

PHILIPS

sense **and** simplicity

HW emulation in MRI development

Hans Peeters

MRI technology development

June 05, 2012

About myself

- 34 years old, married, 2 children
- M.Sc. Biomechanical engineering -> Ph.D. Medical Physics -> Philips
- MRI Domain expert, Methods & Reconstruction
- Pulse sequences, reconstruction algorithms, workflow, image quality, hardware interaction

Contents

- MRI basics
- Design
- HW emulation examples

MRI basics

MRI basics

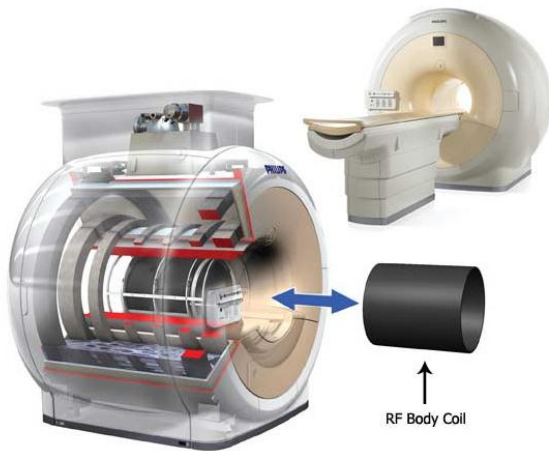


Some configurations

Achieva 1.5T XR

rampable magnet.

upgradeable to 3.0T on site without swapping the magnet.



Panorama HFO

1.0T high field open magnet.



Sonalleve MR-HIFU

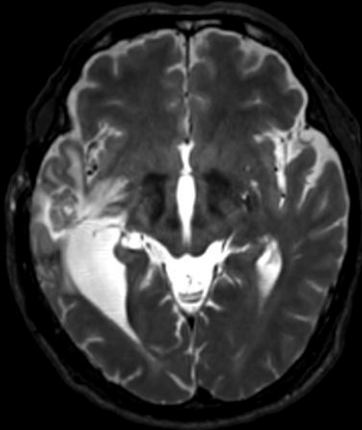
MR-guided high intensity focused ultrasound therapy



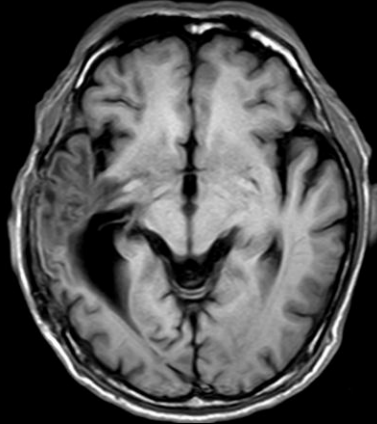
Example images

Comprehensive Brain imaging –Tumor

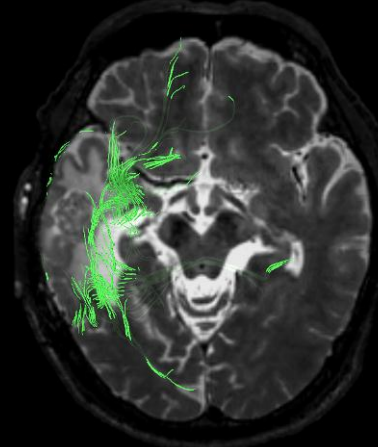
VISTA



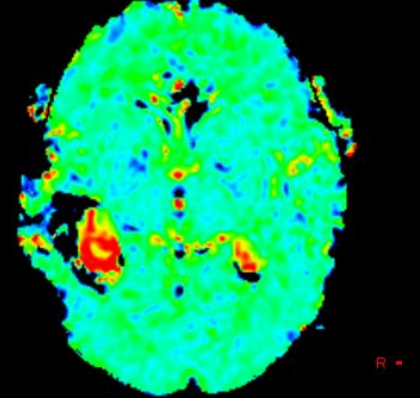
T1W IR



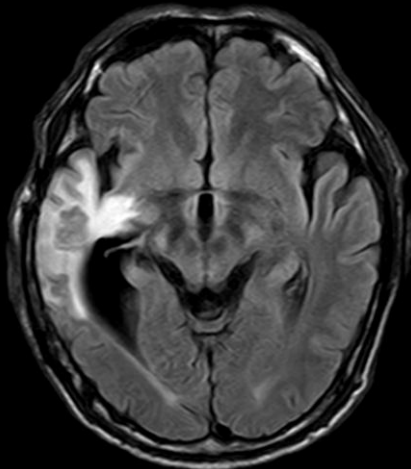
FiberTrak



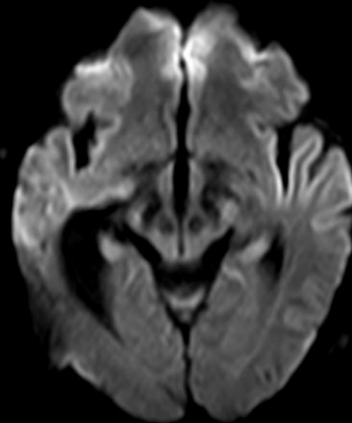
Perfusion



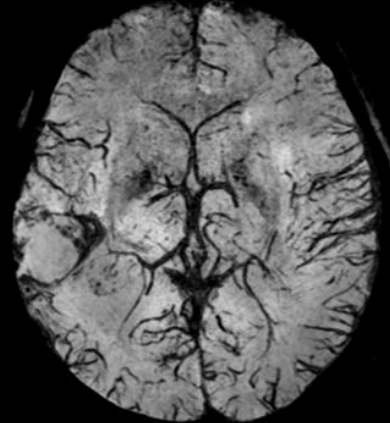
FLAIR



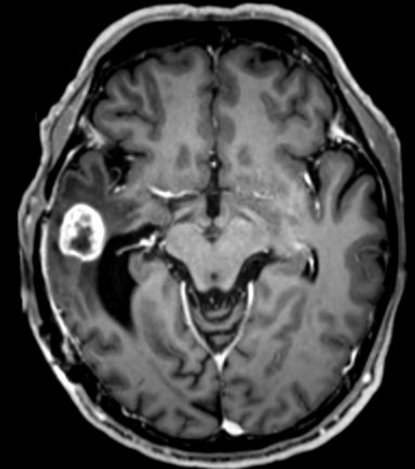
DWI



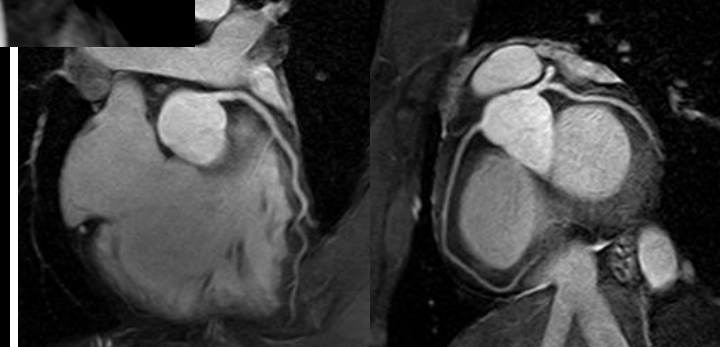
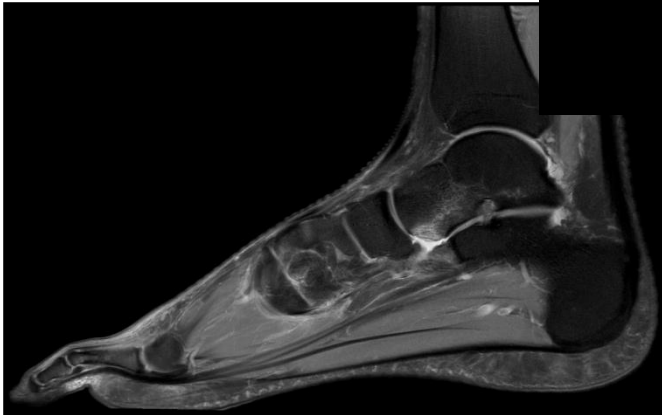
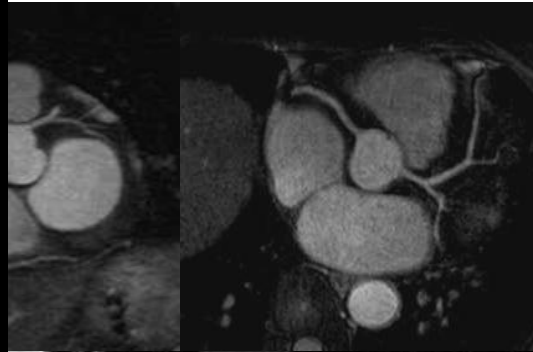
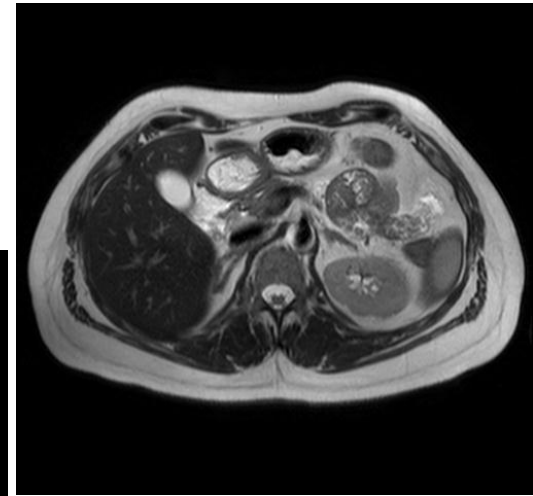
Venous Bold



THRIVE

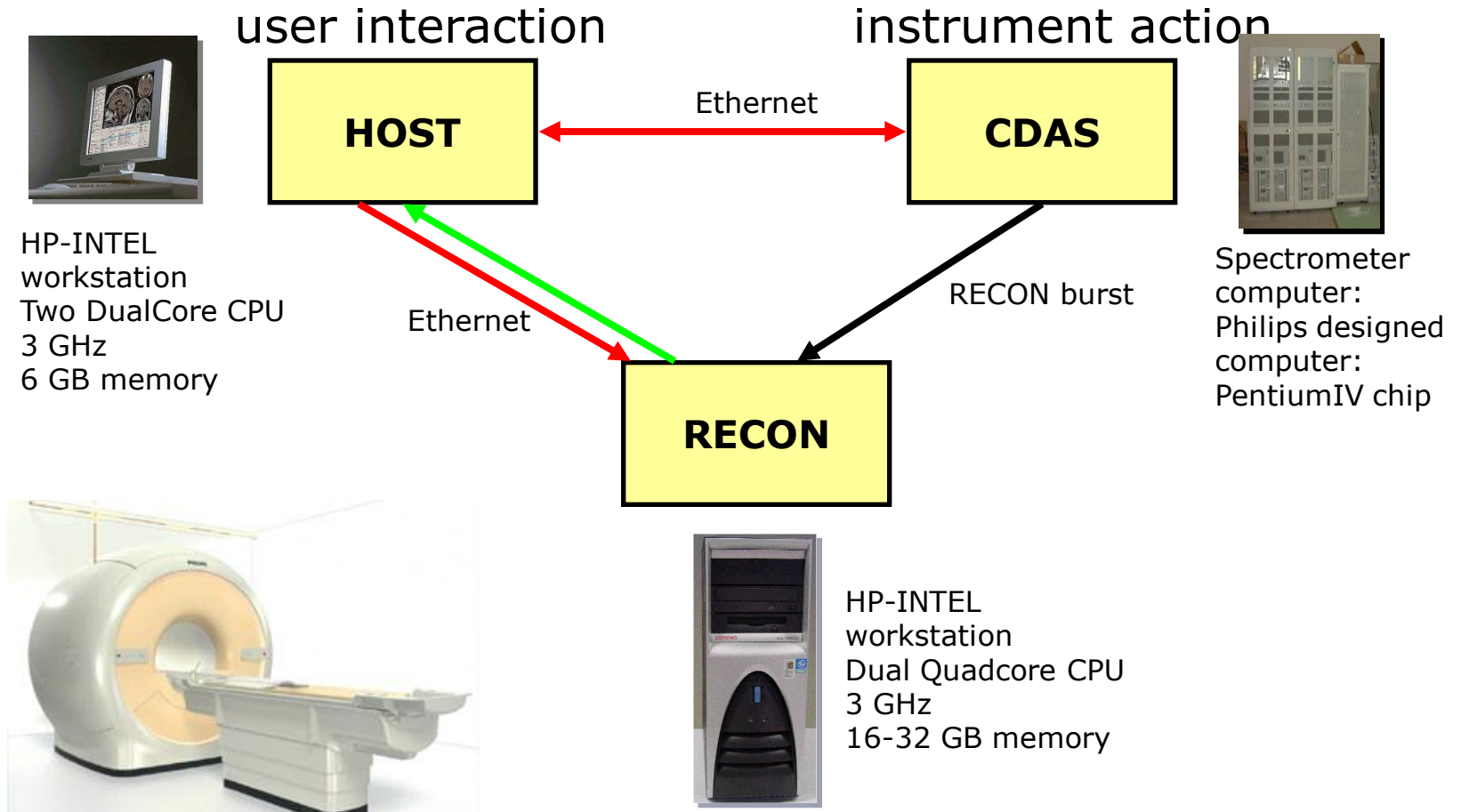


Example images

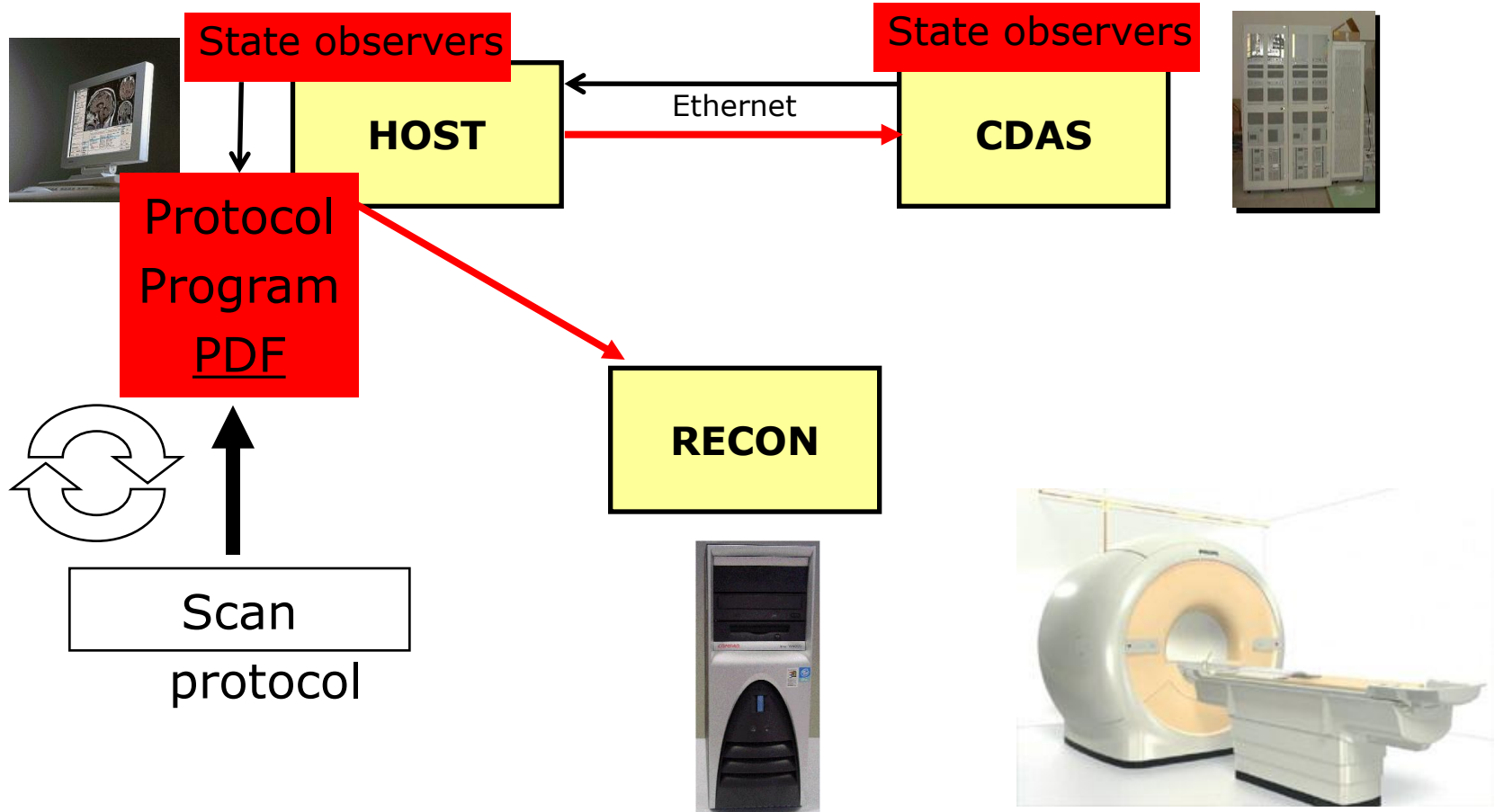


system design

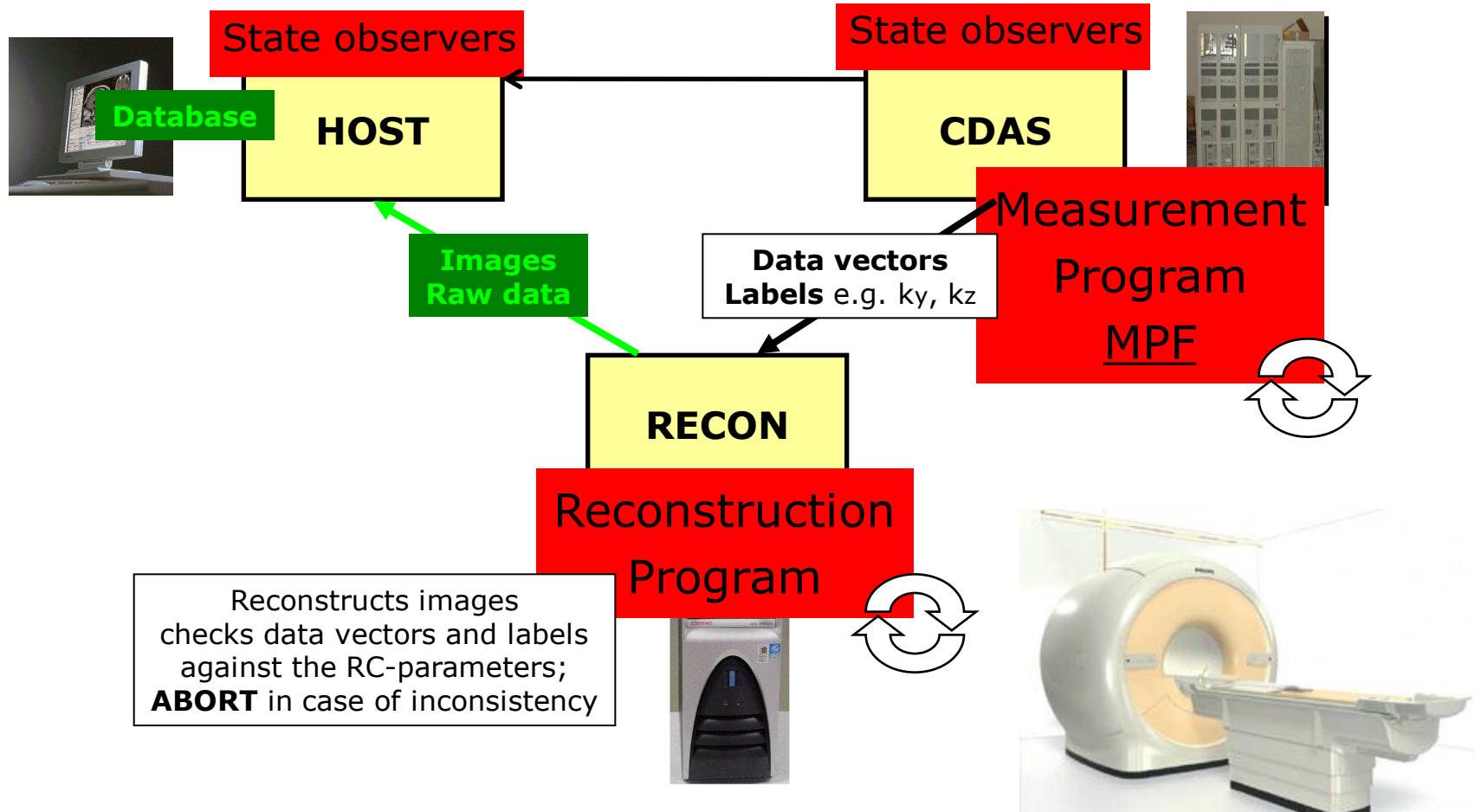
3 computer system



Starting a scan...



...during a scan



State observers

- Scanning/planning state
- Table and integrated posterior coil position
- Coils
- Gradient and RF Amplifiers
- Technical and scanner room temperature
- Connected physiology devices
- Helium level
- Cooling Water temperature
- Etc, etc, etc

Emulation

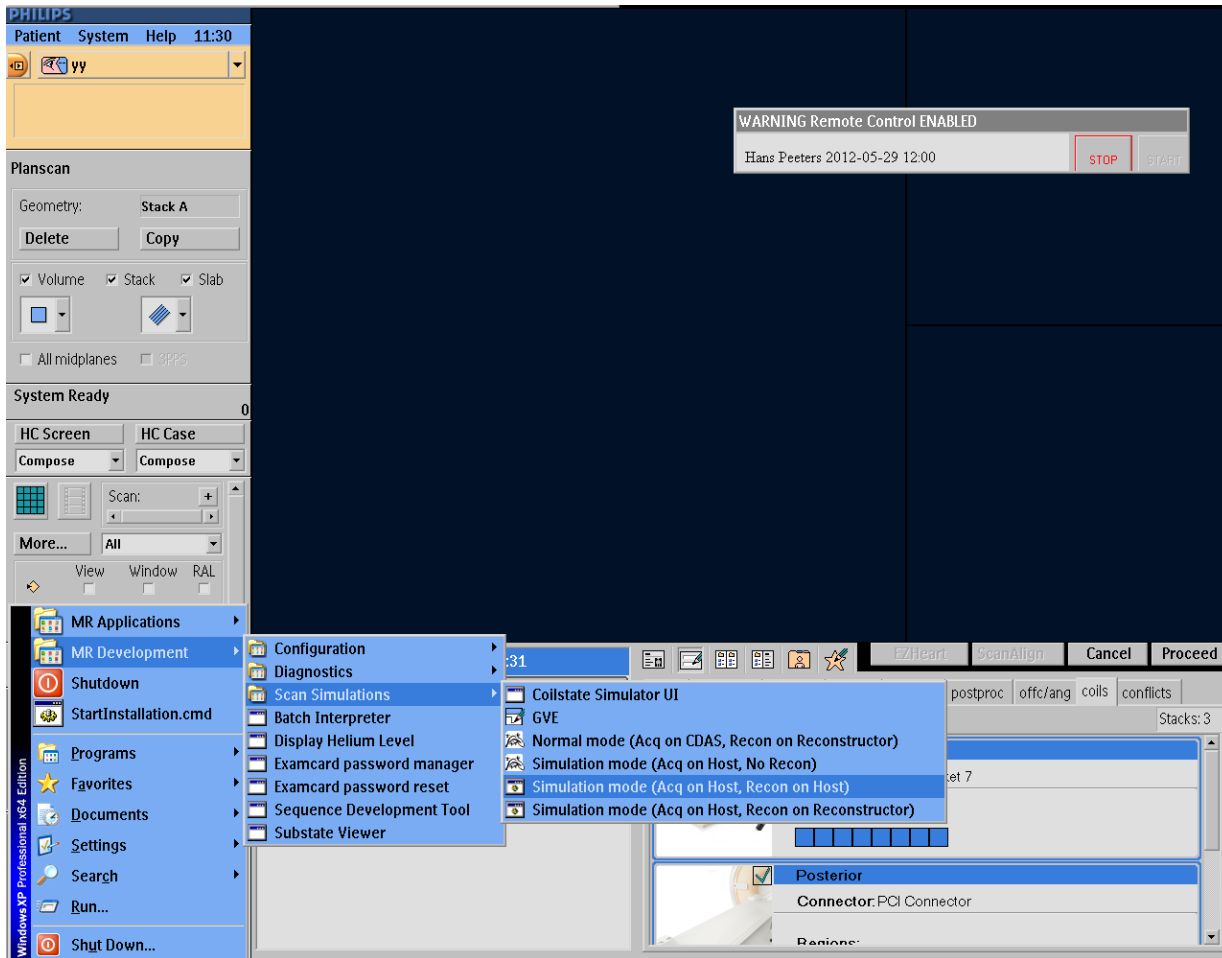
HW emulation

- Initial costs high, especially the magnet, but also amplifiers, coils, ...
- Maintenance costs
- Volunteers
- Availability: Multi-site, over 200 engineers in different domains
 - Emulation/simulation

Examples

- VMWare, Reconstruction Test Machine (RTM), Software Test Machine (STM)
- Coil simulation, scannersim, reconsim, patient communication, patient environment
- SW regression testing
- Refscan insertion
- System performance tooling (SPT)
- Computer links
- Physiology simulation

Some simulation processes



Planning STM

The screenshot displays the Philips MRI planning software interface for STM. The top-left panel shows patient information: **Patient System Help 11:43**, user **yy**, date **20-Jan-2000**, WIP Survey, and FOV 250. The **Planscan** panel includes **Geometry: Stack A**, **Delete Copy** buttons, and checkboxes for **Volume Stack Slab**, **All midplanes**, and **3PPS**. The **System Ready** panel shows **HC Screen HC Case** and **Compose** buttons. The main image area shows two slice stacks: **Sc 1 T1T2/M SI 2** and **Sc 1 T1T2/M SI 5**. A **WARNING Remote Control ENABLED** message is visible, along with the name **Hans Peeters 2012-05-29 12:00** and **STOP START** buttons. The bottom panel shows a scan list with **1,1 Survey** and **T2W_TSE Geo1**. The scan list includes **Multi_echo**, **T2W_TSE**, **T2W_DRIVE**, **DUAL_TSE**, **Multi_echo_**, **T2W_FFE**, **mFFE**, and **3D_Brain_View_T2_SHC**. The bottom control panel has buttons for **Start Scan** and **Stop Scan**, and a status bar showing **60 SAR:**.

Scanning STM

The screenshot displays the Philips MRI scanner's control interface during a T2W_TSE scan. The interface is divided into several functional areas:

- Top Left Panel:** Contains patient information including the name 'yy', birth date '20-Jan-2000', and scan date '29-May-2012,11:42'. It also shows 'WIP Survey' and 'FOV 250'.
- Main Scan Area:** Shows a large, grainy MRI image. A warning box is overlaid on the image: 'WARNING Remote Control ENABLED' with a 'STOP' button and the name 'Hans Peeters 2012-05-29 12:00'.
- System Ready Panel:** Shows 'System Ready' and '9'.
- Scan Progress Panel:** Located at the bottom left, it shows 'T2W_TSE' with a progress bar at 26% and a remaining scan time of 00:01:06.
- Scan List Panel:** Located at the bottom center, it lists the current scan '1,1 Survey' and other scans like 'T2W_DRIVE', 'DUAL_TSE', etc.
- Status Bar:** At the very bottom, it shows 'SAR: < 88%' and a warning: '11:43 PU phase deviation too large. Recalibration of the TX phases is requ'.

Coil simulation

WARNING Remote Control ENABLED

Hans Peeters 2012-05-29 12:00

STOP START

Planscan

Geometry: Stack A

Delete Copy

Volume Stack Slab

All midplanes 8PPS

System Ready

HC Screen HC Case

Compose Compose

Scan: + -

More... All

View Window RAL

yy

Blank 5 s

Remaining scan time:

Autoview...

Device Simulator

Plug and Unplug coils

Socket	Real or Simulated Device	Emulation Mode
CBH.ConnRF	SBM (HwDEF_453567378293)	Eeprom
SBM.ConnPSU	PSU (HwDEF_452211797832)	Eeprom
SBM.ConnTFINT	TFINT (HwDEF_452213319291)	Eeprom
SBM.DCC0	NVC_BASE (HwDEF_459800097971)	Eeprom
SBM.DCC1		
SBM.DCC2		
SBM.DCC3	DCP (HwDEF_452213700461)	Eeprom
TFINT.ConnTRC		
NVC_BASE.CONNB	NVC_HEAD (HwDEF_459800097981)	Eeprom
DCP.ConnPC	POSTERIOR (HwDEF_452213278103)	Eeprom
PFEI.ConnTRC_MN		

Disconnect all

Refresh




00:00:31

Survey

initial geometry contrast motion dyn/ang postproc offc/ang colls conflicts

Smart Select Stack Select

Stacks: 3

<input checked="" type="checkbox"/>		dS Base	Connector: Table Socket 7	Elements: 
<input checked="" type="checkbox"/>		dS Head	Connector: Base Connector	Elements:

EZHeart ScanAlign Cancel Proceed



Coil simulation

The screenshot displays the Philips MRI software interface for coil simulation. At the top right, a status bar shows "WARNING Remote Control ENABLED" and "Hans Peeters 2012-05-29 12:00" with "STOP" and "START" buttons. The main window is titled "Device Simulator" and contains a table for configuring coils:

Socket	Real or Simulated Device	Emulation Mode
CBH.ConnRF	SBM (HwDEF_453567378293)	Eeprom
SBM.ConnPSU	PSU (HwDEF_452211797832)	Eeprom
SBM.ConnTFINT	TFINT (HwDEF_452213319291)	Eeprom
SBM.DCC0	NVC_BASE (HwDEF_459800097971)	Eeprom
SBM.DCC1		
SBM.DCC2		
SBM.DCC3	DCP (HwDEF_452213700461)	Eeprom
TFINT.ConnTRC		
NVC_BASE.CDNNB		
DCP.ConnPC	POSTERIOR (HwDEF_452213278103)	Eeprom
PFEL.ConnTRC_MN		

Below the table are "Disconnect all" and "Refresh" buttons. To the left, the "Planscan" panel shows "Stack A" geometry with "Delete" and "Copy" buttons, and checkboxes for "Volume", "Stack", and "Slab". The "System Ready" panel includes "HC Screen" and "HC Case" sections with "Compose" buttons. At the bottom, a "Survey" panel shows a 3D model of the scanner table with two coils selected: "dS Base" (Connector: Table Socket 7) and "Posterior" (Connector: PCI Connector). The "Elements" bar shows a progress indicator with 7 segments, and the "Regions" bar is empty. The bottom status bar includes "EZHeart", "Scan/Align", "Cancel", and "Proceed" buttons, along with a timer showing "00:00:31".



Table position

The screenshot displays the Philips MRI console interface. A central dialog box titled "Scanner" is open, asking: "Allow system-controlled table top movement?". Below the question are two buttons: "Yes to All" and "Yes".

In the top right corner, a warning box states: "WARNING Remote Control ENABLED" with the user name "Hans Peeters 2012-05-29 12:00" and "STOP" and "START" buttons.

The interface includes several panels:

- Planscan:** Contains "Geometry:" with "Delete" and "Copy" buttons, and checkboxes for "Volume", "Stack", "Slab", "All midplanes", and "3PPS".
- System Ready:** Shows "System Ready" with a "0" indicator.
- HC Screen / HC Case:** Includes "Compose" dropdowns.
- More...:** Features "View", "Window", and "RAL" options.
- Bottom Panel:** Shows a "Survey" scan with a timer at "00:00:31". A table of scan parameters is visible on the right.

General Push Nodes	
Patient Position	Supine
Patient Orientation	Head First
Laterality	Unpaired
Anatomic Region	Optic canal (Not Specified)
Table Usage	Use
Automatic Heart Rate Update	No
Heart Rate (beats/min)	60
Align Overlap (mm)	30
GeoLink Propagation	No
Geometries	
Disengage posterior coil	No

Physiology simulation

The screenshot displays the Philips MRI software interface. A central dialog box titled 'Control Parameter Editor' is open, showing various scan parameters. The 'Physiology simulation' parameter is highlighted in blue and set to 'yes'. A 'WARNING Remote Control ENABLED' message is visible in the top right corner of the main window. The background shows a grayscale MRI scan of a brain slice.

Control Parameter Editor

Scan	Reconstruction	Preparation	General
Enable IQT parameters			no
Adaptive filtering			yes
VCG gradient delay			3
<input checked="" type="checkbox"/> SAR max levels			
<input checked="" type="checkbox"/> High weight extra SAR factors			
<input checked="" type="checkbox"/> High weight range [kg]			
SAR alert level			2.00
Heart rate update interval (s)			0
Physiology simulation			yes
VCG gradient simulation			0.0
- No of RR intervals			8
<input checked="" type="checkbox"/> - RR intervals (ms)			
- No of resp. intervals			1
<input checked="" type="checkbox"/> - Insp. intervals (ms)			

Physiology simulation
(Allowed values: no, yes)

Show Help

Buttons: Load..., Save..., Store..., Reset, Apply, Factory Defaults..., Hide

Physiology simulation

Patient System Help 11:51

20-Jan-2000 yy
WIP Survey
29-May-2012,11:42

FOV 250
Slice 2/9

Planscan

Geometry: []
Delete Copy

Volume Stack Slab

All midplanes 3FPS

System Ready

HC Screen HC Case
Compose Compose

Scan: 1

More... All

View Window RAL

yy

00:00:00

1,1	✓	Survey	
2,1	✓	T2W_TSE	Geo1
3,1	✓	T2W_TSE	Geo1
	✗	T2W_TSE	Geo1
5,1	✓	T2W_TSE	Geo1
6,1	✓	QFLOW_FB	Geo3

initial	geometry	contrast	motion	dyn/ang	postproc	offc/ang	coils	conflicts	
Cardiac synchroniz... retrospective								Total scan duration	04:01.5
device	ECG							Rel. signal level (%)	100
R-R window (%)								Act. TR/TE (ms)	4.0 / 2.4
heartphases	50							ACQ matrix M x P	140 x 120
arrhythmia rejec...	yes							ACQ voxel MPS (mm)	2.50 / 2.50 / 8.00
Heart rate > 250 bpm	no							REC voxel MPS (mm)	1.22 / 1.21 / 8.00
Respiratory compe...	no							Scan percentage (%)	100
Navigator respirato...	no							Act. Phase acq (%)	249.5
Flow compensation	yes							Act. WFS (pix) / BW ...	0.603 / 720.0
fMRI echo stabilis...	no							Min. WFS (pix) / Ma...	0.304 / 1428.6
NSA	2							SAR / head	< 8%
SMART	yes							Whole body / level	0.0 W/kg / nor

PHILIPS

Sensor

- VCG
- VCG1+VCG2
- PPU
- Resp
- VCG+PPU
- VCG+Resp**
- PPU+Resp
- External
- VCG+Ext
- PPU+Ext
- Resp+Ext
- Blank

Display range: 5 s Heart rate: 60 beats / min

Summary

- MRI is a 3 computer system
- Many hardware components that need to be monitored
- Hardware is expensive
- Volunteers are not always available and expensive
- Emulation\simulation is a must
- To my opinion tooling is part of the development project and should be maintained as normal product sw

