CAST 3HE SYSTEM

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Goal: scan over a wide range of axion masses

Setting different 3He densities in the cold bore of CAST

Hermetic gas circuit assuring full recovery of 3He

Storage of 3He

Vessel volume dimensioned to keep Helium gas pressure below atmospheric

Trap purging system

Sequential charcoal traps to remove oil mist from the pumps (RT), water and other vapors (LN2)

Metering and ramping of gas

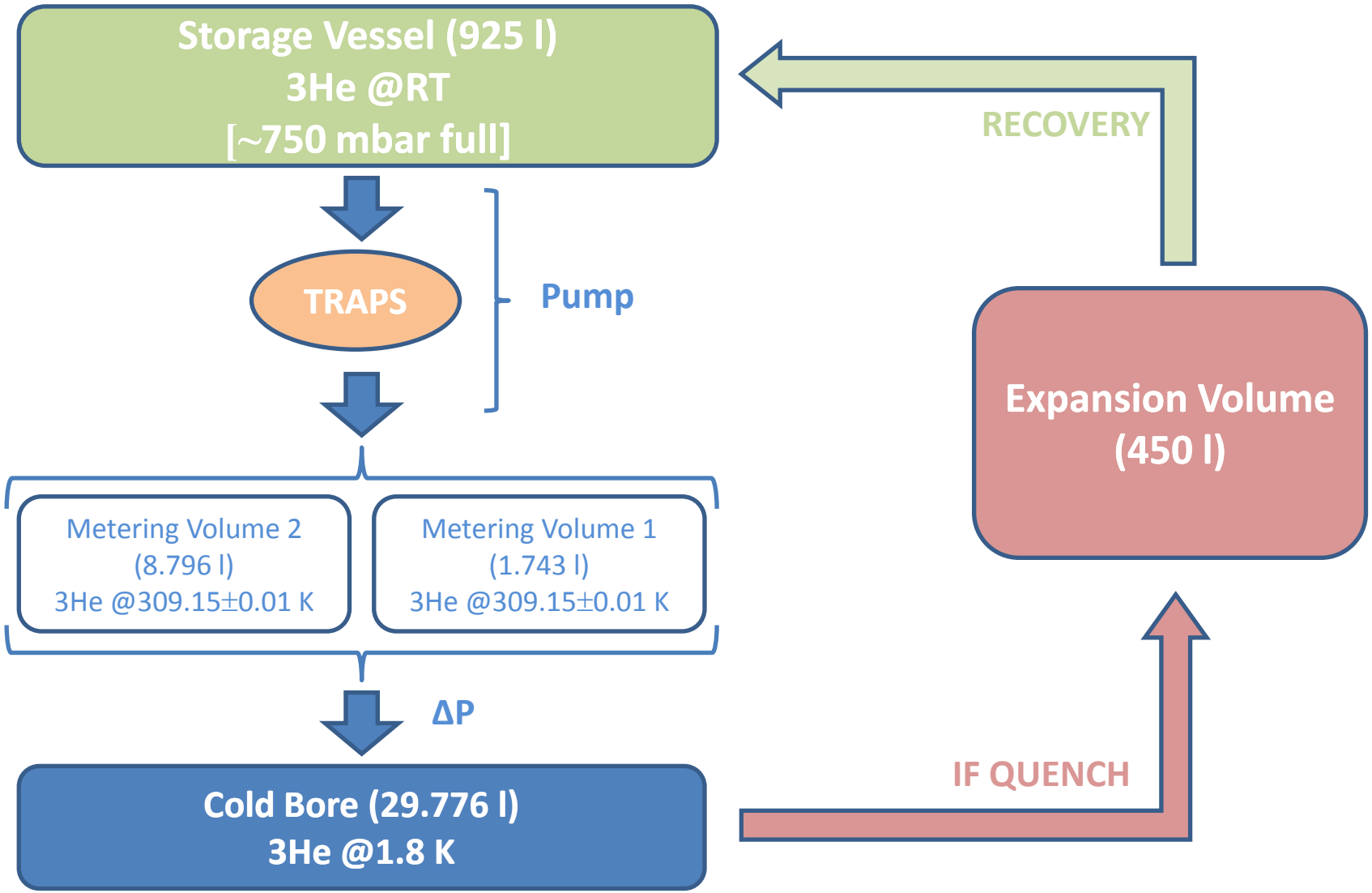
Filling the cold bore with precisely metered amounts of gas in incremental steps. The precision of the metering is achieved by the accurate temperature control of the metering volumes and by the use of a metrology-grade pressure-measuring instrument.

Recovery

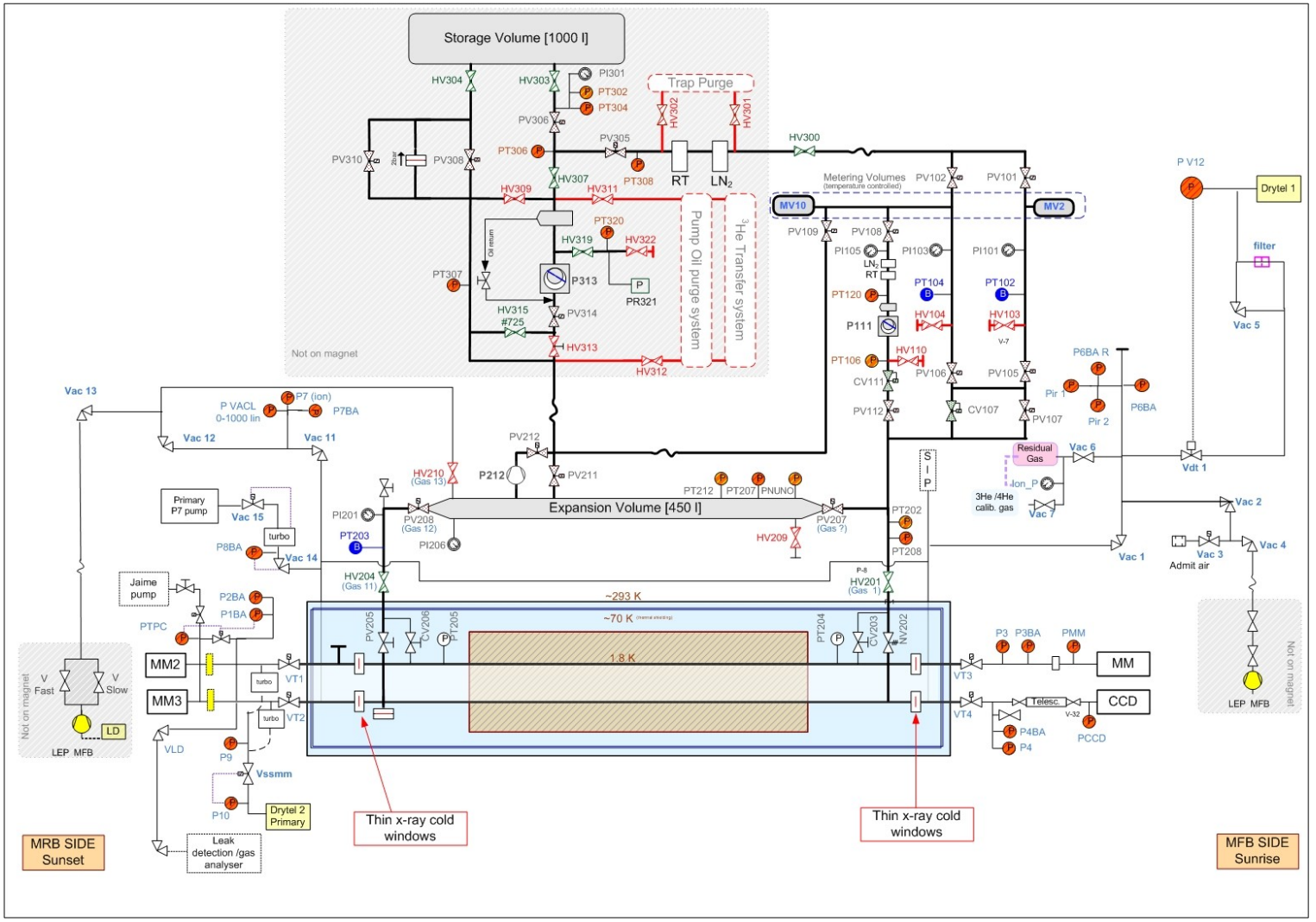
In case of quench the pressure of 3He present in the system increases due to the temperature evolution of the system. That could destroy the cold windows of the 3He buffer and produce 3He loses.

An external volume is automatically linked to the system to contain the maximum pressure of the 3He below atmospheric

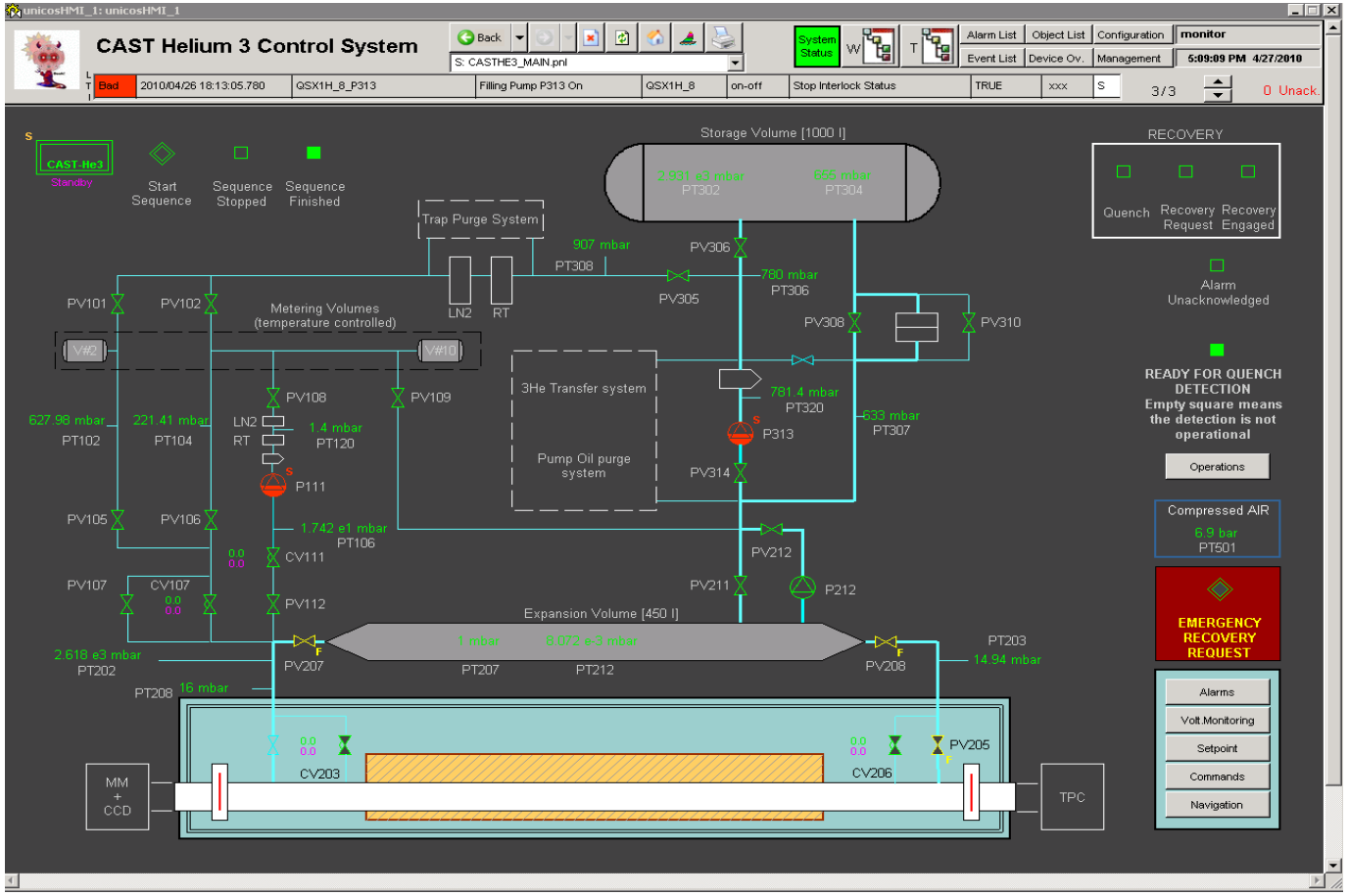
CAST 3HE SYSTEM



CAST 3HE SYSTEM



CAST 3HE SYSTEM



PLC Controlled System. Sequential protocols

CAST 3HE SYSTEM

OVERPRESSURE SAFETY STOP INTERLOCK

PV305 or PV306 NOT OPEN

PV108 NOT OPEN

PT320 > 1100 mbar

PT306 > 1100 mbar

QUENCH SAFETY INTERLOCKS

QUENCH trigger + POWER converter ENABLE

PLC controled PT208 > 600 mbar

RELAY controlled PT208 > 800 mbar

DETERMINATION OF EFFECTIVE AXION MASSES AT CAST

CAST ¾-Helium buffer. CFD Simulations

4-HELIUM

Real gas approach. Peng-Robinson

Include experimental data available (windows @120K)

Interpretation of the results → New formulas

Application to the data

3-HELIUM HEATED WINDOWS

Real gas approach. Peng-Robinson

Include experimental data available (windows @70K)

Interpretation of the results → Formulas/Consequences

Validation with experimental data

3-HELIUM NON-HEATED WINDOWS

Real gas approach. Peng-Robinson

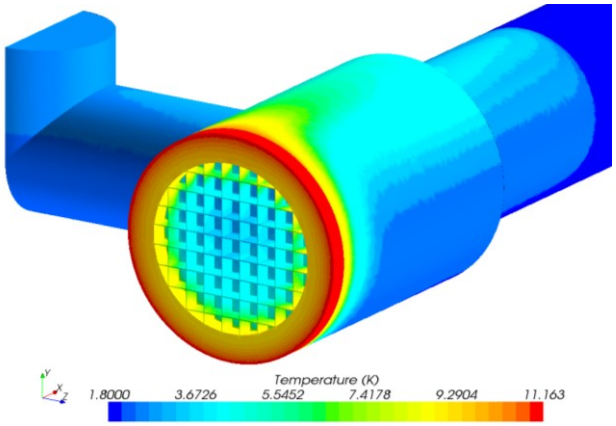
Include experimental data available (windows @12K)

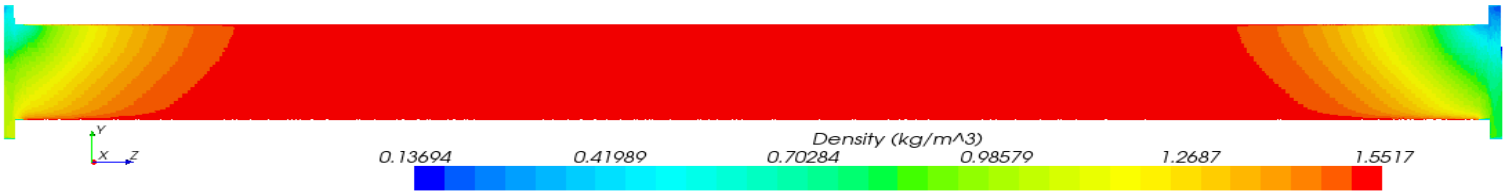
Interpretation of the results → Formulas/Consequences

Validation with experimental data

CAST 3HE SIMULATIONS

CFD simulations. Non-Heated windows @ 15K
Real gas: Peng-Robinson state equation

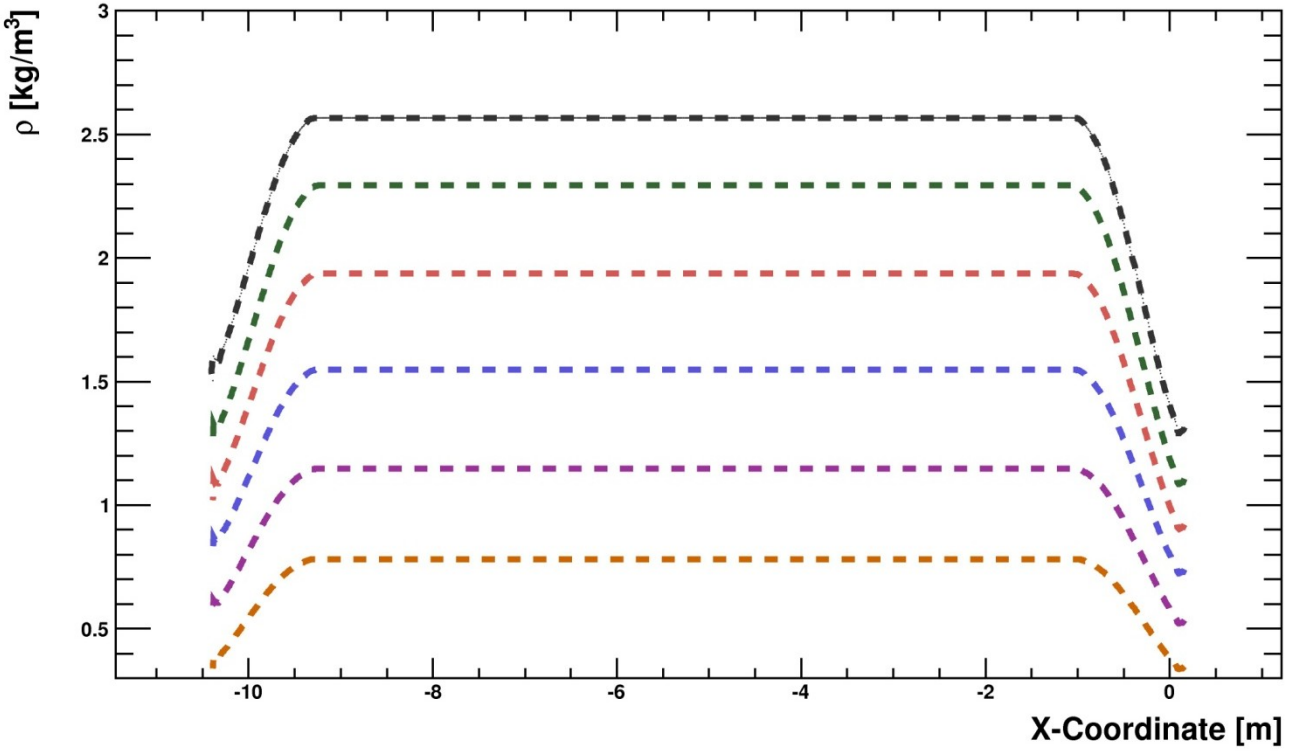




Temperature and density distributions

CAST 3HE SIMULATIONS

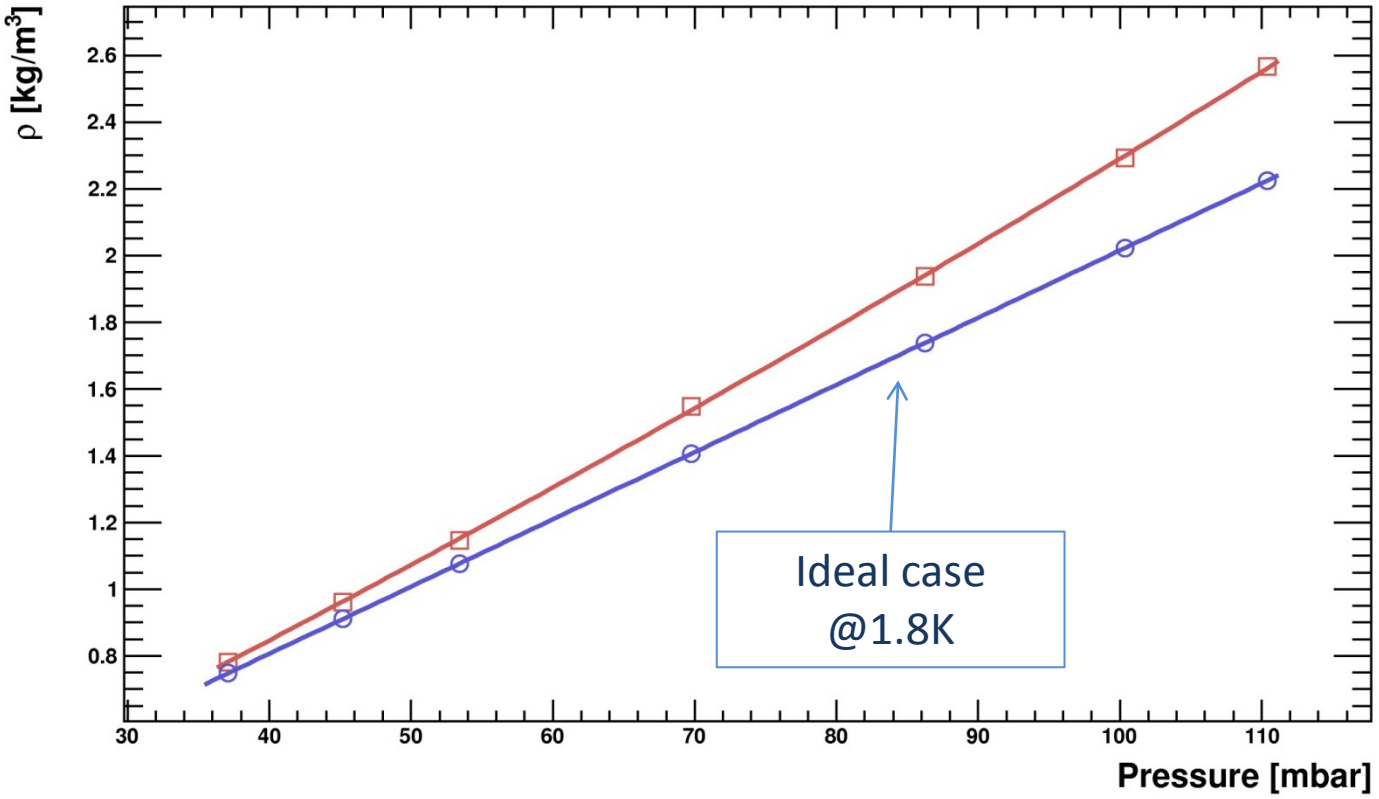
CFD simulations. Non-Heated windows @ 15K
Real gas: Peng-Robinson state equation



Density profile for different pressures

CAST 3HE SIMULATIONS

CFD simulations. Non-Heated windows @ 15K
Real Gas: Peng-Robinson state equation

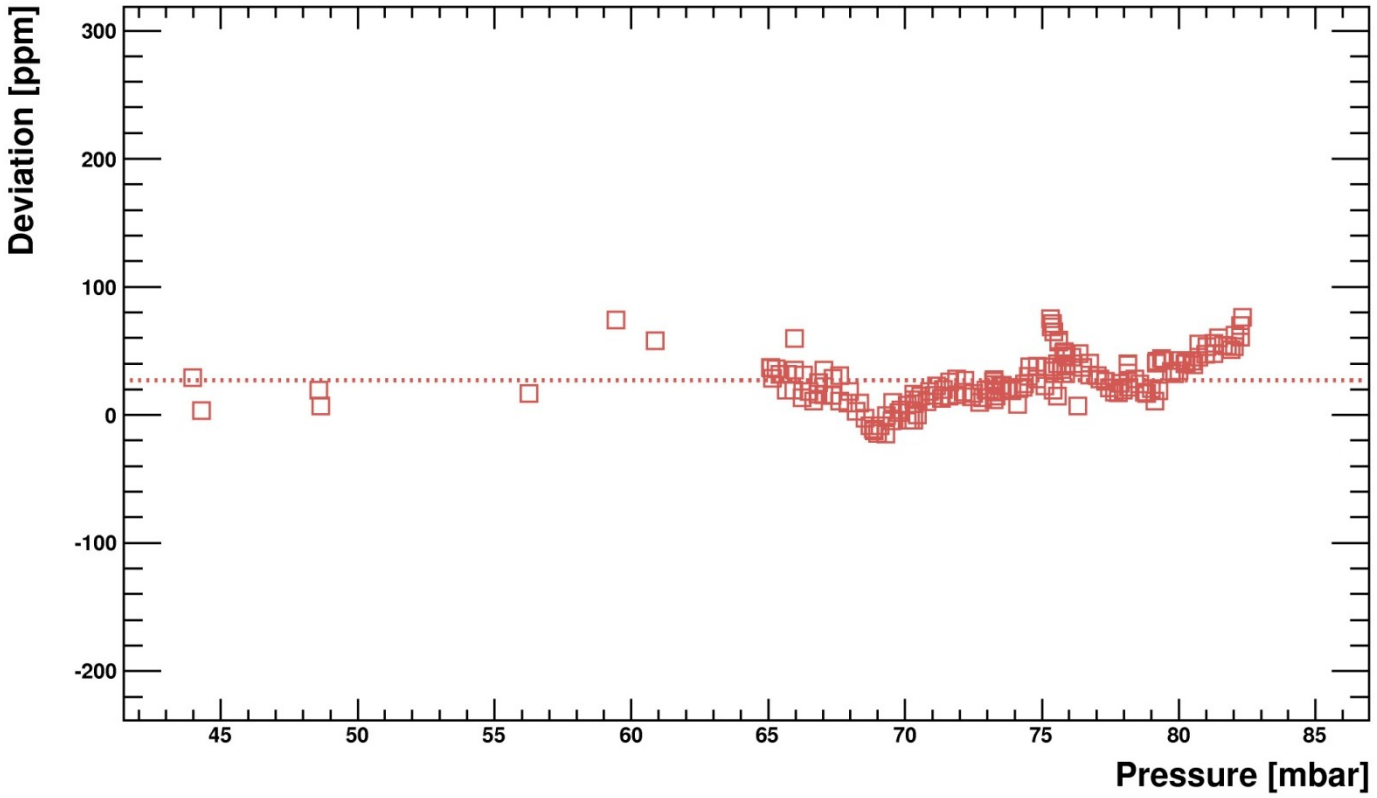


Density in the center of the cold bore at different pressures

CAST 3HE SIMULATIONS

CFD simulations. Heated windows @ 15K

Real Gas: Peng-Robinson state equation



Data validaton

CAST EXPOSURE

Calculation of the effective axion mass at CAST

Apply results from CFD simulations to the specific boundary conditions of the data taking periods

Take as input of the value of pressure in the cold bore, translating it to P@1.8K

Instant effective masses at CAST

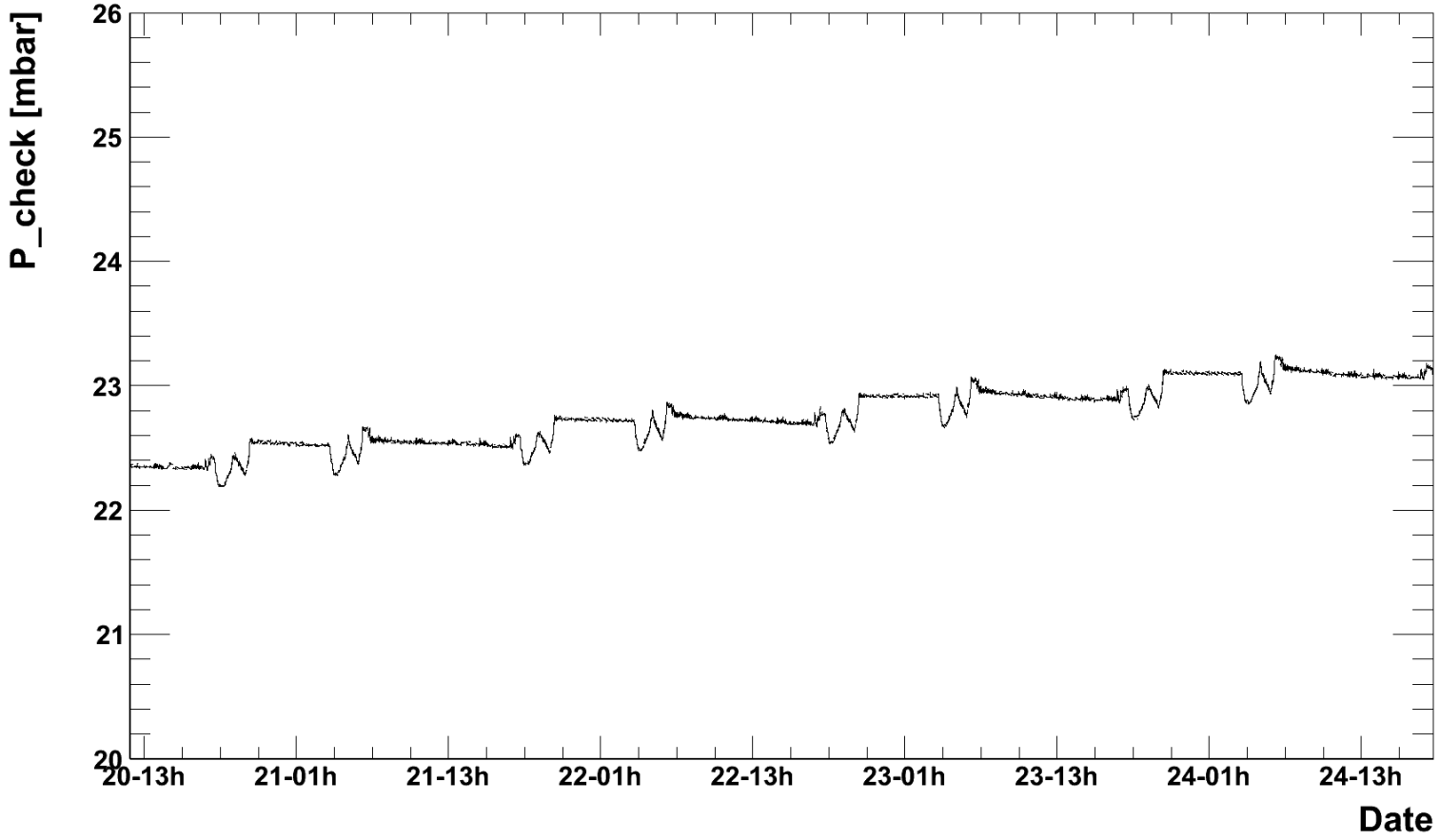
The pressure of the cold bore drifts during tracking.

The tilting of the magnet while Sun tracking modifies hydrostatic and buoyancy conditions affecting the density profile inside the cold bore

First approach to include such effects it o apply the instant values of P@1.8K while the movement of the magnet takes place

In-tracking scan

CAST EXPOSURE



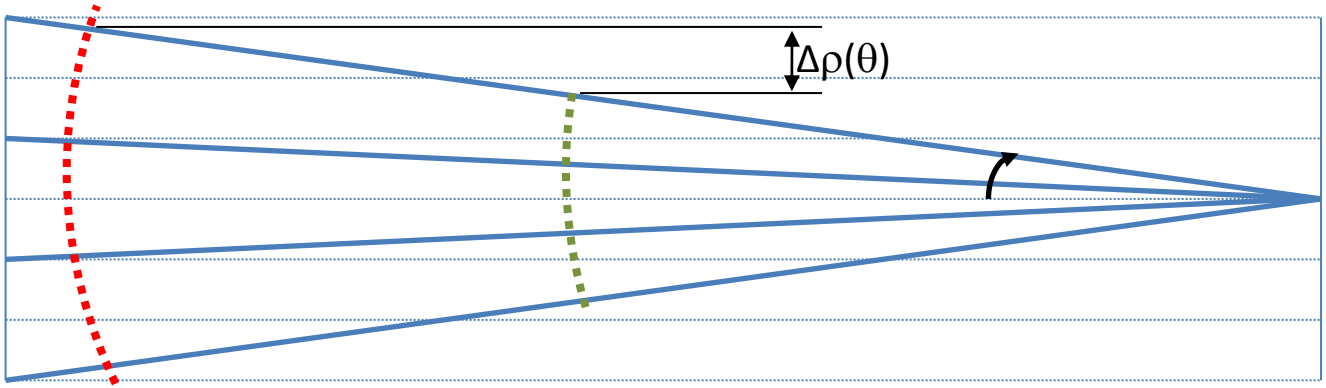
SYSTEMATIC ERROR CORRECTION

Correction to instant effective masses at CAST

The pressure measured in the cold bore is taken at the MRB side.

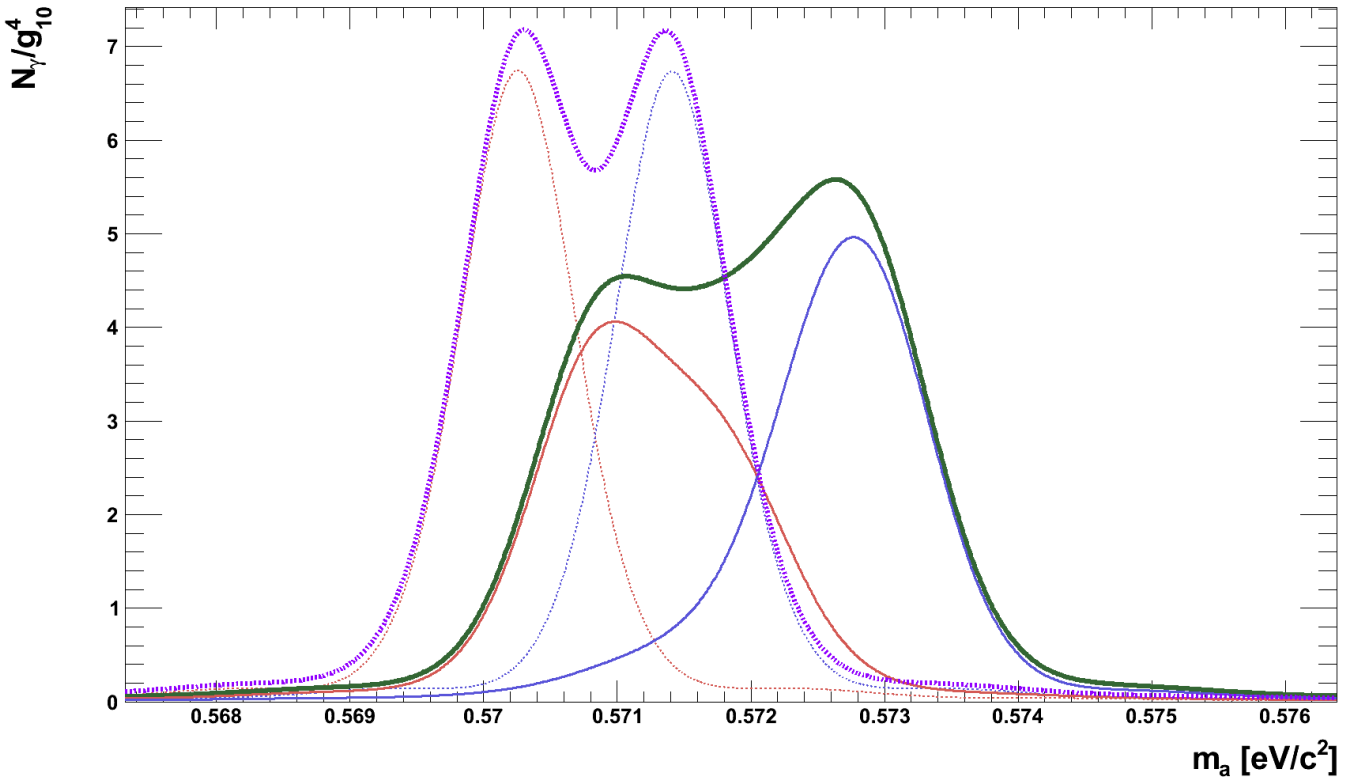
Movement of the magnet displaces the sensor a range of ±2 meters

Hydrostatic effects to cold bore pressure measurements provoke systematic errors in the tuned masses



CAST EXPOSURE

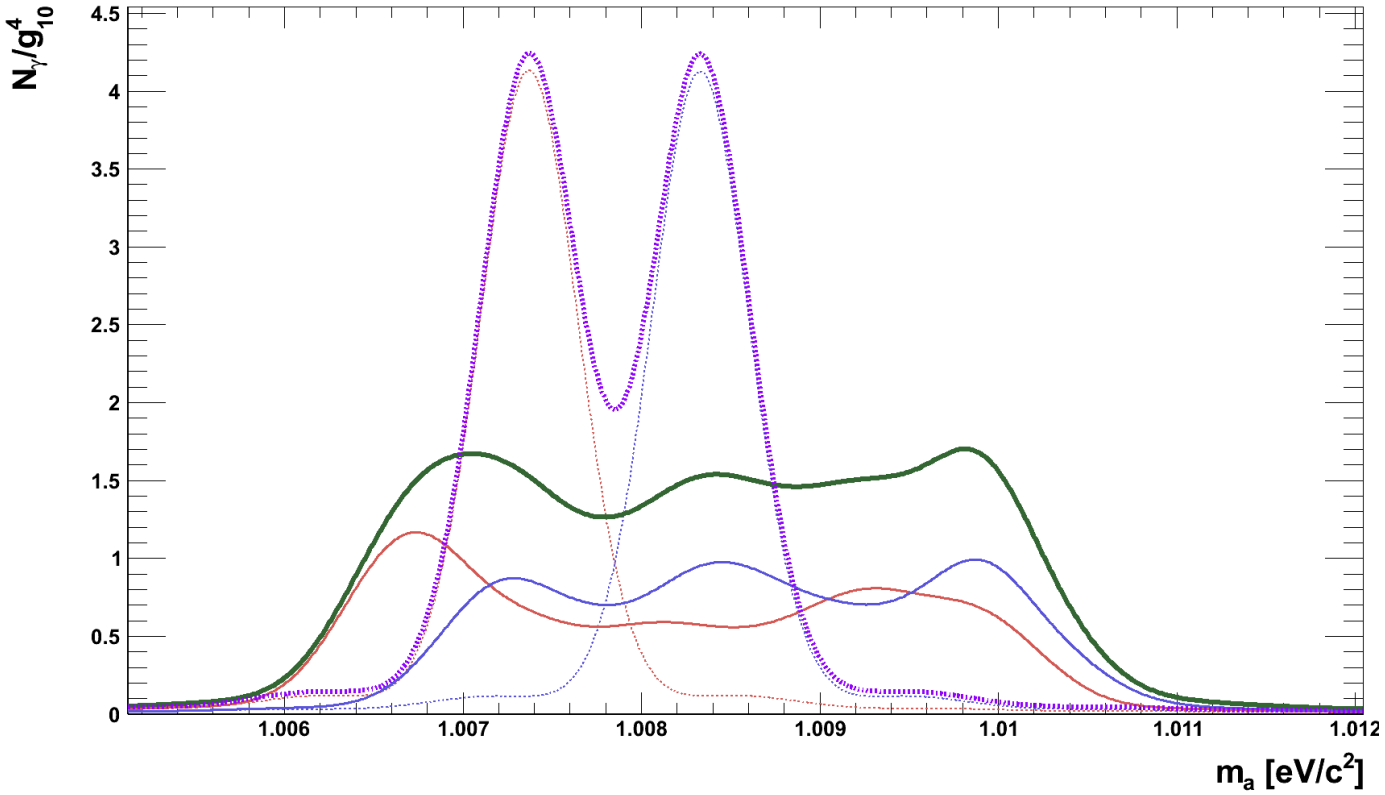
Consecutive settings after correction



Cold windows. Mid-low pressure

CAST EXPOSURE

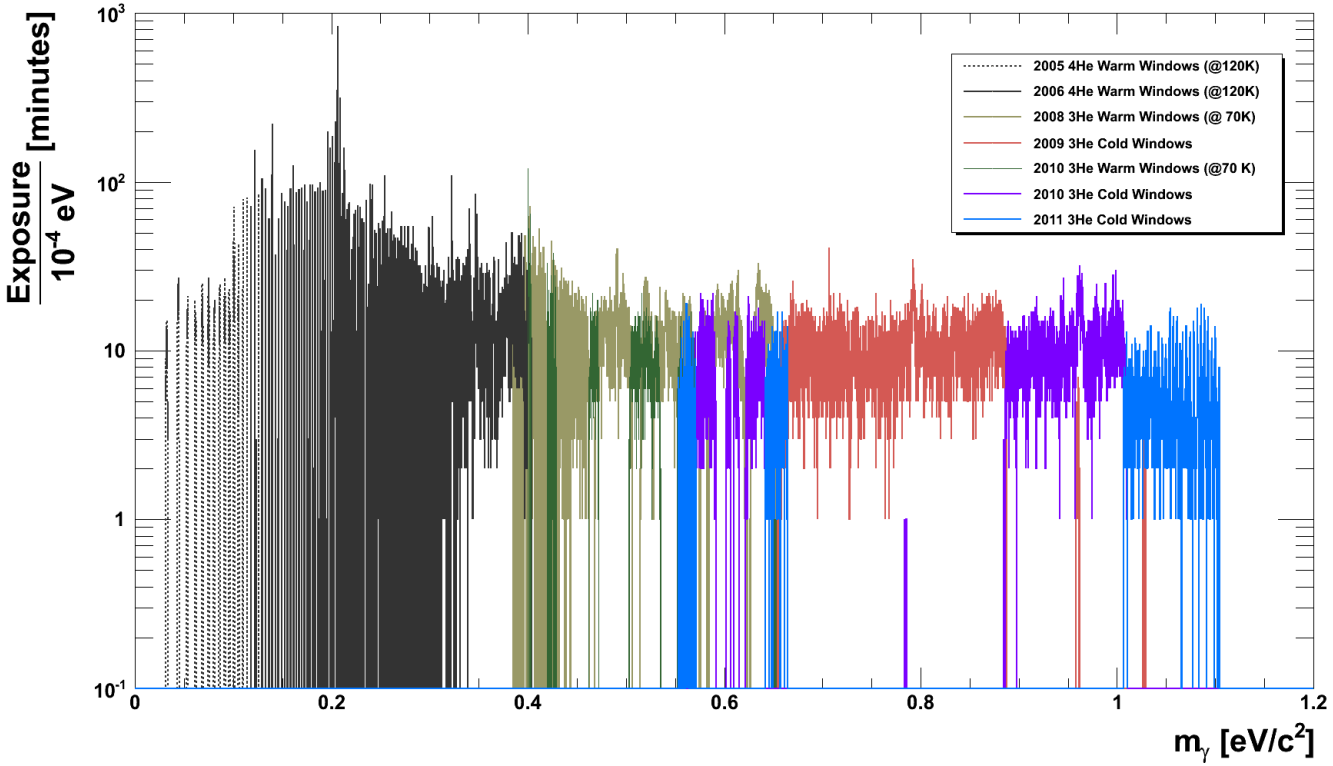
Consecutive settings after correction



Cold windows. High pressure

CAST EXPOSURE

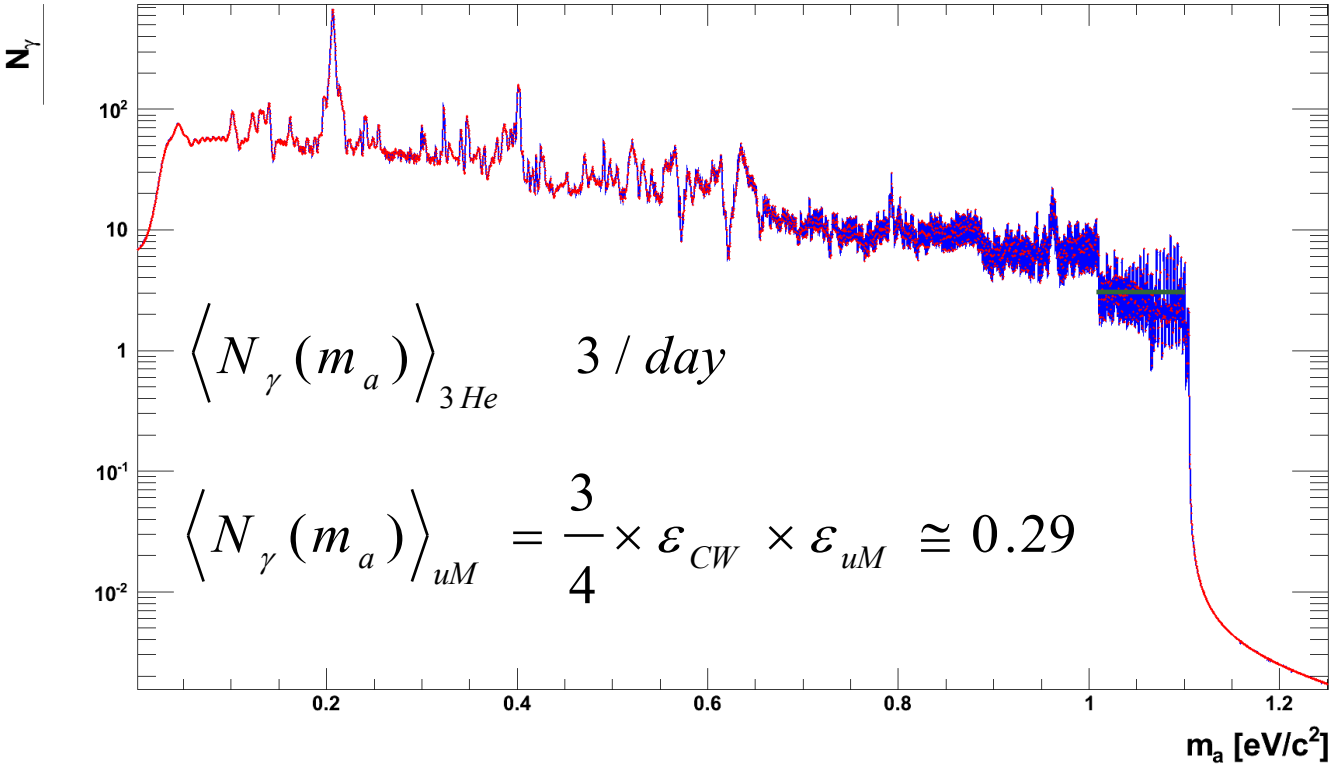
Effective photon masses tuned at CAST after GAP covering



Contribution from the different data taking periods

CAST EXPOSURE

Expected photons from Primakoff conversion



Simulated conversions after GAP covering

THANK YOU