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AI for NDA Field Measurements

Practical Applications and Insights

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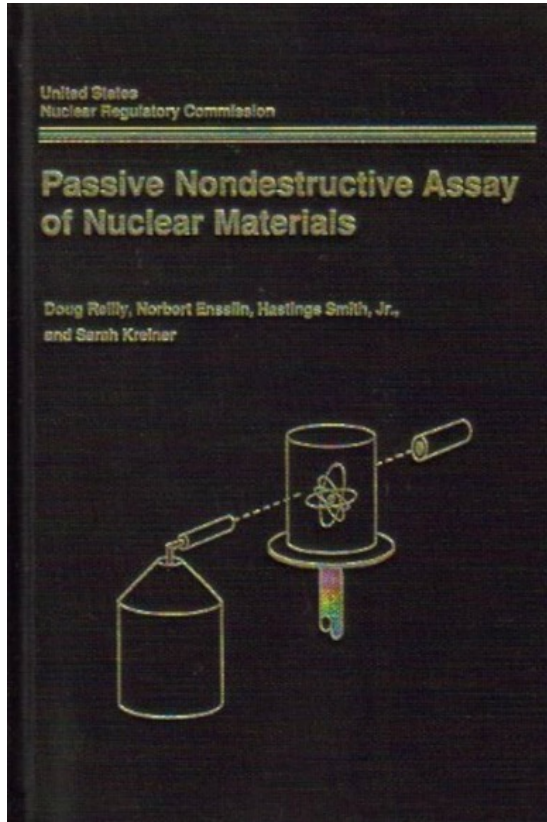
Topics

- *AI for NDA (Gamma)*
- *Data Acquisition (NDA AI Multi-View DATAQ).*
- *Software/Hardware Implementations*

AI for NDA



NDA AI/Traditional NDA



- *Traditional algorithms have limitations.*
- *Counting statistics can obscure the results.*
- *Default efficiency models are often more wrong than correct.*
- *Extreme biases may not be detected.*
- *Tools to correct efficiency models require intensive human interactions.*
- *TMU estimates are too high which can be very costly.*
- *Crux of the problem is traditional NDA always leans towards VWA solutions where this is never the case.*
- *There is the need to have more “view” data and some means to analyze such using non-traditional NDA algorithms.*

NDA AI/Requirement Specifications

Software Requirement Specifications



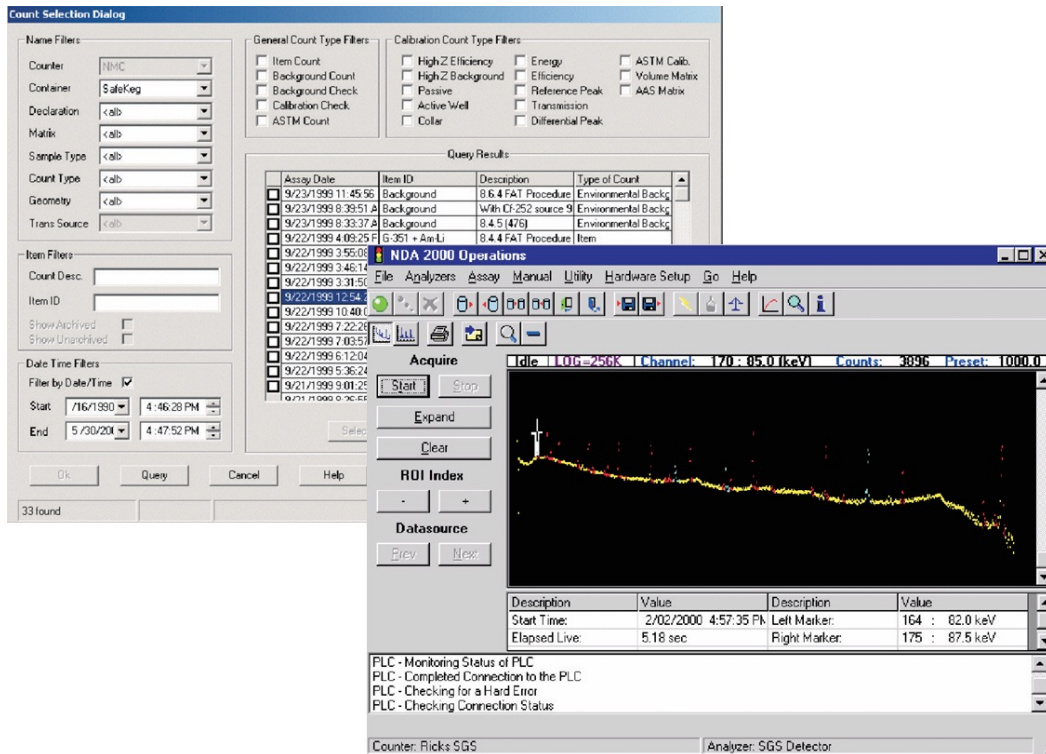
- Must support NDA 2000 for Windows 10 and Windows 11.
- Support NDA 2000 Operations and Data Review.
- Supply an architecture to support other Canberra application SW.
- *Analytical NDA Goals:*
 - A feature to improve throughput.
 - Improved accuracy/lower TMU.
 - 2D and 3D images (GIFs).
- Simple upgrade path as newer and faster GPU technologies become available.
- Target the Nvidia Blackwell technology; perhaps support the AMD Radeon RX at a later date.
- Initially only support emission view data with transmission view data to follow.
- SQA must include known and unknown data - NQA-1 Compliance.
- First release will be for the MILCC and Q2 system configurations. Subsequent releases will support the AQ2, IQ3, SGS, TGS, etc.

NDA Neural Processor



- *NDA Neural Processor consists of:*
 - *NeRF – Neural Radiance Field which facilitates the emission imaging (Cameron’s talk yesterday).*
 - *PINN’s – Physics Informed Neural Networks which facilitates the NDA algorithms.*
- *NeRF and PINN’s are generally accessed via PyTorch (Python) but may alternately be implemented in C++.*
- *NDA algorithms include and not limited to:*
 - *Differential peak and self attenuation analysis.*
 - *Isotopic ratio/enrichment.*
 - *Co-location.*
 - *Most importantly, multi-view data.*

NDA 2000 AI Approach



- NDA 2000 provides the following:
 - ISOCS detector information (PAR/TXT).
 - All geometrical information, e.g., detector standoff, drum dimensions, etc., via ISOCS GIS.
 - ISOCS mu library.
 - Process knowledge, e.g., declared isotopics, sample type, fill height, etc.
 - Nuclide library.
 - View emission and transmission, if applicable, spectra.
- NDA AI Neural Processor returns the following:
 - Efficiencies per view including associated error.
 - Computed activity for the container.
 - GIF images (similar to what Cameron showed yesterday).
- NDA 2000 computes:
 - Activity per view from the efficiencies per view.
 - Activity for the drum and first pass TMU.
 - FOM analysis and scoring adjustment to TMU.

Data Acquisition



NDA AI Multi-View DATAQ Capable Systems

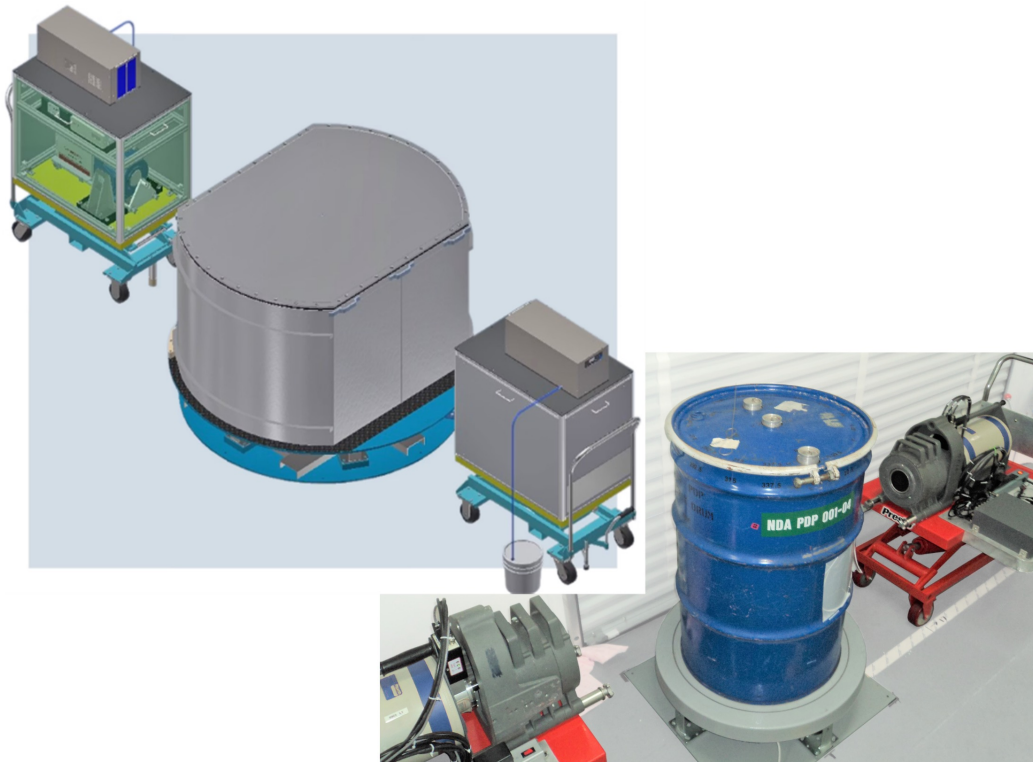
- *Shielded Systems: Q2, AQ2, IQ3
(3 detectors)*
- *Segmented Gamma Scanner
(SGS)*
- *Mobile ISOCS Large Container
Counter (MILCC)*

Q2/AQ2/IQ3



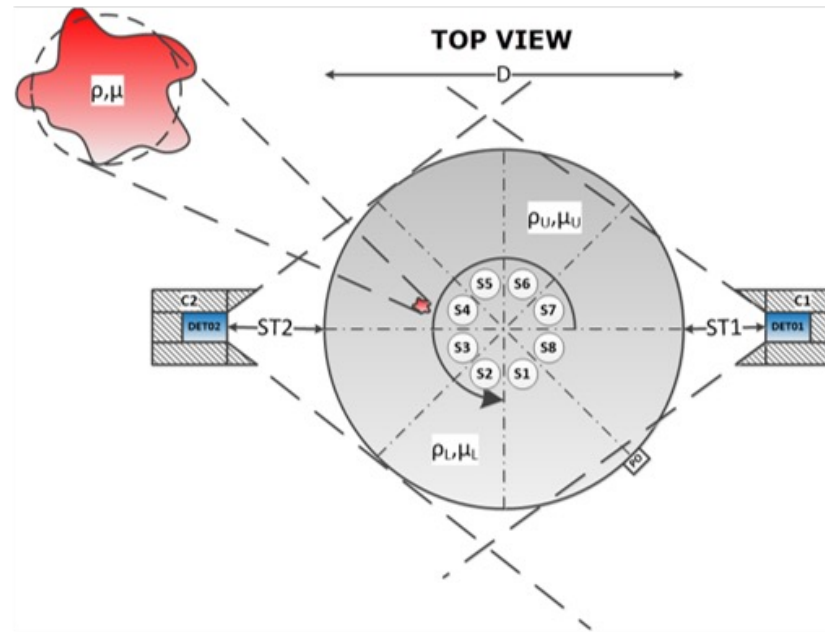
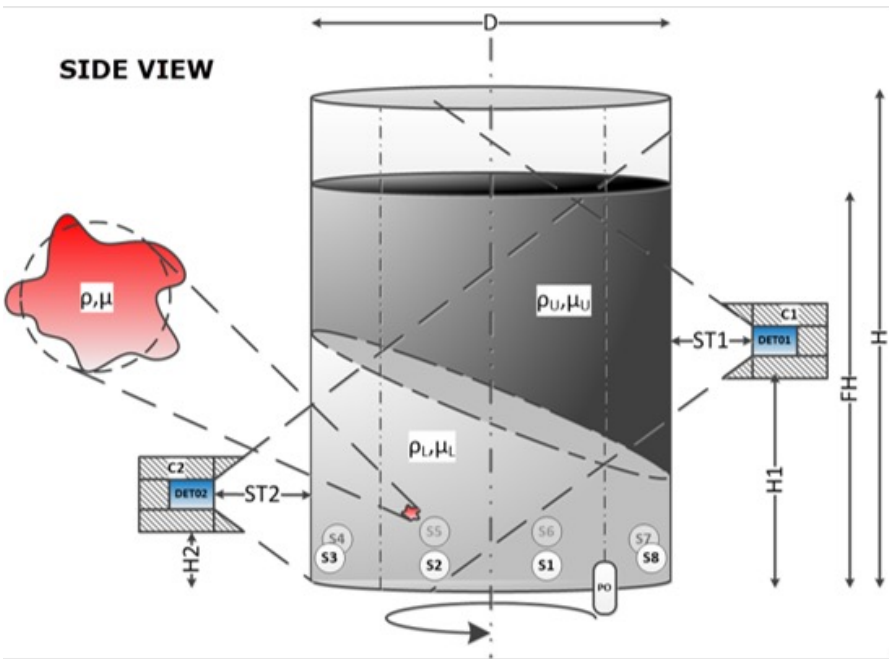
- The Q2, AQ2 and IQ3 are large shield-based (4" and 6" thick options) LLW NDA systems with rotators.
- The AQ2, shown in the image to the left, has an automatic conveyor for loading the drum.
- There are three detectors: bottom middle and top.
- There are three transmission sources opposing each detector with the drum axis centered in between.
- There is a synch pulse generated for each rotation facilitating the NDA AI Multi-View DATAQ.

MILCC/SWB/55G Drum



- *The MILCC is one or two detectors with a rotator in between.*
- *There is a synch pulse generated for each rotation.*
- *There are no transmission sources.*
- *With the NDA AI Multi-View DATAQ option, the detectors are generally set for different heights.*

NDA AI Multi-View DATAQ



- The “difficult drum” can be rather complex; heterogenous matrix distributions and lumpy (dense) materials.
- The “MILCC Approach” is a two-detector system designated for boxes but can be utilized for drums.
- To provide meaningful spectral data view data, we have developed a special mode of data acquisition called Multi-Scaling Spectra (MSS).
- Goal is to use measure “view” responses with known physical properties of the material and feed to neural networks with custom topologies to considerably improve accuracy, remove biases and lower the TMU.

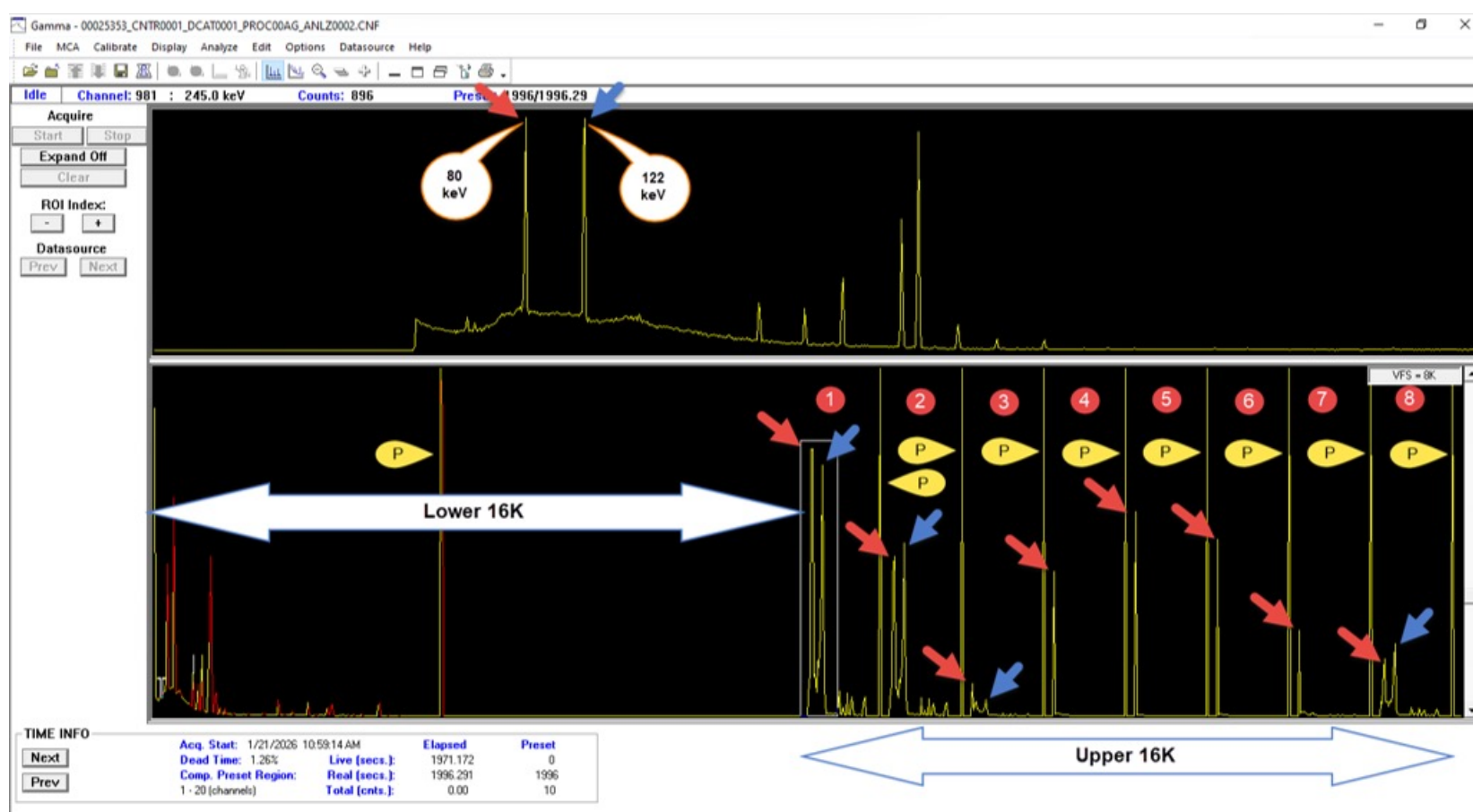
NDA AI Multi-View DATAQ

- The Lynx DSA (I and II) have MSS mode built in with special features for syncing with the Pick Off (PO).
- We have NDA SW that accumulates this MSS spectra into two formats:
- Visual mode where 8 spectra are shown in the MCA and summed over the sync indexes from the Pick Off (PO).
- Data Compression mode where 100's of spectra may be stored in a CAM file for later retrieval and analysis (new feature).



NDA AI Multi-View DATAQ

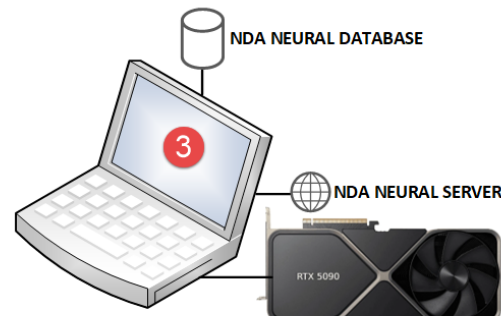
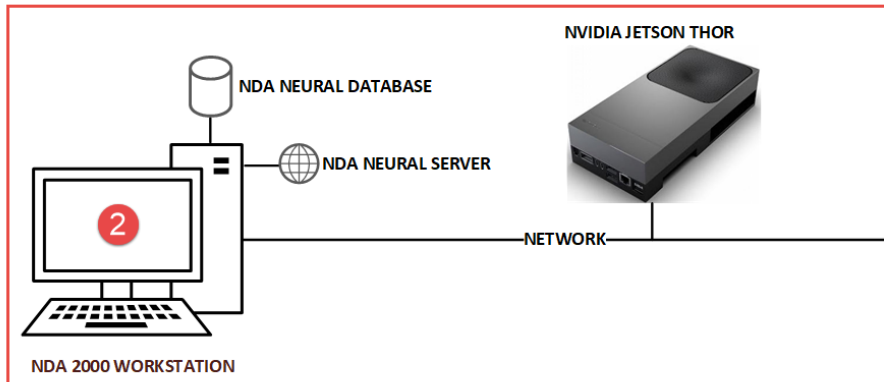
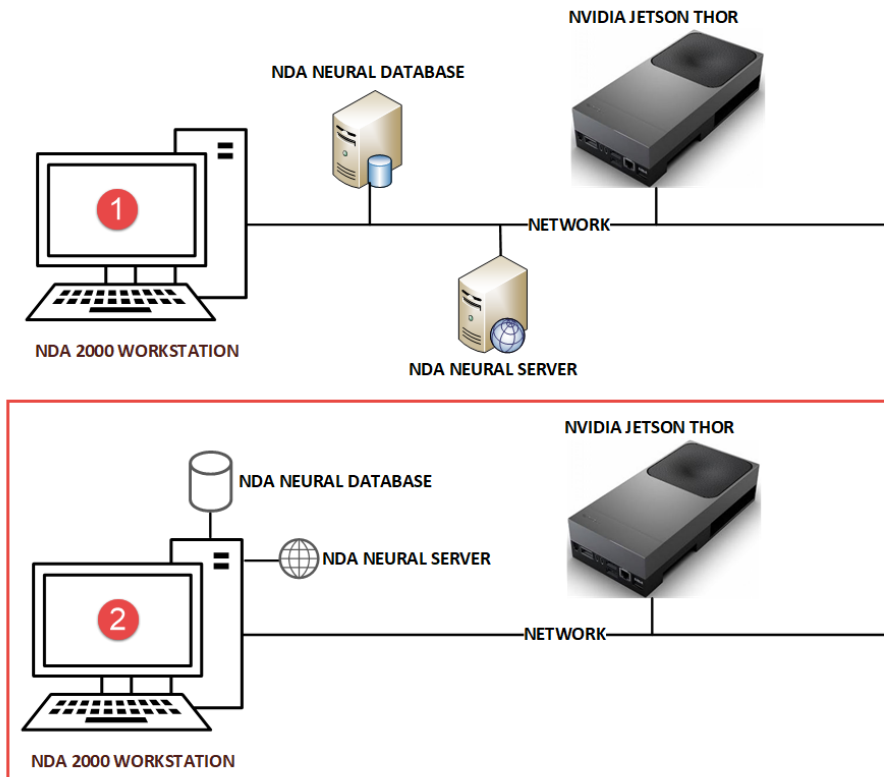
- Works with HRGS and MRGS.
- For each detector 32K channels are acquired.
- The 8 MSS spectra are found in the upper 16K (2K per spectra).
- The lower 16K channels contains the summed, over 8 views.
- The live time per view can be quite different so a reference pulser is introduced (although not required – this is a new feature)
- The Lynx DSA also provides live time per view.
- The figure to the left shows 2 point sources, Ba-133 and Eu-152, at two different locations with the volume of the drum.



NDA AI Software/Hardware Implementations



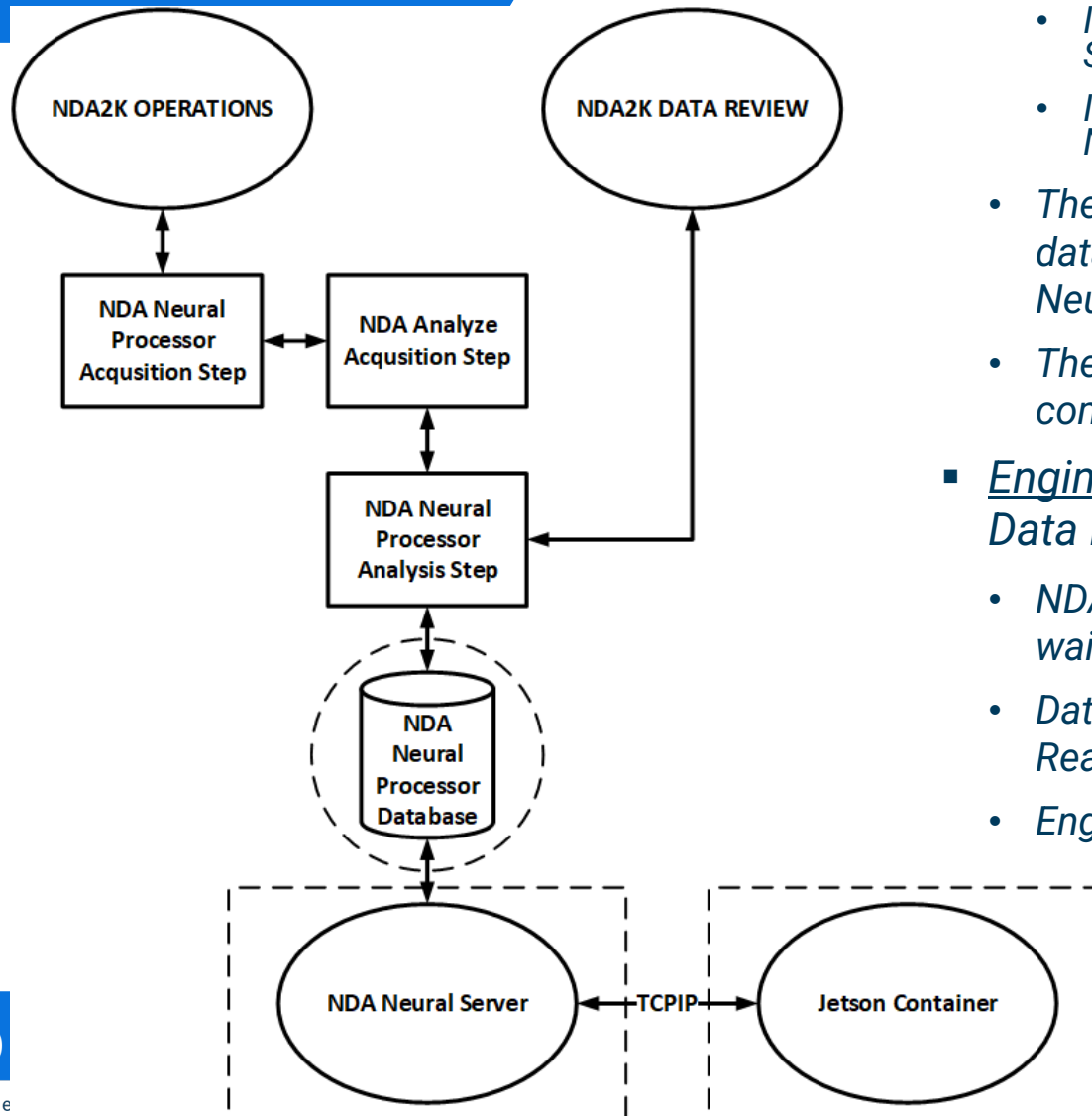
NDA AI/NDA 2000/Architecture



■ Potential Configurations:

1. NDA 2000 workstation with the NDA Neural Database located on a shared folder and network access to the NDA Neural Server and Nvidia Jetson Thor device.
2. Only the Nvidia Jetson device is on the network; the NDA Neural Database and NDA Neural Server are local to the machine with the server running in a Virtual Machine or Container.
3. Most portable, similar to configuration 2. with the Nvidia Jetson Thor replaced by the Nvidia GeForce RTX 5090 (gaming laptop).

NDA AI/NDA 2000/Architecture



- Architecture works with multiple versions of NDA 2000.
- Genie 2000 compatible engine.
 - The NDA Neural Processor Database is searched for an existing record:
 - If no existing record – create new record – triggers NDA Neural Server.
 - If existing record – are AI results available – if not, then NDA Neural Server is retriggered.
 - The engine writes all the processing information to the database required by the NDA AI facilitated through the NDA Neural Server.
 - The NDA AI results are written to the same record once completed.
- Engine can be executed from within NDA 2000 Operations, Data Review and command line:
 - NDA Neural Processor Acquisition Step facilitates option of wait for AI to complete or commence to the next measurement.
 - Data Review access to the engine is supported for Batch and Reanalyze Count.
 - Engine has option to query if AI analysis is completed.

NDA AI Targets

- *Prototype before the end of Q3 2026.*
- *Released (NQA-1) version by Q4 2026 for MILCC and Q2 systems.*
- *Q1 2027, begin implementations for transmission-based systems(AQ2, SGS) with NDA AI Multi-View DATAQ and significantly improve the TGS analysis.*
- *Late 2027/early 2028, include neutron systems which are also view based (PANWAS, LINAS).*

Thank you

