A Workplan for EIC ECAL @DESY Beam-Test

Jan C. Bernauer

Streaming Readout VI, May 2020

RBRC
RIKEN BNL Research Center

Stony Brook
University

~~A Workplan for EIC ECAL @DESY Beam-Test~~
TPEX@DESY

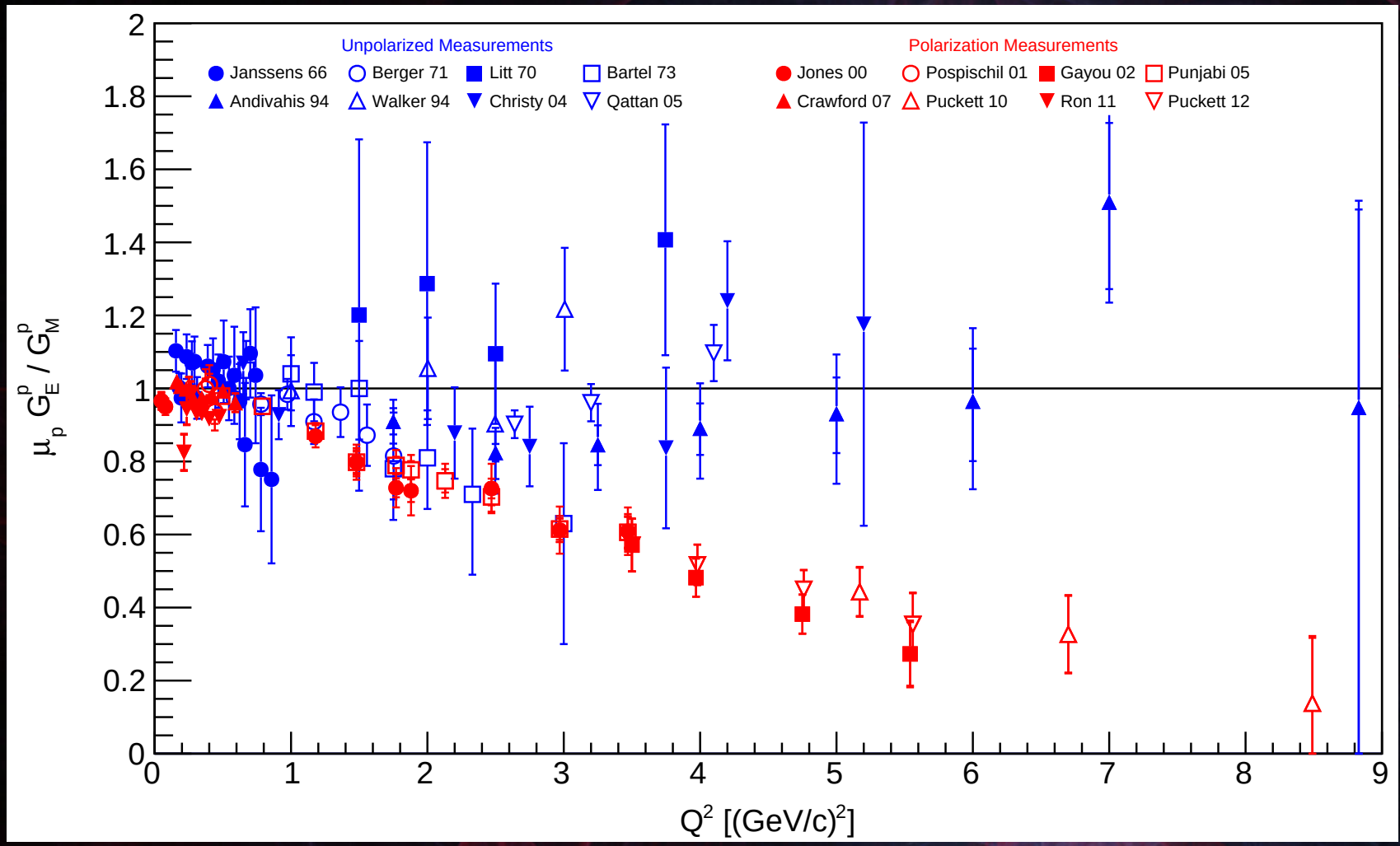
Jan C. Bernauer

Streaming Readout VI, May 2020

RBRC
RIKEN BNL Research Center

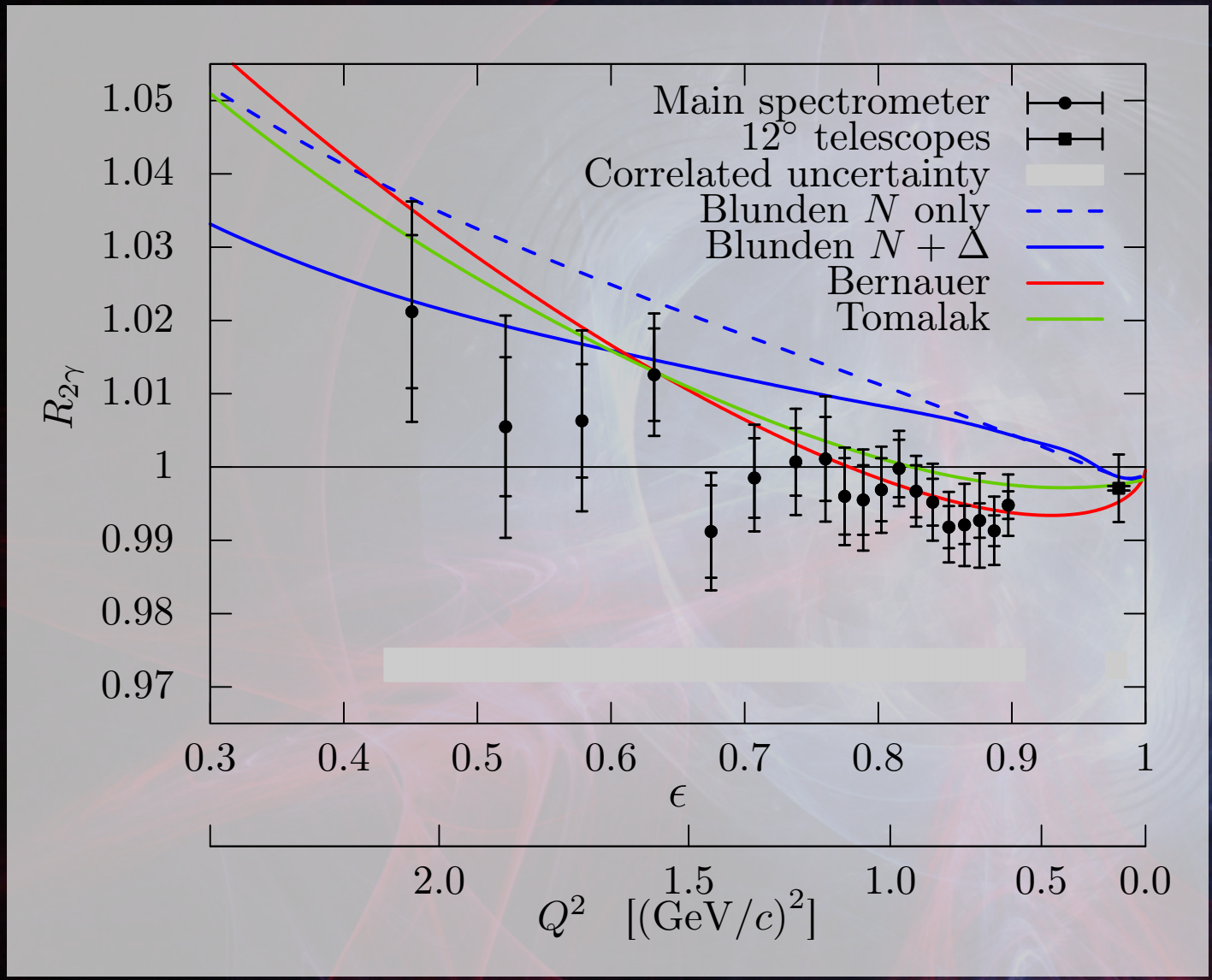
Stony Brook
University

Physical motivation



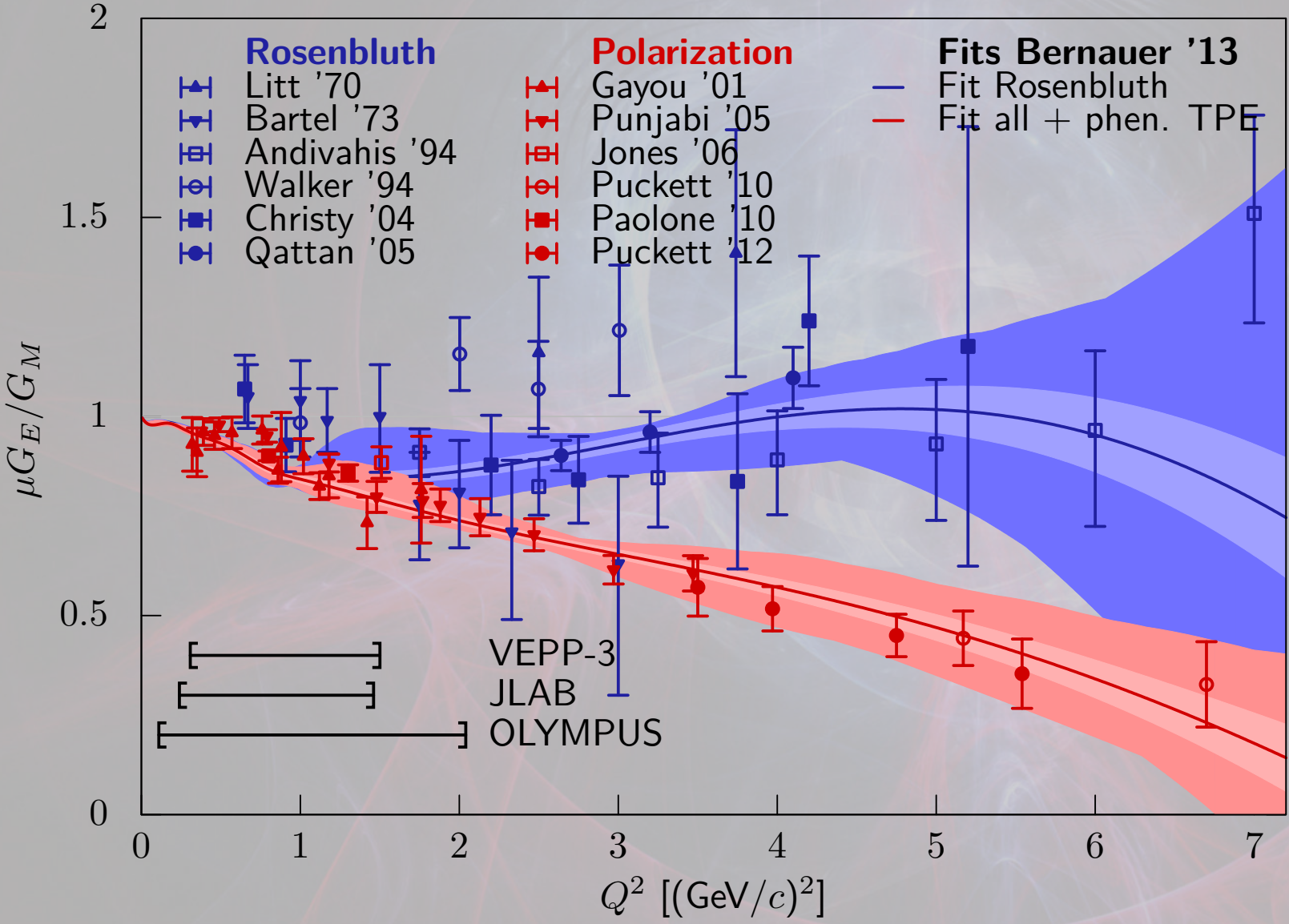
- Supposed explanation: Hard Two-Photon Exchange. Can be measured via $\frac{e^+p}{e^-p}$ scattering

Earlier measurements

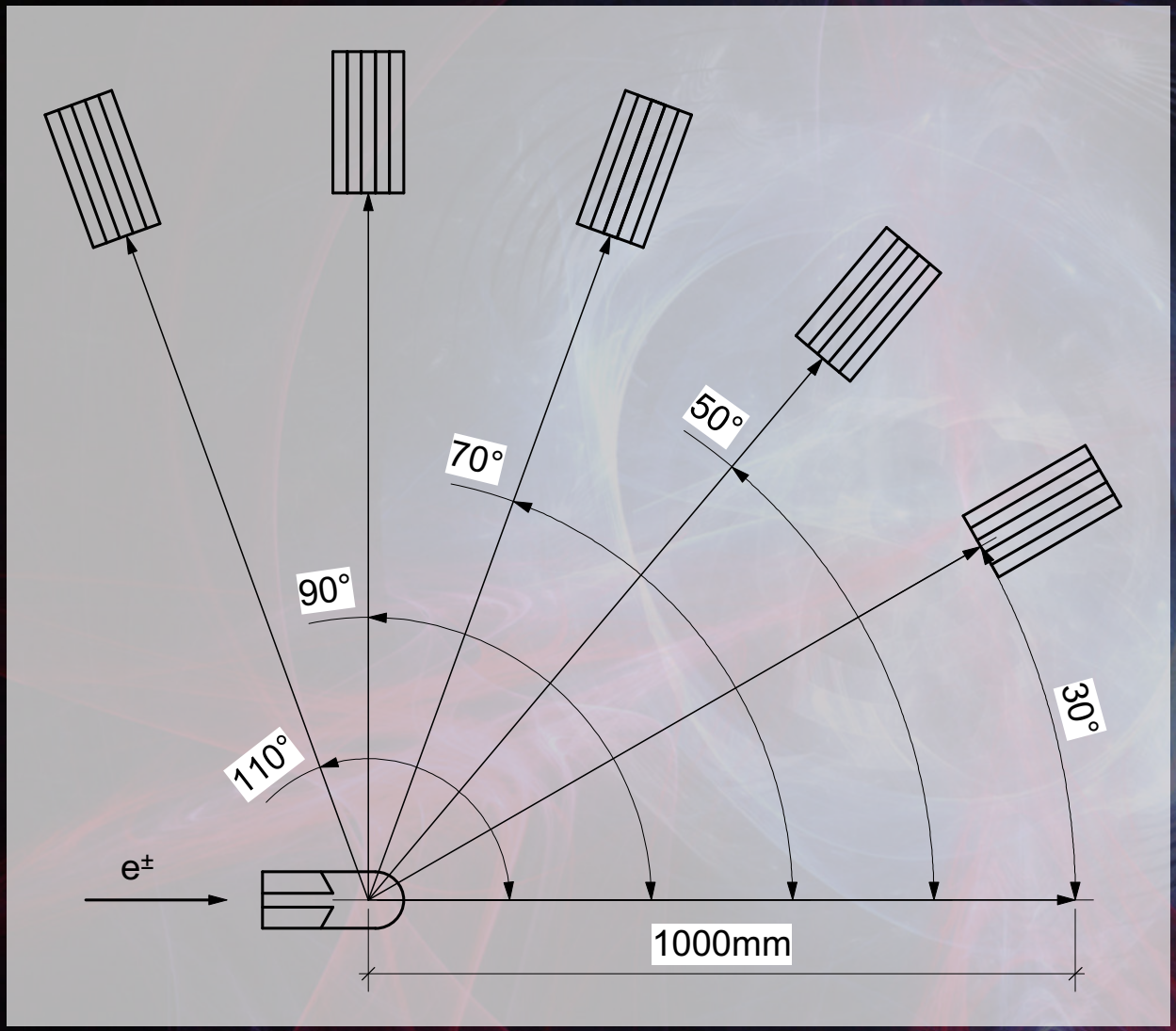


- Vepp-3, CLAS12, OLYMPUS (shown)
- Situation still unclear

Next-gen measurement



TPEX@DESY



- DESY is currently the only lab which has the right beams.

Setup

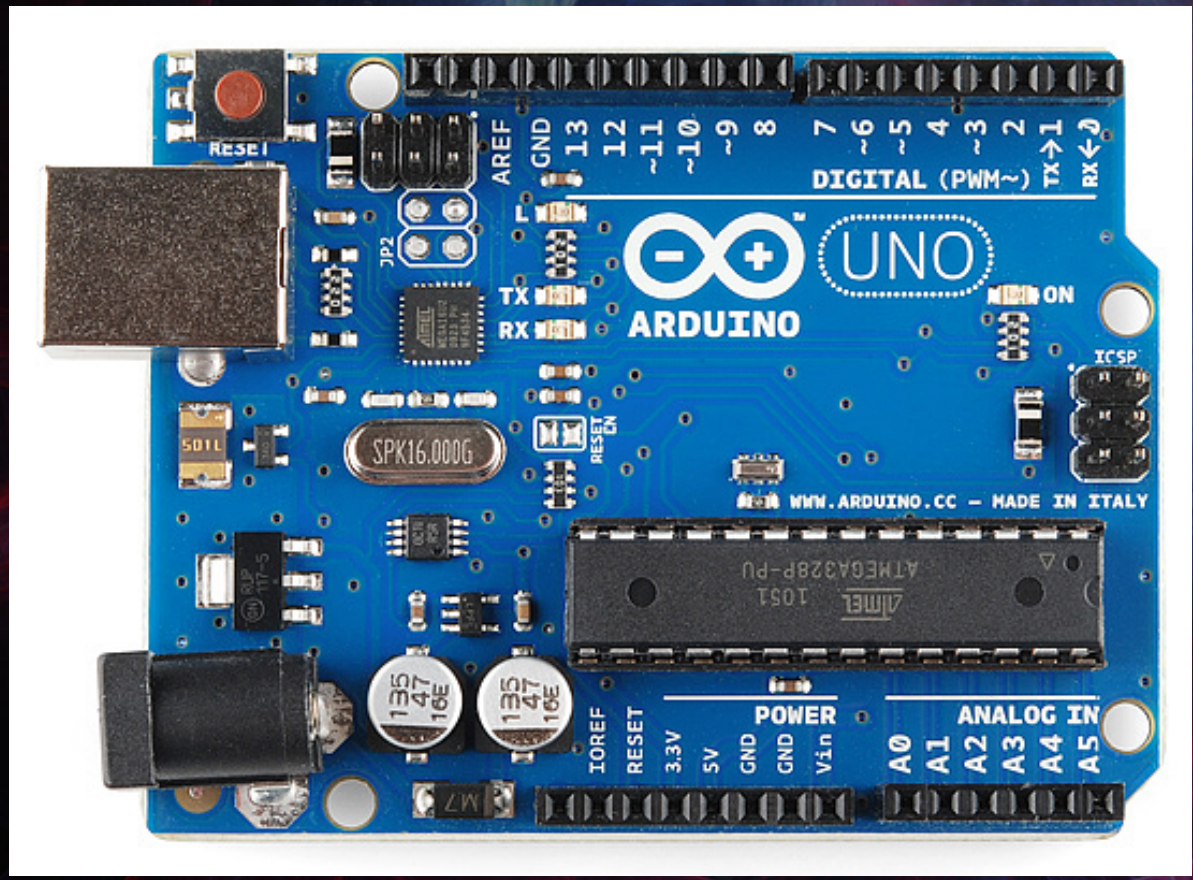
- 5 calorimeters
- 5x5 crystals each
- Energy resolution $\ll$ 210 MeV at 1.5 GeV (given by pion background)
- $PbWO_4$ crystals or glass from eRD1 SP 4 (Tanja Horn)

Why am I talking about this here?

- We will have test beams for detector development
- Can test triggered readout vs streaming readout in a very simple system.
  - Low channel count – do not need to invest much to have a full system
  - Extreme end of spectrum. Can keep all data, don't even have to do zero suppression!

Beam structure for the final experiment

- 12.5 Hz bunches, 30/60nA e^+/e^- beam.
- Trivial electronics:
  - trigger on all bunches
  - any old QDC will do
  - probably even a couple of these:



Streaming readout for the final experiment

- For a full non-compressed streaming:
- 250 MS/s *128 ch *1.5 Byte/s = 50 GByte/s
- 5x sPHENIX :)

Streaming readout for the final experiment

- For a full non-compressed streaming:
- 250 MS/s *128 ch *1.5 Byte/s = 50 GByte/s
- 5x sPHENIX :)
- But: Let's say we save a 10us every 50 Hz, in phase with beam
- That's about 25 MByte/s. Thats's trivial, but gives us
  - Full wave form
  - 3x out-of-sync data for background, baseline
  - No threshold at all, so no efficiency loss by the DAQ.
- Problem in a triggered setup: Have to move beam clock by up to 80 ms, with ns precision!
- Trivial in SR via software.

Test beams

- Small setup, between 9 and 25 channels
- Continuous, low rate beam (kHz)
- Signals are big. Can split to have parallel readouts.

First test beam

- Calorimeter: 3x3 array of crystals (thanks Tanja) and PMTs
- DESY provided telescope for triggering

DAQ for test beam: Triggered

- CAEN V792 QDC
  - 32 channels
  - 12 bit
- Improvised busy logic with some logic modules
- Could read all channels of calorimeter

DAQ for test beam: Streaming

- CAEN V1725 Digitizer
  - 14bit at 250 MS/s
  - only 8 channels
- Each channel is individually zero suppressed
- Waveform saved
- Read out 7 channels of calorimeter, one channel for "trigger", to timestamp trigger events

DAQ software/sync

- Two PCs:
  - VME board for V792
  - Standard PC via fiber for V1725
- Time synchronized via NTP to ∼ms
- Record data readout time in package header
  - V792: Should be close to the event
  - V1725: Package can contain multiple events, but v1725 firmware provides additional timetag.
  - No docu on this :(
- Had the trigger as one of the ADC channels of V1725

You done messed up, A-A-Ron

- I implemented the data structure developed together with Markus, Dmitry (see SR-IV)
- For the time tag, I used the PC time:

```
1  void gettime(uint64_t *coarse, uint32_t *fine) {
2      struct timespec res;
3      clock_gettime(CLOCK_REALTIME,&res);
4      __int128 time=(((__int128) res.tv_sec)*1e9 +
           res.tv_nsec)*1000;
5      *fine=time & 0xffffffff;
6      *coarse= time >>32;
7  }
```

- Spot the mistake!

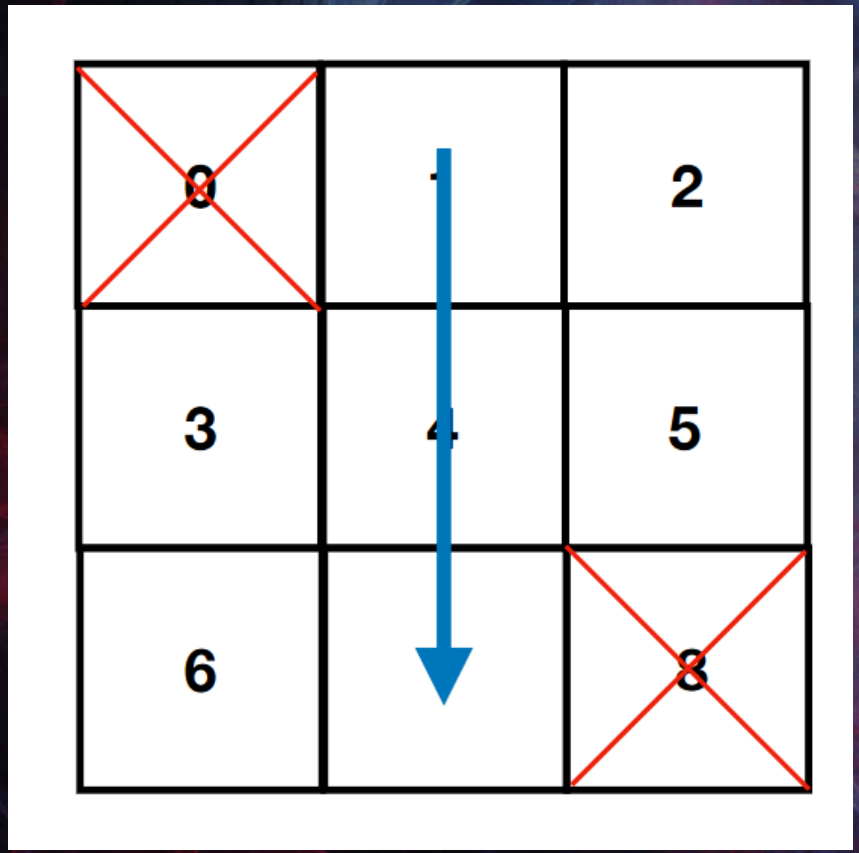
Some experiences

- Delay cables are as "convenient" as ever. Streaming can avoid them.
- Commercial documentation is as "good" as ever.
- V1725 event decode (by caen library) sometimes errors out. Not clear what that means.
- Self-triggering loses small signal neighbour channels

Some analysis results: Digitizer

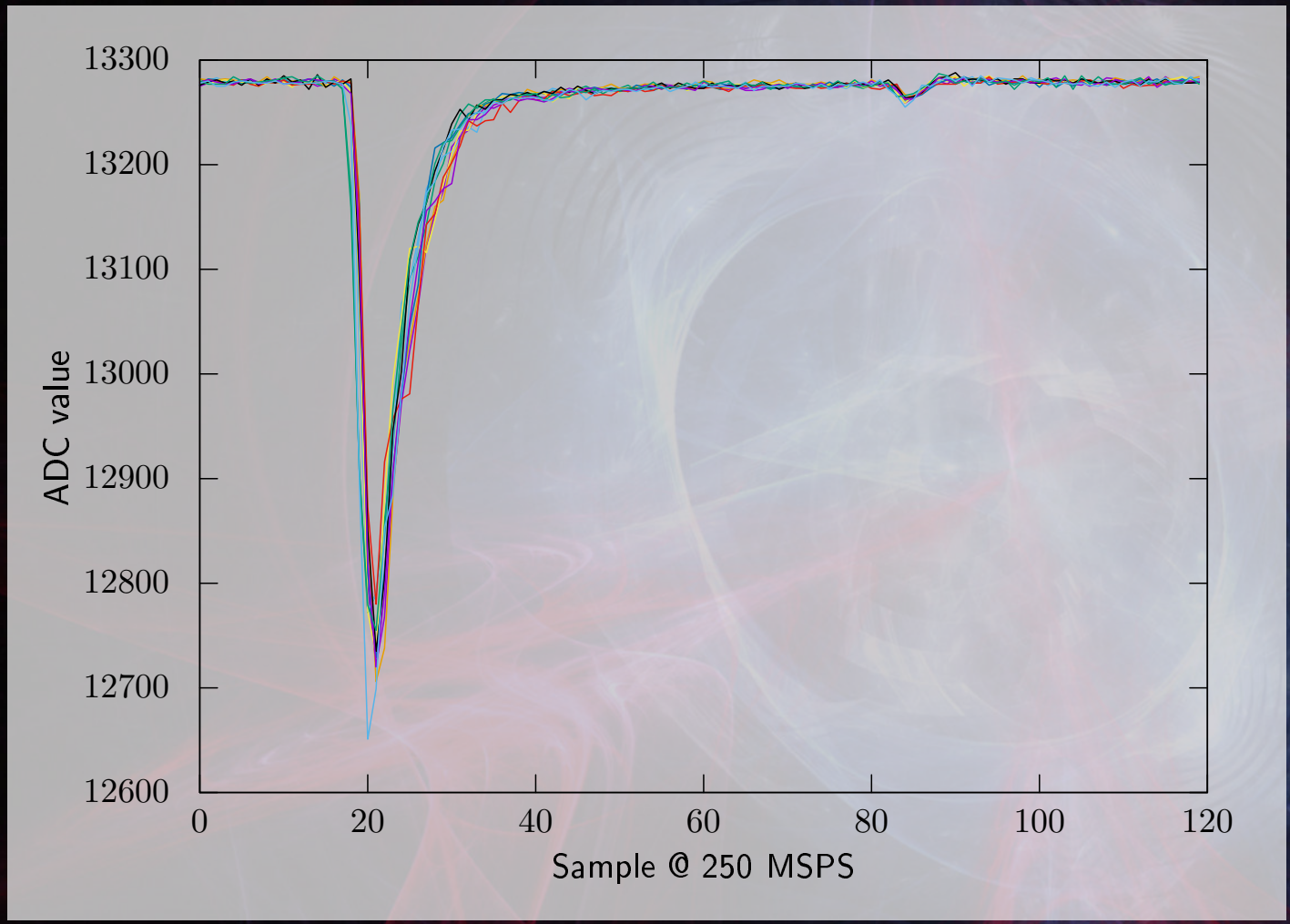
(Thanks to Ivica and Ethan)

- Tried to look at cosmics in the digitizer
  - Problem: only eight channels, one of them used to see "trigger" signal



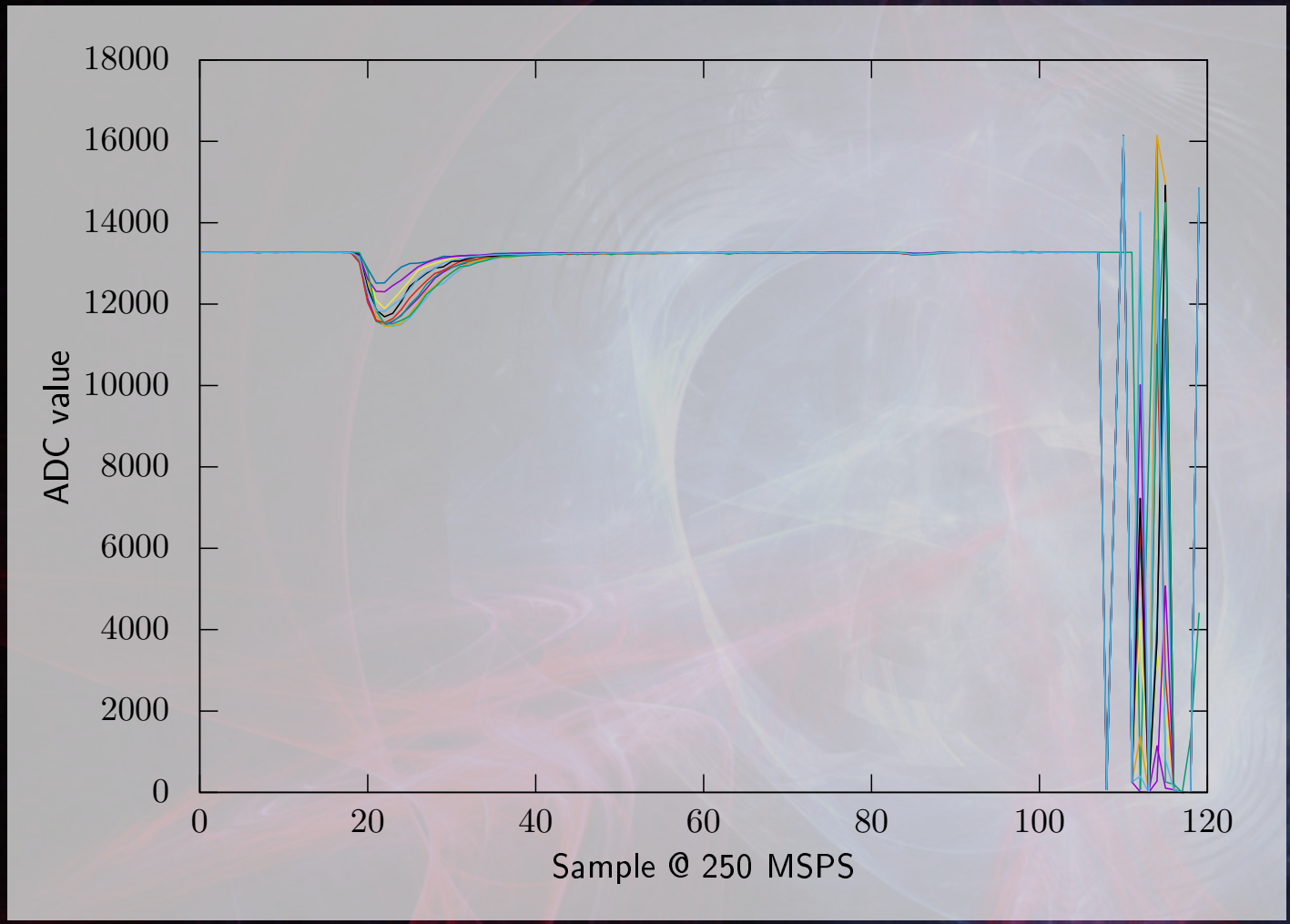
- Didn't work out. Need more channels :)

Having waves helps



- These are good signals which had no trigger

Having waves helps a lot



- Again, no trigger. Garbarge looks like overflow. Rare!
  - In a QDC, hard to diagnose. Can't be rescued.
  - Streaming: Diagnosis and rescue possible.

The next steps

- Supposed to have next beam time last month... Postponed because of COVID
- Aim to test Waveboard 2.0 in addition to existing hardware.
- Maybe with Tanja's glass!