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CAMPUS GROSSHADERN

LIFE-ZENTRUM – LASER-FORSCHUNGLABOR (LFL)

LFL

Laser applications in medicine

Ronald Sroka
Herbert Stepp, Max Aumiller, Christian Homann, Adrian Rühm

GlioLighT-Consortium Meeting
Pre-Meeting Workshop
VINCA – Institute of Nuclear Science, Belgrade, Serbia
01. September 2026

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Outline

Laser-Tissue Interaction

PDD – brain tumor

Coagulation / Vaporisation

kidney

Point-of care

PDT – PDD basic

PDT – brain tumor

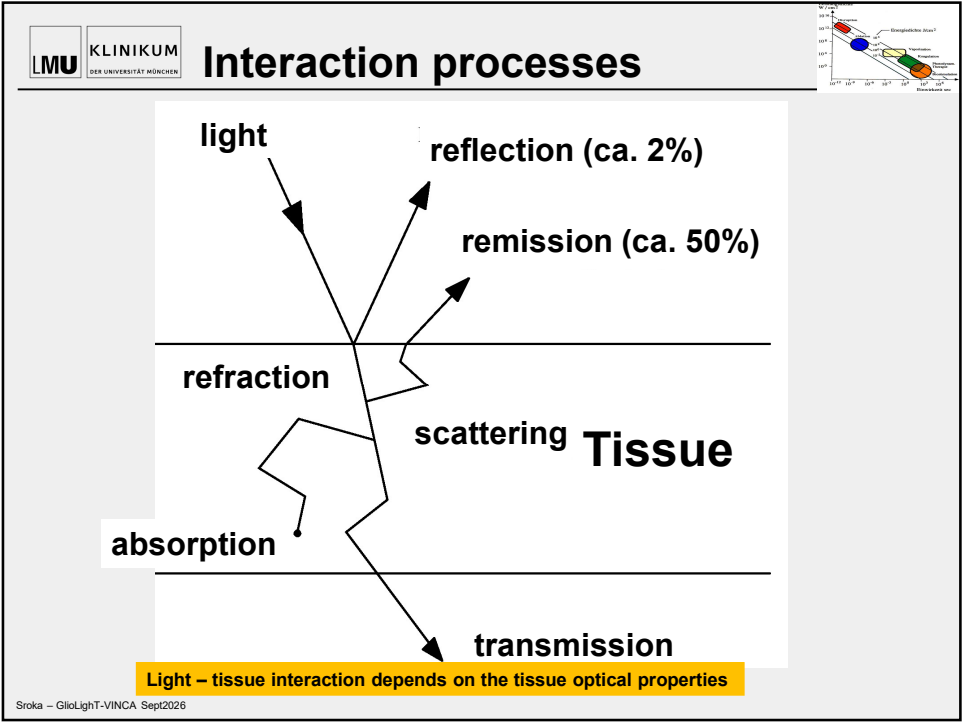
lung

vein

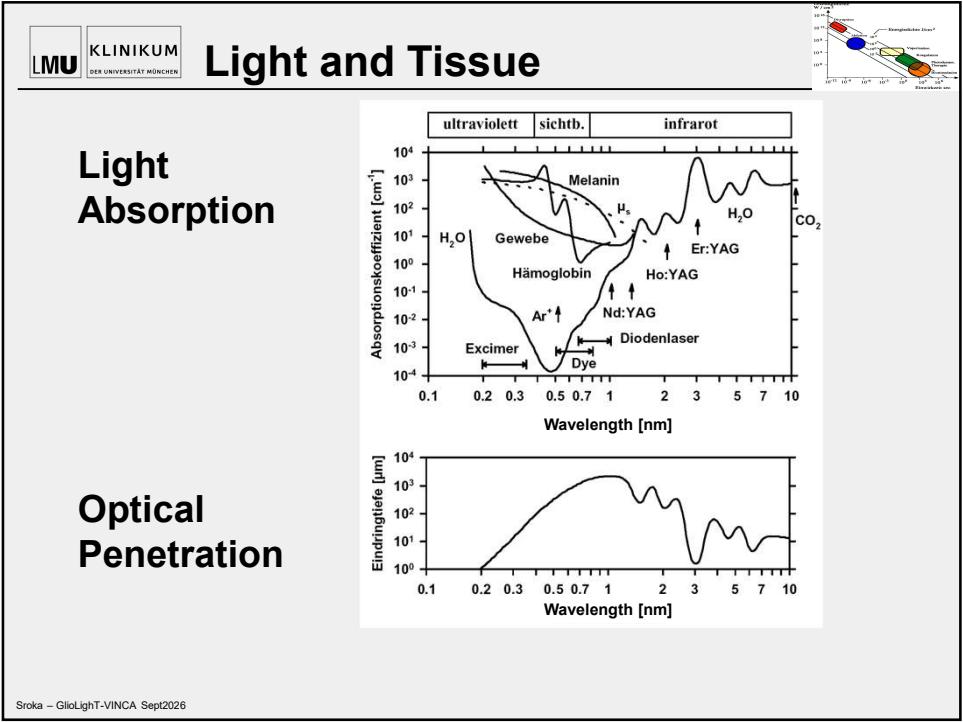
Lithotripsy – Urology

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Laser-Forschungslabor
LASER-FORSCHUNGLABOR (LFL)

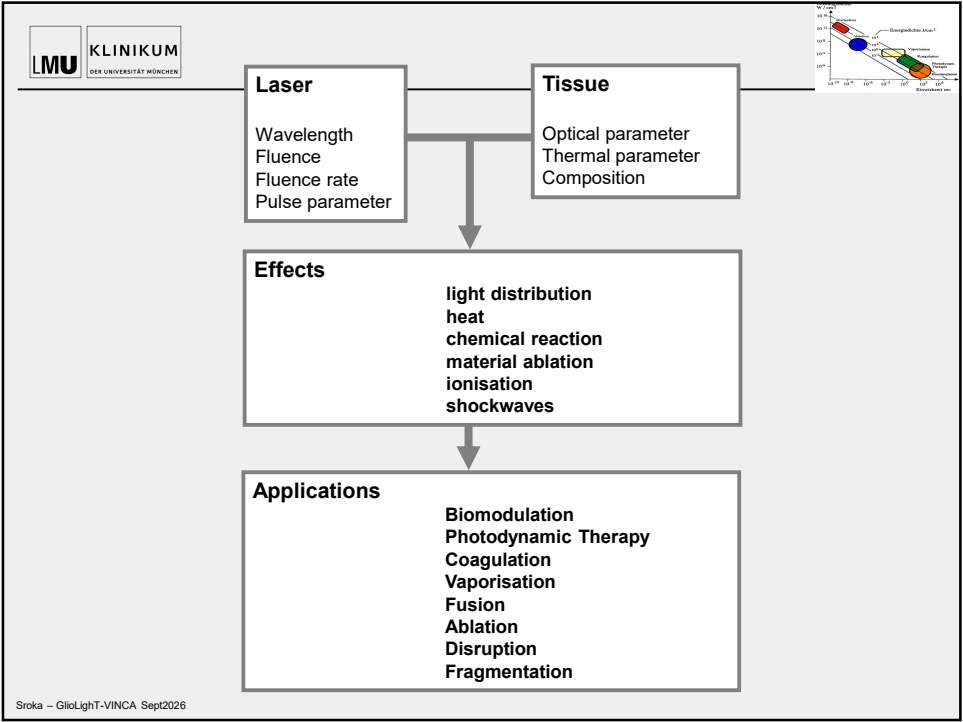
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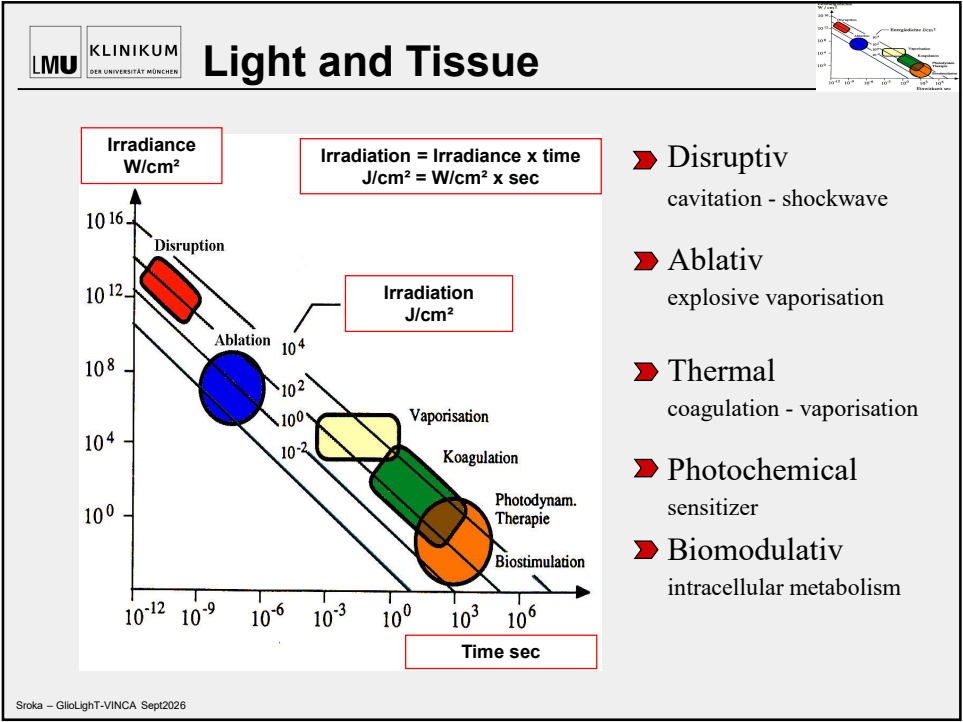
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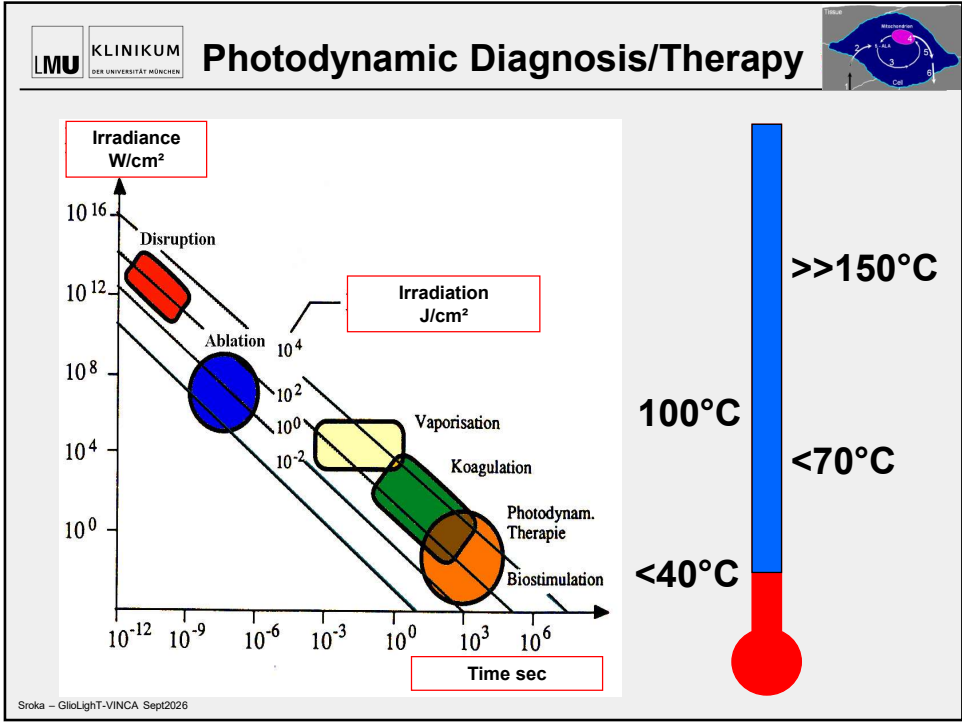


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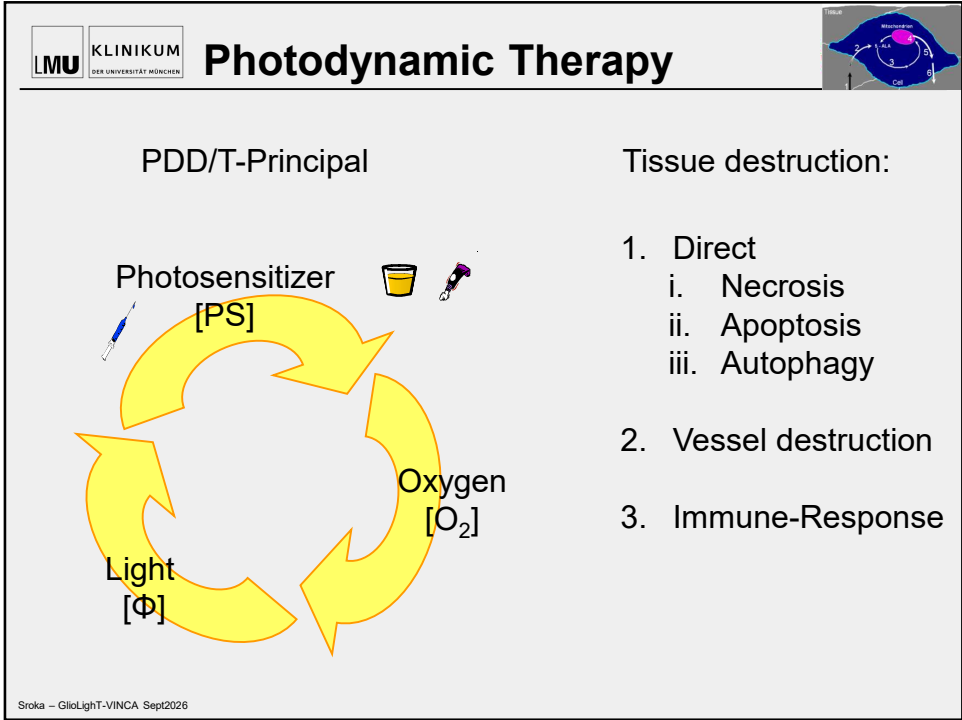


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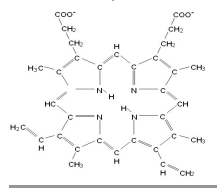




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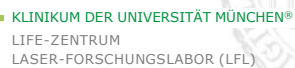


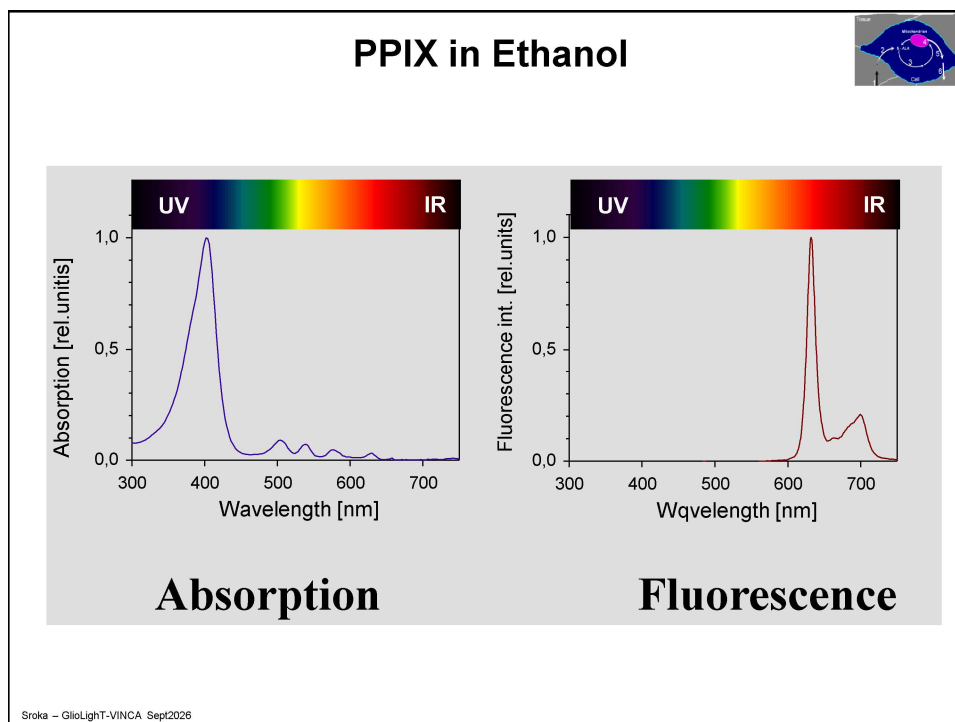
8



- Endogenous substance
- Topical application possible
- Sensitizer is synthesized intracellularly
- High tissue and tumor-selectivity
- **Fast pharmacokinetics**
- Lowcost drug
- Shows photobleaching

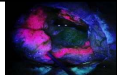
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Malignant Glioma




- ca. 50% of primary brain tumors
- **Very bad prognosis**
WHO III median survival ca. 2 years
WHO IV (GBM) 15 months
- Growth with diffuse infiltration into functional brain
- Resection with safety margin not possible
- Therapy: surgery, radiotherapy, chemotherapy
- The more complete the surgery, the longer the survival

→ safe gross total resection --- 5-ALA based **Fluorescence Guided Resection (FGR) !**

- Still not curative, may only prolong progression free survival

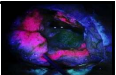
→ 5-ALA based Photodynamic Therapy (PDT) ? - **next session**

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LIFE-Zentrum

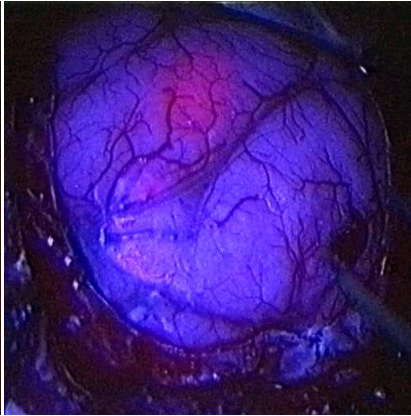
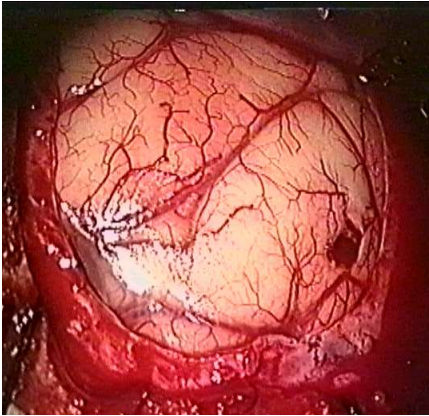
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Fluorescence assisted Operation



Glioblastoma

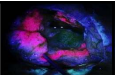


White light for visual orientation

Blue light for fluorescence excitation

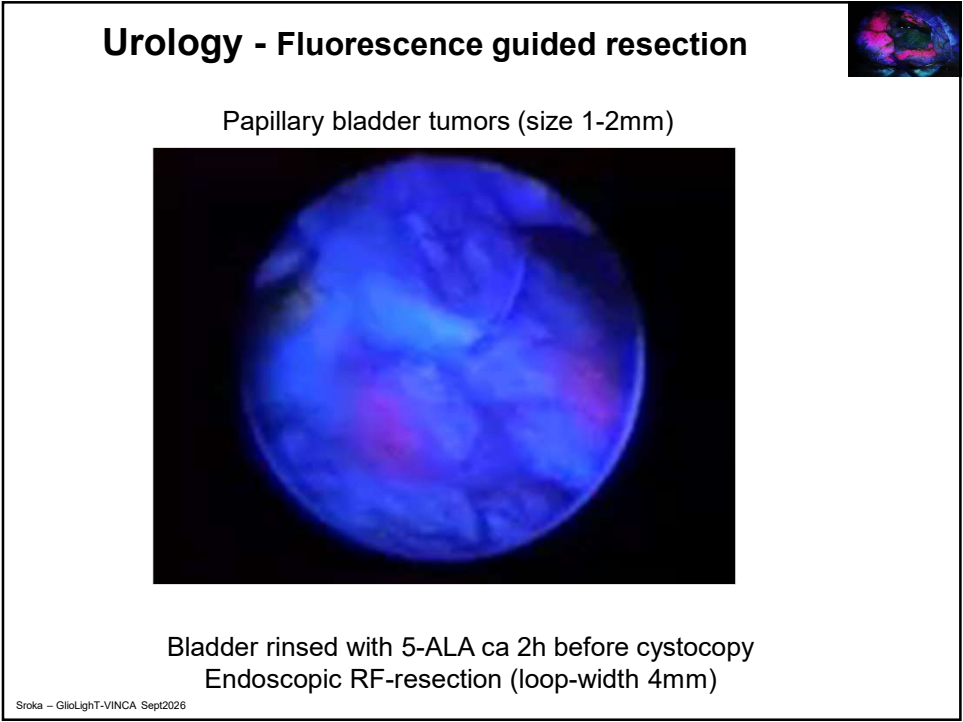
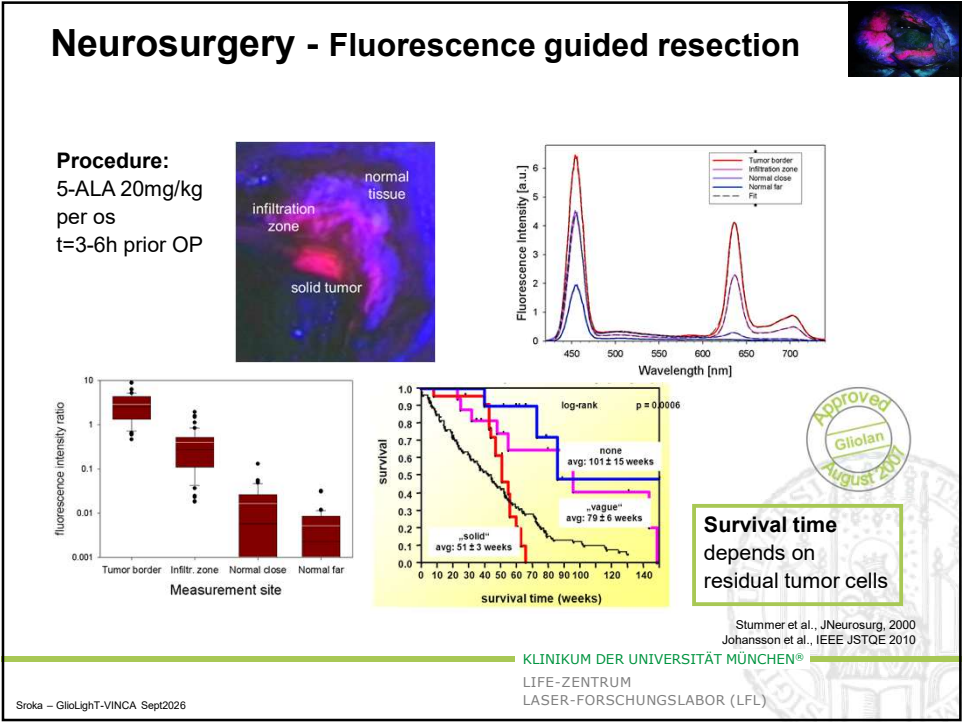
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Fluorescence guided resection - Braintumor





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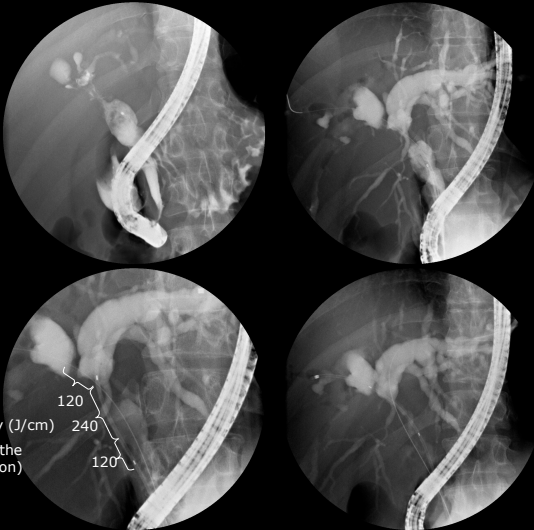




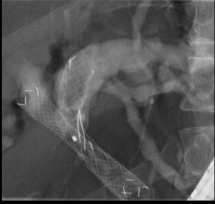
Gastroenterology - Cholangiocarcinoma



Klatskin tumor



Y-shaped stent



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Datum

17



Gastroenterology - Cholangiocarcinoma



Outcome

Median survival:

PDT + drainage/stent (n=68)

enhanced in comparison to

drainage/stent only (n=56)

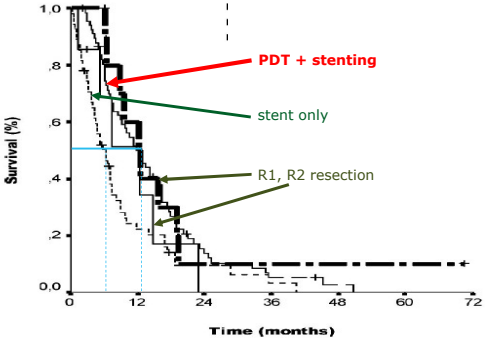
identical to

R1, R2 resection (n=11+7)

ca. 12 mths

ca. 6 mths

ca. 12 mths



Witzigmann et al., Ann Surg 2006

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One Health One World

Photodynamic Inactivation – antimicrobial

Selectivity

Photosensitizer

Drug-Light Interval

Light
Dosimetry

Oxygen

Human health **Animal health** **Plant health**
Food **PDI as solution for One Health** **Food**

photo-larvicides
surface-disinfection
nose-disinfection

reduction of Moscito-Larve to prevent for Malaria
reduction of contact-contamination with bacteria
reduction of bacterial load in OR to prevent for infections

Glas Edeltahl Kunststoffe

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Coagulation

Irradiance W/cm²

Irradiation J/cm²

Time sec

Disruption
Ablation
Vaporisation
Koagulation
Photodynam. Therapie
Biostimulation

>>150°C
100°C
<70°C
<40°C

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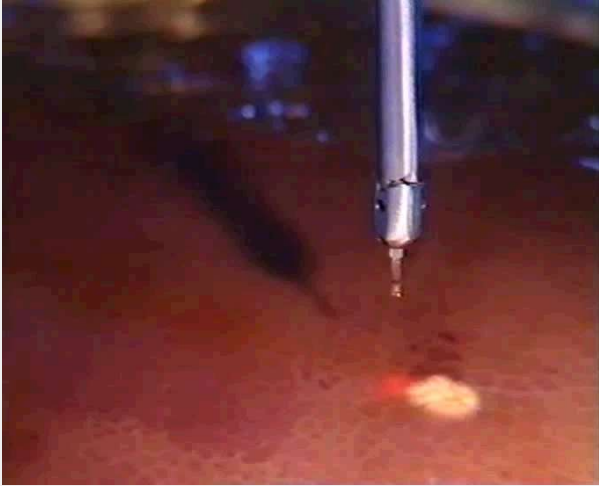
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Coagulation



protein-denaturation in the depth



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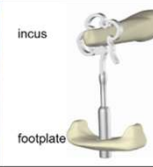
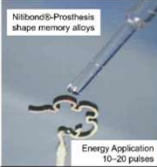
Otho-Rhino-Laryngology



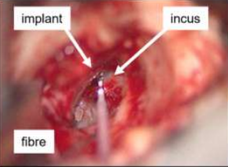
Tumor-Diagnosis: PDD, OCT, HSI
PDT: Tumore



Stapesimplantation - Nitinol







Laser-Surgery

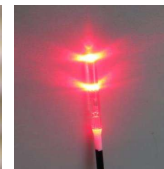
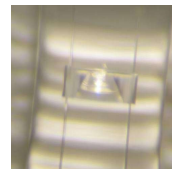
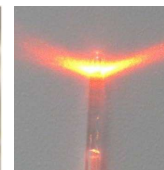
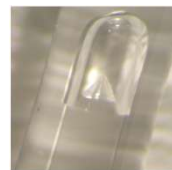
Nasel turbinate Reduction
Tonsillotomy / Tonsillectomy
Salivary Stone-Lithotripsy



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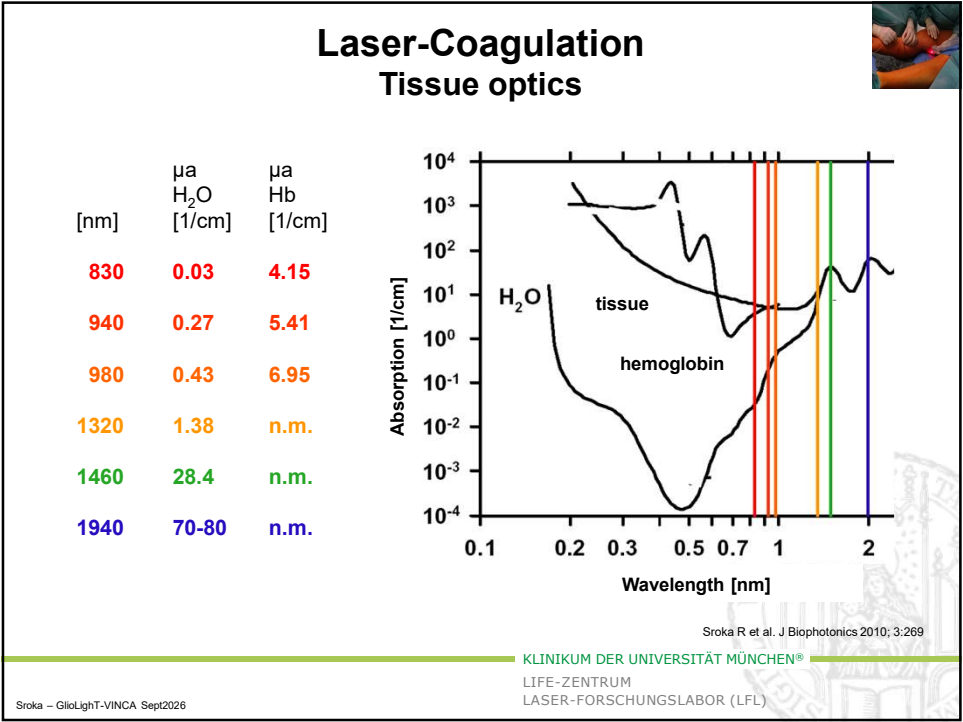
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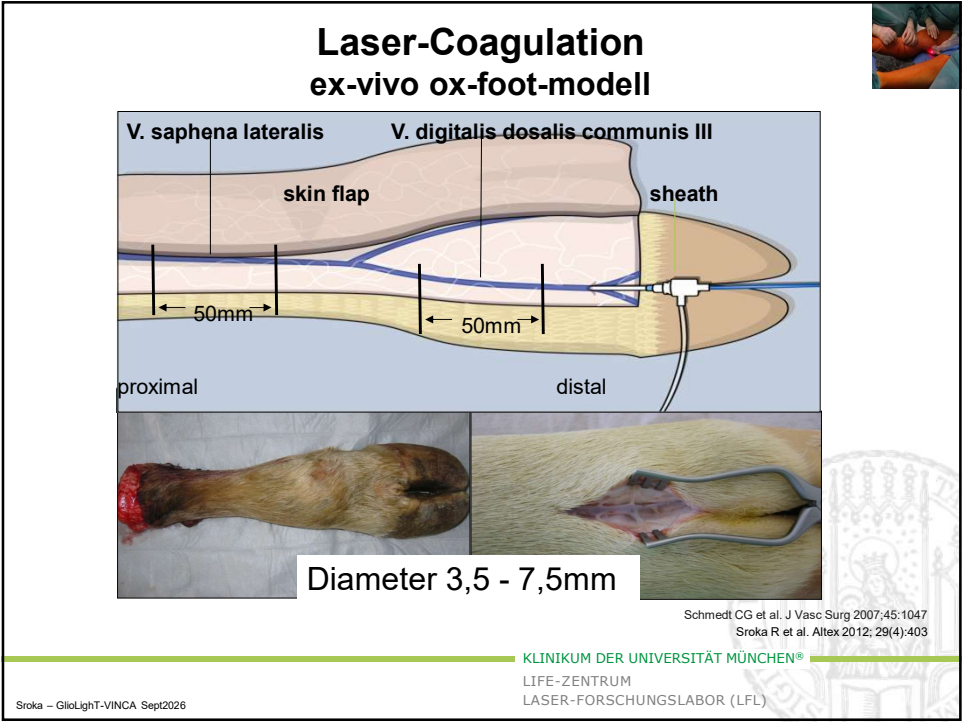


norm: 500µm/600µm
norm: 630µm/1850µm

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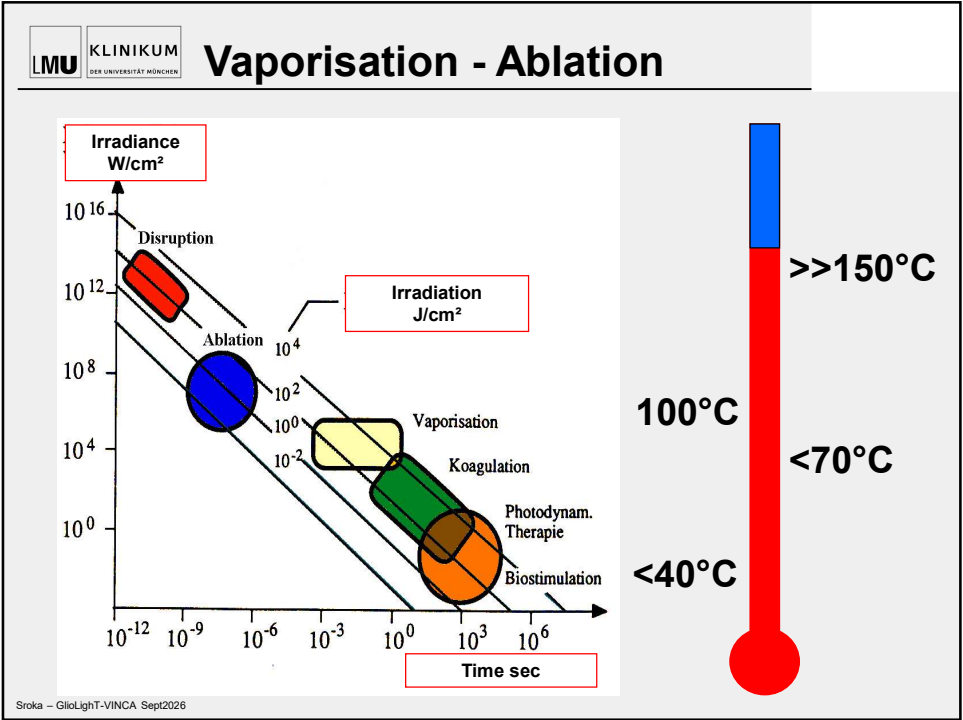
Laser-Coagulation
clinical protocols

EU-Guideline
2015

Protocol		prior 2006	2009	2013	2015
wavelength	[nm]	800-1320	1470	1940	1470
pull-velocity	[mm/s]	div.	1	1	1
fibre		bare fiber	1-ring	1-ring	2-ring
carbonisation energy	[J]	50	600	1000	1000
power	[W]	15-30	8-12	3-9	10
irradiance	[W/cm²]	<10000	<400	<150	<200
EFE	[J/cm²]	40-100	25-50	<15	<25
LEED	[J/cm]	40-80	60-100	40-80	60-100
tissue effect		carbonized	cylindrical homogenous coagulation		
occlusion rate	[%]	>90	>95	-100%	???
side effects		diverse	pain	minor	???



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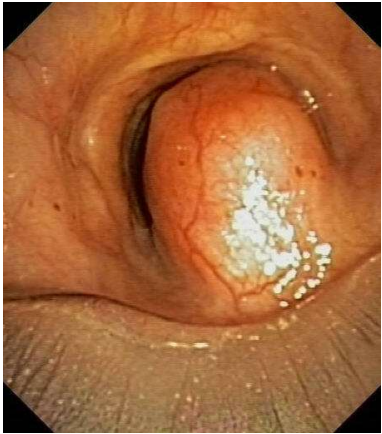
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Tissue reduction



Endoscopy in pulmonology



In interventional pulmonology there is a frequent need for tissue ablation in pre-existing airway stents.

In benign stenosis severe incorporation of stents in granulation tissue can occur.

In malignant stenosis progressing tumour can protrude into silicone stents or overgrow partially covered metallic stents.

Removal of these stents can be hazardous and quality of life can be severely compromised in these patients.

So-far Nd:YAG-Laser assisted ablation had been performed showing prominent side effects

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Gesierich W et al., J Thorac Cardiovasc Surg. 2014;147(6):1827-32.

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Example

5W-1940nm Tm:fibre laser

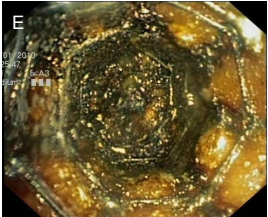


left main bronchus laser resection of granulated obstructing tissue

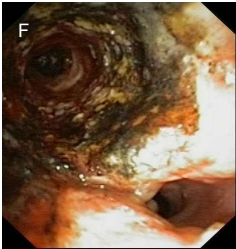
prior



after tissue removal



after extraction



extracted stents



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Gesierich W et al., J Thorac Cardiovasc Surg. 2014;147(6):1827-32.

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Bleeding vessel

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Bleeding vessel

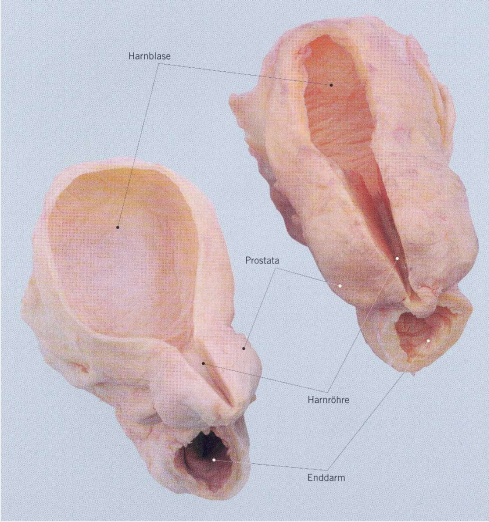
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Benign Prostate Hyperplasia





Harnblase
Prostata
Harnröhre
Enddarm

aus: Körperwelten (v. Hagen)

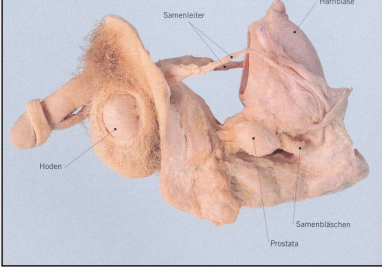
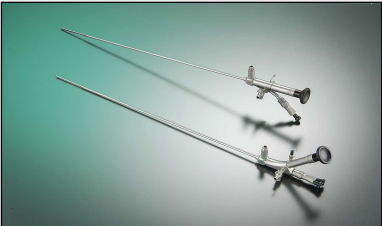
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Urethra-Cystoscopy





Samenleiter
Harnblase
Hoden
Samenbläschen
Prostata

aus: Körperwelten (v. Hagen)

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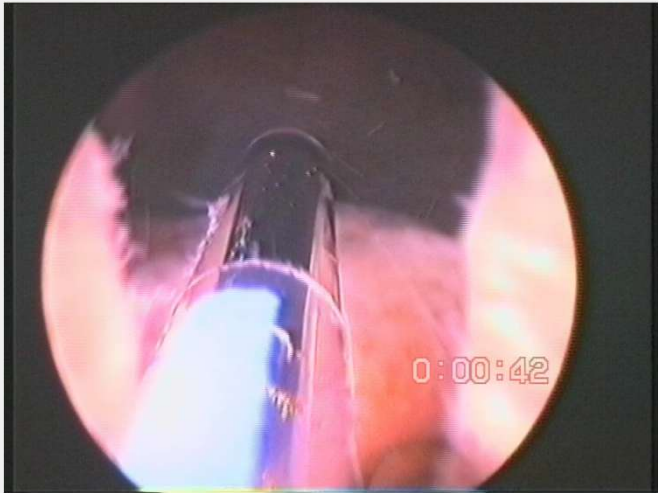
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Prostate Vaporisation



Side Fire Technik – High Power Laser



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UNIVERSITY

Prostate Enucleation Strategy



Enucleation with
vapor bubbles

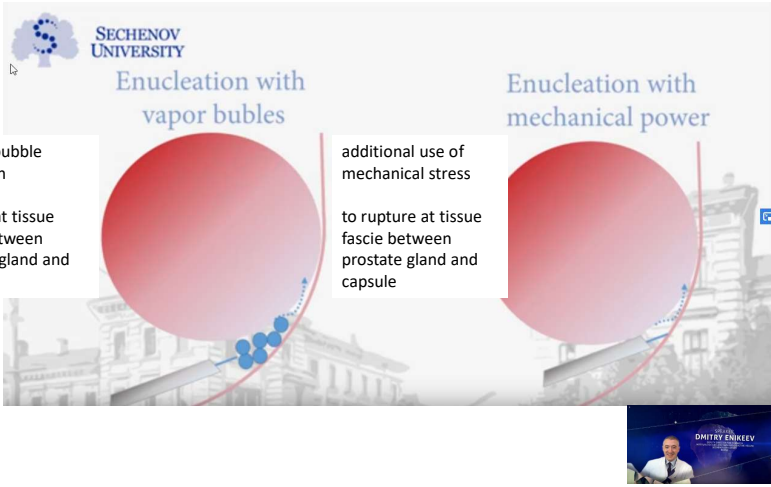
Ho:YAG bubble
formation

rupture at tissue
fascie between
prostate gland and
capsule

Enucleation with
mechanical power

additional use of
mechanical stress

to rupture at tissue
fascie between
prostate gland and
capsule



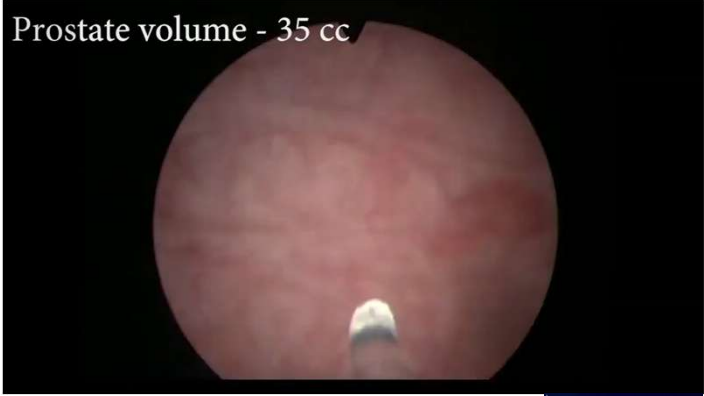
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Prostate Laser Enucleation

ThuFLEP (1940nm)

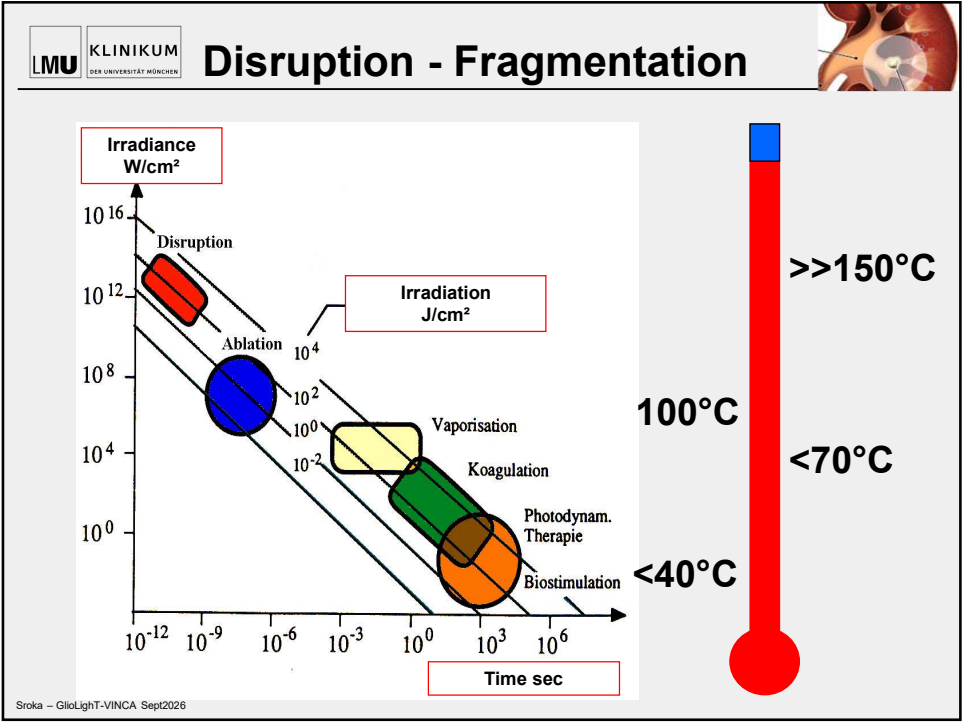
Prostate volume - 35 cc





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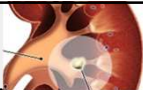
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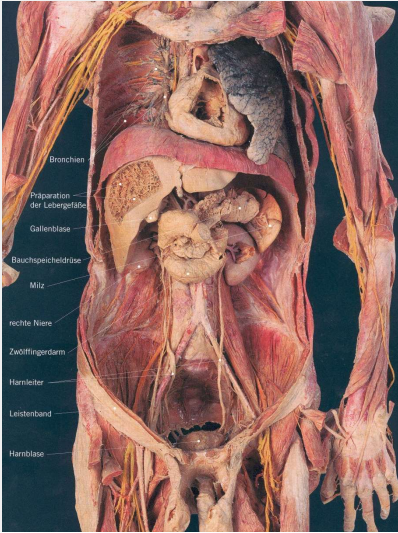
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Lithotripsy clinic







aus: Körperwelten (v. Hagen)

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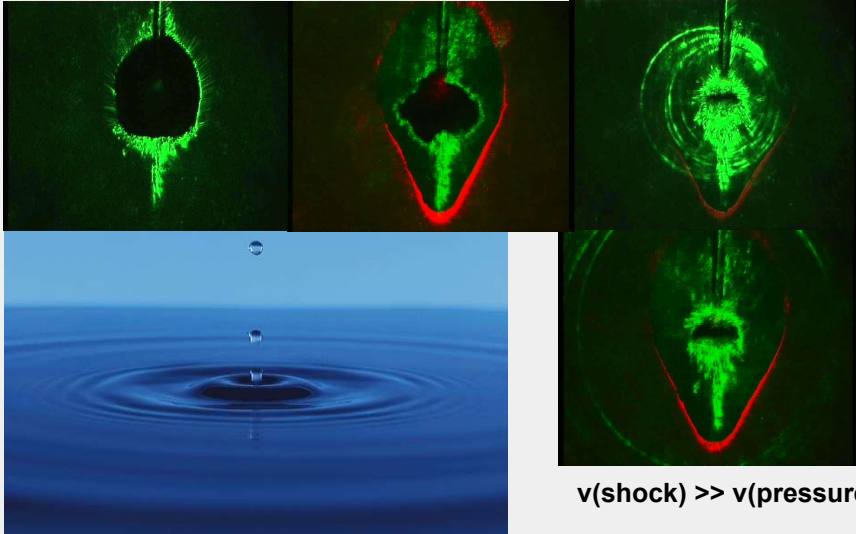
Laserpulse in water



Steam-bubble

Pressure-wave

Shock-wave



v(shock) >> v(pressure)

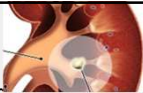
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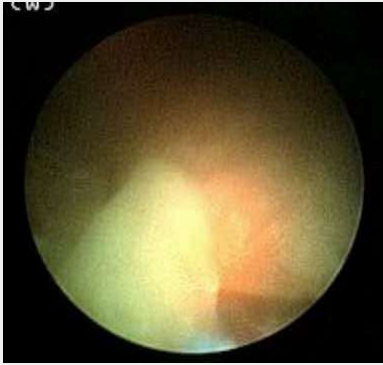
Lithotripsy



µs-Laserpulse



ms-Laserpulse



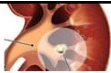
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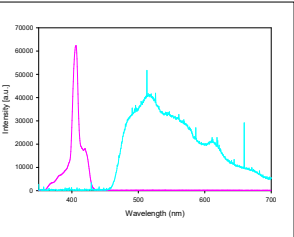
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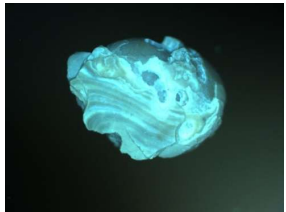
LASER-FORSCHUNGSLABOR (LFL)



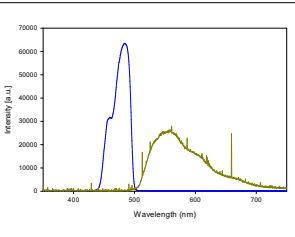
Feedback - Stone Fluorescence Microscopy

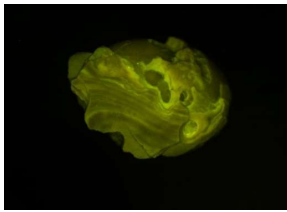
$\lambda_{exc} = 400\text{ nm}$
 $\lambda_{det} > 470\text{ nm}$



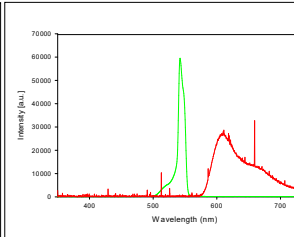


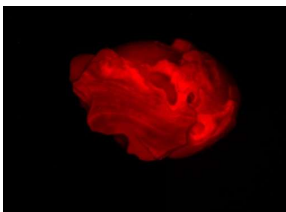
$\lambda_{exc} = 450\text{ nm}$
 $\lambda_{det} > 520\text{ nm}$





$\lambda_{exc} = 550\text{ nm}$
 $\lambda_{det} > 590\text{ nm}$





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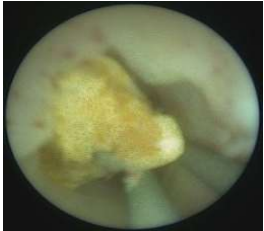
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Feedback – Clinical endoscopic images

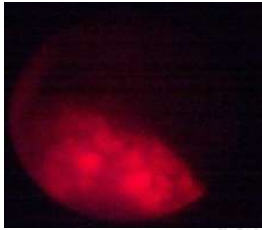
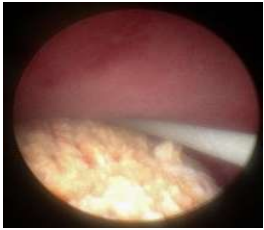
White light illumination

Green light illumination
 $\lambda_{exc} = 500 - 570 \text{ nm}$
Filter: $\lambda_{det} > 610 \text{ nm}$

Stone sample 1

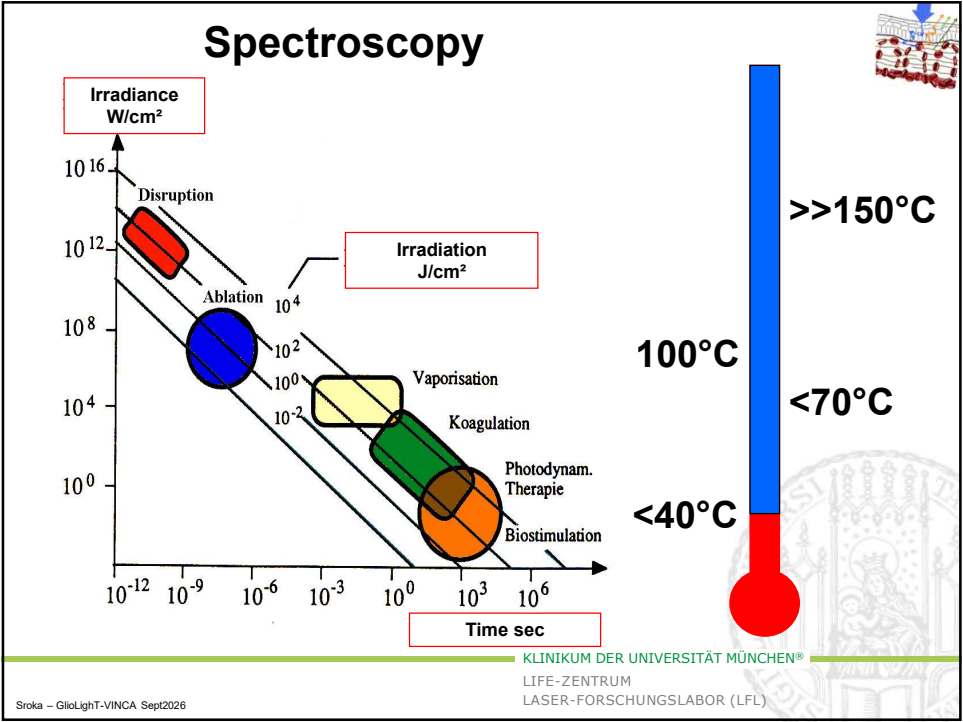


Stone sample 2



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IRON DEFICIENCY AND POINT-OF-CARE TESTING

- Affects > 2 billion people world-wide
- Causes anemia, impairs cognitive development and immunity
- Increases risk of death in children in malaria endemic areas
- Iron supplementation of iron-deficient children **decreases mortality**
- But:** Iron supplementation on iron-replete children **increases mortality**

→ WHO: Screen for iron deficiency before iron supplementation

Preferred marker: erythrocyte **Zinc Protoporphyrin-IX (ZnPP)**

→ But: blood withdrawal often critical
(missing laboratory infrastructure, religious beliefs)

WHO (2007) Food and nutrition bulletin 28(4 Suppl)

Stoltzfus et al. (2007) Food and nutrition bulletin 28(4 Suppl)

Sazawal et al. (2006) Lancet 367

Tielsch et al. (2006) Lancet 367

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ERYTHROCYTE PROTOPORPHYRINS

Protoporphyrin-IX (PPIX)

Cc1c(C)nc2c(c1)c(C(=O)O)cc2C(=O)O

Heme

Cc1c(C)nc2c(c1)c(C(=O)O)cc2C(=O)O

Zinc Protoporphyrin-IX (ZnPP)

Cc1c(C)nc2c(c1)c(C(=O)O)cc2C(=O)O

→ (Latent) Iron deficiency: ZnPP / Heme ↑

Ratio ZnPP/Heme in healthy individuals < 1:20.000

Labbe et al. (1999) Clin. Chem.

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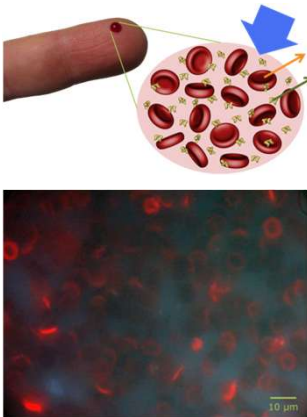
LASER-FORSCHUNGSLABOR (LFL)

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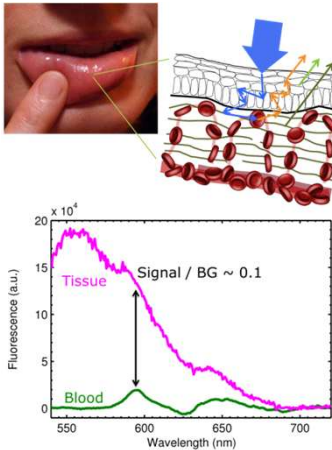
Lab-Medicine: Fe-deficiency detection

invasive procedure



detection of zinc protoporphyrin fluorescence in erythrocytes as marker for iron deficiency

non-invasive procedure



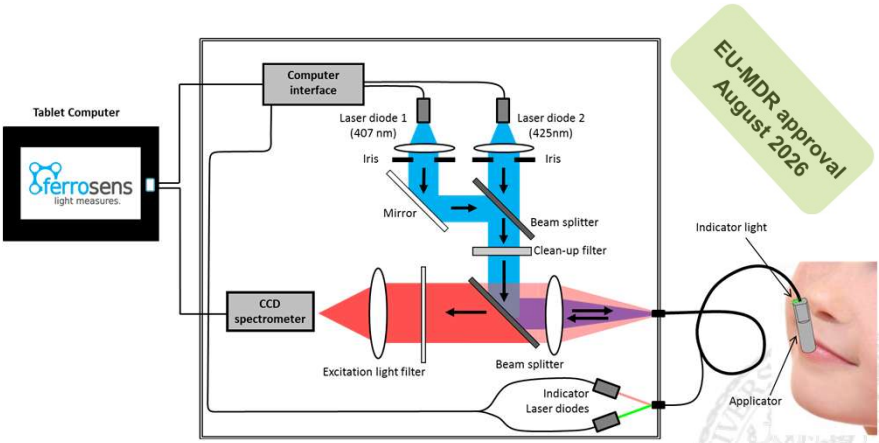
Signal / BG ~ 0.1

Hennig G et al., Rev Sci Instrum. 2013; J Biophotonics. 2014; Nat. Commun. 2016
SPIN-OFF-company FerroSens

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SCHEMATIC SETUP



EU-MDR approval August 2026

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Outline

Laser-Tissue Interaction

PDT – PDD basic

PDD – brain tumor

PDT – brain tumor

Coagulation / Vaporisation

nose

lung

kidney

vein

Point-of care

Lithotripsy – Urology



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Translation from Experiment to Clinic



Neurosurgery
PDT tumors
PDT residues
FG resection
FG biopsy

Pulmonology
PDT and FD, pCLE
Stent removal

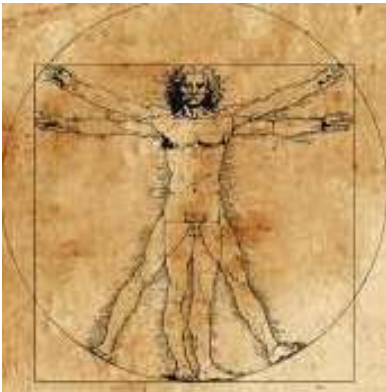
Gastroenterology
PDT-bile duct
FD, OCT, pCLE-Diagnostic
PDT-abscess-drainage
FD-thyroid

Radiology
controlled drug release
Hyperthermia
PDT-MRI-follow-up

Orthopedics
antimicrobial PDT

Dermatology
PDT, OCT

Dentistry
material characterisation



Laboratory Medicine
Fe-deficiency (Spin-Off)
Porphyrin-Detection
Breathe-Analysis
Bacteria-Detection

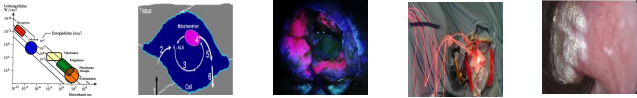
Otorhinolaryngology
Laser assisted stapes implant fixation
PDT-tumor
Fluorescence-diagnostics
HSI-perfusion indices
Nasal-Turbinate Reduction
Tumor resection

Gynecology
PDT Cervix dysplasia
FD and OCT diagnostic

Phlebology
Varicose Vein (ELT)

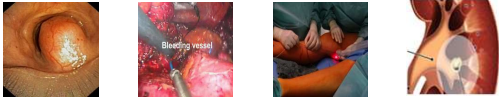
Urology
Bladder-PDT
ProstateCa-PDT
HSI-perfusion indices
Laser-Lithotripsy
Laser-Nephrectomie
LITT – Prostate
LVap – Prostata
Bladder-FD, FGR, OCT, pCLE

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Conclusion

- New photonic technologies can be addressed to clinical needs, but will be established after positive clinical trials and approval
- Knowledge of clinical environment is necessary to adopt application devices and parameters
- Intense communication and lab-training with medical doctors is mandatory



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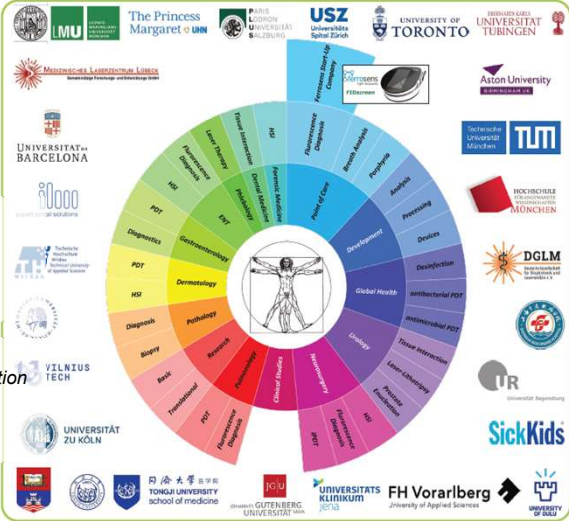
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LIFE – Laser-Forschungslabor R&D Activities

LFL-Team & Students:
Internship, Bachelor
Master, PhD & MD

Collaboration
KUM-Departments
Hospitals
Universities
Companies

Funding:
Alexander von Humboldt-Foundation
BMBF, Deutsche Krebshilfe, ZIM
DFG, Wilhelm-Sander, EU,
Bayerische Forschungs-Stiftung



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