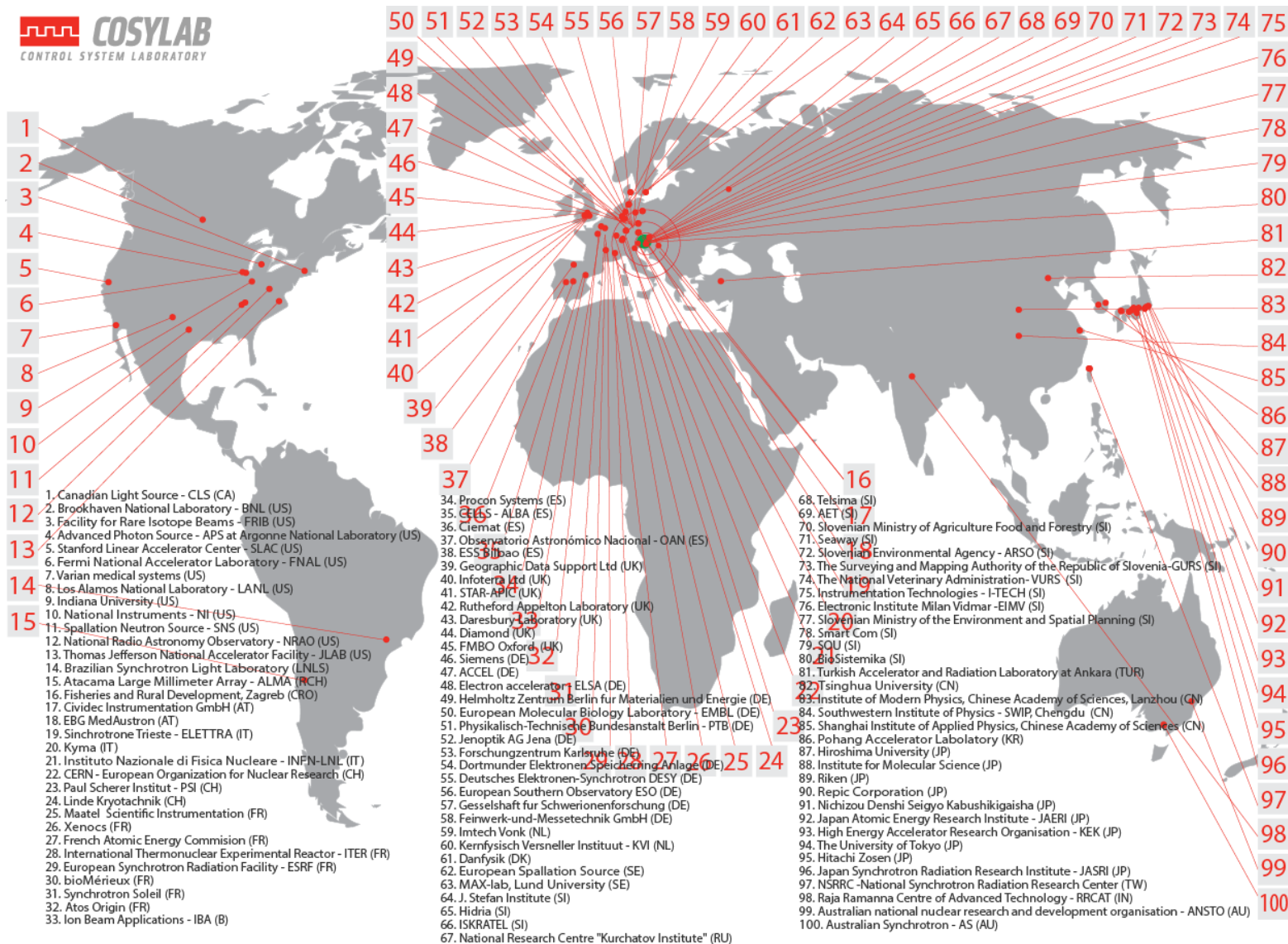


Controlling Medical Accelerators and Medical Processes

Your **TRUSTED** Control System Partner



The Only Slide About Cosylab: The World Leader In Control Systems For Large Physics Facilities and Particle Therapy



Your **TRUSTED** Control System Partner

Let's start with some questions



- How do you configure all the medical and room systems for treatment?
- Who manages the patient registration?
- How do you get all relevant DICOM objects (e.g. spot map) from OIS to the scanning system?
- How do you save CT images back to the PACS?
- How do you make sure treatment starts only after patient has been correctly aligned?
- How do you correct patient alignment?
- What are the prerequisites for safe operation, and how do you make sure it is safe to irradiate the patient?

In other words: which system manages the treatment workflow of all interconnected medical systems, executes the irradiation and monitors the progress?

The problem in a nutshell

- All different systems, such as: scanning, accelerator, patient imaging and positioning, gantry, OIS, PACS, safety systems, are by default not integrated with each other, but they have to be to get the job done...



The Therac-25 Incident

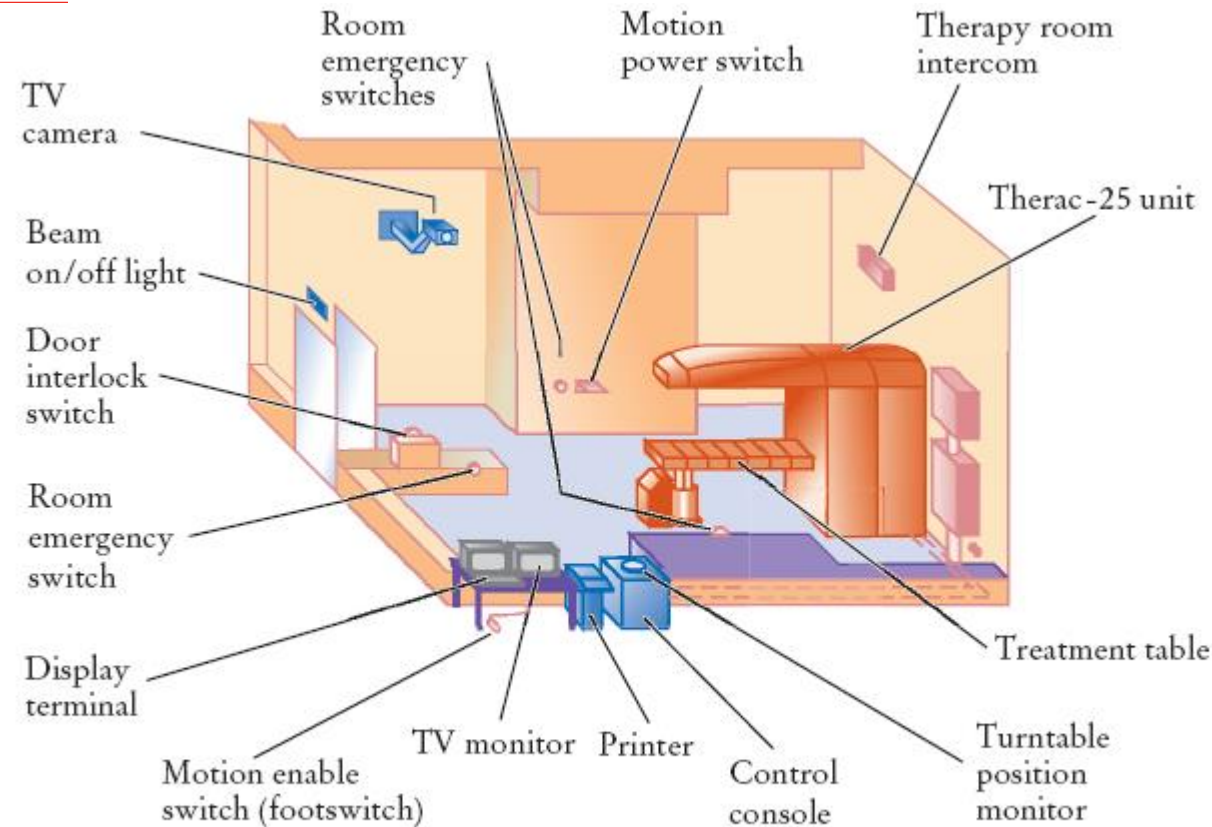
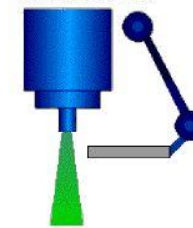


Figure 9 Typical Therac-25 Facility

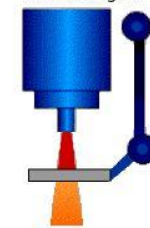
<https://www.crcpress.com/authors/i351-john-wang/news/i3158-therac-25-and-industrial-design-engineering-of-socio-technical-systems>

low current
electron beam
was scanned
across the field



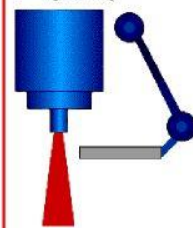
Electron Mode

high current
electron beam
was tracked
at the target



X-Ray Mode

high current
electron beam
with no target
> 'lightning'

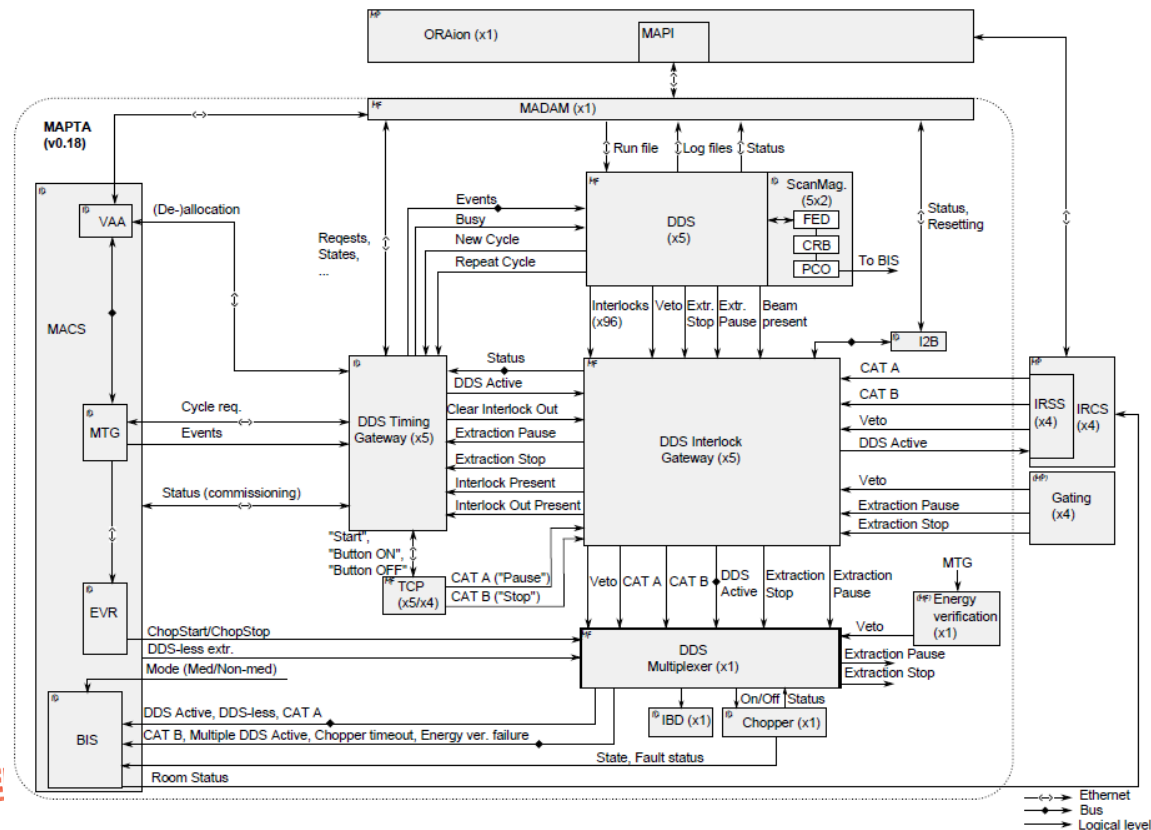


THE PROBLEM

tray including the target, a flattening filter, the collimator jaws and an ion chamber was moved OUT for "electron" mode, and IN for "photon" mode.

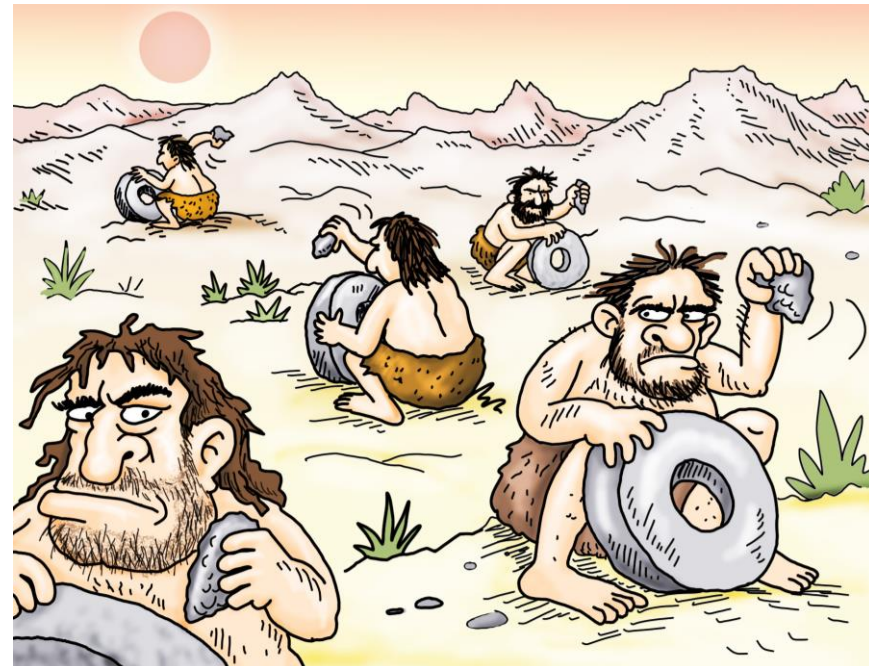
Example (no names mentioned...) COSYLAB

- ❑ just interfacing* accelerator and scanning system took 12 Manyears of highly skilled engineers
 - *Medical gateways between Accelerator Control System, Dose Delivery System, and Patient Treatment Plan Software
 - 1000 pages documentation for certification



Why Is Software So Special?

- ❑ It doesn't matter if the magnets are round or square
- ❑ But if the interface to the control system changes, you have to rewrite the software and also get it newly certified!
- ❑ SW comes last, but it encompasses all subsystems!
- ❑ Not everyone can write good software the proper way!



How To Manage Your Boss

**TECHNOLOGY IS FINE, BUT
WHAT DO THE BOSSES
REALLY CARE ABOUT?**

Your **TRUSTED** Control System Partner

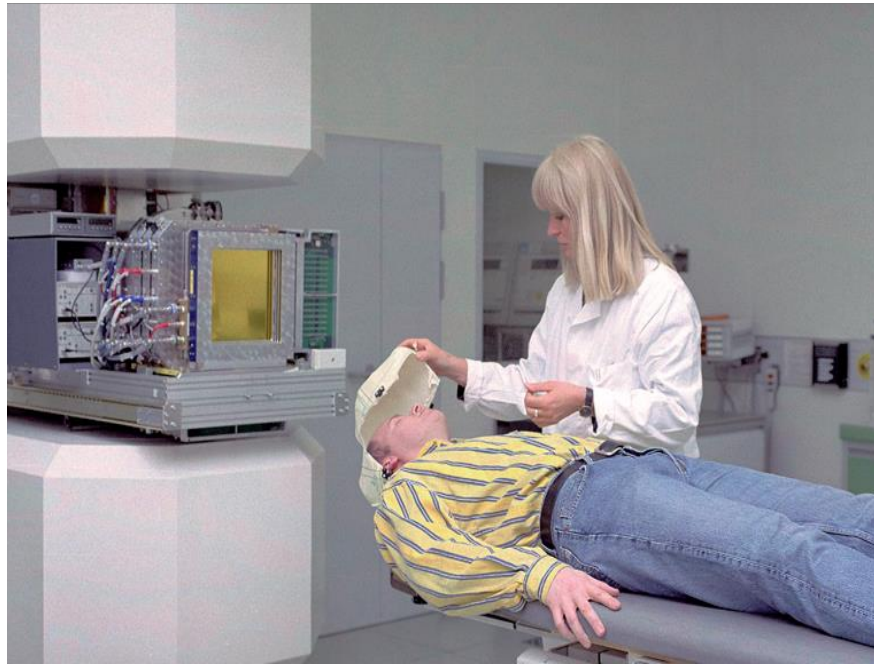


So What Are The Real Goals Of A PT Facility?

9



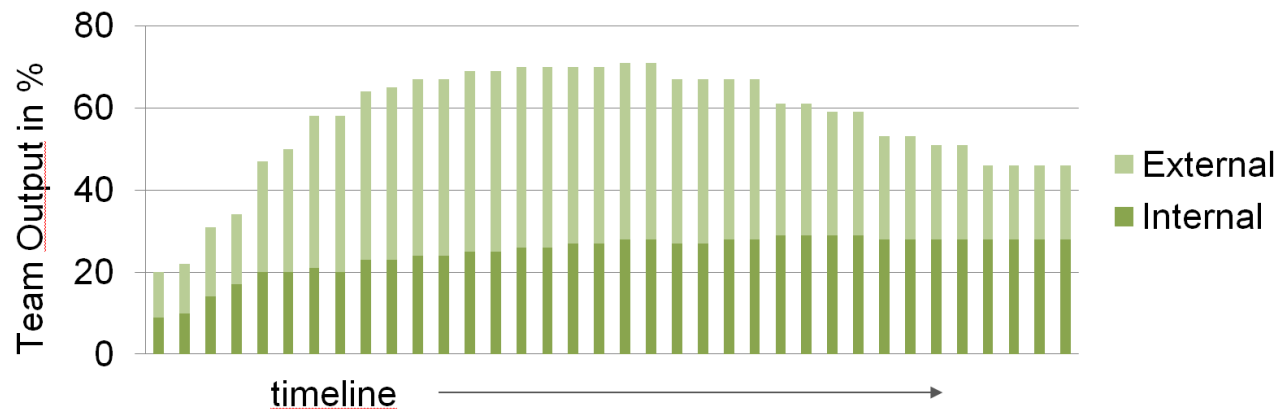
1. Getting the whole medical facility certified
2. Meet the milestone: first patient



How does the Control System contribute to these?

1. Getting the whole medical facility certified COSYLAB

- MedAustron experience: more time than anticipated on interfacing and documenting for medical certification.
 - **~100 man-years (MY) just for the ACS, 7 years to the 1st patient**
- Siemens in Shanghai: they needed 5 years(!) to get through the certification process.



Digression: The Mythical Man-Month

2. When do you want to have 1st patient?



- ❑ If it is in **3 years**, you'll have to do the Control System in **1-2 years**
 - Because it takes about 1 year for Validation&Verification and commissioning, where you already need the CS
- ❑ We are not aware of any project that has done it so quickly from scratch.



- ❑ CS must be fully documented as required for the certification of the whole medical facility:

project plan, development plan, QA plan, requirements specifications, architecture & design, test plan, test report, risk management plan, risk analysis, release notes, installation manual, user manual,...

- ❑ For **each** moderately complex device:

- 50 pages of project plan
- 250 individual requirements
- 100 pages of architecture and design
- 350 pages of test plans
- 400 identified risks



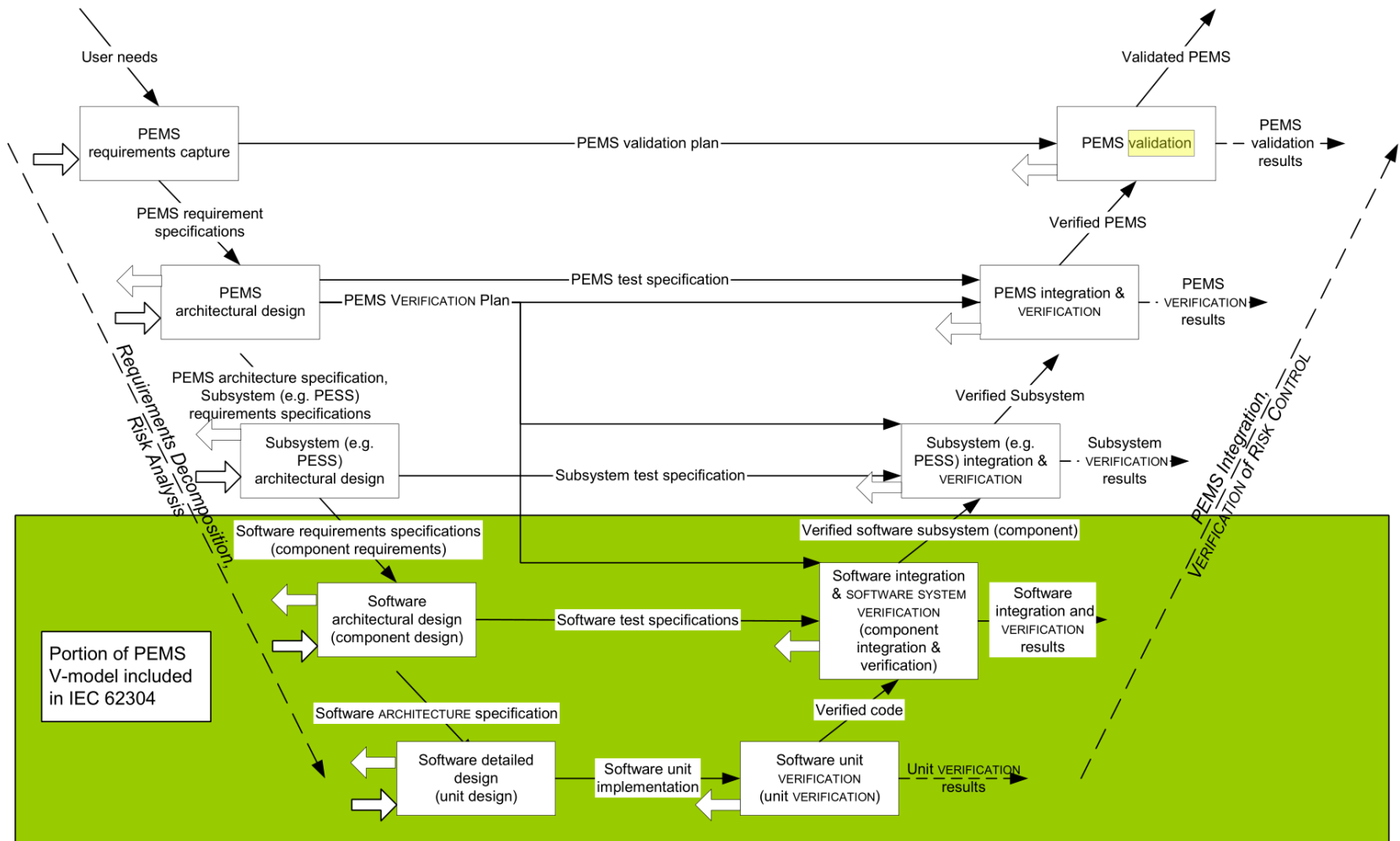
- ❑ On-site **installation & commissioning problems** and pitfalls.

- This is often highly underestimated.
- Here, vast experience really counts a huge deal.



Medical system engineering overview – V-model

13



Key:

- Boxes represent typical development lifecycle activities
- Solid Arrows indicate typical deliverables transferred into/out of activities
- Dotted arrows indicate deliverables just to the Risk Management File

- Outputs from problem resolution process
- Inputs to problem resolution process

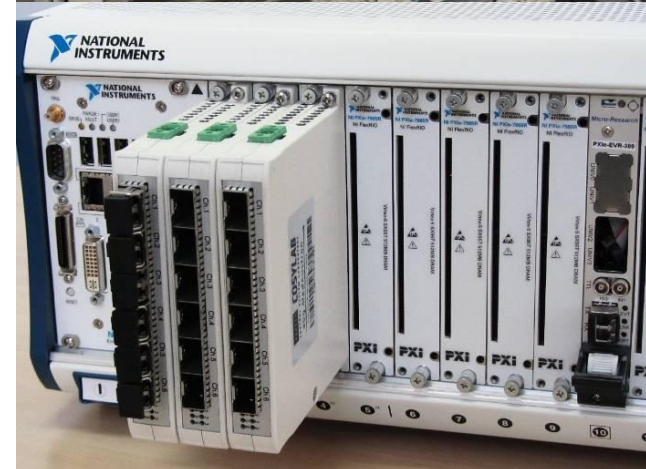
Also the Hardware Has To Be Chosen Wisely

14



For a medical machine, we find these requirements crucial:

- ❑ HW should have **industry-standard drivers available**
 - which saves a lot of development time & effort for our customers and lower the time to market!),
- ❑ HW should have **long-term support** guaranteed (if possible, it should cover the life-time of a PT facility!),
- ❑ HW should be **quickly-available** when replacement is needed,
- ❑ Should be **affordable enough** to also cover small, one-room facilities.



TCS - Treatment Control System

Your **TRUSTED** Control System Partner



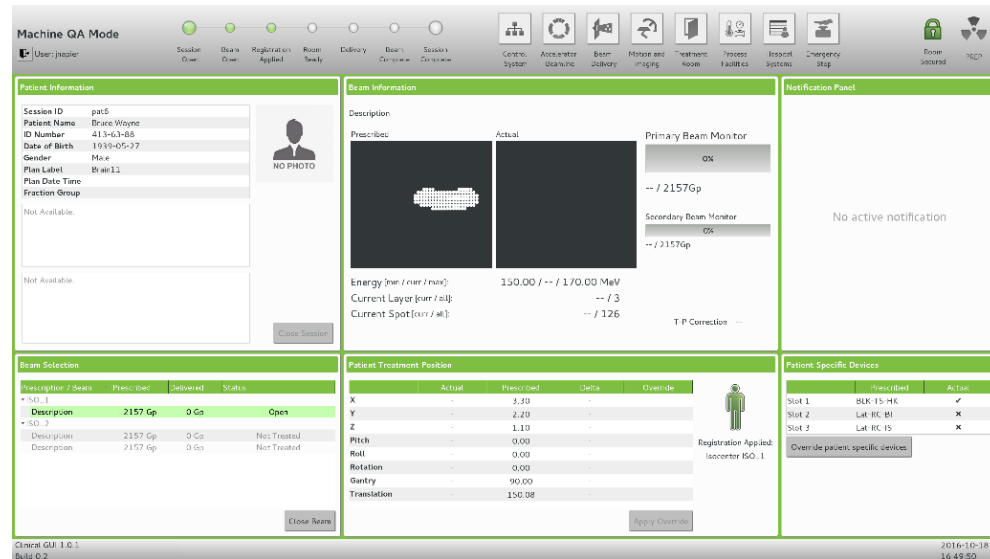
TCS – Treatment Control System

Execution of clinical workflow

- Patient selection
- Treatment Plan verification, conversion and propagation to subsystems
- Execution of patient alignment, imaging, registration, beam delivery
- Generation of treatment logs

Support for QA activities

- Treatment plan validation
- Treatment simulation
- Daily machine QA etc.



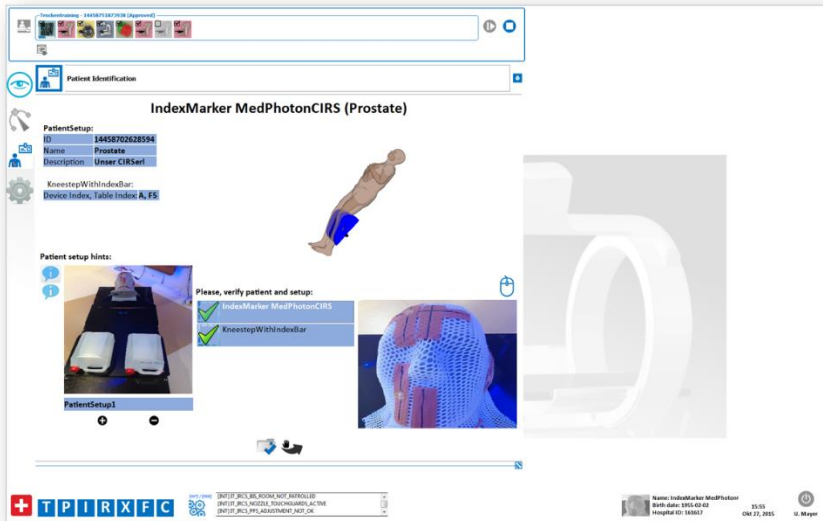
The screenshot displays the TCS Operator interface in 'Machine QA Mode'. The interface is organized into several panels:

- Patient Information:** Shows details for patient 'Drane Wayne' (ID: 41134-3-88, DOB: 1939-05-27, Gender: Male, Plan Label: B1411).
- Beam Information:** Displays 'Prescribed' and 'Actual' beam parameters, including Energy (150.00 / 170.00 MeV), Current Layer (1 / 3), and Current Spot (1 / 126).
- Beam Selection:** A table listing beam descriptions and their status.
- Patient Treatment Position:** A table showing actual vs. prescribed values for X, Y, Z, Pitch, Roll, Rotation, Gantry, and Translation.
- Patient Specific Devices:** A table listing devices like BLK 15 HK, Lat. RC. BI, and Lat. RC. IS.

At the bottom, the system version is 'Clinical GUI: 1.0.1' and 'Build: 0.2'. The date and time are '2016-10-18 16:49:50'.

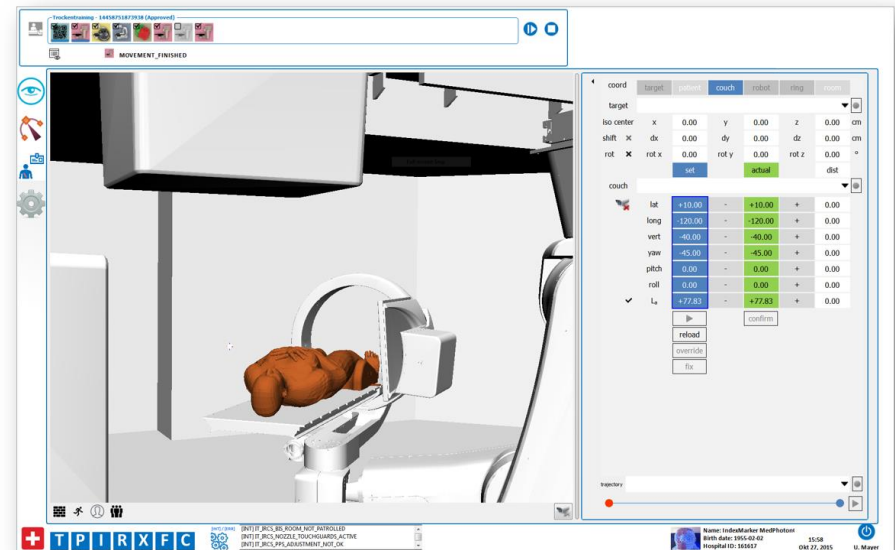
TCS – Treatment Control System

Examples from TCS implementation for MedAustron

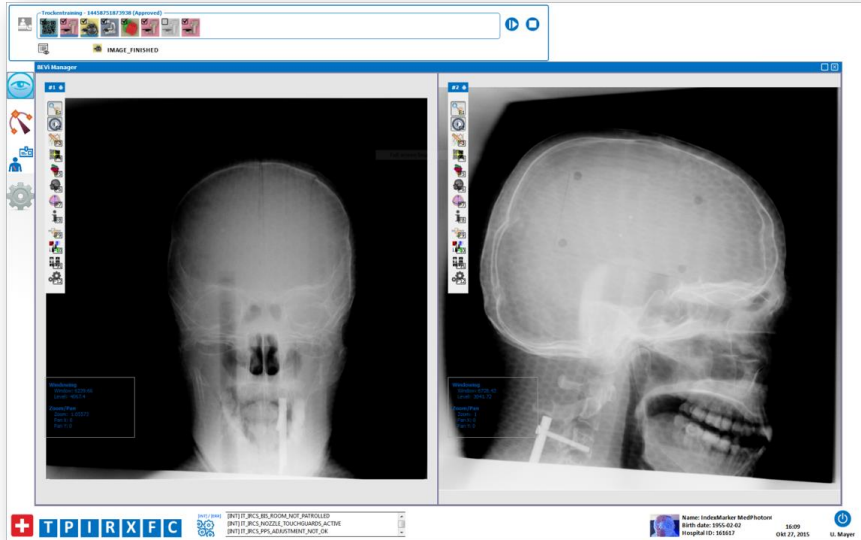


In-room identification of the patient and the immobilization devices

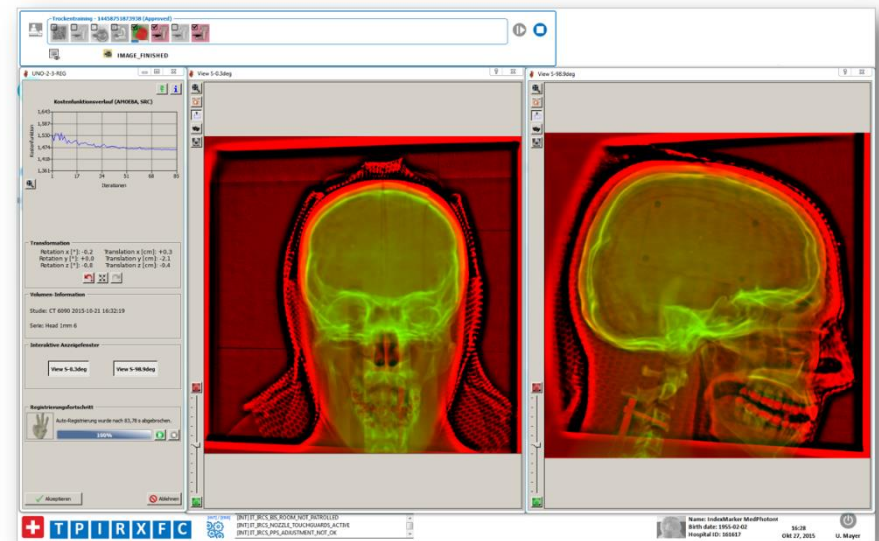
Couch movement (and online collision checking)



Examples from TCS implementation for MedAustron

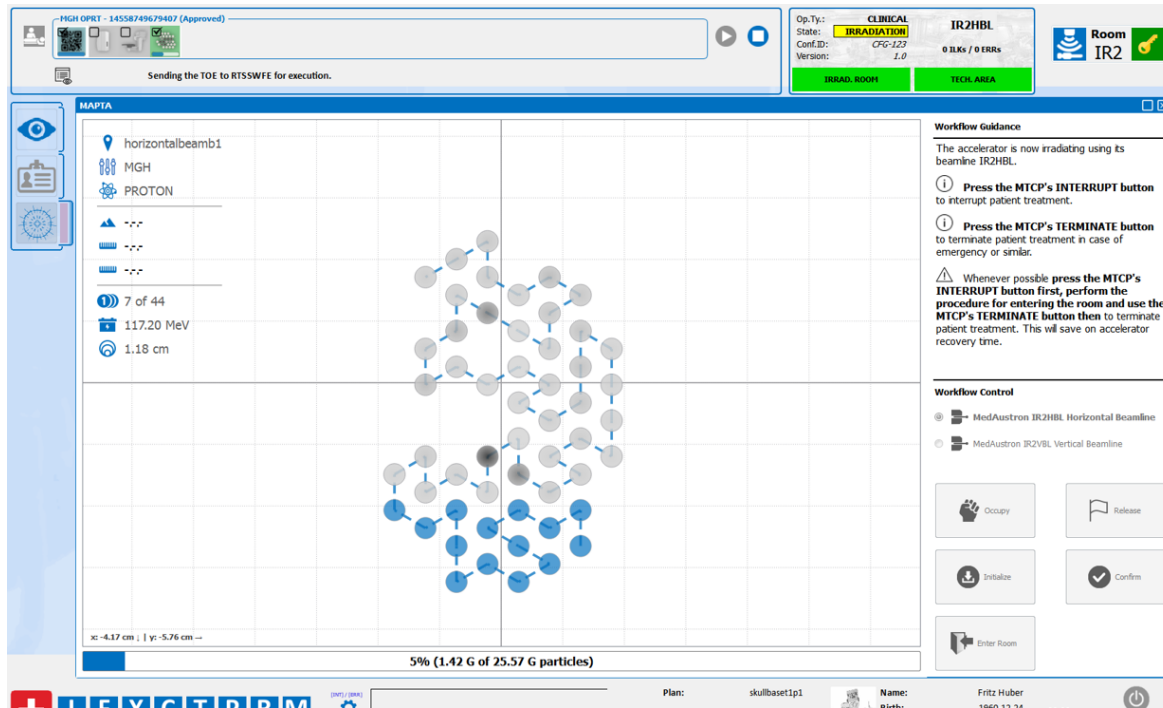


Online 2D/3D image registration for determination of correction vector



TCS – Treatment Control System COSYLAB

Examples from TCS implementation for MedAustron



Op. Ty.: CLINICAL
State: IRRADIATION
Conf. ID: CG-123
Version: 1.0

IR2HBL
0 IRLs / 0 ERRs

Room
IR2

SENDING THE TOE TO RTSSWEE FOR EXECUTION.

MAPTA

horizontalbeamb1
MGH
PROTON

7 of 44
117.20 MeV
1.18 cm

x: -4.17 cm | y: -5.76 cm

5% (1.42 G of 25.57 G particles)

Plan: skullbasel1p1
Name: Fritz Huber
1660.11.24

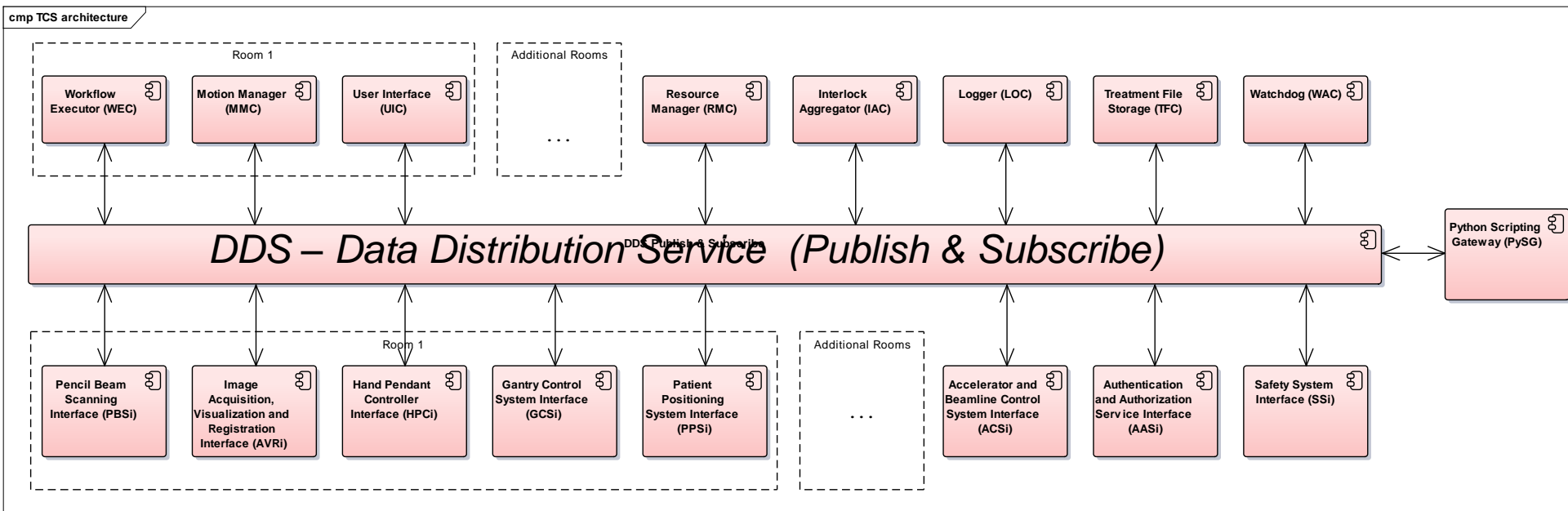
Workflow Guidance
The accelerator is now irradiating using its beamline IR2HBL.
① Press the MTCP's INTERRUPT button to interrupt patient treatment.
① Press the MTCP's TERMINATE button to terminate patient treatment in case of emergency or similar.
⚠ Whenever possible press the MTCP's INTERRUPT button first, perform the procedure for entering the room and use the MTCP's TERMINATE button then to terminate patient treatment. This will save on accelerator recovery time.

Workflow Control

- MedAustron IR2HBL Horizontal Beamline
- MedAustron IR2VBL Vertical Beamline

Occupancy: Release
Initialize: Confirm
Enter Room

Visualise proton/Carbon beam delivery

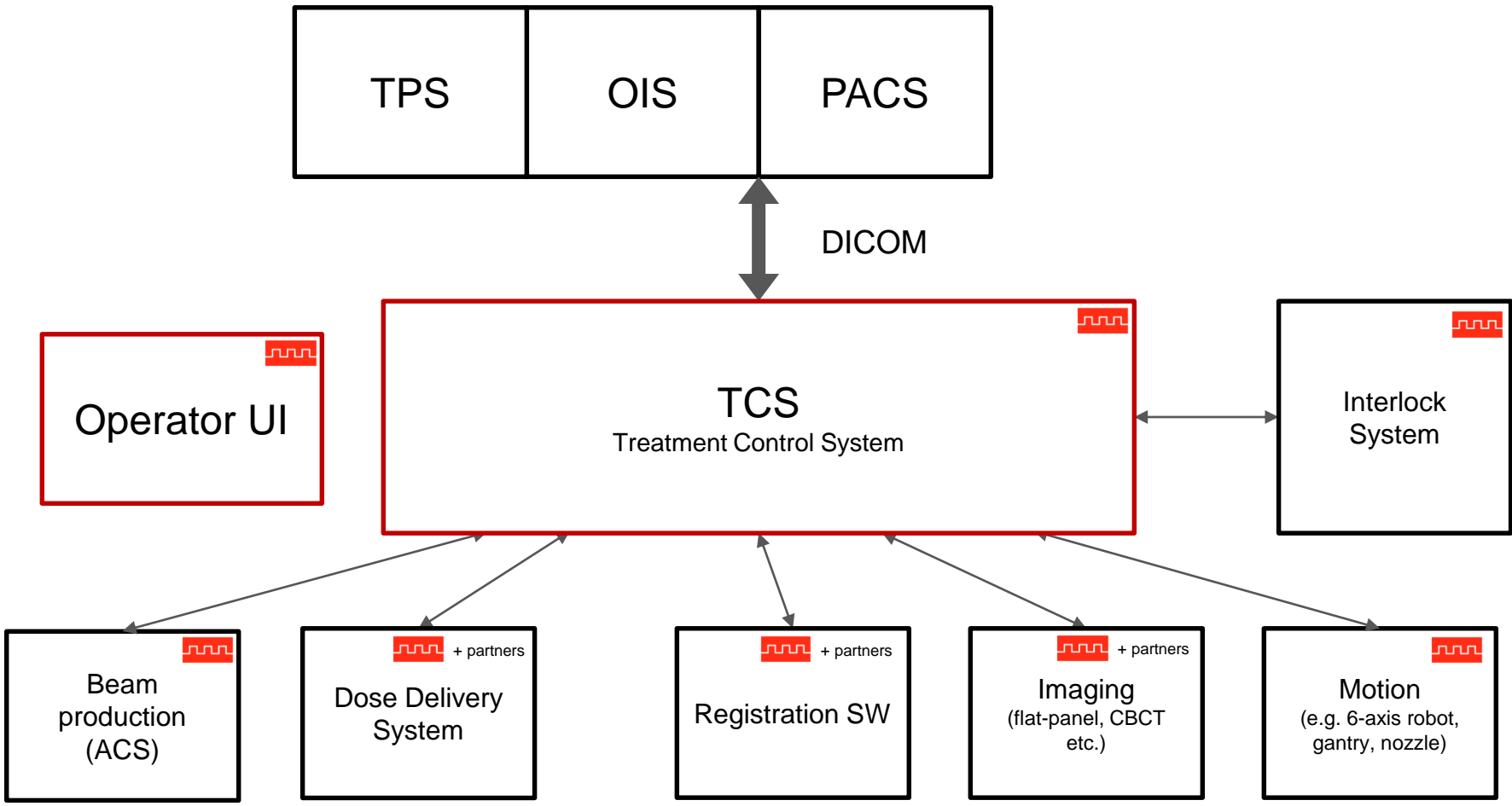


**Individual modules are described elsewhere 😊*

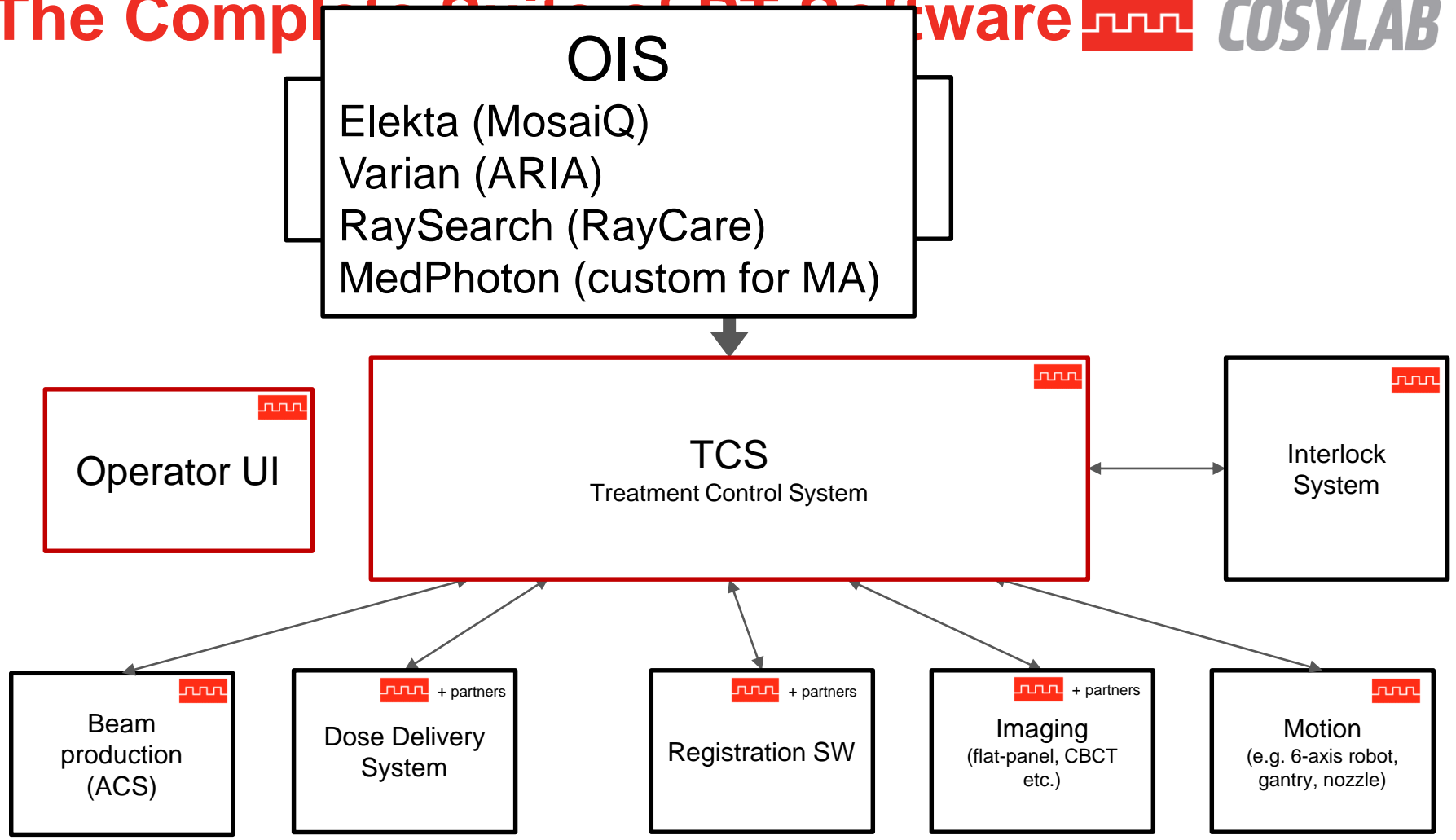
Either trivial or too detailed 😞

THE HIGH LEVEL ARCHITECTURE

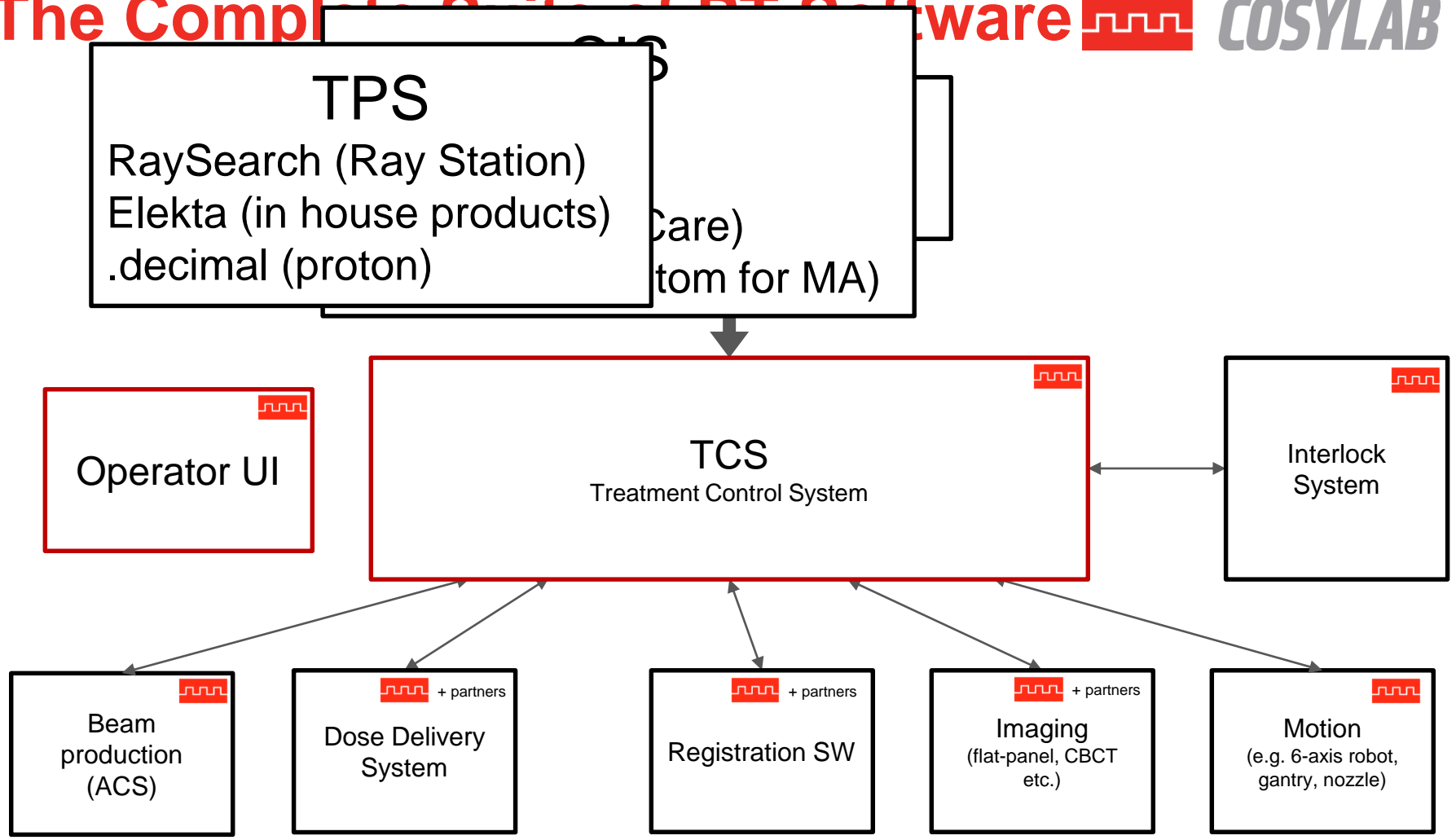
The Complete Suite of PT Software **COSYLAB**



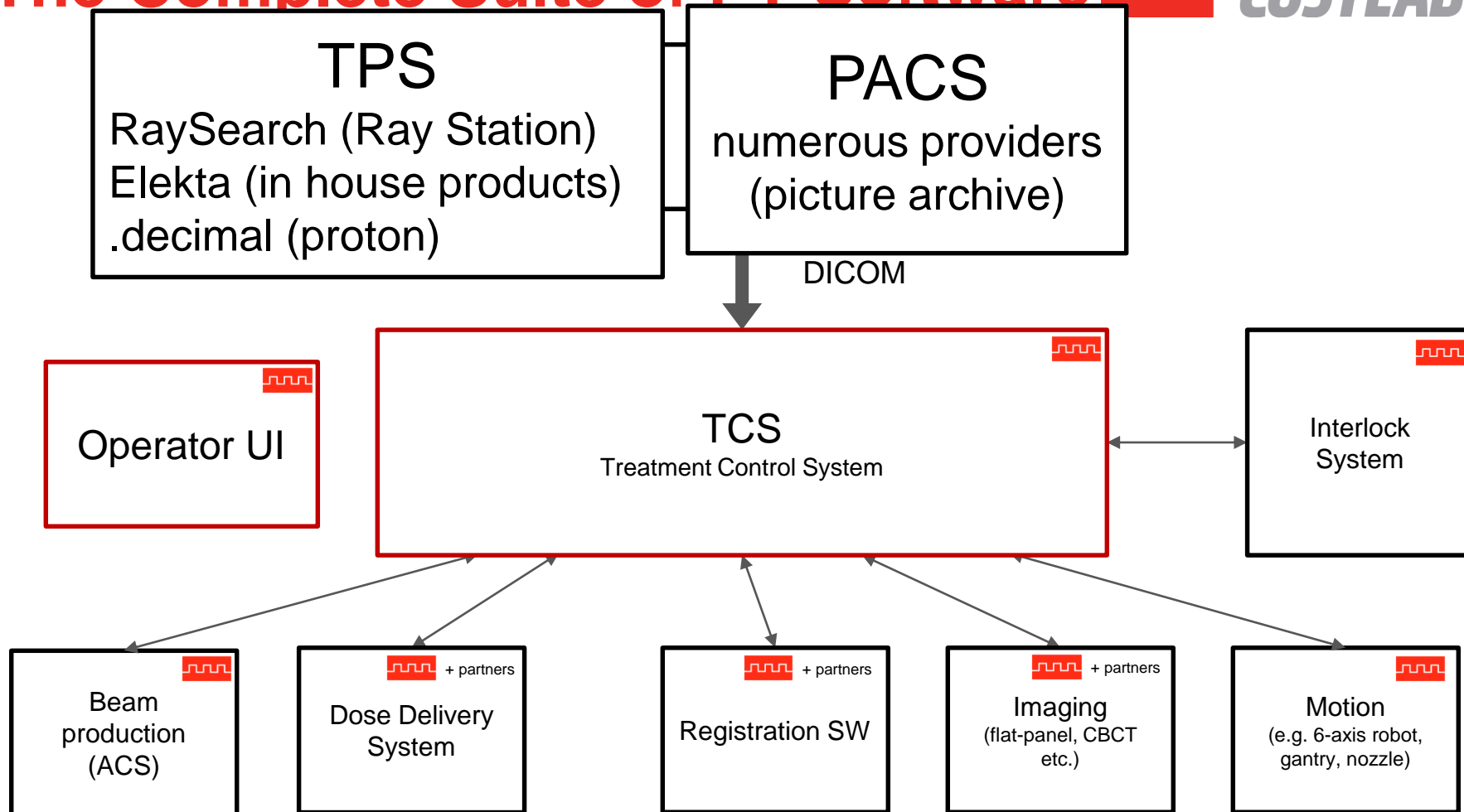
Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)



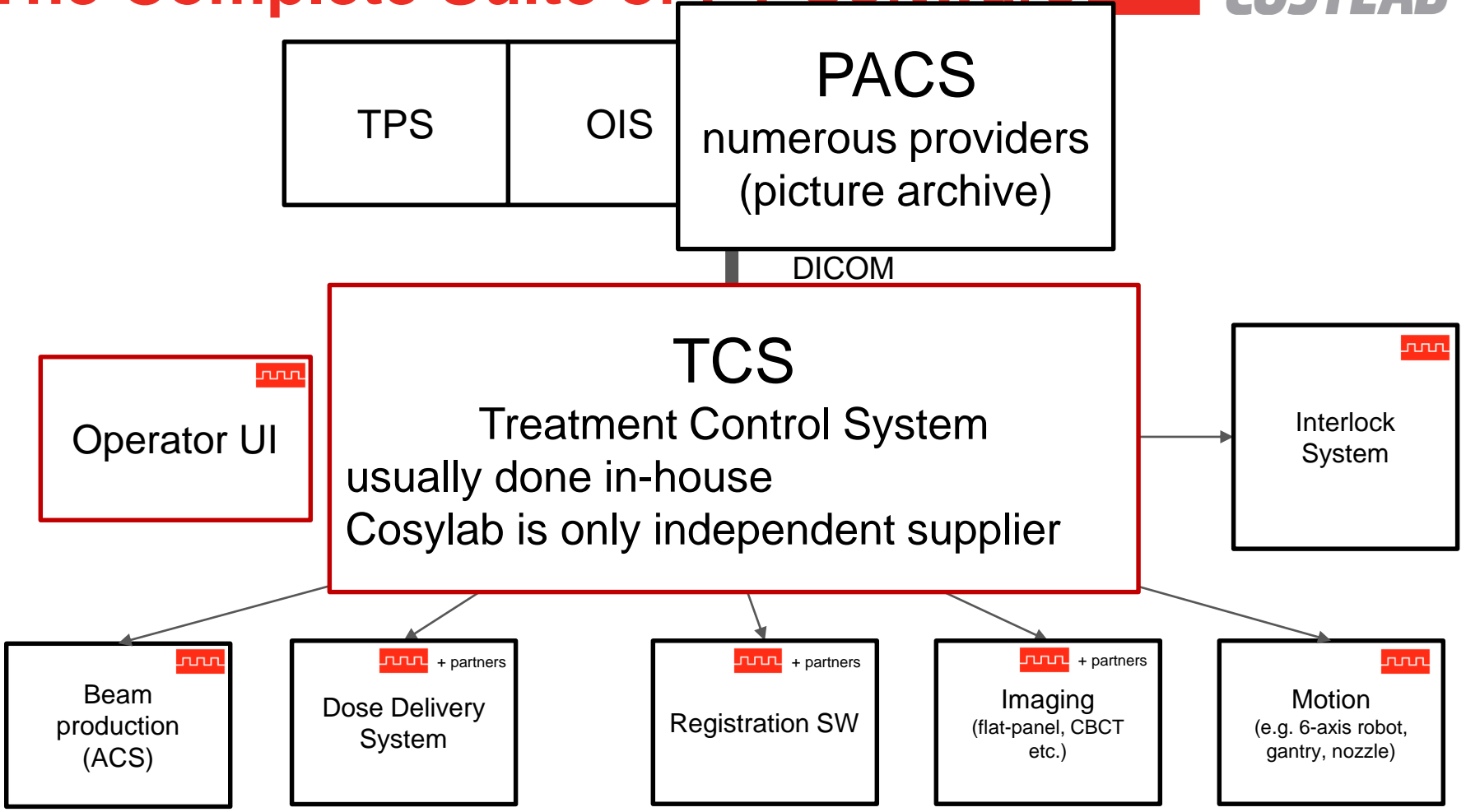
Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)



Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)

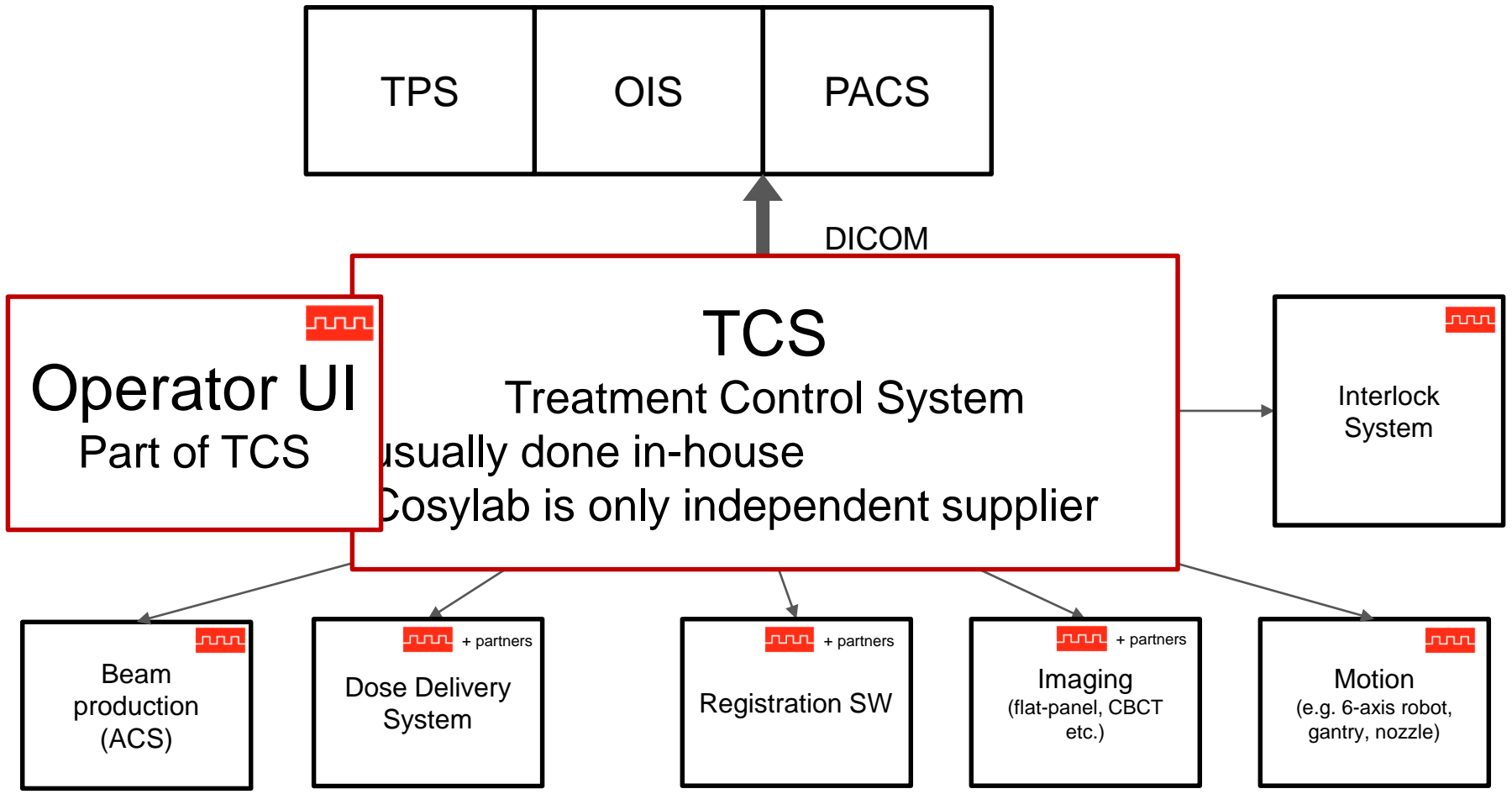


Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)



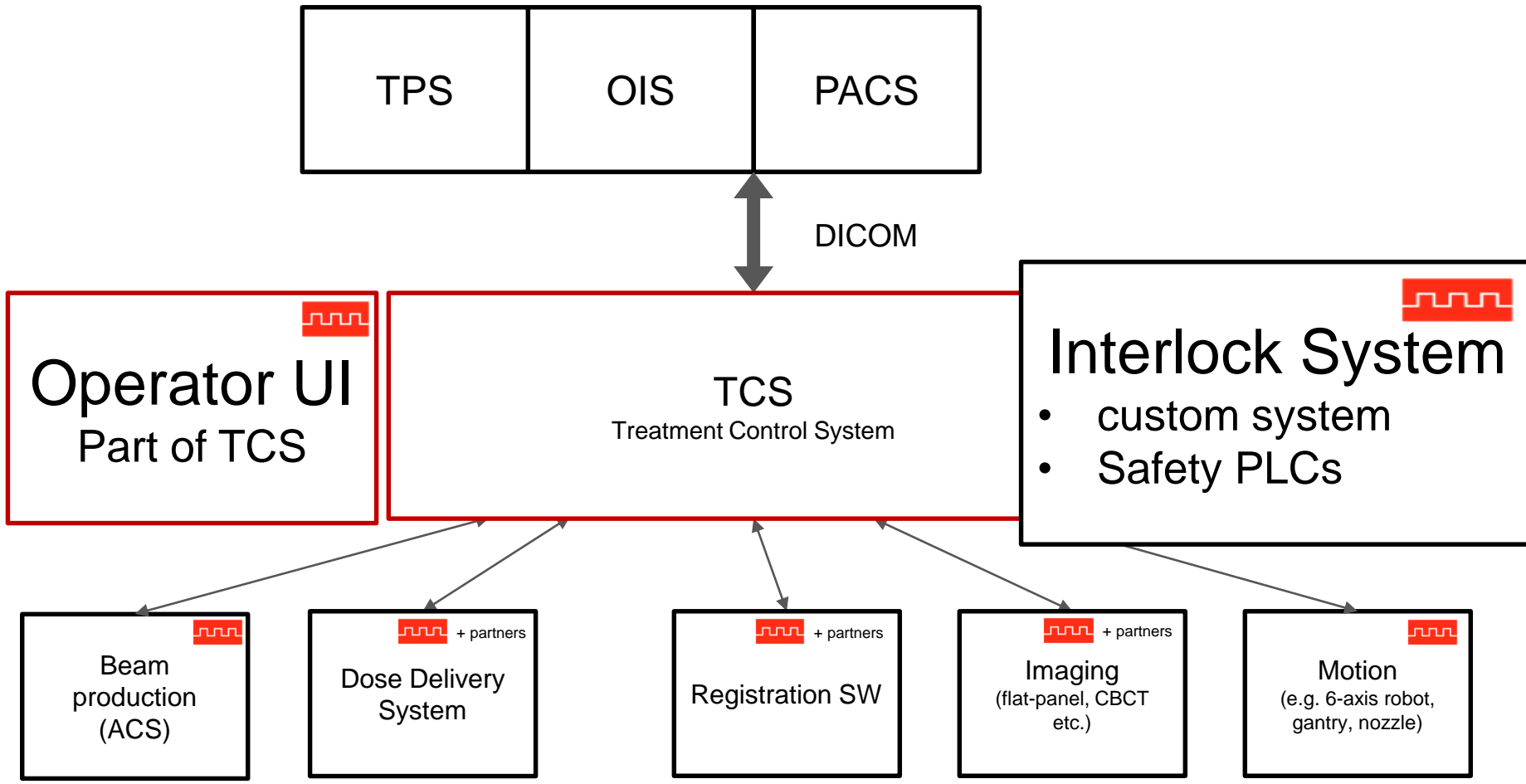
Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)

The Complete Suite of PT Software COSYLAB



Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)

The Complete Suite of PT Software **COSYLAB**

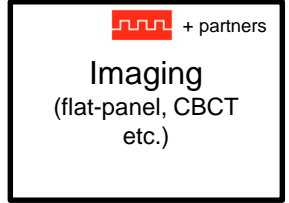
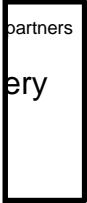
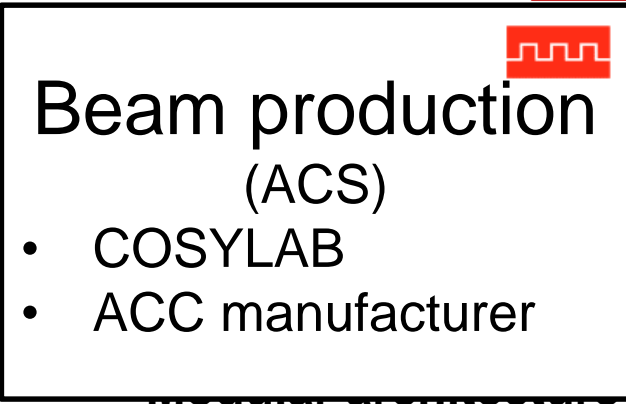


Modular architecture to enable fast development of custom interfaces (OIS, imaging, motion etc.)

The Complete Suite of PT Software COSYLAB

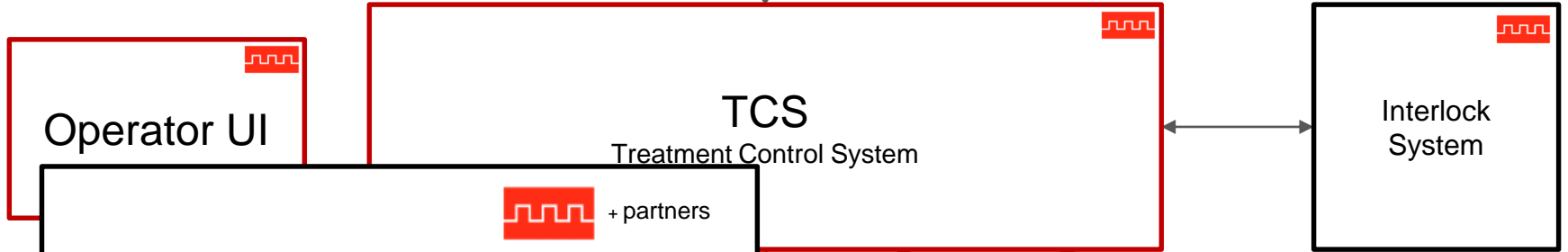
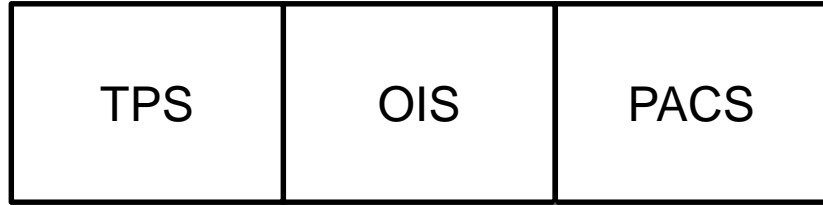



DICOM



to enable fast development of custom interfaces
(OIS, imaging, motion etc.)

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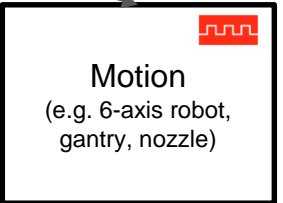
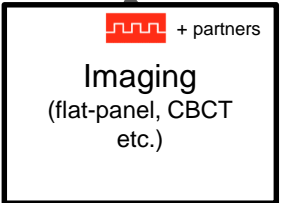
 + partners

Dose Delivery System

- Pyramid (PBS)
- Varian (proprietary)
- IBA (proprietary)

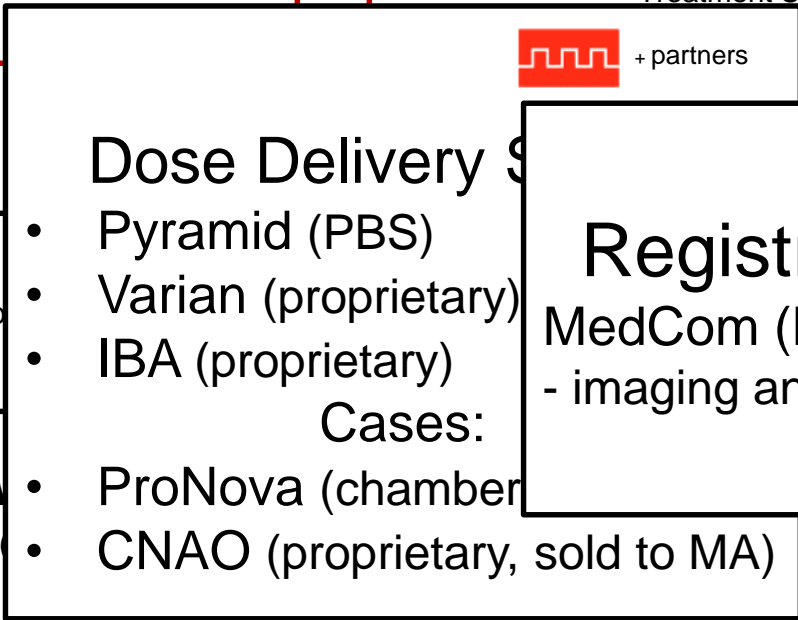
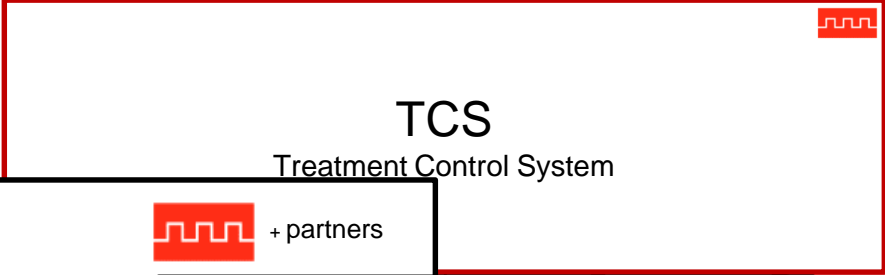
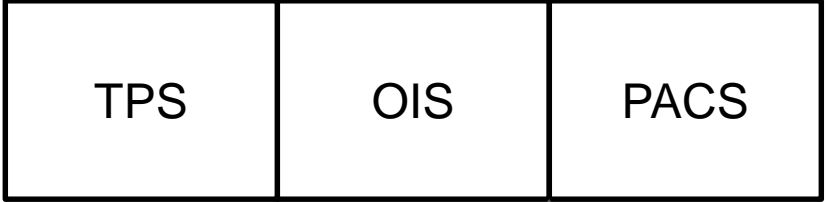
Cases:

- ProNova (chamber bought)
- CNAO (proprietary, sold to MA)



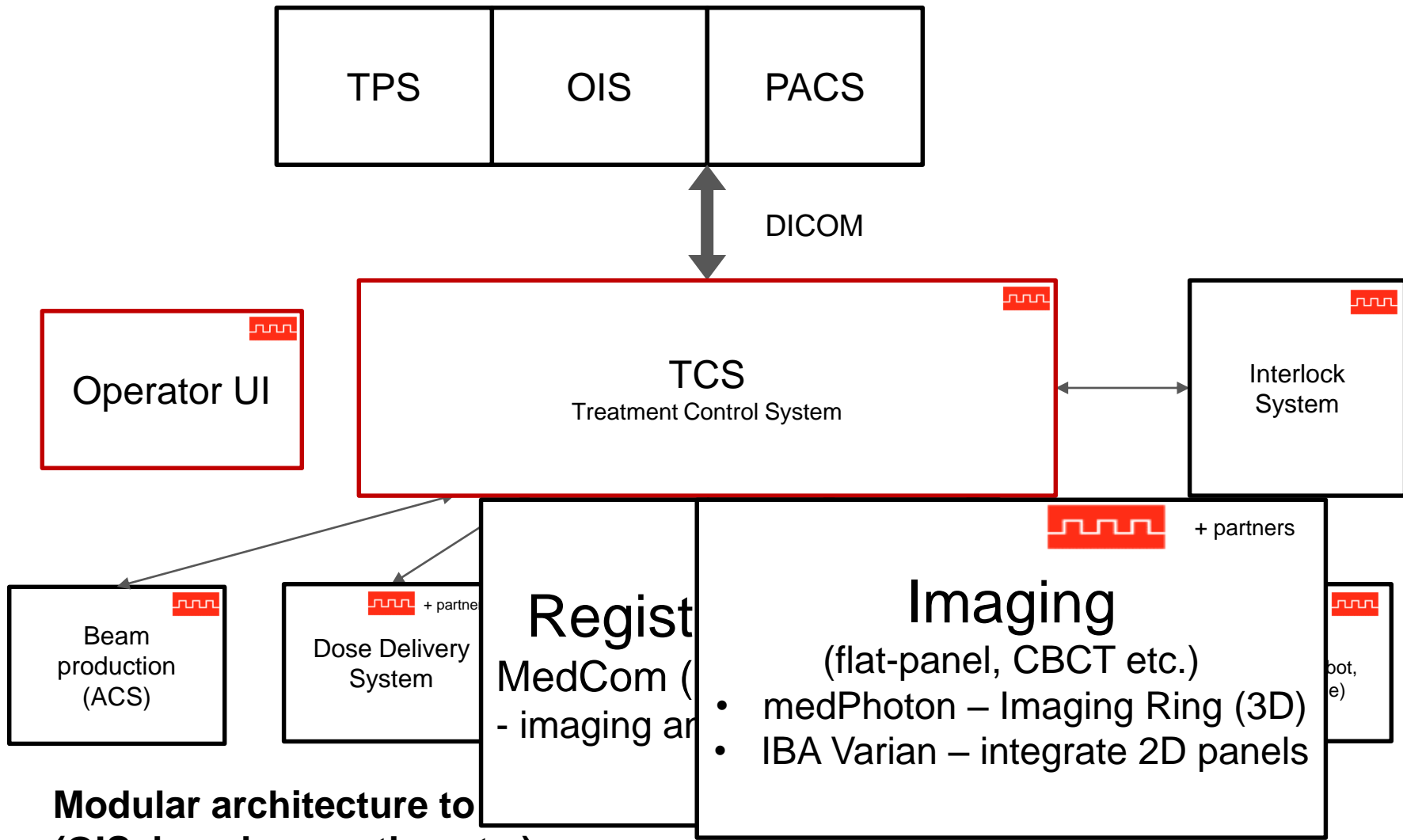
development of custom interfaces

The Complete Suite of PT Software **COSYLAB**



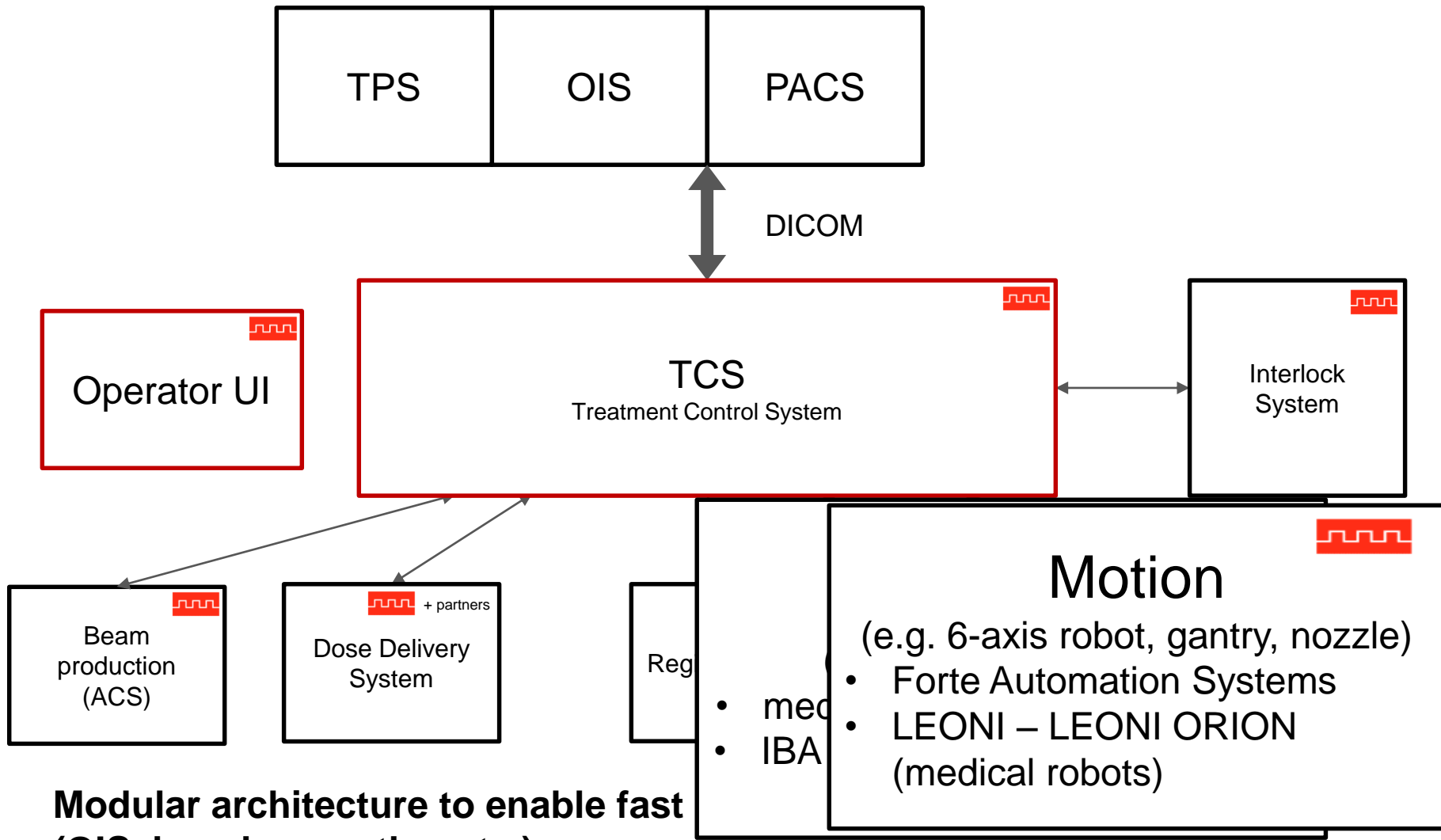
custom interfaces

The Complete Suite of PT Software COSYLAB



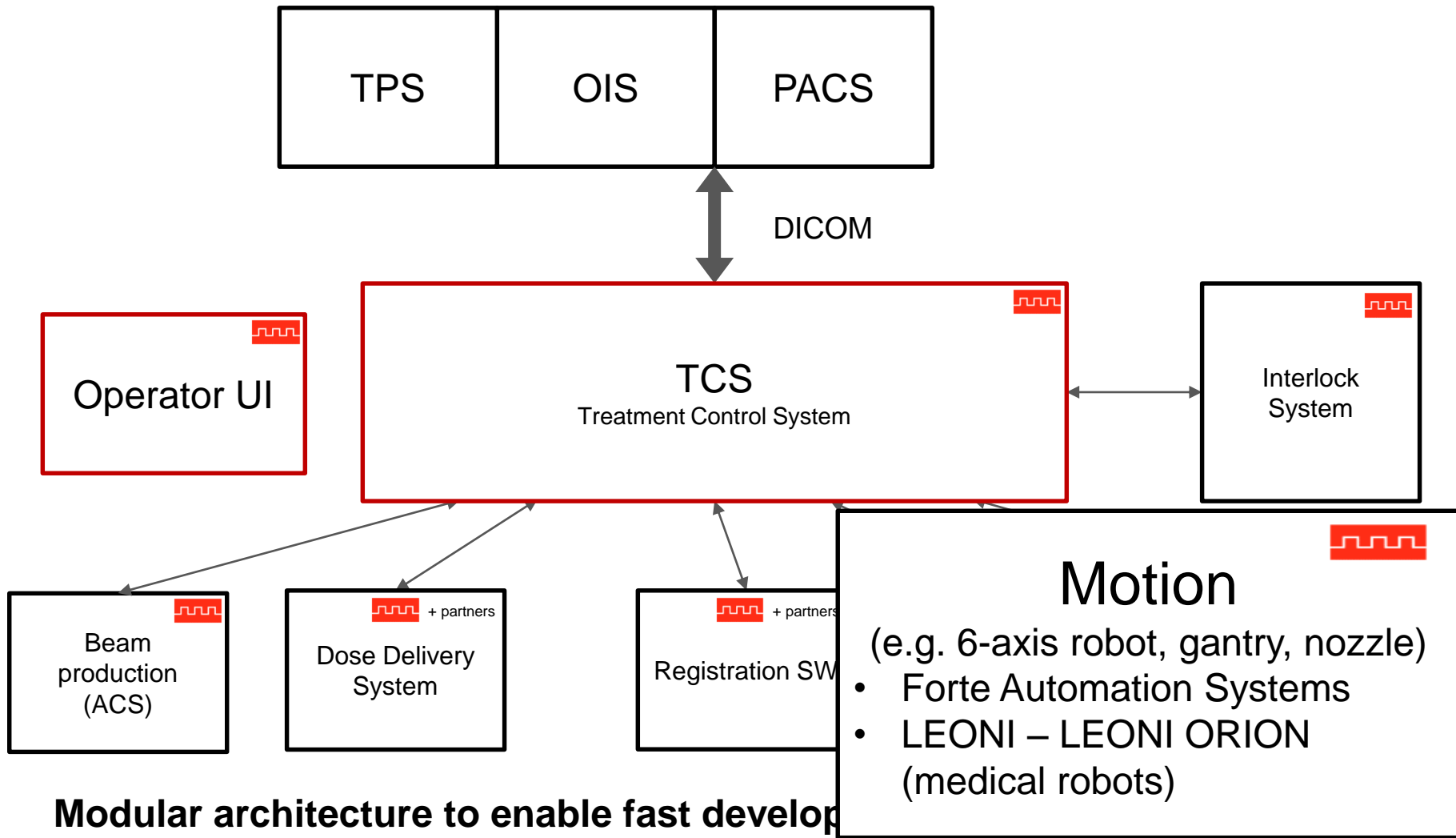
Modular architecture to (OIS, imaging, motion etc.)

The Complete Suite of PT Software COSYLAB



Modular architecture to enable fast (OIS, imaging, motion etc.)

The Complete Suite of PT Software COSYLAB



Modular architecture to enable fast development (OIS, imaging, motion etc.)

**OK, I GIVE UP – WHERE
CAN I JUST BUY THE
CONTROL SYSTEM?**

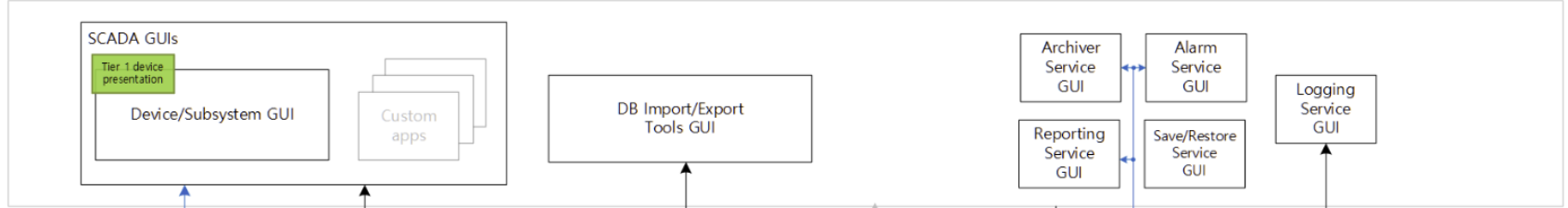
Your **TRUSTED** Control System Partner



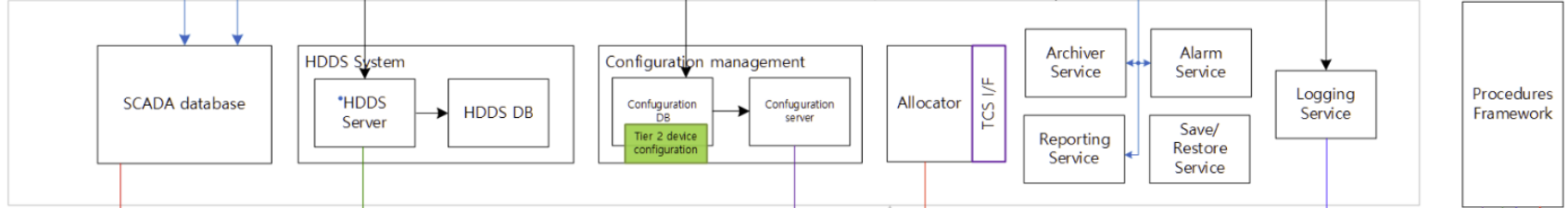
What is provided by the Installation-ready SW (white), what has to be implemented (green), and where the interfaces are (red)



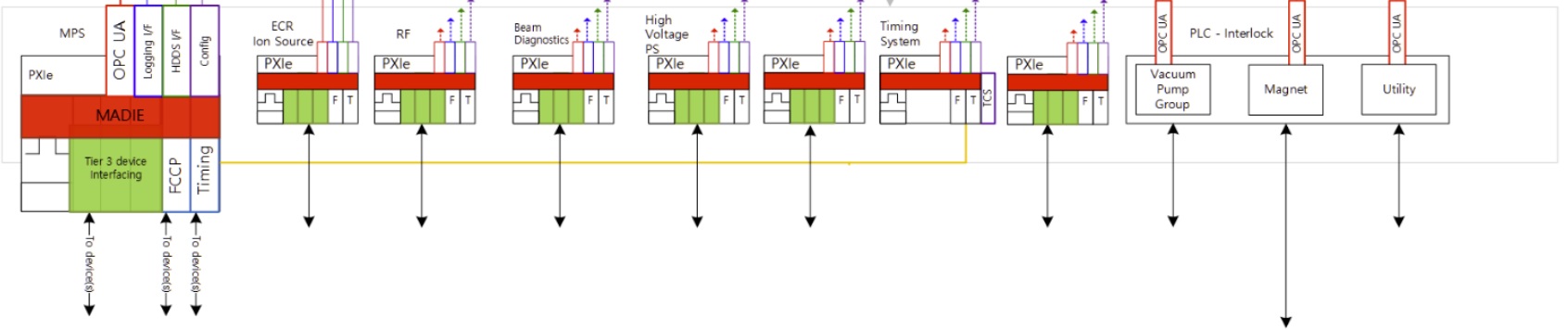
Tier 1 – Presentation /GUI



Tier 2 – Service (Process)



Tier 3 – Equipment



Let's talk dimensions

integration



SUMMARY: What Are The Hidden Problems When Developing the CS?



- We must make sure that it will work in all the fine details
 - In time, In budget
 - No bugs in all the systems interconnected
 - All documentation for all the subsystems will be written properly
- The difficulties and time spent on integrating different subsystems
- To certify the development AND work processes
- BONUS PROBLEM:
 - On-site **installation & commissioning**



Thank You!

Your **TRUSTED** Control System Partner

