Technical design of the RPC-based ToF wall

iTOF

for the R3B experiment at FAIR

E. Casarejos , Y. Ayyad, C. Paradela, J. Benlliure, I. Durán,

J.L. Rodriguez, M. López-Lago, A. Segade, J.-A. Vilán

Universidade de Santiago de Compostela (Spain)

Universidade de Vigo (Spain)

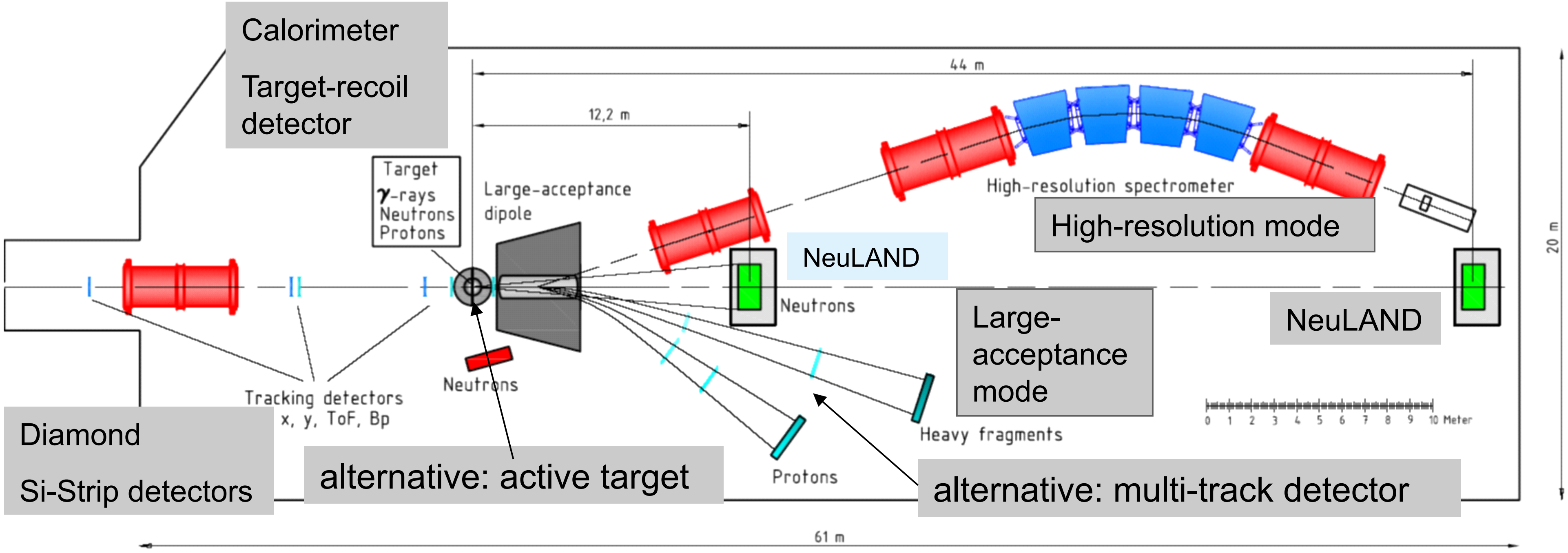
USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

R3B

Universida de Vigo

Reactions with **R**elativistic **R**adioactive **B**eams

~250 scientists, 8 countries



Kinematically complete measurement of reactions with high-energy secondary beams (~ 700 MeV/nucleon)

Nuclear Astrophysics

Structure of exotic nuclei

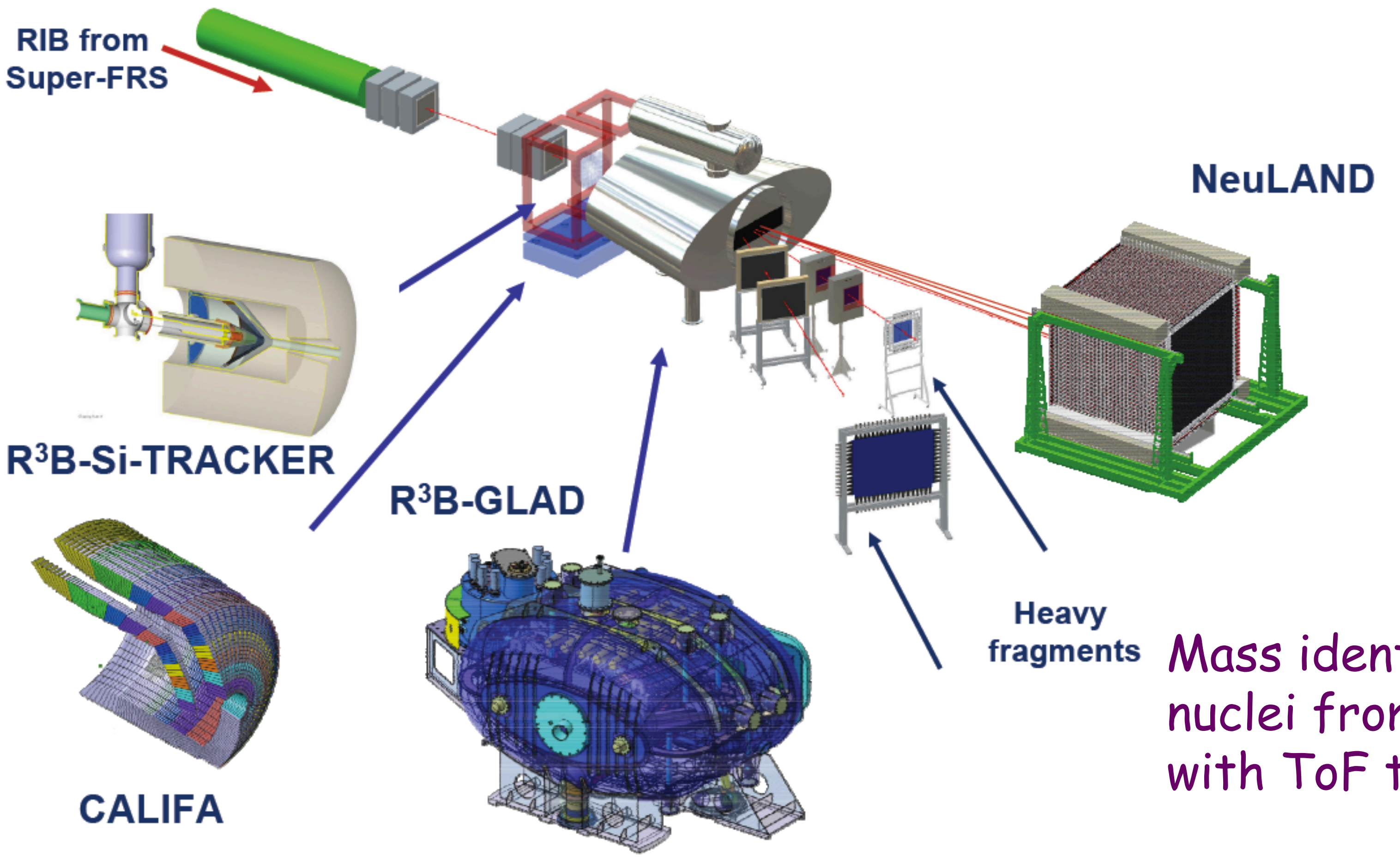
Neutron-rich matter

High efficiency

High acceptance

High resolution

R3B Start version 2016



Mass identification of nuclei from p up to U with ToF techniques

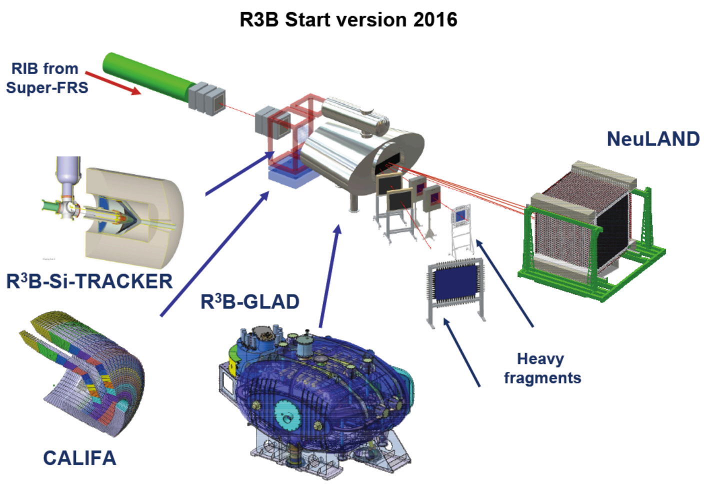
A ToF wall for heavy ions: iToF

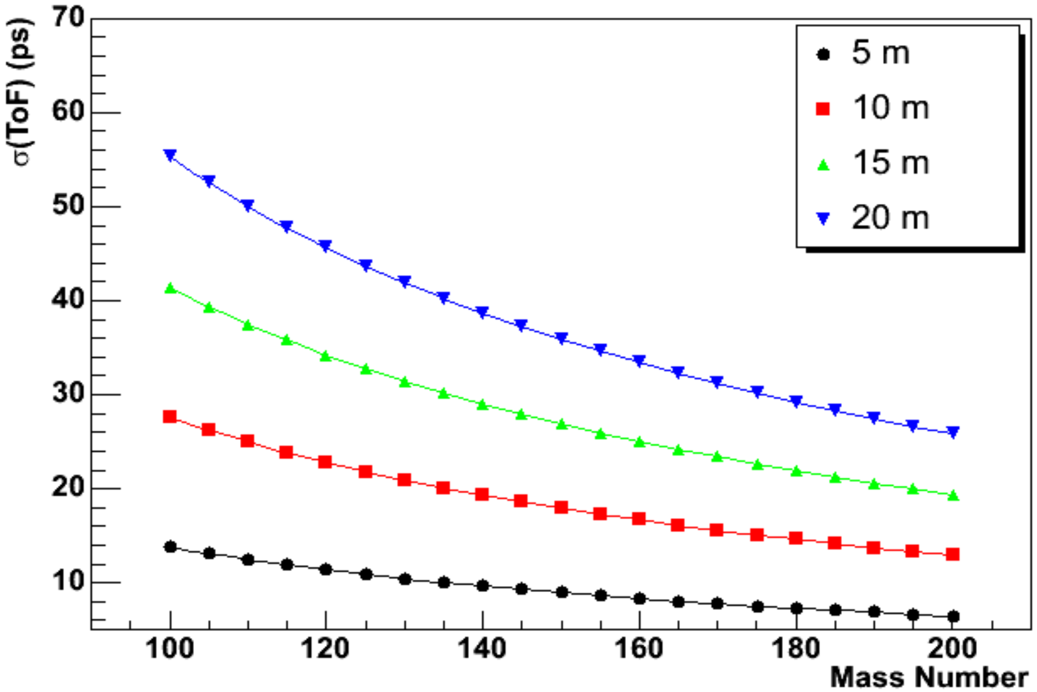
detector dedicated to relativistic ions:
- spallation / fragmentation reactions
- fission reactions

$$\frac{\Delta B\rho}{B\rho} \approx 3 \cdot 10^{-3} \Rightarrow \frac{\Delta(ToF)}{ToF} \approx 10^{-3}$$

$$A \approx 200 \Rightarrow \Delta A / A \approx 3 \cdot 10^{-3}$$

Isotopic identification
with ToF techniques





D. P. Loureiro, master-degree.
Nominal GLAD maximum field (18 degree deviation for 15.6 Tm rigidity).
Three tracking detectors (0.20 mm resolution). Straggling included.

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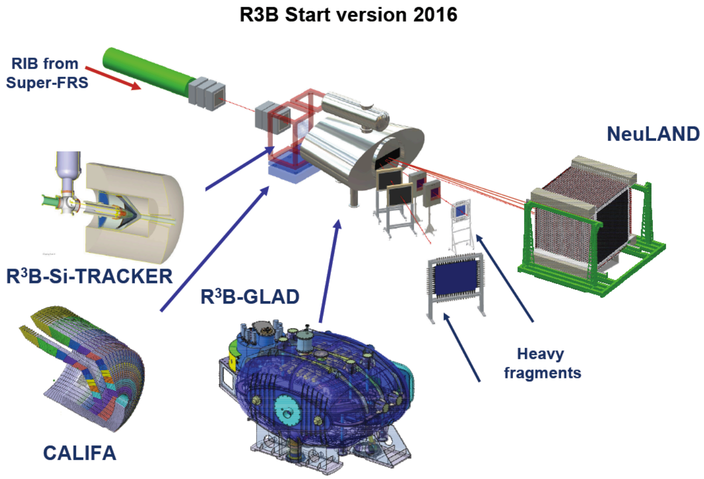

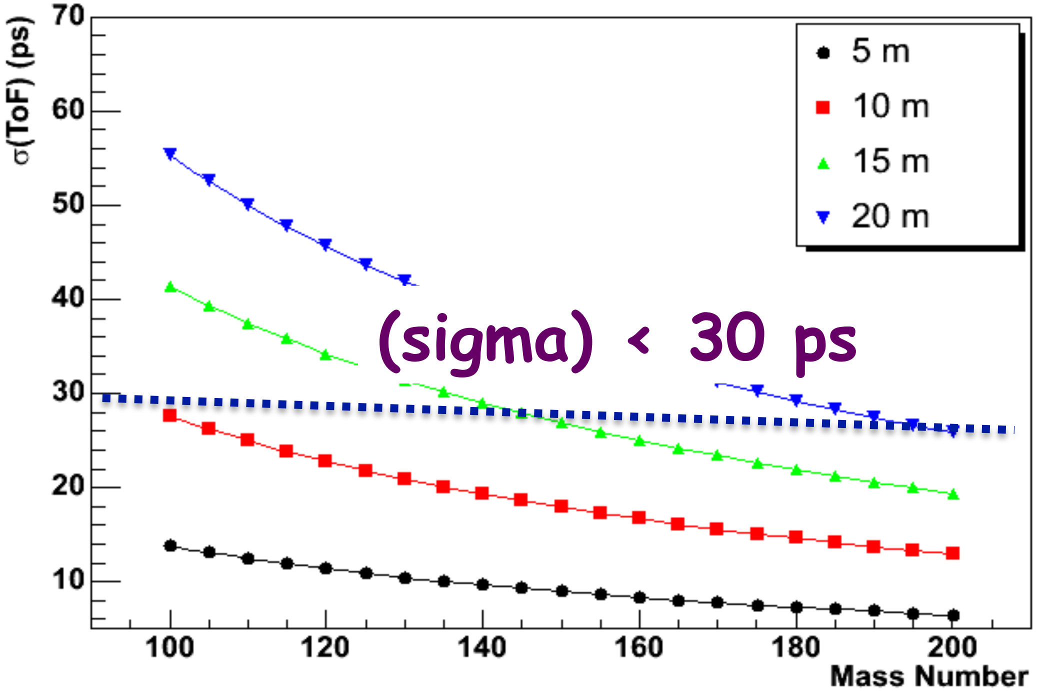

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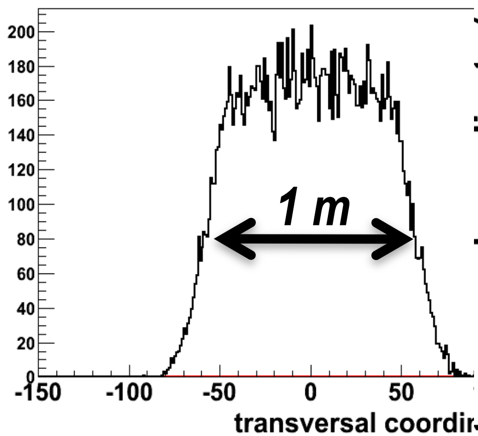
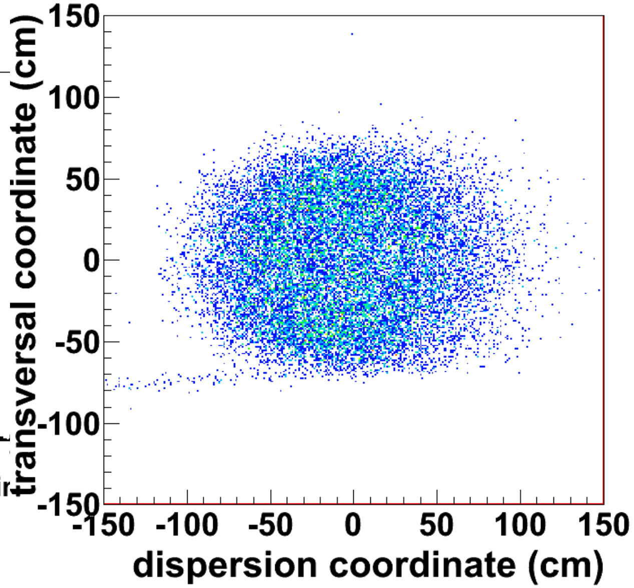
iToF: detector requirements

The distribution of fragments depends on:

→ reaction type
→ energy
→ flight path

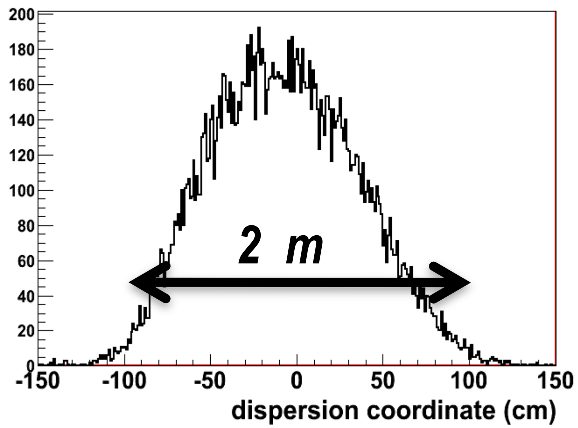




Extreme case:
Fission of 238U (400 MeV/u) + Be at 15 m studied with GEANT

✓ **Requirements:**

- 15 m flight path
- time resolution (FWHM) <70 ps :: fission (A < 150)
- detection efficiency close to 100%
- surface: 1 x 2 m^2
- position resolution: 1-2 cm (tracking correction)
- multi-hit capabilities



iToF: detector requirements → conceptual design

✓ **Proposed solution:**

- Resistive Plate Chambers (RPCs)

  tRPC: resolution (sigma) < 50 ps

- Several detection planes

  total resolution $\propto 1/\sqrt{n}$

- tRPCs with 16 strips of 100 cm x 2 cm

  to cover 1 m X 2 m

  vertical detection planes: 5 modules

  horizontal detection planes: 2 x 3 modules

- modular design: adaptable geometry

- below 1000 electronic channels

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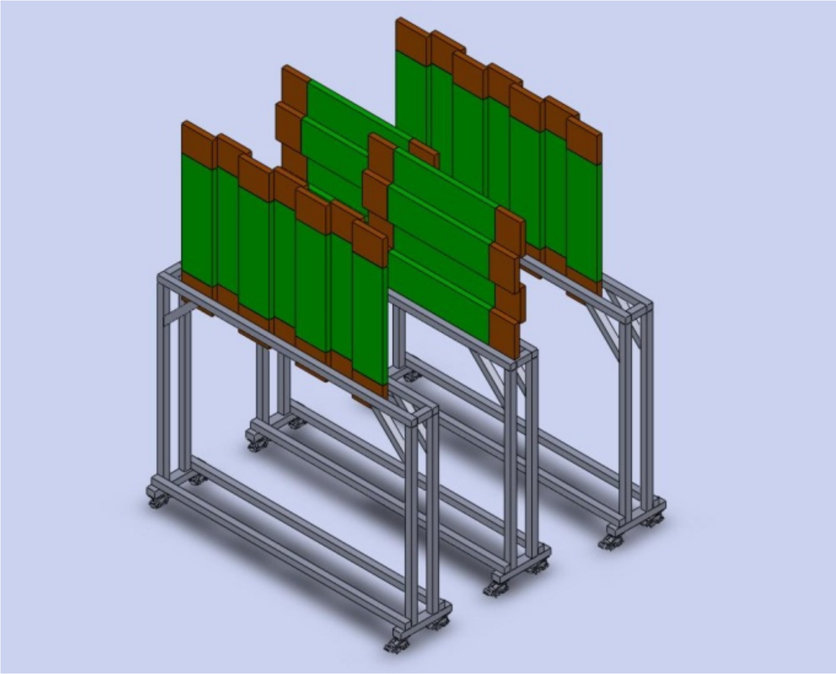

H. Alvarez-Pol et al., Nuc. Phys. B (2006)
E. Casarejos et al., NIM A (2010)

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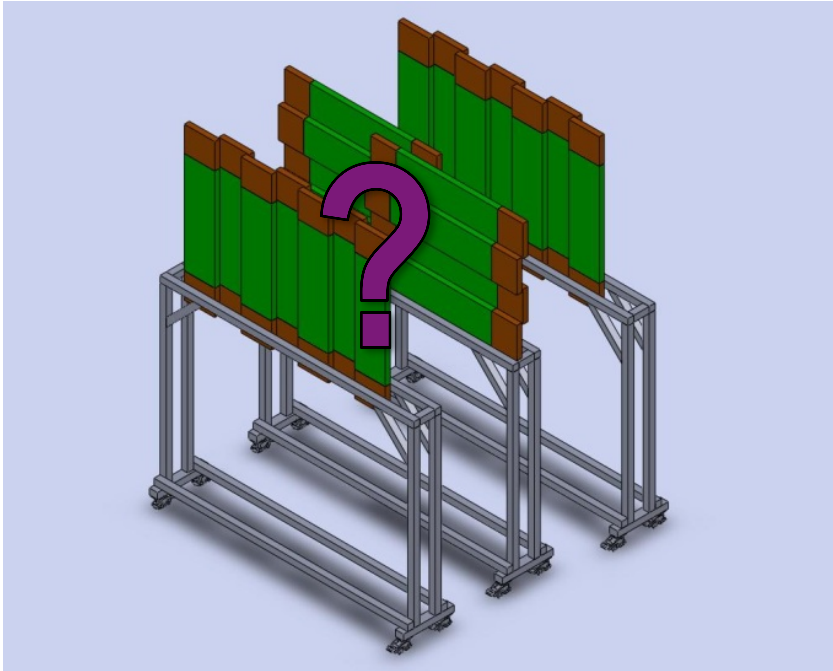

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→ challenges: measuring heavy ions, and keeping a good enough time-resolution for a large detector size

RPC design of real-scale modules

Working with heavy ions:

→ **Energy straggling due to layers of matter**

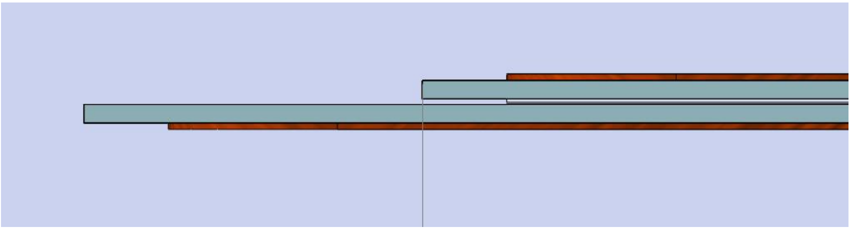
→ **Range of ions in matter**

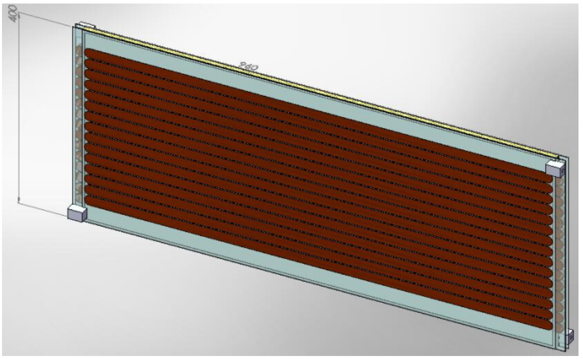
208Pb (400 AMeV) : 13.5 mm of glass

238U (400 AMeV) : 12.5 mm of glass

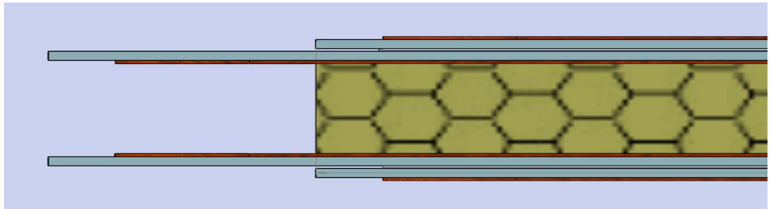
E. Casarejos et al., NIM A (2010)

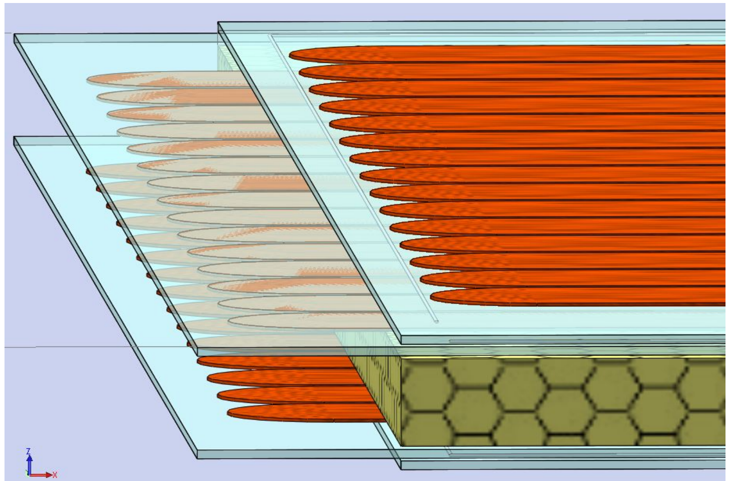
✓ **self-supported RPC**





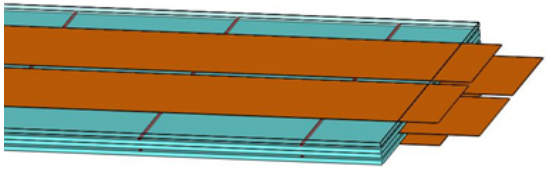
✓ **sandwich**

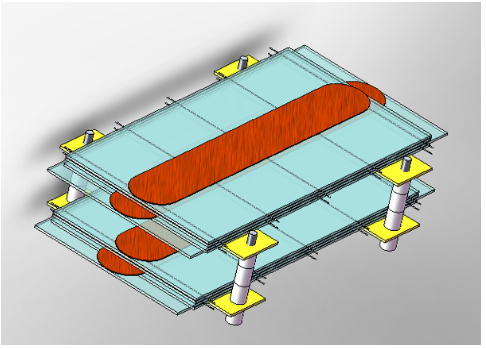




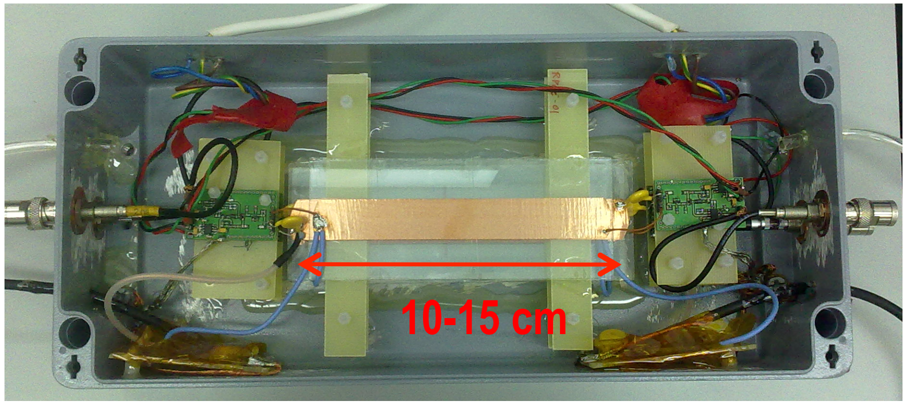
R&D: prototypes

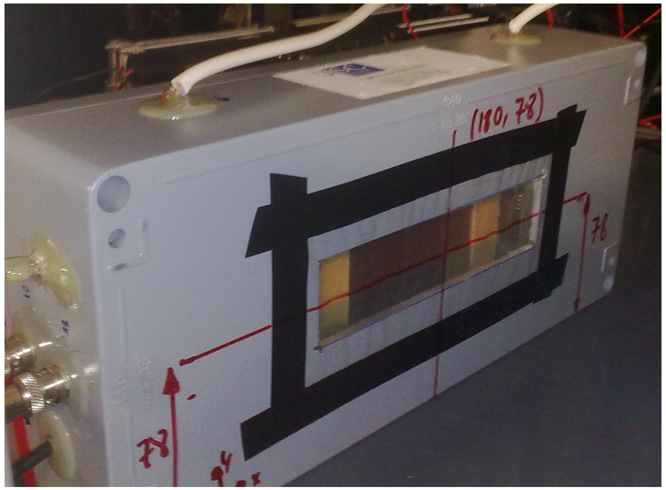
prototypes: single and double gap





✓ integration in 'ready-to-use' gas –tight boxes
for tests with ions and cosmic-rays





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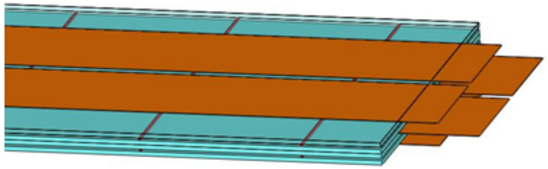
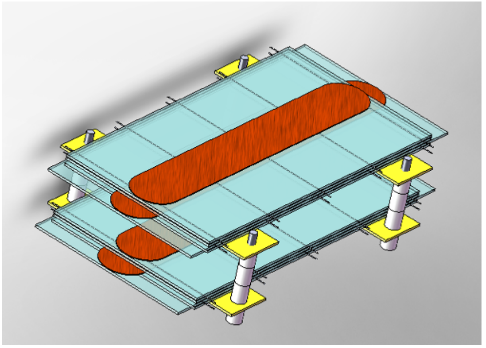
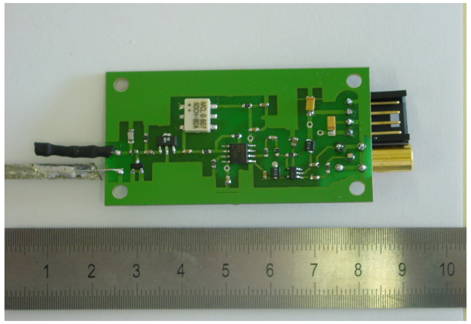
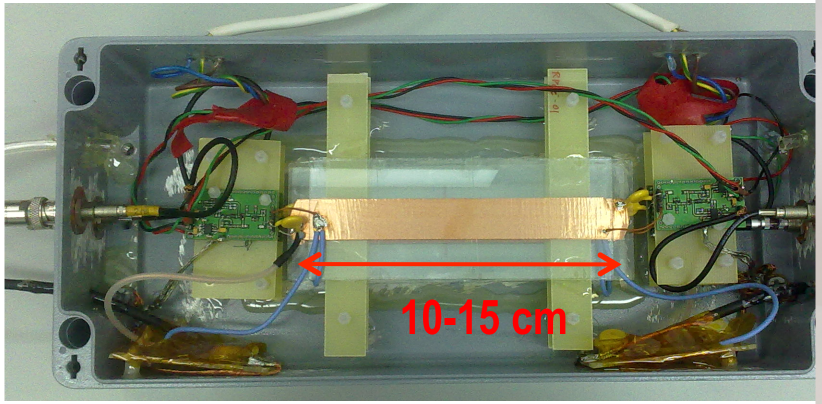


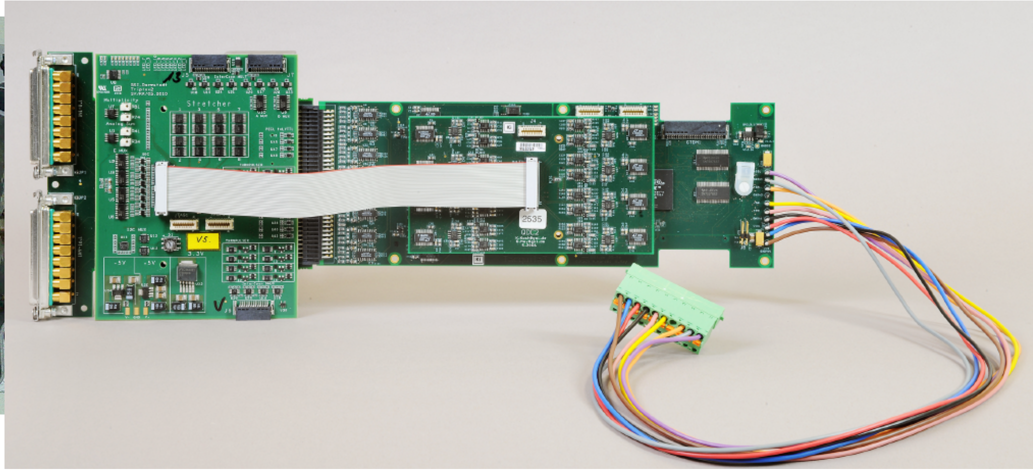




- ✓ dedicated vFEE

- ✓ TACQUILA FEE:
  TAC and QDC

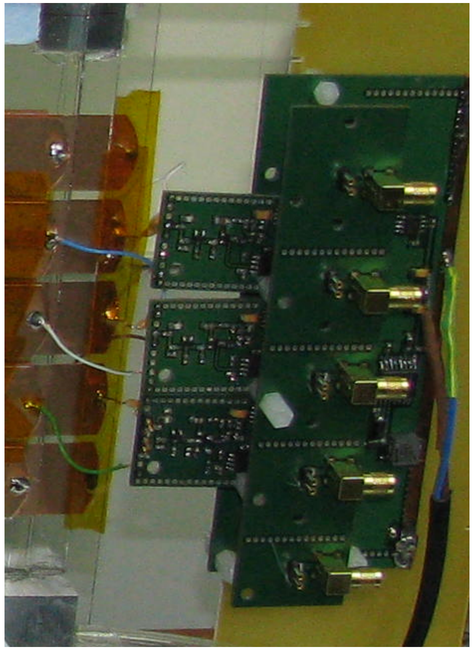


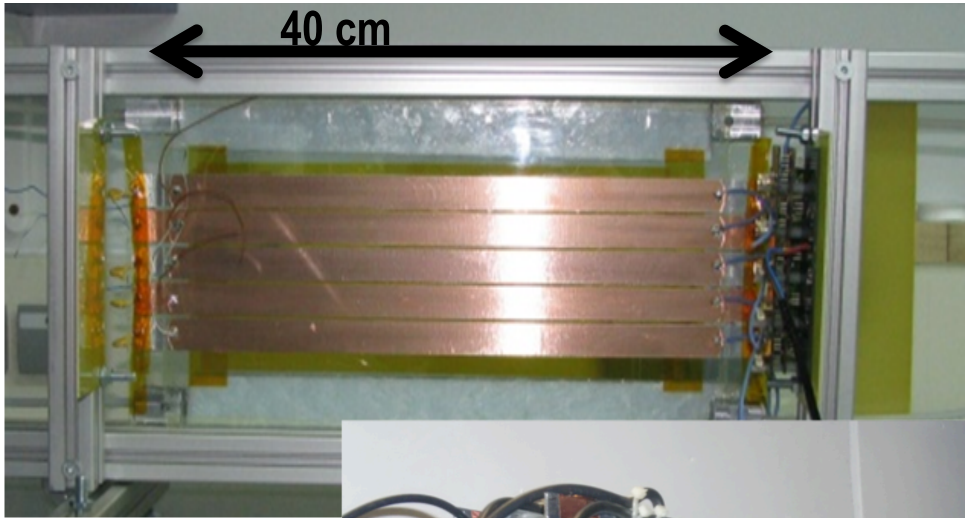


R&D: prototypes

→ increasing sizes
→ multi-strip designs
→ vFEE development

✓ beam test !!!





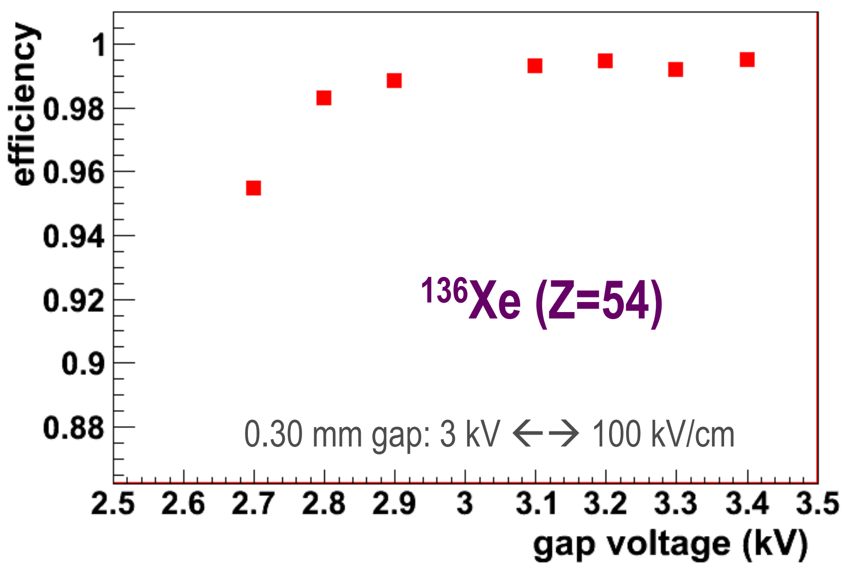
Tests of RPCs with relativistic heavy ions

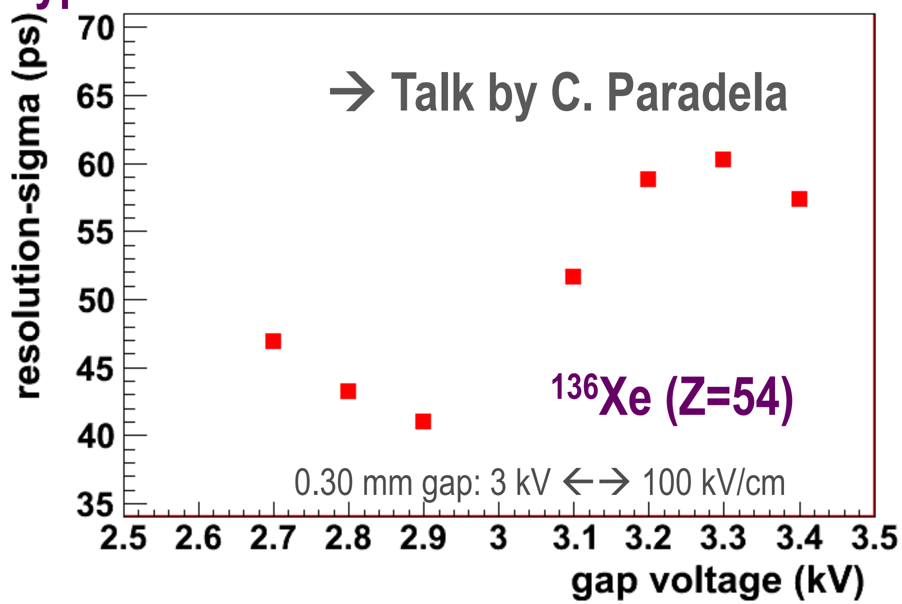
✓ ***Tests done at GSI with relativistic heavy ions***

E. Casarejos et al., NIM A (2010)
Y. Ayyad et al., NIM A (2010)
E. Casarejos et al., NIM A (2012)
C. Paradela et al., in preparation, about timing of e- and 136Xe
Y. Ayyad et al., in preparation, about 238U fission fragments

→ ***RPC design***
→ ***Efficiency***
→ ***Streamers***
→ ***Timing***
→ ***Large ranges of atomic numbers***

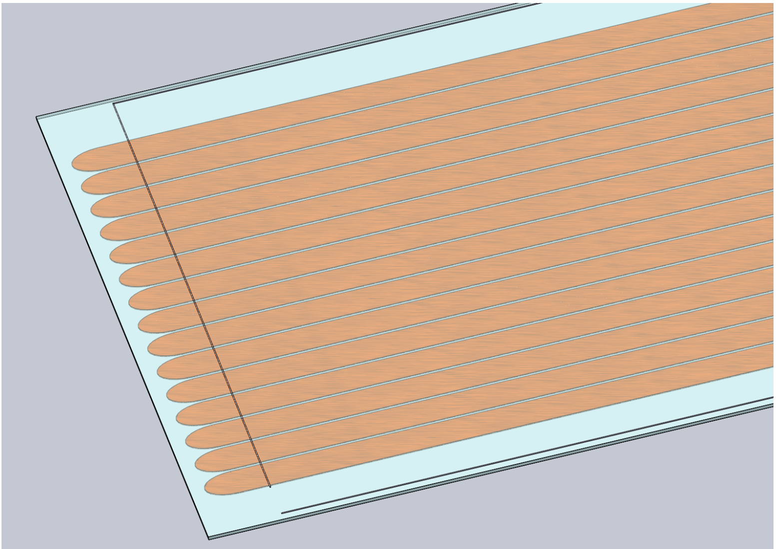
→ single-gap tRPC prototype





RPC design and construction of iToF

✓ sealed glass core



→ 1mm thick soda-lime glass

compromise between limited thickness and robustness

→ 16 strips: 100 cm x 2 cm

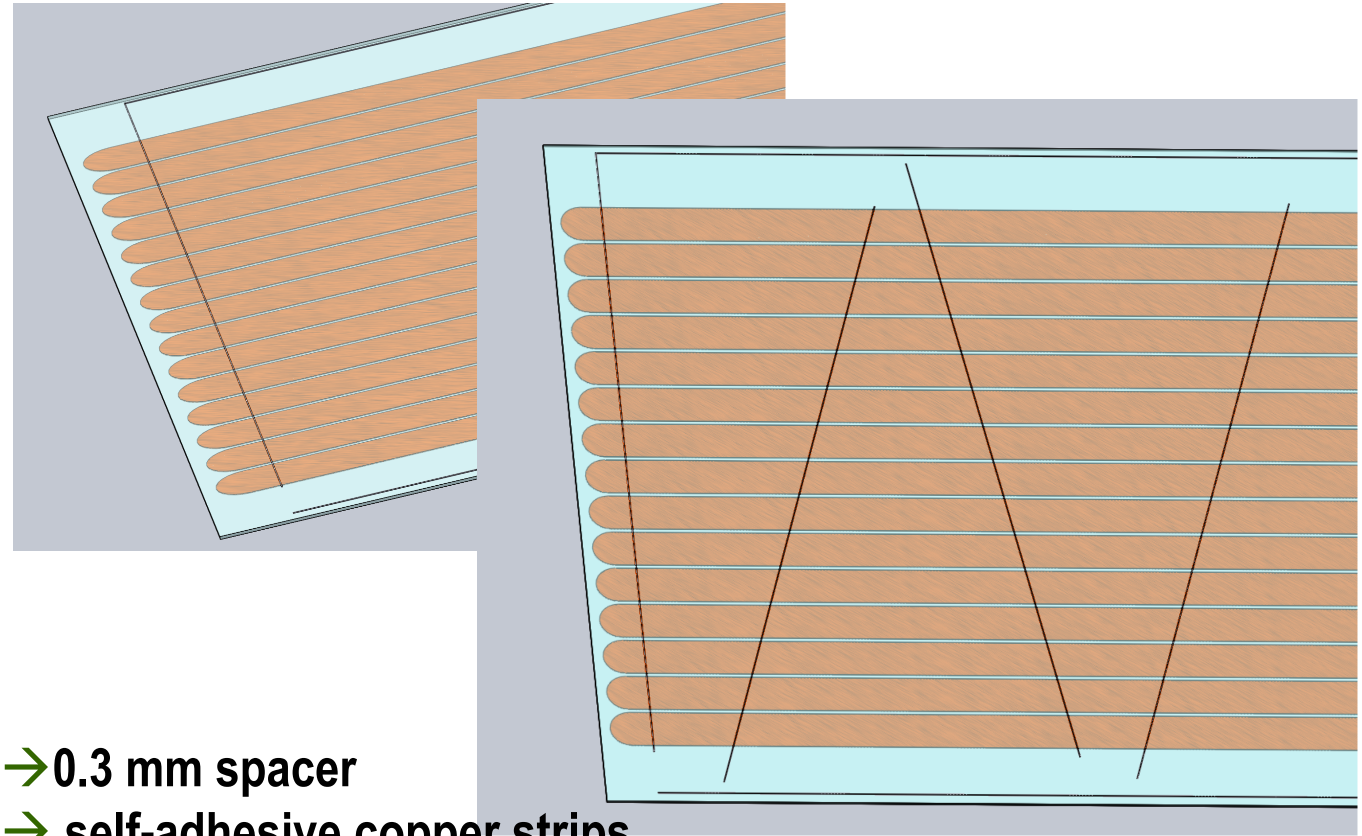
22 mm pitch

→ guard-strips

→ 0.3 mm spacer
→ self-adhesive copper strips
→ soda-lime glass

RPC design and construction of iToF

✓ sealed glass core



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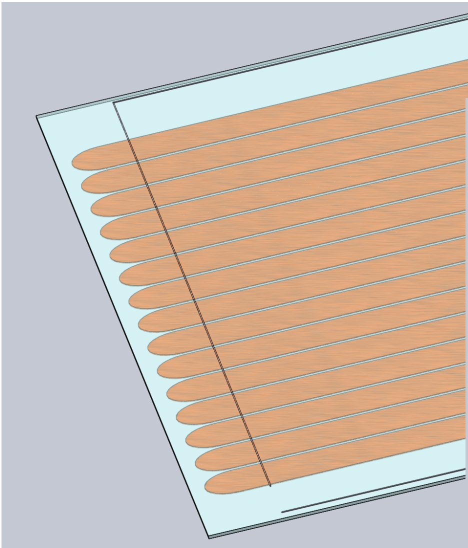

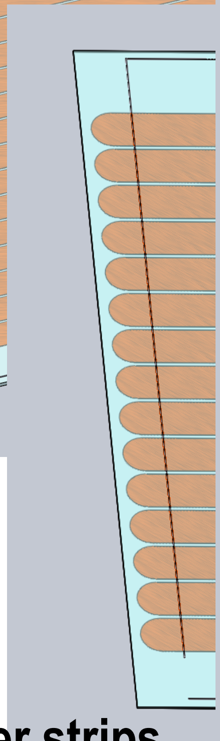

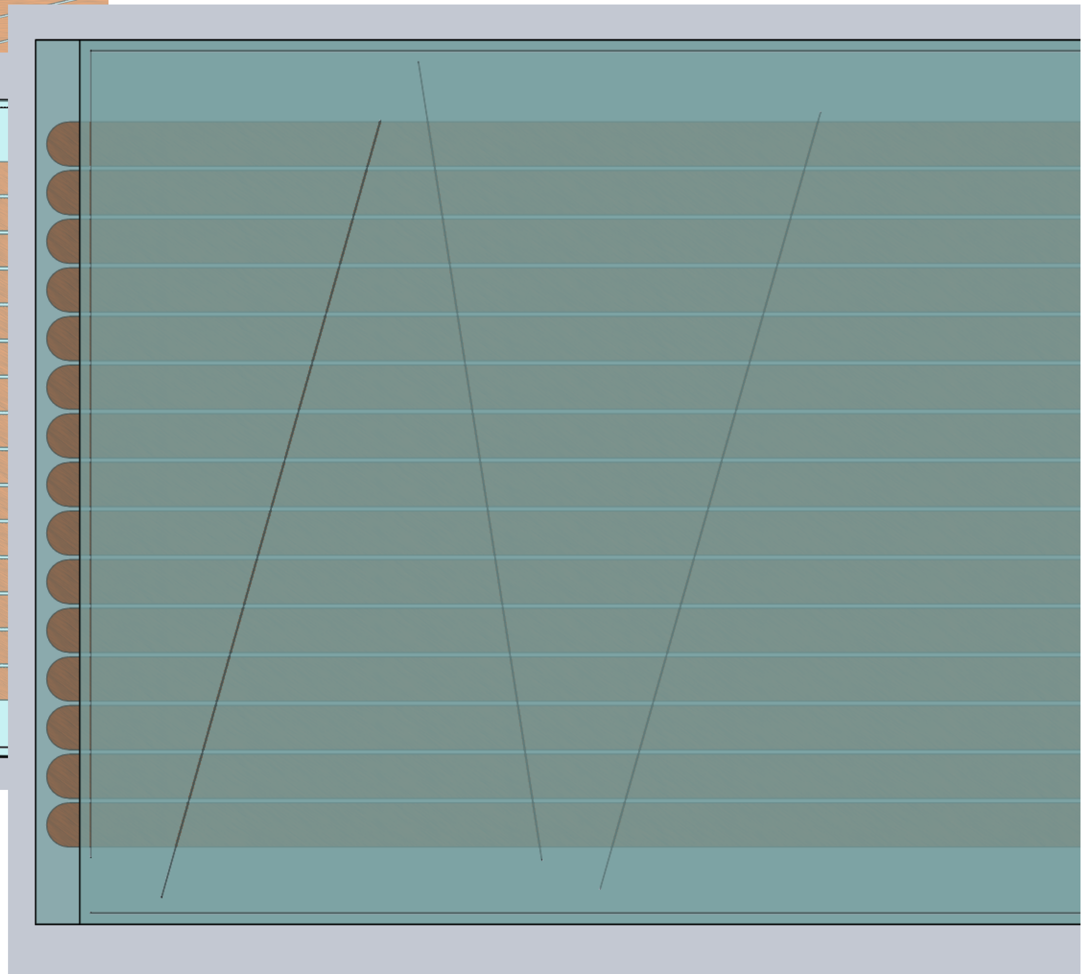

→0.3 mm spacer
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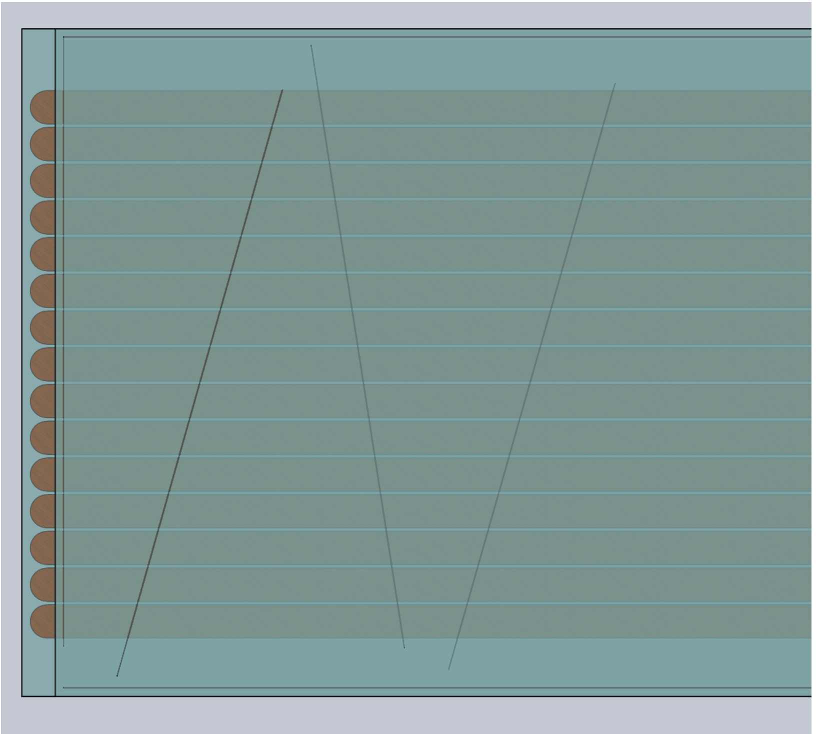
RPC design and construction of iToF

✓ **sealed glass core: gas injection ?**



RPC design and construction of iToF

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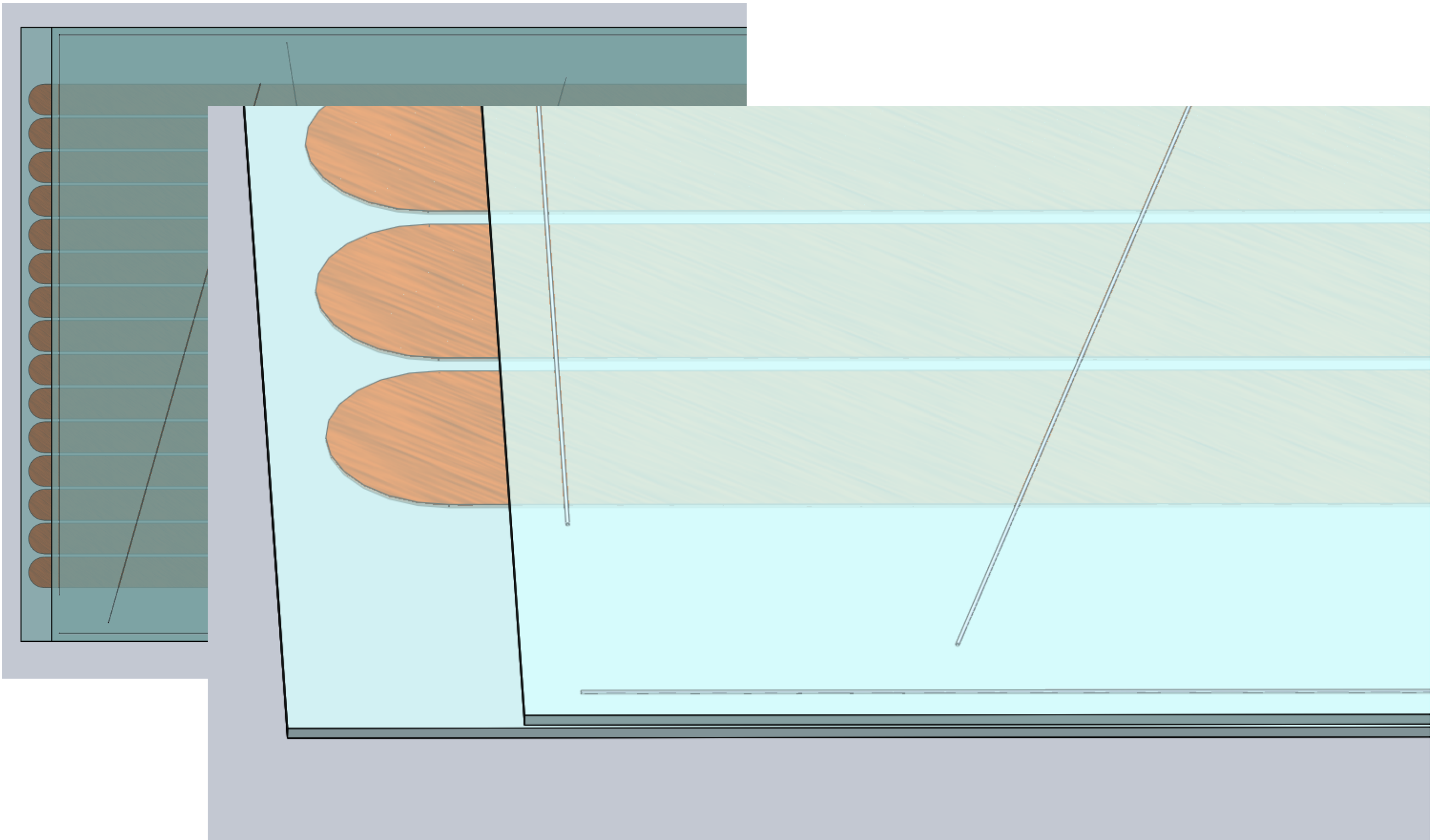
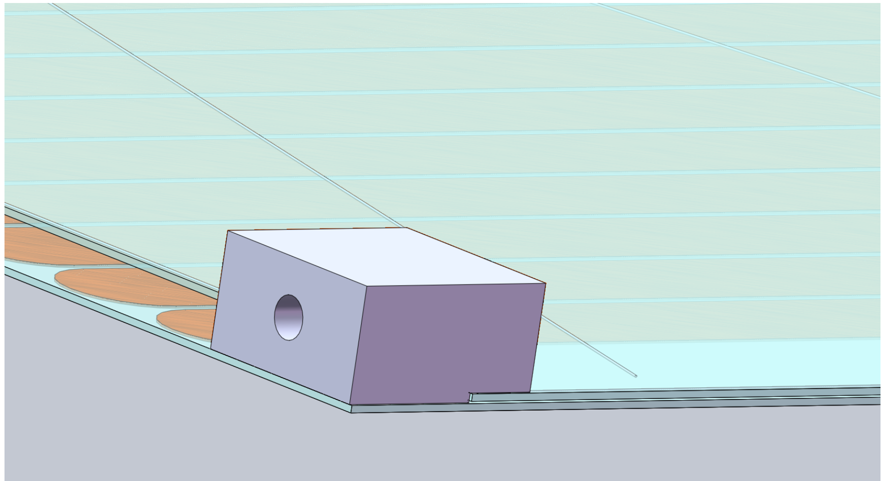


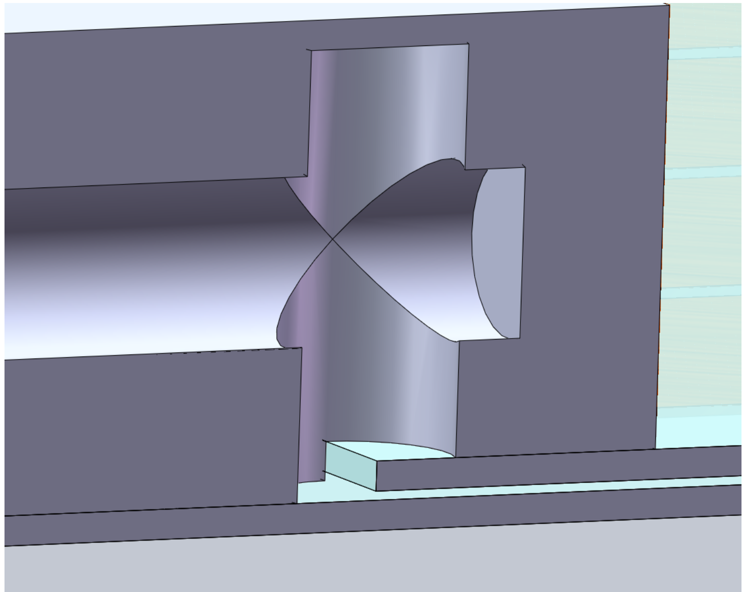
RPC design and construction of iToF

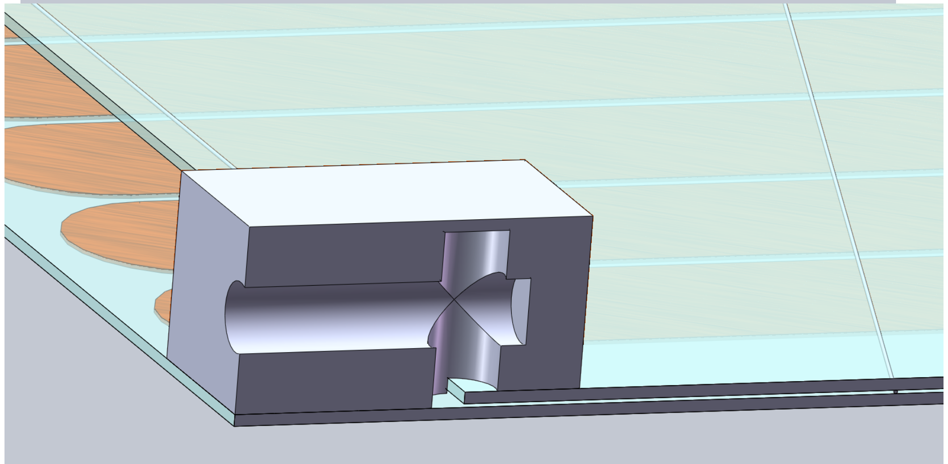
✓ **sealed glass core: gas injection ?**

→ **simple & robust solution**

connection to commercial pipes

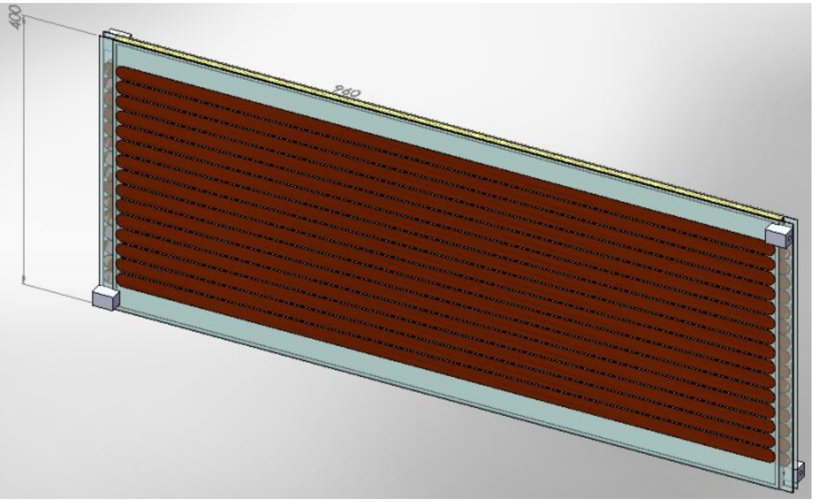






RPC design and construction of iToF

✓ **sealed glass core: gas volume**



Active volume:

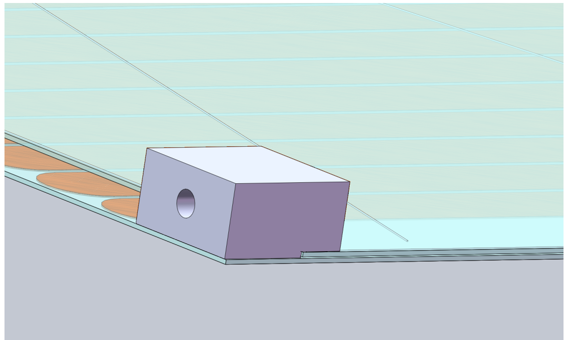
→ 140 cc /gap (active surface: 0.35 m^2)
→ < 4.3 L / detector (10.5 m^2)

Gas renovation:

→ a flux of 22 cc / min will renovate 30% of the total gas of the detector per hour
→ < 32 L of gas per day will be delivered if not recycled
→ < 3.2 L / day of SF_6 (mixture of R134a : SF_6 of 9:1)

Control:

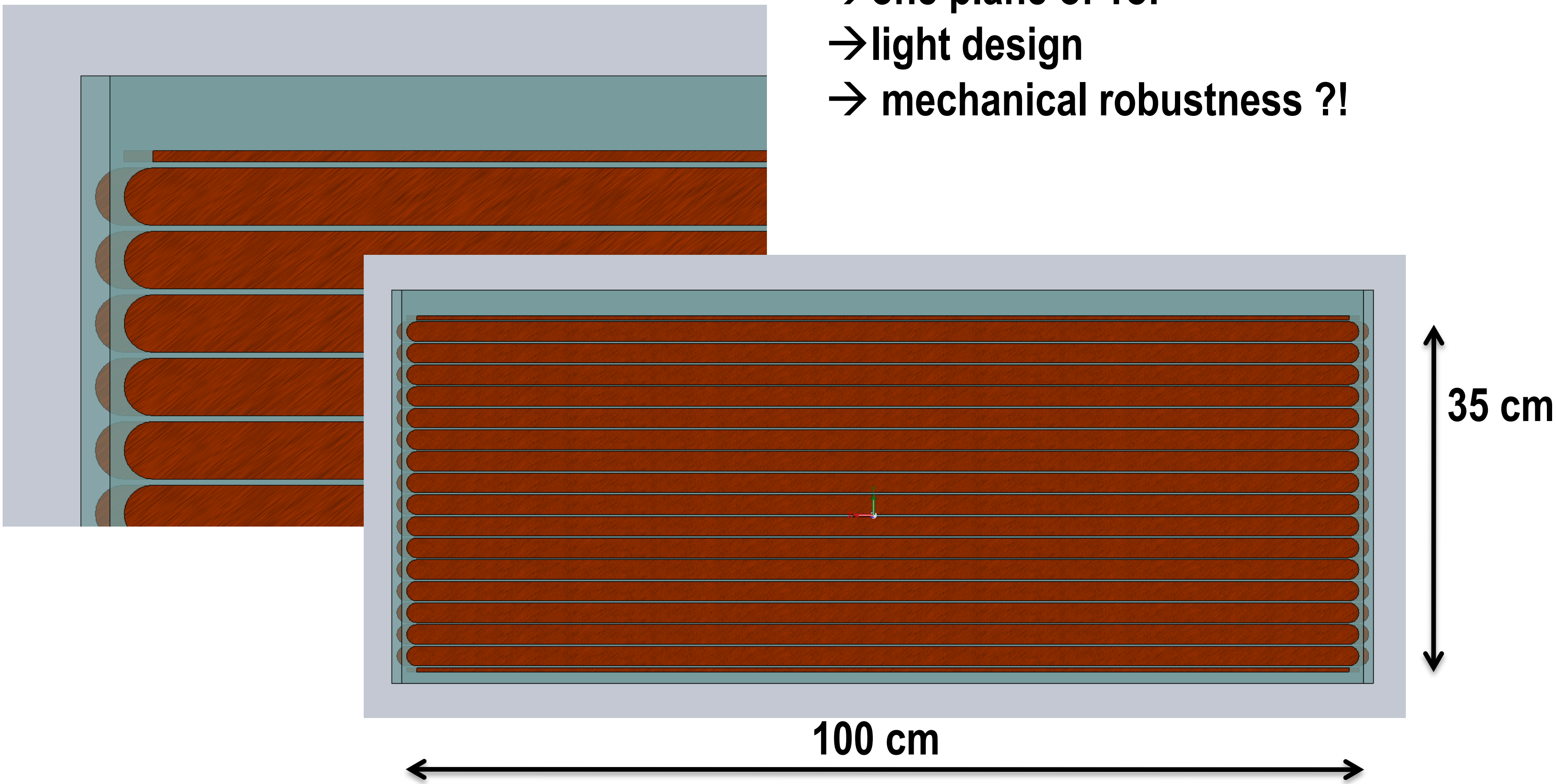
→ oxygen and humidity content
→ volumen flow: crash risk
→ pressure of injection : crash risk



RPC design and construction of iToF

✓ module: single core ?

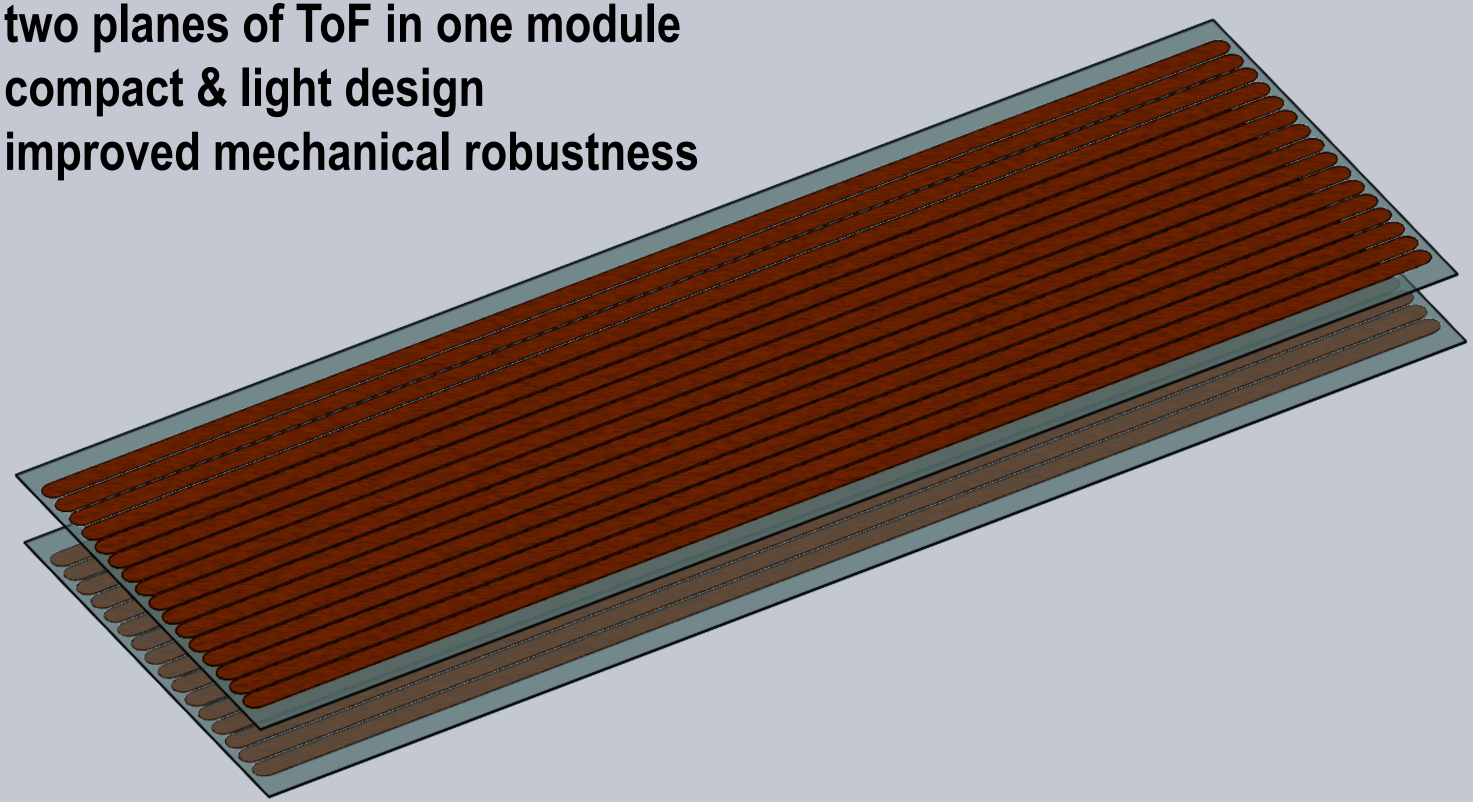
→one plane of ToF
→light design
→ mechanical robustness ?!



RPC design and construction of iToF

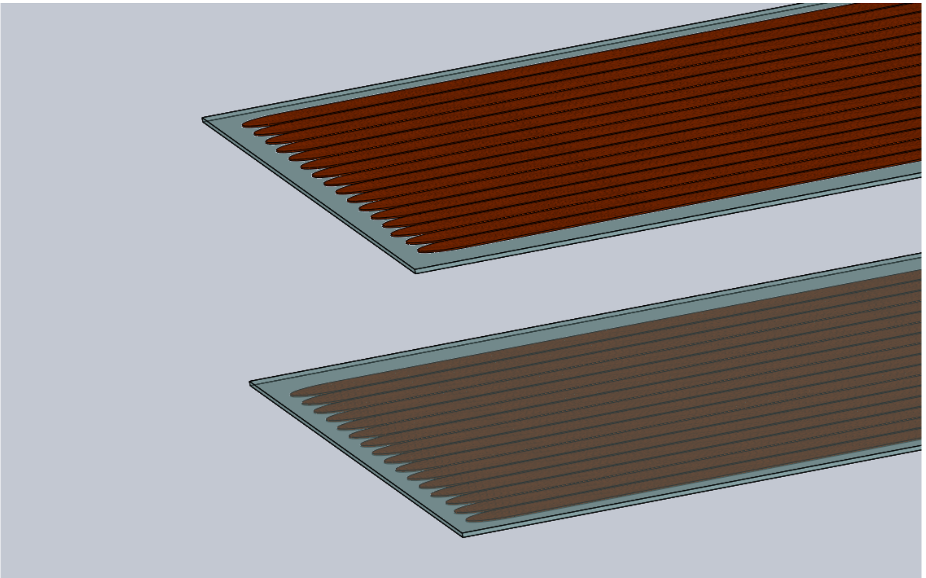
✓ **module: paired cores ?**

→ two planes of ToF in one module
→ compact & light design
→ improved mechanical robustness



RPC design and construction of iToF

✓ **module: paired cores**



RPC design and construction of iToF

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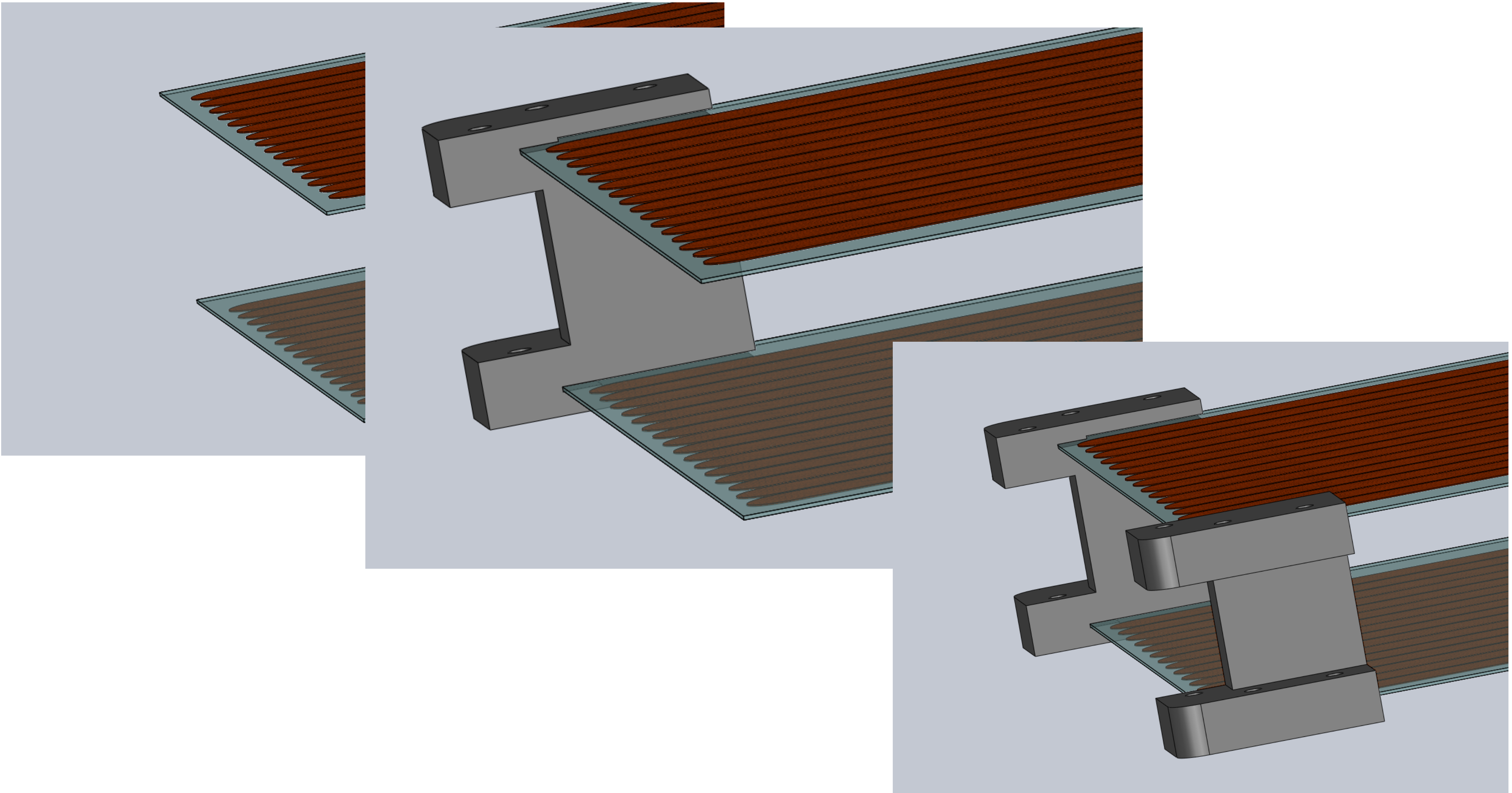

RPC design and construction of iToF

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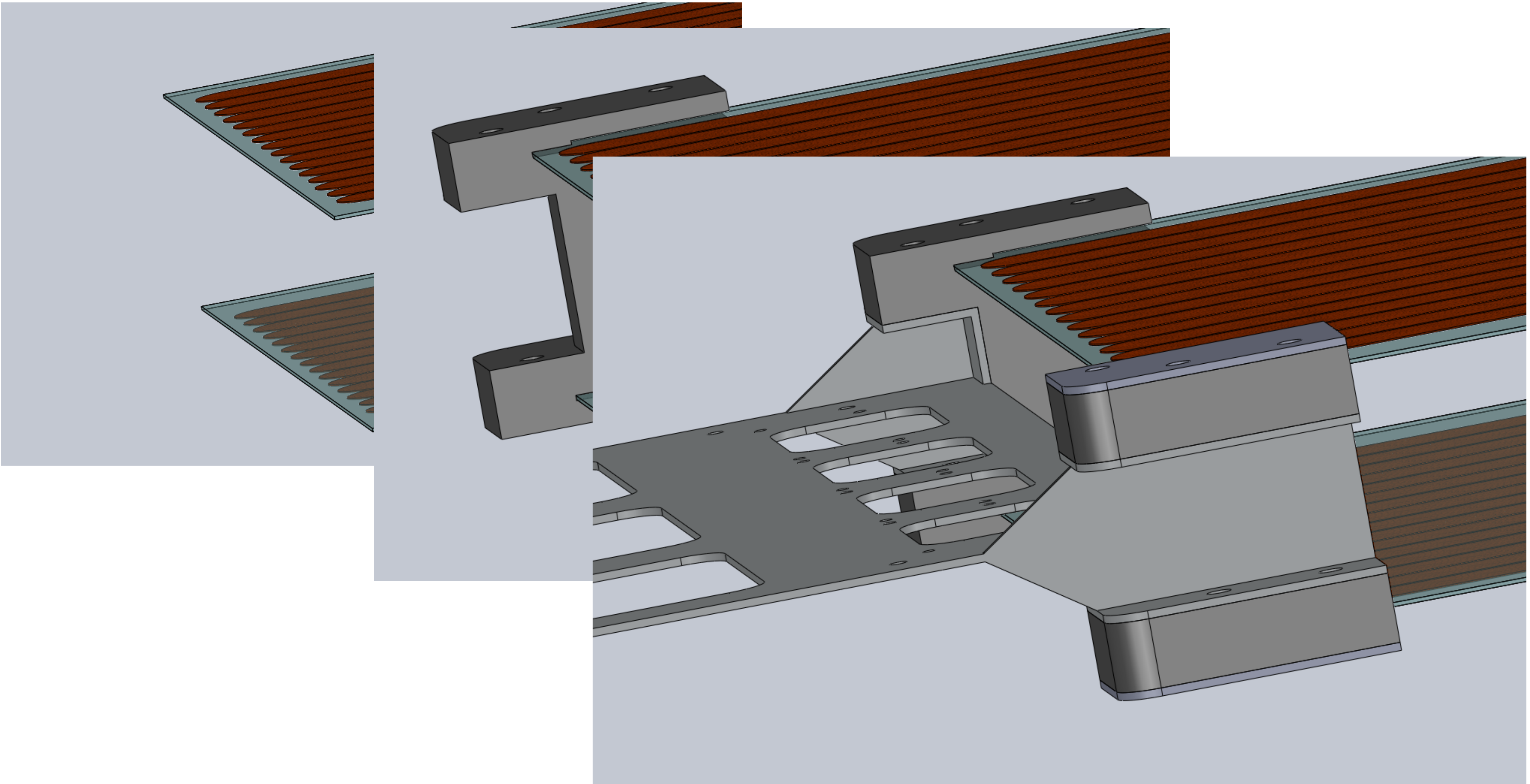
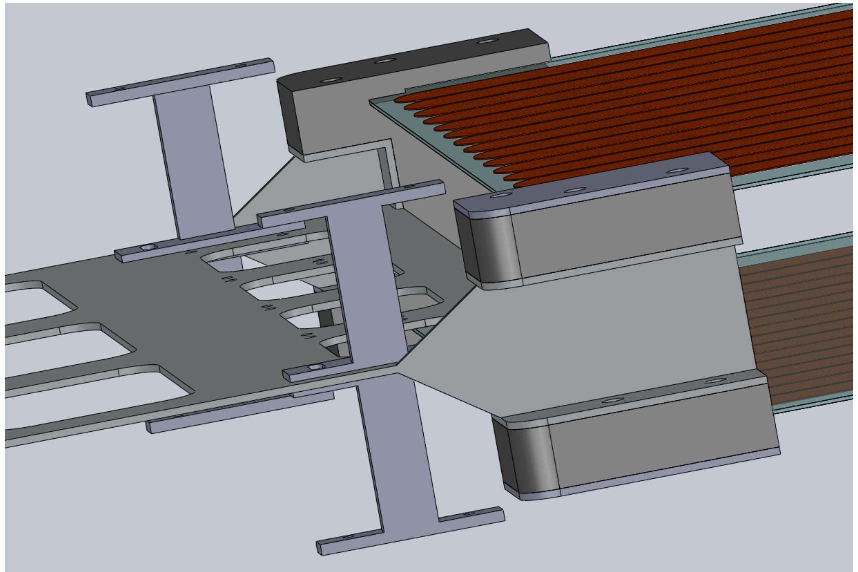


RPC design and construction of iToF

✓ **module: paired cores**

what about VFEE electronics ?



RPC design and construction of iToF

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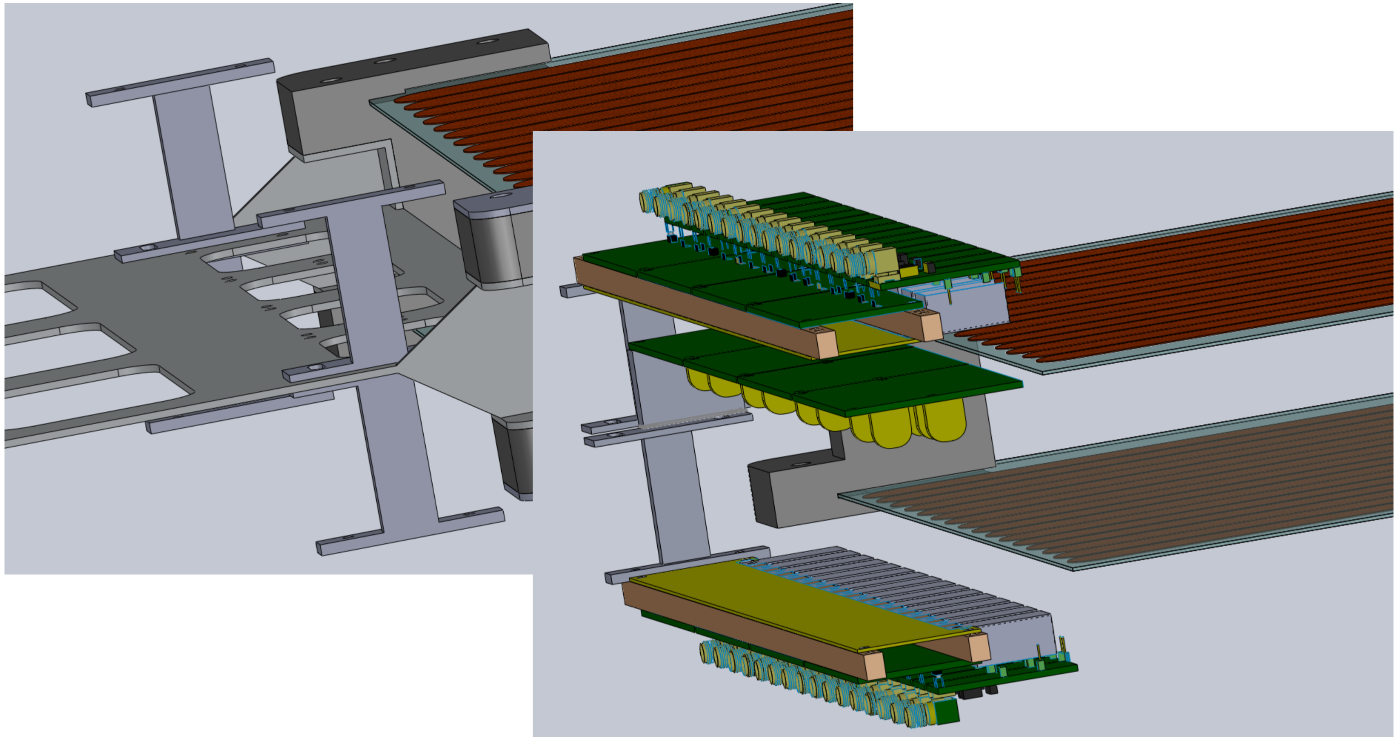

RPC design and construction of iToF

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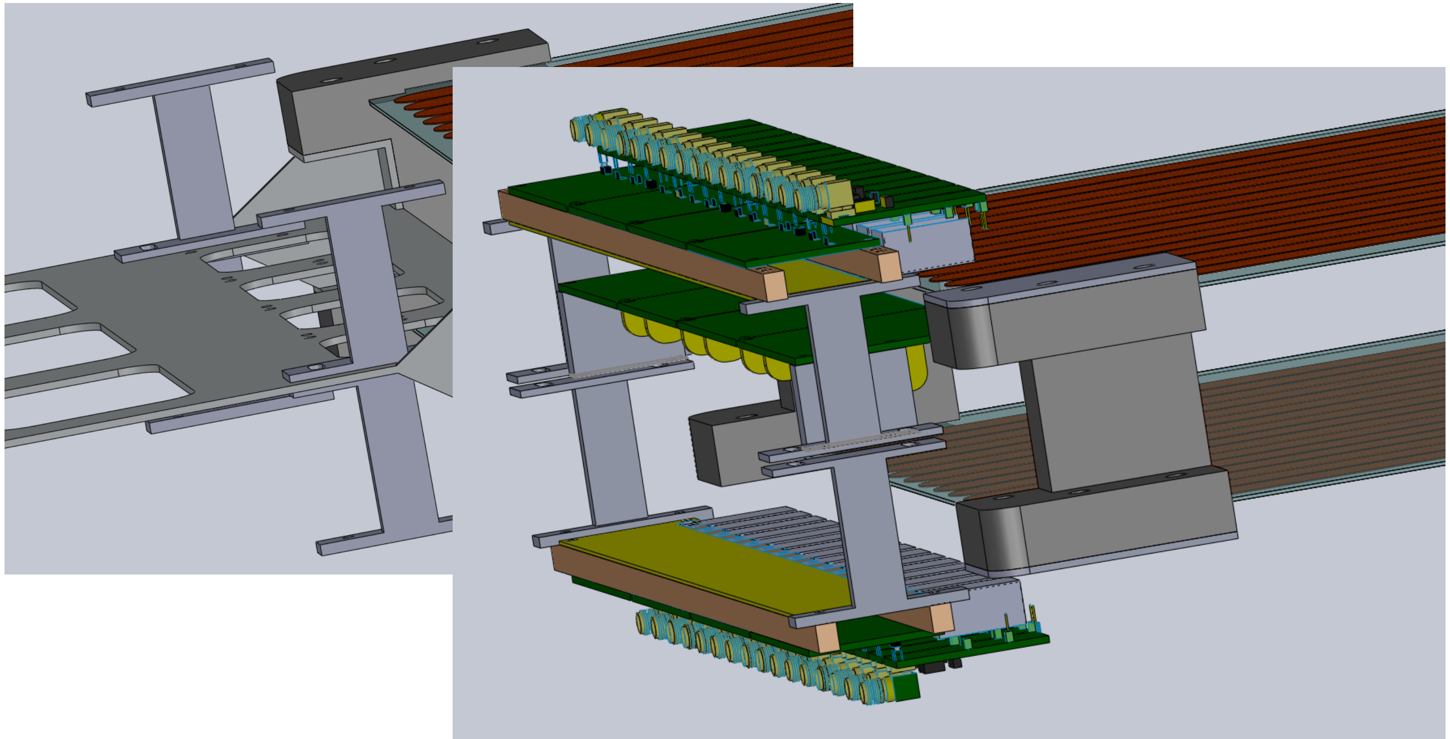

RPC design and construction of iToF

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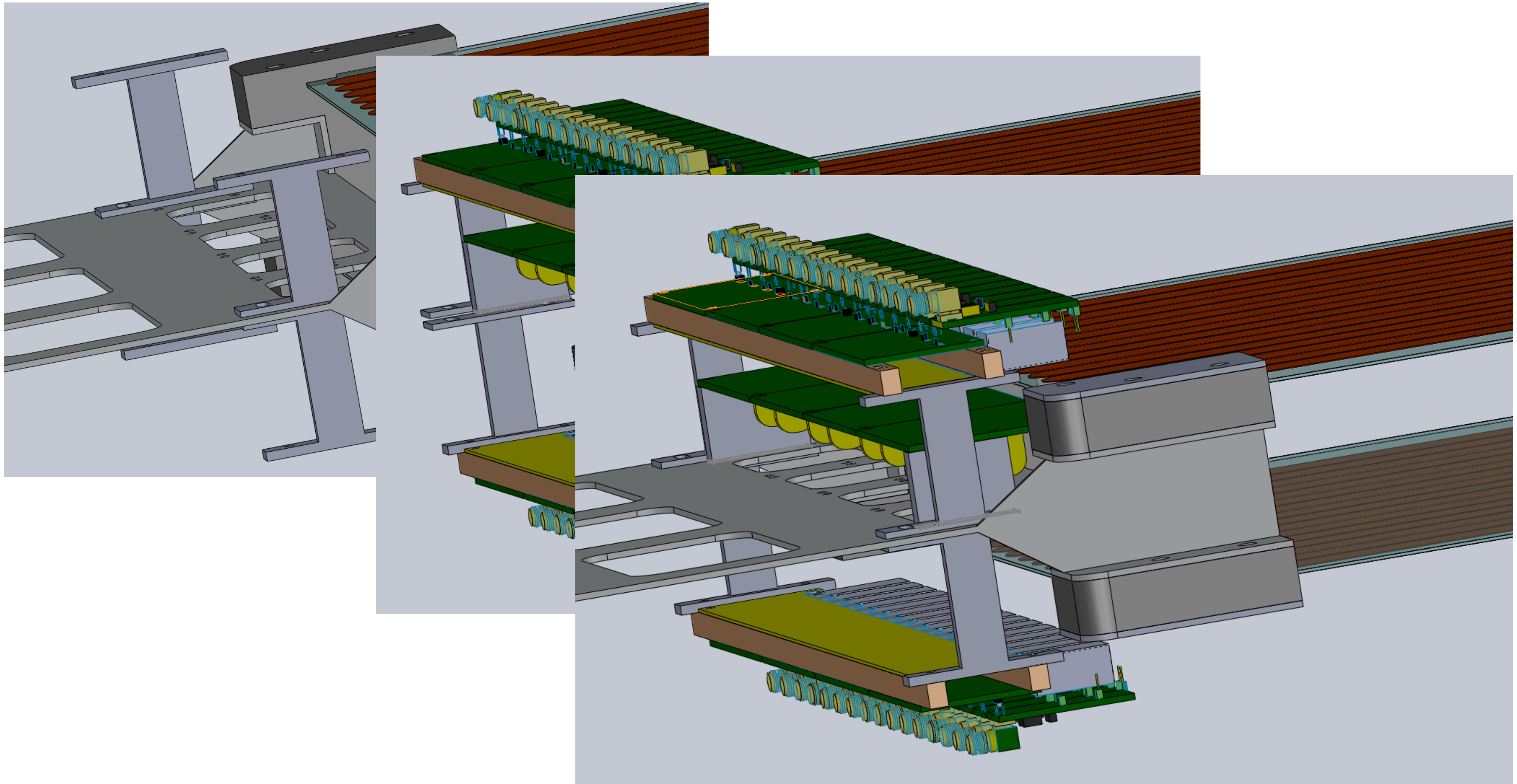
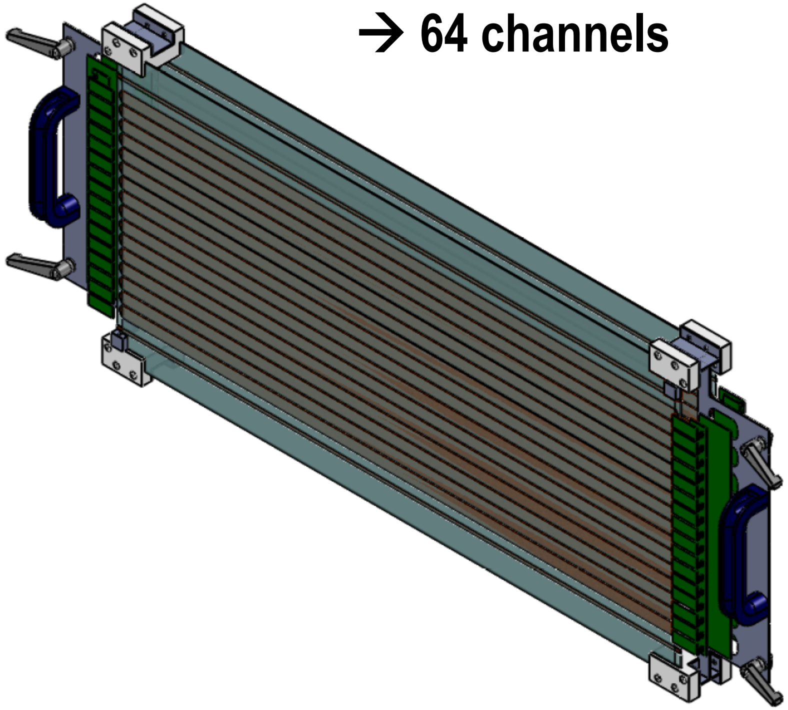


RPC design and construction of iToF

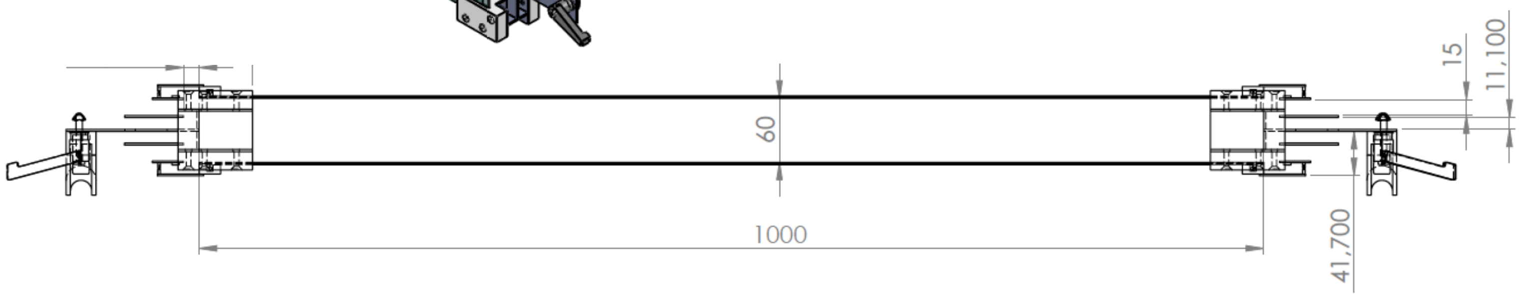
✓ **modules:**

→ compact sandwich with two independent planes of ToF

→ 64 channels

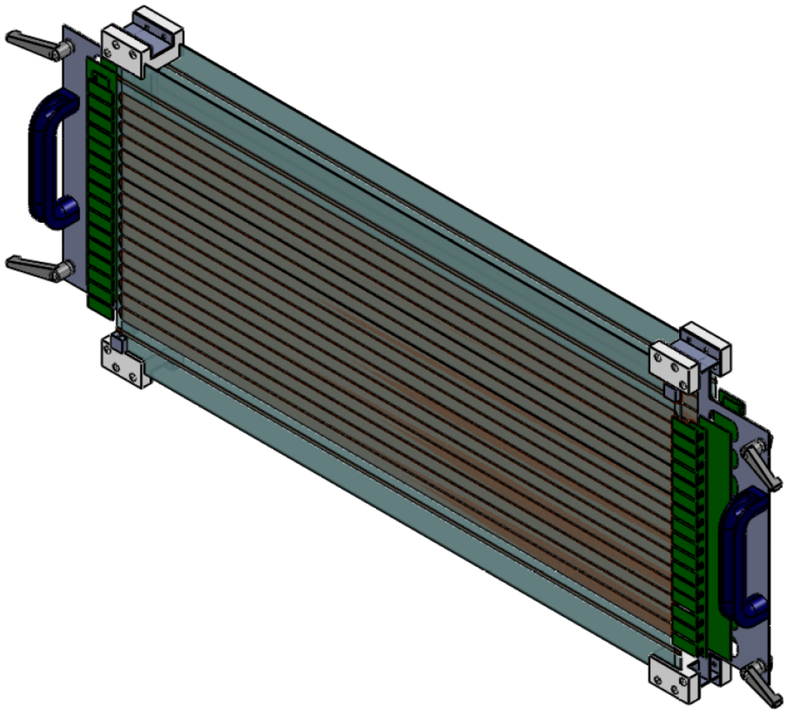


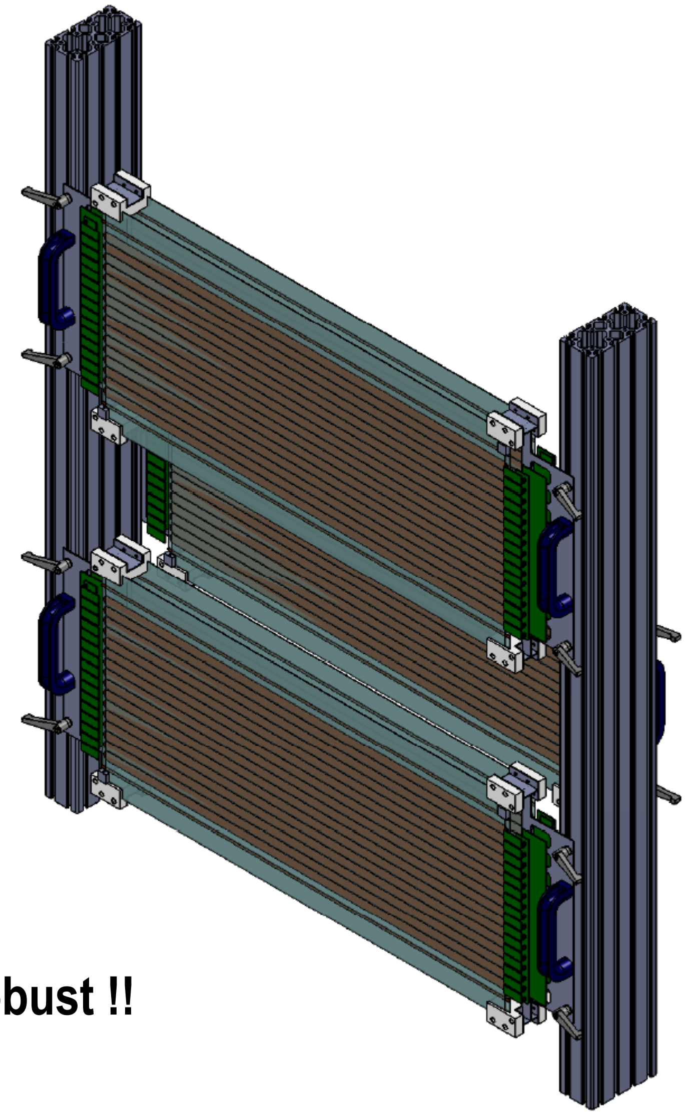
✓ **what about the detector ??**



RPC design and construction of iToF

✓ **modular detector**

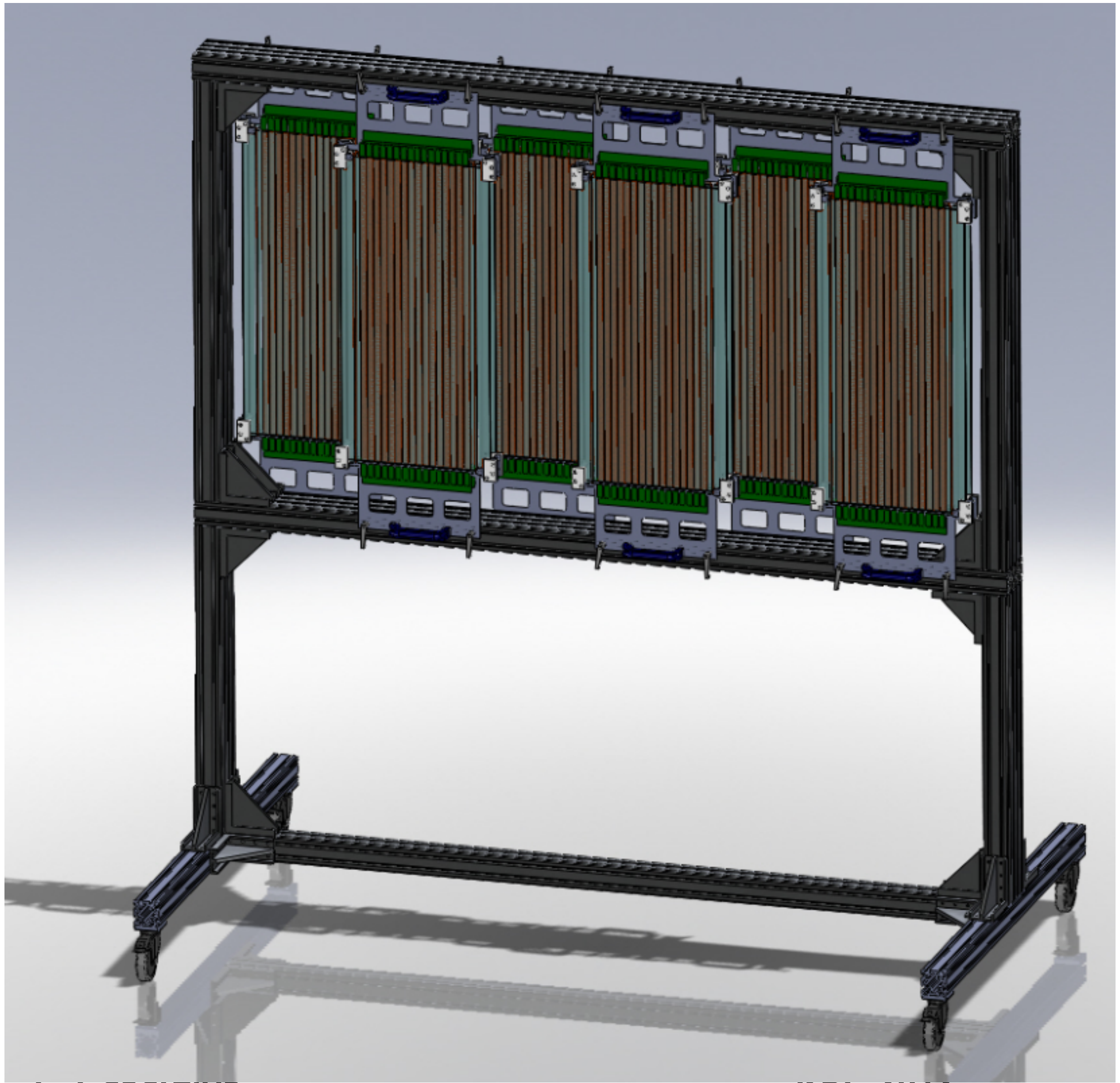


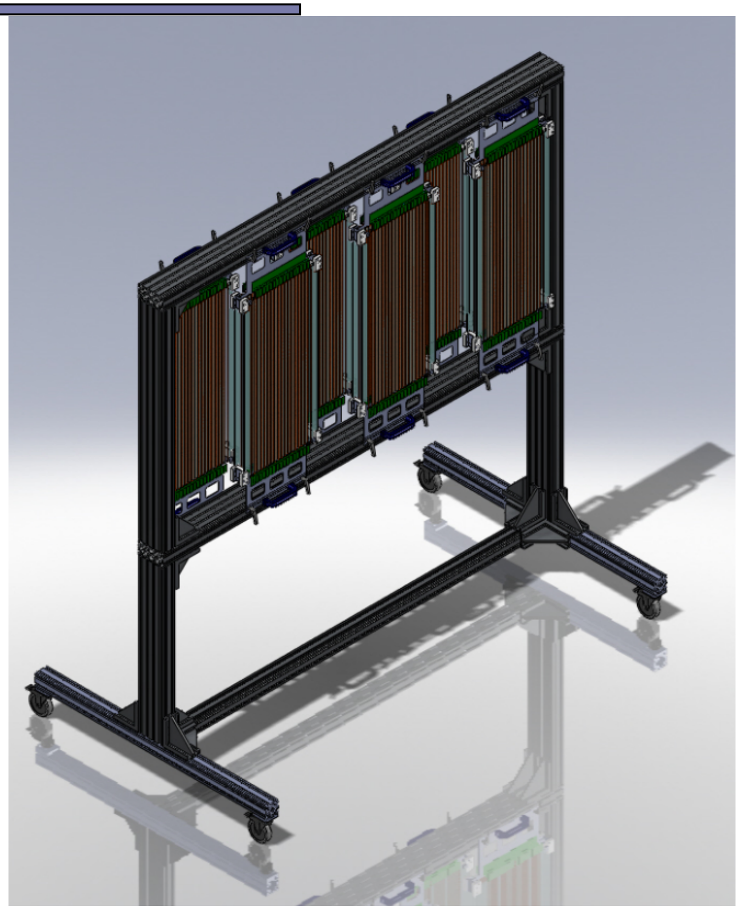


→ **Robust !!**

RPC design and construction of iToF

✓ **modular detector: iToF**





RPC design and construction of iToF

✓ **modular detector:**

what is missing (only in the in figures) ?

vFEE – strip : straight contact point (signal pick-up)

Cables vFEE – FEE (TACQUILA-GSI)

→ Tflex-405 (low-loss) or LMR-240 (Times Microwave)

→ SMA connectors (50 Ohm)

FEE: TACQUILA-GSI

→ 16 #: one board per RPC side: 4 boards per module

→ power-supply centralized. Slow control within R3B frame

HV: standard HV-cable and SHV connectors and splitter boards at RPC level

→ standard HV power supply

→ one HV line per RPC : 16 strips powered together

→ slow control within R3B frame

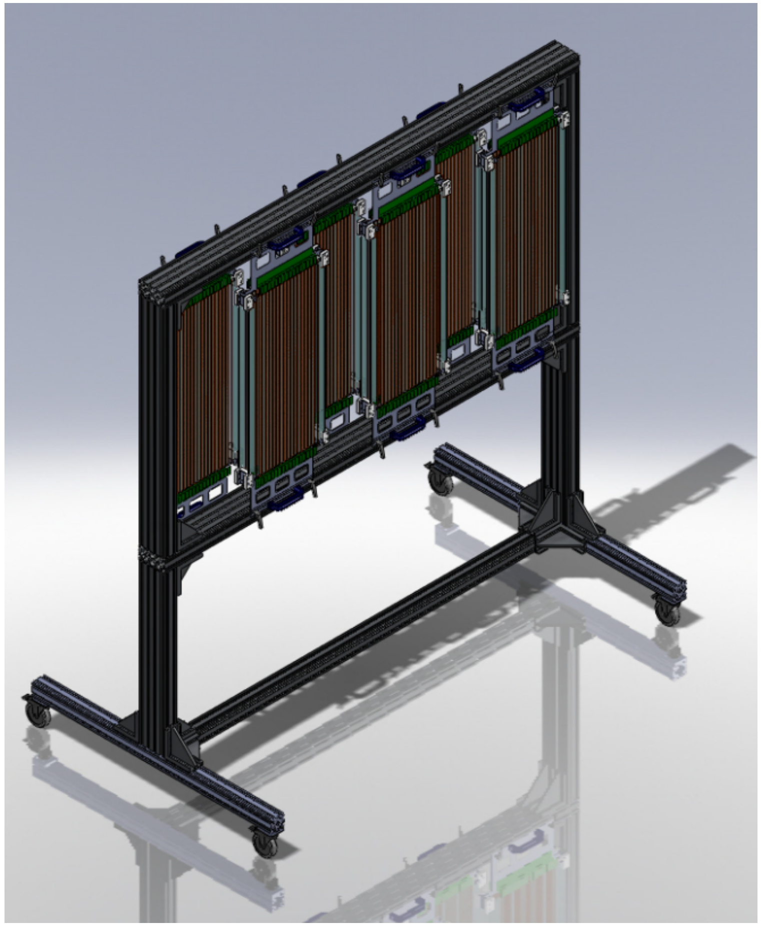
Gas mixing and distribution

→ standard gas mixing unit. 6 and 4 mm diameter pipes. Isolated modules.

→ oxygen and humidity control

RPC design and construction of iToF

✓ **construction ?**



RPC design and construction of iToF

✓ **construction ?**

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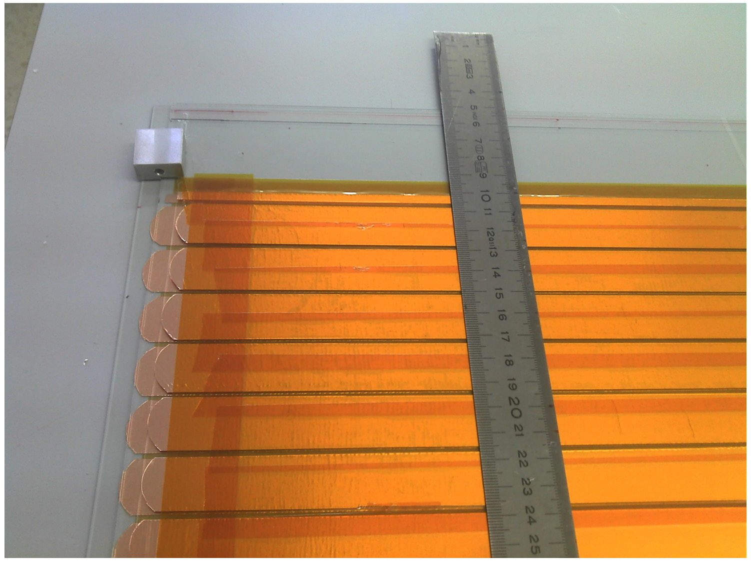
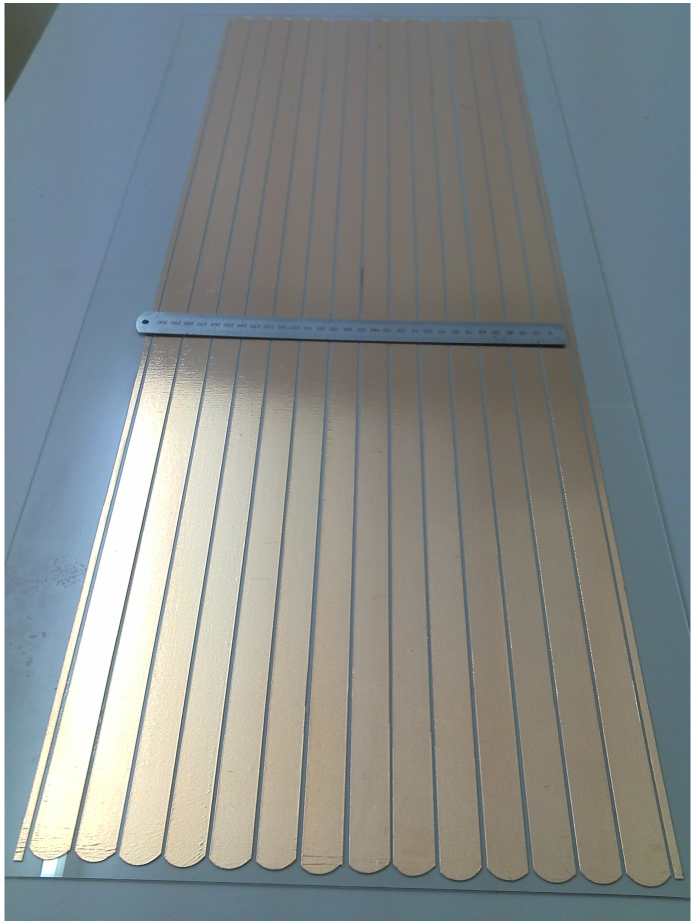


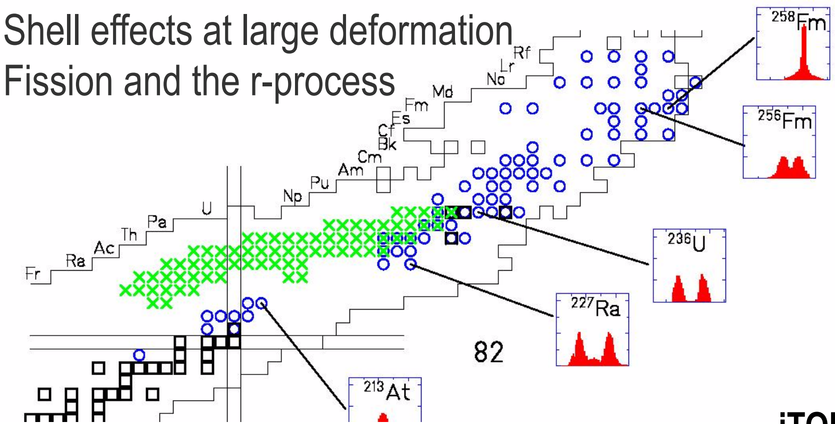


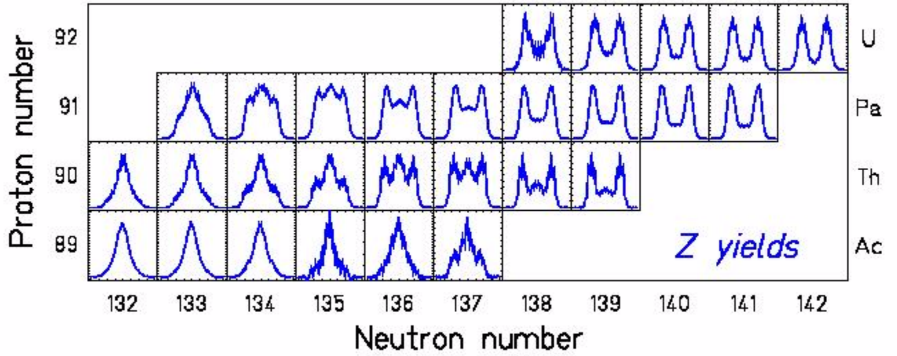
Plans for 2012

Fission studies with radioactive nuclear beams

Experiment S312-GSI: spokespersons: J. Benlliure and J. Taieb

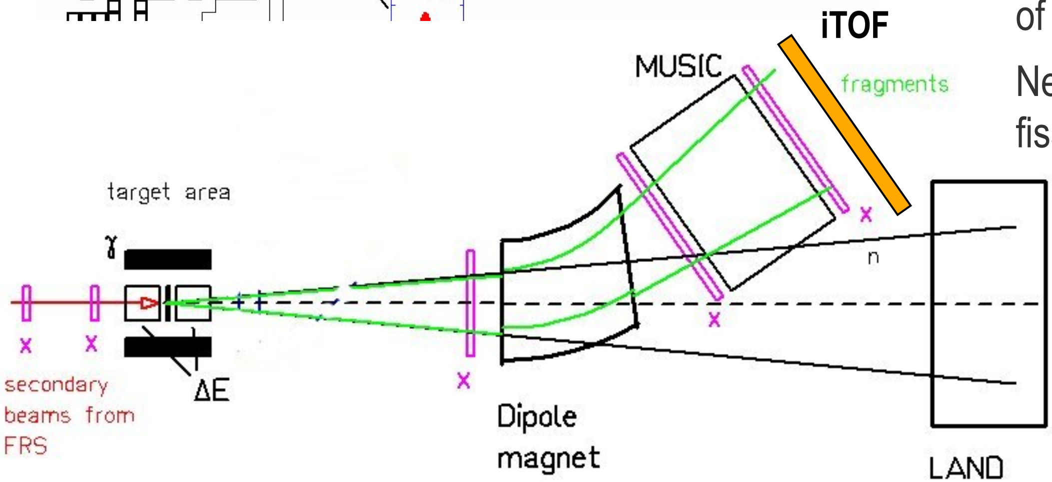
- Shell effects at large deformation
- Fission and the r-process





Previous experiment in 1996, only Z identification of the fission fragments.

New experiment in 2011, A and Z identification of fission fragments using **iTOF**



Technical design of the RPC-based ToF wall

iTOF

for the R3B experiment at FAIR

E. Casarejos , Y. Ayyad, C. Paradela, J. Benlliure, I. Durán,

J.L. Rodriguez, M. López-Lago, A. Segade, J.-A. Vilán

Universidade de Santiago de Compostela (Spain)

Universidade de Vigo (Spain)