RPC ML Efforts

University of Sofia “St. Kliment Ohridski”

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Outline

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

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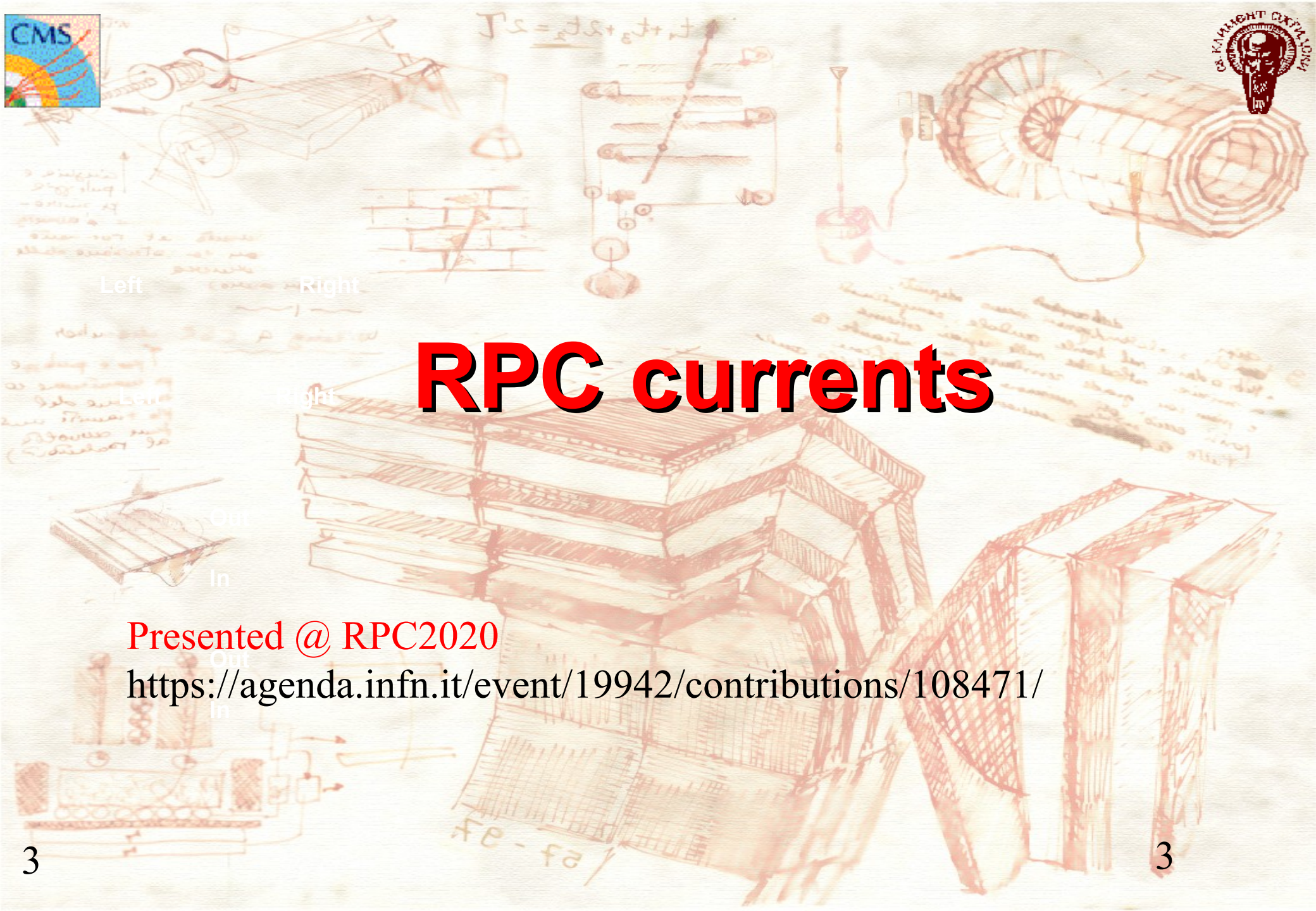

RPC currents

Presented @ RPC2020

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

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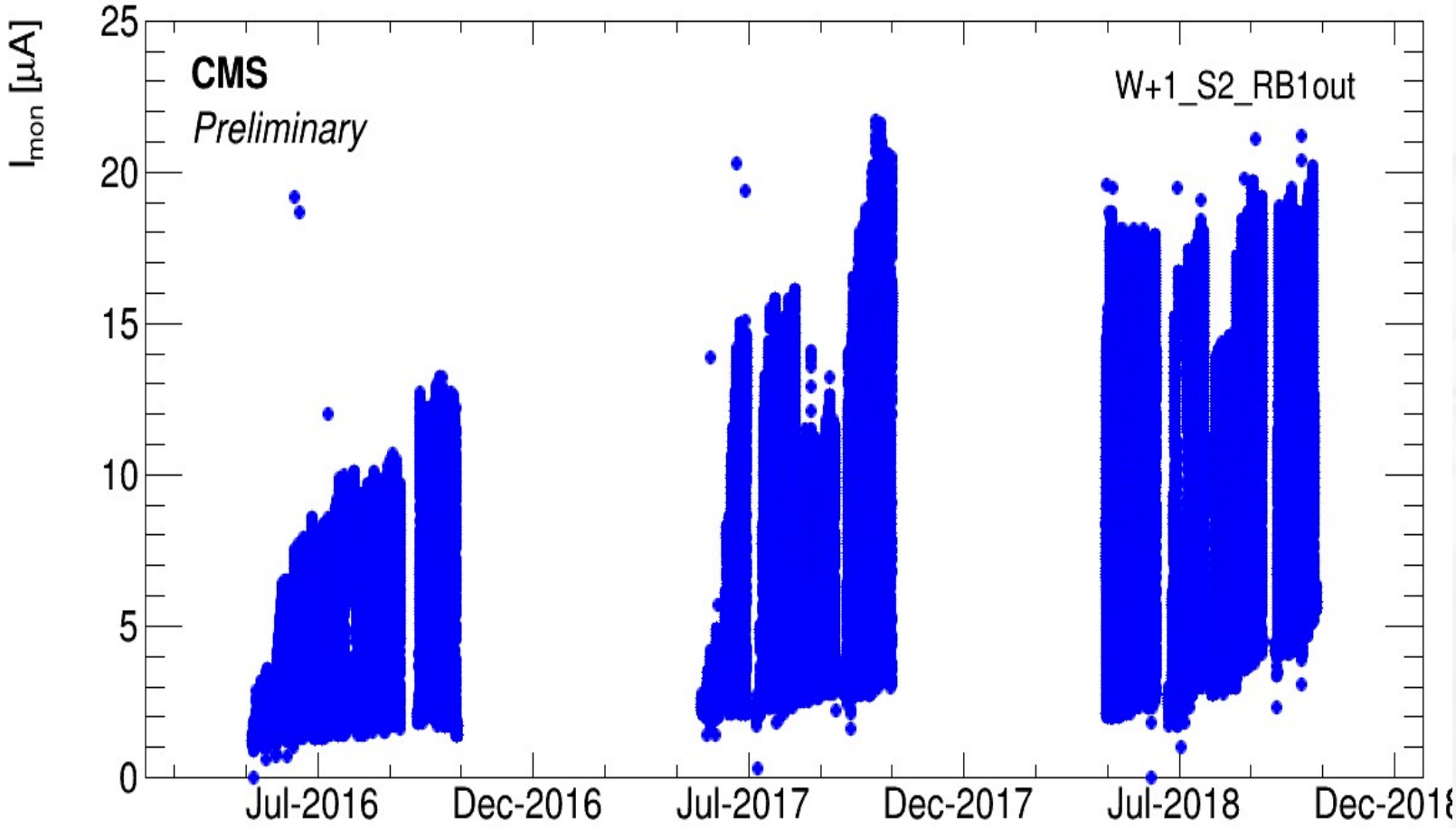
Input data - current (I_{mon}) during pp collisions



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

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

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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
- $C_7 * \Delta t$ – accounts for the tendency of the current to increase with time w.r.t the initial conditions for a given year

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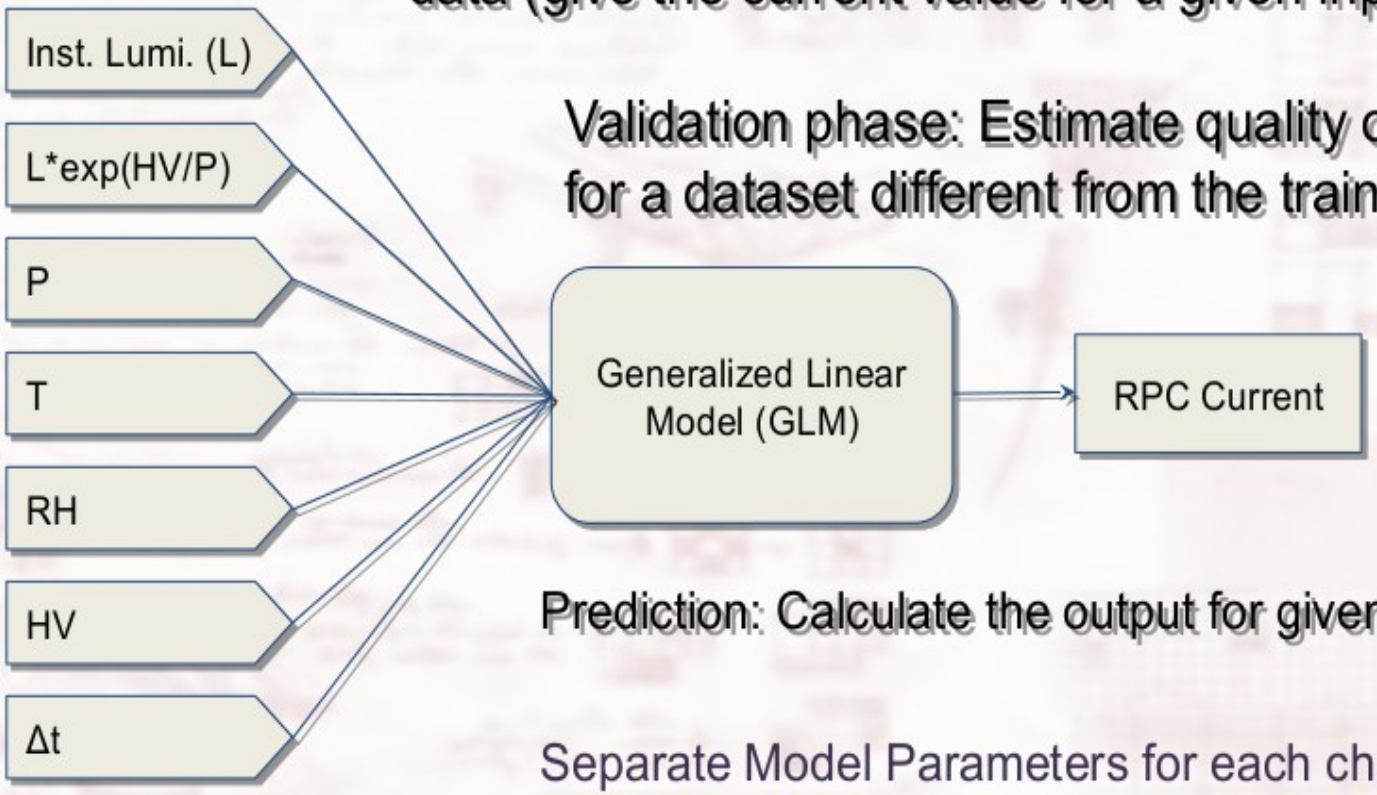
The ML Approach

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!...

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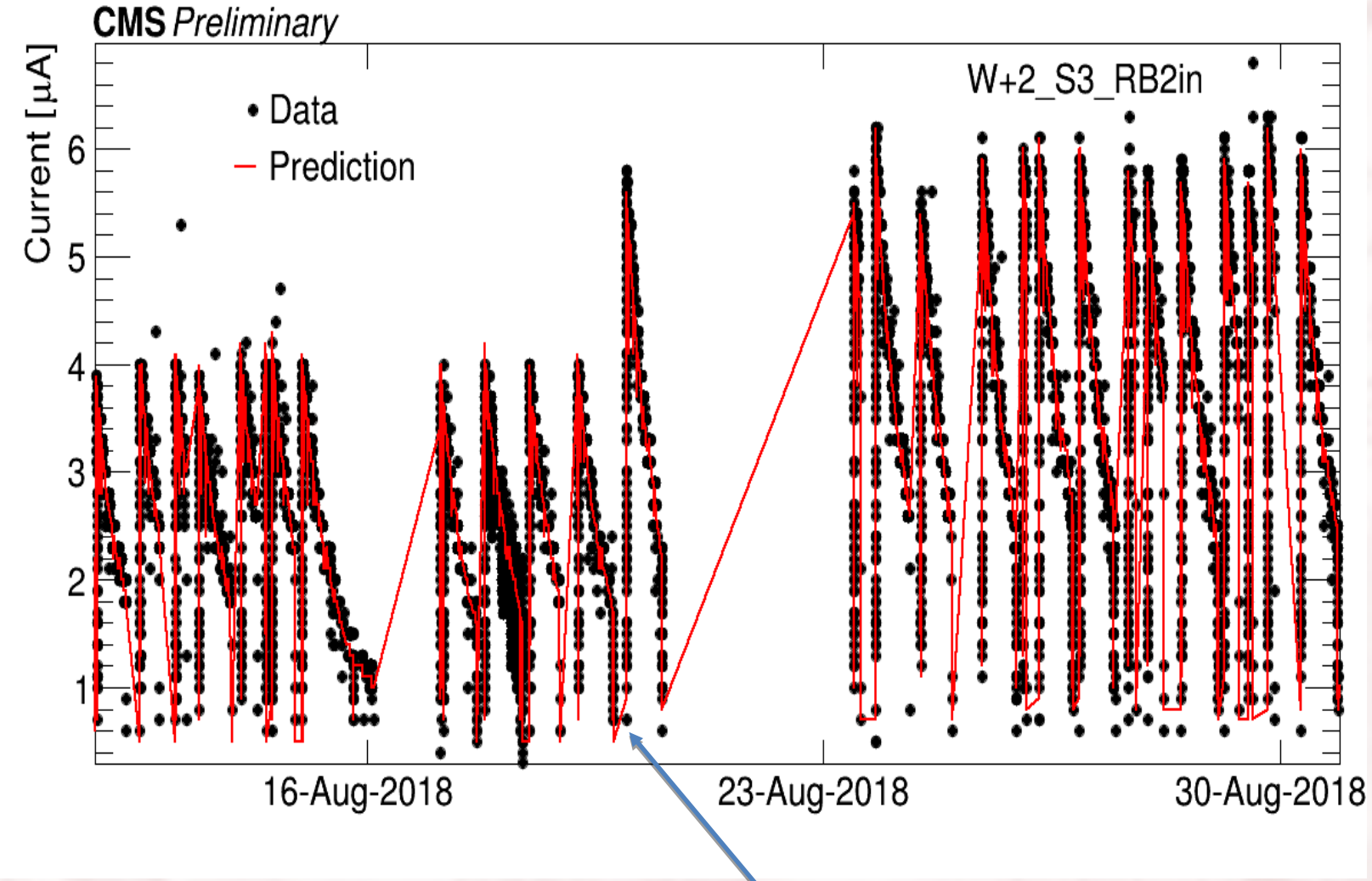
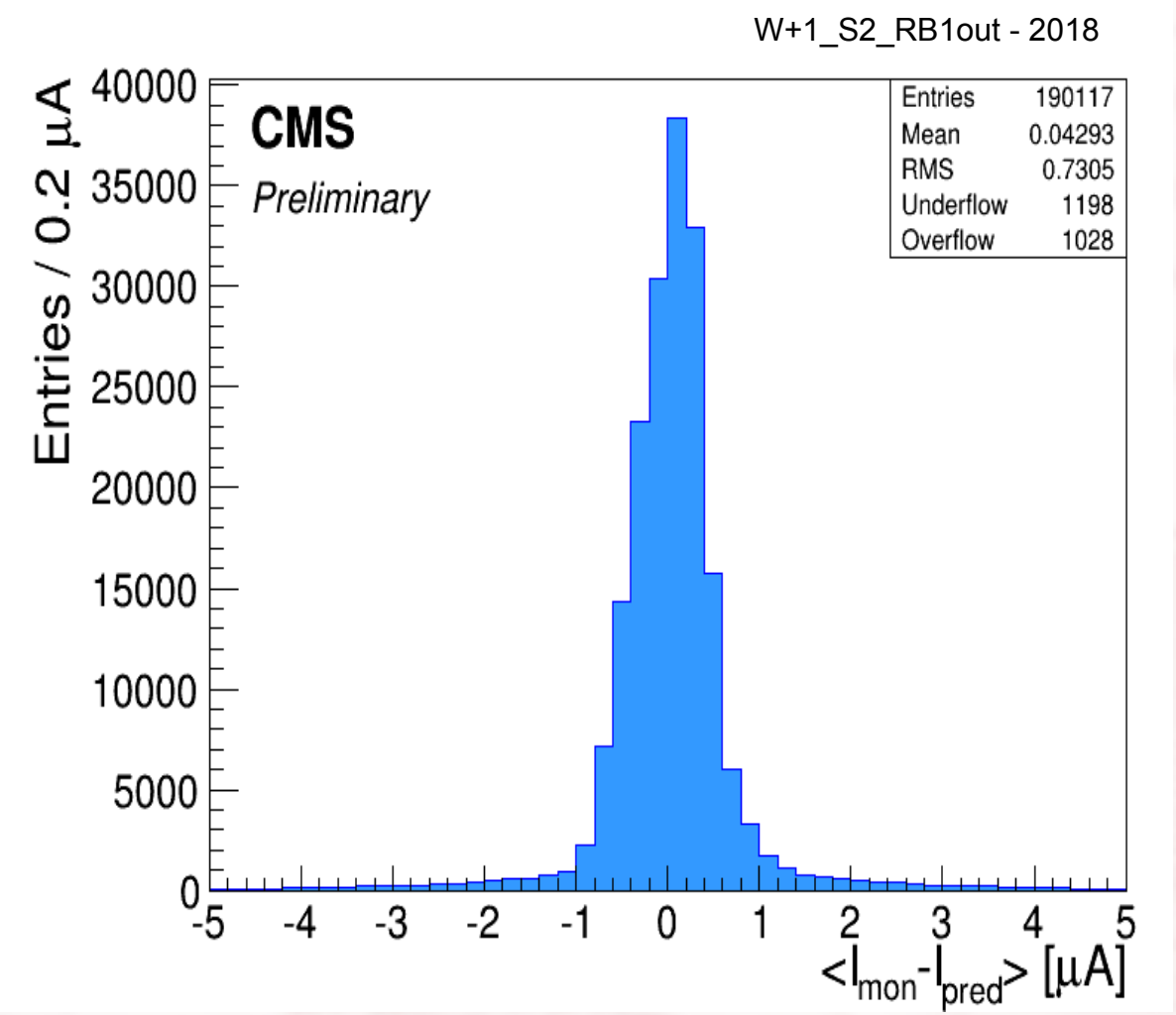
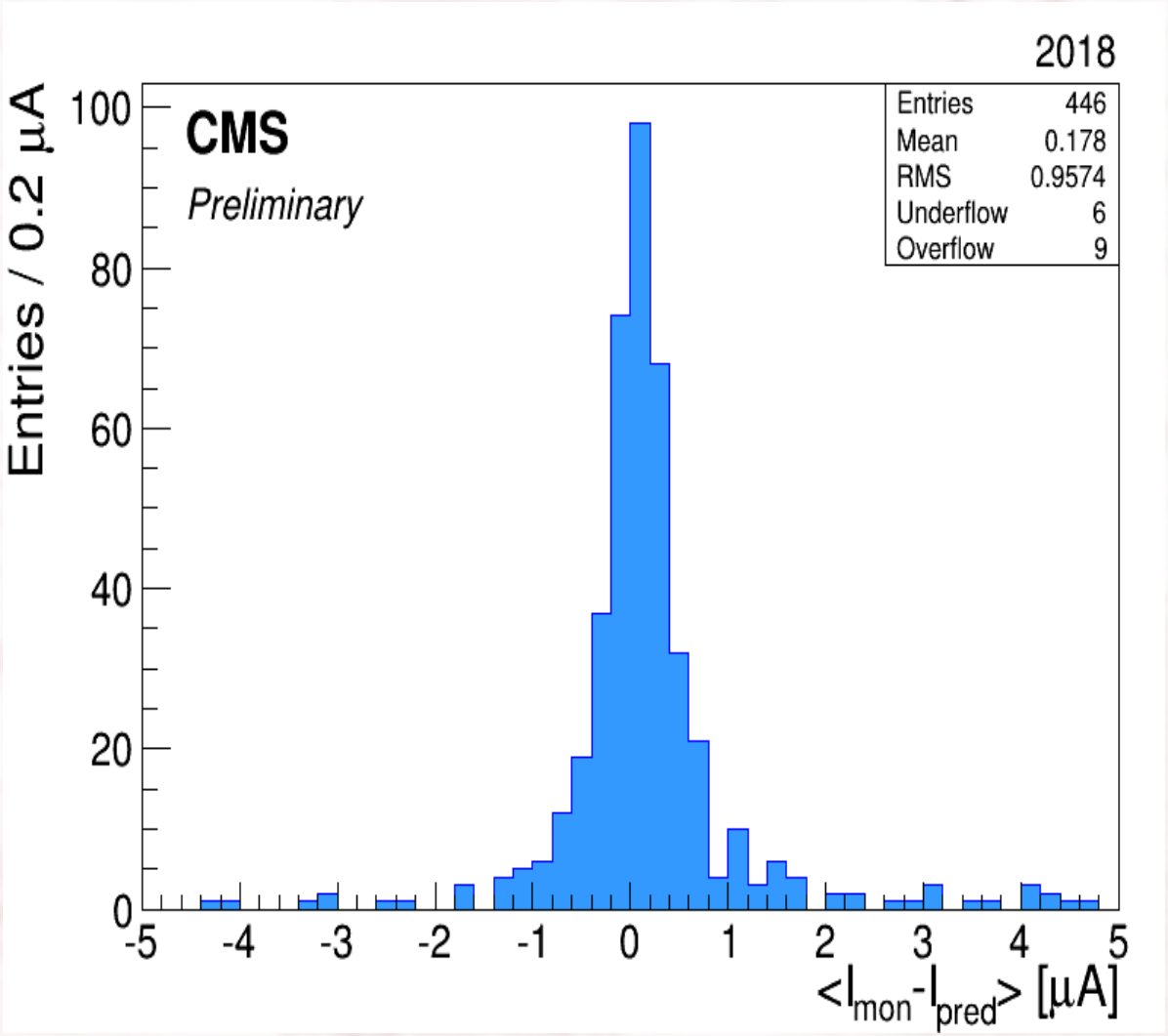
Predicted RPC Current - example

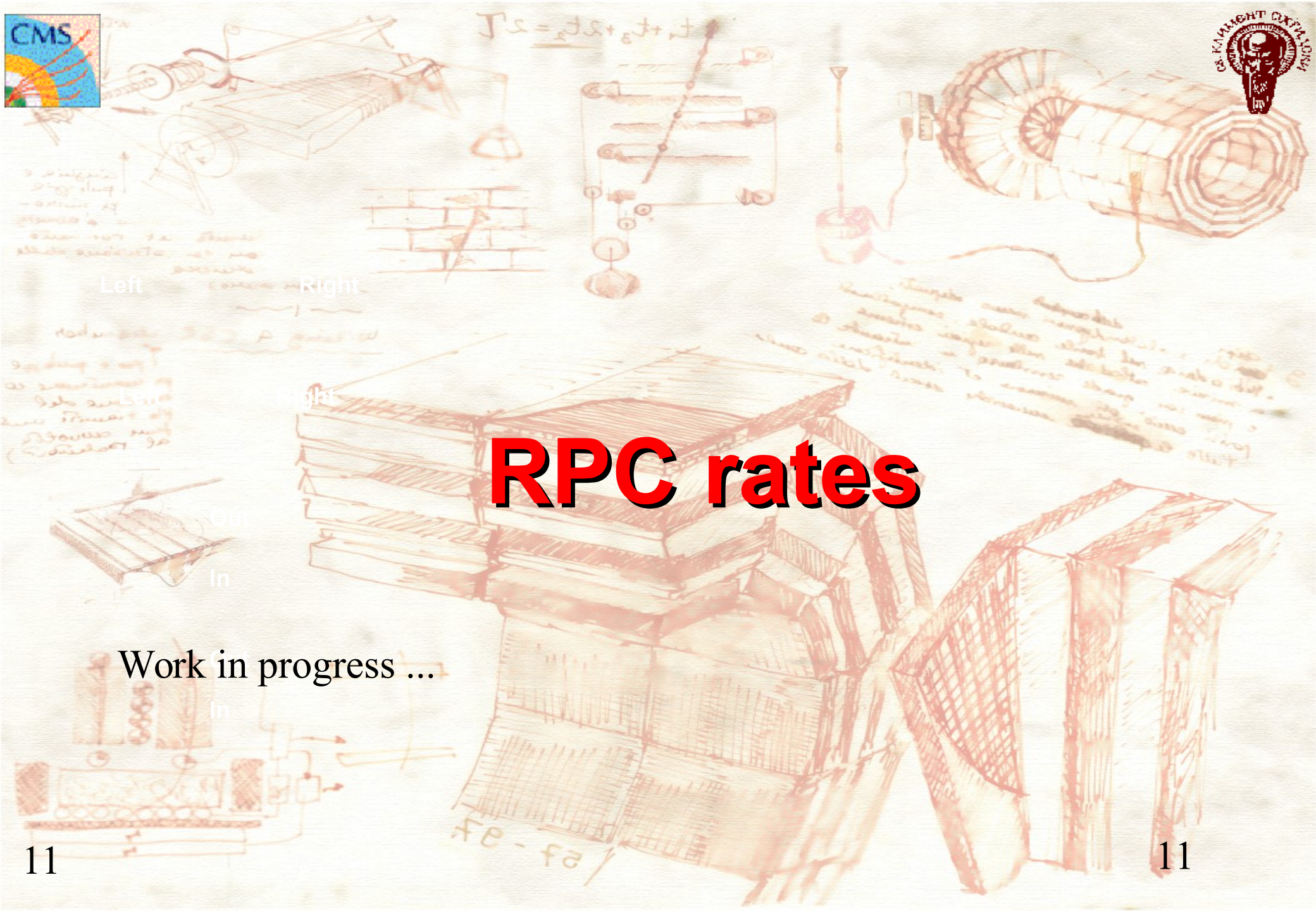


Typical distribution of the difference between monitored and predicted current (W+1_S2_RB1out)



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





RPC rates

Work in progress ...

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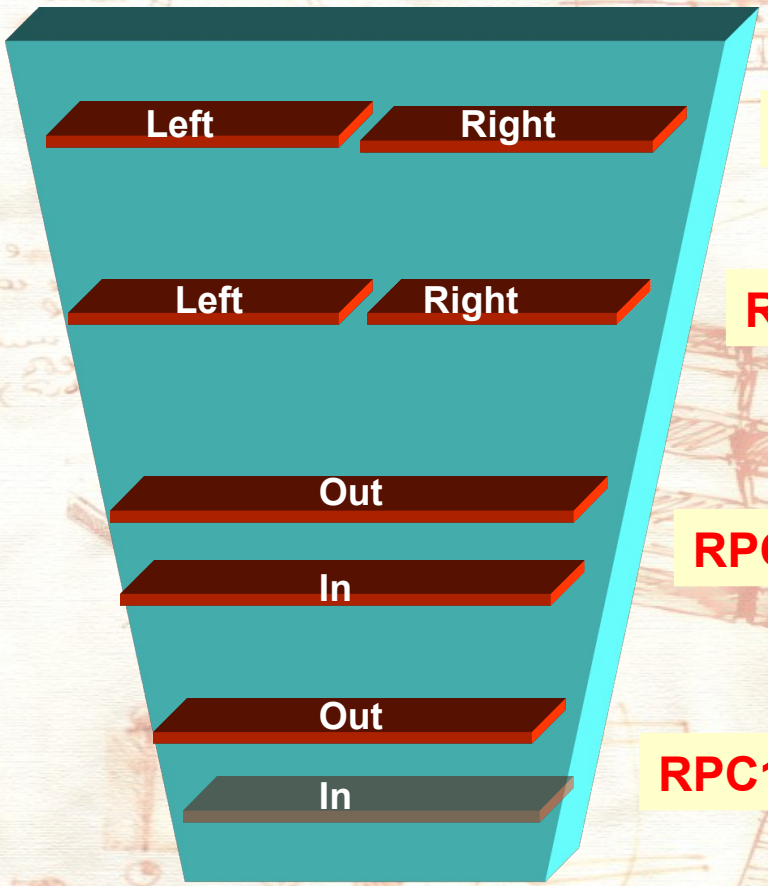
Input data



- 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

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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

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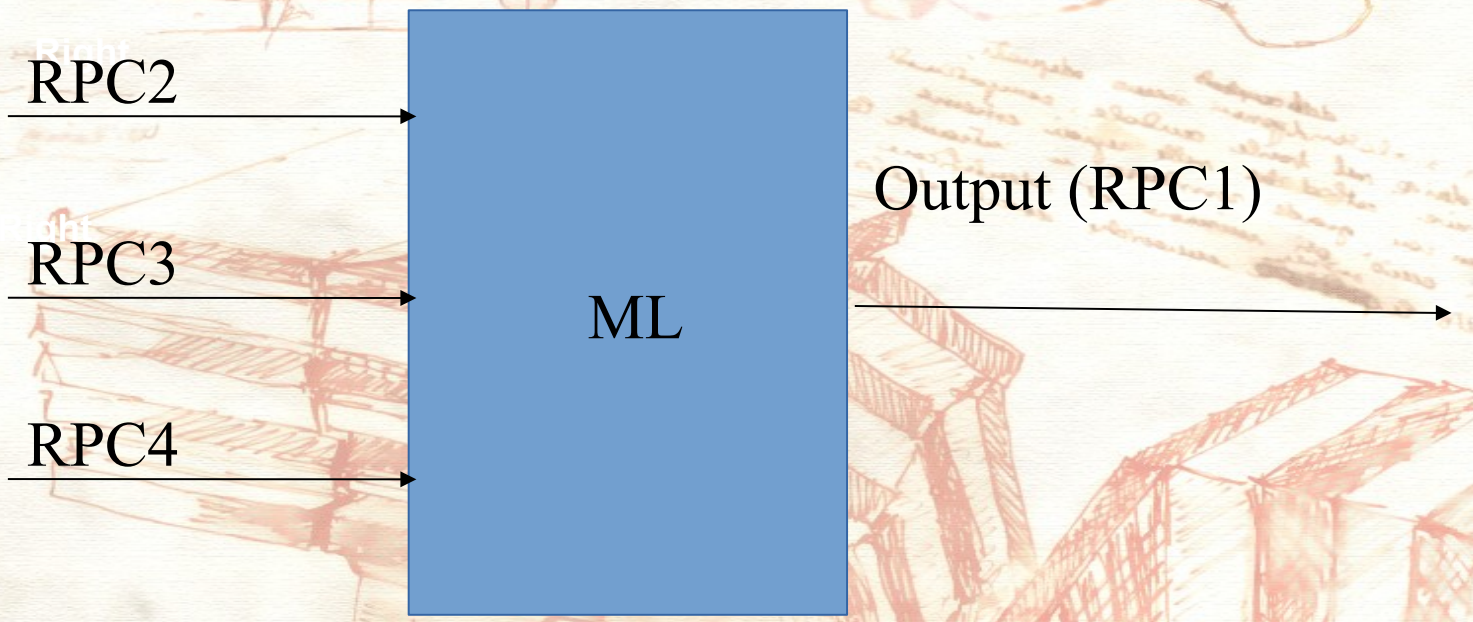
ML model



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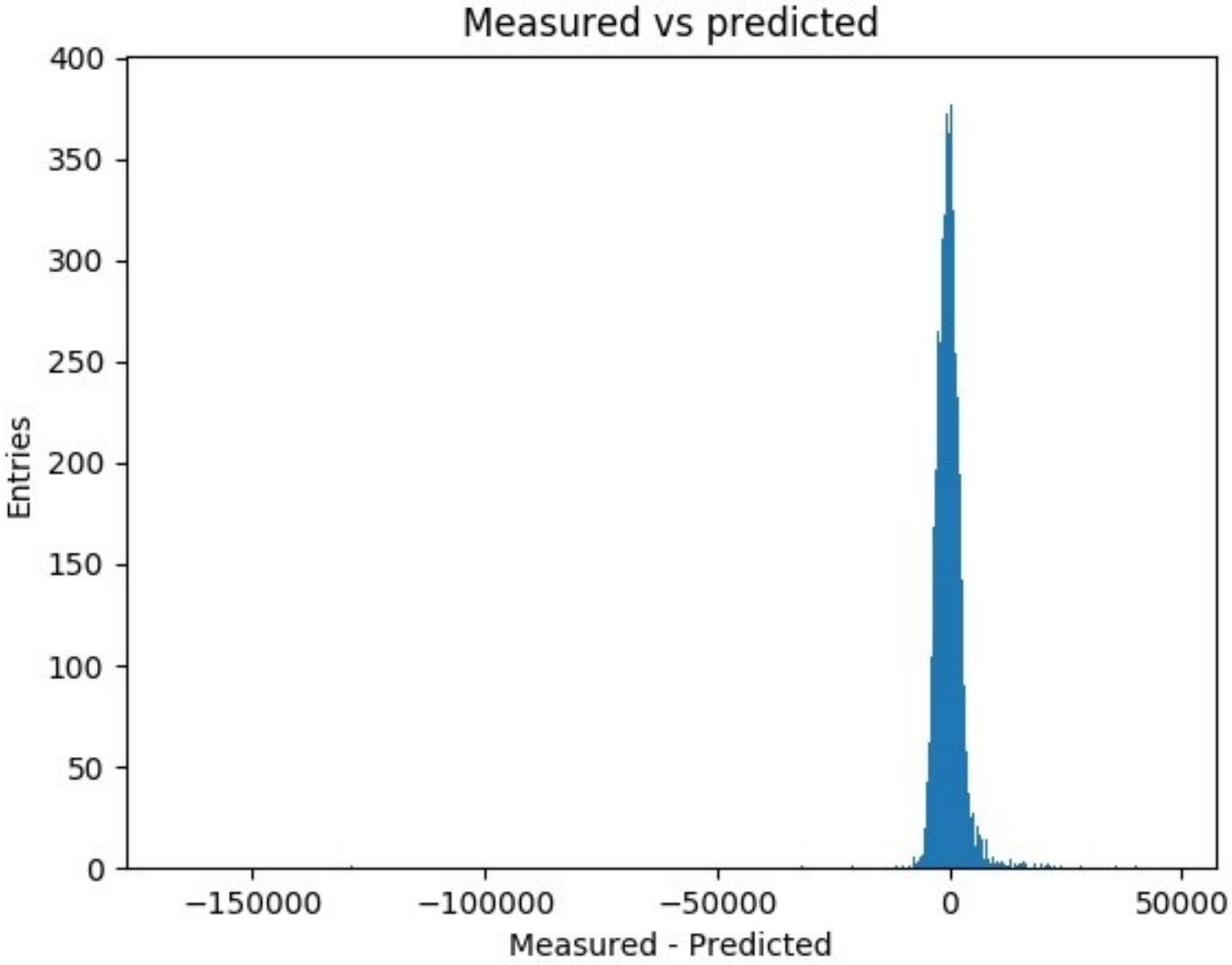
Predicetd vs Measured (learning run 306138)



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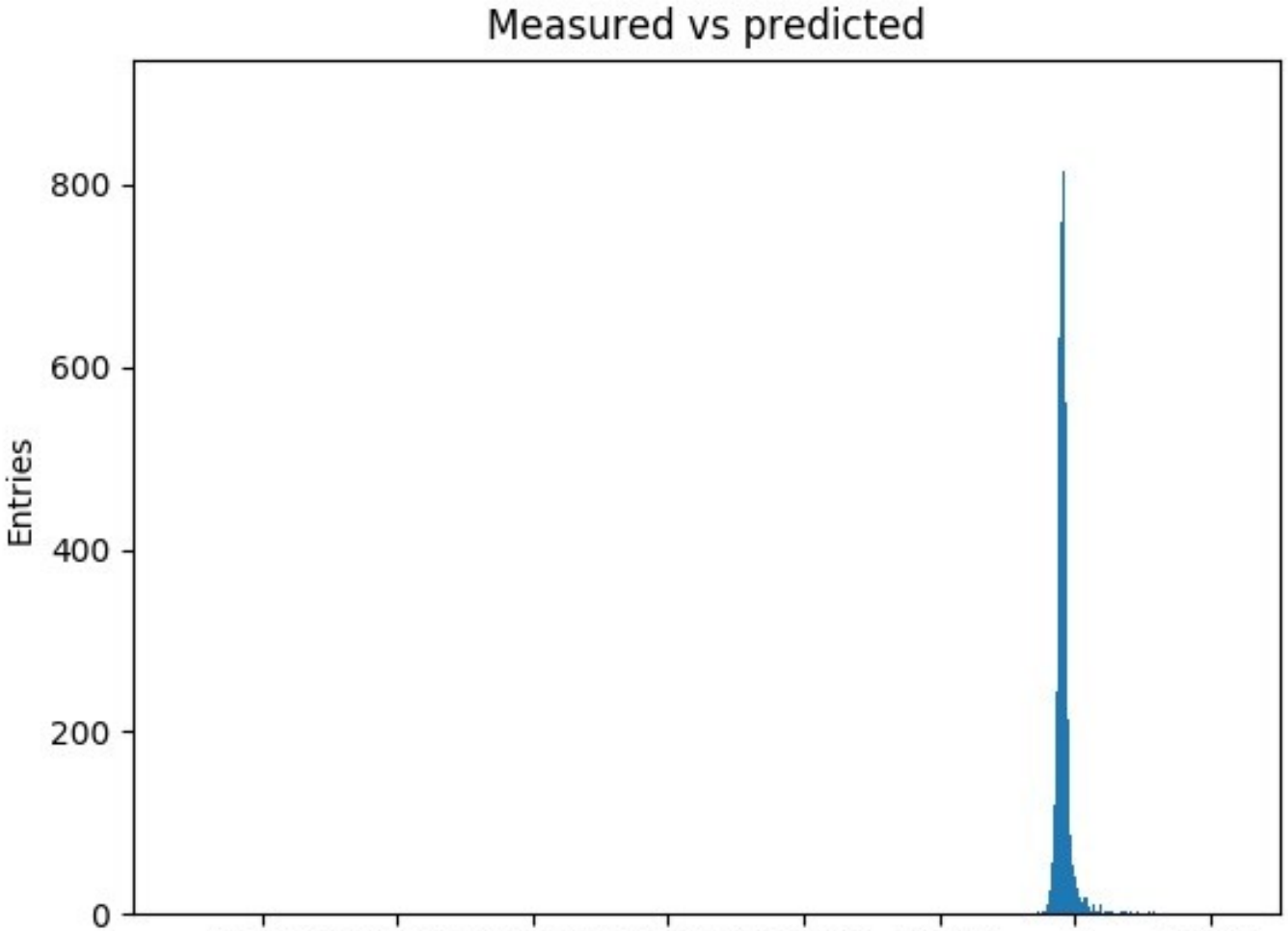
Predicetd vs Measured (test run 306139)



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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.

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Backup

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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)

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

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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

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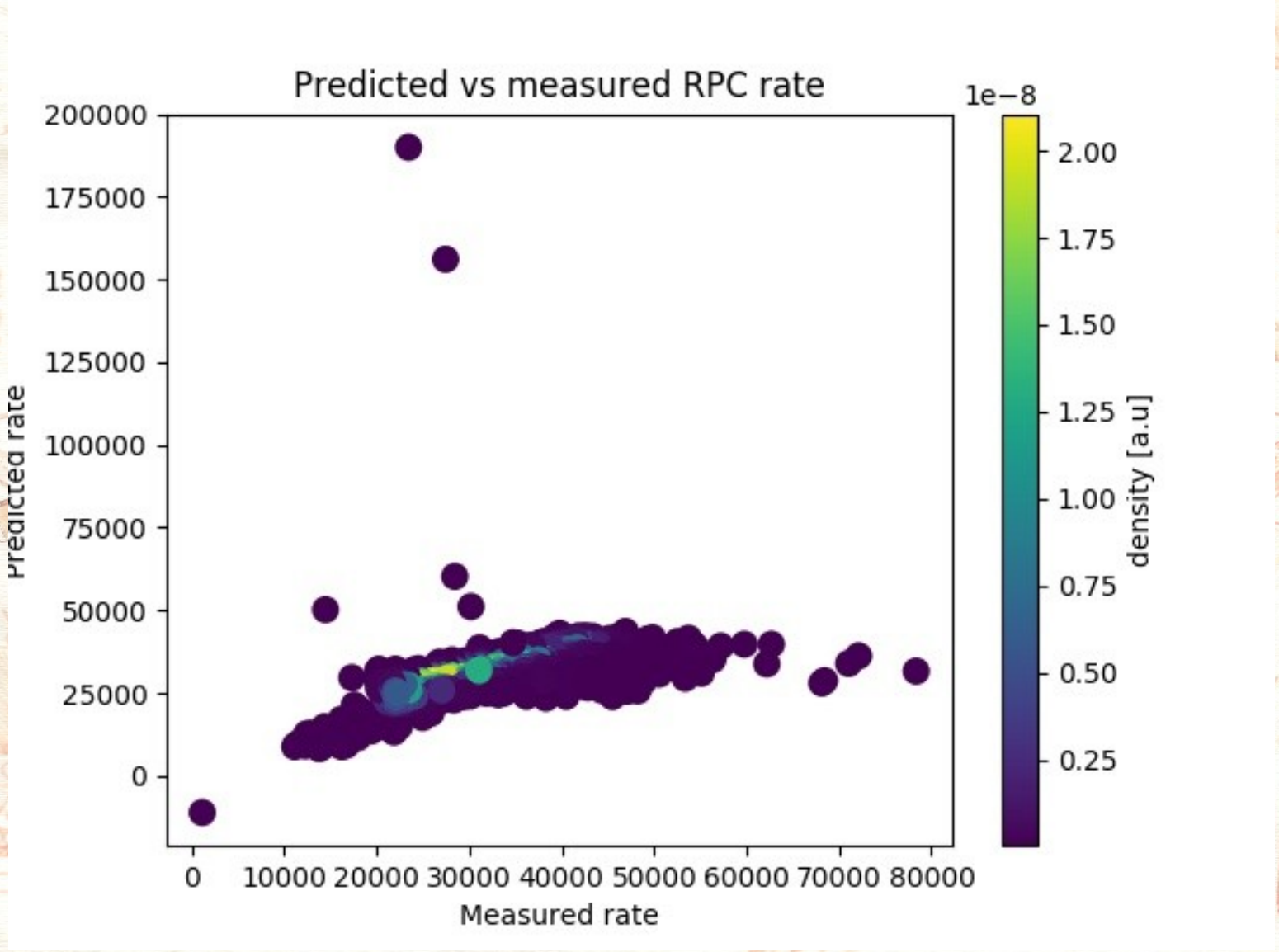
Predicetd vs Measured (learning run 306138)



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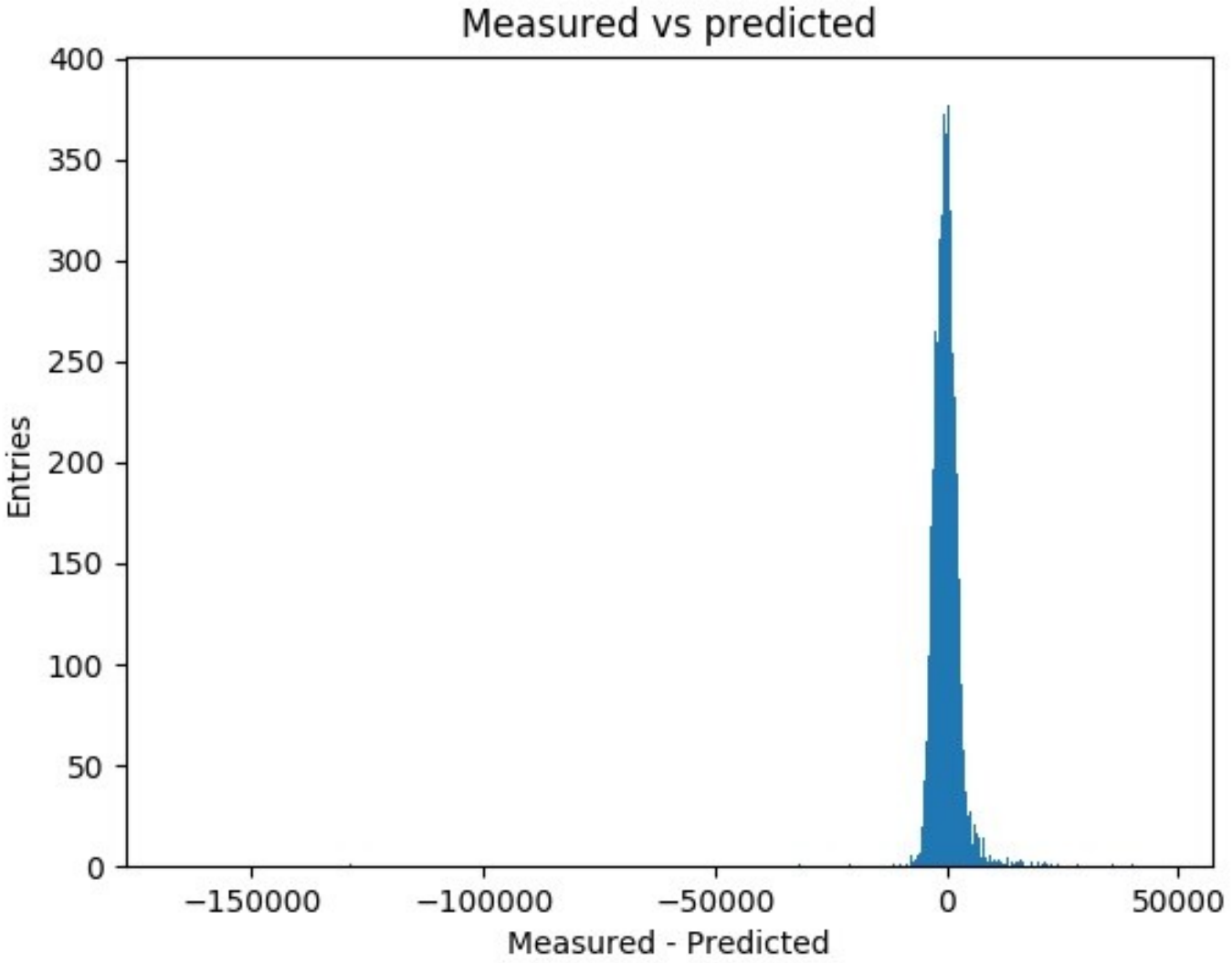
Predicetd vs Measured (learning run 306138)



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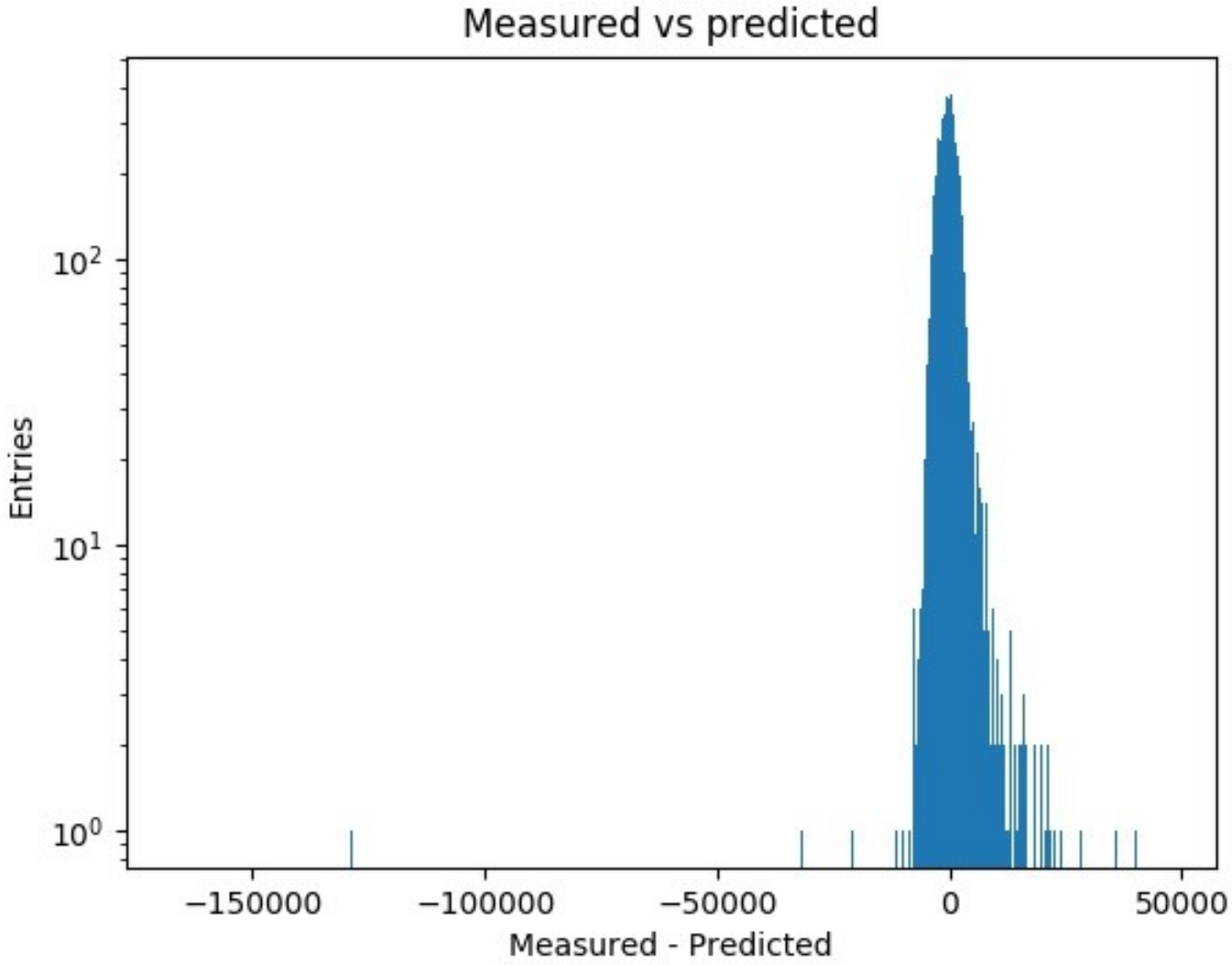
Predicetd vs Measured (learning run 306138)



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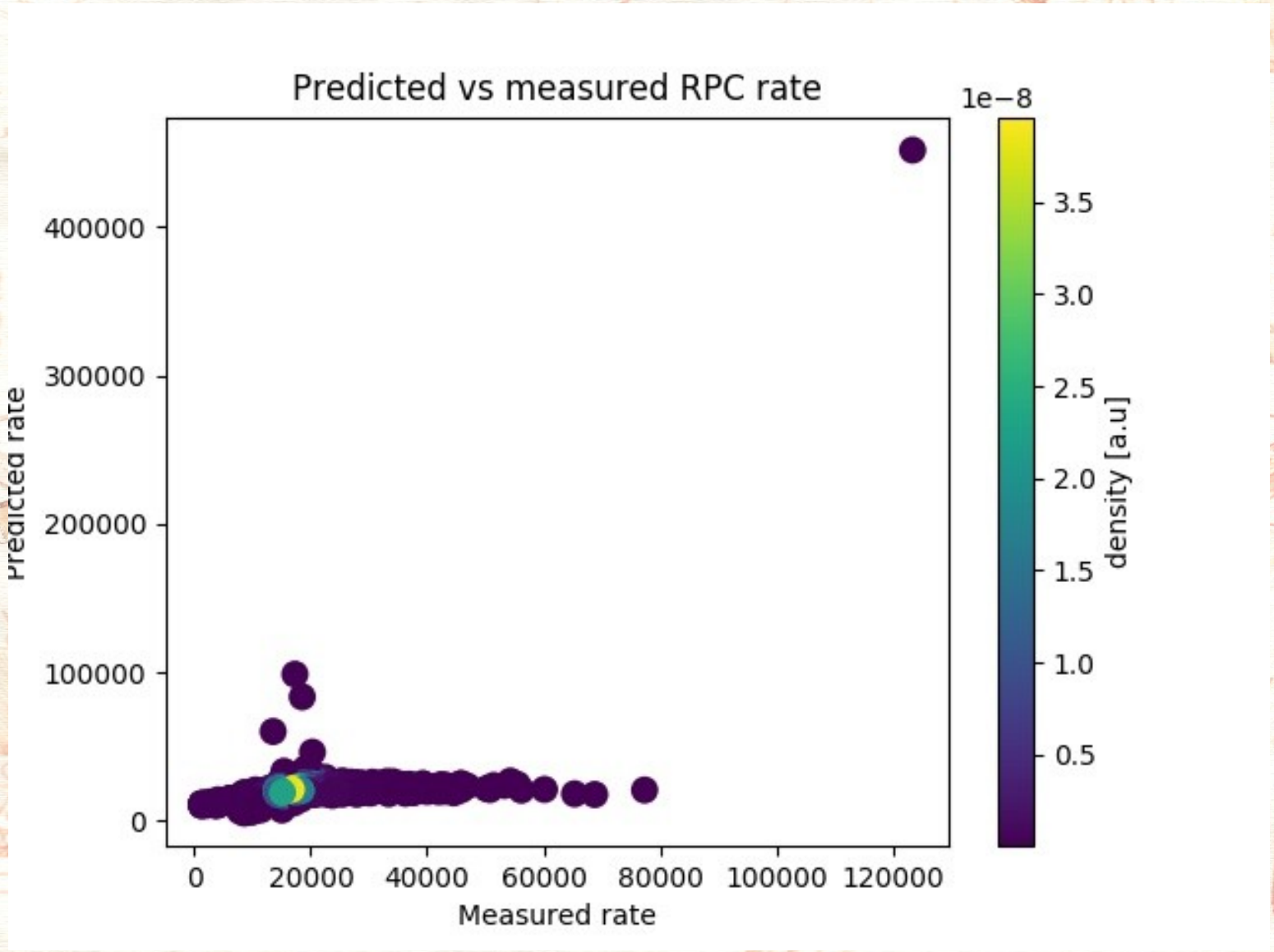
Predicetd vs Measured (test run 306139)



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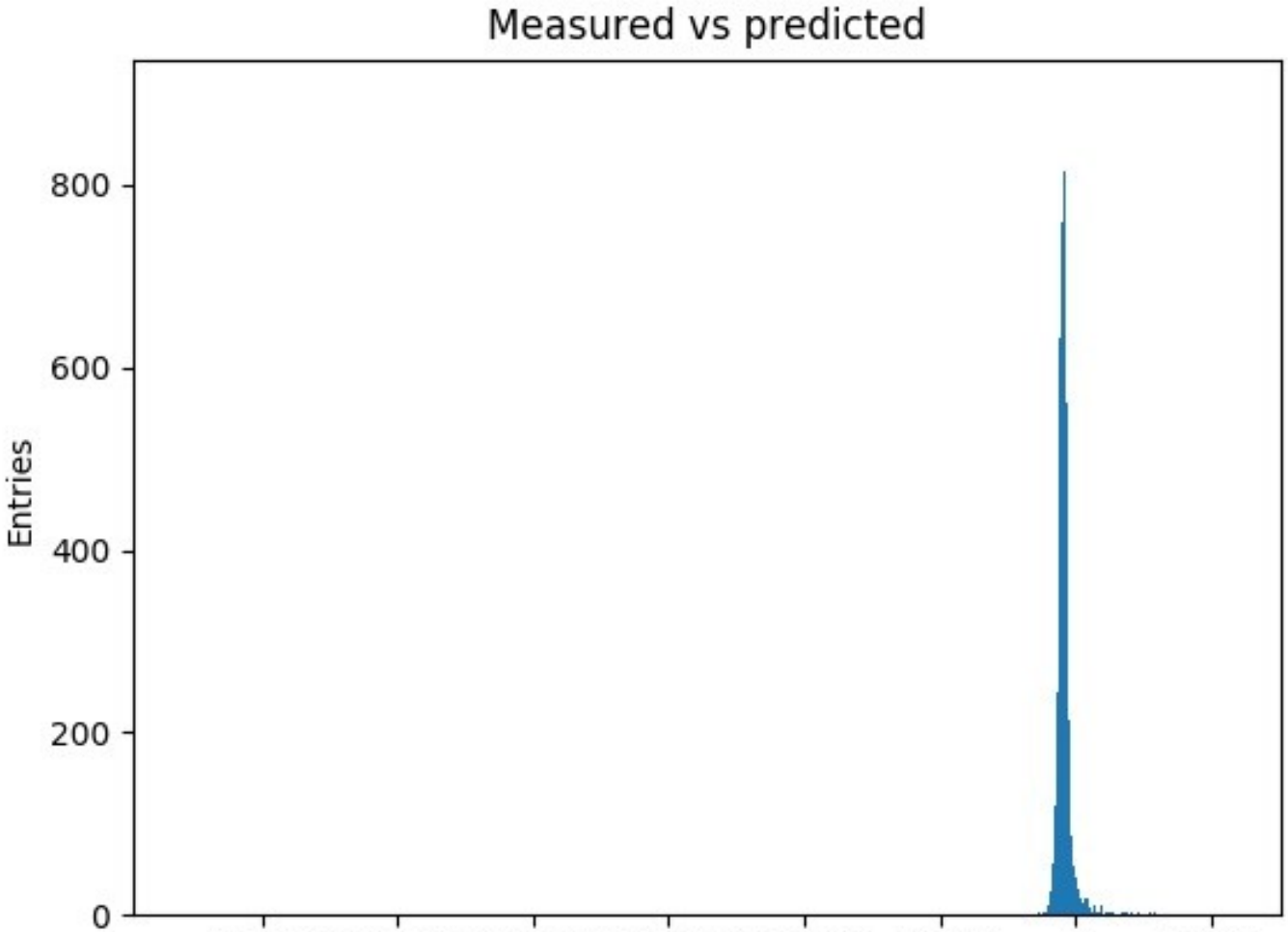
Predicetd vs Measured (test run 306139)



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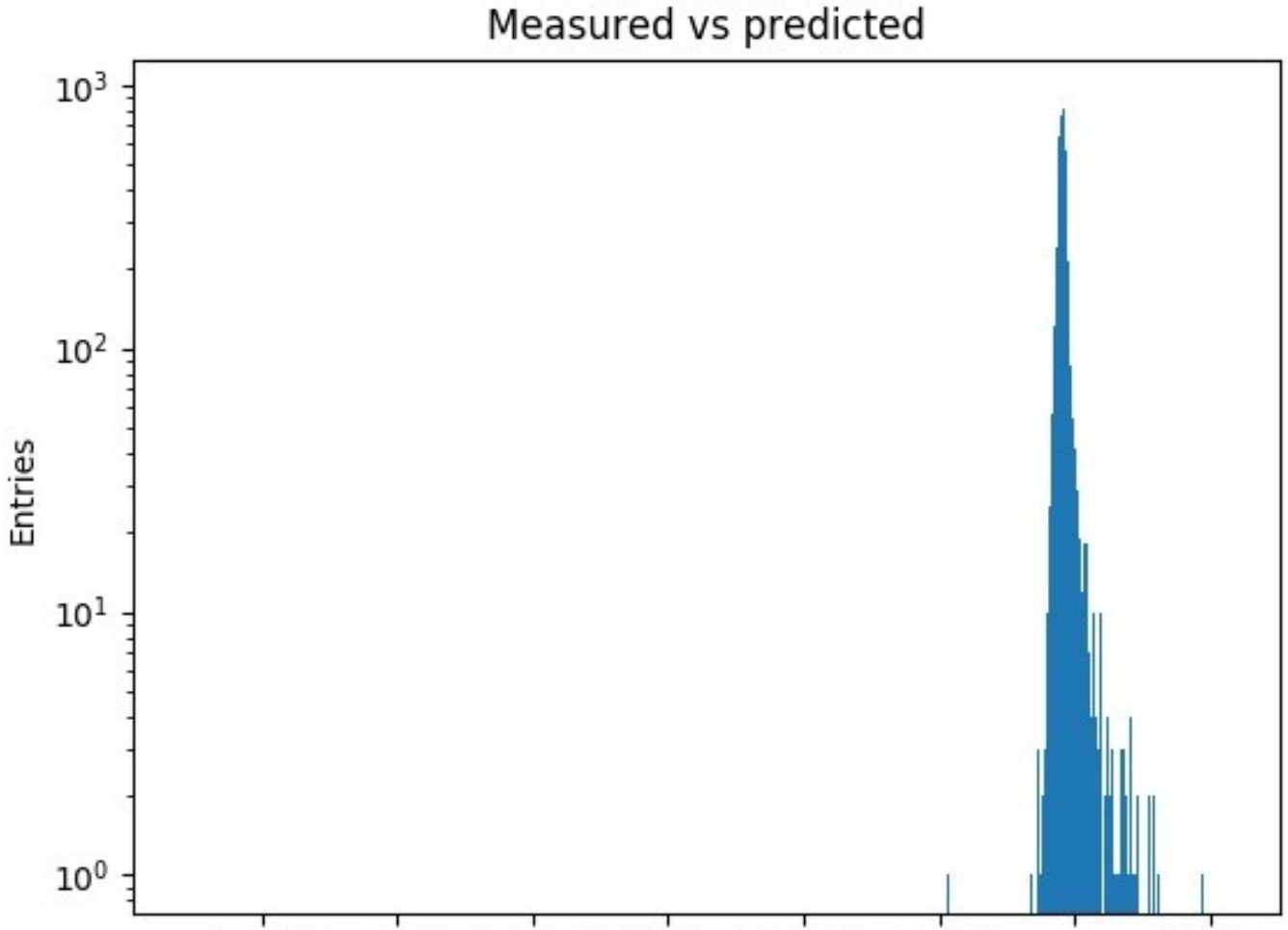
Predicetd vs Measured (test run 306139)



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Main Barrel RPC Types

RB4

RB3

RB2

RB1

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