

# **BIOKMOD 6.0 beta (updated to ICRP 130/134/137);**

Draft. Updated: 2019-02-11

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Thank to M. Antonia López & Montse Moraleda (CIEMAT)  
BASIC

EURADOS 2019 presentation (TG7). Lodz. Poland

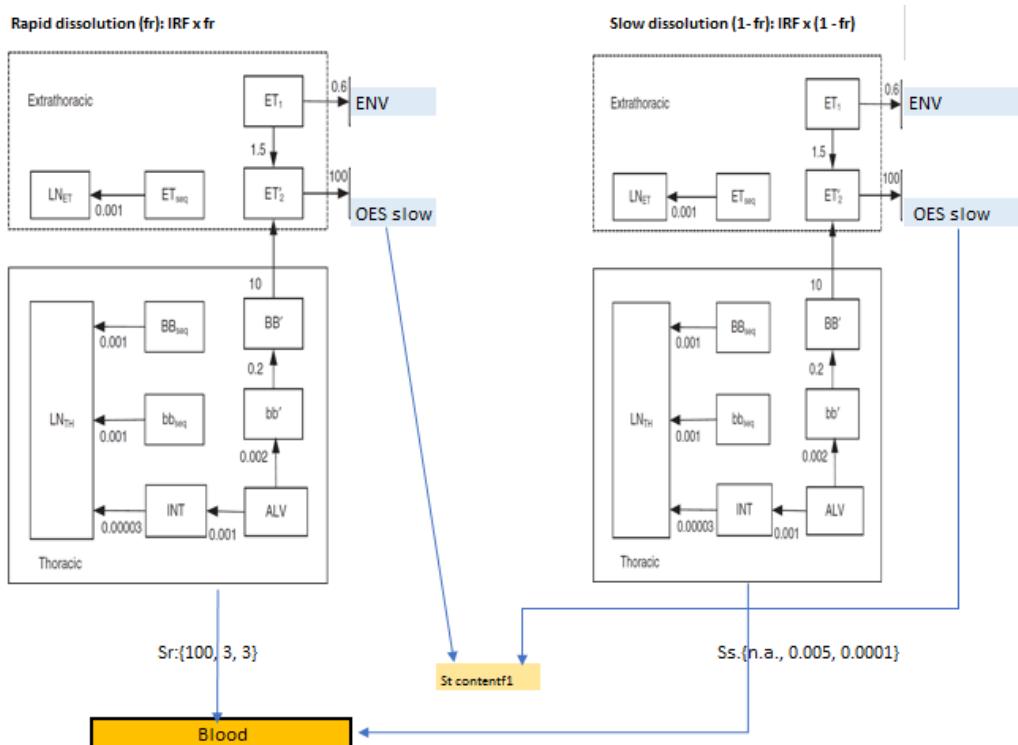
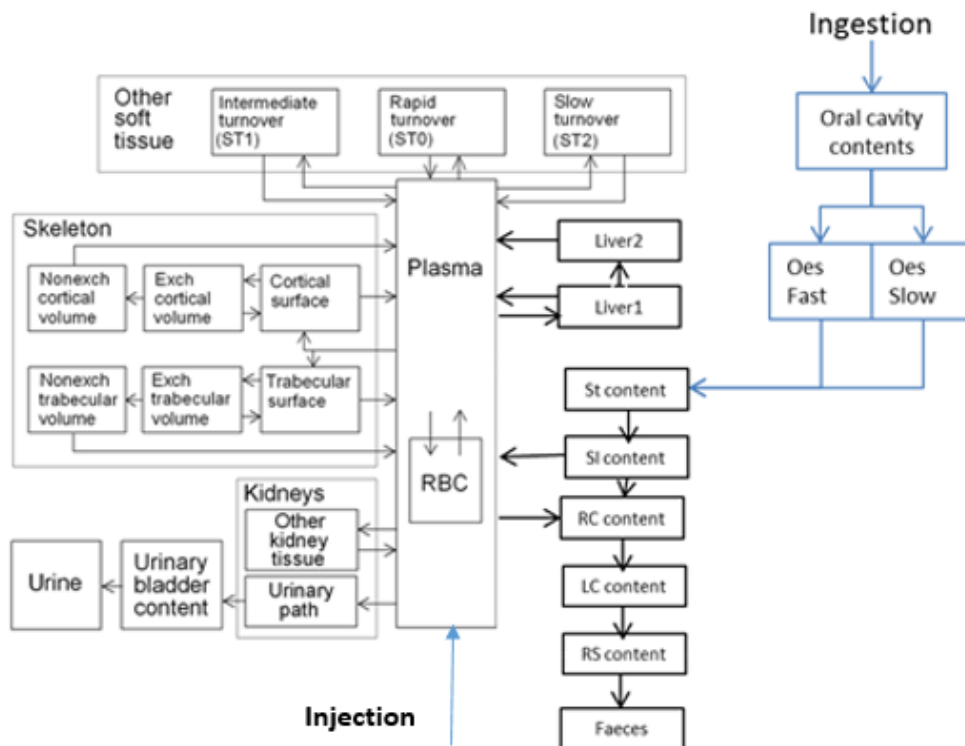
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**URANIUM ICRP models solved with BIOKMOD. APPLICATIONS. The method can be applied to the isotopes of other elements (Cs, Co, I)**

<http://oed.usal.es/webMathematica/Biokmod/index.html>

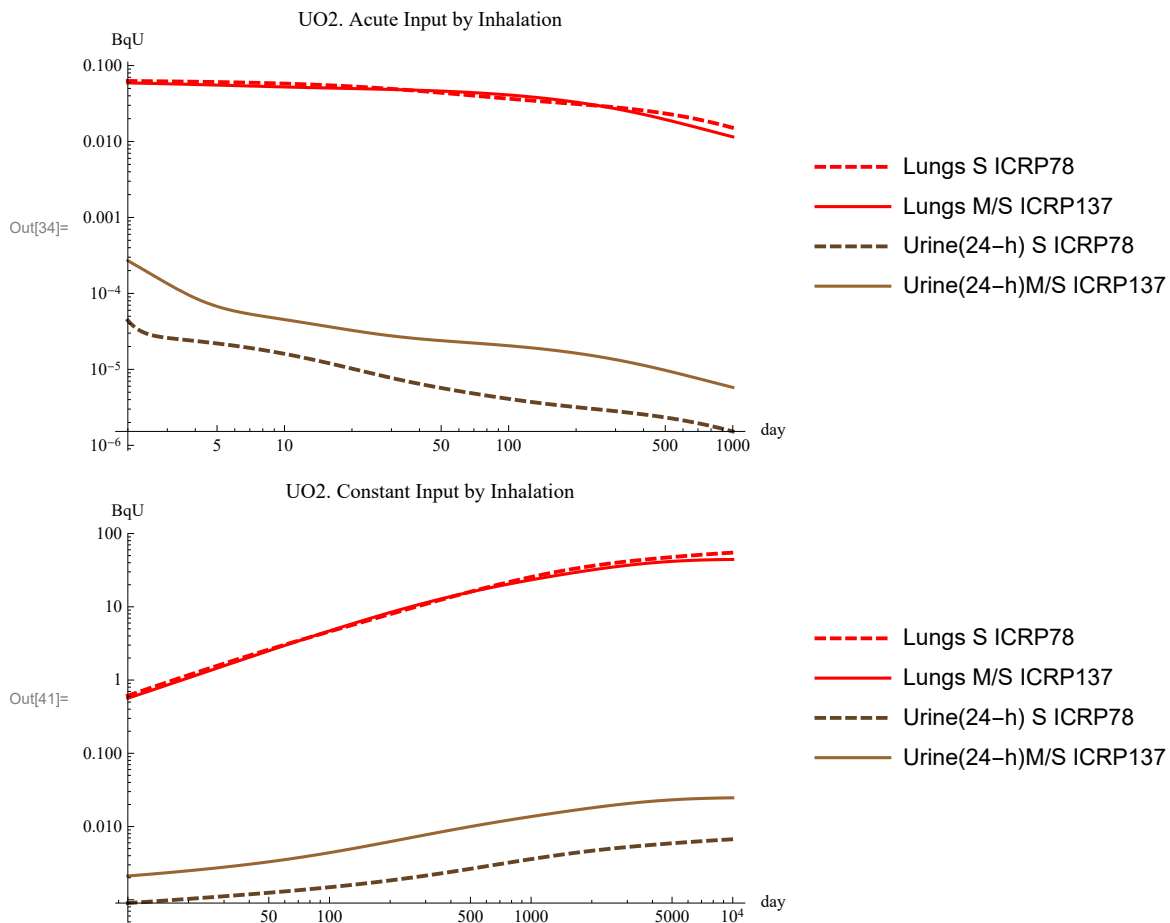
- **Run functions**
- **ICRP 66/78 U Model**

■ ICRP 130/137 U Model



- *Injection: Acute*
- *Ingestion: Acute*
- *Inhalation: Acute and Chronic*

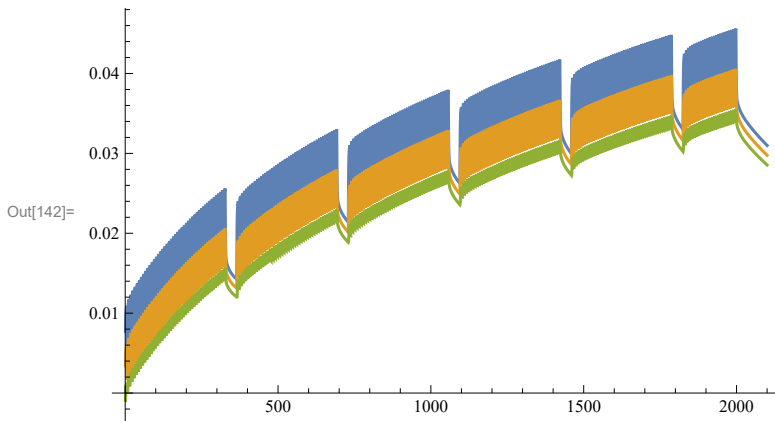
- Ingestion ICRP78 vs ICRP137
- Inhalation ICRP66/78 vs ICRP130/137 UO2 AMAD 5  $\mu\text{m}$
- UO2: Type S ICRP 78 vs S//M ICRP 137 Acute and Chronic



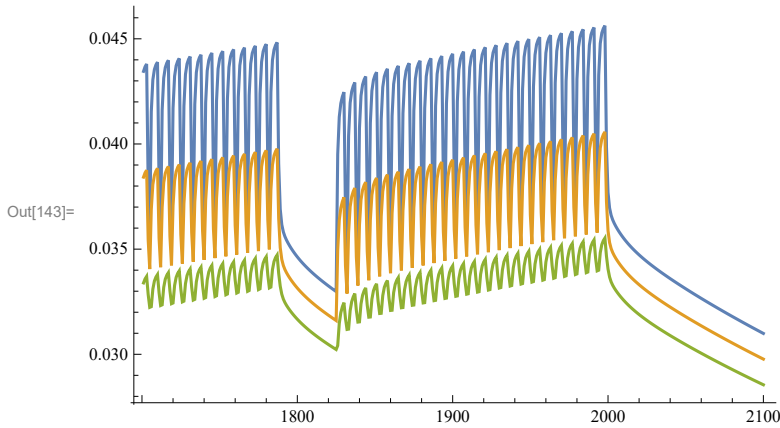
■ Example of Application

A worker has been exposed during the last 2000 days of an intake by inhalation of radioactive aerosols (UO2 M/S, AMAD 5) during 8 h every working day, 5 days per week 47 week per year. It is known that the average daily intake in this area is 3.3 BqU with a standard deviation of 2.1 BqU. The day  $t = 2000$  ceased the incorporation. We wish estimate the 24 h- urine excretion and the corresponding confidence intervals a long of the time.

- Hidden cell
- Fig 1.- Here is represented the 24 h urine excretion and the corresponding confidence interval.

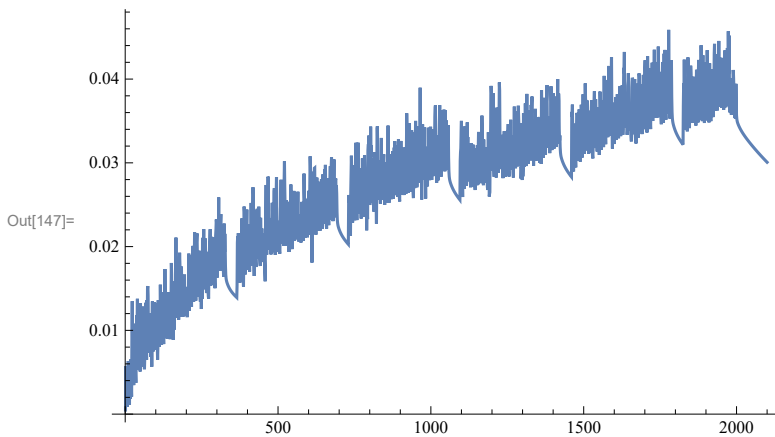


- Zoom: The last 400 days detailed.

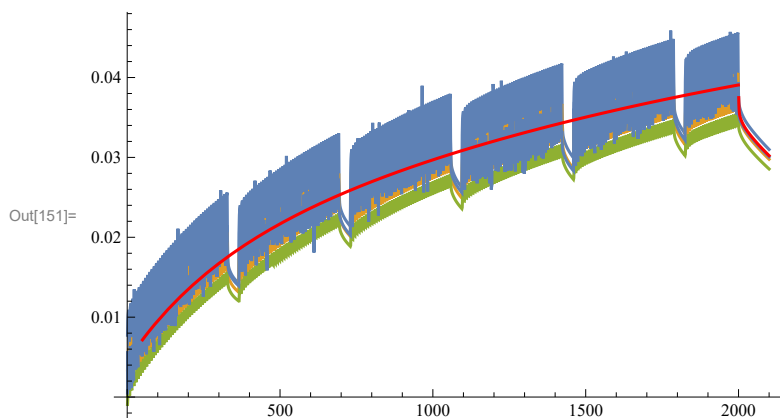


It can be observed that the confidence interval decreases dramatically after a few days without exposition. A practical consequence is that the urine sample should be taken after at least 2 days without exposition,

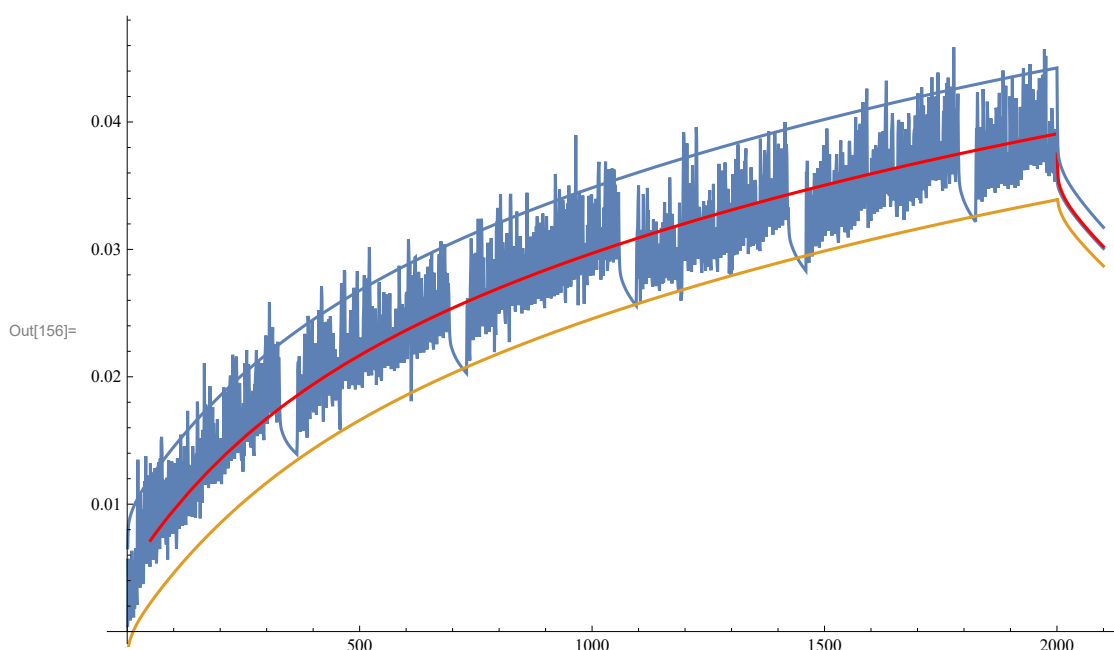
- Fig 2.- Assuming a random intake [NormalDistribution[3.3, 2.1]], neither week nor holidays the worker is exposed



- Fig3.- Here is compared with constant intake with a random intake



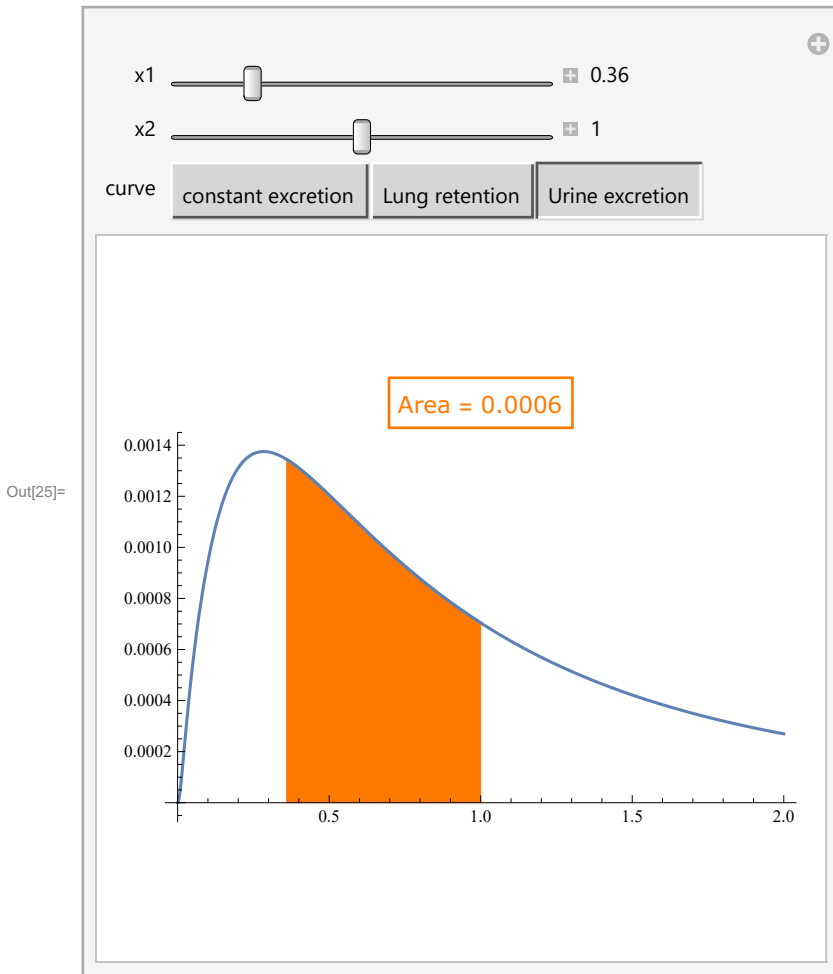
• Fig 4.- Here is assumed a constant intake including confidence intervals



□ **Relevant conclusions**

- A constant intake can be used as a very good approximation of a variable intake as it happens in real situation of workers exposed to the UO2 aerosols inhalation
- The Urine excretion (24-h) should be taken at least after one day (better 2 days) without exposition

```
In[20]:= quri[t_] = x21[t] /. qUInhalation[t, idfAMAD5, 0.0006, 0.03, 1, 0.0005, 0] // ExpandAll // Chop;
In[21]:= rUriSMb[t_] = quri'[t];
In[22]:= f3 = rUriSMb[x];
          f1 = 2;
          f2 = qLungSM1[x];
```



■ **A real case of intake estimation using the new U model**

A worker that has been exposed to the uranium UO<sub>2</sub> aerosols during the following periods: T<sub>1</sub> {06/01/1998 to 12/09/2015}, T<sub>2</sub>= {12/11/2015 to 10/29/2016}, T<sub>3</sub>: {from 01/16/2017 to 03/26/2017}, T<sub>4</sub>: { from 01/10/2018 to 03/21/2018}. During this time the several 24 h urine samples (mBq U-234) .were taken from the worker with results shown in the below Table We want to estimate the total intake quantity in periods T<sub>1</sub>+T<sub>2</sub> and T<sub>3</sub>+T<sub>4</sub>

$s_1$	$T_1$	$t_1$	$s_2$	$T_2$	$t_2$	$s_3$	$T_3$	$t_3 = s_4$	$T_4$	$t_4$
1	6400	6401	6402	323	6726	6804	69	7163	70	7235
		$y_1$			$y_2$			$y_3$		$y_4$
		1.76			2.23			1.54		2.09
		$\sigma_1$			$\sigma_2$			$\sigma_3$		$\sigma_4$
		0.26			0.32			0.27		0.31

■ **The methodology**

■ **The solution: Assumption: An input b<sub>1</sub> from 0 to s<sub>2</sub>+T<sub>2</sub>, and b<sub>2</sub> from s<sub>3</sub> to s<sub>4</sub>+T<sub>4</sub>: WLSE .**

□ **Method 1**

- inputs to the program

```
In[31]:= periods = {{0, 6400}, {6402, 323}, {6804, 69}, {7163, 70}}; (*{{s1, T1}, {s2, T2}, .....}*)
```

```
In[32]:= sampletime = {6401, 6726, 7163, 7235};
(*{t1, t2, ...}*)
```

```
samplevalues = {{1.76, 0.26}, {2.23, 0.32}, {1.54, 0.27}, {2.09, 0.31}};
(* mBq U-234, urine 24h/day*)
(*{{y1, σ1}, {y2, σ2}, .... *}
```

- Estimation of the average daily intake of UO2 (mBq-U234/day):

```
In[35]= solf = fitAssay[periods, sampletime, samplevalues, 2]
```

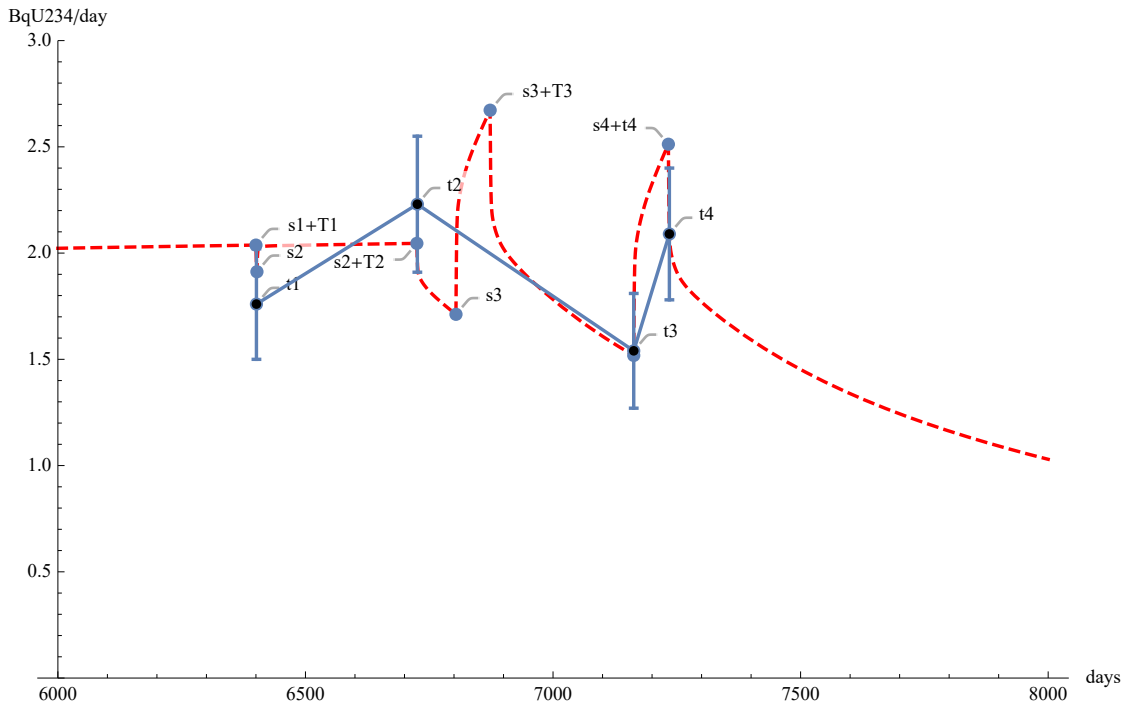
Out[35]= {85.9435, 294.72}

- Total intake in period T1+T2 and T2+T3

```
;(*{{s1, T1}, {s2, T2}, .....}): {{0, 6400}, {6402, 323}, {6804, 69}, {7163, 70}}
```

```
In[37]= solf {6400 + 323, 69 + 70}
```

Out[37]= {577798., 40966.1}



ADITIONAL