USING AN EXPERT SYSTEM FOR ACCELERATORS TUNING AND AUTOMATION OF OPERATION FAILURE CHECKS

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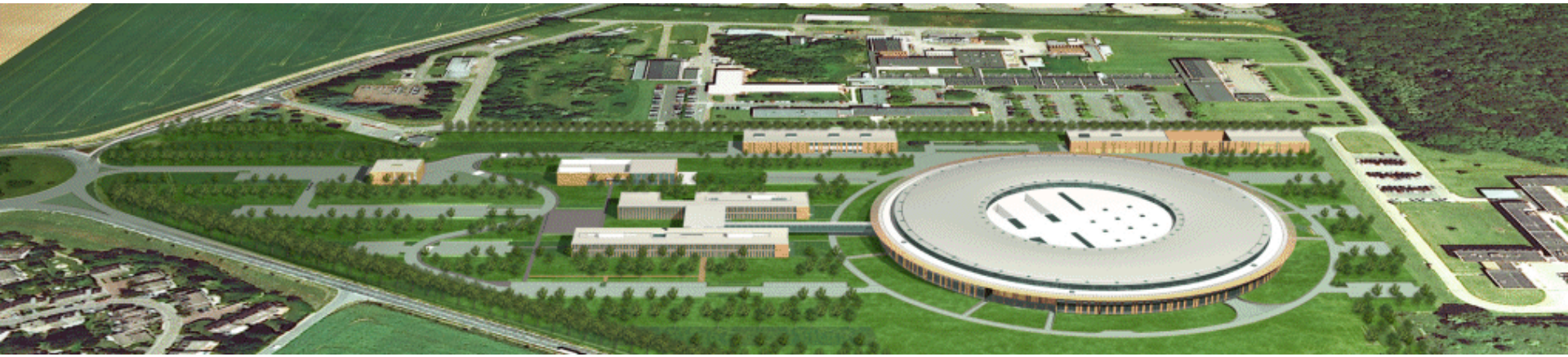

Synchrotron SOLEIL, Saint Aubin, France,
http://www.synchrotron-soleil.fr

Content

- **Motivations**
- *SOLEIL Expert System Building Blocks*
  - *Passerelle*
  - *Drools*
  - *CDMA*
- *Use Case*

Repetitive Accelerator Operation failure check tasks

⇨ In daily operation an operator has to perform many manual checks

- Are the control system services working fine *(i.e is the archiving system really logging data ?)*
- Is the alarm detected by a supervision application linked to a control system sub module or is it an equipment problem ?
- Is beam correctly delivered to beamlines ?

- **Same kind of problems analysis to do again and again**
- **Many different applications to interact with**
- **Diagnose quality is operator knowledge dependent**
- **Very error-prone**

Why not automate all these tasks?

Repetitive Accelerator Operation analysis and diagnosis tasks

⇨ In case of abnormal operation (beam loss)

- Collect data for analysis (extract archived data, post-mortem data,…)
- Check the elog book or an accelerator expert to see what is the relevant recovery process to apply
- Perform in sequence the advised operation/rules for the given situation

- No uniform way to **collect data** from different sources
- Lack of centralization accelerator operation **expertise**
- Non automated repetitive **sequences** of operations
- Very **error-prone**

Why not use an expert system ?

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Aim of the expert system

Automation of an analysis/diagnosis process workflow takes care of :

- Collecting and consulting the available data for analysis
- Formulating decisions/diagnosis rules
- Preparing advised actions to repair the problematic situation

- **Need for a workflow modeling environment : Passerelle**
- **Need for a uniform data access layer : CDMA**
- **Need for a rules based environment : Drools**

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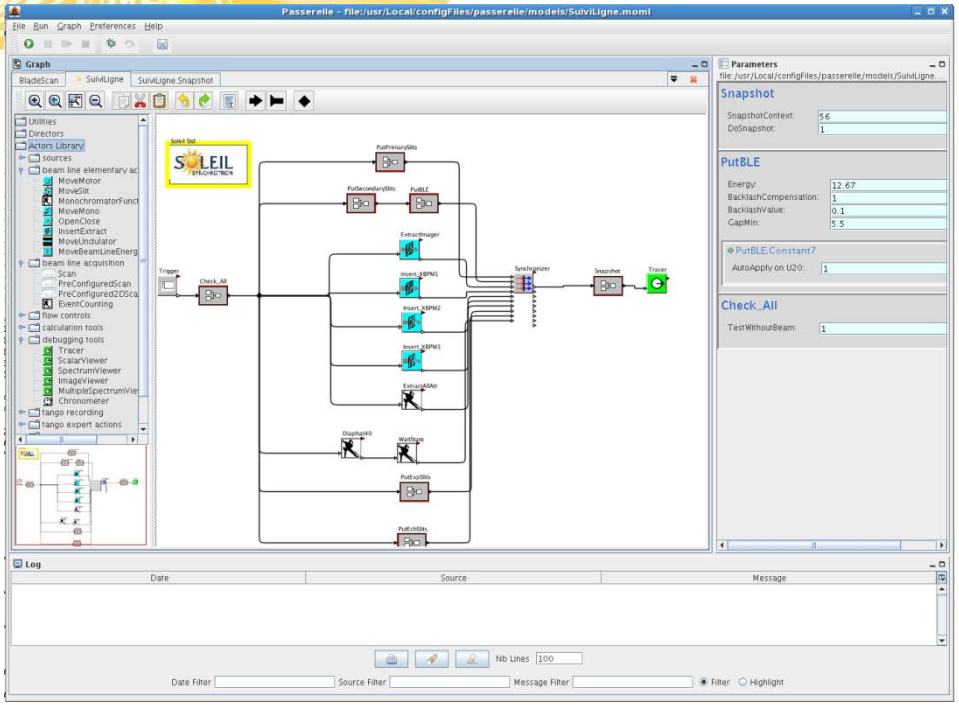
PASSERELLE workflow engine

PASSERELLE allows to graphically design complex workflows and execute them

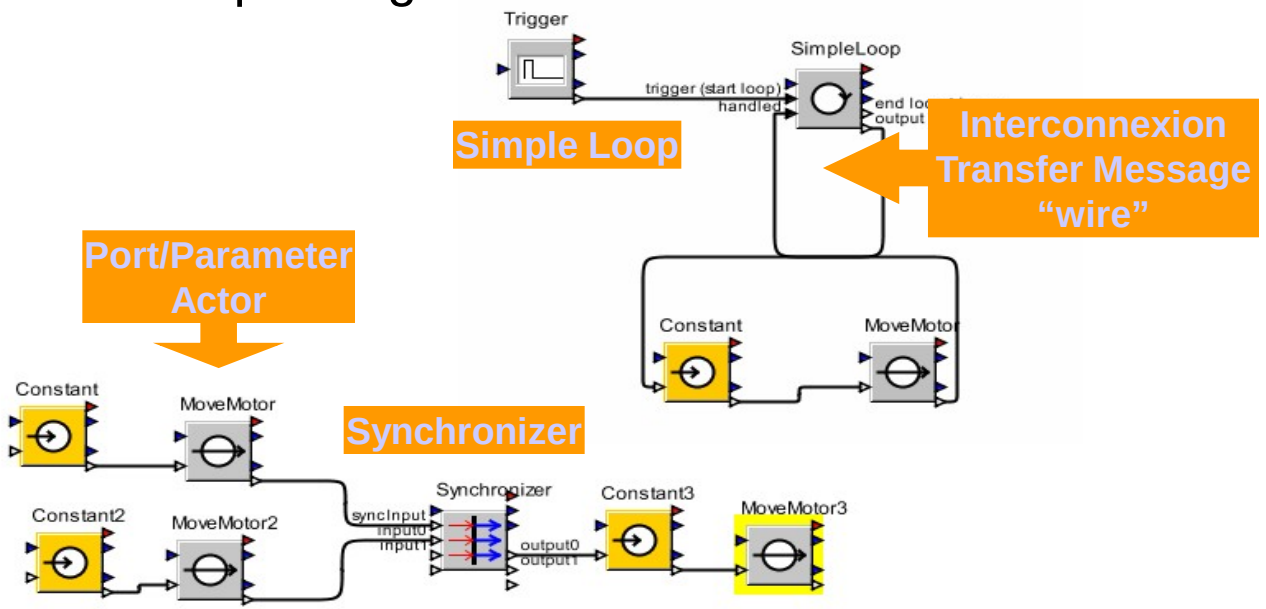


- PASSERELLE is provided by a company called ISENCIA
  - ✓ Specialized in process driving for industrial companies.
- PASSERELLE is based on an environment for scientific modelisation and simulation: **PTOLEMY** *(developed by the Berkeley University)*

http://ptolemy.eecs.berkeley.edu/ptolemyII/

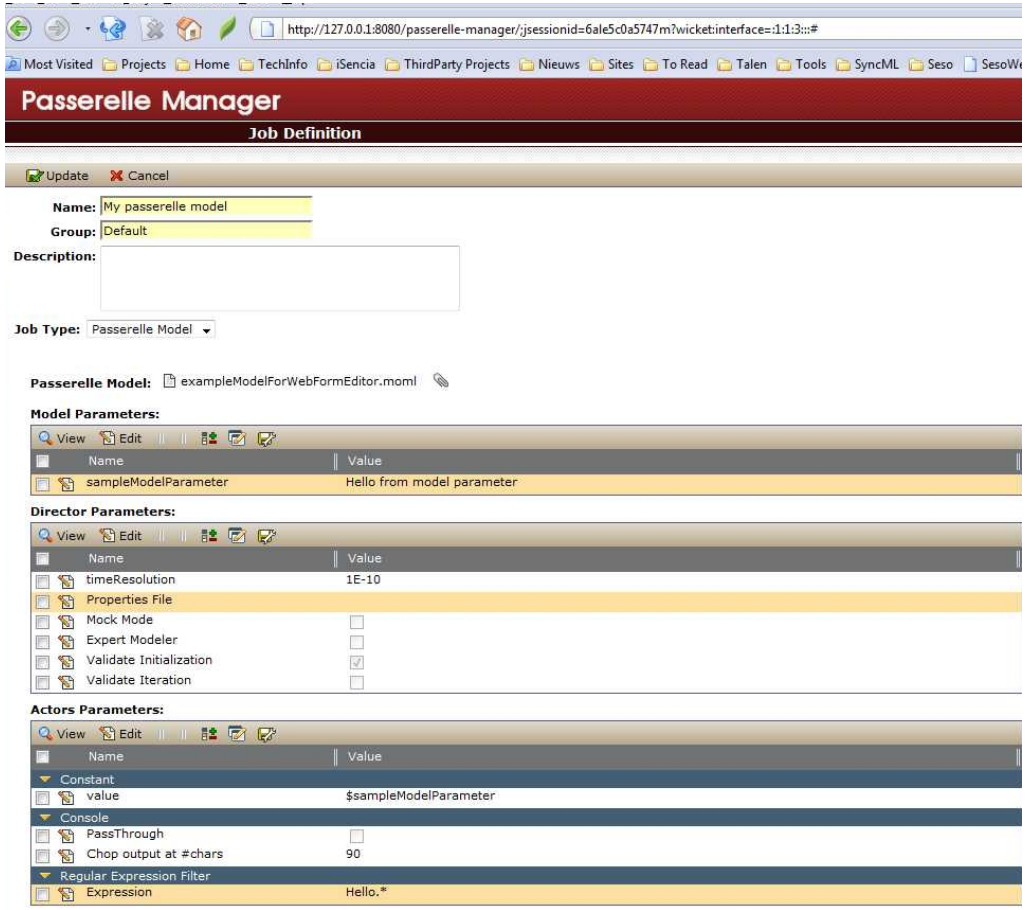
PASSERELLE : principles

- Workflows are developed by connecting « boxes » and « wires »:
  - The « boxes » are called **ACTORS** : they execute an action.
  - The « wires » are called **MESSAGES:** they transfer data.
- The graphic language for editing sequences provides all functionalities to build complex logics:



- Loops
- Comparison
- Error Management
- Parameterization

PASSERELLE : Remote Execution Environment through a Web interface



Full-featured remote access via standard web technology

- ✓ **Allows workflows design, execution, monitoring etc on a secure and robust server-based platform**
- ✓ **Automated scheduling of workflows executions**
- ✓ **Monitoring and diagnostics of workflows execution**
- ✓ **A relational DB stores :**
  - **Workflows definitions**
  - **their configuration**
  - **the analysis rules**
  - **the execution traces**

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Drools : The inference system principle

- **Jboss Drools is an inference system**
  - It can be seen as an advanced “if-then” programming language interpreter

- **Rules engine**
  - Is based on a declarative (“what to do”) programming model
    - *instead of the usual imperative (“how to do it”) programming*
  - It evaluates a collection of registered “facts” in a “knowledge base”
  - New facts can be derived by the rules, and added to the knowledge base
  - This can trigger (other) rules again

Drools Java API

- Drools is an easy-to-use Java API which can be integrated in a “normal” Java program in 2 different ways:
  - Using the standard Java Rules API (JSR 94)
  - Or using a proprietary Drools API (more feature-rich)

- Rules can be defined in different ways
  - Using the usual Java programming mixed with “when/then” Drools syntax (which allow complex and powerful rules to be defined))
  - Using Domain specific languages (user-friendly)
  - Using Decision tables (spreadsheet definition)

Passerelle & Drools integration

- **We developed a library of Passerelle actors for**
  - Data collection
    - Adaptation of existing Tango actors (AttributeReader etc)
    - SQL-Database-Reader (CDMA plugin)
    - HDF files reader (CDMA plugin)
  - Analysis
    - Drools Expert actors which bridges the Passerelle and Drools worlds
  - Diagnosis
    - Report generator (based on the eclipse BIRT package)

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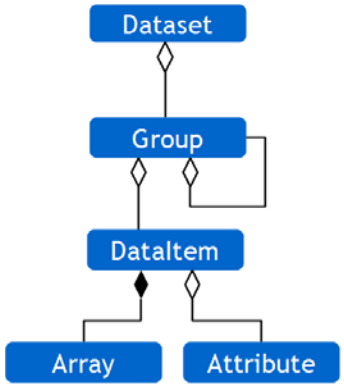
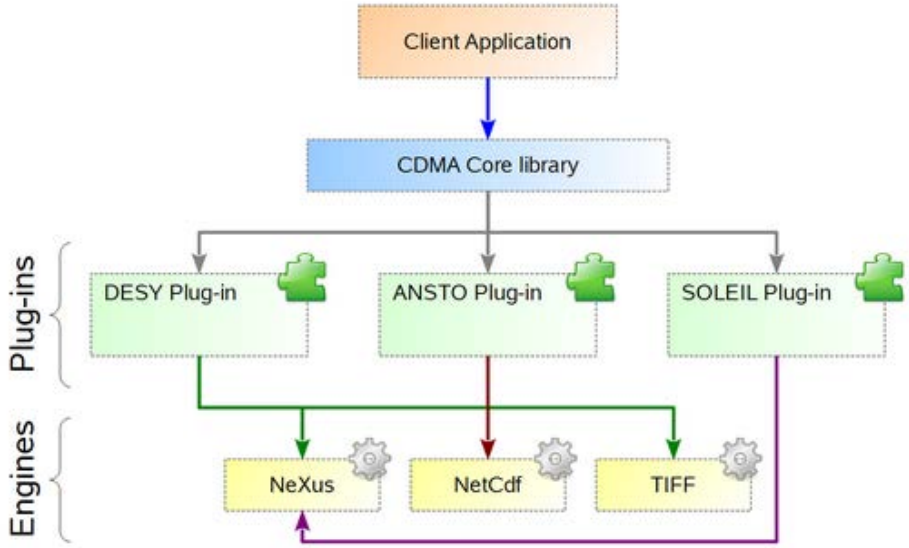
CDMA API : An abstraction to access data

- CDMA is an API providing a unified data layer
  - independently of the kind of the data source (database, HDF5 files)
- CDMA key points are :
  - An abstract interface to navigate in a uniformed way through data sources using a unique data model
  - A plugin system to cope concretely with the real kind of data source (database, HDF5 files)
  - A dictionary mechanism to cope with data organization in the data sources
- CDMA is an open source collaboration project :
  - http://code.google.com/p/cdma/wiki





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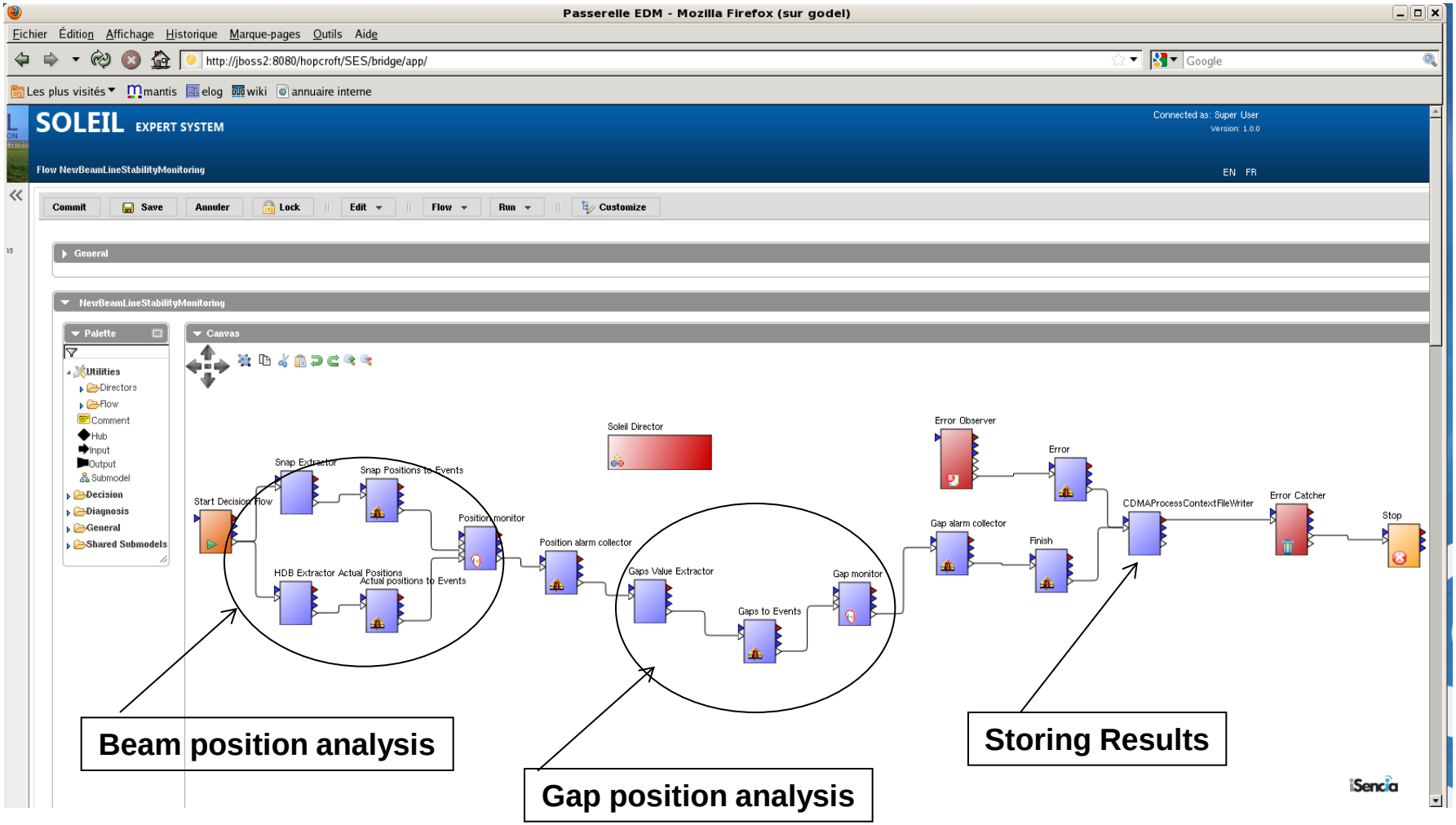
Use Case : Beam Stability in the storage ring

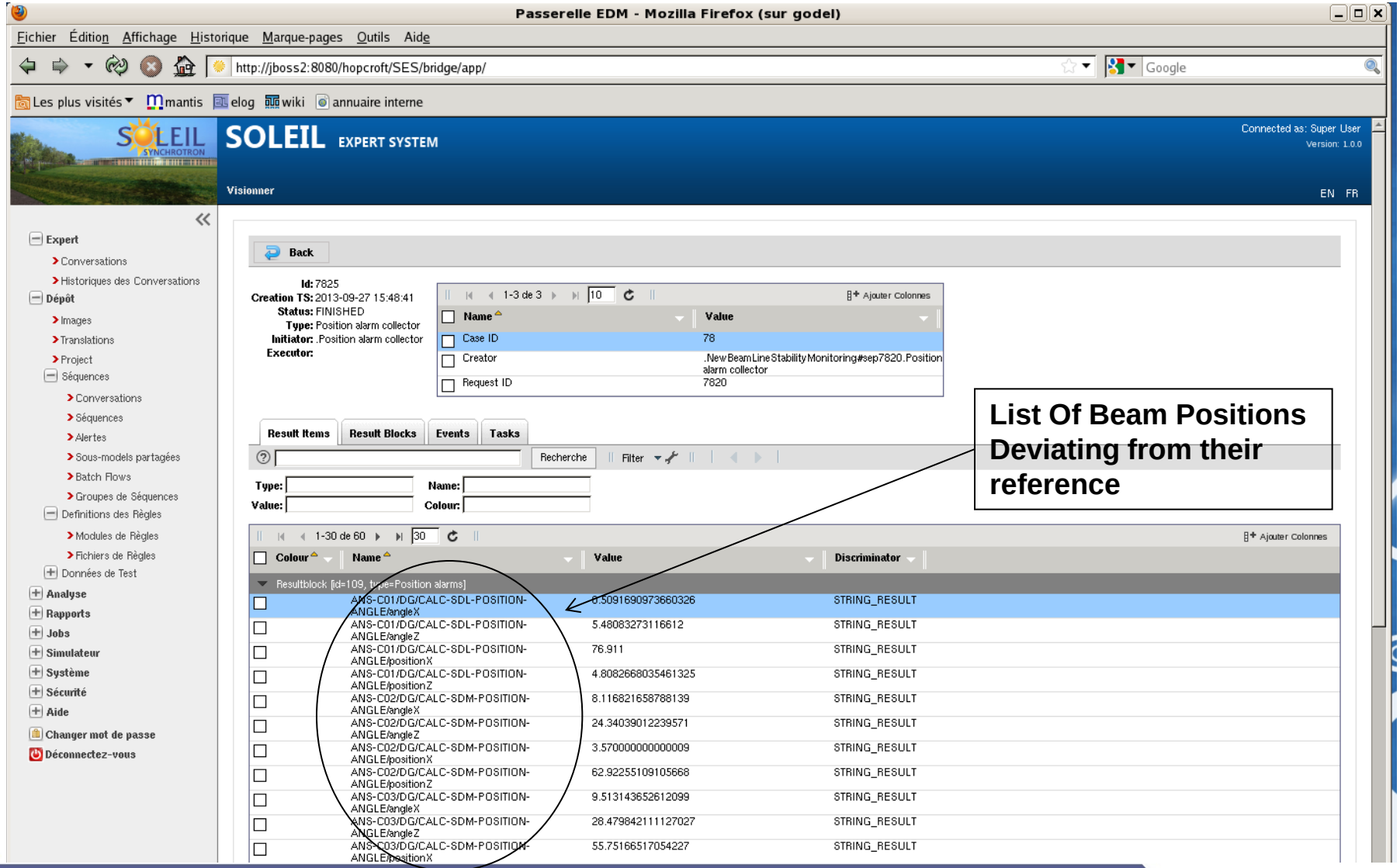
The Simplified prototype we developed for this scenario does :

- Data collection phase
  - Gets from a database the “Reference storage beam orbit”
  - Compare It to last 10 seconds “Archived Beam Positions”
- Data analysis/diagnosis
  - If these 2 orbits differ see if any of the insertion devices gap positions has changed during the last 100 seconds
  - Store all these collected data thanks to CDMA layer
- Diagnosis report
  - Done through the BIRT reporting package

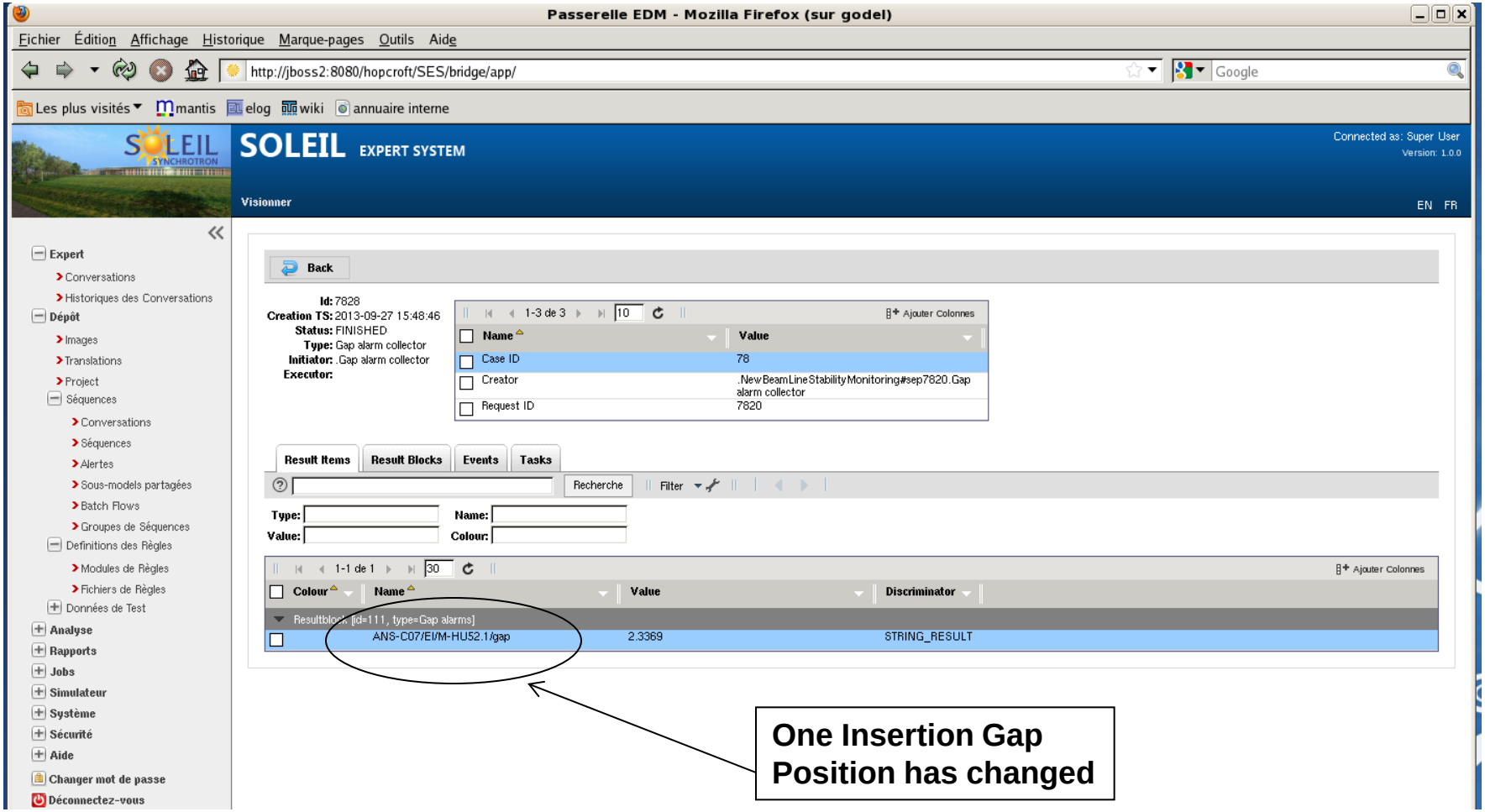
Simple Beam Stability Scenario
Passerelle Workflow



Analysis report



An example of a possible Reason : Deviation of an Insertion device Gap Positions



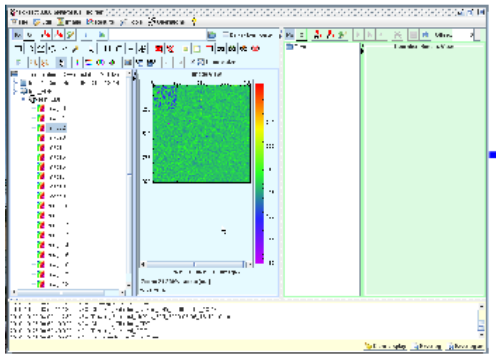
Conclusion

An expert system is a promising environment to cope with the problem of automating diagnosis of abnormal accelerator operation

- Foreseen
  - To perform a complete beam stability diagnosis workflow
  - To develop a beam Post mortem diagnosis workflow which integrate knowledge from all accelerator experts
- The most challenging will be to
  - Convince our operators and physicists to put (part of) their knowledge in an expert system
  - But the very high requirements in term of beam stability and beam availability will be an important driver

Thanks for your attention

CDMA API : Accessing data through keywords thanks to its dictionnary mechanism



keywords Declaration file

```
<data-def name="Experiment name">
<!-- ex: EXAFS, SAXS,... →

  <item key="mono_energy">
  <item key="mono_type">

</data-def>
```

CDM

Files format plugin

0100110
1001110
0100110
11110...

keywords Mapping file

```
<map-def name="Experiment name">
<!-- ex: EXAFS, SAXS,... -->

  <item key="mono_energy">
    <path>path/to/user/mono/energy</path>
  </item>
  <item key="mono_type">
    <path>path/to/user/mono/type</path>
  </item>
  ...
</map-def>
```