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Book of Abstracts

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The Future of Nuclear Energy; Chemistry is the Problem, Accelerators the Solution

Author: Charlie Bowman[1]

Co-author: Ganapati Myneni [2]

[1] *ADNA Corporation*

[2] *Jefferson Lab*

Corresponding Authors: cbowman@cybermesa.com, rao@jlab.org

Throughout mankind's existence it has been impossible to mine nuclear weapons material directly from the earth. Although natural uranium can be mined, separating the 235 U still requires difficult and expensive technology and time. And even if 235 U is obtained by isotopic enrichment, it can be rendered useless for weapons simply by mixing it with natural uranium and returning it to the earth.
Plutonium is another matter as there is no natural plutonium with which to dilute it. If weapons plutonium (W-Pu) is returned to the earth, it can be dug up quickly and cheaply. It is commonly claimed that commercial reactor waste containing plutonium (C-Pu) containing large amounts of 240 Pu is not weapons useful and therefore need only be made unavailable by burial. However 239 Pu lives about three times as long as 240 Pu, so the 240 Pu decays away leaving W-Pu after one 239 Pu half life. Yucca Mountain as planned therefore would eventually contain about 350 tons of W-Pu that need only be dug up and chemically separated…sufficient for about 70,000 nuclear weapons from this one site. Worldwide nuclear would eventually enable millions from many sites….an absurd legacy to permit from today's nuclear technology.
The world cannot leave underground weapons plutonium or these dangerous commercial isotopic mixtures of plutonium. These remnants must be burned in reactors optimized for this purpose. That will happen only if burning is cost competitive with present reactors, but such waste-burning critical reactors after sixty years still do not exist. The ideal reactors are GEM*STAR reactors based on accelerator-driven molten-salt thermal-spectrum systems. GEM*STAR reactors are advantageous for many reasons, but mostly because they require no chemical/isotopic separation for fuel, no chemistry for solid fuel preparation, and no chemical reprocessing, and because they eliminate the chemical overhead of fission product and higher actinide waste streams and chemistry-driven nuclear weapon proliferation. The implementation of accelerators displaces expensive chemistry thereby enabling nuclear energy cheaper than any other system. GEM*STAR can, without chemistry, burn safely and economically both W-Pu and C-Pu into isotopic mixtures that cannot decay to W-Pu. Nuclear energy has no long term future without eliminating the long-term legacy of mining nuclear weapons material from today's critical reactors.

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On the qualification of niobium materials for Superconducting Radio Frequency Cavity applications

Author: Sindhunil Barman Roy[1]

Co-author: Ganapati Myneni [2]

[1] *1Magnetic & Superconducting Materials Section, Materials & Advanced Accelerator Sciences Division, Raja Ramanna Centre for Advanced Technology, Indore 452013, India*

[2] *Accelerator R&D, Jefferson Lab, 12050 Jefferson Ave, MS 602, Newport News, VA 23606 USA*

Corresponding Authors: rao@jlab.org, sbroy@rrcat.gov.in

High energy particle accelerators with continuous wave or long-pulse accelerating fields (or gradients) above a few million volts per meter (MV m−1) will be of much interest in the context of the future ADS programs. In such applications niobium-based superconducting radio frequency (SCRF)

cavities bring various advantages over the conventional copper RF cavities. Here we address the issues related to the qualifications of the niobium materials to be used for cavity fabrications, focusing particularly on the materials properties of niobium required for the functioning a SCRF cavity, and optimizations of the same properties for the best SCRF cavity performance in a reproducible manner. In this way the niobium materials are not necessarily characterized by their purity alone, but in terms of those materials properties, which will define the limit of the SCRF cavity performance and also other related material properties like thermal diffusivity in niobium at the cavity operating temperatures necessary for sustaining this best SCRF cavity performance. Furthermore we point out the need of standardization of the post fabrication processing of the niobium-SCRF cavities, which does not impair the optimized superconducting and thermal properties of the starting niobium-materials required for the reproducible performance of the SCRF cavities according to the design values

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Low Cost is Mandatory for Widespread Success

Author: Lars Jorgensen[1]

[1] *ThorCon, Royal Oaks, CA, USA*

Corresponding Author: lars.jorgensen90@gmail.com

Electrical demand world-wide is likely to increase at 100 GWe per year for the next 50-100 years. The vast majority of this will occur in the developing world where they will install the cheapest electricity as soon as they can afford it. Currently that is coal. In order to change this forecast we must invent a power generator that is cheaper than coal and can be massively and rapidly deployed. ThorCon using a thorium molten salt reactor is one such candidate.

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Virginia Tech Activities on the Design and Analysis of Advanced Subcritical Reactor Systems

Author: Alireza Haghighat[1]

Co-author: Bruce Vogelaar [2]

[1] *1Nuclear Science and Engineering Lab (NSEL) at Arlington, Nuclear Engineering Program, Department of Mechanical Engineering, Virginia Tech*

[2] *Department of Physics, Virginia Tech*

Corresponding Authors: vogelaar@vt.edu, haghighat@vt.edu

Over the past eight years, the Virginia Tech group has been working on the design and analysis of the GEM*STAR concept. This is a Molten Salt fueled Accelerator-Driven Subcritical Reactor (MS-ADSR) that uses a graphite moderator and a proton accelerator with a uranium target.

In previous analysis of the GEM*STAR reactor system, several simplifying assumptions were made about the neutronics modeling. In this paper, we report on a more detailed study using the Monteburns code system which employs the MCNP6 and CINDER90 code systems for neutronics and burnup calculations, respectively. For the tested fuel-feed compositions, the calculated equilibrium isotopic concentrations and electric multiplication factors are within similar orders of magnitude. Burnup analysis shows that the approach to equilibrium takes approximately two years for natural uranium fuel. Considering a natural uranium fuel, we have examined several feed materials including natural uranium, LWR spent fuel and weapon grade plutonium (WGPu).

Further, we have initiated a multidisciplinary program entitled Safe, Secure and Sustainable Nuclear Power (S3NPower) cluster. S3NPower brings together a group of VT faculty members from Nuclear Engineering, Physics, Material Science and Engineering and Mechanical Engineering to engage in the design and analysis of innovative reactor designs such as GEM*STAR. The team will address topics including Physics and Kinetics, Thermal Hydraulics, Nuclear Materials, Fuel Cycle and Waste, Monitoring Systems, and Nuclear Nonproliferation and Safeguards. This paper will report our preliminary efforts on comparing the safety and physics of a MS-ADSR prototype with a reference Molten Salt Reactor (MSR). The goal is to identify advantages/disadvantages of a subcritical reactor versus a critical reactor.

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GEANT4 SIMULATIONS OF PROTON-INDUCED SPALLATION FOR APPLICATIONS IN ADSR SYSTEMS

Author: David Sangcheol Lee[1]

Co-authors: Cristian Bungau [1]; Rebecca Seviour [1]; Robert Cywinski [2]

[1] *IIAA*

[2] *U*

Corresponding Authors: c.bungau@hud.ac.uk, sangcheol.lee@hud.ac.uk, r.seviour@hud.ac.uk, r.cywinski@hud.ac.uk

Neutron spallation is an efficient process for producing intense neutron fluxes that can be exploited in Accelerator Driven Subcritical Reactors (ADSRs) for energy production and the transmutation of nuclear waste. In order to assess the feasibility of spallation driven fission and transmutation we have simulated proton induced neutron production using GEANT4, initially benchmarking our simulations against published experimental neutron spectra produced from a thick lead target bombarded with 0.5 and 1.5 GeV protons. The Bertini and INCL models available in GEANT4, coupled with the high precision (HP) neutron model, are found to adequately reproduce the published experimental data. Given the confidence in the GEANT4 simulations provided by this benchmarking we have then proceeded to some preliminary studies of neutron production using Thorium in an ADSR with a geometry similar to that of the proposed Belgian MYRRHA project with 0.6 GeV proton beam energy that proposed by SCKCEN.

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Prototyping activities in view of realising the phase 1 accelerator for MYRRHA

Author: Dirk Vandeplassche[1]

[1] *SCK-CEN*

Corresponding Author: dirk.vandeplassche@sckcen.be

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Practical experience of running the ISIS proton accelerator spallation source

Author: John Thomason[1]

[1] *STFC*

Corresponding Author: john.thomason@stfc.ac.uk

The ISIS neutron and muon source is based on a high intensity proton accelerator and has run for over 30 years producing world-leading science. However, keeping such an accelerator running sustainably and at >90% availability to the user community is challenging, particularly considering that some accelerator components significantly predate the present machine. This talk will cover aspects of accelerator performance, fault finding and maintenance regimes, the ISIS sustainability programme and thoughts about facility upgrades.

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Reliability of high power neutron sources in the design phase

Author: Enric Bargalló[1]

[1] *European Spallation Source*

Corresponding Author: enric.bargallo@esss.se

Reliability of high power neutron sources is difficult to predict; however, there are ways to drive the design towards high reliability performance. In this contribution, the tools, methods and experiences from some of these facilities will be presented.

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An Overview of the High Power Radio-Frequency Distribution System of the ESS

Author: Norman Turner[1]

[1] *University of Huddersfield*

Corresponding Author: norman.turner@hud.ac.uk

The European Spallation Source (ESS) is a high brightness source of slow neutrons which is currently under construction in Sweden. ESS uses a linear accelerator to accelerate protons to 2000MeV. The superconducting cavities of the accelerator are supplied with power by a radio-frequency (r.f.) distribution system. The design, construction and operation of this r.f. system will provide valuable design information for an ADS driven by a linear accelerator. Here we provide an overview of the r.f. distribution system for ESS including protection against electrical breakdown in the waveguides.

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Accelerator Reliability requirements for ADS: the MYRRHA project goals

Author: Tomas Junquera[1]

[1] *Accelerator and Cryogenic Systems*

Corresponding Author: tomas.junquera@acsfrance.com

Beam stability and overall reliability of the Accelerator systems are major concerns in ADS technology. Short beam interruptions can induce high thermo-mechanical stress and fatigue in the reactor structure. Beam stops lead also to safety related procedures reducing the reactor availability.
In the Myrrha project, the main reliability requirement is to reduce the number of short beam interruptions to levels not yet reached in research accelerators. It represents a major challenge, needing special design approachs.
In the last period, several collaborating projects, developed within the Euratom framework programs, have performed detailed evaluation of the reliability expected performance and have proposed new concepts looking to overcome these difficulties. These proposals represent important guidelines for the new phases of development of an ADS demonstrator.

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Status and progress of front end injectors for CADS

Author: Zhijun Wang[1]

[1] *IMP-CAS*

Corresponding Author: wangzj@impcas.ac.cn

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Reliability and fault-tolerance strategy in CADS linac and beam commissioning of CADS injector-I

Author: Cai Meng[1]

[1] *ihep*

Corresponding Author: mengc@ihep.ac.cn

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the present status and future plans of Chinese ADS project

Author: Yuan He[1]

[1] *IMPCAS*

Corresponding Author: hey.yuan@yahoo.com

Chinese ADS project started in 2011. It has taken around 6 years in the first stage. There are great progress have been achieved on the key technologies on accelerator, target and sub-critical reactor and will be introduced. The CW, ~4 mA, ~5 MeV proton beam has been domostrated stably in the last year. The demo linac with 25 MeV based on HWR and Spoke cavities is constructing and will

commission by the end of year. A new conception of granular target has been proposed to sustain the beam power as high as 6 MW. The small-scale tests have been done and a large-scale loop bench is constructing to demonstrate the feasibility. The property of pellets is improving by material methods. A LBE loop has been developed and some long-term material experiments have been done. The second stage project, CIADS, was approved last year. It consists a superconducting proton linac with beam current of 10 mA and energy of 600 MeV, a granular target with tungsten pellets, and a LBE sub-critical reactor. The total thermal power of reactor and beam is 10 MW. It is a demonstration of high power coupling and transmutation. Base on the investigations in the fist stage, a new concept of ADANES (Accelerator Driven Advanced Nuclear Energy System) was put forward. It will be introduced too as the future plan.

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Energy Efficiency of Accelerator Driven Sub-critical Reactors for Nuclear Waste Transmutation

Author: Malek Haj Tahar[1]

Co-authors: Francois Meot [2]; Stephen Peggs [3]

[1] *Brookhaven*

[2] *Unknown*

[3] *BNL*

Corresponding Authors: mhajtahar@bnl.gov, peggs@bnl.gov, francois.meot@cern.ch

Energy efficiency is a major criterion for modern economic decision-making. However, in matter of nuclear energy, the costs of nuclear waste disposal are generally externalized by passing them to the environment or to future generations. In this study, we investigate the impact of the accelerator on the overall efficiency of an Accelerator Driven Sub-critical Reactor aimed for nuclear waste transmutation and for better fuel utilization. Several considerations include the transmutation characteristics, the wall- plug efficiency of the accelerator as well as the technology choice.

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Studies of The PSI Injector II high current cyclotron

Author: Anna Maria Kolano[1]

[1] *CERN*

Corresponding Author: anna.maria.kolano@cern.ch

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Simulation and parametrisation of spallation neutron distributions

Author: Asiya Rummana[1]

[1] *Huddersfield*

Corresponding Author: asiya.rummana@hud.ac.uk

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Studies of MYRRHA with thorium fuel

Author: Asiya Rummana[1]

[1] *Huddersfield*

Corresponding Author: asiya.rummana@hud.ac.uk

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A model for neutron production from deuteron breakup

Author: Simon Albright[1]

[1] *CERN*

Corresponding Author: simon.albright@cern.ch

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Current research on ADS at the Joint Institute for Nuclear Research

Author: Miroslav Zeman[1]

[1] *Brno University of Technology*

Corresponding Author: zeman@jinr.ru

The research on Accelerator Driven Systems (ADS) has more than 20 year's tradition at the Joint Institute for Nuclear Research. Since 2010, the most experiments have been performed with a spallation target composed of 512 kg of natural uranium QUINTA irradiated with proton and deuteron beams of high energies. Currently, final preparations of a new spallation target BURAN consisting of 20 tons of depleted uranium are under away. The main tasks of the project are experimental investigation of neutron production inside the spallation target, possibility of natural thorium utilization and transmutation of the long-lived fission product. The supplementary tasks are measurement of nuclear data and verification of nuclear codes and theoretical models related to the ADS technologies. Recently, the group also investigates possibility of determination of the fission heat flux with the use of highly accurate thermocouples.

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iThEC ADS Initiatives

Author: Maurice Bourquin[1]

[1] *University of Geneva*

Corresponding Author: maurice.bourquin@unige.ch

The international Thorium Energy Committee (iThEC), a not for profit association, under Swiss law, was founded in 2012. Its members are engineers, physicists, and other concerned citizens acting to promote R&D on the use of thorium in order to transmute nuclear waste and produce safe, clean and abundant energy. To meet the tremendous world energy needs, systematic R&D has to be pursued to replace fossil fuels. Nuclear energy, which produces no green-house gases and no air pollution, should be a leading candidate, and in this context, thorium represents a great potential. iThEC is at the origin of two new initiatives, which I will present: a first ADS experiment of substantial power (≥ 1 MW) and a high-power superconducting cyclotron design. Global cooperation is highly desirable in this domain, and I will discuss possibilities of cooperation based on the CERN experiment model.

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Status and challenges of the European Spallation Source

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MYRRHA project status and contribution for HLW management and SMR based on Lead Technology

Author: Hamid Aït Abderrahim[1]

[1] *SCK.CEN*

Corresponding Author: haitabde@sckcen.be

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Recent developments of high purity niobium metal ingots for ADS applications

Author: Gustavo Abdo[1]

[1] *BMM*

Corresponding Author: gustavo.abdo@cbmm.com.br

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A compact, high power FFAG proton driver for ADS

Author: Carol Johnstone[1]

[1] *Fermilab*

Corresponding Author: cjj@fnal.gov

Fixed-field alternating gradient accelerators are proving to be a highly promising candidate for next-generation 10 MW-class high power proton drivers due to recent advances in design which demonstrate continuous (CW) operation combined with stable, 2-4 m long straight sections allowing insertion of high-gradient RF. The resulting 1-GeV 'FFAG cyclotron' thus supports a continuous (CW) beam with far lower peak current than the pulsed alternative. lattice mitigaBoth a circular and racetrack version have been designed including modeling 3D space charge using the OPAL framework and beam dynamics with fast acceleration in the 'serpentine channel'. The addition of strong and reverse gradient in a nonscaling optimized lattice are found to mitigate space charge and emittance blowup. Simulations indicate stability above the 10 mA threshold required for 10 MW operation.

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Energy Efficiency of Accelerator Driven Sub-critical Reactors for Nuclear Waste Transmutation

Author: Malek HAJ TAHAR[1]

Co-author: Stephen Peggs [2]

[1] *Brookhaven National Laboratory*

[2] *BNL*

Corresponding Authors: hajtaham@gmail.com, peggs@bnl.gov

Energy efficiency is a major criterion for modern economic decision-making. However, in matter of nuclear energy, the costs of nuclear waste disposal are generally externalized by passing them to the environment or to future generations. In this study, we investigate the impact of the accelerator on the overall efficiency of an Accelerator Driven Sub-critical Reactor aimed for nuclear waste transmutation and for better fuel utilization. Several considerations include the transmutation characteristics, the wall-plug efficiency of the accelerator as well as the technology choice.

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Thorium power - where are we?

Corresponding Author: r.cywinski@hud.ac.uk

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The Beam Raster System of the European Spallation Source

Corresponding Author: heinetho@phys.au.dk

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The Beam Raster System of the European Spallation Source

Author: Heine Thomsen[1]

[1] *Aarhus University, Denmark*

Corresponding Author: heinetho@phys.au.dk

The European Spallation Source (ESS) will apply a fast beam raster system to redistribute the proton beam transversely across the spallation target surface. The system operates at sweep frequencies of tens of kHz and efficiently evens out the time-averaged beam intensity, thus reducing the level of beam-induced material damage and decreasing component cooling demands. Designed for a long-pulse spallation neutron facility, the ESS raster system will operate at only 5% duty cycle (covering the proton beam pulses) and provide a nominal beam footprint with a rectangular outline (matching the target and moderator geometry). Following a presentation of the ESS design, ideas of how the concept could be adapted to be more suitable for ADSRs will
be presented.

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Thorium Fuelled reactors: do they need an accelerator?

Corresponding Author: roger.barlow@cern.ch

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Modelling accelerator reliability

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ADSRs and Thorium power - what next?

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DOE/NNSA paying for an ADS pilot plant to dispose of WGU?

Corresponding Author: rol@muonsinc.com