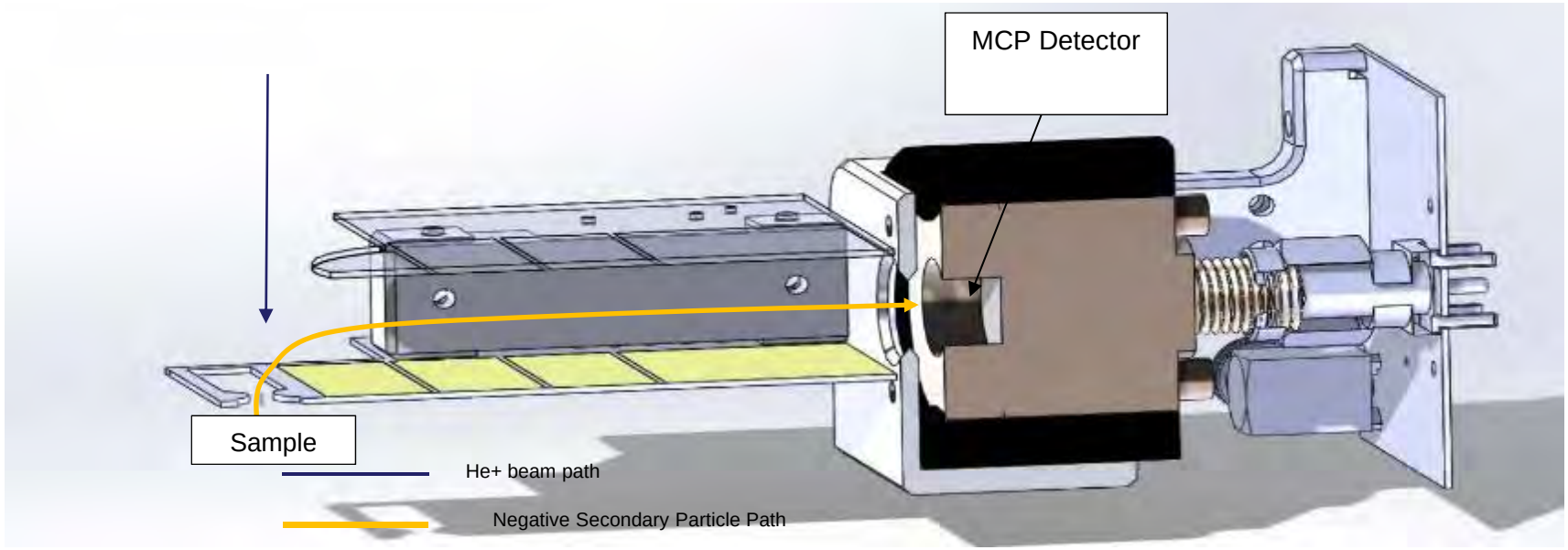
New detection system – HIM – Ionwerks/Rutgers

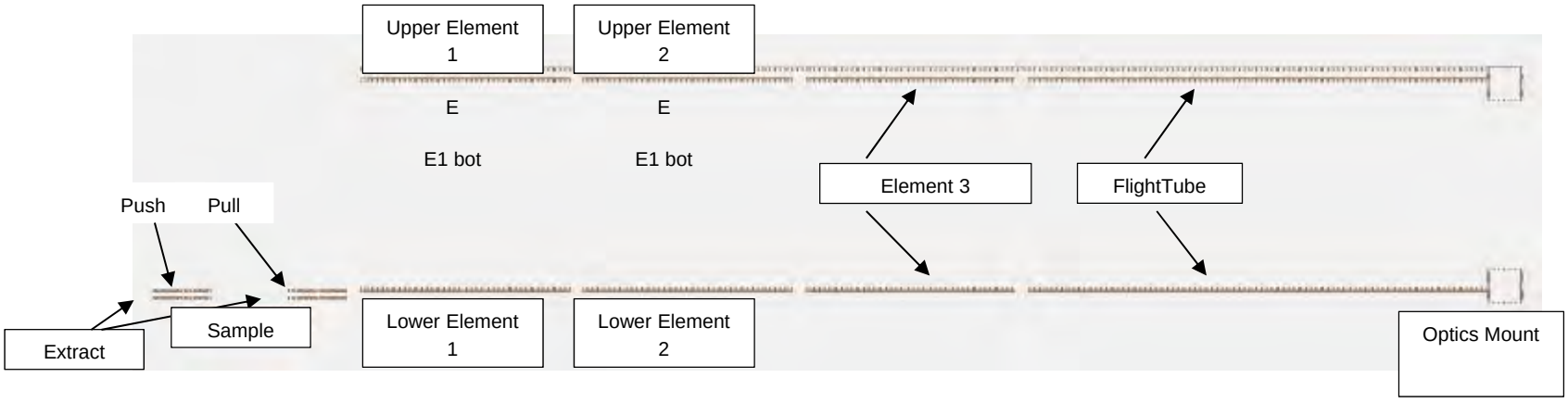


- He-e coincidence
- Time-of-flight spec

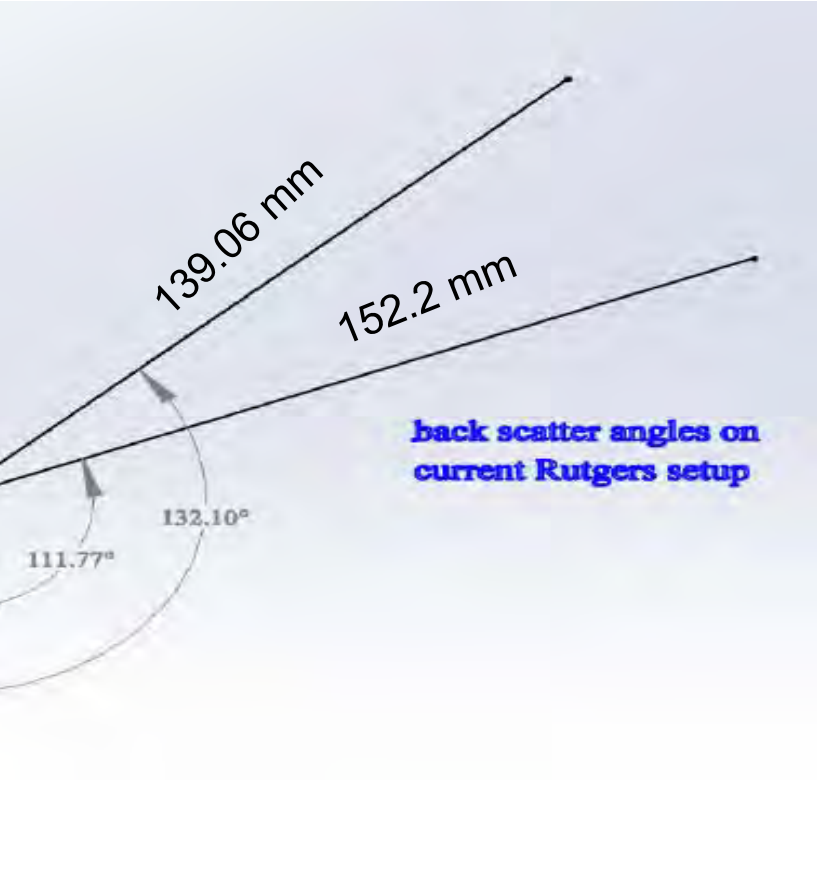
$$E_d = \frac{1}{2} m \left(\frac{L}{t}\right)^2$$

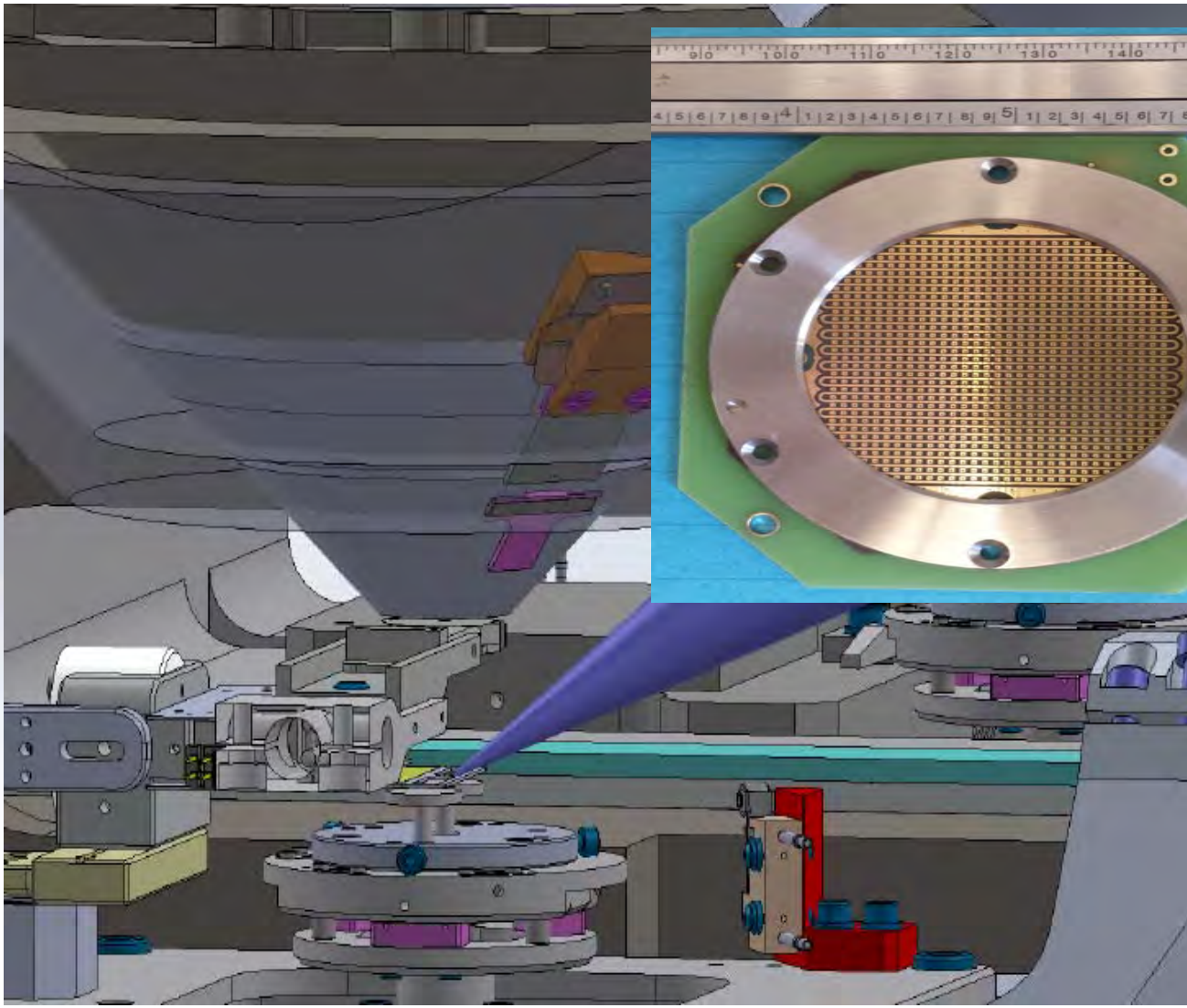
Detectors - SED





etectors

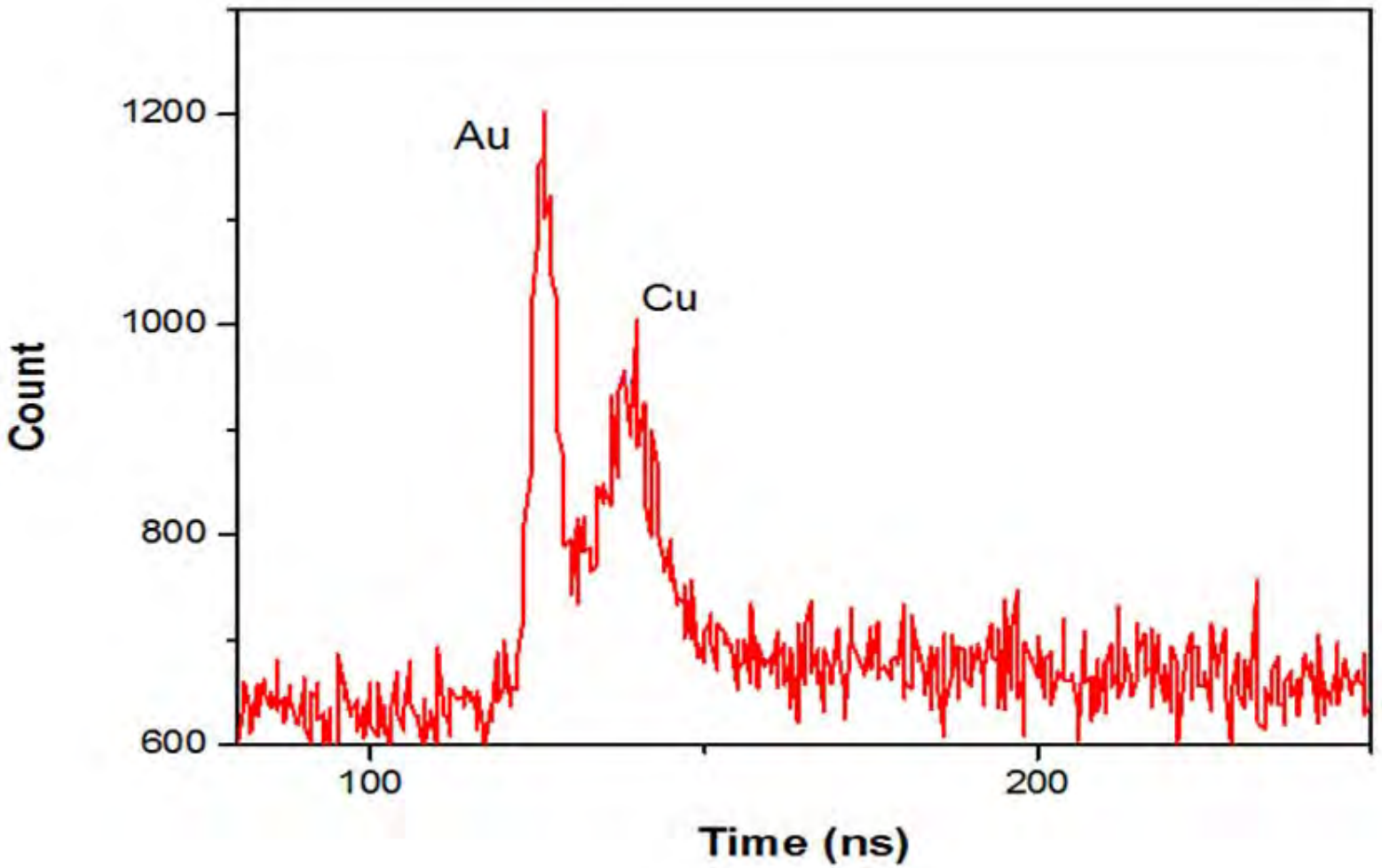

139.06 mm
152.2 mm
back scatter angles on
current Rutgers setup
132.10°
111.77°



Target Specifications

- Flight Length ~130mm (110ns)
- Energy Resolution: 0.11 Kev or 200ps (Today 1.1 Kev or 2 ns)
- Operating Beam Current ~1 pA
- Separate ^{69,71}Ga from ^{75}As, ^{12}C from ^{13}C
- Depth resolution: 0.7 nm in silicon (at 180^{o}, better at glancing angle)

Time spectrum of Au(1nm) on Cu(2-3nm) on Al_2O_3



STEM Imaging of Ion-Beam induced Defects in MoS_2 monolayers

In collaboration with

Maureen J. Lagos, Philip E. Batson, Manish Chhowalla, I.Boskurt, Jieun Yang

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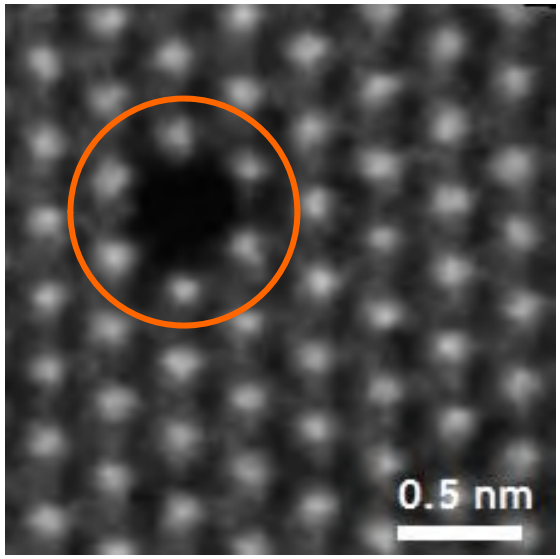
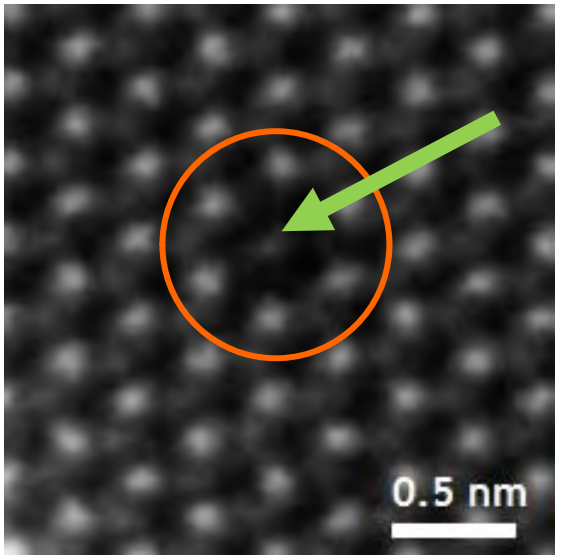
Vacancies

- MoS_2 is CVD grown
- Irradiated in HIM
- Imaged in STEM



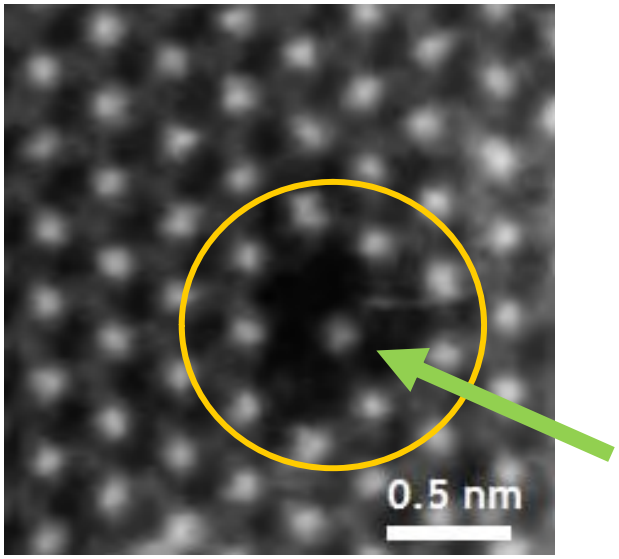


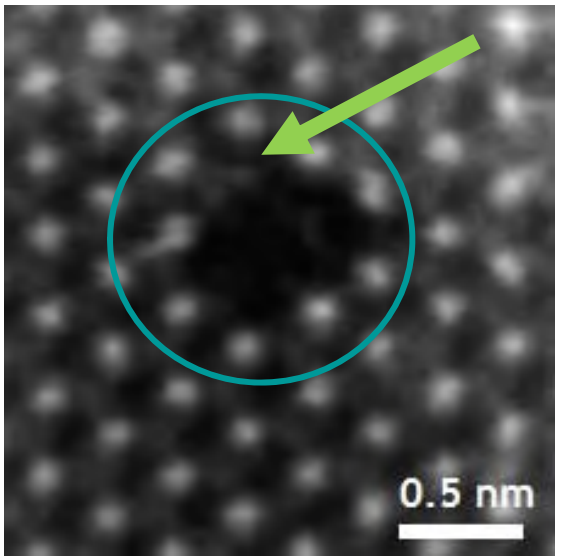
VACANCIES:

1 Mo atom

2 Mo atoms

3 Mo atoms



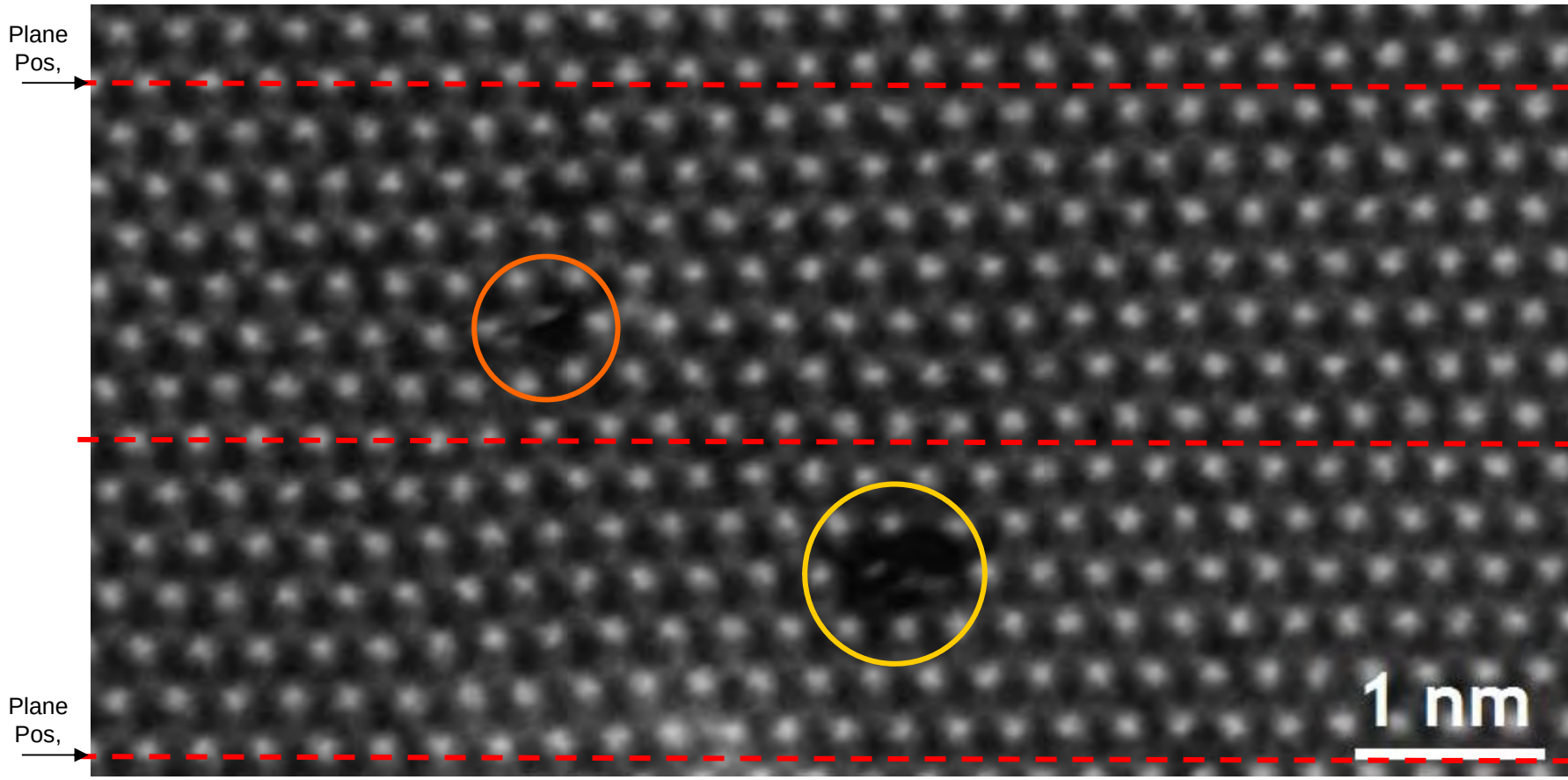


Defect-Induced Strained Domains

VACANCIES:

1 Mo atom

2 Mo atoms

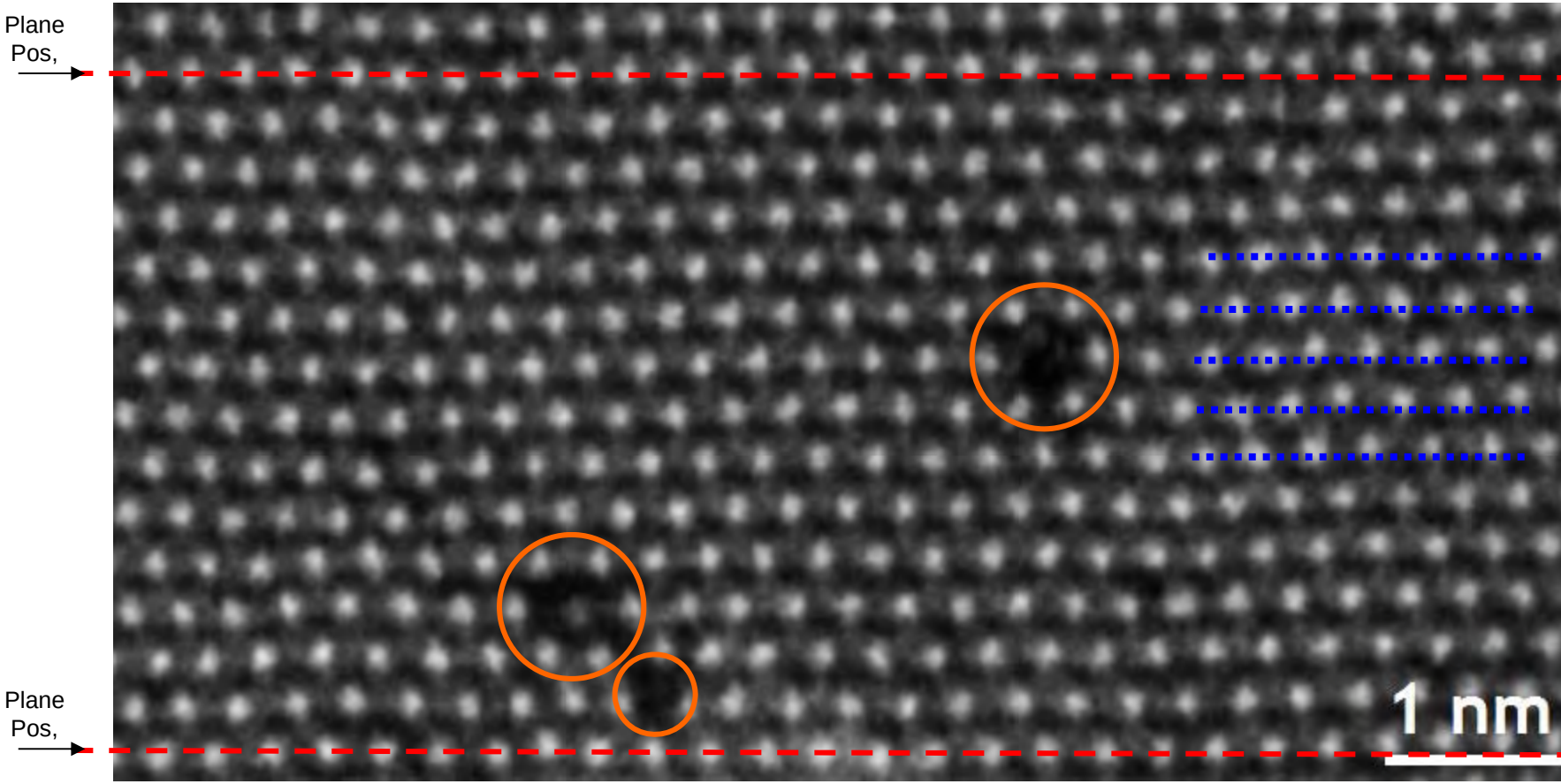


Strained domains > 5X5 nm^2

Defect-Induced Strained Domains

VACANCIES:

1 Mo atom



Strained domains > 5X5 nm^2

Conclusions

Imaging of rat kidney samples provided a very clear evidence of podocyte **deterioration** due to disease *and* **reconstruction** after the treatment

HIM images of corals revealed amorphous nanoparticles of calcium carbonate with unprecedented detail, suggesting a possible **mechanism for calcification and crystallization**

Time-of-Flight detector demonstrates ability of elemental specificity in HIM with **2ns resolution**. Further work is continuing to achieve an order of magnitude improvement in energy resolution

Irradiation of MoS_2 with 30keV alpha particles preferentially produces **Mo vacancies** in the **monolayer films**

Thank you!

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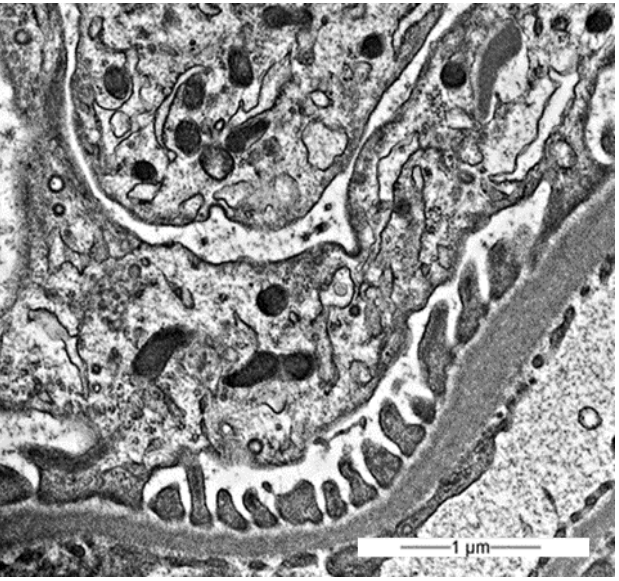
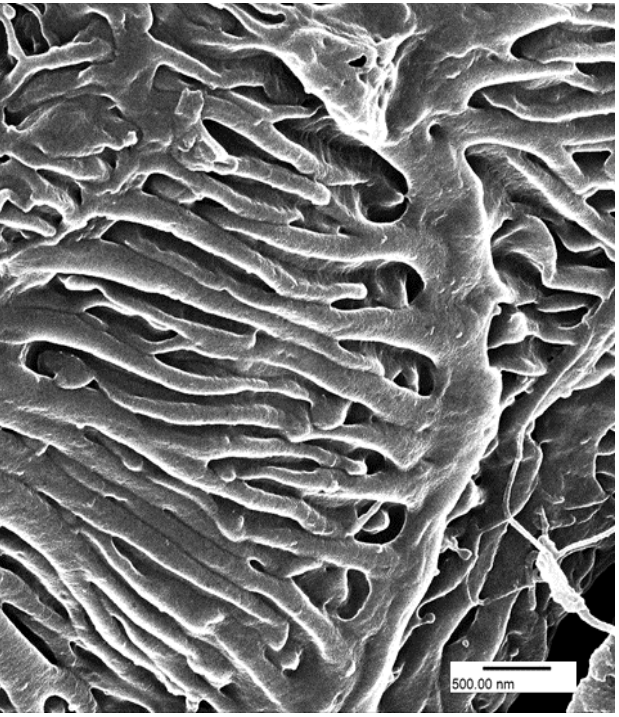
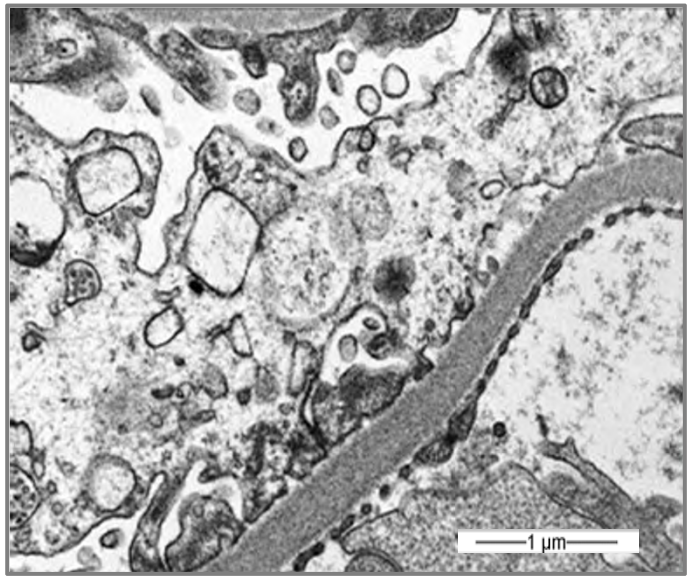
HIM at Rutgers

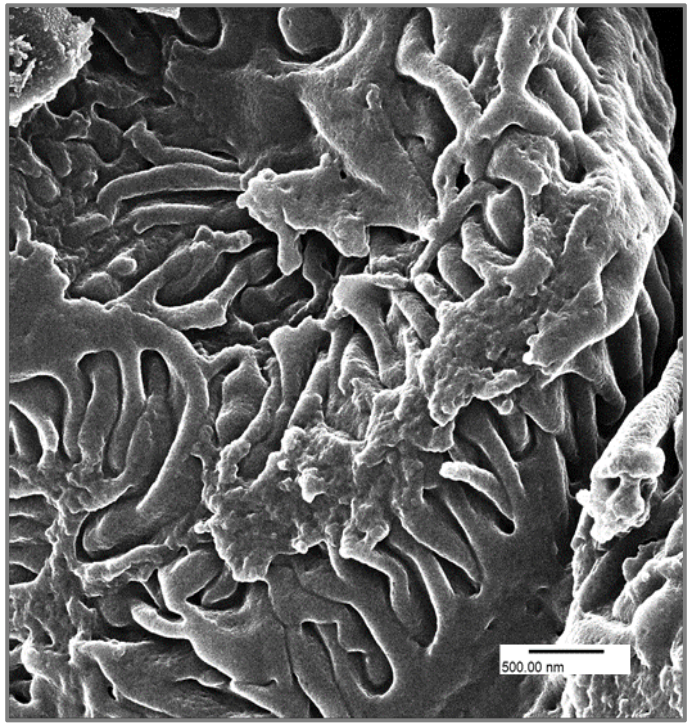
Normal podocytes





34 weeks after ischemia





SS-20 treated after ische