ACCELERATORS FOR ADS WORKSHOP SUMMARY

1st EuCARD2 annual meeting
G Bellodi – CERN
WP4 AccApplic
21-05-2014
Hamburg

Joint ADS workshop -
@ CERN, 20-21 March 2014

J.-L. Biarrotte and A.Lombardi (chairs)
G. Bellodi and F. Bouly (secretaries)

- 42 registered participants
- 12 Laboratories
- 34 Contributions
- Projects:
  - Myrrha
  - Linac4/SPL
  - ESS
  - SARAF
  - SPIRAL2/IPHI

Focus on:

Design and technical issues of high-power high-intensity linear accelerators for ADS applications

→define the necessary R&D
→ find synergies

- Link to agenda and slides
- EuCARD2 publication of workshop summary soon!

ACCAPPLIC

AccApplic: Applications of Accelerators Towards Industry and Healthcare
a networking activity within EUCARD2

Amongst its objectives are to:

- facilitate the activities of the European accelerator communities in the development of accelerators for applications in industry, healthcare, energy production and security
- assess the use of novel technology
- determine the requirements for high power accelerator applications, in particular for Accelerator Driven Systems (ADS)

Promote workshops, exchange b/w experts, journal dissemination & web databases

More information on:
http://eucardapplications.hud.ac.uk/

MAX-MYRRHA

MAX is a FP7 Euratom project addressing the issue of high-level long-lived radioactive waste transmutation through R&D on a high-power proton accelerator as specified by the MYRRHA ADS demonstrator project in Belgium.

→ Increase confidence on feasibility of the project through simulation studies and experiments on dedicated accelerator test sections

*MYRRHA
Belgian project for flexible fast spectrum irradiation facility
Strongly embedded in the EU EURATOM Framework Programme
2020 construction horizon if approved
November 2012 design review → positive outcome
Appreciation of progress on MAX , need to establish a core accelerator competency within MYRRHA team, fostering collaborations

→ Organization of the workshop, critical timing! (MAX2 proposal deadline by end 2014)

WHY ADS?

Review talk by Jean Pierre Revol (Centro Fermi, Roma/ iThEC, Geneva)

The framework:

World power consumption will have to increase by a factor of 3 by the end of the century and viable innovative alternatives to fossil fuel need to be researched. Renewable energy sources are dispersed and intermittent, interest is now turning towards fast critical reactors or thorium energy.

→ Thorium in fast neutron ADS : “a sustainable source of energy on the human time scale” (ThEC13 conference)

Main issue is absence of demonstrator.

Basic elements of an ADS system are
1) a particle accelerator to provide a neutron source
2) a core.

ADS ACCELERATOR REQUIREMENTS

- **Beam particle: protons** [electrons (low spallation neutron yield), deuterons (neutron background)];
- **Beam structure: CW** preferential, pulsed heating is problematic!
- **Beam power: a few to 10-15 MW** depending of choice of ks value, and desired unit power output;
- **Beam Energy:** $E_{beam} \geq$ 800-900 MeV
- **Beam spot size (footprint):** large on impact on window, but perhaps some limitation due to beam transport issues (studies at JAEA: $\leq$ 0.1-0.2 mA/cm^2 ?), MYRRHA has 0.07mA/cm^2;
- **Beam losses:** minimize irradiation of the accelerator and of the environment; impact on the maintenance and repair (main issue for any high power beam, not only for ADS);

ACCELERATOR REQUIREMENTS II

- **Reliability,** minimize beam trips (have multiple sources); the limitation comes mainly from thermal stress in fuel structure.
  - Trip < 0.1 s no limit
  - 0.1 s < Trip < 3 s not more than 100 per day
  - Trip > 3 s 10 in three months
  - Parallel/serial redundancy – large acceptance and margins for retuning, fast controls!
- **Beam power stability and control**: 1% fluctuation on beam intensity is 1% fluctuation on the thermal power;
- **Large operational range of beam intensity**: to follow demand; factor 10?
- **Energy efficiency:** maximize fraction of electric grid power stored in the beam. Relevant to overall energy efficiency of system
- **Size of accelerator:** for waste elimination, people might want to fit it on the site o a standard nuclear power plant
- **Cost:** This is very important. One main criticism of ADS is that "the accelerator does not exist and will be too expensive"

In the end, the solution chosen among LINAC, Cyclotron or FFAG will be the one best fulfilling all these requirements

MYRRHA R&D FUTURE

Project is partially funded and strongly supported by Belgian government.

Present R&D happening thanks to MAX collaboration; need to build up a strong internal core team at SCK-CEN.

inj@UCL project is ongoing (ion source operational and LEBT under construction). The development of a spoke cryomodule prototype is envisaged.

Possible follow-up :

- First Euratom H2020 Fission call deadline in Sept 2014
- Output of preliminary discussions with SK-CEN :
  - Only 1 integrated project with 3 big WPs
    (reactor safety, liquid LBE R&D, acceleratorsR&D)
  - Focus efforts to build a full-scale injector demonstrator

EURATOM H2020

Possible list of topics for a future accelerator WP:

WP.1: construction of a full RFQ demonstrator
WP.2: 176 MHz RF power amplifier development
WP.3: Digital LLRF development
WP.4: Beam diagnostics
WP.5: Controls
WP.6: Beam simulation code development
WP.7: LEBT space-charge experiments
WP.8: Injector commissioning
WP.9: Detailed injector reliability analysis
WP.10: SRF spoke R&D – prototyping, multipacting
WP.11: SRF CH demonstration with beam

MAIN COMMON THEMES

- RELIABILITY
- LEBT dynamics and neutralisation effects
- Virtual Accelerator
- Possibility to use framework of EUCARD2/H2020 as a catalyst for organising mini-workshop on a very specific topic

RELIABILITY

Create a catalogue of faults from existing linacs

Identify what can be addressed wrt:

- Making the system more reliable
- Mitigation measures
- Automated reaction

Idea to use the planned LINAC4 reliability run in 2016 as test bed
the RFQ@UCL test stand could also be used for benchmarking/improving reliability models

Prepare a proposal to the next EC infrastructure call (sept. 2014) on "accelerator reliability" project . Obvious parners would be SCK, CNRS, CERN, CEA, ESS…

dedicated studies to cryogenic system reliability, especially focused on the cryomodule component are needed.

LEBT DYNAMICS AND NEUTRALISATION EFFECTS

Better understanding of the Space Charge compensation phenomenon in magnetic LEBTs:

- Compensation level
- Transient time
- Pressure & gas effects

Only qualitative agreement so far with self-consistent codes

Dedicated test-bench experiment in Saclay : BETSI (ESS chopper tests)
Use the MYRRHA@UCL (@LPSC) for experiments, LIPAc in Rokkasho

Collaboration with interested partners (CEA, CERN, GSI) to share & exchange results
Benchmark/improve simulation codes

VIRTUAL ACCELERATOR

A simulation code connected to the control system of the real machine.

3 different approaches based on read/write access to real/virtual machine databases: control tower, flight simulator and autopilot.

A Light solution of the autopilot mode is being developed at CEA using Tracewin and EPiCS.

Keep developing the Virtual machine concept: complete the CEA tools and test on Myrrha injector

Improve longitudinal dynamics simulations in fast retuning procedures:

- Include more realistic models for the V/phase tuning method to better assess possible related losses
- Develop dedicated algorithms for automatic set-points reconfiguration (fault cases)

OTHER POSSIBLE COMMON TOPICS

- Control systems and DLLRF
- Multipacting studies :

  Dedicated test stands under construction by CNRS
  Collaboration interest to study coating solutions
  ESS interested on multipacting issues in power couplers

- Beam diagnostics

The organisation of dedicated workshops is presently being discussed in the framework/mandate of the AccApplic WP.