Detector structure:

Carbon-aluminum composite structures for the TPC

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JCL 2013

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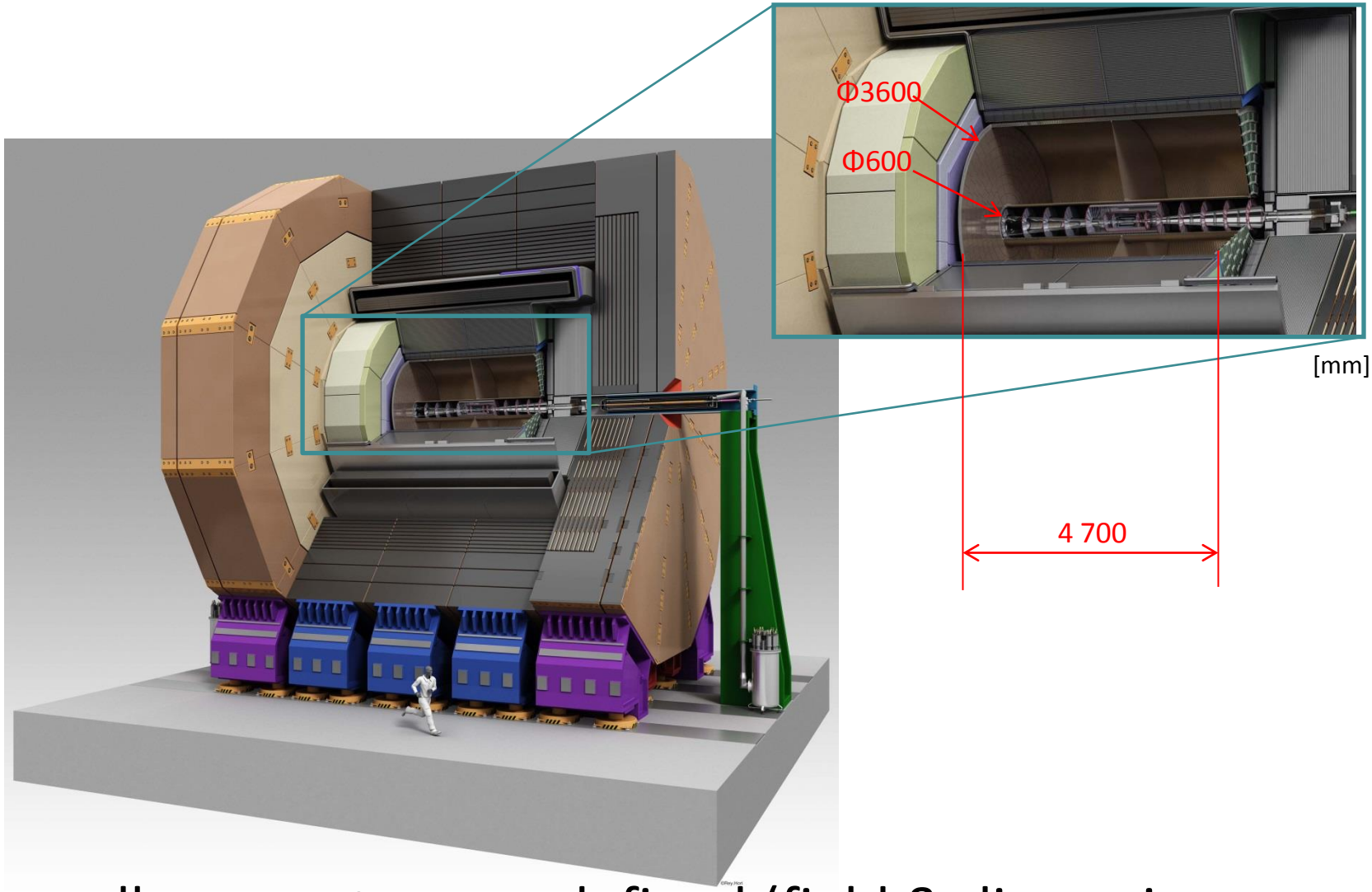
- 1| Context and constraints
- 2| Large prototype: status and options
- 3| Options for the ILD-TPC

1 | Context and constraints



- Overall parameters are defined (field & dimension range)

1 | Context and constraints

- Detector resolution strongly depends…

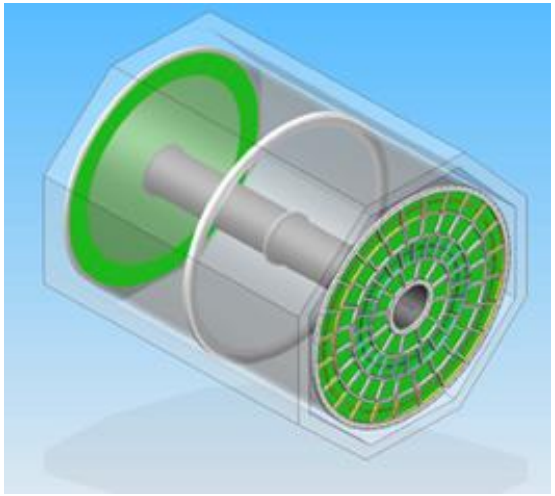
…on the layout of the tracking system…

…which depends on mechanical design…

…which depends on structural materials and layout.

Material budget of the TPC:

- 5% X_0 in the barrel region
- 25% X_0 in the endcap region

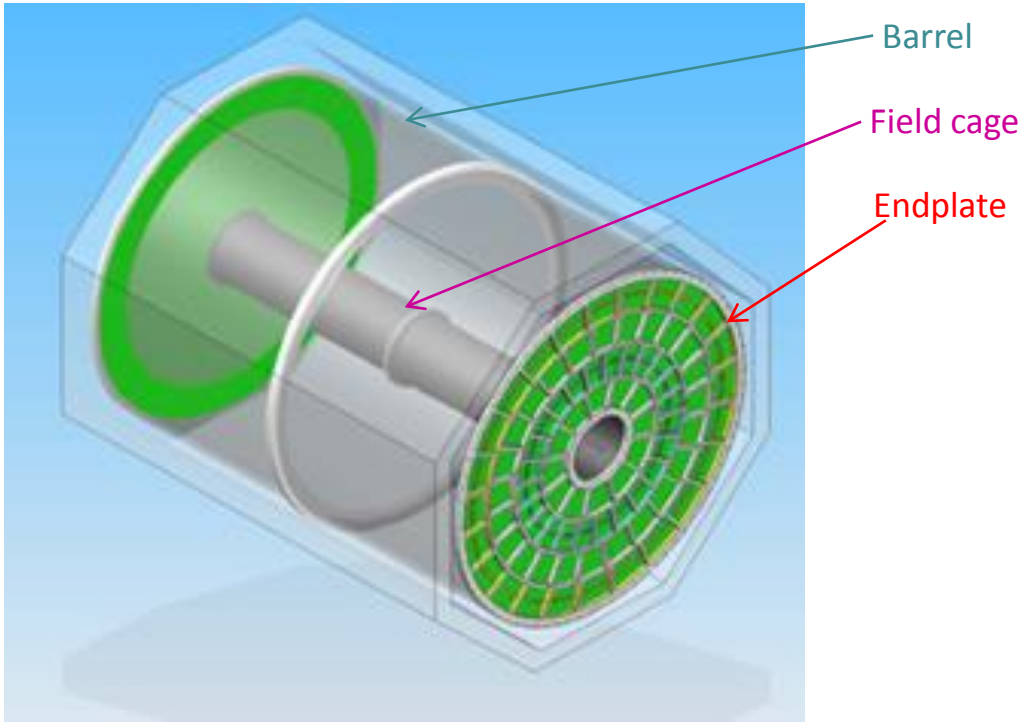


+ Challenge of high precision ~10 µm syst. error on Sagitta

[TPC-PRC2010 report]

1 | Context and constraints

- Focus on the endplate

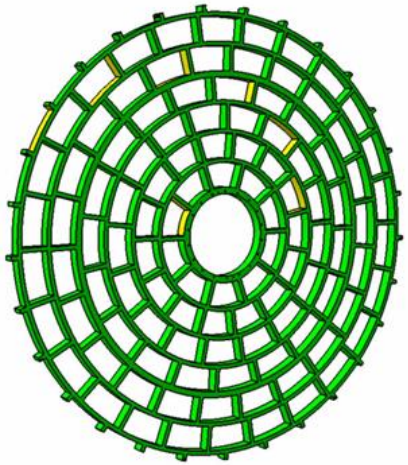


[courtesy of M. Carty]

1 | Context and constraints

Constraints on the endplate:

- Maximum surface coverage
- Dismontability of individual modules
- X-Y precision and stability < 50 µm
- Thickness < 100 mm
- Material budget: 25% X_0
  - Readout & FEE: 5%?
  - Cooling: 2%?
  - Power: 10%?
  - Mechanics: 8%?
- Interface with the field cage / barrel + support



[courtesy of J. Kaminski]

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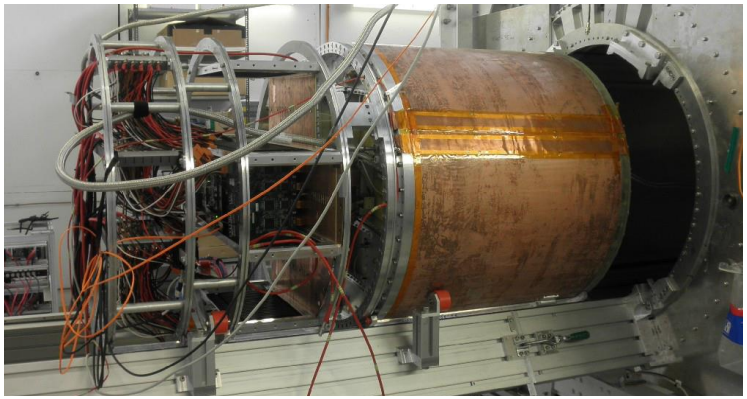
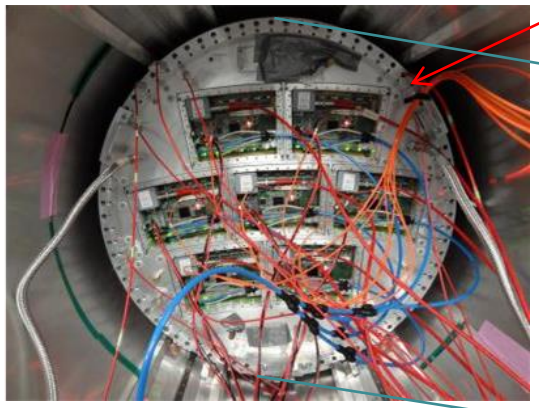
2| Large Prototype status

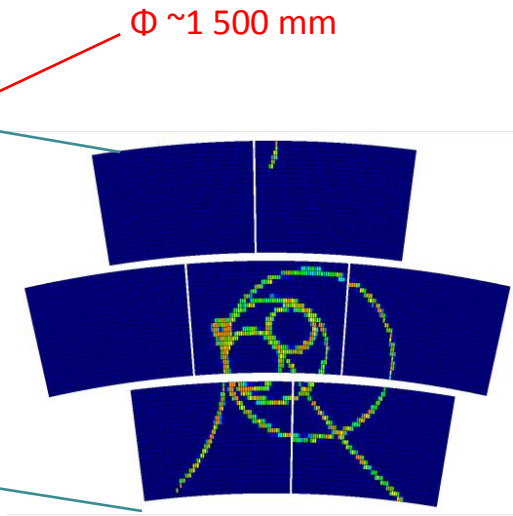
- Detector R&D (readouts)
- Hands-on experience of integration
- Design of a large TPC with high precision & stability
- 3 modules (GEM) / 7 modules (Micromégas)



with 3 GEM modules



with 7 MM modules

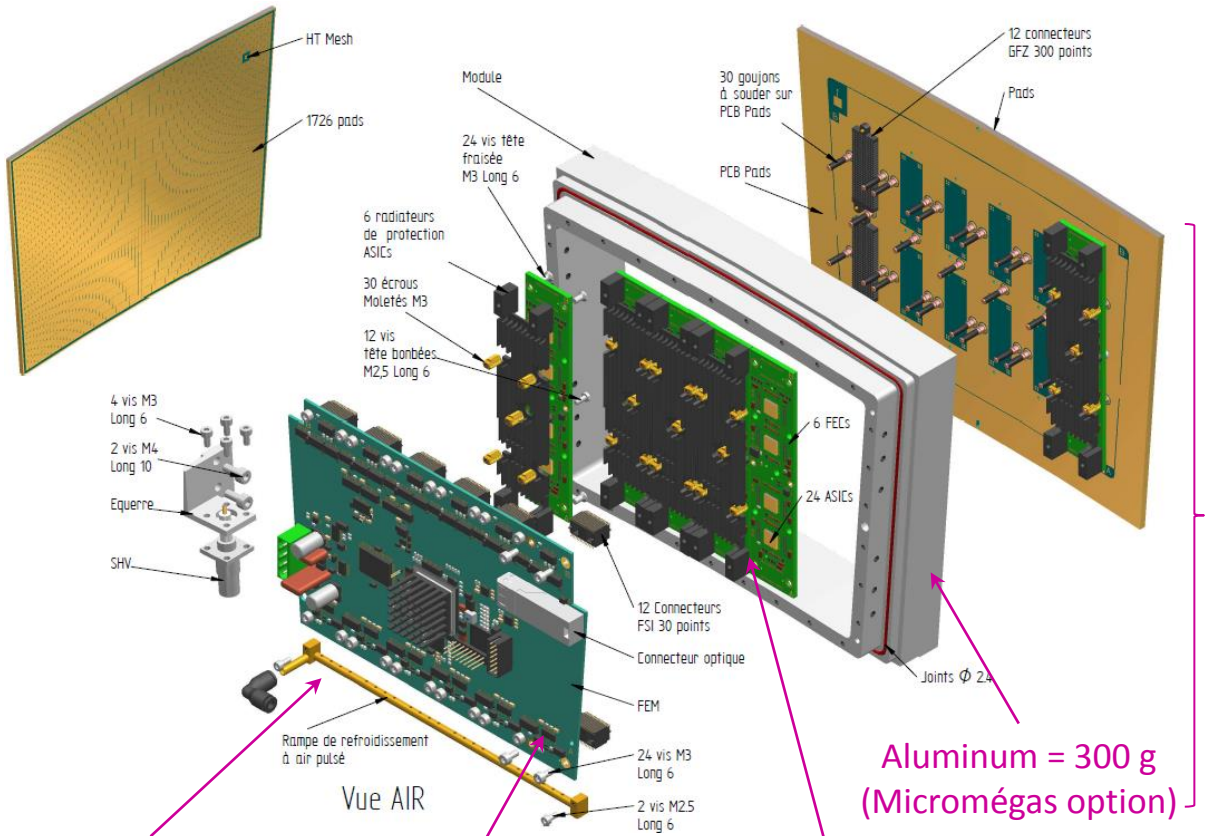


[courtesy of P. Colas, J. Kaminski]

2| Large Prototype status

- 374 cm²
- ~1 500 g

} 4 g/cm² on Si/Al → < 25% X_0



Frame + Detector = 750 g

Aluminum = 300 g (Micromégas option)

Air cooling = 140 g *(cf. David Attié's talk)*

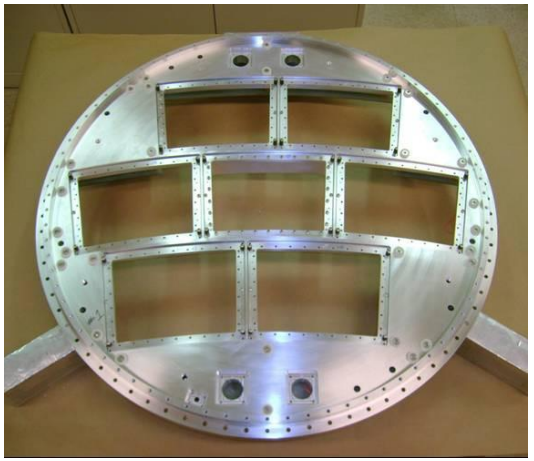
FEMI = 170 g

6 FECS = 300 g

[courtesy of M. Riallot]

Large Prototype status

- « LP1 »: 100% aluminum frame
- Built by Cornell in 2008 (accuracy ~30 µm)
- Tested at DESY in 2008-11 with 1 module,
  2010 with 6 modules, 2013 with 7 modules

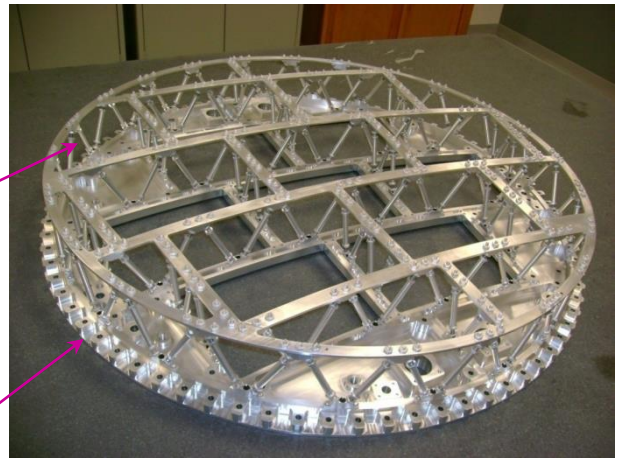


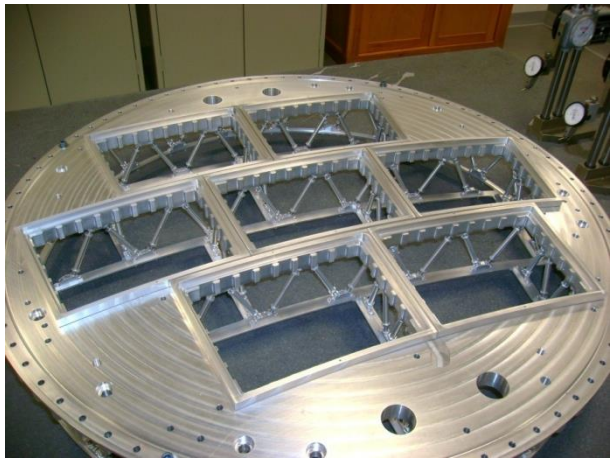
⇒ Precision OK with plain aluminum (deflection = 33 µm)

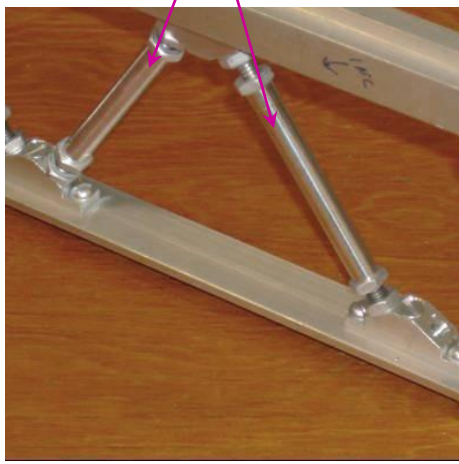
⇒Still too heavy: ~19 kg over 4 650 cm² → 17 % X_0

2| Large Prototype status

- « LP2 »: 100% aluminum **strut-based** space-frame
- Built by Cornell in 2013 (2 ex.)
- Shipped to DESY for tests







⇒ Max. deflection = 23 µm for 100 N load

⇒ ~8.5 kg after optimization → 8.6 % X_0

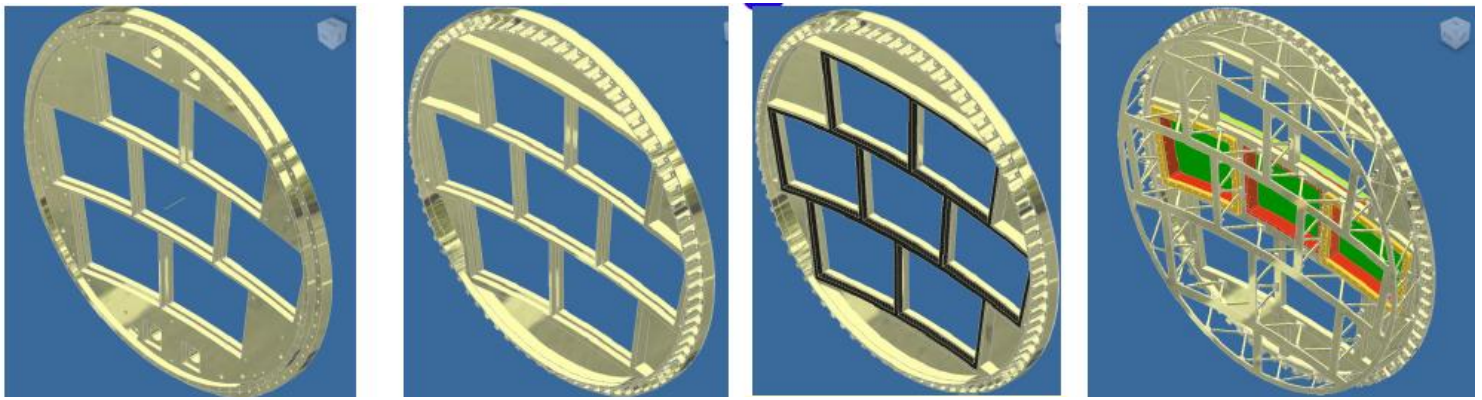
⇒ Additional work on lateral rigidity & stability

[courtesy of D. Peterson]

2| Large Prototype options

- Aluminum brings surface precision (planarity…)
- Carbon can bring stiffness/light

⇒ Al plates and struts + C backframes seem attractive



LP1 LP1+ Al+C LP2

⇒ Struts + C backframes is a good candidate to meet ILD's requirements (8 % X_0)

[courtesy of J. Kaminski]

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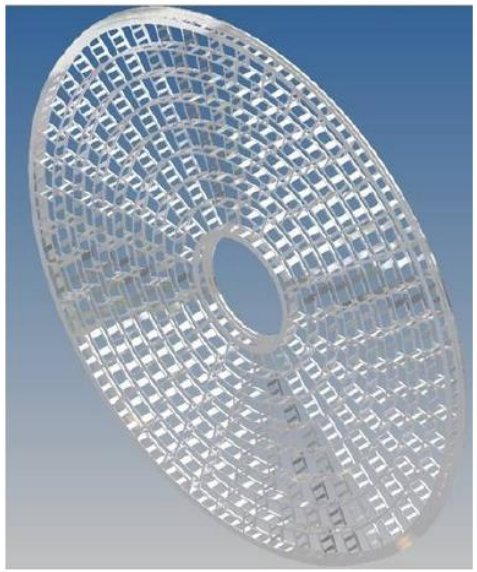
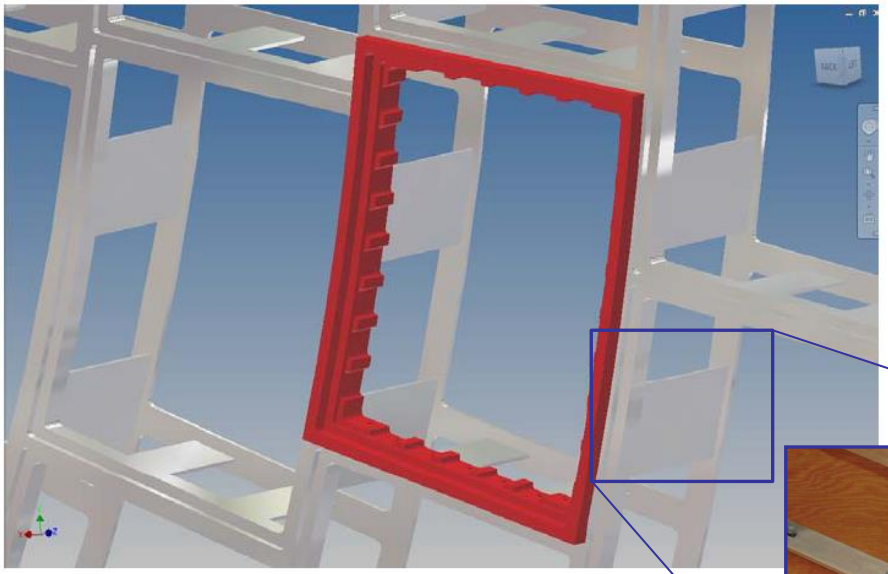
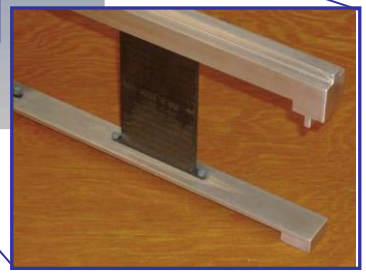
Options for the future ILD-TPC

- ILD endplate design (8 rows):





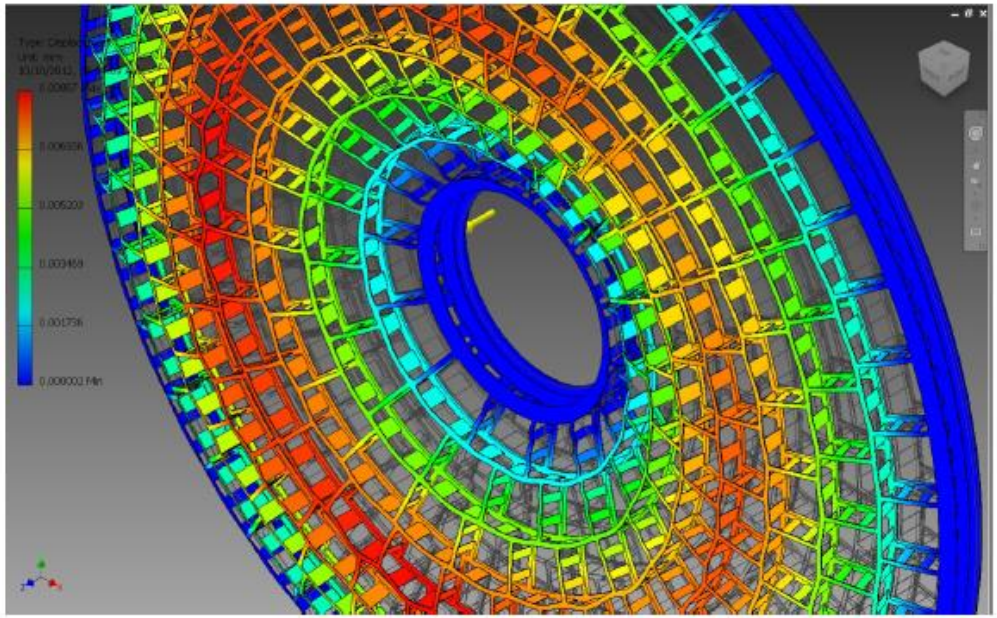


- Frame = 136 kg → 5.7 % X_0
- Backframe: C-fiber necessary to keep < 2.3 % X_0 !

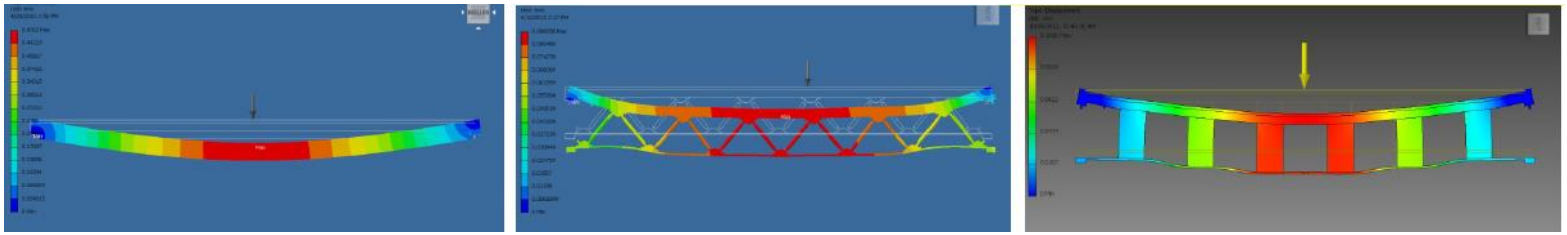
[courtesy of D. Peterson]

3 | Options for the future ILD-TPC

- FEM performed by Dan Peterson (Cornell)



- Cross-check with sample tests



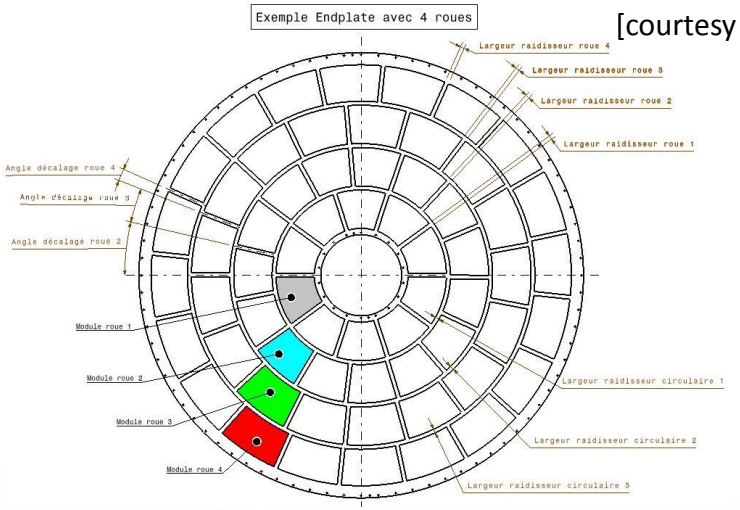
[courtesy of D. Peterson]

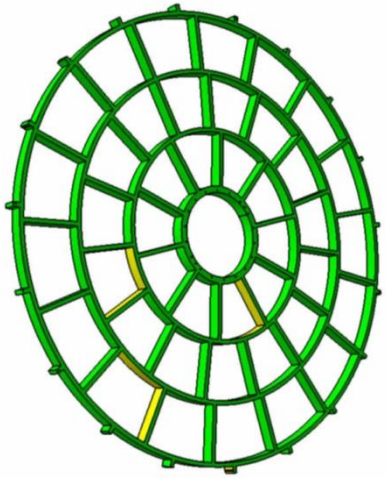
3 | Options for the future ILD-TPC

- Changing the modules' dimensions?

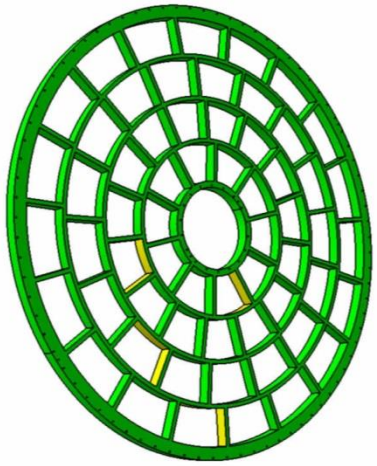
⇒ AIDA 2014

[courtesy of D. Bachet]

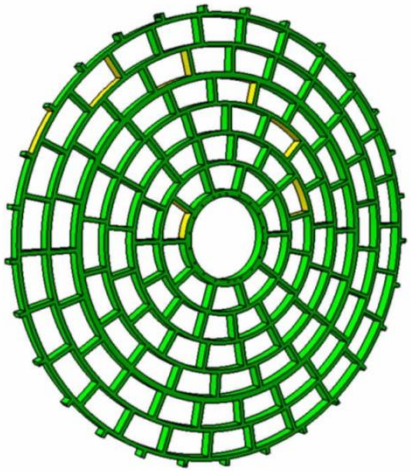




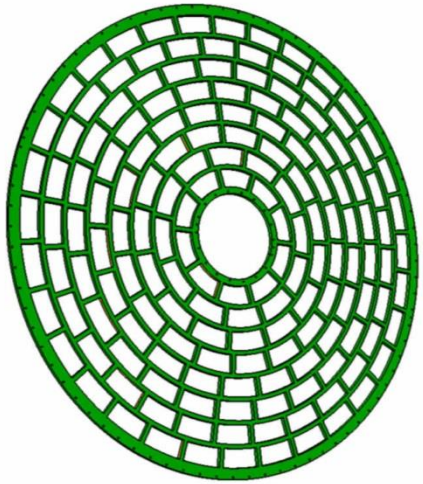
3 wheels
42 modules
m



4 wheels
61 modules
1.5 m



6 wheels
110 modules
1.9 m

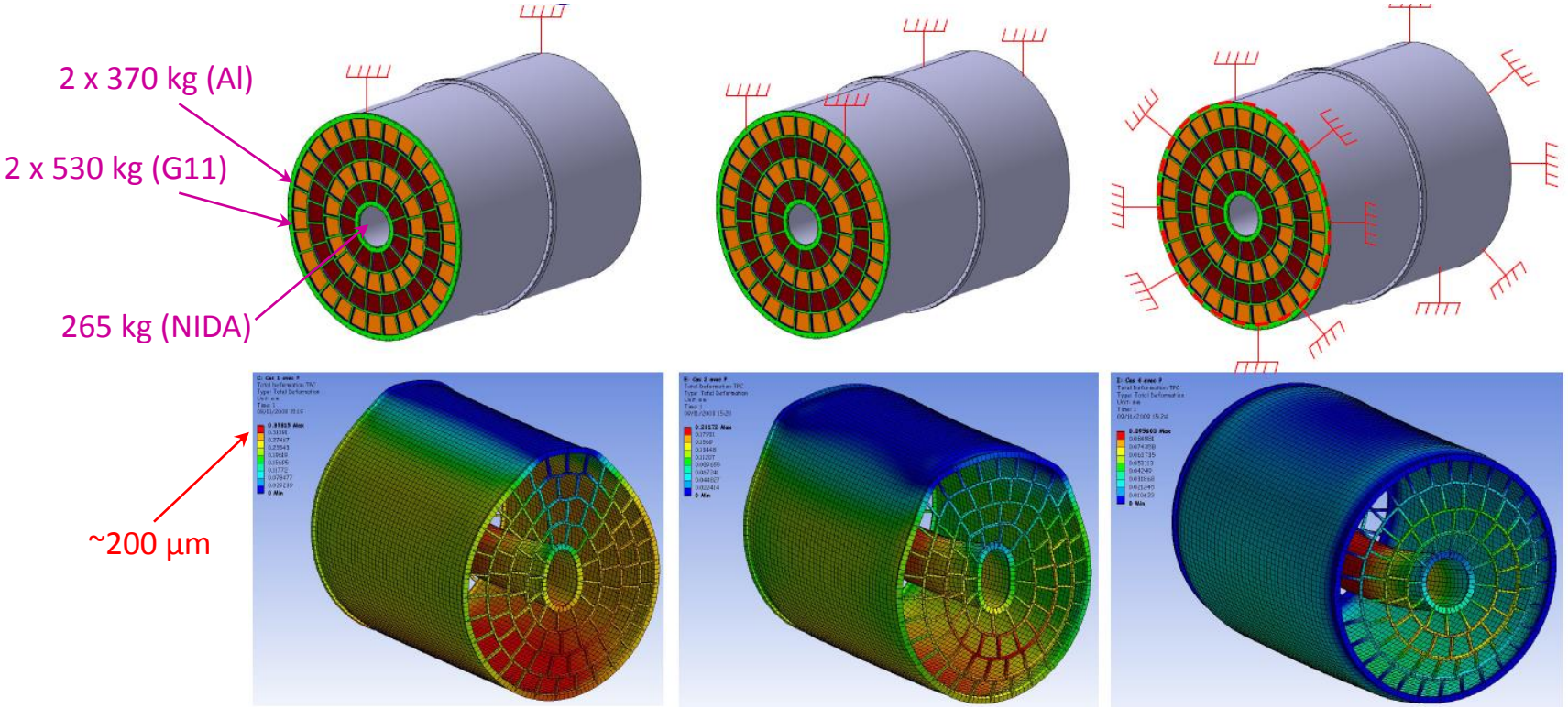


8 wheels
171 modules
2.2 m

3 | Options for the future ILD-TPC

Full TPC analysis:

- Self-weight and mounting (2 tons)
- Overpressure (ΔP = 3 mbar)



[courtesy of M. Carty]

Conclusions

- Large Prototype (LP) was built and tested
- Strut-based aluminum endplate will be tested
- Satisfying solution in terms of mass for LP
- Hybrid carbon-aluminum solution necessary for ILD
- Parametric simulations are necessary
  - On materials
  - On detector layout

Thank you