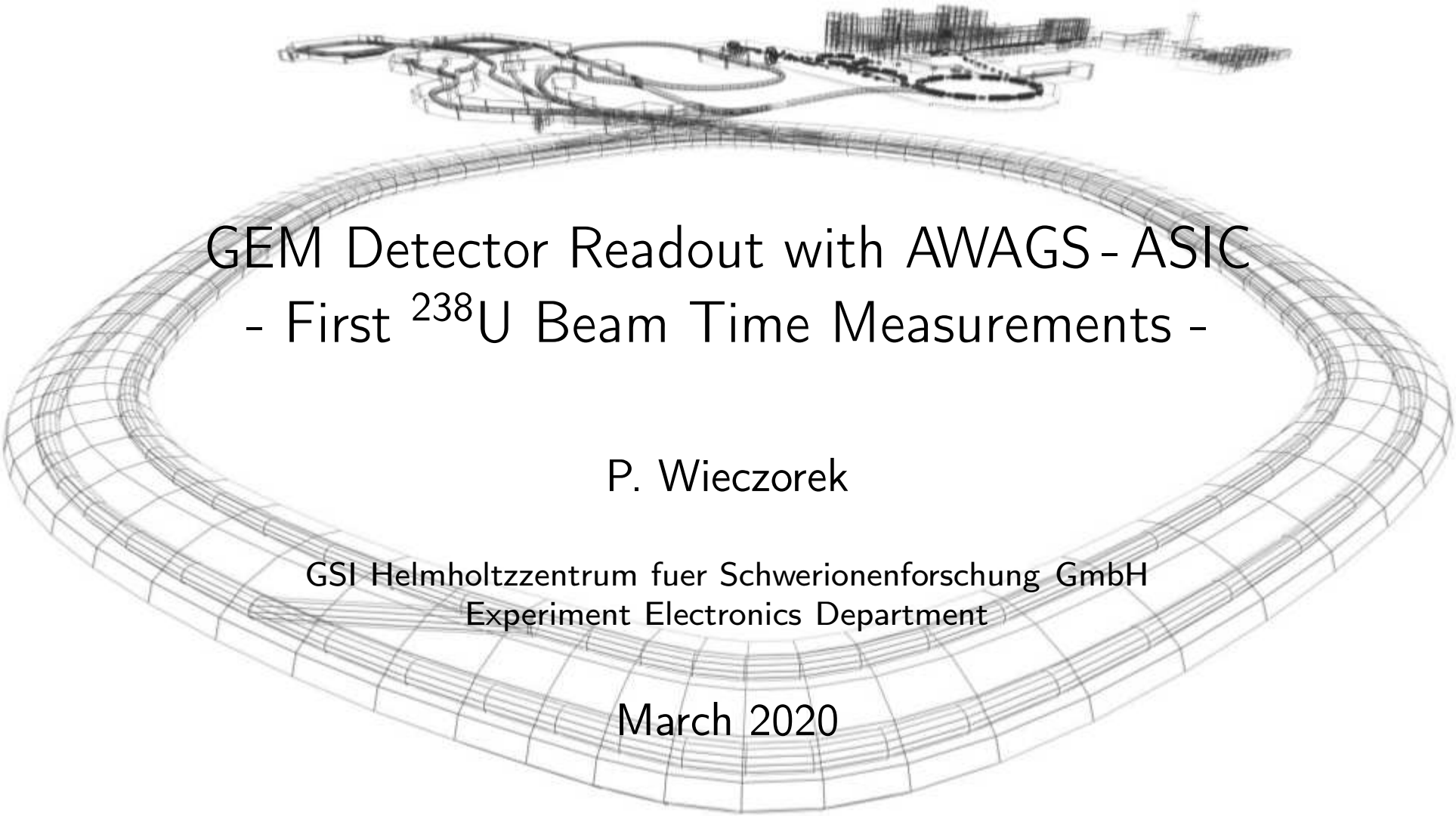

GEM Detector Readout with AWAGS - ASIC
- First ^{238}U Beam Time Measurements -

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Outline

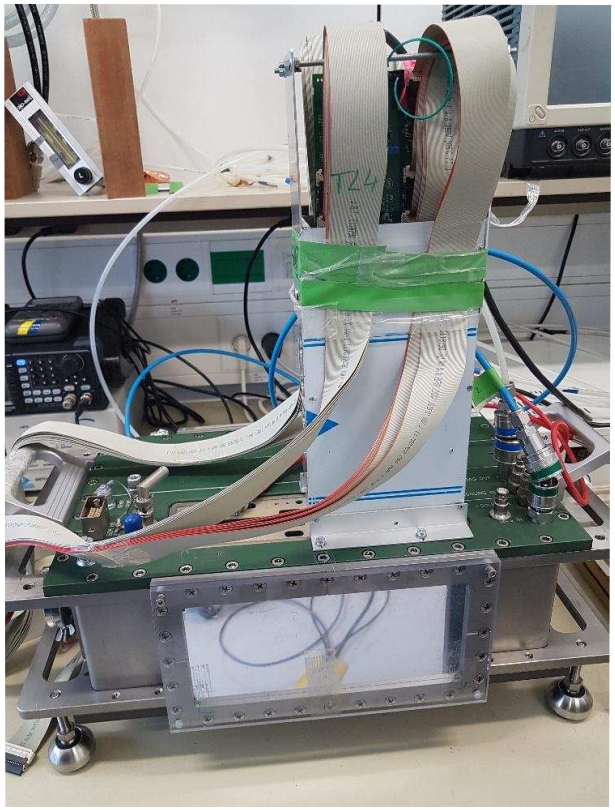
Beamtime Goal

- Investigate the performance of the AWAGS - ASIC (Amplifier With Adaptive Gain Setting) as amplifier for the prototype of GEM detector

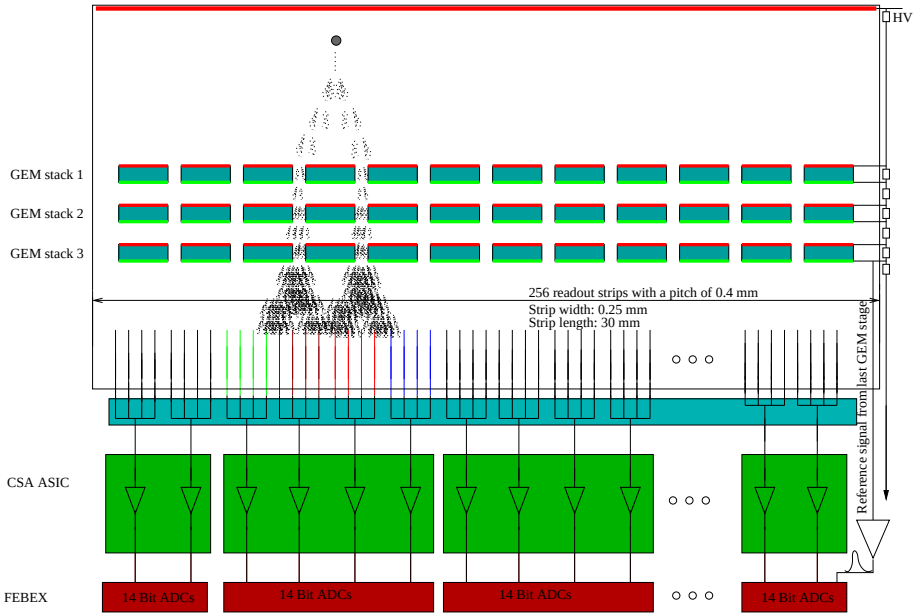
- Measurement goal: Verify if the developed charge sensitive amplifier can be used for the GEM detector readout
  Identify noise, input charge, dynamic range, signal shape and how to handle with AWAGS amplifier

- Prototype of the GEM detector was only half equipped
- EEL developed a setup for PANDA and Super-FRS
  - Readout all 256 strips individually
  - Data taking with different ASIC gain settings
  - Measure different HV configurations
  - Determine the maximum event rate
- Data analysis: Determine position and find optimum for strip granularity and resolution

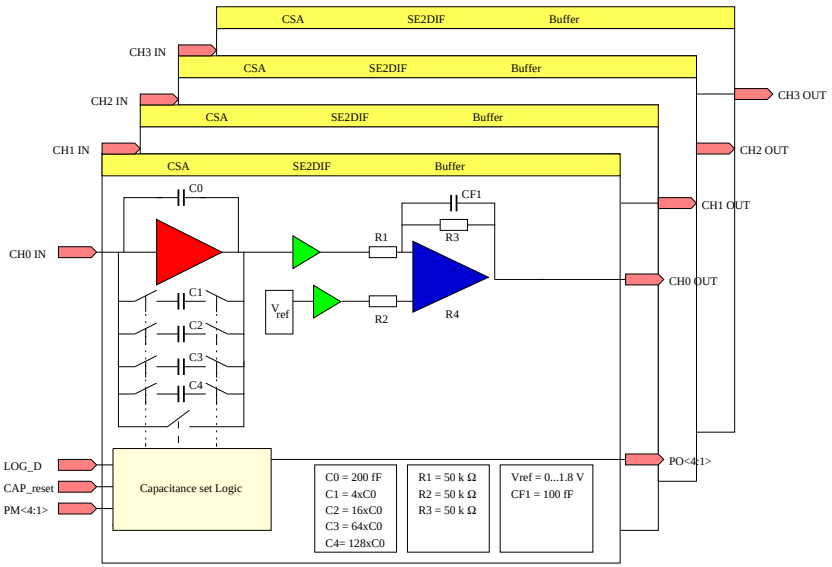
Outline



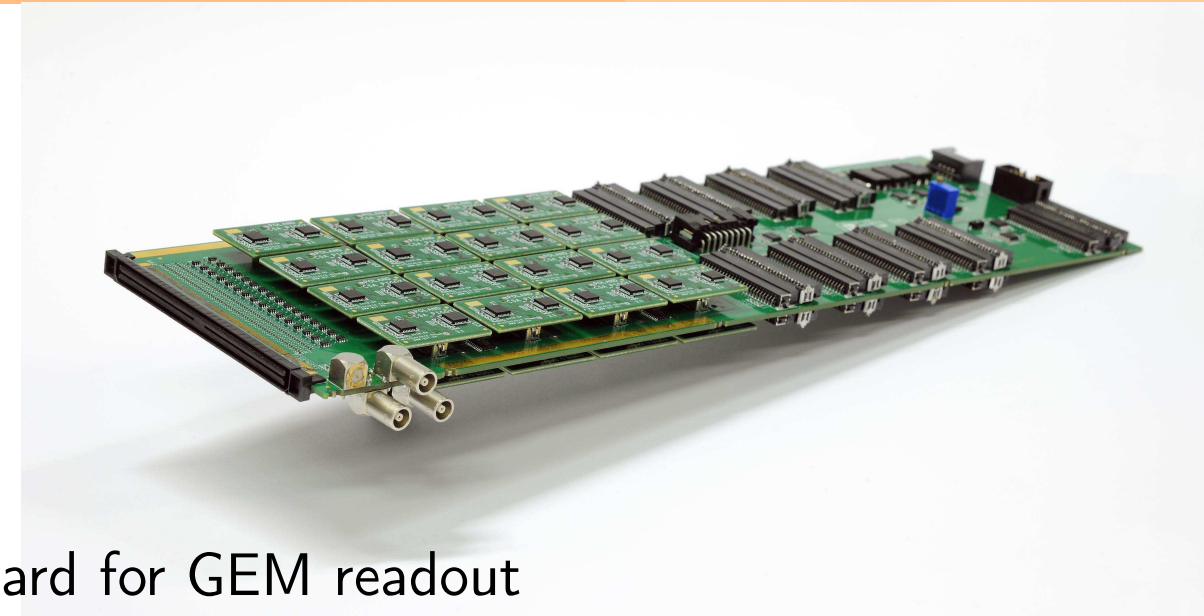
- SFRS prototype GEM detector
- Design: 2×256 strips
- Only half of the strips are read out during beamtime
- Strip pitch of 400 µm
- GEM is built up in 3 stacks
- GEM geometry: $200 \times 100 \times 25\,\mathrm{mm}^3$



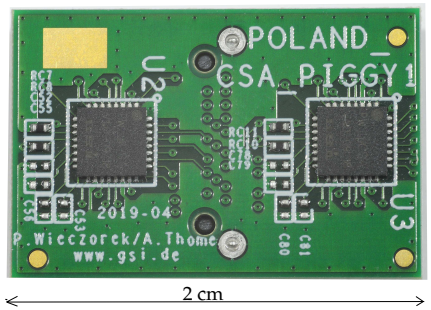
- Energy deposition by the beam in the drift region
- Charge drift in electrical field to the GEM stack
- Gas amplification due to the electrical field between GEM surfaces

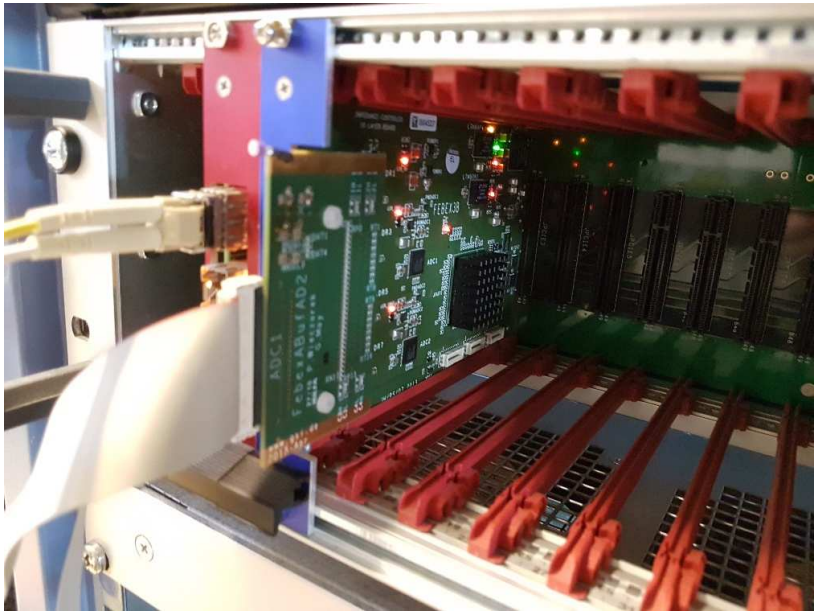


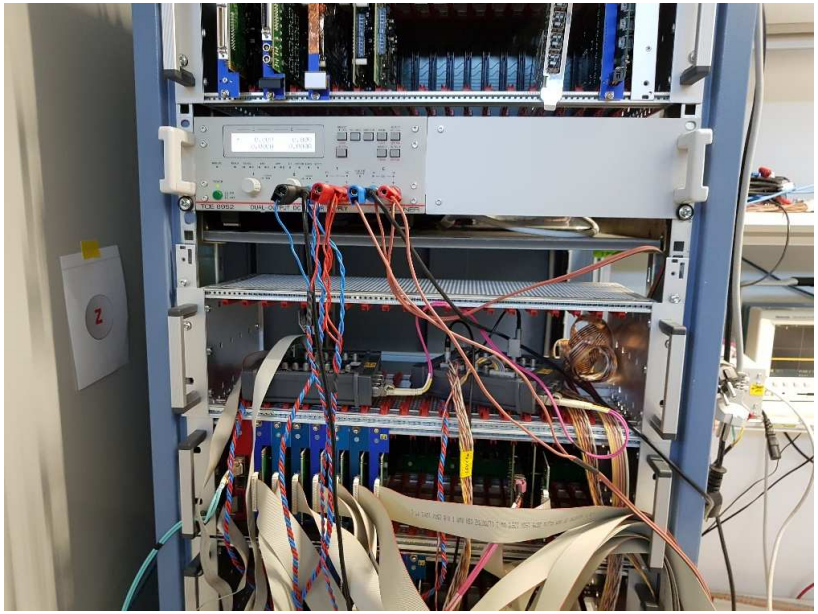
- FEE (Amplifier With Adaptive Gain Setting) AWAGS - ASIC
- 4 Channels per AWAGS - ASIC
- Charge sensitive input stage
- Single ended output buffer
- Not yet optimized for PANDA or SFRS setup
- 2 operation modes:
  manual or auto feedback setting



- Main board for GEM readout
- 32 plug-in boards with AWAGS-ASICs
- 2 AWAGS - ASICs per plug-in board
- Over all power (0.28 A at 12 V)
- Thanks to Sven Loechner (EEL)

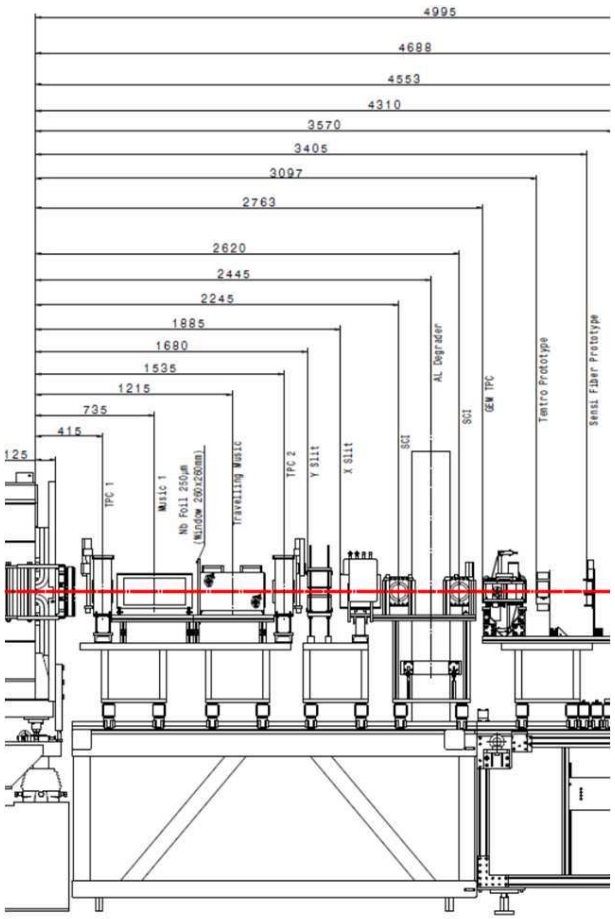


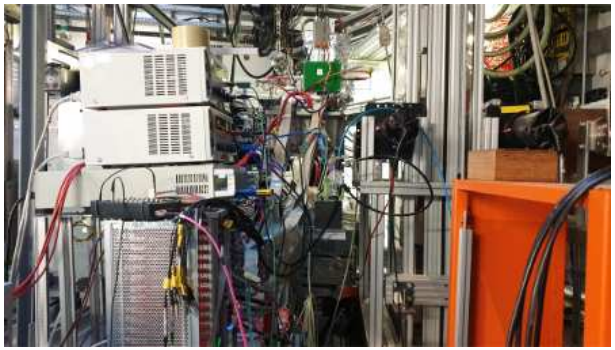




- Digitizer FEBEX ADC cards
- 16 differential channels per FEBEX
- 14 bit, 50MS/s, input $\pm 1\,\mathrm{V}$

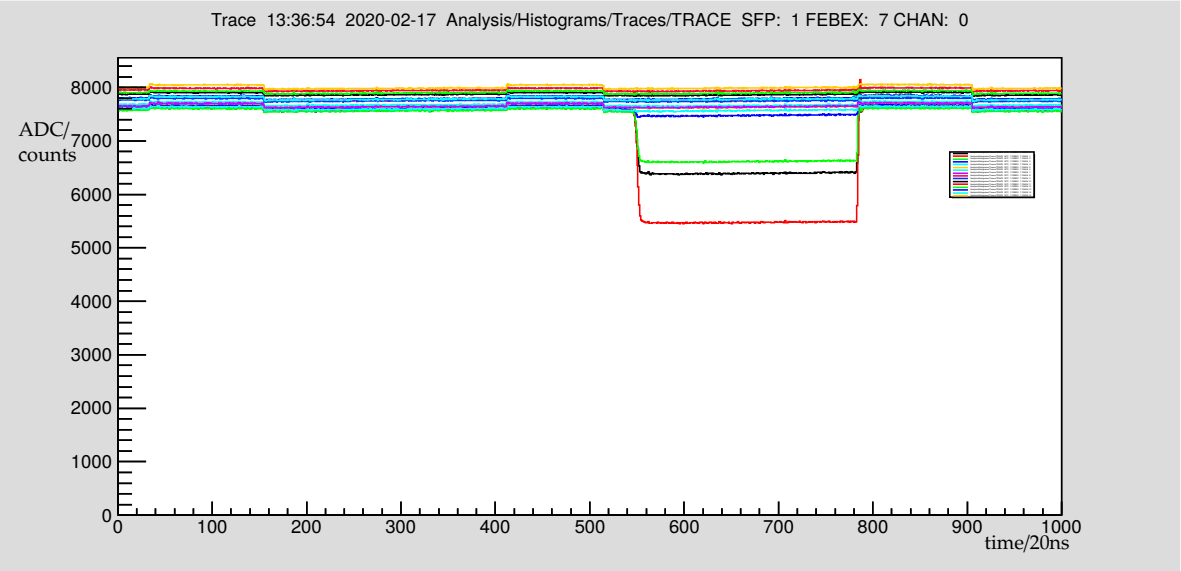
- Readout for 256 channels
- 16 FEBEX card
- Thanks N. Kurz (EEL)



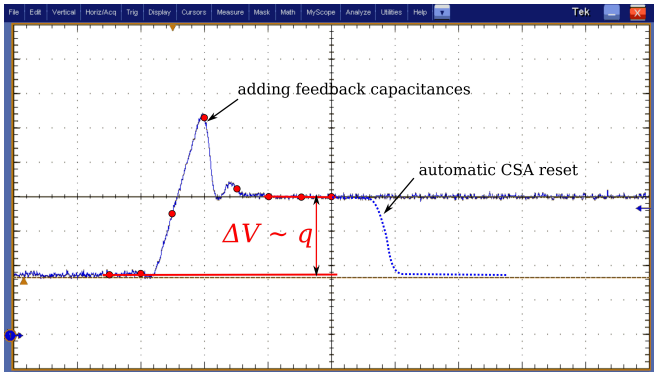


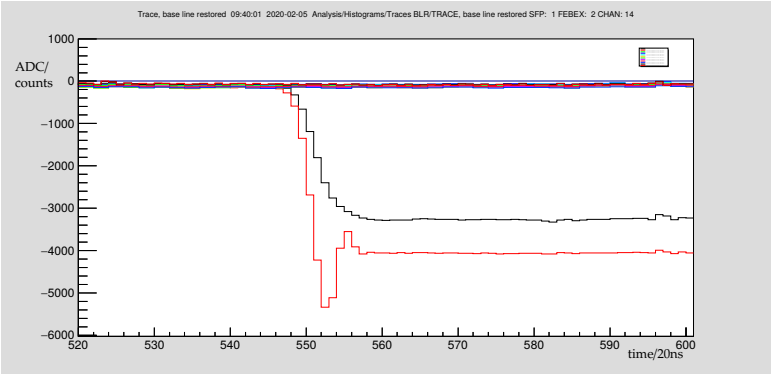
- Setup with 2 TPCs and 1 GEM
- Periodic reset: every 5 µs
  reset time of 2 µs
- Reset is disabled after accepted trigger

Outline

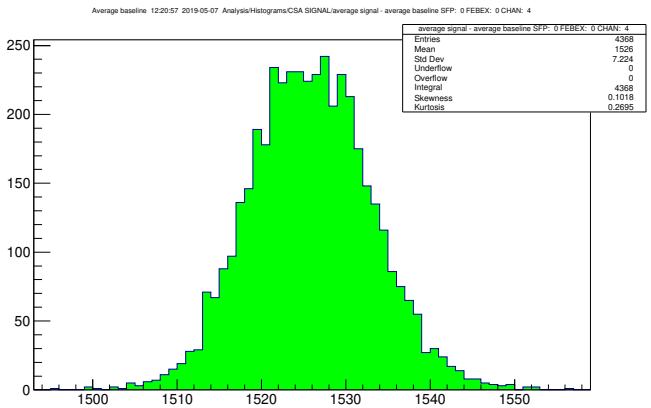


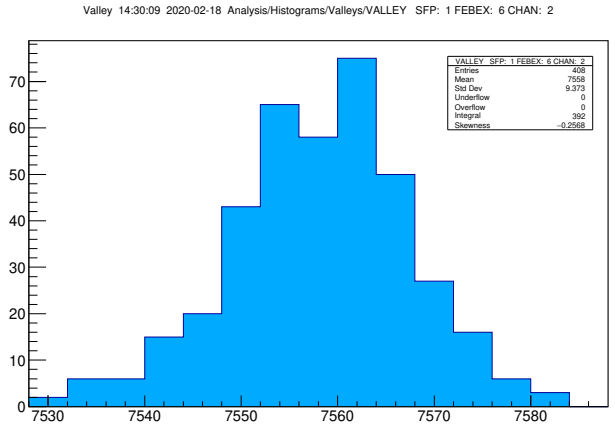
- Figure shows trace with lenght of 1000 x 20 ns
- Active reset 100 x 20 ns
- Manual Mode: fixed feedback capacitance
- Pulse height: 1/8 mV per ADC count
  results from 14 bit ADC and ± 1 V input range





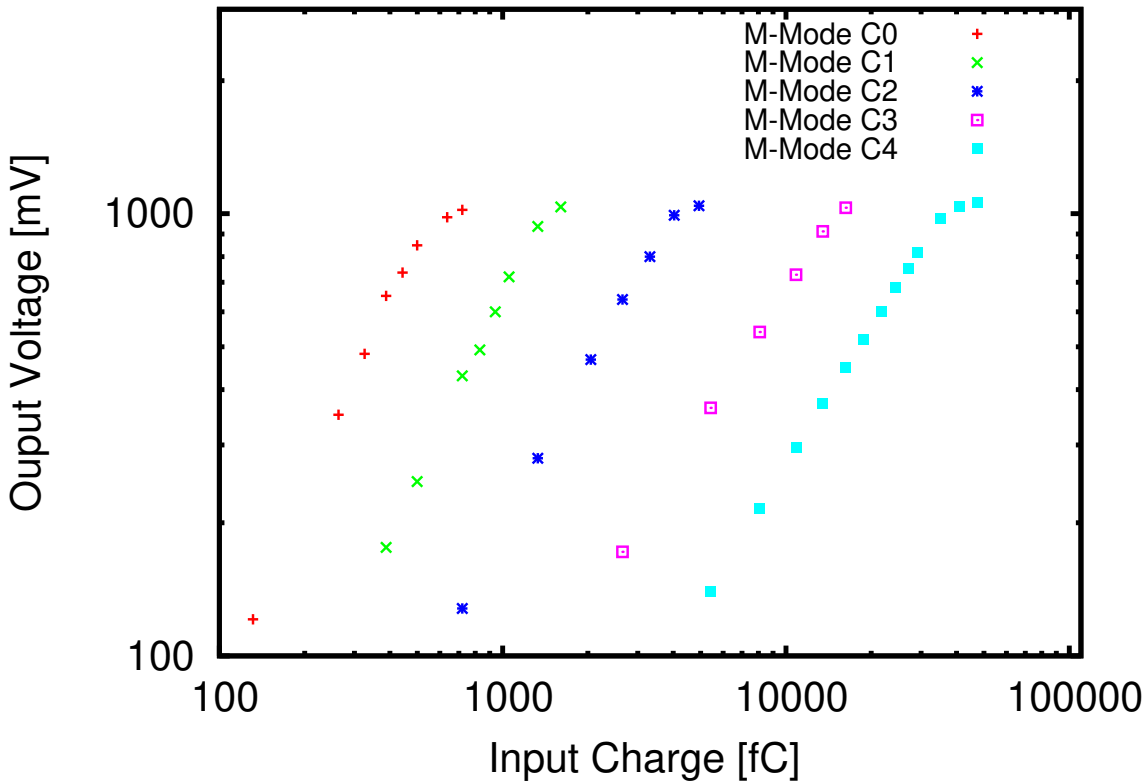
- Auto mode: adaptive gain setting
- Left figure: Test signal measured with an oszilloscope
- Right figure: signal taken during beam time 2019
  - Channel (black) below SW TH $\rightarrow$ only C_0 feedback is active
  - Channel (red) over SW TH $\rightarrow$ C_0 and C_1 feedback is active



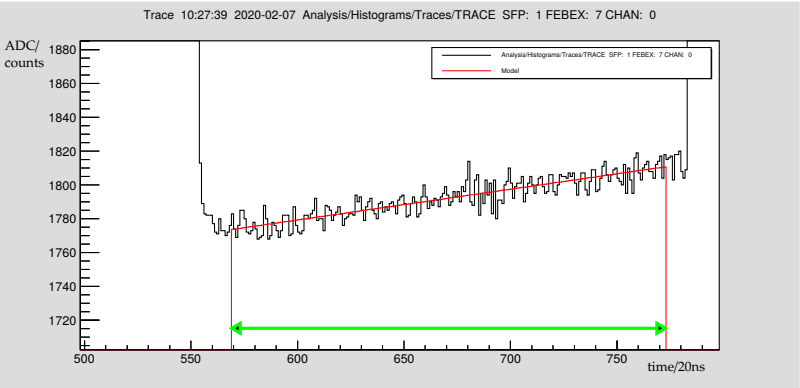


- Laboratory noise measurements (full setup, no beam)
- $ENC = (0.43 \pm 0.04) fC$ or $(2697 \pm 251) e^-$.

- Beamtime noise measurements (full setup beamtime 2019)
- $ENC = (0.56 \pm 0.052) fC$ or $(3502 \pm 321) e^-$.

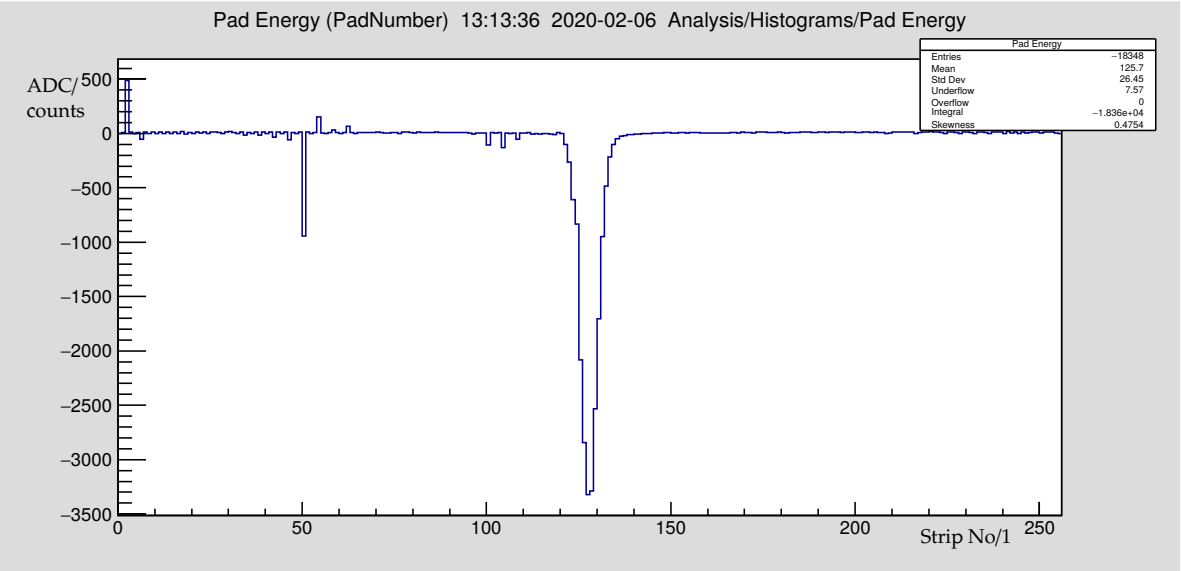


- Laboratory measurements for dynamic range
- Output voltage as function of input charge
- Max. input charge up to 40 pC



Cap. No.	Drift	Unit
C_0	8.94 $\pm$ 0.79	mV/μs
C_1	3,28 $\pm$ 0.15	mV/μs
C_2	0,925 $\pm$ 0.051	mV/μs
C_3	0.287 $\pm$ 0.026	mV/μs
C_4	0,088 $\pm$ 0.0031	mV/μs

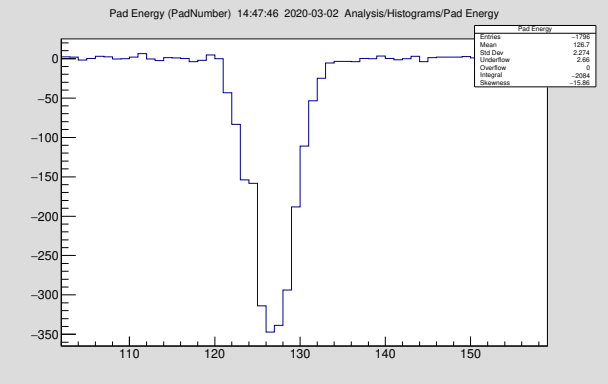
- Active reset topology has a drawback $\rightarrow$ leakage current
- Each event shows a drift results from leakage current in the feedback switch
- Slope is proportional to the amplification



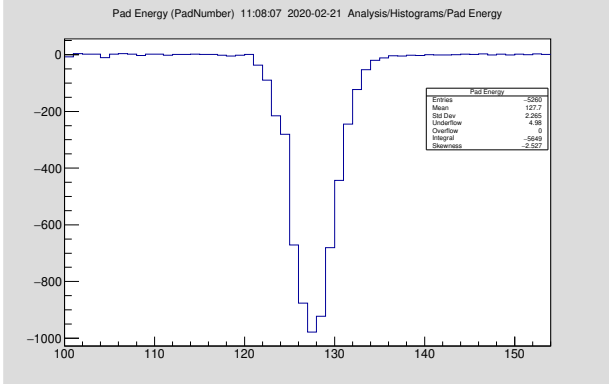
- Determine beam position
  - Plot the measured amplitude for 256 strips
  - All ASICs are programmed to the same amplification

- Special Thanks to the Go4 group especially to Nik Kurz and Joern Adamczewski-Musch for the analysis

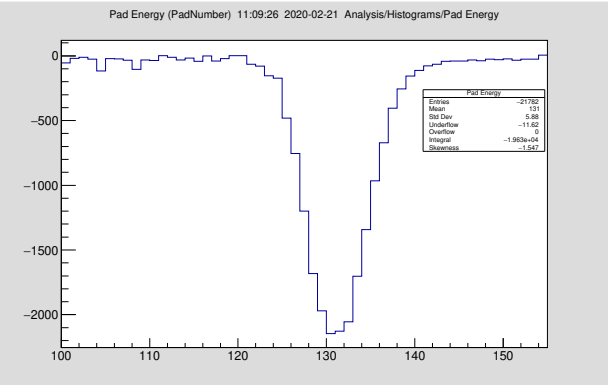
- Beam positions for different configurations and constant HV=3470V(Drift)/2300V(Stack)



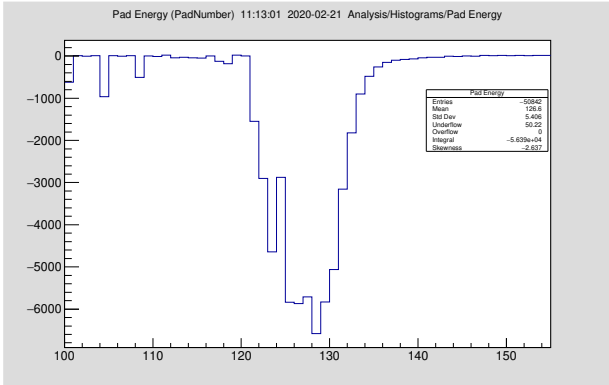
- Feedback configuration: 15



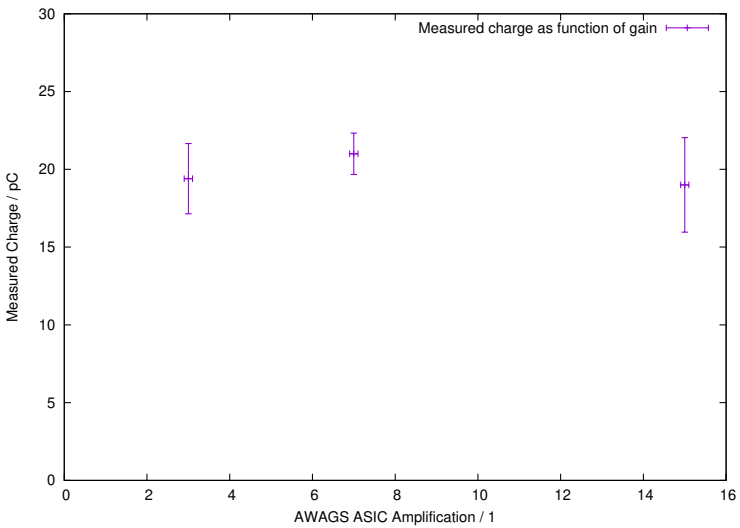
- Feedback configuration: 7



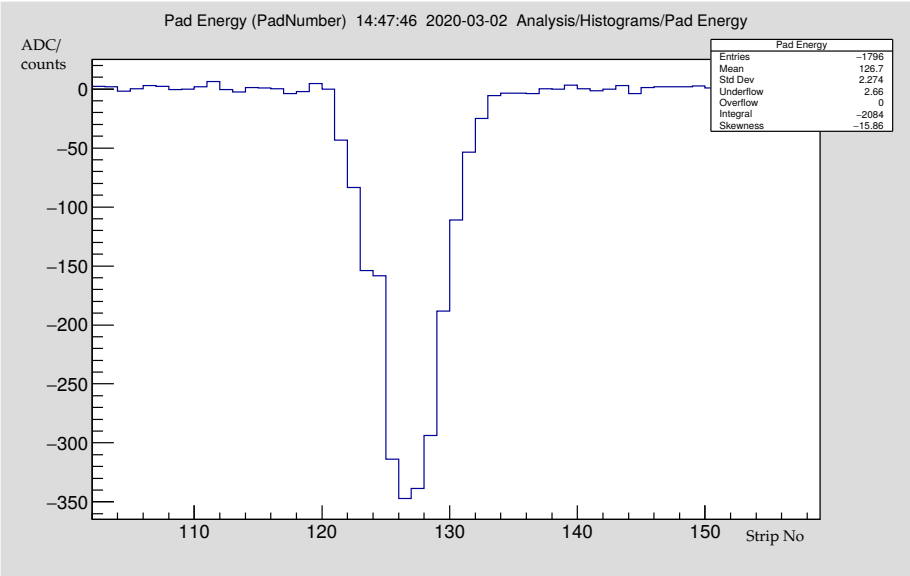
- Feedback configuration: 3



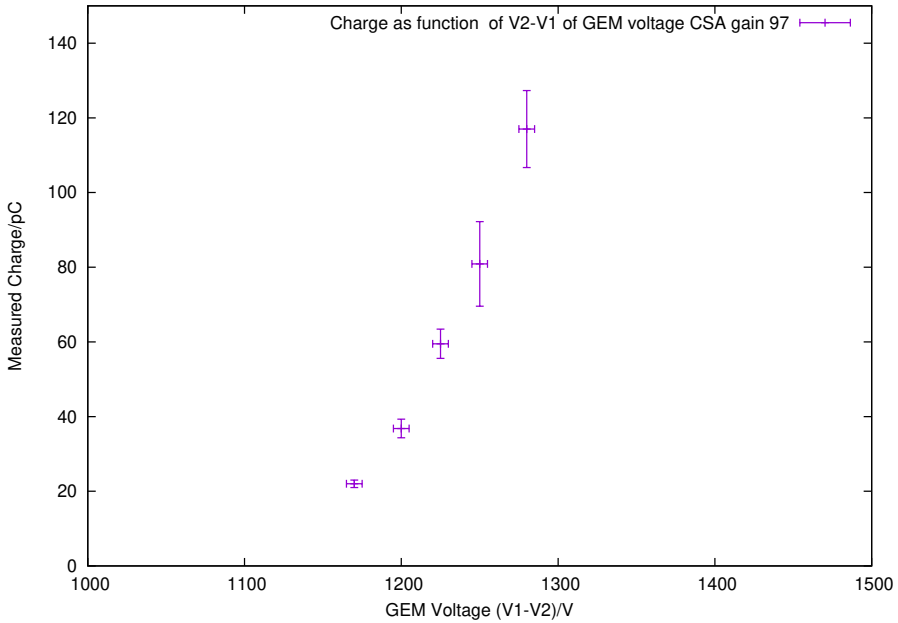
- Feedback configuration: 1



- Plot shows results for total charge measurements
  - Approximately 20 pC measured with all feedback configurations
  - Feedback config. 1 was not considered because of clipping
- Gain calculation of the GEM
  - SFRS sim. data: 835 MeV U^{238}-beam $\rightarrow$ 200 fC/u in drift region
  - Gain of GEM detector: $Gain_{GEM} \approx 20\,pC/200\,fC \approx 100$



- Lowest AWAGS-ASIC gain (config. 15): 0.0117mV/fC
- E.g. peak voltage of one strip: about 350 counts/8 = 44mV $\rightarrow$ 3.7pC
- Amplifier clipping starts at $>$ 5000 ADC counts
- Max. input charge for one channel is $>$ 40 pC



- GEM amplification vs high voltage
- Measured charge is between 20 pC and 120 pC
- Gain of the prototype GEM was between 100 - 600

Outline

- First readout of a GEM prototype with AWAGS - ASIC in laboratory was done 2019
- Successful test with γ-source in July 2019
- Designed first prototype for 256 channel readout
- Successful beamtime December 2019
- Preliminary results from electronics are presented and are promising

- Calculate/analyse the position resolution with TPC - data from beamtime 2019
  - Get response for clustering of pads
  - Is the pitch of 400 µm necessary? Higher clustering produces more charge but what about the resolution?
- Thanks to Klaus Götzen

- Event rate constrains
  - Beamtime 2019: kHz event rate
  - What is the event rate for the final design?
- Rise time
  - Dependency between GEM amplification and rise time was observed
  - Low GEM amplification (about 100)$\rightarrow$ risetime is about 120 ns
- PANDA: Rare U - beam
  - What about protons?! How many electrons per nucleon in drift region?
  - What is the required time and position resolution?
  - New beamtime with p with the existing setup?

Thanks to
T. Blatz, C. Caesar, D. Chokheli, F. García, T. Grahn, C. Karagiannis, N. Kurz, S. Löchner, M. Luoma, S. Pietri, M.-M. Schmidt, B. Voss, H. Weick, C. Nociforo and the FRS team

CSA No.	C_0	C_1	C_2	C_3	C_4	No. Cap.	Value/fC	Gain/mV/fC
0	1	0	0	0	0	1	200	2.5
1	1	1	0	0	0	5	1000	0.5
2	1	0	1	0	0	17	3400	0.1471
3	1	1	1	0	0	21	4200	0.1190
4	1	0	0	1	0	65	13000	0.0385
5	1	1	0	1	0	69	13800	0.0362
6	1	0	1	1	0	81	16200	0.0309
7	1	1	1	1	0	85	17000	0.0294
8	1	0	0	0	1	129	25800	0.0194
9	1	1	0	0	1	133	26600	0.0188
a	1	0	1	0	1	145	29000	0.0172
b	1	1	1	0	1	149	29800	0.0168
c	1	0	0	1	1	193	38600	0.0130
d	1	1	0	1	1	197	39400	0.0127
e	1	0	1	1	1	209	41800	0.0120
f	1	1	1	1	1	213	42600	0.0117