The Spectrometer and Target Systems for Hypernuclear Physics at MAMI

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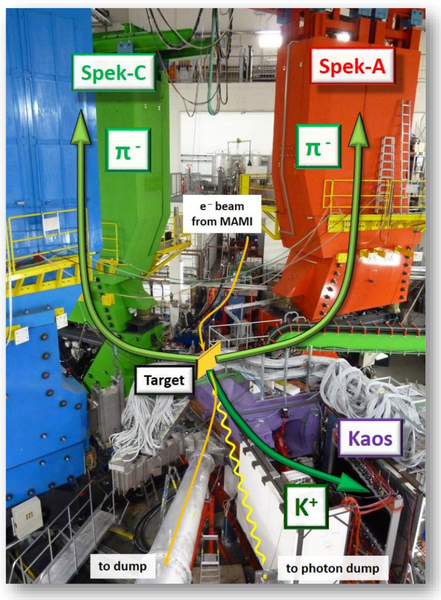
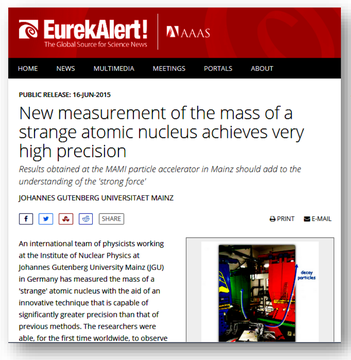
Decay-Pion Spectroscopy at MAMI

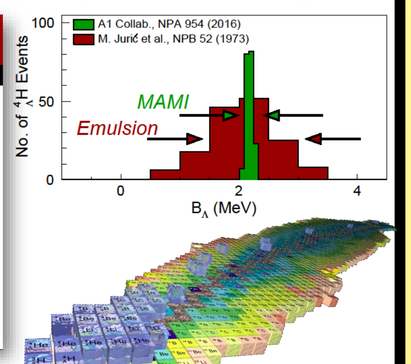


High-resolution decay-pion spectroscopy pioneered at Mainz Microtron (MAMI)

A. Esser et al. (A1 Collaboration), PRL 114, 232501 (2015)

Precision of $^{4}_{\Lambda}$H binding energy improved largely:



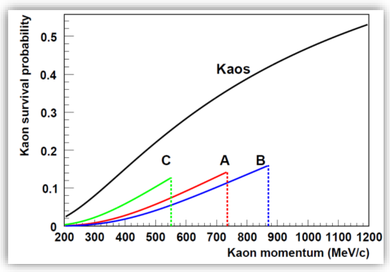


Hypernuclei as third dimension in nuclear chart

Focusing spectrometers at MAMI:

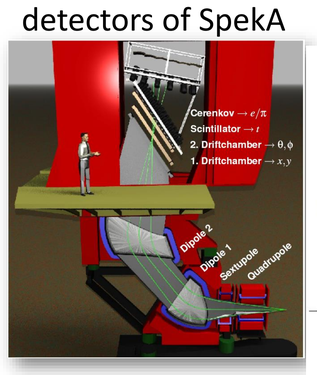
- 3 high-resolution $\Delta p/p \approx 10^{-4}$ spectrometers (SpekA,B,C)
- 1 short-orbit spectrometer (KAOS used as kaon tagger)

Kaon detection:

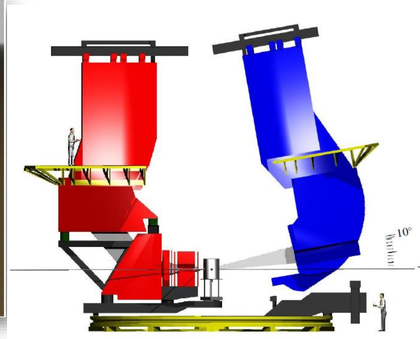


High-Resolution Spectrometers

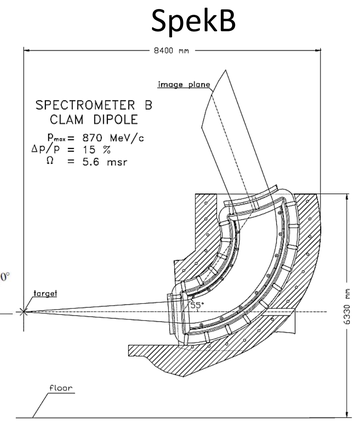
Magnet optics and detectors of SpekA

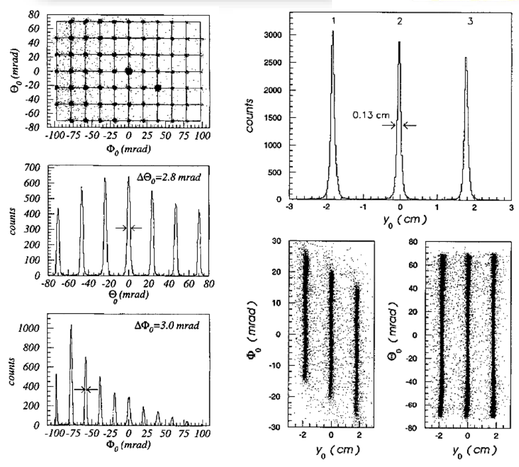


Out-of-plane capability of SpekB



Magnet optics of SpekB





Angular Resolution

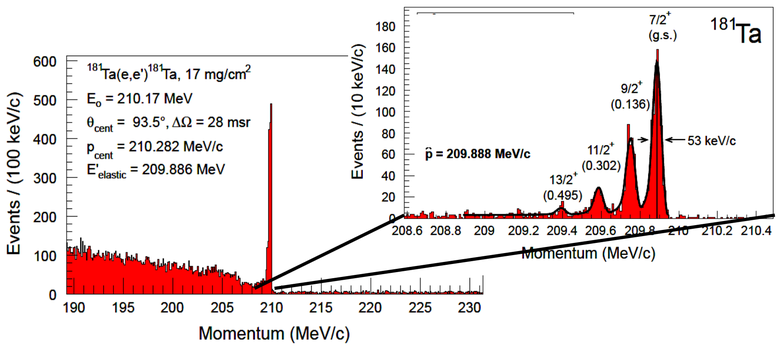
Vertex resolution

Spectrometer		A	B	C
Configuration		QSDD	D	QSDD
Focussing properties				
dispersive plane		pt →pt	pt →pt	pt →pt
nondispersive plane		|| →pt	pt →pt	|| →pt
Maximum momentum	[MeV/c]	735	870	551
Solid angle	[msr]	28	5.6	28
Angular range				
minimum angle		18°	7°	18°
maximum angle		160°	62°	160°
Momentum acceptance	[%]	20	15	25
Angular acceptance				
dispersive plane	[mrad]	±70	±70	±70
nondispersive plane	[mrad]	±100	±20	±100
long-target acceptance	[mm]	50	50	50
Angle of focal plane		45°	47°	45°
Length of focal plane	[m]	1.80	1.80	1.60
Length of trajectory	[m]	10.75	12.03	8.53
Dispersion (central)	[cm/%]	5.77	8.22	4.52
Magnification (central)		0.53	0.85	0.51
Dispersion / Magnification	[cm/%]	10.83	9.64	8.81
Momentum resolution		10^{-4}	10^{-4}	10^{-4}
angular resolution at target	[mrad]	≤3	≤3	≤3
position resolution at target	[mm]	3 – 5	1	3 – 5

[K.I. Blomqvist et al., Nucl. Inst. Meth. A 403 (1998)]

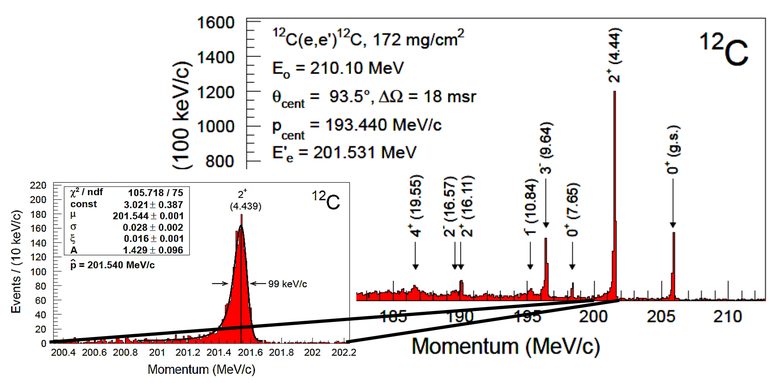
Spectrometer Momentum Calibrations for Unprecedented Resolution

Scattering off a thin tantalum foil

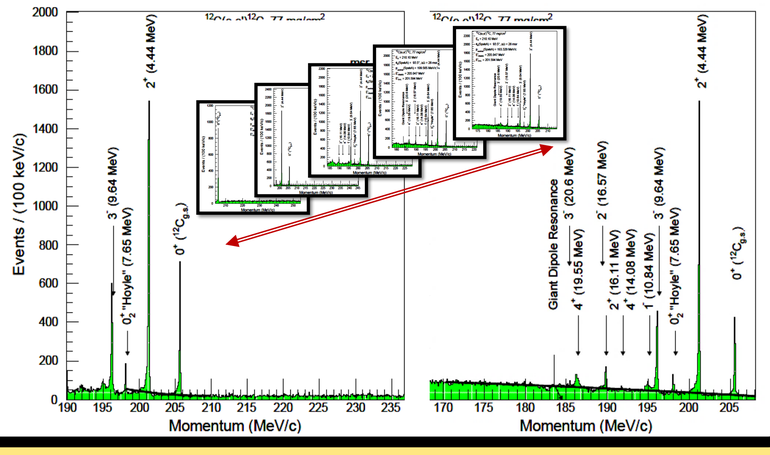


Spectrometer FWHM of 53 keV/*c* → δp/p ~ 2·10^{-4}

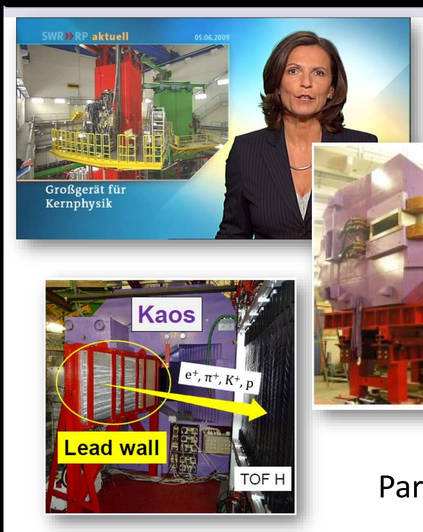
Scattering off a carbon target



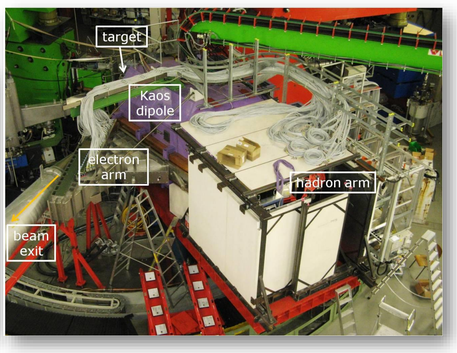
Multiple magnetic field settings



Dedicated Kaon Tagging and High-Luminosity Target



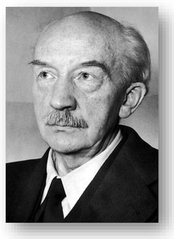
Setup at MAMI:



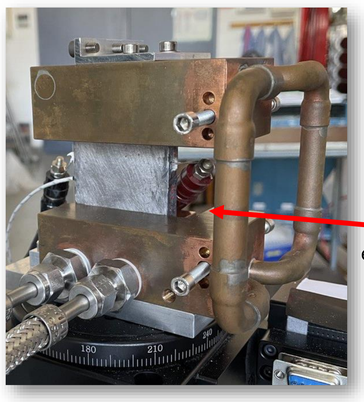
Coincidence method:

Walther Bothe: The Nobel Prize in Physics 1954:

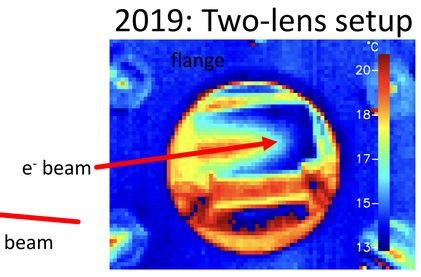
"for the coincidence method and his discoveries made therewith"



High-luminosity lithium target:



2019: Two-lens setup

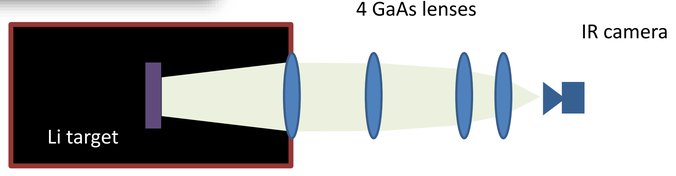


In this experiment:

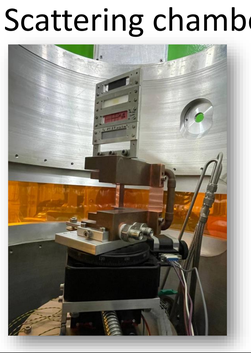
	Detector System A & C	Detector System Kaos
Track Reconstruction & Momentum Determination:	Vertical Drift Chambers	Multi-Wire Proportional Chambers or Segmented ToF-Walls
Energy Loss & Time-of-Flight Measurement:	Plastic Scintillator Detectors	Plastic Scintillator ToF-Walls
Particle Discrimination:	Gas Threshold Cherenkov Detector	Aerogel Cherenkov Detectors

4 GaAs lenses

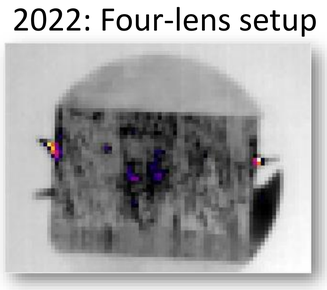
IR camera



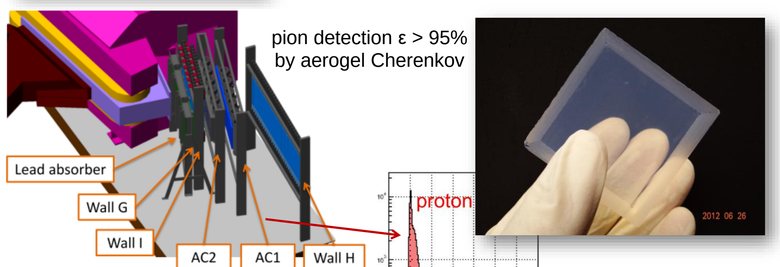
2022: Scattering chamber

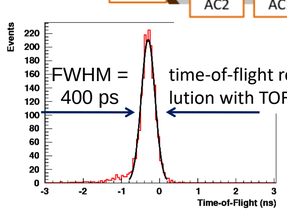


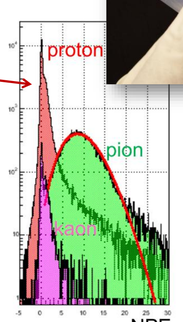
2022: Four-lens setup



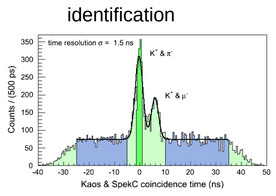
Particle detection system:



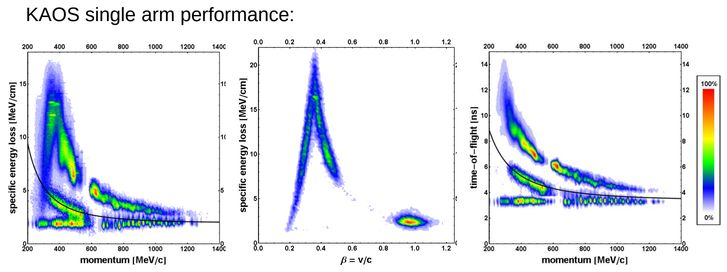




Coincidences for reaction identification



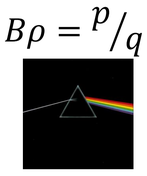
KAOS single arm performance:



- **High-resolution decay-pion spectroscopy pioneered at Mainz Microtron MAMI**
- **Precision system of focusing spectrometers and high-luminosity target**

Good physics needs precision tools!

$B\rho = {}^{p}/_{q}$



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