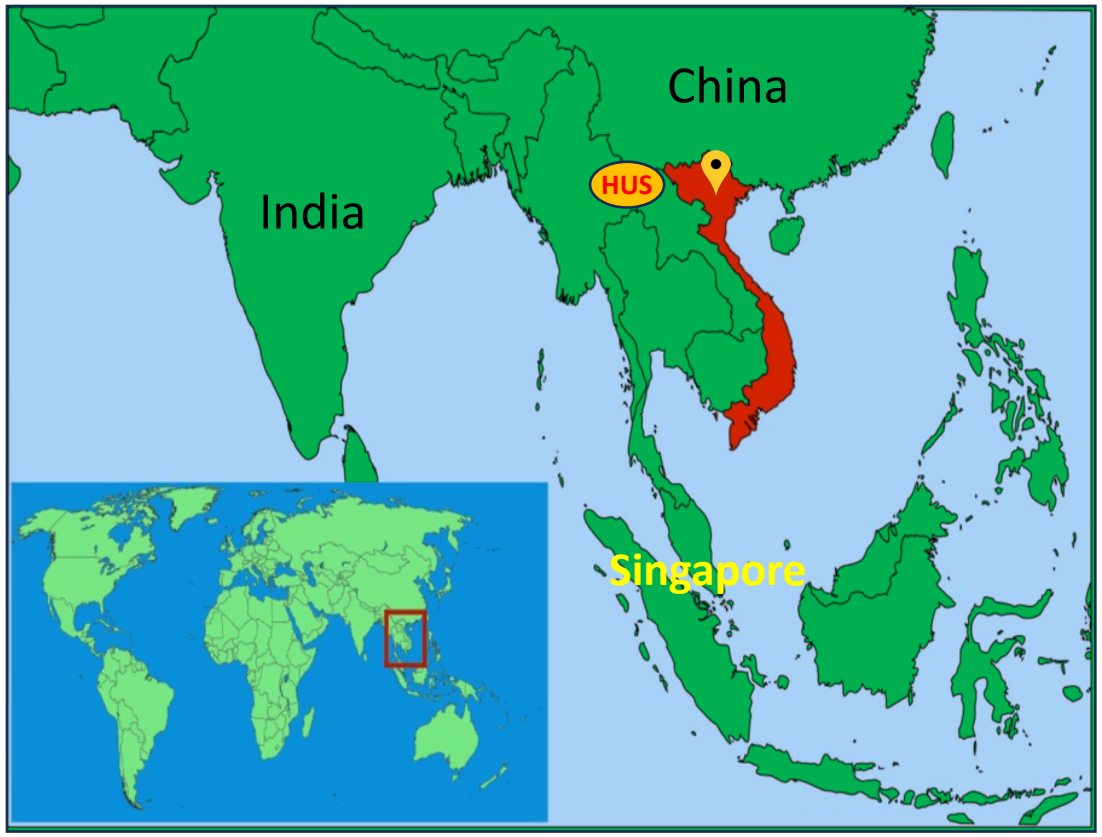
Confirmation the ^{8}Be anomaly with a different spectrometer

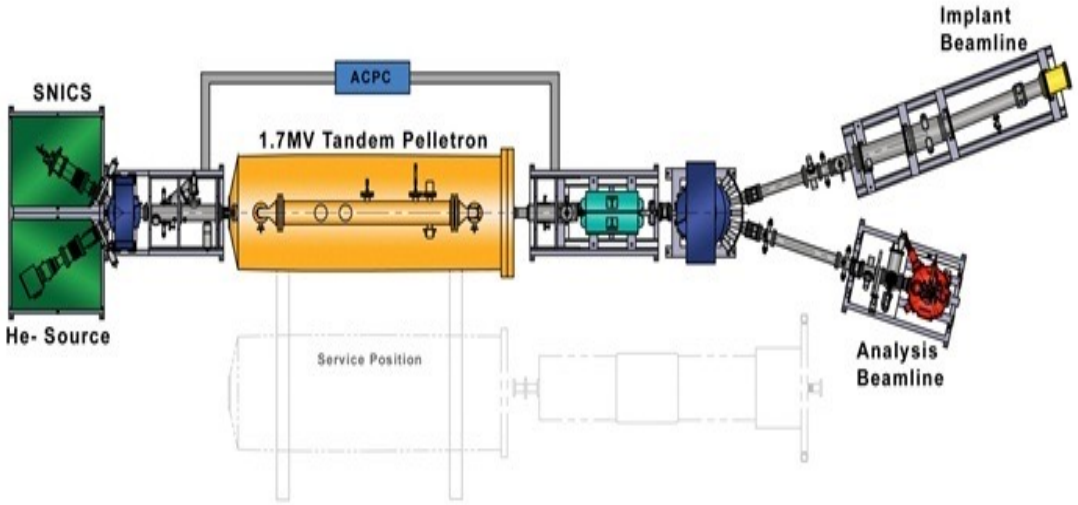
Tran The Anh

VNU University of Science, Hanoi, Vietnam

ISMD August 21, 2023 Gyöngyös, Hungary

HUS - Facilities



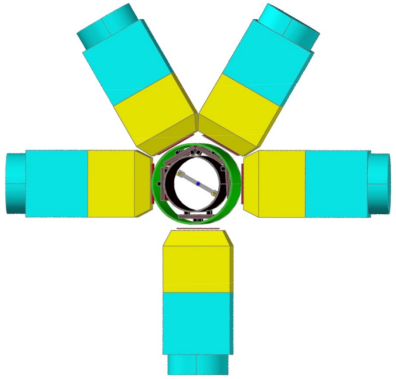


Pelletron Beamline, analysis beamline
Terminal Voltage: 1.7 MV
Ion: H^+, He^+, C^+, Si^+, Cu^+, Au^+…
Beam Current: 1nA – 2microA

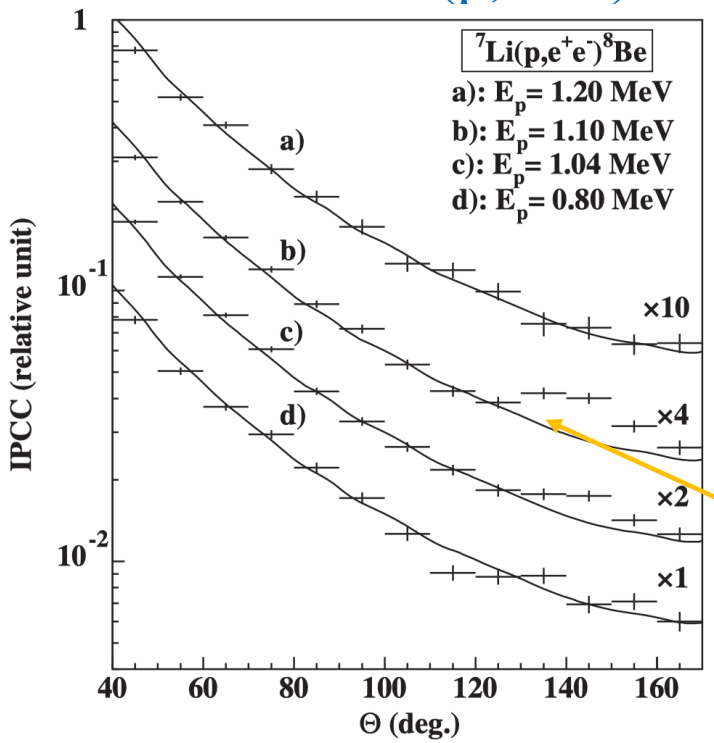
Main tasks:
RBS
PIXE
Ion implantaion
Astro nuclear reactions

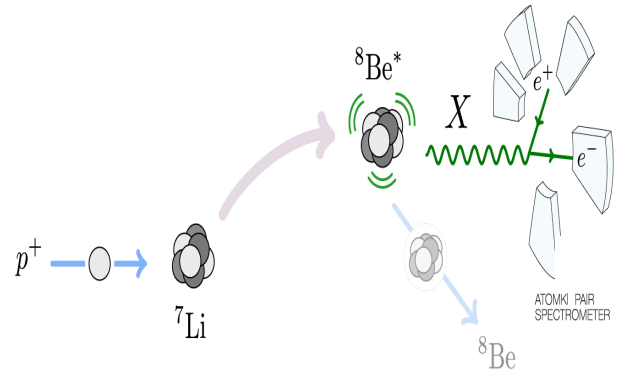
Introduction

In 2016, an experiment conducted at the ATOMKI laboratory (Debrecen, Hungary) studied the nuclear reaction $^{7}Li(p,e^{+}e^{-})^{8}Be$. [1,2]



The Atomki 5 arms spectrometer used in the first ^{8}Be measurement in 2016





Deviation from IPC

To measure the distribution of the relative angle between positron and electron (e^{+} e^{-}) produced in the Internal Pair Creation (IPC) in the transitions from the exited to the ground state of ^{8}Be

The results showed an enhancement for 18.15 MeV transition around 140° in the distribution of angle (e^{+} e^{-}) difference from the expectations

[1] A. Krasznahorkay et al., PhysRevLett.116.042501(2016)

[2] J. Gulyás et al., Nucl. Instrum. Methods A 808, 21 (2016)

Why Experiment in Hanoi

After 2016 the ATOMKI Exp. they improved the measurements in many ways but the anomaly did not disappear.

And, no nuclear physics model could fully explain the anomaly.

This led to a surprising explanation of physics beyond the SM model that there may be a boson have created and it decayed by $e^+ e^-$ pair which made the deviation from IPC theory.

There are many theoretical approach to explain the deviation and there are some experiments have been planed and built to produce more experimental data but there is no new data published up to now.

We have a PELLETRON, we can do that!

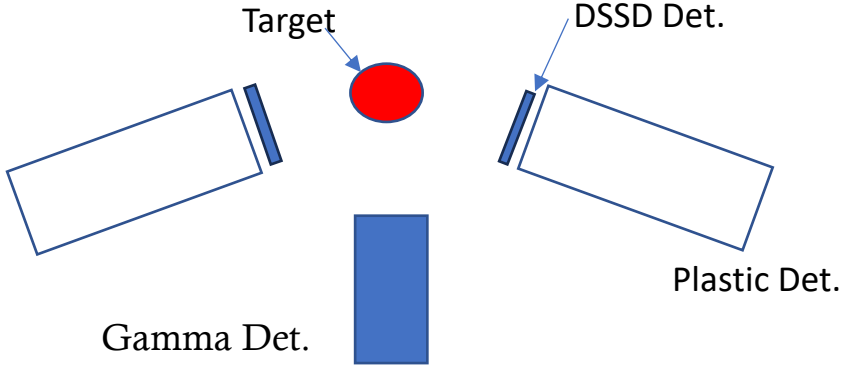
In 2018, a professor of VNU have read the ATOMKI-Publication (2016) and realize that there may be conducted an experiment at the pelletron accelerator laboratory in Hanoi to verify the ATOMKI-results

The Exp have been planned to build since 2018 but because of Covid 19 pandemic it delayed to 2022. In July 2022 the Exp was started.

Experiment Setup

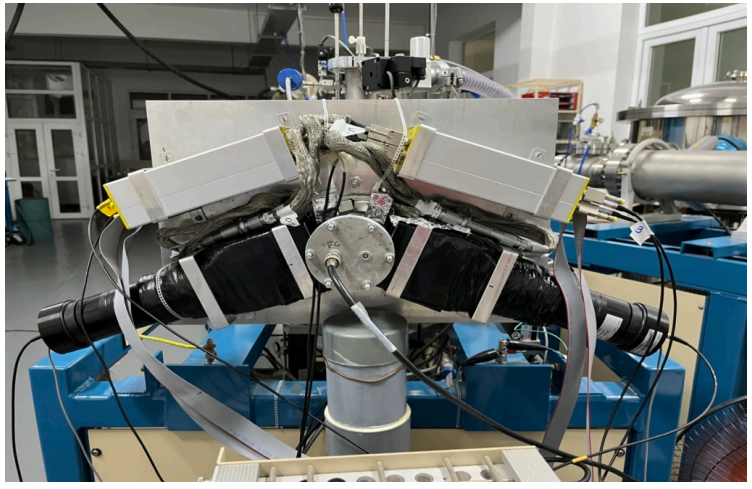
We used p-beam with different energies to bombard the Li-target to populate 18.15 and 17.6 MeV ^{8}Be excited states with resonant proton capture.

$^{7}Li(p,e^{-}e^{+})^{8}Be$

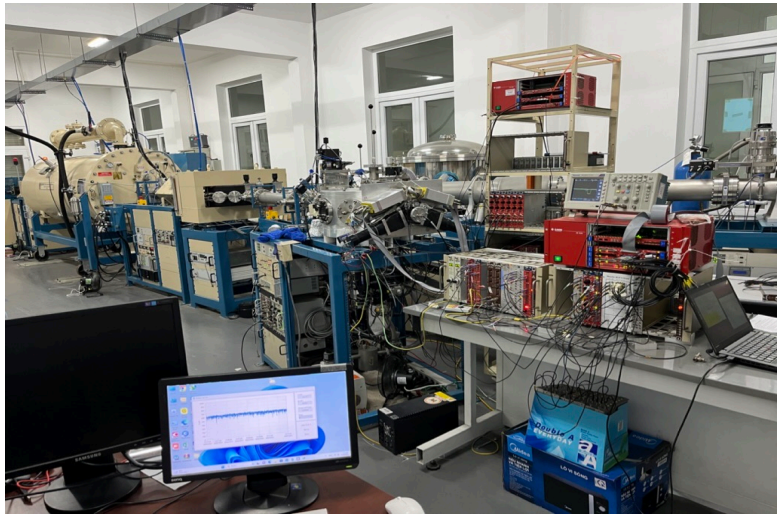


Why did we arrange the Det-system like this?

Detector setup to measure the energies and the angle between the e^{+} e^{-} particles.



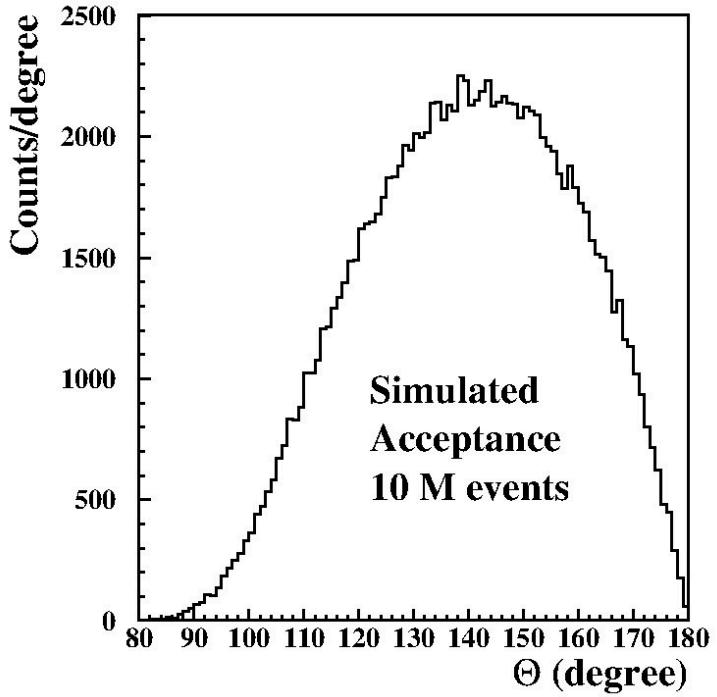
Picture in lab of the detector system and the DAQ connected to Pelletron



Experiment Setup

The idea of the new e^+e^- spectrometer with two arms

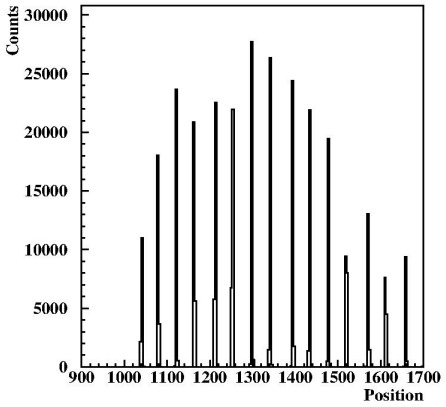
- Concentrate on the 140 degree region.
- Put the detectors closer to the target 30 mm than they were used in Debrecen (60 mm).
- We can have similar acceptance at 140 degree in this way for the two cases.



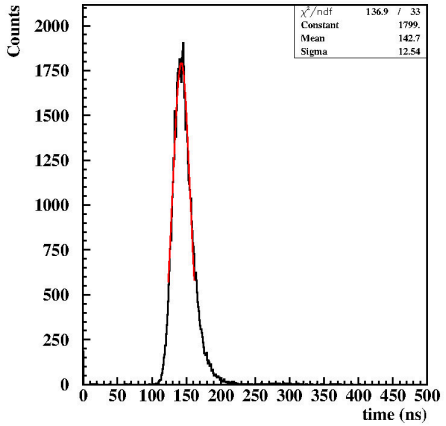
The simulation curve of acceptation before making setup

First raw data coming from the $^{11}B(p,e^+e^-)^{12}C$ reaction measured with the spectrometer

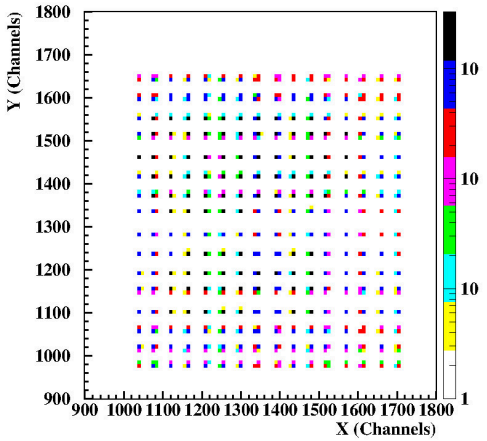
DSSD Position Spectrum



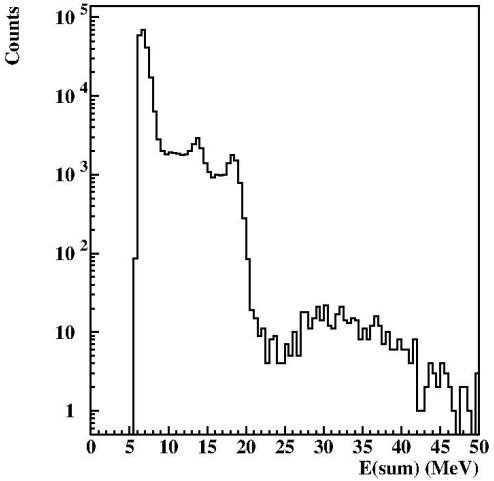
DSSD Timing Spectrum



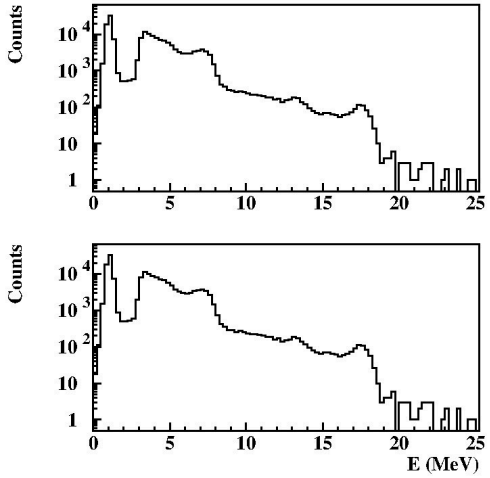
Hit Positon in DSSD



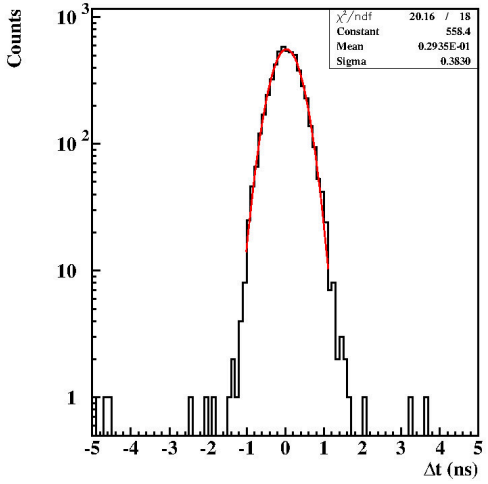
Sum of Plastic Engergy



Plastic Energy Spectrum

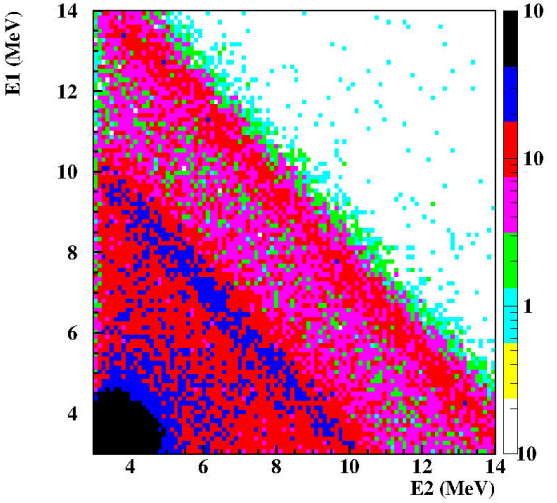


Plastic Timing Spectrum



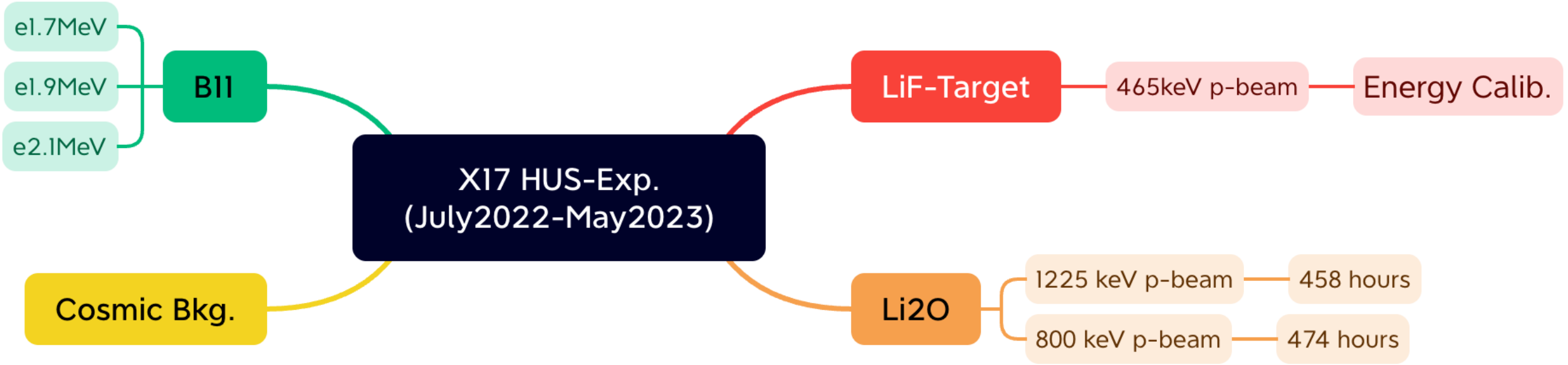
Performance of the DSSD detectors and plastic detectors.

Energy correlation of the e^+e^- pairs



Experiments at HUS

- The experiments were performed between July 2022 and May 2023 at HUS

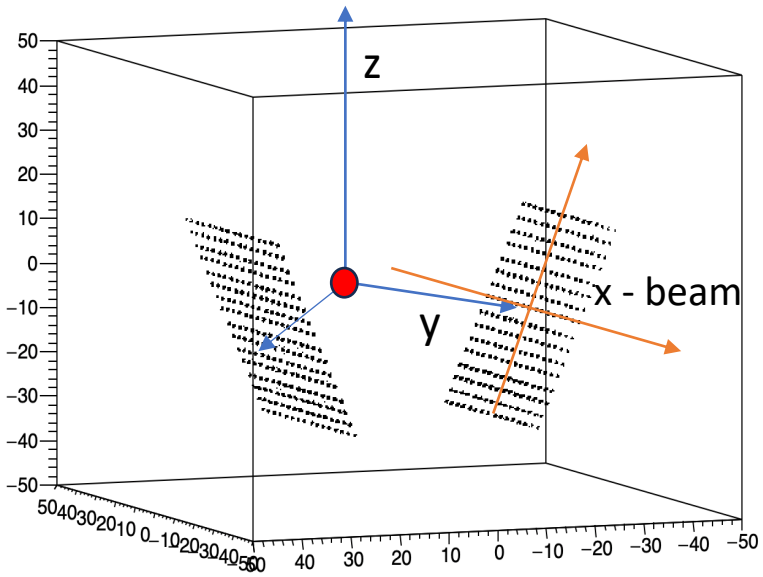


Target: ^{11}B
Proton beam energies 1.7;1.9; 2.1 MeV
Beam current: 1 μA

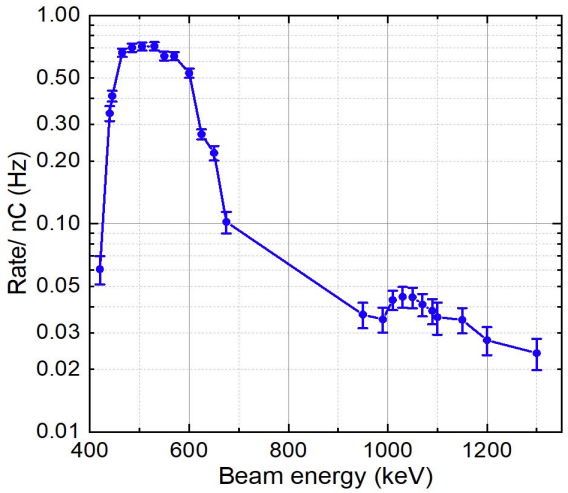
Target: ^{7}Li
Proton beam energies 1.7;1.9; 2.1 MeV
Beam current: 1 μA

Selecting the beam energies and acceptance

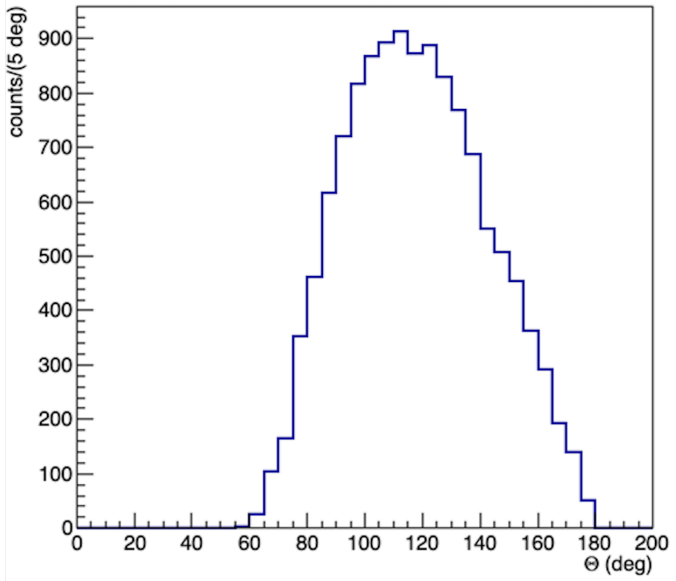
Hit Position



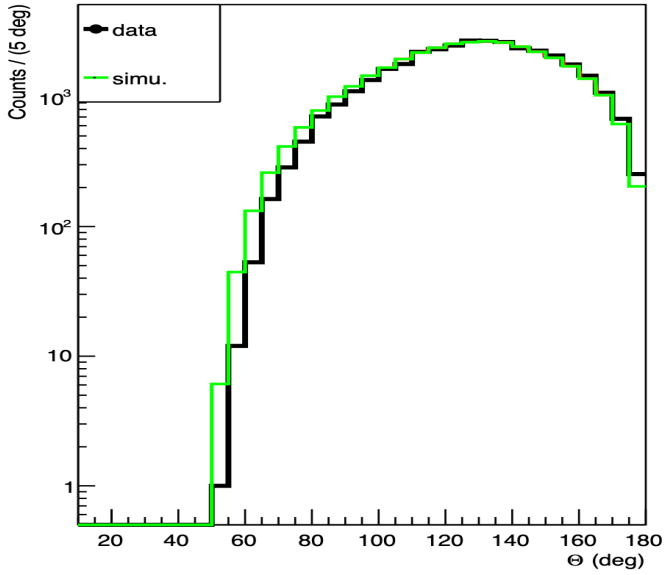
Resonance curve for e^+ e^- pairs coming from a thick Li_2O target as a function of the proton beam energy.



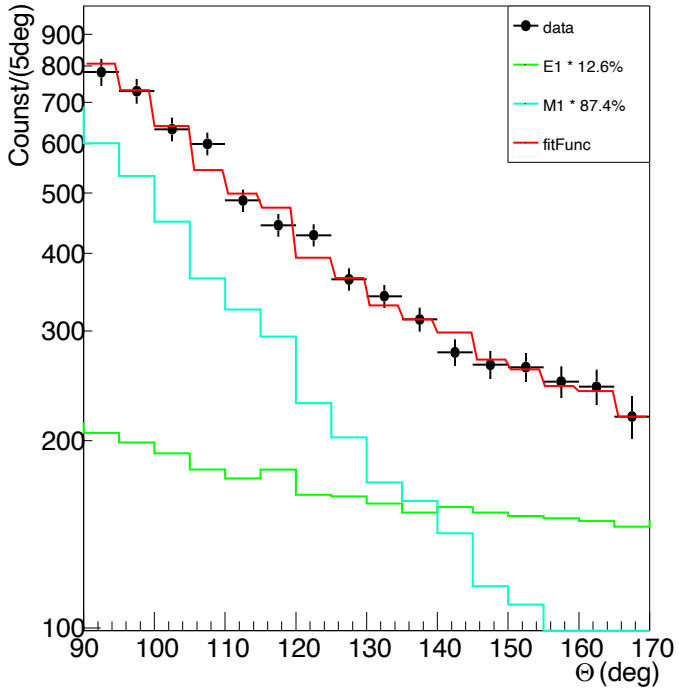
Angular correlation of the e^+ e^- coincidence events.



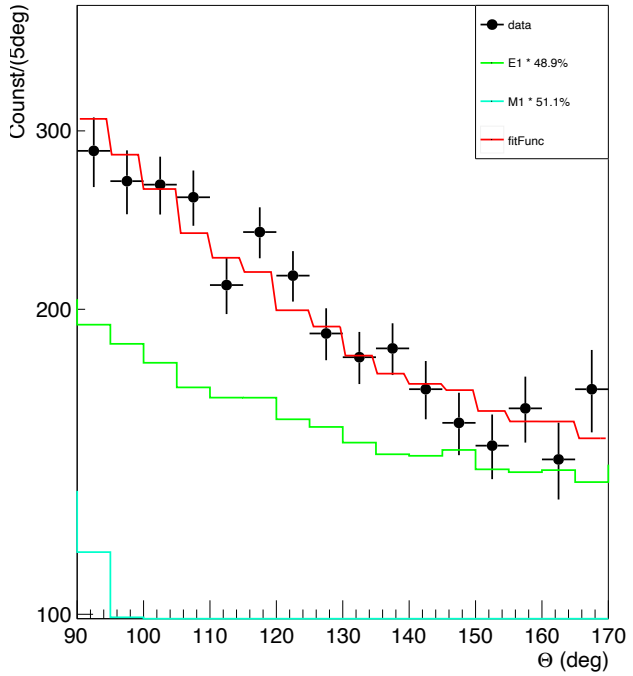
Experimental and simulated acceptance of two-arms spectrometer.



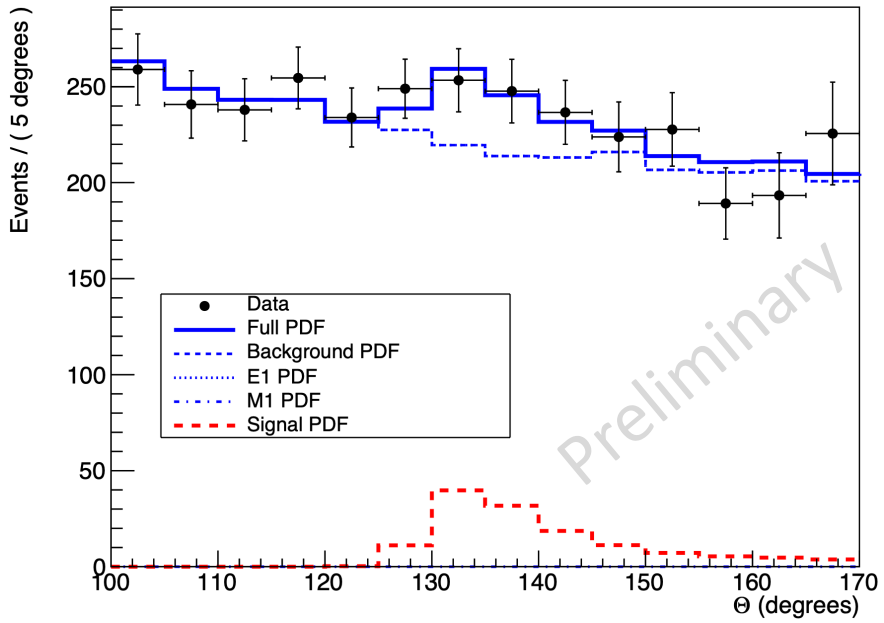
Aceptance corrected angular correlations



E_p=441 keV
No anomaly



E_p=800 keV
Off-resonance
No anomaly



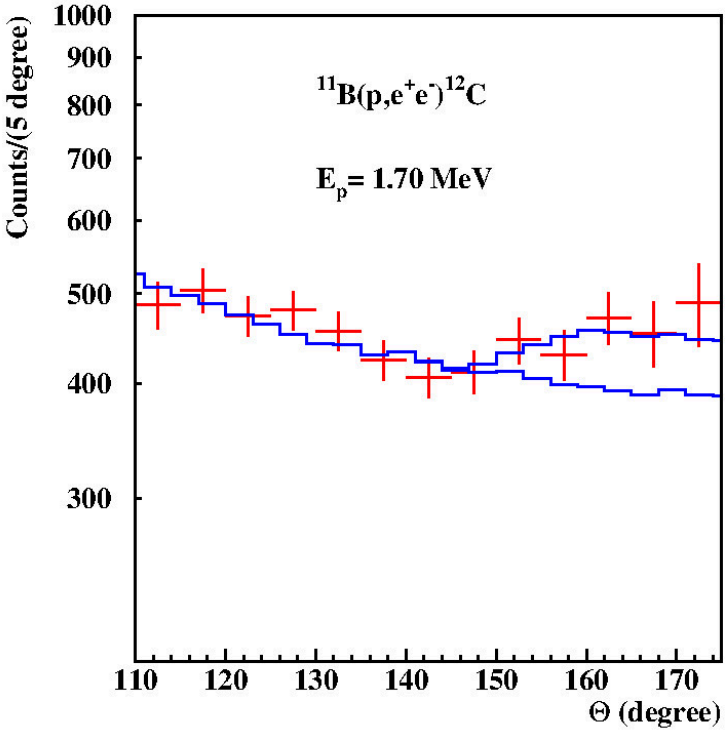
E_p=1.04 MeV. Background: M1+E1
The anomaly appears at angle around 140° (*)

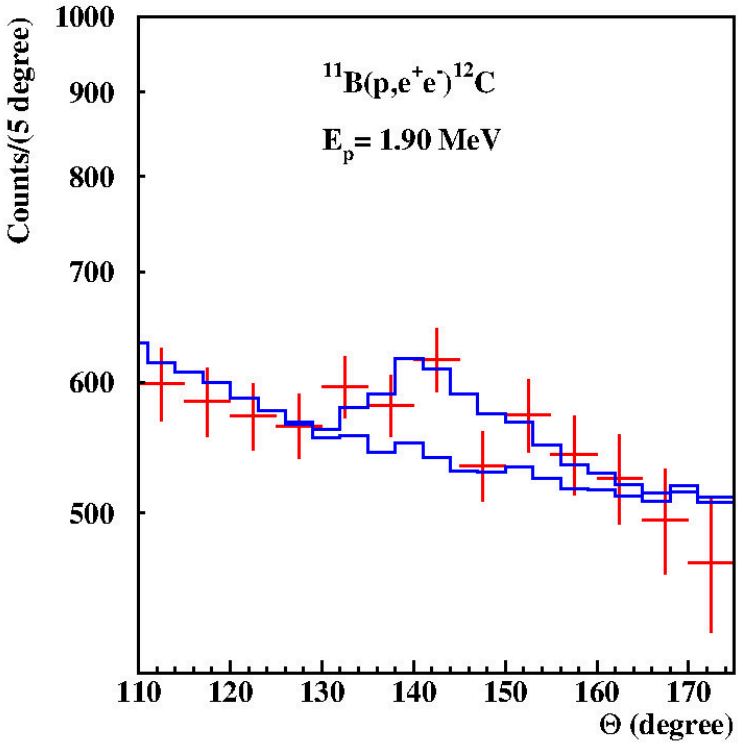
m_{boson}=16.7 ± 0.47 (MeV)
Significance: 4-5σ

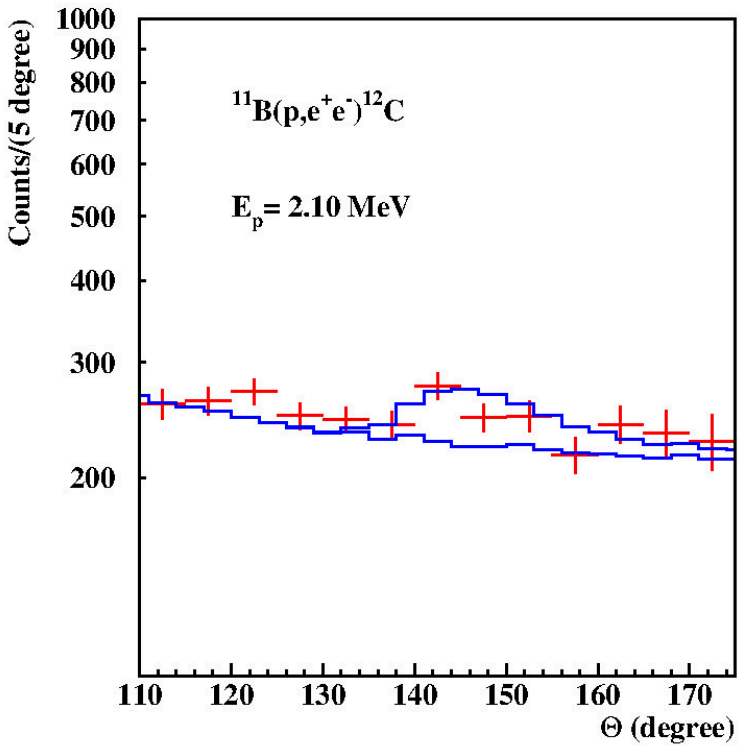
 (*) A. J. Krasznahorkay et al., Phys. Rev. Lett. 116, 042501 (2016)

Preliminary results for $^{11}B(p, e^+ e^-)^{12}C$ reaction

Preliminary angular correlations for ^{12}C







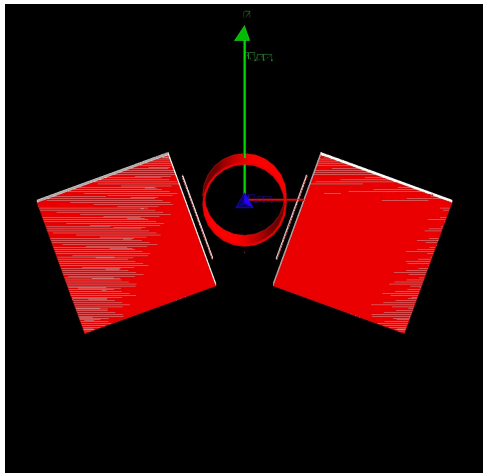
Agreement with ATOMKI result (2022) (*)

Preliminary

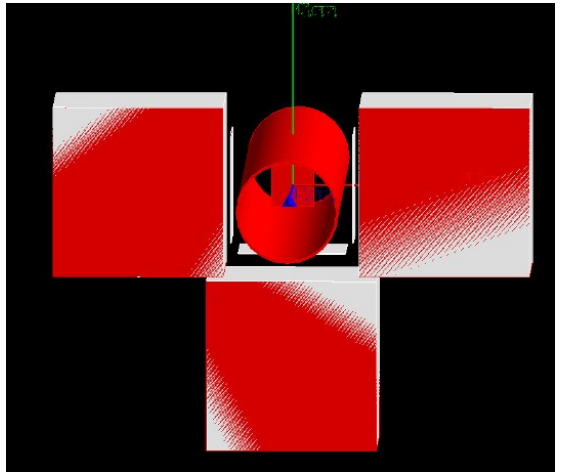
(*) A. J. Krasznahorkay et al, Phys. Rev. C 106, L061601 (2022)

Upgrade HUS – Spectrometer.

To improve the acceptance, it is neccesary to add more "arms" to cover wider angular correlation region.

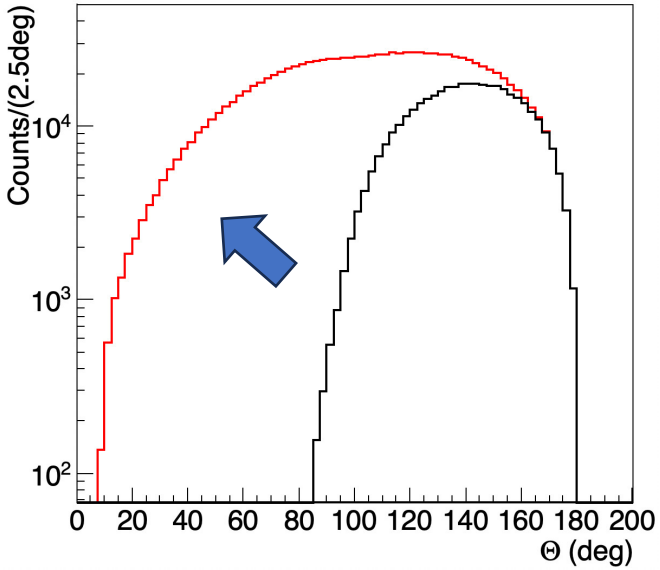


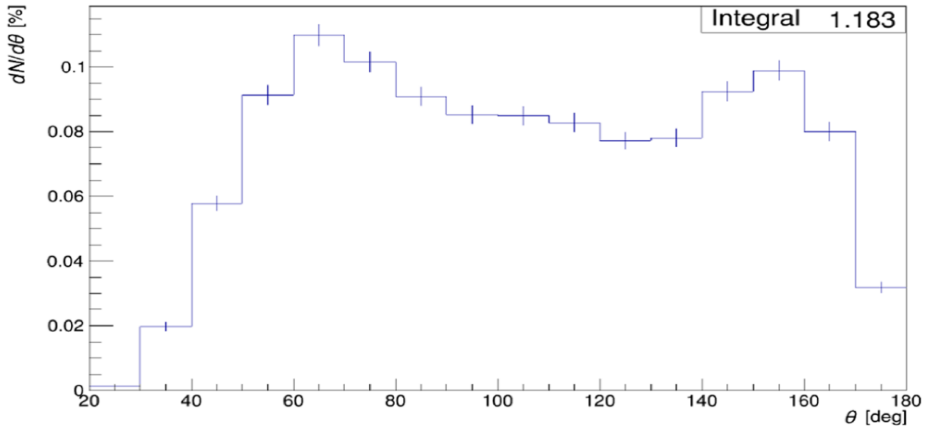
Two - amrs system



Three- amrs system

Simulated Acceptances of Detector systems (*)





ATOMKI-Acepptance five Arms

Conclusion

- We successfully built a two-arm e^+ e^- spectrometer in Hanoi.
- The spectrometer was tested and calibrated using the 17.6 MeV M1 transition excited in the ^{7}Li(p,e+e-)^{8}Be reaction.
- We have got nice agreement between the experimentally determined acceptance of the spectrometer with the simulated one.
- The angular correlation of the e+e- pairs measured for the 17.6 MeV transition agrees nicely with the simulated one for the M1 transition. No anomaly was observed.
- No anomaly was observed for Ep= 800 keV either.
- A significant anomaly (>4σ) was observed however for the 18.15 MeV transition at around 140 degree, in a nice agreement with the ATOMKI results published in 2016.
- The mas of the boson was obtained to be: m_{boson}=16.7 ± 0.47(statistical) (MeV).
- We are planning to upgrade the spectrometer to get a wider angular acceptance.

List of colaborators

Attila. J. Krasznahorkay – ATOMKI

József Molnár - ATOMKI

Zoltán Pintye - ATOMKI

Tran Dinh Trong – IOP, Vietnam

Nguyen Ai Viet - VNU

Nguyen The Nghia- HUS

Do Thi Khanh Linh – INST

Bui Thi Hoa – HUS

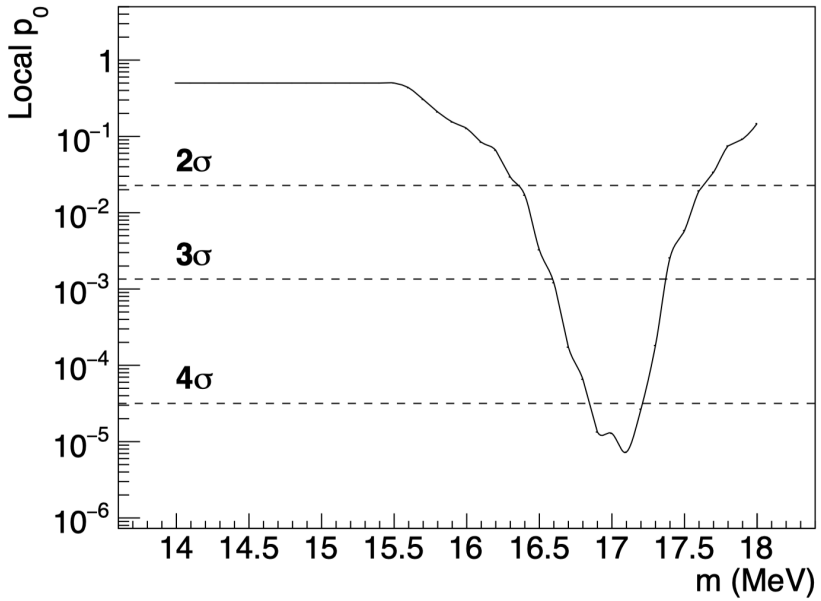
Le Xuan Chung – INST

Nguyen Tuan Anh - HIC

Thank you
for your attentions

Back up

Significance



Test Beam Position