AUTOMATING/AUGMENTING ANALYSTS WITH ROBUST & SAFE AI

2/21/23

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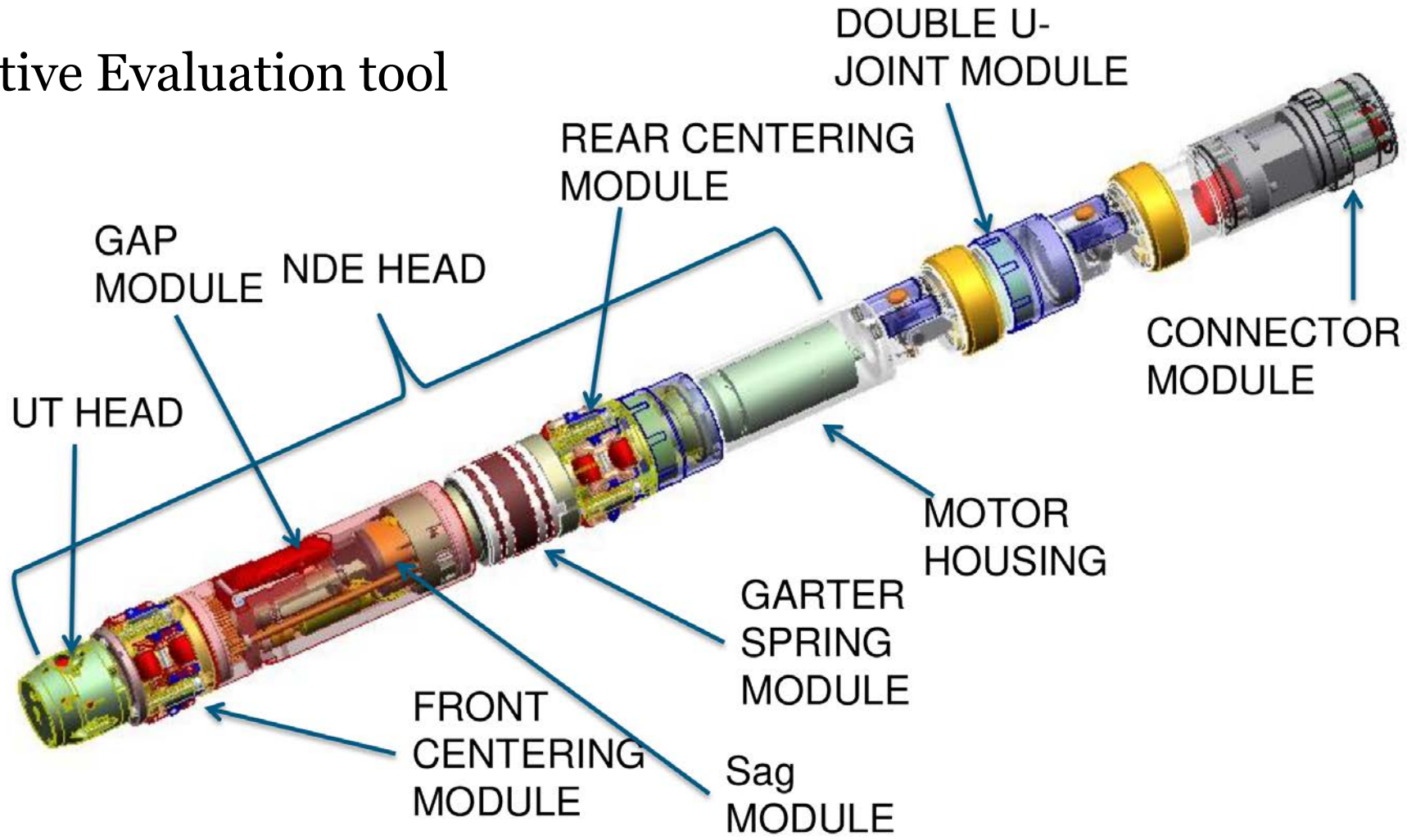
ANDE Analysis

Advanced Nondestructive Evaluation tool



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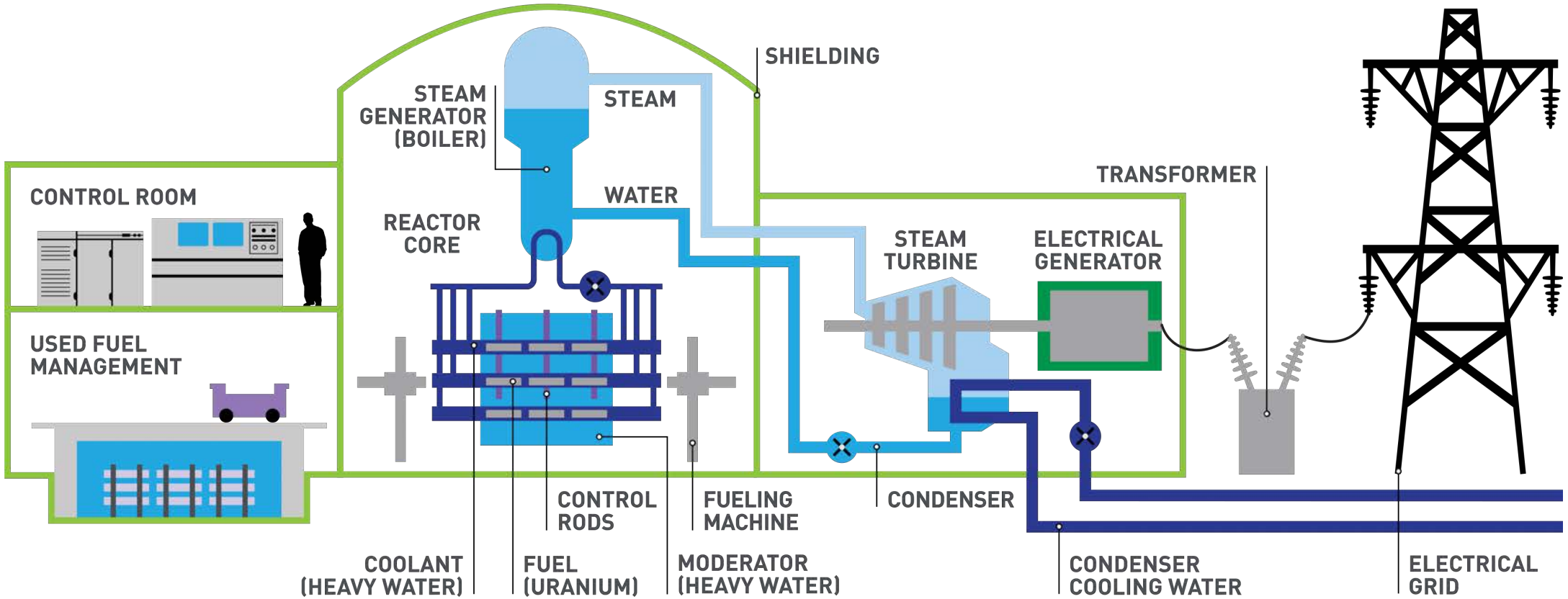
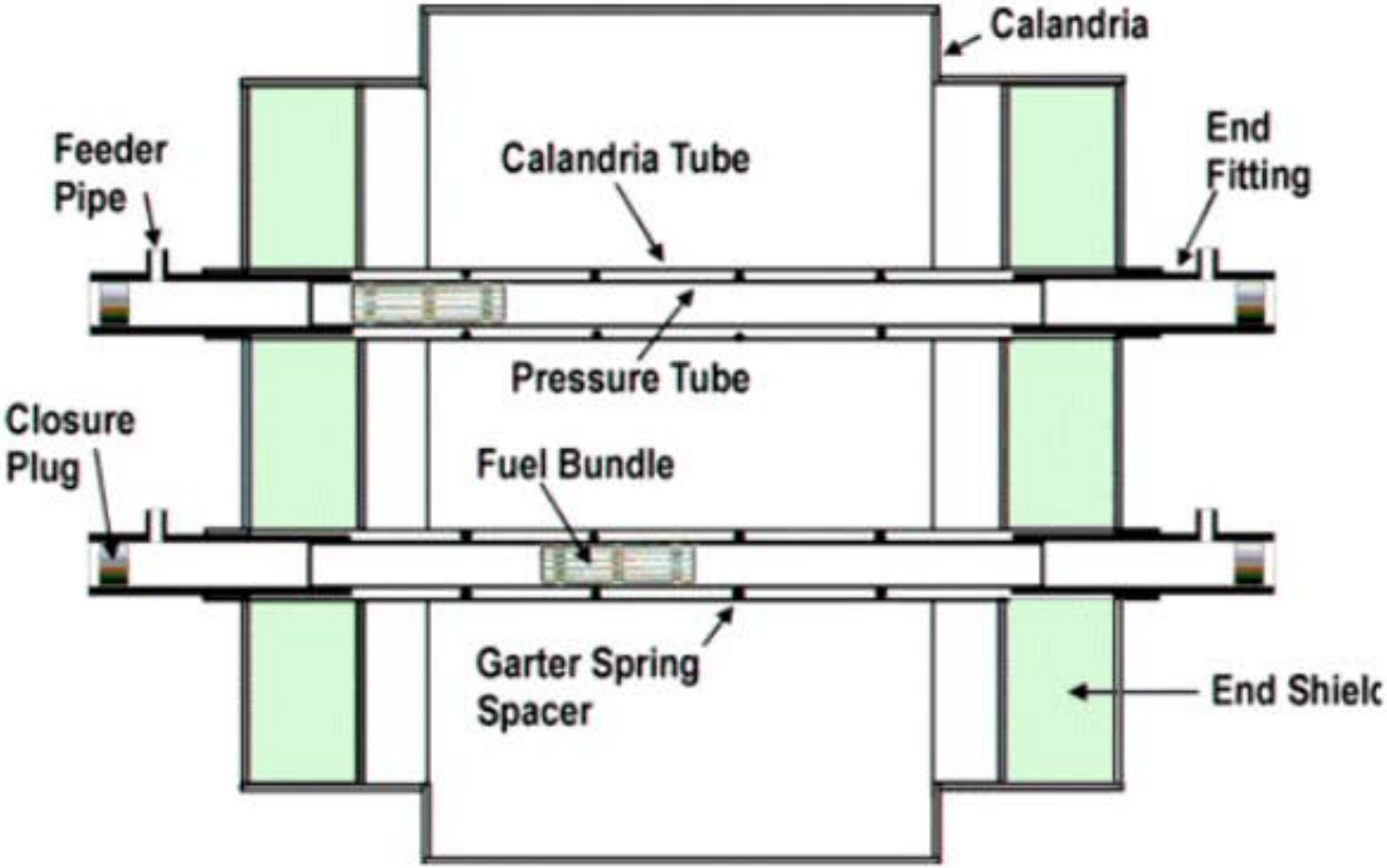
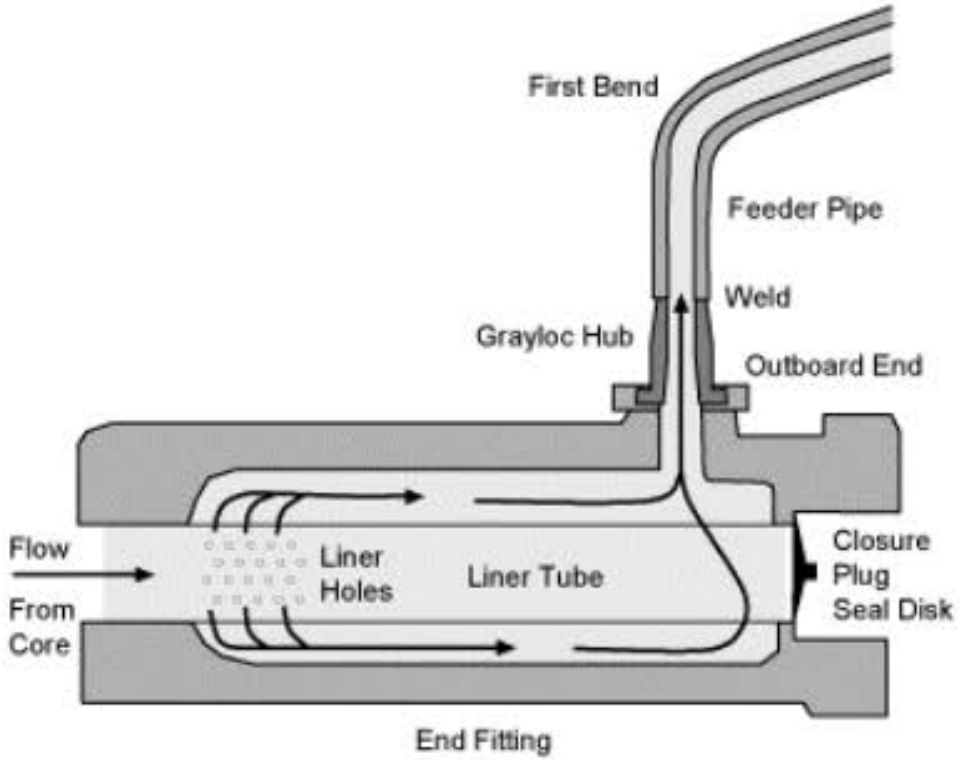
The CANDU Reactor



Fuel Channel Assembly





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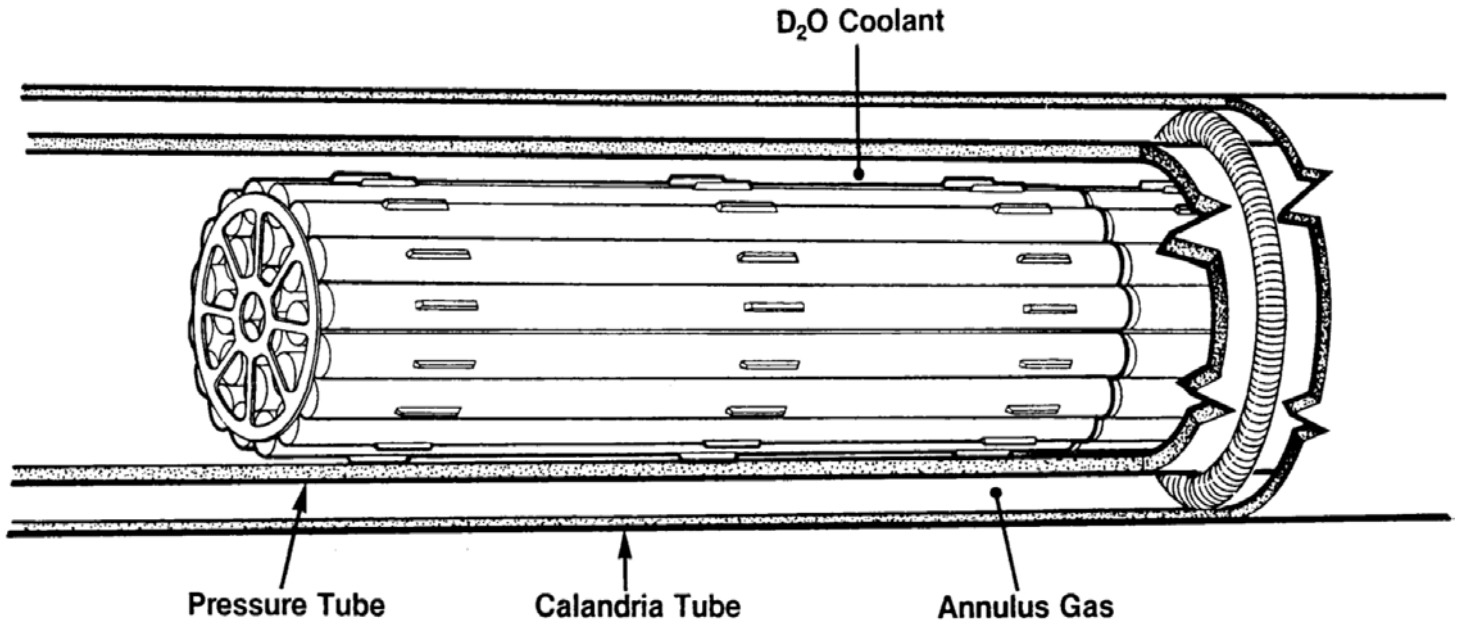
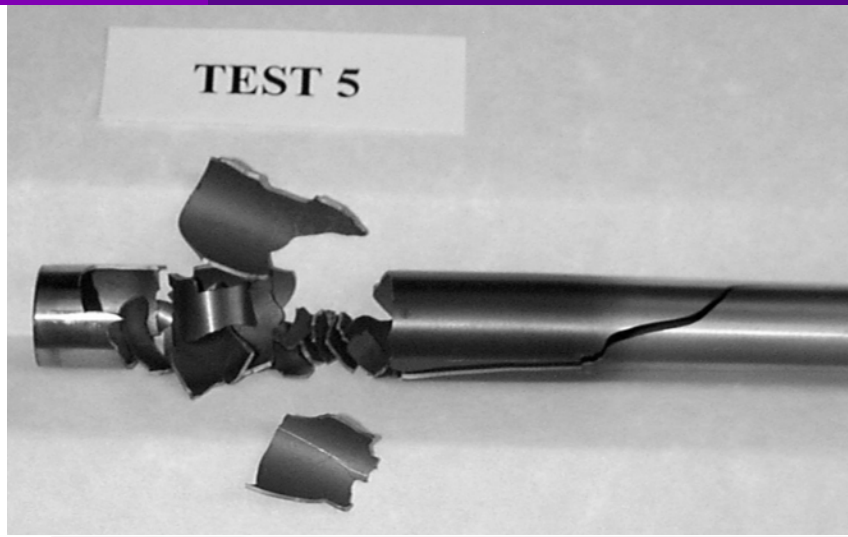
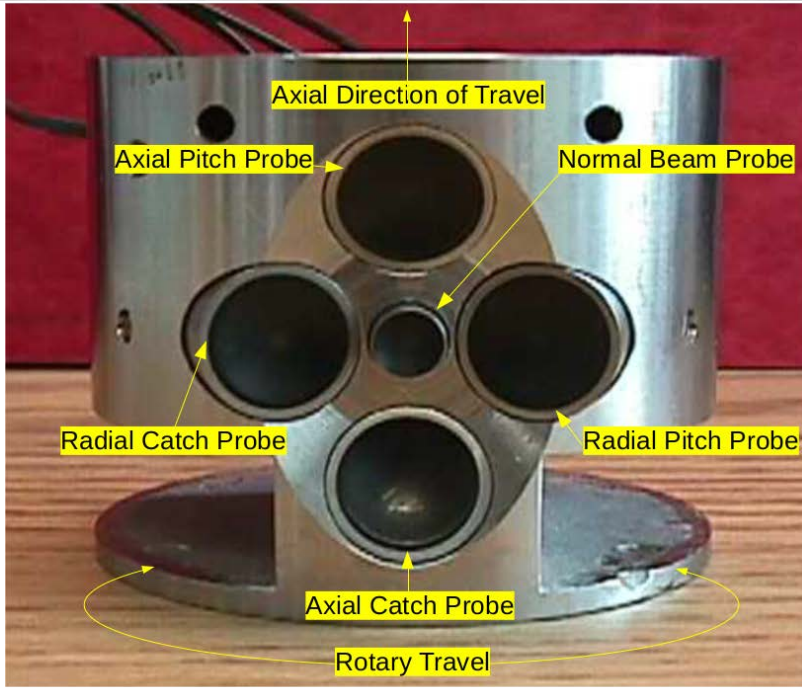
Fuel Channel Assembly







High mechanical stress, junction of dissimilar metals can cause hydride formation -> catastrophic failure!

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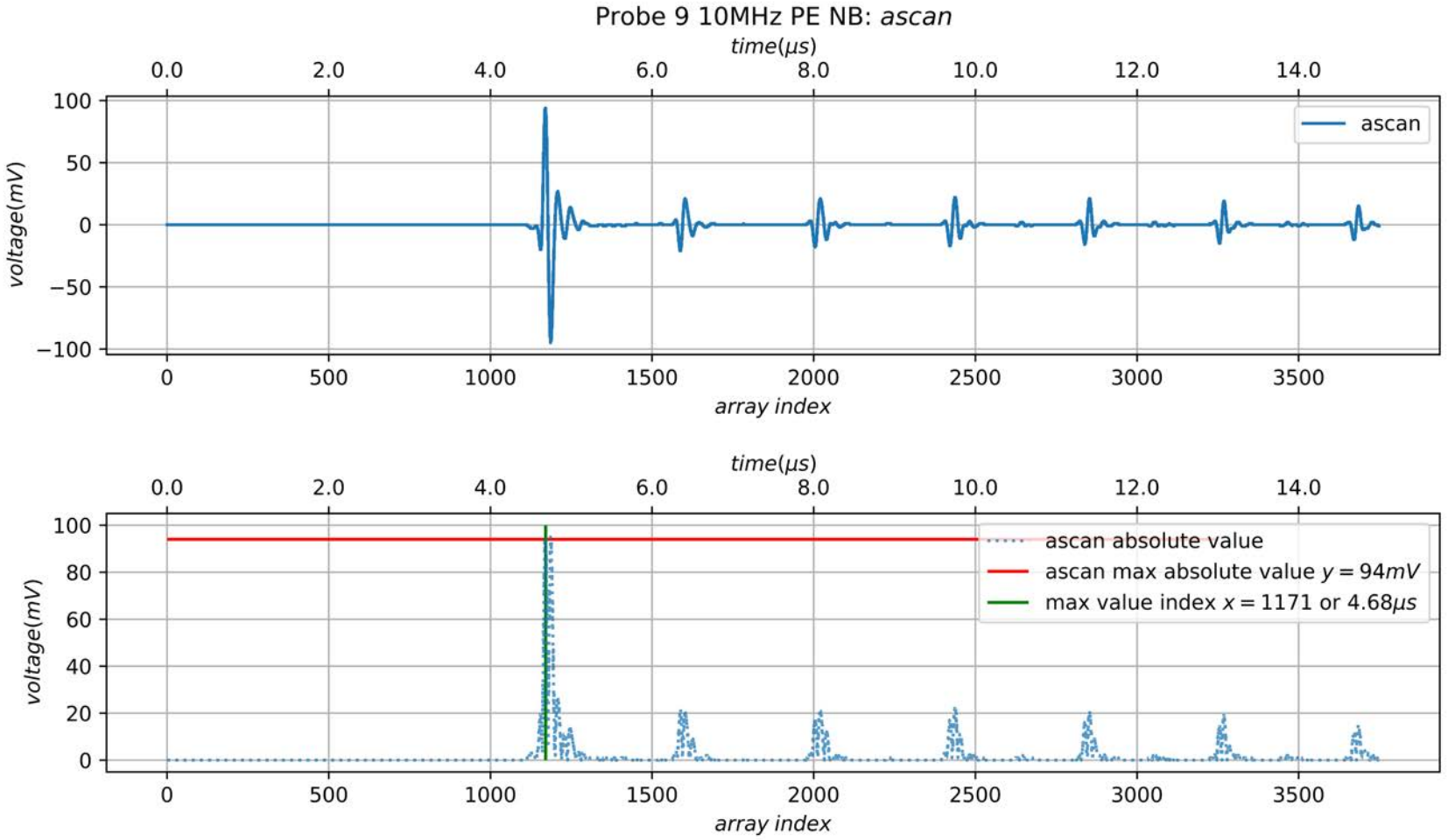
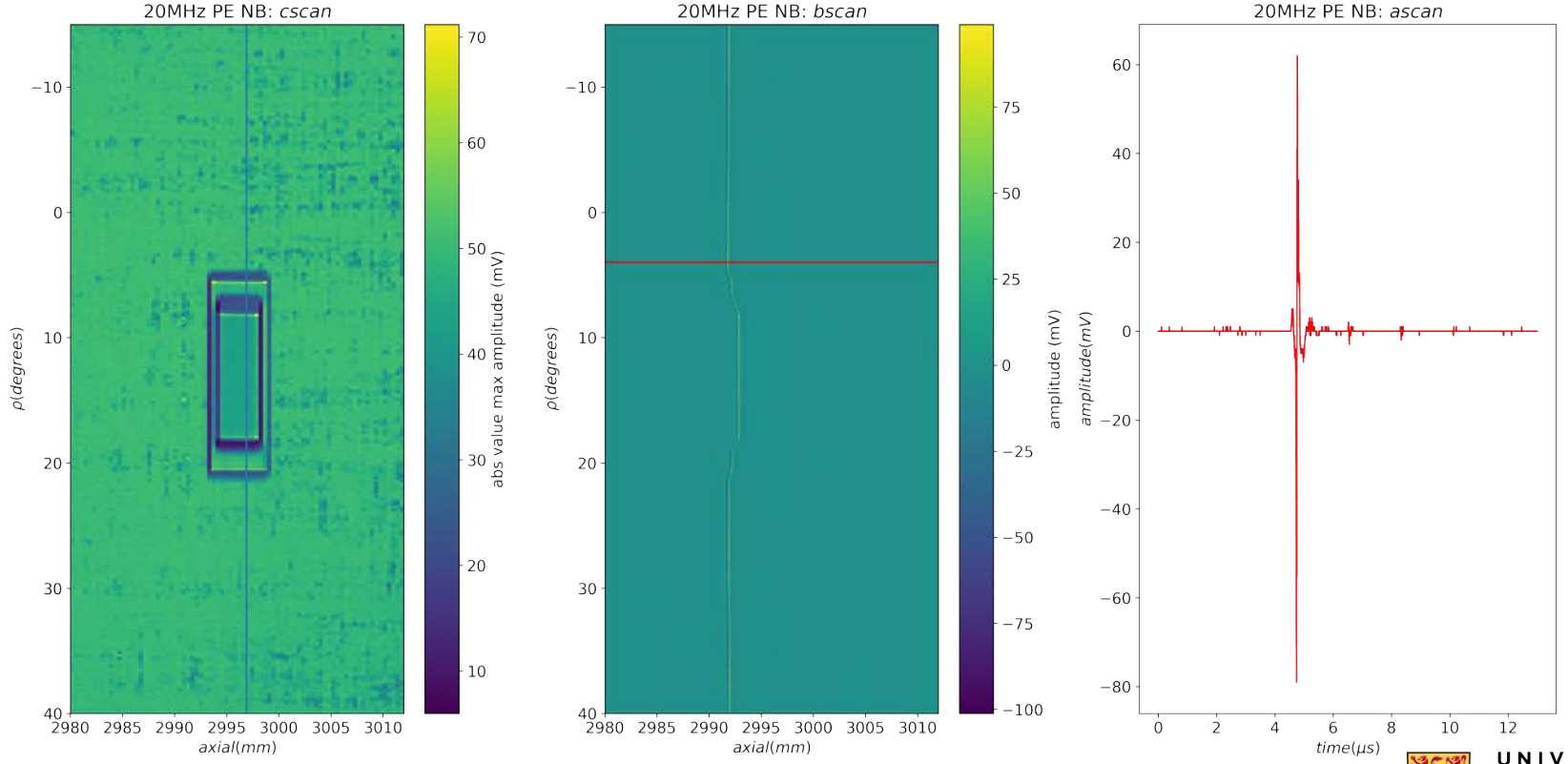
Ultrasonic Data Analysis - a lot of data

Single pressure tube inspection yields 3TB of ultrasonic data



Ultrasonic Data Analysis - strategy

Analysis assumes that unobserved nominal values @ flawed/defective areas can be inferred from local nominal data. A deterministic statistical method is used to guide a neural network to detect these flaws. The statistical & NN methods are compared to ensure robustness & correctness.



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Ultrasonic Data Analysis - machine learning

For each channel

- use heuristics (stats) to label data
- Train CNN to infer data labels
- Train VAE to get flawed region proposals
- use other deterministic method (e.g., ADAPT) to characterize same regions
- compare deterministic methods & NN results for consensus
- minimize work of analysts to where consensus not attained

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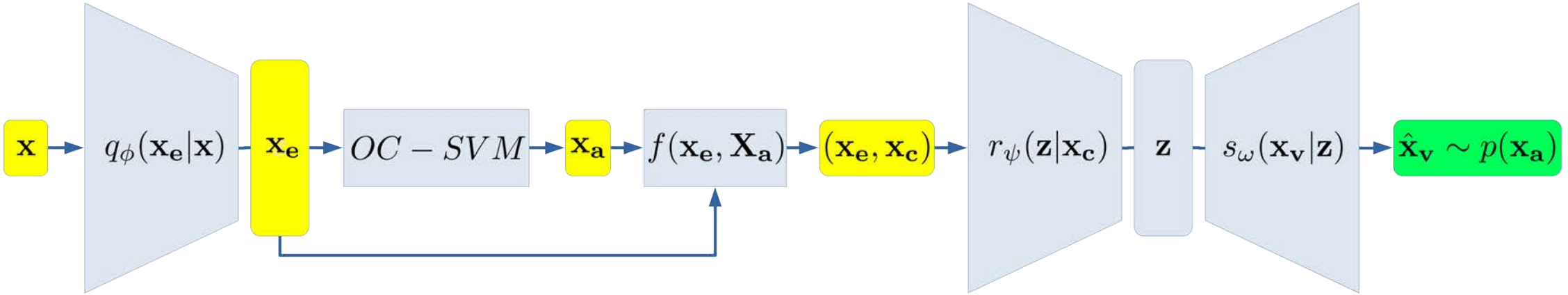
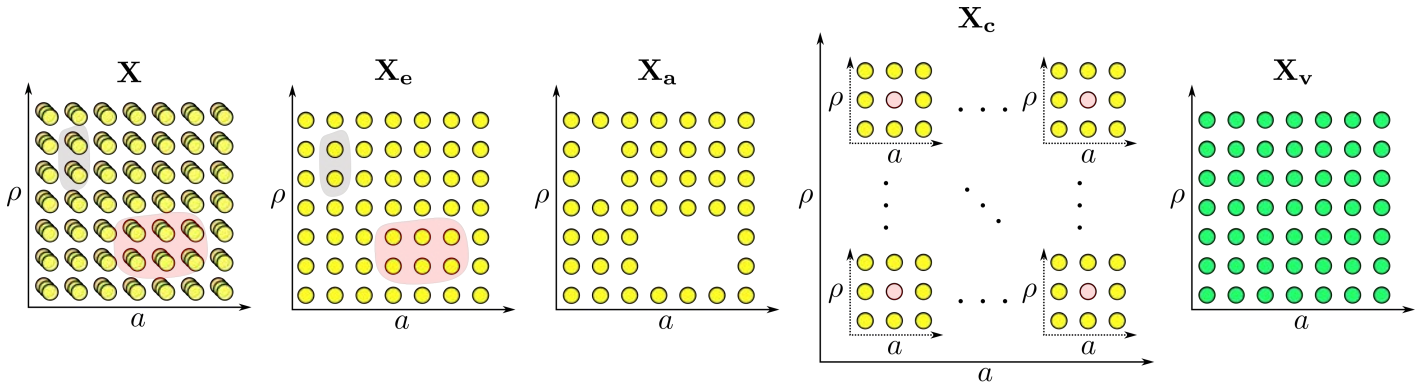
machine learning





$e : \mathbf{X} \to \mathbf{X_e}$

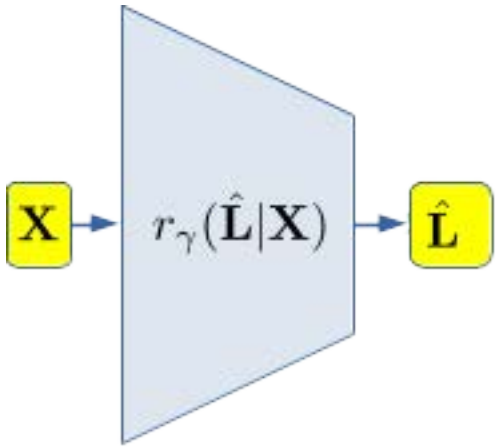
$a : \mathbf{X_e} \to \mathbf{X_a}$

$c : (\mathbf{X_e}, \mathbf{X_a}) \to \mathbf{X_c}$

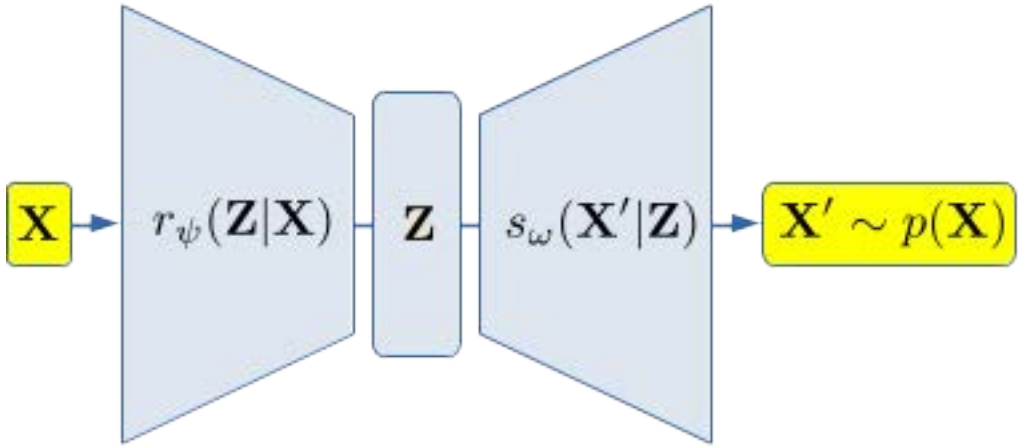
$v : \mathbf{X_c} \to \mathbf{X_v}$

- High dimensional datum
- Encoded datum
- Unobserved feature
- Estimated feature
- Nuisance data generating factors

machine learning



$CNN\ is\ trained\ on\ (\mathbf{X}, \mathbf{L})$



$\beta VAE\ is\ trained\ on \mathbf{X}$

$ultrasonic\ dataset : \mathbf{X}$

$label\ generation : f_1(\mathbf{X}) \rightarrow \mathbf{L}$

$flawed\ region\ proposals : f_2(\mathbf{X}', \mathbf{X}) \rightarrow \mathbf{F}$

$flaw\ characterization\ heuristic : f_3(\mathbf{X}, \mathbf{F}) \rightarrow \mathbf{L}'$

$confidence/similarity\ measure : f_4(\mathbf{L}', \hat{\mathbf{L}}, \hat{\mathbf{X}}) \rightarrow C$

Ultrasonic Data Analysis - challenges

A tripartite label: CNN, VAE, heuristic (statistical, rule-based)

- Each individual method is promising but, yields too many false +/- to be of practical value

So:

- Combine the voice of the various methods & use their similarity to gain confidence
- use similarity as a criteria for inserting human into the loop

Current practice is fraught with subjectivity & potential human error:

- this is an efficient, efficacious, objective & repeatable process
- confidence measures identify data for which a human must be in the loop

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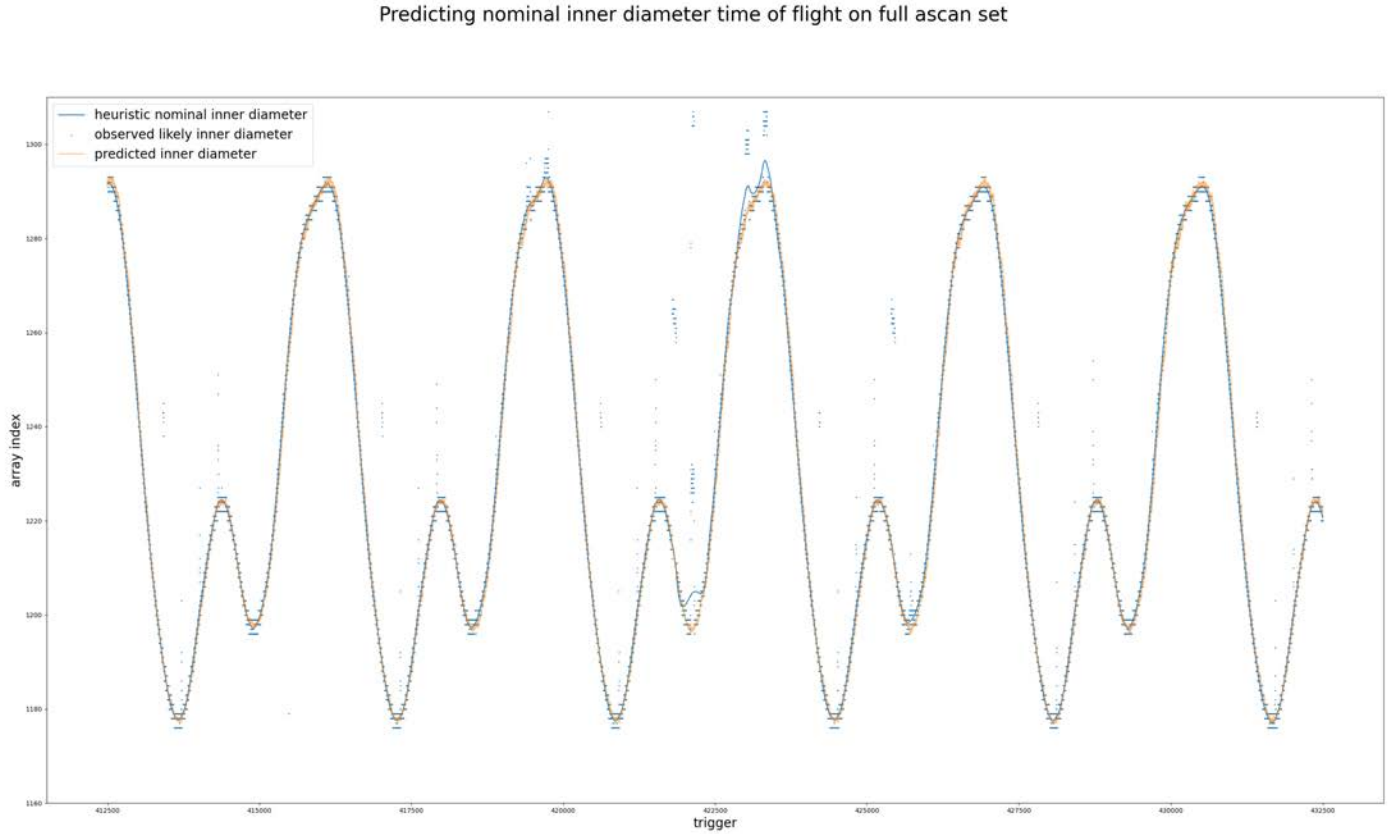
Ultrasonic Data Analysis Automation: progress

Focus on developing a prototype system capable of automatically analyzing ANDE tool calibration scan datasets

- VAE for data compression & disentangled feature generation
- disentangling tool wobble
- GAN for ultrasonic data simulation
- CNN model & hyper parameter selection for prediction & estimation
- Denoting & curve fitting techniques for label generation
- data visualization software

Automation: learning nominal inner diameter

CNN trained to predict the array index at which reflected energy from the nominal inner diameter is incident on the probe given the four normal bean scan @ that location



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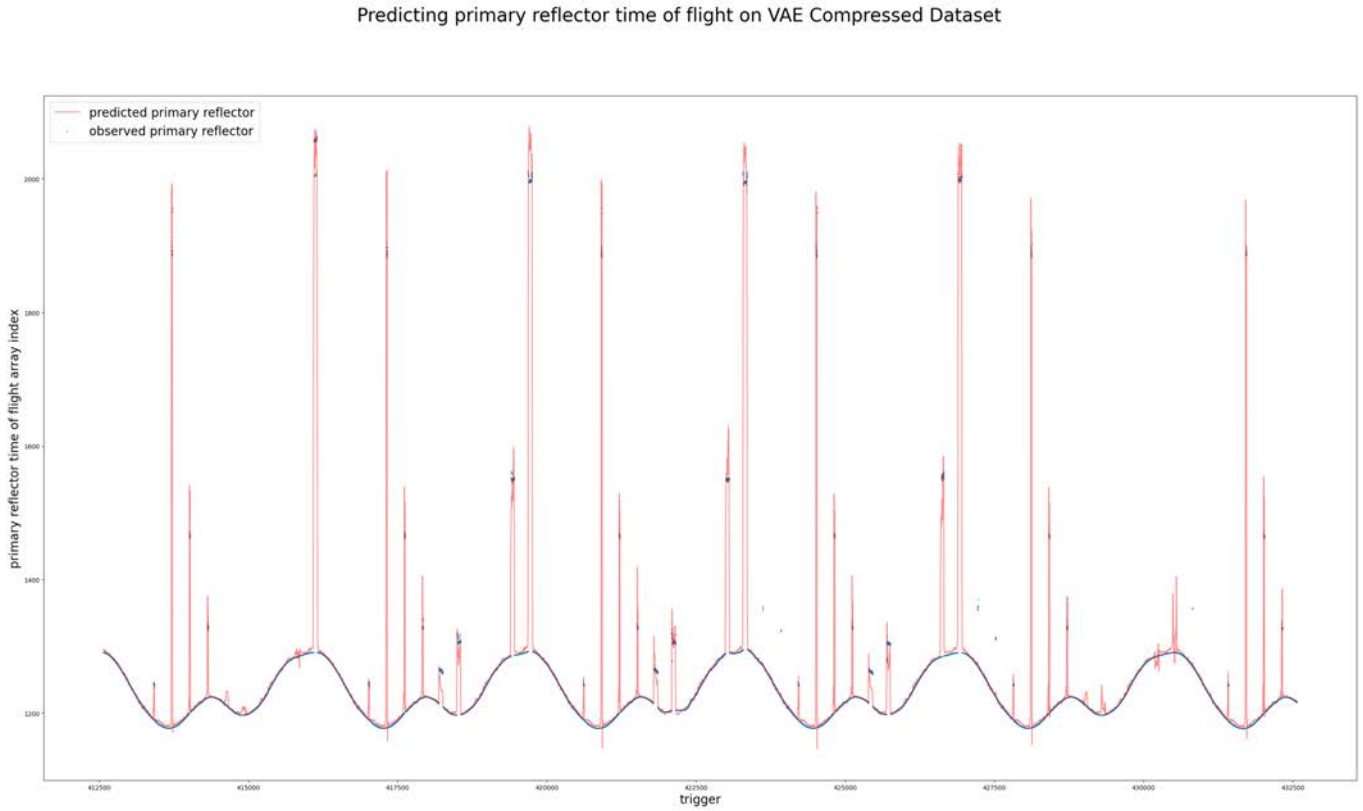
Automation: learning primary reflectors

CNN trained to predict the array index at which reflected energy from the primary reflector is incident on the probe given a 128 element VAE generated representation of the four normal beam scan take at that location



Other project

Calandria Tube Sheet Bore analysis

- camera sensor deteriorates due to radiation
- register & fuse images, geometrically correct
- remove text on video
- detect anomalies

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Other relevant research @ UW-VIP

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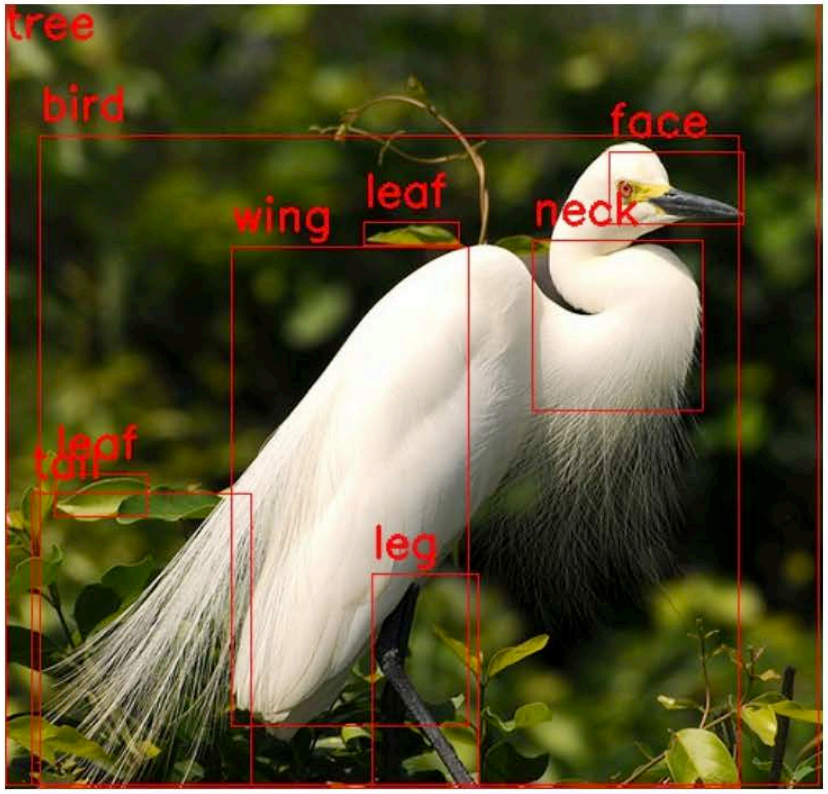
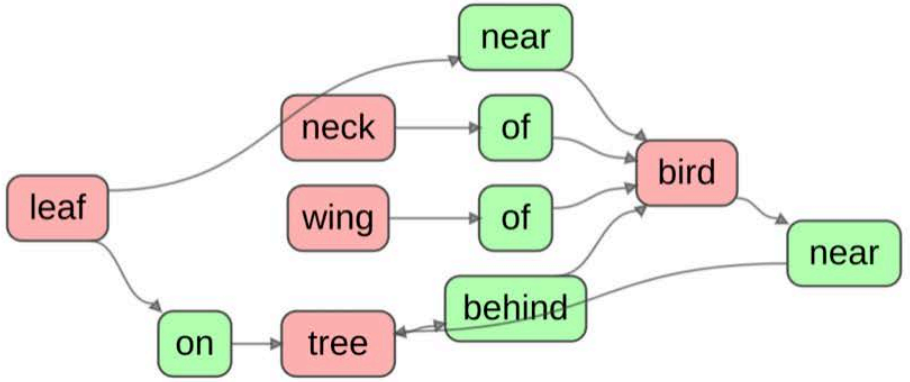
The Task: Scene Graph Generation



(Krishna et al., 2016)



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Other relevant research @ UW-VIP

(a) MSRA-TD500 (b) ICDAR-15 (c) ICDAR-17

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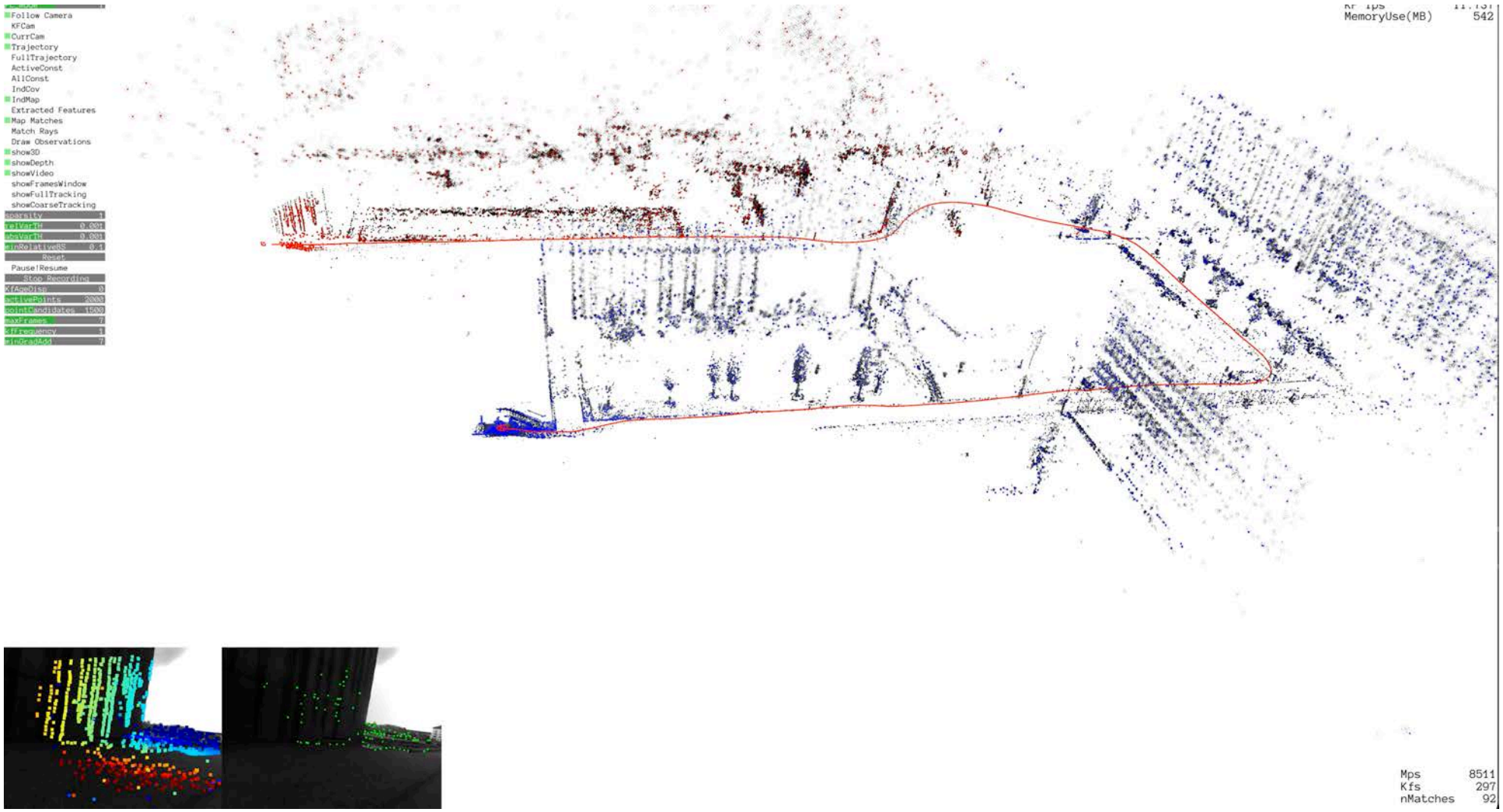

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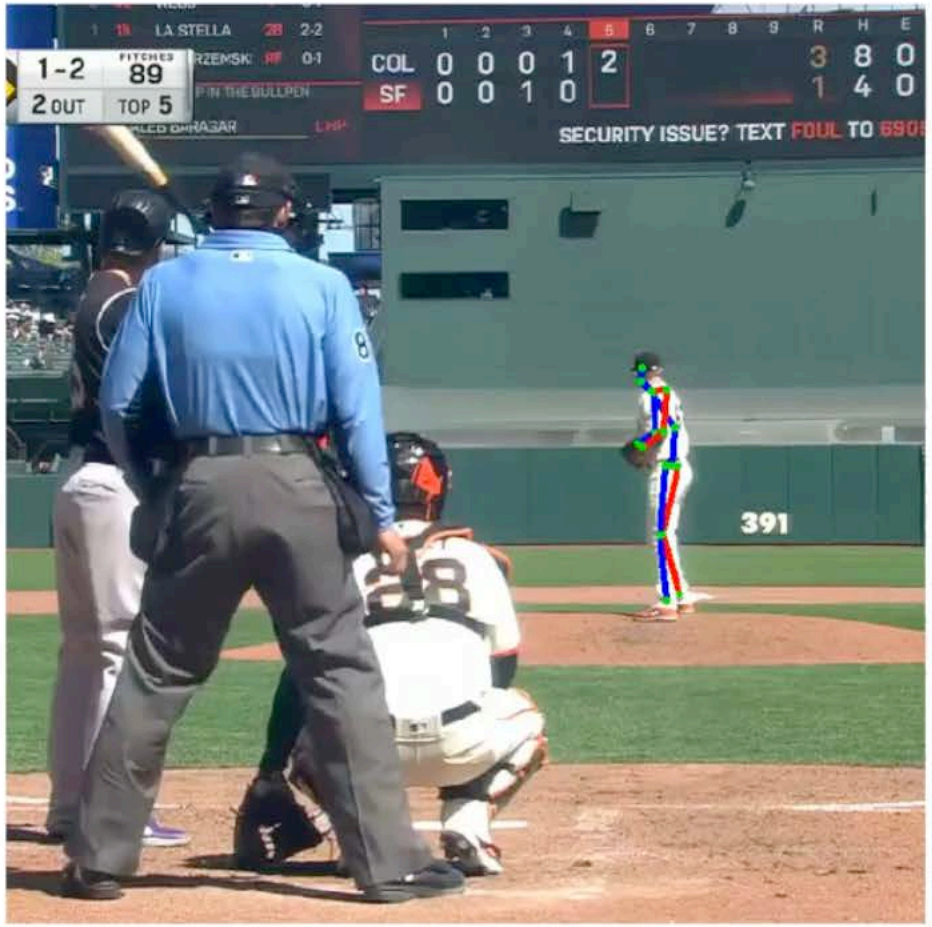
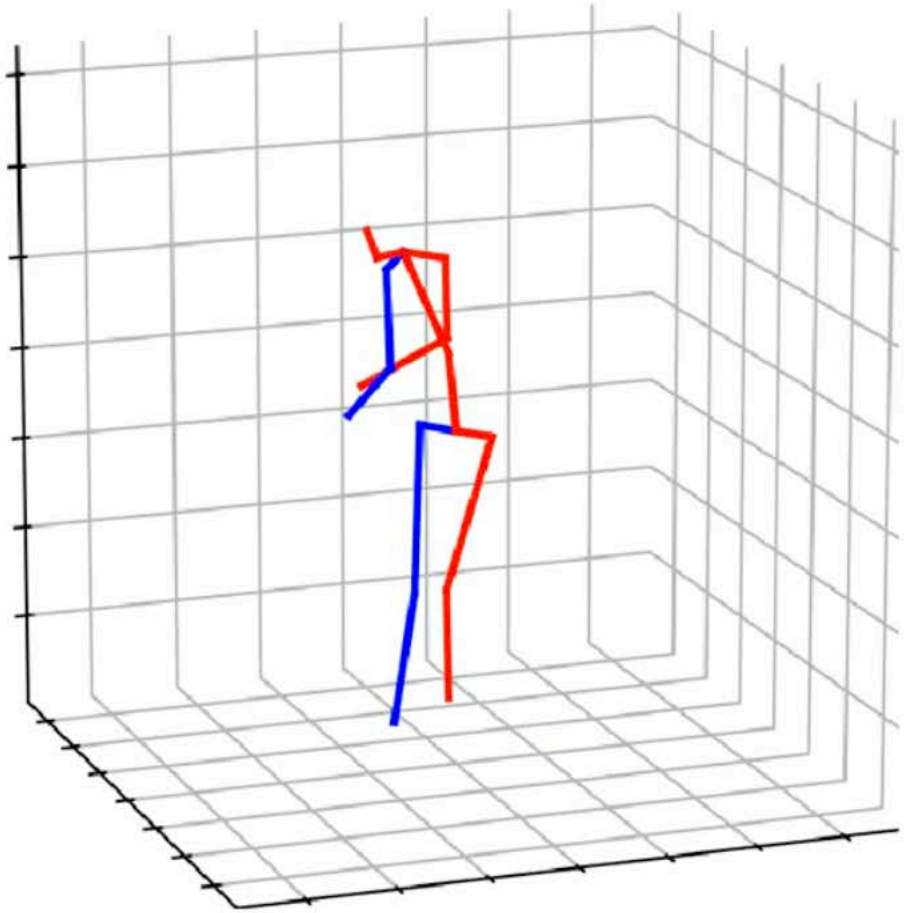
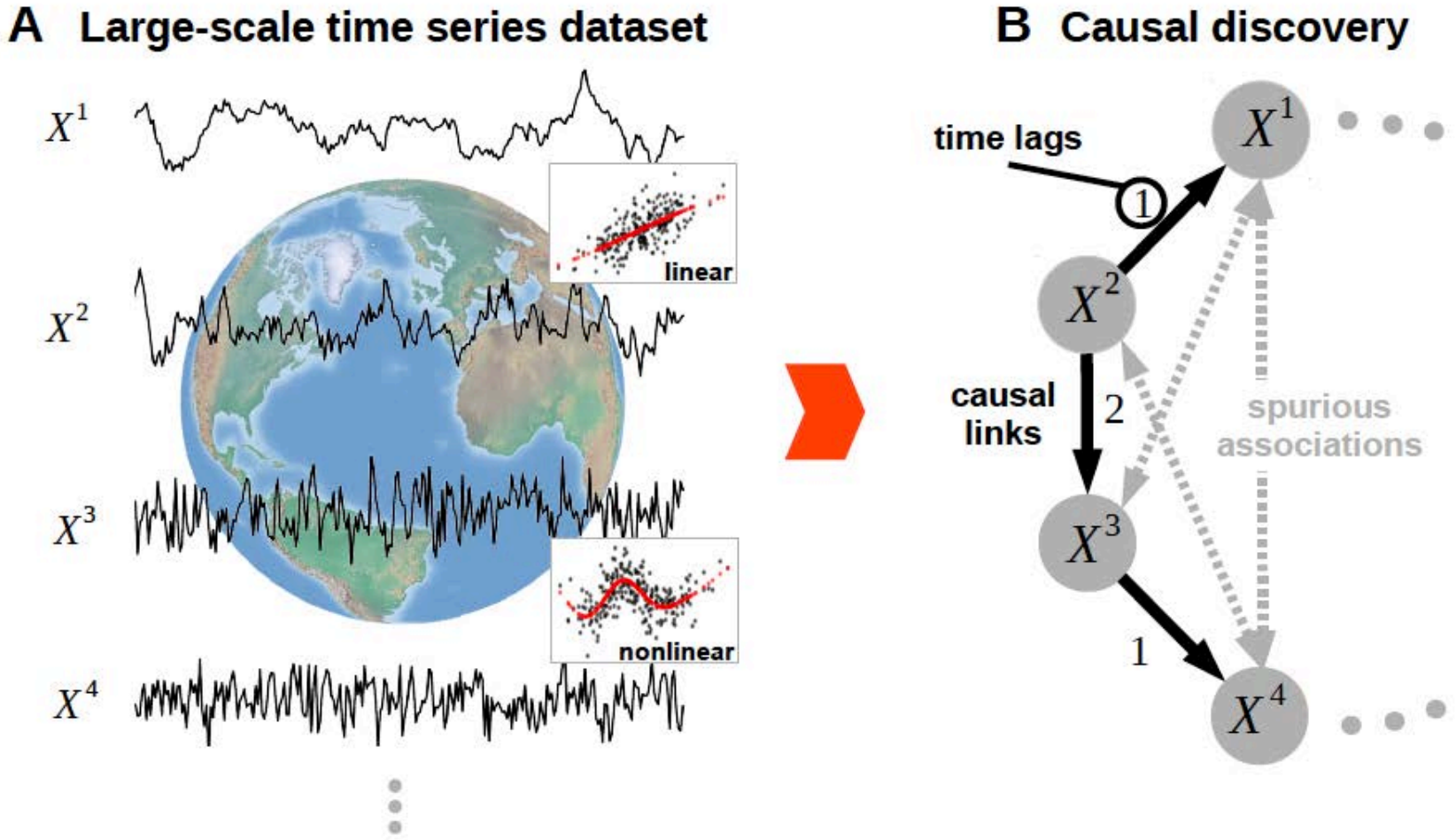
Input



Reconstruction



Other relevant research @ UW-VIP



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