# Calculation of yield in OMC on $^{24}Mg$

**Yu.Shitov**

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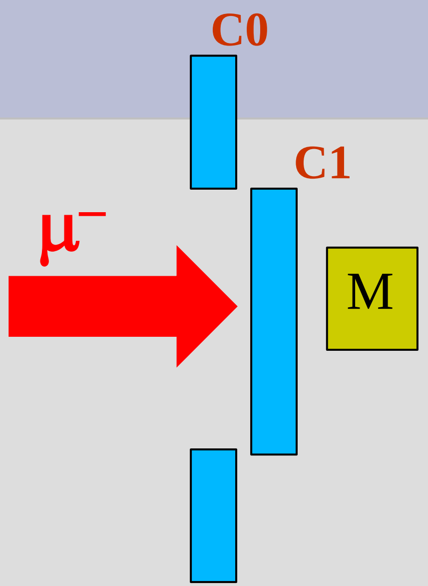
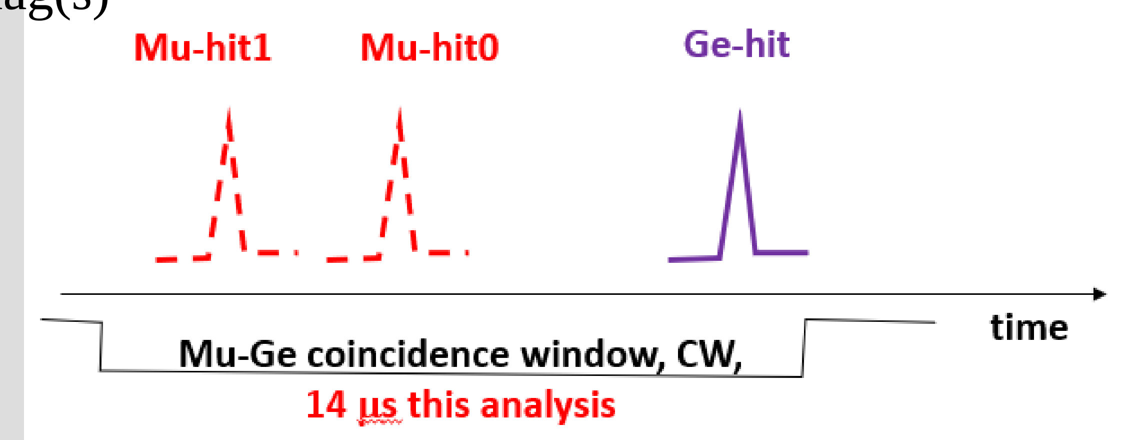
# Data processing and hit types

- **μ-stops are analyzing separately in C0 and C1 counters inside CW=14 μs coincidence window. For each ge-hit we determine its type:**




// mu-ge hits coincidences determined with
// C1 entrance counter while C0 (ring) counter is using as veto
// Hit types:
// 1 - **good**: events with single muon in C1 in CW
// 2 - **multiple**: multiple muons in C1 in CW
// 3 - **flagged**: single mu in C1, but non-zero flag(s)
// either in ge- or/and muon hit
// 4 - **uncorrelated**: no muons in C1 in CW
// 5 - **uncorrelated0**: like 4, but was muon in C0
// 6 - **good0**: like 1, but was muon in C0

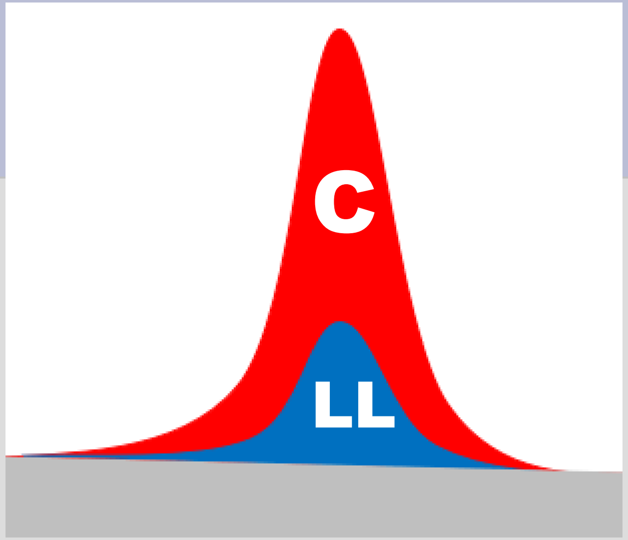



**For yield analysis we group 1-3+6-hit as correlated (C), and 4+5 as uncorrelated (LL).**

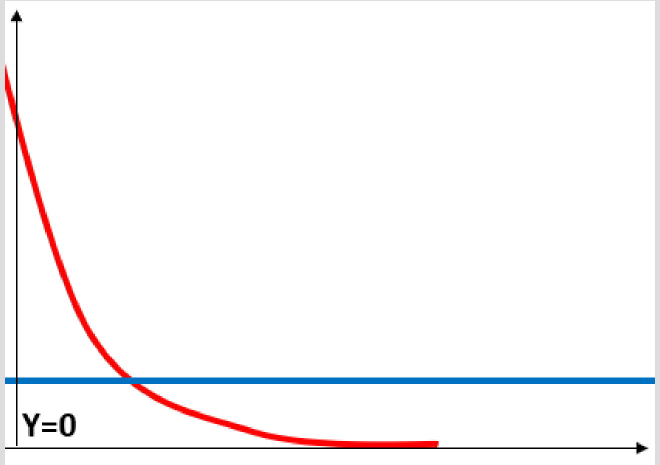
# γ-peak: contributions

- In γ-peak we have 3 contributions:
  1. γ-rays from isotope produced in OMC (C)
  2. γ-rays from the same long-lived (LL) (w.r.t. CW=14 μs) isotope (0 if not exist)
  3. From pedestal, but don't care if count peak intensities.
- Our task is to determine both C and LL production w.r.t. to OMC rate

Energy spectra

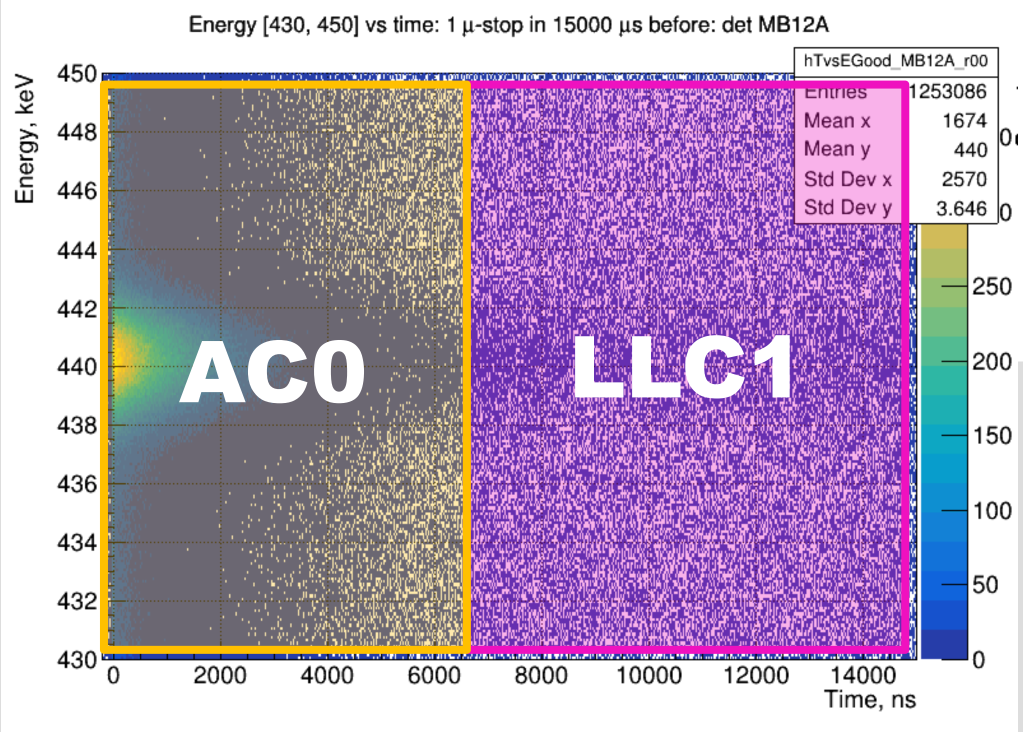


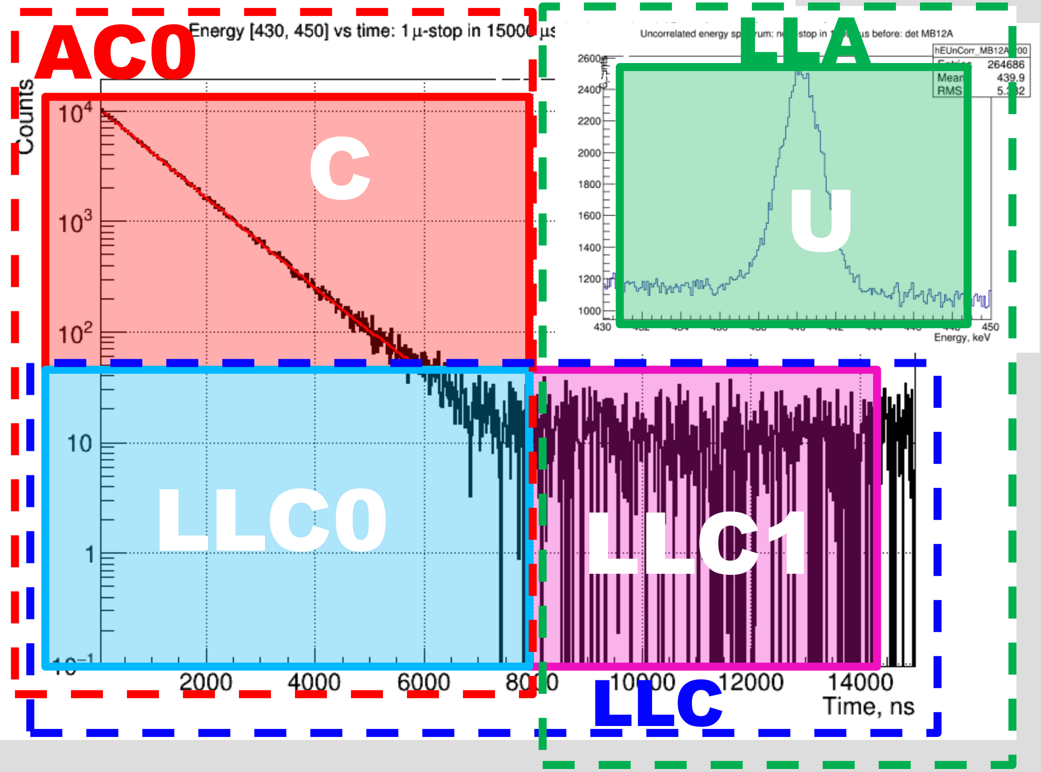

Time spectra



# Fractions of spectra (applied for 440 keV for example)

- LLC1 – Long-lived part of spectra in uncorrelated part of correlated spectra
- LLC0 – long-lived part of spectra in OMC-correlated part of spectra
- C – OMC-correlated (directly produced in OMC) events
- U – long-lived part in uncorrelated spectra.



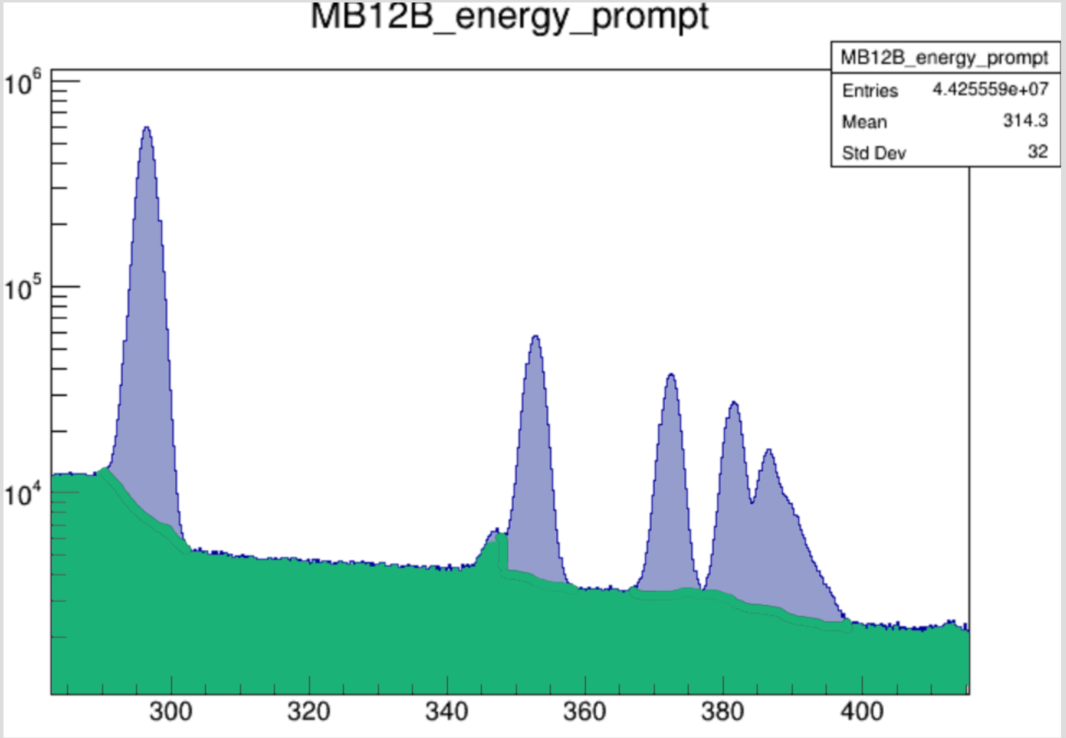



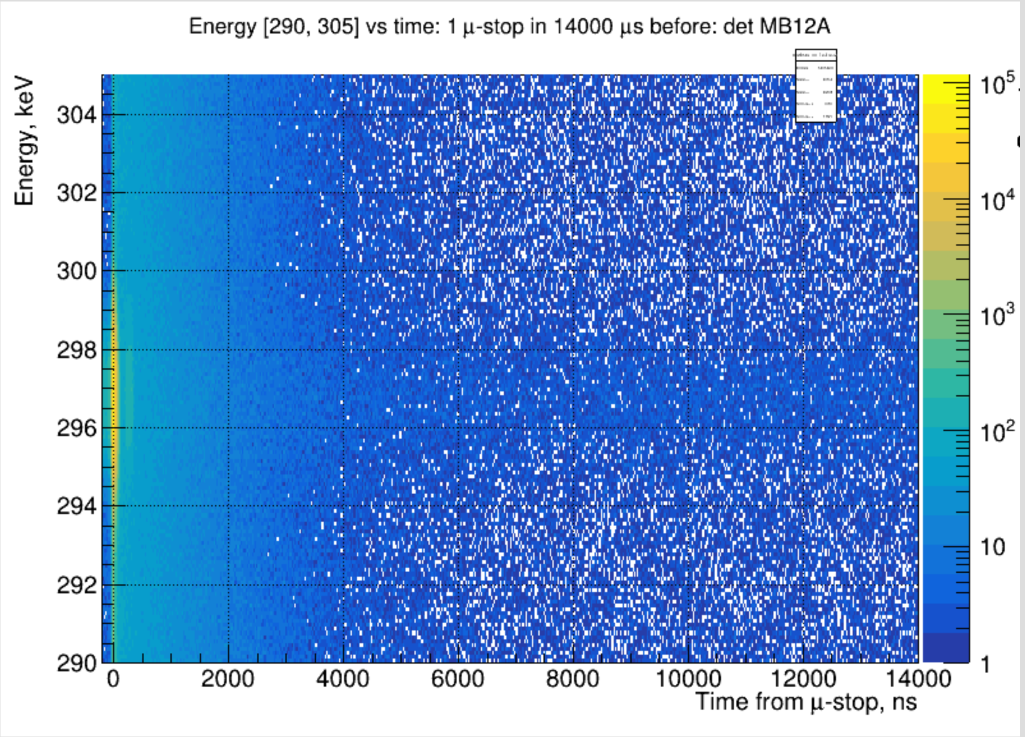
# How to calculate C and LLA?

1. Taking 2D histos for all correlated event ( Good+Mult + Good0),
2. Making hAC0 1D histo as TH2::ProectionY(), for correlated part of spectra [0, Tmin=8] mks fit counting area (no fit) and AC0 = C + LLC0.
3. Making hLLC1 1D histo as TH2::ProjectionY() for OMC-free tail in [Tmin=8, Tmax=14] mks
4. Make aggregated histo hLLC1U = hU (histo of all uncorrelated events U + U0) + hLLC1, fit it with gauss + pol1 model and take gaus area as LLC1U = LLC1 + LLU. Fix position&sigma of gauss for all next fits as it is natural peak w/o Doppler broadening with maximal intensity.
5. Fit hLLC1 with gauss + pol1 model (fixed position & sigma from 4.) and take gauss area as LLC1.
6. Assuming flat LL distribution in correlated spectra one can calculate LLC0 = LLC1 * Tmin / (Tmax - Tmin)=LLC1*4/3.
7. Now one can count total intensity of OMC-correlated events as C = AC0 – LLC0
8. Finally calculate total number of LL events as LLA = LLC1U + LLC0.

# Defining number of mu-stops

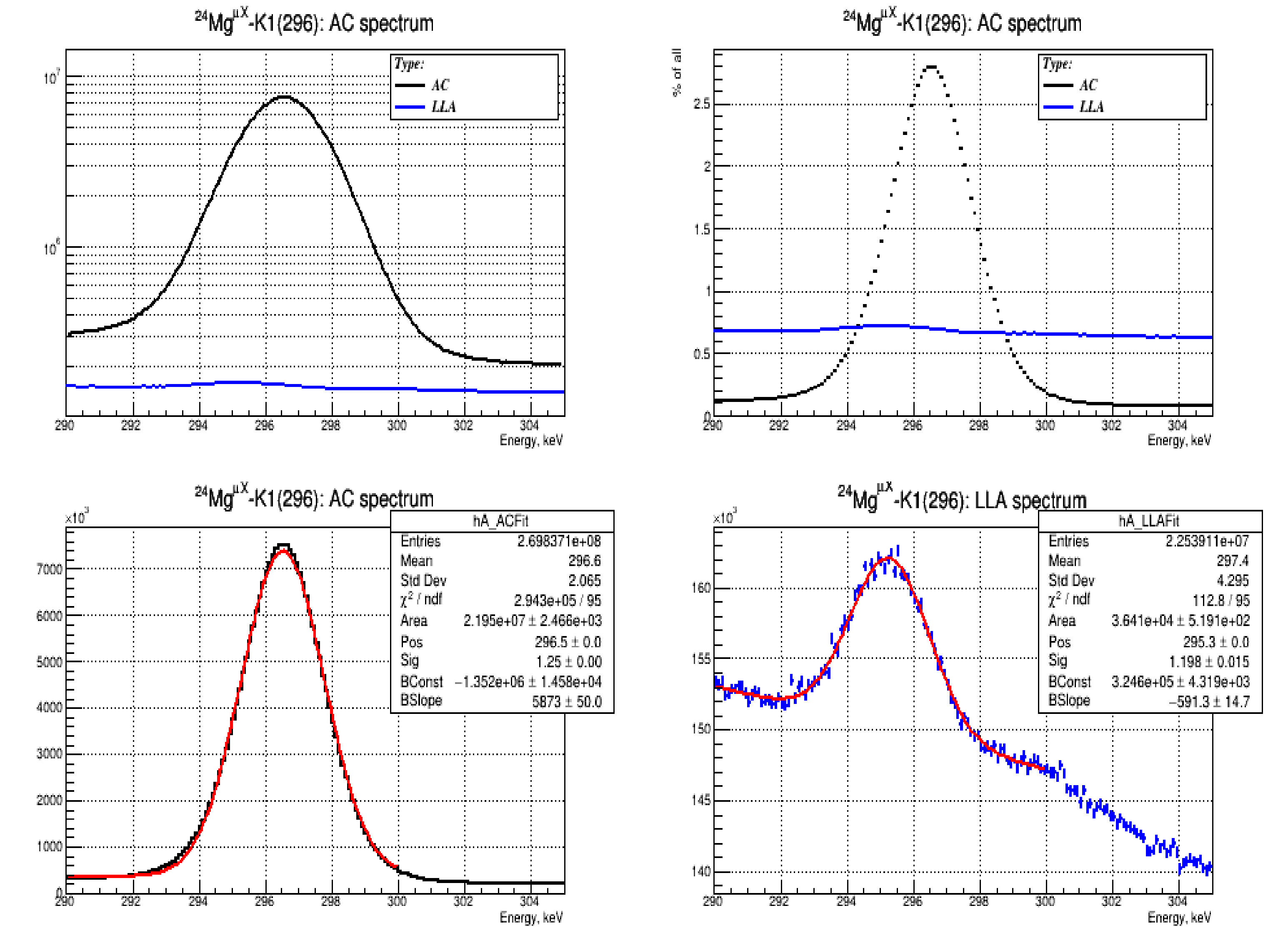
- **Determined using full set of Mg-24 μX-ray K-series lines. Peak intensities has been counted as all counts (light blue) above linear background (shown by green color).**



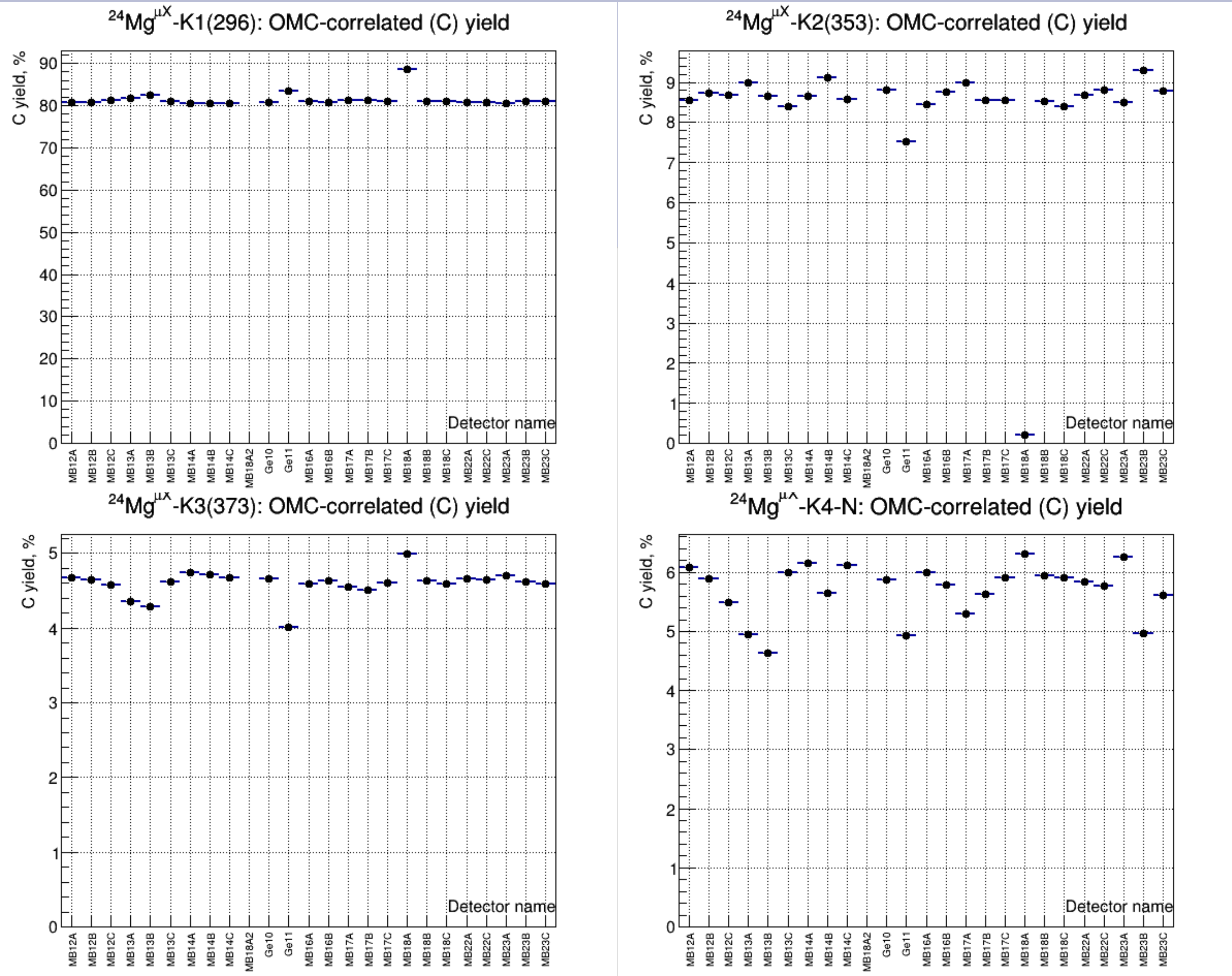
# Check random coincidences on μX K-α

- **It is obvious that events correlated with OMS can randomly fall into the uncorrelated part of the spectrum for various reasons.**
- **The proportion of such events can be estimated by repeating the described analysis for the μX-ray K-α line, calculating the number of correlated AC and all long-lived LLA.**
- **The analysis shows that the proportion of random LLA/AC = 0.17%, while for some reason there is a shift in the peak position by 1.23 keV for correlated and random LLA. The reason for the shift is not clear.**



# Test on μX K-series

- **Determined ratios of lines from K-series of μX.**
- **No correction on efficiencies has been applied here**



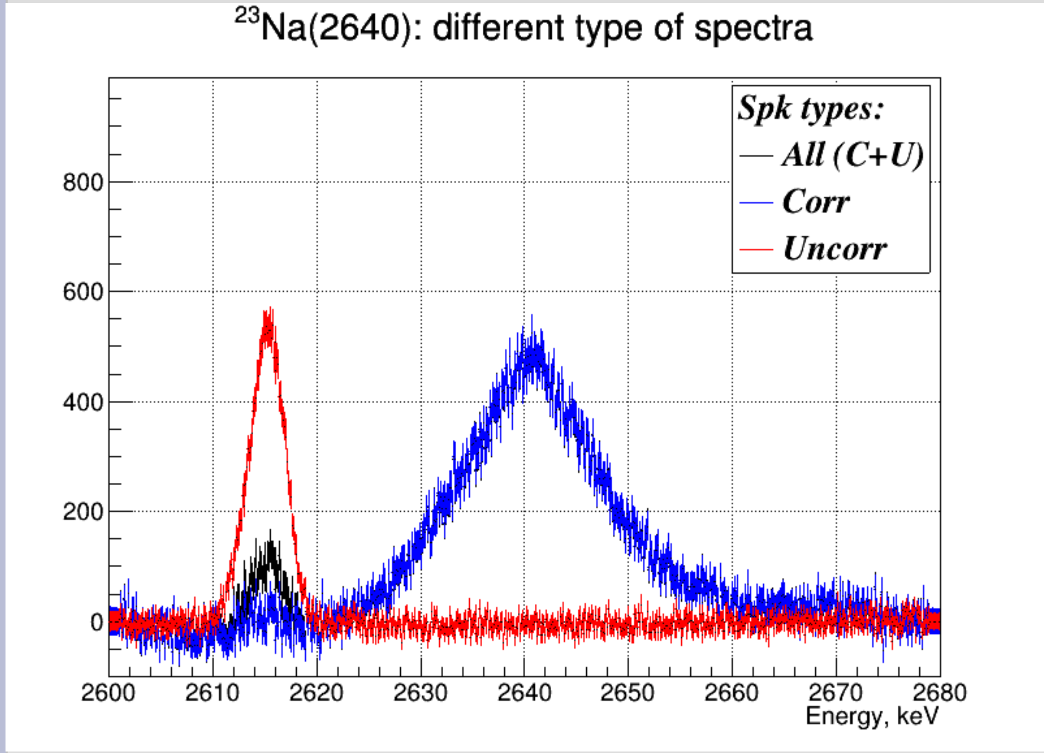
# Results for different lines

- **NOTE! Next  some results were NOT corrected on detector efficiency factor eff(∑μX(K))/eff(Eγ).**
- **Just show some interesting lines to demonstrate different features**

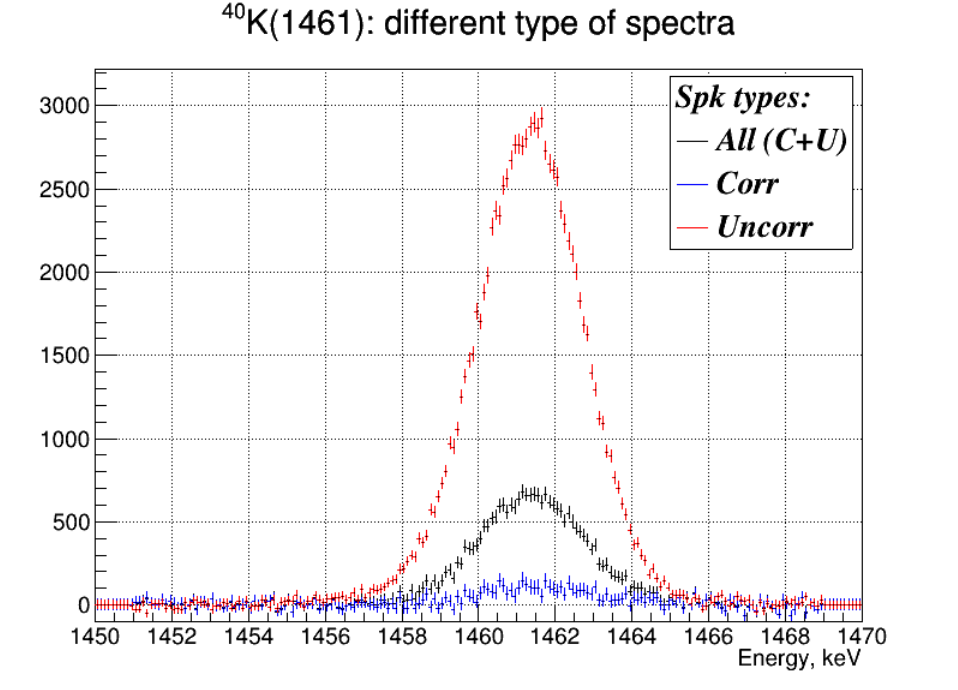
# Example of lines

- **Left picture - center - clean correlated line with clean doppler broadening – perfect triangle.**
- **Left wing - standard uncorrelated Tl-line**
- **Right picture - K-40 line**

$^{23}$Na(2640 keV) & $^{208}$Tl(2615 keV)

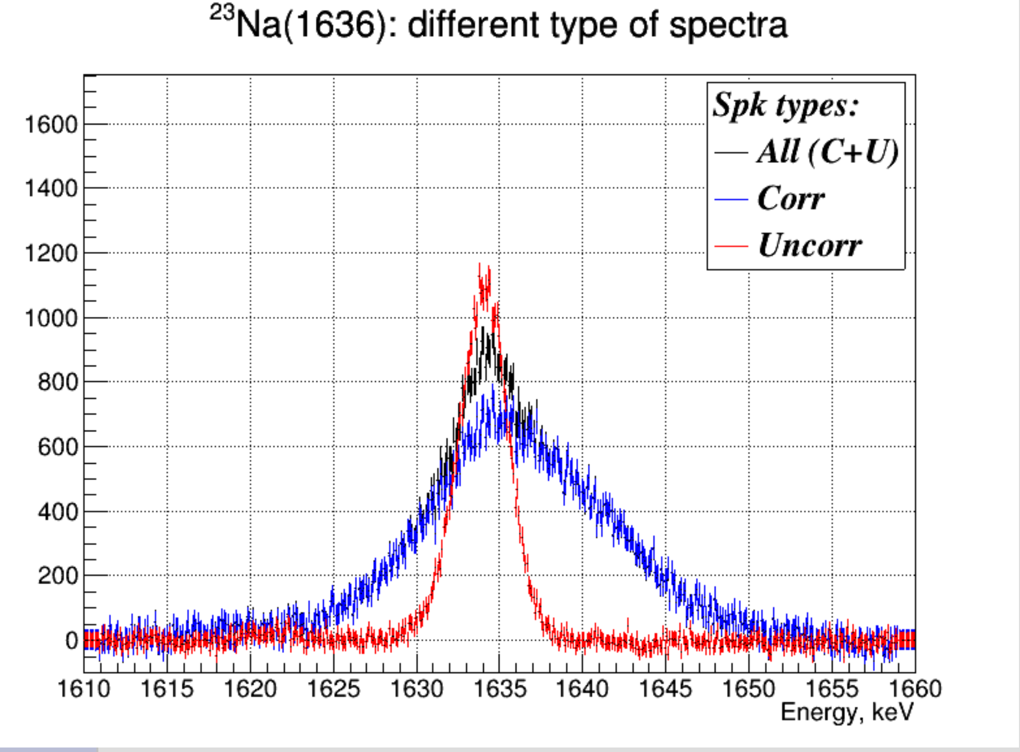


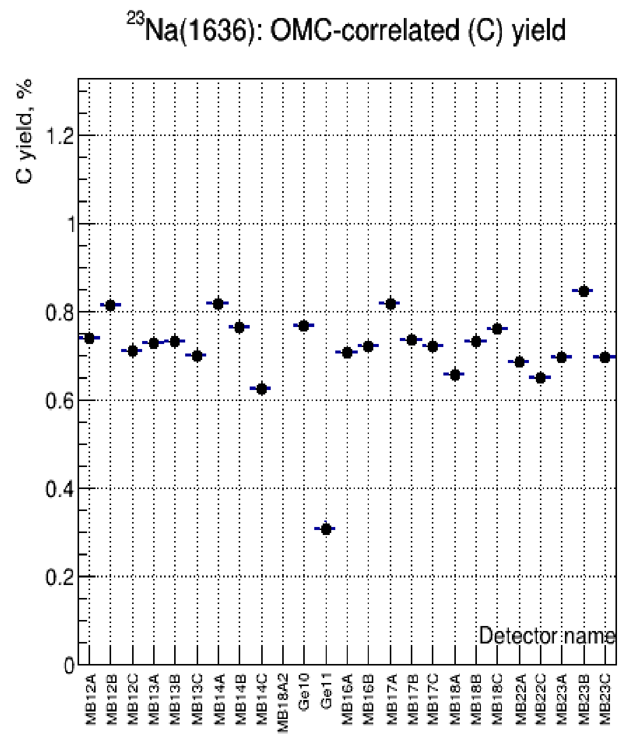

$^{40}$K (1491 keV)

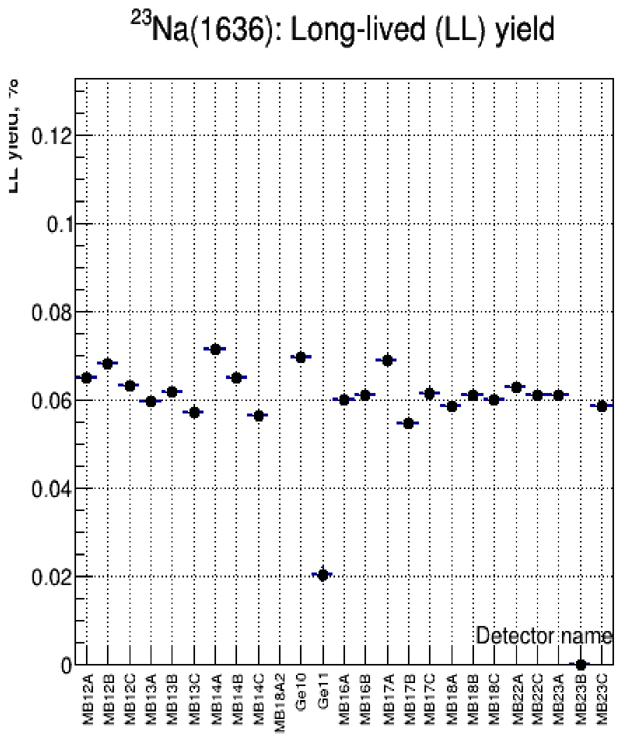


# $^{23}$Na(1636 keV)

- **Beautiful example of mixture doppler boarded and asymmetric correlated & uncorrelated lines.**

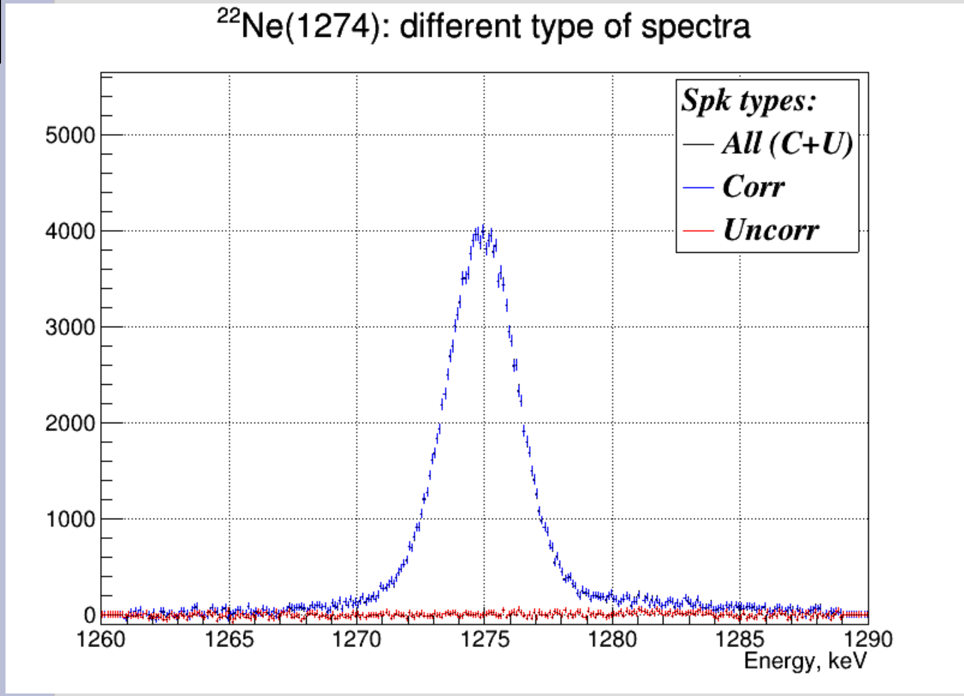


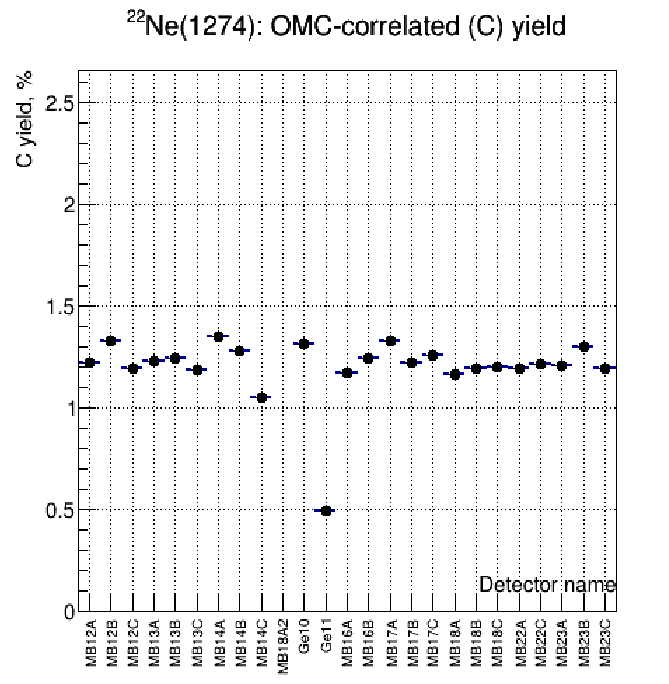



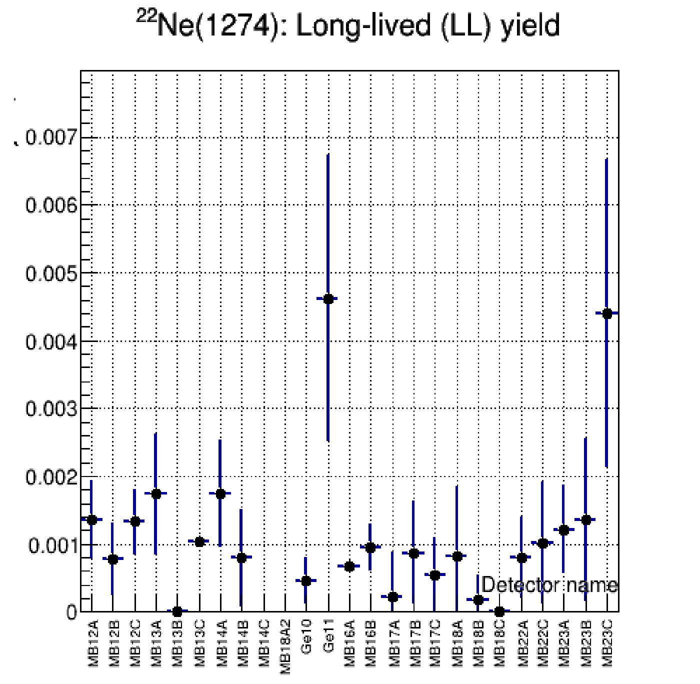



# $^{20}$Ne(1274 keV)

- **Clean correlated line without visible doppler broadening**

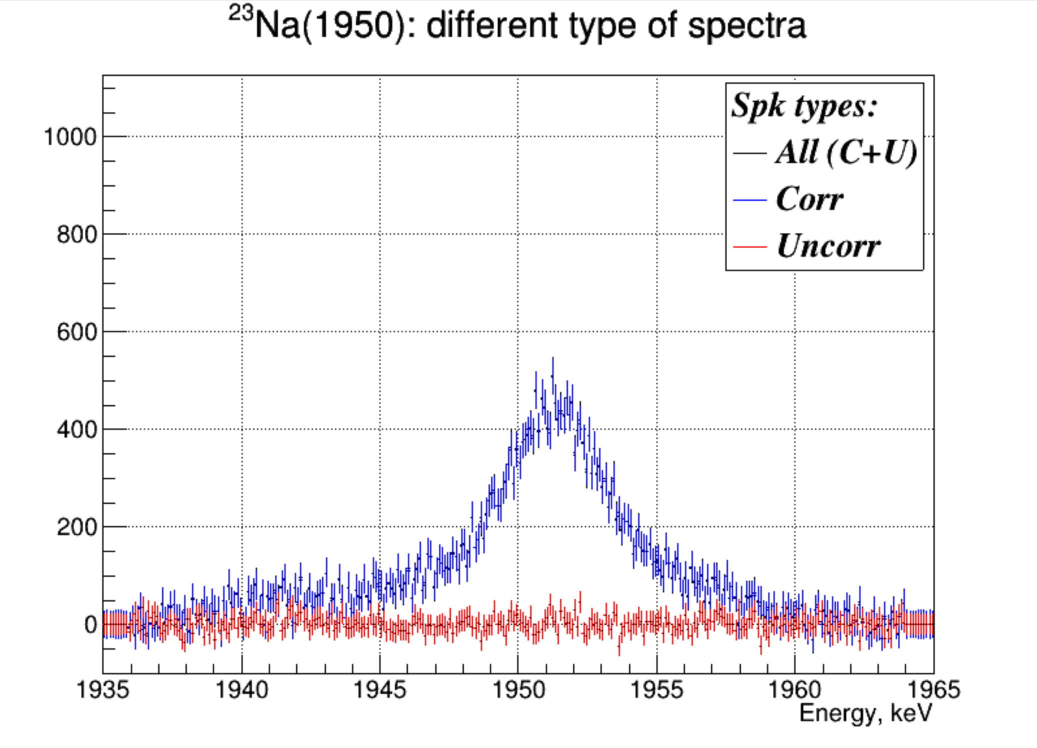


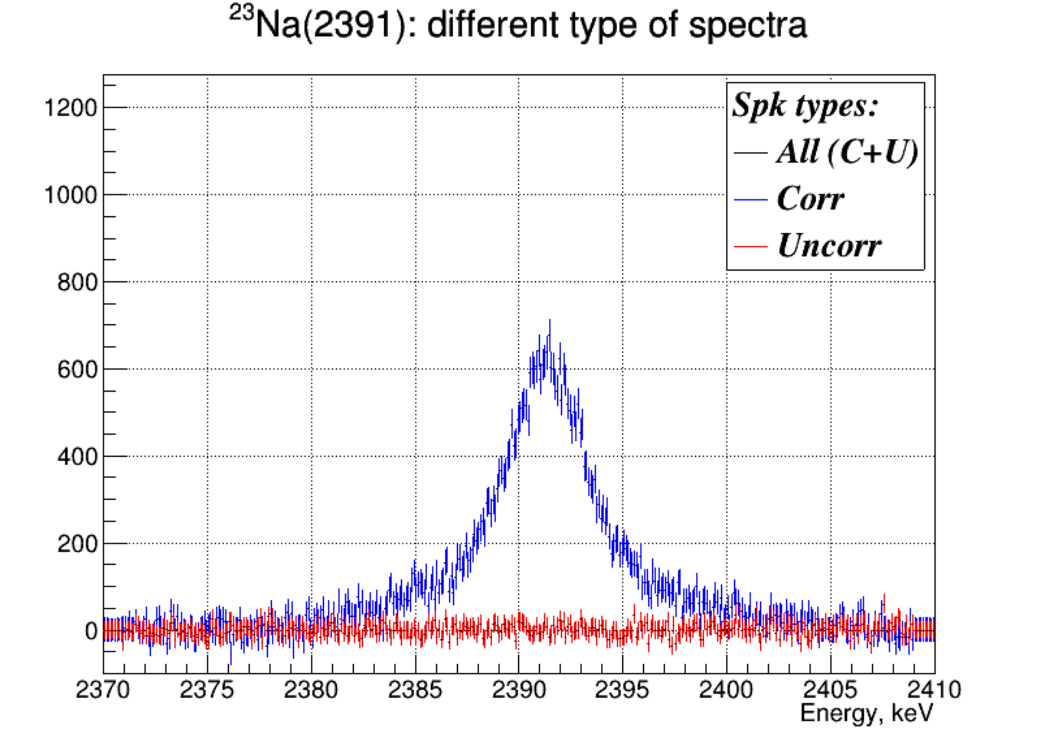



# $^{23}$Na(1950 & 2391 keV)

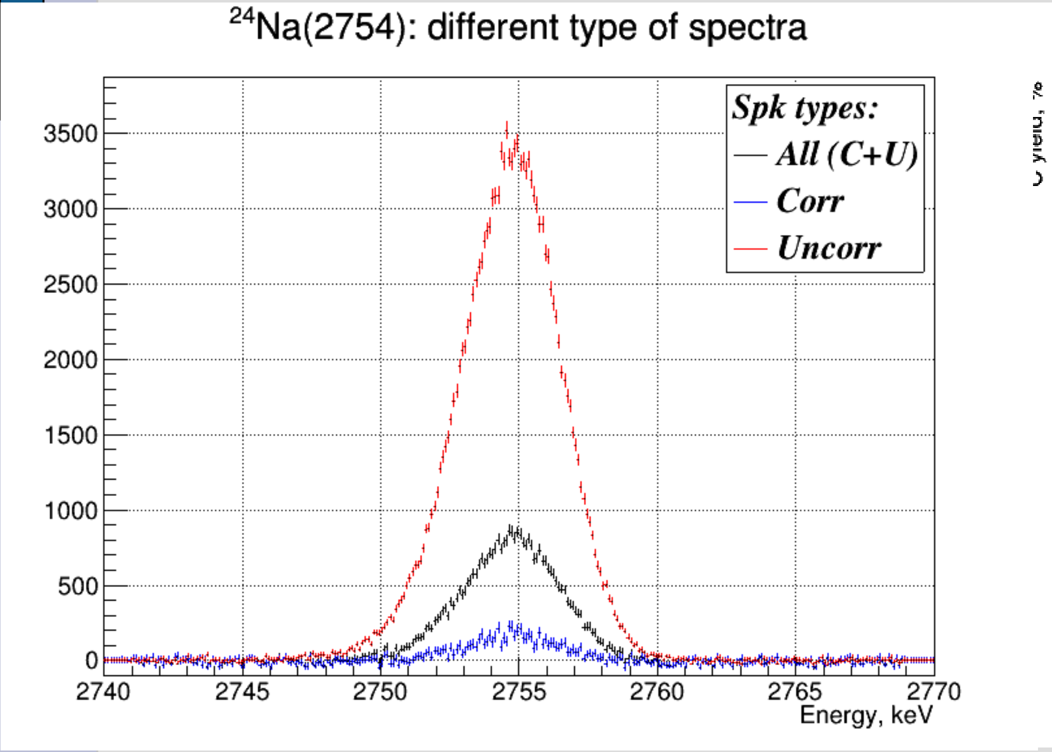
- **Clean correlated lines with visible doppler broadening – right left tails**

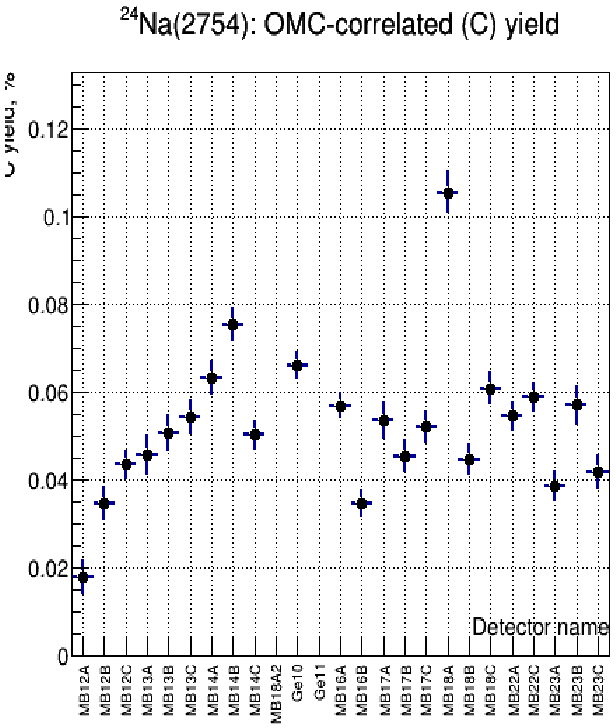


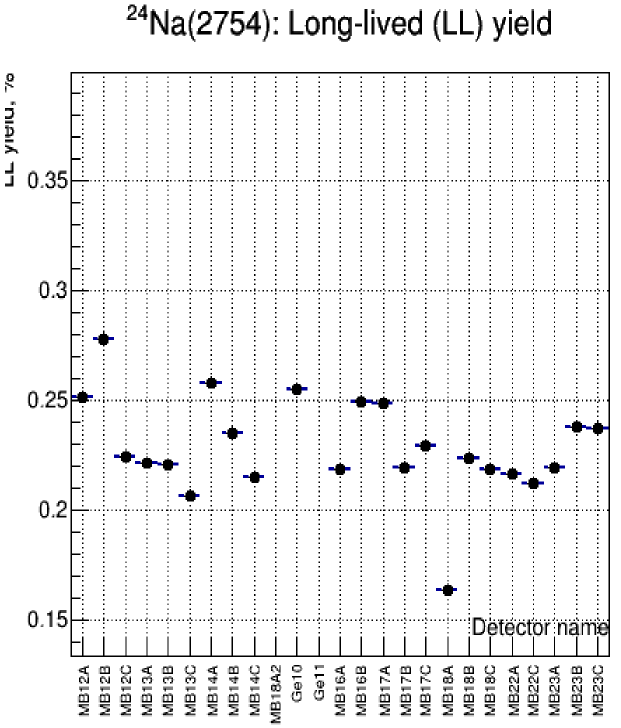



# $^{24}$Na(2754 keV)

- **Mixture of correlated (no visible doppler broadening) & uncorrelated lines.**

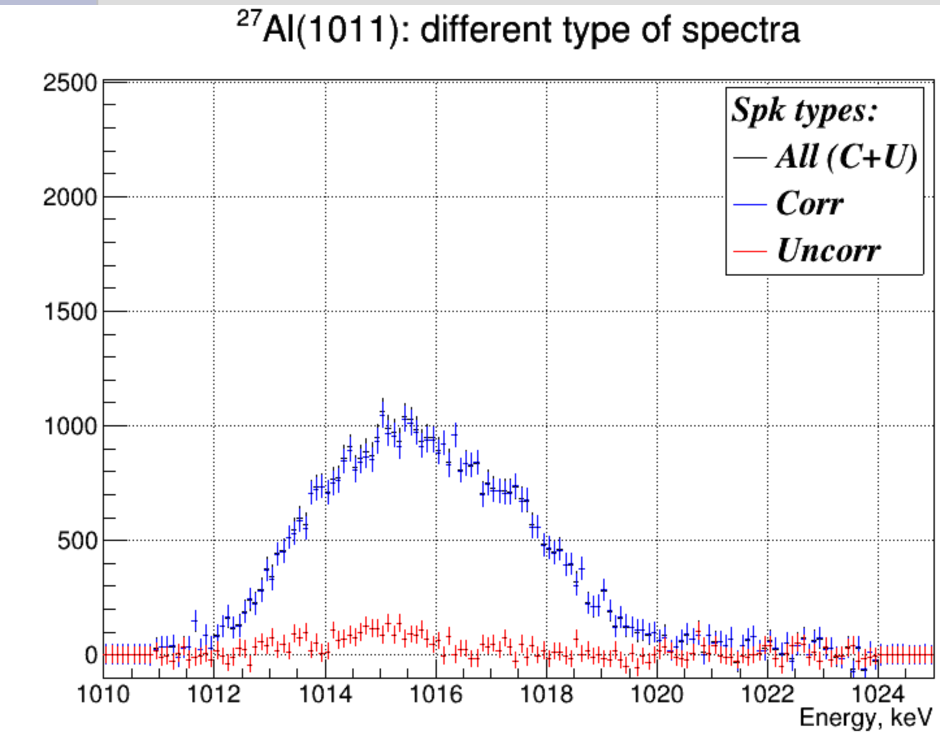


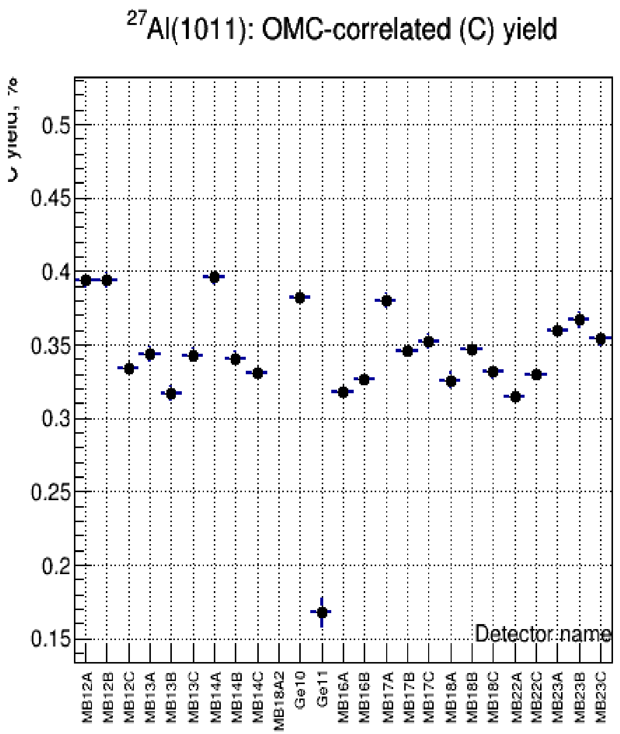



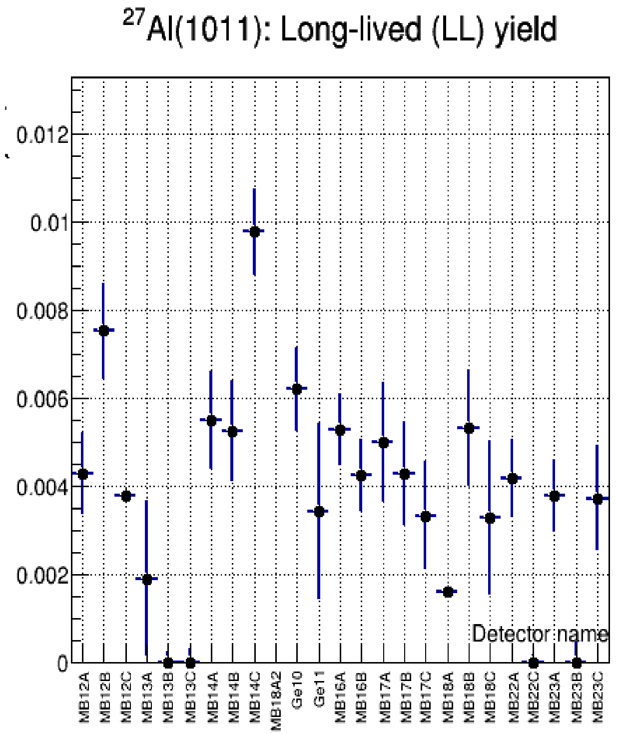



# $^{27}$Al(1015 keV)

- **Pure correlated, but strong doppler broadening. Could be mixture of OMC from Mg-24 and Al-27 – to be checked with the fit of time evolution…**

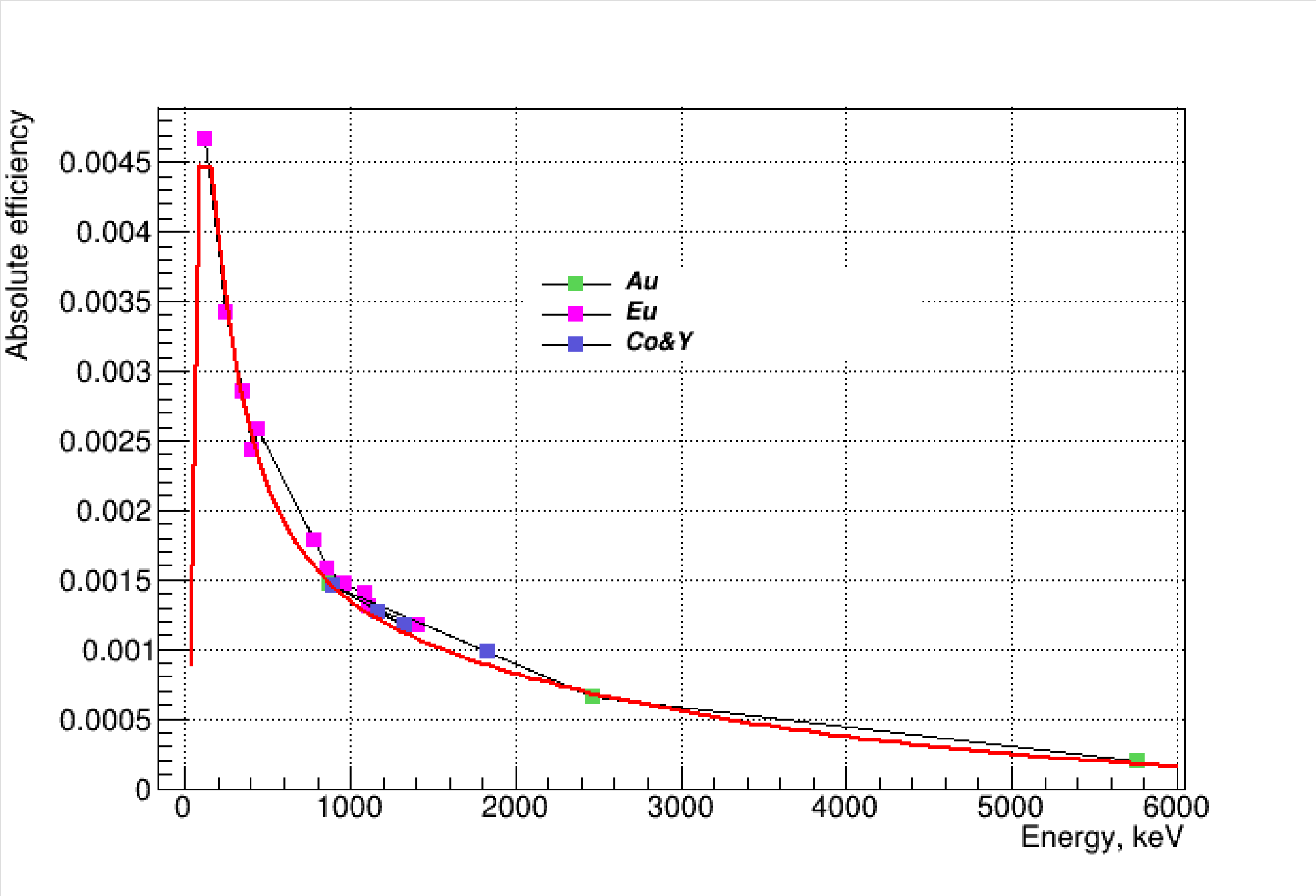


# Efficiencies are taken into account…

**We are adding efficiencies calculated by Nadya** **Efficiency factor eff(∑μX(K))/eff(Eγ).**



# And branching ratios

| ID in code (gr==2) | E_g | Nature | Branching | |
|---|---|---|---|---|
| 0 | 350.7 | 21Na / 22.49 s | 0.0507 | |
| 1 | 439.9 | 23Ne / 37.24 s | 0.33 | |
| 2 | 472.2 | 24mNa/ 20.18ms | 0.9995 | |
| | 996.6 | ?? | | не видно в спектре |
| 3 | 1014.52 | 27Mg / 9.458 m | 0.282 | |
| | 843.52 | 27Mg / 9.458 m | 0.718 | слияние с другой линией |
| 4 | 1274.5 | 22Na / 2.6018 y | 0.9994 | |
| 5 | 1368.6 | 24Na /14.997h | 0.999936 | |
| 6 | 1635.6 | 23Ne / 37.24 s | 0.01 | |
| 7 | 2075.9 | 23Ne / 37.24 s | 0.00101 | |
| 8 | 2754.007 | 24Na /14.997h | 0.99855 | |
| | 1395.1 | 21F / 4.158 s | 0.153 | не видно в спектре |
| | 1633.6 | 20F / 11.163 s | 0.991 | слияние с 23Ne |
| | 197.1 | ?? | | |
| | 1356.8 | ?? | | |
| | 659.2 | ??? | | |
| | 1041.5 | ?? | | |
| | 1700.7 | 27Mg / OMC | | |
| | 1809 | 27Al(n,n') | | |

**Normalization on branching ratios was added for long-lived lines**

# Preliminary results of the RI yields produced in OMC in $^{24}$Mg (W=-0,2-6-12 us) (MB23A)

| Uncorr-d_th | Energy_all | Uncor_d | Isotope/Life-time | %_BR_theor | eff-cy_exp | Int_ener_all | Int-ty_Uncorr-d | Int-ty_Uncor/BR_theor | Ycap_Uncord | Pcap_Uncord=Ycap*Lkoef | Int-ty_Eall/BR_theor | Ycap_Eall | Pcap_Eall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 472,2 | 50812,4 | 29805,1 | 24mNa/20,18ms | 0,9995 | 0,002232 | 70641,074 | 41436,03284 | 41411,15878 | 0,080362925 | 0,14051779 | 70598,66817 | 0,08090816 | 0,14147115 |
| 350,7 | 70092,1 | 2000,6 | 21Na/22,49 s | 0,0507 | 0,0027615 | 78760,0168 | 2248,003549 | 44290,54724 | 0,085950697 | 0,150288231 | 1551743,21 | 1,77834353 | 3,10950479 |
| 439,9 | 111287 | 1489,45 | 23Ne/37,24 s | 0,33 | 0,0023485 | 147040,052 | 1967,963956 | 5956,967259 | 0,011560153 | 0,020213389 | 445085,7802 | 0,51008144 | 0,89189781 |
| 1274,5 | | | 22Na/2,6018 y | 0,9994 | 0,0011567 | | | | | | | | |
| 1368,6 | 23940 | 13359 | 24Na/14,997h | 0,999936 | 0,00110622 | 67152,8448 | 37472,63383 | 37433,8097 | 0,07264444 | 0,12702171 | 67083,27002 | 0,07687941 | 0,13442672 |
| 2754,007 | 13460 | 7895 | 24Na/14,997h | 0,99855 | 0,000656 | 63668,2622 | 37344,79421 | 37357,88387 | 0,072497098 | 0,126764076 | 63690,57845 | 0,07299128 | 0,12762818 |
| 1635,6 | | | 23Ne/37,24 s | 0,01 | 0,0009865 | | | | | | | | |
| 2075,9 | | | 23Ne/37,24 s | 0,00101 | 0,0008345 | | | | | | | | |
| 1633,6 | 6840,71 | 1997,76 | 20F/11,6 s | 0,991 | 0,0009873 | 21499,7702 | 6278,789912 | 6328,842828 | 0,012281818 | 0,02147525 | 21671,16091 | 0,02483579 | 0,04342637 |

$\tau$ = 945 ns

$\Lambda_{cap}$ = 0,605 x $10^6$

$\Lambda_{tot}$ = 1,058 x $10^6$

$\Lambda_{koef}$ = 1,74864

**Yield of $^{24}$Na in OMC with $^{24}$Mg is: 12,7 %**

**Yield of $^{24m}$Na in OMC with $^{24}$Mg is: 14,05 %**

**Yield of $^{23}$Ne in OMC with $^{24}$Mg is: 2,02 %**

**Yield of $^{20}$F in OMC with $^{24}$Mg is: 2,14 %**

**From Daniya**

# Preliminary results of the RI yields produced in OMC in $^{24}Mg$ (W=-0,2-6-12 us) (MB18B)

| Uncorr-d_th | Energy_all | Uncor_d | Isotope/Life-time | %_BR_theor | eff-cy_exp | Int_ener_all | Int-ty_Uncorr-d | Int-ty_Uncor/ BR_theor | Ycap_Uncord | Pcap_Uncord=Ycap*Lkoef | Int-ty_Eall/ BR_theor | Ycap_Eall | Pcap_Eall |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 472,2 | 47749,7 | 28049,1 | 24mNa/ 20,18ms | 0,9995 | 0,00225642 | 66332,4302 | 38964,95617 | 38941,5655 | 0,079149248 | 0,138395626 | 66292,61082 | 0,078657449 | 0,1375357 |
| 350,7 | 70092,1 | 2000,6 | 21Na / 22,49 s | 0,0507 | 0,0027918 | 78697,325 | 2246,214174 | 44255,29266 | 0,089949469 | 0,157280244 | 1550508,047 | 1,839707405 | 3,21680199 |
| 439,9 | 105965 | 1407,49 | 23Ne / 37,24 s | 0,33 | 0,0023745 | 139883,172 | 1858,011278 | 5624,143835 | 0,011431147 | 0,019987818 | 423422,1213 | 0,502398432 | 0,87846375 |
| 874,4 | | | | | | | | | | | | | |
| 996,6 | | | | | | | | | | | | | |
| 1274,5 | | | 22Na / 2,6018 y | 0,9994 | 0,00114093 | | | | | | | | |
| 1368,6 | 22912,6 | 13021,9 | 24Na /14,997h | 0,999936 | 0,001087 | 66072,3922 | 37550,87088 | 37511,96569 | 0,076243567 | 0,133314927 | 66003,93683 | 0,078314931 | 0,13693679 |
| 2754,007 | 12988,7 | 7641,54 | 24Na /14,997h | 0,99855 | 0,00060791 | 66973,2848 | 39401,86739 | 39415,67807 | 0,080112888 | 0,140080589 | 66996,75952 | 0,079492935 | 0,13899658 |
| 1635,6 | | | 23Ne / 37,24 s | 0,01 | 0,00095869 | | | | | | | | |
| 2075,9 | | | 23Ne / 37,24 s | 0,00101 | 0,0007959 | | | | | | | | |
| 1395,1 | | | | | | | | | | | | | |
| 1633,6 | 4369,9 | 1840,46 | | 0,991 | 0,00095954 | 14275,2465 | 6012,270351 | 6060,198642 | 0,012317434 | 0,021537526 | 14389,04515 | 0,017072877 | 0,02985261 |

$\tau$ = 945 ns

$\Lambda_{cap} = 0,605 \times 10^6$

$\Lambda_{tot} = 1,058 \times 10^6$

$\Lambda_{koef} = 1,74864$

**Yield of $^{24}Na$ in OMC with $^{24}Mg$ is: 13,3 %**

**Yield of $^{24m}Na$ in OMC with $^{24}Mg$ is: 13,8 %**

**Yield of $^{23}Ne$ in OMC with $^{24}Mg$ is: 1,99 %**

**Yield of $^{20}F$ in OMC with $^{24}Mg$ is: 2,15 %**

**From Daniya**

# Conclusion

- **Analysis of LL-isotopes is in progress**
- **Two approaches (me and Daniya) are developing.**
- **Comparison of results and joint analysis & result will be soon.**