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OVERVIEW OF WORLDWIDE ACCELERATORS FOR ADS *

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Abstract

Many interesting proposals and programs for accelerator driven subcritical facilities for waste transmutation(ADS) in the world have been developed, which is to speed up from the basic study to the real facility in recent years, and the significant progresses in the development of accelerator technologies, in particular, in superconducting RF linacs for ADS have been made, but the key technologies in high power proton accelerator are still severe challenges which call for the close international cooperation.

INTRODUCTION

In past decades, worldwide nuclear power developed rapidly, meanwhile, nuclear waste is a bottleneck for nuclear power development. ADS is considered as a good option for nuclear waste transmutation (Figure 1).

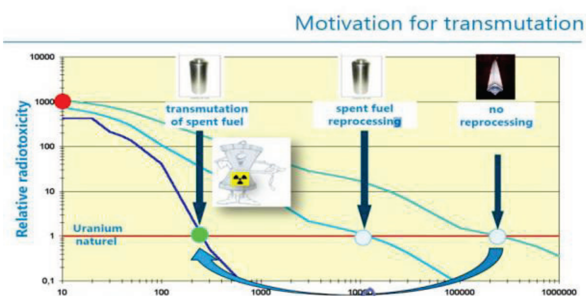

Figure 1: Nuclear Waste Management [1].

ADS mainly has two aims: one is burn-off of long-lived actinide waste from traditional nuclear reactors, another is energy production from Thorium fuel (Figure 2).

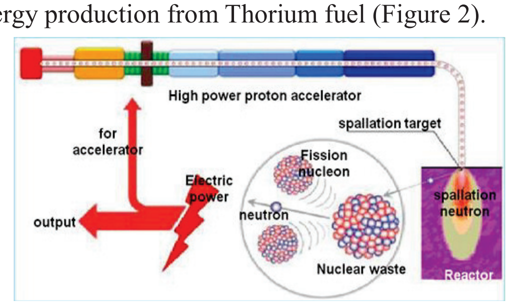

Figure 2: ADS system.

BASIC REQUIREMENTS OF ADS ACCELERATOR

Generally, transmutation demonstration facility requires a beam power of 1-2 MW to deliver a thermal power of 50-100 MW. As a typical example, MYRRHA Project designs 600 MeV /1.5 MW beam power，and 85 MW thermal power [1].

CW beams are preferential for ADS, because the target for pulsed heating is a challenge, and beam space charge effect is weaker in cw.

ADS accelerators require many restrictions that include high beam power and very high stability as well as very low beam loss(<1W/m) , it's more severe than in conventional research accelerators , so, the special design is needed. For fault tolerance and redundancy of the accelerator, the key accelerator's components need much over their limits, and have ability to fast repair failings. For the high availability, the control strategies should be considered, including over-design, using reliable components in key parts, redundant elements, perfect protections and fault predicting function.

INTRODUCTION OF WORLDWIDE ADS ACCELERATOR PROGRESSES

MYRHHA

Multipurpose Hybrid Research Reactor for High-tech Applications (MYRHHA) will couple accelerator, spallation target and sub-critical reactor as a transmutation demonstrator.

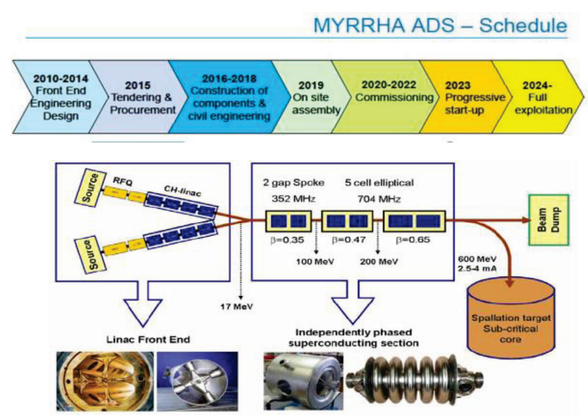

Figure 3: MYRRHA ADS schedule and accelerator [1].

MYRRHA accelerator's high power proton beam is up to 2.4 MW with extreme reliability level.

A MYRRHA Accelerator has completed spoke cavity prototype EM optimization and mechanical optimization. The cavity manufacturing and integration are under way.

A power coupler 350 MHz, 20 kW CW (designed) was manufactured and tested at 8 kW (limited by amplifier) CW on a 350 MHz, beta= 0.15 Spoke cavity.

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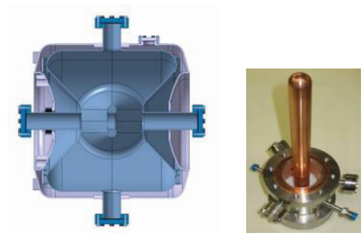

Figure 4: Spoke cavity and input coupler.

Table 1: MYRRHA Proton Beam Requirements [2]

Parameter	value
Proton energy	600 MeV
Peak beam current	0.1 to 4.0 mA
Repetition rate	1 to 250 Hz
Beam duty cycle	10-4 to 1
Beam power stability	< ± 2% on a time scale of 100ms
# of allowed beam trips on reactor longer than 3 sec	10 maximum per 3-month operation period
# of allowed beam trips on reactor longer than 0.1 sec	100 maximum per day
# of allowed beam trips on reactor shorter than 0.1 sec	unlimited

J-PARC

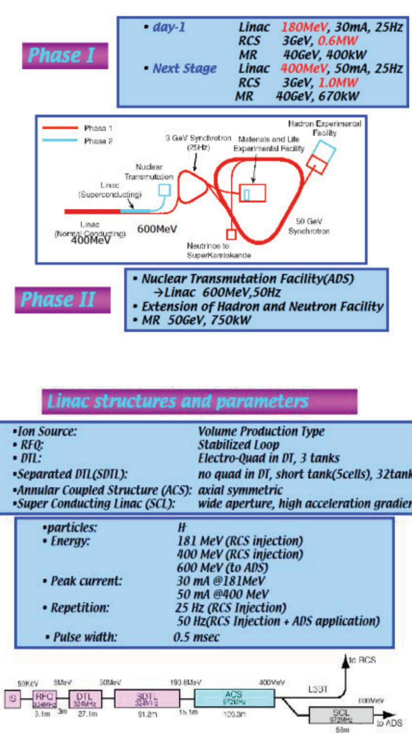

Figure 5: ADS accelerator Program of J-PARC[3].

KIPT Experimental Neutron Source Facility

One purpose of KIPT Experimental Neutron Source at Ukraine is to provide capabilities for performing basic and applied research using neutrons and perform physics and material experiments inside the subcritical assembly and neutron experiments using the radial neutron beam ports of the subcritical assembly.

The maximum beam current obtained at the injector exit is ~2A with 2.7 μs beam pulse. Energy spread is ~2% @ 1σ.

Figure 6 : Injector testing facility installed.

HYPER

The Korea Atomic Energy Research Institute (KAERI) performs Hybrid Power Extraction Reactor(HYPER) for the transmutation of nuclear waste and energy production, to develop the elemental technologies for the subcritical transmutation system and build a small bench scale test facility (5 MW). 1 GeV 16 mA proton beam is designed to be provided for HYPER [4].

KOMAC

Korea multi-purpose accelerator complex (KOMAC) accelerator facility was put into operation from July 2013, which consists of a 100MeV proton linac including a 50keV ion source, a 3MeV RFQ and a 100MeV DTL, and 20MeV and 100MeV beam lines. Goal of the beam commissioning is delivering 100MeV/1kW proton beams [5] .

Proton Linac in India ADS Program

Accelerator for ADS consists of 30 mA /20 MeV Linac injector (LEHIPA) and High energy Linac (1 GeV). Design of completed & fabrication is in progress (ECR Ion Source, LEBT, RFQ, DTL, RF coupler and klystron).

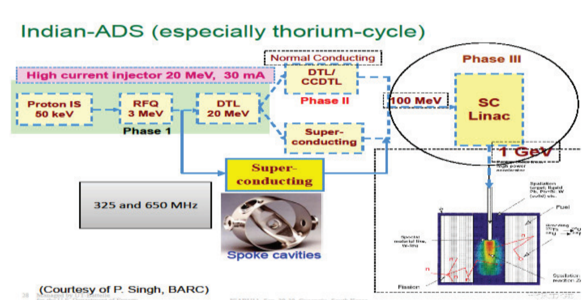

Figure 7: India ADS accelerator Program [6].

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TAC

Turkic Accelerator Complex project (TAC) plans to set up GeV scale proton accelerator which has two-fold goal: Neutron Spallation Source (NSS) and ADS. The proton accelerator construction will have 3 MeV, 100 MeV, and 1 GeV phases [7].

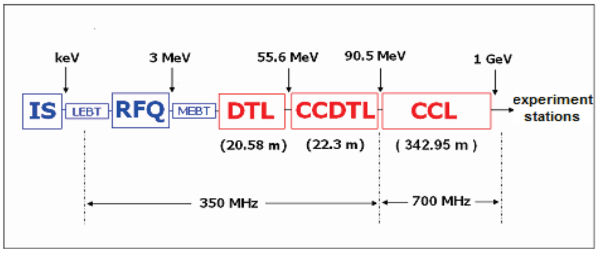

Figure 8: GeV energy high intensity (>1mA) proton linac.

China ADS Project

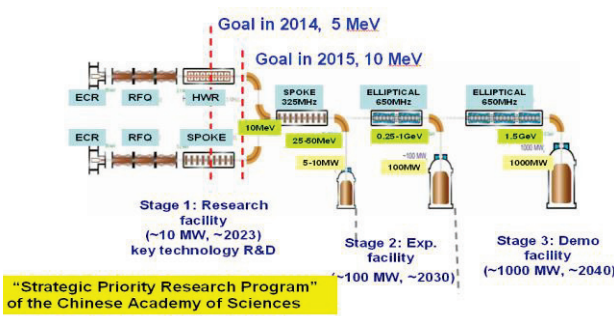

Figure 9: Roadmap of ADS Project in China.

The proton accelerator is being built by institute of high energy physics (IHEP) and institute of modern physics (IMP) together, and project started from early 2011.

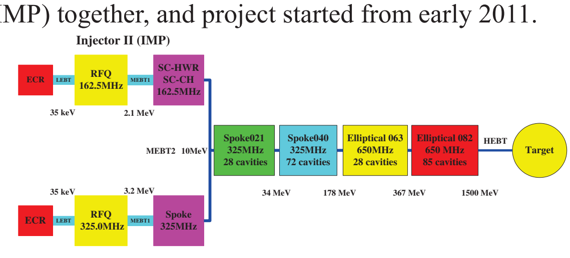

Figure 10: Layout of ADS accelerator.

China ADS has successfully completed ECR ion source test with 25 mA/35 keV proton, V-T and H-T for 325MHz SC spoke cavity &162.5MHz HWR, commissioning of 162.5 demo RFQ with 10mA/CW. SC Cro-modules are being manufactured for two injectors. CW conditioning for both RFQ with difference frequencies is arriving to design value. Other components and equipment for injectors are ready for integration of machine.

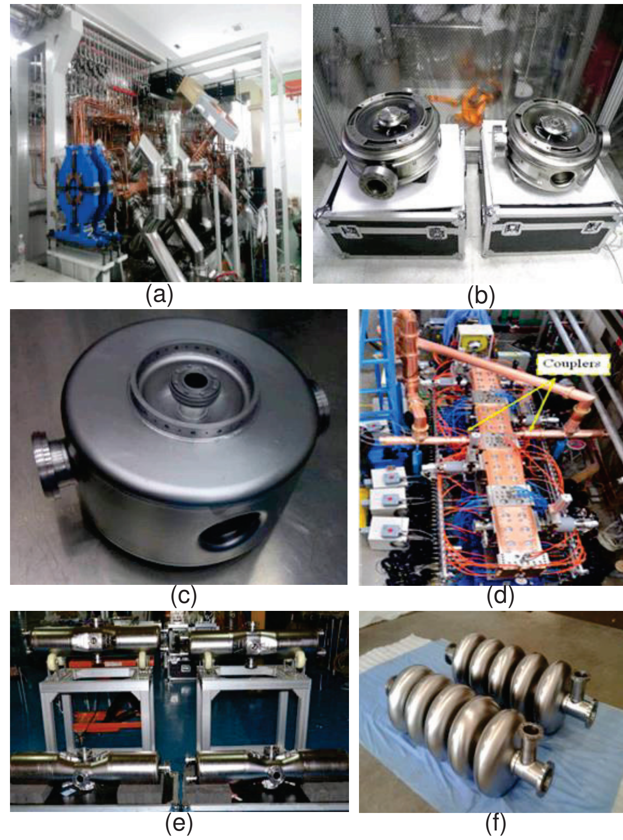

Figure 11: (a) 325MHz RFQ Conditioning: 80% full power,220 kW in CW; (b) 325MHz spoke012 cavity; (c) 325MHz spoke021 cavity with Hpeak of 107mT; (d) 162.5MHz RFQ Conditioning: full power, 93 kW in CW; (e) mass production of 162.5MHz HWR; (f) 650MHz elliptical cavity ready for test.

Probably there are other ADS programs uncovered. IAEA reported that 18 countries are performing ADS R&D.

CONCLUSION

The ADS program is to speed up from the basic study to the real facility, but the key technologies in high power proton accelerator are severe challenges. Many good technologies have been developed, e.g. SRF became a choice especially for high power and high duty factor machines, SNS demonstrated <1 W/m beam loss in MW-class pulsed accelerator.

There are many common interests in the high power proton acceleration technology for the laboratories involved in proton accelerator. Close international cooperation is very important and expected.

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REFERENCES

[1] Hamid Aït Abderrahim, Multipurpose Hybrid Research Reactor for High-tech Applications, Project Status,The 3rd Pillar of the European Strategy for P&T, September, 2012.

[2] Frédéric BOULY, CNRS-IN2P3 / LPSC Grenoble, Jean-Luc BIARROTTE, CNRS-IN2P3 / IPN Orsay, France,The MYRRHA Accelerator experiment R&D programme.

[3] Masahito Tomizawa, J-PARC Accelerators, KEK Acc. Lab., Japan.

[4] T. Y. Song, etc, HYbrid Power Extraction Reactor,Korea Atomic Energy Research Institute, Yuseong, Daejeon, 305-600, Korea.

[5] Yong-Sub Cho, etc, THE KOMAC ACCELERATOR FACILITY, KOMAC/KAERI, Gyeongju, Korea.

[6] Sang-ho Kim, Overview of the High Power Proton Accelerator Project, ICABU11, Gyeongju, Korea, September 29-30, 2011.

[7] M. Arik, etc, A PROVISIONAL STUDY OF ADS WITHIN TURKIC ACCELERATOR COMPLEX PROJECT, Bogazici University, Istanbul, TOBB University of Economics and Technology, Ankara, Kastamonu University, Kastamonu, Institute of Physics of ANAS, Baku, Azerbaijan, Turkey.

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