Background investigation in EDELWEISS-III

Silvia Scorza on behalf of the EDELWEISS collaboration

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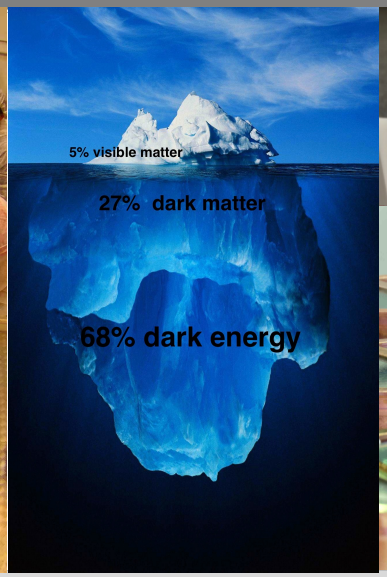
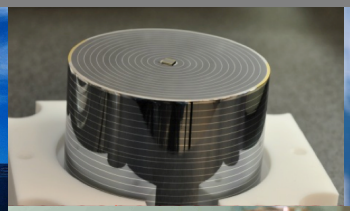
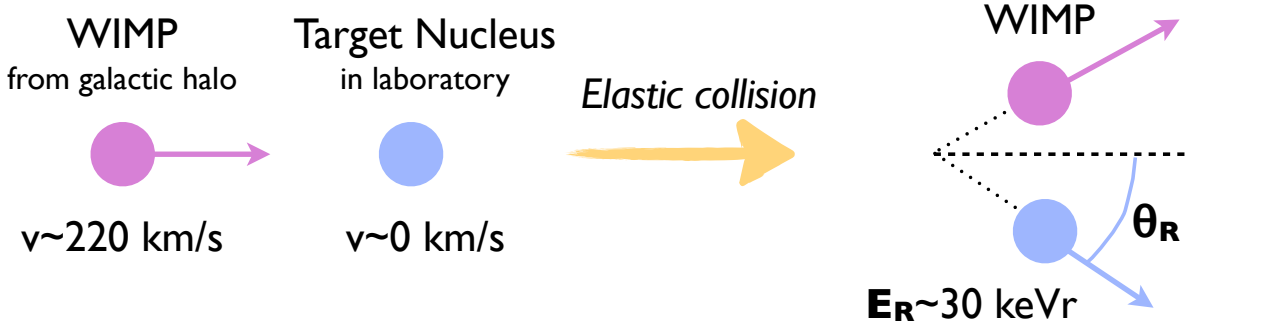


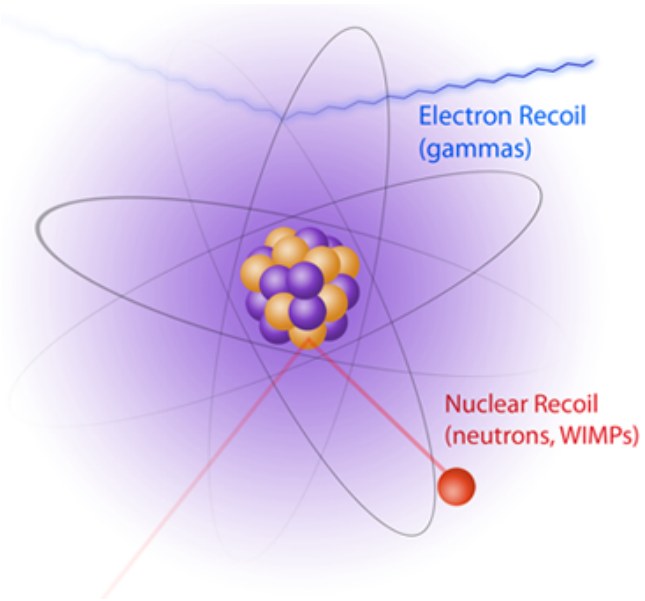


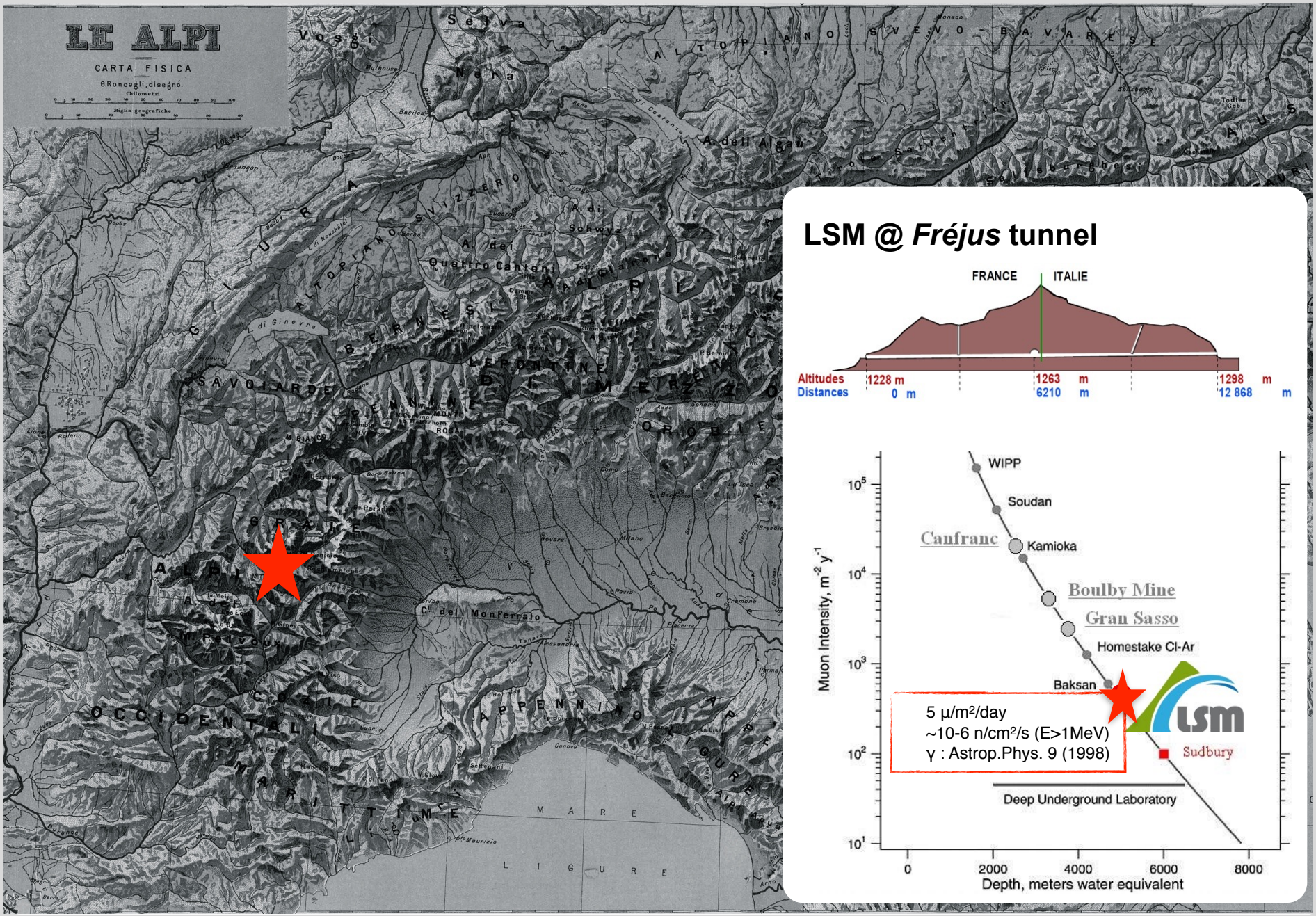
Direct Detection Principle

Detection of the energy deposited due to elastic scattering off target nuclei



- Ge crystal: event ID from measurements of ionization and phonon energies
- Elastic scattering of a WIMP deposits small amount of energy into recoiling nucleus (~ few 10s of keV)
- Expected rate:
  < 1 interaction per kg per year
- Radioactive background of most materials gives higher rate

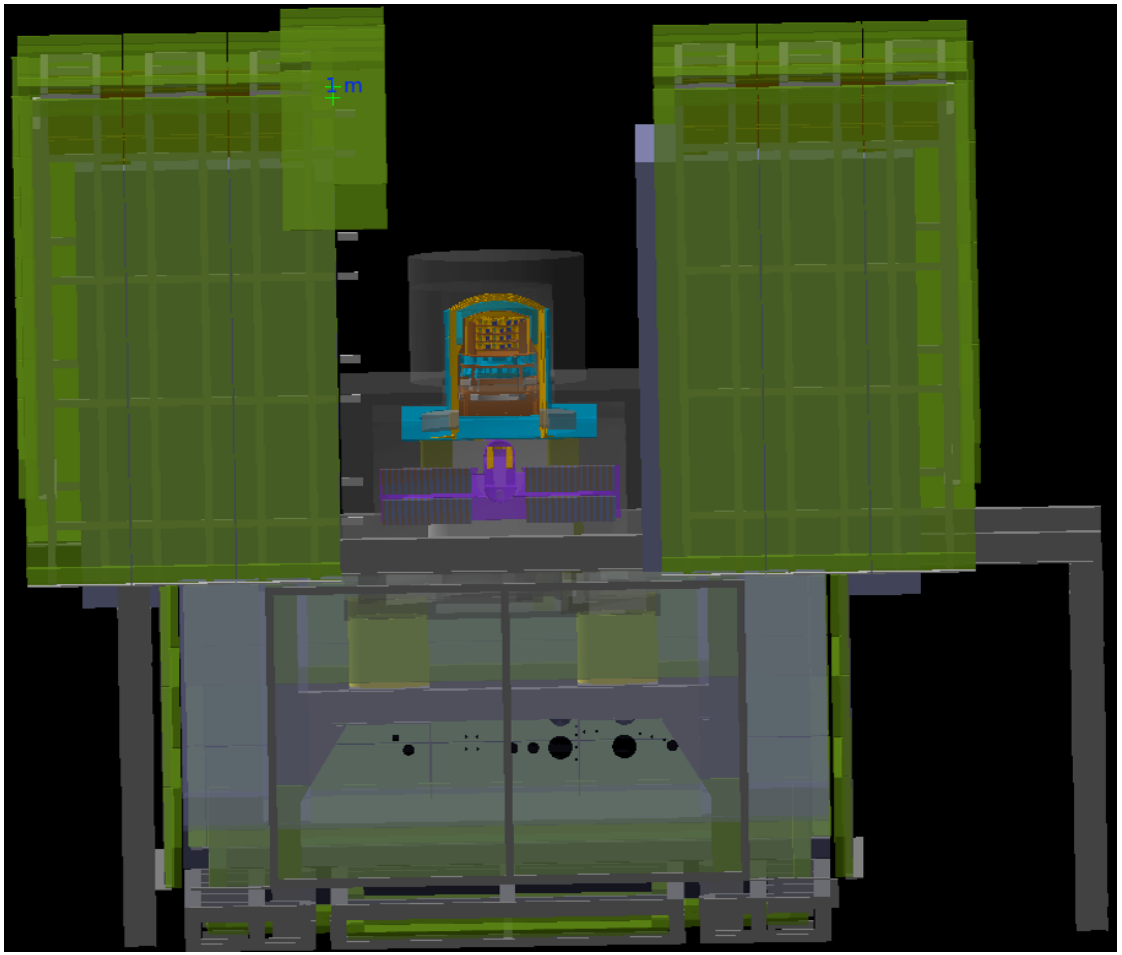



LE ALPI
CARTA FISICA
G.Roncagli, disegnò.
Chilometri
Miglia geografiche
LSM @ Fréjus tunnel
FRANCE
ITALIE
Altitudes
Distances
1228 m
0 m
1263 m
6210 m
1298 m
12 868 m
WIPP
Soudan
Canfranc
Kamioka
Boulby Mine
Gran Sasso
Homestake Cl-Ar
Baksan
Sudbury
LSM
5 μ/m²/day
~10-6 n/cm²/s (E>1MeV)
γ : Astrop.Phys. 9 (1998)
Deep Underground Laboratory
Muon Intensity, m⁻² y⁻¹
Depth, meters water equivalent

clean room (Rn)

with deradonized air supply

(from 10 Bq/m^3 → ≈ 30 mBq/m^3)



active muon veto (μ)

97.7% geometric coverage

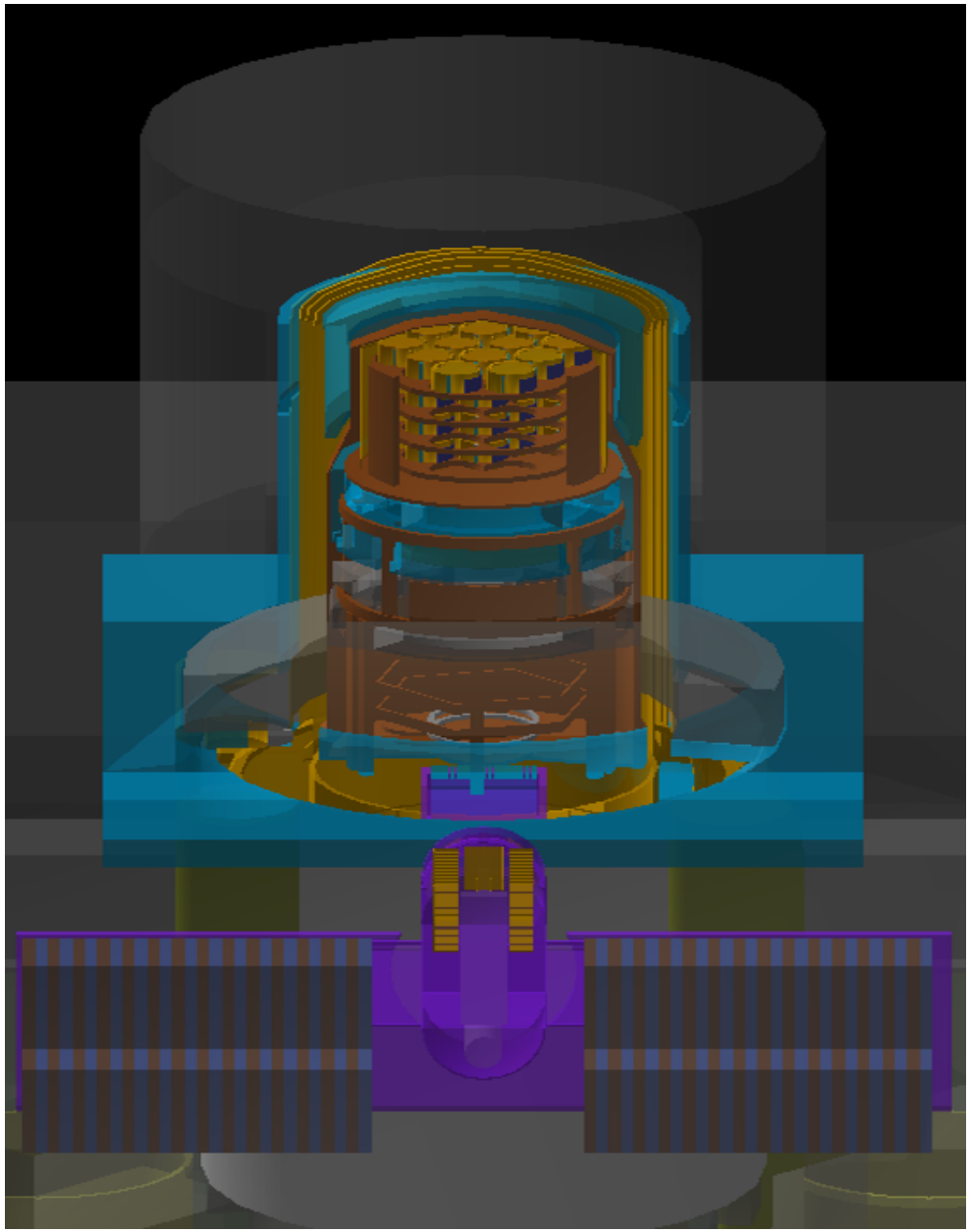
$N^{\mu\text{-n}} = 0.6^{+0.7}_{-0.6}$ evts

(90%CL, 3000kg.d)

4 additional muon-veto modules to increase coverage

- Calibration of the muon-veto ongoing to determine the position-dependent module response and thus a more precise muon-veto efficiency

- Full MC Geant4 simulation of the EDW-III setup to determine the expected μ-induced background and the μ-induced event topology

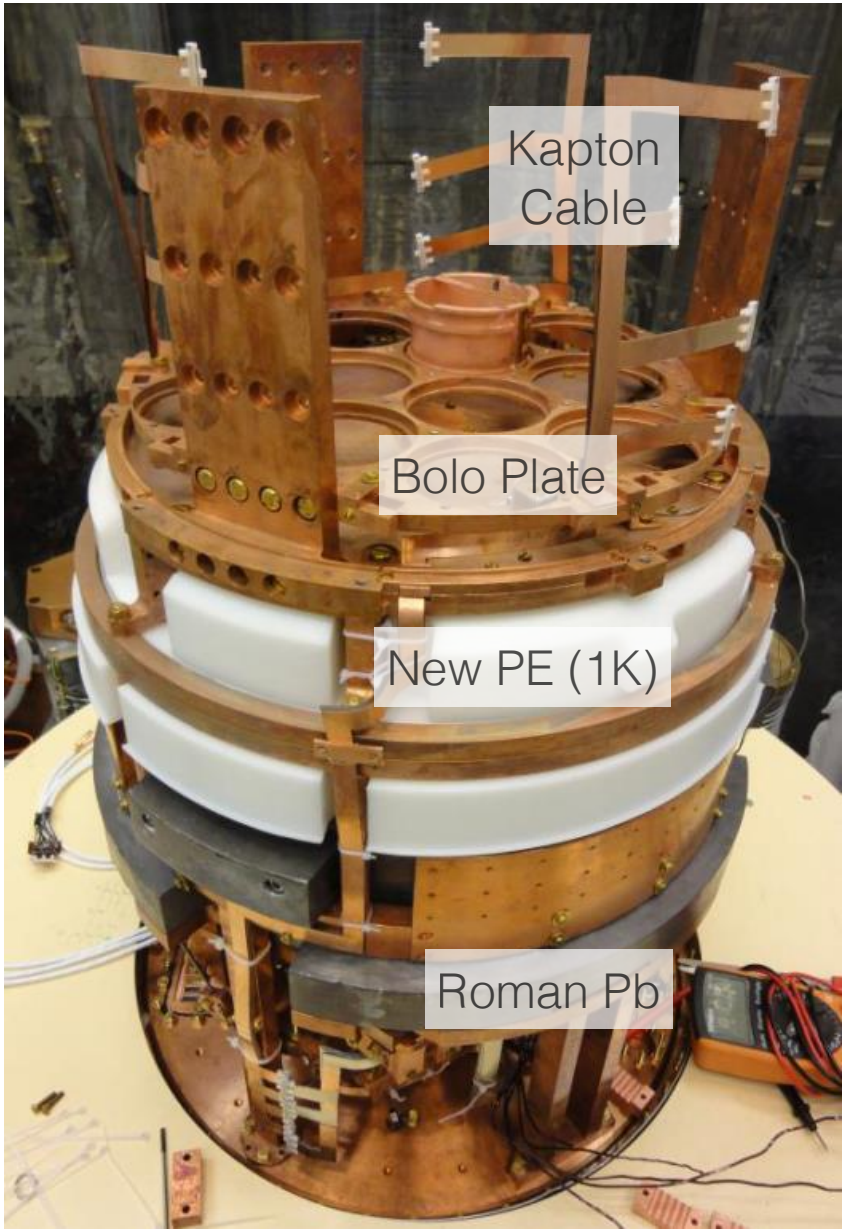


Polyethylene shielding (n)
50cm for moderation

Lead shielding (β, γ)
18cm + 2cm ancient lead

Copper cryostat (β, γ)
thermal shielding

- extra 10 cm below detectors PE shield
- extra 15 cm Roman Pb (1K)



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(Known) Background Sources

- Gamma background from radioactive contamination in set-up material and shielding
- Beta surface events from radioactive contamination in material close to detectors
- Cosmogenic Neutrons
  - Neutrons from μ's
- Radiogenic Neutrons
  - Neutrons from rock produced by (α, n) reactions in ^{238}U and ^{232}Th decay chains and spontaneous fission in ^{238}U
  - Neutrons from material produced by (α, n) reactions in ^{238}U and ^{232}Th and their isotope daughters and spontaneous fission in ^{238}U in set-up material and shielding

(Known) Background Sources

- Gamma background from radioactive contamination in set-up material and shielding
- Beta surface events from radioactive contamination in material close to detectors **Surface Rejection < $4 \cdot 10^{-5}$ @90% CL (Er >15 keV)**
- Cosmogenic Neutrons
  - Neutrons from μ's
- Radiogenic Neutrons
  - Neutrons from rock produced by (α, n) reactions in ^{238}U and ^{232}Th decay chains and spontaneous fission in ^{238}U
  - Neutrons from material produced by (α, n) reactions in ^{238}U and ^{232}Th and their isotope daughters and spontaneous fission in ^{238}U in set-up material and shielding

Gamma Background Simulation

Geant4.6.9

Physics List: Shielding
G4LEDATA "G4EMLOW6.23"
G4LEVELGAMMADATA "PhotonEvaporation2.3"
G4RADIOACTIVEDATA “RadioactiveDecay3.6"
G4NEUTRONHPDATA "G4NDL4.2"
G4NEUTRONXSDATA "G4NNEUTRONXS1.2"
G4PIIDATA "G4PII1.3"
G4REALSURFACEDATA "RealSurface1.0"
G4SAIDXSDATA "G4SAIDDATA1.1"

Geant4.10.1

Physics List: Shielding
G4LEDATA "G4EMLOW6.23"
G4LEVELGAMMADATA "PhotonEvaporation2.3"
G4RADIOACTIVEDATA “RadioactiveDecay4.2”
G4NEUTRONHPDATA "G4NDL4.2"
G4NEUTRONXSDATA "G4NNEUTRONXS1.2"
G4PIIDATA "G4PII1.3"
G4REALSURFACEDATA "RealSurface1.0"
G4SAIDXSDATA "G4SAIDDATA1.1"

^{40}K 1460 keV

^{60}Co 1173 keV, 1332 keV

^{137}Cs 661.7 keV

^{238}U chain

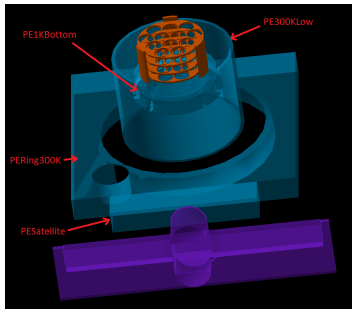
^{232}Th chain

For U and Th the full decay chains is considered when measured activities for the daughter isotopes are compatible

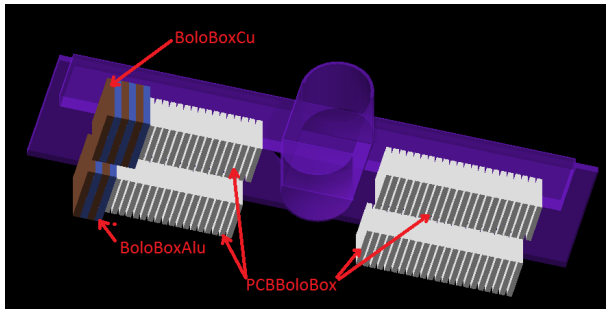
Otherwise, decay chains are split (surface pollution)

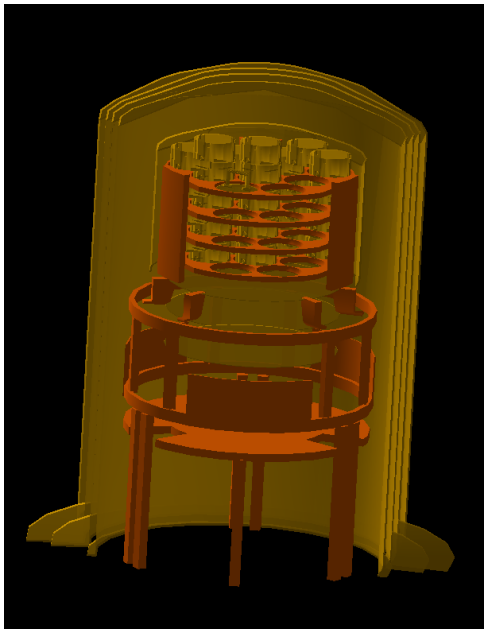
Gamma Background Simulation

Shielding



- Polyethylene
- Copper
  - NOSV
  - Edelweiss II (old 1K screen + …)
- Steel
- PCB from FET Boxes
- Bolo box
  - Aluminium
  - PCB



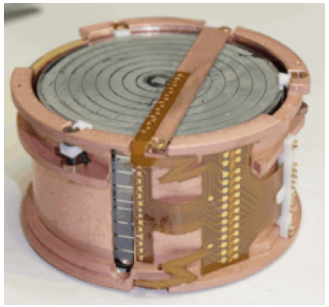


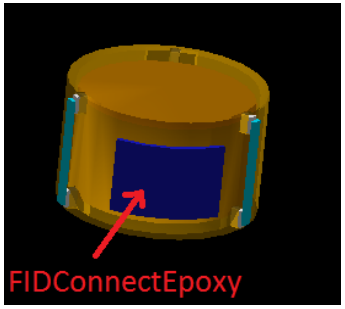
10mK Area :

- Brass
  - Plates screws
  - Casing screws
- Teflon
- Connectors
  - Delrin/Pin/socket
  - Kapton

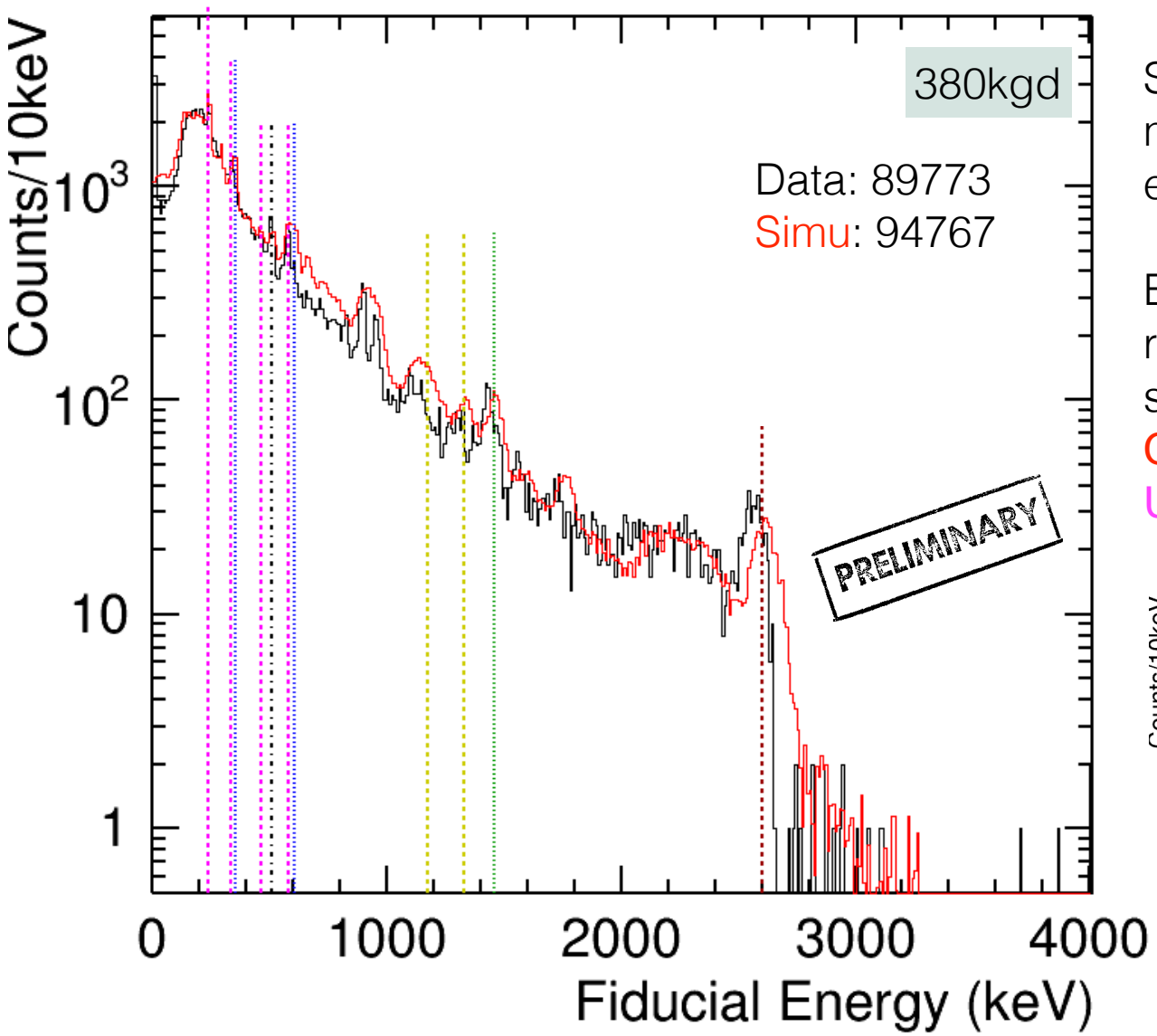
1K area

- Teflon Axon cables
- Connectors



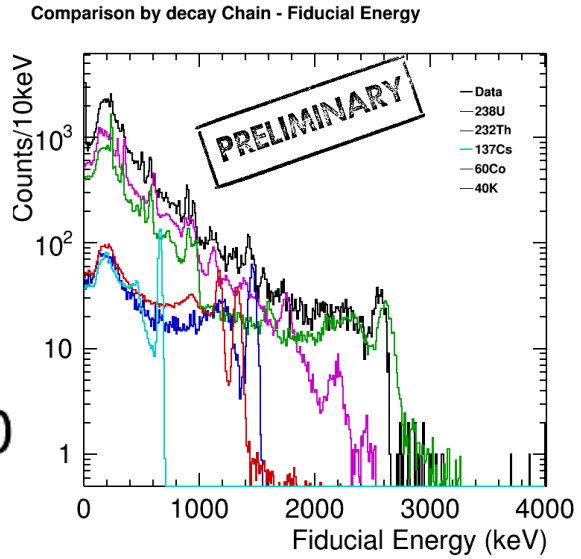


Comparison Fiducial Energy



Simulation spectrum normalized to experimental livetime

Best fit for contaminant results in an additional scaling factors
Co: 0.45, K: 0.405, Cs:1
U: 0.54, Th: 0.9



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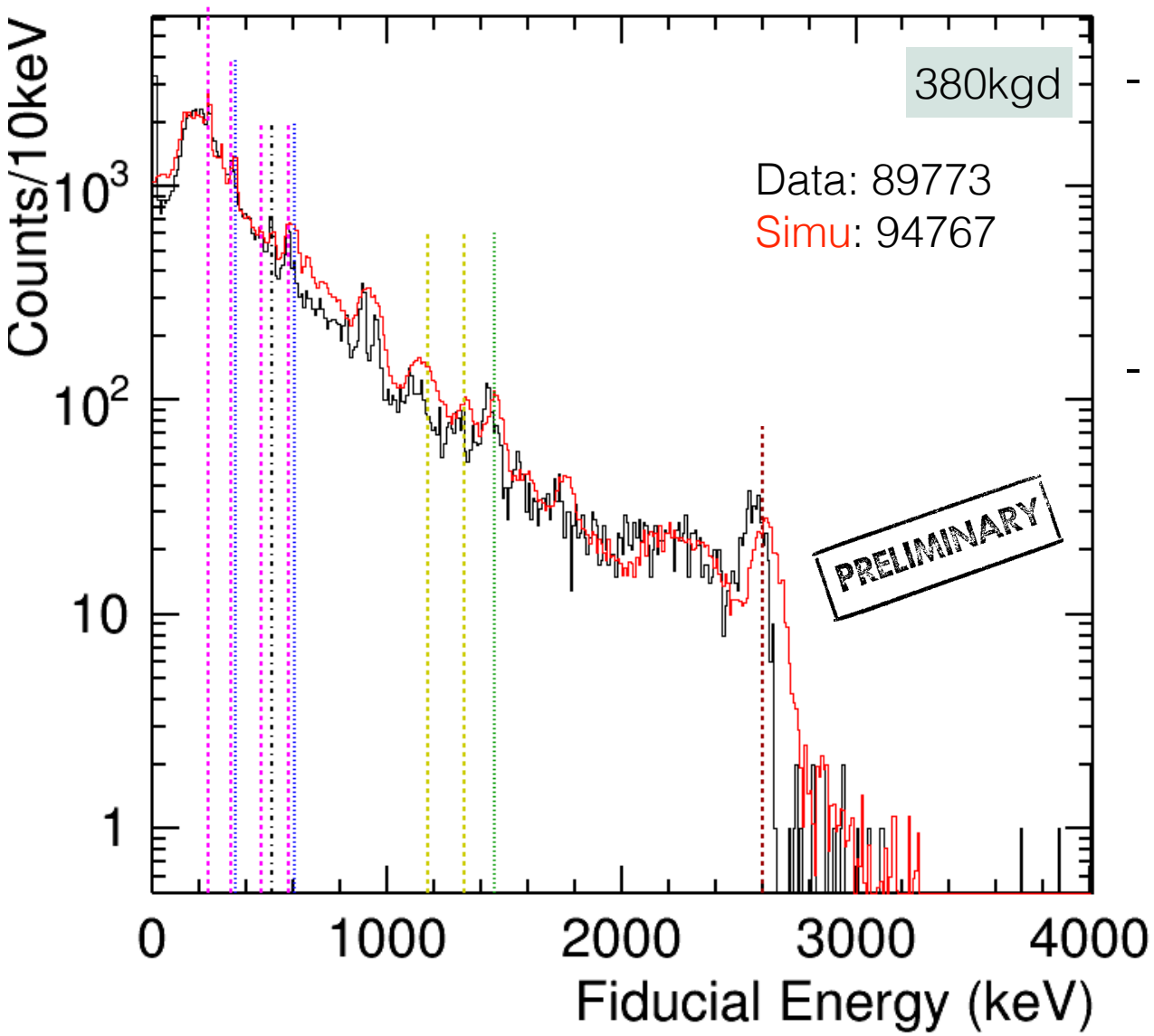
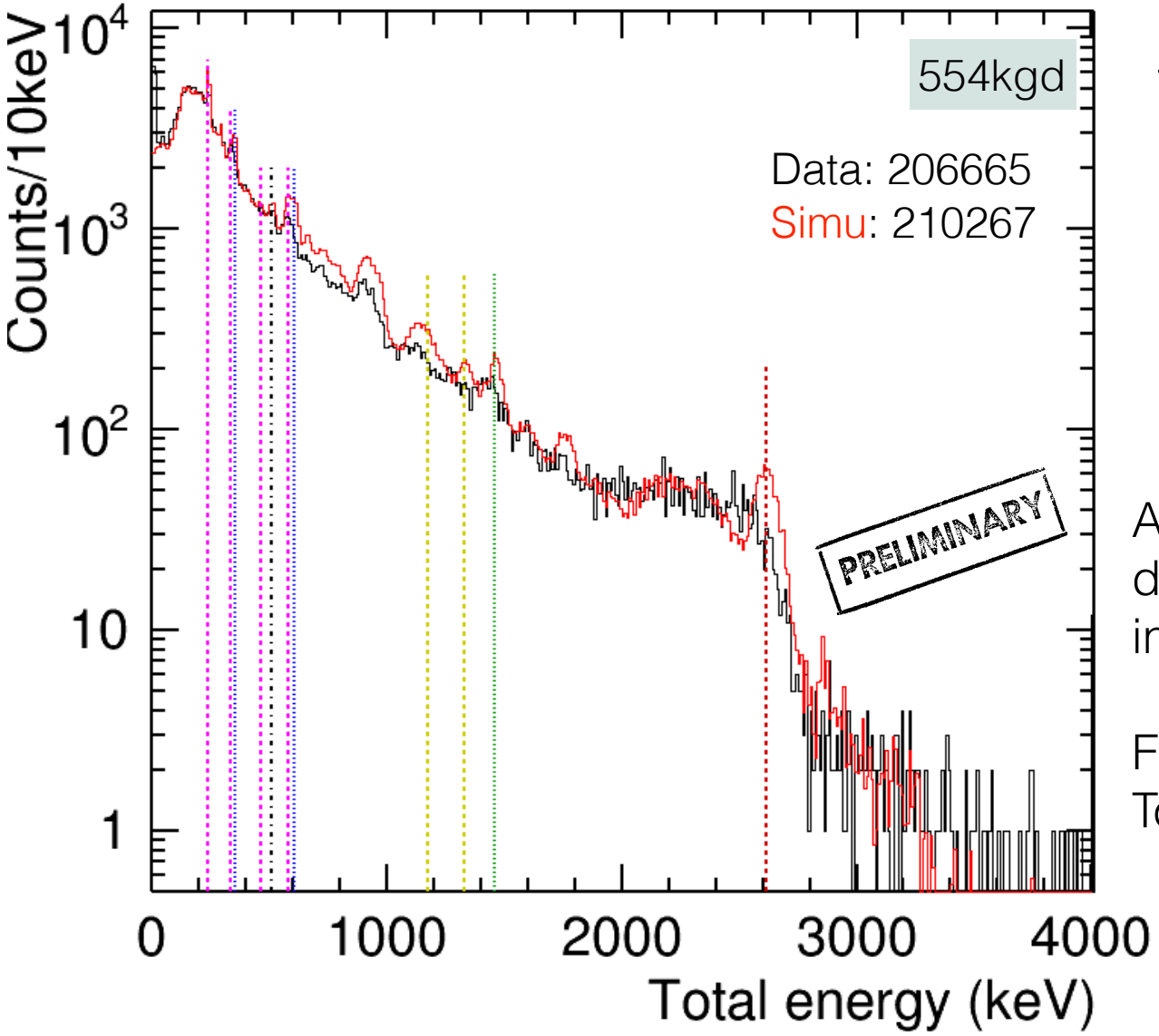


- Nice lines in data (good detector performances in term of resolutions)
- Simulation slightly overestimate the real gamma background
  - It might be due to different fiducial volume selection in simulation and data analysis
  - Upper limits or important measurement errors

Comparison TotalE



Total volume selection shows the same agreement
-> no important bias in the fiducial volume

Although a better fit to data is under investigation

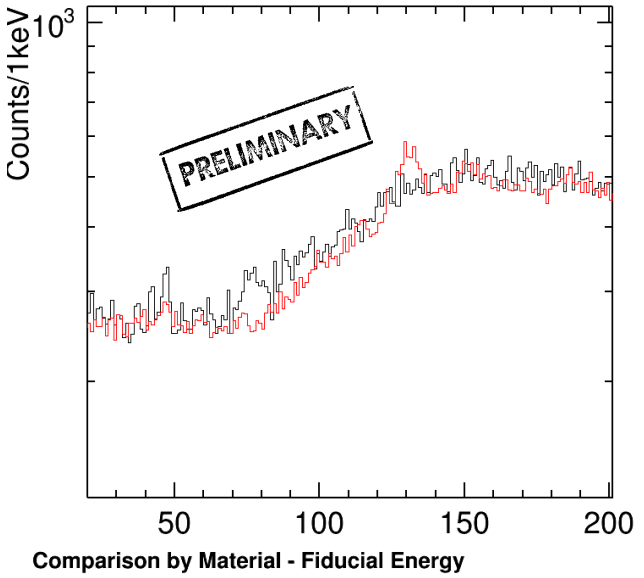
Fiducial γ : 70 evts/kgd
Total γ : 128 evts/kgd in 20-200keV

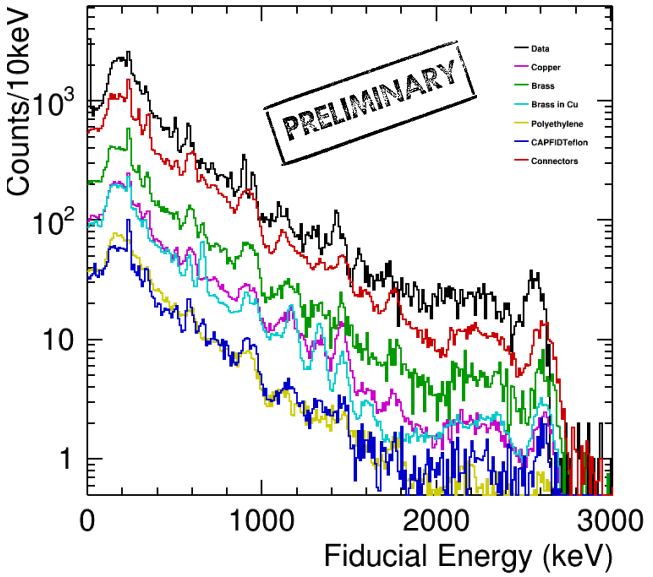
Contributions @LE

Event Rate in 20-200 keV (evts/ kg day)

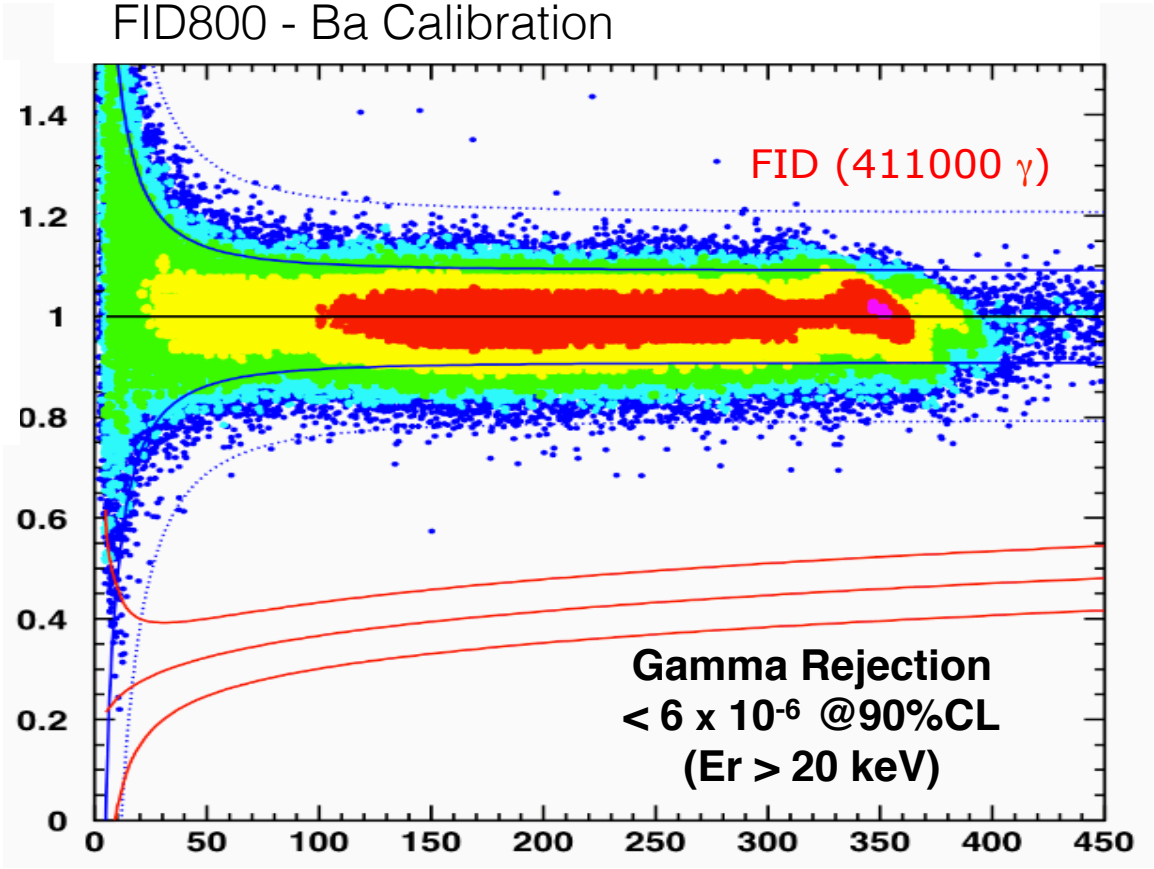
	Fiducial	Total
Copper	7.3 (10%)	12.8 (10%)
Brass	14.7 (20%)	22.9 (18%)
Brass in Cu	6.9 (9.4%)	10.3 (8%)
Polyethylene	2.6 (3.5%)	4.6 (3.6%)
Teflon	2.2 (3%)	4.0 (3%)
Connectors (pin+delrin+socket +pressfit+ kapton)	39.7 (54%)	63.1 (50%)
Total MC	78	125
Total Data	70	128

Highest contribution ~50% from connectors (delrin PTFE +pin Mill-Max+pressfit Mill-Max +socket Mill-Max+kapton connectors)





FID Gamma Rejection



Ba calibration data:
fiducial events only
0 events in more than
4×10^5 events

Rejection factor
$<6 \times 10^{-6}$ /γ

WS data:
2.6×10^4 γ's fiducial
(20-200keV)

<0.16 events
in ~380 kg·days

Radiogenic Neutron Background

Neutron from cryostat and electronics $< 1.7 \times 10^{-4}$

Fiducial Volume Eion_veto<3keV
Total mass ~ 620g x #FIDs
Running 1 year @90%C.L.

PRELIMINARY

Errors are statistical errors + errors on radio purity when existing

Detector		24 FIDs	36 FIDs
kd days		**5431**	**8147**
Eth >10keV Eth_aux > 3keV	Singles 10-200 keV	1.2 (2)	1.7 (2)
	Multiples > 10keV	3.8 (5)	6.1 (8)
Eth > 20keV Eth_aux > 10keV	Singles 20-200 keV	0.9 (8)	1.4 (2)
	Multiples > 20keV	2.7 (4)	4.2 (6)

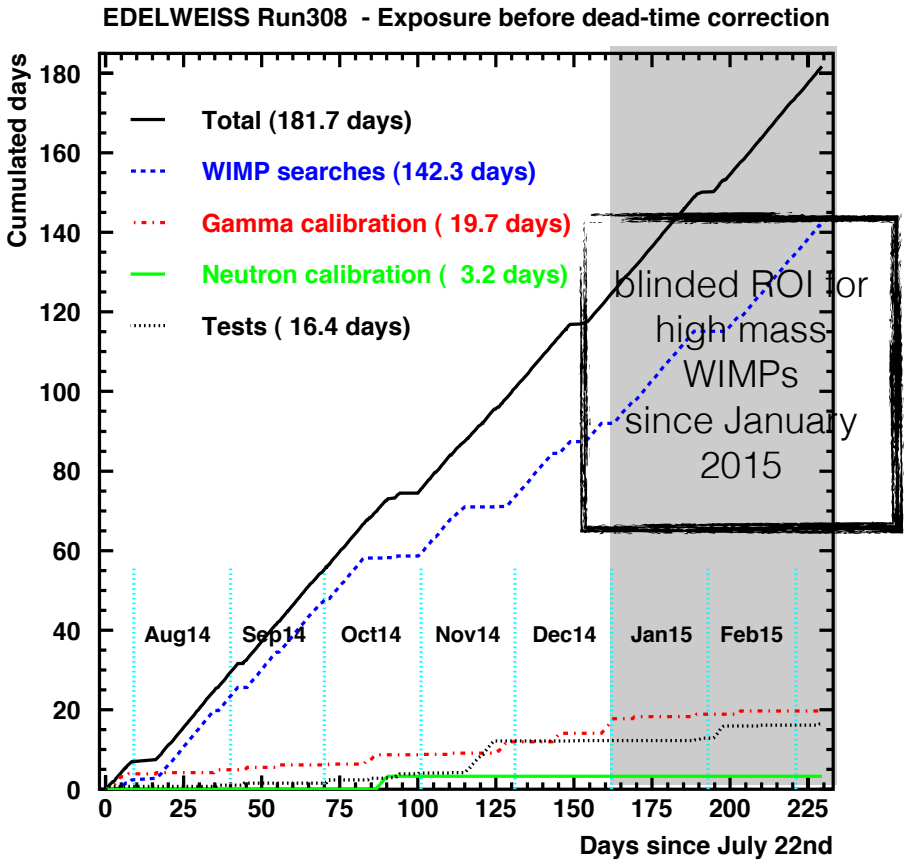
more than an order of magnitude smaller than EDW-II

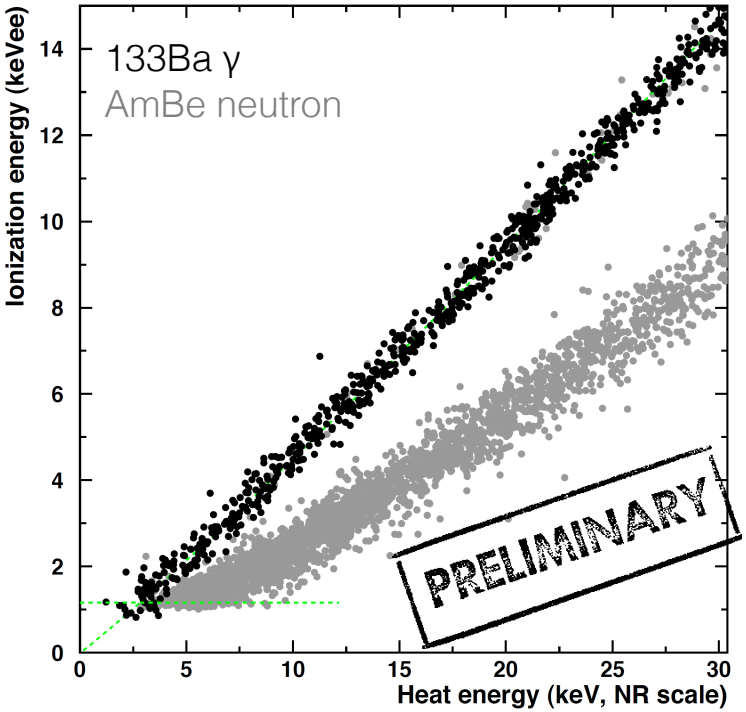
Energy spectra and neutron yields in each material calculated via SOURCES4A, then neutrons are propagated in the set-up using GEANT4 code

Evaluation of radiogenic neutron contributions from shielding and walls are ongoing.

Current Status

- Thirty-six detectors installed, twenty-four being read out
- Data taking ongoing
- Improved performance at low energies with FID800 detectors





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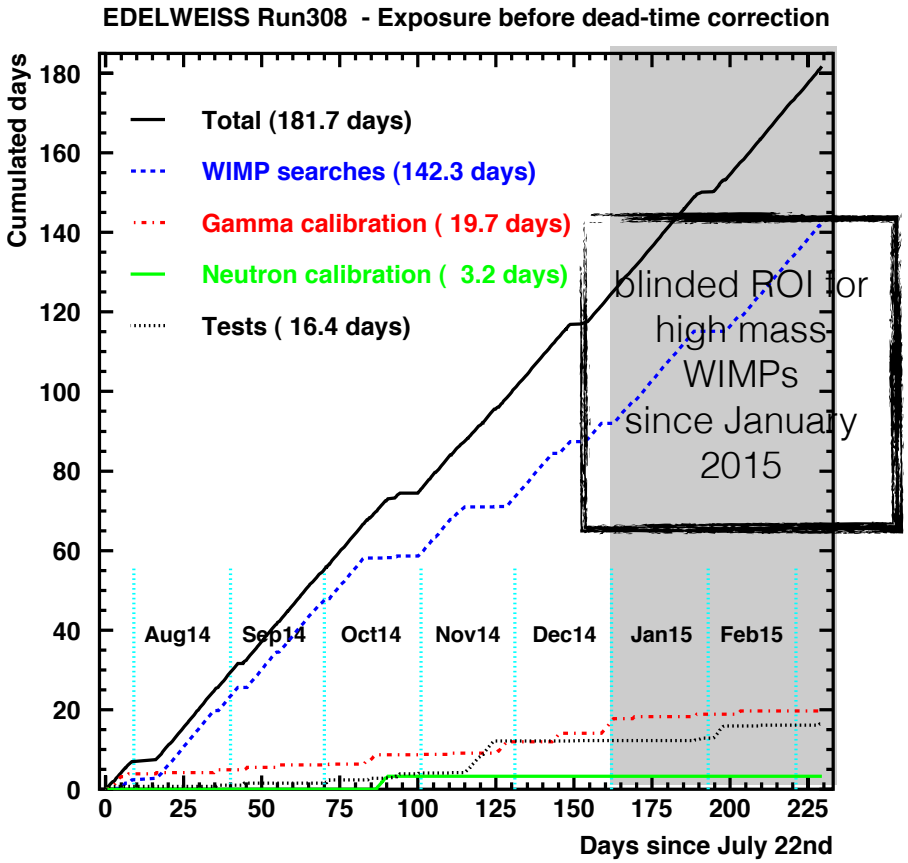

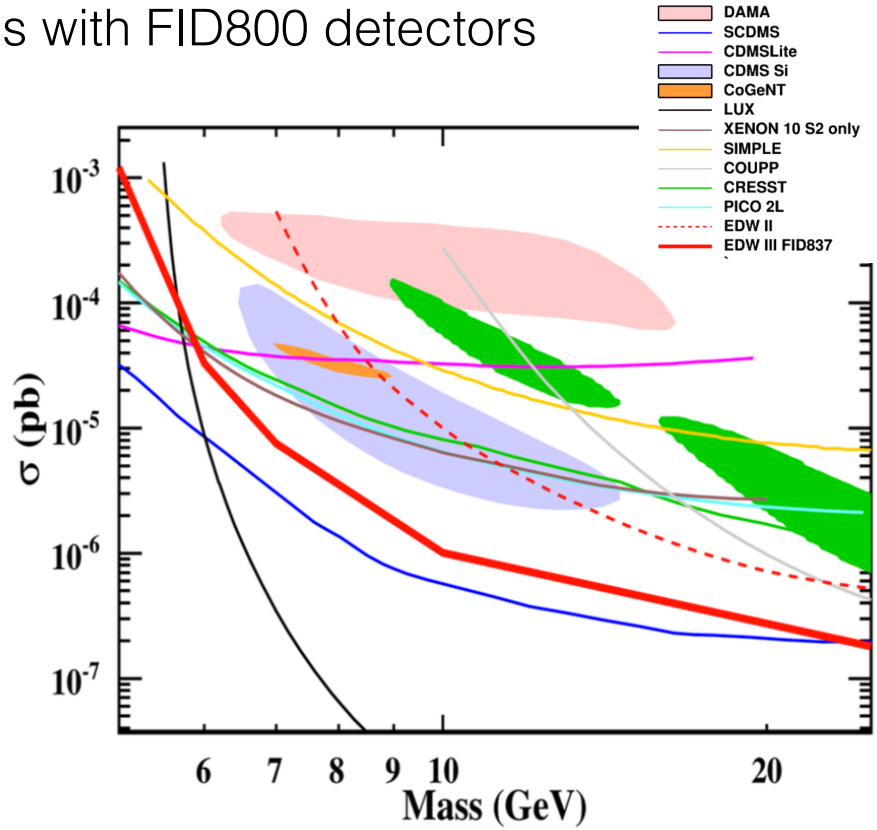

Low WIMP mass analysis results:
1FID800, 35kgd

Conclusions

- Validation of background study based on Monte Carlo simulation with GEANT4 using detailed set-up geometry. Measured radioactivity values of all relevant set-up components have been considered and quality check are ongoing.

- Gamma MC simulations need to be further improved, but they are already showing a good agreement with data.
- New screening and material selection efforts have lowered the contribution of radiogenic neutrons from materials inside the shielding by an order of magnitude w.r.t EDW-II. Evaluation of radiogenic neutron contributions from shielding and walls are ongoing.

- Low energy WIMP mass analysis shows competitive results, different analysis are ongoing and we are taking data…

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Néel Grenoble (CNRS/INP)
LPN Marcoussis (CNRS)

KIT Karlsruhe (IKP, EKP, IPE)

JINR Dubna

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