Studies for a Xenon1t Dark Matter Detector

- Gamma Background

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University of Zürich

Structure

I. Introduction

- XENON 1t
- LVD

II. Gamma Measurements

III. Background Simulations for Xenon1t

IV. Summary and Outlook

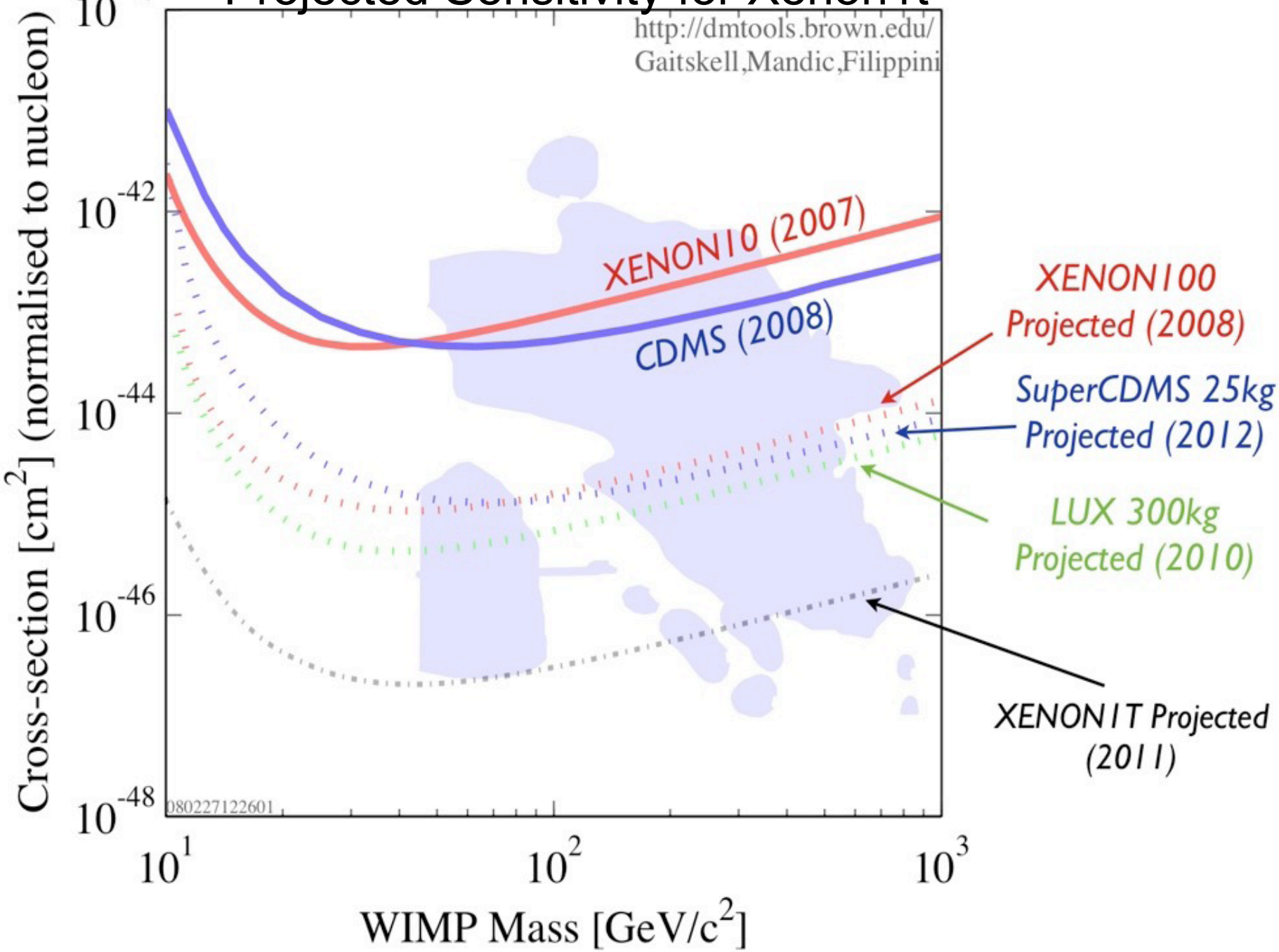
I. Introduction
Xenon1t

- Next step of Xenon100

- Fiducial Volume mass: 1t
- Mass of Liquid Xenon: 3t

- Goal

Projected Sensitivity for Xenon1t



I. Introduction
Xenon1t

- Next step of Xenon100

- Fiducial Volume mass: 1t
- Mass of Liquid Xenon: 3t

- Goal

Gamma BG	**10^{-4} DRU**
Neutron BG	**1 / (2 years)**
Exposure	**2 years**
WIMP sensitivity (100GeV)	**$3 * 10^{-47}$ cm^2**
BG reduction	factor 100 -> Xe100

I. Introduction
Xenon1t

- Challenges
  - reduce BG
  - technical demands (like drift field)
  - find new Location
    - in Gran Sasso or other Underground Lab

I. Introduction
Xenon1t

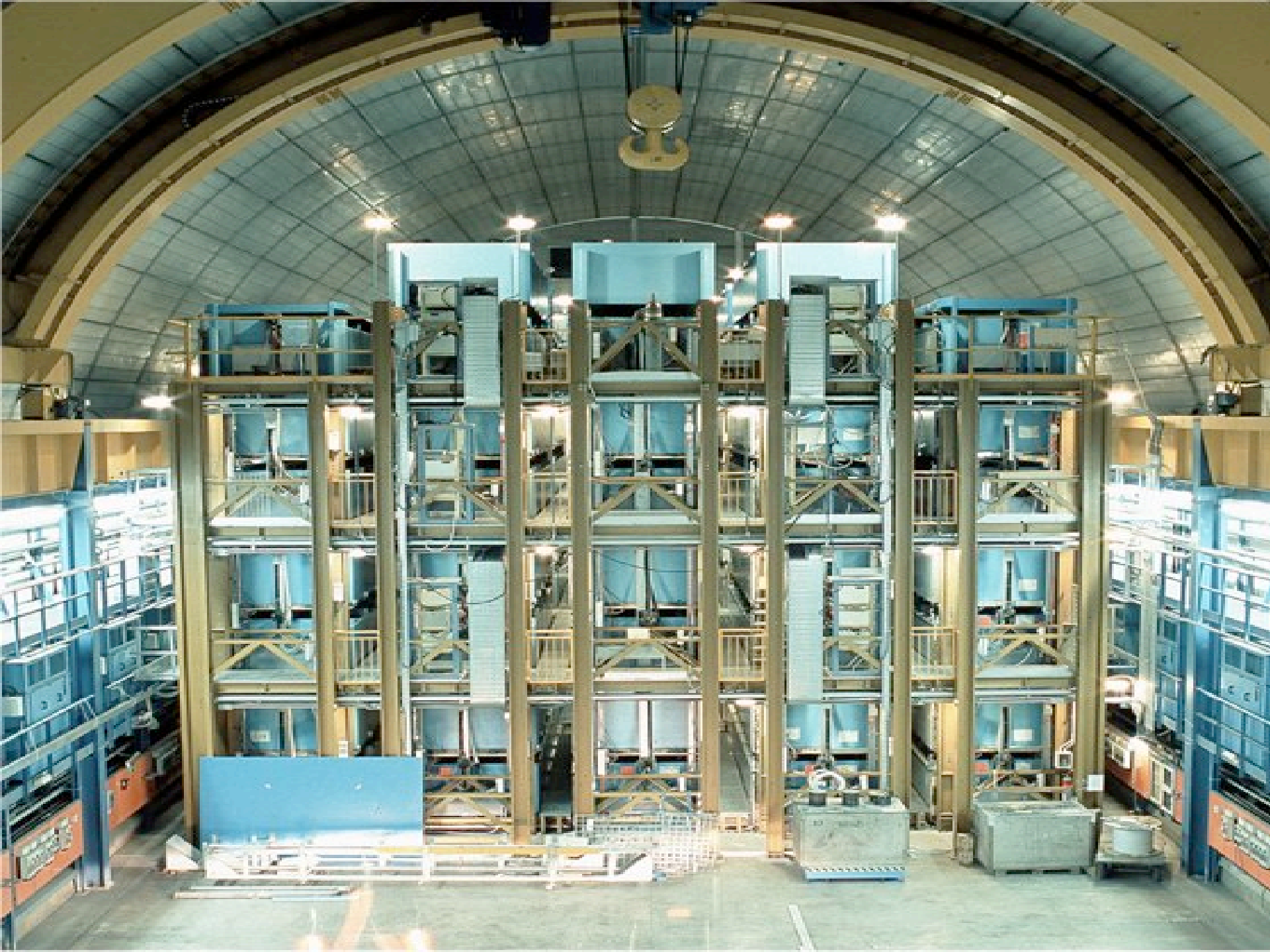
- Challenges
  - reduce BG
  - technical demands (like drift field)
  - find new Location

- Possible Location: Inside LVD Detector
  - My Work:

    Studies of the expected gamma backgrounds

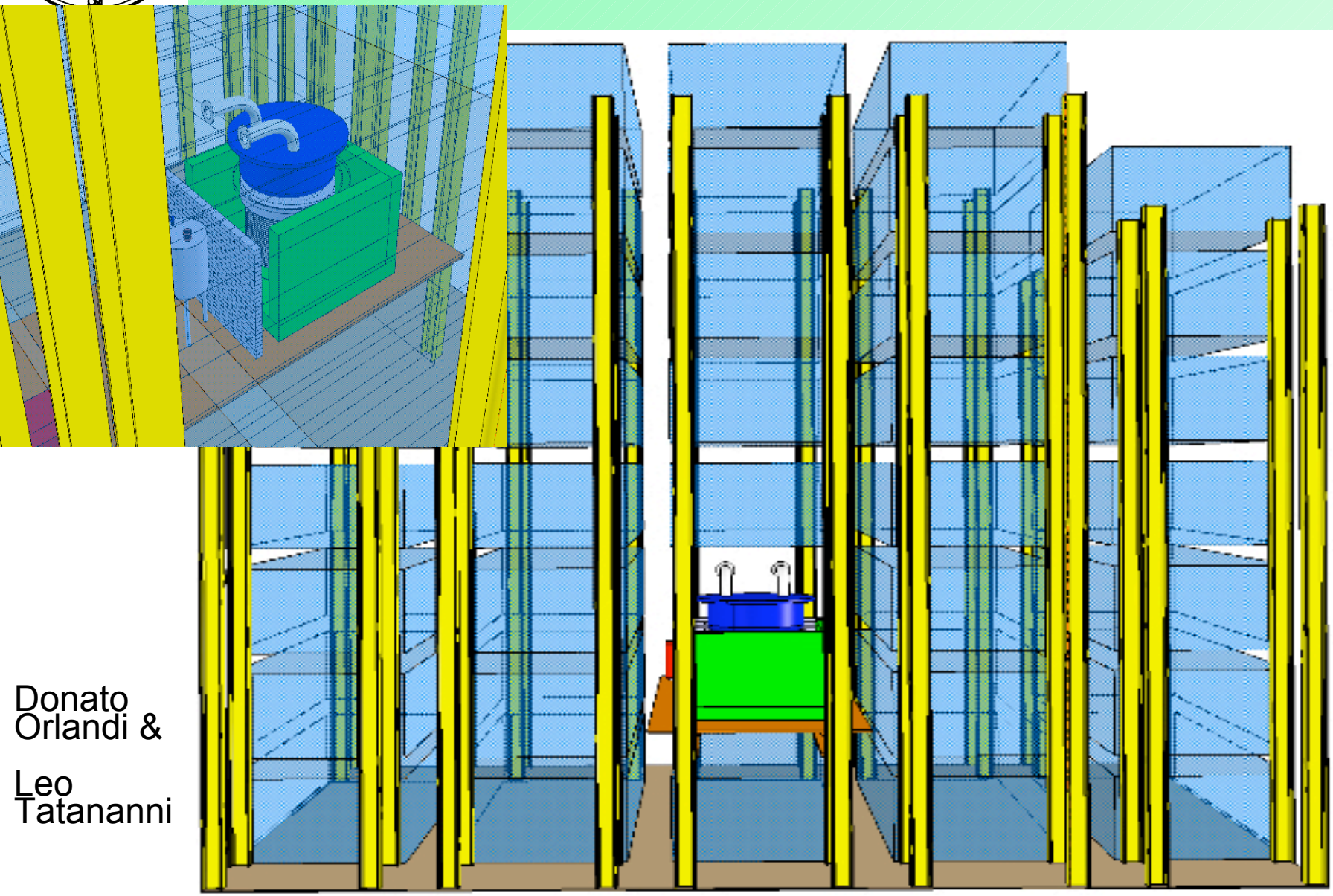
I. Introduction
LVD

- Large Volume Detector
- Hall A of the Gran Sasso Laboratory
- Aim: Detecting stellar collapses, high energy neutrinos
- Dimensions: 49 m long
  13 m high
  12 m wide



I. Introduction

XENON inside LVD



Donato Orlandi &

Leo Tatananni

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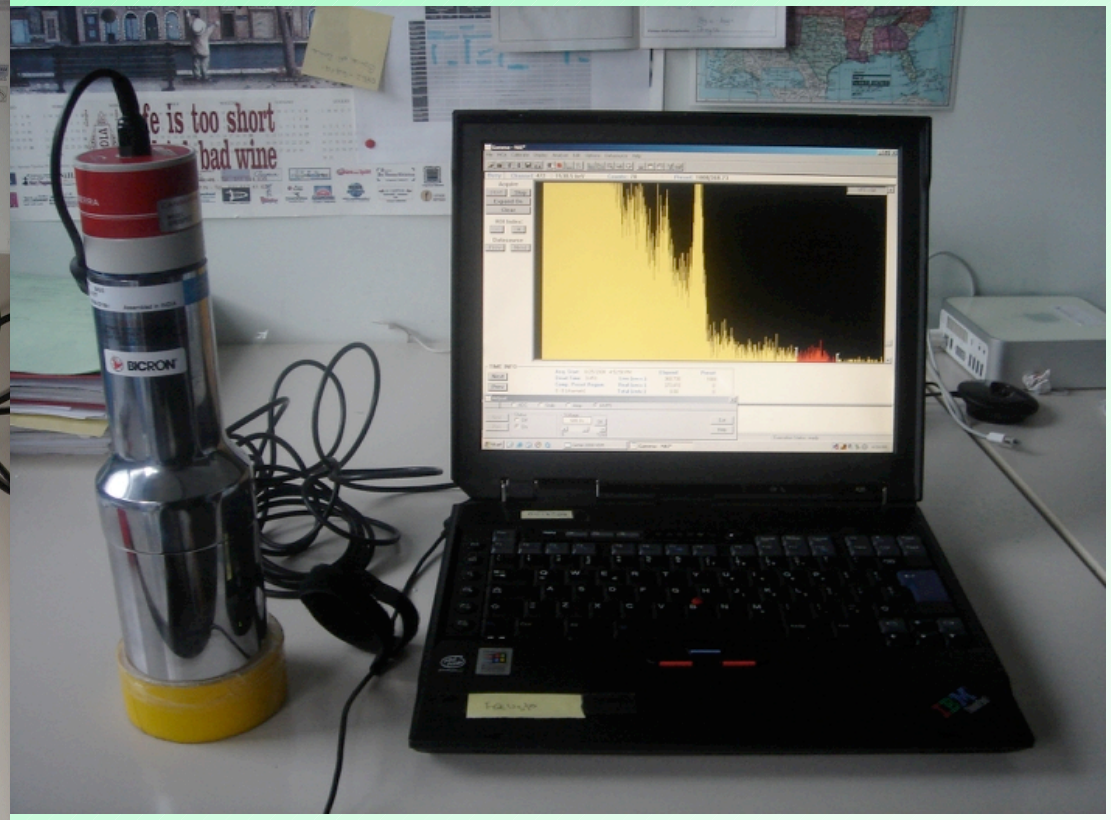
I. Gamma Measurement
NaI

- NaI Detector from Saint Gobain

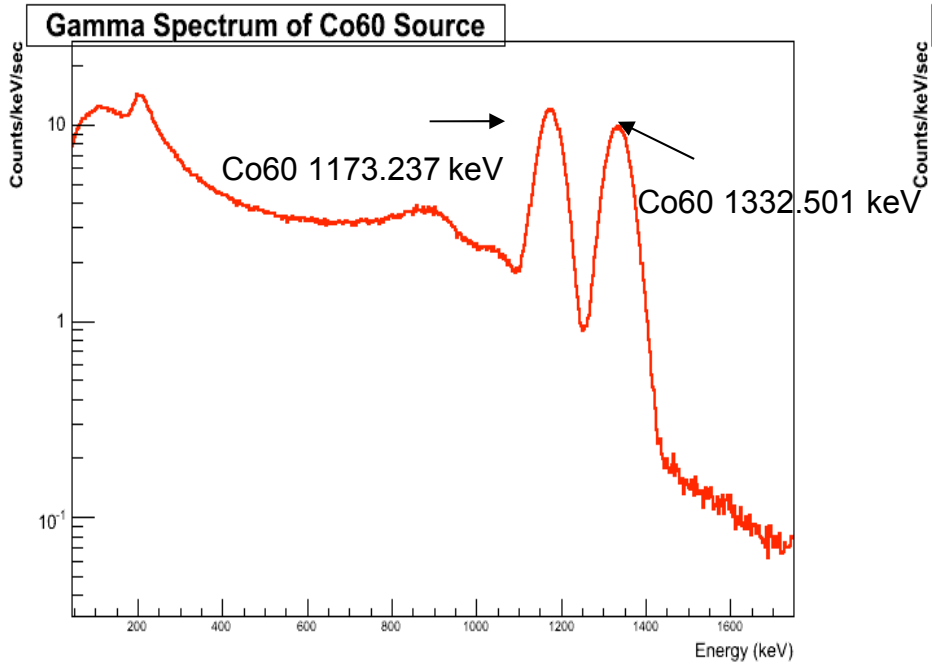


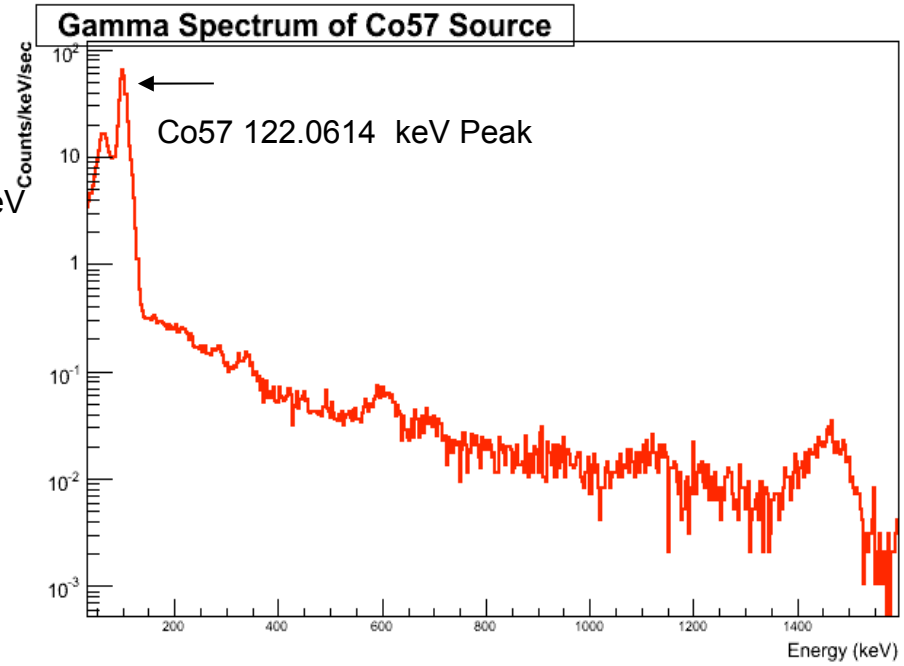
I. Gamma Measurement
NaI - Calibration

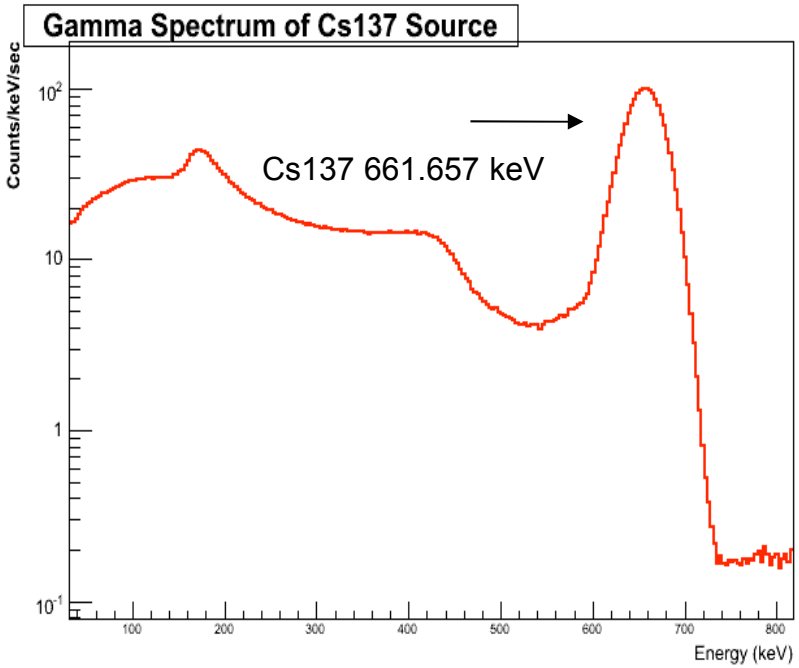
- Calibration Measurements with
  - Th228, Cs137, Co60, Co57 sources

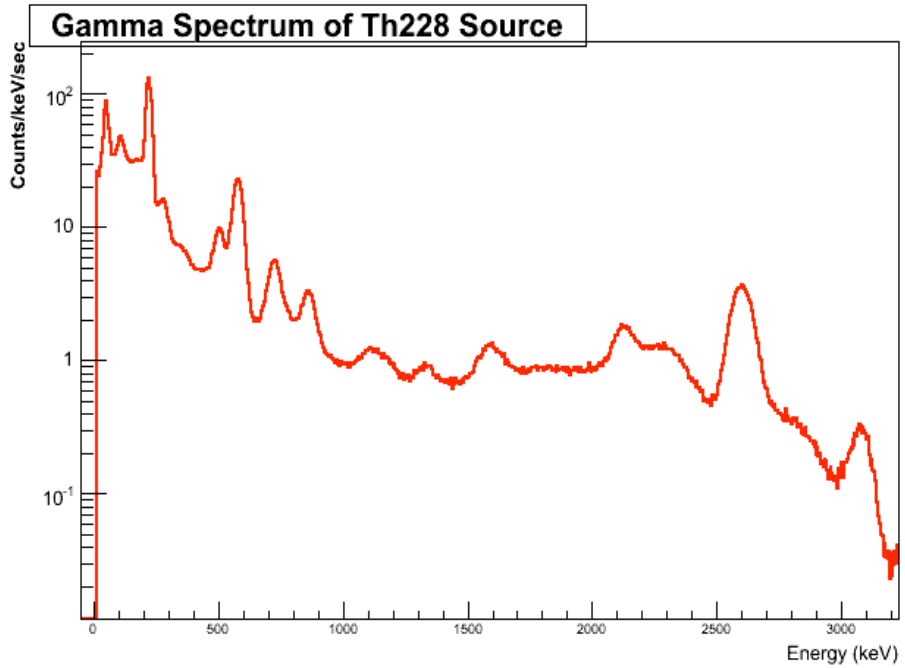
I. Gamma Measurement
NaI - Calibration

- Spectra

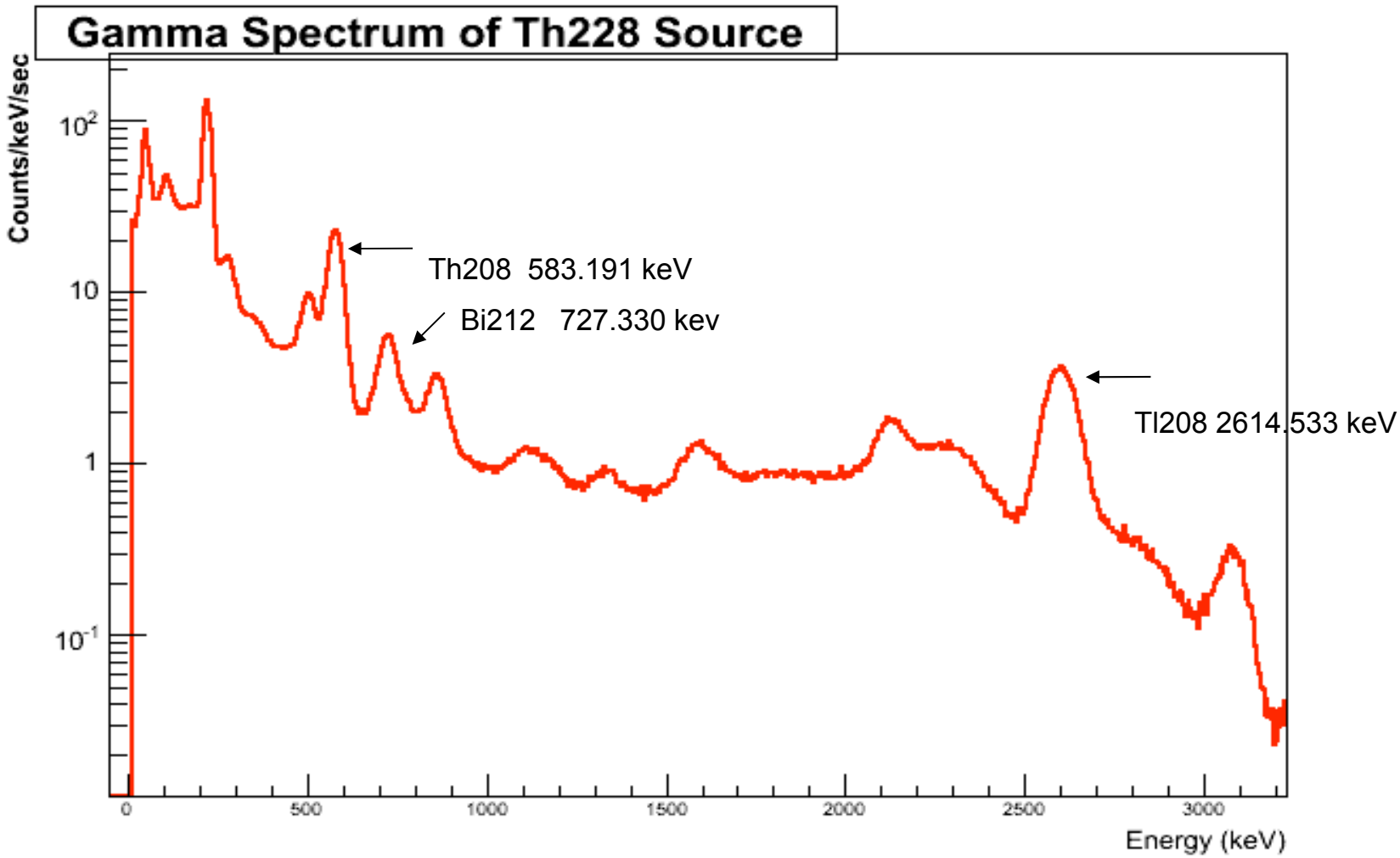

Gamma Spectrum of Co60 Source
Counts/keV/sec
Co60 1173.237 keV
Co60 1332.501 keV
Energy (keV)


Gamma Spectrum of Co57 Source
Counts/keV/sec
Co57 122.0614 keV Peak
Energy (keV)


Gamma Spectrum of Cs137 Source
Counts/keV/sec
Cs137 661.657 keV
Energy (keV)


Gamma Spectrum of Th228 Source
Counts/keV/sec
Energy (keV)

I. Gamma Measurement
NaI - Calibration



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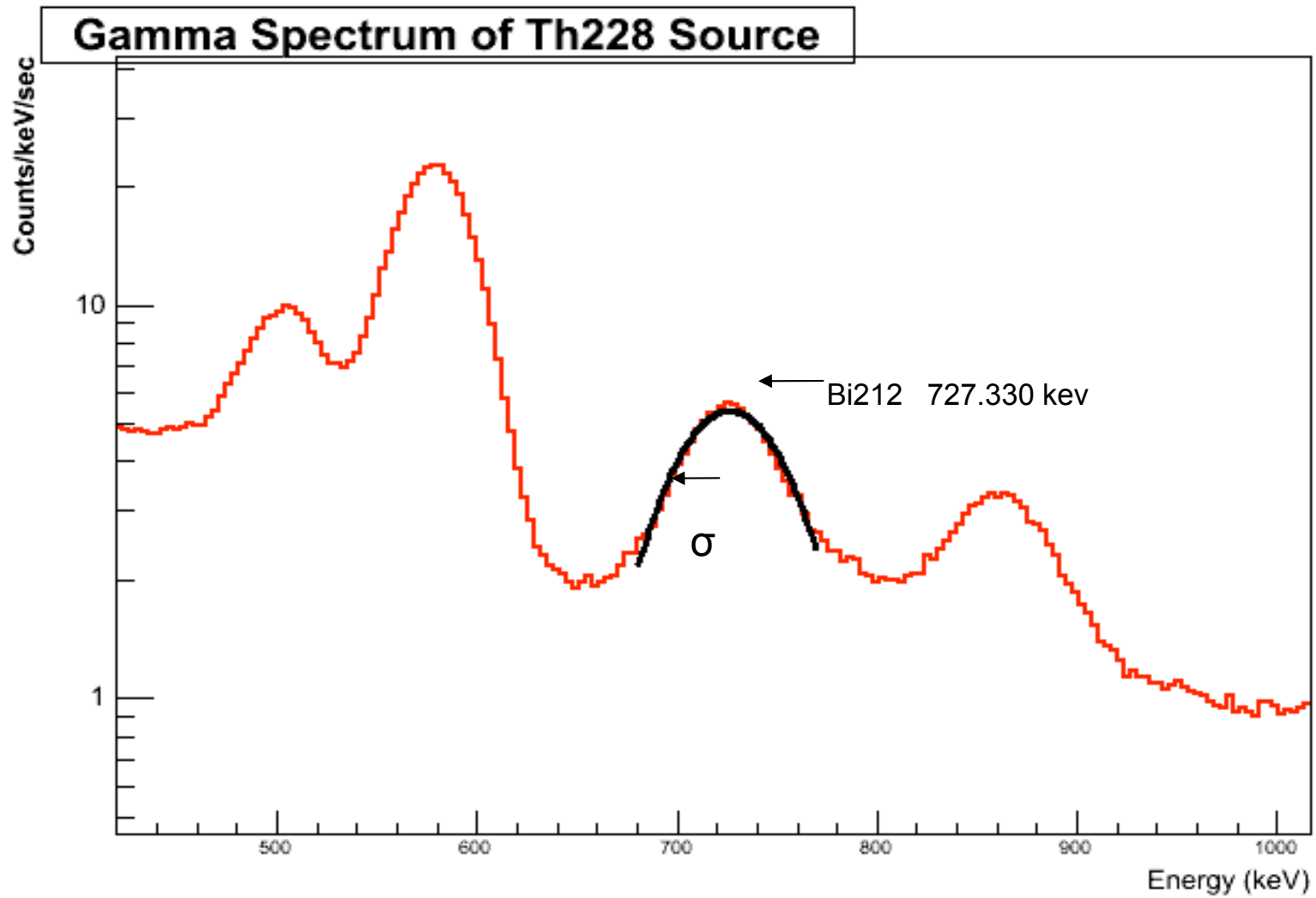
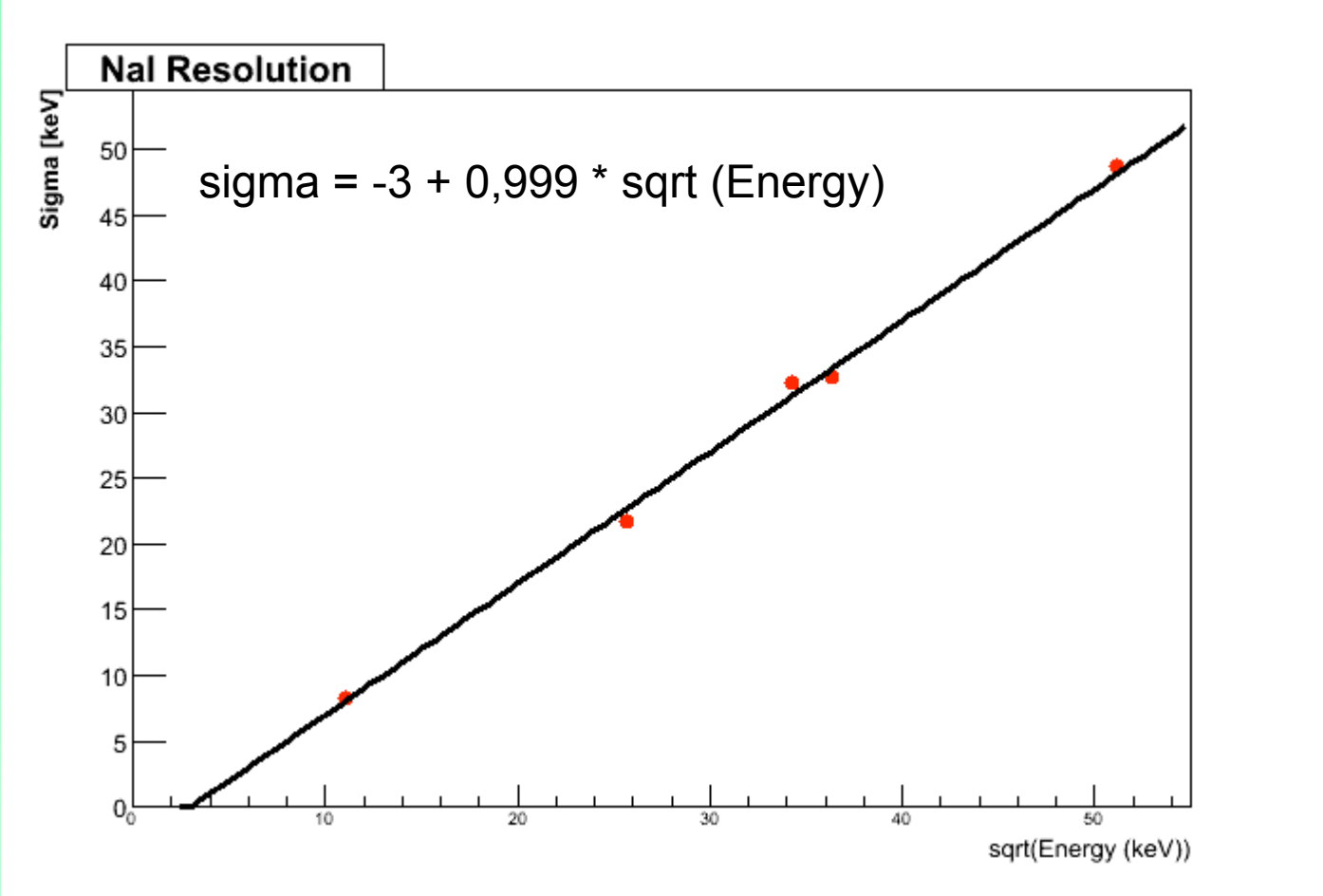
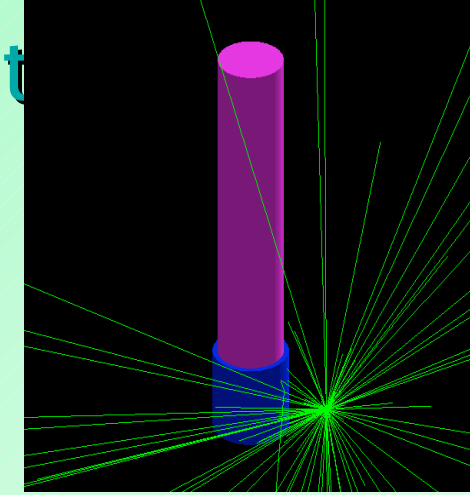


I. Gamma Measurement
NaI - Calibration

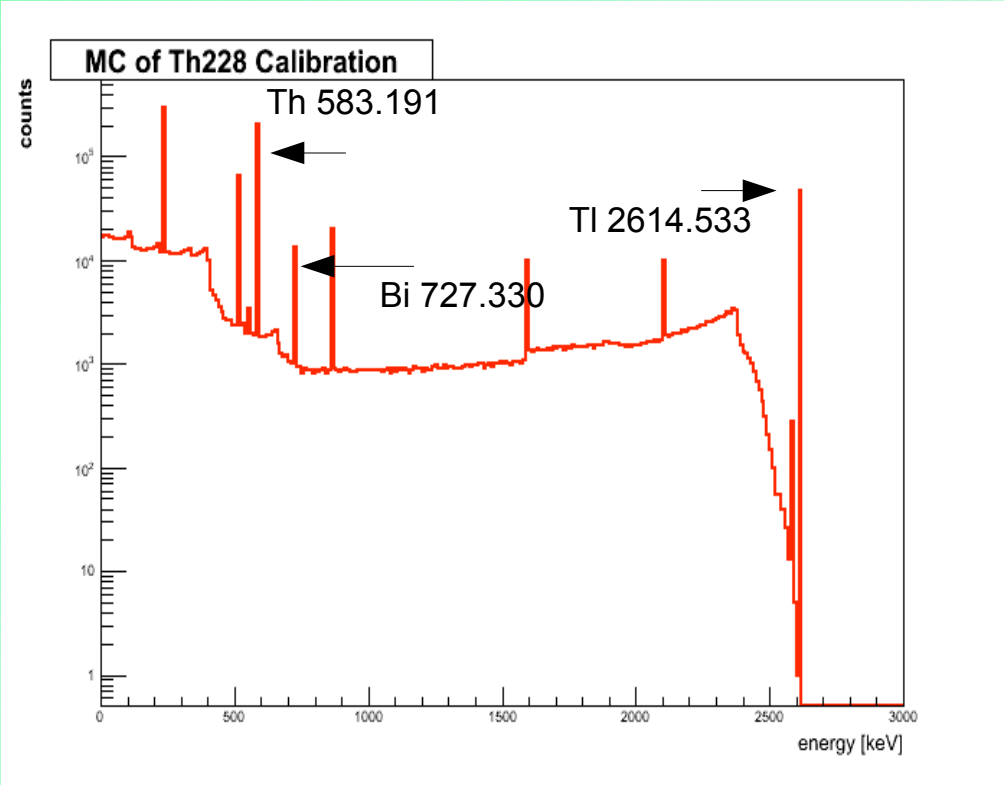
- Energy resolution of NaI



I. Gamma Measurement
NaI - Calibration



- Geant4 Simulations of Calibration
- Th 228



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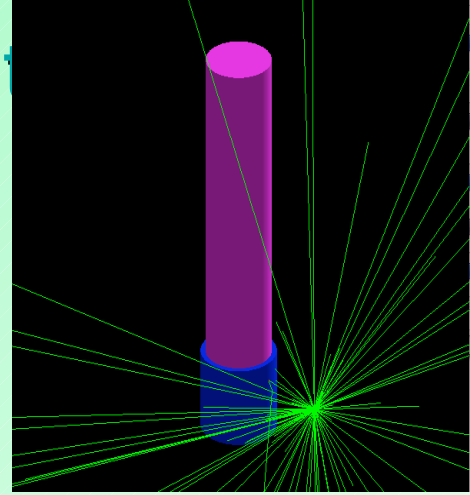
NaI - Calibration



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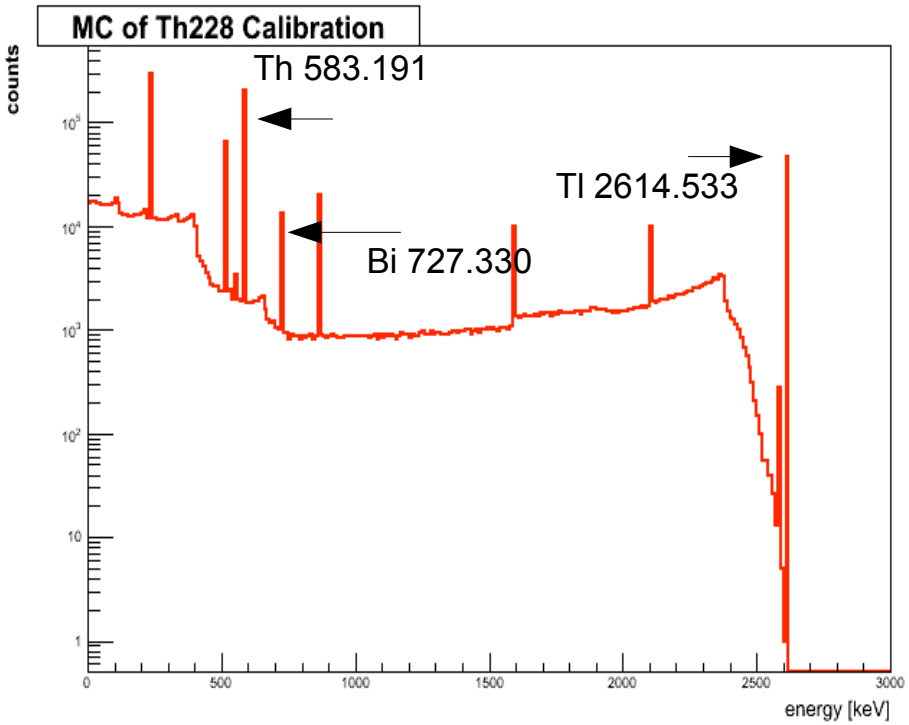
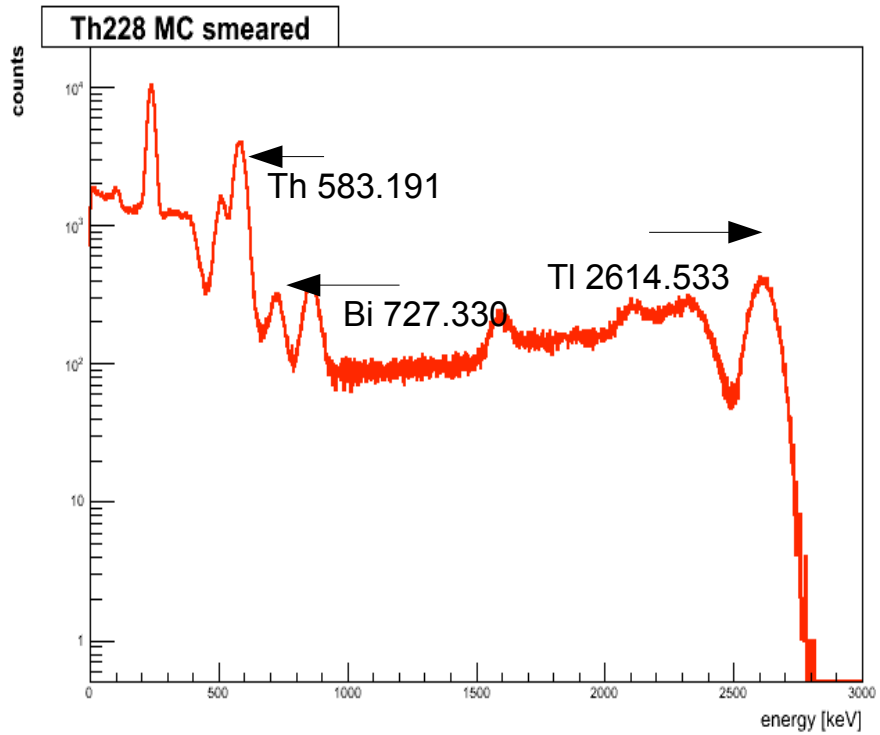
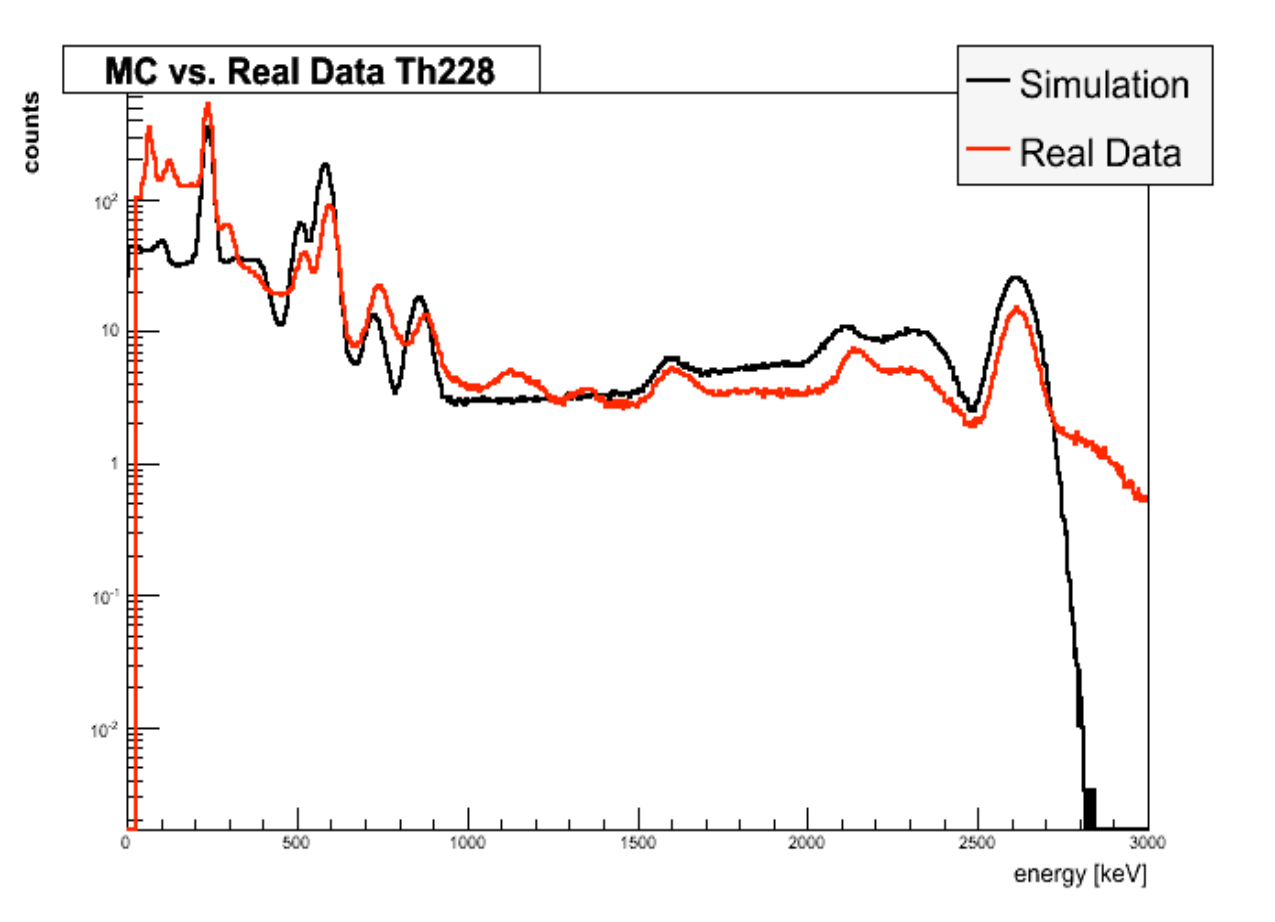




I. Gamma Measurement
NaI - Calibration

- MC vs real data

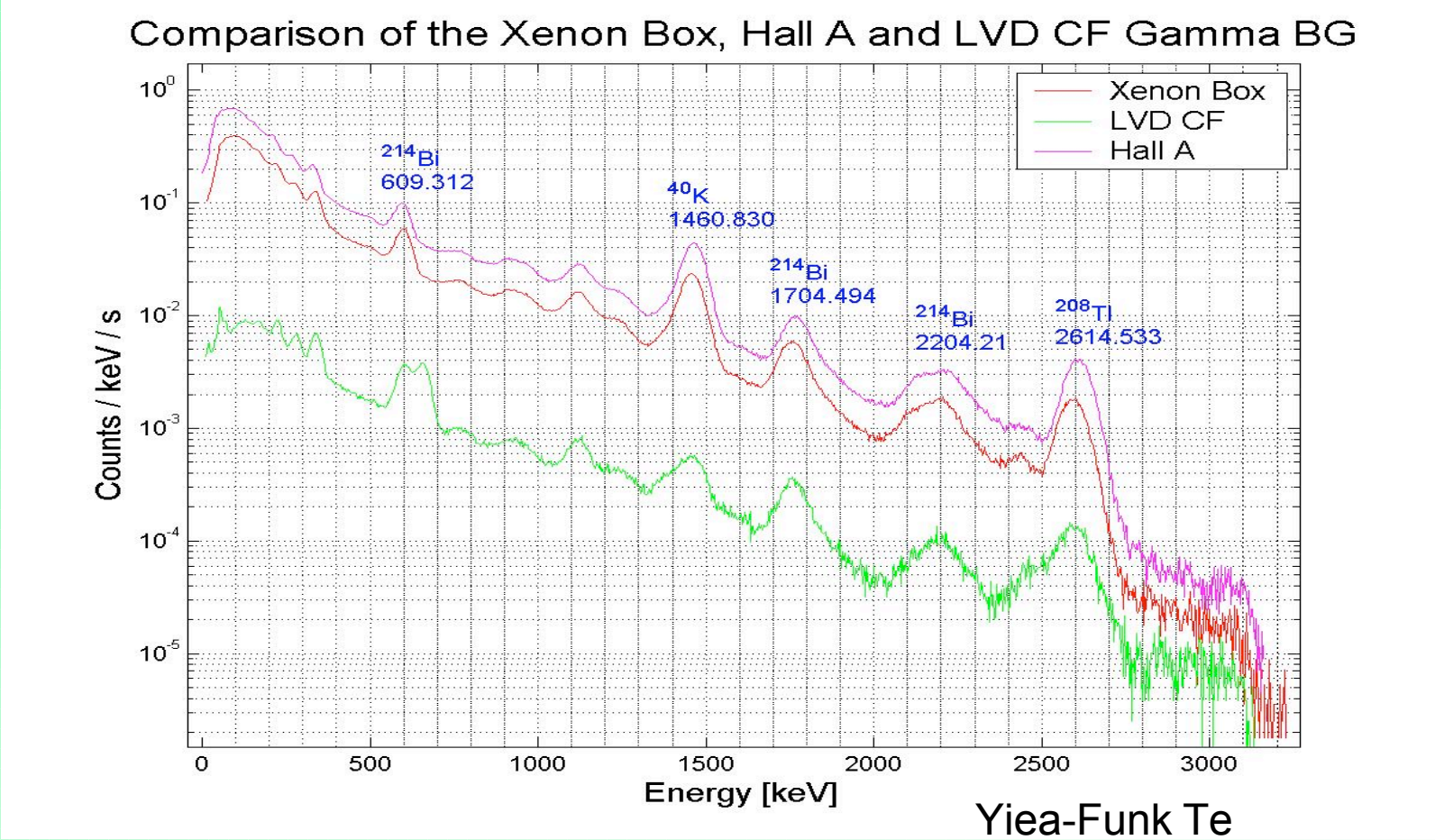


I. Gamma Measurement
NaI - Measurements

- Measurement of different locations in LNGS
  - Hall A
  - XenonBox
  - LVD Core Facility

I. Gamma Measure
NaI - Measurem

- Measurements LNGS



I. Gamma Measurement
NaI - Measurements

- Measurement of different locations in LNGS
  - Hall A
  - XenonBox
  - LVD Core Facility
    - => LVD CF has ~ factor 10 lower BG

Structure

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- Hollow Sphere
- Xenon inside LVD

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II. Gamma Simulations Xe1t
Hollow Sphere

- Geant4 Geometry:
  - Outer Cryostat (made of SSteel):

    130 cm diameter, 100cm height
  - Inner Can (made of SSteel):

    123 cm diameter, 100 cm height
  - Inner Teflon Tube:

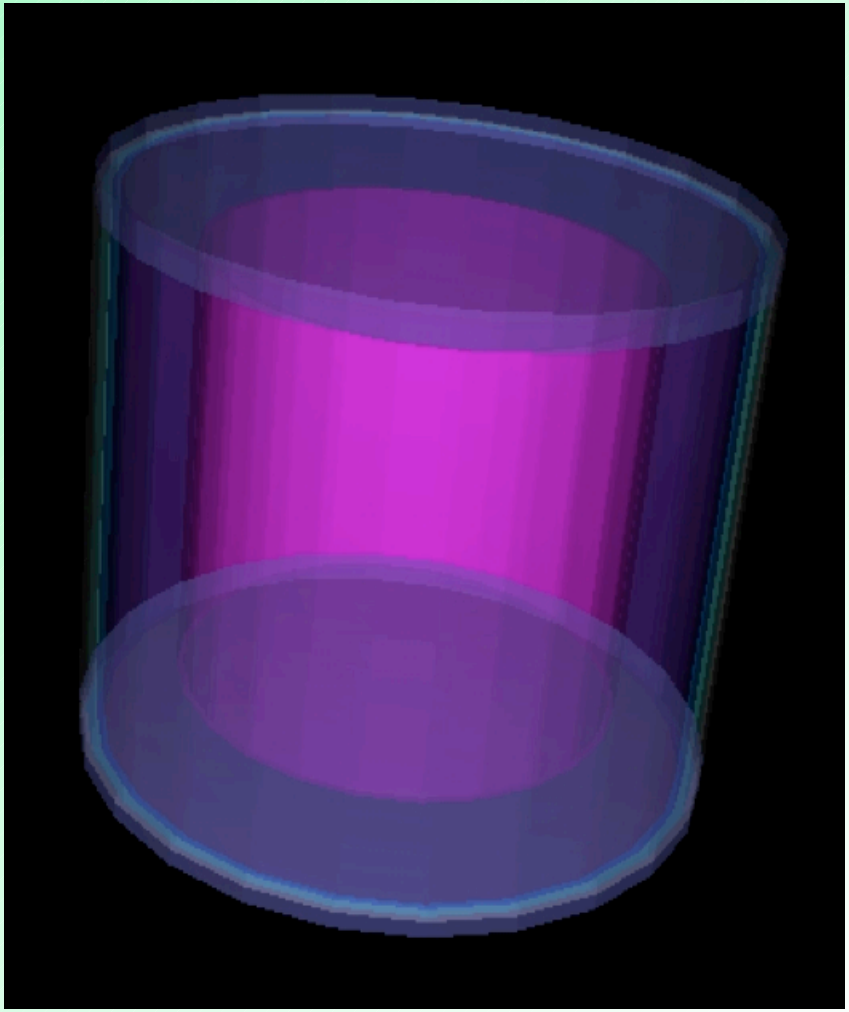
    91 cm diameter, 80 cm height
  - Liquid Xenon:

    ~3 t in total

    ~1 t FV

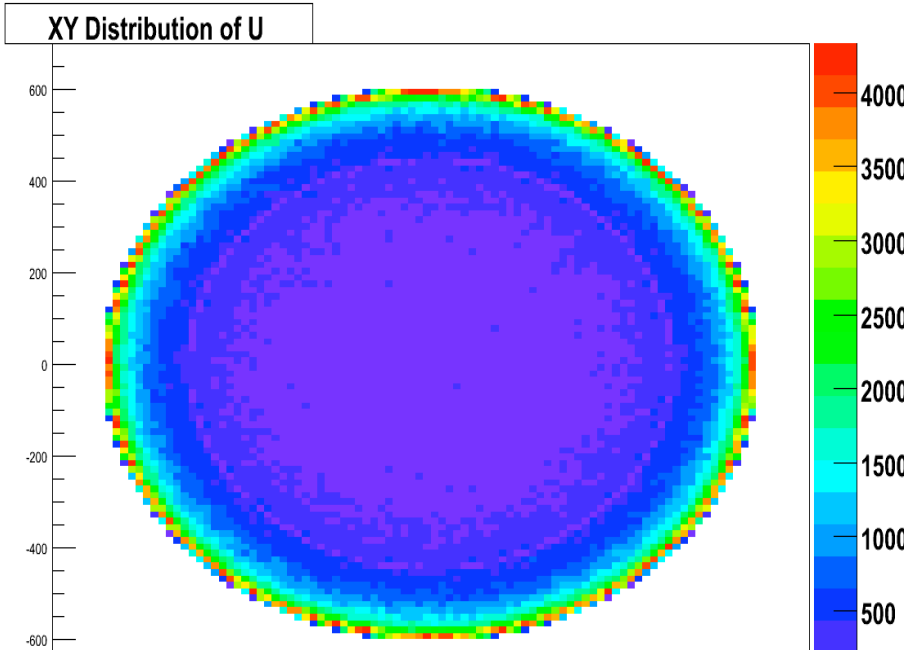
II. Gamma Simulations Xe1t
Hollow Sphere

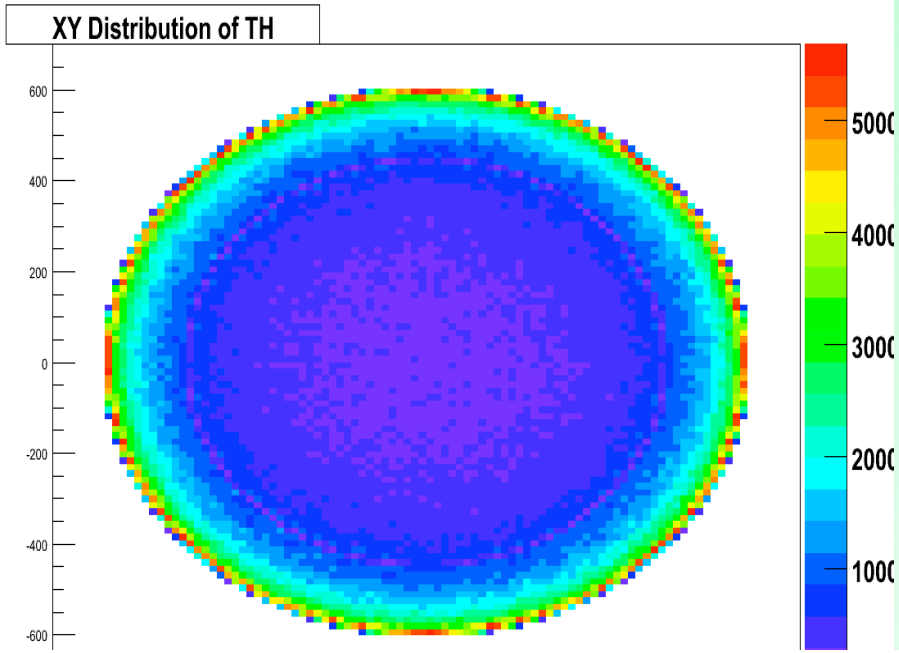
- Started Gammas from „HollowSphere" of 2m radius around Xenon1t detector
- 10^9 events each for:
  - U238
  - Th232
  - Co60
  - K40

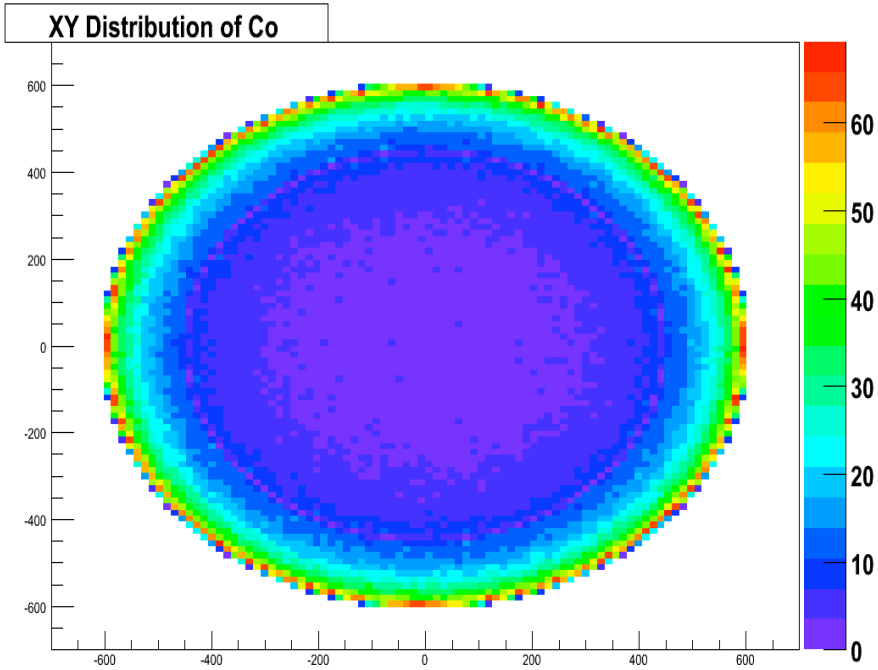


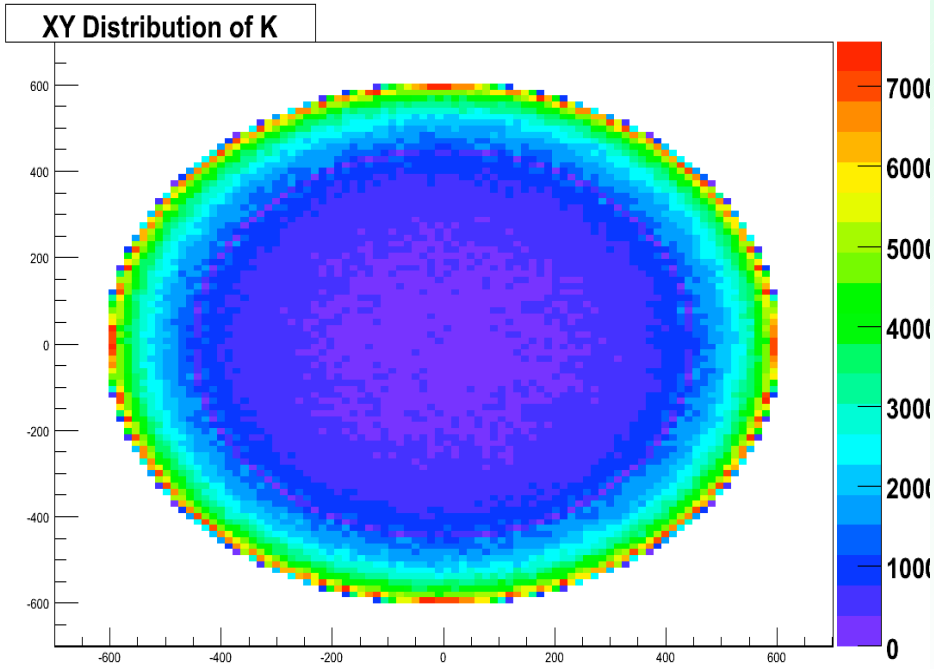
II. Gamma Simulations Xe1t
Hollow Sphere

- Spatial Distribution of Events


XY Distribution of U
600
400
200
0
-200
-400
-600
4000
3500
3000
2500
2000
1500
1000
500

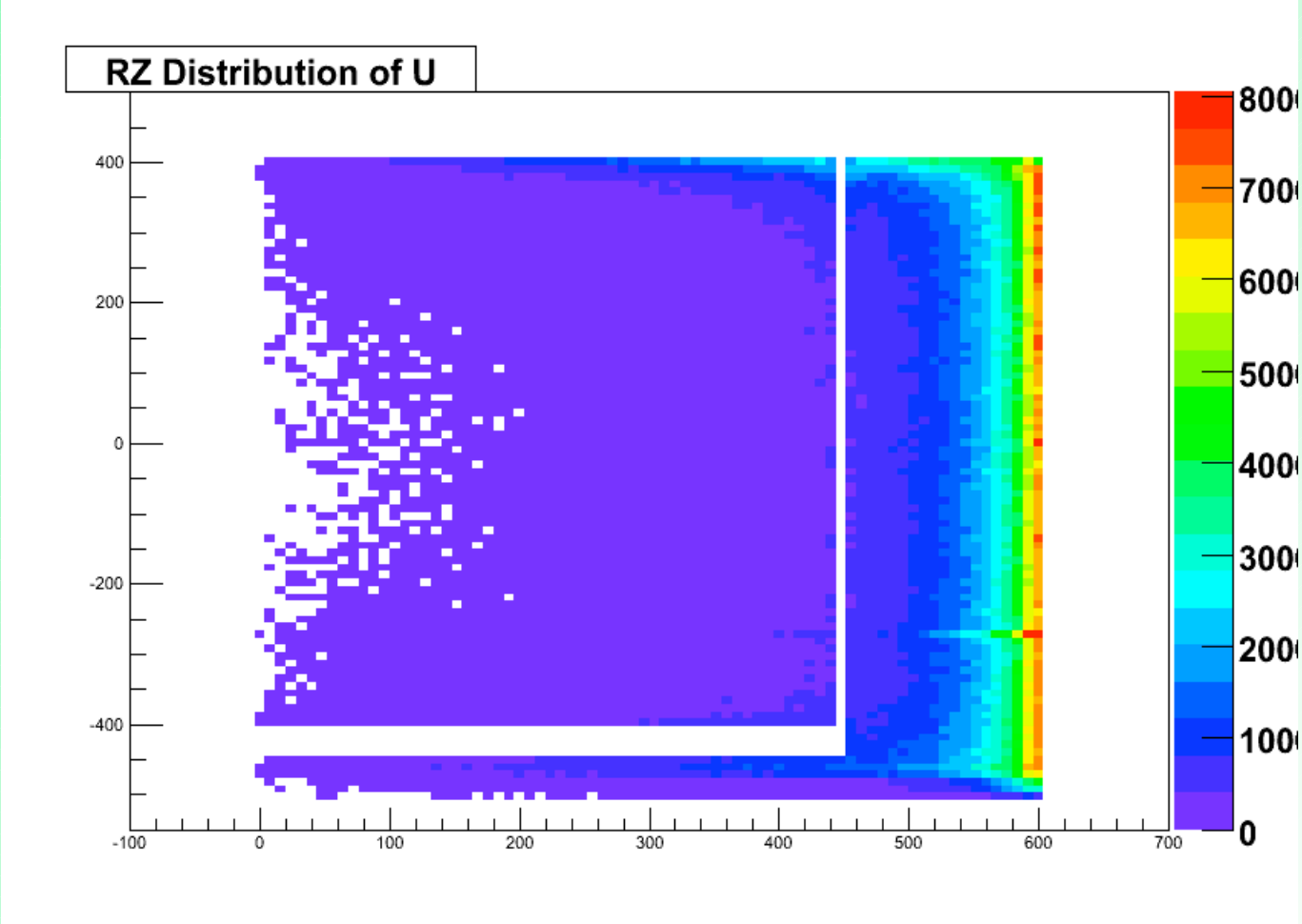

XY Distribution of TH
600
400
200
0
-200
-400
-600
5000
4000
3000
2000
1000


XY Distribution of Co
600
400
200
0
-200
-400
-600
-600
-400
-200
0
200
400
600
60
50
40
30
20
10
0


XY Distribution of K
600
400
200
0
-200
-400
-600
-600
-400
-200
0
200
400
600
7000
6000
5000
4000
3000
2000
1000
0

II. Gamma Simulations Xe1t
Hollow Sphere

- Spatial Distribution of Events

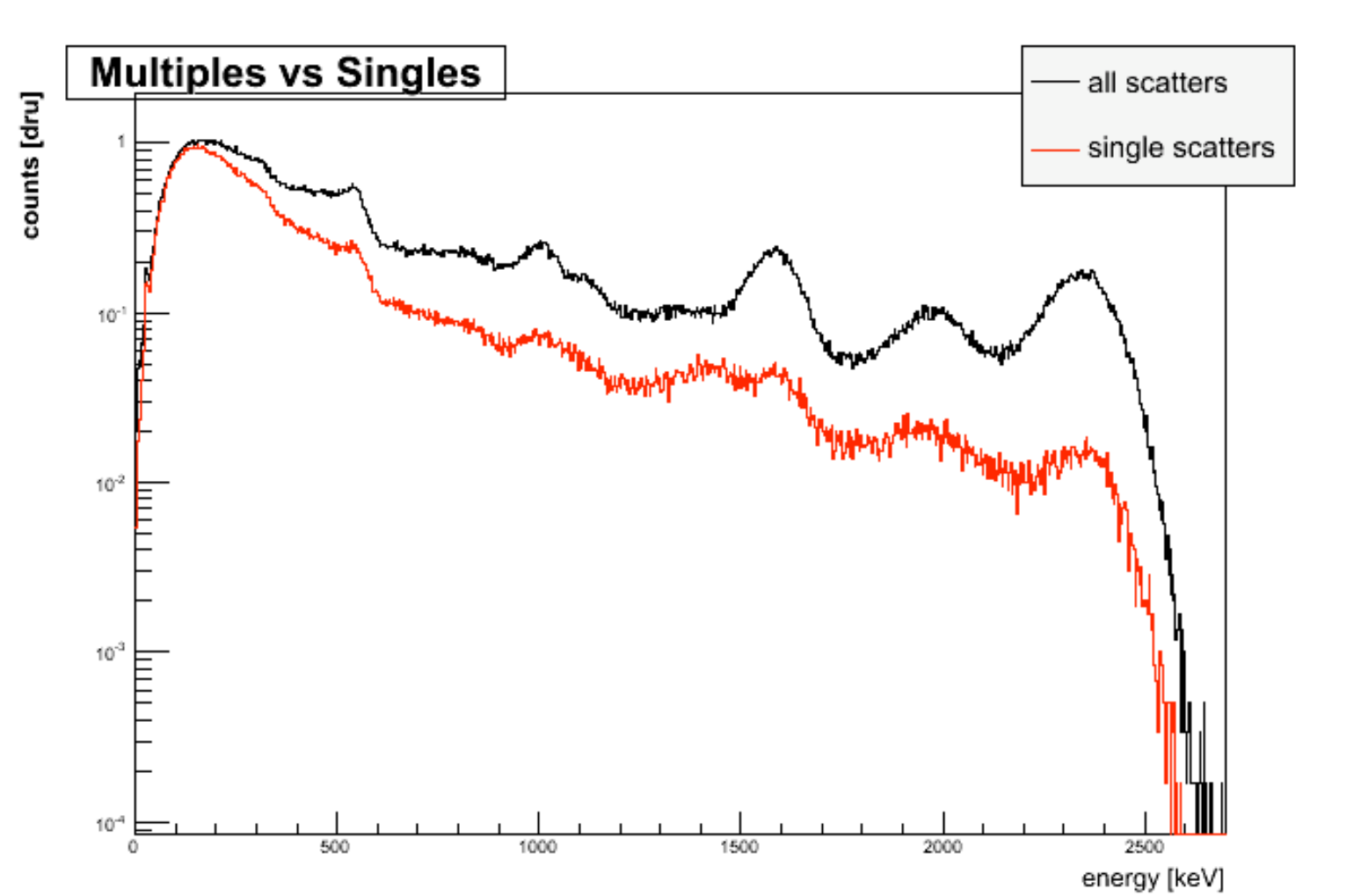


II. Gamma Simulations Xe1t
Hollow Sphere

- Energy Spectra
- Singles for a detector resolution of 3 mm in z

II. Gamma Simulations Xe1t
Hollow Sphere

- Energy Spectra



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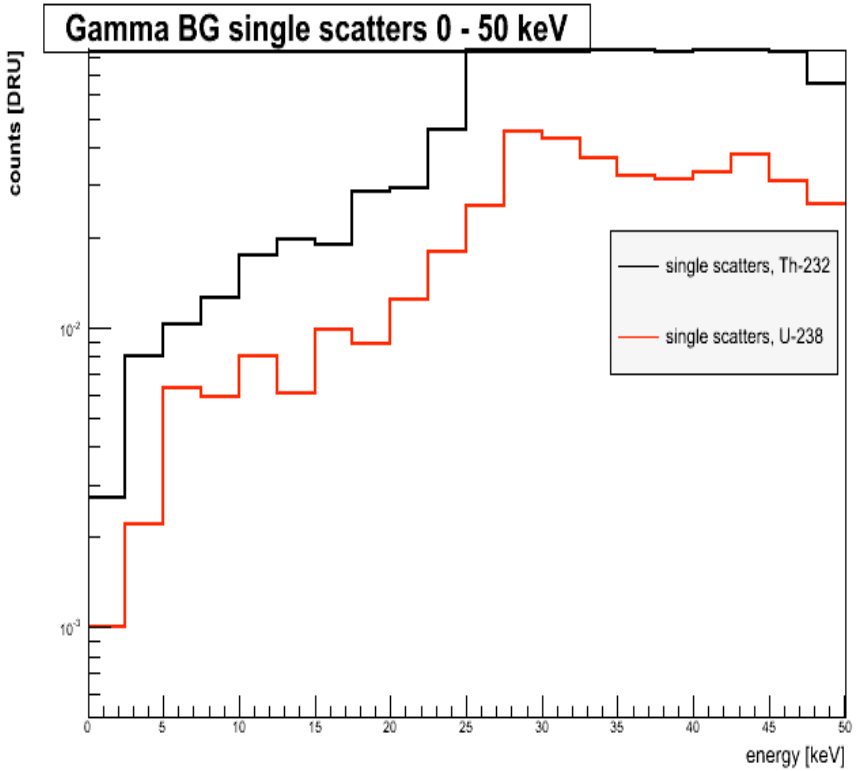
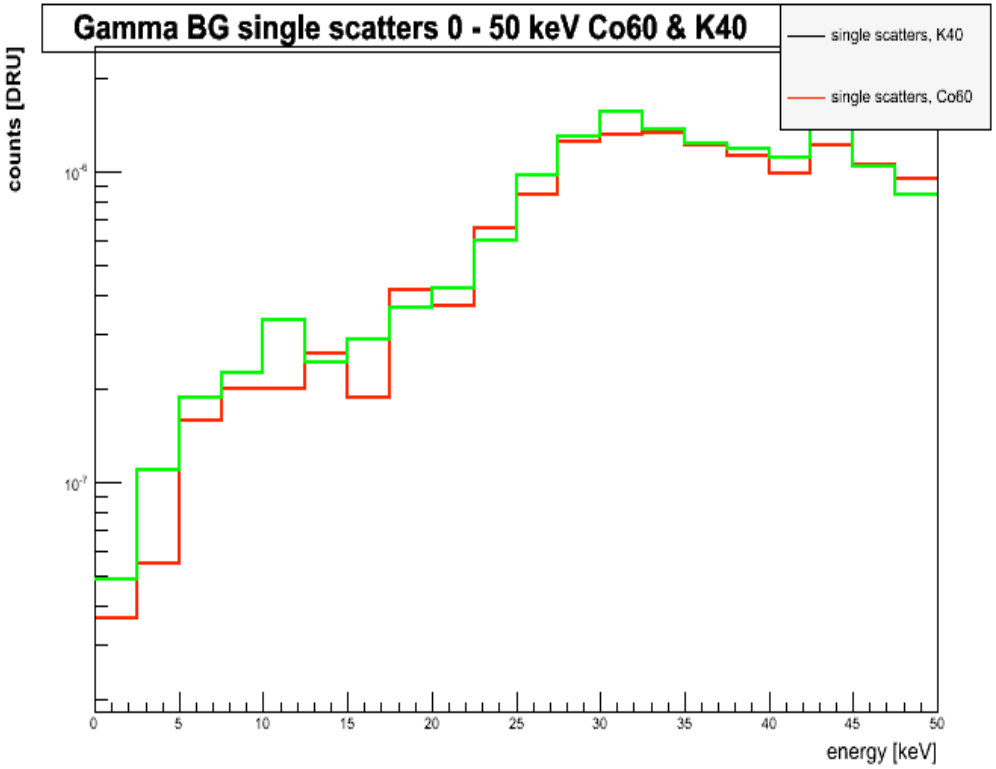
- Energy Spectra





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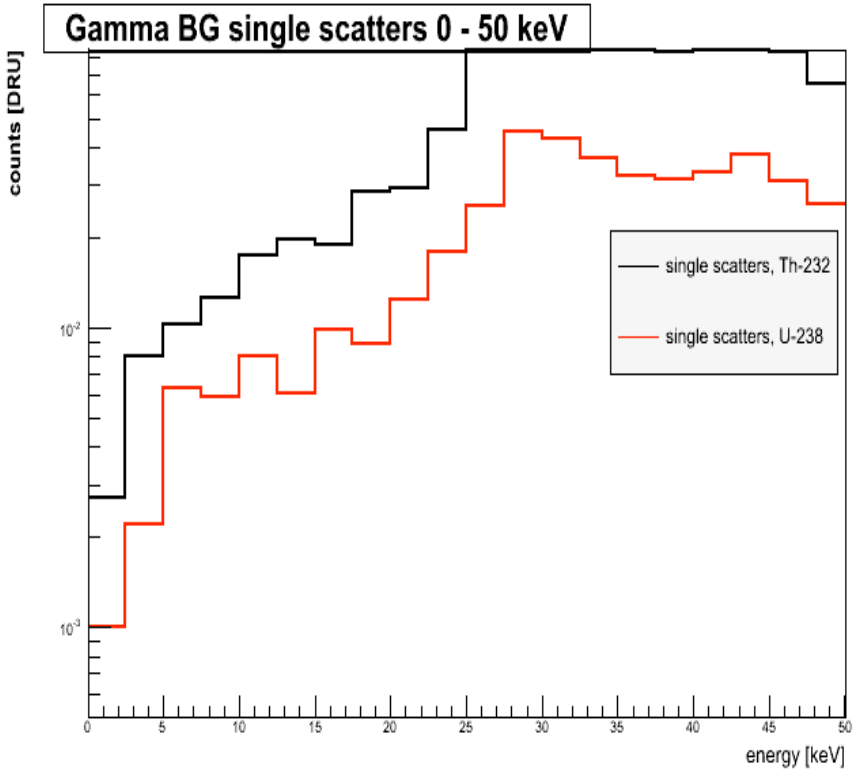

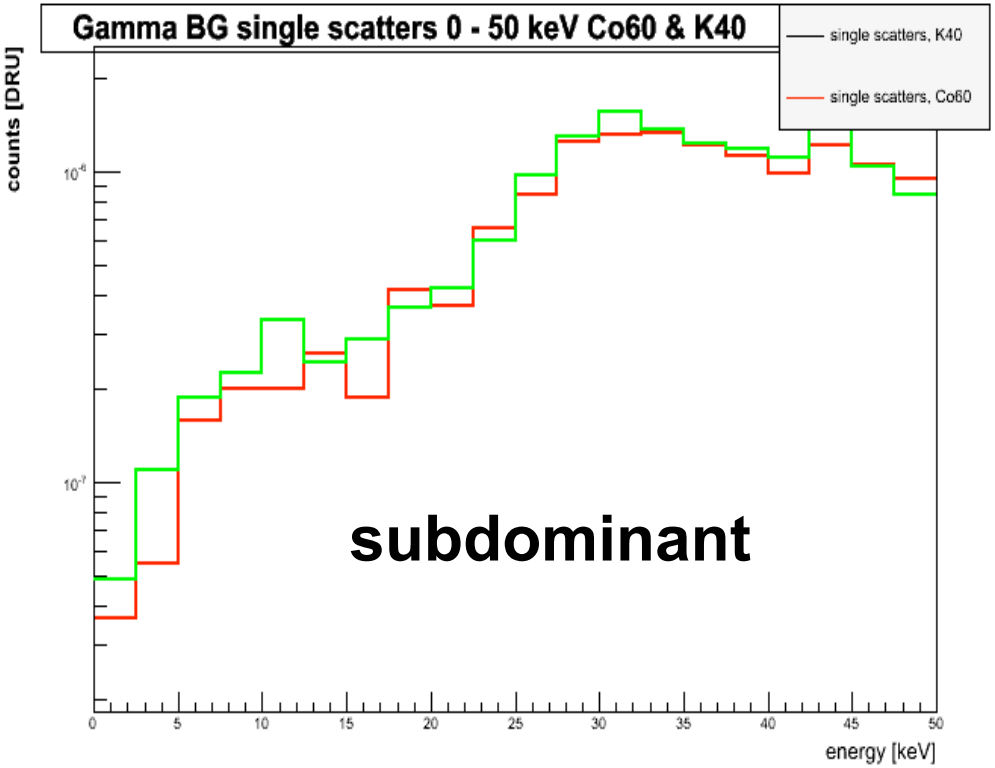

II. Gamma Simulations Xe1t
Hollow Sphere

- Energy Spectra
- Result HollowSphere Analysis:
  - we will need outer shield to reach 10^{-4} DRU

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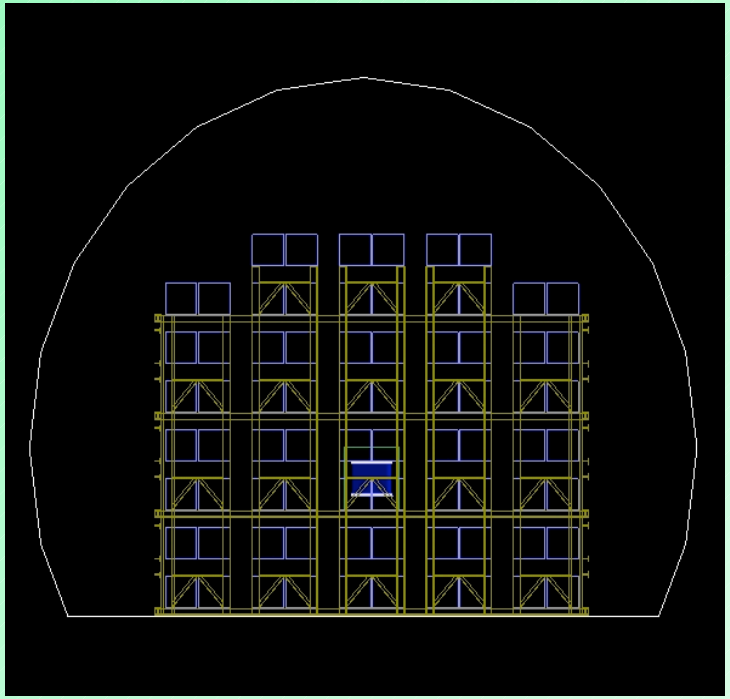
Hollow Sphere

- Energy Spectra
- Result HollowSphere Analysis:
  - we will need outer shield to reach 10^{-4} DRU
- but:
- normalization of the MC is preliminary
  - waiting for more precise new measurements
- more precise simulations => Outlook

II. Gamma Simulations Xe1t

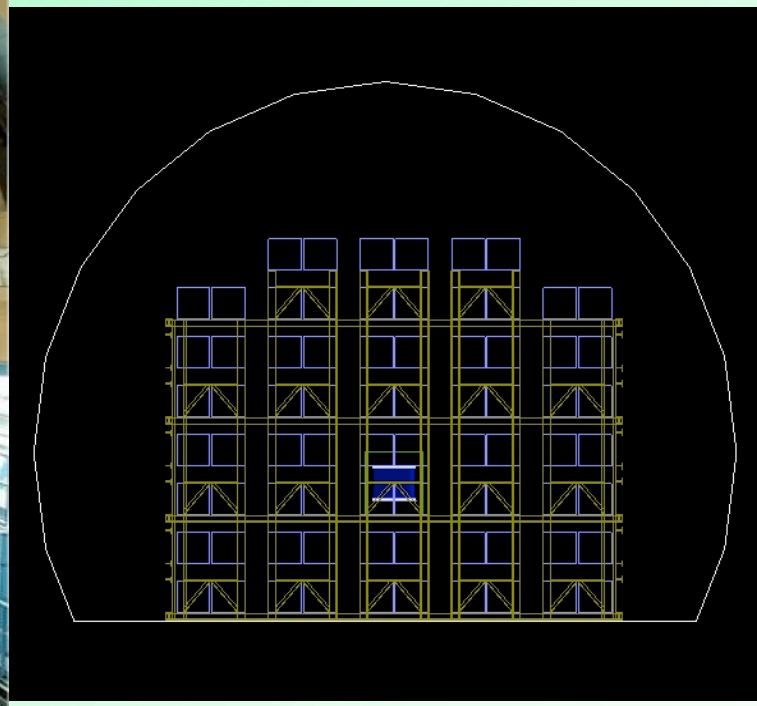
Xenon inside LVD



LVD Geant4 Geometry of Rino Persiani

II. Gamma Simulations Xe1t

Xenon inside LVD



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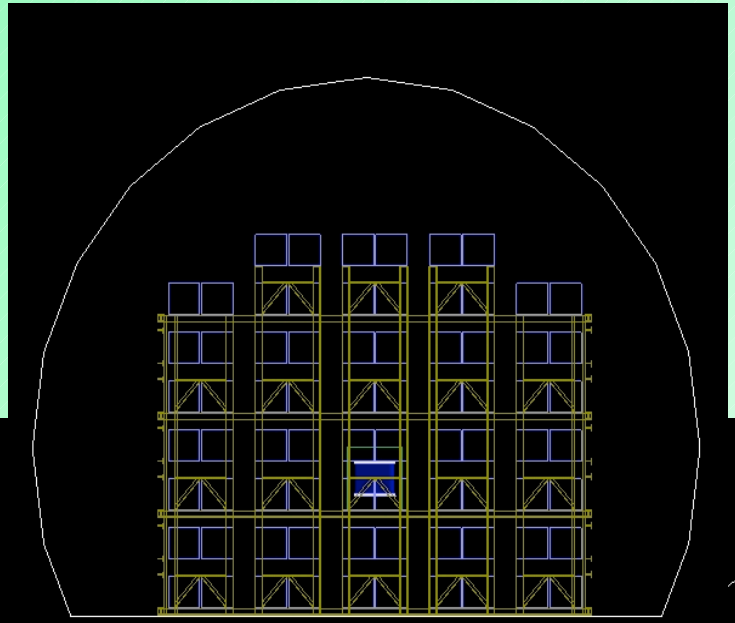

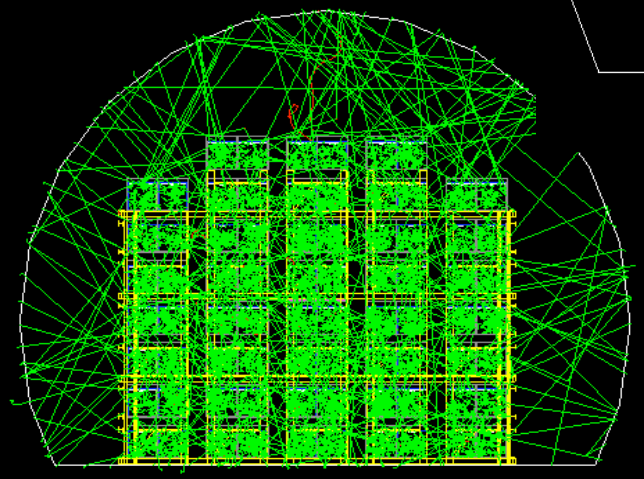

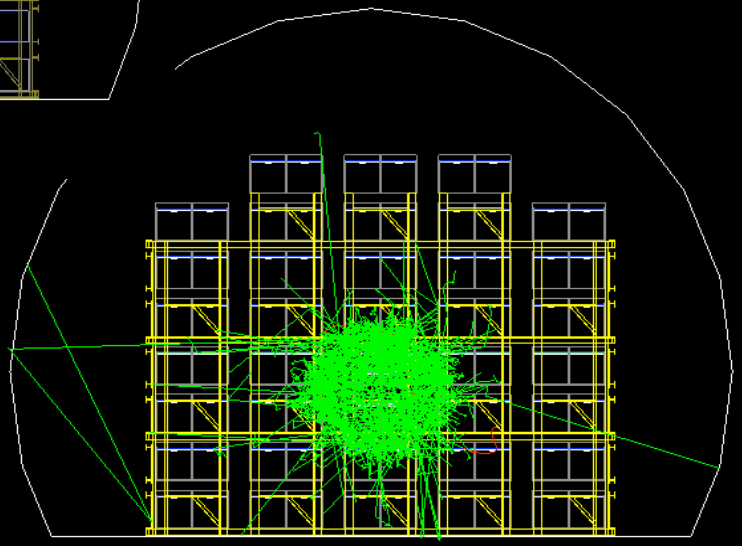

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- NaI-Gamma-Measurements in LNGS => LVD Core facility has very low Gamma BG (~ * 10)
- HollowSphere Simulations for Xenon1t => need additional outer shield

Outlook:

- intrinsic BG NaI => Activity of LVD CF
- Simulations of Gammas from LVD
- Simulations of BG from Xenon1t materials