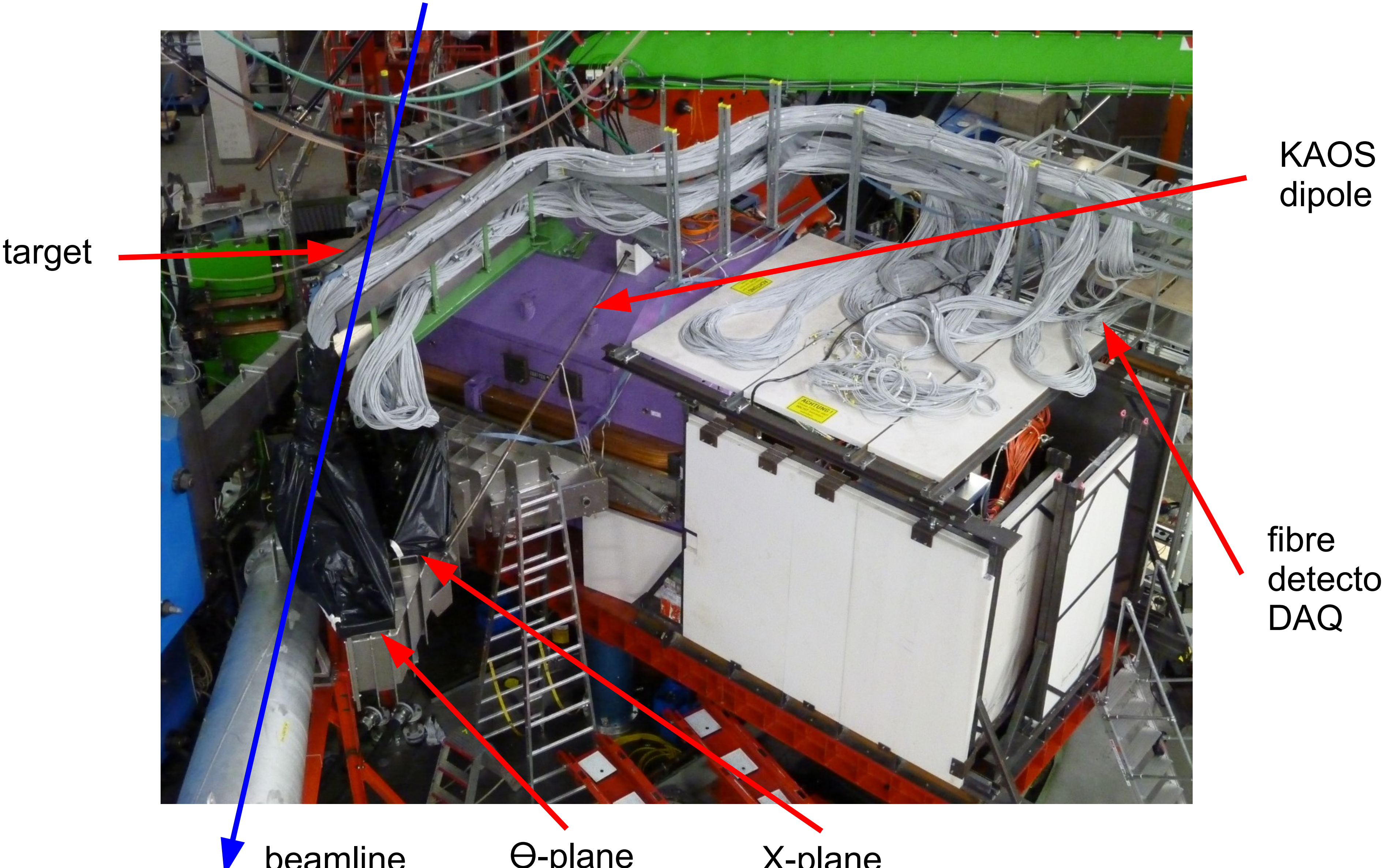
Calibration and Alignment of a focal Plane Detector System of ~20000 scintillating fibres

Anselm Esser, KPH Mainz

KAOS Setup at MAMI

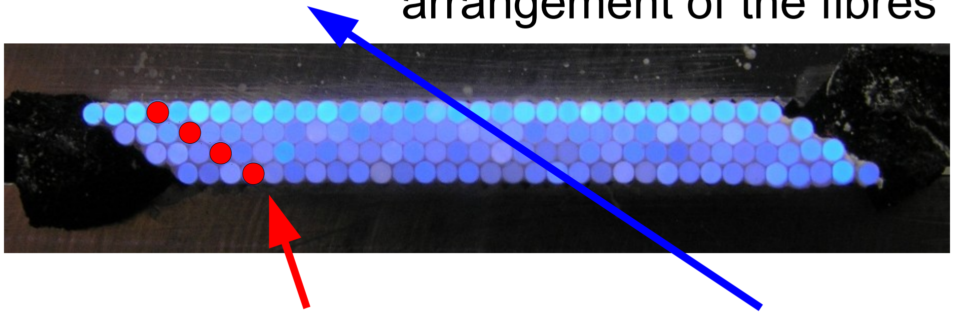


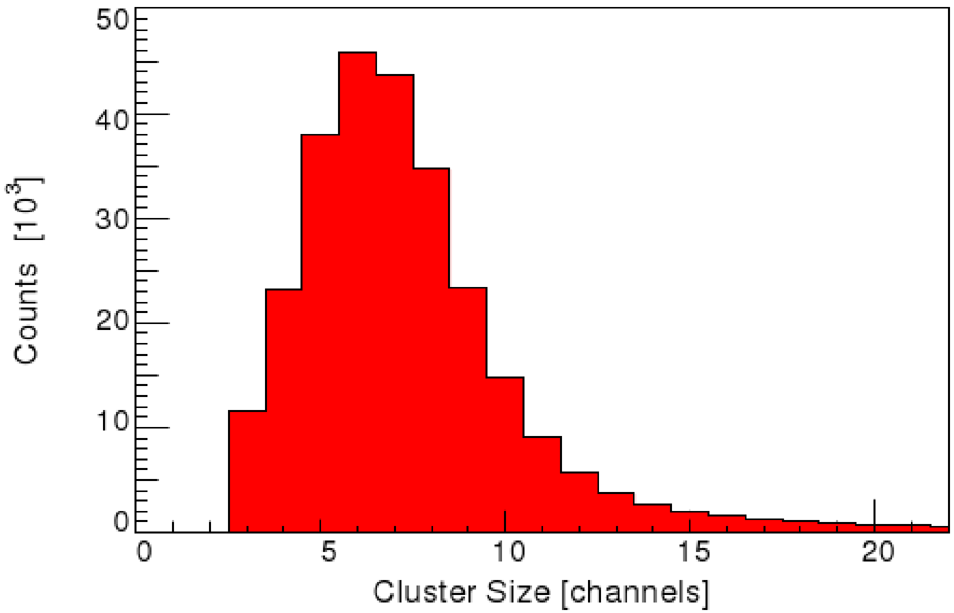
Fibre detector

photo of one detector plane

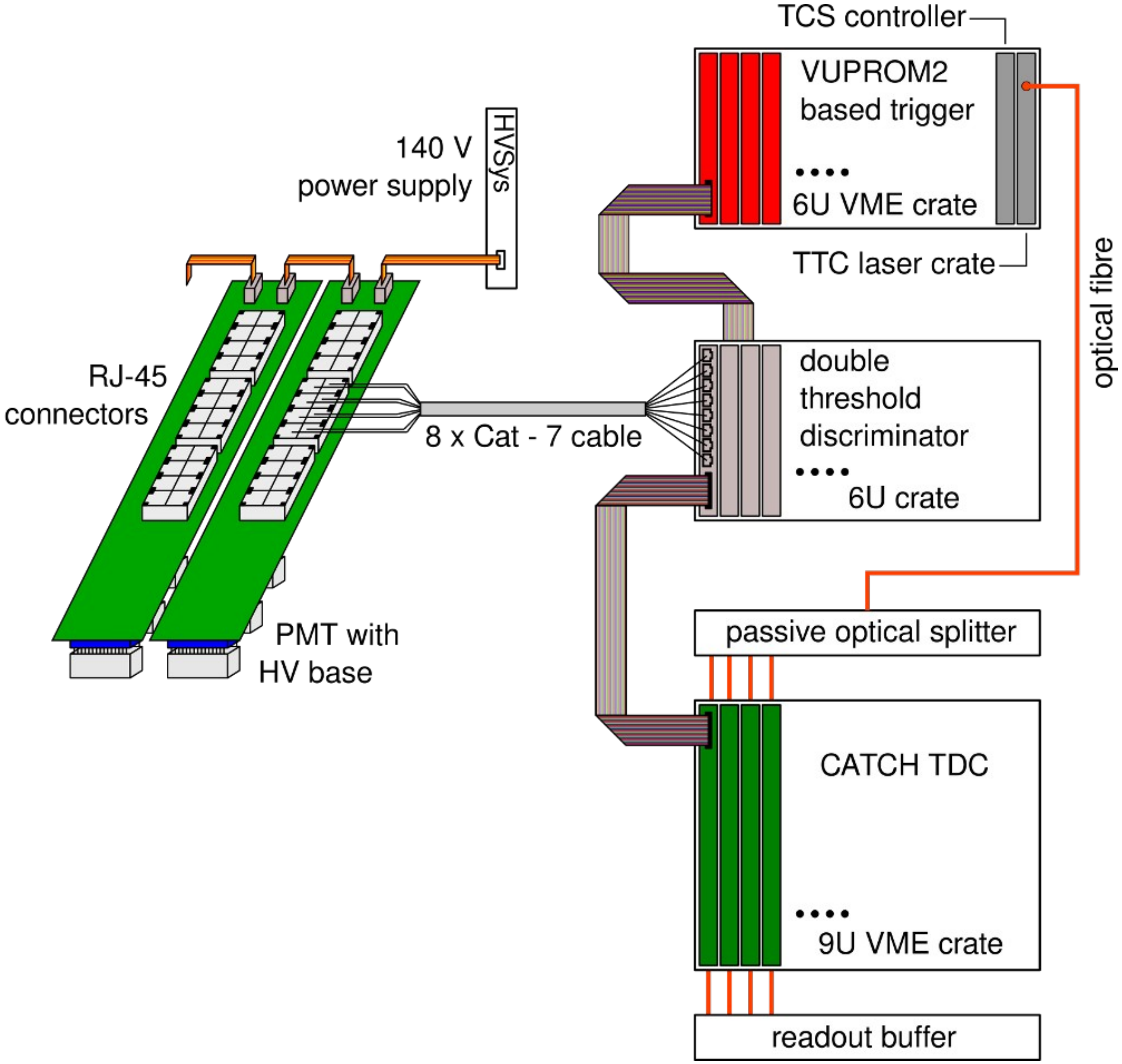
Parameters of the fibre detector

- 2 planes
- 2304 channels each
- 4 fibres are read out as one channel
- Hexagonal arrangement of the fibres

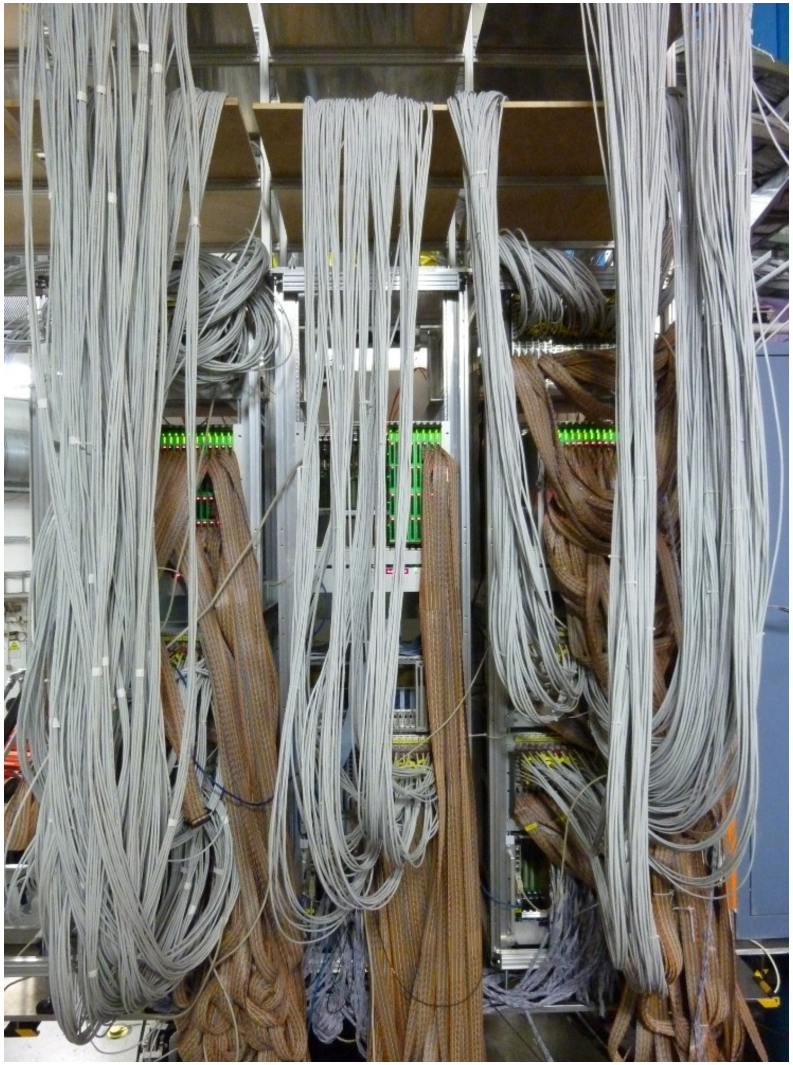




DAQ System



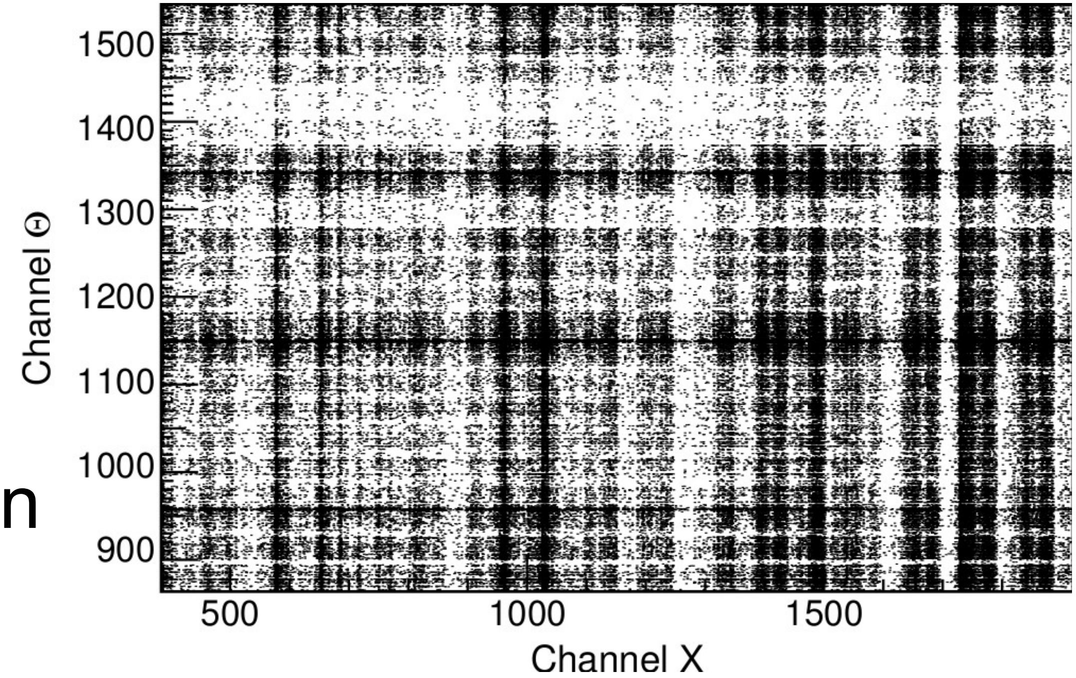
.. in theory



.. in reality

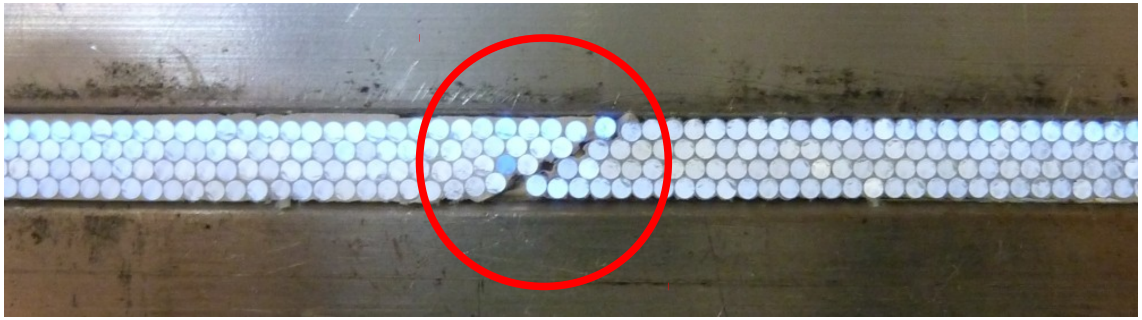
Gain calibration

- Motivation:
  - Beamtests results show regions of different count rates
- Problem: Large number of channels
  - 144 PMT HVs
  - 2304 discriminator thresholds
- Soultion:
  - Automated calibration



Idea

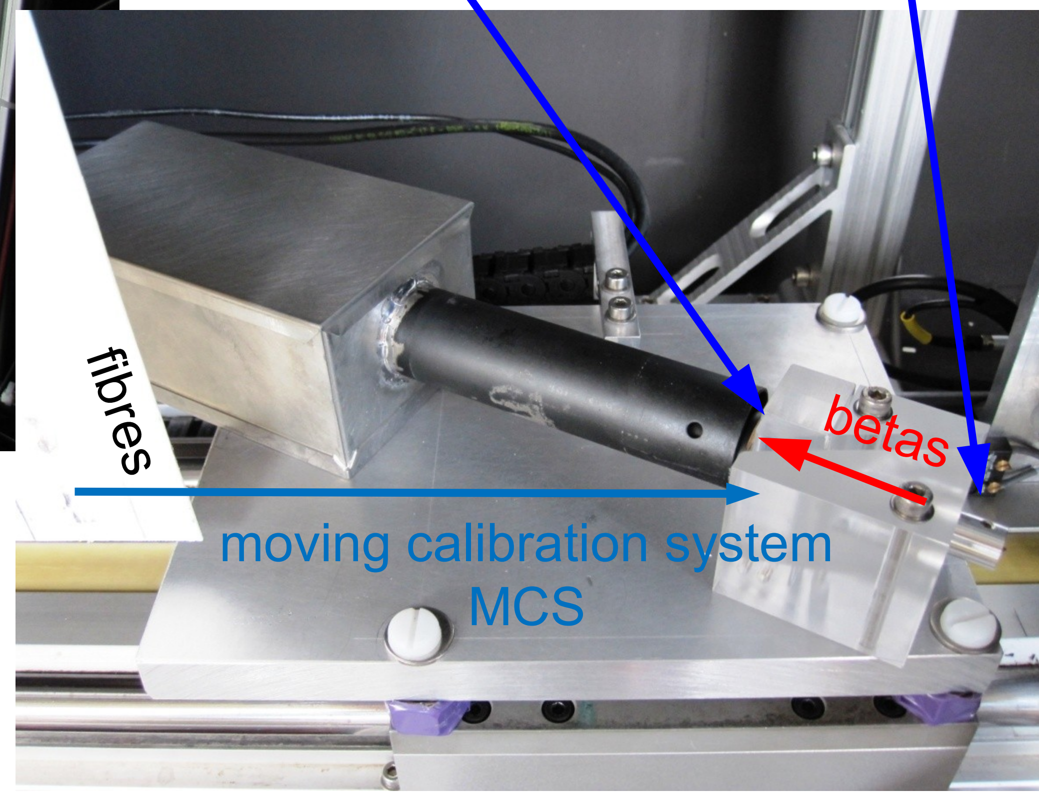
- Fully automated calibration procedure
  - Usage of a constant source of (scintillation) light
  - Meassure ADC values of each channel
  - Apply different setups
  - Obtain best values for HVs and thresholds
- Positive side effict
  - Fibre position is automatically meassured
  - Software correction of position offsets possible



Calibration Setup

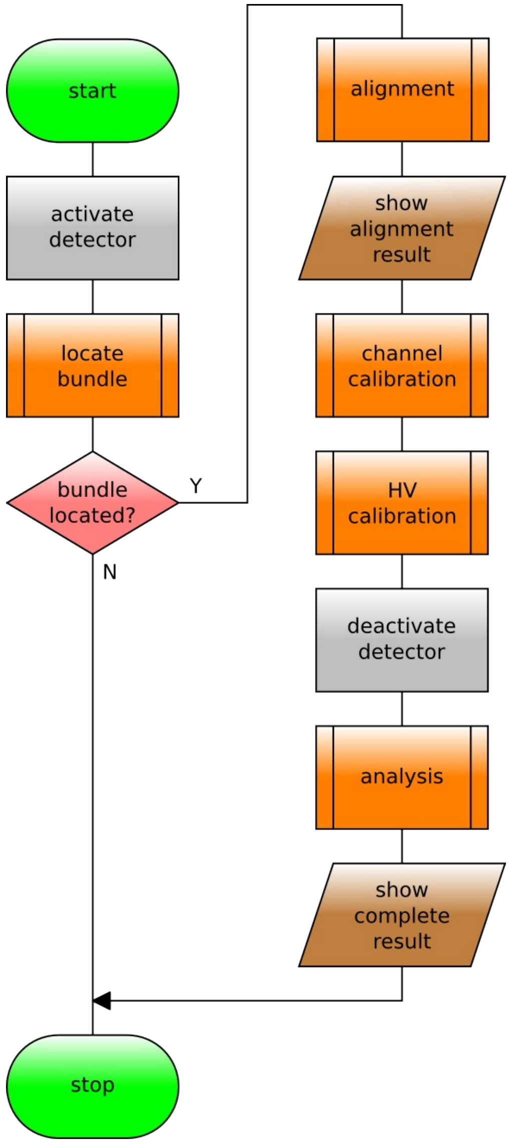
collimated 23 Mbq
^{90}Sr- source

Trigger detector:
Stack of scintillating fibres:
L x W x H = 20 x 0.5 x 20 mm³



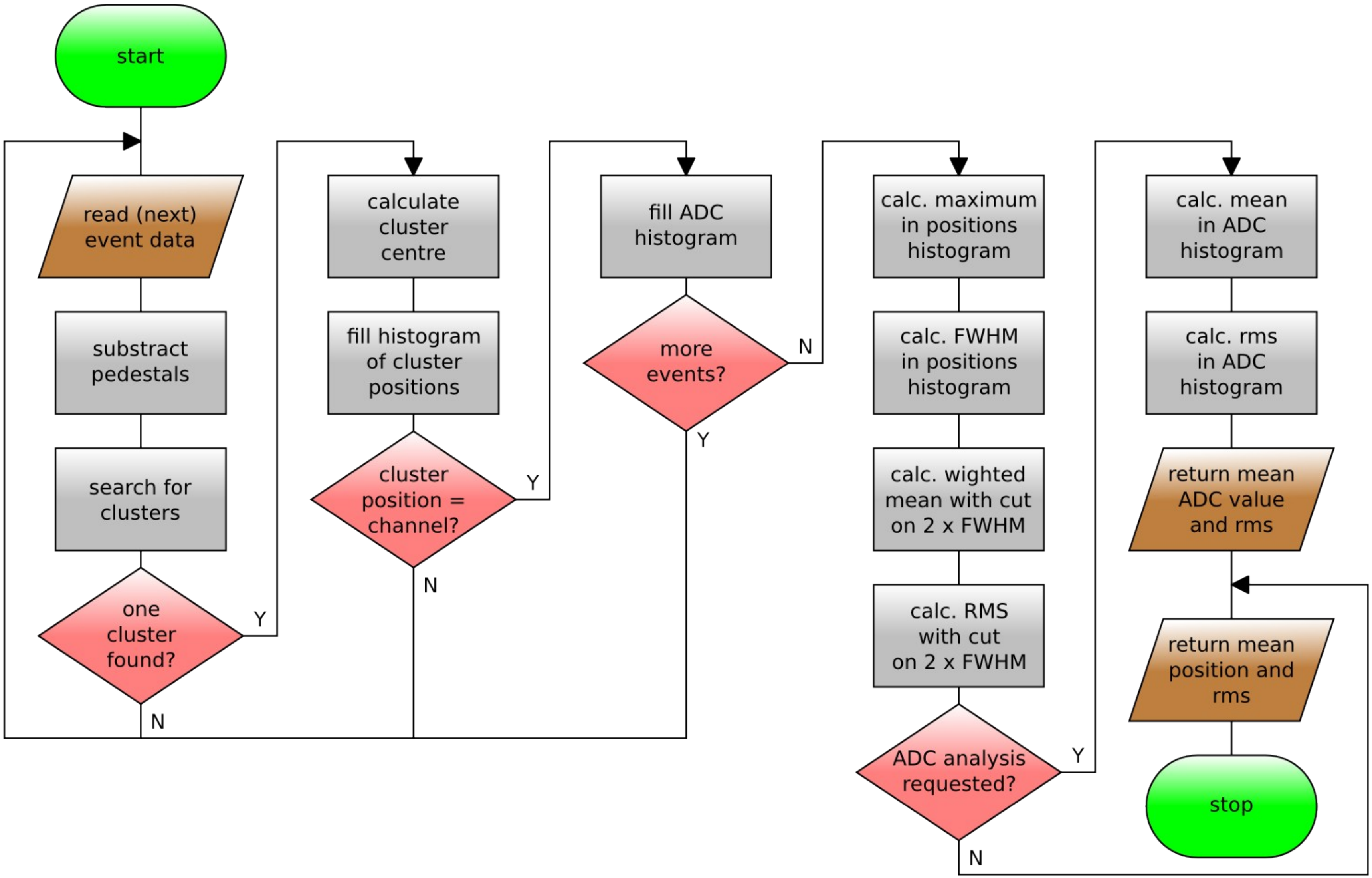
stepping motor positioning
0.1 mm accuracy

Calibration script

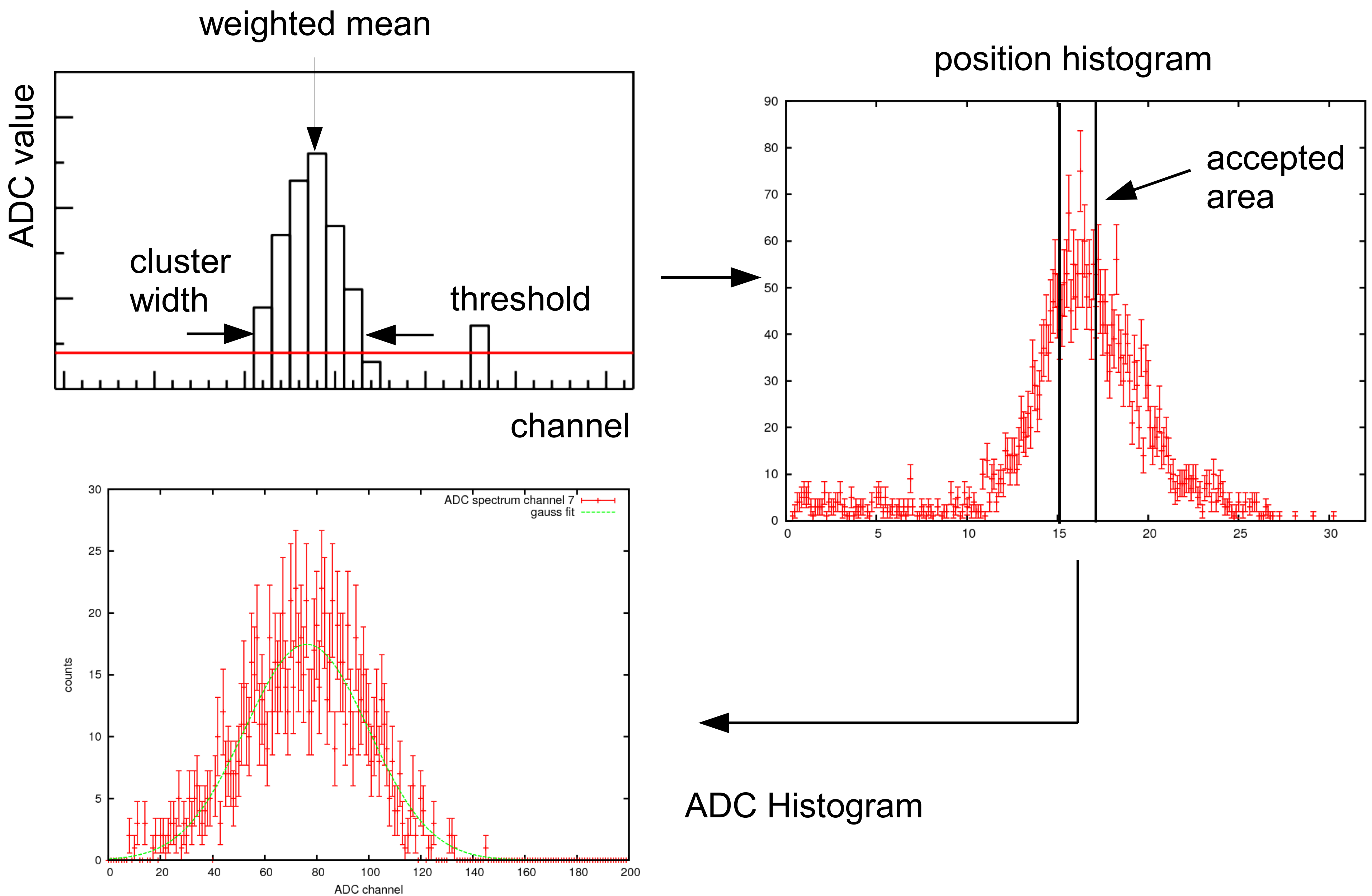


- 1.5 k lines of perl code
- Control functions
  - Positioning
  - Start / stop of DAQ
  - Control of Hvs
- Online Analysis
- Data stored for reanalysis
- Display of results using gnuplot

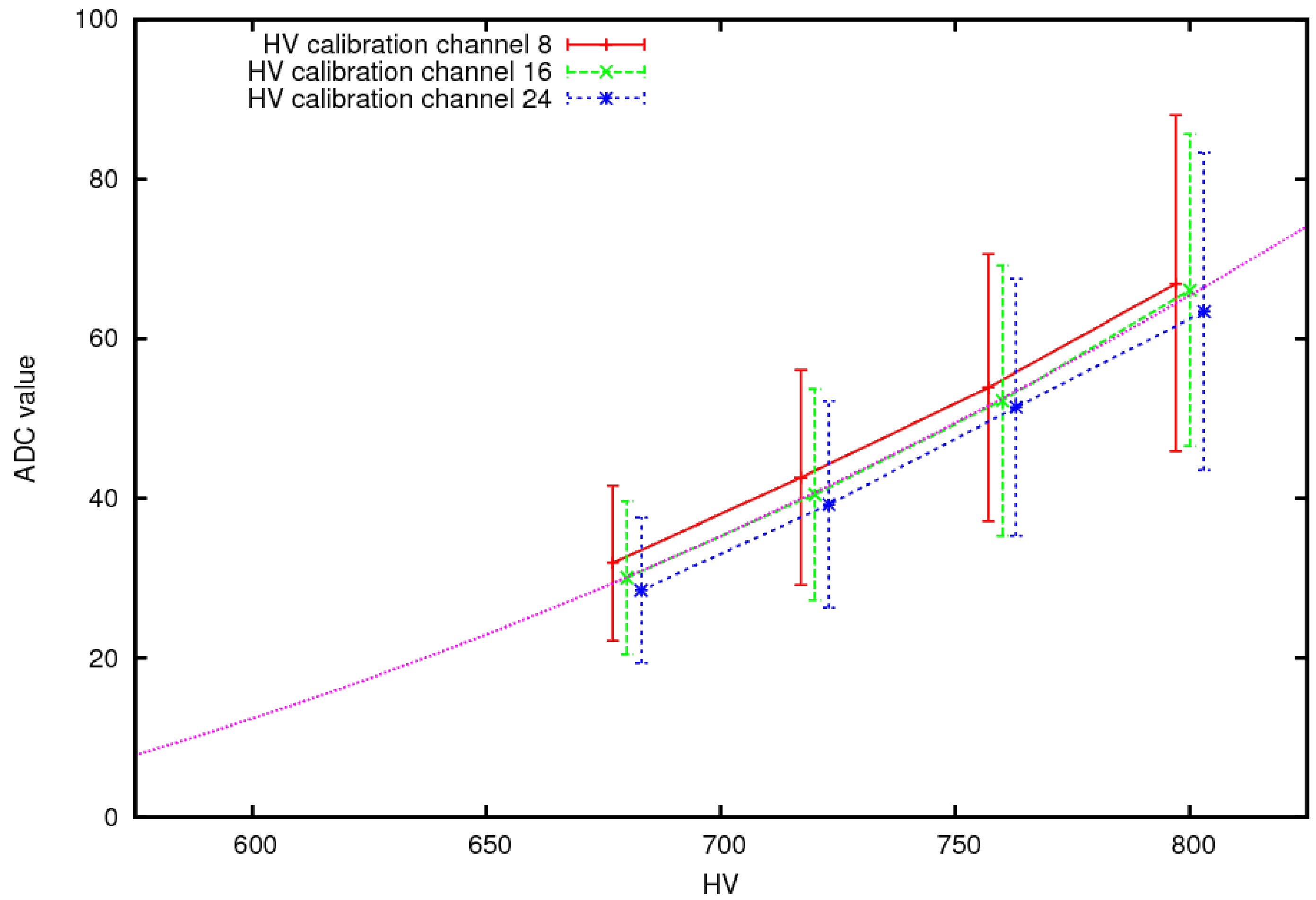
Online Analysis



Online Analysis

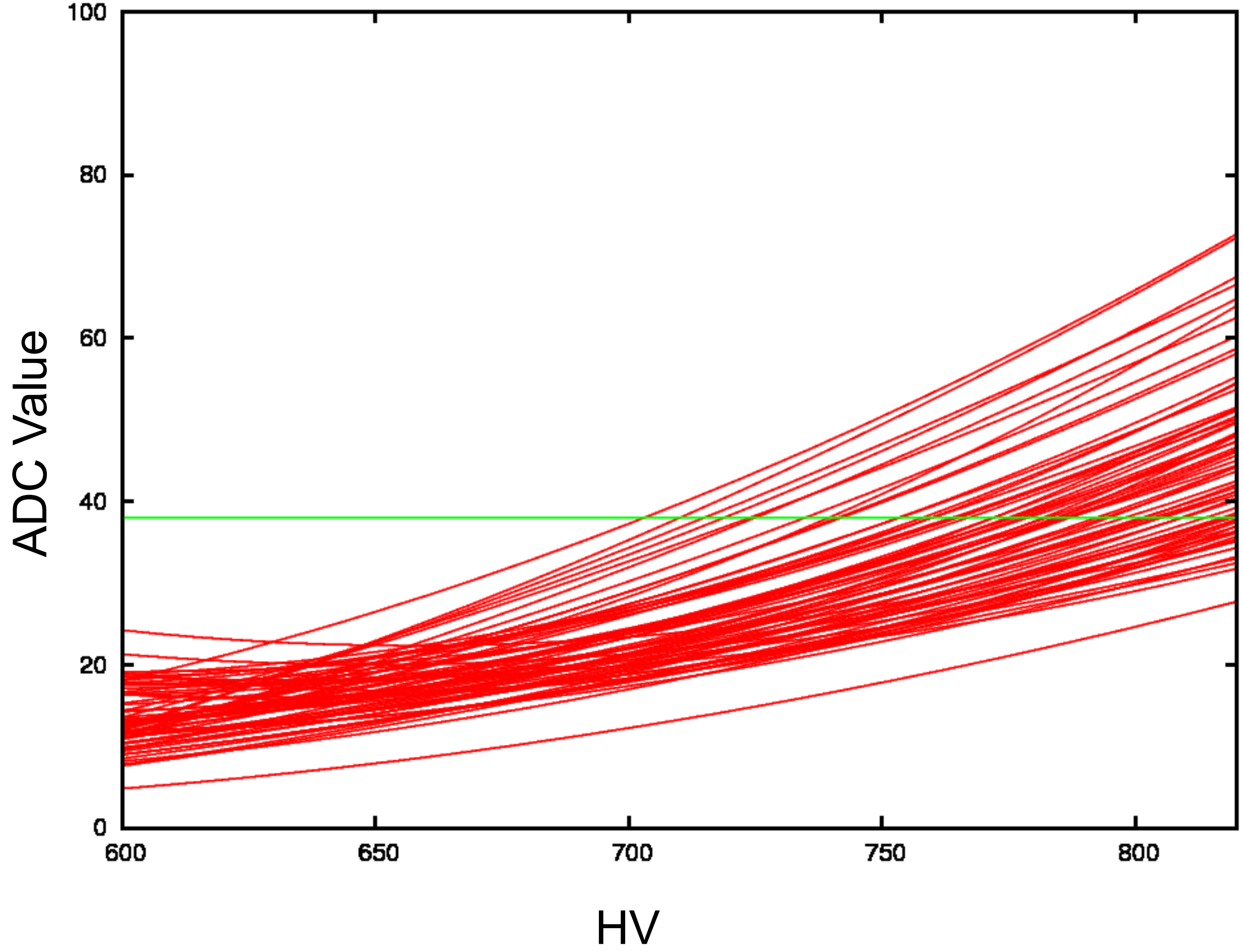


Results



- Fit method:
  - Polynomial fit for every channel
  - Averaging of fit parameters
- Advantage:
  - Single data points with low statistics can be disregarded

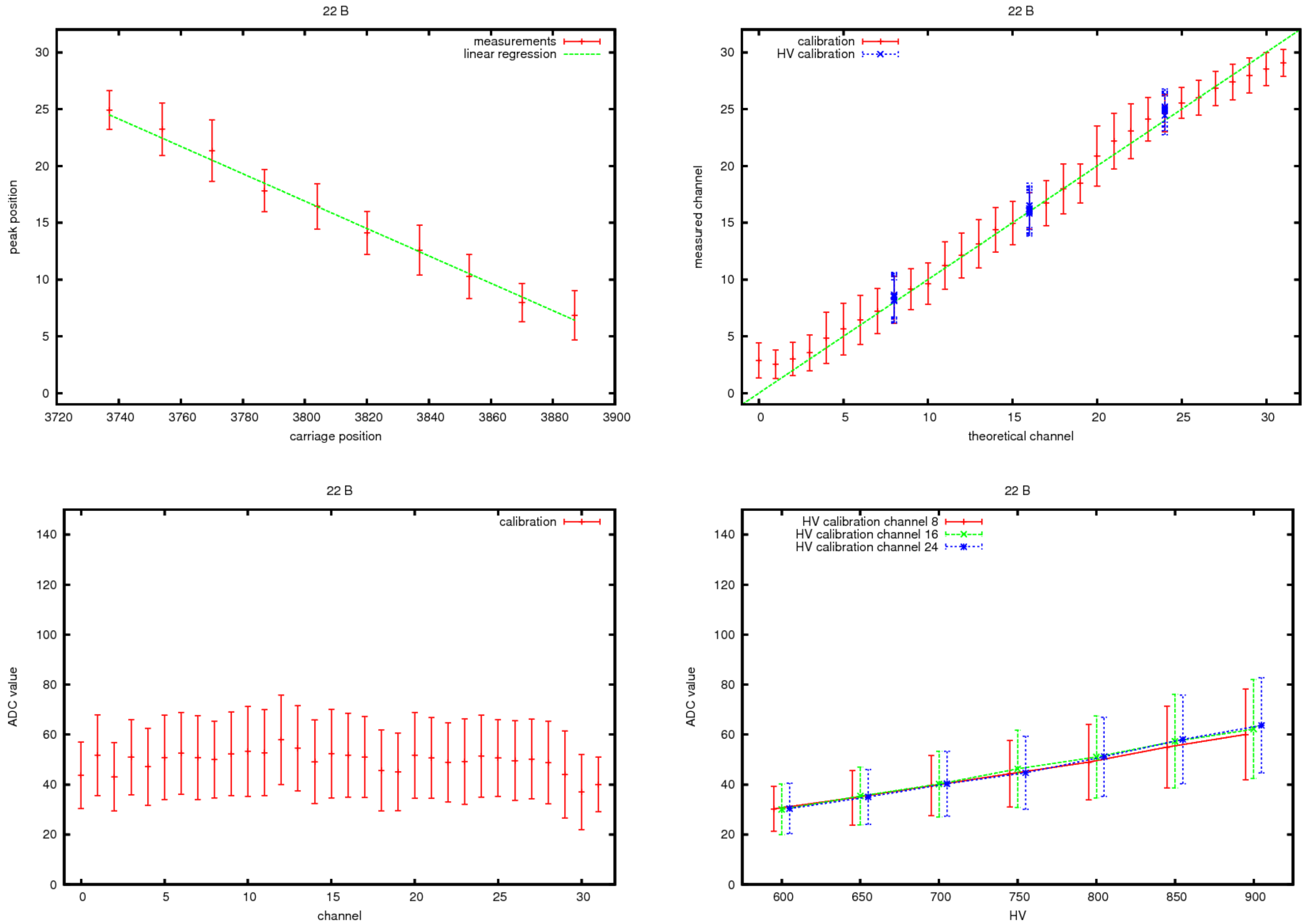
HV Calculation



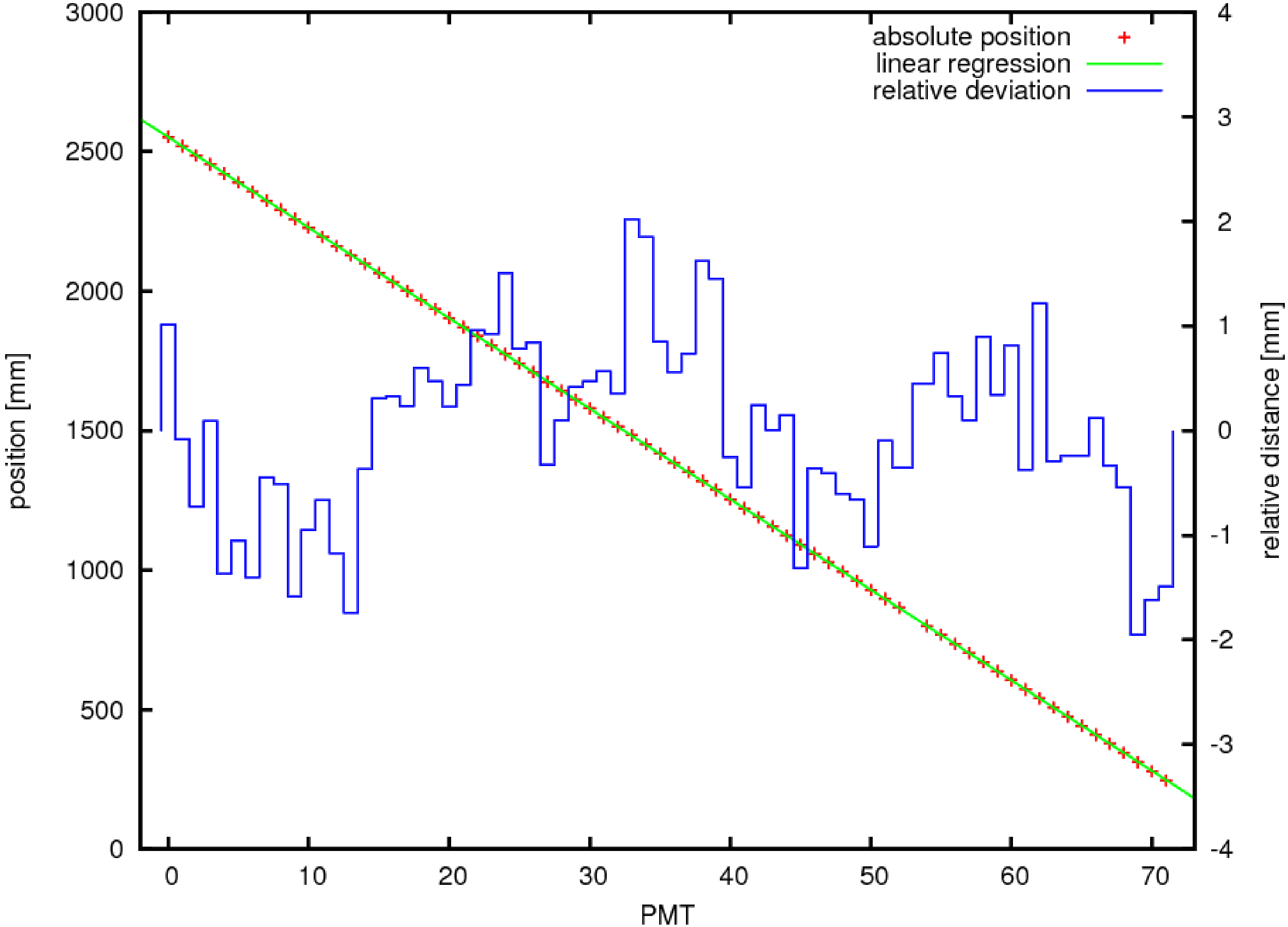
1A	842.92 V
1B	785.58 V
1C	784.19 V
2A	723.78 V
2B	816.96 V
2C	818.93 V
3A	801.60 V
3B	782.49 V
3C	829.65 V
4A	824.06 V
4B	809.26 V
4C	734.68 V
5A	794.65 V
5B	818.53 V
5C	710.02 V
6A	776.00 V
6B	825.64 V
6C	822.20 V
7A	766.89 V
7B	830.56 V
7C	739.41 V
8A	775.22 V
8B	852.27 V
8C	781.71 V
9A	841.14 V
9B	759.69 V
...	

set ADC value -> solve polynimial equation -> obtain list of individualHVs

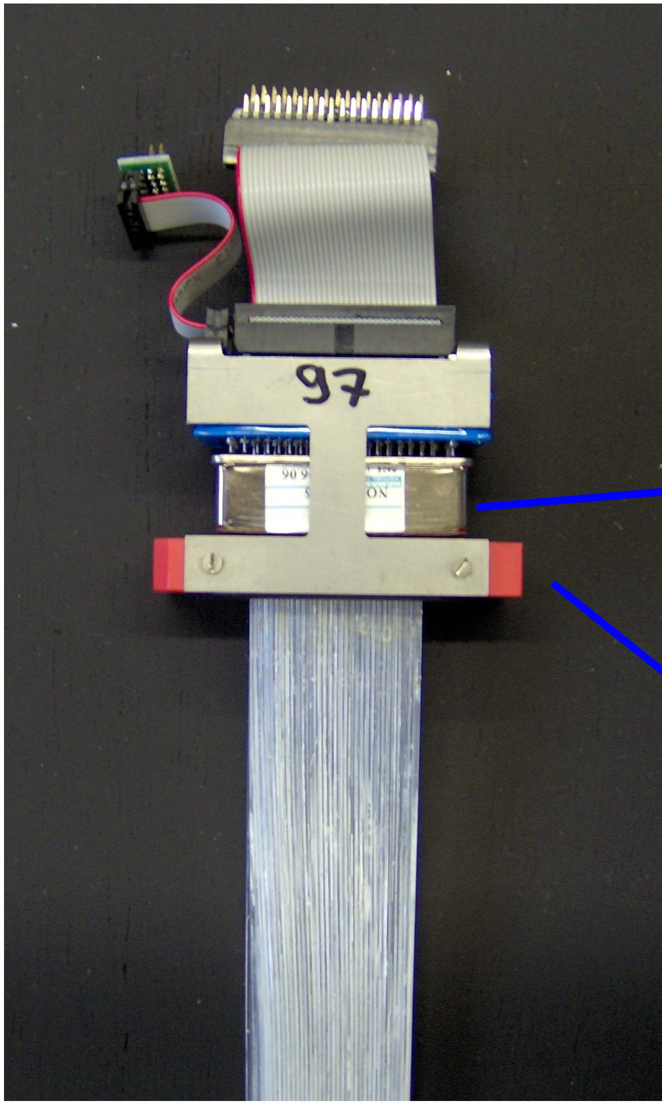
Results Display

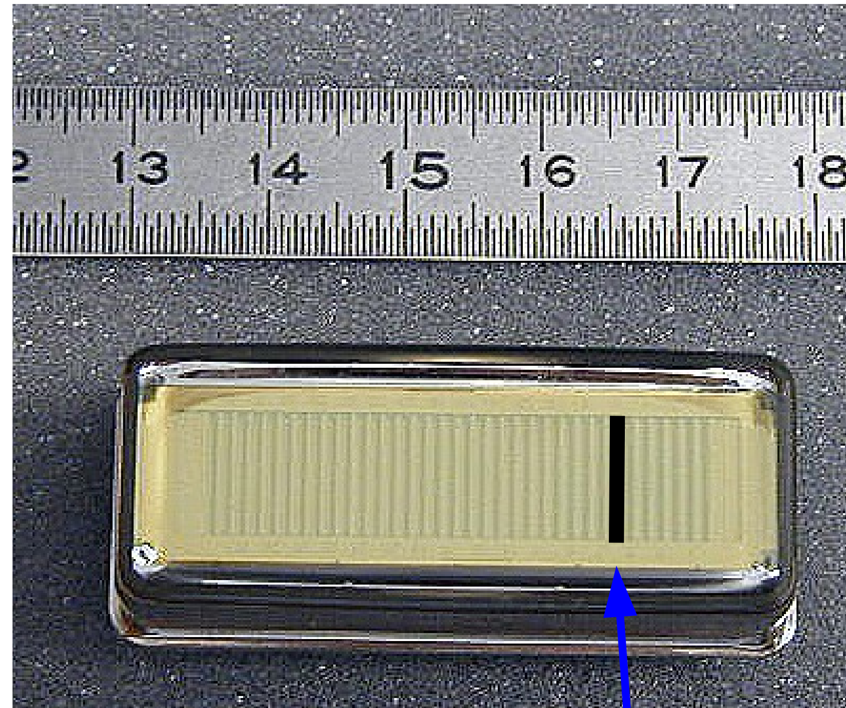


Results: Bundle Alignment



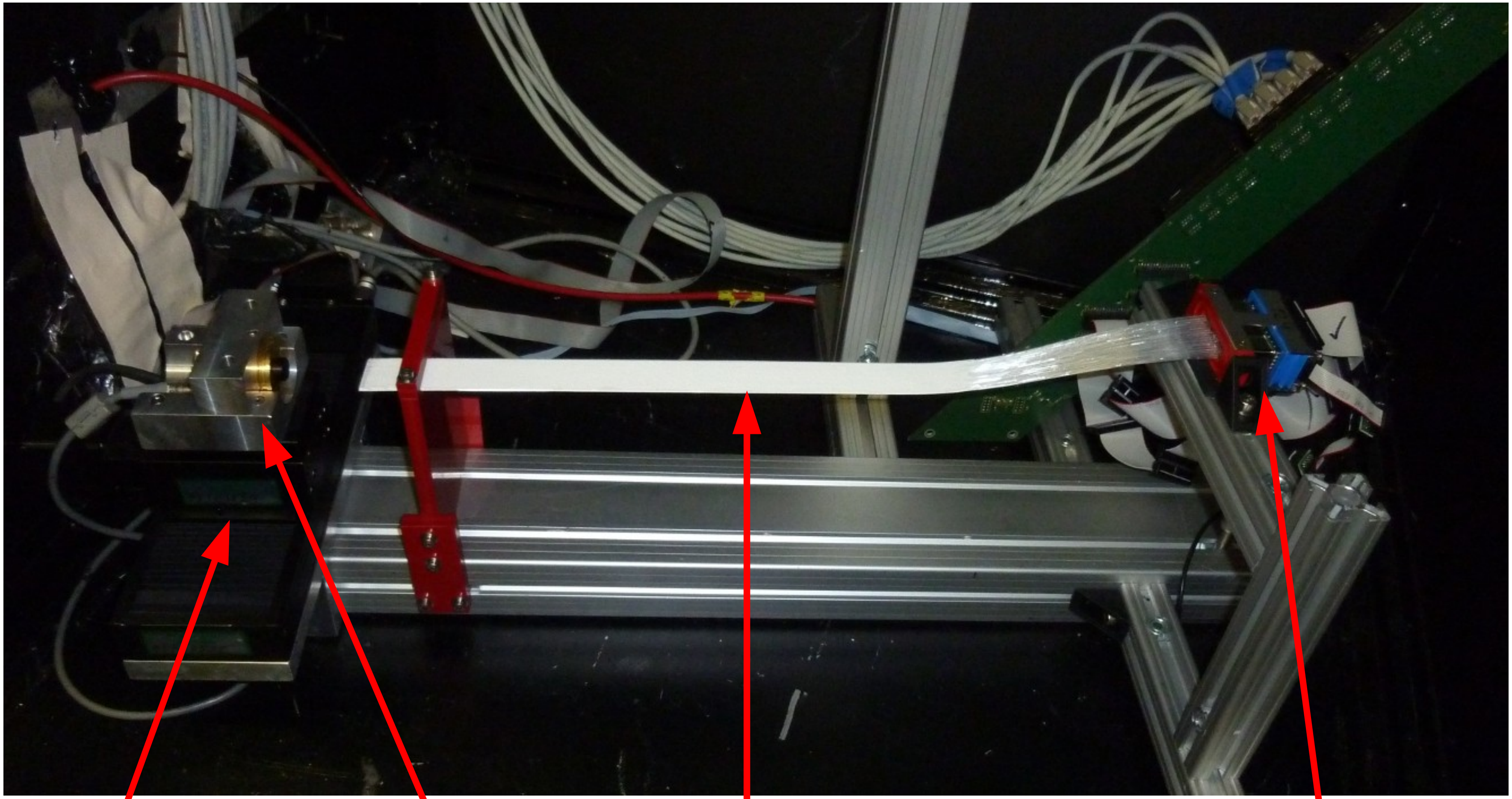
PMT Alignment





width = 0.83mm

Alignment Setup



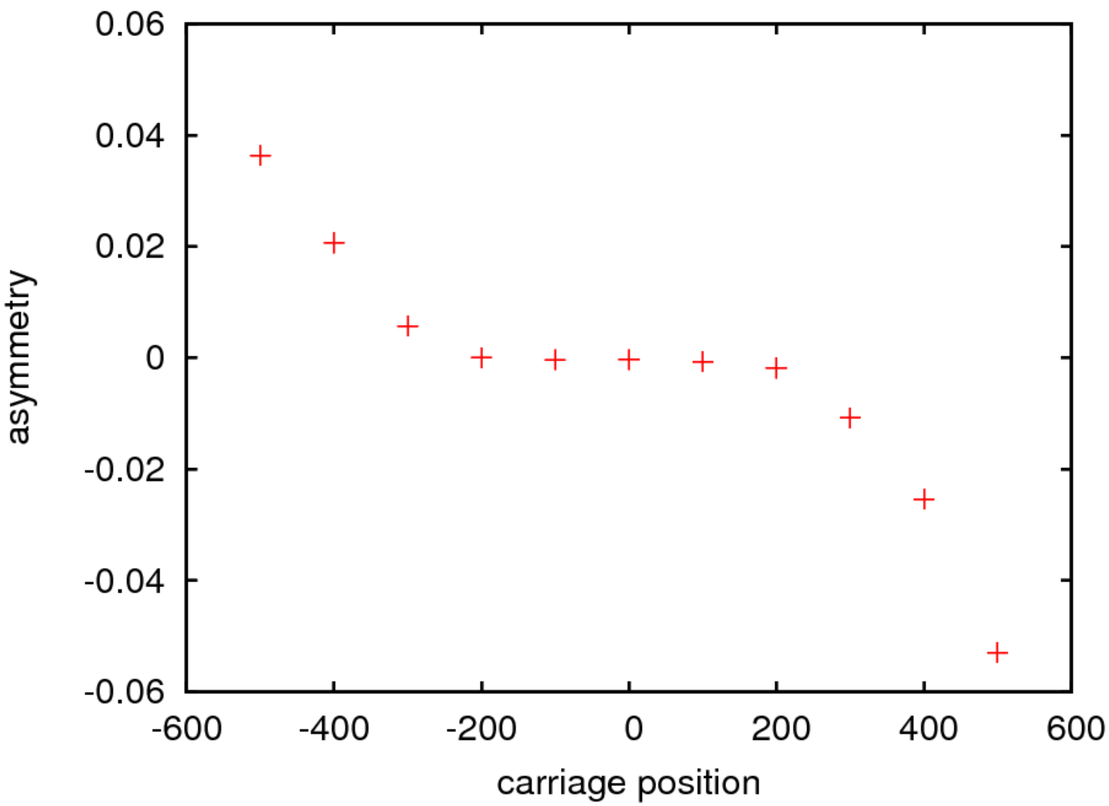
2 axes stepping motor positioning

pulsed laser

fibre bundle

PMT

Procedure

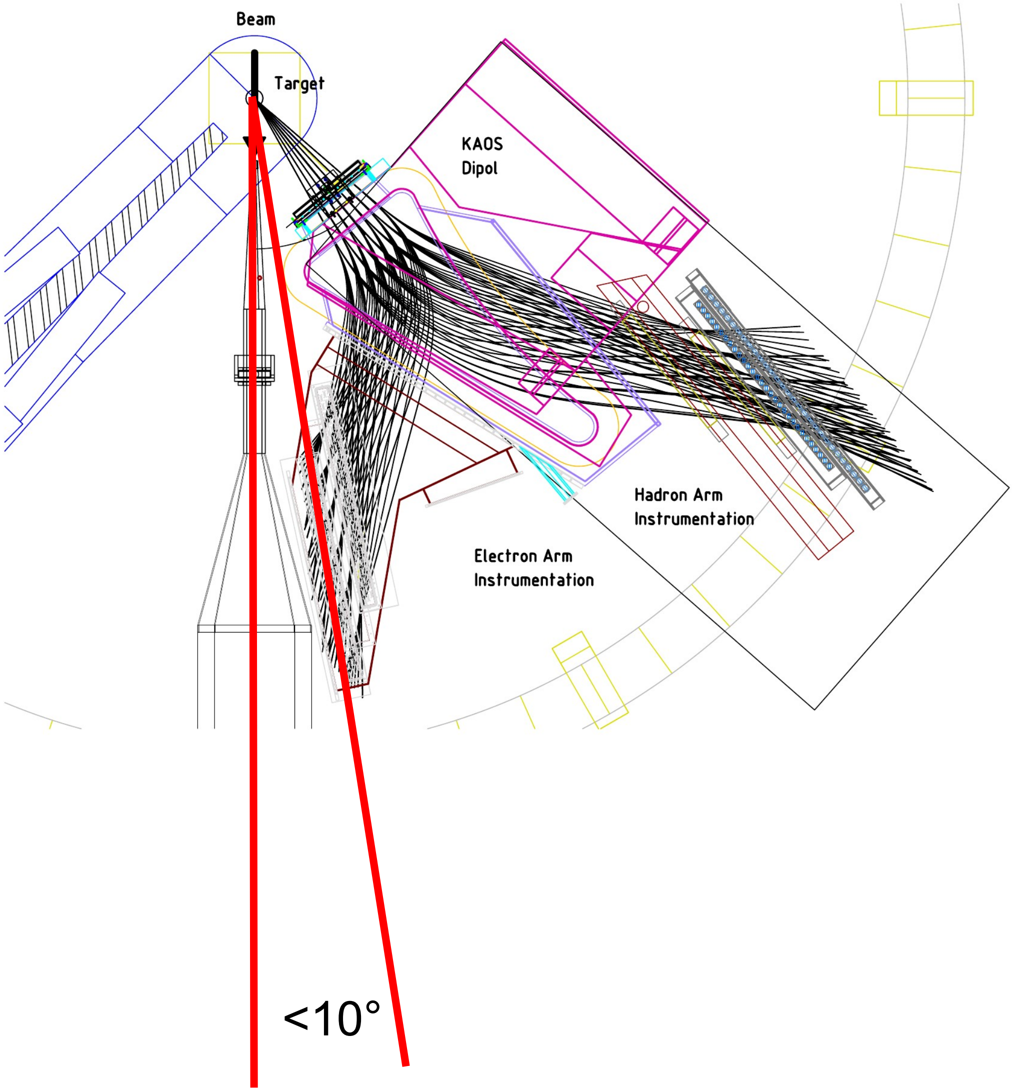


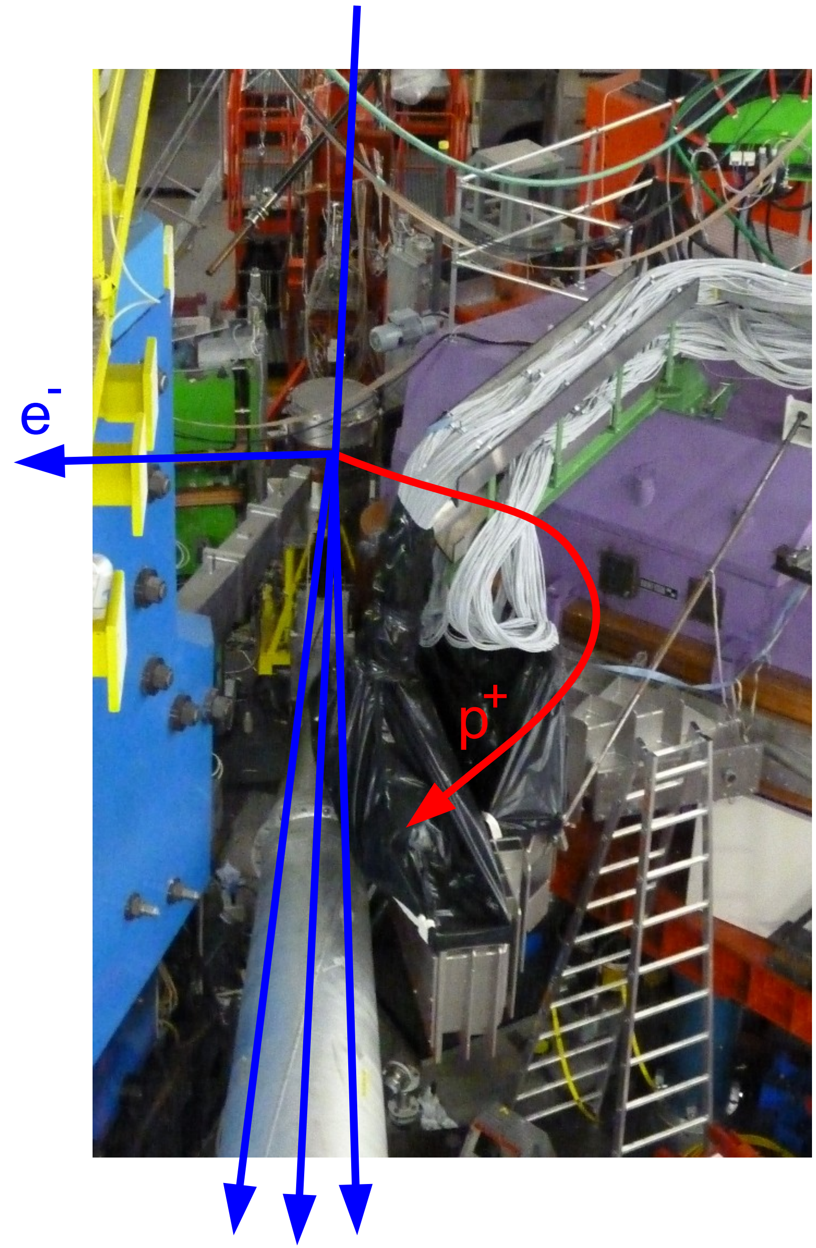
500 steps ~ 1mm

asymmetry: $a = \frac{ADC(17) - ADC(15)}{ADC(17) + ADC(15)}$

- Laser positioning by hand
- Usage of optical crosstalk
- Calculation of asymmetry
- Automated DAQ and analysis
- Asymmetry for all bundles < 0.01

Beam tests at MAMI

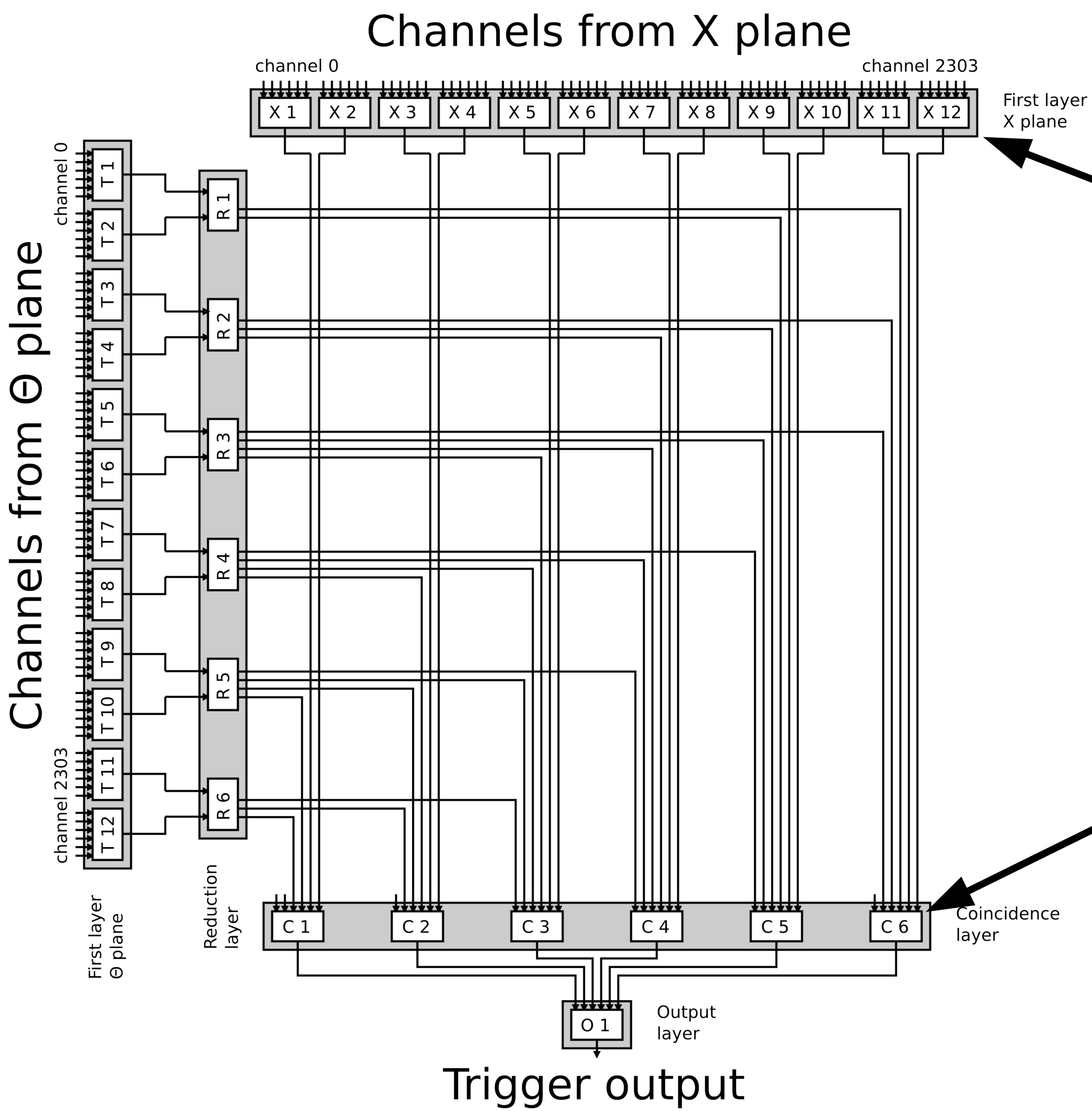


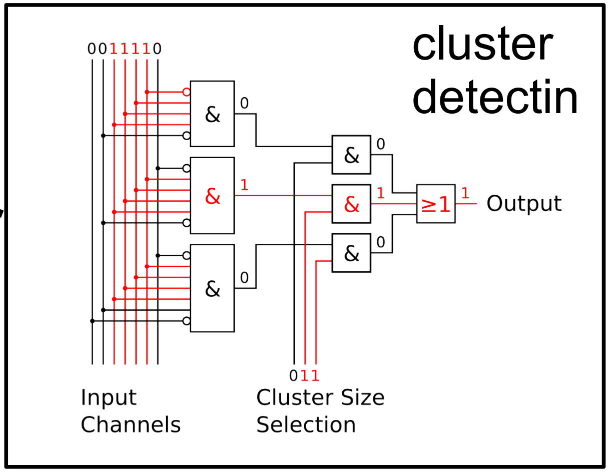


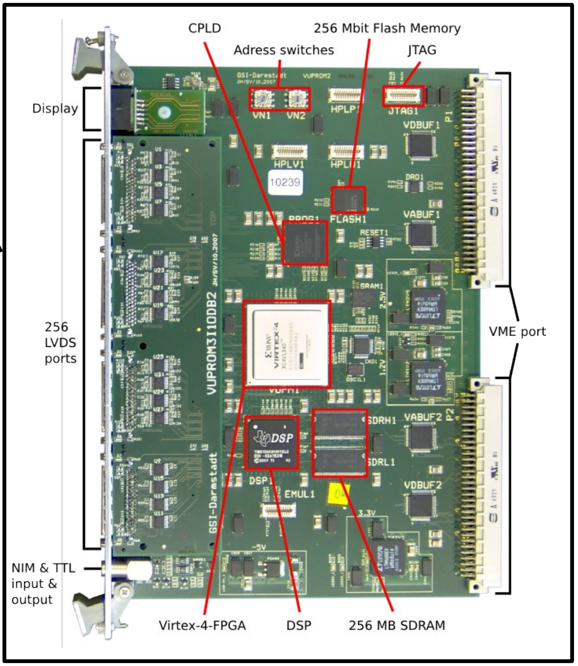
Trigger Setup

- Trigger logic based on 37 Virtex-4-FPGAs
- 4608 Input channels
- Detection of signal clusters on both detector planes
- Coincidence logic between planes
- Angular acceptance test
- Extendable to missing-mass-trigger
- Online access to trigger parameters
- Filtering of underground rates of the order of MHz

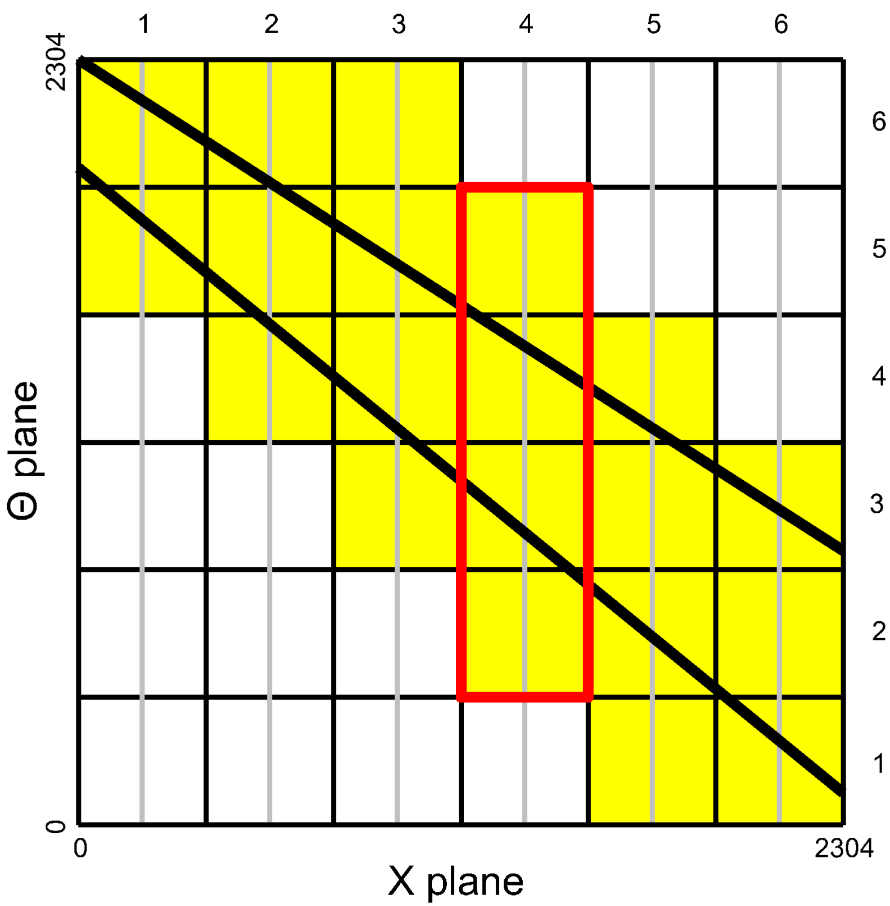
Trigger Setup



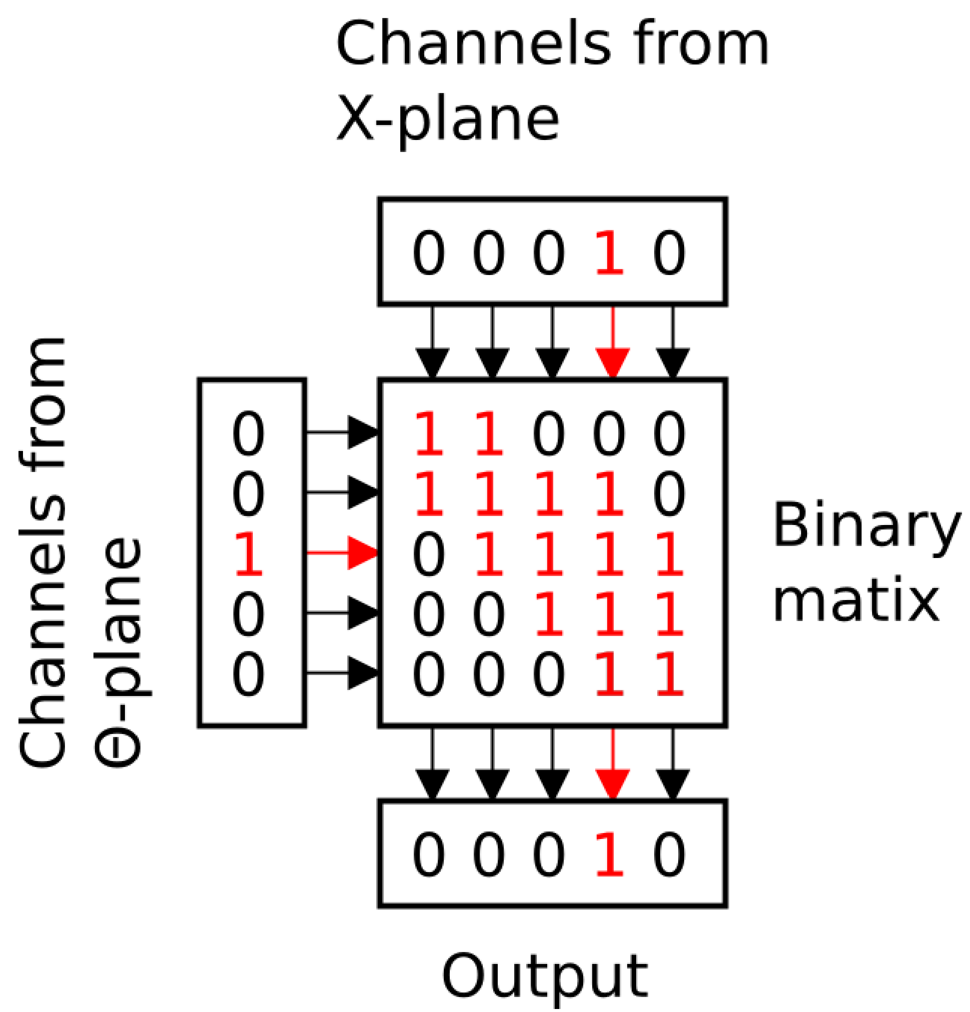




Angular Acceptance Test



Coincidence matrix
(from simulations)

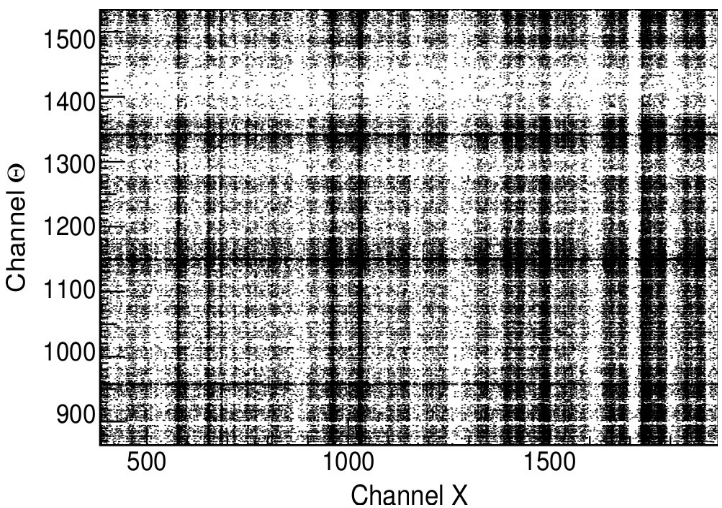


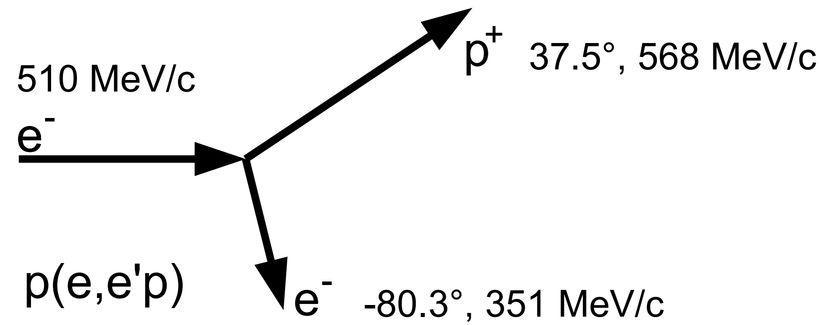
Trigger Rates

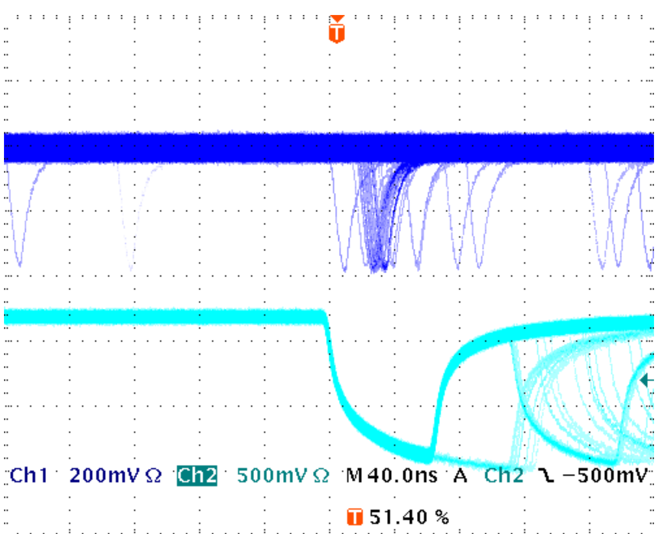
Beam current: 1µA	X-plane		Θ-plane
Raw data rate	820 kHz		3.8 MHz
Rate of clusters	160 kHz		630 kHz
Coincidence rate		26 kHz	
Tracking trigger rate		8.2 kHz	
Coincidences with other spectrometer		~0.1 Hz	

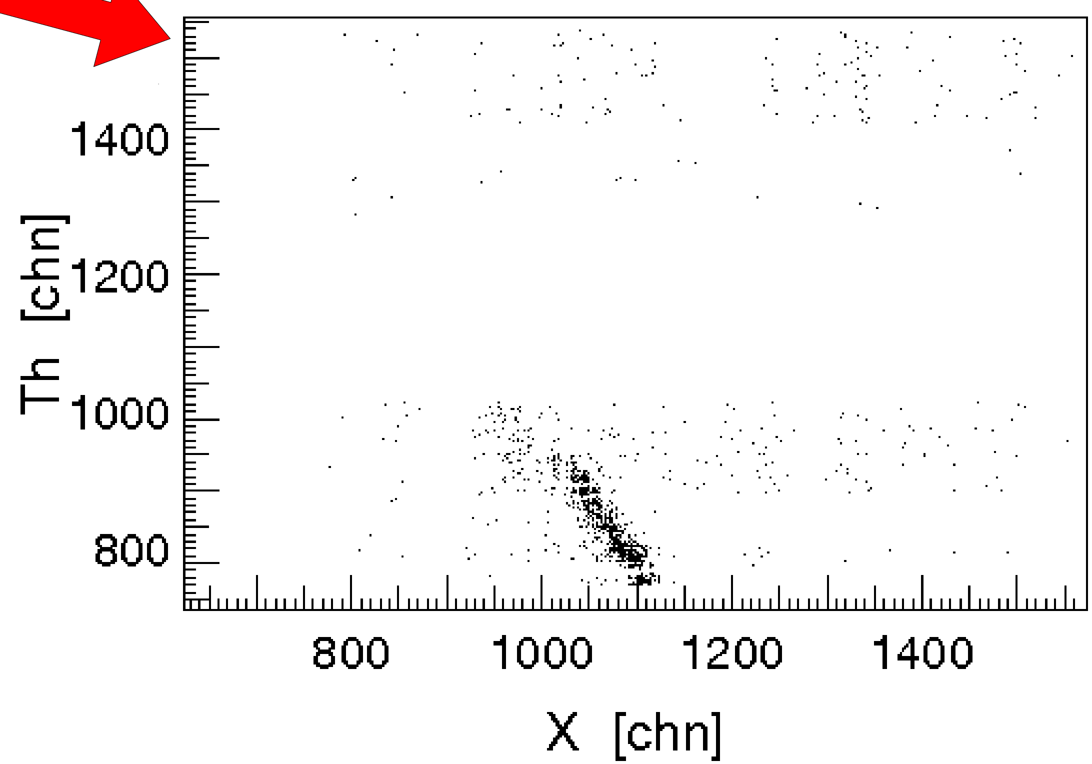
ratio: 1/500

Beamtest Results









Summary / Outlook

- Current status:
  - One detector plane is assembled and HV calibrated
  - 2/3 of other plane are assembled
  - DAQ is assembled (except for some discriminators and parts of the TDC readout)
  - 28 of 37 trigger modules are set up
- To do:
  - Discriminator threshold calibration one plane
  - Complete calibration of the other plane