

EUROfusion Databases Meeting

The EUROfusion Disruption Database

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IMAS contact person: F. Imbeaux

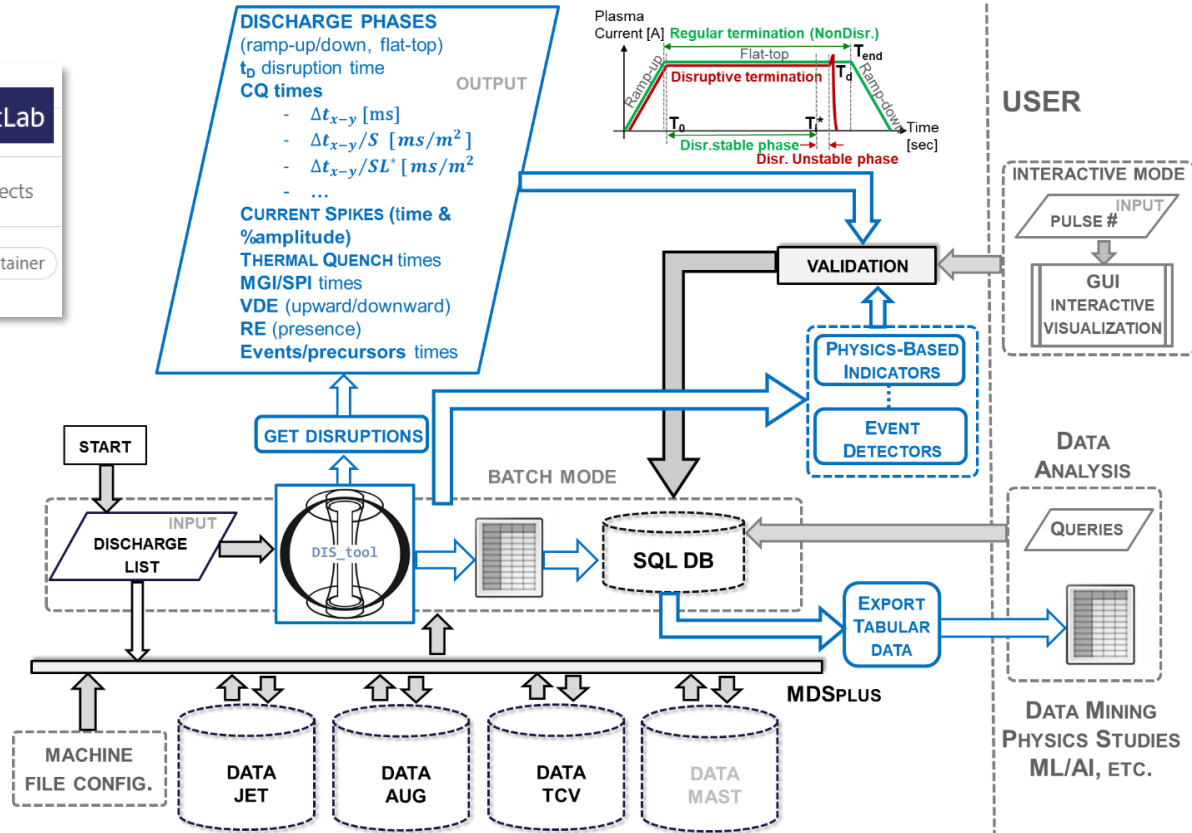
Collaborators: O. Sauter

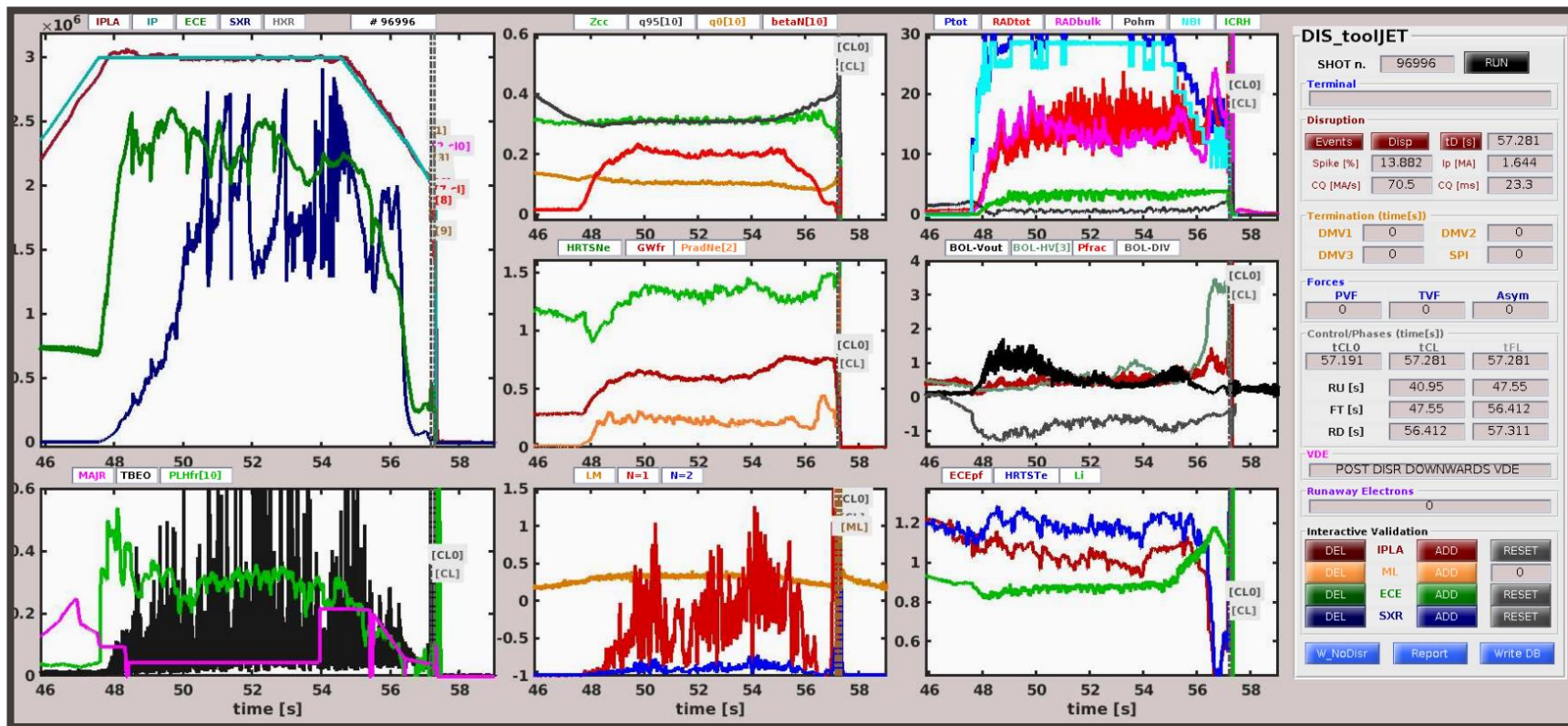
^(*) alessandro.pau@epfl.ch

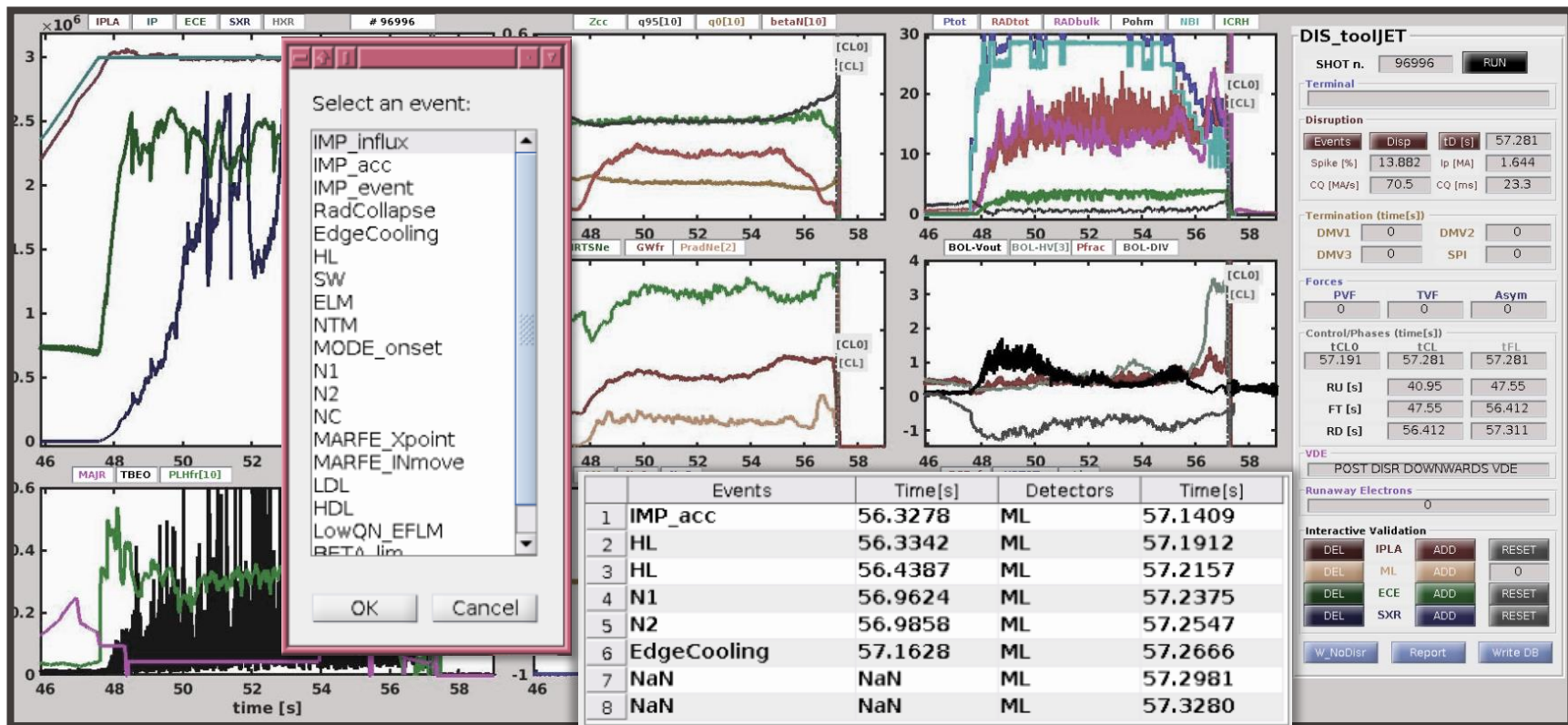
- Disruption Database **workflow**;
- **DIS_tool** framework: an **integrated approach** for data-validation and DB construction;
- Integration with a **Relational Data Model [SQL-DB]**
- **ERD** and definition of “**data-dictionaries**” and corresponding **objects**: validation, data provenance tracking and DB construction automatization;
- **Applications** with preliminary validated databases:
 - Termination analysis for scenario development.
 - Disruption prediction and avoidance in connection with modeling (H-mode density limits).
- **Future perspectives**: what needs to be improved and timelines.

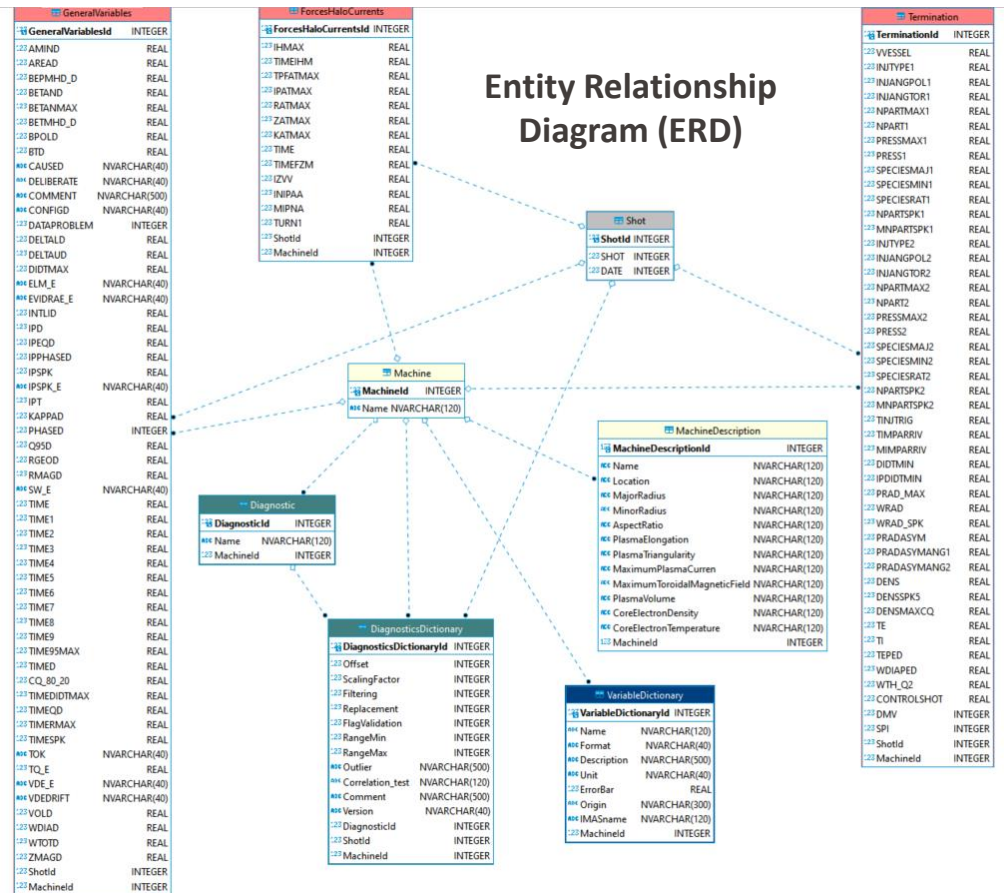


- Project under **version control**;
- Regularly maintained by **SPC-EPFL** (full pipeline implemented on “Lacs”);
- The code can be run as well on **FREIA**, **Heimdall** (CCFE) and **TOKI** (IPP) computing clusters.









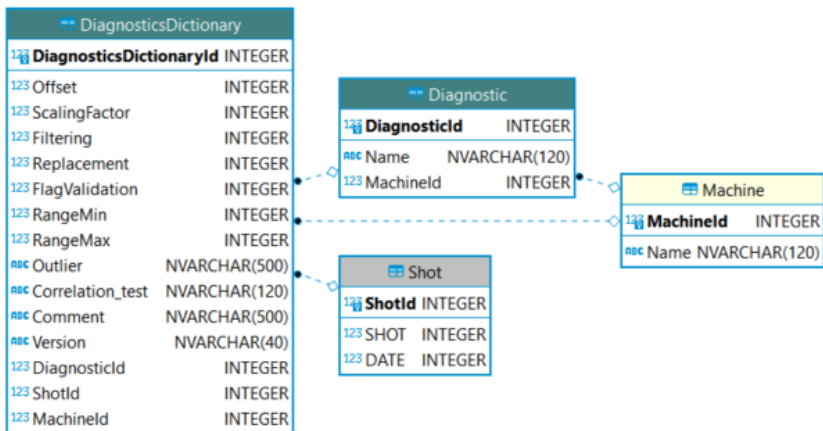
- **Normalized Data Model**;
- Easily accessible from **different languages** [Matlab, R, Python, IDL];
- **Checks and constraints** on mandatory fields -> **validation rules**;
- Connection with **objects** (defined as classes in *DIS_tool*):
 - *Set(Machine_DB)*
 - *Get(data)*
 - *Put(data)*

```

classdef Data_DB
    % Class_Instance = Data_DB();
    % -----
    % definition of disruption database objects
    % structured database with methods to r/w database fields
    %
    properties
        machine(1,:) char % {mustBeMember(machine, {'AUG', 'JET', 'MAST', 'TCV'})}
        data struct
    end

    methods
        % Initialize Shot Nodes
        function obj = InitializeNodes(obj,shotList)
            % obj = InitializeNodes(obj,shotList)
            % -----
            if isempty(obj.data)
                dummy.init = 1;
                obj.data = dummy;
            end
            fprintf('Initializing shot nodes \n')
        end
    end
end
    
```

Multimachine DDB Design: SQL (2)

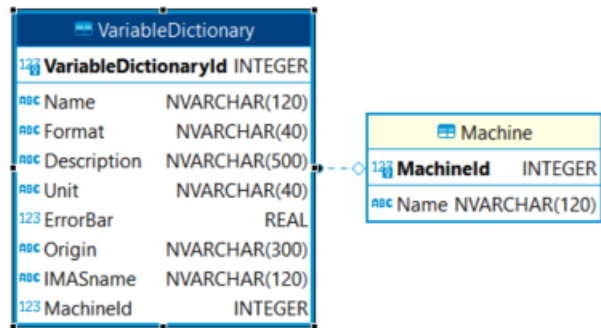


- **Variables** and **Diagnostics dictionaries** for entries validation;
- **Object** defined as instances of “superclasses” (**properties** and **methods** generically defined for each diagnostic and associated to **validation rules**);
- Generation of **configuration files** (spreadsheets, XML, JSON, etc.) read by DIS_tool and translated in **validation-rules**.

```

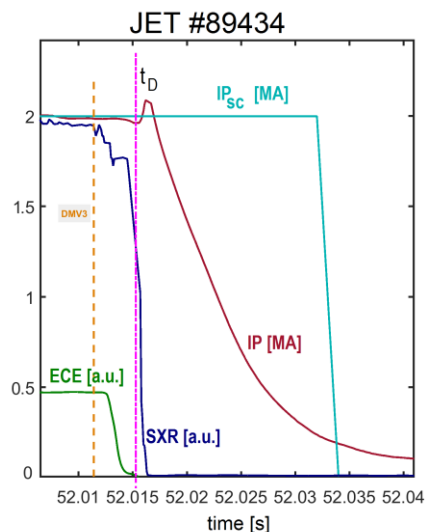
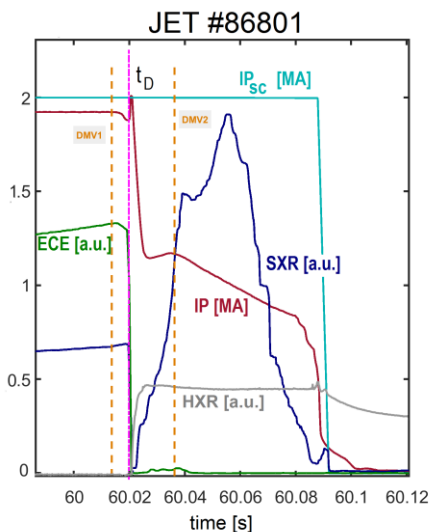
classdef DIAG
    % Class_Instance = DIAG();
    % -----
    % definition of DIAG object
    % diag object (subclass) inherits properties & methods for generic data-sanity check

    properties
        label(1,:) char
        data % tabular data
        fields struct = struct('time','t','spatial_coord','x','data','z') % mapping [t,x,z] -> [nt,nx,nz]
        processing struct = struct('offset',[],'scaling_factor',[],'filtering',[],'replacement',[])
        validity struct = struct('validation',[],'range',[],'outliers',[],'correlation_test',[])
        provenance struct = struct('shot',[],'source',[],'units',[],'version',[])
    end
end
    
```



Detectors: REs detection with statistical test (1)

- $\Delta t_{x-y} = \frac{t_y - t_x}{(x-y)\%}$ [ms] Linear Current Quench Extrapolated Time (LCQET)
- $\Delta t_{x-y}/S$ [ms/m²] LCQET normalized by the plasma cross section
- $\Delta t_{x-y}/SL^*$ [ms/m²] LCQET normalized by the plasma Self Inductance L^* [$L^* = \ln\left(\frac{8R}{a}\right) - 1.75$]



```

classdef Detector
    % Definition of disruption database objects
    % Superclass with generic properties and methods characterizing the detection

    properties
        Type_Detector(1,:) char (mustBeMember(Type_Detector,{'OffNormal','Disruptive','Instability','Transient'})) = 'OffNormal'
        Thresholds_Detection (mustBeNumeric)
        Method_Detection(1,:) char (mustBeMember(Method_Detection,{'Equal','LessThan','GreaterThan','GreaterThanLessThan'})) = 'Equal'
        Detection_AssertionTime (mustBeNumeric)
    end

    data struct

    methods
        function obj = InitializeDetector(obj)
            dummy = [];
            if isempty(obj.data.time) || isempty(obj.data.signal)
                obj.data.time = dummy;
                obj.data.signal = dummy;
                fprintf('Initializing Detector with empty structure')
            else
            end
        end
    end
end
    
```

- **Objects** to detect events and reconstruct the chain of events leading to disruption (LM, Radiative Instabilities);
- **Automatized** run and **standardized** encoding for the different machines;
- Data **provenance**: mapping between object fields and tables/config. files -> reconstruct generated DB (including remote source/origin).

Detectors: REs detection with statistical test (2)

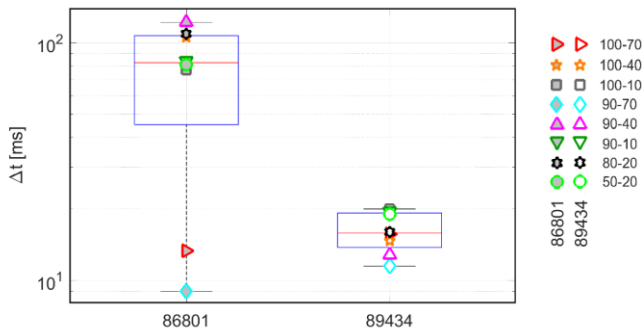
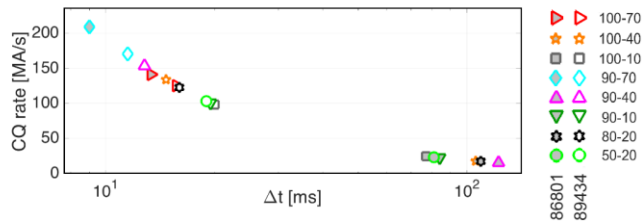
- $\Delta t_{x-y} = \frac{t_y - t_x}{(x-y)\%}$ [ms]
- $\Delta t_{x-y}/S$ [ms/m²]
- $\Delta t_{x-y}/SL^*$ [ms/m²]

Linear Current Quench Extrapolated Time (LCQET)

LCQET normalized by the plasma cross section

LCQET normalized by the plasma Self Inductance L*

Statistical dispersion
[MAD]



Δt [ms]	
86801	[ms]
min:	9.0
max:	122.4
mean:	75.2
median:	82.5
std:	42.48
range:	113.4

$\Delta t/S$ [ms/m ²]	
86801	[ms/m ²]
min:	2.36
max:	32.15
mean:	19.75
median:	21.67
std:	11.16
range:	29.78

$\Delta t/SL^*$ [ms/m ²]	
86801	[ms/m ²]
min:	1.66
max:	22.59
mean:	13.88
median:	15.22
std:	7.84
range:	20.93

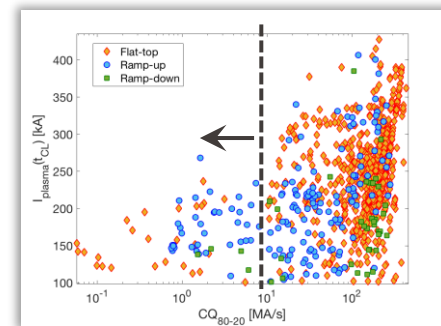
Δt [ms]	
89434	[ms]
min:	11.5
max:	20.0
mean:	16.1
median:	15.8
std:	3.15
range:	8.5

$\Delta t/S$ [ms/m ²]	
89434	[ms/m ²]
min:	2.70
max:	4.70
mean:	3.79
median:	3.72
std:	0.74
range:	2.00

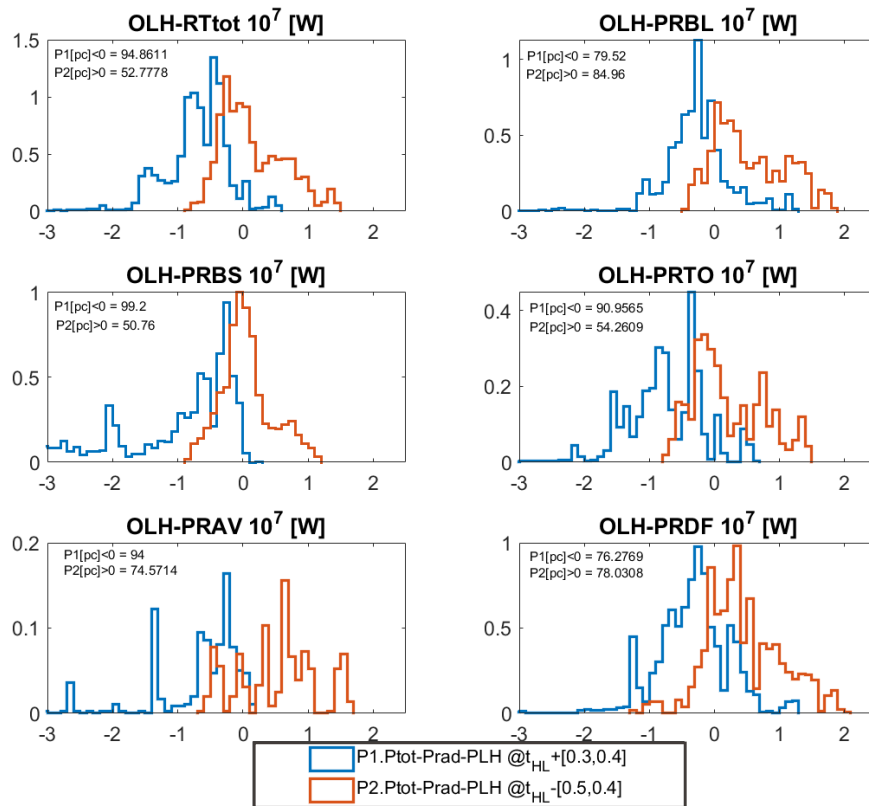
$\Delta t/SL^*$ [ms/m ²]	
89434	[ms/m ²]
min:	1.85
max:	3.21
mean:	2.59
median:	2.54
std:	0.51
range:	1.36

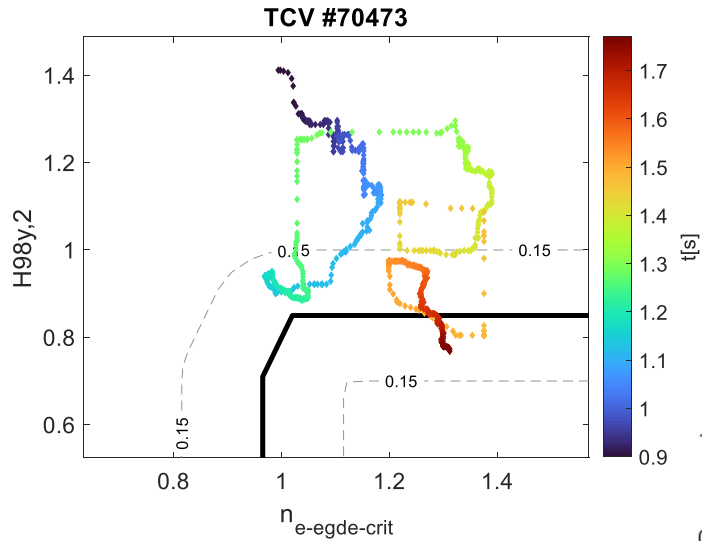
$$L^* = \ln\left(\frac{8R}{a}\right) - 1.75$$

TCV REs



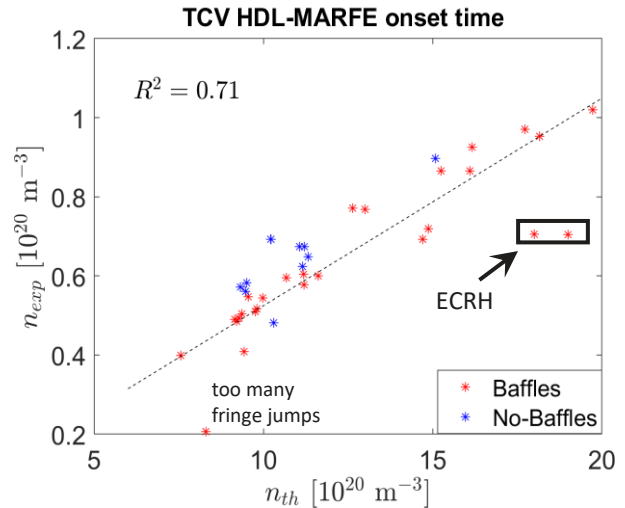
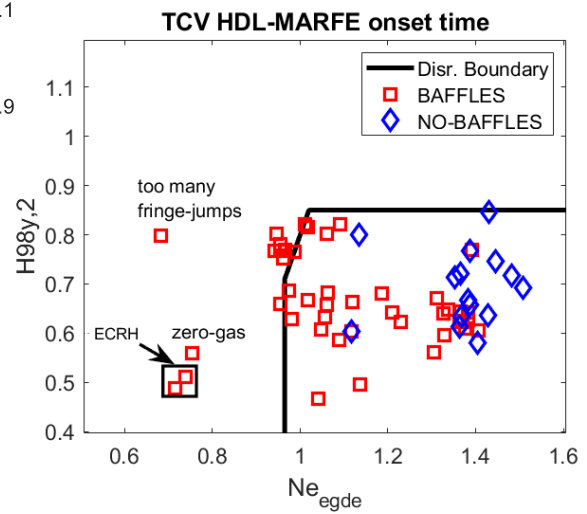
- **JET terminations** in high-current high-power baseline scenario
- **Statistical analysis** for parameters optimization of P_{NBI} RT-control [O. Sauter]
- Automatic **RUN** of a shot with user-defined data-processing provided as a **configuration file**.
- Almost automatic generation of **tabular data**, including time traces





$$n_{th} = \alpha a^{1/2} B_T^{6/5} P_{SOL}^{2/5} q_{95}^{-6/5} R_0^{-7/10} (1 + \kappa^2)^{-3/5}$$

DL when $L_p \sim a$



- **DB construction workflow** finalized in a standardized/generic way (easy application to other devices and other domains) ;
- **DIS_tool** refactoring based on object-oriented philosophy and full integration with **SQL database**;
- Definition of a flexible scheme and **relation data model** where it is relatively easy integrating new objects for various analysis;
- Importance of having a **well-structured** and standardized **architecture**: consistent data validation, provenance tracking and capability of reproducing analysis.
- **Future work**: advance with **disruption validation** (several concrete applications so far and preliminary validation for hundreds/thousands of disruptions for AUG-TCV-JET) and fill **Web catalogue**.
- **Issues**: lack of man-power (machine **contact persons** – AUG and JET - and **collaborators**) in particular for data-validation -> ITER relevant!

Backup slides

EUROfusion user

Web catalogue



<http://imas-1.jet.apps.l/catalog Qt/ui2/>

Catalogue Query Tool

DEBUG Version

AND OR

Machine equal JET_disruption

Reset Search2

+ Add rule + Add group

Close

#	ID	User	Machine	Shot	Run	DS_Version
6	10650	gratta	JET_disruption	92482	0	2018
7	10651	gratta	JET_disruption	92497	0	2018
8	10652	gratta	JET_disruption	92448	0	2018
9	10653	gratta	JET_disruption	92480	0	2018
10	10654	gratta	JET_disruption	92433	0	2018
11	10655	gratta	JET_disruption	92461	0	2018
12	10656	gratta	JET_disruption	92432	0	2018
13	10657	gratta	JET_disruption	92459	0	2018
14	10658	gratta	JET_disruption	92459	0	2018
15	10659	gratta	JET_disruption	92477	0	2018
16	10660	gratta	JET_disruption	92454	0	2018
17	10661	gratta	JET_disruption	92487	0	2018
18	10662	gratta	JET_disruption	92456	0	2018
19	10663	gratta	JET_disruption	92452	0	2018

Page 1 of 1 20 Displaying 1 to 19 of 19 items

Entry Annotations

#	ID	Text	User	Date
No rows to display.				

Page 0 of 0 15

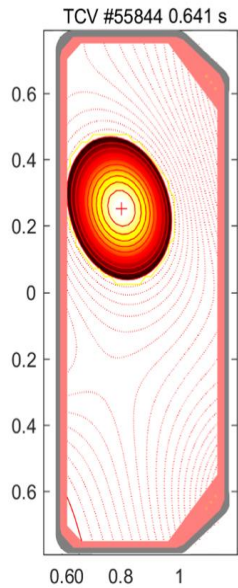
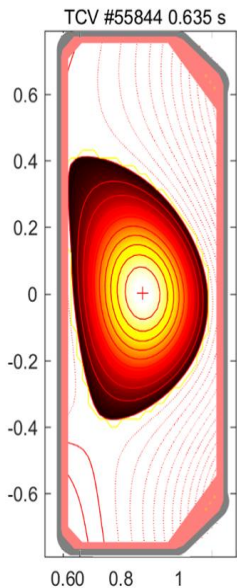
#	ID	Variable	Value	Type	Units
39	1130122	global_quantites/trivalue_error_upper	10000.000000	Double	1
40	1130123	global_quantites/trivalue	POG_U: Morita code provided by S. Moradi	String	0
41	1130124	global_quantites/trivalue	0.899190	Double	1
42	1130125	global_quantites/trivalue_error_lower	-12.6191058	Double	1
43	1130126	global_quantites/trivalue_error_upper	7.396635	Double	1
44	1130127	global_quantites/r5source	POG_U: Morita code provided by S. Moradi	String	0
45	1130128	global_quantites/r5value	3.254683	Double	1
46	1130129	global_quantites/r5value_error_lower	0.387144	Double	1
47	1130130	global_quantites/r5value_error_upper	6.511165	Double	1
48	1130131	global_quantites/volume_source	PPF-ETR/VOLU	String	0
49	1130132	global_quantites/volume_value	72.545540	Double	1
50	1130133	global_quantites/volume_value_error_upper	1.000000	Double	1
51	1130134	tbl_properties.comment	Impurity accumulation with core collapse=>1 mode L	String	0
52	1130135	tbl_properties.comment	1	String	0

Page 1 of 1 100 Displaying 1 to 53 of 53 items

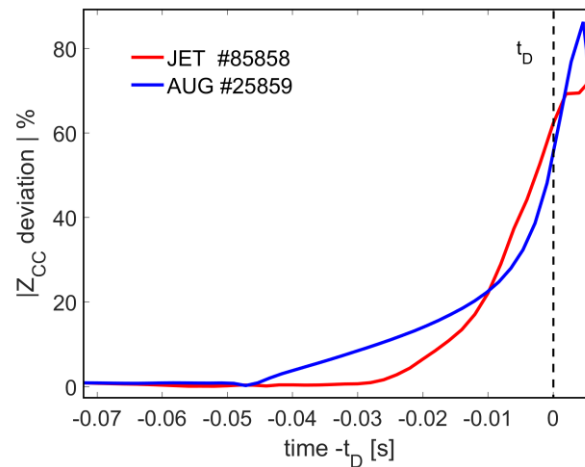
```
SELECT entry_fm.machine_name,u.user_name FROM machines m,users u,entry entry INNER JOIN machines machines1 ON entry.machine_id=machines1.id WHERE machines1.machine_name = 'JET_disruption' AND entry.machine_id=m.id AND entry.user_id=u.id GROUP BY entry.id LIMIT 0,20
```

TCV

Hot VDEs

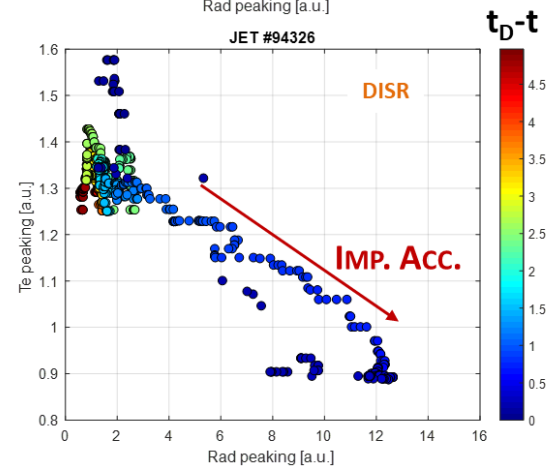
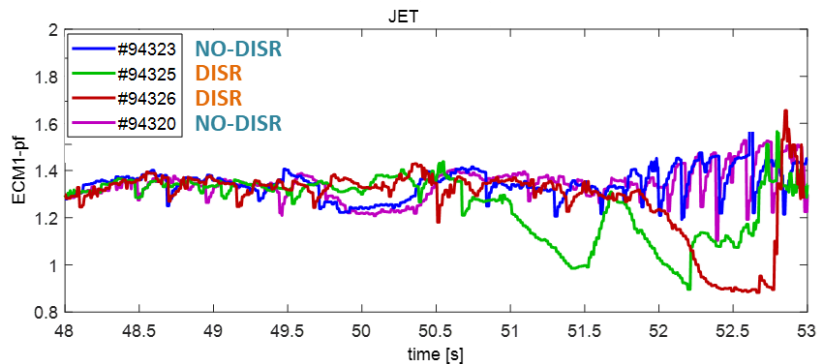
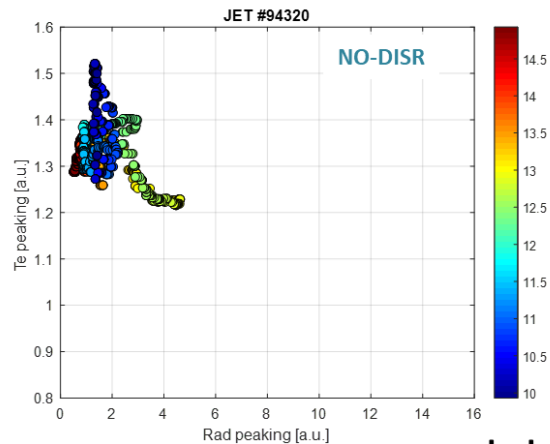
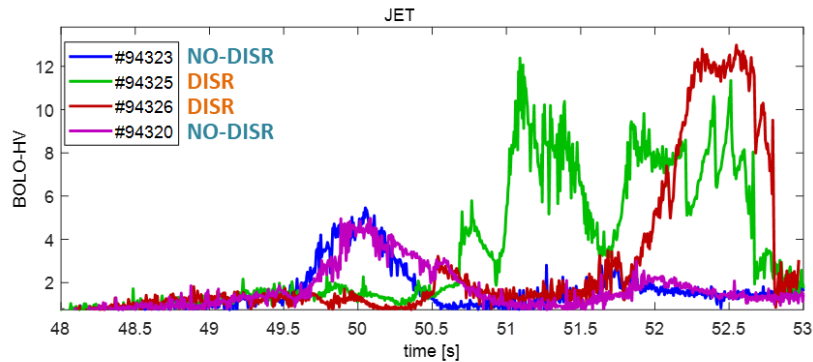


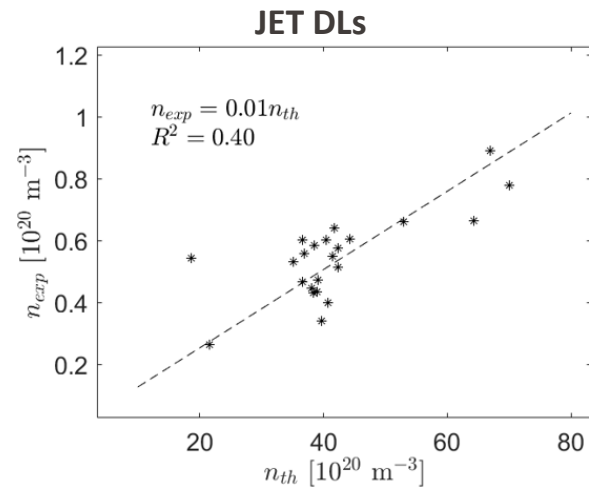
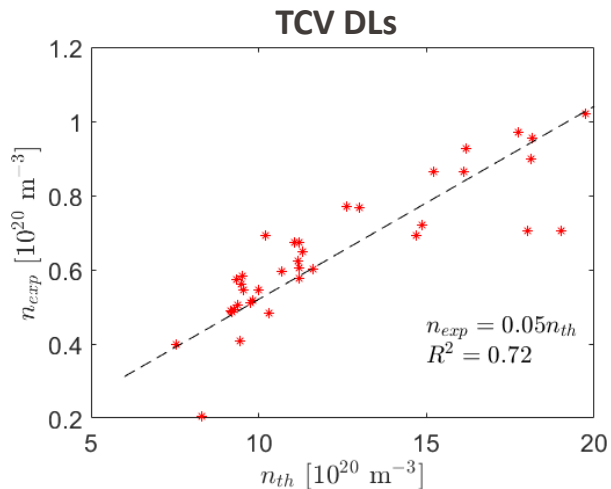
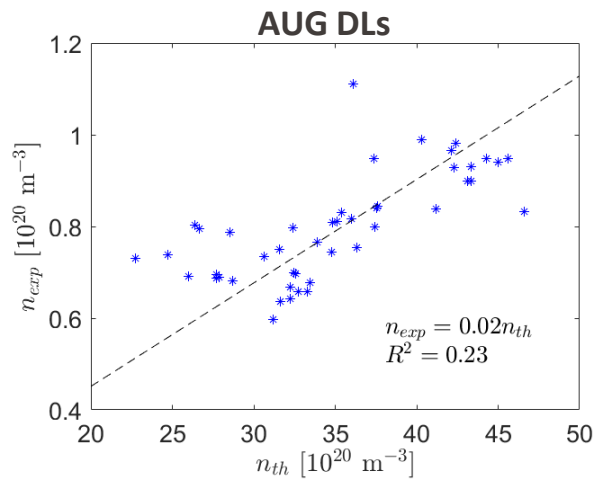
VDE normalized parameter



$$|Z_{CC \text{ dev.}}| \% = 100 \cdot \frac{|Z_{CC} - \langle Z_{CC} \rangle_{FT}|}{\langle b \rangle_{FT}}$$

Impurity Accumulation detection





[Preliminary analysis – M. Giacomini & P. Ricci]

$$n_{th} = \alpha a^{1/2} B_T^{6/5} P_{SOL}^{2/5} q_{95}^{-6/5} R_0^{-7/10} (1 + \kappa^2)^{-3/5}$$



DL when $L_p \sim a$