PAUL SCHERRER INSTITUT

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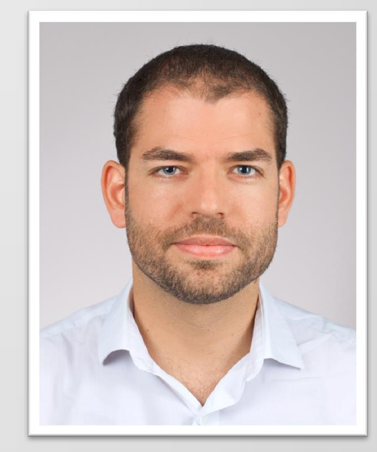
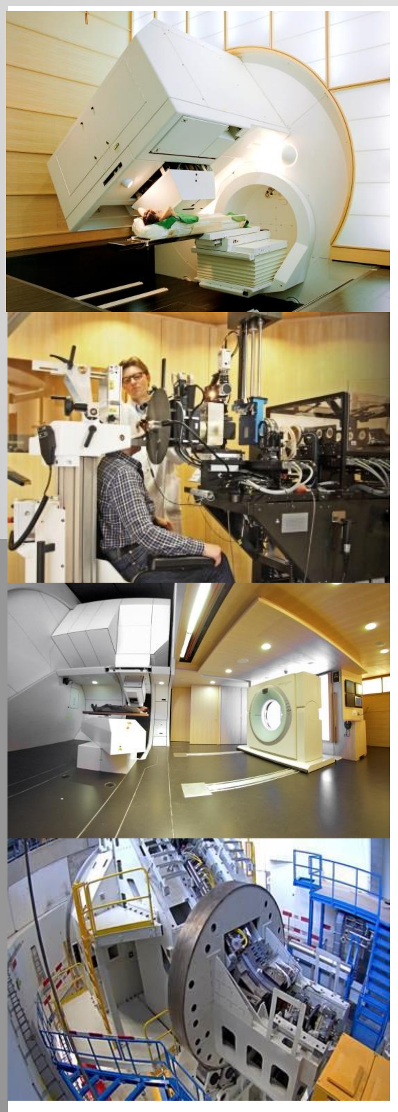
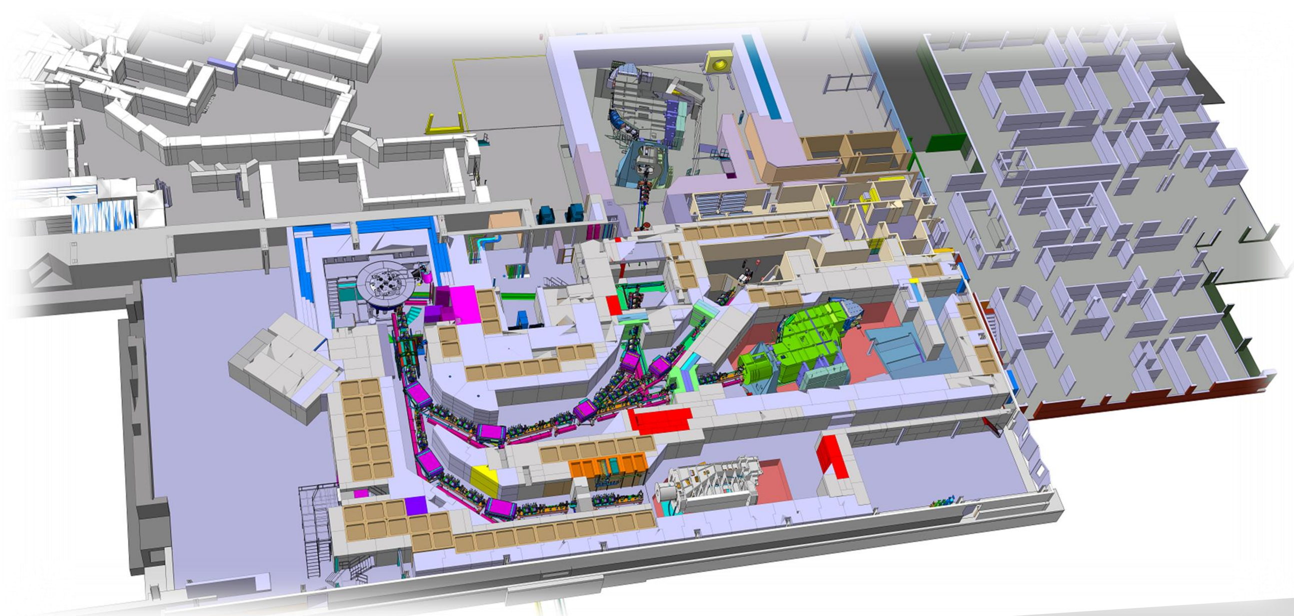


SIGNIFICANT ACCELERATION OF DEVELOPMENT BY AUTOMATING QUALITY ASSURANCE OF A MEDICAL PARTICLE ACCELERATOR SAFETY SYSTEM USING A FORMAL LANGUAGE DRIVEN TEST STAND

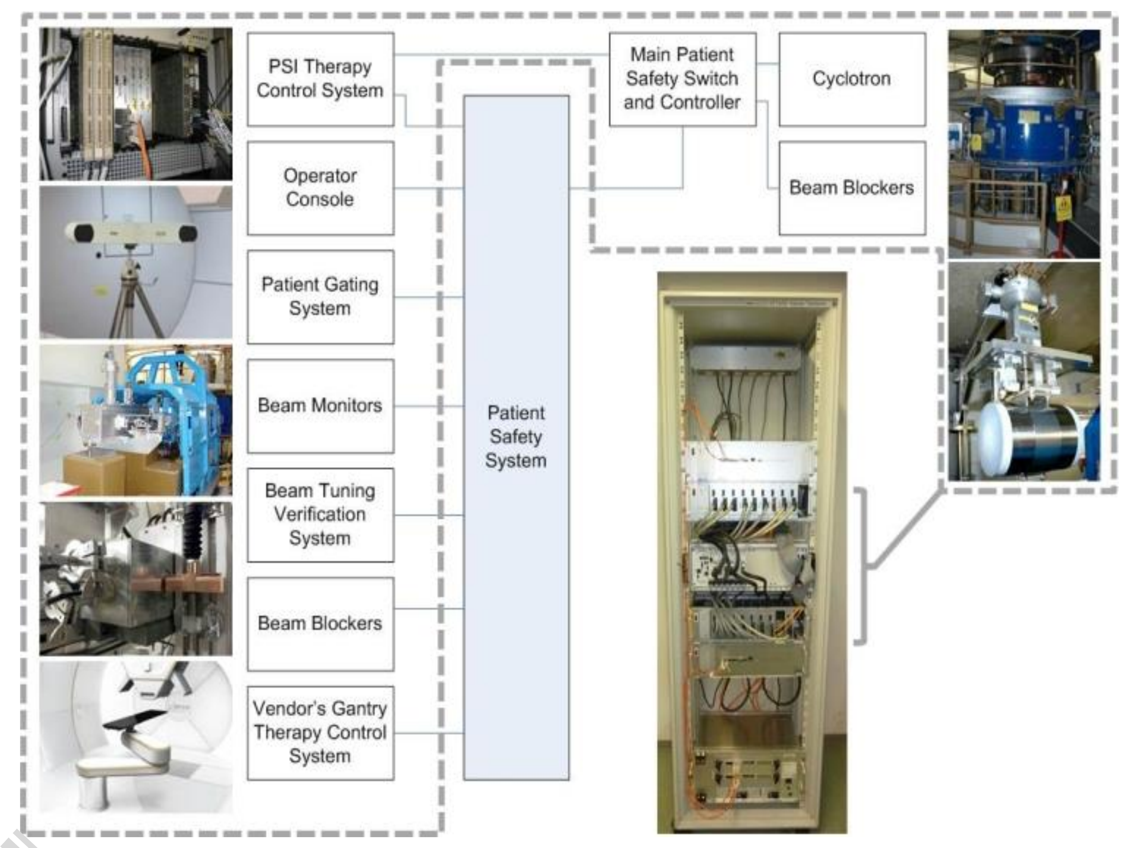


INTRODUCTION

At the Centre for Proton Therapy at the Paul Scherrer Institute in Switzerland, cancer patients are treated with a fixed beamline and in two gantries for ocular and non-ocular malignancies, respectively. For the installation of a third gantry a new patient safety system (PaSS) was developed and is sequentially being rolled out to update the existing areas. The aim of PaSS is to interrupt the treatment whenever any sub-system detects a hazardous condition.

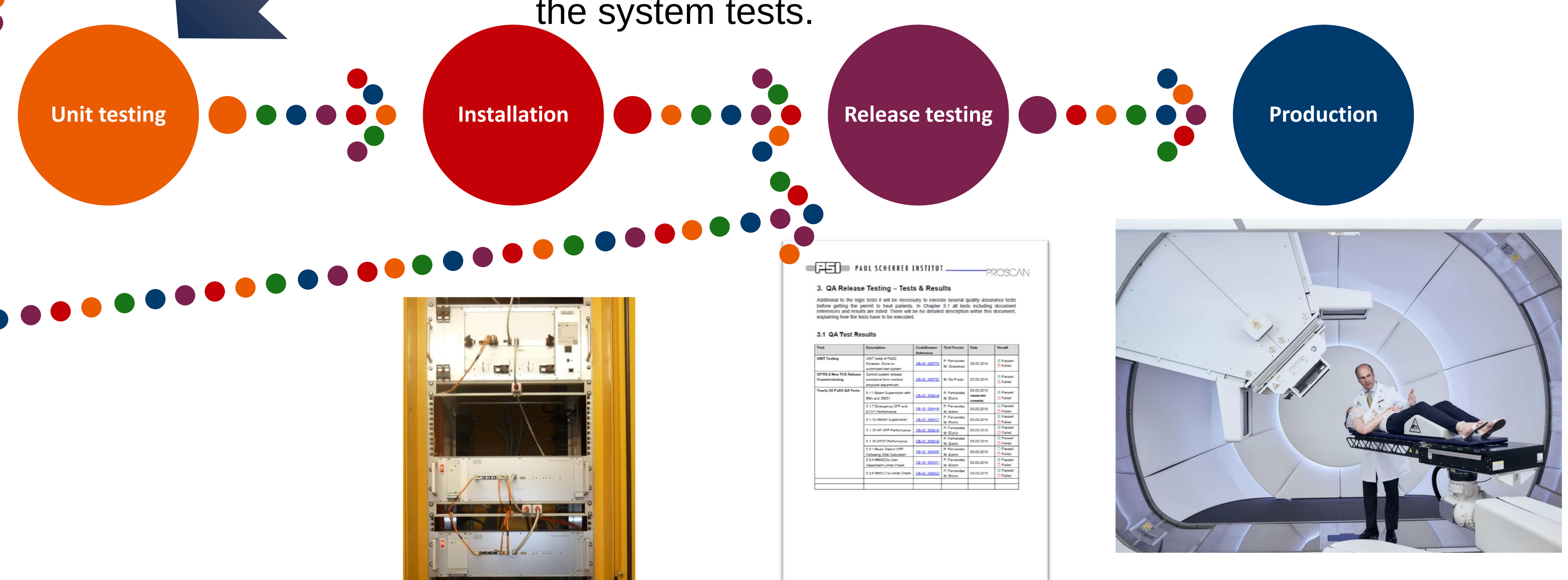


To ensure correct treatment delivery, this system needs to be thoroughly tested as part of the regular quality assurance (QA) protocols as well as after any upgrade. In order to significantly reduce the time, an automated PaSS test stand for unit testing was developed.



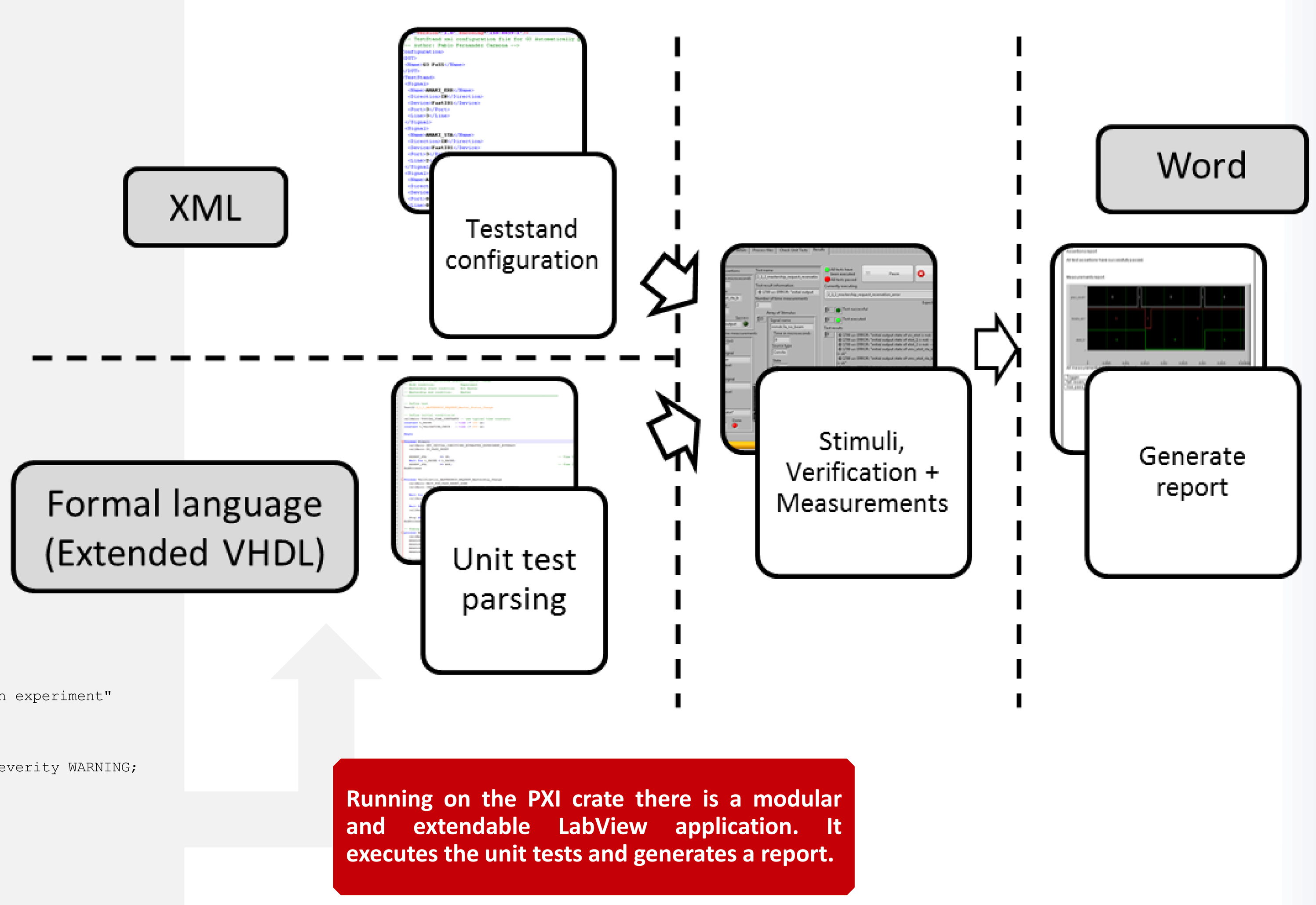
DESIGN & QA FLOW

The report on safety measures is the gold standard from which the PaSS specifications are derived. The testing is divided into unit testing in the lab using the newly designed test stand, and release testing in the facility. Once the system is in production it undergoes regular planned QA. In case of changes, the unit testing is repeated as well as a subset of the system tests.

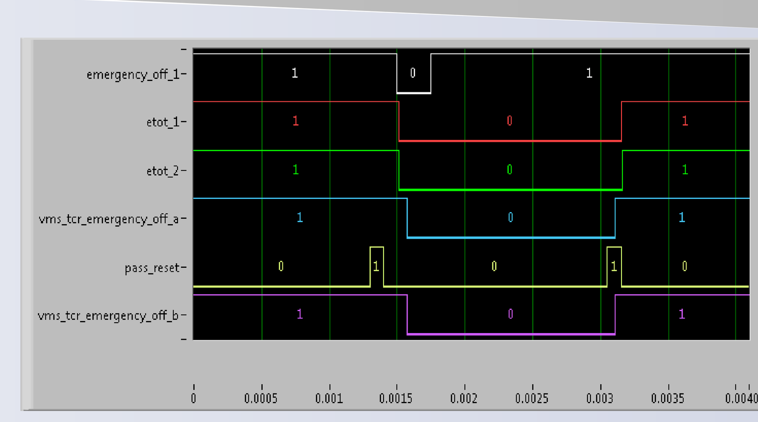


TEST STAND & UNIT TESTS

```
DefineMacro SET_INITIAL_CONDITIONS
   -- PaSS Signal Inputs from control system
      TDS_RDY                  <= OK;
      START_TREATMENT          <= NOK;
   -- PaSS Signal Inputs from Operating Box
      MODE                     <= NOK;
      OPERATOR_RDY             <= NOK;
EndMacro
...

-- Define test
TestID 1_1_CHECK_BASIC_INTERLOCK
constant t_PAUSE              : time := 100 us;
constant t_VALIDATION_CHECK   : time := 200 us;

Begin
Process Stimuli
 Loop
  Tag Experiment
   callMacro SET_INITIAL_CONDITIONS
   MODE  <= OK; -- Overwrite macro default
  EndTag
  Tag Therapy
   callMacro SET_INITIAL_CONDITIONS
  EndTag
 EndLoop
 Loop
  Tag Master
   AREA_IS_MASTER  <= OK;
  EndTag
  Tag NotMaster
   AREA_IS_MASTER  <= NOK;
  EndTag
 EndLoop
 callMacro DO_PASS_RESET
 Wait for t_PAUSE;
 START_TREATMENT  <= OK;
EndProcess

Process Verification_BASIC_INTERLOCK
 Wait for t_VALIDATION_CHECK;
 Loop
  Tag Experiment
   Assert OUTPUT_ILK = NOK report "No treatment allowed in experiment"
severity ERROR;
  EndTag
  Tag Therapy
   Assert OUTPUT_ILK = OK report "Unexpected interlock" severity WARNING;
  EndTag
 EndLoop
 Stop after 100 us;
EndProcess

-- Timing measurements
process Measure_times
 callMacro WAIT_FOR_MEASURE_DELAY
 measure rising_edge(RESET) to falling_edge(OUTPUT_ILK) name "time to clear
interlocks";
 measure rising_edge(START_TREATMENT) to falling_edge(OUTPUT_ILK) name
"interlock reaction";
EndProcess
EndTestID
```

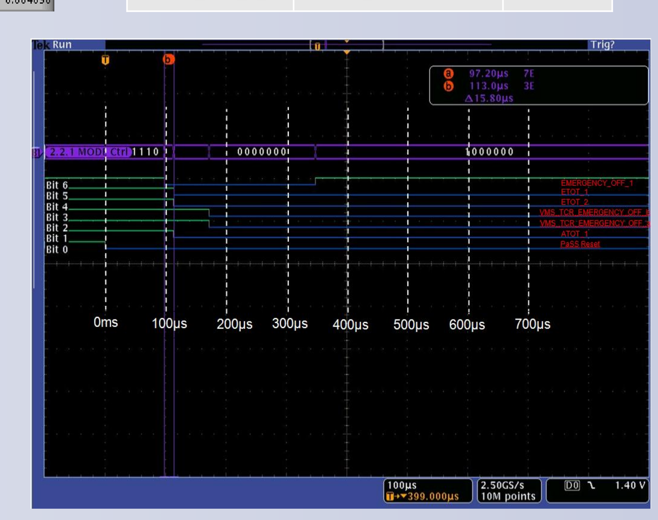


Running on the PXI crate there is a modular and extendable LabView application. It executes the unit tests and generates a report.



CALIBRATION

Trigger	Stopper	Result (us)
fall vms_atot_2_a	rise atot_sta_1	100
fall vms_atot_2_a	rise atot_sta_2	100
fall vms_atot_2_a	rise mmdc3a_no_beam	100
fall vms_atot_2_a	rise mmdc4a_no_beam	2300
fall vms_atot_2_a	fall atot_1	6
fall vms_atot_2_a	fall etot_1	2006
fall vms_atot_2_a	fall etot_2	2006



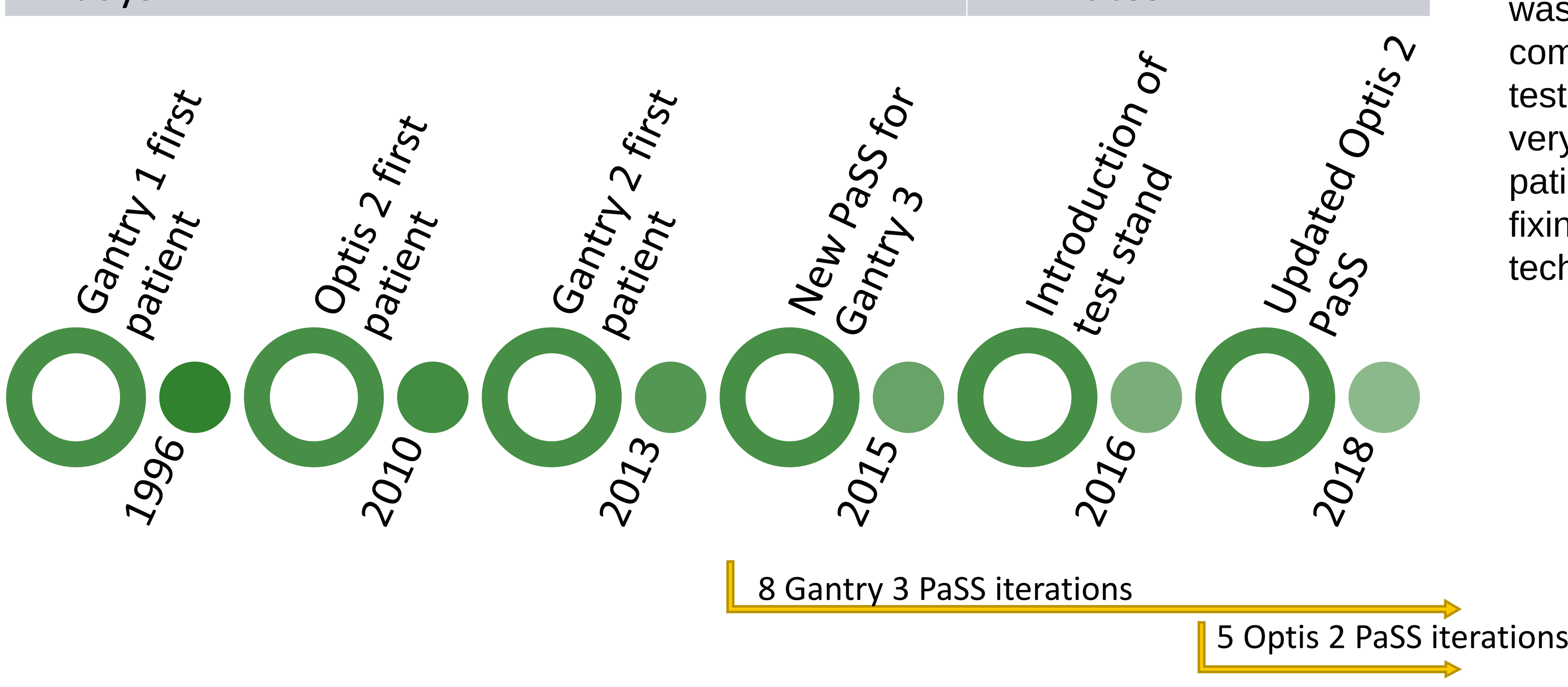
In order to guarantee the correct behavior of the test stand and to be able to trust the unit testing reports, it was calibrated. We chose a subset of real unit tests which were manipulated in a way that the test stand application should detect errors at an expected time.

The tests were executed to generate a test report. It was then verified that all the tests failed as intended. Also, by comparing the generated waveforms from the report and the logic analyzer, it was confirmed that the time measurements matched.

RESULTS

Full PaSS unit testing execution time

14 days	4 minutes



At PSI, a test stand has been developed to automate most of the development QA of the PaSS of our newly installed Gantry 3. The test stand executes unit tests under controlled conditions in the laboratory. It is fast, precise and extendable. The unit tests are written in a formal language that was developed based on VHDL for this purpose and which guarantees a compact, easy to read and unambiguous description. By automating the unit testing of PaSS, an increased level of safety has been achieved, allowing very complete tests scenarios in less time, therefore freeing up beam time for patient treatment and research. The development cycles in upgrades and bug fixing have also been shortened, as showed in the implementation of this new technology rolled out in the Optis 2 area.

CONTACT
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PLEASE ALSO CHECK
Pixel Detector System for Pencil Beam Scanning Proton Therapy
Michael Eichin Thursday 14th, 10:40
Progress in Particle Therapy Enabled by Technology
David Meer Friday 15th, 08:30