IRSN
INSTITUT
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ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

SYLVIA : General Presentation

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SYLVIA

SYstème de Logiciels pour l'étude de la Ventilation, de l'Incendie et de l'Aérocontamination

- Designed to study the behavior of a ventilation network in normal, degraded or accidental operation, including in case of fire:
  - Fire evolution
  - Transport of the hot gases, soot, aerosols
  - Filters clogging
  - Impact on sectoring elements (doors and fire dampers)

Use

- Exploitation of existing networks (prediction of consequences before intervention)
- Fire safety studies
- Validation stages of decommissioning of a facility
- Validation of design choices (pre-computation)
- Exploitation of existing networks (predicting consequences before operation)

Modelling: ventilation

- Simplified modelling of the ventilation network based on a graph of connections nodes/branches:
  - Multi-local modelling (nodes): conservation of mass, species and energy.
    1 or 2 areas, ISIS coupling;
  - Modelling a complex ventilation system based on generalized Bernoulli equation (branches).
  - About 20 types of branches:
    - Static parts: pipe, filter, door, openings (horizontal or vertical), leak, crack ...
    - Elements with behaviour law: fans, controllers (PID or perfect, in Q or P), vane, inverter, imposed flow (M or V), dampers (fire, non-return, pressure, depression), register, valve ...
  - Functioning criteria of sectoring elements
    - breaking pressure

Modelling: species

- Multi-species
  - Gas, combustibles, particles (aerosols), sprays
  - M, H(T), λ(T), μ(T), ε(T)
- Satie law: ideal gas mixture
- Particles/Sprays
  - Spherical
  - Size classes
- Combustibles …/…

Modelling: fire

- Fire types
  - Pool fires, electrical cabinets, gas burners, cable trays or fires with imposed heat release rate
  - Pyrolysis rate: from mass or from surface
  - Ignition model
  - External flux model
- Combustible
  - Constant combustion reaction (in t, T et P); defined in moles or in mass
  - O_2 limitation (Peatross & Beyler, LOL, No Limit)
  - Extinction model (pyrolysis rate, T, oxidant)
  - Scale effect on pyrolysis rate (Babrauskas, Hottel)
- Fire place
  - Plume model (air entrainment, radiation)
  - Localization
  - Flame temperature (imposed, f(pyrolysis), f(plume))
  - Unburned

Modelling: thermal exchanges

- Radiation:
  - Gray gas model,
  - source point model for the fires
- Convection:
  - natural and/or forced in branches and nodes
- Conduction in walls: 1D
- Aspersion (water mist)
- Vapor condensation on walls
- Target elements
  - Sensors-like
- Imposed flux on a wall

Modelling: sources and sinks

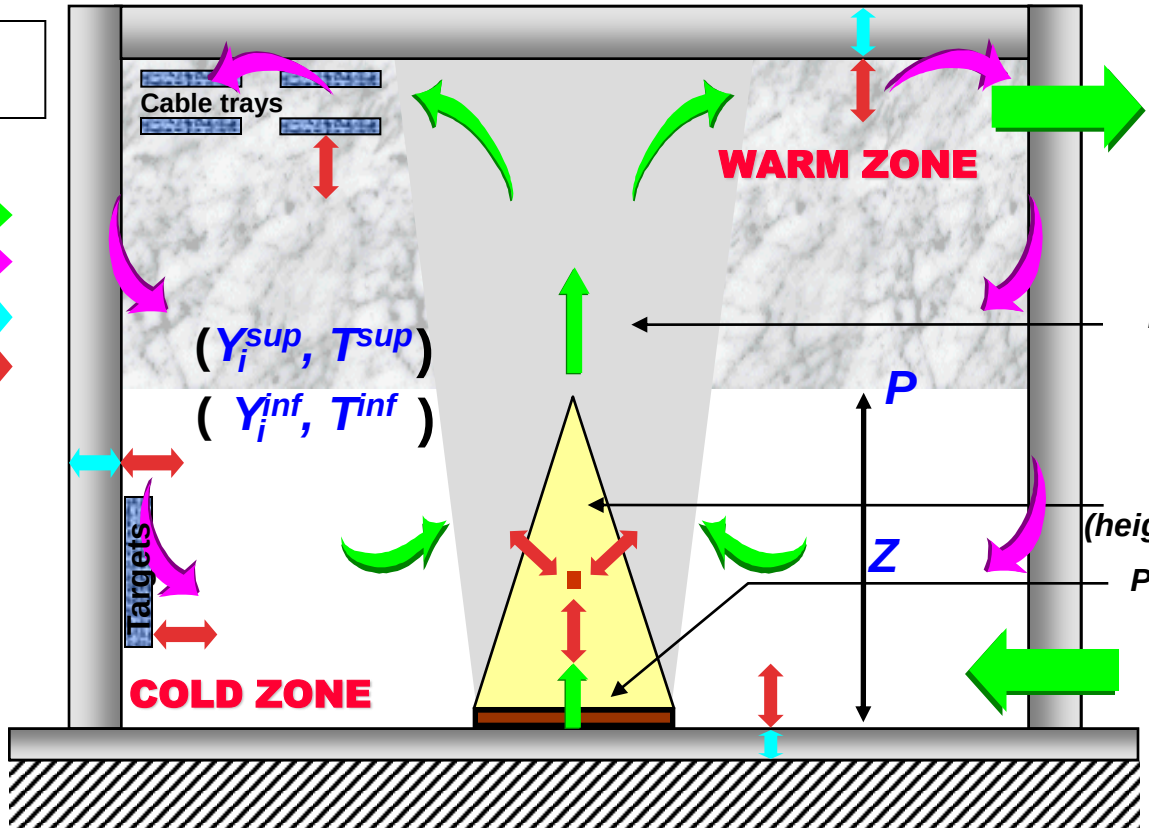
- Mass source in a node
  - Injected flow, injected temperature, injected mixture
- Energy source/sink in a node
  - yield
- Heat sink thermal mass in a node
  - Structure description
- Node, branch, filter deposit
  - Imposed, or,
  - Computed
    - Node: sedimentation + diffusion + thermophoresis
    - Filter: calculating efficiency
    - Pipes: straight or bent
- Chemical reactions (Arrhenius)
- Particules agglomeration

Modelling

System unknown :
P, T, Y_i, Qm

Exchange :
Convection :
Conduction :
Radiation :

But also modelling of:
- ***Water mist***
- ***Aerosol deposit***
- ***« Source»***
- ***« Sink »***
- ***Horizontal opening***
- ***Vertical opening***
- ***Ignition***
- ***Extinction***
- ***Chemical reactions***



Numerical aspects

- Model implicit coupling
  - ventilation, combustion, thermal exchanges, …
- Time discretisation of BDF type (Backward Difference Formulation) at first order (default)
- UMFPack solver
  - Last LGPL release
- Alterable time step management
  - min, max, coefficients, passage time
- Alterable convergence criteria adaptation
  - Pressure, temperature, mass fraction, mass flow

Validation

- Verification : 27 models – 130 tests
- Validation : 218 cases
  - Validation of ventilation models
    - IRSN ventilation mock-up (small scale)
    - Scale 1 facility: CHICADE (CEA)
    - Filter clogging tests [BANCO/10]
    - Deposit models [Liu, Pui, Charuau]
    - Tunnel : Helium injection
    - Thermal exchanges in duct [PRS-LK4]
    - Chemical reactions [H2PAR/1]
    - Mass flow across horizontal opening [VSP/16]
    - Condensation [TOSQAN/2]
  - Validation of fire models
    - Small scales tests of gas burner : 6 tests Cooper (NIST)
    - Pool fires in well or under ventilated condition with 1 or more rooms [DIVA/1, LIC/2, FLIP/6, PRISME (1,2)/20, ICFMP/15, Steckler/50, Ulvents/4]
    - Complex fires [PXL/8, CFS/4, BAG-CSS/1, EP/2]
    - Aspersion [CARAIDAS/3, PRISME-Int/1]
    - Second item ignition [PARFFIN/1]
    - Tunnels [FOA/36]

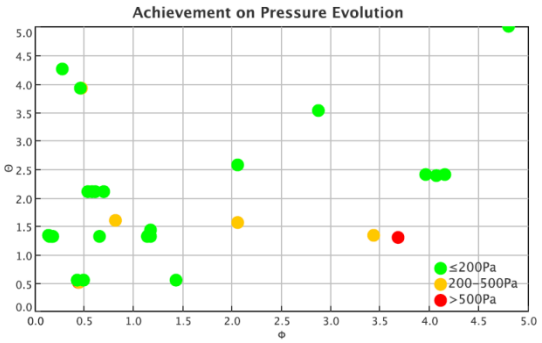
Validation synthesis

- Observation:
  - Access to IRSN tests results is restricted
  - Users need to known the trust they can give to the results given by SYLVIA

- Validation synthesis (fire scenario only) :
  - 1 scenario

  ⇨2 parameters (fire power, ability to absorb heat released)

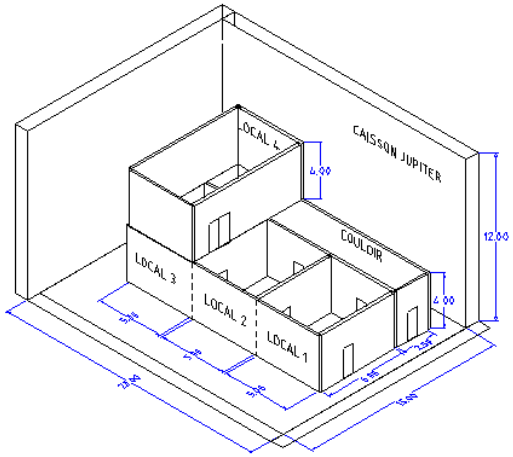
  ⇨1 confidence interval for the duration of the fire, the temperature (peak and average) and the pressure (peak and average)

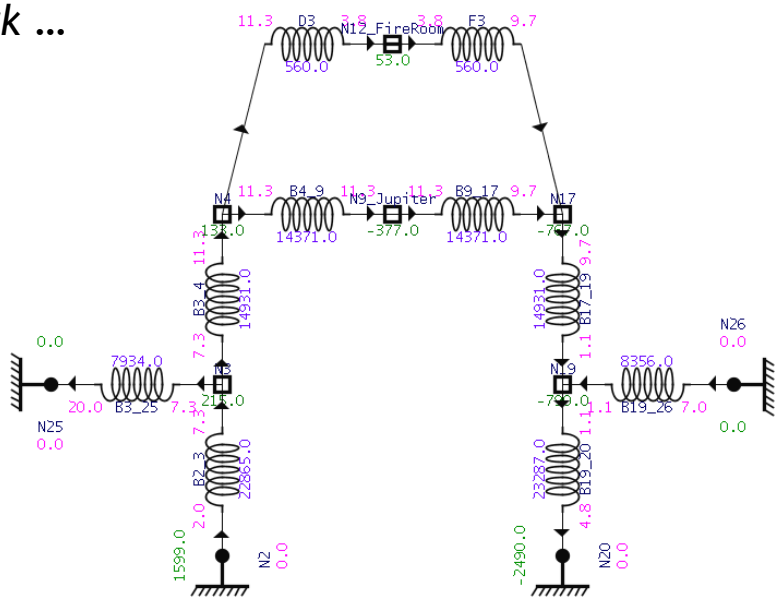


use

- SYLVIA is:
  - Quick,
  - Flexible and user-friendly: the entire network can be described using the GUI.

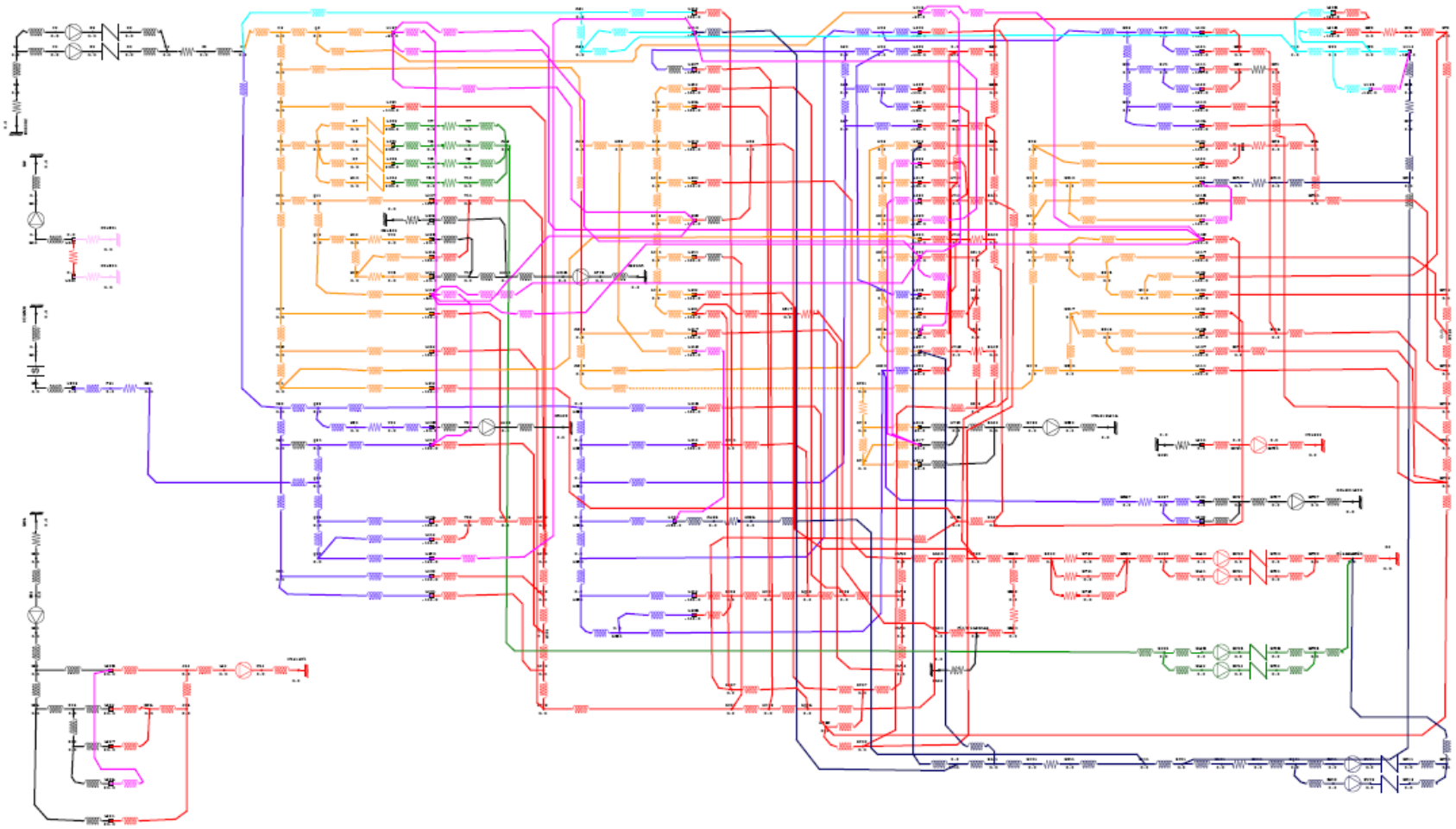
From a simple network …



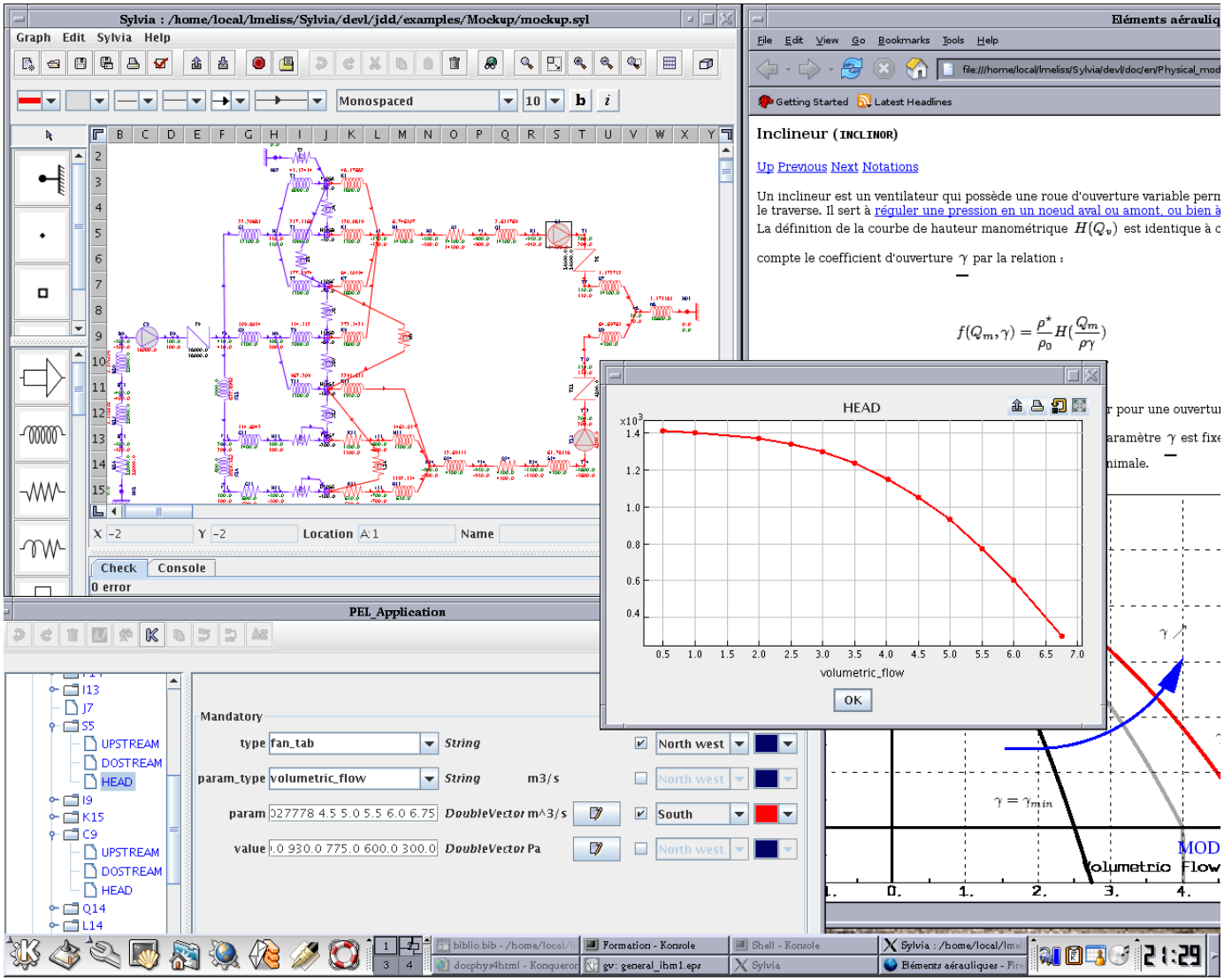


Use

… to a complex network representing a real facility



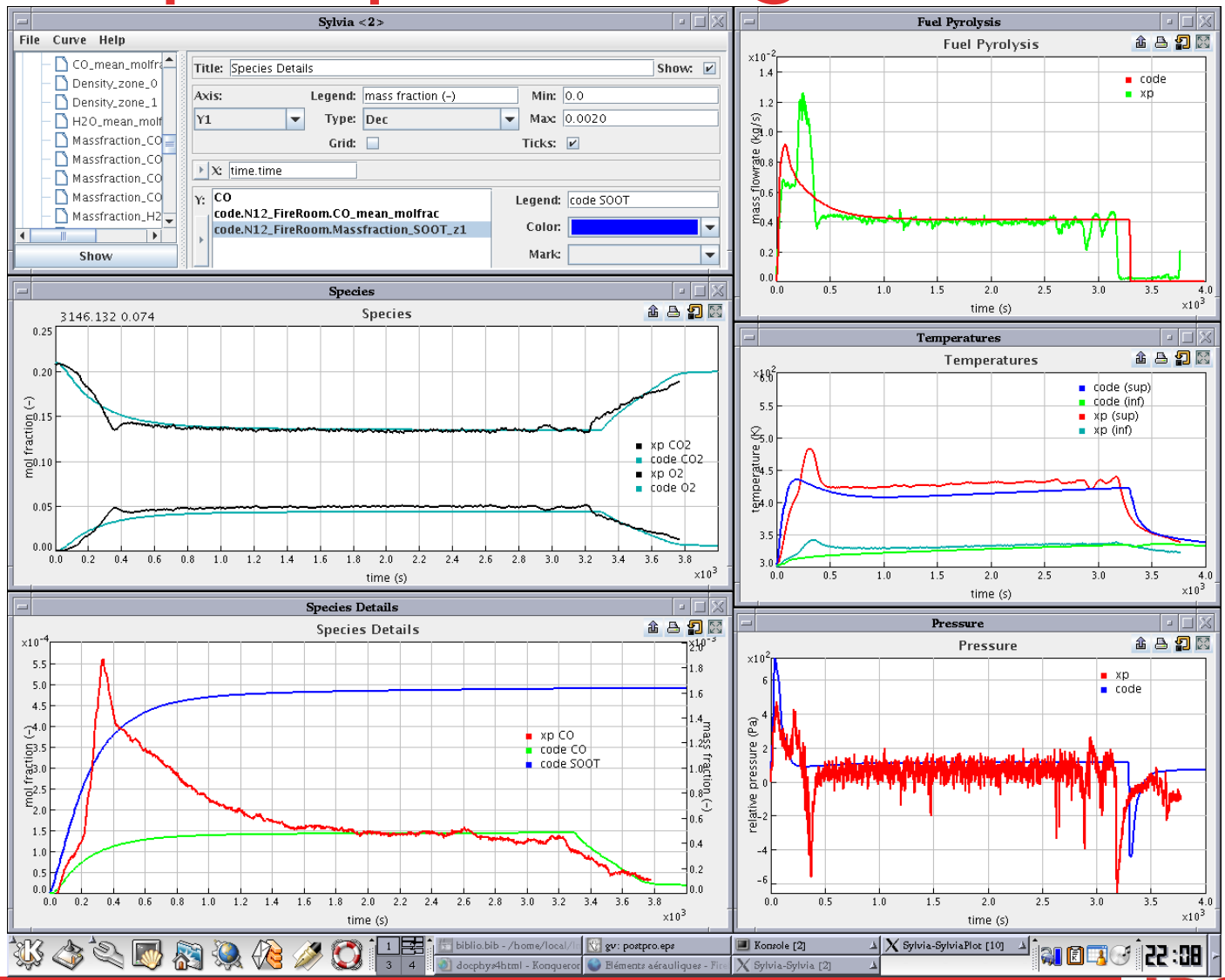
Construction of a data set



Data set editor

- Editing the network
  - Zoom, image export, printing, graphic properties, comments, tabs
  - Cut/Copy/Paste, Undo/Redo, CSV Import/Export
- Editing information
  - Cut/Copy/Paste, Undo/Redo, CSV Import, material data base, devices, ….
- Graphic representations of information
  - Behaviour laws,
  - Physical properties,
  - Rooms and walls topology
- Documentation access
- Data set control and error display
- Run

Results post processing



Plotting

- Multi file – Multi format (CSV, FITS, intern, …)
- Curve configuration file
- Batch/interactive : zoom, coordinates, scroll, input file monitoring
- Curves: 1D, histograms, dials, profiles
  - Legends, title, colors, thickness, marks, dashes, 2 Y axes
- Curve comparator and error computation
- Image export:
  - vectorial (eps, pdf, wmf, …)
  - bitmap (png, gif, bmp, …)
- Drag'n Drop
- Scripting language: JavaScript

SYLVIA Roadmap

2006 v1.0	• Concepts from FLAMME-S and SIMEVENT software
12/2011 v1.5	• Regulator improvements (convergence, parallel), Horizontal openings, Water mist
06/2013 v1.6	• Second item ignition, Clogging model, Alteration of aeraulic resistances (irreversibility, state, addition of elements, ...)
12/2014 v1.7	• Chemical reactions, Conditional actions, Thermal exchanges in pipes, Tunnels, ISIS-SYLVIA
06/2016 v1.8	• Condensation of vapors and deposits in pipe, “Device” databases, Optimizations RAM + CPU, Refactoring
12/2017 v1.9	• Soot removal, Thermoregulation, Diffusion limitations, ISIS-SYLVIA windows
06/2019 v1.10	• Solid Fires, Radiation model enhancement, Phenomenological clogging model, Target temperature, Multi-stage combustion

Release contents

- SYLVIA code
- GUI: pre and post processing
- Material data base
- Documentation
  - Physical models
  - GUI user manuals
  - Getting started
  - User guide
  - Validation synthesis
- Example, non regression and verification data sets

Distribution / Training / Access

- 2 distribution modes with access to any release during the contract period
  - Commercial : node locked or floating license
    - 17 running contracts : CEA(4), AREVA(3), EDF, ITER, ONET, BOUYGUES, SPIE, ARCHYTAS, NUVIA, … corresponding to 25 licenses (au 01/01/2017)
  - Partner; non commercial use:
    - NRA, *KINS*, BelV, CNSC, ANRA, *ECP*, Universities, INRS
- Training: 2 days sessions
  - Ventilation/S1 and Fire/S2 : initial trainings
  - Network Setting/S3 and Macros/S4 : advanced trainings
- A secure single access point https://gforge.irsn.fr to:
  - Get the latest releases
  - Report and monitor anomalies
  - Suggest improvements

SYLVIA is also…

- The program itself:
  - 5800 files with 20% of source files (C++) representing 65000 statements managed by GIT
  - Daily tests on supported platforms :
    - Windows 7 64 bits
    - Linux 64 bits
- The Graphical User Interface
  - 1800 files with 50% of source files (Java) representing 65000 statements managed by CVS
- A development team:
  - 2 people in charge of modeling and validation
  - 3 people in charge of development and maintenance

Questions…

- Thank you for your attention