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 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 outline the design of the BES – CPO, responsable for handling all data relevant for the RENATE sysnthetic diagnostic within the EU-IM mainframe.

Summary layout of the BES-CPO:

time [tag]:

- parameter that tags each timeslice with the corresponding values of the CPO

beam [tag]:

- beamlet positions, current and energy distribution on beamlets

profiles [tag]:

- density, temperature and impurity values registered for every point along the beamlets

equilibrium [tag]:

- RENATE relevant data inherited from equilibrium CPO

observation [tag]:

- observation point, spatail calibration, lens size, transmission rate

datainfo [tag]:

- contains data relevant to simulation (switches and distributions applied)
- contains data gathered from shot (beam current, beam energy, beam radius)

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 fluctiuation 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:

A. time (:)

1. **slice** [s] [integer]: Contains the number of the time slice in question.
2. **fluctuation** [s] [1D array]: Contains the time instances on a turbulence timescale.

B. beam (:)

1. **parameters** (:) Contains the numerical resolutions of the 3D modelled beam
    a. **size** (:) Contains the size of the beam in SI coordinates
        i. along [m] [float]: length of the modelled beam
        ii. width [m] [float]: width of the modelled beam
        iii. height [m] [float]: height of the modelled beam
    b. **resolution** (:) Contains the numerical resolution of the modelled beam
        i. along [-] [integer]: number of points along each beamlet
        ii. width [-] [integer]: number of beamlets in beam width
        iii. height [-] [integer]: number of beamlets in beam height
    c. **divergence** [rad] [float]: the divergence angle of the beam
    d. **shape** [-] [string]: describes the shape of the beam (elliptical or rectangular)
    e. **type** [-] [string]: Sets the type of atoms in the beam (H,D,Li,Na)
2. **geometry** (:) Contains all data precluding to the spatial location of beam
    a. **position** [-] [1D array]: Contains an index of the possible beam positions, for all available timesteps, characteristic of the turbulence timescale.
    b. **init** [m,m,m] [3D array] [position_index, 2, 3]: Contains the start and waypoint coordinates for each beam position
    c. **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.
3. **energy** [keV] [1D array]: Contains the beam energy corresponding to each beamlet.
4. **current** [A] [1D array]: Contains the beam current values corresponding to each beamlet

C. profiles (:)

1. **components** [-] [string list]: Contains all the plasma components: (e, H, D, C, O, etc)
2. **density** [m^-3] [4D array] [time_steps, components, n_beamlets, n_points_along]: Contains density values for all beamlets of various plasma components for all turbulent timesteps.
3. **temperature** [eV] [4D array] [time_steps, plasma_comp, n_beamlets, n_points_along]: Contains density values for all beamlets of various plasma components for all turbulent timesteps.

D. equilibrium

Contains a 2D array [n_beamlet, n_point_along] with the flux surface values of all the points along the beamlets.

E. observation (:)

1. **general** (:) Contains general information precluding to the observation system.
    a. **lens_diameter** [m] [float]: Contains the diameter of the last optical element
    b. **observation_point** [m] [1D array]: Contains the [x,y,z] coordinates of the observation point.
    c. **observed_point** [m] [1D array]: Contains the [x,y,z] coordinates of the observed point.
    d. det_pixels: interger, containing the number of detector pixels used for modelling.
    e. pixel_type: string, determines the shape of the detector pixels. Can be 'rectangular' for detector pixels or 'elliptical' for optical wire based observation.
    f. obs_volumes (:) Structure containing information regarding the observation volumes
        i. pyramid:
        ii. elliptic:
2. lens_diameter $[m]_{SI}$: float, contains the diameters of the last optical element
3. observation_point $[m]_{SI}$: 1D array, containing the [x,y,z] coordinates of the observation point.
4. pixel_type $[-]_{SI}$: 1D list of strings conting the type of

F. datainfo (:)

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.
    a. **amplitude** [m^-3] [float]: Density amplitude of the induced fluctuations.
    b. **size** [m] [float]: Size of the induced fluctuations.
    c. **spacing** [-] [float]: The ratio of distance between perturbations with regard to its size.
    d. **temperature_ratio** [-] [float]: The temperature perturbation amplitude with regard to the magnitude of the normalized density perturbation.

G. output (:)

1. **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.
    a. **emissivity** [au] [3D array] [timestep, n_beamlet, n_point_along]: Contains the emissivity along each individual beamlet, result of the beam evolution calculation.
    b. **photon_current** [1/s] [2D array] [timestep, n_detector]: Contains the detected photon count on each detector for all timesteps in question.
    c. **relative_population** [au] [4D array] [timestep, levels, n_beamlet, n_point_along]: Contains the relative populations for all calculated atomic levels along each individual beamlet.
2. **fluctuation_response** [au] [2D array] [n_perturbation, n_detector]: Contains the responses in the detected photon current of various density perturbations in the beam evolution.
3. **spatial_resolution** (:) Contains values for various calculations for the spatial resolution.
    a. **atomic_smear** (:) Contains the smearing caused by the atomic physics processes on each detector pixel
        i. radial [m] [float]: Radial component of spatial resolution from atomic physics processes.
        ii. vertical [m] [float]: Vertical component of spatial resolution from atomic physics processes.
    b. **magbeam_smear** (:) Contains the smearing of emission caused by the beam and magnetic geometry with respect to the LOS, for each detector pixel.
        i. radial [m] [float]: Radial component of spatial resolution from smearing caused by the misalignment of the magnetic field lines with LOS within the beam geometry.
        ii. vertical [m] [float]: Vertical component of spatial resolution from smearing caused by the misalignment of the magnetic field lines with LOS within the beam geometry.
    c. **pixel_proj** (:) Contains the size of the projections for each detector pixel.
        i. radial [m] [float]: Radial component of detector pixel projection.
        ii. vertical [m] [float]: Vertical component of detector pixel projection.
    d. **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.
        i. radial [m] [float]: Radial component of the total spatial resolution.
        ii. vertical [m] [float]: Vertical component of the total spatial resolution.
    e. **sensitive_area** (:) Contains the spatial resolution calculated from fluctuation response calculation for all detector pixels.
        i. radial [m] [float]: Radial component of spatial resolution from fluctuation response calculation.
        ii. vertical [m] [float]: Vertical component of spatial resolution from fluctuation response calculation.

H. measurement

Contains 2D array [nr_detectors, data_point], with experimental BES measurements for the shot data in question.