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LEIBNIZ INSTITUTE of PHOTONIC TECHNOLOGY

Advancing Photonics for Health Care in Europe

Public Private Partnerships

Jürgen Popp

InfectoGnostics Research Campus Jena

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

PHOTONICS21

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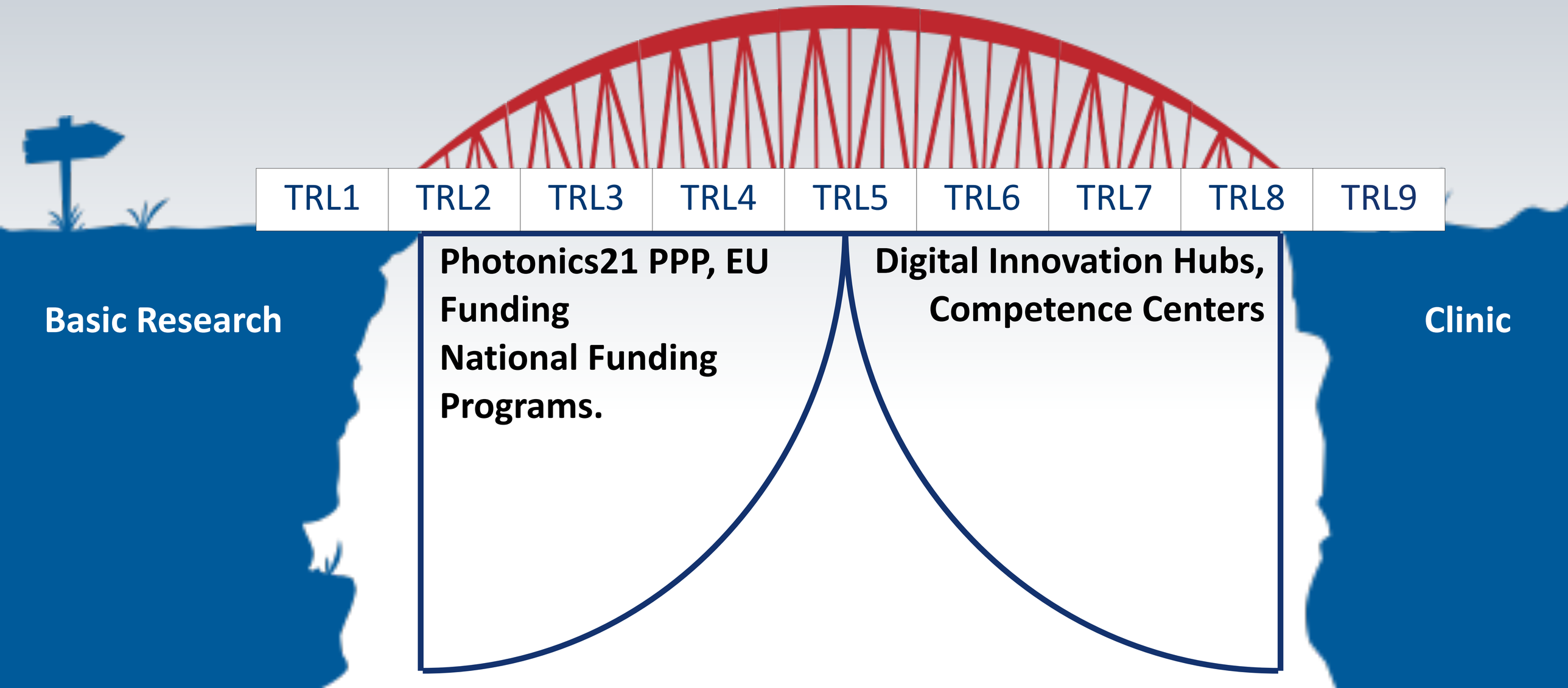
Translation Problem: the Valley of Death

D. Butler, Nature 453, 840-842 (2008)



Photonics21 – Selected Milestones

April 2006

First European Strategic Research Agenda published and handed over to Commissioner Viviane Reding

Establishment of a Photonics Unit within the European Commission

Draft of a Multiannual Strategic Roadmap for Horizon 2020

Foundation of a PPP between Photonics21 and Photonics Unit

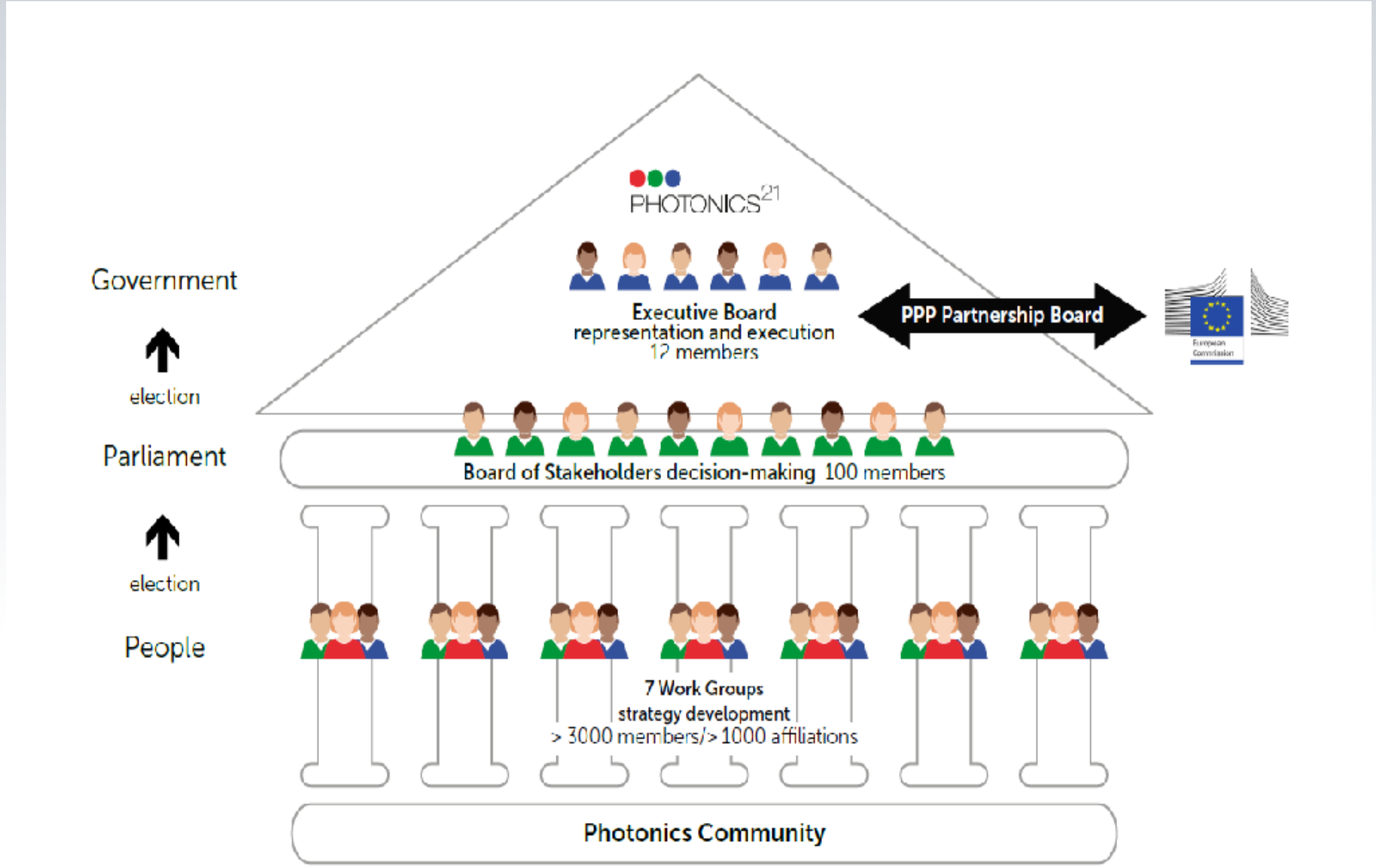
Draft of new Multiannual Strategic Roadmap for Horizon Europe

Foundation
European Technology Platform
Photonics21

2005 2006 2007-2013 2013-2020 2020-2027

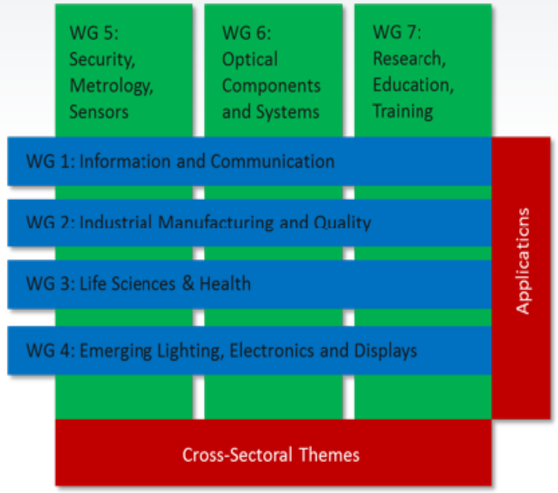
PHOTONICS PUBLIC PRIVATE PARTNERSHIP

Photonics21: Bottom-up Organisation and Structure of the Photonics Public Private Partnership



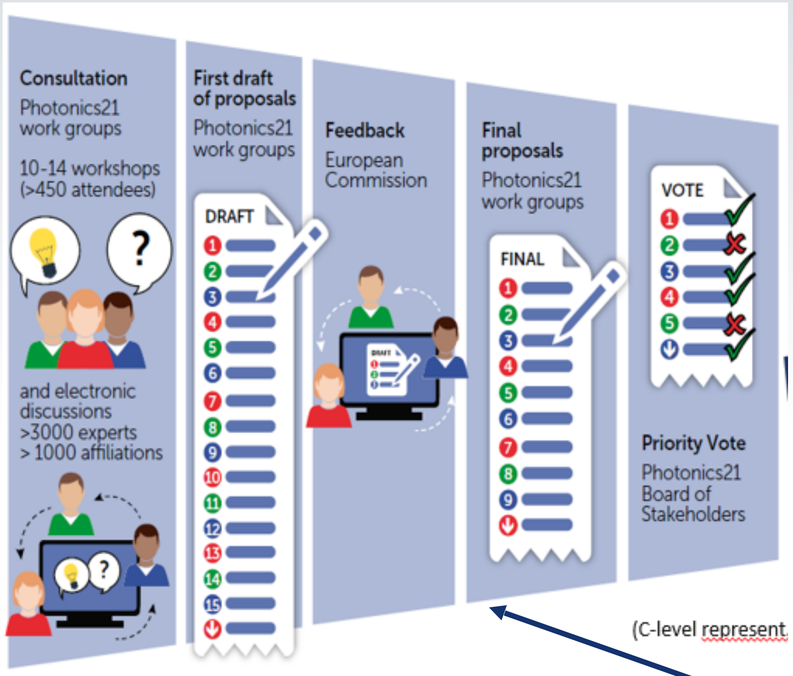
PPPP

- Lean Photonics21 Association as the PPP-contact partner of the EC
- Open, transparent and inclusive processes and structures
- Full control of the Photonics21 BoS over the Association
- Changes in the Terms of Reference:
  - New BoS members elected by Work Group members
  - Association financed by the BoS
  - BoS membership became institutional

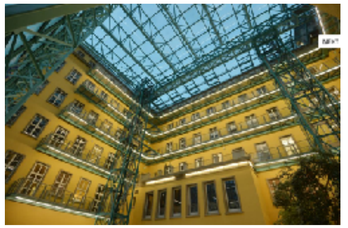


Photonics21: Strategic Research and Innovation Agenda Process towards Horizon Europe – Standard Process Applied

Photonics PPP Annual Meeting March 2018	Photonics PPP Annual Meeting March 2018	June – July 2018	July – December 2018	Photonics PPP Annual Meeting 2019



2nd Workshop: Thursday, July 5th, Berlin, Leibniz-Geschäftsstelle



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Photonics21: Europe‘s Age of Light – Our Vision & Missions for the next Decade

Instant diagnosis of major diseases

Sub-missions/Targets

1. **Mobile/wearable photonics** devices and advanced **biosensors** for **instant** point-of-care (-use) **detection/ diagnostics** and **treatment**, that measure the wearer’s medical condition and wellness, wearables for monitoring environmental parameters
2. **Photonic tools for life science industry as well as endusers** (e.g. medical doctors, research)
   - Photonic tools for real time proteomics, genomics, metabolomics.
   - Accelerating and enabling photonic tools for pharmaceutical industry, understanding, regenerative medicine, personalized medicine, high throughput high content screening
   - Photonic tools for understanding the origin of diseases beyond risk factors, finding pathways for treatment, photonics for health (nutrition, life style, environmental influences, toxicity)
3. **Affordable photonics-based real time diagnostics** to stratify and classify disease status, monitor and assess treatment response will open the door to the practical implementation of precision medicine. **Optogenetics for treatment** of brain, heart diseases etc.; **Photonics for Physiological treatment**. Photonics for **interventional guidance** (Augmented reality). Multiscale access to the body (depth of penetration/optical resolution)
4. **“vertical issues”**: Augmented reality, standardization, big data (data processing, AI, data mining)

Instant diagnosis of major diseases

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National Photonic Funding Programs

- Only Germany has a dedicated Photonics Funding Program („Photonik Forschung Deutschland“)
- Usually other European countries do not even have specific photonics budgets. If photonics topics are currently on the national political agenda, they are usually addressed as a topic or a thematic priority in a broader technology or application context ("scope").
- At Innovate UK, e.g., this is the corresponding higher-level department "electronics, sensors & photonics".
- Austria uses the production program or the ICT program for photonics subsidies - depending on the topic.
- Other countries are promoting photonics through cross-cutting programs (e. g. "Innovation", "Emerging Technologies" etc.).
- Funding on a smaller level like e.g. the Irish Photonic Integration Centre (IPIC) or “Challenge Photonics” in France

→ National / Regional initiatives and Digital Innovation Hubs gain importance

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Translation in Biophotonics:

How Innovation Hubs and Competence Centers Can Help.

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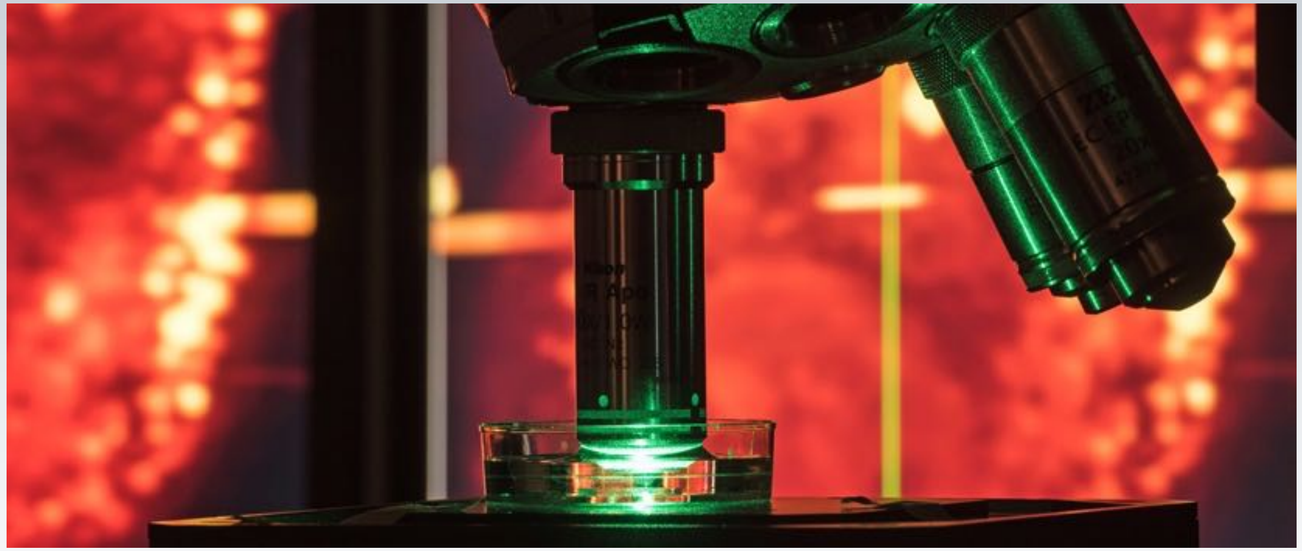
The Challenge(s)

- Address the unmet medical need
- Develop the technological solution



© InfectoGnostics / European Commission

- Finding technological solutions within a highly regulated environment,
  e. g. for infection diagnostics (infectious agent, antimicrobial resistance)

The Challenge(s)

Infectious Diseases

Epidemics

Irresponsible Use of Antibiotics

Unavoidable use of broad-spectrum antibiotics

Inappropriate therapy doubles mortality risk

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Medical Need: Precise Diagnostics for Targeted Therapy

- Need for rapid identification of pathogens and drug resistances – **diagnosis before therapy**
- Goal: fast, non-invasive diagnostics that are cost efficient
- Biophotonics is a key enabling technology for diagnostical purposes

Technology Proven, but What's Next? Scientist Left Alone

Photonic Technologies

Chip-based Methods
Imaging
Spectroscopy

Target Identification

Assay Development

Animal Model

Verification

Validation

New Anti-Infectives

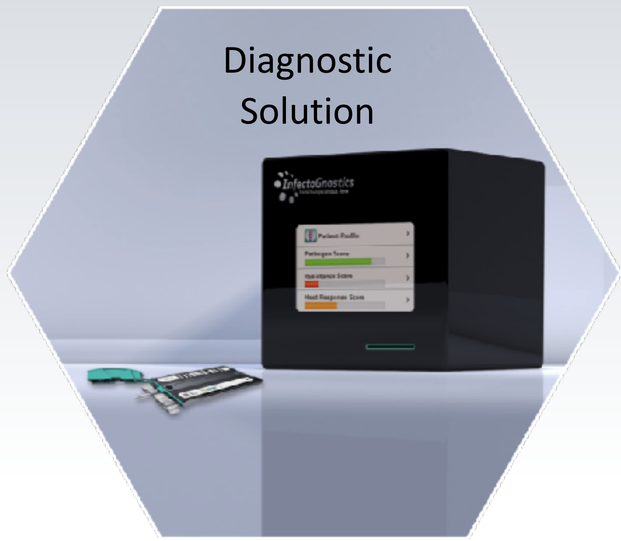
Sample Center / Biobank

Market Analysis

Clinical Utility

Small Series Production

Diagnostic Solution



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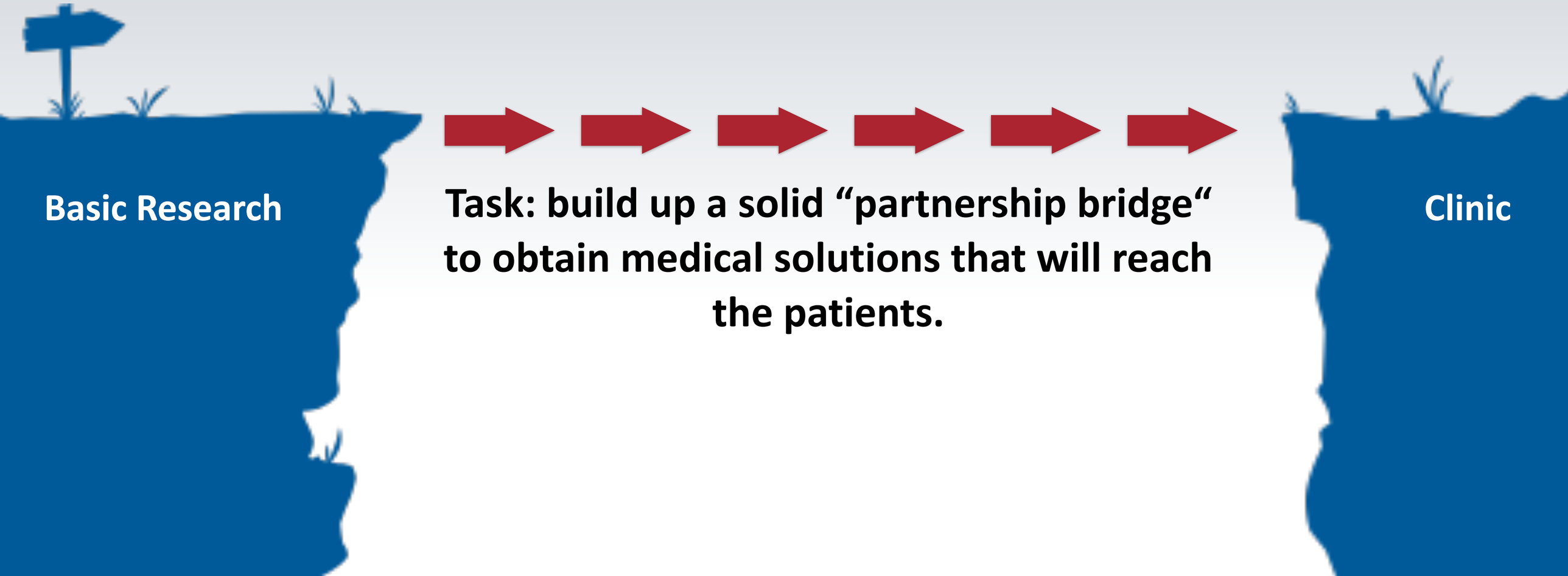

Task: build up a solid “partnership bridge“ to obtain medical solutions that will reach the patients.

Translation Problem: the Valley of Death

D. Butler, Nature 453, 840-842 (2008)

- **Closing the gap** between basic research and application / clinics
- Organized as **public-private partnership (PPP)**
- Defined **handover points** to the industrial partners

FORSCHUNGS CAMPUS
öffentlich-private Partnerschaft für Innovationen

THE NEW HIGH-TECH STRATEGY
Innovations for Germany

Value chain with gaps

Knowledge-oriented basic research	Application-oriented basic research	Contract / joint application-oriented research	Product-oriented research	Develop-ment	Validation / clinical tests	Pro-duction	Service

Research

Industrial Realization

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Closed Value Chain – The Jena Solution

Knowledge-oriented basic research | Application-oriented basic research | Alliances/ joint application-oriented research | Product-oriented research | Develop-ment | Validation / clinical tests | Pro-duction | Service

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Research → Industrial Realization

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Phase 1: Innovation Hub Organized as Public-Private Partnership

One stop shop along the value creation chain

- Services for research transfer and project control, networking from idea to market entry
- Mentoring by experienced entrepreneurs, support for the start-up companies - 4 founded so far
- Infrastructure: laboratories, esp. photonic instrumentation, biosafety labs, access to clinical samples and clinical experts
- Impact on teaching/ education:
  - Master in medical photonics (Univ. of Jena) started 2016
  - Diagnostics-oriented graduate program

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InfectoGnostics Labs @Jena University. Germany

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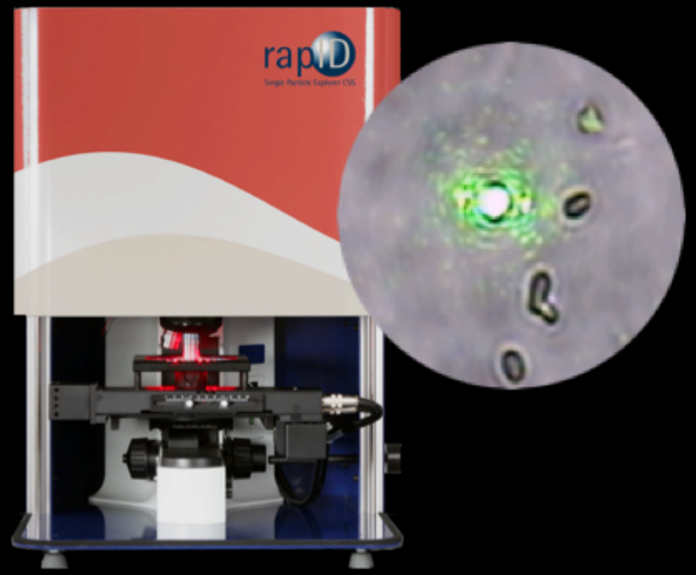
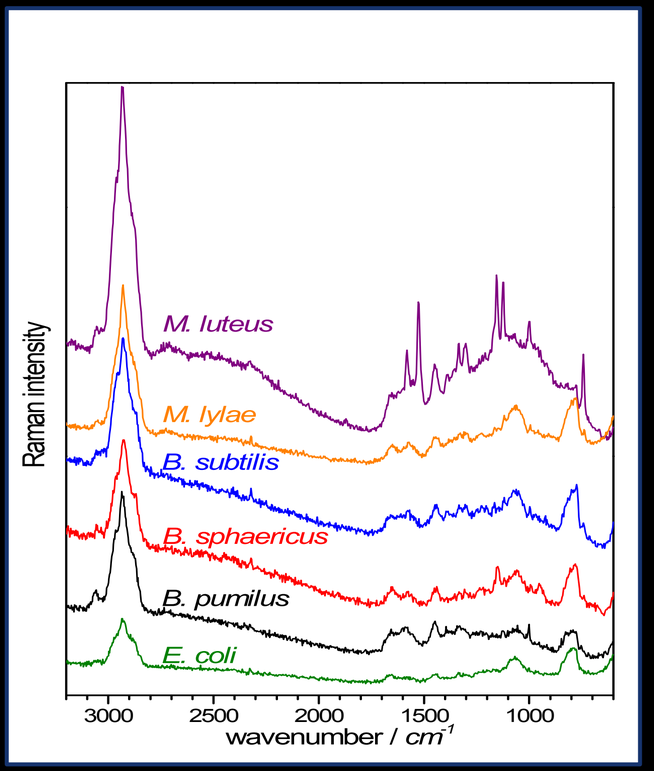
Example: Portable Device for Raman Spectroscopical Detection of Pathogens and Resistance Profiles

Raman spectroscopy-based diagnostics





Identification of single microbes without cultivation (realtime)

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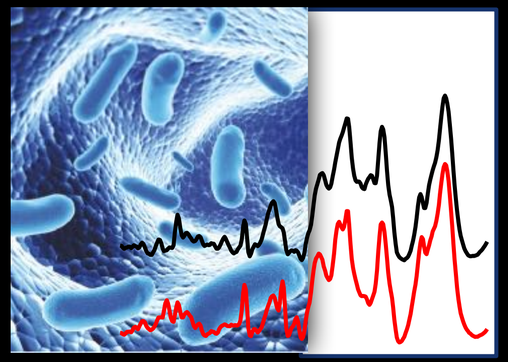
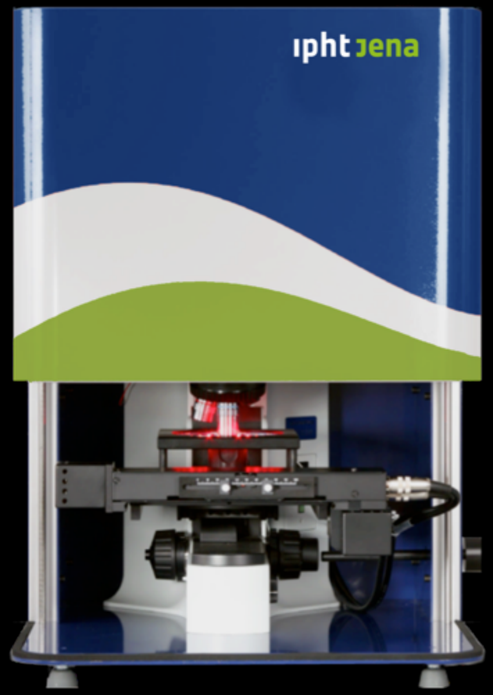
Example: Portable Device for Raman Spectroscopical Detection of Pathogens and Resistance Profiles

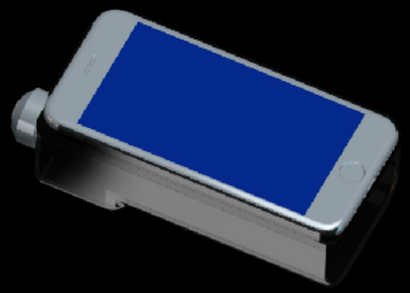
Future of Raman spectroscopy

2015 → 2020



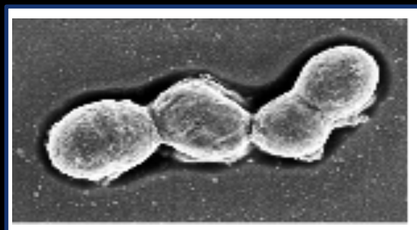


200,000 → 3,000 EUR

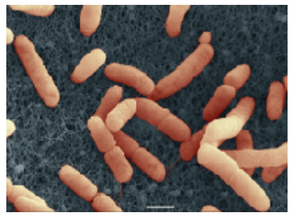


Cost-efficient miniaturized Raman Spectrometer: **Raman2GO**

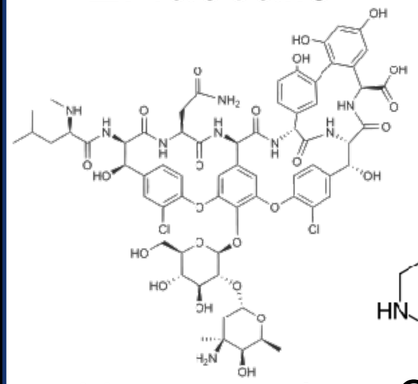
Example: Identifying the Susceptibility and the MIC of pathogens



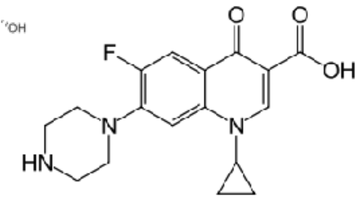
E. faecalis



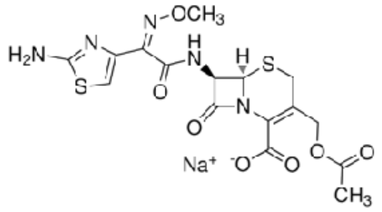
E. coli



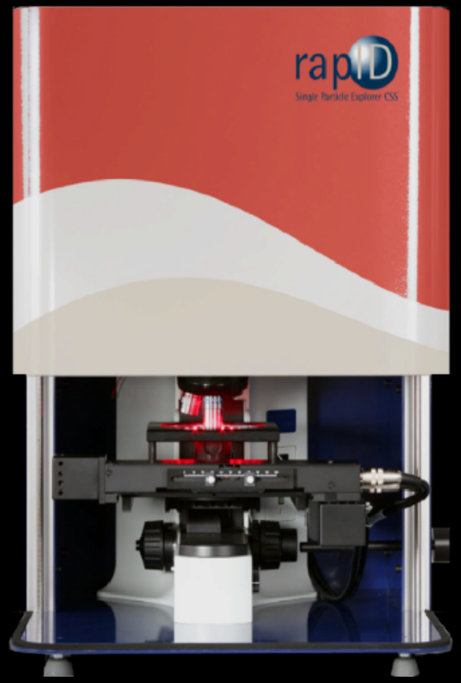
Vancomycin



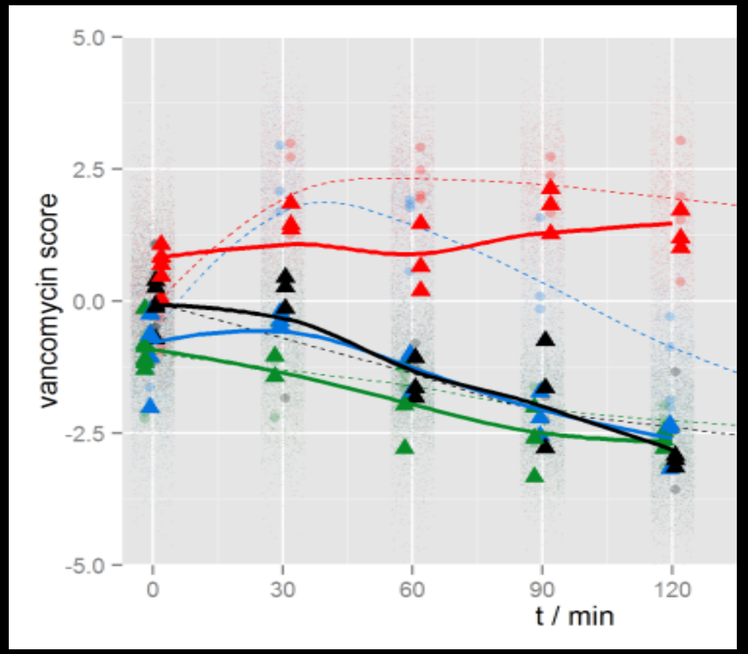
Ciprofloxacin



Cefotaxim



Raman and Imaging after various time perioids



statistical analysis

sensitiv

resistent

Schröder et al., Scientific Reports, 2015, 5, 8217.; Neugebauer et al. Submitted.

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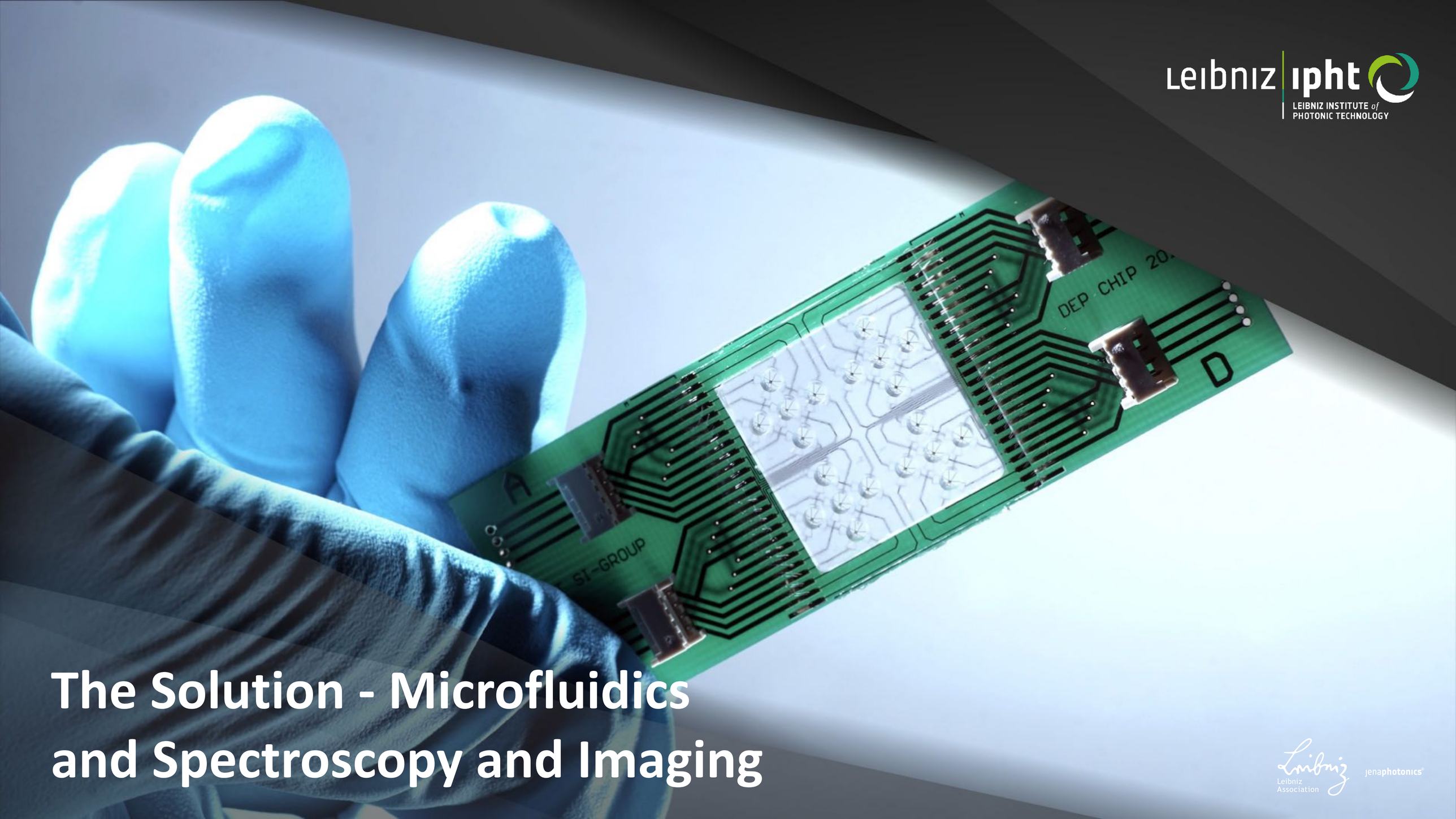

The Solution - Microfluidics and Spectroscopy and Imaging

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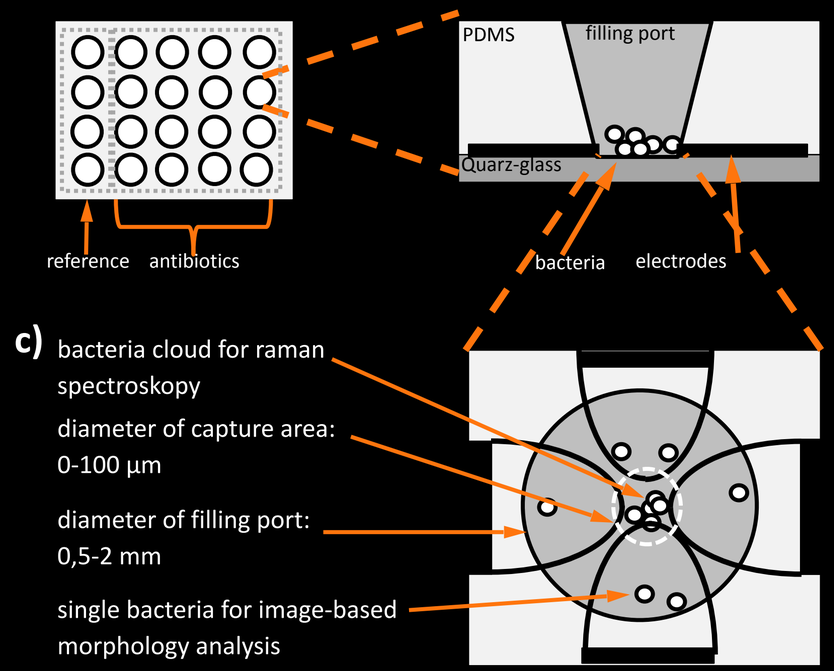
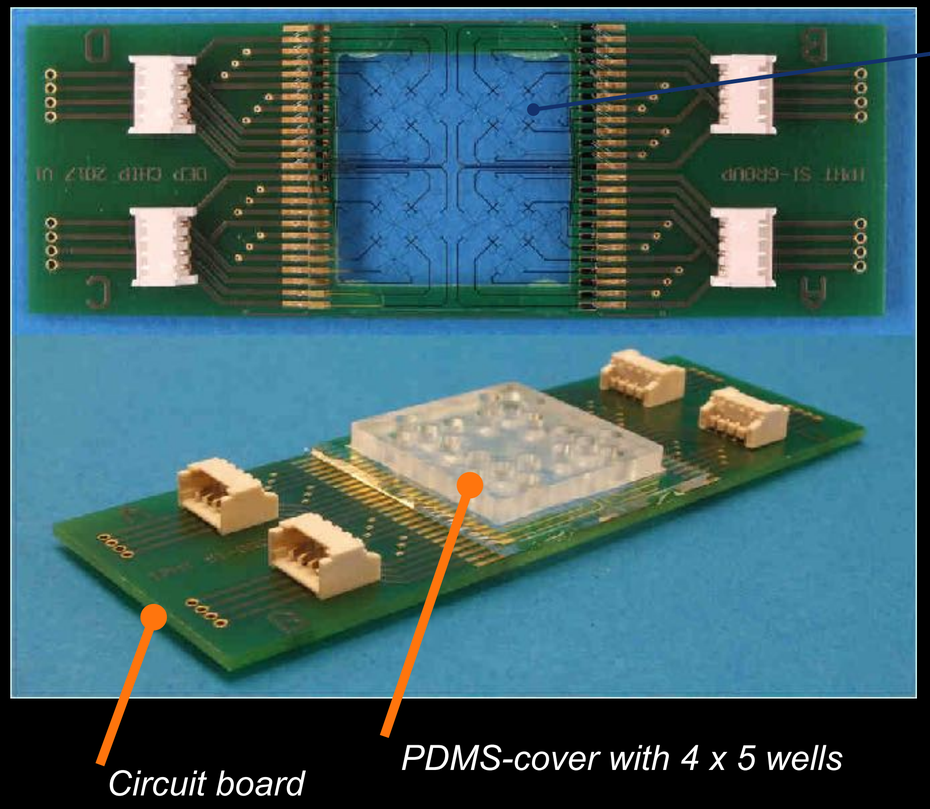
Development of a analytical system for urin diagnostics

Concept: plate with microwells



Principle of function of a chip with 20 wells a); side view of a well inside of the chip b); top view of a well with integrated electrodes c).



Pictures of the test platform (76 x 26 mm²) with integrated circuit board, glass plate with electrodes and PDMS well cover for four different antibiotics.

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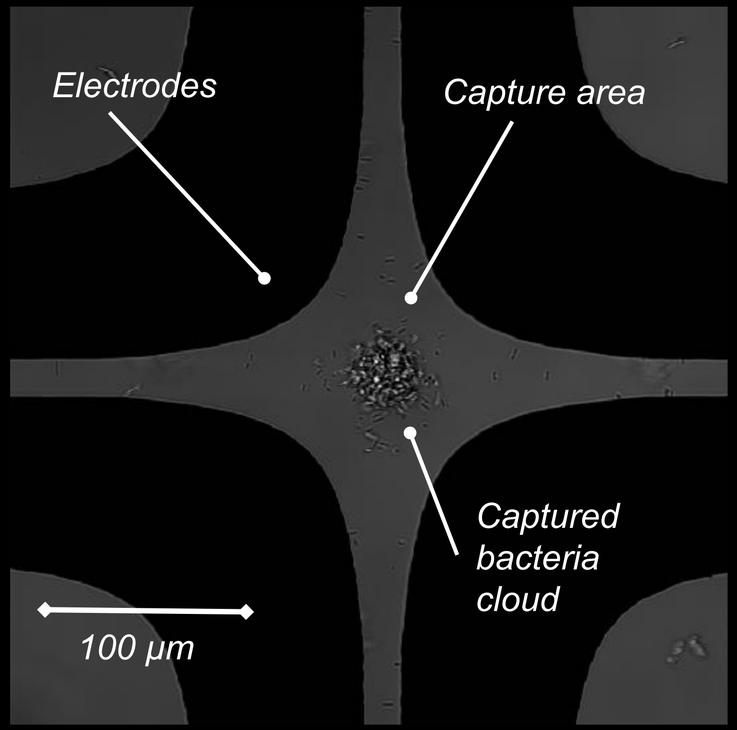
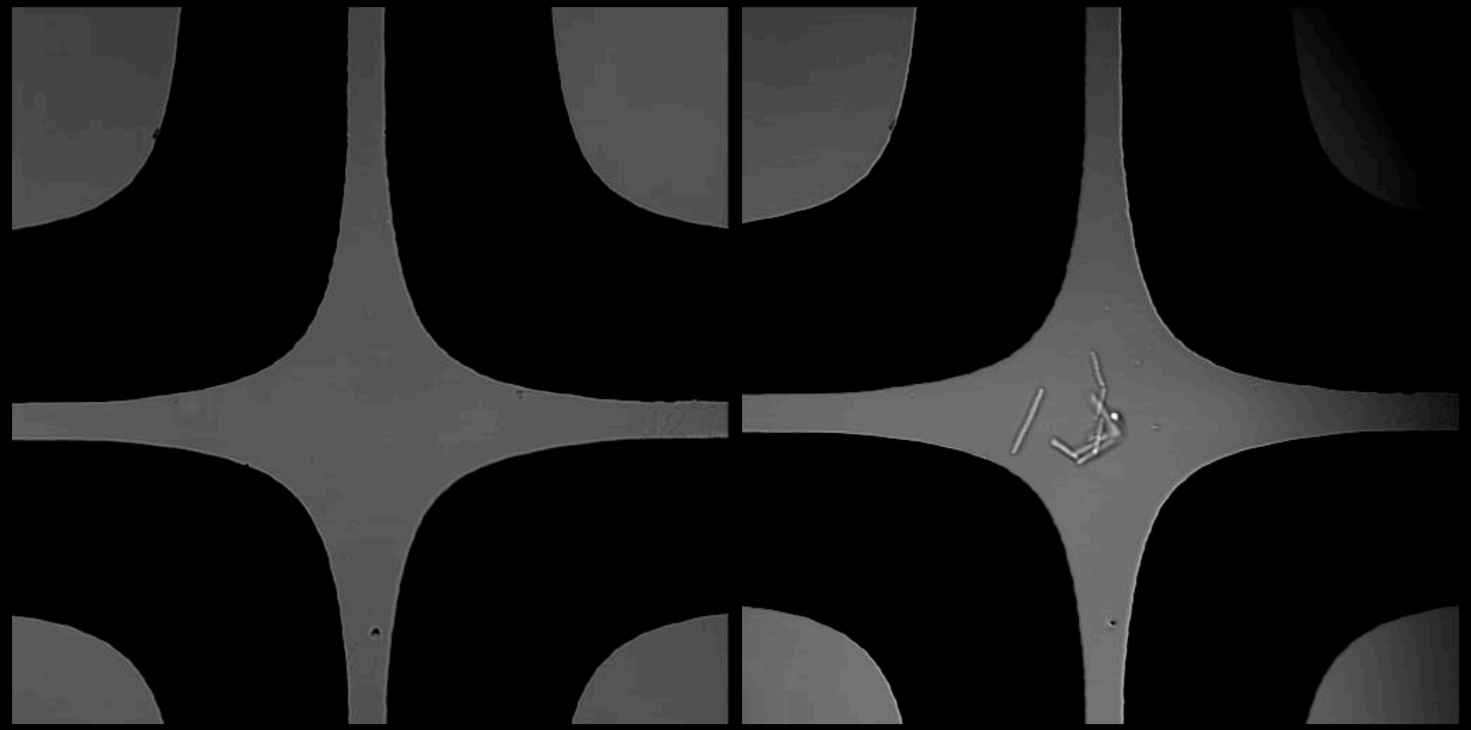
Development of a analytical system for urin diagnostics

Results of the first experimental test runs:

The developed platform is able to capture bacteria for further imaged-based analysis and raman spectroscopy.



Picture of a captured bacteria cloud with DEP



Videos of the capture porcess of bacteria (left) and the division of bacteria in culture medium (right). Concentration $3x10^3$

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Detection of AMR and MIC

E. coli **strain**	Ciprofloxacin concentration [mg/L]												Raman		BMD
	0	0,008	0,016	0,032	0,064	0,125	0,25	0,5	1	2	4	8	Classification	MIC [mg/L]	MIC [mg/L]
	sensitive							i	resistant						
AG100	✓	✓	✓	✓	✗	✗							S	0,032	0,032
	✓		✓	✓	✗	✗	✗	✗	✗				S	0,032	
	✓		✓	✓	✗	✗	✗	✗	✗				S	0,032	
3-AG100	✓							✓	✓	✗	✗	✗	R	1	1
	✓							✓	✓	✗	✗	✗	R	1	
	✓							✓	✓	✗	✗	✗	R	1	
387	✓				✓	✗	✗	✗	✗				S	0,064	0,032
	✓		✓	✓	✓	✗	✗	✗	✗				S	0,064	
405	✓					✓	✓	✓	✓	✗			R	1	0,5 - 1
407	✓					✗	✗	✗	✗	✗			S	≤ 0,125	0,016
416	✓						✓	✓	✓	✓	✓		R	> 4	1
	✓							✓	✓	✓	✓	!	R	4	
422	✓						✓	✓	✓	✓	✗		R	2	1
500	✓					✓	✓	✓	✓	✗			R	1	0,5
	✓						✓	✓	✓	✗	✗		R	1	
539	✓				✓	✓	!	!	✗				S	0,125	0,25
	✓						✓	✓	!	✗	✗		S	0,25	
544	✓						✓	✓	✓	✓	✓		R	> 4	≥ 32
545	✓	✓	✓	✓	✓	✗							S	0,064	0,125
	✓			✓	✓	!	✗	✗					S	0,064	
554	✓						✓	✓	✓	✓	✓		R	> 4	≥ 32
579	✓						✓	✓	✓	✓	✓		R	> 4	≥ 32
673	✓	✓	✓	!	✗	✗							S	0,016	0,032
683	✓	✓	✓	!	✗	!							S	0,016	0,032
	✓		✓	!	!	!	✗	✗	✗				S	0,016	

Assmann et al., Analytical Chemistry 2018, accepted

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Phase 2: Innovation Hub Plus Competence Centre

- **Competence Centre for photonics in infection research**
  located directly at Jena University Hospital
- State-of-the-art plus emerging technologies
  (e.g. XUV microscope, super-resolution Raman)
- From nanoscale to macro (molecule to first-in-man)
- Technological workflow from sample preparation to the solution
  (incl. SOP development)
- Clinical expertise directly influences technology development
- Pipeline concept for a **closed value chain**

The LPI @Jena concept: www.lpi-jena.de

LEIBNIZ CENTER *for*
PHOTONICS *in*
INFECTION RESEARCH

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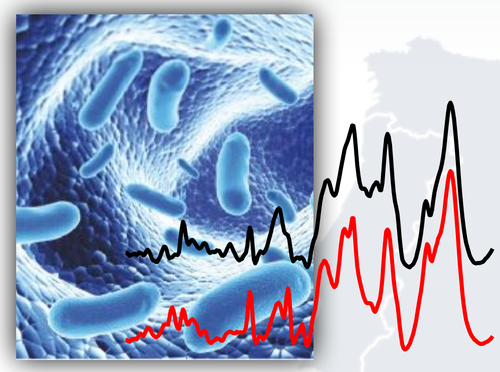
Going Beyond the Limits

LPI's Diagnostic Service Pipeline



Physician

Technology Scout

Flying Study Nurse

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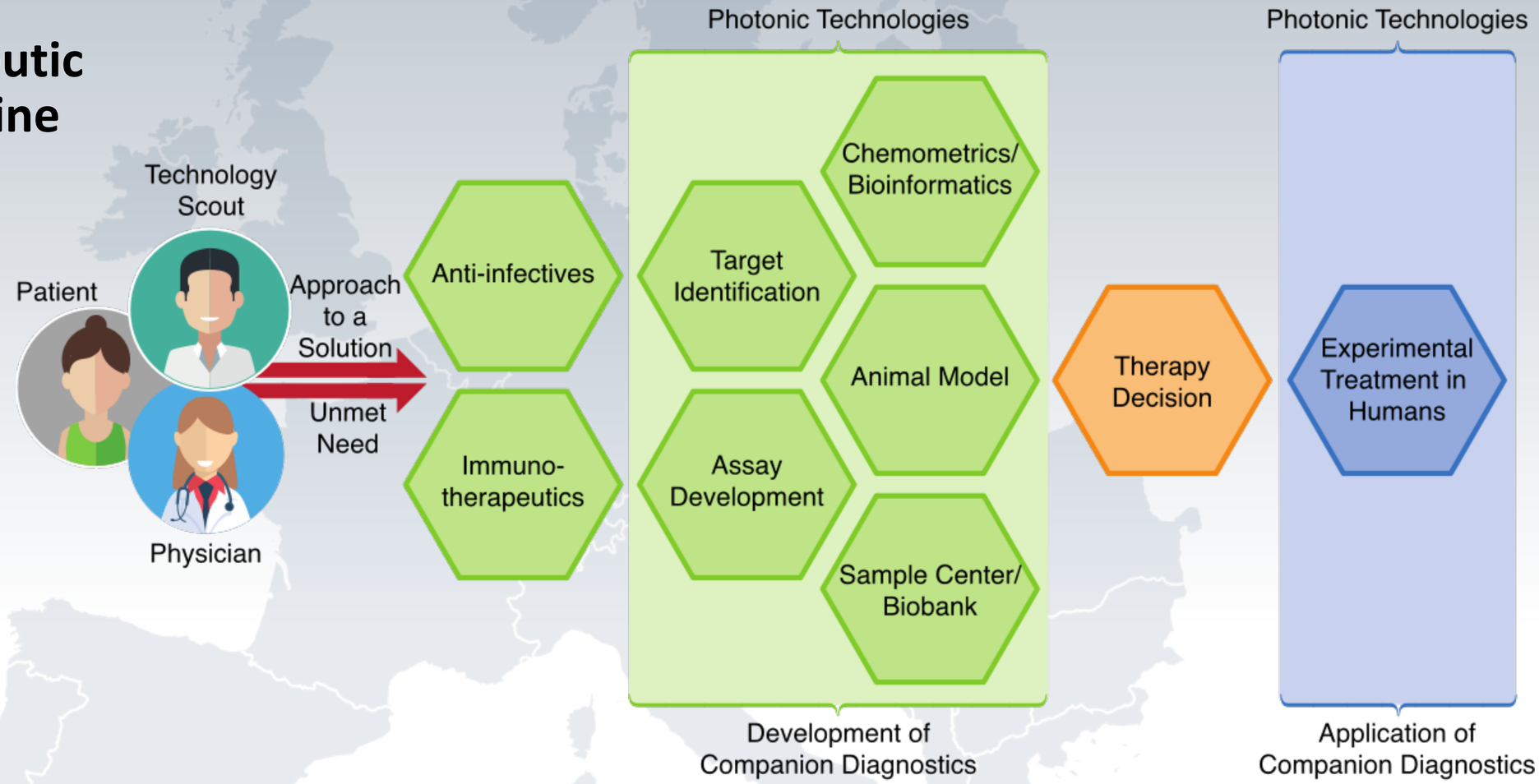
More than Diagnostics: Therapeutic Approaches

LPI's Therapeutic Service Pipeline

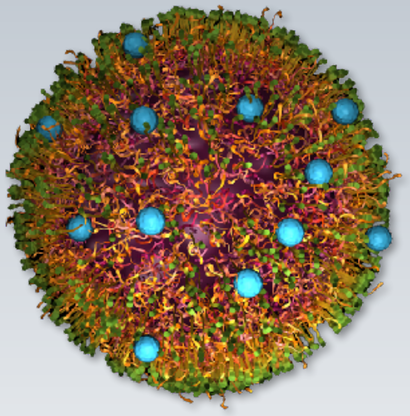


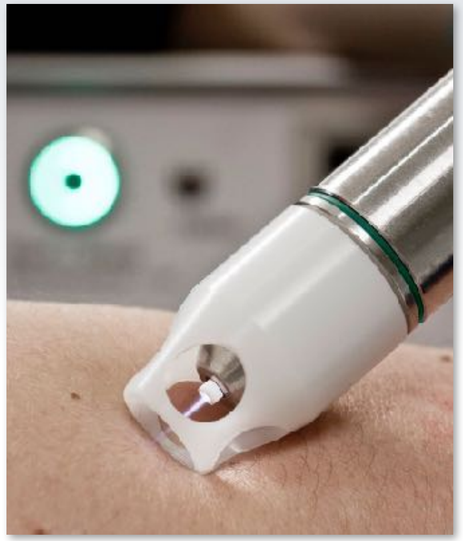
Diagnostics, Monitoring, Therapy

Examples of Therapeutic Approaches

- treatments with new anti-infective drugs or recombination of existing active substances,
- topical treatment of wounds, eg by using:
  - nonwovens that are releasing reactive oxygen species, photosensitizers, phage therapy, plasma medicine
- treatment with stimulated pathogen-specific T cells
- treatments with antibiotic theragnostic nanoparticles to make the substances bioavailable where needed in the body

> “first in man / first in patient”-unit





Top: SmartDyeLivery GmbH
Bottom: kinPEN, neoplas tools GmbH.

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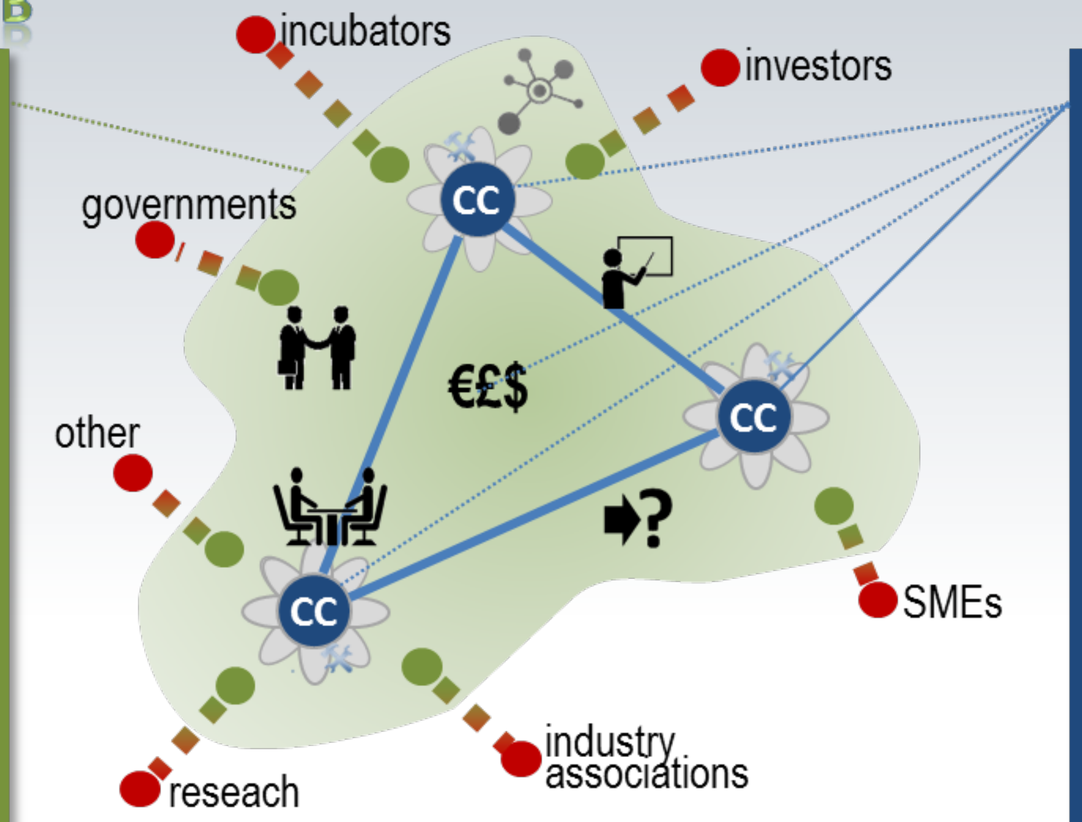
Future of Networking: Regional Innovation and Competence Centres

DIGITAL INNOVATION HUB

- Making use of CCs for equipment and expertise
- Development of ecosystem
- Support of brokerage
- Access to finance
- Market intelligence
- Training and education
- Incubator services

- ***Supporting the innovation ecosystem***



COMPETENCE CENTRE

- Technological infrastructure, technology platform
- Available expertise to make it operational
- Support of experimentation in business environment
- Showing best practices

- ***Sharing costs and development of expertise***

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Thank You.

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