TMVA Tutorial

Sergei Gleyzer, Lorenzo Moneta

for the ROOT-TMVA Team

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Outline

- **Status and Overview**
- **New TMVA Features**
  - **External Interfaces**
  - **Deep Learning, Jupyter, Parallelization**
- **Future Plans and Outlook**
- **Summary**

TMVA

Toolkit for Multivariate Analysis:

- **HEP Machine Learning workhorse**
- **Part of ROOT**
- **In LHC experiments production**
- **Easy for beginners, powerful for expert**
- **New TMVA version released in the ROOT version 6.0.8**

New TMVA Features

Modularity, External Interfaces, Updated SVMs

Analyzer Tools: Variable Importance

Added beginning of 2016

Deep Learning CPU, GPU

Parallelization with multithreading and GPUs

Analyzer Tools: Cross-Validation, Hyper-Parameter Tuning

Regression Loss Functions

Jupyter: Interactive Training, Visualizations

Added in TMVA ROOT 6.0.8

Unsupervised Learning

Deep Autoencoders

Multi-processing, Spark parallelization

Upcoming

TMVA Interfaces

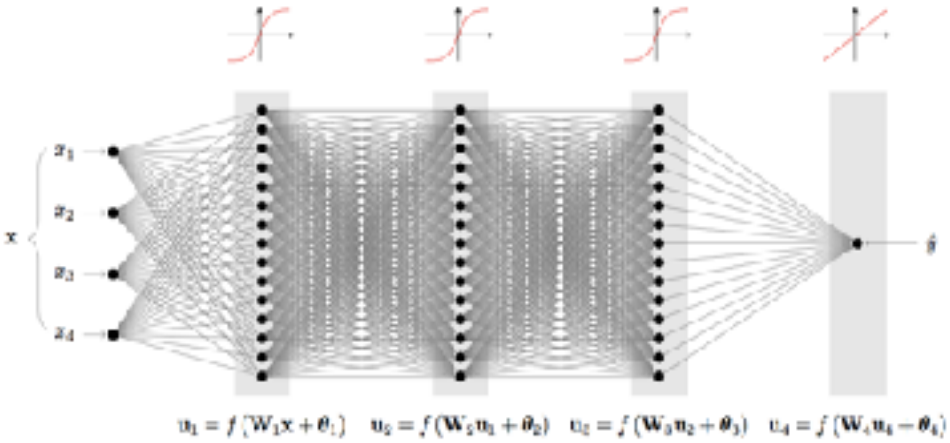
Interfaces to External ML Tools

- **RMVA interface to R**
- **PyMVA interface to scikit-learn**
- **KMVA interface to Keras**
  - **High-level interface to Theano, TensorFlow deep-learning libraries**

Deep Learning

New Deep-Learning Library in TMVA

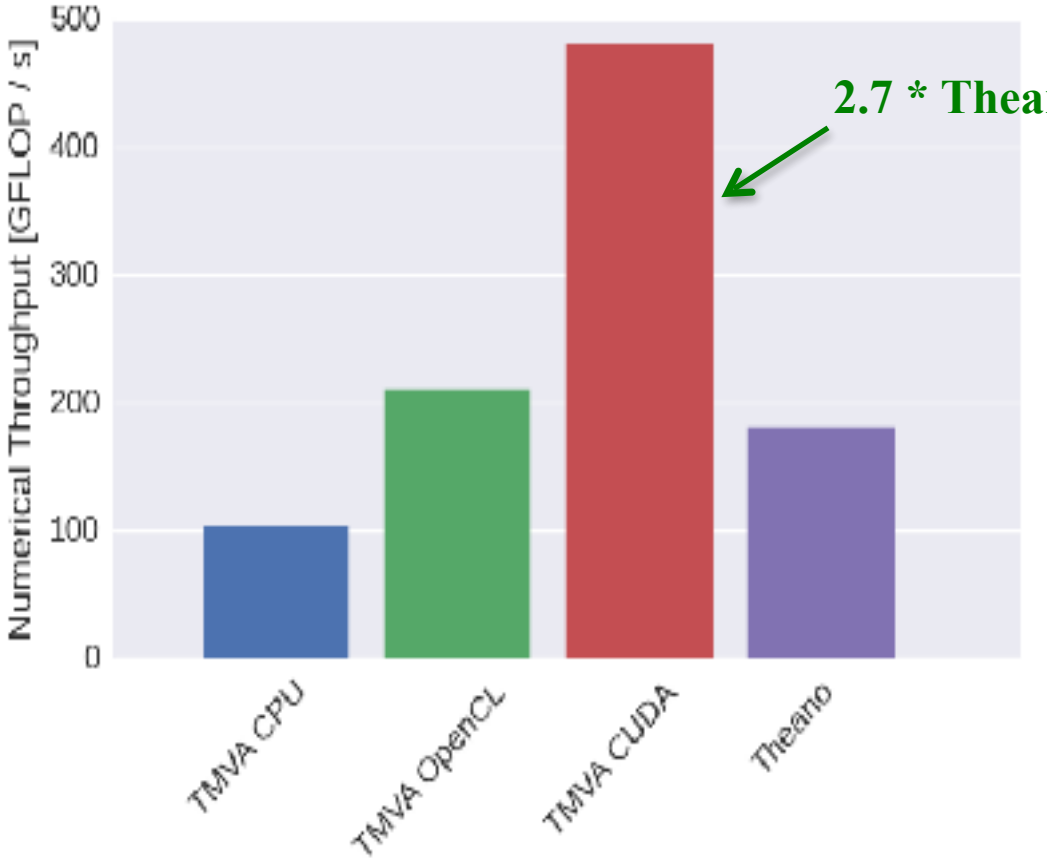
- **GPU support**
  - **CUDA**
  - **OpenCL**



- **Excellent performance and high numerical throughput**

Deep Learning

Throughput Comparison

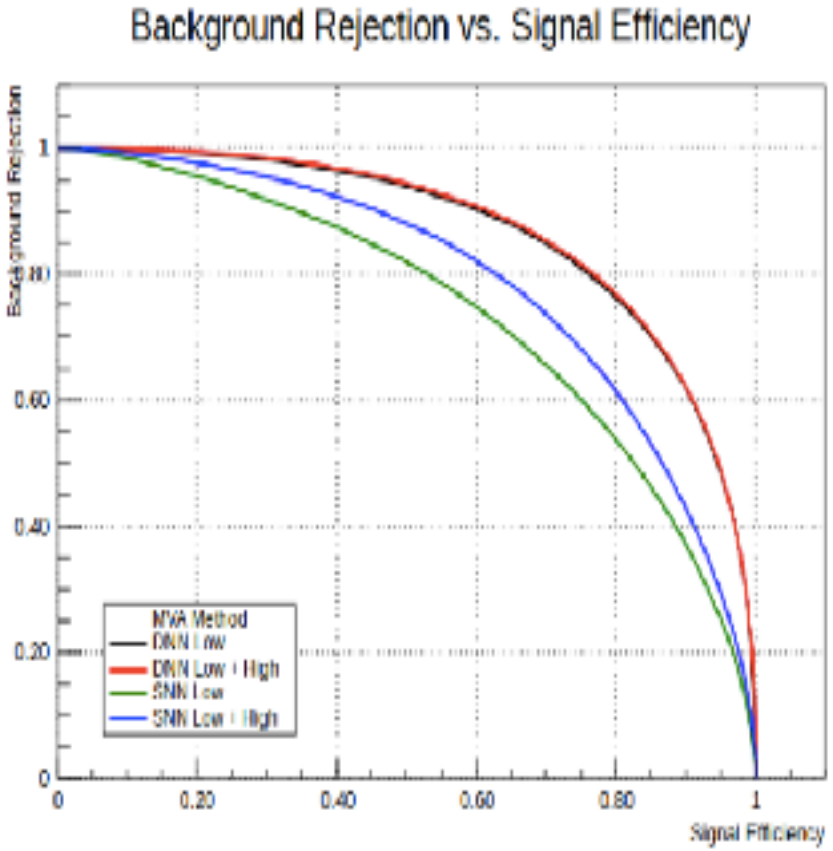


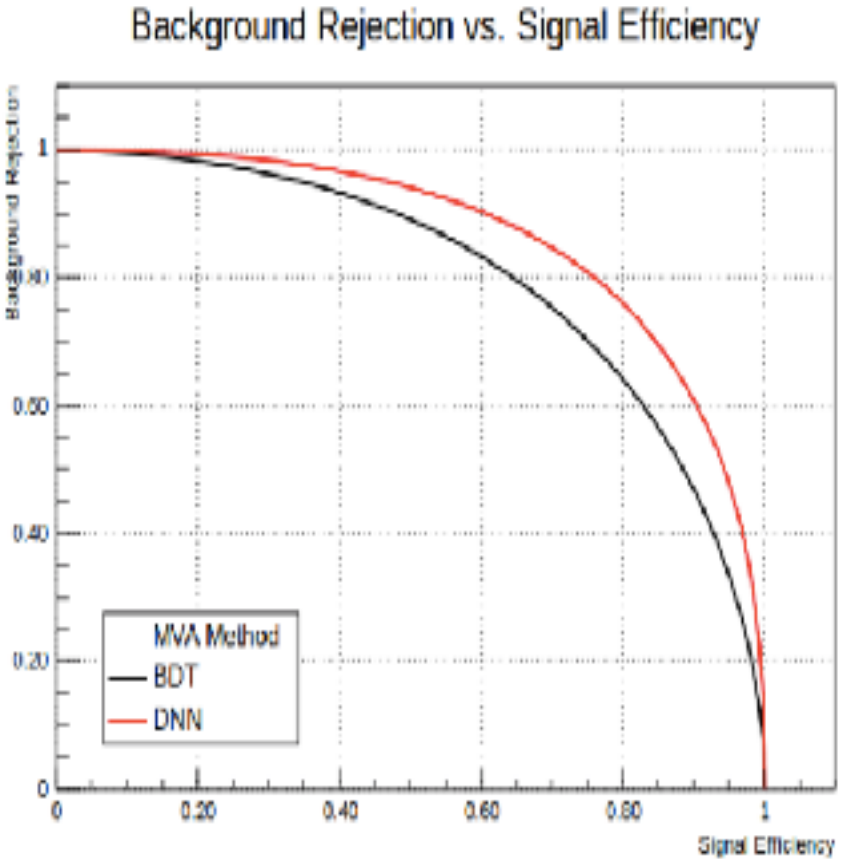
Single precision

batch size = 1024

Excellent throughput compared to Theano on same GPU

Deep Learning





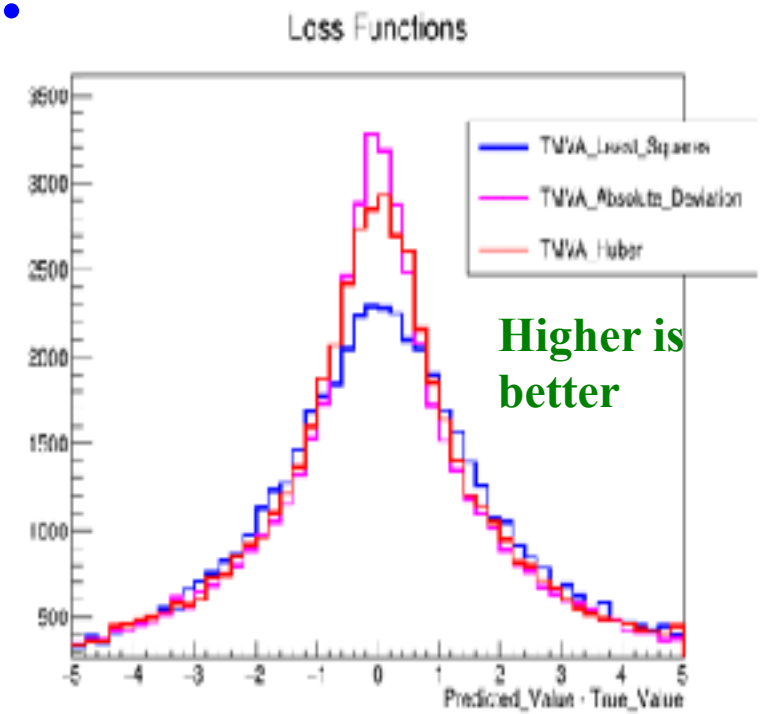
ROC Performance: significant improvements compared to shallow networks and boosted decision trees

Regression

New Regression Features:

Loss functions:

- Huber (default)
- Least Squares
- Absolute Deviation
- Custom Function

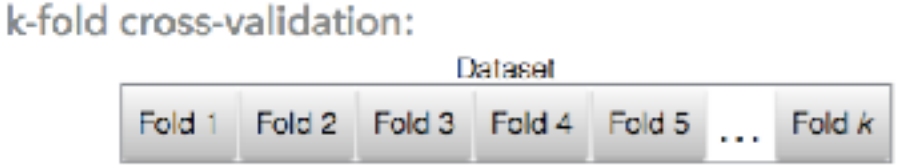


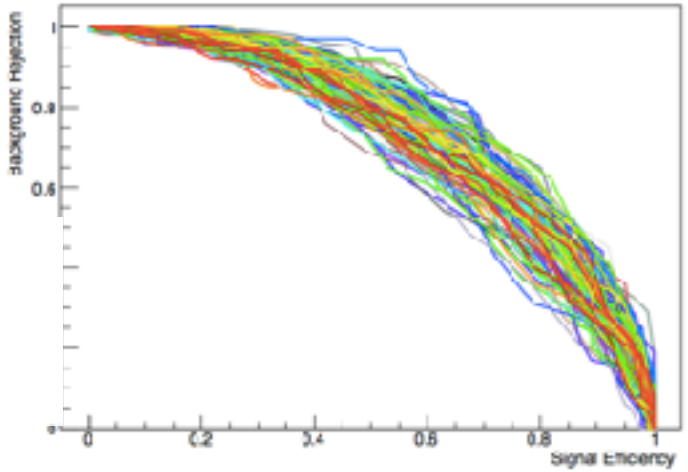
Important for regression performance

Cross Validation

New features:

- **k-fold cross-validation**





- **Hyper-parameter tuning**
  - **Find optimized parameters (SVM, BDT)**

TMVA Tutorial

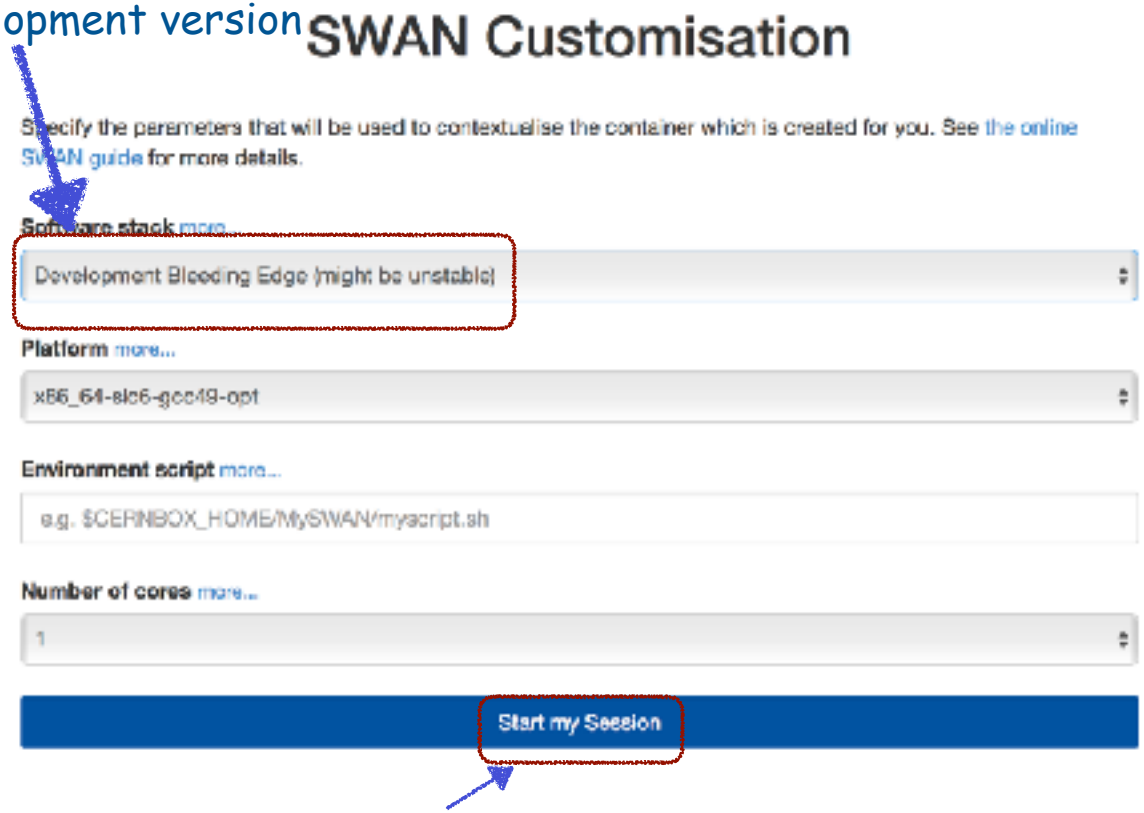
- **Run tutorial on notebook**
  - use **SWAN**
    - go to swan.cern.ch

  - **or running local notebooks**
    - root —notebook

If you don't have CERN account for using SWAN please contact me
Some temporary account can be made available

Starting SWAN

make sure to have selected
the development version



click here to start

Starting a Terminal in SWAN

After login cernbox home directory will be visible

Start a terminal window

Getting the Notebooks

- **Clone the git repository**
  - **git clone https://github.com/lmoneta/tmva-tutorial.git**
    (link available also in Indico)

```
bash-3.2$ git clone https://github.com/lmoneta/tmva-tutorial.git
Cloning into 'tmva-tutorial'...
remote: Counting objects: 15, done.
remote: Compressing objects: 100% (11/11), done.
remote: Total 15 (delta 2), reused 15 (delta 2), pack-reused 0
Unpacking objects: 100% (15/15), done.
bash-3.2$
```

TMVA Contributors

• Sergei Gleyzer	Analyzer Tools, Algorithm Development
• Lorenzo Moneta	Multi-threading, Multi-processing
• Omar Zapata Mesa	PyMVA, RMVA, Modularity, Parallelization
• Peter Speckmeyer	Deep-Learning CPU
• Simon Pfreundschuh	Deep-Learning CPU and GPU
• Adrian Bevan, Tom Stevenson	SVMs, Cross-Validation, Hyperparameter Tuning
• Attila Bagoly	Jupyter Integration, Visualization, Output
• Albulena Saliji	TMVA Output Transformation
• Stefan Wunsch	KERAS Interfance
• Pourya Vakilipourtakalou	Cross-Validation, Parallelization
• Abhinav Moudhil	Pre-processing, Deep Autoencoders
• Georgios Douzas	Spark, Cross-Validation, Hyperparameter Tuning
• Paul Seyfert	Performance optimization of MLP
• Andrew Carnes	Regression, Loss Functions, BDT Parallelization

Continued invaluable contributions from Andreas Hoecker, Helge Voss, Eckhard von Thorne, Jörg Stelzer, and key support from CERN EP-SFT Group

More Information

Websites: http://root.cern.ch
http://iml.cern.ch
http://oproject.org