**PROPOSAL FOR BES-CPO**

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**Purpose of the proposal:**

The RENATE synthetic diangnostic, designed for arbitrary BES diagnostic system modelling is to be integrated into EU-IM. Communication of various actors responsable for executing code is only possible through **C**oherent **P**hysical **O**bjects (CPO). The current proposal outlines the design of the BES – CPO, responsable for handling all data relevant for a BES sysnthetic diagnostic within the EU-IM mainframe.

**Highest level summary layout of the BES-CPO:**

**time [tag]:**

* Parameters that tags each timeslice with the corresponding values of the CPO, it presents the time instances chartacteristic of turbulence timescales.

**beam [tag]:**

* Handles all data pertinent to 3D beam modelling: beam dimensions, positions, current and energy distributions.

**profiles [tag]:**

* Stores density and temperature for all points along the beamlets for every atomic species present in the plasma.

**equilibrium [tag]:**

* Stores the flux surface values for all the points along the beamlets.

**observation [tag]:**

* Stores all pertinent data regarding observation geometries, such as: lens radius, observation point, transmission matrices, pinhole observation data.

**output [tag]:**

* Contains the light profile along each beamlet, the detected photon current on each detector, the expected spatial resolution for each detector and a fluctuation response matrix for given time interval.

**measurement [tag]:**

* Contains the registered signal from the existing shot modelled, if it is available.

**Detailed layout and design of BES – CPO tags:**

1. **time (:)**
2. **slice** [s] [integer]: Contains the number of the time slice in question.
3. **fluctuation** [s] [1D array]: Contains the time instances on a turbulence timescale.
4. **beams (:) Vector of different beams; each beam having following structure [n\_beams]**
5. **parameters** (:) Contains the numerical resolutions of the 3D modelled beam
   1. **size** (:) Contains the size of the beam in SI coordinates
      1. along [m] [float]: length of the modelled beam
      2. width [m] [float]: width of the modelled beam
      3. height [m] [float]: height of the modelled beam
   2. **resolution** (:) Contains the numerical resolution of the modelled beam
      1. along [-] [integer]: number of points along each beamlet
      2. width [-] [integer]: number of beamlets in beam width
      3. height [-] [integer]: number of beamlets in beam height
   3. **divergence** [rad] [float]: the divergence angle of the beam
   4. **shape** [-] [string]: describes the shape of the beam (elliptical or rectangular)
   5. **type** [-] [string]: Sets the type of atoms in the beam (H,D,Li,Na)
6. **geometry** (:) Contains all data precluding to the spatial location of beam
   1. **position** [-] [1D array]: Contains an index of the possible beam positions, for all available timesteps, characteristic of the turbulence timescale.
   2. **init** [m,m,m] [3D array] [position\_index, 2, 3]: Contains the start and waypoint coordinates for each beam position
   3. **coordinates** [m,m,m] [4D array] [position\_index, nr\_beamlets, nr\_points\_along, 3]: Contains the coordinates of points within the beam, pertinent to beam evolution calculation.
7. **energy** [eV] [-]: Energy of the beam.
8. **current** [A] [1D array]: Contains the beam current values corresponding to each beamlet
9. **profiles (:)**
10. **components** [-] [string list]: Contains all the plasma components: (e, H, D, C, O, etc)
11. **density** [m^-3] [5D array] [n\_beams, time\_steps, components, n\_beamlets, n\_points\_along]: Contains density values for all beamlets of various plasma components for all turbulent timesteps.
12. **temperature** [eV] [5D array] [n\_beams, time\_steps, plasma\_comp, n\_beamlets, n\_points\_along]: Contains density values for all beamlets of various plasma components for all turbulent timesteps.
13. **equilibrium (:)**
14. **norm\_toroidal\_flux** [psi] [3D array] [n\_beams, n\_beamlet, n\_point\_along] Contains a 3D array with the flux surface values of all the points along the beamlets.
15. **magnetic\_vector** [-] [4D array] [n\_beams, n\_beamlet, n\_point\_along, 3] Contains array with the unit vectors of magnetic field at all the points along the beamlets.
16. **observation (:)**
17. **lens\_diameter** [m] [float]: Contains the diameter of the last optical element of the observation system.
18. **pixel\_number** [-] [integer]: Gives the number of detector pixels the optical system is modelled with.
19. **spatial\_calibration** (:) Contains information with regard to the observation volumes used for the pinhole optics modelling.
    1. **pyramid** (:) Contains the data for pyramid shaped observation volumes.
       1. center [m] [2D array] [n\_detectors, 3]: Coordinates of the center of the observation pyramids.
       2. edges [m] [3D array] [n\_detectors, 4, 3]: Coordinates of the edges of the observation pyramids.
    2. **cone** (:) Contains the data for pyramid shaped observation volumes.
       1. center [m] [2D array] [n\_detector, 3]: Coordinates of the center of the observation cones.
       2. radius [m] [1D array]: Contains the radii of the bases of each observation cone.
20. **transmission** (:) Contains the various forms of transmission rates that are applicable for each detector.
    1. **rate** [-] [1D array]: Contains the transmission rates for each detector that arises from the optical system in case of the pin hole optical model.
    2. **matrix** [-] [2D array] [n\_detector, points]: Contains the transmission matrix for each detector pixel. Used in case of the Zmax model.
21. **observation\_point** [m] [1D array]: Contains the coordinates of the observation system.
22. **focus\_point** [m] [1D array]: Contains the coordinates of the focus point of the observation system.
23. **filter (:)** Contains data regarding the filter capabilities modelled.
    1. **transmission** [-] [2D array] [n\_beams, n\_detector]: Contains the spectral transmission rate for each detector pixel.
    2. **characteristic** [-] [3D array] [n\_beams, n\_detector, wavelengths]:Contains the filter characteristics for each detector pixel.
24. **output (:)**
25. **beam\_evolution** (:) Contains data resulting from the beam evolution calculation as well as detected photon current profiles. All arrays of the output.beam\_evolution tag will have an added temporal dimension to accommodate for turbulence timescale.
    1. **emissivity** [-] [4D array] [n\_beams, timestep, n\_beamlet, n\_point\_along]: Contains the emissivity along each individual beamlet, result of the beam evolution calculation.
    2. **photon\_current** [1/s] [2D array] [timestep, n\_detector]: Contains the detected photon count on each detector for all timesteps in question.
    3. **relative\_population** [-] [5D array] [n\_beams, timestep, levels, n\_beamlet, n\_point\_along]: Contains the relative populations for all calculated atomic levels along each individual beamlet.
26. **fluctuation\_response** [m^2/s] [2D array] [n\_perturbation, n\_detector]: Contains the responses in the detected photon current of various density perturbations in the beam evolution.
27. **spatial\_resolution** (:) Contains values for various calculations for the spatial resolution.
    1. **atomic\_smear** (:) Contains the smearing caused by the atomic physics processes on each detector pixel
       1. radial [m] [1D array]: Radial component of spatial resolution from atomic physics processes.
       2. vertical [m] [1D array]: Vertical component of spatial resolution from atomic physics processes.
    2. **mag\_beam\_smear** (:) Contains the smearing of emission caused by the beam and magnetic geometry with respect to the LOS, for each detector pixel.
       1. radial [m] [1D array]: Radial component of spatial resolution from smearing caused by the misalignment of the magnetic field lines with LOS within the beam geometry.
       2. vertical [m] [1D array]: Vertical component of spatial resolution from smearing caused by the misalignment of the magnetic field lines with LOS within the beam geometry.
    3. **pixel\_proj** (:) Contains the size of the projections for each detector pixel.
       1. radial [m] [1D array]: Radial component of detector pixel projection.
       2. vertical [m] [1D array]: Vertical component of detector pixel projection.
    4. **total** (:) Contains the total spatial resolution as a convolution of the atomic smearing, magnetic and beam geometry smearing and detector projection components for each detector pixel.
       1. radial [m] [1D array]: Radial component of the total spatial resolution.
       2. vertical [m] [1D array]: Vertical component of the total spatial resolution.
    5. **sensitive\_area** (:) Contains the spatial resolution calculated from fluctuation response calculation for all detector pixels.
       1. radial [m] [1D array]: Radial component of spatial resolution from fluctuation response calculation.
       2. vertical [m] [1D array]: Vertical component of spatial resolution from fluctuation response calculation.
       3. center [m] [2D array] [n\_detector, 2]: Radial and vertical coordinates of the center of the sensitive area.
28. **measurement** (:)
29. **data** [-] [2D array] [n\_detectors, data\_point]: Contains experimental BES measurements for the shot data in question.
30. **beam\_on** [s] [1D array]: Contains the time intervals where the beam was on, used for beam chopping.

**Datainfo (:) TO XML not in CPO**

1. **atomic\_levels** [-] [integer]: sets the number of atomic levels to be used for beam evolution calculation.
2. **field\_line\_step** [m] [float]: length of field line trace step.
3. **velocity\_distribution** [-] [string]: sets the type of velocity distribution used for rate generation
4. **fluctuation** (:) Contains relevant data used for fluctuation response calculation.
   1. **amplitude** [m^-3] [float]: Density amplitude of the induced fluctuations.
   2. **size** [m] [float]: Size of the induced fluctuations.
   3. **spacing** [-] [float]: The ratio of distance between perturbations with regard to its size.
   4. **temperature\_ratio** [-] [float]: The temperature perturbation amplitude with regard to the magnitude of the normalized density perturbation.