Intrinsic position resolution of gaseous detectors for X-ray photons: simulation results from Degrad

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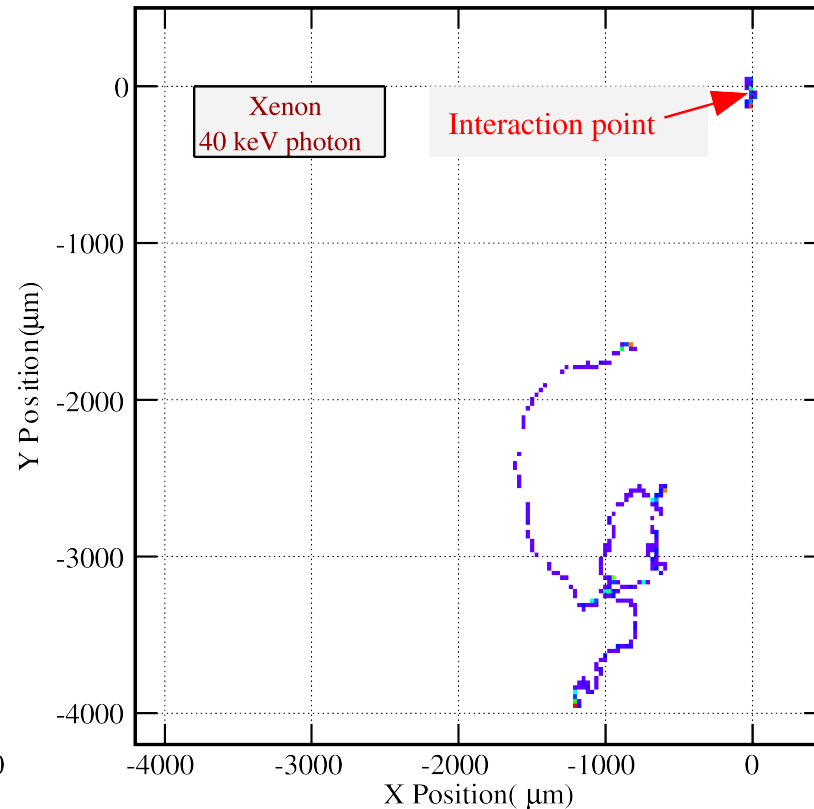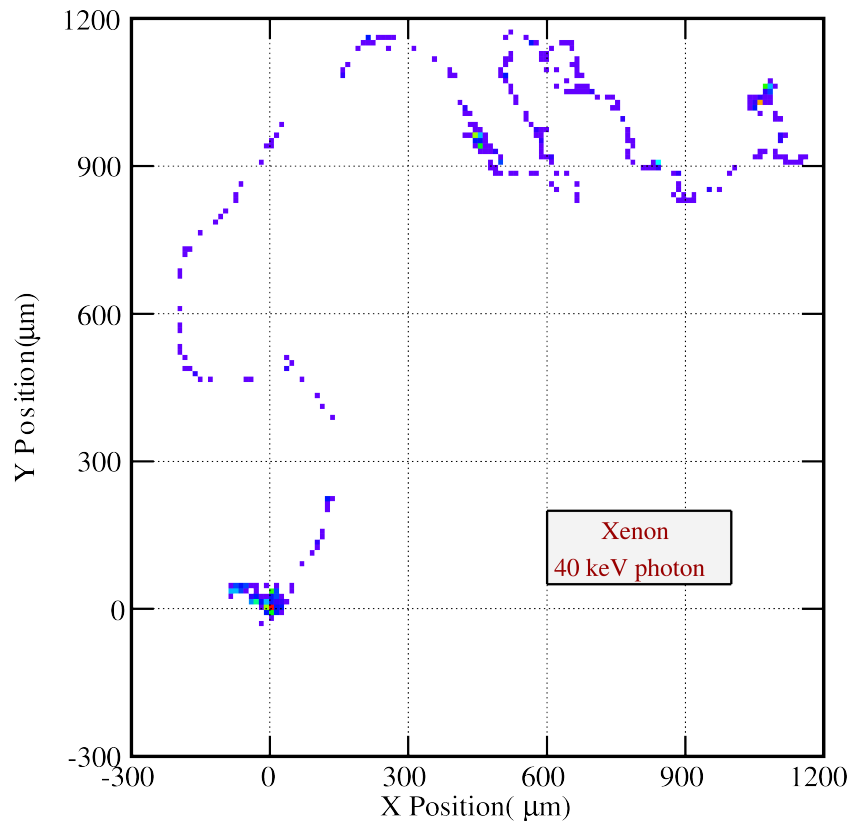[1] I3N - Physics Department, University of Aveiro, 3810-193 Aveiro, Portugal
[2] Uludağ University, Faculty of Arts and Sciences, Physics Department, Bursa – Turkey
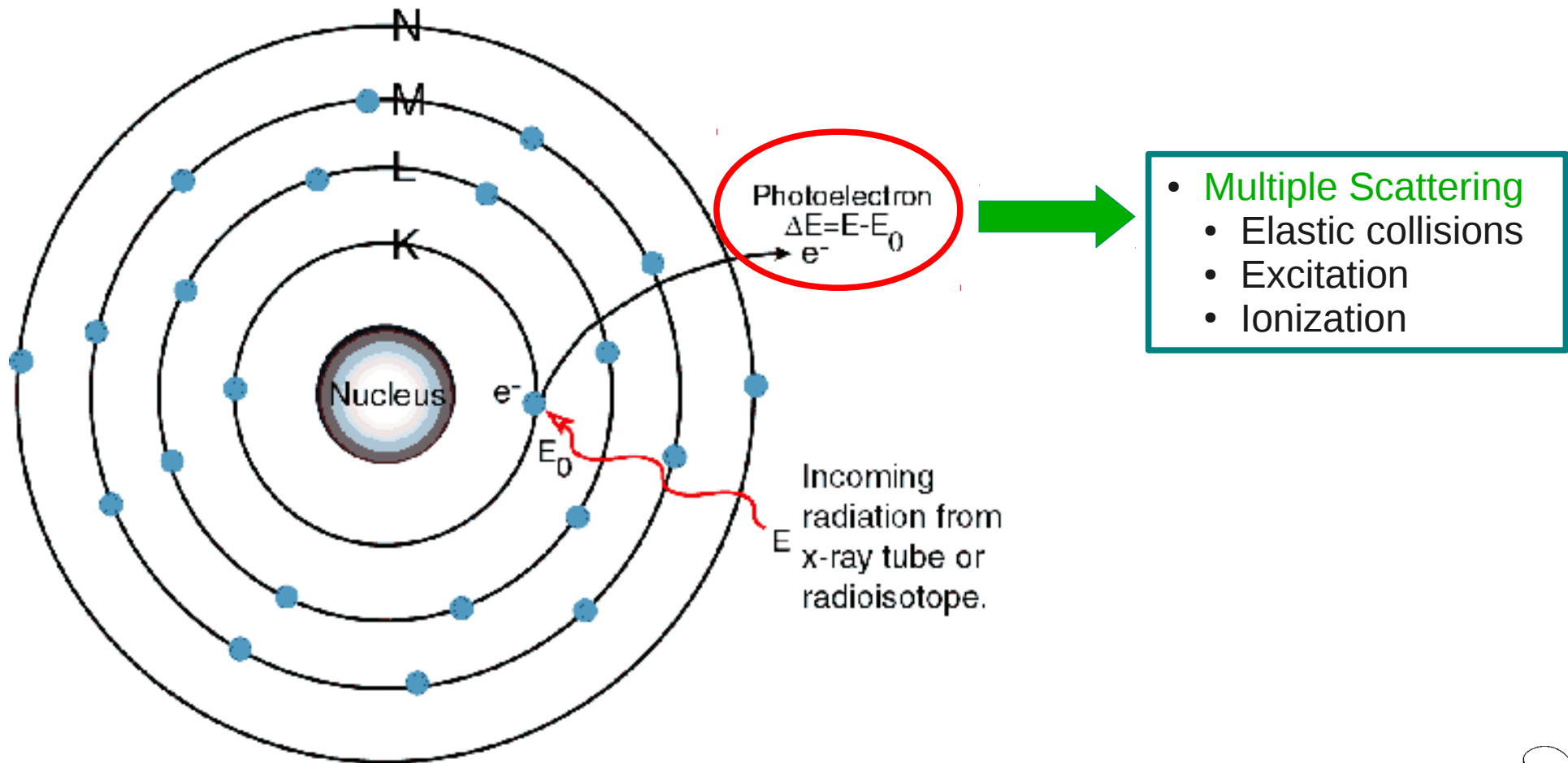
X-ray Position Resolution in gas

- ## Where is the problem?

  - ### Photoelectron range

    - #### Electron scattering

 - ### Fluorescence photons

- **Photon energy dependence**
- **Gas dependence**

Radiation Interaction With Matter

- Photoelectric absorption

Photoelectron
$\Delta E = E - E_0$
e^-

- Multiple Scattering
  - Elastic collisions
  - Excitation
  - Ionization

Incoming radiation from x-ray tube or radioisotope.

http://www.amptek.com/xrf.html

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De-excitation Processes

- ## Radiative processes

  - ### Fluorescence photon

- ## Nonradiative processes

  - ### Auger electron

    - Shell electron transition

  - ### Coster-Kronig

    - Subshell electron transition

  - ### Shake-off

    - Electron emission due to potential change
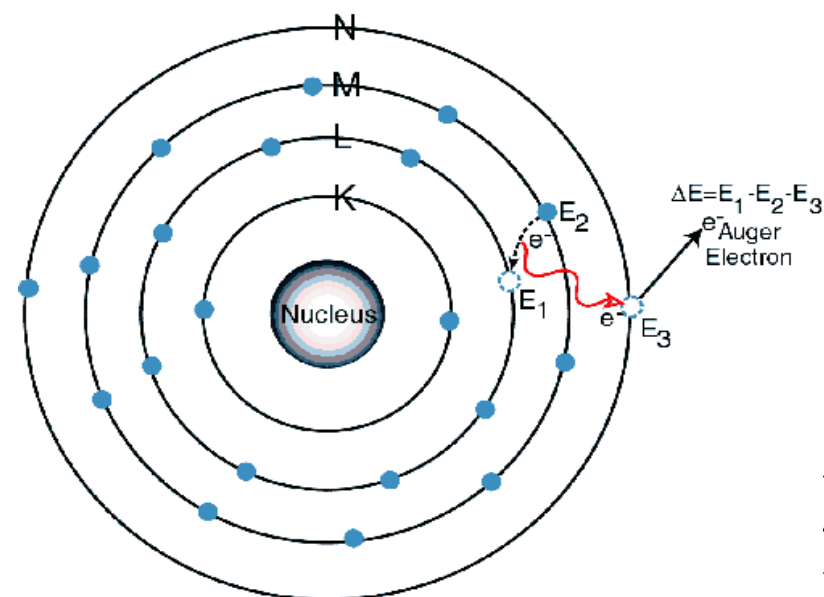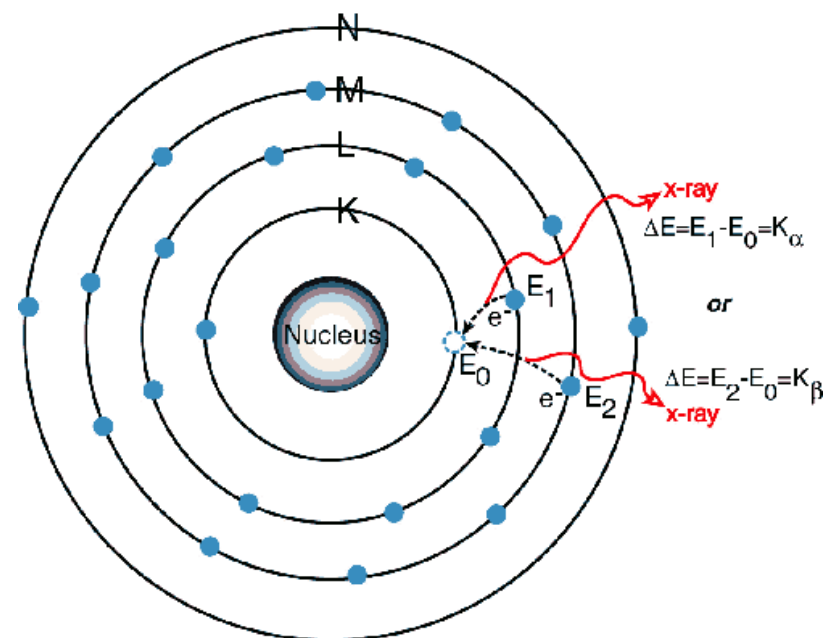
http://www.amptek.com/xrf.html
G. Zschornack. Handbook of x-ray data, Springer, 2007

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Simulation tool: DEGRAD

- Calculates the cluster distribution in gas mixtures:
  - Minimum ionizing particles.
  - Delta electrons
  - Photons
    - Photoelectric effect, Compton scattering, pair-prodution and Rayleigh scattering.
- Electric and magnetic fields
- Cascade model
  - Auger and Coster-Kronig, Fluorescence, Shake off
- Electron scattering:
  - Rotational, vibrational, excitation and ionization scattering
  - Bremsstrahlung to be included in March upgrade.
- Output
  - Fano factors for electrons and excitations
  - Cluster size and cluster size spatial distribution
  - W value

http://consult.cern.ch/writeup/magboltz/
http://indico.cern.ch/getFile.py/access?contribId=14&sessionId=5&resId=1&materialId=slides&confId=245535
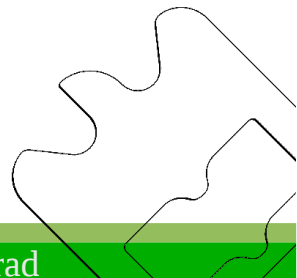
DEGRAD Calculations conditions

- **Gas:**
  - He, Ne, Ar, Kr, Xe
  - 20 ºC, 760 Torr
- **110000 events**
- **Photon energy**
  - 1-60 keV in 1 keV step
- **No magnetic field**
- **1 kV/cm electric field**
  - Direction parallel to the photon incoming direction
- **Stop energy**
  - 1 eV below the lowest excitation energy*

* Values from Magboltzl
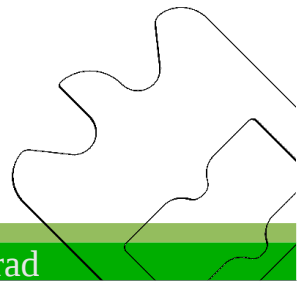
Data analysis

- **Geometry**

  - Infinite (photons interacting without distance restriction)

  - Detector

    - 10x10x1 cm^3

    - Photon interaction point in the center of the detector

- **Each single event:**

  - Primary electron position distribution

    - X and Y Position obtained from the averaged distribution

    - Number of primary electrons produced (energy distribution)

- **Image**

  - Reconstructed from the detected position distribution (2D histogram)

  - All energies considered (full spectrum), including fluorescence photons

  - Position resolution obtained from the FWHM of a Gaussian distribution

Data analysis

Images

- Argon

Intrinsic position resolution of gaseous detectors for X-ray photons: simulation results from Degrad
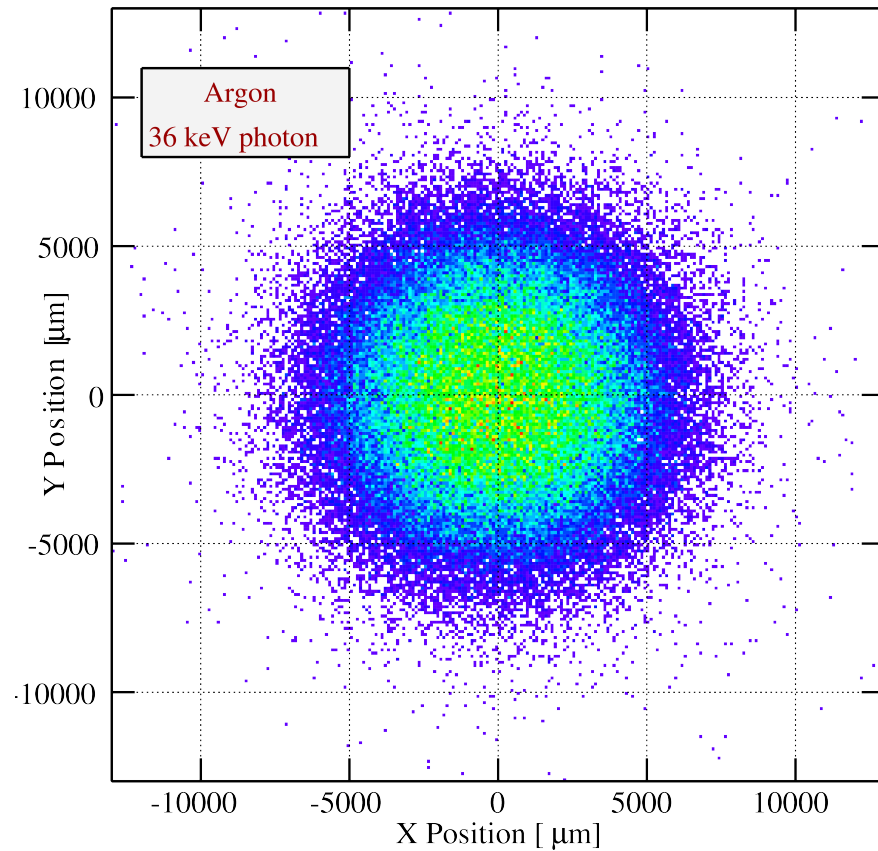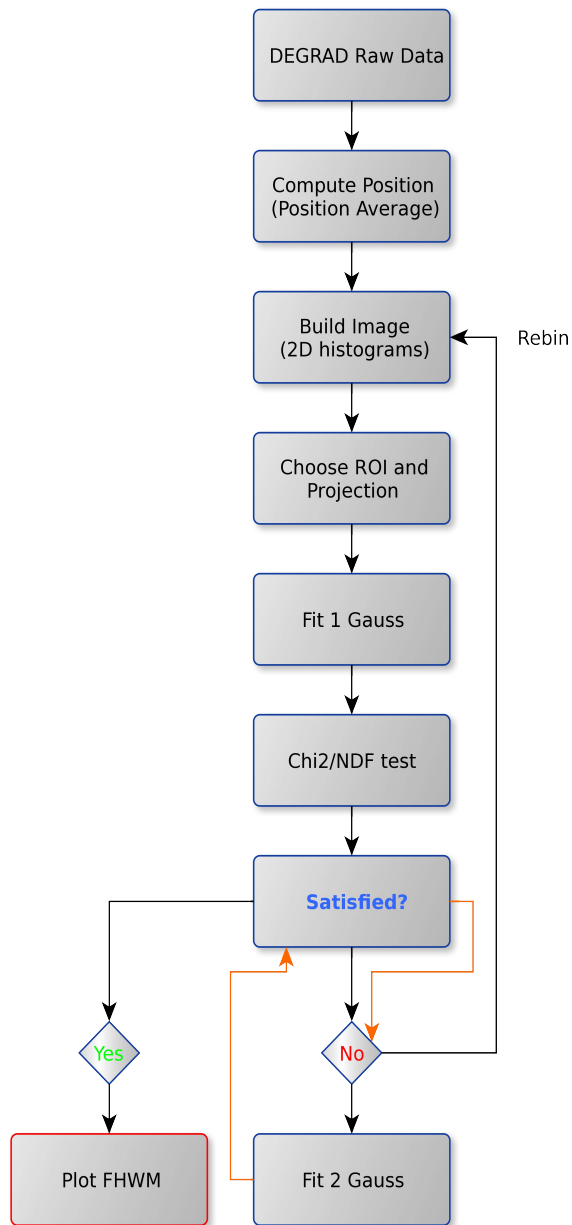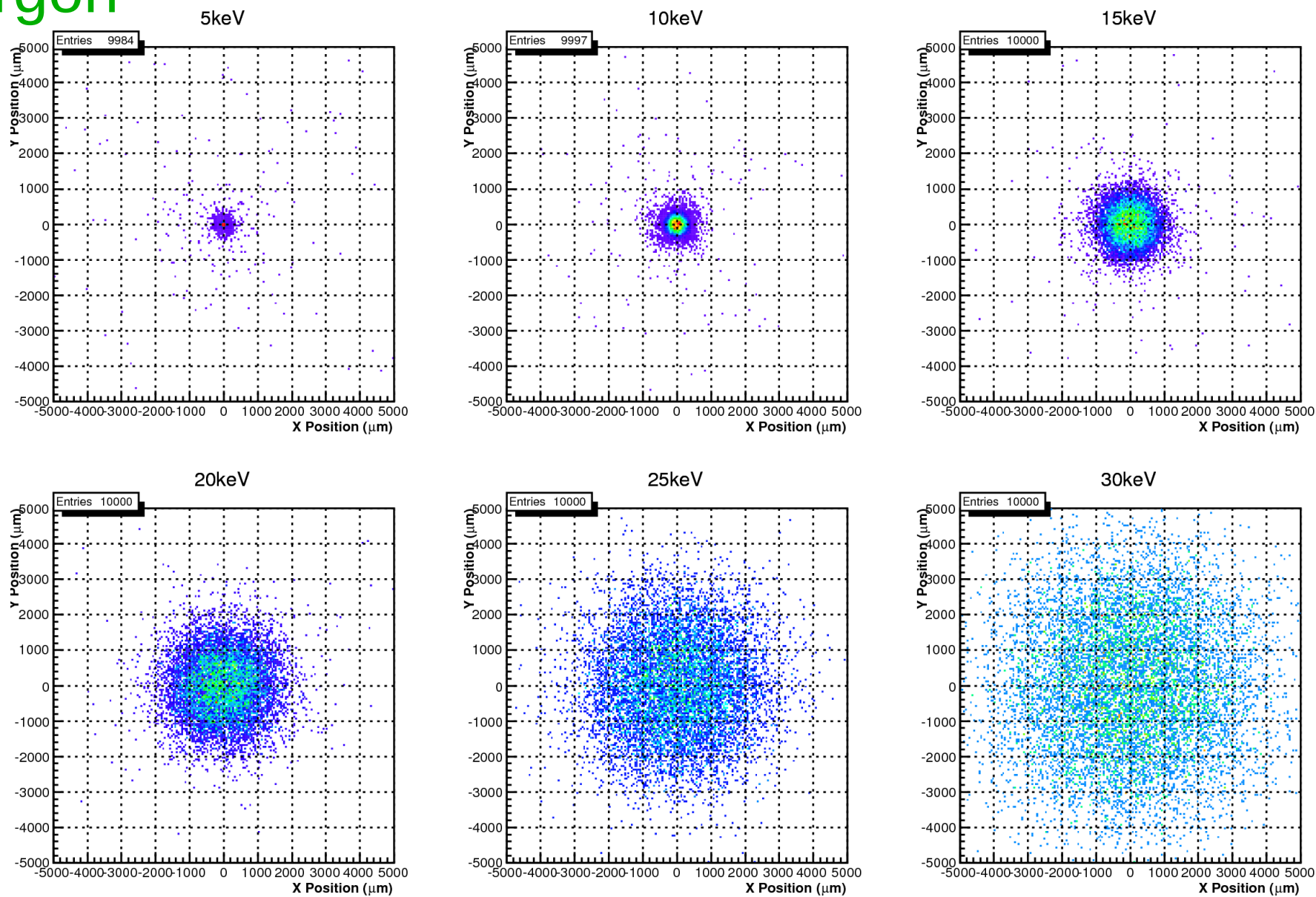
Images

- ## Neon

Images

- Krypton

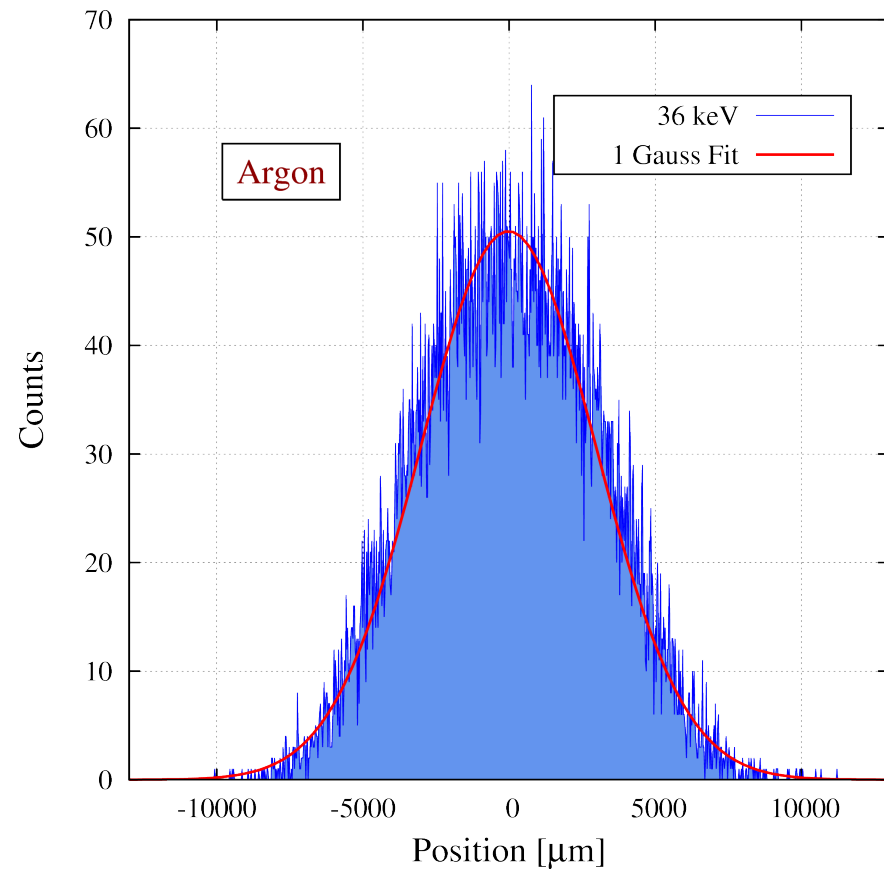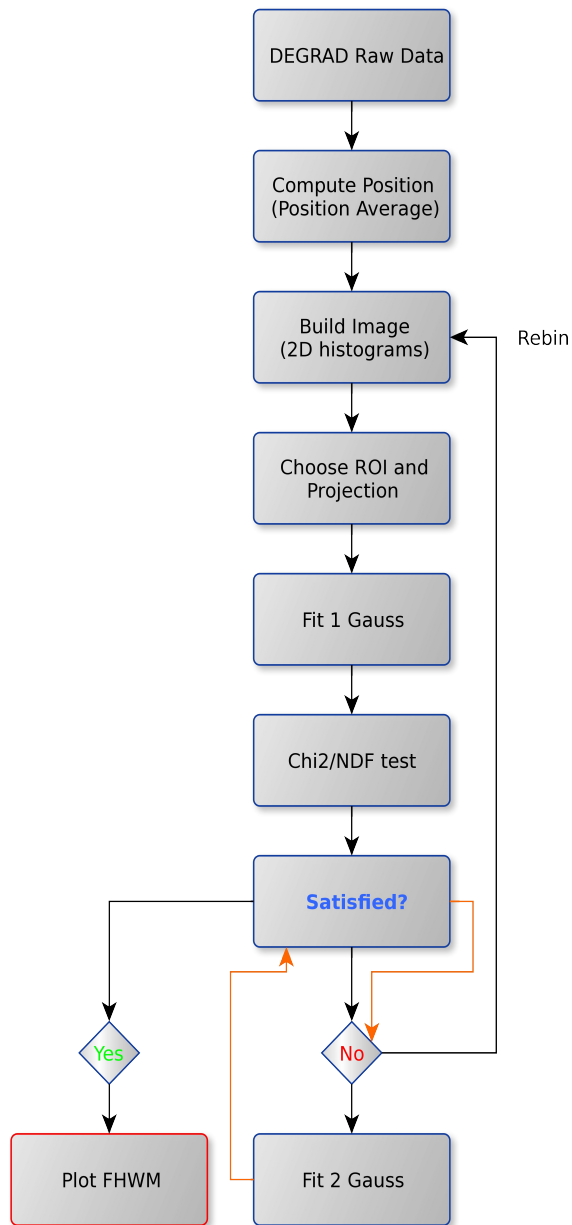Intrinsic position resolution of gaseous detectors for X-ray photons: simulation results from Degrad
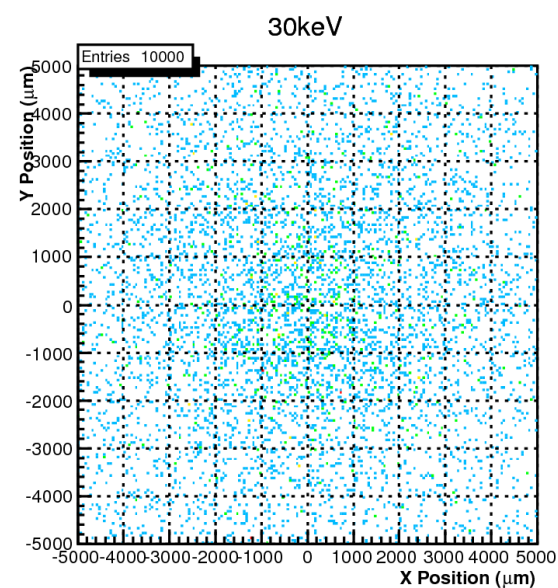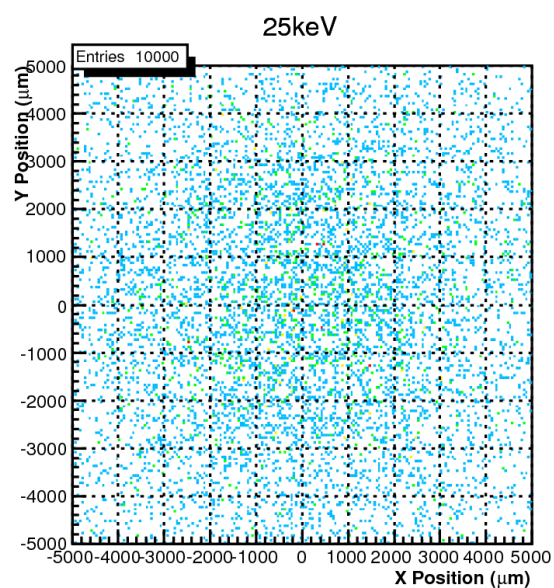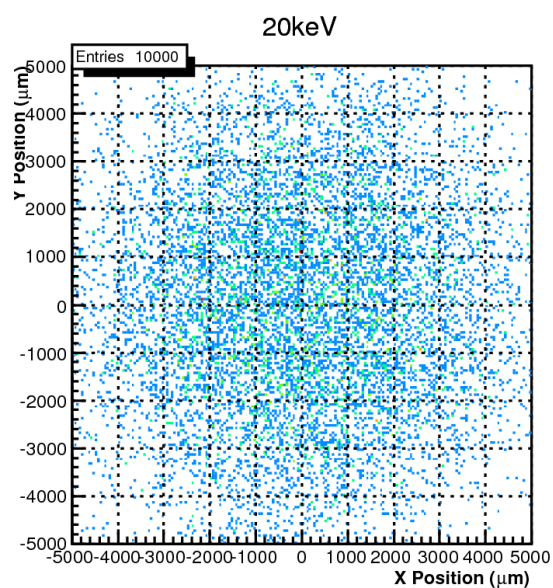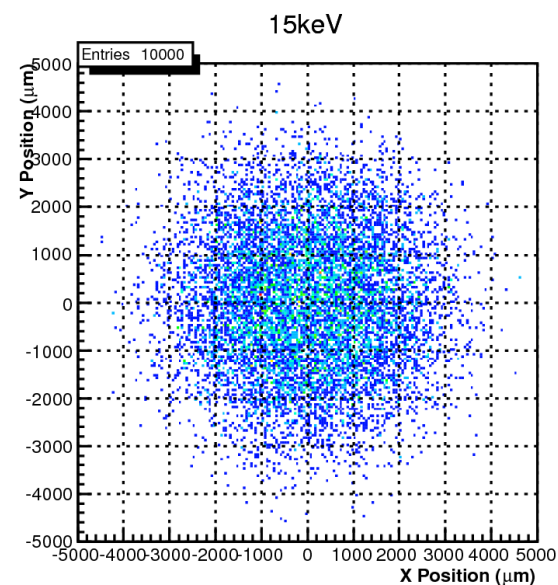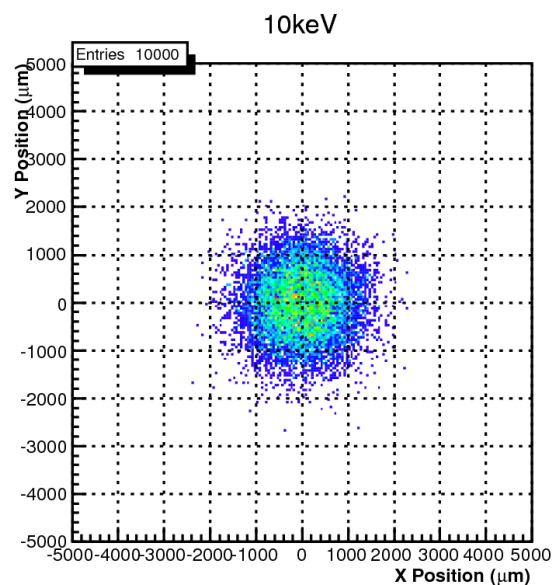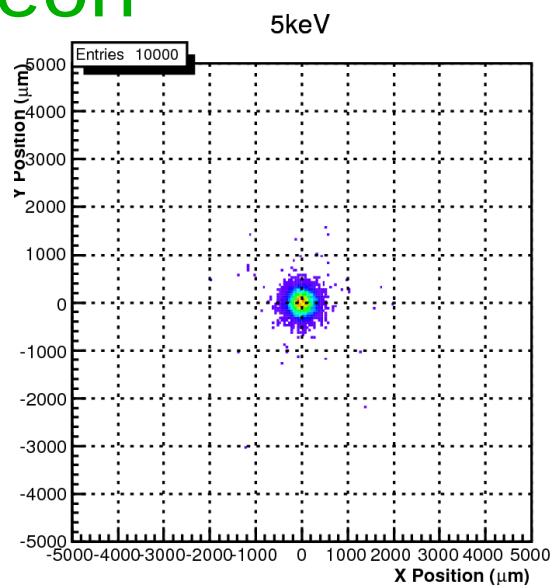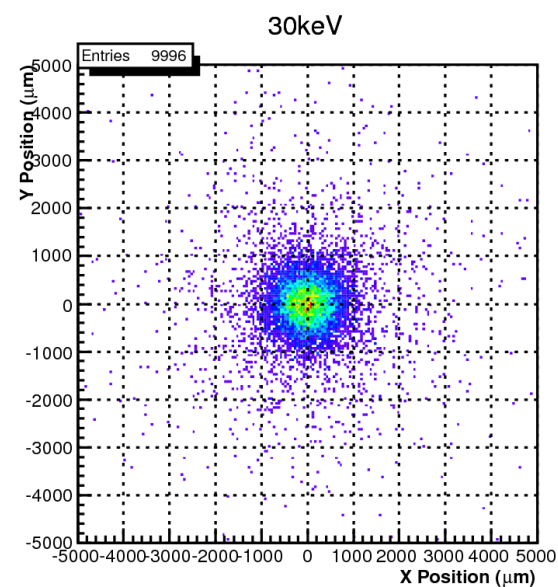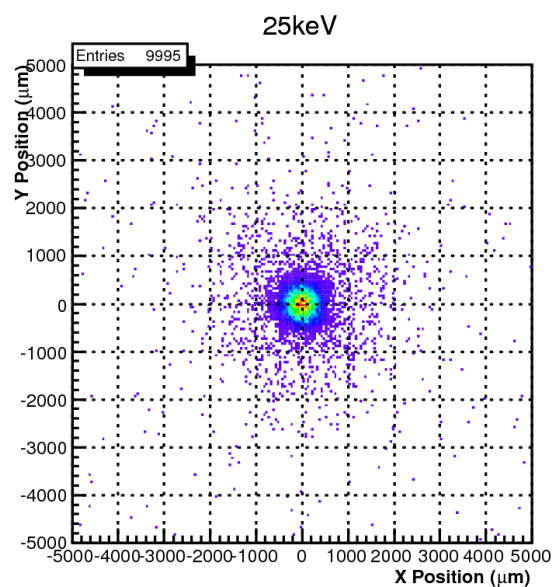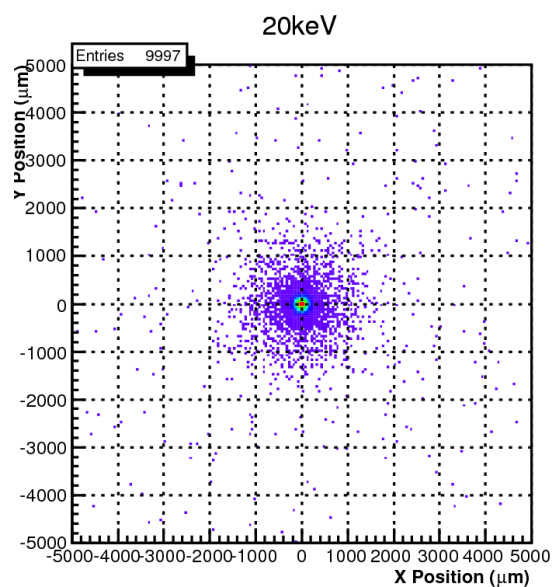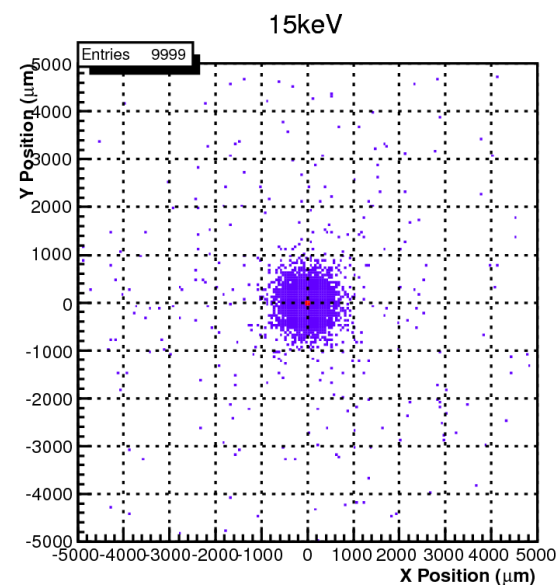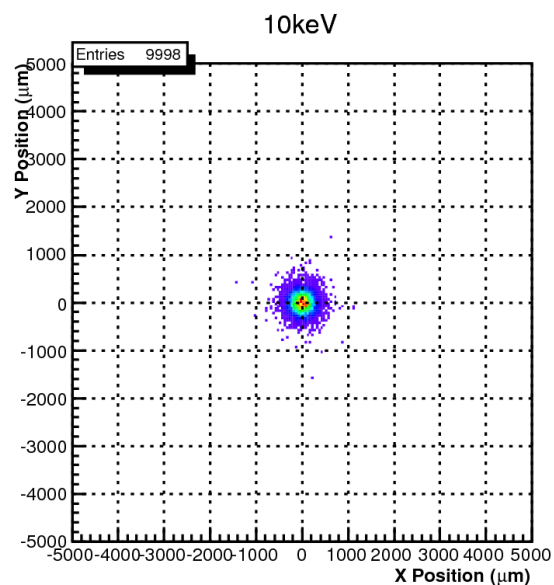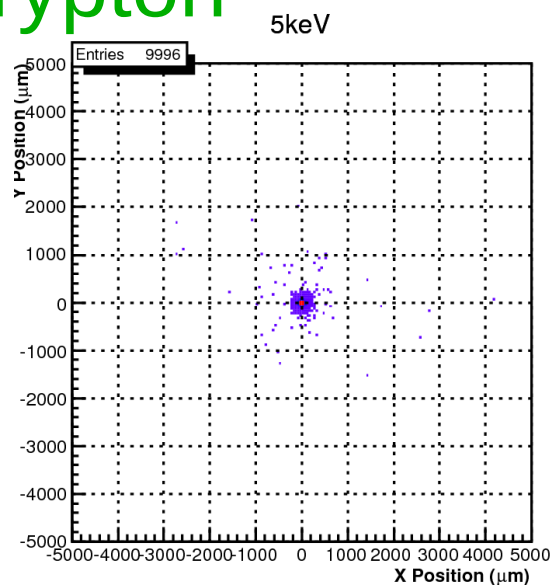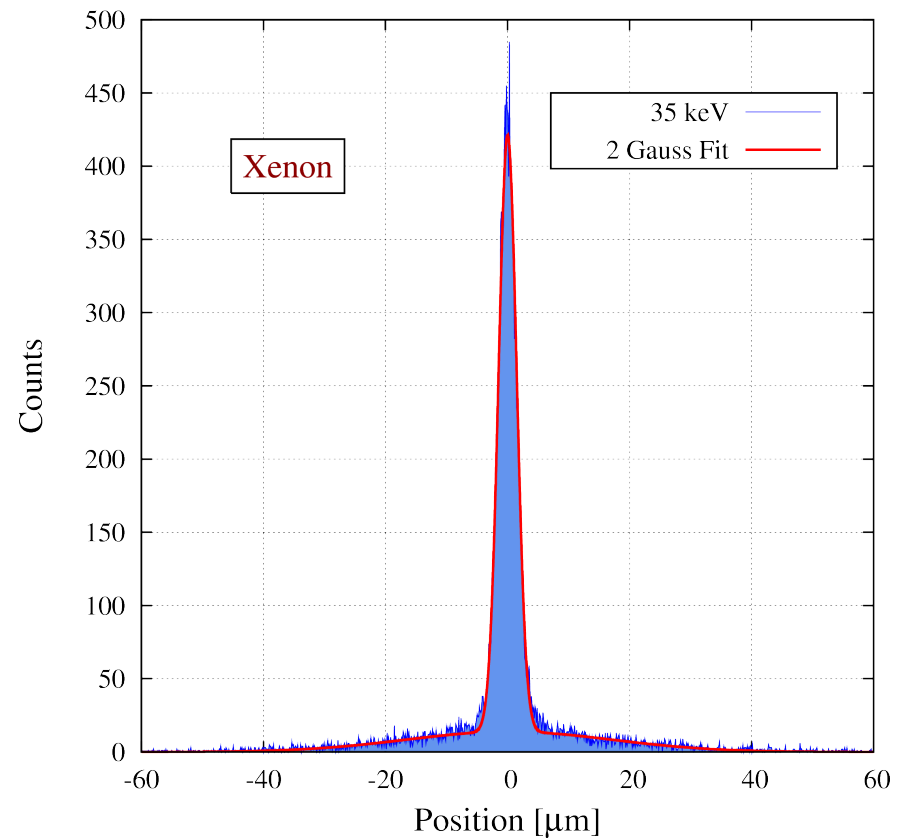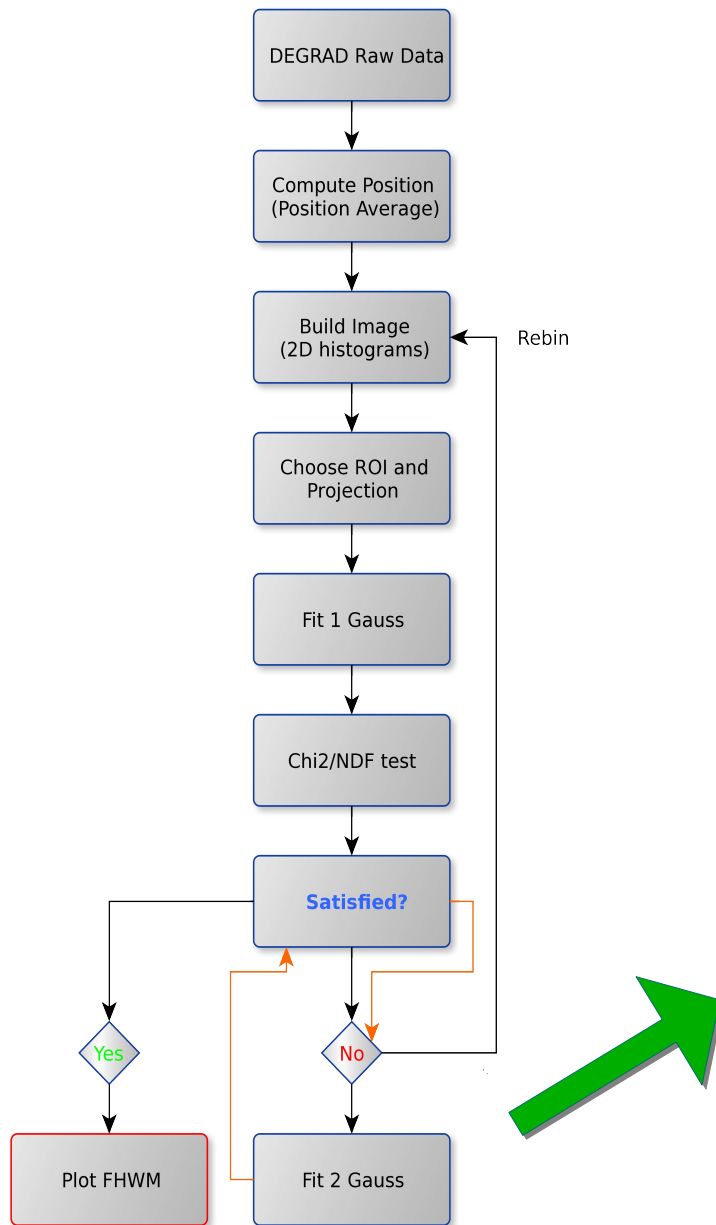
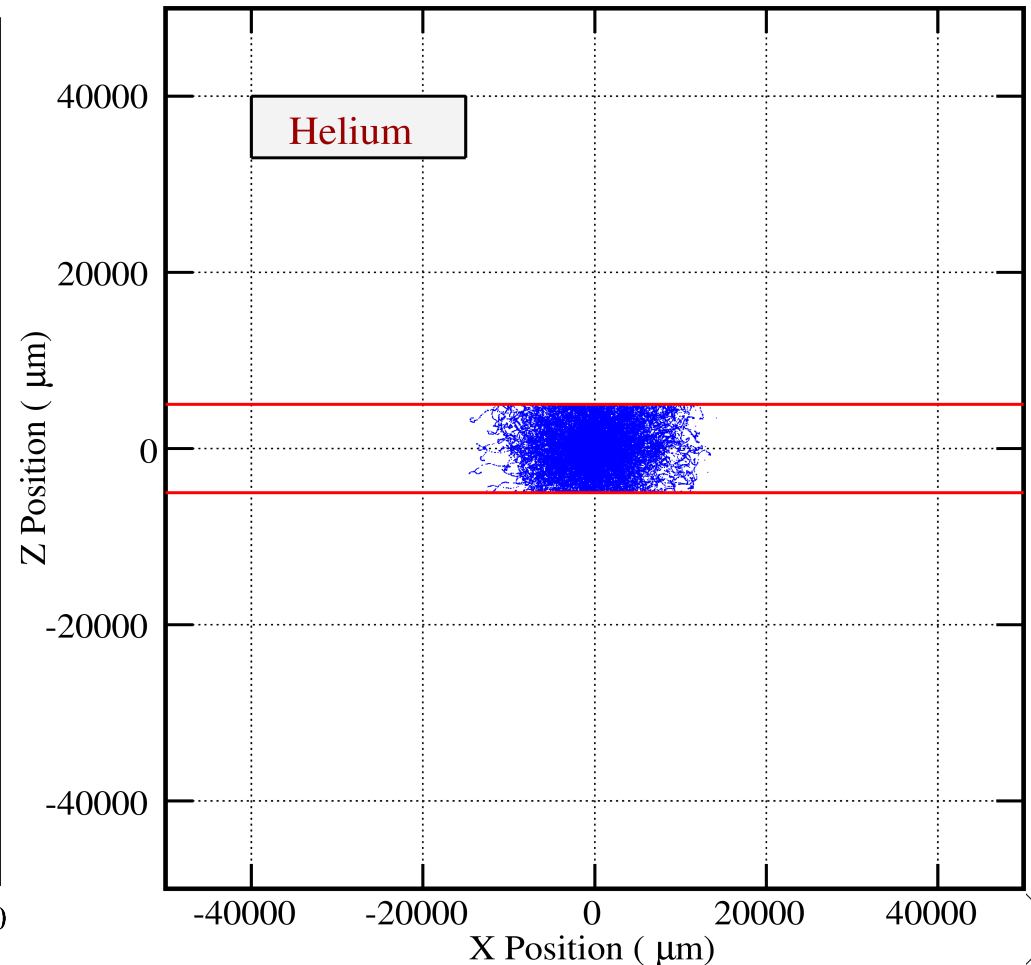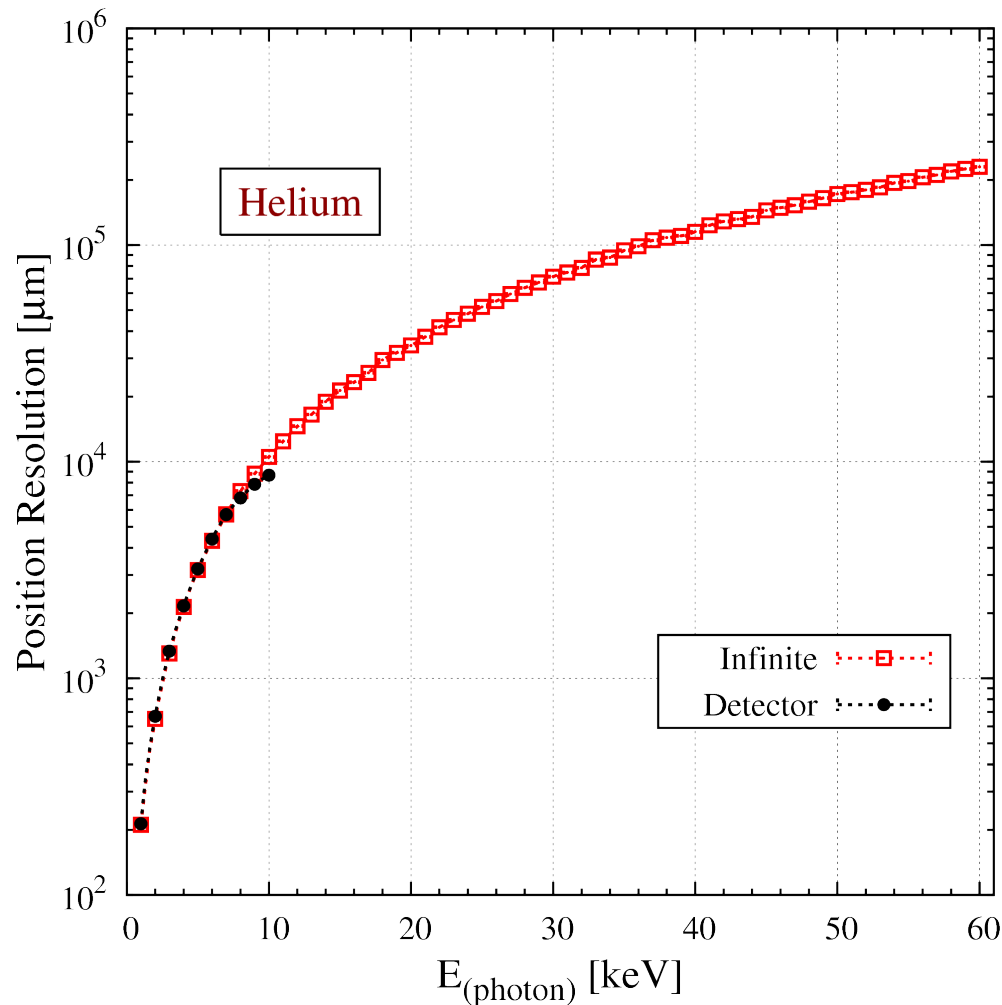# Images

- Xenon
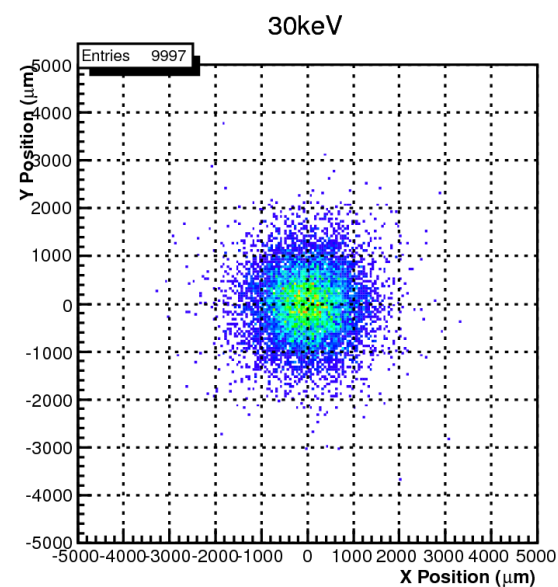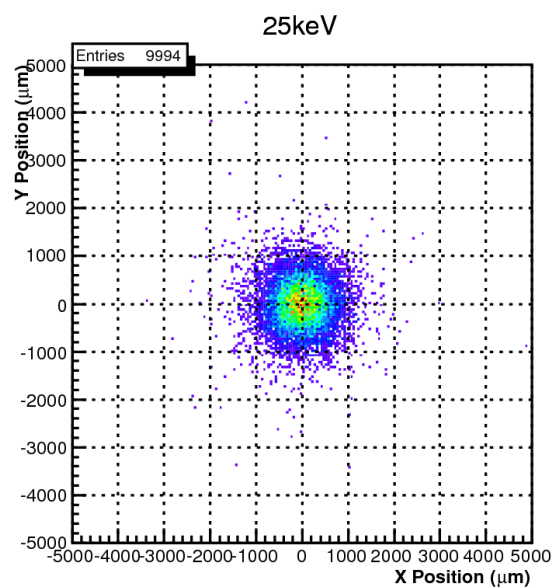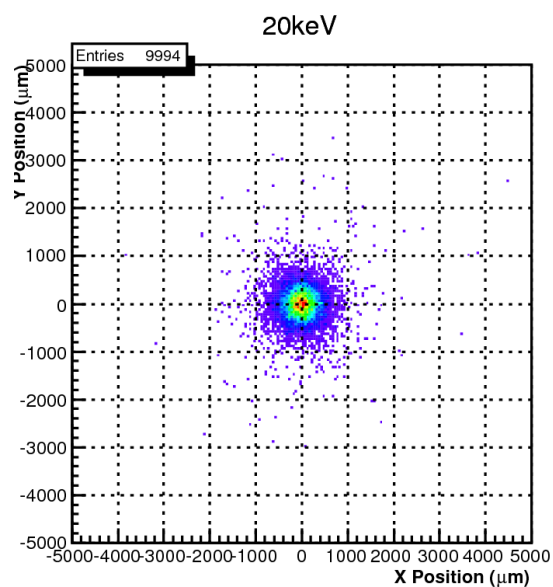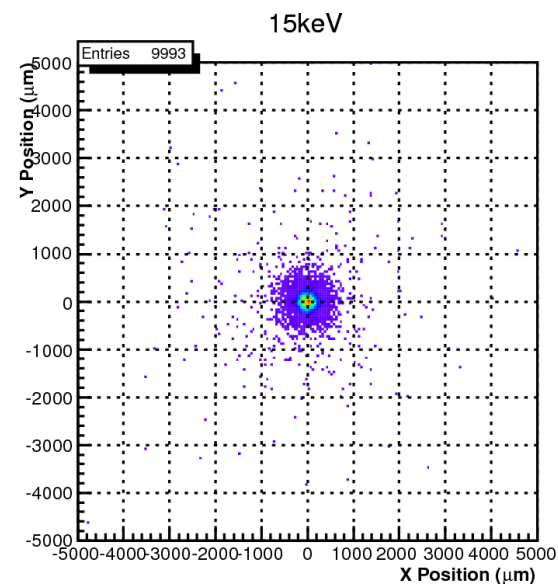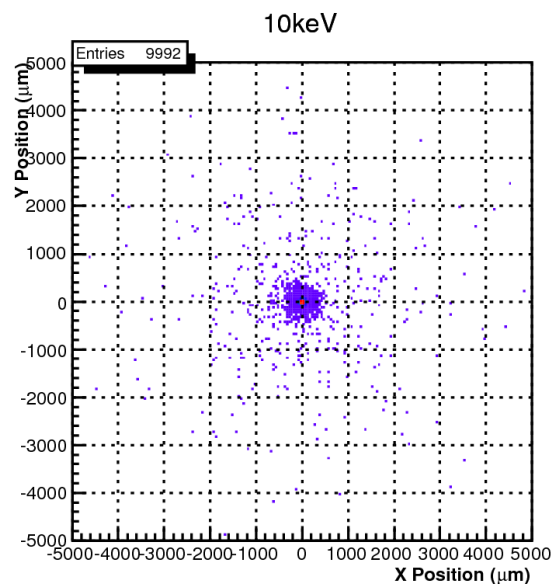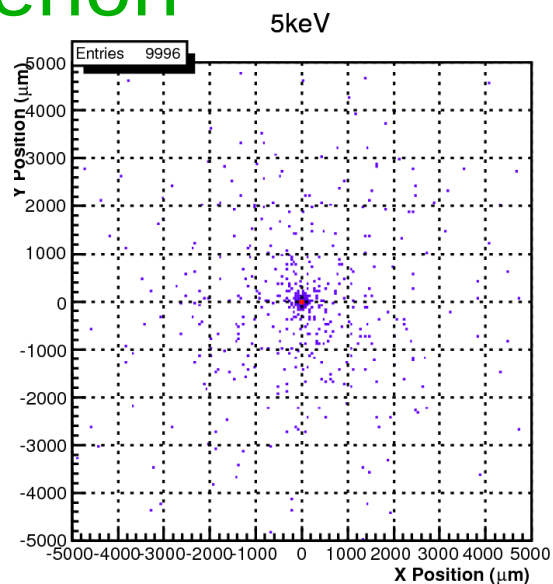
Data analysis
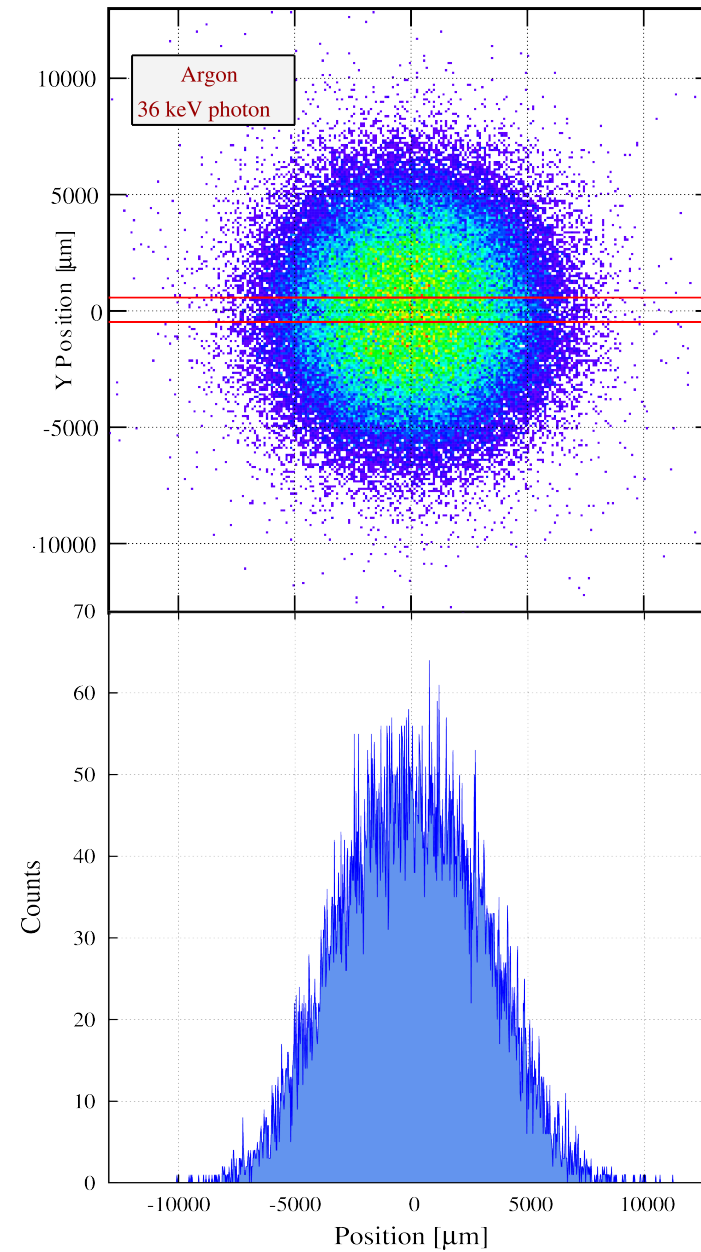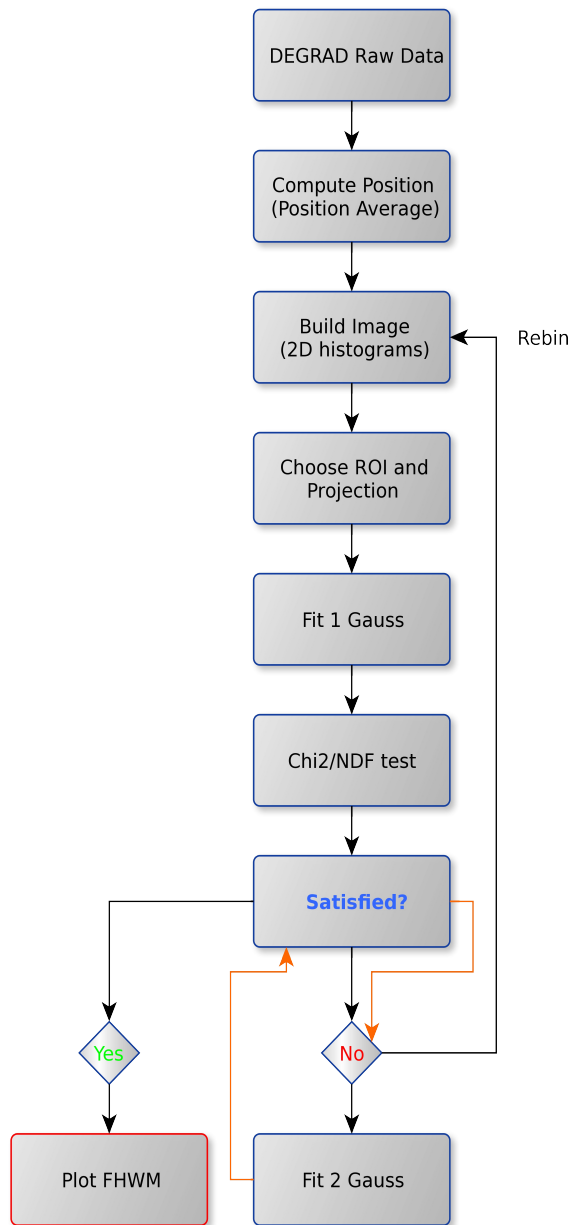
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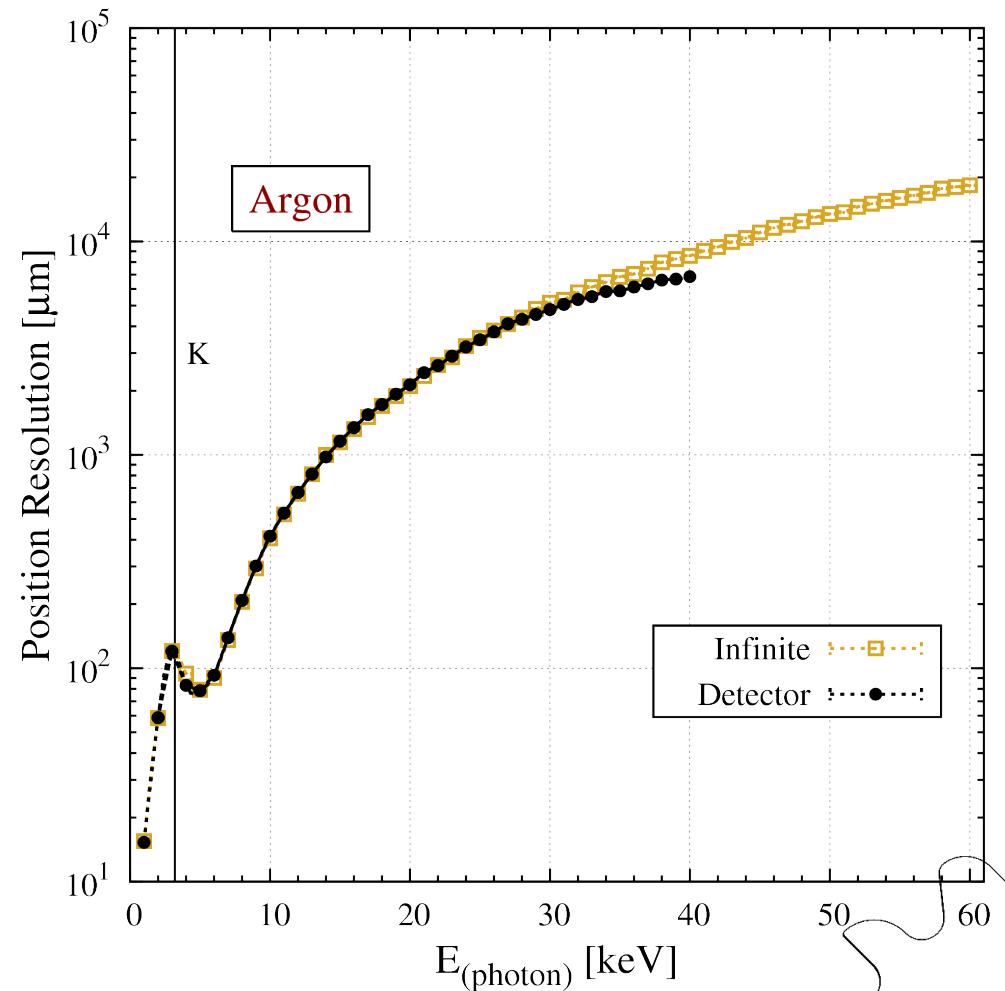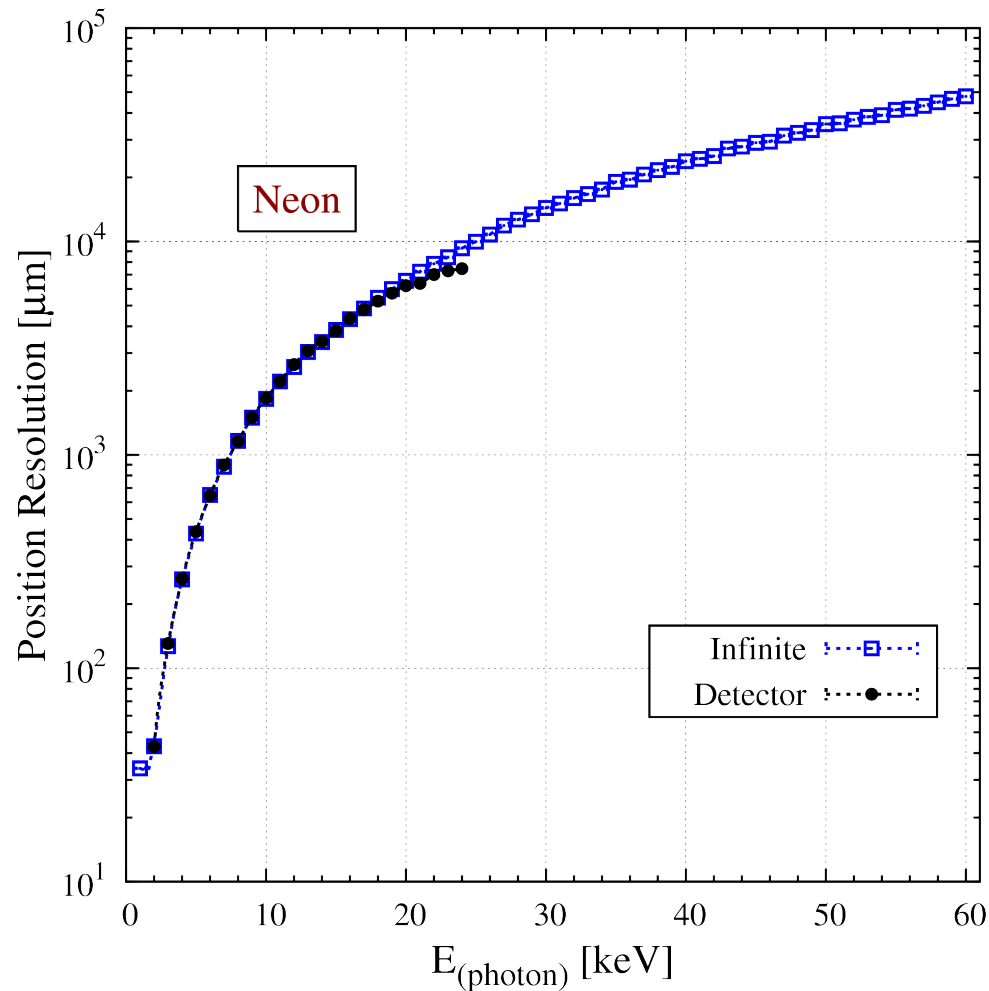
Data analysis

Position Resolution VS Energy

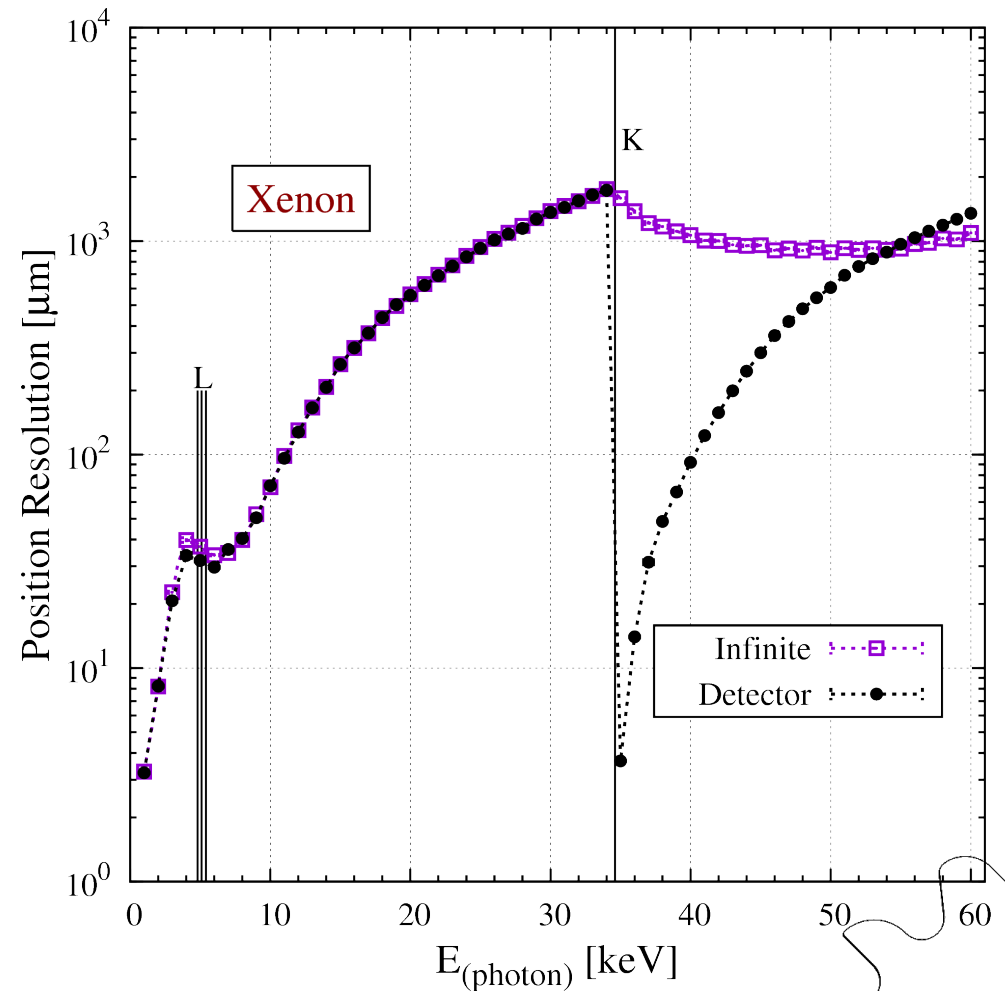- ## Influence of the detector dimension (drift)
  - ### Electron loss to the detectors walls

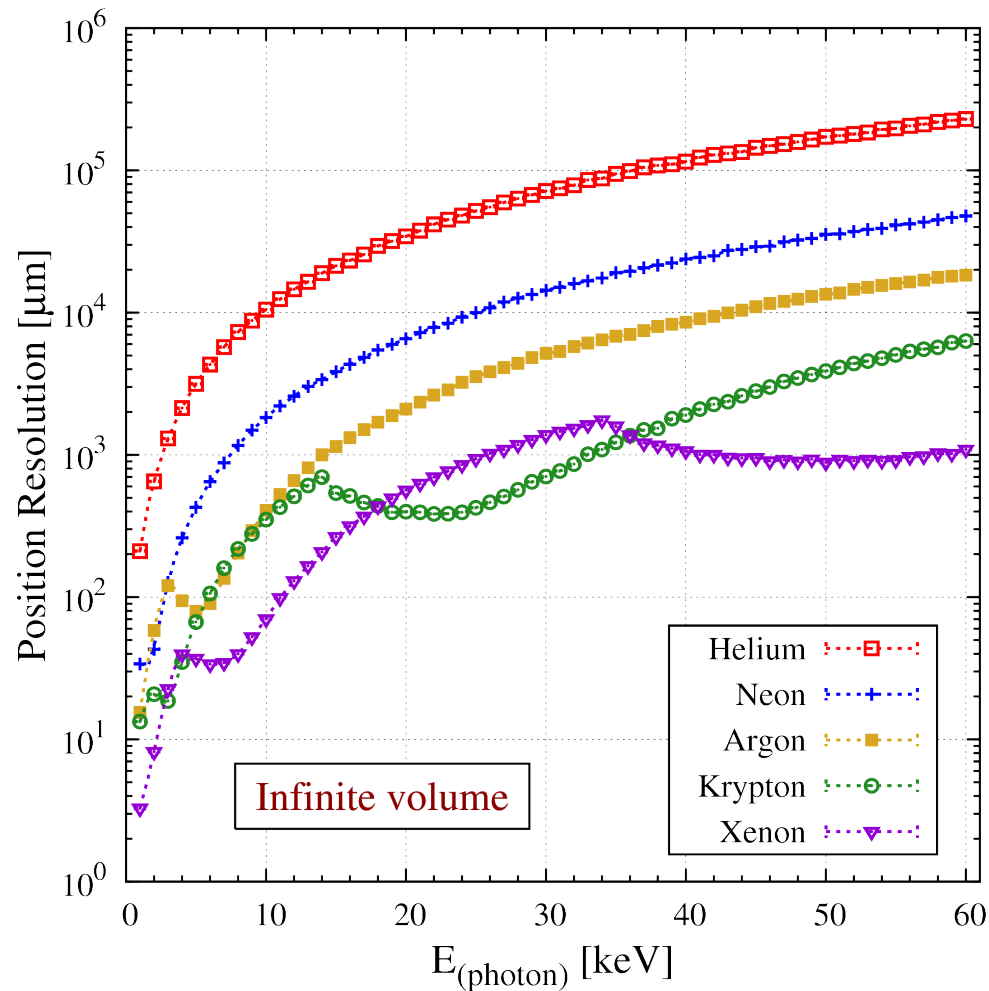# Position Resolution VS Energy

- Influence of the K shell (Argon)

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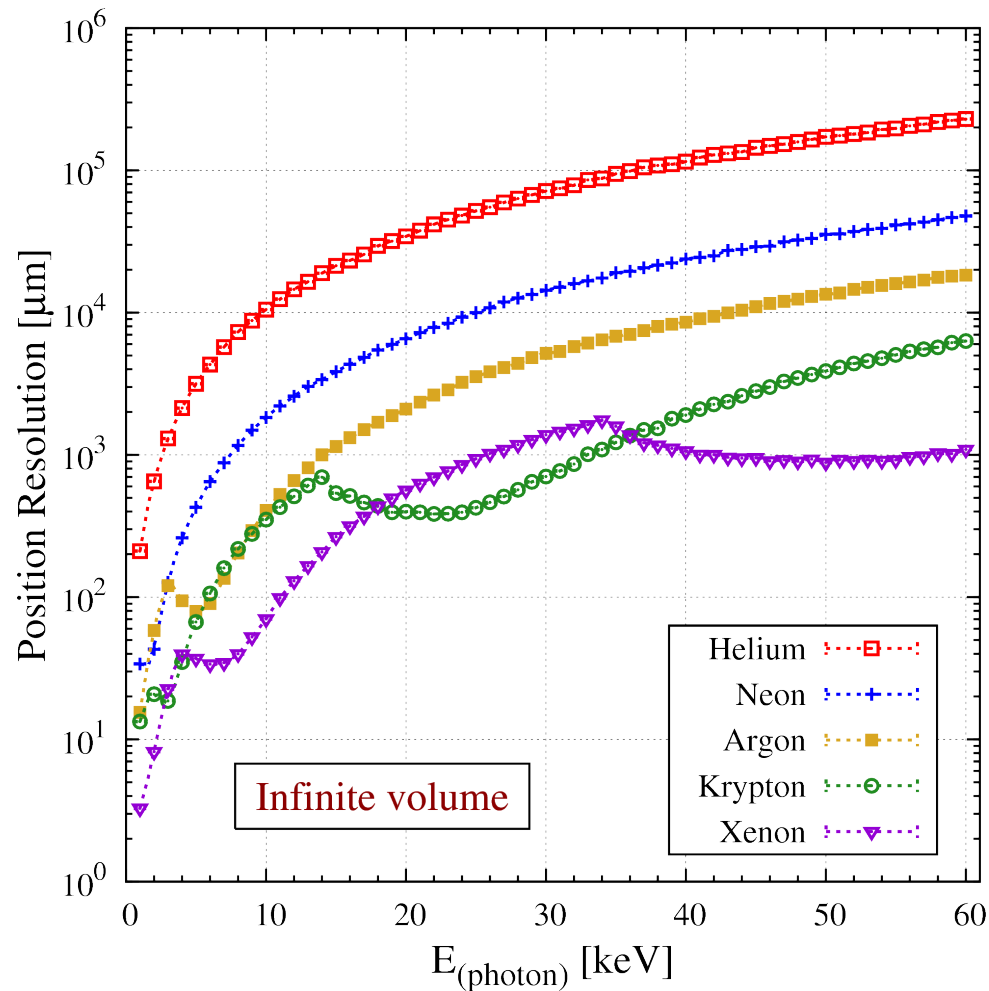# Position Resolution VS Energy

- Influence of the K and L shells
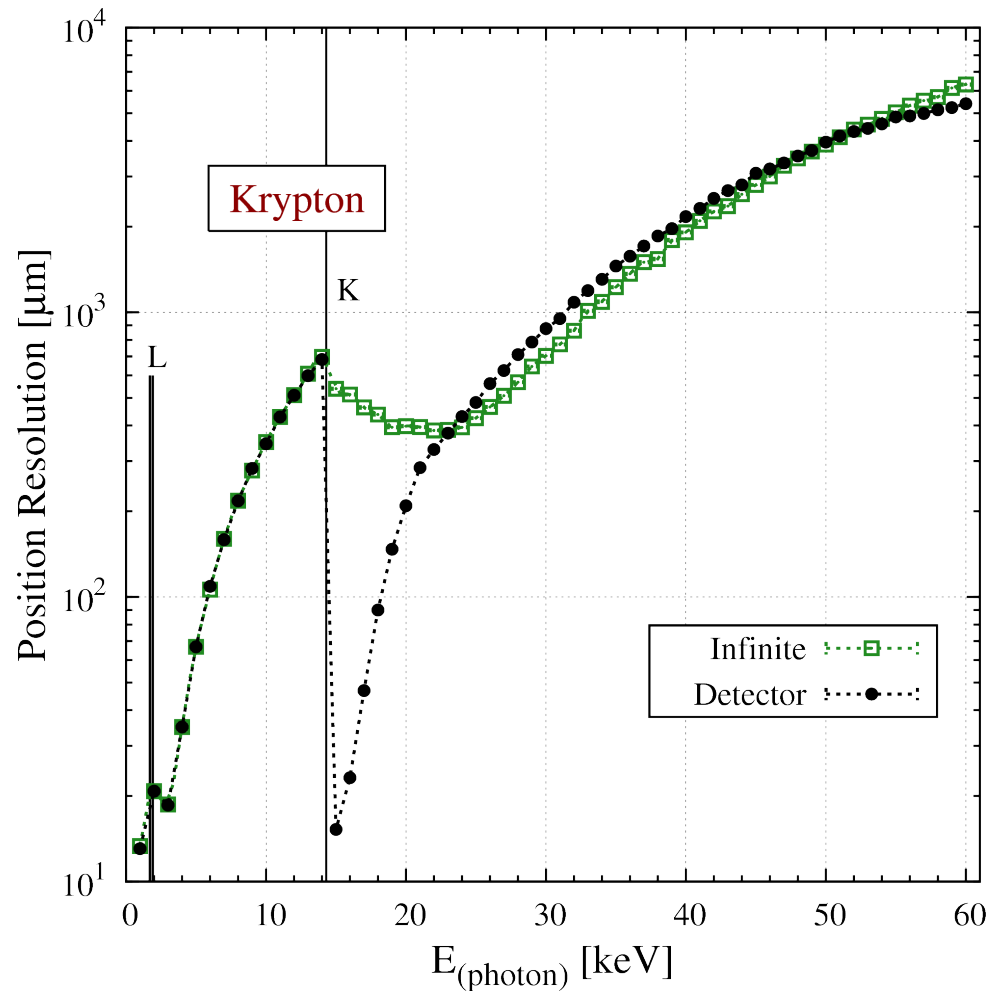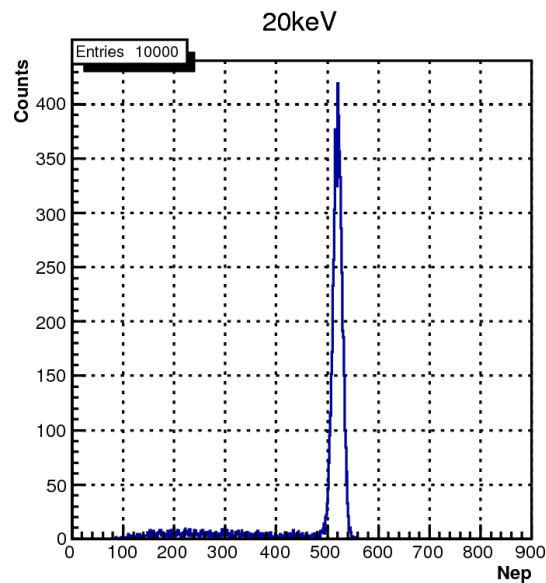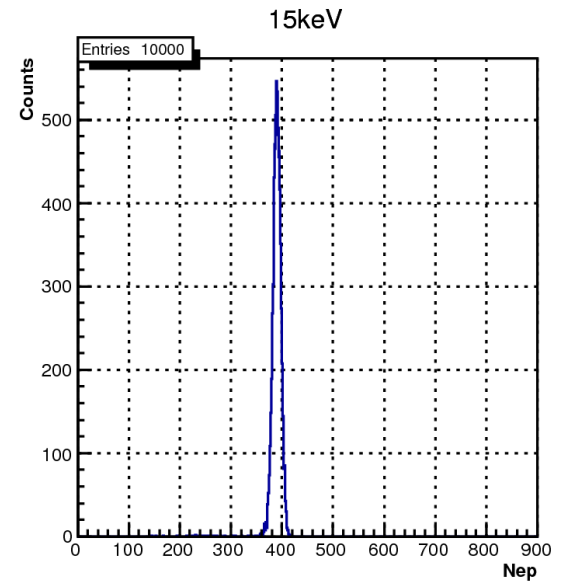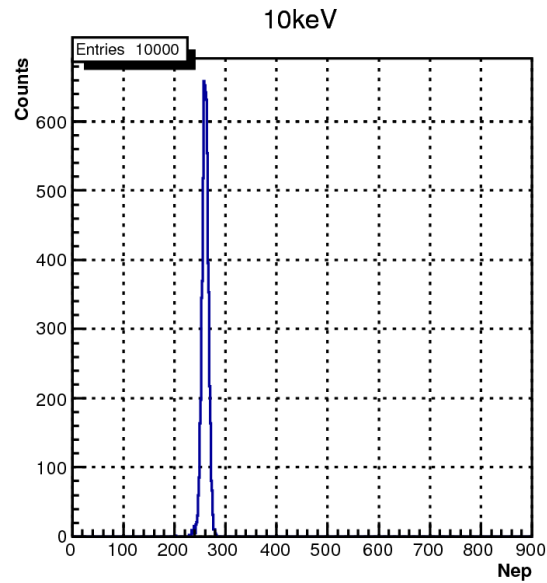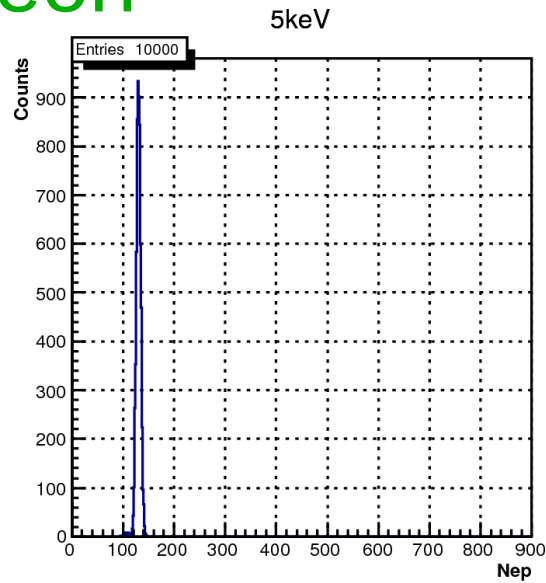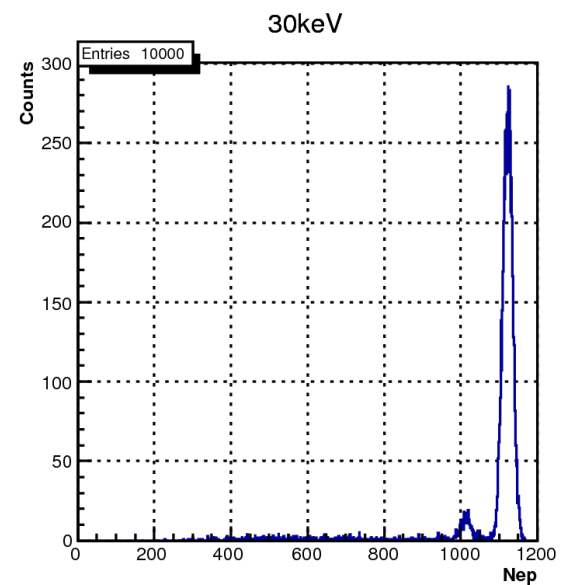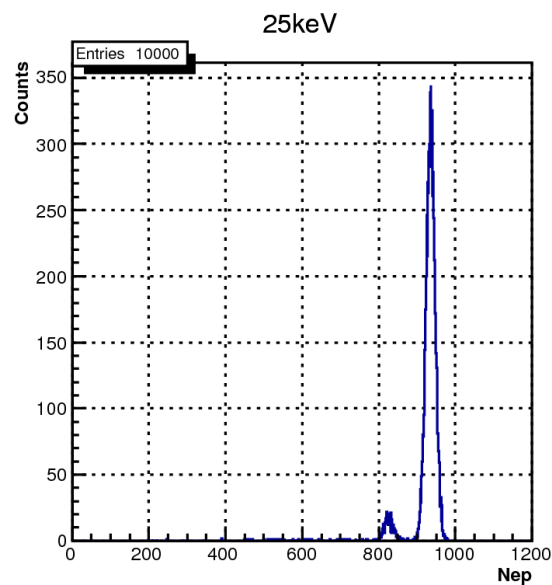
Position Resolution VS Energy

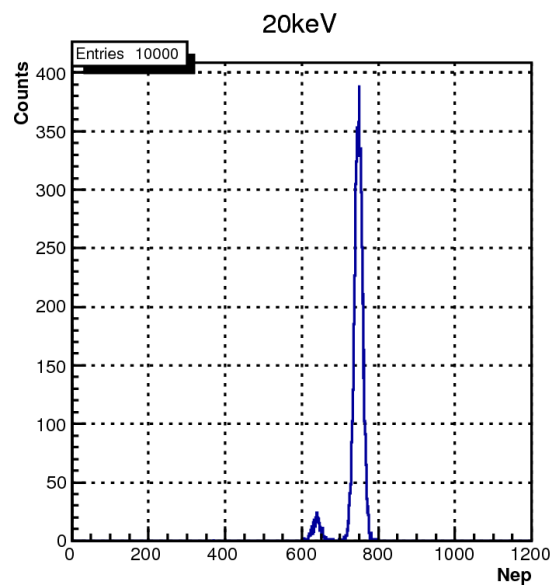- Infinite vs Detector Geometry
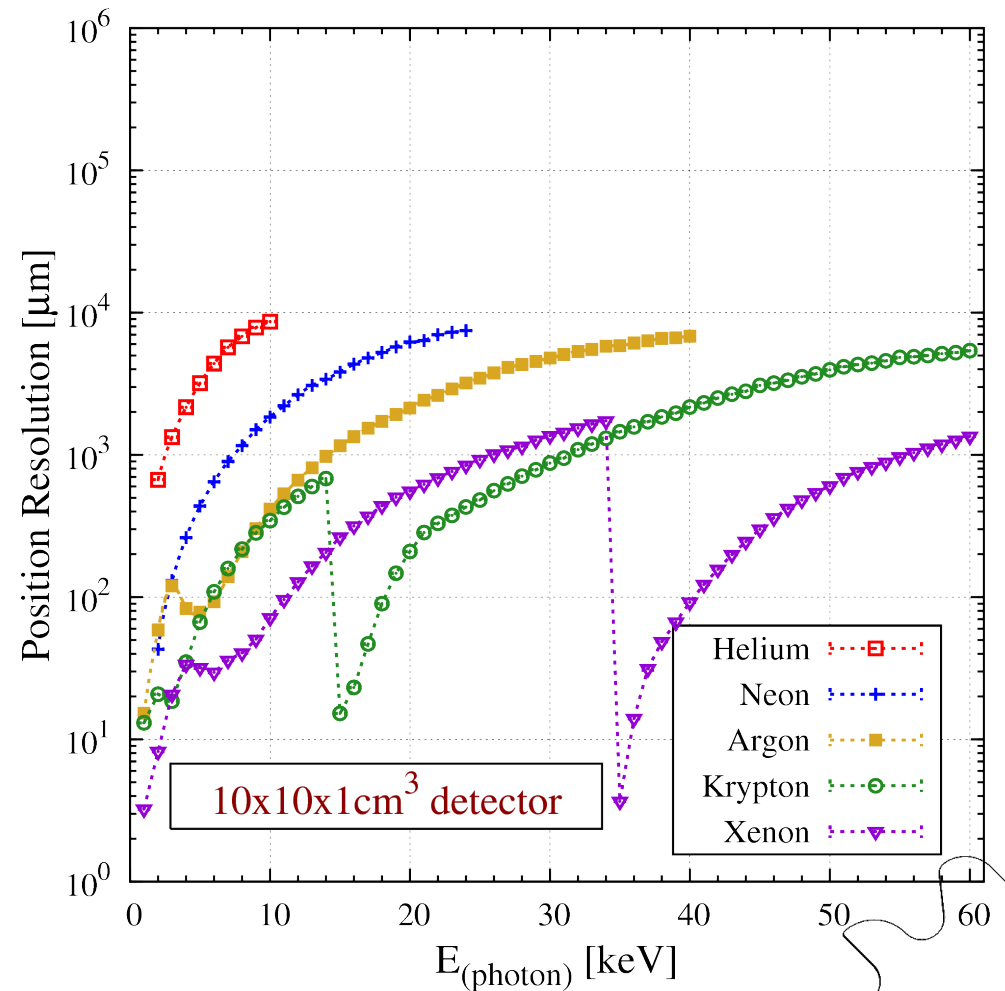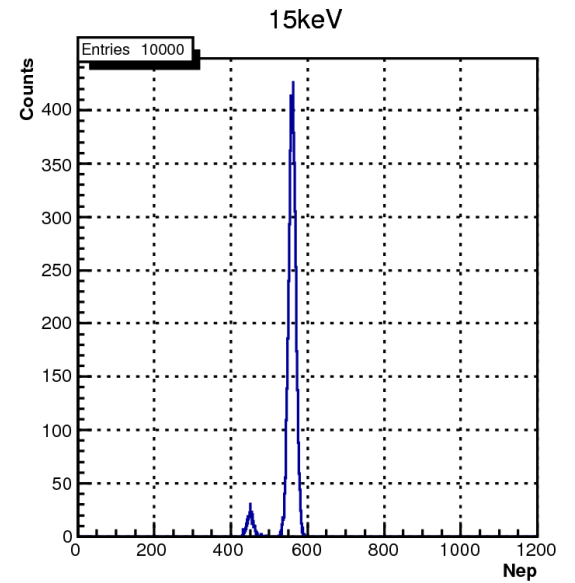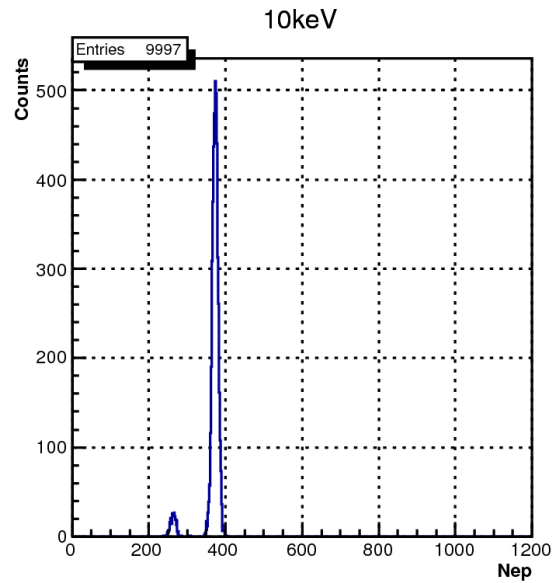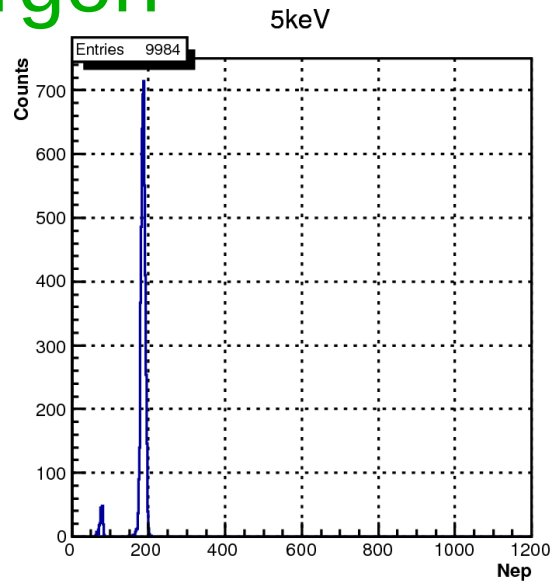
Position Resolution VS Energy

- ## Infinite vs Detector Geometry

Primary electron distribution

- Neon

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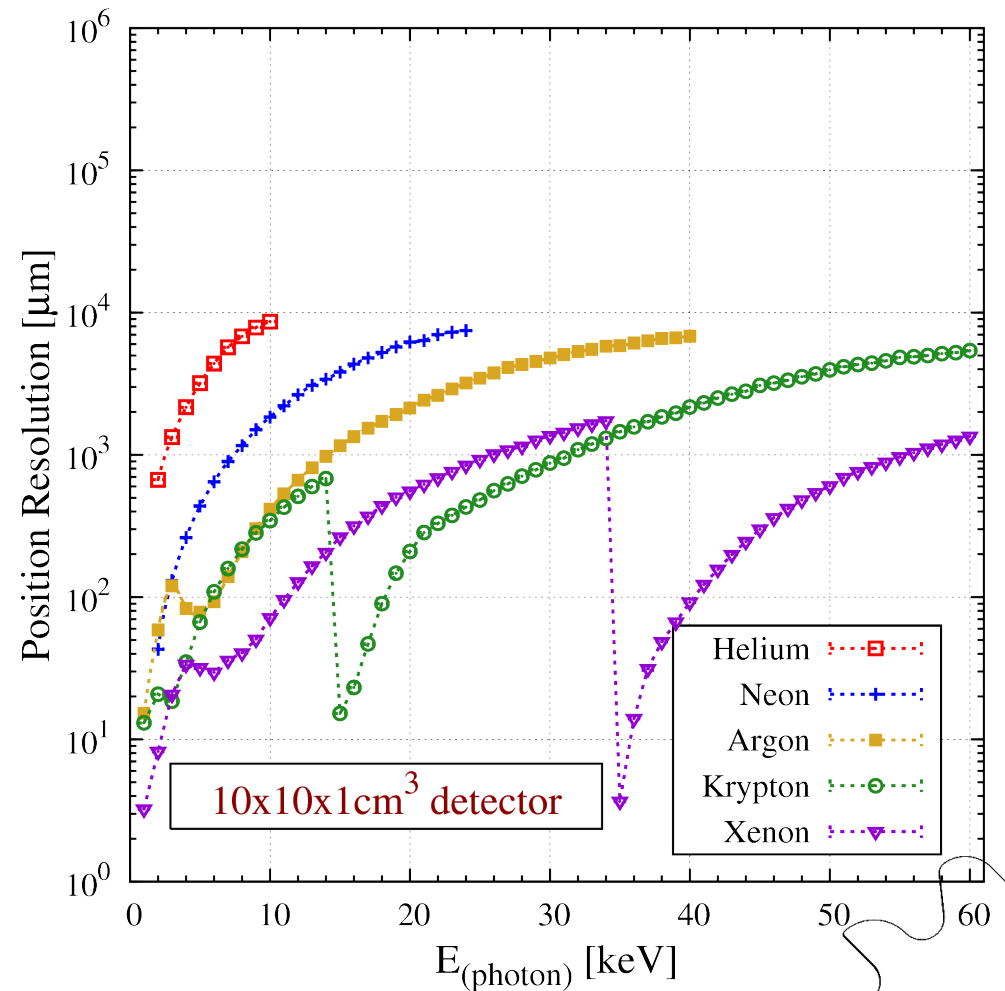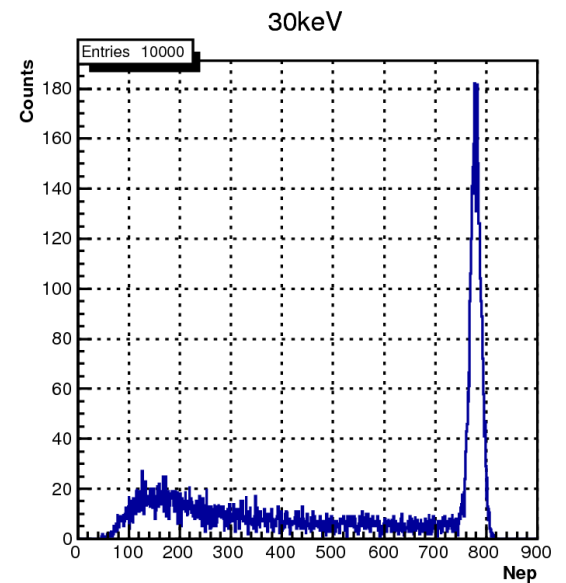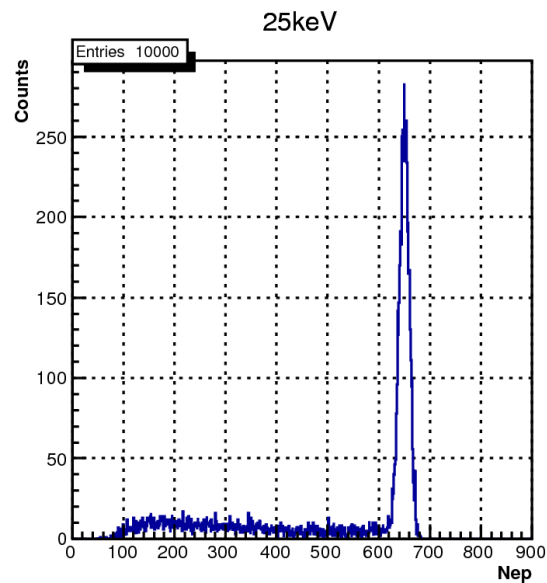
Primary electron distribution

- ## Argon

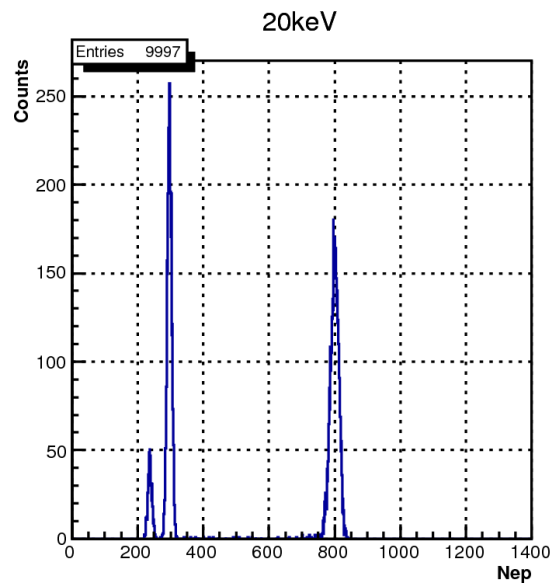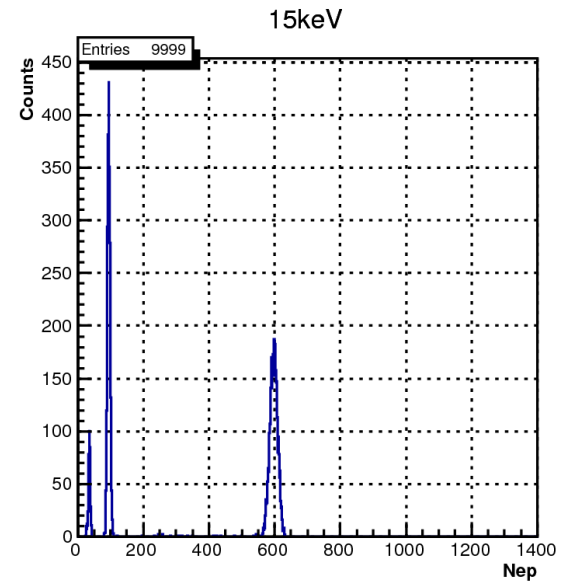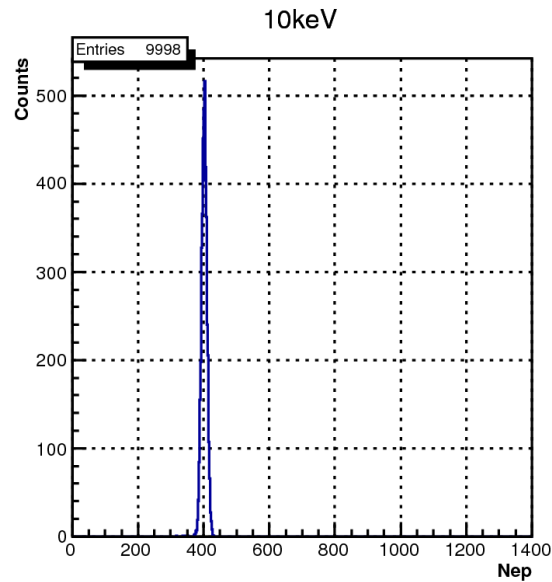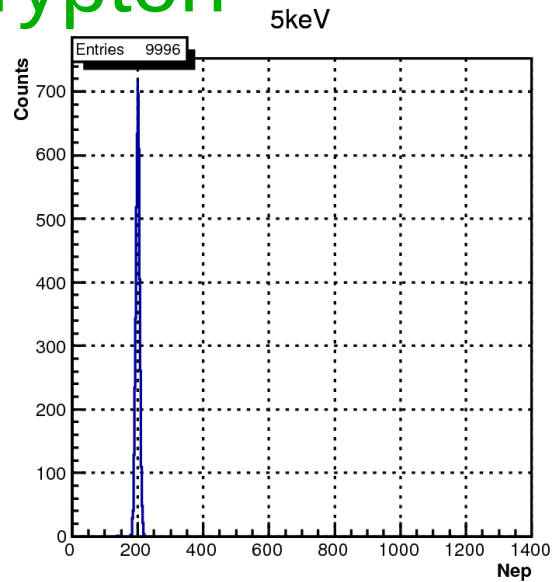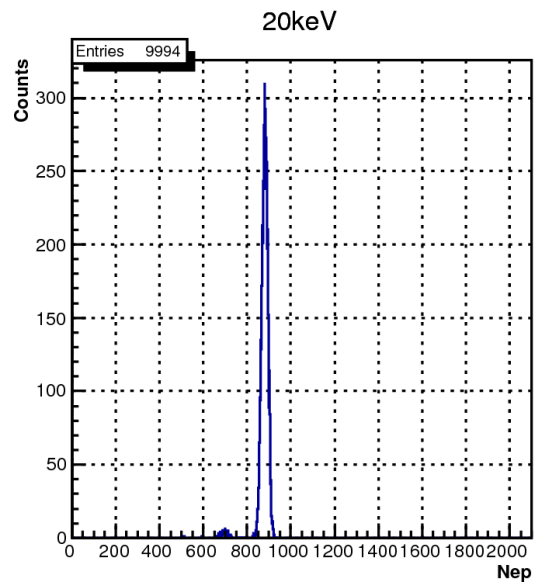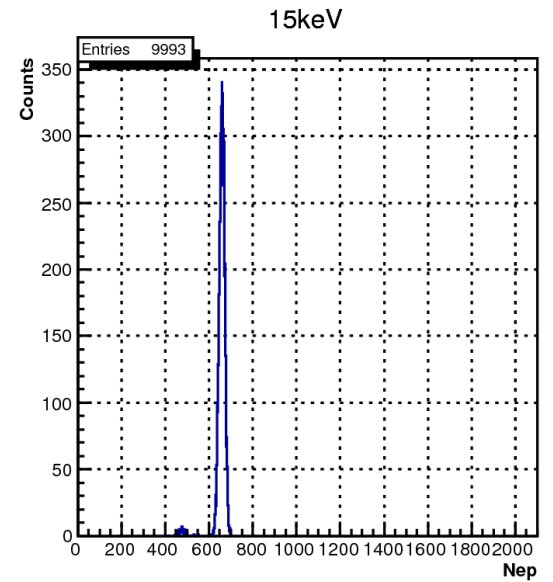# Primary electron distribution

- **Krypton**

Primary electron distribution

- ## Xenon

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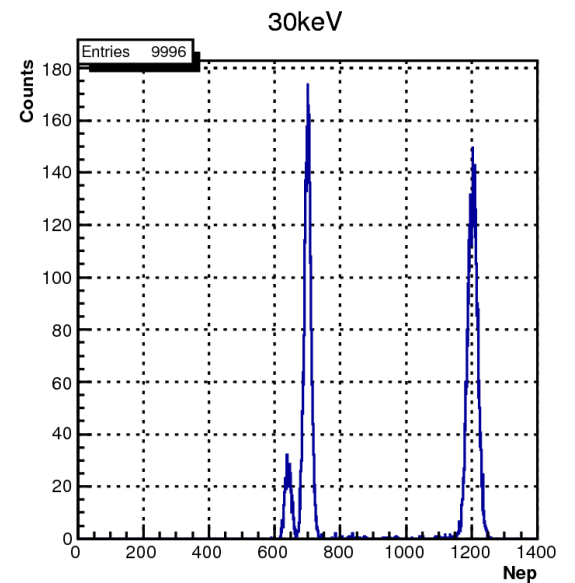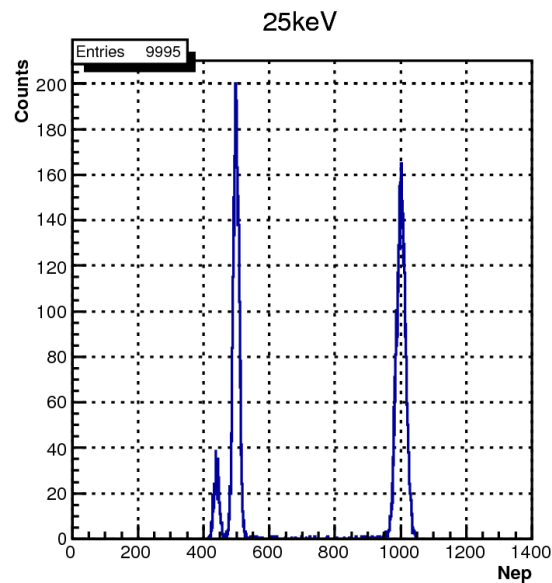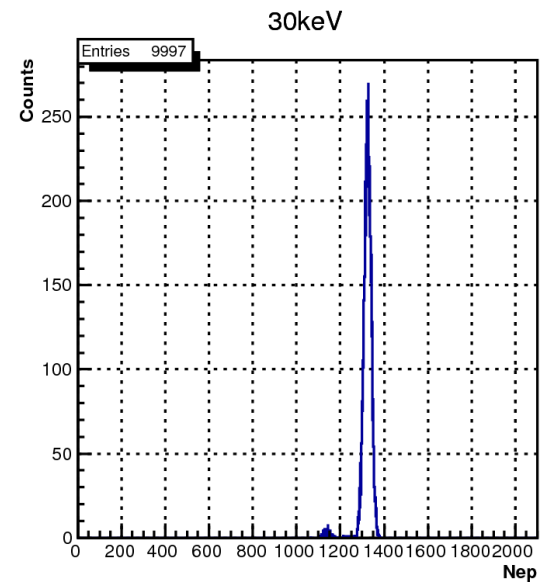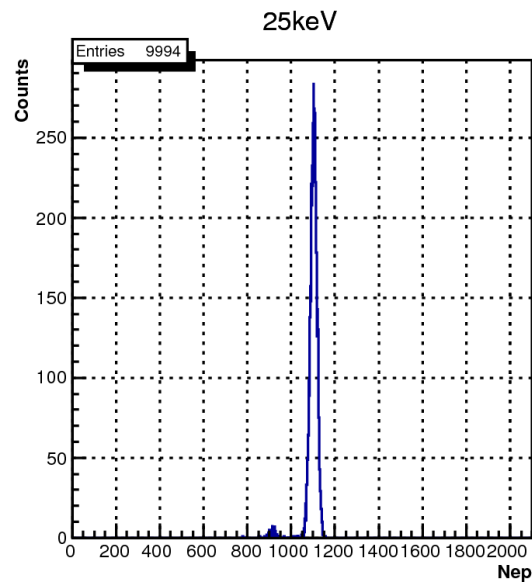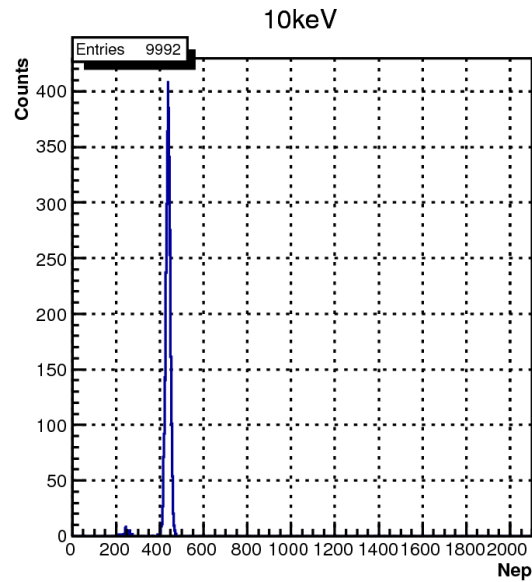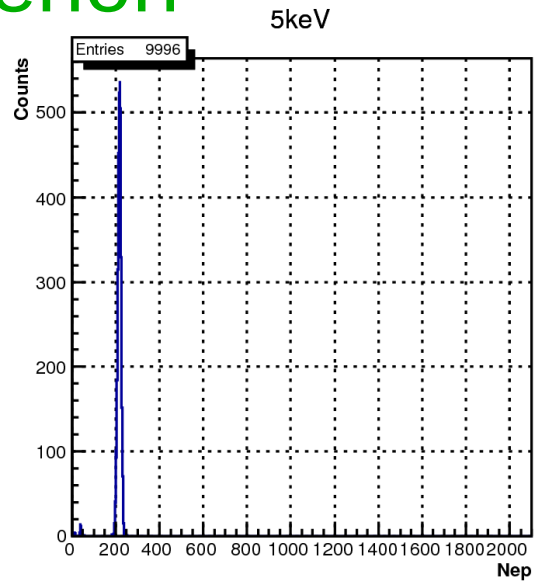
Conclusions and Future Work

- ## Preliminary results:

  - ### Energy resolution and position resolution degradation depending on the detectors geometry

  - ### Kr competes with Xe in the region 15-35 keV

    - #### BUT: image performance also depends on the statistics

      - Absorption probability should be included

- ## Experimental results needed

- ## Improve the position resolution by using clusterization algorithms (pixelated detectors).