Current Status and Future Outlook of TPEX

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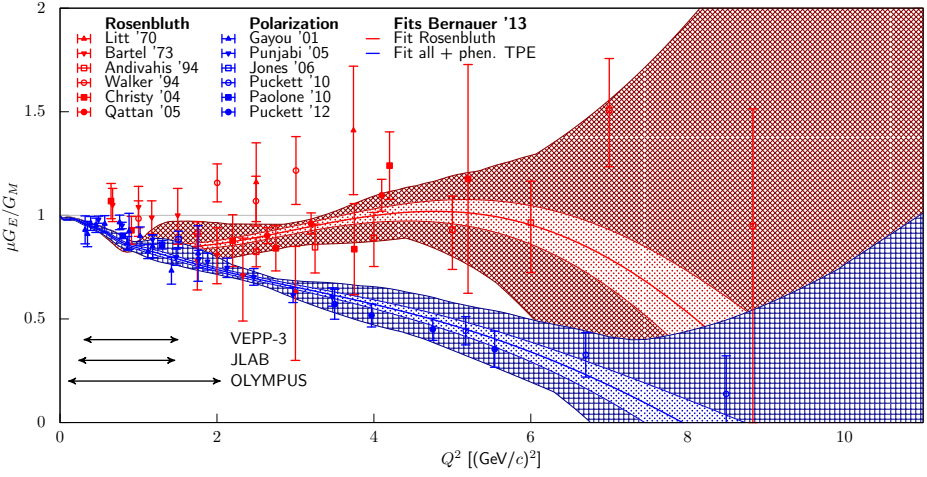
Streaming Readout Workshop VIII

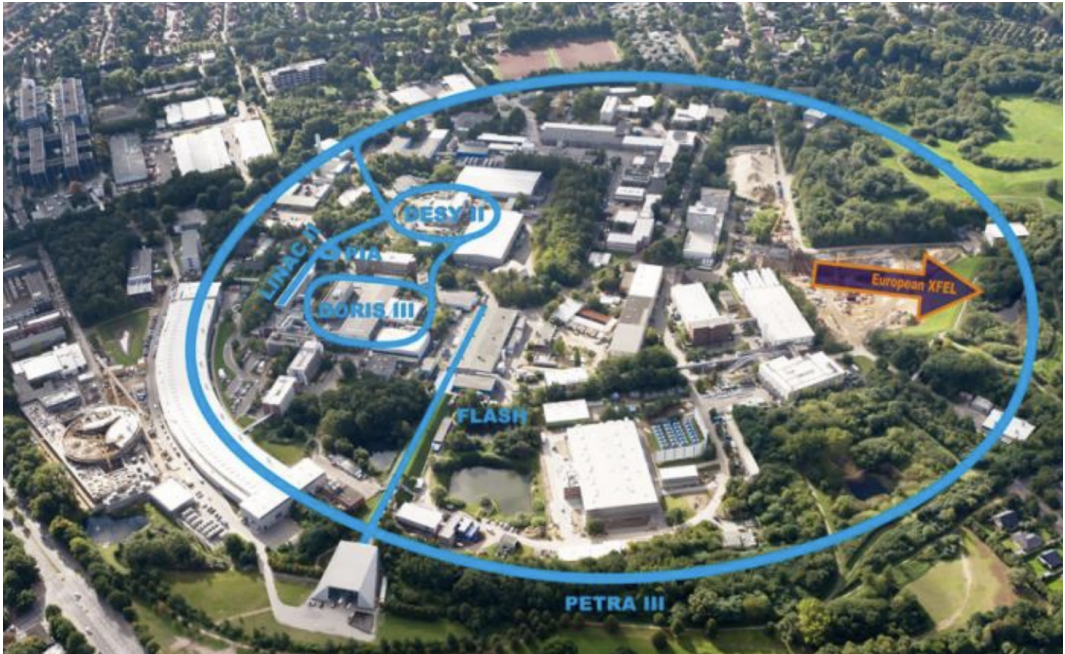
April 30, 2021

Existing Two-Photon Reach

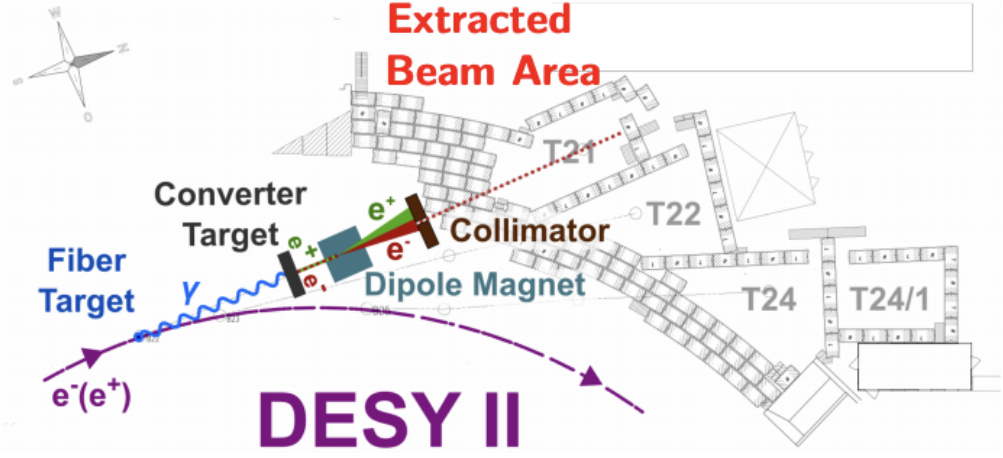


Not covering the existing region

TPEX @ DESY!

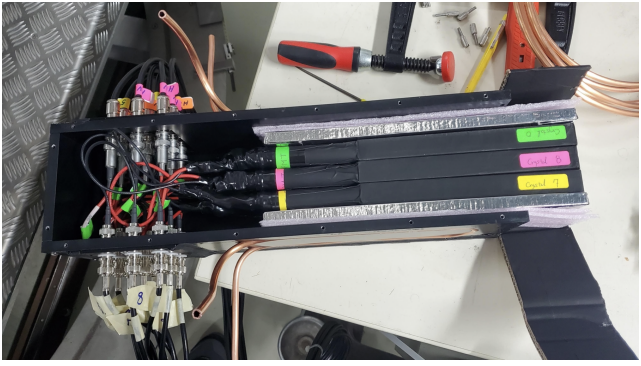


TPEX @ DESY!

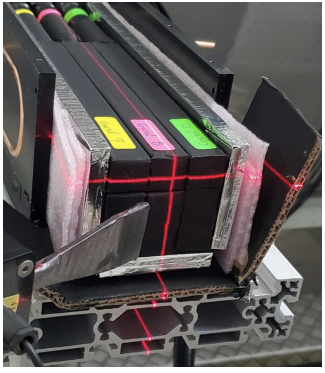

Extracted
Beam Area
T21
T22
T24
T24/1
Converter
Target
Collimator
Fiber
Target
Dipole Magnet
e⁺
e⁻
γ
e⁻(e⁺)
DESY II

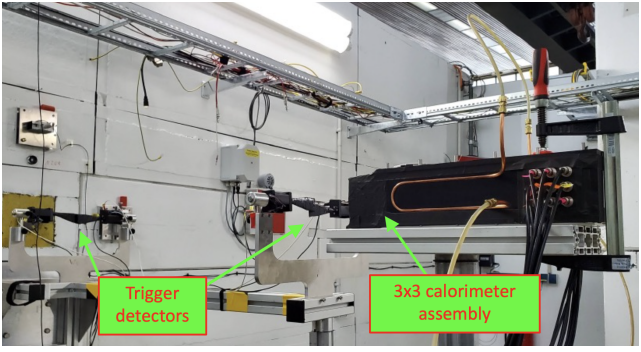
TPEX Calorimeter Test Setup

- Nine 2x2x20 cm lead tungstate (PbWO4) crystals
- Wrapped with one layer of white Tyvek (0.4 mm thick) and with one layer of opaque aluminum foil (0.09 mm thick)
- Hamamatsu R1166 PMT powered by LeCroy 1461N modules



TPEX Calorimeter Test Setup





DAQ Electronics and Detector Mapping

- Triggered DAQ
  - Caen V792 QDC (Energy)
  - CPU Time
- Streaming DAQ
  - Caen V1725 Digitizer (Energy, waveform, timing)
  - CPU Time

QDC channels

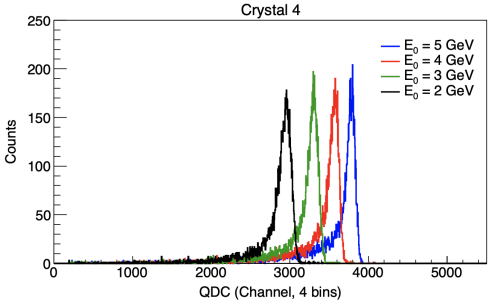
6	7	8
3	4	5
0	1	2

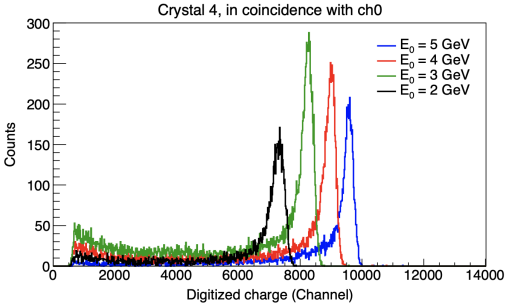
Digitizer channels

6	7	--
3	4	5
Tr	1	2

Example Spectra Comparison

- Gain matched at 5.2 GeV
- Data taken at 2, 3, 4, 5 GeV





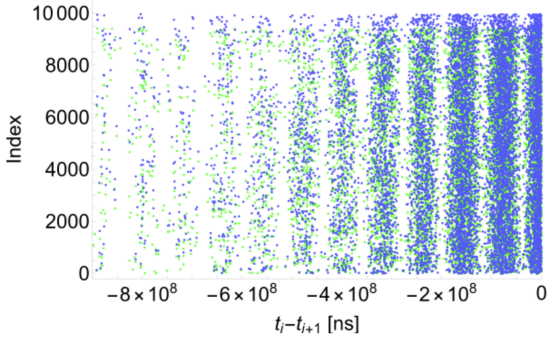
Advantage of Streaming Readout

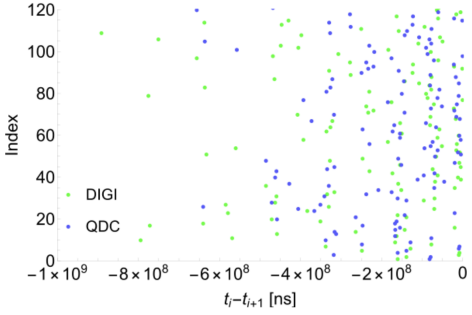
- Due to QDC readout limitations (dead time, trigger signal size, and the requirement that the electron needs to strike the trigger detectors in a given time window) causes the QDC to see fewer events than DIGI
- Strategy to select all events produced by the electron beam:
  - Use the time stamp information
  - Select coincidence events between the trigger signal and other crystals
  - Use selected events to determine coincidence/time offsets between crystals
  - Use the time offsets on original data
- Example: for one data set we see $\sim$10k QDC events and $\sim$20k DIGI events.

Identification of QDC Events in Digitizer Data

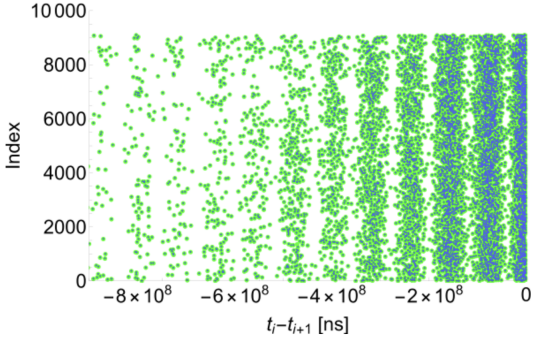
- We start with CH0-CH4 coincidence preselected data
- Number of recorded triggers in digitizer is $\sim$4% smaller than in QDC (Digitizer events with "conversion not finished" error were discarded)
- Direct comparison of QDC and digitizer data would be difficult
- Idea: calculate the time intervals between subsequent events in QDC and digitizer and compare these

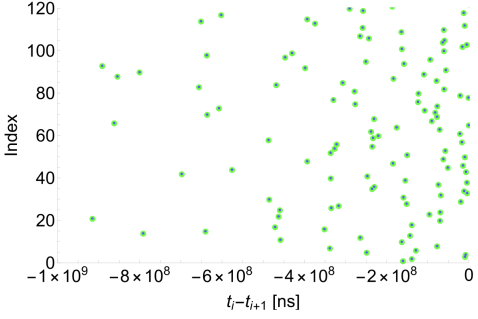
Uncorrected Time in Readout



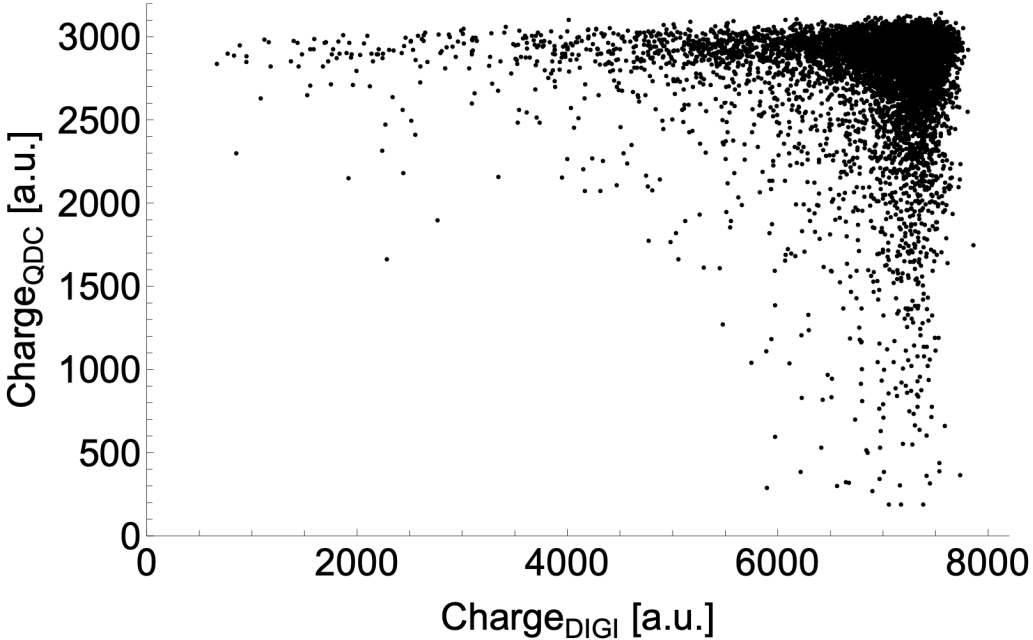


Corrected Time in Readout



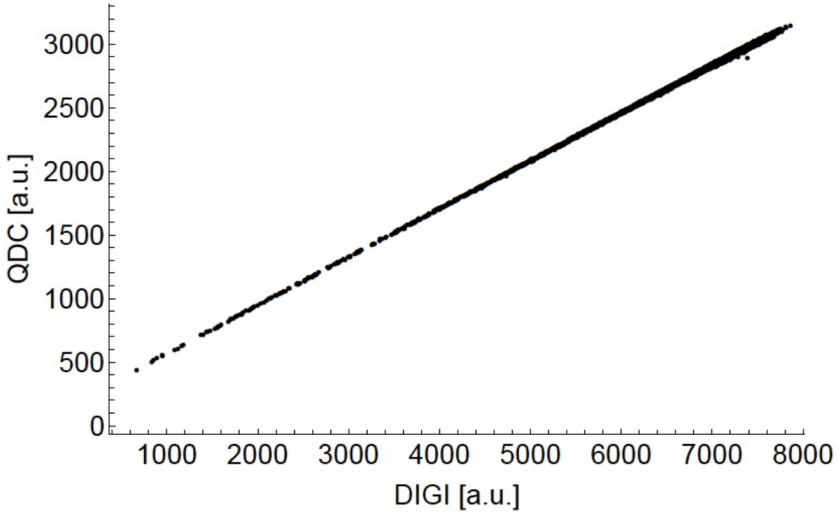


Uncorrected Energy in Readout

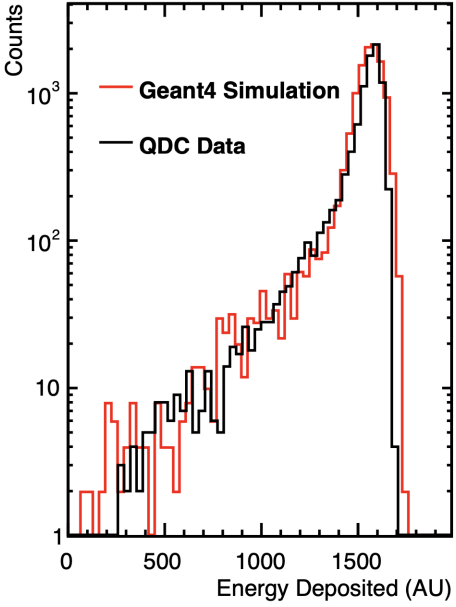


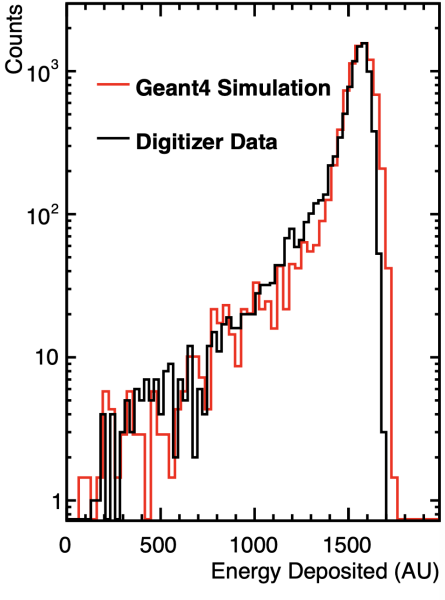
Corrected Energy in Readout

- QDC was not clearing at being of run
- Throw out first 30-40 QDC events



Comparison to Simulation



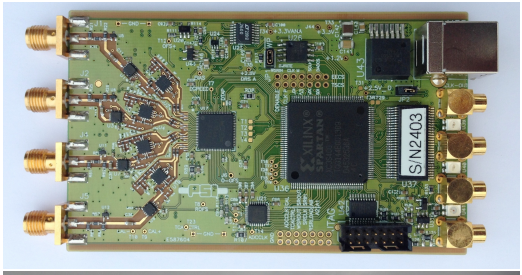


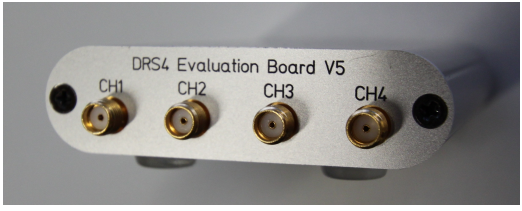
Outlook

- Triggered and streaming readout schemes were used to measure electron beam with 3x3 PbWO4 calorimeter
- Using the offline analysis the advantage of the streaming readout compared to the triggered readout was demonstrated
- While correlating QDC and Digitizer data we successful showed agreement in energy deposition
- In next beam time we will test 5x5 PbWO4 calorimeter at DESY Test Beam Facility

Future DAQ Tests

- DRS Board from PSI
- One DRS4 chip samples four input signals simultaneously 0.7 - 5 GSPS with 1024 sampling points each
- Readout rate is 500 events/sec
- Readout via Xilinx SPARTAN 3 FPGA

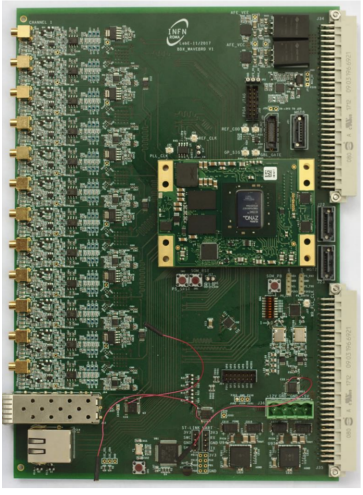




Picture from Stefan Ritt. https://www.psi.ch/en/drs/evaluation-board

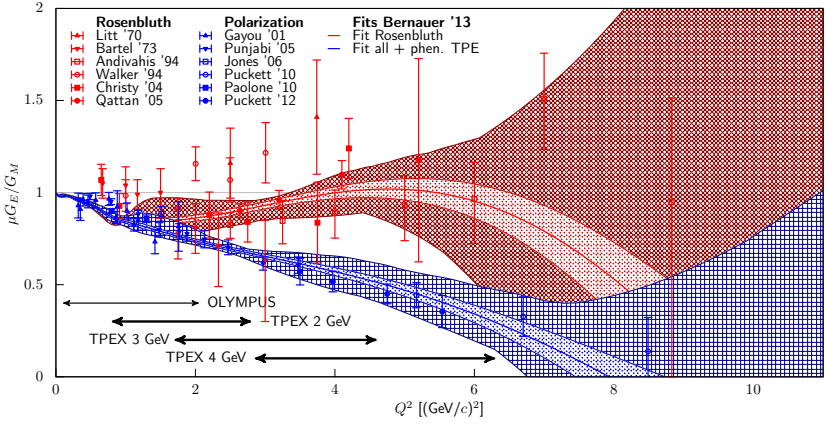
Future DAQ Tests

- INFN Waveboard
- Commercial Zynq mezzanine card
- Selectable gain
- PLL to generate and distribute clocks
- External clock and reference signals
- 12 channel, 12/14 bit 250 MHz
- USB, SATA, SFP, GbE, serial, I2C ports for high and low speed communication



Picture from Fabrizio Ameli, SRO Workshop IV.
https://agenda.infn.it/event/18179/contributions/89837/attachments/63423/91184/SRO_2019_05_23_IV_WRKSP_AMELI.pdf

TPEX Projected Reach



Thank You!

Any Questions?

TPEX Sketch

- Very conceptually simple
- Will run at DESY with e^+ and e^- beam
- Direct $R_{2\gamma}$ measurement
- LH_2 target
- 5 sets of 5×5 $PbWO_4$ crystals
- 2 luminosity monitors