Updates to the simulation model

WEIZMANN INSTITUTE OF SCIENCE

Apr 14 2021

Intro

- Next major milestone: TDR by the ~end of this year with a much better simulation models

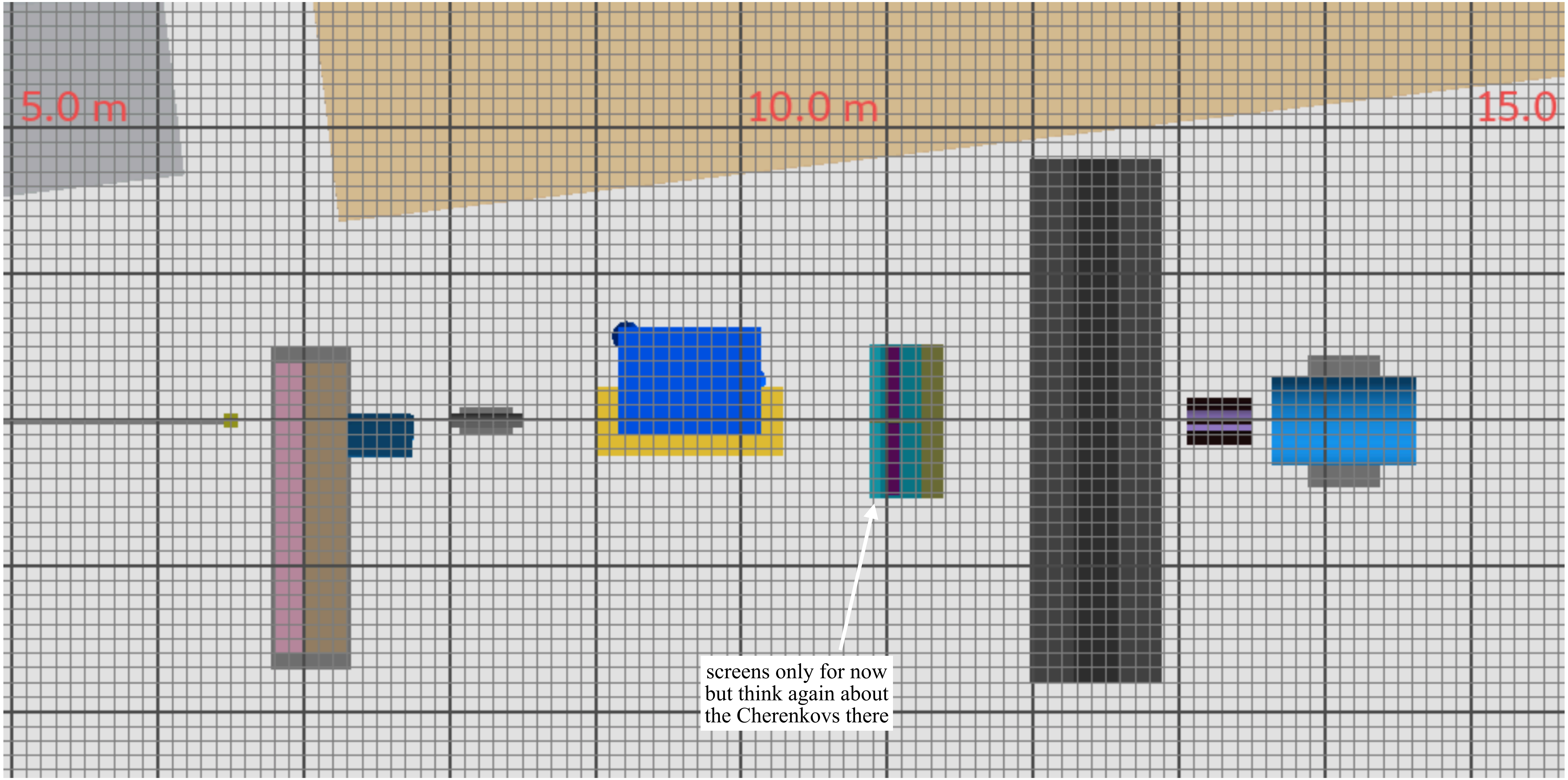
- This means we need the simulation model to be fixed by early summer so we have enough time to launch large scale production(s), analyse, debug, rerun as needed, summarise the results, etc.

- Strong push in the last few weeks to tackle weak/missing points

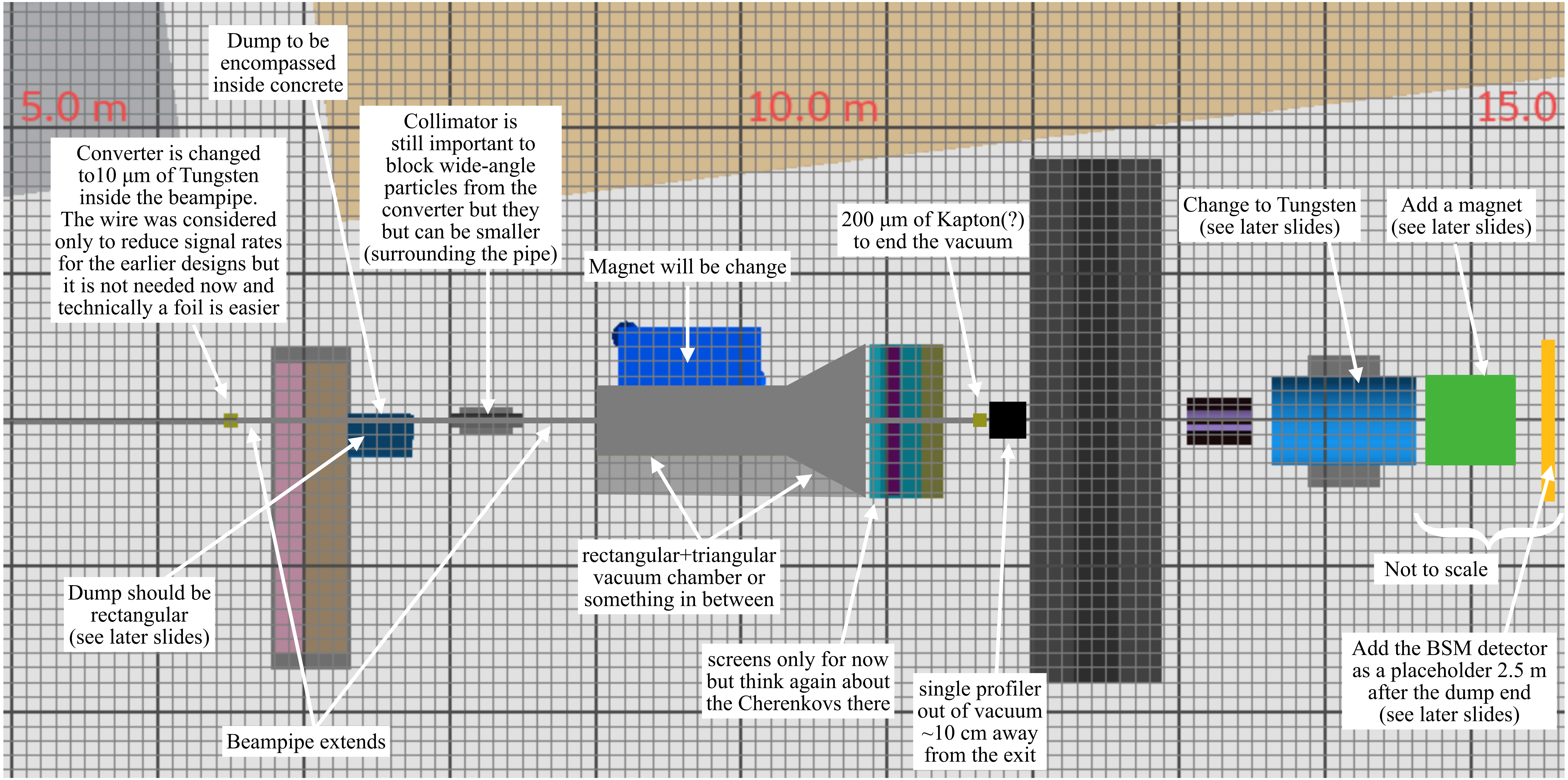
S&A meetings throughout March/April

- **Tuesday, Mar 2: forward system discussion inc. vacuum options there and the profiler location** [link]
- **Tuesday, Mar 9: towards a decision on the vacuum chamber of the IP area: yes/no/partially/how?** [link]
- **Tuesday, Mar 16: engineering review (with Benny & Oz from WIS) of all elements** [link]
  - **Mandate:** the goal is to have a basic review of the design of the components in the hall from an engineering perspective for the purpose of refining the simulation model for the timescale of April-May. For all active and passive components that are of relevance for the simulation, it should be reviewed how these are supported, whether these should/can be movable, whether these should/can be in a vacuum, how these can be aligned and where services are routed, etc. In addition, the location of racks, cooling elements, vacuum pumps (etc) and their connections as relevant to the simulation will also be reviewed. Finally, we will review also how to control the environment around the elements (if not completely in vacuum) as needed and again, as relevant to the simulation
- **Tuesday, Mar 30: collective definition of the EDM and GEANT4 output format** [link]
- **Tuesday, Apr 6: ICS discussion on the physics simulation and the technical implementation** [link]

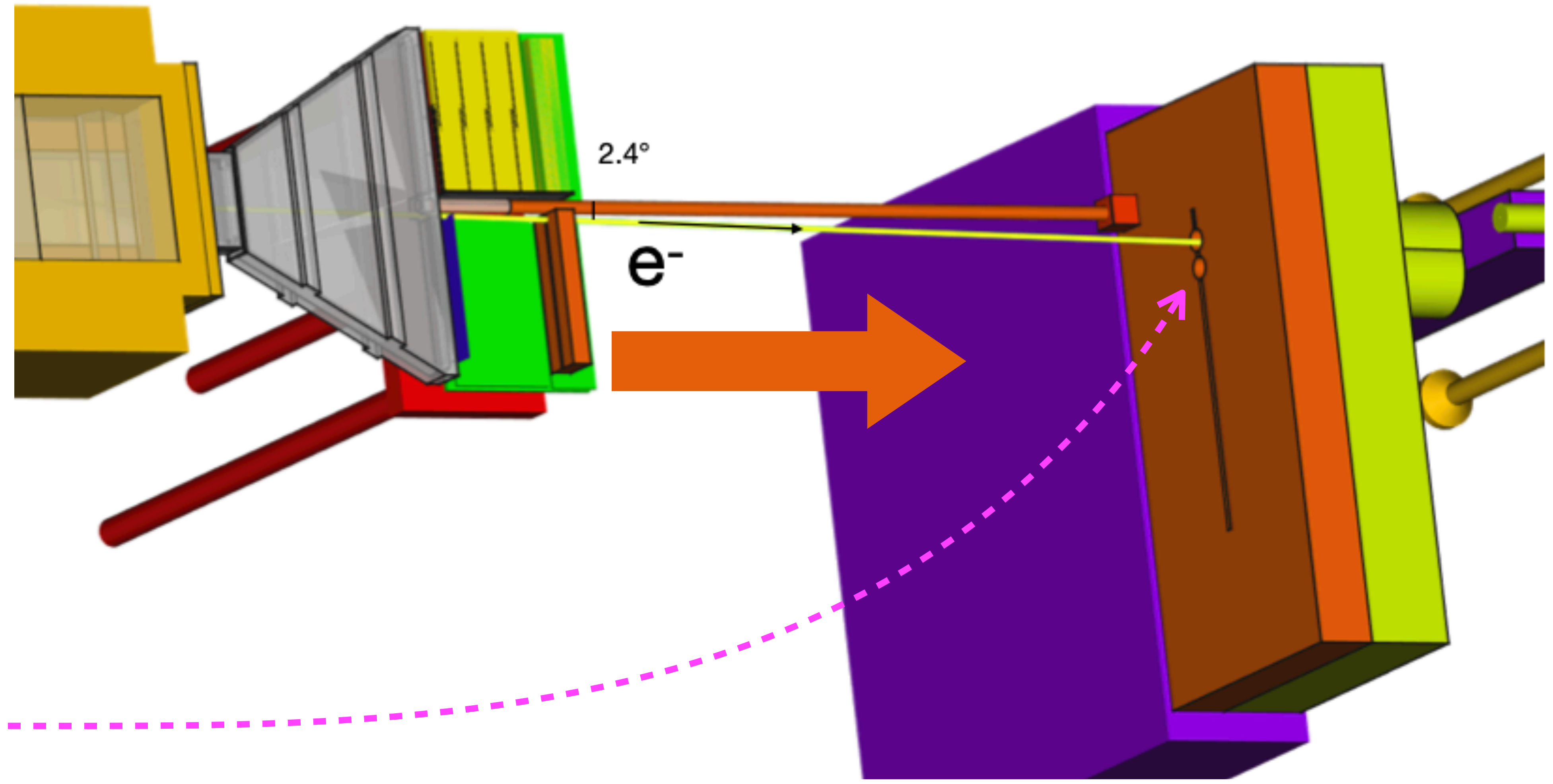
Forward photons system: CDR



Forward photons system: NOW

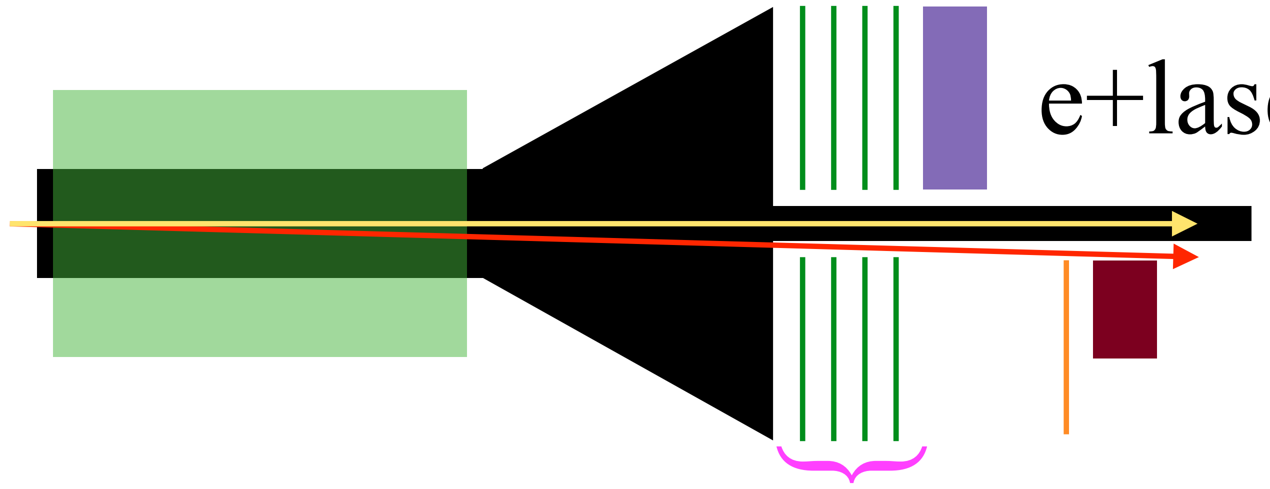


NO vacuum @ the IP detectors



- XFEL: no problem to have the beam flying in air for a few m's
  - no need to work in vacuum from safety point of view
  - already demonstrated that can reconstruct the physics w/o vacuum

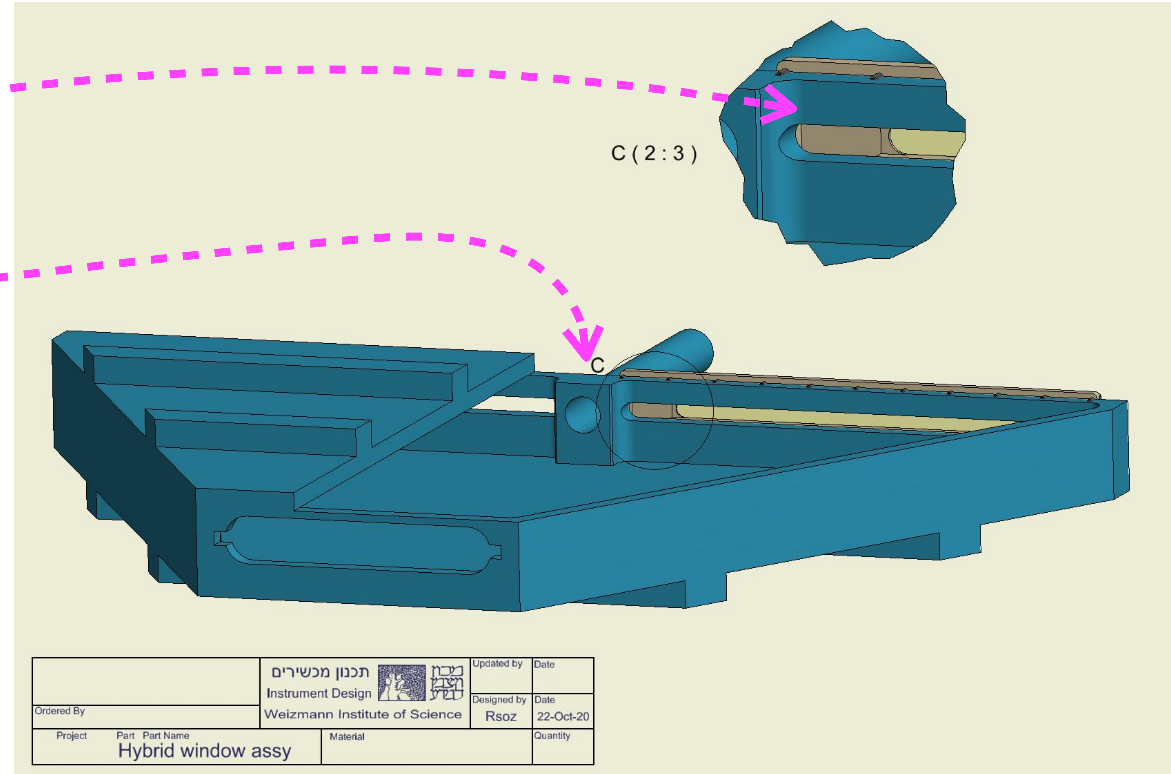
- Won't be able to reach a 2 T B-field
  - push the screen+Cherenkov downstream by ~1.5 m
    - edge reconstruction is possible even with 1.5 T
    - need one dump for the electron beam after the detectors
    - will have to switch to a long (0.5 m?) long dump in x for the Comptons



Electron tracker is below the e-beam path

- Electron tracker can be in the same z position as the screen+Cherenkov but
  - away from the beam path when running in e+laser mode
  - inline with the positron tracker when running in γ+laser mode
  - use hexapod or equivalent

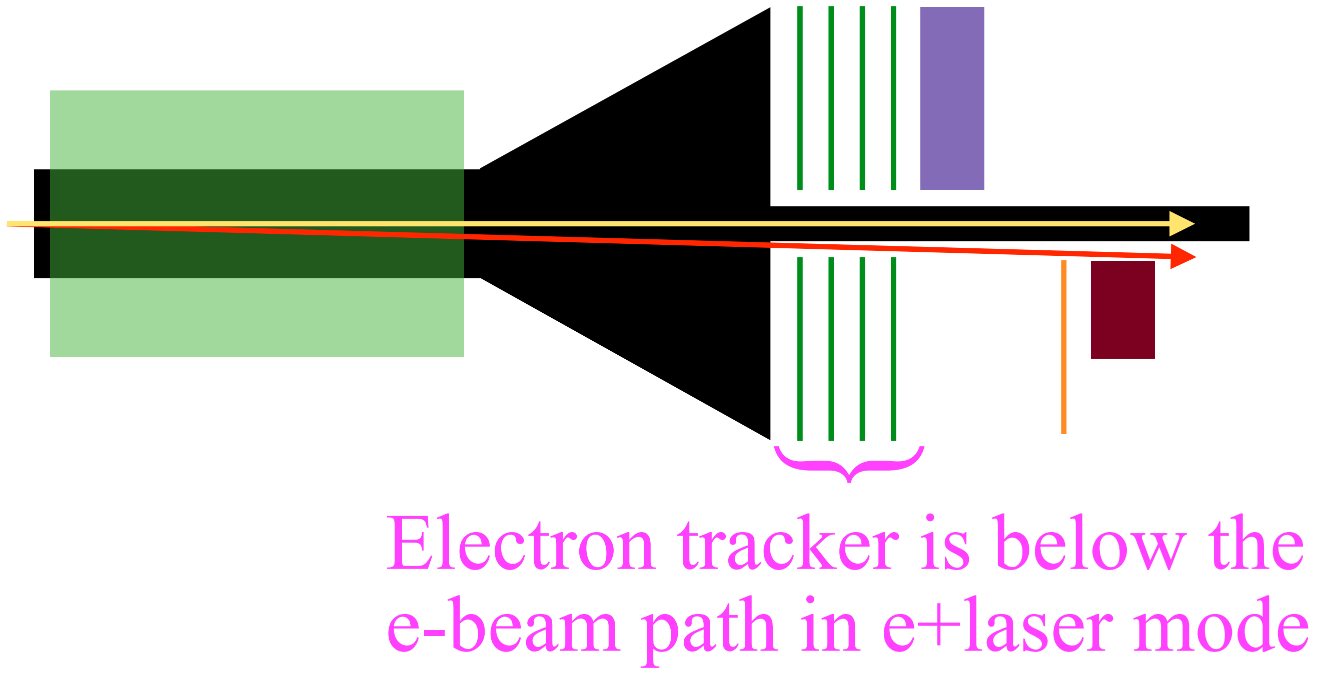
- Triangular chamber exit window: testing the impact (sig/bkg) of "full-length" 0.5 mm Aluminium instead of 0.5 mm Aluminium + 200 μm Kapton mixture
  - need some optimisation of the joint to the pipe going to the FWD part



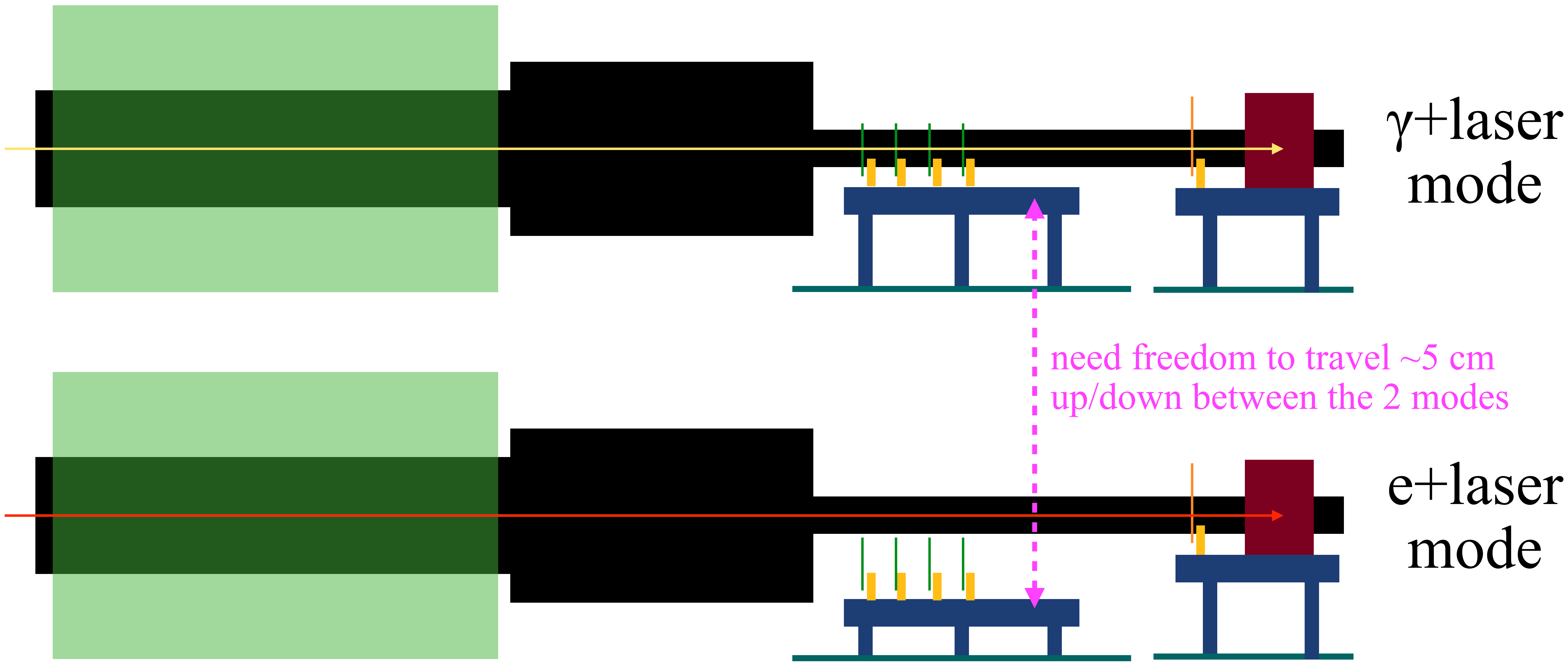
- Still need to discuss the upstream movable conversion target (early April, with ICS)

Hybrid setup @ the IP detector

Top view

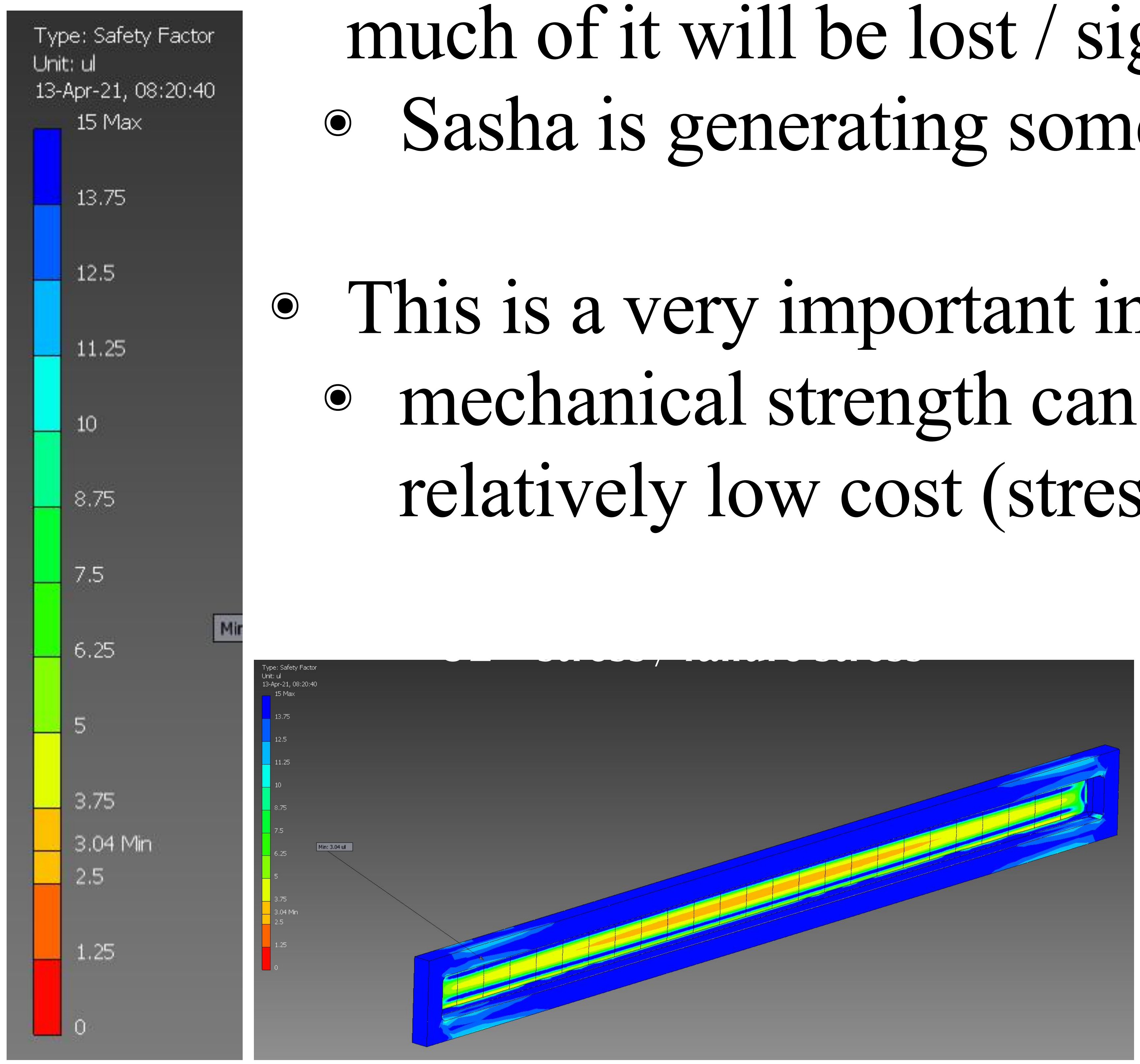


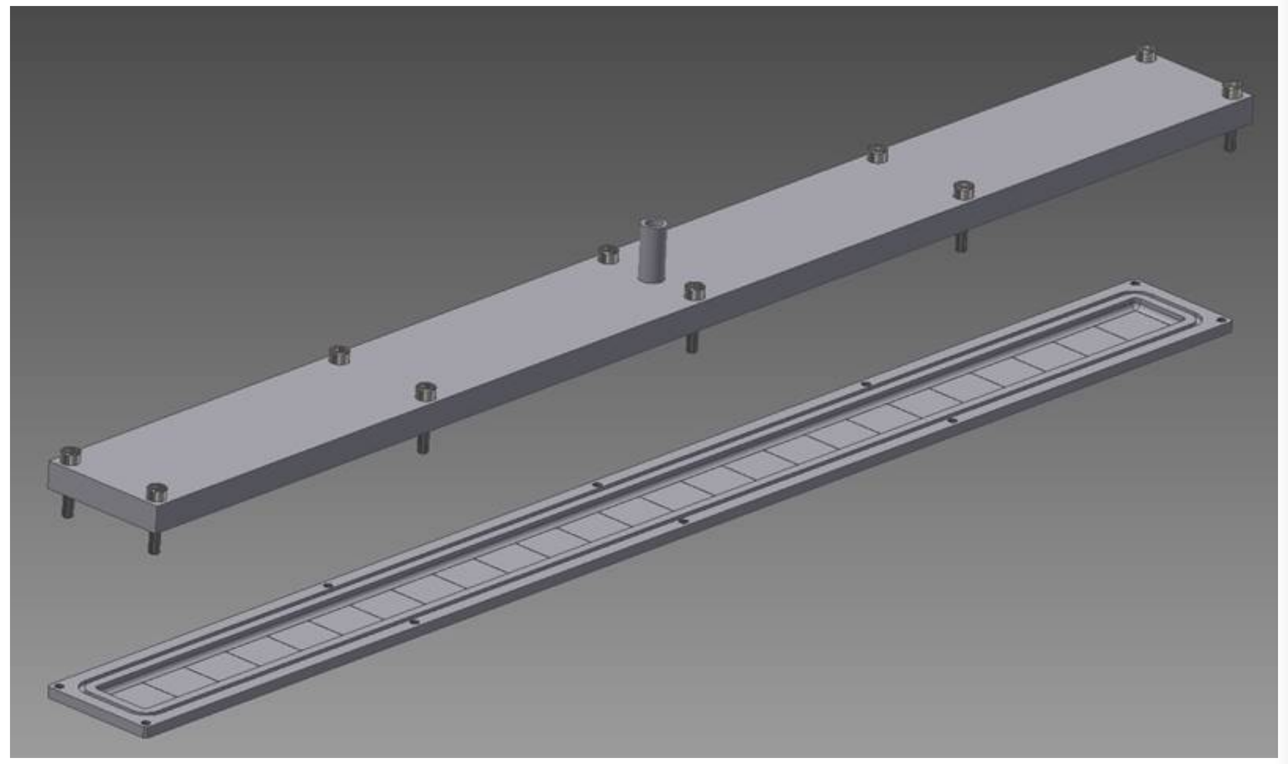
Side view (showing only the electron side)

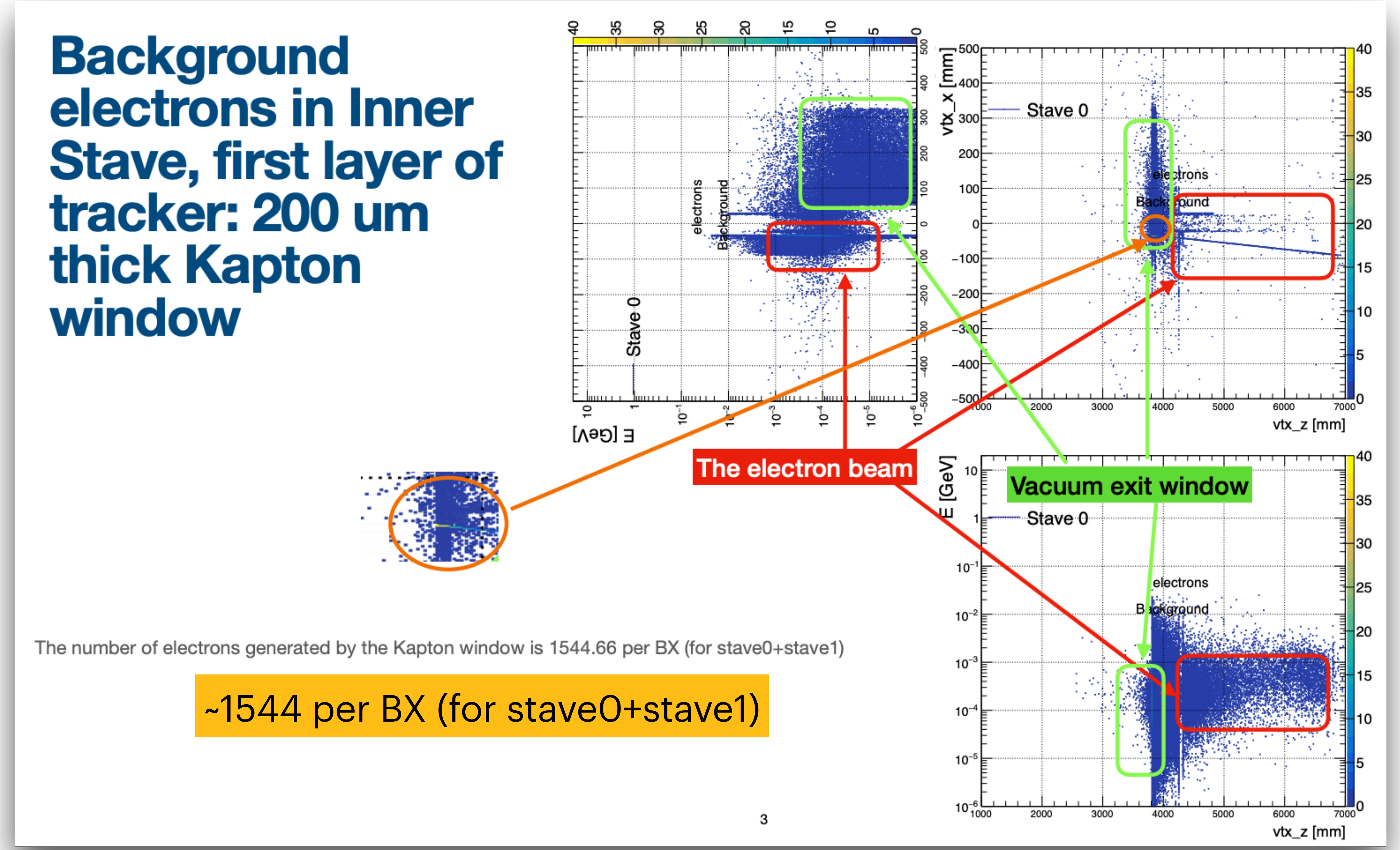


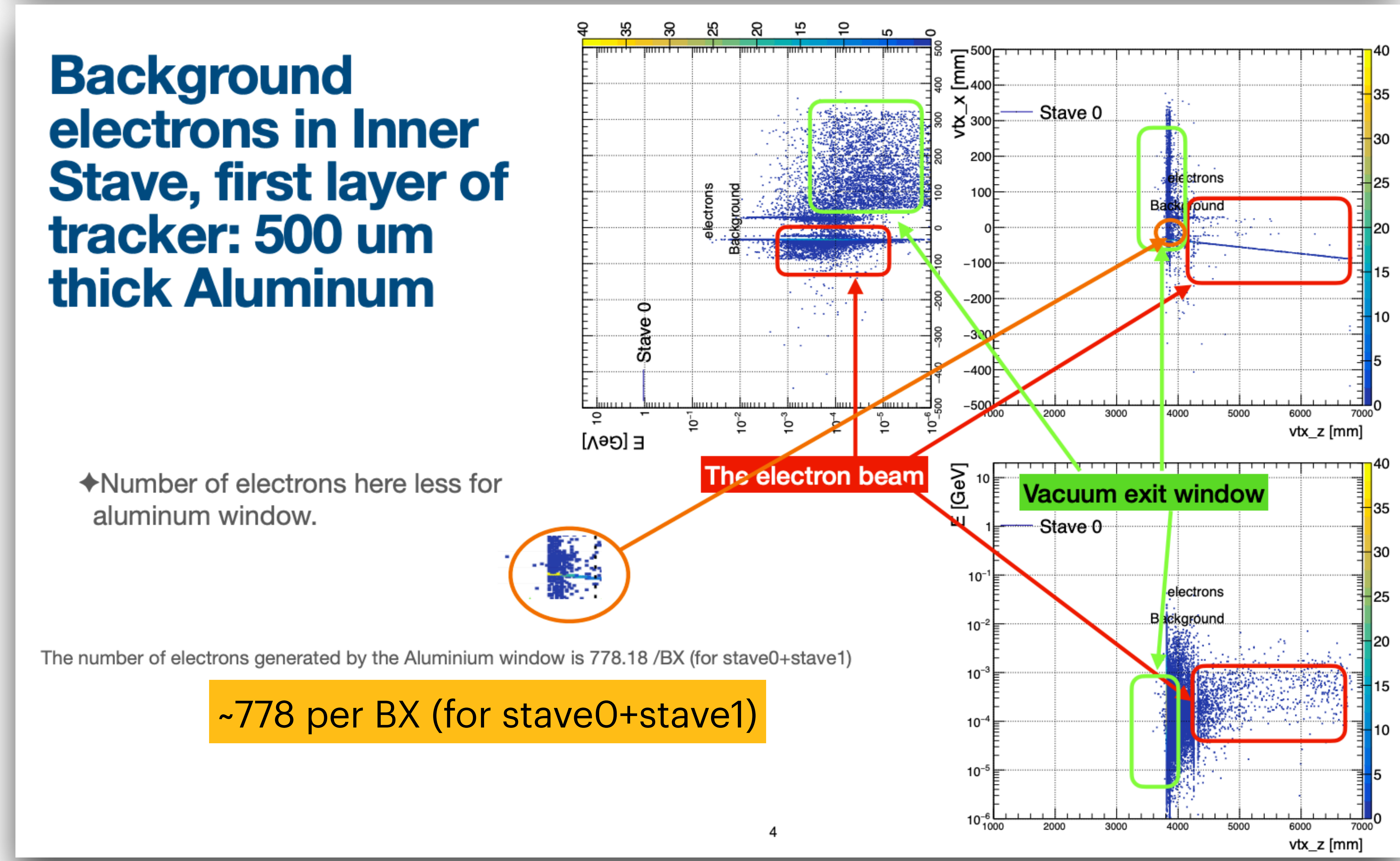
IP vacuum chamber exit window

- Bkg seen by the tracker seems smaller for the the Al case than for Kapton: ~$N_{e-}/1.5$, ~$N_{e+}/3$ and ~$N_{\gamma}/3$
  - need a confirmation from the calo and the screen
- Still need to check the impact on the signal (how much of it will be lost / significantly altered)
  - Sasha is generating some BXs (with large trk mult.)
- This is a very important ingredient of the experiment
  - mechanical strength can be tested in the lab with a relatively low cost (stress failure and deformations)



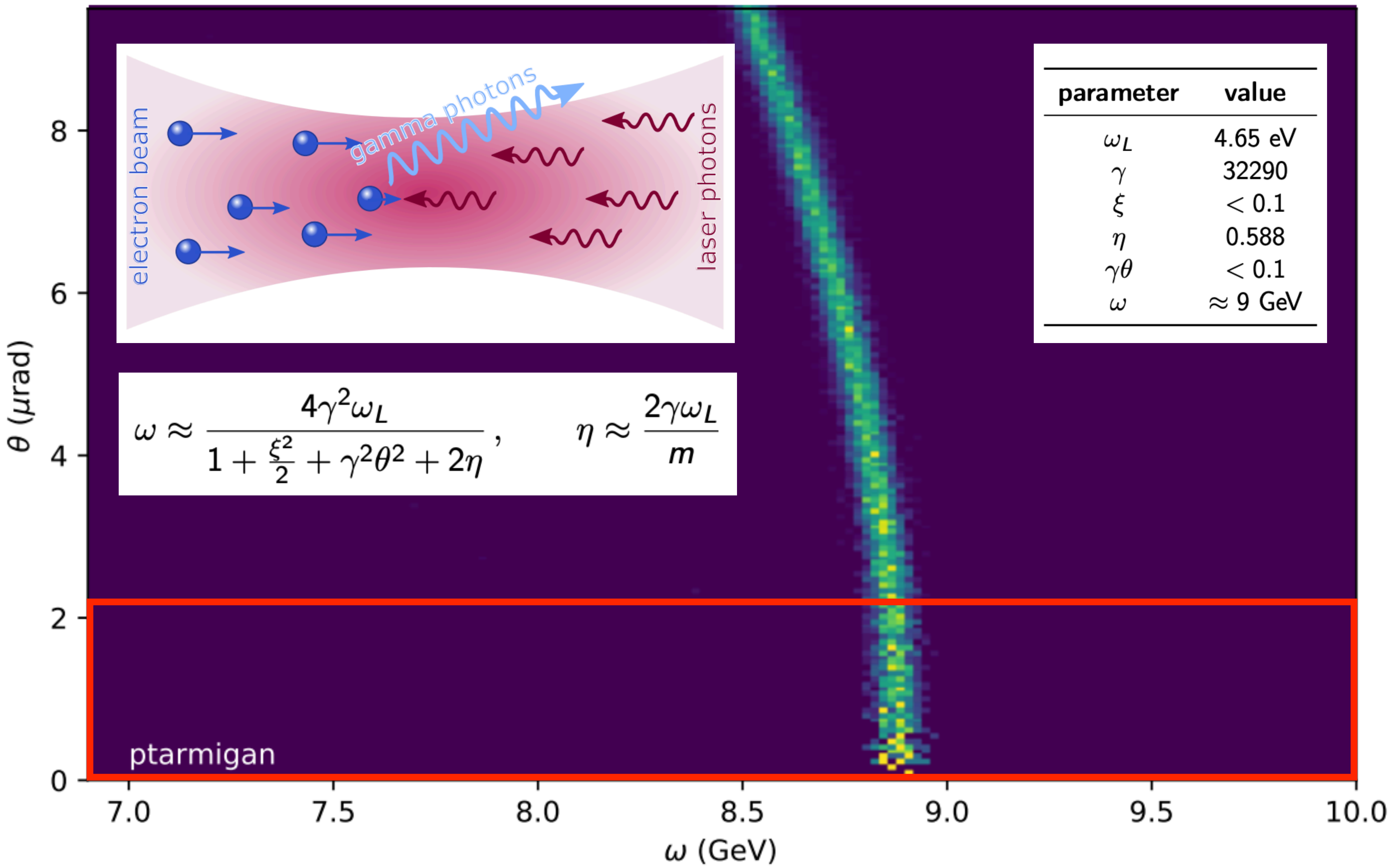


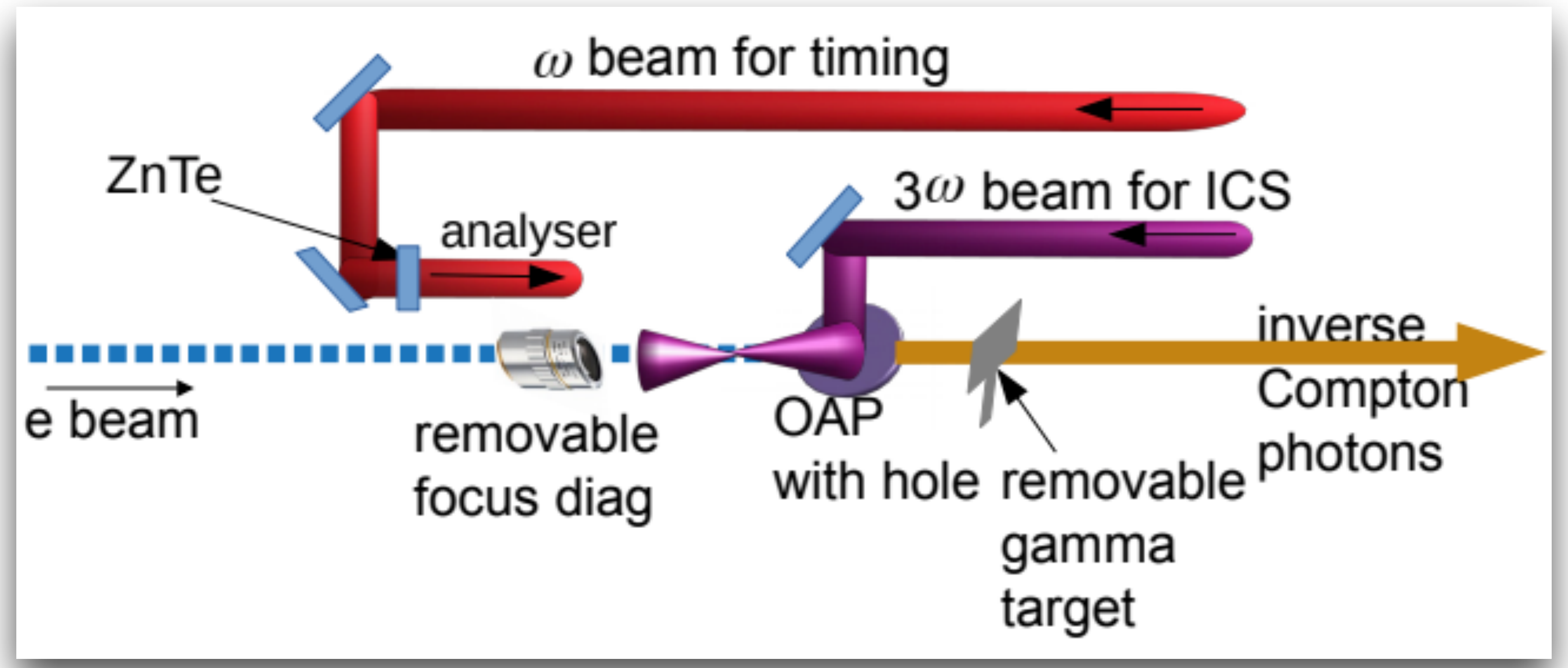




Inverse Compton Scattering

- γ-laser (head-on!) collisions
  - need $\chi \sim 1$ to get $\omega \sim 9$ GeV (with a ~narrow bandwidth)
  - better knowledge of the BW pair initial state
  - better reco of the SFQED interaction
- Need frequency ~tripling for a "branch" of the main pulse (which goes to the main IP chamber)
- Need the big laser: can only operate in <u>phase1</u>
  - The (relatively small!) ICS chamber can be decoupled from the Bremss' target chamber (design it later)
  - The 2 chambers can be merged to one
- Tom's code (ptarmigan) can produce the signal
  - only circular polarisation now (LP later)



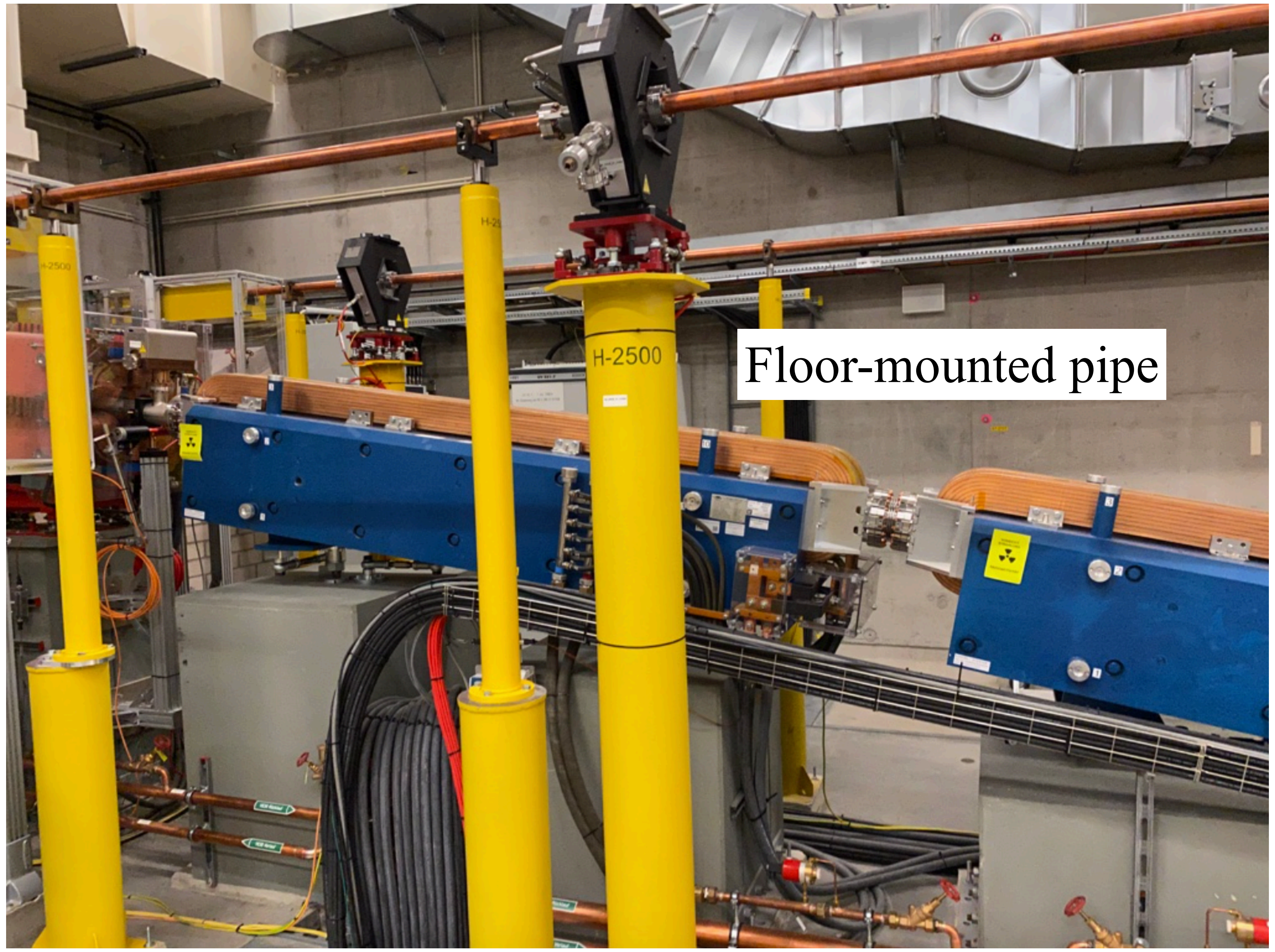


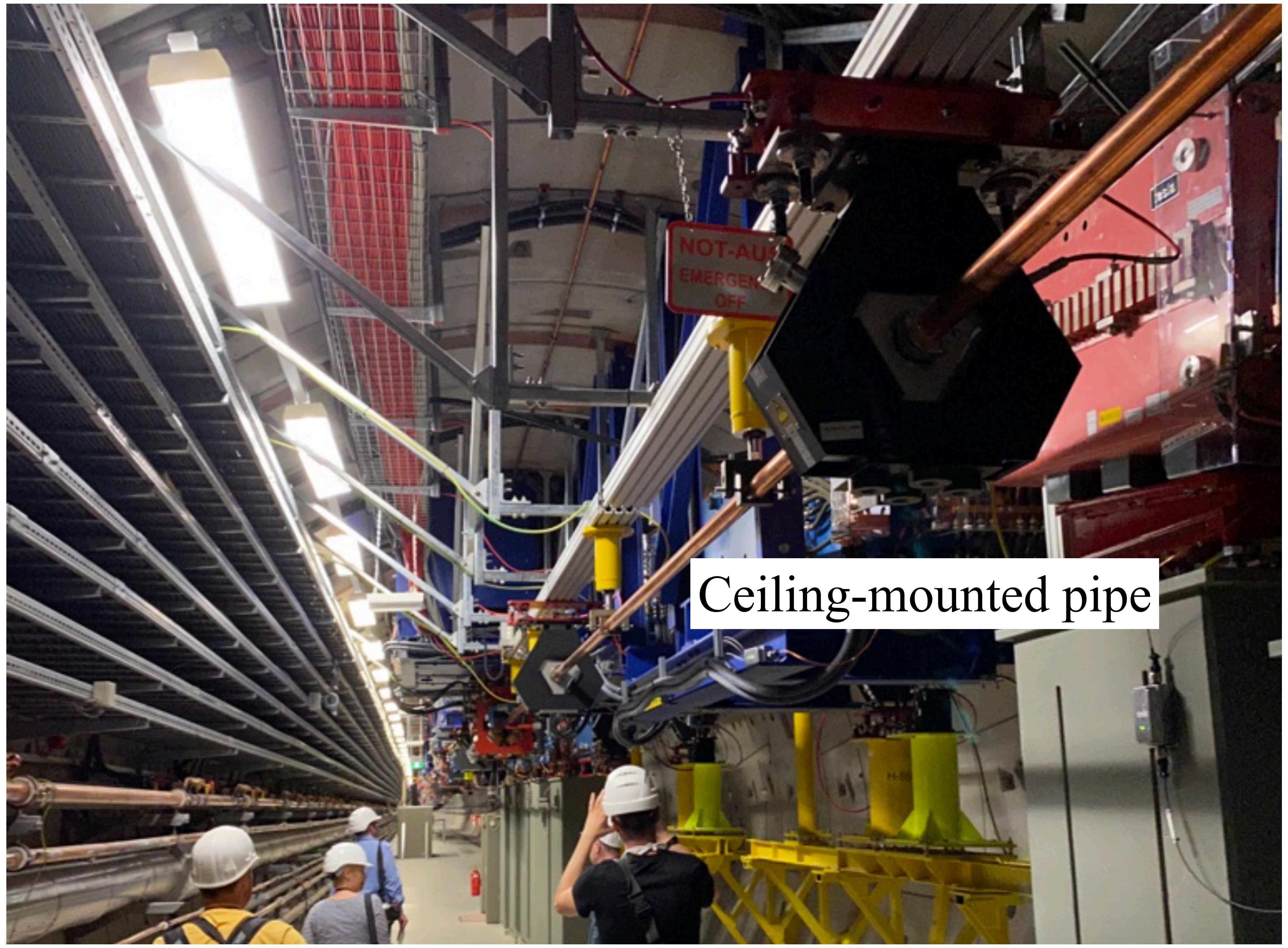
Feedback from the engineering review

Thanks to Louis, all CAD models are kept here:
https://syncandshare.desy.de/index.php/s/cfw6pLebTKCSYaY

Beampipe

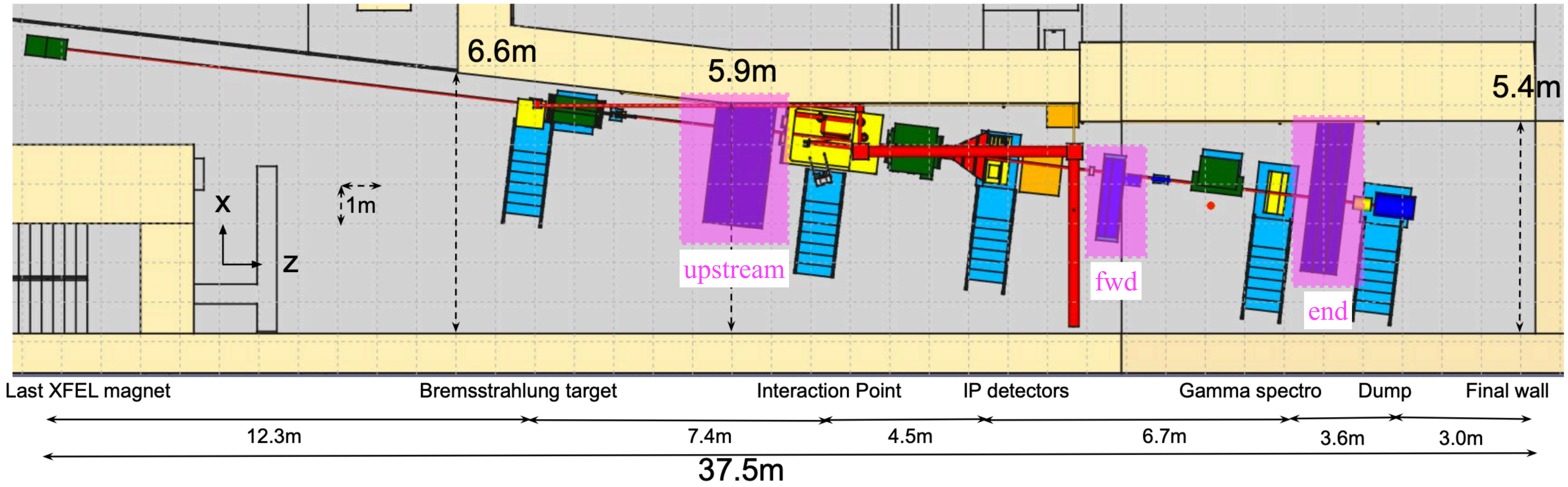
- Must add the pipe mounts in the simulation:
  - need the drawings
  - how many of these should be used to prevent sagging?
- Will probably need to use the ceiling mounts (too crowded otherwise)
- Need to specify the vacuum points along the pipe





Shielding & dumps

- Way too heavy (Iron+Aluminium now) and too large: **upstream**: xyz={3m,4m,1.5m}, 192T(!), **fwd**: xyz={2m,1m,1m}, 1.9m above a concrete block, 13.5T, **end**: xyz={4m,4m,0.9m}, 50T(!)
- All shielding should be sitting on concrete blocks (cannot assume a thick metal wall sitting on the floor)
  - check idea to integrate polymers in the dumps to stop ("thermalise") neutrons more efficiently
  - fwd dump needs to be rectangular and fully enclosed in the concrete
- Need to run some tests in GEANT4 to see how the metal budget can be minimised

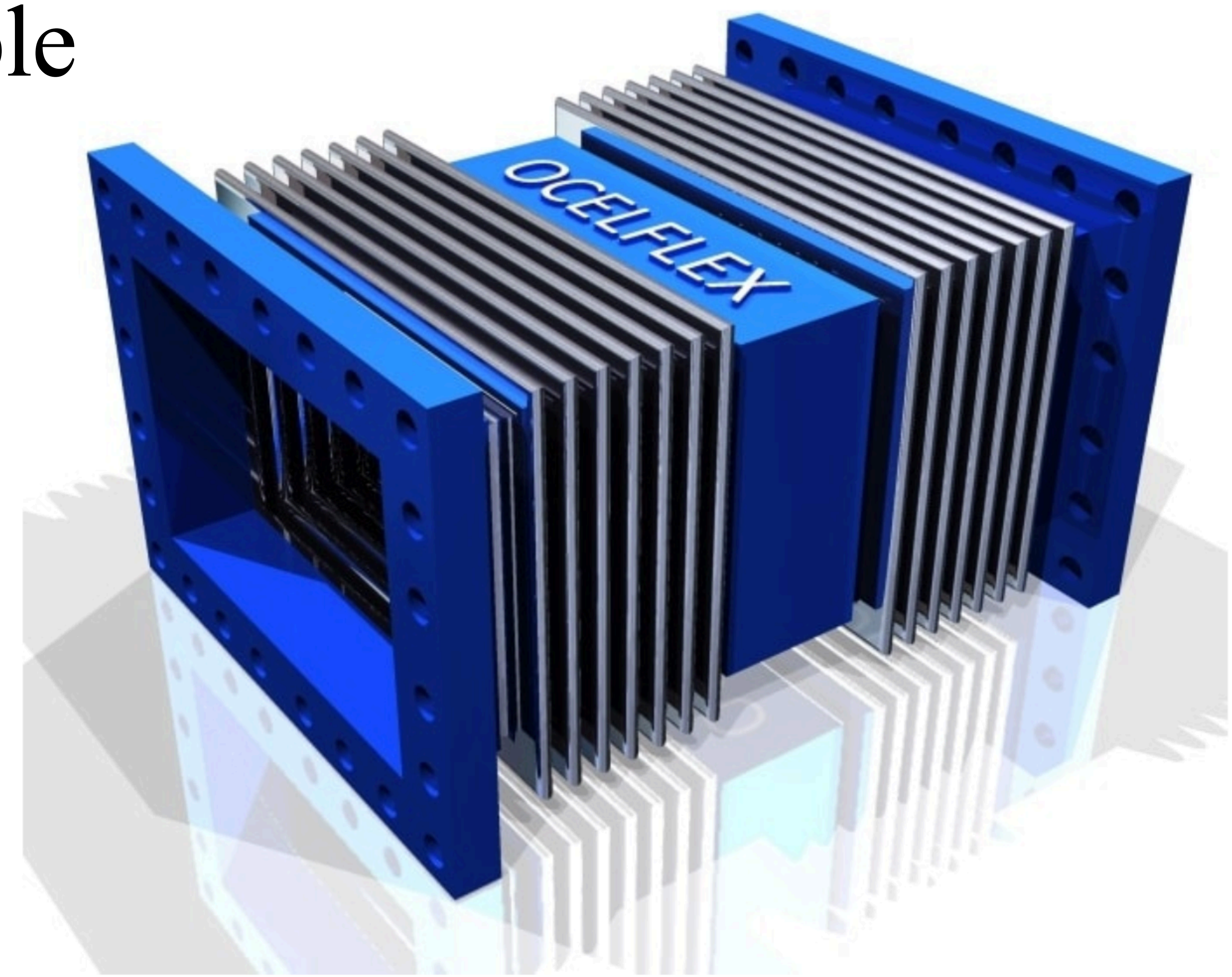


IP chambers connectivity and vacuum

- IP chamber should be connected directly to the dipole (rectangular) chamber with a flexible bellow [example] which can hold the vacuum

- Must have gate-valve in the entrance and exit of the IP chamber (already planned)

- Not enough space (~17 cm) between the IP chamber and the dipole
  - IP chamber should be taken a bit upstream if possible



IP area and Targets

- Upstream area:
  - magnet is flipped: can it actually be supported like that by construction? won’t the foils be able to “drift”?
  - missing a model for the Cherenkov+Screen mechanics in the upstream part (vertical & tilted) and the IP part (horizontal)

- Targets:
  - no real designs of the target chambers (upstream and fwd)
  - how is the foil supported in the box?
  - should we be able to move the foil in the box (overheating and deformation)?
  - does it have to be cooled somehow?
  - can we have the upstream ICS box the same as the target chamber?
  - no supports in the model

IP area (see slides 5-6)

- In general - need to explore the possibility to make the IP chamber smaller as it leaves ~2 cm of space to the wall right now and this is what prevents us to move the experiment upstream as needed to have more space for other elements. Also, the ~17 cm between that and the dipole chamber prevents to possibility to work in that area

- Can the IP chamber include shielding inside it?
- IP chamber is not supported in the model and we need to position the vacuum pumps for the chamber
- Missing support for the triangular chamber
- Remove positron-side hexapod and replace with simple stages
- Screen+Cherenkov move downstream by ~1.5 m (see slides 5-6)
- There's no fixation for the screen(s) - need to position the camera(s) and the racks at least as placeholders
- Optimise the joint between the triangular chamber and the downstream pipe to minimise material budget
- Check if 200 um of Aluminium window (2 cm times 50 cm) in terms of vacuum and manufacturing (background is being checked independently)
- Design a tent around the IP detectors to control cleanness, humidity and temperature (see last slides)
- Put a shielding plate behind the calorimeter (~1 cm thick, but large-area)
- Check how the ~5 mm lead shielding plate we put on the positron side an fit and be fixed

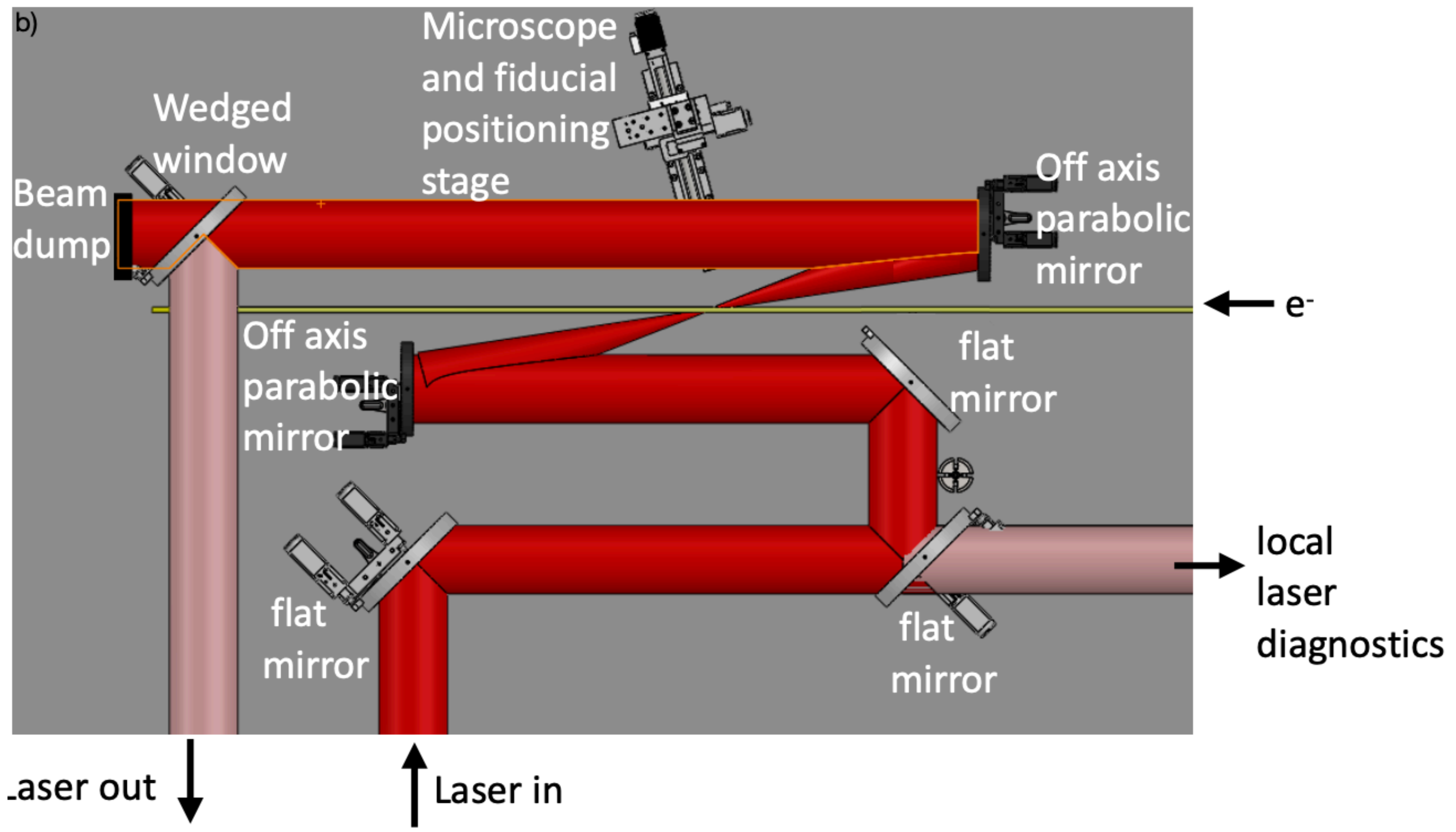
IP Chamber: from a discussion with Ishay

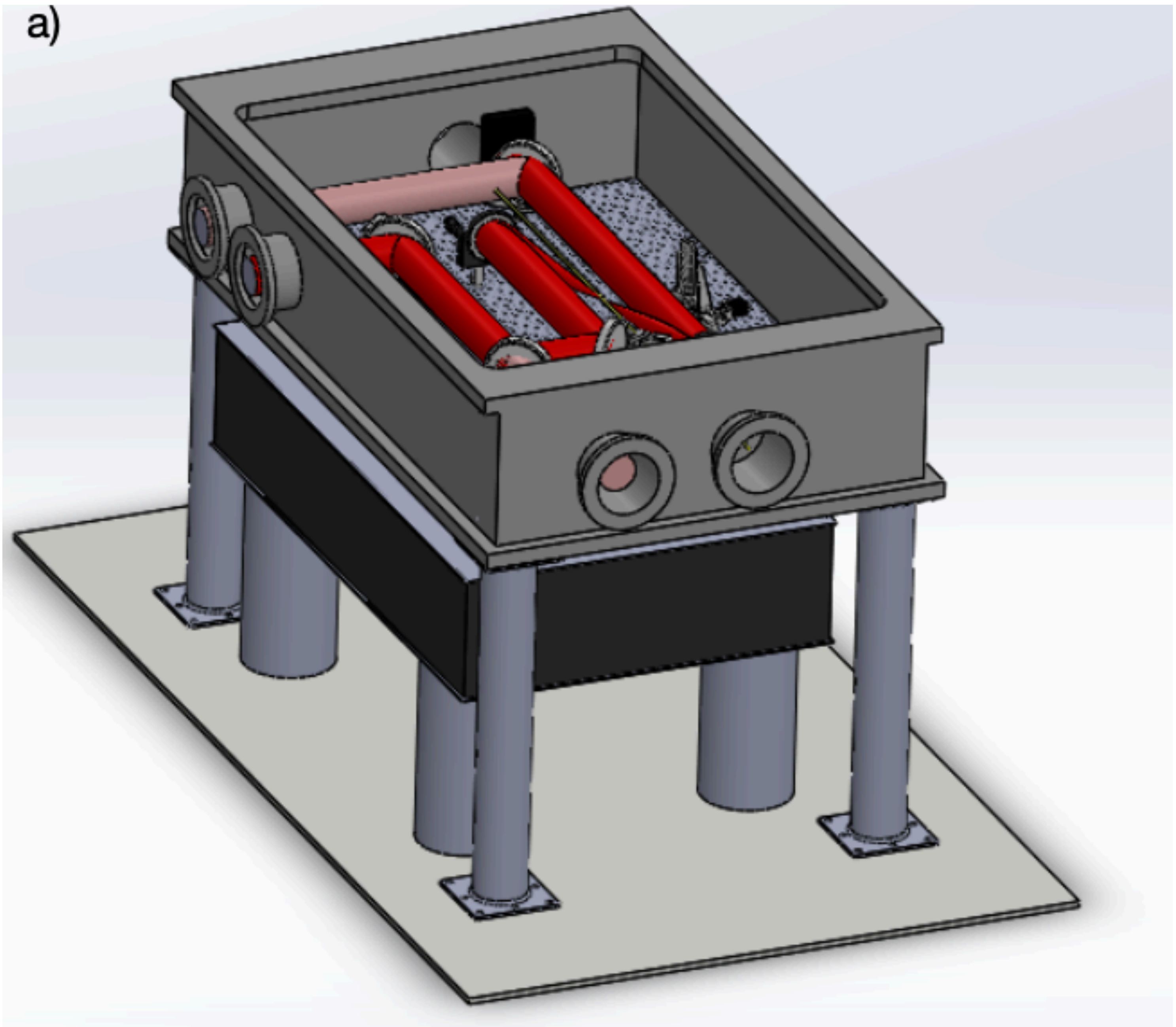
- Potentially remove one mirror
  - saves ~10 cm in width
  - solves the conflict with the wall
  - but cannot move the chamber upstream

- Change the approach of the laser vacuum pipe?
  - allows to maybe flip the geometry inside the chamber and thus to narrow it substantially

- Flip the chamber vertically?
  - will solve all problems
  - possible but difficult in terms of optics positioning.

- Already has a movable-needle acting as a target for calibration. This will be very useful for calibration of the IP detectors (through conversion) - should be put in the simulation





Fwd area (see slide 4)

- check if we can move the fwd target a bit upstream (~0.5 m)
  - probably not, if we move the IP Screen+Cherenkov downstream…

- add the rectangular+triangular chambers with pumps

- add the profiler and make sure there's enough place to work between the fwd detectors and the shielding wall (now about 60 cm to end the vacuum of the beampipe and to put the profiler)

- add racks for the fwd detector, backscattering calo

“BSM” area

- The exact location depends on the IP chamber position…
- Change to a Tungsten dump (already 1 m of Lead?)
- Detector placeholder disk with R=1 m at ~2.5 m after the dump end
- The simulation of the background generated in the dump is tricky
  - probably should be done separately
  - but starting with the proper photon-beam spectrum and shape
- Add a magnet between the dump and the detector
- Add racks as placeholders
- Can we dig in the wall?

Misc

- Start putting alignment targets on all relevant elements (~100 μm)
- Need to design a tent around the IP detectors to control cleanness, humidity and temperature

Summary

- Lots of very useful discussions in the last few weeks
  - many thanks for everyone who has provided inputs!

- Many news also on the signal simulation (Tom) and on the data formatting (Sasha and Federico) - not discussed today.

- Now focusing on the implementation of all these points in GEANT4 (Sasha, Maryna and John for now)
  - missing mostly: a semi-decision about the IP chamber, a design of the targets and the design of the beampipe supports. We also need a semi-decision about the magnets and use the B-field map in the simulation and then implement non-uniformities.
  - will move carefully in steps with crosschecks after every major revision

- In parallel, individual subsystems are now working on full implementation of the detectors' elx responses ("digitisation") based on energy depositions