The ARGO detector readout and DAQ

Audrey Corbeil Therrien, PhD, ing.

For the ARGO collaboration

23/06/2026

The Global Argon Dark Matter Collaboration

400 researchers from 100 institutions in 14 countries

With many thanks for support to:

CFI and NSERC (Canada)

IN2P3 (France)

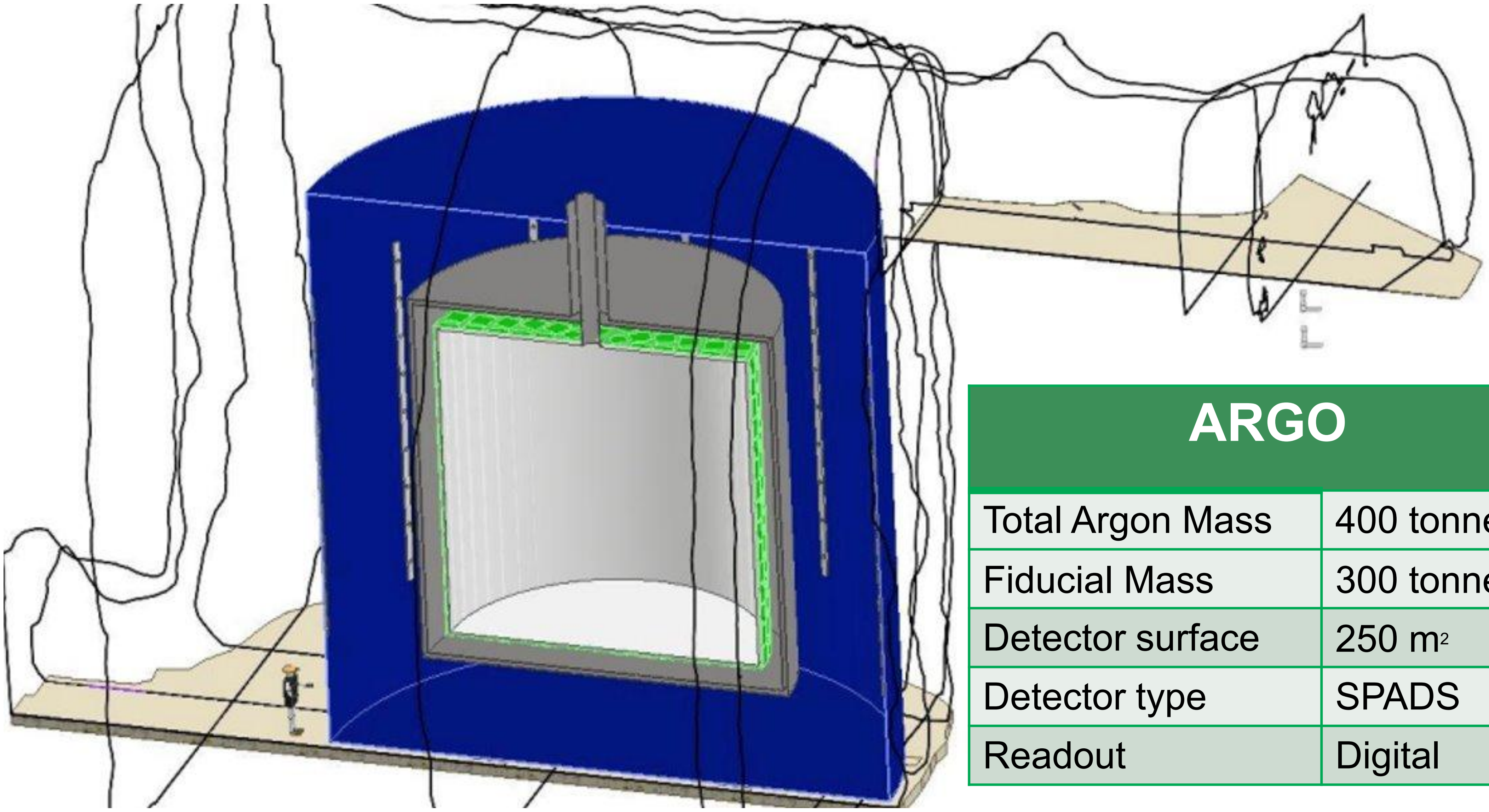
INFN (Italy)

STFC (UK)

NSF and DOE (U.S.)

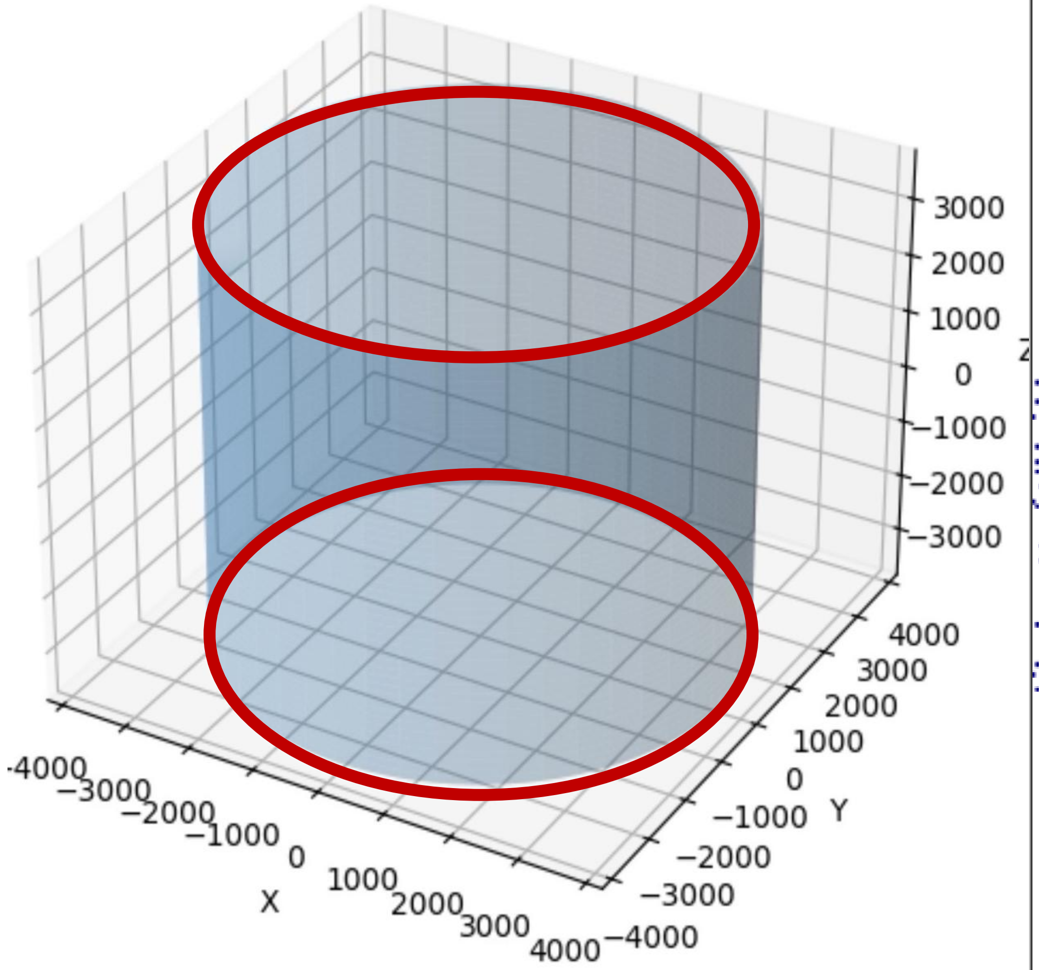
Poland and Spain Ministries for Science and Education

ARGO

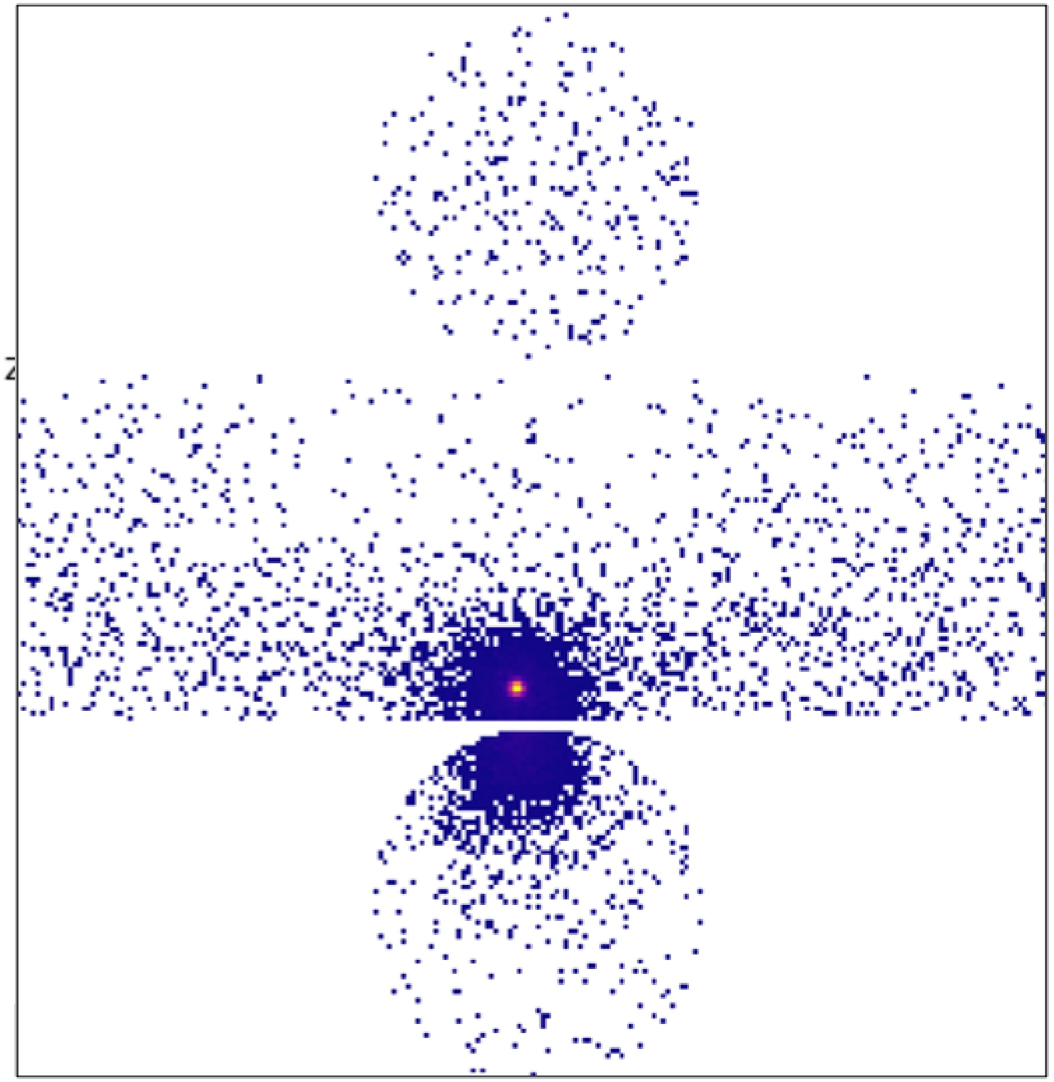


ARGO	
Total Argon Mass	400 tonnes
Fiducial Mass	300 tonnes
Detector surface	250 m^2
Detector type	SPADS
Readout	Digital

ARGO



3000
2000
1000
0
−1000
−2000
−3000
4000
3000
2000
1000
0
−1000
Y
−2000
−3000
−4000
-4000
−3000
−2000
−1000
0
1000
2000
3000
4000
X

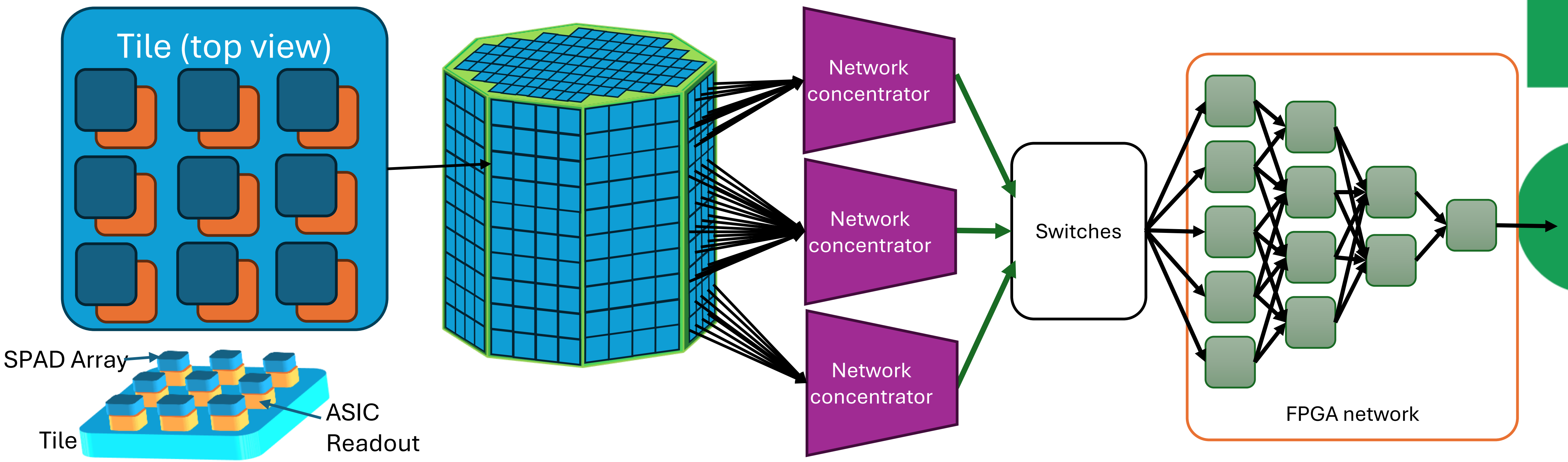


ARGO

~250 m^2 of detector surface

Individual detector « tile »	Number of data channels
10x10 cm^2	25 000
1x1 cm^2	2 500 000
1x1 mm^2	250 000 000

ARGO DAQ


Tile (top view)
SPAD Array
Tile
ASIC
Readout
Network concentrator
Network concentrator
Network concentrator
Switches
FPGA network

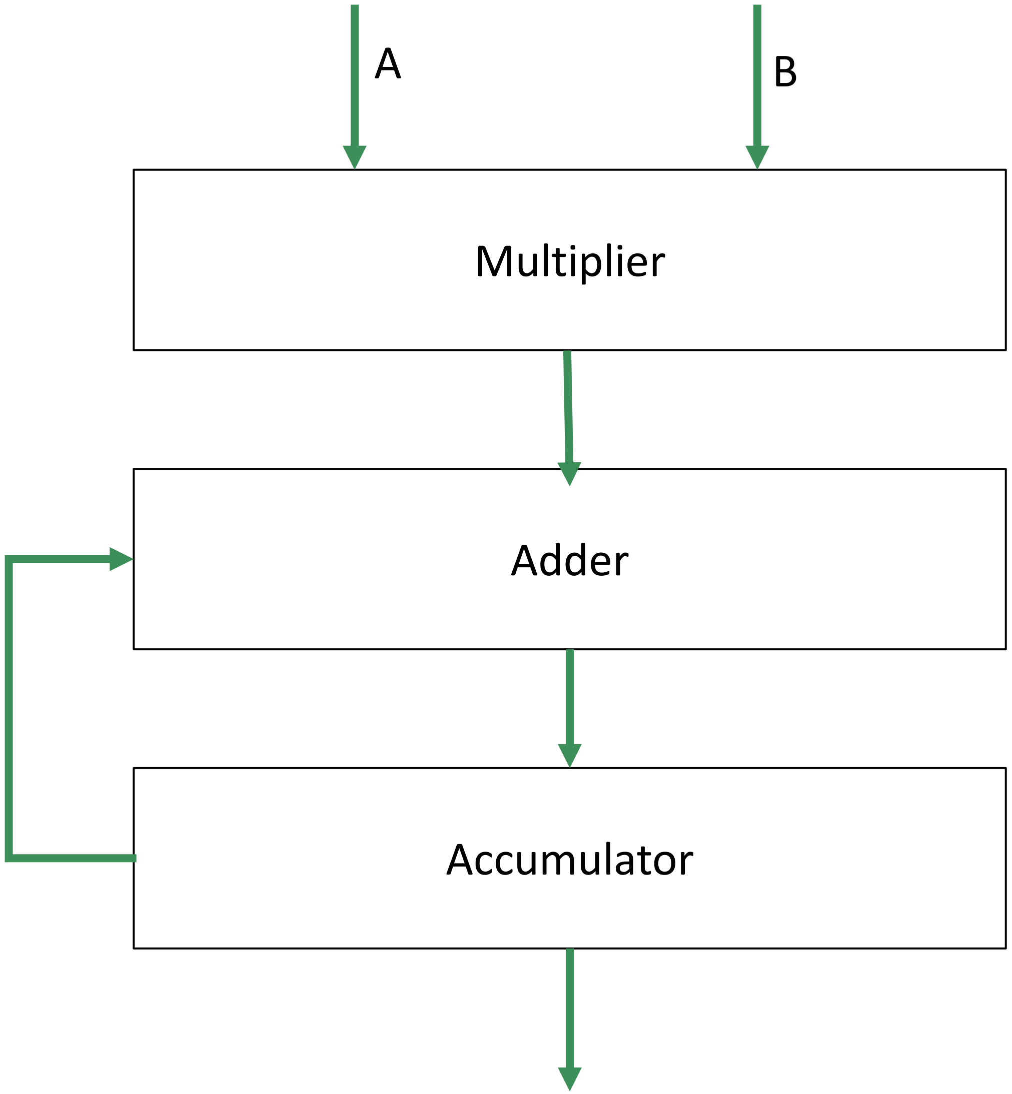
Machine Learning and Hardware

- Machine Learning operations
  - Multiplications
  - Additions
  - Non-linear fixed function
  - Memory transactions

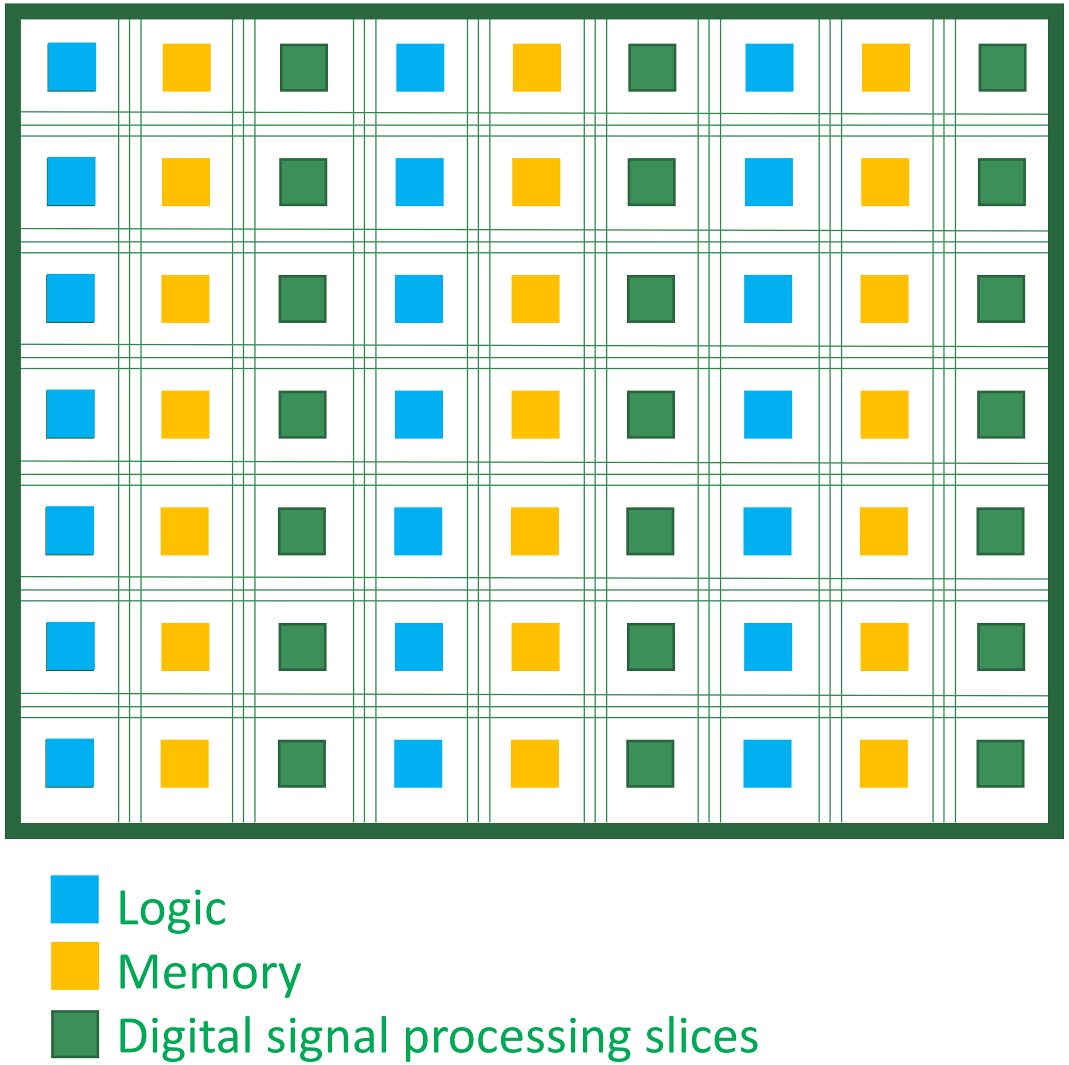
- MAC unit
  - Multiply-and-accumulate

- Look-up-table
  - No need to compute the function

- Data transfers



Machine Learning and FPGA



Reconfigurable

Efficient

I/O capacity

Programming

Limited clock

Limited resources

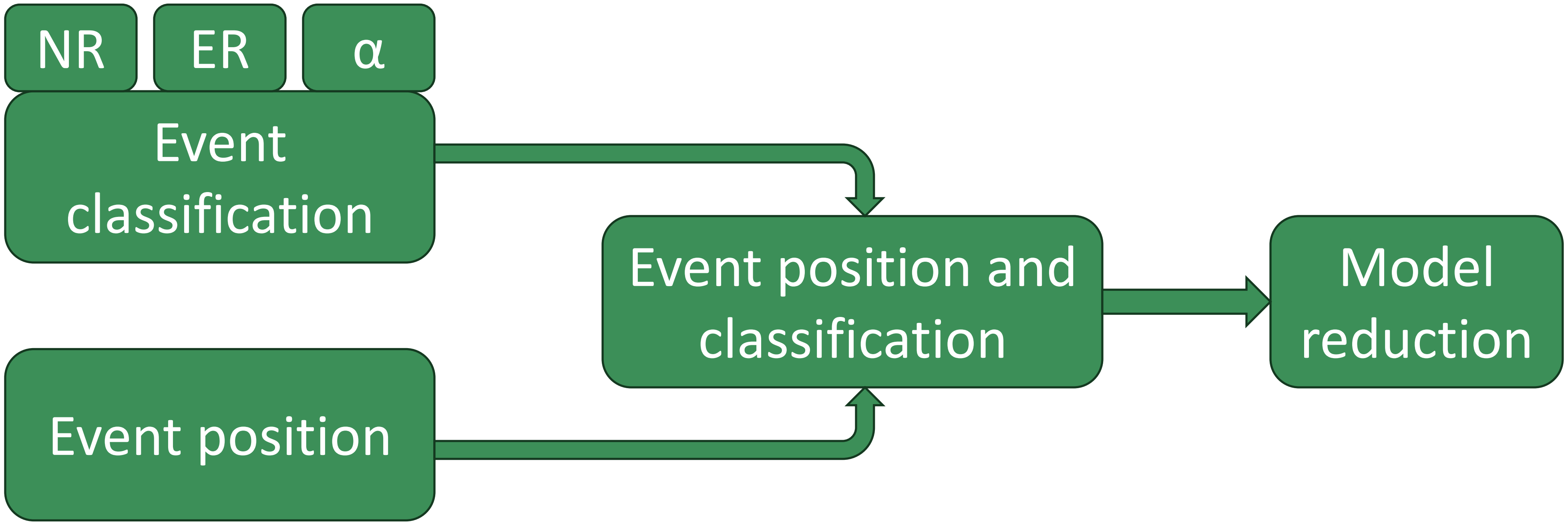
Machine Learning and Hardware

- Machine learning can analyse data using simple operations
- FPGA have several I/O
- FPGA can run ML models fully parallel and pipelined

Continuous readout and analysis

Machine Learning for ARGO

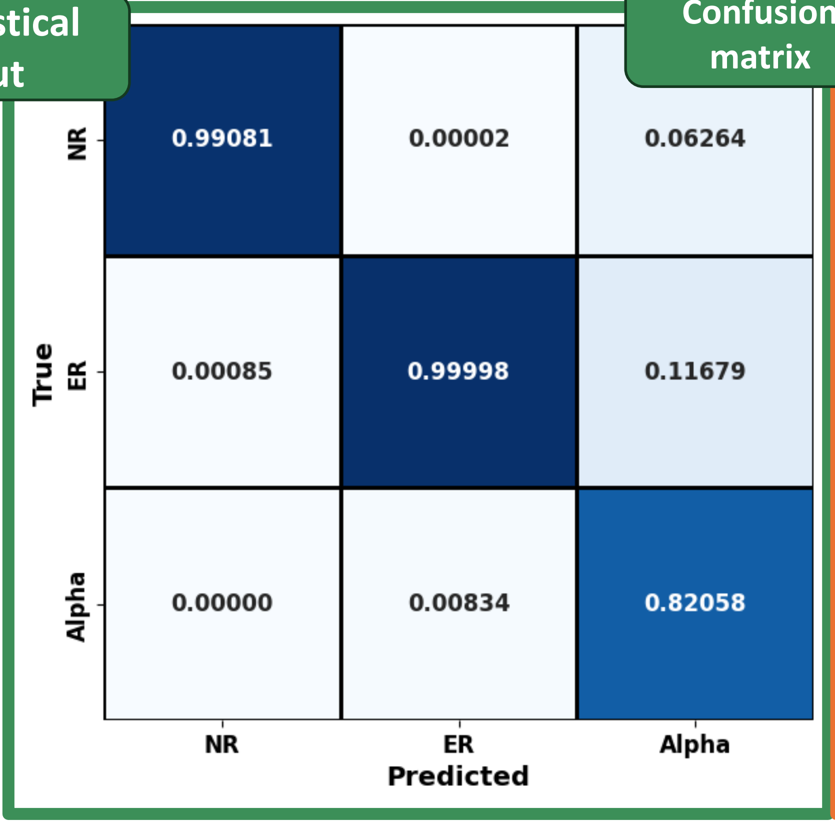
Start simple, build up, squish down.



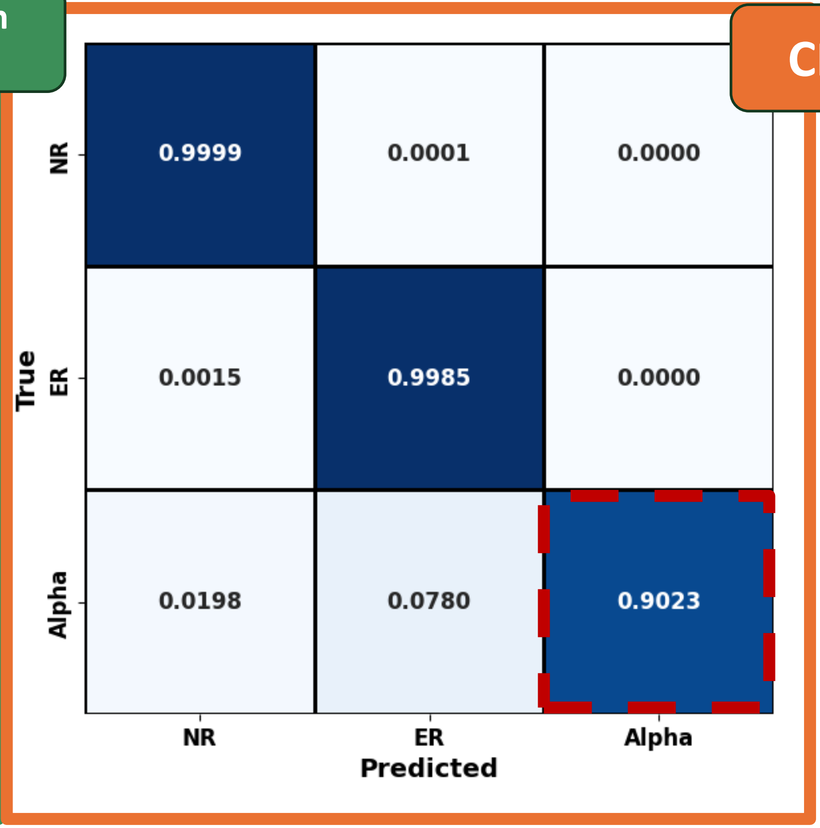
Event classification

Statistical Cut

Confusion matrix



CNN



Accuracy: 97.81%

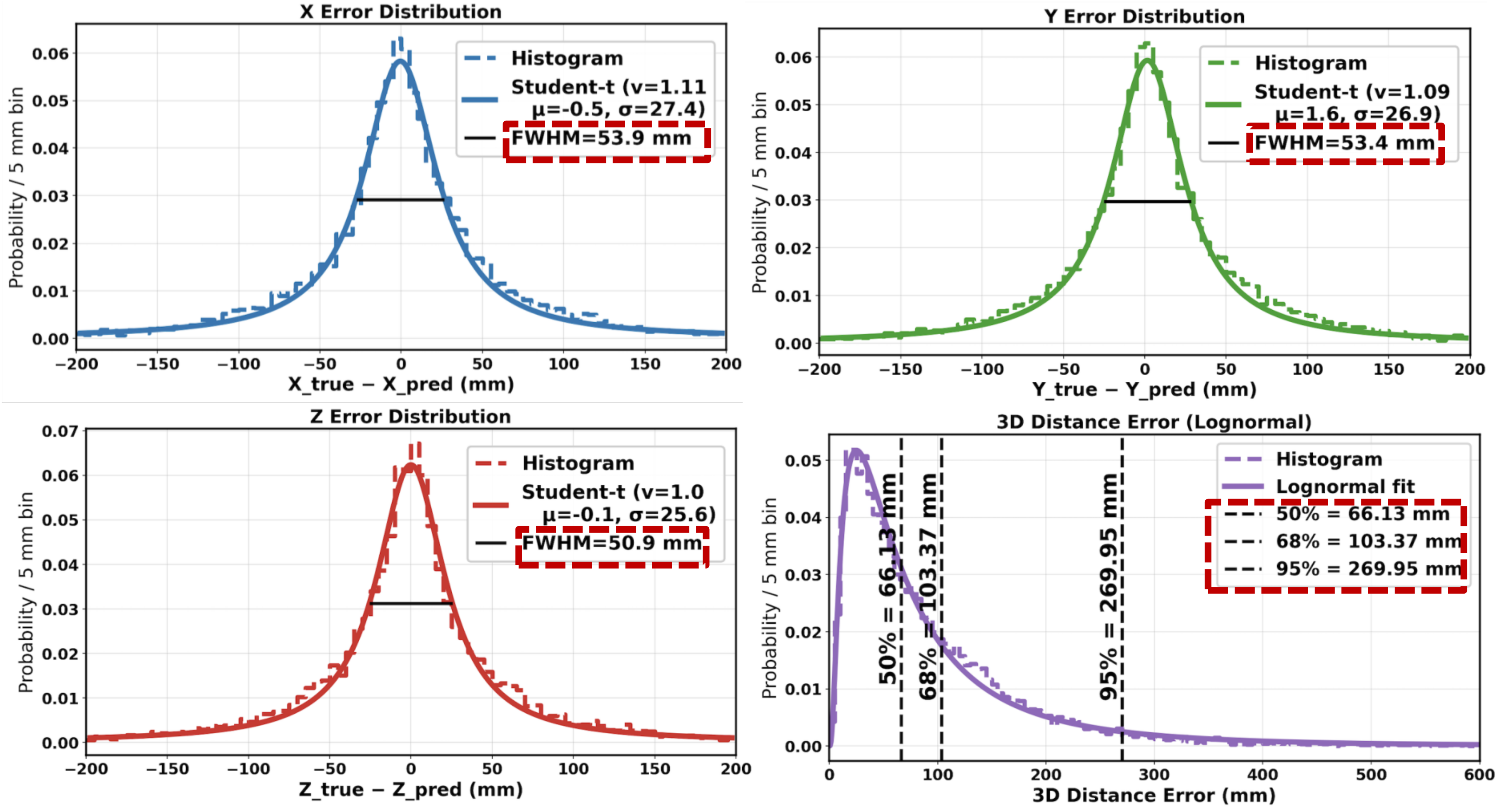
Events: 220,000

Accuracy: 99.09%

S. Esmaeilzadeh, IEEE NSS 2025

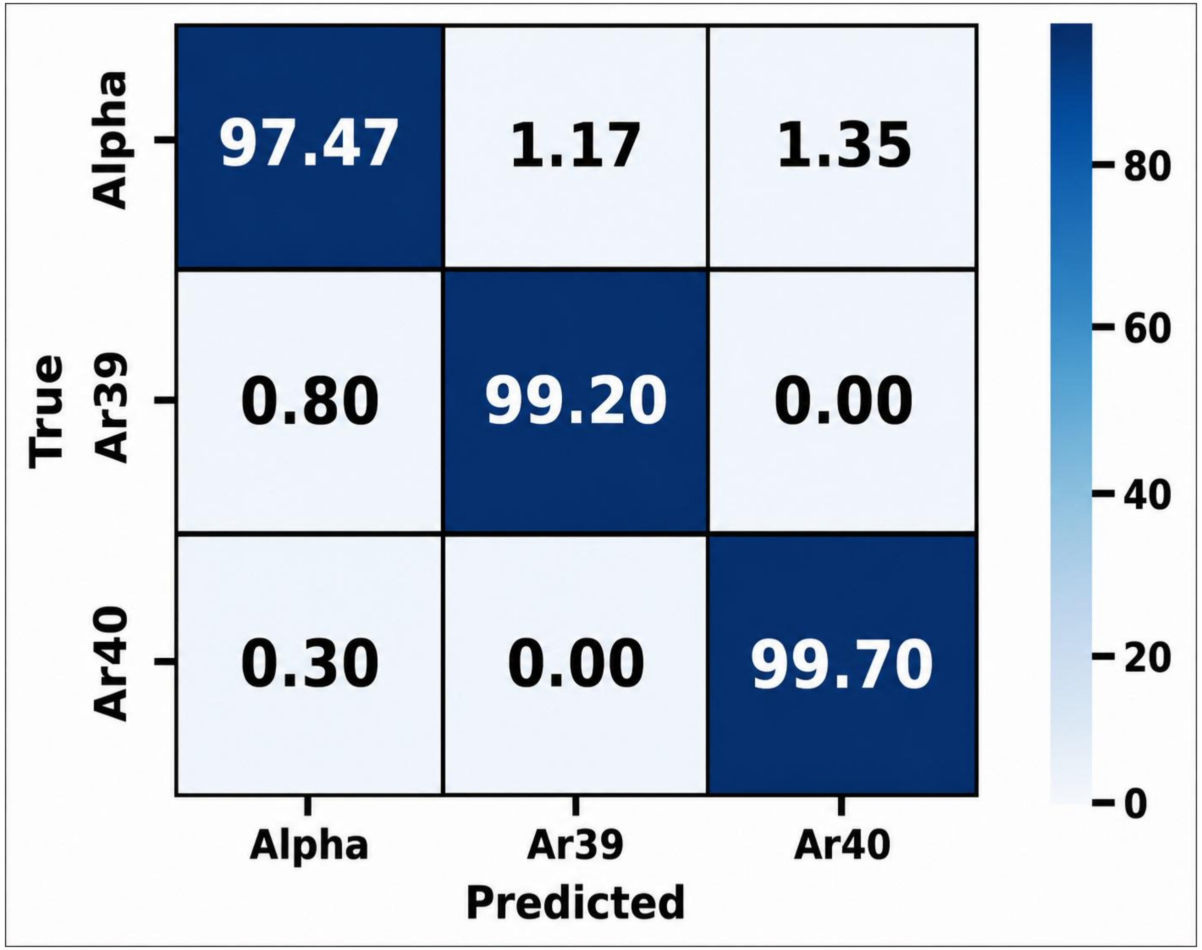
Event position

100x100 mm^2 tiles



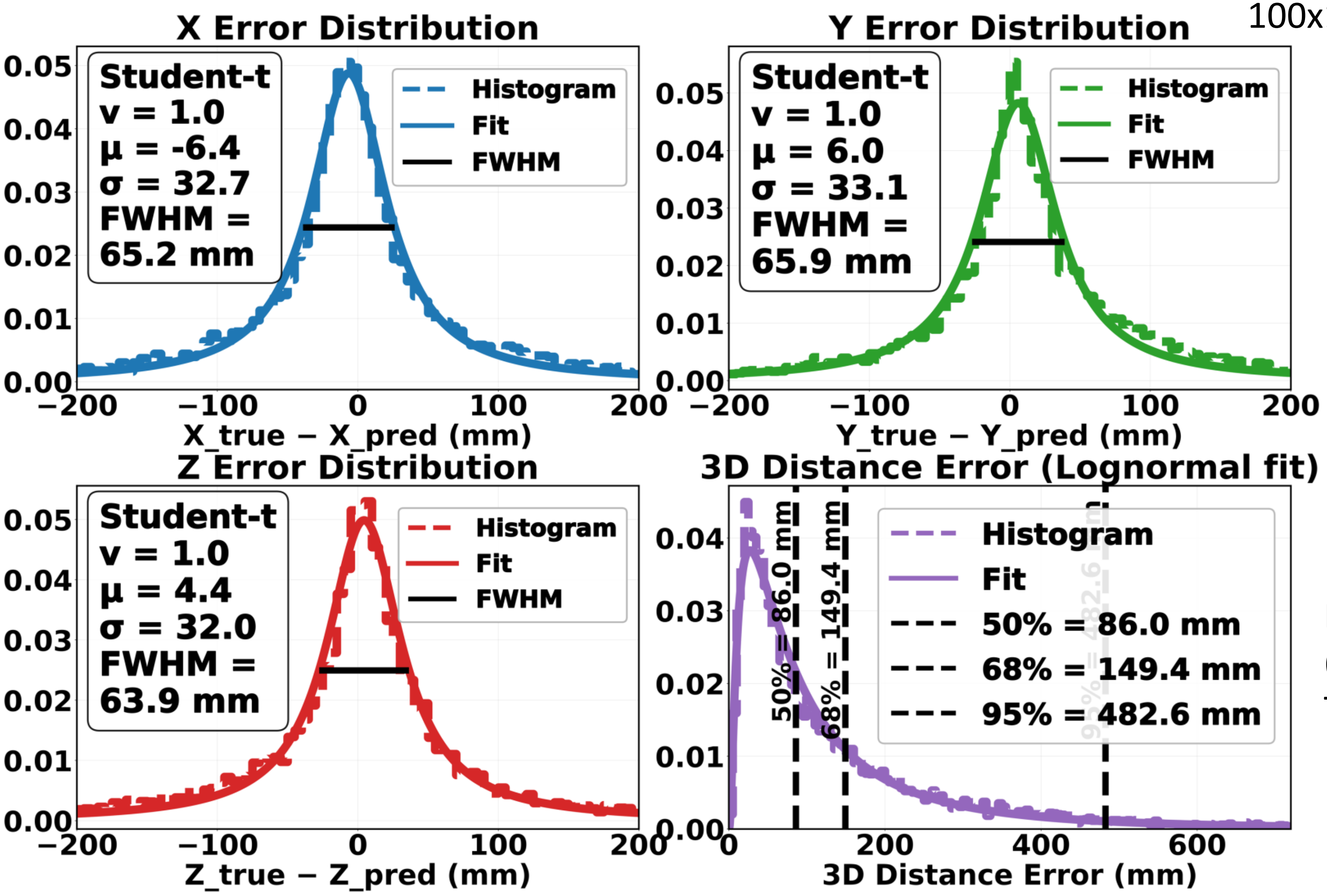
S. Esmaeilzadeh, IEEE NSS 2025

Combined model – event classification



Poster by Sajedeh Esmaeilzadeh (POS-21)
Today at 18:00

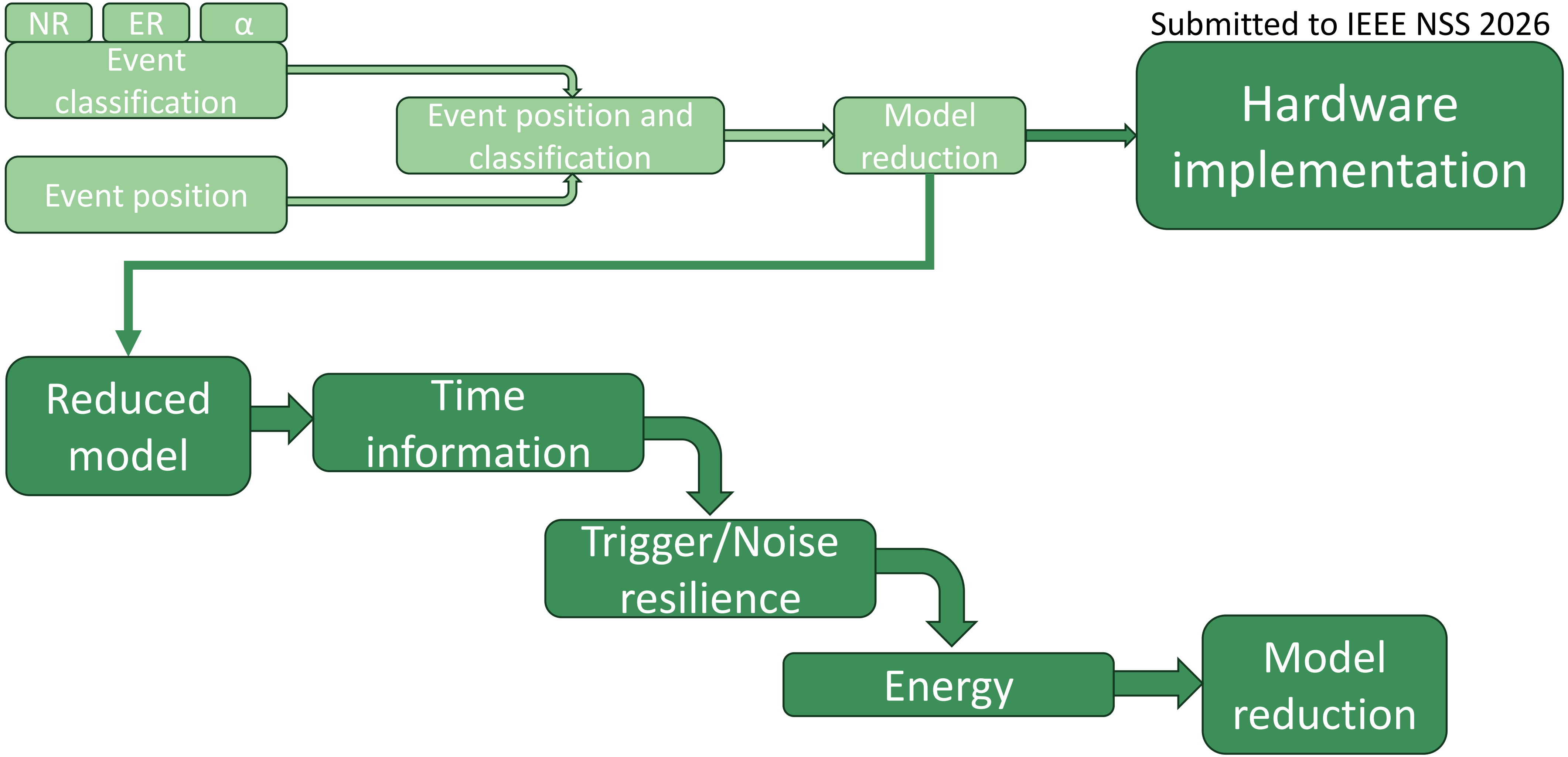
Combined model – event position



100x100 mm^2 tiles

Poster by Sajedeh Esmaeilzadeh (POS-21)
Today at 18:00

Next steps


NR
ER
α
Event classification
Event position
Event position and classification
Model reduction
Submitted to IEEE NSS 2026
Hardware implementation
Reduced model
Time information
Trigger/Noise resilience
Energy
Model reduction

Conclusion

ARGO pushes sensitivity to dark matter, but presents several challenges for DAQ systems

We built a single hardware aware ML model that can extract interaction type and position simultaneously

EdgeAI requires new tools and new methods to meet the requirements for experiments

Institut interdisciplinaire d'innovation technologique UdS
Canada Research Chairs www.chairs-chaires.gc.ca
NSERC CRSNG
INNOVATION Canada Foundation for Innovation Fondation canadienne pour l'innovation
Digital Research Alliance of Canada | Alliance de recherche numérique du Canada
hls4ml
CMC MICROSYSTEMS
XILINX ALL PROGRAMMABLE

CNN and ARGO

Poster by Sajedeh Esmaeilzadeh

(POS-21) Real-time Machine Learning for ARGO Data Acquisition System

Today at 18:00