



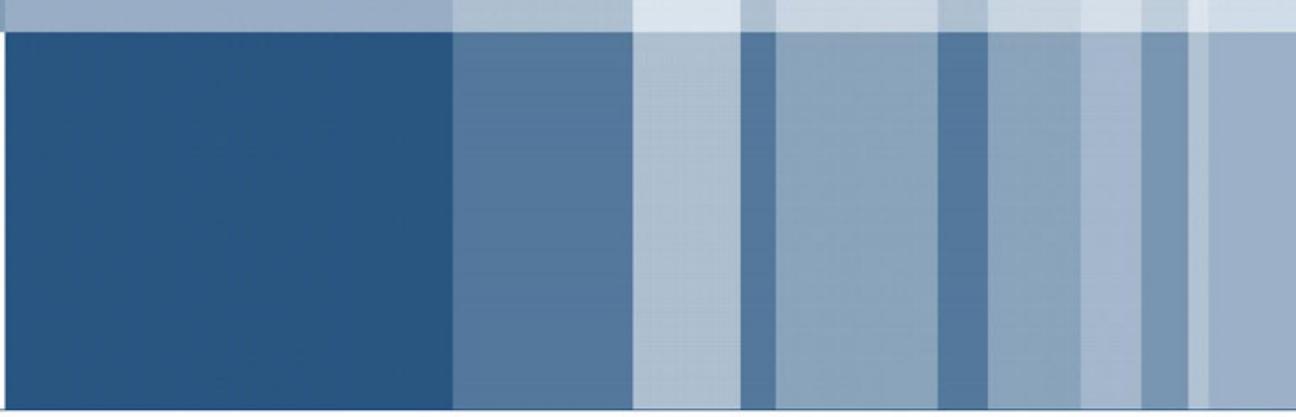
fondazione **CNAO**



CartLab
Computer Aided RadioTherapy



POLITECNICO
DI MILANO



Reliability of the Optical Tracking System for patient positioning at CNAO

M. Desplanques

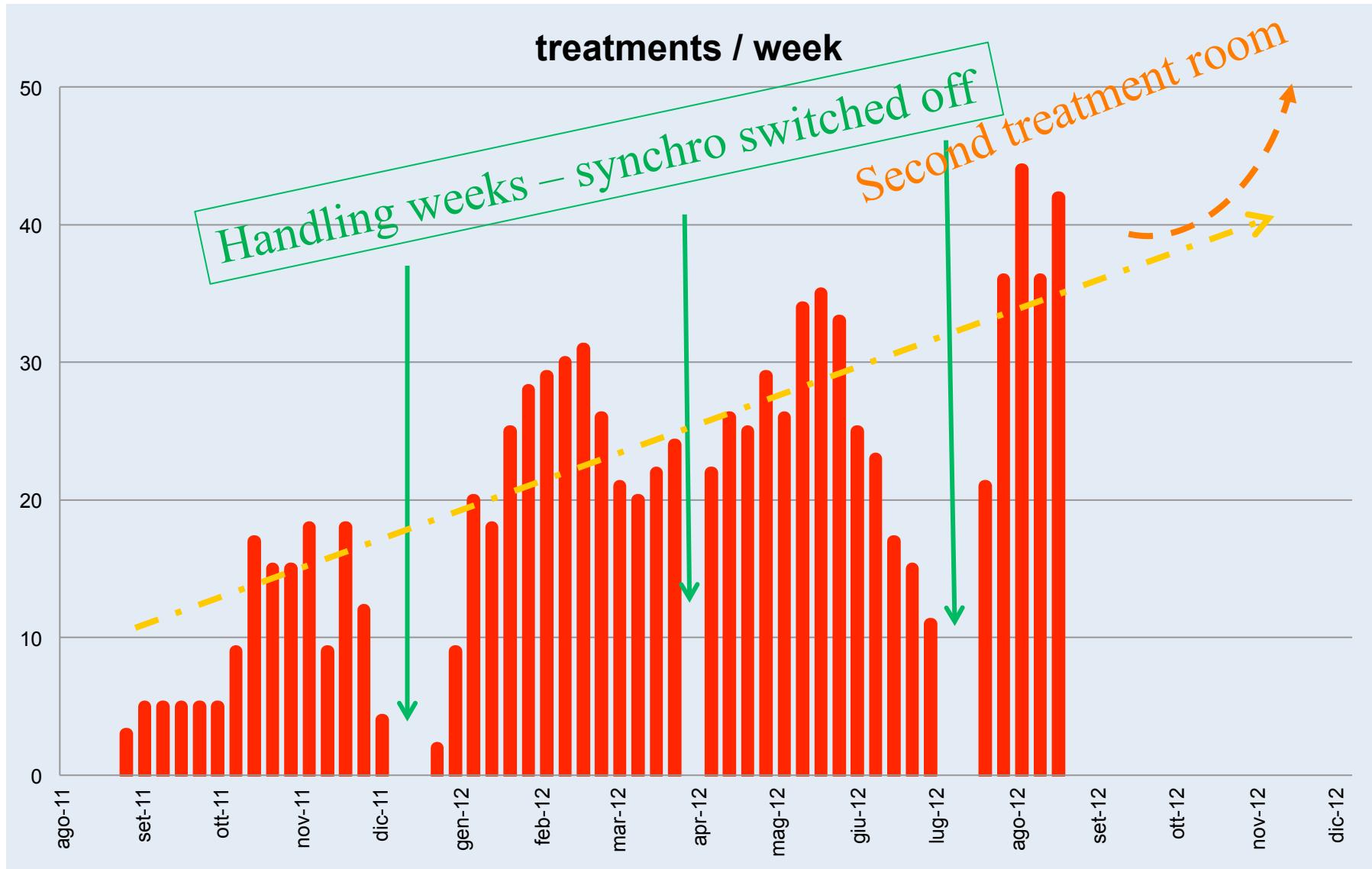


CNAO – Centro Nazionale di Adroterapia

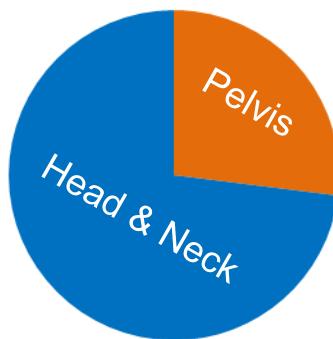
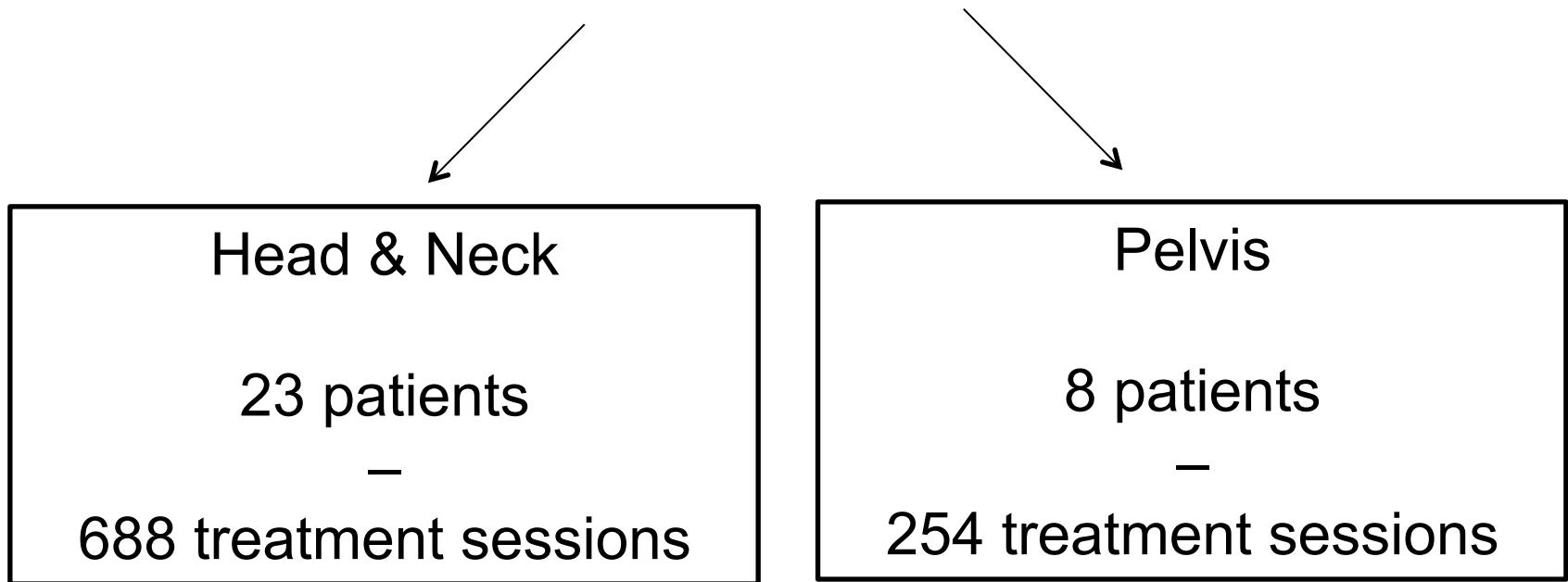
- ✓ Staff: 102 persons ✓ Imaging:
- ✓ 1 Synchrotron ✓ *CT, RMI, PET*
- ✓ *Proton & Carbon ions*
- ✓ 3 treatment rooms ✓ First patient treated
✓ *3 horizontal beams,* in September 2011
✓ *1 vertical beam*



Sept. 2011 – Sept. 2012 – 1 year after



31 patients treated – 942 treatment sessions



3D Real-time IR Optical Tracking (OTS)

- Sub-millimeter accuracy : <0.5 mm
 - 3D data flow at 70 Hz
- Real time detection - position of spherical markers



X-ray Patient Verification System (PVS)

- 2 X-ray tubes (deployable) , 2 flat panels (deployable)
- Supporting structure rotation: $\pm 180^\circ$
- Rotation and deployment accuracy: $\pm 0.15\text{mm}$, $\pm 0.1^\circ$

Patient Positioning System (PPS)

- Automatic couch or chair docking
- Absolute accuracy: $\approx 0.3 \text{ mm}$

OTS / PVS benchmark on CNAO patients

Patient setup procedure:

- ✓ Patient prepared outside the treatment room for Pelvis
- ✓ Docking of the couch
- ✓ **PPS** in nominal configuration (according to TPS)
- ✓ **OTS** based setup correction (6 dof correction vector)





OTS – Real-time application

*CNAO-OTS v1.0.3 c2007-2012

File Acquisition Graphics View Help

Treatment Data

Patient Name: [Redacted]
Patient Sex: [Redacted]
Date of Birth: [Redacted]
Patient ID: [Redacted]
Study Description:
SOPInstanceUID: 1.2.840.113854.303704443471717659726.15289
Treatment support: TABLE
Number of Beams: 3
Treatment Sequence: B1:TX
Volume Center: X=-9999.0 Y=-9999.0 Z=-9999.0
Isocenter: X=0.0 Y=-242.0 Z=-13.0
Indexing position: F10 Bar DISTAL
Table Lateral [mm]: 1.1
Table Longitudinal [mm]: -1120.6
Table Vertical [mm]: -163.2
Table Pitch [deg]: 0.2
Table Roll [deg]: -0.3
Table Rotate (Yaw) [deg]: 90.1
Acquisition Data
Acquired Frames: 22262
Displayed Frames: 19683
Saved Frames: 0
Sample Rate [Hz]: 66.7
Lock PPS/Treat Enable

Correction Parameters

X(RCS): -0.5 [mm]
Y(RCS): -0.3 [mm]
Z(RCS): 0.4 [mm]
Pitch(RCS): 0.3 [deg]
Roll(RCS): 0.2 [deg]
Rotate(RCS): -0.4 [deg]

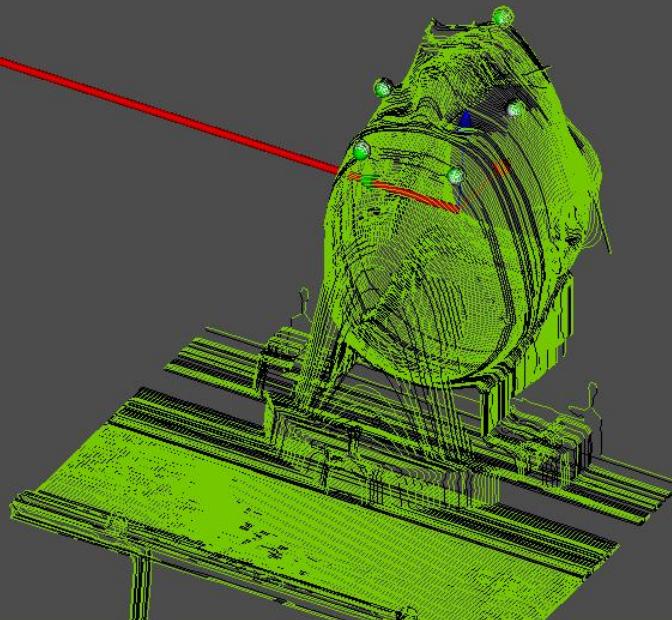
Send Correction to PPS

15.03.2012 service service logged in Administrator Acquisition system connected Network NOT connected OTS calibrated at isocenter CNAO Timing NOT connected

Y (RCS)[mm] Z (RCS)[mm] X (RCS)[mm] 3D [mm]

M1 M2 M3 M4 M5

OK 029 126 033 094 116



post_ots.JPG - Paint

C:\Documents and Settings\SMARTcapture C:\OTS\CurrentData M:\ CNAO-OTS v1.0.3 c... 12.59

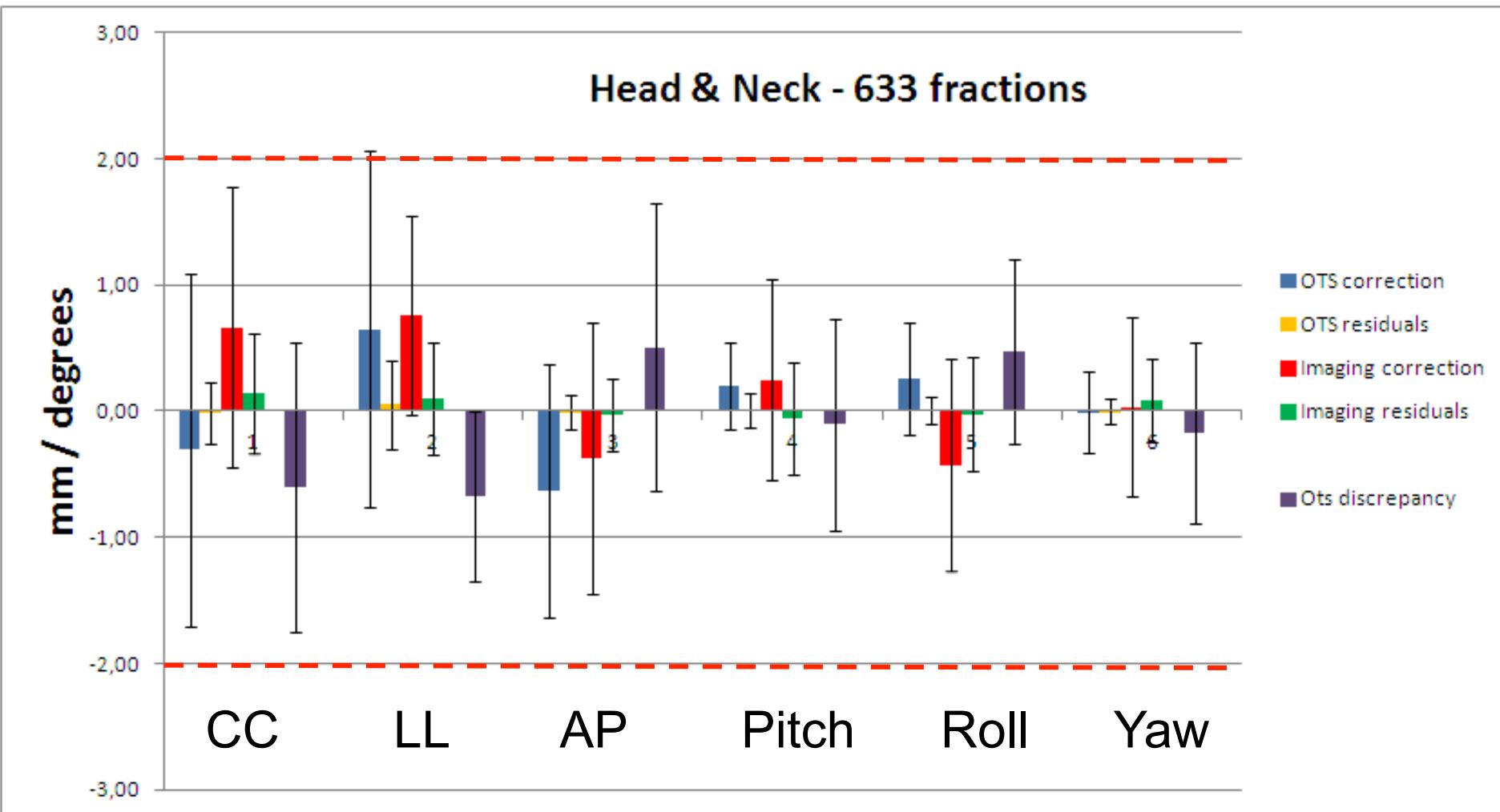
OTS / PVS benchmark on CNAO patients

Patient setup procedure:

- ✓ Patient prepared outside the treatment room for Pelvis
- ✓ Docking of the couch
- ✓ **PPS** in nominal configuration (according to TPS)
- ✓ **OTS** based setup correction (6 dof correction vector)
- ✓ **Imaging** verification (w/wo correction, threshold at [0.5 mm, 0.5 °])
- ✓ Second imaging for verification - possible
- ✓ **633** H&N fractions evaluated in **23** patients
- ✓ **236** Pelvis fractions evaluated in **8** patients

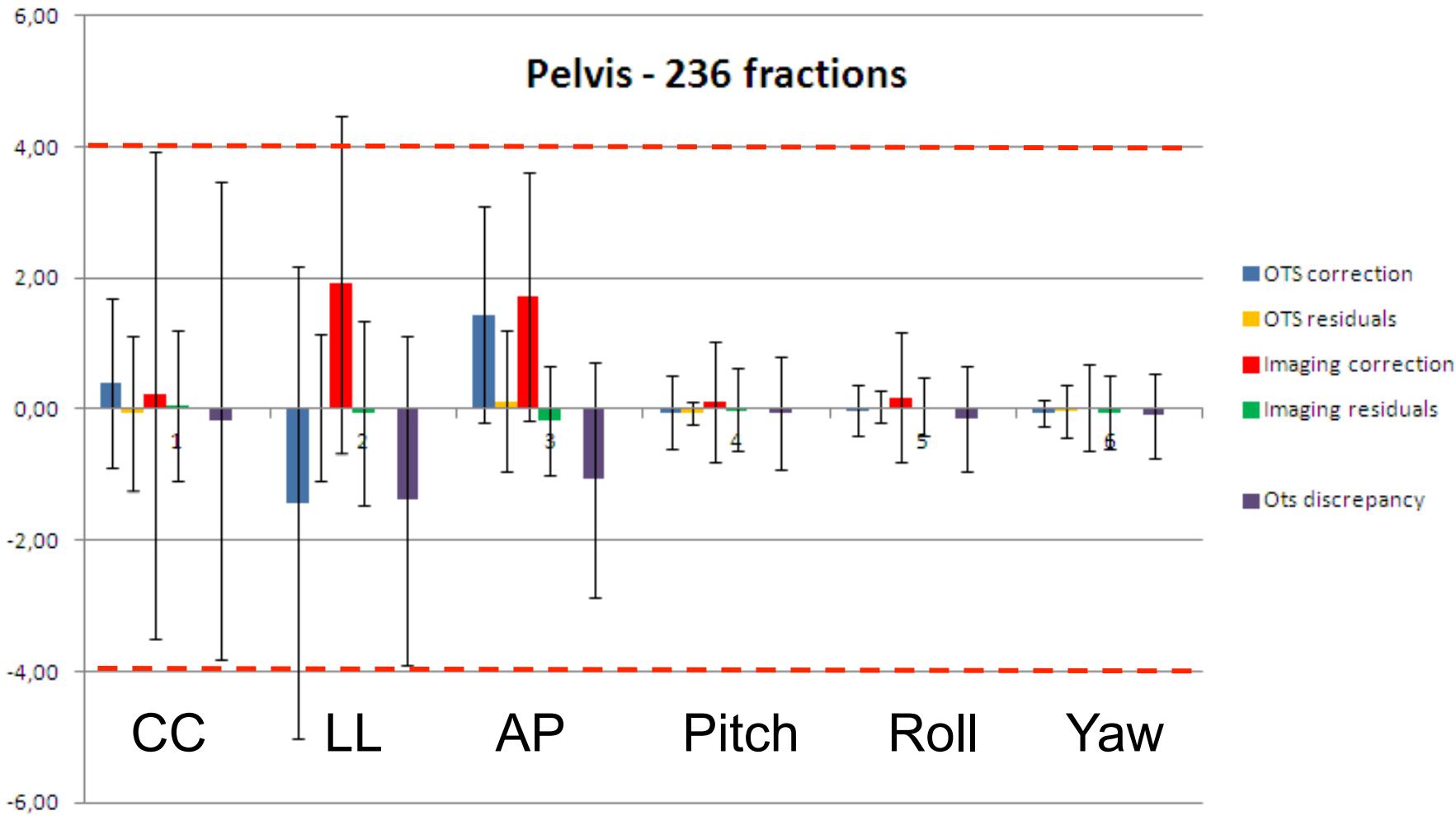


OTS / PVS benchmark on CNAO patients



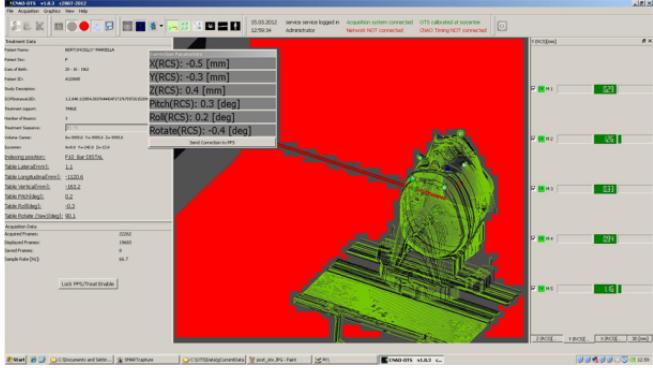
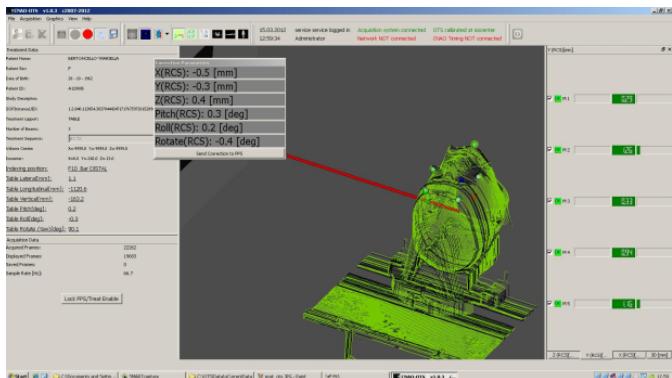


OTS / PVS benchmark on CNAO patients



Conclusions

- ✓ **CNAO-Patient Positioning System** assessed in specification : 0.3 mm
- ✓ **CNAO-Patient Verification System** verified (mechanically). Image registration found stable, reproducible within specs (~ 0.5 mm, 0.5 °)
- ✓ **CNAO-Optical Tracking System** : 0.5 mm 3D accuracy in the treatment working volume
- ✓ Set-up mismatches OTS vs Imaging : <2mm in H&N; up to 8-10 mm in pelvic cases
 - ✓ Differences due to daily variability of the patient positioning inside the mask
- ✓ Corrections very small with the Imaging System after correction using the OTS
 - ✓ Automatic matching is helped by the OTS correction
- ✓ The OTS is a secondary and independent system to check the patient positioning
 - ✓ It checks also the intrafractional immobility of the patient in real time
 - ✓ It will be applied for respiratory motion monitoring in support to motion compensated irradiation strategies (4D dose delivery)





Thank you



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