gamma ray

November 14, 2021

[13]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d, UnivariateSpline
from scipy.signal import find_peaks
import warnings

warnings.filterwarnings("ignore")
```

1 Datas

[14]:
```
# unkown sample datas
data_uk = pd.read_excel("radiation_datas.xlsx", sheet_name="unknown")
uk_channel = data_uk["u_channel"]
uk_counts = data_uk["u_counts"]

# cobalt-60 datas
data_co = pd.read_excel("radiation_datas.xlsx", sheet_name="cobalt")
co_channel = data_co["c_channel"]
co_counts = data_co["c_counts"]

# Barium-133 datas
data_ba = pd.read_excel("radiation_datas.xlsx", sheet_name="barium")
ba_channel = data_ba["b_channel"]
ba_counts = data_ba["b_counts"]
```

2 Functions

[15]:
```
# interpolation function
def interpolate(x, y):
    f = interp1d(x, y, kind="cubic", fill_value="extrapolate")
    a = np.arange(x[0], x[len(x) - 1], 0.001)
    b = f(a)
    return a, b
```

```
# full width half maxima function
def FWHM(x_n, y_n):
    # create a spline
    spline = UnivariateSpline(x_n, y_n - np.max(y_n) / 2, s=0)
    x1, x2 = spline.roots()  # find the roots
    return x1, x2


def FWHM_co(x_n, y_n):
    # create a spline
    spline = UnivariateSpline(x_n, y_n - np.max(y_n) / 2, s=0)
    x1, x2, x3, x4 = spline.roots()  # find the roots
    return x1, x2, x3, x4
```

3 Interpolation

[16]:
```
channel_interpolated_ba, counts_interpolated_ba = interpolate(ba_channel,␣
 ↪ba_counts)
channel_interpolated_co, counts_interpolated_co = interpolate(co_channel,␣
 ↪co_counts)
channel_interpolated_uk, counts_interpolated_uk = interpolate(uk_channel,␣
 ↪uk_counts)

element_name = ["Barium-133", "Cobalt-60", "Unknown Source"]
channel_interpolated = [channel_interpolated_ba, channel_interpolated_co,␣
 ↪channel_interpolated_uk]
counts_interpolated = [counts_interpolated_ba, counts_interpolated_co,␣
 ↪counts_interpolated_uk]
channel_original = [ba_channel, co_channel, uk_channel]
counts_original = [ba_counts, co_counts, uk_counts]
```

4 Calculations

4.1 Finding the Full width at half maxima(FWHM)

From the above graph, I am considering the interpolated datas and then going to find the FWHM here

[17]:
```
# plt.style.use("seaborn-poster")
# plt.figure(figsize=(15, 24))

del_V = []
vi = []
for i in range(len(element_name)):
    if element_name[i] != "Cobalt-60":
        r1, r2 = FWHM(channel_interpolated[i], counts_interpolated[i])
```

```
        vi.append(r1)
        vi.append(r2)
        del_V.append(r2 - r1)
        if element_name[i] == "Unknown Sample":
            print(f"{element_name[i]}: \n\t V1 = {r1:.2f}, V2 = {r2:.2f}, del_V␣
↪= {del_V[i+1]:.2f}")
        elif element_name[i] == "Barium-133":
            print(f"{element_name[i]}: \n\t V1 = {r1:.2f}, V2 = {r2:.2f}, del_V␣
↪= {del_V[i]:.2f}")

    if element_name[i] == "Cobalt-60":
        r1, r2, r3, r4 = FWHM_co(channel_interpolated[i],␣
↪counts_interpolated[i])
        vi.append(r1)
        vi.append(r2)
        vi.append(r3)
        vi.append(r4)
        del_V.append(r2 - r1)
        del_V.append(r4 - r3)
        print(
            f"{element_name[i]}: \n\t V1 = {r1:.2f}, V2 = {r2:.2f}, del_V =␣
↪{del_V[i]:.2f} \n\t V3 = {r3:.2f}, V4 = {r4:.2f}, del_V = {del_V[i+1]:.2f}"
        )
```

```
Barium-133:
         V1 = 12.16, V2 = 13.97, del_V = 1.82
Cobalt-60:
         V1 = 40.93, V2 = 44.19, del_V = 3.26
         V3 = 47.21, V4 = 50.76, del_V = 3.55
```

4.2 Peak determination

[18]:
```
res_name = ["Barium-133", "Cobalt-60 lower peak", "Cobalt-60 upper peak"]

for i in range(3):
    peak_id_max = find_peaks(counts_interpolated[i], height=np.
↪max(counts_interpolated[i]) - 5000)
    heights = peak_id_max[1]["peak_heights"]
    pos = channel_interpolated[i][peak_id_max[0]]
    print(f"{element_name[i]}: \n\t channel = {pos} and peak = {heights}")


peak_counts = [110920, 28887, 25867]
peak_channel = [13, 42, 49]
known_energy = [0.356, 1.173, 1.332]
```

```
Barium-133:
         channel = [13.05] and peak = [110919.8321568]
```

```
Cobalt-60:
        channel = [42.314 48.832] and peak = [28886.73655762 25866.93528931]
Unknown Source:
        channel = [23.949] and peak = [43029.88507938]
```

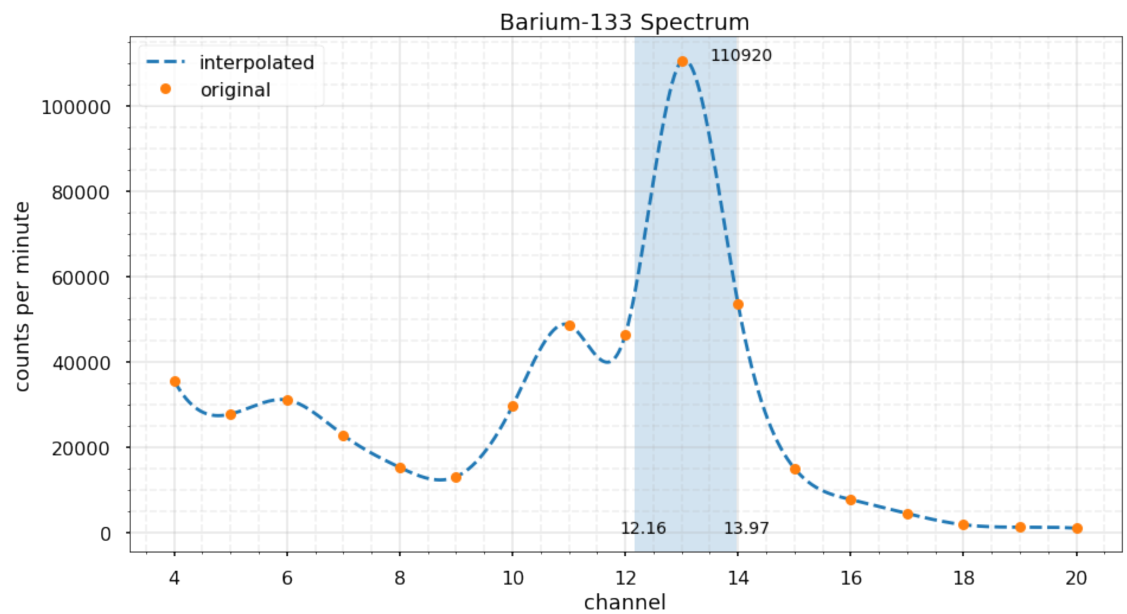
5 Spectrums

5.1 Barium-133

[19]:
```python
plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))

plt.axvspan(vi[0], vi[1], alpha=0.2)
for i in range(2):
    plt.annotate(f"{vi[i]:.2f}", xy=(vi[i]-0.25, 0), fontsize=14)
plt.annotate(f"{peak_counts[0]}", xy=(peak_channel[0] + 0.5, peak_counts[0]),
 ↪fontsize=14)

# plt.title(f"{element_name[0]} Spectrum")
plt.xlabel("channel")
plt.ylabel("counts per minute")
plt.plot(channel_interpolated_ba, counts_interpolated_ba, "--",
 ↪label="interpolated")
plt.plot(ba_channel, ba_counts, "o", markersize=9, label="original")
plt.legend(loc="upper left")
plt.grid(alpha=0.3, which="major")
plt.minorticks_on()
plt.grid(alpha=0.2, which="minor", ls="--")
```



5.2 Cobalt-60

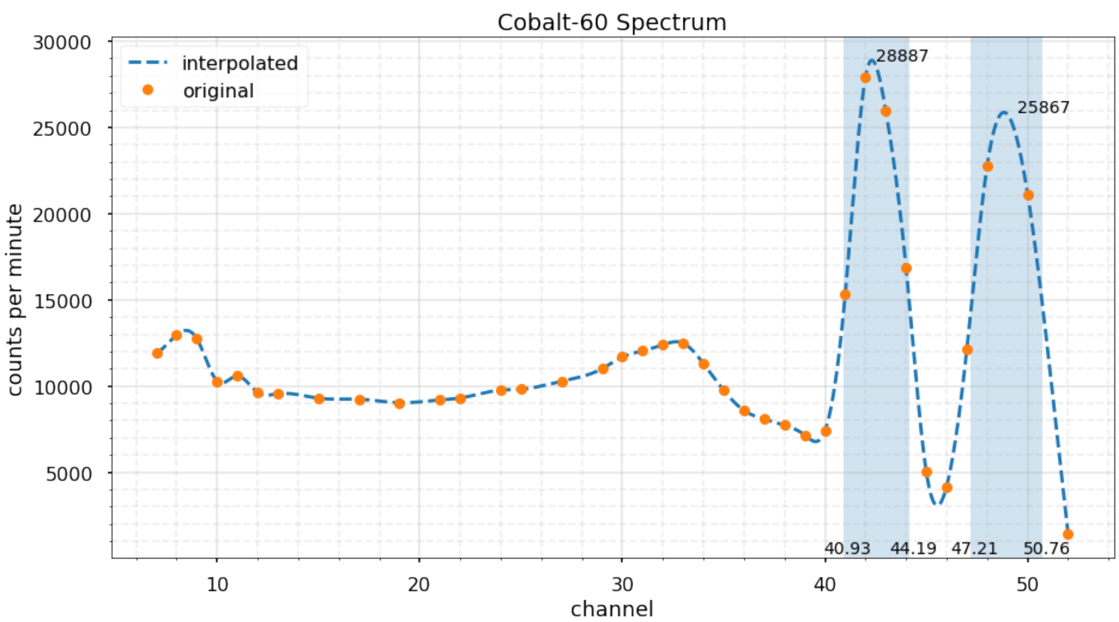
[20]:
```
plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))

plt.axvspan(vi[2], vi[3], alpha=0.2)
plt.axvspan(vi[4], vi[5], alpha=0.2)

for i in range(2, 6):
    plt.annotate(f"{vi[i]:.2f}", xy=(vi[i]-1, 300), fontsize=14)
for i in range(1,3):
    plt.annotate(f"{peak_counts[i]}", xy=(peak_channel[i] + 0.5,␣
 ↪peak_counts[i]), fontsize=14)

# plt.title(f"{element_name[1]} Spectrum")
plt.xlabel("channel")
plt.ylabel("counts per minute")
plt.plot(channel_interpolated_co, counts_interpolated_co, "--",␣
 ↪label="interpolated")
plt.plot(co_channel, co_counts, "o", markersize=9, label="original")
plt.legend(loc="upper left")
plt.grid(alpha=0.3, which="major")
plt.minorticks_on()
plt.grid(alpha=0.2, which="minor", ls="--")

plt.show()
```

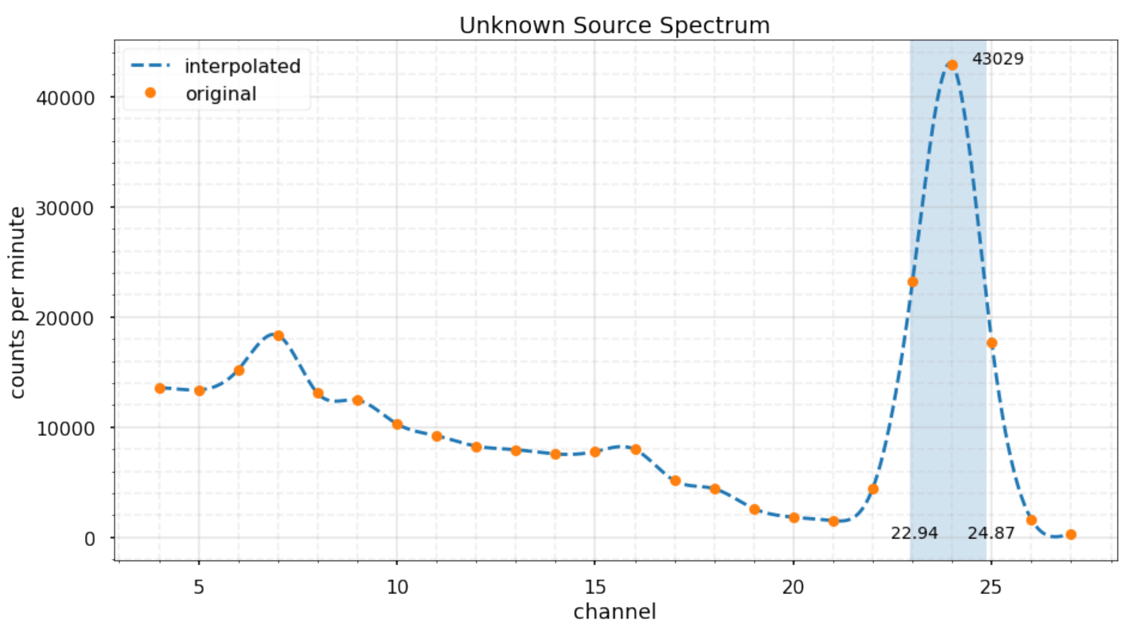


5.3 Cesium-144

[21]:
```
plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))

plt.axvspan(vi[6], vi[7], alpha=0.2)
for i in range(6, 8):
    plt.annotate(f"{vi[i]:.2f}", xy=(vi[i]-0.5, 0), fontsize=14)
plt.annotate(f"43029", xy=(24 + 0.5, 43029), fontsize=14)

# plt.title(f"{element_name[2]} Spectrum")
plt.xlabel("channel")
plt.ylabel("counts per minute")
plt.plot(channel_interpolated_uk, counts_interpolated_uk, "--",␣
 ↪label="interpolated")
plt.plot(uk_channel, uk_counts, "o", markersize=9, label="original")
plt.legend(loc="upper left")
plt.grid(alpha=0.3, which="major")
plt.minorticks_on()
plt.grid(alpha=0.2, which="minor", ls="--")
```



5.4 Unknown samples energy

The energy of the unknown sample is calculated from the calibaration curve

[22]:
```python
unknown_energy = np.interp(24, peak_channel, known_energy)
print(f"Energy of Unknown Sample from the calibaration curve = {unknown_energy:.
 ↪3f} MeV")

peak_channel.append(24)
known_energy.append(unknown_energy)
res_name.append("Unknown Source")
```

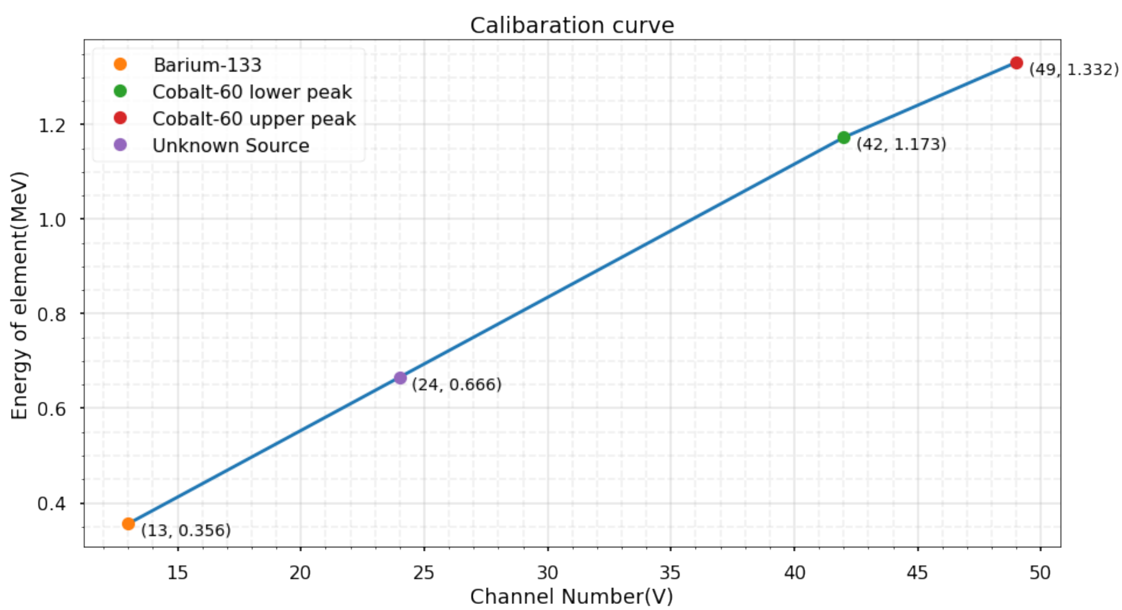
```
Energy of Unknown Sample from the calibaration curve = 0.666 MeV
```

6 Finding the Energy

6.1 Calibaration Curve

[23]:
```python
plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))
# plt.title(f"Calibaration curve")
plt.xlabel("Channel Number(V)")
plt.ylabel("Energy of element(MeV)")

plt.plot(np.sort(peak_channel), np.sort(known_energy))
for i in range(len(res_name)):
    plt.plot(peak_channel[i], known_energy[i], "o", label=res_name[i])
    plt.annotate(f"({peak_channel[i]}, {known_energy[i]:.3f})",␣
 ↪xy=(peak_channel[i]+0.5,known_energy[i]-0.025), fontsize=14)
plt.legend(loc="upper left")
plt.grid(alpha=0.3, which="major")
plt.minorticks_on()
plt.grid(alpha=0.2, which="minor", ls="--")
plt.show()
```



7 Resolution Curve

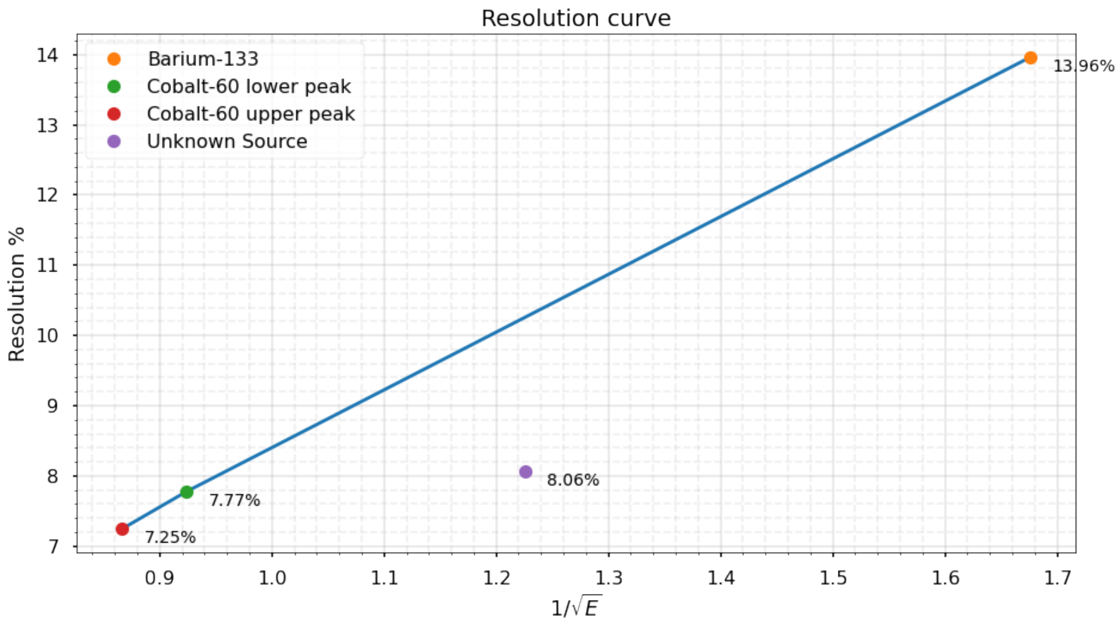
[24]:
```
# resolution
V = peak_channel
resolution = []

for i in range(len(res_name)):
    res = (del_V[i] / V[i]) * 100
    resolution.append(res)
    print(
        f"{res_name[i]}: \n\t resolution = {resolution[i]:.2f}%, del_V =␣
 ↪{del_V[i]:.2f}, V = {V[i]}"
    )
sqrt_energy = 1 / np.sqrt(known_energy)

plt.style.use("seaborn-poster")
plt.figure(figsize=(15, 8))
# plt.title(f"Resolution curve")
plt.xlabel(r"$1/\sqrt{E}$")
plt.ylabel("Resolution %")
plt.plot(np.sort(sqrt_energy[:3]), np.sort(resolution[:3]))
for i in range(len(res_name)):
    plt.plot(sqrt_energy[i], resolution[i], "o", label=res_name[i])
    plt.annotate(f"{resolution[i]:.2f}%", xy=(sqrt_energy[i]+0.
 ↪02,resolution[i]-0.2), fontsize=14)

plt.legend(loc="upper left")
plt.grid(alpha=0.3, which="major")
plt.minorticks_on()
plt.grid(alpha=0.2, which="minor", ls="--")
plt.show()
```

```
Barium-133:
         resolution = 13.96%, del_V = 1.82, V = 13
Cobalt-60 lower peak:
         resolution = 7.77%, del_V = 3.26, V = 42
Cobalt-60 upper peak:
         resolution = 7.25%, del_V = 3.55, V = 49
Unknown Source:
         resolution = 8.06%, del_V = 1.93, V = 24
```



The plot shows that it is following the resolution vs. square root of energy realtion. Only the unknown sample is outside the curve, which is probably because of some instrumental error