The CBM/HADES/PANDA-DiRICH Project and Experiences with the Series Production

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Outline

Motivation

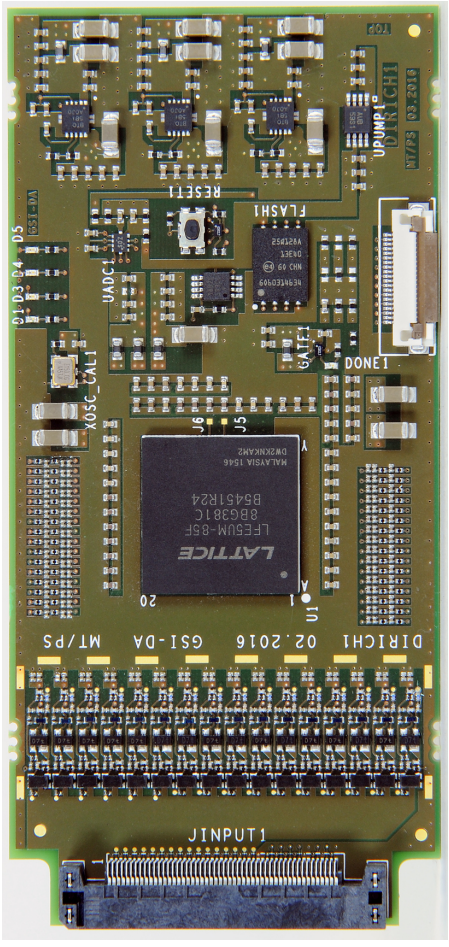
- Joint Venture Frontend-Electronics for MAPMT/MCP-PMT readout for

Experiment	Number of Channels
PANDA Barrel DIRC	~11k
CBM RICH	~65k
HADES RICH	27392

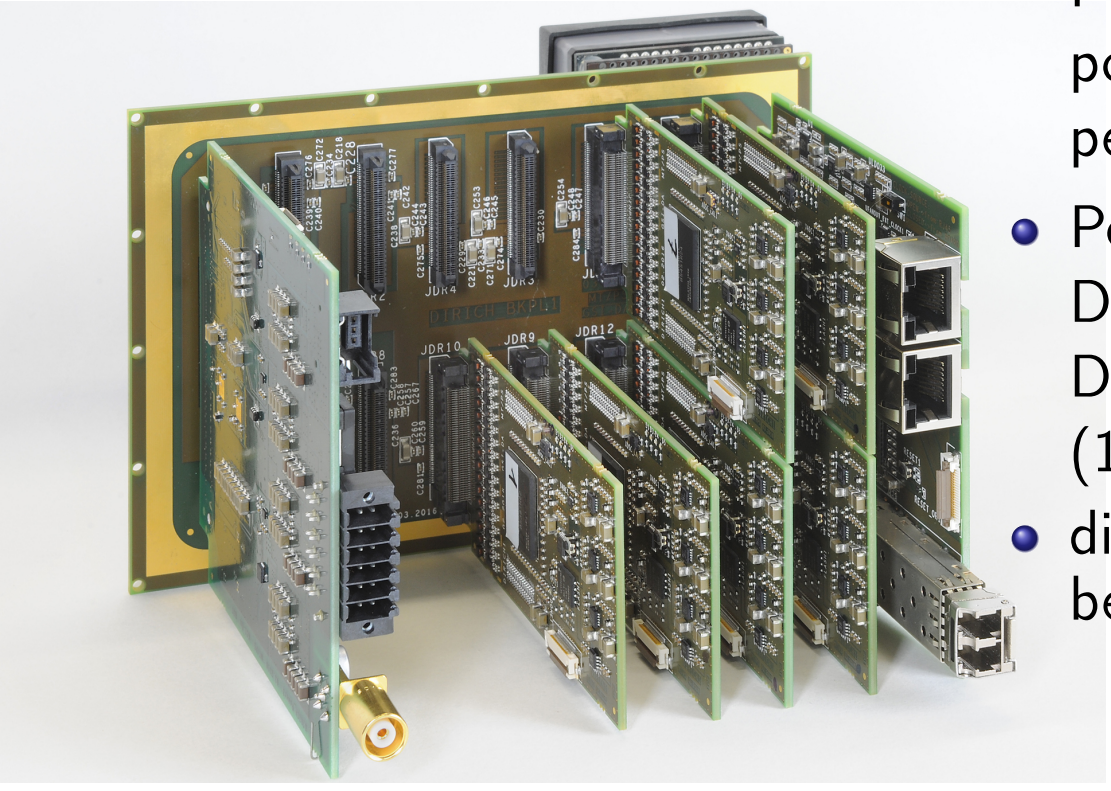
  - a lot of work to develop, qualify the electronics and write the necessary control and analysis software
  - task is shared among all groups, experience is shared!
  - many more applications will most likely jump on the moving train...

DiRICH FEE

- 32 channels
- galvanic isolation of PMT to FEE (transformer)
- ~factor 30 gain amplifier, 12mW
- individual threshold for each discriminator
- TDC with ~10ps intrinsic time precision (ToT measurement)
- data acquisition system included (TRBNet)
- data is sent out on the same connector
- only one connector for everything => cable-free system

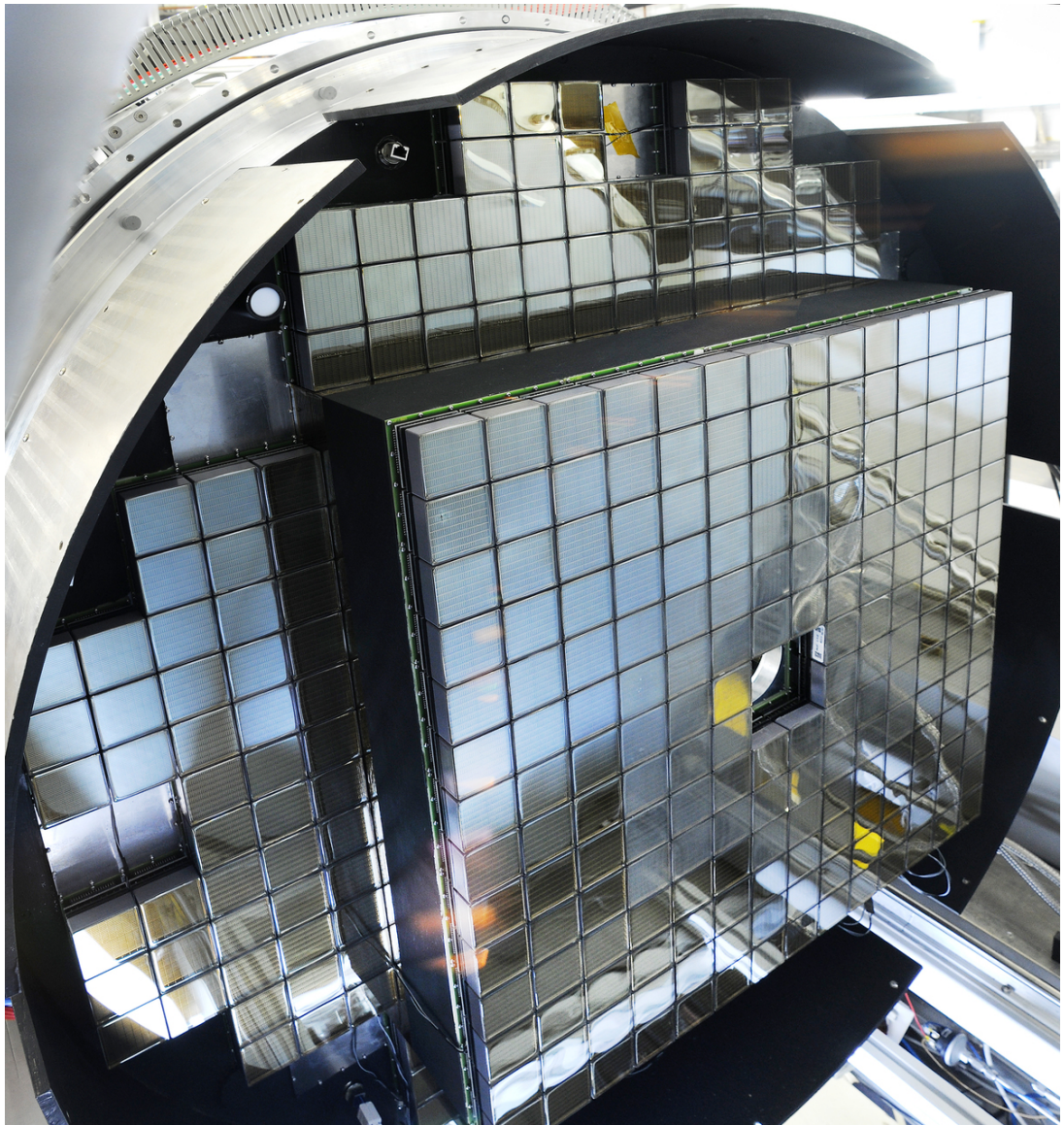


DiRICH FEE / Full module

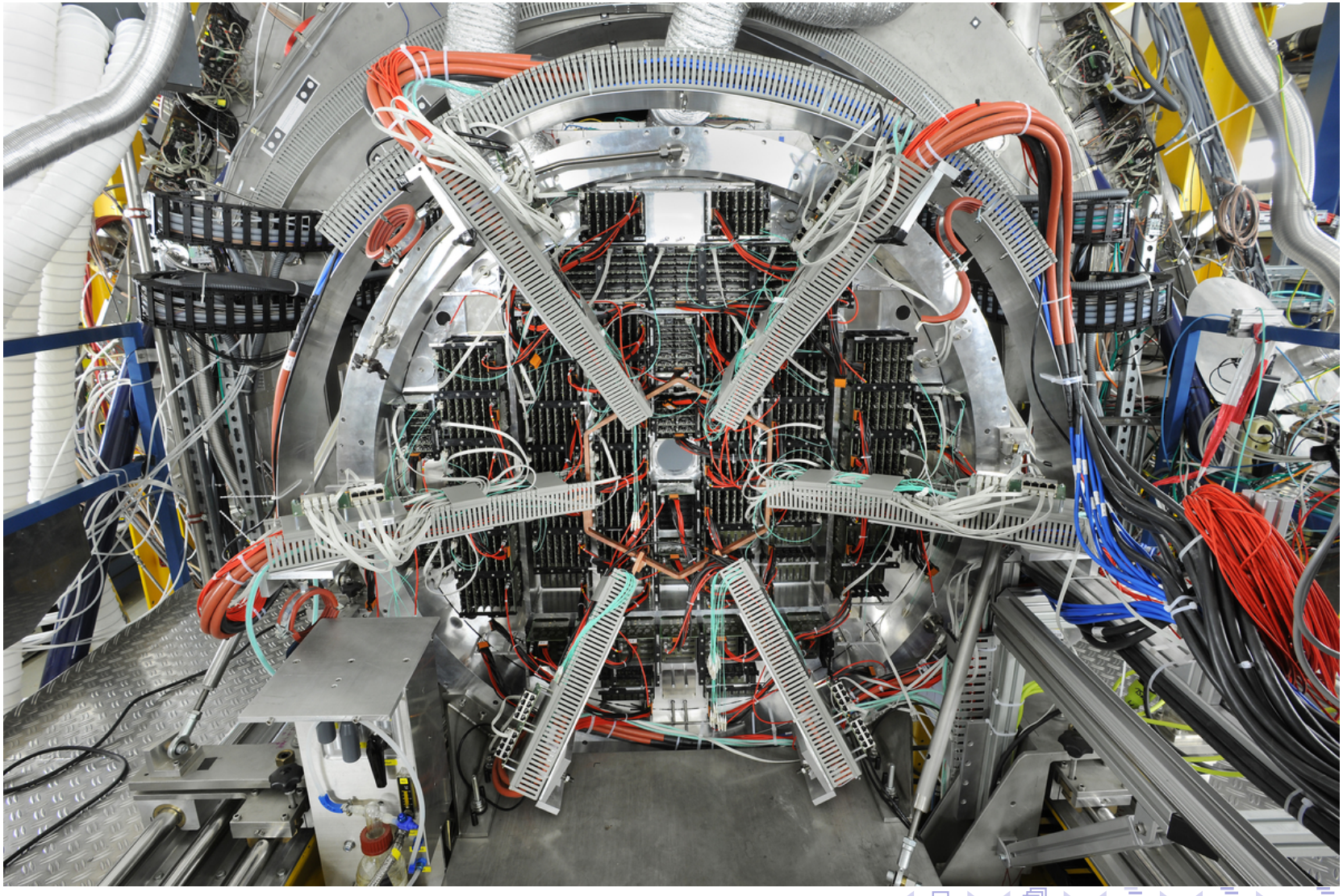


- backplane for 6 MAPMTs
- backplane routes all PMT-signals, clock, trigger, power, HV and 2Gb/s DAQ per DiRICH
- Power (linear or DC/DC-converter) and DAQ-data-concentrator (12:1) modules are needed
- different variations have been built:
  - 4 MAPMTs
  - 4 MCP-PMTs
  - the rest of the infrastructure stays as it is

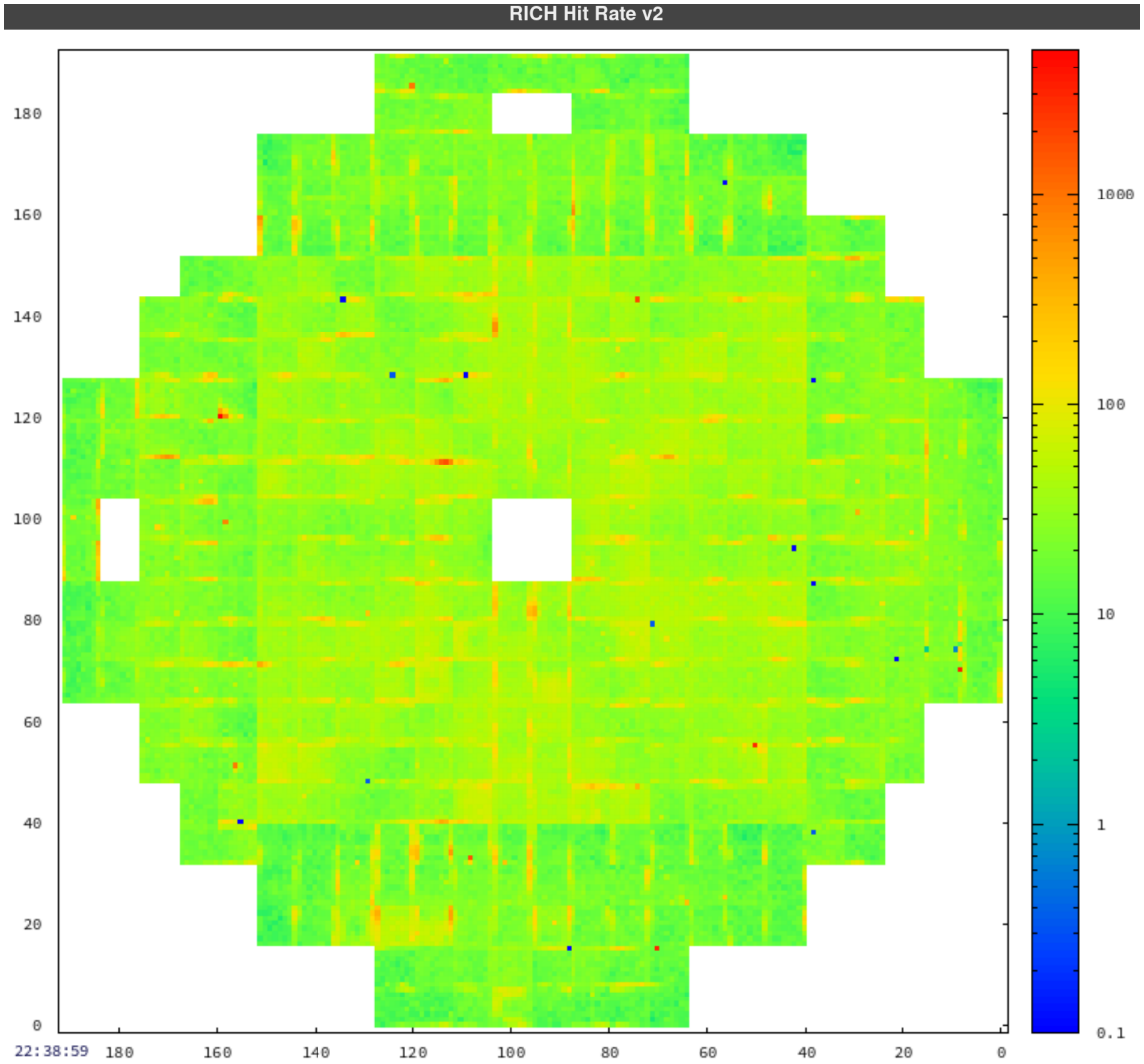
HADES RICH / Full system I / PMTs



HADES RICH / Full system II / Electronics



HADES RICH / PMT Dark Rates



Everything Straight Forward?

We encountered problems until we reached the goal!

Electronic Issues During Development

- late in the project (too late to change the FPGA):
  - ECP5UM needs lowering of the SERDES-PLL analog voltage by ~60mV to work on all FPGAs stable at 2Gb/s.
  - FPGA-SERDES works for other transmission speeds
  - still not understood but workaround works for 1000 DiRICH modules
    - High risk: Not understood problems normally strike back
    - only way to stay inside the time schedule

Other Technical Lessons Learned I

LV-supply

- Decided to go for external power-supplies to get best front-end performance
  - DC/DC convertors on Power-Supply-module only 20mm away from the DiRICH produces visible noise in the system
  - Standard Industry AC/DC convertors are used
  - bad noise performance directly at the output
  - ~1m distance (and cable) the noise is as low as operated with a lab-power-supply
- Delivering 1.1V @ 1000A to the FEE is not a big deal
  - and not dangerous (power supplies have a current limit and shut down)

Other Technical Lessons Learned II

Cooling

- MAPMTs should be operated below 30°C to reduce the dark rate and maximize by this the life-time
- After simulations and many measurements
- HADES-RICH: the temperature of the PMTs is quite indirectly coupled to the FEE-electronics temperature
  - Keeping the FEE temperature low in every corner is demanding
  - it is much more efficient to cool the PMTs
- 3 normal 200mm fans are enough to cool the whole HADES RICH FEE: ~1500W FEE (incl. LDO) + ~500W cables
- Conclusion
  - Put temperature sensors everywhere to reduce the guessing
  - Seems to be hard to simulate and needs quite some testing to find the least effort strategy for cooling

PCB Production

- demanding PCBs needed to reach the channel density
  - stacked micro-vias, buried vias
    - up to five PCB-pressing steps needed
- all fine for prototypes until we asked for the "mass" production
  - The PCB-manufacturer claimed that the yield was too bad and they don't want to produce it...
    - Demanded change in layout
    - would need a new test
    - delay of project beyond the deadline (~70 working days to get the PCBs)
  - only after long negotiations they continued
- worth the effort: only this kind of PCB-technology allowed a "noise-free" operation of small signals and DAQ on the same connector

Material and PCB Assembly I

- 1100 DiRICH result in ~1 Million components
- electronics component market is in allocation
- delivery of a 100nF capacitor: 52 weeks (we order that!)
- results in a lot of effort to find alternatives from different vendors or even change technology from wire wound coils to printed coils

Acceptance of Order

040	44.14.30	CC0201KRX5R5BB333	30.000	0	30.000	28.09.18 13.05.19	4,22	1.000	Stk
	ROHS-Y	MLCC 0201 (0,6 x 0,3 x 0,3 mm) 33,0 nF 6,3V X5R (EIA) ±10% (K) Herstellerartikel-Nr.: CC0201KRX5R5BB333 Hersteller: YAGEO VPE: 15000 Stück Zolltarif-Nr : 85322400 Ursprungsland : China Praeferenzberechtigt: NEIN **Allocation** Der genannte Liefertermin ist aufgrund der Liefersituation unseres Herstellers nicht verbindlich!							
050	44.14.47	CC0201KRX7R5BB103	75.000	0	75.000	28.09.18 13.05.19	2,22	1.000	Stk
	ROHS-Y	MLCC 0201 (0,6 x 0,3 x 0,3 mm) 10,0 nF 6,3V X7R (EIA) ±10% (K) Herstellerartikel-Nr.: CC0201KRX7R5BB103 Hersteller: YAGEO VPE: 15000 Stück Zolltarif-Nr : 85322400							

Material and PCB Assembly II

Tender process for PCB Assembly

- The administration of the University was not able to conduct the whole process of the European wide tender in a compatible time frame (<3 month)
- more complicated: external company also needs to acquire components in a market in allocation: each replacement part needs approval by developer
- our deadline in 5 month (beam time) required to shift all production to GSI
  - At GSI we were able to directly put the needed resources in materials procurement (even a day before Christmas!) and PCB-assembly
  - causing friction and delays for other projects

Material and PCB Assembly III

Production Conclusion

Plan ~1 year for a stress-free formal tender process, material procurement and production of larger quantities of electronics with electronics-test, solder error correction and some contingency (for additional delays, like e.g. PCB-production failures).

Thanks!

Thank you for your attention!