Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF

C²TN

nTOF

WP 1.4: Report on the development and performances of the new detectors for non-energy applications

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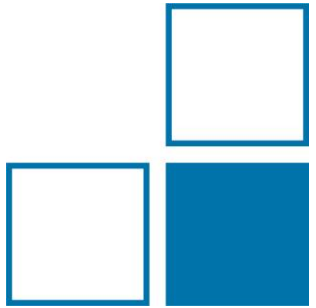


DDX for neutron-induced emission of light charged particles

Data required for calculation of kerma factors:

- Out-of-field neutron dose in particle therapy
- Radiation damage in aircraft and space instrumentation

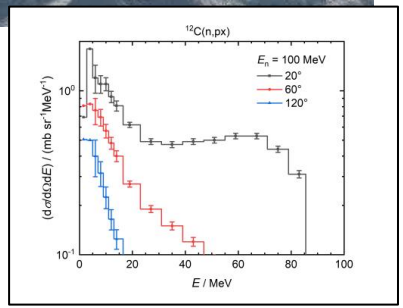
Present situation:

- Only few DDX data for emission of $_1$H and $_2$He ions from C, N, O, Si above 100 MeV
- Complex product particles still a challenge for the INC model

n_TOF is the only neutron source above 100 MeV in Europe:
Continuous energy coverage but low brillance:

- Low mean count rates
- Intense γ–flash
- High instantaneous rates

$\Rightarrow$ Prototype experiment to evaluate feasibility of DDX measurements above 100 MeV at n_TOF



High-energy DDX for ^{12}C(n, lcp x) at n_TOF

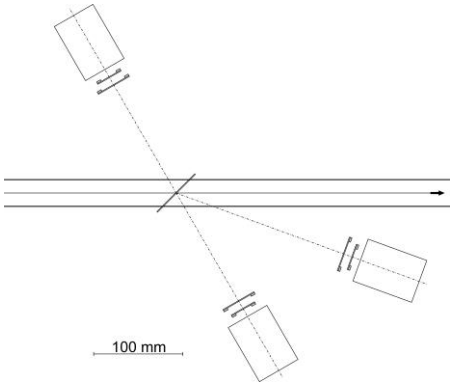
Experiment:

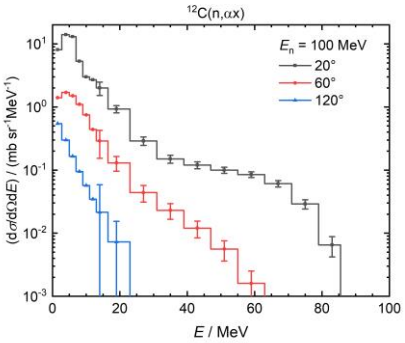
- n_TOF EAR1
- 3×10^{18} protons on spallation target (≈ 30 days)
- sample: 225 mg/cm² C
- development of ΔE^2-E telescopes
- neutron energy range of interest: 100-200 MeV

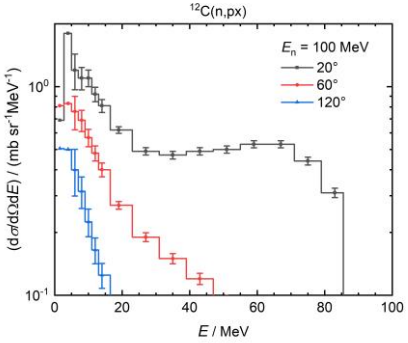
Expected statistical uncertainty of DDX data:

- ≈ 10% per energy bin for ^{1}H
- ≈ 20% - 30% per energy bin for ^{4}He
- neutron energy resolution $\Delta E_n/E_n$ ≈ 10%

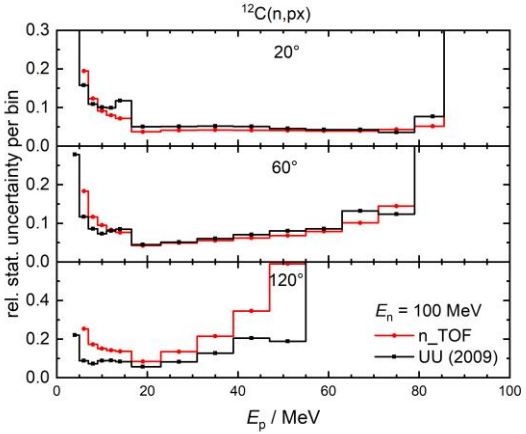
Goal: provide data to support improvement of INC models

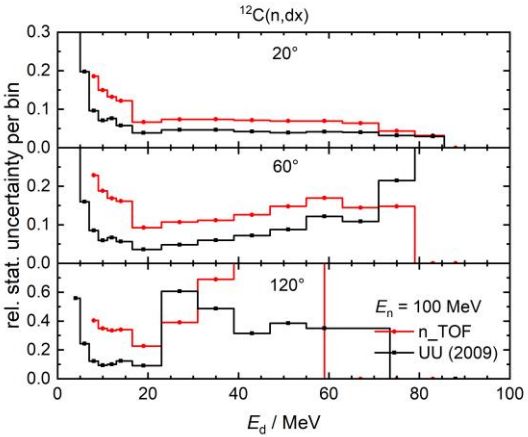


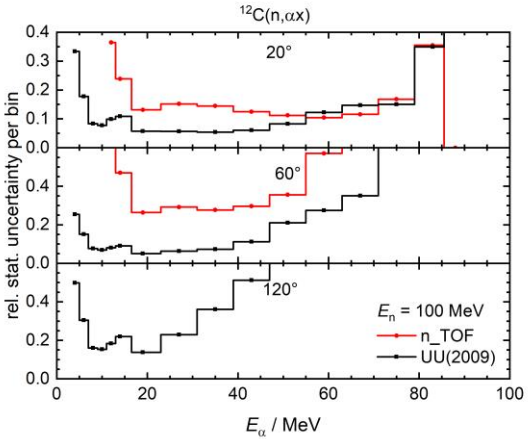




Details: expected statistics for E_n = 100 MeV







- N_p = 3×10¹⁸ protons
- m_C = 225 mg/cm² graphite (1 mm)
- $\Delta E_n/E_n$ = 0.1
- p, d: 20 x 20 mm² @ 150 mm, $\Delta\Omega_{p,d}$ = 18 msr
- α : 20 x 20 mm² @ 100 mm, $\Delta\Omega_\alpha$ = 40 msr

UU(2009): U. Tippawan *et al.*,
Phys. Rev. C **79** (2009) 064611,
EXFOR Entry 14236001

WP 1: Development of detectors

Experience from previous ^{235}U(n,f)/^{1}H(n,n) experiment at n_TOF:

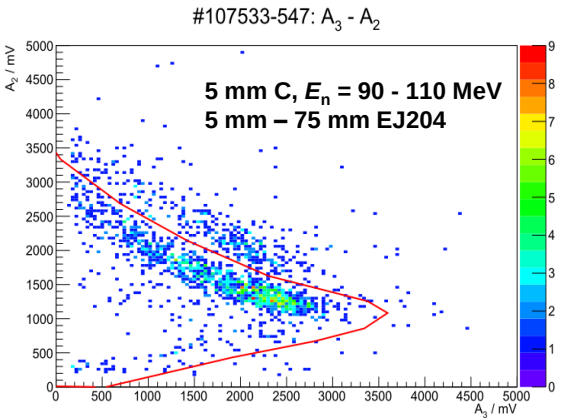
Recoil proton telescopes based on plastic scintillators worked up to 150 MeV

Improvements required for DDX measurements:

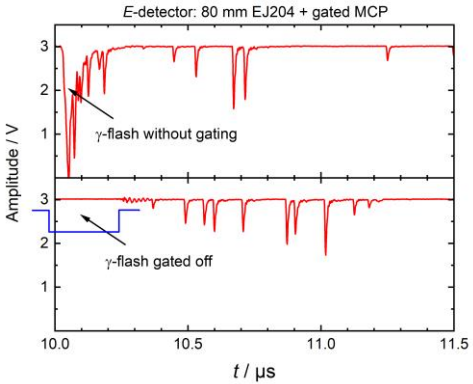
- Better resolution
- Lower thresholds: thinner ΔE detectors for $_2$He ions
- Higher max. neutron energies: 200 MeV

Lines of development:

- ΔE detectors: Si diodes + gated PreAmps
  (adaption of HZDR-IPN development for IC/HPGe)
- E detectors: $CeBr_3$, plastic scint. + gated MCPs (already tested),
  PMTs or SiPMs (… if that works)



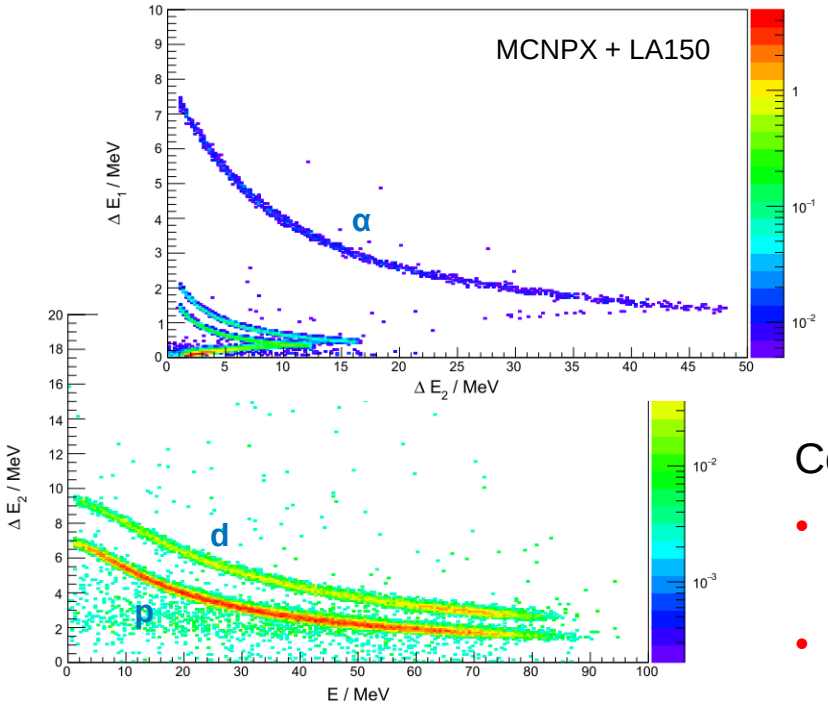
Demonstrated experience at n_TOF



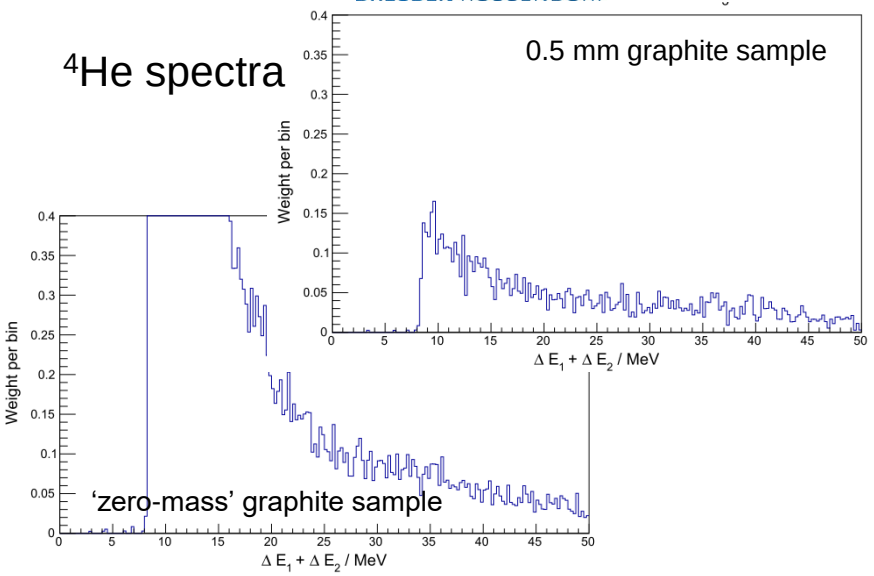
WP1: Monte Carlo studies

E_n = 100 MeV, 0.5 mm graphite sample, θ = 45°

ΔE_1-ΔE_2-E Telescope: 50 µm Si – 1 mm Si – 51 mm $CeBr_3$



^{4}He spectra



Conclusions:

- Strong corrections for energy loss of alpha particles in the sample
- ^{4}He DDX will be a challenge!

Present state of the project

PostDoc for the project: Mirco Dietz joined us in July 2020

- SANDA Project
- Upgrade of the TLABS neutron beam line
- Support analysis of the ^{235}U(n,f) / ^{1}H(n,n)p experiment

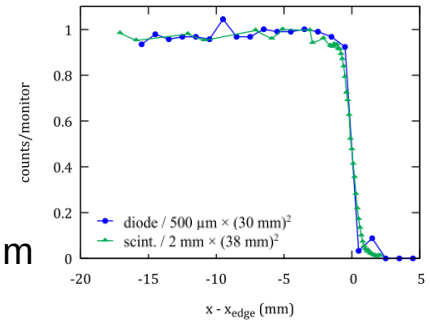
Successful LOI to the INTC for test beam time at n_TOF:

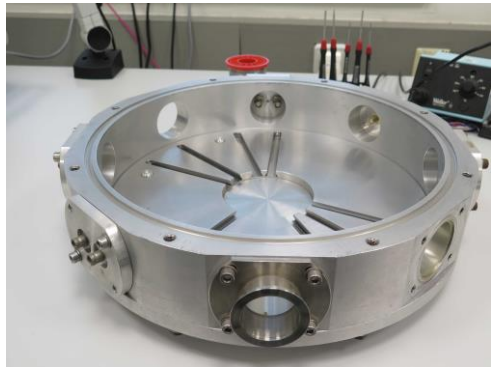
- $1 \cdot 10^{18}$ protons (about 10 days) granted
- First run expected for 2022

Procurement of detectors for tests in 2020:

- Si diodes: 50 µm – 1 mm
- SiPMs for read out of plastic scintillators in vacuum
- 2″ × 2″ $CeBr_3$ with standard PMT
- Some tests at the PTB micro beam already performed

Conversion of an old scattering chamber
for test experiments at PIAF and n_TOF





Next steps

Adaption of gated pre-amps (HZDR development) for Si diodes (ΔE detectors):

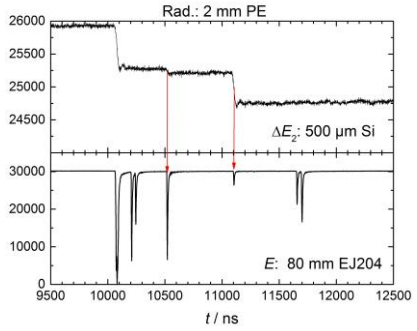
- γ-flash immunity
- improved dynamic range

delayed due to travel restrictions!

Readout of *E* detectors in vacuum using SiPMs

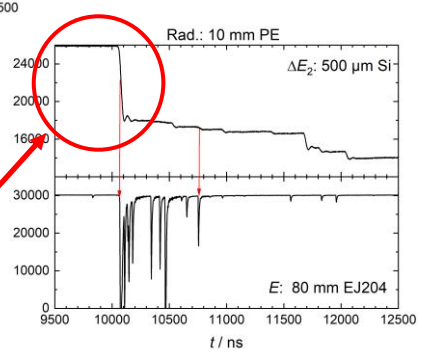
Test of telescope configurations at PIAF using proton and alpha beams

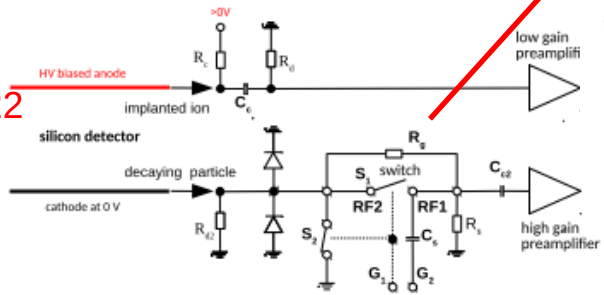
Test at n_TOF not yet scheduled: probably in 2022



Canberra 2006 preamp:

γ-flash limits dynamic range





Ref.: Sebastian Urlass (CERN/HZDR), PhD Thesis

WP1: Status of deliverables and milestones

Milestones and Deliverables:

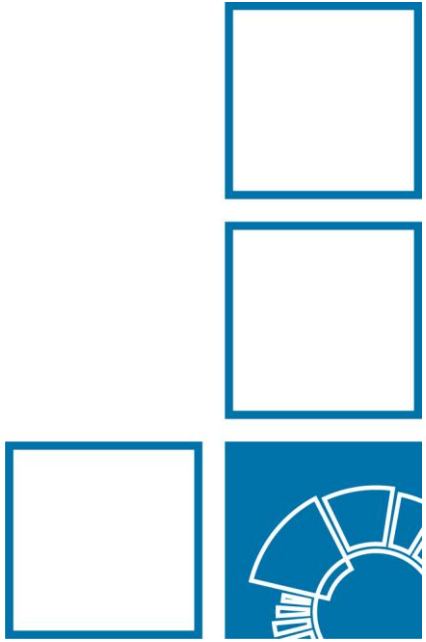
- D.1.8 Report on the development and performances of the new detectors for non-energy applications (M24)

  → Use laboratory report to prepare a later ‘technical paper’

  Expected delay: 6 months

- M.1.11 Test of prototype detectors and electronics at a spallation neutron source (M36)

  Depends strongly on the n_TOF schedule



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