Results
The response of the system was linear with dose from 1 to 990 MU ($R^2=1$) and consistent with dose rate varying from 70 to 500 MU/min ($m/σ=0.06$). Measured dose was repeatable ($m/σ=0.07$) and reproducible ($m/σ=0.2$). For H&N treatment plan, iViewDose system detected a shift of 1 mm on a single bank ($γ_3D$ percentage decreased from 91.7% to 67.6%), a 2° collimator rotation ($γ_3D$ percentage decreased to 76.8%) and 1% MU increase ($γ_{1D}$ percentage decreased to 84.6%). For first in vivo fraction, $γ_{3D}$ percentage decreased to 84.6% (average for all $γ$ percentage of 87.6%). For 6 of the non-ART patients the $γ_{3D}$ was deteriorated during the treatment course. CBCT images analysis highlighted several phenomena: shoulder relaxation, patient anatomical changes (tumor shrinkage, weight loss) (Fig 1). Based on planning CT-CBCT registrations, a replanning was triggered for the 6 patients. Re-planning improved the $γ_{3D}$ percentage from 58.8% to 86.8% (average on 5 fractions before and after re-plan).

Conclusion
This study shows the iViewDose capability to detect LINAC accuracy potential errors. A daily analysis of EPID-based transit dosimetry adds the dose guided dimension to an adaptive radiotherapy process and accuracy can potentially improve with reconstruction on CBCT images. The clinical impact of this tool warrants further investigation in the context of an ART workflow.

PO-0890 EPID for QA and pre-treatment verification of electron beams in absolute dose using EpiDream method
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Purpose or Objective
The objective of the study was to evaluate the use of EPID for electron beams quality assurance (QA) and pre-treatment verification with a new approach in absorbed dose to water reconstruction: the EpiDream method [1].

Material and Methods
The study was performed on Varian LINAC, equipped with EPID A1000 imager for electron beams energies of 6, 9, 12, 15 and 18 MeV. For each energy reference water depth (zref), EPID was calibrated with EpiDream application in order to obtain the dose to water matrix from the Grey Level (GL) image. EPID integrated images were corrected of dark field and acquired using AM Maintenance system (Varian) at the detector source distance (DSD)=(100+zref) cm for different parameters: applicator sizes ($6×6-20×20$ cm²), delivered MUs (3-300 MU), dose rate (100-300 MU/min). For a 15×15 cm² applicator size, comparison was performed between water radial and transverse profiles measured with a 0.125 cm³ ionization chamber (IC) (PTW31010), in water at zref for SDD=100 cm and dose profiles extracted from EpiDream matrices. For gantry angle of 90°-270°, EpiDream matrices were compared with PROFILER2 (Sun Nuclear, Melbourne, FL) profiles obtained at DSD 100+zref. Rescaling of each measured profile was performed using a Kriging interpolation method with a 0.02 mm step. Analyse was performed considering: flatness and symmetry parameters, penumbra and field size. EPID images of 10 irregularly clinical block electron fields were acquired for all energies mentioned above. A gamma analysis was performed between EpiDream matrices and corresponding TPS (eMC v13.6, Varian) 2D dose matrices, using criteria of 2%mm absolute dose for beam QA and 3%mm for irregular clinical fields with threshold of 15%.

Results
Kriging interpolated profiles comparisons show that EpiDream profiles are substitutable to IC and PROFILER2 profiles. From the range of 15 to 300 MU, for 10x10 cm² applicator size, the mean gamma index value for 6-9-12-15-18 MeV was respectively: 96.6%($σ=1.6%$), 99.9%($σ=0.1%$), 100%($σ=0.16%$), 99.8%($σ=0.6%$), 99.8%($σ=0.1%$). For clinical fields, the gamma index values for 6-9-12-15-18 MeV ranged from 97.6% to 100%.

Conclusion
The EpiDream method allows to perform electron beams QA in 2D absolute dose using EPID for all gantry angles by maximizing measurement reproducibility and optimizing time dedicated to QA process. Our results show that pre-treatment verification of electron beams in absolute dose is possible using EPID combined with EpiDream method. [1] Boutry, C., Sors, A., Fontaine, J., Delaby, N. and Delpont, G. (2017), Technical Note: A simple algorithm to convert EPID gray values into absorbed dose to water without prior knowledge. Med. Phys. doi:10.1002/mp.12587

PO-0891 Enhancing efficiency of proton macro Monte Carlo dose calculation by an adaptive step size algorithm
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Purpose or Objective
To implement an adaptive step size algorithm to provide fast and accurate dose calculations by improving the efficiency of the proton macro Monte Carlo (pMMC) method for voxelized geometries.

Material and Methods
The in-house developed local-to-global macro MC method for proton dose calculation was extended to further improve efficiency of proton transport and energy deposition in voxelized geometries. The Geant4 MC
Treatment plans were created in Monaco treatment equipped with Agility MLC and 6 MV FFF photon beam. The accelerator used in this study was Elekta Versa HD. Tumors were selected for the study. The first group consisted of patients planned with VMAT technique using four non-coplanar arcs. The second group included patients planned with VMAT technique using full coplanar arc. The PTV volumes were less than 2.5 cc in all selected cases. The linear planning system. The model describing gantry sag in the TPS consisted of the next stages and assumptions. First, all segments from the original plan were divided into four groups according to the corresponding gantry angles: the upper, the lower, the left and the right quadrants (Fig1). Then segments from the upper quadrant were shifted towards “Gun”, segments from the lower quadrant were shifted towards “Target” while segments in the left and right quadrants were left at their original positions. Apart from the shift, all other segment parameters (number of MU, shape, gantry angle etc) were kept unchanged. Lastly, dose distribution for the modified plan with shifted segments was recalculated on the original CT set. The magnitude of the shift was 0.5 mm, 1 mm and 1.5 mm in each direction, which corresponds to 1 mm, 2 mm and 3 mm of gantry isocenter diameter. To estimate the changes in dose distribution between the original and modified plans the following parameters were tracked: maximum dose in PTV \( D_{max(0.1cc)} \), PTV coverage \( V_{95Rx} \), PTV conformity index \( CI \), gradient index \( GI \). In this study, organs located at a distance of 0 to 5 mm from PTV were assigned as organs at risk (OAR). The change of a point dose in OAR \( D_{0.035cc} \) was also tracked. For the second group of patients the parameter of \( V_{12Gy} \) of brain tissue was analyzed.

**Results**

Slab size choice limited by material interfaces in proton direction as well as in lateral direction were shown to yield an efficient proton transport in voxelized geometries. Restriction of slab size to ensure a maximum density variation of 5% with respect to the density at the starting point of a proton track provided an excellent trade-off between accuracy and efficiency of the proton transport. For the homogeneous and inhomogeneous academic phantoms, dose differences of within 1% or 1 mm compared to full Geant4 MC simulation were found, while achieving an efficiency gain factor of 130 for a complex patient CT.

**Conclusion**

An adaptive step size algorithm for proton macro Monte Carlo was implemented and evaluated. The dose calculation provides the accuracy of full MC simulations, while achieving an efficiency gain factor of 130 for a complex patient CT.

**PO-0892. Dosimetric evaluation of the gantry sag effect**

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**Purpose or Objective**

The gantry sag introduces a largely reproducible variation of the radiation field center around the radiation isocenter. The purpose of this work is to assess the change of the dose distribution caused by the gantry sag in clinical stereotactic plans with coplanar and non-coplanar dose delivery techniques.

**Material and Methods**

Two equal groups of ten SRS patients with intracranial tumors were selected for the study. The first group consisted of patients planned with VMAT technique using full coplanar arc. The second group included patients planned using four non-coplanar arcs. The PTV volumes were less than 2.5 cc in all selected cases. The linear accelerator used in this study was Elekta Versa HD equipped with Agility MLC and 6 MV FFF photon beam. Treatment plans were created in Monaco treatment planning system. The model describing gantry sag in the TPS consisted of the next stages and assumptions. First, all segments from the original plan were divided into four groups according to the corresponding gantry angles: the upper, the lower, the left and the right quadrants (Fig1). Then segments from the upper quadrant were shifted towards “Gun”, segments from the lower quadrant were shifted towards “Target” while segments in the left and right quadrants were left at their original positions. Apart from the shift, all other segment parameters (number of MU, shape, gantry angle etc) were kept unchanged. Lastly, dose distribution for the modified plan with shifted segments was recalculated on the original CT set. The magnitude of the shift was 0.5 mm, 1 mm and 1.5 mm in each direction, which corresponds to 1 mm, 2 mm and 3 mm of gantry isocenter diameter. To estimate the changes in dose distribution between the original and modified plans the following parameters were tracked: maximum dose in PTV \( D_{max(0.1cc)} \), PTV coverage \( V_{95Rx} \), PTV conformity index \( CI \), gradient index \( GI \). In this study, organs located at a distance of 0 to 5 mm from PTV were assigned as organs at risk (OAR). The change of a point dose in OAR \( D_{0.035cc} \) was also tracked. For the second group of patients the parameter of \( V_{12Gy} \) of brain tissue was analyzed.

**Results**

The mean relative change of \( D_{max(0.1cc)} \), \( V_{95Rx} \), \( V_{12Gy} \) and \( GI \) was within -2.5% / +1% range for both techniques. The exception was the \( CI \) value for 1.5 mm shift where the difference increased up to -4.5% and -6% for non-coplanar and coplanar plans respectively. \( D_{0.035cc} \) in OAR was changed within ±1% for 0.5 mm, ±2% for 1 mm, and ±3% for 1.5 mm shift. The results are shown in Fig2.