



THE MAC

*Terahertz Materials
Analysis Center*





Head:

Vanya Darakchieva

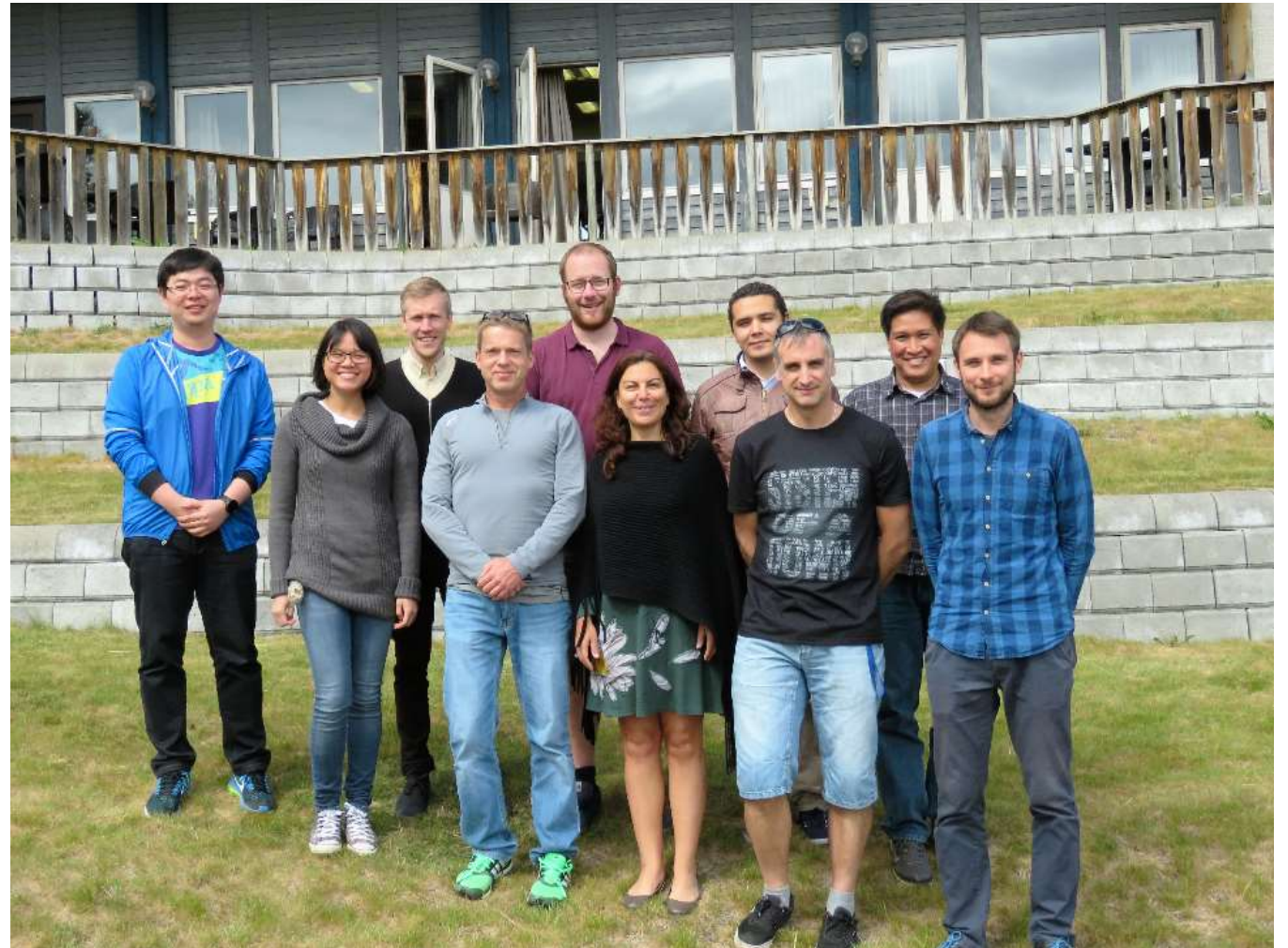
vanya.darakchieva@liu.se

Deputy Head:

Philipp Kühne

philipp.kuhne@liu.se

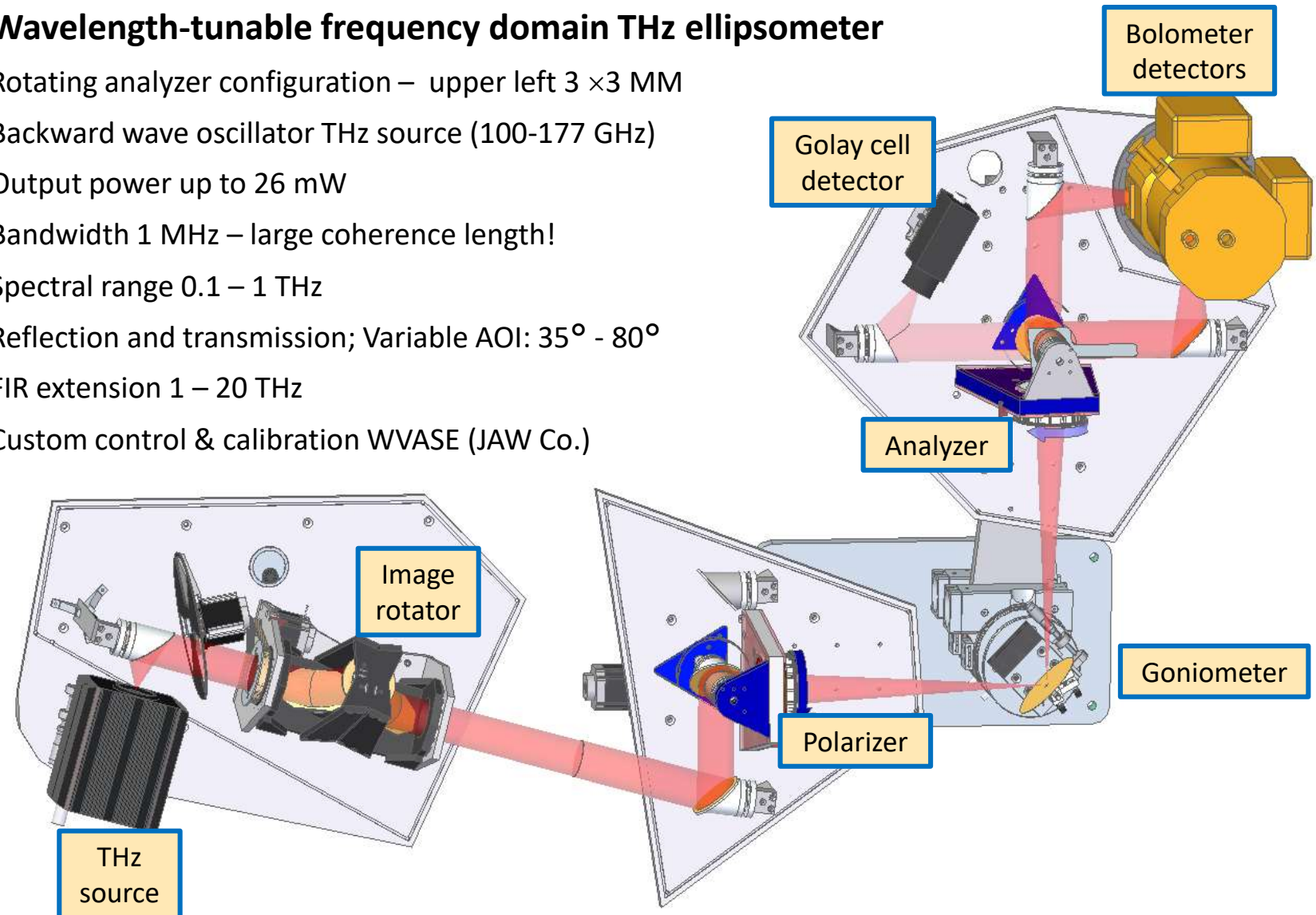
<https://www.ifm.liu.se/materialphysics/semicond/staff/vanya/themac/>



Our Facilities

Wavelength-tunable frequency domain THz ellipsometer

- Rotating analyzer configuration – upper left 3 × 3 MM
- Backward wave oscillator THz source (100-177 GHz)
- Output power up to 26 mW
- Bandwidth 1 MHz – large coherence length!
- Spectral range 0.1 – 1 THz
- Reflection and transmission; Variable AOI: 35° - 80°
- FIR extension 1 – 20 THz
- Custom control & calibration WVASE (JAW Co.)



Our Facilities



Swedish Foundation for Strategic Research,
Research Infrastructure Fellow (2016-2020)

Magnetic
field
0T to ± 8 T

Variable
temperature
1.5 to 400 K

FIR
extension
1 to 20 THz

Dual rotating
compensator

e – access
free of
charge

Data storage
and analysis

Data model
methodology

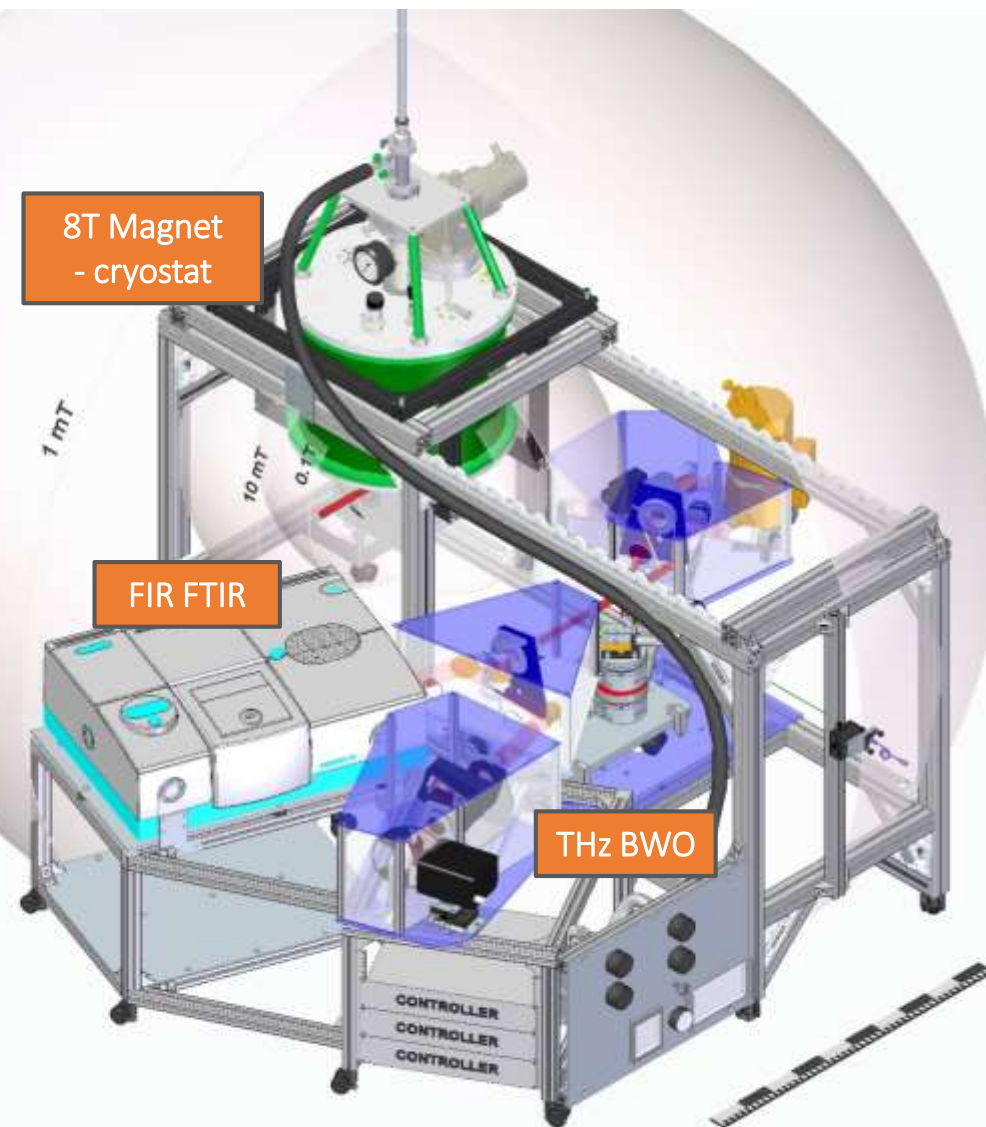
Data bank

User training

User service

THz
workshops

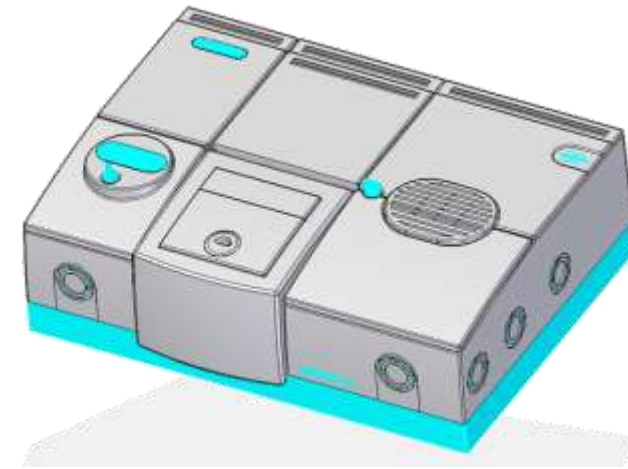
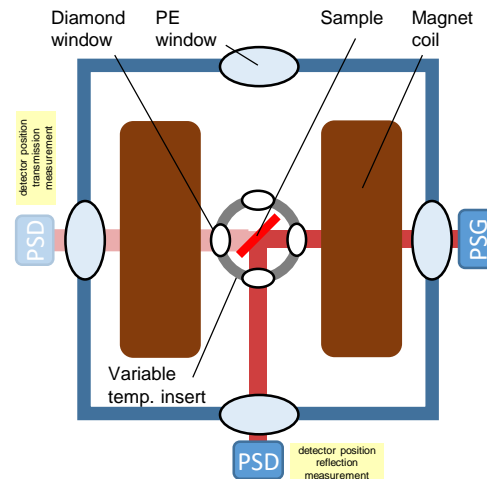
Outreach



New instrument/method development



Swedish Foundation for Strategic Research,
Research Infrastructure Fellow (2016-2020)



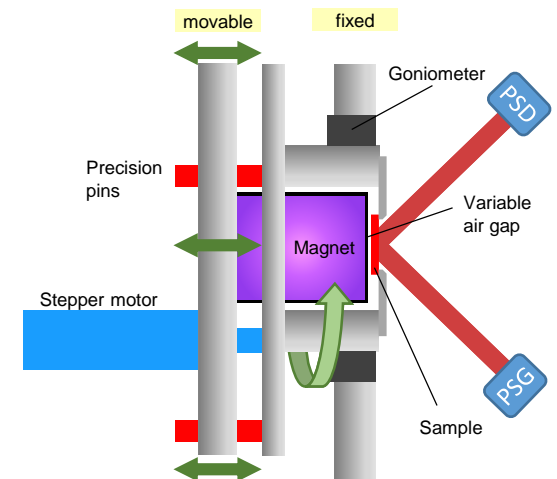
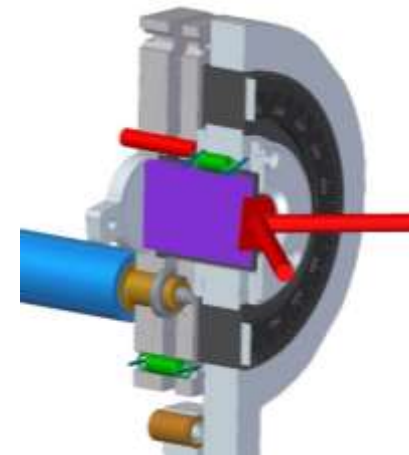
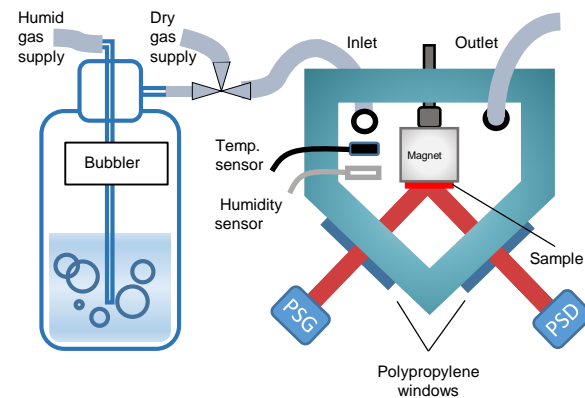
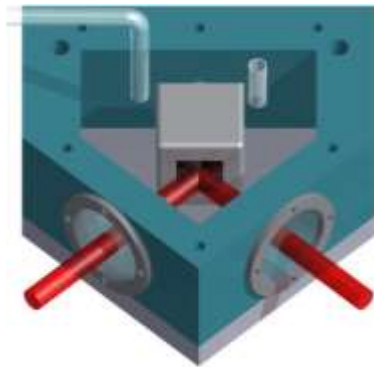
New instrument/method development



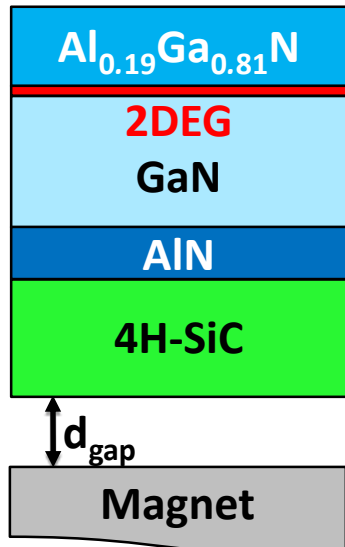
Swedish Foundation for Strategic Research,
Research Infrastructure Fellow (2016-2020)
Future Research Leader Grant (2014-2018)



Swedish Research Council
Young Researcher Grant (2014-2017)
Consolidator Grant (2017 – 2022)
AFM (2016 – 2017)

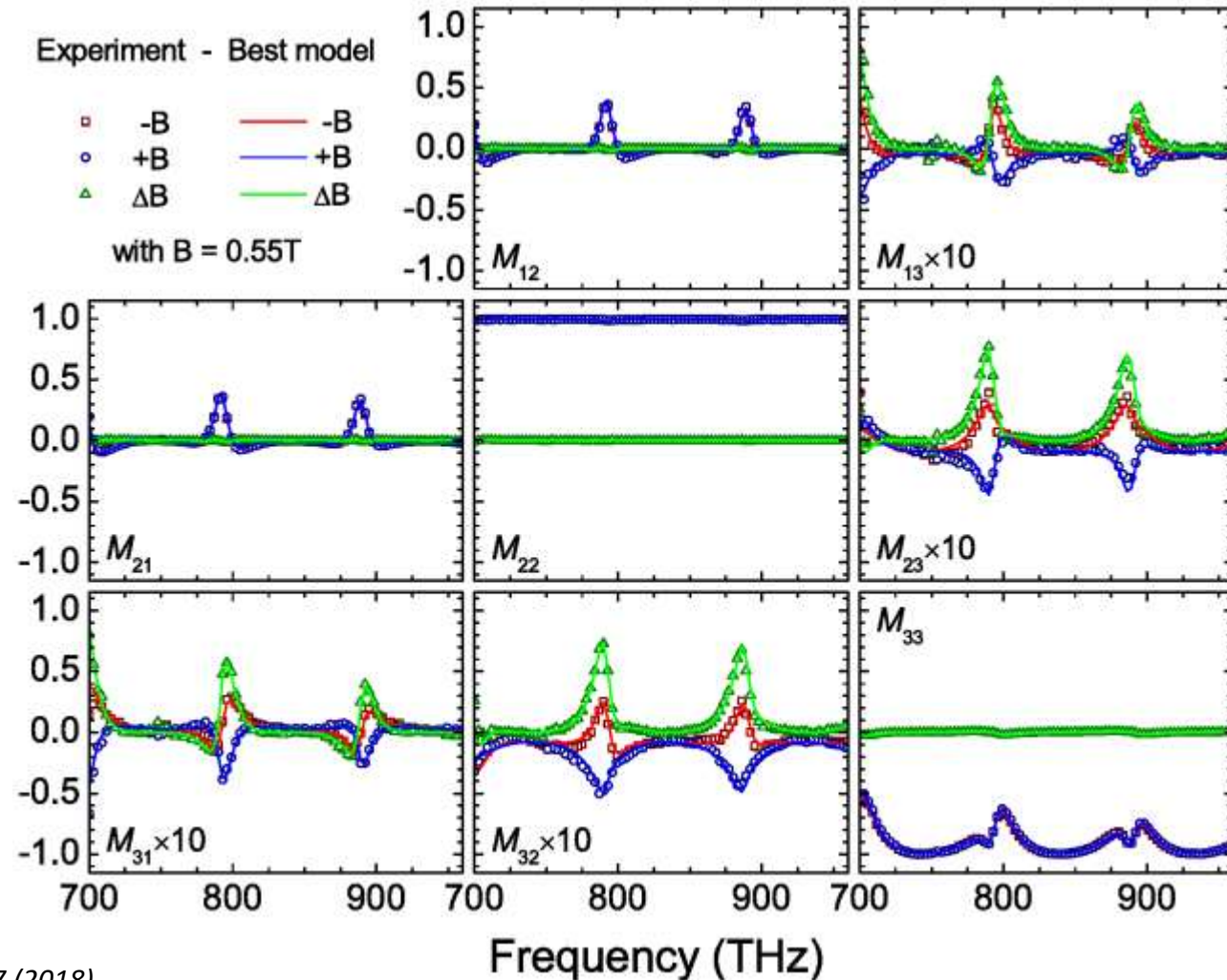


Cavity enhanced THz optical Hall effect



- Interface roughness scattering reduced
- Highest 2DEG mobility for AlGaN/GaN structure
 $\mu = 2330 \pm 60 \text{ cm}^2/\text{V}\cdot\text{s}$
- Increased carrier density for long exposure

<https://liu.se/en/research/centrum-for-iii-nitridteknologi>

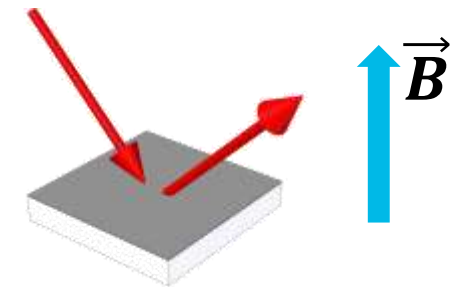
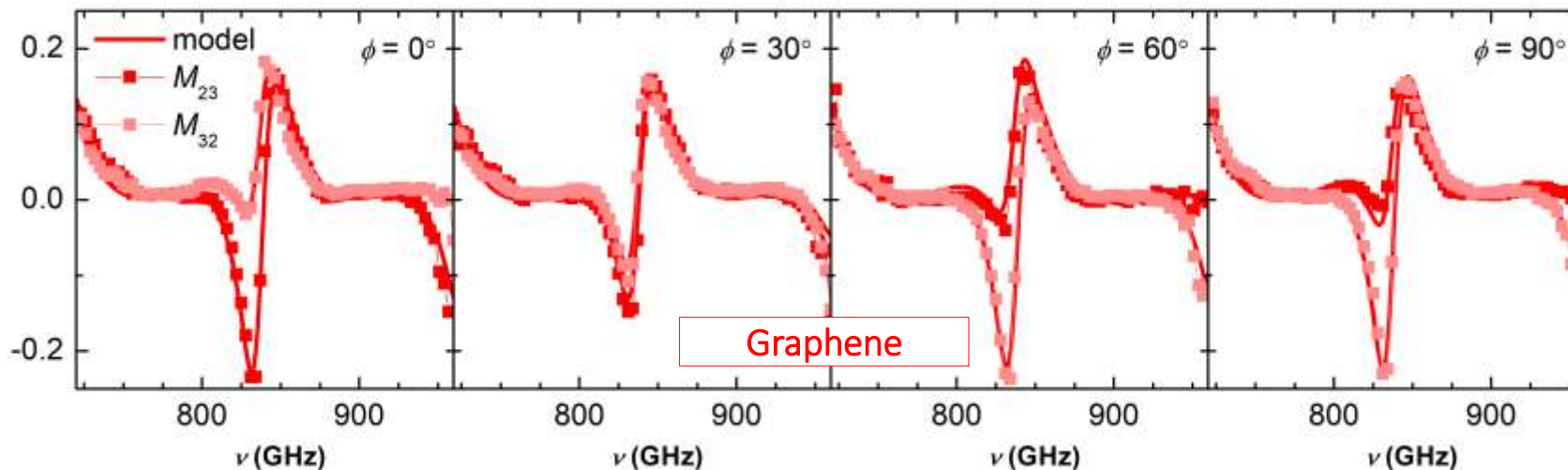
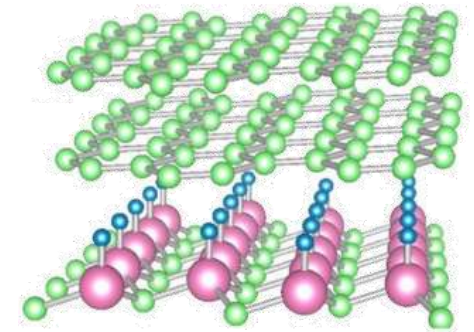
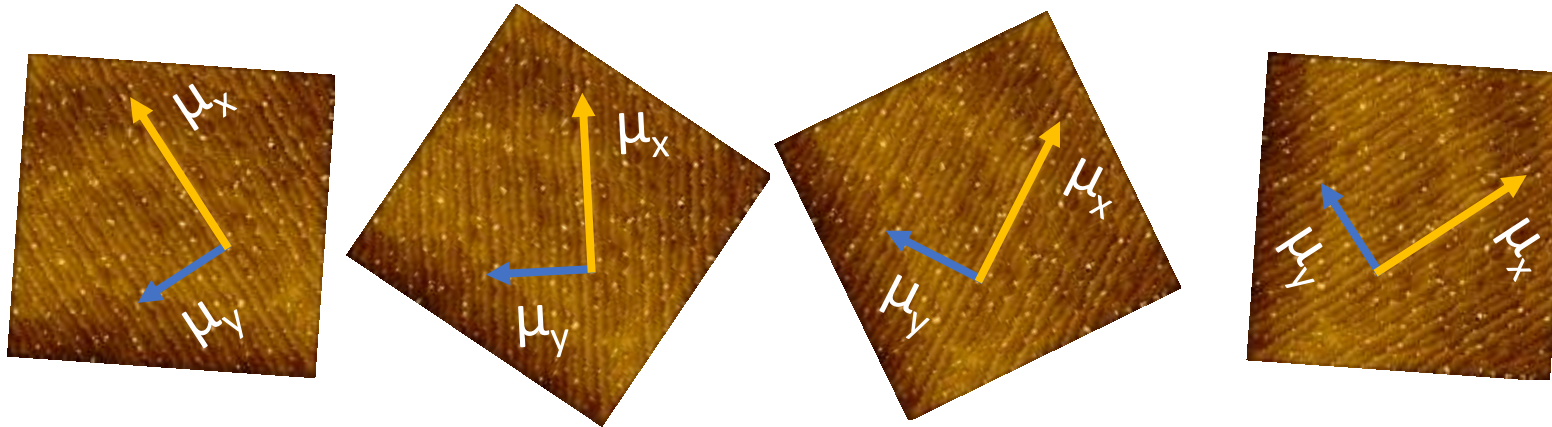


Research highlights: graphene

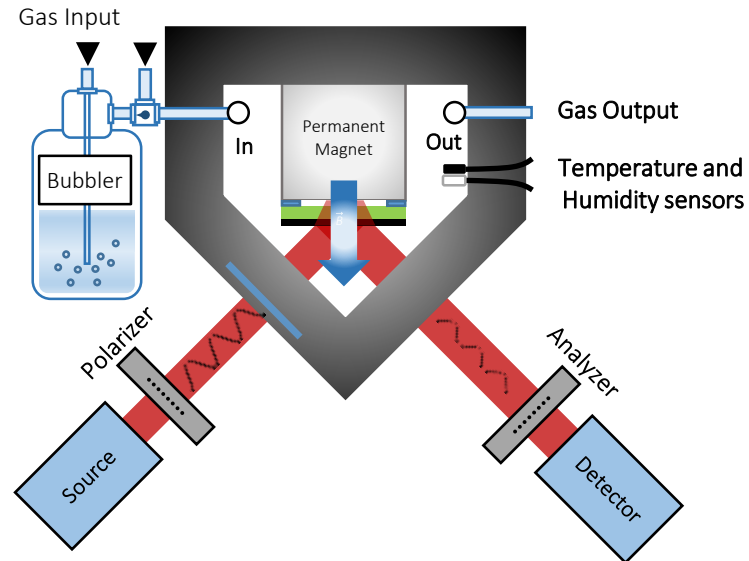


AFM and THz measurements reveal correlation between mobility anisotropy in graphene and steps formed at the SiC surface

μ_x	$2318 \pm 32 \text{ cm}^2/\text{V}\cdot\text{s}$
μ_y	$1866 \pm 25 \text{ cm}^2/\text{V}\cdot\text{s}$

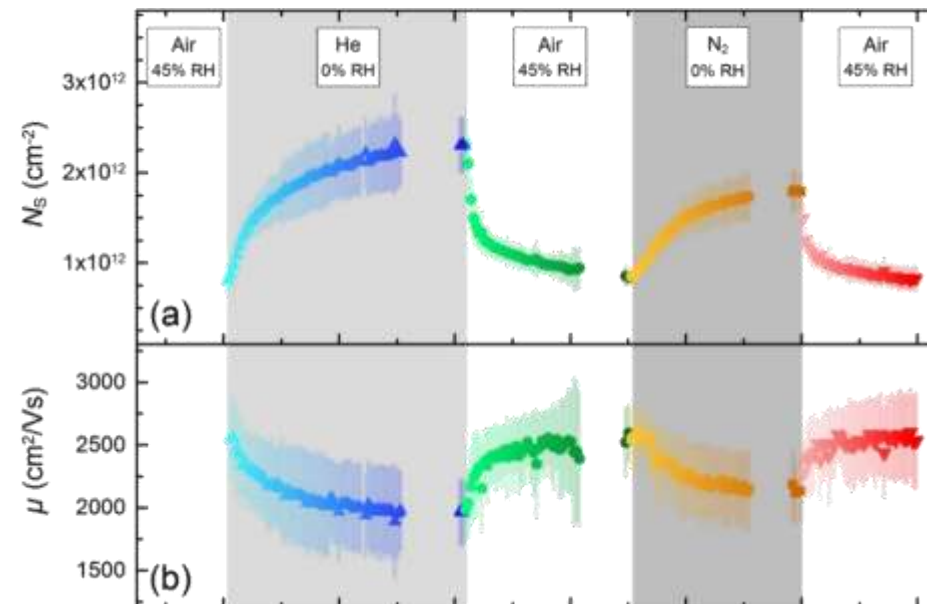
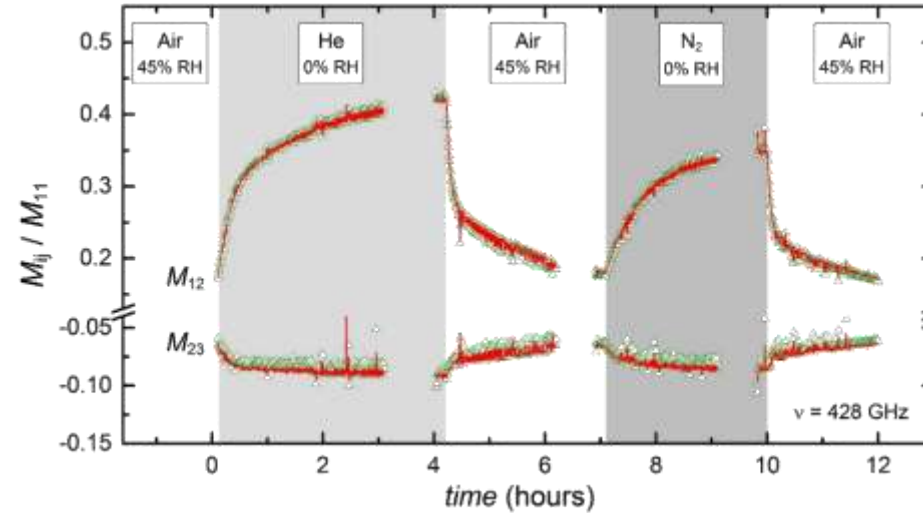


Research highlights: graphene

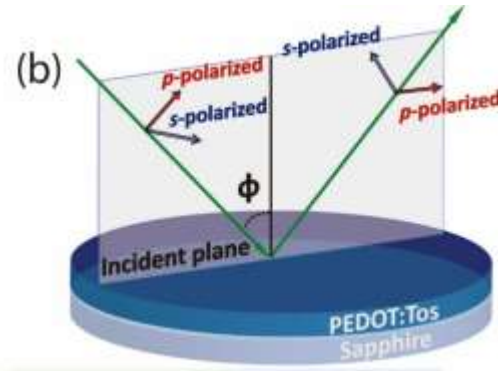
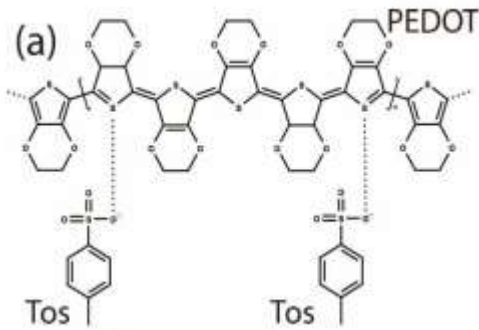


- N_s and μ as function of different gases and humidity levels
- strong changes in doping and mobility
- long term stabilization (\sim days)

Knight,..., Darakchieva, *Scientific Reports* **7**, 5151 (2017)



Research highlights: conductive polymers



Uniaxial Model

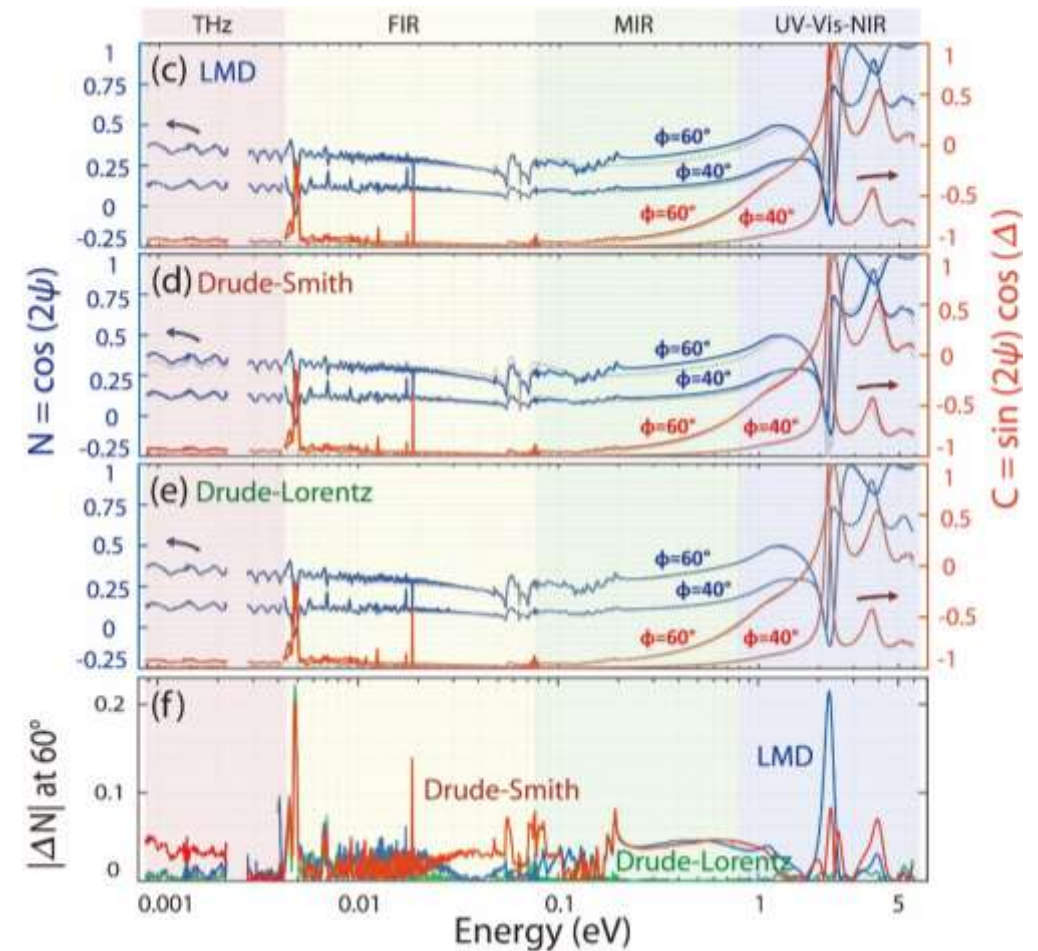
(ordinary axis perp. surface):

- Band to band (band transitions)
- Lorentz (IR vibrational modes)
- “Ordinary” Drude model (free charge)

Charge Carriers

- $n = 2.2 \times 10^{21} \text{ cm}^{-3}$
- $\epsilon_{\perp, \infty} = 1.96$
- $\epsilon_{\parallel, \infty} = 2.45$
- $\mu_{\perp} = 2.0$
- $\mu_{\parallel} = 0.09$

Chen, Kühne,...,Jonsson, Darakchieva, in submission
LiU, UNL, ITN, Acreo



Outreach

Invited Talks

2018 - AVS 65th International Symposium & Exhibition, Long Beach, USA

2018 - Spring E-MRS 2018, Strasbourg, France;

2017 - Current trends in Optical and X-Ray metrologies of key enabling nanomaterials/devices for the Ubiquitous Society, renewable energy and health, Okayama, Japan;

2017 – International Wide Bandgap Power Electronics Workshop, IWBGPPEAW 2017, Stockholm

2016 - Optics and Photonics in Sweden, Linköping, Sweden;

2015 – E-MRS Spring Meeting, Lille, France...



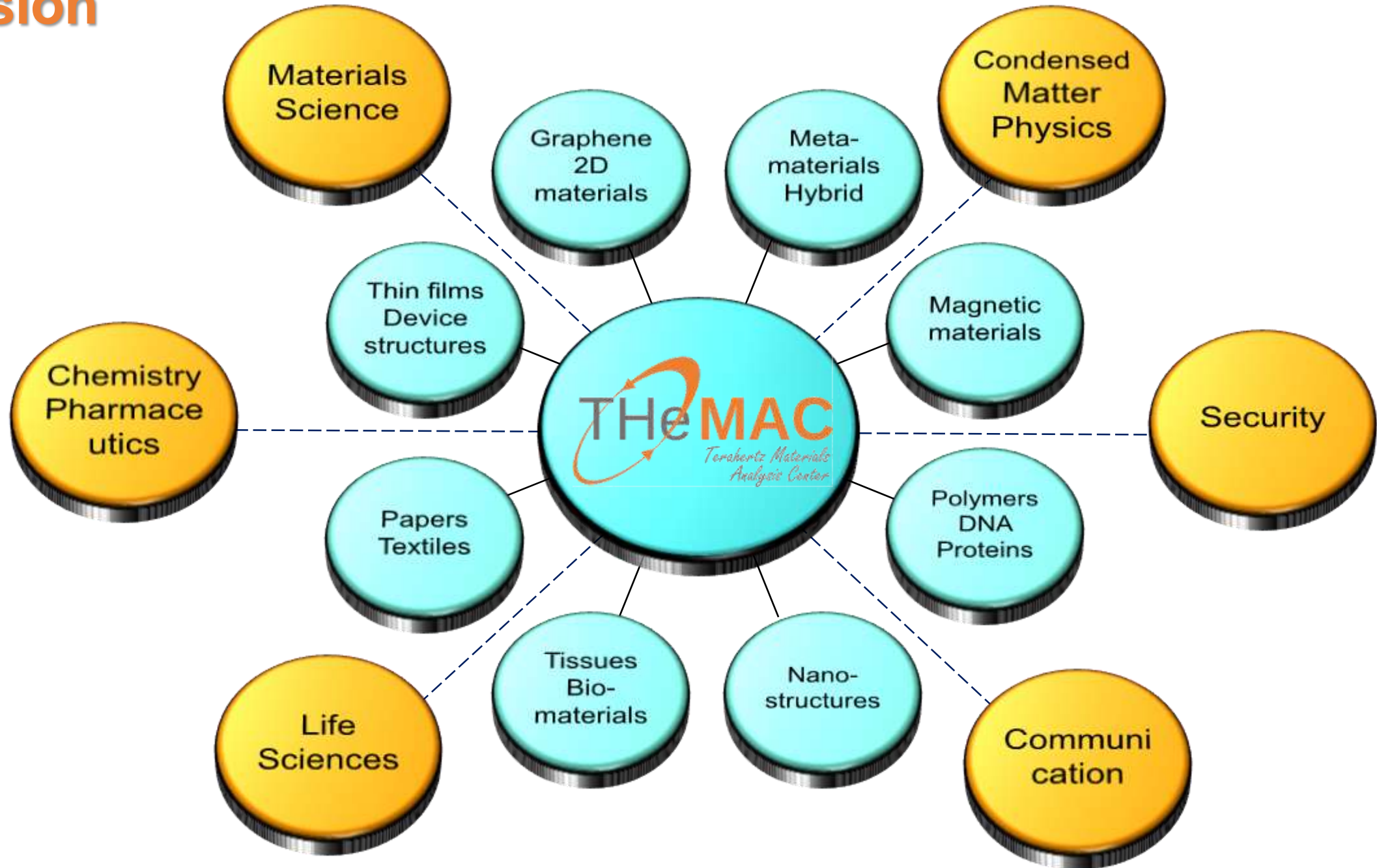
**Swedish THz workshop
14 March 2016**



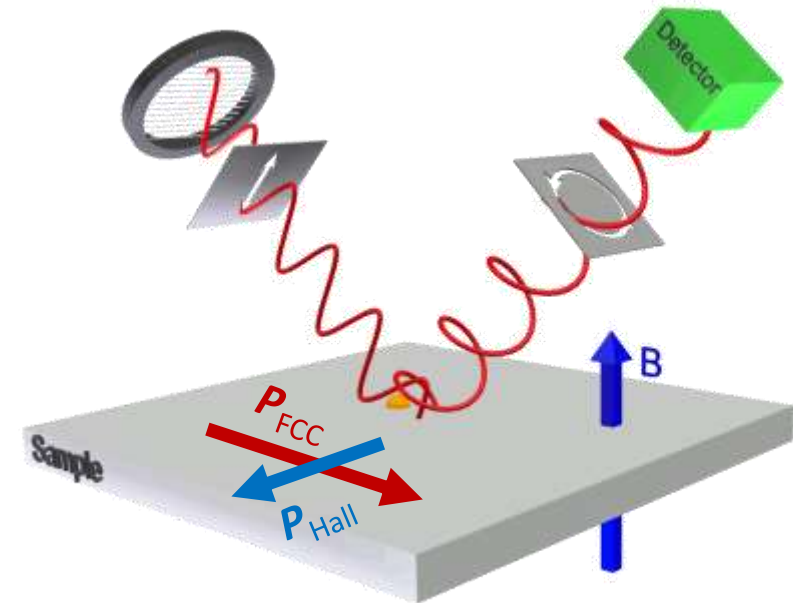
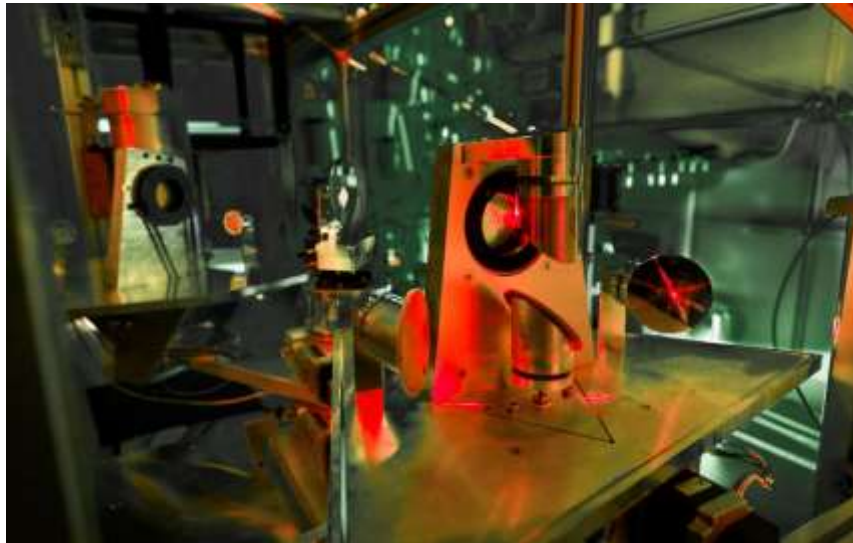
**1st Nordic Ellipsometry
Workshop – NEW
1st November 2016 LiU
Sweden**



Mission



Develop and employ unique THz ellipsometry and imaging techniques to address current and future needs of fundamental and applied research in materials science, physics, chemistry, life sciences, defense, medicine and communication.



***Aim:* THz materials characterization platform for academic and industrial collaborations in Sweden and worldwide**