QA/QC during construction

Final Design Review
9th November 2015

Fabien Jeanneau on behalf of MM community

Preliminary remarks

- Centralized order at Cern:
  - Check compliance of delivery (except for FR4 sheets for instance)
  - Dispatch in construction sites and complete check locally
  - Time needed to garantee replacement in case of non-conformity

- Requirements:
  - Expressed in absolute tolerance and nominal value
  - Mean value, r.m.s., min and max are needed to evaluate the quality of a component and for acceptance/rejection decision in non-conformity procedure

Parameters

- Geometrical
  - Thickness (boards, panels, frames, inserts)
  - Planarity (panels, quadruplets)
  - Position, alignment (boards, strips, panel)
- Operational
  - Electrical (HV, grounding, insulation)
  - Gas tightness
  - Module validation (see presentation by P. Iengo)

FR4 sheets thickness

Parameter	Requirement	# measurements
Thickness	± 50 µm	~10

- Nominal thickness
  - Central drift and RO boards:
    - copper clad on one side
    - 0.5 mm + 0.17 µm
  - Outer skin of outer drift: raw FR4 sheet (0.5mm)

- Tool: digital thickness caliper

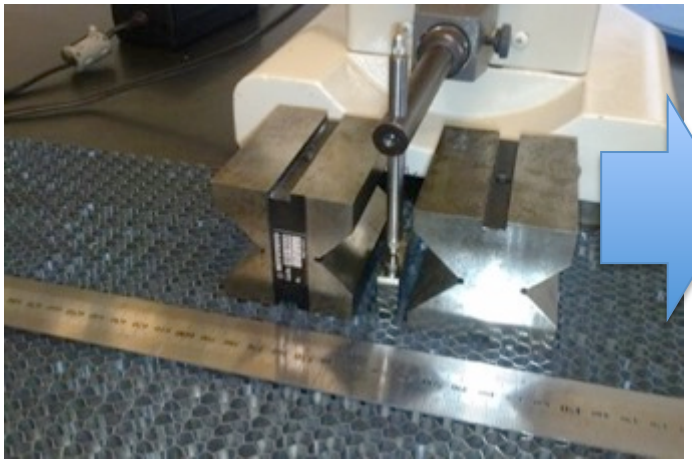
- Method: Measurements on 10 points on the edge of the sheet.

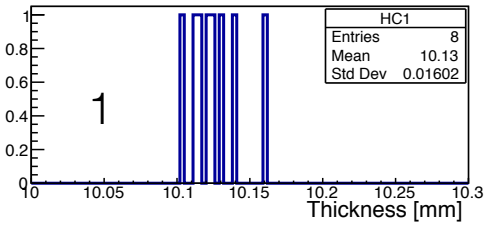
- 10% of batch for module 0 have been measure:
  - Thickness variations within a sheet are below 25 µm, with an rms of 5–8 µm

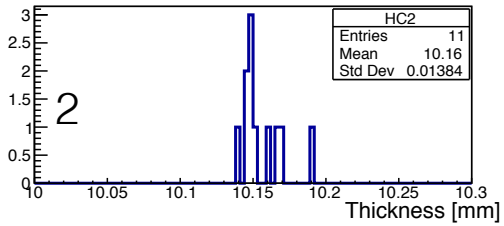
Honeycomb foils

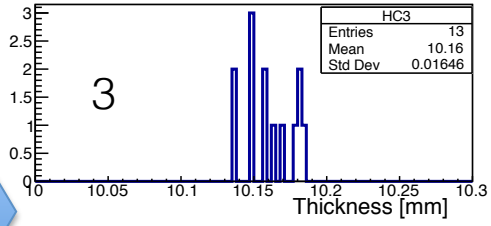
Parameter	Requirement	# measurements
Thickness	10.1 mm ±60 µm	~50

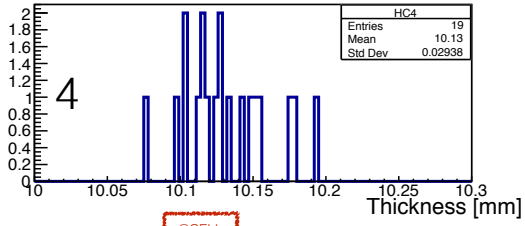
- Tools
  - Height gauge
  - Depth micrometer
  - CMM

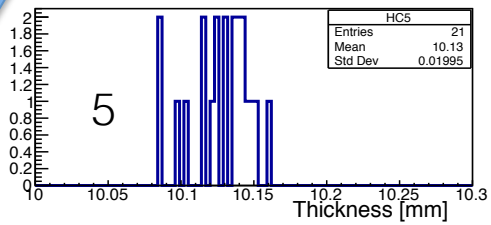


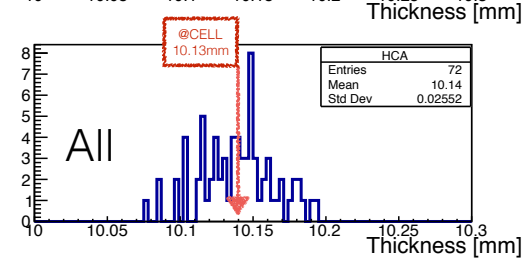












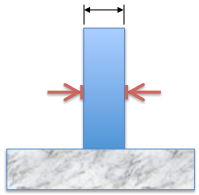
- Methods
  - Foils sticked on granite table with weight or by vacuum
  - Before cutting (delivery):
    - measurements are done in industry
    - Preliminary checks with a thickness caliper

Frames

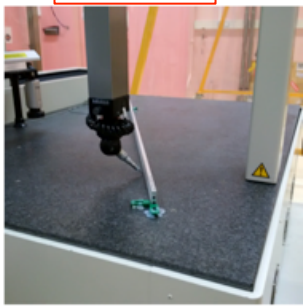
Parameter	Requirements			# Measurements
	Type 1, 2.1, 4, 5	Type 3 (Mesh)	Type 6 (Gas gap)	
Thickness	10 mm ± 60 µm	5.06 ± 25 µm	5.17 ± 30 µm	~80 for 1m long

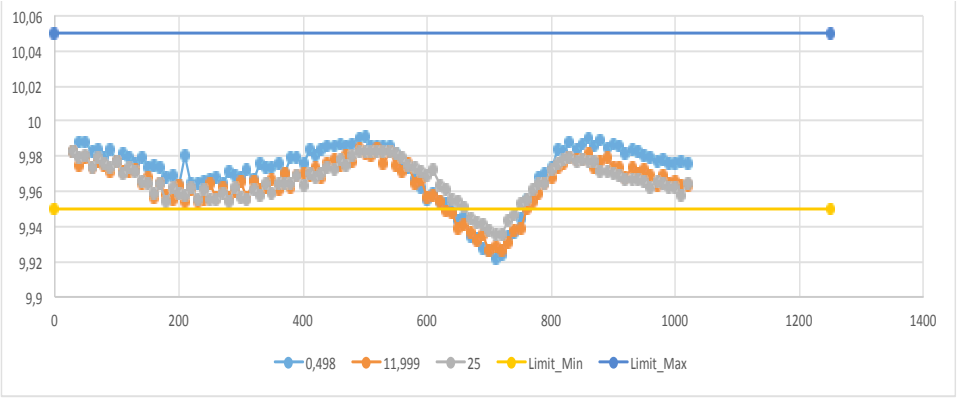
Tools

- CMM
- Vertical gauge or ruler
- Limbo



Saclay

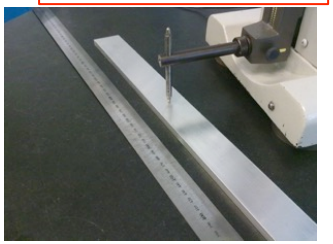




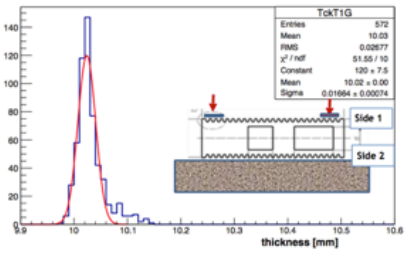
Methods

- Before machining: sampling 10%
- After machining: each frame
- Pitch of measurement: 5 cm

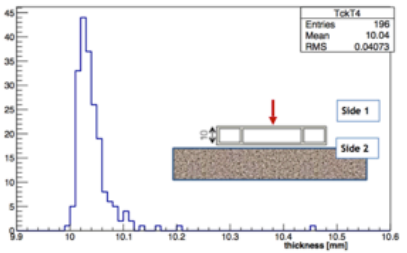
INFN-Roma1



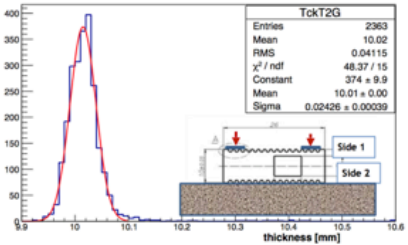
Type 1



Type 4



Type 2



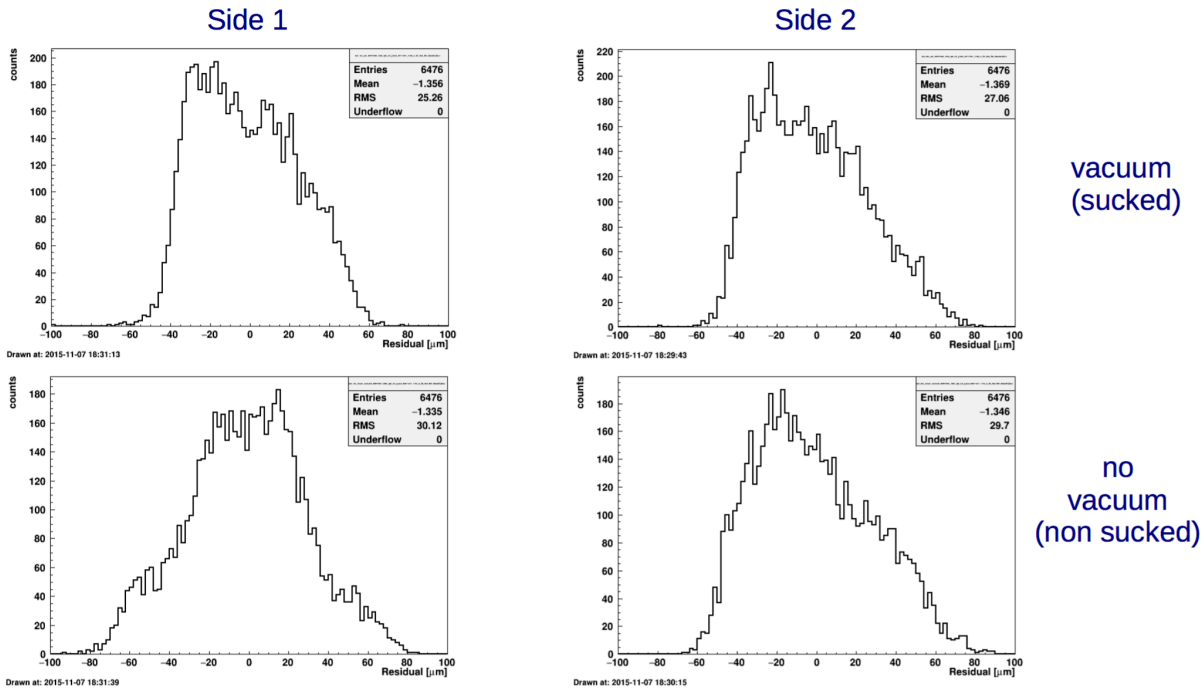
Frame	MeanThickness (mm)	RMS (mm)
1	10.03	0.03
2	10.02	0.04
4	10.04	0.04

Panel thickness and planarity

Parameter	Requirement	# measurements
Thickness	- RO panel: **11.7 mm** - Drift panel (vacuum bag): **11.1 mm** - Drift panel (stiffback): **11.3 mm**	
Planarity	**± 110 μm** w.r.t. nominal thickness	~2000/side

- Tools
  - CMM
  - Laser-tracker
  - Probe-ruler
- Methods
  - Panel are measured on a granite table every 10 or 20 cm, on both sides
  - Combined measurement:
    - Vacuum → thickness
    - Free (under its ow weight) → planarity (global shape)

RMS: deviation from parallel plane to granite table (no tilt of fit-plane)



all: RMS < 30 μm Max-Min: < 150μm

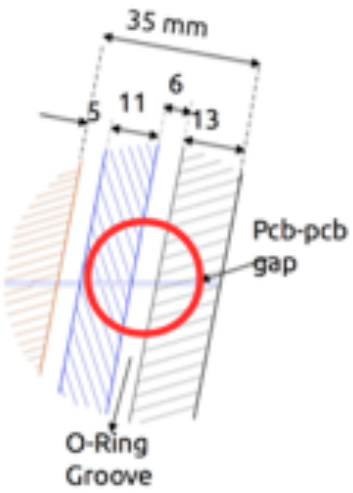
BMBF

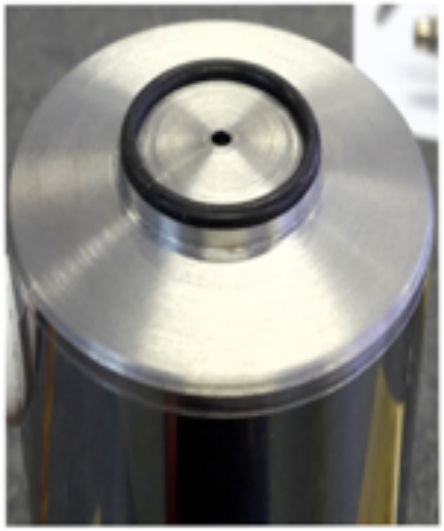
Gas tightness

Parameter	Requirement
Gas leak rate	< 10^{-6} bar L/s (10^{-4} vol/min)
Flow rate loss	< 10^{-5} l/s

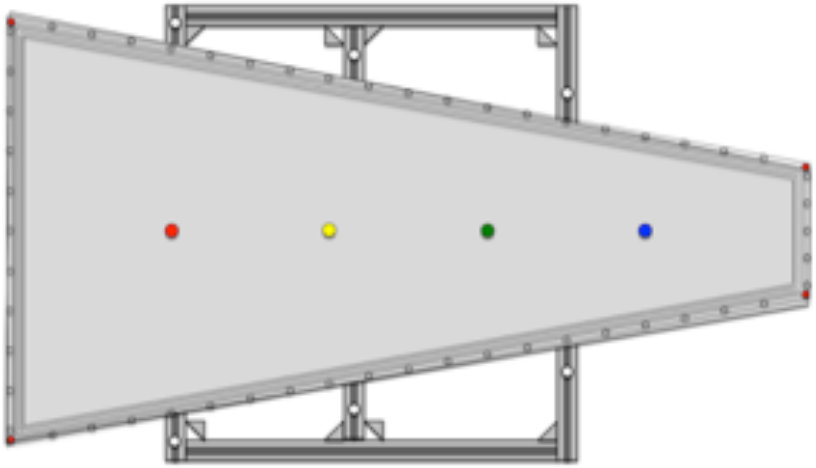
- Tools: Local detector or vessel based on a differential pressure sensor

Local tightness check (at the junction between 2 boards)



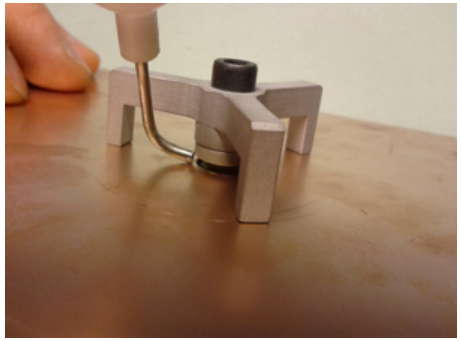


Global gas tightness check (with a vessel)



Drift panel completion

- Mechanical checks
  - Mesh-frame height after fixation: **5.06 mm ± 45 µm**
  - Drift spacer (IC): **5 mm ± 45 µm**
  - Tool/method: height or depth caliper

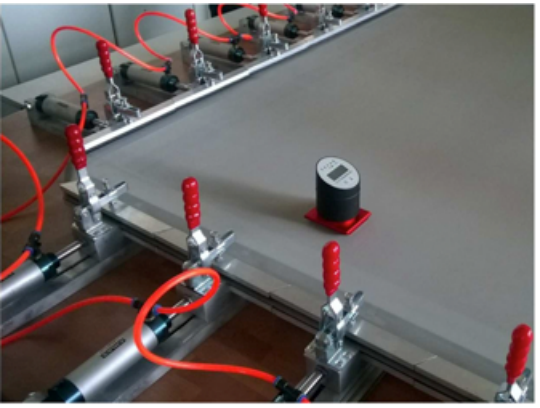


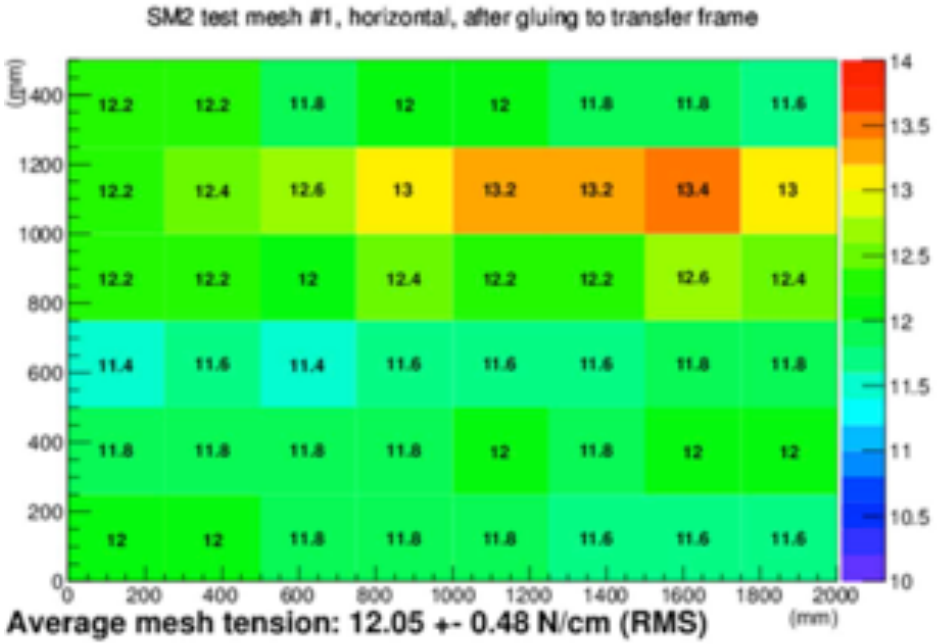
- Electrical and grounding tests
  - Mesh frame:
    - Shortcuts with cathode
    - Grounding → **R < 0.1 Ohm** (to be checked also for HC and frames)
  - Cathode:
    - HV contact, continuity
    - Insulation: **500 V / <1 nA**
  - Tool/ method: Ohmmeter and power supply

Mesh

Parameter	Requirement	# measurements
Tension	nominal between 7 and 10 N/cm	50 - 100

- QC of mesh is detailed in ATL-M-CD-0001 v.1
- Tool : commercial tensometer (e.g. SEFAR tensocheck 100)





Quadruplets

- Gas tightness: same requirement than for panels
  - **Leak rate <10^{-6} bar L/s**
  - **Flow rate loss < 10^{-5} l/s**

- Planarity: same requirement than for panels
  - **± 110 µm** w.r.t. nominal thickness
  - Nominal thickness → **77 < T < 77.**6 (stiffback vs vacuum bag)

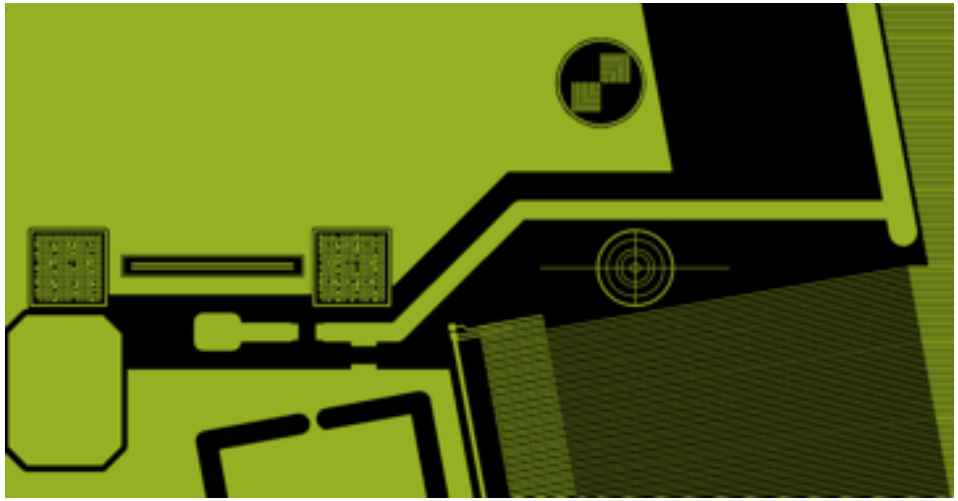
- HV tests:
  - Resistive strips
    - **At 800 V in air, i < 40 nA/m^2 (affected by humidity)**
    - **At 580 V in standard gas mixture, i < 1 nA/m^2**
  - Cathode
    - **i=0 nA @ 1000V in air**

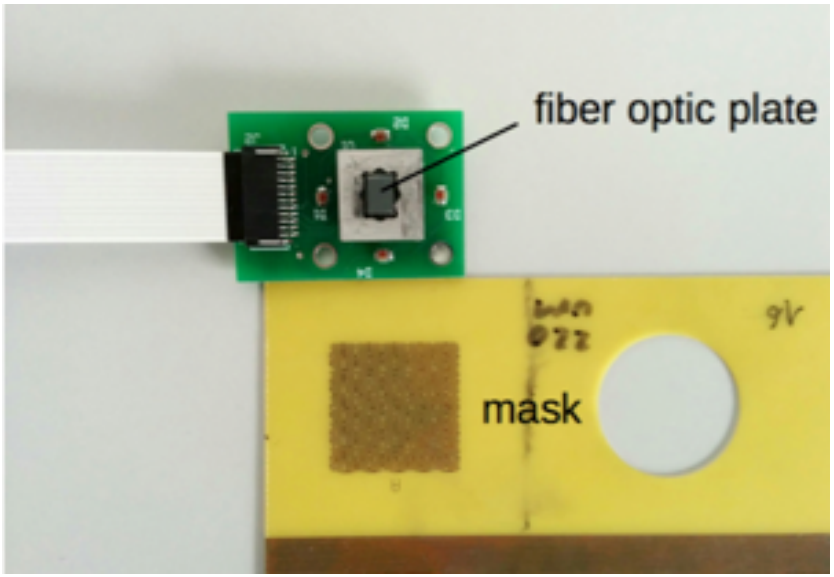
Alignment checks

Parameter	Requirement
Strips on one side	**±40 µm (with constant allowed displacement ±20 µm)**
Strips relative positioning side-to-side	**± 60 µm (with constant allowed displacement ±35 µm)**
Strips relative positioning panel-to-panel	**± 60 µm (with constant allowed displacement ±35 µm)**
2 RO panels relative position	**± 20 µm (perpendicularity of alignment pin)**

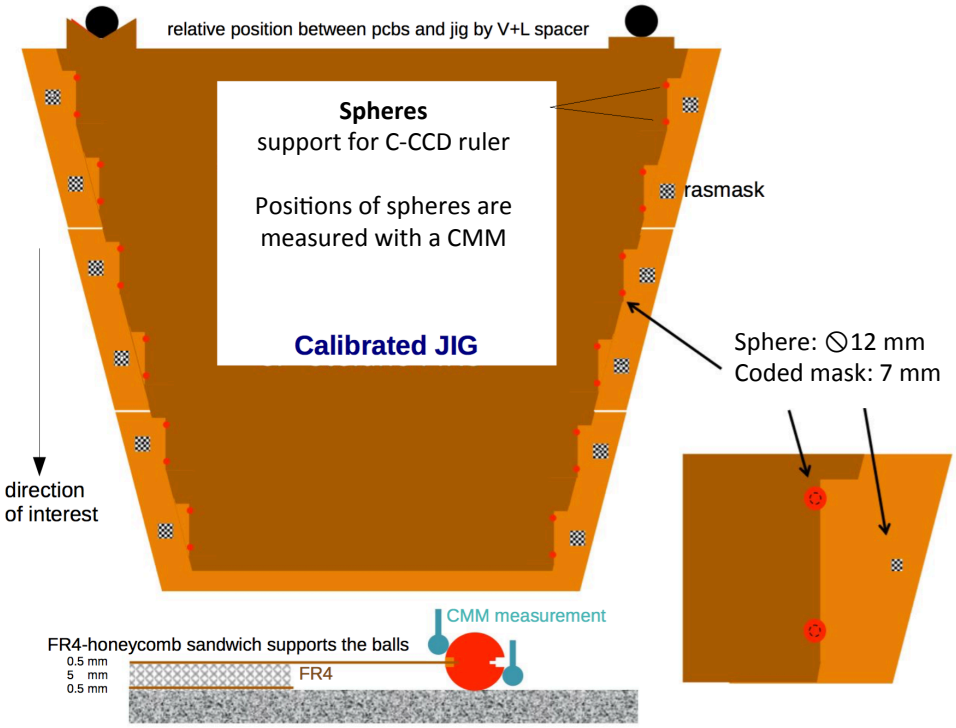
Tools for strip-alignment checks are based on:

- Contact-CCD: CCD + fiber optics
- Coded masks: rasmask





Strip-alignment checks: methods and tools

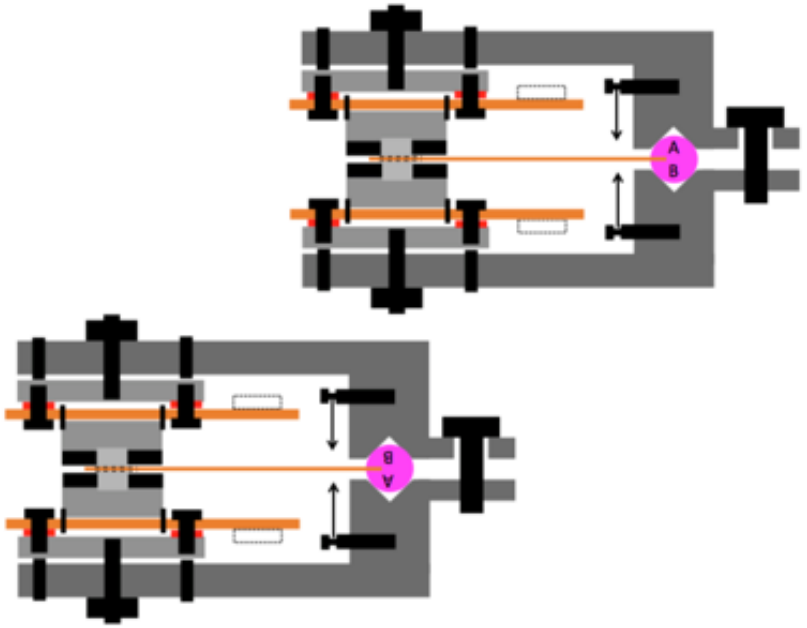


Strip position **on one side** is checked using a calibrated jig made of FR4-Honeycomb sandwich with spheres to position the C-CCD ruler on the coded masks

C-CCD rulers can be mounted on a U-shape mechanics.

Side-to-side strip positioning can be checked with a “doublet clip”

A dedicated mechanical support can be used ti check the **alignment of strips panel-to-panel**



Acceptance criteria

- Non-conformity procedures must be defined case by case for
  - Thickness: HC, perimeter frames (type 2.1, 4, 5), panels, quadruplet
  - Alignment:
    - Strip on one side
    - Strip side-to-side
    - 2 RO panels
  - Gas tightness
  - Mesh tension
  - Grounding
- Following requirements are very tight and components out of specs must be rejected:
  - FR4 thickness
  - Frames with tight thickness (type 3 and 6, mesh frame and gas-gap frame)
  - Mesh-frame height after gluing and drift spacer (IC)
  - Cooling leaks
  - Electrical tests:
    - Cathode insulation
    - Resistive strips current consumption

Conclusion

- Each steps of QC during construction is well identified
- Most of the tooling is ready (still need to finalize C-CCD tool)
- Methods:
  - Not all have been tested (will be during completion of module-0)
  - Some need to be refined (e.g. number of measurements to achiev the requested accuracy)
- Acceptance criteria are still mainly based on tolerance
  - Case by case aceptance/rejection criteria still need to be defined (Non-conformity procedures)