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Henrique Takato

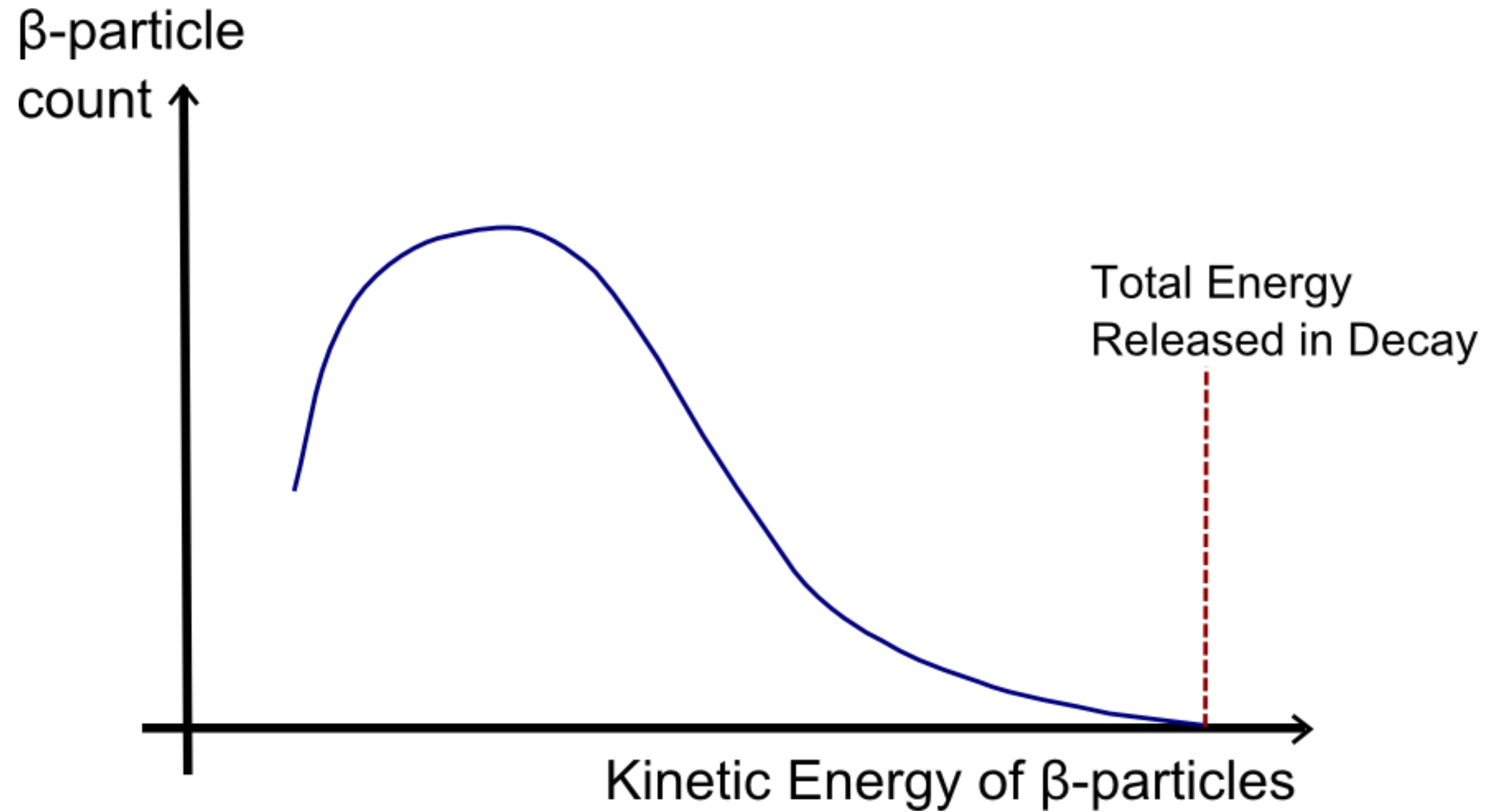
05/09/2025

Alexandre Lindote, Paulo Brás

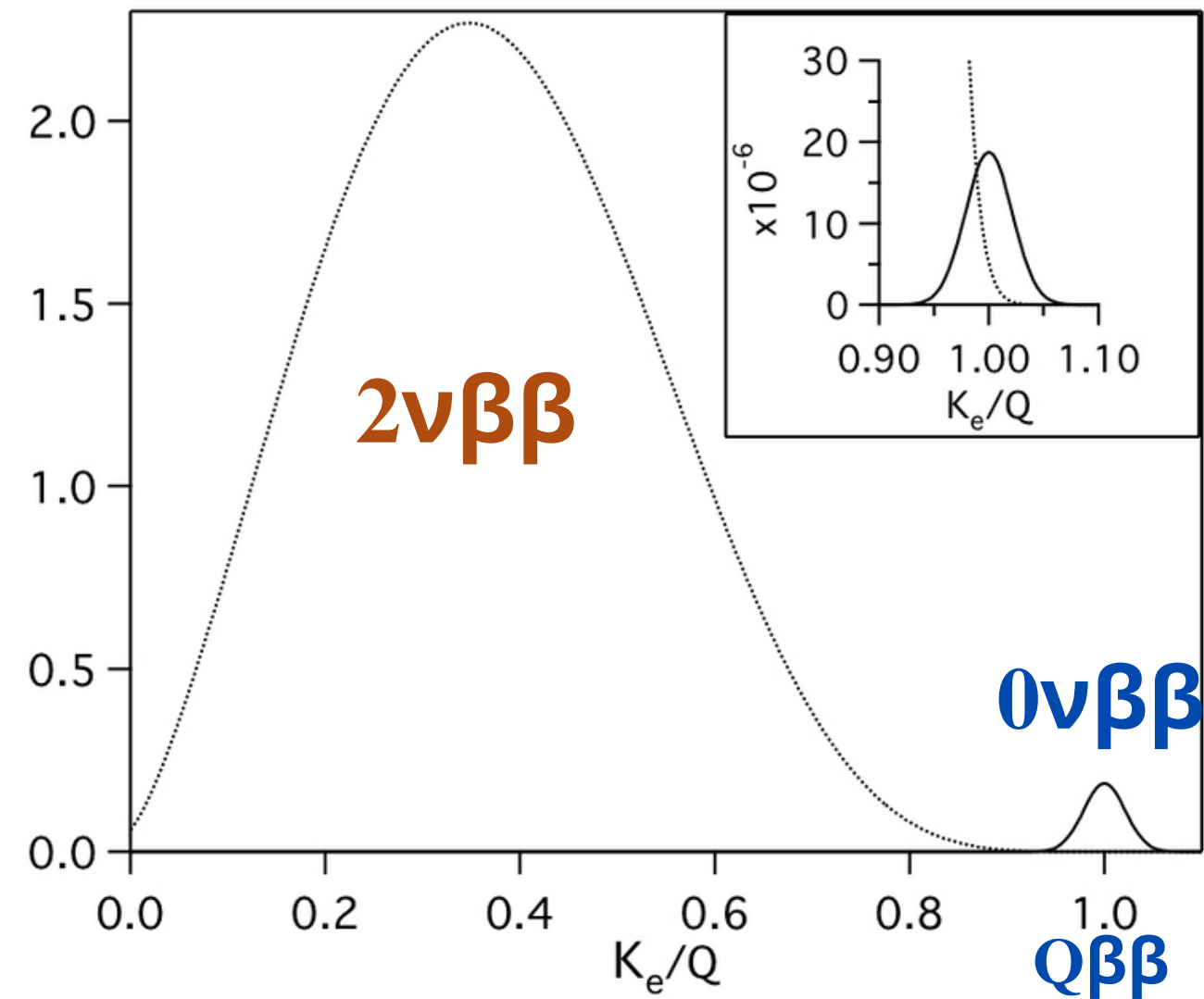
Compreendendo a natureza do neutrino: a busca por decaimento beta duplo sem neutrinos com o detector LZ

Decaimento $0\nu\beta\beta$

01



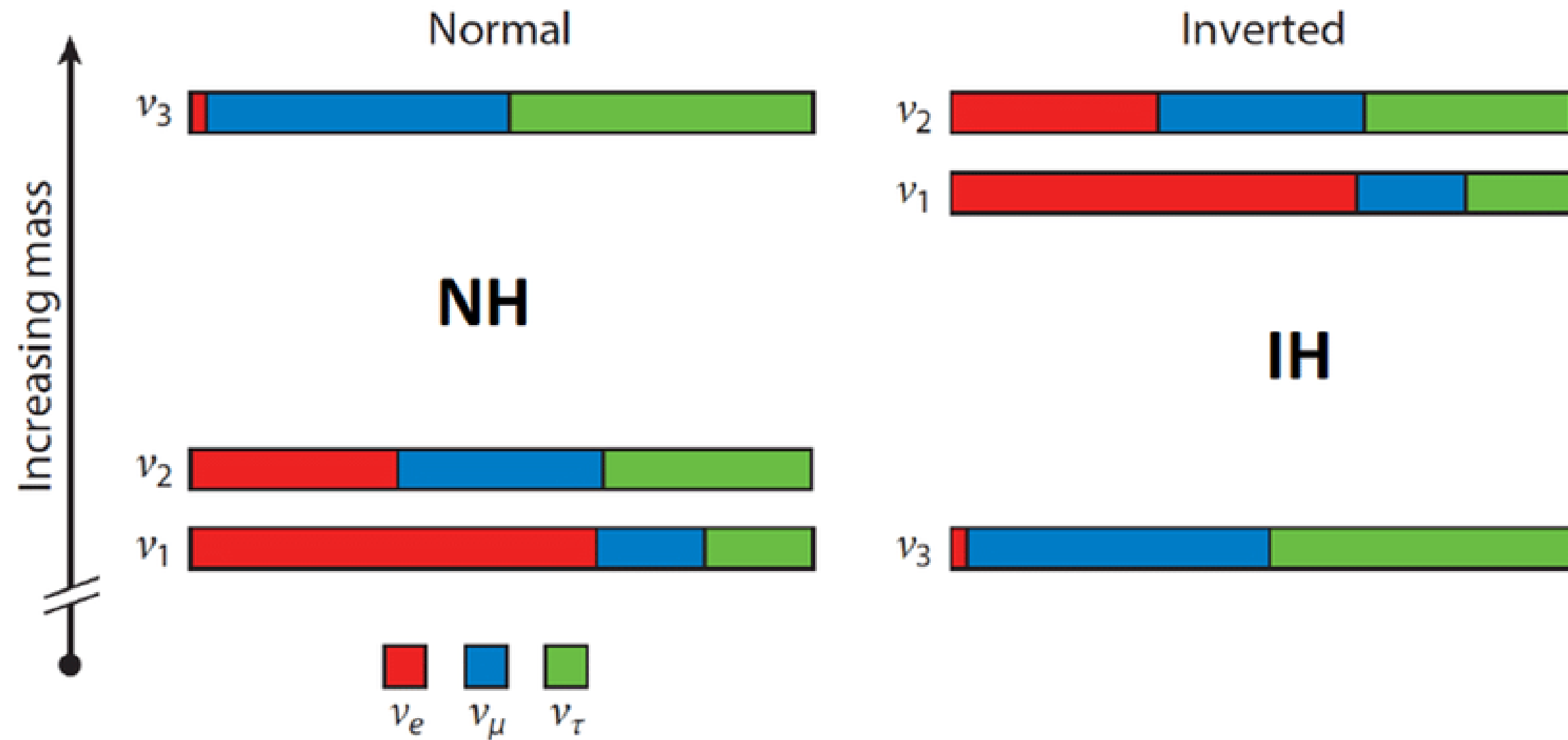
$0\nu\beta\beta$ vs $2\nu\beta\beta$



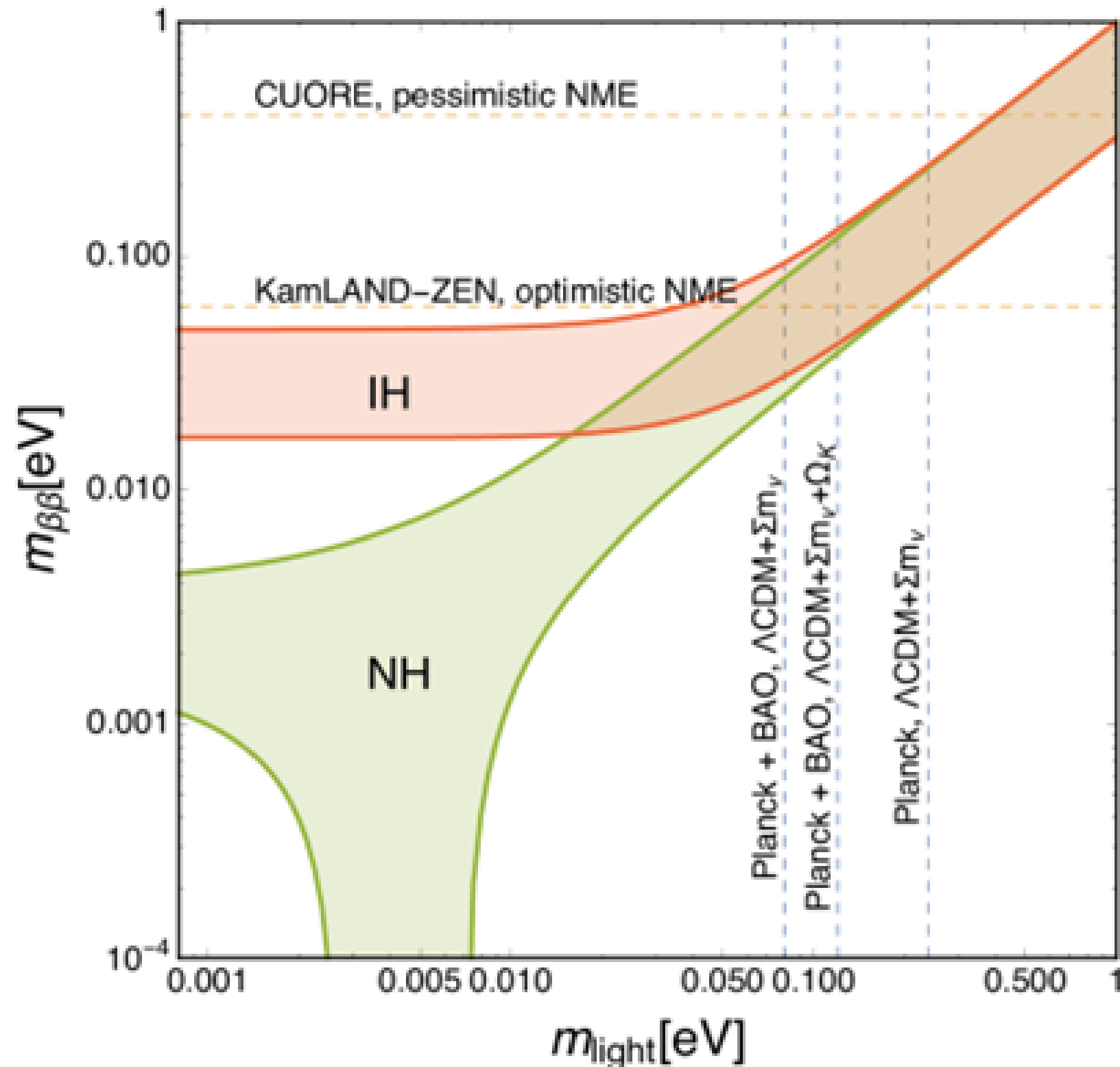
Enquanto no decaimento $2\nu\beta\beta$ o espectro de energia dos elétrons é contínuo, no decaimento $0\nu\beta\beta$ manifesta-se como um pico (região de interesse) !!!

Oscilação e hierarquia de massa

02



Hierarquia de massa



A hierarquia de massa do neutrino pode ser estudada determinando a massa efetiva de Majorana do neutrino, dada por:

$$\langle m_{\beta\beta} \rangle = \left| \sum_i U_{ei}^2 m_{\nu_i} \right| = \sqrt{\frac{\Gamma_{\beta\beta}^{0\nu}}{G^{0\nu} |M^{0\nu}|^2}}$$

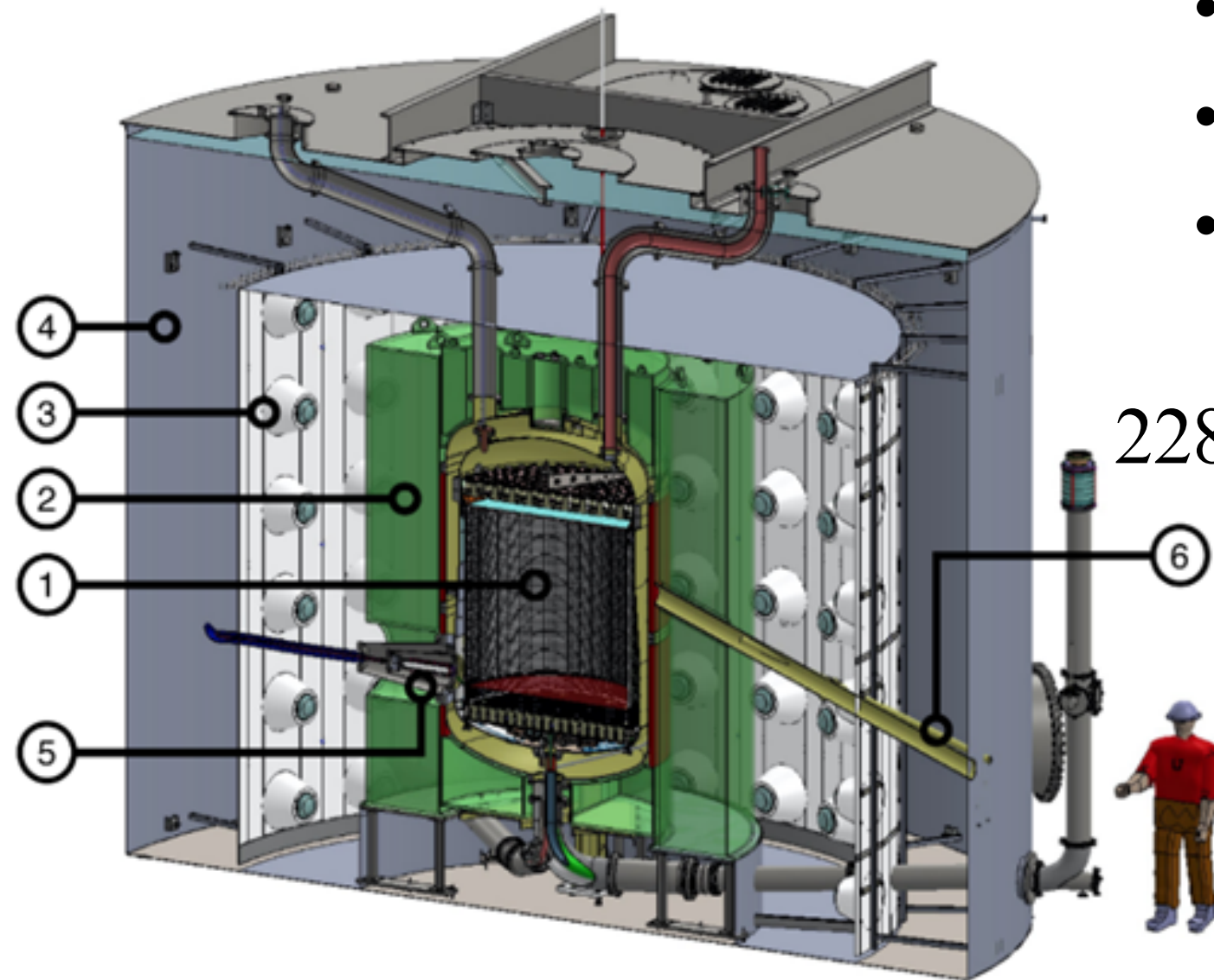
em que $\Gamma_{\beta\beta}^{0\nu}$ é a taxa de decaimento de $0\nu\beta\beta$, que será determinado com os dados obtidos na experiência LUX-ZEPLIN

A Experiência

Composed of 3 distinct detectors:

- 7 t dual-phase Xe TPC with 494 PMTs (1)
- ~3 tonne Xe “skin” detector around TPC
- 17.3 tonne Gd-loaded liquid scintillator Outer Detector (2) with 120 PMTs (3)

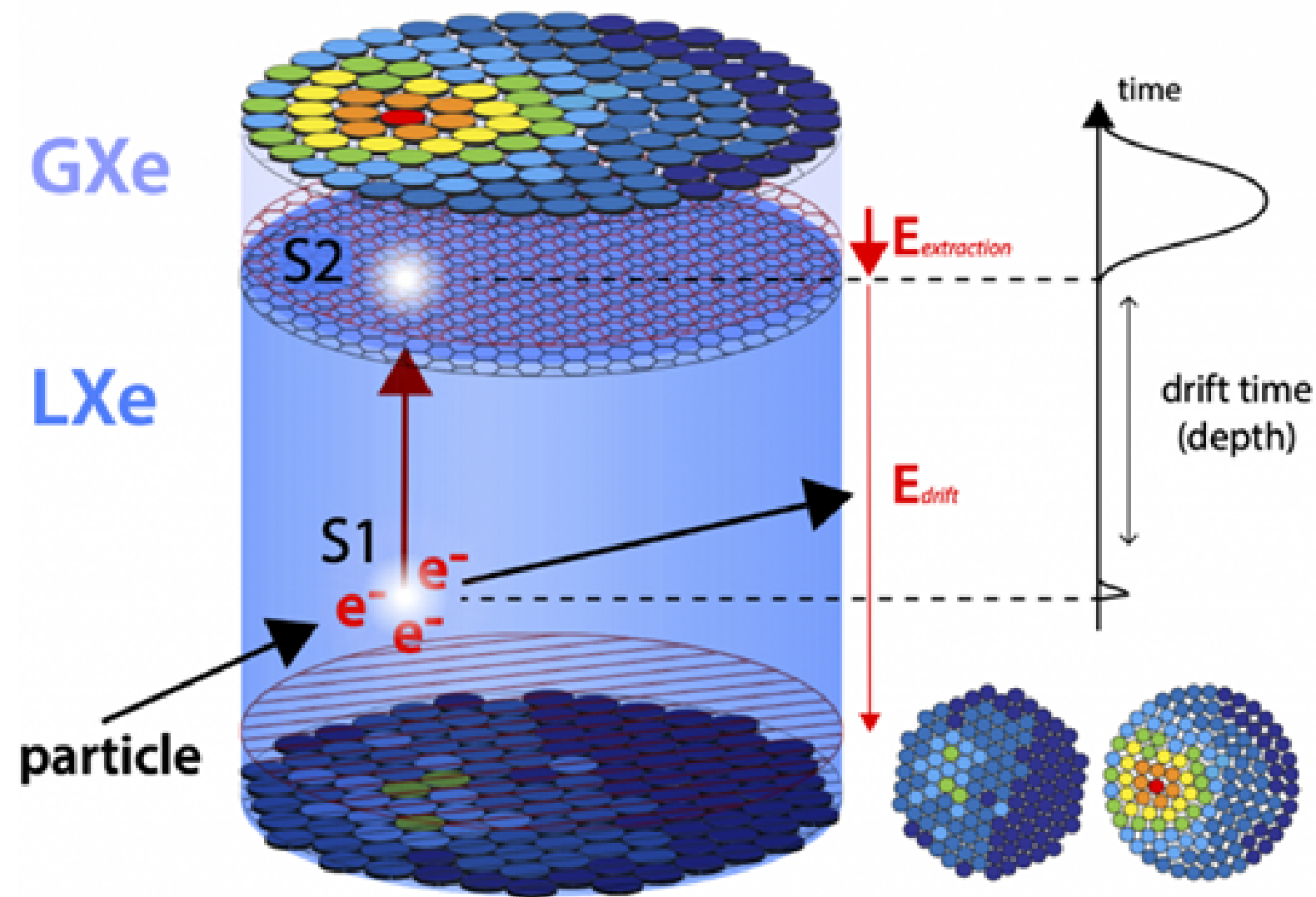
228 tonne water shield and muon veto (4)



High-voltage umbilical (5)

Neutron source tube (6)

Princípio de funcionamento do TPC



- A partícula deposita energia no Xénon líquido, produzindo luz de cintilação imediata (sinal S1).
- Os elétrons que não se recombinam chegam ao Xénon gasoso e produzem luz de eletroluminescência atrasado (sinal S2).
- Este setup é capaz de determinar a posição de interação inicial: o Z é determinado pelo intervalo de tempo entre S1 e S2 e XY é determinado pelo padrão de luz de S2 captado na matriz de PMTs superior.

Dados

Os dados usados de SR1 de LZ, com uma exposição total de cerca de 90 live-days (25 de fevereiro até 28 de junho de 2022)

Energia (keV)

Raio (cm)

Tempo de deriva (us)

S1 e S2

Cortes

ROI

cxMuonVeto

cxBufferLG

CxWindowS1

cxWindowS2

cxS1TBA

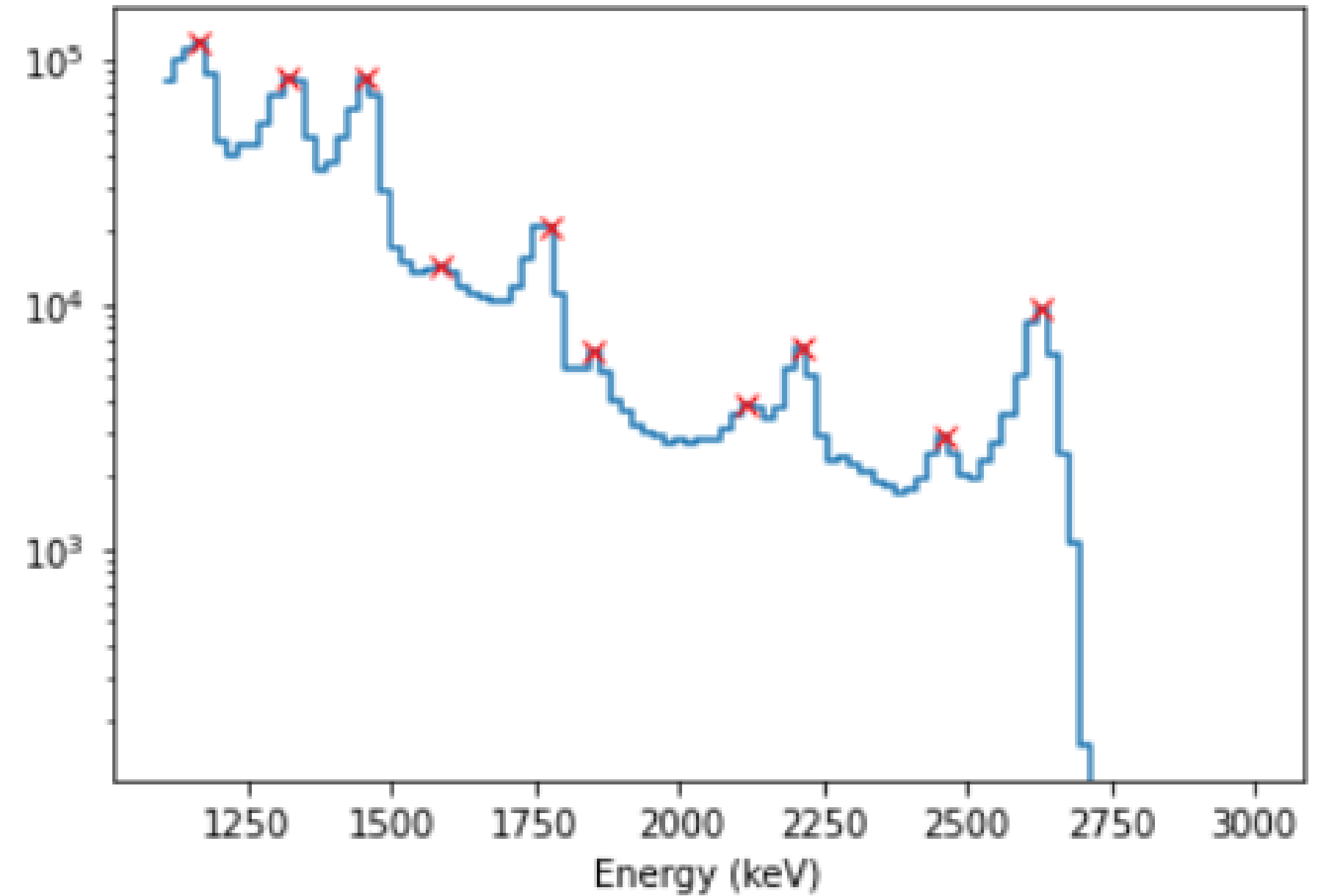
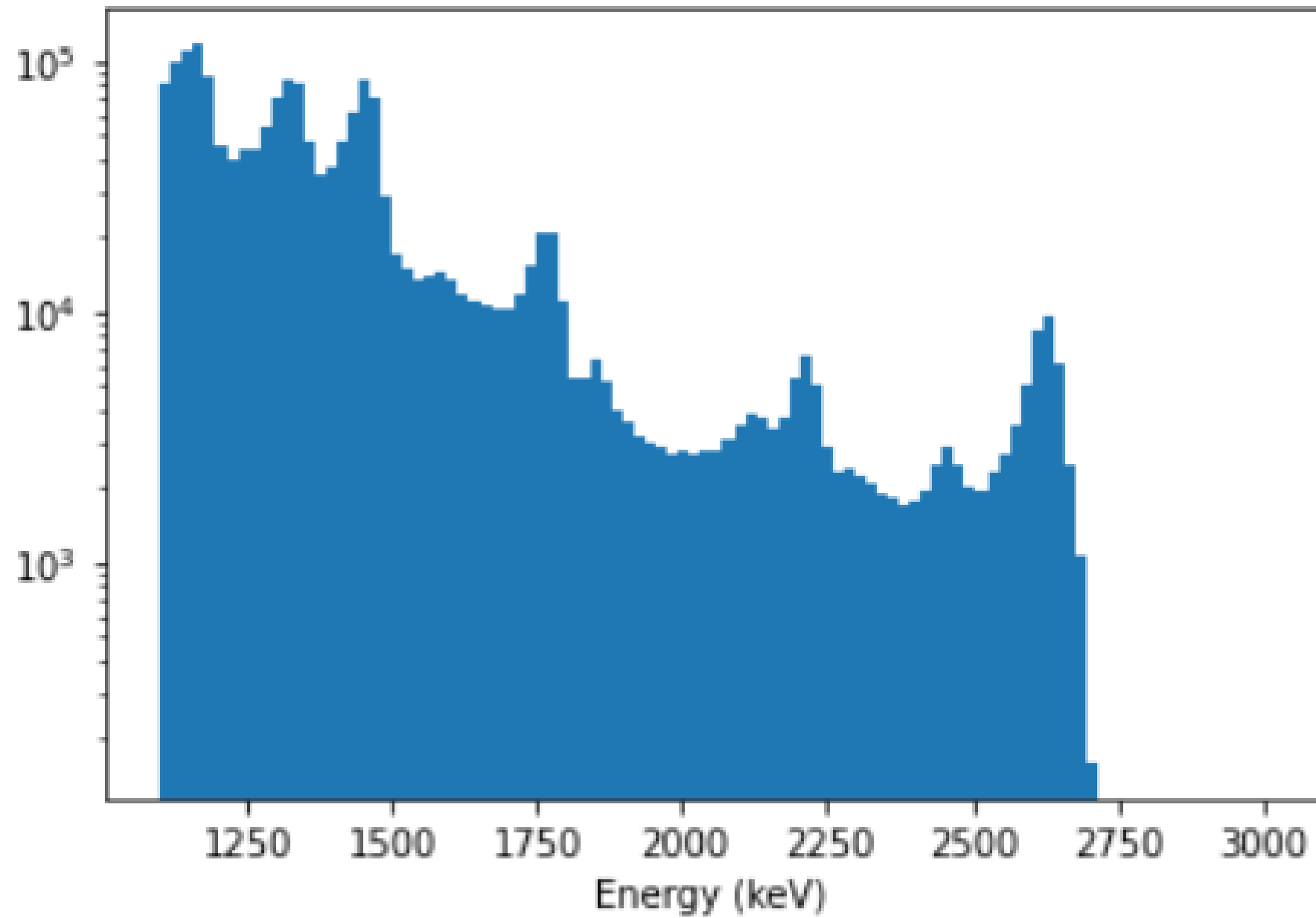
cxOuterShell

cxHESkinPromptVeto

cxODPromptVeto

ENERGIA (keV)

06.1



Only ROI cuts

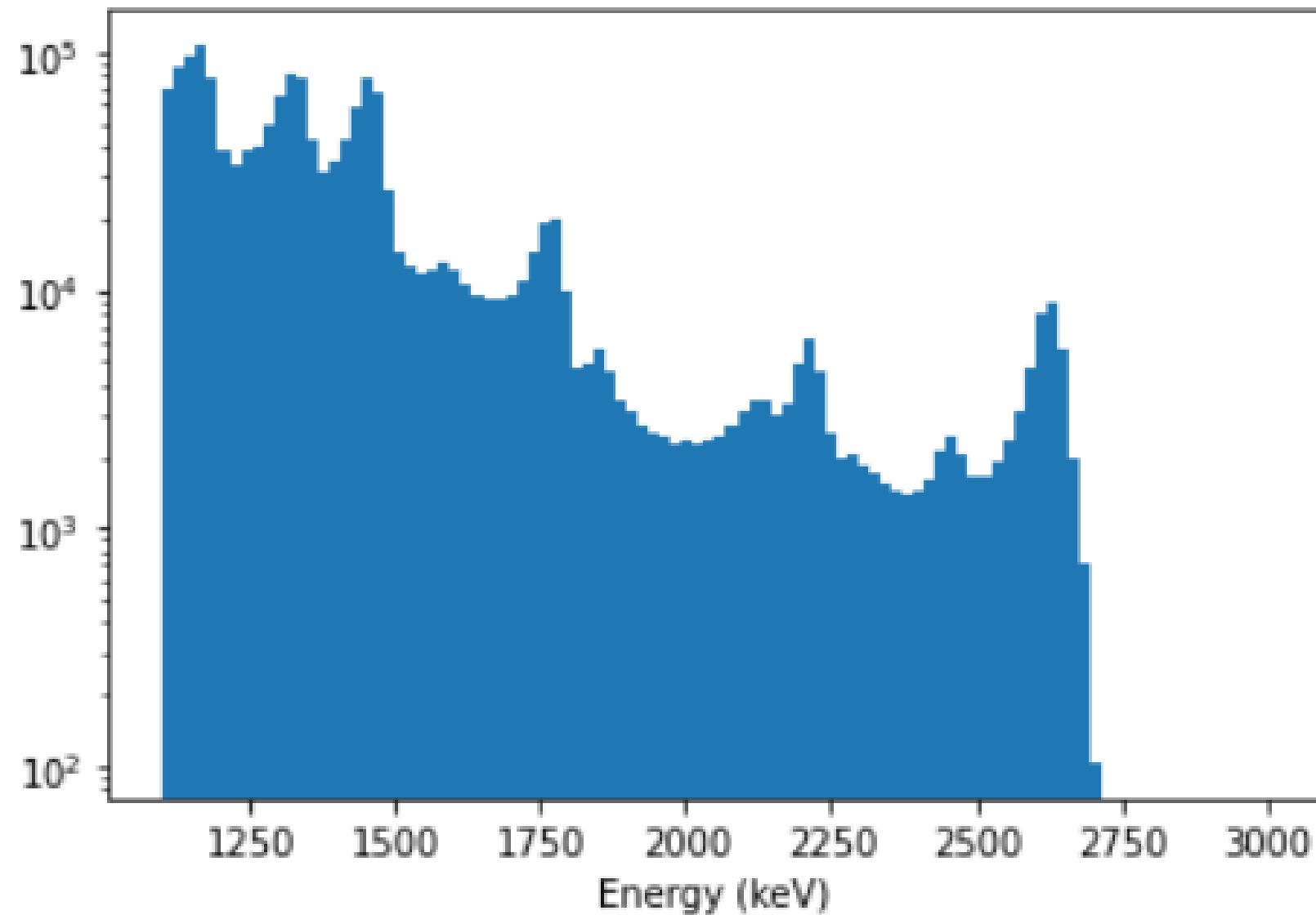
Identificar as diferentes estruturas visíveis no espectro (picos e principais fatores de forma) e associá-las a decaimentos conhecidos

Energy resolution of the LZ detector for high energy|| Background Determination for the LUX-ZEPLIN (LZ) electronic recoils Dark Matter Experiment

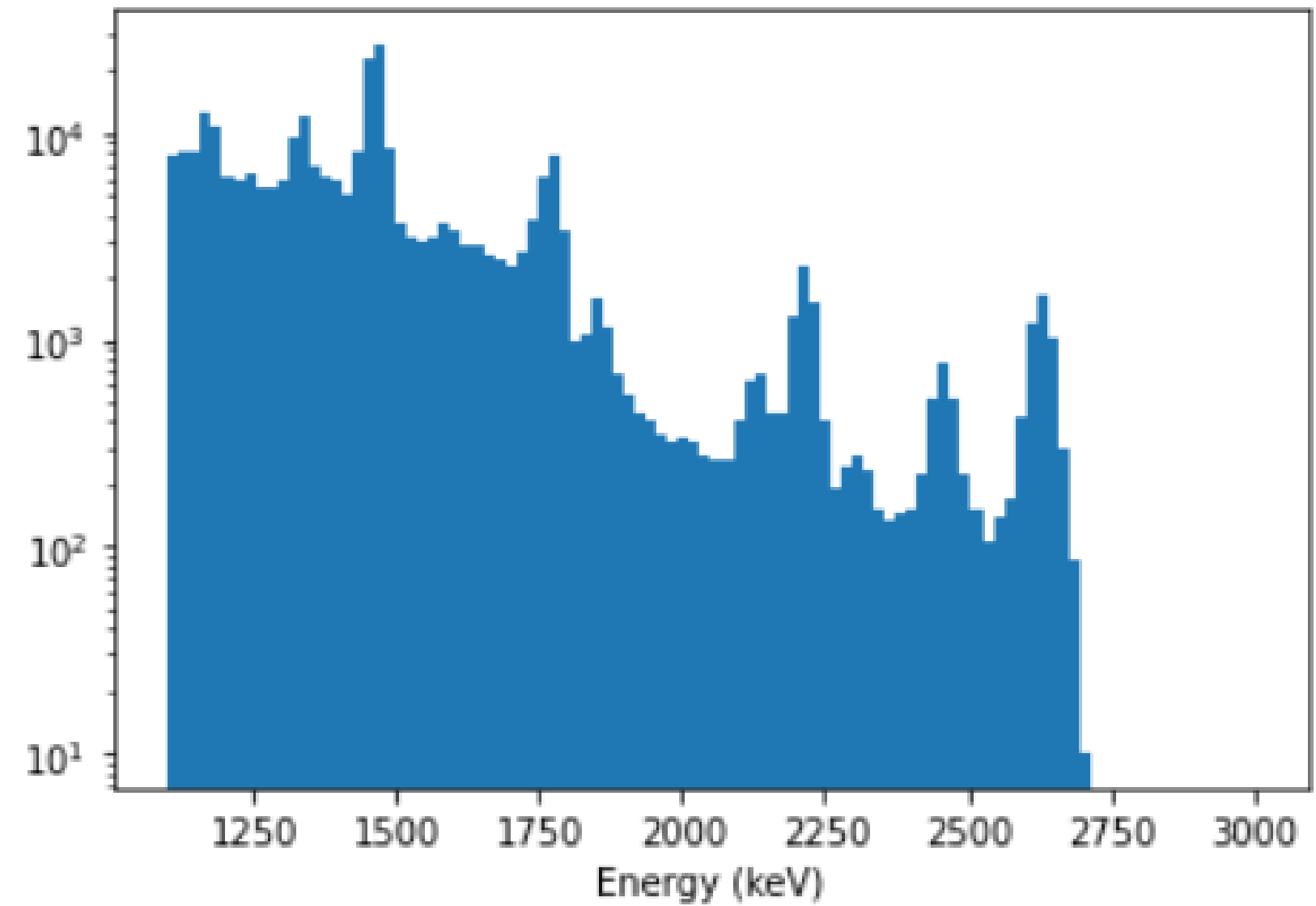
Pico 1: Energia = 1166.50 keV (Bi-214: 1120.3 keV - Co-60: 1173.2 keV)	U-238(late)
Pico 2: Energia = 1318.50 keV (Co-60: 1332.5 keV)	
Pico 3: Energia = 1451.50 keV (K-40: 1460.8)	U-238(late)
Pico 4: Energia = 1584.50 keV (-)	
Pico 5: Energia = 1774.50 keV (Bi-214: 1729 - 1765 keV)	U-238(early and late)
Pico 6: Energia = 1850.50 keV (Bi-218: 1847.4 keV)	U-238(early and late)
Pico 7: Energia = 2116.50 keV (Bi-214: 2118.55 keV)	U-238(late)
Pico 8: Energia = 2211.50 keV (Bi-214: 2204 keV)	U-238(late)
Pico 9: Energia = 2458.50 keV (Bi-214: 244 7.9 keV)	U-238(late)
Pico 10: Energia = 2629.50 keV (Th-208: 2614 keV)	

ENERGIA (keV)

06.1



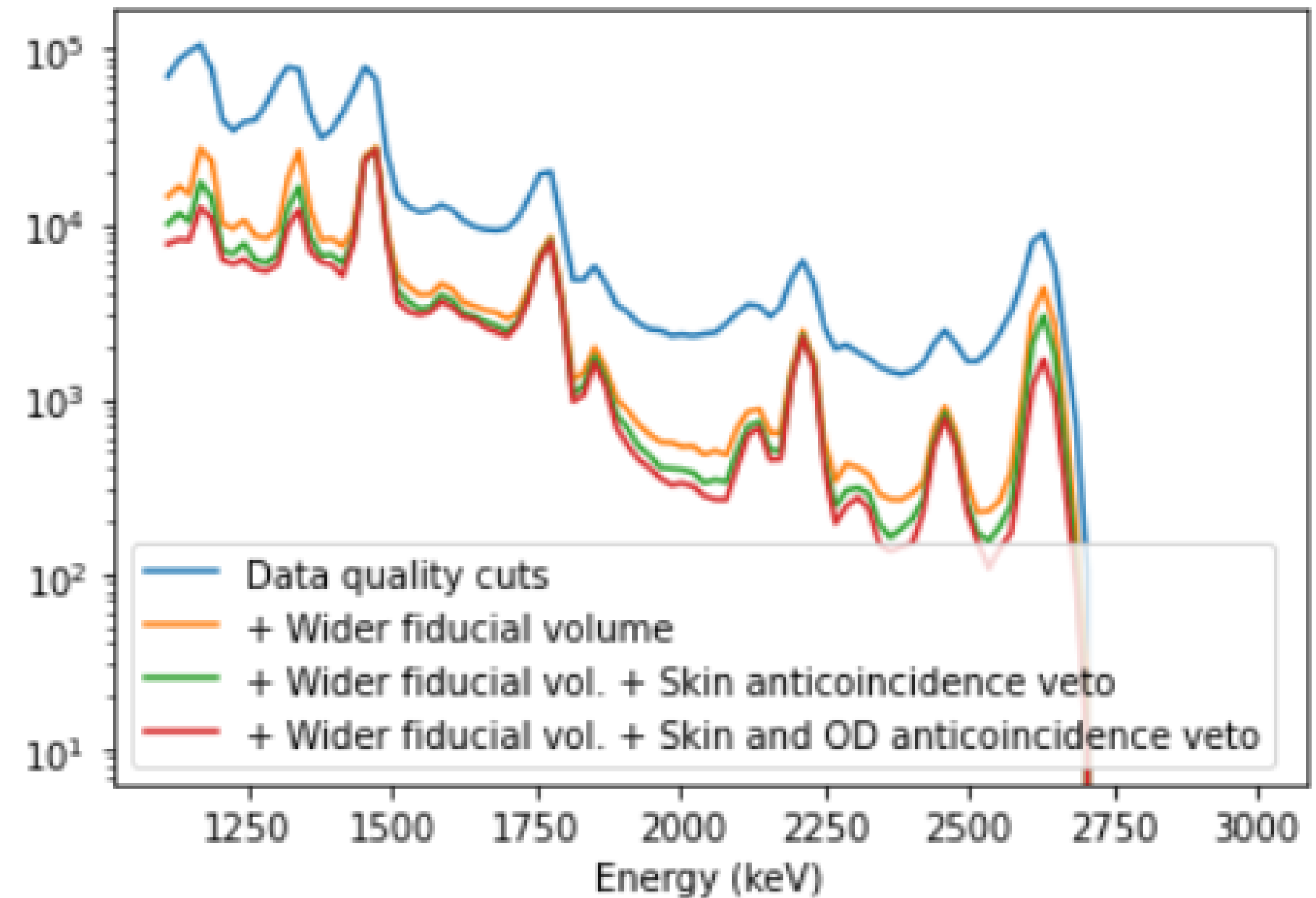
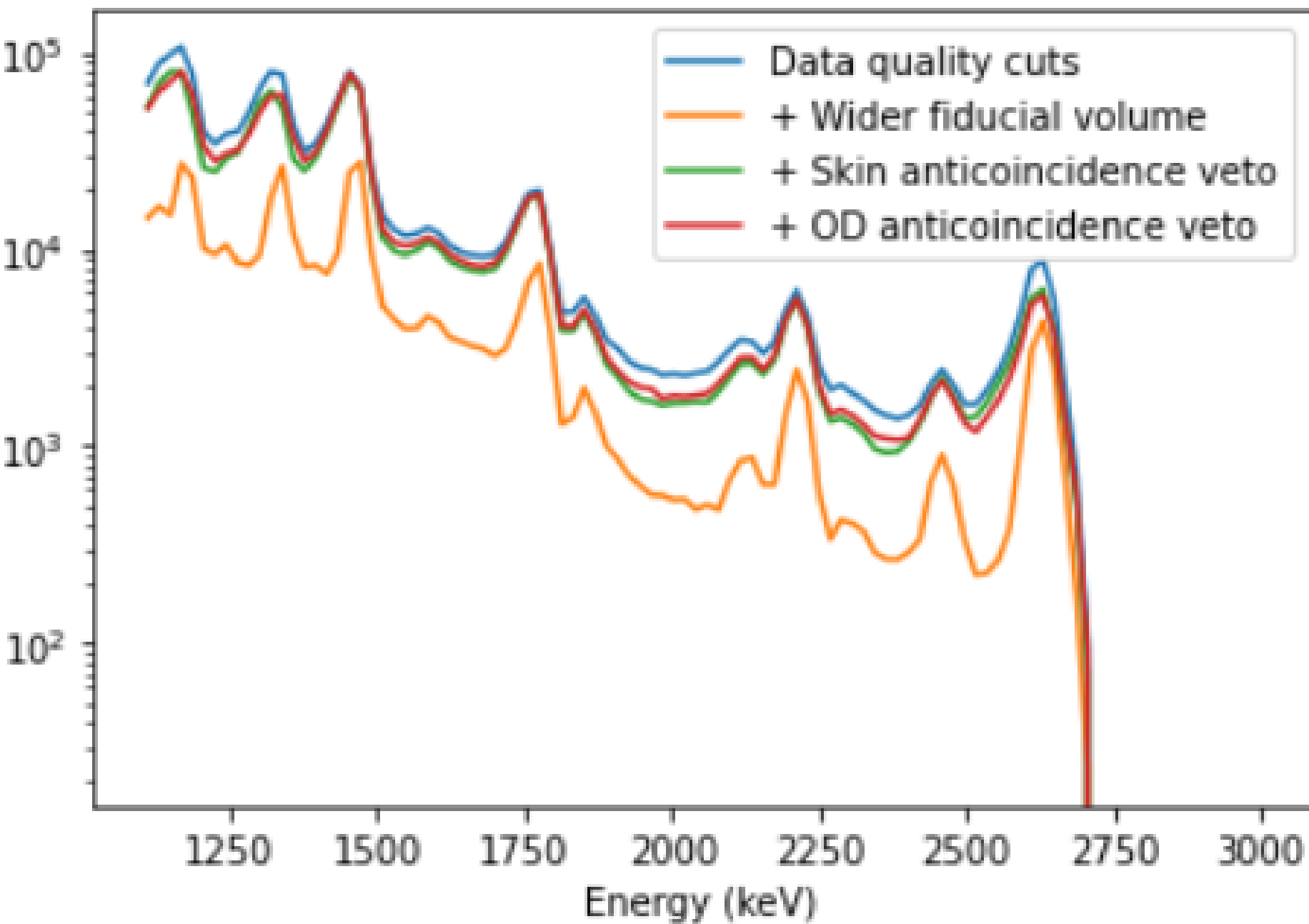
ROI + cxMuonVeto + cxBufferLG +
CxWindowS1 + cxWindowS2 + cxS1TBA



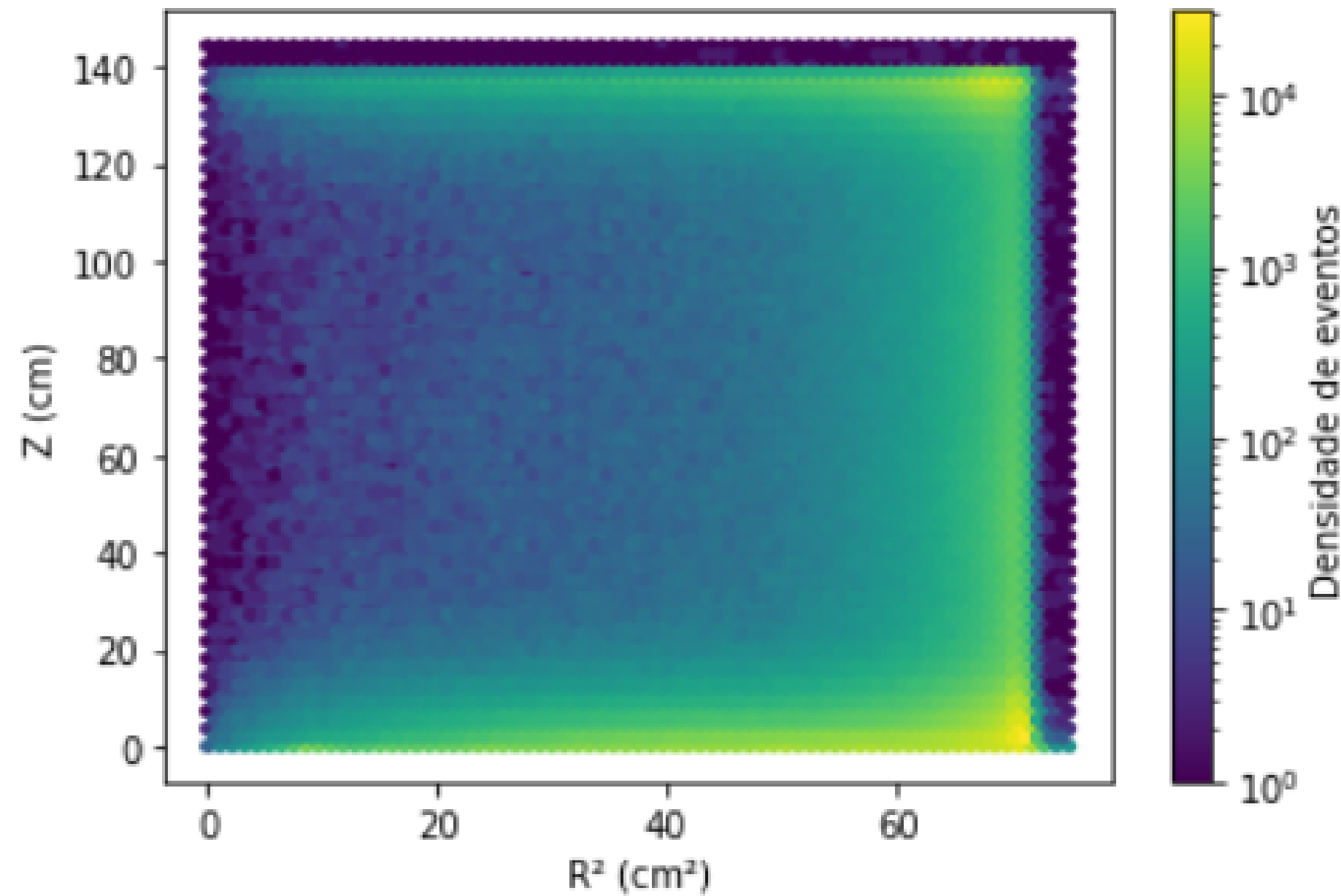
ROI + cxMuonVeto + cxBufferLG +
CxWindowS1 + cxWindowS2 + cxS1TBA
+ cxOuterShell + cxHESkinPromptVeto +
cxODPromptVeto

ENERGIA (keV)

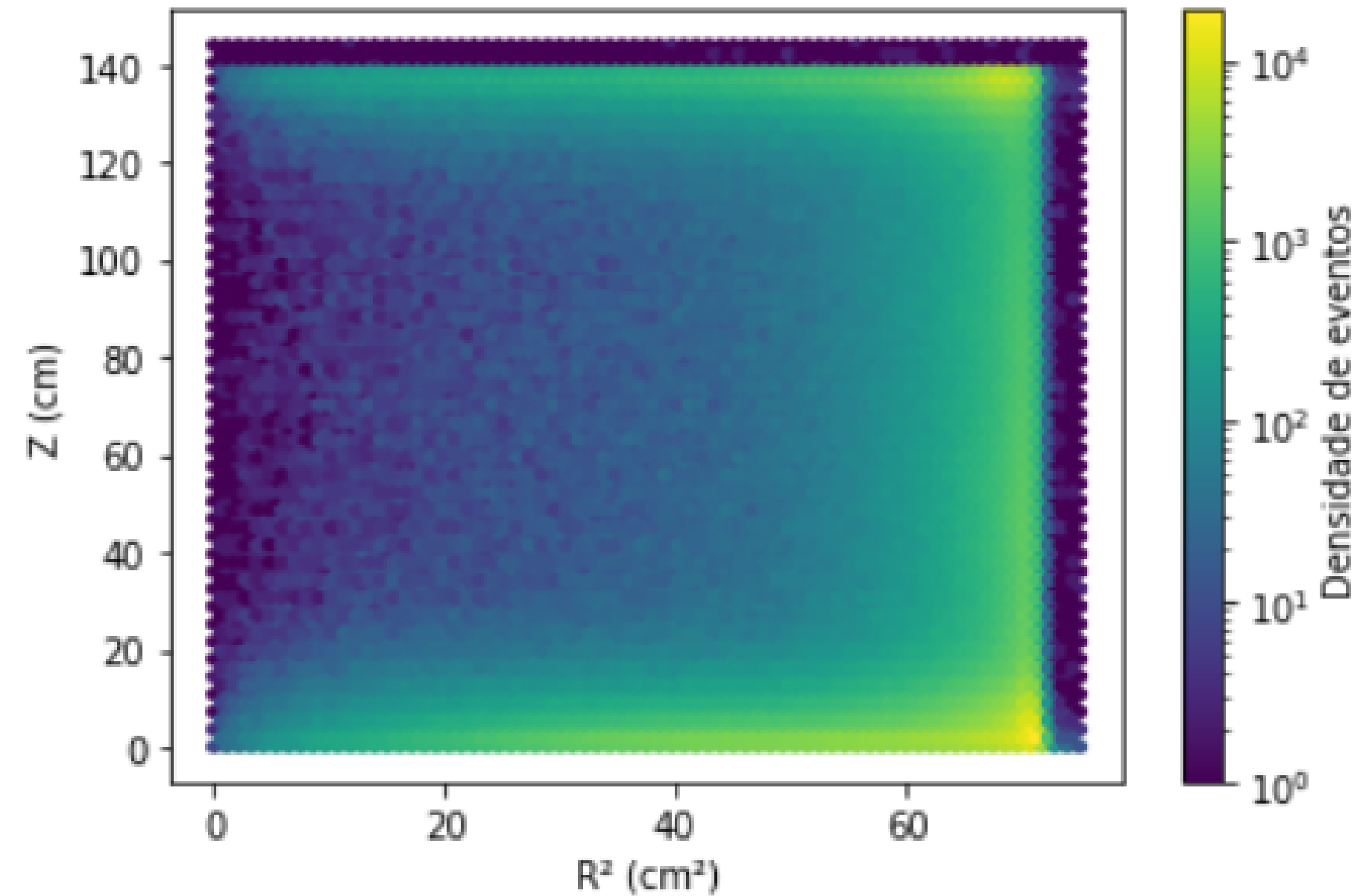
06.1



$R^2(\text{cm}^2)$ vs $Z(\text{cm})$

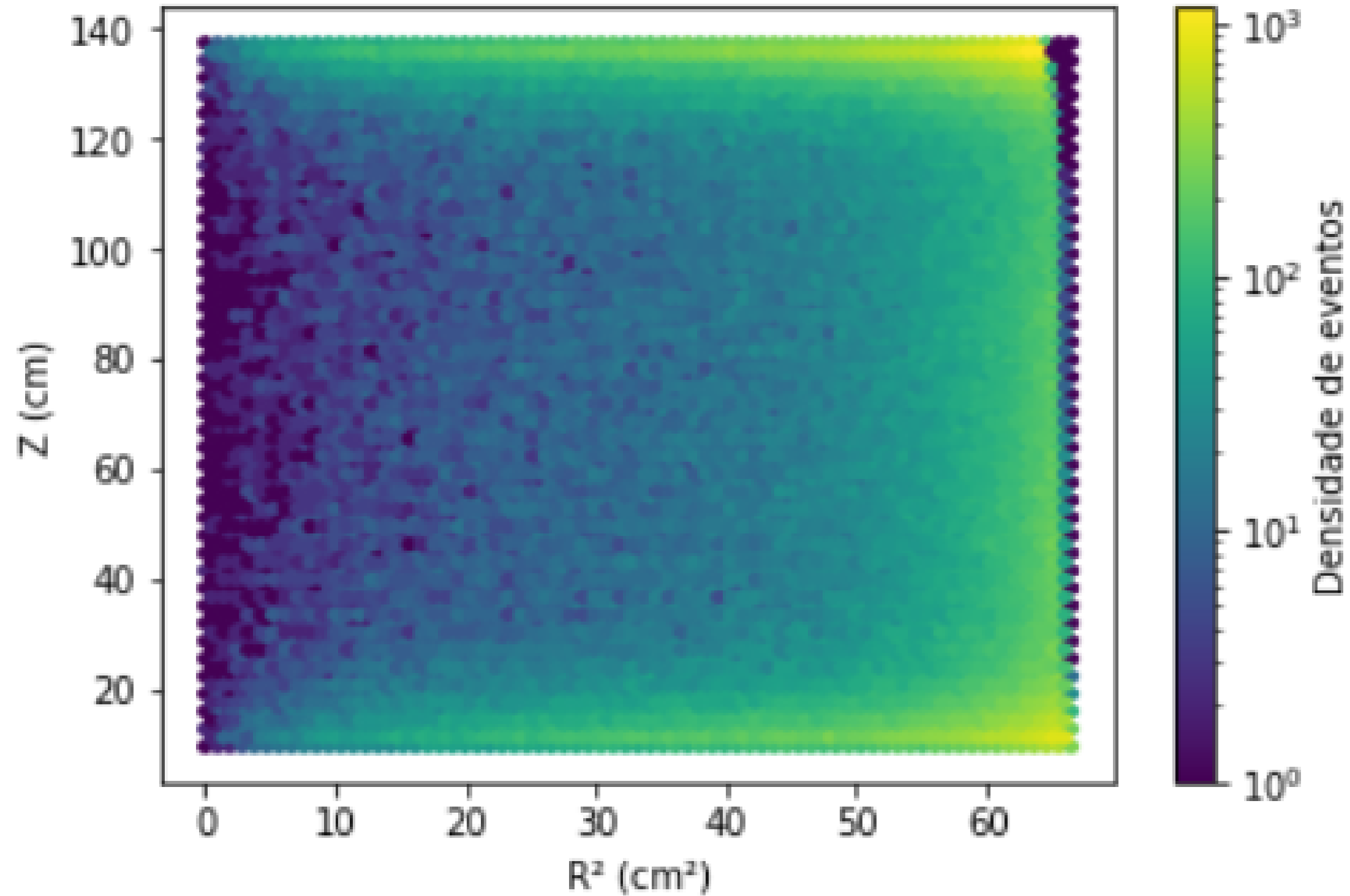


ROI



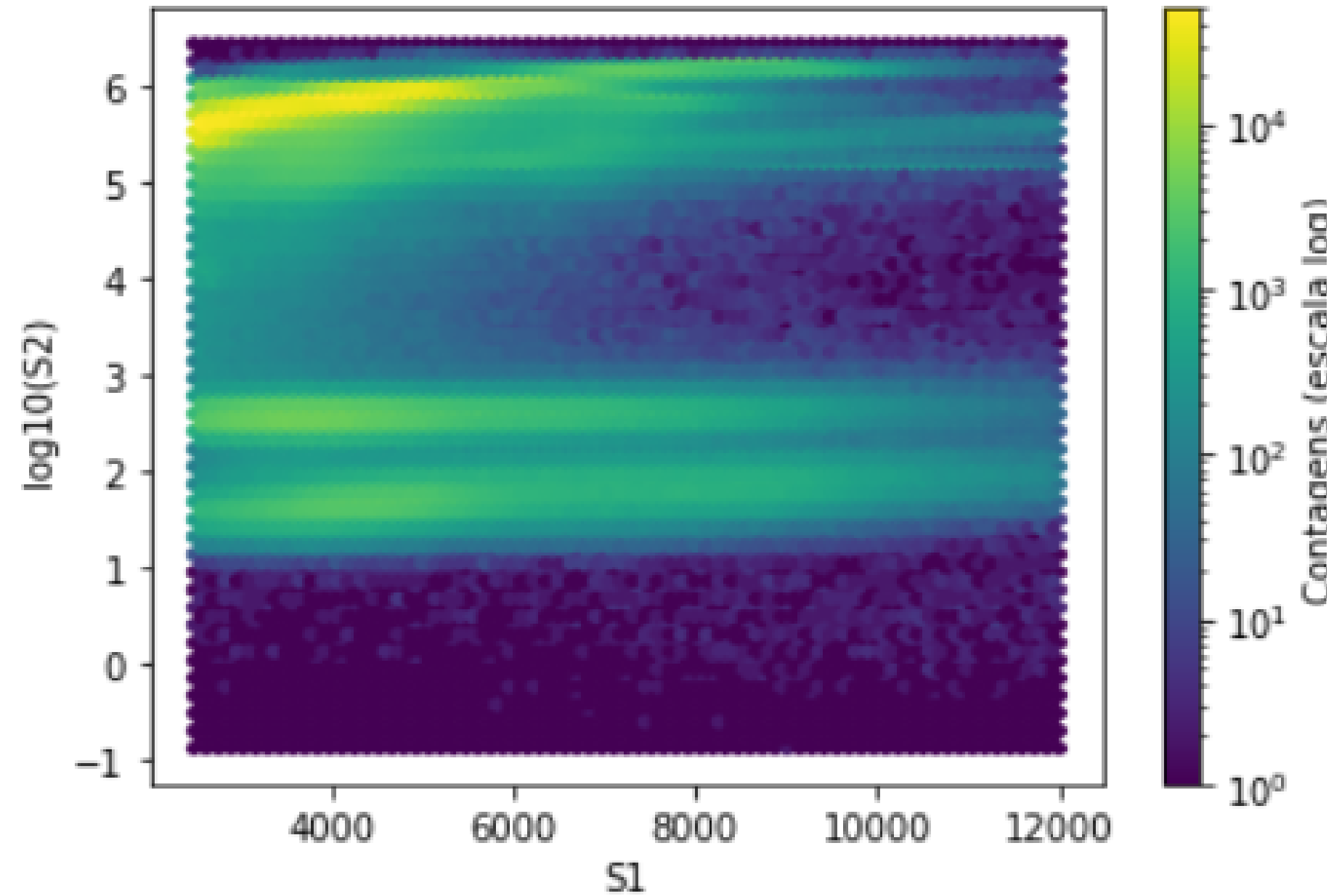
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$R^2(\text{cm}^2)$ vs $Z(\text{cm})$

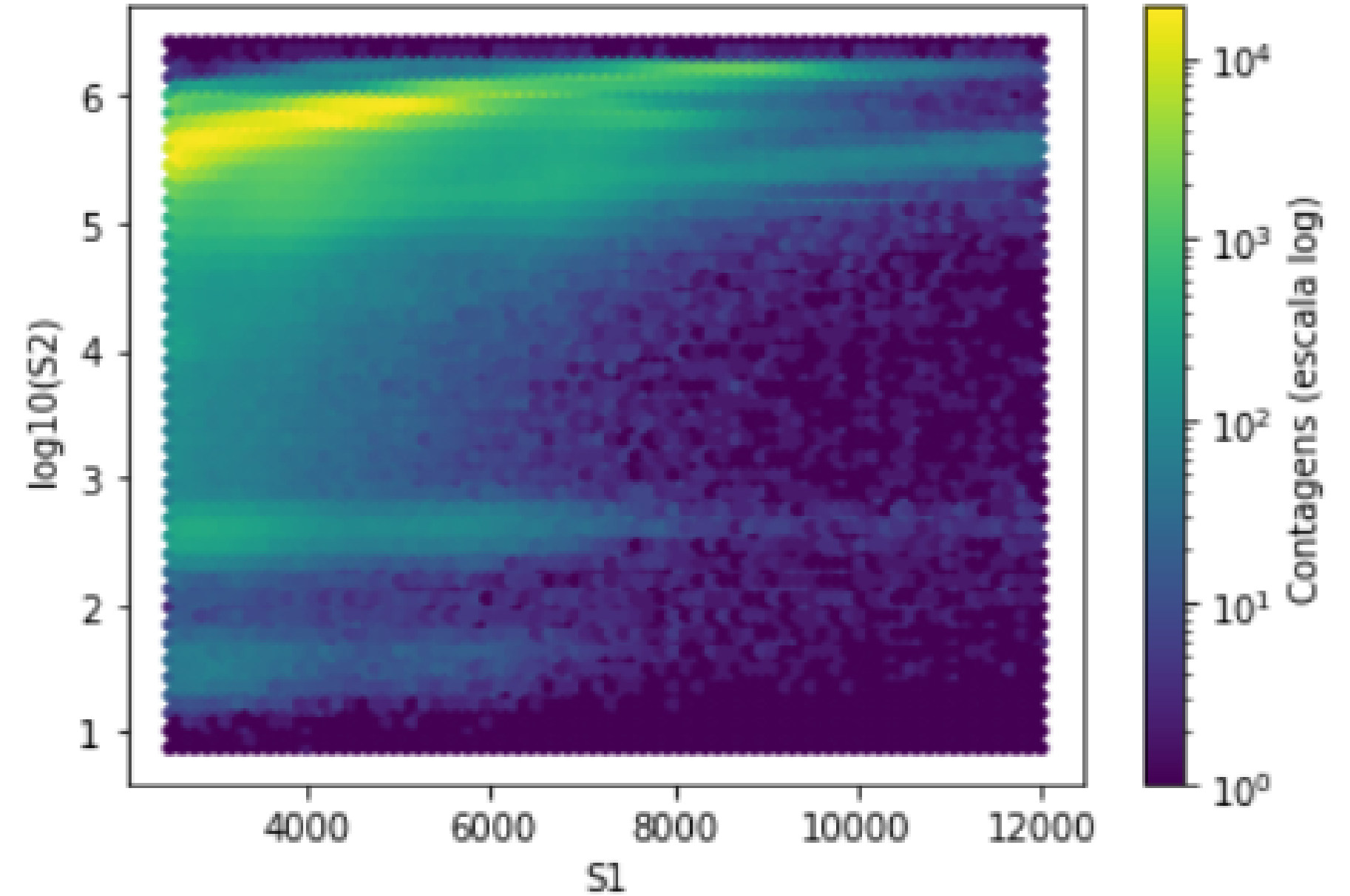


ROI + cxMuonVeto + cxBufferLG
+ CxWindowS1 + cxWindowS2 +
cxS1TBA
+ cxOuterShell +
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cxODPromptVeto

S1 vs $\log_{10}(S2)$

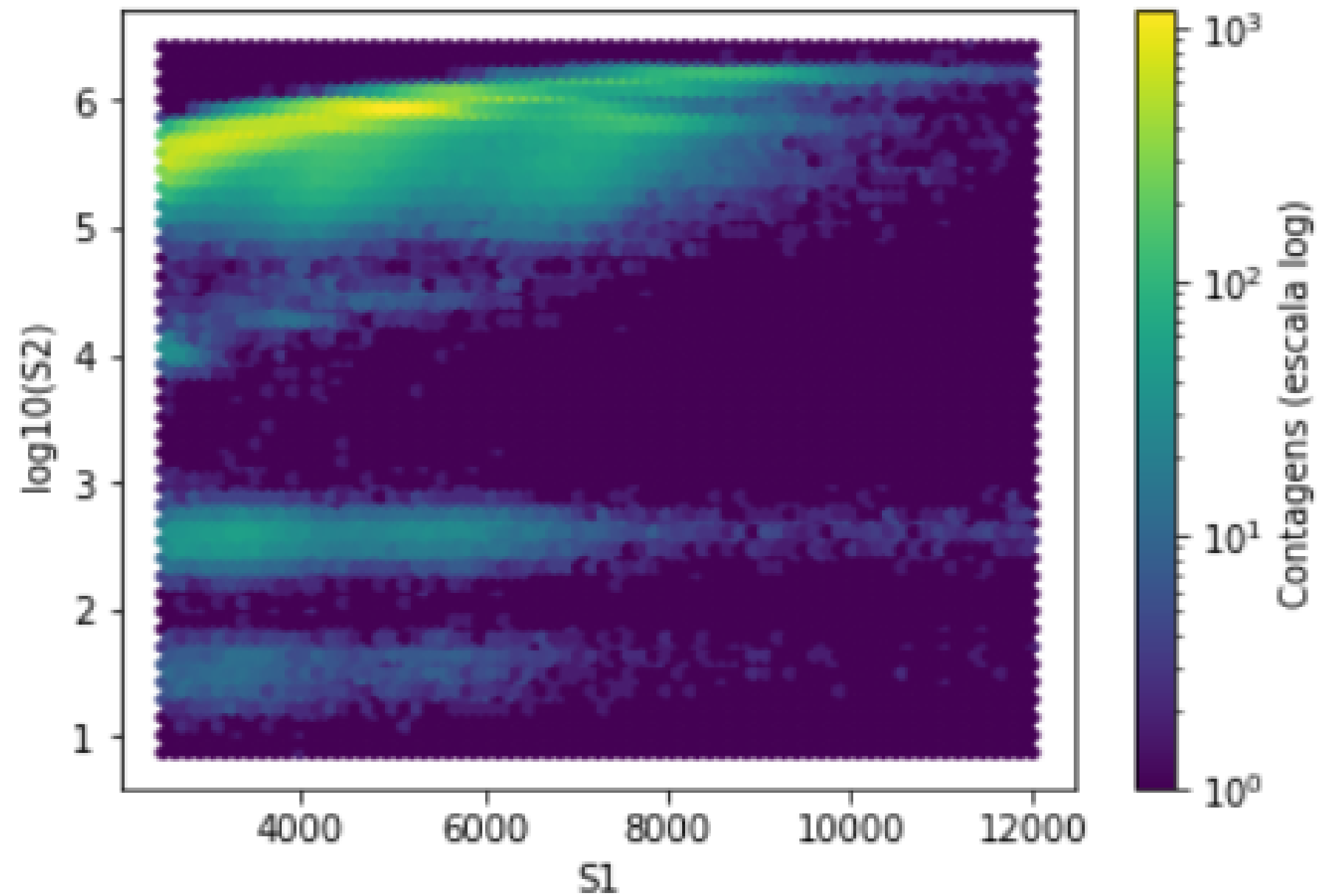


Only ROI cuts



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S1 vs $\log_{10}(S2)$



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Conclusões