PCGrate® v.6.7.1

International Intellectual Group Inc. (I.I.G., Inc.)

is a world leader in modeling of the diffraction gratings efficiency for spectroscopy, astronomy, telecommunications, photolithography, and nanotechnology

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PCGrate® Software Worldwide

- Company History
- PCGrate® Capabilities
- PCGrate® Results
- PCGrate® Advantages
- PCGrate® Distributors

Since our commercial debut, we sold more than 500 packages to recognized governmental & military laboratories, private companies, universities and research centers.

Company History

Our company has a wealth of experience in diffraction efficiency modeling of various types of relief and phase gratings. The most important outcome of our 30 years' work was the advent of PCGrate®, a modeling tool for analysis and optimization of the absolute diffraction gratings efficiency by an accurate boundary integral equation method. Development of such sophisticated software became possible as a result of the multidisciplinary collaboration between many experts in the domains of theoretical physics, applied mathematics, and computer science.

All that time our team has been working in collaboration with world-leading manufactures of ruled and holographic diffraction gratings, as well as with governmental laboratories and private companies. The PCGrate (earlier known as ProGrate and PC Grate) team was the first to create commercially available, PC-oriented software for exact analysis and optimization of the efficiency of relief and phase gratings. In 1989 the first PCGrate worked well enough under DOS on a PC/AT (or even XT!) with only 640 KB of RAM.

Today optical engineers and scientists all over the world make use of PCGrate®-S(X)™ codes as a research tool to simulate spectroscopic and micro/nano-electronic & photonic systems.

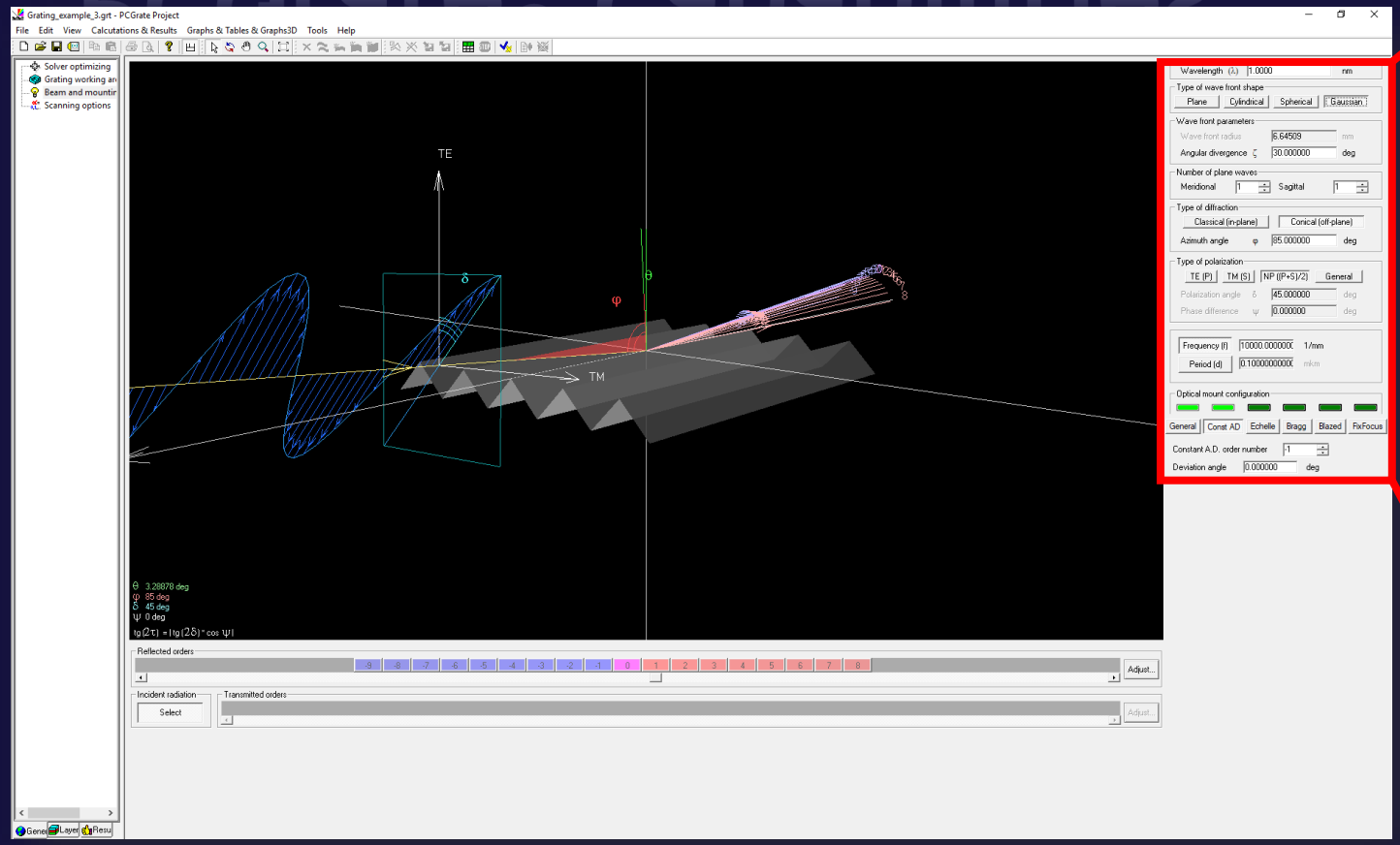
Company History

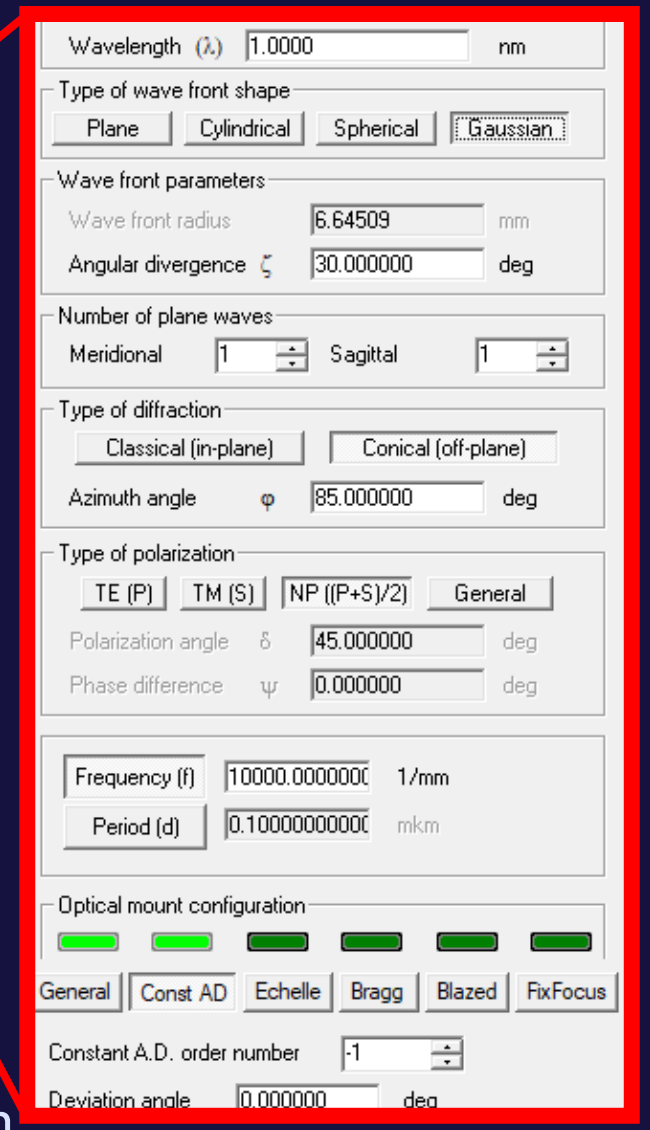
Our specialists live in Russia, United States, Canada, and Germany. We implement a true international cooperation, regularly perform distributed project development via the internet, and partly place our R&D orders in well-established companies. We are open to any questions or proposals pertaining to related scientific research and software development. Our experts take active part in various international conferences/projects and publish many articles in prestigious scientific journals.

The prime object of our activity is to bridge the gap between theory and experiment for all types of gratings, and to provide researchers with more versatile tools and methods for increasing performance of the next generation of photonics devices. That also becomes possible owing to our collaborators from:

- **NASA GSFC**
- **NRL Space Science Division**
- **Richardson Gratings of Newport Corp.**
- **Laurence Berkeley National Laboratory**

PCGrate® Capabilities

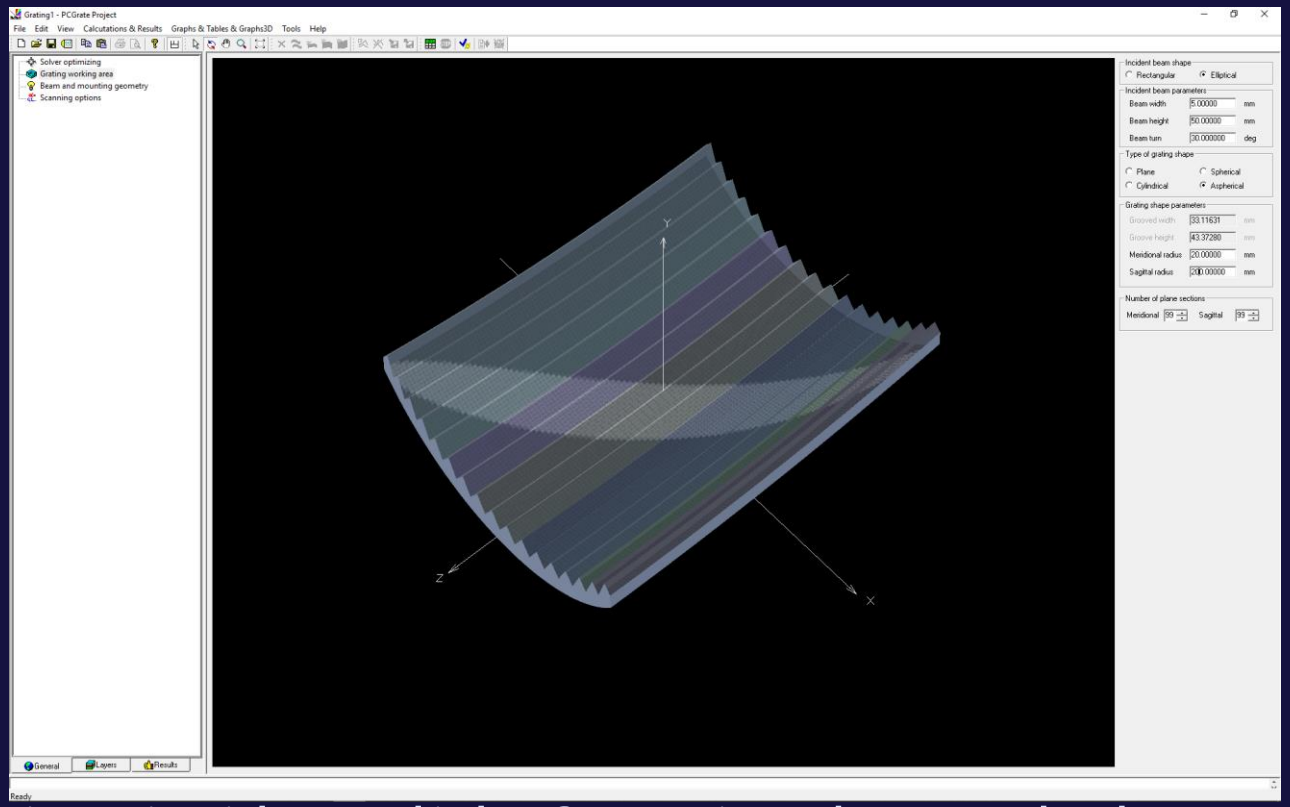


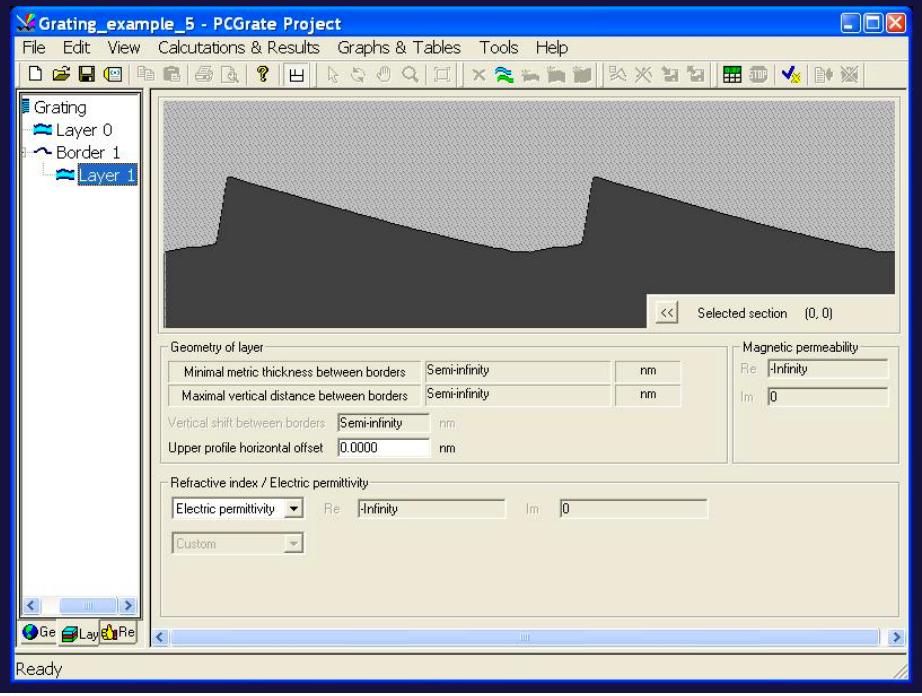


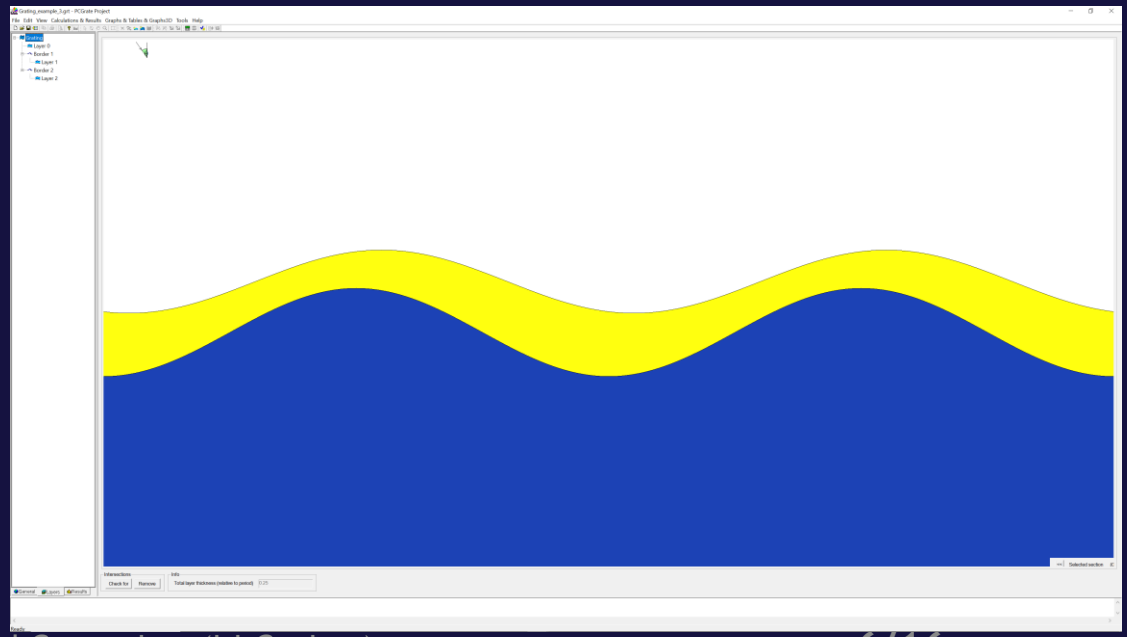
PCGrate® programs enable the user to accurately solve periodic boundary value problems*, which describe the incidence of a light beam on the relief or phase diffraction grating, zone plate & rough mirror.

*Goray, L. I. & Schmidt, G. (2014). In *Gratings: Theory and Numerical Applications*, E. Popov, ed., Ch.12: https://www.fresnel.fr/files/gratings/Second-Edition/Chapter12.pdf

PCGrate® Capabilities





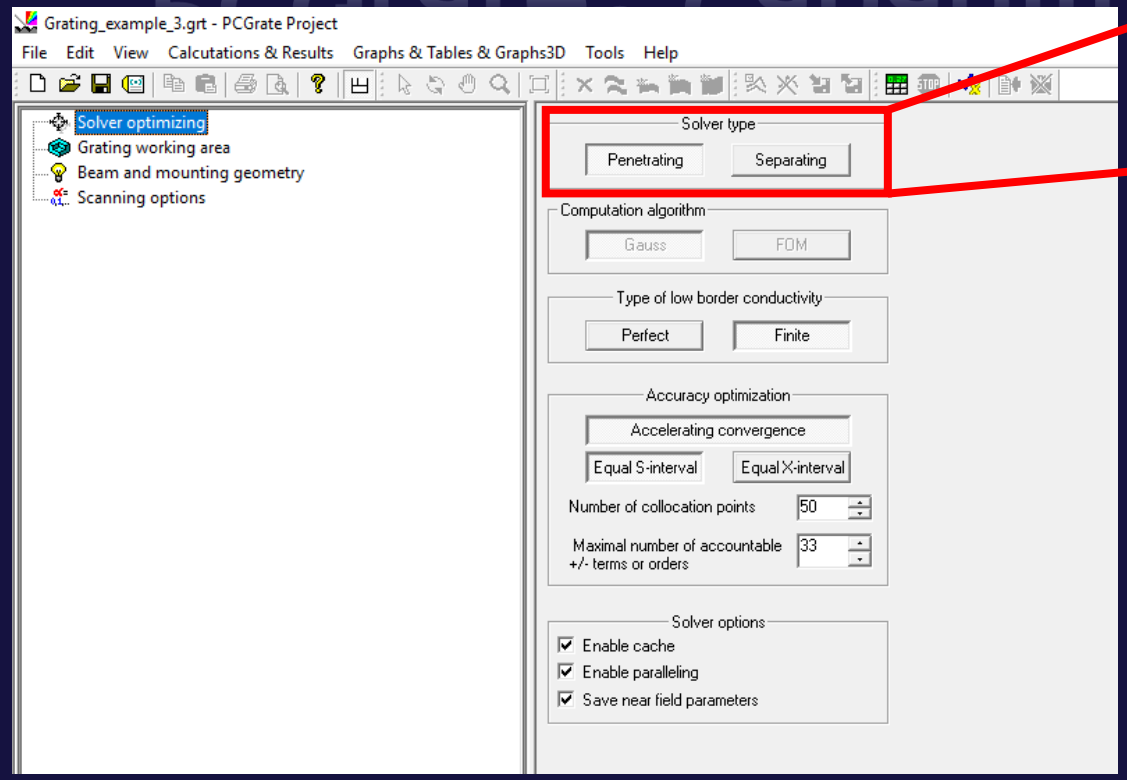


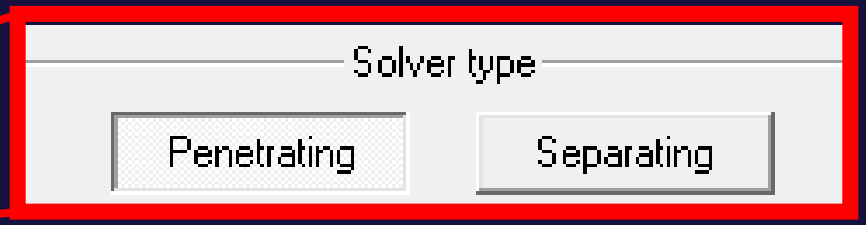
Various incidence light & grating shape calculus including:

- Non-planar incident waves and concave/convex grating shapes;

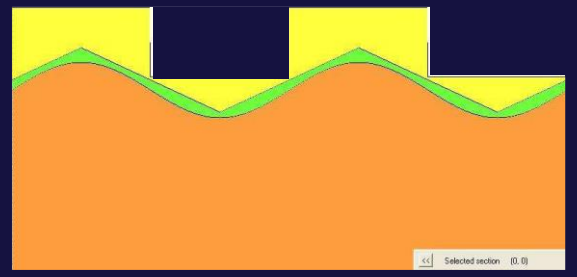
- Many-shaped, with non-conformal and non-function border profiles.

PCGrate® Capabilities

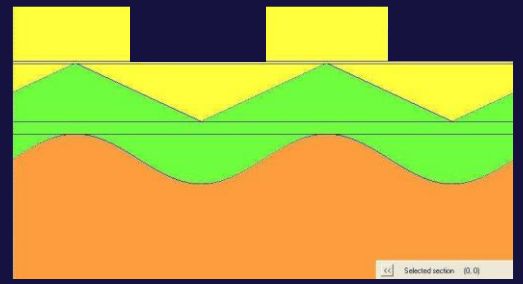




A multi-boundary grating model which can be calculated with the Penetrating solver only



A multi-boundary grating model with plain gaps between two adjacent corrugated regions



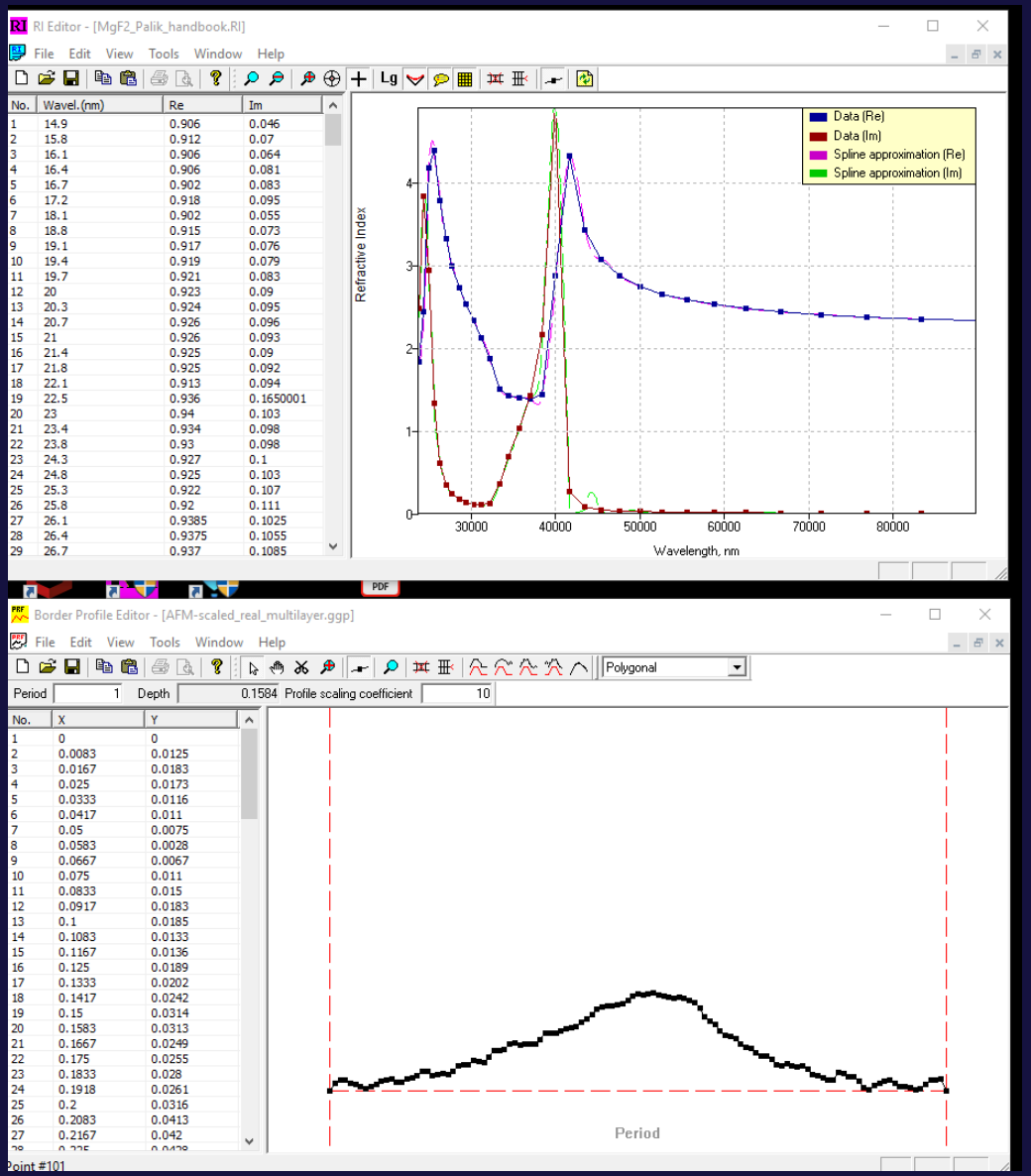
There are two types of solvers available in **PCGrate**®, i.e. ***Penetrating*** and ***Separating***. The solvers have different behavior and mutually complementary capabilities for many difficult cases such as coated gratings with thin layers, randomly rough periodical or non-periodical structures, grazing incidence, and photonic crystals.

PCGrate® Capabilities

PCGrate® software also includes two separate applications:

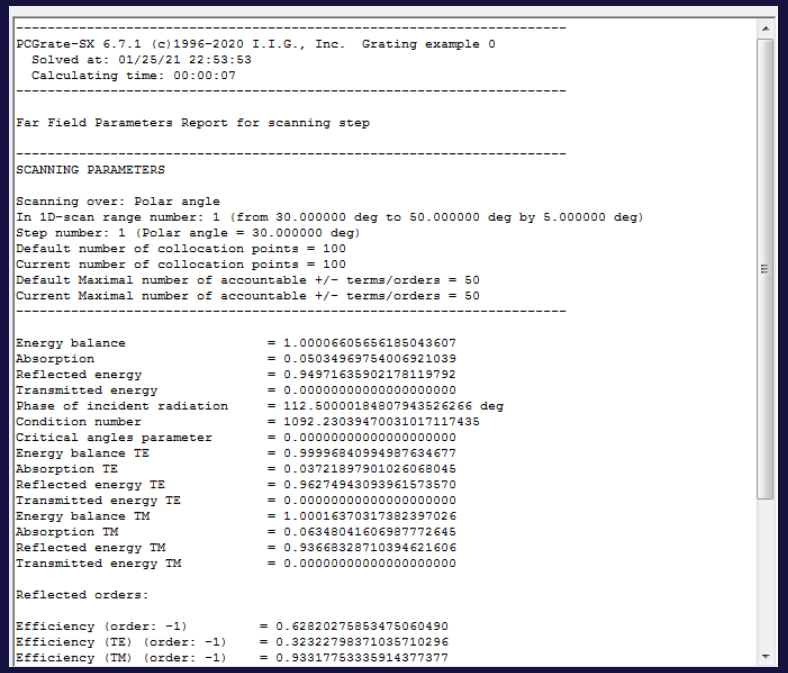
- Refractive Index Editor is a tool for working with Refractive Indices Libraries. You can create new libraries, view their contents, edit them, and import/export them. It has a multiple document interface, i.e. you can open as many documents for editing as you wish.
- Border Profile Editor is a tool that enables you to edit the files that contain border profile functions of grooves.

RI & Border Profile Editors:

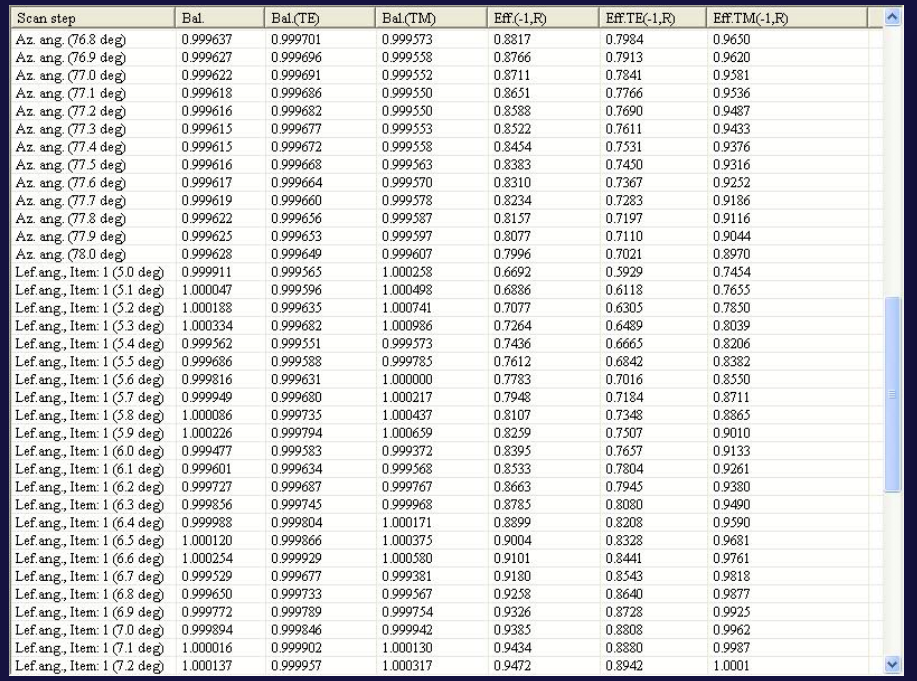


PCGrate® Results

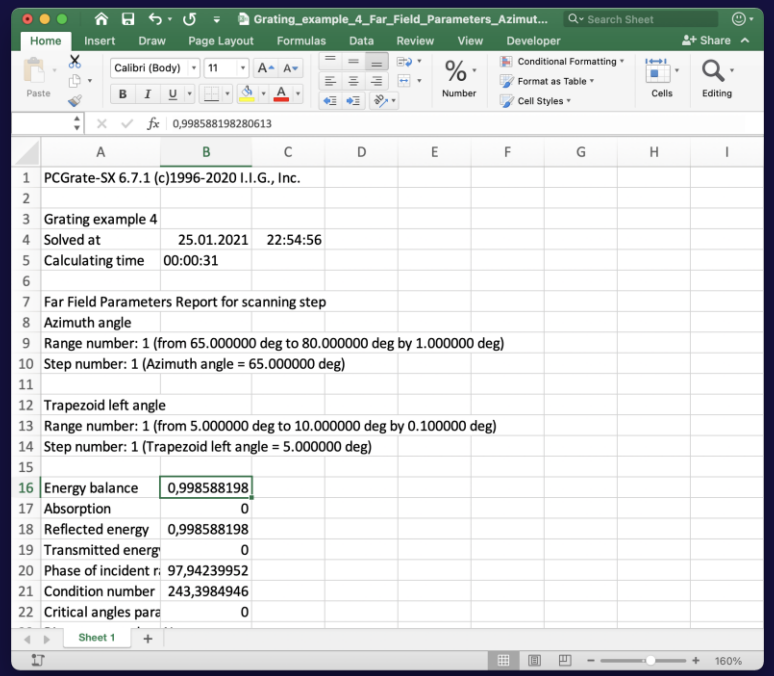
There are a lot of output formats:



```
------------------------------------------------------------------------
PCGrate-SX 6.7.1 (c)1996-2020 I.I.G., Inc.  Grating example 0
  Solved at: 01/25/21 22:53:53
  Calculating time: 00:00:07
------------------------------------------------------------------------

Far Field Parameters Report for scanning step

------------------------------------------------------------------------
SCANNING PARAMETERS

Scanning over: Polar angle
In 1D-scan range number: 1 (from 30.000000 deg to 50.000000 deg by 5.000000 deg)
Step number: 1 (Polar angle = 30.000000 deg)
Default number of collocation points = 100
Current number of collocation points = 100
Default Maximal number of accountable +/- terms/orders = 50
Current Maximal number of accountable +/- terms/orders = 50
------------------------------------------------------------------------

Energy balance                  = 1.0000660565618504 3607
Absorption                      = 0.0503496975400692 1039
Reflected energy                = 0.9497163590217811 9792
Transmitted energy              = 0.0000000000000000 0000
Phase of incident radiation     = 112.5000018480794352 6266 deg
Condition number                = 1092.2303947003101711 7435
Critical angles parameter       = 0.0000000000000000 0000
Energy balance TE               = 0.9999684099498763 4677
Absorption TE                   = 0.0372189790102606 8045
Reflected energy TE             = 0.9627494309396157 3570
Transmitted energy TE           = 0.0000000000000000 0000
Energy balance TM               = 1.0001637031738239 7026
Absorption TM                   = 0.0634804160698777 2645
Reflected energy TM             = 0.9366832871039462 1606
Transmitted energy TM           = 0.0000000000000000 0000

Reflected orders:

Efficiency (order: -1)          = 0.6282027585347506 0490
Efficiency (TE) (order: -1)     = 0.3232279837103571 0296
Efficiency (TM) (order: -1)     = 0.9331775333591437 7377
```



Scan step	Bal.	Bal.(TE)	Bal.(TM)	Eff.(-1,R)	Eff.TE(-1,R)	Eff.TM(-1,R)
Az. ang. (76.8 deg)	0.999637	0.999701	0.999573	0.8817	0.7984	0.9650
Az. ang. (76.9 deg)	0.999627	0.999696	0.999558	0.8766	0.7913	0.9620
Az. ang. (77.0 deg)	0.999622	0.999691	0.999552	0.8711	0.7841	0.9581
Az. ang. (77.1 deg)	0.999618	0.999686	0.999550	0.8651	0.7766	0.9536
Az. ang. (77.2 deg)	0.999616	0.999682	0.999550	0.8588	0.7690	0.9487
Az. ang. (77.3 deg)	0.999615	0.999677	0.999553	0.8522	0.7611	0.9433
Az. ang. (77.4 deg)	0.999615	0.999672	0.999558	0.8454	0.7531	0.9376
Az. ang. (77.5 deg)	0.999616	0.999668	0.999563	0.8383	0.7450	0.9316
Az. ang. (77.6 deg)	0.999617	0.999664	0.999570	0.8310	0.7367	0.9252
Az. ang. (77.7 deg)	0.999619	0.999660	0.999578	0.8234	0.7283	0.9186
Az. ang. (77.8 deg)	0.999622	0.999656	0.999587	0.8157	0.7197	0.9116
Az. ang. (77.9 deg)	0.999625	0.999653	0.999597	0.8077	0.7110	0.9044
Az. ang. (78.0 deg)	0.999628	0.999649	0.999607	0.7996	0.7021	0.8970
Lef.ang., Item: 1 (5.0 deg)	0.999911	0.999565	1.000258	0.6692	0.5929	0.7454
Lef.ang., Item: 1 (5.1 deg)	1.000047	0.999596	1.000498	0.6886	0.6118	0.7655
Lef.ang., Item: 1 (5.2 deg)	1.000188	0.999635	1.000741	0.7077	0.6305	0.7850
Lef.ang., Item: 1 (5.3 deg)	1.000334	0.999682	1.000986	0.7264	0.6489	0.8039
Lef.ang., Item: 1 (5.4 deg)	0.999562	0.999551	0.999573	0.7436	0.6665	0.8206
Lef.ang., Item: 1 (5.5 deg)	0.999686	0.999588	0.999785	0.7612	0.6842	0.8382
Lef.ang., Item: 1 (5.6 deg)	0.999816	0.999631	1.000000	0.7783	0.7016	0.8550
Lef.ang., Item: 1 (5.7 deg)	0.999949	0.999680	1.000217	0.7948	0.7184	0.8711
Lef.ang., Item: 1 (5.8 deg)	1.000086	0.999735	1.000437	0.8107	0.7348	0.8865
Lef.ang., Item: 1 (5.9 deg)	1.000226	0.999794	1.000659	0.8259	0.7507	0.9010
Lef.ang., Item: 1 (6.0 deg)	0.999477	0.999583	0.999372	0.8395	0.7657	0.9133
Lef.ang., Item: 1 (6.1 deg)	0.999601	0.999634	0.999568	0.8533	0.7804	0.9261
Lef.ang., Item: 1 (6.2 deg)	0.999727	0.999687	0.999767	0.8663	0.7945	0.9380
Lef.ang., Item: 1 (6.3 deg)	0.999856	0.999745	0.999968	0.8785	0.8080	0.9490
Lef.ang., Item: 1 (6.4 deg)	0.999988	0.999804	1.000171	0.8899	0.8208	0.9590
Lef.ang., Item: 1 (6.5 deg)	1.000120	0.999866	1.000375	0.9004	0.8328	0.9681
Lef.ang., Item: 1 (6.6 deg)	1.000254	0.999929	1.000580	0.9101	0.8441	0.9761
Lef.ang., Item: 1 (6.7 deg)	0.999529	0.999677	0.999381	0.9180	0.8543	0.9818
Lef.ang., Item: 1 (6.8 deg)	0.999650	0.999733	0.999567	0.9258	0.8640	0.9877
Lef.ang., Item: 1 (6.9 deg)	0.999772	0.999789	0.999754	0.9326	0.8728	0.9925
Lef.ang., Item: 1 (7.0 deg)	0.999894	0.999846	0.999942	0.9385	0.8808	0.9962
Lef.ang., Item: 1 (7.1 deg)	1.000016	0.999902	1.000130	0.9434	0.8880	0.9987
Lef.ang., Item: 1 (7.2 deg)	1.000137	0.999957	1.000317	0.9472	0.8942	1.0001

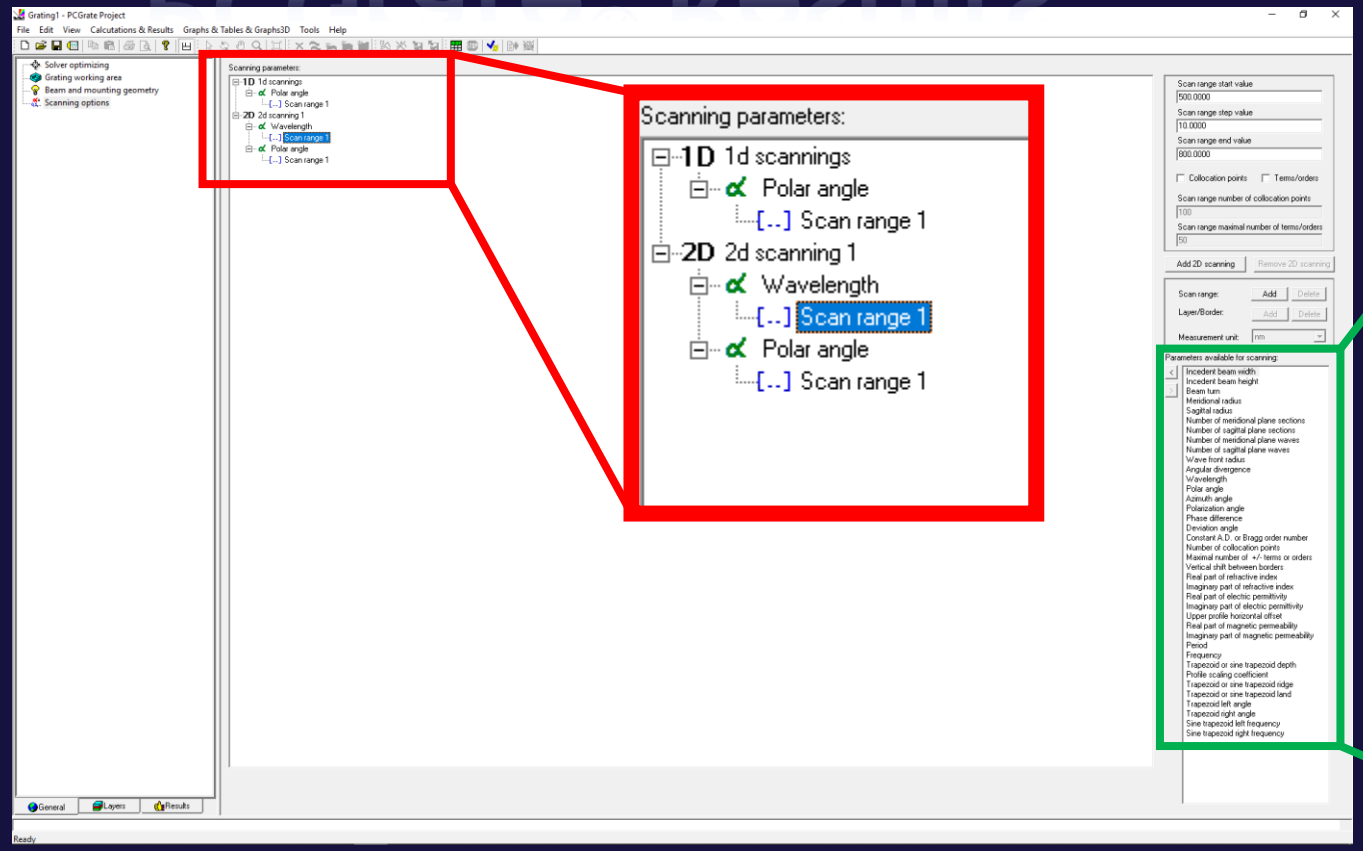


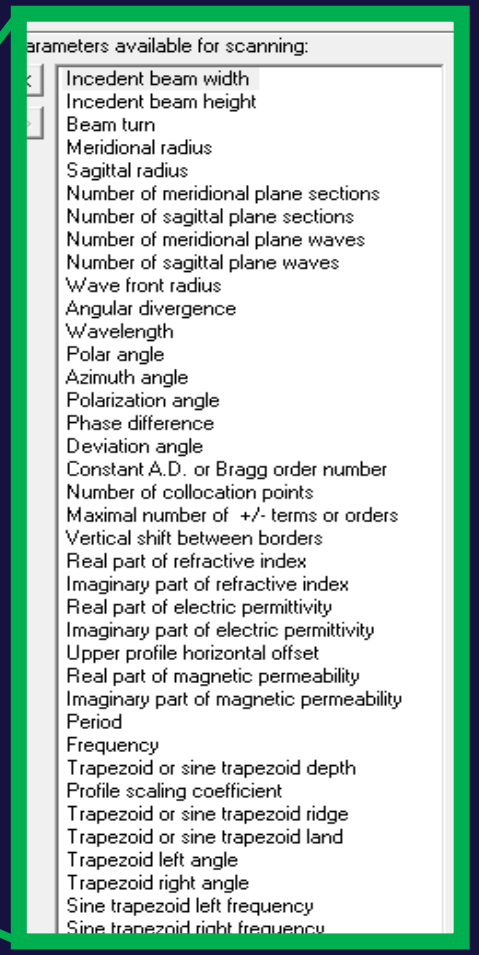
Grating_example_4_Far_Field_Parameters_Azimut...

	A	B	C
1	PCGrate-SX 6.7.1 (c)1996-2020 I.I.G., Inc.		
2			
3	Grating example 4		
4	Solved at	25.01.2021	22:54:56
5	Calculating time	00:00:31	
6			
7	Far Field Parameters Report for scanning step		
8	Azimuth angle		
9	Range number: 1 (from 65.000000 deg to 80.000000 deg by 1.000000 deg)		
10	Step number: 1 (Azimuth angle = 65.000000 deg)		
11			
12	Trapezoid left angle		
13	Range number: 1 (from 5.000000 deg to 10.000000 deg by 0.100000 deg)		
14	Step number: 1 (Trapezoid left angle = 5.000000 deg)		
15			
16	Energy balance	0,998588198	
17	Absorption	0	
18	Reflected energy	0,998588198	
19	Transmitted energ	0	
20	Phase of incident r	97,94239952	
21	Condition number	243,3984946	
22	Critical angles para	0	

Results can be presented in any convenient format: classical text reports, Tables, and 2D or 3D Plots. Obtained results can be also exported to *.csv* or *MS Excel*® formats.

PCGrate® Results



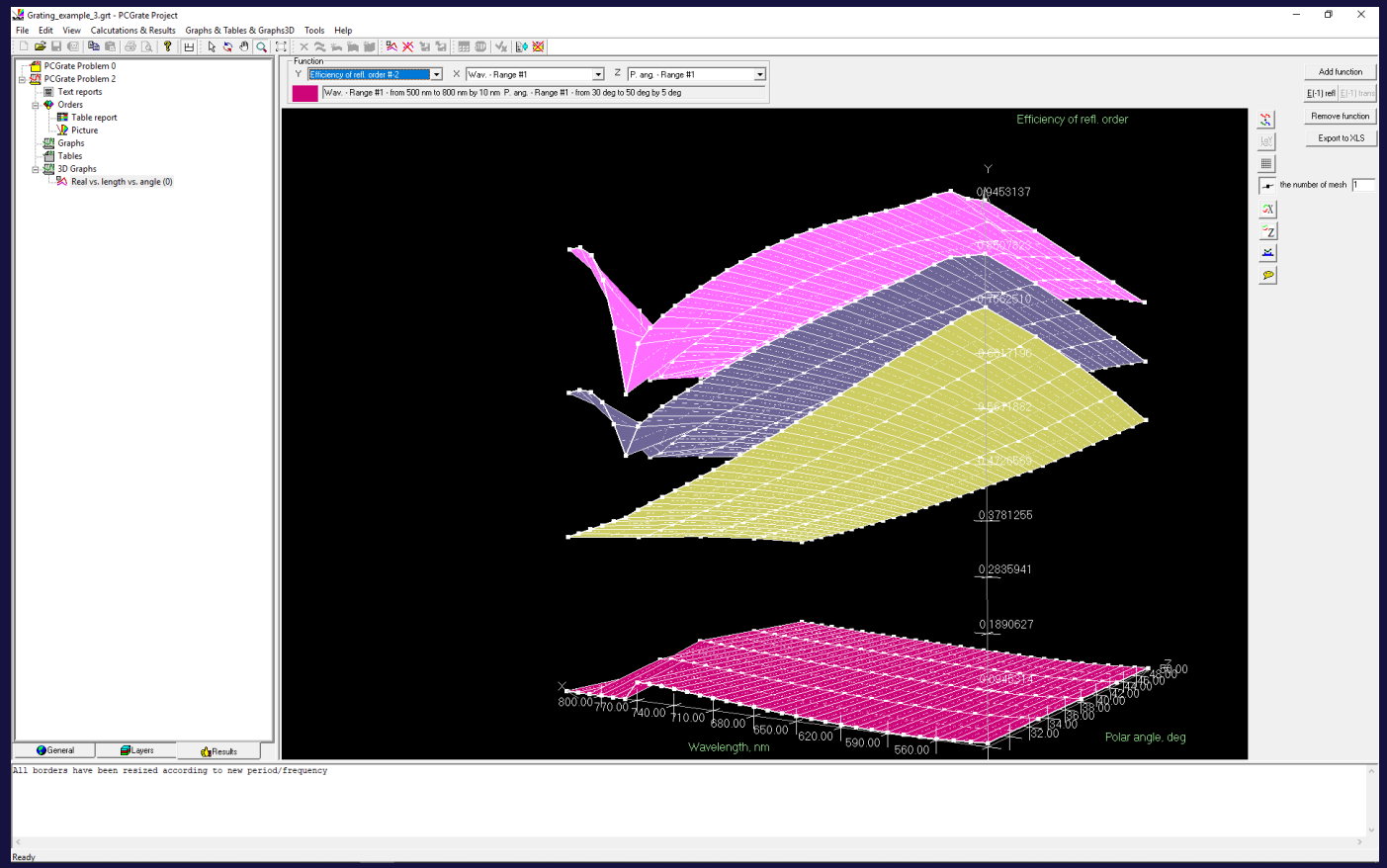


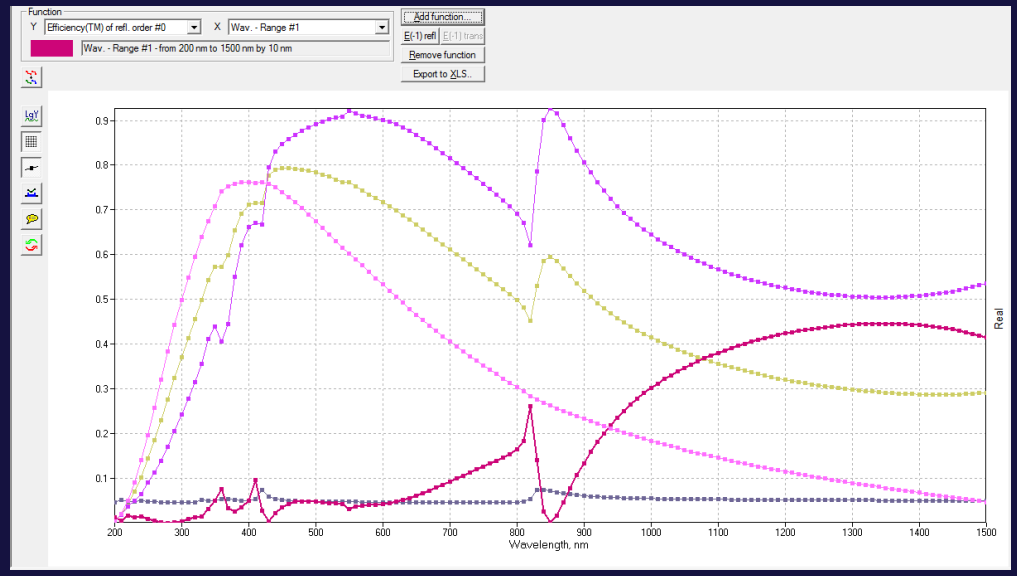
2d- & 1d-scannings include a wide range of scanning parameters.

PCGrate® includes 2d scanning & 3d efficiency plots. 2d scanning allows one to vary two independent parameters together to solve grating efficiency tasks.

PCGrate® Results

3d & 2d efficiency plots allow one to visualize the results obtained with 2d & 1d scannings.





PCGrate® uses modern Graphical User Interface with 3d and 2d Open GL graphs.

PCGrate® Advantages

Our codes are indispensable for efficiency calculations in the following problems:

-The x-ray–EUV range and very small wavelength-to-period ratios.

- Echelles and grisms at diffraction order numbers ranging from low to very high (thousands).
- Taking rigorously into account periodical and random roughnesses of any kinds.
- Rigorously accounting diffuse light intensity (ghosts and scattering).
- Pulse compression and high conductivity.
- 1-D & 2-D photonic crystals and multilayers with rough and non-conformal borders.
- Very deep reflection and transmission grooves (aspect ratios up to hundreds).
- Non-planar incident waves and concave/convex grating shapes.
- Any polarization states and other fine peculiarities.

The codes are especially convenient and accurate for modeling with the real border profile function. An example of this type is the case of groove profiles determined by: an atomic-force microscope (AFM), a transmission electron microscope (TEM), a micro-interferometer, a stylus profilometer, and also by indirect methods like actual growth modeling, etc.

PCGrate® Advantages

The PCGrate®-S(X)™ v. 6.7.1 32/64-bit series available for Windows OS machines from Windows Vista™ to Windows 10.

Key parameter	PCGrate®-S™ v.6.7.1	PCGrate®-SX™ v.6.7.1
Wavelength	From x-rays to meters	
Minimal wavelength-to-period ratio	0.02	2e-13
Diffraction order range	± 100	± 10000
Maximal number of layers	20	10000
Non-periodical structures, non-function border profiles & photonic crystals	Yes	
Rigorously accounting random roughness	Yes	
Gaussian beams, concave/convex & VLS gratings	Yes	

PCGrate® Interface types

Interface type availability	XML	GUI	Complete
Graphical User Interface	No	Yes	Yes
Command Line Interface	Yes	No	Yes

PCGrate® Advantages

There are two types of PCGrate® licenses available:

Key parameter	Permanent	Perpetual
Upgrades	Not included	Included
Tech support	1 year	2 years
Key types	USB and SL	SL only

PCGrate® Distributors

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