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Technical log files analysis for patient treatment optimization

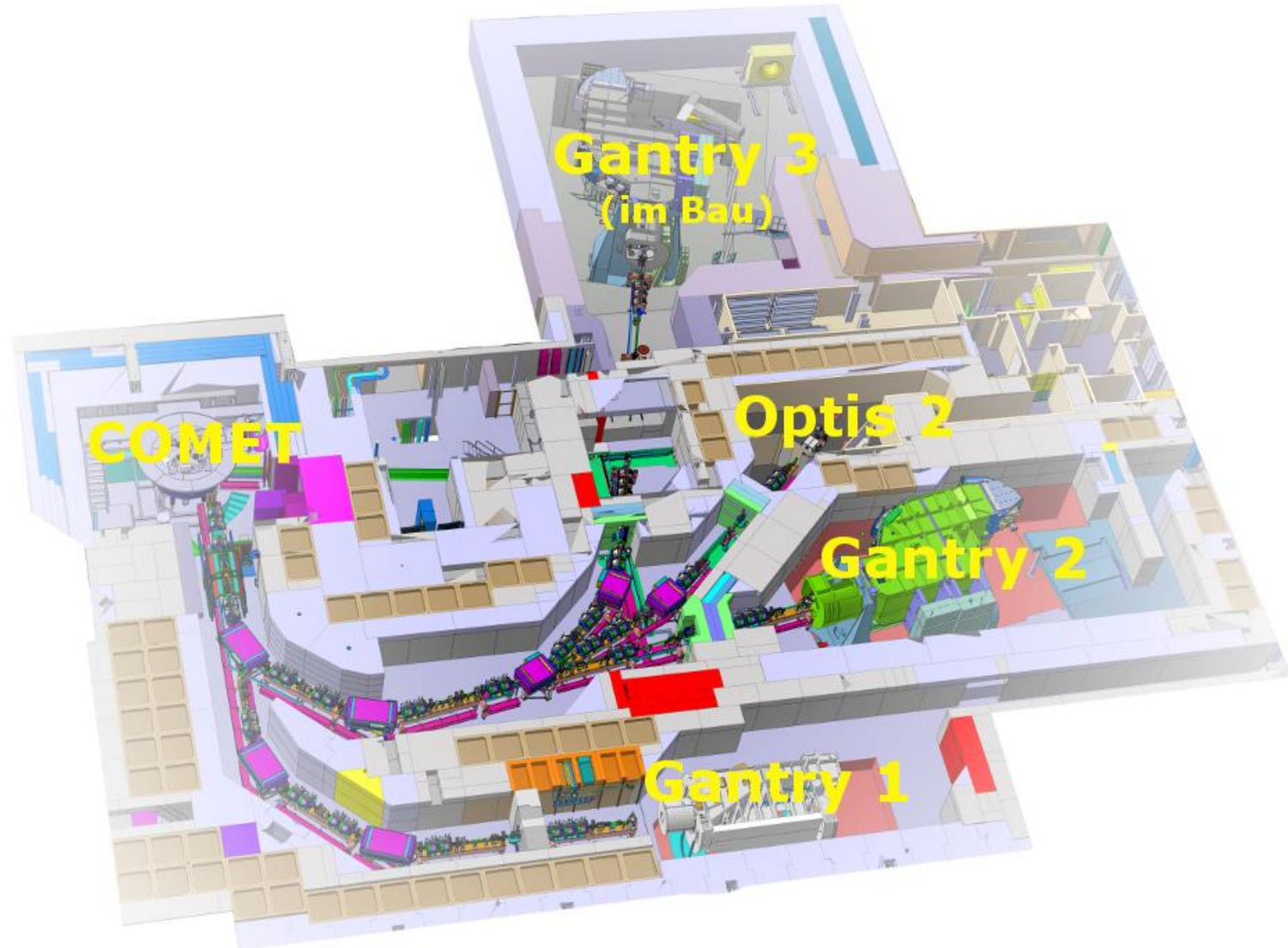
1st OMA Workshop 2018 – 13 March 2018

Log files are an essential basis for proton therapy facility development and optimization.

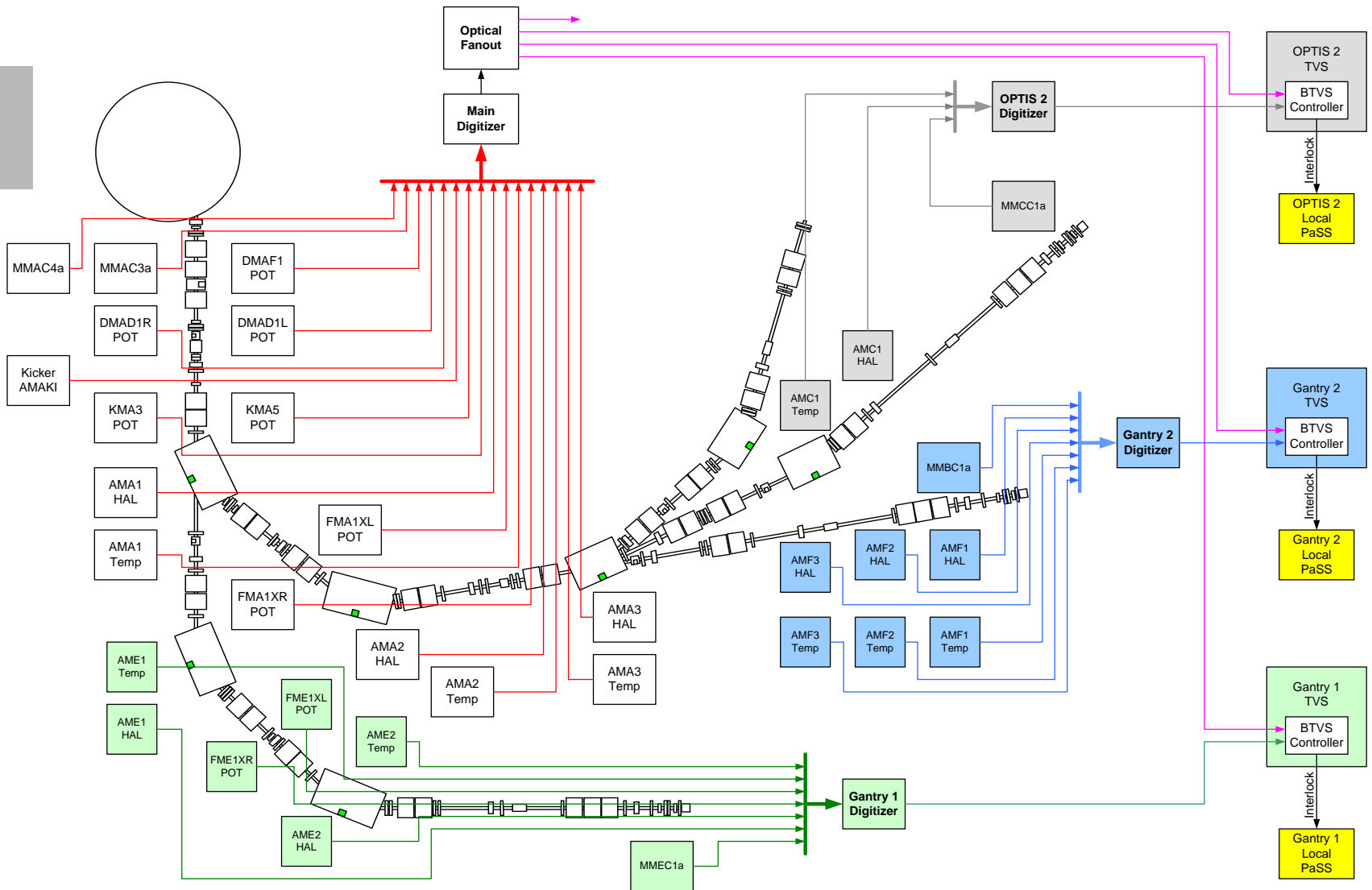
- Provide insight of the machine performance
- Allow diagnostic and prevention of technical issue
- Basis for future upgrades

This presentation is about the solution adopted at CPT

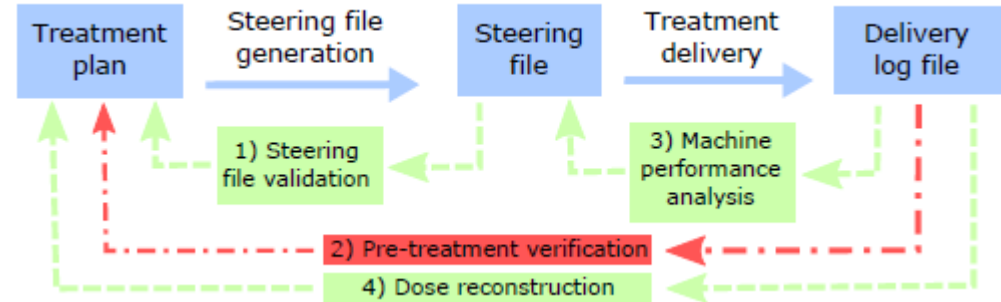




Introduction – CPT systems example : BTVS



Treatment verification process



1. Steering file validation
2. Pre-treatment verification
3. Post-treatment machine performance analysis
4. Dose reconstruction

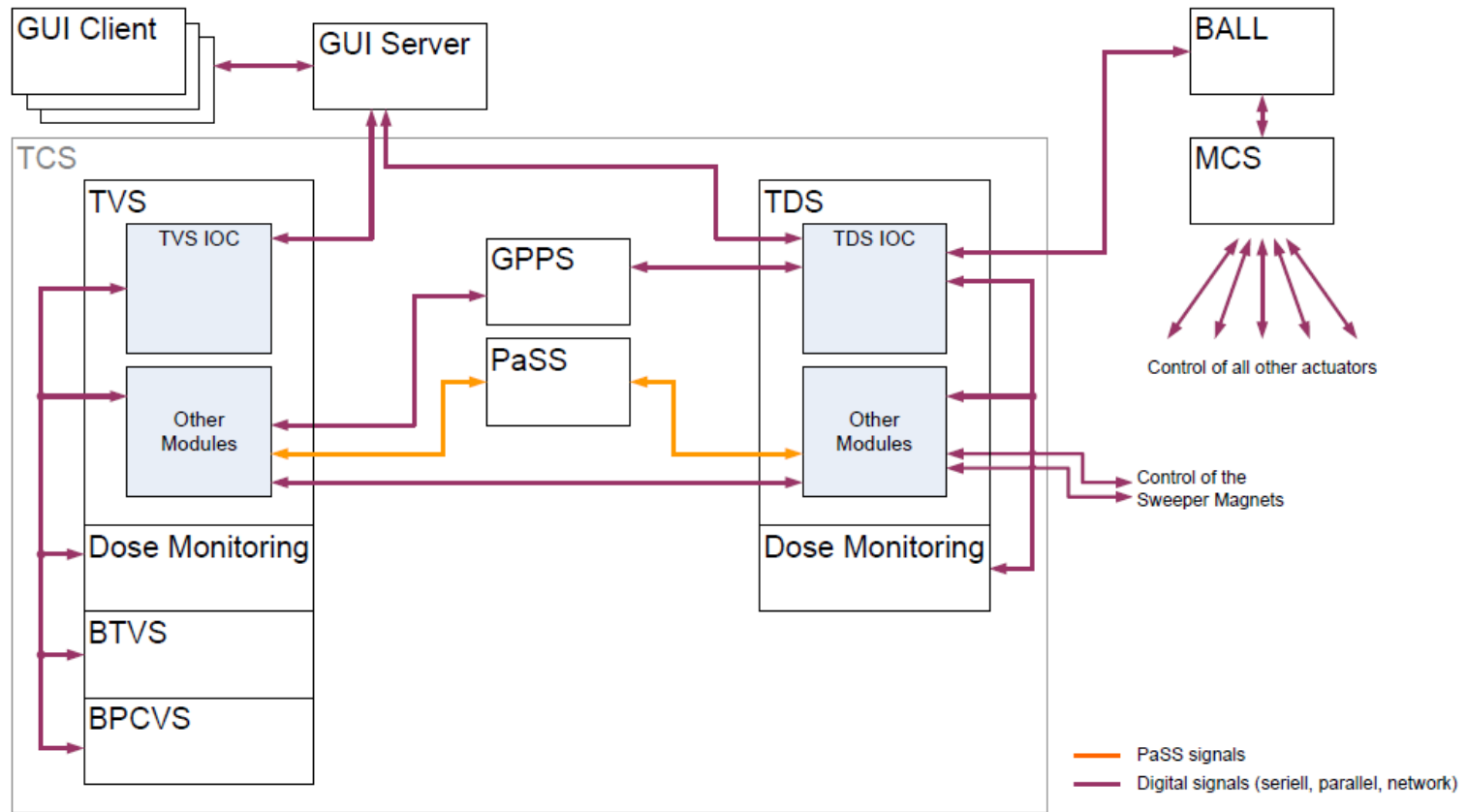
Some considerations

The log files need some foreseeing

- Log file format
 - Easy to read or not (Human readable or binary format?)
- Log file structure
 - How to structure the information inside a file?
- Log file archiving
 - How the data is stored and access by users?
 - How to protect patient confidentiality?
- What is your main objective?



The Therapy Control System



TCS : Therapy Control System

TVS : Therapy Verification System

TDS : Therapy Delivery System

BTVS : Beam Tune Verification System

BPCVS : Beam Position and Current Verification System

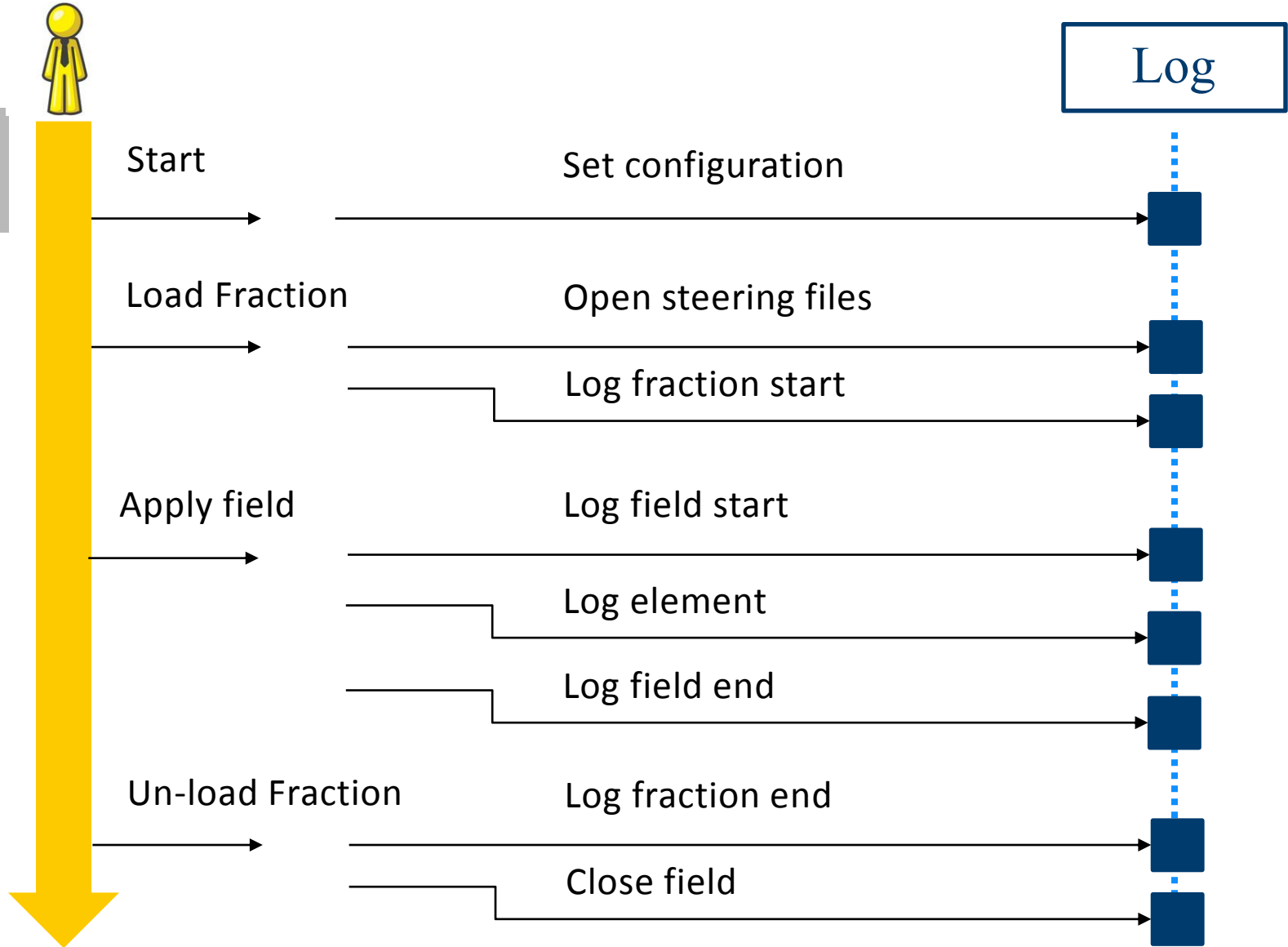
PaSS : Patient Safety System

GPPS : Gantry Patient Positioning System

MCS : Machine Control System

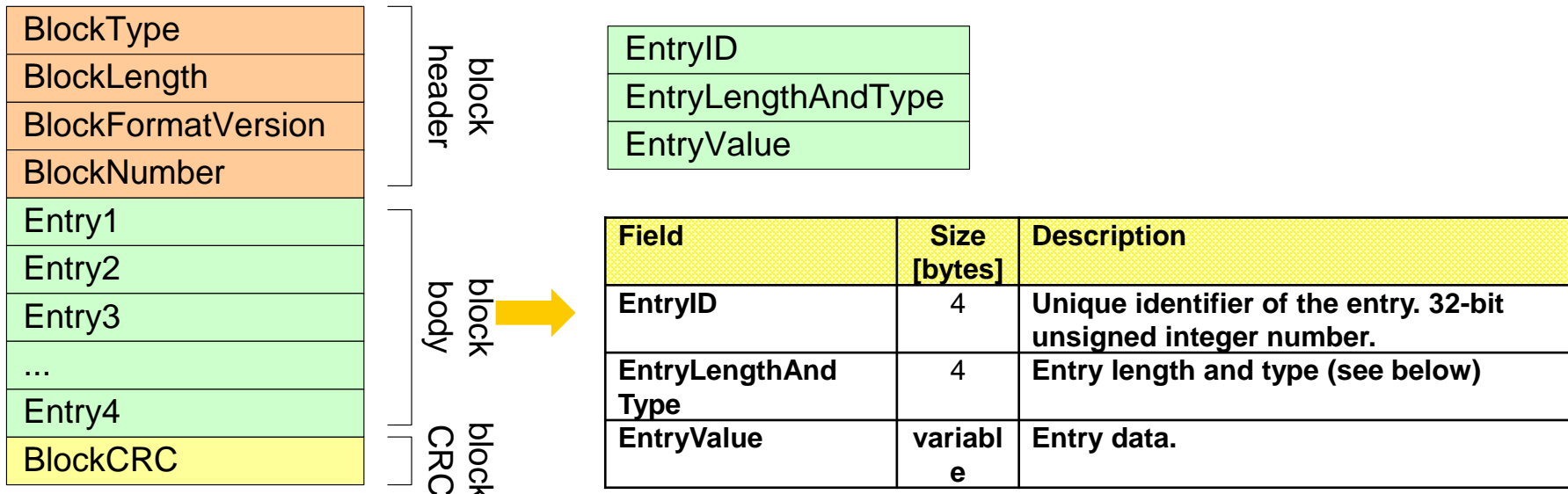
Ball : Beam Allocation

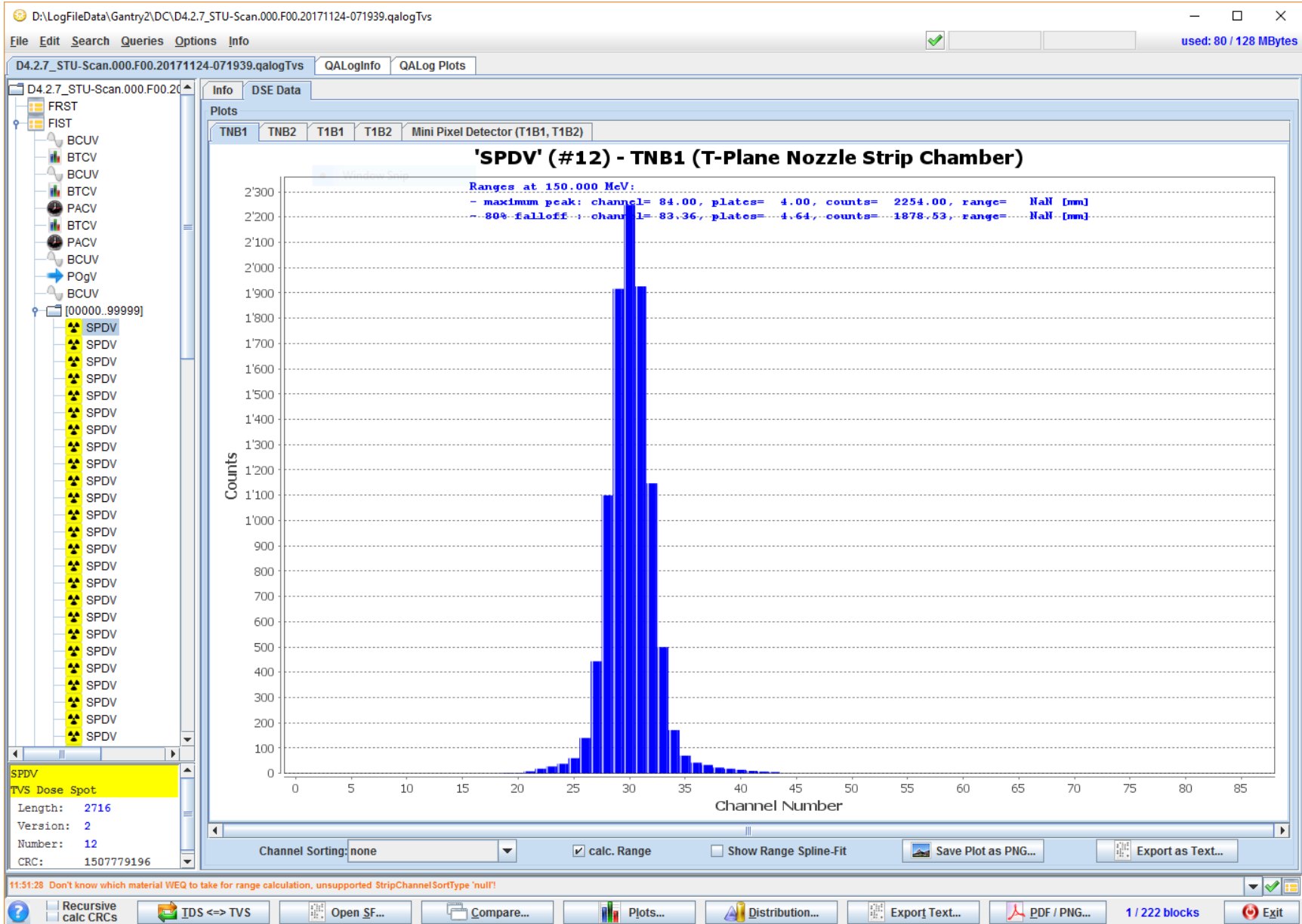
Log file sequence



Log file format

- Format identical to steering files
- Binary format
- Block structure
 - Block header
 - Sequence of entries
 - CRC checksum





What can we learn from log files

The main goals are

- Part of our legal obligations
- Insure health of the therapy system
- Diagnose problems before they affect the clinical operations
- Improve the clinical operations

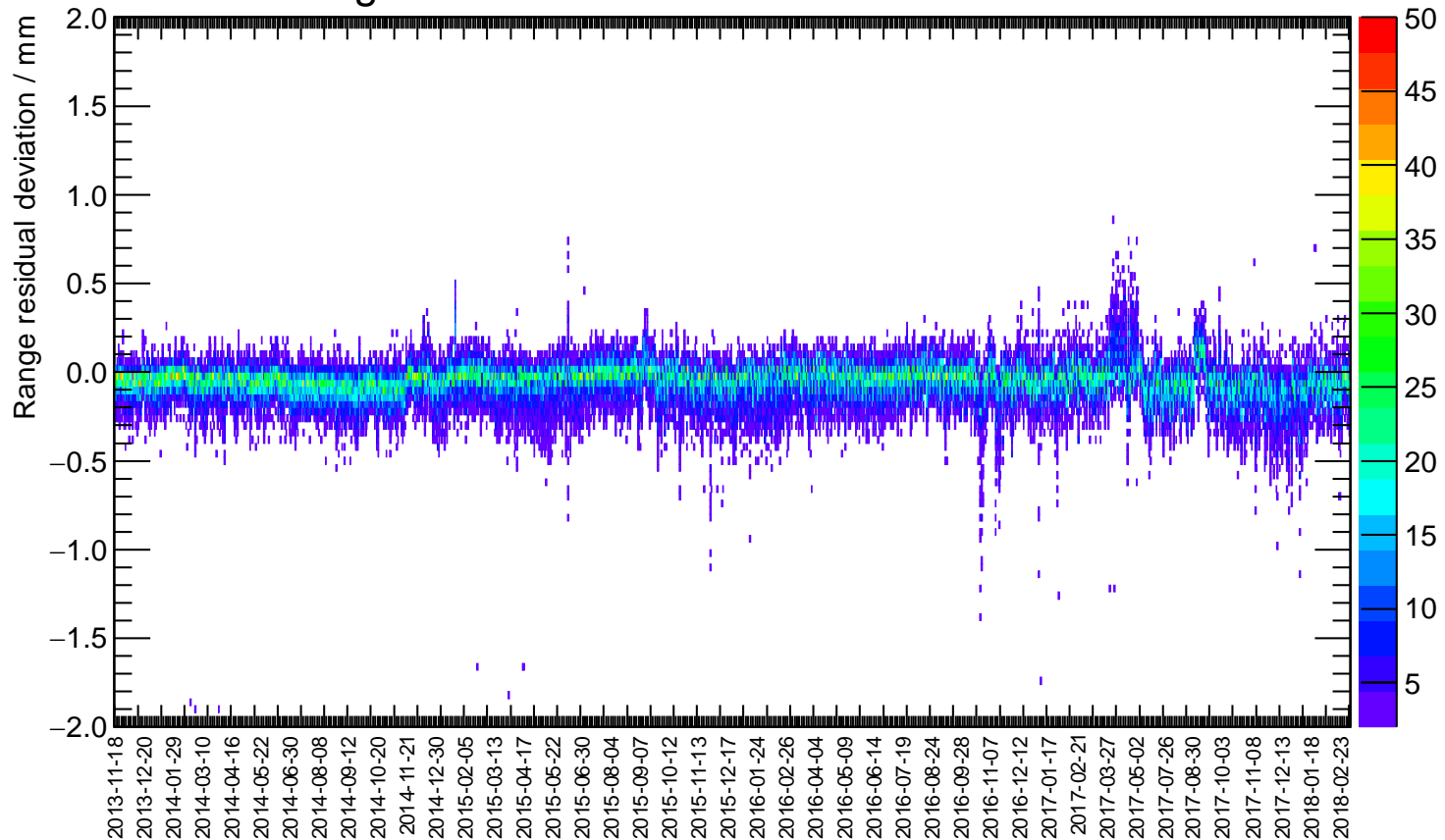


To insure these goals, the machine performance is analyzed using a standard sequence daily and for each fraction delivered to patients.

Daily check key elements

- Dose monitor calibration
- 115 energies range measurement
- (limited) beam phase space measurement
- TVS/TDS interlocks checks
- Dose measurement
- Software written in Matlab
- Results stored in a database
 - Allows easy long term analysis

Range deviation distribution from 2013 to 2018



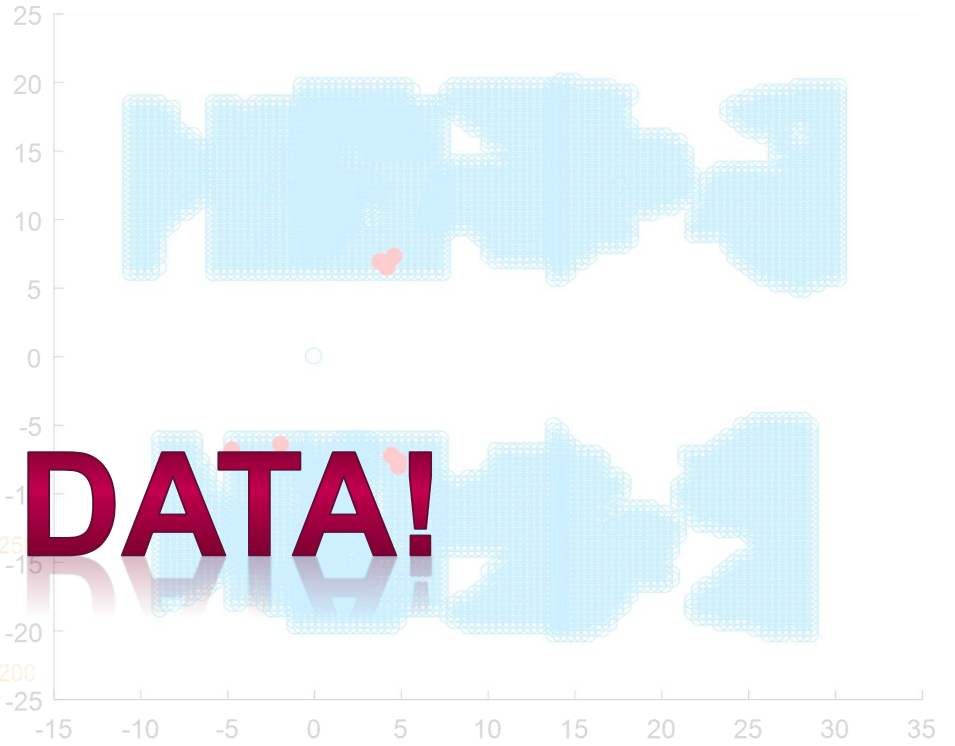
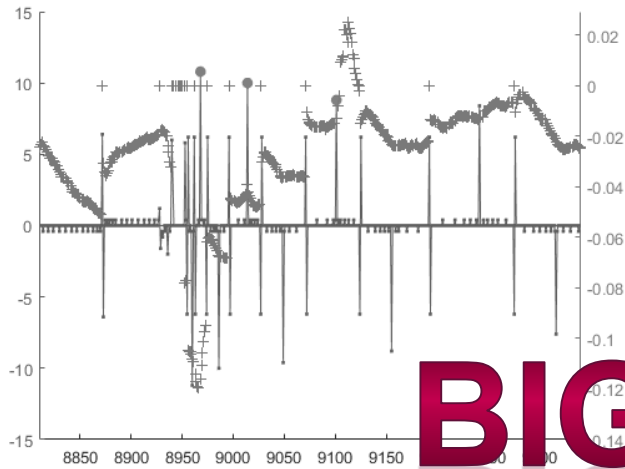
- Double and/or missing spots
 - Interlocks
 - Monitor checks
 - Positioning accuracy
 - Delivery settings
 - Warnings and exceptional events
-
- Software written in Matlab
 - Report is produced on a ~35 pages PDF files.
 - No database

Log file analysis summary

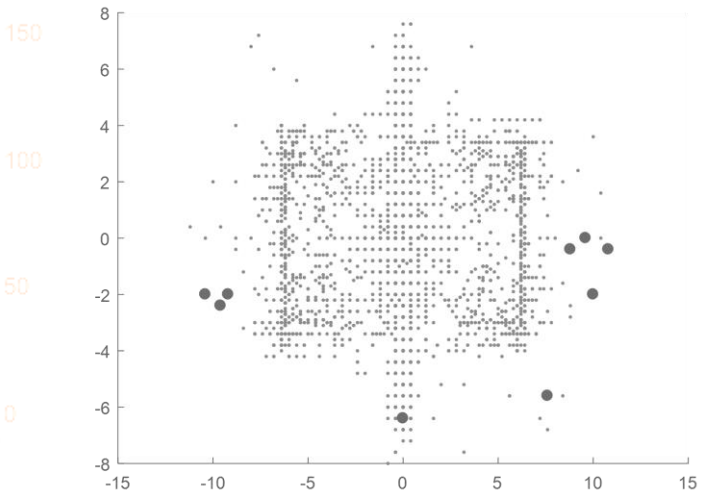
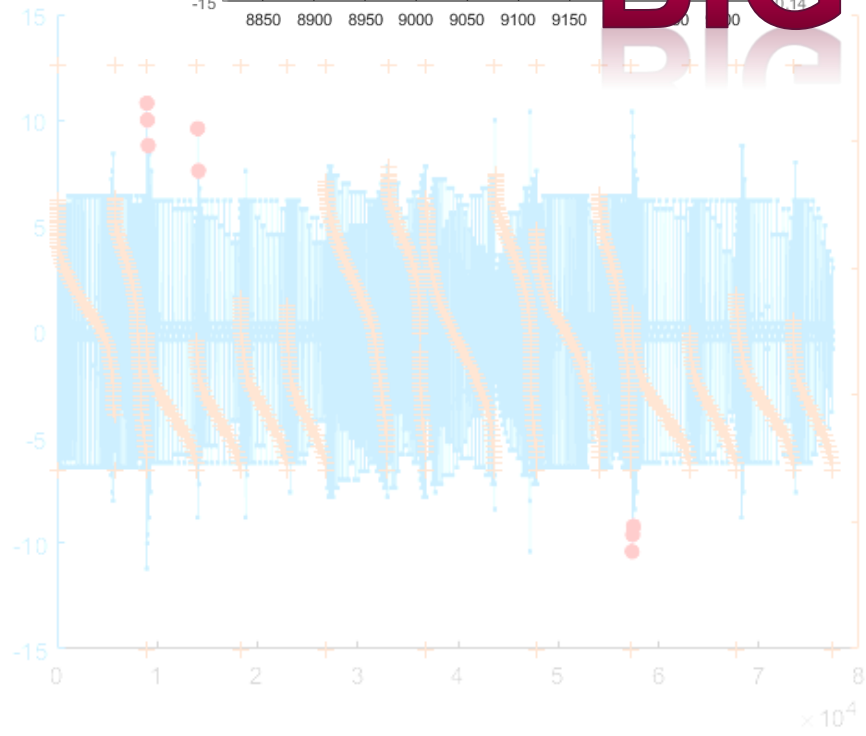
Table 1: Summary information of log file analysis.

Parameter	Value	Unit	Low. lim.	Upp. lim.	Status
Warning messages	No				OK
Param. out of tol.	No				OK
Param. close to tol.	No				OK
Number of interlocks	0				OK
Missing spots	0				OK
M1 total meas. dose	9654568	MU			
M2 total meas. dose	7068368	MU			
M1 total dose dev.	0.177	%	-1.5	1.5	OK
M2 total dose dev.	0.772	%	-1.5	1.5	OK
Skipped spots	0				OK
M1 skipped dose	0.000	%	-1.5	1.5	OK
M2 skipped dose	0.000	%	-1.5	1.5	OK
M1 mean rel. dev.	0.176	%	-1.5	1.5	OK
M2 mean rel. dev.	0.766	%	-1.5	1.5	OK
U position dev.	0.040	mm	-1	1	OK
T position dev.	0.220	mm	-1	1	OK

Example of summary for the log file analysis

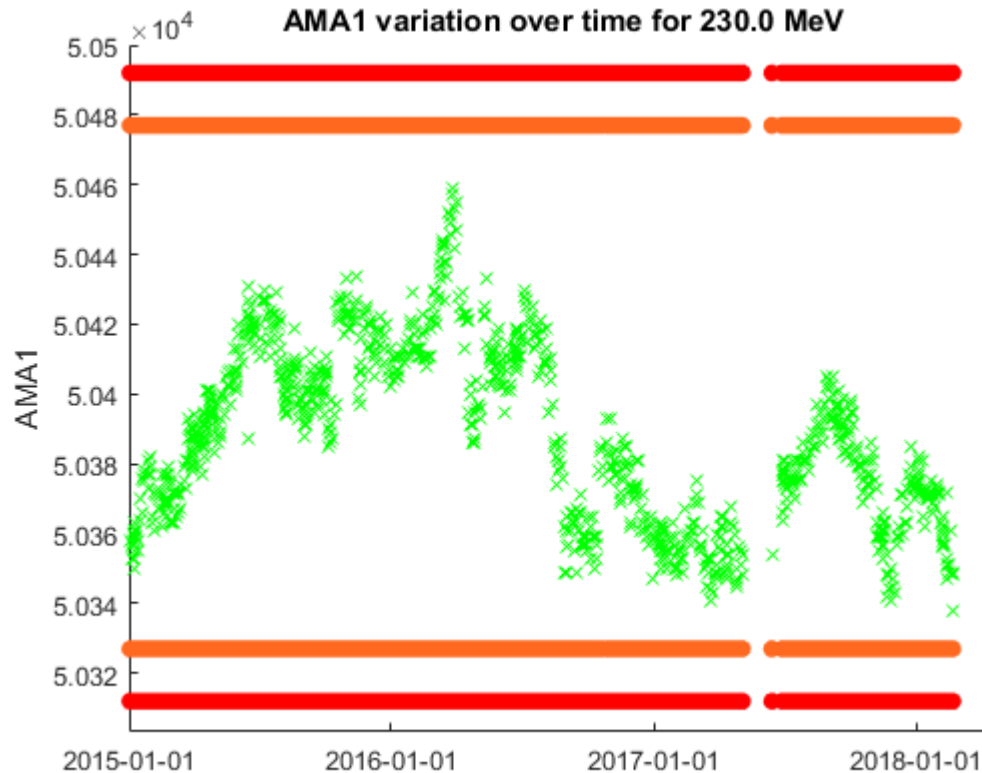


BIG DATA!



Over 5 years of operations: what did we learned?

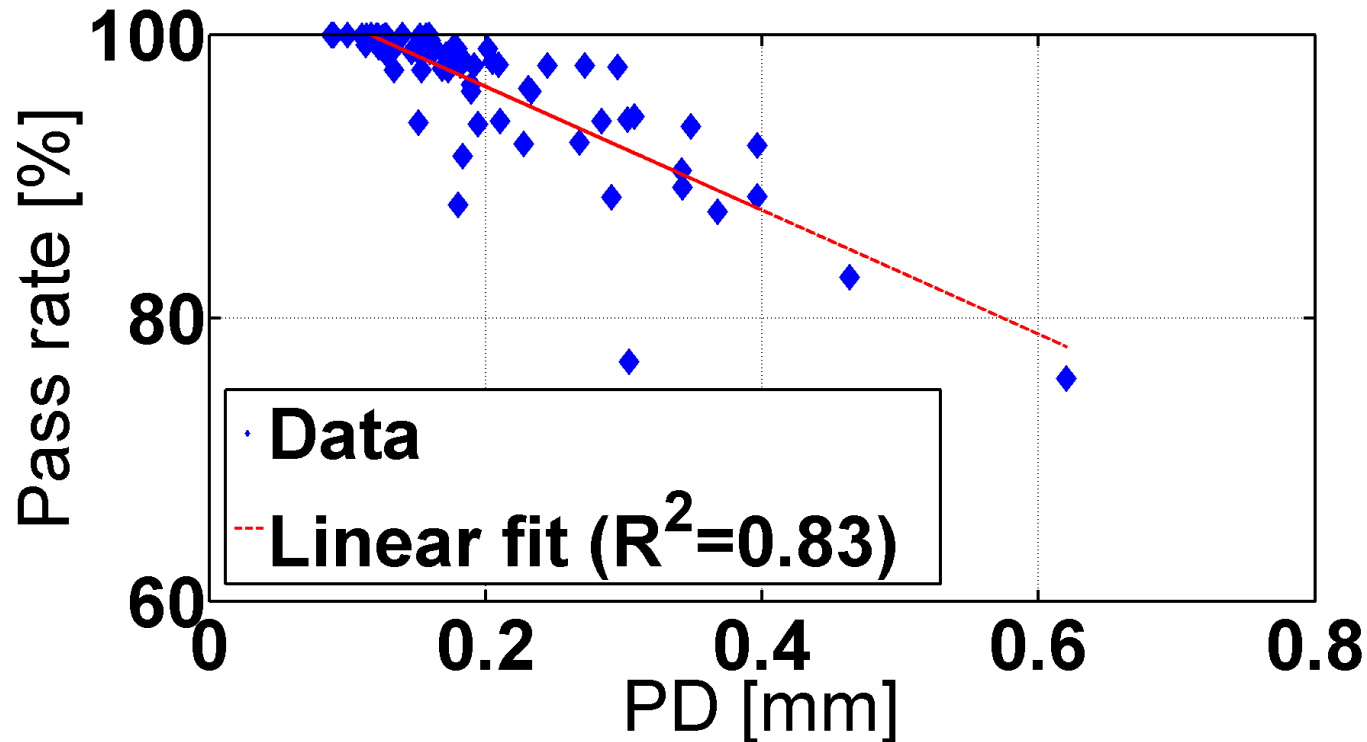
The log file analysis allowed us to get a better prevention routine calibration & part exchanges



Example : deterioration of the AMA1 hall probe over the last year

Over 5 years of operations: what did we learned?

We analyzed 85 delivered fractions in G2 over the first years of treatment (a)



Position deviation (PD) is defined as :

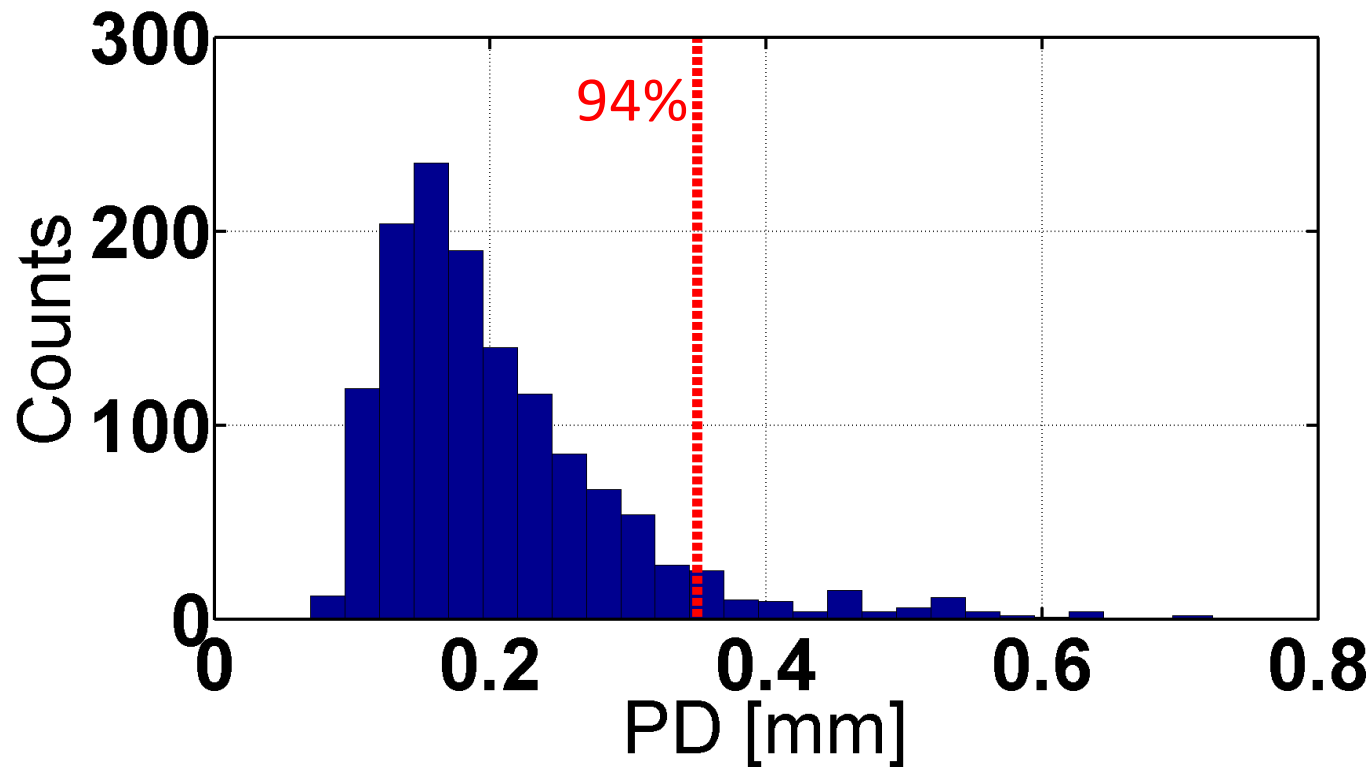
$$PD = (\Delta T_{mean}^2 + \Delta U_{mean}^2)^{1/2}$$

Pass rate is defined as the % of voxels with a dose deviation less than 1%.

Over 5 years of operations: what did we learned?

To achieve a **pass rate > 90%**, a **PD < 0.35 mm** is required.

This correspond of **94% of 1350 fractions** delivered in G2 over the first years of operations



- Too much logging can severely impact machine performance

Example :

Lowering the log of TCS message level from ERROR only to all INFO level
(all TCS actions are then recorded, not only error)



3x delivery time!

- Haystack problem
 - Provide a clear structured logging
 - Database
 - Tools
 - Document!!

And still, one will need a lot of time...



Conclusions

- Log files are essential for Gantries and treatment operations and optimization
 - Trends can be analyzed to enact preventive measures
 - Gives essential input of the quality of treatment
 - Are essential QA tools
- Log files are can be difficult to organize, but the better they are, the better the outcome will be.
- There is plenty of options and you need to define your needs carefully beforehand, but the reward can be worth it!



Wir schaffen Wissen – heute für morgen



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