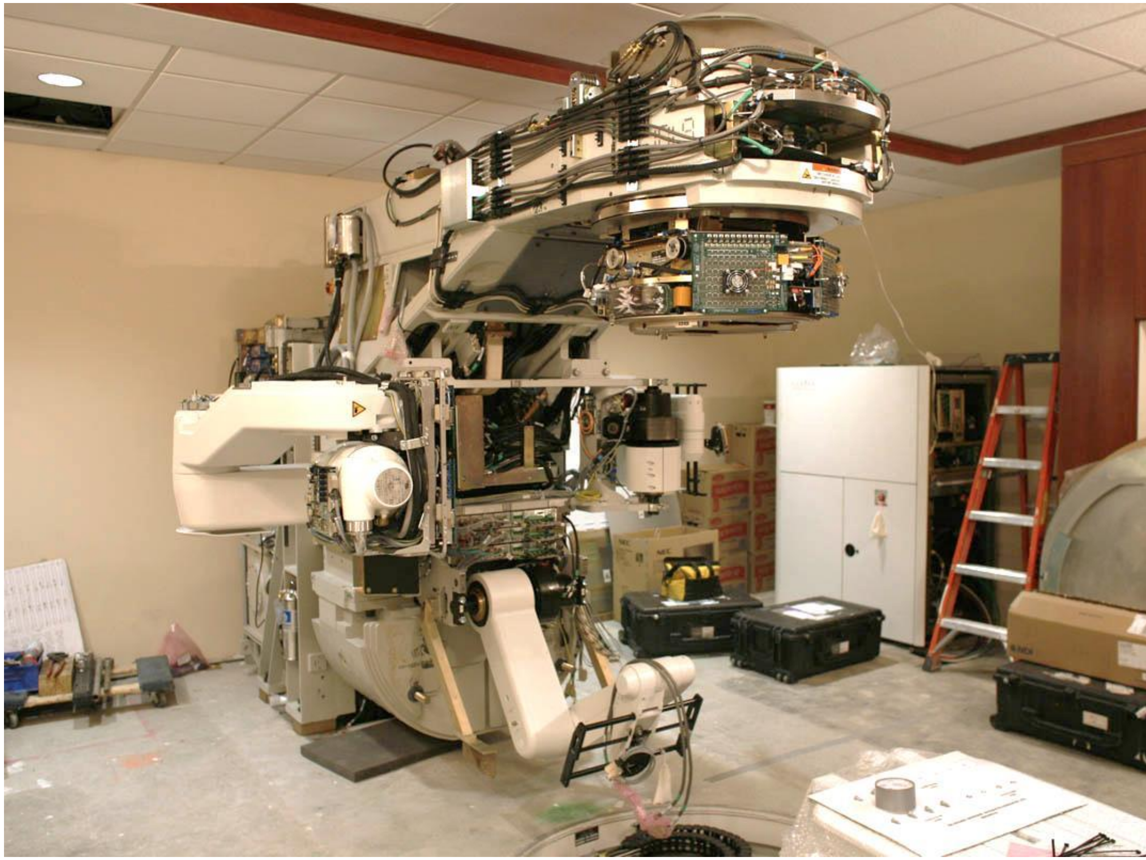
GCRF RTT Accelerator Design Study

Peter Macintosh,
STFC Daresbury Laboratory

Outline

- Challenge and Opportunity
- Project Scope
- Benefits
- Staffing
- Partners
- Costing



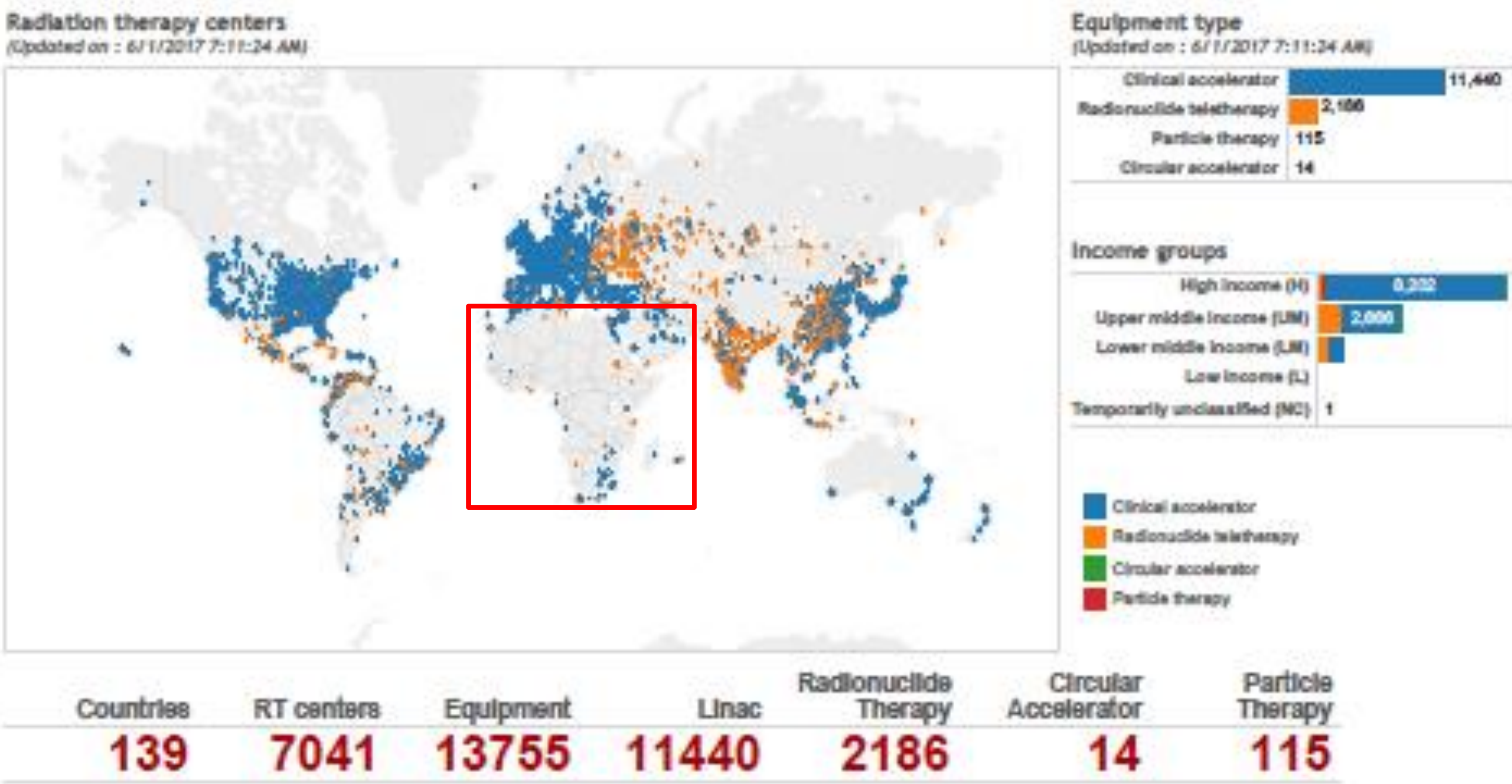
ODA Challenge

- **Global cancer challenge:**
  - **15 million (2015) to 25 million in (2035)**
- **Effective cancer care uses RT for about 50% of the patients.**
- **1 million inhabitants recommendation is 5 or more linacs.**

Challenge in Africa:

- How to go from no or limited RT to high quality RT globally.

Global RT Picture (2017)



ICEC-CERN-STFC R&D Activities

- 3 workshops organised:
  - Nov 2016 @ CERN
  - Nov 2017 @ CERN
  - Mar 2018 @ Daresbury
- Remit for workshops to find best ways to 'Bury the Complexity' of RTT systems, to enable a solution which is most effective for application in challenging environments.

- Five STFC GCRF 'seed-corn' projects 17/18 funded covering:
  - **RnD1** Study of **Accelerator Technology** Options – P McIntosh STFC
  - **RnD2** Robust **Permanent Magnet** Beam Delivery Systems for Medical Radiotherapy Linacs – S Sheehy Oxford
  - **RnD3** **RF Power Systems** and Optimized **RF Structures** for Electron Beam Acceleration – I Konoplev Oxford
  - **RnD4** Linear **Accelerator Simulations** for Stable and Sustainable Operation of Developing Country Radiotherapy Linear Accelerators – S Boogert RHUL
  - **RnD5** **Cloud-based Electronic Infrastructure** in Support of Linac-based Radiotherapy in Challenging Environments – A Aggarwal KCL
- STFC Opportunities Call 18/19 covering:
  - A modular, integrated **electron gun** and **RF cavity** for RTT systems in developing countries – Graeme Burt
  - Novel **optimisation framework** for real-time automated radiation therapy – Suzie Sheehy
  - **Dosimetry and multi leaf collimators** of RTT machines – Jaap Velthius/Lana

STFC Funding Opportunities

Global Challenge Research Fund

Framework criteria:

- problem and solution focus
- research excellence
- likelihood of impact
- capacity building and partnerships

- **Proposals required to demonstrate relevance to promoting the economic development & welfare of developing countries.**
- Vital that applicants consider the **international development context** of their proposed projects, including **socio-economic and environmental factors** as appropriate.
- Projects must focus on evidenced, **unmet needs identified by stakeholders** and/or collaborators in countries on the Development Assistance Committee (DAC) list.

21st Century Challenge Network Fund

- **Focused on addressing user needs**, including those of Government departments, Government agencies, industry and other academic communities.
- Defined as the big and often **complex social, environmental and economic challenges** facing the UK and other countries.
  - Examples: energy, infrastructure, resources, **health**, development, defense, security and resilience
- **Develop interdisciplinary communities** focused on addressing challenges through:
  - Enabling engagement of STFC researchers,with challenge owners,
  - People exchange,
  - Exploratory workshops,
  - Sandpits and scoping studies.

Closing dates for both calls in Sept/Oct 2018

RTT Platform Development Project

STFC Global Challenge Research Fund

WP1 Management

WP2 Specification
- Beam delivery parameters
- Patient treatment requirements
- Operational tolerances
- Simulations
- RAMI analysis

WP3 Accelerator
- **Electron beam generation (Opp18/19)**
- **Linac and RF (RnD1+3 and Opp18/19)**
- Beam diagnostics
- **Simulations and Controls (RnD4)**
- Vacuum systems
- Power supplies
- Gantry configuration

WP4 System Integration
- Packaging
- User interface

WP6 Beam Delivery
- **Magnets (RnD2)**
- MLC's (excluded)

WP7 Sustainability and Maintenance
- Modularisation
- Servicing and Maintenance

Project structure defined at ICEC-CERN-STFC 3rd Workshop in March 2018

STFC 21st Century Networking Fund

GRACENet

WP8 Imaging
- CT scanning
- Data acquisition

WP9 Dosimetry and QA
- Remote diagnostics

WP10 Treatment Planning
- **Cloud/grid/data architecture (RnD5)**

WP11 Education and Training
- Outreach

WP12 Costs

WP13 Installation
- Utilities and services
- Shielding

WP14 Industrialisation

Not included in either proposal

GCRF Project Scope

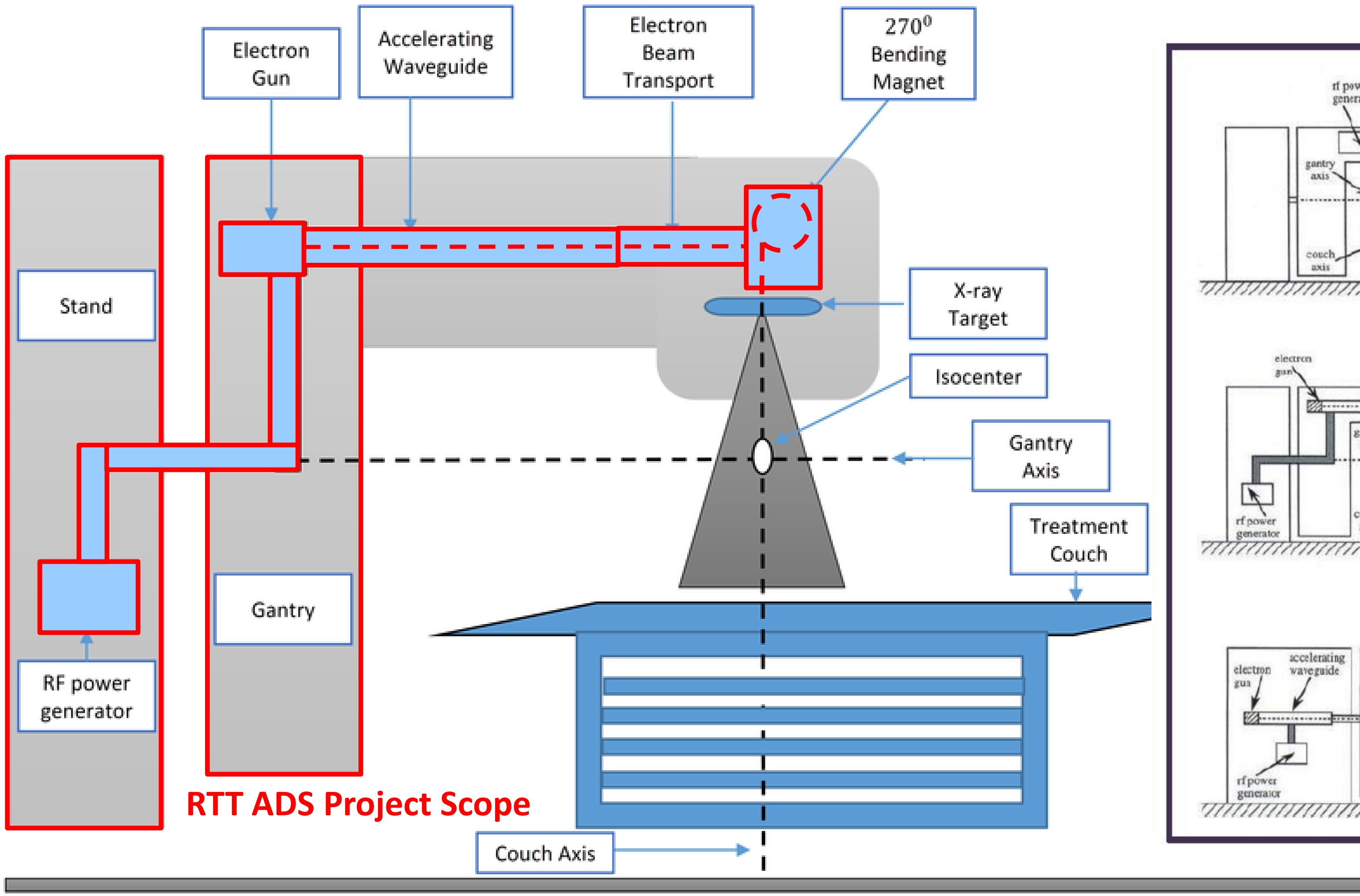
- This **Accelerator Design Study** will identify the fundamental **specifications** for an **appropriate RT treatment system** for **application in the challenging environments** associated with ODA countries, particularly those on the **African continent**.
- A suitable **electron-beam accelerator** will be developed which matches those requirements, incorporating **modern optimization processes** and technologies which are able to provide **robust operation and modularized implementation**:
  - **Electron beam source**
  - **Linear accelerator**
  - **RF power source**
  - **Beam delivery system**
- The system integration of such technologies will exploit **value engineering** and **failure mode analysis techniques** which can offer a more **cost effective treatment platform** solution:
  - **Simpler installation**
  - **Robust operation**
  - **Easier to maintain**
  - **Reduced cost**
- This programme **channels** each of the 5 STFC GCRF ‘seed-corn’ activities into a **common reference design** process.

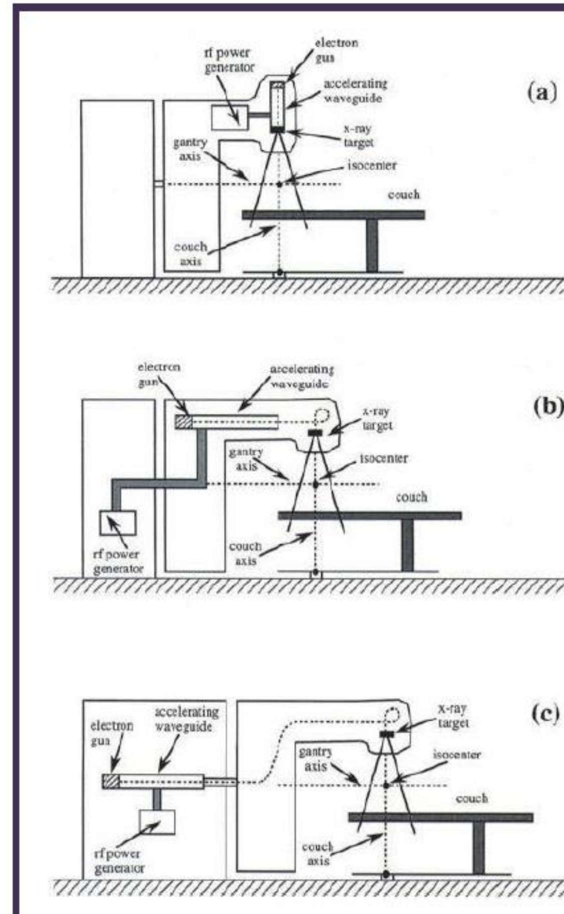
Global Benefits

- ODA Recipients:
  - Provide basis for an innovative **RT system design** which is:
    - **more reliable**,
    - **easier to operate**,
    - **simpler to maintain**,
    - **cheaper to procure** and **operate**.

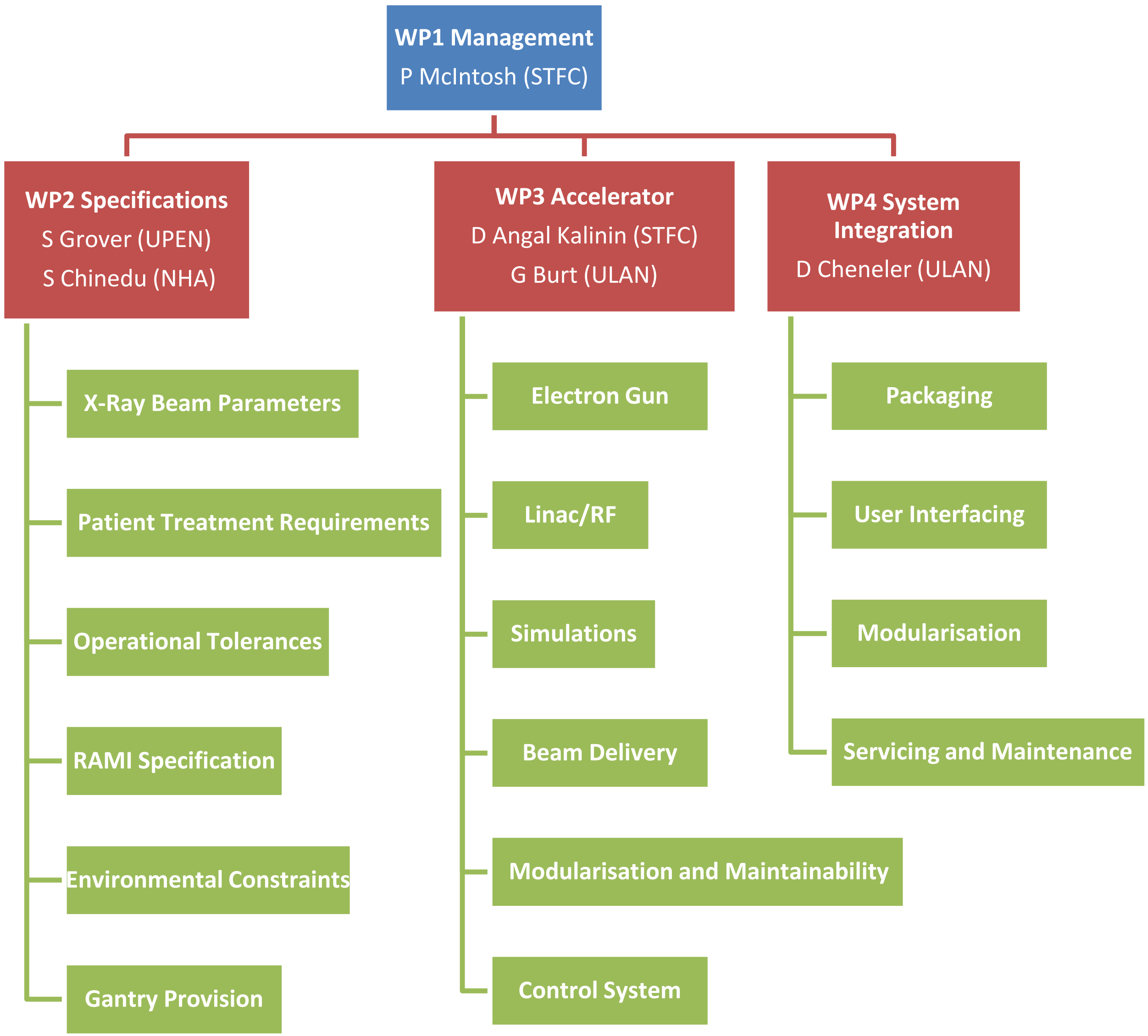
- ICEC-CERN-STFC
  - **Strategic partnerships** developed between specialist **ICEC CERN and STFC** expert groups.
  - **Reputation enhanced** in field of **medical accelerator** delivery.
  - Puts **collaborative programme** in **strong position** for **next-phase technology development** opportunities.

Conventional RTT Technology





GCRF Accelerator Design Study (ADS) Project Structure



Partners

- STFC – ASTeC and Technology Dept
  - Management
  - Electron Gun
  - Simulations
  - Modularisation and Maintainability
  - Control System
  - Beam Delivery
- Lancaster University
  - Gantry Provision
  - Linac/RF
  - Simulations
  - System Integration
- Oxford University
  - Linac/RF
  - RAMI
  - Simulations
  - Beam Delivery
- Strathclyde University
  - Electron Gun
- Kings College london
  - Patient Treatment
- University Pennsylvania-Botswana
  - X-Ray Parameters
  - Patient Treatment
- National Hospital Abuja, Nigeria
  - Patient Treatment
  - Operational Tolerances
  - Environmental Controls
  - System Integration

Specialist Advisory Partners

- International Cancer Expert Corp (ICEC)
  - Oncologists
  - Medical Physicists
  - Toxicologists
  - Technologists
- CERN
  - Medical Applications
  - Accelerator Design Specialists
    - Linac and RF systems
    - Integration and Modularisation

How to move forward:

Global Radiotherapy Access in Challenging Environments Network 'GRACENet'

Dr. Suzie Sheehy
University of Oxford
(& University of Melbourne)

The Cockcroft Institute of Accelerator Science and Technology
John Adams Institute for Accelerator Science
UCL
King's College London
University of Oxford
CERN
International Cancer Expert Corps
Partnering to transform global cancer care

GRACENet: the vision

Enormous thanks to all our ODA partners for their support and help, as well as Ajay Aggarwal, Manjit Dosanjh, Simon Jolly (UCL), David Pistenmaa and Norm Coleman who worked on this proposal.

The delivery of affordable and equitable radiotherapy treatment is a Global 21st Century Challenge

GRACENet aims to enable equitable access to cancer treatment by bringing together a unique multidisciplinary network.

Together we will **scope and undertake research projects**, consider opportunities for new **technological innovations** that meet country-specific challenges to broadening radiotherapy capacity, and consider **sustainable models for education/training**

GRACENet: the partners

International Organisations & NGOs
ICEC
IAEA
WHO
UICC

UK Partners
clinical, oncology,
medical physics, LINAC engineers,
radiologists & technicians

GRACENet:
Global Radiotherapy Access in Challenging Environments Network

LMIC and ODA Partners
clinical, oncology,
medical physics, LINAC engineers,
radiologists, technicians,
policy makers

STFC Expertise
Science & technology
accelerators, detectors, imaging, computing,
grid/data, engineering, power

The Cockcroft Institute of Accelerator Science and Technology
JAI John Adams Institute for Accelerator Science
UCL
King's College London
University of Oxford
CERN
International Cancer Expert Corps
Partnering to transform global cancer care

Aims/Objectives

NETWORK

Create a multidisciplinary network aimed at improving access, capacity and capability of ODA Countries to deliver high quality radiotherapy for cancer care

INTERACT

Bring together disciplines who don't usually interact, break down academic silos and produce true challenge-led & responsible innovation.

Position new multi-disciplinary research teams to leverage additional funding.

PROJECTS

Produce a range of small pilot projects co-designed with ODA partners which will offer demonstrable impact at the clinical interface.

TRAINING/EDUCATI ON

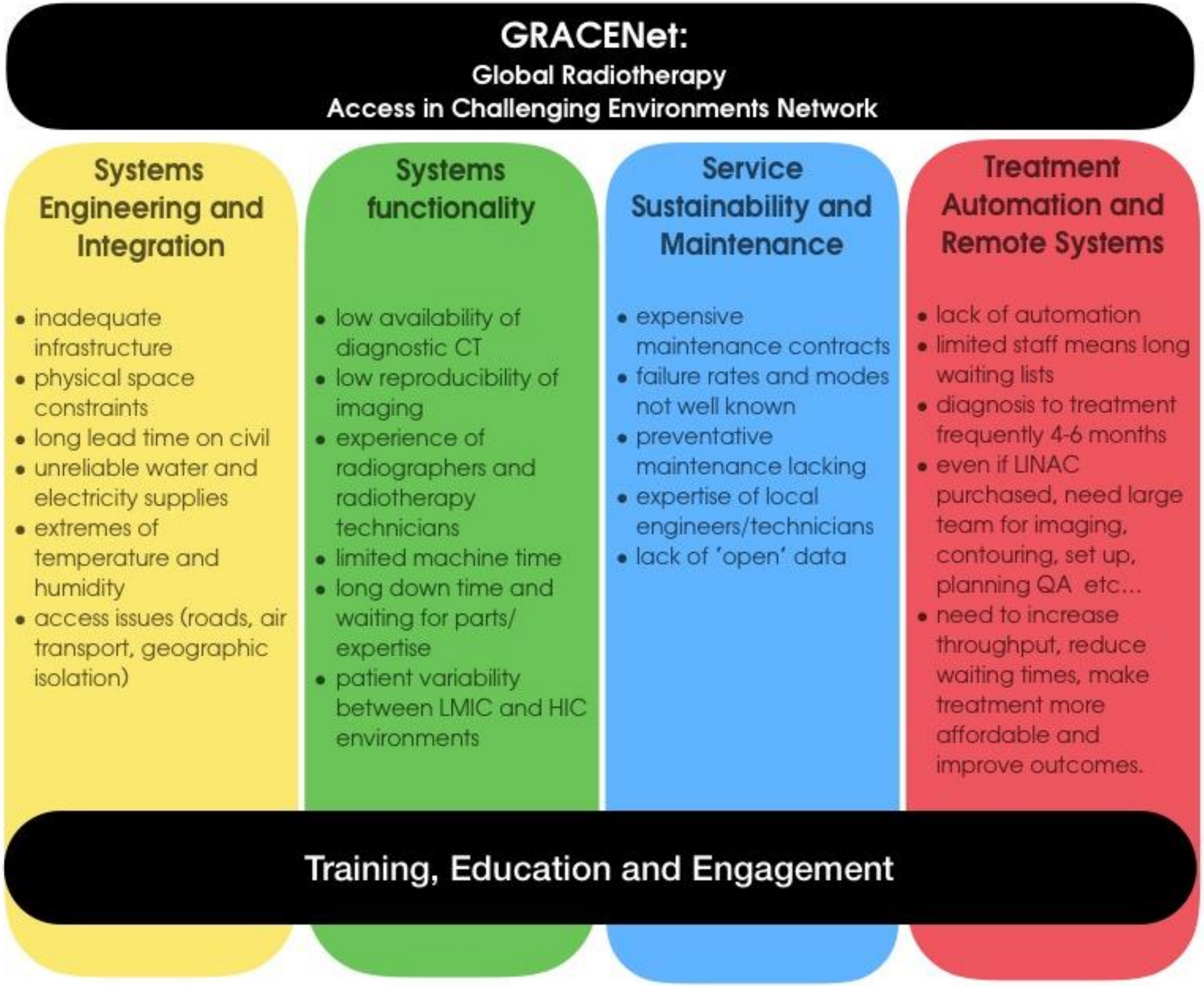
Identification and pilot programmes of sustainable training and education initiatives to address shortfalls in expertise.

Undertake a public/patient outreach programme co-designed and delivered with ODA partners.

COMMUNICATION

Disseminate the work of the Network through publications, reports, publicity and a dedicated website.

Consolidate and grow existing relationships between UK based academic institutions, NGOs (ICEC, UICC, AFRICSIS) and key international institutions and professional bodies (ESTRO, IPEM, CERN) as well as other leading international institutions in global cancer research.


GRACENet:
Global Radiotherapy
Access in Challenging Environments Network
Systems Engineering and Integration
• inadequate infrastructure
• physical space constraints
• long lead time on civil
• unreliable water and electricity supplies
• extremes of temperature and humidity
• access issues (roads, air transport, geographic isolation)
Systems functionality
• low availability of diagnostic CT
• low reproducibility of imaging
• experience of radiographers and radiotherapy technicians
• limited machine time
• long down time and waiting for parts/ expertise
• patient variability between LMIC and HIC environments
Service Sustainability and Maintenance
• expensive maintenance contracts
• failure rates and modes not well known
• preventative maintenance lacking
• expertise of local engineers/technicians
• lack of 'open' data
Treatment Automation and Remote Systems
• lack of automation
• limited staff means long waiting lists
• diagnosis to treatment frequently 4-6 months
• even if LINAC purchased, need large team for imaging, contouring, set up, planning QA etc...
• need to increase throughput, reduce waiting times, make treatment more affordable and improve outcomes.
Training, Education and Engagement

Systems engineering/integration

- consider how these access barriers may be overcome so services can be set up over a short time frame even in settings which lack many elements of the basic infrastructure required.
- Address environmental factors, external power sources, packaging or portability, adaptability as well as space requirements.
- Examples include:
  - the creation of a temporary shielded facility within existing buildings to reduce the service setup time,
  - the design of a portable linac solution e.g. in a shipping container, with an all in one diagnostic CT and treatment delivery capability to enable radiotherapy to be delivered safely in remote locations.

System Functionality

Systems functionality

- low availability of diagnostic CT
- low reproducibility of imaging
- experience of radiographers and radiotherapy technicians
- limited machine time
- long down time and waiting for parts/ expertise
- patient variability between LMIC and HIC environments

- ensure that treatment quality in LMICs is not compromised by the complexities/issues with equipment and interface functionality.
- Learn from the experience of radiographers, radiotherapy technicians and other ODA staff to address functionality aspects of radiotherapy systems and validate concepts for operation and user interface.
- It will also explore ‘modular’ systems to address this challenge including on-board dose monitors, on-board kV portal imaging and/or CT imaging, patient setup systems, streamlining of treatment processes, data architecture and data acquisition.

Service Sustainability & Maintenance

Service Sustainability and Maintenance

- expensive maintenance contracts
- failure rates and modes not well known
- preventative maintenance lacking
- expertise of local engineers/technicians
- lack of 'open' data

- focus on the infrastructure necessary to provide sustainable delivery of service and maintenance to ensure clinical operation.
- initiatives to deliver sustainable training and education aspects of technical staff,
- opportunities for developing remote engineering maintenance, on-board machine diagnostics, dynamic monitoring of radiotherapy systems, and considerations for creating a more robust accelerator design.

Treatment Automation & Remote Systems

Treatment Automation and Remote Systems

- lack of automation
- limited staff means long waiting lists
- diagnosis to treatment frequently 4-6 months
- even if LINAC purchased, need large team for imaging, contouring, set up, planning QA etc…
- need to increase throughput, reduce waiting times, make treatment more affordable and improve outcomes.

- define and undertake R&D to automate many of these processes,
- minimize the time from diagnosis to initiation of treatment
- reduce the personnel requirements.
- increase throughput, reduce costs and increase capacity of the radiotherapy service.
- use of clouds and grids have the potential to facilitate remote training, maintenance, treatment planning and international research collaborations.

Other aspects: communication

- Create a website for the Network
- A regular newsletter for policy makers and wider audience.
- Publish easily readable articles in magazines, popular science and media outlets.
- Continue to engage with media to enhance visibility (BBC, documentaries etc…)
- Publish results in high quality peer reviewed journals
- A co-created public/patient engagement programme to overcome patien

Reviews

“Compared to what this network can rapidly accomplish to progress through mentor/mentee relationships, fostering new collaborations among thought leaders, and realization of many opportunities to develop novel concepts and projects in low- and LMICs … the added value for the proposed budget seems to be many orders of magnitude, in my opinion.

“There is no question about importance of the project and the possibly very significant impact it may have on the provision of the radiation therapy in the low and middle income countries, if delivered successfully.”

Conclusions

- We have identified, together with everyone in this room, the challenges we are facing.
- We know how to move forward
- Networking is *essential* to our goals
- We will continue to seek greater funding to help this collaboration improve access to radiotherapy.