ASDEX Upgrade SPI: design, status and plans

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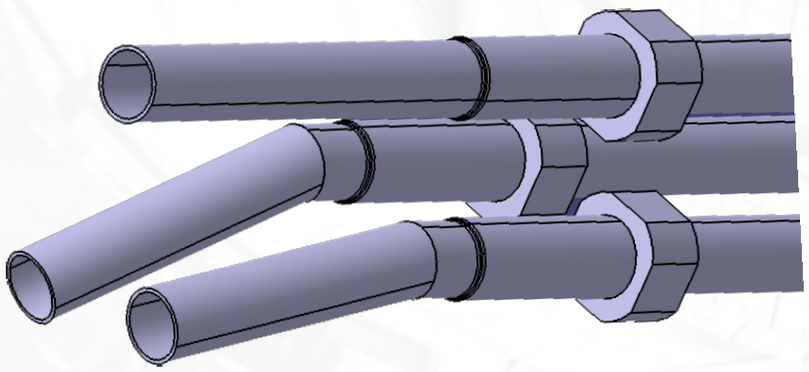

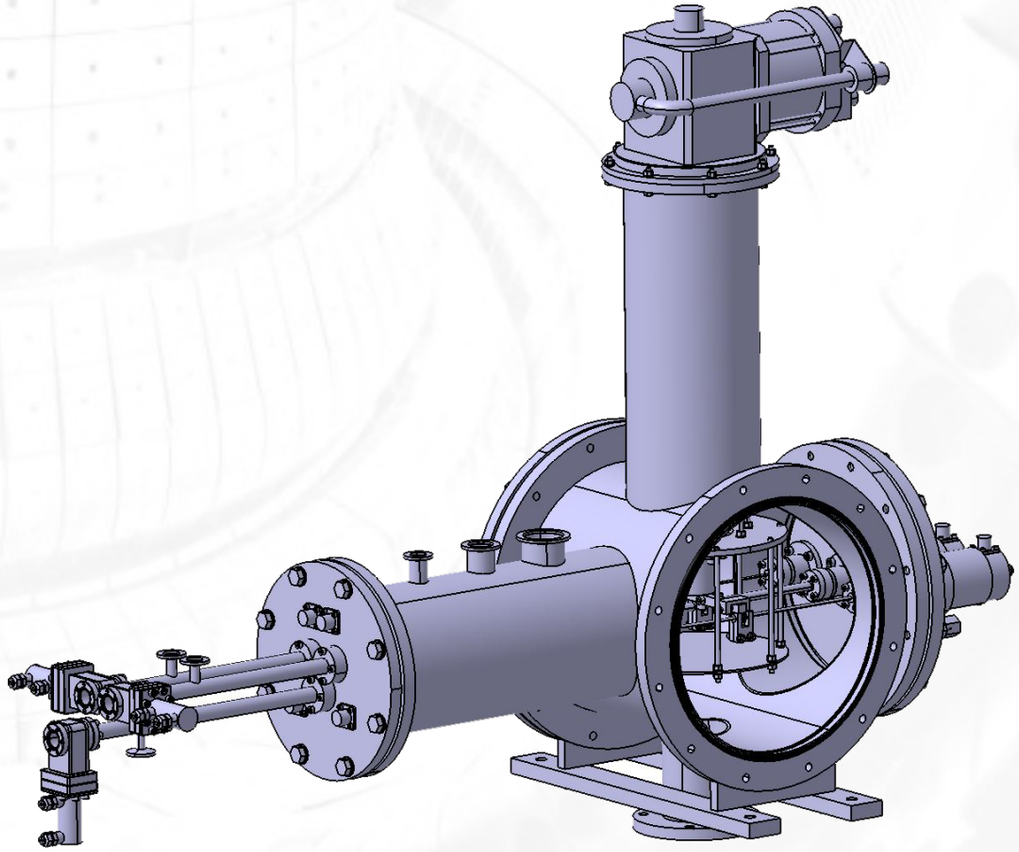

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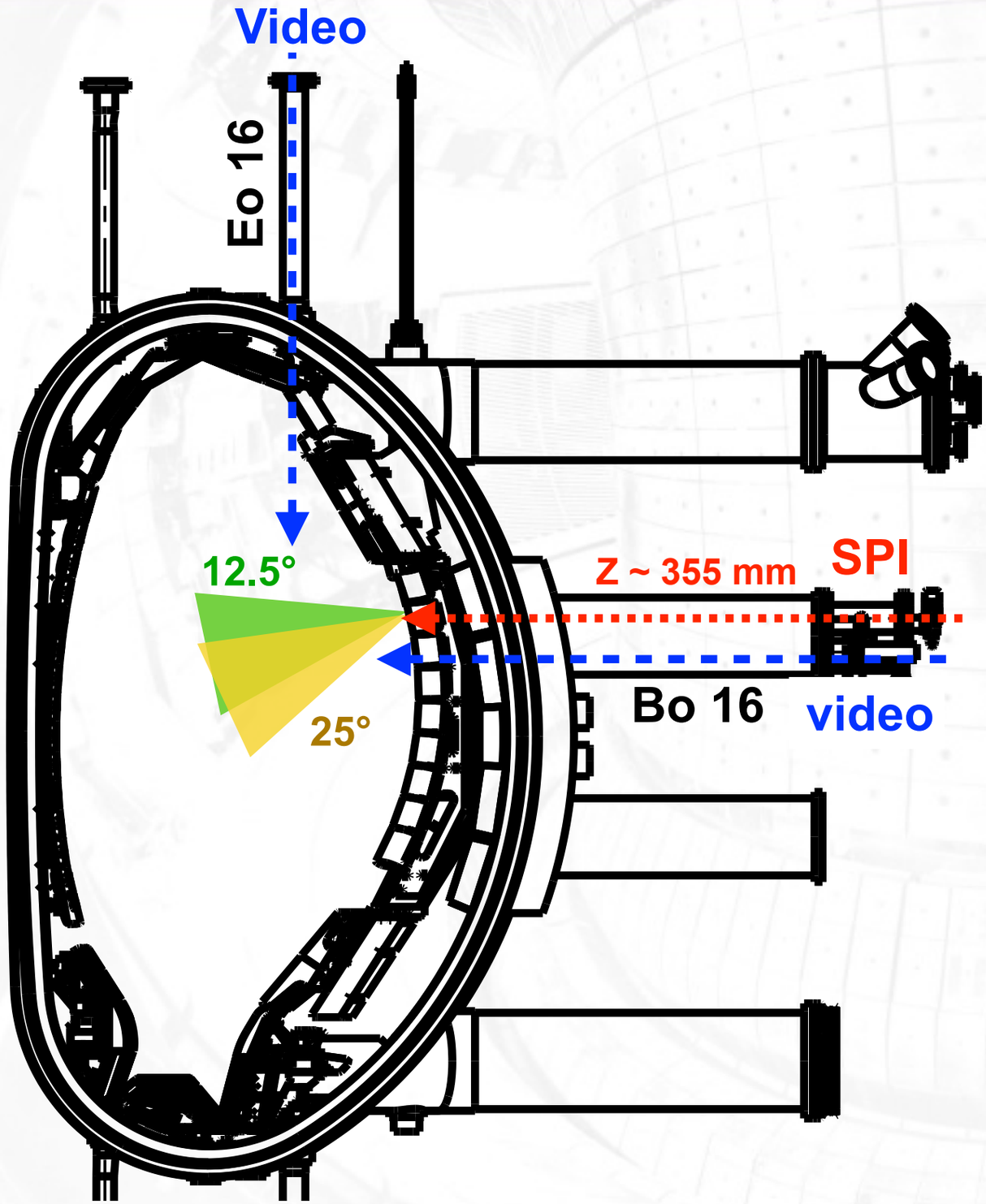
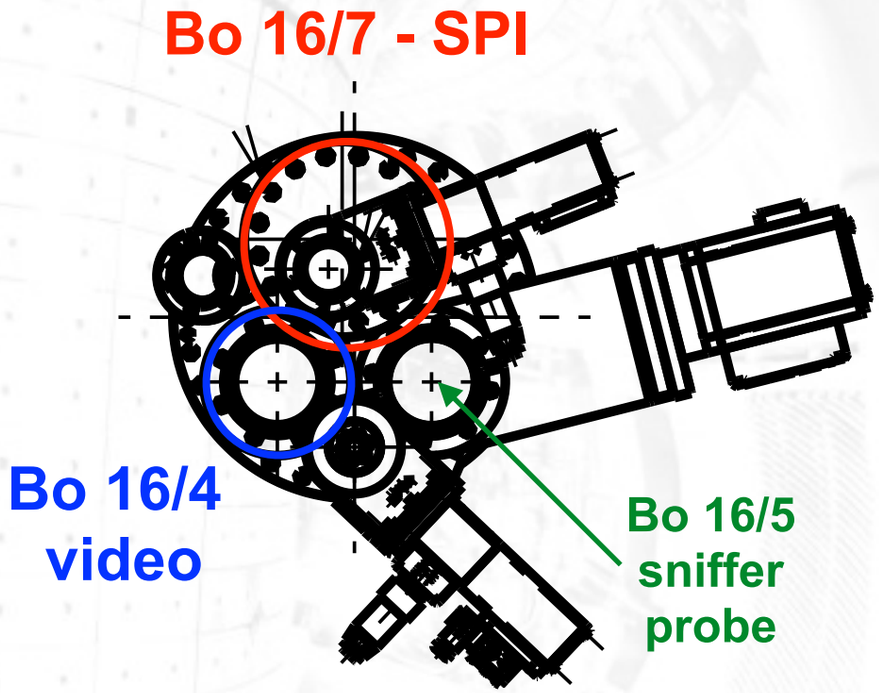
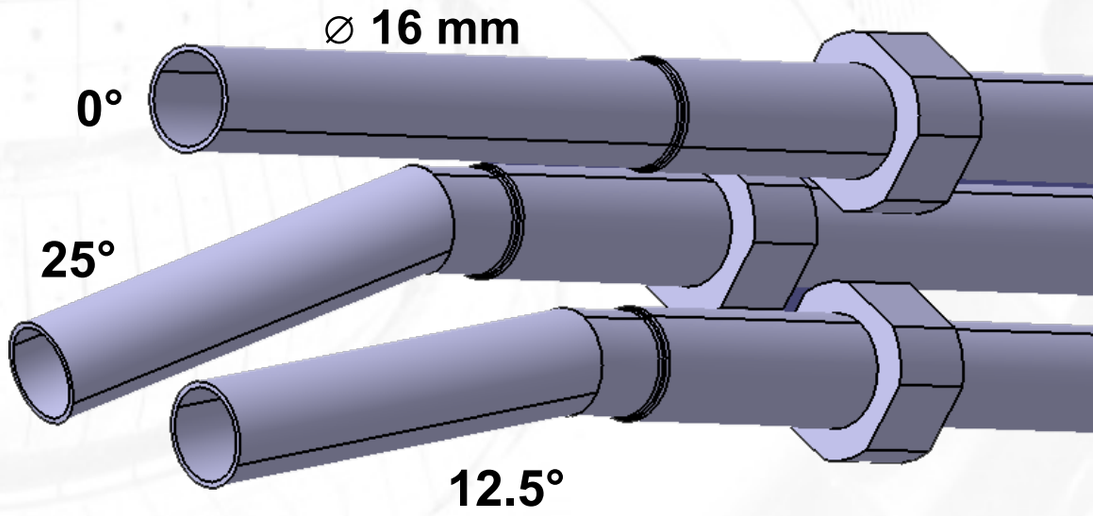
AUG SPI Project

- **Project within the ITER DMS Task Force -- 2020-2022**
  - ➡ AUG: medium sized tokamak, high energy operation
  - ➡ All metal (W) wall, wide array of existing diagnostics
  - ➡ Extend number of labs working with SPI
- **Focus: effect of shard size distribution on disruption mitigation characteristics**
  - ➡ 3 independent tubes w/ different shatter angles 0°, 12.5° and 25°; more geometries characterized in lab Option for small unbroken pellets
  - ➡ D_2 / Ne / Ar / D_2+Ne pellets; D_2 propellant ($D_2 \leftrightarrow H_2$)
  - ➡ Pellet diameter 1-8 mm, max speed 600 m/s (D_2)
  - ➡ Pellet integrity diagnostic: fast camera after barrel shutter
- Injector provided by ITER ➡ PELIN

SPI location on AUG



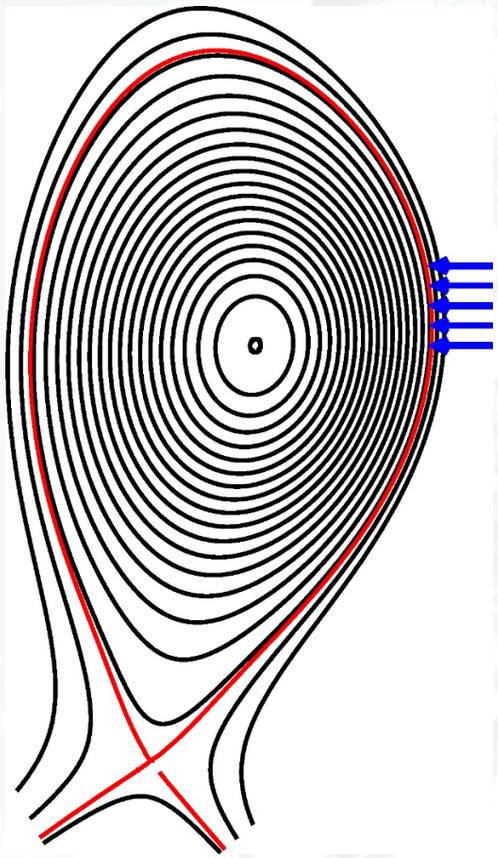




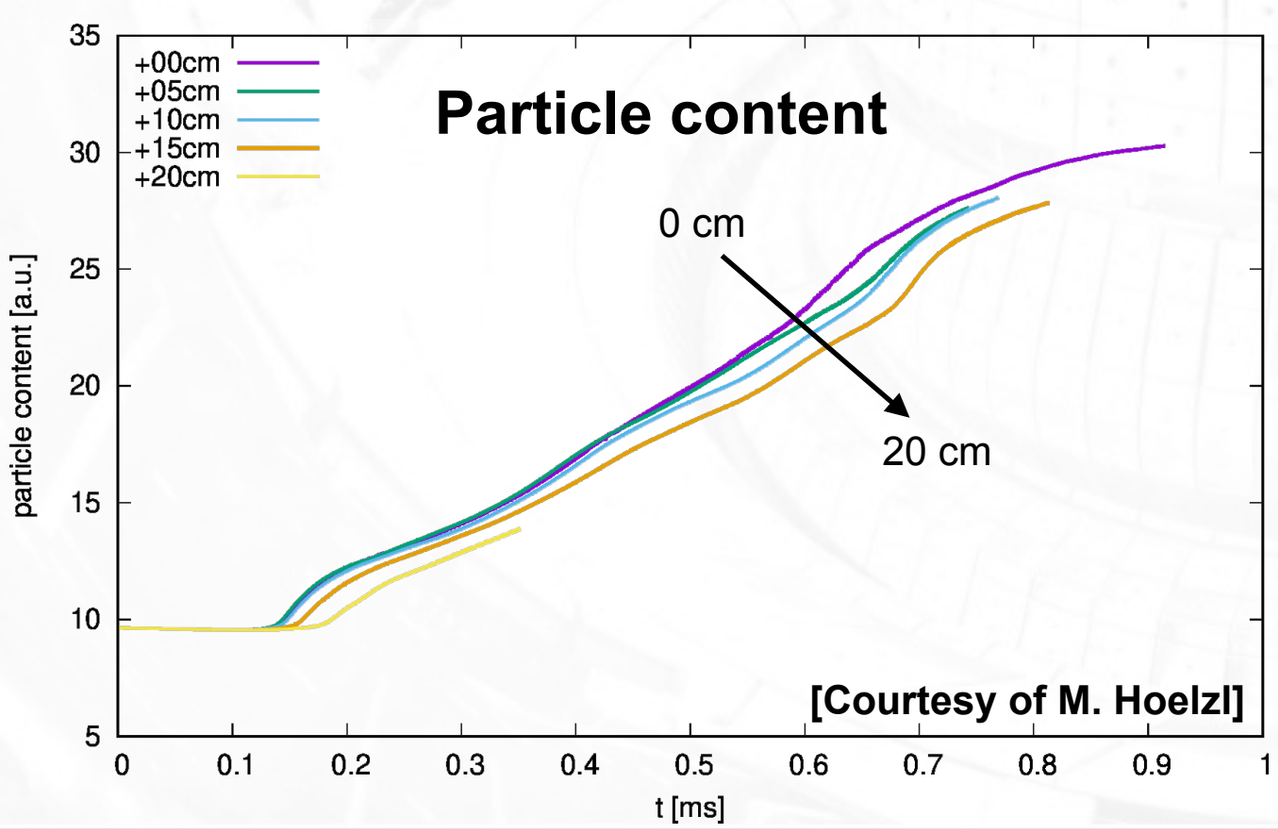
JOREK: exact vertical location (+/- 10 cm) is not too sensitive

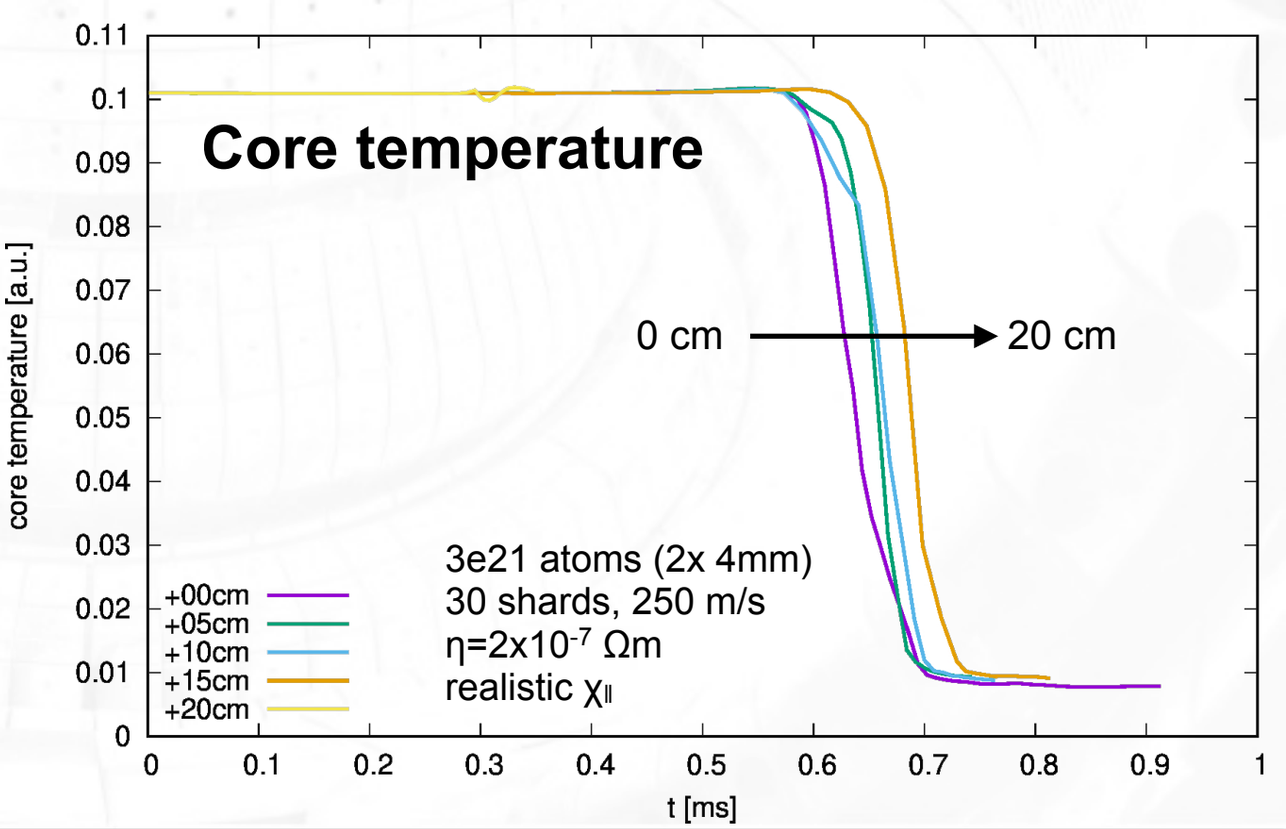
[M. Hoelzl *et al.*, PoP 27 022510 (2020); https://doi.org/10.1063/1.5133099]

JOREK scan of injection location



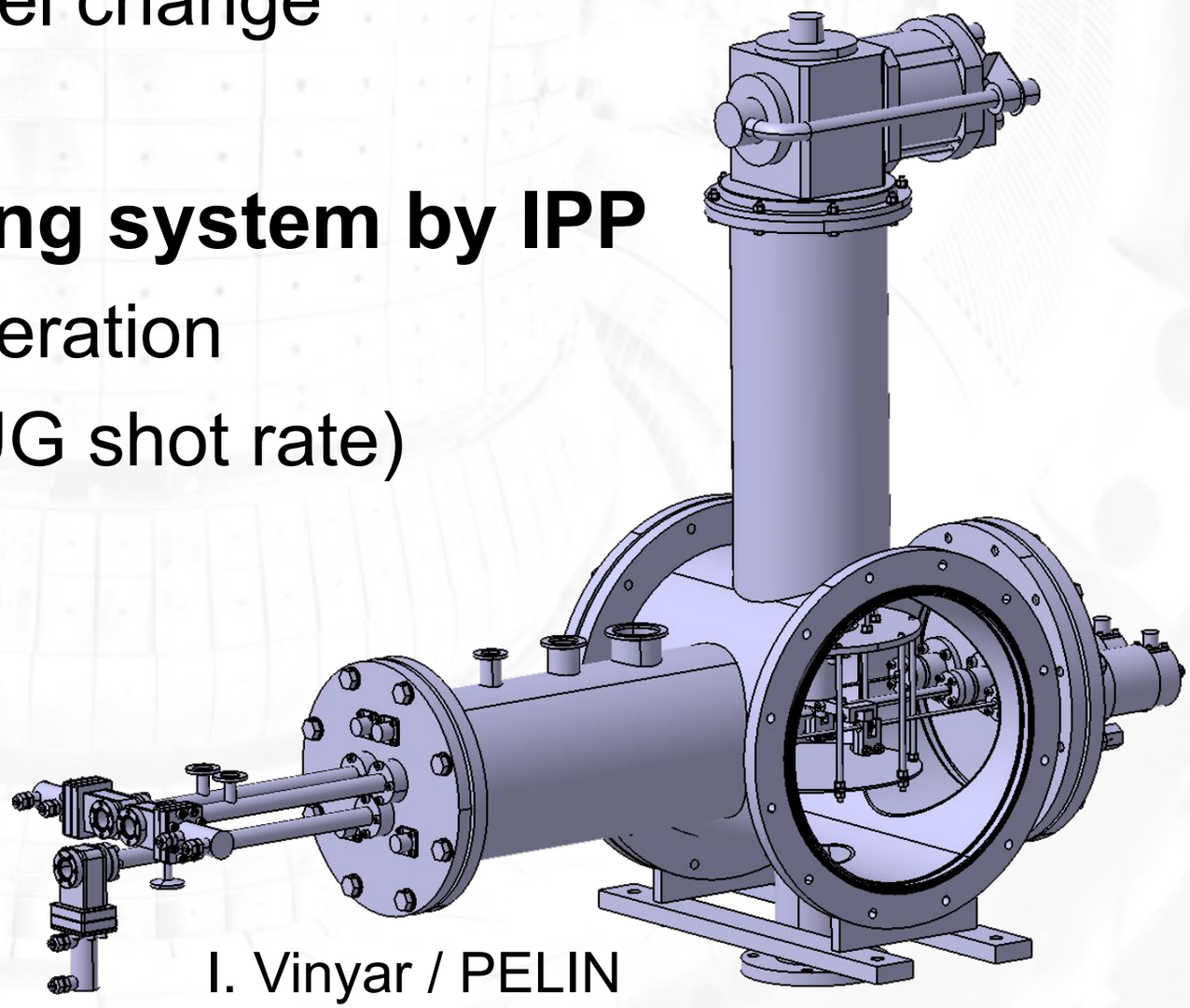
- **Port at Z ~ 350 mm above the axis**
- JOREK scan of the effect of height 0-20 cm
  - ➡ AUG H-mode plasma scenario, D_2 SPI
  - ➡ "case O" [https://doi.org/10.1063/1.5133099]
- **Plasma response is not particularly sensitive to height of injection location**





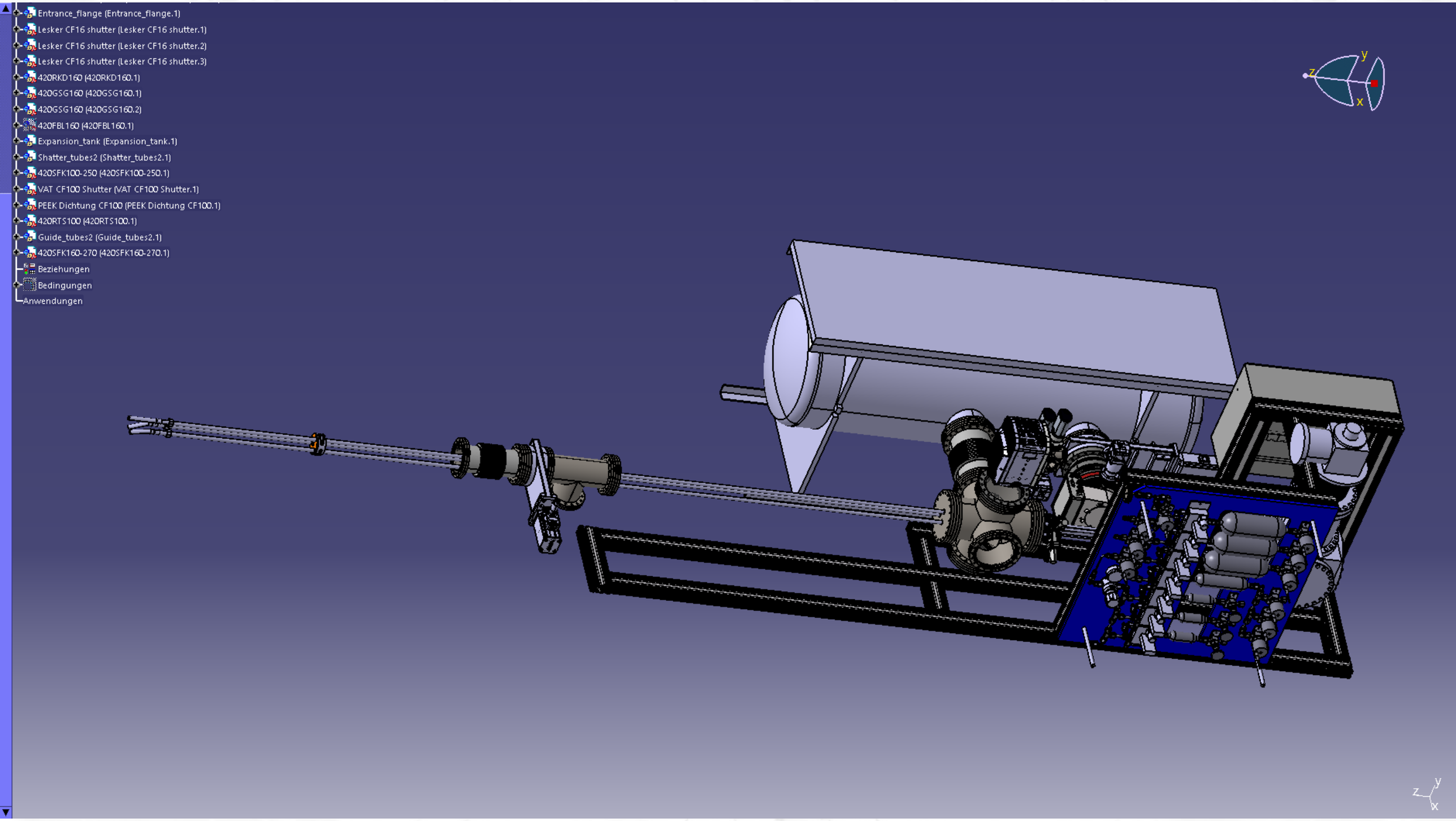
SPI Injector

- **Provided by ITER ➡ design & manufacture by Pelin LLC**
  - ➡ Close collaboration with IPP on the integration
- 3 interchangeable barrels, shared cold head
  - ➡ D2+Ne *or* Ar pellets at the same time
  - ➡ Different diameter with barrel change
  - ➡ Cryocooler design
- **Gas distribution & pumping system by IPP**
  - ➡ Goal: automated pellet generation
  - ➡ Freezing time < 15 min (AUG shot rate)
- Lab characterization at IPP

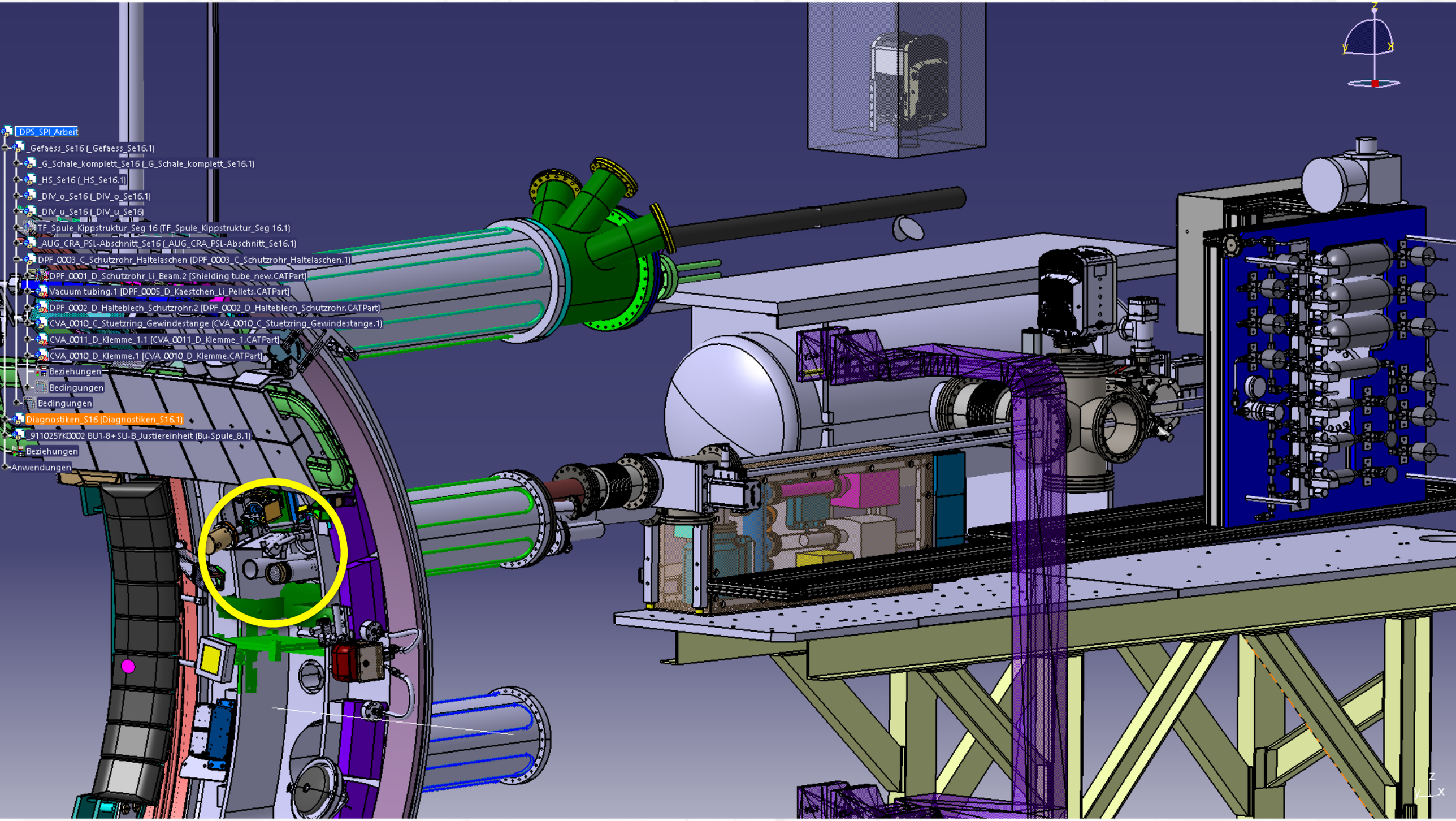


I. Vinyar / PELIN

SPI integration



SPI integration



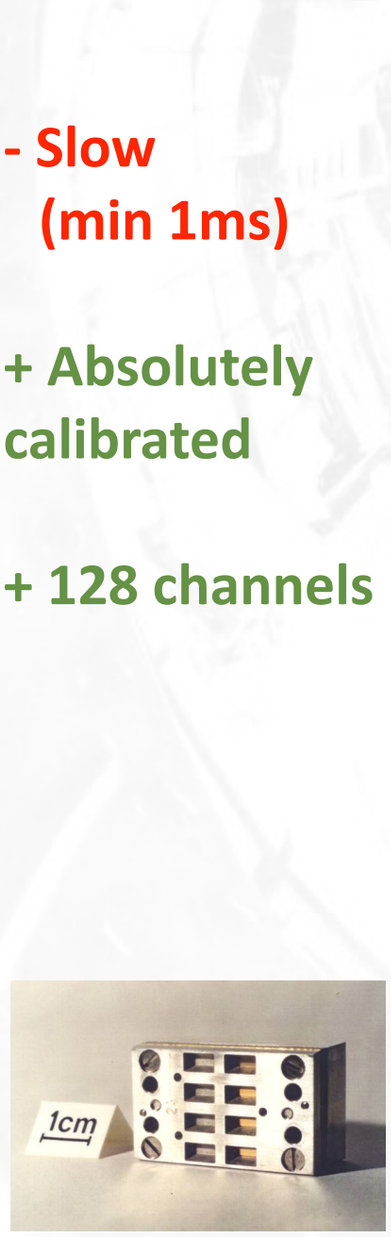
Existing bolometry system

Foils
S5

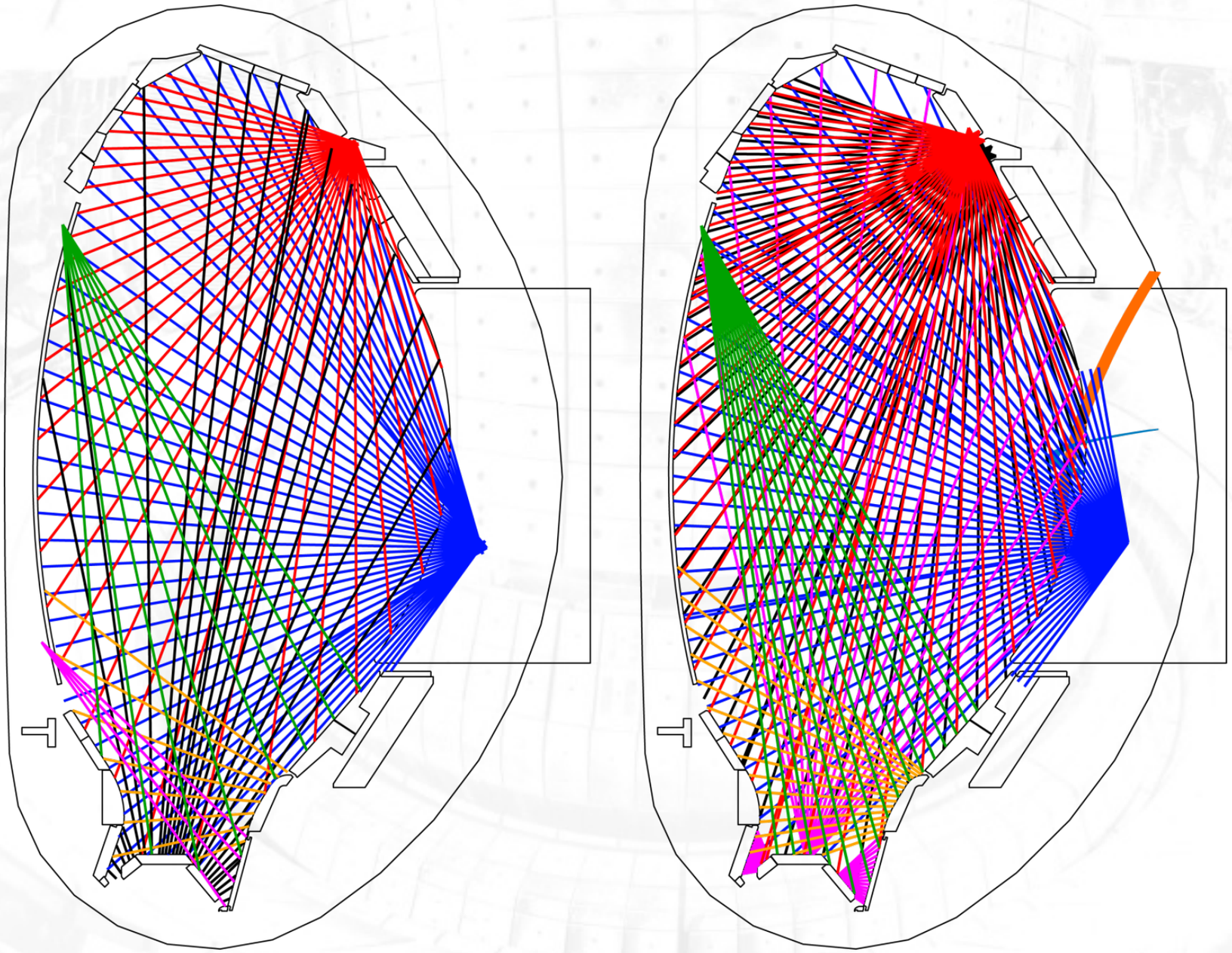
- Slow
  (min 1ms)

+ Absolutely calibrated

+ 128 channels



Diodes
S5 + S13



+ Fast
  (200kHz)

- Energy dependent sensitivity

- Degrading

+ 256 channels

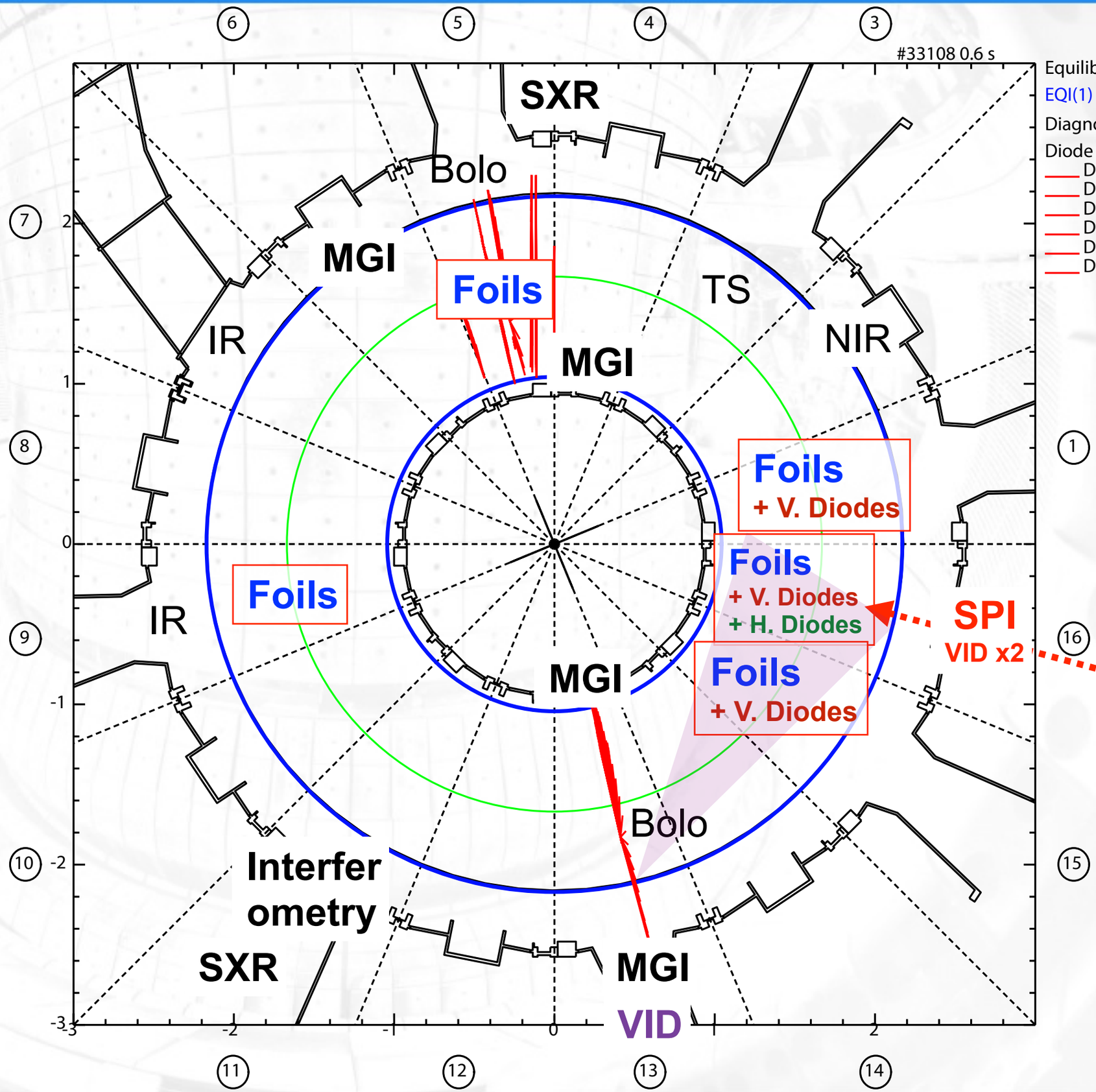
Diagnostic upgrades - overview

SPI Bolometry needs

- @SPI location
- 2D preferred
- Toroidal resolution
- High time resolution (AXUV)
- Absolute power (foils)

Upgrades

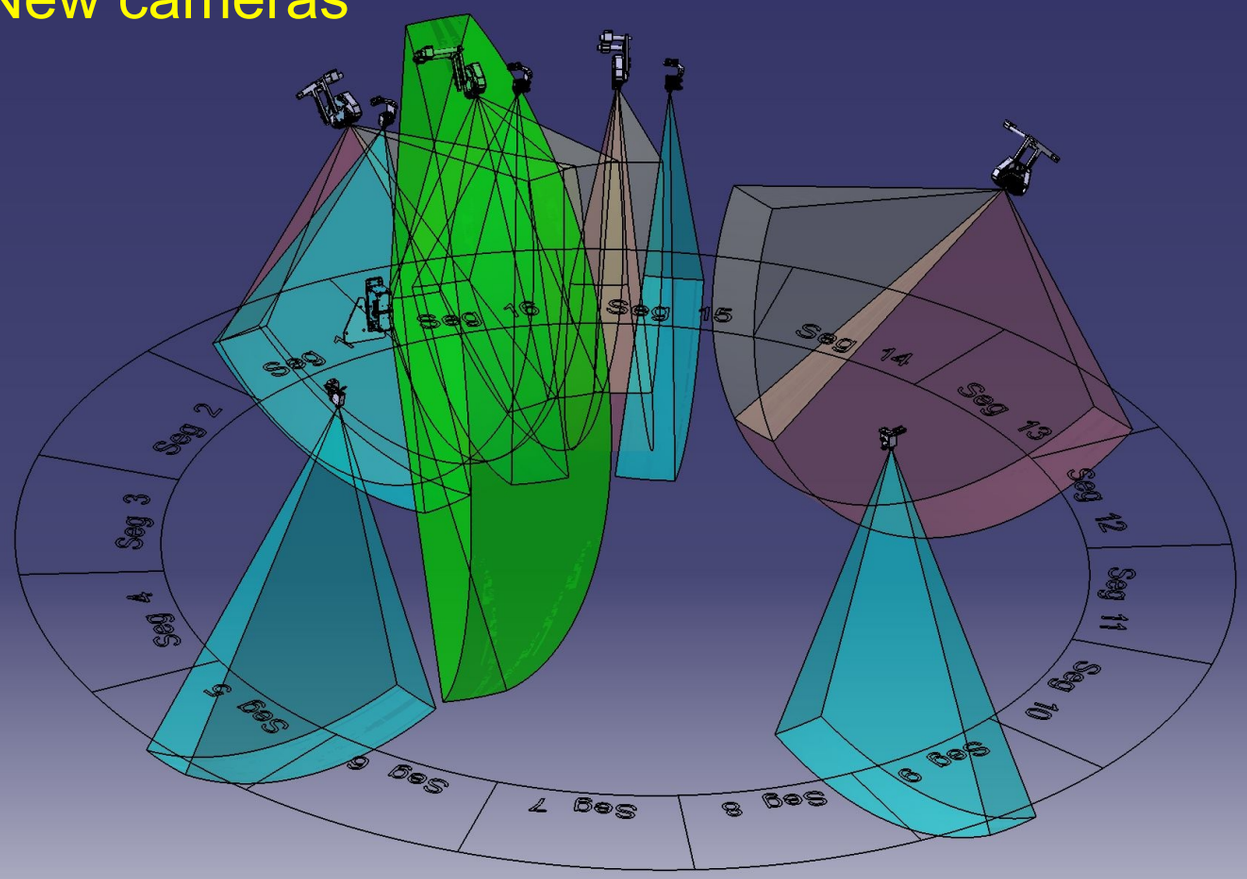
- 1x New Horizontal diodes 48 ch
- 3x New Vertical diodes 32-48 ch
- 5x New Foils upper div 4 ch

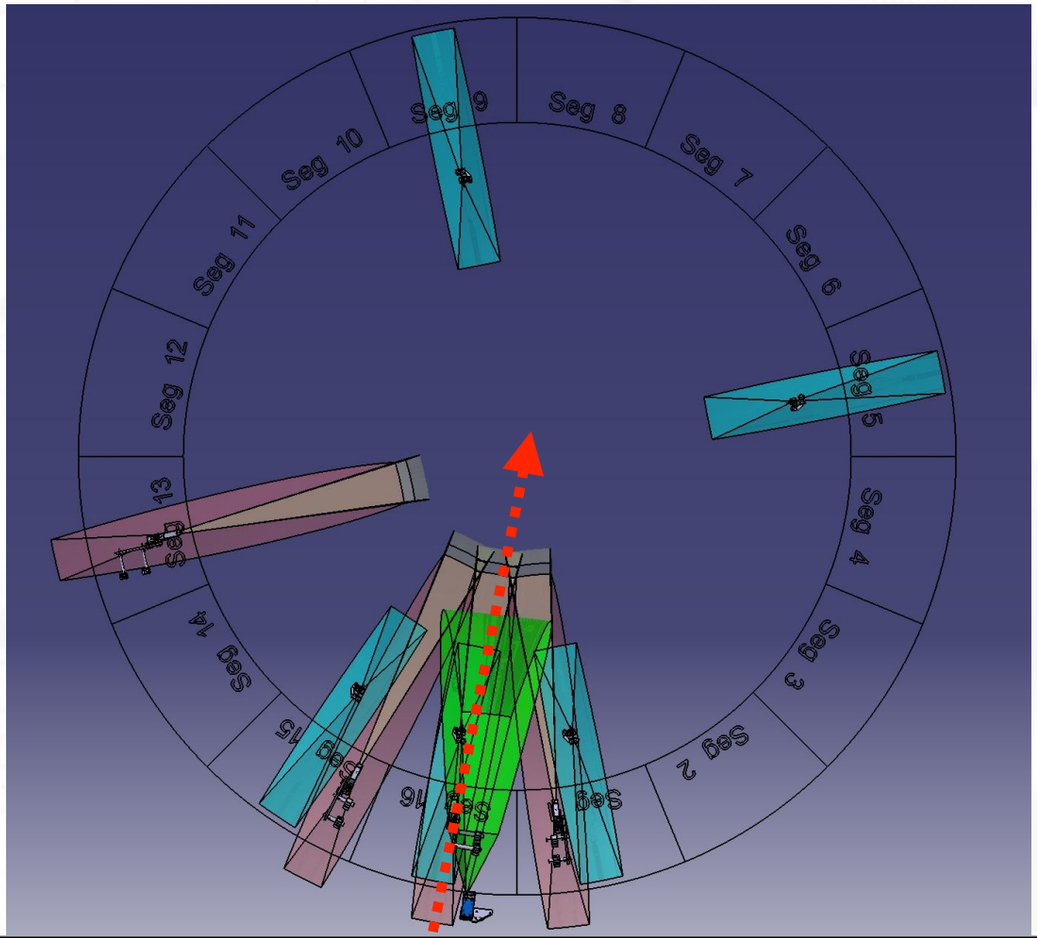


Diagnostic upgrades - bolometry

- Substantial extension of existing bolometry system (ITER financing)
  - ➡ 1x New Horizontal diodes 48 ch
  - ➡ 3x New Vertical diodes 32/48 ch
  - ➡ 5x New Foils upper divertor 4 ch
- Not all systems expected to be installed in 2020 (COVID)

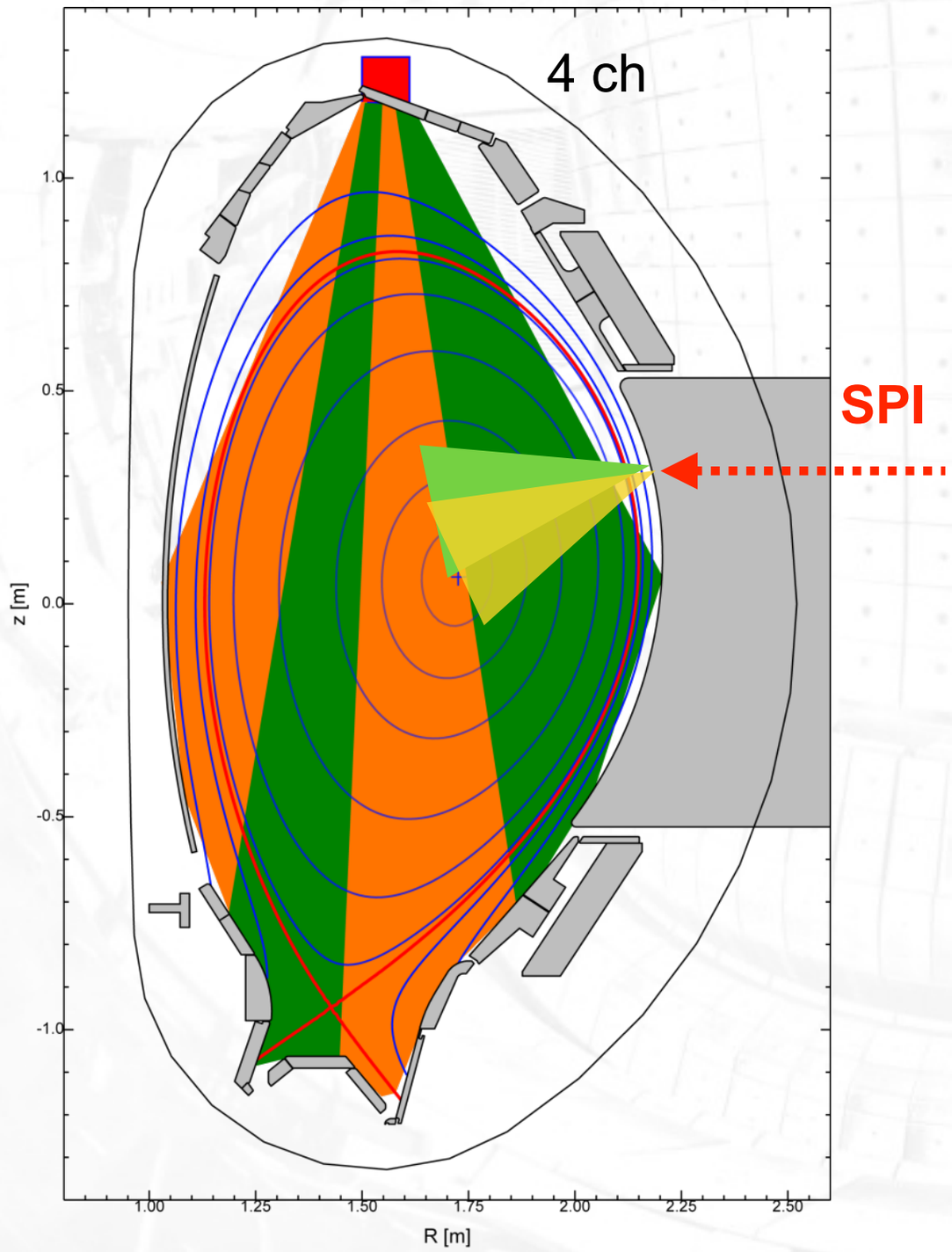
New cameras



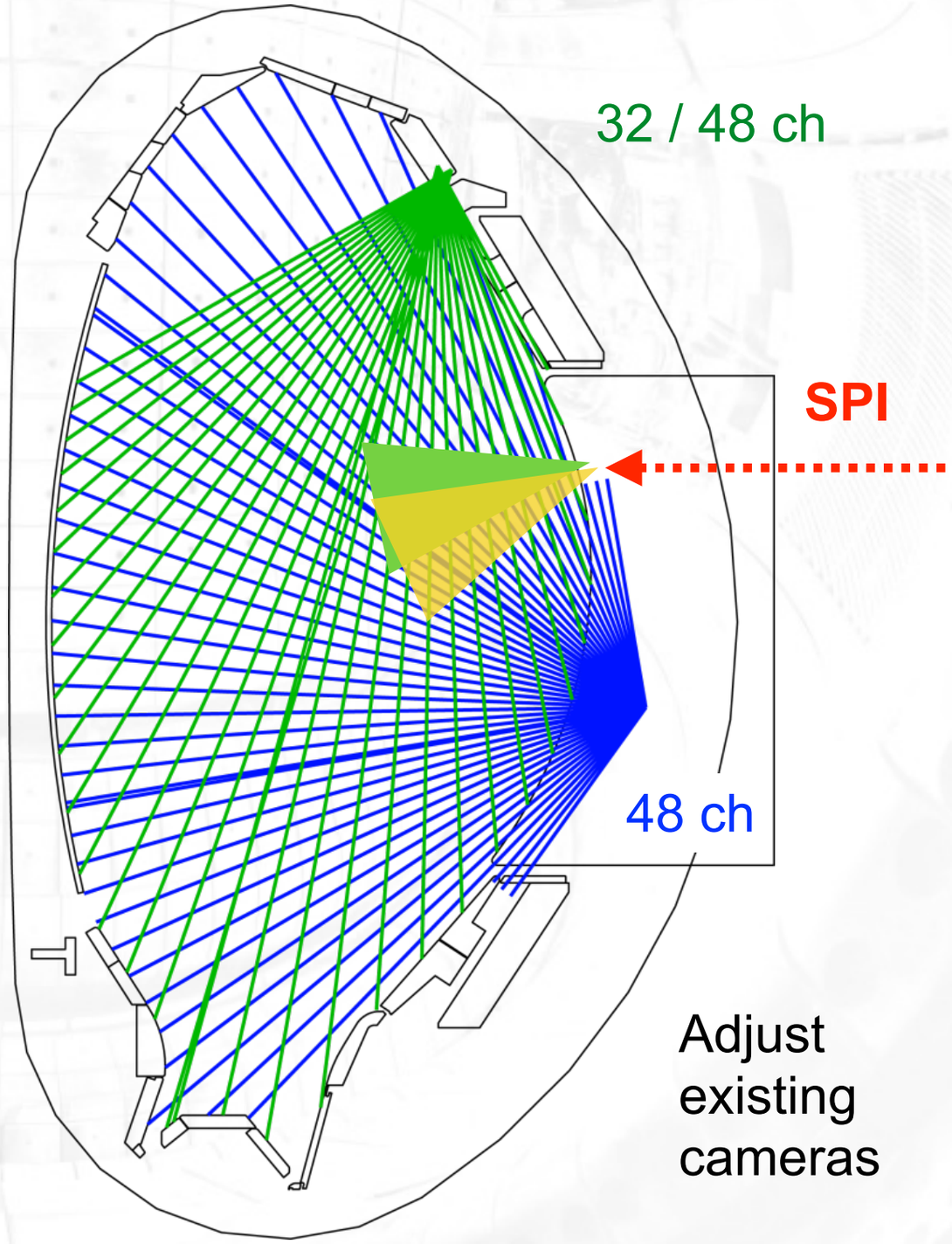


Diagnostic upgrades - bolometry

Foils: 5 toroidal positions

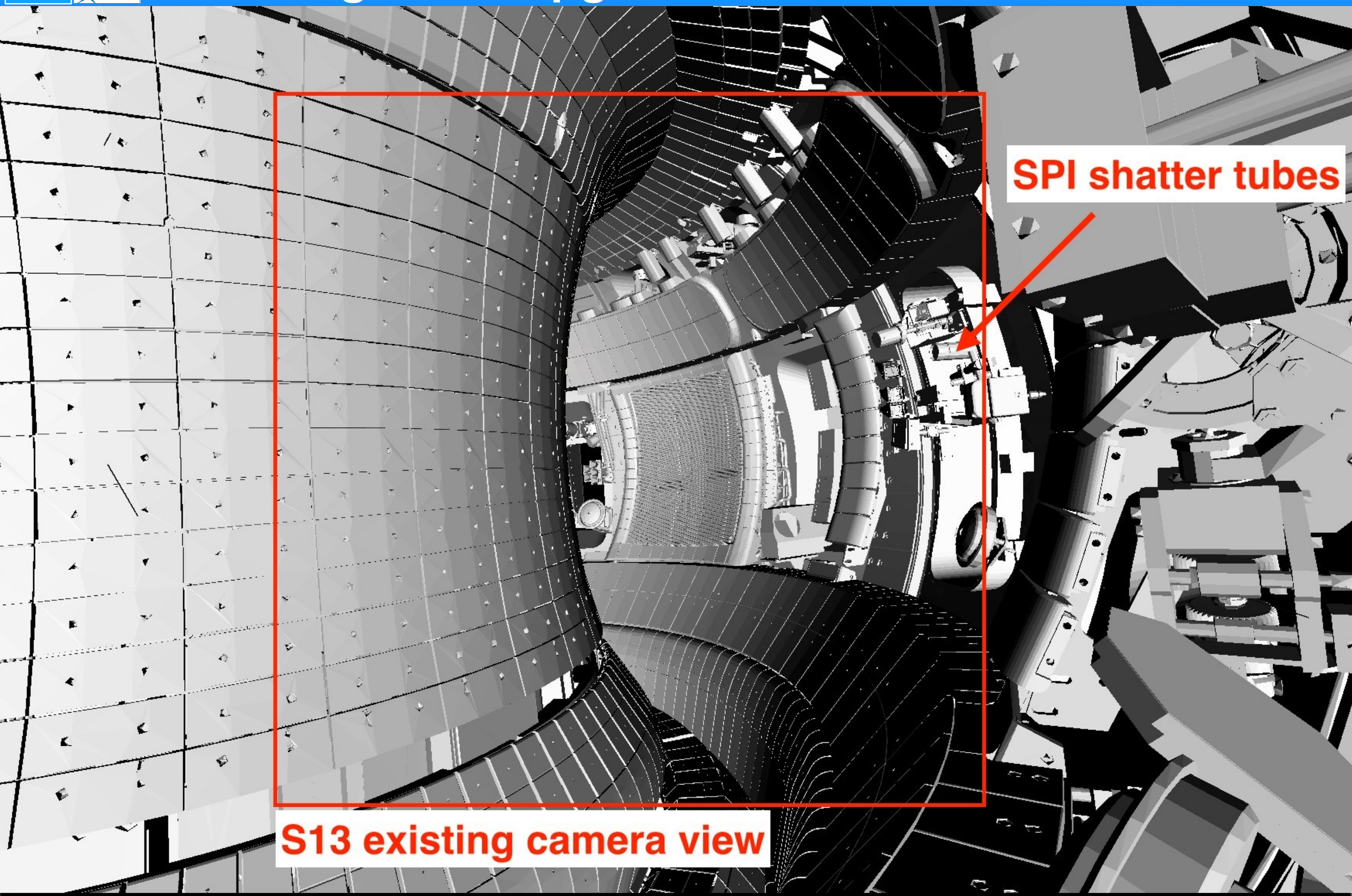


Diodes: 3 tor. positions (vert)
1 tor. positions (hor.)

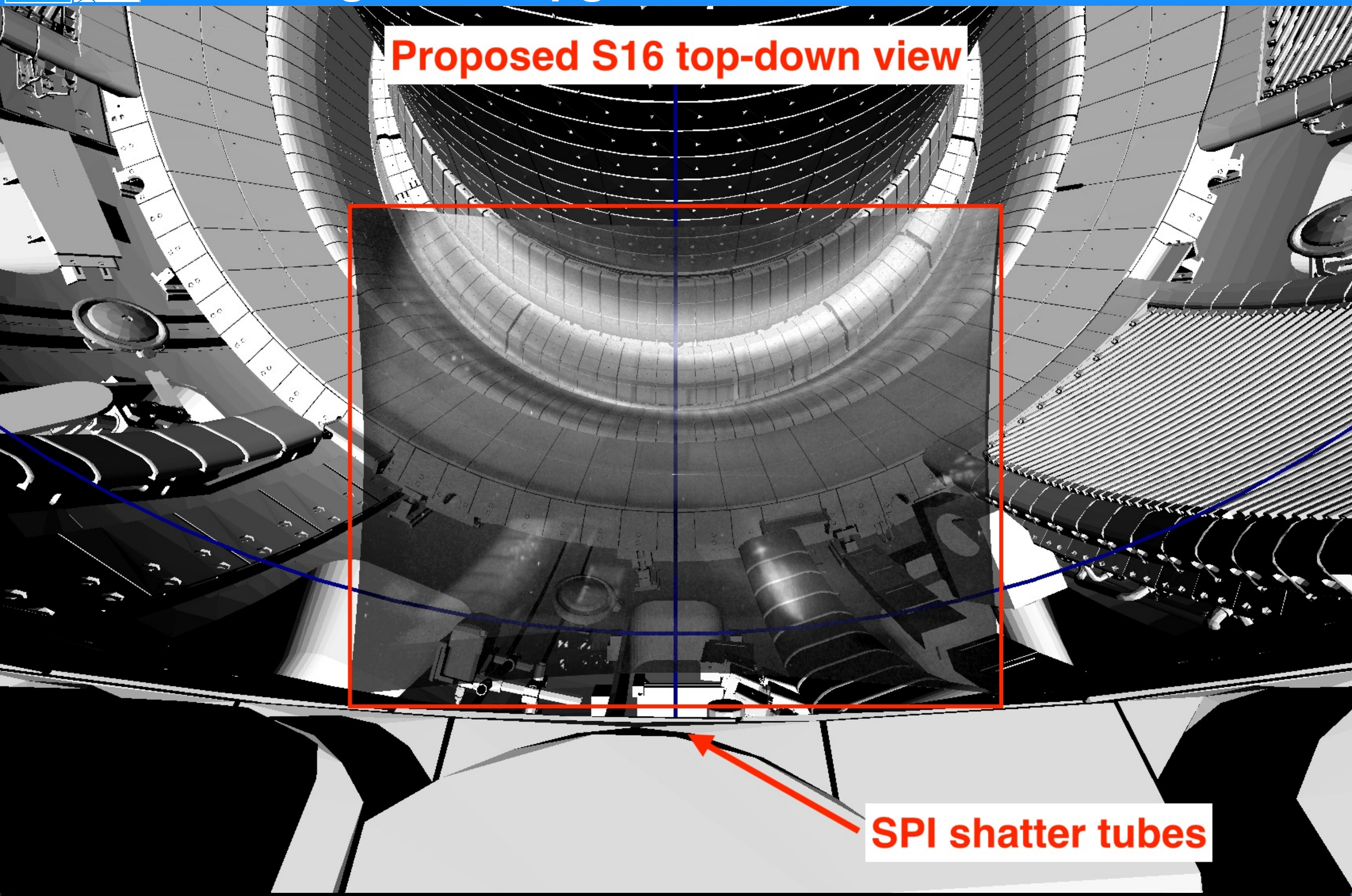


Adjust existing cameras

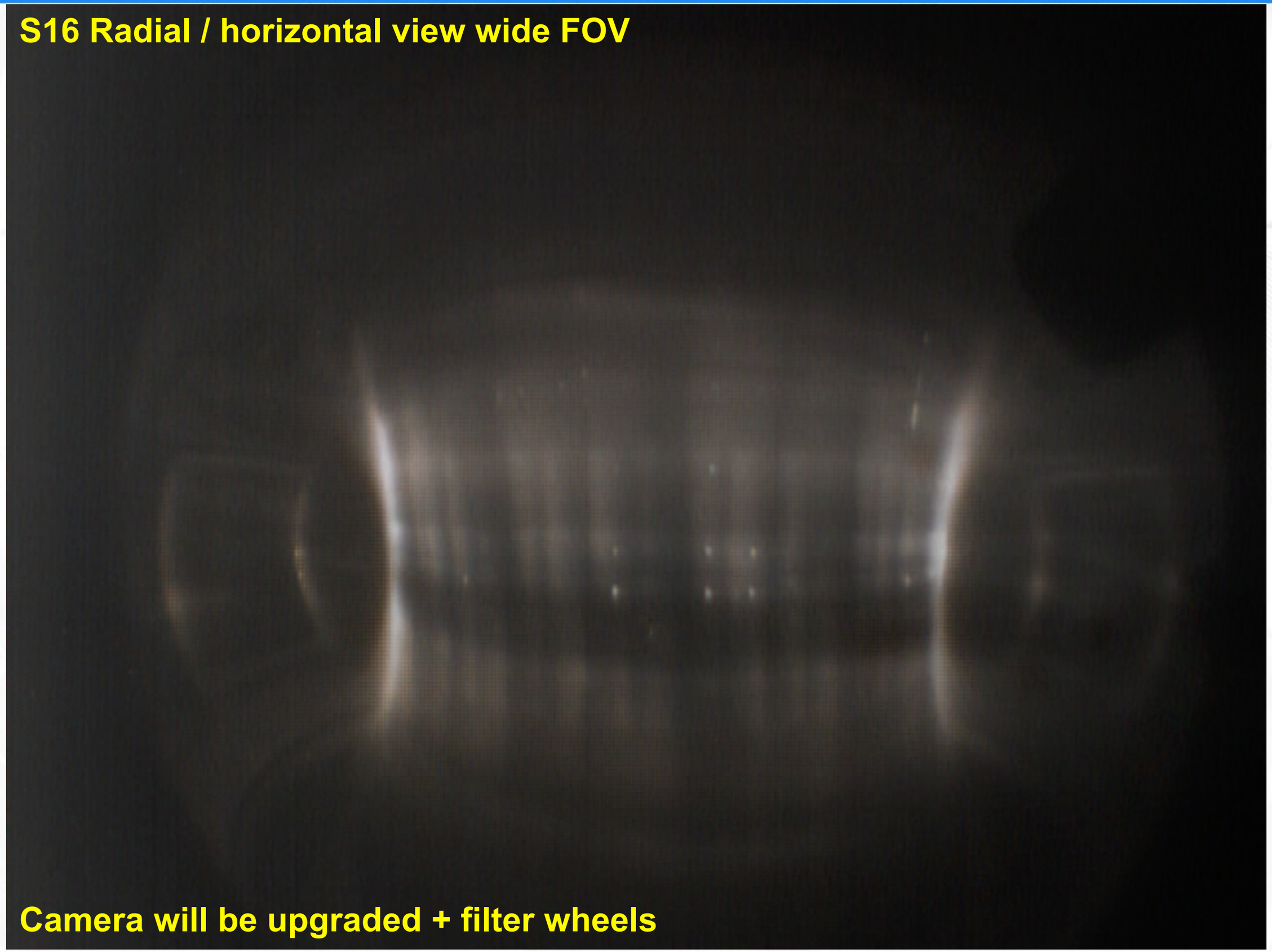
Diagnostic upgrades - Fast cameras S13 T



Diagnostic upgrades - Fast cameras S16 V



Diagnostic upgrades - Fast cameras S16 H



AUG operational scenarios for disruptions

- **< 1 MJ W_{th} + < 1.4 MJ W_{mag}**
- I_p < 1.2 MA, B_t < 2.9 T, n_e > 3x10^{19} m^{-3}
  - ➡ 2/4 in-vessel + 2 ex-vessel MGI valves available
- For relevant scenarios, see
  - ➡ G. Pautasso *et al.*, PPCF **59** 014046 (2017)
  - ➡ U. Sheikh *et al.*, NF (2020) in review (and references therein)

- Planning of experiments will start once design is finalized
  - ➡ Discussion at the ITPA / MHD meeting and within DMS TF
  - ➡ Feedback & suggestions are welcome!

Summary - AUG SPI

- **Collaboration to install SPI on AUG in 2020/21**
  - ➡ **Main focus: different shattering angles (0°, 12.5°, 25°)**
  - ➡ Experiments in 2021 / 2022
- Injector supplied by ITER / PELIN
  - ➡ 3 independent barrels, 1-8 mm
    D2 / Ne / Ar / Ne+D2 pellets < 600 m/s
- **Diagnostic upgrades**
  - ➡ 3-axis fast video system
    (toroidal, vertical, radial)
  - ➡ Upgraded bolometry
    Diodes in 3 & foils in 5 sectors
    > 200 new channels, ~600 in total
- **Experiments & analysis is expected in broader teamwork**