

A Lightweight and Portable Communication Framework for Multimodal Image-Guided Therapy

A. Schoch, **Bernhard Fuerst**, F. Achilles, S. Demirci and N. Navab

Computer Aided Medical Procedures,
Technische Universität München, Germany



Introduction to EndoTOFPET-US

- Applications
 - Image-guided diagnosis, and
 - Minimally invasive surgery
- Motivation
 - Low sensitivity of PET for pancreatic tumors
 - Unspecific tumor markers for prostatic tumors

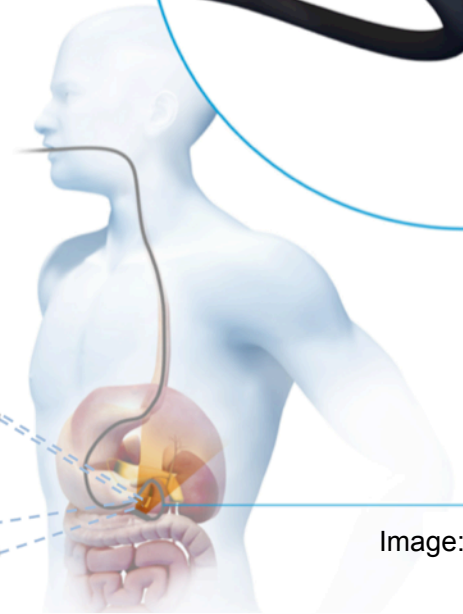
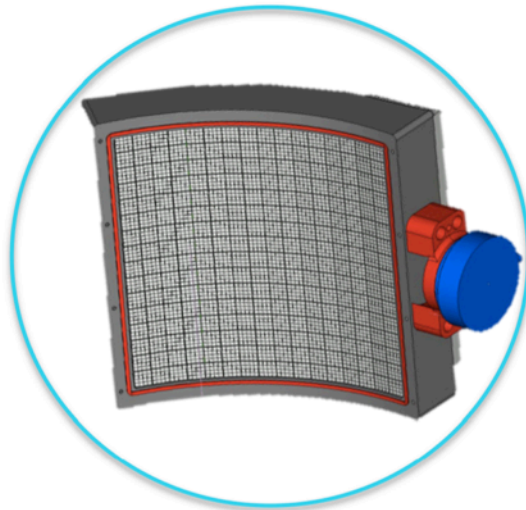
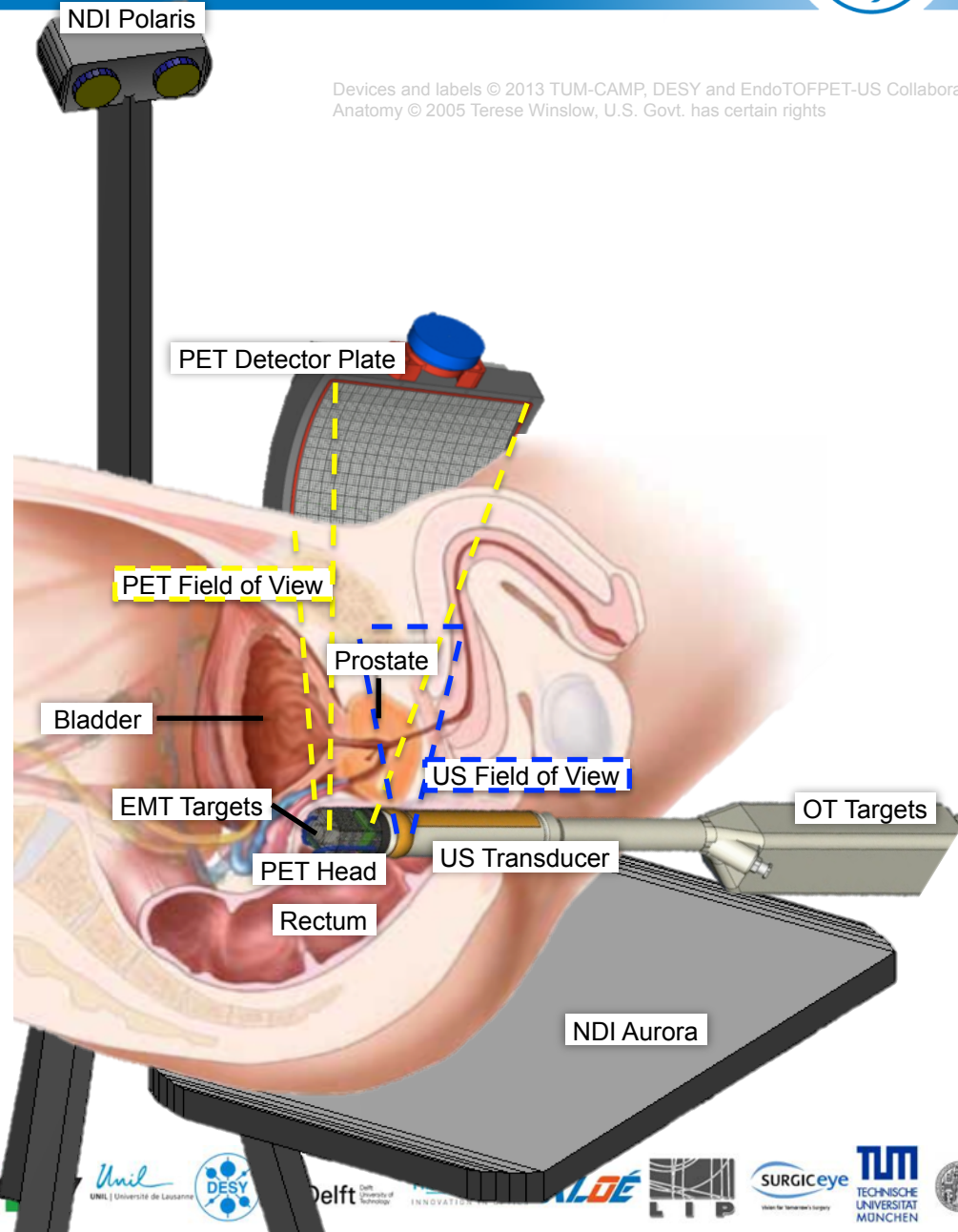
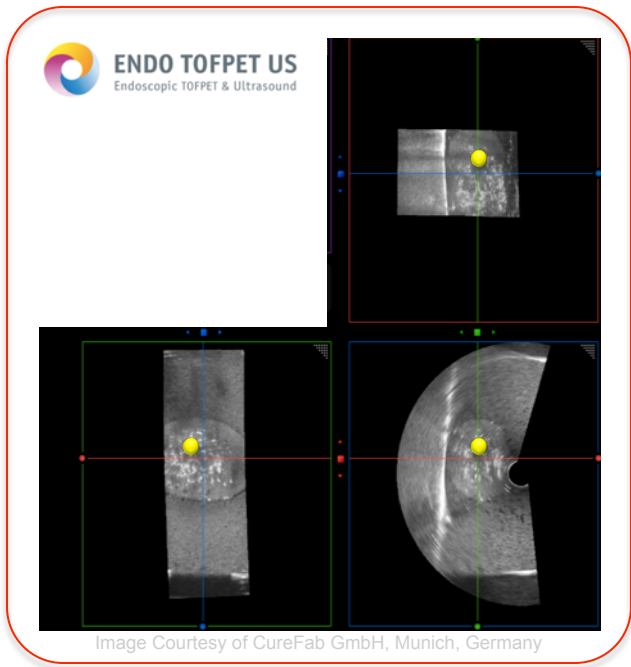


Image: DESY

EndoTOFPET-US Device Setup

Devices and labels © 2013 TUM-CAMP, DESY and EndoTOFPET-US Collaboration.
Anatomy © 2005 Terese Winslow, U.S. Govt. has certain rights



PET head mechanical design

K. Gadow
(DESY)

Cables soldering point
0.4mm/
cable

FPGA

r/o PCB
14x16x1
mm

Free space for bonding wires

SPAD PCB 15x20x1 mm

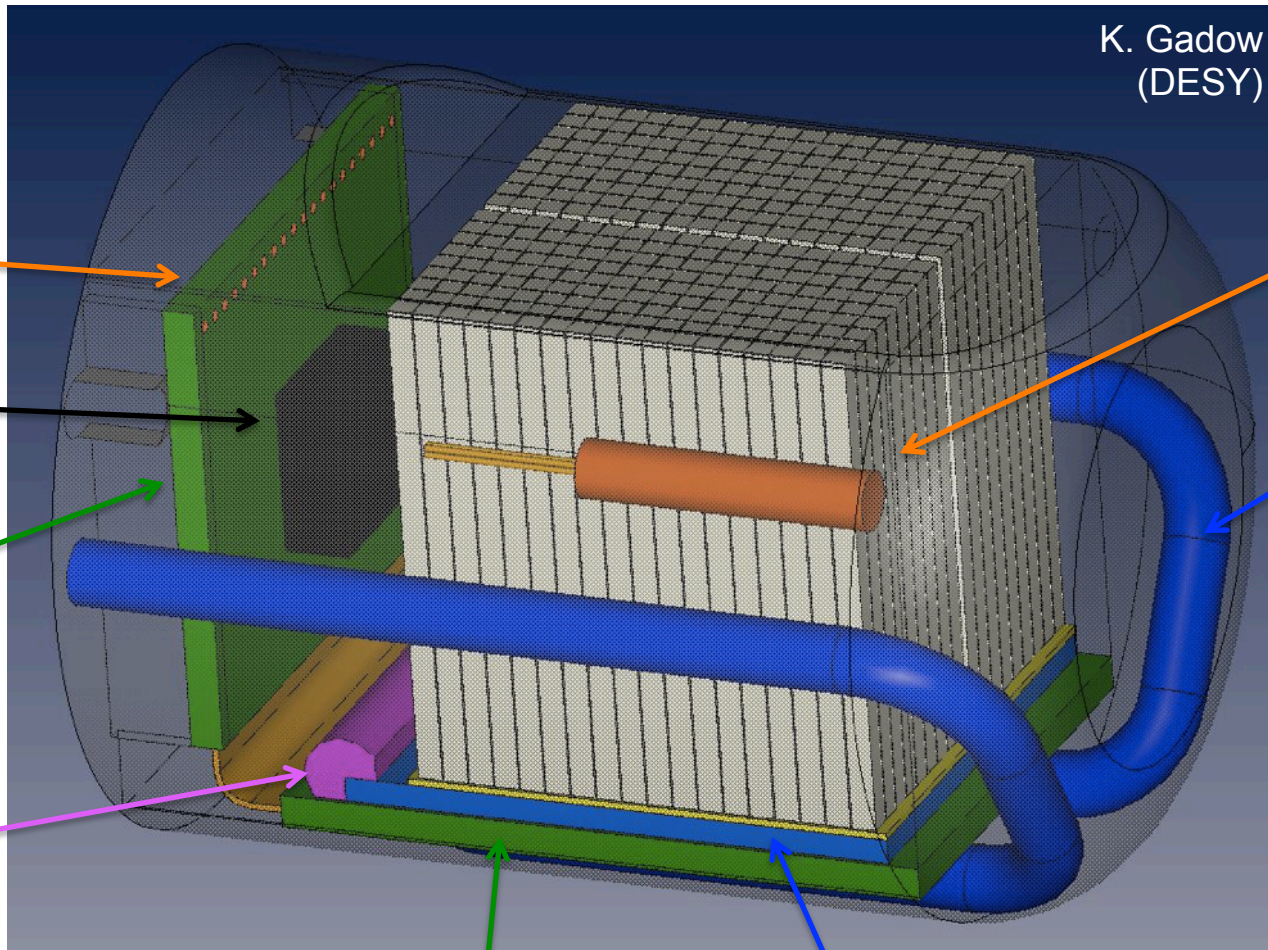
Interconnected via 3.5 mm long flex (bending radius 0.9 mm)

SPAD array

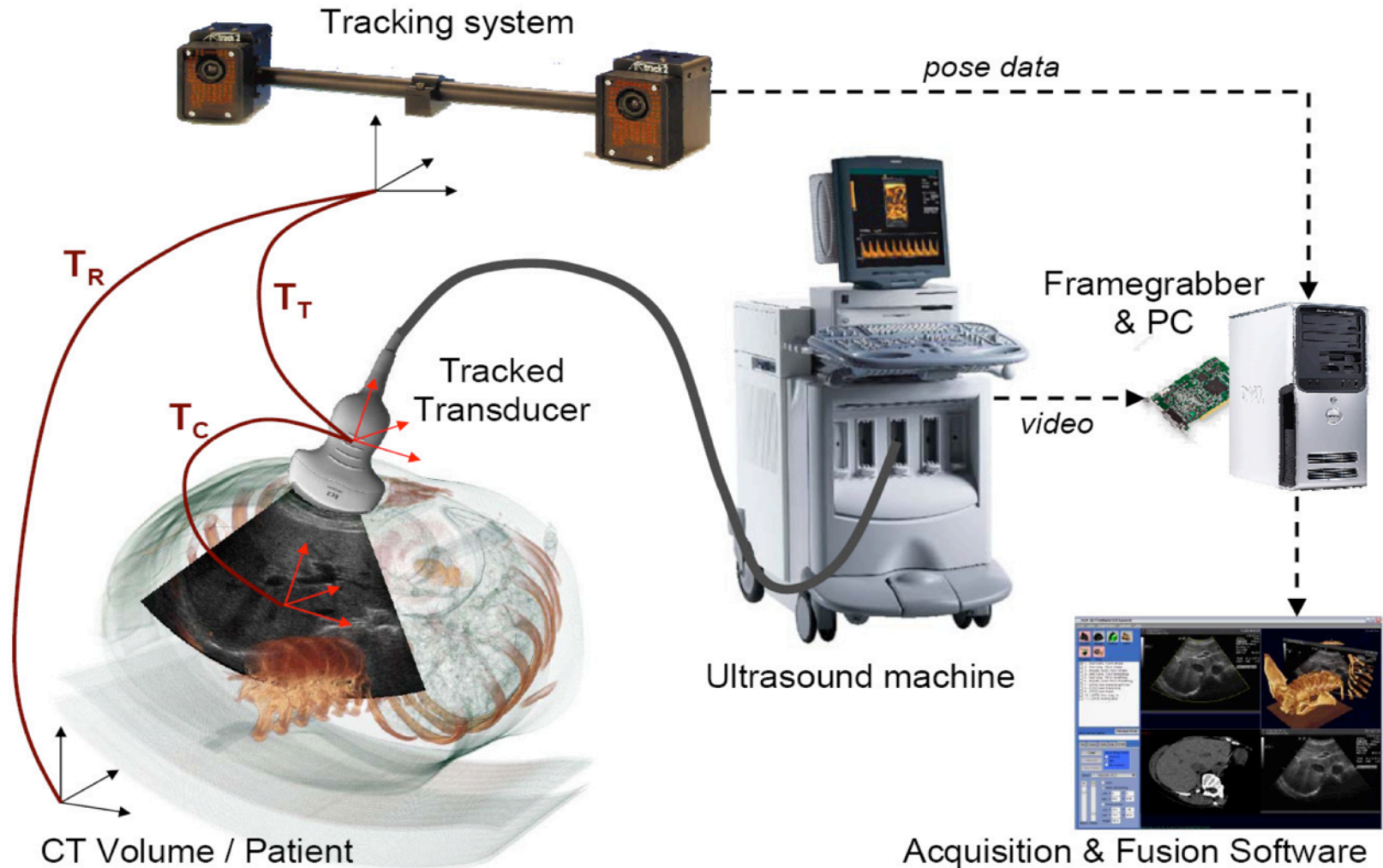
EM tracking sensor

water cooling lines

Maximum crystal length
15 mm



Acquisition of 3D Freehand Ultrasound (Optical)



Optical 3D Freehand Ultrasound Tracking Scheme (Wein 2007)

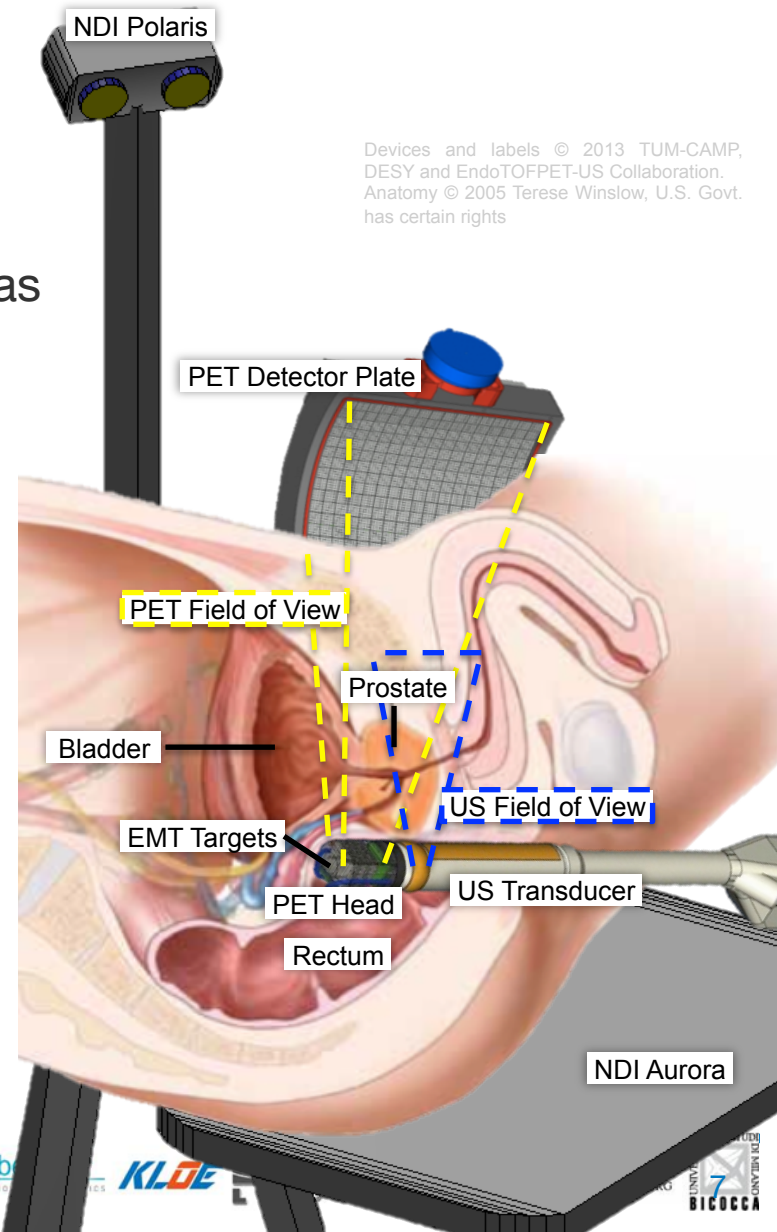
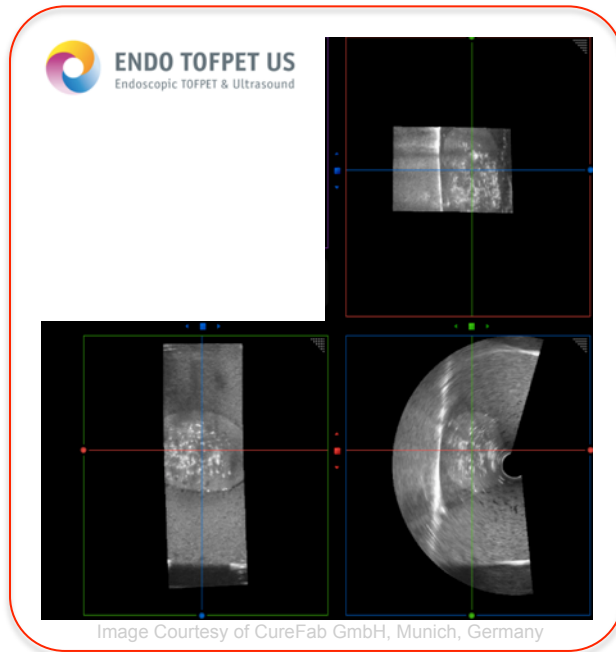
Global Registration of Ultrasound to MRI Using the LC^2 Metric for Enabling Neurosurgical Guidance

Wolfgang Wein, Alexander Ladikos
ImFusion GmbH, Munich, Germany

Bernhard Fuerst, Amit Shah, Kanishka Sharma, Nassir Navab
Computer Aided Medical Procedures, TUM Germany

CAMPCom Motivation

- Multimodal and Intra-Operative Imaging
- Collaboration of researchers from various areas
- Monitoring & centralized control of system

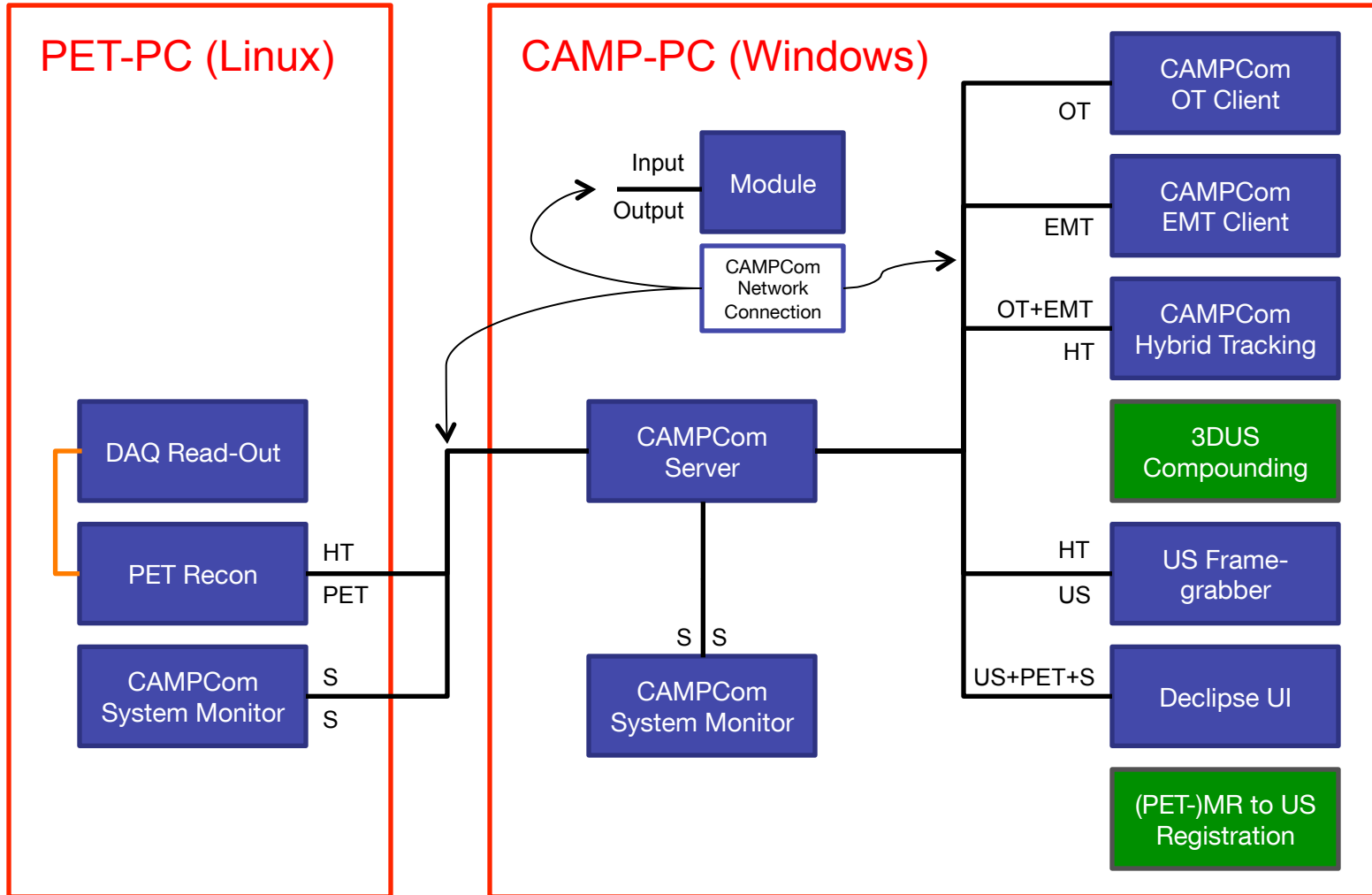


Devices and labels © 2013 TUM-CAMP, DESY and EndoTOFPET-US Collaboration. Anatomy © 2005 Terese Winslow, U.S. Govt. has certain rights

CAMPCom Goals

- Simple to use communication framework (“one header only”)
- Plug-Ins for visualization (CAMPVis)
- Open-source: <https://campar.in.tum.de/Main/CAMPCom>
- **Control & Data Flow:** communicate data and system messages between various components
- **Efficiency:** lightweight & efficient communication
- **Platform Independency:** serialization and transmission
- **Abstraction & Extensibility:** support extension, general interface
- **Prioritization:** asynchronous function to support efficiency

EndoTOPPET-US Device Setup



CAMPCom Features

- Client/Server Subscription
 - Subscribe to data stream
 - Automatic handling of ports, connections, thread pools
- Query Handling
 - Automatic queuing and dispatching
 - Prioritization possible
 - Sending/receiving does not block client
 - Buffering
- Compression
 - Improve throughput of large data using compression
- Platform Independent
- Easy use, type adding,...

- Tools: CAMPLog, CAMPMath and CAMPVis

CAMPCom Examples

```
#include "CAMPComDefinitions.h"  
#include "CAMPComClient.hpp"  
  
using namespace campcom;  
std::string serverAddr = "127.0.0.1";  
CAMPComClient client("TestClient", Device_TestDevice, serverAddr);
```

CAMPCom Examples

```

void printOutOT(std::vector<Byte> &msg) {
    if (msg.size() == 0) return;
    OptTrackingData return_payload;
    Header header;

    TypeHandler<OptTrackingData>::deserializePayload(&msg[0], msg.size(), return_payload);
    //do something with return_payload...
}

int main(int argc, char* argv[]) {
    //connect to server
    client.connect();

    //receive data
    client.subscribe(Type_OptTracking, &printOutOT, &successPrintOut);

    //send something
    TrackingData data;
    data.position = campmath::vec3d(0.5,0.5,0.5);
    client.send(&data);

    //clean up
    client.unsubscribe(Type_OptTracking);
    client.disconnect();
}

```

Brief Results & Conclusion

- Stability and Reliability
 - 24h random data tests
 - Low server load, no memory leaks,...
- Transfer Rates
 - As fast as other frameworks (OpenIGTLink)
- Prioritization and Compression
 - Improve overall transfer rate for large data by approx. 19% (MRI data)
- Simple to use/implement
- Stable, fast, reliable framework for IGT
- Complex communication process hidden
- Platform independent

Outlook

- “Roll-out” to EndoTOFPET-US partners
- Porting to Android
- Extension of subscription model (“filtering”)
- Looking forward to contributions

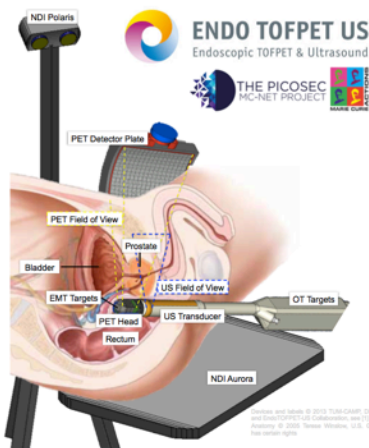


EndoTOFPET-US has received funding from the European Union 7th Framework Program (FP7/ 2007-2013) under Grant Agreement No. 256984.

PicoSEC MC-Net Project is supported by a Marie Curie Early Initial Training Network Fellowship of the European Union 7th Program under contract number (PITN-GA-2011-289355-PicoSEC-MCNet).

A. Schoch, B. Fuerst, F. Achilles, S. Demirci and N. Navab
Computer Aided Medical Procedures (CAMP), TU Munich, Germany

Introduction



Motivation

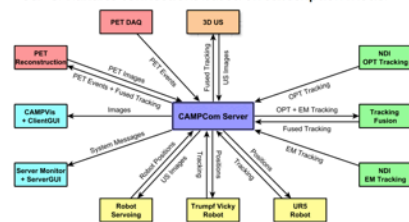
- Multimodal and Intra-Operative Imaging (EndoTOPPET-US) [1]
- Collaboration of researchers from areas:
 - computer science (GUI, tracking, reconstruction)
 - physics (crystals, optics, attenuation and scatter correction)
 - medicine (tracers, pre-op imaging)
 - electronics (photo electronics, read-out, DAQ cards)
- Full monitoring and centralized control of system required

Goal

- Simple to use communication framework ("one header only")
- Plug-Ins for visualization (CAMPvis)
- Open-source: <https://campar.in.tum.de/Main/CAMPCom>
- Control & Data Flow:** communicate data and system messages between various components
- Efficiency:** lightweight & efficient communication
- Platform Independency:** serialization and transmission
- Abstraction & Extensibility:** support extension, general interface
- Prioritization:** asynchronous function to support efficiency

Methods

- Sample setup for EndoTOPPET-US Project
- Server handles connections based on subscription model



Query Handling & Prioritization

- Activity diagram for client library
- Simplified (without dispatcher thread pool)



Evaluation

Client/Server Communication Stability and Reliability

- 24h random data test
- No data loss, connection issues, memory leaks, or CPU loads
- Server memory approx. 1.4MB, CPU < 3%

Prioritization and Compression

- zlib based compression of MNI BITE dataset [3, 4]
- 67.60% compression → overall transfer rate 3.35MB/sec
- 19.52% overall improvement compared to no compression

Transfer rates

- Average transfer rate 90% of SMB; Compared to [2]
- 6 Experiments: different 100MB data packages

	Loading data	Serialization	Sending	Receiving	Deserialization	Total
OpenIGTLink						
Duration [sec]	16.464	0.728	8.837	11.258	0.052	37.311
Transfer rate [MB/sec]	6.074	137.269	11.316	8.883	4035.152	2.680
CAMPCom (Compression and Prioritization off)						
Duration [sec]	14.026	0.666	9.272	12.247	0.882	37.094
Transfer rate [MB/sec]	7.129	150.039	10.785	8.165	113.399	2.696

Conclusion

- Stable, fast, reliable framework for IGT
- Easy integration, complex communication process hidden
- Similar performance compared to state of art
- Added features: prioritization, compression, subscription, thread pool, memory efficiency, simple integration

[1] Erika Garutti. EndoTOPPET-US: a Novel Multimodal Tool for Endoscopy and Positron Emission Tomography. arXiv preprint arXiv:1303.4603, 2013.
 [2] Junichi Tokuda, Gregory S. Fischer, Xenophon Papadimitrakis, Ziv Yaniv, et al. OpenIGTLink: an open network protocol for image-guided therapy environment. INT J MED ROBOT CODIP, 5(4):403–434, 2008.
 [3] <http://zlib.net/faq.html>
 [4] Laurence Morice, Roland P. Del Maestro, Kevin Perreco, David Araujo, Claire Haegelen, and D Louis Collins. Online database of clinical MRI and ultrasound images of brain tumors. Med. Phys., 39:2023, 2012.

EndoTOPPETUS has received funding from the European Union 7th Framework Program (FP7) (2007–2013) under Grant Agreement No. 256984. PicoSEC MC-Net Project is supported by a Marie Curie Early Initial Training Network Fellowship of the European Community's Seventh Framework Programme under contract number SP7N-GA-2011-298305-PicoSEC-MCNet.

Thank you!

Computer Aided Medical Procedures