Limitations of on-line gas chemistry technique to α-spectroscopy in ^{48}Ca induced SHE applications.

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Rn production in the reaction ^{48}Ca on ^{248}Cm

$$\sigma(Z,M) = \sigma_{max}(Z) \cdot e^{-\frac{(M-M_{max}(Z))^2}{w^2}}$$

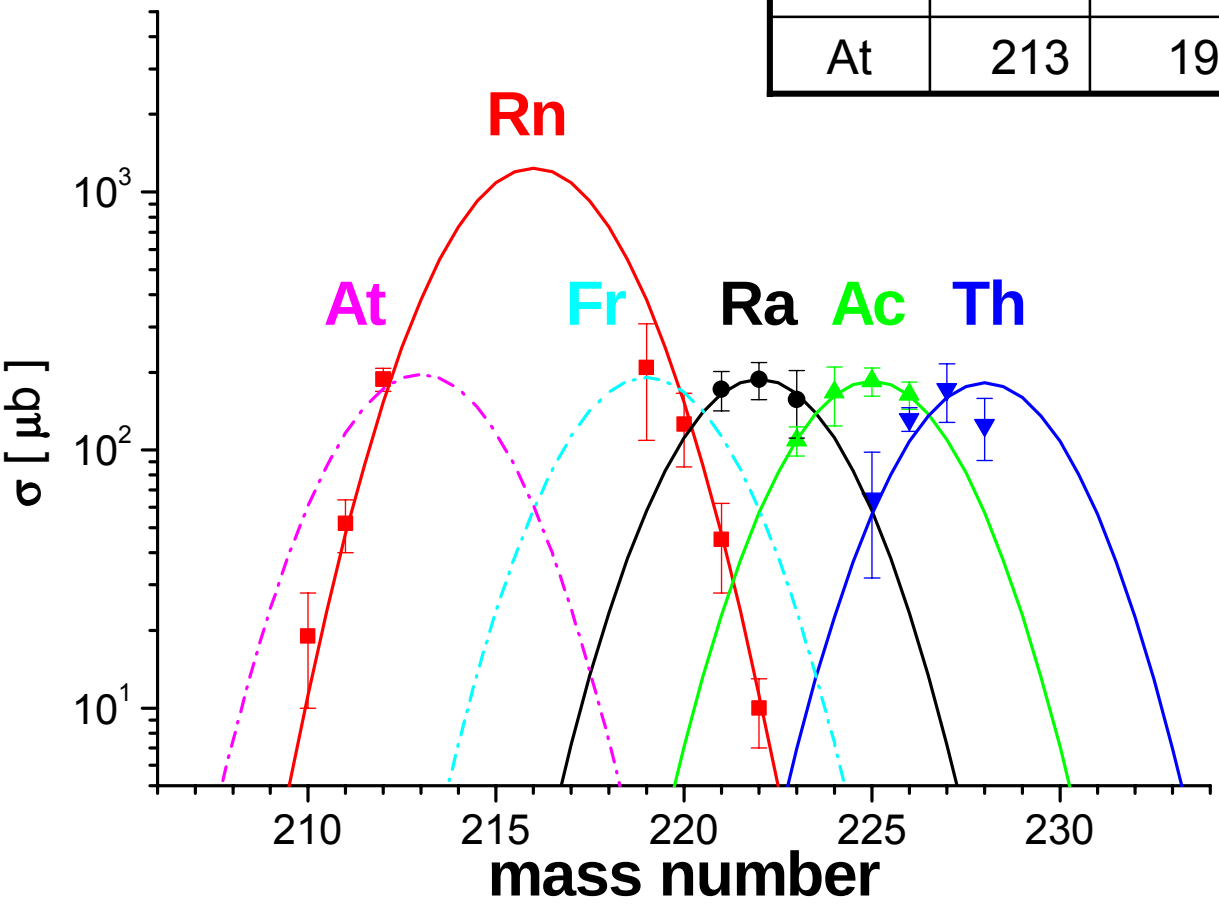
$$\sigma_{max}(Z) = (410 - M_{max}(Z))\mu b$$

$$\sigma_{max}(86) = 1237\,\mu b$$

$$M_{max}(Z) = 2 \cdot Z - 42$$

$$w = 4.2 \;\rightarrow\; FWHM = 5.3$$

	M_{max}	σ_{max} [µb]
Th	228	182
Ac	225	185
Ra	222	188
Fr	219	191
Rn	216	1237
At	213	197



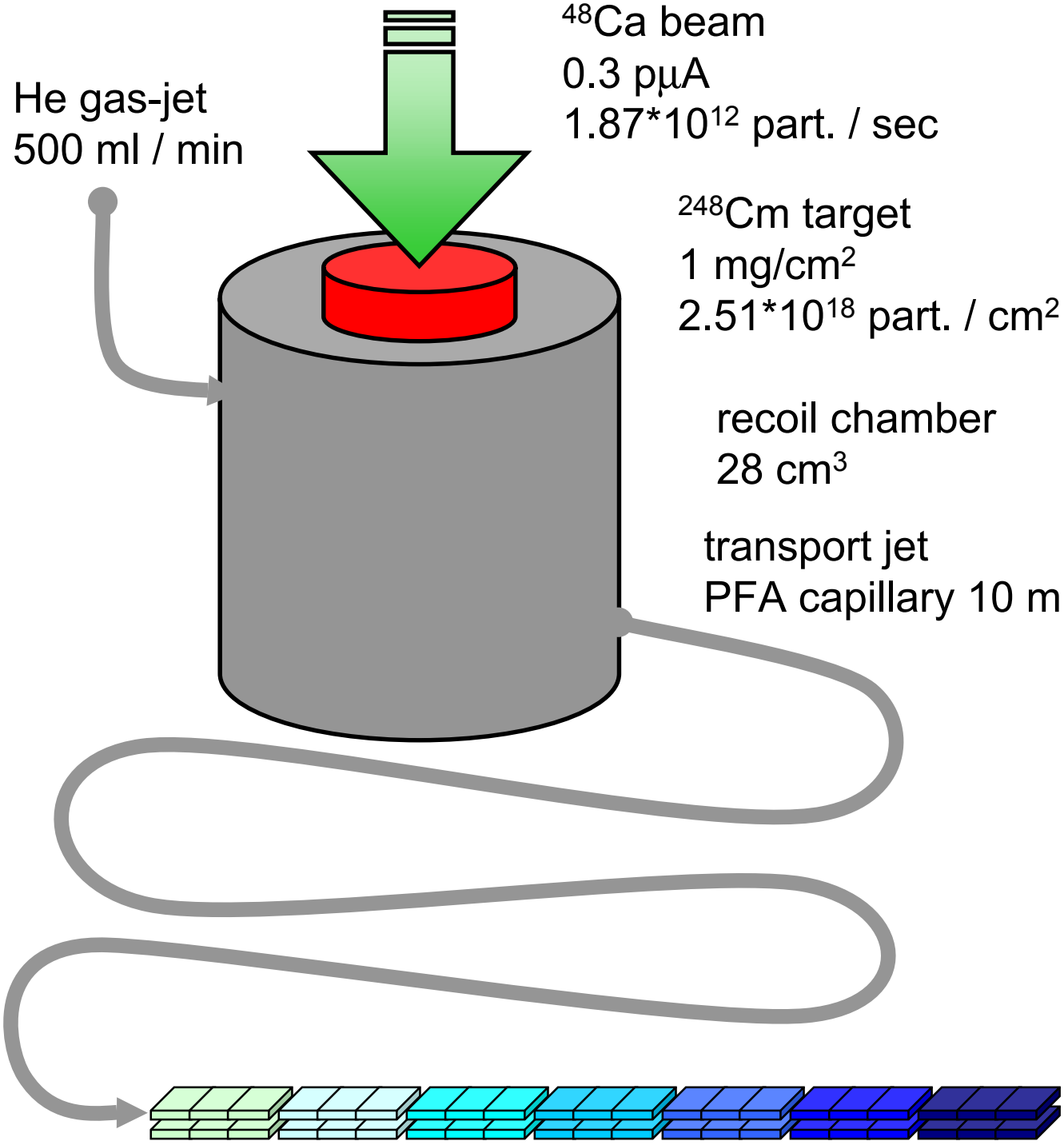
H.Gäggeler, et al.: Phys. Rev. C 33 (1986) 1983

Generator nuclides for Rn in the reaction ^{48}Ca on ^{248}Cm

	$T_{1/2}$	σ [μb]
^{219}Rn	3.96 s	382
^{227}Th	18.72 d	160
^{223}Ra	11.43 d	165
^{223}Fr	21.8 min	24
^{219}Rn	**total**	**734**
^{220}Rn	55.6 s	153
^{224}Ac	2.9 h	146
^{224}Ra	3.66 d	112
^{224}Fr	3.3 min	7
^{220}Rn	**total**	**418**
^{221}Rn	**25.0 min**	**47**

- 5450 Radon atoms are produced per second
- most of them will reach the detector
- cross sections of the same order of magnitude are expected for lighter target materials

Monte Carlo simulation I



Cryo **O**n **L**ine **D**etector system
12 sandwiches of 2x3 PIN diodes gold covered
Temperature range from 298 K down to 95 K

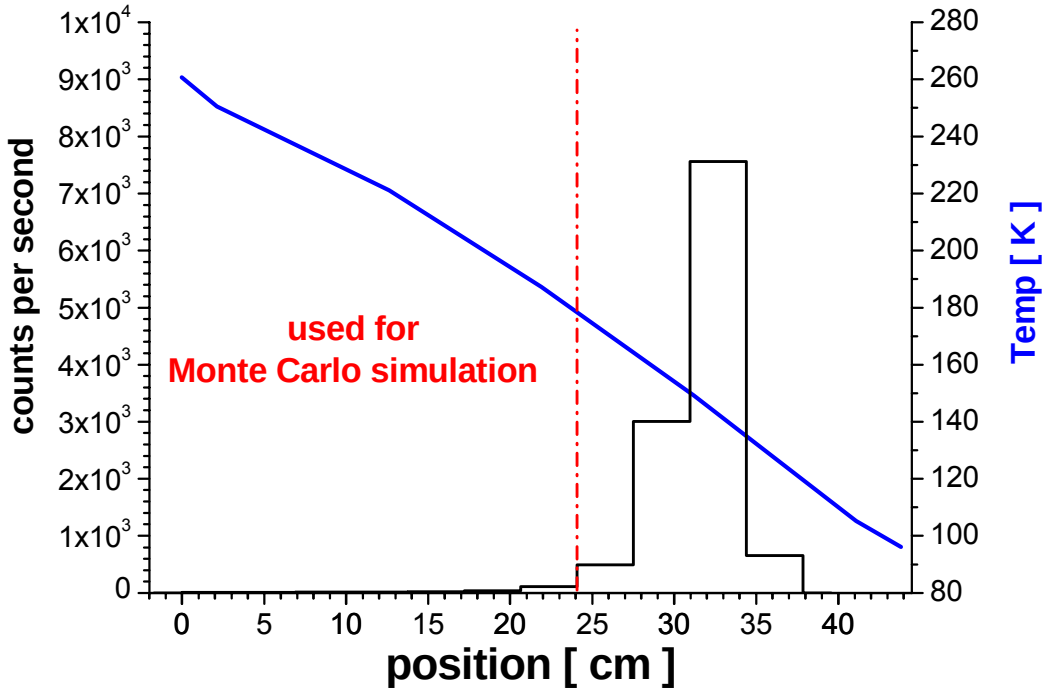
Monte Carlo simulation II

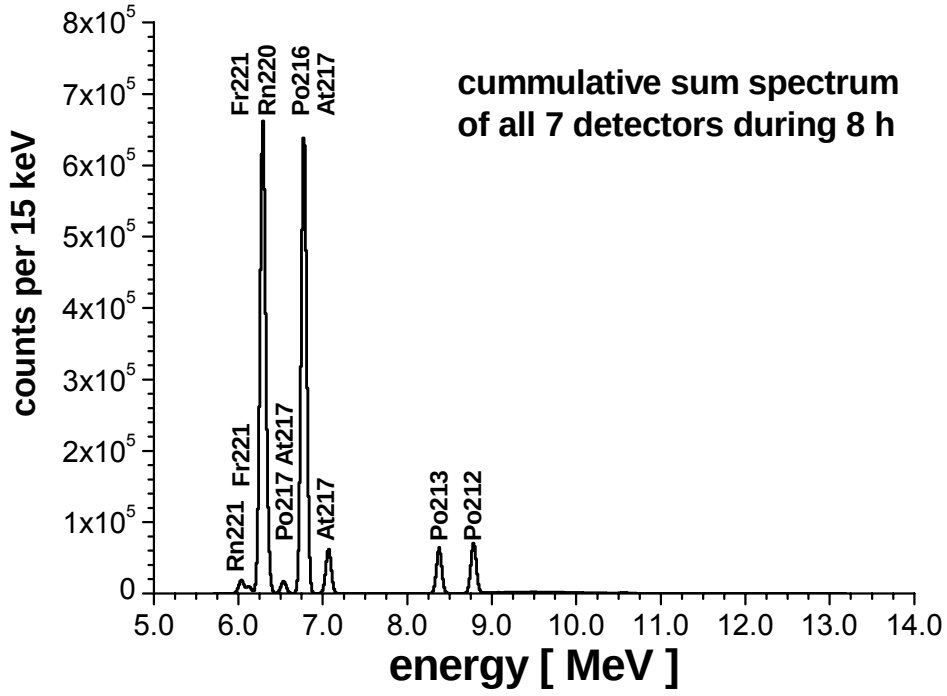
- Production : equally distributed during 8 h
- Sweep out : exponentially distributed
  mean time = plug flow time
- Transport : isothermal gas chromatography of Rn and all decay products until ^{212,213}Po
- Detection : gas chromatography inside COLD
  detection of all α-particles with
  88% efficiency , 70 keV FWHM
  β pileup if time delay to next α < 0.5 μs

- Gas chromatography : microscopic model by I. Zvara
  Radiocimica Acta 38 (1985) 95

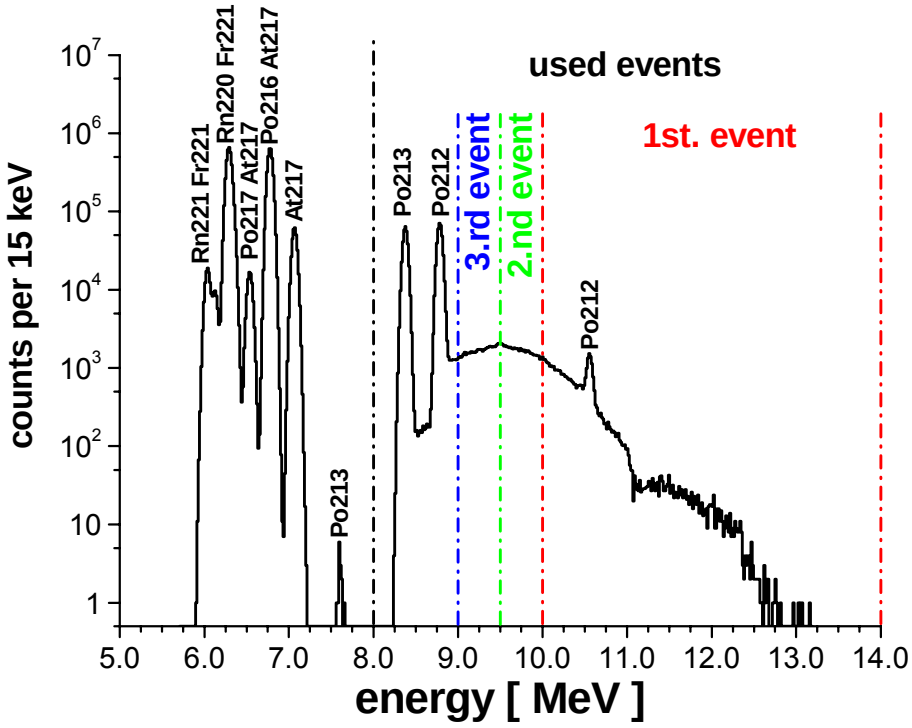
	ΔH_{ads} [kJ/mol] on quartz	ΔH_{ads} [kJ/mol] on gold
Fr	-65.0	-145.0
Rn	-20.0	-29.0
At	-30.0	-120.0
Po	-85.3	-199.6
Bi	-131.9	-227.2
Pb	-134.2	-219.1

Results I: detector load & α-spectrum





Results II:
α-spectrum & correlations



search windows for correlated events

1.st event	⇨ 2.nd event	⇨ 3.rd event
10 MeV< E_α	⇨ 9.5 MeV< E_α<10 MeV	⇨ 9.0 MeV< E_α< 9.5MeV
no time limit	⇨ Δt<20 s	⇨ Δt<200 s

about 2 events per second are recorded in each region

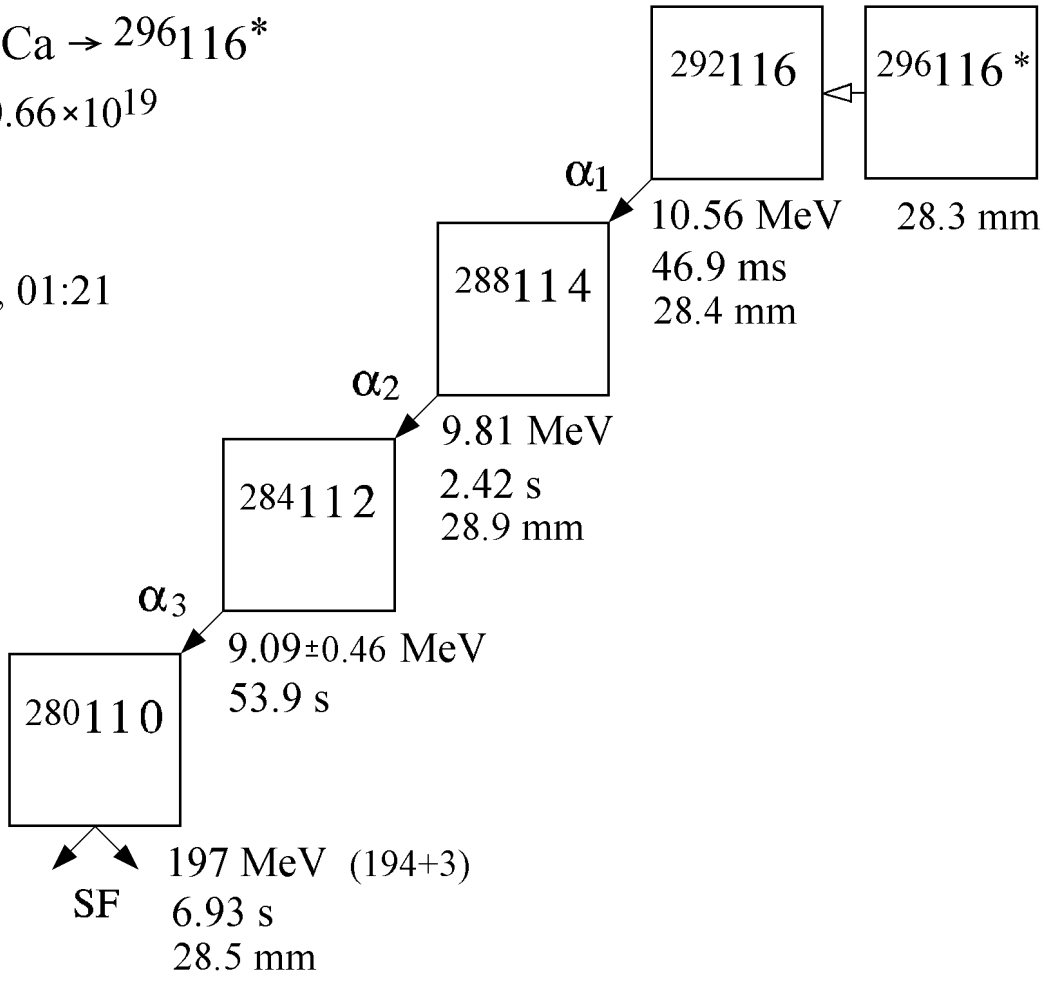
all events with E_α > 8 MeV are used
only consecutive events can pass the correlation filter

Results III:
Dubna $^{292}116$ event

$^{248}Cm + ^{48}Ca \rightarrow ^{296}116^*$

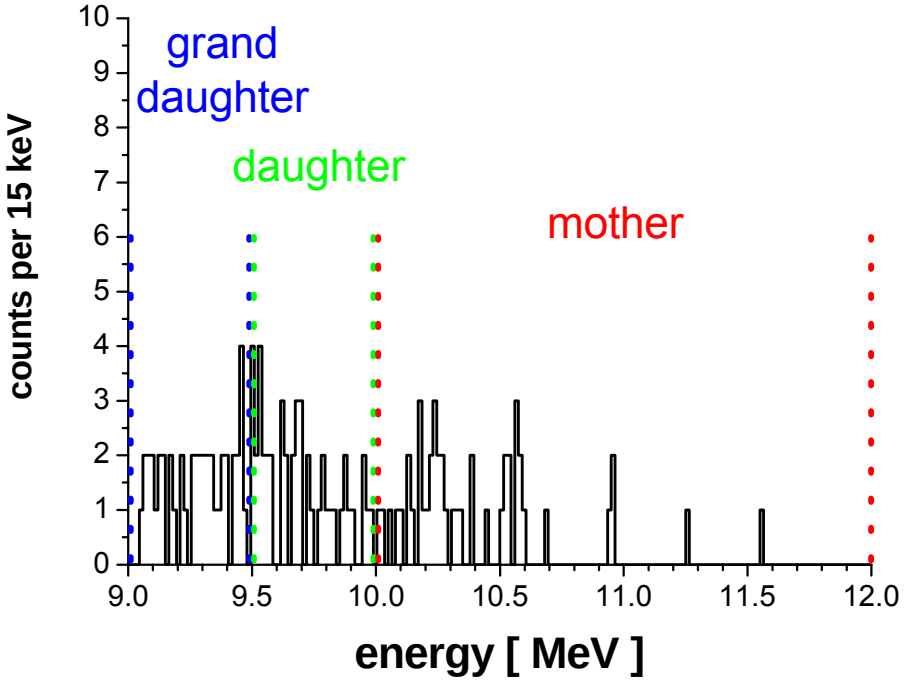
Beam dose 0.66×10^{19}

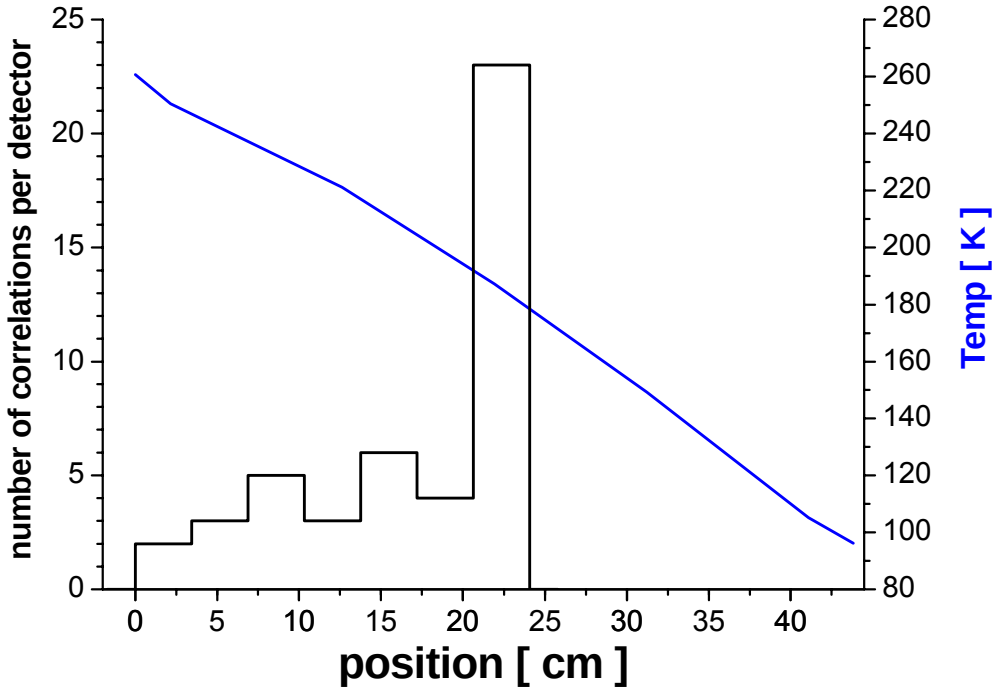
Jul.19, 2000, 01:21



Yu.Ts. Oganessian, et al.: Rhys.Rev. C 63 (2000) 011301(R)

Results IV:
Pseudo correlation spectrum





Results V: True & Random correlations

Dubna ^{292}116 (19.July 2000)

10.56 MeV ⇨ 9.81 MeV ⇨ 9.09 MeV ⇨ SF
0.0469 s ⇨ 2.420 s ⇨ 53.600 s ⇨ 6.930 s

Dubna ^{292}116 (2.May 2001)

10.49 MeV ⇨ 9.81 MeV ⇨ 9.15 MeV ⇨ SF
0.1255 s ⇨ 0.31 s ⇨ 88.54 s ⇨ 23.0 s

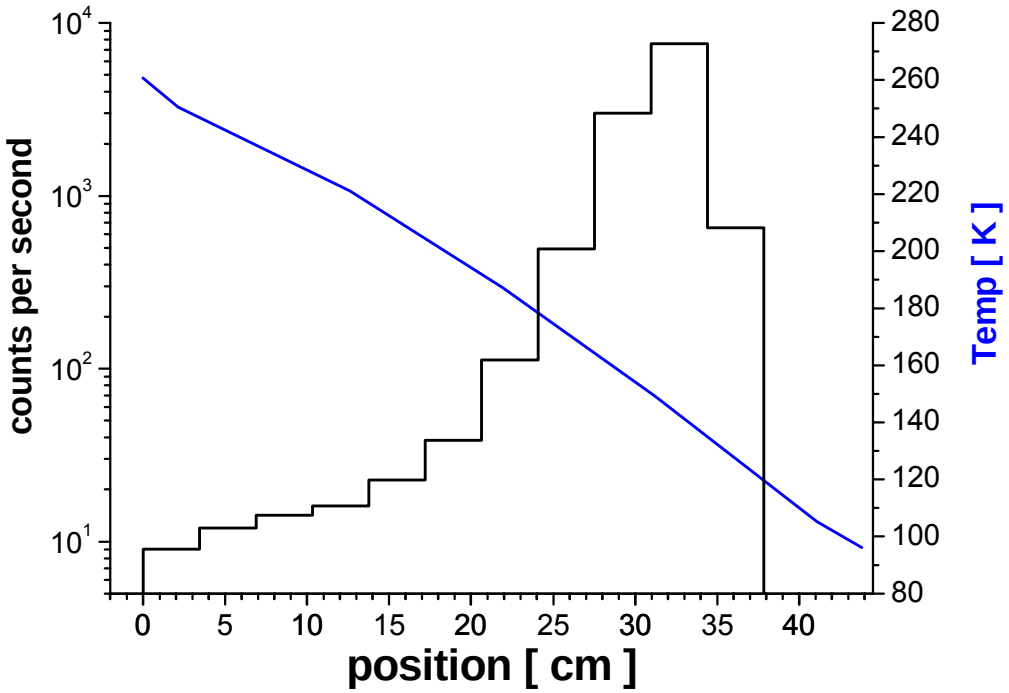
Dubna ^{292}116 (8.May 2001)

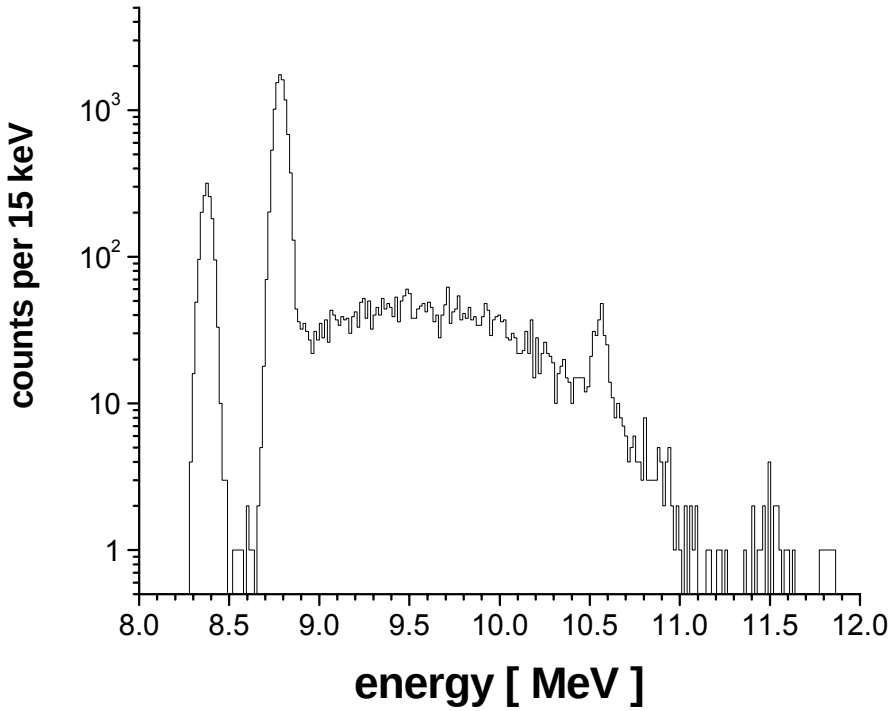
10.54 MeV ⇨ 9.80 MeV ⇨ 9.11 MeV ⇨ SF
0.055 s ⇨ 10.97 s ⇨ 152.62 s ⇨ 3.15 s

Results from the Monte-Carlo simulation in COLD

Det.2:	10.23 MeV	⇨ 9.84 MeV	⇨ 9.14 MeV
		5.67 s	⇨ 2.77 s
Det.2:	10.44 MeV	⇨ 9.50 MeV	⇨ 9.08 MeV
		8.15 s	⇨ 2.12 s
Det.4:	10.33 MeV	⇨ 9.80 MeV	⇨ 9.07 MeV
		1.62 s	⇨ 2.51 s
Det.5:	10.58 MeV	⇨ 9.64 MeV	⇨ 9.09 MeV
		0.26 s	⇨ 1.11 s
Det.6:	10.57 MeV	⇨ 9.86 MeV	⇨ 9.18 MeV
		0.52 s	⇨ 0.68 s

Results VI: detector load α-spectrum of detectors 1 - 3





Conclusions

- 10^4 α-events will be recorded in the detection device with out pre separation of Rn.
- Up to 50 pseudo correlations with three consecutive and energetically reasonable events will be recorded even in the first detectors.
- A correlation analysis which starts from the terminating SF event and searching backwards the precursors, find an un-disturbed chain only with a probability of 10^{-48}.
- To found a real SHE chain with a probability of 90 %, the Rn background above 9.0 MeV must lowered by at least a factor of 10^3.

- For very volatile elements, this can only reached with a **physical separator**.