Hybrid options with TE coolers

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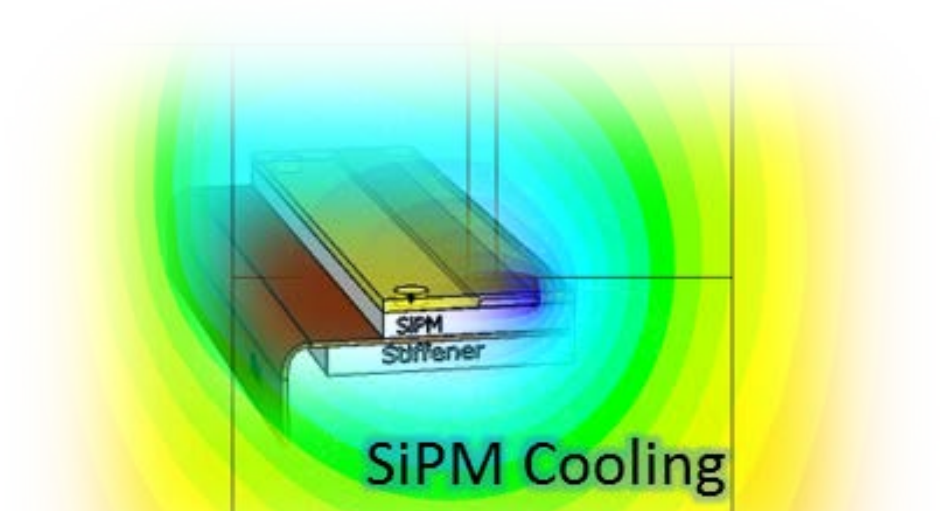
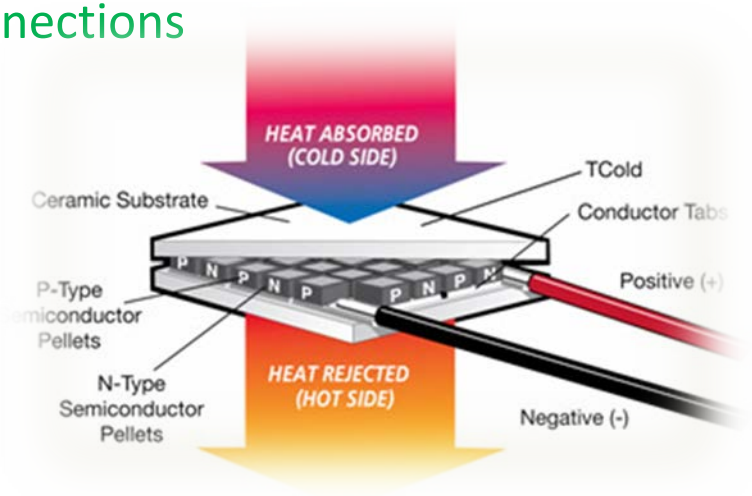


1st Workshop on SiPM cooling for Fiber Tracker, CERN 17 October 2013

TE coolers (TEC): motivation

- Historically, one of the first proposed options for SiPM cooling (November 2012, then for T=-25°C)
- Widely used for compact cooling systems
- ΔT up to **100°C** for 2-stage modules
- Ideal modular solution with “warm-only” connections
- Precise local temperature control (0.1°C)
- No moving parts, environmentally safe
- Reliable (typical lifetime > 200 000 h)
- Reversible (cooling/heating)
- Resistant to ionizing radiation



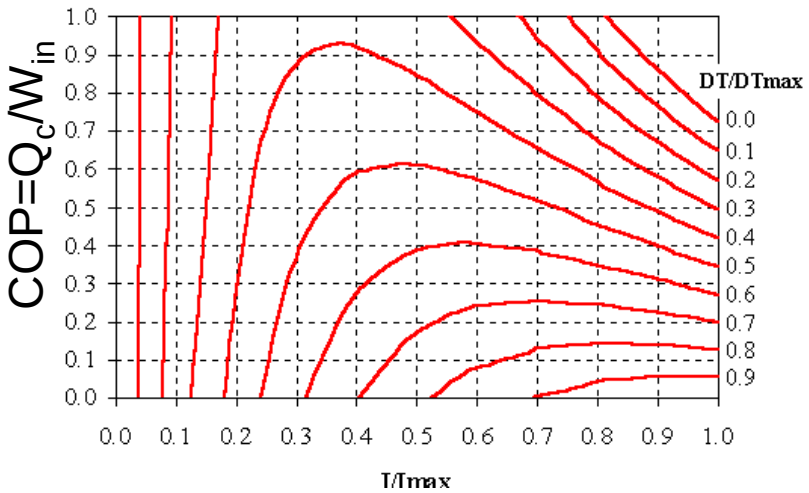
(Image from http://www.tellurex.com/technology/peltier-faq.php)

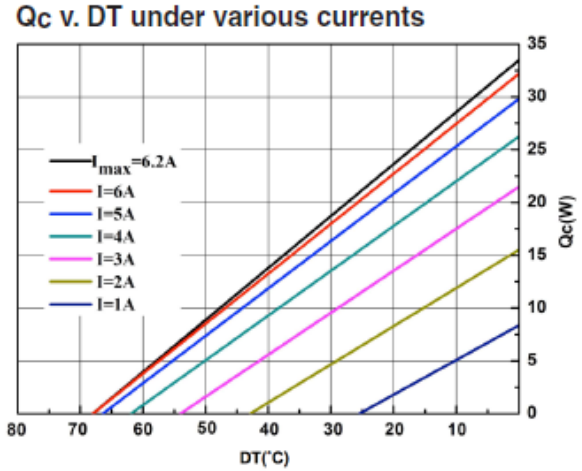
Interest expressed by:

- Myself!
- Uni. of Heidelberg (B.Leverington + student)
- Inst. of Thermoelectricity (ITE, Chernovtsy/Ukraine)

TEC drawbacks

- **Low efficiency** at extreme *ΔT,* generate a lot of heat (from Watts, to tens of Watts), require DC of O(1-10A): applications are limited to small setups
- Very little is known about their **resistance to neutron radiation** (recently, TEC samples were irradiated at the Ljubljana reactor, to be examined at CERN soon)

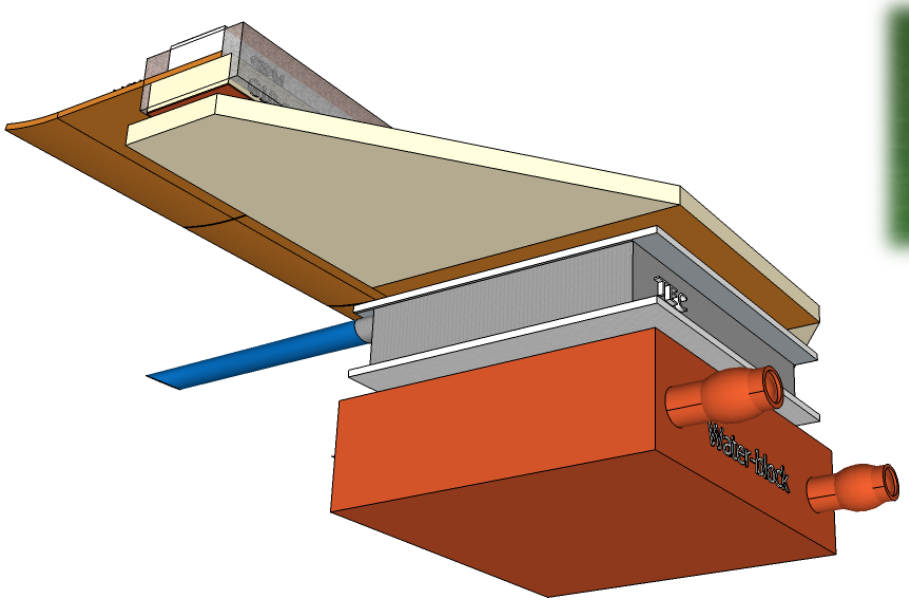


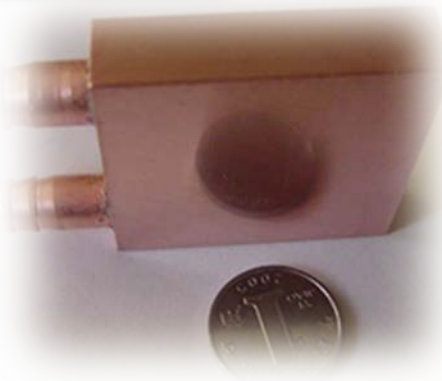


Typical 30x30 mm2 TEC (Tellurex C2-30-0806), At I=4A, Win ~ 20W

FT-specific aspects

- Require water cooling at extreme ΔT
- Can be expensive (linear floating power supplies, ~1200 ~30W channels ~300K Euros (CAEN))
- High currents (Amps): must be moved away from SiPMs (nano-Amps)
- pipes) require R&D

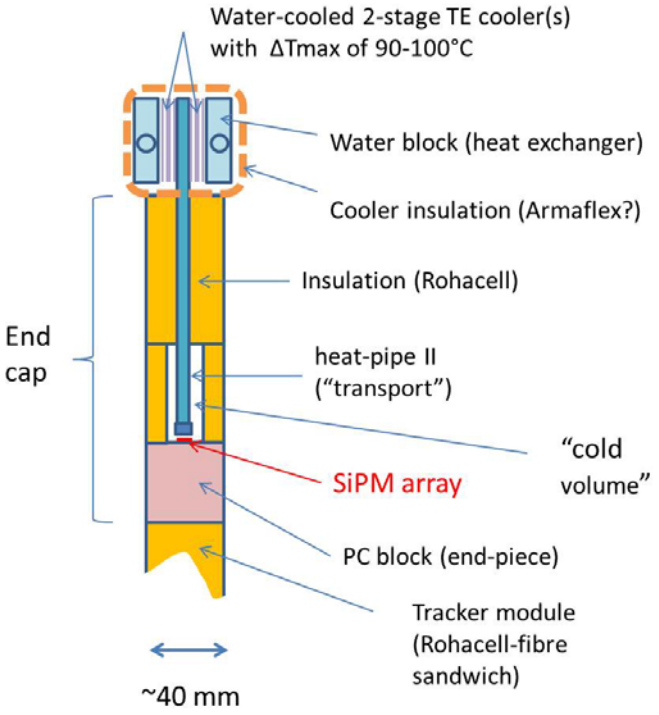




Follow-up

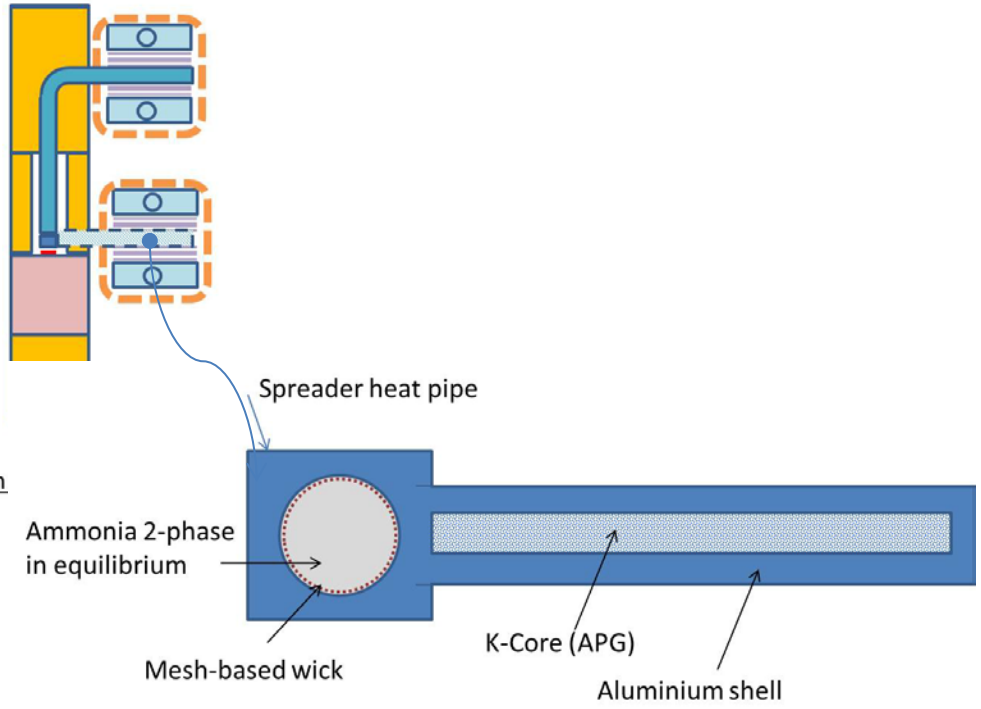
- Established contacts with leading TEC developers and manufacturers
- Visit to ITE (Chernovtsy/UA), to discuss ways to optimize the use of TECs with SiPMs
  - They favored hybrid solutions: a fully integrated version (1-stage Peltier in the SiPM package), or a custom-designed TEC with liquid precooling at -10…-20°C. Both options were rejected at CERN: prefer a simpler solution
- Contacts and visit to Thermacore (UK), to discuss another hybrid option with an external 2-stage TEC bridged to a low-temperature ammonia-filled heat pipe attached to the SiPM array inside the end cap. The heat pipe acts as a perfect heat spreader providing a uniform (within 1°C) temperature profile along the 53 cm-long detector array.
  - Thermacore presentation at CERN (24 July 2013)
  - Offer to design and manufacture prototype heat pipes; cost estimate for mass production (~1 kEuro/piece). Rejected at CERN: high cost, ammonia

Heat-pipe/TEC hybrid concept:



Option (a): top cooler on top

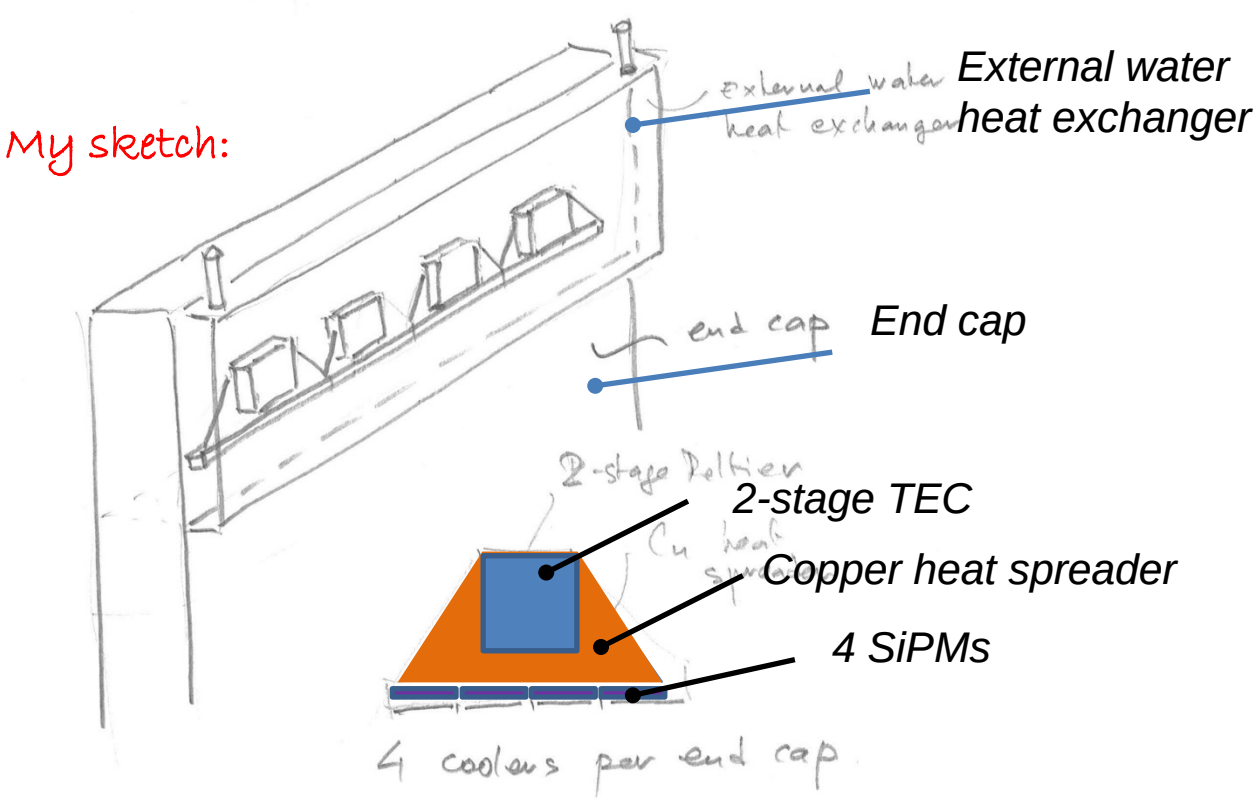
Swiftech MCW-Chill 452



Option

The latest concept

- Decision to return to the original proposal with an external TEC and copper heat spreader (one per 4 SiPMs = 1 fibre mat), using the existing end cap design concept as the basis
- ITEP design engineer currently working on the CAD drawings.



Summary

- TE cooling (or a hybrid TE/water) represents a potential solution, fully matching the requirements of modularity, “warm connections” and ability to cycle between cooling and warming.
- R&D is required to prove its viability
- At least one group (Uni. Heidelberg) expressed an interest (with no commitments yet). ITE (UA) is willing to design and produce the TECs.
- This solution can be expensive (unless cheaper multi-channel floating PSs can be found): 300+300(60+250)+100≈500 KCHF

PSs TECs+HEX cabling