Sparking PMTs in ARCA & ORCA

Jannik Hofestädt
10.01.2018

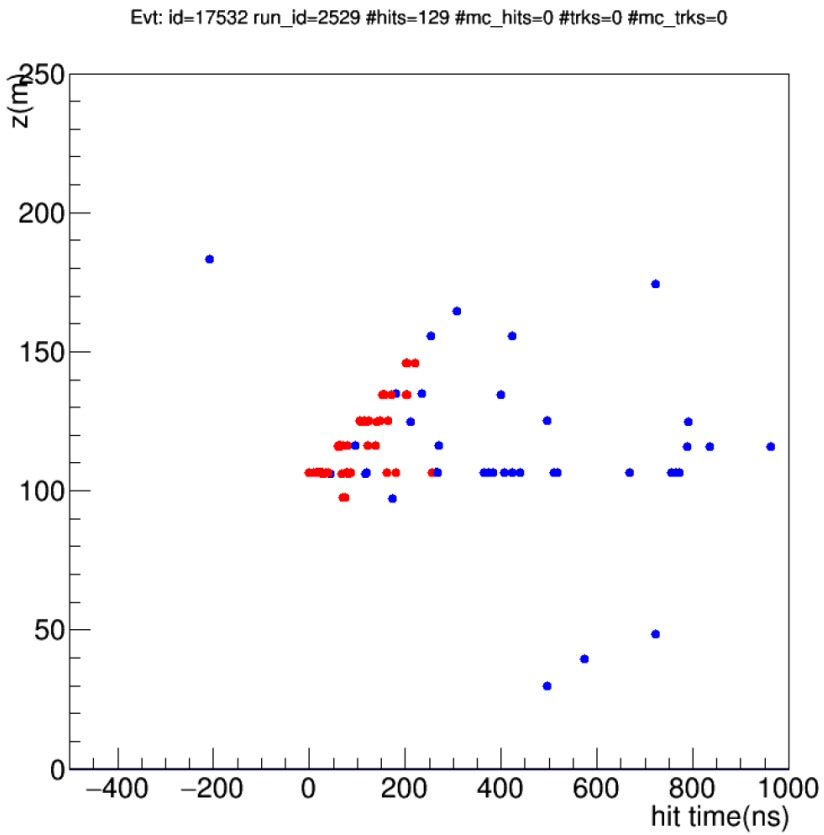
ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

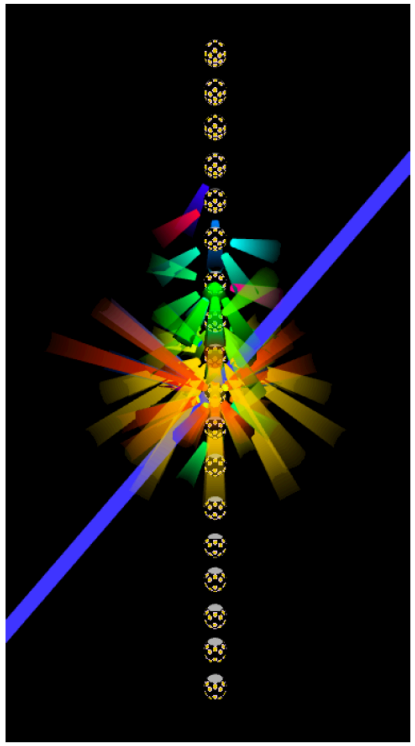
FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

Recap of Dmitry's findings

- Dmitry Zaborov found sporadic flashing DOMs in upgoing track search presented on 6th Dez https://indico.cern.ch/event/684096/
- Hypotheses:
  - nanobeacon
  - sparking PMTs

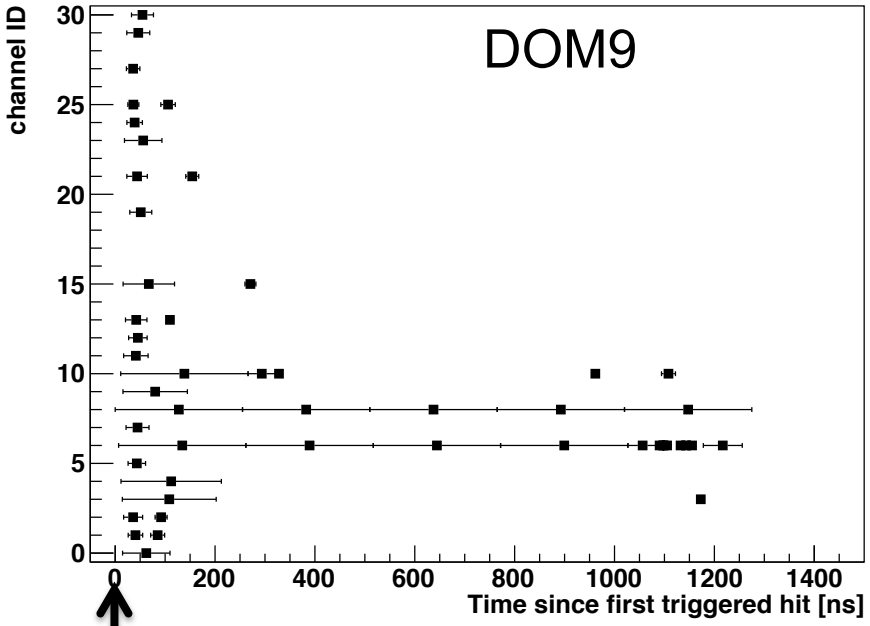
Example of strange event

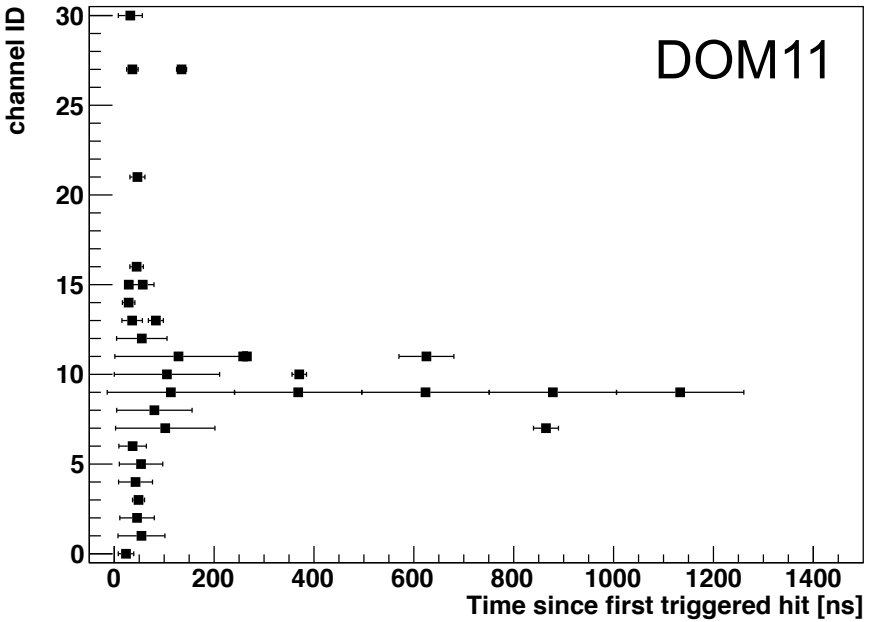




How do hits on fashing DOM look like?

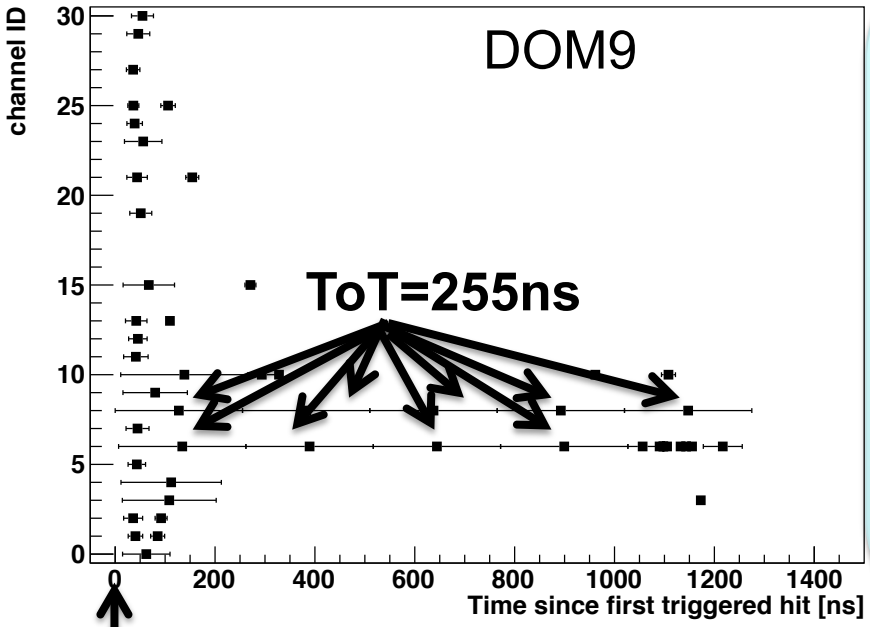
- I investigated the hit patterns on the flashing DOM for many events found by Dmitry
- Here, example events on DOM9 and DOM11 in run 2528
- Many events show nearly identical hit pattern





How do hits on fashing DOM look like?

- I investigated the hit patterns on the flashing DOM for many events found by Dmitry
- Here, example events on DOM9 and DOM11 in run 2528
- Many events show nearly identical hit pattern



0=first triggered hit

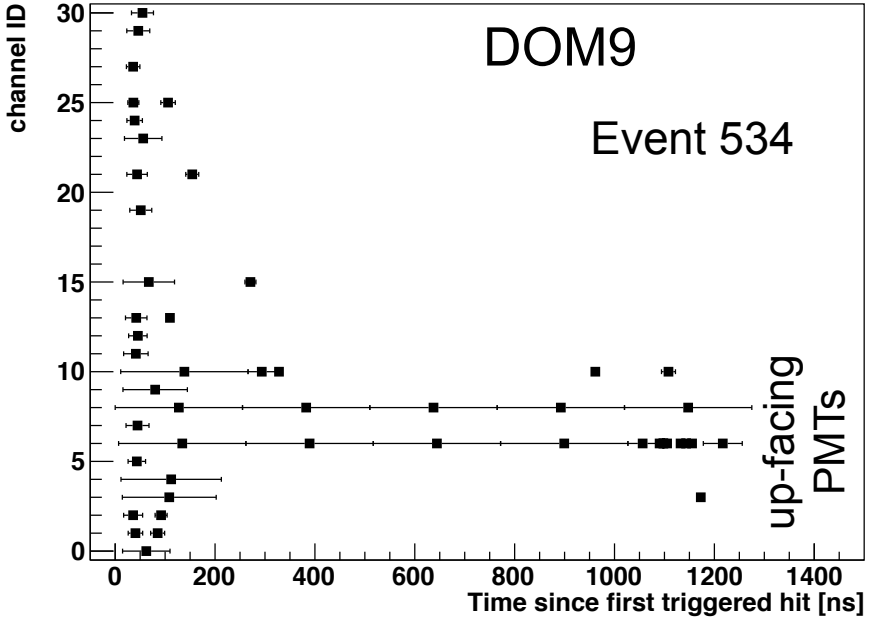
Observations:

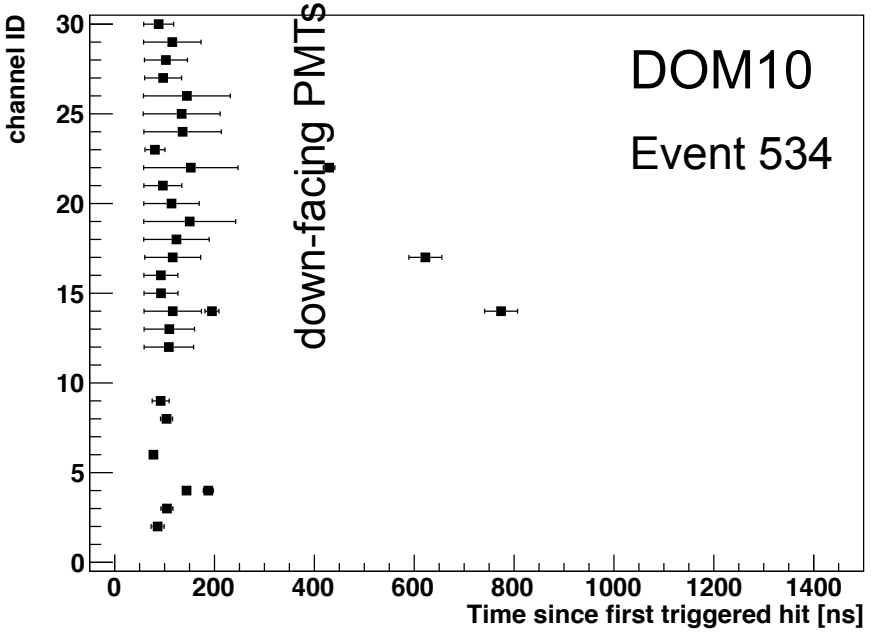
Few PMTs show several consecutive hits with ToT=255ns → source or close to source of the flashes

Often PMT with most ToT=255ns hits is also the first hit → either 1) more photons and therefore higher pre-pulse probability or 2) flash starts in this PMT

How do hits on DOM above flash look like?

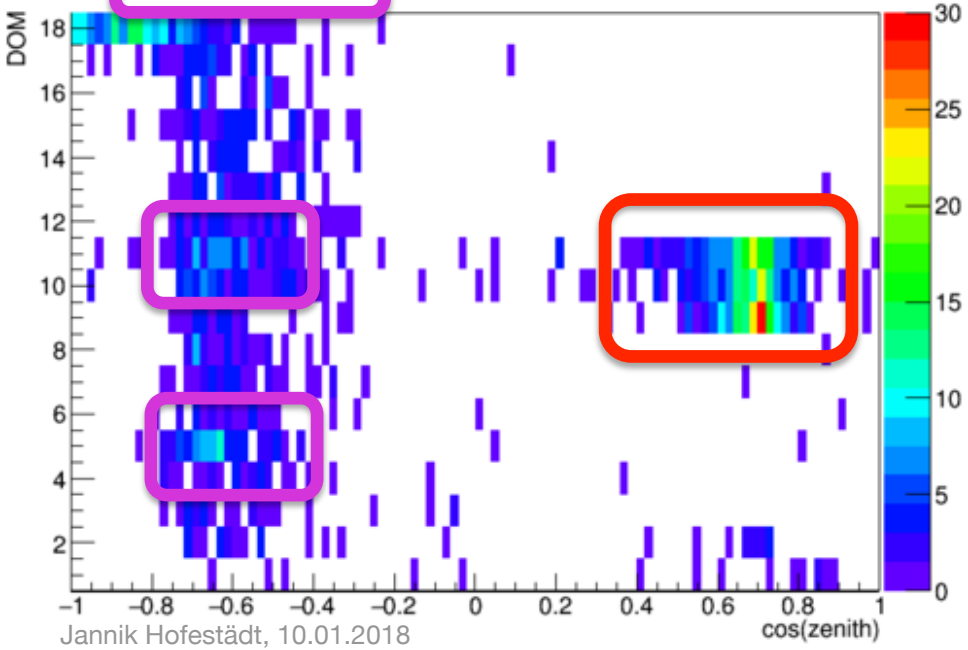
- On DOM above flash the light intensity is often high → multi-PE hits → larger ToT, but light intensity much smaller than on flashing DOM
- Here, same example event

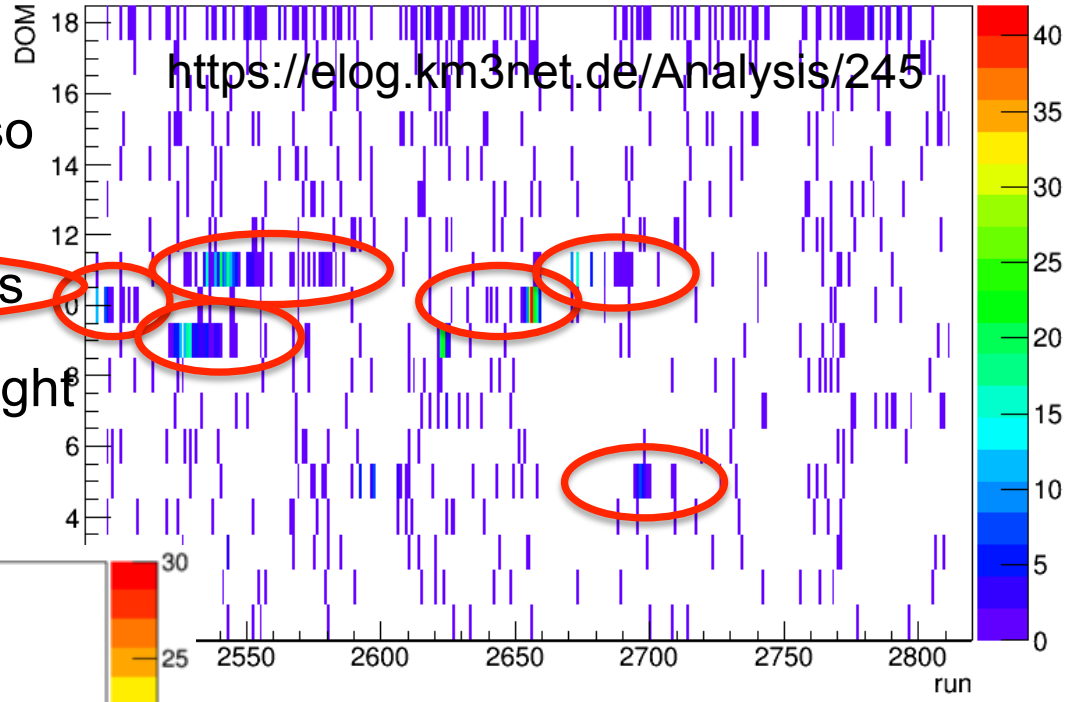




Recap of Dmitry's findings (II)

- Using ToT=255ns hits, Dmitry expanded search also to downgoing light fronts
- Periods with sporadic fashes
- Many fashes with upgoing light front, but some show also downgoing light fronts



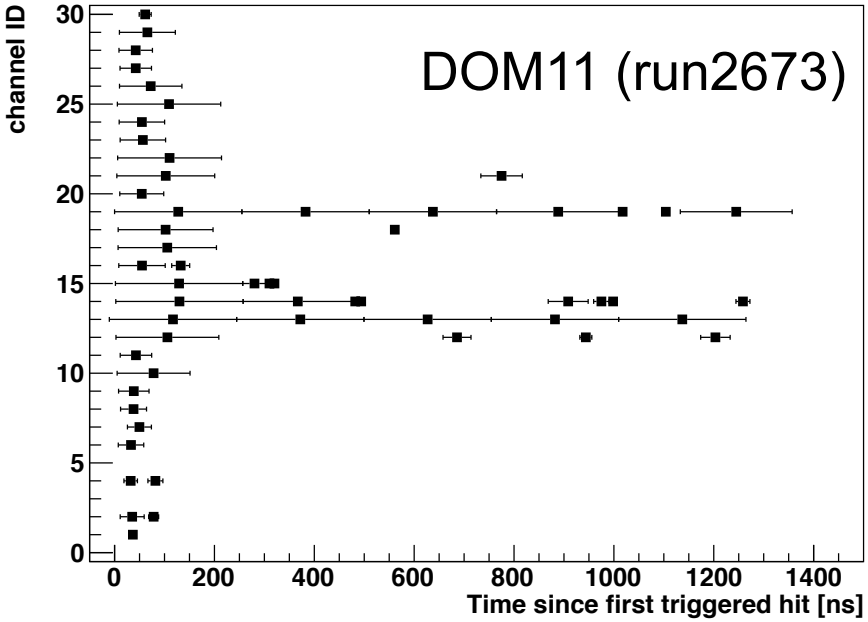


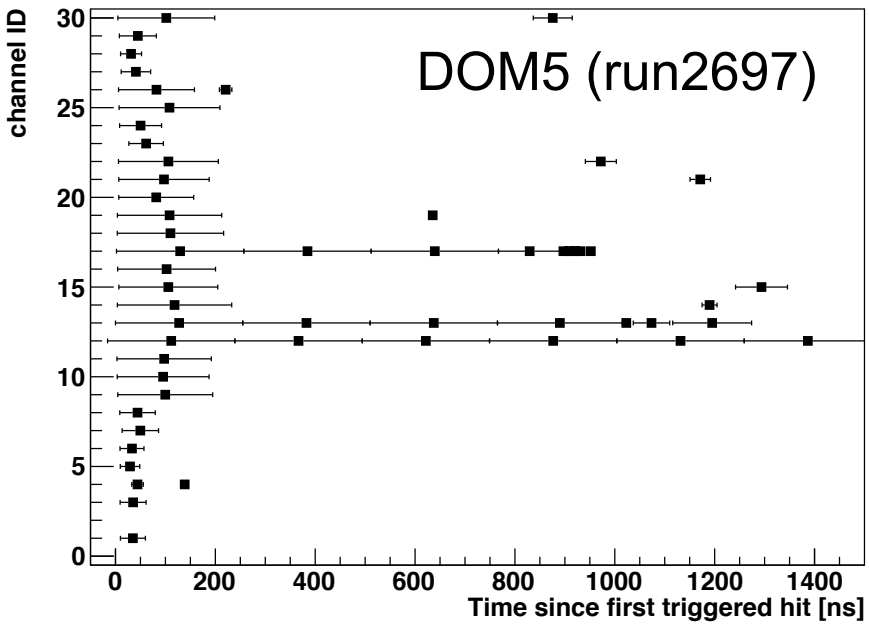
- Existence of downward-flashing events → favouring 'sparking PMT hypothesis' rather than 'nanobeacon hypothesis'

Hit pattern on downward fashing DOMs

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

- Example hit pattern for downward light fronts found by Dmity
- Here:
  - DOM5 (run 2697): channelIDs 12, 13 and 17 seem source of flashes
  - DOM11 (run 2673) :channelIDs 13, 19 and 14 seem source of flashes





https://elog.km3net.de/Analysis/246

More sparks?

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

- Do we have more flashing events than already found with Dmitry's analysis?
- E.g. what about sparking PMTs that are horizontal in DOM?

  (Due to single-string detector layout → less light on adjacent DOMs → maybe not enough hits for triggering)

→ Other search strategy:

  Idea: multiple ToT=255ns hits with many other hits in coincidence, and often consecutive ToT=255ns hits (again often in coincidences)

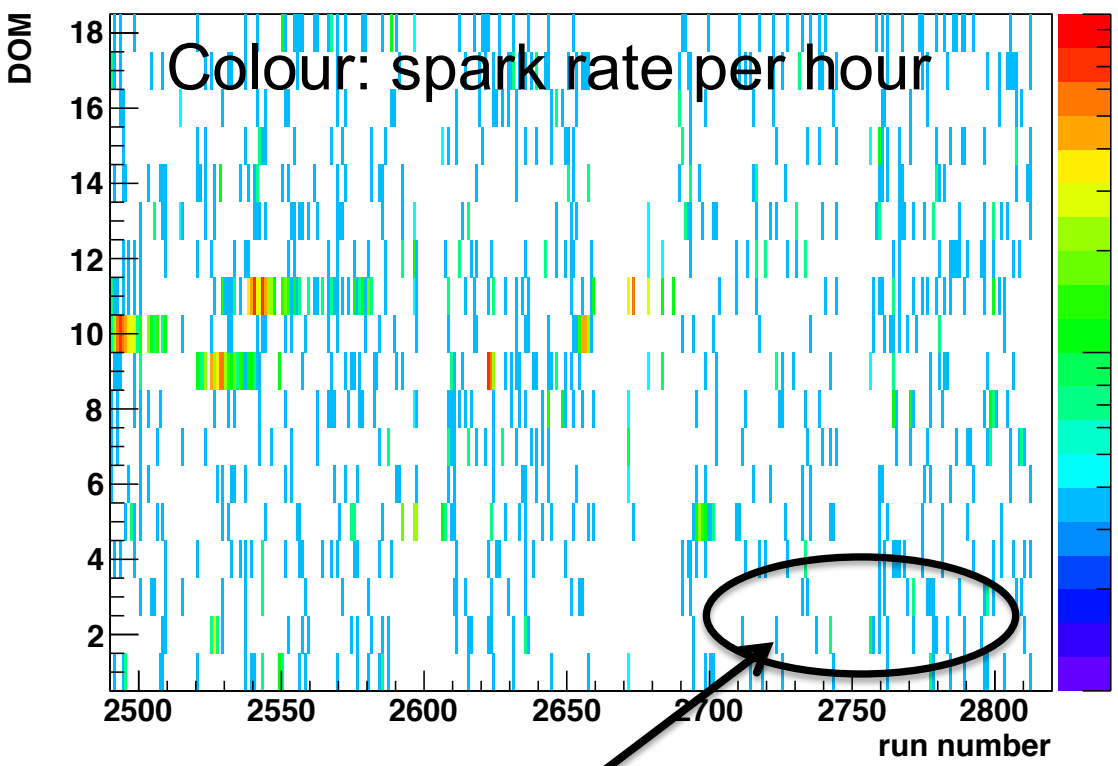
→ Search for multiple coincident ToT=255ns hits in L1 data stream

→ Side effect: based on single DOMs and independent of triggering

  → independent of flash direction, ie. also sensitive to horizontal flashes

  → also applicable to ARCA with larger inter-DOM distances where flashes might not lead to triggered events (fashes in ORCA visible on ~5 adjacent DOMs → ~1 adjacent DOM in ARCA)

Spark Search Results in ORCA

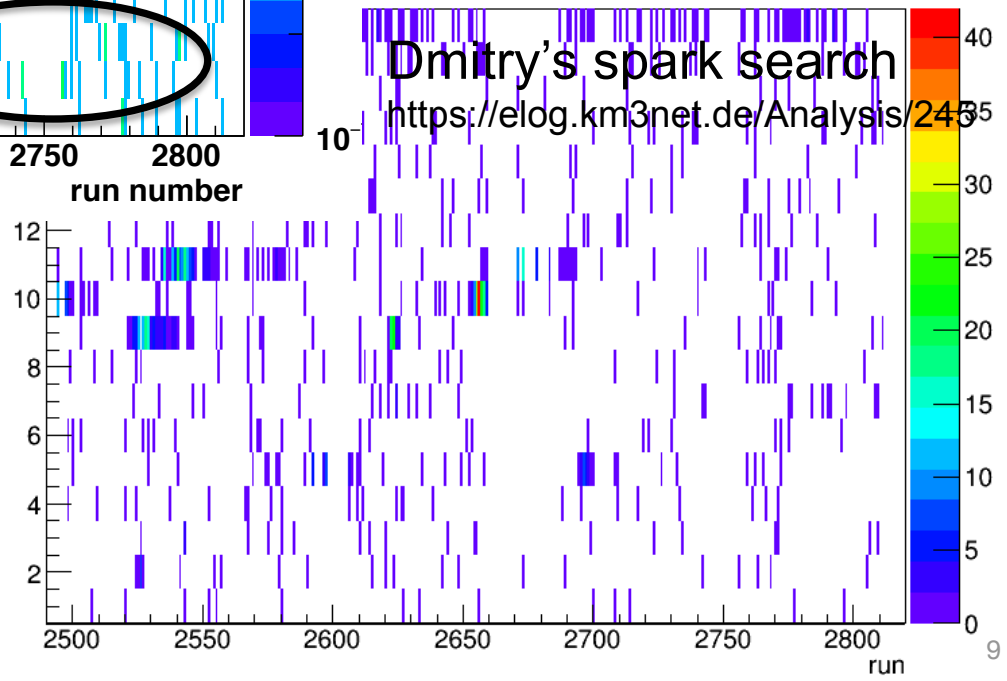


- Finding very similar pattern as Dmitry

→ method works

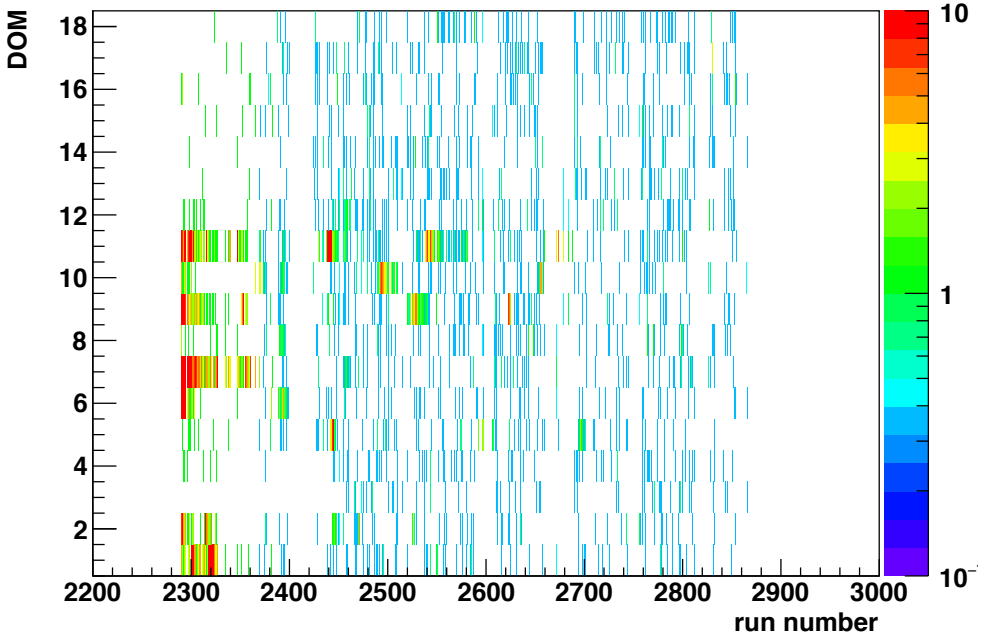
→ good: no further periods

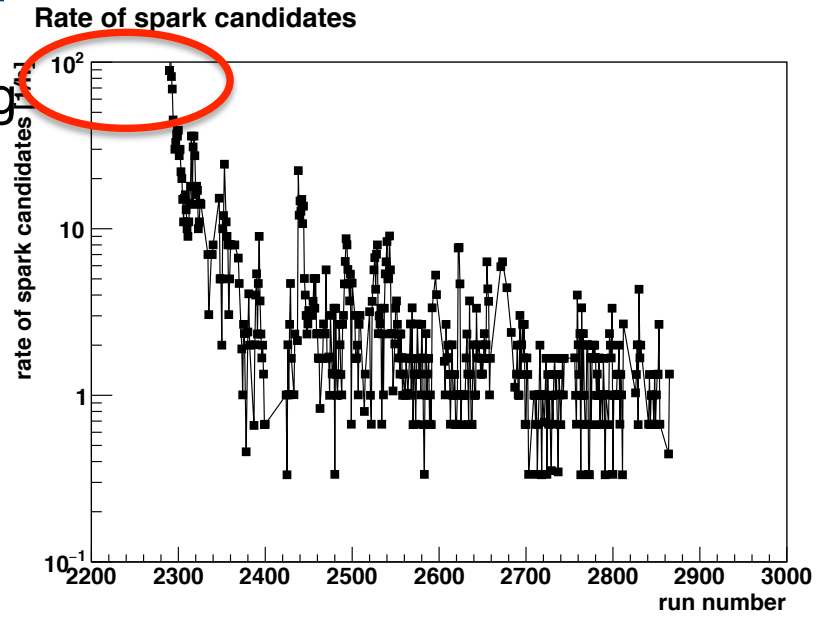
‘muon contamination’
in spark candidates

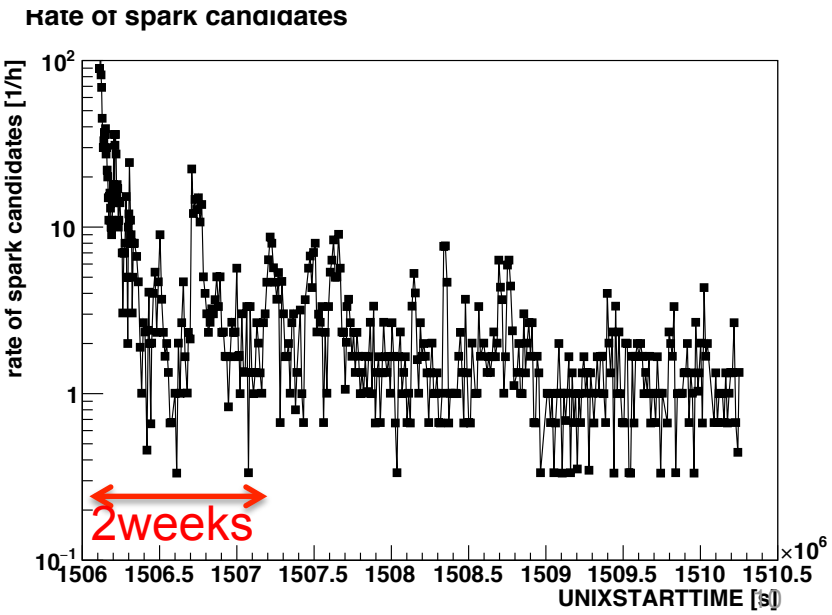


Spark Search Results in ORCA

- ‘interesting’ first 2 weeks of data taking
- After deployment: ~100 sparks/hour
- Since few weeks after deployment: only sporadic periods with sparks



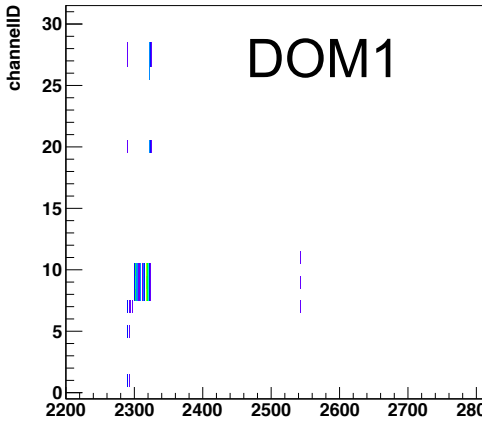


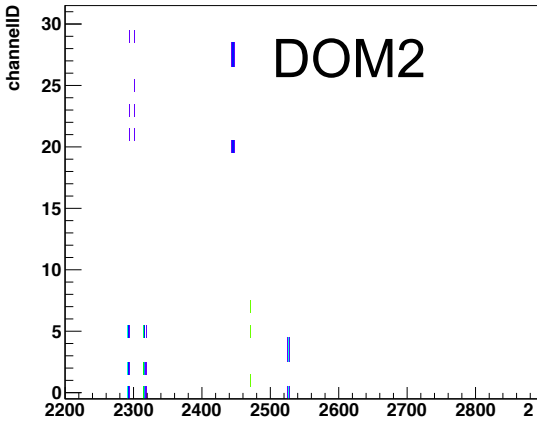


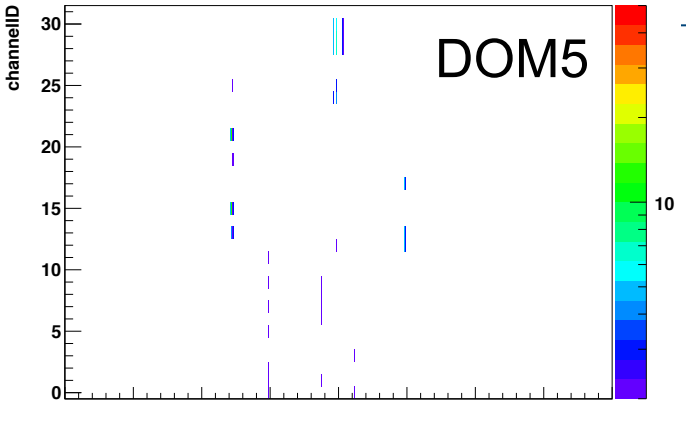
NB: typical run duration changes over time
→ rate for 1 spark candidate in run changes color

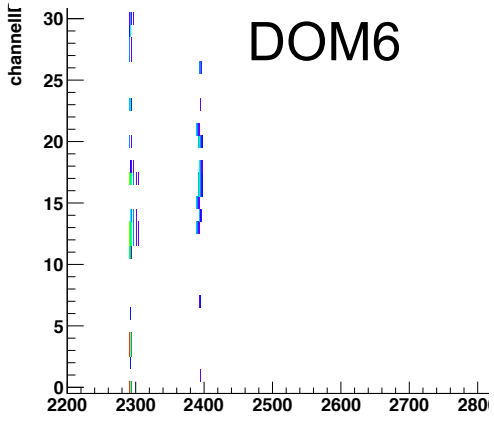
Here, only plotting PMTs that occur >=2 times in spark candidates

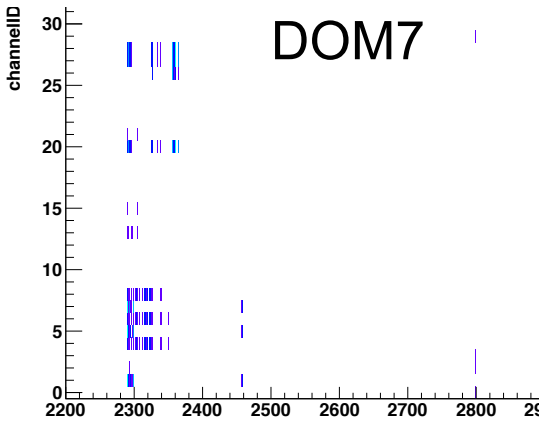
Spark Search Results in ORCA

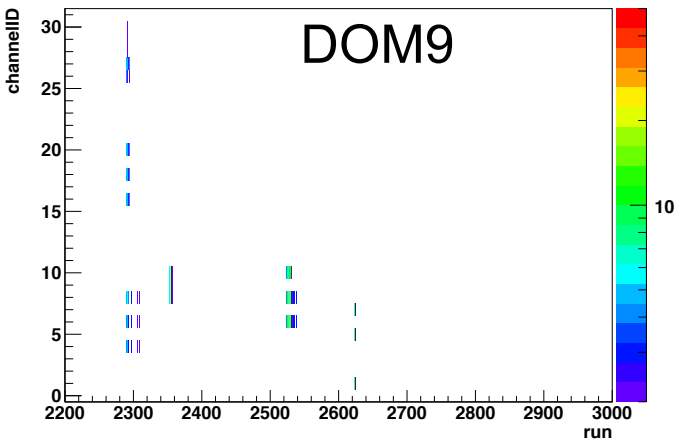


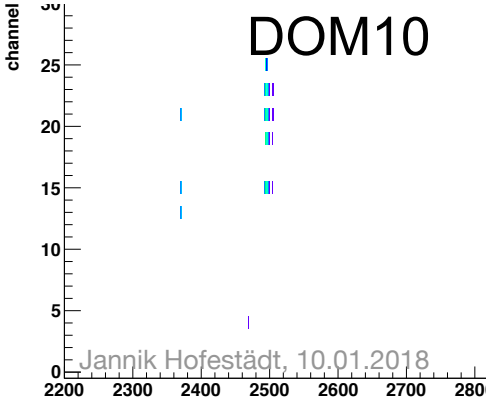


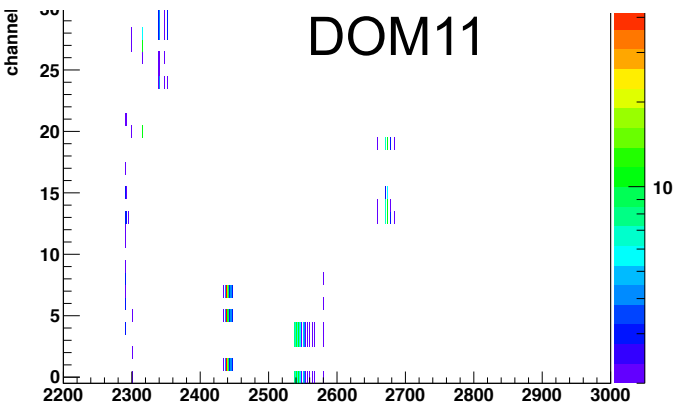








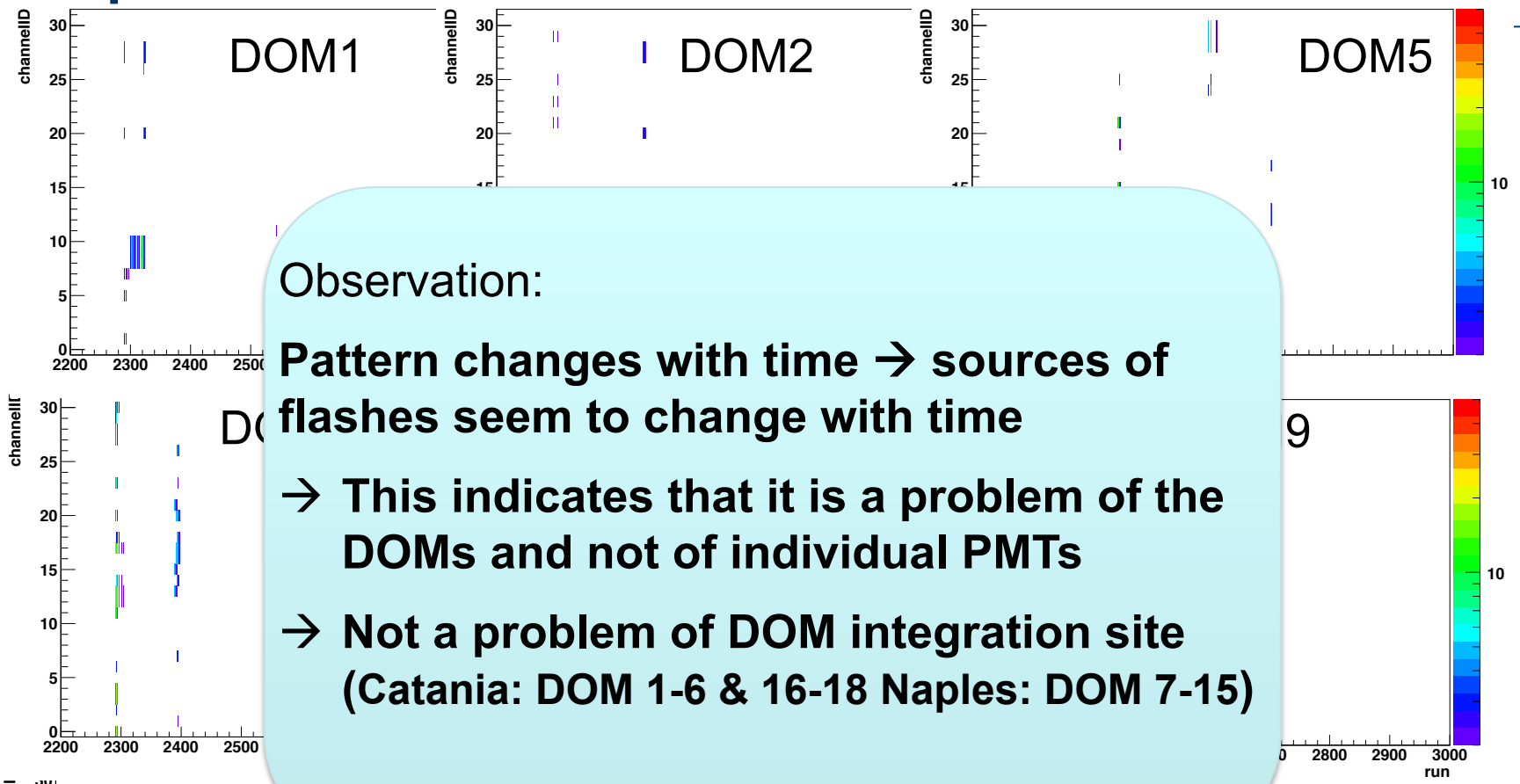




Other DOMs do not have spark-like signaures

Here, only plotting PMTs that occur >=2 times in spark candidates

Spark Search Results in ORCA



Observation:

Pattern changes with time → sources of flashes seem to change with time

→ **This indicates that it is a problem of the DOMs and not of individual PMTs**

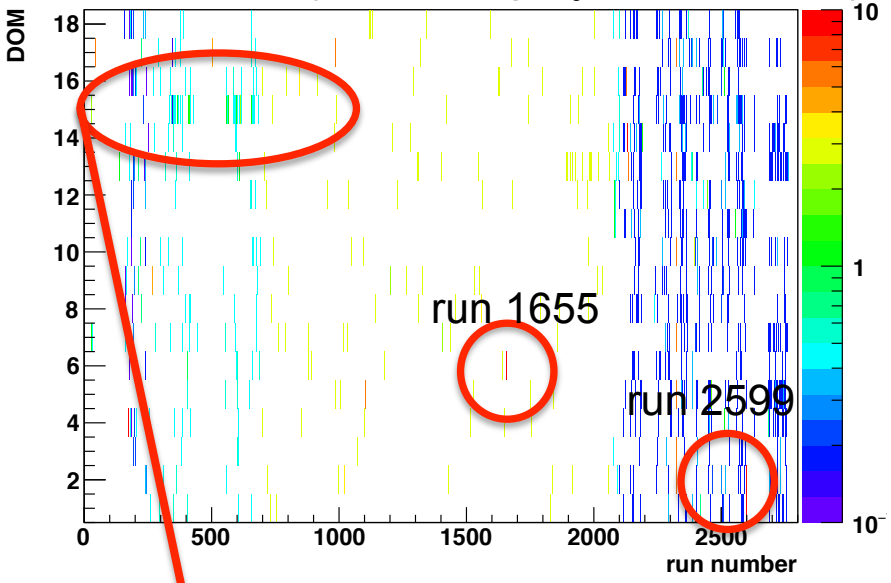
→ **Not a problem of DOM integration site (Catania: DOM 1-6 & 16-18 Naples: DOM 7-15)**

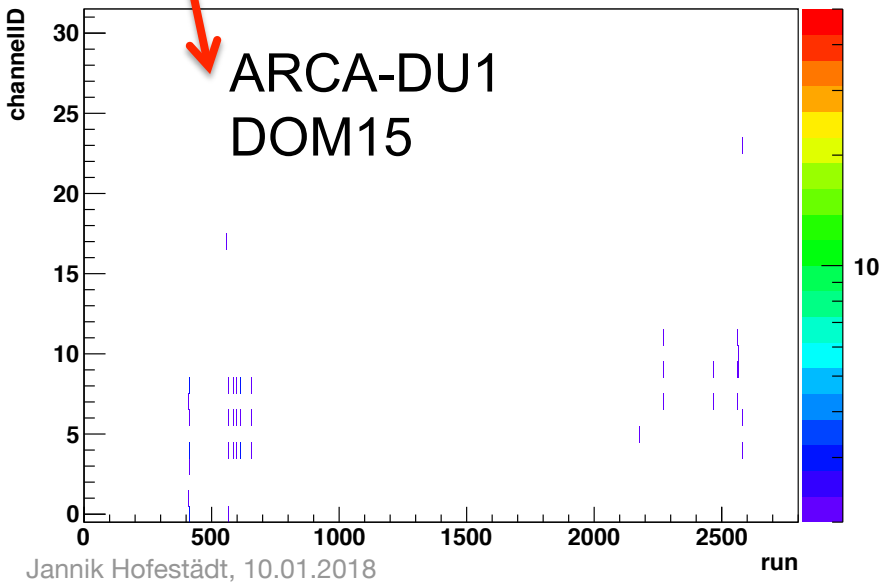
Other DOMs do not have spark-like signaures

Spark Search Results in ARCA-DU1

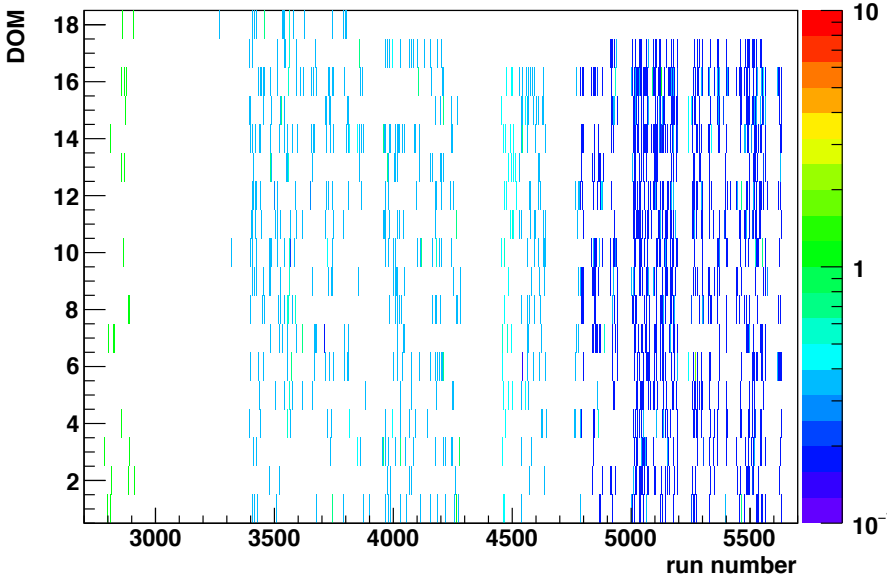
ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

ARCA-DU1 (before deployment of DU2)



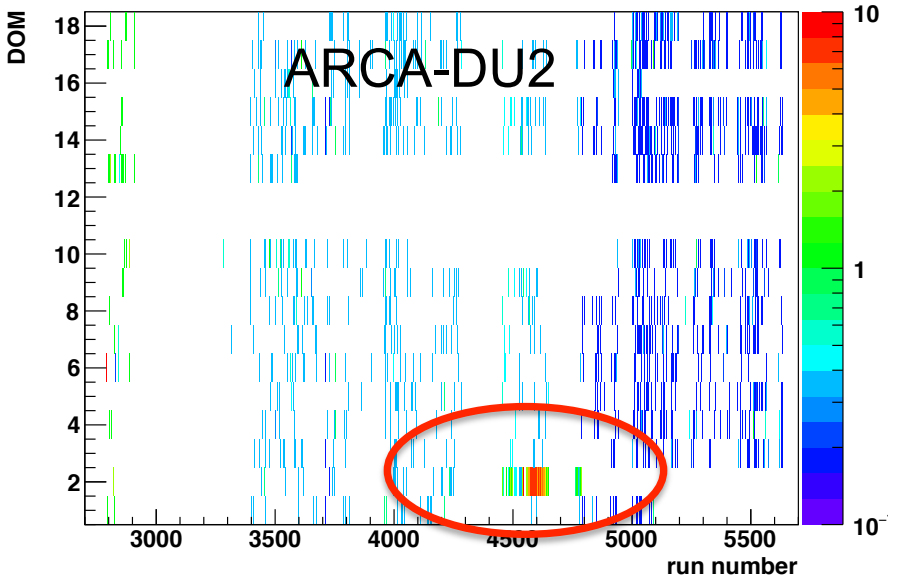


ARCA-DU1 (after deployment of DU2)

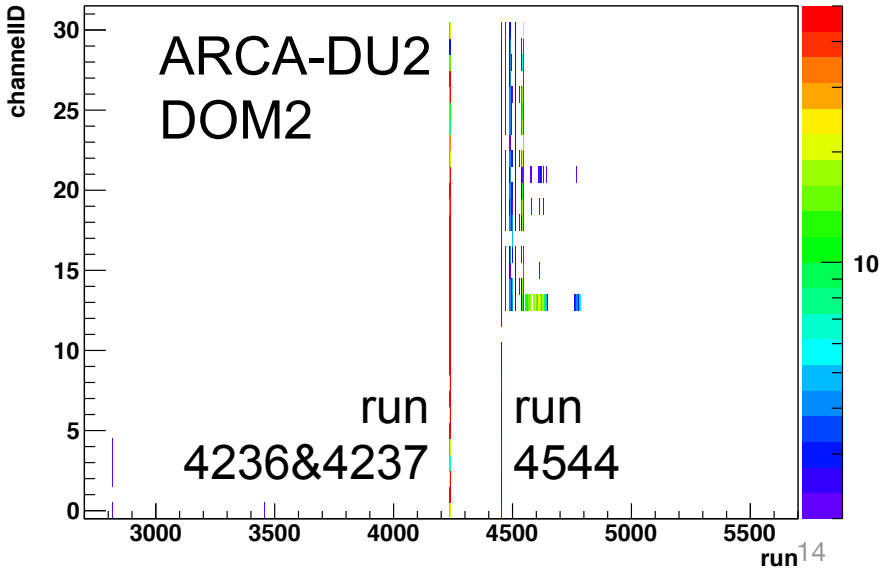


- ARCA-DU1 DOM15 has sporadic sparking periods
- DOM6 and DOM1&2 show single runs with many spark candidates
- No enhanced sparking period at the beginning of data taking, after deployment

Spark Search Results in ARCA-DU2



- ARCA-DU2 DOM2 has sparking period
  - Seem to very bright, because many PMTs are affected
  - → Maybe visible on adjacent DOMs?
- No enhanced sparking period at the beginning of data taking



Summary & Conclusions

ERLANGEN CENTRE FOR ASTROPARTICLE PHYSICS

- (At least one class of) sparks can be identified based on ToT=255ns hits
- Many sporadic sparking PMTs in ORCA
- The first 2 weeks after deployment showed very high sparking rates (up to 100 sparks / hour), exponentially decay of spark rate
- 'Nanobeacon hypothesis' disfavoured, because downward fashes
- ARCA-DU2-DOM2 has ONE sparking period

- The problem seem to be on problematic DOMs and not a problem of individual PMTs (other possibility: it exists problematic PMTs which are integrated only in DOM 1,2,5,6,7,9,10,11)

- If first 2 weeks are always with such high spark rates, this means 2weeks * 30 deployment operations = 60 weeks out of 200weeks building entire detector → ~1/3 of time affected → we cannot discard this data → we have to cope with these sparks, identify & reject them on event-by-event basis (not rejecting entire runs)
  → long term: we have to prove that final neutrino sample is spark free!