DISCOVERING THE IMPORTANCE OF DEW POINT SENSOR MEASUREMENTS IN THE ECAL SAFETY SYSTEM

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WHAT IS CMS?

- The Compact Muon Solenoid

- General-purpose detector at the Large Hadron Collider (LHC)

- Built around a huge solenoid magnet

- Generates a field of 4 Tesla (about 100,000 times the magnetic field of the Earth)

- Detector's weight is 14,000-tonne

WHAT IS ECAL?

- The Electromagnetic CALorimeter

- Sub-detector of CMS

- Electrons and photons are measured using ECAL

- Contains nearly 80,000 crystals ($PbWO_4$)

- Crystals each weigh 1.5kg

- Made up of a barrel section and two "endcaps"

- Formed into 36 "supermodules" + 4 "Dees"
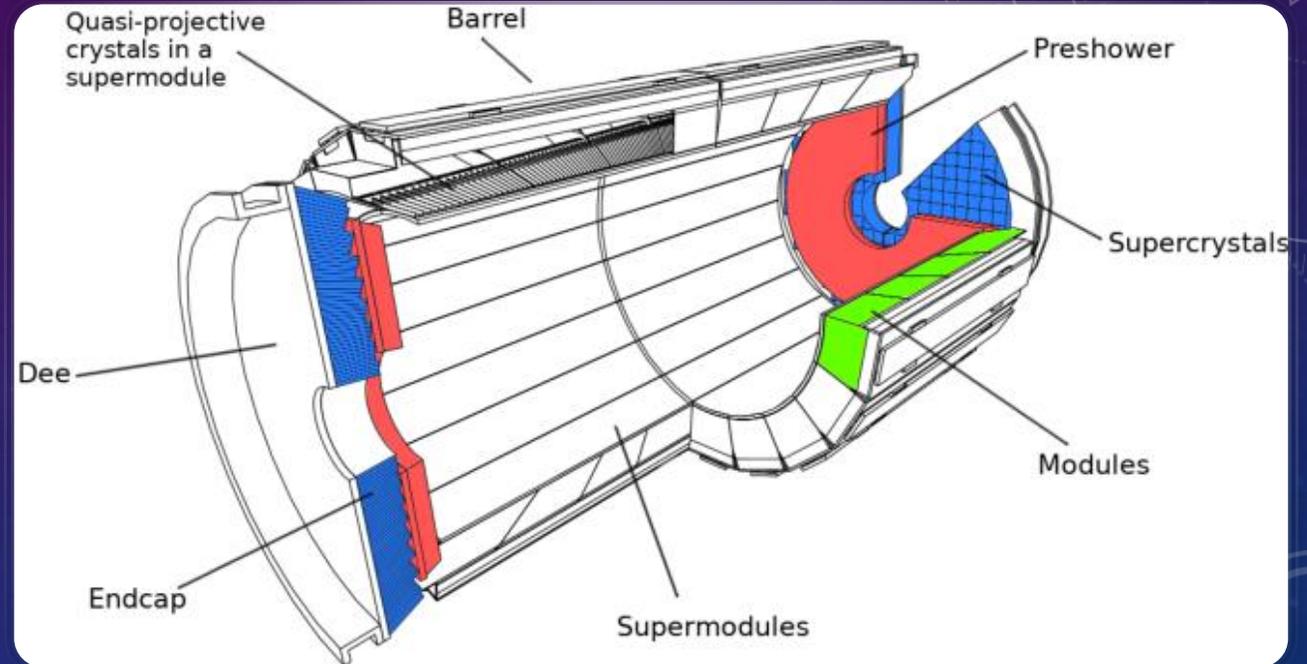
SAFETY VS MONITORING SYSTEM

- Safety system is control of critical parameters in order to avoid serious accidents (risk-free management strategy)

- On the other hand, monitoring system is used for offline analysis of the different systems and the main idea is to predict and avoid problems in the future

- Safety system has actions based on various problems inside the subdetector

- Monitoring system is helpful for detection of different conditions and monitoring a lot of real values which are really important for better understanding of the subdetector behavior
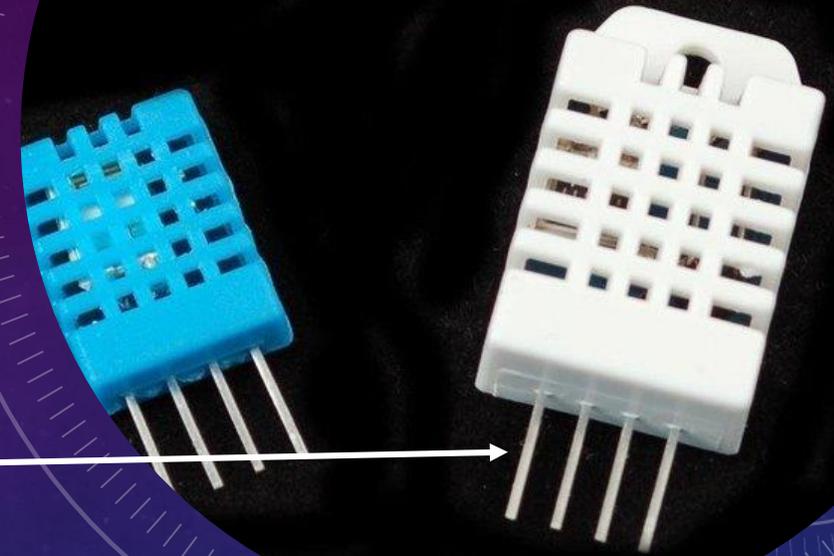
T&H SENSOR TYPES

DHT11

- Ultra low cost (5$)

- Humidity between 20-80%, 5% accuracy

- Temperature between 0-50°C, ±2°C accuracy

- 1 Hz sampling rate

DHT22

- Low cost (15$)

- Humidity between 0-100%, 2-5% accuracy

- Temperature between -40-80°C, ±0.5°C accuracy

- 0.5 Hz sampling rate

HMP155 Vaisala

- Ultra high cost (>1000$)

- Humidity between 0-80%, 1% accuracy

- Temperature between -80-20°C, ±0.1°C accuracy

- 19200 bit/s

MICRO CONTROLLERS

Arduino

- Operating voltage: 5V

- Input voltage: 6-20V

- Digital I/O pins: 14 (of which 6 provide PWM output)

- Analog I pins: 6

INDUSTRY CONTROLLERS

Siemens S7-400 and S7-1500 PLCs

- Operating voltage: 24/48V

- Input voltage: 24VDC/230VAC

- Digital I/O pins: 2048 (expansion is also possible)

- Analog I/O pins: 1024 (expansion is also possible)

DEW POINT

$$T_{dp} = \frac{c \ln \frac{P_a(T)}{a}}{b - \ln \frac{P_a(T)}{a}} = \frac{c \ln\left(\frac{RH}{100}\frac{P_{s,m}(T)}{a}\right)}{b - \ln\left(\frac{RH}{100}\frac{P_{s,m}(T)}{a}\right)} = \frac{c\gamma_m(T, RH)}{b - \gamma_m(T, RH)}$$

- Formal definition: The dew point is the temperature the air needs to be cooled to (at constant pressure) in order to achieve a relative humidity (RH) of 100%.

- Actually, the dew point is the temperature at which condensation begins to form

- **Extremely important in all safety systems at CERN – we want to avoid condensation inside a detector full of electronics!**

- We used an approximate formula to calculate the dew point in our project

$$T_{dp} \approx T - \frac{100 - RH}{5};$$

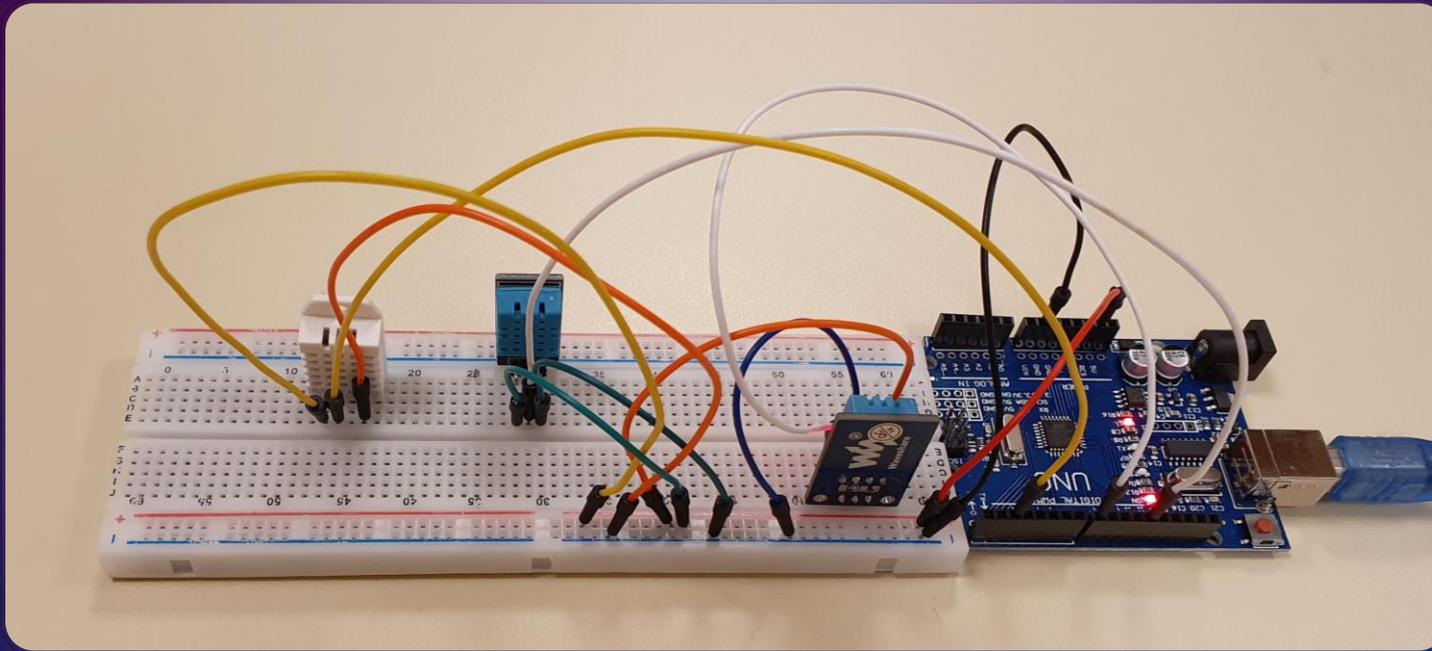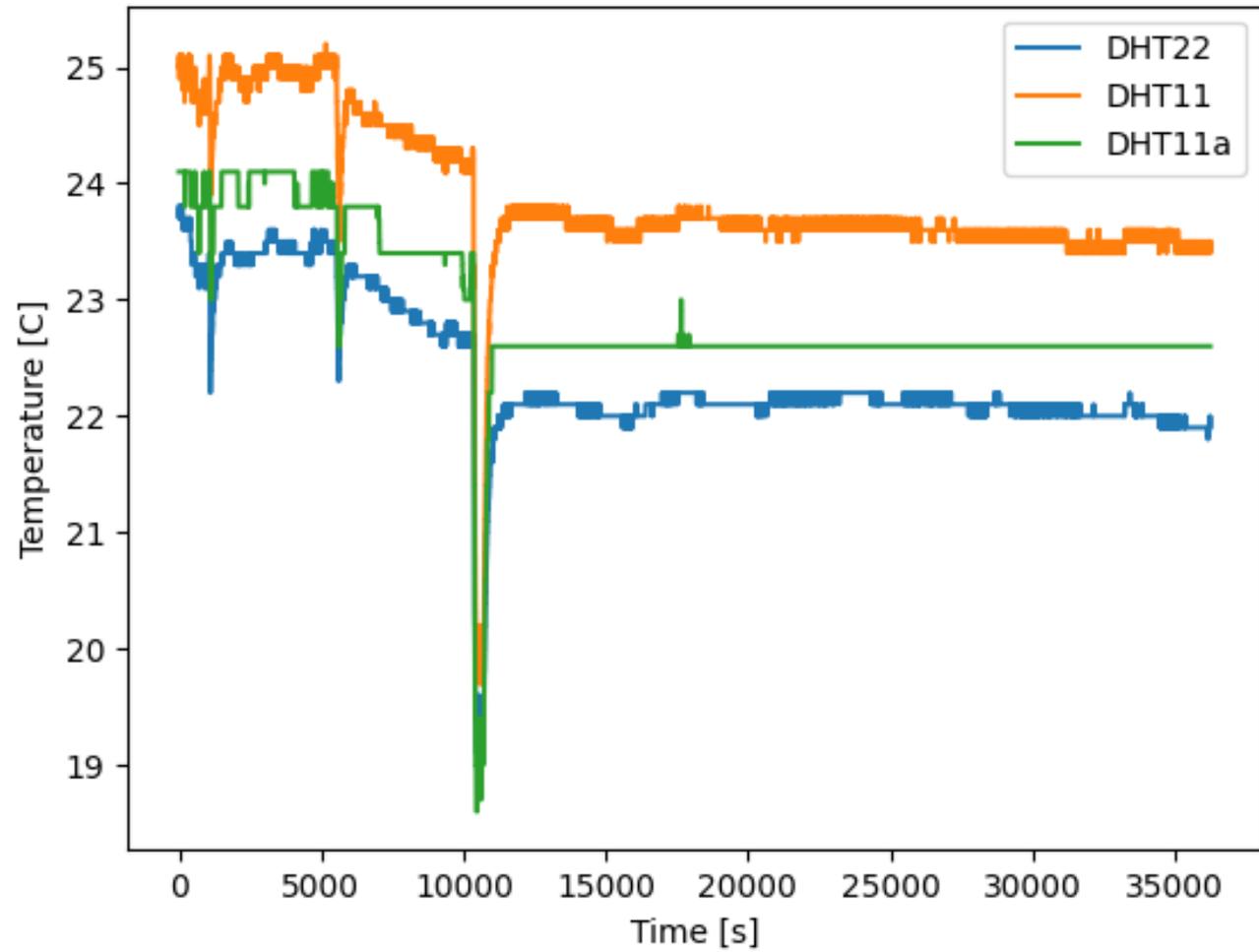$$RH \approx 100 - 5(T - T_{dp});$$

OUR SETUP

Hardware

- 1x Arduino UNO

- 1x Breadboard

- 2x DHT11 sensors

- 1x DHT22 sensor

- Copper wires

Software

- Arduino IDE
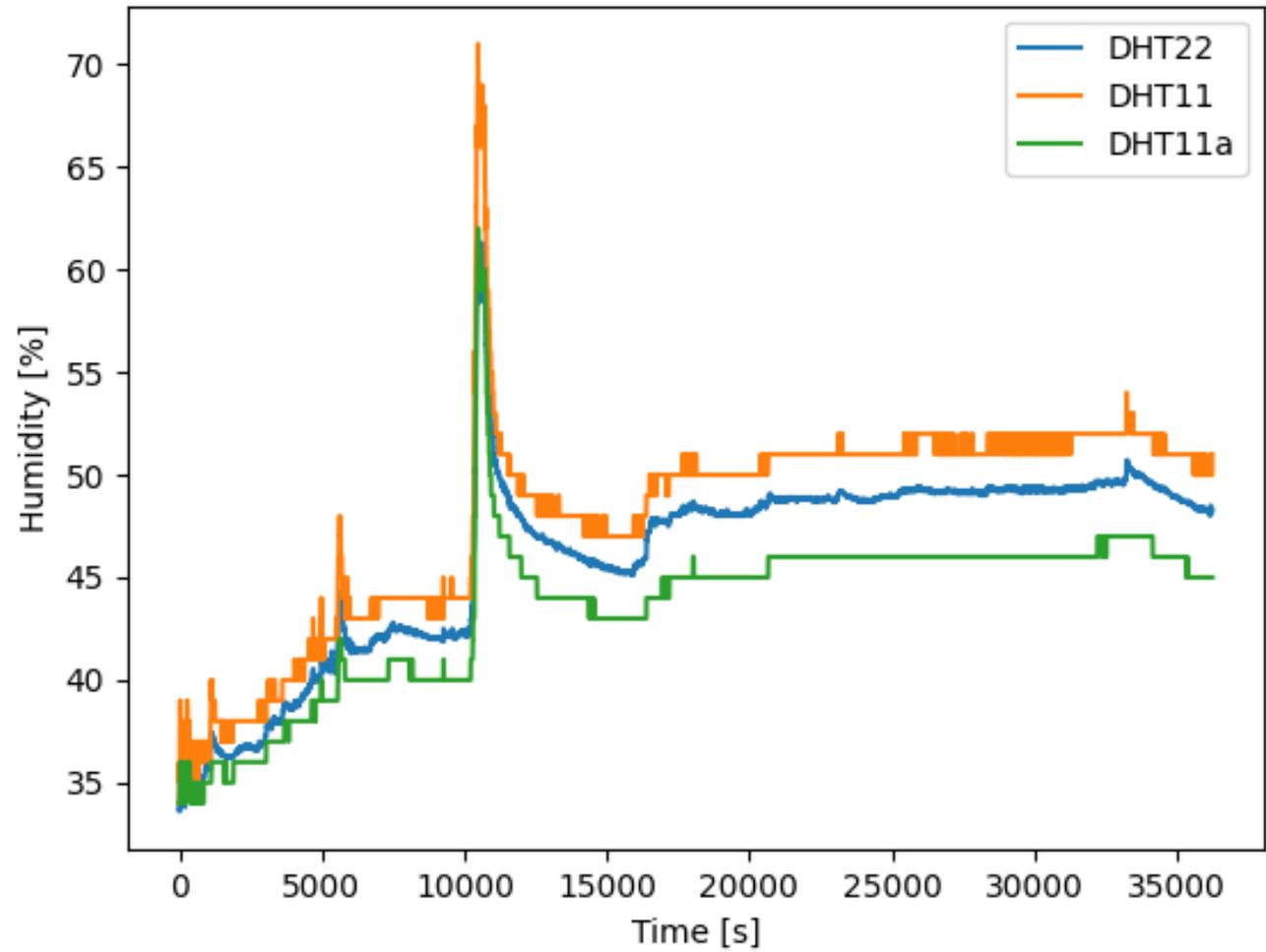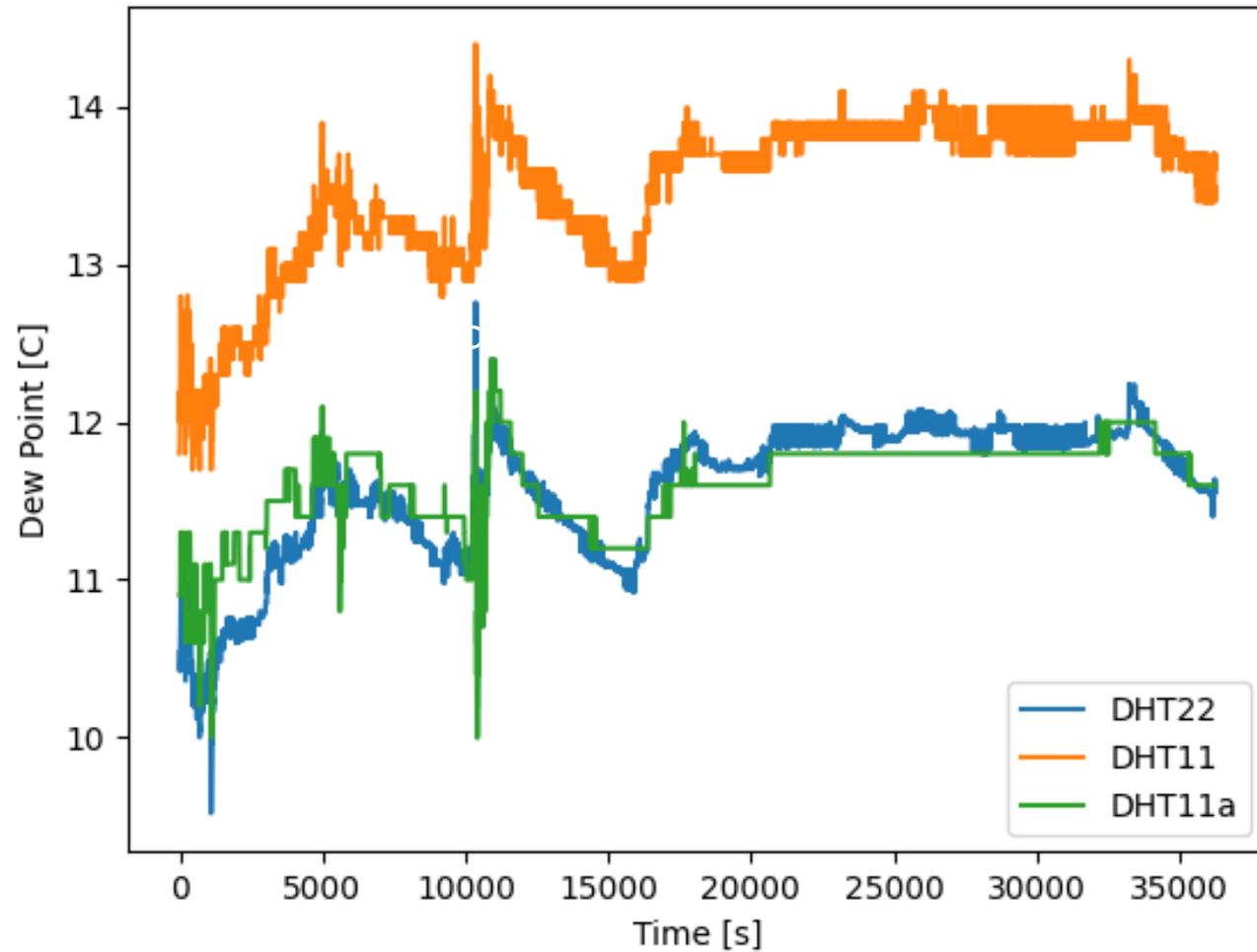
- Python

- Putty

- Excel

TEMPERATURE MEASUREMENTS

HUMIDITY MEASUREMENTS

DEW POINT CALCULATION

THANK YOU FOR YOUR ATTENTION