MFront for the Code-Aster'users and beyond

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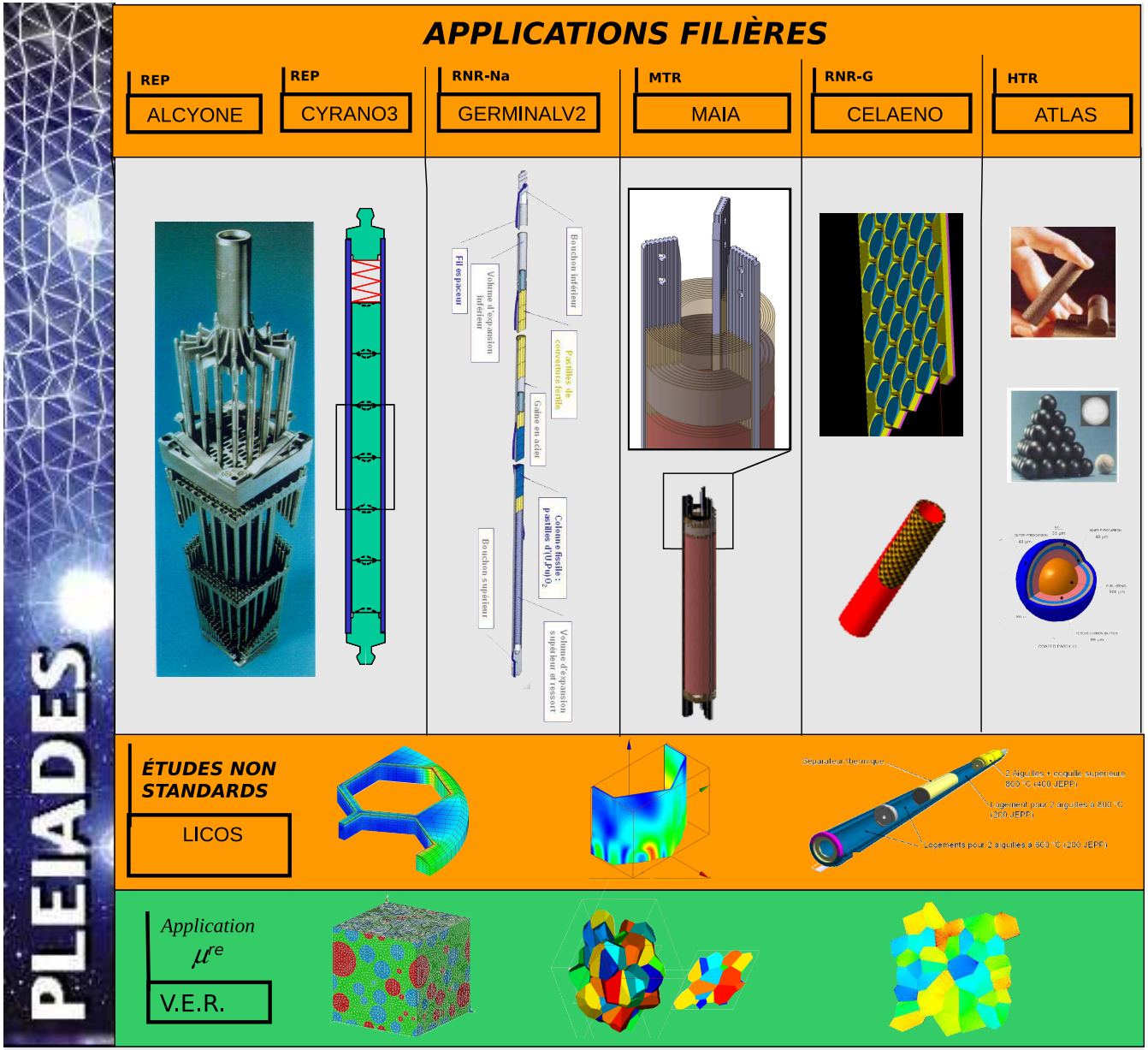
Pleiades


PLEIADES
APPLICATIONS FILIÈRES
REP
ALCYONE
REP
CYRANO3
RNR-Na
GERMINALV2
MTR
MAIA
RNR-G
CELAENO
HTR
ATLAS
Bouchon inférieur
Fils espaceur
Volume d'expansion inférieur
Pastilles de couverture fertile
Gaine en acier
Colonne fissile : pastilles d'(U,Pu)O2
Bouchon supérieur
Volume d'expansion supérieur et ressort
ÉTUDES NON STANDARDS
LICOS
Application μre
V.E.R.

A brief tour of MFront

MFront

- `MFront` is an **open-source** code generator based on C++ developed within the `PLEIADES` platform for :
  - material properties
  - mechanical behaviours
  - models

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  - reliability (gives the correct result)
  - robustness (gives a result)
  - numerical efficiency (is as fast as possible).

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- Interoperability (rule of four ? See "Intefaces" below).

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- **Strong emphasis on Quality Assurance** (rule of five ? See "Material knowledge management" below).

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PLEIADES **goals : building high quality fuels performance codes**

A first example : material property

```
@DSL MaterialLaw;                    // treating a material property
@Material UO2;                       // material name
@Law YoungModulus_Martin1989;        // name of the material property
@Output E;                           // output of the material property
@Input T,f;                          // inputs of the material property
@Function                            // implementation body
{
  E = 2.2693e11*(1.-2.5*f)*(1-6.786e-05*T-4.23e-08*T*T);
}
```

$$E(T,f) = 2.2693\,10^{11}\,(1-2.5\,f)\,(1-6.786\,10^{-5}\,T-4.23\,10^{-8}\,T^2)$$

- usable in Code-Aster through the `python` interface.
- also in `C`, `C++`, `fortran`, `excel`, `Cast3M`, etc..
- usable in `MFront`'s mechanical behaviours !

A first example : material property

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@Material UO2;                       // material name
@Law YoungModulus_Martin1989;        // name of the material property
@Author   T. Helfer;                 // author name
@Date     04/04/2014;                // implementation date
@Description                         // detailled description
{
  The elastic constants of polycrystalline UO2 and
  (U, Pu) mixed oxides: a review and recommendations
  Martin, DG
  High Temperatures. High Pressures, 1989
}

@Output E;                           // output of the material property
E.setGlossaryName("YoungModulus");
@Input T,f;                          // inputs of the material property
T.setGlossaryName("Temperature");
f.setGlossaryName("Porosity");

@PhysicalBounds T in [0:*[;     // Temperature is positive
@PhysicalBounds f in [0:1.];    // Porosity is positive and lower than one
@Bounds T in [273.15:2610.15]; // Validity range

@Function                            // implementation body
{
  E = 2.2693e11*(1.-2.5*f)*(1-6.786e-05*T-4.23e-08*T*T);
}
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Mechanical behaviours

```
@DSL IsotropicPlasticMisesFlow;
@Behaviour plasticflow;
@Author Helfer Thomas;
@Date 23/11/06;

@MaterialProperty stress H;

@FlowRule{
  f       = seq-H*p;
  df_dseq = 1;
  df_dp   = -H;
}
```

- A simple J_2 (isotropic) plastic behaviour :
  - $f\left(\sigma_{eq}, p\right) = \sigma_{eq} - H\,p \leq 0$
  - example of specific behaviour implementation
  - automatic computation of the consistent tangent operator

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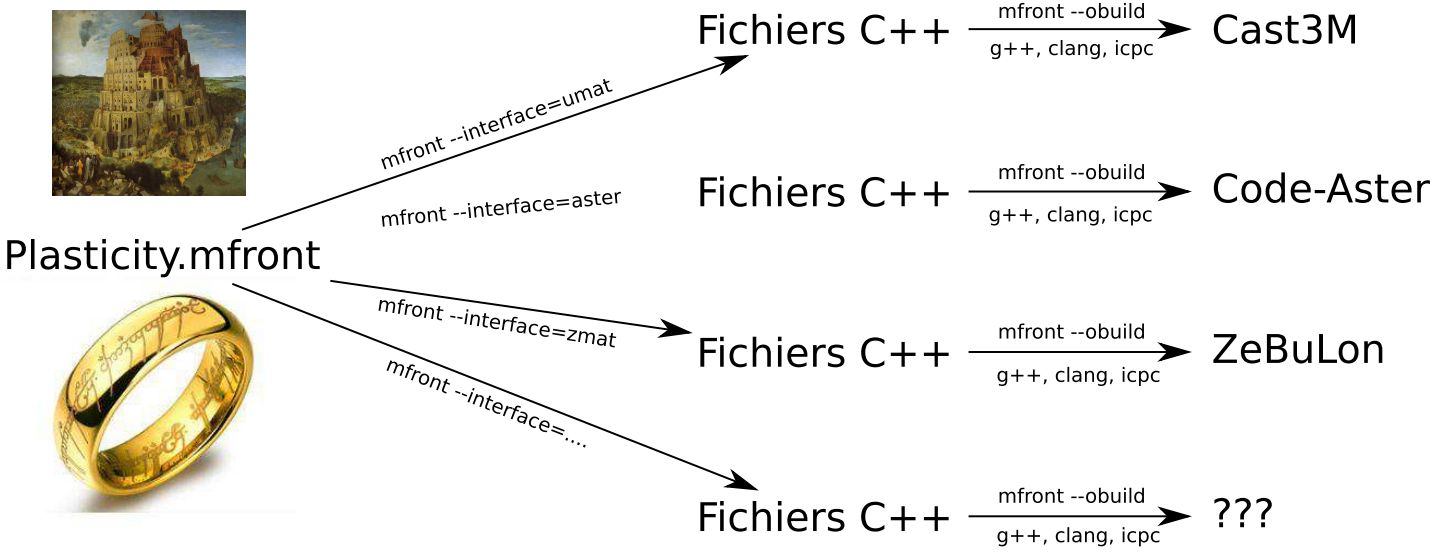
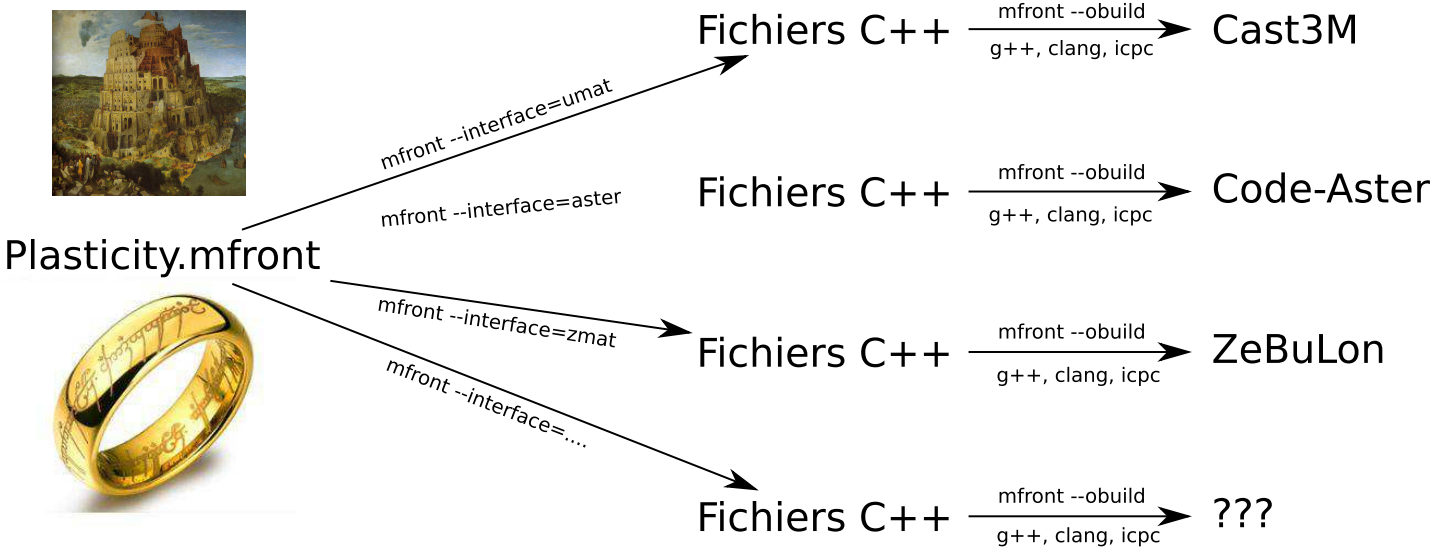
- A simple J_2 (isotropic) plastic behaviour :
  - $f\left(\sigma_{eq}, p\right) = \sigma_{eq} - H\,p \leq 0$
  - example of specific behaviour implementation
  - automatic computation of the consistent tangent operator
- various domain specific languages are available to cope with :
  - general small strain behaviours, general finite strain behaviours, cohesive zone models
  - any mechanical behaviour, including plasticity, viscoplacity, damage, etc...
    - explicit or implicit integration schemes are available

Code generation and interfaces



- Finite elements solvers :
  - Code-Aster, `Cast3M`, `ZeBuLoN`.
- Fast Fourier transform solvers :
  - `TMFFT`, `AMITEX_FFT`
- Fuel performance codes :
  - Cyrano3

Code generation and interfaces



- Finite elements solvers :
  - Code-Aster, Cast3M, ZeBuLoN, EuroPlexus, Abaqus, Ansys.
- Fast Fourier transform solvers :
  - TMFFT, AMITEX_FFT, CraFT
- Fuel performance codes :
  - Cyrano3, Galileo

- working
- planned
- signs of interest

Material knowledge management

Studies quality assurance

- One of the main benefits of `MFront` is to make the link between :
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  - **Technical notes, experimental data, etc...**
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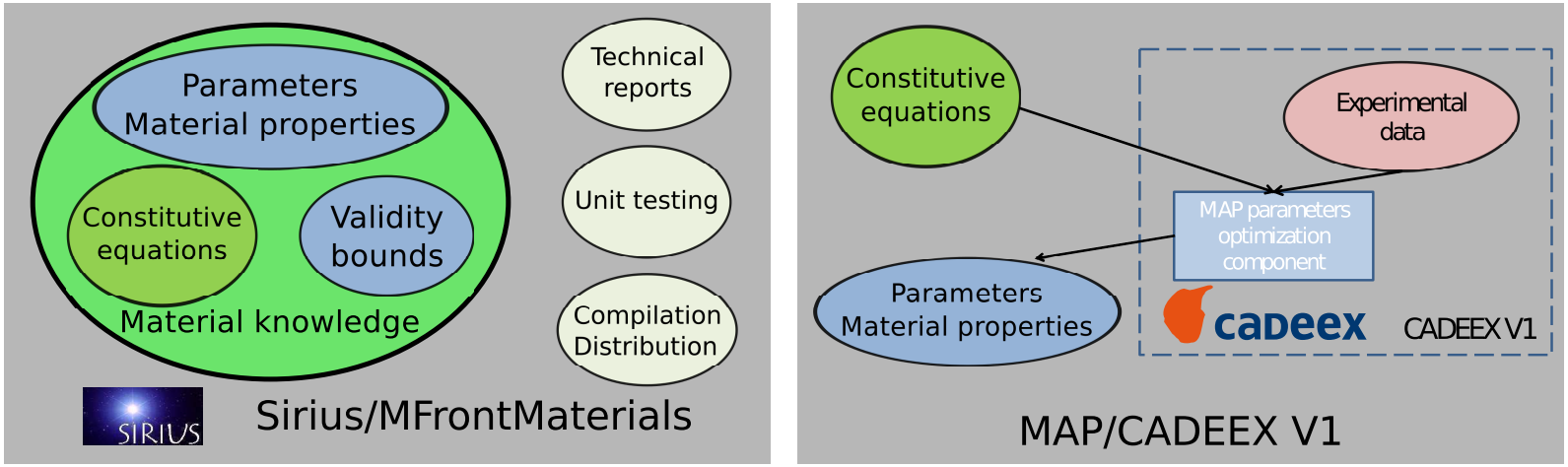
Stronger quality assurance for the end user studies

Sirius and Cadeex : some unformalised perspectives



- Two material knowledge management tools : `Sirius` database in `PLEIADES`, `Cadeex` at `EDF`.
  - Those projects have followed complementary paths.
    - many experience to share
    - would benefit from a standard file exchange : MADNEX ?

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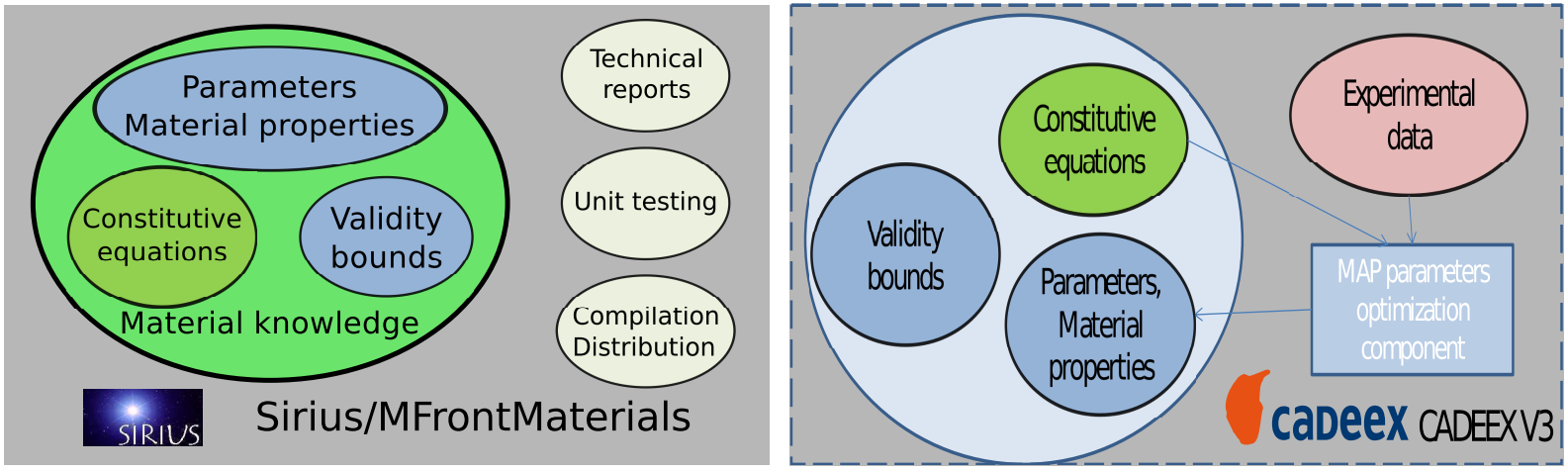

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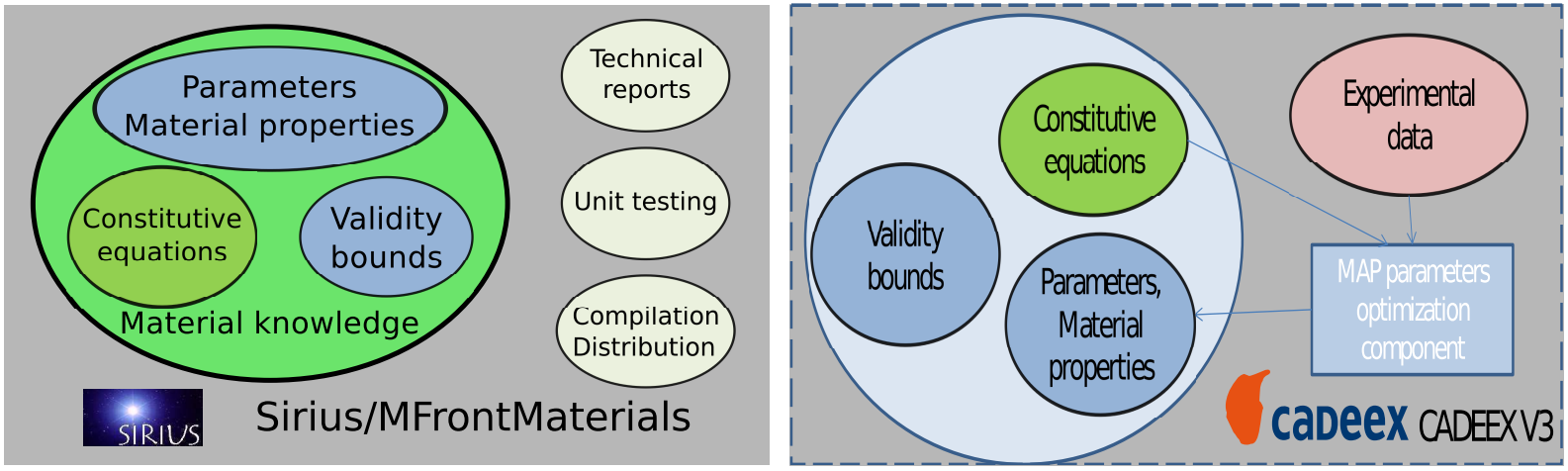

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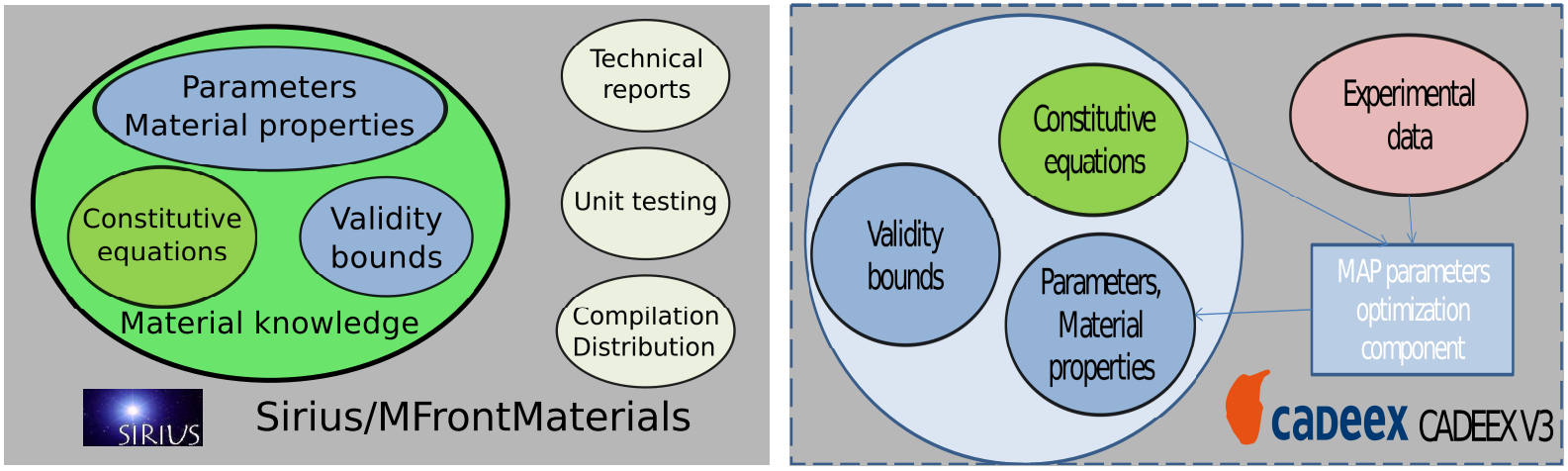

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  - Those projects have followed complementary paths.
    - many experience to share
    - would benefit from a standard file exchange : MADNEX ?
- End-user would greatly benefit from a **Salome interface**
- Solver inputs files would greatly benefit from **allowing access to the underlying material data (Salome again)**

Conclusions

Acknowledgements

- J. M. Proix, J. Hure, F. Hamon, I. Ramière, , É. Castelier O. Fandeur, V. Blanc, J. Julien, B. Michel, B. Bary, F. Milliard, A. Courcelle, and all the others for various contributions.
- all the persons who contributed to the open-source release of `TFEL` : J. P. Defain, D. Banner, T. De Soza, V. Marelle, É. Lorentz, C. Toulemonde, F. Curtit, R. Masson, and all the others.
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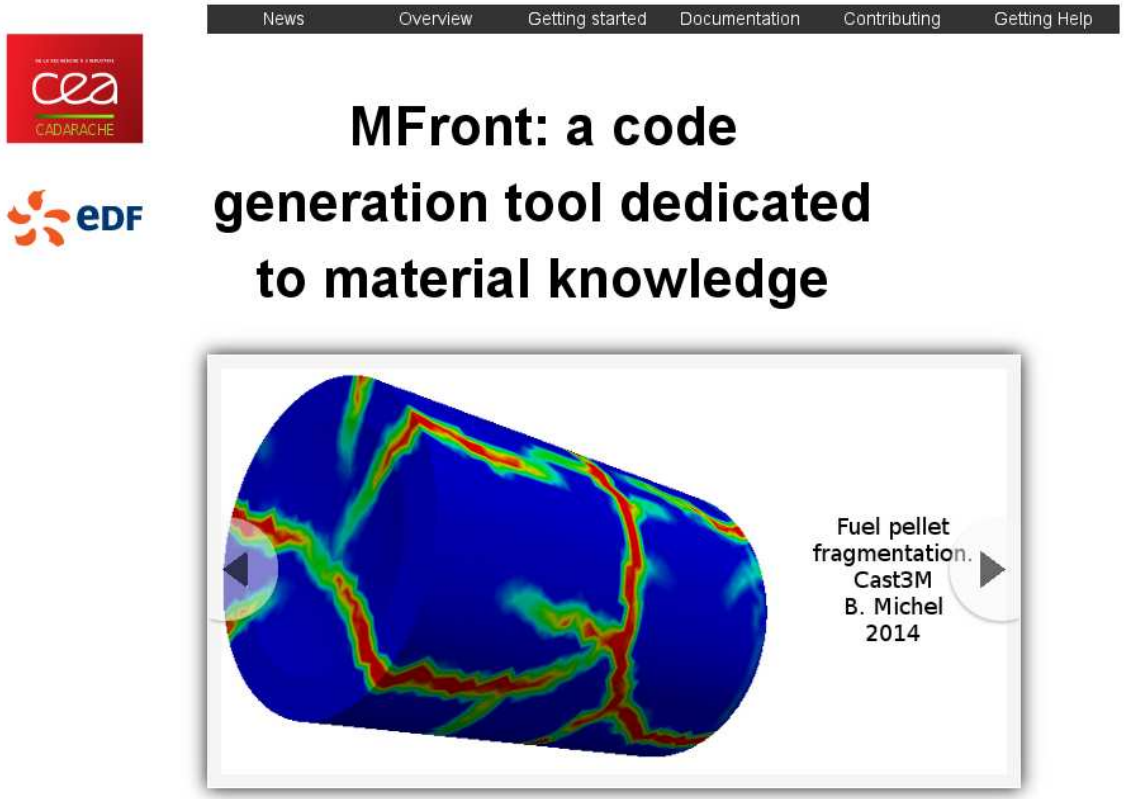
Thanks your for your attention. Questions ?



New users/contributors are welcomed !

http://tfel.sourceforge.net

Appendix

Licences

- To meet CEA and EDF needs, TFEL 2.0 is released under a multi-licensing scheme :
  - open-source licences :
    - GNU Public License : This licence is used by the Code-Aster finite element solver.
    - CECILL-A : License developped by CEA, EDF and INRIA, compatible with the GNU Public License and designed for conformity with the French law.
  - CEA and EDF are free to distribute `TFEL` under custom licences : Mandatory for the `PLEIADES` plateform.