Proposal for the changes in IDS data structure to accommodate the fluctuation BES synthetic diagnostic

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Purpose of the proposal

The RENATE-OD synthetic diagnostic, designed for fluctuation BES diagnostic system modelling is to be integrated into EU-IM and IMAS, consequently. Communication of various actors responsible for executing code is only possible through IDS data structures. The current proposal outlines a possible extension of the existing IDS structure necessary to accommodate fluctuation BES data.

General considerations

There are a large number of diagnostic systems at a magnetic fusion device. As the integrated modelling effort matures there will be a need to integrate a growing number of different synthetic diagnostic codes. These diagnostic systems typically share some sub-level physics models with one-another and/or with auxiliary systems. In order to avoid massive multiplication of IDS sub-structures, in the IDSs of different diagnostic systems we propose to identify key common components and design corresponding IDSs with general enough structure to accommodate the needs of every synthetic diagnostic using it.

In the context of RENATE-OD this would imply to have:

1. A neutral beam IDS that is capable of describing all necessary aspects including fast temporal changes, like tilting or chopping the beam.
2. An optical system IDS that is capable of describing the optical system in the required considerable detail.
3. An actual BES IDS that would serve solely as an output from the modelling and maybe the storage of the actual measurement.

Modifications deemed necessary to existing IDSs

1. The **nbi** IDS is suitable for BES modelling. To be able to model accurately beam tilting, which may be employed for the purpose of 2D measurements, a temporal dimension will have to be added to the beamlets_group structure. Due to the repetitive nature of the tilting and chopping scenarios, storing short time scale on-off times of beamlets_goup-s would be sufficient.

2. The **spectrometer_visible** IDS is suitable for the modelling of the observation system used by the BES synthetic diagnostic. We propose the following additions to the IDS structure:
    a. **observation /** [struct]: Holding data characteristic of the observation system, regardless to the individual detector LOS.
        i. **detectors** [-] [INT_0D]: Number of detectors that build the observation system.
        ii. **layout** [-] [STR_0D]: Specifications to the layout of the detector grid employed. Ex:'4x16', '4x32', '1x18'.
        iii. **input_aperture/** [struct]: Contains data regarding the radius of the first optical element.
            1. **radius** [m] [FLT_0D]: radius of the first optical element.
            2. **radius_error_upper** [m] [FLT_0D]: Upper error for "radius".
            3. **radius_error_lower** [m] [FLT_0D]: Lower error for "radius".
            4. **radius_error_index** [-] [int_type]: Index in the error description list for "radius".
        iv. **position /** [struct]: Position in [r,z,phi] of the center of the input aperture.
            1. **r** [m] [FLT_0D]: Major radius.
            2. **r_error_upper** [m] [FLT_0D]: Upper error for "r".
            3. **r_error_lower** [m] [FLT_0D]: Lower error for "r".
            4. **r_error_index** [-] [int_type]: Index in the error description list for "r".
            5. **z** [m] [FLT_0D]: Height.
            6. **z_error_upper** [m] [FLT_0D]: Upper error for "z".
            7. **z_error_lower** [m] [FLT_0D]: Lower error for "z".
            8. **z_error_index** [-] [int_type]: Index in the error description list for "z".
            9. **phi** [rad] [FLT_0D]: Toroidal angle.
            10. **phi_error_upper** [rad] [FLT_0D]: Upper error for "phi"
            11. **phi_error_lower** [rad] [FLT_0D]: Lower error for "phi"
            12. **phi_error_index** [-] [int_type]: Index in the error description list for "phi".
    b. **channel** (i1): Contains the description of the observation volumes for each detector pixel at the focal plane of the optical system. This is basically the image of the detector pixels on the focal plane.
        i. **circular /** [struct]: Contains data to model circular observation cones.
            1. **radius** [m] [FLT_0D]: For circular based observation volumes holds the base radius of the observation cone
            2. **radius_error_upper** [m] [FLT_0D]: Upper error for "radius".
            3. **radius_error_lower** [m] [FLT_0D]: Lower error for "radius".
            4. **radius_error_index** [-] [int_type]: Index in the error description list for "radius".
            5. **ellipticity** [-] [float]: Provides the ellipticity for cone based observation volumes.
            6. **ellipticity_error_upper** [-] [FLT_0D]: Upper error for "ellipticity".
            7. **ellipticity_error_lower** [-] [FLT_0D]: Lower error for "ellipticity".
            8. **ellipticity_error_index** [-] [int_type]: Index in the error description list for "ellipticity".
        ii. **polygonal /** [struct]: Contains data regarding any polynomial based observation pyramid.

1. **nr_points** [-] [INT_0D]: Number of points shaping the polygon based observation volume.
2. **position** (i2): Coordinates of the points shaping the polygon of the observation volume.
    a. **r** [m] [FLT_0D]: Major radius.
    b. **r_error_upper** [m] [FLT_0D]: Upper error for "r".
    c. **r_error_lower** [m] [FLT_0D]: Lower error for "r".
    d. **r_error_index** [-] [int_type]: Index in the error description list for "r".
    e. **z** [m] [FLT_0D]: Height.
    f. **z_error_upper** [m] [FLT_0D]: Upper error for "z".
    g. **z_error_lower** [m] [FLT_0D]: Lower error for "z".
    h. **z_error_index** [-] [int_type]: Index in the error description list for "z".
    i. **phi** [rad] [FLT_0D]: Toroidal angle.
    j. **phi_error_upper** [rad] [FLT_0D]: Upper error for "phi".
    k. **phi_error_lower** [rad] [FLT_0D]: Lower error for "phi".
    l. **phi_error_index** [-] [int_type]: Index in the error description list for "phi".

c. **light_collection_efficiency** (i2): For non-pinhole optics, presents a data structure that contains emission weights for beam points located within various 3D ROI-s designated for each detector or channel.
    i. **emission_frac** [-] [FLT_0D]: Contains the emission fraction detected by the observation system from a certain point within the ROI.
    ii. **emission_frac_error_upper** [-] [FLT_0D]:
    iii. **emission_frac_error_lower** [-] [FLT_0D]:
    iv. **emission_frac_error_index** [-] [int_type]:
    v. **position /** [struct]: Position in [r,z,phi] of the emission dampening within the specific ROI.
        1. **r** [m] [FLT_0D]: Major radius.
        2. **r_error_upper** [m] [FLT_0D]: Upper error for "r".
        3. **r_error_lower** [m] [FLT_0D]: Lower error for "r".
        4. **r_error_index** [-] [int_type]: Index in the error description list for "r".
        5. **z** [m] [FLT_0D]: Height.
        6. **z_error_upper** [m] [FLT_0D]: Upper error for "z".
        7. **z_error_lower** [m] [FLT_0D]: Lower error for "z".
        8. **z_error_index** [-] [int_type]: Index in the error description list for "z".
        9. **phi** [rad] [FLT_0D]: Toroidal angle.
        10. **phi_error_upper** [rad] [FLT_0D]: Upper error for "phi"
        11. **phi_error_lower** [rad] [FLT_0D]: Lower error for "phi"
        12. **phi_error_index** [-] [int_type]: Index in the error description list for "phi".

3. A **BES_diagnostic** IDS would be needed to store all the BES data resulted from the modelling. The data stored in the BES_diagnostic IDS would contain:
    a. **channel (i1):** Contains all modelled BES data for current channel in question.
        i. **name** [-] [STR_0D]: Name of BES channel.
        ii. **type** [-] [STR_0D]: Type of BES channel (ex: APD, CCD).

iii. **modelled_signal /** [struct]: Contains the detected photon count as a result of the beam emission modelling.
    1. **clean** [1/s] [FLT_1D]: Contains the time dependent modelled BES signal. The BES signal contains no noise.
    2. **clean_error_upper** [1/s] [FLT_1D]: Upper error for “clean”.
    3. **clean_error_lower** [1/s] [FLT_1D]: Lower error for “clean”.
    4. **clean_error_index** [-] [int_type]: Index in the error description list for “clean”.
    5. **noisy** [1/s] [FLT_1D]: Contains the time dependent modelled BES signal with added noise specific to the diagnostic at hand.
    6. **noisy_error_upper** [1/s] [FLT_1D]: Upper error for “noisy”.
    7. **noisy_error_lower** [1/s] [FLT_1D]: Lower error for “noisy”.
    8. **noisy_error_index** [-] [int_type]: Index in the error description list for “noisy”.
    9. **time** [s] [FLT_1D_type]: Generic time specific to beam modelling.

iv. **measured_signal /** [struct]**:** Contains measured signals for the modelled discharge.
    1. **signal** [V] [FLT_1D]: Measured BES signal on the respective channel.
    2. **signal_error_upper** [V] [FLT_1D]: Upper error for “signal”.
    3. **signal_error_lower** [V] [FLT_1D]: Lower error for “signal”.
    4. **signal_error_index** [-] [int_type]: Index in the error description list for “signal”.
    5. **time** [s] [FLT_1D_type]: Generic time specific to measurements.

b. **fluctuation_sensitive_region /** [struct]: Contains values for various calculations regarding spatial resolution and location of detector sensitivity on the poloidal plane. This is necessary for interpretation.

i. **estimated /** [struct] Contains an estimate of the total spatial resolution calculated as a convolution of the atomic smearing, magnetic and beam geometry smearing and detector projection components for each detector pixel.
    1. **r_extent** [m] [FLT_0D]: Radial component of the total spatial resolution.
    2. **r_extent_error_upper** [m] [FLT_0D]: Upper error for “r_extent”.
    3. **r_extent_error_lower** [m] [FLT_0D]: Lower error for “r_extent”.
    4. **r_extent_error_index** [-] [int_type]: Index in the error description list for “r_extent”.
    5. **z_extent** [m] [FLT_0D]: Vertical component of the total spatial resolution.
    6. **z_extent_error_upper** [m] [FLT_0D]: Upper error for “z_extent”.
    7. **z_extent_error_lower** [m] [FLT_0D]: Lower error for “z_extent”.
    8. **z_extent_error_index** [-] [int_type]: Index in the error description list for “z_extent”.
    9. **r_center** [m] [FLT_0D]: Radial center of sensitive area.
    10. **r_center_error_upper** [m] [FLT_0D]: Upper error for “r_center”.
    11. **r_center_error_lower** [m] [FLT_0D]: Lower error for “r_center”.

12. **r_center_error_index** [-] [int_type]: Index in the error description list for “r_center”.
13. **z_center** [m] [FLT_0D]: Vertical center of sensitive area.
14. **z_center_error_upper** [m] [FLT_0D]: Upper error for “z_center”.
15. **z_center_error_lower** [m] [FLT_0D]: Lower error for “z_center”.
16. **z_center_error_index** [-] [int_type]: Index in the error description list for “z_center”.

ii. **fluctuation_response /** [struct] Contains the spatial resolution calculated from actual fluctuation response calculation for all detector pixels.

1. **r_extent** [m] [FLT_0D]: Radial component of the total spatial resolution.
2. **r_extent_error_upper** [m] [FLT_0D]: Upper error for “r_extent”.
3. **r_extent_error_lower** [m] [FLT_0D]: Lower error for “r_extent”.
4. **r_extent_error_index** [-] [int_type]: Index in the error description list for “r_extent”.
5. **z_extent** [m] [FLT_0D]: Vertical component of the total spatial resolution.
6. **z_extent_error_upper** [m] [FLT_0D]: Upper error for “z_extent”.
7. **z_extent_error_lower** [m] [FLT_0D]: Lower error for “z_extent”.
8. **z_extent_error_index** [-] [int_type]: Index in the error description list for “z_extent”.
9. **r_center** [m] [FLT_0D]: Radial center of sensitive area.
10. **r_center_error_upper** [m] [FLT_0D]: Upper error for “r_center”.
11. **r_center_error_lower** [m] [FLT_0D]: Lower error for “r_center”.
12. **r_center_error_index** [-] [int_type]: Index in the error description list for “r_center”.
13. **z_center** [m] [FLT_0D]: Vertical center of sensitive area.
14. **z_center_error_upper** [m] [FLT_0D]: Upper error for “z_center”.
15. **z_center_error_lower** [m] [FLT_0D]: Lower error for “z_center”.
16. **z_center_error_index** [-] [int_type]: Index in the error description list for “z_center”.