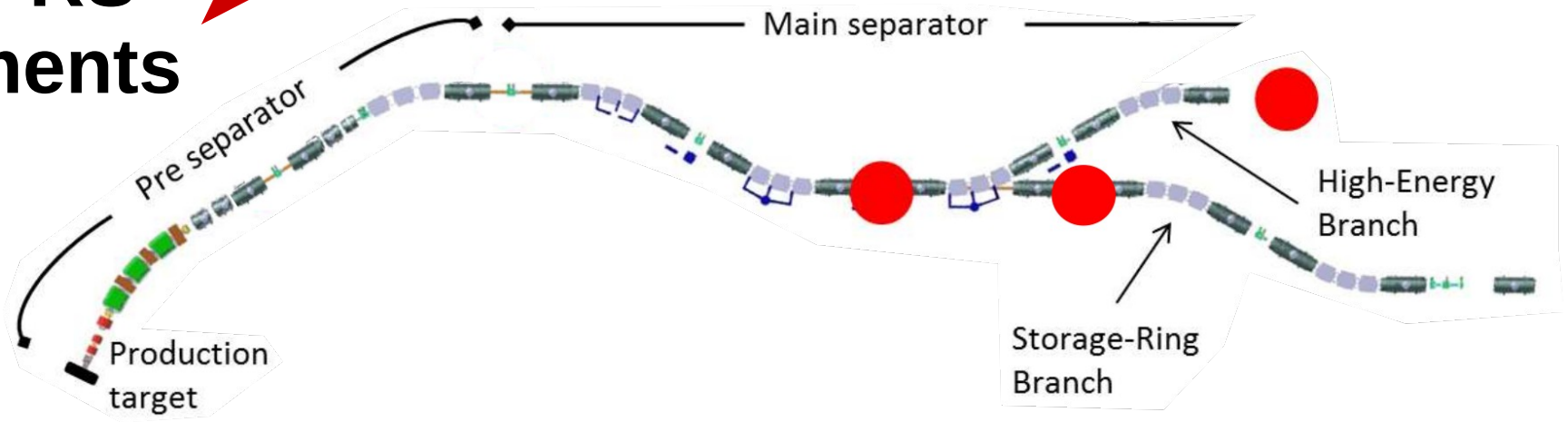
Status of EXPERT

V. Chudoba on behalf of EXPERT group

Silesian University in Opava, Czech Republic

NUclear STructure, Astrophysics and Reactions

SuperFRS Experiments

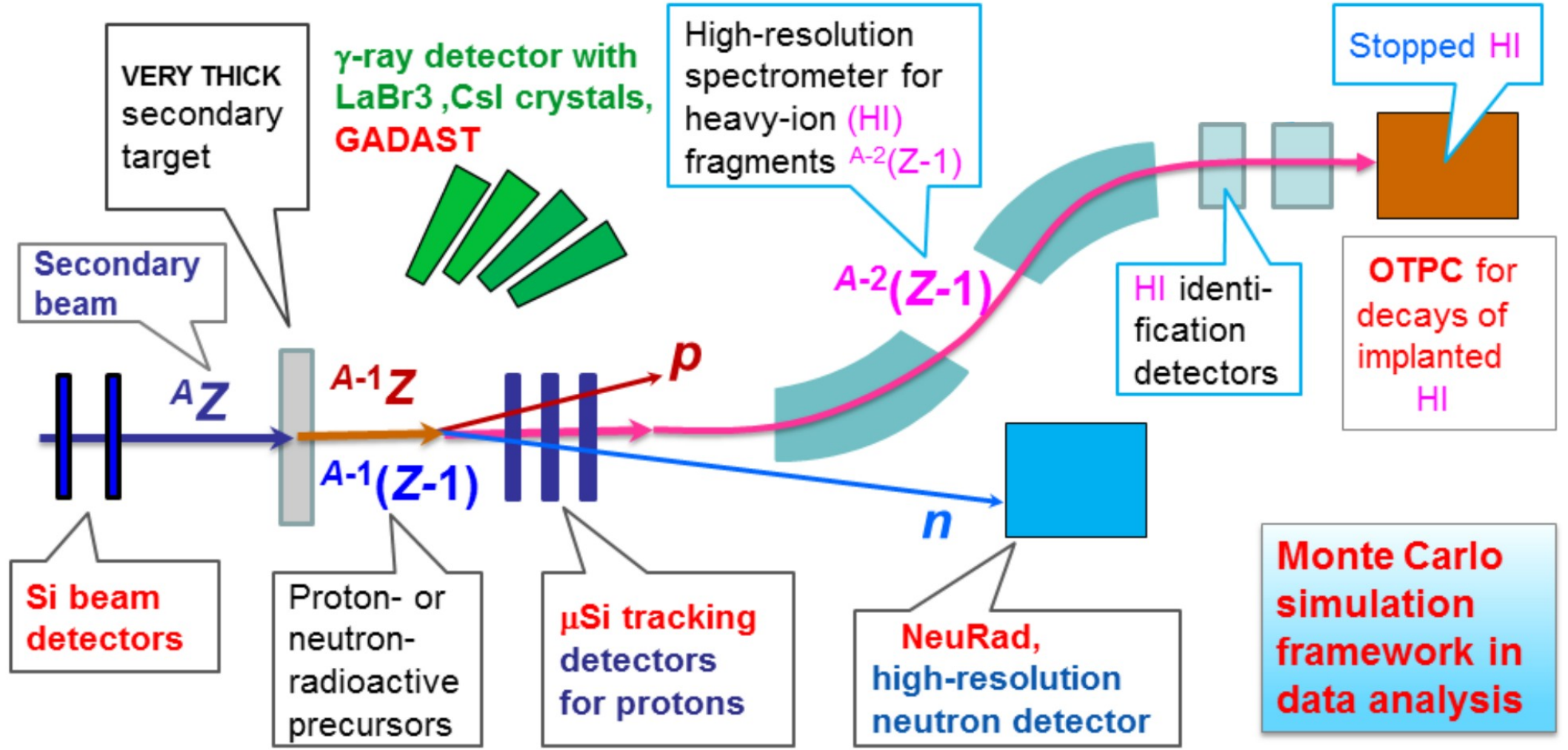


EXPERT (EXotic Particle Emission and Radioactivity by Tracking)

Physical case of EXPERT

- unknown exotic nuclear systems
- new types of radioactivity
- resonance decays
- beta-delayed decays
- exotic excitation modes

Experimental design



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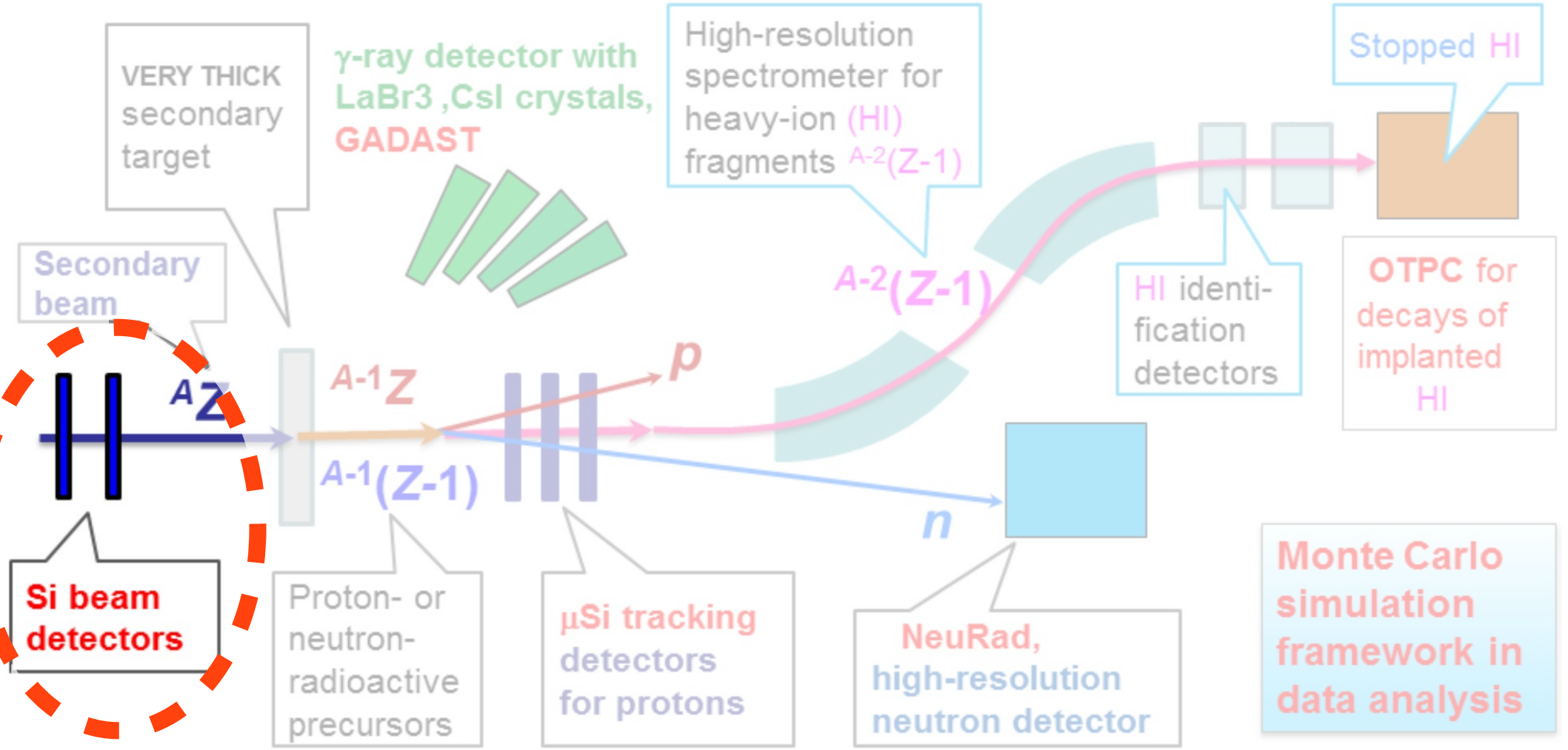

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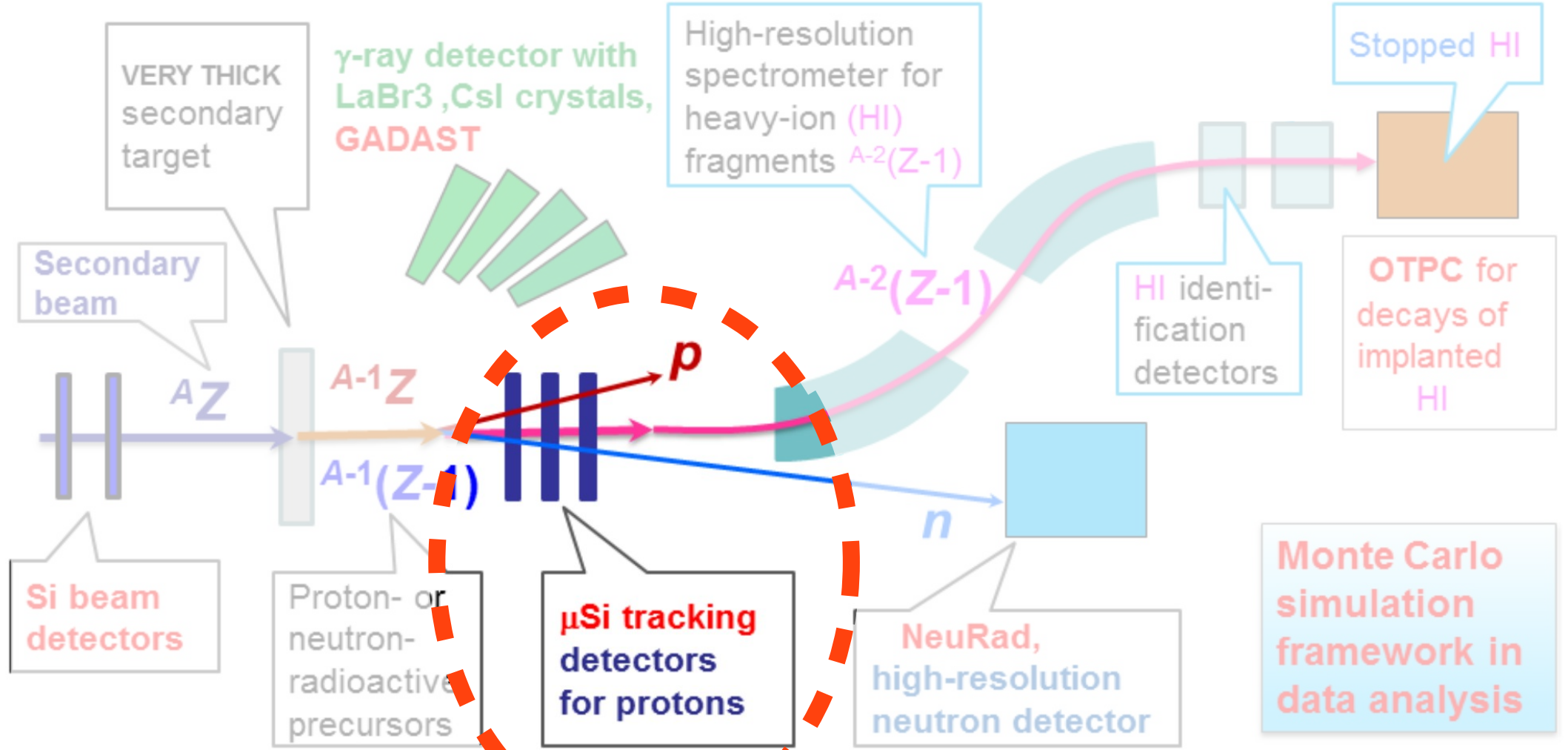

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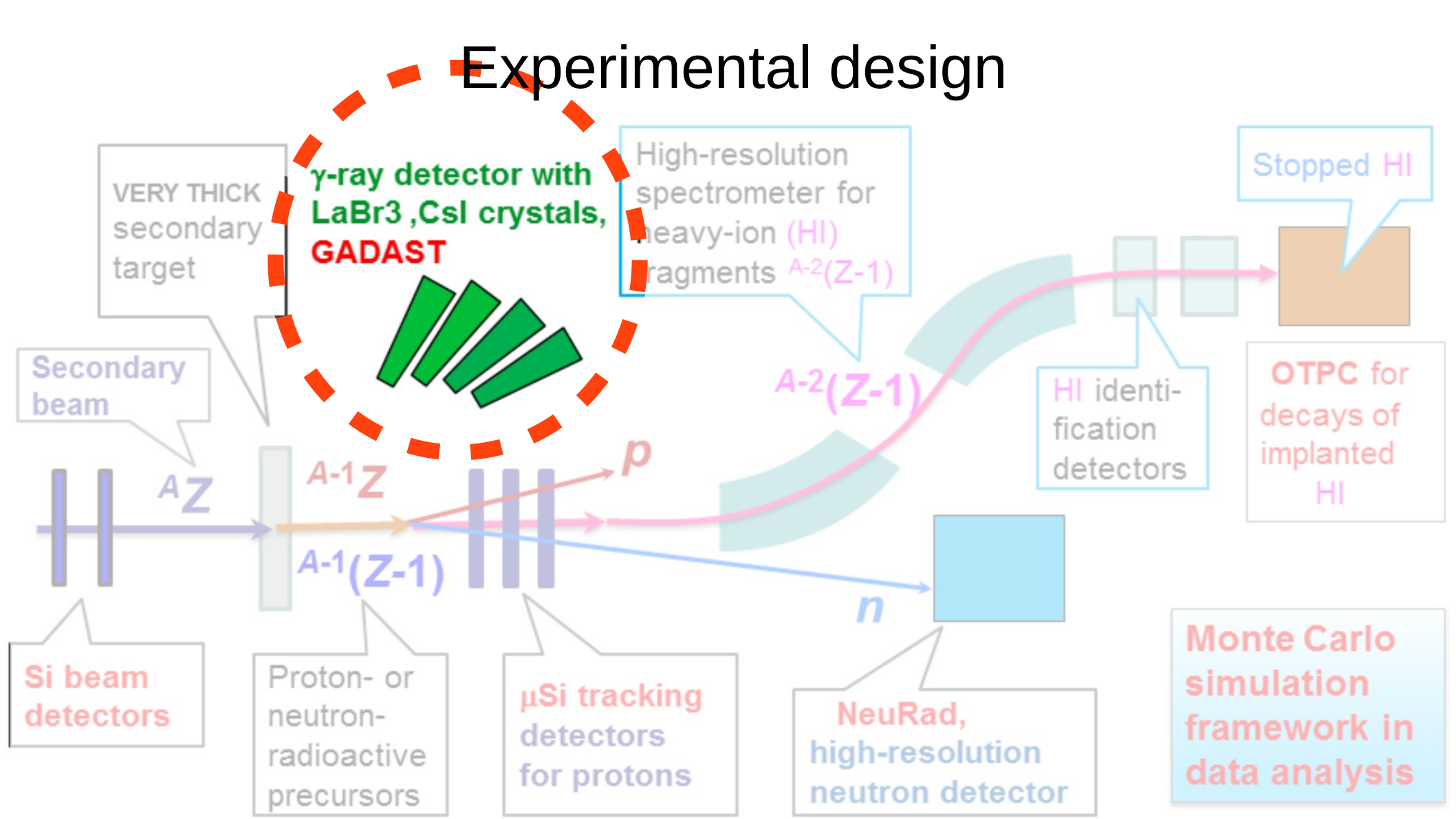

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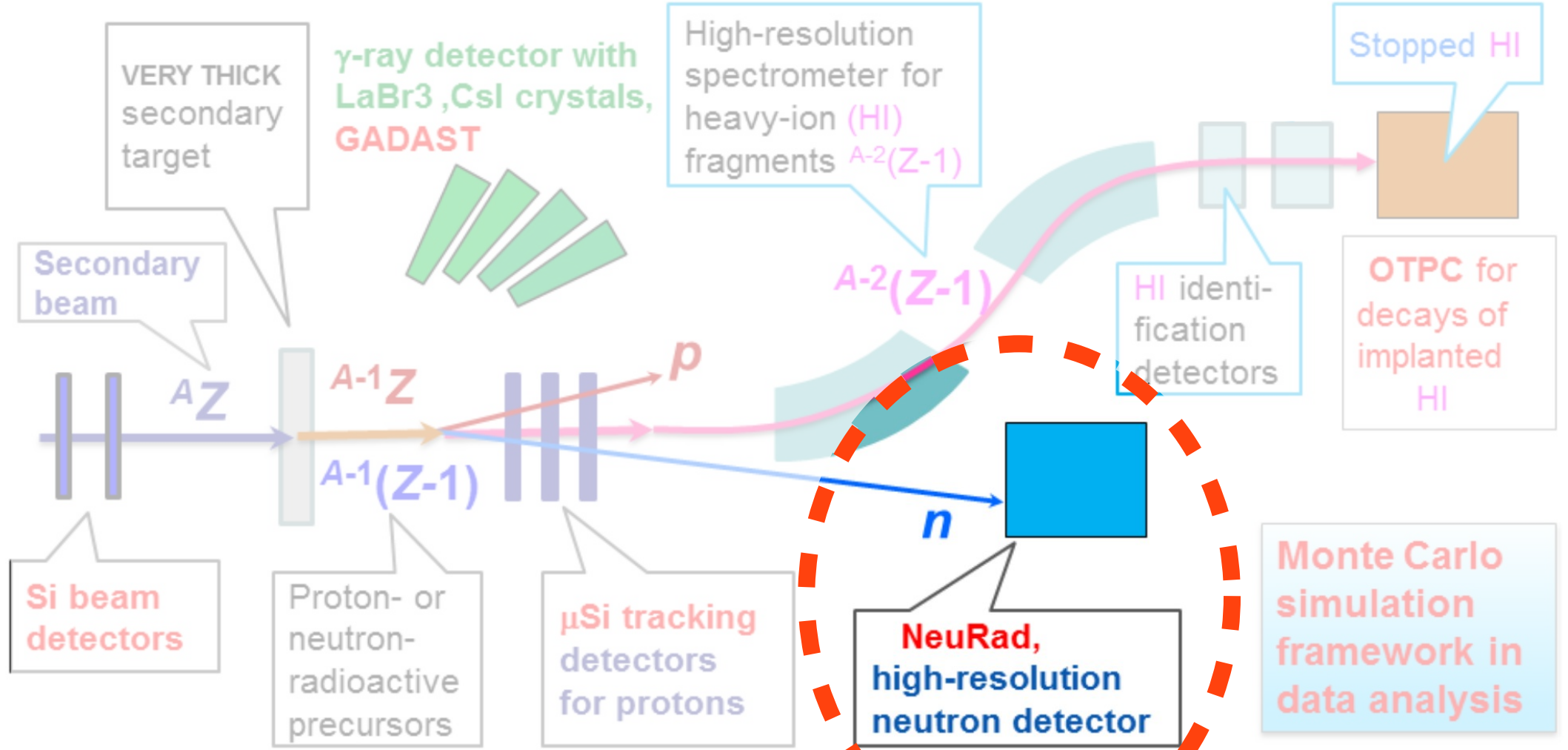

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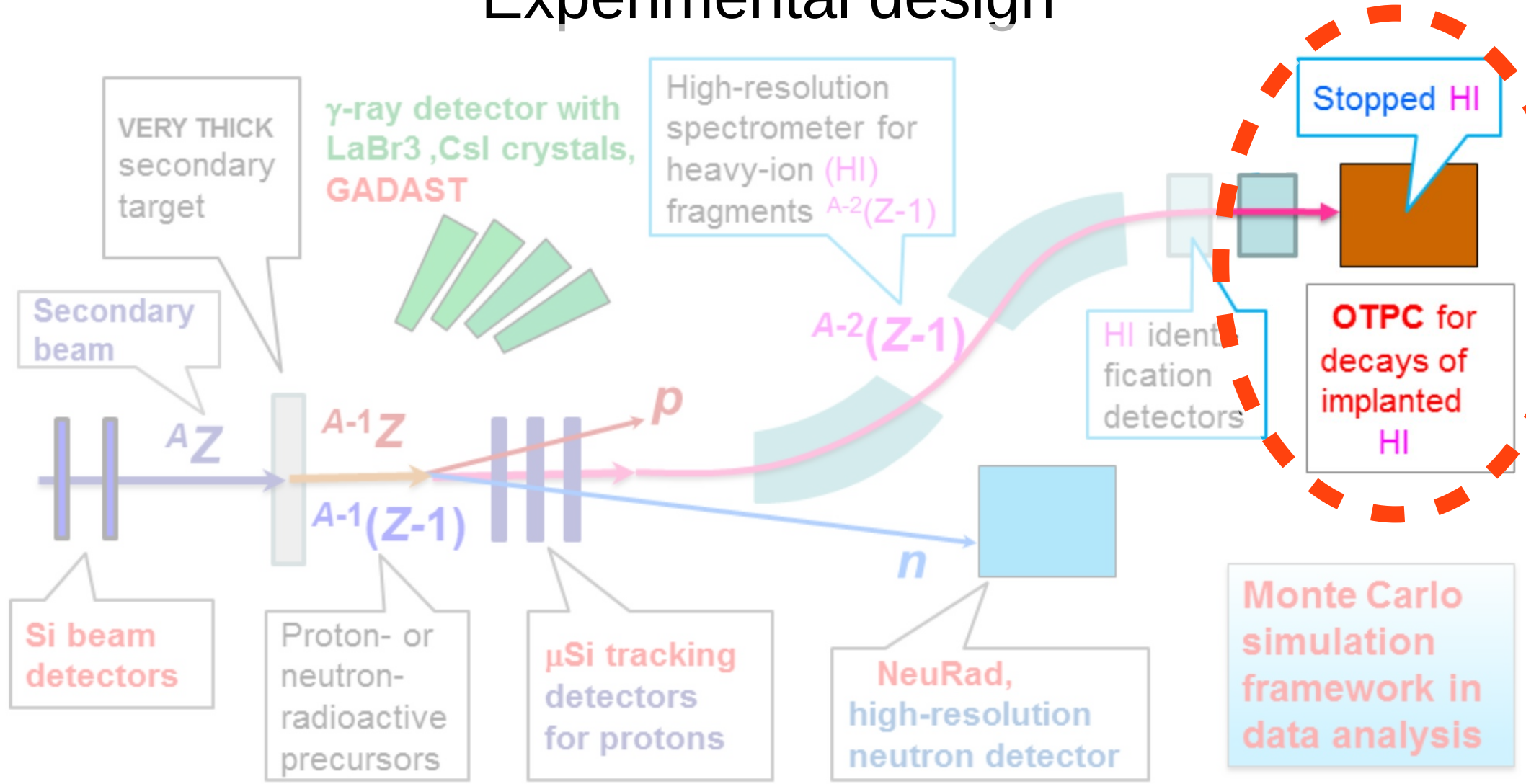
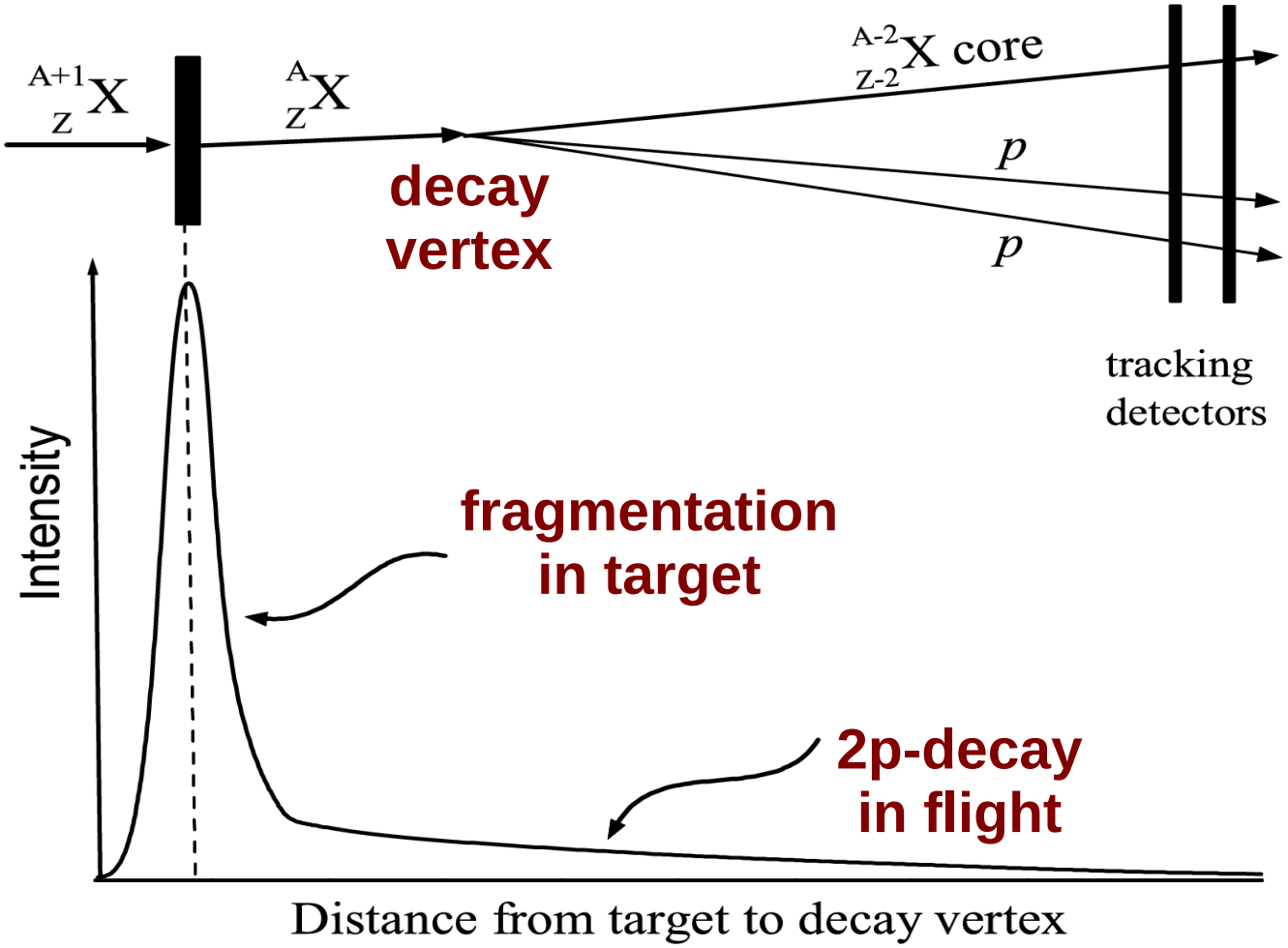


Available experimental methods

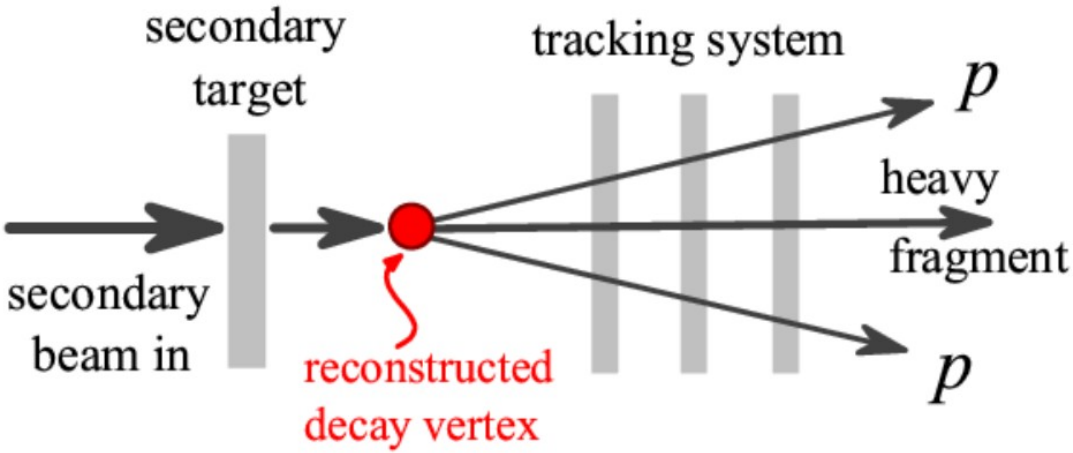
- ion-implantation method
- decay-in-flight by tracking technique
  - information on life-time accessible
  - identification of 2p-decay channels by correlations

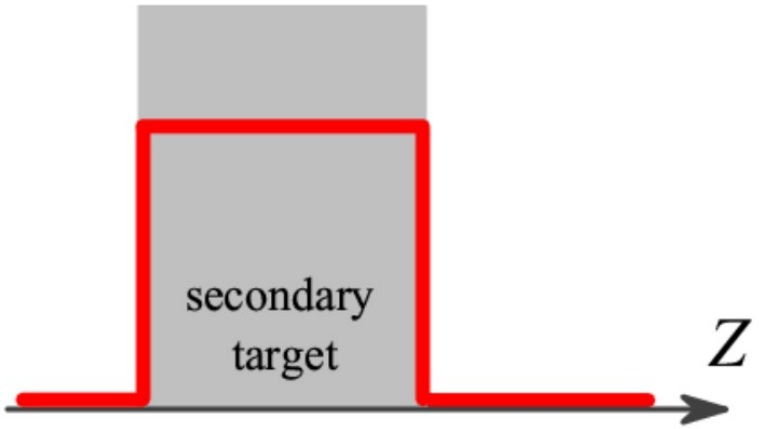
Decay-in-flight by tracking

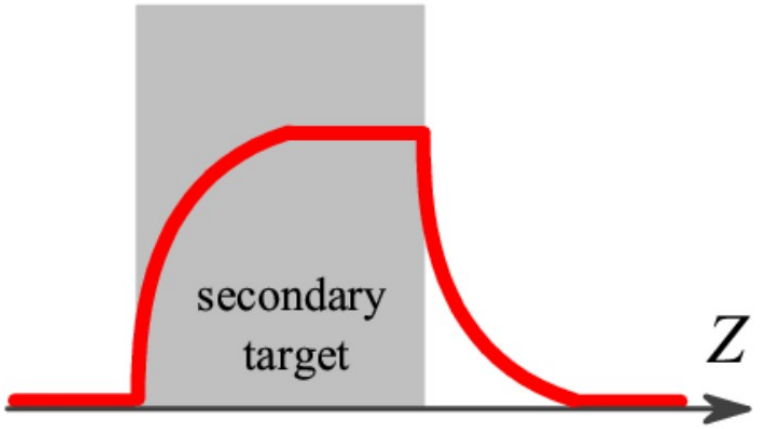


Life-time measurement by tracking

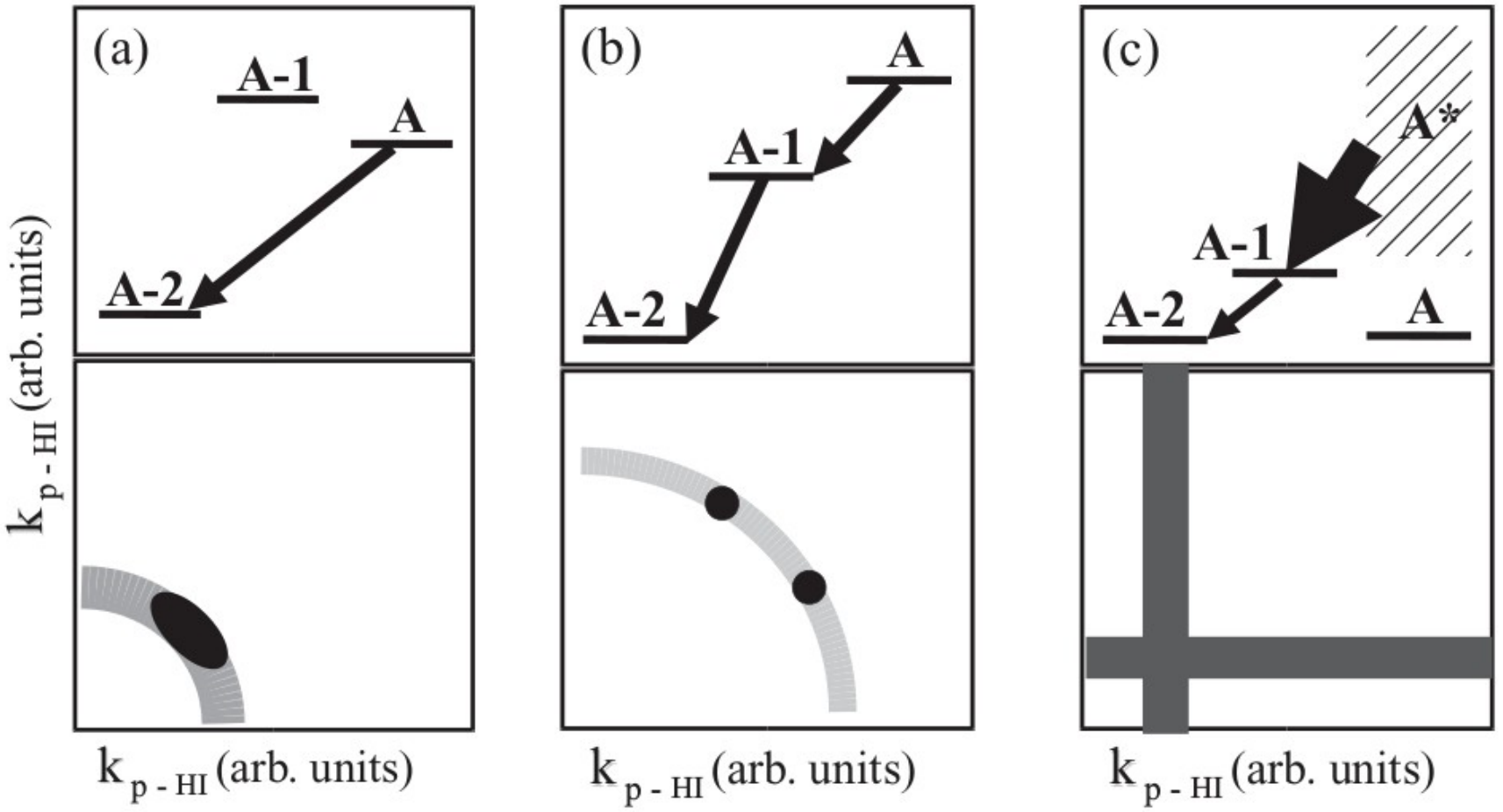
- characteristic shape of vertices distribution
- suitable for lifetimes 10^{-7} – 10^{-12} s



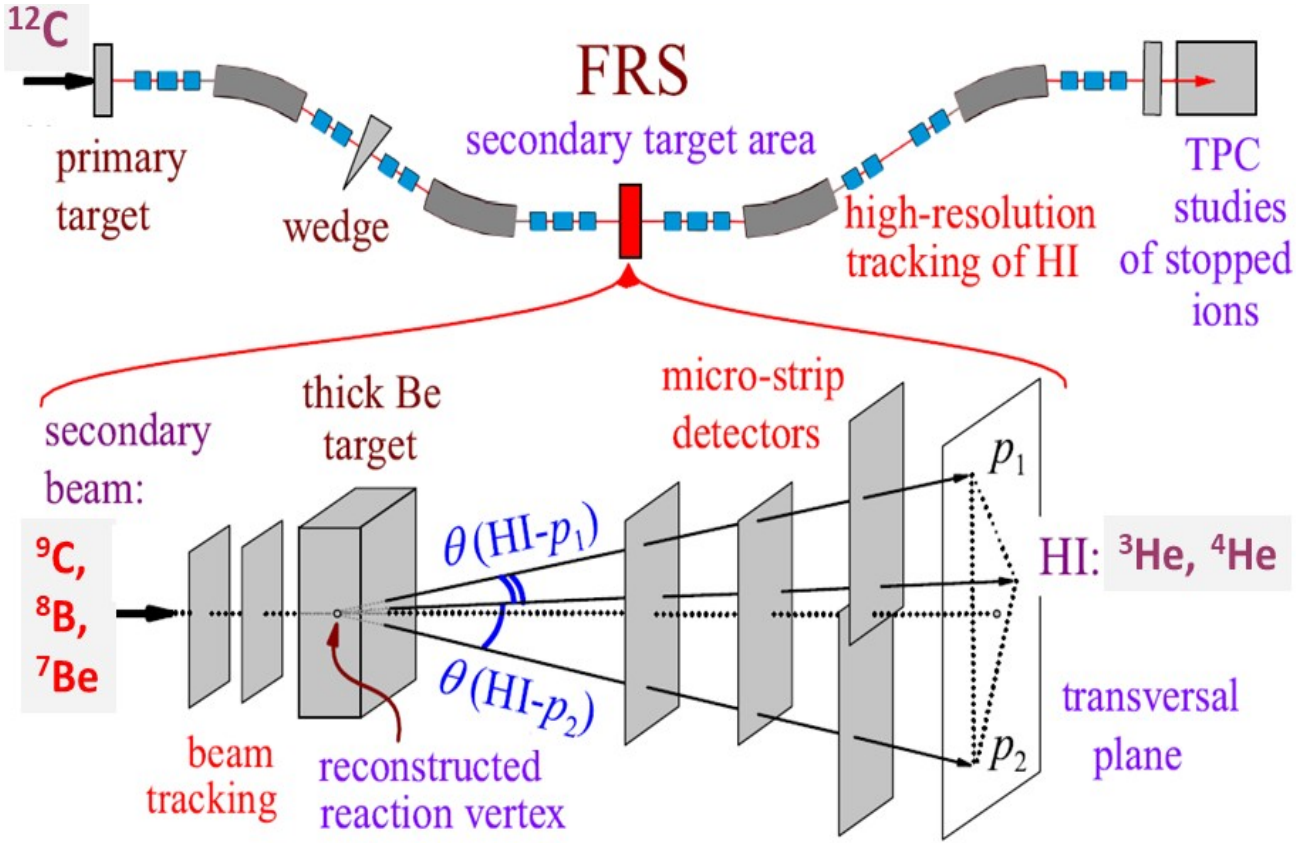




Identification of 2p-decay channels



Experimental design



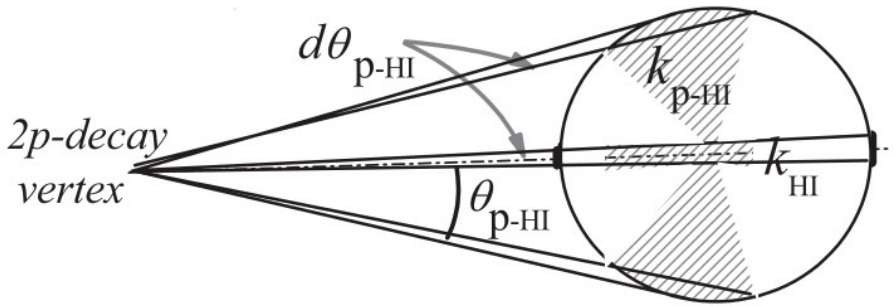
- in-flight decay method and ion-implantation simultanously
- EXPERT setup for Phase-0 at FRS

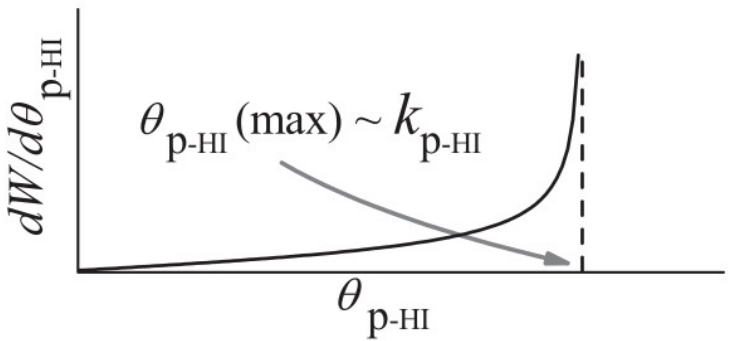
Identification of 2p-decay channels

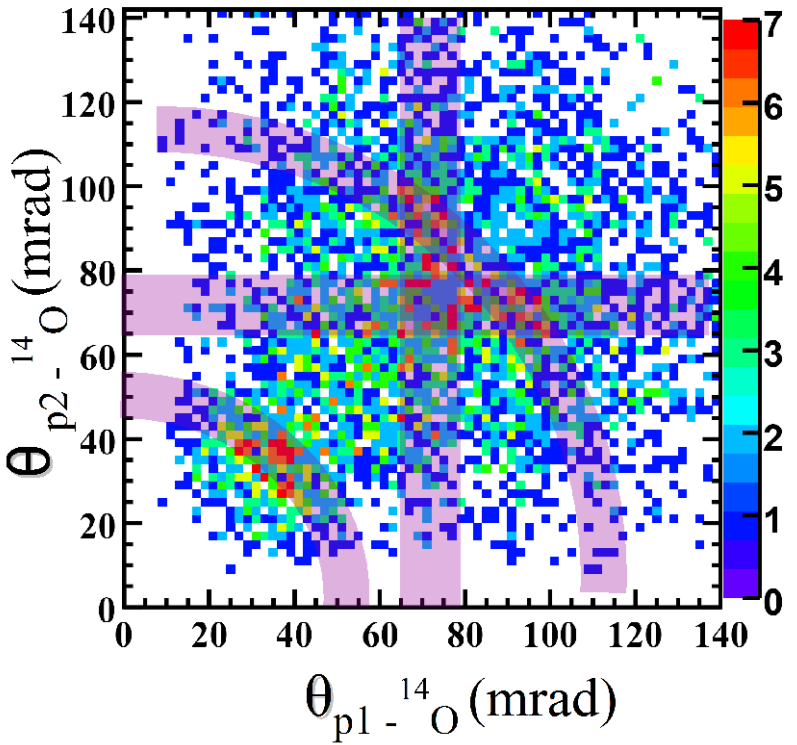
- transition $k_{p\text{-}HI} \rightarrow \theta_{p\text{-}HI}$
- without measurement of proton energies

I. Mukha et al. Phys. Rev. C 82 (2010) 054315

^{16}Ne







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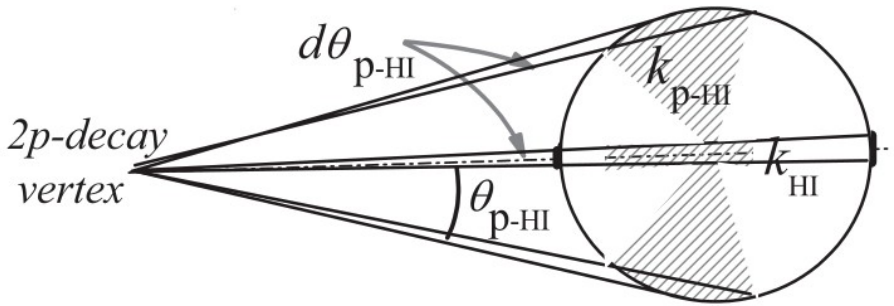
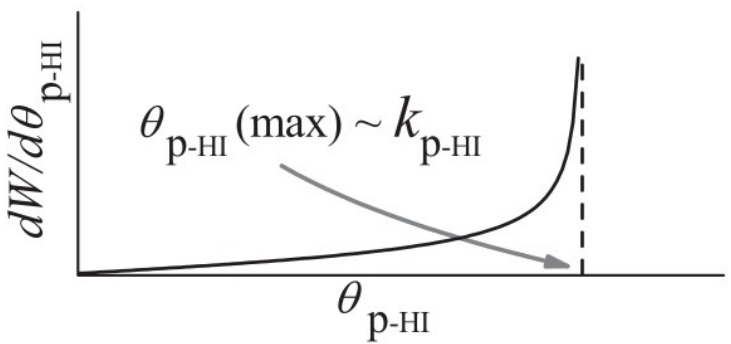
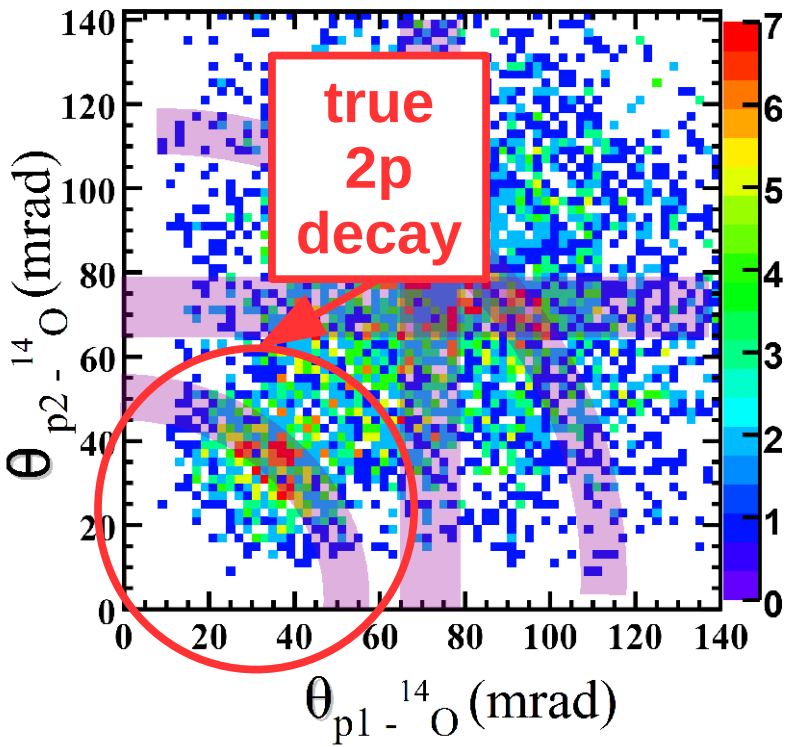






Background and previous results

- two successful beam times
  - **2006;**
  - **2012;**

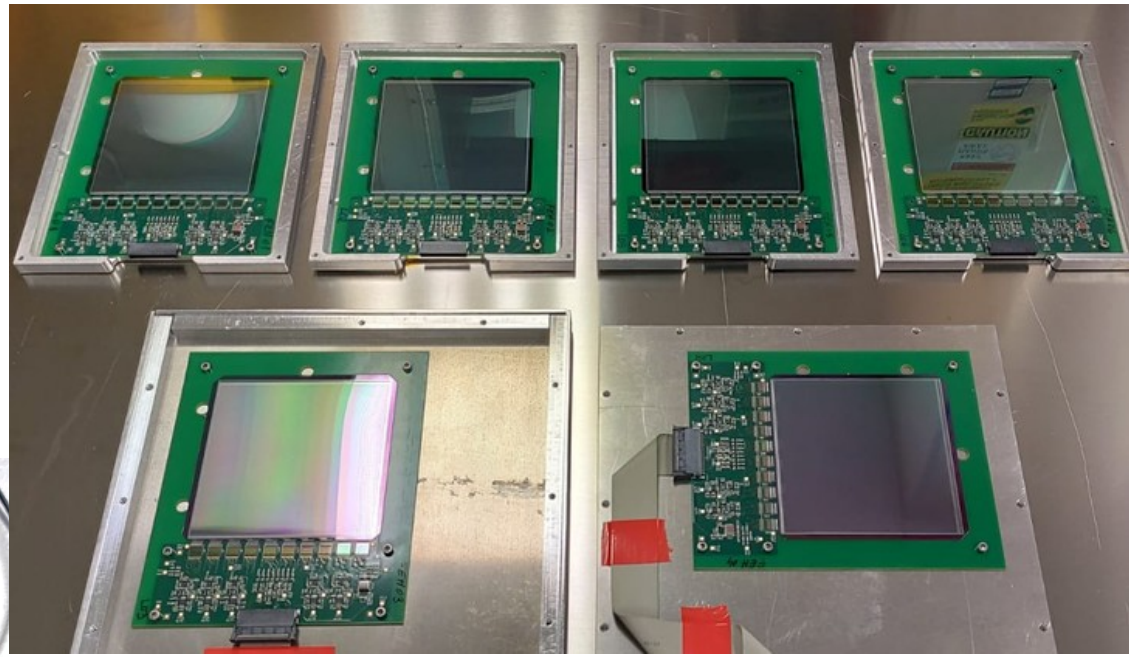
Background and previous results

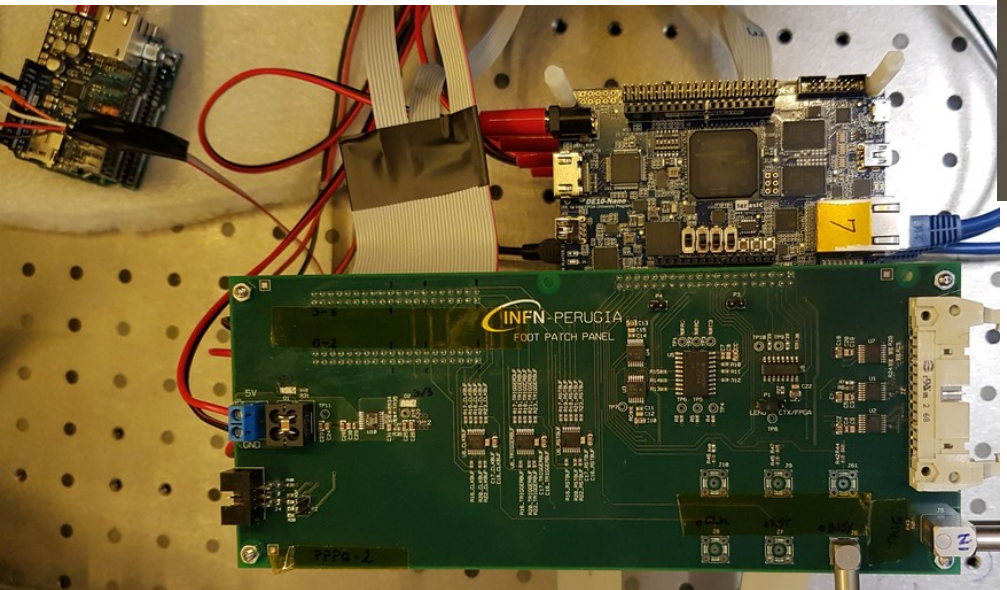
- **Beam time 2006**
  - [1] I. Mukha et al., PHYSICAL REVIEW LETTERS 99, 182501 (2007)
  - [2] I. Mukha et al., PHYSICAL REVIEW C 77, 061303(R) (2008)
  - [3] I. Mukha et al., PHYSICAL REVIEW C 79, 061301(R) (2009)
  - [4] I. Mukha et al., PHYSICAL REVIEW C 82, 054315 (2010).
  - [5] I. Mukha et al., PHYSICAL REVIEW C 85, 044325 (2012)
- **Beam time 2012**
  - [6] I. Mukha et al., PHYSICAL REVIEW LETTERS 115, 202501 (2015)
  - [7] A.A Lis et al., PHYSICAL REVIEW C 91, 064309 (2015).
  - [8] T.A. Golubkova et al., PHYSICS LETTERS B 762, 263 (2016)
  - [9] X.D. Xu et al., PHYSICAL REVIEW C 97, 034305 (2018)
  - [10] I. Mukha et al., PHYSICAL REVIEW C 98, 064308 (2018)
  - [11] L.V. Grigorenko et al., PHYSICAL REVIEW C 98, 064309 (2018)
  - [12] D. Kostyleva et al., PHYSICAL REVIEW LETTERS 123, 092502 (2019)

FOOT microstrip detectors (O. Kiselev)

new detectors for vertex method

- developed with INFN Perugia
- 1920 physical strips, 10 x 10 cm
- floating strips coupled to 640





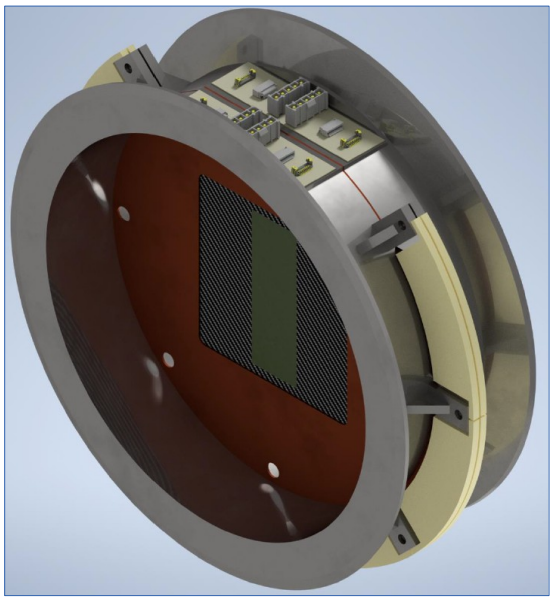
current status

- 2 pcs., counting rate up to 5 kHz
- 6 pcs., counting rate up to 10 kHz
- tests on proton beam in November

ALPIDE pixel detectors (O. Kiselev)

alternative detectors for vertex method

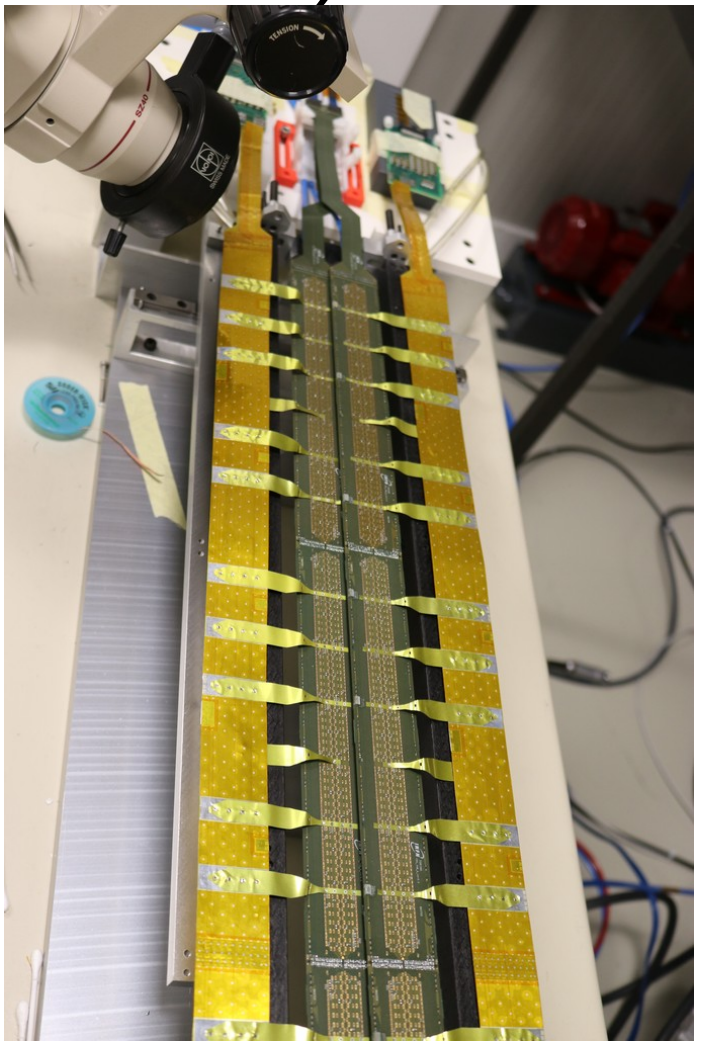
- thickness 50 or 100 μm
- arrays of wafers 30 x 15 mm
- each pixel cell contains a sensing diode, a front-end amplifier and shaping stage, a discriminator, and a digital section



ALPIDE pixel detectors (O. Kiselev)

alternative detectors for vertex method

- radiation hard detectors
- maximum trigger rate – 100 kHz
- time resolution ~5 μs
- spatial resolution - 5 μm
- cooling needed
- wide range of detected particles
- multiple hits (pixels with no hits are not read out)



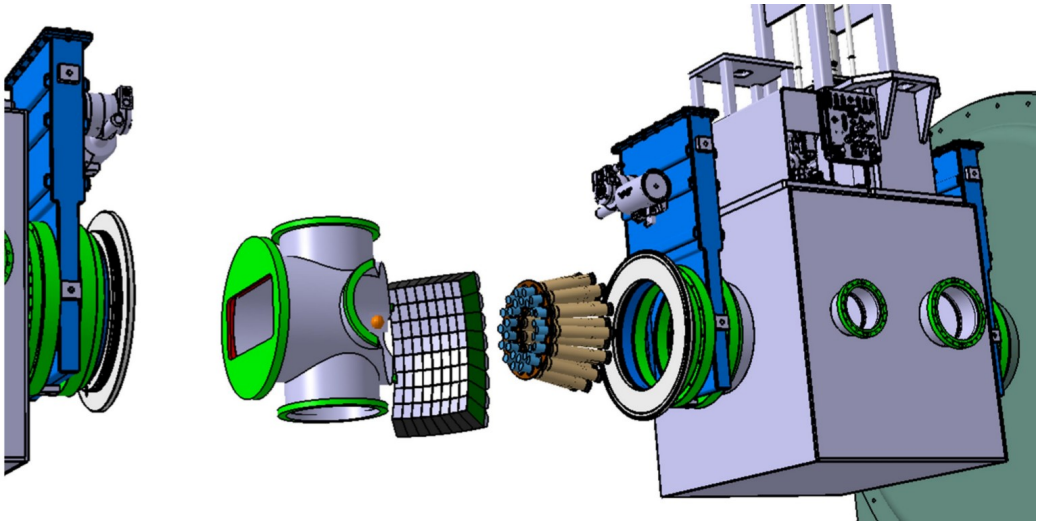
GADAST

GADAST (according to TDR)

- tagging of gammas from 2p-radioactivity and detector of charged particles
- E_g ~ 100 keV – 2 MeV
- trapezoidal CsI(Tl) crystals more than 15° in LAB
- cylindrical $LaBr_3(Ce)$ crystals around the beam

in the middle of SuperFRS in FMF2

128 CsI(Tl) modules
32 $LaBr_3(Ce)$ modules



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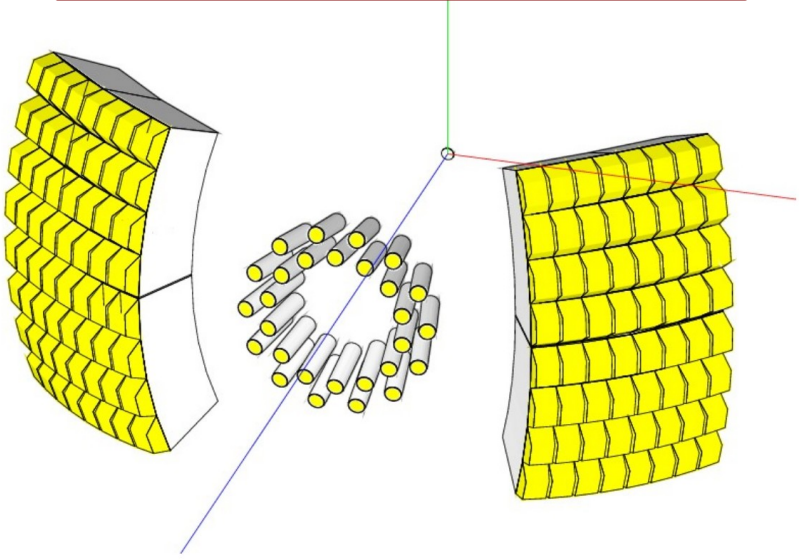
available 32 CsI(Tl) modules with R7600U-300 PMT

in the middle of SuperFRS in FMF2

128 CsI(Tl) modules
32 $LaBr_3(Ce)$ modules



Recent activities

- realization of purchase of GADAST modules by Silesian University in Opava (Czechia)
  - one wing of CsI(Tl) – 32 modules (enhanced crystal geometry, new R11265U-300 PMT)
- testing of LYSO crystals launched

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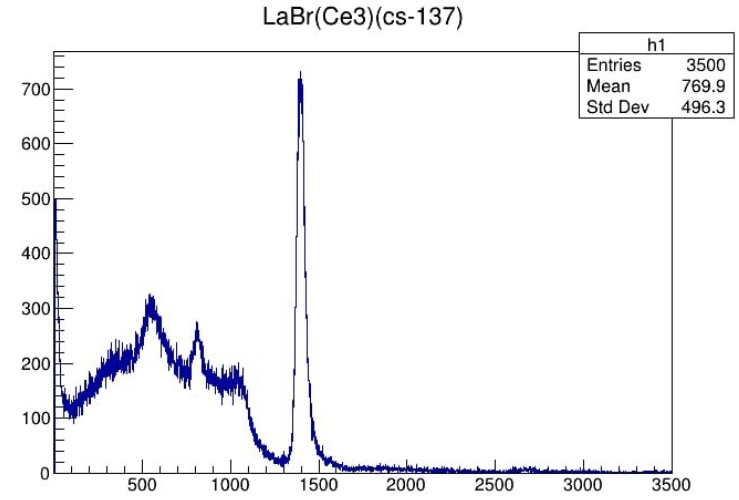
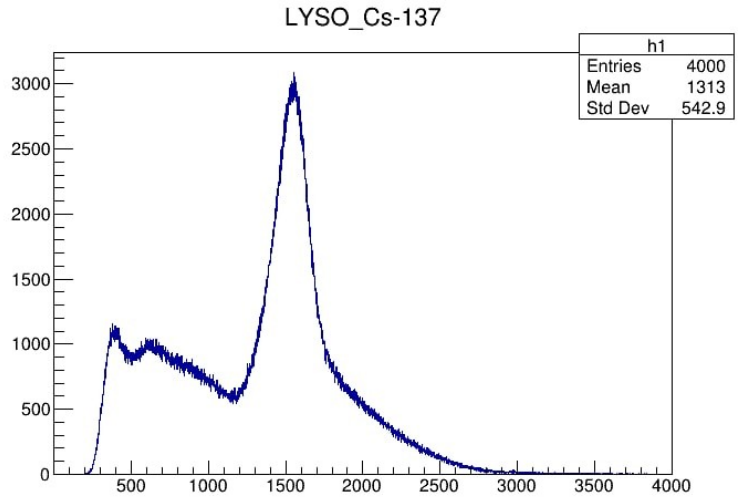




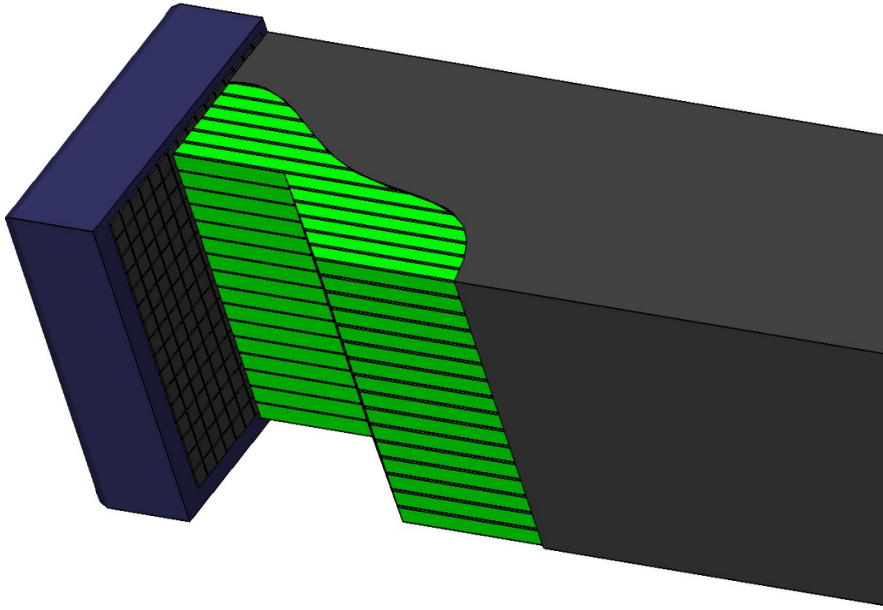
GADAST outlook

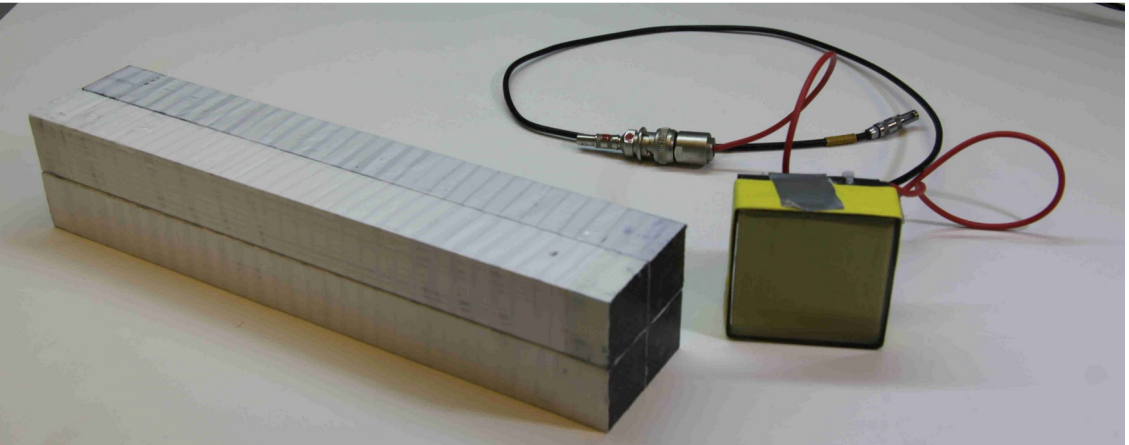
- transfer to FAIR property until the end of 2022
- tests to be performed by Silesian University in Opava
  - on gamma sources in 2021
  - beam tests in 2022
- acceptance tests at FAIR

NEURAD

NeuRad

- neutron radioactivity studies
- E_n ~ 200 – 800 MeV in LAB
- low transverse momenta
  0.1 – 100 keV
- precise information on angular correlations of decay neutrons with a charged fragment
- angular resolution ~0.1 – 0.2 mrad

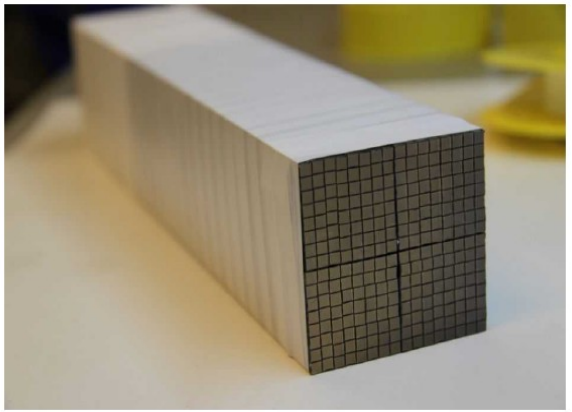




28 m from the target in FMF2

at least 36 modules
30 x 30 x 100 cm^3

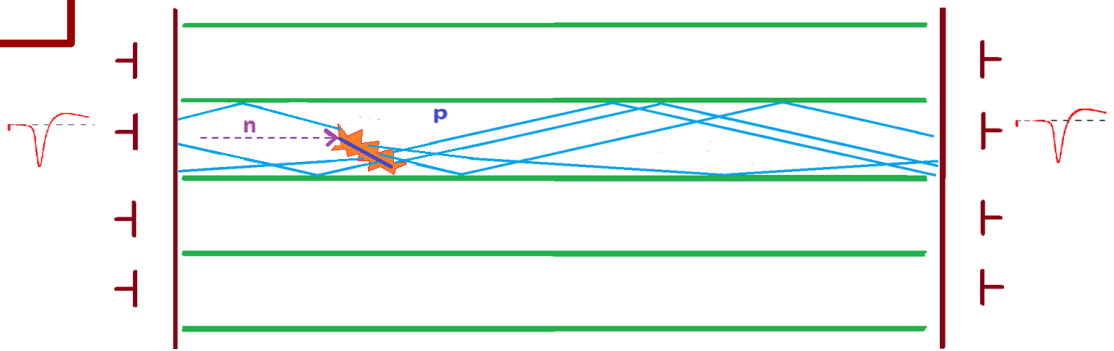
NeuRad



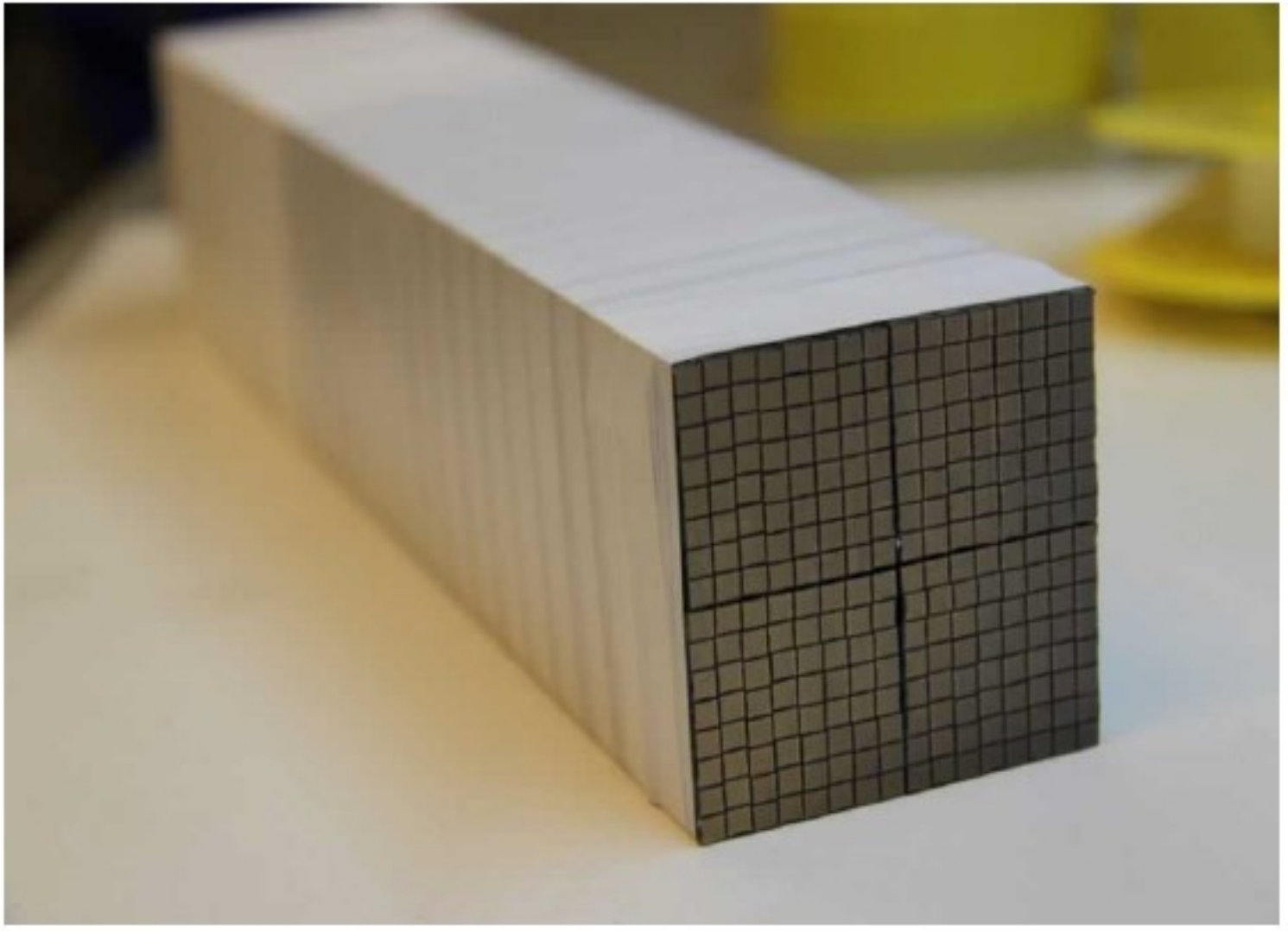
bundles

- 3 x 3 mm scintillation fibers BCF12
- 48 x 48 x 1000 mm
- 2 MAPMT from both sides

neutron beam



- **longitudinal coordinate** of the n interaction along the fiber
- **determination the very first hit**
- avoid **neutron cross-talk**



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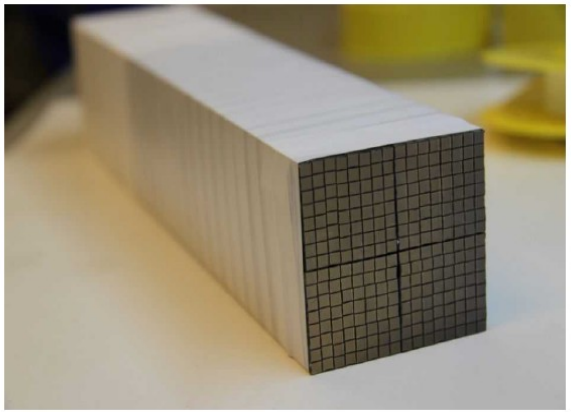

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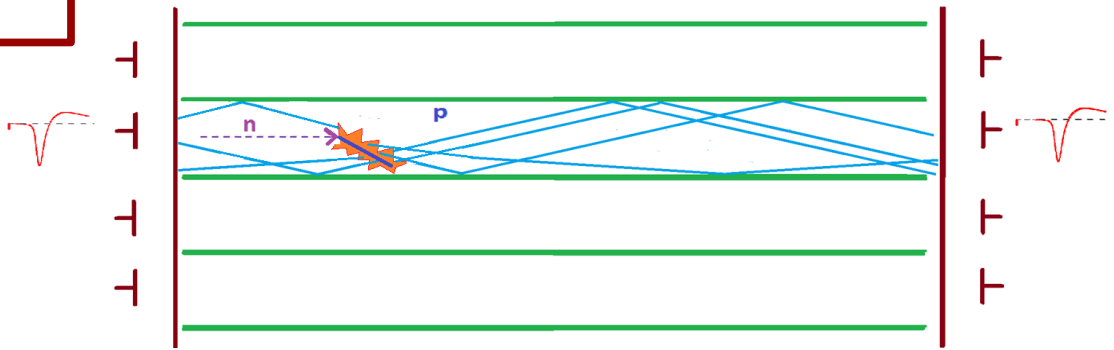

- **longitudinal coordinate** of the n interaction along the fiber
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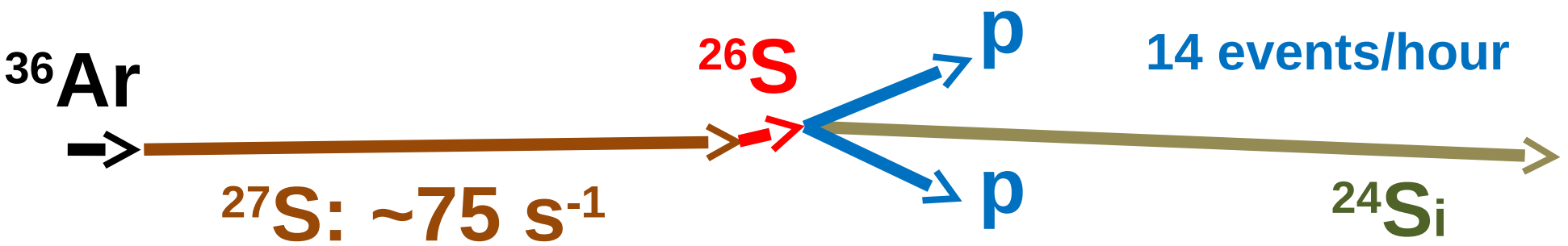
- avoid **neutron cross-talk**

Proposal S478 (A. Fomichev)

- primary beam of ^{12}C, 14 shifts ranked "B" by G-PAC.
- secondary beams of ^{7}Be, ^{8}B, ^{9}C
- search unobserved ^{5}Be, ^{6}B, ^{7}C and ^{9}N isotopes
  - extremely large proton-neutron ratio
  - anticipated two-, three-, four- and five-proton decays
- structure of the ^{7}C ground state – mirror to ^{7}H
- beta-delayed proton emission from ^{9}C via implantation method

Proposal S459

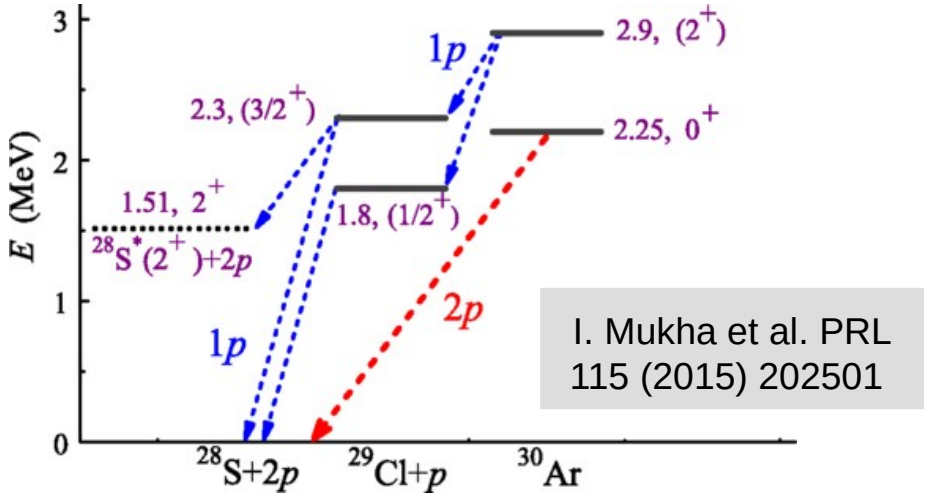
ranked "A-" by G-PAC.



- primary beam of ^{36}Ar, 9 shifts
- ^{26}S not observed yet
- 2p-radioactivity candidate
- most reach statistics expected (1000 decay events expected)

Proposal S459

GADAST: gamma tagging



I. Mukha et al. PRL 115 (2015) 202501

gamma tagging (E_γ = 1.51 MeV) was needed for ^{30}Ar

possible decay ^{30}Ar (2^+) → ^{28}S(2^+) + p + p indicated

analogous situation possible for ^{26}S

Conclusion and outlook

- detectors for in-flight decay method under construction, tests on proton beam in November
- 32 modules for GADAST detector purchased, tests scheduled for the very near future
- transfer to FAIR property have to be finished until the end of 2022 year

Thank for your attention