Update on FRM II Detector Group Activities

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Gaseous detectors with solid ^{10}Boron converter

FRM II doesn't pursue anymore a distinct project for gaseous detectors with solid ^{10}Boron converter, but provides support to other detector groups

- **SINE 2020: ^{10}B-based RPC-detectors built by LIP Coimbra:**

  Test of novel anode substrate materials for RPCs with solid $^{10}B_4C$ converter at the beam line V17 at HZ Berlin

  Study of different position reconstruction techniques with a double-gap RPC

The CHARM project

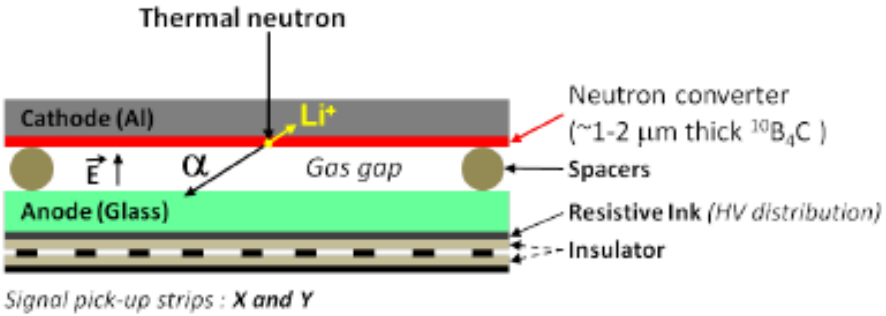
- **2-D curved ^{3}He-based MWPC for powder diffraction instruments**

  Resent results of the 30° prototype built in collaboration with ILL and PSI

  Update on the production of two 130° full size detectors for ErwiN & DMC

Study of substrate materials

Single-Gap RPC



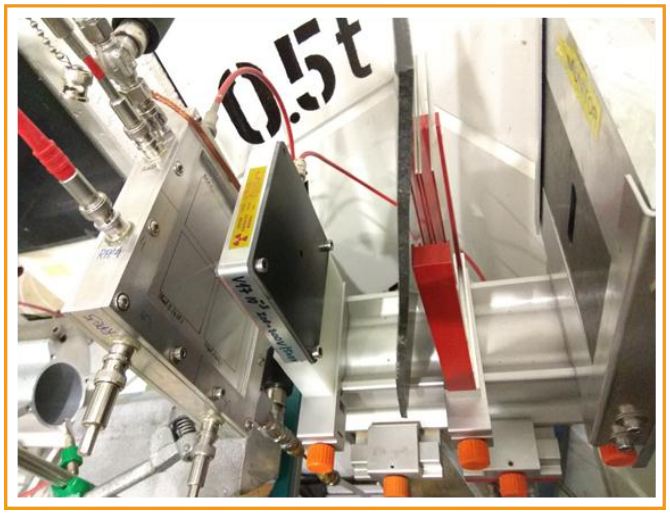
Detector operated with $C_2H_2F_4$ @ 1atm

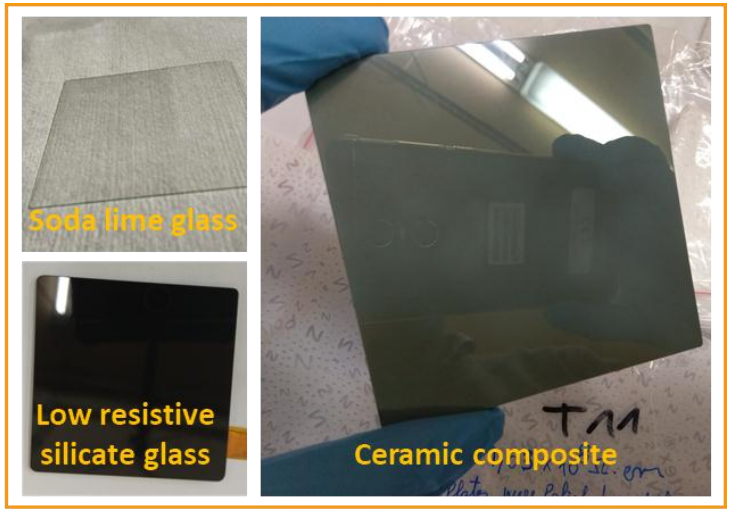
$^{10}B_4C$ coatings provided by ESS / Linköping

Anode substrate materials

- **Soda lime glass**
  0.35mm / 0.28mm thick, $\rho \approx 10^{13}$ Ωcm
- **Low resistivity silicate glass**
  1mm thick, $\rho \approx 4\times10^{10}$ Ωcm
- **Ceramic composite**
  2mm thick, $\rho \approx 10^{10}$ Ω cm
  (provided by HZ Dresden)

Detector setup at V17 beam line at HZ Berlin (λ = 3.35A) during study of substrate materials





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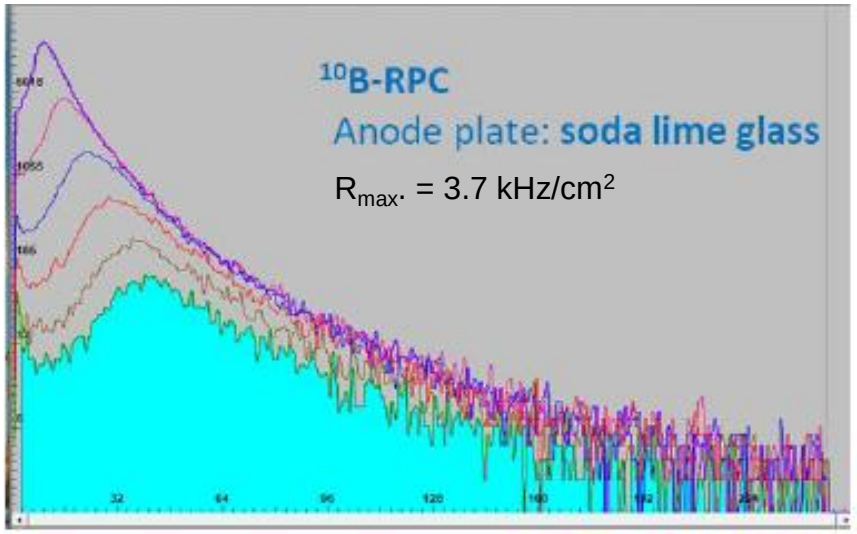
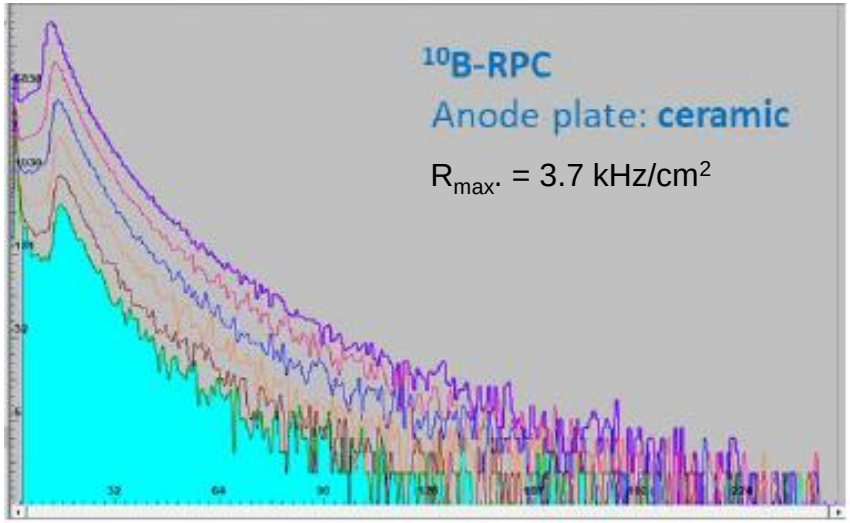
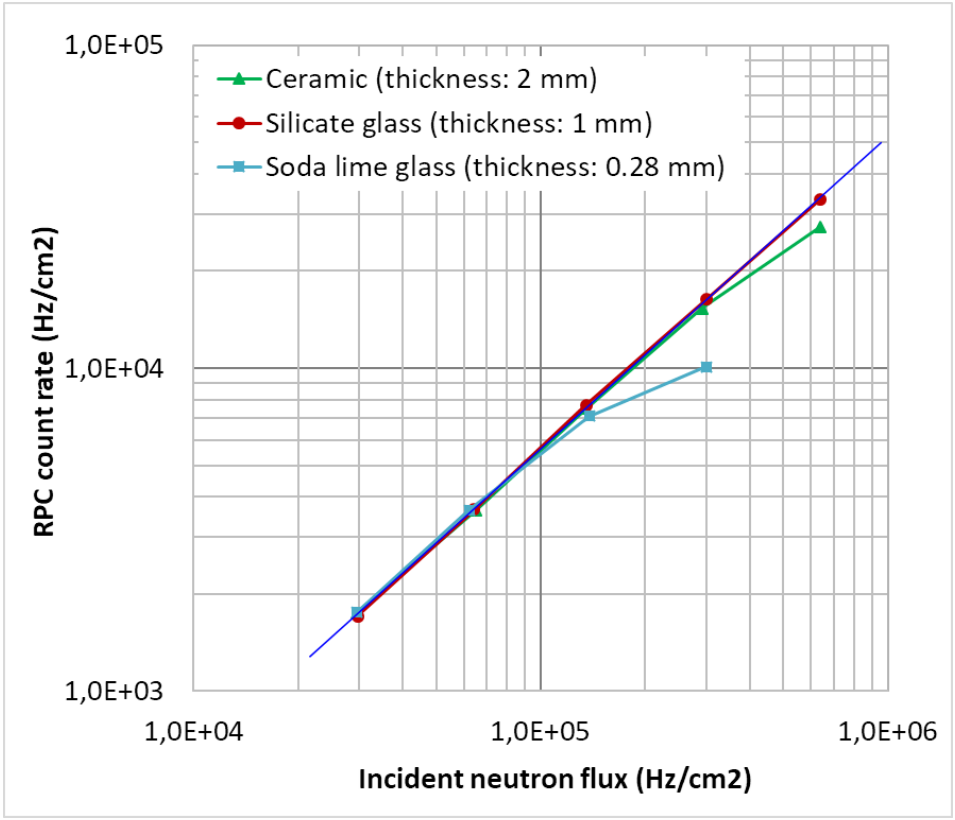
Count rate capability of B-RPCs

Pulse height spectra recorded for increasing incident neutron flux





Measured count rate vs. incident flux



- Incident flux determined by a calibrated FC-monitor

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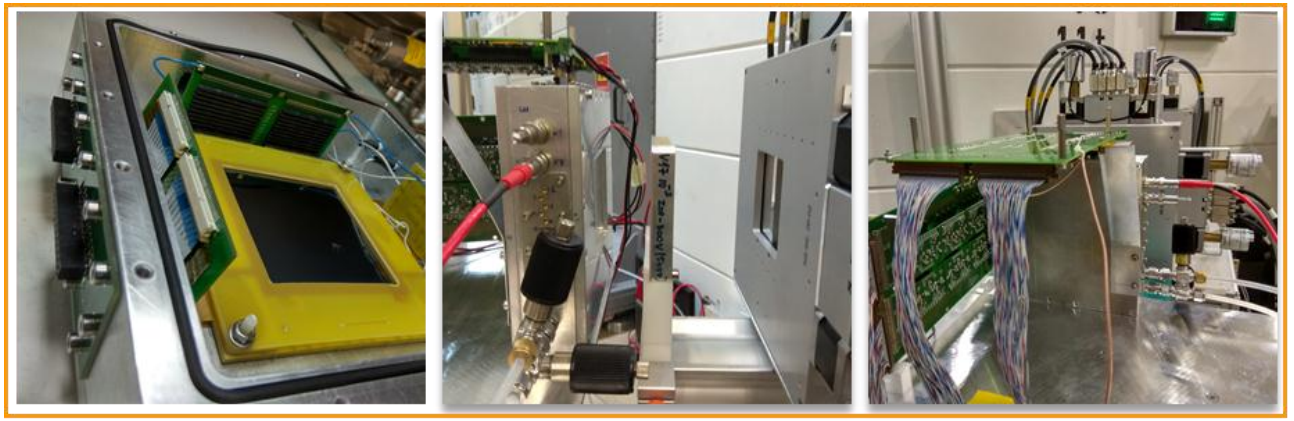
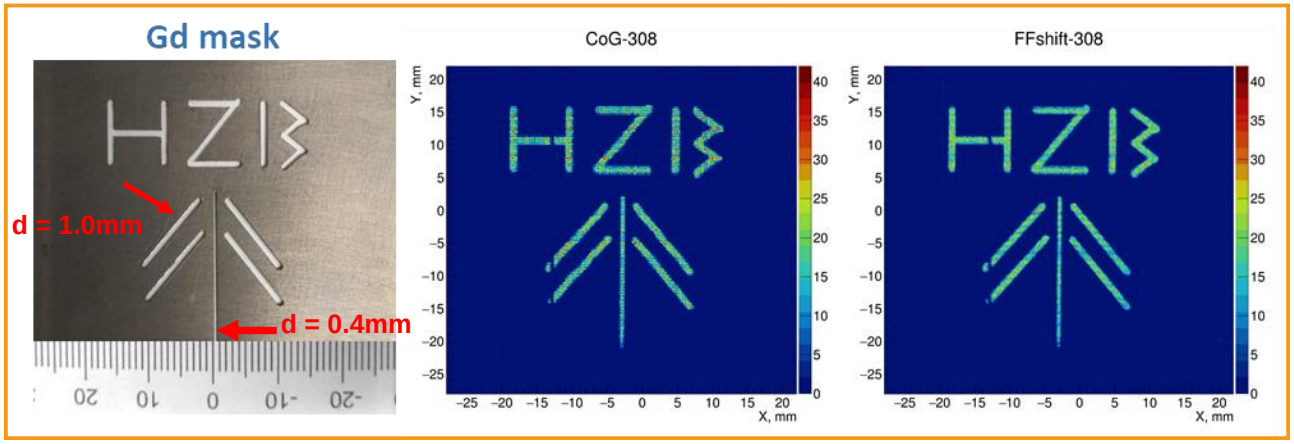
Position recognition techniques

Study of advanced position reconstruction techniques

"Standard" Centre-of-Gravity method vs. a statistical method based on a detailed model of the detector response function

Double gap RPC with 2D-readout mounted at the HZB V17 beam line





L. Margato et al.;
LIP Coimbra

CHARM project update

Two curved ^{3}He-based MWPCs covering 130° for powder diffractometers ErwiN & DMC

- *9 MWPC segments mounted seamlessly in a pressure vessel*
- *Fully modular design*
- *Individual wire / strip readout*
- *ToT-based CoG algorithm for position determination*
- *2D-position, time & energy data*
- *Gas filling: 6.5bar ^{3}He + 1.5bar CF_4*

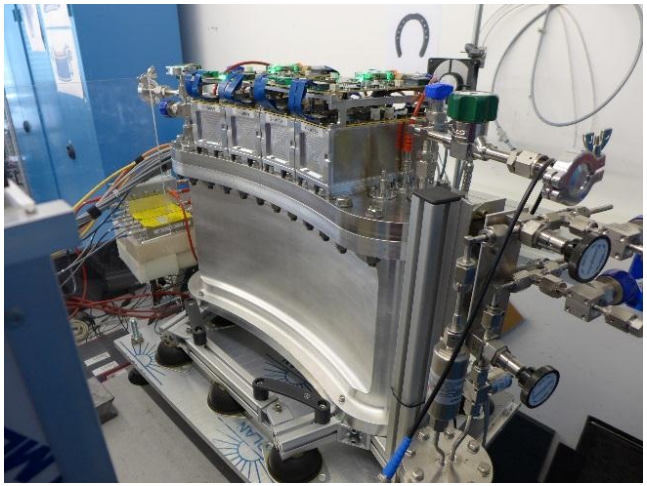
Status 30° demonstrator

- *Demonstrator built in collaboration with ILL & PSI to be installed at ErwiN as 2nd detector in 2020*
- *2 MWPC segments covering 30°*
- *Frontend & Signal processing electronics built and tested at ^{252}Cf-Lab source*
- *Development of FPGA firmware for online recognition ongoing*

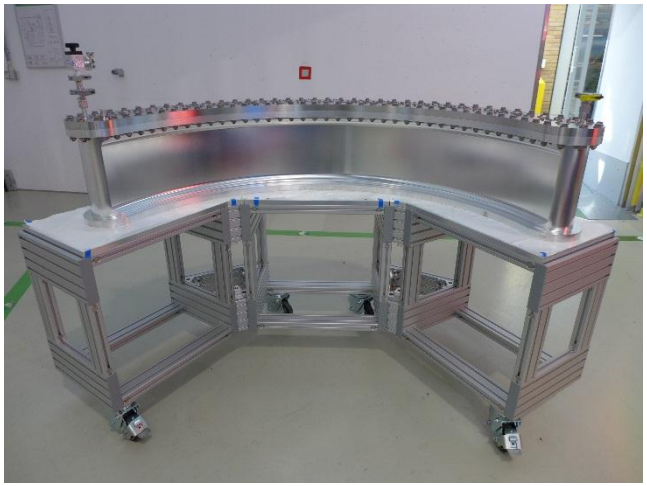
Status 130° full size detectors

- *24 MWPC segments built, #19 - #24 still to be tested*
- *Pressure vessels built and CE-certified to EN 2014/68/EU*
- *Series production of readout electronics ongoing*
- *Integration of both detectors foreseen in first half of 2020*

30° demonstrator

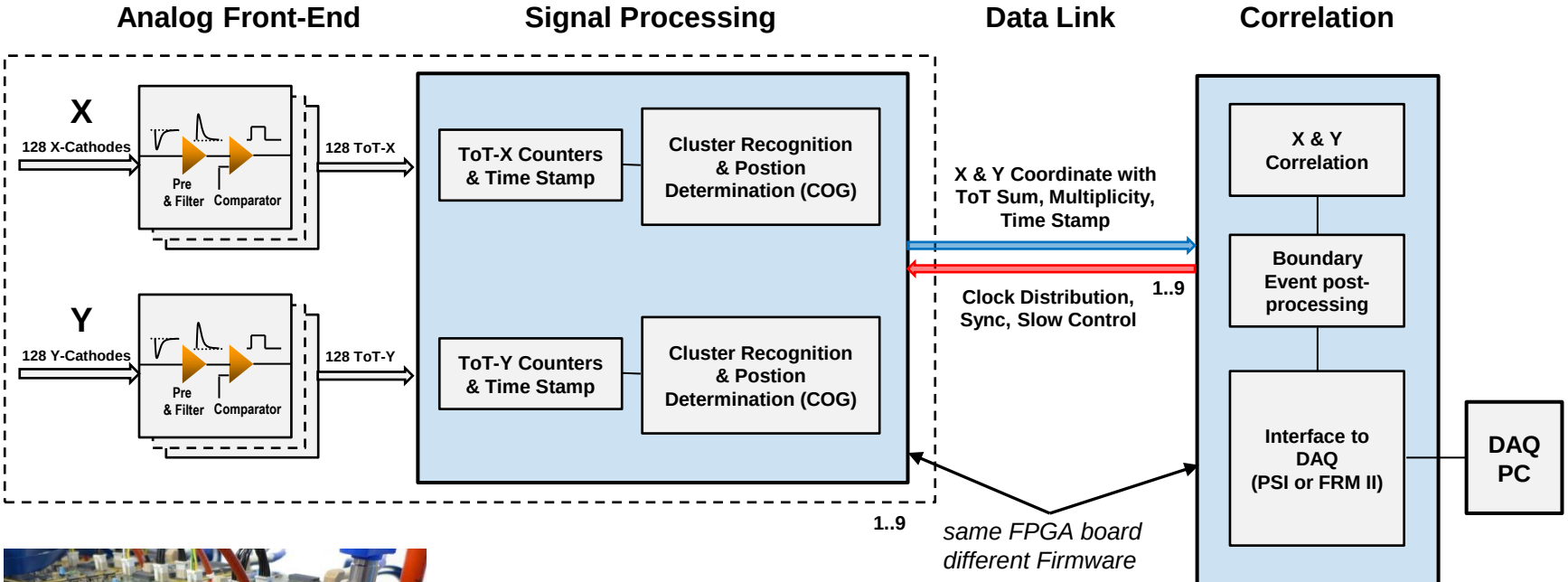


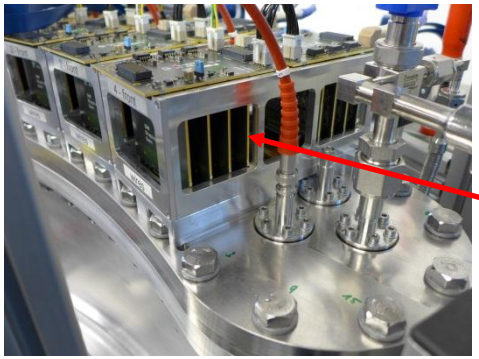
130° full size detector

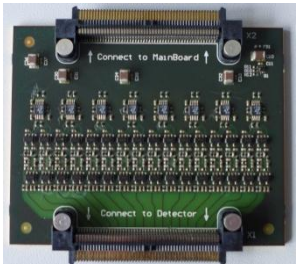


Readout Architecture

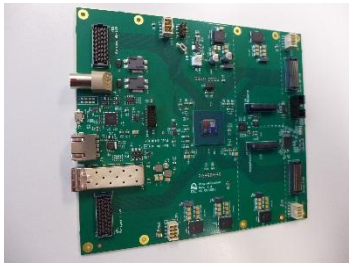
- *Individual readout of 128 (x) + 128 (y) channels per segment*
- *Position determination: Center of Gravity of ToT*
- *LIST mode: Position, Time Stamp, Energy (ToT Sum)*



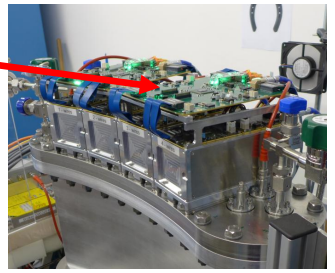




16 chs Preamp with ToT



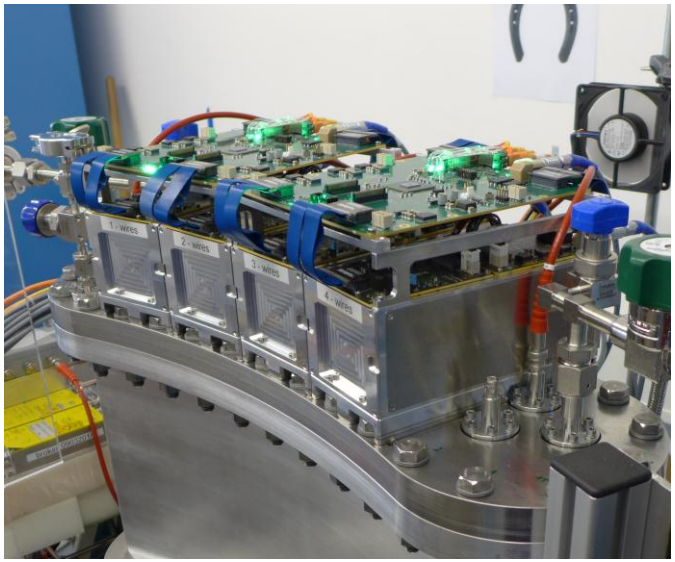
Signal processing board



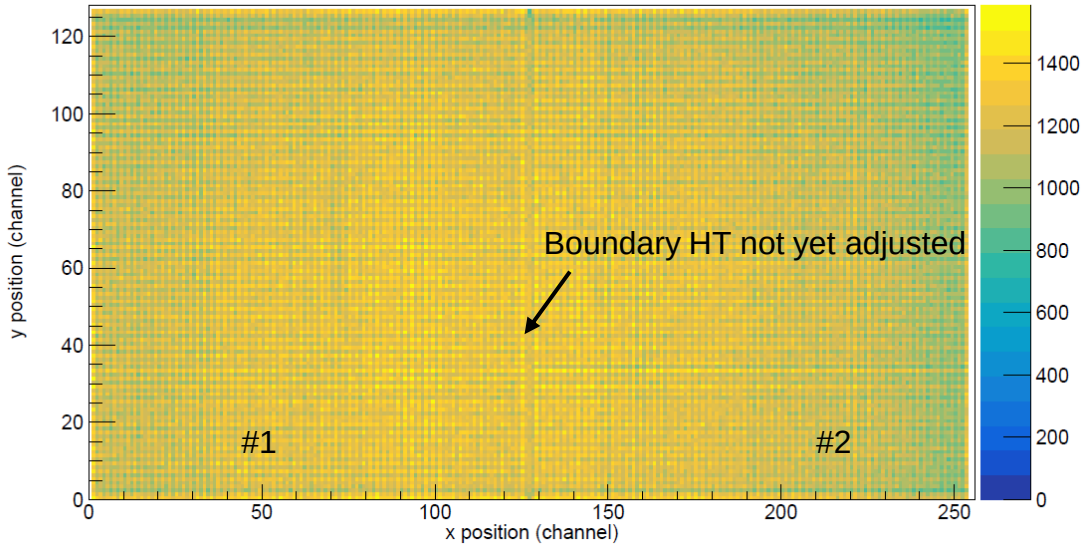
Readout test at ^{252}Cf source

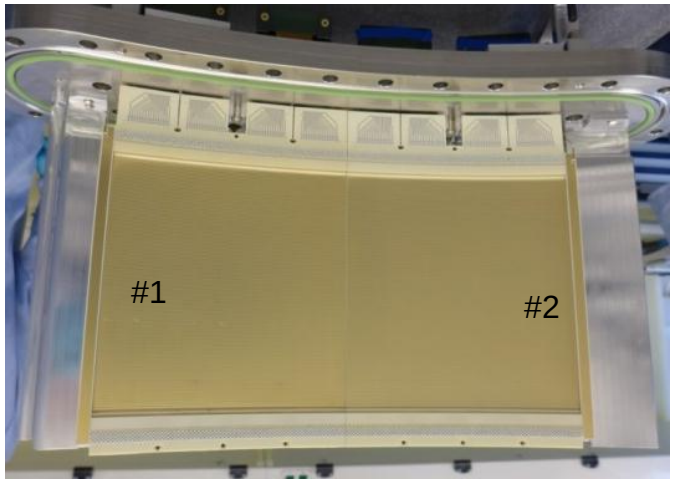
30° demonstrator mounted at ^{252}Cf Lab-source

- *No reactor operation at FRM II since March 2019 !*
- *Functionality test of FE- & signal processing boards*
- *First tests with final readout architecture*
- *Study of homogeneity*
- *Development of FPGA firmware for online recognition*
- *Study of long term stability (gas gain & purity) with "Helicoflex" metal seal*



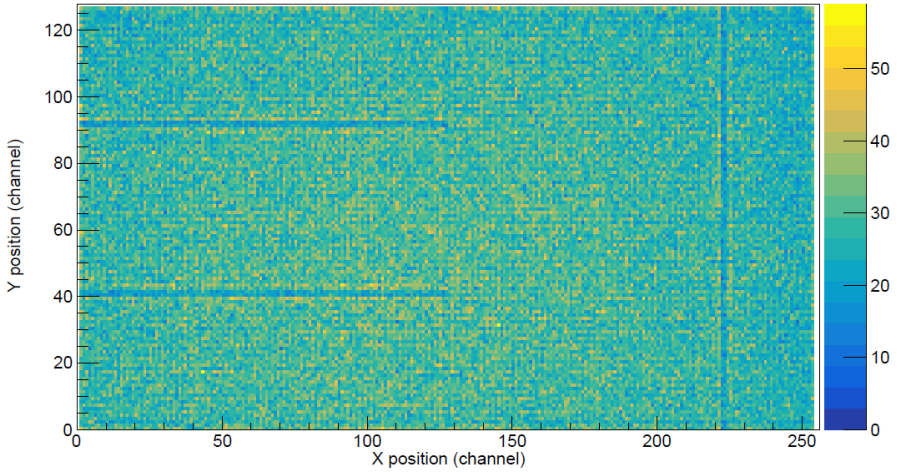
2D-position histogram for homogenous illumination with thermal neutrons



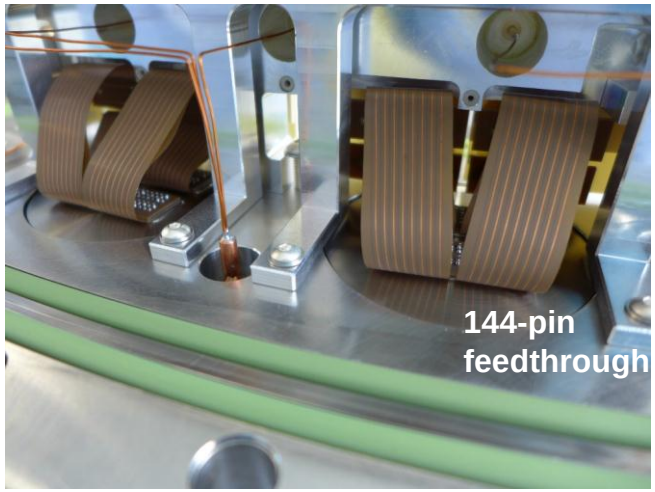


Real life I

After more than 1 year of operation



- *Increasing number of failing readout channels due to shorts ($\rho \approx 100\Omega$ -1 kΩ) at 144-pin feedthrough*



144-pin Electrical Feedthrough

- *144pin-feedthrough for high pressure (VACOM)*

  pin diameter 0,5mm;
  Material: NiFe-alloy Au-plated

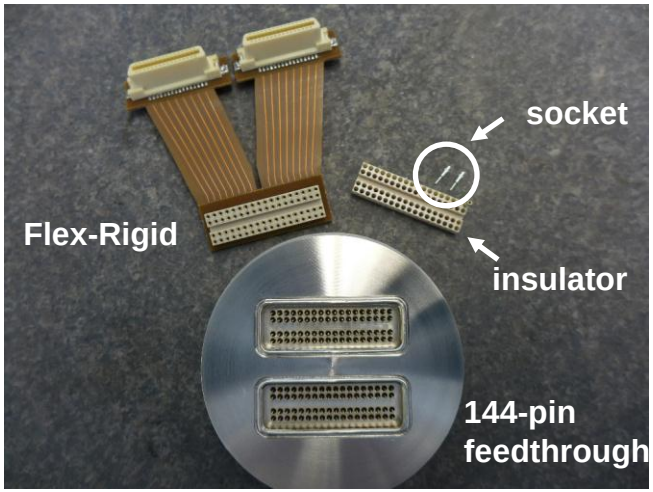
- *Inside Flex-Rigid Connector:*

  Insulator PEEK,

  socket-type Fischer Elektronik BYL1K
  Material: Body: CuZn-alloy Ni+4-6µ Sn-plating;
  Spring: CuBe-alloy Ni+ 0,25µ Au plating

- *Pins on Ground potential; Max. current: 100nA*

144-pin feedthrough & Flex-Rigid connector

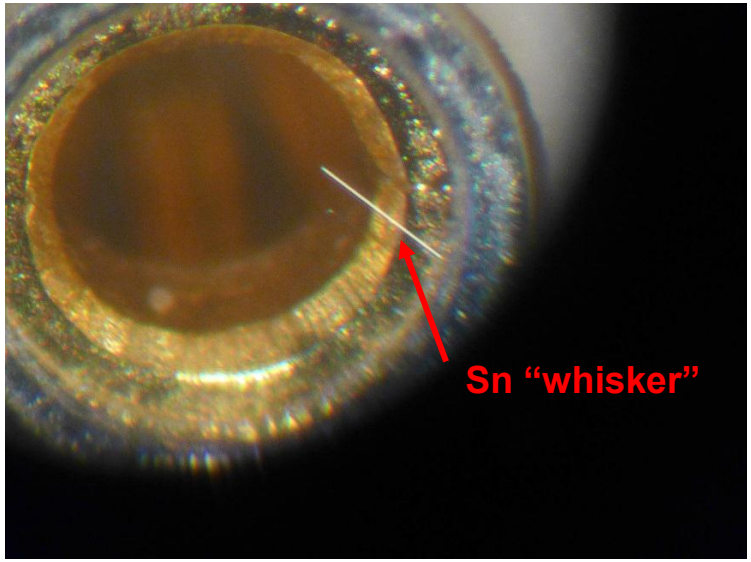


Real life II

Cause of failure

- *Growth of Sn-whiskers of several mm of length inside the Fischer Elektronik socket, which occasionally touch the stainless steel flange of the 144-pin feedthrough*

Views of sockets under a microscope



⇨ ***Old socket type has been replaced by a fully Au-plated version***

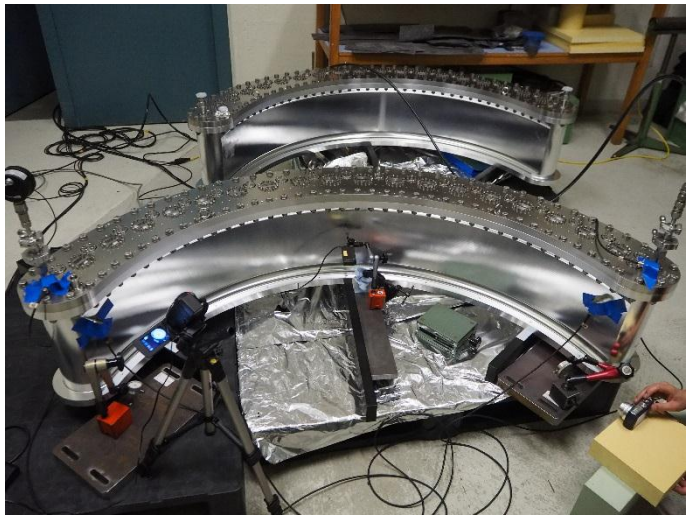
Status update full size detectors

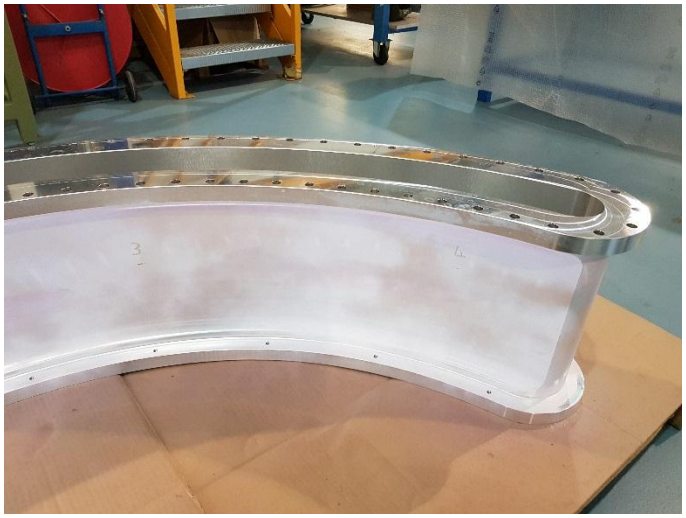
Pressure vessel production

- *Pressure vessels produced by ALCA Technology (I)*
  - *Top hat flange: Stainless steel 1.4404*
  - *Vessel: Aluminium 5083 forged by Imbach & CIE (CH)*

Procedures for Certification acc. EN 2014/68/EU

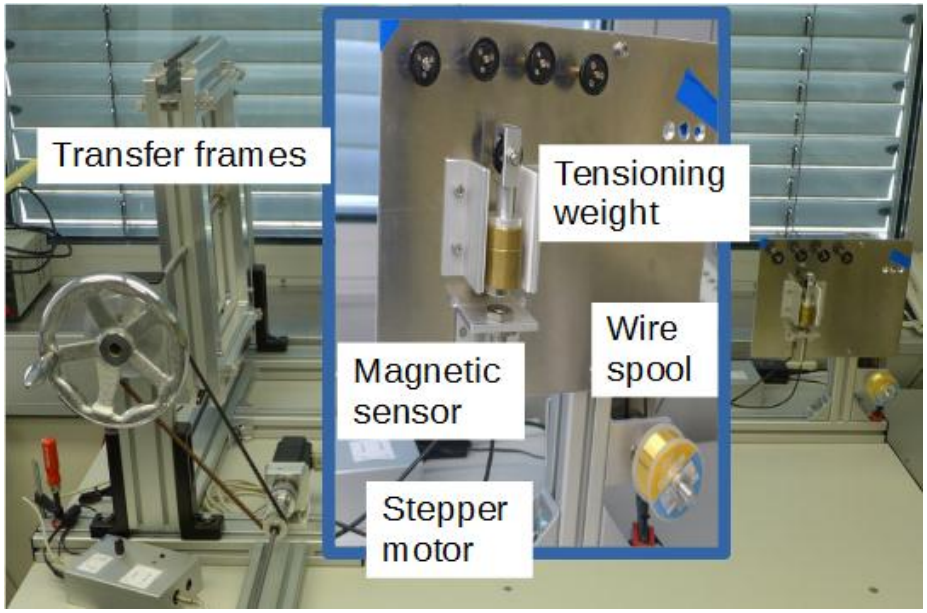
- *Ultrasonic test of forged Al-5083 ring*
- *Production of standard samples and performance of tensile and hardness tests to confirm material parameters*
- *Dye test of vessel after production at ALCA*
- *He-leak vacuum test*
- *Pressure test at 7.7bar diff. pressure in bunker at PSI*

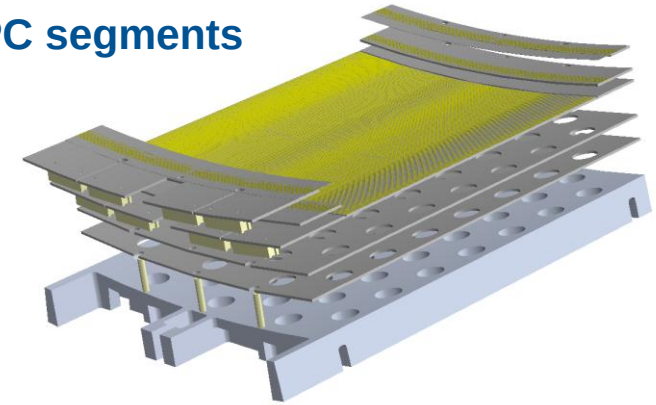




Status update full size detectors

Production of 24 MWPC segments



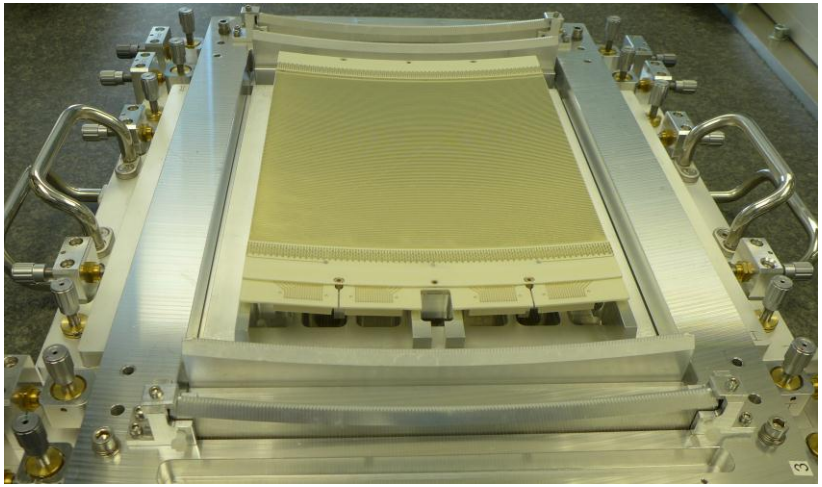


Soldering station

- *Wire grids aligned using microscope*
- *Position controlled using precision screws (250 µm per revolution)*

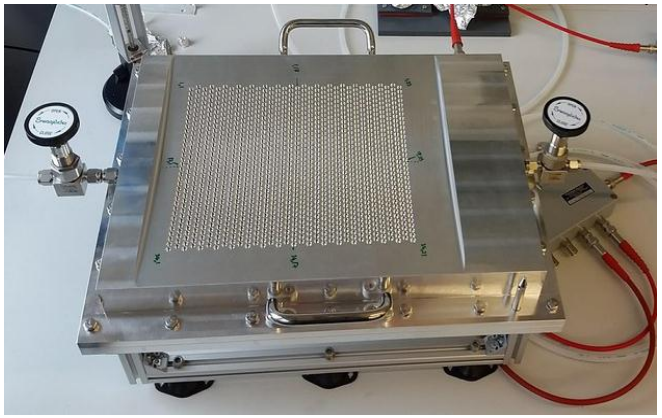
Automated wire tensioning

- *50 µm cathode wires at 100 g*
- *15 µm anode wires at 35 g*
- *Wires wound with proper relative positioning using combs*
- *Winding two frames takes ~6 hours*



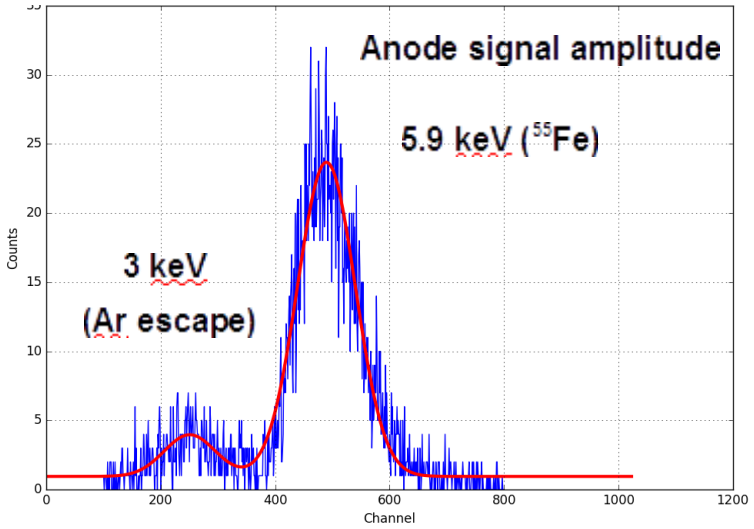
Status update full size detectors

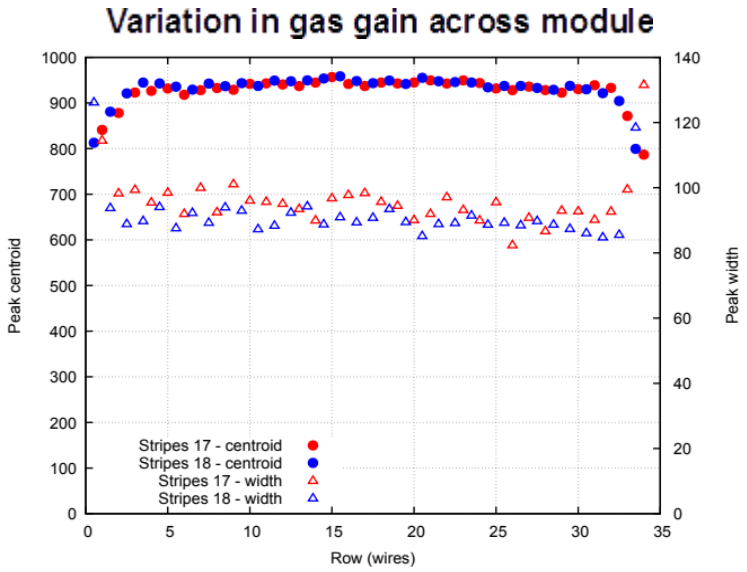
X-ray test of segments



Scan of gas gain

- *Ar CO_2 (80:20) flowed through vessel*
- *^{55}Fe source moved over surface*
- *Anode spectrum measured at each point*
- *Sensitive to gain changes due to wire-tension variations or misalignment*





24 MWPC segments completed; already 18 tested successfully

Conclusion

RPC with solid $^{10}B_4C$ converter:

- Single gap-RPC with various anode substrate materials tested at V17 beam line at HZ Berlin
- Low resistivity glass and ceramics show improved count rate capability allowing for up to 30 kHz/cm^2
- Double gap RPC with standard glass used for study of advanced recognition techniques aiming at improved spatial resolution.

Update on CHARM project:

30°- prototype

- 30°- prototype built and problems with Flex-Rigid connectors solved
- FE- and Signal processing boards built and tests performed at ^{252}Cf source
- Development of FPGA firmware for online recognition ongoing
- Implementation at ErwiN under construction

130°- full size detectors

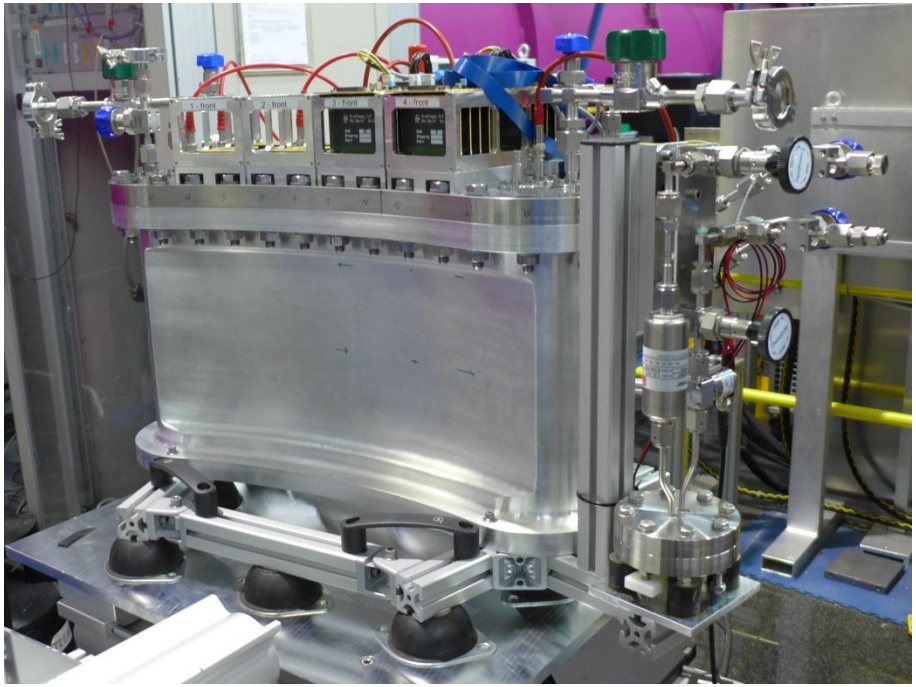
- Pressure vessels of 130°-detectors built and CE certified acc. EN 2014/68/EU
- 24 MWPC module built, 6 still to be tested
- Series production of FE-readout electronics started
- Tooling for assembly in clean room under construction

Update on FRM II Detector Group Activities

^{3}Helium based detectors:

- **2-D curved MWPC for powder diffraction instruments ERWIN & DMC**

First results of a 30° prototype built in collaboration with ILL and PSI

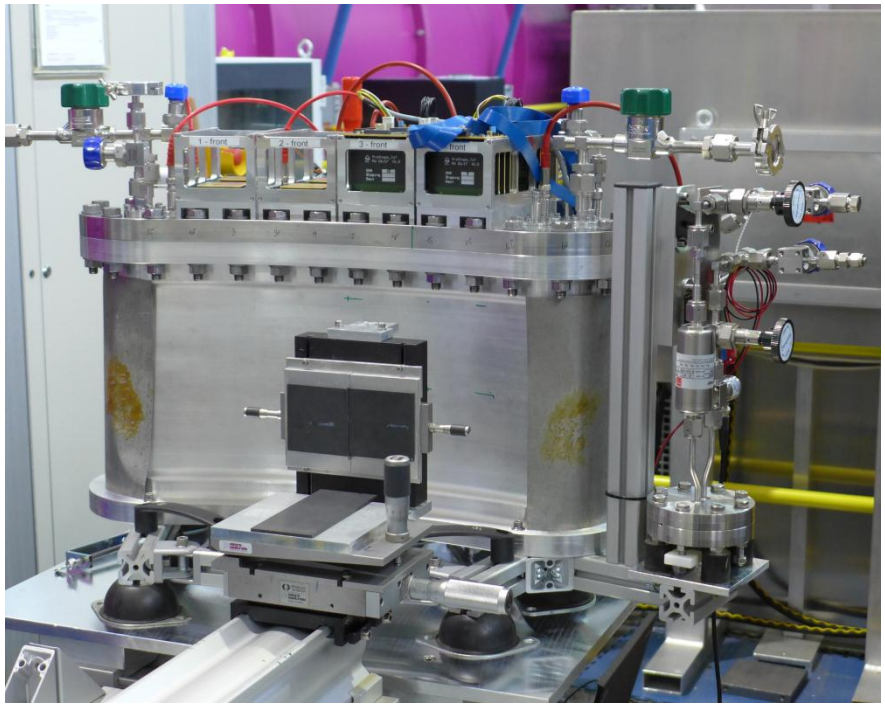


Results presented in PSND2018

OW-04: I. Defendi:
"CHARM - A Prototype of a fast, high resolution curved ^{3}He-based Multiwire - Proportional Chamber for the powder diffractometers DMC and ERWIN"

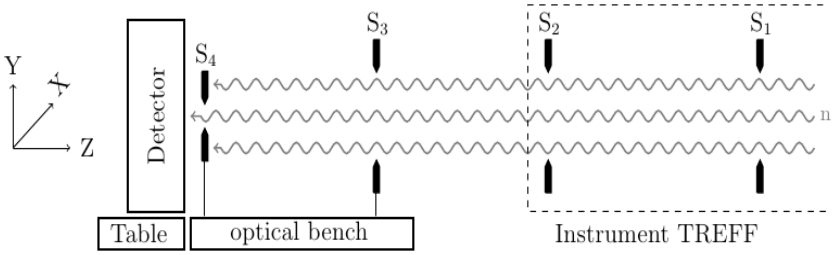
PT-10: A. Howard:
"Semi - automated wire winding, precise positioning and wire-tension control for a high-resolution curved Multiwire - Proportional Chamber"

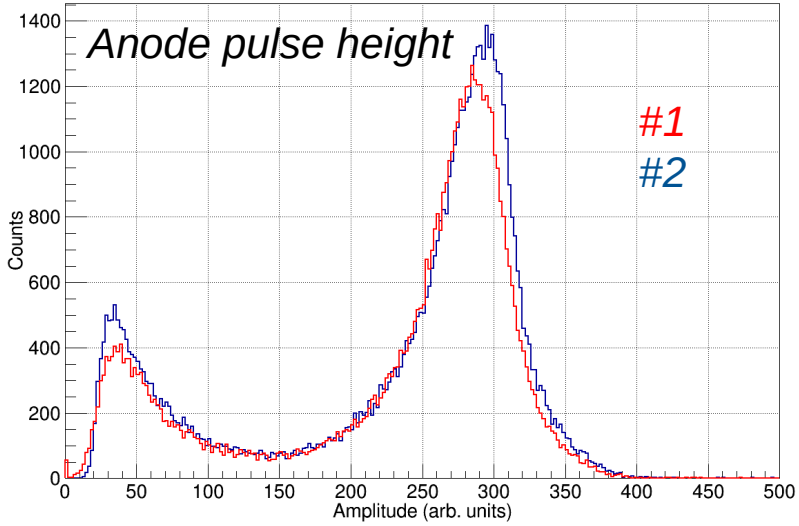
30° Prototype (2 MWPC segments)



Prototype @ TREFF

Collimated beam of λ = 4.73 A neutrons

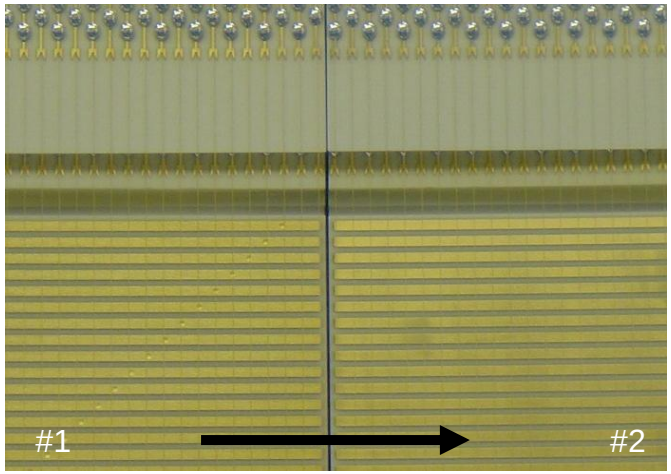




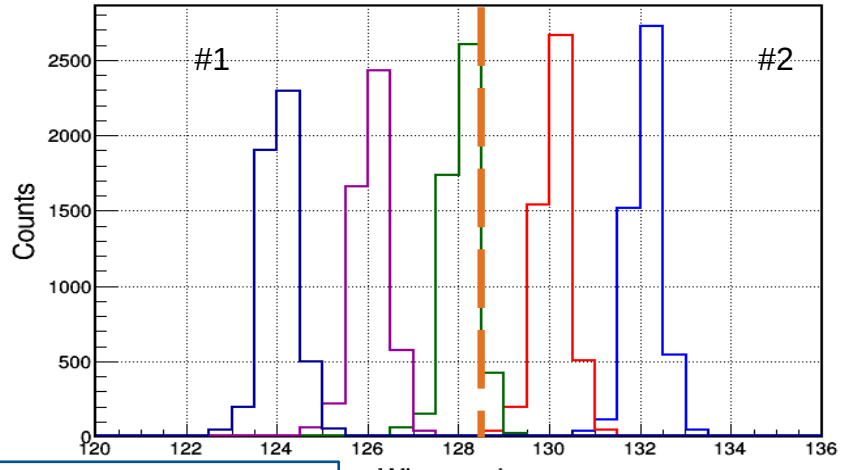
- Gas filling:
  p =1bar ^{3}He + 5bar ^{4}He + 1,5bar CF_4
- *MWPC operated at gain G ~100*
  U_a = 2100 V, U_{drift} = -1000V

30° Prototype (2 MWPC segments)

Horizontal scan across two segments

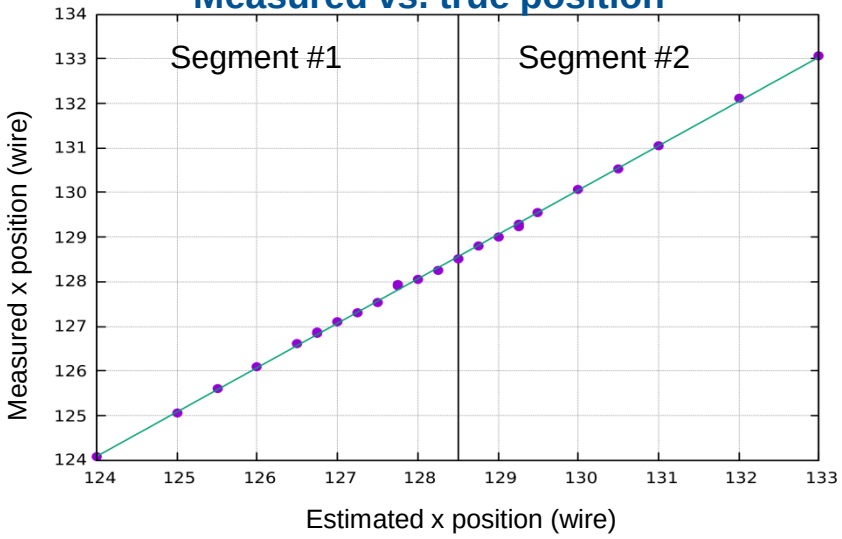


Position spectra for five positions

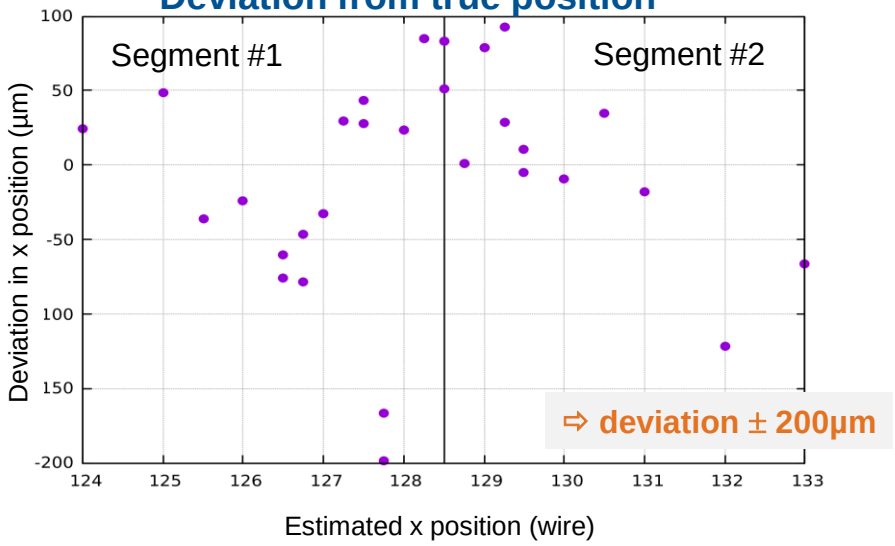


1 bin = ½ channel = 0.8 mm

Measured vs. true position



Deviation from true position



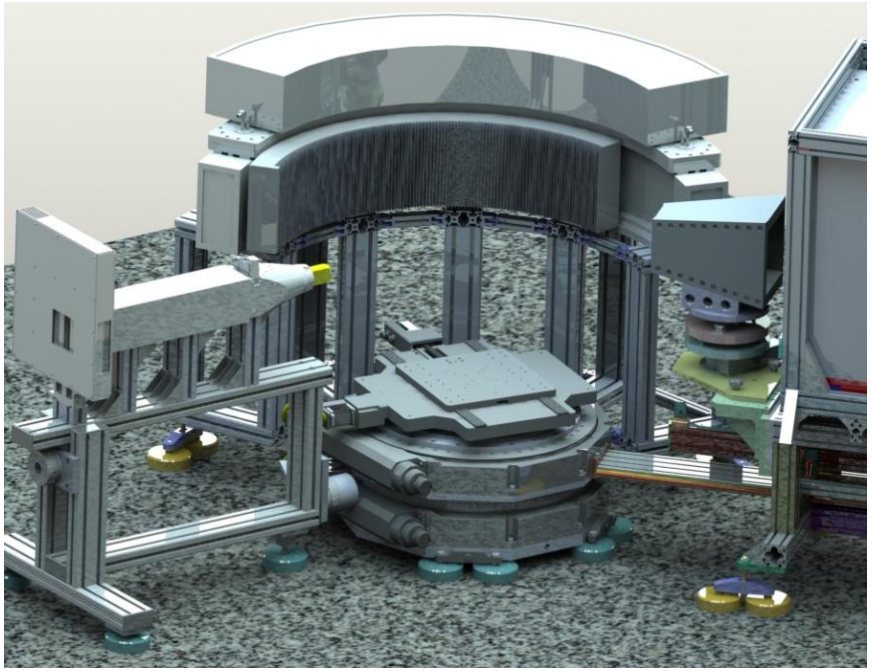
⇨ deviation ± 200µm

CHARM project update

Curved ^{3}He-based MWPC covering 130°

- *9 MWPC segments mounted seamlessly in a pressure vessel*
- *Fully modular design*
- *Individual wire / strip readout*
- *ToT-based CoG algorithm for position determination*
- *2D-position, time & energy data*

Angular coverage	≥ 130° (curved)
Aperture vertical	≥ 14° (200 mm)
Radius (anode)	800 mm
Wire Pitch & Gap	1,6 mm
Resolution horizontal	0,115°
Strip Pitch & Gap	1,6 mm
Resolution vertical	0,115°
Gas Mixture	6.5 bar ^{3}He+ 1.5 bar CF_4
Gas Volume	200 bar * liter
Gas Depth	16,5 mm
Efficiency	75 % @ 1,8A
Nominal Gas Gain	~100
Counting rate	50 kHz / wire, 200 kHz / segment
Weight	290 kg



ERWIN: A new powder diffractometer @ FRM II

- *MWPC design closely derived from BNL-design [1]*
- *30°- demonstrator built in collaboration with ILL & PSI to be installed at ErwiN as 2nd detector*
- *Two full size detectors under construction: ERWIN @ FRM-II, DMC @ PSI*

[1] B. Yu et al. / Nuclear Instruments and Methods in Physics Research A 485 (2002) 645–652

30° Prototype