A NEW OPEN FIELD-CAGE TPC FOR THE MAGIX EXPERIMENT

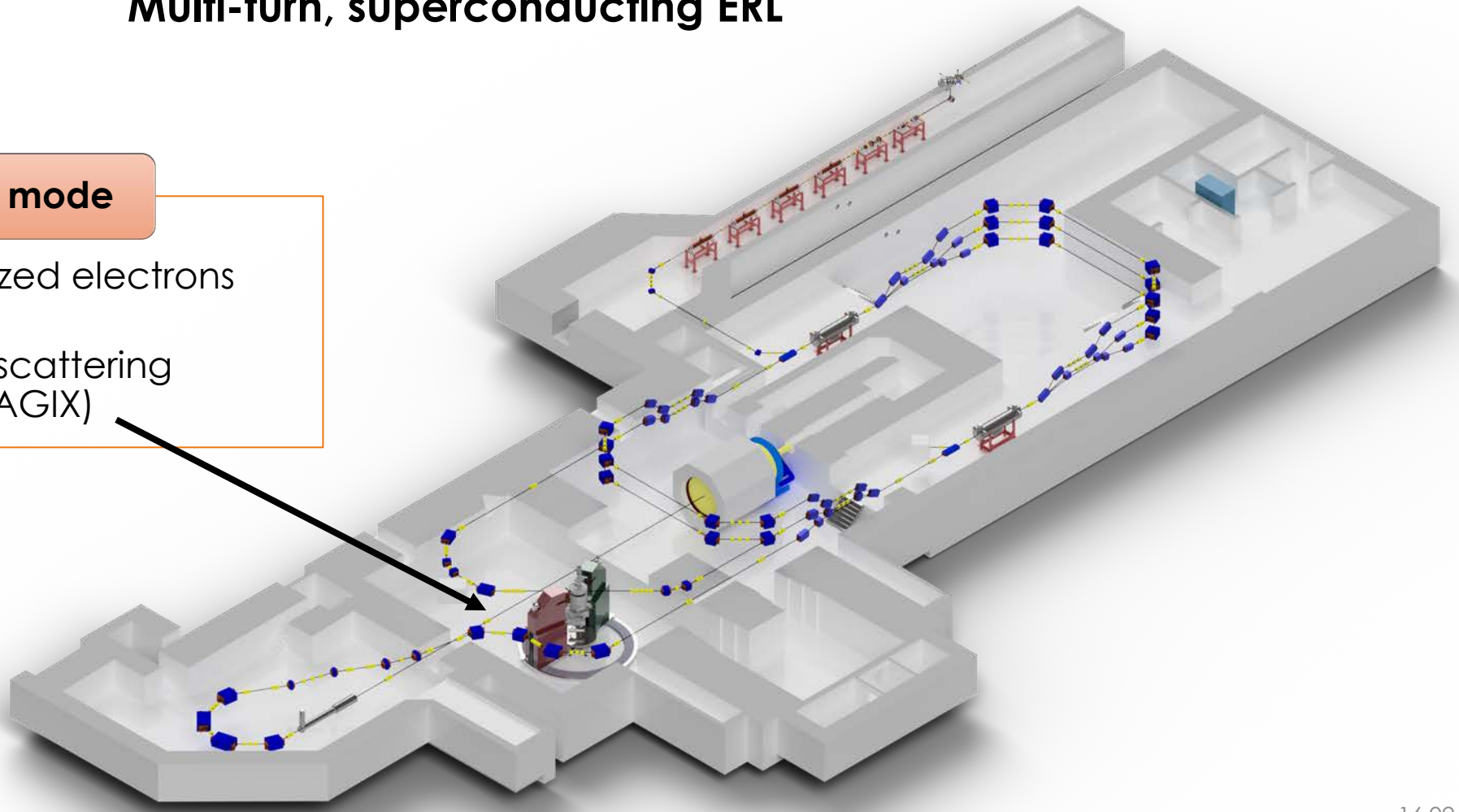
On the way to the first full scale prototype of the MAGIX open field-cage TPC

THE MESA ACCELERATOR

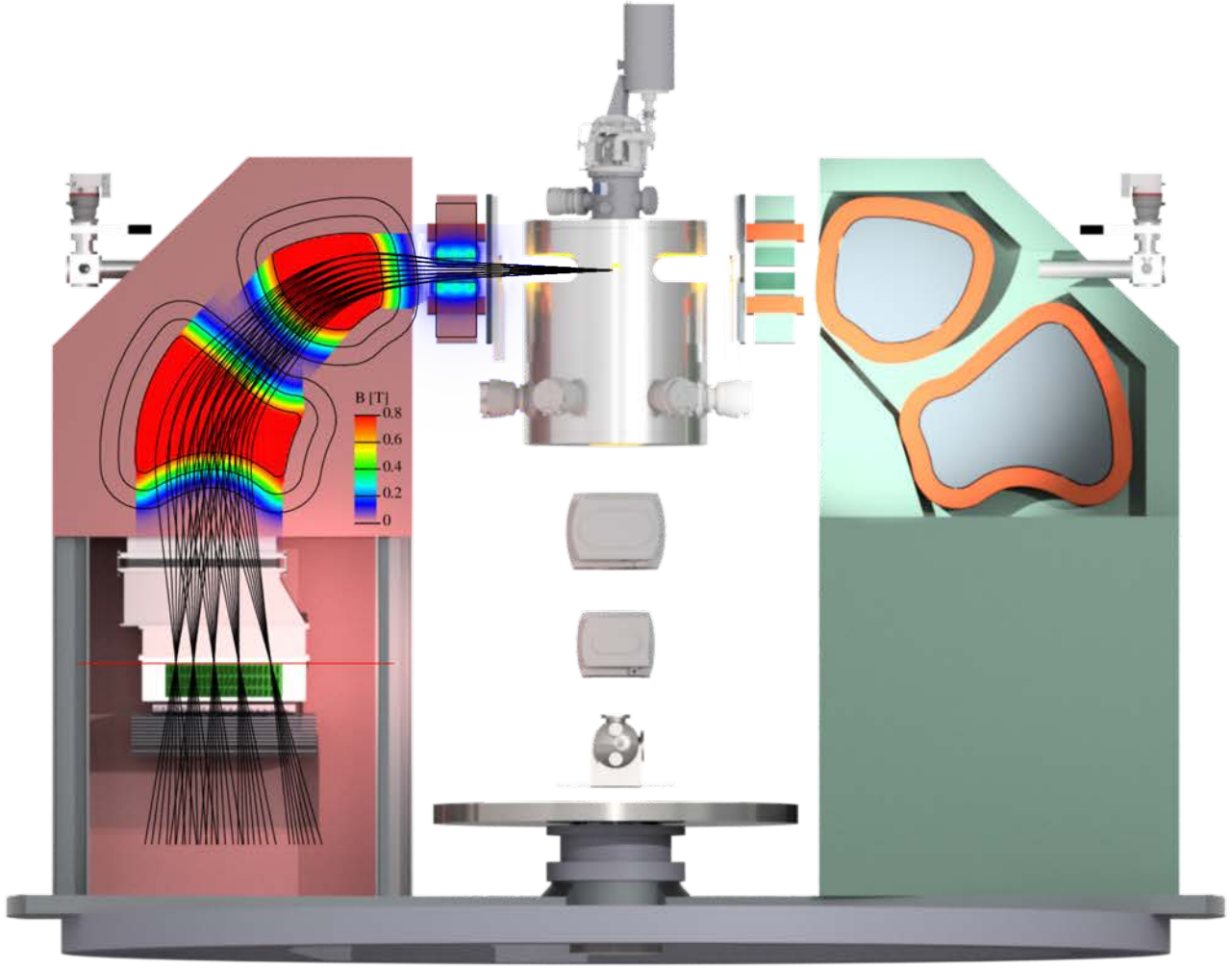
Multi-turn, superconducting ERL

Energy recovery mode

- 105 MeV polarized electrons @ 1 mA
- Internal target scattering experiment (MAGIX)



THE MAGIX EXPERIMENT



THE MAGIX EXPERIMENT

A high-precision multi-purpose experimental setup

Internal Gas Target

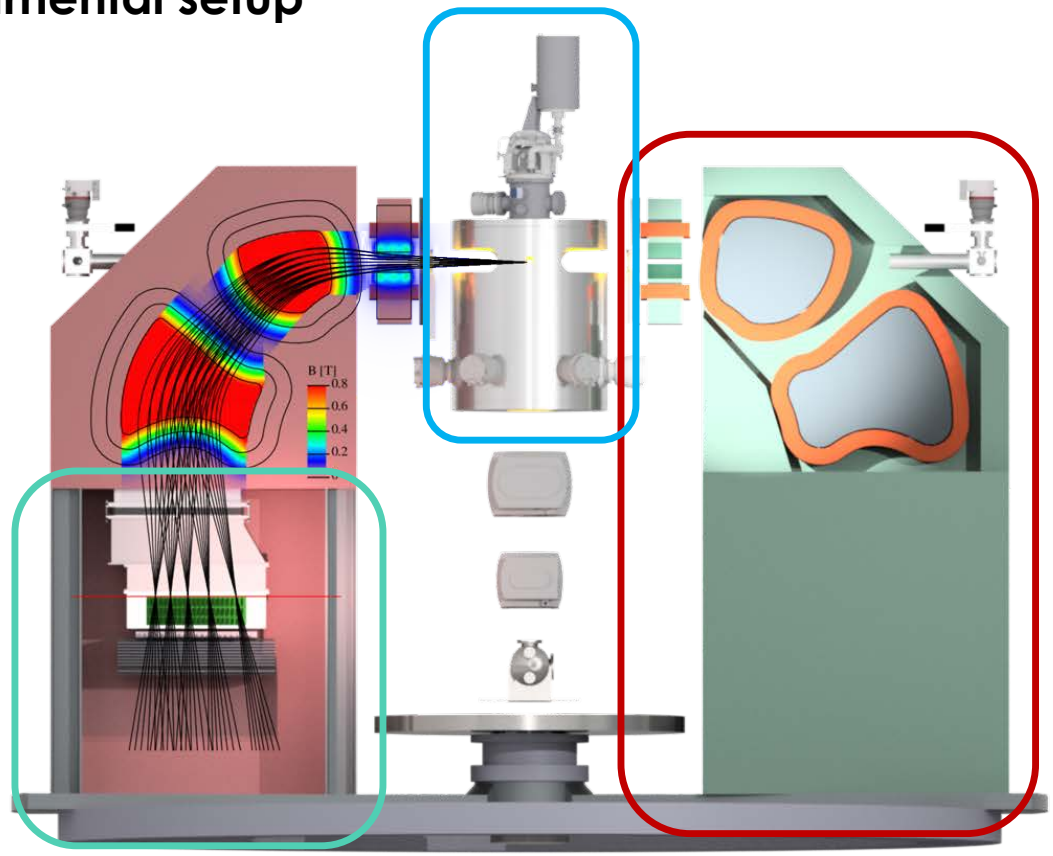
- Windowless gas target
- Integrated recoil silicon detectors
- Forward luminosity monitors

Spectrometers

- StarPort magnetic spectrometers
- Zero-degree tagger spectrometer

Focal Plane Detectors

- GEM-based TPC tracker
- Timestamping trigger



WHY A TPC?

Minimal material budget

- Reduces the detection threshold and the effect of multiple scattering

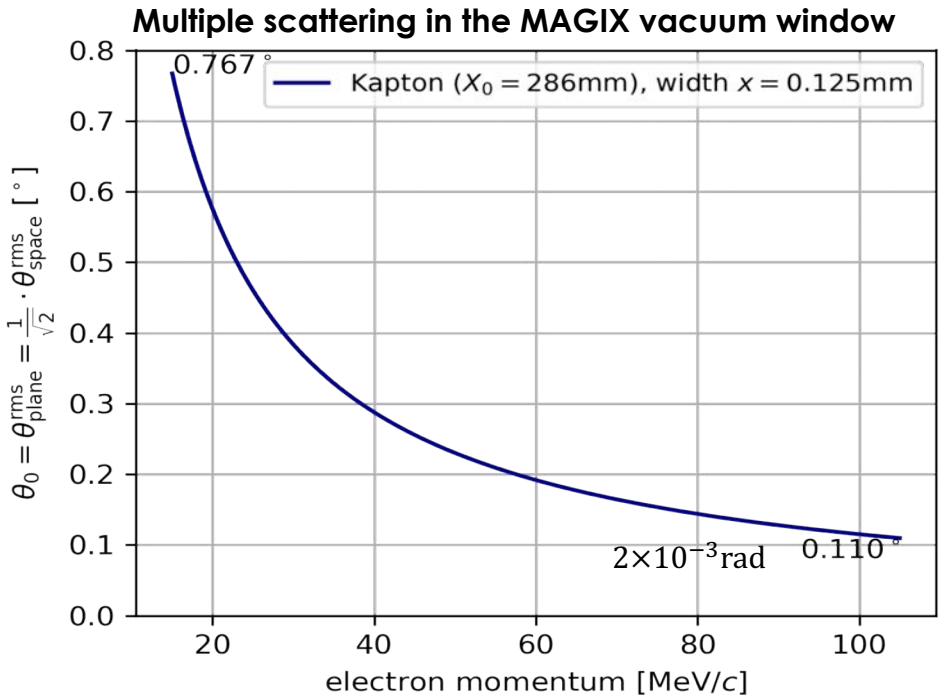
Efficiency and uniformity

- Up to 24 samples along each track allows to achieve close to 100% efficiency
- All samples neighboring each other allows for an easier tracking even with multiple tracks
- A single gas volume with the same geometry for all angles and energies

Compact and cost effective

- A single detector with a single amplification layer can fulfill all the tracking needs

TRACKING REQUIREMENTS



Resolution

- The actual requirements depend on the specific physics channel
- $\frac{\delta P}{P} < 10^{-4}$ corresponding to $\delta x \approx 200\ \mu m$ at the focal plane
- Angular resolution of about 1 mrad at the focal plane

Multiple scattering

- The limiting factor for the TPC performance
- Mostly from the vacuum foil separating it from the spectrometers

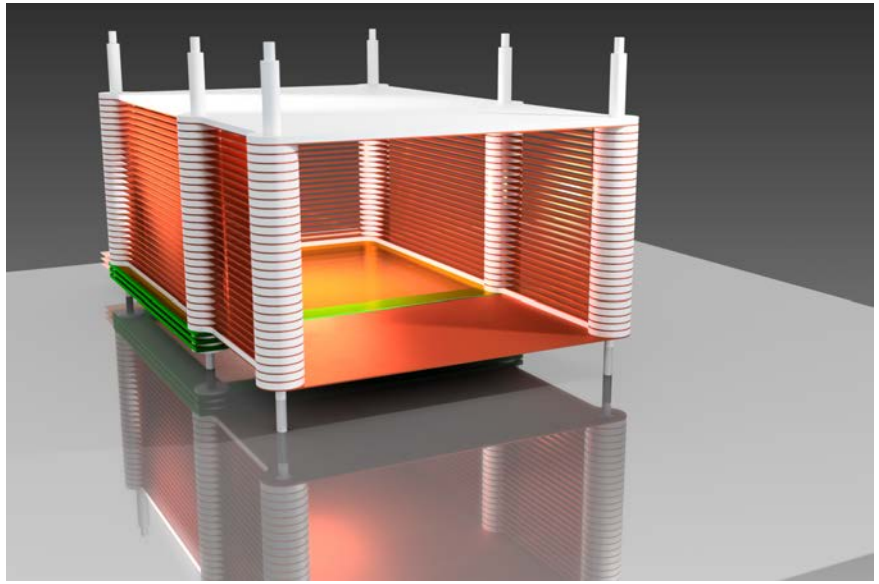
CONCEPTUAL DESIGN

Open field cage TPC

- No field shaping in the entrance window.
- Multiple scattering reduced and uniformed
- Extension plates in the spectrometer vacuum to reduce field distortions

Amplification and readout

- GEM amplification stage
- Rectangular pad readout with VMM electronics



The MAGIX focal plane TPC (Proceedings)

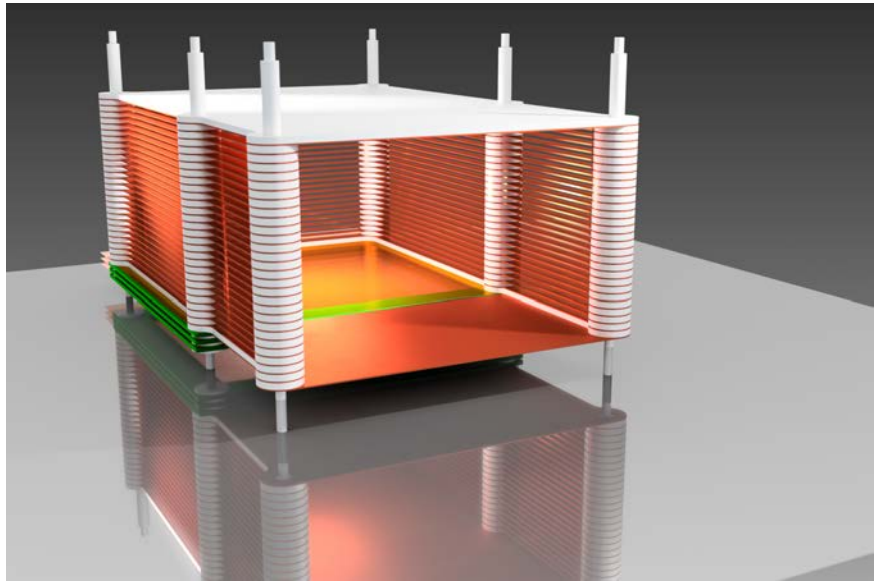
CONCEPTUAL DESIGN

Gas volume

- Drift length: $150\ mm$
- Active area: $772{\times}205\ mm^2$

Readout

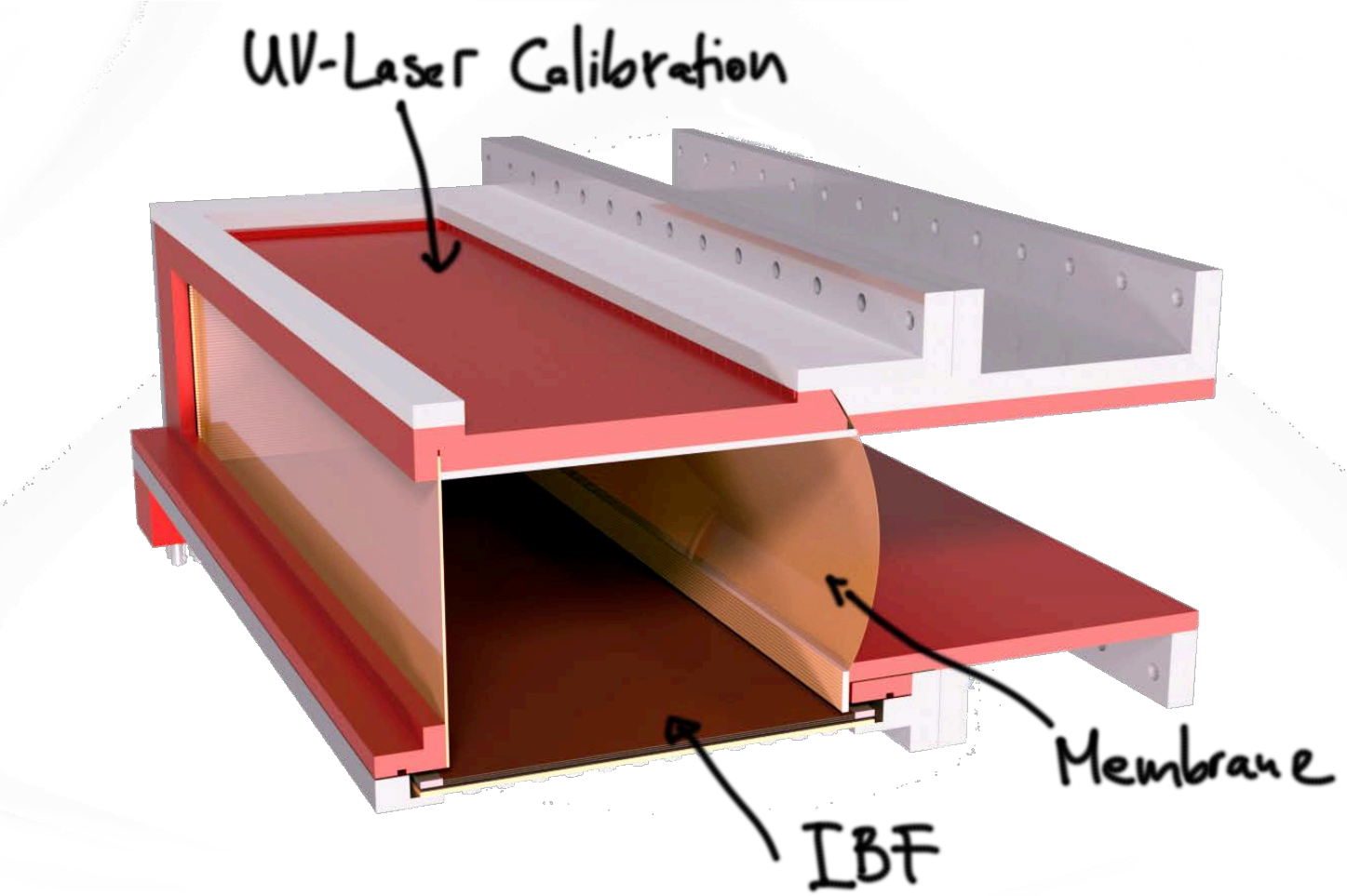
- Pads : $2 \times 8\ mm^2$
- No of VMMs: 72

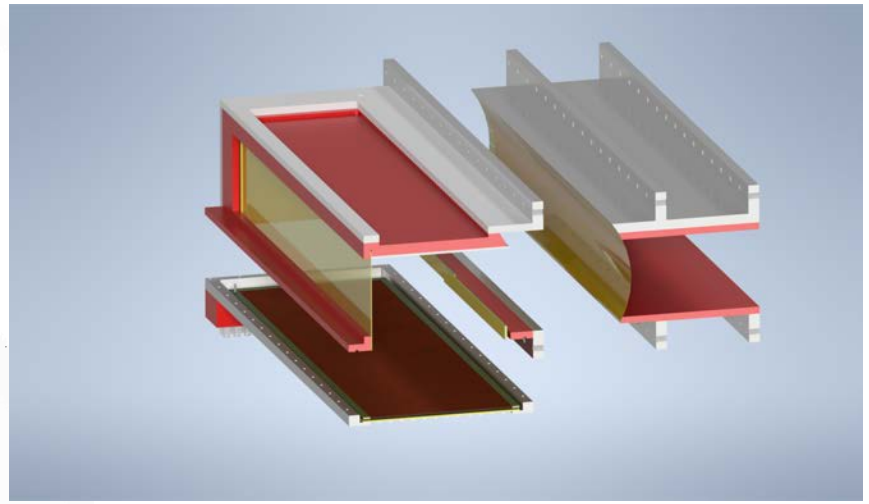


The MAGIX focal plane TPC (Proceedings)

3 IMPORTANT DESIGN CHOICES

ON THE WAY TO A FULL-SCALE PROTOTYPE





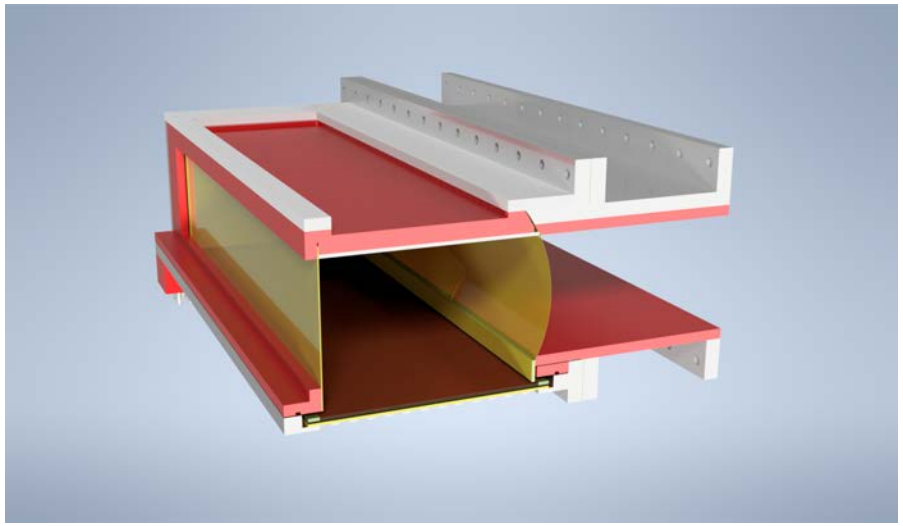
THE VACUUM SEPARATION MEMBRANE

Reminder:

- There is just this membrane separating the vacuum from the counting gas.
- No field cage!

Dielectric material

- in contact with counting gas
- 125 um Kapton
- Take care of charge-up

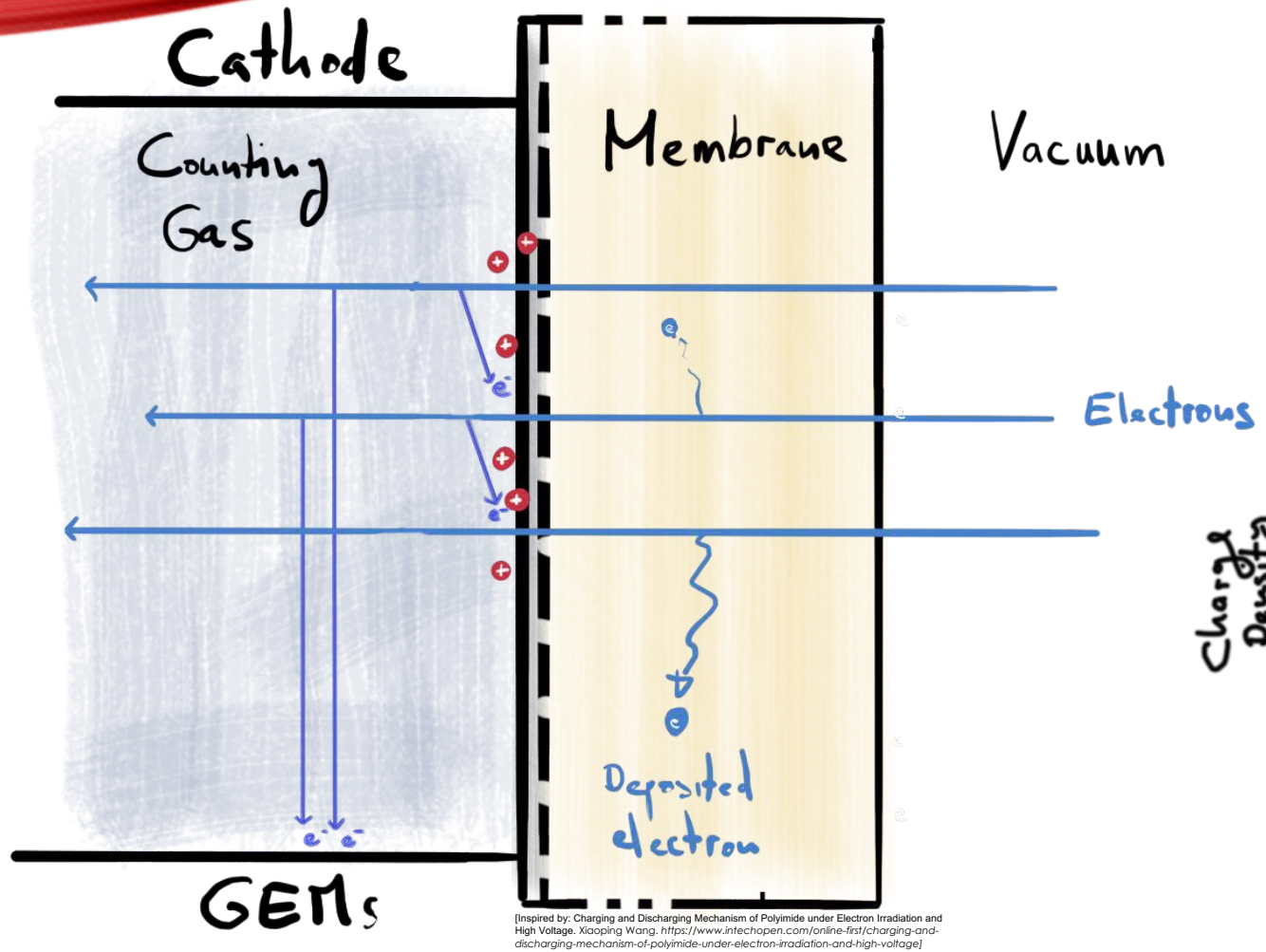


CHARGING UP OF A DIELECTRIC

- GEMs violate the 1st law of gas-based detectors: active gas must not be in contact with an insulator.

https://indico.desy.de/event/7435/attachments/55173/67200/09_-_Rob_Veenhoff_-_IBF.pdf

DEEP IONIZATION

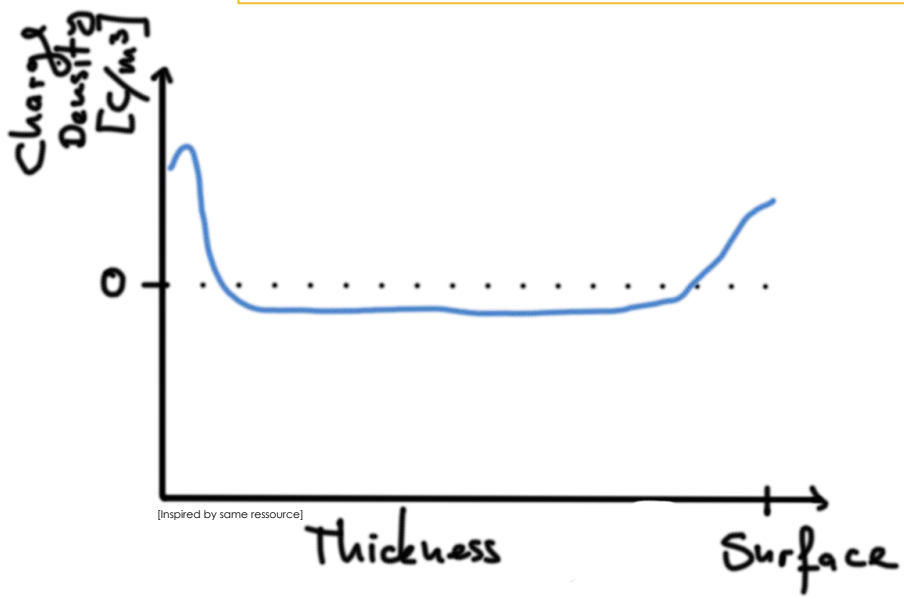


[Inspired by: Charging and Discharging Mechanism of Polyimide under Electron Irradiation and High Voltage. Xiaoping Wang. *https://www.intechopen.com/online-first/charging-and-discharging-mechanism-of-polyimide-under-electron-irradiation-and-high-voltage*]

Membrane gets polarized

- Distorts drift field
- Traps secondary electrons
- Competing effects may partially neutralize the distortion

Hard to simulate



[Inspired by same ressource]

POSSIBLE SOLUTIONS

Get data

- Measure the membrane charging up with the MAMI electron test-beam
- Short bursts to polarize membrane
- Small current to measure distortions

Potential mitigations

- Electrodes at the edge of the membrane to evacuate charge
- Resistive polyimide instead of a purely insulating one to increase the evacuation rate
- Increase humidity to depolarize the membrane

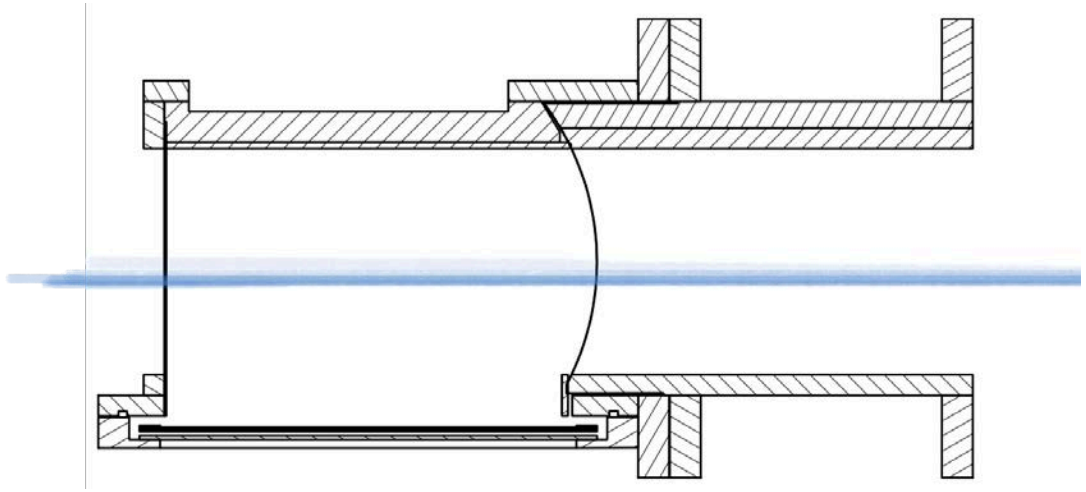
IBF FROM THE AMPLIFICATION REGION

Reminder

- The TPC sits in focal plane of a spectrometer
- We measure electron scattering
- With elastic line in detector easily >100kHz in small area (~

IBF

- Ion backflow very inhomogeneous
- Space charges may distort drift field



3 OR 4 GEMS?

Current prototype

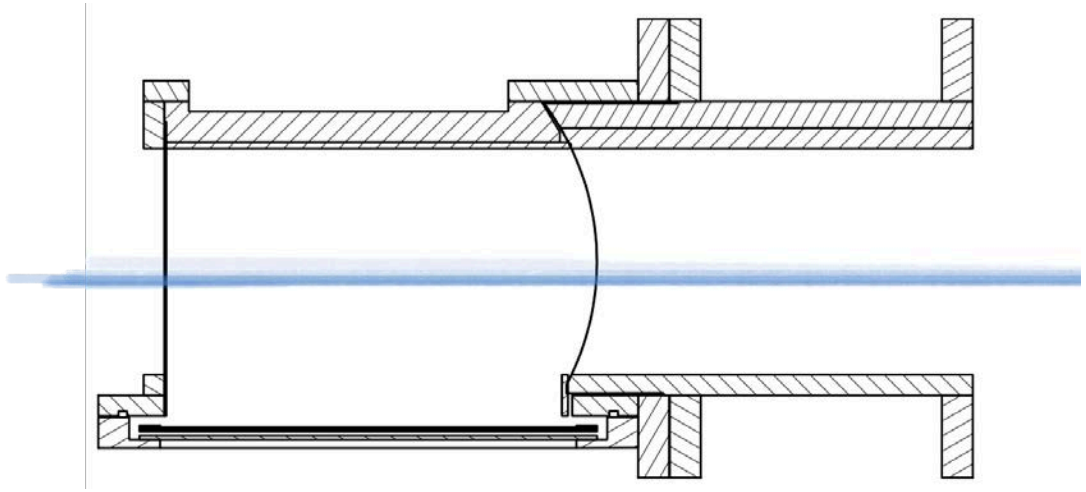
- 3 default GEMs

ALICE 4 GEM setup

- minimal IBF
- increased complexity
- increased costs

3 GEMs with different pitches

- also good IBF reduction



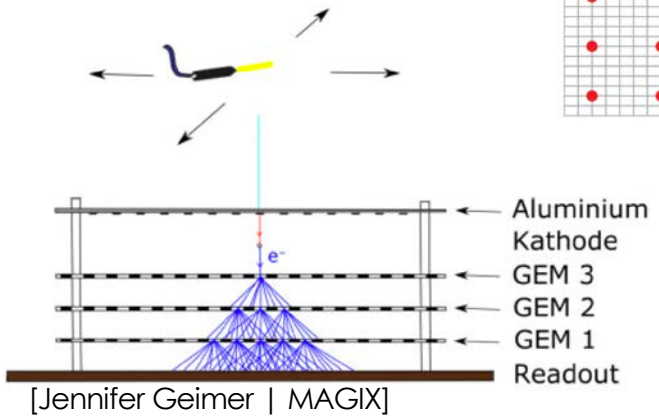
A LASER CALIBRATION SYSTEM

Why calibration?

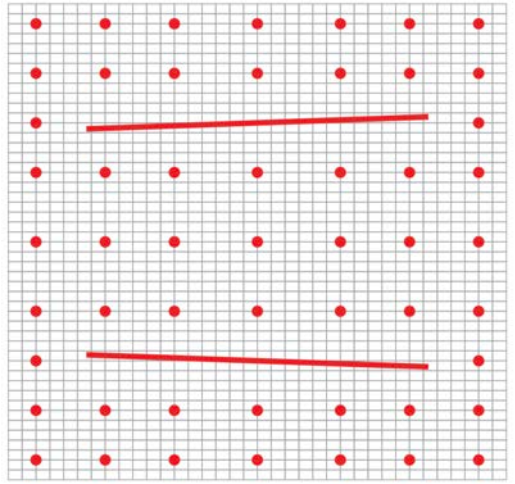
- correct deviations in
- projection and
- time

Different approaches:

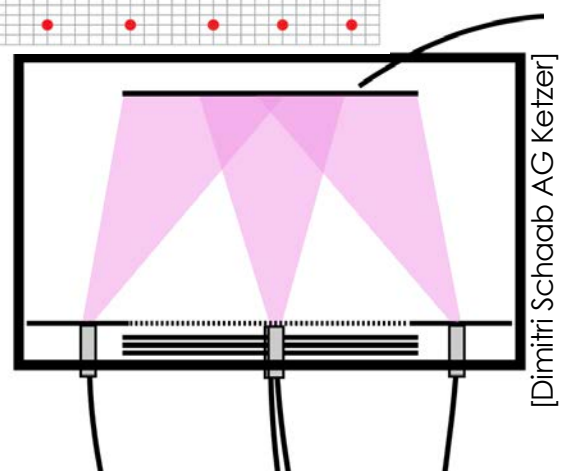
- Differential & static
  - external detector(s)
  - spectrometer collimator
- Integral & dynamic
  - with UV-Laser



[Jennifer Geimer | MAGIX]

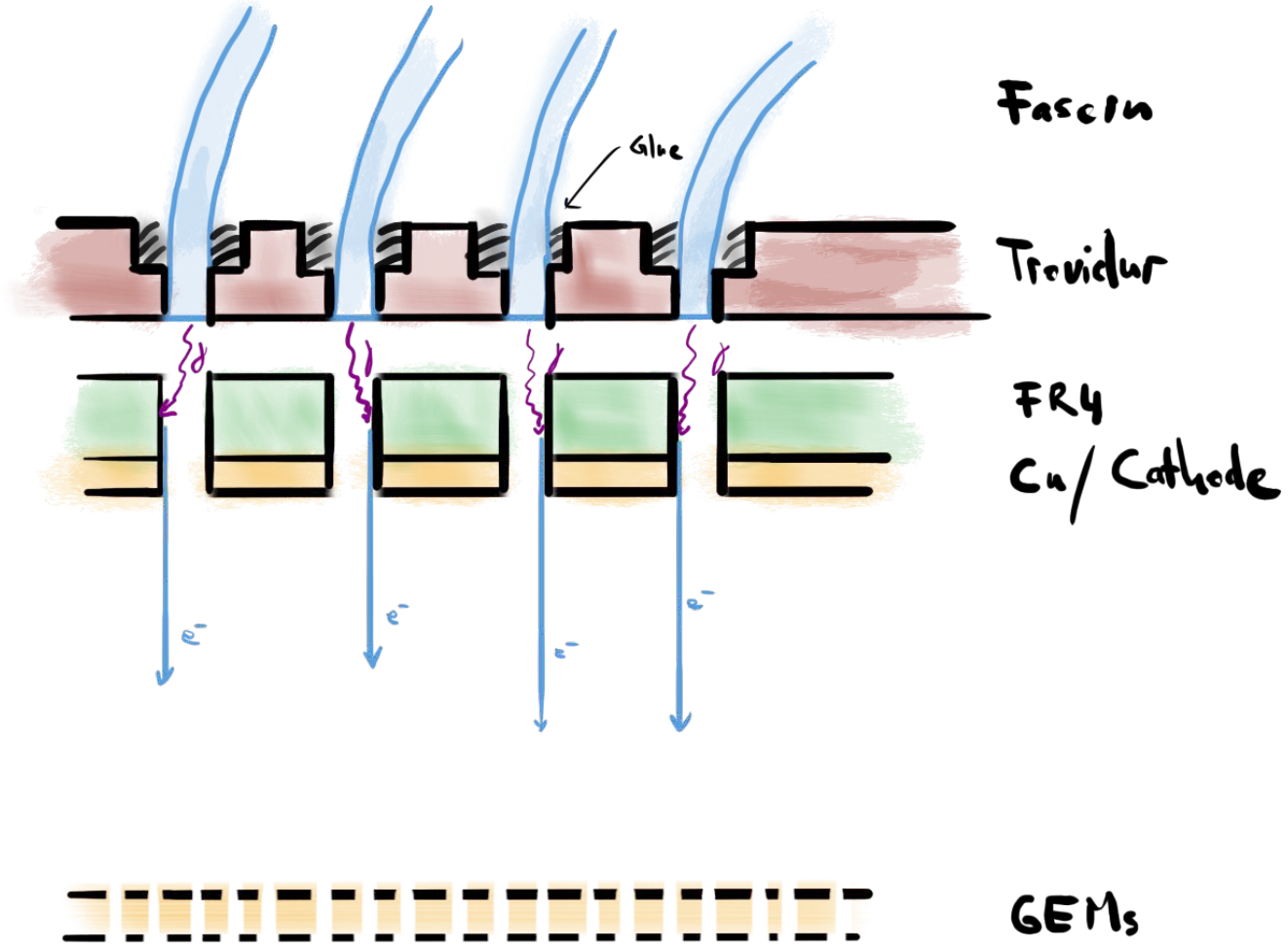


[T2K arXiv:1012.0865v1]



[Dimitri Schaab AG Ketzer]

UV-LASER CALIBRATION 'STARRY NIGHT'



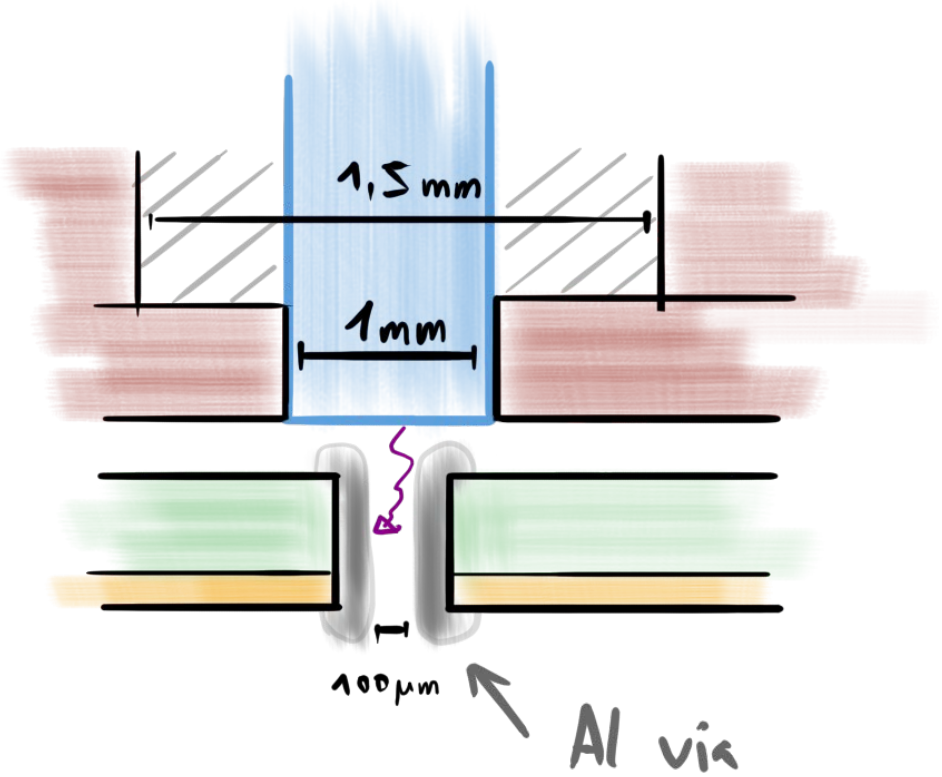
UV-Laser

- 266 nm
- 10 mJ
- pulsed

Illuminate cathode from top

- use fibers to guide light in detector
- extract electrons from holes/vias in cathode
- full coverage
- no problems on entrance face

UV-LASER CALIBRATION



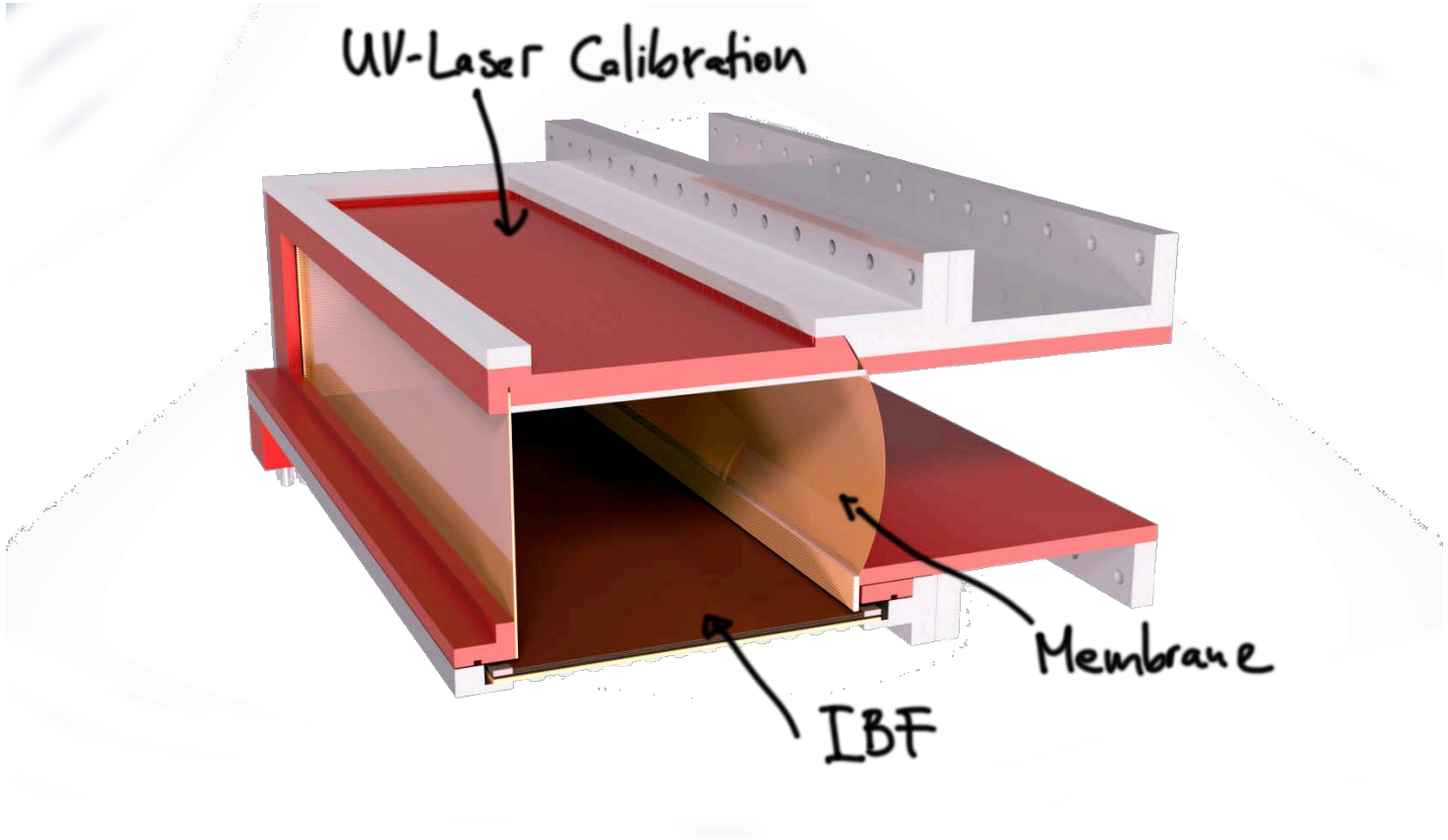
Collimate light

- electrons should be extracted in holes not in gas
- contrast has to be sufficient

Aluminiun plate as cathode

- Cu coating on inside

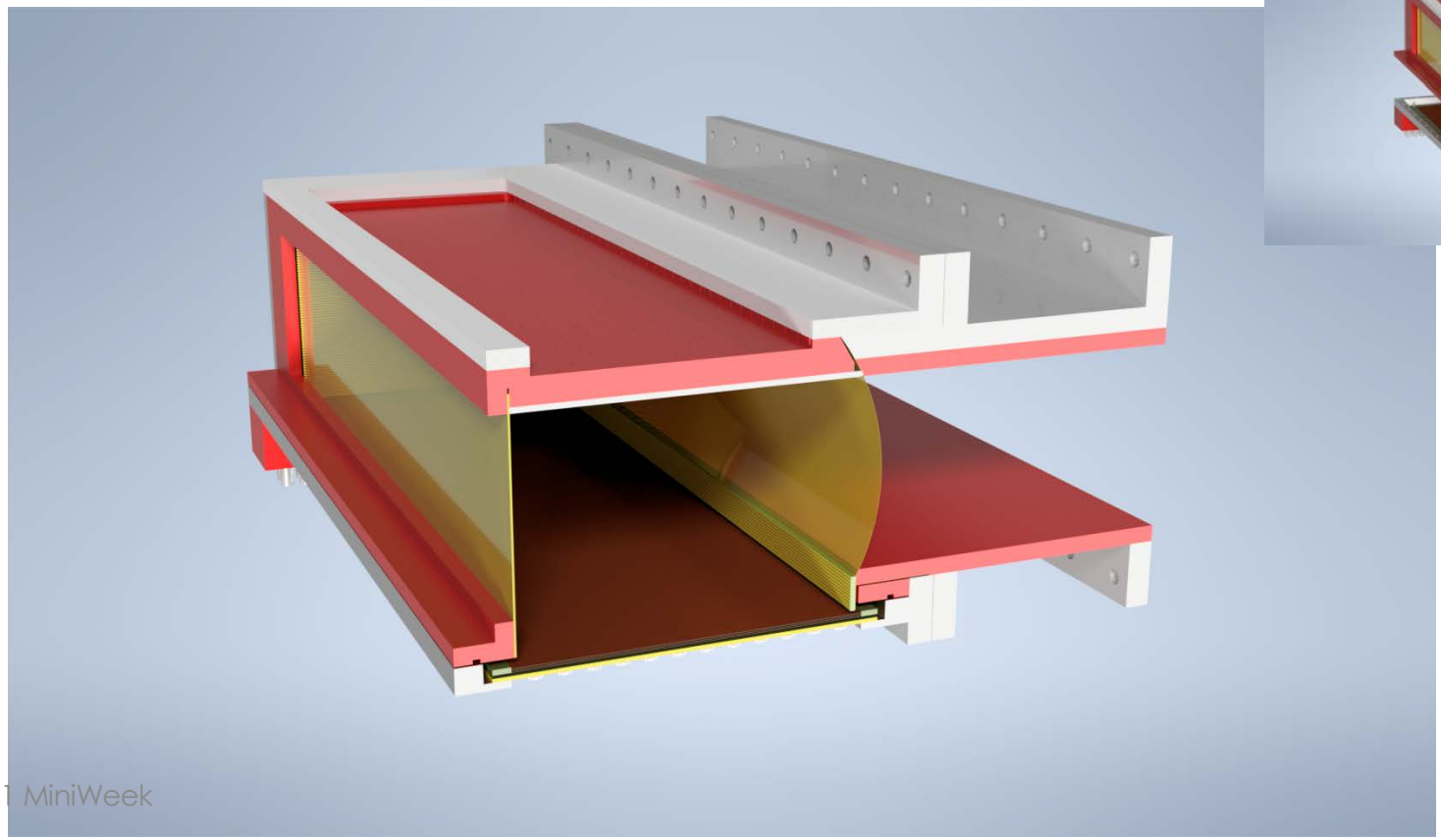
THANK YOU

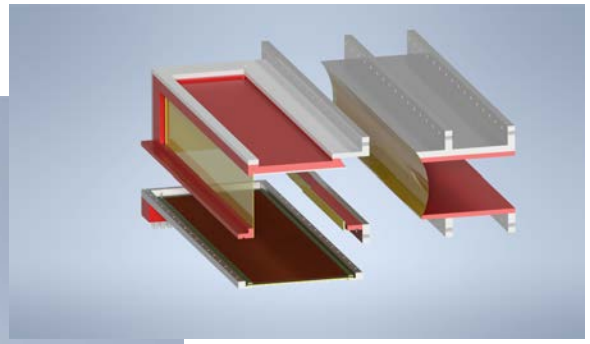


Questions?

Feedback!

BACKUP

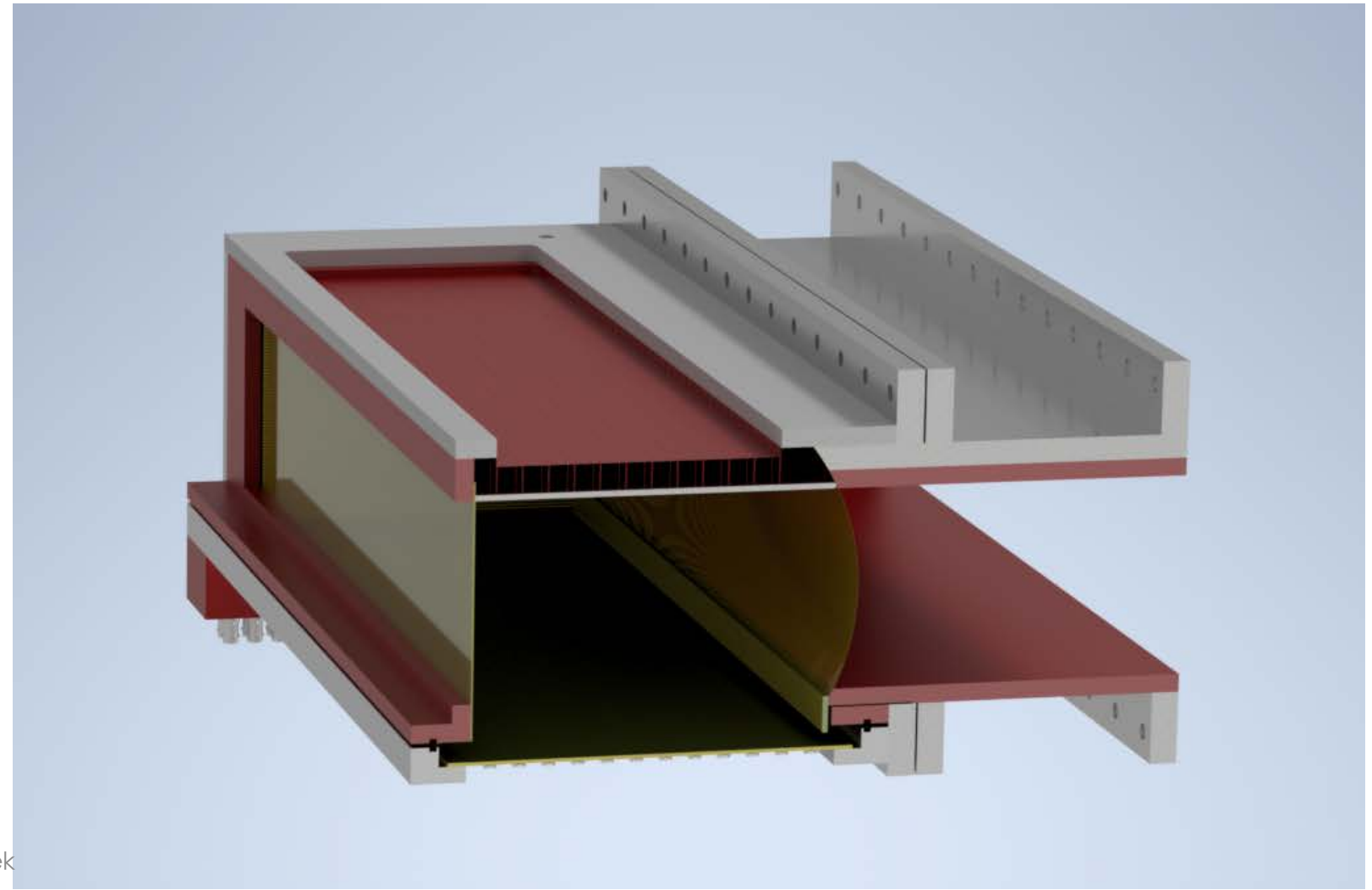




2 (Space) Frames:
* TPC
* Extension

Membrane fixed to Extension

CURRENT DESIGN



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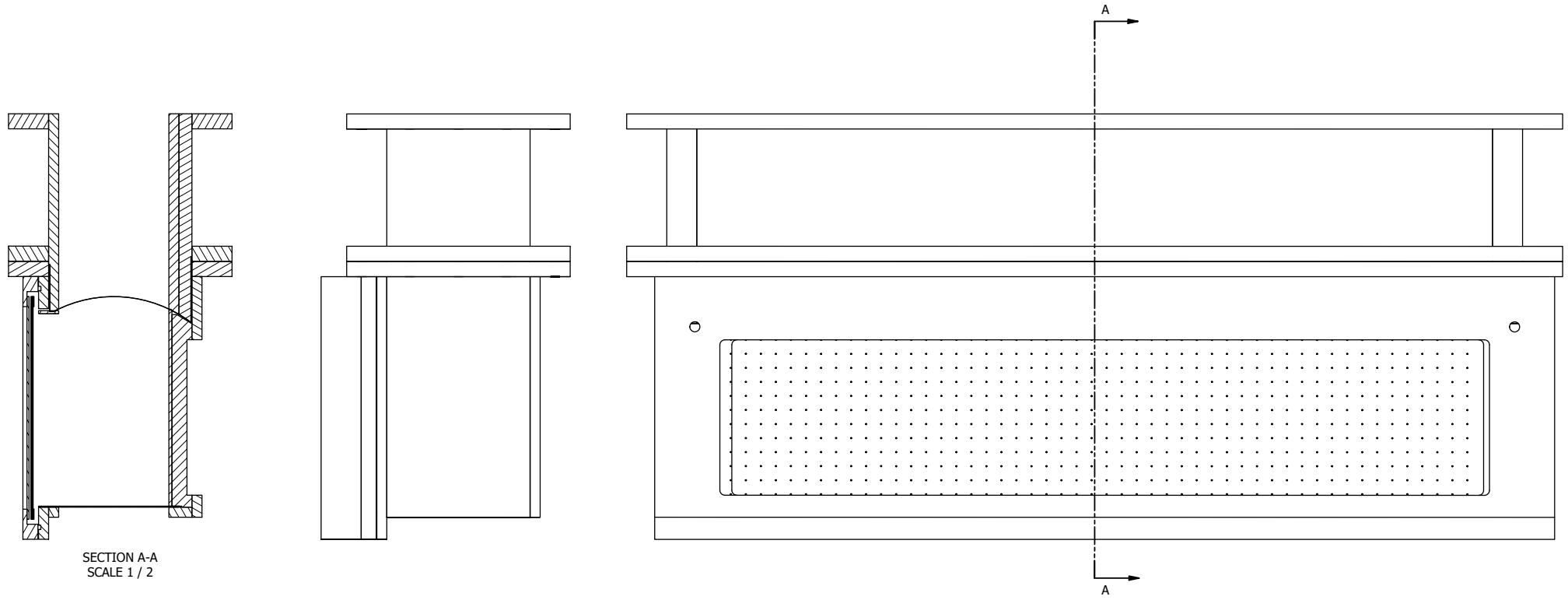
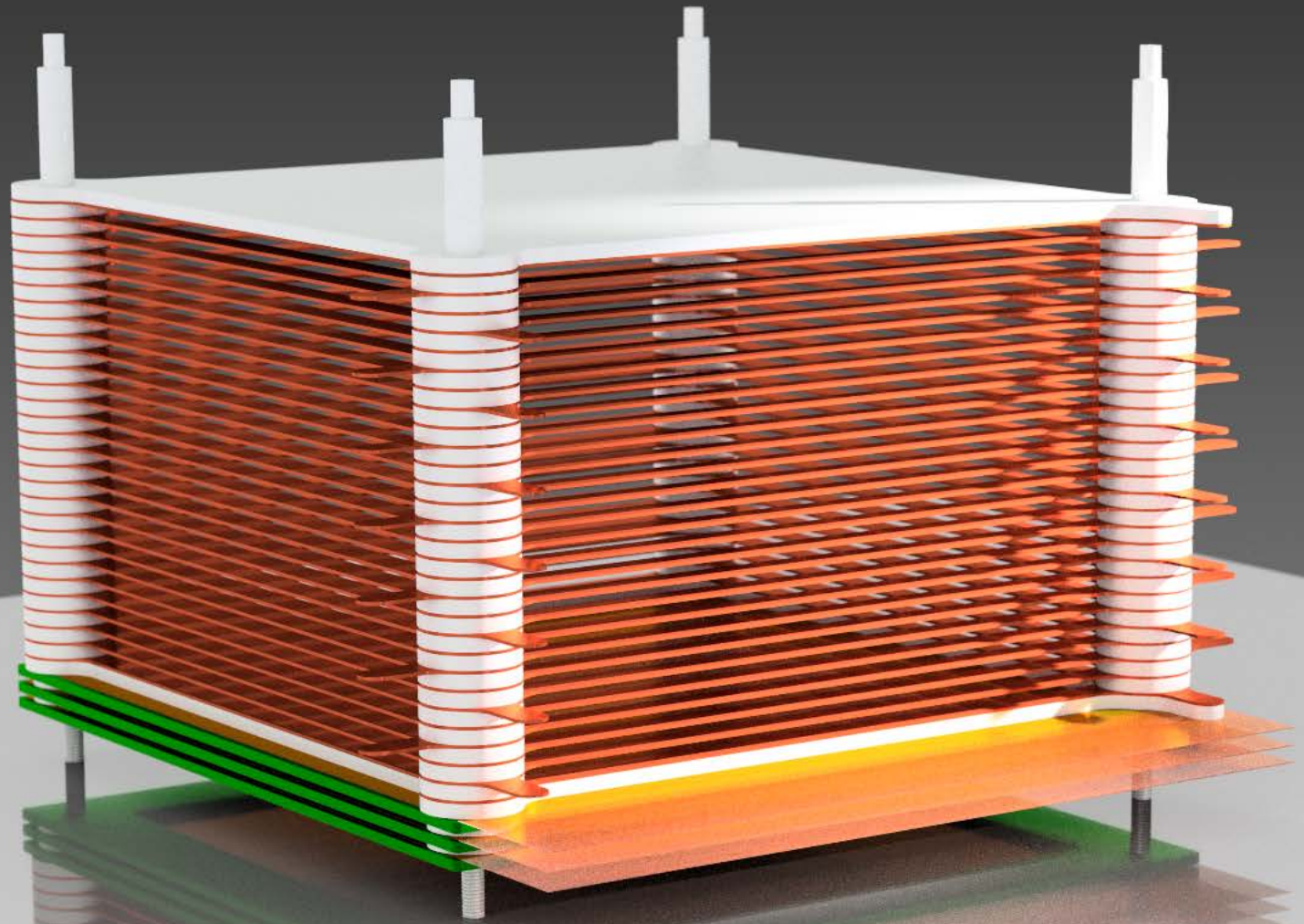
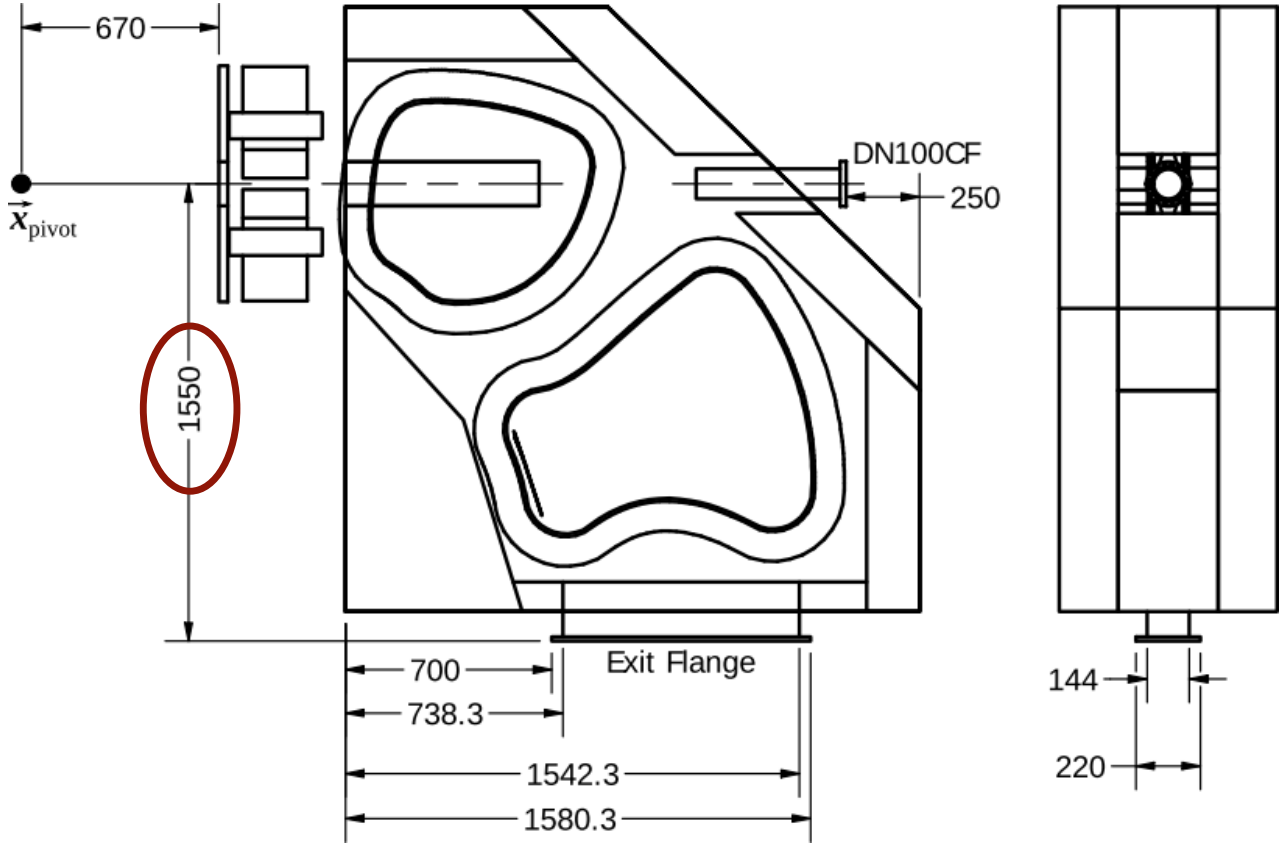




SPECTROMETER CONSTRAINTS

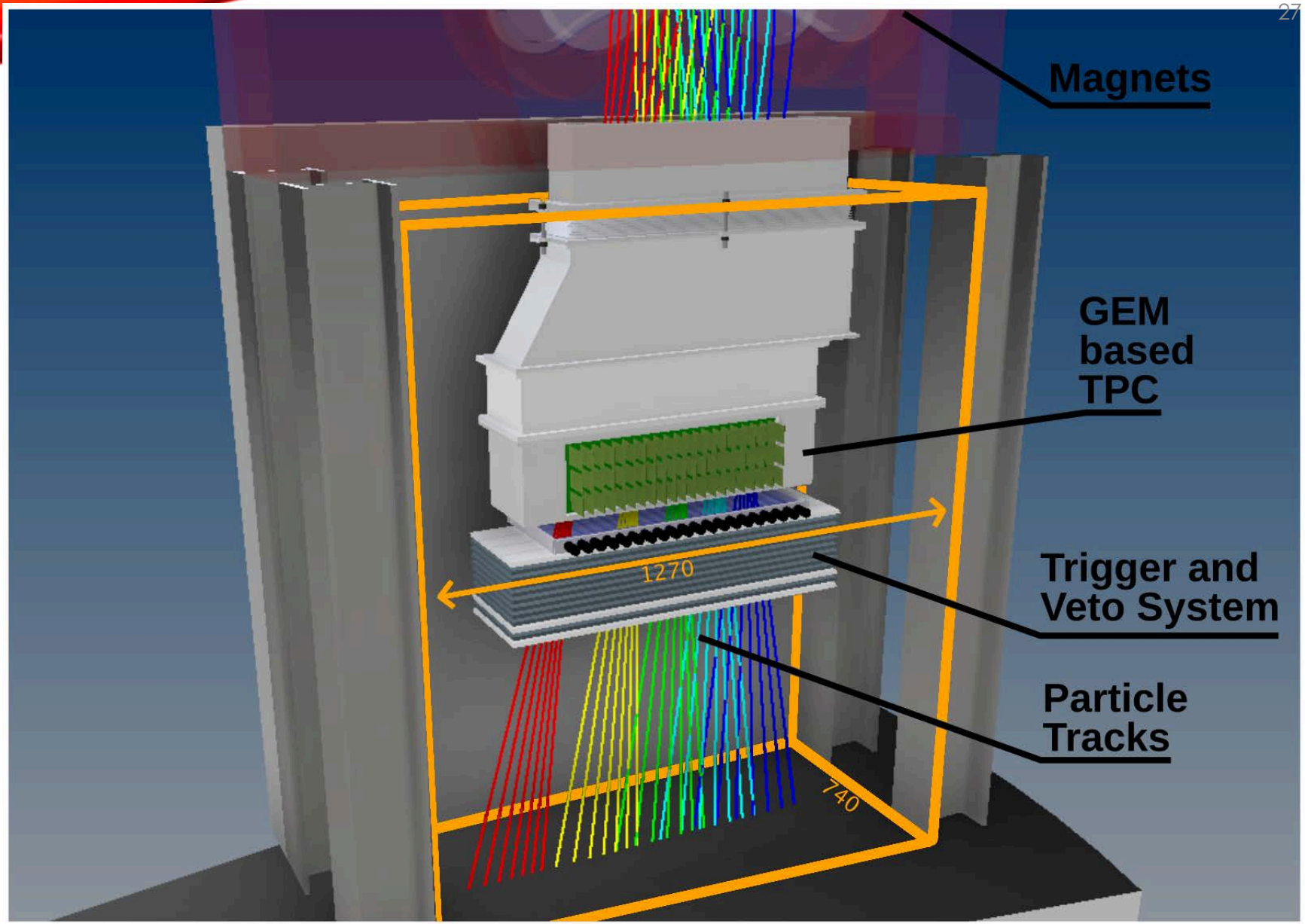


Focal plane position

- $X = -2150\ mm$
- Size = $650 \times 140\ mm^2$

Acceptance

- 30% momentum acceptance


Magnets
GEM based TPC
Trigger and Veto System
Particle Tracks
1270
740

THE MAGIX EXPERIMENT

A high-precision multi-purpose experimental setup

Internal Gas Target

- Windowless gas target
- Integrated recoil silicon detectors
- Forward luminosity monitors

Spectrometers

- Twin Arm Dipole Spectrometer
- Zero-degree tagger spectrometer

Focal Plane Detectors

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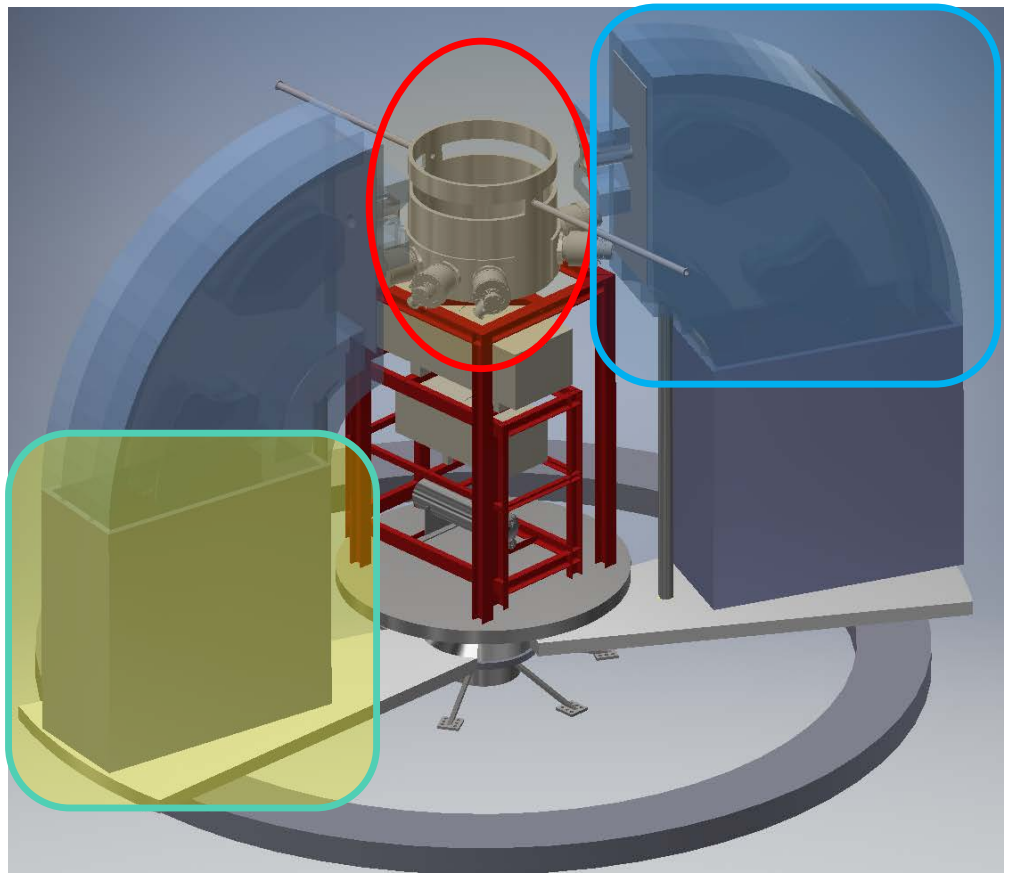

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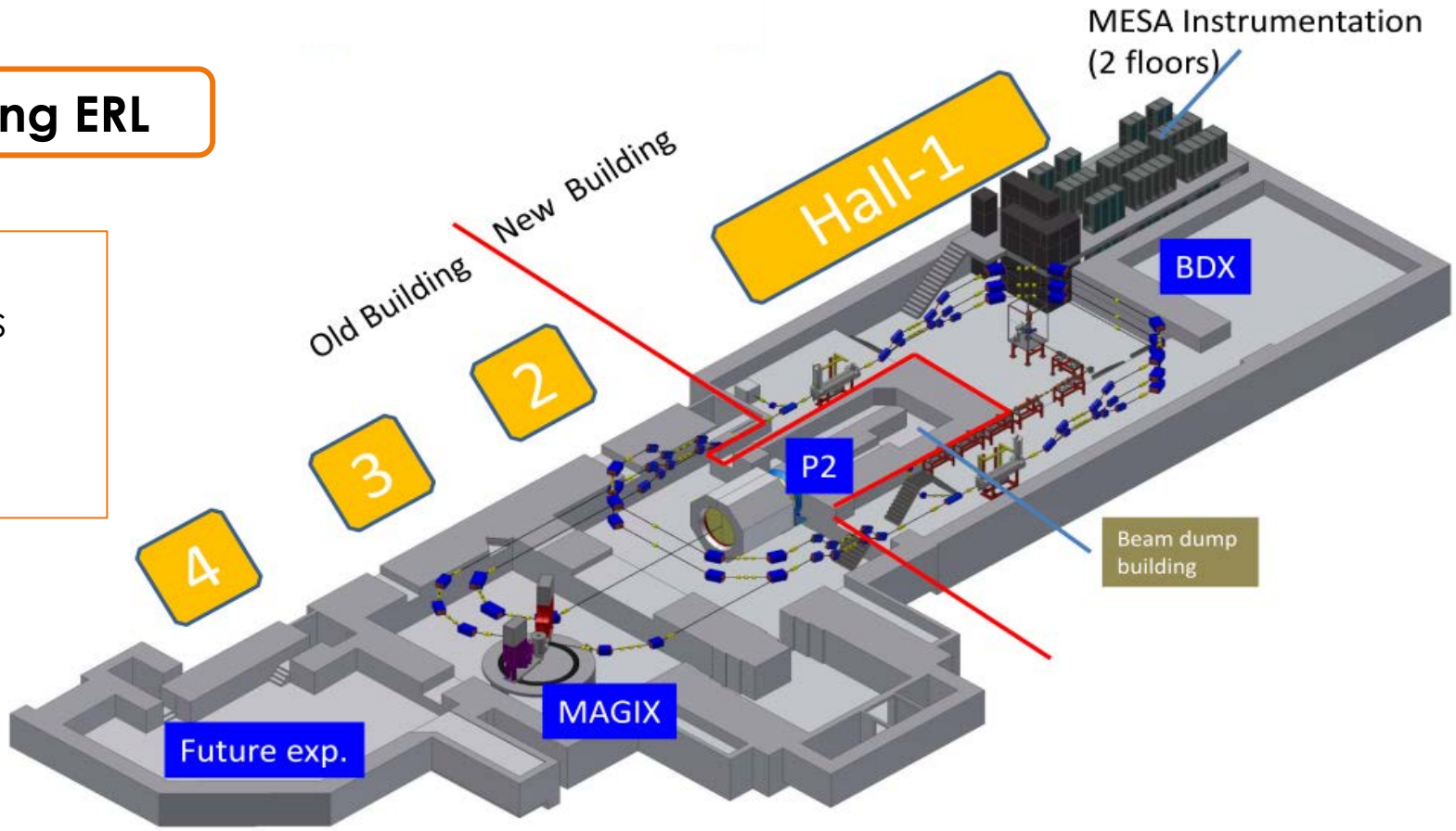

POSSIBLE SOLUTIONS

- We need the beam to have a large enough primary ionization
- Take some data at very small rate
- Pump the rate for n seconds and then measure again at very low rate
- Increase n systematically changing position from time to time
- There will be a "baseline distortion" due to the surface ionization due to cosmics.
- It should be possible to measure the surface potential somehow
- Ideally it would be great to use the photoelectric laser emissions from the cathode or in the gas to evaluate the distortions carefully