ñAutomation in patient specific QA using in vivo portal dosimetry "

P. Francois
Physics Unit
CHU J. Bernard Poitiers

pascal.francois@chu-poitiers.fr

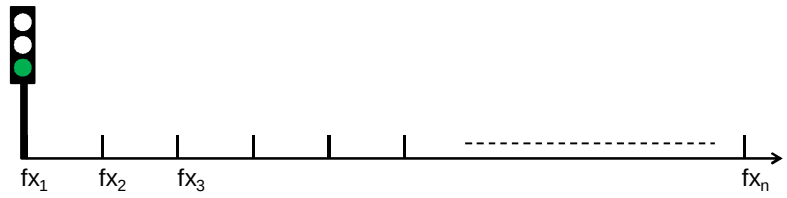
Outlines

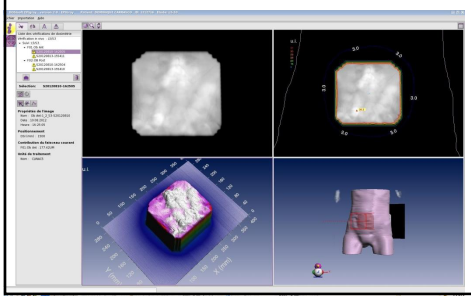
- What becomes possible now with in vivo portal dosimetry
- Interest of automation with ñon lineòverification
- Interest of automation with ñoff lineòverification
- Interest of systematic Statistical analysis of the data to manage the dose delivery process

The medical physicist dream?

Set and Manage a permanent survey system during the dose delivery procedure

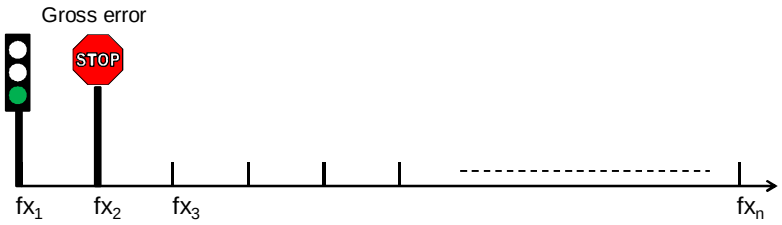
A permanent survey system(1/4)

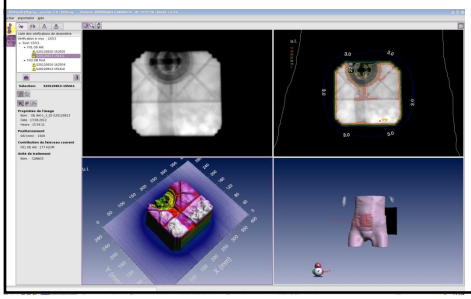




❶ To verify the actual radiation dose delivered to the patient

A permanent survey system(2/4)

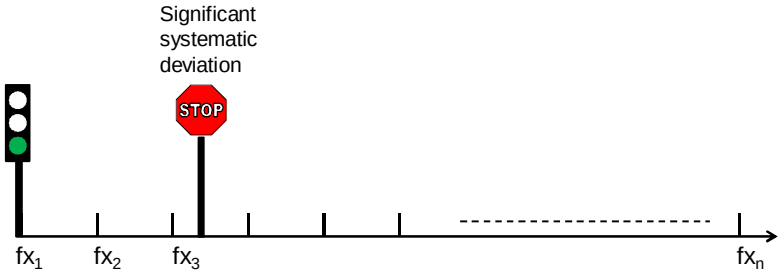


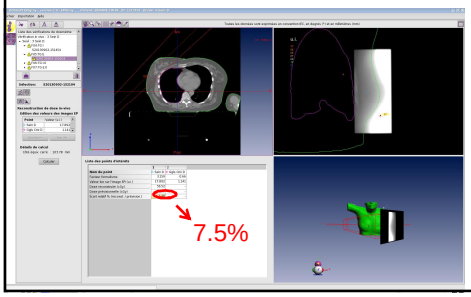


❷ Detect errors

⇨ Unexpected high density object in the beam for an hypofractioned TT due to patient misplacement on the couch

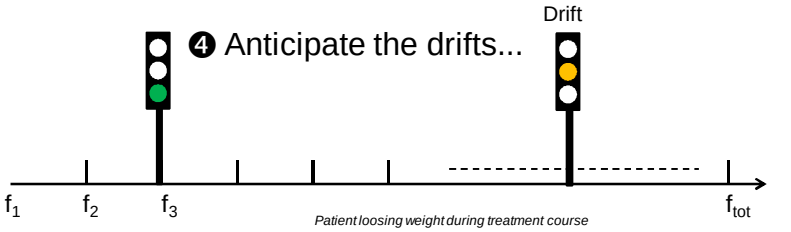
A permanent survey system(3/4)



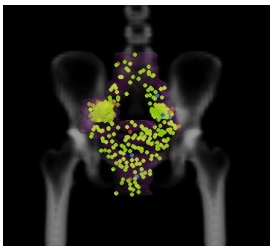


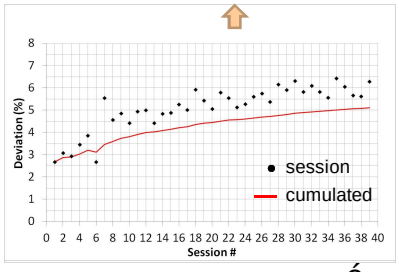
❸ Detect systematic deviationé é

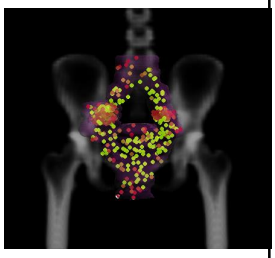
A permanent survey system(4/4)



Patient loosing weight during treatment course





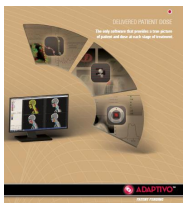


é .. Before it is too late

EPID dosimetry at every session becomes realistic

- New tools available allowing
  - automated image acquisition
  - periodical inspection of record-and-verify database
  - automated run of EPID dosimetry software
- Processed Data available
  - a few minutes after delivery
  - will be soon available
    - during delivery
    - On daily CBCT

Å Alerts are immediately raised when deviations are outside clinical criteria
  Å Reduces human intervention



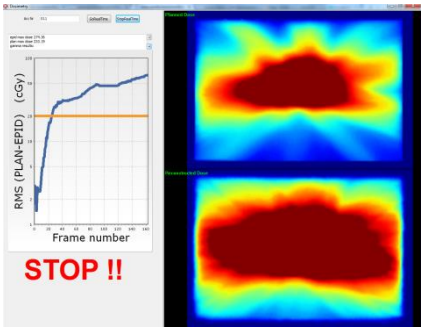
Different strategies to implement in the clinic

1) Patient oriented
   - ñon lineòstrategies
     - Gross errors: Short time to react => Hypofractionation
   - ñoff lineòstrategies
     - ñmoreòtime to react => Normal fractionation
2) Process oriented
   - Large variability and high frequency of controls
     - more powerful than planned QC
   - statistical significance and follow up
     - Machine, energy, technique, etcé .

Interest of automation with ñon lineò verification

(Courtesy P. Gonzalez -NKI Amsterdam-)

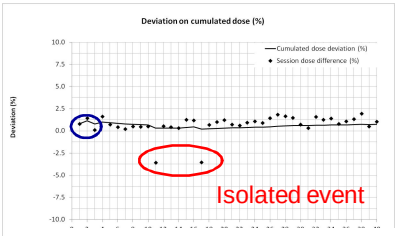
- Online in vivo dose verification approaches can be used to halt the treatment machine in case of severe errors

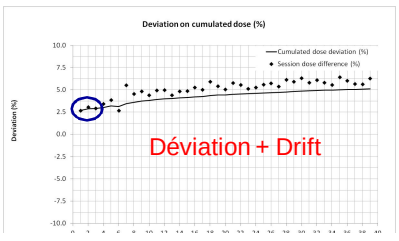


Interest of automation with ñoff lineò verification

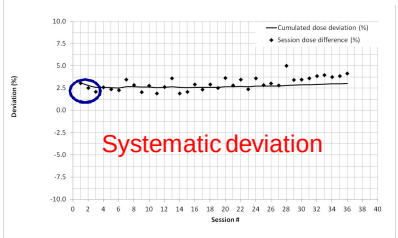
- Automatic offline EPID-based transit dosimetry
  - facilitate large scale clinical verification of dose delivery
  - provides clinically useful information
  - without significant increase of necessary resources
  - less time consuming than patient-specific pre-treatment verification of IMRT/VMAT treatments

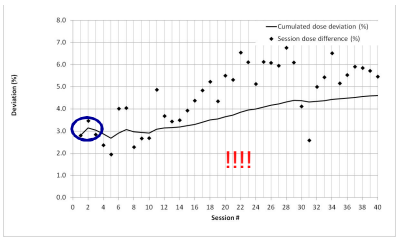
Examples of patient specific follow up





In our protocol, due to the lack of resources, only the 3 first fractions are analyzed
But all sessions are acquiredé é .





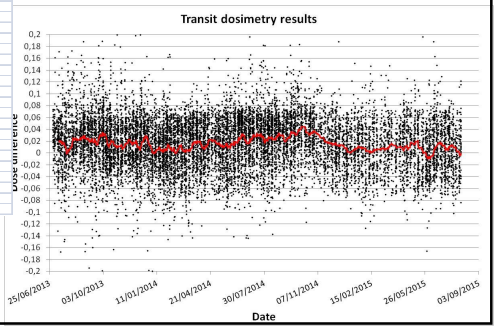
Can we detect other things than patient specific problems?

Large and very extensive amount of data available (compared to QCé é ..)

PATIENT	MACHINE	ENERGY	TIME	TECHNIQUE	SSD (mm)	Dpresc (Gy)	Drec (Gy)	Difference (%)	Etc.....
2458	CLINAC4	6 MV	18/08/14	STATIC	920.365	0,810	0,826	1,9	.....
2859	CLINAC4	20 MV	18/11/14	STATIC	891.948	1,329	1,353	1,8	.....
3260	CLINAC4	20 MV	18/11/14	STATIC	891.75	2,671	2,750	3,0	.....
3661	CLINAC4	6 MV	04/12/13	IMRT	912.767	0,331	0,332	0,5	.....
4062	CLINAC4	6 MV	04/12/13	IMRT	935.692	0,360	0,362	0,6	.....
4463	CLINAC2	6 MV	12/11/13	STATIC	949.6	1,600	1,644	2,8	.....
4864	CLINAC2	6 MV	13/11/13	STATIC	949.6	1,600	1,674	4,6	.....
5265	CLINAC2	6 MV	14/11/13	STATIC	949.6	1,600	1,619	1,2	.....
5666	CLINAC2	6 MV	12/11/13	STATIC	958.011	1,600	1,629	1,8	.....
6067	CLINAC2	6 MV	13/11/13	STATIC	958.011	1,600	1,664	4,0	.....
6468	CLINAC2	6 MV	14/11/13	STATIC	958.011	1,600	1,615	1,0	.....
6869	LINAC1	15 MV	11/07/14	STATIC	926.66	2,547	2,557	0,4	.....
7270	LINAC1	15 MV	11/07/14	STATIC	890.542	2,453	2,466	0,5	.....
7671	CLINAC4	6 MV	19/12/13	ARC_DYN	893.988	1,170	1,110	-5,2	.....
8072	CLINAC4	6 MV	20/12/13	ARC_DYN	893.988	1,170	1,150	-1,8	.....
8473	CLINAC4	6 MV	23/12/13	ARC_DYN	893.988	1,170	1,125	-3,8	.....
8874	CLINAC4	6 MV	19/12/13	ARC_DYN	893.971	0,854	0,895	4,7	.....
9275	CLINAC4	6 MV	20/12/13	ARC_DYN	893.971	0,854	0,886	3,8	.....
9676	CLINAC4	6 MV	23/12/13	ARC_DYN	893.971	0,854	0,884	3,5	.....
10077	CLINAC2	6 MV	07/08/14	STATIC	999.655	1,568	1,653	5,4	.....
10478	CLINAC2	6 MV	08/08/14	STATIC	999.655	1,568	1,602	2,1	.....
10879	CLINAC2	6 MV	11/08/14	STATIC	999.655	1,568	1,663	6,1	.....
11280	CLINAC2	20 MV	07/08/14	STATIC	999.655	0,398	0,420	5,7	.....
11681	CLINAC2	20 MV	08/08/14	STATIC	999.655	0,398	0,423	6,4	.....
12082	CLINAC2	20 MV	11/08/14	STATIC	999.655	0,398	0,431	8,3	.....
12483	CLINAC4	6 MV	08/07/13	IMRT	930.324	0,361	0,375	3,8	.....
12884	CLINAC4	6 MV	08/07/13	IMRT	926.137	0,313	0,324	3,3	.....
13285	CLINAC4	6 MV	09/07/13	IMRT	926.137	0,313	0,321	2,4	.....
13686	CLINAC3	4 MV	29/06/15	STATIC	939.826	0,632	0,616	-2,5	.....
14087	CLINAC3	4 MV	30/06/15	STATIC	939.826	0,632	0,628	-0,6	.....
14488	CLINAC3	4 MV	01/07/15	STATIC	939.826	0,632	0,608	-3,7	.....
14889	CLINAC3	4 MV	02/07/15	STATIC	939.826	0,632	0,621	-1,8	.....
15290	CLINAC3	4 MV	29/06/15	STATIC	942.961	0,924	0,893	-3,4	.....

Inferential statistical analysis

- Statistical process control
- Mean difference
- Variance analysis
- Correlation
- etc

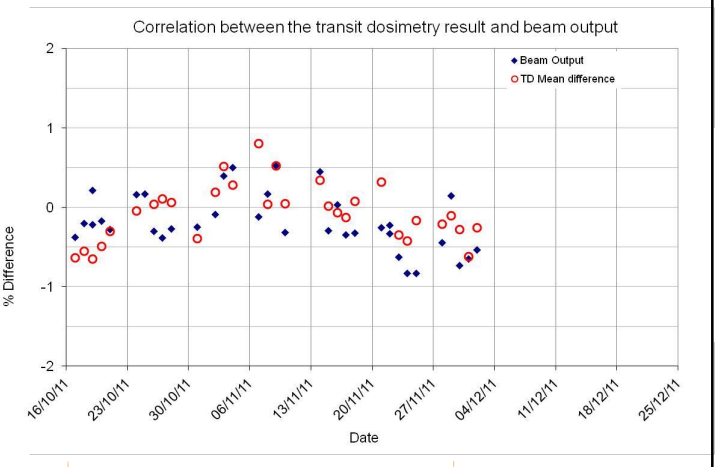


Example 1: Delivery proces follow up

Prostate treatment
5 beams (20MV) - 40x2Gy
IMRT technique (SW)
Same dose constraints
Same LINAC
Daily kV-kV on 3 implanted markers
TD with EPIGRAY (Dosisoft)

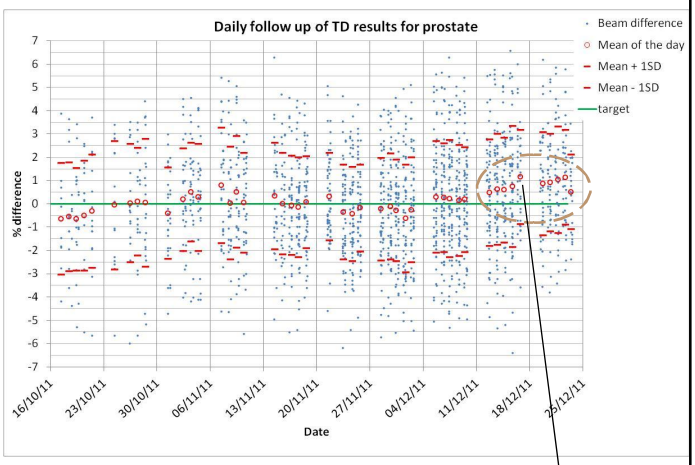
○ = average of all beams for a given day

◆ = beam output in the morning before first patient



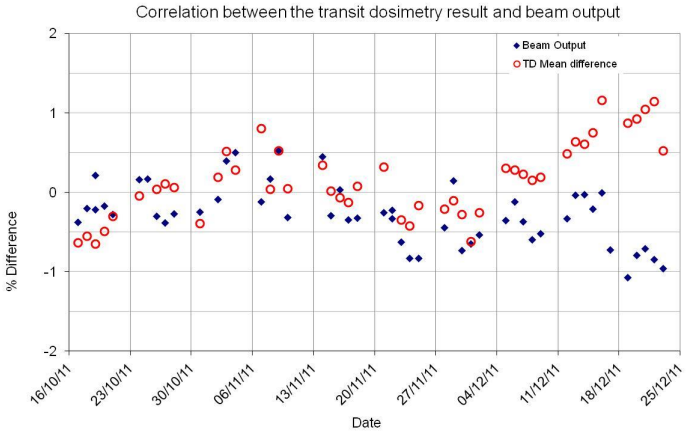
Homogenous data set
ÅDaily mean = -0.086
ÅDaily SD = 2.186

Example 1: Delivery proces follow up



Mean is not equal to -0.086
p-value = 0.0006152
sample estimates: mean of x 1.16243
95% CI: [0.4876619 ,1.8372030]

Example 1: Delivery proces follow up



Exemple 2: decision making

Prostate treatment

Dose difference analysis
Å38 patients
Å1365 sessions
Å6825 beams

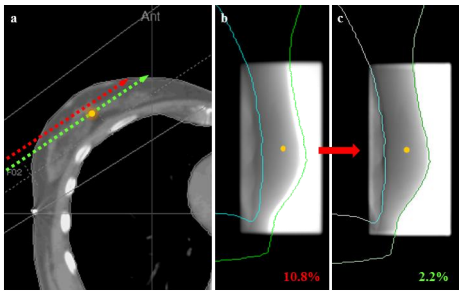
	beam	session	treatment	beam 123	session 123
Mean	0,03	0,08	0,08	0,03	0,06
Median	-0,01	-0,02	-0,08	-0,05	-0,09
SD	2,51	1,64	1,39	2,36	1,55
min	-12,4	-4,5	-2,1	-9,1	-9,1
max	14,1	5,0	2,7	7,5	3,7
p	$4{,}6 .10^{-2}$	$2{,}4 . 10^{-3}$	$3{,}2 . 10^{-4}$	$3{,}4 . 10^{-2}$	$1{,}3 .10^{-3}$

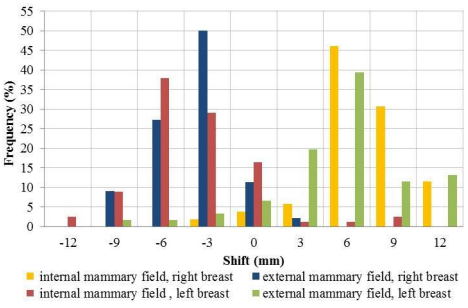
Probability (or risk) to have a value outside the +/- 5%

Good confidence to stop pre treatment DQA for this localisation

Example 3: Set up problems

- Systematic Breast shift(*)
  - RC3D technique
  - Set up verification using EPID once a week





(*) S. Celi, E. Costa, C. Wessels, A. Mazal, P. Francois.
EPID based in vivo dosimetry system: clinical experience and results. JACMP 2016

Conclusion

- Tools are now available for a permanent survey of dose delivery
- Without significant demand of resources (staffing, time, etcé)
- Large amount of data will be available
- New challenges for medical physicists

Special thanks to Institut Curie: All the data reported in this presentation are coming from patients who were treated in this institution