Decay-Pion Spectroscopy of Λ-Hypernuclei at MAMI 2014

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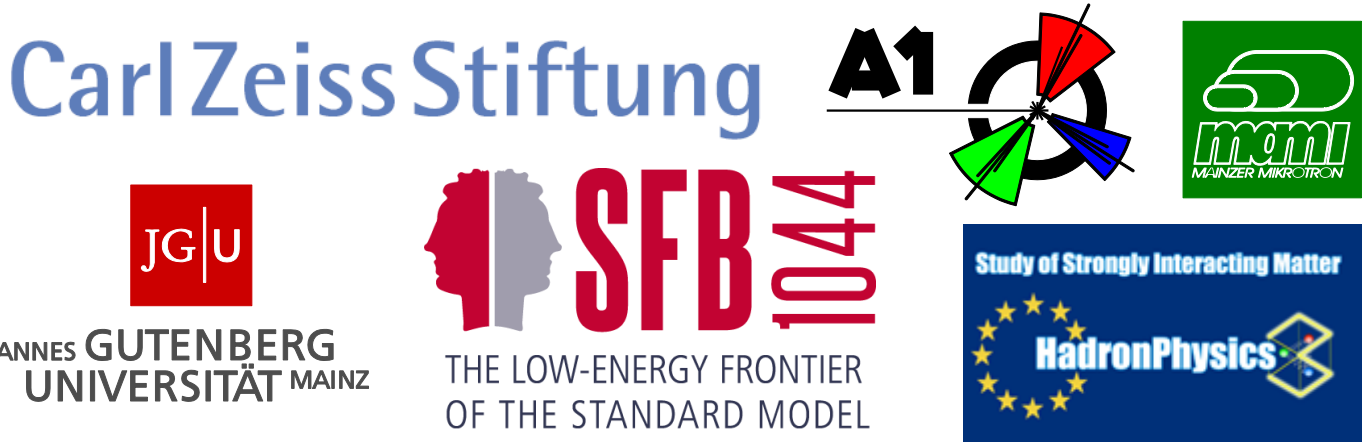
for the A1 Collaboration at MAMI



Outline

- 2014 beam time
- Absolute momentum calibration

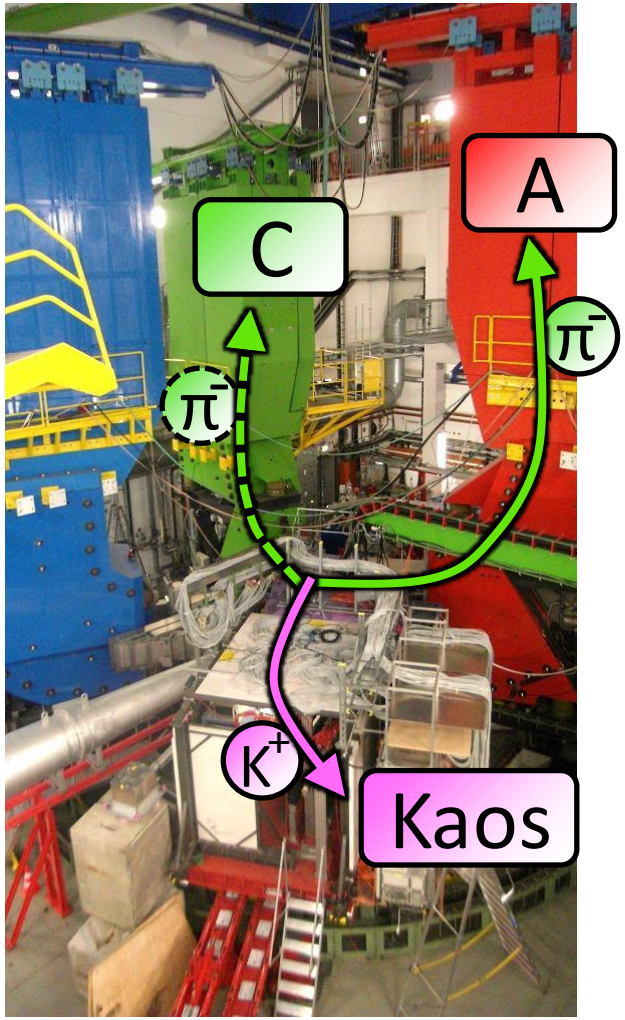
2014 beam time

Decay-pion spectroscopy of Λ-hypernuclei in 2014

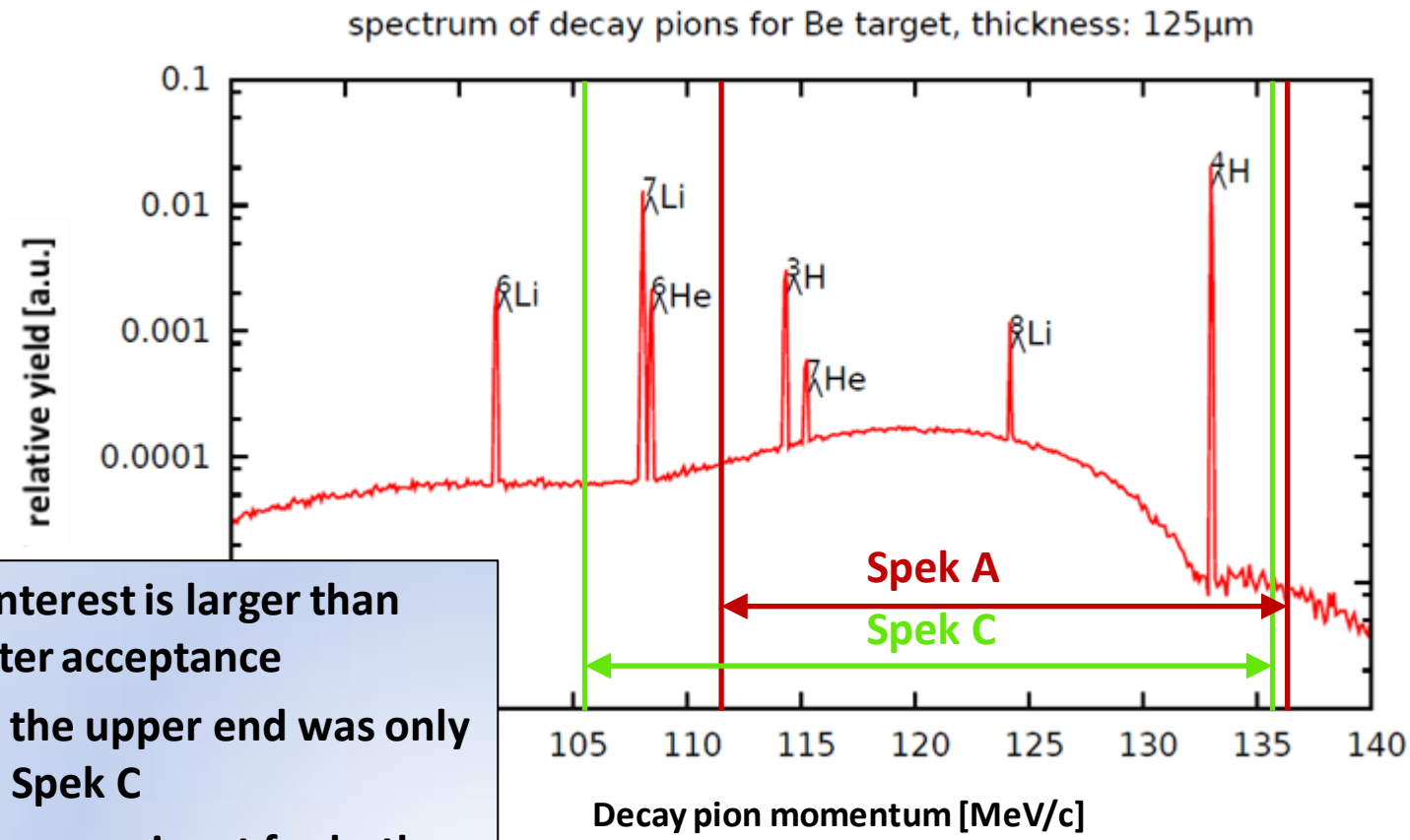
Coincident measurement of Spek A & Kaos and Spek C & Kaos

- Target : ^{9}Be, 22 (44) mg/cm^2
- Beam energy : 1.508 GeV
- Beam current : 20 - 50 µA

- Spectrometers : Kaos with A || C
- Kaos angle : 0°
- Spek A angle : 93.5°
- Spek C angle : 126°



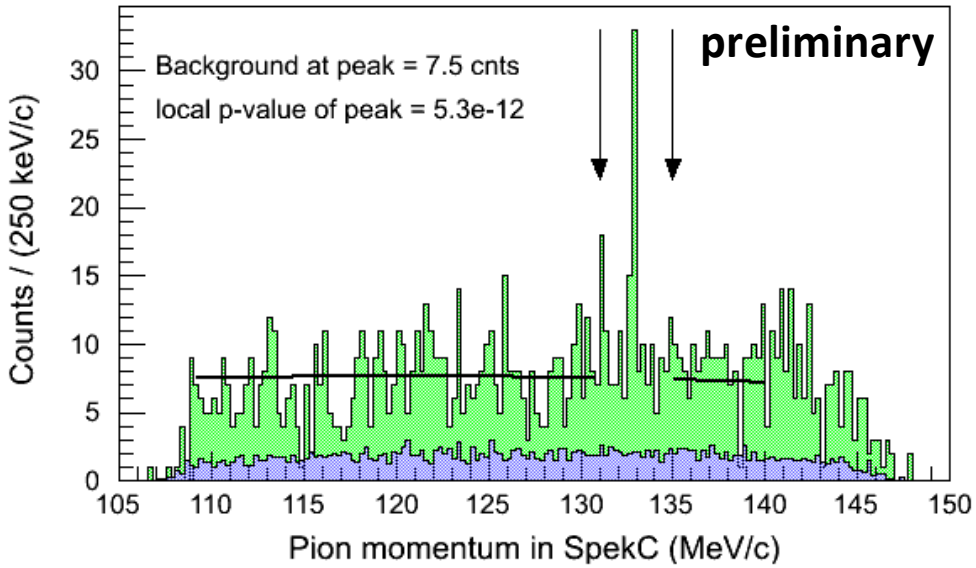
A / C Momentum Acceptance



- **Region of interest is larger than spectrometer acceptance**
- **$^{4}_{\Lambda}$H lying on the upper end was only covered by Spek C**

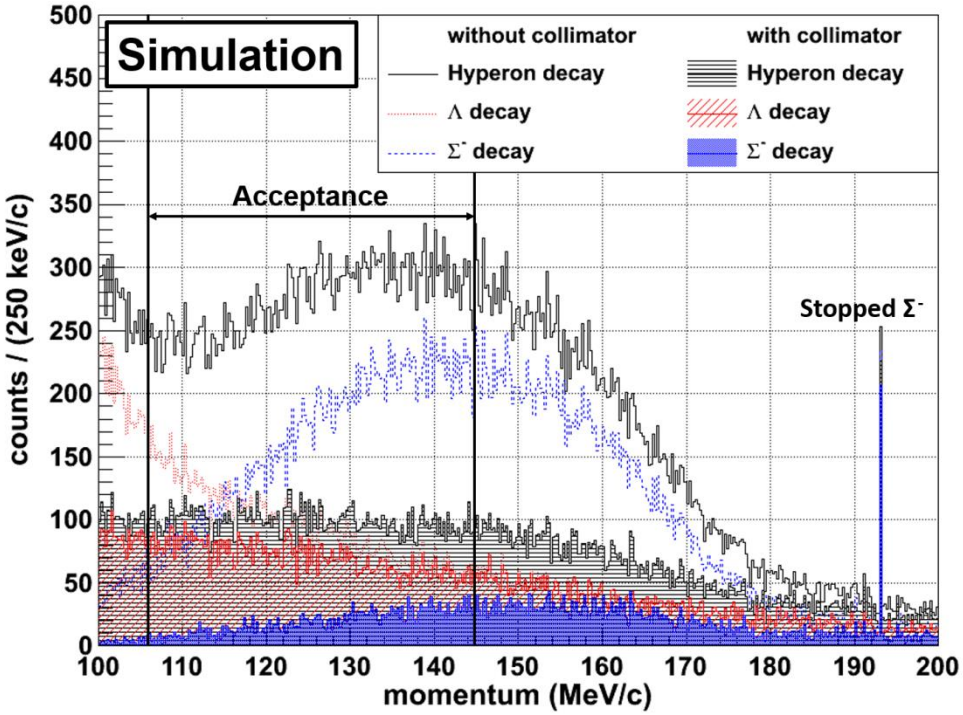
➢ **Momentum range is set for both spectrometers to cover $^{4}_{\Lambda}$H**

Pion Background



- **Most background from decay of coincident quasi-free Λ and Σ^-**
- **Quasi-free hyperons easily escape the target**
- **A collimator can block pions from the region behind the target**

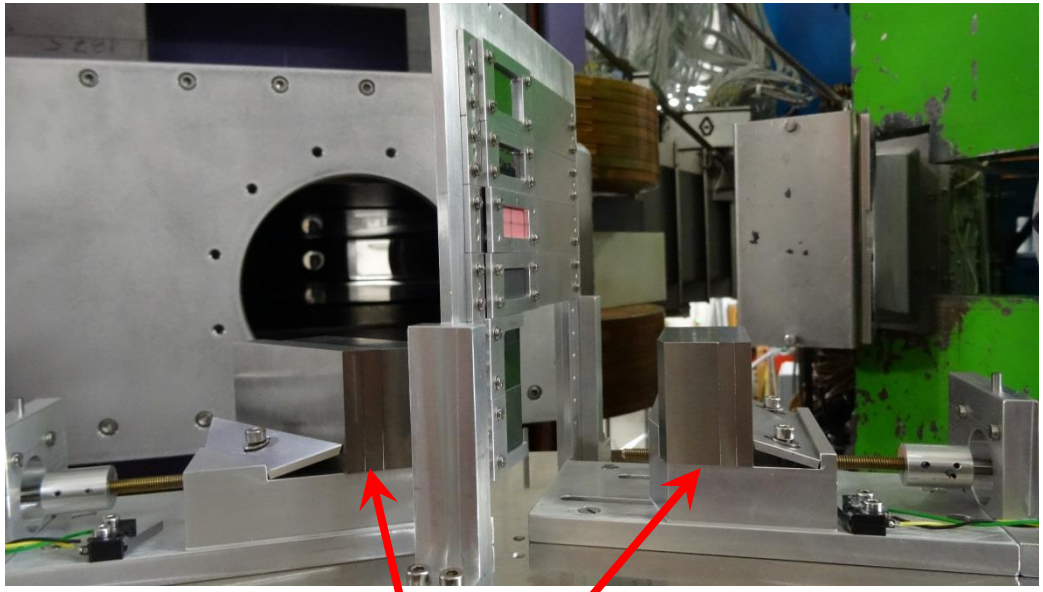
Pion Background



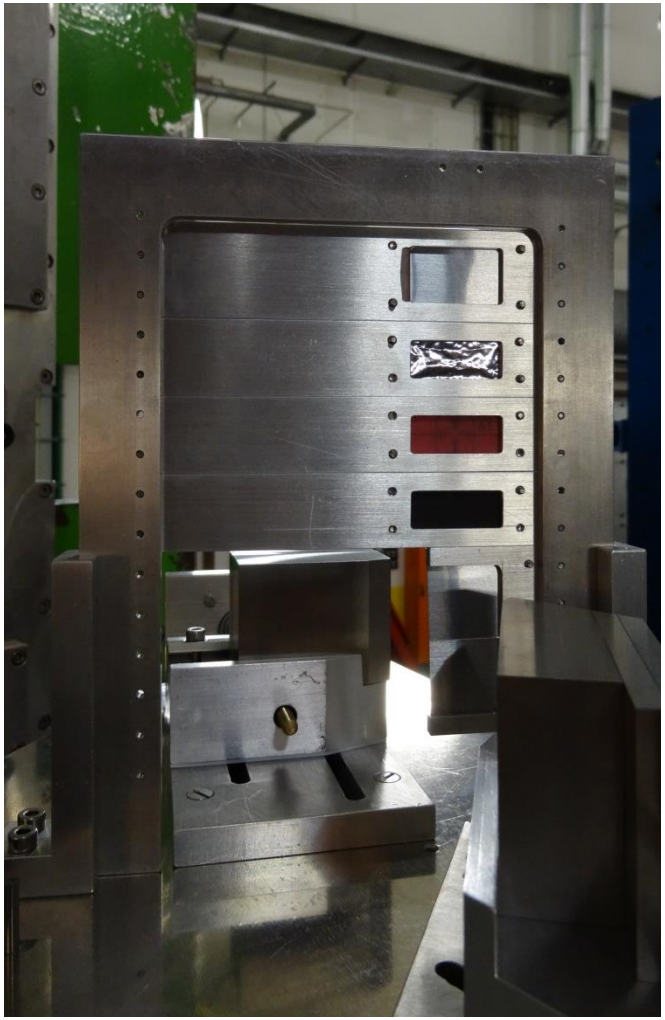
- **Most background from decay of coincident quasi-free Λ and Σ^-**
- **Quasi-free hyperons easily escape the target**
- **A collimator can block pions from the region behind the target**

➢ **According to simulation this can reduce the background by more than a factor of 2**

Absorber at Target



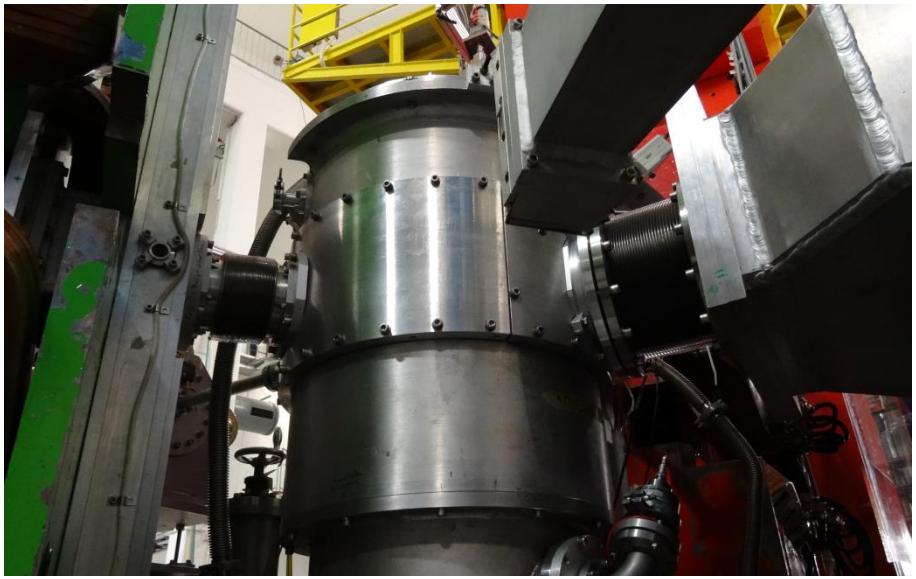
- **2 Tungsten absorber**
- **Remote controllable**



Decay-Pion Momentum Straggling

- **Pions scatter and lose energy statistically when passing trough material**
- **Replaced all kapton windows with direct bellows connections to the spectrometer**

➢ **This reduces material budget, mean energy loss and momentum straggling by a factor of 2**



Further Improvements

Spectrometer magnetic fields

- **Field stabilization of Spek C could go out of control range**

➢ **Automatic NMR measurements every 5 minutes for all spectrometers**

Kaos Cherenkov detectors

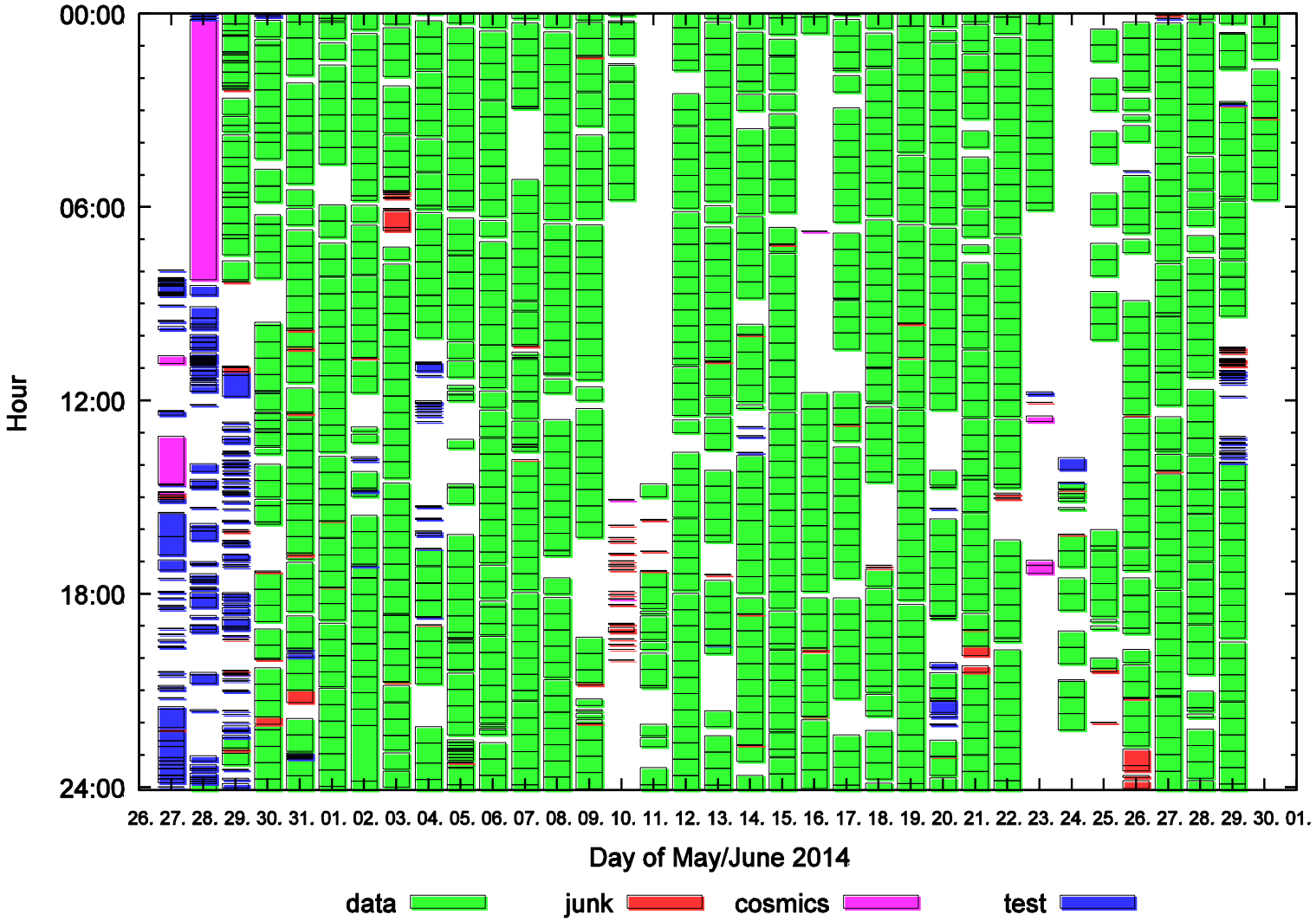
- **Cherenkov detector close to the dipol magnet suffered from fringe field**

➢ **Bucking coils compensating the fringe field**

- **No Cherenkov TDC information, ADC problematic**

➢ **New ADC and TDC**

Beam Time Overview

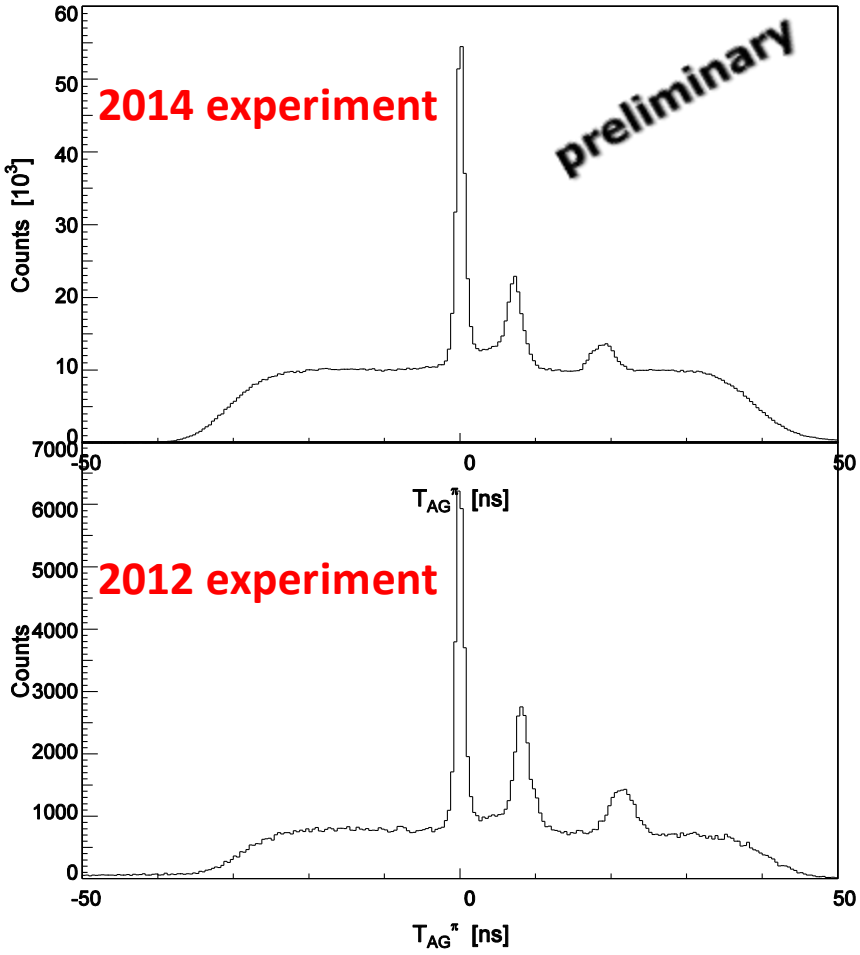


Collected Data

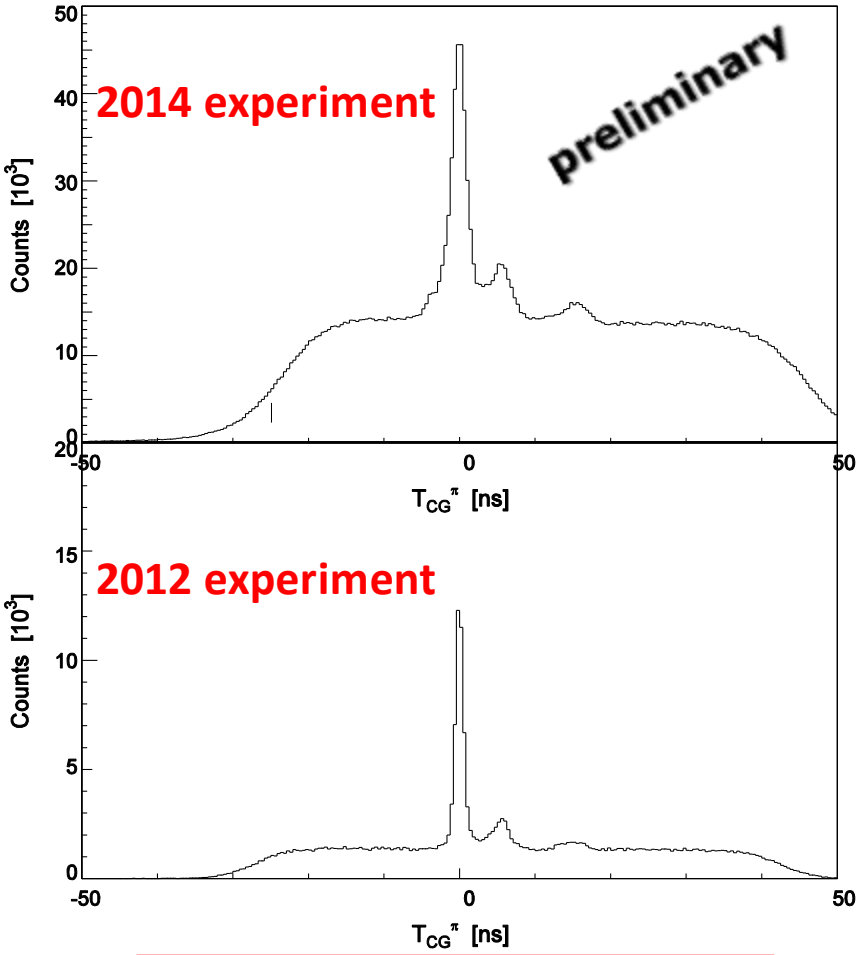
Setting	Runs	Events	$\int L \cdot dt$ [fb^{-1}]	$\int L_{cor} \cdot dt$ [fb^{-1}]	$\bar{I}$ [μ A]	$\int I_{cor} \cdot dt$ [mC]	dead time	run time
Be9_125_20uA	24	1M 656k	11	10	19.9	584	12.3 %	9h 18' 59"
Be9_125_20uA+0	12	312k	2	2	19.7	124	11.1 %	1h 58' 19"
Be9_125_20uA+2	15	655k	6	5	20.0	309	12.5 %	4h 55' 32"
Be9_125_25uA	2	156k	0.8	0.7	25.0	40	19.3 %	0h 33' 05"
Be9_125_30uA	5	597k	3	2	29.8	121	23.9 %	1h 29' 02"
Be9_125_35uA	77	9M 506k	71	60	34.3	3634	15.8 %	34h 56' 54"
Be9_125_40uA	45	7M 577k	50	39	38.4	2399	20.7 %	21h 54' 25"
Be9_125_40uA-2	194	25M 173k	396	325	38.2	9927	17.8 %	87h 52' 03"
Be9_125_50uA	586	131M 278k	747	514	47.3	31357	31.2 %	267h 32' 30"
Sum_125	960	176M 911k	1287	958		48495		430h 30' 48"
Be9_250_25uA	142	64M 637k	198	102	24.1	3101	48.6 %	69h 39' 06"
Be9_250_30uA	58	32M 320k	84	33	27.0	1018	60.5 %	26h 25' 16"
Be9_250_35uA	36	16M 405k	64	32	30.0	968	50.2 %	17h 58' 48"
Be9_250_40uA	4	1M 620k	4	1	32.1	41	70.2 %	1h 11' 52"
Sum_250	240	114M 982k	351	168		5128		115h 15' 02"
Total 2014	1200	291M 894k	1638	1127		53623		545h 45' 50"
Total 2012	553	98M 173k	285	235		15054		248h 45' 04"

4.8 the statistics of 2012

Coincidence Time Spectra



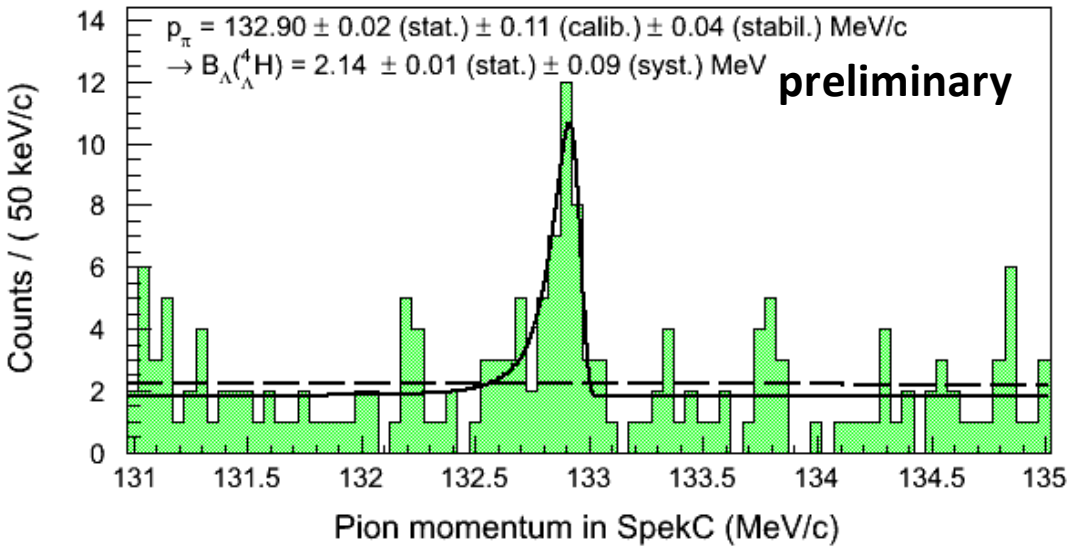
Spek A: 7.2 times higher signal



Spek C: 5.5 times higher signal

Absolut momentum calibration A / C

Systematic Error Evaluation



calibration errors:
- uncertainty on beam energy (dominant)
- uncertainty on beam position
- uncertainty on spectrometer angle
- uncertainty on energy loss

stability error:
- magnetic field stability (sub-dominant)

scale error:
- momentum acceptance linearity

Elastic Scattering

For calibration it is desirable to probe the spectrometer in experimental condition with particles of known energy (momentum)

- **Elastic electron scattering, expected energy of the scattered electron:**

$$E' = \frac{E}{1 + (2E/M)\sin^2(\theta/2)}$$

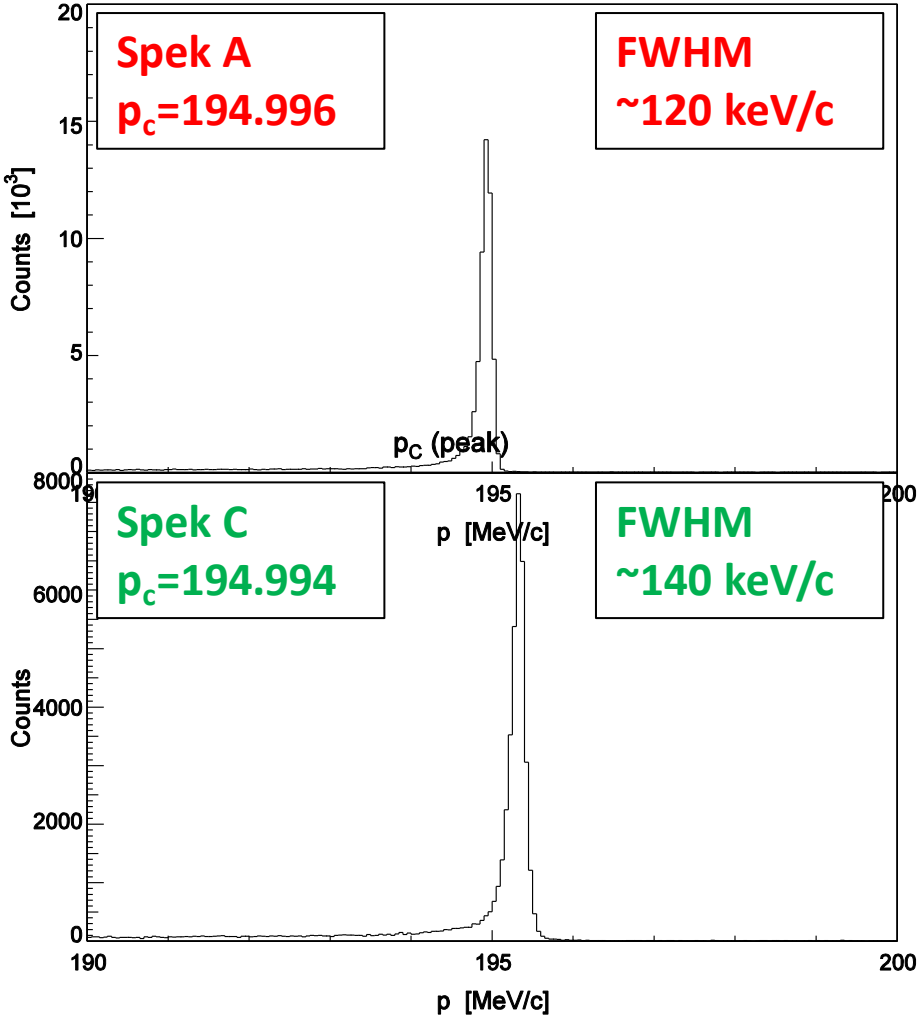
E: electron energy (MAMI measurement)

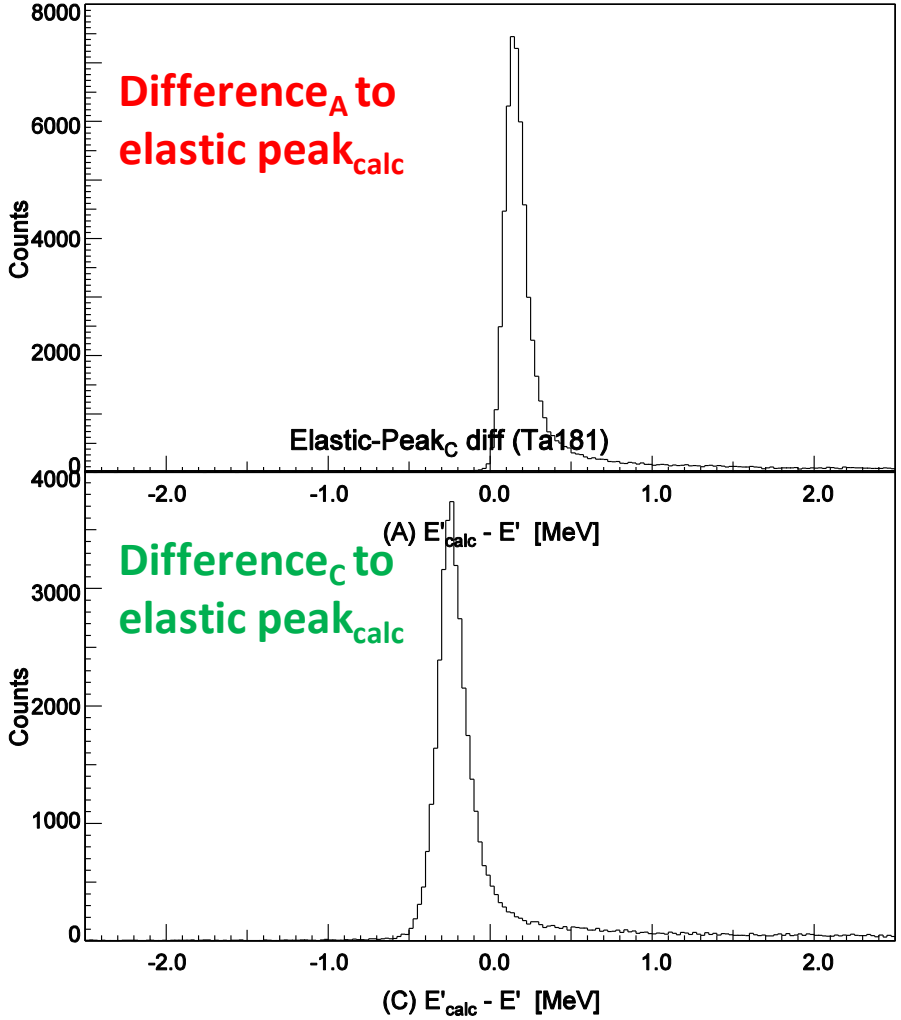
M: mass of target nuclei (^{181}Ta)

θ: angle of scattered electron

January 2014 calibration beam time

Target: ^{181}Tantalum
Beam energy: 195.17 MeV ± 160 keV
Spectrometer angle: 52°





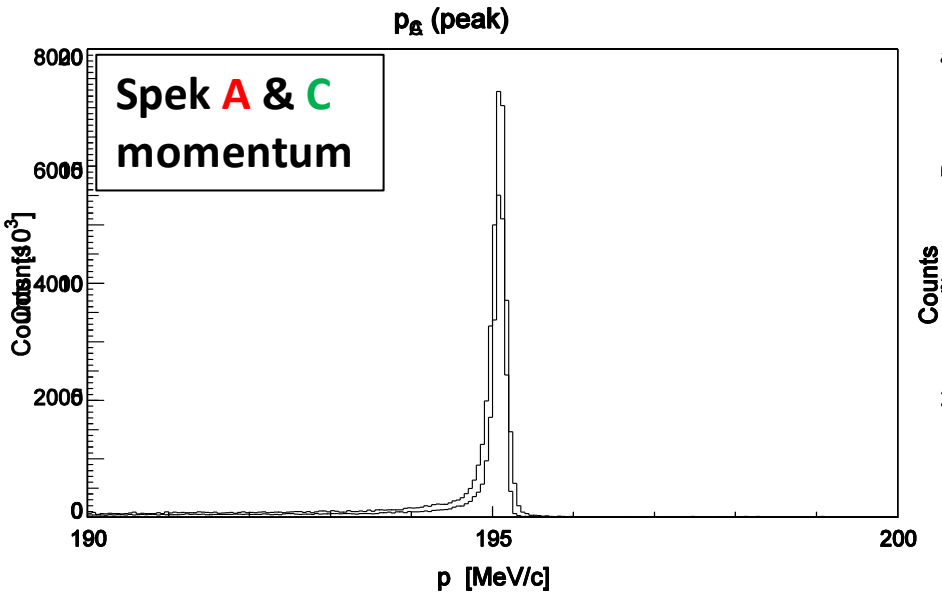
Correction for Spek A

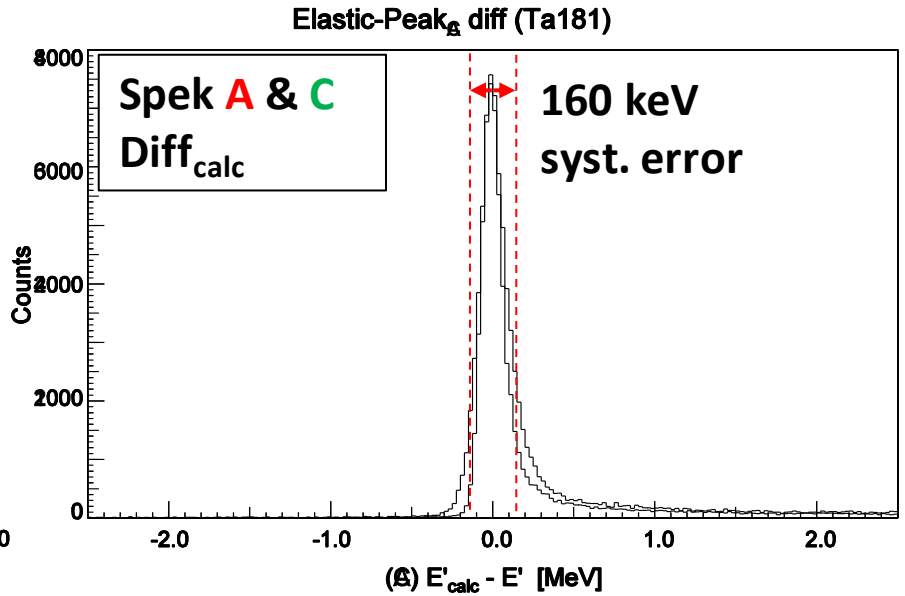
$p_0^{corr} = p_0 + 0.00080 * p_0 = 1.00080 * p_0$

Correction for Spek C

$p_0^{corr} = p_0 - 0.00125 * p_0 = 0.99875 * p_0$

Target: ^{181}**Tantalum**
Beam energy: 195.17 MeV ± 160 keV
Spectrometer angle: 52°





Thank you for your attention

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