IAEA TPS AUDIT PROJECT – PORTUGAL REPORT

INTRODUCTION

The General Assembly of the Portuguese Medical Physics Society (DFM_SPF – http://dfm.spf.pt) on January 29, 2011 approved the Annual Plan for 2011 including as a main objective to develop at the national level the IAEA dosimetry audit on TPS for external radiotherapy.

The formal application to the IAEA, in February, led to the designation of the pilot centre – IPOCFG, E.P.E. (Coimbra) and the national coordinator – Maria do Carmo Lopes, PhD. After that, the project was presented to the National Coordinator for the Oncology Diseases (a national organ of the Ministry of Health) in order to obtain his support for the development of the project in Portugal.

The following months were devoted to the preparation of the kick-off workshop that was held in Coimbra, on September 24, 2011 in coordination with the audit measurements at the pilot centre. According to the IAEA TECDOC 1583 methodology the CIRS phantom had been sent to the pilot centre on the previous week. We have count for the workshop with two IAEA experts: Eduard Gershkevitsh and Ben Mijnheer and 80 participants. The scientific programme of the workshop is presented in Appendix 1 of this report: Scientific_Program_Workshop_IAEA_supported_national_TPS_audit.pdf).

The development of the project in Portugal was financially supported through this workshop. The registration fee was 60€ (30€ for students) and a technical exhibition with 7 booths gave a total budget of 5400 € for travel and accommodation.

The following implementation phases have been:

- Individual centres application (volunteer basis) – September and October 2011
- First round of the audit through the 24 participating centres: performance of the two phantom scans (the first for CT to ED conversion purposes and the second for planning the test cases) – November and December 2011
- Second round of the audit: performance of the audit measurements in each centre after that centre has calculated the Test Cases plans for the different energies and algorithms used in its clinical practice, always in contact with the national coordination for answering questions and clarifying doubts – January to March 2012
- Evaluation workshop – June 23, 2012 (presentation of the European results, presentation of the national results and global discussion). The scientific programme is included in Appendix 2 of this report (SCIENTIFIC PROGRAMME_23Jun12.pdf)

NATIONAL CHARACTERIZATION

The project counted with 100% of participation, including the total of the 24 existing radiotherapy centres in Portugal. 44 linear accelerators are presently installed in the country. From these just 25 have entered the audit, corresponding to a total of 50 beam energies (Figs 1 and 2)

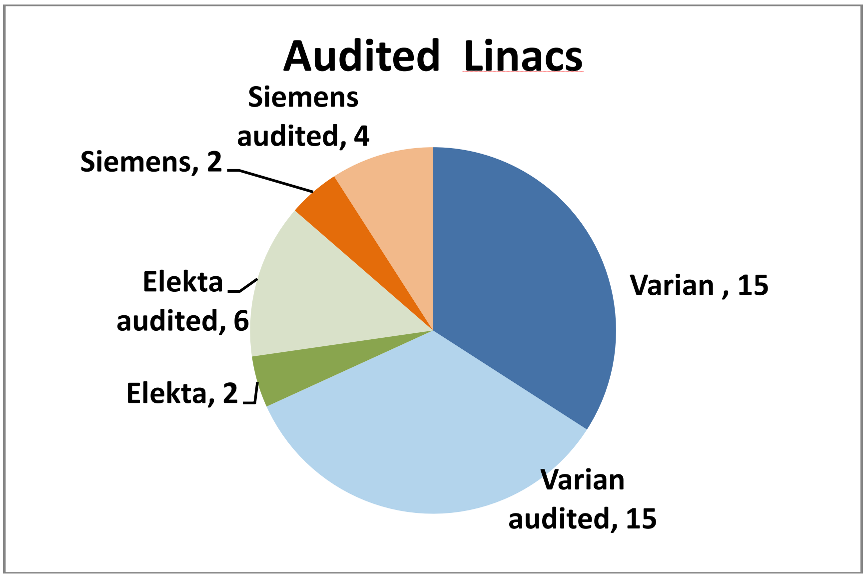


Fig. 1 – Audited and total installed linacs – distribution by make

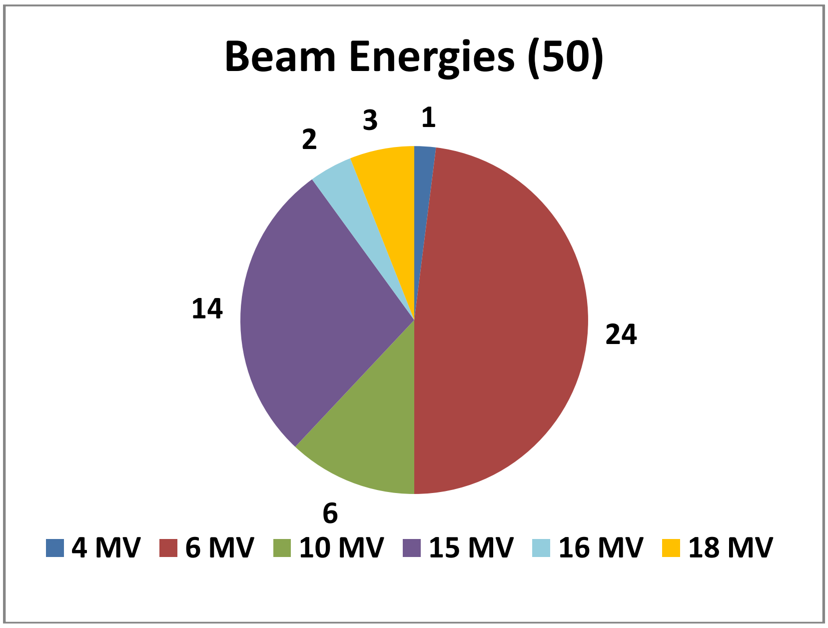


Fig. 2 – Audited beam energies

25 TPSs have been audited with the following distribution by make: Eclipse (Varian) 14; XiO (CMS) 9 and Oncentra (Nucletron) 2. From these 32 algorithms have been tested (Fig. 3)

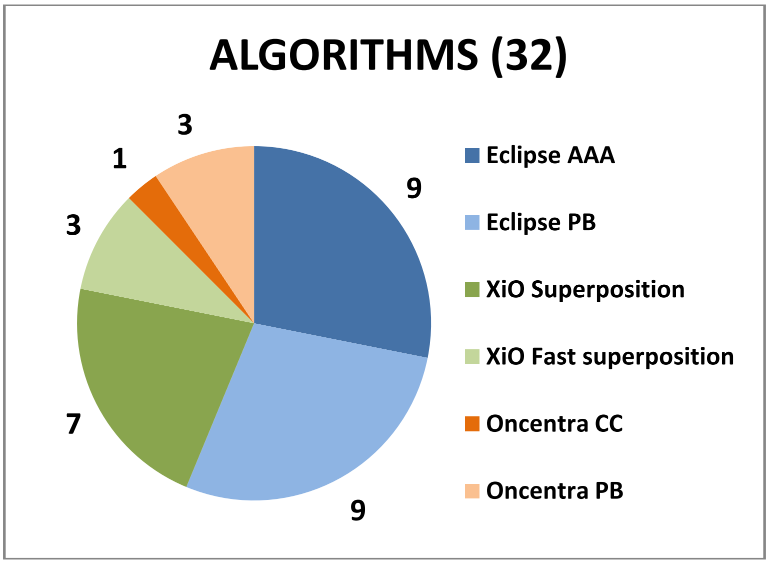


Fig. 3 – Distribution of audited TPS calculation algorithms

DOSE INTERCOMPARISON

The reference dosimetric system from the pilot centre was intercompared with the one from the IAEA with a result within 0.2%. This dosimetric system is composed by a Farmer chamber type 30013-46 and a Unidos 10370 electrometer both from PTW, Freiburg. This dosimetric system has then travelled around the participating centres where the audit started by a dose intercomparison with the local reference dosimetric system. The results are presented in Fig. 4 and for all 50 beam energies dose calibrations are within 1.5 to -2.2% when compared with the pilot centre measurement (Test Case 1, point 3) as shown in Fig.4.

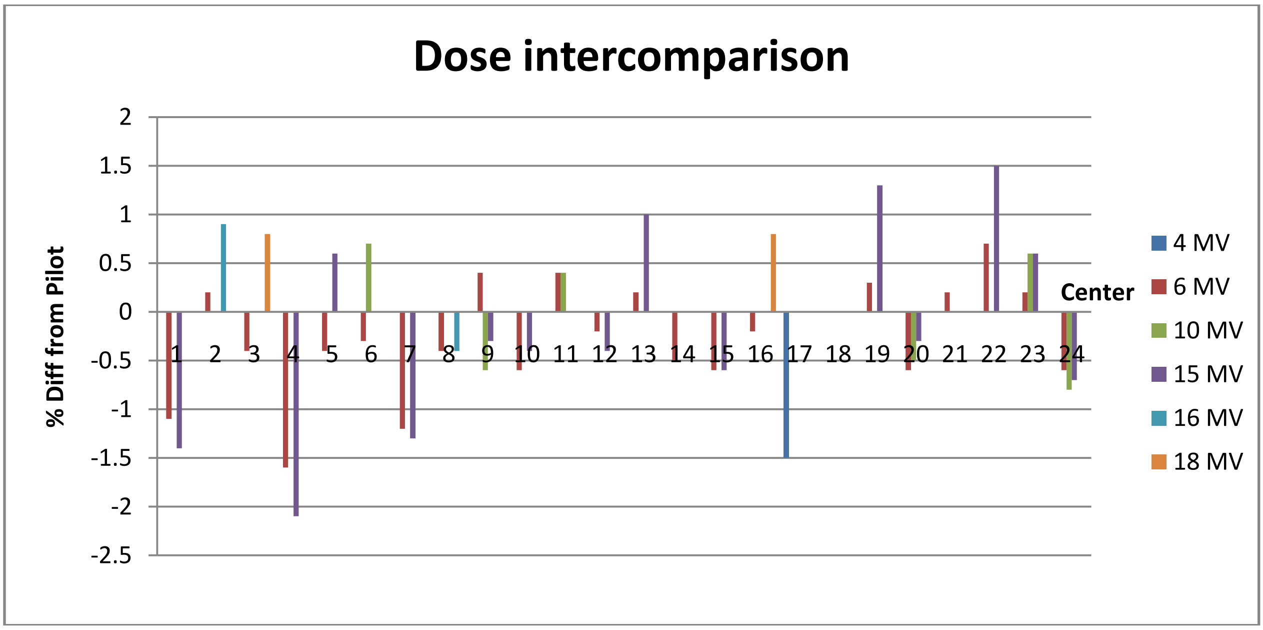


Fig. 4 – Percentage difference from pilot centre for dose intercomparison – all energies and centres

TPS INPUT DATA CHECK

Generally a very good consistency with reference data supplied by IAEA was shown for all make and energies, concerning both output factors ($S_{c,p}$) and wedge factors (WF). Exceptions for Sc,p in one centre and WF for another centre (both Elekta) with no major consequences in terms of the dosimetric test cases of the audit.

NON-DOSIMETRIC TESTS

From the 24 CT scanners that entered the audit, half of them are from Siemens, 37% from GE and 13% from Philips. Most of them are RT dedicated scanners so kVp has not been a problem for the audit as the majority of the centres use a constant kVp value for the planning CTs. A general failure of CT to ED conversion has been observed in Bone (92%) and Dense Bone (75%) reference materials. Nevertheless, as almost all centres use customized CTtoED curves in their TPSs, no major influence in dose calculations was verified.

Oncentra (Nucletron) TPS has a unique feature concerning CT to ED conversion as it does not deal directly with electron densities. In this TPS the CT Hounsfield Units, or the manually specified density, are mapped to a list of typical tissue types. For each of these tissue types a lookup table exists containing the elemental composition and parameters describing the radiological properties for this elemental composition. Should the HU value fall between two tissue types, then these parameters will be interpolated.

DOSIMETRIC TESTS

Globally 53 sets of algorithm-energy could be analysed for the 8 Test Cases corresponding to 33 dose results for each set. As it is shown in Fig. 5, the larger number of failures corresponded to measuring points 6 (lung) and 10 (bone) for Test Case 4 (box technique). Fortunatelly when the sum result for the four incidencies is computed for these points the number of failures is irrelevant.

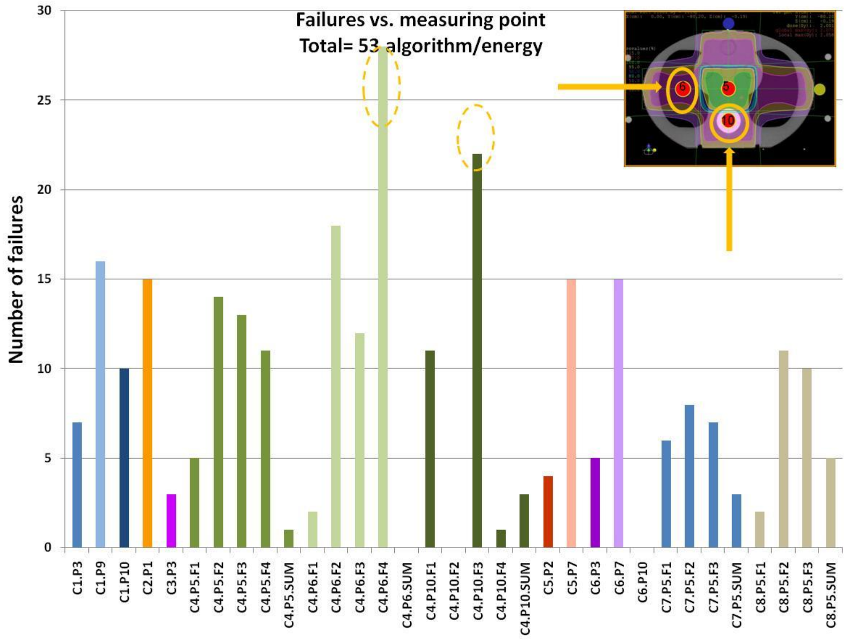
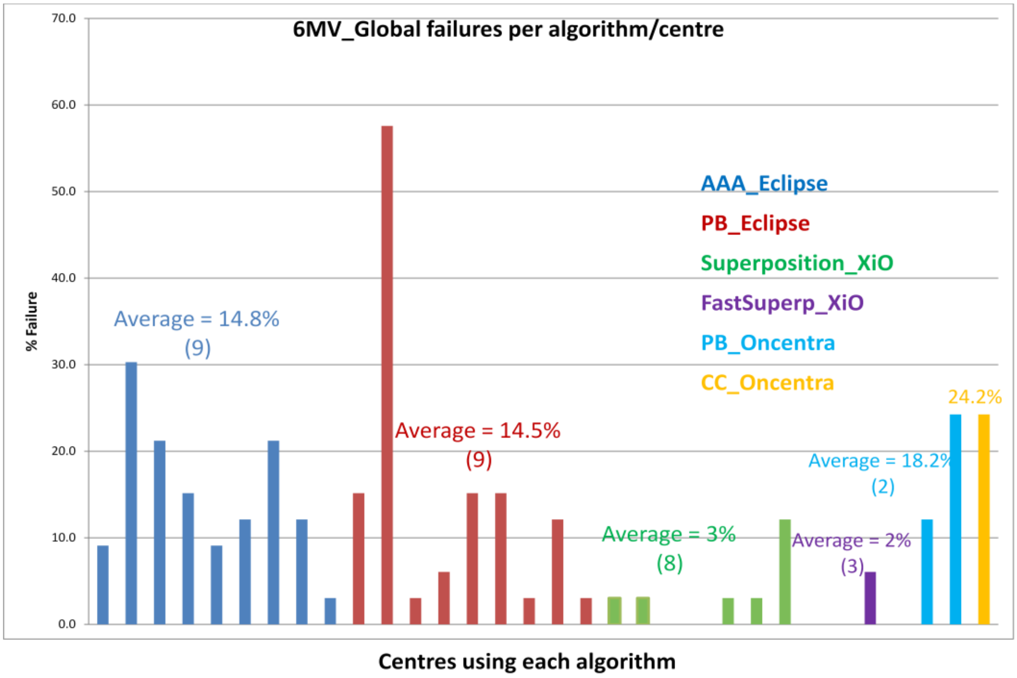


Fig 5 – Global number of failures per measuring point for all 53 sets algorithm-energy, emphasizing the larger failures point results.

In Fig. 6 another view of the global results is presented. The percentage of failures for each centre is presented for 6 and 15 MV (a) and b) respectively) separating the different types of algorithms by colors. Each bar corresponds to the percentage of failures for one centre, considering all 33 dose tests results.



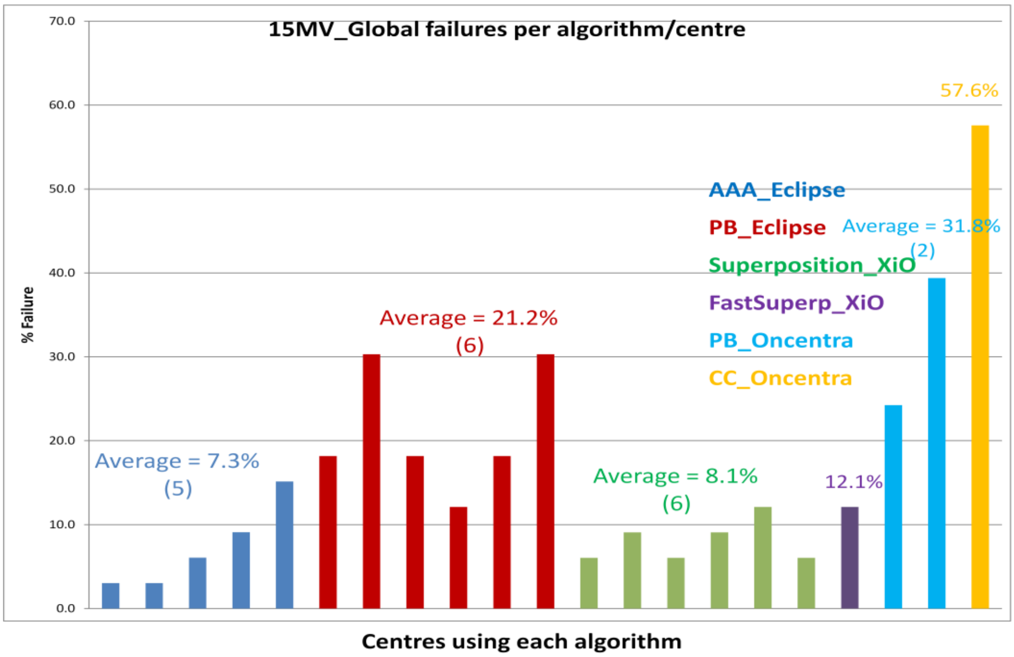


Fig. 6 – Percentage of failures (all 33 test results) for each centre. The different algorithms are presented by different colors – a) 6MV; b) 15 MV

A detailed analysis including the complete set of results for each centre-algorithm-energy has been performed and is included in Appendix 3 (Global_Portugal.xlsx). In general a very good consistency was observed for the same type of algorithm in all centres and for each energy. The known calculation limitations of TPS in heterogeneities have been confirmed.

In 6 MV, the results of one centre for Eclipse PB algorithm contributes for the raising of the average of failures for that algorithm. This result has its origin in a calibration failure (Test Case 1, point 3) of 3.3% that influences most of the other results for that centre, as it can be seen in Fig. 7, below:

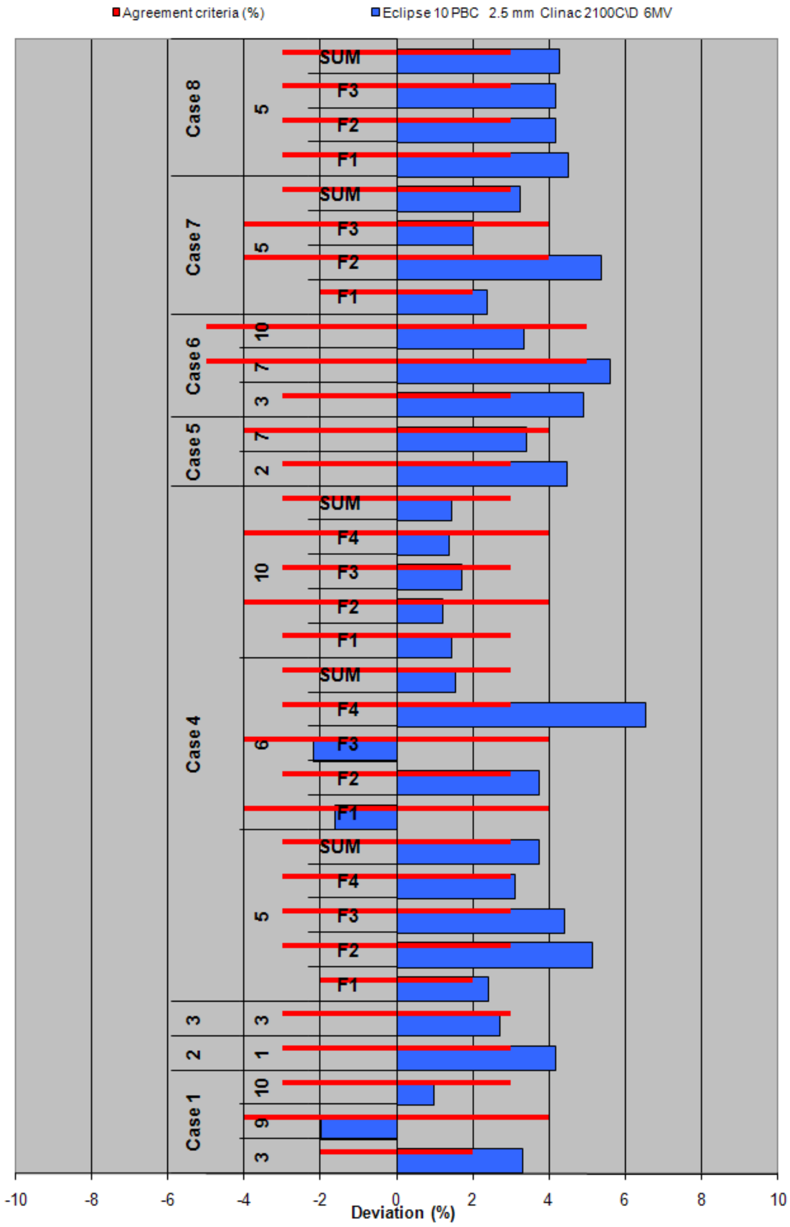


Fig. 7 – Graphic results for the centre that corresponds to the larger bar in Fig. 6 a) for Eclipse PB in 6MV.

Another important evidence of this audit was the major deviations of Oncentra (Nucletron) Collapsed Cone (CC) algorithm, mainly for 15 MV (57.6% failures).

CONCLUSIONS AND FUTURE DEVELOPMENT

The IAEA TPS audit project carried out in Portugal between September 2011 and April 2012 had 100% of participation of the radiotherapy centres in the country. The whole process was supported by the Portuguese Medical Physics Society (DFM_SPF). It contributed to the strengthening of the cooperation between all centres and professionals, paving the way to further national collaborations.

The overall results revealed that the national status of TPS calculations and dose delivery for 3D conformal radiotherapy is globally positive with no major causes for concern.

The dose intercomparison for the audited 50 beam energies was remarkably good with an average value for the percentage difference from pilot of -0.14%±0.8%.

In general a very good consistency was observed for the same type of algorithm in all centres and for each energy. The known calculation limitations of TPS in heterogeneities have been confirmed and so the general trend is that centres are gradually moving to more advanced algorithms.

The results for CC algorithm in Oncentra (Nucletron) deserved a special attention. The IAEA methodology was developed for the systems which report dose to large water cavity inside a medium. CC algorithm in Oncentra TPS reports dose to media so the results would need a correction through the ratio of stopping powers material/water which would imply that the phantom company discloses the atomic composition of the materials, which has been tried without success.

This is in this concern the unique system at the national level to report dose to medium instead of dose to water. Recently, also other TPS vendors are coming up with new algorithms such as Eclipse Acuros XB, CMS Monaco MC and BrainLab iPlan MC, where the calculation of dose to medium is an option. So this is an issue that should be taken into account for future developments of this kind of audit.

MC calculation would be a very interesting inclusion which could help to extent the methodology for dose to medium approach and enabling a benchmark data which could also clarify other issues, such as the perturbation of fluence by introducing the ionization chamber in lung or bone material.

A first contact with the University of Seville (Spain) Monte Carlo group has been made in order to have a student that could dedicate his/her MSc. Thesis studies to model the linac beams of the pilot centre and perform the MC calculations for the audit test cases.

Also further developments of this kind of audit, namely including advanced treatment techniques would be well welcomed and certainly hosted by the medical physics community in Portugal.

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Maria do Carmo Lopes, PhD

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Appendix 1:

Scientific_Program_Workshop_IAEA_supported_national_TPS_audit.pdf

Appendix 2:

SCIENTIFIC PROGRAMME_23Jun12.pdf

Appendix 3:

Global_Portugal.xlsx