ICHEP Conference 2020

Cosmic and atmospheric background stability with (stopping) muons in the SoLid experiment

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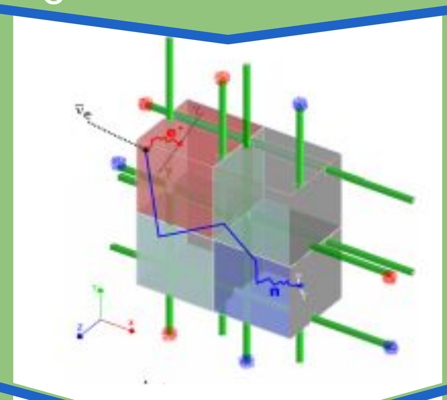
SoLid
GHENT UNIVERSITY

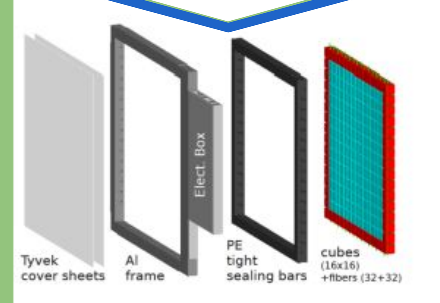
The SoLid Detector [1]

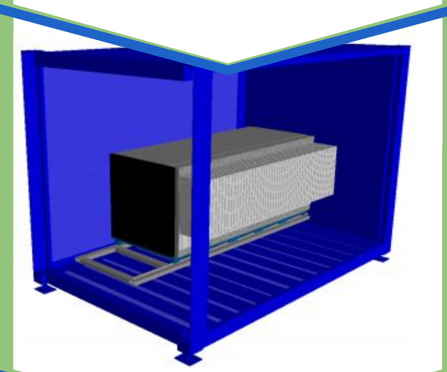
- 12800 Cubes
  - PVT → EMs (e/γ/μ)
  - ^{6}LiF:ZnS(Ag) → neutrons
- 50 Planes
  - 16x16 cubes
  - 64 wavelength shifting fibres
  - Fibres read out with SiPMs
- Detector
  - 5 modules of 10 planes each
  - Cooled to ~10℃

IBD Interaction

$\bar{\nu}_e + p \rightarrow e^+ + n$



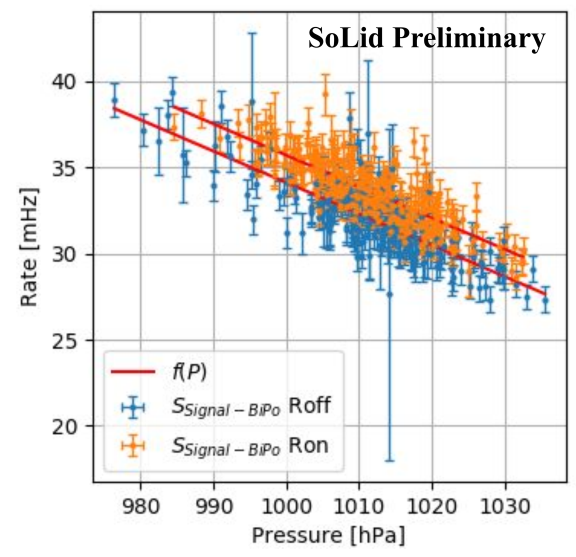




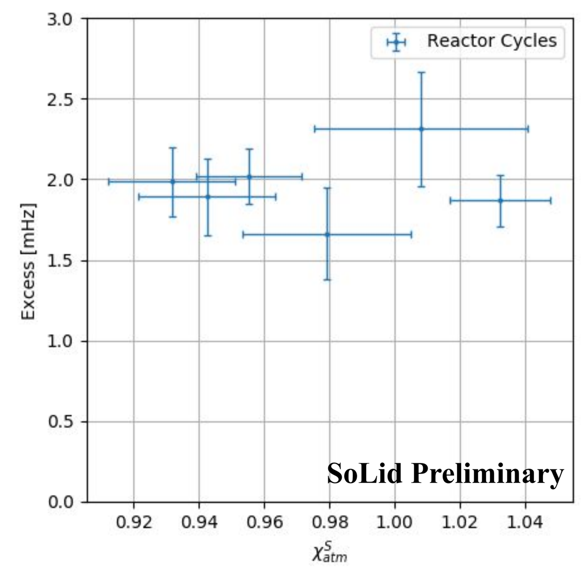
Goals:
- Measure neutrino oscillations at a 5-10m baseline
- Measure ^{235}U anti-neutrino energy spectrum

Atmospheric Background

- Cosmic particles are the main source of background for reactor neutrino experiments with low overburden
- The IBD selection ($S_{Signal\ -\ BiPo}$) is parametrized with the atmospheric pressure
- Subtract reactor on from reactor off to get IBD excess



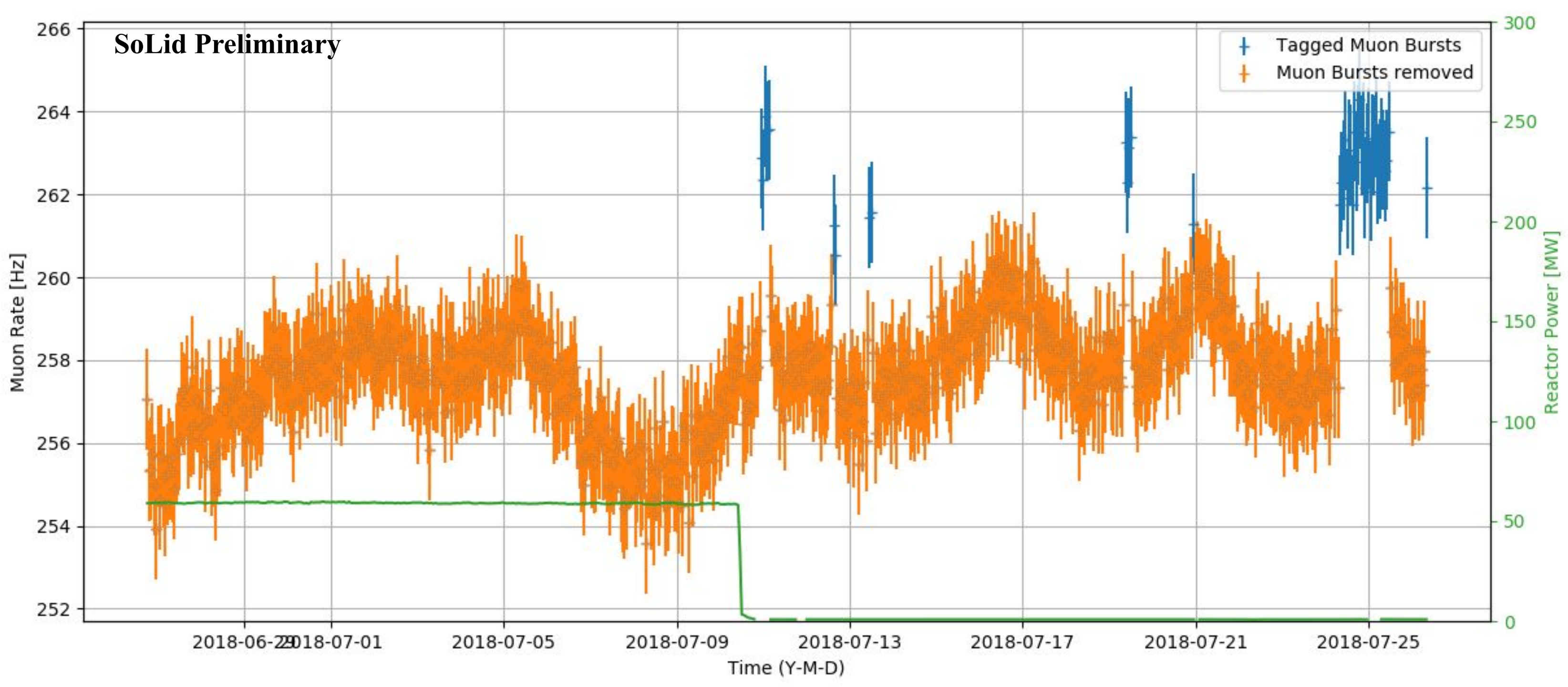
- Define independent atmospheric selection (S_{atm})
- Ratio between reactor on and off (χ^{S}_{atm}) gives atmospheric asymmetry for each reactor cycle ➪ excess is stable



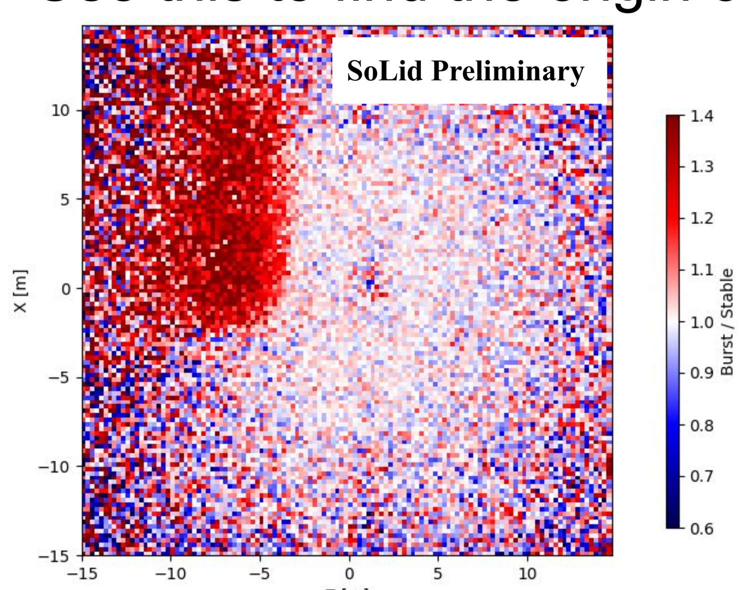
- Check the stability of the background with muon signals too

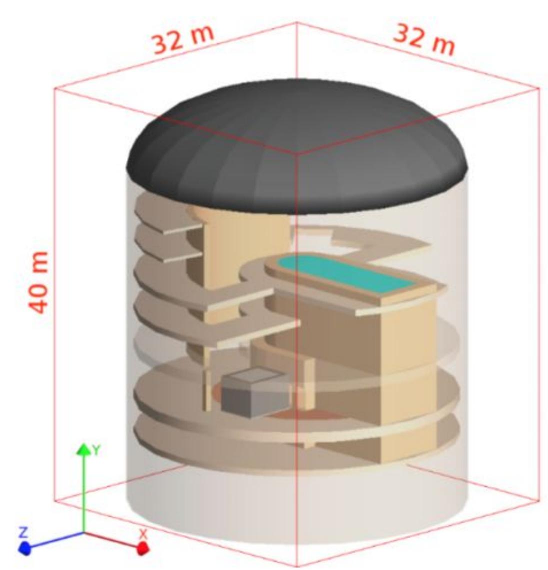
Muon Trending

- Follow up muon rate variations during data taking
- Variations due to changes in atmospheric conditions observed
- But, also sudden bursts are observed



- SoLid detector is perfectly fit for muon tomography
- Use this to find the origin of the muon bursts





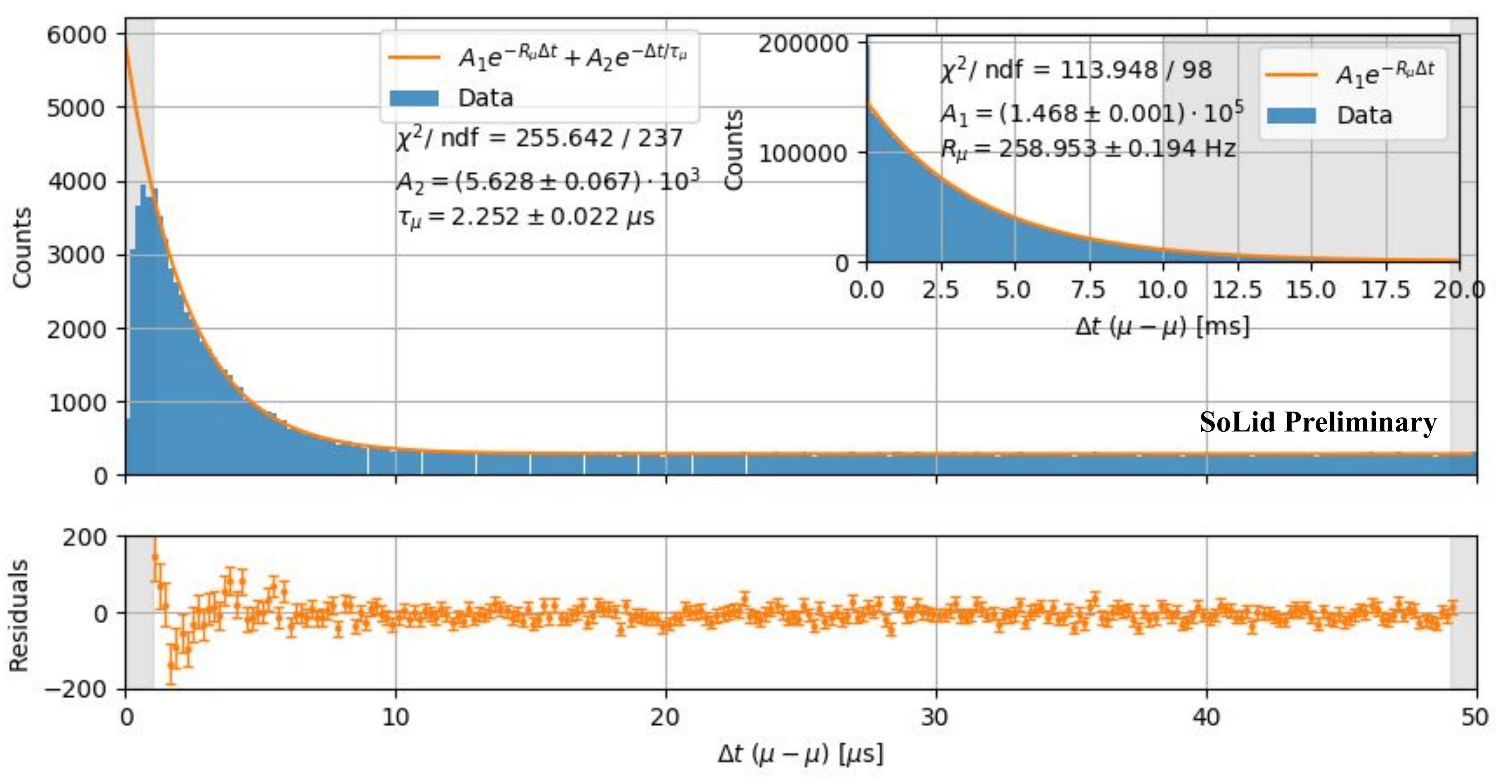
- Direction of the bursts matches with position of the reactor pool
- Reactor pool is drained multiple times during reactor off period, which results in removal of passive shielding of detector

Stopping Muons

- Muons can stop inside detector after losing their energy
- Decay creates a Michel electron and two neutrinos

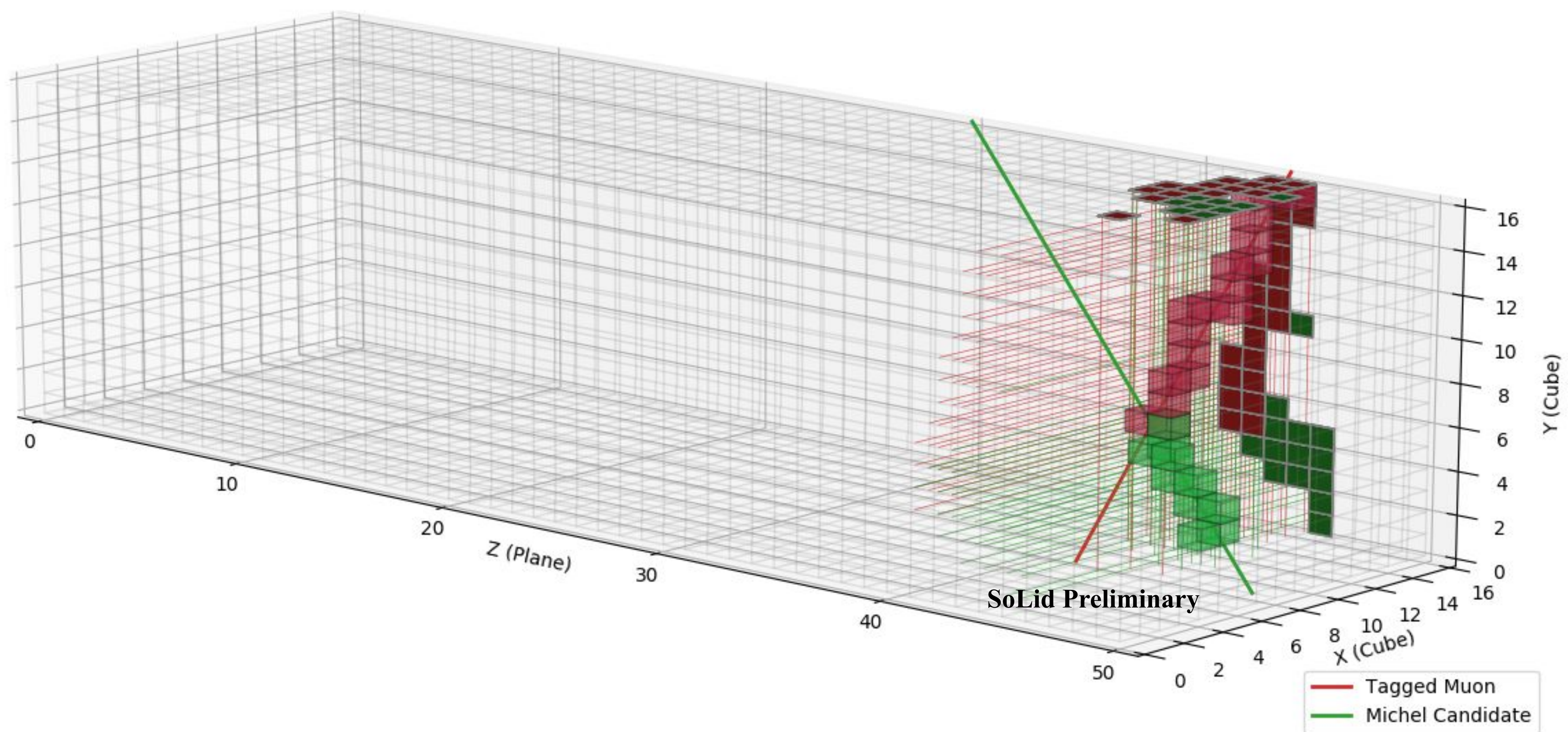
$$\mu \rightarrow e + \nu_e + \nu_\mu$$

- Due to the track like nature of a Michel electron, it will get reconstructed as a muon
- The time difference between muons will therefore have two contributions:
  - At the milliseconds scale, an exponential for the muon rate
  - At the microseconds scale, an exponential for the muon decay



- Decay time in good agreement with literature:
  τ = [2.1969811 ± 0.000002] μs

- Event view of muon decay inside the SoLid detector



Outlook and Conclusions

- Atmospheric background is parametrized with pressure
- Muon trending can identify changes in the reactor pool
- Stability background is ensured by removing data during bursts
- Muons mean energy loss per distance also used for stability [2]
- Stopping muons are well identified in the SoLid detector
- Investigation to probe background stability with stopping muons on going

[1] arXiv:1703.01683 / arXiv:1806.02461 [2] arXiv:2002.05914