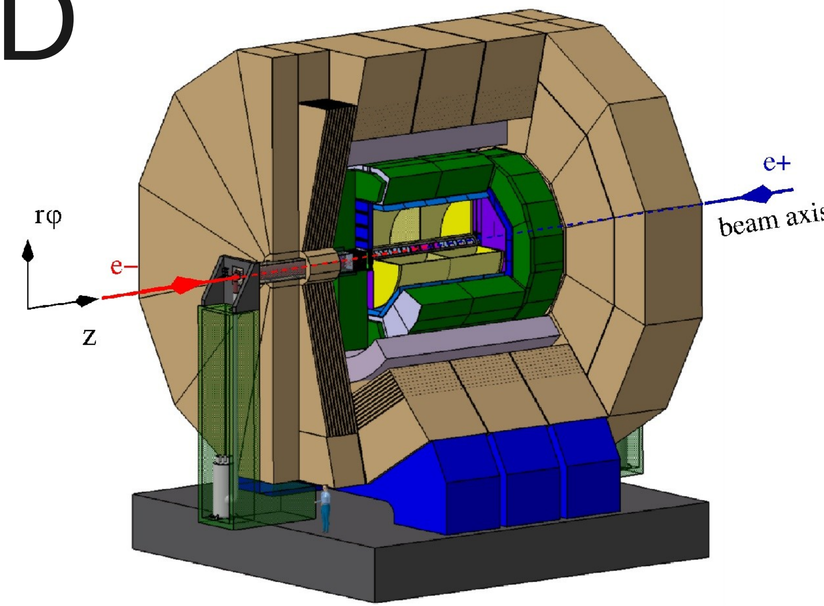
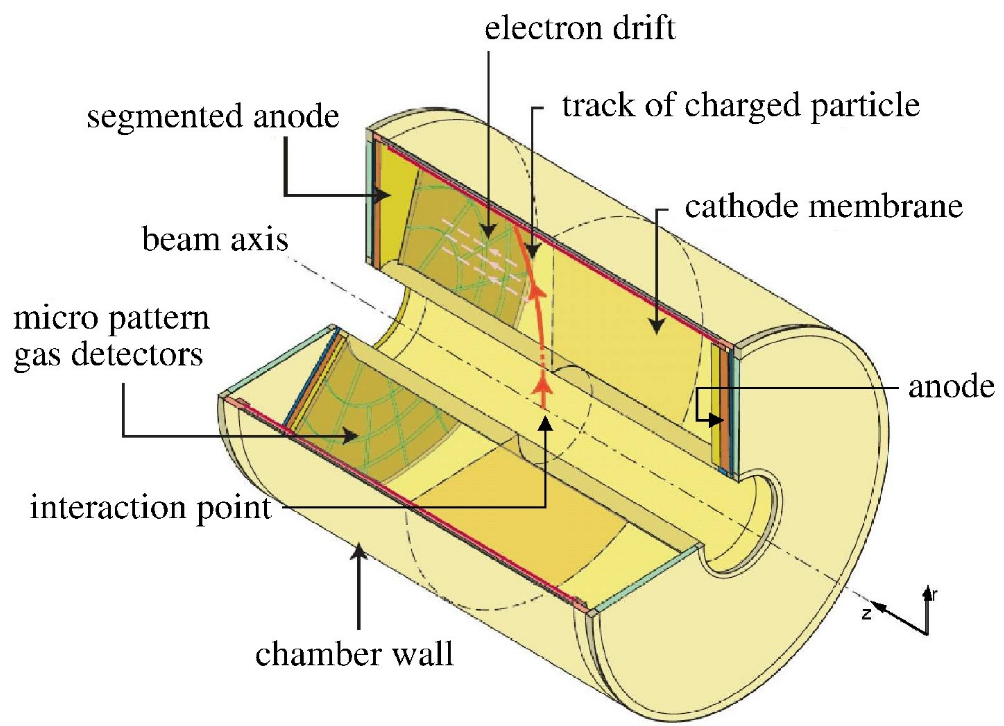
LCTPC status and progress

- Quick introduction to LCTPC
- Status of the readout technologies
  - Electron amplification
  - Electron readout
  - Readout electronics
- The Large Prototype (LP1->LP2)
- Simulation and reconstruction challenges
- Conclusion and outlook

TPC@ILD

- TPC as main tracker for ILD
  - Robust tracking, ~ 200 space points per track:
    - Easy pattern recognition
    - Robust towards machine backgrounds
    - dE/dx-measurement input to particle ID
    - $\sigma \leq 100\mu m$ (rφ) @ 3.5 T and $\leq 500\mu m$ (rz) => $\Delta(1/p_T) < 10^{-4}$/GeV/c
  - Well suited for Particle Flow concept:
    - Good track separation
    - Good pattern recognition
    - Very lightweight
      barrel < 5%X_0
      end plate ~ 25%X_0





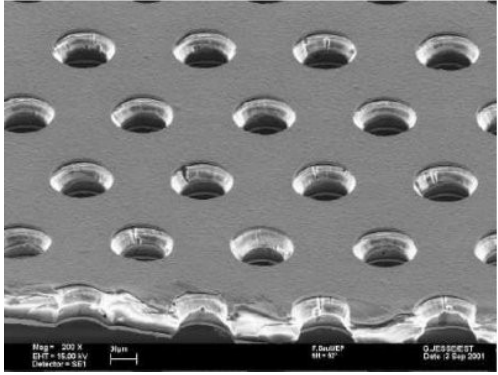
Challenges of LCTPC

- Field cage
  - Mechanical properties
    Field quality
- Endplate
  - Material budget
- Amplification structure
  - Technology choice: MPGD
    Electrical and mechanical stability
    large area coverage ↔ dead space
    Ion back-drift
- Readout structure
  - Pad or pixel based
    Compactness and integration
    Cooling, power pulsing
- Reconstruction
  - Calibration and alignment
    Correction of field inhomogeneities
    Curled tracks

Technologies

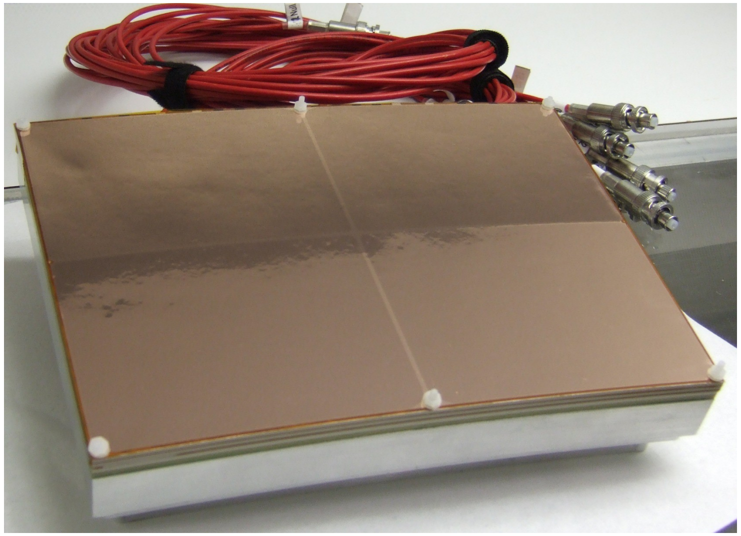
- Electron Amplification with MPGDs
  - GEM
  - MicroMEGAS
- Electrons readout
  - Classic pad readout
  - Pixel detectors
- Readout electronics
  - Present: ALTRO, SALTRO, AFTER
  - Future: GdSP

GEM



“DESY” Module

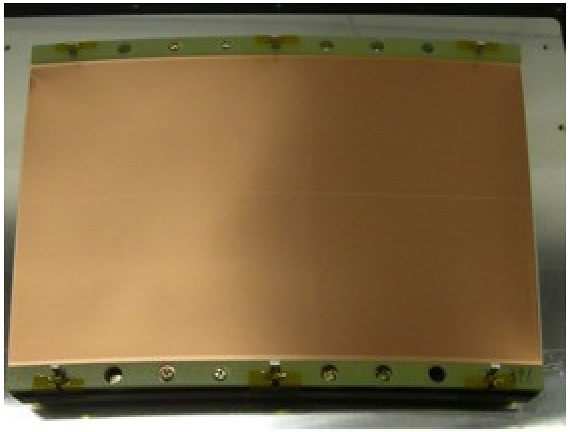
- “Thin” (50μm) GEM
- Triple GEM stack
- Ceramic support



- New module will be tested end of summer

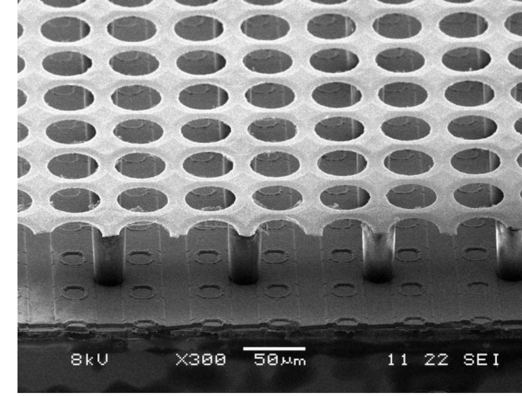
“Asian” Module

- “Thick” (100μm) GEM
- Double GEM stack
- Stretching to minimise dead region in the phi direction

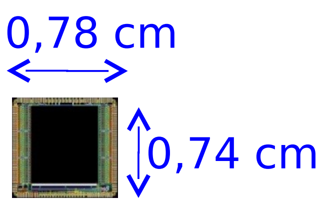


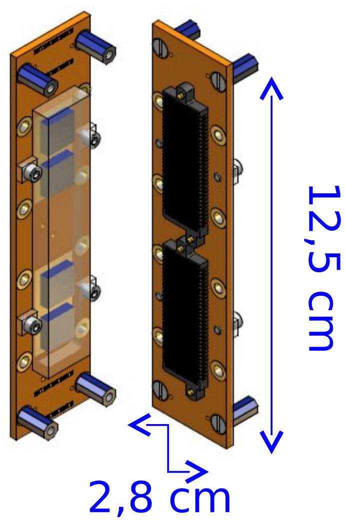
- New GEM (new processing)
- New readout electronics in 2013

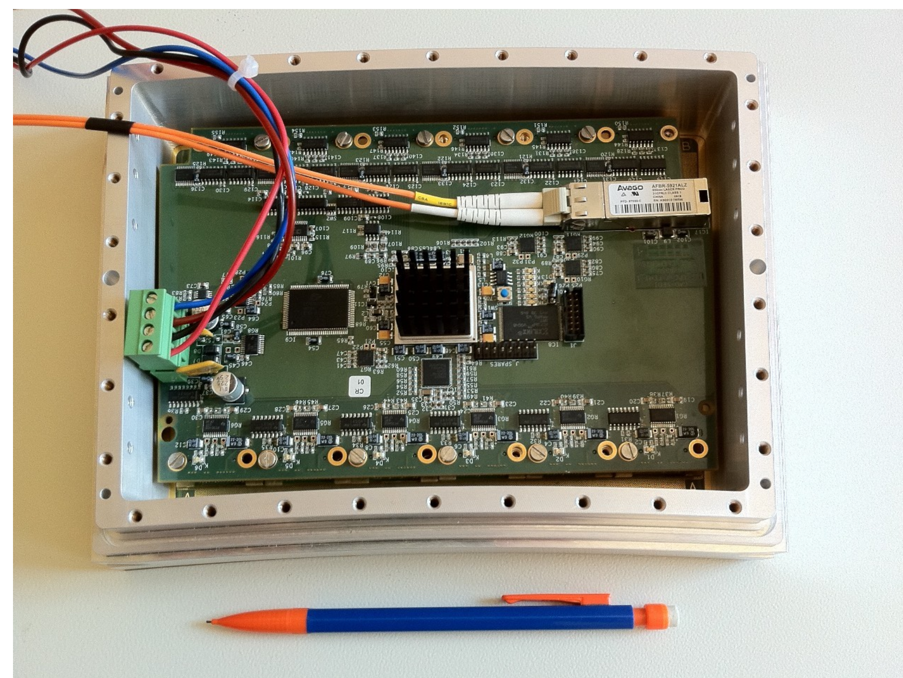
Micromegas



- Micromesh gas amplification
- New modules with integrated electronics (AFTER chips) in Saclay
- Should be tested in Large Prototype in DESY in July



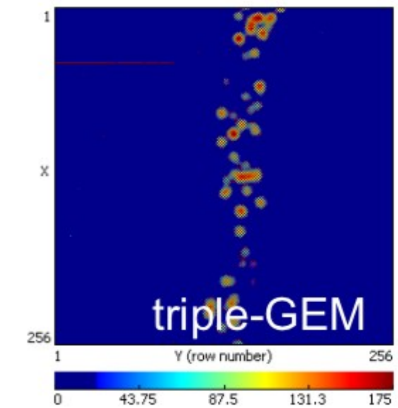


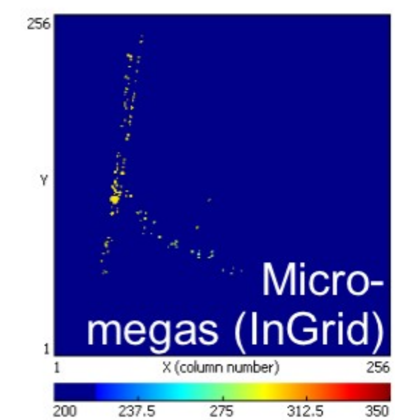


Timepix

- Classic pad readout ~1x5mm^2 => Timepix chip readout 55x55µm^2
- Resolution to distinguish single ionisation electrons
  => diffusion is the only limitation to momentum resolution
- Readout possible with different MPGDs (GEM or Micromegas)

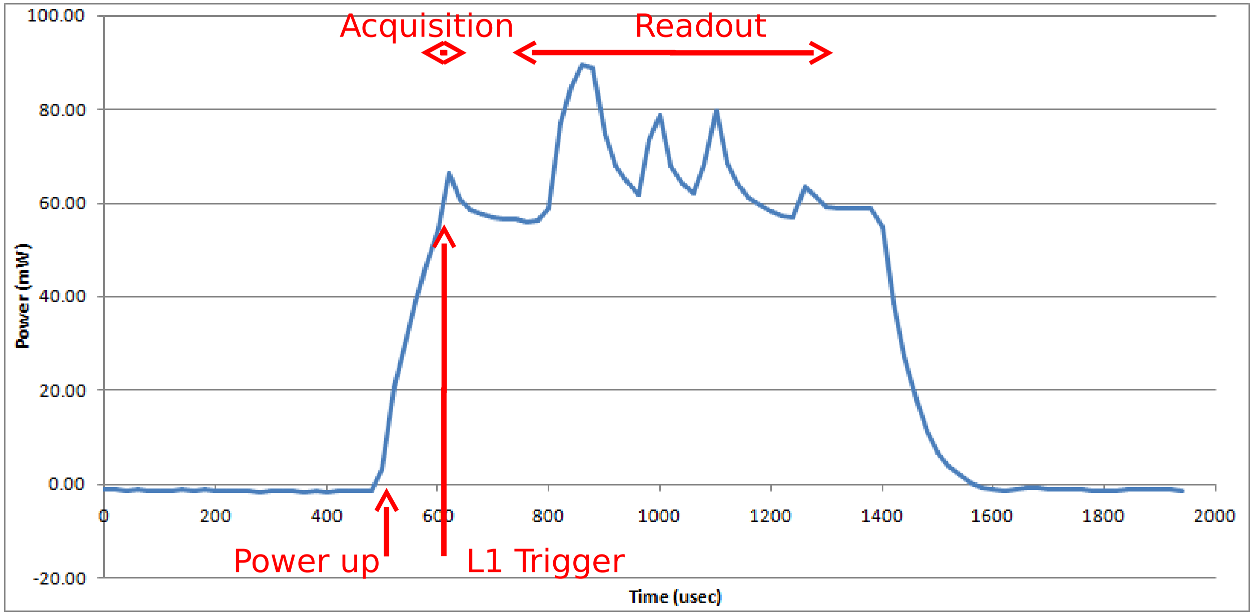
- New process being studied for InGrid (Micromegas)
- Work started for a full module
  (~120 Timepix chips ≈ 8 million pixels)





Readout electronics SALTRO16

- SALTRO16 tested successfully on electronics testbench
- Power pulsing demonstrated to reduce power consumption by a factor 60 with 5Hz repetition

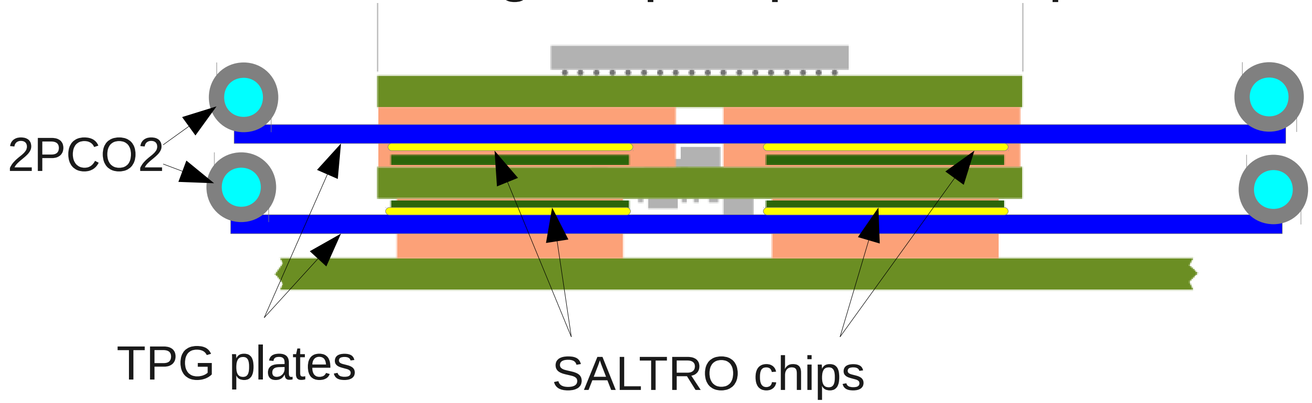


- SALTRO shows very good performance. Work has already started on GdSP, a final version for LCTPC

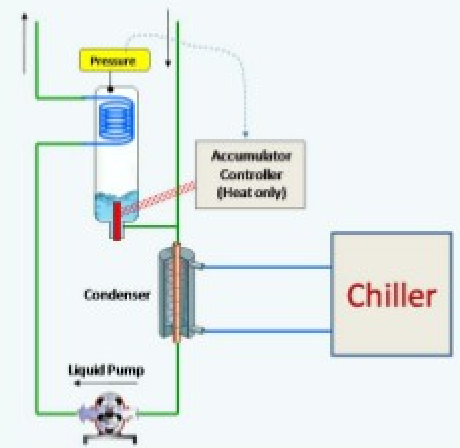
Electronics cooling

- 2-phase CO2 cooling system
- Preliminary investigations to cool the SALTRO via plates of highly conductive material (TPG)

Necessary for LP test (no power pulsing)
Interesting for pad plane temperature



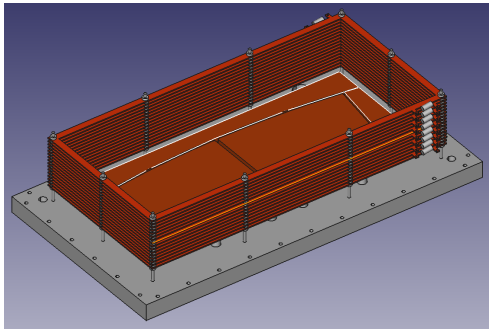
Integrated 2PACL



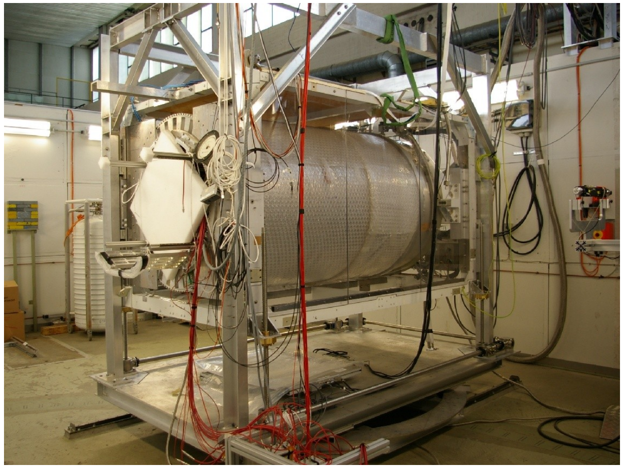
- Simple control
  - 1 heater with standard controller
  - Simple interlocking with conditioners and relays to guard pump sub cooling
  - Start-up procedure within interlock logic
- Single chiller loop
- Small size
- Large possible operating range (-40 to +25°C)*

* Depending on primary chiller used

Test setups

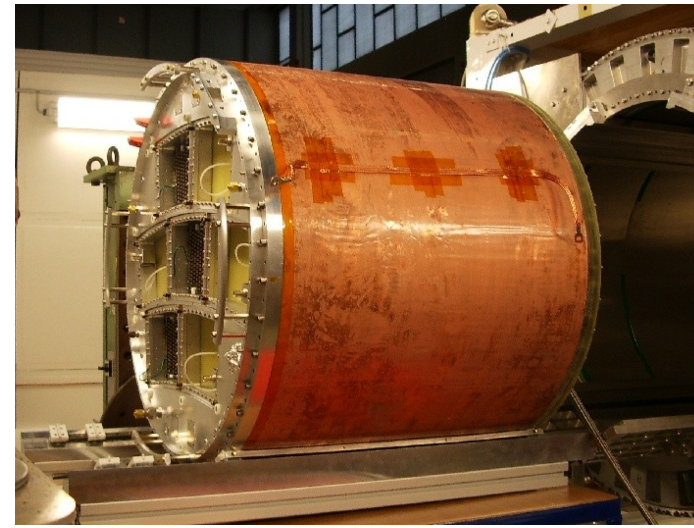


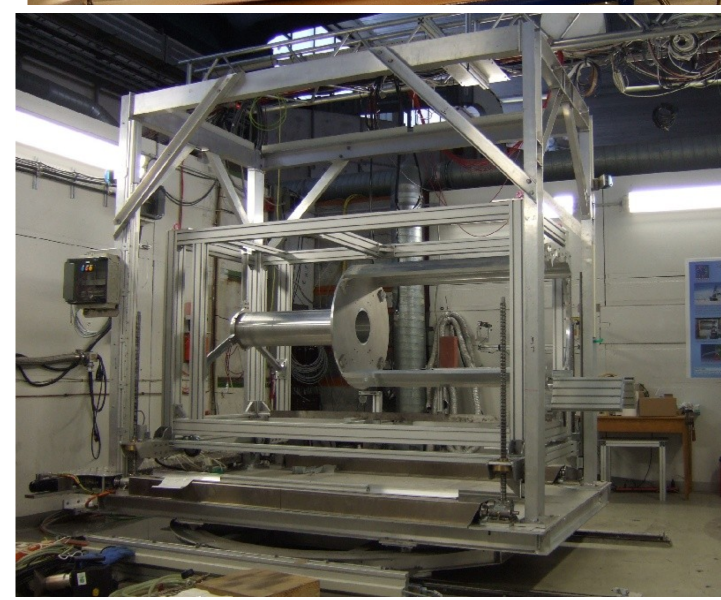
- Small prototypes
  - Proof of principle
  - Test of technical details
  - At local institutes
- Large Prototype
  - LP1
  - Upgrade to LP2
  - Test beam (e^-@DESY, hadron beam?)



LP1

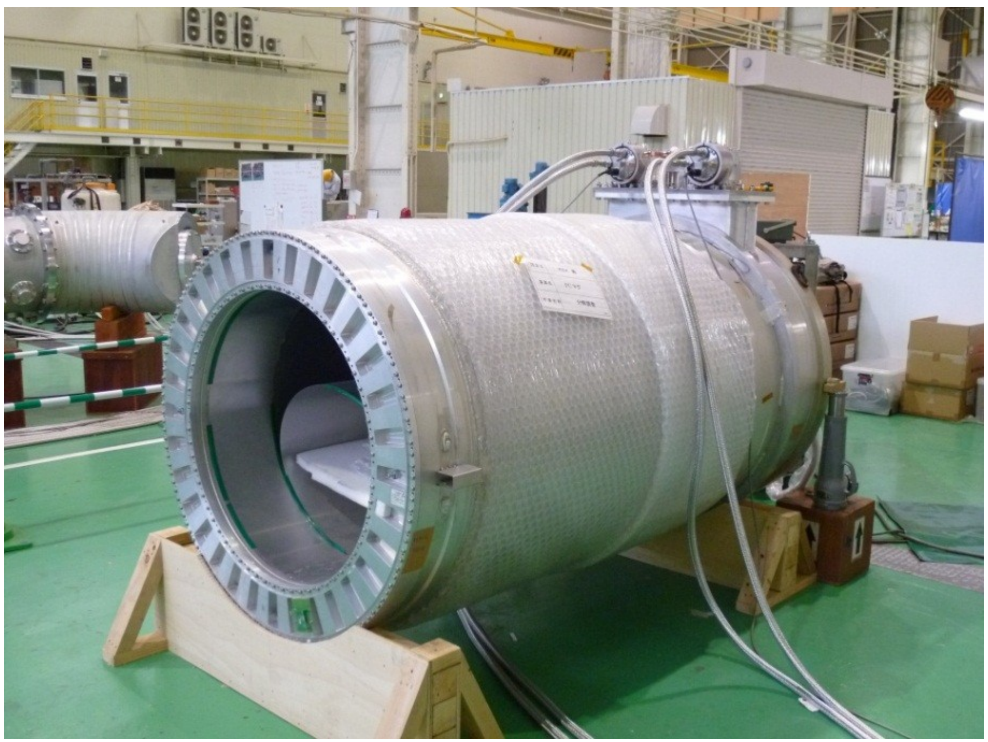
- Large Prototype 1
  - Ø=72cm, L=61cm
  - 1T magnetic field
  - 7 readout modules
- Test beam at DESY
  - 1-6 GeV electron beam
- Upgrades towards LP2
  - Upgraded PCMAG (in DESY, being installed)
  - New end plate (built, being tested)
  - New field cage (end 2012)

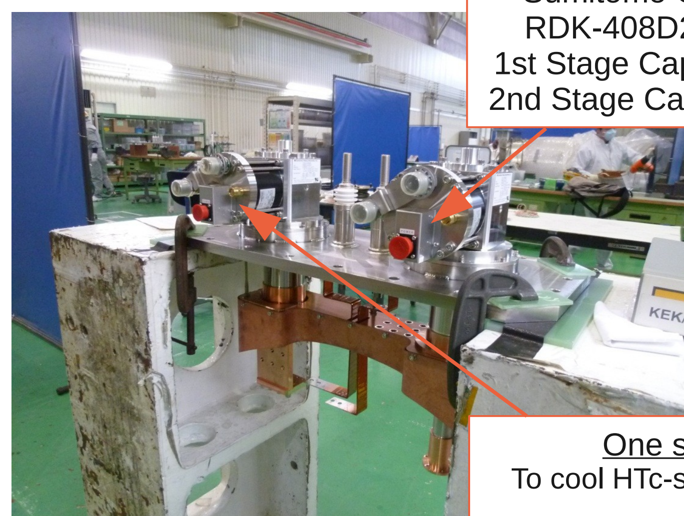




PCMAG

- PCMAG: 1T superconducting magnet
- Upgraded: Liquid Helium → Cryocoolers





Two-stage 4k cryo-cooler
To cool coil and the 1st -radiation shield

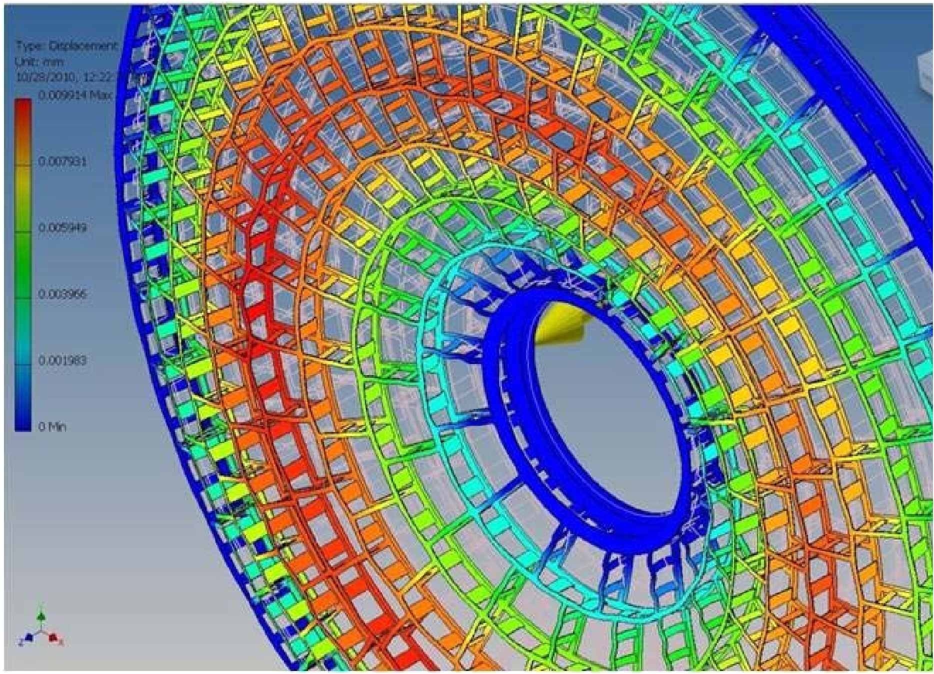
Sumitomo Cryogenics 4K cryo-cooler
RDK-408D2 with a compressor F-50:
1st Stage Capacity : 34W @40K @5 0Hz
2nd Stage Capacity 1.0W @4.2K @ 50Hz

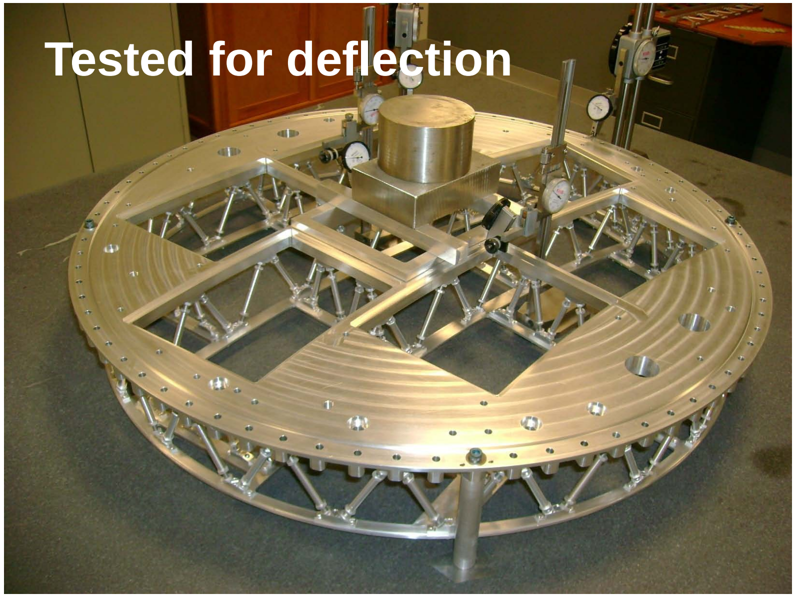
One stage 10K cryocooler
To cool HTc-superconductive current leads

Sumitomo Cryogenics 10K cryo-cooler
RDK-400B with a compressor F-50
1st Stage Capacity : 54W@40K @ 50Hz

End plates

- LPTPC material budget (25% X_0)
    - readout 5%
    - cooling 2%
    - power cables 10%
    - mechanical structure 8%
- Rigid
    - Precision of x,y positions < 50µm



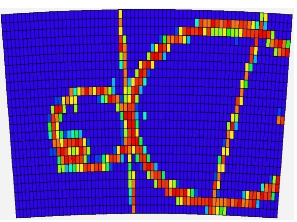


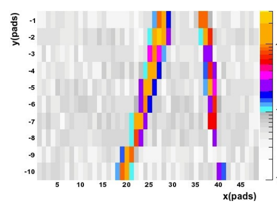
Data reconstruction and simulation

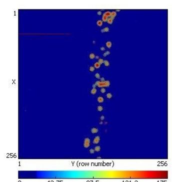
- Understanding the possible distortions
- Reconstruction and simulation framework

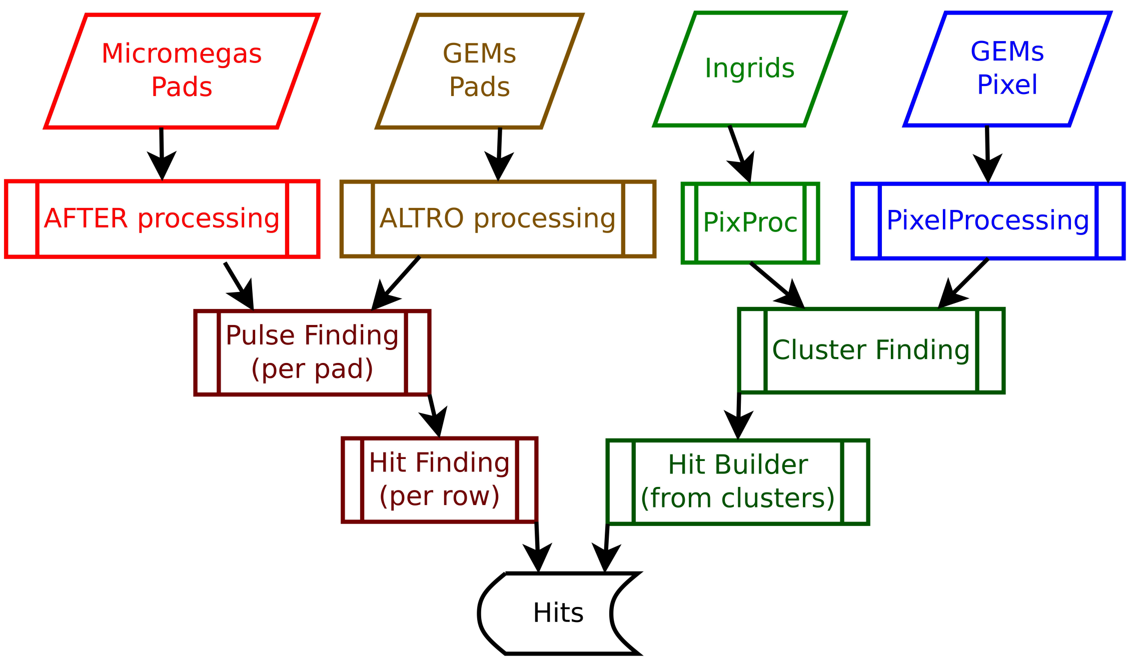
Software framework: MarlinTPC

- Reconstruction for all module types









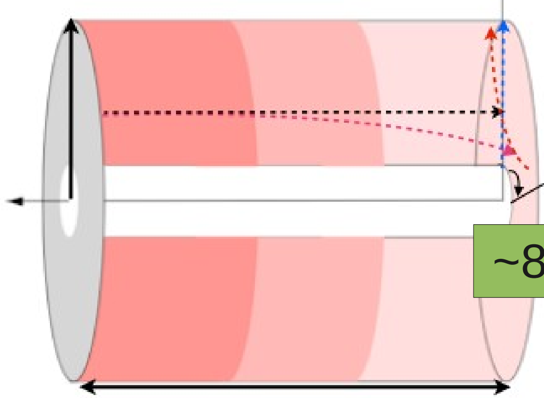
- Continued improvement and debugging
- More and more functionalities integrated
- Ongoing work to improve calibration and alignment
- Extension of simulation capabilities

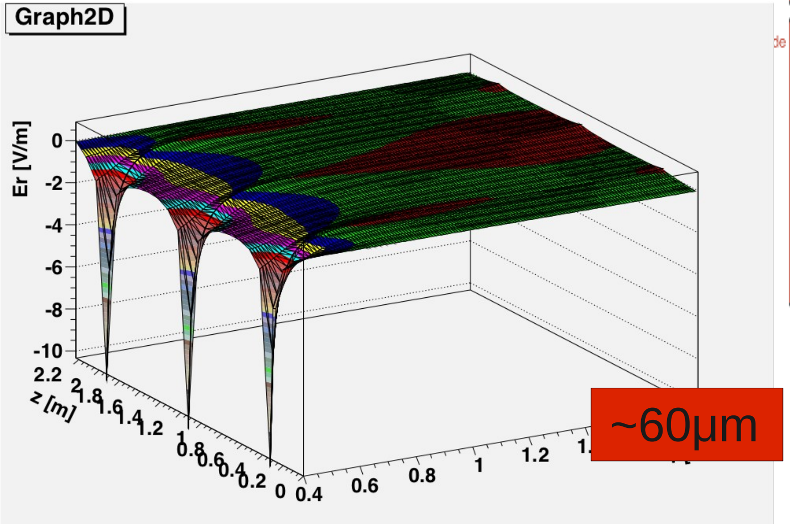
Ion back drift

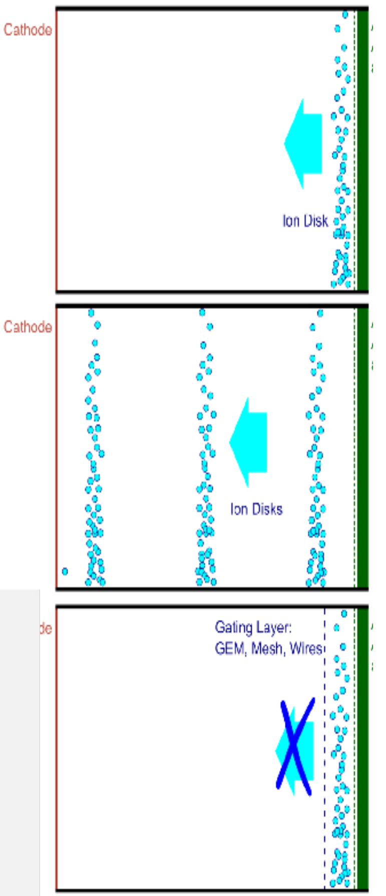
- Simulation of positive ion effects
- Compare effect of:

primary ions created by the tracks (3 trains)

ion disc created by amplification





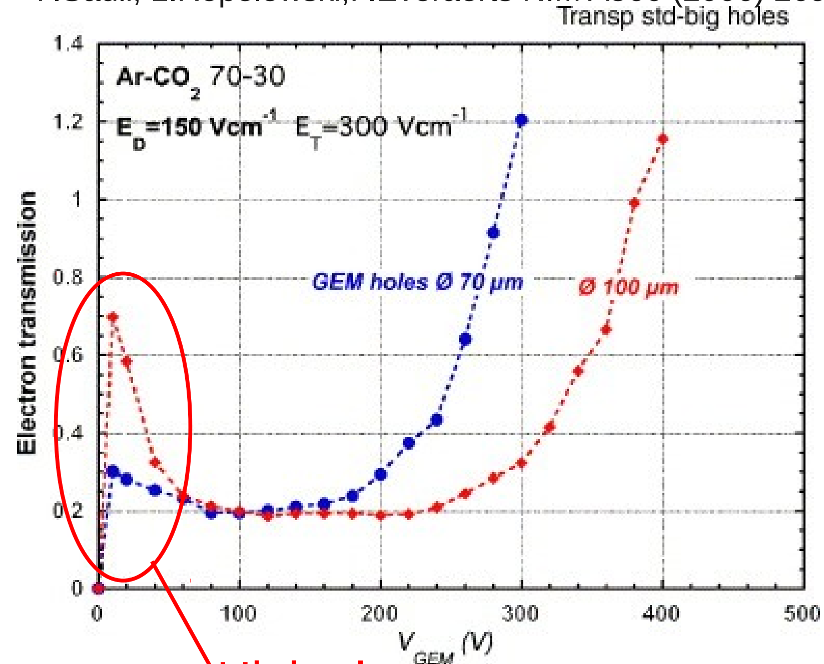


- Primary ions effect **small**
- MPGD ions effects **too large**
  => gate required

Gating system investigation

- GEM gating:
  - possibility shown by Sauli
- Need of thin GEM with wide aperture for good electron transmission
  - Technically difficult, work ongoing
- Wire gate considered as backup solution

F.Sauli, L.Ropelewski,P.Everaerts NIM A560 (2006) 269-277



High electron transmission at low V_{GEM}

Conclusion and outlook

- All systems are progressing, modules going to realistic configurations
- Good space point resolution on single modules
- Upgraded test beam facility (PCMAG, LP2) to test momentum resolution
- Plans to go to hadron beam to test multitrack environment