TUPV042

COLLISION AVOIDANCE SYSTEMS IN SYNCHROTRON SOLEIL

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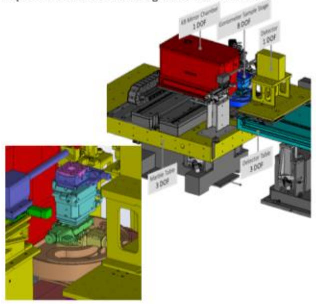
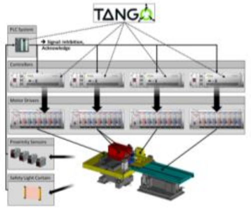
A Static Collision Avoidance System, PUMA Beamline

The experimental station in the SOLEIL PUMA beamline consists of two motorised table platforms, all holding amongst other: beam-focusing systems, sample-stage, and detector-support – all within collision range of each other. As such, a Collision Avoidance System (CAS) has been implemented into the existing control architecture.



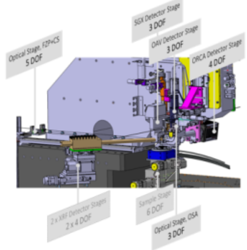
The control-CAS architecture consists of a a SOLEIL-standardised 4-controller(ControlBox)-driver(DriverBox) setup and a PLC system, and high-level control is done via the TANGO framework.



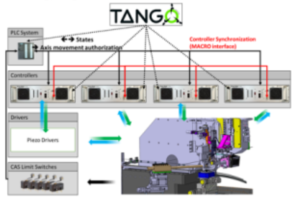
The CAS framework is introduced at the low-level, with proximity-sensors and a safety light curtain sensor strate-gically installed at collision risk-zones. A PLC continually monitor and filter these sensor states and blocks (via dedicated PLC-controller TTL signals, here marked 'Inhibition') specific axis movements if it deems a collision is imminent.

B Static Collision Avoidance System, NANOSCOPIUM Beamline

The NANOSCPIUM CX2 environment holds a sample stage and detector sections that are installed in close proximity to each other. In addition, the Fresnel Zone Plate (FZP) and Central-Stop (CS) optical stages may also approach the same area and possibly collide with the vertical support marble during their displacements. The risk of collision doesn't only present itself from the motorised elements: users should be able to manually displace certain sections (e.g.: the XRF stations along a circular rail) and possibly install/uninstall beam transfer tubes that approach the sample environment.



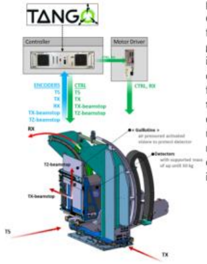
The control-CAS architecture consists of a high-performing SOLEIL-standardised 4–controller (Powerbrick LV & Controller+Piezo driver) setup and a PLC system. All the controllers (1 master and 3 slaves) are synchronized by a fibre-optic ring network (MACRO ring). High-level control is exerted via the TANGO framework.



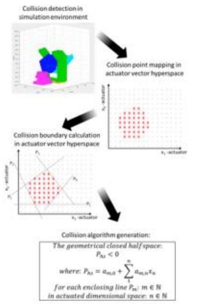
The NANOSCOPIUM-CAS operates primarily in the PLC system and continually receives: the states of all the CAS-limit switches, each controller state (ex: run-ning/not-running), and the general locations of the sub-systems (based on encoder feedback). The PLC system also relies on user-specified (via TANGO devices) experimental configurations – where each configuration de-fines a set of optical stages and detectors to be used in the workspace. The PLC then authorizes/refuse stage move-ments depending on the combined sensor- and user-configuration- data with pre-filled reference tables.

C Dynamic Collision Avoidance System, MARS Beamline

The MARS Detector Support was installed in the MARS CX3 experimental station to actuate heavy detectors (<~ 50kg) for SAXS experiments and would be doing so using relatively large movements in the sample stage vicinity - and would therefore induce risk of system-collisions. The system contains 5 motorised axes, of which the three axes (TS, TX, RX) are the ones running the risk of system-collision with its surrounding environment.



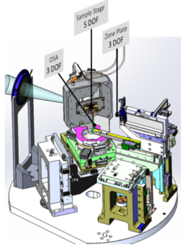
The control- & CAS architecture contains a single high-performing SOLEIL controller is used which is connected to a high-powered (> 1 kW) motor amplifier for the rotational axis. The CAS algorithm here is generated from the system 3D-models and is entirely implemented in the controller which will dynamically calculate the (TS, TX, RX) motor software limits in function of their respective encoder values to prevent their entries in collision areas. This constant re-calculation of the motor software limits al-lows for a more complex and detailed workspace - assuring that movements on the (TS, TX, RX)-axes would never cause a system-collision with a perceived virtual object in its vicinity.



The general process of finding collision point data and generating the dynamic-CAS algorithm on the MARS beamline.

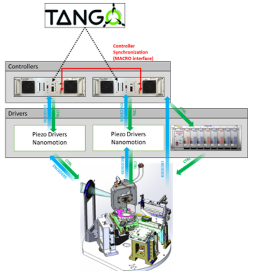
D Dynamic Collision Avoidance System, ANTARES Beamline

The ANTARES experimental station is set in a vacuum chamber and contain several piezo-driven stages. Three of these stages: the Order-Sorting-Aperture (OSA), the Fresnel-Zone-Plate (FZP), and the Sample Stage have their workspaces overlap and run the risk of collision when in use.



The experimental station makes use of a two-controller configuration two synchronized Delta Tau Controllers, both using Piezo- and stepper-drivers to interface with the motors and actuators. The control-CAS system controls 11 DOF in total.

The ANTARES beamline makes use of a dynamic-CAS – here essentially blocking\unblocking motor axes in function of the system encoders. It does this by identifying what specific region each subsection finds itself and blocks other stages from entering the same space.



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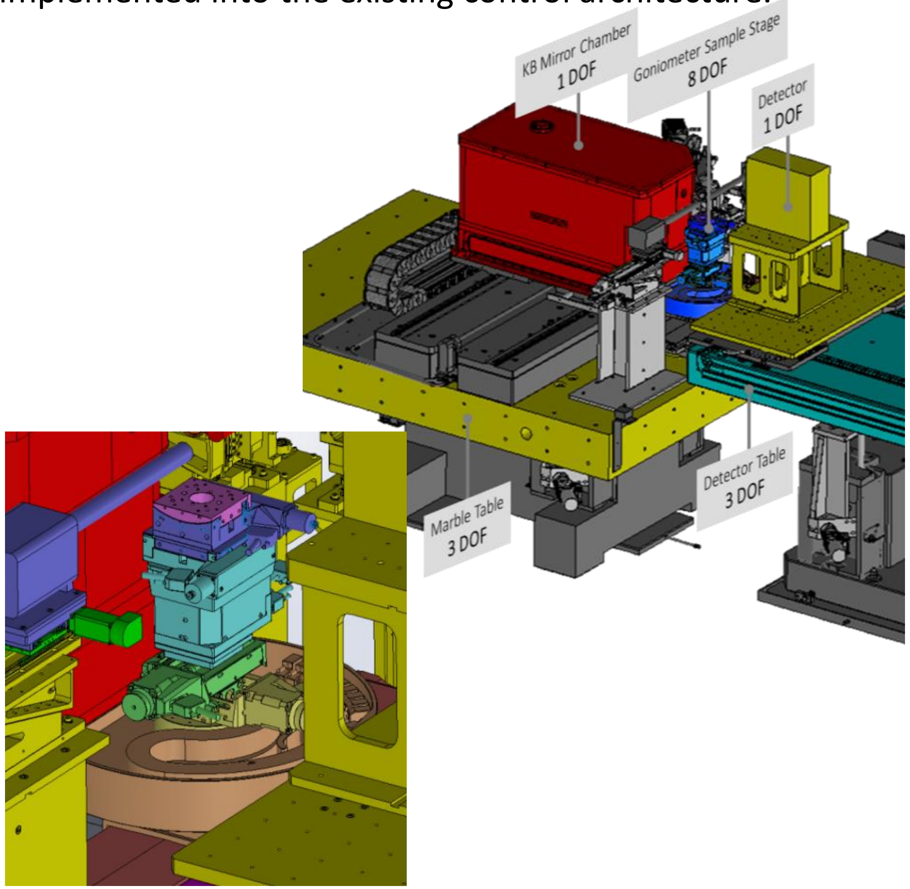

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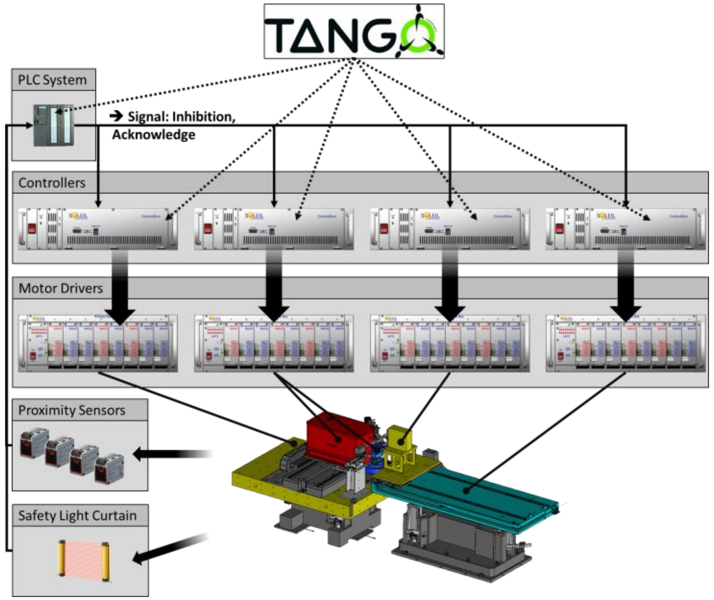

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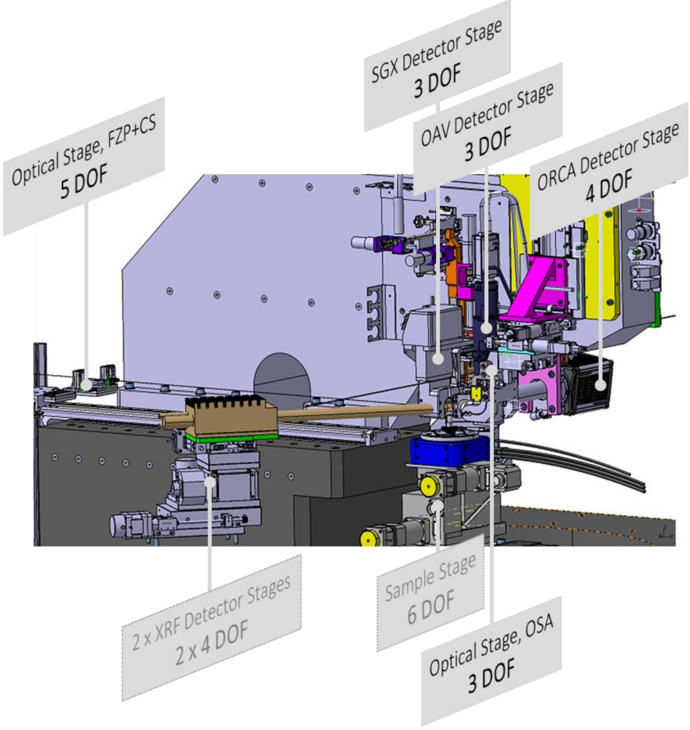

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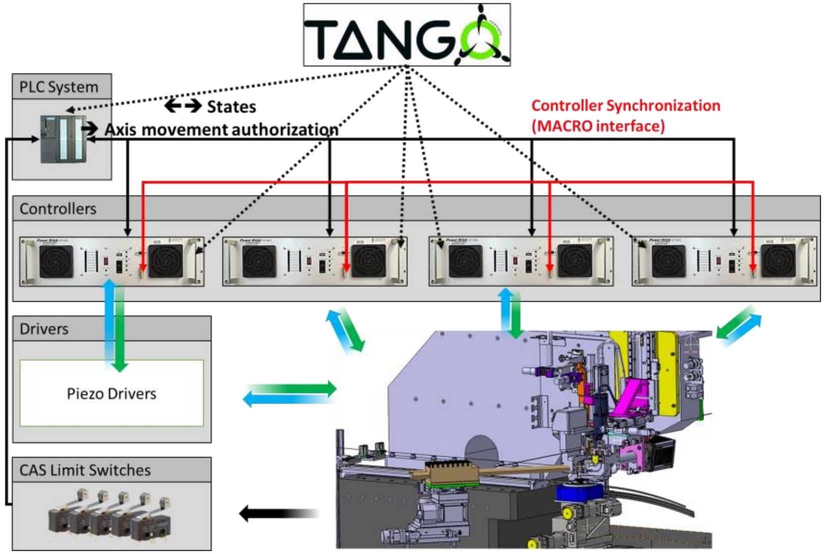

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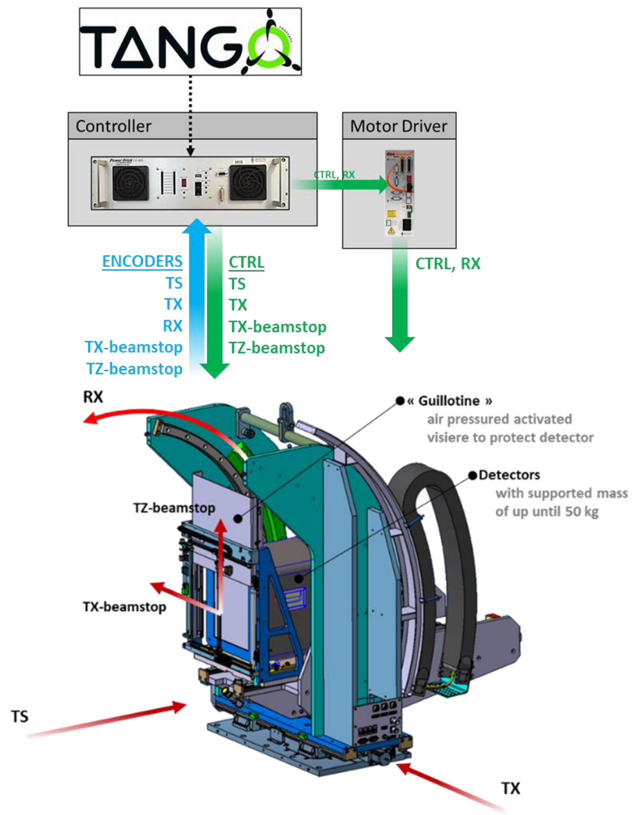

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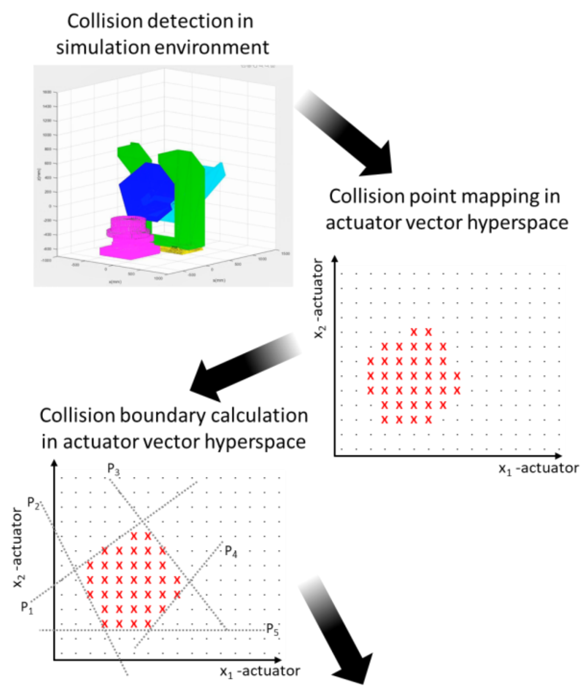

Collision algorithm generation:

The geometrical closed halfspace:

$$P_{hs} < 0$$

$$\text{where: } P_{hs} = a_{m,0} + \sum_{1}^{n} a_{m,n} x_n$$

for each enclosing line P_m: $m \in \mathbb{N}$
in actuated dimensional space: $n \in \mathbb{N}$

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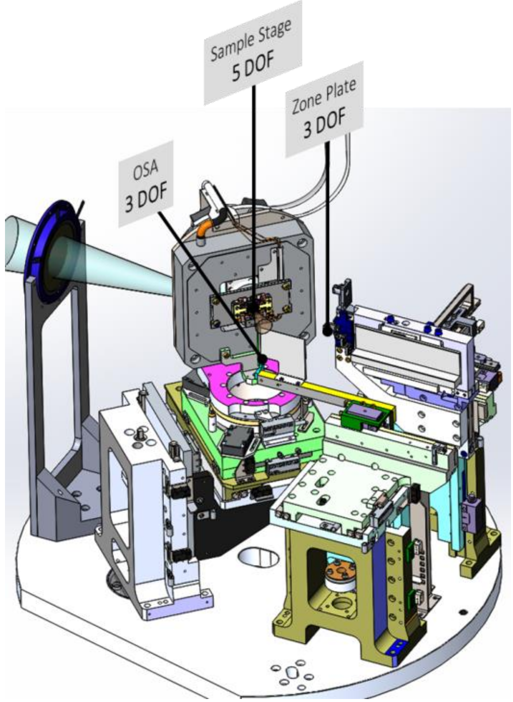

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