

Comments:  
 05/25 – Memorial day  
 05/26-05/29 Oleg in vacation 6 h/day

- //-----
- // 14.6.2 05/22/20
- // \* d\_Secondary\_reactions dialog : **DONE!**
- // \* d\_CN\_optimumTarget : redesign 80%, connection 50%
- // \* d\_Plot\_targetOptimal : redesign 80%, connection 50%
- // \* d\_Calculator\_phys dialog: : redesign 100%, connection 80%

Physical Calculator dialog box showing input parameters for a secondary reaction calculation. The 'After / Into material' section is set to W 1e+010 micron. The 'Range and Energy Loss in' section is set to Si. The 'Calculation method of' section shows Energy Losses set to 2 and Energy straggling set to 1. A table of nuclides is visible in the background.

Output window for C:/LISEcute/\_install/CrossSections/test2.cs2. It displays a table of calculated cross sections for secondary reactions. The primary reaction is identified as "Projectile Fragmentation".

Protons (Z)	Neutrons (N)	CS (mb)
20	28	1.2081e+002
21	30	1.9037e-004
21	29	9.4739e-002
21	28	1.5139e-001
21	27	7.9628e-001
21	26	4.2891e-001
21	25	2.0391e-001
21	24	8.8296e-002
21	23	3.5033e-002
21	22	1.0919e-002
21	21	2.3810e-003
21	20	3.3487e-004
21	19	1.8520e-005
21	18	1.1916e-006
20	30	1.5961e-003
20	29	7.9610e-001
20	27	7.9609e+001
20	26	4.2844e+001
20	25	2.0350e+001
20	24	8.8053e+000
20	23	3.4923e+000
20	22	1.0883e+000
20	21	2.3732e-001
20	20	3.4712e-002
20	19	3.2624e-003
20	18	2.6585e-004
20	17	2.1166e-005
20	16	1.6708e-006
20	15	1.3147e-007

Secondary Reactions Analysis Plots dialog box. It includes options for using secondary reactions for fragment output calculations, a dimension of 16, and buttons for calculating down to Z=1, saving reduced cross sections, and clearing SR memory. It also features filter settings for acceleration filters, corner rectangle filters (delta N and delta Z), and diagonal filters.

```
// 14.6.3 05/23/20
// * new basic class (dialog) d_CN0_baseT      : DONE!
// * d_Transmission_statistics dialog          : DONE!
// * d_Goodies dialog remade based on d_CN0_baseT
//
// CN0_base & CN0_baseT dialogs should be remade
// in order to exclude their UIs (write forms manually) and join them
```

**Transmission statistics results are the same in Borland and Qt cases.**  
**Borland's case has been attached as well**

**Transmission statistics dialog** *Borland*

Choose a BLOCK: I2\_wedge

A	Element	Z
41	S	16

Beta- decay

Table of Nuclides

Charge states: 16+ D1

Reaction: Projectile Fragmentation

Quit

\* - calculated by "Distribution" method

INTO this BLOCK

Lost events	2.798e+0	pps
Lost charge states	2.798e+0	pps
Lost all "reaction" events	2.798e+0	pps
Total transmission	98.41	%
X space transmission	100	%
Y space transmission	100	%
X angular transmission	100	%
Y angular transmission	100	%
Unreacted in mater.	98.43	%
Unstopped in mater.	100	%
Q (charge) ratio	100	%
Secondary Reactions	100	%

Energy Loss [MeV] Plot

mean*	1.395e+1	FWHM=	1.753e+1
max =	2.753e+1	St.Dev.=	1.317e+1

**Trasmission statistics dialog** *Qt*

Choose a BLOCK: I2\_wedge

A	Element	Z
41	S	16

Beta- decay

Table of Nuclides

Charge states: 16+ D1

Reaction: Projectile Fragmentation

Quit

Help

\* - calculated by "Distribution" method

INTO this BLOCK

Lost events	2.76e+00	pps
Lost charge states	2.76e+00	pps
Lost all "reaction" events	2.76e+00	pps
Total transmission	98.43	%
X space transmission	100	%
Y space transmission	100	%
X angular transmission	100	%
Y angular transmission	100	%
Unreacted in mater.	98.43	%
Unstopped in mater.	100	%
Q (charge) ratio	100	%
Secondary Reactions	100	%

Energy Loss [MeV] Plot

mean*	3.87e+02	FWHM=	7.94e+00
max =	3.87e+02	StDev=	3.39e+00

```
//
// 14.6.3 05/23/20
// * new basic class (dialog) d_CN0_baseT      : DONE!
// * d_Transmission_statistics dialog          : DONE!
// * d_Goodies dialog remade based on d_CN0_baseT
//
// CN0_base & CN0_baseT dialogs should be remade
// in order to exclude their UIs (write forms manually) and join them
```

**Remade**

A	Element	Z
42	S	16

Beta+ decay

Table of Nuclides

← Z →  
← N →

Charge states

Set

16+ D1

✓ Exit  
? Help

*calculated by "Ellipse" method*

**AFTER**

Energy	122.46	MeV/u
sig.(Energy)	0.803	MeV/u
Brho	4.3147	Tm
Energy Stragglng	0.068	MeV/u
Angular Stragglng	1.7845	mmrad
Velocity	14.0257	cm/ns
Beta	0.4678	
Rest after reactions	98.413	%

after I2\_wedge

Range to	Si
	2302.693 mg/cm <sup>2</sup>
	9920.268 micron

Energy Loss to

	Si 100 micron
	30.134 MeV

**INTO**

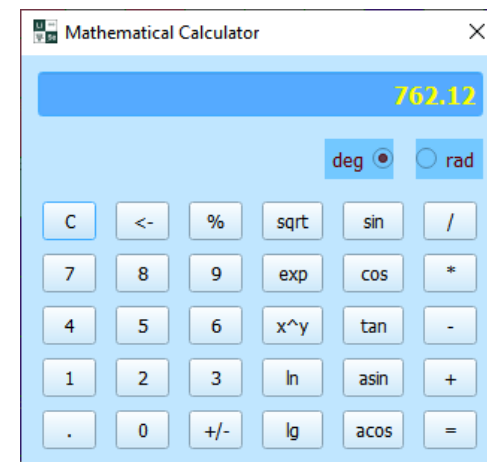
into I2\_wedge

Energy	397.606	MeV
sig.(Energy)	8.349	MeV
Energy Stragglng	0.068	MeV/u
Angular Stragglng	1.7845	mmrad
Loss due to reactions in this material (%)	1.5868	

Time of Flight

Start of TOF	Target
Stop of TOF	FP_PPAC1
Time of Flight	255.607 ns
sig.(TOF)	1.29 ns
Length	35.843 m

```
//-----
// 14.6.4 05/25/20
// * d_Calculator\d_Calculator_math      : redesign 90%, connection 10%
// * d_Mechanism\d_Mechanism_fissionProperties : redesign 100%, connection 60%
// * d_Options\d_Secondary_target          : DONE!
```



**Options of Fragment Production in Material (wedge)**

Dimension of distributions used for fragment production calculations in Material or Wedge: **ACCURATE** (16) or **FAST** (8)

Use fragments produced in Material (Wedge) for fragment production in the following Material or Wedge with the "Calculate fragment production" option turned on: Yes or No

Method to calculate kinematic of fragment produced in Material or Wedge: "Distribution", "Gaussian", or "Dispersion" (special case)

Rate Threshold for the parent-daughter link: 1e-010 pps

Buttons: set all to "Accurate", set all to "Fast"

Calculation Rectangle of fragments produced in Material

"DAUGHTER region"		Z	N
first corner =>	6Li	min 3	3
second corner =>	48Ca	max 20	28

Buttons: Show statistics of fragment production in Materials (Wedges), Make default, OK, Cancel, Help

**Fission properties**

Cross sections:
 

- Us Odd-Even corrections for fragments
- Include post-scission (n,p,a) evaporation

Parameters for shell structures\*\*

Shell position (N sh,i)	Strength (dU <sub>i</sub> )(MeV)	Curvature (2C sh,i)(MeV)
1 83	-2.65	0.7
2 90	-3.8	0.15

Buttons: Potential energy plot, Put original values \*1\*, Put "2005" values \*2\*

\*1\* J.Bebliure et al., NPA628(1998)458  
\*2\* see LISE++ v.7.5 documentation

Cross section suppression values

Fragment excitation (TXE) depends on:
 

- #0 Dissipated energy [NPA 628(1998)458] TXE = E\* - Bf + Edis
- #1 Reaction Q-value [EPHysJA14(2002)459] TXE = (a1 + a2) (f Q)^2 + E\* f = 0.0045 default 0.0035

Fragment excitation energy width: St.Dev = 5.5 MeV default 5.5

Angular distribution cut by momentum slits:
 

- Do not use
- Use just for "MatrixKinematics" class
- Use for all Angular Distributions (deft)

Angular distribution shape: Isotopic  Anisotropic

Settings of Quadrupole deformation (beta) at the scission point:
 

- Manual B.D.Wilkins et al., PRC14 (1976) 1832
- Fit (Pr.v.1) tip distance: d (TKE) = 2 default 2 fm

Beta values:
 

- 1. light = 0.625 default 0.625
- 2. heavy = 0.625

 These values are used for Wilkins's TKE plot, and in the "manual" mode in LISE++ fission kinematics calculations with TXE #0 mode

Buttons: Make default, OK, Cancel, Help

```
//-----
// 14.6.5 05/26/20
// * d_Calculator\d_Suppression_fissionCS : DONE!
// * d_Mechanism\d_Mechanism_fissionProperties : DONE!
// * d_Options\d_Secondary_targetStatistics : redesign 90%, connection 20%
// * d_Calculator\d_Calculator_math : DONE!
// * d_Calculator\d_Calculator_math has been updated by Log window
```

**Fission cross section suppression values**

Modes	Suppression Values (mb)
to keep in memory	1.000e-10
just for TKE plots	1.000e-09

If the fragment production cross section less than product of the total fission cross section and the suppression value then the fragment is excluded from calculations. Large suppression values decrease cross section calculation time. (0 < values < 1, default 1e-10 mb)

Make default

**Mathematical Calculator**

2208.347991887209

deg  rad

0.866025 'A'  
Answer 60  
1.0472 'S'  
Answer 0.5  
0.5 + 14.9  
Answer 15.4  
15.4 'E'  
Answer 4.8768e+06  
4.8768e+06 'Q'  
Answer 2208.35

**Fission properties**

Us Odd-Even corrections for fragments  
 Include post-scission (n,p,a) evaporation

Parameters for shell structures\*\*

Shell position (N sh,i)	Strength (dLi)(MeV)	Curvature (2C sh,i)(MeV)
1 83	-2.65	0.7
2 90	-3.8	0.15

Fragment excitation (TXE) depends on

#0 Dissipated energy [NPA 628(1998)458]  
TXE = E\* - BF + Edis

#1 Reaction Q-value [EPhysJA14(2002)459]  
TXE = (a1 + a2) (f Q)^2 + E\*  
f = 0.0045 default 0.0035

Angular distribution cut by momentum slits

Do not use  
 Use just for "MatrixKinematics" class  
 Use for all Angular Distributions (defit)

Angular distribution shape

Isotopic  Anisotropic

Settings of Quadrupole deformation (beta) at the scission point

Manual B.D.Wilkins et al.,PRC14 (1976) 1832  
 Fit (Pr. v.1) tip distance: d (TKE) = 2 default 2 fm ? Help

Beta values

Fragments: 1. light = 0.625 default 0.625  
2. heavy = 0.625

These values are used for Wilkins's TKE plot, and in the "manual" mode in LISE++ fission kinematics calculations with TXE #0 mode

Make default

//-----  
 // 14.6.6 05/27/20  
 // \* d\_Mechanism\d\_Mechanism\_fusion : redesign 100%, connection 80%  
 // \* d\_Evap\d\_Evaporation : redesign 80%, connection 20%



**Evaporation Calculator**

Initial nucleus: 40Ar  
 Excitation energy window: Lower = 32.1 MeV, Upper = 32.1 MeV  
 Initial nucleus production cross-section = 25.5 mb  
 make calculations down to Z = 1

Modes:  
 Fragmentation of beam (Abrasion-Ablation)  
 Excited nucleus evaporation  
 Load initial conditions from file

2D-plots:  
 Final Evap.Residue CS  
 Decay channel analysis  
 Fission channel CS  
 Temperature  
 Break-up channel CS  
 Fission Excitation Energy

**Final nucleus**  
 !!!!! Minimum sum of separation energy or CB is less than 0 !!!!!

Final fragment production cross-section	Minimum separation energy (SE)	Average values
25.5 mb	120.22 MeV	<Ex> = 120.21
Initial production CS of Final fragment (for fragmentation or file options)	Minimum sum of (SE + deduced effective Coulomb barrier)	<T> = 1
25.5 mb	120.21 MeV	<Ex_fis> = 120.21
Cross section from EPAX 2.15	Fission barrier at L=0	
25.5 mb	11.21 MeV	

PARENT: par1n, par2n, par1p, par2p, par\_a, par\_d, par\_t, par\_3he, par\_Fis, par\_Bkp, par\_sum, par\_max  
 Decay modes: 1n, 2n, 1p, 2p, alpha, d, t, 3He, Fission, Break-up, sum, Break-up  
 DAUGHTER: dau1n, dau2n, dau1p, dau2p, dau\_a, dau\_d, dau\_t, dau\_3he, dau\_Fis, dau\_Bkp, dau\_sum, dau\_max

Sum: sum1n, sum2n, sum1p, sum2p, sum\_a, sum\_d, sum\_t, sum\_3he  
 Initial Residues: sum\_init, sum\_resid, sum\_Fis, sum\_Bkp

N' of all calculated nuclei: 5

Output cross-section file, Output file of parent daughter references, Fission CS output file

Initial Prefragment Plot for final nucleus, Initial Fissile nucleus plot for final fragment

**Fusion -> Residues**

Evaporation settings:  $^{48}\text{Ca}(140.0 \text{ MeV/u}) + ^9\text{Be} \rightarrow ^{57}\text{Cr}^* (E_x = 1081.9 \text{ MeV})$

Fusion properties:  
 Transmission probability for a one-dimensional potential barrier:  
 Classical  
 Quantum-mechanical  
 h\_omega - Curvature parameter of the parabolic potential describing the barrier (default value 3 MeV): 5 MeV

Nuclear potential:  
 Bass formalism  
 Wood-Saxon  
 V0 = 105 MeV, R0 = 1.12 fm, a = 0.75 fm

Calculation:  
 L (B<sub>fis</sub> = 0) = 62  
 L<sub>critical</sub> = 27  
 L<sub>direct</sub> (@ C<sub>p</sub>C<sub>+</sub>) = 113  
 L<sub>max</sub> (grazing) = 181.7  
 L<sub>max</sub> (@ R<sub>int</sub>) = 181.6

Probability for compound nucleus formation P\_{CN}:  
 Take into account the Probability for compound nucleus formation P\_{CN} according to V.Zagrebaev & W.Greiner, PRC78, 034610 (2008)

Fission barrier vanishing:  
 Take into account the Fission barrier vanishing with:  
 0 - "Barfit" - A.J.Sierk, PRC33(1986)2039  
 1 - "FisRot" - S.Cohen et al., An.P 82(1974)

Parameters for partial cross section calculations:  
 Fusion L-diffuseness: 1 MeV

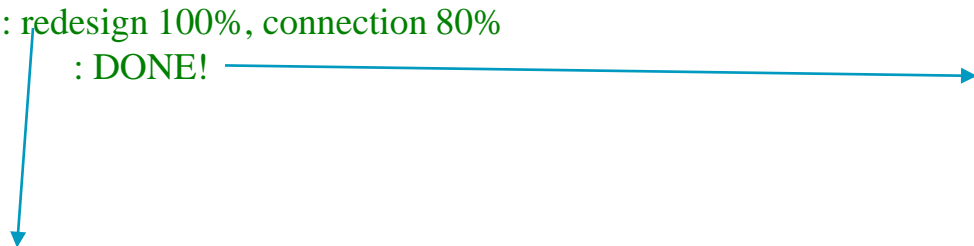
Plots:  
 Partial Cross Sections  
 Barrier properties as f(L)  
 Potentials V<sub>i</sub> = f(R)  
 Bass Fusion CS & Barrier  
 T,PCN,dEx-chan as f(L)  
 2D: Barrier V=f(R,L) & dVdR

Information about Reactions:  
 General reaction characteristics  
 Fusion information window

Partner site:  
 Fusion  
 Evaporation

OK, Cancel, Help

//-----  
 // 14.6.7 05/28/20  
 // \* d\_Evap\d\_Evaporation : redesign 100%, connection 80%  
 // \* d\_Mechanism\d\_Fusion\_inform : DONE!



**Evaporation Calculator**

Initial excited nucleus: 48Ca, Excitation energy window: Lower = [ ] MeV, Upper = [ ] MeV, Initial nucleus production cross-section = [ ] mb, make calculations down to Z = 15

Modes:  Fragmentation of beam (Abrasion-Ablation),  Excited nucleus evaporation,  Load initial conditions from file

2D-plots: Final Evap.Residue CS, Decay channel analysis, Fission channel CS, Temperature, Break-up channel CS, Fission Excitation Energy

Final nucleus: Cross sections (Final fragment production cross-section: 0.00e+00 mb, Initial production CS of Final fragment: 8.79e+00 mb, Cross section from EPAX 2.15: 5.10e-02 mb), Separation energies, barrier (Minimum separation energy (SE): 6.7 MeV, Minimum sum of (SE + deduced effective Coulomb barrier): 6.7 MeV, Fission barrier at L=0: 0 MeV), Average values (<E\*>: 78.95, <T>: 3.58, <E\*\_fis>: 78.86)

Channels	Parent	1n	1p	alpha	Fission	Break-up	sum	max
PARENT	3.60e-01	1.22e-02	3.62e-04				3.72e-01	43S
Decay modes	1n	1p	alpha					
DAUGHTER	6.25e-01	5.63e-03	2.72e-03		8.53e+00	9.16e+00	41S	
Sum	2.08e+01	2.64e+00	6.47e-01		1.04e+03	0.00e+00	1.04e+03	6.32e-01

Output cross-section file [ ] Browse Show, Initial Prefragment Plot for final nucleus [?]  
 Output file of parent daughter references [ ] Browse Show, Initial Fissile nucleus plot for final fragment [?]  
 Fission CS output file [ ] Browse Show

**Fusion information window**

$^{48}\text{Ca}(140.0 \text{ MeV/u}) + \text{Be} \rightarrow ^{57}\text{Cr}^* \rightarrow ^{42}\text{S}$

Q-value of reaction = 19.649 MeV  
 Fusion max. barrier = 11.71 MeV  
 Fusion radius = 5.7 fm

Depending on a place of reaction in the target

	beginning	middle	end
Beam energy (Lab) [MeV/u]	140	136.47	132.88
Beam energy (Lab) [MeV]	6711.8	6542.6	6370.3
Center of mass energy [MeV]	1062.23	1035.45	1008.18
Excitation energy [MeV]	1081.88	1055.1	1027.83
Compound recoil energy [MeV]	5649.6	5507.1	5362.1
Compound formation CS [mb]	1.03e+03	1.03e+03	1.03e+03
Compound Surv. Prob. (L=0)	1.00e+00	1.00e+00	1.00e+00
Fusion cross section [mb]	1.03e+03	1.03e+03	1.03e+03
Compound- 1stFission CS [mb]	0	0	0
Compound-Breakup CS [mb]	1.03e+03	1.03e+03	1.03e+03

for setting residue after the stripper

Energy diapason (MeV/u)	92.483	-:-	94.152
Corresponding ion charge state	16	-:-	16

Plot the excitation function

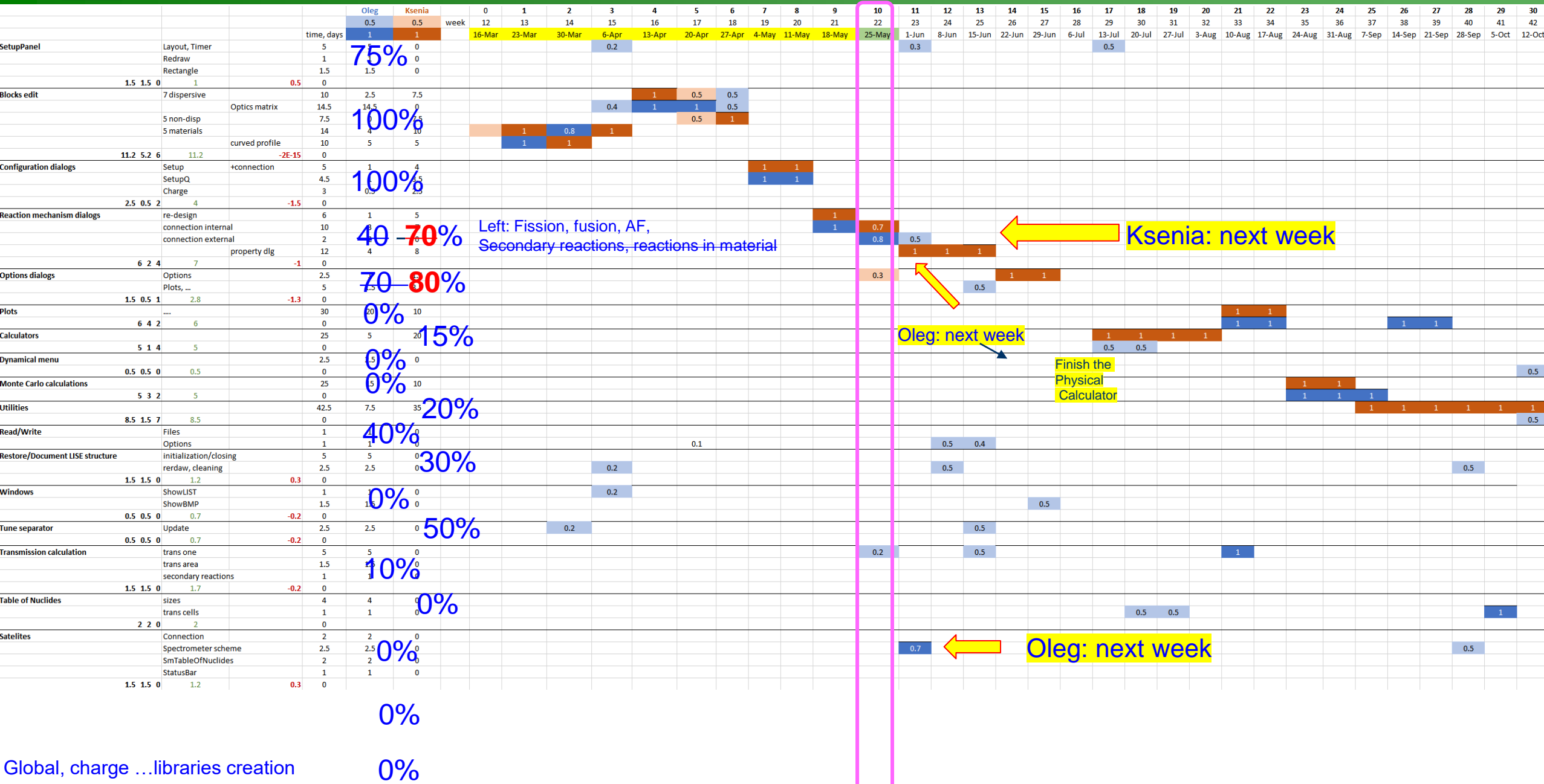
All fusion characteristics are calculated with BASS-model

Fusion-Residue calculator

Quit



# LISE++ porting schedule



Left: Fission, fusion, AF, Secondary reactions, reactions in material

Ksenia: next week

Oleg: next week

Finish the Physical Calculator

Oleg: next week