RF Technologies

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RTT RF Technologies

- RF power and Linac technologies very well established.
- Magnetrons and Klystrons are primary solutions currently for high frequency linacs i.e. >S-band, with Solid-state developing to higher frequencies and power ~1GHz and 1MW currently:
  - Higher efficiency, multi-beam klystron developments underway to increase power with reduced size.
- SW and TW linac technologies available now, some reaching very high gradients (v. small footprints), with high power delivery efficiency:
  - S, C and X-Band linac technologies applicable for 6 – 15 MeV beam delivery.
  - Lower frequency SW/TW linac solutions also available!

Quality/Stability

- Quality
  - Key parameters – spot size of 1-3mm (FWHM) typically, any less not beneficial
  - Dispersion occurs at the target, increasing energy spread and generating leakage – impact on local electronics!
  - Improving beam emmitance may be beneficial. This parameter is unknown and difficult to comment on. However delivering electron beam of a good quality to the target may improve the stability and device robustness.
  - Need stable pulse-pulse capability, dose varied by changing the pulses/s.
- Stability
  - Should not operate at maximum performance, relax state of the art parameters available from state-of-the art linacs in order to improve reliability/robustness.
  - Beam jitter to be controlled to within ~10% spot size.
  - Vacuum system critical to maintain reliable RT operation – NEG pumping and/or sealing the system, or even removing pump and vacuum ports may be a solution.
  - ODA country energy challenges are major factor – how can system be made more resilient to power fluctuations:
    - Solar, wind, diesel, batteries, energy storage, gyroscopic supplies …. Improve reliability and quality.
  - Humidity also significant challenge – RTT packaging should be able to cope with large variations:
    - Noted that Halcyon system environmental spec is: 16-27C (ambient) and 15-80% humidity
    - RTT facility operating temperature is however typically much higher at ~42C
  - Dust – RTT facility must also have to operate in such environments reliably:
    - Sealing of rotating components or even removing, AC management, air filtration systems etc
  - Need to package RTT system to be compliant with ODA country constraints – to be defined!

Operational Experience

- Operational Experience (J Van Dyk):
  - Acceptance testing (3-5 days)
    - Dose, interlocks, parameter checks, rad safety checks, isocentre checks, reproducibility
  - Commissioning (2-3 months)
    - Treatment planning, beam calibration, dose profiles, document operational procedures, downtime procedures, staff training ….
    - Pre-commissioning options with vendor – TomoTherapy and Halcyon systems – readiness time significantly reduced (£$€!!!)
  - Quality Control
    - Prove compliance: weekly, weekly, monthly, yearly.
    - Document procedures and tolerances – non-conformance management.
    - What automation can be incorporated, some dictated by regulatory requirements.
    - Patient specific treatment QA.
  - **Commissioning and QA needed for each specific beam and treatment delivery mode!**
- All above main responsibility of Medical Physicist.

RTT Operation Support

- Support staffing, supervisory/scientific/technical important:
  - http://www-pub.iaea.org/books/IAEABooks/7694/Setting-Up-a-Radiotherapy-Programme-Clinical-Medical-Physics-Radiation-Protection-and-Safety-Aspects
  - http://www-pub.iaea.org/books/IAEABooks/10800/Staffing-in-Radiotherapy-An-Activity-Based-Approach
    - Includes spreadsheet calculator!
      - ~11FTE identified for suite of RT treatment options
  - All documents posted onto indico:
    - https://indico.cern.ch/event/661597/contributions/2731062/

Operation Issues

- Priority to have modular systems, easy maintenance, rapid recovery times, better upgradability and functionality.
- RTT system costs overwhelmed by indirect factors:
  - marketing, servicing, treatment planning, informatics and support:
    - How can we break this model?
- Operational costs are very important:
  - system reduction, simplification, improved efficiency, standardised components.
- Open access software would be preferred – allowing cooperative development and better standardisation:
  - Simple to use and intuitive interfacing.
- Patient driven RTT aesthetics very important:
  - What ODA country factors should be taken into account?

Possible RTT Facility R&D Proposals

1. Key parameters and RTT specification to be defined:
   - Energy, Dose, RF power, beam current, length, spot size, energy spread, MLC leakage, temperature, modularity, space constraints, reliability …..
   - 6MeV seems to be the preferred requirement, with some variation about this optimum (TBD) - upgrade options?
   - Self-checking/automation – what should/can be included?
     - QA processes and/or system checks, regulatory compliance?
   - Environment constraints – Power, temperature, humidity etc
   - Operational requirements (technical and clinical).

2. Document trade-offs for various linac/RF source options, factor in any integration constraints (technical and clinical):
   - How can key components be removed – circulator, magnets, vacuum pumping – how can system be made more robust (combining components)!
   - Low frequency (around 1GHz) solution – SSA options, efficient power combining, simpler configuration (no HVPS), reduced costs potentially:
     - Separate linac/RF from gantry and rotate beam delivery only!
     - Stability/robustness benefits may be significant.
   - Upgrade options – energy reach, imaging, treatment requirements.

- Ideally perform both in parallel if feasible!

Thank You