SoLid

Recent results from the SM1 run

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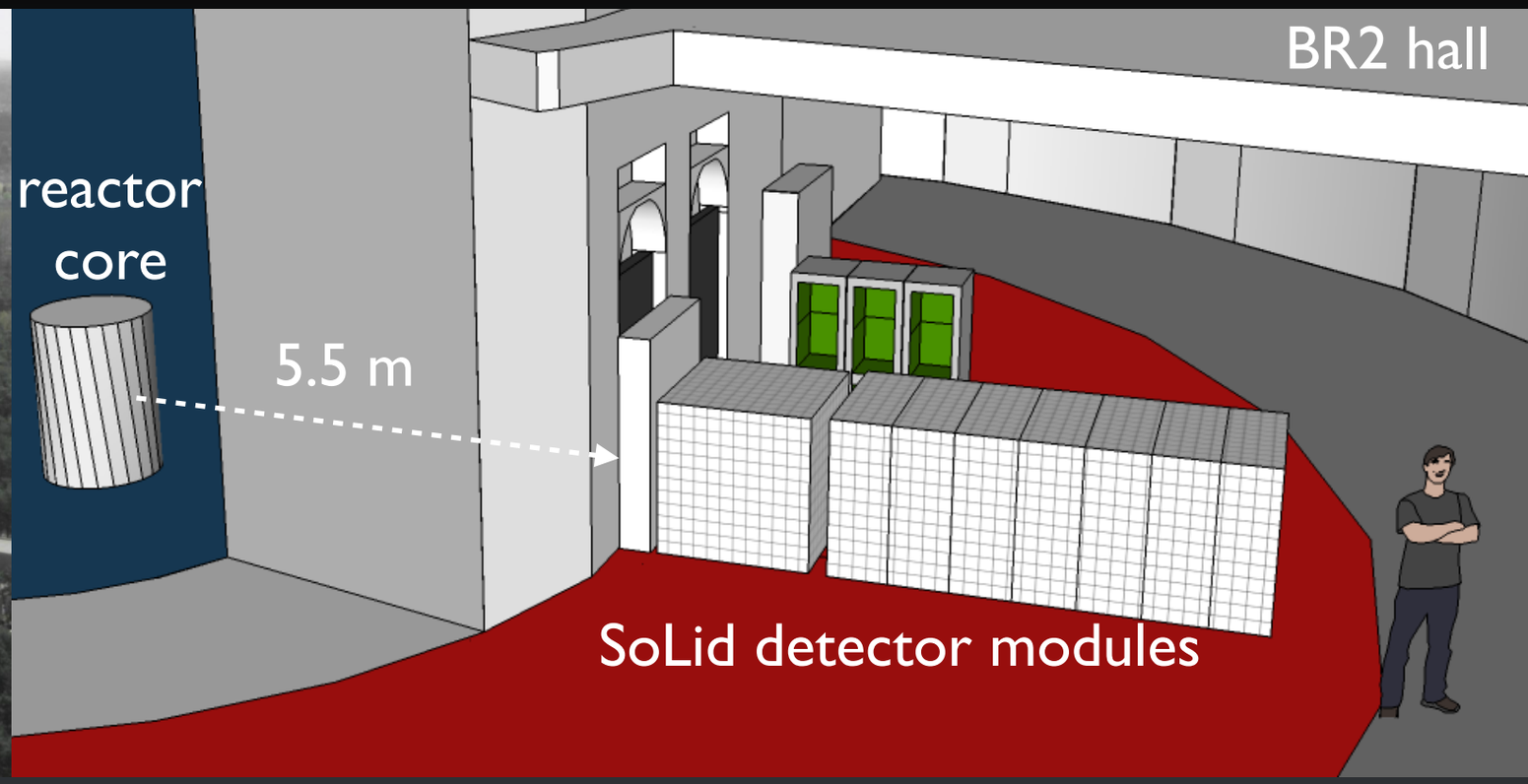
for the SoLid collaboration

AAP 2015
Arlington, Virginia, USA

Outline

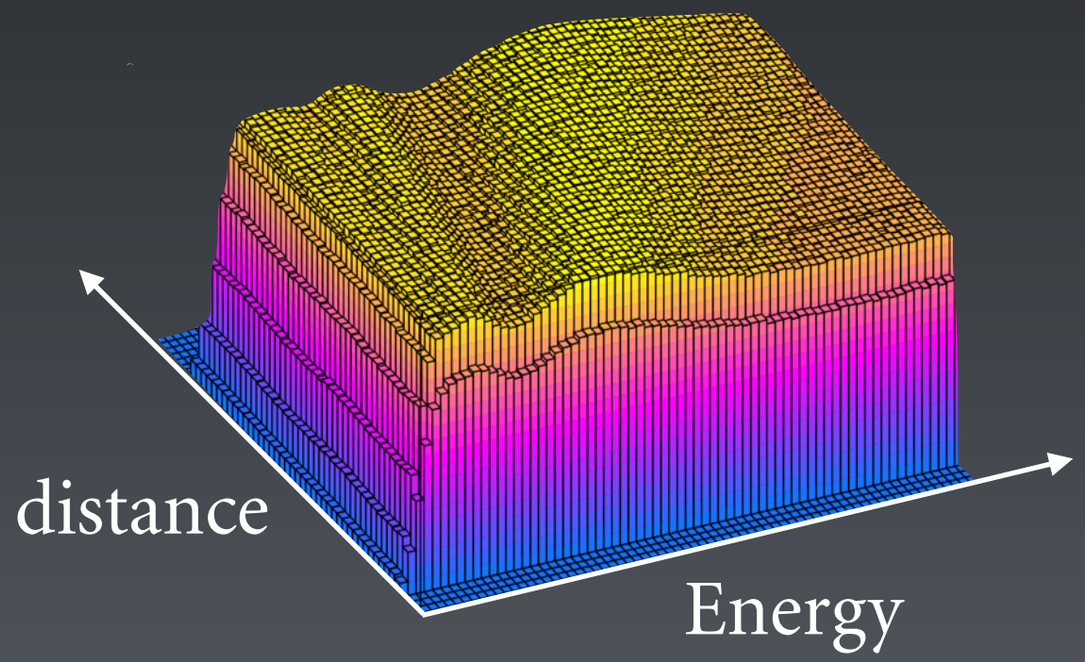
- The SoLid experiment & technology
- New results from the first SoLid module
- summary and outlook

The SoLid experiment



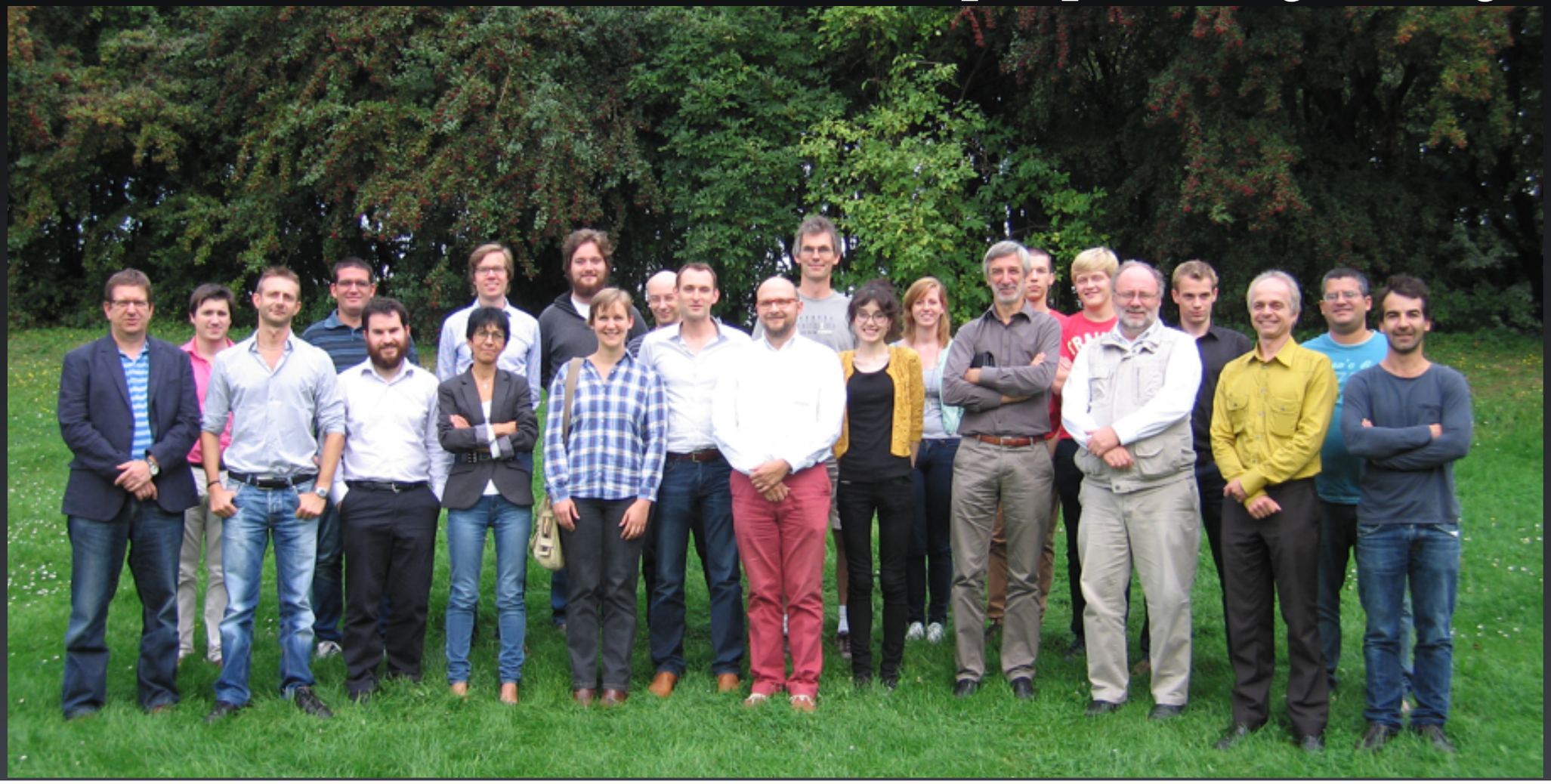
personal communication. By courtesy of SCK•CEN

- Search for new oscillation
  - Precise position and energy measurement to demonstrate oscillation
- ^{235}U flux measurement
  - improve reactor flux prediction
  - demonstrate reactor monitoring with a new generation of compact detectors



SoLid collaboration

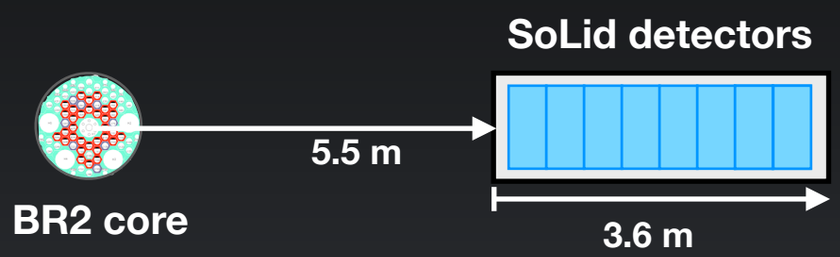
- 4 countries, 10 institutes, ~ 50 people and growing…



SCK•CEN
Universiteit Antwerpen
Vrije Universiteit Brussel
UNIVERSITEIT GENT
LAL Laboratoire de l'Accélérateur Linéaire
lpc caen
Subatech
University of Oxford
University of Bristol
Virginia Tech Invent the Future

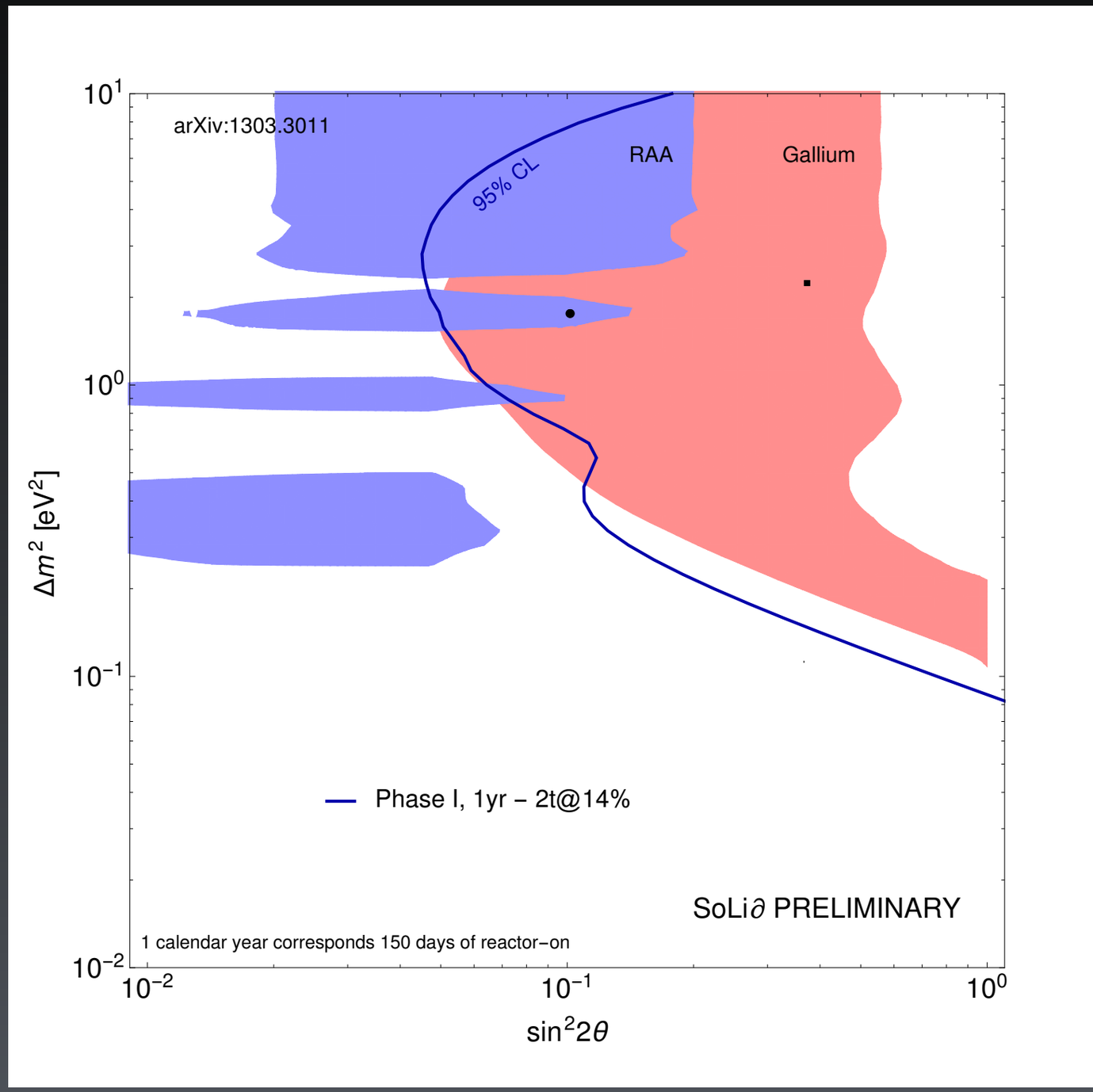
Sensitivity to a new massive neutral state

Phase I

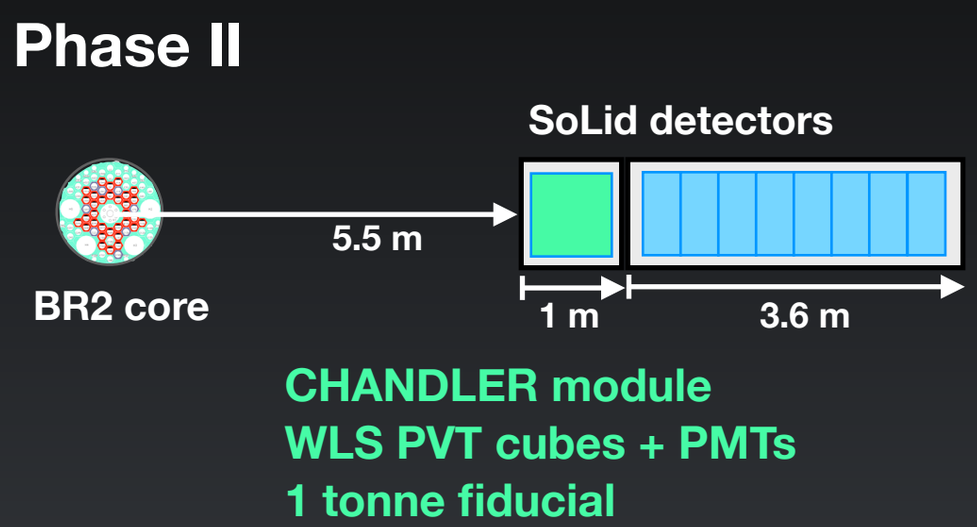


8x sub-modules
PVT cubes + WLS fibres
up to 2 tonnes fiducial

- 40% IBD efficiency
- S:B ~ 3
- Background is $1/E^2$ and flat
- 2% relative energy scale uncertainty
- shape only measurement



Sensitivity to a new massive neutral state



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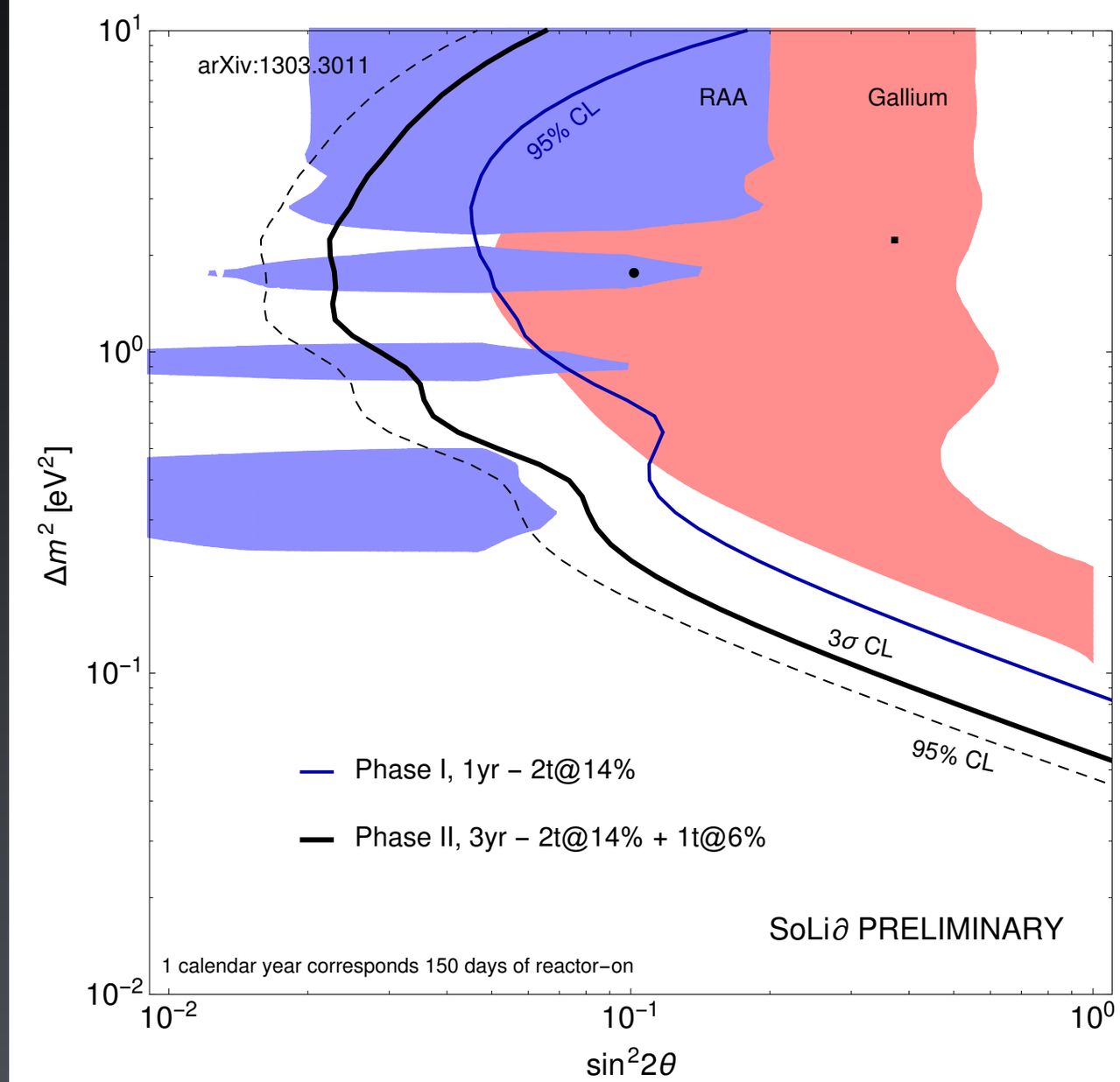


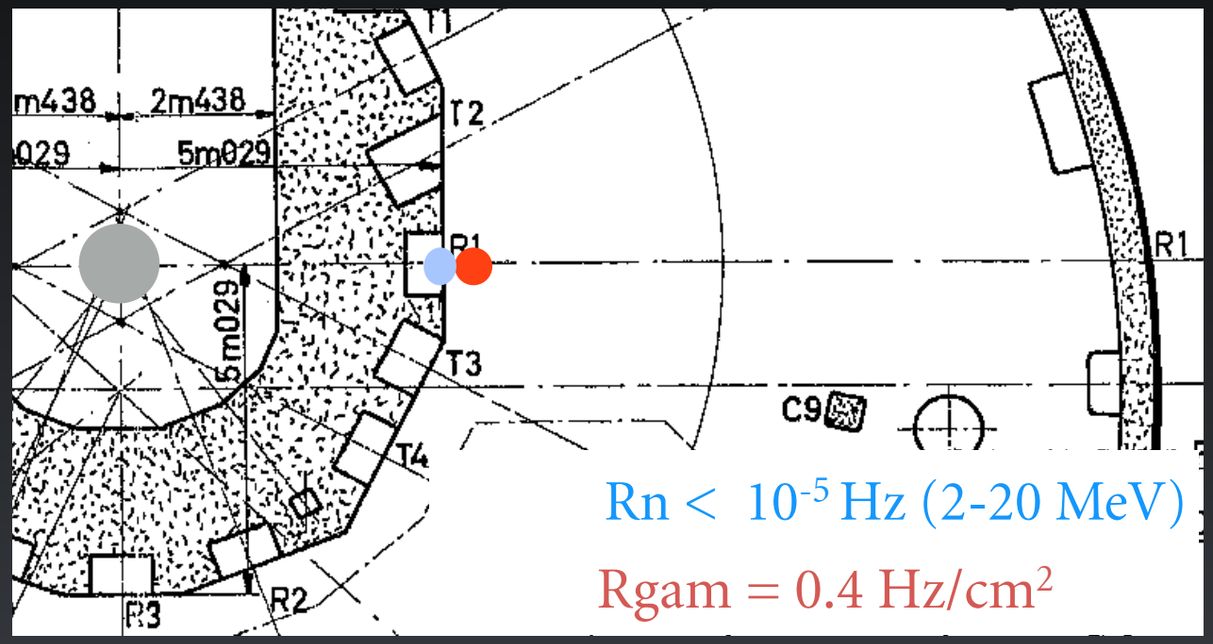
The neutrino source : BR2

Personal communication. By courtesy of SCK•CEN

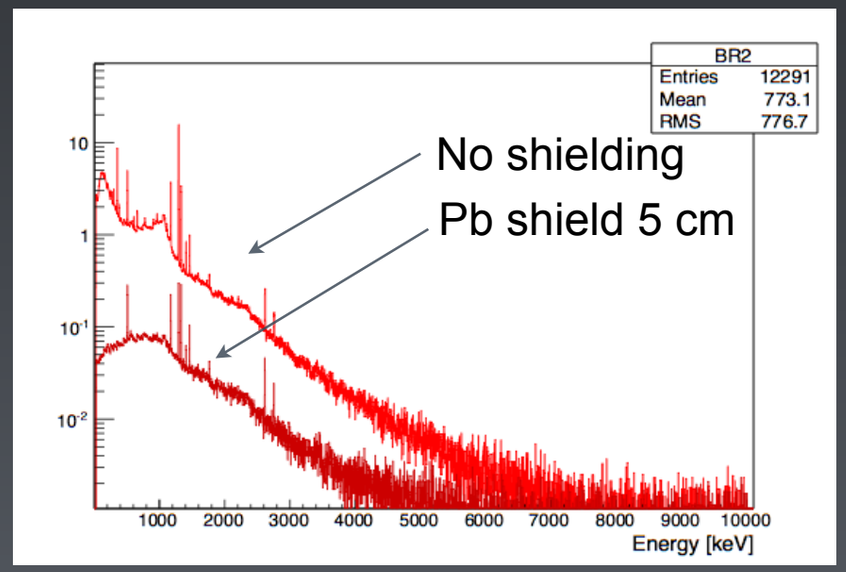
- Compact source
- Highly enriched Uranium
  - pure ^{235}U antineutrino flux
- High Power (40-80) MW
- duty cycle : 150 days / year

personal communication. By courtesy of SCK•CEN

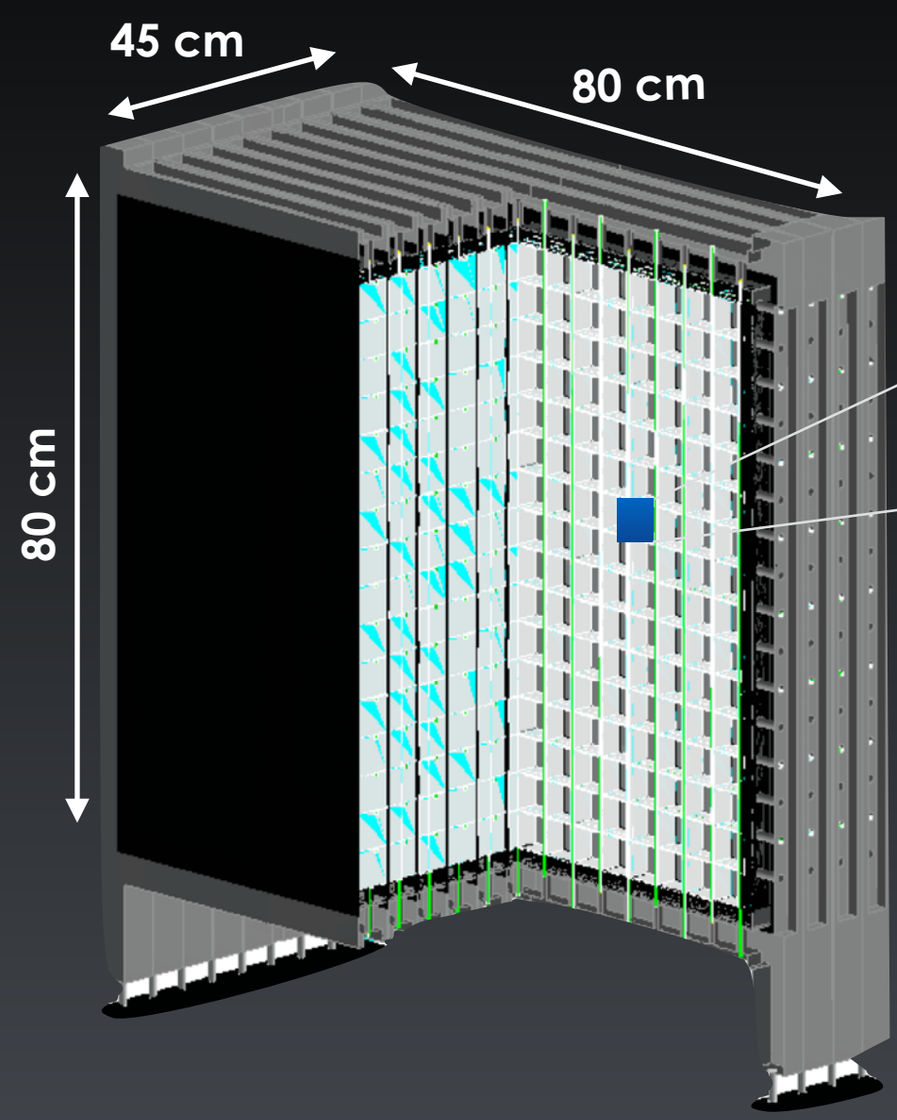
- Careful assessment of reactor backgrounds reveals low energy gamma-rays and very low neutron rate

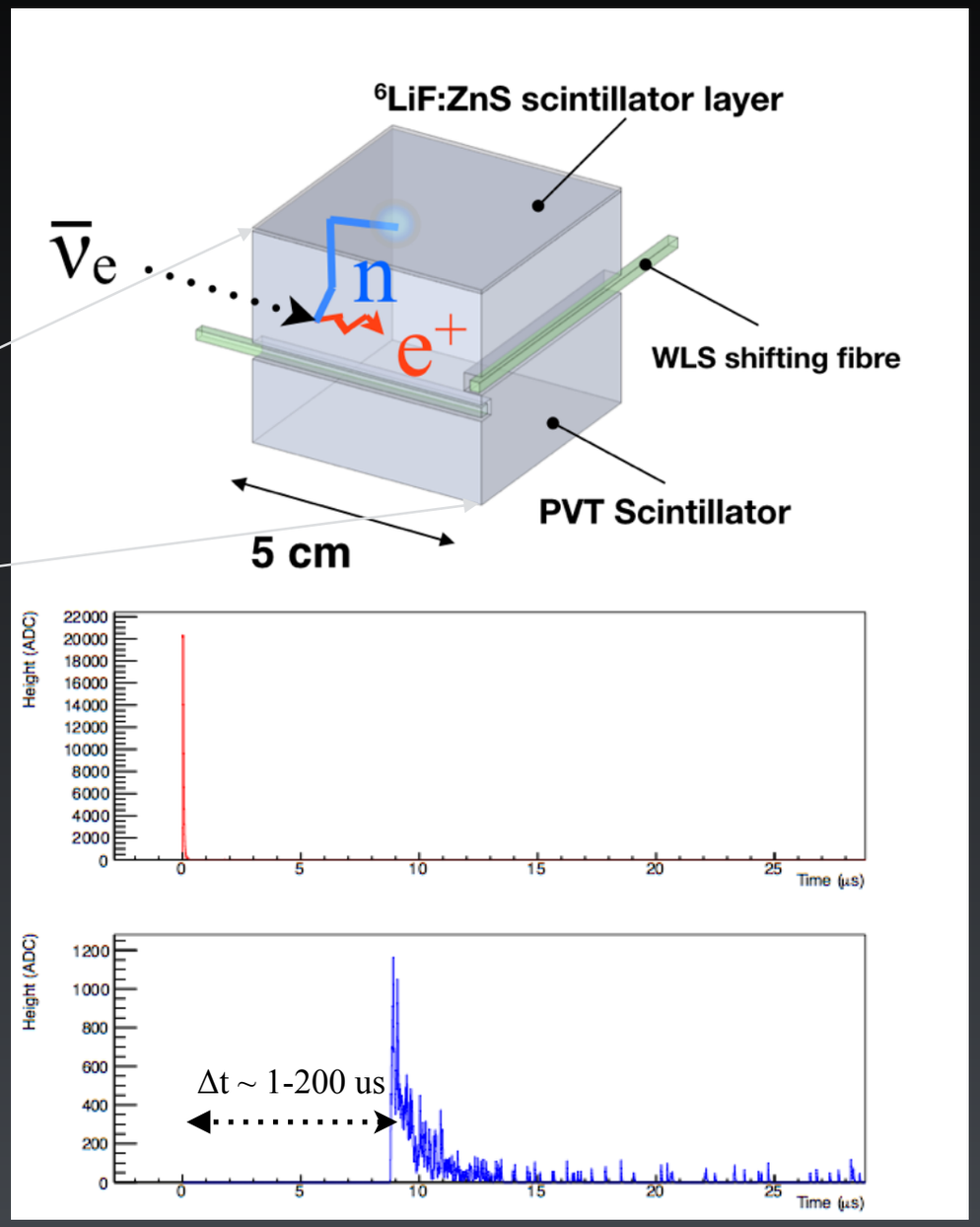


- Pth = 72 MW at R1 port 5.0 m from core



SoLid detector module SM1

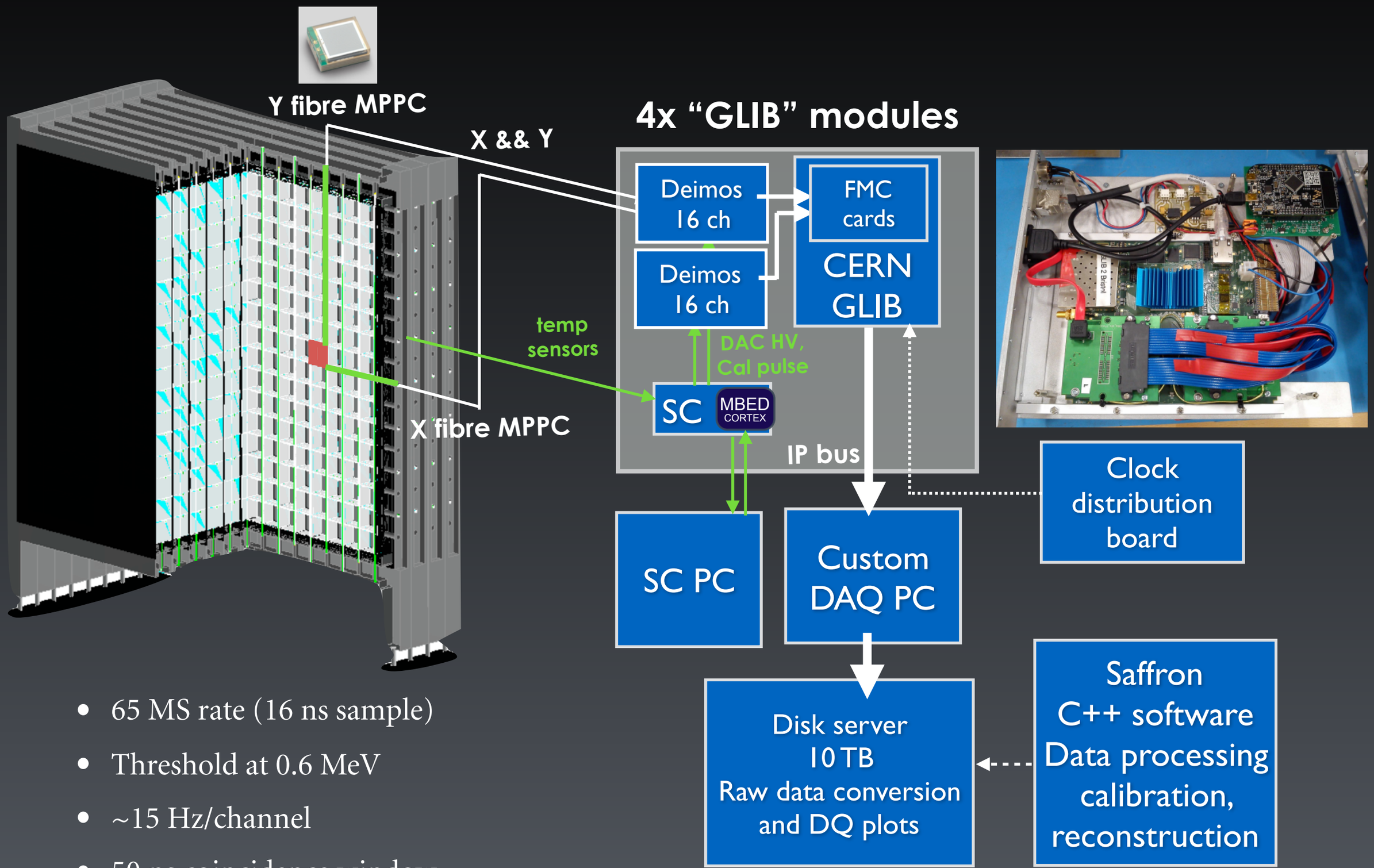




- 16 x 16 x 9 PVT cubes
- 9 detector planes
- 288 read out channels
- 288 kg fiducial mass

- Robust neutron ID
- High segmentation
  - localisation of IBD
  - positron only energy reconstruction

SM1 module DAQ & trigger

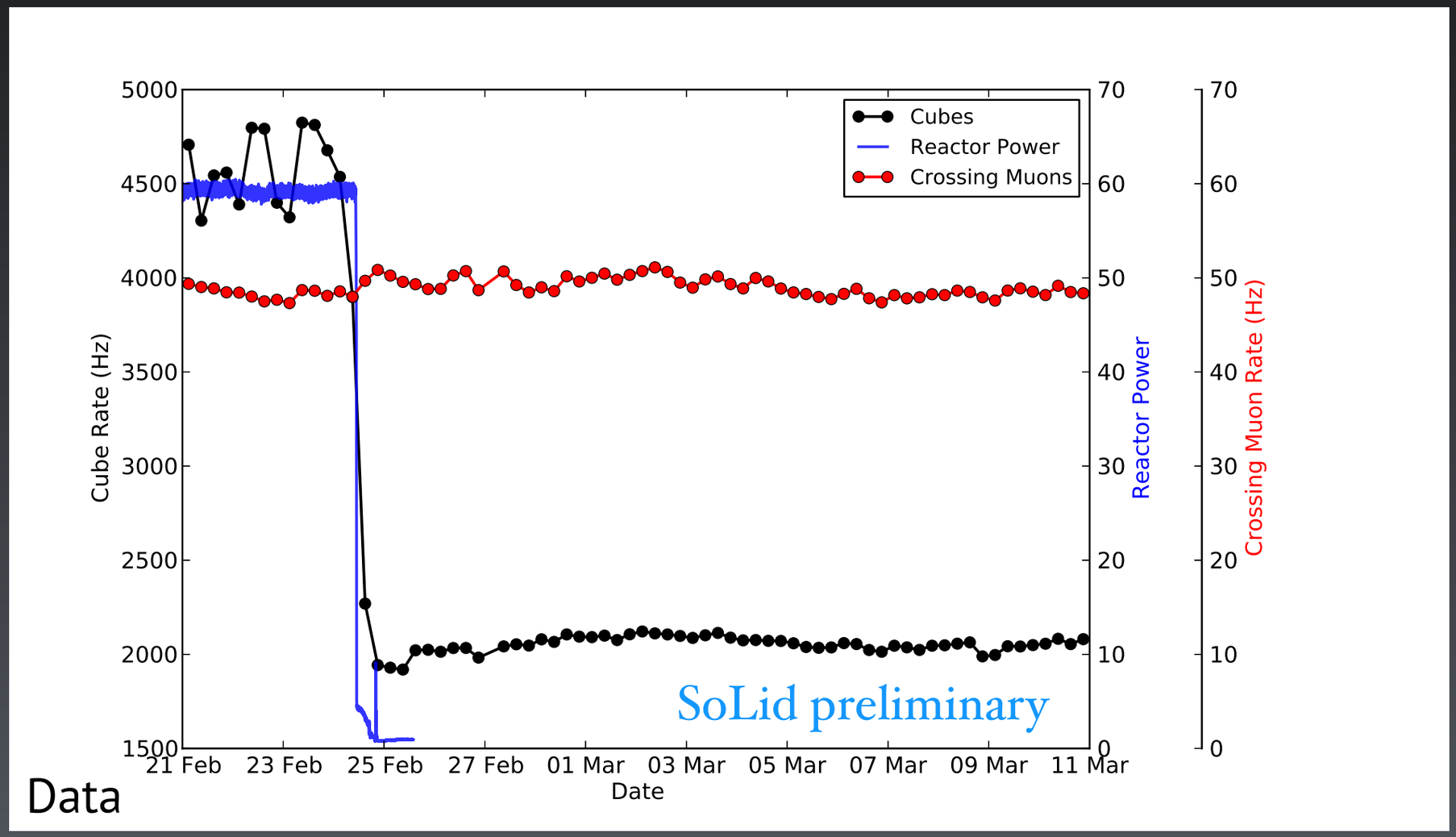


- 65 MS rate (16 ns sample)
- Threshold at 0.6 MeV
- ~15 Hz/channel
- 50 ns coincidence window

Test run at BR2

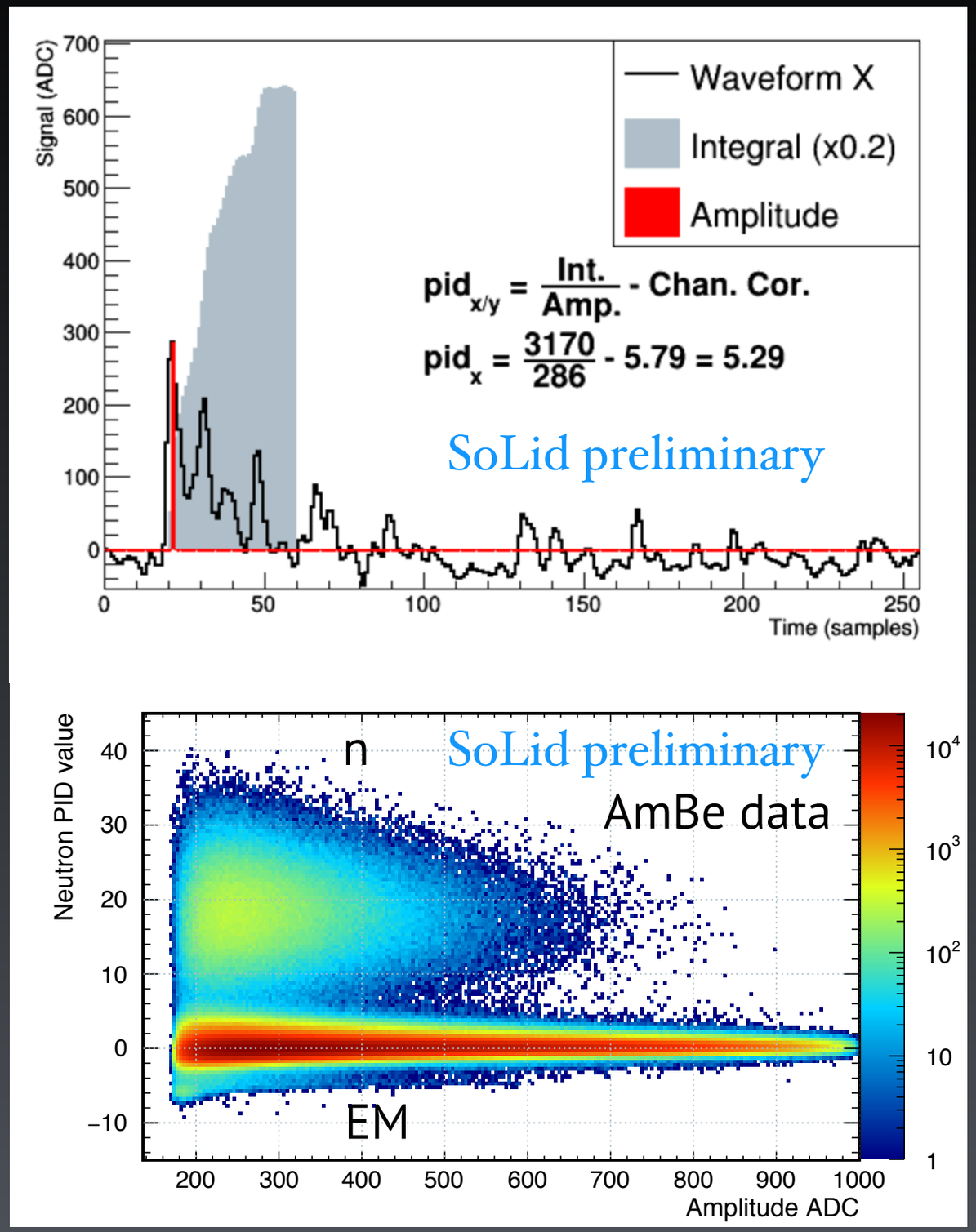
SM1 run at BR2

- SM1 run Dec 2014 - March 2015
  - 3-4 days reactor ON
  - ~ 1 month reactor OFF period in March
- Calibration with sources
  - ^{60}Co, AmBe in April 2015
  - ^{252}Cf in situ August 2015

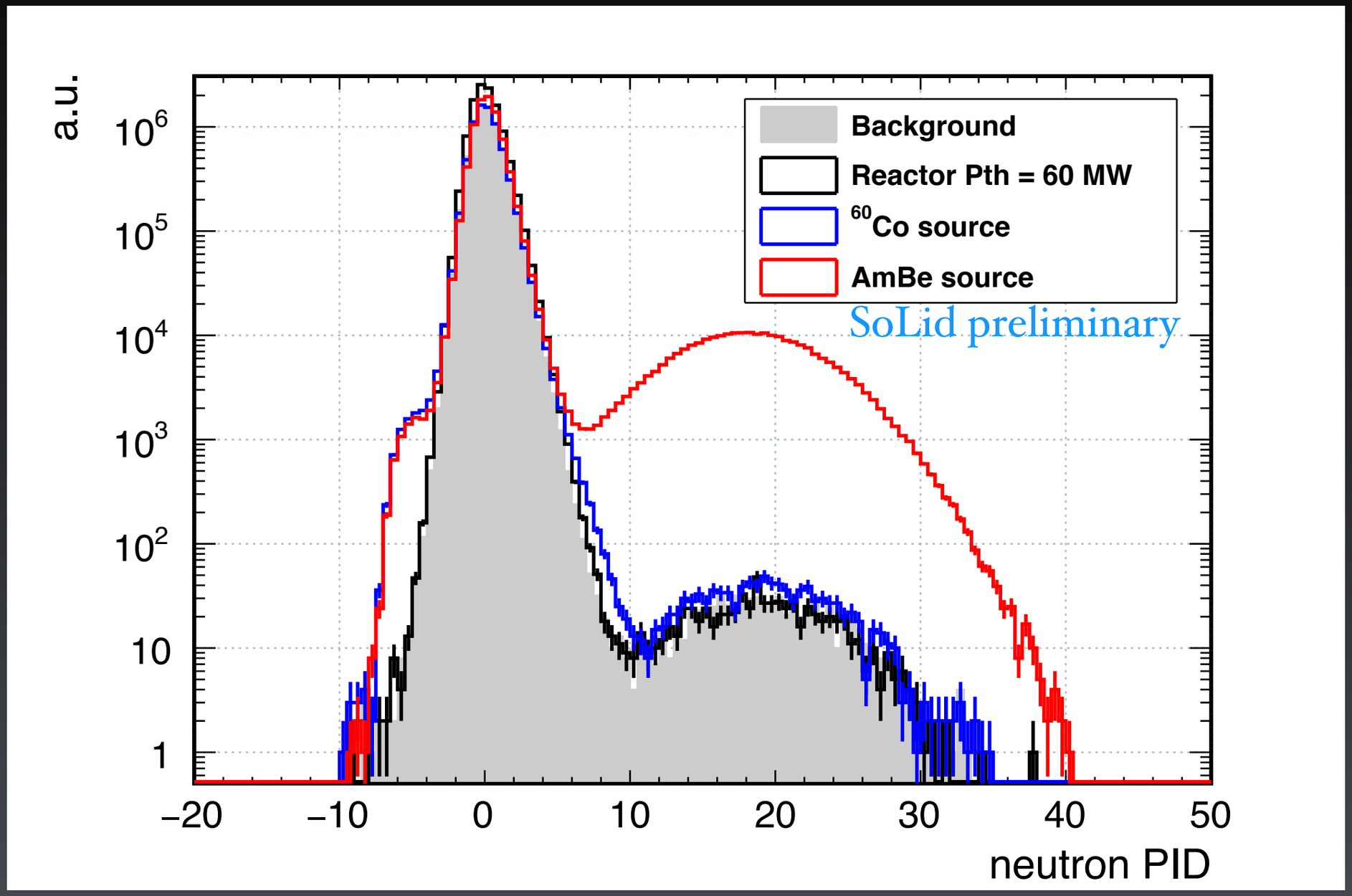


^{6}LiF:ZnS neutron identification

- Identification based on neutron pulse shape
  - proportional to integral
- Data confirms robustness of ^{6}LiF:ZnS neutron tag
  - neutron ID to be implemented in trigger decision

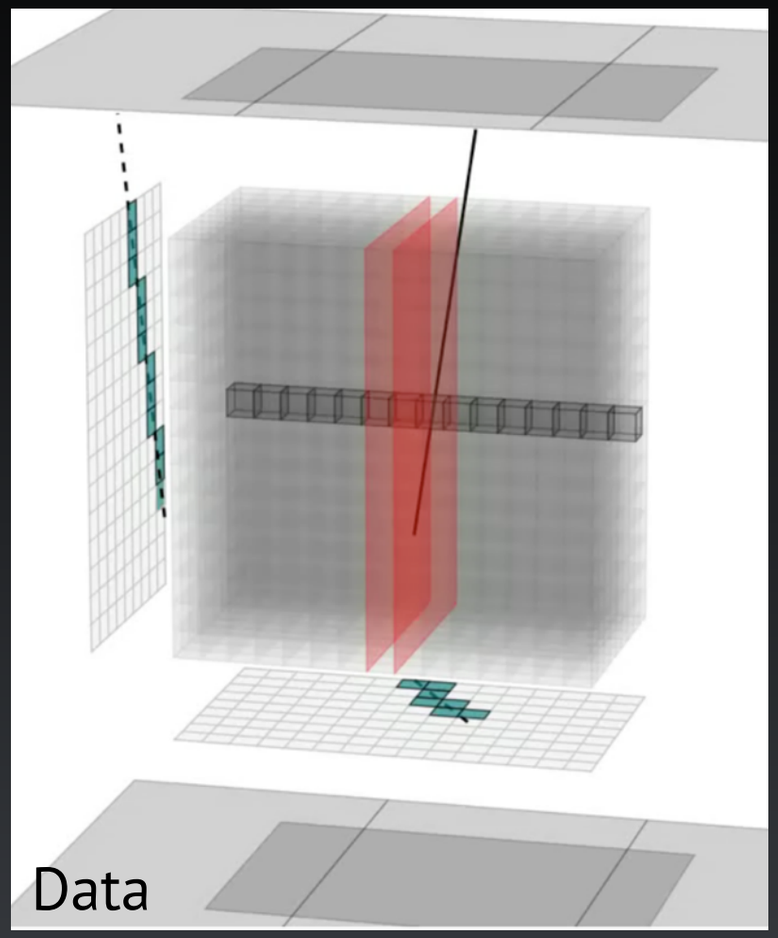


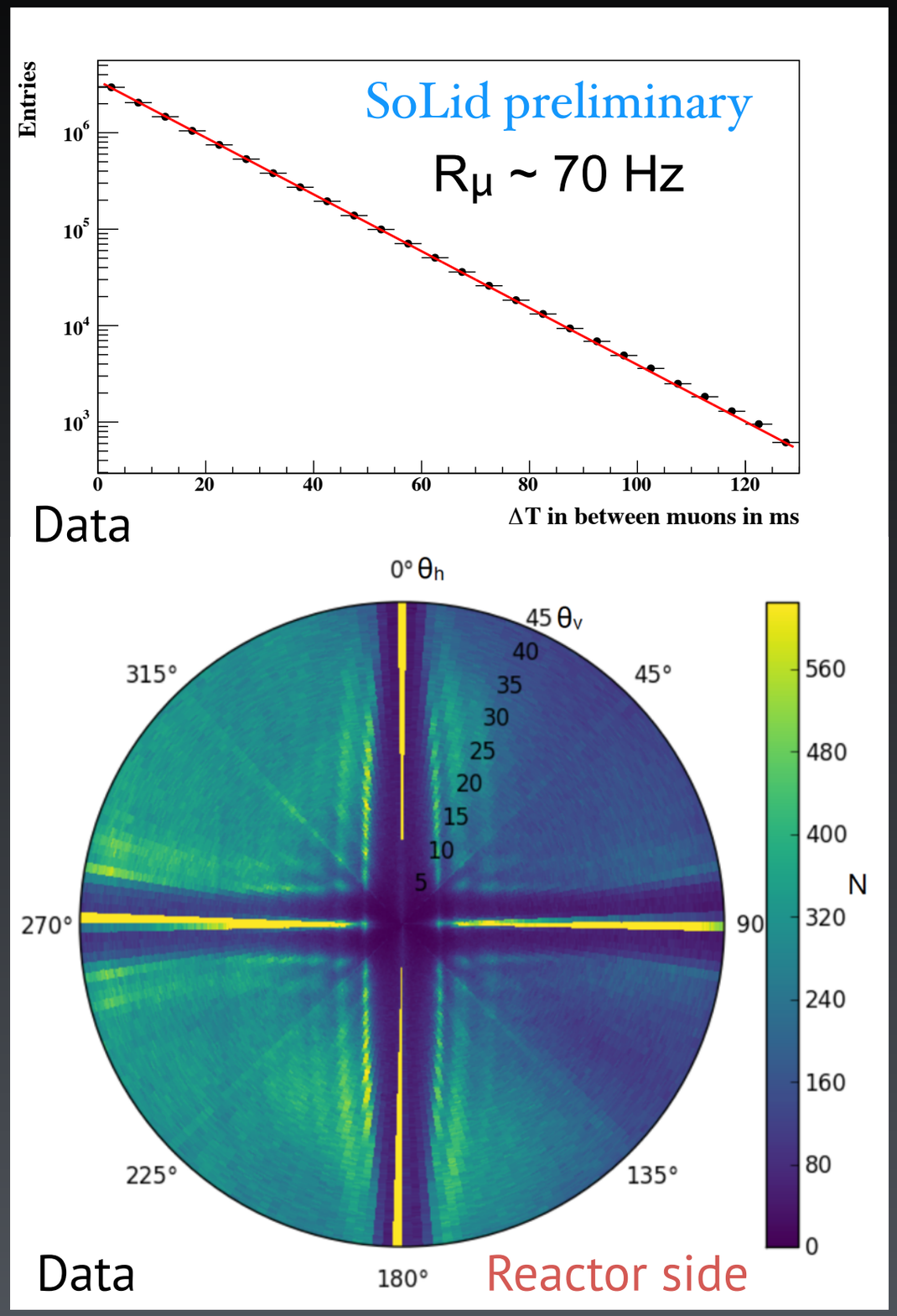
SM1 Neutron PID



- Can distinguish a neutron in millions of signals

Muons @ SoLid

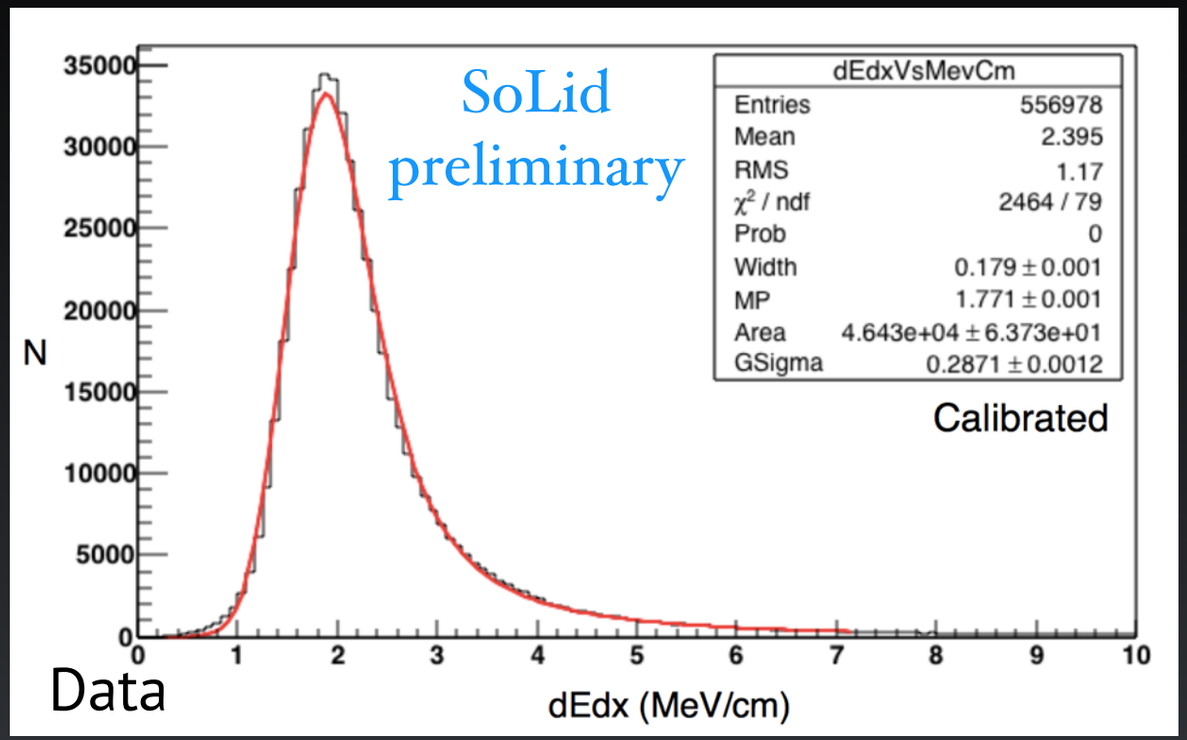


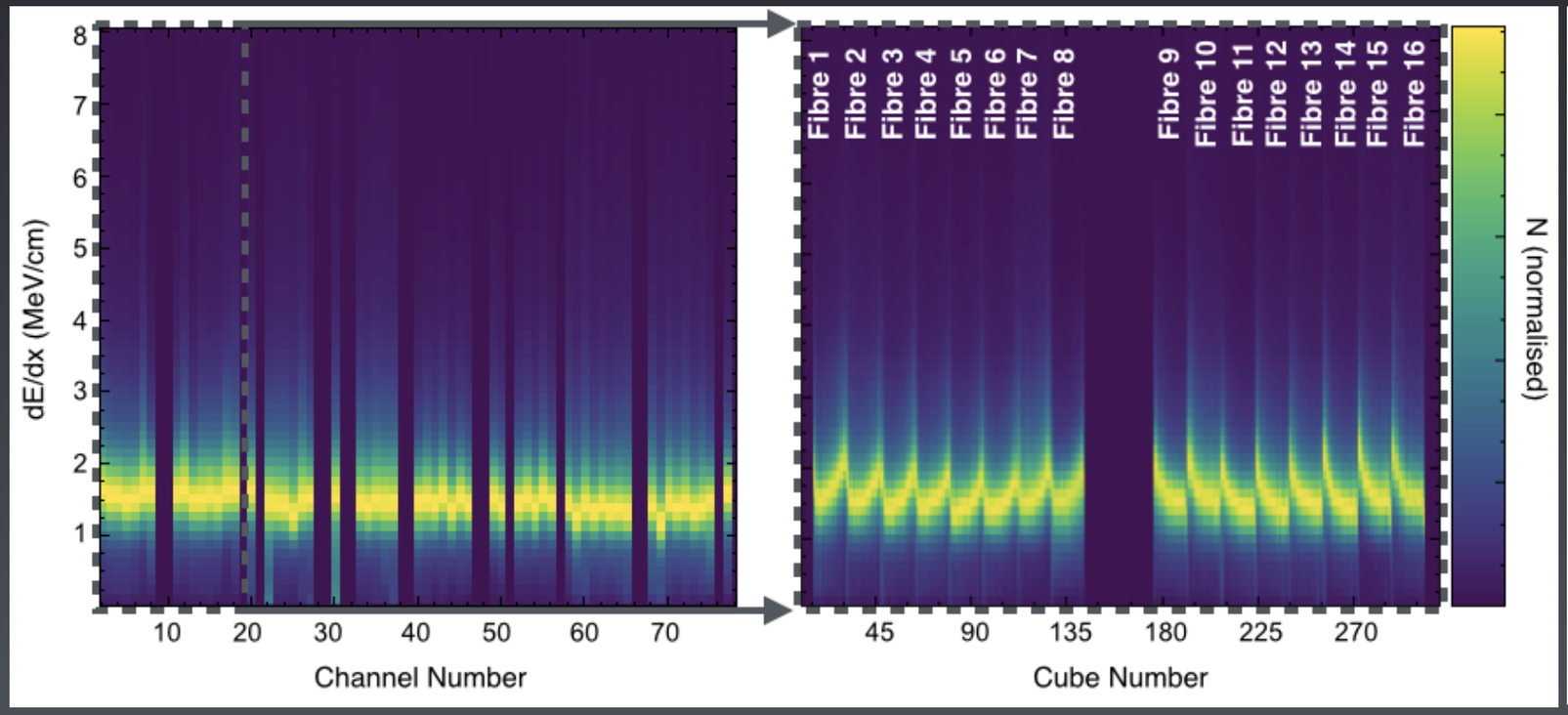


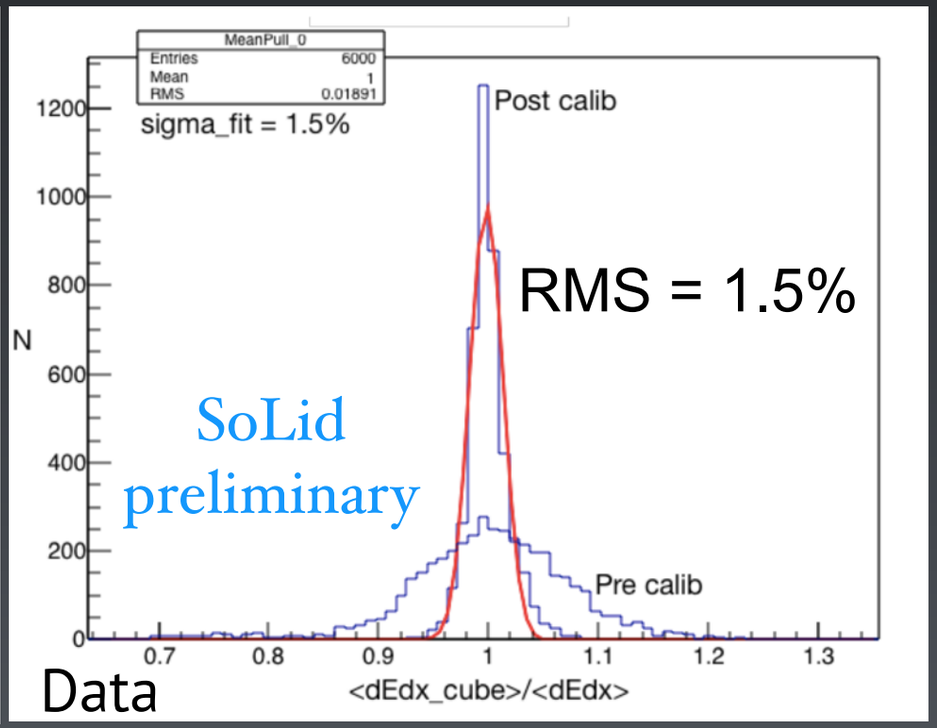
- tracking of muons:
  - precise in-situ calibration and monitoring with dEdx
  - simplify source calibration
- Handle on correlated backgrounds

In situ calibration with muons

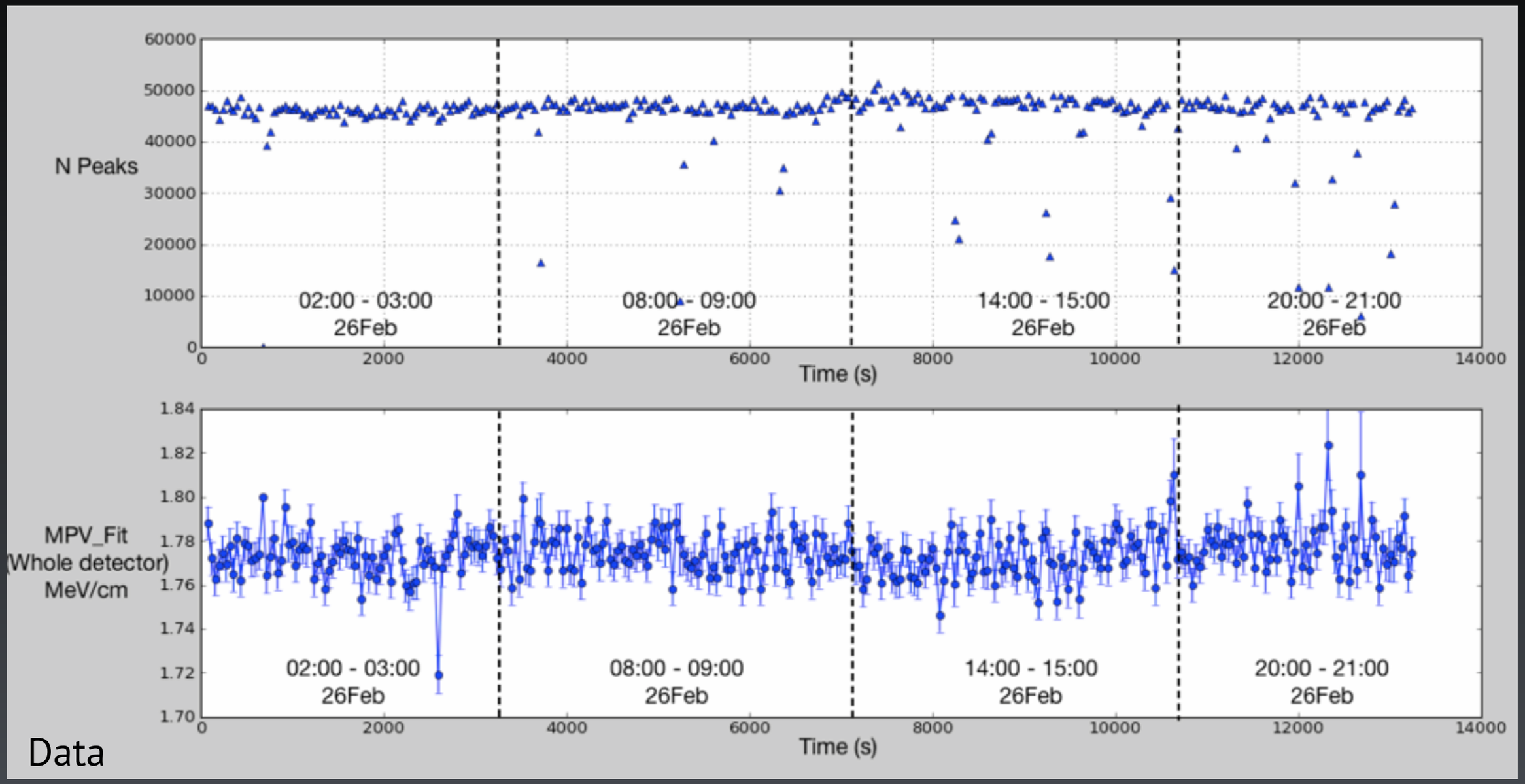
- in-situ energy calibration using dEdx
  - channels intercalibration
  - cube response equalisation
- Light yield measured : 25 PA/cube
- MPPC gain measured with dark count rate
  - no need for LED system





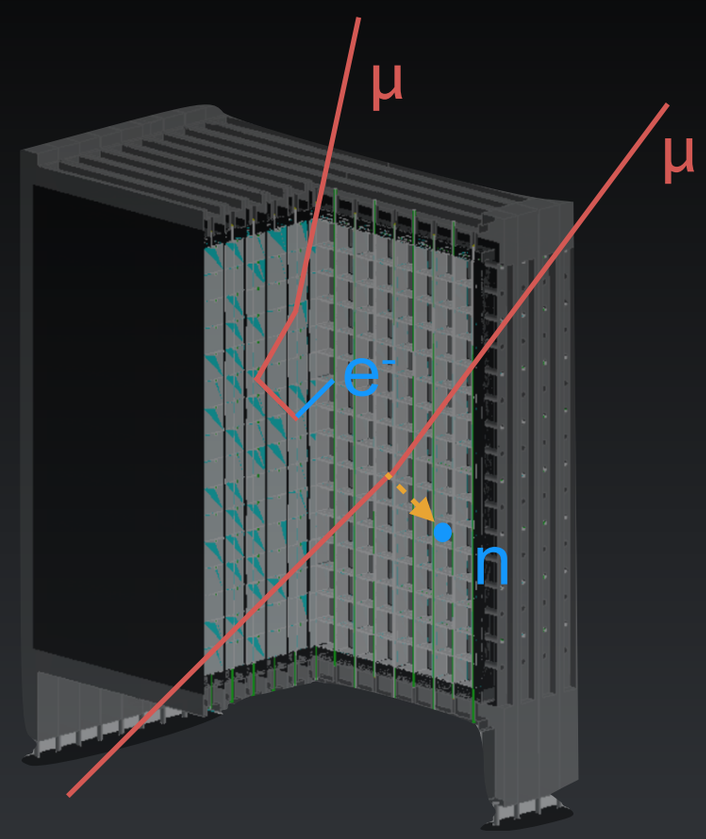


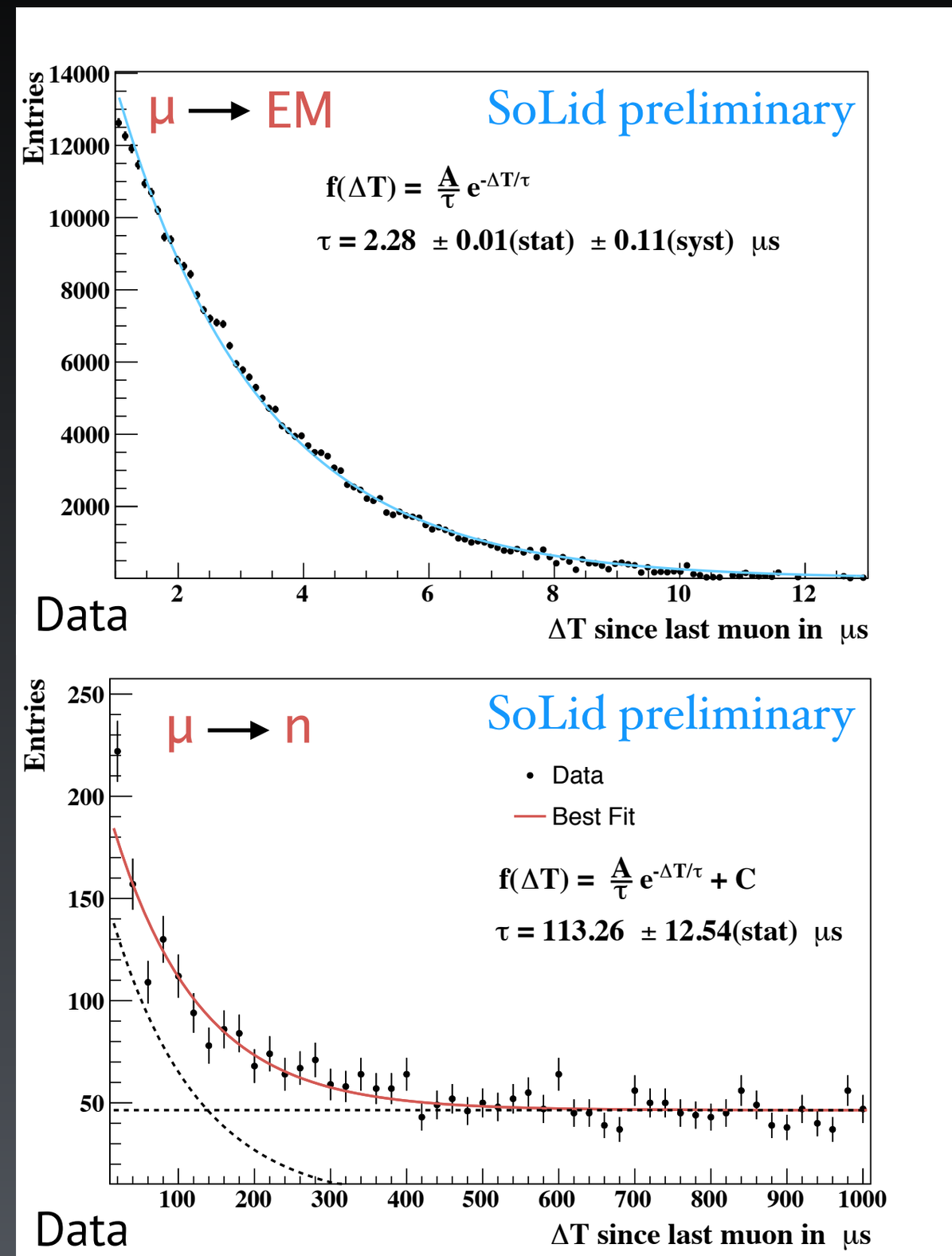
Calibration stability



- First look at stability over time
  - Very good stability of energy scale observed (few %)
- Temperature is well controlled at BR2 : ± 0.5 C variations

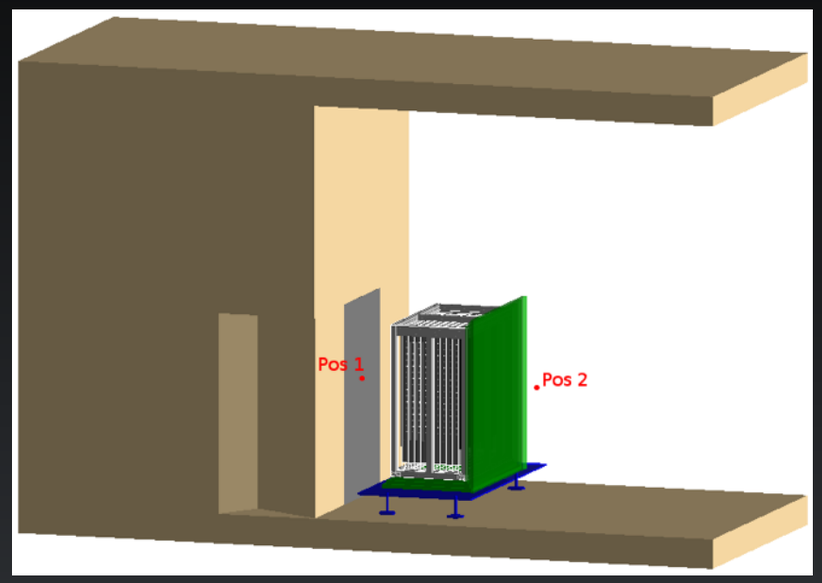
Muon correlated events

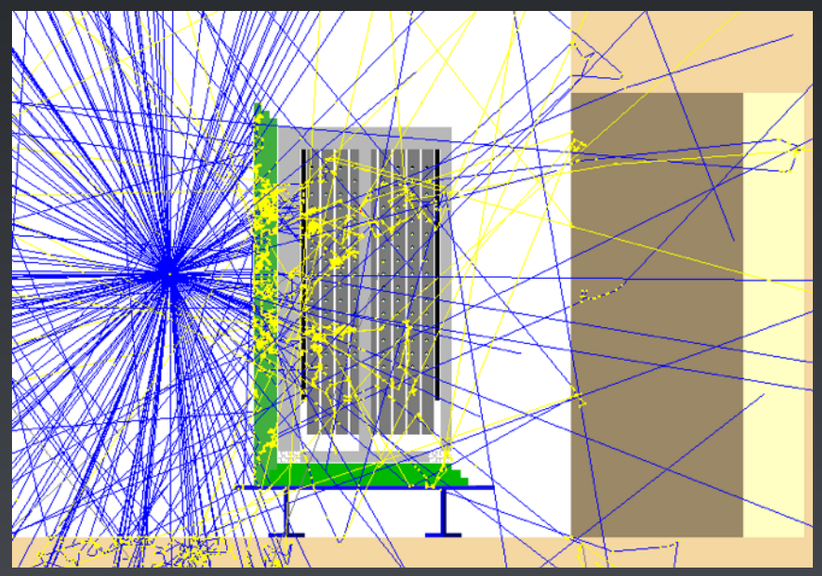


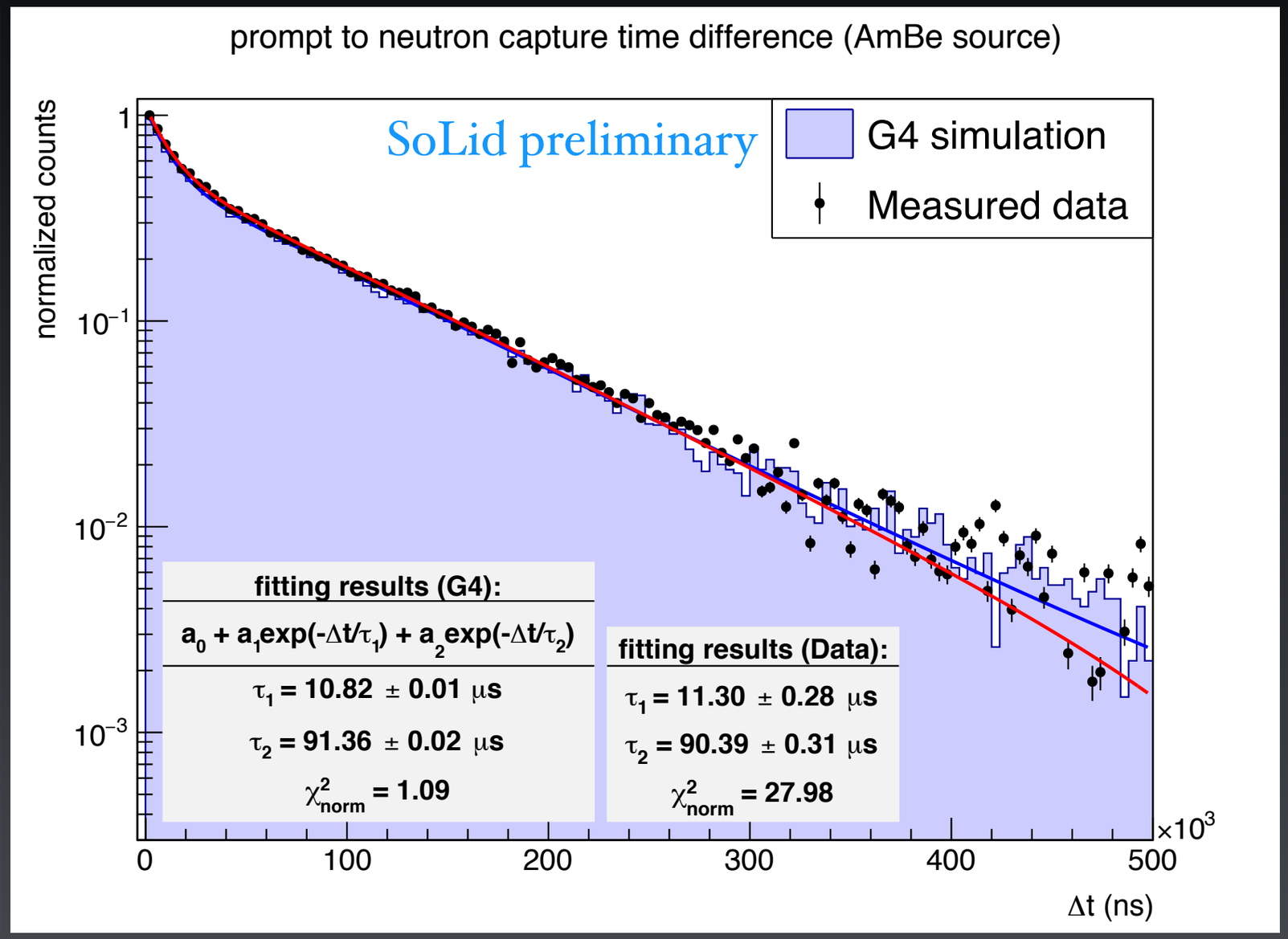


- Michel electrons activity observed
- Muon - neutron-like events correlations observed
- Use for muon veto cut

Detector capture time : AmBe



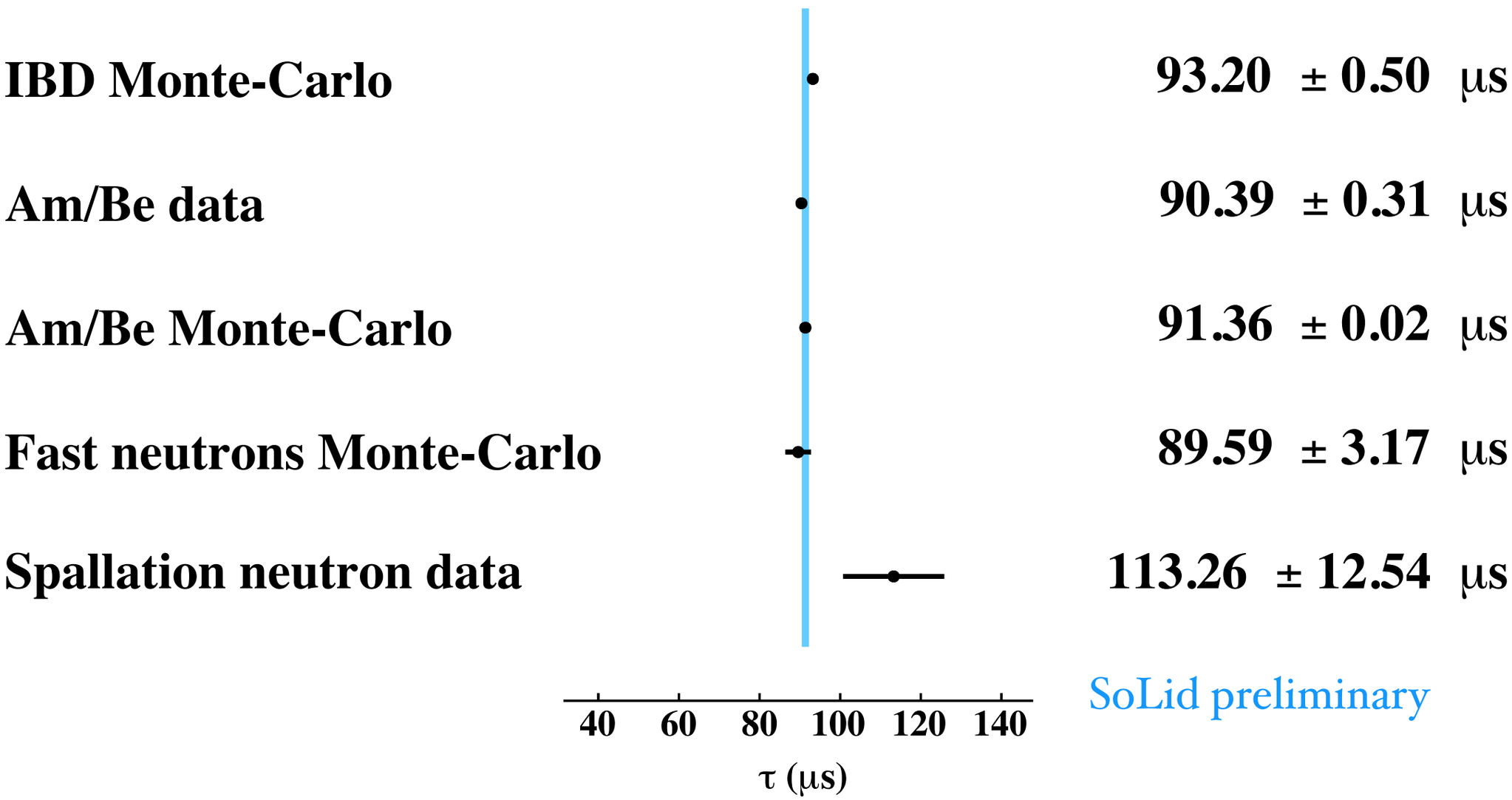




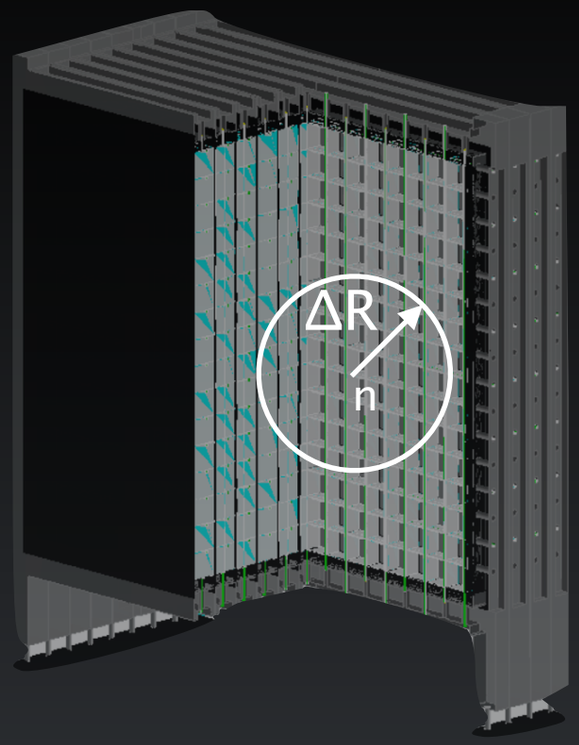
- AmBe source run used to study fast neutron signature and time coincidence

Neutron capture time summary

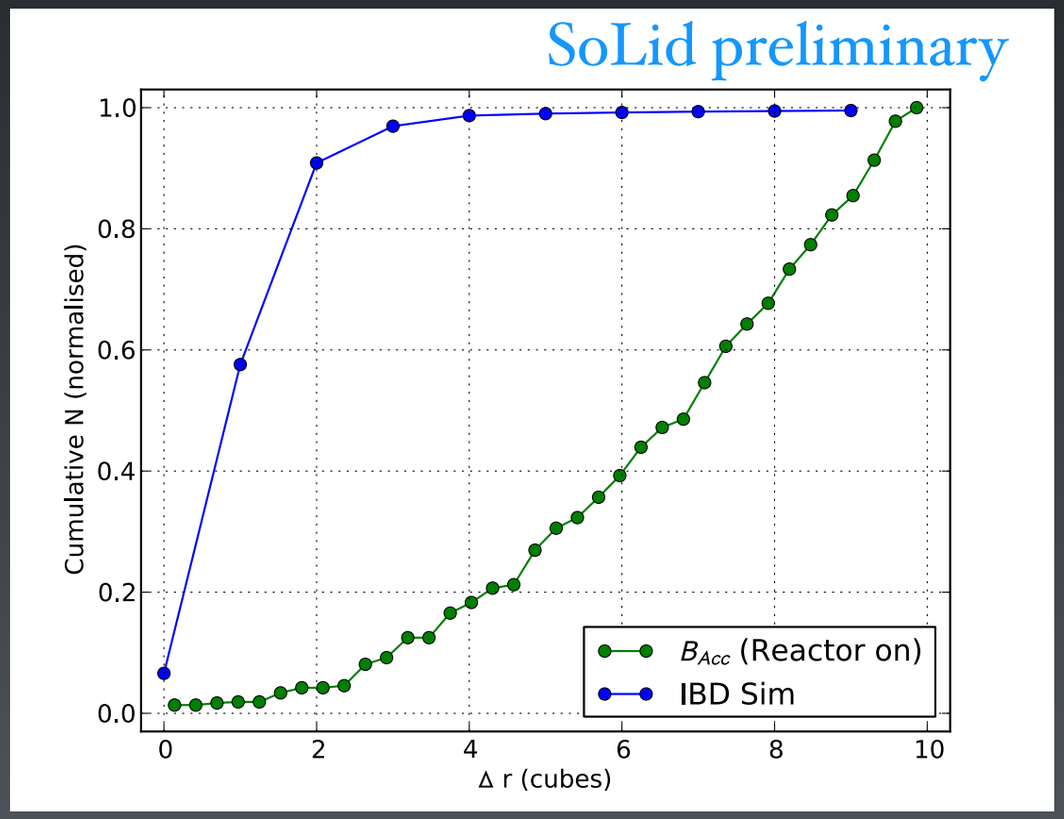
Neutron capture time on LiF:ZnS(Ag)



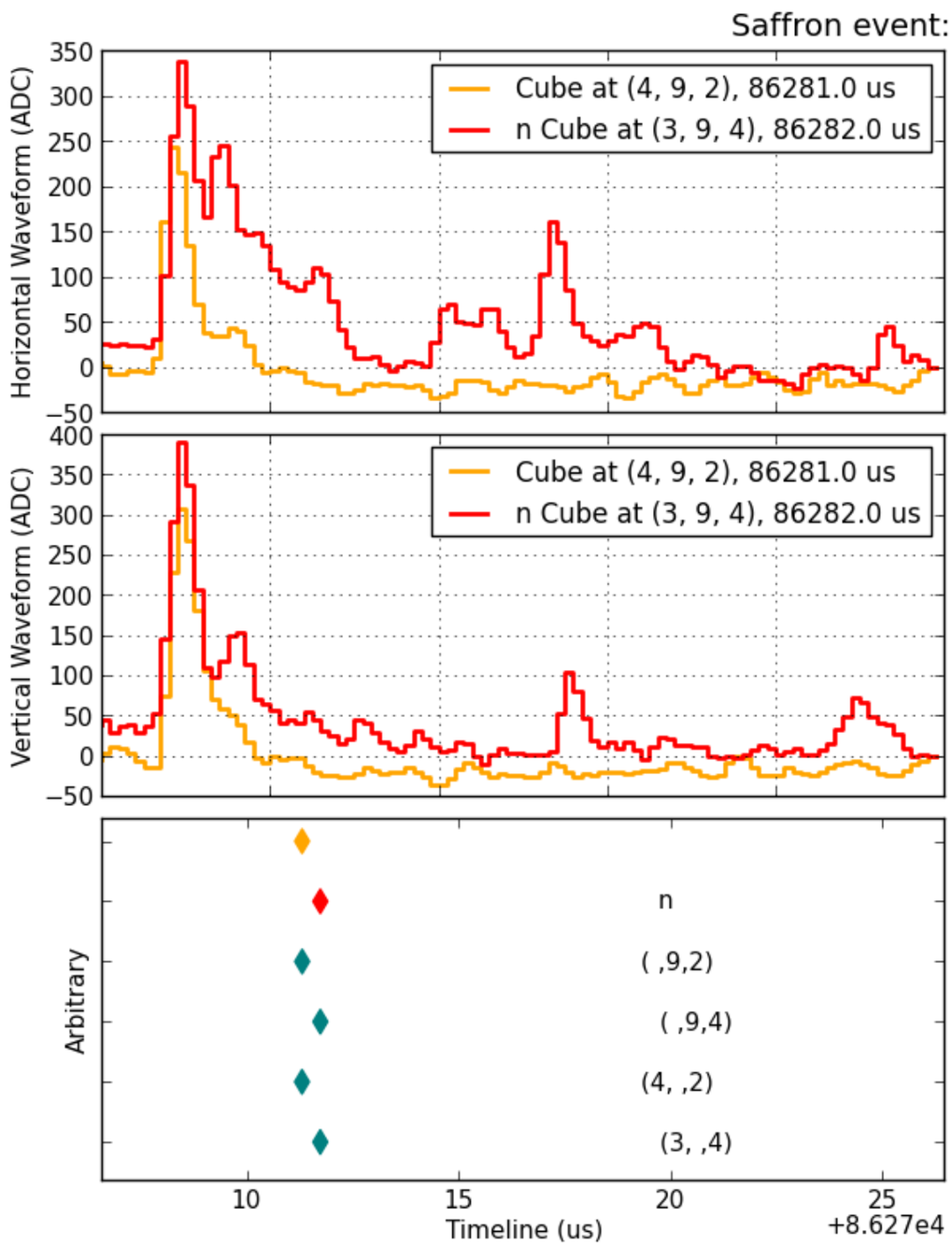
IBD analysis

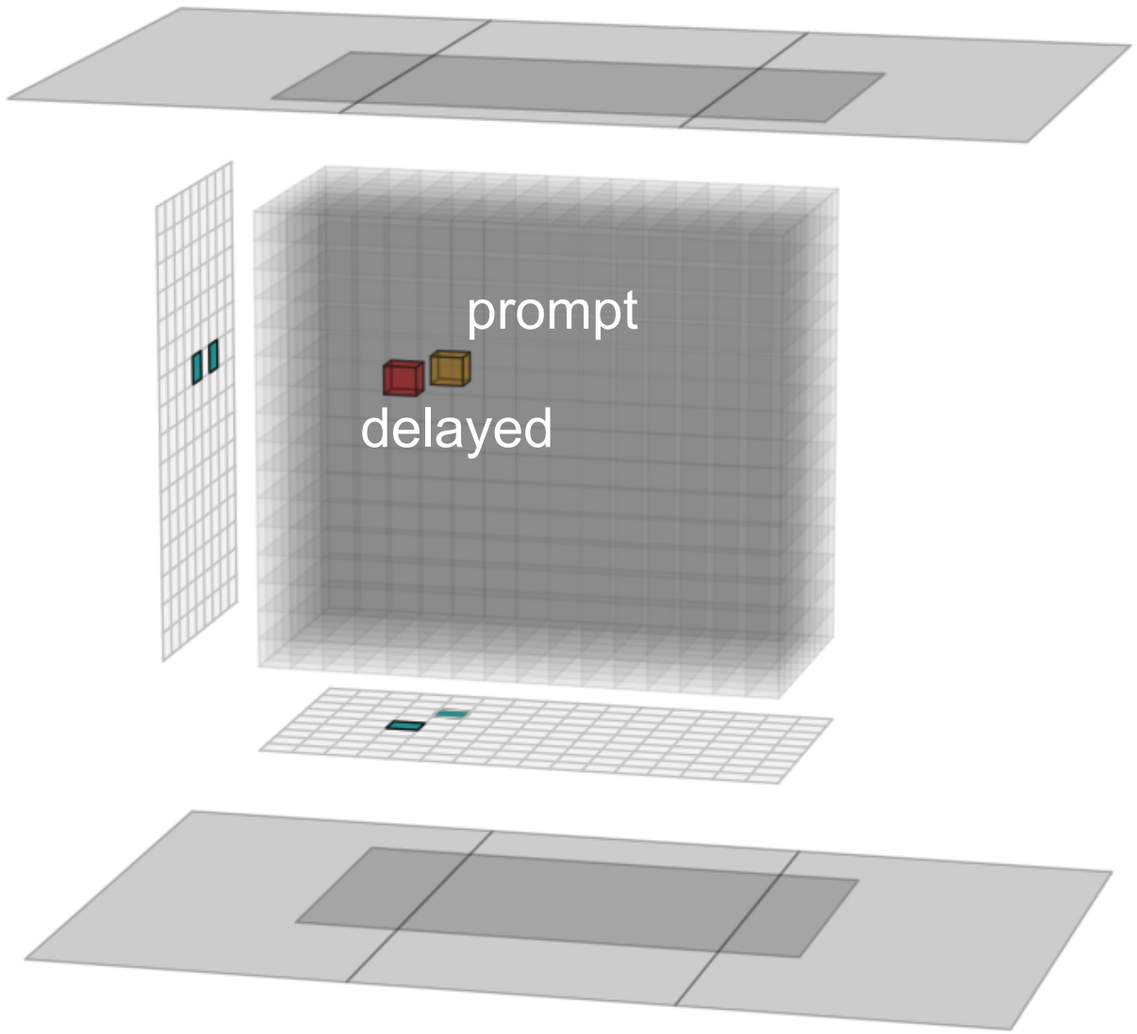


- First data processing completed
  - data reduction, filtering, calibration and reconstruction
- SM1 MC response tuning ongoing
- Study of background events and selection cuts started
  - Expect S:Bacc ~2:1 using cube segmentation
- aim for result early next year



IBD candidate event display





SM1 data
Reactor wall behind

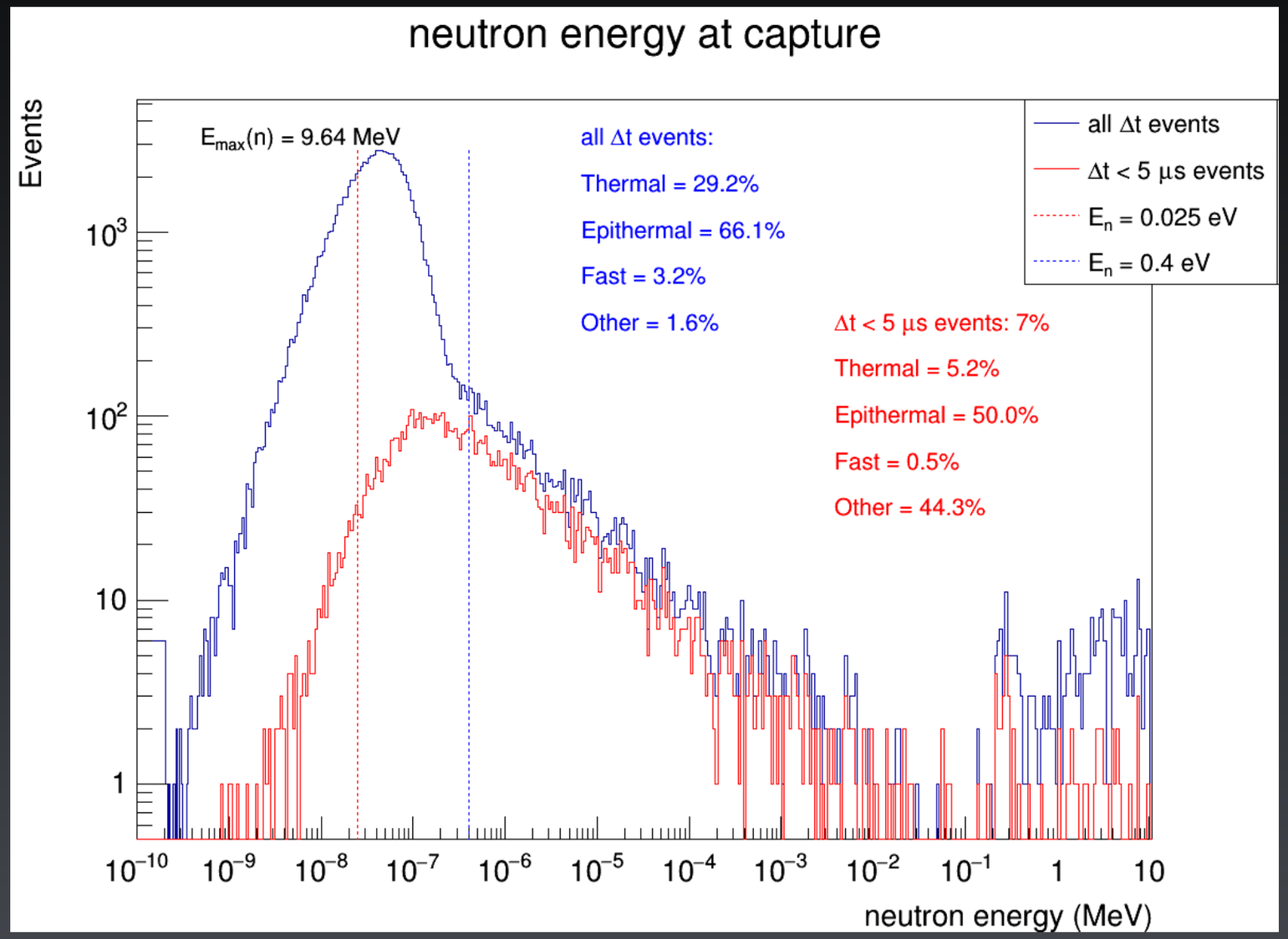
Summary

- The SoLid experiment will make a very sensitive search for antineutrino disappearance using a new generation of compact detector
- The SM1 run has been succesfull
  - Excellent neutron ID
  - Precise calibration with muons
    - cube PVT response equalisation at 1.5% level !
    - simplify calibration procedure
  - Low background at BR2 has been confirmed
    - segmentation is already effective in reducing accidental background
    - focus now on correlated signals and antineutrinos !
- more results in the new year

Outlook

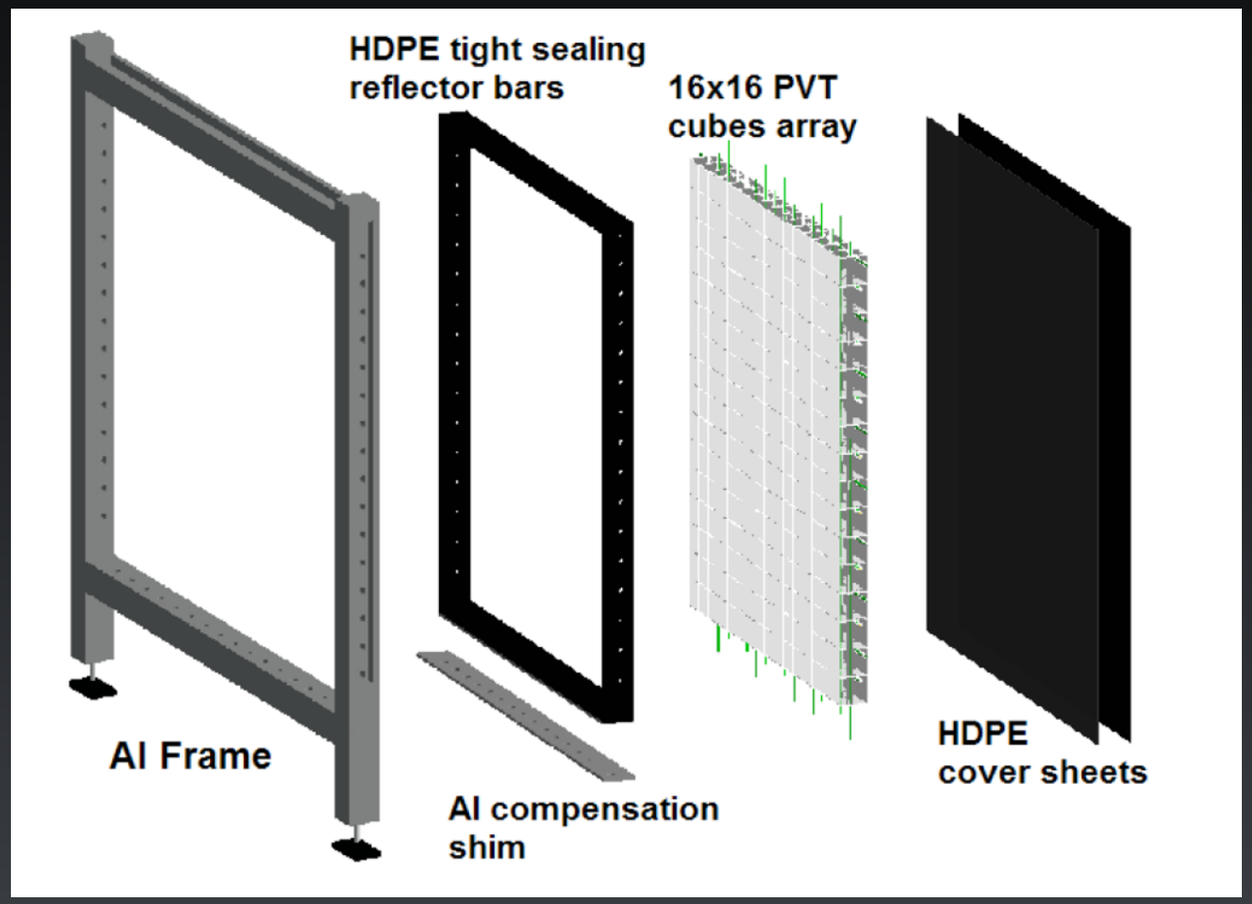
- R&D phase now completed
- cost-performance optimisation ongoing
  - Light yield increase per fibre end
  - mechanical design
- Electronics
  - target lower cost-per-channel
  - development of a neutron trigger and new triggering scheme
    - increase low energy sensitivity
    - enable full use of event topology
- Construction phase to start early next year
- Phase I planned to start in second half of 2016

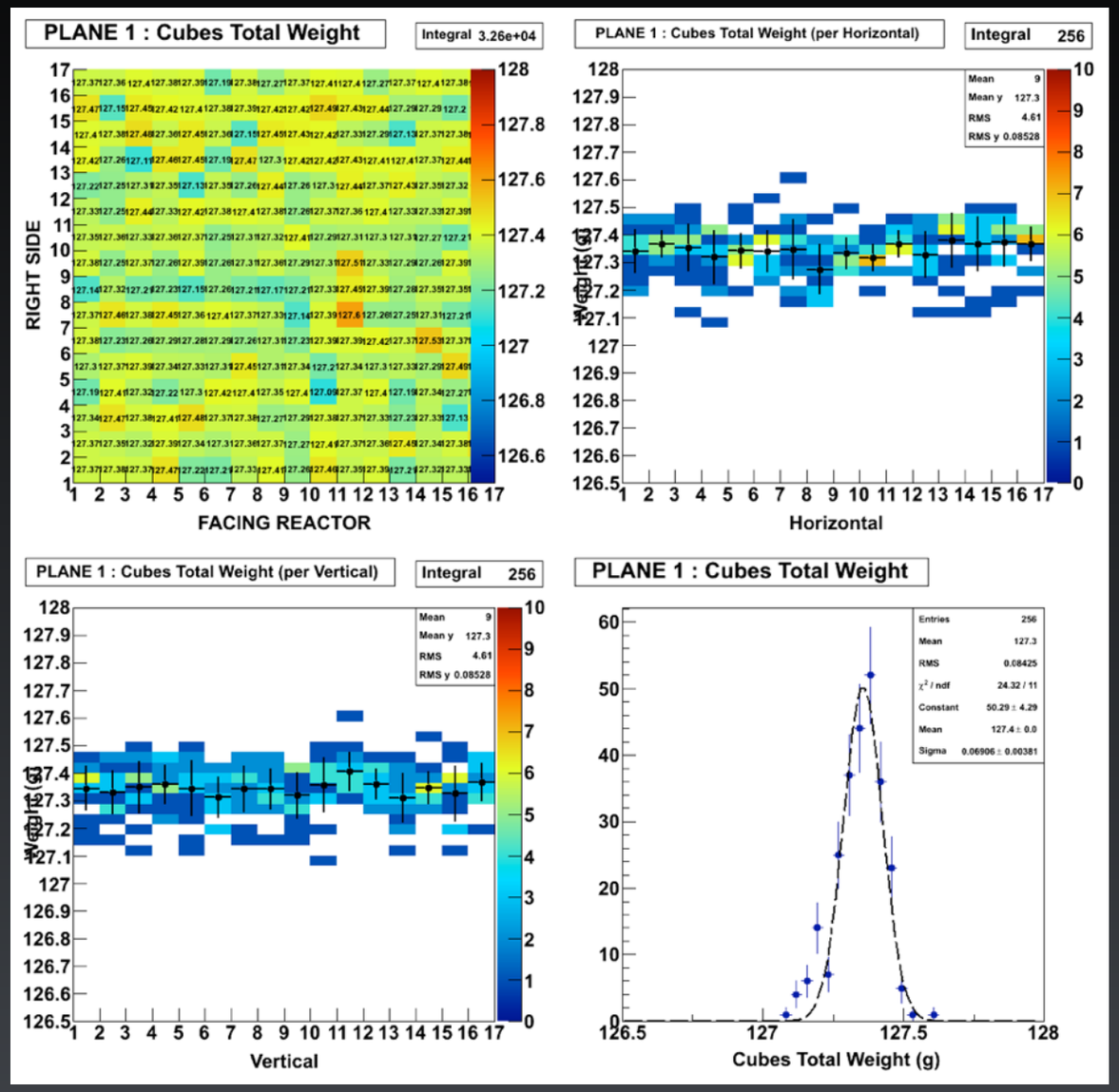
AmBe neutrons energy and capture time



- neutrons with short coincidence time are captured before reaching thermal energy

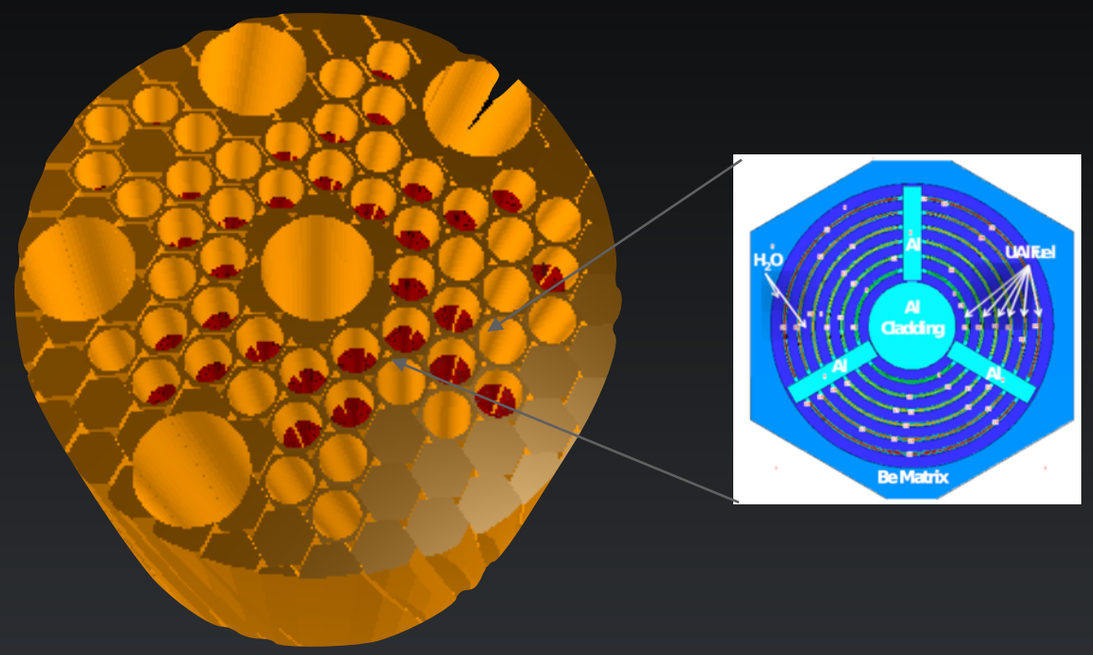
Proton target determination

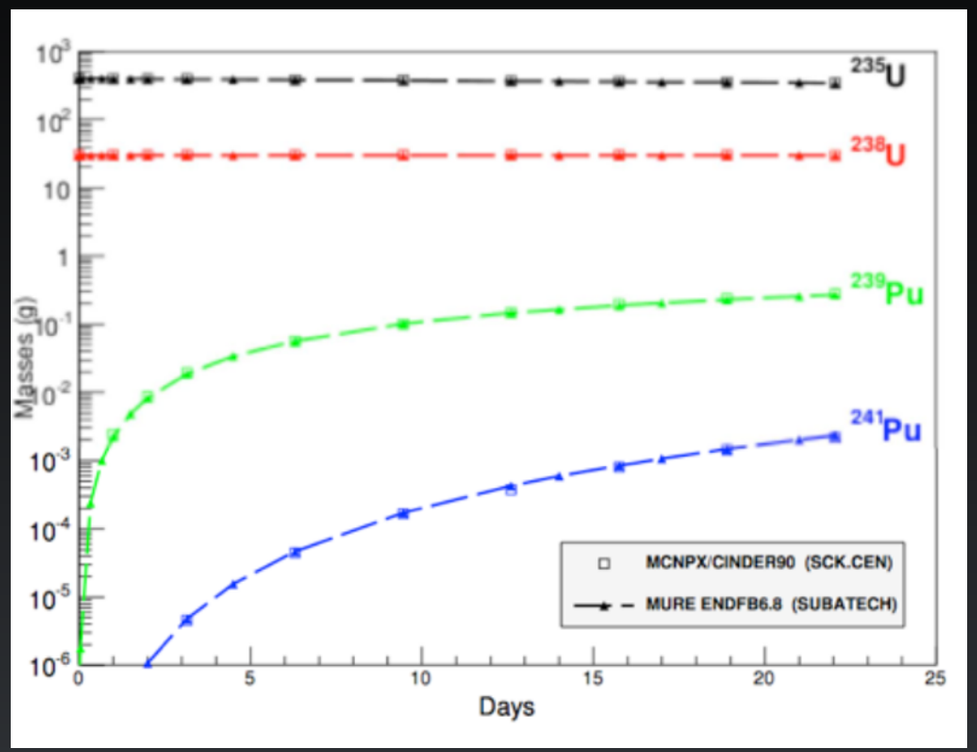




- Precision measurement rely on precise target mass determination
  - $dN_p < 1\%$ achieved !

Flux determination





- Reactor group lead by Subatech and SCK•CEN experts
- MCNP geometry from BR2
- evolution validated in MURE
- Acceptance correction in tracking MC
- HEU core gives pure ^{235}U flux :
  - key ingredient for precise flux determination