Search for anomalous couplings in the HWW vertex with the ATLAS detector at LHC
ATLAS Hadronic Tile Calorimeter caesium calibration

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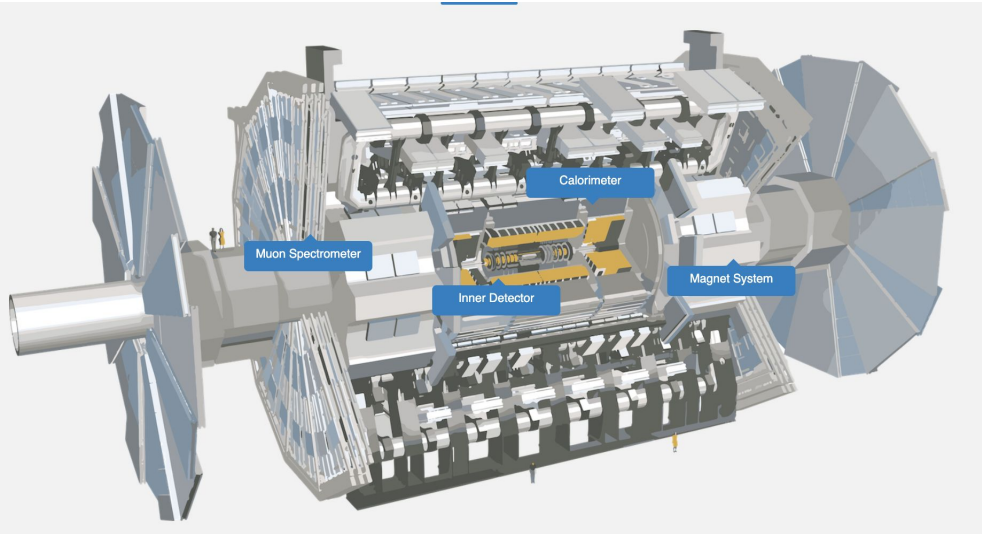
Outline

- **ATLAS experiment**
- **Physics:** Search for anomalous couplings in the HWW vertex
- **Operation:** Hadronic Tile Calorimeter (TileCal) caesium calibration

ATLAS experiment

Forward-backward symmetric cylindrical geometry and a near **4π coverage** in solid angle.
ATLAS consist of:

- **The inner tracking detector** (silicon pixel,silicon microstrip and transition radiation tracking detectors, surrounded by
- thin superconducting solenoid (2T),
- **Lead/liquid-argon sampling calorimeter**
- **Steel/scintillator-tile hadron calorimeter**



- **The Muon System** surrounds calorimeters and based on three large superconducting air-core toroidal magnets (2-6 T m) . It includes precision tracking chambers and fast detectors for triggering.
- **Two -level trigger system**: hardware (rate below 100kHz) and software-based trigger (1kHz on average)

Search for anomalous couplings in the HWW vertex

Motivation

- **Matter-antimatter asymmetry problem**
- One of the three Sakharov conditions to explain baryon asymmetry: **Charge-Parity (CP) violation**
- **Standard Model (SM) Higgs boson CP-even**
- **CP even/odd mixing is still possible**

Search for CP violation in Higgs boson interactions

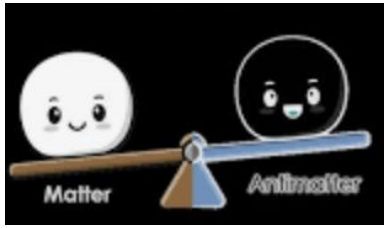
- CP-odd contributions may enter only at higher orders terms and be suppressed by powers of $1/\Lambda$
- **SM effective field theory (EFT) approach**

CP-even

$$|\mathcal{M}|^2 = \left|\mathcal{M}_{SM} + \sum_i \frac{c_i}{\Lambda^2}\mathcal{M}_{BSM,i}\right|^2$$
$$= |\mathcal{M}_{SM}|^2 + 2\sum_i \frac{c_i}{\Lambda^2}\Re\left(\mathcal{M}^*_{SM}\mathcal{M}_{BSM,i}\right) + \sum_i\sum_j \frac{c_i c_j}{\Lambda^4}\Re\left(\mathcal{M}^*_{BSM,i}\mathcal{M}_{BSM,j}\right)$$

CP-odd

CP-even



Latest ATLAS/CMS measurements:

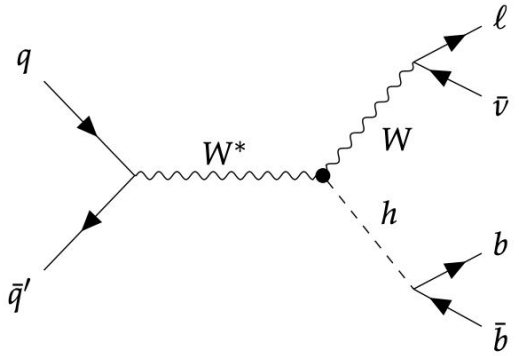
- VBF, $H\to\gamma\gamma$
- VBF ,$H\to WW^*\to e\nu\mu\nu$
- $H\to ZZ^*\to 4l$
- $H\to\tau\tau$

EFT approach:

- Dim-6 CP-odd operators
- Measure the couplings: **Wilson coefficients c_i**
- **CP-odd sensitive observable**

Search for anomalous couplings in the HWW vertex

- Probe specifically **HWW vertex**
- **Better sensitivity** than H → WW*
- Cross-section measurements with **EFT interpretation in the Warsaw basis**
- **Constraint on Wilson coefficients**



Ongoing analysis:

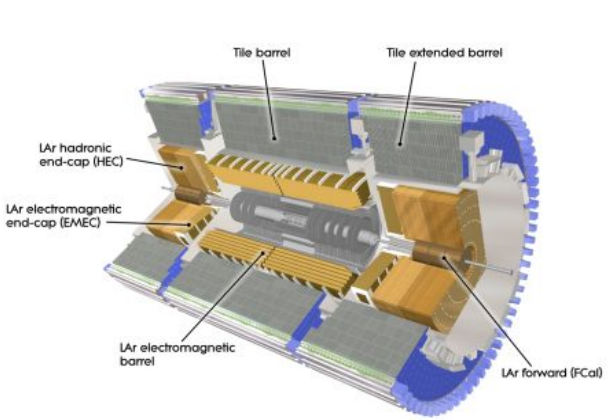
- **ATLAS Run 2 data** (2015-2018)
- **CP-odd sensitive angular observable**
- Get inclusive WH→bb signal strength
- Cross-section measurements in W-boson transverse momentum and angular observable bins
- **Constraint on the coupling $C_{Hw\tilde{}}$**
- More details in Ricardo Barrué talk

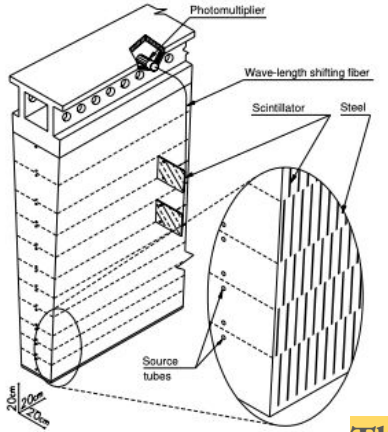
Next steps:

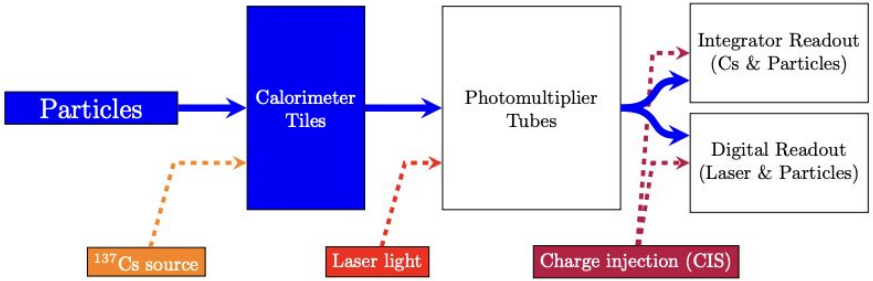
- ATLAS **Run 2 + Run 3 (partial Run 3)** data (2022-2026)
- **Angular observables or NN-based optimal observables**
- **combined constraints on CP-even and CP-odd** anomalous couplings: C_{HW}, $C_{Hw\tilde{}}$, $C_{Hq(3)}$

TileCal cesium calibration

Hadronic tile Calorimeter





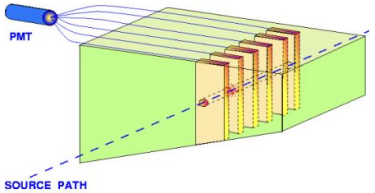


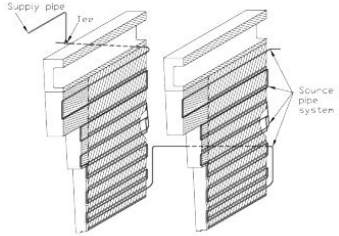
- Particle, jet and missing transverse energy measurements
- **Three segments with 64 modules**
- **Absorber:** steel plates (14 mm)
- **Active material:** organic scintillator (3 mm)
- **The tiles** - along the radius from the beam pipe (11 tile rows of different size).

Three calibration systems: the electronic charge injection system, the cesium radioactive γ-source system and the laser system;
The cesium and laser systems - the degradation of the TileCal signals due to their exposure to a high radiation level

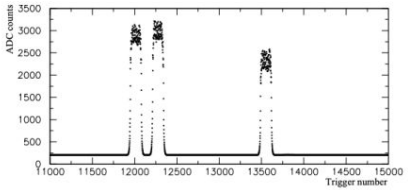
$$E[GeV] = \frac{A[ADC]}{f_{pC\rightarrow GeV} f_{Cs} f_{Las} f_{ADC\rightarrow pC}}$$

Caesium calibration



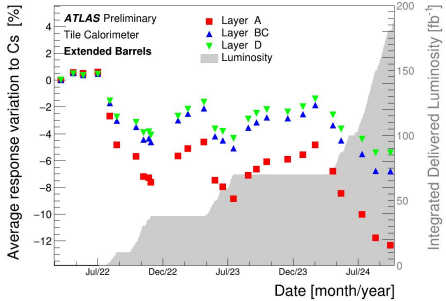


Capsule with caesium source

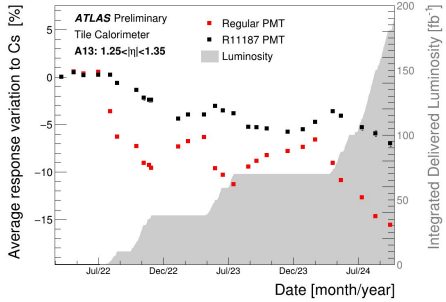


- Caesium γ-source propelled by hydraulic system
- Traverse all modules, deposit the energy of γ-ray
- To monitor the whole optical path
- Requires 6-8 hours without pp collisions (scintillating tiles, fibers, PMT)
- One scan per month: the caesium constants are updated in DB during data-taking and for data reprocessing

Caesium response variation for 3 radial layers



Caesium response variation for the most affected cell



Thank you!