LA-UR- 10-02623

Approved for public release; distribution is unlimited.

Title: The Design and Implementation of the AVNG

Author(s): Sergey Razinkov
Alexander Livke
Sergey Kondratov
Duncan MacArthur
Jonathan Thron

Intended for: The 51st Annual INMM Annual Meeting

Los Alamos
NATIONAL LABORATORY
EST. 1943

THE DESIGN AND IMPLEMENTATION OF THE AVNG MEASUREMENT SYSTEM

Sergey Razinkov,* Sergey Kondratov,* Alexander Livke,* Duncan MacArthur,† and Jonathan Thron†

* Institute of Nuclear & Radiation Research, All-Russian Scientific Research Institute of Experimental Physics (RFNC-VNIIEF), 607190 Sarov, Mira Ave. 37, Nizhegorodsky Region, Russia

† Los Alamos National Laboratory, Los Alamos, NM 87545, USA

ABSTRACT

An attribute measurement system (AMS) measures a number of unclassified attributes of potentially classified material. By displaying these unclassified results only as red or green lights, the AMS protects potentially classified information while still generating confidence in the measurement result. The AVNG that we describe is an AMS built by RFNC–VNIIEF in Sarov, Russia. The AVNG detects neutron and gamma radiation signatures and displays the three unclassified attributes of "plutonium presence," "plutonium mass >2 kg," and "plutonium isotopic ratio (^{240}Pu to ^{239}Pu) <0.1."

In this presentation, we will describe the design of the AVNG neutron and gamma detector subsystems, as well as the design of the entire AMS incorporating these detectors. We will also describe the construction of the AVNG and the final design that was demonstrated in June 2009.

AVNG DESIGN

An attribute measurement system (AMS) measures a number of unclassified attributes of potentially classified material. [1] This paper is part of a series describing the AVNG in a special session at the 2010 INMM meeting. [2] By displaying unclassified results only as red or green lights, the AMS protects potentially classified information while still generating confidence in the measurement result. More details of AMSs [3] and AVNG design [4] are included in earlier papers in this series. The AVNG that we describe is an AMS built by RFNC–VNIIEF in Sarov, Russia. [5 & 6]

The AVNG System measures the following attributes of plutonium inside of an AT-400R container:

1) plutonium presence in the container (detected by the presence of characteristic lines in the gamma radiation spectrum),
2) plutonium quality (weapons/non-weapons grade) (detected by the radiation intensity ratio of isotopes ^{240}Pu/^{239}Pu in a narrow energy range near 640 keV), and
3) confirmation of plutonium mass in the container greater than an agreed-upon threshold value (based on neutron multiplicity counting and isotopic ration information obtained in test 2)

The AVNG (shown schematically in Fig.1.) includes the following basic elements: gamma-radiation detector based on a high-purity germanium detector, high efficiency neutron detector based on ^{3}He counters in polyethylene moderator, an instrument rack with a set of measurement and control equipment (analyzers of gamma and neutron measurement systems, measurement and control computers, controllers for security systems, data protection components, and power supplies), and a control/indicator panel.

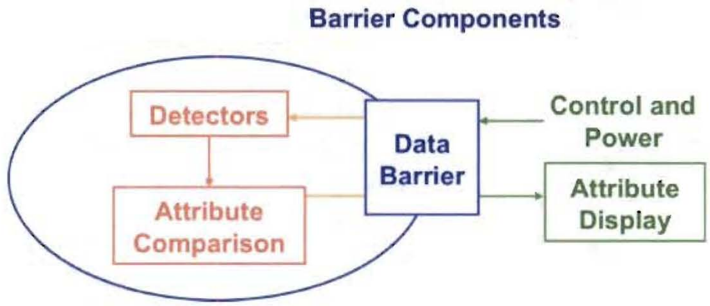

Fig. 1. Schematic outline of an attribute measurement system. The major features include gamma and neutron measurement subsystems, information protection components including the information barrier and data barrier, and an operator console including a red light/green light display.

THE AVNG ATTRIBUTE MEASUREMENT SYSTEM

All the system components, with the exception of the operator's panel, are located in a shielded box. Signals from the operator's panel to the system and *vice-versa* are transmitted via hardware and software (the data barrier) through the information barrier to prevent classified information transmission to the panel. Figure 2 illustrates the initial design layout of the AVNG within a shielded enclosure. As-built photographs are shown later in this paper.

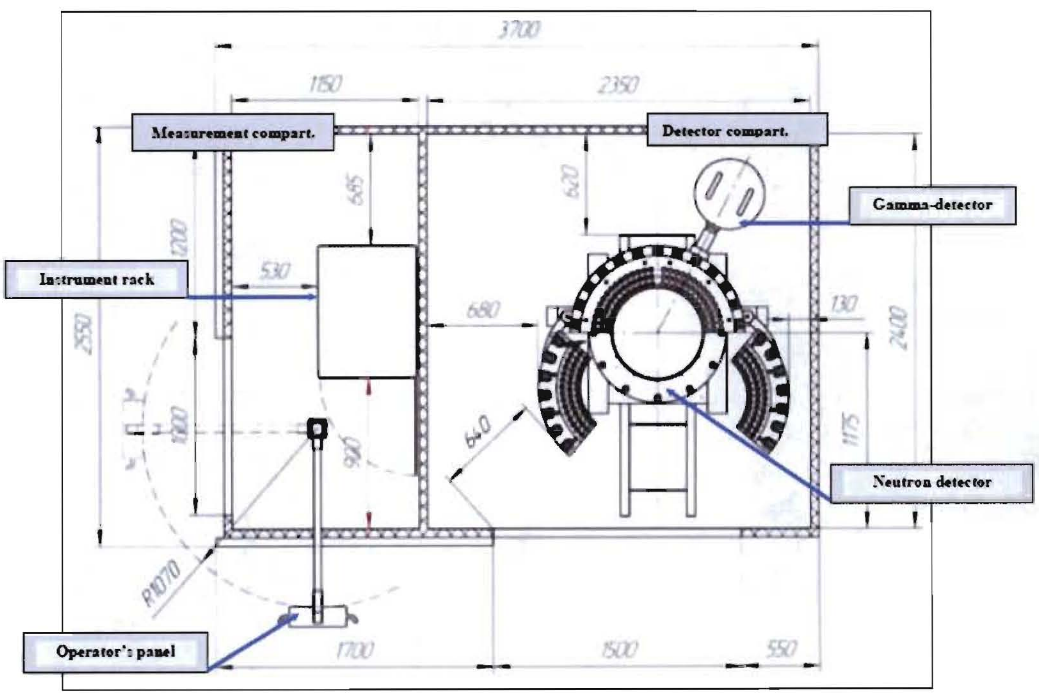

Fig. 2. Initial design drawing of the AVNG system within a shielded enclosure. (All dimensions are in mm)

A three dimensional model of the designed AVNG system within a notional measurement facility is shown in Fig. 3. Figure 4 shows a photograph of the finished shielded enclosure and the instrument rack located within the measurement compartment of the enclosure.

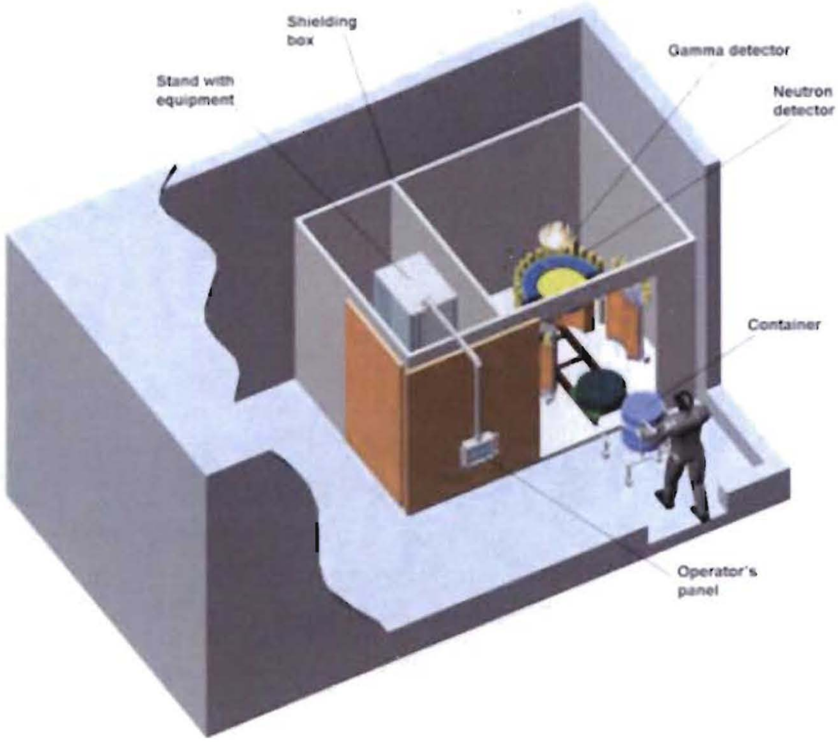

Fig. 3. Cutaway view of the AVNG design illustrated in Fig. 2.

Fig. 4. Photograph of completed shielded room showing the measurement compartment door and equipment rack in the center and the detector compartment door on the right.

RADIATION DETECTORS

Figures 5 and 6 present a model and photographs of the main elements of the radiation detectors of the AVNG – gamma and neutron detectors together with the support platforms that provide reproducible measurement geometry.

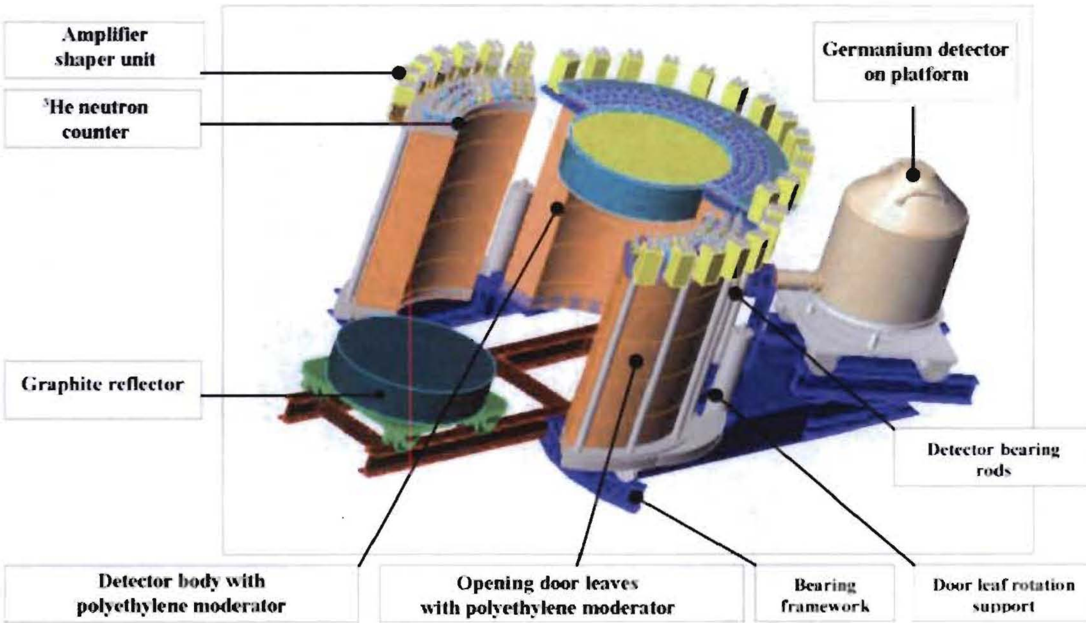

Fig. 5. Neutron and gamma detectors used in the AVNG together with support structures and mechanical details.

Fig. 6. Neutron (left, with doors open) and gamma (right) detectors used in the AVNG.

The neutron detector is a purpose built cylindrical three-ring neutron multiplicity counter (NMC) with a cavity of 491-mm diameter by 600-mm tall. This NMC utilizes 164 10-atm ^{3}He tubes which are 1-m long and 25.4-mm in diameter. The signals from these tubes are fed into 28 preamplifier modules, which are based on the Amptek A111 integrated circuit. The gamma detector is a XX% coaxial p-type ORTEC model SGD-GEM-25175.

OTHER AVNG MECHANICAL COMPONENTS

To allow automatic switching, without operator's control, into the "unclassified" mode of operation (when modified containers containing SRM are placed in the measurement cavity) the neutron detector is equipped with a doubled set of container type sensors shown in Fig. 7. These optical sensors are used to detect the presence of the two groves in a modified AT-400R container. If these groves are not present, the AVNG cannot be switched into the unclassified mode.

Fig. 7. Optical sensors located within the cavity of the neutron detector to detect the presence of a modified AT-400R container.

A hydraulic loading system (Fig. 8) was developed in order to load AT-400R containers (both modified and unmodified) into the cavity of the NMC. The containers are loaded through doors in the side of the AVNG NMC as shown in Figs. 2 and 5. This loading system is required in order to load the AT-400R containers horizontally into the NMC cavity.

Fig. 8. Hydraulic AT-400R loading system. AT-400R containers (both modified and unmodified) are placed on the lower graphite reflector of the NMC. This reflector is mounted on wheels, which allow it to be moved into the remainder of

the NMC.

AVNG ELECTRICAL COMPONENTS

Although the necessary electronic subsystems can be built at the component level, [7] debugging such a system has shown this type of construction to have low reliability because of a large number of signal lines coming from the detector and measurement compartments, and from the operator's console. More than a hundred lines provide communication with the measurement and control microcomputers as shown in Fig. 9. Due to this low reliability of component level construction, a modular design based on the I-7000 family of controllers and modules was used (see fig. 10).

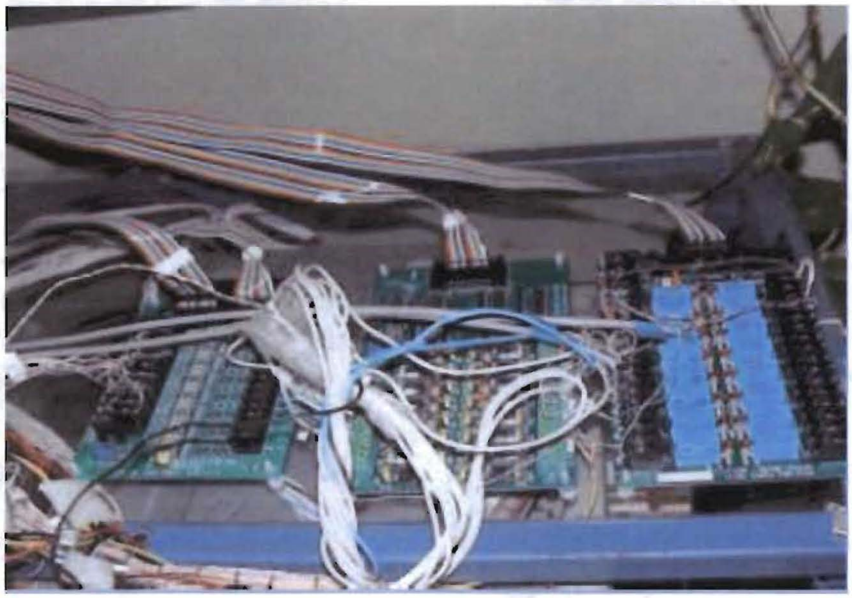

Fig. 9. A breadboard of the control system showing the many input and output cables.

Each I-7000-series module is a functionally complete device located in a body made of flame-proof plastic. Any necessary plug, sockets and clip connectors are located on the body for connection of external input and output circuits. No special motherboards are needed to install the modules. The modules can be mounted either on a standard load-carrying 35-mm DIN-strip, or on any flat surface. Standard software is used for the entire line of modules.

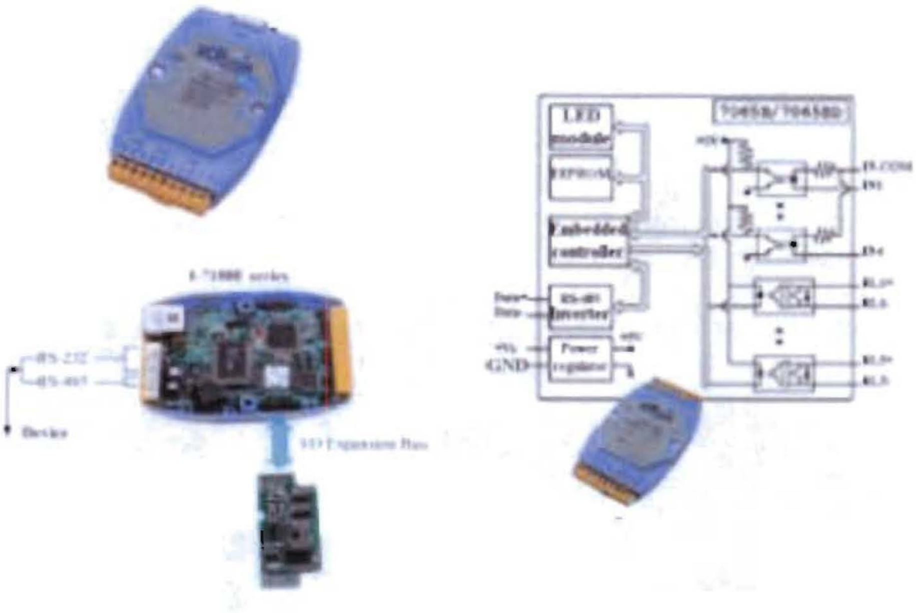

Fig. 10. One of the distributed I/O controllers of I-7000 series.

All I-7000-series modules have both a performance certificate and a type approval certificate for measuring instruments.

The operator's control panel (Fig. 11) is used both to control the AVNG's operation and display the yes/no results. The control panel is connected to the remainder of the AVNG using fiber optic cables.

Fig. 11. The operator's control panel and display. The three pairs of red and green lamps on the upper right indicate whether or not an item being measured meets each of the three attributes.

AVNG SOFTWARE

Due to the conceptual and hardware complexity of the AVNG system and the interface requirements imposed on the individual elements and systems, a concept of operations was developed for AVNG system's operation. This concept is outlined in Fig. 12.

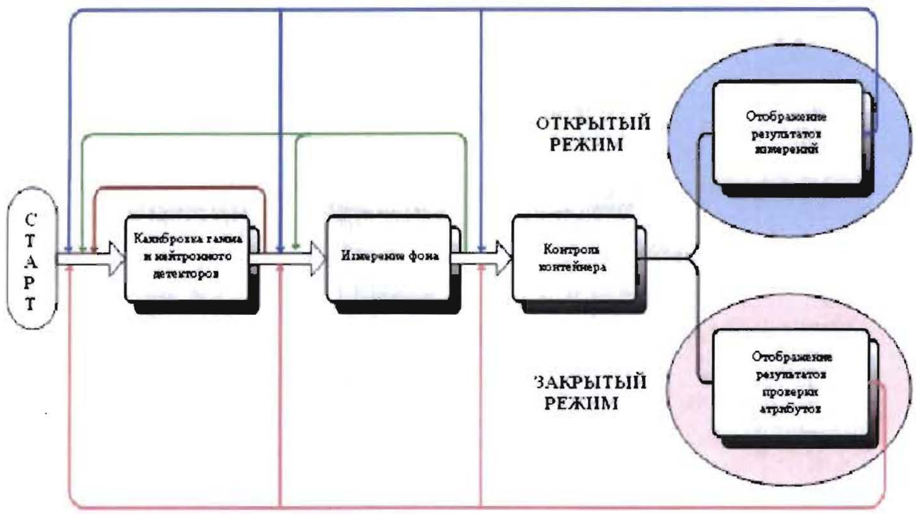

Fig. 12. AVNG concept of operations.

The AVNG operates in a series of states shown in Fig. 13. The control computer can be in the following states: Initialization, Intermediate State 1, Calibration, Intermediate State 2, Background, Intermediate State 3 and Measurement. The controls for passing between each state ensure that the detector systems are setup with the correct parameters and calibrations before performing a measurement. The arrows indicate allowable transitions between the various states. Any earlier operation can be repeated if necessary, but it is not possible to "skip ahead" (e. g. perform a measurement without performing background and calibration steps.

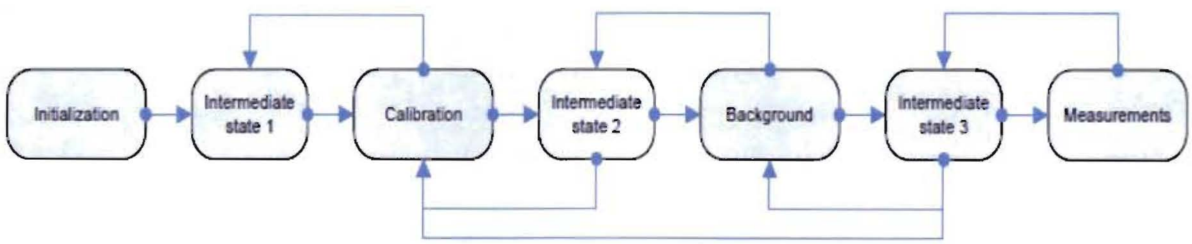

Fig. 13. State diagram of the operation of the control microcomputer.

The AVNG measurement system, the components of which are described in this paper, was tested [6] and demonstrated [8] as detailed in other papers presented during this INMM meeting.

ACKNOWLEDGEMENT

This work is supported by the United States National Nuclear Security Administration's Office of Dismantlement and Transparency.

REFERENCES

[1] Pucket, J., *et.al.*, "General Technical Requirements and Function Specifications for an Attribute Measurement System for the Trilateral Initiative," *Proceedings of the 42nd INMM Annual Meeting, Indian Wells, CA, July 2001.*

[2] Special Session (2010) Nonproliferation and Arms Control – The Russian AVNG Attribute Measurement System (A total of nine papers by M. Smith, D. MacArthur, S. Razinkov, J. Thron, S. J. Luke, A. Livke and S. Kondratov). *Proceedings of the 51st INMM Annual Meeting, Baltimore, MD, July 2010.*

[3] MacArthur, D., *et. al.*, "The Attribute Measurement Technique," *Proceedings of the 51st INMM Annual Meeting, Baltimore, MD, July 2010.*

[4] Razinkov, S., *et. al.*, "AVNG System Objectives and Concept," *Proceedings of the 51st INMM Annual Meeting, Baltimore, MD, July 2010.*

[5] Budnikov, D., *et.al.*, "Progress of the AVNG System – Attribute Verification System with Information Barriers for Mass and Isotopics Measurements, " *Proceedings of the 46th INMM Annual Meeting, Phoenix, AZ, July 2005.*

[6] Kondratov, S., *et. al.*, "AVNG System Demonstration," *Proceedings of the 51st INMM Annual Meeting, Baltimore, MD, July 2010.*

[7] Modenov, A., *et. al.*, "AVNG System Software – Attribute Verification System with Information Barriers for Mass and Isotopics Measurements, " *Proceedings of the 46th INMM Annual Meeting, Phoenix, AZ, July 2005.*

[8] Kondratov, S., *et. al.*, "Testing the AVNG," *Proceedings of the 51st INMM Annual Meeting, Baltimore, MD, July 2010.*