Note.
It is only the brief description.
More detailed description can be downloaded at www.alphysica.com.
The comprehensive user manual will be supplied with paid software.

VENECIA

SOFTWARE PACKAGE
FOR THERMAL HYDRAULIC ANALYSIS OF
FORCED FLOW COOLED SUPERCONDUCTING MAGNETS
AND THEIR PRIMARY CRYOGENIC SUBSYSTEMS

BRIEF DESCRIPTION

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Karlsruhe

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INTRODUCTION

The software package **VENECIA** is the next generation of the code Vincenta. **VENECIA** offers more flexible and general application and significant innovations given rise from 10 years experience of thermal hydraulic simulations for large magnet systems (ITER, KSTAR, JT-60) and validation of code by cryogenic tests of Central Solenoid Model Coil for ITER.

APPLICATIONS

VENECIA is applicable for thermohydraulic studies for a wide range of devices including:

- thermonuclear facilities;
- accelerators and transport systems, MRI-magnets;
- superconducting motors, generators and storage rings;
- experimental and diagnostic devices for scientific research;
- generators, SMES, cryopumps;
- superconducting cables and joints,
- components of magnet primary cryogenic circuits (rotary machine for forced flow cooling, cold vapor compressors, force flow heat exchangers, bath with boiling coolant, long coolant transfer lines and control/relief valves).

VENECIA enables numerical simulation of transient behavior of superconducting magnet systems as whole making allowance for:

- real geometry of magnet structure
- real nonlinear properties of materials
- real coolant properties
- real cryogenic accessories.

Efficient and adequate simulation is possible for both “short” transients (stability and quench of conductors etc.) and "long" transients (normal operation, warm up etc.).

VENECIA has benefits of an enhanced modular architecture and database approach. Each module implies a generalized algorithm for different calculation/modeling/control options. Particularly, complex schematics are implemented for a primary cryogenic circuit that allows different modifications of control and adjustment of cryogenic parameters.
The software is now capable of simulation of up to 5 different fluids simultaneously within a single model. Databases of thermodynamic and kinetic properties of most conventional cryogenic fluids are available as external database file in the unified tabular format. The helium properties database is expanded to supercritical, superfluid and two-phase states on the basis REFPROP data (NIST). Additional databases can be synthesized from universally recognized data sources, such as CRYOSOFT GASPAK.

Due to extended functionality, **VENECIA** offers efficient solution for some intricate aspects of thermohydraulic analysis, including:

- Simulations of coolant transients in superconducting magnets and their primary forced flow cryogenic circuit that includes helium circulators and cold vapor compressors for decreasing the operating temperature down to 1.8K.
- Stability and normal zone propagation studies, analysis of nominal cooling conditions, and emergency situations similar to quench resulted in realise of large quantity of coolant from the magnets.
- Prediction of heat load variations on the cryoplant from magnets, active mitigation of these heat variations and analysis of flow transients at inlets of rotary machines for forced flow cooling of magnets (circulator) and cold compressors for decreasing of operating temperature.

Minimal requirements:

- Intel Pentium IV, 1Gb RAM
- Microsoft Windows XP or higher

VENECIA VERSIONS

There are three VENECIA versions:

1) VENECIA DEMO: ADJUSTABLE EXAMPLES (hereinafter referred to as VENECIA DEMO)

2) VENECIA Light

3) Venecia Full

VENECIA DEMO.

VENECIA DEMO is a free of charge software. The VENECIA DEMO contains trial examples to demonstrate principal features and benefits of the code. The trial examples are composed so as to demonstrate key capabilities and benefits of VENECIA simulation.

The hydraulic schematics and basic parameters in the trial examples are fixed:

DEMO1	DEMO2
▪ Channel lenghts	▪ Max. pump capacity
▪ Max. heat-transfer coefficient for Channel 1	▪ Channel lengths
▪ Initial field in conductor	
▪ Heater power Q_x	
▪ Heat pulse duration	
▪ Safety valves opening	
▪ Volumes #1-3	
DEMO 3	DEMO 4
▪ Max. number of channels is 68	▪ Computation starts after 3600 sec.
▪ Max. number of conductors is 68	▪ Max. computation time is 10,2 sec.
▪ Fixed lengths of channels #1, 2, 3, 19	▪ Min. volume of V289 is 700m^3
▪ Min. volume of V21, 23, 67 is 1000m^3	▪ Max. number of nodles in the channel 765 is 220

User can change an input data of the examples to evaluate an adequacy of code. The results of trial examples are illustrative and do not claim to be precise. In particular, the mesh used in DEMO1 is rather rough for satisfactory approximation of transition zones where He II transforms to He I and saturated liquid He I transforms to saturated vapour. To achieve good approximation of properties near the normal zone boundary and improve integral convergence the mesh size should be fined by approximately 10 times (up to 0.01 m).

VENECIA DEMO does not allow the user any changes of the design of cryogenic system in the trial examples. Other restrictions of the VENECIA DEMO are mentioned in the chapters describing different VENECIA DEMO modules.

The trial examples for VENECIA DEMO were choosen from fusion researches as the most complicated research area in comparing with other VENECIA's applications. Full description of the examples DEMO1, DEMO2, DEMO3, DEMO4 see at www.alphysica.com/demoversion.php

VENECIA Light

VENECIA Light allows the user to design a cryogenic system. Several restrictions of the VENECIA Light are listed in the end of this document. VENECIA Light can be provided with additional options, that user informs to ALPHYSICA GmbH (shatil@alphysica.com). Minimal configuration of VENECIA Light costs from 6.700 Euro.

VENECIA Full

VENECIA Full provides complete functionality and includes all options listed in the end of this document. On demand can be added other options required by user. The price of VENECIA Full to be defined on demand also.

HOW TO WORK WITH VENECIA?

VENECIA FILE STRUCTURE.

VENECIA Demo includes the following files:

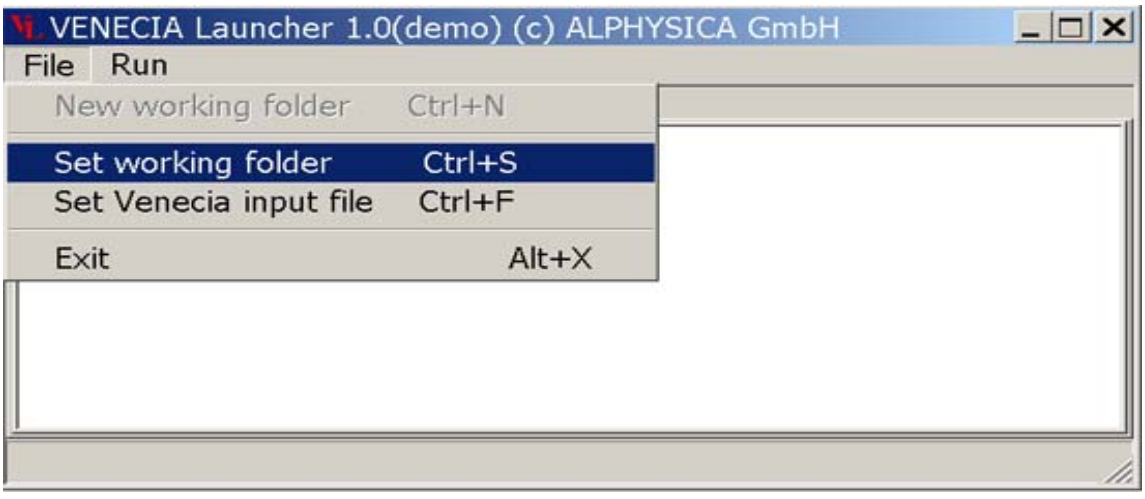
- executable VENECIA.EXE
- run-time monitor VV_1.35.EXE
- 2D viewer V2DV.EXE
- data converter for 2D viewer MkMap.exe
- data converter for Visio
- data converter for Excel
- helium property database HELIUM.BS
- list of coolant databases available BASES.IN
- solid material database VENECIA.MAT
- input data files for trial examples DEMO1.IN, DEMO2.IN and etc.
- description of the trial examples with statement, schematics, input data and some typical outputs DEMO1.PDF, DEMO2.PDF and etc.

File structures of VENECIA LIGHT and VENECIA FULL depend on configaration.

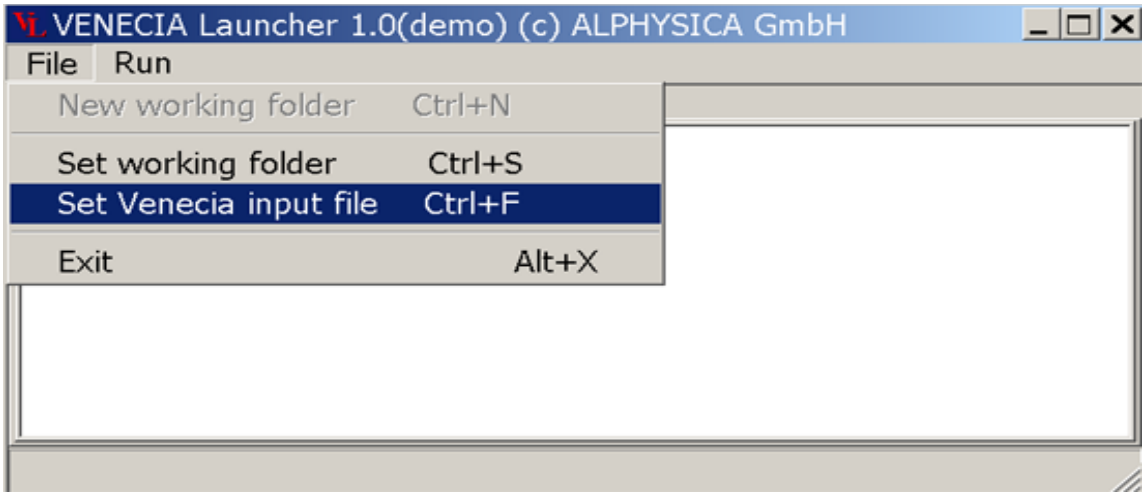
INPUT DATA.

The requirements for input data files are described in the user manual. For VENECIA DEMO all input data files (demo1.in, demo2.in and venecia.mat) are composed.

1. *Extract VeneciaDemo.exe*
2. *Launch Launcher_demo.exe*
3. *Select working folder (DEMOx)*

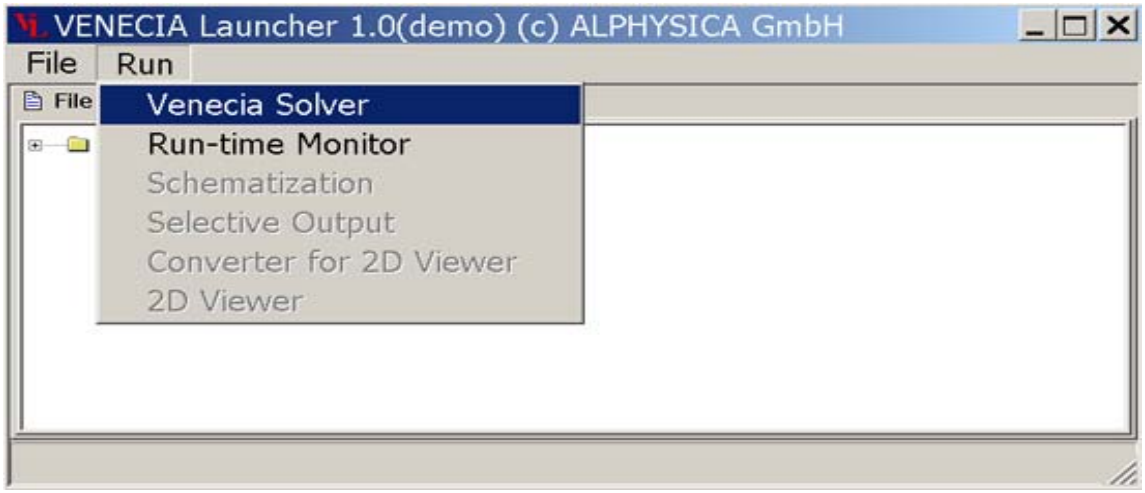


4. *Select input file (demo1.in, demo2.in, demo3A.in or demo4.in) from selected working folder:*

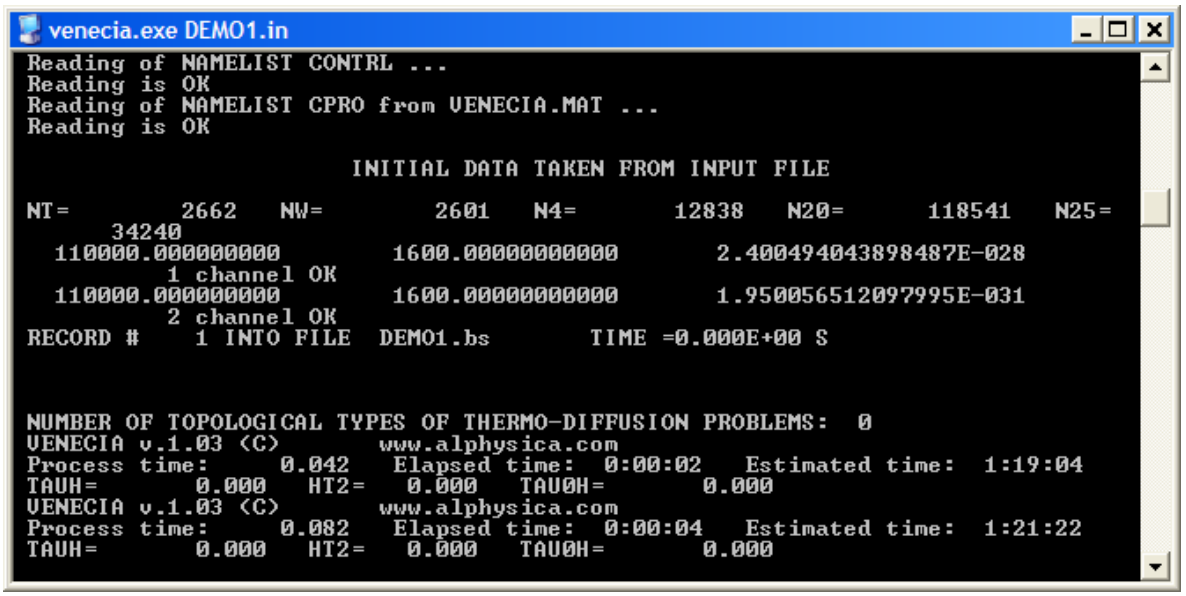


VENECIA MODULES.

1. THE MODULE "VENECIA Solver".



VENECIA Solver performs all calculations of selected input data file.



VENECIA DEMO RESTRICTION: estimated time does not includes elapsed time.

When running, VENECIA Demo generates 11 output files:

- VENECIA.CHK
- STR.GRF
- PLOT.GRF
- DEMO1.BS
- DEMO1.OUT
- DEMO1.PRN
- DEMO1W.PRN
- DEMO1CL.PRN
- DEMO1V.PRN

- DEMO1CH.PRN
- DEMO1CO.PRN

Note:

1. Except for the first three files VENECIA.CHK, STR.GRF, PLOT.GRF, the names of all other files are user-defined and specified in the input data file DEMO1.IN.
2. Similar output files are generated for the DEMO2 example.

- VENECIA.CHK contains a summary of inputs formatted for the ease of check up.
- DEMO1.BS stores unformatted current data for a set of time points to restart the simulation.
- DEMO1.OUT contains calculated results for the same stored time points as in DEMO1.BS but in a tabular format.
- STR.GRF and PLOT.GRF contain data for run-time plotting of main parameters with the viewer VV_1.35.EXE.
- The files *.PRN contain tabulated results that can be read and visualized with original VENECIA post processor (not included in VENECIA DEMO) or common commercial programs such as MS EXCEL.

DEMO1.PRN Tabulated outputs on coolant flows in Channels in 7-column format: pressure, velocity, temperature, density, convective heat, enthalpy, heat from 2D boundary.
First line format: Channel #, number of nodes, space step, cross-section area, wetted perimeter; twice current time points to fit the format

DEMO1W.PRN Tabulated outputs on Conductors in 5-column format: temperature, Joule heat, conductive heat, convective heat, heat load applied.
First line format: Conductor #, number of nodes, space step, cross-section area, current time

DEMO1V.PRN Tabulated outputs on Collectors in 10-column format: pressure, temperature, enthalpy, density, humidity, vapor enthalpy, vapor density, liquid density, total heat released in Collector, "smart" heater power.
Odd line format: Collector #, Collector volume, DVDP, P_0, P_1, TV2, SV2, ALFV2, twice current time points to fit the format

DEMO1CH.PRN Tabulated outputs on helium flows in Channel in 6-column format: Re, Pr, Alfa, fr_factor, gravity(m/s^2), humidity.
First line format: Channel #, number of nodes, space step, cross-section area, wetted perimeter; twice current time points to fit the format

DEMO1CO.PRN Tabulated outputs on Conductors in 9-column format: B(T), dB/dr(T/m), □[EPS], I_crit(A), I_op(A), T_c(K),

T_cs(K), T_cs – T_op(K), Econd(V/m).
First line format: Conductor #, number of nodes, space step, cross-section area, current time, current time, current time, current time, current time

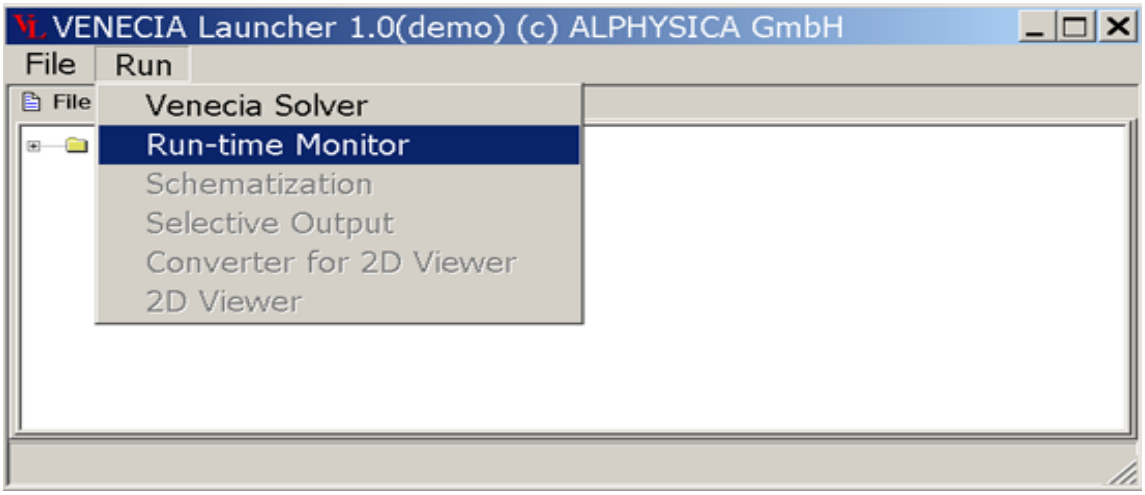
DEMO1CL.PRN Tabulated outputs on Valves in 6-column format:.
First line format: current time, Valve #, Opening area, pressure, mass flow rate, velocity.

2. THE MODULE "Run-time monitor".

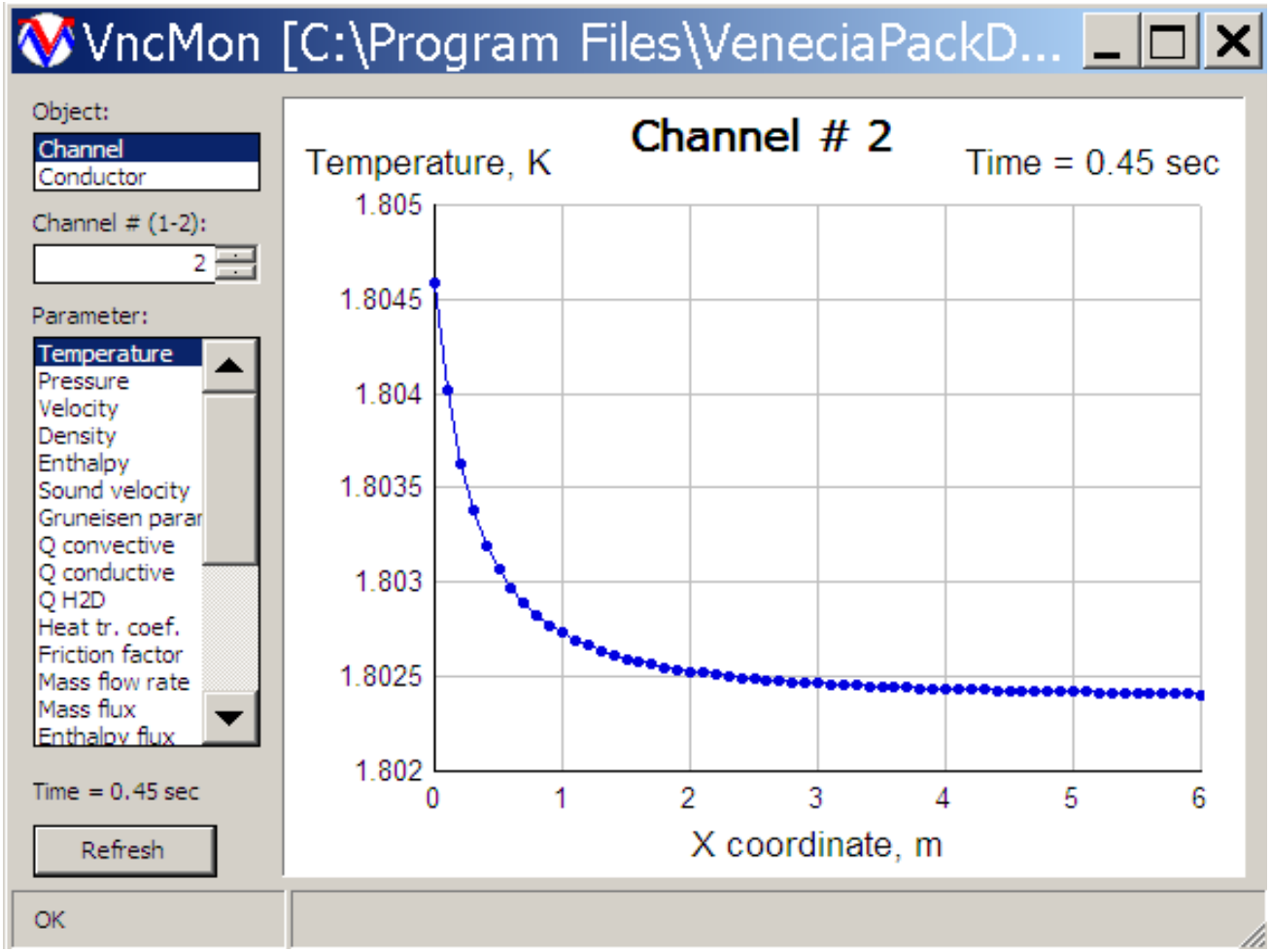
Run-time monitor allows the user to monitor in real time any changes of following key parameters:

Channel	**Conductor**
Temperature	Temperature
Pressure	Q-convective
Velocity	Q-conductive
Density	Q-Joule
Enthalpy	Q-external
Sound velocity	Electric field
Grun parameter	Magnetic field
Q-convective	dBdn
Q-conductive	strain
Q_H2D	
Heat tr. Coef.	
Frict. Factor	
Mass flow rate	
Mass flux	
Enthalpy flux	
Vapor quality	
Gravity	
Viscosity	
Conductivity	
Specific heat	
Re	
Pr	
Heat flux for He	
1/f for HeII	

2.1 Press "Run-time monitor" from menu "RUN":

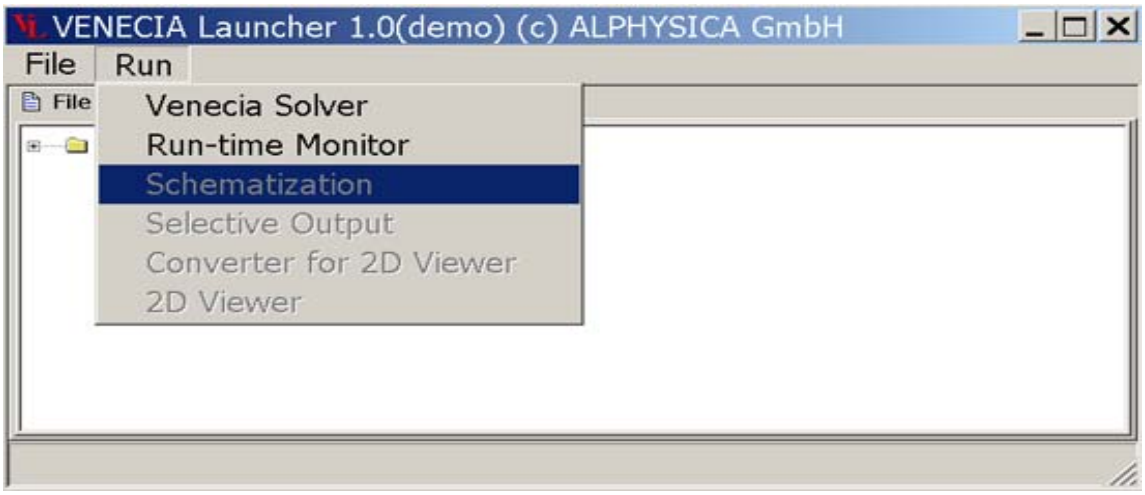


2.2. User can select to display key parameters of channel or conductor:

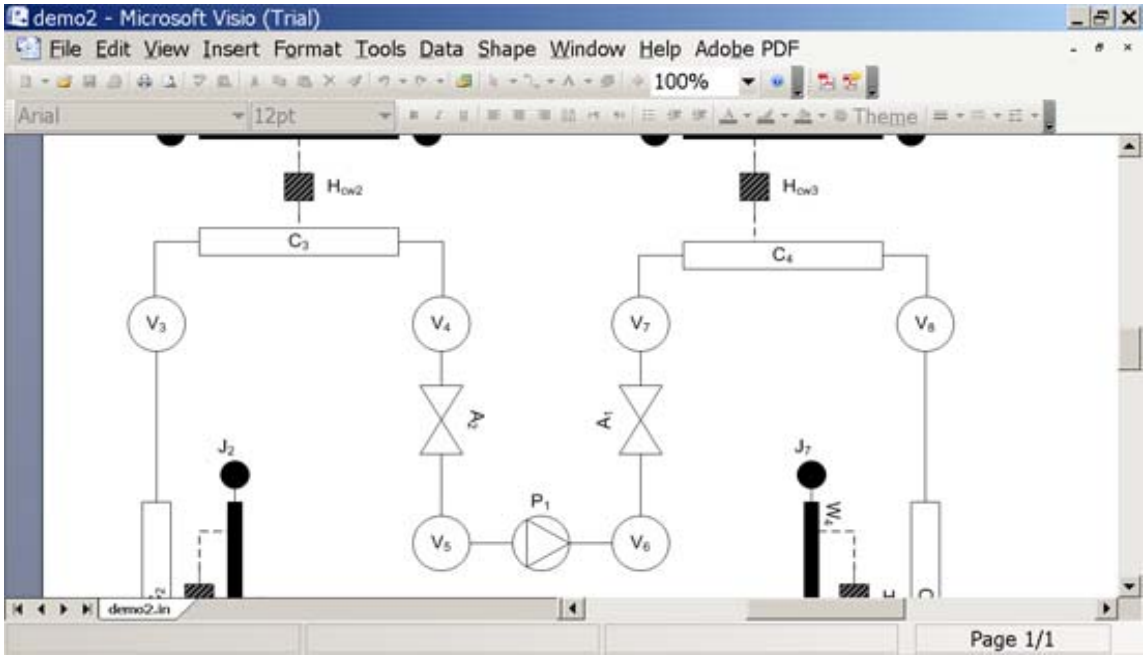


3. THE MODULE "SCHEMATIZATION" (**Inactive in VeneciaDemo**).

3.1 Select "Schematization" from "RUN" menu:



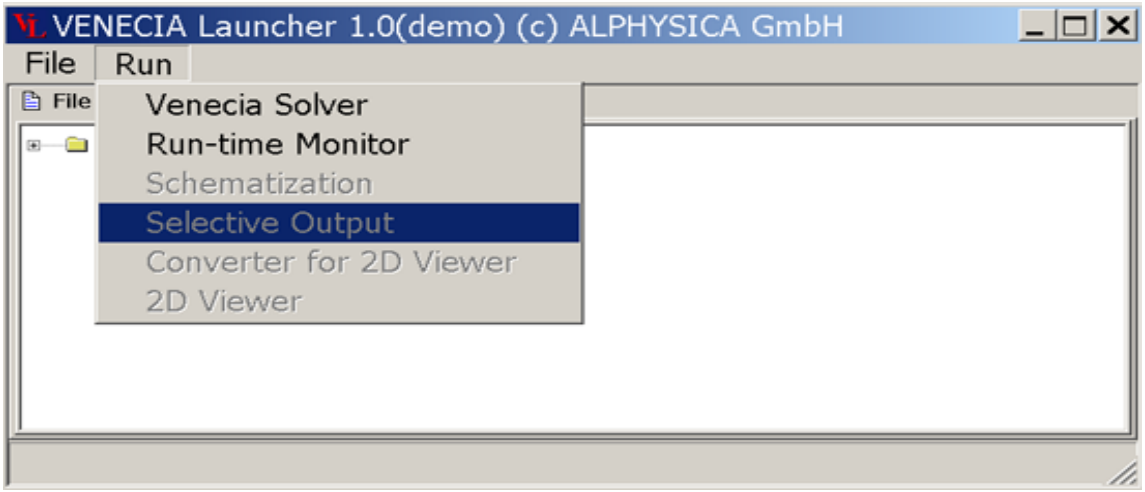
SCHEMATIZATION can be used to visualize as a layout in MS Visio[1] a cryogenic system described in the input file. This module creates a VNC2VDX.VDX for DEMOx that can be opened in MS Visio. The opened layout can be arranged during some minutes.



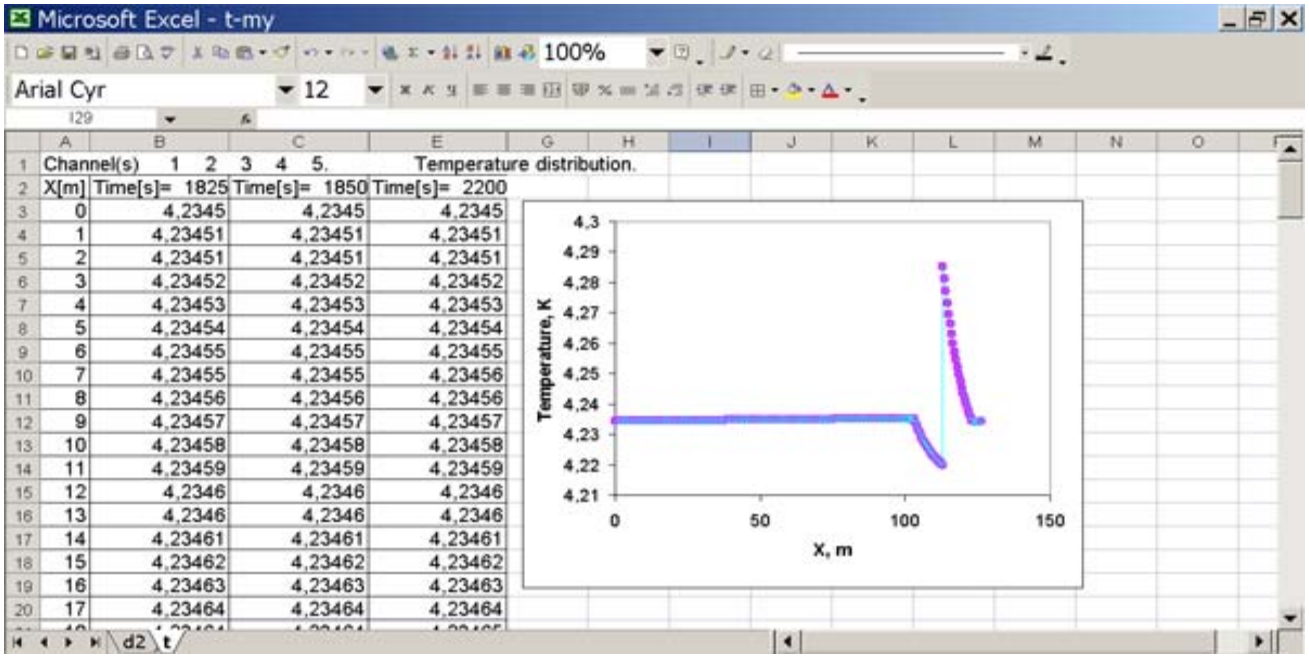
Fragment of the layout for DEMO2 (Microsoft Visio).

[1] Microsoft Vision can be downloaded at www.microsoft.com

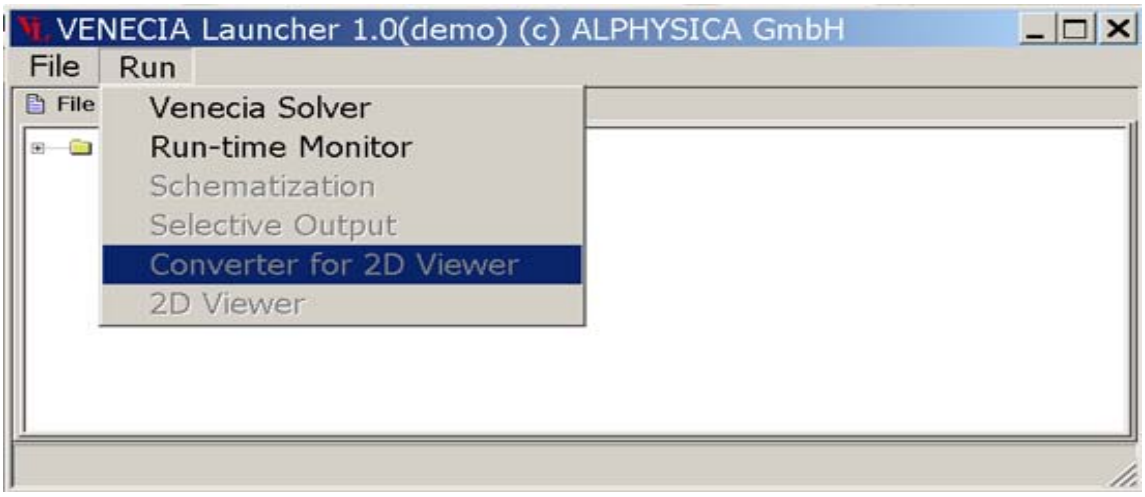
4. THE MODULE "SELECTVE OUTPUT" (**Inactive in VeneciaDemo**).



The module "SELECTIVE OUTPUT" allows to analyse in MS Excel a results of computations.



5. THE MODULE "CONVERTER FOR 2D VIEWER" (**Inactive in VeneciaDemo**)



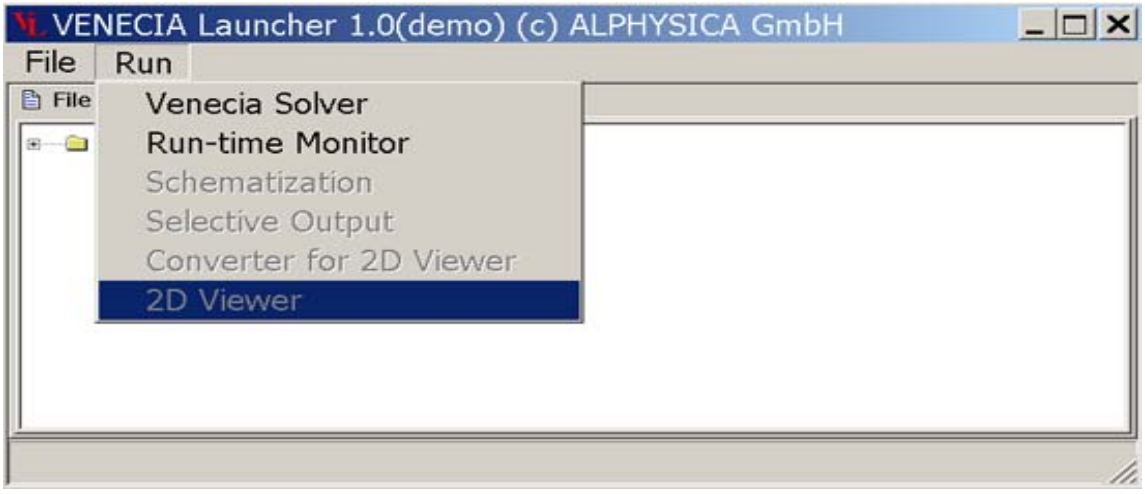
The modul "Converter for 2D Viewer" is necessary to convert VENECIA's output file to the format suitable to be viewed in built-in VENECIA's 2D Viewer.

After launching "Converter for 2D Viewer" will be created V2DV-files in the working folder for 2D Viewer.

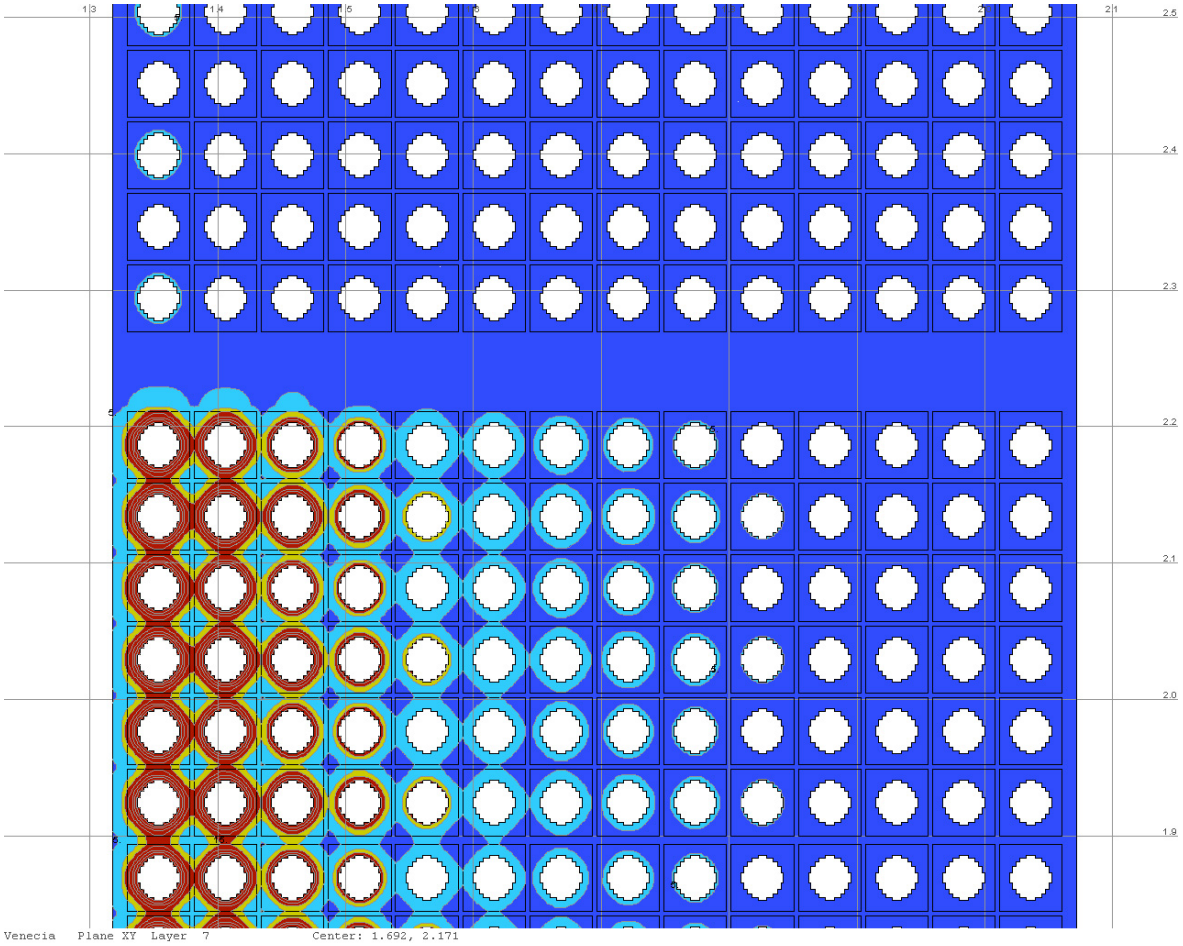
VENECIA DEMO RESTRICTION: Example DEMO1 has not 2D task, therefore only example DEMO2 can be implemented to 2D Viewer.

6. THE MODULE "2D Viewer" (**Inactive in VeneciaDemo**)

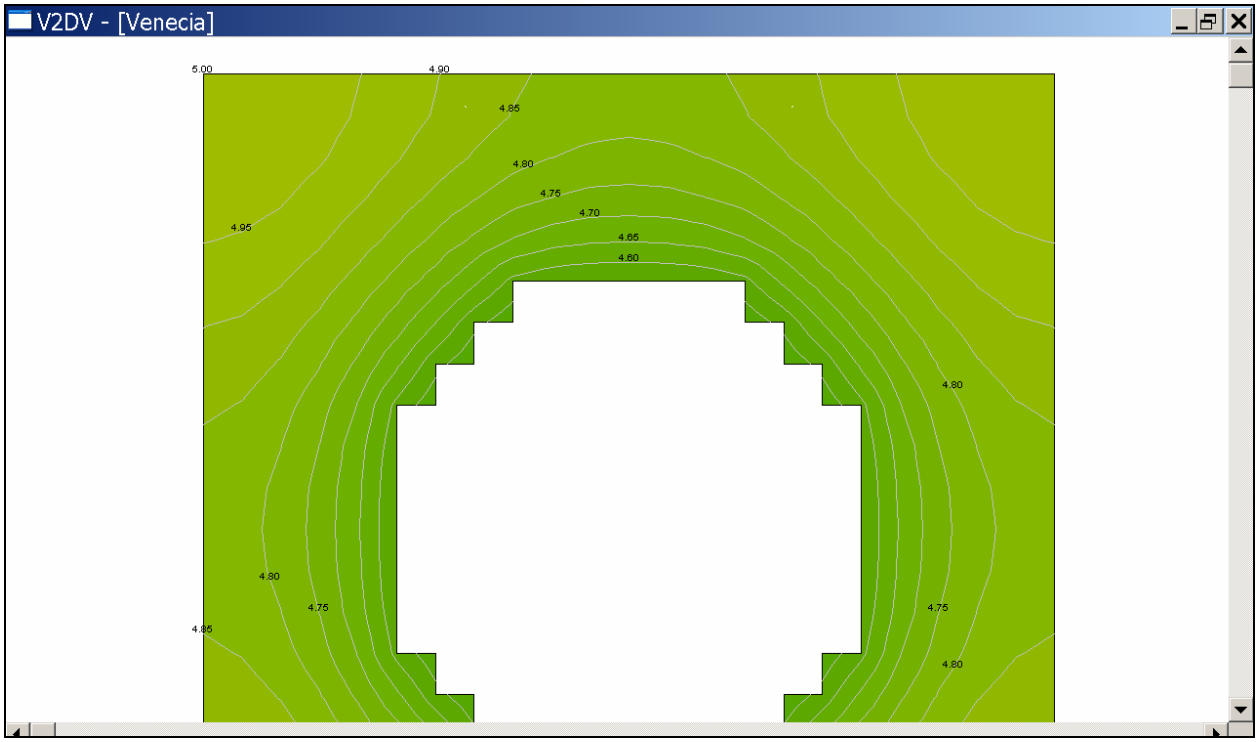
2D Viewer is built in VENECIA and does not require an additional software.



This modul allows to view a result of computations.



The inner gap is the channel with Helium (DEMO2)



More detailed VENECIA description can be downloaded at www.alphysica.com

Any suggestions and questions may be addressed to shatil@alphysica.com

ALPHYSICA

Version	**VENECIA** DEMO ADJUSTABLE EXAMPLES	**VENECIA** LIGHT*		**VENECIA** FULL*
Price	free	from 6.700 €		on demand
AVAILABLE FUNCTIONALITIES				
Number of coolants simultaneously modeled	1	1	**	up to 5
Number of type pumps (circulator, cold compressor, etc.)	1	1		up to 40
Number of different type valves (safety, releef, control, etc.)	up to 2	up to 4		up to 750
Number of 1D coolant flows (channels)	up to 5	up to 20		up to 750
Number of 1D conductors (walls)	up to 5	up to 20		up to 750
Number of 0D volumes (collectors)	up to 5	up to 20		up to 750
Number of SHe heat exchangers	up to 2	up to 3		up to 40
Visualization of model linkage via MS Visio	•	up to 10		up to 750
Critical properties for different types of superconductors	NbTi	NbTi, NbSn^		NbTi, NbSn^^
Mass exchange between different coolant flows	-	•		•
Heat exchange between different coolant flows	-	•		•
Convective heat exchange between 1D flows and 1D conductors	•	•		•
Conductive heat exchange between different 1D conductors	•	•		•
Heat exchange between conductors and collectors	•	•		•
Quench simulation in superconductors cooled by He I	•	•		•
Real-time monitoring	•	•		•
Extended real-time parametric plotting	-	•		•
Two-phase He treated as homogeneous vapour/liquid mixture at thermal equilibrium	•	-		•
Two-phase He treated separately for vapour/liquid phases	•	-		•
Control of liquid level in coolant bath	-	-		•
Control of pressure/temperature in coolant bath	•	-		•
Mitigation of heat load coming in a coolant bath^^^	•	-		•
Simulation of mass forces (gravity, centrifugal force)	-	-		•
Quench simulation in superconductors cooled by He II	•	-		•
2D thermo-diffusion simulations	•	-		•
Visualization of output 2D temperature maps	•	-		•
Helium 4 (Helium I)	•	•		•
Superfluid He (Helium II)	•	-		•
Two-phase He	•	-		•
Nitrogen, valid to 5000 K	-	-		•
Hydrogen normal, valid to 5000 K	-	-		•
Hydrogen para, valid to 5000 K	-	-		•
Hydrogen equilibrium, valid to 5000 K	-	-		•
Hydrogen ortho, valid to 5000 K	-	-		•
Oxygen	-	-		•
Neon	-	-		•
Water	-	-		•

*customizable on demand
**in this column mark by "X" an options needed for you and send to shatil@alphysica.com
^classic parametric law for NbTi and Summer's law for NbSn
^^tabular description as function of B, I, T, gradient B and strain
^^^via controled valves or circulation pumps

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