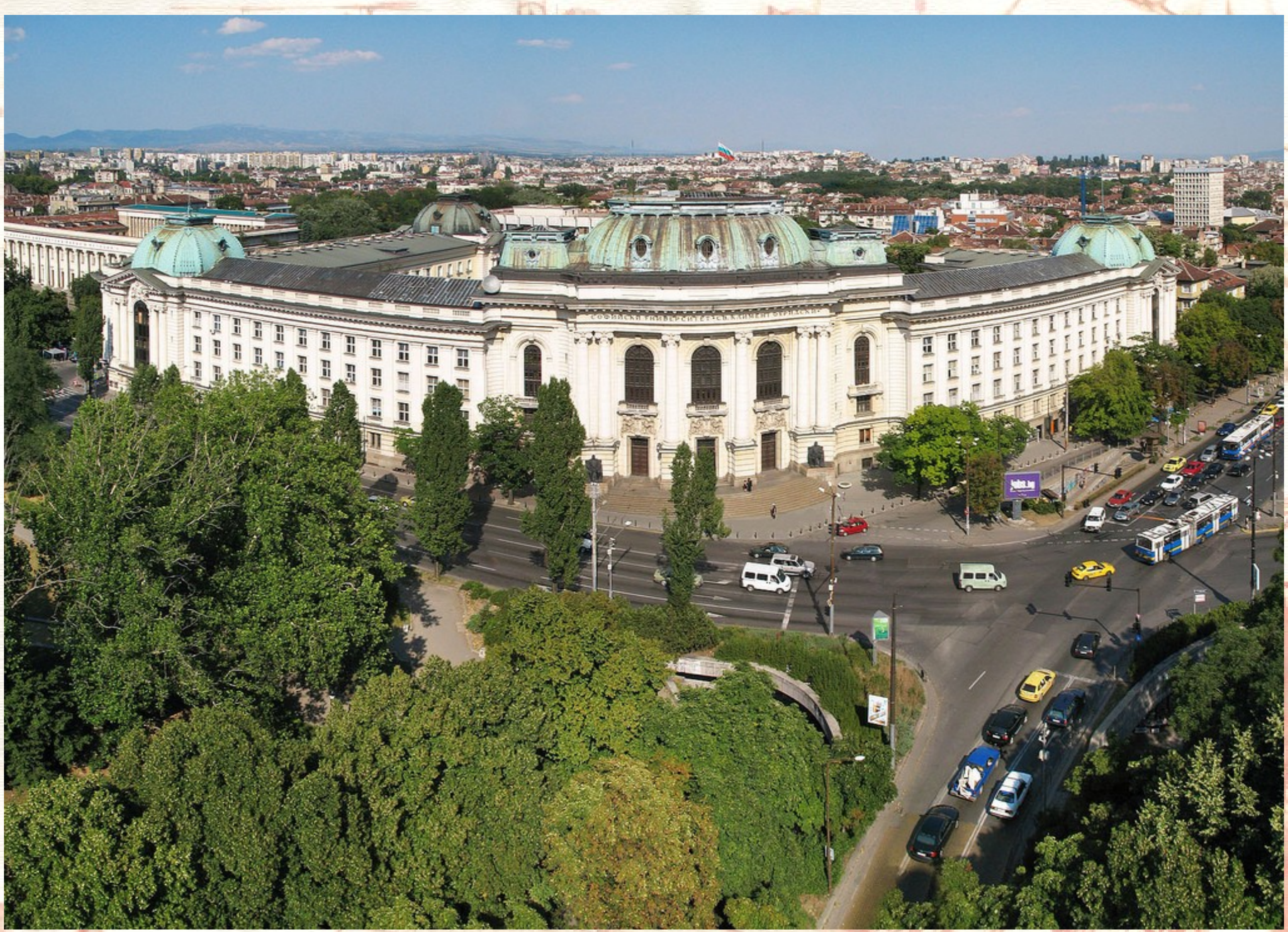
RPC ML Efforts



University of Sofia "St. Kliment Ohridski"

Outline

- ML for RPC currents
- ML for RPC rates
- Conclusions
- Further work

2

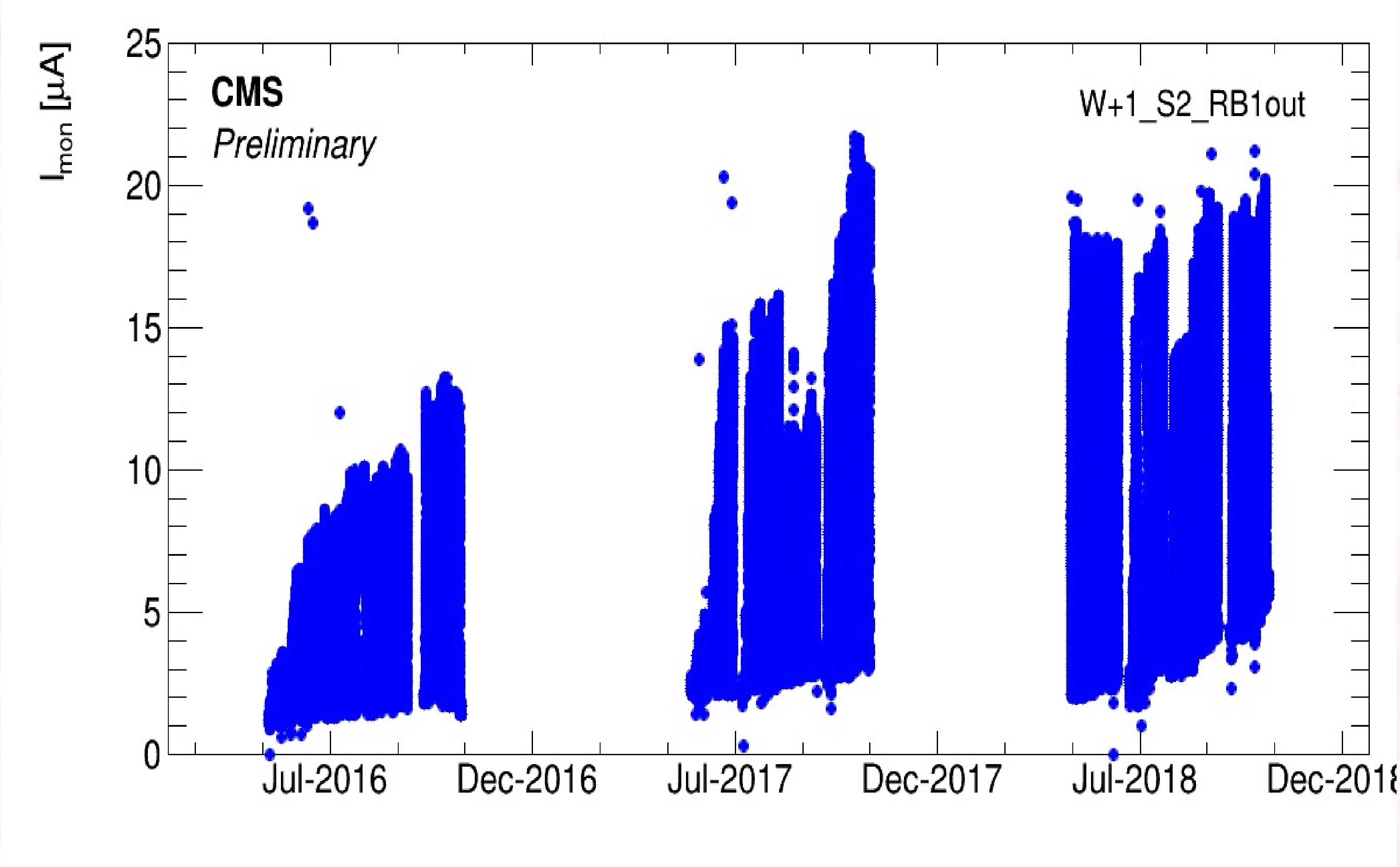
RPC currents

Presented @ RPC2020

https://agenda.infn.it/event/19942/contributions/108471/

3

Input data - current (I_{mon}) during pp collisions



4 I_{mon} and V_{mon} – taken from dedicated database produced by RPC Current Automat.

The Model

Predicted RPC current:

$$I_{pred} = C_0 + C_1{*}L_{inst} + C_2{*}HV + C_3{*}T + C_4{*}L_{inst}{*}e^{(HV/P)} + C_5{*}RH + C_6{*}P + C_7{*}\Delta t$$

C_i – parameters specific for each chamber

L_{inst} – instantaneous luminosity

HV – applied high voltage

T – environmental temperature

P – environmental pressure

RH – environmental relative humidity

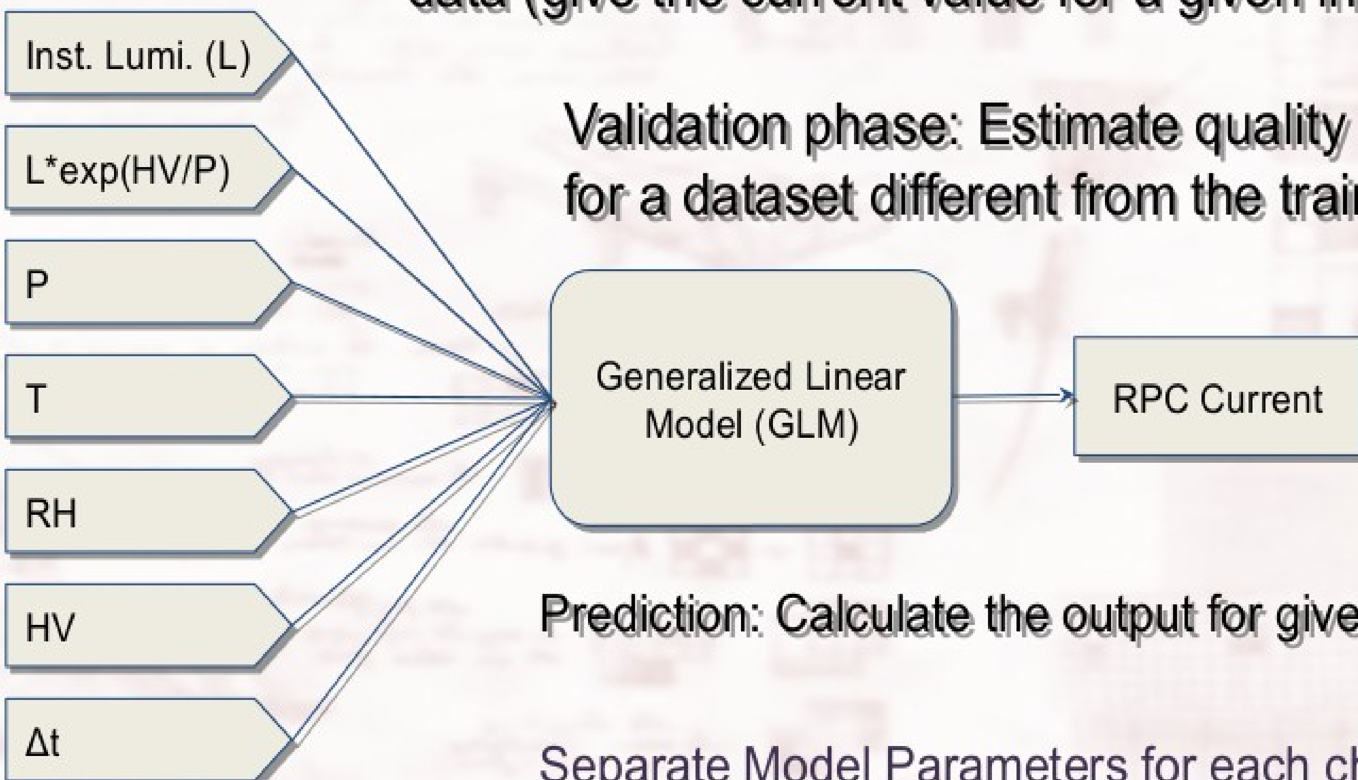
Δt – the time interval since the origin for a given year

The Model (cont.)

- C_1*L_{inst} – RPC current linear w.r.t instantaneous luminosity
- C_2*HV – proportional to the ohmic current
- C_3*T – “pedestal” proportional to the temperature
- C_4*L_{inst}*$e^{(HV/P)}$ – working point correction
- C_5*RH – environmental relative humidity influence
- C_6*P – environmental pressure influence
- C_7*Δt – accounts for the tendency of the current to increase with time w.r.t the initial conditions for a given year

The ML Approach

Training phase: Find coefficients using historical data (give the current value for a given input data)



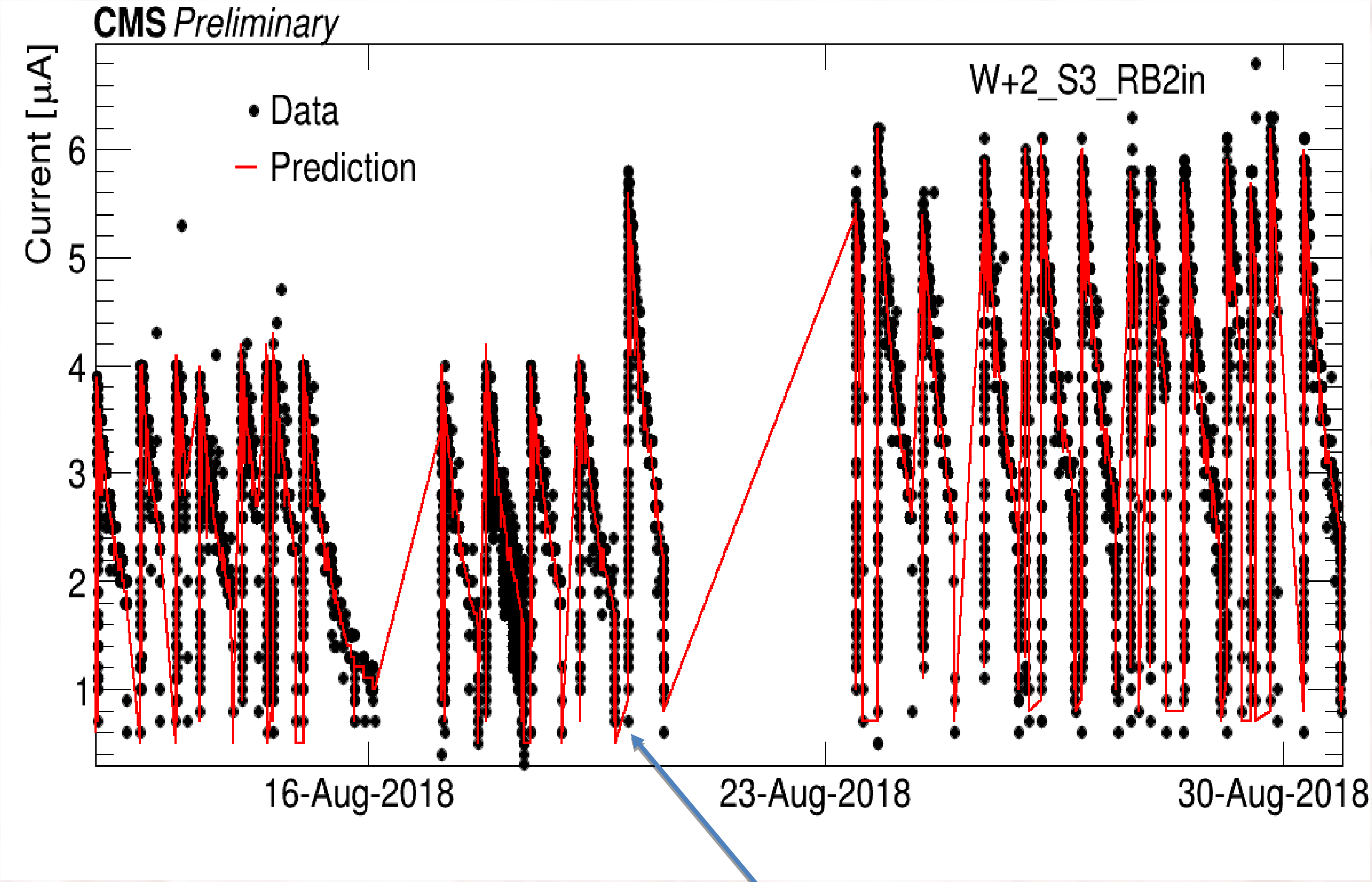
Validation phase: Estimate quality of the prediction for a dataset different from the training set

Prediction: Calculate the output for given input data.

Separate Model Parameters for each chamber!...

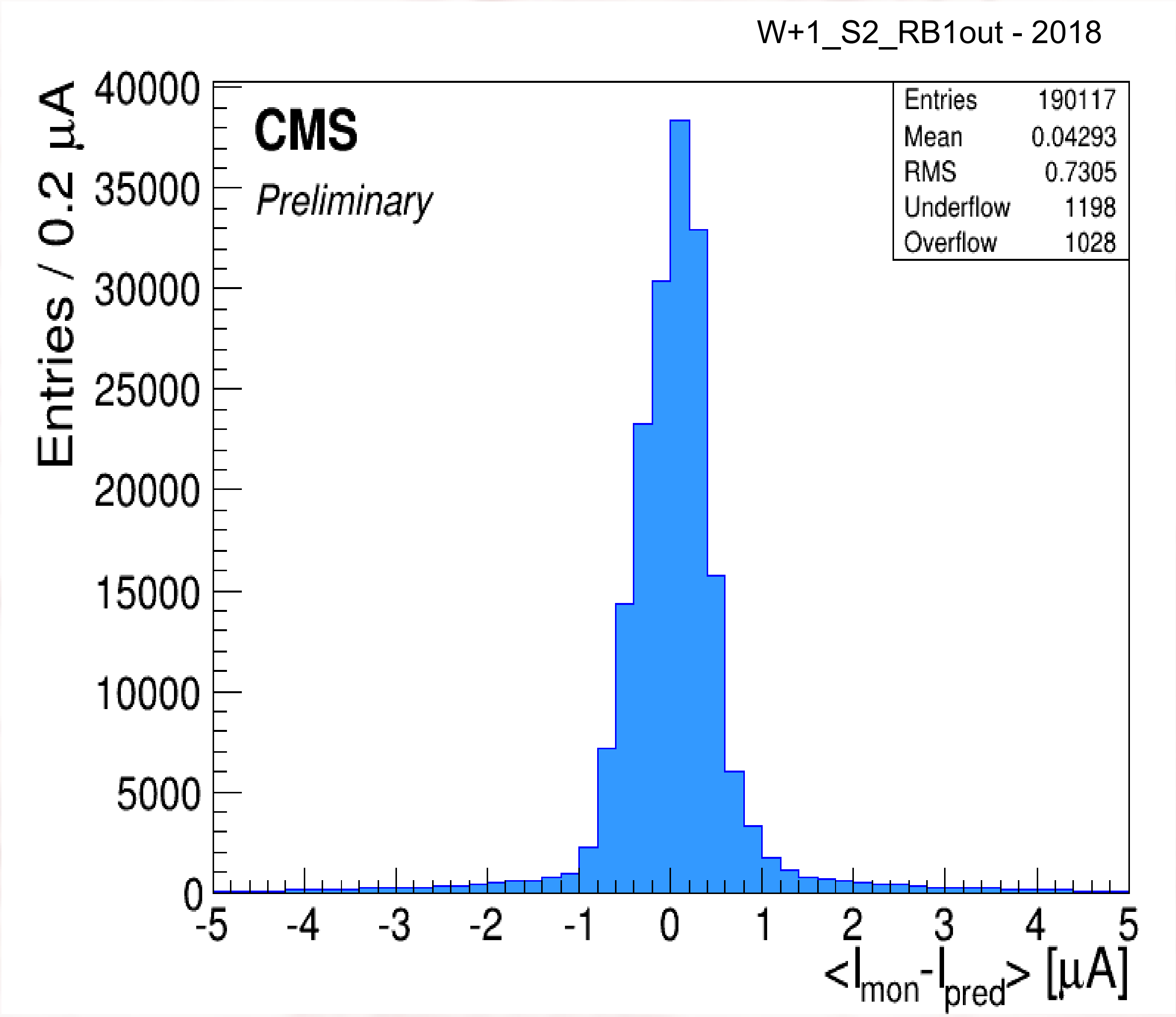
7

Predicted RPC Current - example

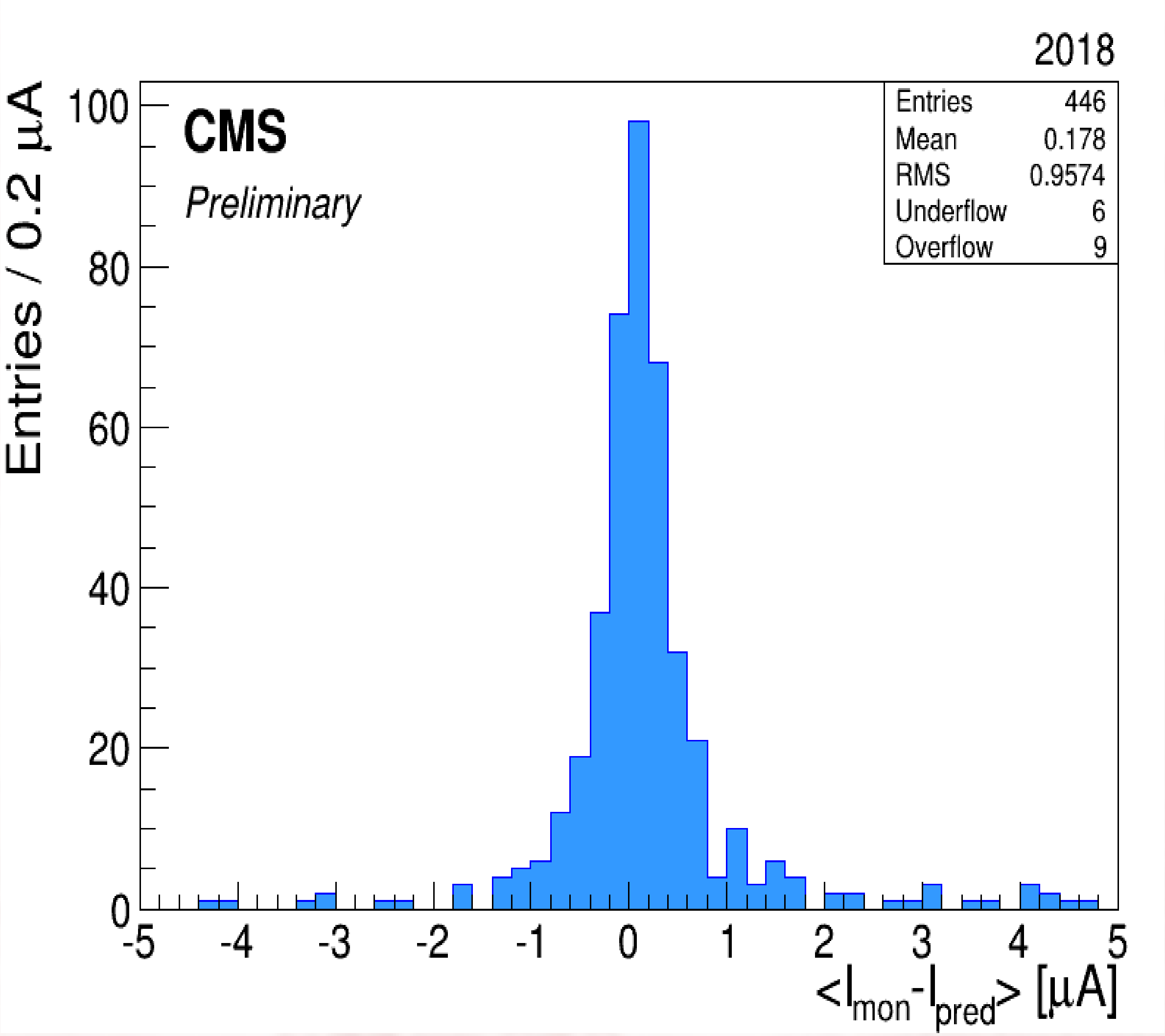


HV working point change by ~ 200V

Typical distribution of the difference between monitored and predicted current (W+1_S2_RB1out)



Distribution of the average Imon-Ipred of 446 CMS Barrel RPCs

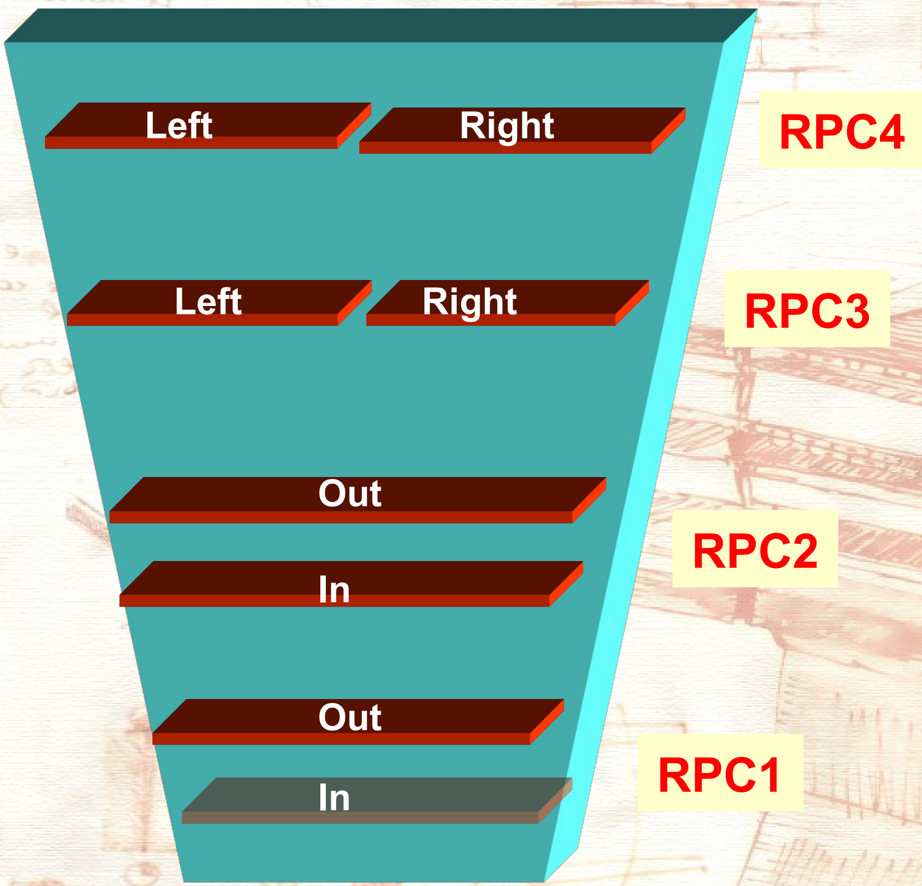


RPC rates

Work in progress ...

11

Input data



- The data comes from TWINMUX logger
- One rate (in Hz not Hz/cm^2) per RPC station
- Rate is recoreded every ~ 2 seconds
- => Huge data sample
- Extracted from TWINUX DB to CSV files

12

ML model

- For first tests only one sector is used (Wheel 0, Sector 7)
- Run used to „teach“ the model: 306138
- Run used to test the model: 306139

$$RPC1 = a + b * RPC2 + c * RPC3 + d * RPC4$$

To be prediced

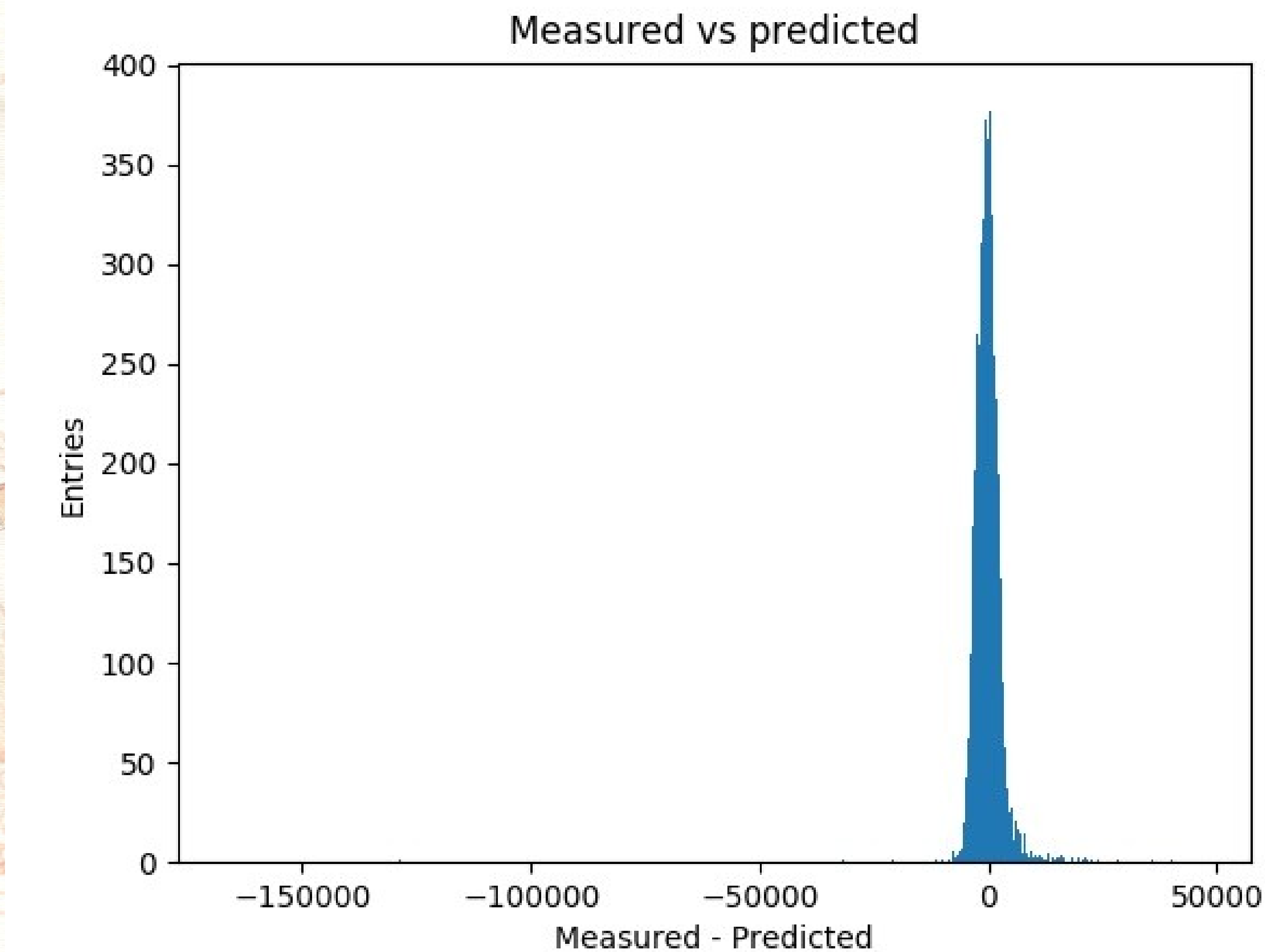
Inputs

13

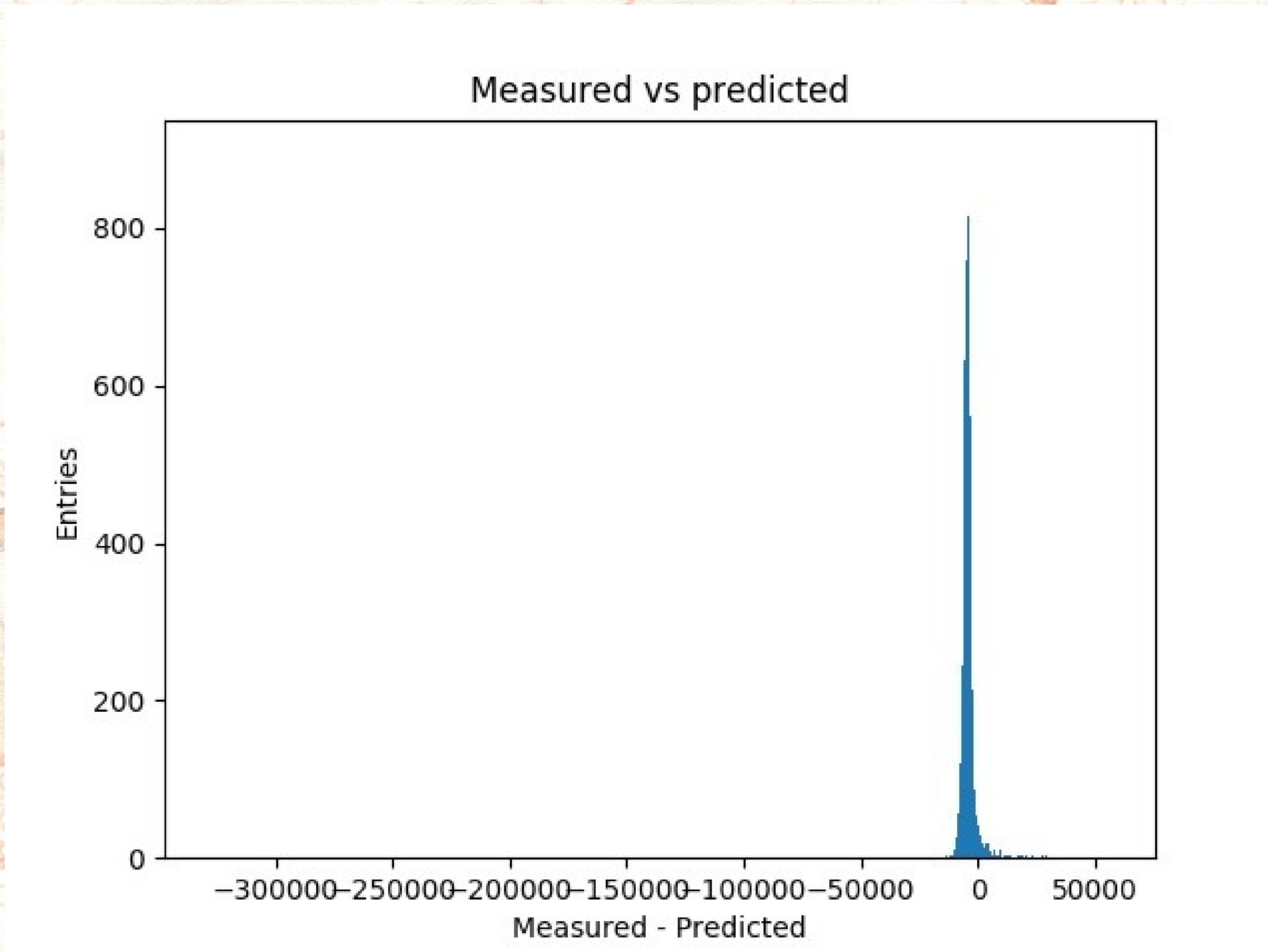
ML model

14

Predicetd vs Measured (learning run 306138)



Predicetd vs Measured (test run 306139)



16

Conclusions and Furture work

- ML for RPC currents tools is fully fucntionl
  - Ready to be integrated on P5

- ML for RPC rate tools needs further elaboration, extension and refinement
  - Study and extend RPC rate model
  - Add lumi to RPC rate model

- Develop a new sophisticated model including RPC currents and rates

- Optimizing & porting models to HPC infrastructure.

17

Backup

18

ML model

- For first tests only one sector is used (Wheel 0, Sector 7)
- Linear model based:
  - RPC1 = a + b*RPC2 + c*RPC3 + d*RPC4
  - The Physics reasoning behind it – each rate is proportional to the instantaneous luminosity, thus the rates are proportional to each other.
- The model is based on correlations within a sector
- Could be changed or generalised
  - Adding DT rates
  - Adding Luminosity
  - Inter-wheel correlations
- Tensorflow implementation
- Ordinary Least Squares (statsmodels.regression.linear_model.OLS)

$$RPC1 = a + b*RPC2 + c*RPC3 + d*RPC4$$

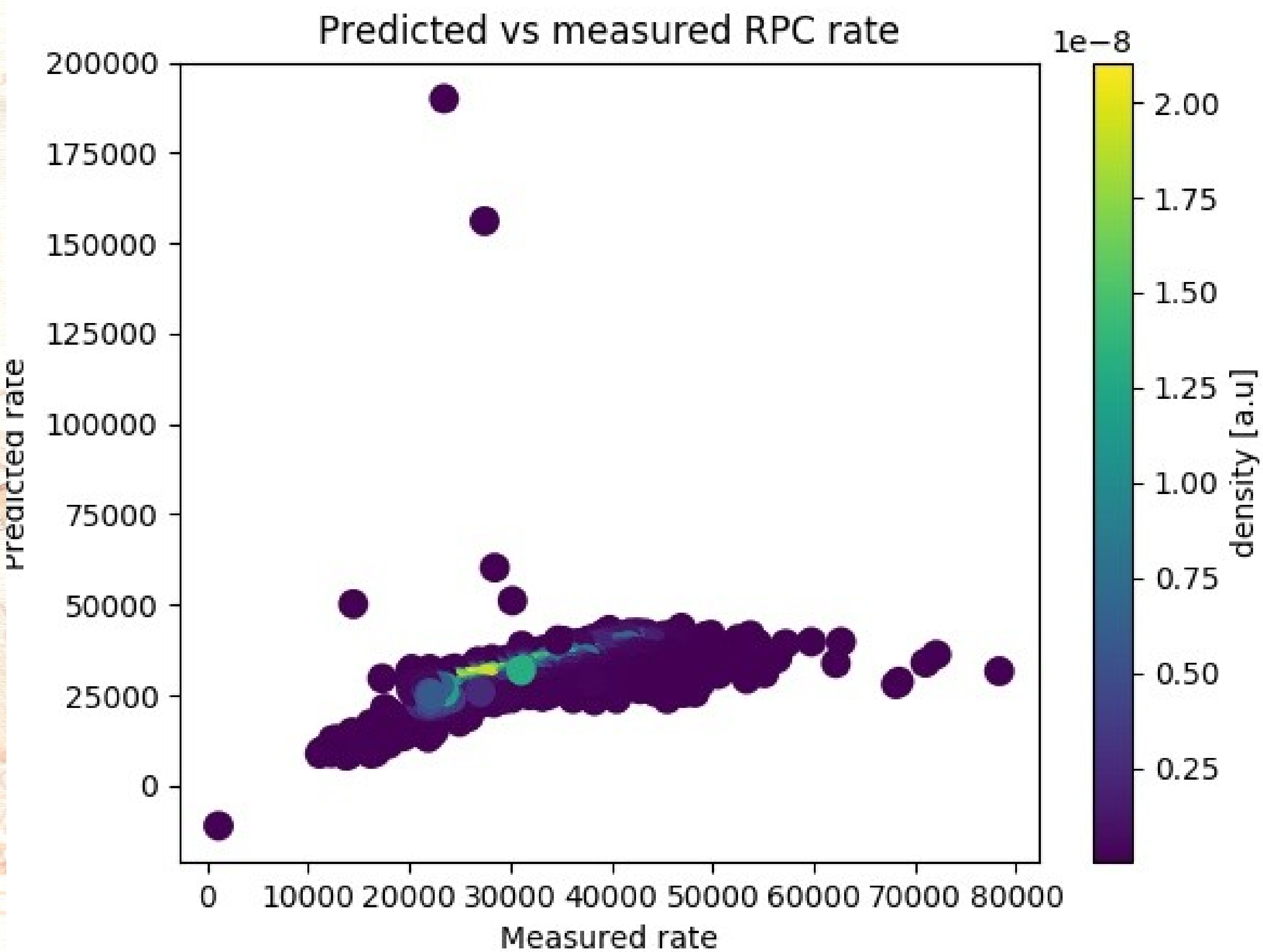
19

Rate ML

- It's the first attempt to treat the rate
- Seems promising
- Model advantages:
  - It's very simple
  - Uses RPC only data
  - Can be improved (adding DT & lumi data)
  - Can be extended easily to all chambers
  - Can work on data logged by the trigger => very fast predictions
- Could be adapted easily for:
  - occupancy
  - efficiency
- Can be extended easily to all chambers

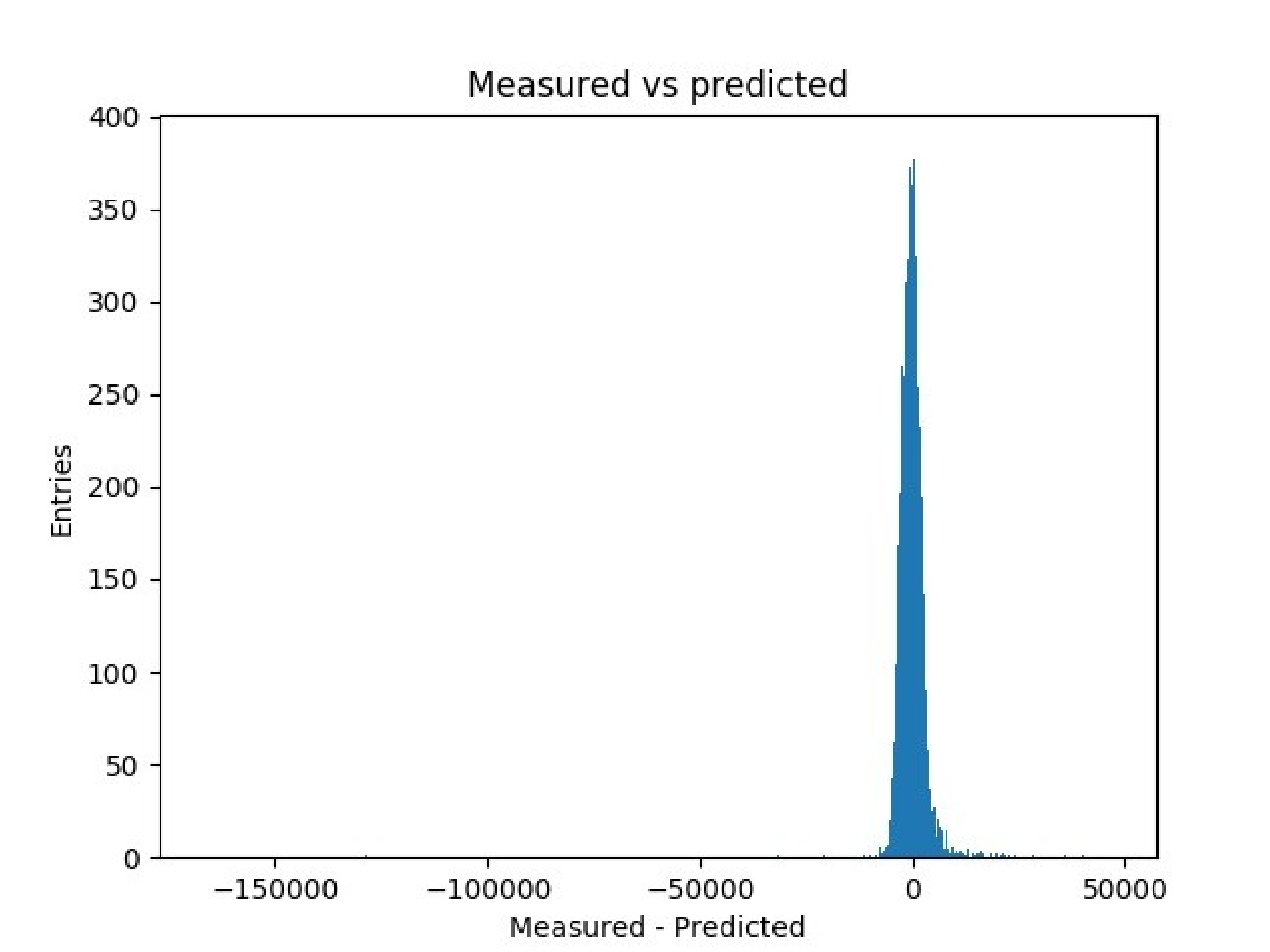
20

Predicetd vs Measured (learning run 306138)

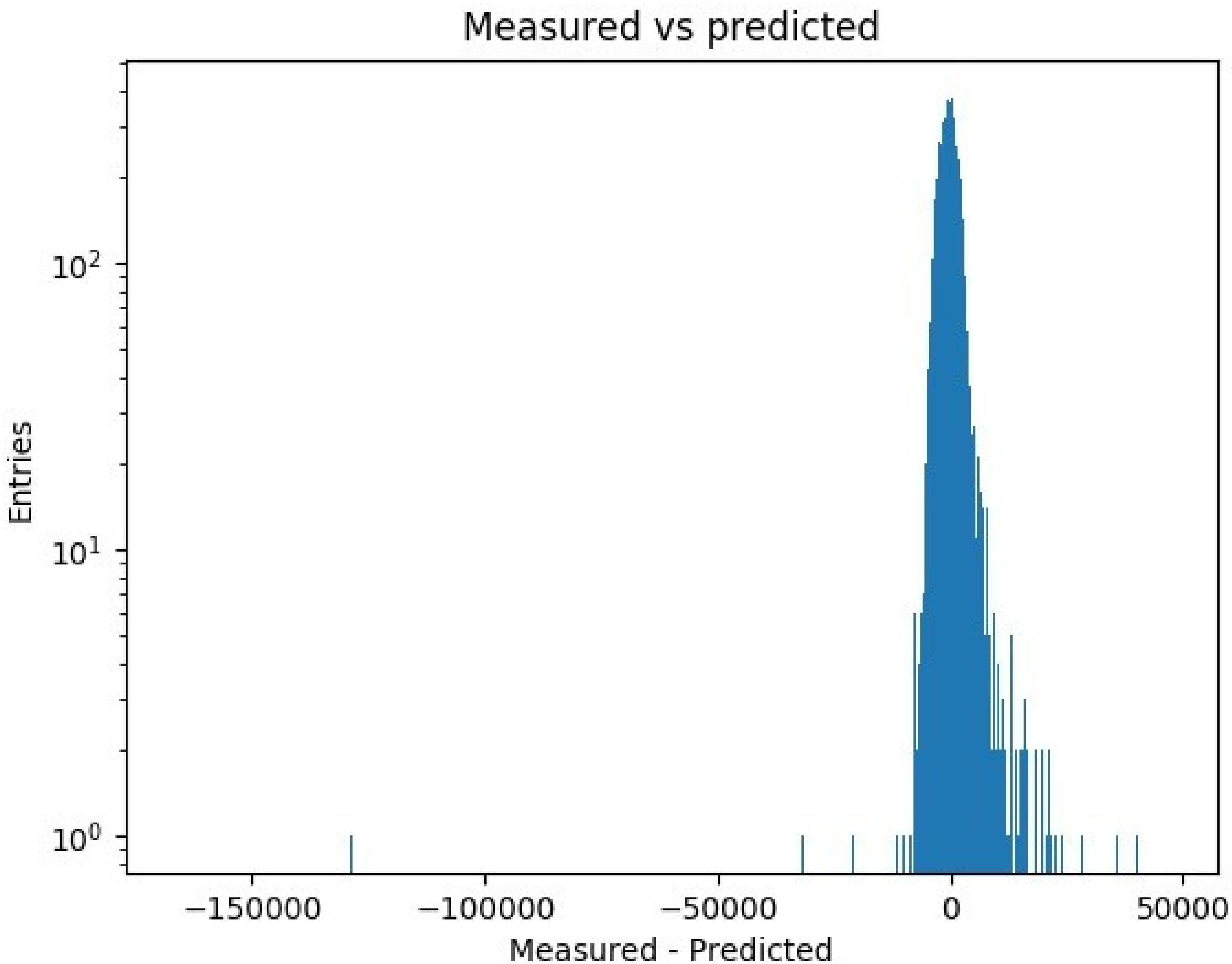


21

Predicetd vs Measured (learning run 306138)

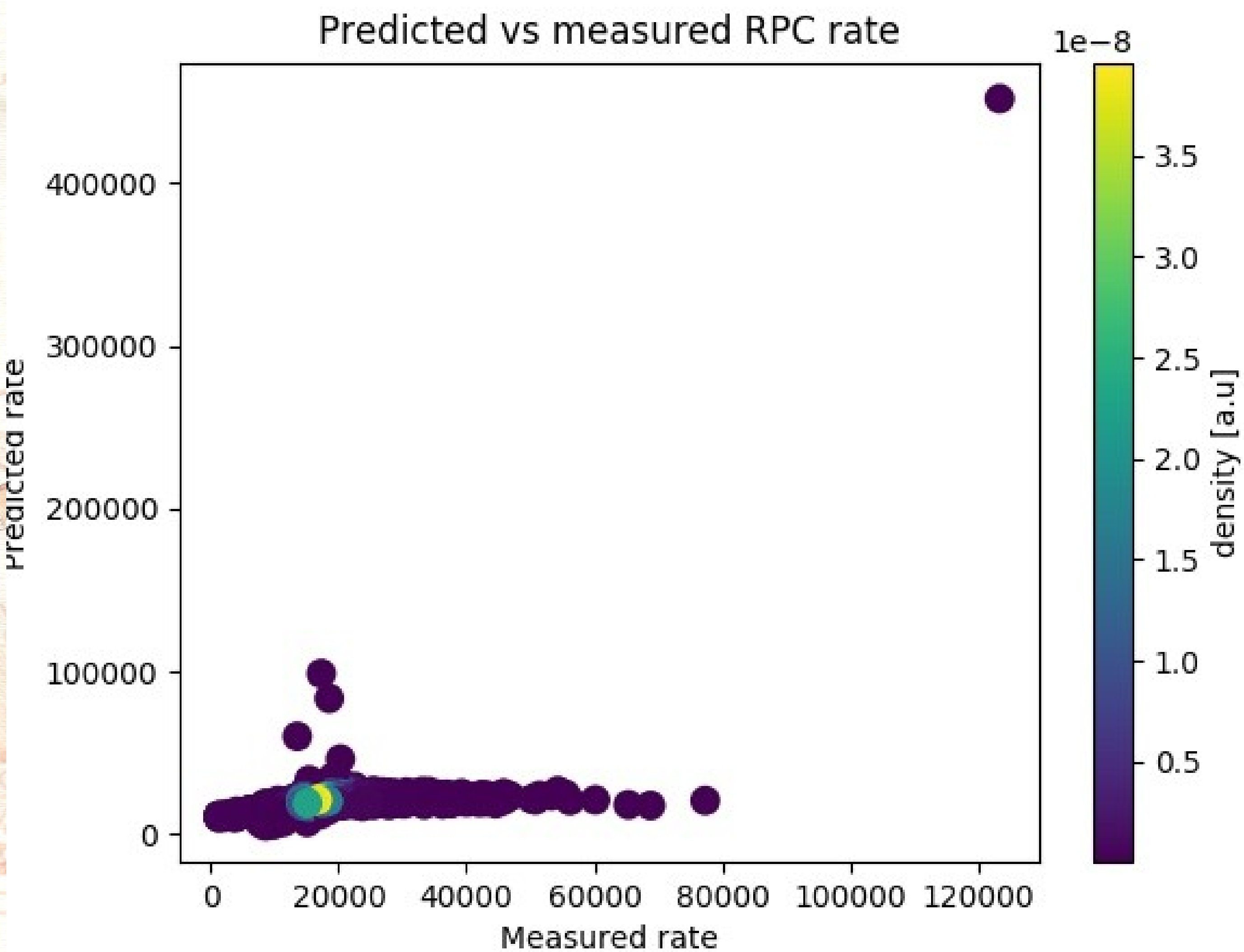


Predicetd vs Measured (learning run 306138)

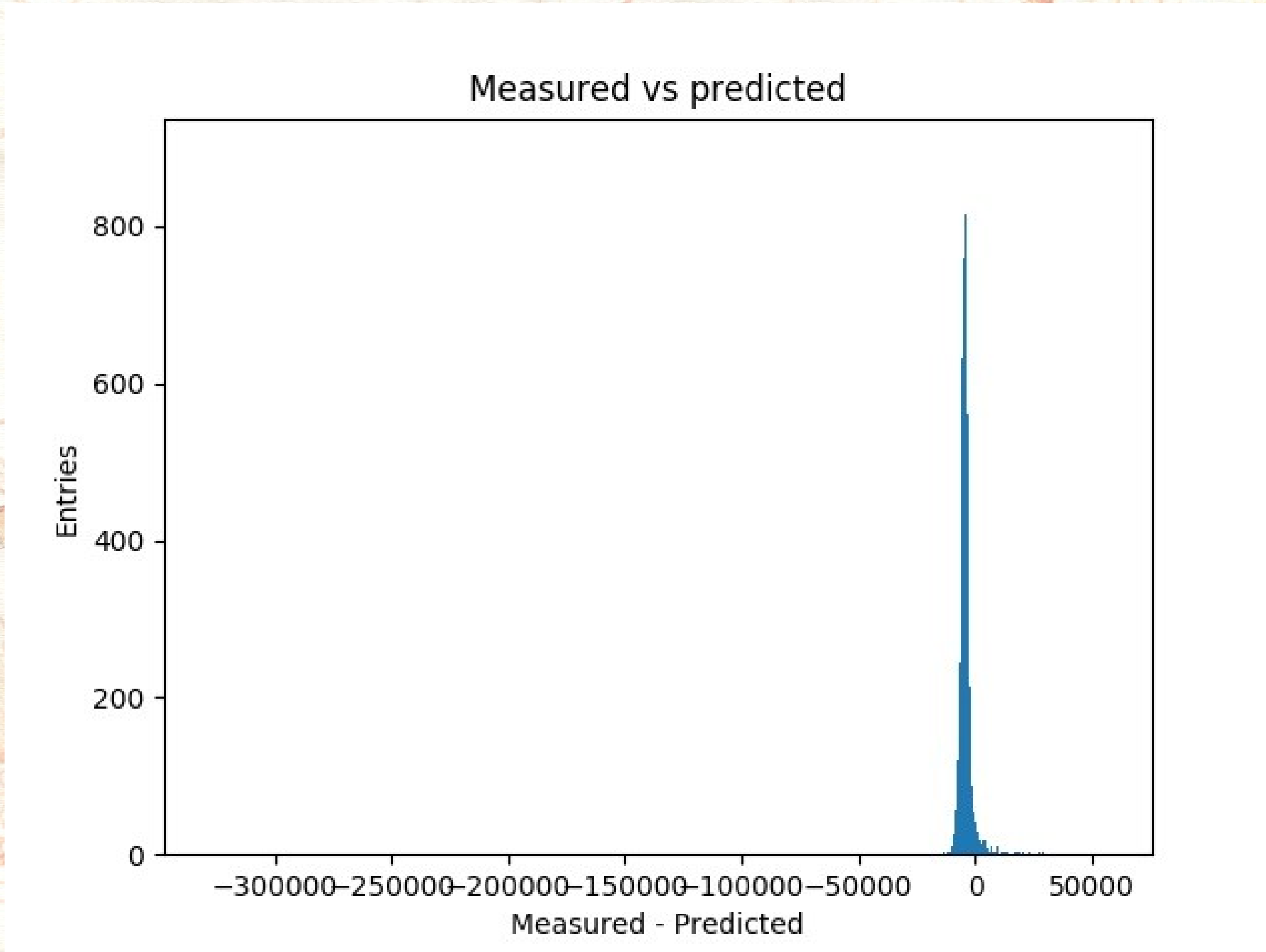


23

Predicetd vs Measured (test run 306139)

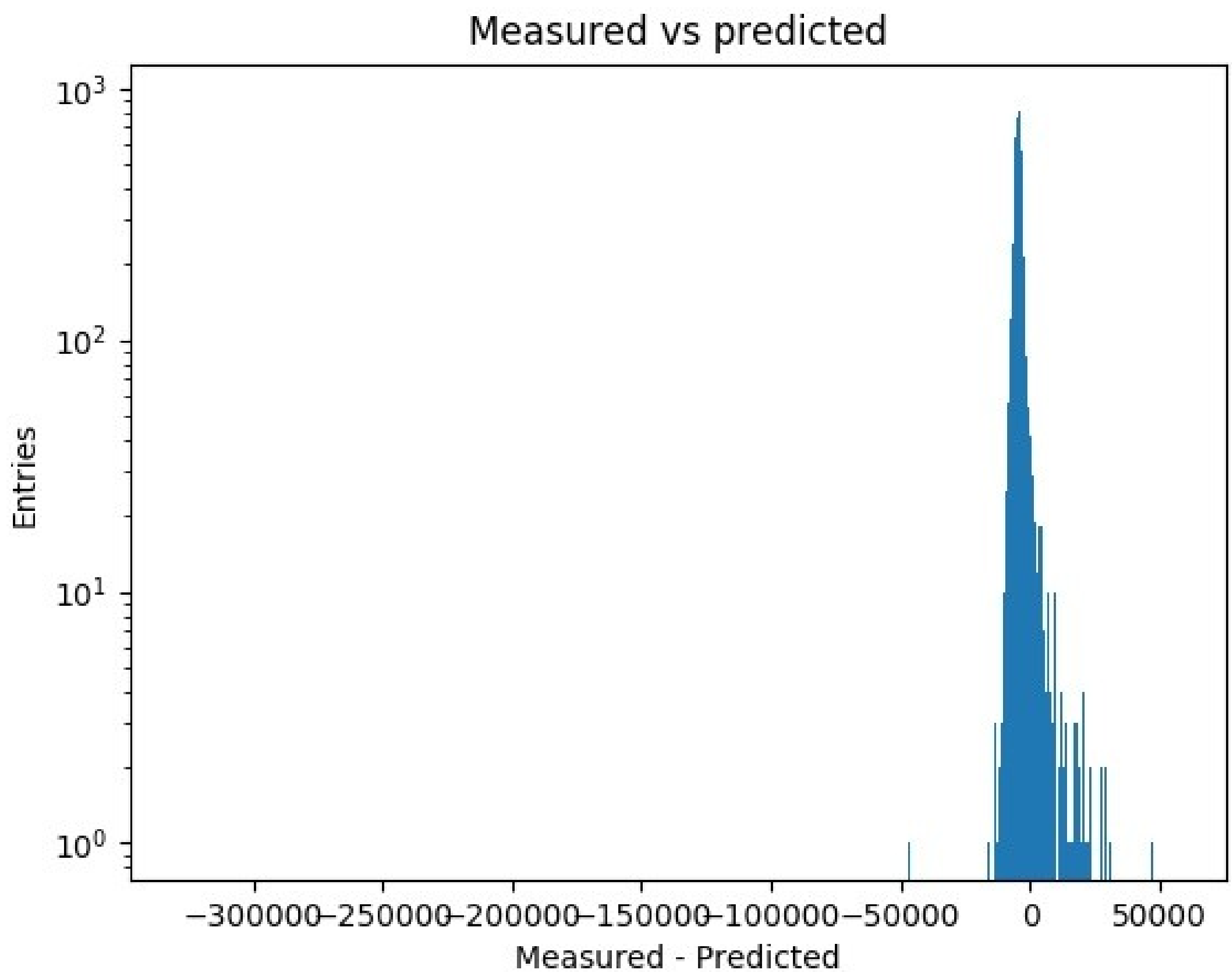


Predicetd vs Measured (test run 306139)



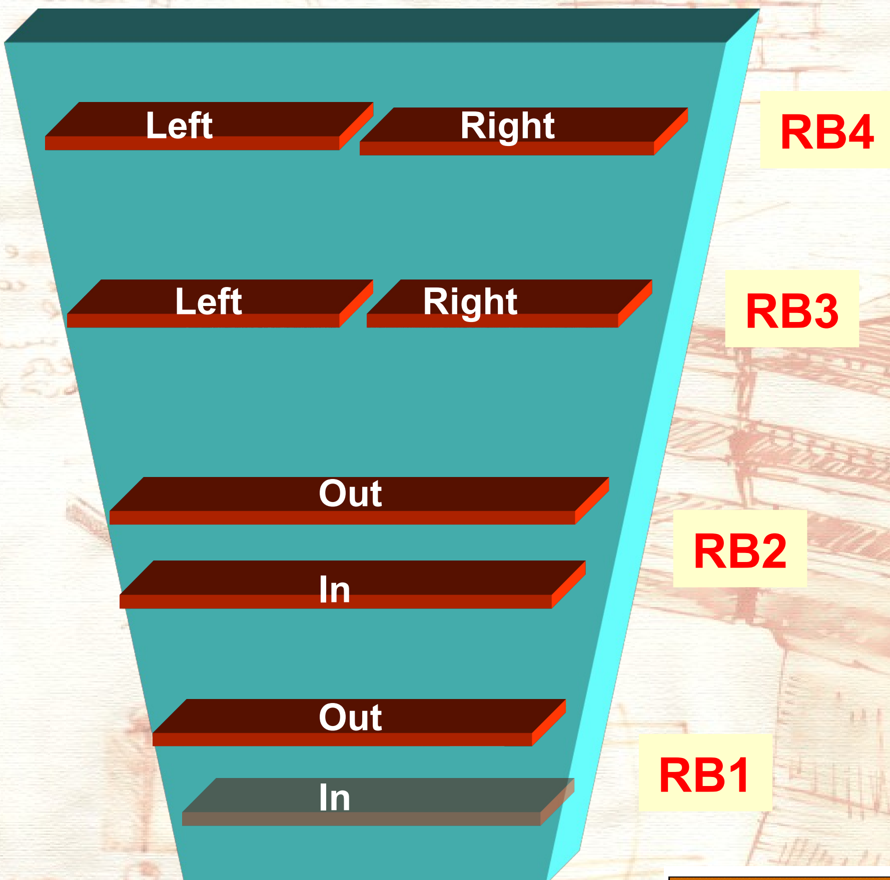
25

Predicetd vs Measured (test run 306139)



26

Main Barrel RPC Types



Length: 2.455 m

Width: 1.5, 2.0 , 2.5 m
Pitch: 40.8, 40.6, 41.0 mm
Strips for Gap: 48, 36, 48, 60

Width: 1.48 m
Pitch: 34.8 mm
Strips for Gap: 42

Width: 1.5, 2.0 , 2.5 m
Pitch: 27.3, 29.3 mm
Strips for Gap: 84, 90

Width: 1.5, 2.0 , 2.5 m
Pitch: 22.7, 24.3 mm
Strips for Gap: 84, 90