Sustainable HEP

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CERN

The remote monitor and control systems of the PADME experiment at the DAΦNE BTF

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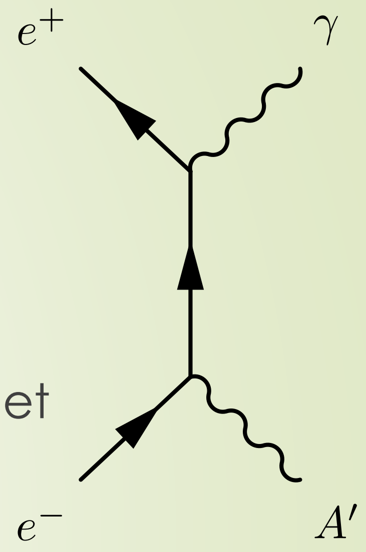
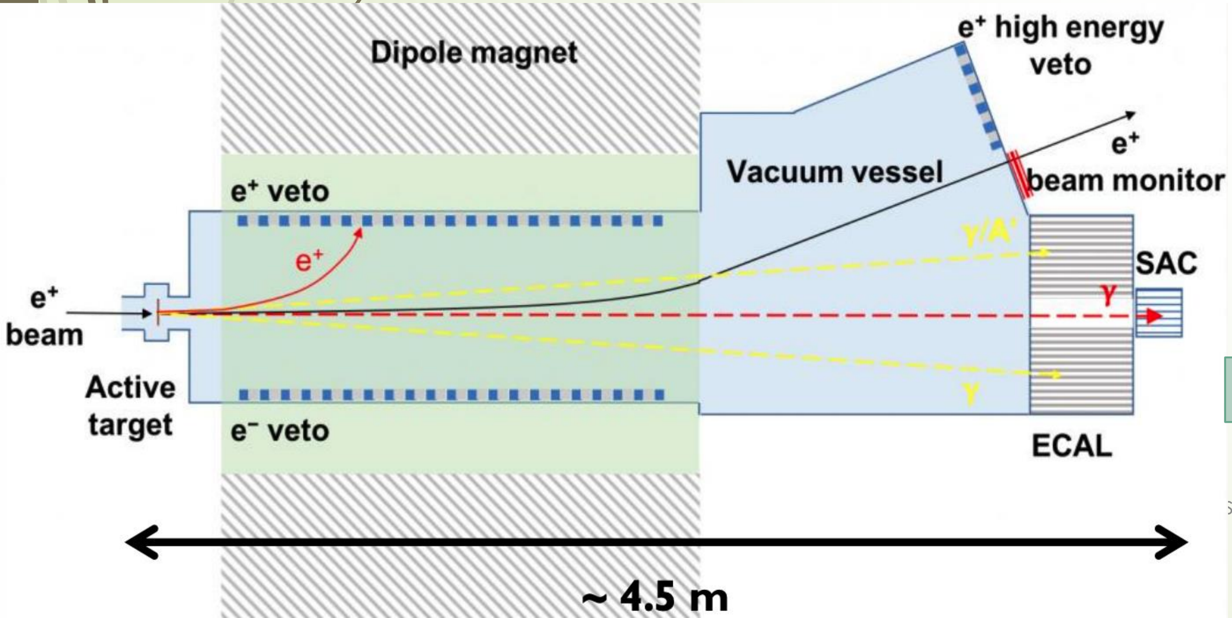
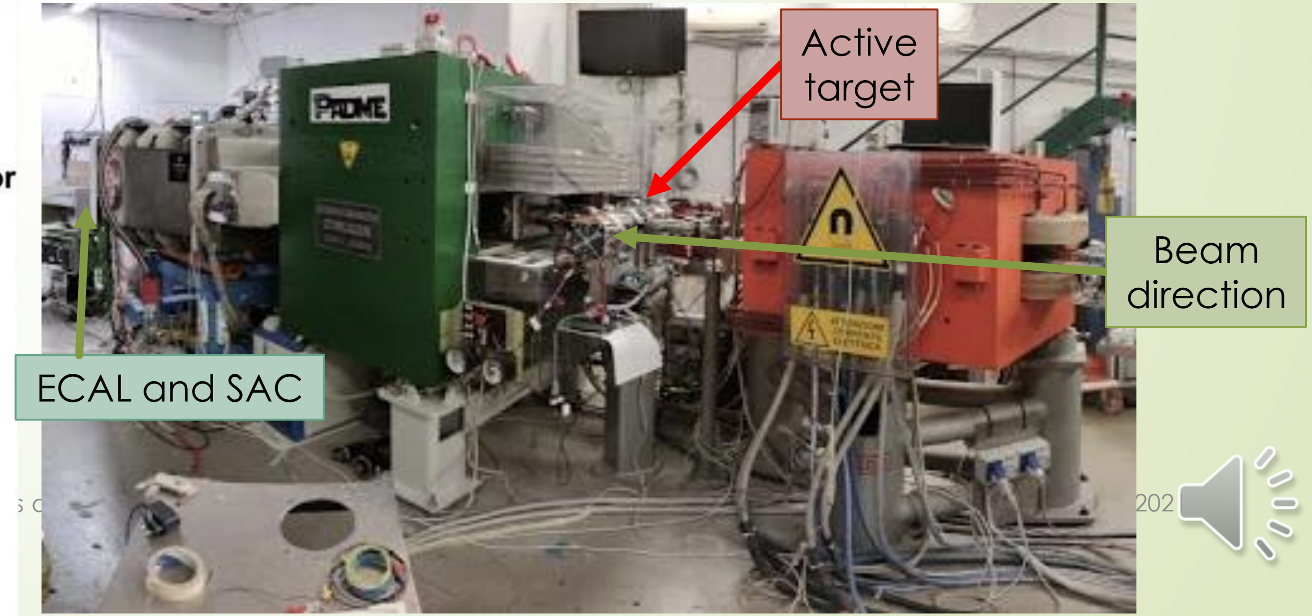
The PADME experiment



M. Raggi and V. Kozhuharov, Adv. High Energy Phys.2014, 959802 (2014), 1403.3041.
M. Raggi, V. Kozhuharov, and P. Valente, EPJ Web Conf.96, 01025 (2015), 1501.01867.

- Positron Annihilation to Dark Matter Experiment: $e^+ e^- \rightarrow \gamma A'$
- Up to 550 MeV e^+ beam from the INFN-LNF Linac on diamond target
- Signal: 1 γ in Electromagnetic Calorimeter & nothing elsewhere
- $\Delta M_{miss}{}^2$ then gives access to $M(A')$





The PADME collaboration

INFN Istituto Nazionale di Fisica Nucleare

Sofia University St. Kliment Ohridski, Bulgaria

MTA Atomki Debrecen

Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

Sapienza Università di Roma

Università degli Studi di Roma Tor Vergata

Università del Salento

Politecnico di Torino

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Plan for 2020 and COVID effects

- PADME Run 1 between Oct 2018 and Feb 2019
- Plan for Run 2 in Sep 2019 postponed to 2020 due to a vacuum accident
- Mar 2020: national lockdown due to COVID-19 pandemics
- Access to INFN-LNF site severely restricted
- After some adjustments, LNF local activities resumed with local personnel
- LNF Linac and BTF back in operation by May 2020
- Travel from abroad and within Italy still almost impossible
- Was it possible to run the PADME experiment exclusively from remote sites?

PADME shift organization

- Local INFN personnel guaranteed 24/7 Linac and BTF activities
- Most PADME shifters worked from remote locations
- Direct contact (telephone) with Linac control room
- For simple interventions, Linac technicians could intervene under remote shifter supervision
- Expert physicists from INFN LNF and Roma1 PADME groups could get access to the lab for more complex interventions
- INFN-LNF network protected: all shifters were required to register as INFN-LNF users to access the local VPN to connect to the PADME on-line servers and control nodes
- All DAQ and monitor applications were reviewed and modified to allow full functionality from remote

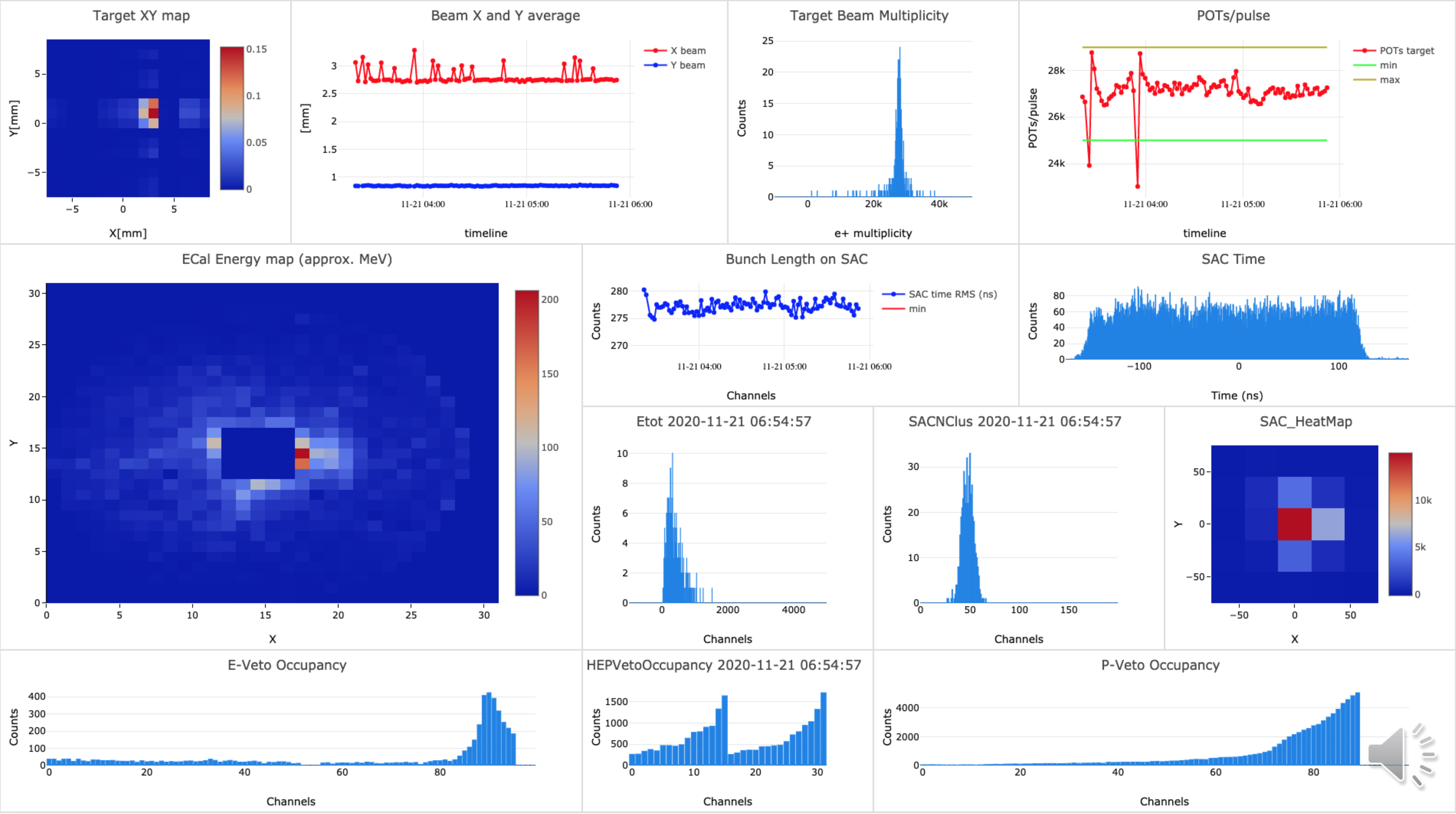
The Run Control

- Run Control is the main interface to the PADME data acquisition system and was developed in Python
- It takes care of initializing the detectors and starting/stopping the DAQ
- DAQ set-up is controlled by human readable configuration files
- The main Run Control server runs continuously on one of the on-line servers
- A text-based client allows the shifter to issue commands to the server
- N.B. A single client can be active at any time to avoid concurrency issues
- The client-server architecture avoided problems due to network glitches, while the absence of a GUI reduced the bandwidth usage

```
[daq@l0padme1 DAQ]$ ./RunControl --server
Starting RunControlServer in background
[daq@l0padme1 DAQ]$ ./RunControl
Connecting to RunControl server on host localhost port 10000
SEND (q or Q to Quit): help
Sending help
Available commands:
help                            Show this help
get_state                       Show current state of RunControl
get_setup                       Show current setup name
get_setup_list                  Show list of available setups
get_board_list                  Show list of boards in use with current setup
get_board_config_daq <b>        Show current configuration of board DAQ process <b>
get_board_config_zsup <b>       Show current configuration of board ZSUP process <b>
get_trig_config                 Show current configuration of trigger process
get_run_number                  Return last run number in DB
change_setup <setup>            Change run setup to <setup>
new_run                         Initialize system for a new run
shutdown                        Tell RunControl server to exit (use with extreme care!)
SEND (q or Q to Quit): get_setup_list
Sending get_setup_list
['2018', '2019', '2020', 'board25', 'board8', 'ecal_cosmics', 'ecal_random']
SEND (q or Q to Quit): get_setup
Sending get_setup
ecal_random
SEND (q or Q to Quit): new_run
Sending new_run
Current setup is ecal_random
Available run types: CALIBRATION,COSMICS,DAQ,FAKE,OTHER,RANDOM,TEST,TESTBEAM
Run type: DAQ
```

The On-line Monitor

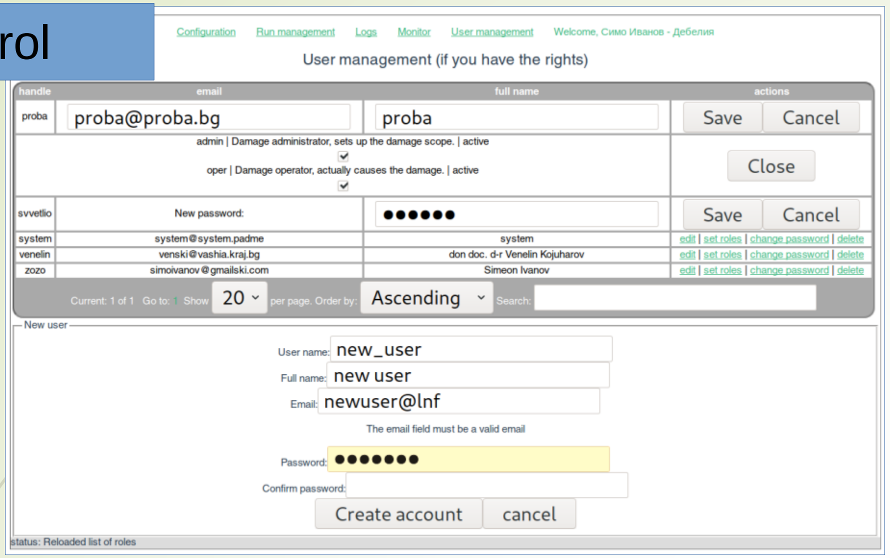
- To monitor the DAQ data quality in real-time, part of the collected raw data are immediately reconstructed to produce several control histograms
- The PadmeMonitor web-based system is a customized **node.js** server that reads the histograms with the relative formatting information into memory and exports them in HTML format
- Histograms and formatting information are encapsulated in human readable JSON files: it is straightforward to add new histograms, new pages and changes to the pages layout
- The remote browser connects to the server to collect the histogram data and format and uses local libraries (e.g. PlotlyJS) to produce the graphics on the browser window
- This architecture greatly reduces server-side load and network bandwidth usage by using client-side resources to actually produce the graphics


Target XY map
Y[mm]
X[mm]
Beam X and Y average
X beam
Y beam
[mm]
timeline
Target Beam Multiplicity
Counts
e+ multiplicity
POTs/pulse
POTs target
min
max
POTs/pulse
timeline
ECal Energy map (approx. MeV)
Y
X
Bunch Length on SAC
SAC time RMS (ns)
min
Counts
Channels
SAC Time
Counts
Time (ns)
Etot 2020-11-21 06:54:57
Counts
Channels
SACNClus 2020-11-21 06:54:57
Counts
Channels
SAC_HeatMap
Y
X
E-Veto Occupancy
Counts
Channels
HEPVetoOccupancy 2020-11-21 06:54:57
Counts
Channels
P-Veto Occupancy
Counts
Channels

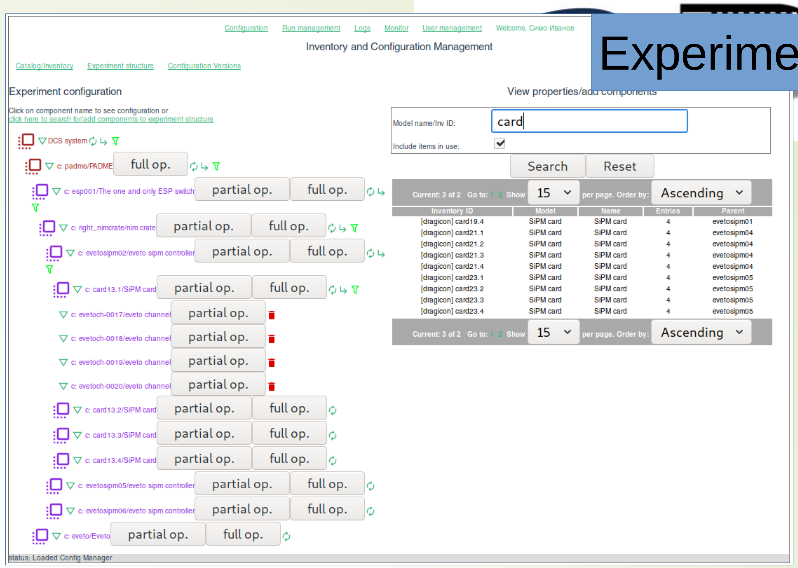
The Detector Control System

- The PADME Detector Control System was designed from the beginning with remote management in mind
- The DCS is based on the BottlePy Python3 web framework interfaced to a MySQL database and uses Vue.js and Netdata for graphical display of slow control parameters
- The system is very versatile and implements a simple inventory and full configuration management to handle detector settings and control
- A web-based access control system allows authorized users to easily control all detector activities and monitor status changes and alarms
- All detectors and instruments were remotely controlled or were connected to a remotely controlled power supply

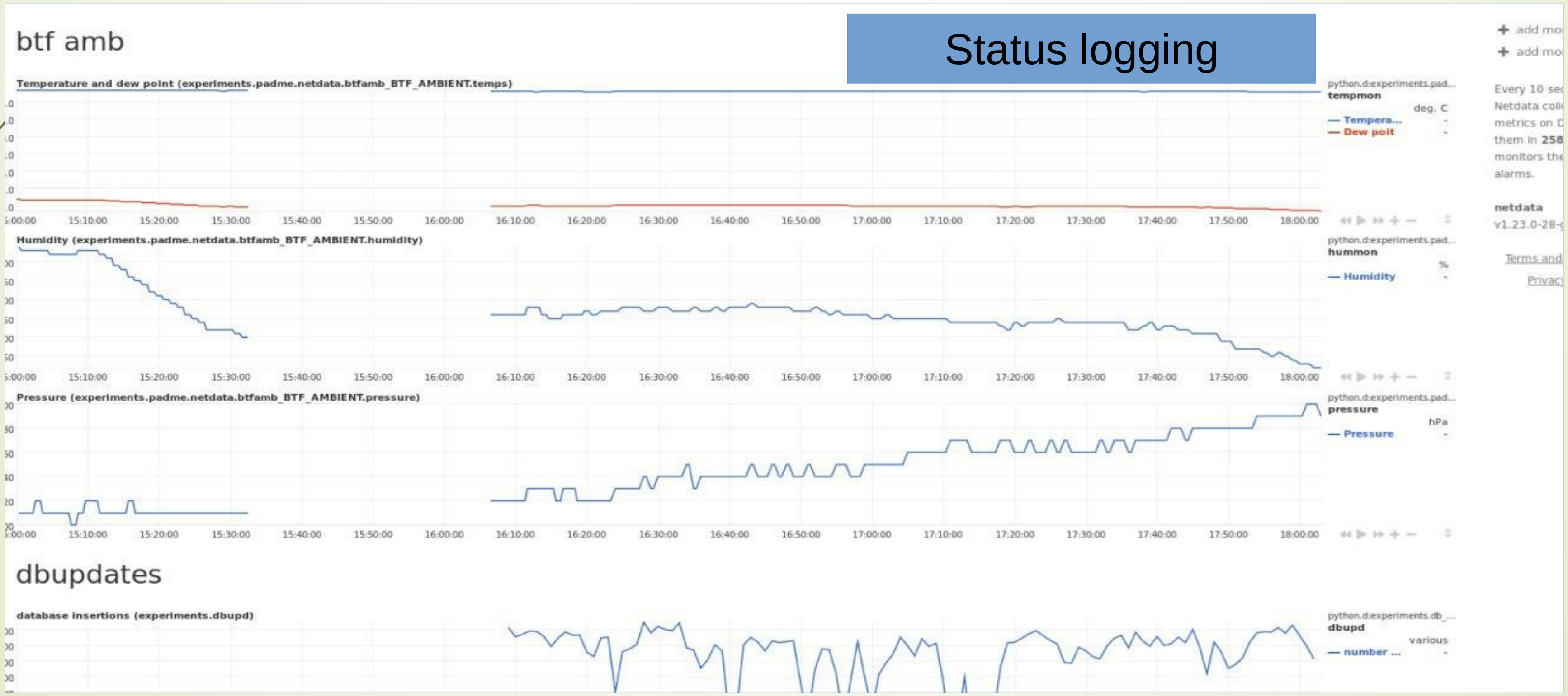
Access control



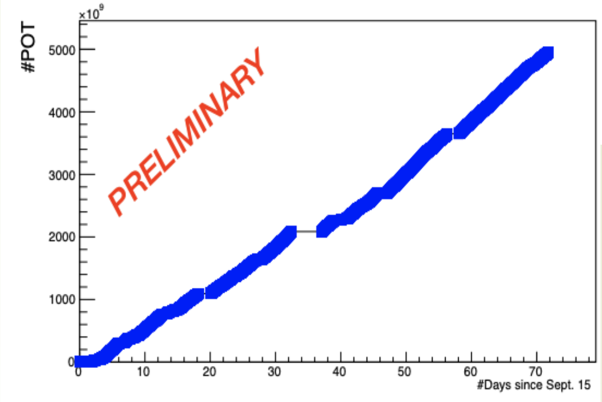
Experiment configuration



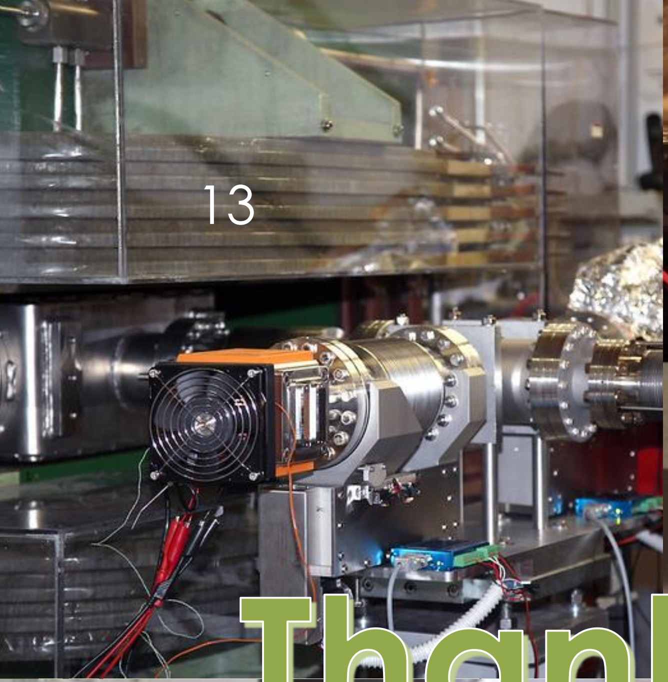
Status logging



The 2020 run



- By the end of Jun 2020 PADME resumed data taking for the commissioning of the experiment
- The physics Run 2 started in Sep 2020 and lasted till the beginning of Dec 2020 collecting a total of 5.6×10^{12} Positrons on Target (PoTs)
- Thanks to the remote management of the experiment, we were able to successfully perform 24/7 shifts and run smoothly even during the lockdown period
- The PADME experience showed that a careful use of the currently available digital and telecommunication technologies allows an (almost) fully remote management of a HEP experiment



Thanks for your attention