The Precise Measurement of Triton-Producing Three-Body Breakup Reaction of ^{7}Li Nucleus Induced by Fast Neutrons with the Multi-purpose Time Projection Chamber at CSNS

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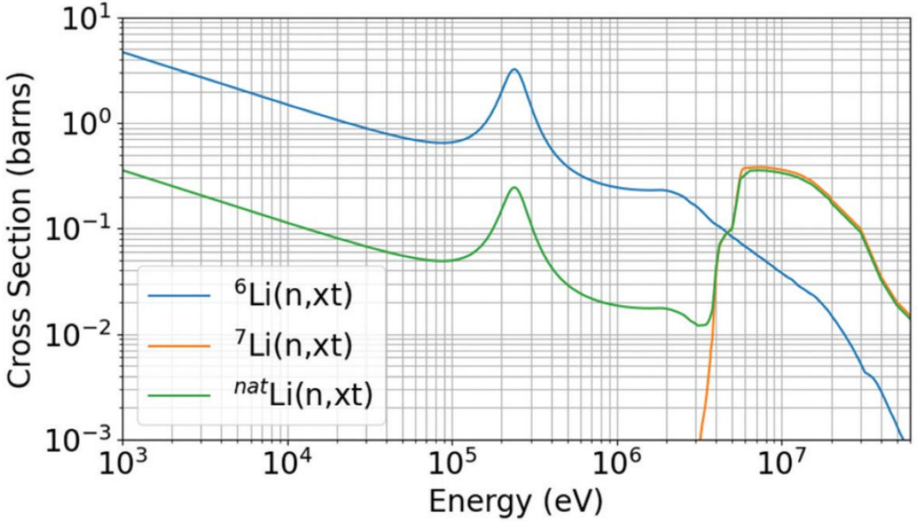
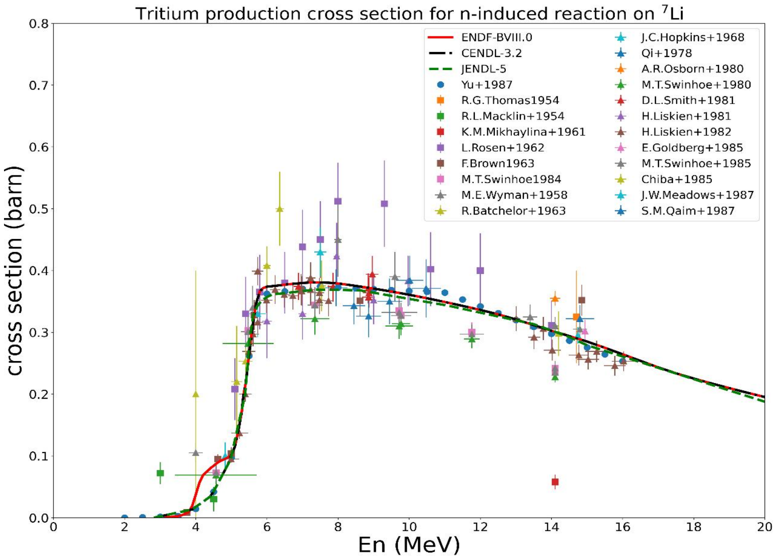
The application of triton-producing reaction cross sections data

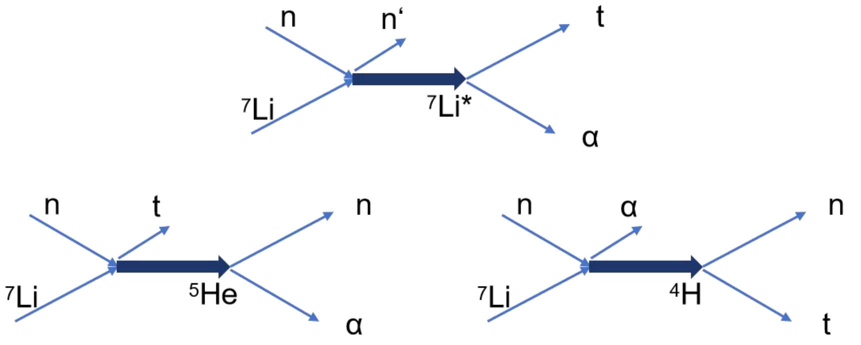
- Tritium is one of the key isotopes in the operation of fusion facility.
- Neutron induced triton-producing reactions of Lithium are important for Tritium generation.
- Key triton-producing reaction channels：
  - $n + {}^{6}Li \rightarrow {}^{3}H + {}^{4}He + 4.78$ MeV，$E_{thr} = 0$ MeV
  - $n + {}^{7}Li \rightarrow n + {}^{3}H + {}^{4}He - 2.47$ MeV，$E_{thr} = 2.82$ MeV
- Reaction of ${}^{7}Li$ contributes more triton-production in the fast neutron energy range, especially in the energy range above 5MeV.
- The cross sections data are important in the research and design of fusion facility.



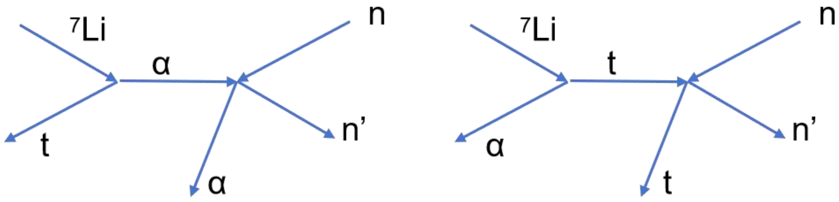


The processes of triton-producing reaction of ^{7}Li: ^{7}Li(n, n’t)α

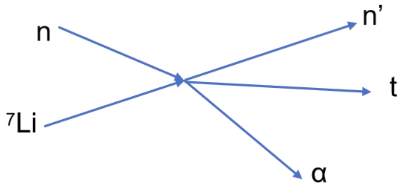
- **Sequential decay**
- reaction through a resonant intermediate state



- **Quasi-elastic scattering:**
- interaction between neutron and cluster structure

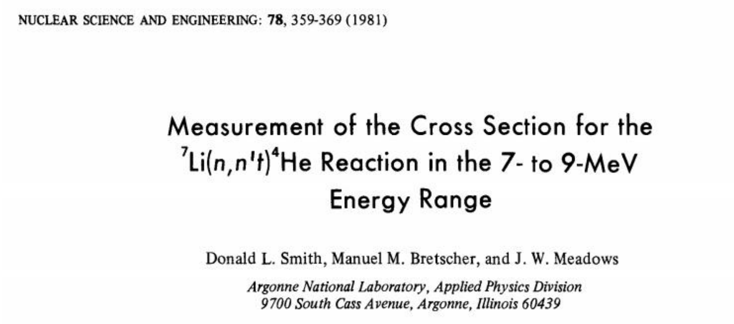


- **Direct breakup:**
- no intermediate state



Measurement of triton-producing reaction cross sections of ^{7}Li

- **Neutron activation analysis: energy-integrated cross sections data**
- ^{7}Li sample was irradiated by mono-energy neutron beam.
- The β-radioactivity of the sample was measured to obtain the cross sections data.


NUCLEAR SCIENCE AND ENGINEERING: **78**, 359-369 (1981)

Measurement of the Cross Section for the $^{7}Li(n,n't)^{4}He$ Reaction in the 7- to 9-MeV Energy Range

Donald L. Smith, Manuel M. Bretscher, and J. W. Meadows

Argonne National Laboratory, Applied Physics Division
9700 South Cass Avenue, Argonne, Illinois 60439

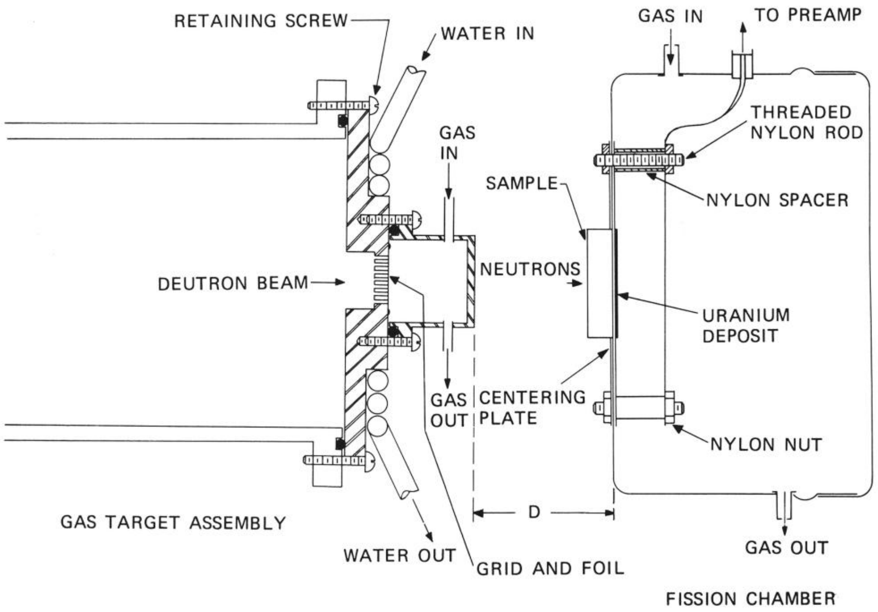


Fig. 1. Apparatus used for irradiation of lithium samples with fast neutrons.

- Donald L. Smith, Manuel M. Bretscher, J. W. Meadows (1981) Measurement of the Cross Section for the 7Li(n,n’t)4He Reaction in the 7- to 9-MeV Energy Range, Nuclear Science and Engineering, 78:4, 359-369.

Measurement of triton-producing reaction cross sections of ^{7}Li

- **Measurement of secondary neutron double-differential cross sections**
- The cross sections was obtained by fitting the secondary neutron spectra with theoretical model.

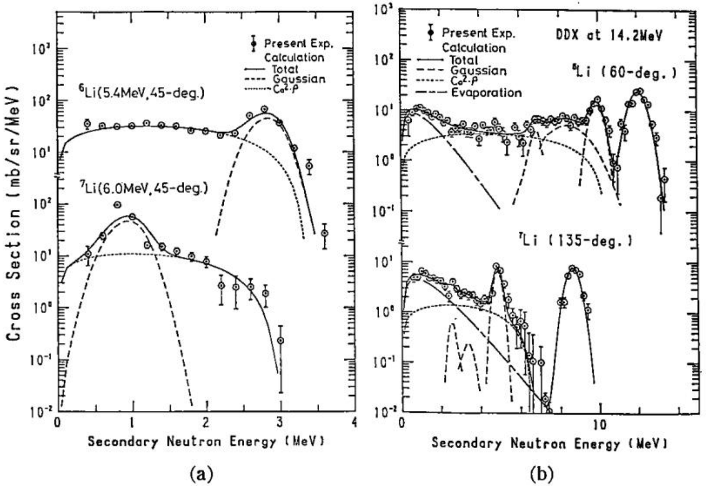


Fig. 4 Examples of double-differential neutron emission cross sections of ^{6,7}Li at incident neutron energies of (a) 5.4 and 6.0 MeV and (b) 14.2 MeV; comparison with least-squares fitting

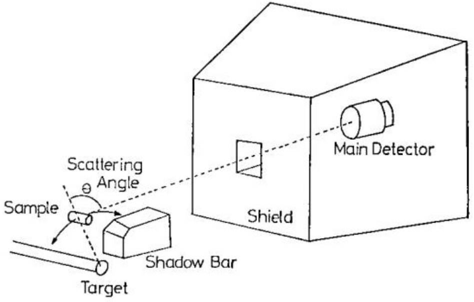


Fig. 1 Layout of 14.2-MeV experiment

resonance term:
elastic & non-elastic scattering

tree-body phase space term:
triton-producing reaction

$$\frac{d^2\sigma}{d\Omega dE'}(E_{in},\ \theta,\ E') = \sum_{i=1}^{4} A_i \exp\left(-\frac{(E'-E_i)^2}{\sigma_i^2}\right) + A_5 C_0^2 \rho(E_{in},\ \theta,\ E') + A_6 E' \exp\left(-\frac{E'}{T}\right),$$

evaporation term：
(n, 2n) reactions

■ Satoshi CHIBA, Mamoru BABA, Hiroshi NAKASHIMA, Masahiro ONO, Naohiro YABUTA, Shigeru YUKINORI, Naohiro HIRAKAWA (1985), Double-Differential Neutron Emission Cross Sections of 6 Li and 7 Li at Incident Neutron Energies of 4.2, 5.4, 6.0 and 14.2 MeV, Journal of Nuclear Science and Technology, 22:10, 771-787.

Measurement of triton-producing reaction cross sections of ^{7}Li

- **Exclusive measurement of charged-particle at certain angle**
- Only zero-degree data is available in the library.

2.A.1

Nuclear Physics **60** (1964) 581—587; © *North-Holland Publishing Co., Amsterdam*

TRITON SPECTRUM FROM THE n+Li^7 REACTION

V. VALKOVIĆ
Institute "Ruđer Bošković", Zagreb, Yugoslavia

- V. Valković, Triton spectrum from the n+Li7 reaction, Nuclear Physics, Volume 60, Issue 4, December 1964, Pages 581-587.

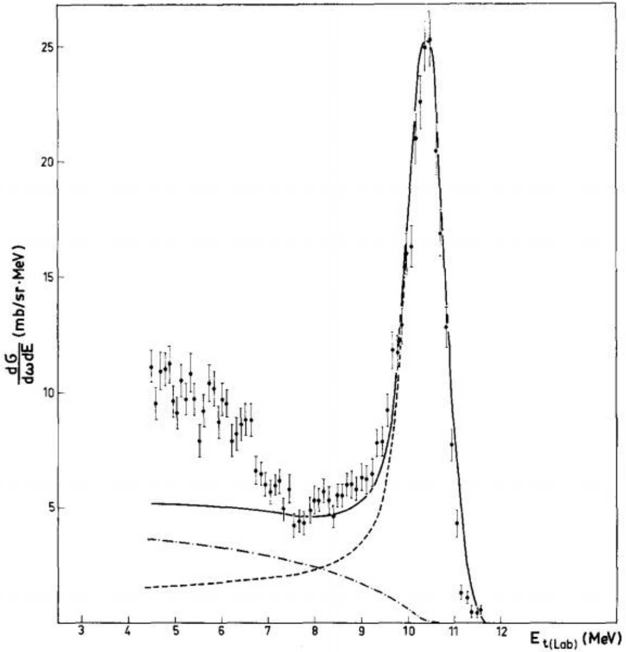
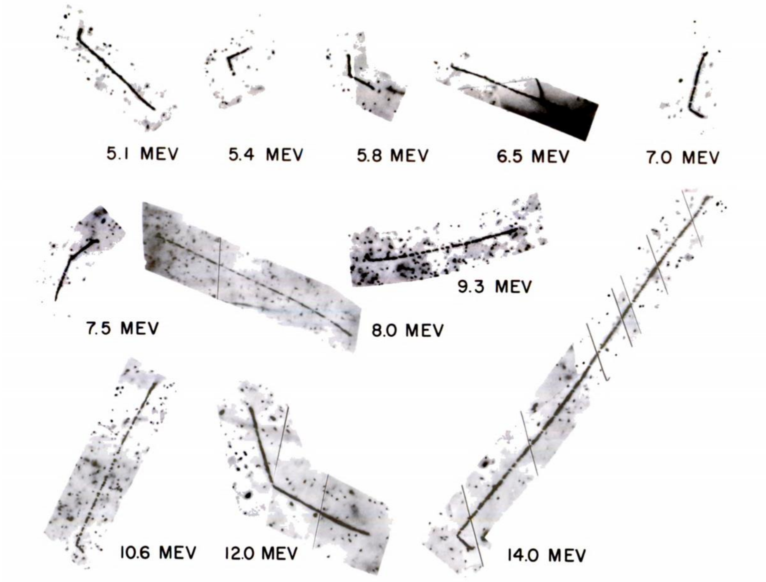


Fig. 3. Triton spectrum from the n+Li^7 → α+t+n reaction. The errors shown are statistical. The dashed curve represents the contribution from the α+n final state interaction in the ground state of He^5. The dashed-dotted curve represents the contribution from the α+t final state interaction in the 4.63 MeV excited state of Li^7. The solid curve is the sum of these two contributions.

Measurement of triton-producing reaction cross sections of ^{7}Li

- **Measurement of reaction kinetics with nuclear emulsion**
- Reconstructing neutron momentum by reaction kinetics to realize quasi-complete measurement.
- The double-differential cross sections of charged-particles and neutron can be both measured.
- The intermediate state in the reaction can be reconstructed.



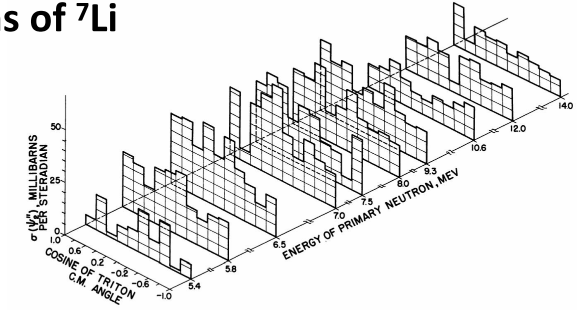


Fig. 6.8 Angular distribution of the tritons in the Li^{7} coordinate system for the 4.6 level in Li^{7}.

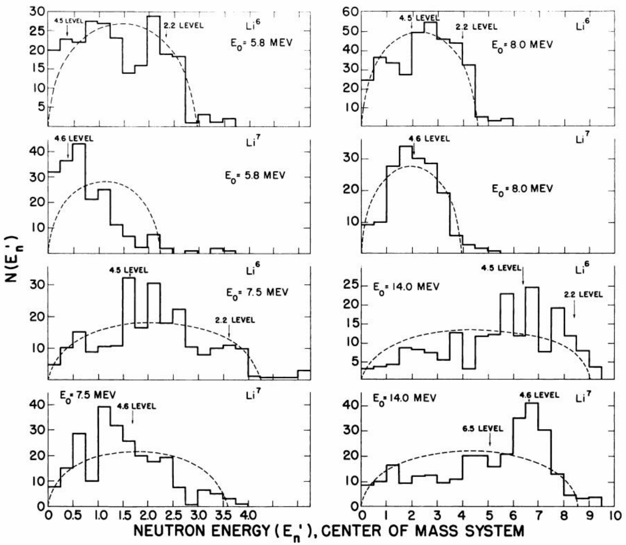
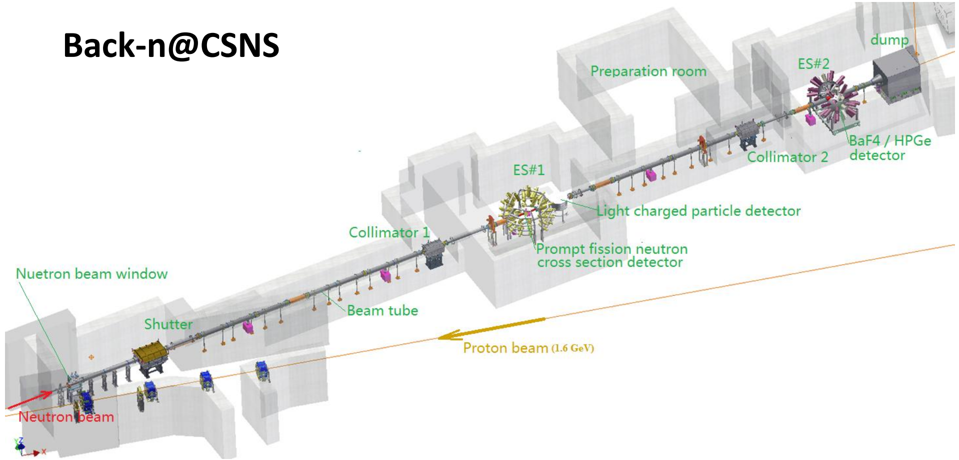


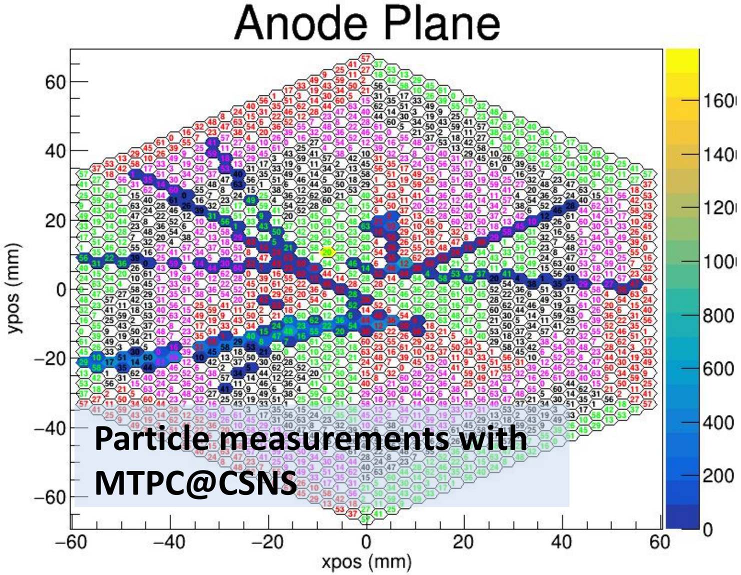
Fig. 7.3 Three-particle phase space distribution of the neutrons for Li^{6} and Li^{7} reactions.

■ [13]L. ROSEN and L. STEWART,"The Neutron-Induced Disintegration of Li6 and Li7 by 5 to 14-MeV Incident Neutrons,"LA-2643, Los Alamos Scientific Laboratory (Dec. 22, 1961).

Proposal for new measurement of triton-producing reaction of ^{7}Li

- **The existing measurements were limited by the detection technique and methods.**
- The requirements of ^{7}Li(n, n’t)α reaction cross sections data in the research:
  - Energy-integrate cross sections with higher precision and wider neutron energy range.
  - Double-differential cross sections cover wider angular and particle energy range.
- **Measurement with the latest developed neutron source and detector technique:**
  - The Back-n@CSNS can provide high flux neutron beam in the fast neutron energy range.
  - The MTPC@CSNS can provide new technique option with better particle identification capability.





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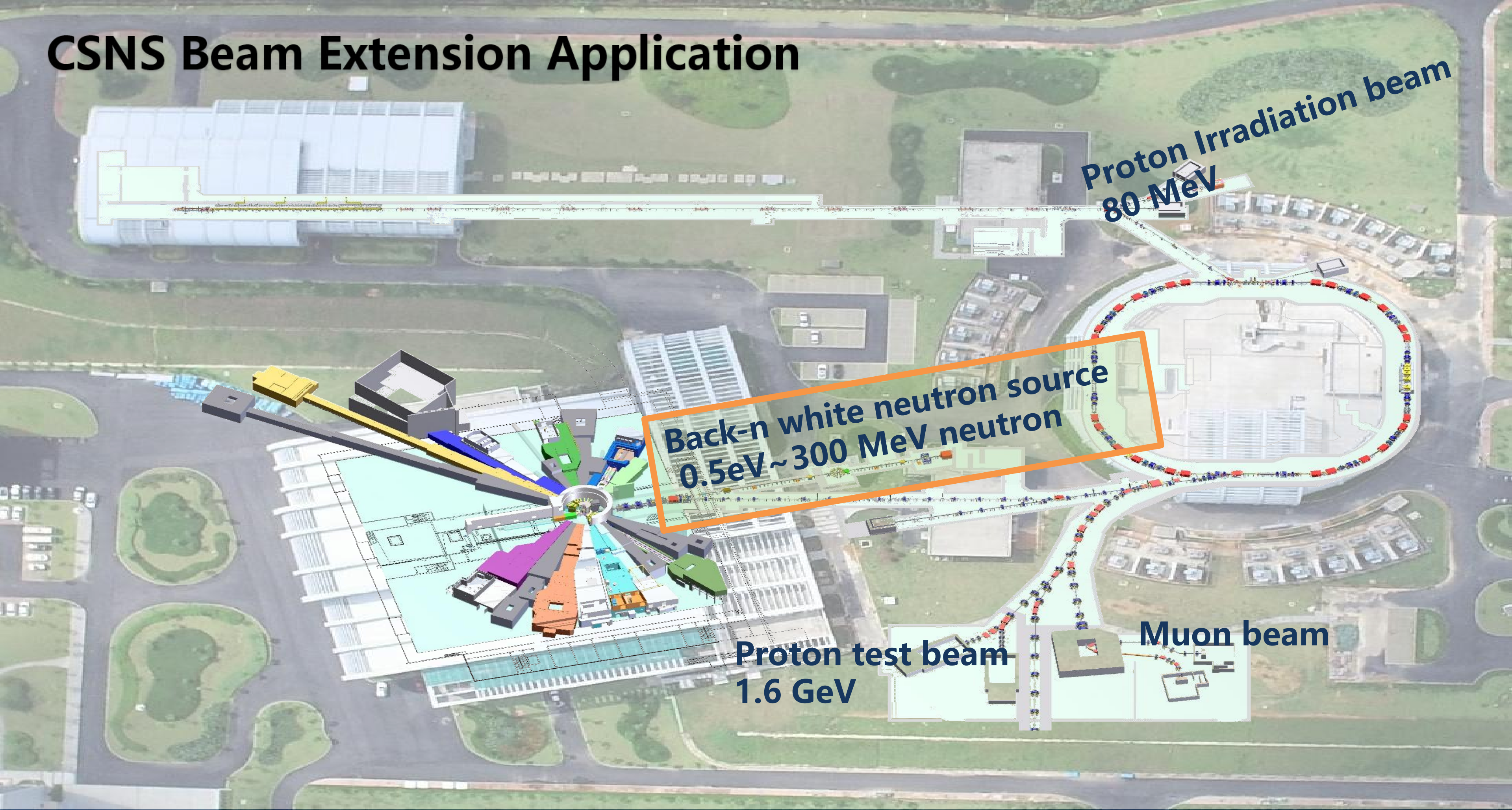
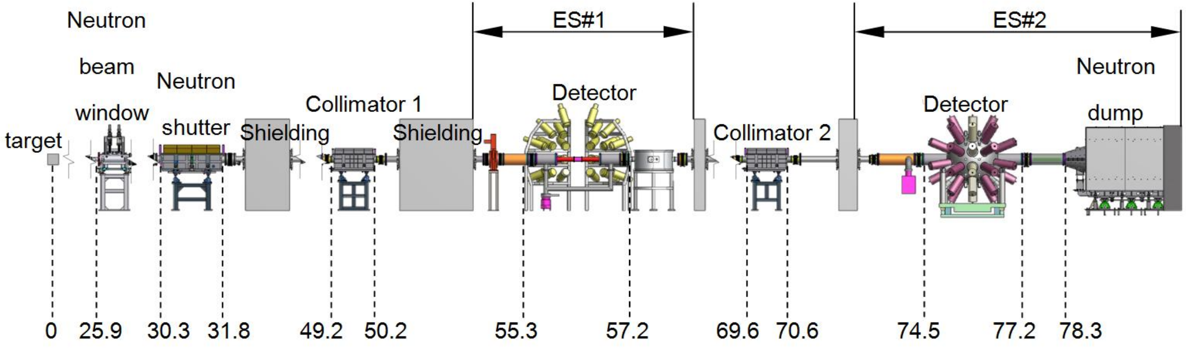
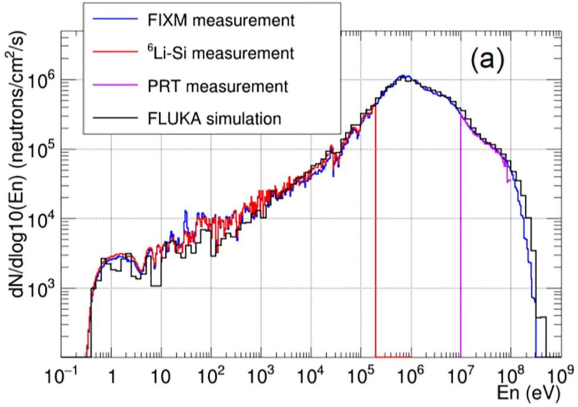
CSNS Beam Extension Application



Back-n white neutron source



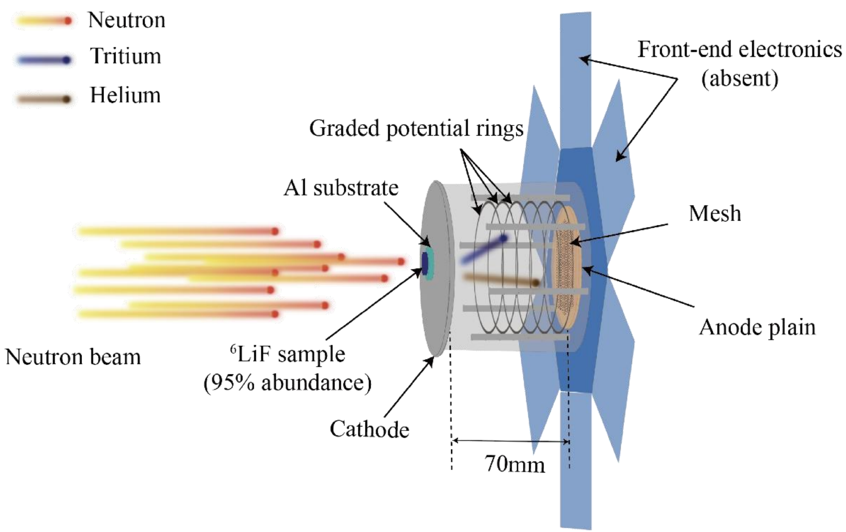


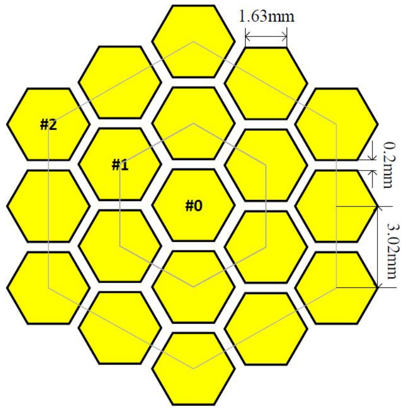
Shutter (mm)	Coll#1 (mm)	Coll#2 (mm)	ES#1 spot (mm)	ES#1 flux ($n/cm^2/s$)	ES#2 spot (mm)	ES#2 flux ($n/cm^2/s$)
Φ3	Φ15	Φ40	Φ15	1.27E5	Φ20	4.58E4
Φ12	Φ15	Φ40	Φ20	2.20E6	Φ30	7.81E5
Φ50	Φ50	Φ58	Φ50	4.33E7	Φ60	1.36E7
78×62	76×76	90×90	75×50	5.98E7	90×90	2.18E7

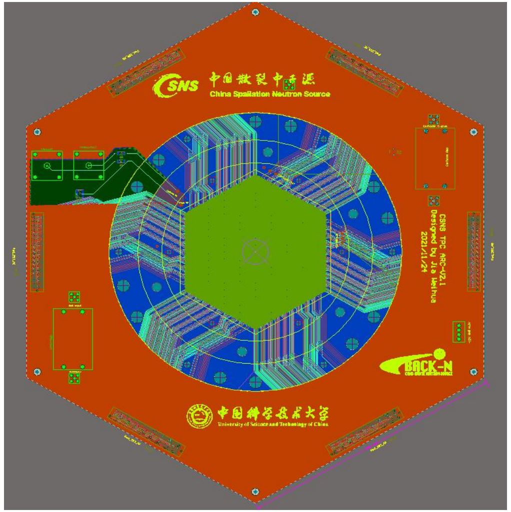
- *Neutron flux for different beamline setup at 100kW proton beam power*
- *Currently the proton beam power is 180kW*

- Back-n is a white neutron beamline with wide energy range and high flux
- Energy range： 0.5eV~300MeV
- Neutron flux： $10^7/cm^2/s$
- Research on neutron nuclear data measurements:
  - Total cross section
  - Fission cross section
  - Neutron capture cross section
  - Charged-particle emission reaction cross section

Multi-purpose TPC (MTPC) @ CSNS





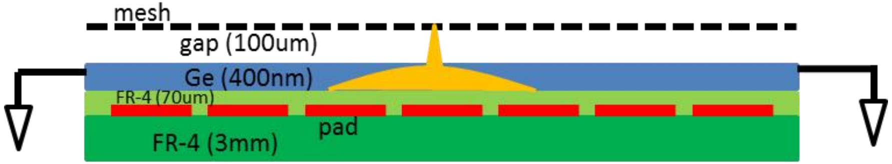


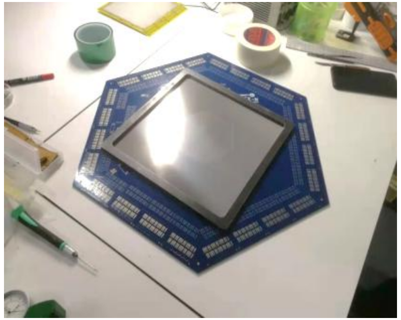
- The shape of the chamber is cylinder.
- The drift distance is adjustable to meet different experimental requirements.
- The Micromegas structure is used between Mesh and Anode to amplify electron signals.
- The readout array uses a hexagonal dense stacking structure.
- There are 1519 anode pads, each with a side length of 64 mil.
- The anode area is a hexagon with a side length of 68 mm.

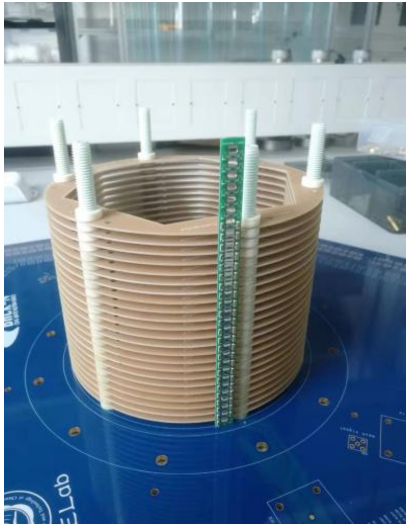
- Weihua Jia, You Lv, Zhiyong Zhang et al. Gap uniformity study of a resistive Micromegas for the Multi-purpose Time Projection Chamber (MTPC) at Back-n white neutron source. NIMA, 1039, 2022.
- Yang Li, Han Yi et al., Performance study of the Multi-purpose Time Projection Chamber (MTPC) using a four-component alpha source, Nuclear Instruments and Methods in Physics Research A 1060 (2024) 169045.

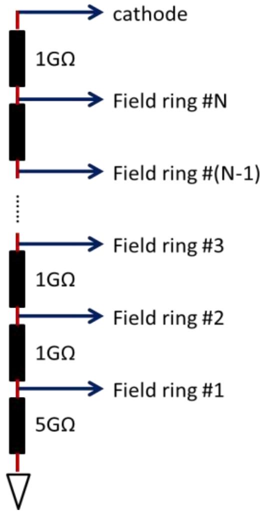
Detector Structure

- The Micromegas structure is manufactured by thermal bonding method.
- The gap between the mesh and anode is 100μm.
- The surface of the anode plate is plated with a 400nm-thick high-resistance germanium layer to increase stability under high voltage.
- Mesh parameters: stainless steel wire diameter 24μm, thickness 25μm, LPI-325
- The field cage is a stack of PCB rings to generate a uniform electric field.



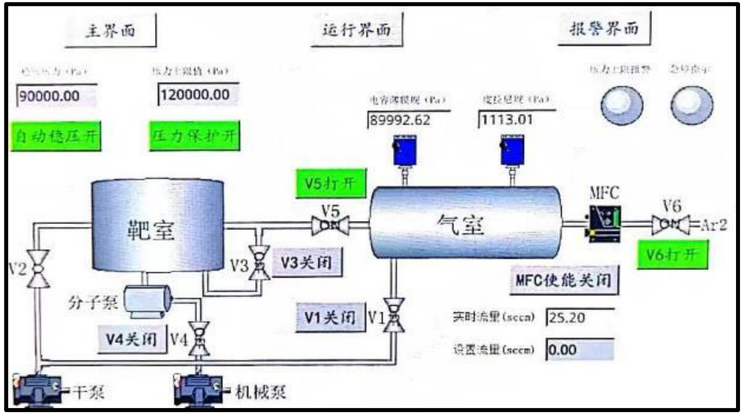






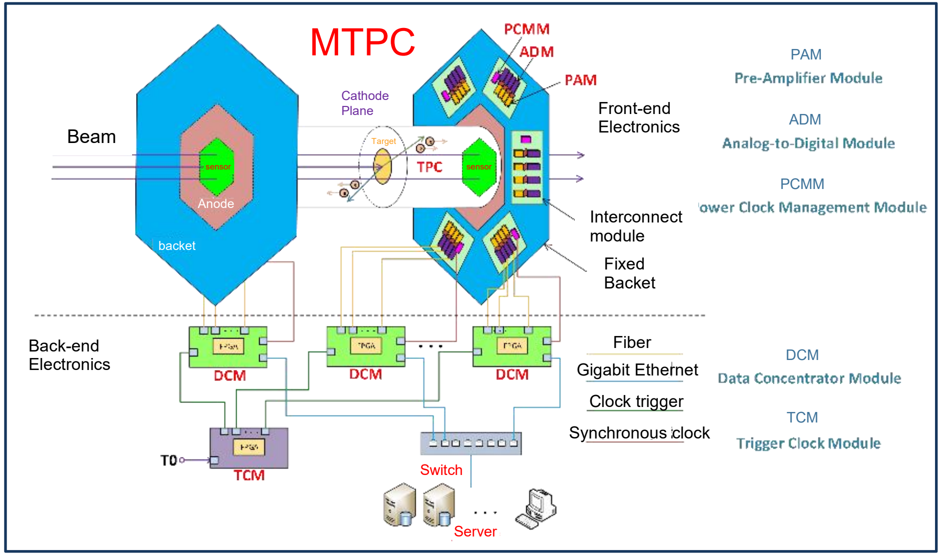
- J. Feng, Z. Zhang, J. Liu, B. Qi, A. Wang, M. Shao, Y. Zhou, A thermal bonding method for manufacturing micromegas detectors, Nucl. Instrum. Methods Phys. Res. A 989 (2021) 164958.
- J. Feng, Z. Zhang, J. Liu, M. Shao, Y. Zhou, A novel resistive anode using a germanium film for micromegas detectors, Nucl. Instrum. Methods Phys. Res. A 1031 (2022) 166595.

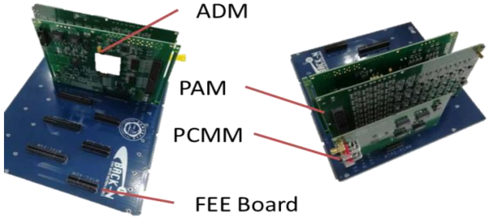
Gas Supply System



- The gas pressure range: 0 bar~5 bar.
- The pressure can be automatically stabilized by the control system.
- The gas mixer control the components proportion of working gas according to the gas flow.
- The detector gas flow is adjusted by the needle valve

Readout Electronics





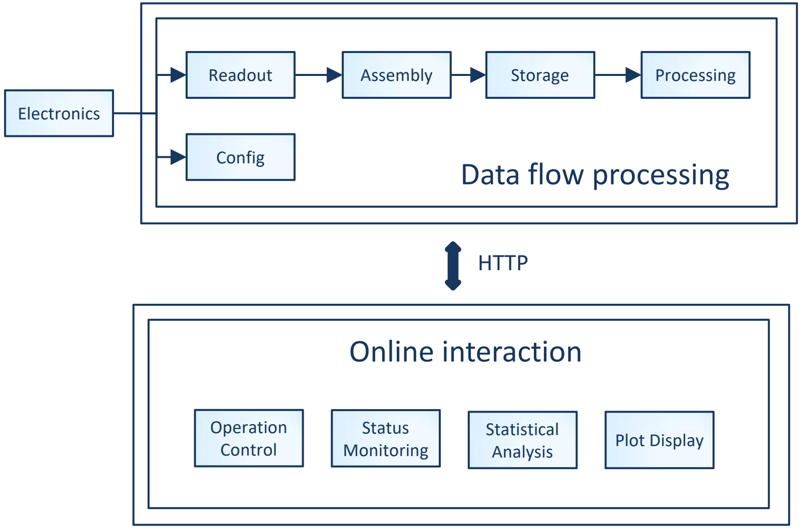
DCM

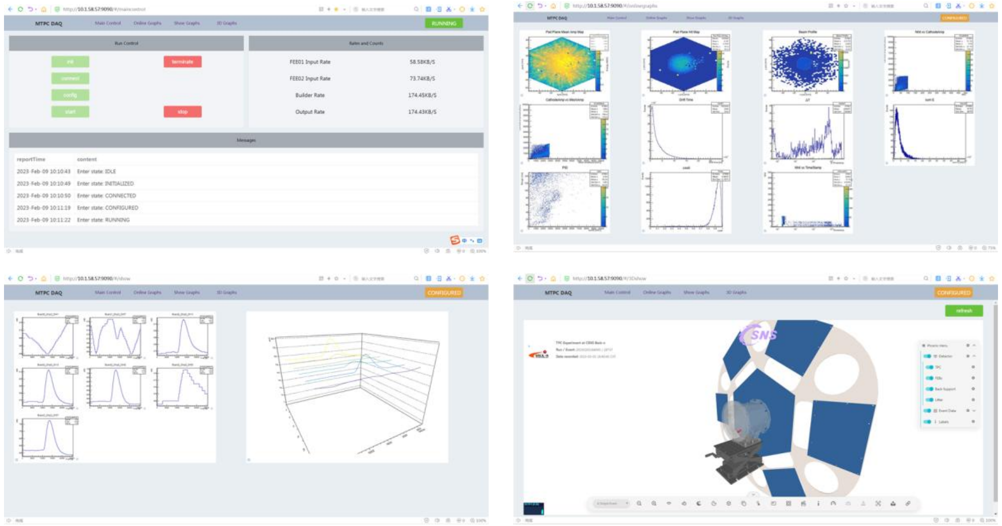
TCM

- Key parameters of the electronics system:
  - Total number of channels: 1536 (MTPC utilizes 1521 channels)
  - Sampling frequency: 40MHz
  - Sampling window width: 1024 sampling points (25.6 μs)
  - ADC resolution: 12 bit

- Z. Chen, C. Feng, H. Chen et al. Readout system for a prototype multi-purpose time projection chamber at CSNS Back-n. Journal of Instrumentation. 17, 2022.

DAQ Program & Online Display





Data Acquisition Program (DAQ core)

Responsible for collecting data:

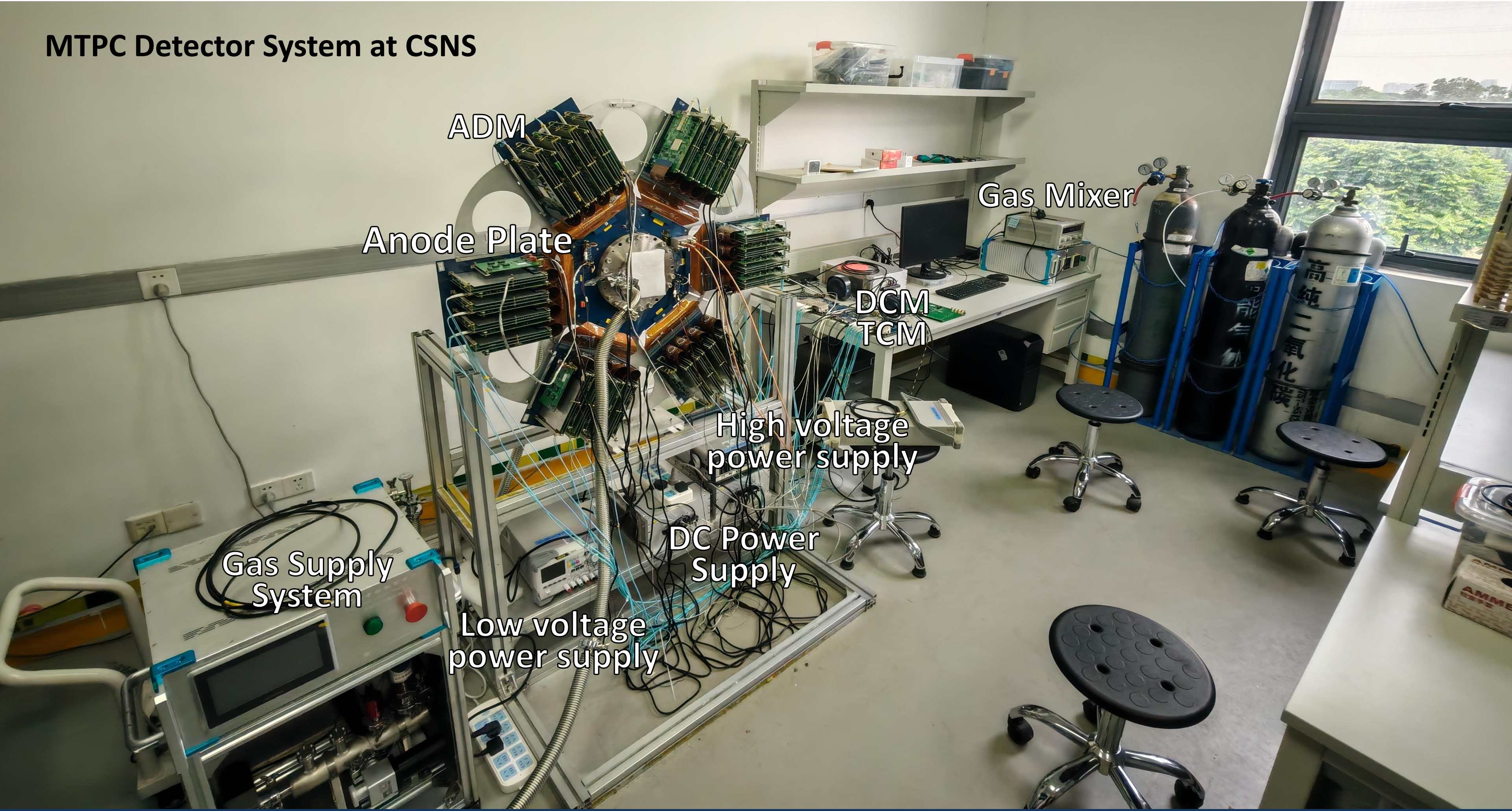
Data receiving, assembly, storage and processing

Online interactive interface

Provide user services upward: execution, feedback

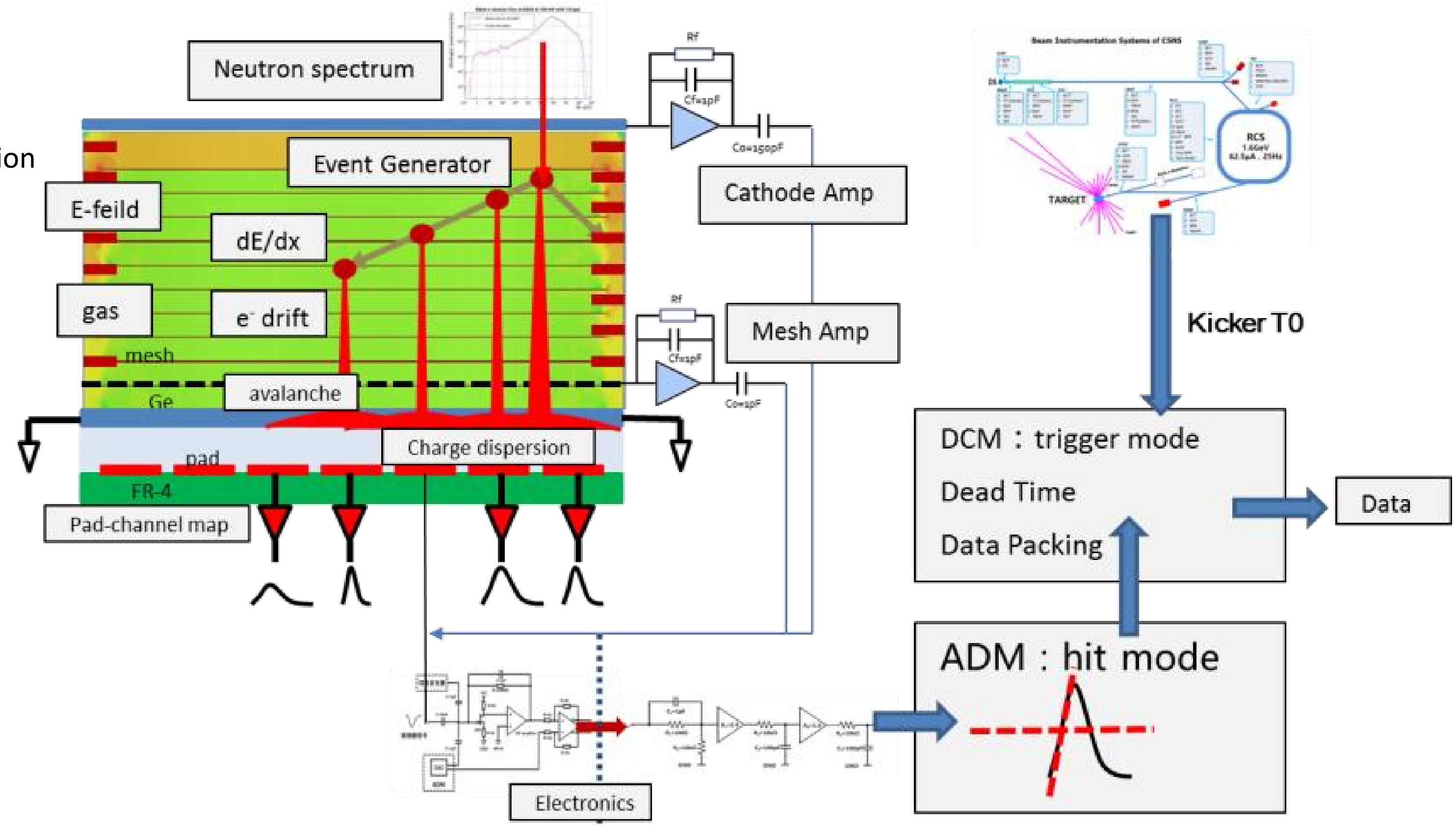
Transfer information downward with the data flow subsystem

MTPC Detector System at CSNS



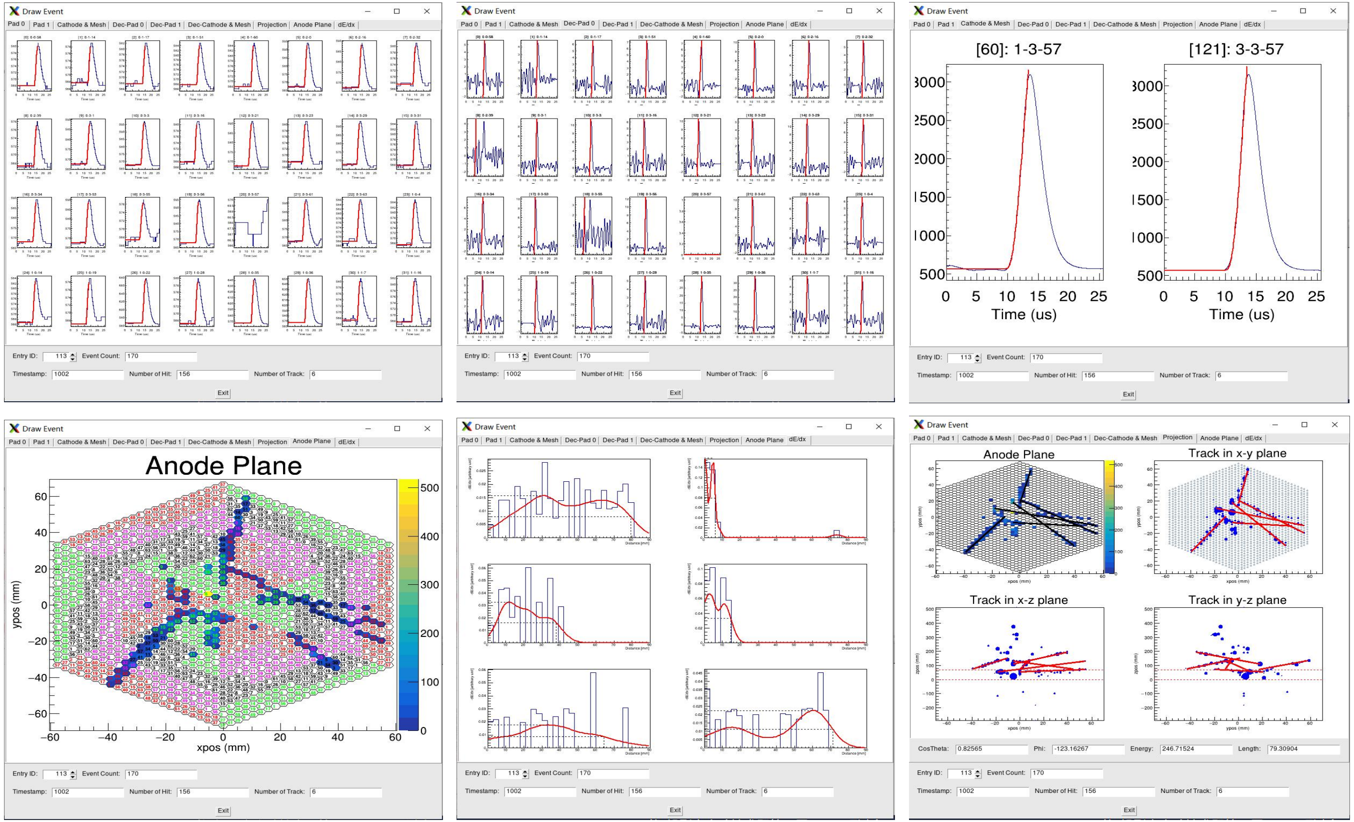
BLUET frame for MTPC simulation

- The simulation framework includes all physical processes
  - Gas parameters
  - Neutron spectrum
  - Event generator
  - Ionization process
  - Electron drift and diffusion
  - Electron avalanche
  - Charge dispersion
  - Electronics model
  - signal waveform
  - Hit and trigger



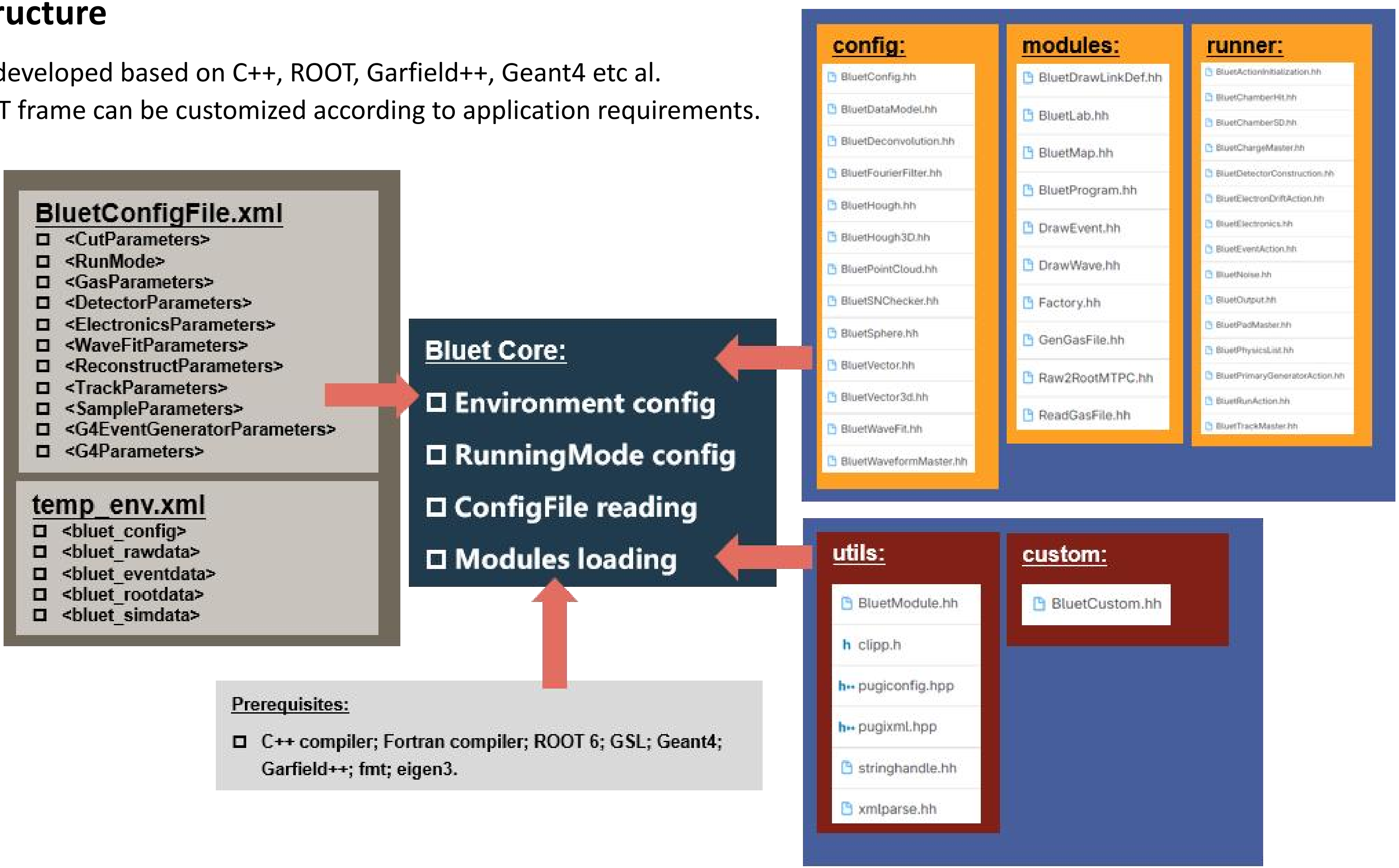
BLUET frame for MTPC data analysis

- User-friendly UI for data display and algorithm testing
- Modules: waveform display, waveform fitting & deconvolution, tracking, dE/dx display, 3D track display etc al.



BLUET structure

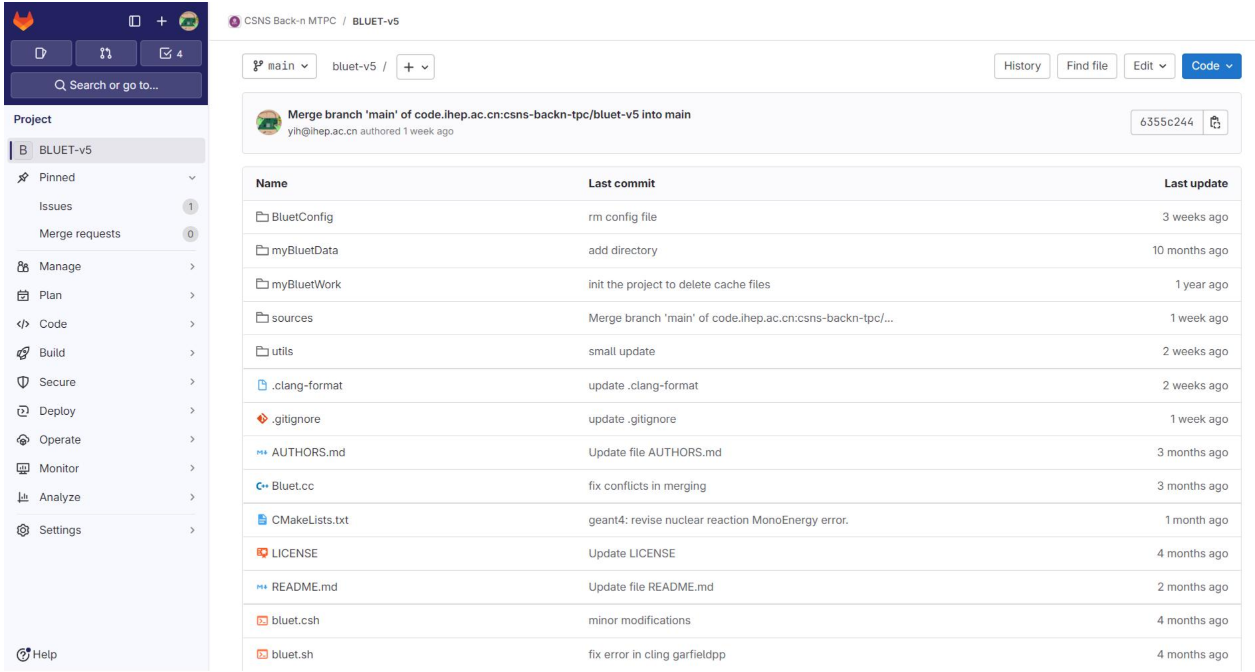
- BLUET is developed based on C++, ROOT, Garfield++, Geant4 etc al.
- The BLUET frame can be customized according to application requirements.



BLUET library on GitLab

- Open source library for TPC simulation and data analysis:
- **https://code.ihep.ac.cn/csns-backn-tpc/bluet-v5**

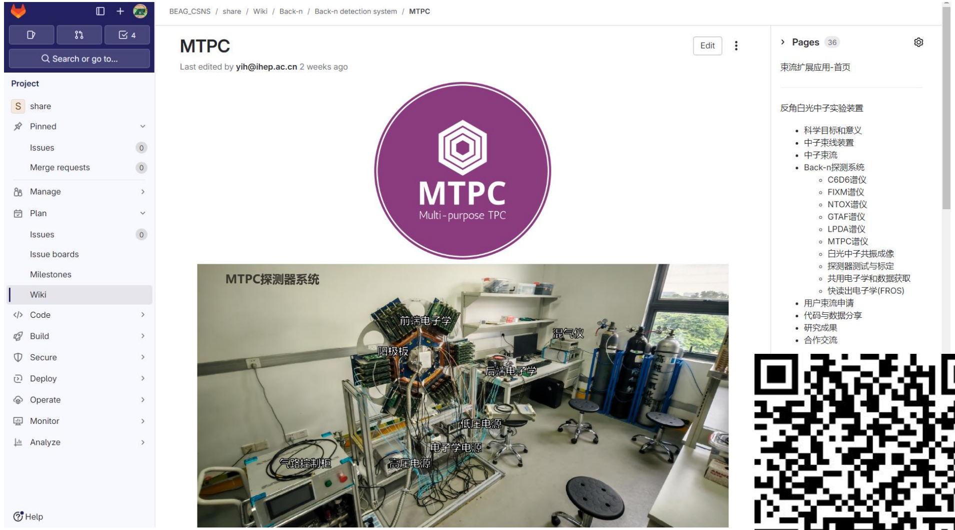
BLUET
bloom through the time



- More details of BLUET can be found in the following reports:
- **Hongkun Chen**: Measurement of the 6Li(n, t)4He Cross Section with Multi-purpose Time Projection Chamber at the Back-n White Neutron Source of CSNS
- **Haizheng Chen**: Multi-purpose Time Projection Chamber (MTPC) Signal Simulation Method and Experimental Verification

MTPC Collaboration

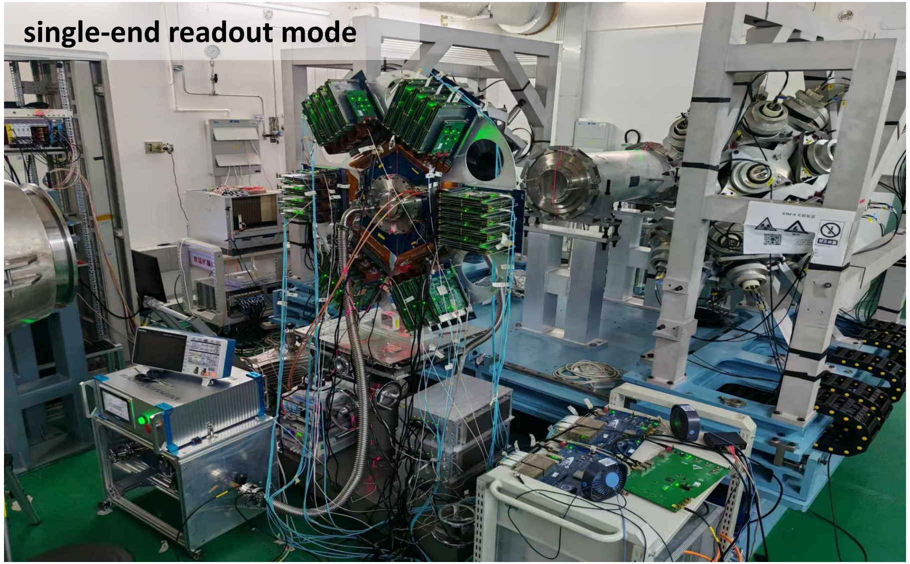
- **MTPC web based on GitLab Wiki**

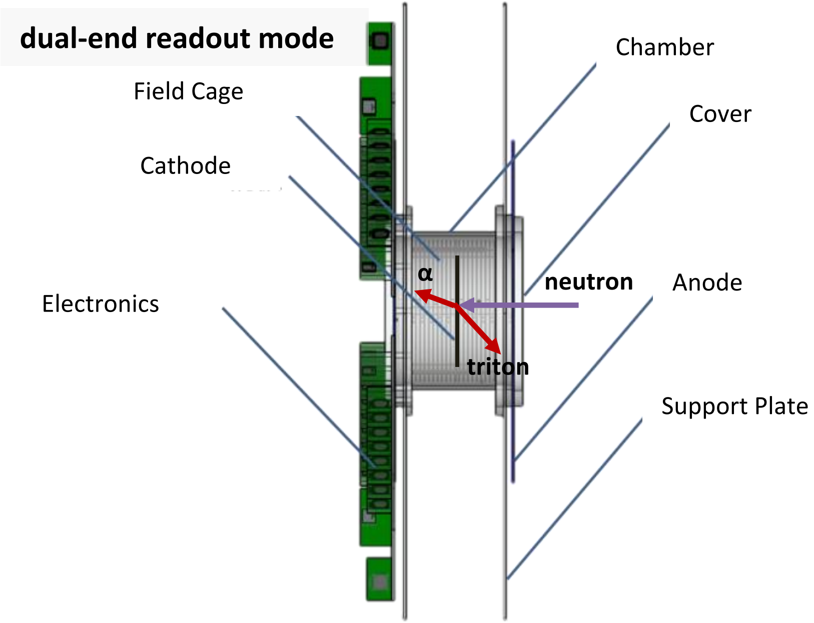


Contents

MTPC setup for measurement

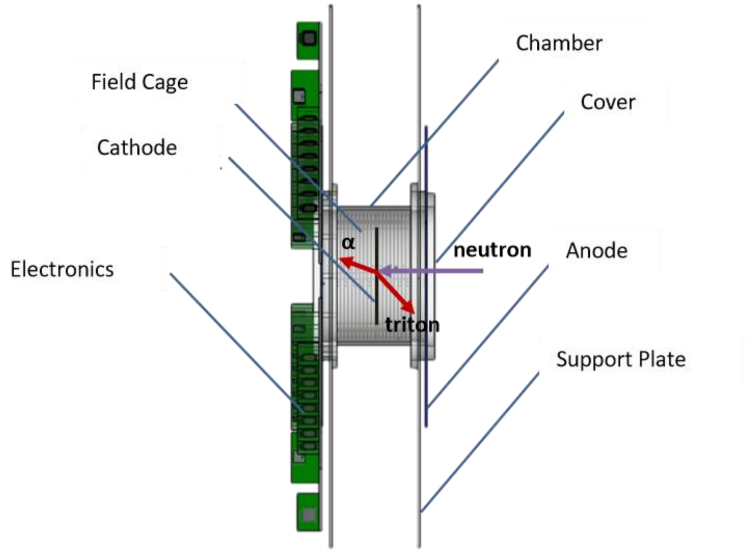
- The current working mode of MTPC is single-end readout mode.
- MTPC has been designed to accommodate a update to dual-end readout mode to meet the requirement of $^{7}Li(n, n't)\alpha$ reaction measurement.
- The dual-end readout mode provide a nearly 4π coverage to reconstruct the reaction kinetics.

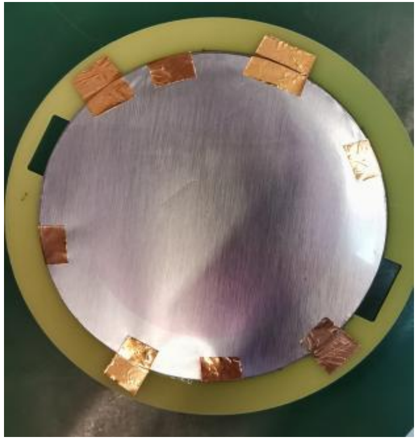


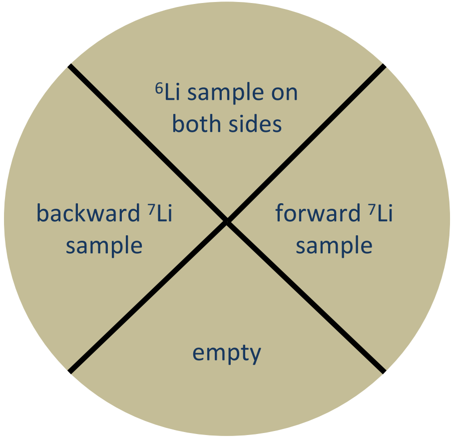


Setup of ^{7}Li sample

- The sample will be evaporated on a Aluminum substrate with a thickness less than 5 μm.
- The sample structure will be mounted on the center of cathode and segmented to 4 regions.
- The 7Li sample will be evaporated on the forward and backward side on different segmented region to realize reconstruction ^{7}Li(n, n’t)α reaction in 4π solid angle.
- The isotope abundance of ^{6}Li and ^{7}Li in the sample are higher than 90% and 99.9% respectively.

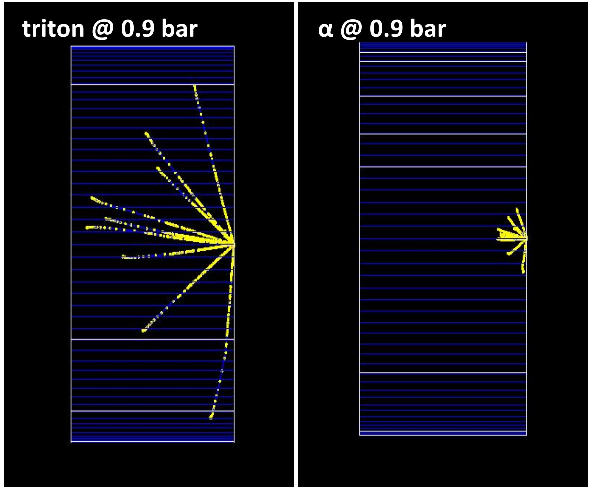


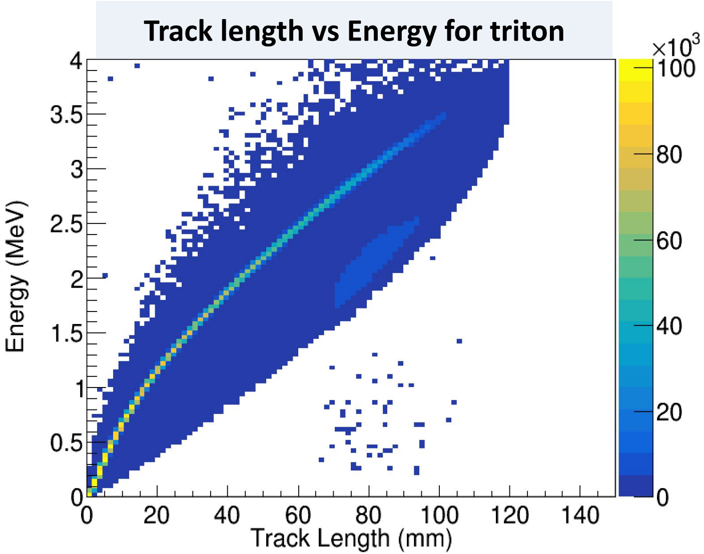




Chamber pressure setup

- Tritons and α-particles generated from three-body reaction have continuous energy distribution.
- The pressure of MTPC chamber should be divided into different ranges to cover the measurements requirements of different energy particles.

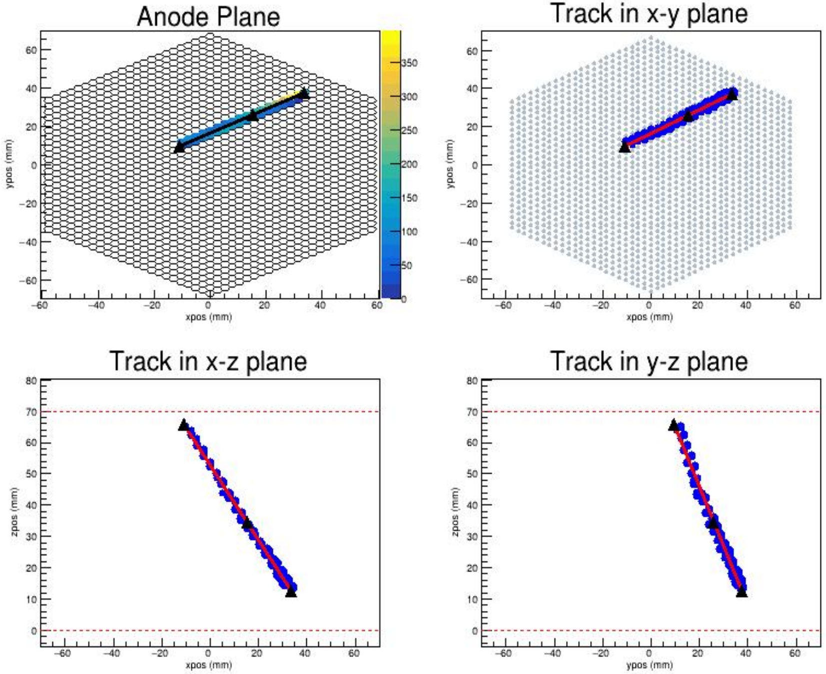




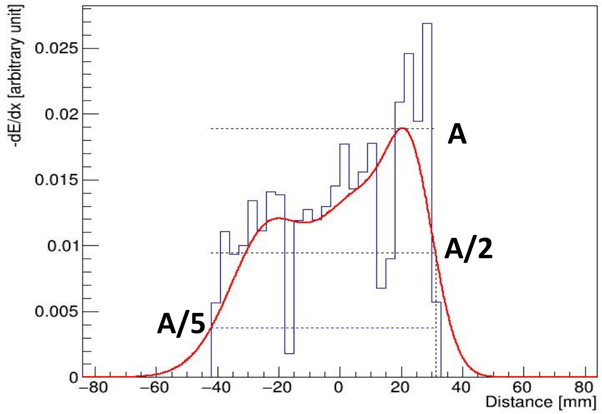
pressure	0.1 bar	0.9 bar	3.6 bar
α energy	0.5~2 MeV	2~5MeV	5~15MeV
triton energy	0.2~0.8MeV	0.8~3.5 MeV	3.5~12 MeV

Particle identification

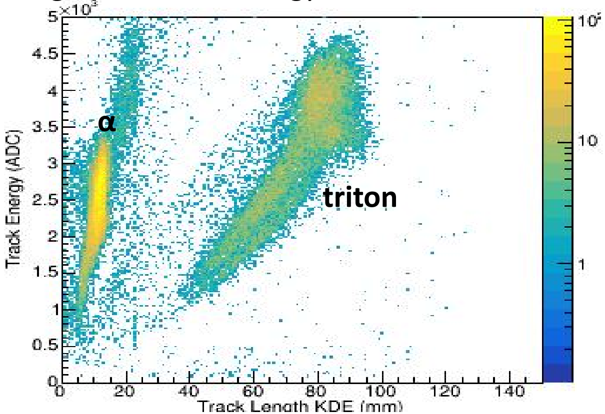
- The identification of proton, triton, α-particle and other particles can be realized with the PID capability of MTPC.
- Multi-parameter analysis can be applied in the process of PID:
  - Track length, Track energy, dE/dx distribution



- KDE smoothing is utilized to get the profile of the dE/dx distribution and the track length is reduced from the profile.

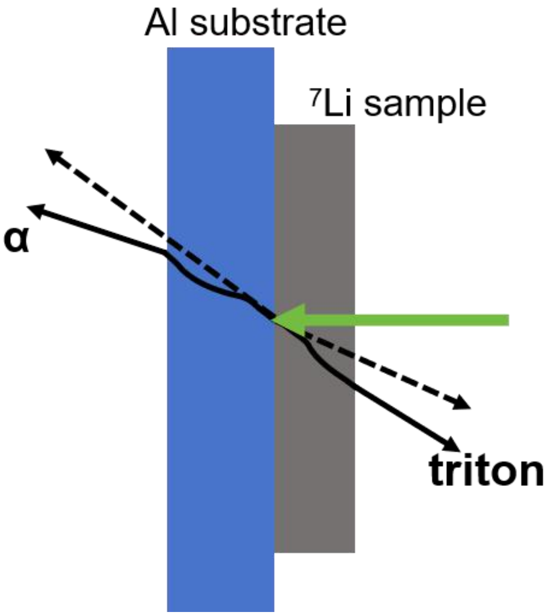


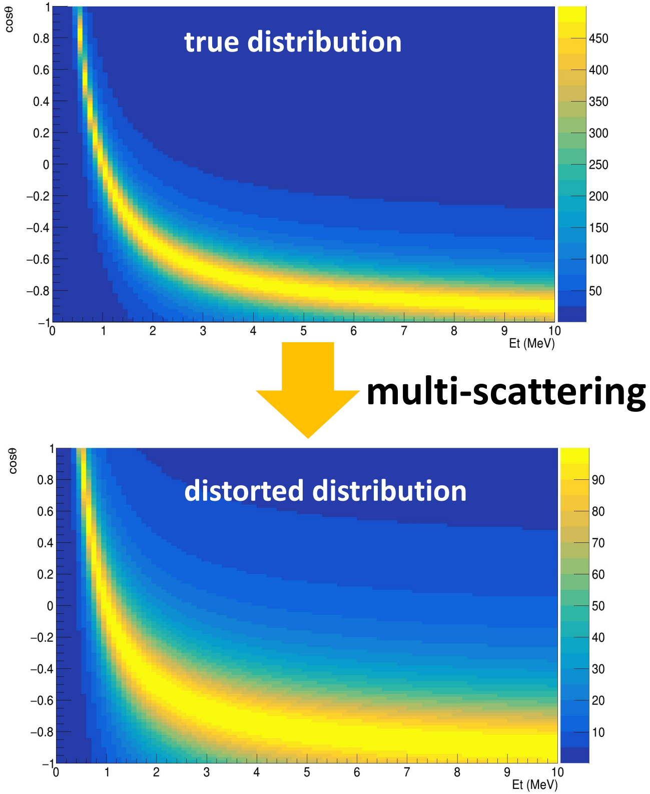
- Primary PID can be done from the correlation between Track length and Track energy.



Correction of double-differential cross sections

- The emitted low-energy particles in the three-body reaction will suffer multi-scattering in the substrate and sample.
- The distortions in the energy and angular correlation should be corrected to get precise double-diffrential cross sections data.

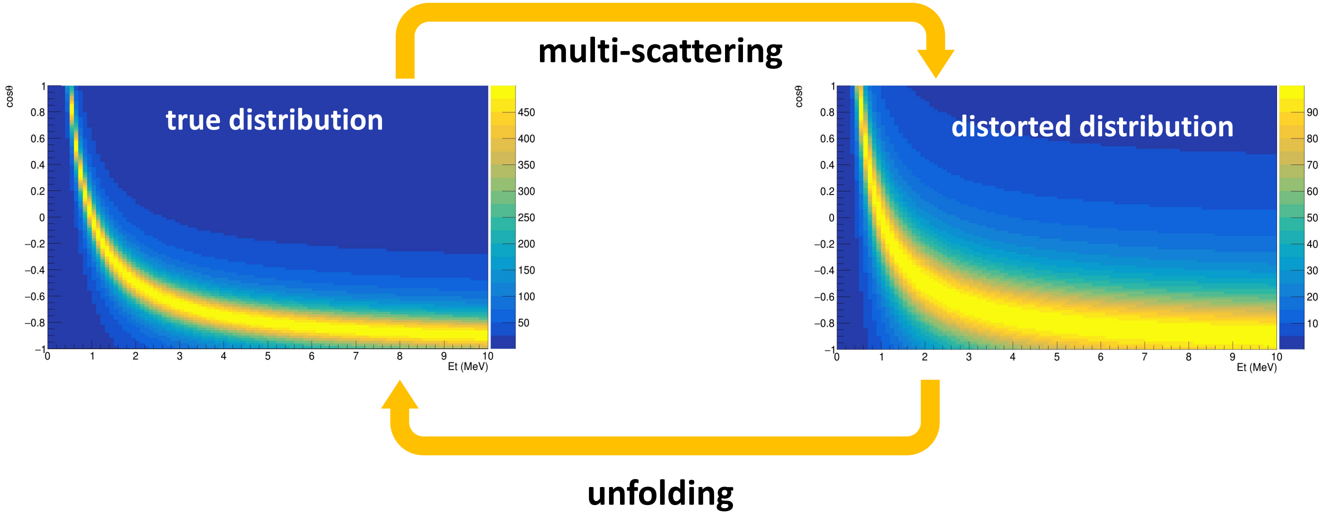




Correction of double-differential distributions

- The distortion in the energy and angular correlation can be described by the error response function.
- $F(r)$: true distribution
- $F'(\mathrm{r})$: measured distribution
- $R(r_0, r')$: error respinse function
- Unfolding method will be applied to get the corrected distribution

$$F'(\boldsymbol{r}) = \iint_S F(\boldsymbol{r_0})R(\boldsymbol{r_0}, \boldsymbol{r}-\boldsymbol{r_0})dx_0dy_0 = F(\boldsymbol{r_0})\otimes R(\boldsymbol{r_0}, \boldsymbol{r}')$$



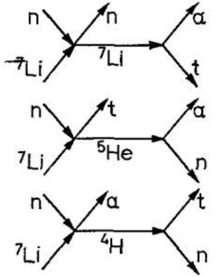
■ H. Yi et al., Double-bunch unfolding methods for the Back-n white neutron source at CSNS, 2020 JINST 15 P03026.

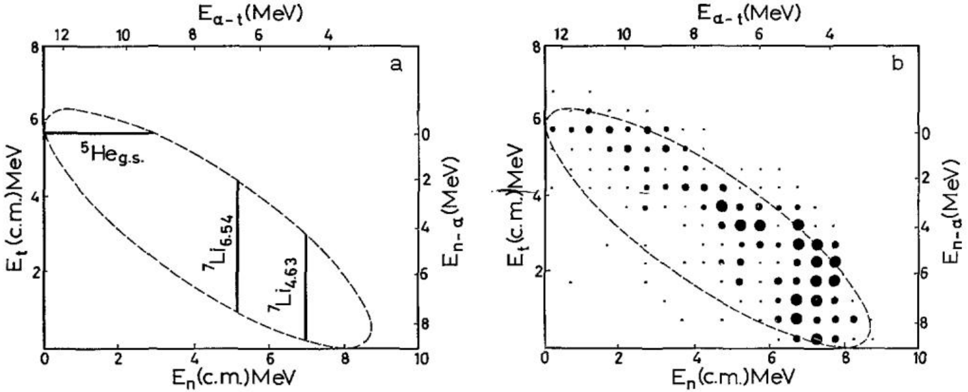
Reconstruction of reaction kinetics

- Identification of the intermediate process is valuable for the research of reaction model.
- Dalitz plot is a powerful tool for resonance state reconstruction in nuclear and particle physics.
- The ^7Li, ^5He or ^4H intermediate state can be identified as the events concentrated in the specific region on the correlation between secondary particles in the C.M. frame.

$$n + {}^7Li \longrightarrow n + \alpha + t$$

$E_n = 14.4$ MeV

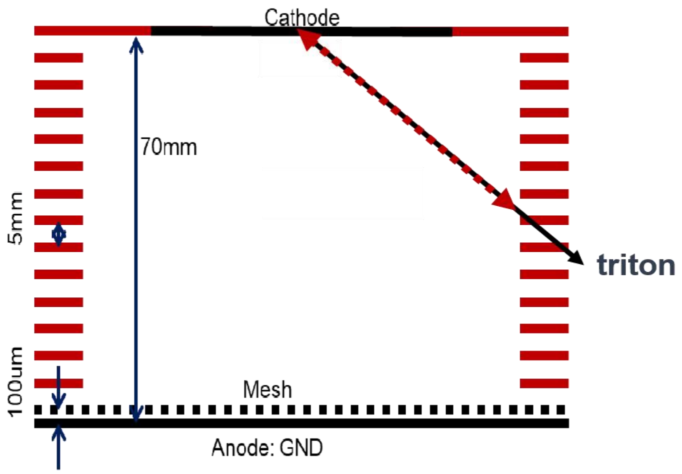


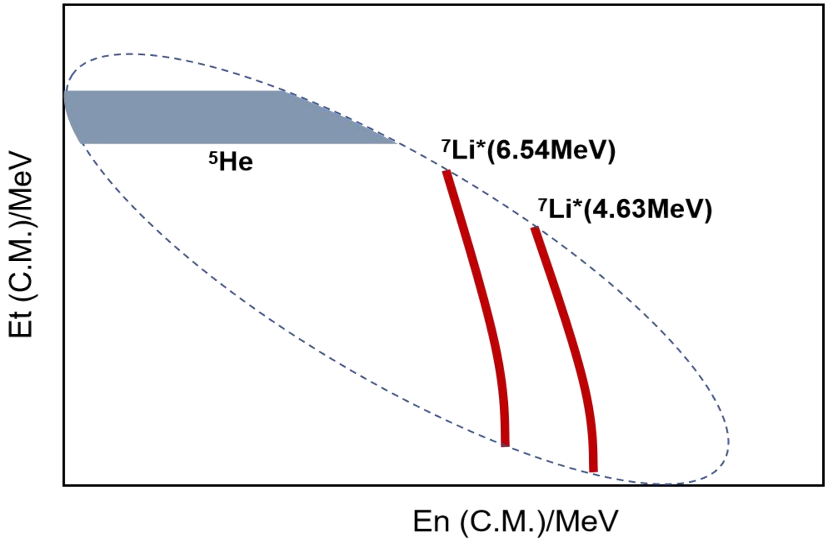


B. Antolković, Correlation measurements of neutron-induced multiparticle reactions in nuclear emulsions, Nuclear Instruments and Methods, Volume 100, Issue 2, 15 April 1972, Pages 211-216.

Reconstruction of reaction kinetics

- There will be deviation between the measured Dalitz plot and the ideal one because of the incomplete energy measurement of the long-range particles.
- The identification of the deviated Dalitz plot will be processed with the combination of the simulation results.





Contents

Summary

- MTPC has the capability to measure complex reactions induced by neutrons.
- Neutron induced triton-producing reactions of ^{7}Li is scheduled to be measured with the application of MTPC at CSNS Back-n.
- The work of dual-end readout update is ongoing and will last in the next few years.

reaction type	reaction channel	MTPC mode	progress
Standard cross sections	$^{6}Li(n,t)$	single-end	conducted (2023)
	$H(n,n)$	single-end	conducted (2024)
	$^{235}U(n,f)$	single-end	conducted (2024)
	$^{10}B(n,\alpha)$	single-end	plan
Astrophysics	$^{17}O(n,\alpha)$	single-end	conducted (2024)
	$^{25}Mg(n,\alpha)$	single-end	plan
Three-body reactions	**$n + {}^{7}Li \rightarrow t + n + \alpha$**	**dual-end**	**plan (2027)**

We are looking forward more peers to join MTPC Collaboration!

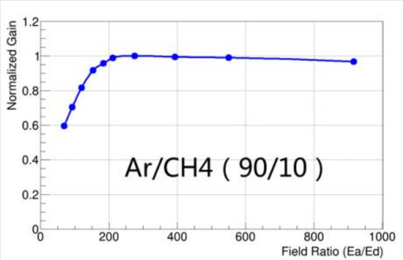
Thank you!

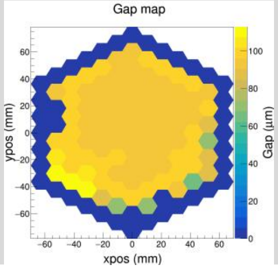
yih@ihep.ac.cn

Backup

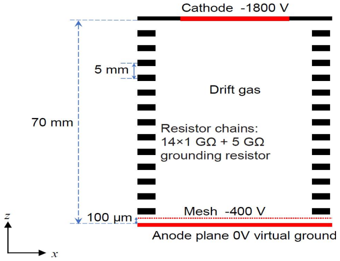
Detector Testing

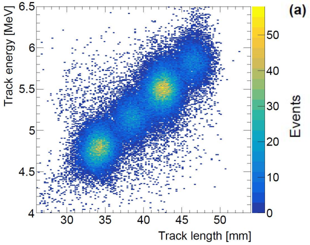
- X-ray test：
  - Electron transmission rate
  - Gain curve
  - Gap uniformity

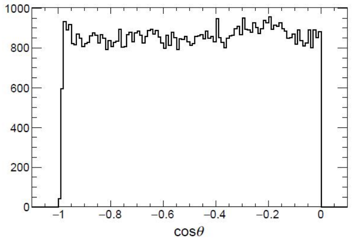




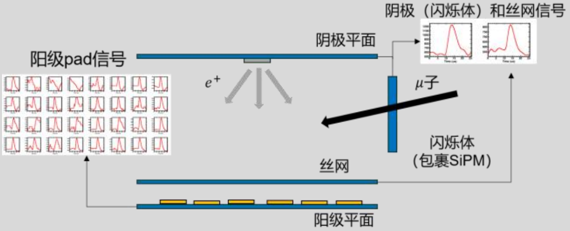
- α radiation source test：
  - Energy resolution
  - Drift velocity
  - Angular distribution

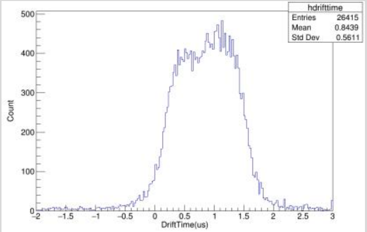






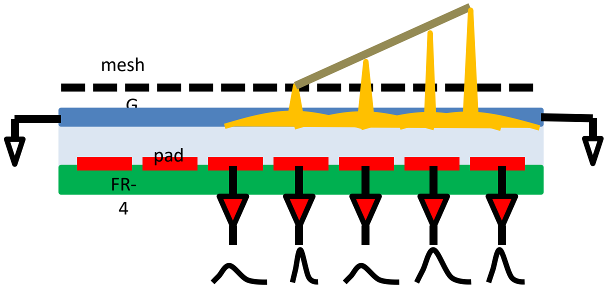
- Cosmic ray test:
  - Drift time distribution
  - Spatial resolution
  - Electric field uniformity



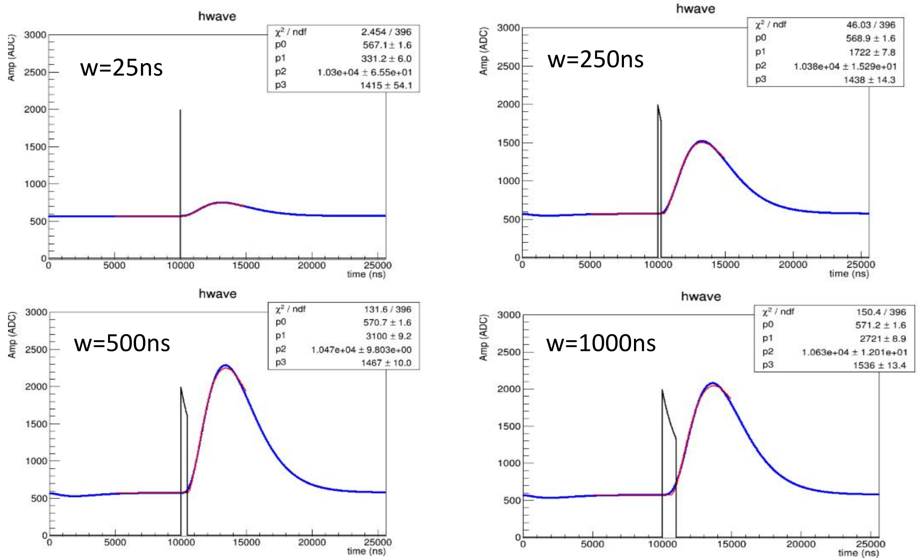


Waveform Fitting Algorithm

- Electronic Transfer Function： $f(t) = B + A\left(\frac{t-t_0}{\tau}\right)^n e^{-(t-t_0)/\tau}$
- The original signal widths of different angle tracks are inconsistent, and the actual waveform differs from the function form.
- Set n=2 for fitting. As the original waveform width w increases, the starting timing of the fitting will be delayed.
- Improve the timing accuracy through waveform inversion

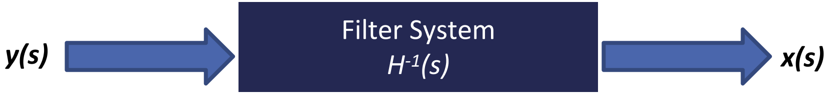


w(ns)	25	250	500	1000
t0(ns)	10300	10380	10470	10630

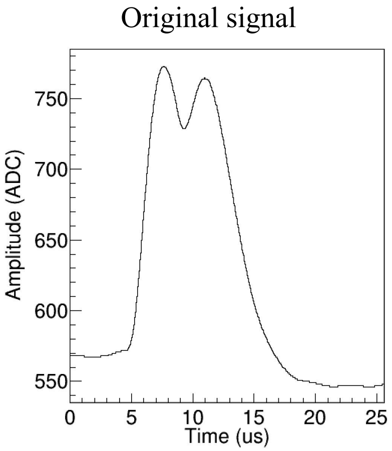


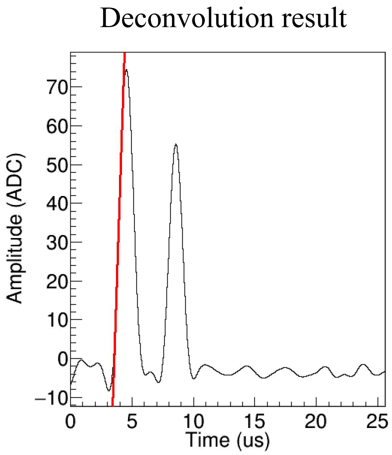
Waveform Deconvolution Algorithm

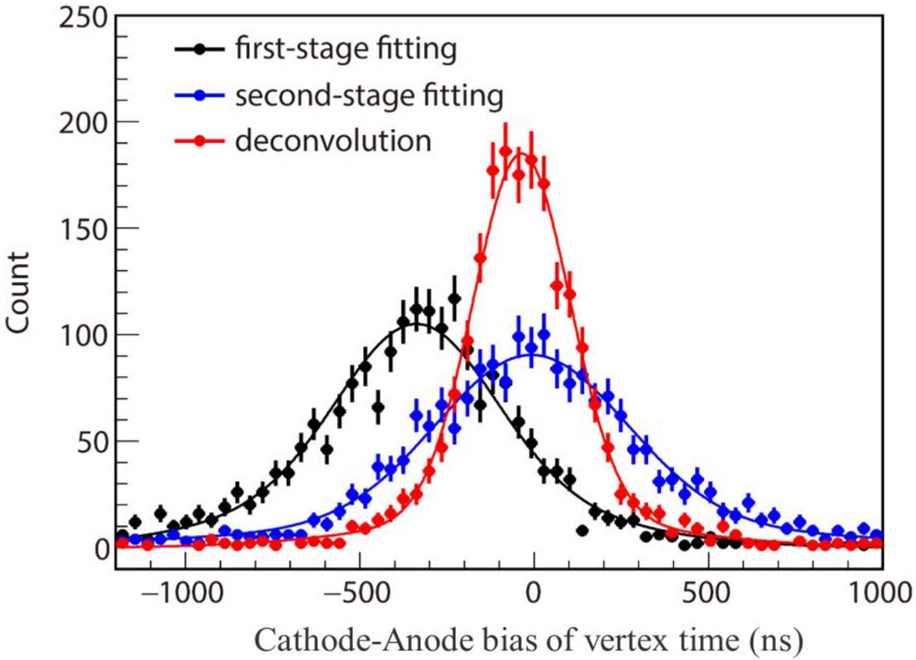
- To improve the time resolution and multi-event resolution capabilities, deconvolution is used here to get the original current signal.
- Starting time is determined by fitting the rising edge.



$$\boldsymbol{x}(\boldsymbol{s}) = \boldsymbol{H}^{-1}(\boldsymbol{s})\boldsymbol{y}(\boldsymbol{s})$$

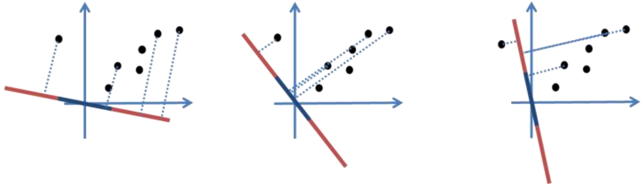


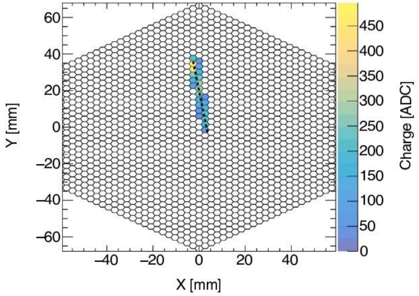




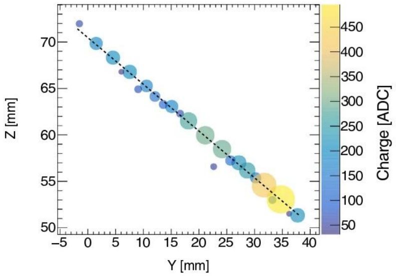
Track Reconstruction

- Track search：
  - Find the maximum value in Hough space, and the points falling in the maximum value bin are considered to belong to a straight line;
- Track length：
  - Project the reconstructed track to the track direction to obtain the dE/dx distribution
  - Use the KDE algorithm to smooth the dE/dx distribution
  - Take the particle range from the starting point of the track to the point corresponding to Qmax/λ, λ=2

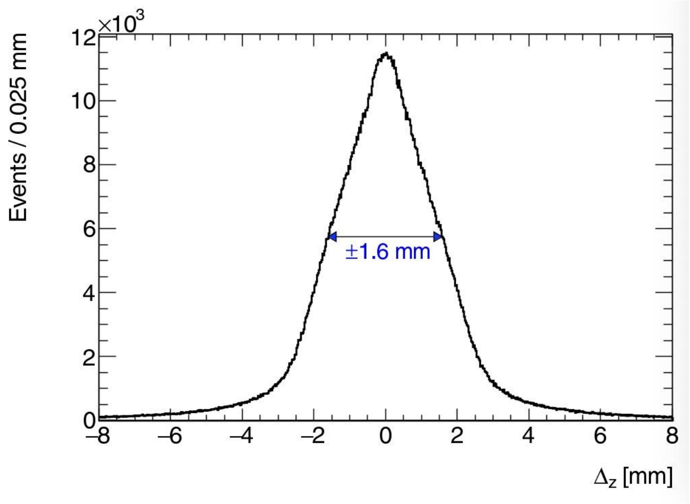




X-Y Track reconstruction



X-Z Track reconstruction

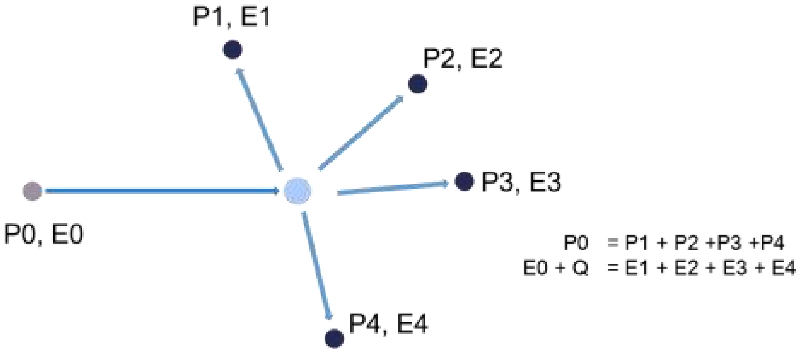


Track reconstruction resolution

Physics model: Event generator

For nuclear reaction mode:

- Use TGenPhaseSpace (ROOT) to determine the parameters of primary particles.
- Set the initial state particles and final state particles, randomly generate the particle phase space parameters according to the uniform distribution of the center of mass system, and the physical quantity is expressed as the Lorentz four-vector
- Input parameters to Geant4: Particle type, energy, direction and position.

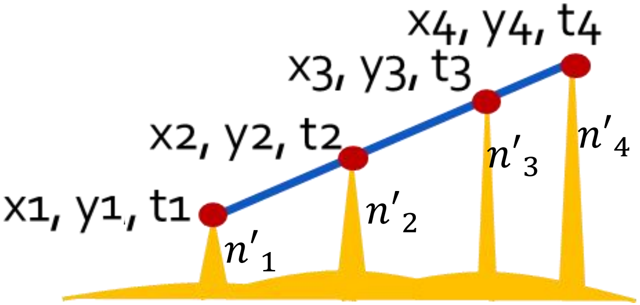


Particle ionization process

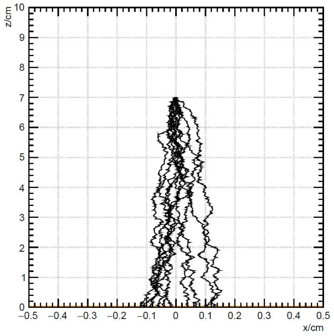
- Geant4 is used here to get the distribution of energy deposition

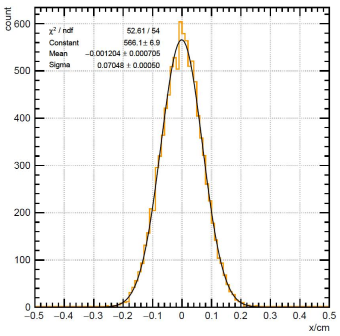
> G4double edep = step->GetTotalEnergyDeposit() - step->GetNonIonizingEnergyDeposit()

- The number of ionized electrons generated by each hit $n = E_{dep}/I$
- The actual number of ionized electrons for each hit is obtained by approximate random sampling according to the Poisson distribution with a mean of n, $n' = P(n)$
- For n' electrons, diffuse sampling is performed on each electron separately to obtain the final drift position and drift time of each electron



Electron drift and avalanche





- Garfield++ is used to simulate transport parameters.
- Horizontal diffusion： $\sigma_T = \sqrt{d_t z}$
- Vertical diffusion： $\sigma'_L = \sigma_L \Big/ v = \sqrt{d_l z}/v$

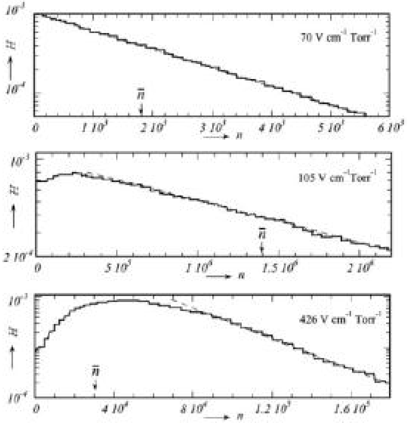
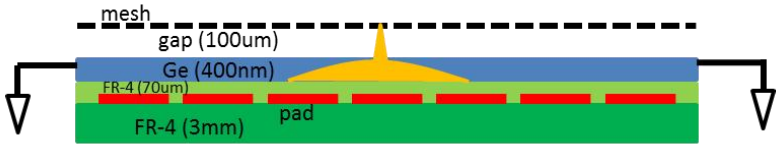


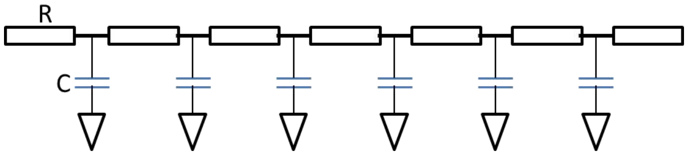
Figure 5.30 Evolution of the avalanche size from exponential to a Polya distribution at increasing values of field (Schlumbohm, 1958). By kind permission of Springer Science+Business Media.

- According to the gas avalanche theory, the number of electrons after the avalanche at low gain: $P(n) = e^{-n/G}$
- Assume that there is no spatial diffusion after the electron avalanche, and the coordinates are the same as the original electrons.
- At high gain, the single electron gain conforms to the Polya distribution (to be implemented)

Charge dispersion in the resistive Ge-layer

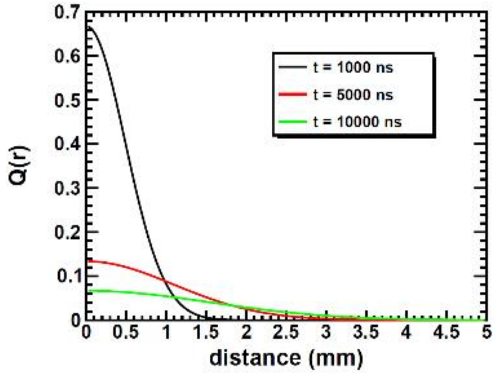
- The charges generated by the avalanche are deposited on the resistive germanium layer and disperses to the surrounding area.
- The signals with small amplitude and shorter rising time are also generated on the pad near the center of the avalanche.
- The signals generated by the charge diffusion depend on the surface resistance of the resistive layer and the coupling capacitance between the resistive layer and the pad layer.





$$\rho(x,y,t) = \left(\frac{1}{2\sqrt{\pi tRC}}\right)^2 exp[-(x^2+y^2)/4tRC]$$

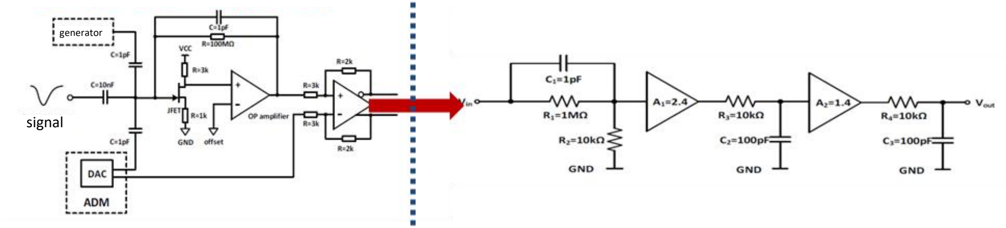
- Charge dispersion is Gaussian, $\sigma = \sqrt{\frac{2t}{RC}}$
- As time increases, σ increases



Electronics Signal Convolution

Charge Sensitive Preamplifier

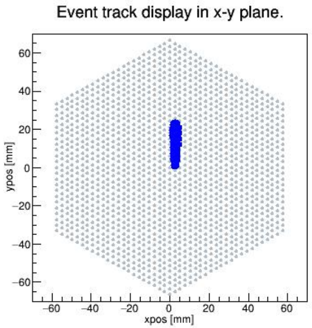
FPGA Waveform Processing: PZ-RC1-RC2

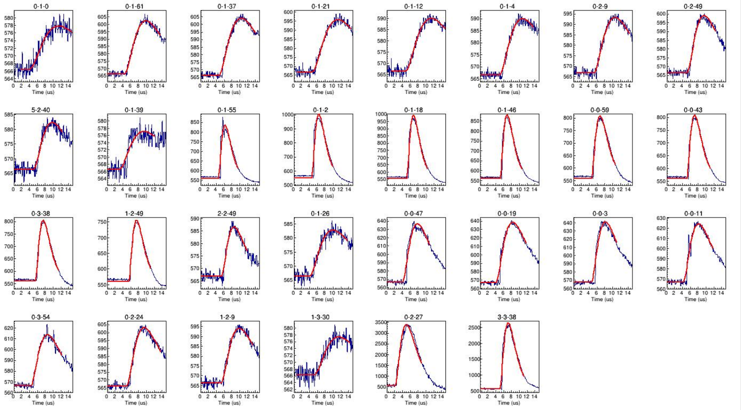


$$\boldsymbol{y(s) = H(s)x(s)}$$

- **Q(t) is used as input signal :**
- Pre-amplifier: $H(t) = 1/C_0\left(-\frac{e^{-\frac{t}{\tau_0}}}{\tau_0} + \frac{e^{-\frac{t}{\tau_r}}}{\tau_r}\right)$
  - $\tau_0 = RC$, integration time; τ_r signal rising time.
- PZ: $H(t) = \delta(t) + 1/\tau_0\left(1 - \frac{\tau_0}{\tau_1}\right)e^{-t/\tau_1}$
  - $\tau_1 = R_2C_1$
- RC: $H(t) = 1/\tau_1 e^{-1/\tau_1}$

Simulated alpha particle events and waveforms





Simulation framework

- **Garfield++ module**
  GenGasFile
  ReadGasFile

<gas_pars>

<u>BluetConfigFile.cfg</u>
<Det_pars>
<Gas_pars>
<EveGen_pars>
<Trking_pars>
<PID_pars>
……

import <pars>

<u>Singleton: BluetConfig</u>
Private:
 <pars_0>
 <pars_1>
 ……
Public:
 ReadConfigFile()
 GetXXXPars()

call GetXXXPars()

<u>Bluet G4 App:</u>
- BluetRunAction
- BluetEventAction
- BluetDetectorConstruction
- **BluetPrimaryGeneratorAction**
- **BluetElectronAction**

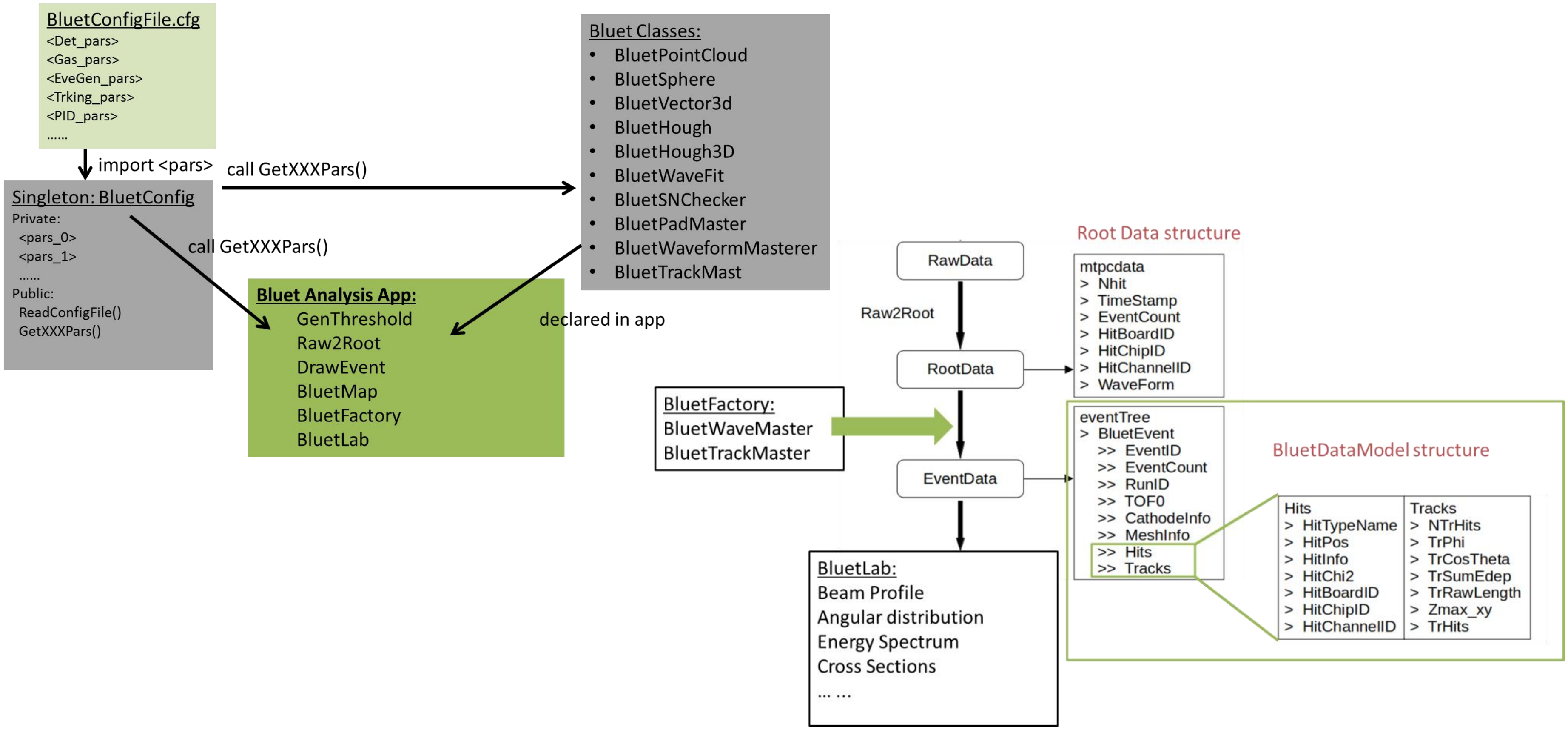
Neutron Energy Spectrum
Gamma Energy Spectrum
Source Particle Energy Spectrum

import

- **BluetPrimaryGeneratorAction**
  Reaction Mode
  Radiation Mode
  Gamma and Neutron Beam Mode
  Fixed Target Mode
  Active Target Mode

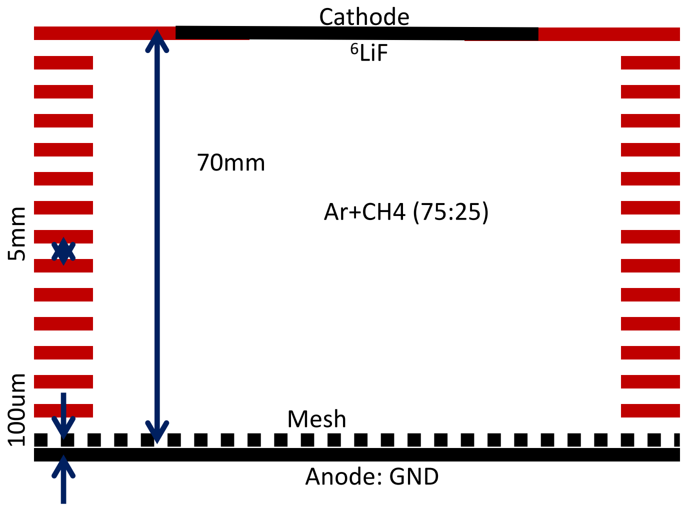
- **BluetElectronAction**
  - electron Drift
  - charge Avalanche
  - charge dispersion (BluetChargeMaster)
  - signal shaping (BluetElectronics)
  - date packing (BluetPadMaster, BluetModule)

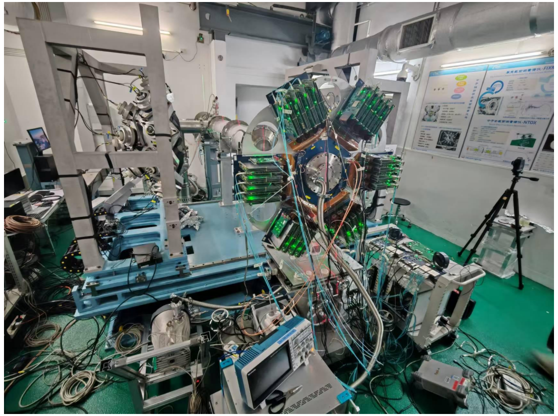
Analysis framework

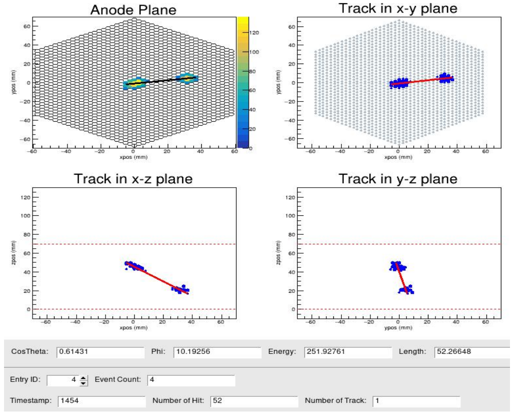


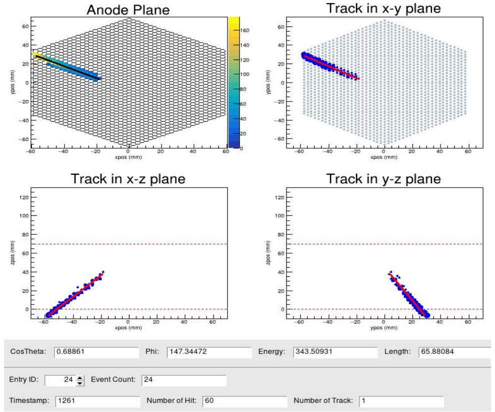
H(n,n) (Oct. 2024, in progress)

- Neutron energy range: 100keV-500keV
- Drift length: 70mm
- Working gas is 75% Ar + 25% CH_4 mixed gas, with H as the target nucleus
- A ^{6}LiF sample is placed in the center of the cathode as a standard sample for detector parameter inspection



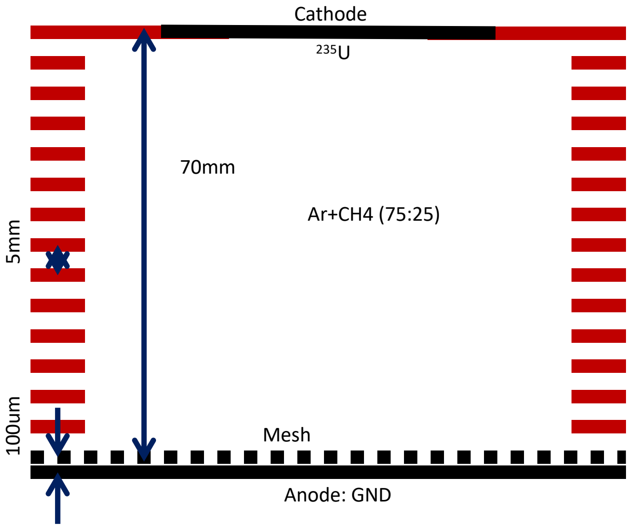


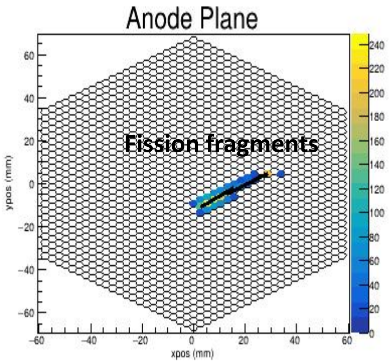


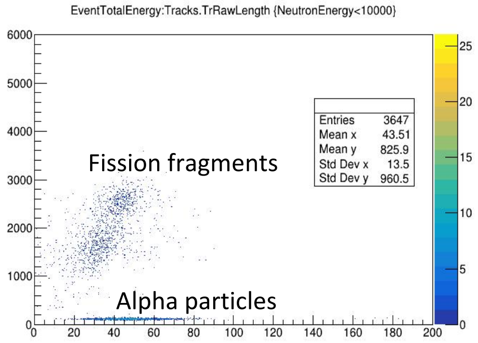


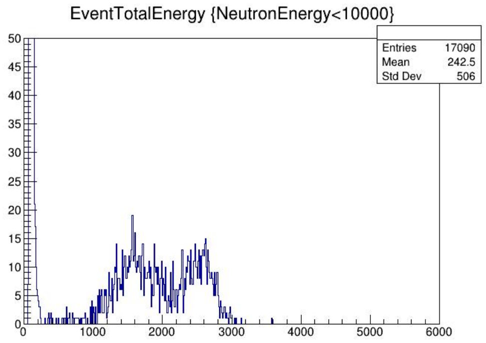
^{235}U(n,f) (Oct. 2024, in progress)

- Use 0.6 bar and low voltage on Mesh to reduce avalanche gain to reduce alpha particle interference and achieve high-precision measurement



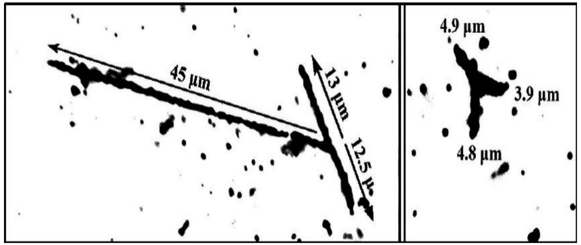


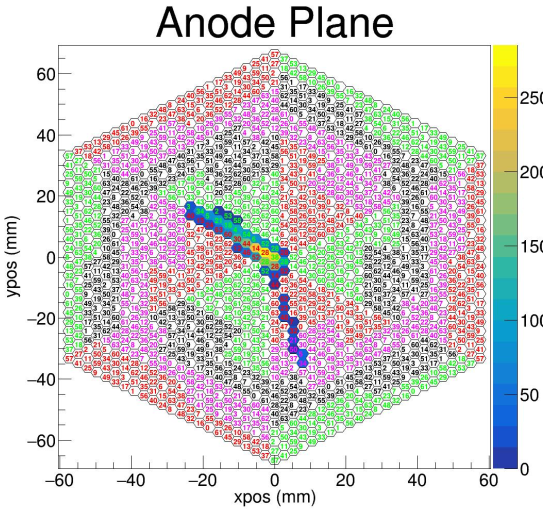


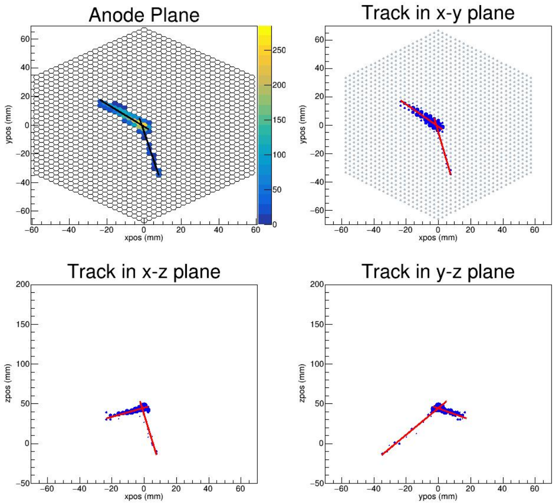


Date 2024-09-29: ^{252}Cf ternary fission measurement in laboratory

- Drift length: 70mm
- Working gas is 75% Ar + 25% CH_4 mixed gas
- High voltage setting: Mesh 270V, Cathode 800V.

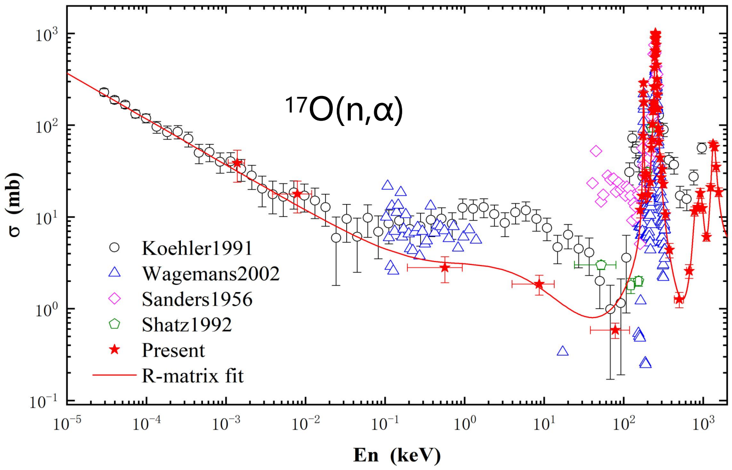






Nuclear physics frontier challenges

- **$^{17}O(n,\alpha)$**
- Existing experiments: $W^{17}O_3$ target + Si/SiC detector array
- Experimental shortcomings: SiC detector has a small receiving solid angle
- The cross section of the key energy region is about an order of magnitude lower than the predicted results
- The cross section measurement is expected to use TPC to solve this problem
- Further attempt to measure the reaction of $^{25}Mg(n,\alpha)$



Reaction	Time
$^{17}O(n,\alpha)$	Oct. 2024 (in progress)
$^{25}Mg(n,\alpha)$	2025-2027