DE LA RECHERCHE À L'INDUSTRIE

THE LASER MEGAJOULE FACILITY: FRONT END'S CONTROL SYSTEM

October 9th 2019

Julien Langot

Presentation Overview

- The Laser MegaJoule Facility
- The Laser MegaJoule Facility Front End's
- The Front-End’s Control Command System
- High Energy Setup
- Conclusion

The Laser MegaJoule

The **Laser Megajoule** (LMJ) is a major installation of the **CEA's Simulation program**.

It is used to **study, on a very small scale, the behaviour of materials under extreme conditions** similar to those reached **during the nuclear operation of weapons**.

The **LMJ is designed to deliver more than one million joules** to a **target of a few millimeters** in a few billionths of a second.

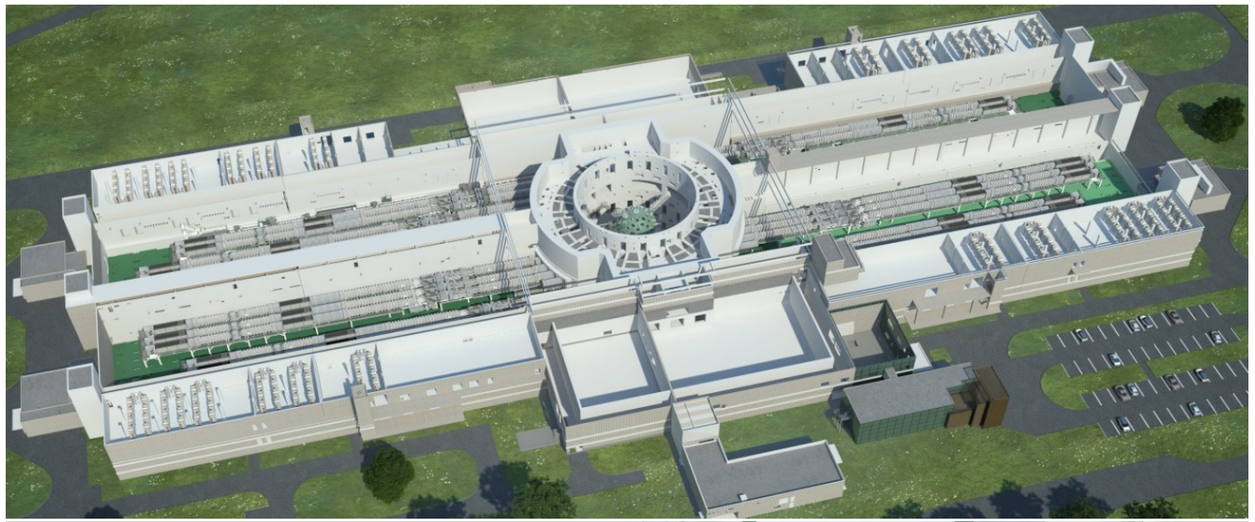
The LMJ was commissioned in 2014, with a first weapons physics campaign.

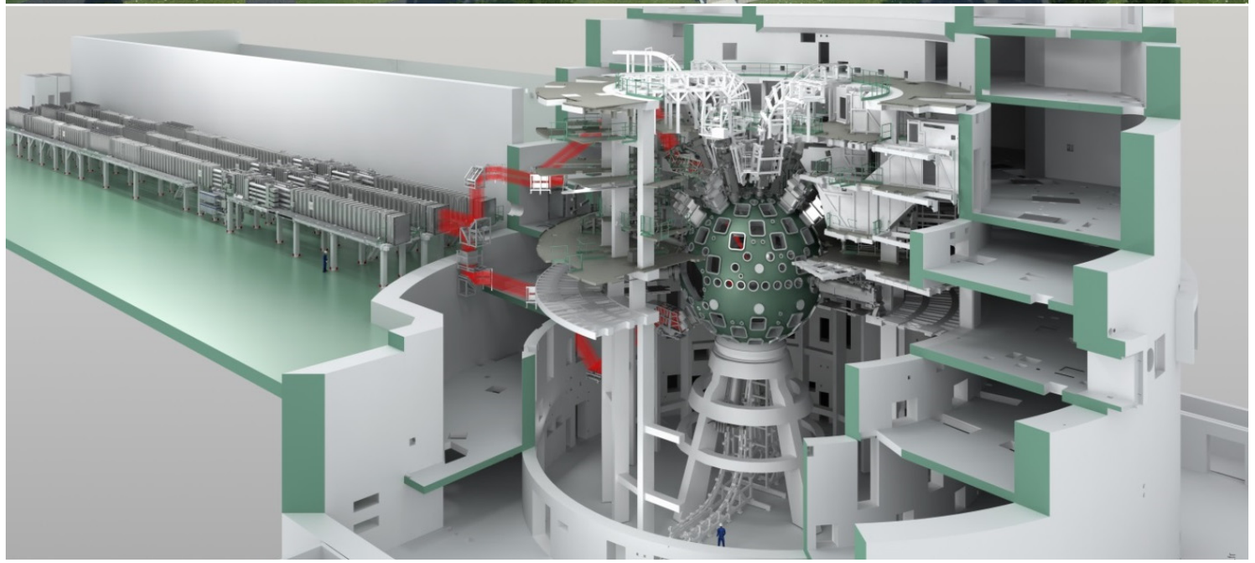
The Laser MegaJoule

Building: **150m x 300m - 35m high**

- **4 Laser bays**
  - **22 bundles** of 8 beams (**176 beams**)
  - Pulse duration: from 0.7 ns to 25 ns
  - **Laser energy about 1.5 MJ**
  - Each bundle is divided in 4 beams (quadruplet)

- **Experiment Room: ∅ 60 m**
- **Experiment Chamber: ∅ 10 m**
- **Target: ∅ 2mm**





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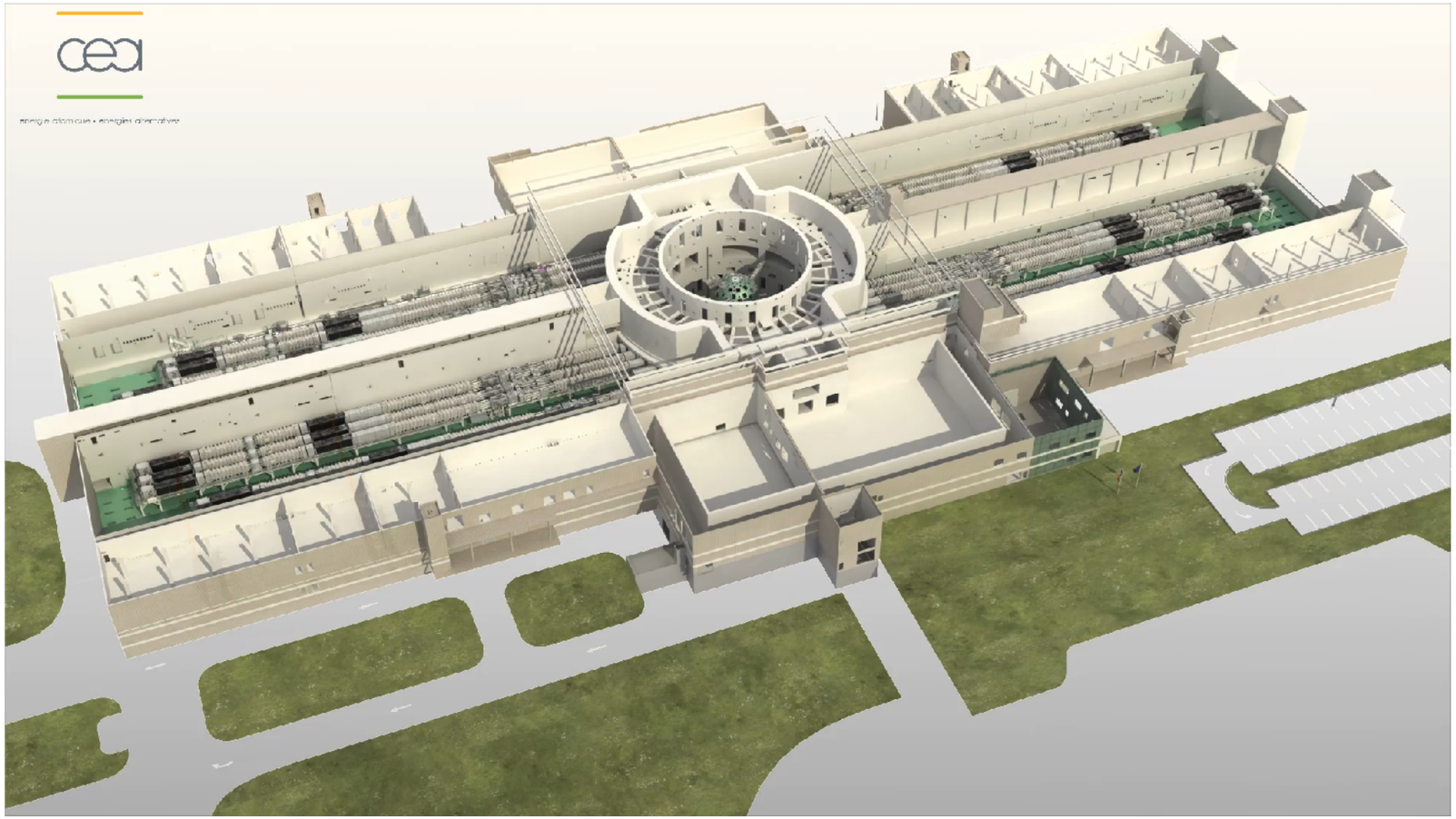

The Laser MegaJoule Front-End's

The **Front-End** mission is to deliver a **laser beam** defined in terms of **time shape**, **spatial shape** and **energy** to the laser bundles.

2 major components:

- **Seeder**
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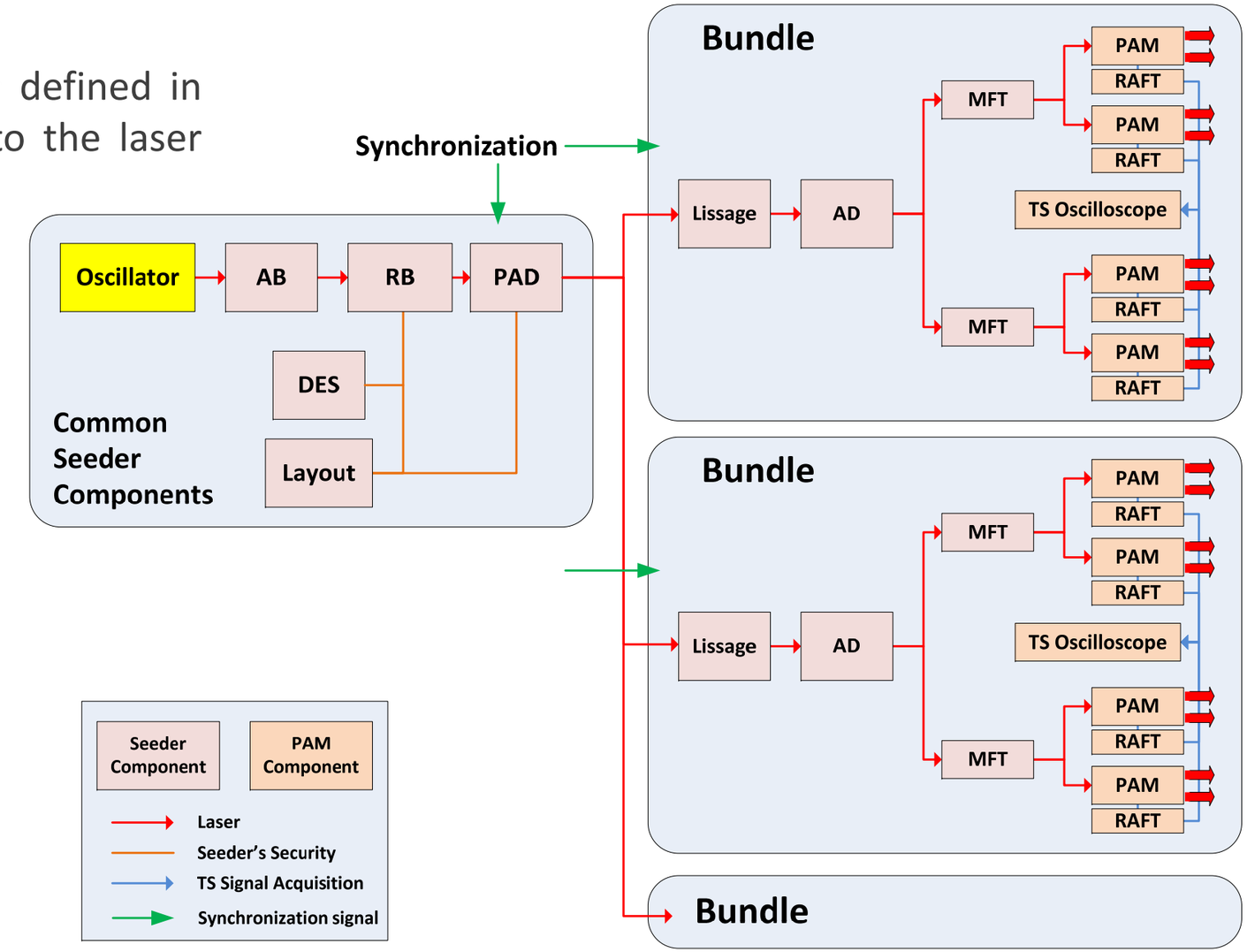

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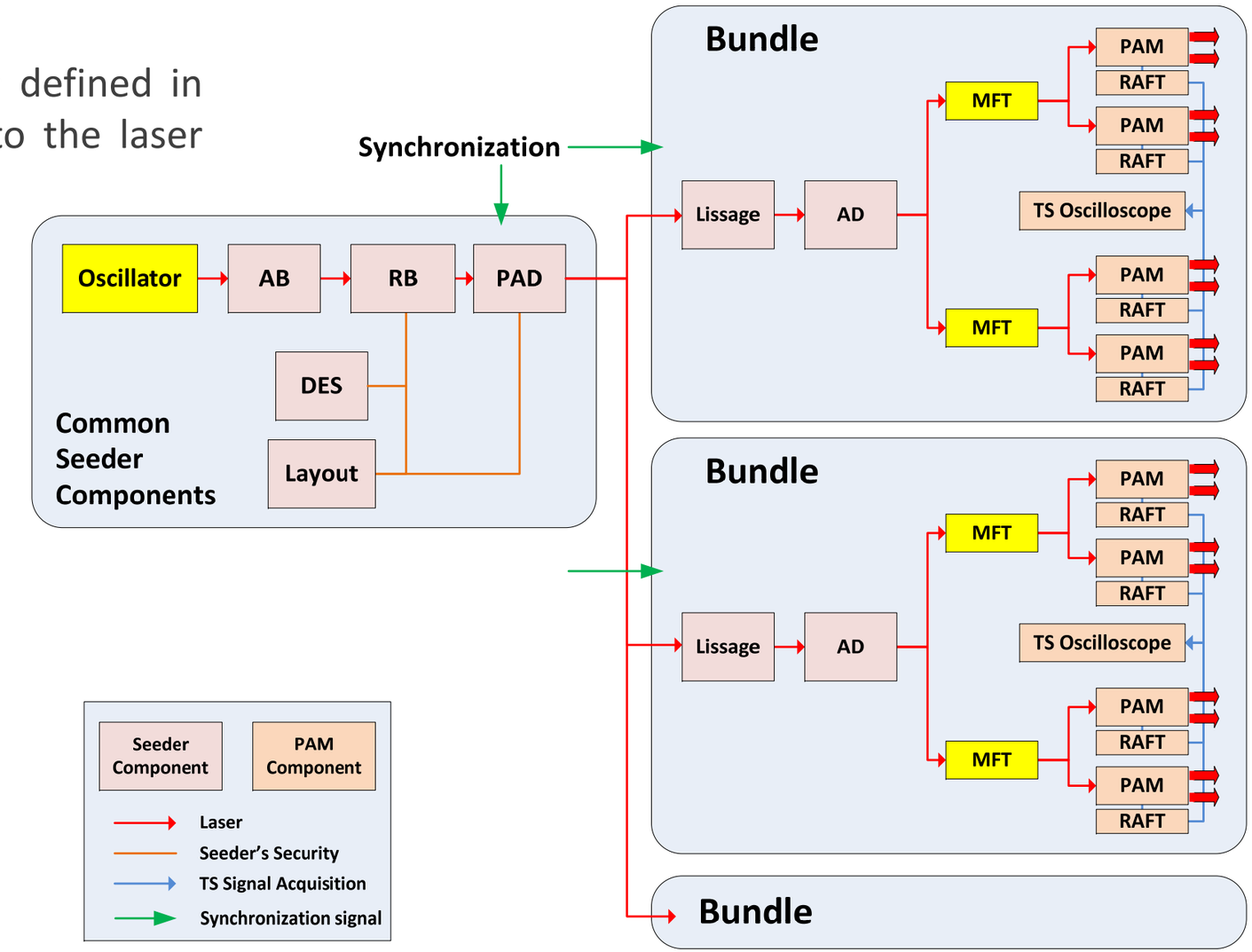

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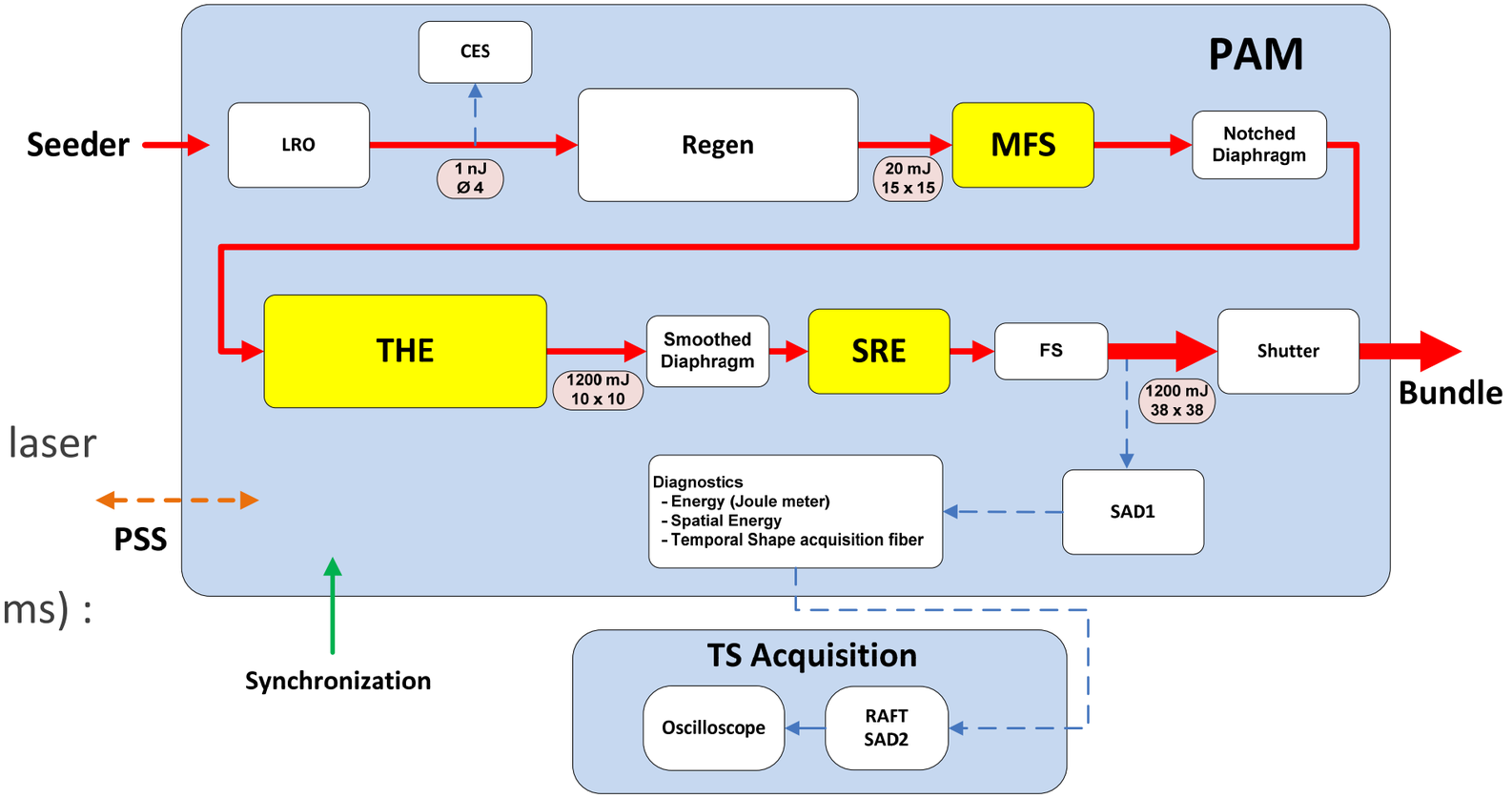
Pre-Amplification Module (1 for 2 laser beams) :

- **MFS** : **Spatial shape**
- **THE** : **Amplification** in 4-pass
- **SRE** : Adjustment of the **energy**

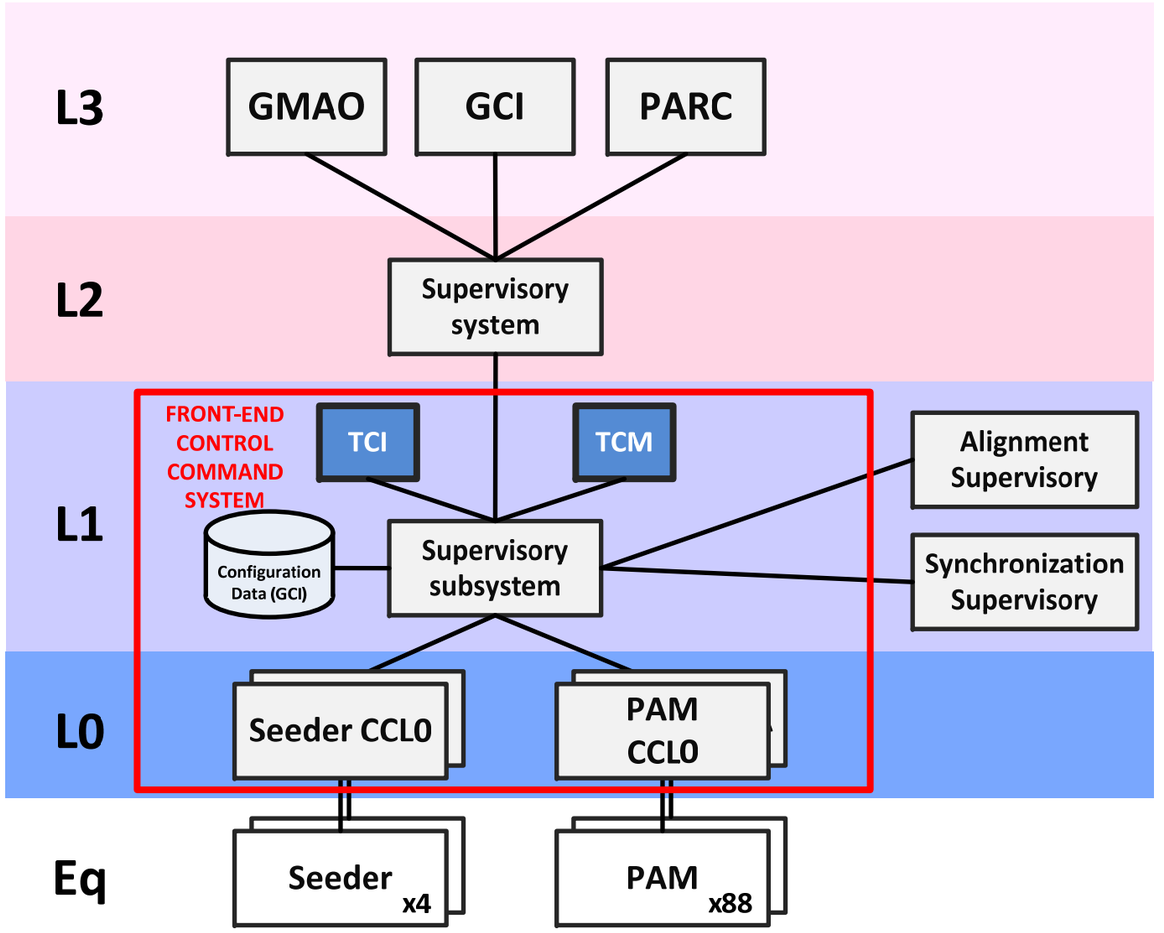


Front-End's Control Command System

The **Front-End equipments are controlled by a control command system** located on **Layer 0** and **Layer 1** of the LMJ CCS architecture

Composed of :

- **2 types of Control Command Layer 0** (CCL0)
  - **Seeder**
  - **PAM**
- **1 Supervisory subsystem** (CCL1)
  - **Control the Seeder and the PAM CCL0**
  - Interface with :
    - **Supervisory system** (CCL2)
    - **Synchronization Supervisory**
    - **Alignment Supervisory**
  - **Human Machine Interface** (TCI – TCM)
  - Configuration Data



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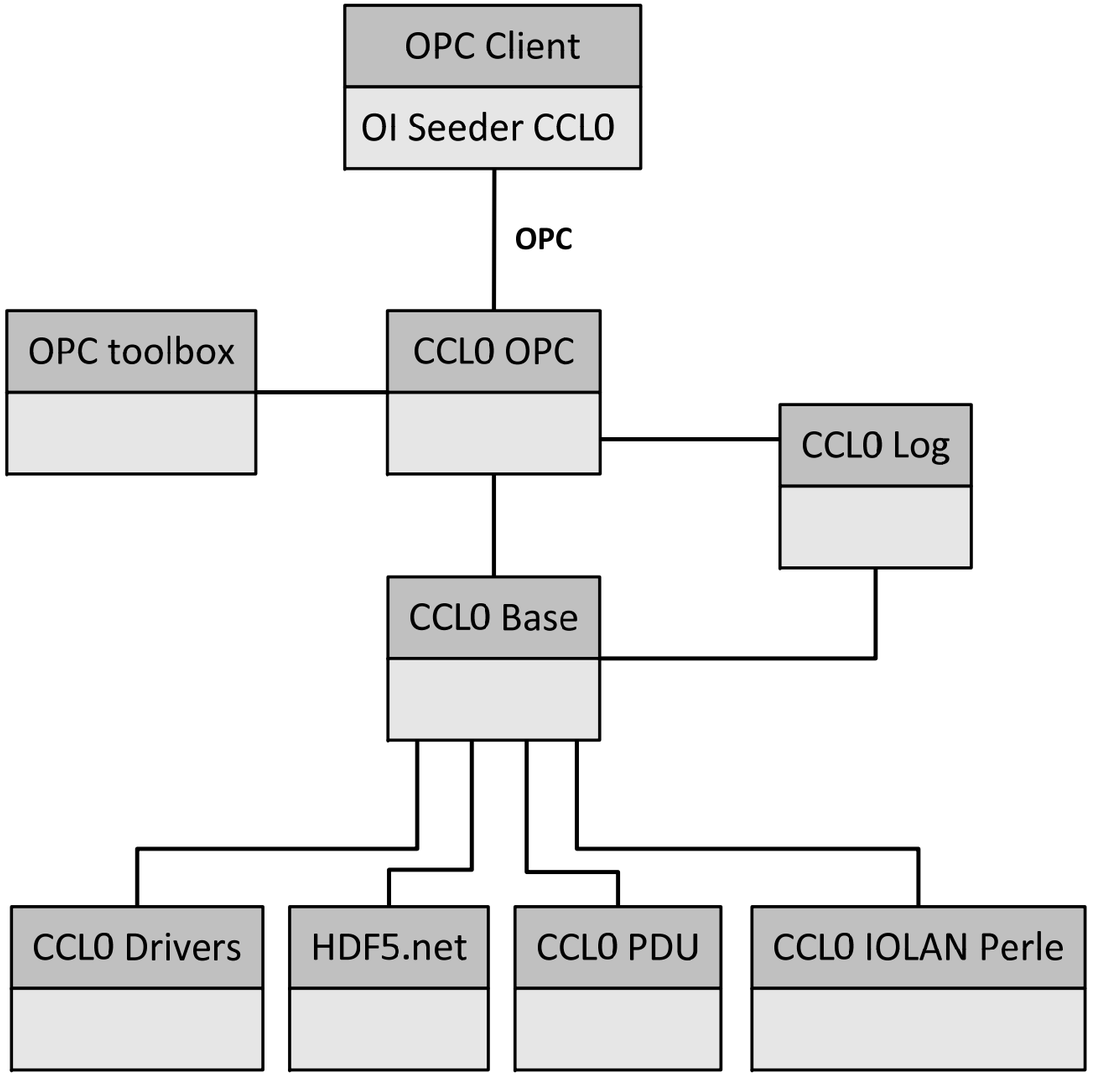
The **Seeder's CCL0** server is a **service application** written in **C# .NET** based on the following components:

- **CCL0 Base**,
- **CCL0 OPC Server**,
- **Hardware drivers**,
- The **system configuration functions**,
- Software **traceability functions**,
- **Event logging** functions.



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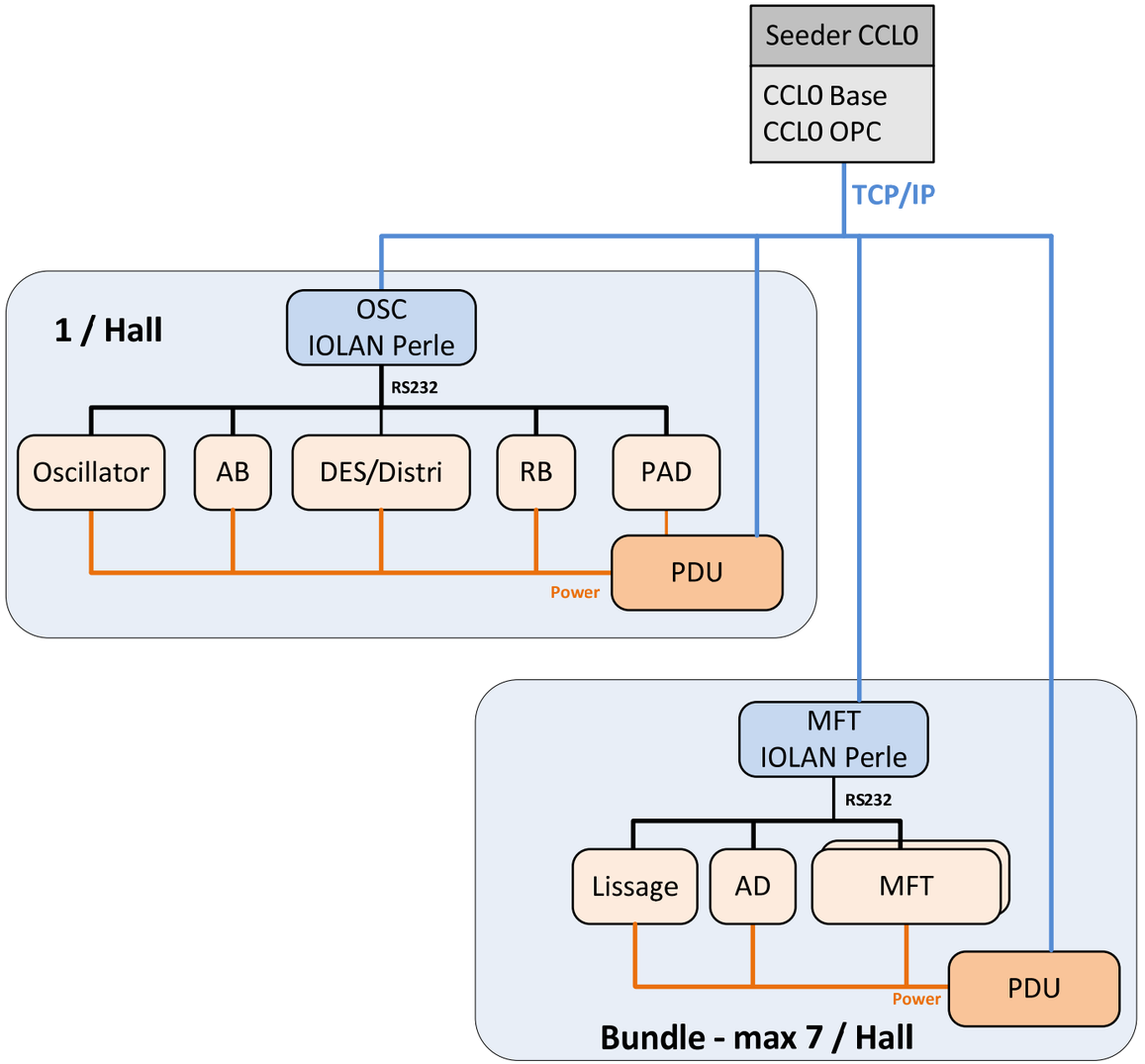

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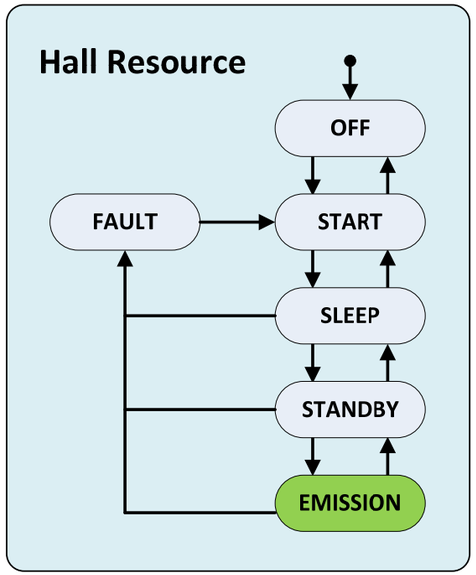
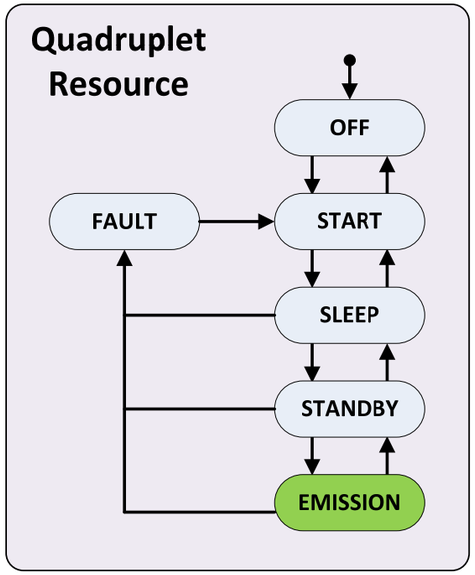
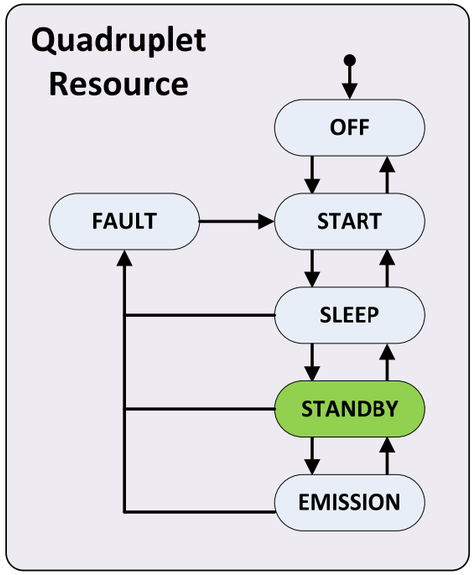
Each LMJ's Seeder resource (hall, bundles, Quadruplet) has a **State diagram** to activate its equipment as needed.

The state of the **Hall resource is synchronized with the bundle resources**.







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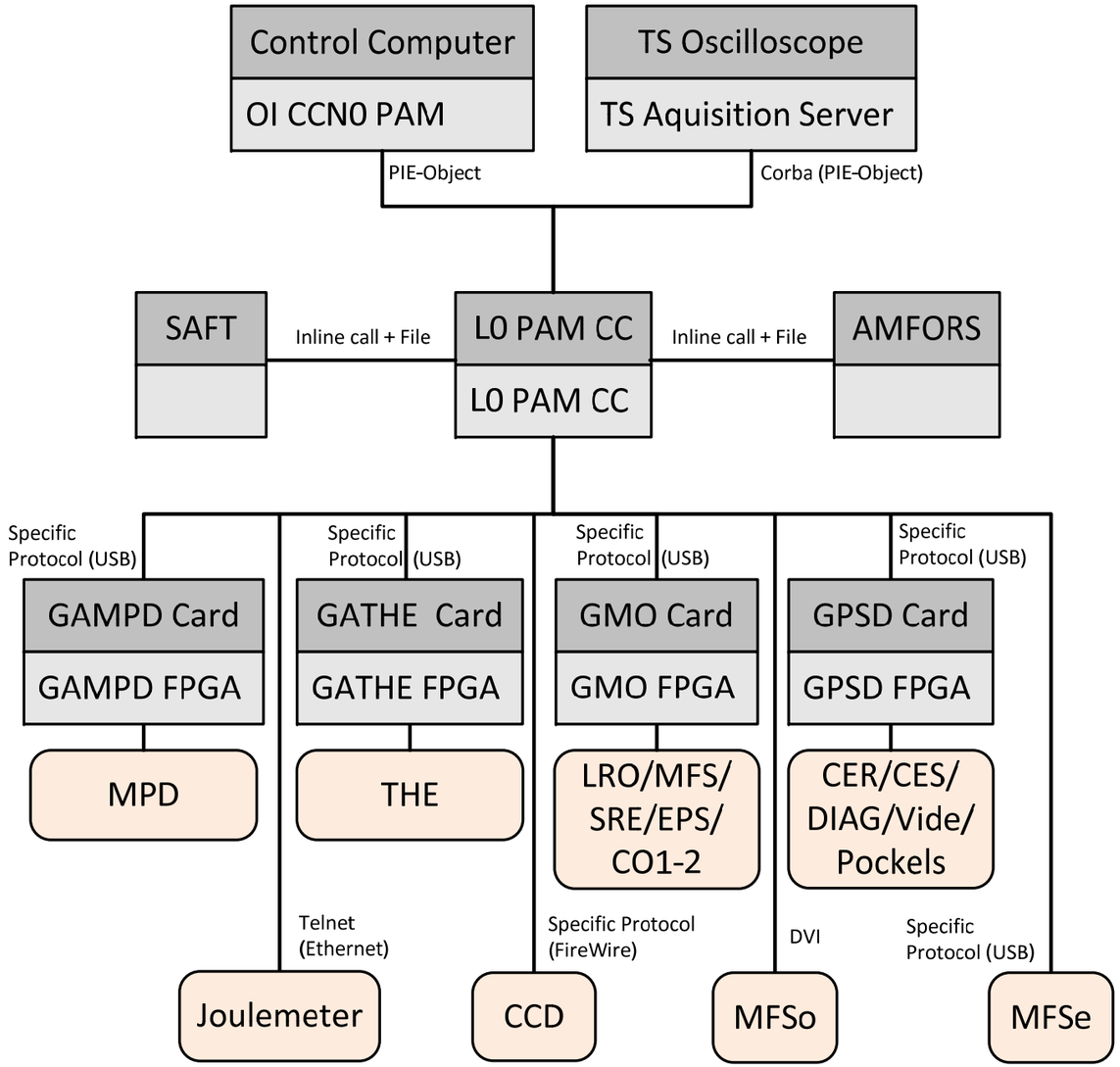
PAM

- **CCL0, written in C++, is integrated into the PAM's equipment.**
- **Interacts with electronic cards, FPGA or with onboard control cards.**



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- **CCL0 is integrated into the PAM's equipment**.
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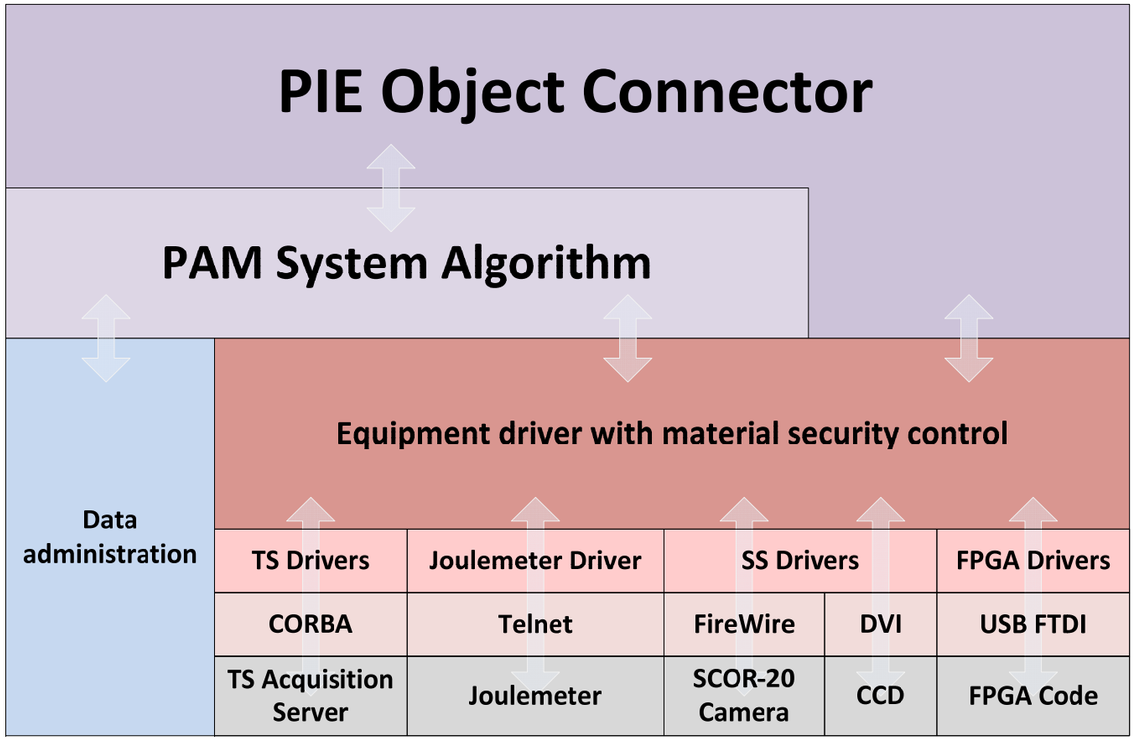
- **Level 0 control interface** (**PIE-Object connector)** insures the interface with the **Front-End's CCL1** and the **PAM's integration software.**
- **System algorithms** enables **Low Energy mode - High Energy mode**



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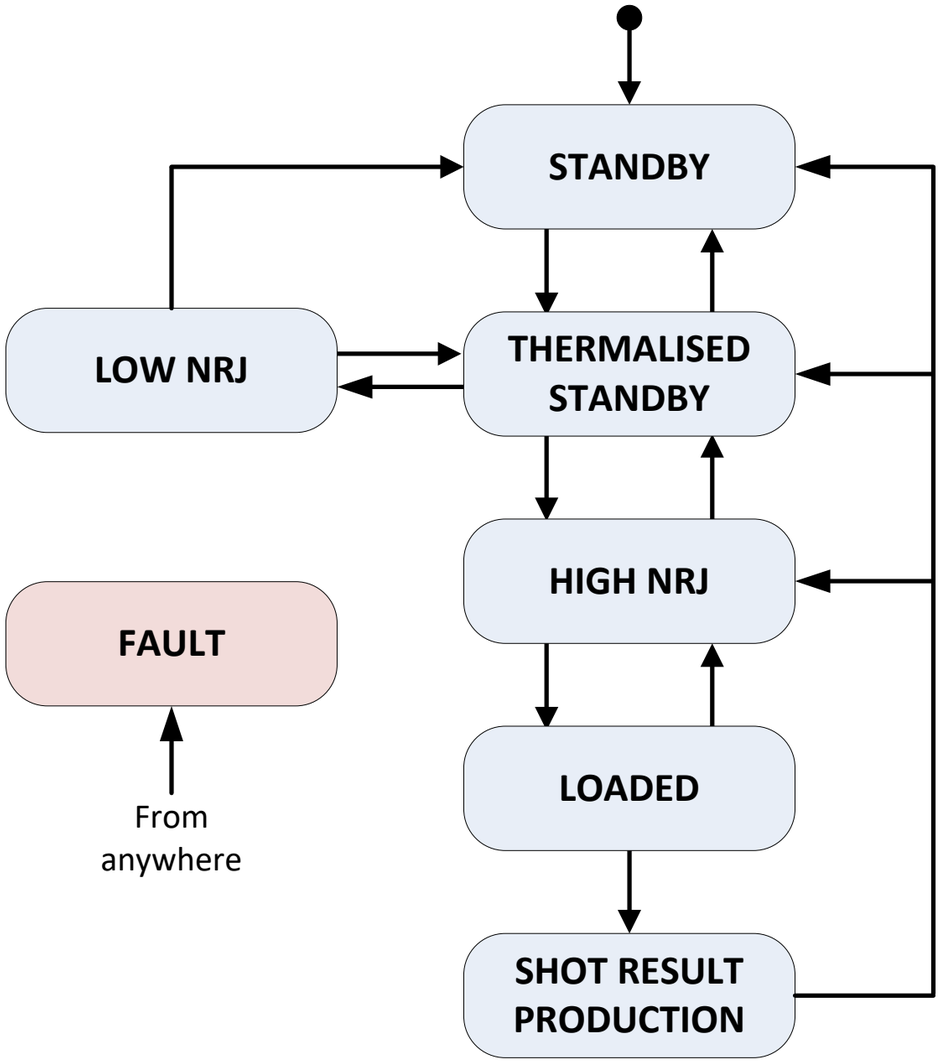

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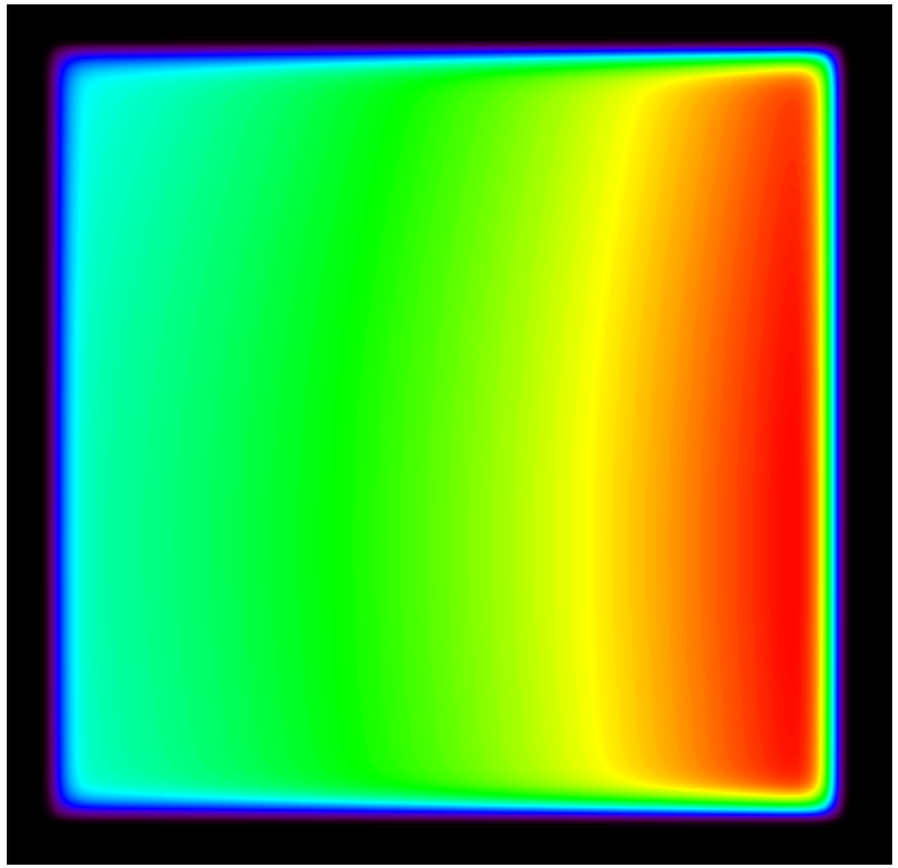
- Integrated into the PAM Module, IDL runtime
- **Processes PAM's spatial shapes images**
- Conditionates the **spatial distribution** of the laser beam energy



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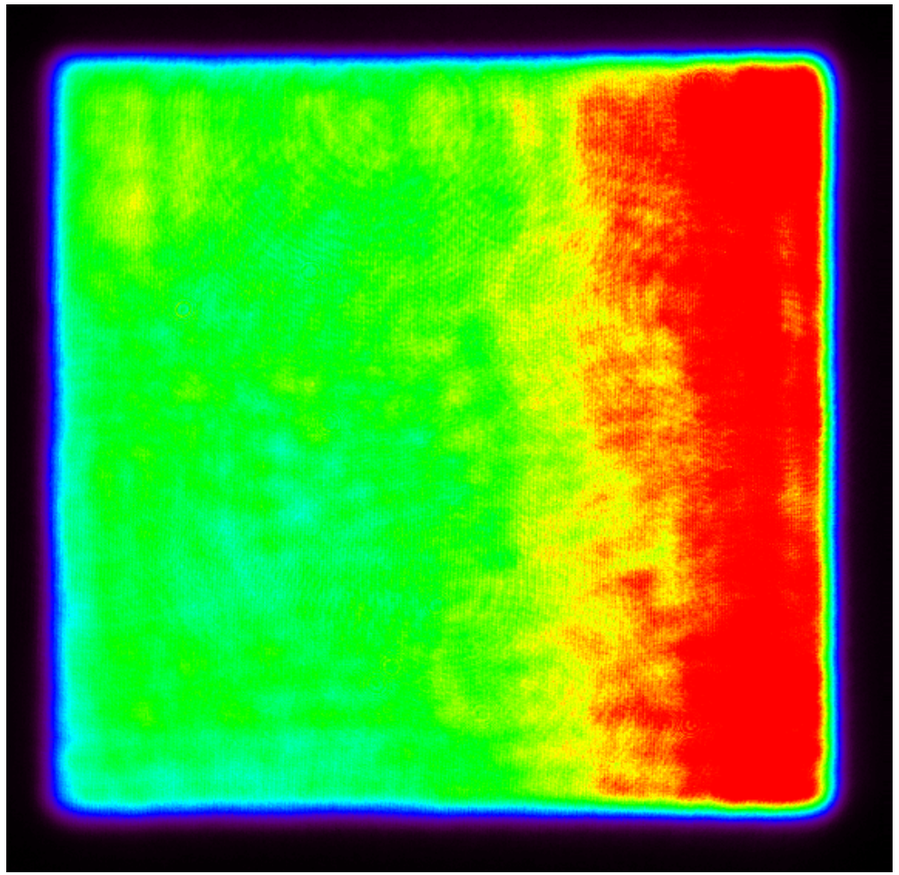

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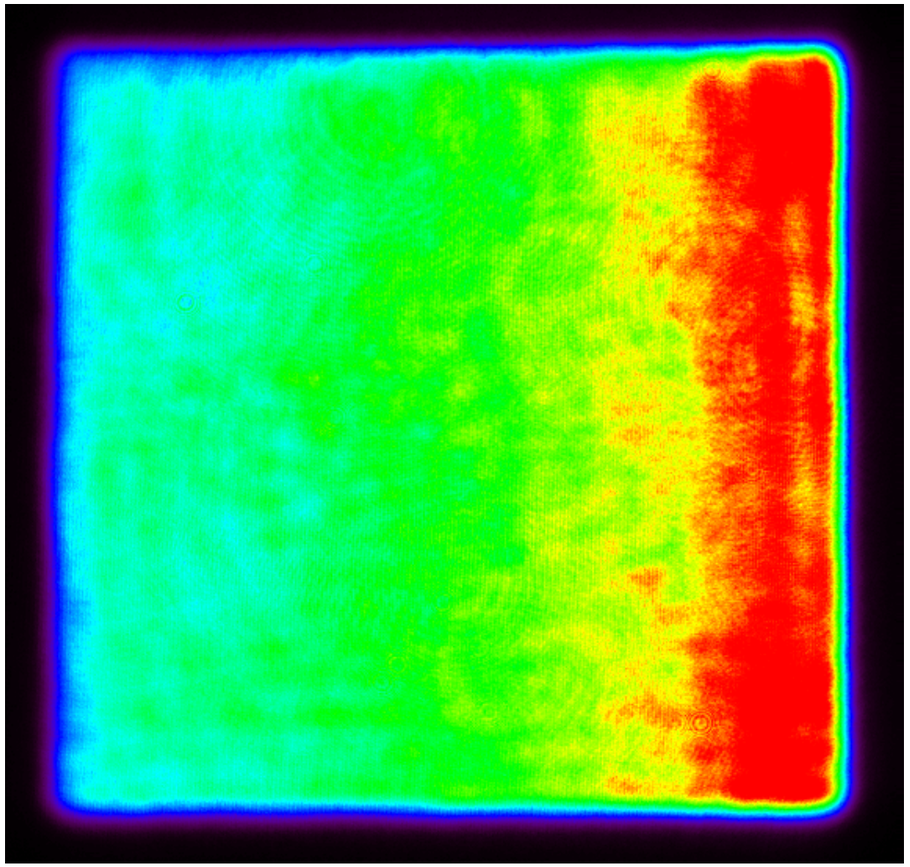

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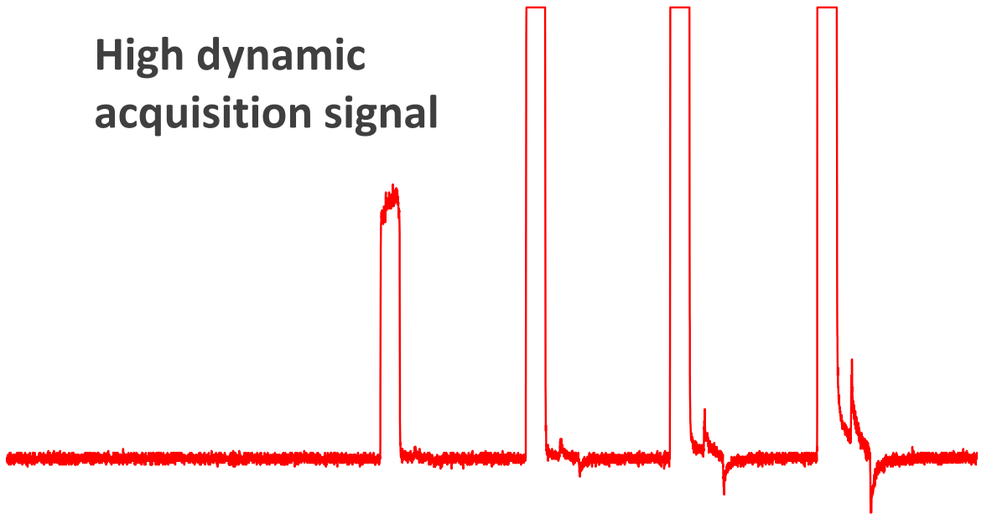
- **Reconstructs a high dynamic signal acquisition (RAFT)**



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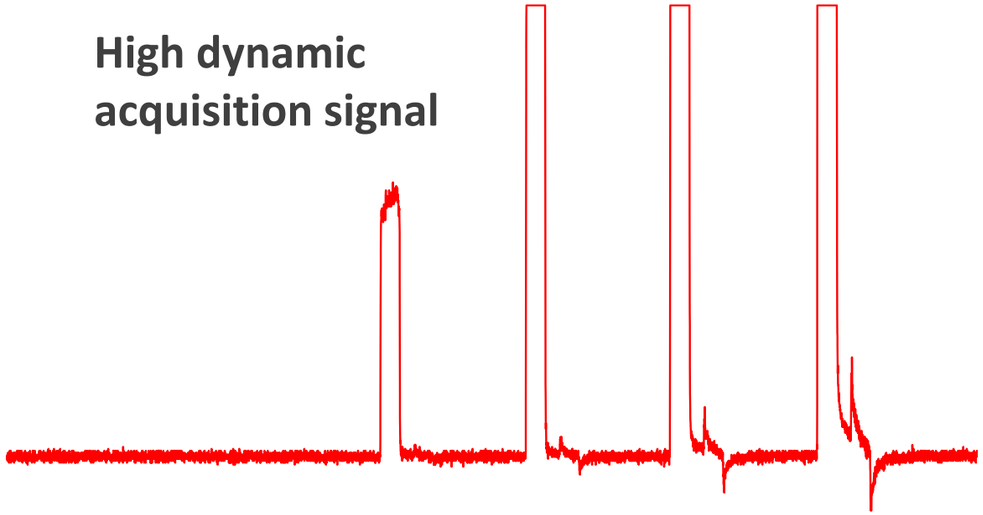
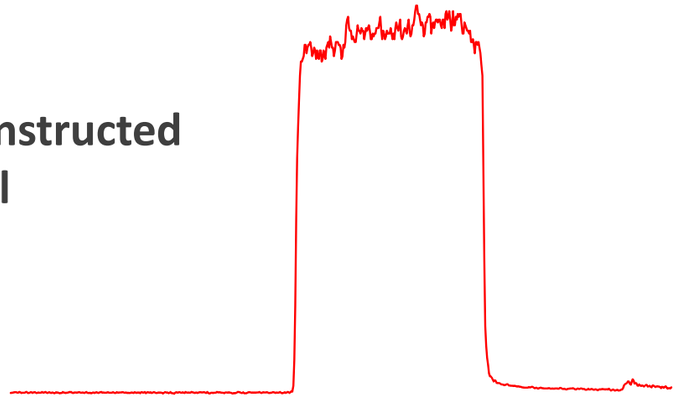
High dynamic acquisition signal



Reconstructed signal



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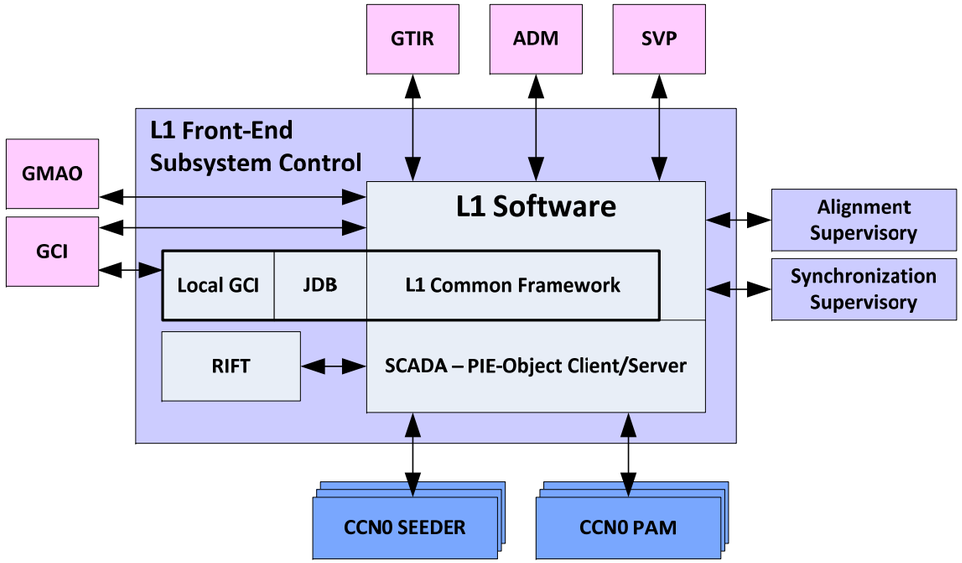
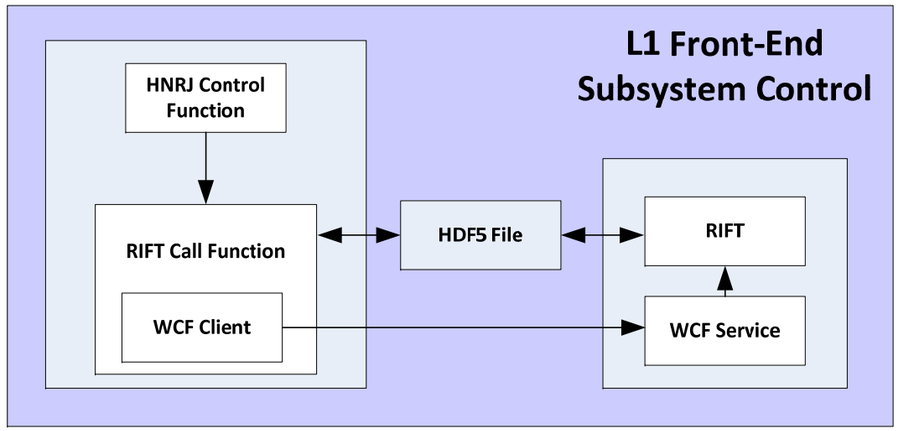
CCL1

- **SCADA based on Panorama E²**
- **Coordinates the activities of the Seeder's and PAM's CCL0**
- **Interfaces with the supervisory system** and third-part supervisory subsystems
- 6 machines: **1 database** server, **3 functional** servers, **2 HMI** station.
- **Interfaces with external software** (RIFT)





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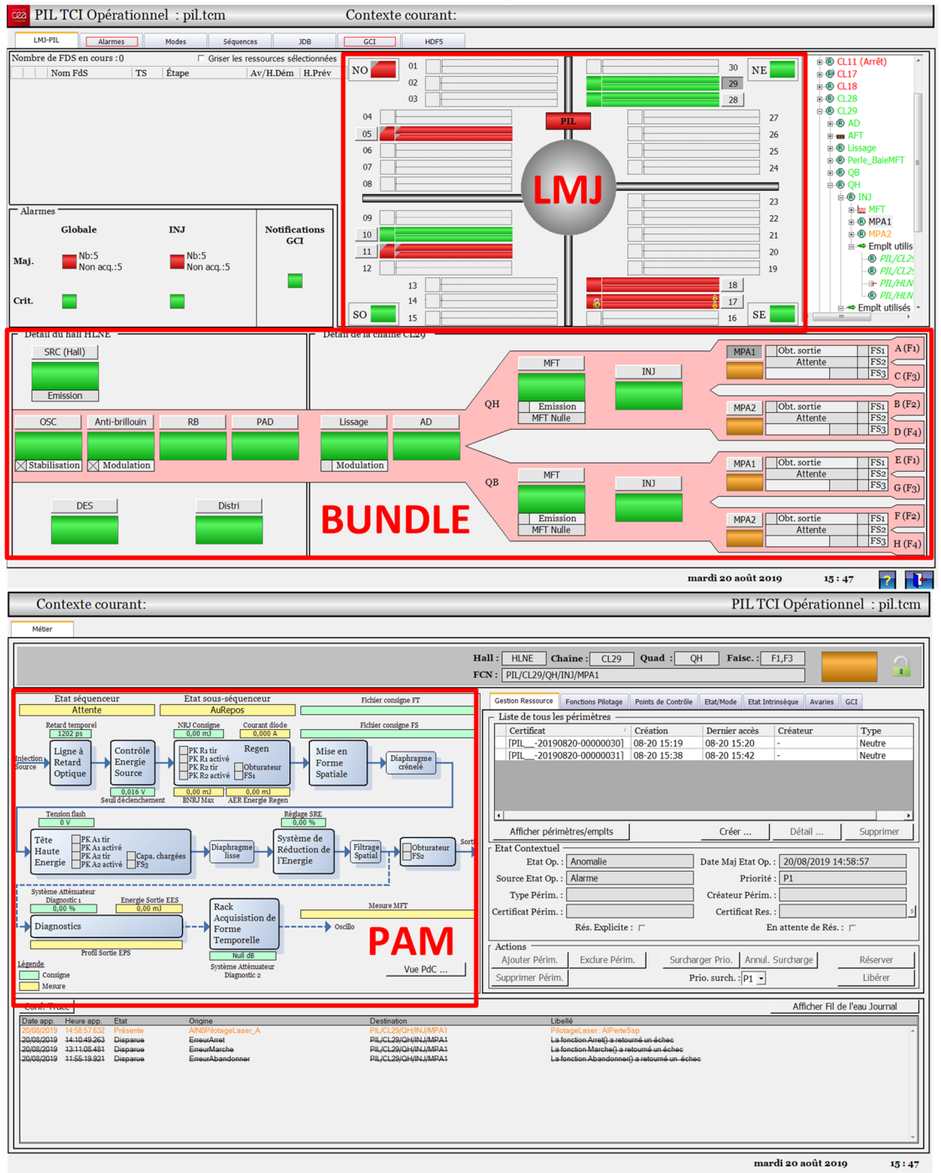

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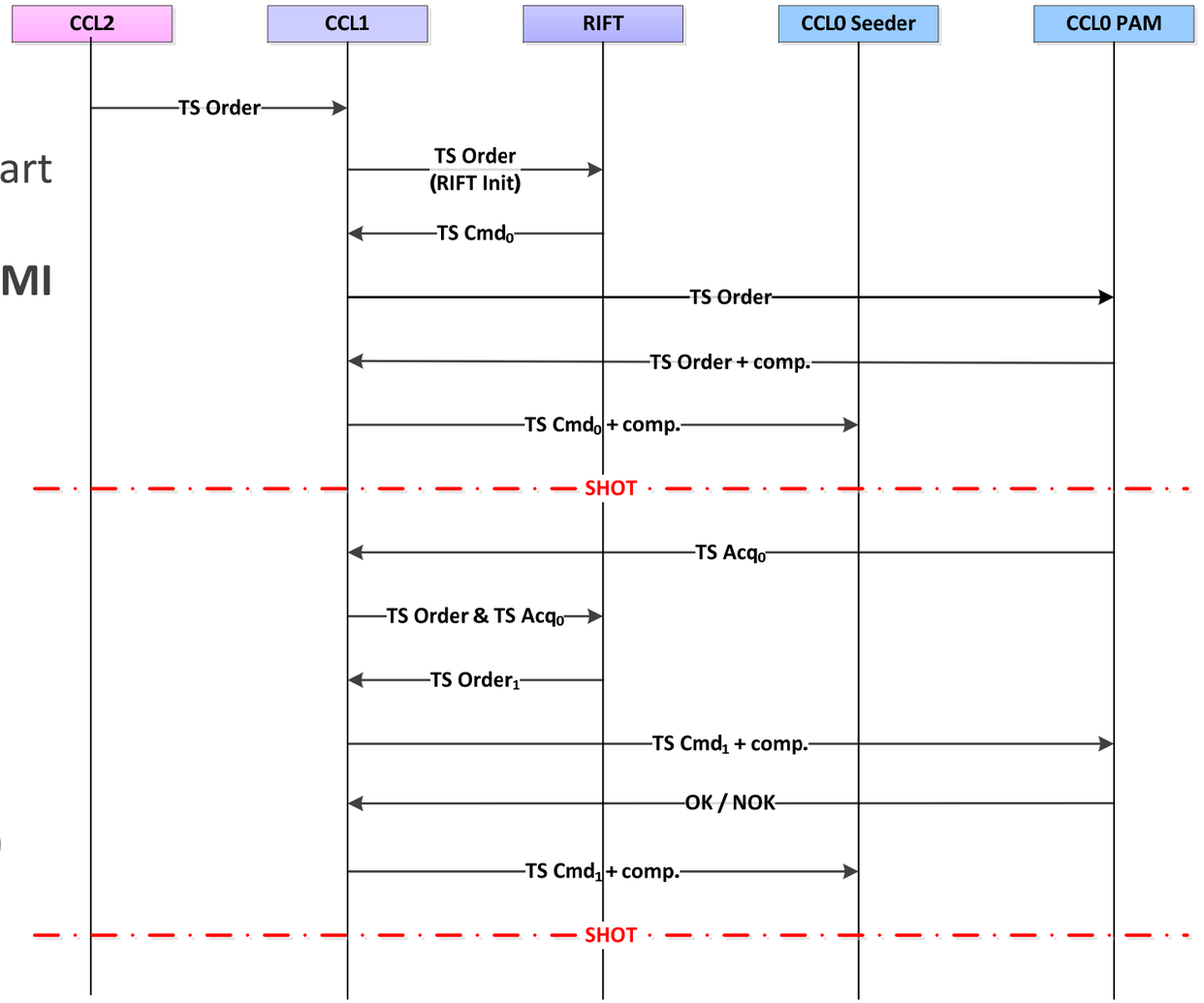
- **Interface with an external software RIFT**

RIFT : Computer Time Shape Control

Feedback of an input command on the observation of the output pulse

- **Input control** is applied to the **MFTs**
- **Acquisition of PAM's output** on an oscilloscope (photodiode)
- The **CCL1 transmits the input data** (input and acquisition) to the **RIFT**, which **calculates the new order** for each Quadruplet based on the acquisition.



High Energy Setup

Major function of the LMJ's Front-End. The **Front-End CC System automatically adjusts its equipments according to the requested instructions**

- **Temporal Shape,**
- **Spatial Shape**
- **Energy**

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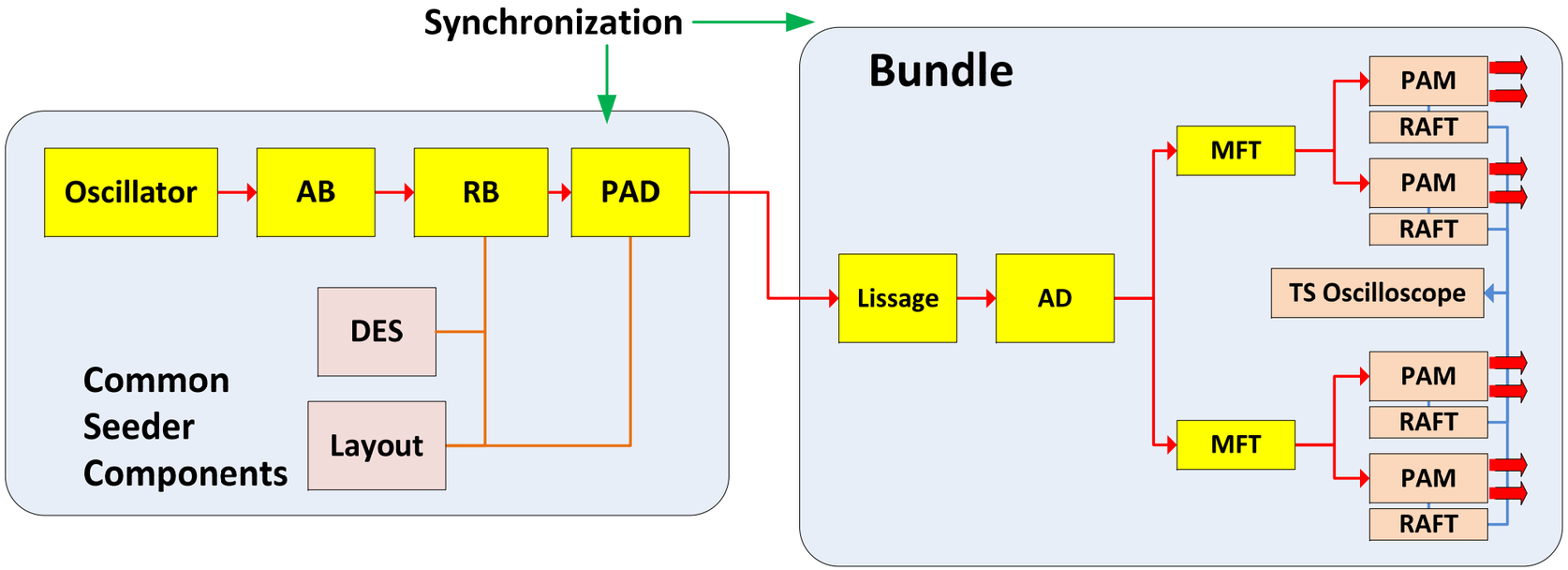

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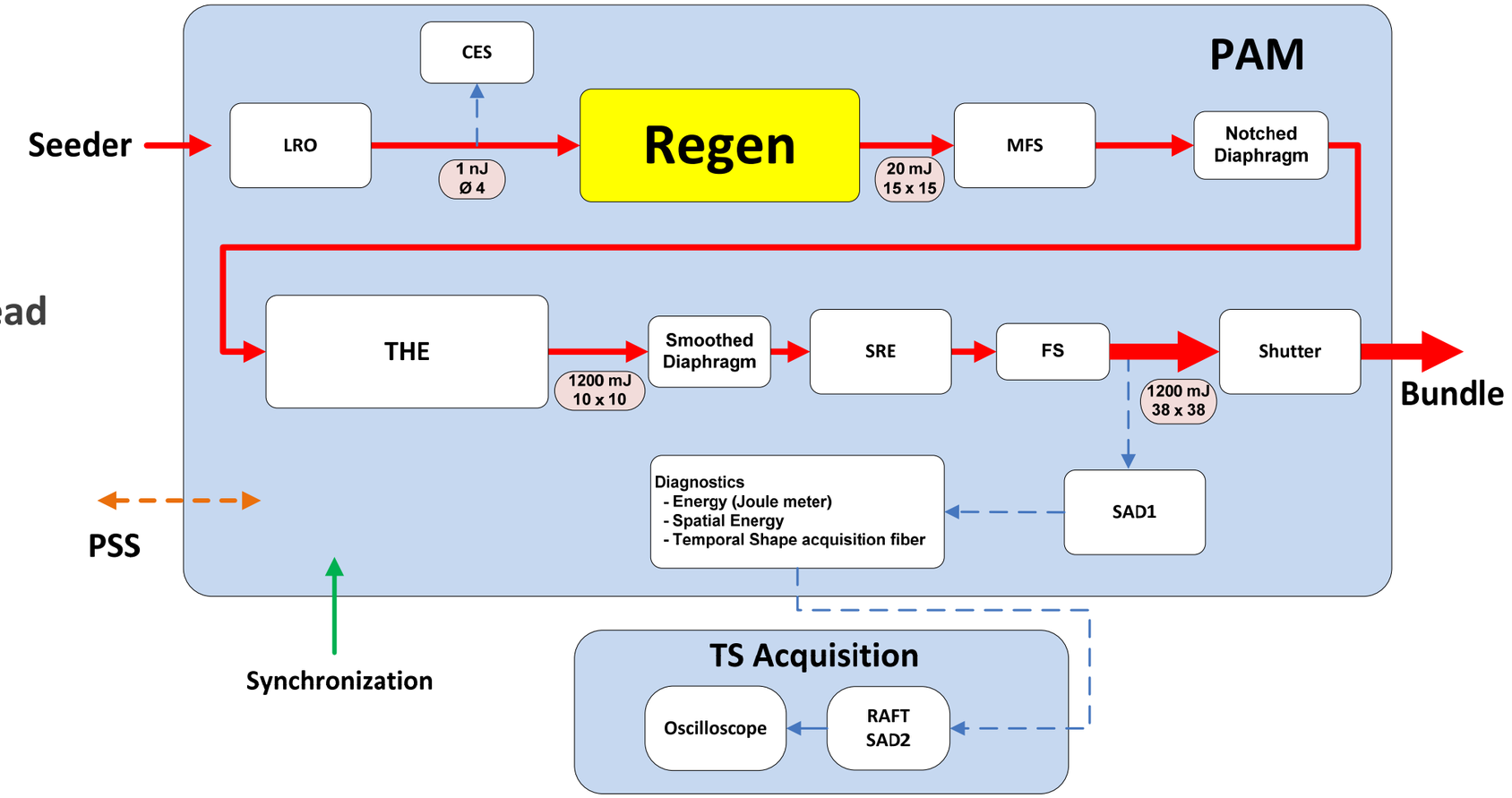

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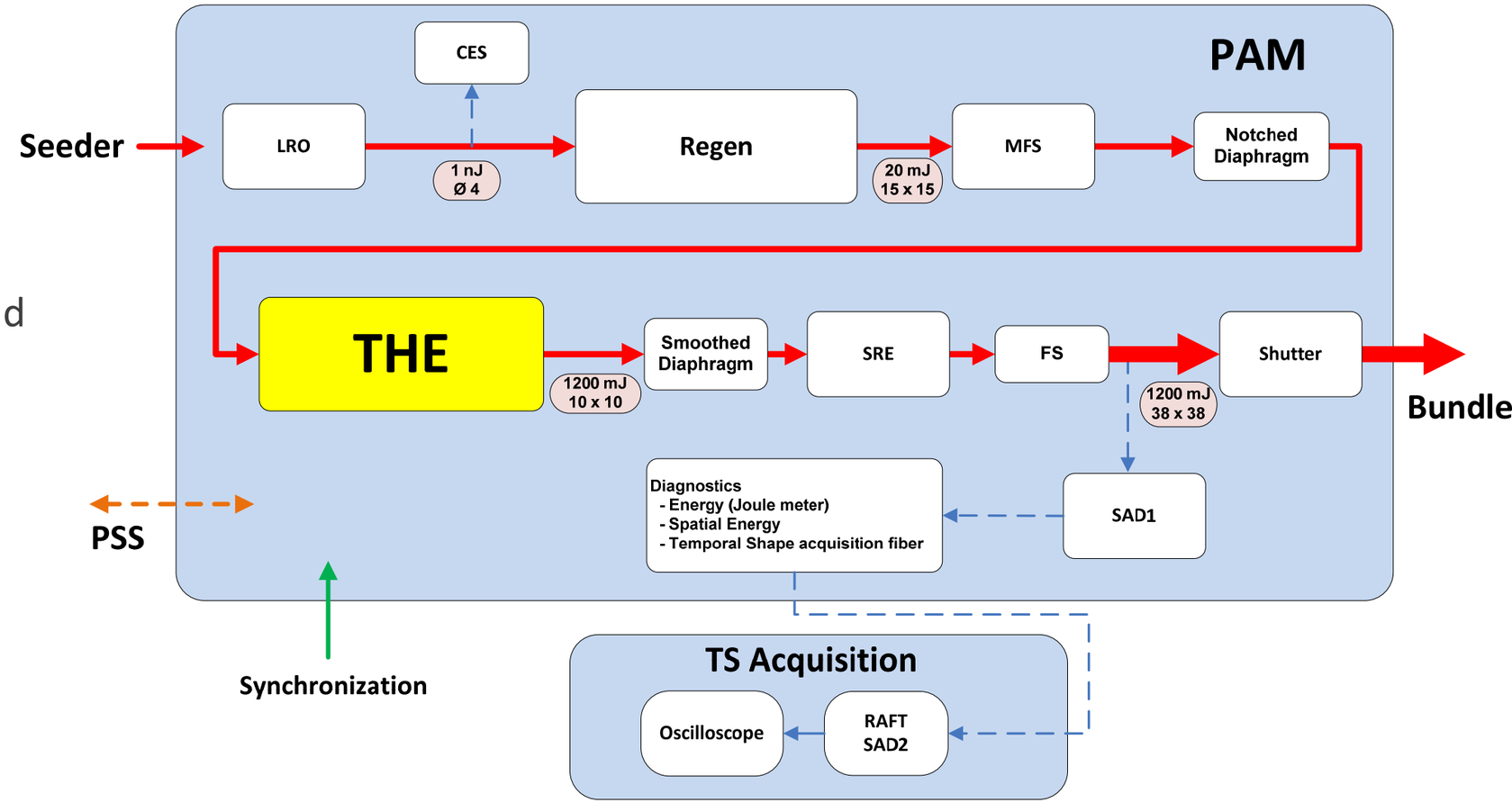

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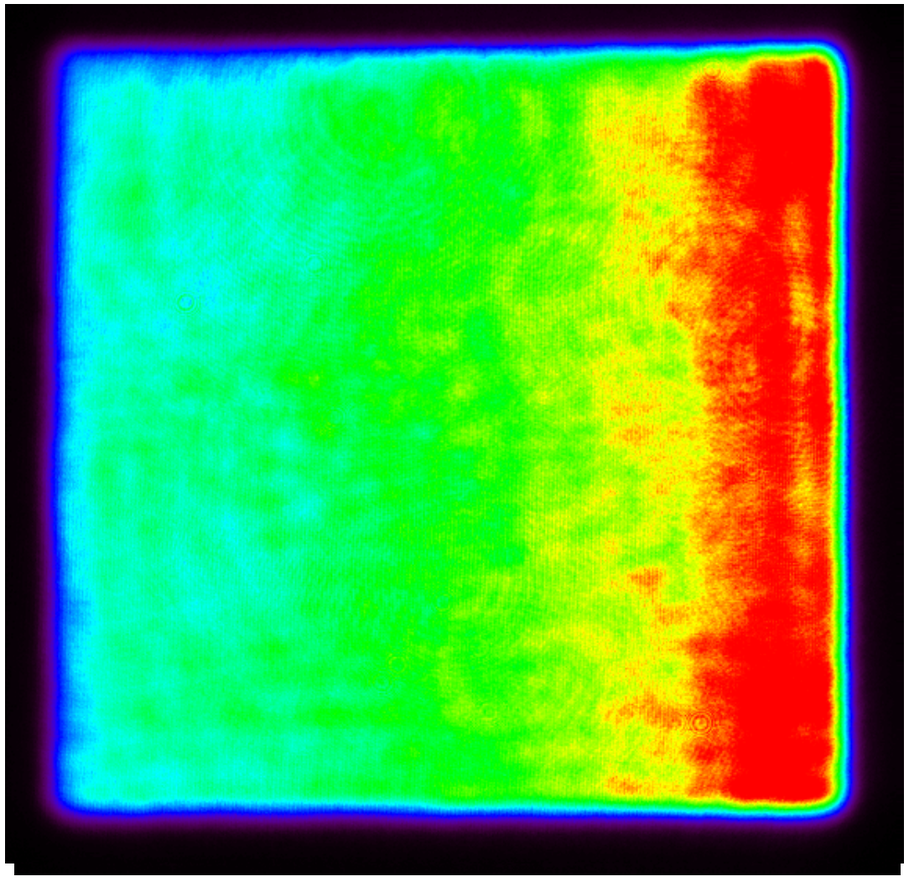
4. **Control of the Spatial Distribution of Energy (AMFORS).**



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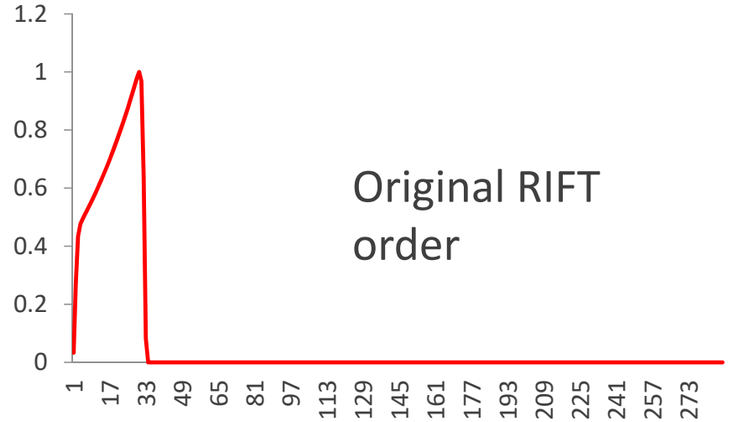

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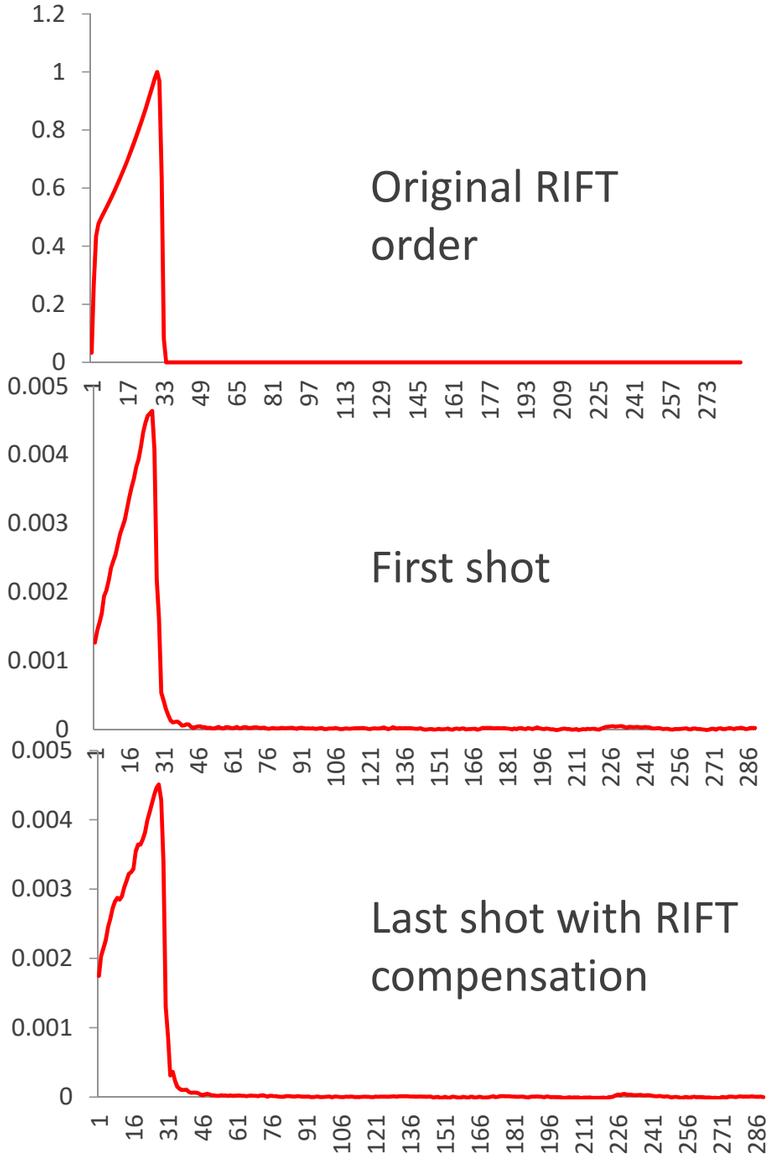

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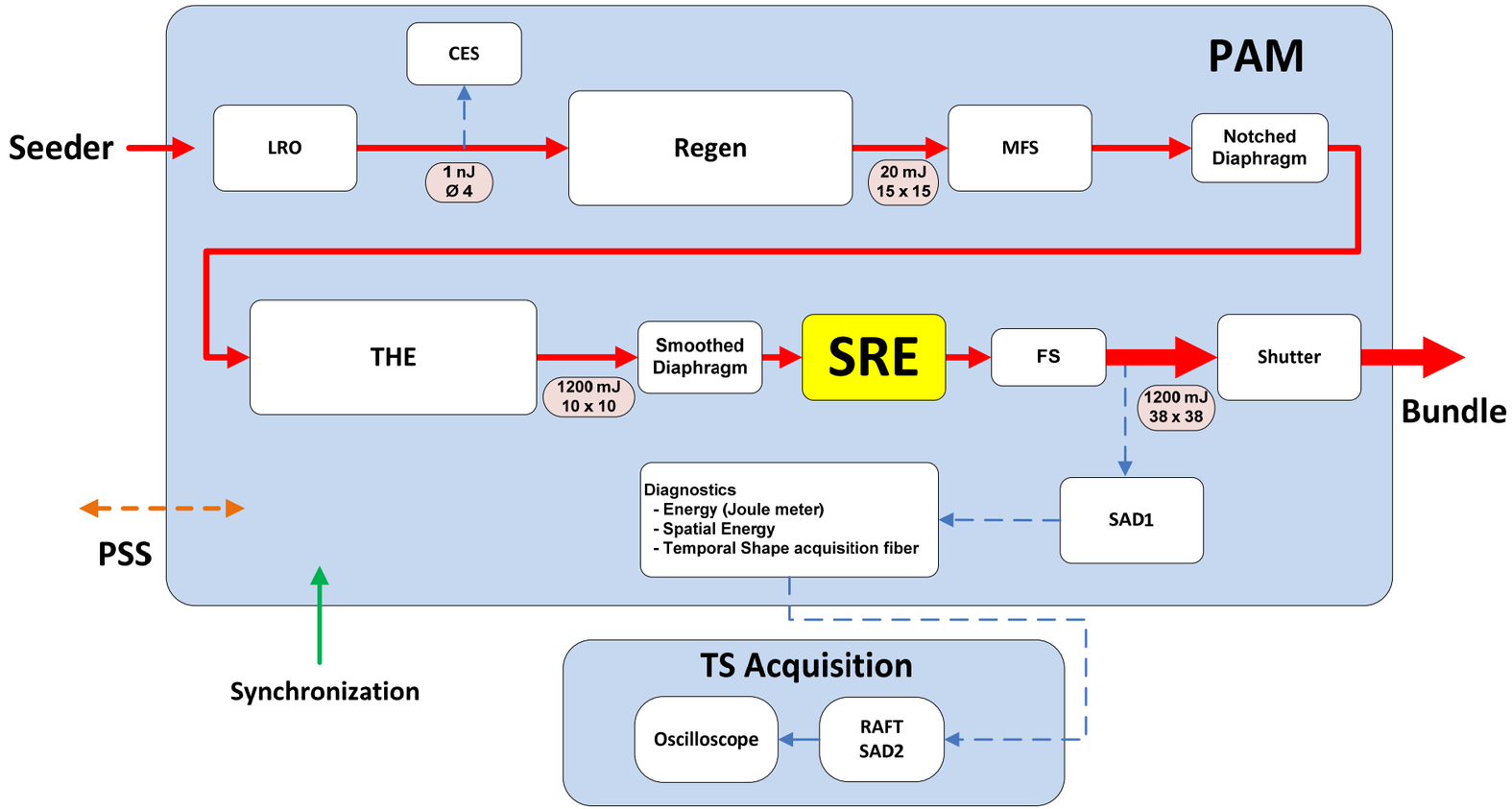
6. **Energy adjustment (PAM SRE)**



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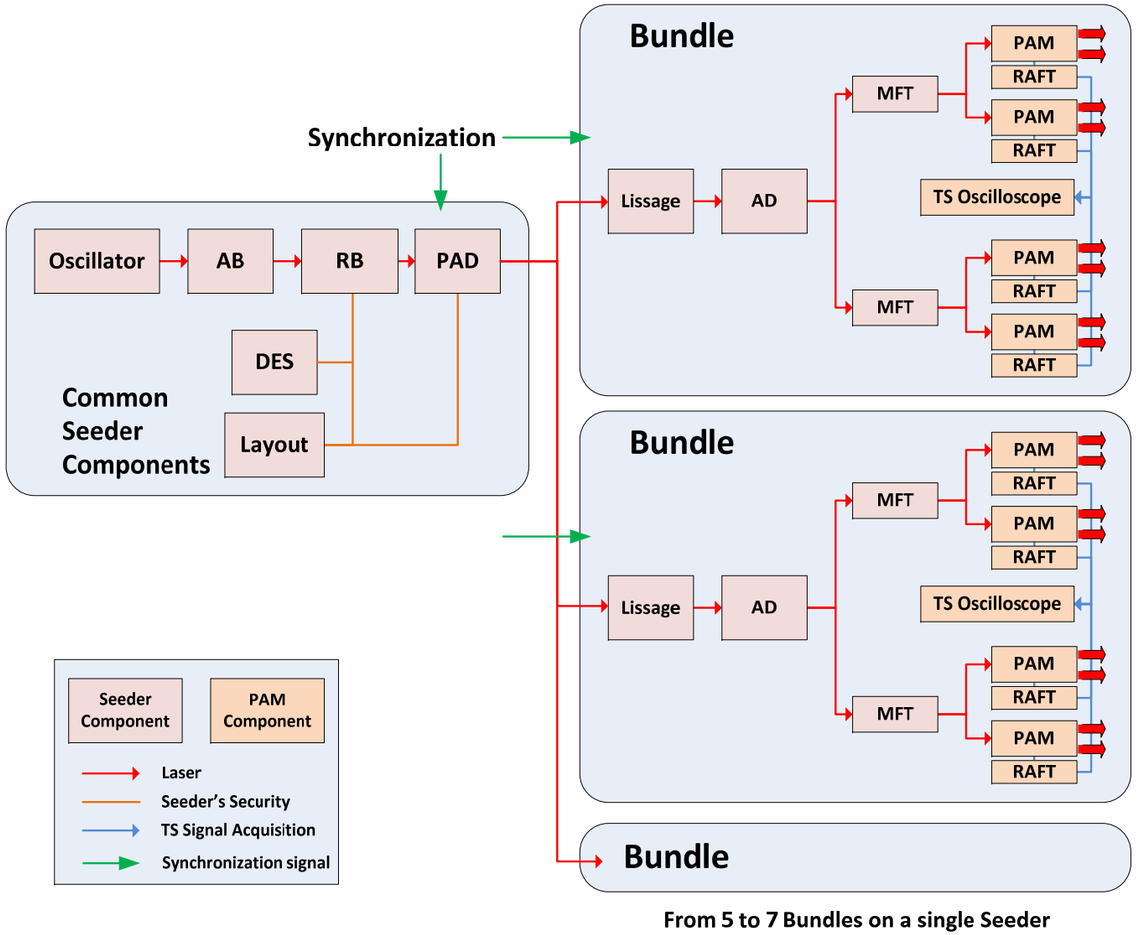
2. Adjustment of the PAM's Regen head
3. Adjustment of the Flash voltages of the High Energy head PAM.
4. Control of the Spatial Distribution of Energy (AMFORS).
5. Control of the Temporal Shape (RIFT)
6. Energy adjustment (PAM SRE)

- A file is produced, it contains the **settings applied to the PAM's and Seeder's equipment** of a Quadruplet
- It will be used in the "**High Energy setup recall**" function



From 5 to 7 Bundles on a single Seeder

Conclusion

- The Front-End Control Command System is a complex subassembly
- Significant impact on the laser performance of the LMJ
- Designed by pieces using various technologies
- Need an update and homogenization of technologies
- Evolution in progress, will be spread over several years as the LMJ will remain in exploitation
- Improve reliability of the High Energy Setup
- Big Data or AI are being studied

Thanks for your attention