CERN

Secondary Infrastructure
Or: Cold boxes and other stuff...

BTTB7

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Secondary Infrastructure?

- Mostly from the point of view of EUDET telescope user support at CERN – telescope (infrastructure) as a service
- Beam and beam instrumentation
- Telescope
- Slow control / Logging / Remote control / Automation
- Reconstruction software
- Analysis software
- And...??? Small stuff that gets forgotten or is deemed “luxury” but costs valuable beam time
- Tools → electronics, scintillator holder, lead bricks, rasps, valves, … → user workshop?
- Log books
- Positioning
- Cold box

Positioning

- Huge demand for small scale and large scale positioning:
  - Telescopes
  - DUTs
- @CERN: DESY table, XSCA table, (PI table – also mix and match between telescope)
- Mechanics astonishingly expensive and takes time to implement
- Increasing demand

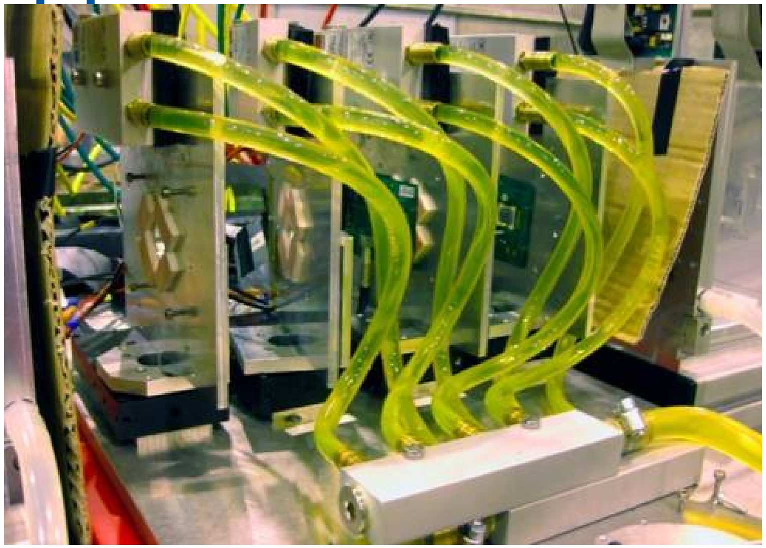


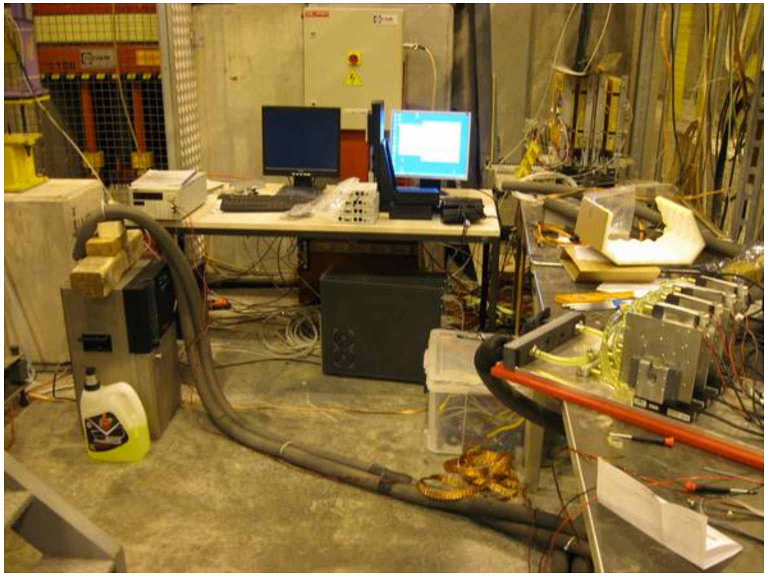
Cold Boxes

- Why cooling – silicon detectors have heat dissipation, need increasingly lower temperatures with progressing radiation damage to avoid runaway: -20°C ... -40°C
- Have to be light tight but easily accessible for mounting and alignment
- Sounds simple but is not trivial
- Compared to the "real" detector:
  - Maximum flexibility
  - Devices not designed for proper heat transfer (PCB instead of stave concept)
  - No dedicated cooling effort
- Now a (not necessarily chronological) gallery of ATLAS pixel (R&D, IBL, ITK...) cold boxes 2009 – 2019

Cold Boxes – The Peltier Approach

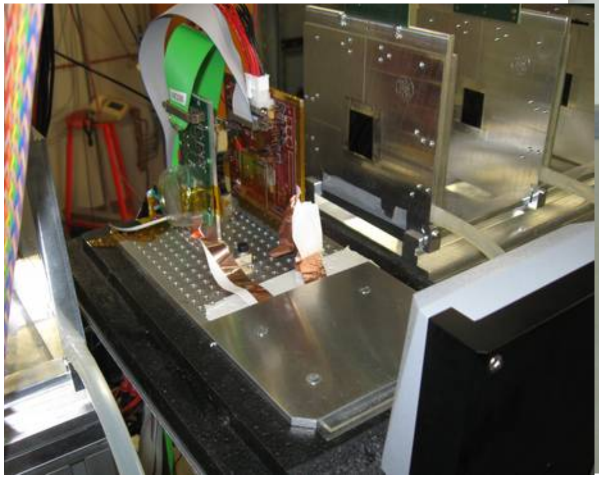
- “Oslo” box ~ 2009
- Holders on rotating stages which were cooled by individually supplied and regulated (commercial PID controller) Peltier elements
- PCBs with sensors mounted with screws on holders and sensors cooled PCBs
- Peltier elements back cooled with water/ glycol mixture by Huber chiller (mid range)
- Flushed with nitrogen
- Pro:
  - Peltier elements are simple and cheap
- Contra:
  - Absolute heat transfer insufficient
  - Only -15°C reached on frame stably this was not sufficient to manage -20°C on sensor
  - Box was very heavy and no stage available thus only manual adjustment of x-y position
  - Only four samples and care necessary to exclude collission

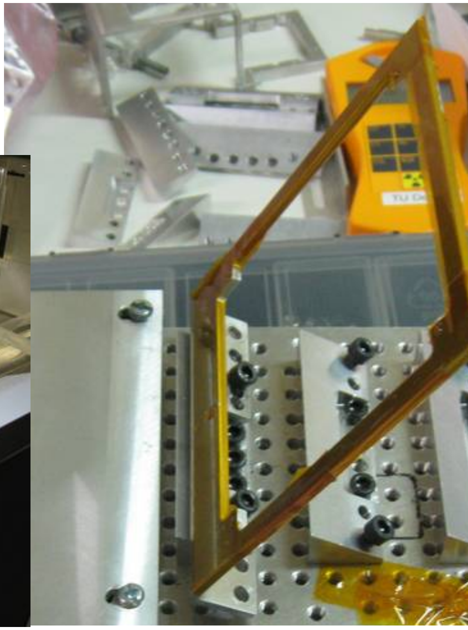


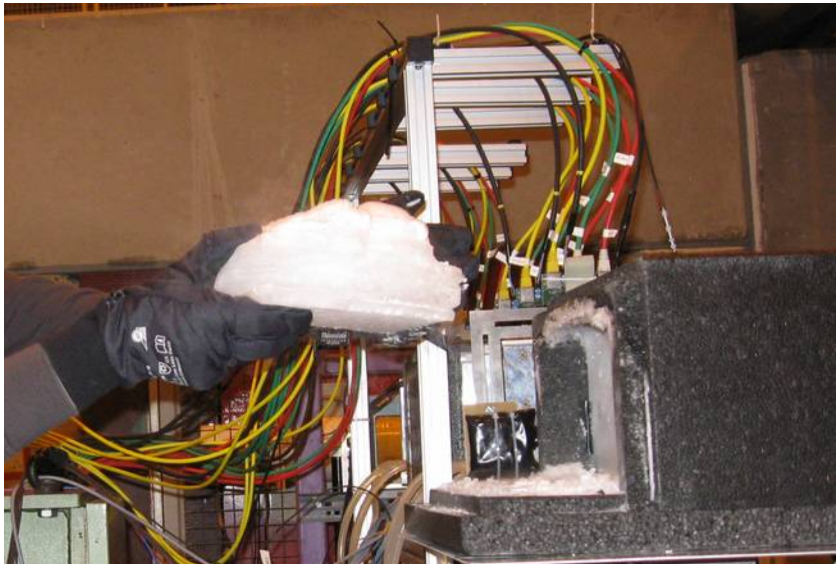


Cold Boxes – Dry Ice aka DOBOX

- Dry ice as a readily available and easily to handle cooling agent: -78°C
- First iteration pellets in box – cold but difficult to remove and quickly consumed
- Next iterations introduced (about three):
  - Dry ice slides
  - Separate compartment for exchange without heating up
  - Heating foil in the bottom for quick heating up
  - Better lid
  - Narrower version for DESY
  - Full mounting set (also used for all other boxes with base plate which became a standard: 1*1 grid of M5 threaded holes)
- Copper stripes attached to back of modules and base plate for heat transfer
- Pros:
  - No movable parts
  - Cheap
  - Big reserve of cooling power

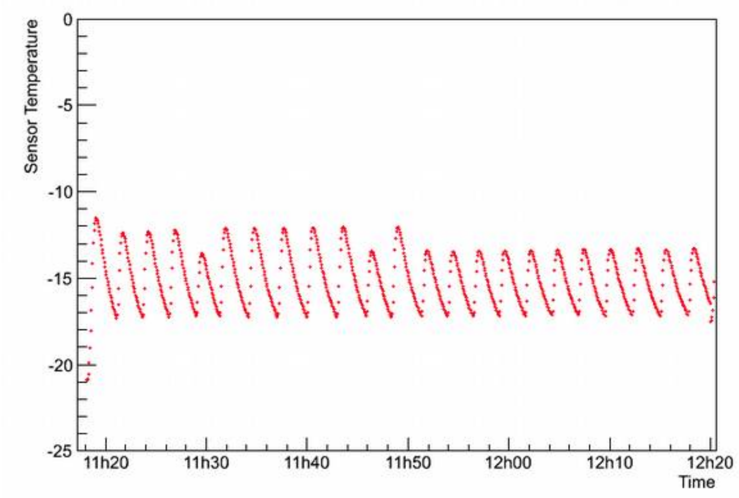


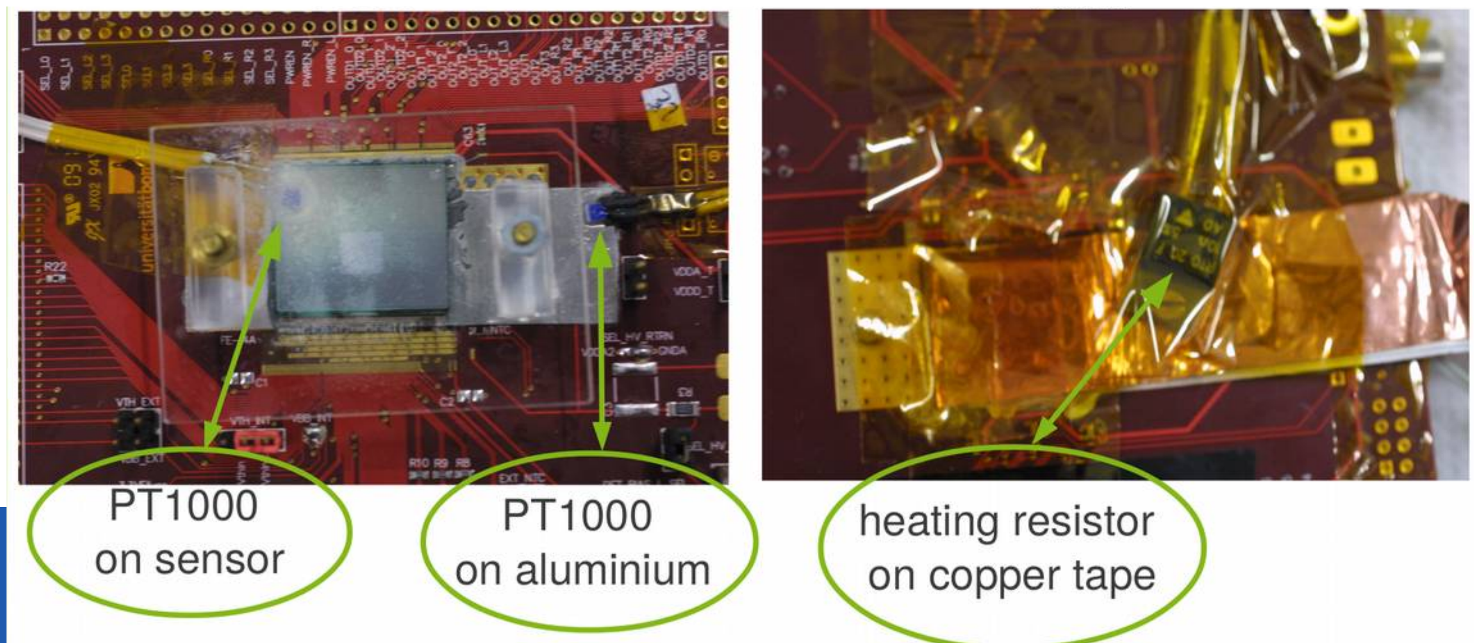




Cold Boxes – Dry Ice aka DOBOX

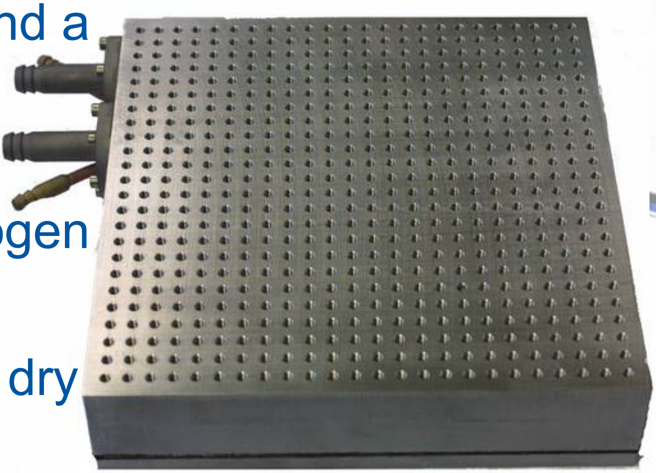
- Temperature on sensor difficult to measure
- Cons:
  - Consumable
  - Heavy / Weight changes through sublimation
  - No Temperature Regulation
  - Attempted quite successfully counter heating with resistor and software PID controlled power supply BUT
  - Quite big overhead

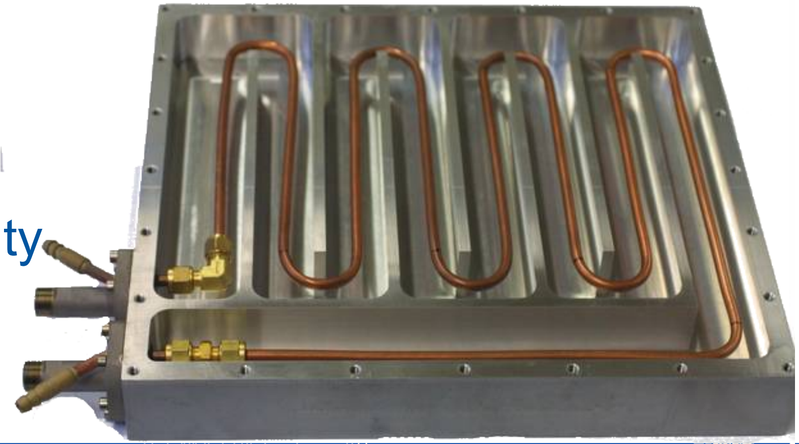




Cold Boxes – Base plate cooled

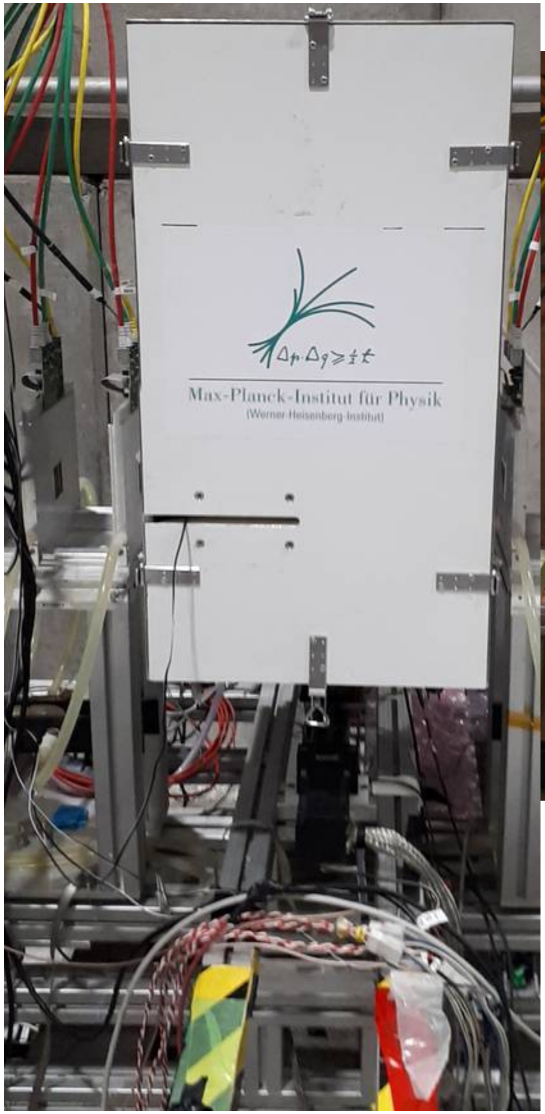
- Derived from Dortmund lab setup
- Operated with silicon oil and a Julabo deep temperature chiller (-90°C)
- Possibility to pre-cool nitrogen for flushing
- Same principle used as in dry ice boxes: contact
- But realized (simulated) that most cooling happened actually through the air as sample mounting not optimized for heat conductivity
- Works well for cold box of FEI4 telescope





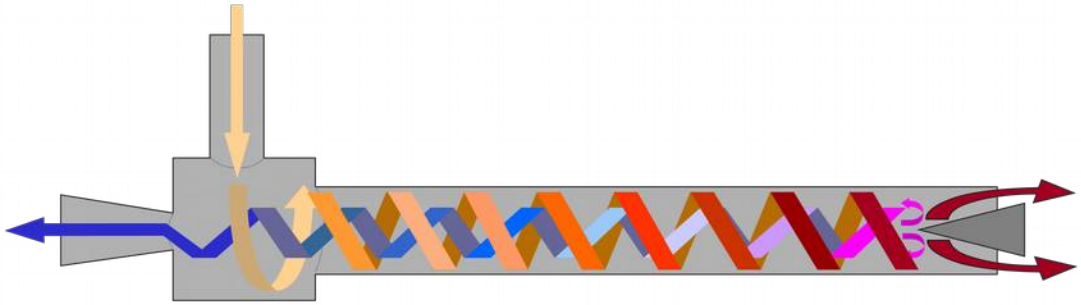
Cold Boxes – Heat Exchanger

- MPI box
- Purely air (nitrogen) cooling with heat exchanger back cooled with Julabo FP-90 deep temperature chiller
- Two versions: Second iteration a bit taller to accommodate new sensors
- Less precise but cheaper and sturdier remote controlled linear stages
- Pros:
  - Works very well down to -40°C
  - Basically plug and play
- Cons:
  - Experienced some issues with this particular chiller
  - Quite long cool down and warm up
  - Now even lower temperatures and higher heat loads are required



Cold Boxes – Alternative

- Future requirements:
  - Lower temperatures
  - Higher heat loads
  - Faster cycles save beam time
  - Magnetic field
  - Light weight for lower energy beams
  - Easier alignment between samples



- Controlled liquid nitrogen evaporation
- Vortex tube:
  - Simple
  - Requires pressurized air
  - Noise
  - Maximum -50°C
- Cold air generator (e.g. TA-5000):
  - Promising
  - Turn key solution
  - Expensive

Backup