The FAZIA setup:
A review on the electronics and the mechanical mounting

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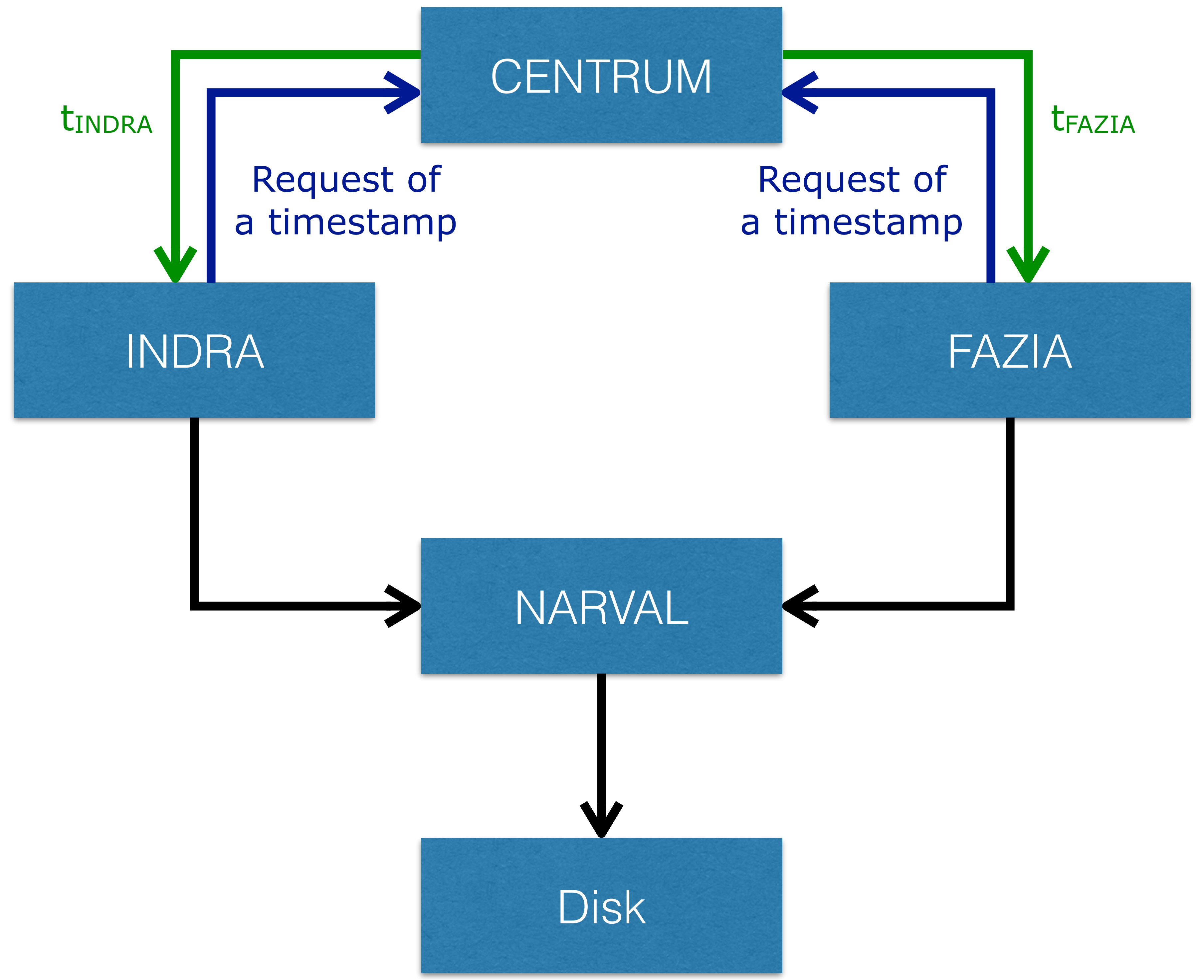
29 Mar 2021

3. Functional description of the electronics
3.5. Coupling with other detectors

- The regional board features some programmable auxiliary connections which can be used to couple FAZIA with other detectors.
  - ex) INDRA-FAZIA at GANIL
- The coupling is done on different levels:
  - 1. Trigger level
  - 2. Generation of a timestamp by CENTRUM
  - 3. Acquisition system by NARVAL
- This system is designed to be as general as possible.
  → can be used with other detectors than INDRA.
- Both CENTRUM and NARVAL technologies support the connections of many apparatuses.
  → can be coupled with three or four different devices.



3.6. Acquisition

- The FAZIA acquisition (DAQ) is a multi-threaded and multi-machine system, written in C++ language and consisting of different classes (DAQ modules) that exchange messages and events through ZeroMQ sockets.

- Some plugins have also been developed to interact with different Run Control systems. These plugins profit of the ZeroMQ network layer of FzController in order to control the data acquisition from different clients.
  - suitable and flexible for integration and coupling with other experiments and detectors.
  - For example, a GANIL plugin was developed to couple FAZIA with INDRA:
    - It is a C++ class of the DAQ which allows the remote control of FAZIA acquisition from NARVAL system using the SOAP protocol.
    - At the same time, the plugin sends data to NARVAL using a TCP/IP connection.

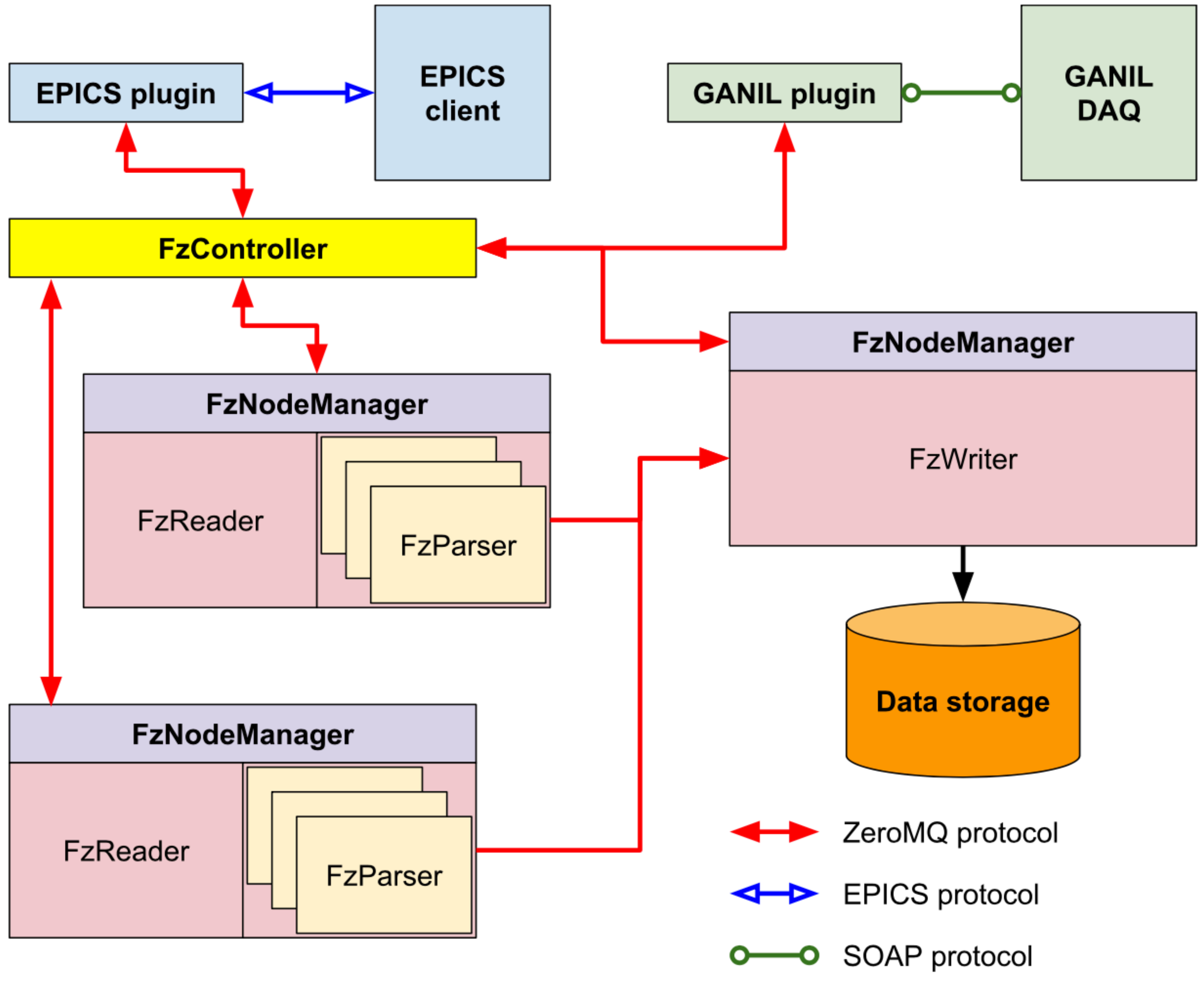


Fig. 6. Schematic representation of the FAZIA DAQ system.

3.7. Slow control

- Slow control instructions permit to control almost every aspect of the electronics.

- The commands, in the form of UDP packets, can be sent by any PC in the same subnet where the regional board is located.

- The RB analyzes the frame to check if the instruction is for the regional board itself.
  - If it is, then the board executes the command and immediately sends a reply.
  - If not, the RB forwards to all the blocks the message via the optical links.
    - On every block, the instruction is dispatched via the backplane to every card containing a PIC (FEEs, PS, and BC). Since the slow control frame uniquely identifies the card to which it is intended, only that card answers and the reply is returned to regional board.
  - In every case, the RB transmits back the reply message to the PC that has sent the request.

- When the slow control request is not for the RB, it must be converted into a standard 115.2 kbit/s serial signal which can be correctly read by the PIC devices on the PS, BC or the FEEs. In particular, in the regional board FPGA code, a universal asynchronous receiver-transmitter (UART) device is implemented. The UART converts the slow control frames received via the Ethernet device into a slow serial data flow which is sent on the optical fibers to all the blocks.

- Of course, since the slow control bit is sent on the fiber at a 25 MHz rate, the 115.2kbit/s serial data flow is oversampled. Vice versa, when the RB receives a slow control reply from a block as a serial data flow, this flow is deserialized by the same UART component described above.

4. Mechanical solutions
4.1. Detector holding mechanics

- Quartetto = 2 x 2 telescopes

- Our choice has been to build the various supports for a distance of **100 cm** between the target and the first Si layer.
    - a compromise between detector granularity and solid angle coverage.
    - the minimum distance from the target which guarantees a negligible channeling contribution
    - a sufficient flight base for time of flight identification.

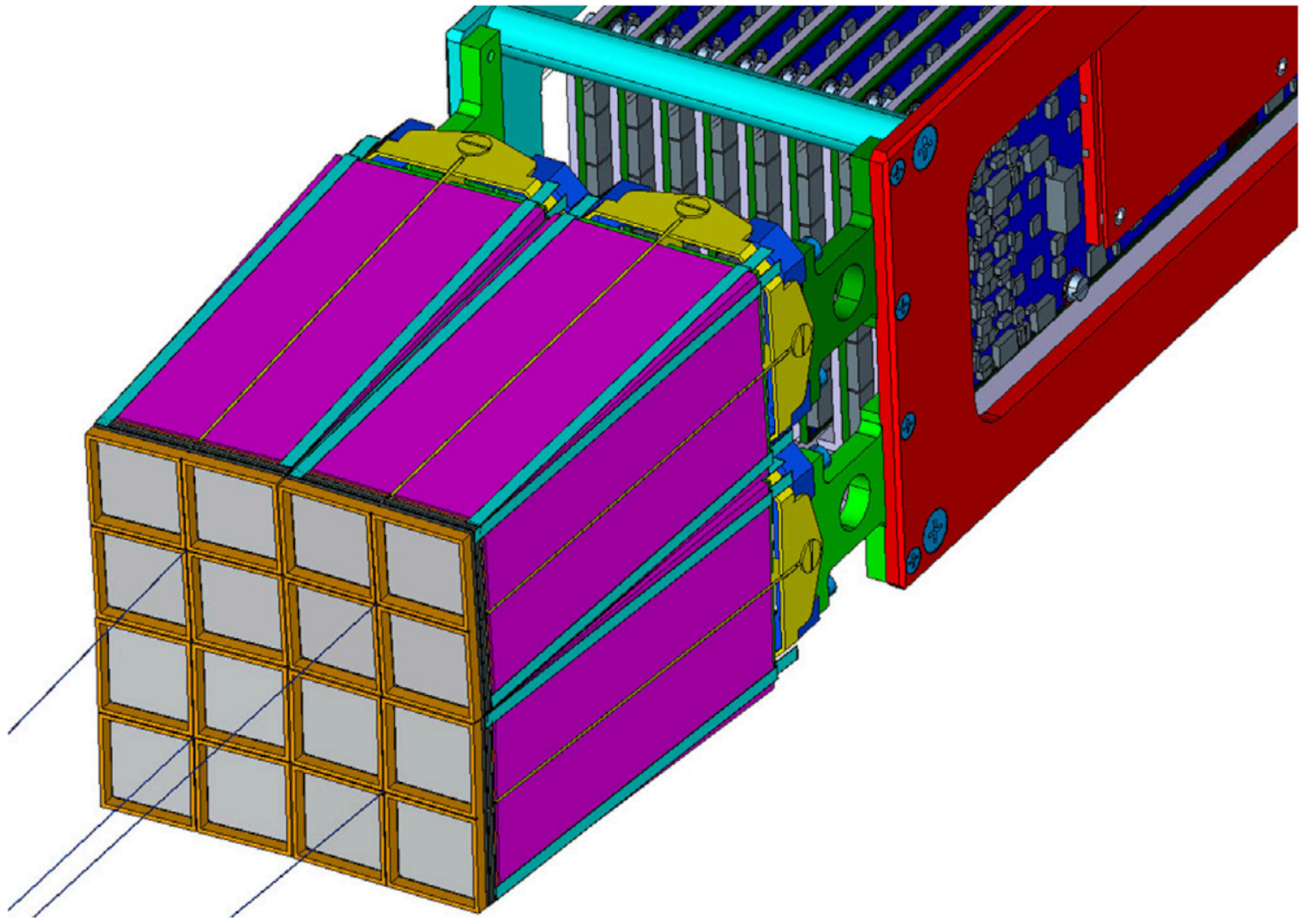
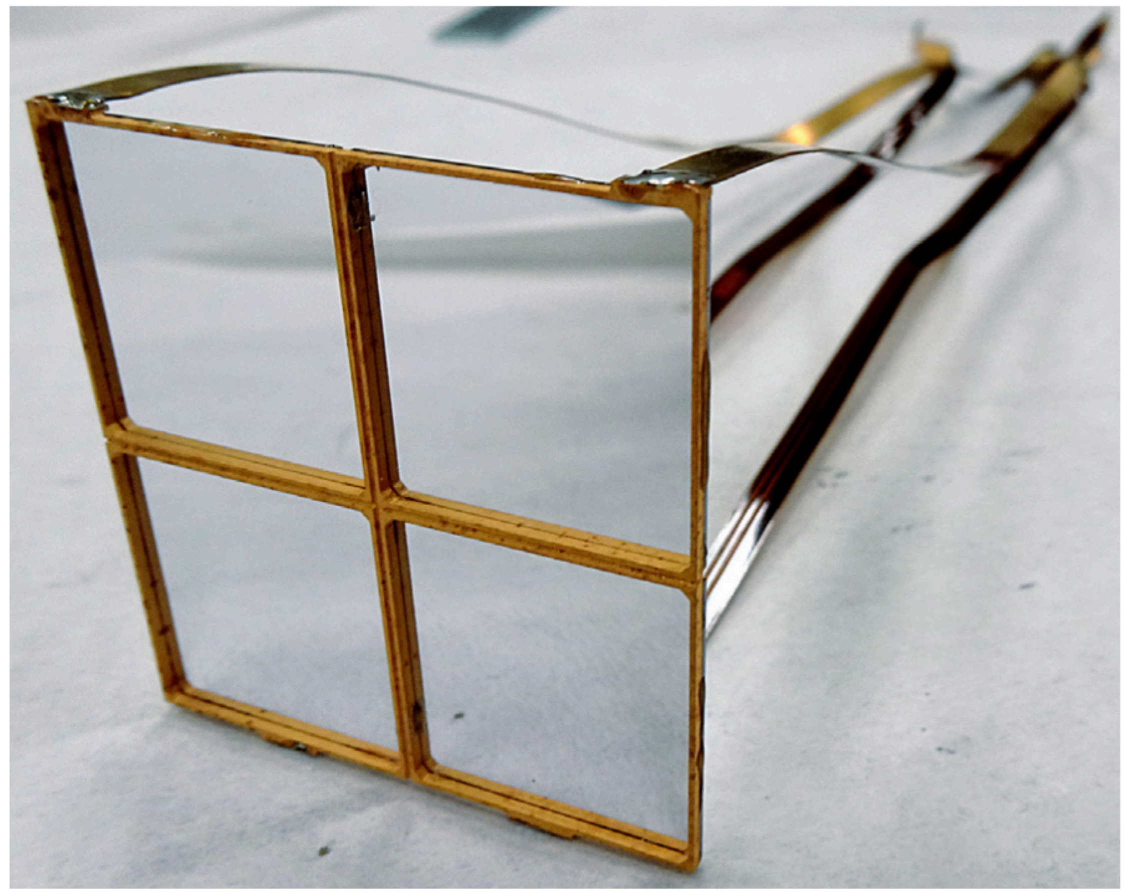


Fig. 7. Rendering of the detectors and their support mechanics. Orientation axes of quartettos are also shown.

4. Mechanical solutions
4.1. Detector holding mechanics



- Main goals:
  - 1. The reduction of the dead regions between quartettos and on external edges.
    - considering a single block, the active area is 84 % of the total front side.
  - 2. The precision of the telescope orientation
    - in order to reduce the channeling effects.
    - The orientation misalignment < 1.5″
- 7075 aluminum alloy:
  - precisely machinable and light, but robust even in thin layers.
- The supports for the 2 x 2 Si pad matrices were built using wire electrical discharge machining.
  - softly acts on the bulk, reduces the strains so that the final piece maintains its planarity and details, needed for a good and precise gluing of the silicon pads and the matching between different parts.
- To form a quartetto, the four CsI(Tl) scintillators are fixed to a central cross-shaped support
  - hold the four crystals (weighing 0.72 kg) and all the silicon pads as a cantilever.
- The fastening between the detectors and the rest of the block is relatively simple, in order to allow an easy replacement of the detector ‘‘nose’’. In this way, when some detectors are damaged, one can replace the whole nose in a reasonable time.

4.2. Frame for the INDRA-FAZIA campaign

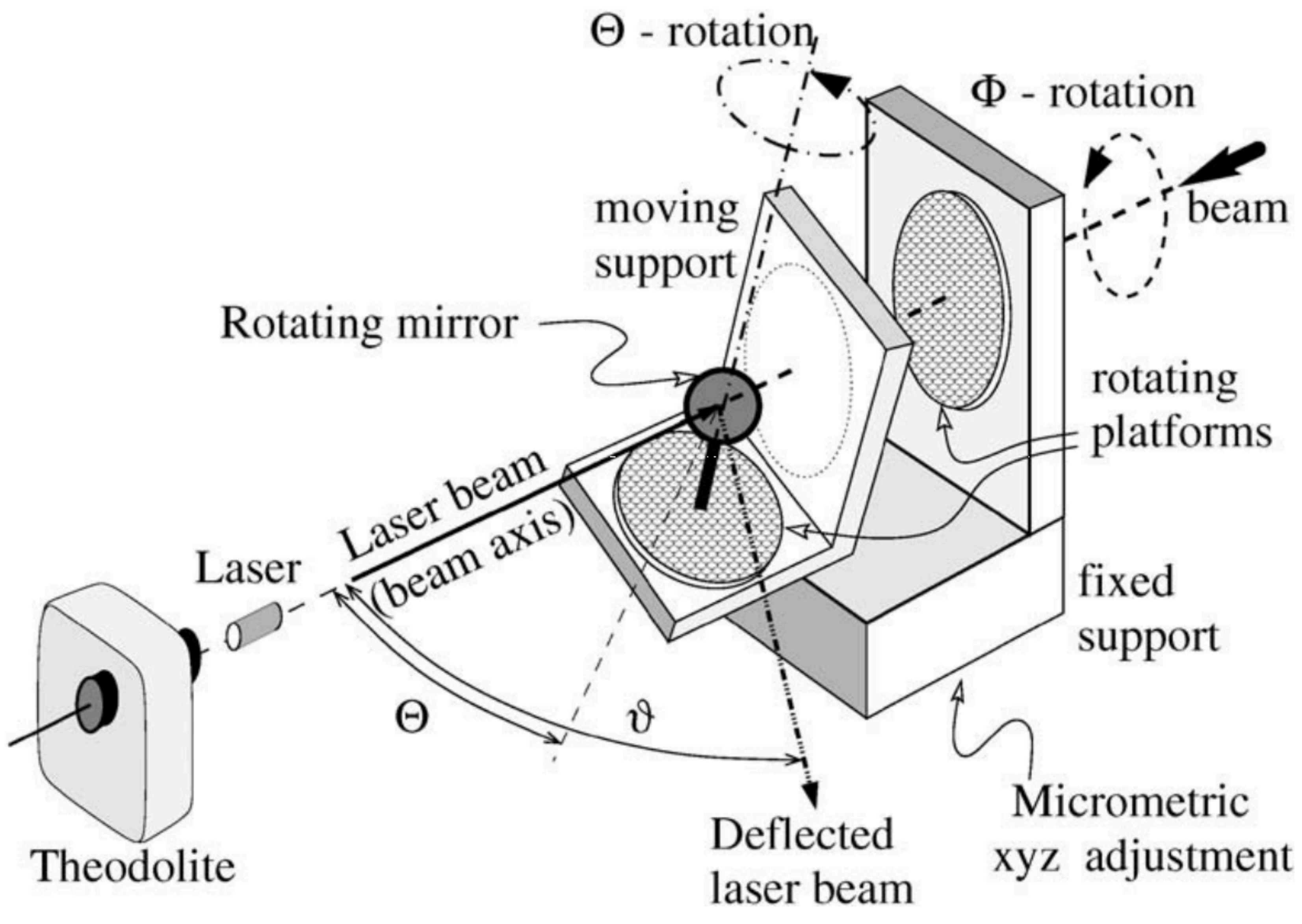
- The INDRA-FAZIA experimental phase at GANIL is foreseen during the period 2019 to 2023.
- It consists of several nuclear physics experiments with different beams (e.g. Ca, Ni, Kr, Sn and Xe) at various energies (from 25 to 80 MeV_u) on a large variety of targets.
- The coupling between the multi detectors INDRA and FAZIA will be fitted in the already existing INDRA vacuum chamber at GANIL
- The first five INDRA rings (from 1.5° to 14°) ⇒ replaced by twelve FAZIA blocks (4 x triplet, FAZIA blocks in a "L" configuration), in order to benefit from its better isotopic, energy and angular resolution.
- The whole final setup with 12 FAZIA blocks ~ 230 kg (a complete single FAZIA < 15 kg)

4.3. Cooling

- A single FAZIA block absorbs almost 300W.
- The final setup consists in a thick copper plate, on which all the cards are screwed on.
- The conduction is ensured by thermal grease between each card and the copper surface.
- The copper plate has been designed in order to efficiently distribute the liquid flow along the entire surface which holds the 8 FEE cards.
- The conflict between the internal pipes for the liquid flow and the many screw holes needed to ensure mechanical and thermal coupling of the electronic boards → about 100 screws
- A copper slab (8mm thick)
  - 2 main internal in-out pipes running longitudinally on the two sides of the plate
  - 8 transversal holes, with variable diameters along the plate length in order to compensate for the pressure drop at the various distances from the entrance/exit tube fittings.
- A powerful chiller (ACW LP60) is mounted to refrigerate the water (with 30 % alcohol or glycol, ~10 ℃).
- To ensure an independent cooling for each block a so called ‘‘clarinet’’ device has been built to dispatch the fluid to all the cooling circuits.

4.4. Laser angle measurement

- The method to precisely measure the polar angles θ and φ of the detectors with respect to the beam direction
  - 1. Dismount a piece of beam line beyond the scattering chamber.
  - 2. Align the laser with the center of beam line and the target, and fire in the opposite direction with respect to the beam.
  - 3. In place of the target, mount a mirror in such a way that its center is exactly on the path of the laser.
  - 4. The mirror equipment is mounted in a gimbal configuration allowing the rotation around two orthogonal axes.
  - 5. The fine regulation of the ‘‘zero’’ position is set once via micrometric screws.
  - 6. Then, by regulating the two mirror angles (using the stepping motors) up to when the reflected laser beam impinges on the center of a telescope, obtain its θ and φ angles via a reading of the encoded current position of the motors.
- The center of the telescope is determined by visual inspection with an estimated accuracy of the order of 1 mm, corresponding to ~3' accuracy on angle measurement.



5. Conclusions and future improvements

- The characteristics of FAZIA
  - **compactness** and **modularity**:
    - FAZIA is structured in independent blocks → various geometry configurations
    - All the analogue chains operate under vacuum, very close to the detectors → electronic noise pick-up and signal distortion along the transmission lines are greatly reduced.
  - **the optimization of the analogue stages**:
    - A good energy resolution in a very wide spectrum of particle energies and charges.
    - The clock distribution → a synchronization among all the acquired channels within 100 ps.
  - **flexibility** and **upgradability**:
    - All the electronic boards contain programmable devices which are steadily maintained and updated to include new features.
    - One can implement new firmware solutions on the onboard FPGA after that a given algorithm has been tested offline using the entire sampled waveforms previously acquired.
    - For example:

      - in this respect we are going to implement the pulse-shape discrimination of silicon signals directly on-board, by adding the search of the current signal maximum on the front-end card FPGA code.

      - An energy shaper on the QL1 signal may be added, to have the high gain energy measurement without the need to send the whole signal to the acquisition.

      - To improve the data bandwidth, we are also going to implement two Ethernet connections between the regional board and the acquisition system.