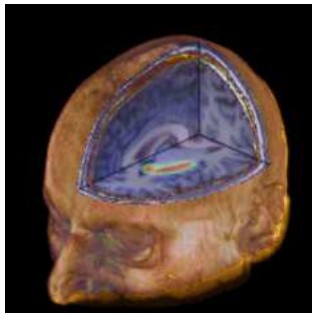
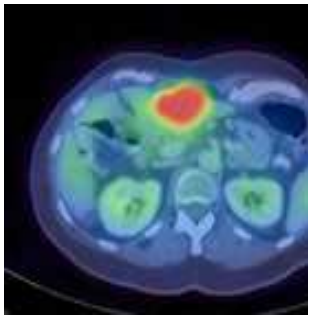
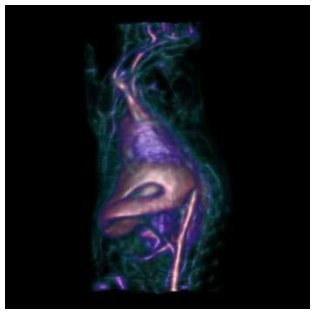
PET UND PET/CT

PRINZIP UND ANWENDUNG

P. Bartenstein
Klinik und Poliklinik für Nuklearmedizin
Ludwig-Maximilians-Universität München

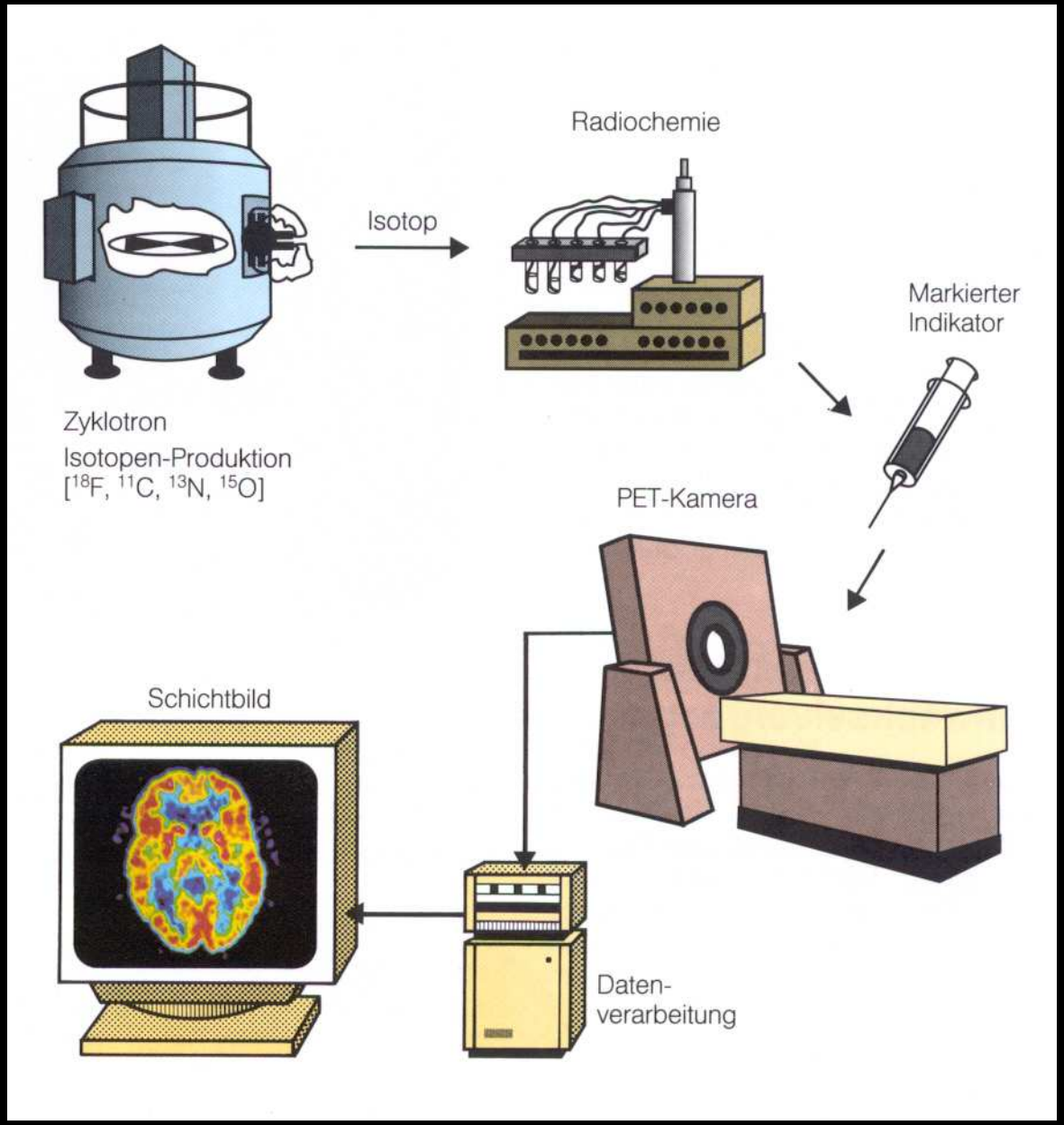


PET und PET/CT

- Methodik

- Klinische Anwendung
  - Neurowissenschaften
  - Kardiologie
  - Onkologie


Radiochemie
Isotop
Markierter
Indikator
Zyklotron
Isotopen-Produktion
[^{18}F, ^{11}C, ^{13}N, ^{15}O]
PET-Kamera
Schichtbild
Daten-
verarbeitung

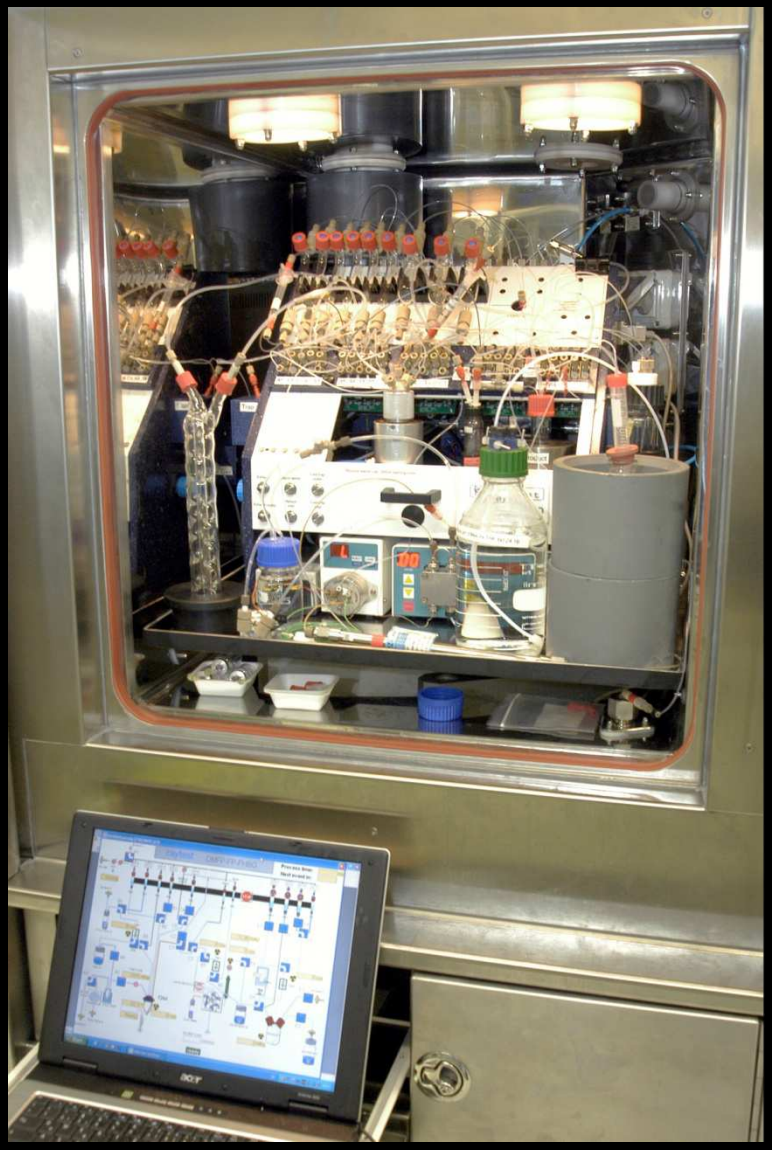
Zyklotron mit Abschirmung

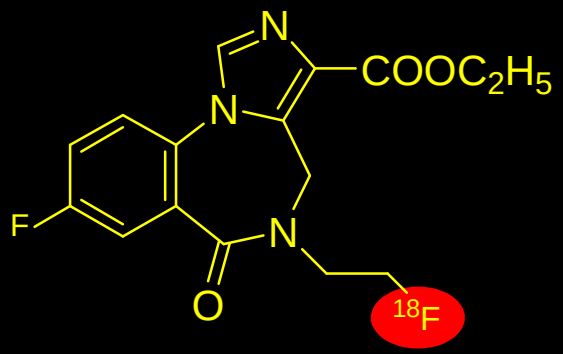
Zyklotron / geöffnete Abschirmung

Radioisotope für PET

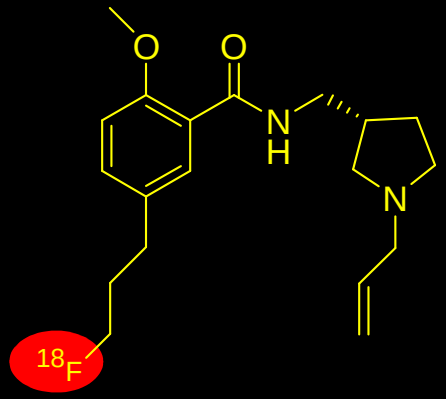
	Halbwertszeit (min)
• ^{11}C	20,4
• ^{13}N	10,0
• ^{15}O	2,1
• ^{18}F	109,7
• ^{68}Ga	68,0

Synthesebox für F-18 Synthesen

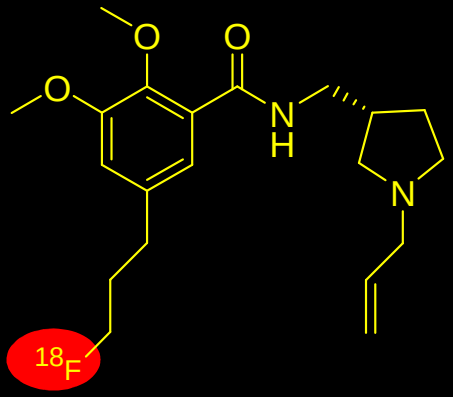




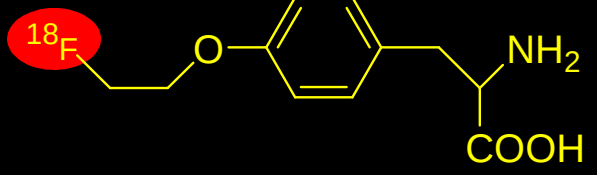
[^{18}F]Fluorethyl-flumazenil



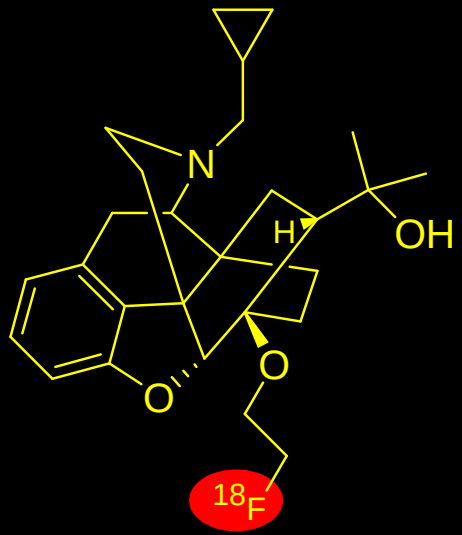
[^{18}F]Desmethoxyfallypride



[^{18}F]Fallypride



[^{18}F]Fluorethyltyrosin



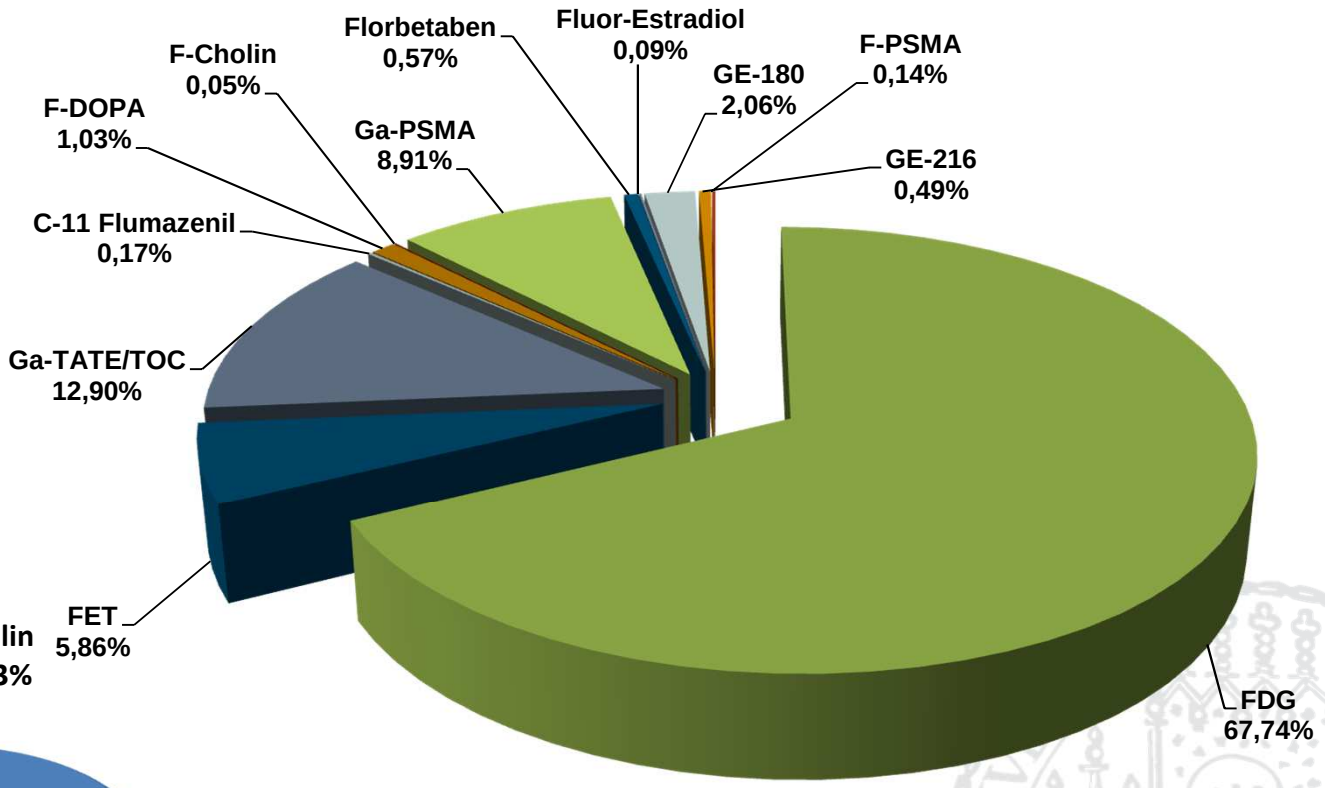
[^{18}F]Fluorethyl-diprenorphin

Extrem niedrige PET-Radiotracerdosen ermöglichen Anwendung am Menschen ohne Berücksichtigung pharmakologischer Effekte

X-ray contrast medium 100 ml, 62 300 000 µg	MRI contrast medium 10 ml, 4 700 000 µg	Bay-949 5 µg

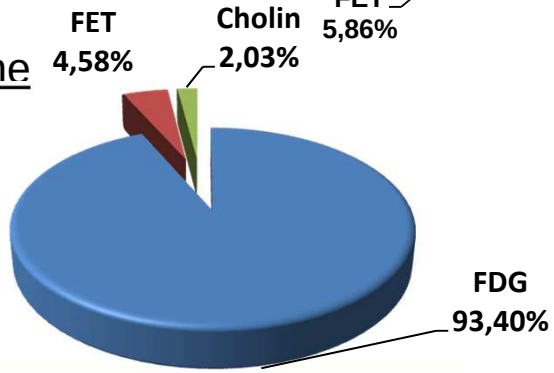
PET-Radiopharmaceuticals 2017

FDG	4416
FET	382
Ga-TATE/TOC	841
C-11 Flumazenil	11
F-DOPA	67
F-Cholin	3
Ga-PSMA	581
Florbetaben	37
Fluor-Estradiol	6
GE-180	134
GE-216	32
F-PSMA	9
total	**6519**



2490 FDG
122 FET
54 Choline
2666 total

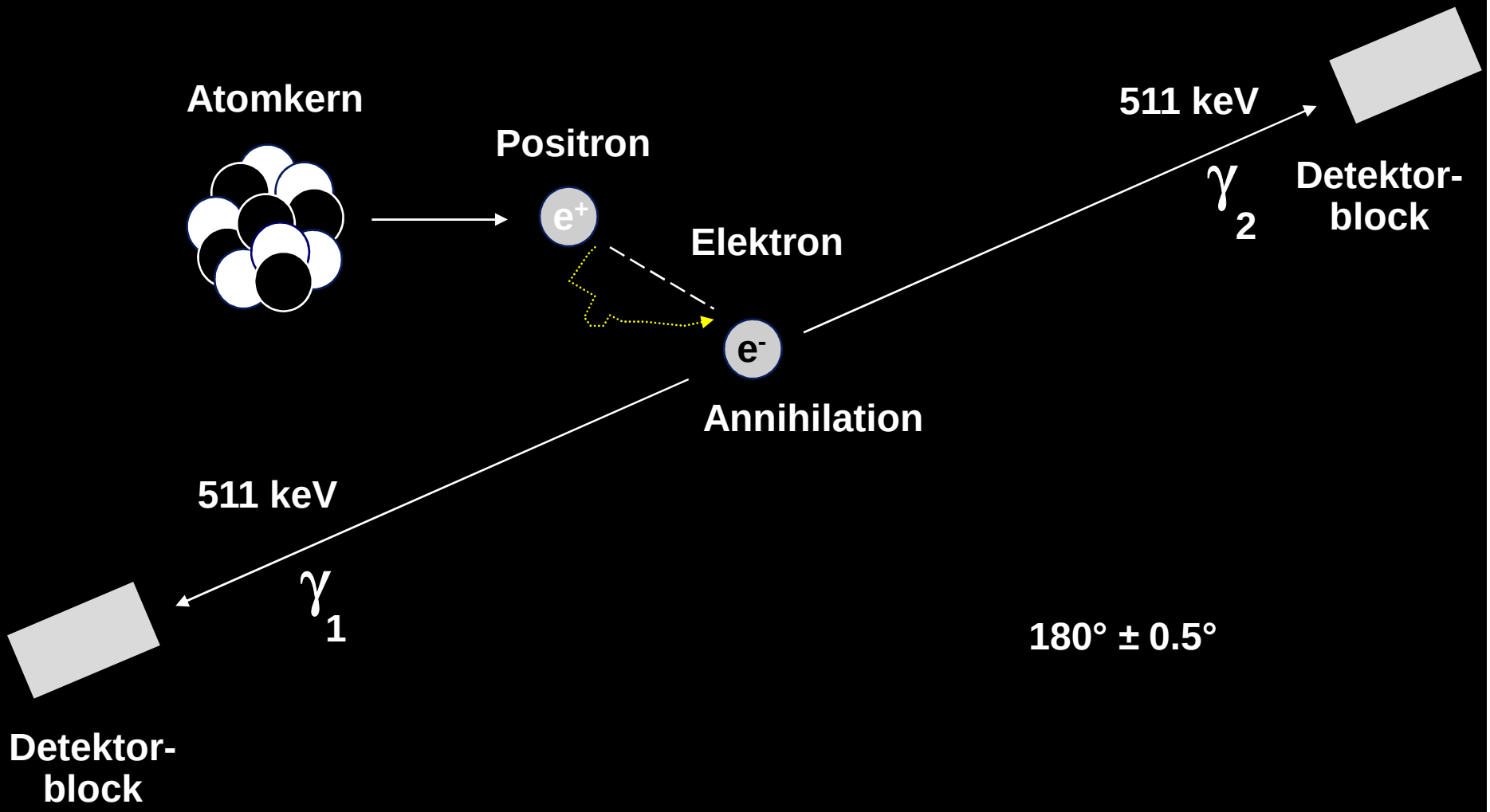
2005



Quelle: NIS/IBC

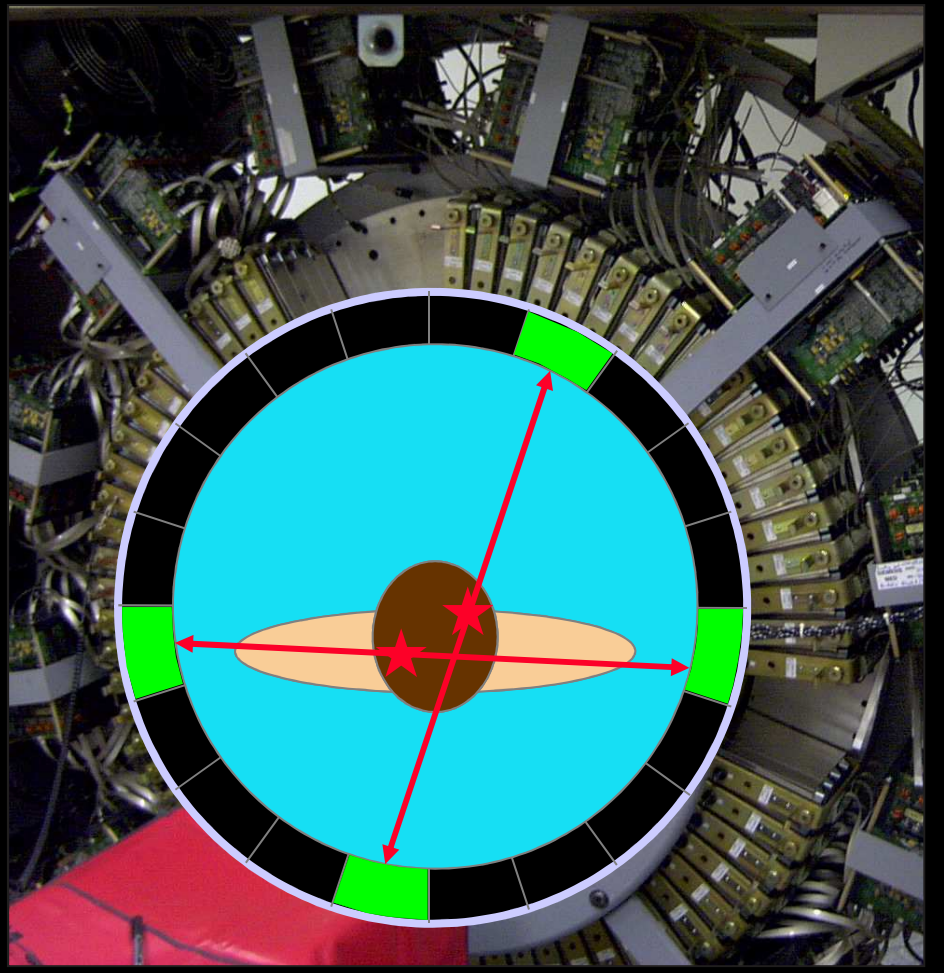
PET

Prinzip


Atomkern
Positron
e^+
Elektron
e^-
Annihilation
511 keV
γ_2
Detektor-
block
511 keV
γ_1
Detektor-
block
180° ± 0.5°

PET

Prinzip



PET/CT (Philips Gemini)

PHILIPS

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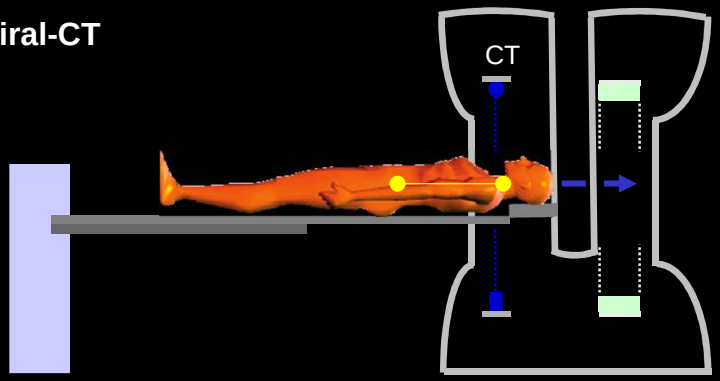
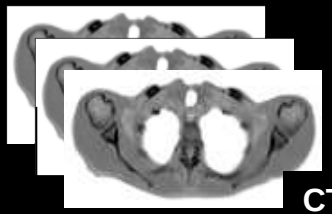
PET/CT: Prinzip

Spiral-CT



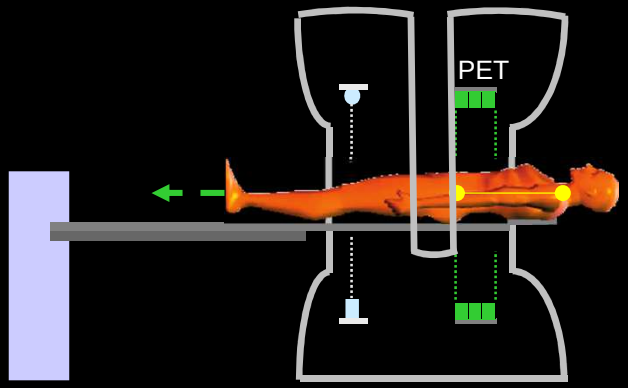
Spiral CT

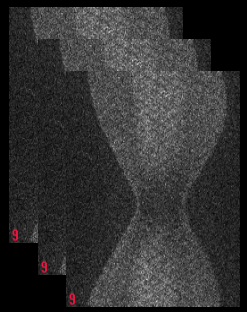


CT Daten

CT-basierte Korrektur

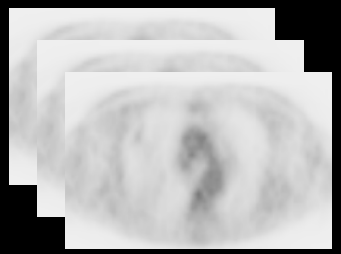
PET





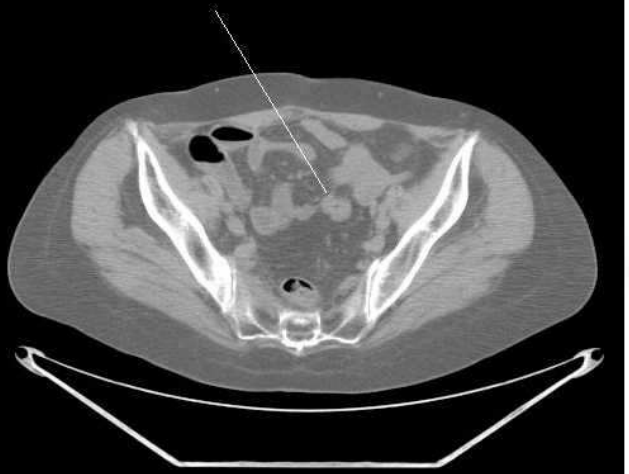
Emissionsdaten

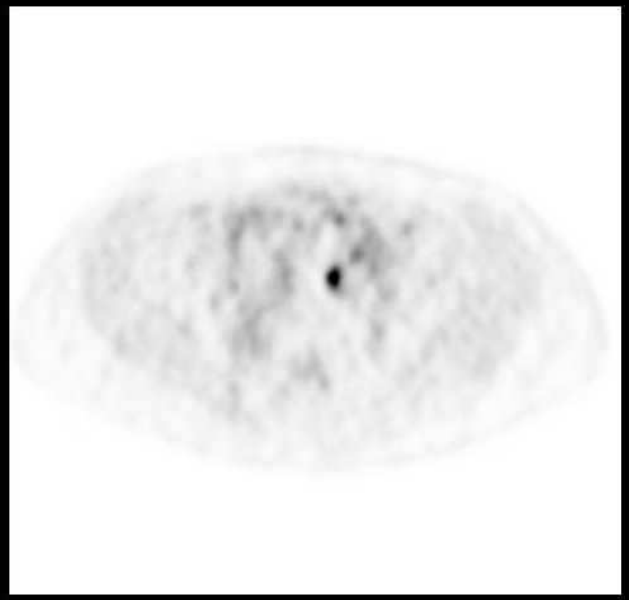
FORE+OSEM

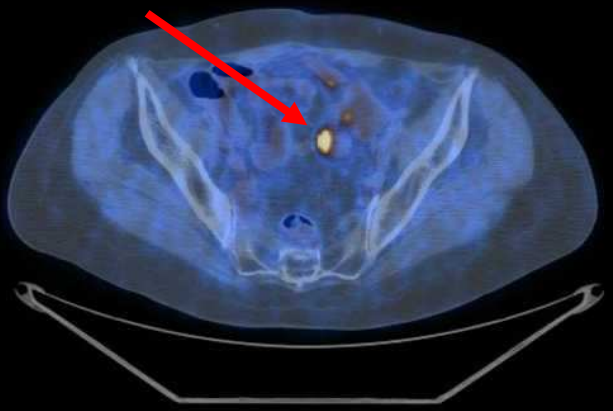


Korrigierte PET Daten

Colon Karzinom: Rezidivdiagnostik

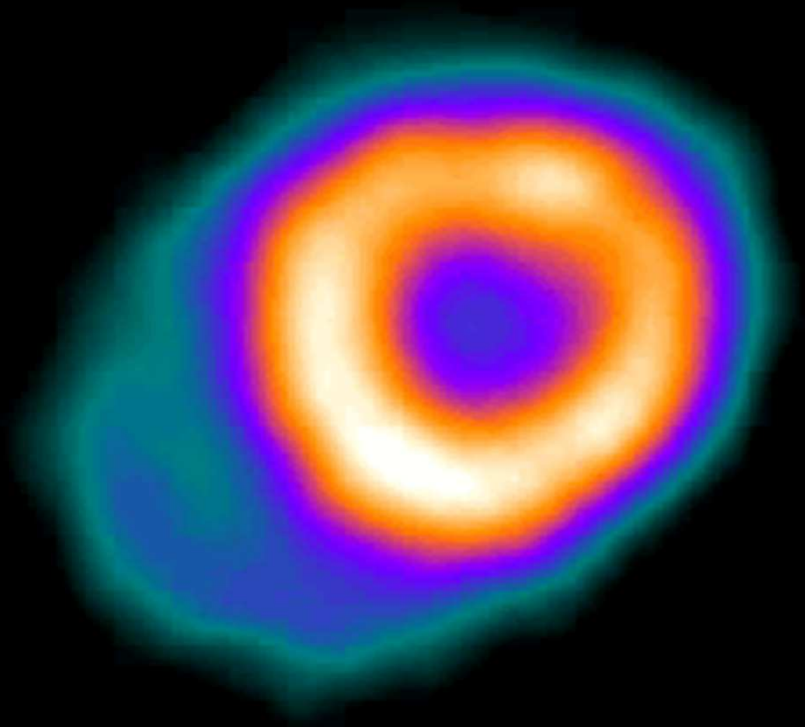




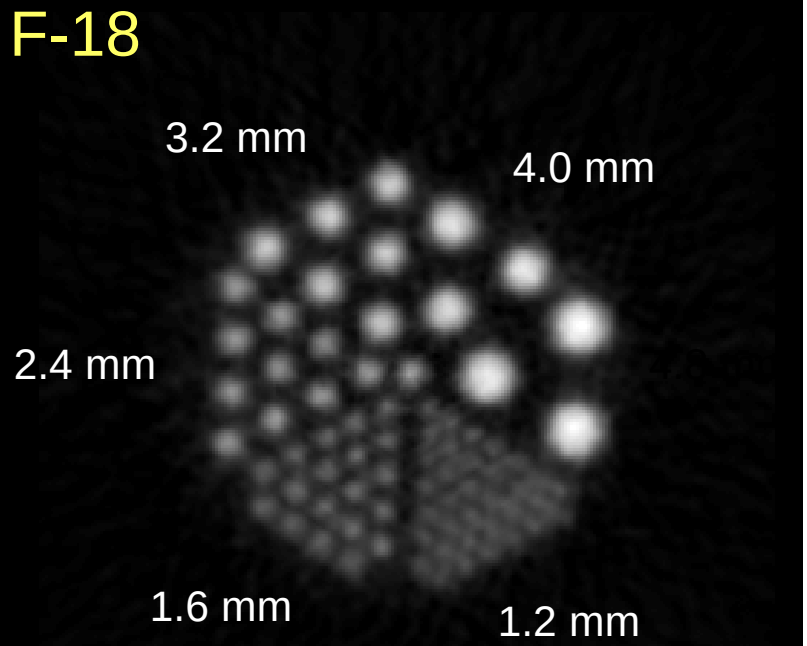


^{18}F-FDG-PET/CT: LK Metastase im Bereich der Iliaca interna

Mausherz EKG getriggert
[^{18}F]Fluor-Deoxyglucose

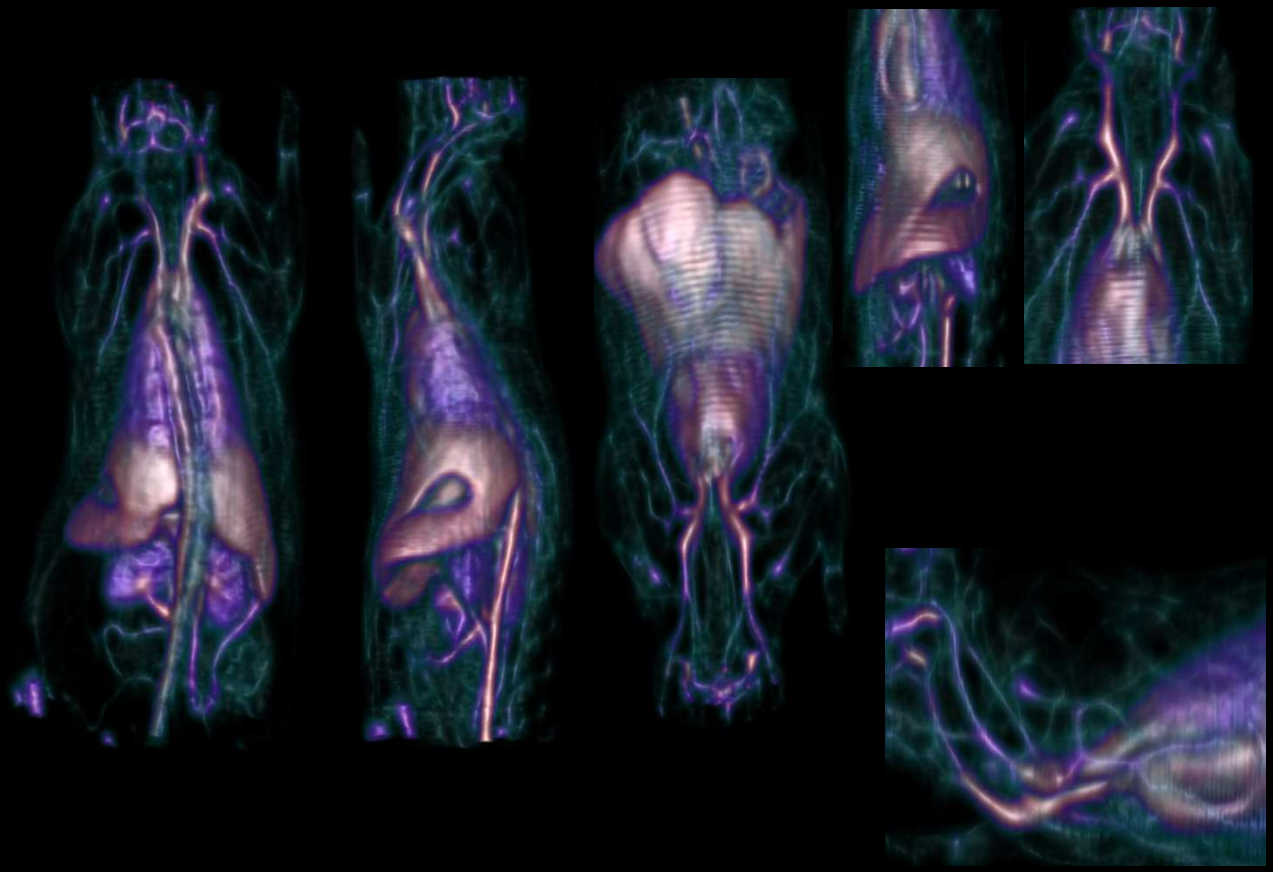


Phantom



Inveon PET

^{18}F Serum Albumin as Bloodpool Tracer



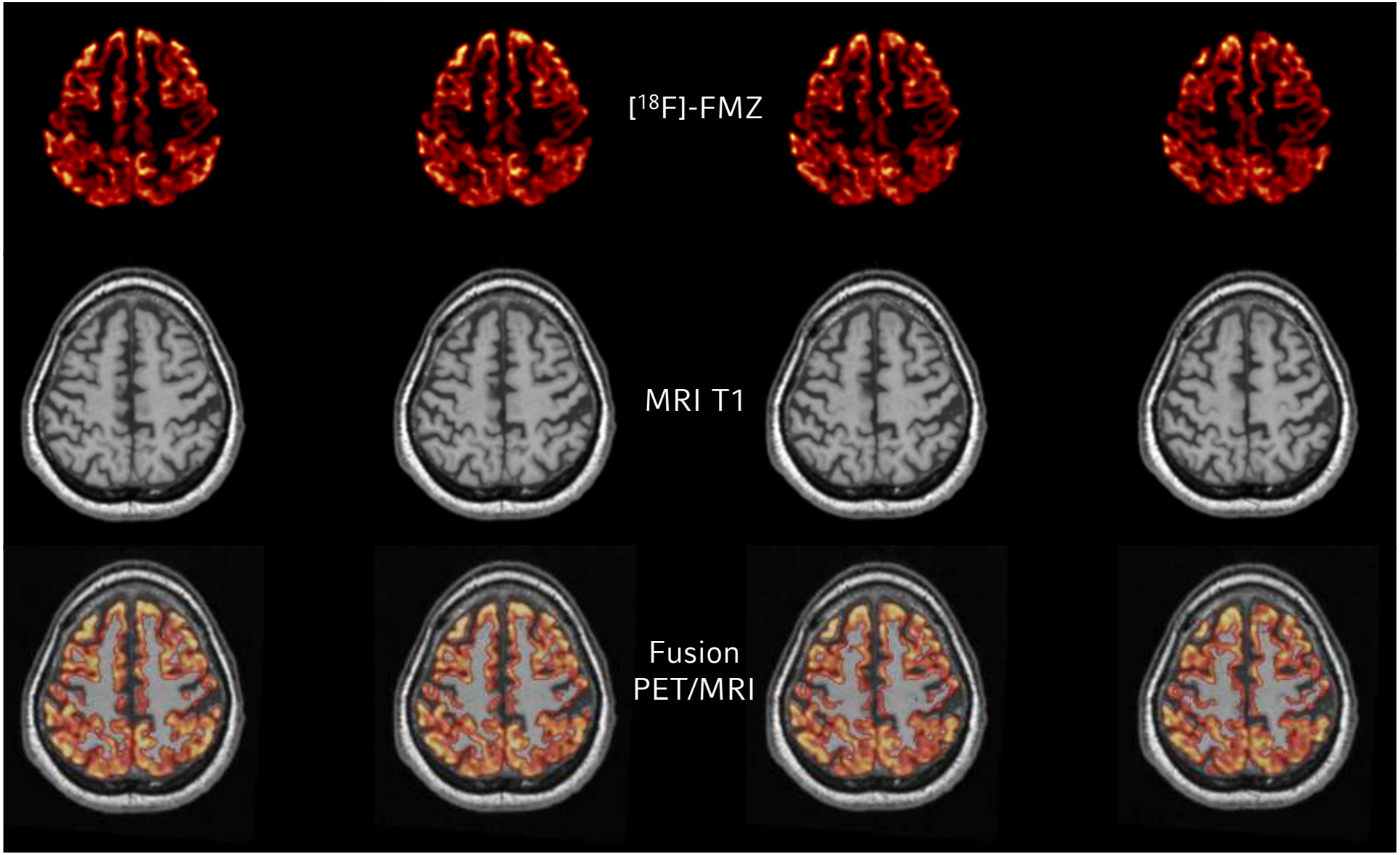
Subject: Rat

Method: Inveon PET. ^{18}F serum albumin, 0-30 minutes post injection
Visualization of circulation using blood pool agent only

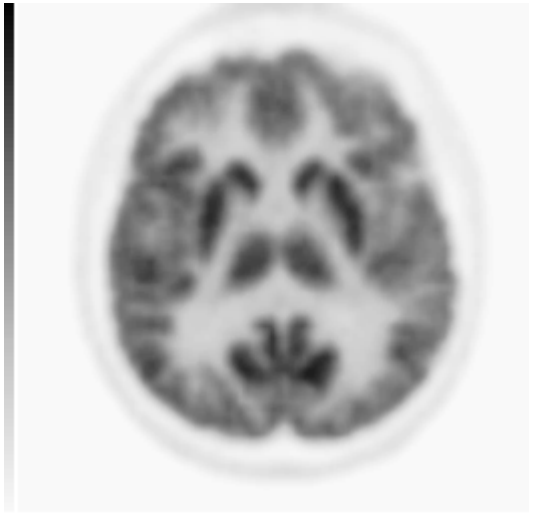
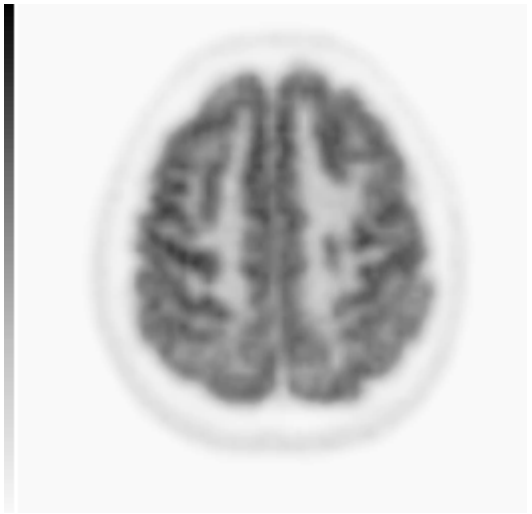
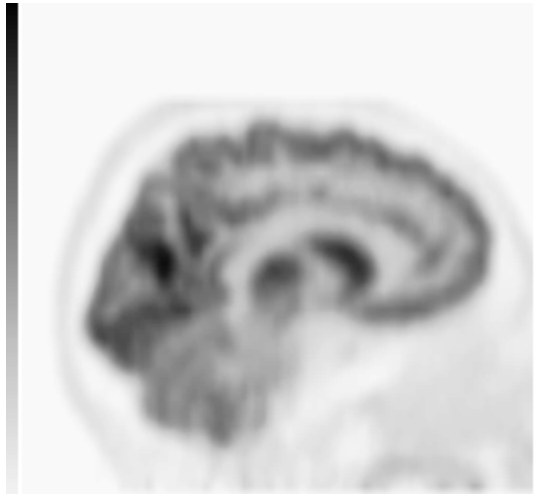
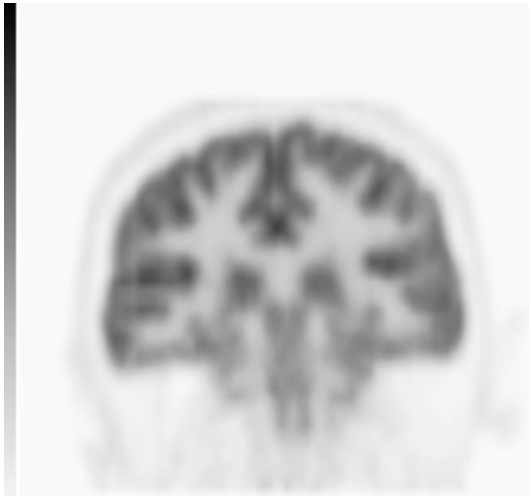
Visualization: Inveon Research Workplace

Data Courtesy of Ludwig-Maximilians-Universitaet Muenchen, Klinik und Poliklinik für Nuklearmedizin, Klinikum Großhadern, Munich, Germany

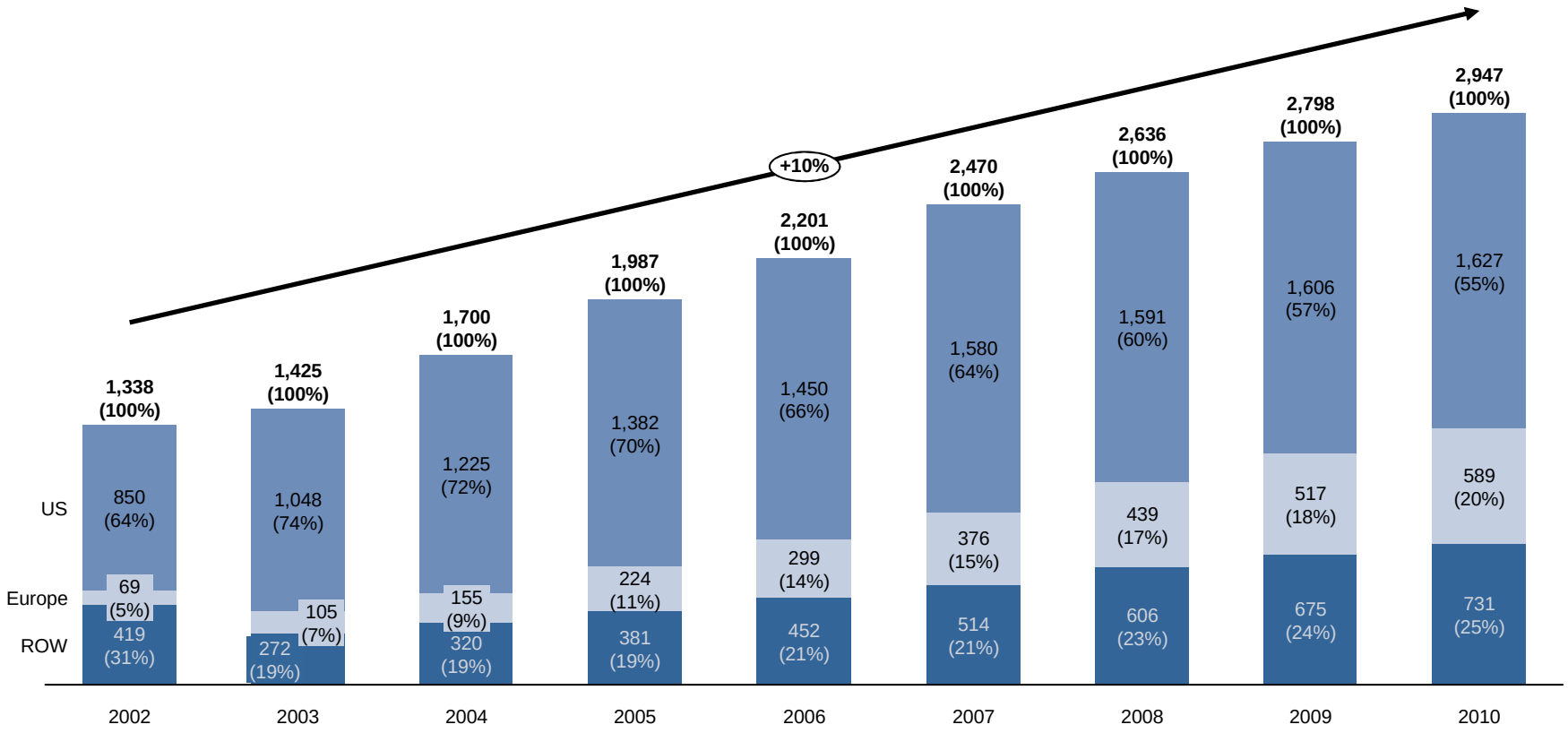
[^{18}F]-Flumazenil PET & MRI



Discovery D690 mit VUE Point HD FX
Rekonstruktionsparameter:
36 subsets; 5 Iterationen, cut off 5,5,
128 Matrix; 3,27mm Schichtdicke

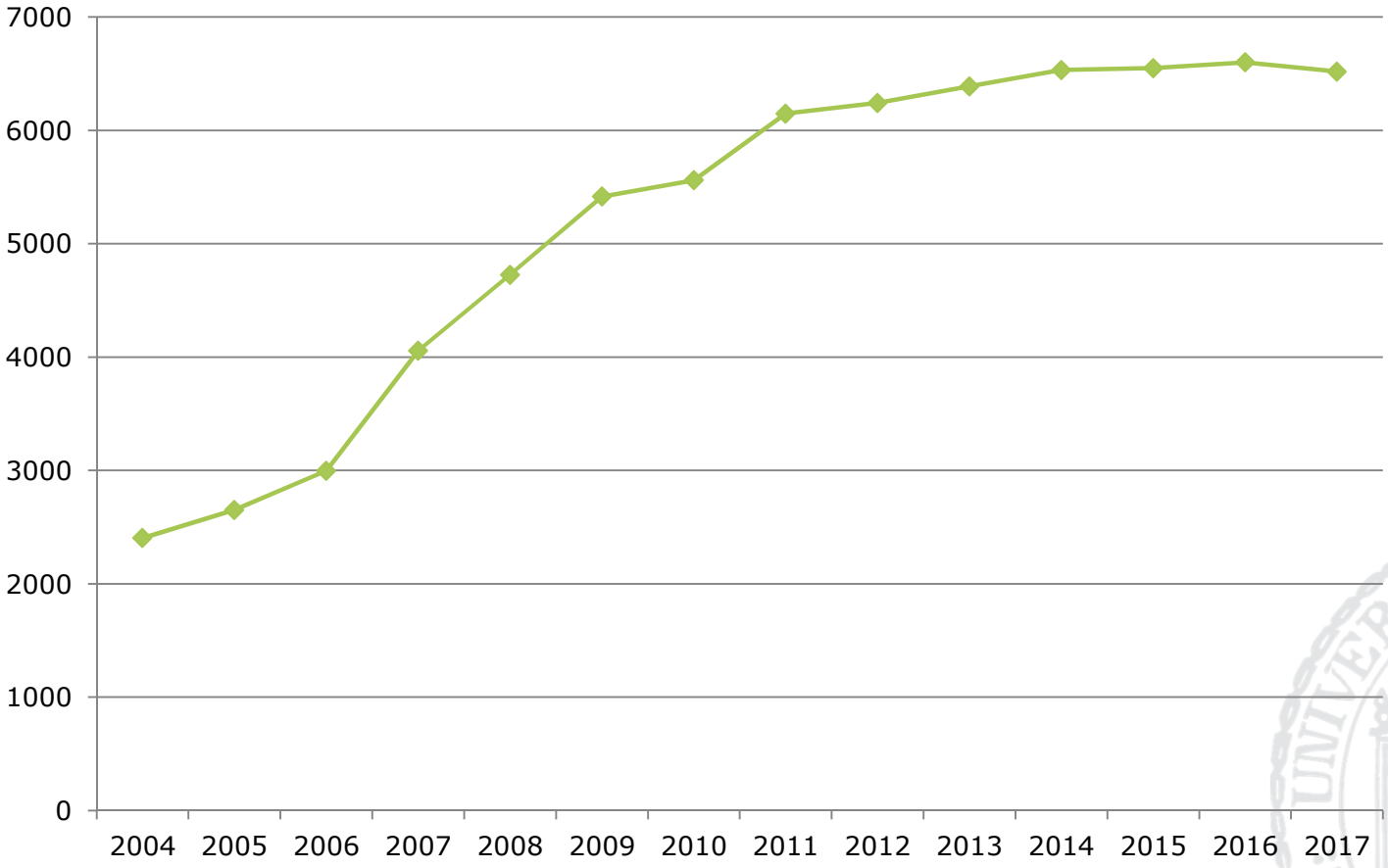
Development of PET & PET/CT installed base over time



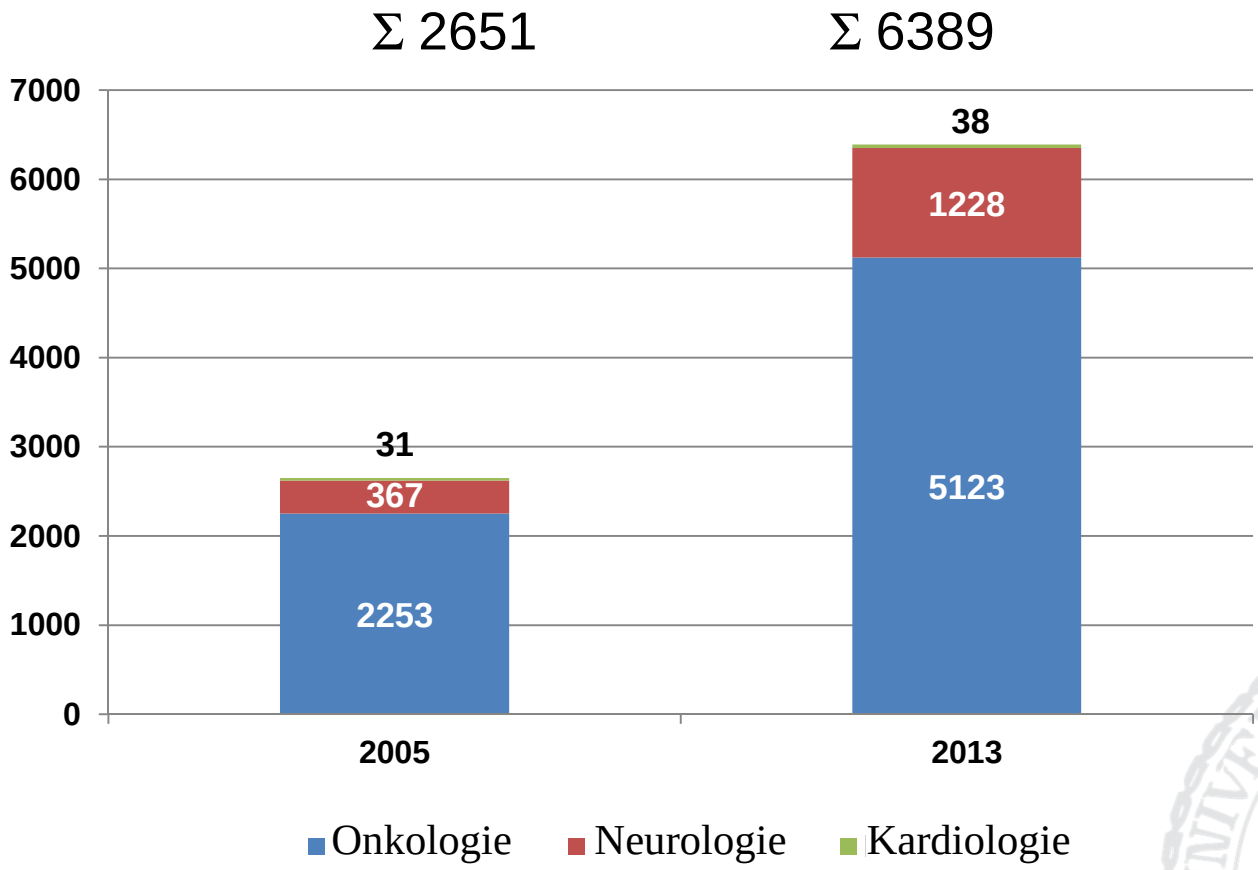
Source: IPB 9-13-10; Medical Options – Europe MI and PET 2010; Internal assumptions

PET/CT investigations / year

2017:
6513 patient studies



PET und PET-CT an der LMU München



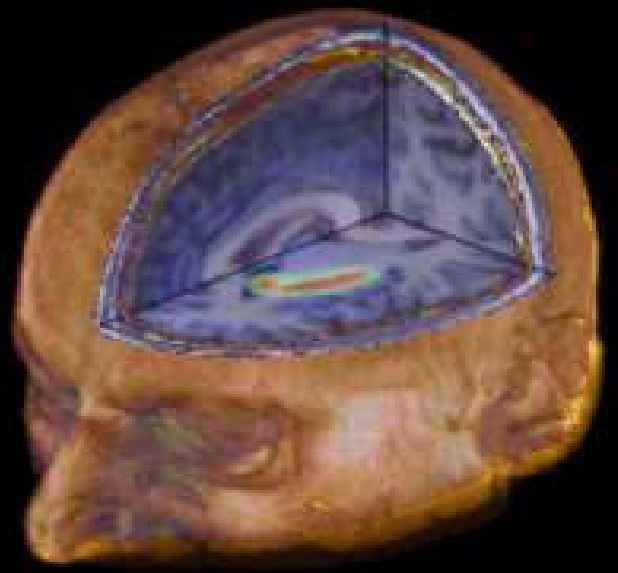
PET und PET/CT

- Methodik
- Klinische Anwendung
  - Neurowissenschaften
  - Kardiologie
  - Onkologie

PET

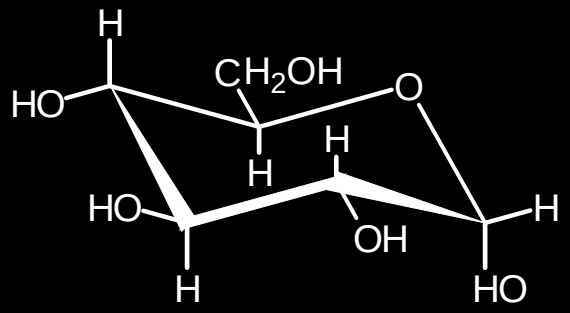
Neurologie

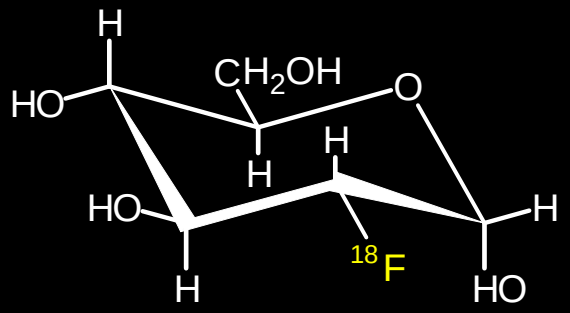
- Demenz
- Parkinson Syndrome
- Epilepsie
- Hirntumoren



FDG PET

Radiopharmakon

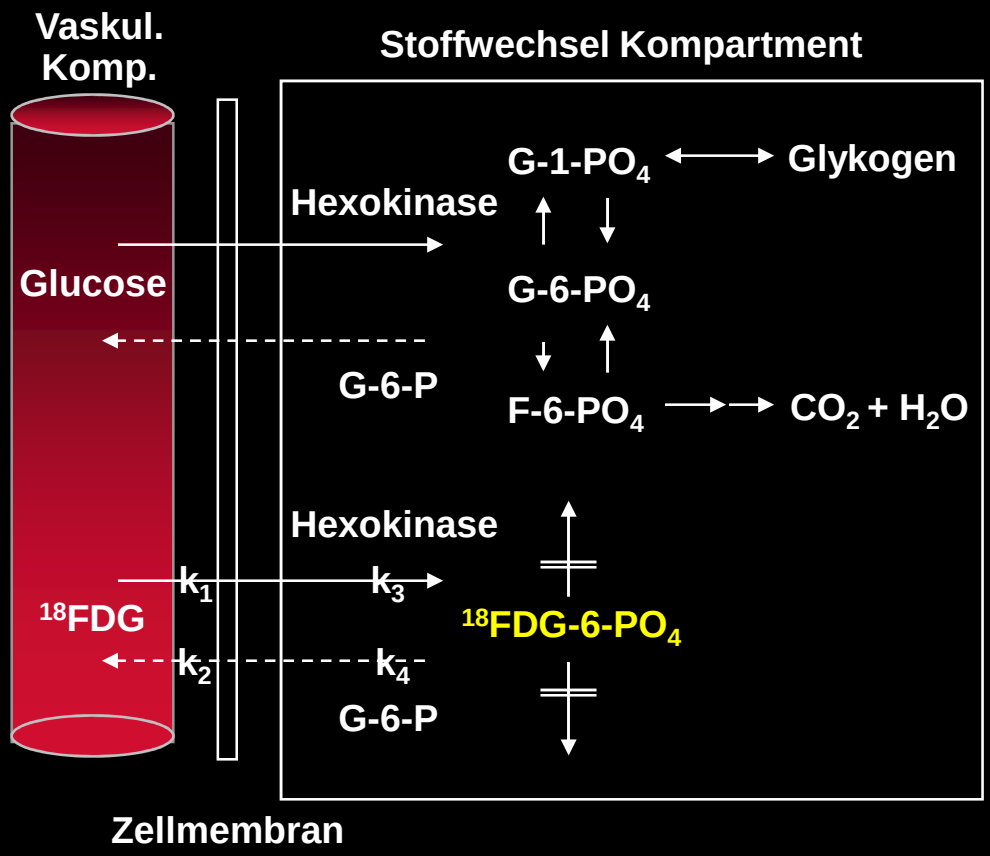




[^{18}F]Fluor- 2 deoxy-D-glukose

Kein Substrat der Glukosephosphat-Isomerase

FDG Aufnahme



Dementielle Erkrankungen:
Indikationen für funktionelle Bildgebung

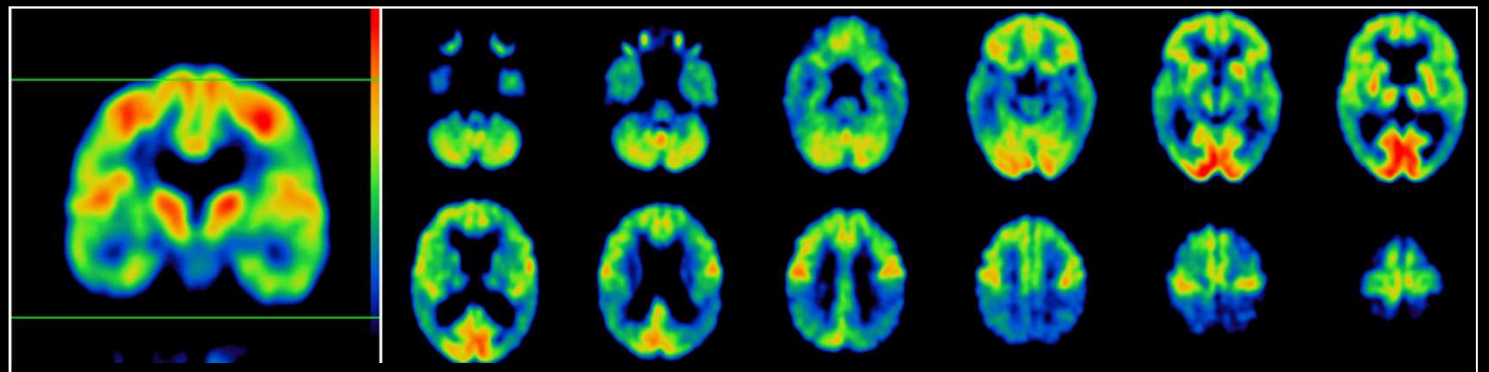
Die nuklearmedizinischen Untersuchungen PET und SPECT können eingesetzt werden zur:

- **Frühdiagnose einer Demenz**
- **Unterscheidung einer Demenz von einer schweren Depression**
- **Unterscheidung verschiedener Demenzformen (z.B. DAT und DI**
- **Verlaufskontrolle (evtl. auch zur Therapiekontrolle)**

➢ ***PET ist etwas aufwendiger aber empfindlicher als die SPECT:***
Daher besonders geeignet für die Frühdiagnostik

Alzheimer Demenz

Muster der Neurodegeneration



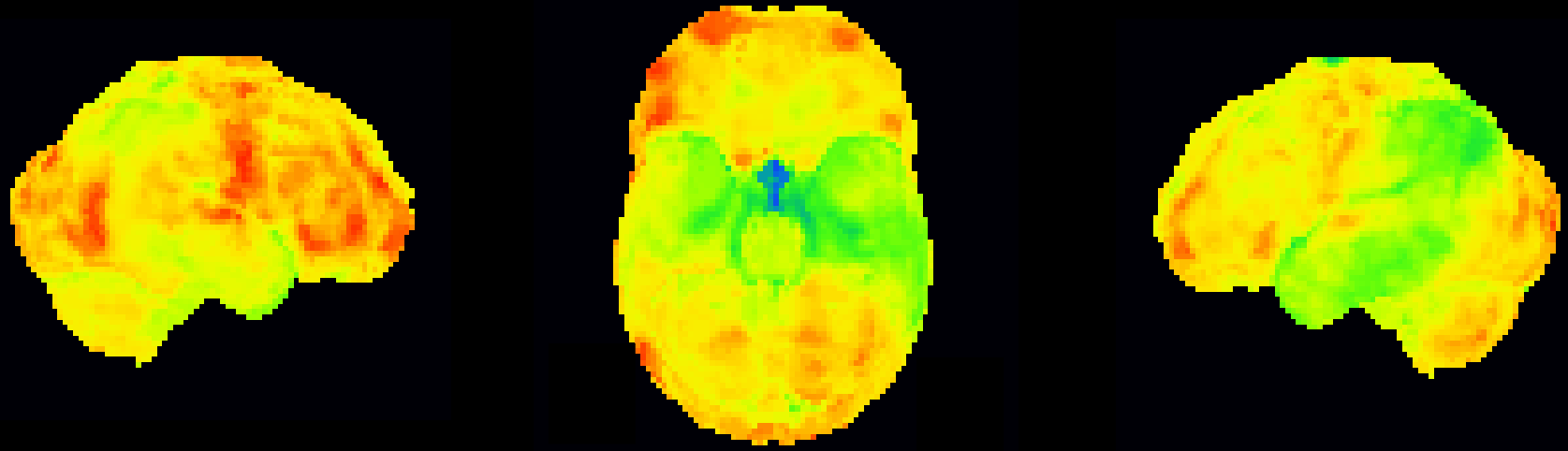
Temporo-parietale Neurodegeneration

Ausbreitung: Temporomesial > post. Cingulum > (bi-)temporo-parietal > frontal

Nicht beteiligt: Thalamus, Basalganglien, Zentralregion, occipitaler Kortex

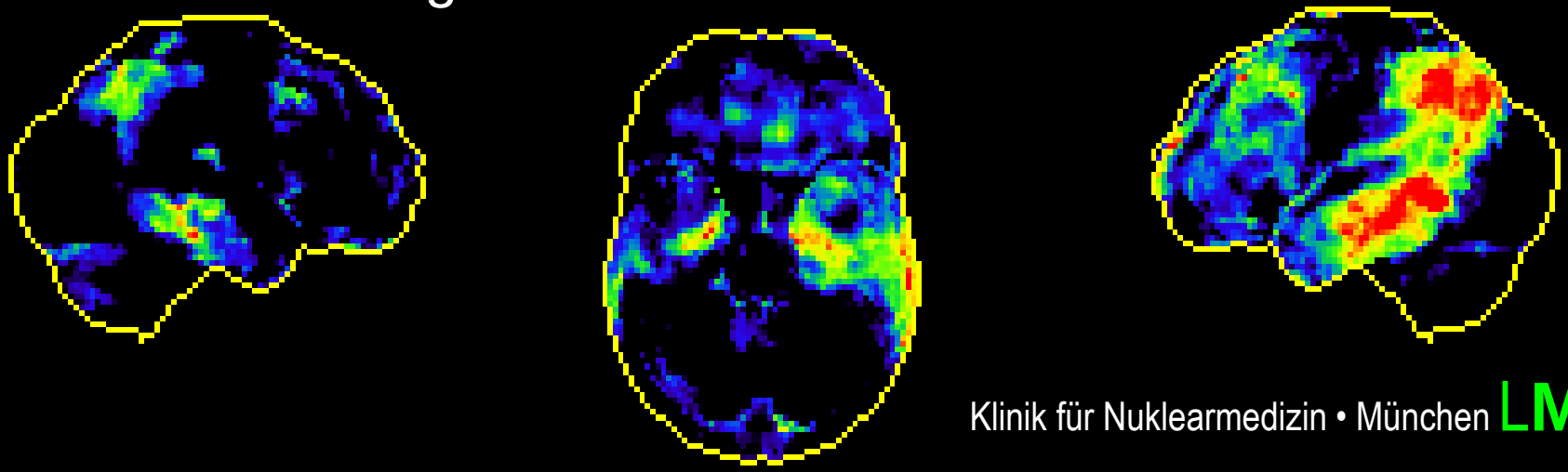
M. Alzheimer / ^{18}FDG-PET

Oberflächenprojektion



rechts lateral | unten | links lateral

Vergleich zu einem Normkollektiv



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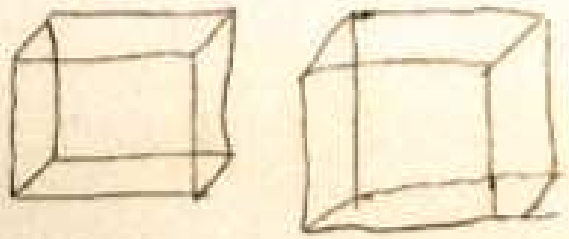
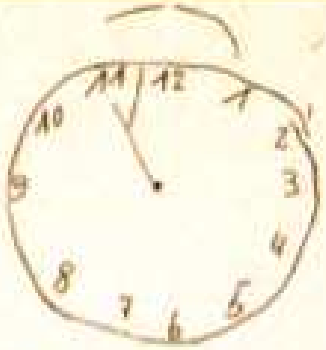
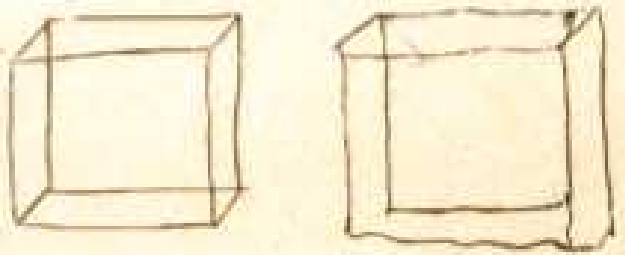
4 / 1995



4 / 1996

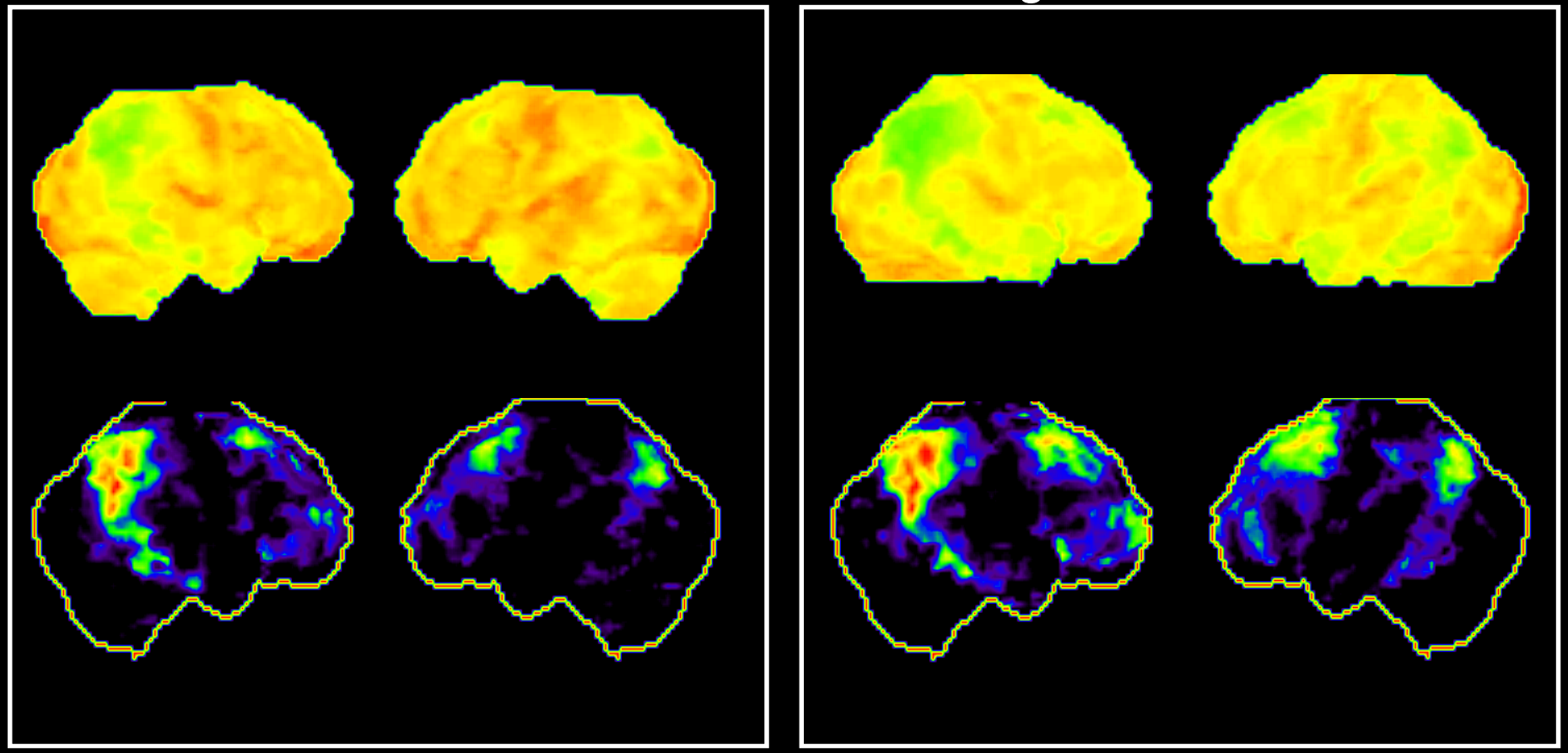




Demenz vom Alzheimertyp / F-18 FDG

4 / 1995 **4 / 1996**

Oberflächendarstellung

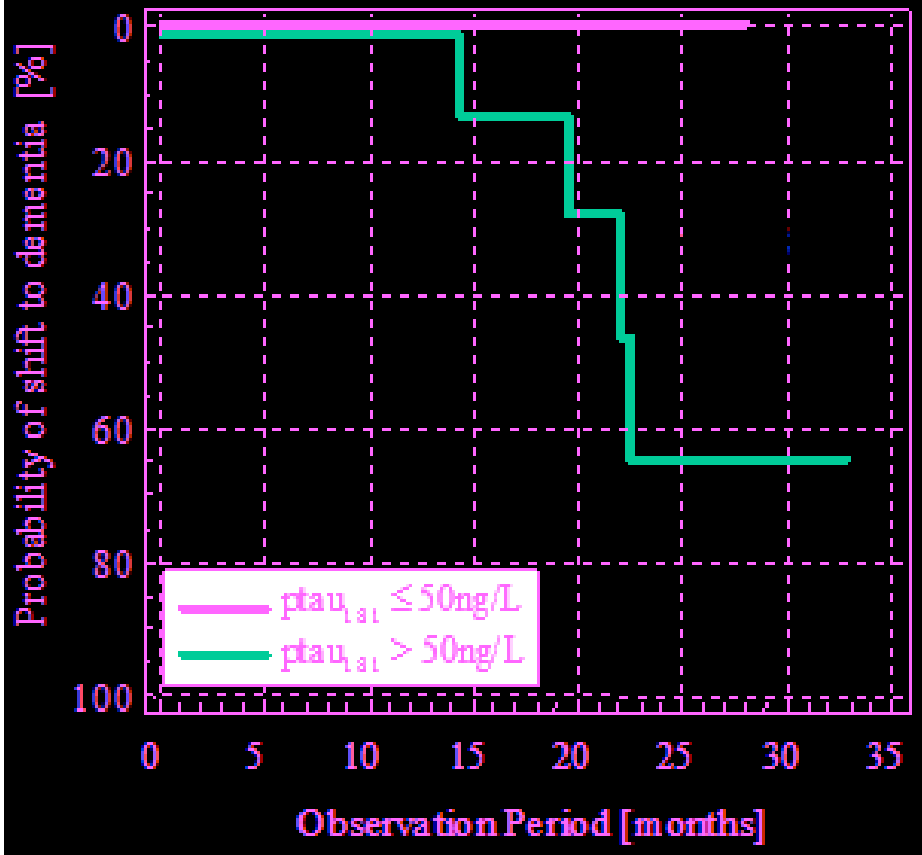


Vergleich mit einem Normkollektiv

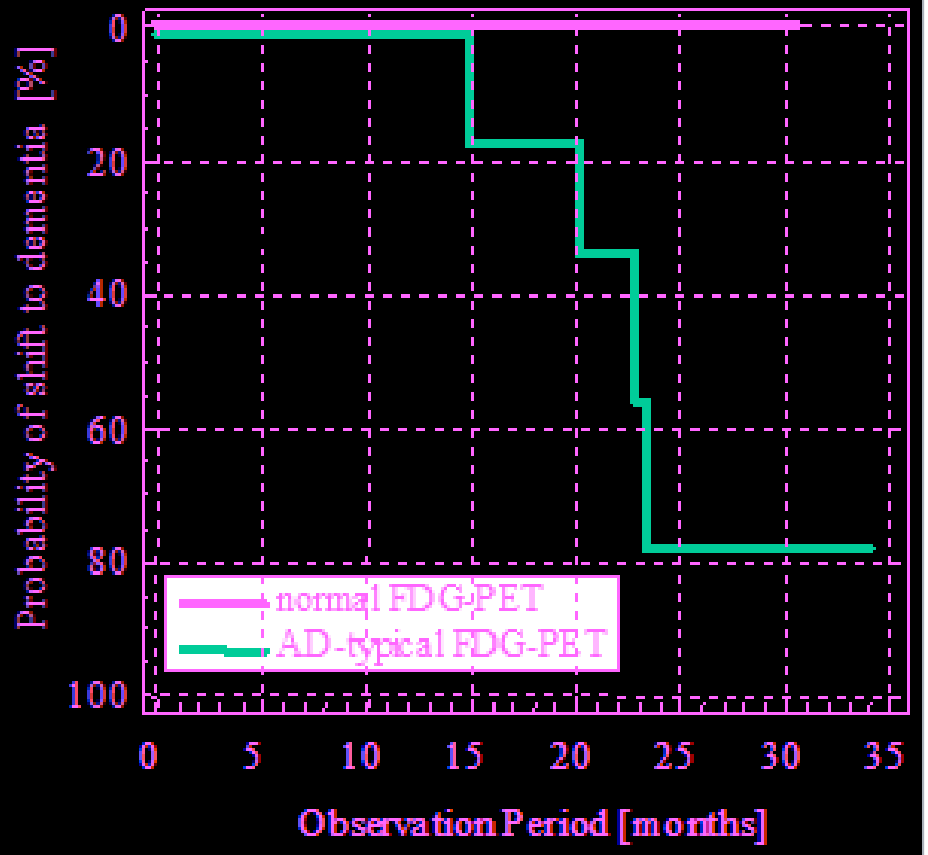
TU München
Nuklearmedizin

Prediction of shift to clinical dementia (Kaplan-Meier survival analyses)

P-Tau levels



FDG-PET

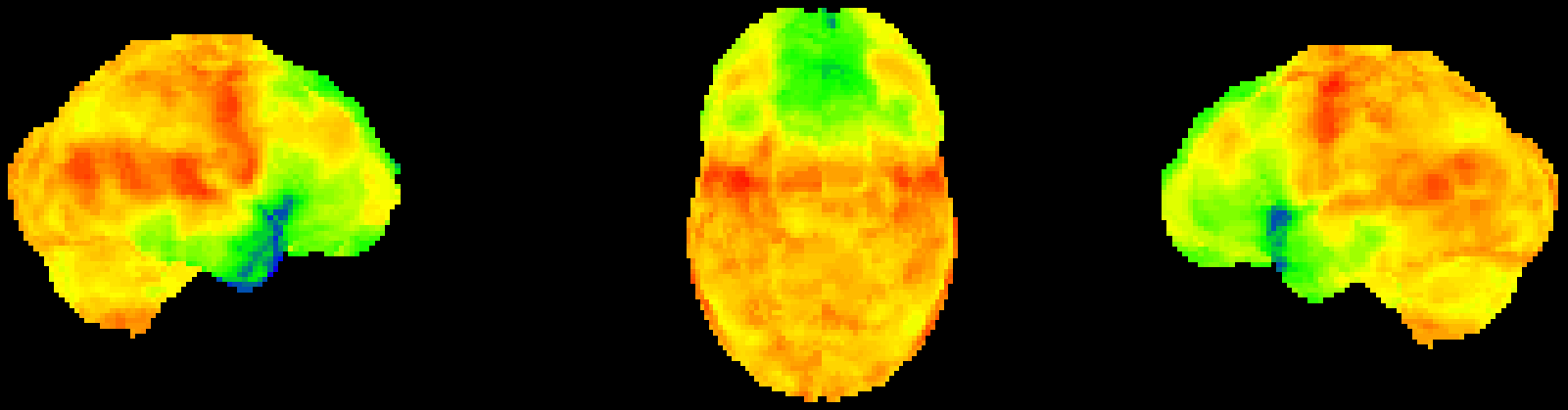


Conclusion: AD-typical FDG-PET patterns were superior to p-Tau levels (and baseline MMSE scores) in predicting conversion to dementia in MCI patients over a 19 months period.

Fellgiebel et al. Psychiatry Res 2007

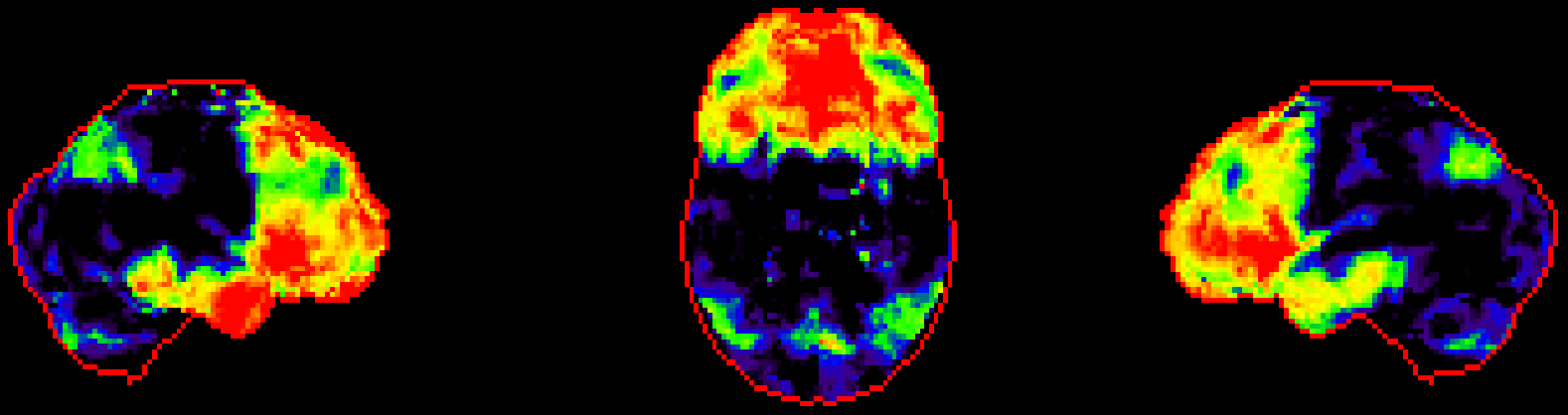
Fronto-Temporale Demenz / ^{18}FDG-PET

Oberflächendarstellung



rechts lateral | oben | links lateral

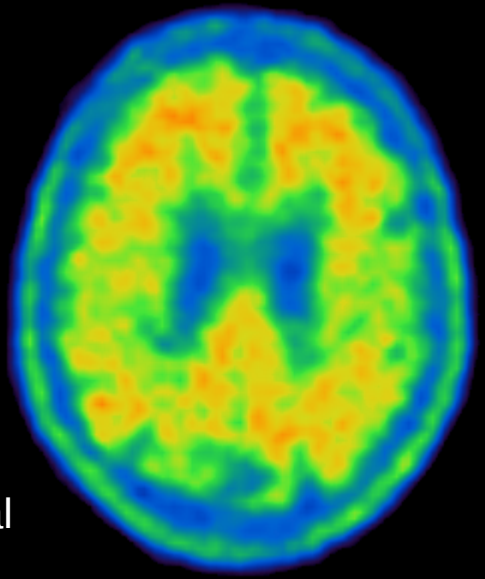
Vergleich zum Normkollektiv



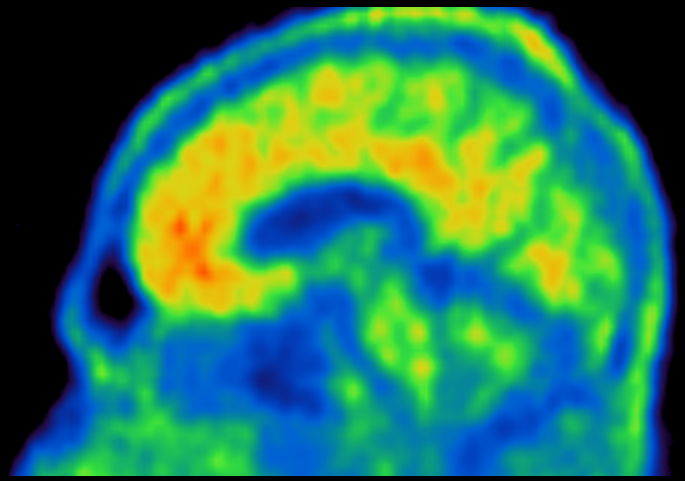
Amyloid imaging / ^{18}F-Florbetaben

M. Alzheimer

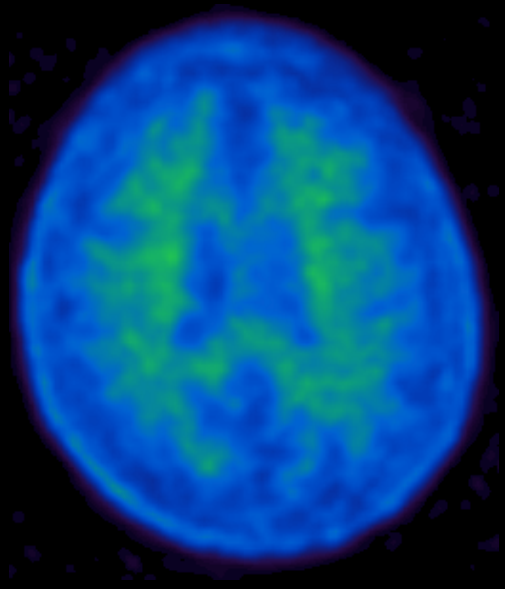
Transversal

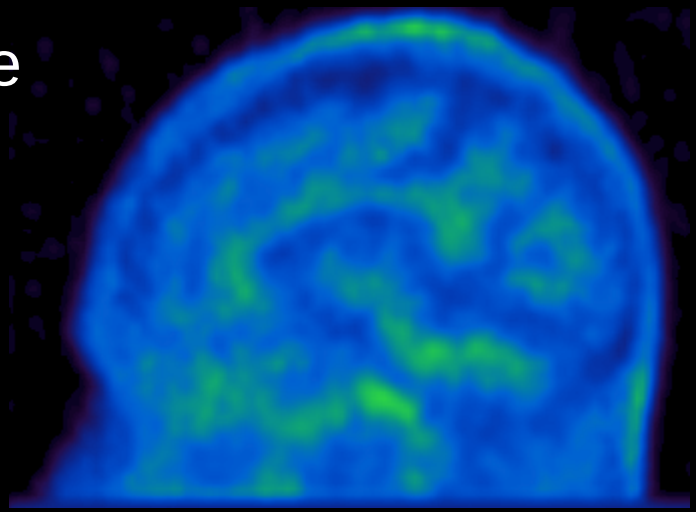


Sagittal



Kontrolle





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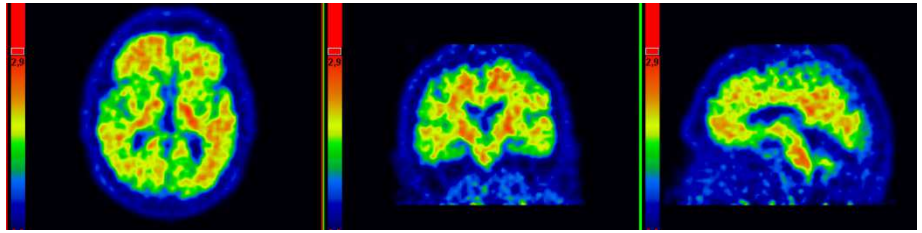
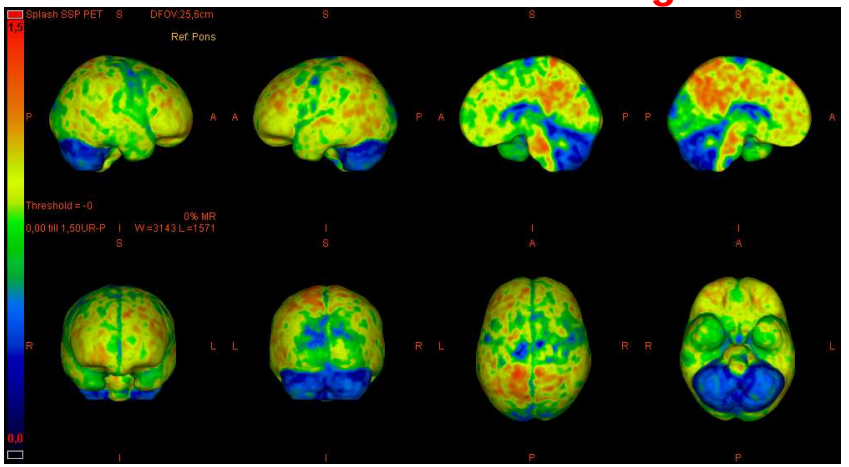
[^{18}F]Flutemetamol / NeuroMarQ

Original PET scan



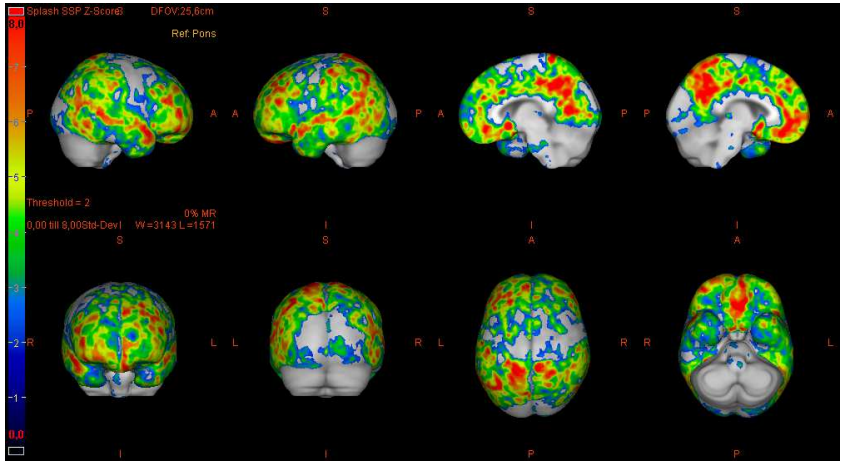
3D SSP of SUVR image



SUVR normalized to pons

Cortical region	Patient	Normal	Z-score
Prefrontal R	0,73	0,46	5,98
Prefrontal L	0,79	0,45	6,87
Sensorimotor R	0,62	0,49	2,58
Sensorimotor L	0,69	0,49	4,05
Occipital R	0,70	0,51	3,39
Occipital L	0,66	0,51	3,04
Parietal R	0,76	0,45	6,96
Parietal L	0,79	0,44	7,38
Anterior Cingulate R	0,81	0,49	5,65
Anterior Cingulate L	0,90	0,53	6,27
Precuneus PostCing R	0,87	0,50	7,96
Precuneus PostCing L	0,92	0,52	8,86
Temporal Lateral R	0,77	0,49	6,24
Temporal Lateral L	0,80	0,48	6,23
Temporal Mesial R	0,58	0,52	1,63
Temporal Mesial L	0,61	0,51	2,10
Cerebellum	0,33	0,40	-1,60
Pons	1,00	1,00	0,00

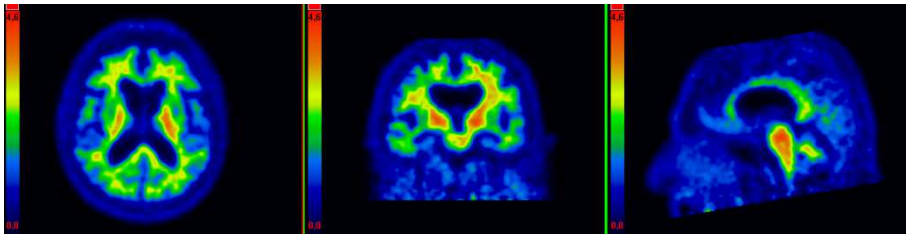
3D SSP Z-scores



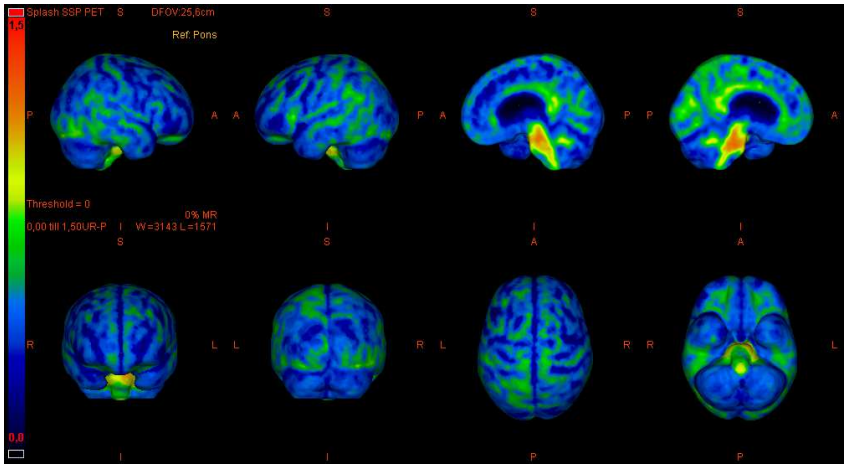
LMU KLINIKUM DER UNIVERSITÄT MÜNCHEN

[18F]Flutemetamol / NeuroMarQ

Original PET scan



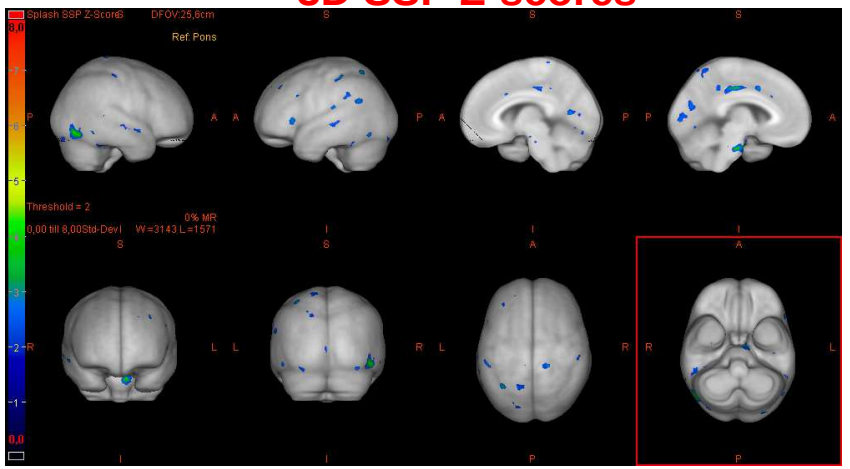
3D SSP of SUVR image



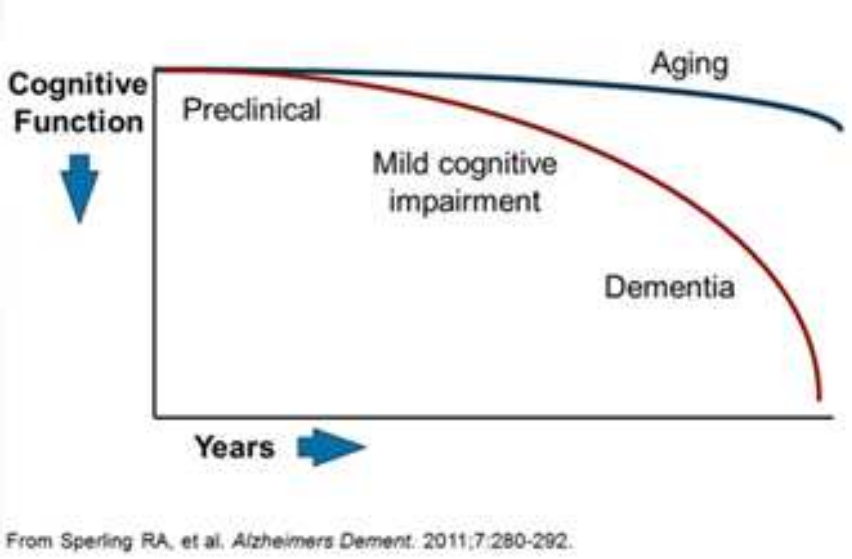
SUVR normalized to pons

Cortical region	Patient	Normal	Z-score
Prefrontal R	0,34	0,46	-2,59
Prefrontal L	0,36	0,45	-1,98
Sensorimotor R	0,36	0,49	-2,36
Sensorimotor L	0,38	0,49	-2,15
Occipital R	0,45	0,51	-1,11
Occipital L	0,46	0,51	-0,81
Parietal R	0,37	0,45	-1,86
Parietal L	0,41	0,44	-0,75
Anterior Cingulate R	0,41	0,49	-1,44
Anterior Cingulate L	0,50	0,53	-0,44
Precuneus PostCing R	0,44	0,50	-1,18
Precuneus PostCing L	0,52	0,52	0,07
Temporal Lateral R	0,45	0,49	-0,96
Temporal Lateral L	0,43	0,48	-1,05
Temporal Mesial R	0,39	0,52	-3,21
Temporal Mesial L	0,42	0,51	-2,12
Cerebellum	0,33	0,40	-1,50
Pons	1,00	1,00	0,00

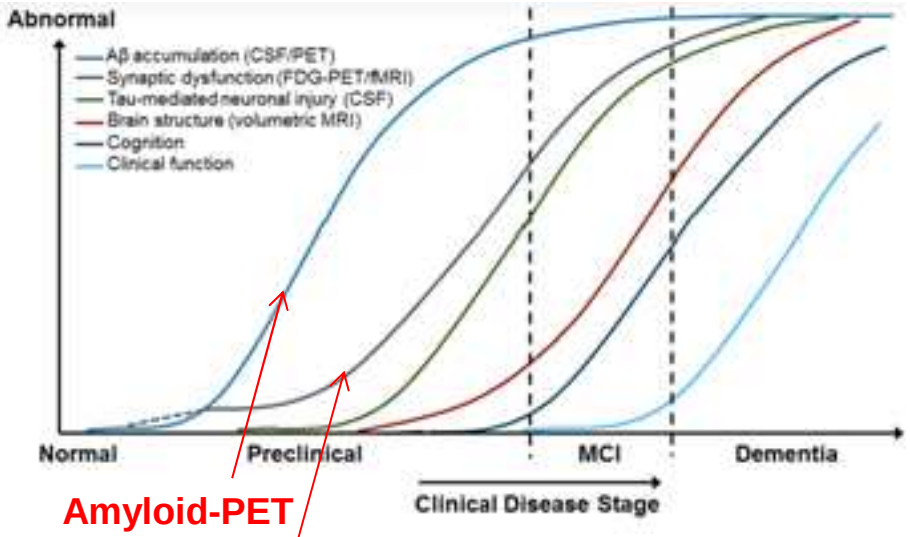
3D SSP Z-scores



Demenz-Imaging



From Sperling RA, et al. *Alzheimers Dement*. 2011;7:280-292.



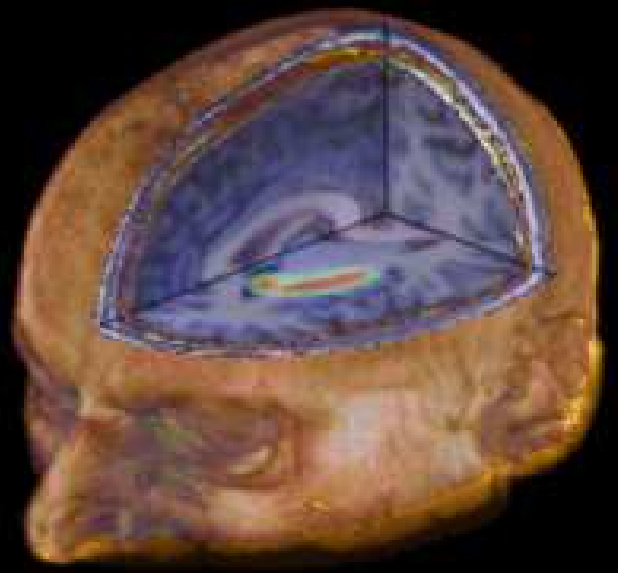
Nutzen von Biomarkern und Frühdiagnostik?

- Identifizierung von At-Risk-Patienten
- Frühzeitiger Therapiebeginn / Lebensplanung
- Krankheits- und Therapiemonitoring
- Einschlusskriterien für Studien

PET

Neurologie

- Demenz
- Parkinson Syndrome
- Epilepsie
- Hirntumoren

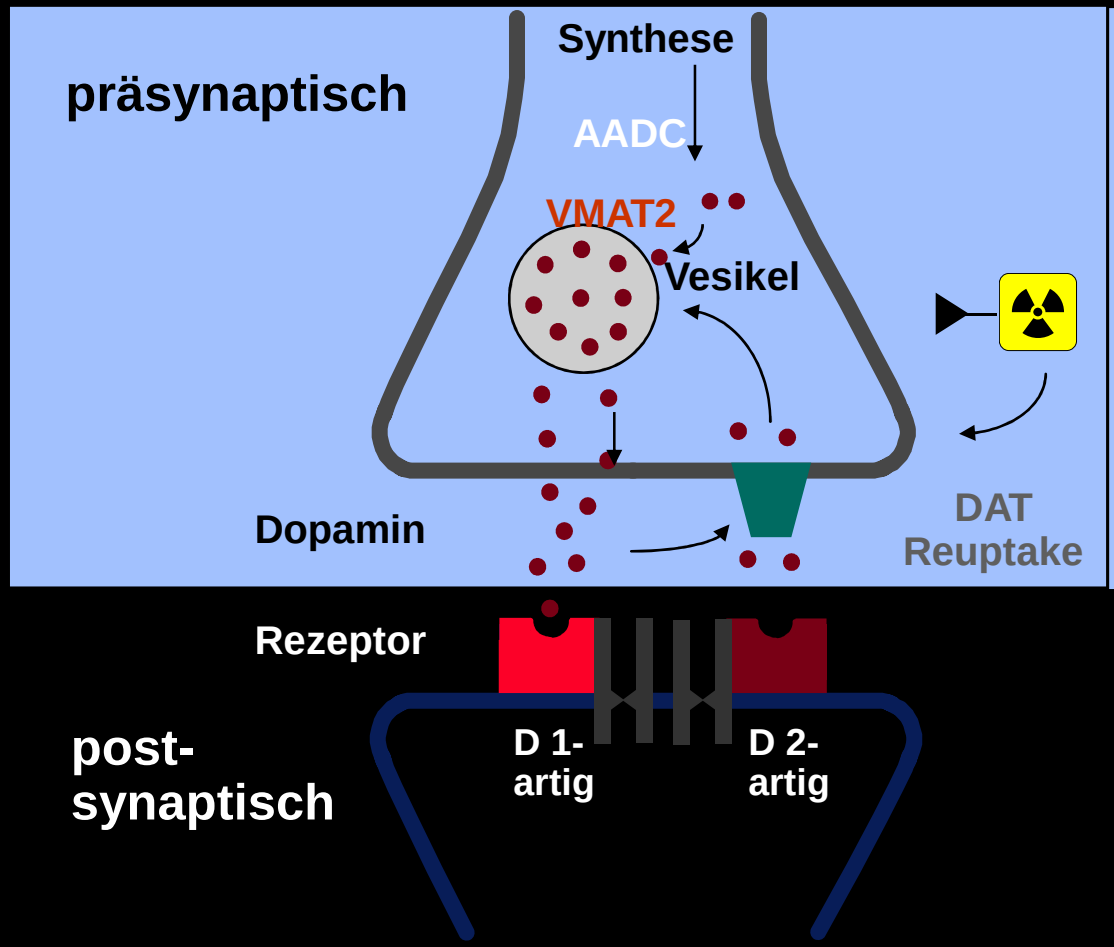


Dopaminerges System: PET-Tracer

Parameter	Tracer
Glukosemetabolismus	^{18}F-Deoxyglukose
Perfusion	$H_2{}^{15}O$
Dopamin-Speicherkapazität	^{18}F-Dopa
Dopamin-Wiederaufnahme	^{11}C-Nomifensin
D_1artige-Rezeptoren (D_1; D_5)	^{11}C-SCH23390
D_2artige-Rezeptoren (D_2 ; D_3 ; D_4)	^{11}C-Racloprid
	^{11}C-/ ^{18}F-Spiperonderivate
	^{18}F-Desmethoxyfallyprid
	^{18}F-Fallyprid
Dopamin-Abbau	^{11}C-Deprenyl

Schema

PET Liganden für das dopaminerge System



PET:

F-18 DOPA

C-11 DTBZ

C-11 Cocaine

C-11 FE-CIT

D 1: C-11 Sch 23390

C-11 NNC112

D 2: C-11 NMSP

C-11 Raclopride

F-18 Fallypride

F-18 Desmeth.

Parkinson-Syndrome

Indikationen für den Einsatz
präsynaptischer Tracer (^{18}F-Dopa, ^{123}I-FP-CIT)

- Frühdiagnostik bei nicht eindeutigem klinischen Befund

- Liegt ein Affektion der striatalen dopaminergen Signaltransduktion vor?

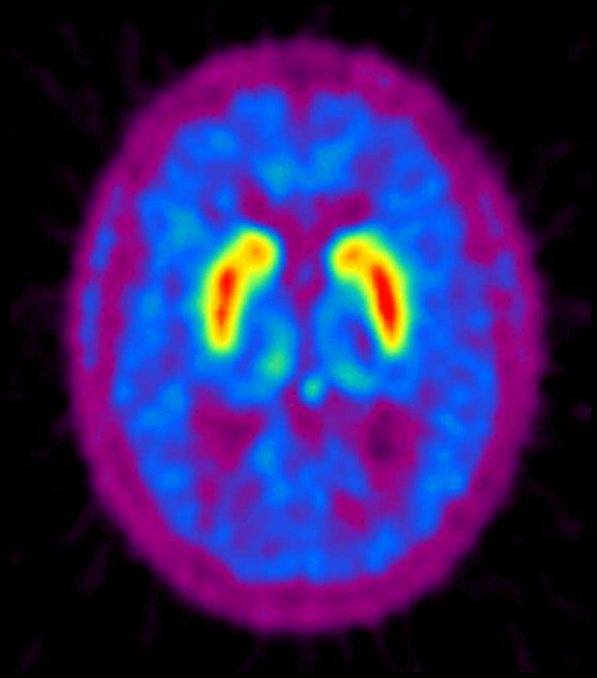
  Z.B. DD essentieller Tremor vs. Parkinson-Syndrom

Patient A

Patient B

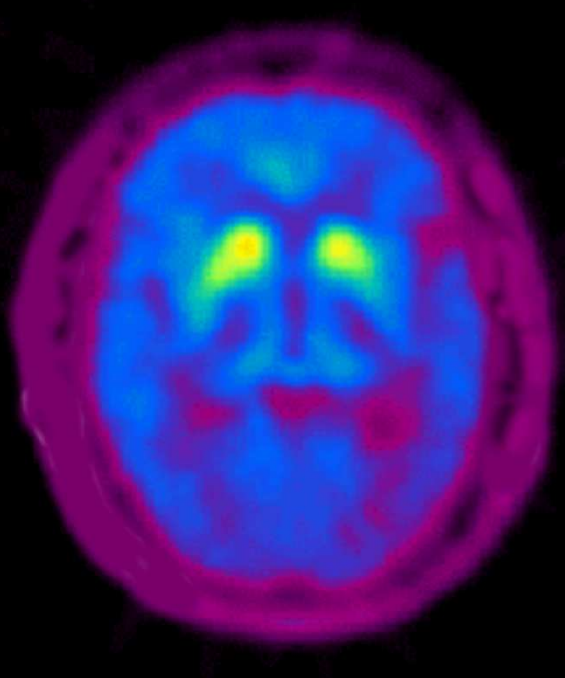
^{18}F-Dopa-PET

Patient A



Essentieller Tremor

Patient B



M. Parkinson

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universitätmainz

Parkinson-Syndrome:

Indikationen für den Einsatz postsynaptischer Tracer = D_2-Rezeptorliganden (^{11}C-Racloprid, ^{18}F-DMFP, ^{123}I-IBZM)

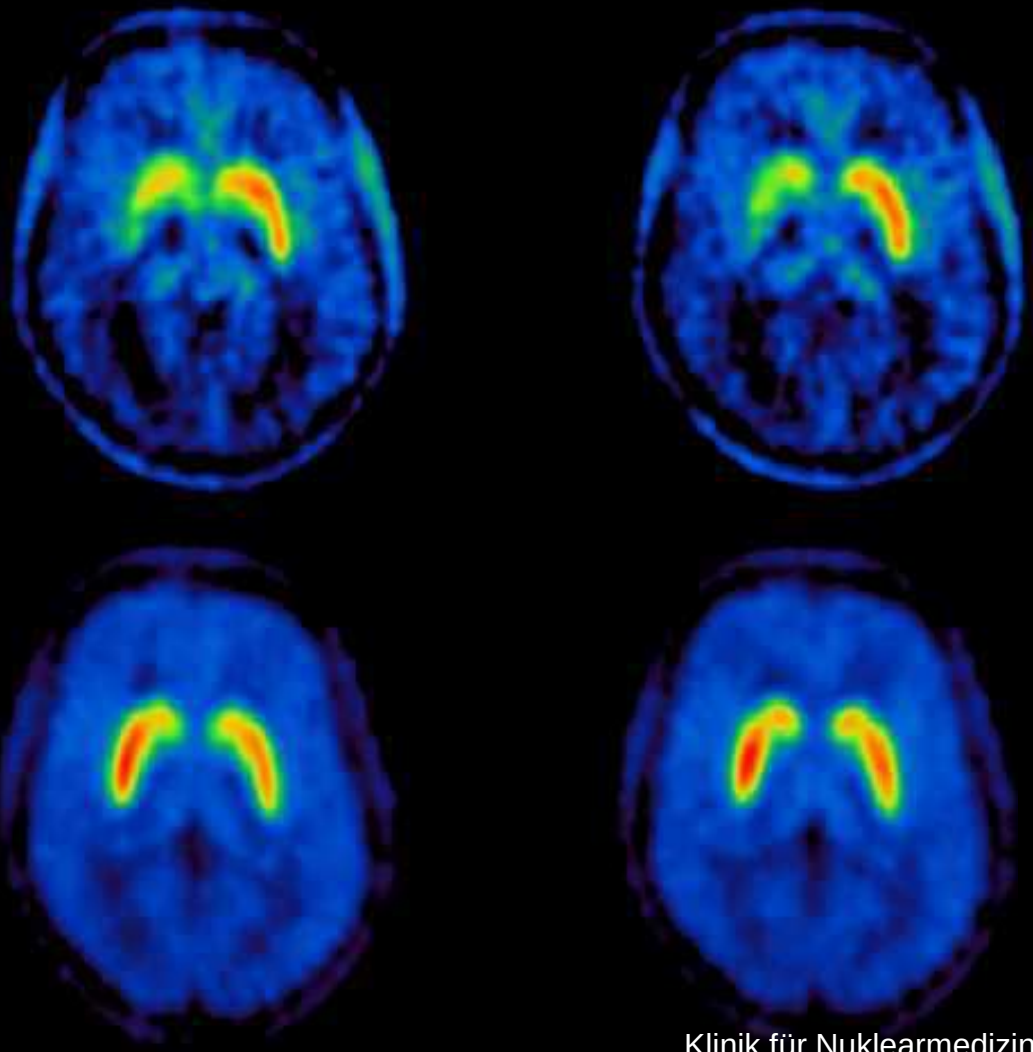
➢**DD M. Parkinson vs. Parkinson-Syndrome anderer Ätiologie:**

- Multisystem-Atrophie (Striato-nigrale Degeneration)
- progressive supranukleäre Lähmung
- kortikobasale Degeneration
- toxische Parkinsonsyndrome
- (- vaskuläre Parkinsonsyndrome)

M. Parkinson

^{18}F-Dopa

^{18}F-DMFP



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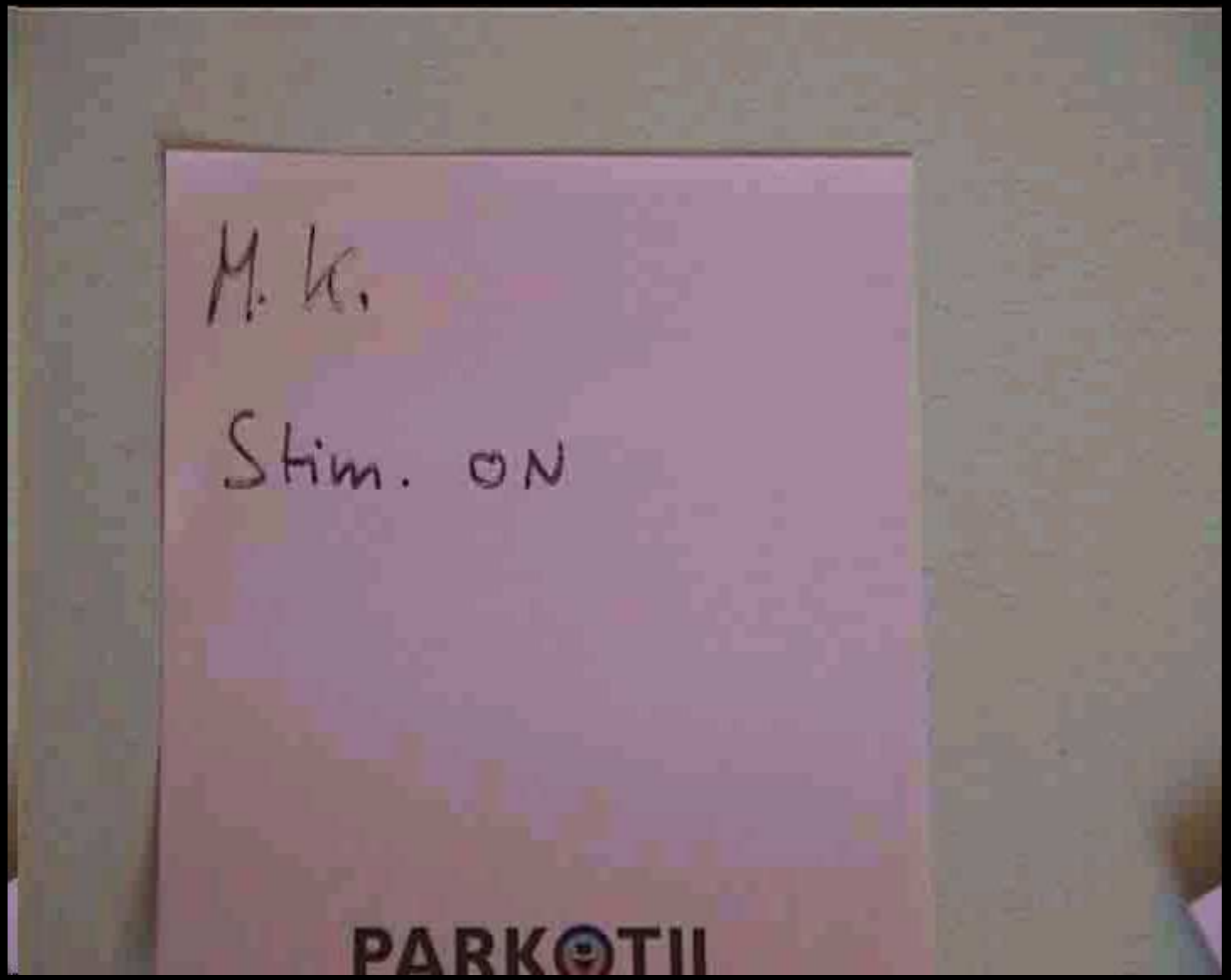
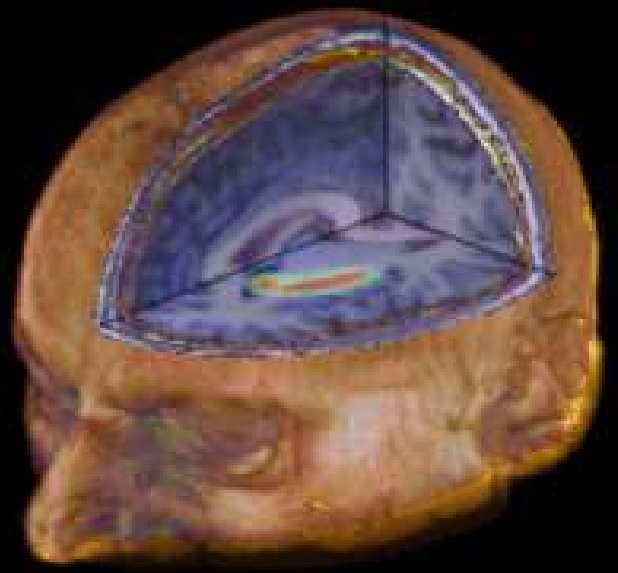

M. K.
Stim. ON
PARKOTIL

PET

Neurologie

- Demenz
- Parkinson Syndrome
- Epilepsie
- Hirntumoren



Epilepsie

Fragestellungen

- Nachweis und Lokalisation der epileptogenen Zone
- Nachweis der funktionellen Integrität nicht involvierter Hirnareale (insbes. Kinder)
- Prognose der postop. Anfalls- und Gedächtnissituation
- DD epileptische/psychogene Anfälle

Methoden

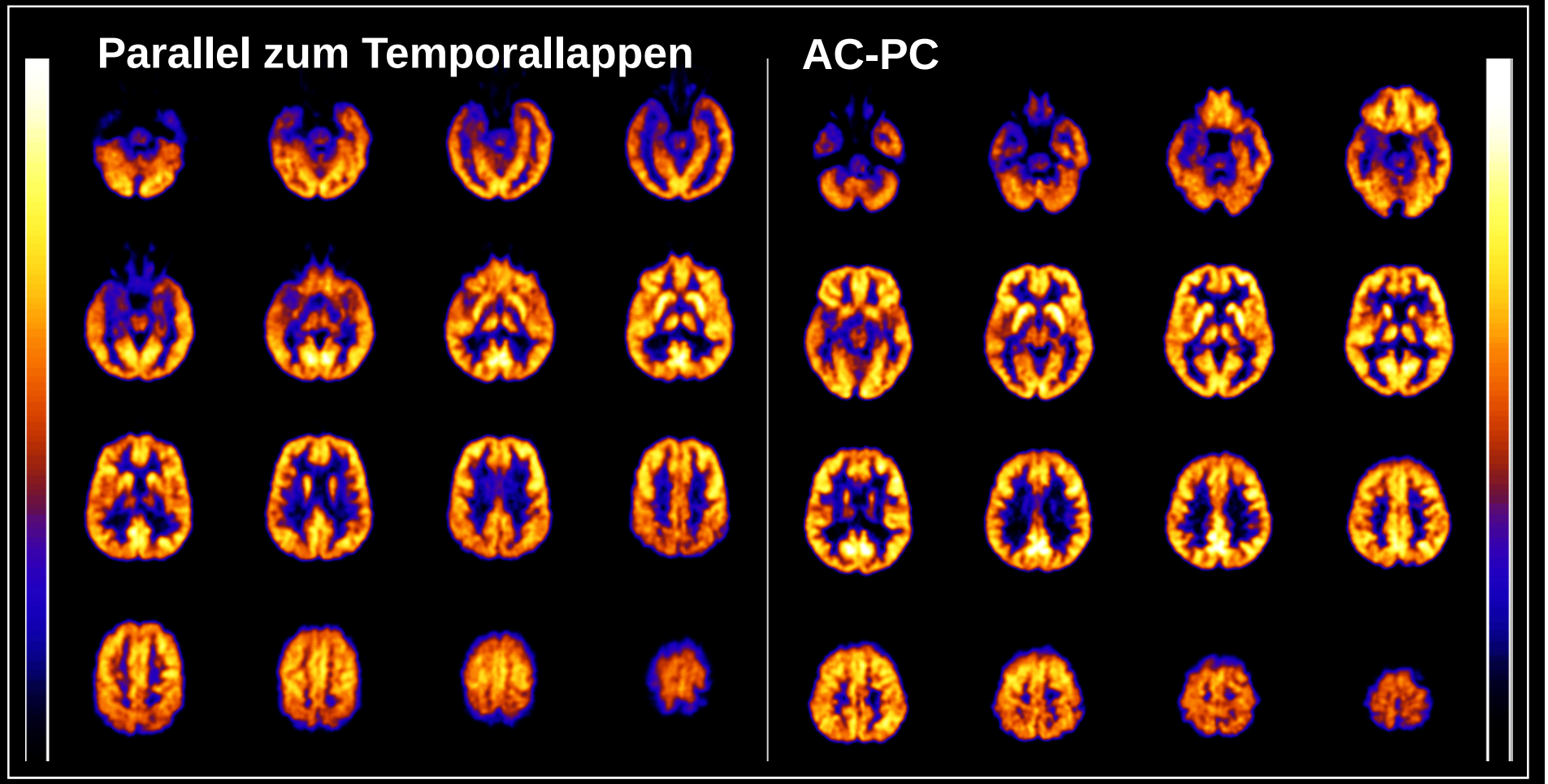
- PET
  - [^{18}F]FDG
  - [^{11}C]Flumazenil
- SPECT
  - ^{99m}Tc-ECD/HMPAO
    - iktal
    - interiktal

Epilepsie

- Die Prävalenz beträgt ca. 0.5 bis 1%
- Etwa 20% der Patienten sprechen nicht ausreichend auf eine antikonvulsive Therapie an
- Ca. 1/6 der Patienten mit pharmakoresistenten Anfällen profitiert von epilepsiechirurgischen Eingriffen
    - Temporallappenepilepsien haben eine günstigere Prognose (ca. 90%) als
    - Extratemporallappenepilepsien (ca. 60%)

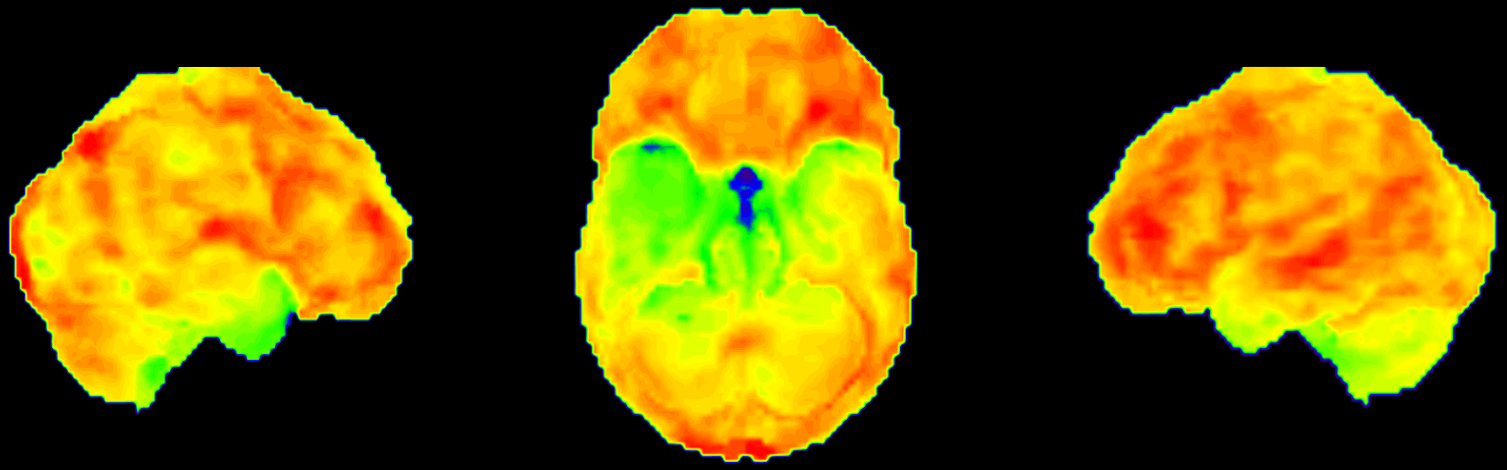
Epilepsie

Temporallappenepilepsie rechts

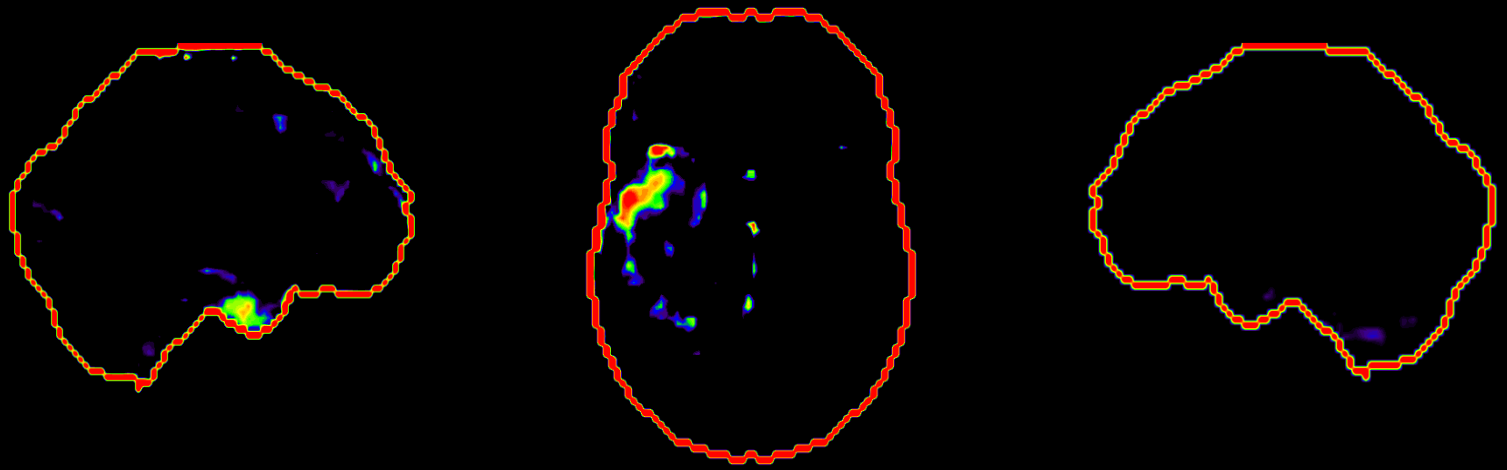


^{18}F-FDG-PET / Temporallappen-Epilepsie rechts

Stereotaktische Oberflächenprojektionen



Rechts lateral **Ansicht von unten** **Links lateral**

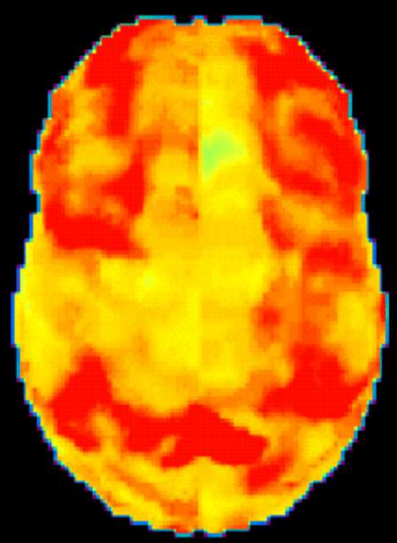


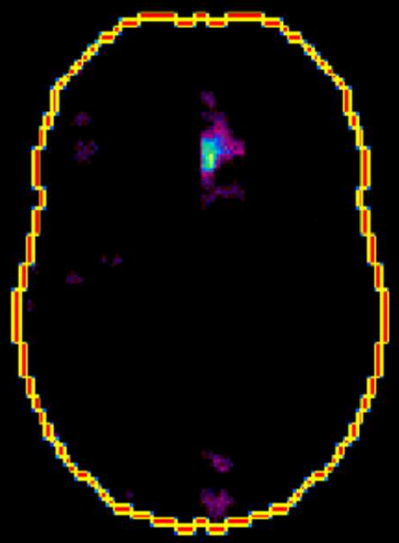
Vergleich mit einem Normkollektiv

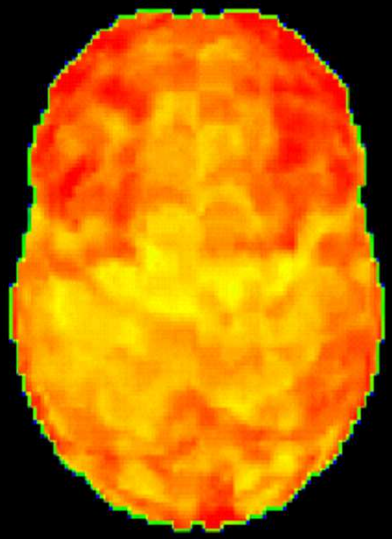
Frontallappen-Epilepsie

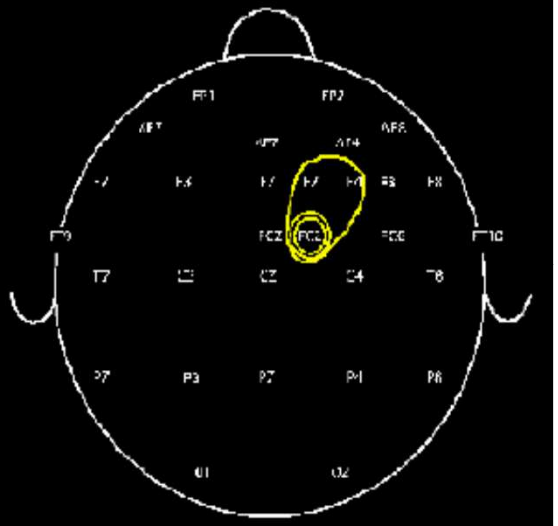
Oberflächenprojektionen
(Ansicht von oben)

^{18}F-FDG **^{11}C-Flumazenil** **EEG**





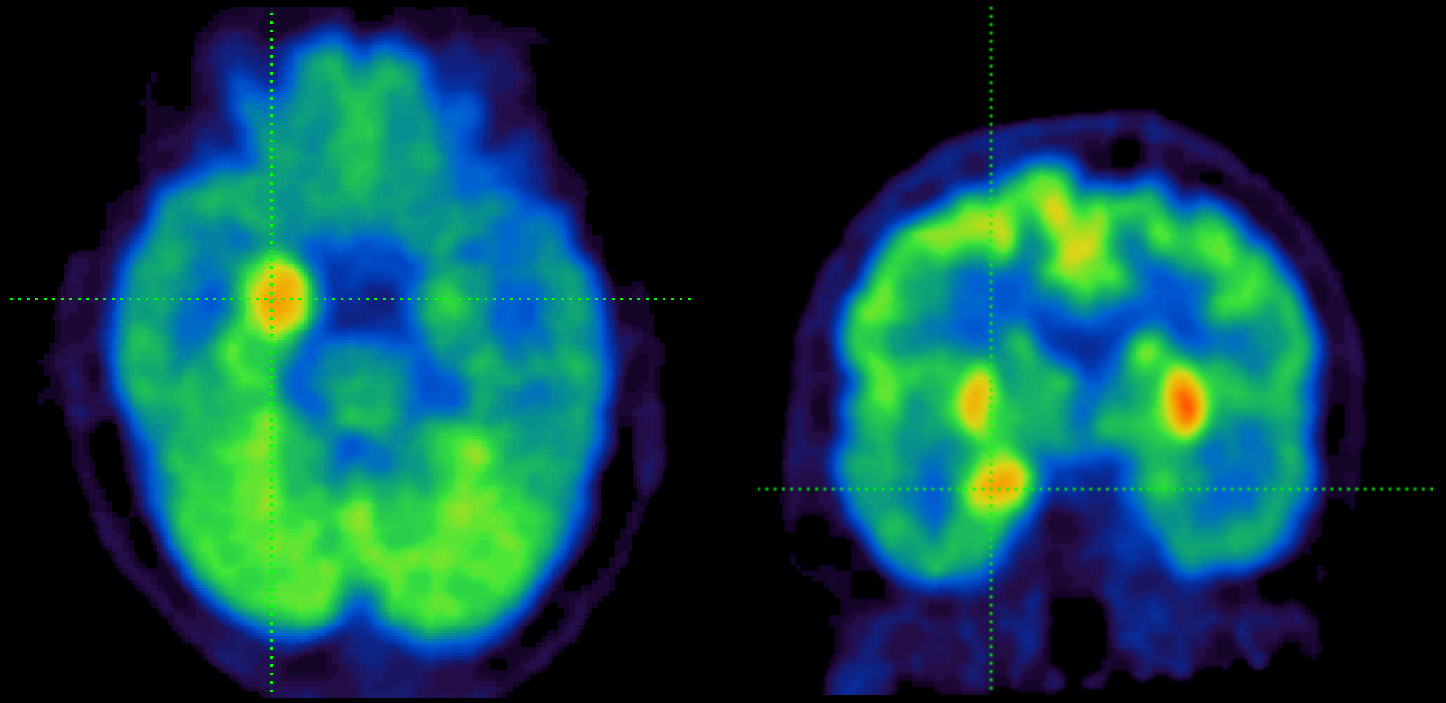




Vergleich mit
dem Normkollektiv

Temporallappen-Epilepsie rechts

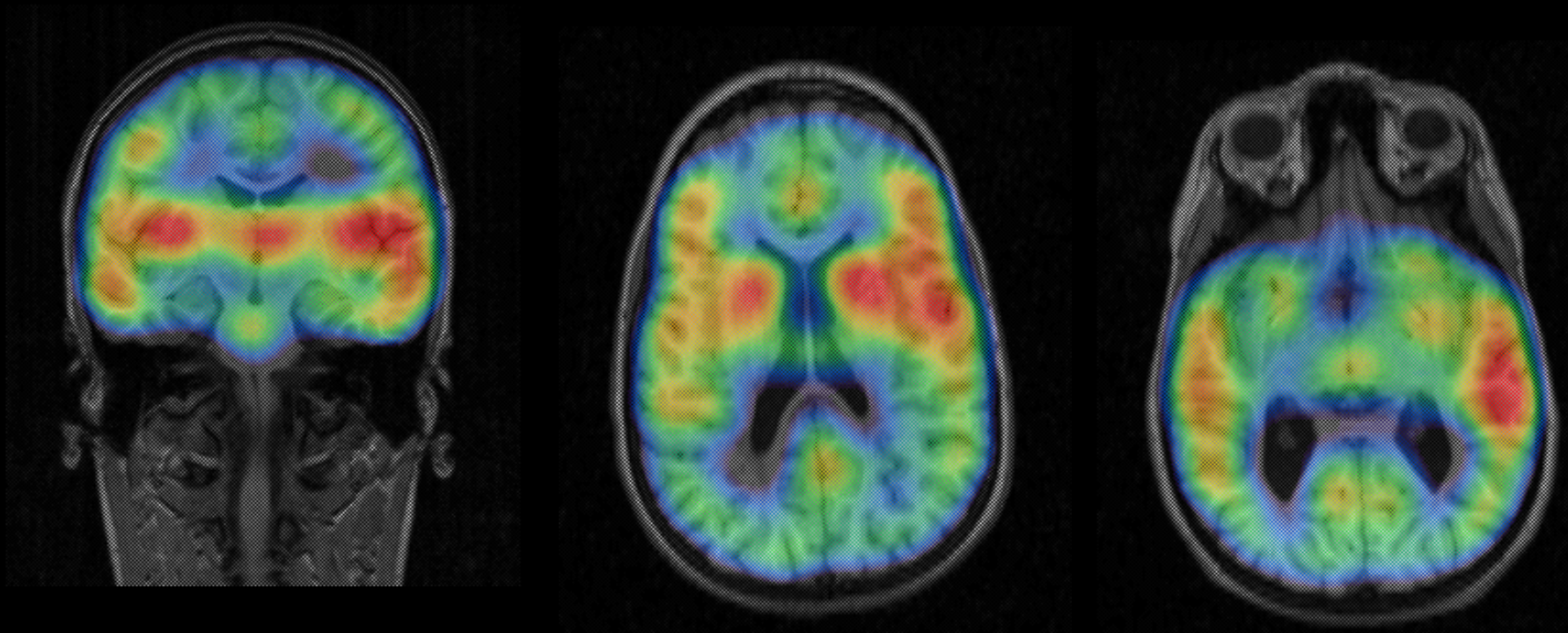
Iktales FDG-PET



Iktales ECD-SPECT

Temporallappen-Epilepsie links

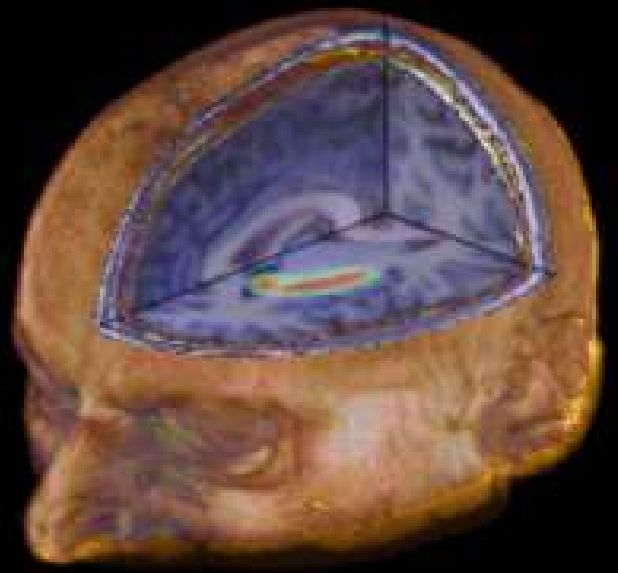
Fusion image SPECT and MRT



PET

Neurologie

- Demenz
- Parkinson Syndrome
- Epilepsie
- Hirntumoren

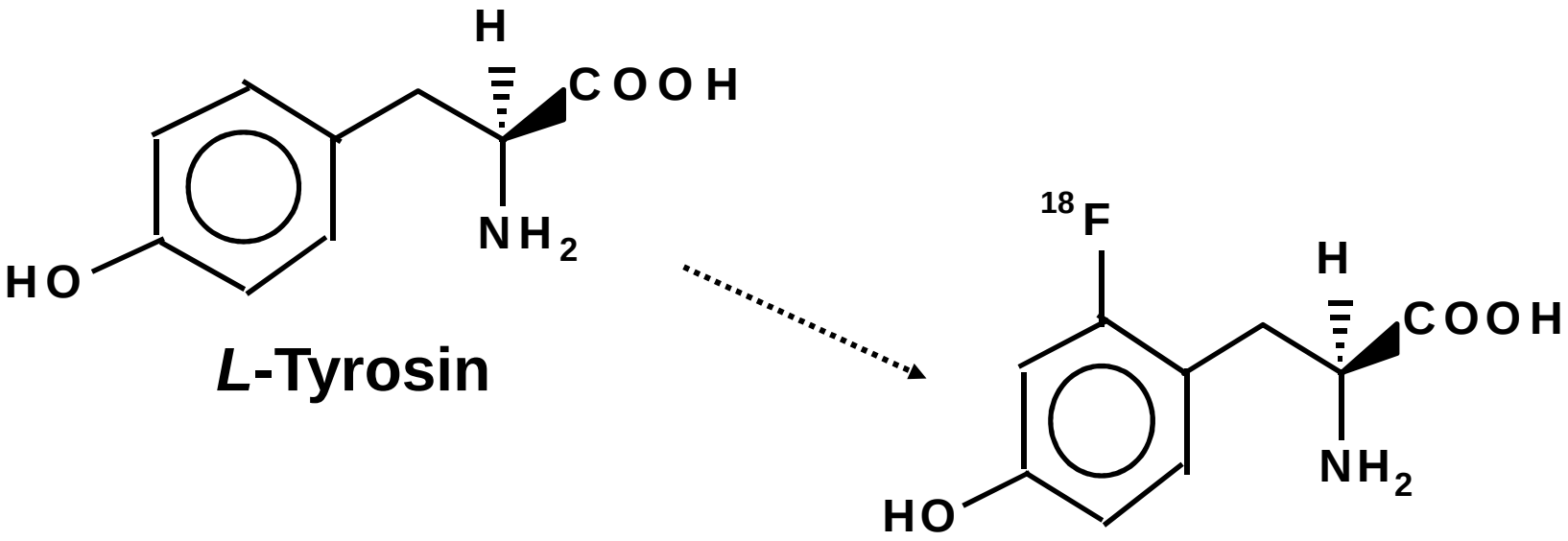


Klinische Wertigkeit von PET bei der Diagnostik von Hirntumoren

- Differenzierung zwischen Rezidiv und Strahlennekrose bei malignen Gliomen
- Erkennung der malignen Entdifferenzierung eines Gliomrezidivs
- Bestimmung des Biopsieortes bei V.a. Gliom
- Beurteilung der biologischen Agressivität von Hirntumoren
- Nachweis von Resttumor bei malignen Gliomen (mit Aminosäuren)
- Differenzierung zwischen Lymphom und Toxoplasmose

Hirntumoren

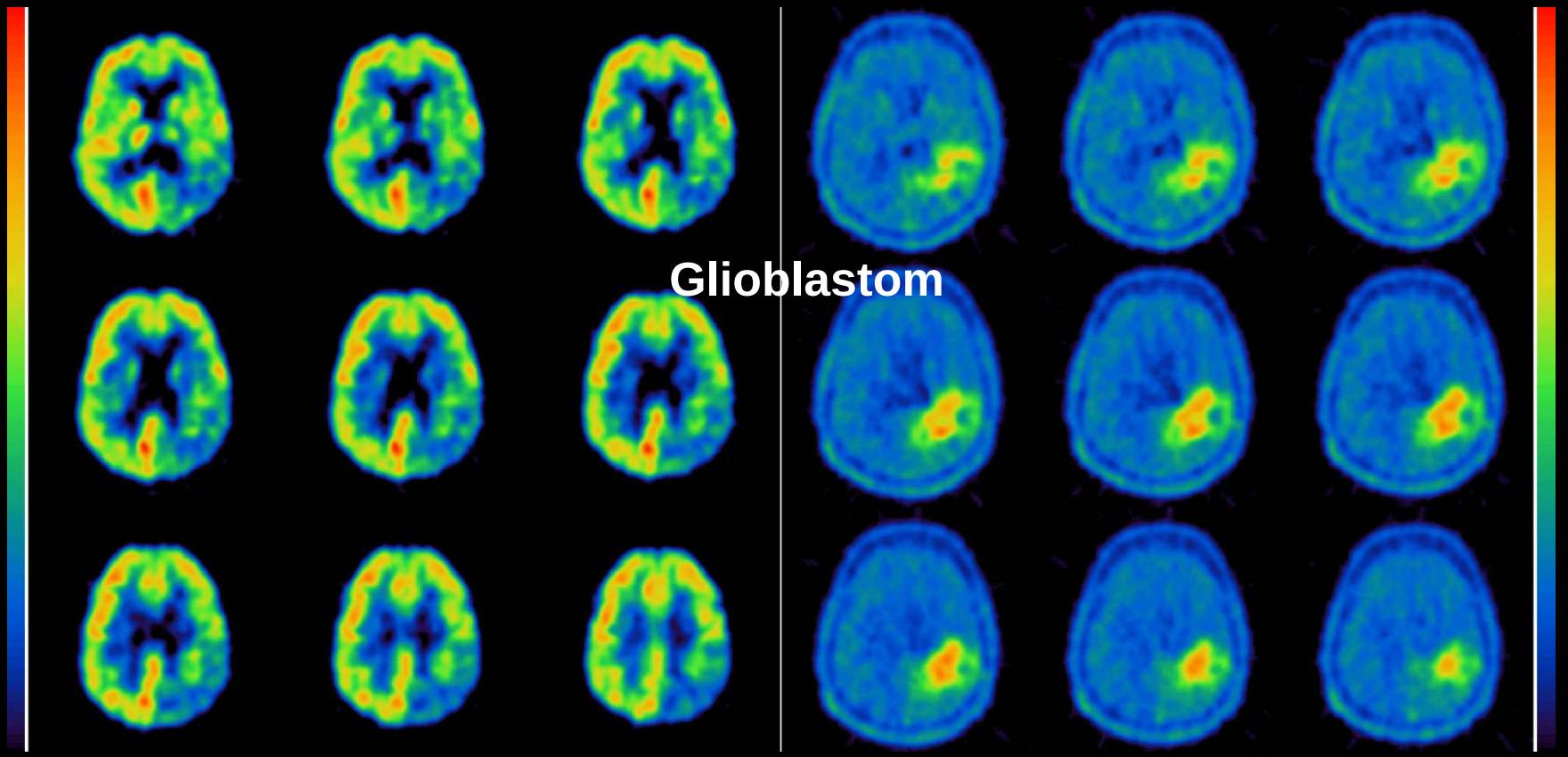
FET PET



Darstellung des Aminosäuretransportes in die Zelle

Hirntumoren

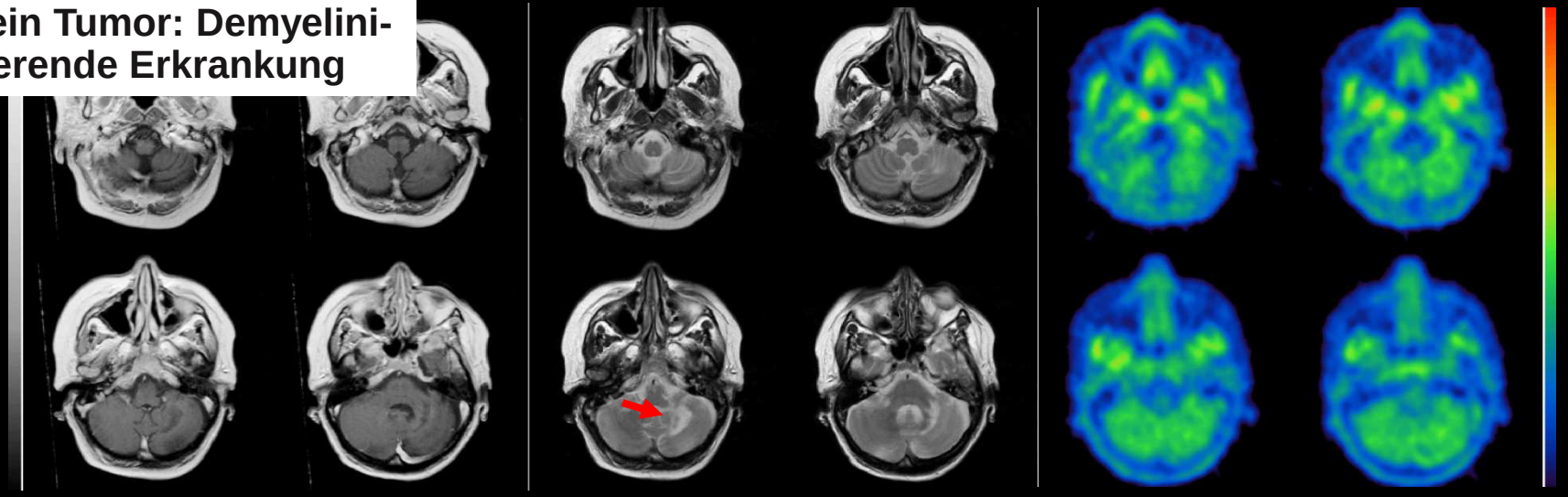
FDG vs. FET PET



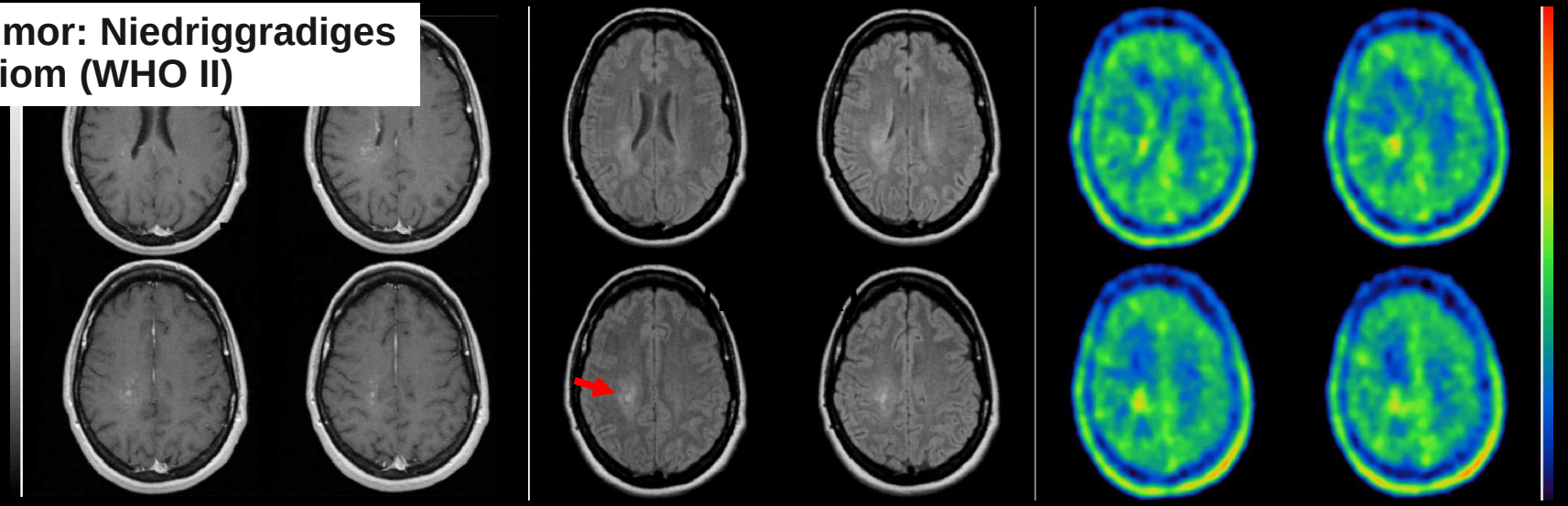
Hirntumoren

Tumor ?

Kein Tumor: Demyelinisierende Erkrankung

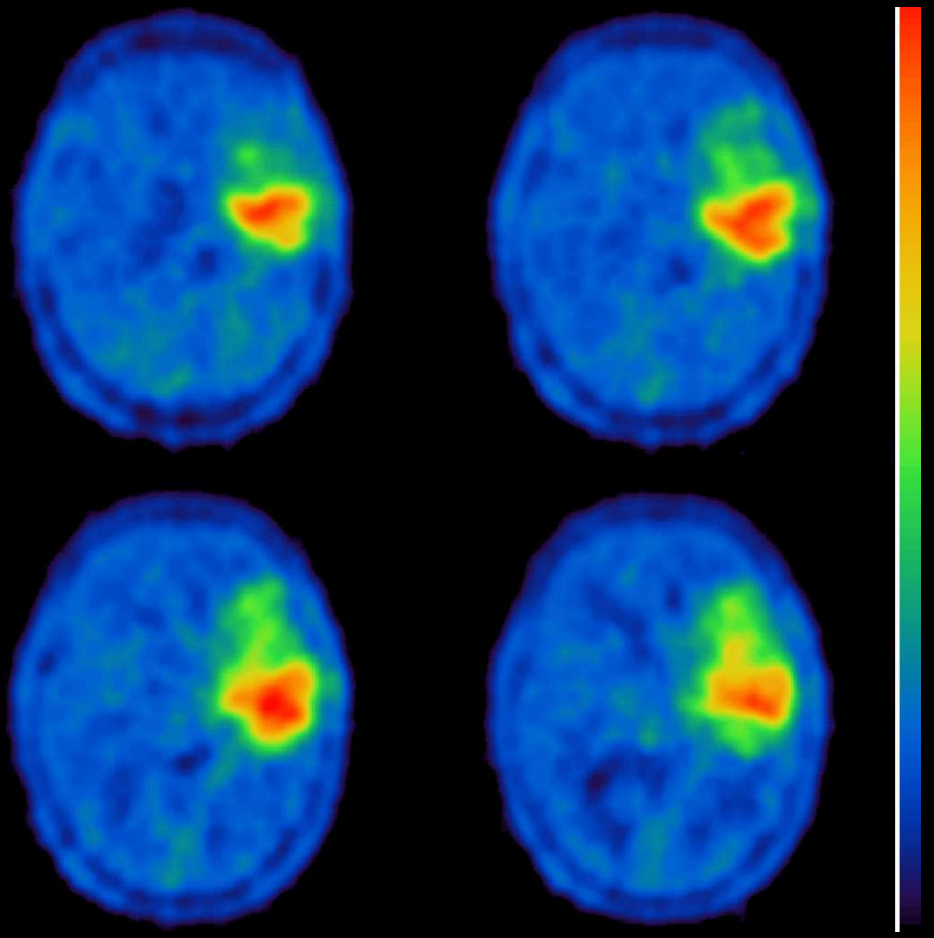


Tumor: Niedriggradiges Gliom (WHO II)



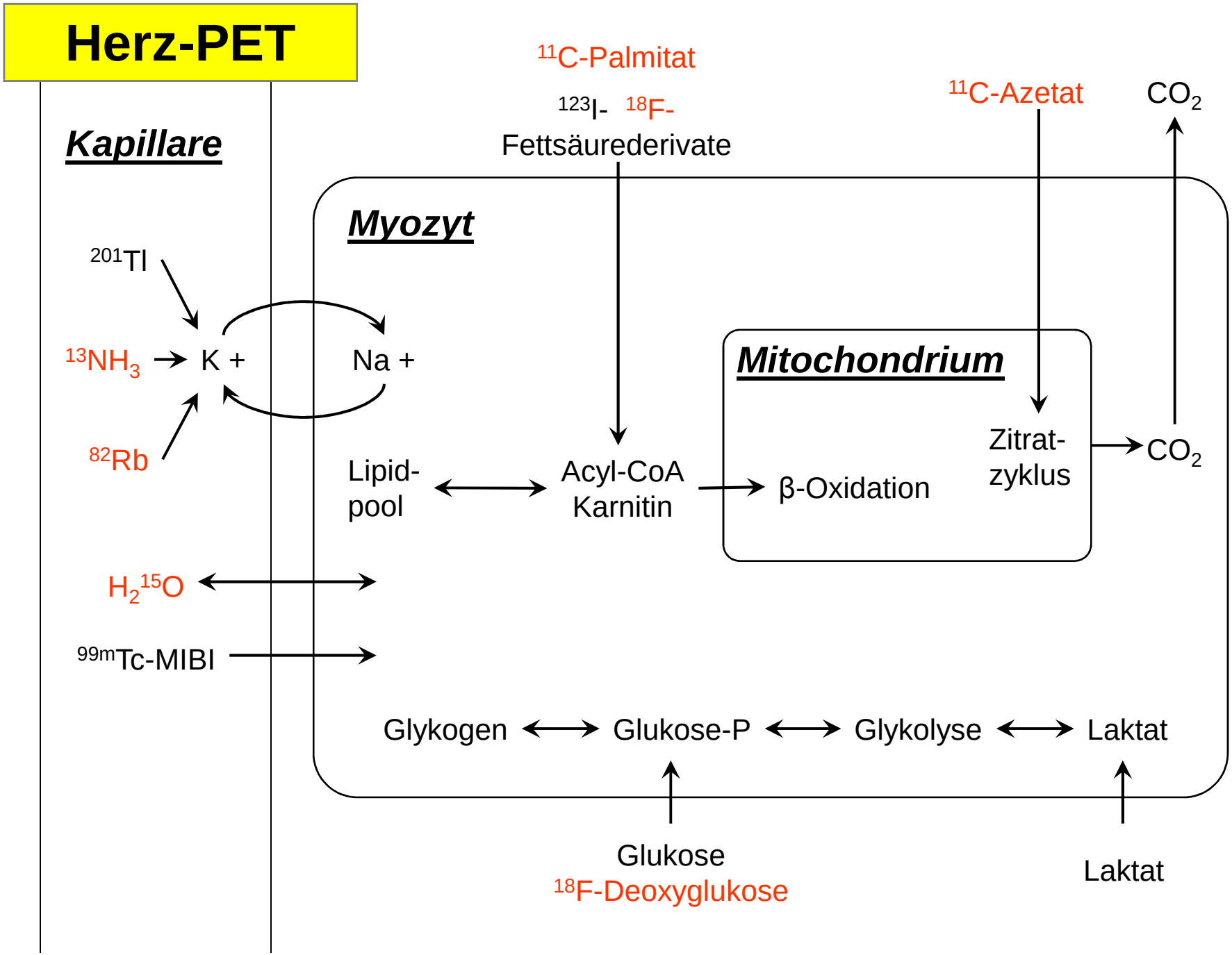
Hirntumoren

Wahl des Biopsieortes



PET und PET/CT

- Methodik
- Klinische Anwendung
  - Neurowissenschaften
  - Kardiologie
  - Onkologie


Herz-PET
Kapillare
Myozyt
Mitochondrium
^{11}C-Palmitat
^{123}I- ^{18}F-
Fettsäurederivate
^{11}C-Azetat
CO_2
^{201}Tl
$^{13}NH_3$
K +
Na +
^{82}Rb
Lipid-
pool
Acyl-CoA
Karnitin
β-Oxidation
Zitrat-
zyklus
CO_2
$H_2{}^{15}O$
^{99m}Tc-MIBI
Glykogen
Glukose-P
Glykolyse
Laktat
Glukose
^{18}F-Deoxyglukose
Laktat

Herz-PET

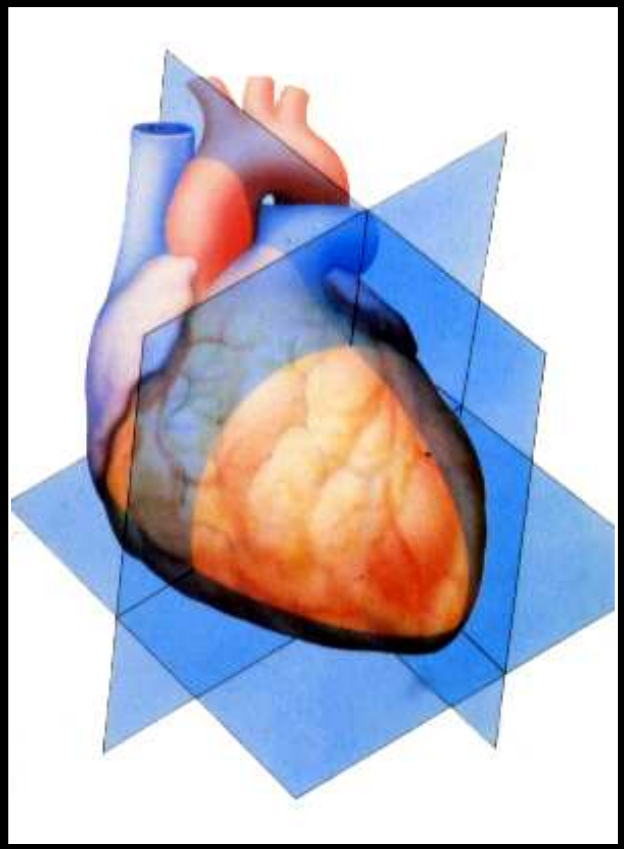
FDG-PET: Klinische Indikationen

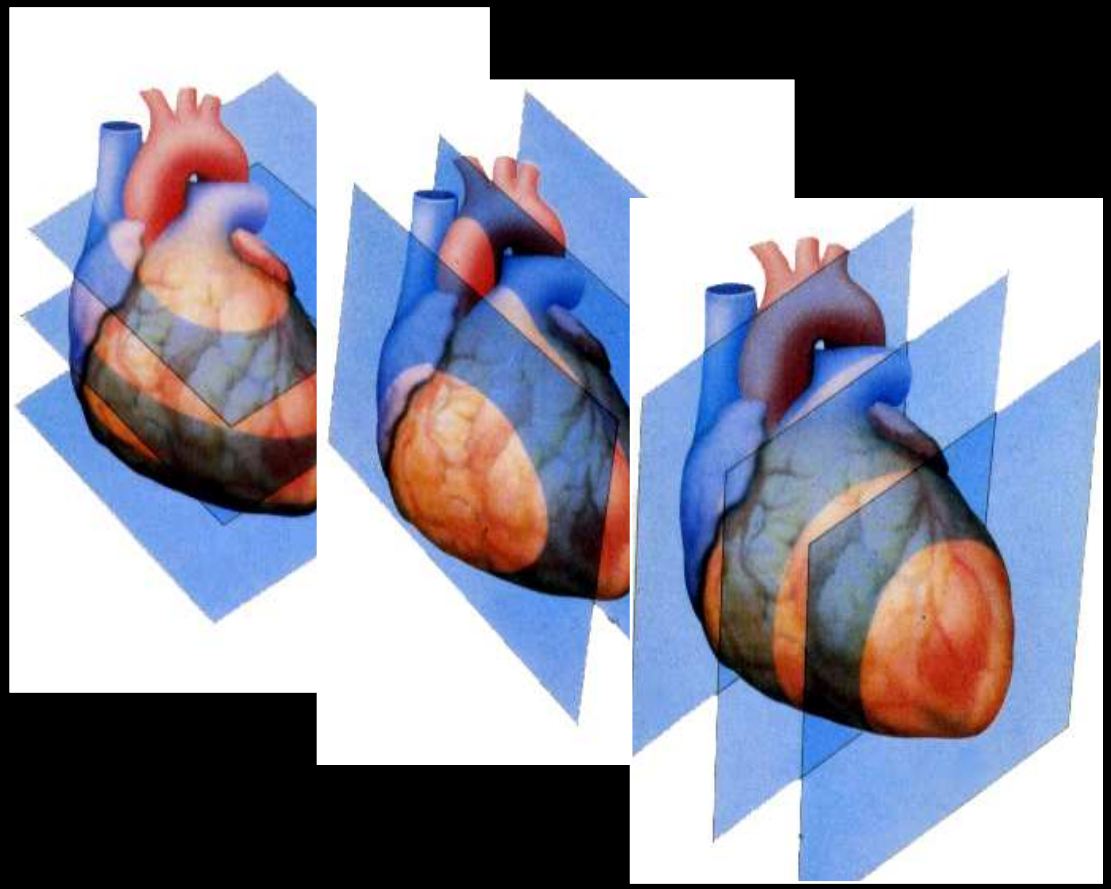
Bestimmung der Gewebevitalität

- FDG PET gilt als Goldstandard für den Nachweis vitalen Myokardgewebes
- Beleg für ‘Hibernating’ Myokard nach ischäm. Schädigung
  - hoher Vorhersagewert für eine funktionelle Erholung
  - Therapieplanung (Kosteneffizienz)
    - Koronarrevaskularisation bei KHK Patienten mit schwerer linksventrikulärer Dysfunktion
    - Indikationsstellung zur Herztransplantation

Herz-PET

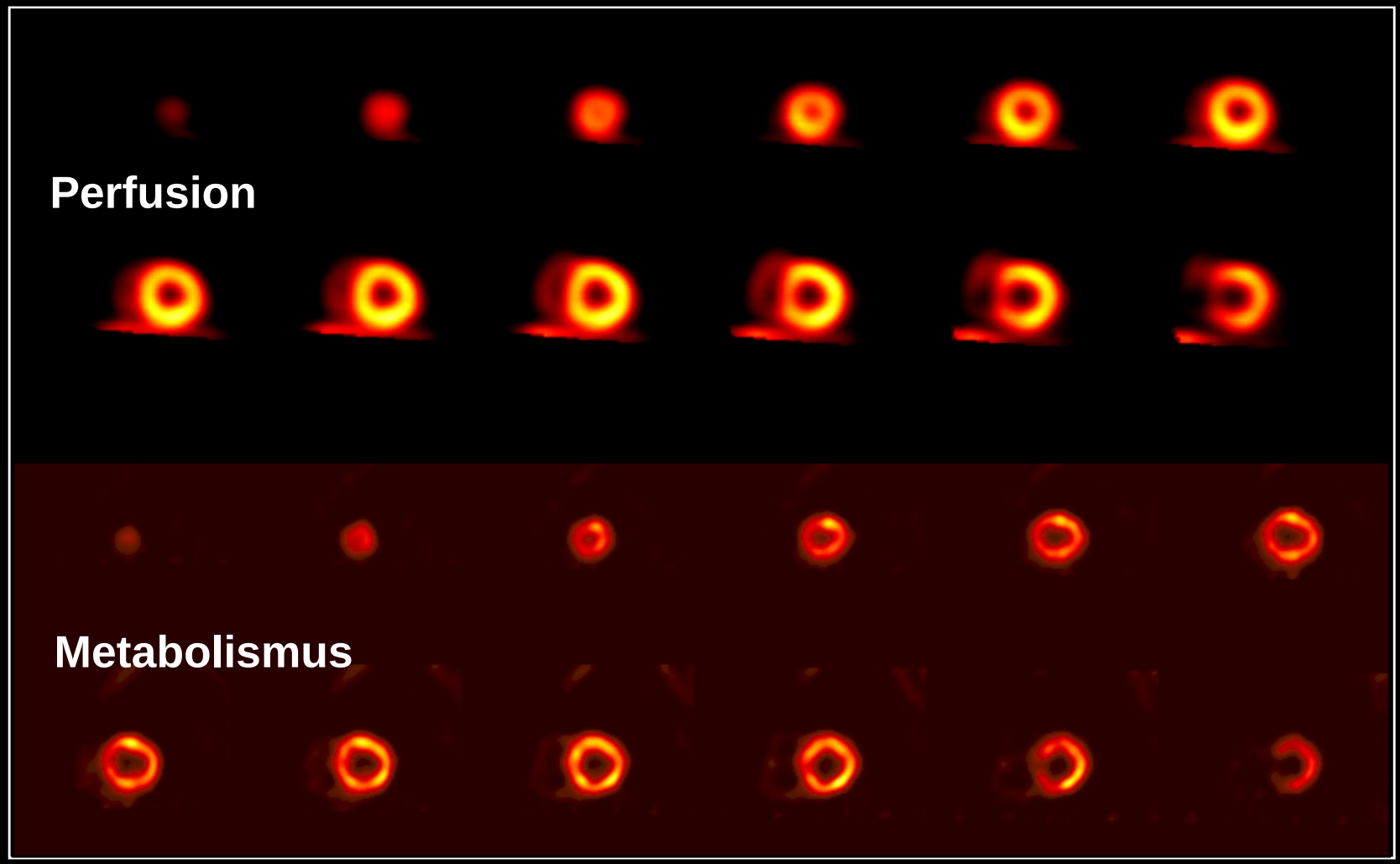
Schnittführung bei Myokard PET





Herz-PET

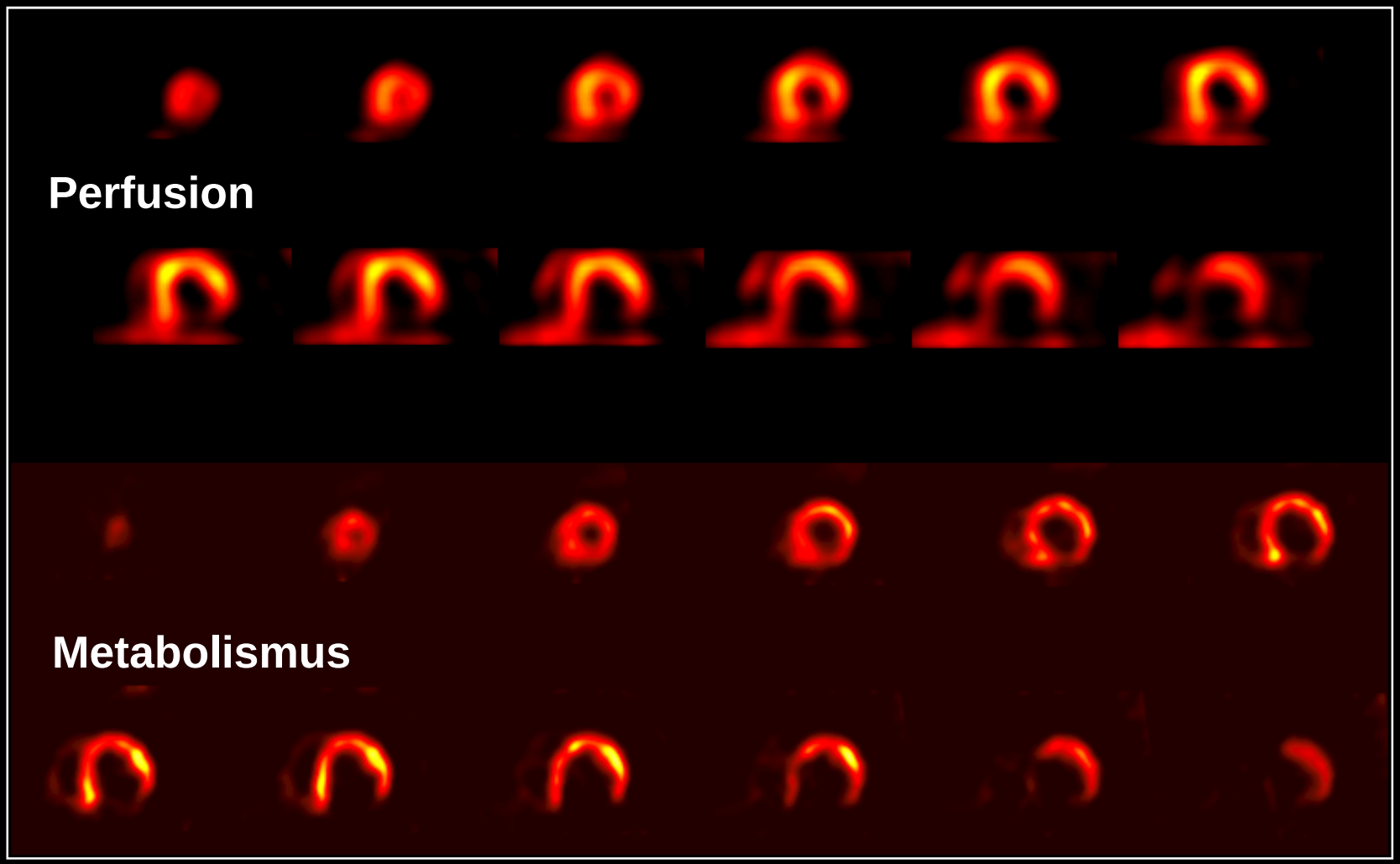
Normalbefund



Matching von unauffälliger Perfusion und Glukoseutilisation

Herz-PET

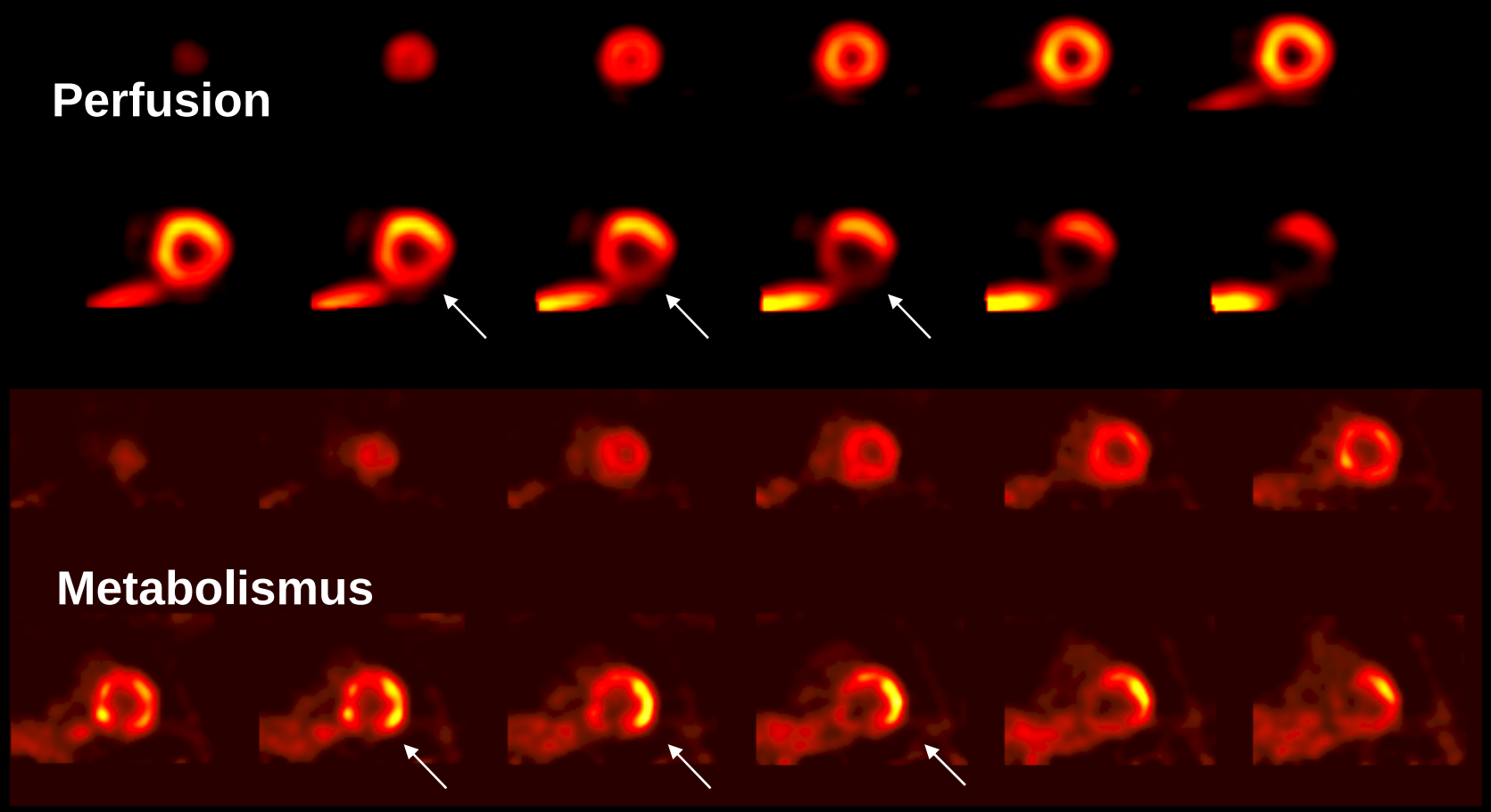
SPECT+PET: Infarkt



Matching der Defekte in Perfusion und Glukoseutilisation

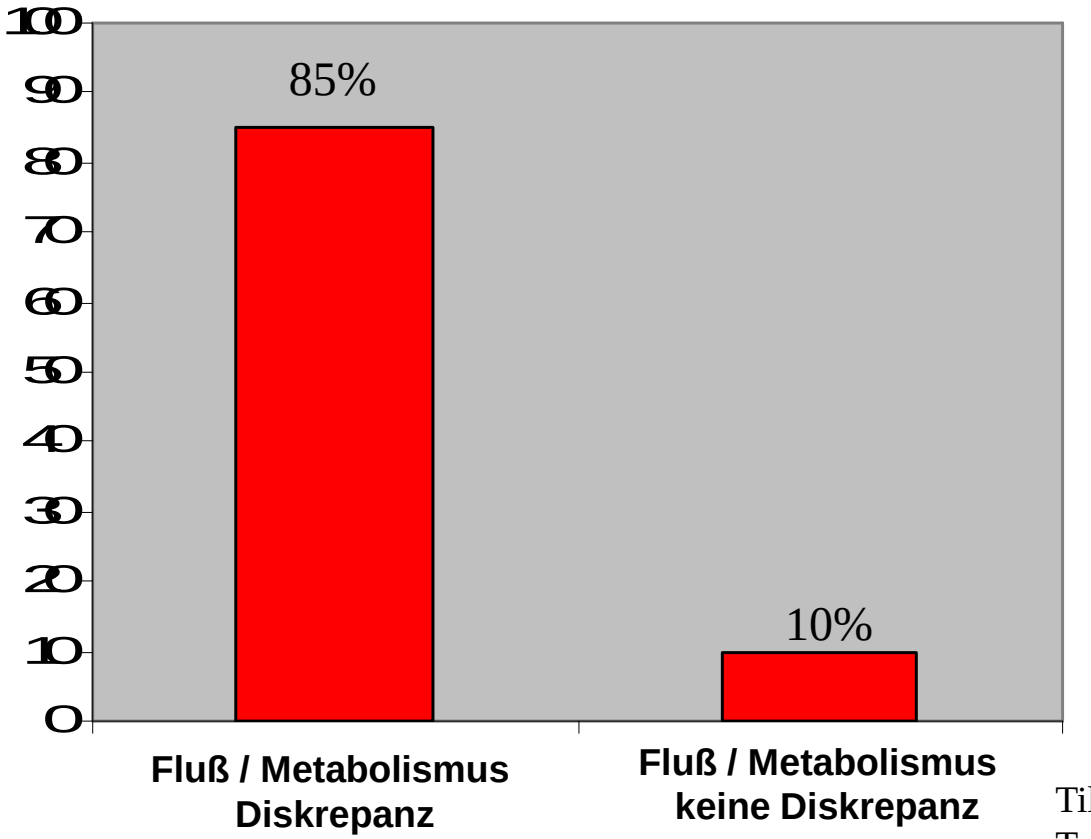
Herz-PET

SPECT+PET: Infarkt + hibernat. M.



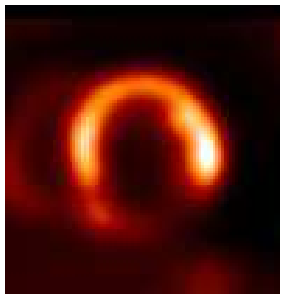
Partielles Mismatch von Perfusion und Glukoseutilisation

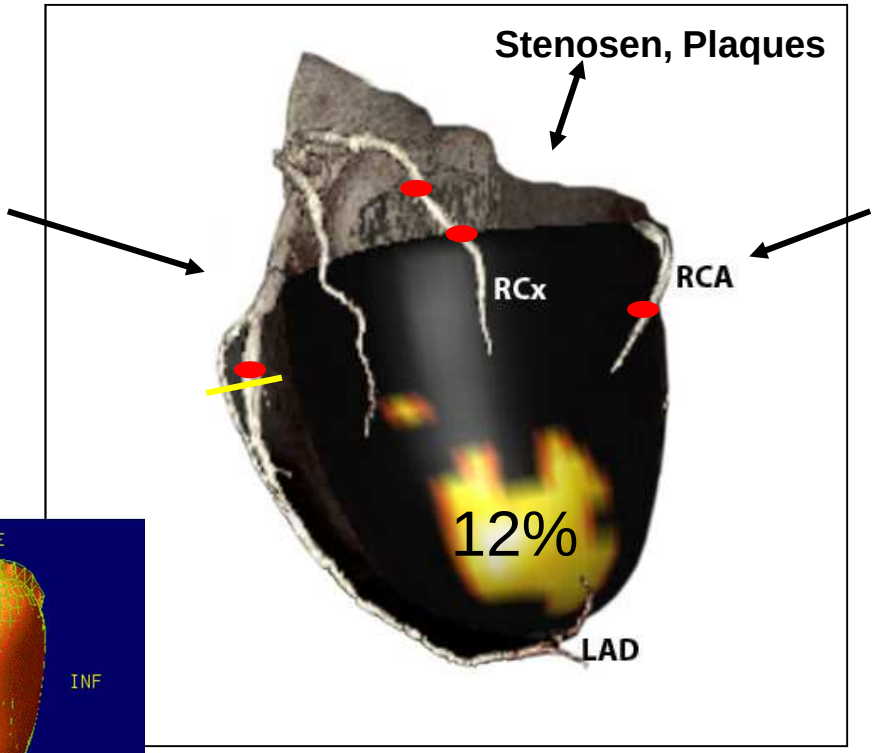
Verbesserung der kontraktilen Funktion nach Revaskularisation

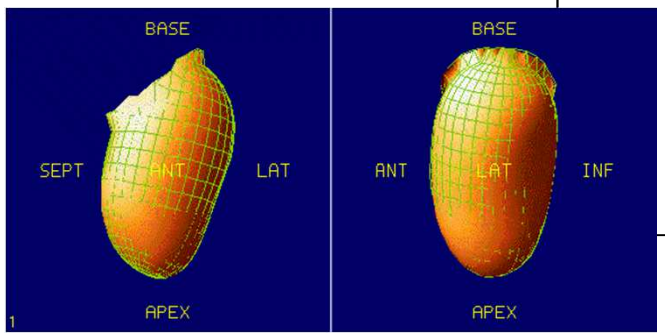


Tillisch et al. N Engl J Med 1986
Tamaki et al. Am J Cardiol 1989

Kombination aus Morphologie und Perfusion / Vitalität







PET und PET/CT

- Methodik
- Klinische Anwendung
  - Neurowissenschaften
  - Kardiologie
  - Onkologie

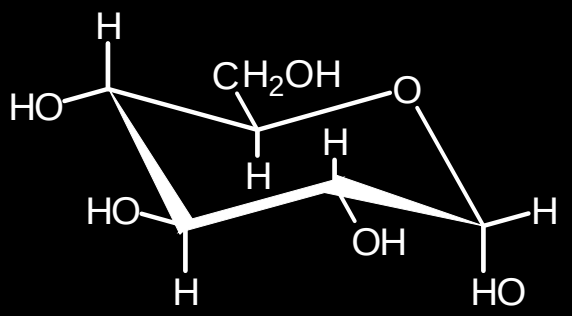
Onkologie – PET/CT

Biologische Grundlagen der Anreicherung in Tumoren

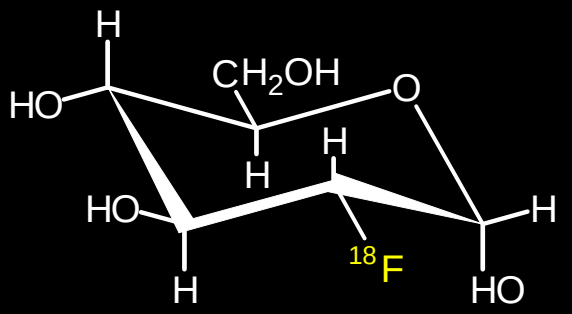
Biologische Grundlagen

- [^{18}F]FDG wird analog zu Glucose in Tumorzellen aufgenommen
- Tumorzellen nehmen vermehrt Glucose auf
- erhöhte Zahl von Glucose-Transporter Molekülen (GLUT1 - GLUT5)
- gesteigerte Glykolyse

Radiopharmakon



α -D-(+)-Glucose

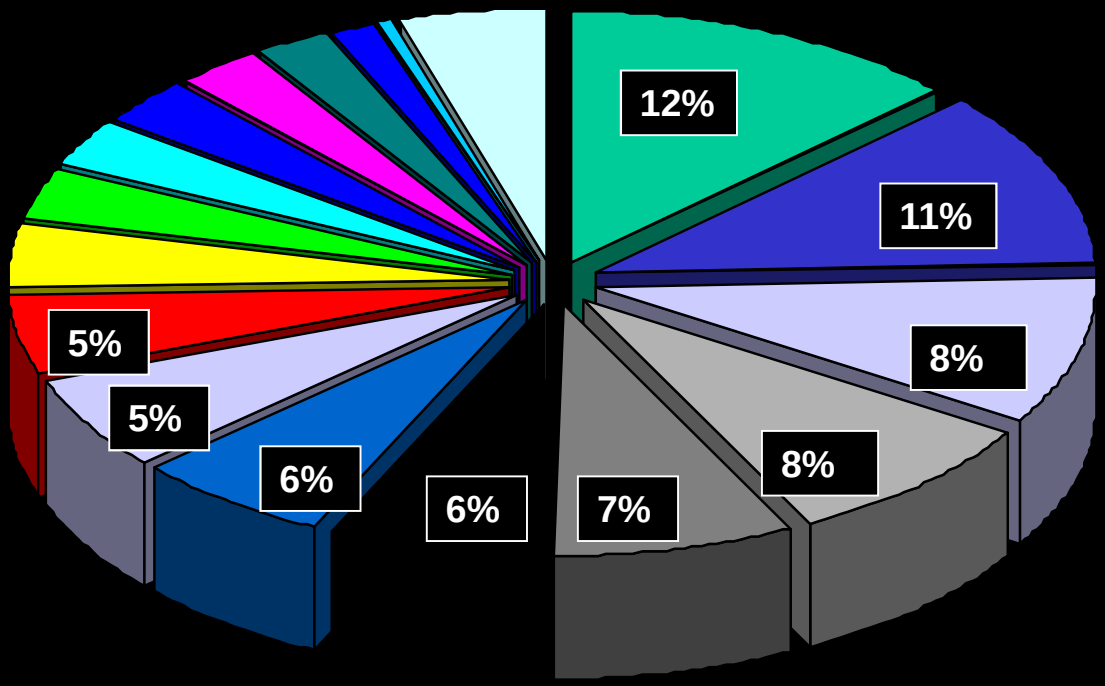


[^{18}F]Fluor- 2 deoxy-D-glucose

PET und PET/CT an der LMU München

Statistik

Untersuchungszahlen: PET/CT Standort Großhadern (2008)



n = 2327 Untersuchungen

- Kolorektale Karzinome
- NET
- Mammakarzinome
- Bronchialkarzinom
- Prostatakarzinom
- CUP
- Lymphome
- Gynäkologische Tumoren
- Sarkome
- Urogenitale Tumoren
- Magenkarzinome, GIST
- HNO-Tumoren
- Schilddrüsenkarzinome
- HCC, CCC
- Melanome
- Pankreaskarzinome
- Ösophaguskarzinome
- sonstige

FDG PET

Indikationen

- DD benigne/maligne Erkrankungen
- initiales (präoperatives) Staging
- DD Narbe vs. vitaler Tumorrest
- Rezidivdiagnostik
- Therapie-Monitoring
- Abschätzung der Prognose

Bezahlung in USA (Medicare)

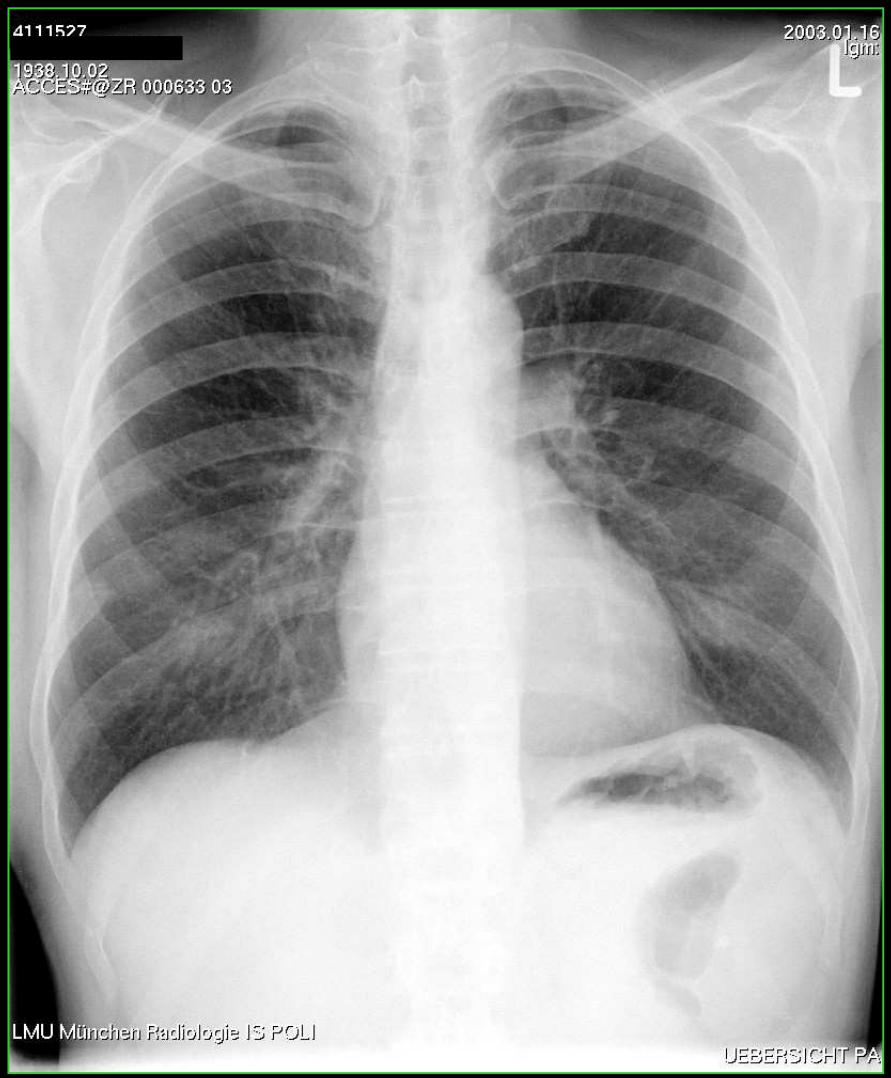
• Bronchial Ca	Dx,St,ReSt
• Ösophagus Ca	Dx,St,ReSt
• Kolorektales Ca	Dx,St,ReSt
• Malignes Lymphom	Dx,St,ReSt
• Malignes Melanom	Dx,St,ReSt
• HNO Tumor	Dx,St,ReSt

Dx: Diagnosestellung
St: Staging
ReSt: Restaging

PET und PET/CT in der Onkologie

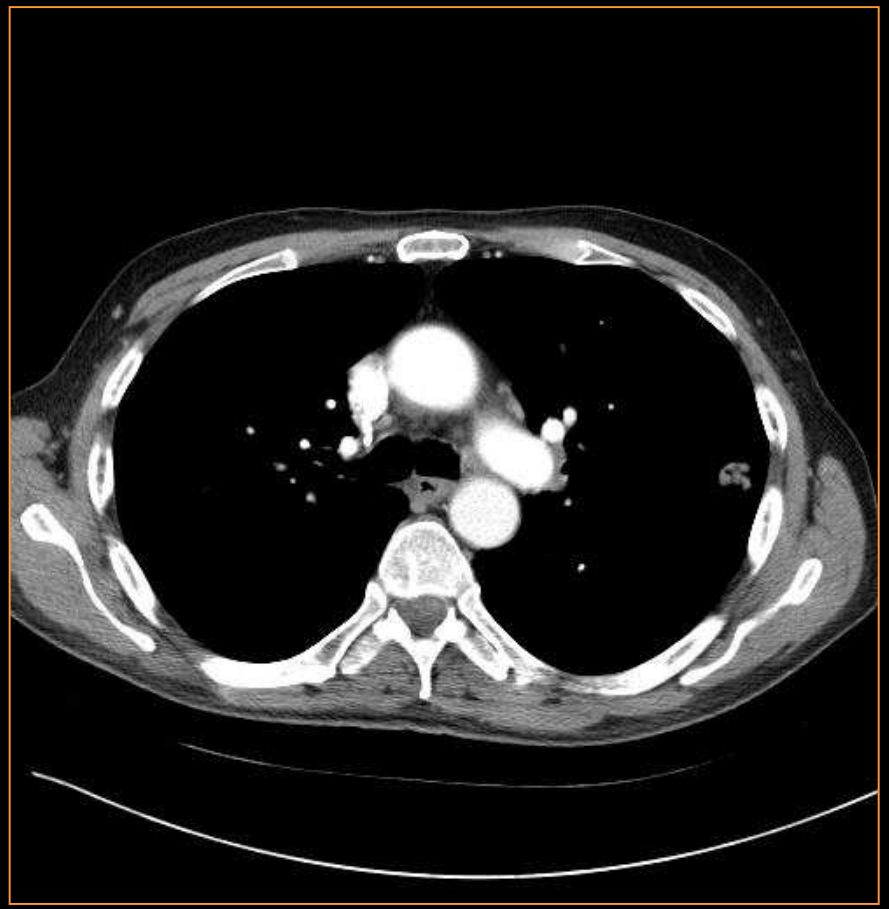
- **Primärtumordiagnostik**
- **Staging**
- **Therapieplanung**
- **Therapiemonitoring**
- **DD Narbe – Rezidiv, Restaging**

Fallbeispiel: 65-jähriger Patient, Raucher



Projektionsradiographie p.a.

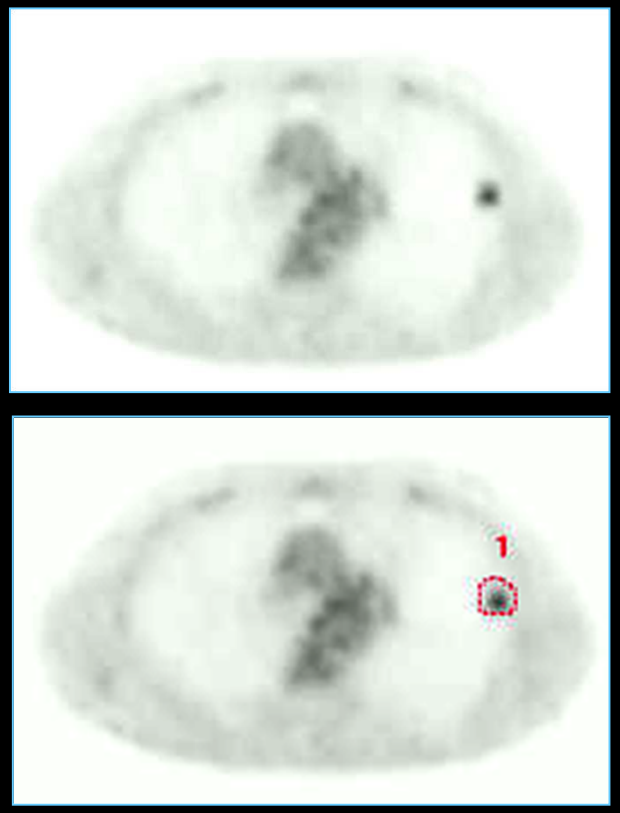
Projektionsradiographie seitlich



CT (mit i.v. KM, Weichteilfenster)

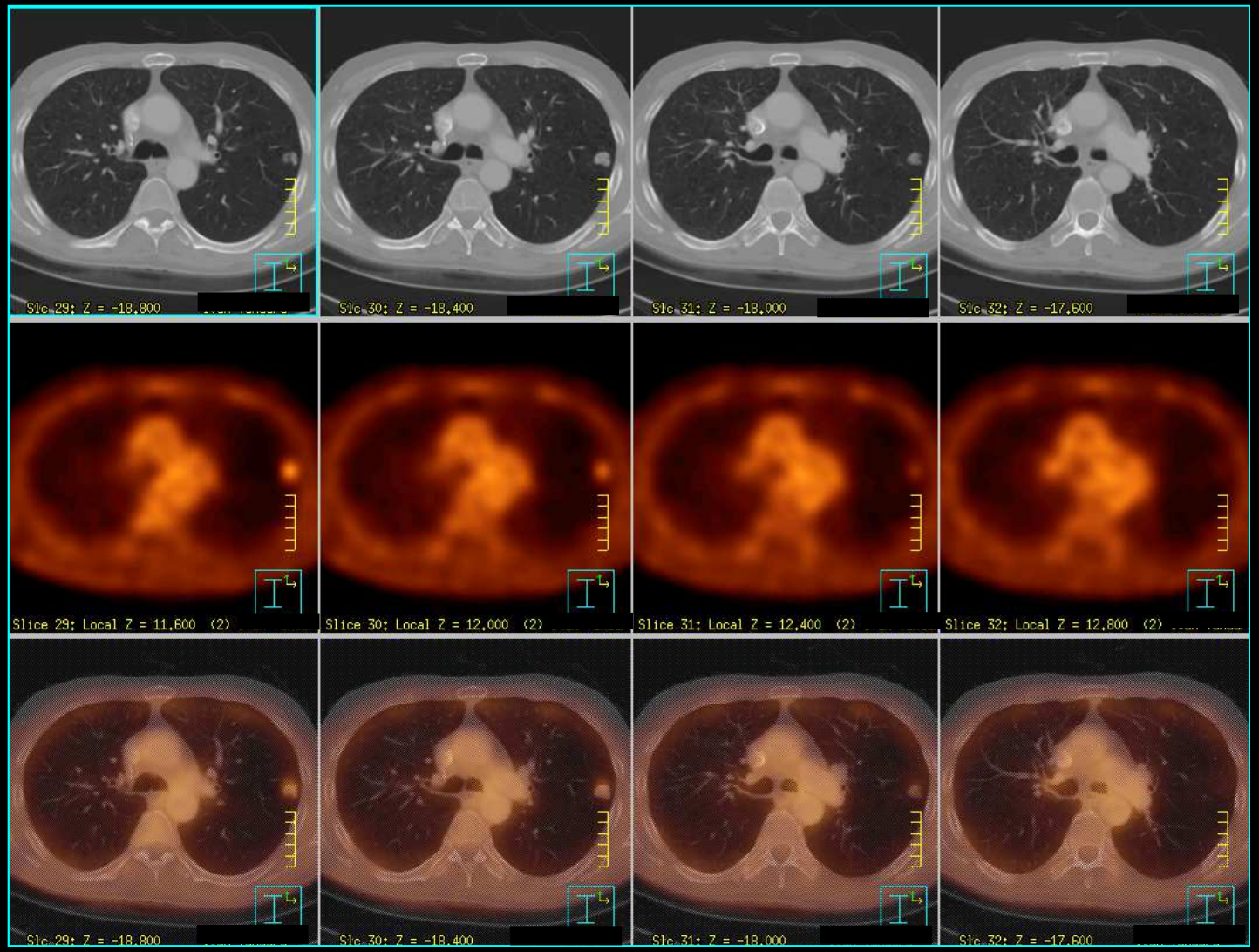
CT (mit i.v. KM, Lungenfenster)

PET (koronare Schnittführung)



SUVmax = 2,8

PET (transversale Schnittführung)



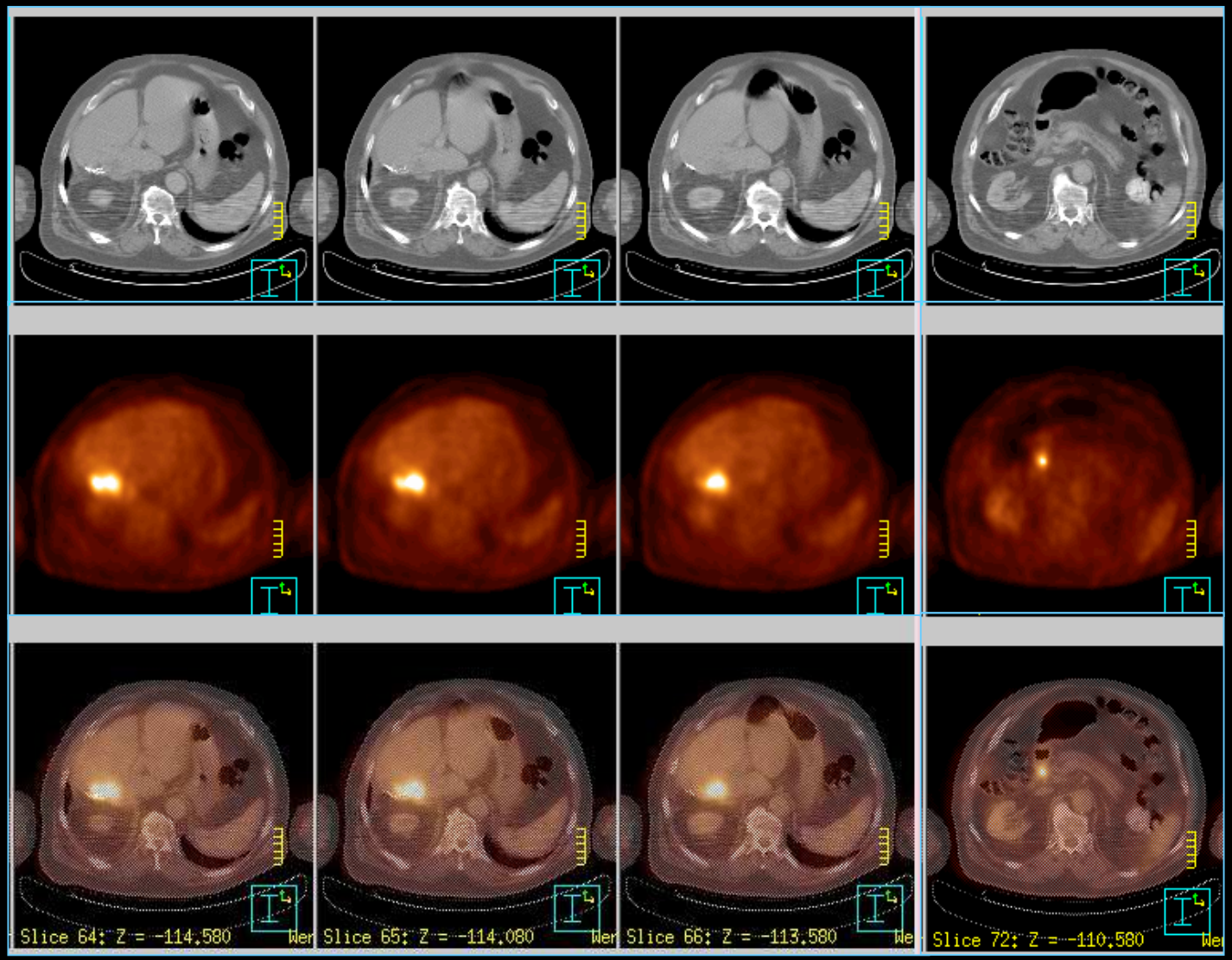
CT (Lungenfenster)

PET

PET/CT (Fusion)

Großzelliges Bronchialkarzinom

Fallbeispiel: 65-jähriger Patient, positiver Hämokkult-Test



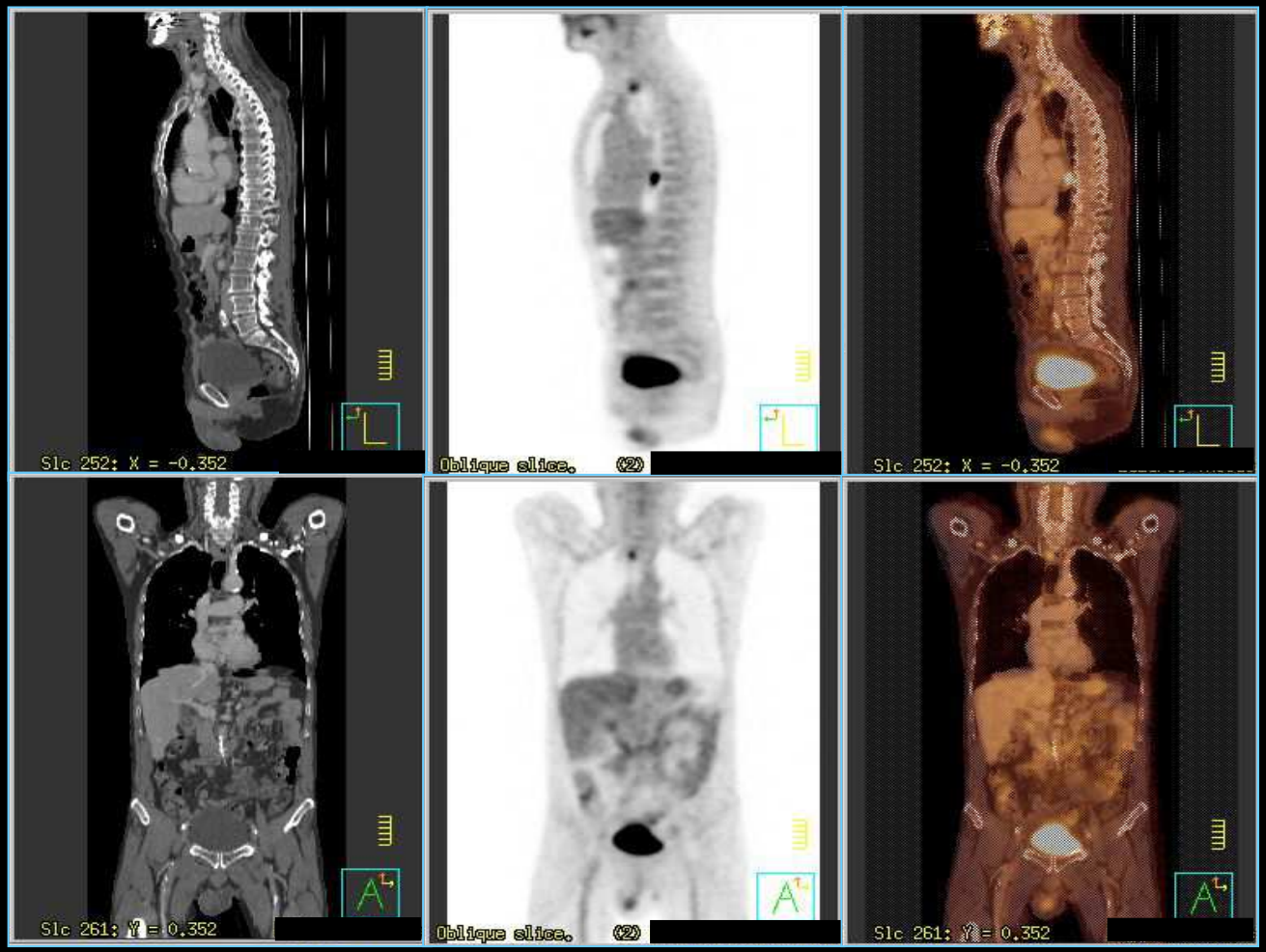
CT (Weichteilfenster)

PET

PET/CT (Fusion)

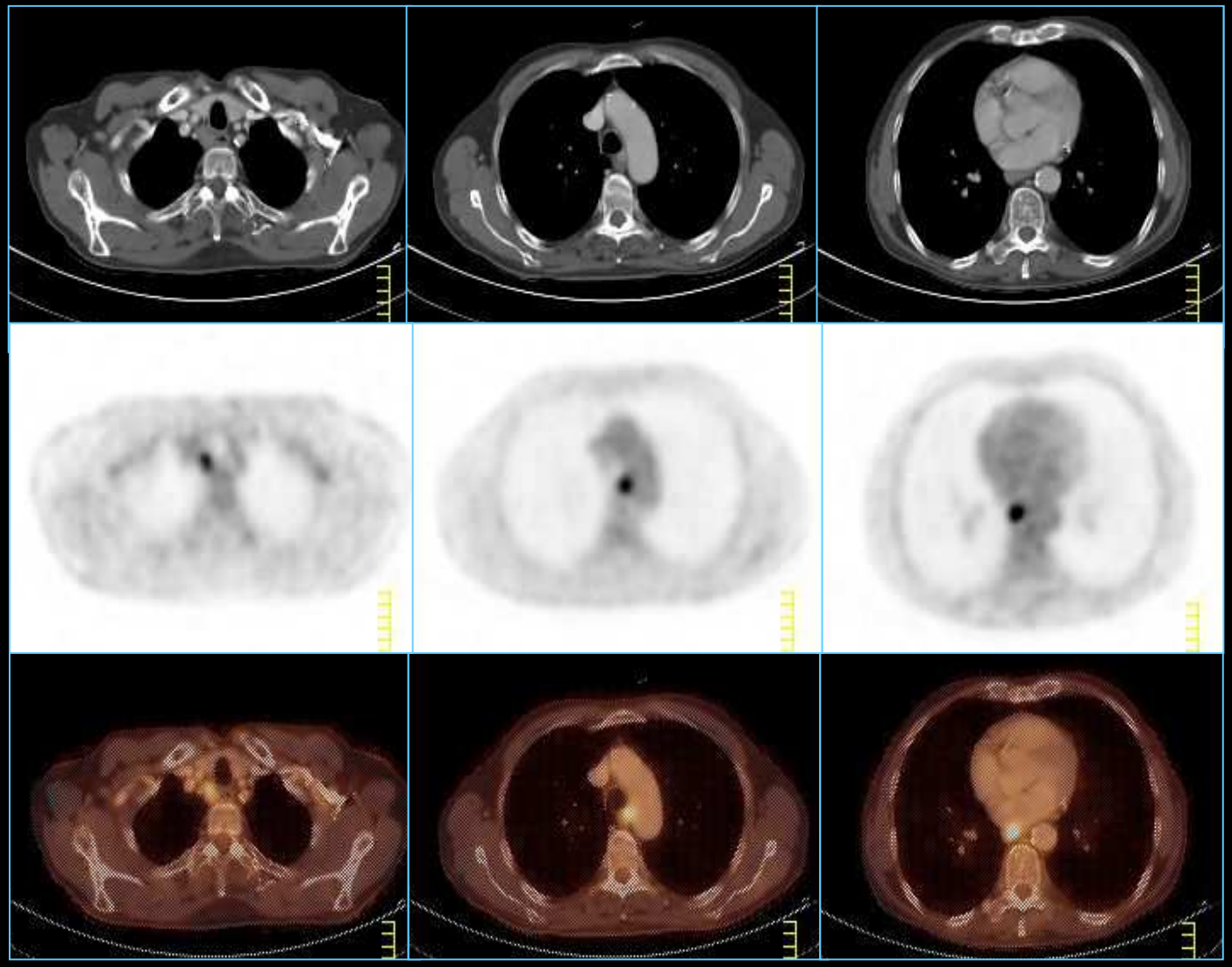
Kolonkarzinom und Leberfilia

Fallbeispiel: 55-jähriger Patient, unklarer Gewichtsverlust



CT (Weichteilfenster) **PET** **PET/CT (Fusion)**

Fallbeispiel: 55-jähriger Patient, unklarer Gewichtsverlust



CT (Weichteilfenster)

PET

PET/CT (Fusion)

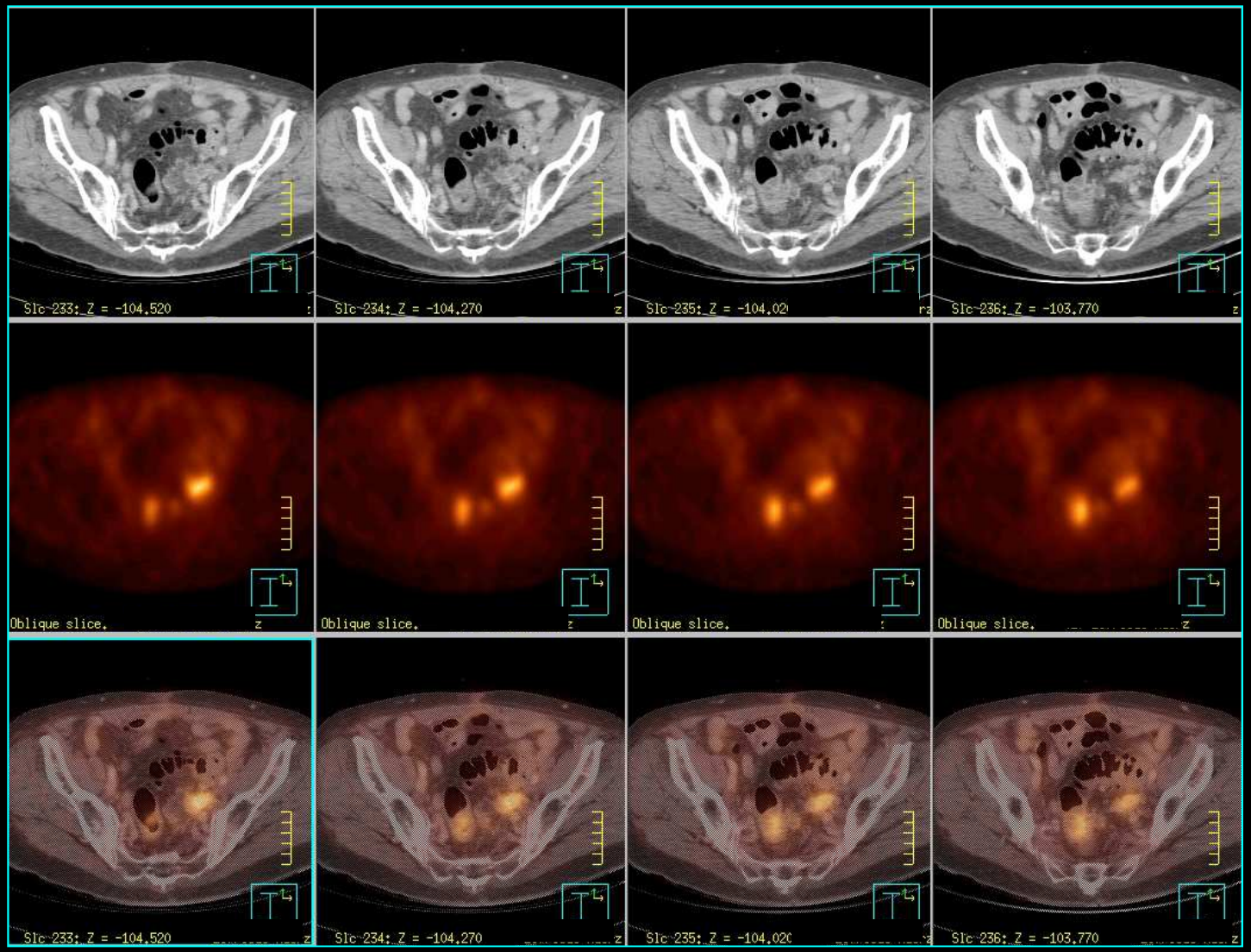
Ösophagus-Ca + LK-Metastasen

PET und PET/CT in der Onkologie

- ✓ Primärtumordiagnostik
- **Staging**
- Therapieplanung
- Therapiemonitoring
- DD Narbe – Rezidiv, Restaging

Fallbeispiel: 78-jährige Patientin, Endometriumkarzinom

Transversale Schnittführung



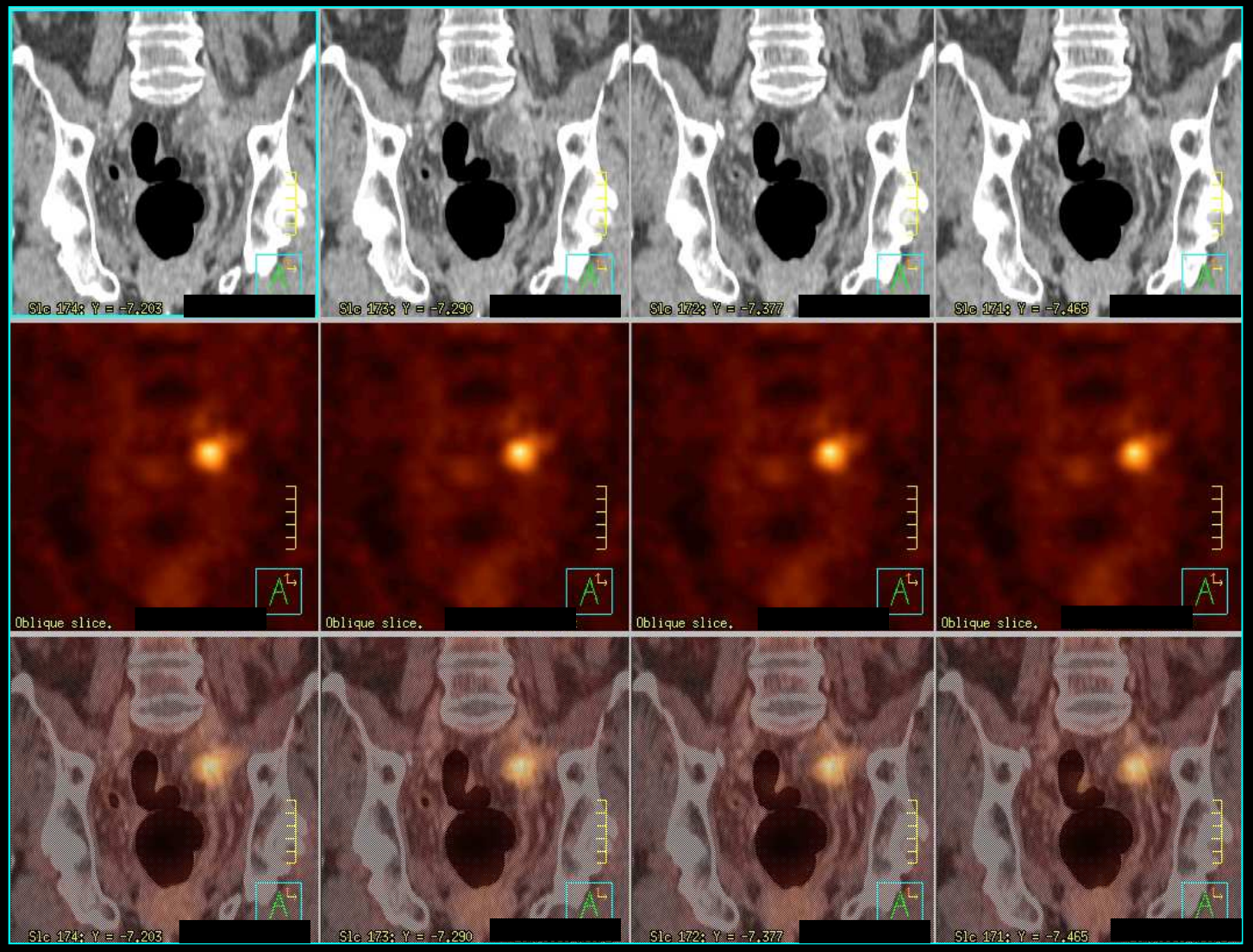
CT (Weichteilfenster)

PET

PET/CT (Fusion)

2 Darmwandfiliae

Koronare Schnittführung



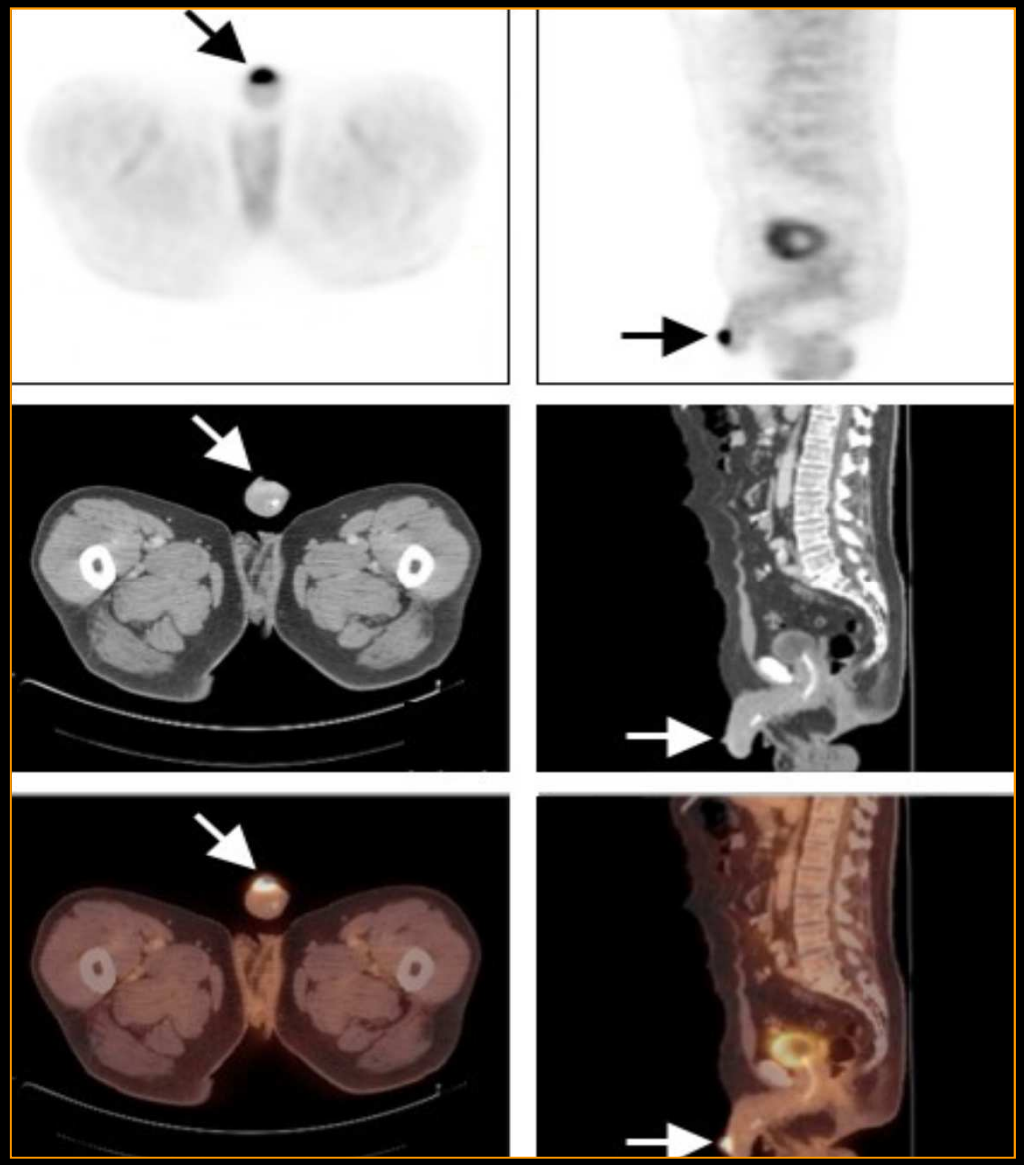
CT (Weichteilfenster)

PET

PET/CT (Fusion)

2 Darmwandfiliae

Fallbeispiel: 54-jähriger Patient, Peniskarzinom



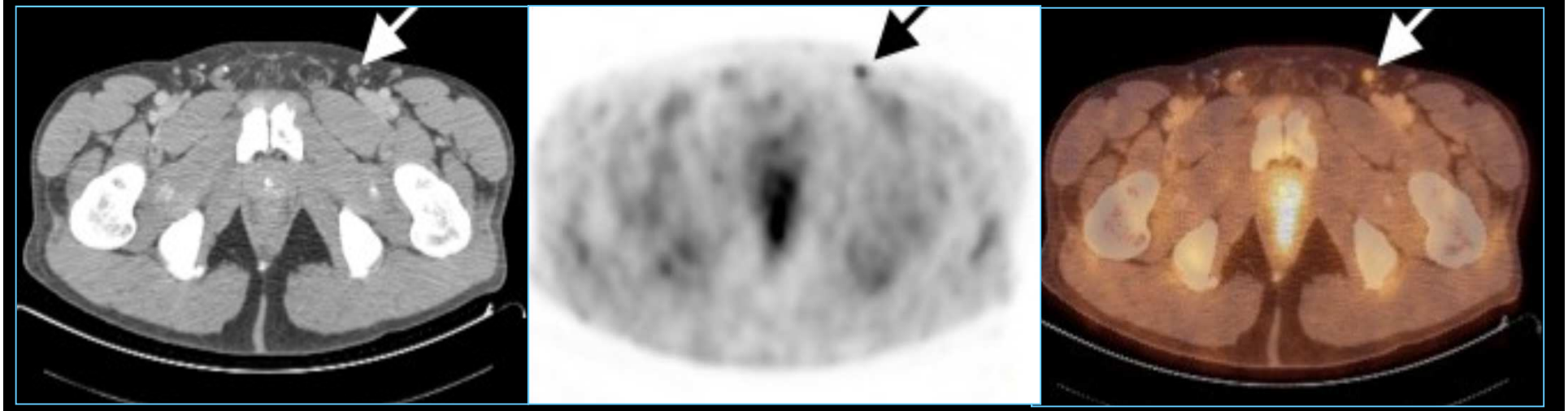
PET

CT (Weichteilfenster)

PET/CT (Fusion)

Primärtumor

Fallbeispiel: 54-jähriger Patient, Peniskarzinom



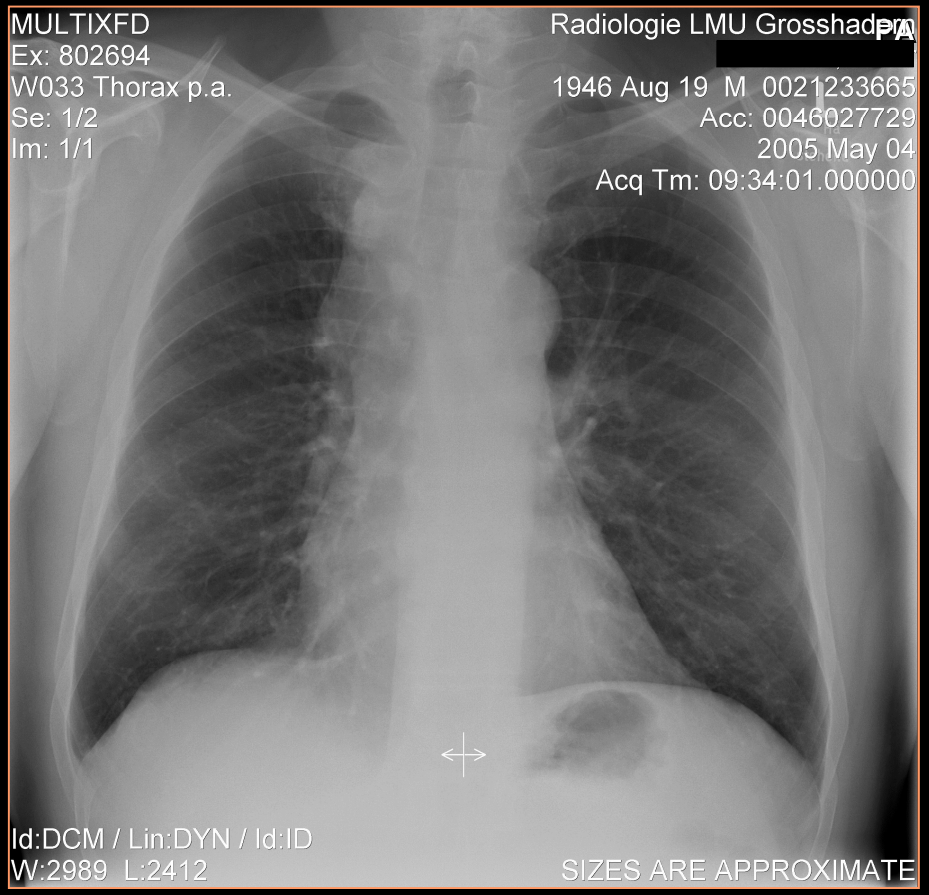
CT (Weichteilfenster) | PET | PET/CT (Fusion)

Inguinale Lymphknotenmetastase

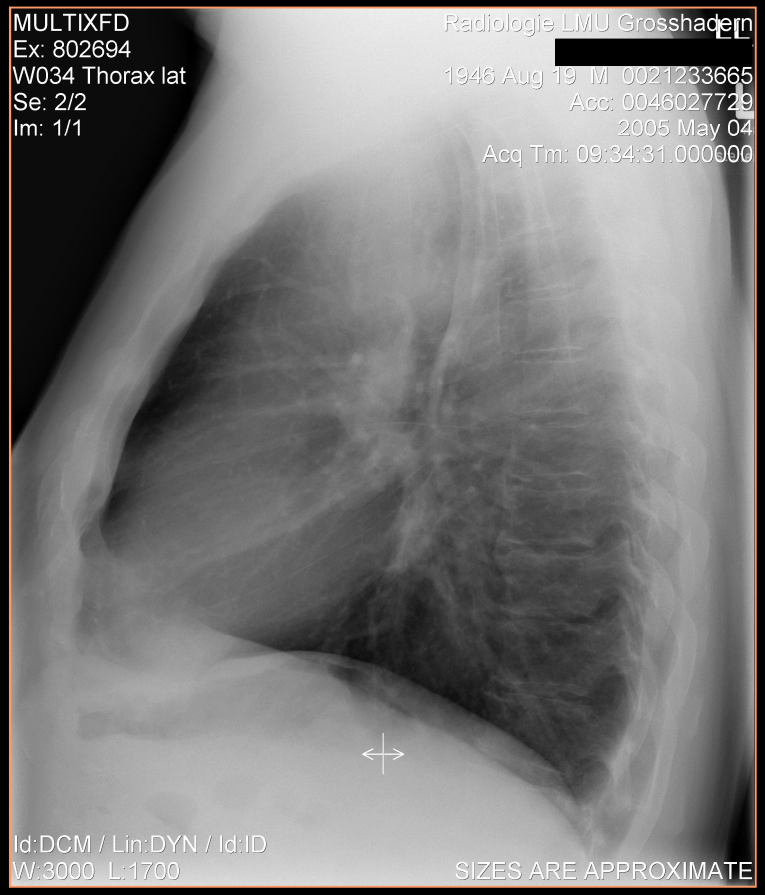
PET und PET/CT in der Onkologie

- ✓ Primärtumordiagnostik
- ✓ Staging
- **Therapieplanung**
- Therapiemonitoring
- DD Narbe – Rezidiv, Restaging

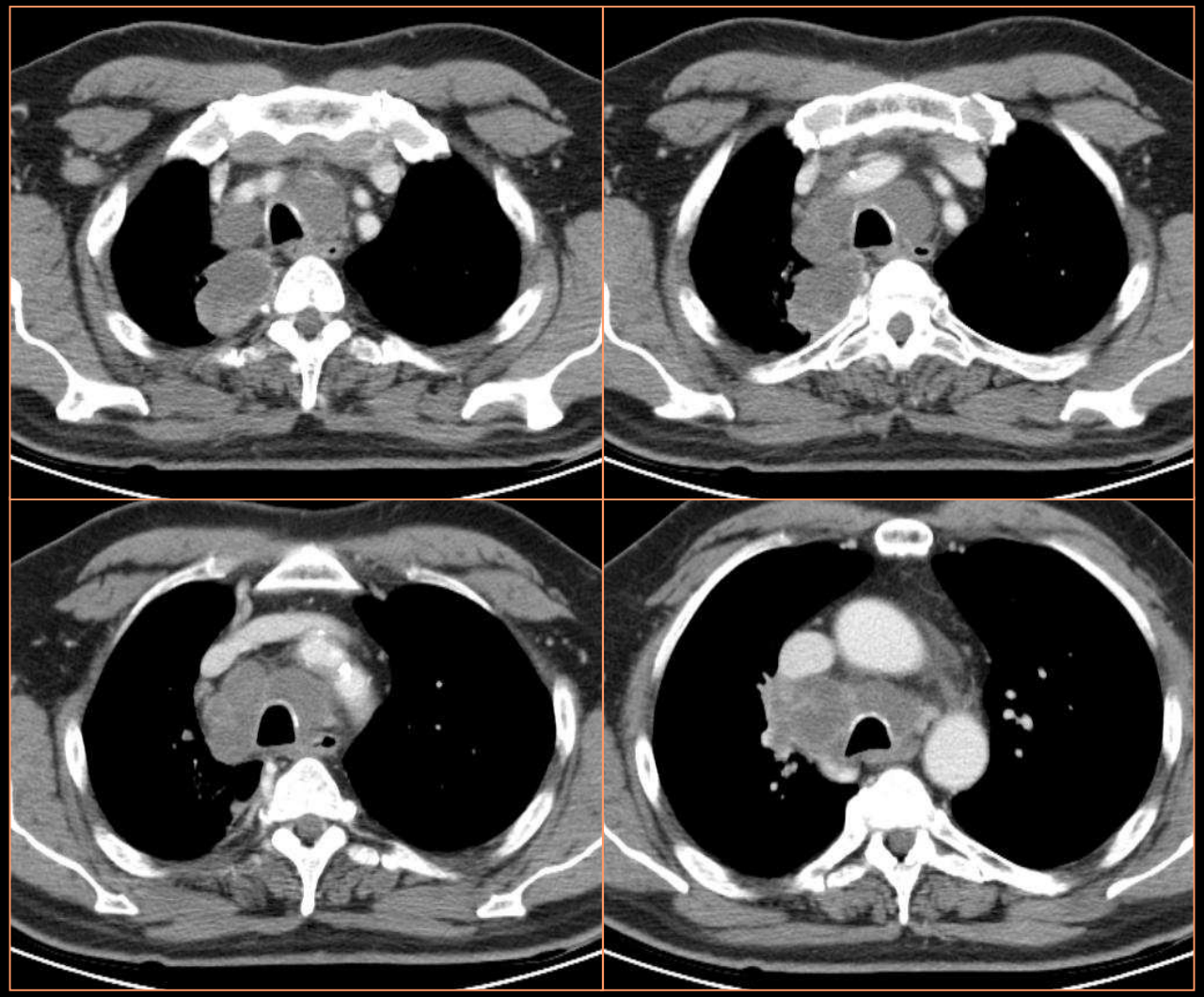
Fallbeispiel: 59-jähriger Patient, Raucher



Projektionsradiographie p.a.

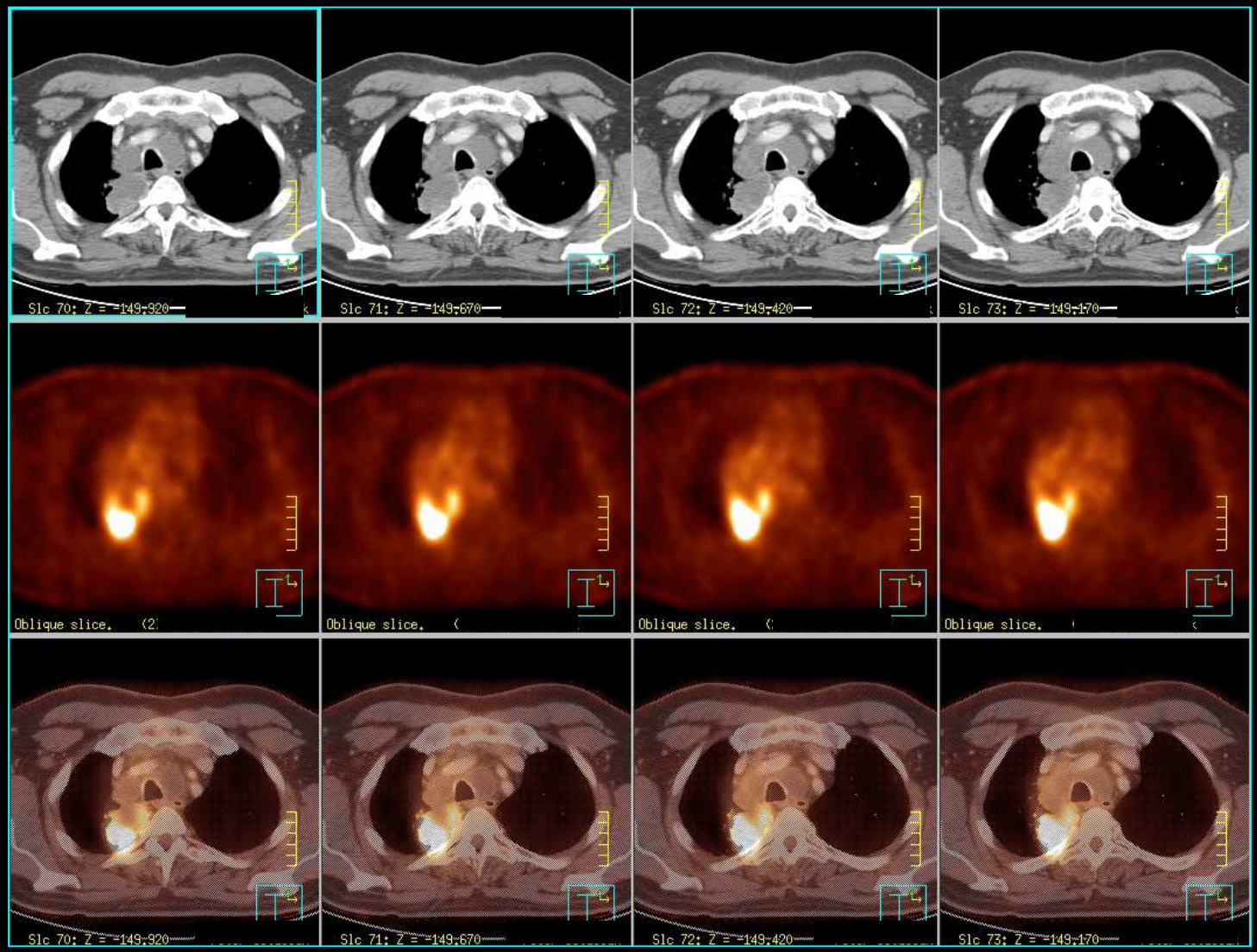


Projektionsradiographie seitlich



CT (nach i.v.-KM Gabe, Weichteilfenster, transversale Schnittführung)

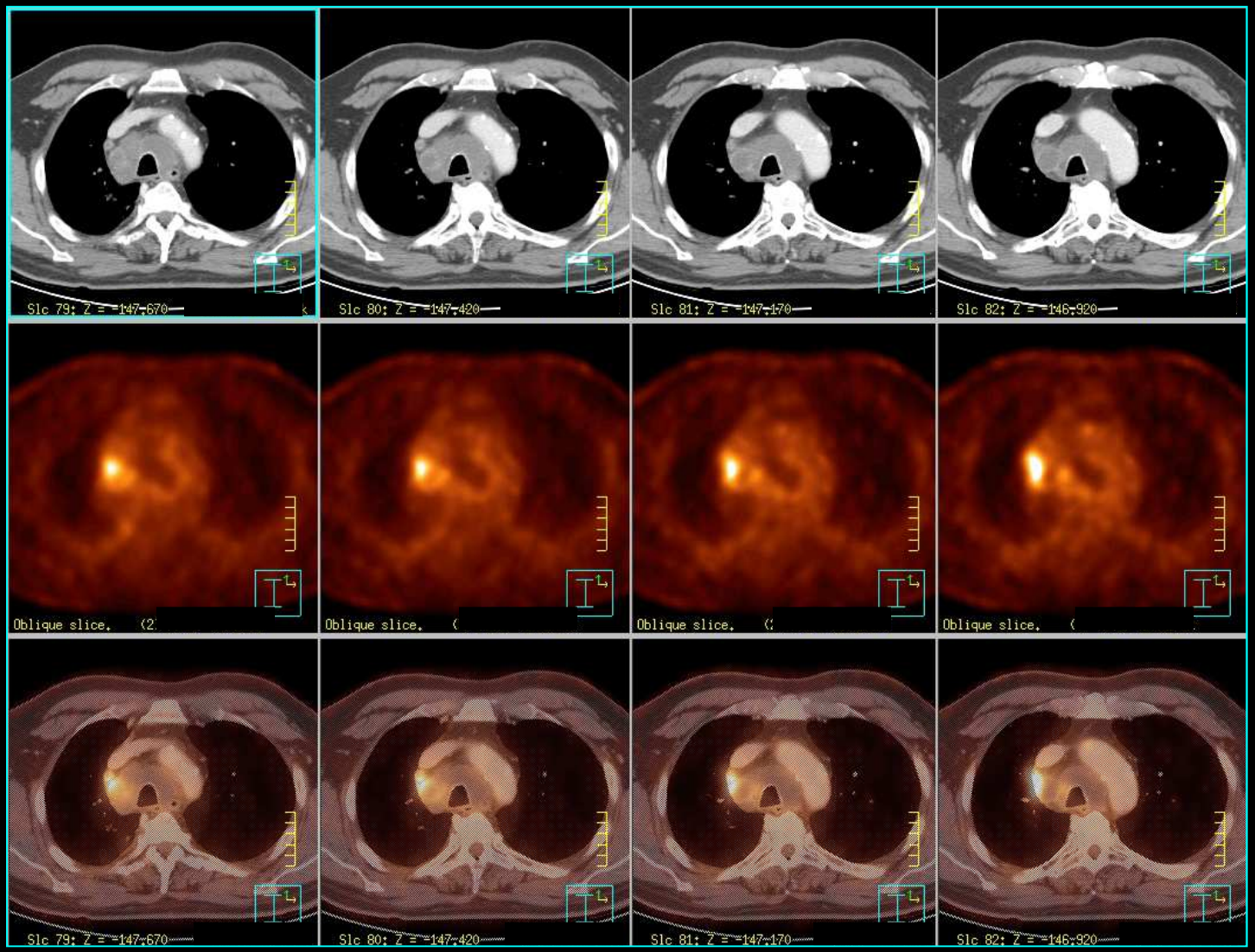
Histologisch (Mediastinoskopie) kein Malignomnachweis



CT (Weichteilfenster)

PET

PET/CT (Fusion)



CT (Weichteilfenster)

PET

PET/CT (Fusion)

Nochmalige Endoskopie (gezielt der im PET stoffwechselaktiven Herde):
Metastasiertes Bronchialkarzinom

PET und PET/CT in der Onkologie

- ✓ Primärtumordiagnostik
- ✓ Staging
- ✓ Therapieplanung
- • Therapiemonitoring
- • DD Narbe – Rezidiv, Restaging

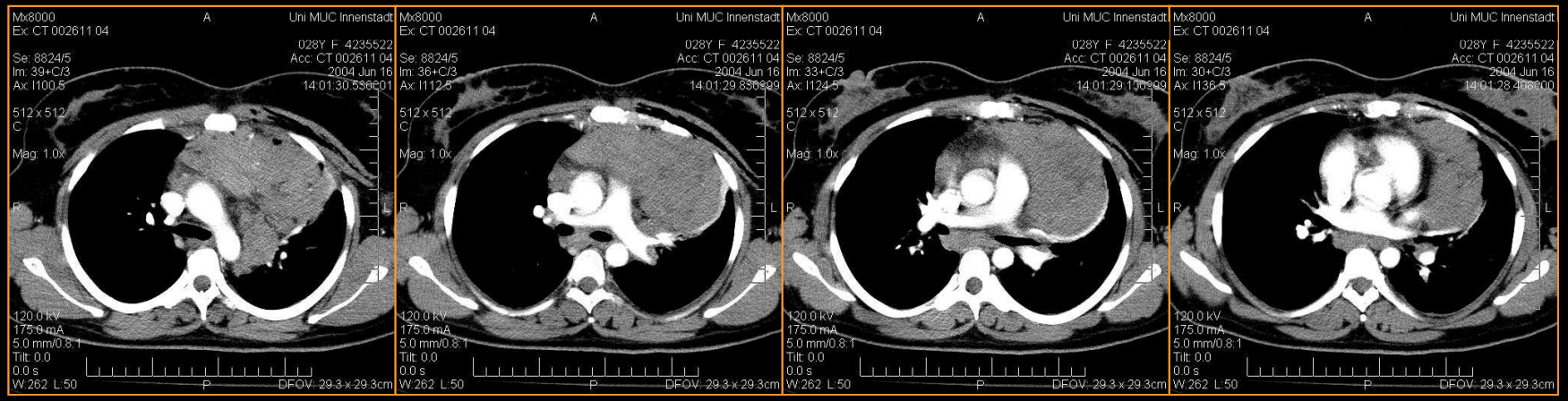
Therapie-Monitoring mit FDG PET: Morbus Hodgkin

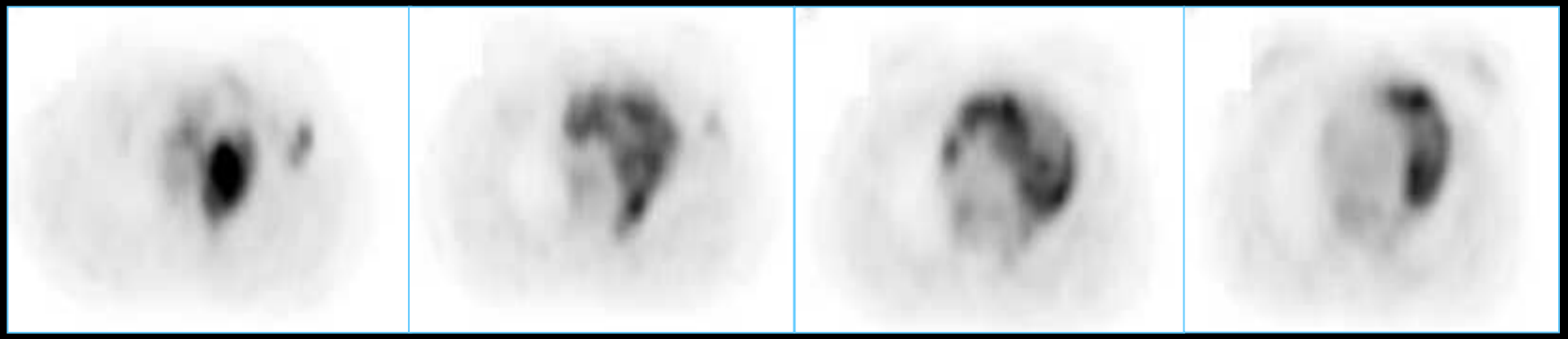
PET (F-18 FDG),
Projektionsdaten koronar

prätherapeutisch (6/04)

Therapie-Monitoring mit FDG PET: Morbus Hodgkin

CT (nach i.v.-KM-Gabe, Weichteilfenster, transversal)





PET (transversale Schnittführung

prätherapeutisch (6/04)

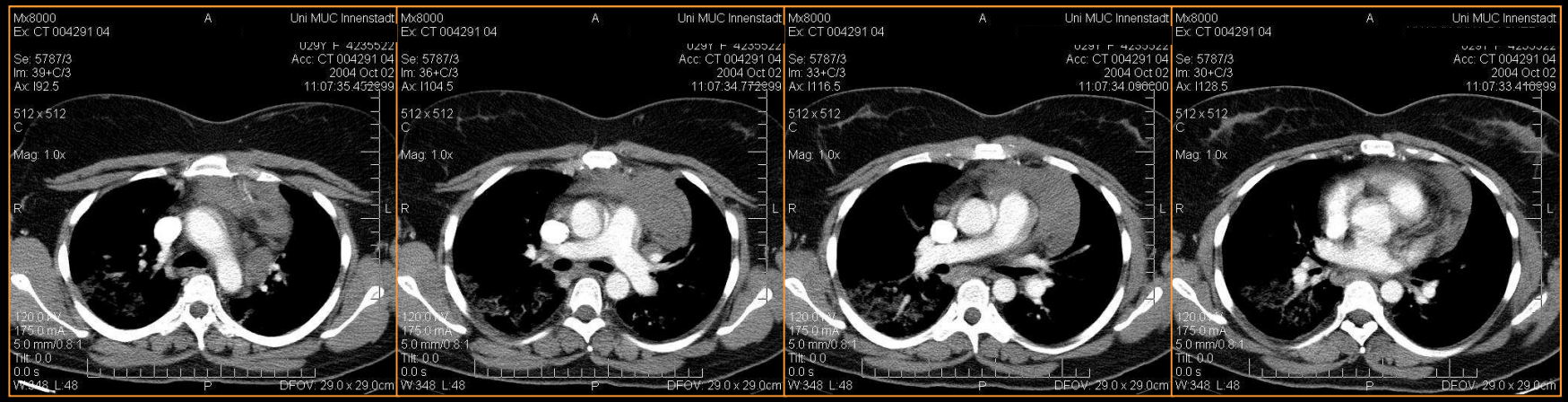
Therapie-Monitoring mit FDG PET: Morbus Hodgkin

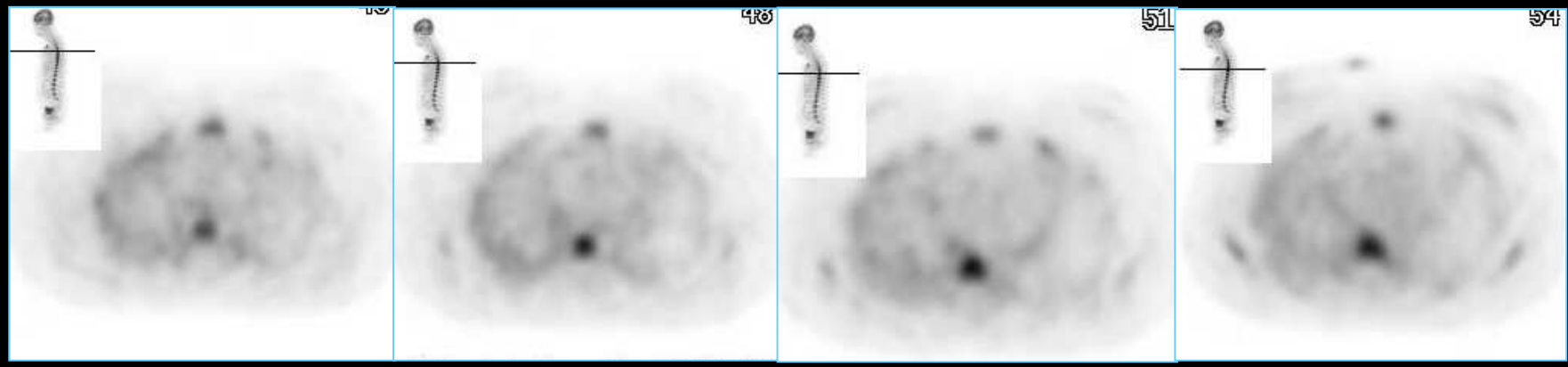
PET (F-18 FDG),
Projektionsdaten koronar

nach 4 Zyklen Chemotherapie (9/04)

Therapie-Monitoring mit FDG PET: Morbus Hodgkin

CT (nach i.v.-KM-Gabe, Weichteilfenster, transversal)

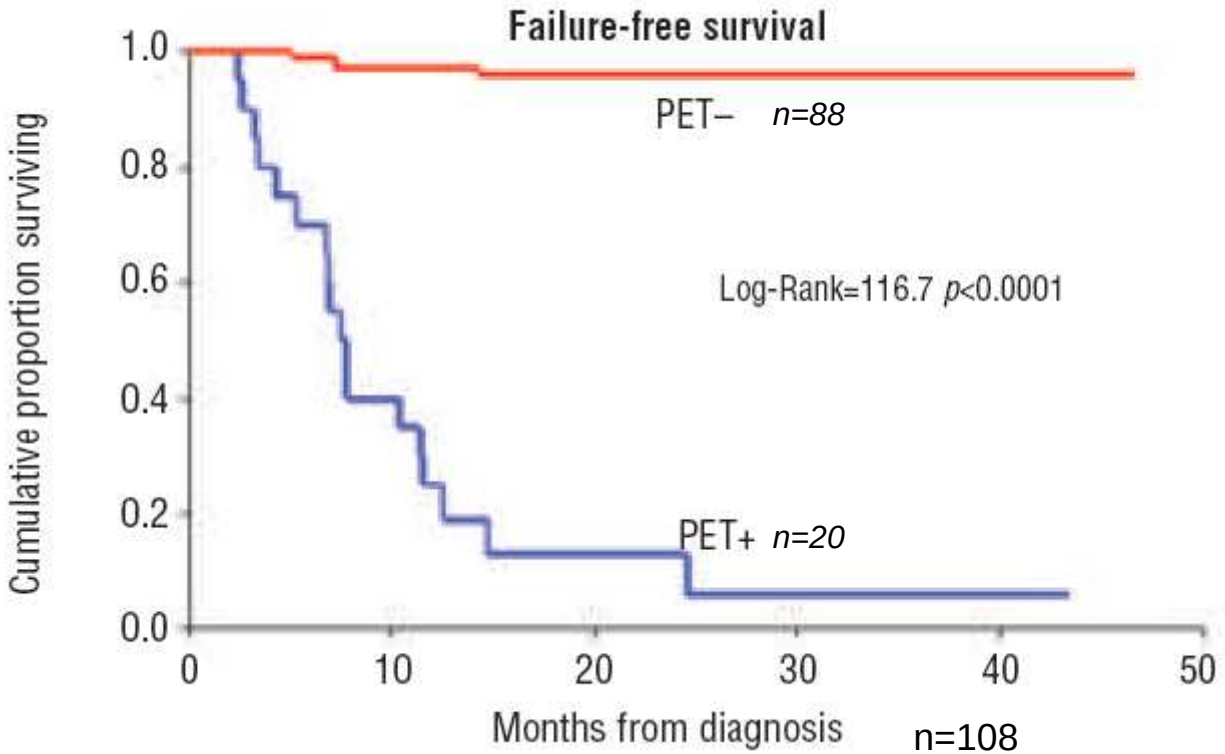




PET (transversale Schnittführung

nach 4 Zyklen Chemotherapie (9/04)

Hodgkin´s disease: prediction of recurrence-free survival with FDG-PET



n=108
stage IIa-IVb
chemotherapy 6 x ABVD
consolidation: radio therapy
therapy control following 2. cycle

Gallamini et al. Haematologica 2006

Therapie-Monitoring mit FDG PET: Gastrointestinaler Stromatumor (GIST)

A

Vor Therapie

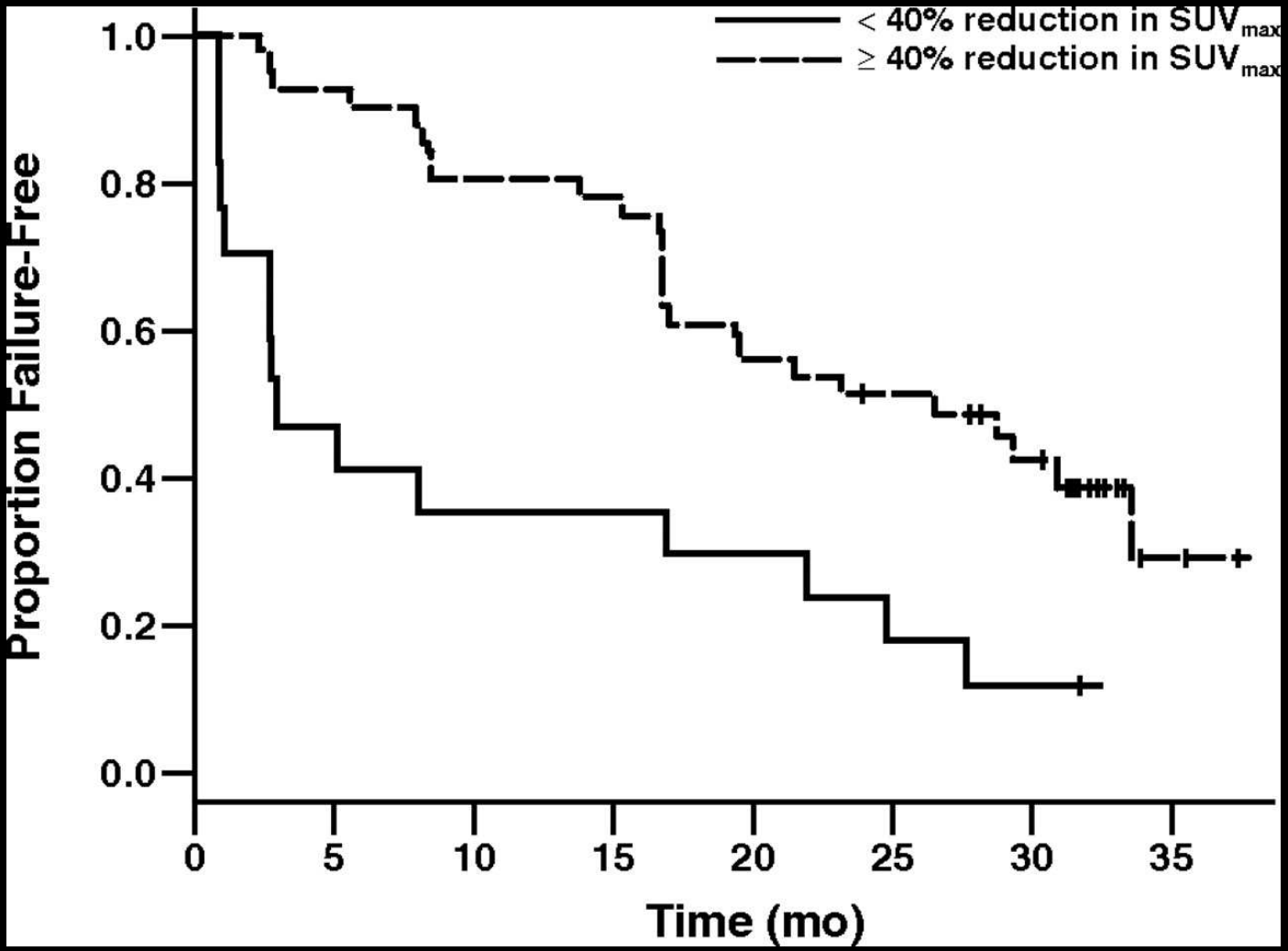
B

8 Tage nach Therapiebeginn mit Gleevec

(Tyrosinkinase-Inhibitor)

PET (F-18 FDG), Projektionsdaten koronar

Kaplan-Meier plots of population split (n = 58)



p=0.00002

South Western Oncology Group (SWOG) criteria n.s.: p=0.55

Holdsworth, C. H. et al. Am. J. Roentgenol. 2007;189:W324-W330

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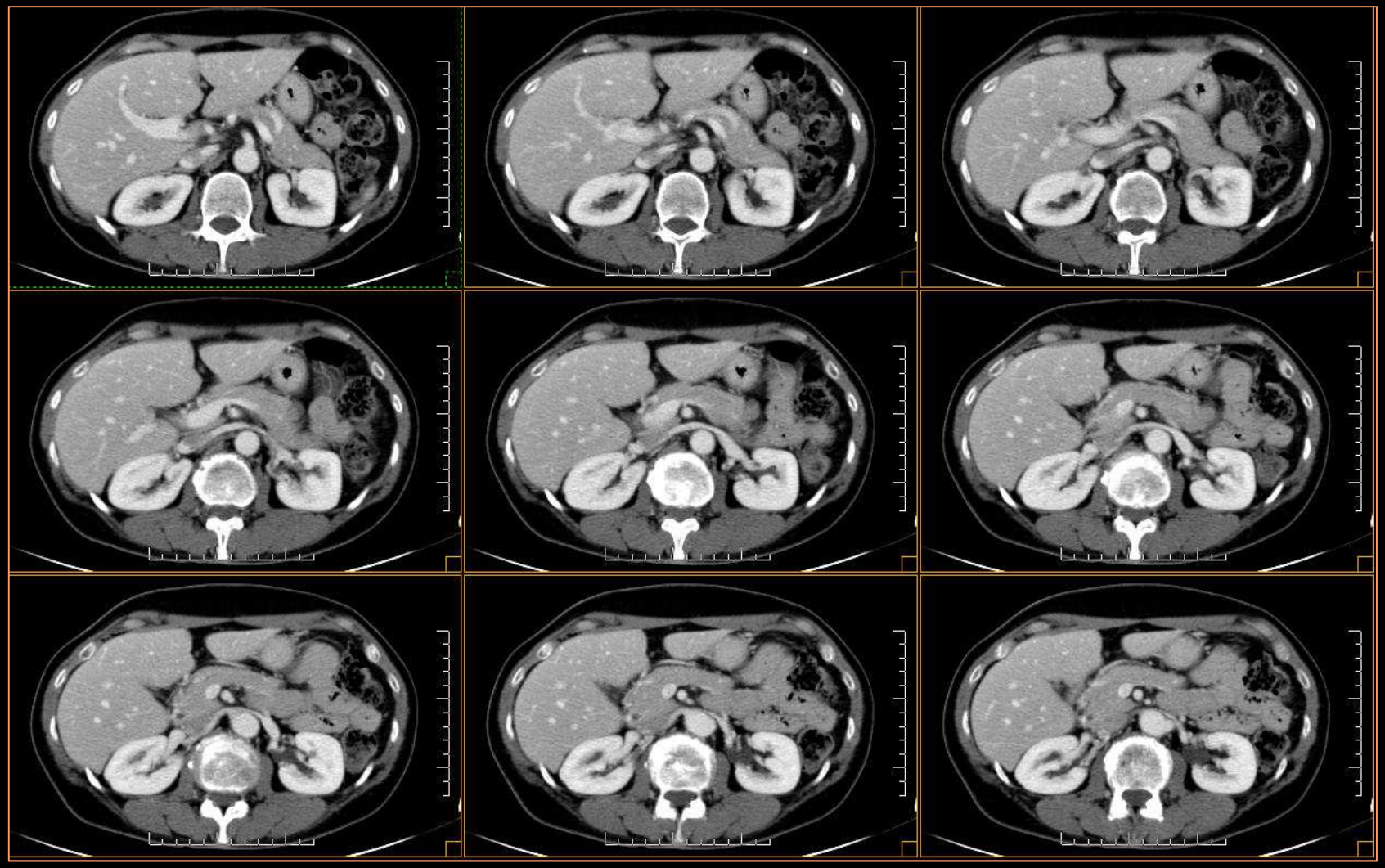
PET und PET/CT in der Onkologie

- ✓ Primärtumordiagnostik
- ✓ Staging
- ✓ Therapieplanung
- ✓ Therapiekontrolle
- • DD Narbe – Rezidiv, Restaging

Fallbeispiel

- **56-jährige Patientin**
- **Z.n. Entfernung axillärer LK-Metastasen bei Malignem Melanom unbekannter Lokalisation vor 1 Jahr**

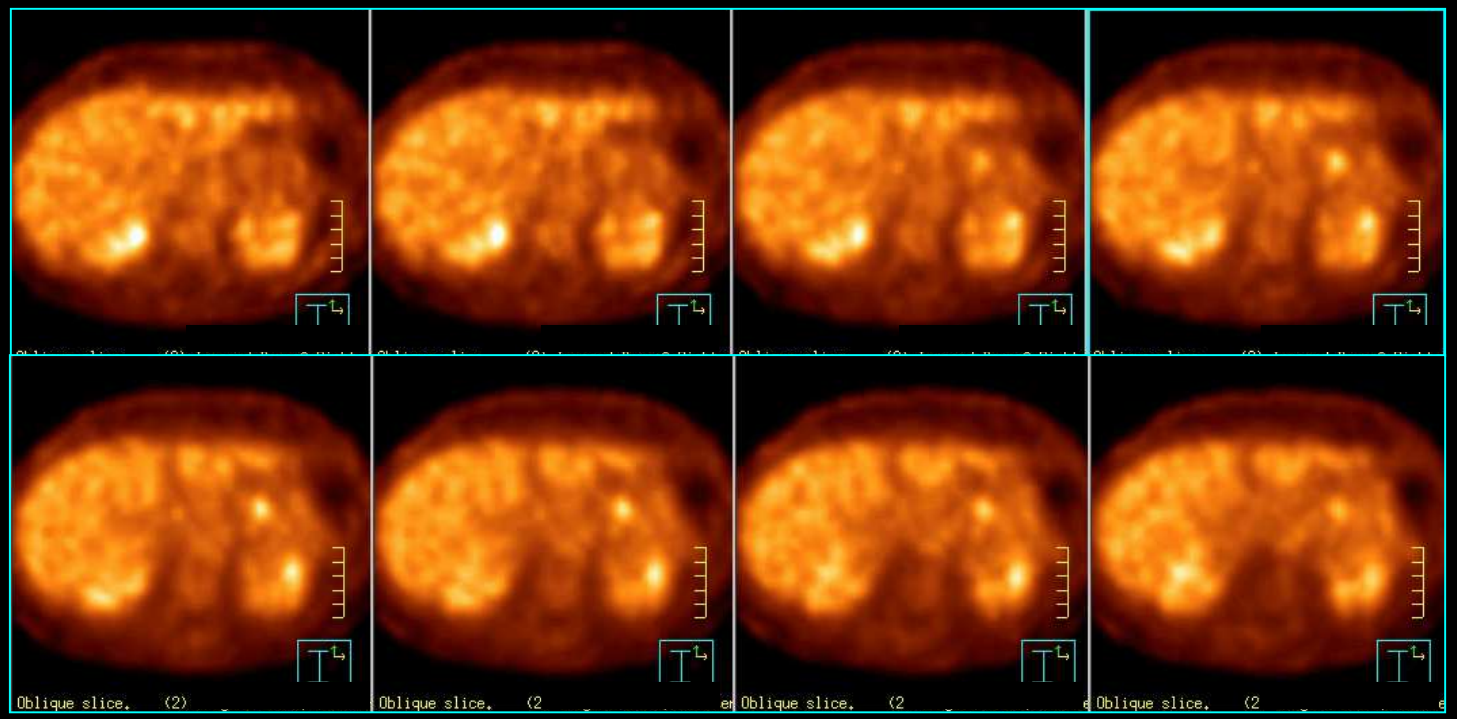
- **Z.n. Entfernung einer Dünndarmmetastase, Restaging**



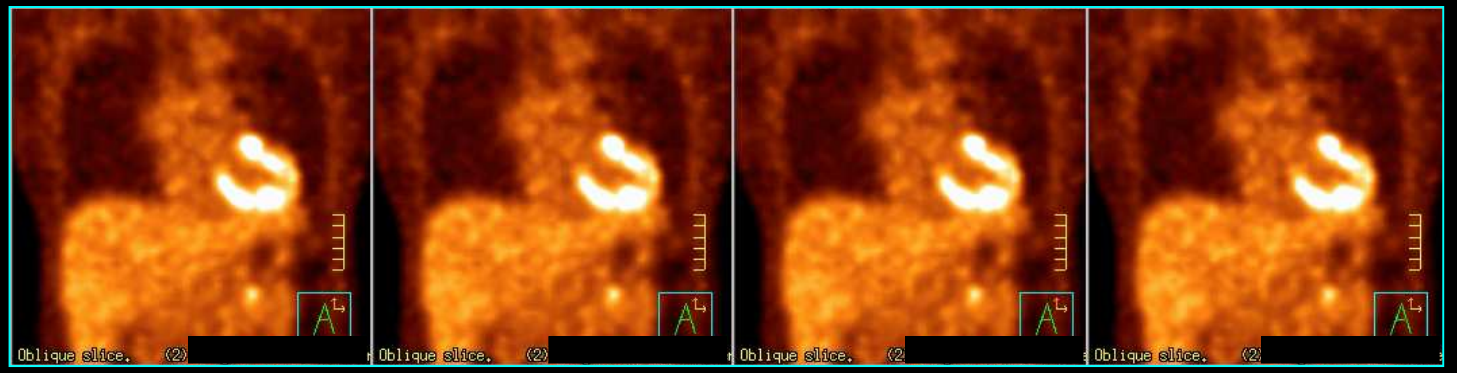
CT (nach i.v.-KM-Gabe, Weichteilfenster, transversal)

PET (F-18 FDG), Projektionsdaten koronar

PET (F-18 FDG), Schnittbilder transversal



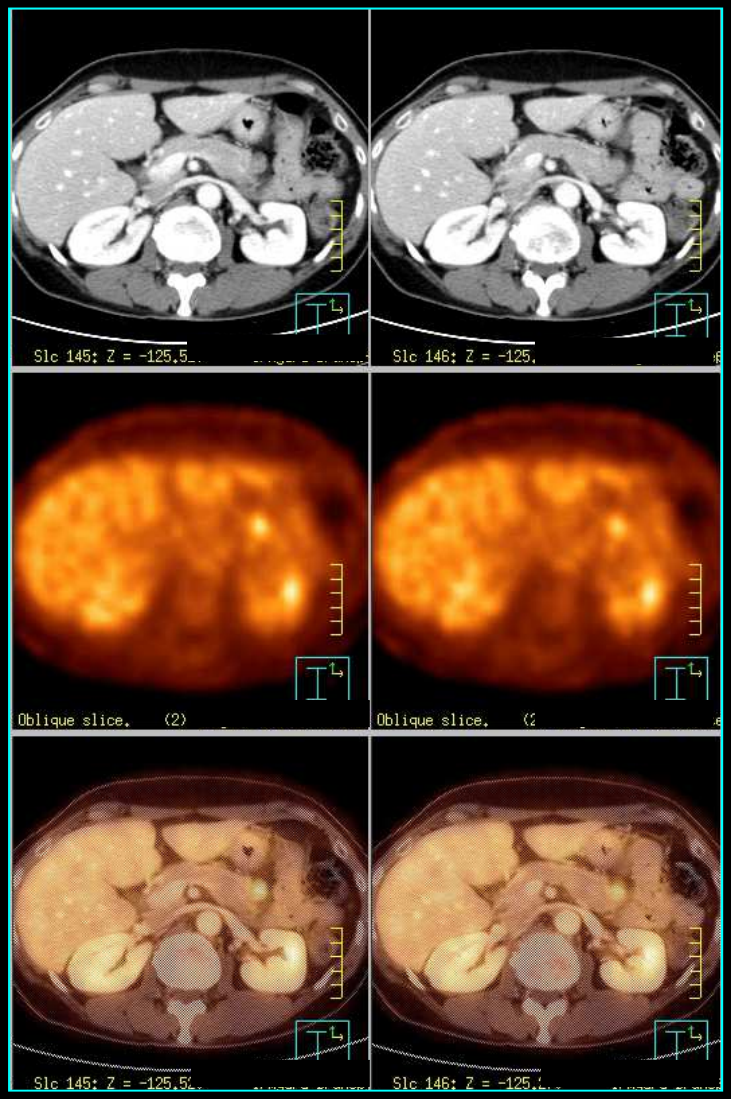
Schnittbilder koronar

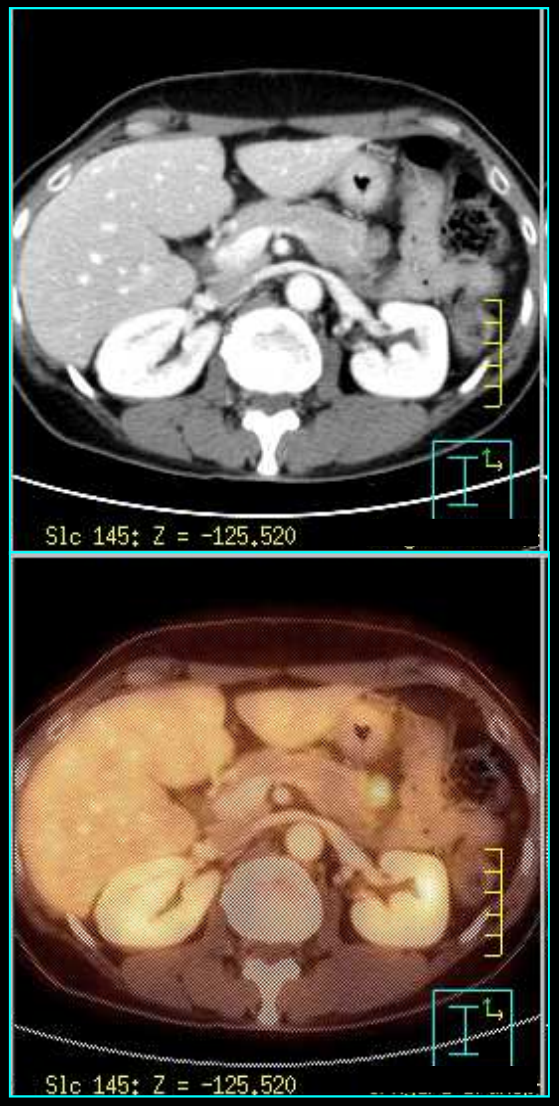


CT (Weichteilfenster)

PET

PET/CT (Fusion)





Dünndarmmetastase

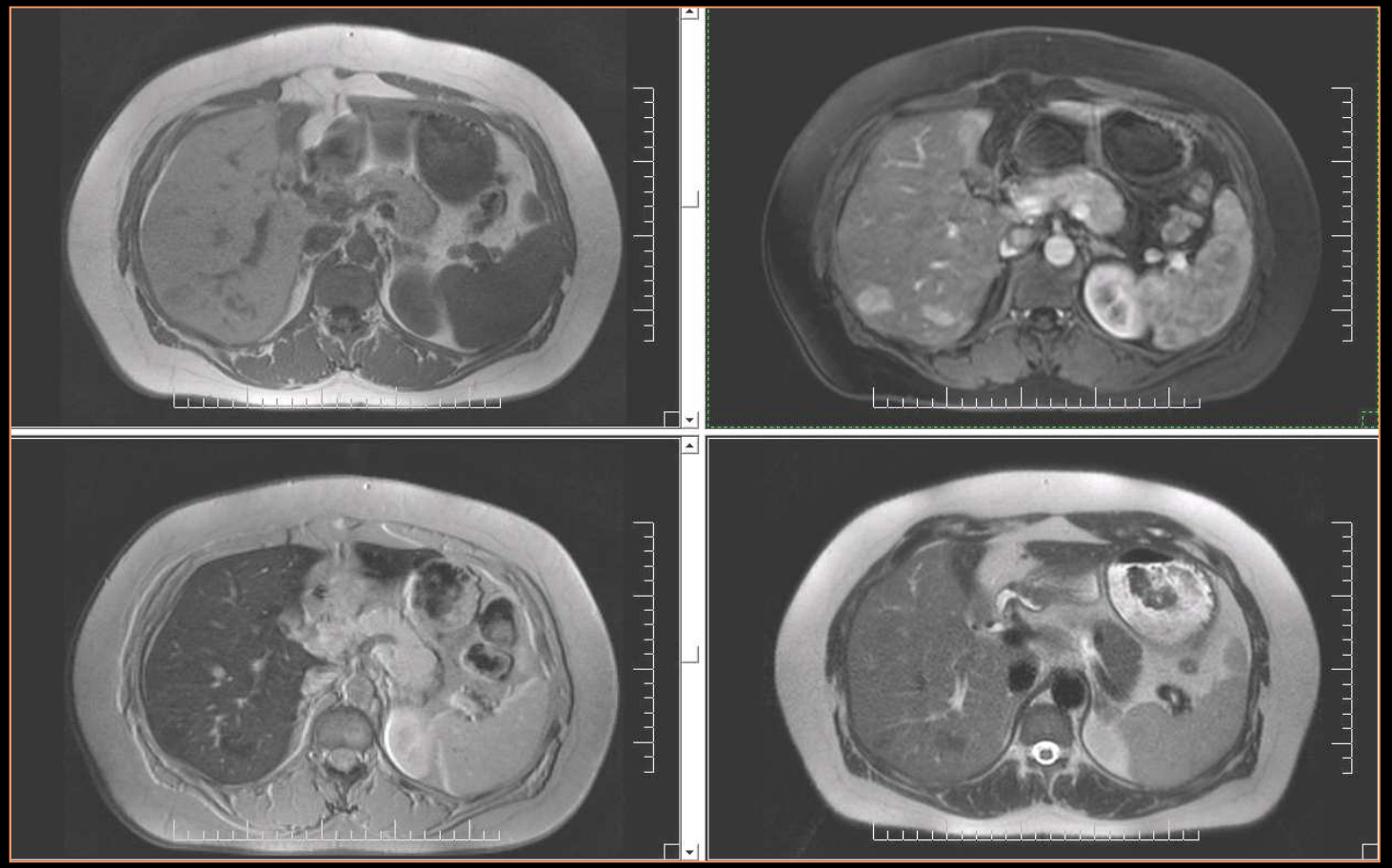
Fallbeispiel

- **38-jährige Patientin**
- **Z.n. Resektion eines Gallenblasenkarzinoms 11/03 als Zufallsbefund nach laparaskopischer Cholezystektomie**

- **Sonographisch dringender Verdacht auf Leberfiliae MRT, PET/CT zum Restaging**

MRT (T1-gewichtet)

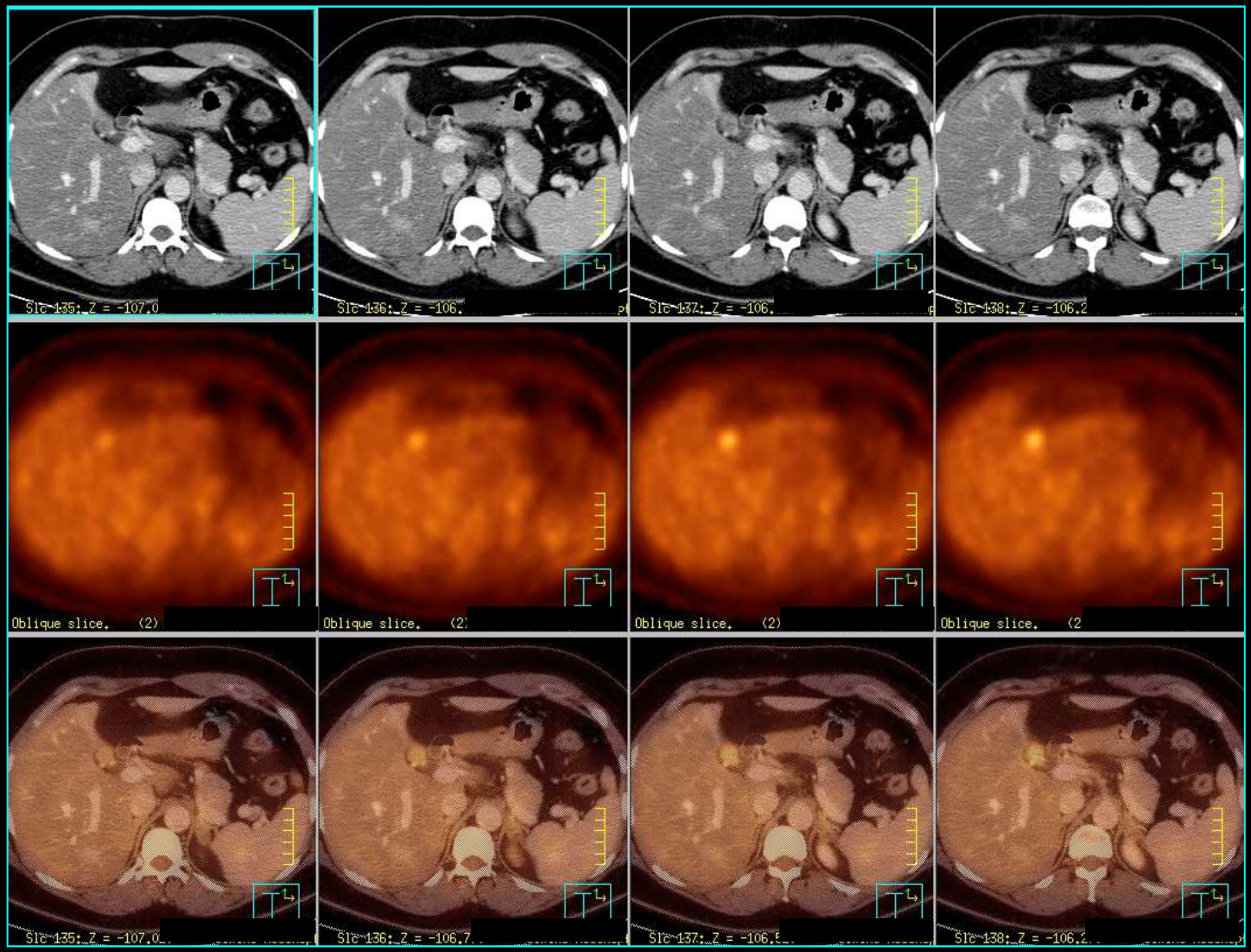
MRT (fettunterdrückt, nach KM-Gabe)



MRT (nach Gabe von Eisenoxiden)

MRT (T2-gewichtet)

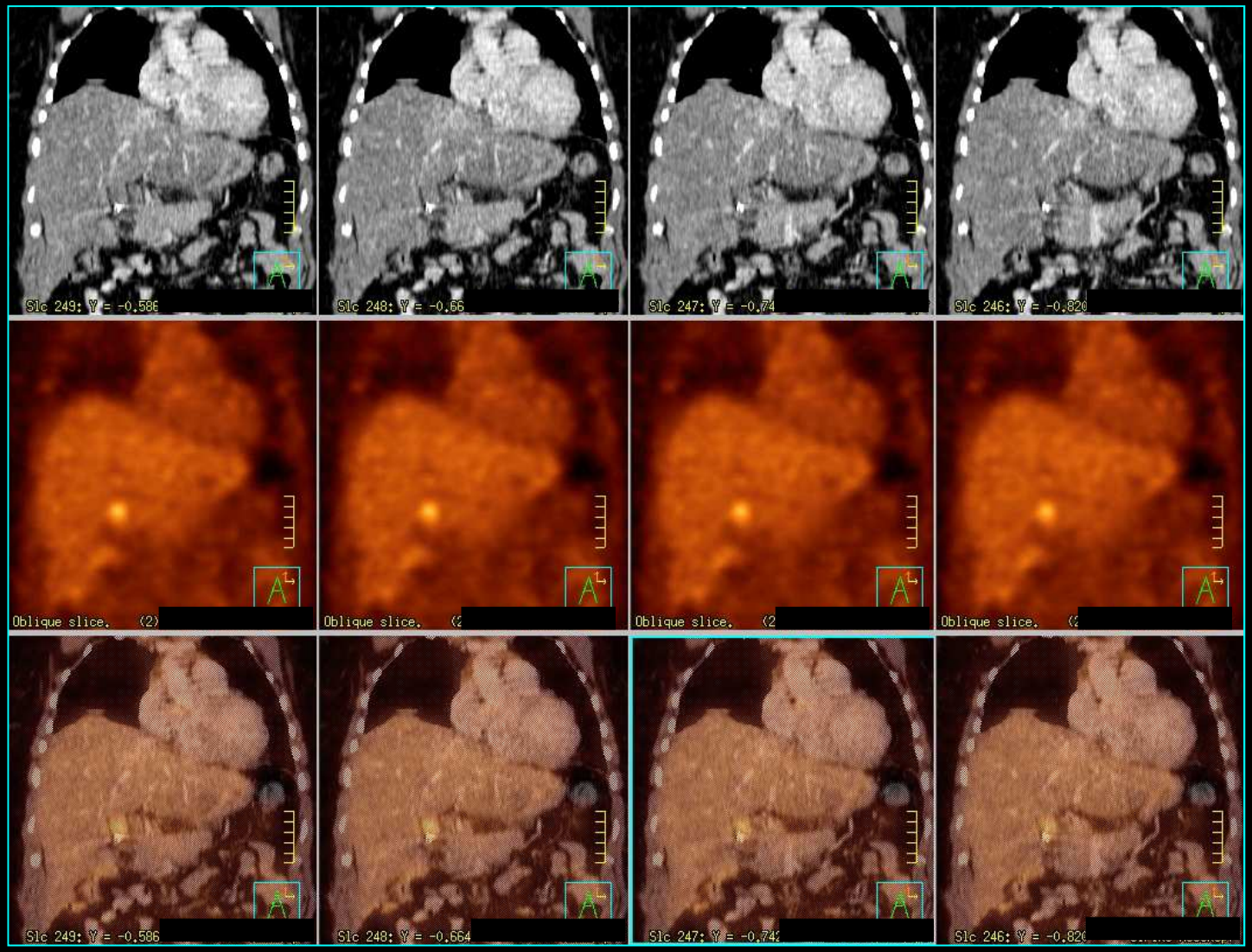
Leberadenome, keine Leberfiliae



CT (Weichteilfenster)

PET

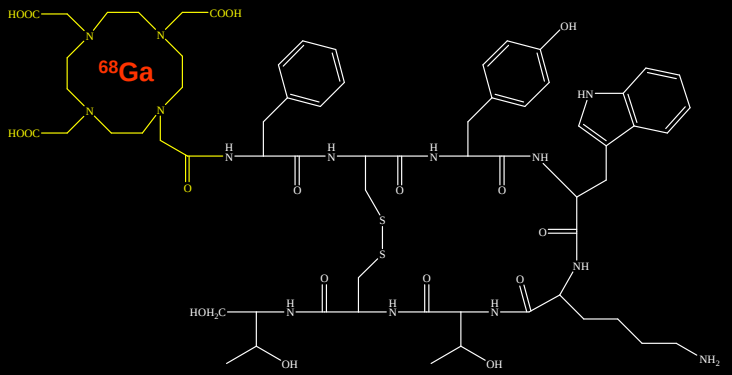
PET/CT (Fusion)



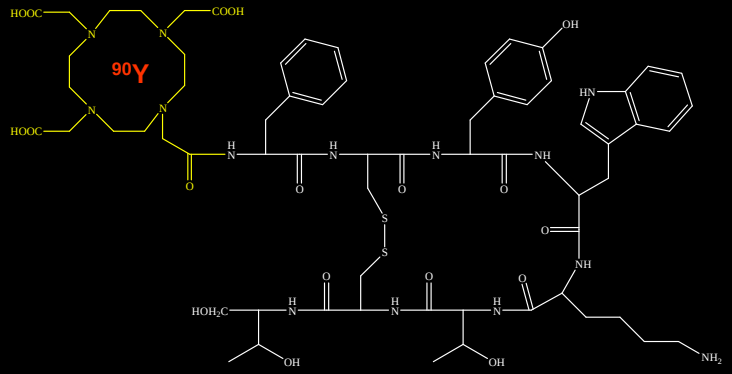
Leberadenome, zusätzlich Tumorrezidiv im Gallenblasenlager

Somatostatin-Rezeptorliganden für Therapie und Diagnostik

^{68}Ga-DOTATATE



^{90}Y-DOTATATE
^{177}Lu-DOTATATE



Andere Tracer z.B.: Neuroendokrine Tumoren

Darstellung von

- **Glukosemetabolismus:**
  - ➢ **FDG**
- **Aufnahme/Decarboxylierung von Vorläufern der biogenen Amine Dopamin/Serotonin**
  - ➢ **F-Dopa**
- **Somatostatinrezeptorbesatz**
  - ➢ [^{68}Ga]DOTA-TATE

Indikationen

- **Lokalisation von gut bis mittelgradig (Proliferationsindex Ki-67 bis 20%) differenzierten NET und deren Metastasen (Tumorsuche/Staging)**
- **Rezidivdiagnostik bei ansteigenden Tumormarkern und Therapie-monitoring**
- **Indikationsstellung und Therapie-kontrolle einer Somatostatin-Rezeptor-vermittelten Radiopeptid-therapie**

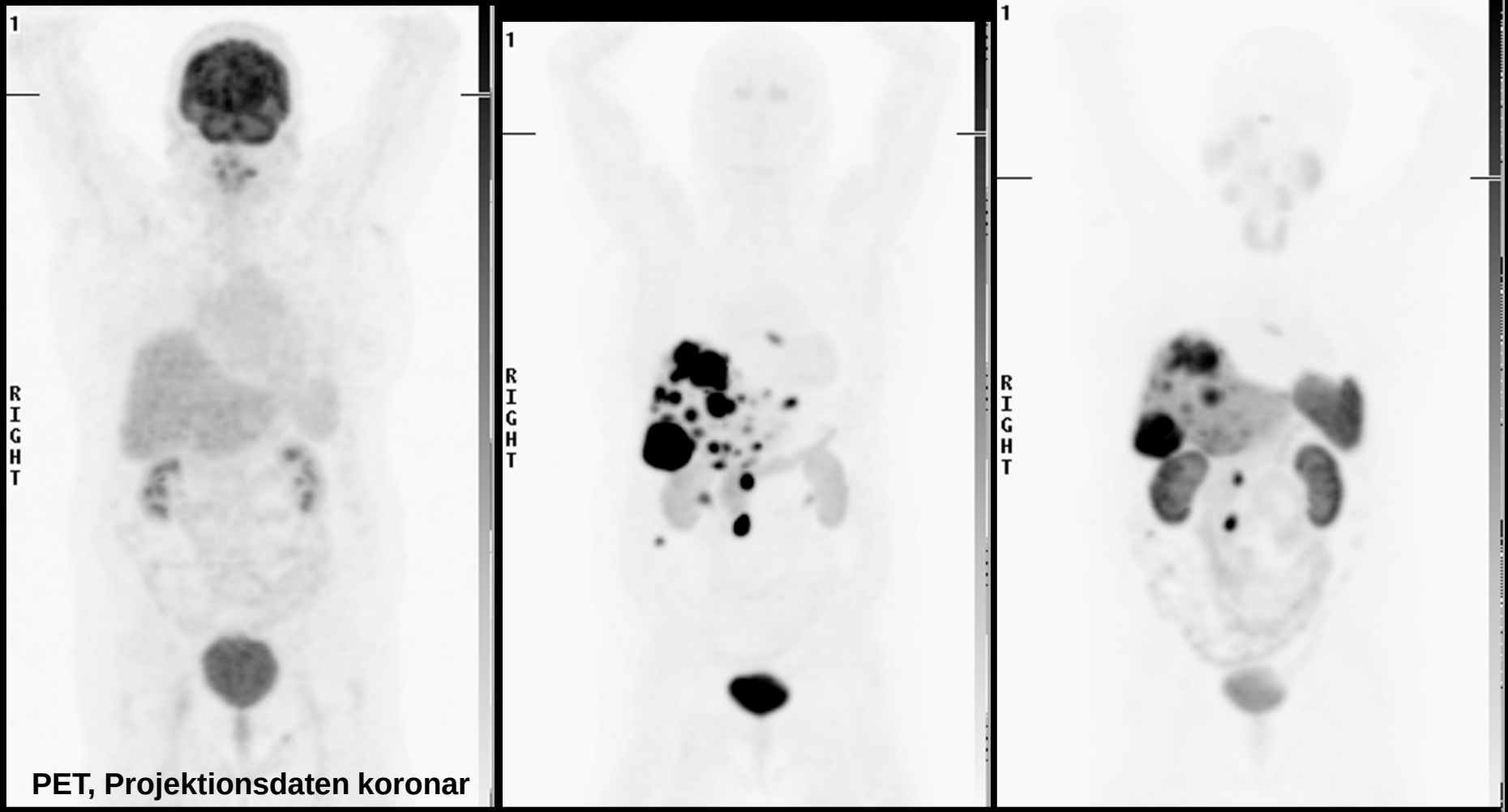
PET/CT bei NET

Welches Radiopharmakon?

FDG

F-Dopa

DOTATATE



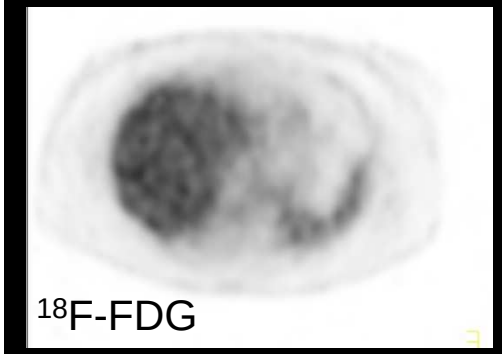
PET, Projektionsdaten koronar

55 j. Patientin Karzinoid mit Leberfiliae, Prä-SIRT

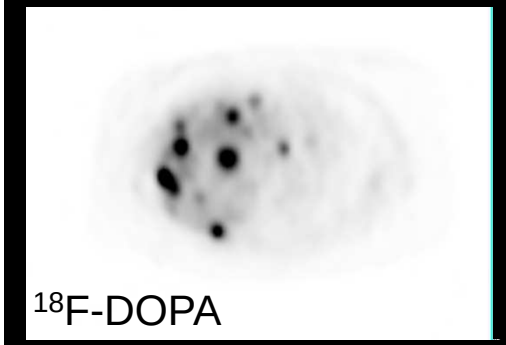
DOTA-TATE Therapie

PET/CT bei NET

Welches Radiopharmakon?

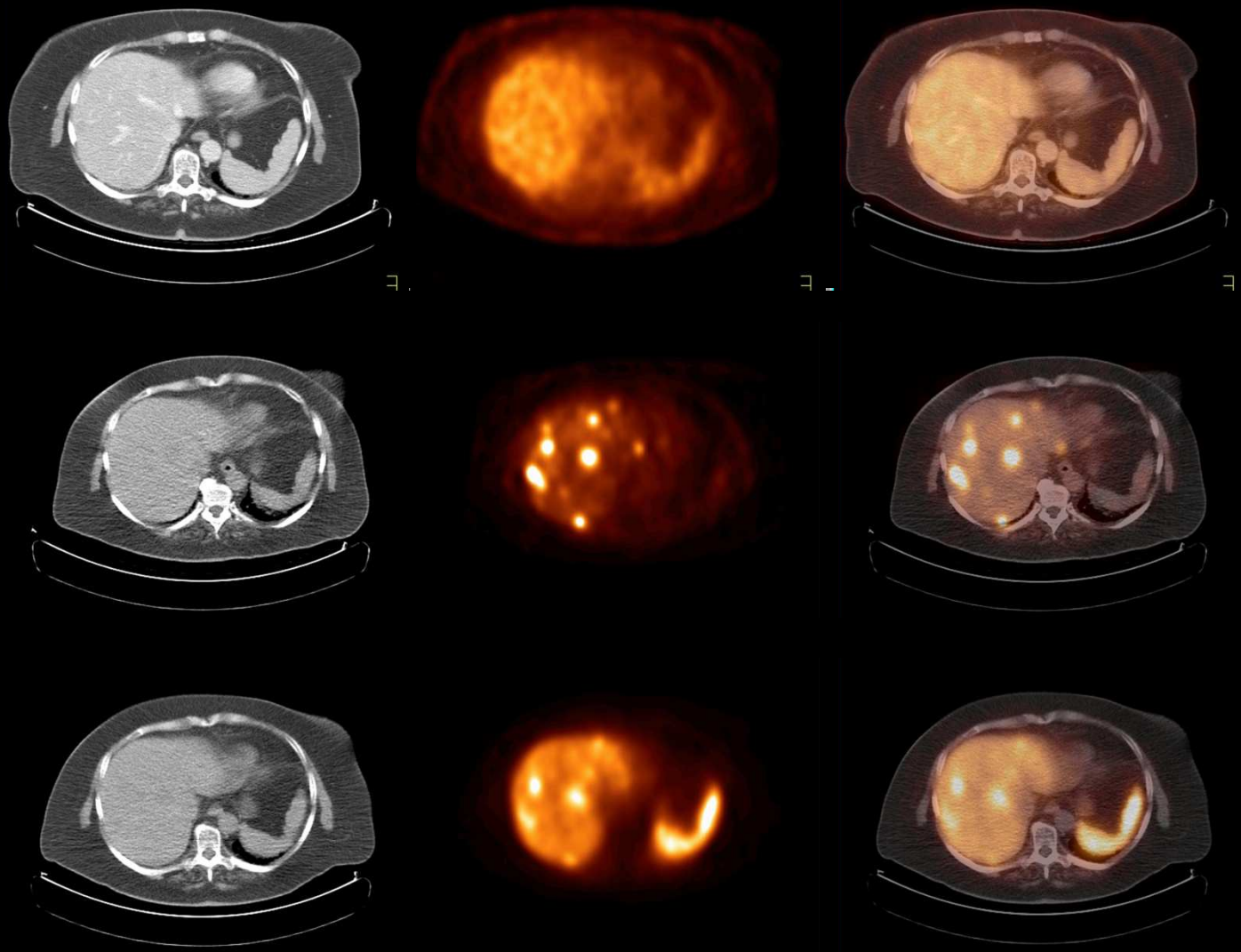


^{18}F-FDG



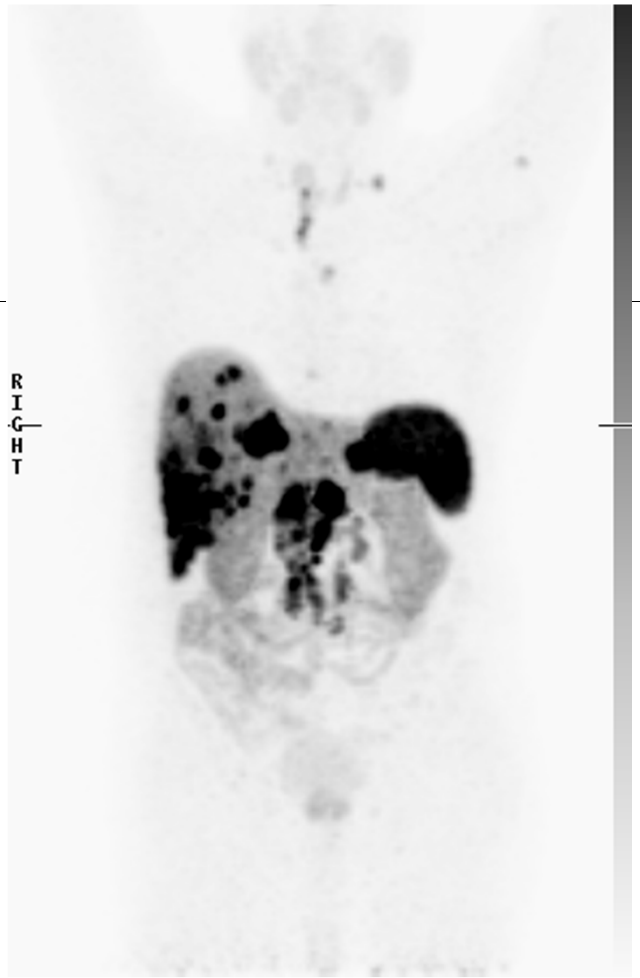
^{18}F-DOPA

^{68}Ga-DOTA-TATE



CT (Weichteilfenster) **PET** **PET/CT (Fusion)**

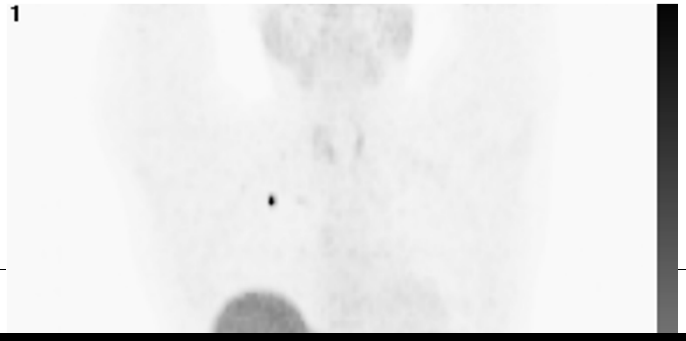
60-jähriger Patient mit NET des Pankreas

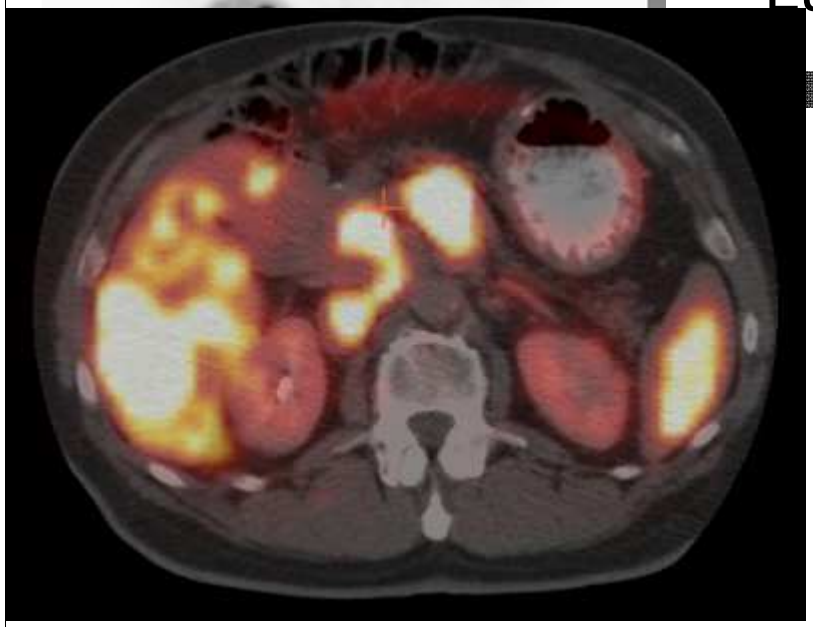


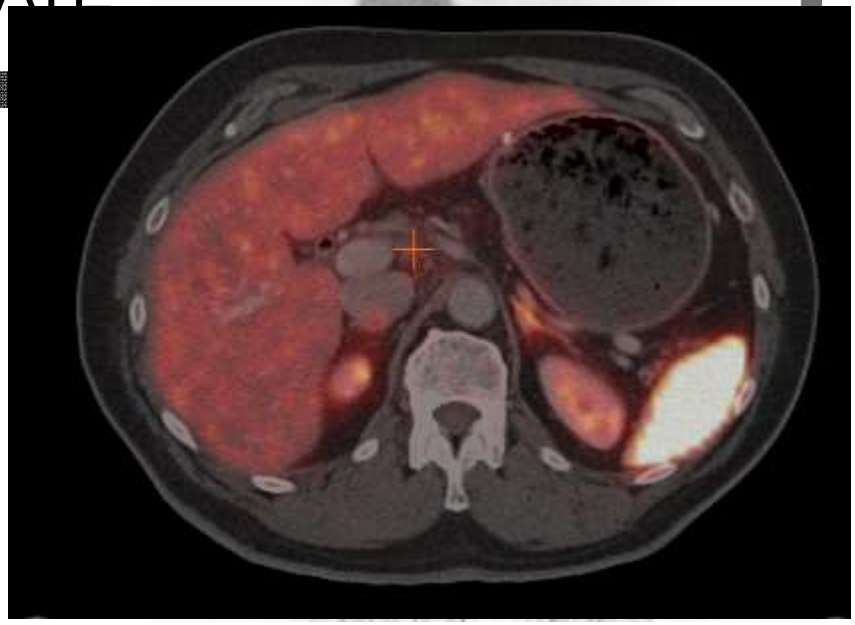
Z.n. 2 x Therapie
mit je 7400 MBq
^{177}Lu-DOTATATE

60-jähriger Patient mit NET des Pankreas

Z.n. 2 x Therapie mit je 7400 MBq ^{177}Lu-DOTATATE



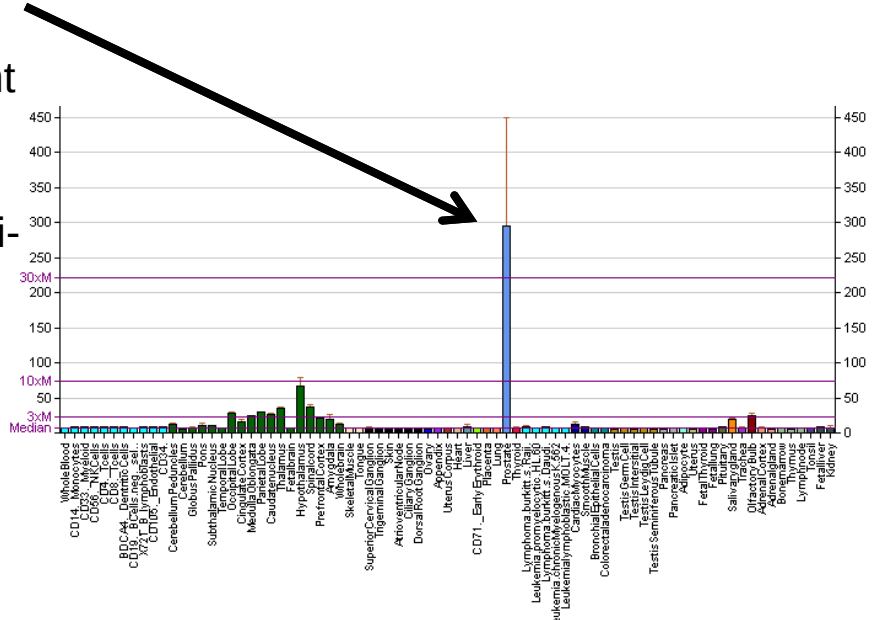




Glutamate Carboxypeptidase II (Prostate specific membrane antigen, PSMA) als Zielstruktur beim Prostatakarzinom

- Glutamate Carboxypeptidase II (GCP-II) / Folate hydrolase (FOLH1):
  - Hydrolyse mit Endprodukten: N-Acetylaspartat und Glutamat

- Expressionsprofil
  - Expression in gesunder Prostata 30-40x erhöht
  - Expression im Prostata-Ca weitere 8-12x erhöht
  - Expression korreliert pos. mit TTP und TTR*
  - In den USA zugelassende Szintigraphie mit anti-PSMA Antikörper (J591, Prostascint™)

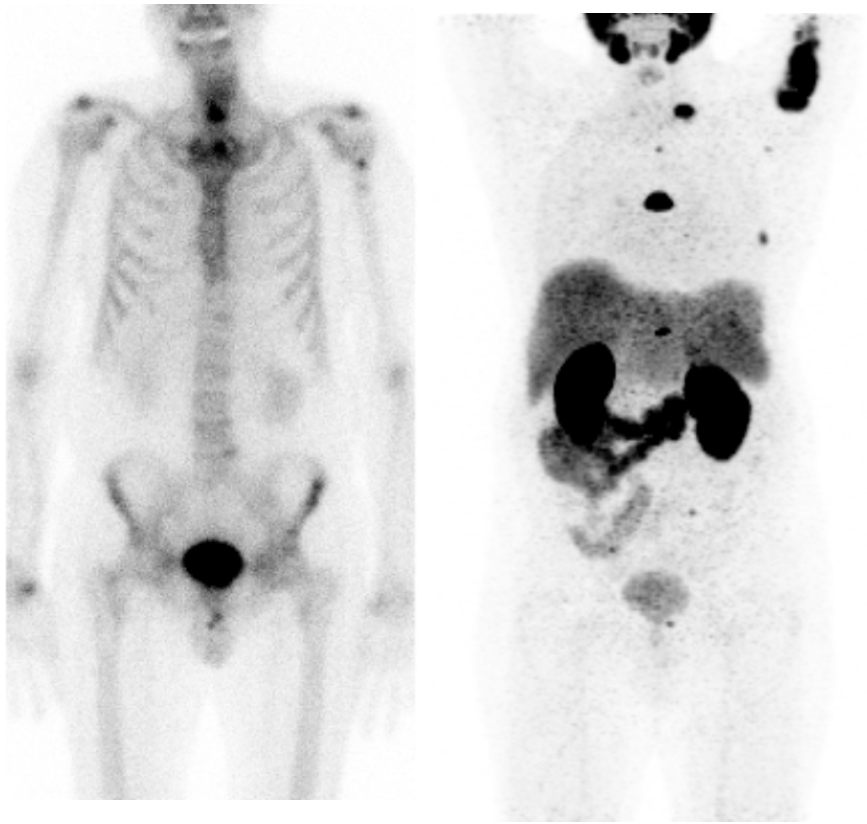


*Clin Cancer Res. 2003 Dec 15;9(17):6357-62.
Correlation of primary tumor prostate-specific membrane antigen expression with disease recurrence in prostate cancer.
Ross JS, Sheehan CE, Fisher HA, Kaufman RP Jr, Kaur P, Gray K, Webb I, Gray GS, Mosher R, Kallakury BV.

62-jähriger Patient, CRPC, PSA 412 ng/ml

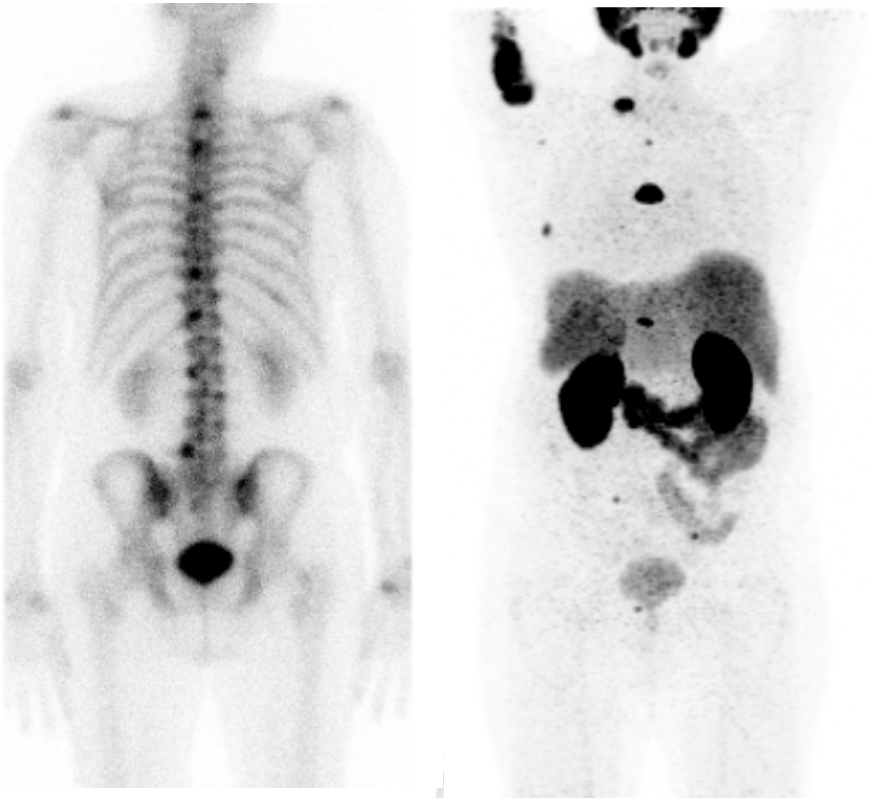
ventral

DPD Szintigraphie PSMA PET/CT

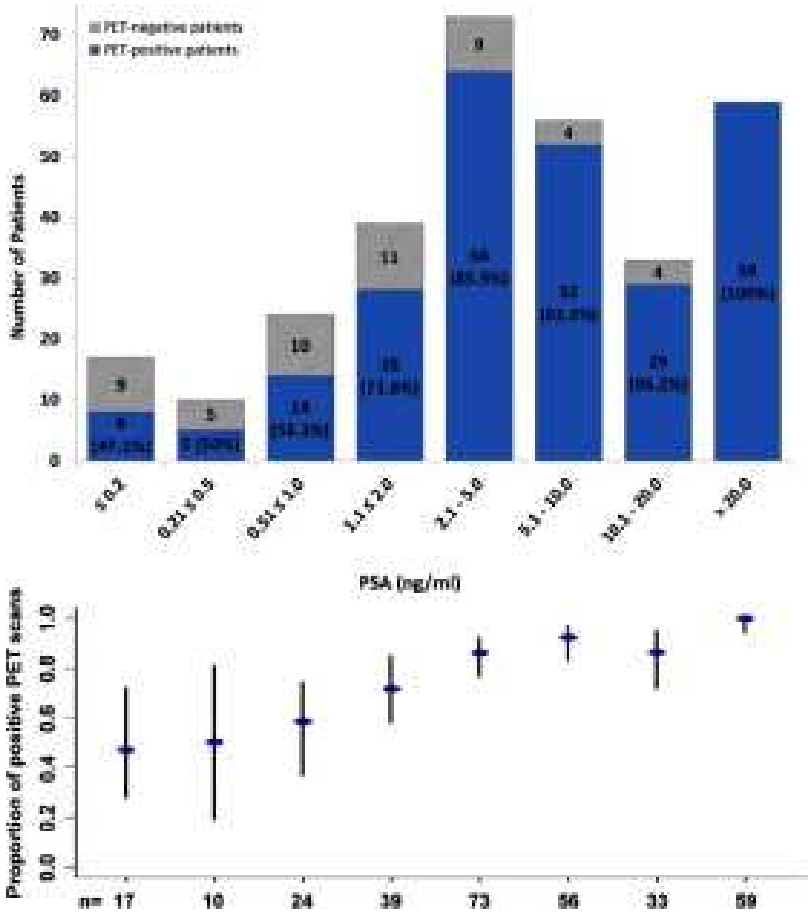


dorsal

DPD Szintigraphie PSMA PET/CT



Biochemisches Rezidiv bei Prostata-Karzinom



Afsahr-Oromieh et al. Eur J Nucl Med Mol Imaging 2015

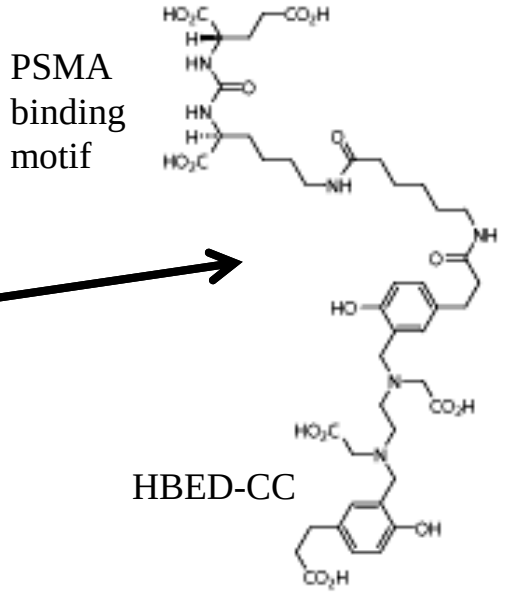
Theranostik mit PSMA Liganden

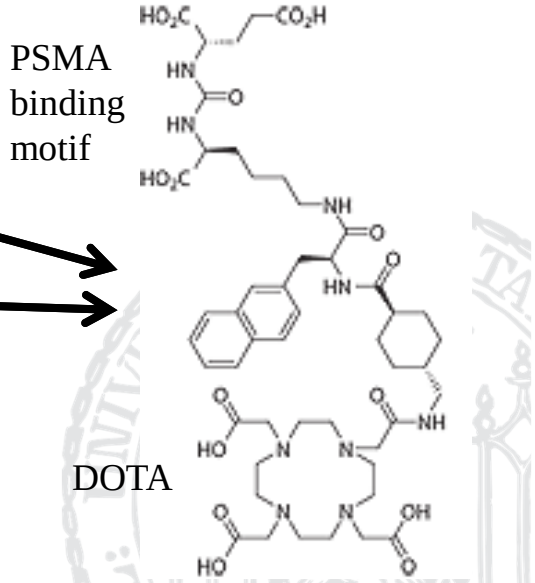
- **Eine Zielstruktur – mehrere Radionuklide**
  zur Therapie und Diagnostik

– ^{68}Ga-HBED-CC-PSMA:
  Positronen Emission (λ 68 min)

– ^{90}Y-DKFZ-PSMA-617:
  Beta Emission (λ 2.7d, 2280 keV)

– ^{177}Lu-DKFZ-PSMA-617:
  Beta Emission (λ 6.7d, 490 keV)
  Gamma Emission (3%: 113 keV, 11%: 210 keV)





Patientenbeispiel 1; 77 j

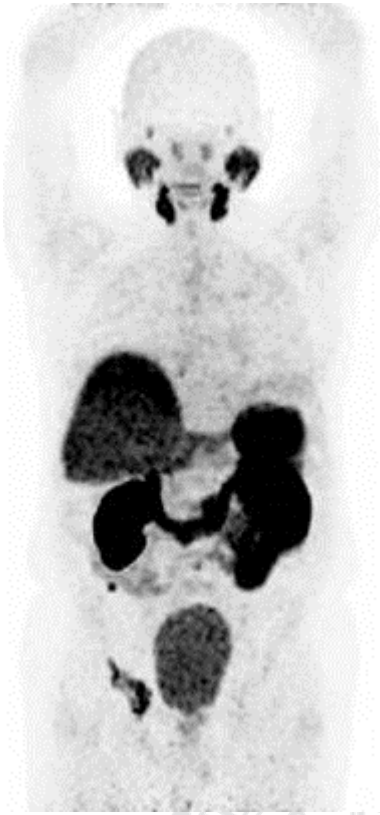
Theranostik mit ^{68}Ga-/^{177}Lu-PSMA Liganden

Vor PSMA-Therapie 08/15

PSA : 453 ng/ml

nach 2 Zyklen PSMA 02/16

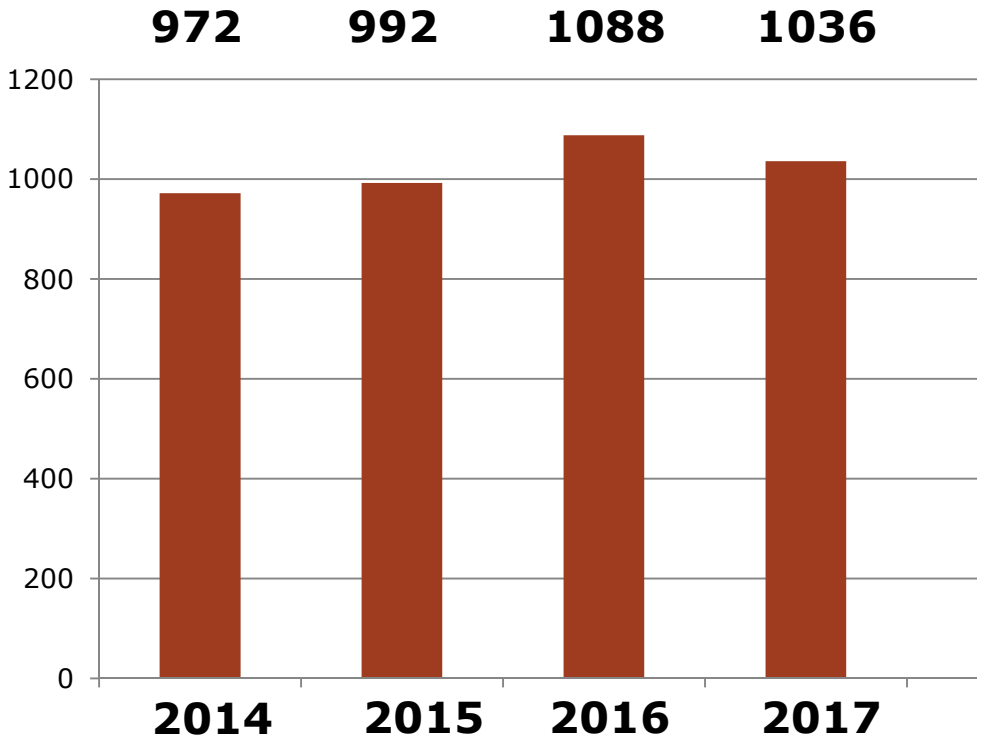
PSA : 1,77 ng/ml



Nach 4 Zyklen PSMA 07/16

PSA : 0,85 ng/ml

Endoradiotherapies
LMU Dept of Nuclear Medicine



Total number of therapies on the ward *(in-patients)*

2017: Non thyroid-therapies= 36 %

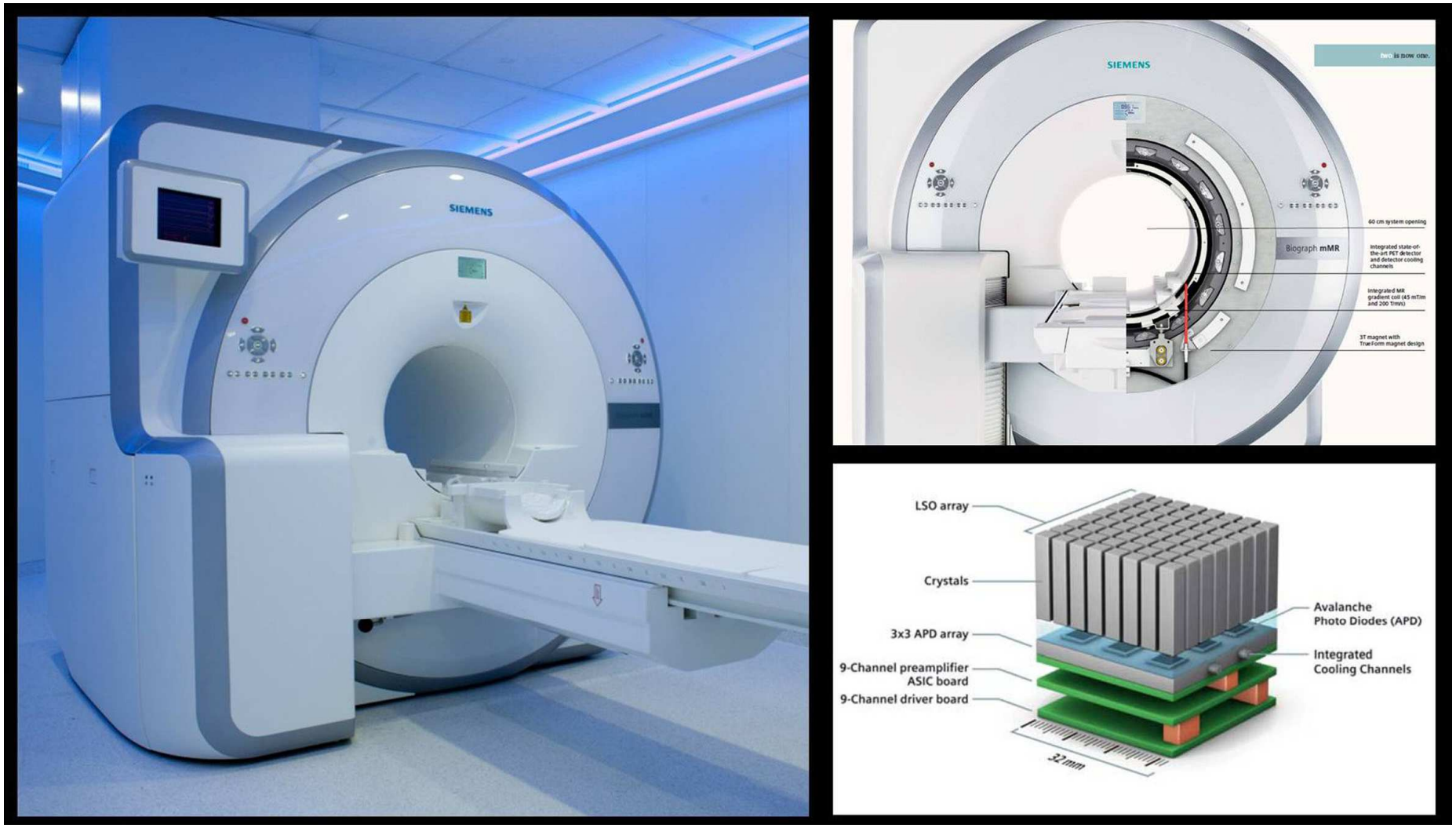
PSMA = 80 (7,7%)
DOTATATE = 140 (13,5%)
SIRT = 153 (14,7%)

Zusammenfassung: Vorteile PET/CT

- **Eine Anmeldung, eine Untersuchung, ein Befund, eine Rückfrage, eine Befund-demonstration**
- **Zeitersparnis für Patient und befundende Ärzte**
- **Verkürzung der Liegedauer (>> DRG)**
- **Der Kliniker versteht den Vorteil der multimodalen Bilddiagnostik**

➢ **Verbesserung von Sensitivität und Spezifität in der onkologischen Diagnostik**

Ganzkörper **MR/PET**



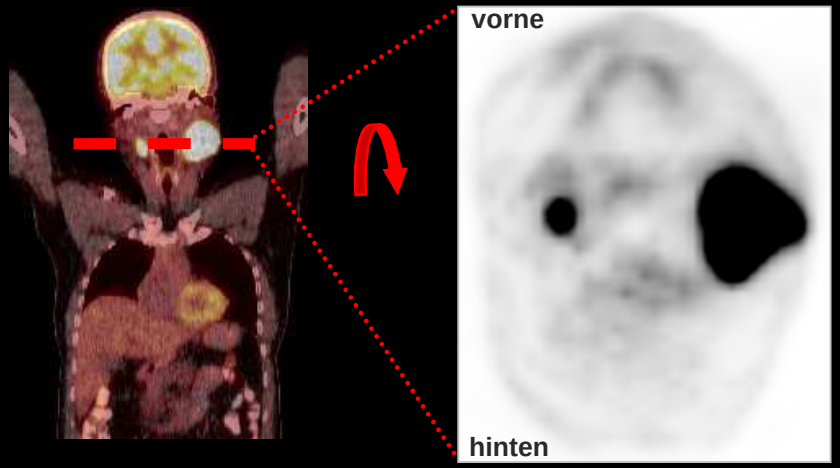
(Siemens Biograph mMR)

seit 11/2010 am Klinikum rechts der Isar der Technischen Universität München

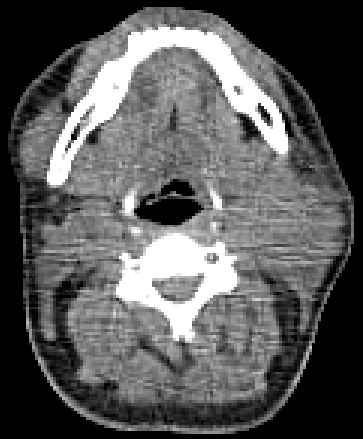
PET-MR versus PET/CT bei Halslymphom

A) Konventionelles PET/CT:

FDG-PET (Metabolismus)



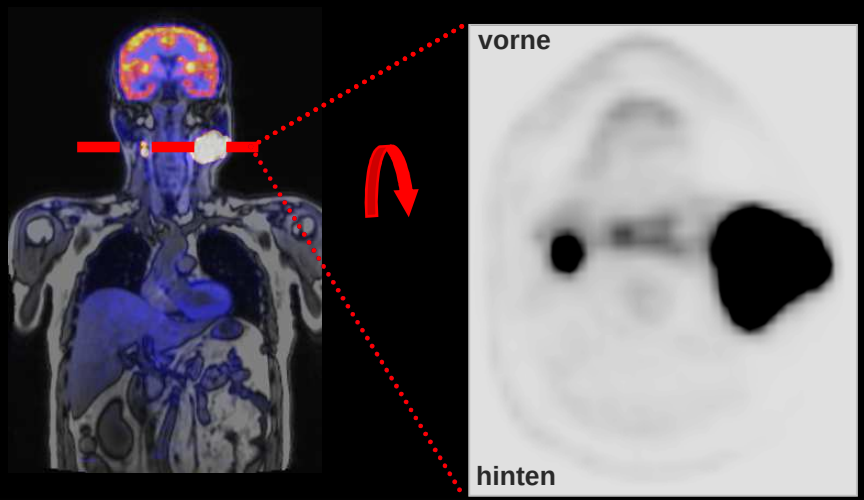
CT
(low dose)



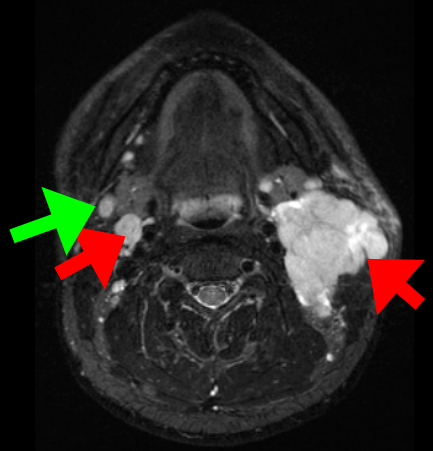
Fusion
FDG-PET & CT

B) PET-MR:

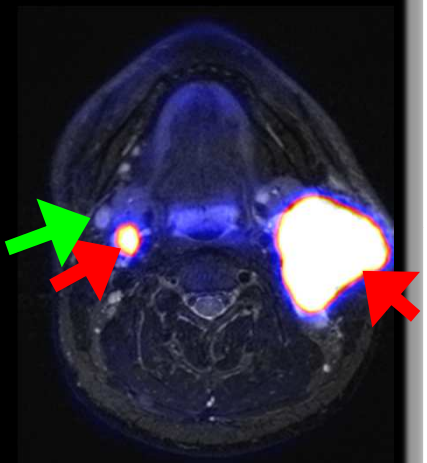
FDG-PET (Metabolismus)



MRI
(Struktur)



Fusion
FDG-PET & MR



Vielen Dank für Ihre Aufmerksamkeit

Team der Klinik und Poliklinik für Nuklearmedizin