Neutron detectors characterization at nTOF

S. Colombi, A. Manna, C. Massimi, M. Marafini, R. Spighi, M. Villa, R. Zarrella
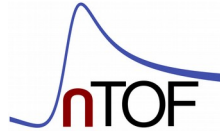
Neutron detectors

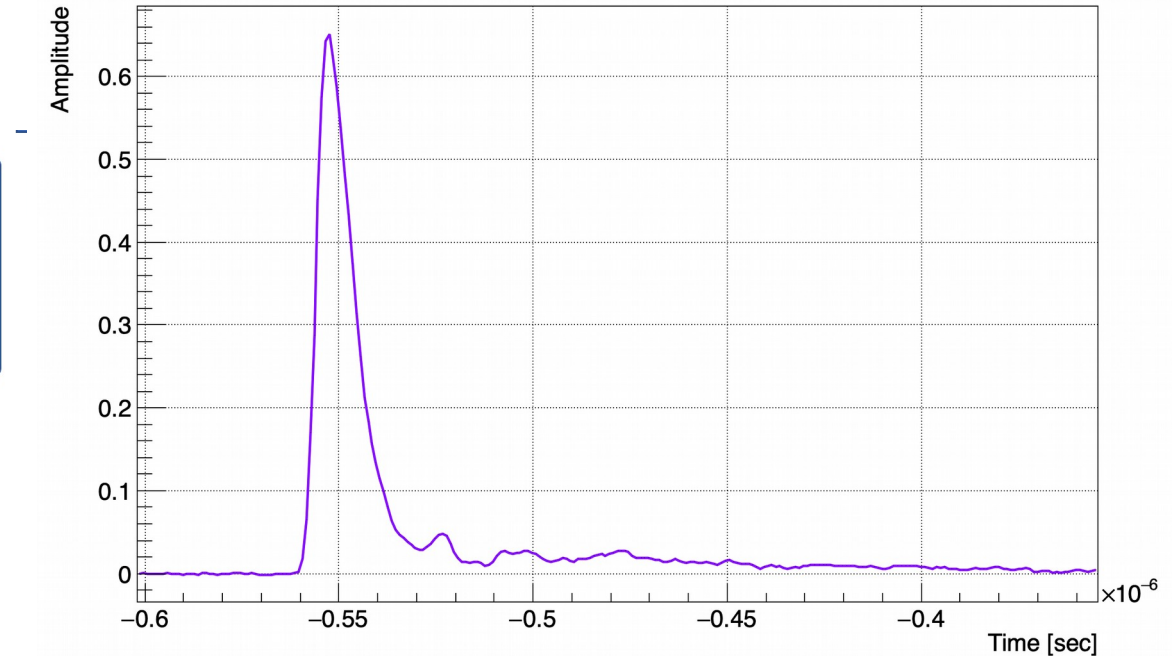Nike - NE213 $\rightarrow$ liquid scintillator:

- n/γ discrimination
- Decay Time components 3.16, 32.3 & 270 ns

h = 3"
7.62 cm

BC-501A

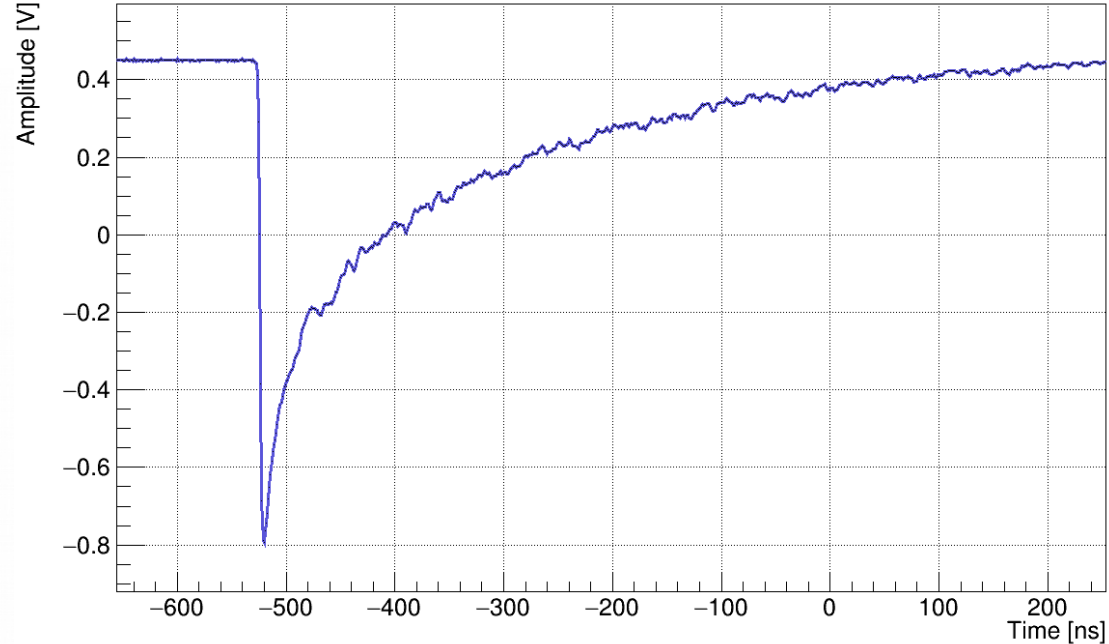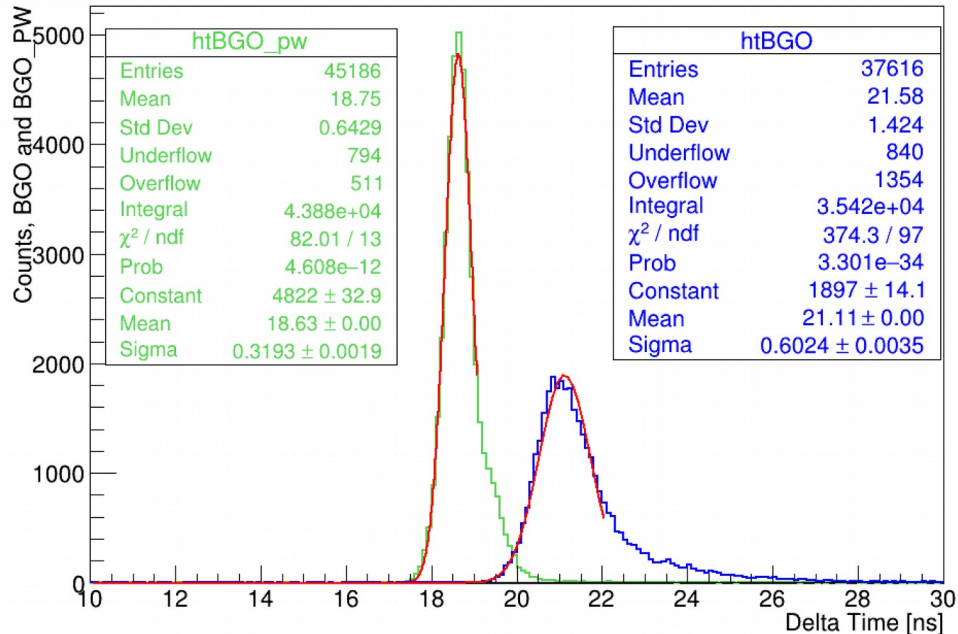diametro=3"
7.62 cm

Neutron detectors

Phoswich: BGO_pw crystals + EJ232

A1: 2.4x2.4 cm²

A2: 3.3 x 3.3 cm²

h: 24 cm

htBGO_pw	
Entries	45186
Mean	18.75
Std Dev	0.6429
Underflow	794
Overflow	511
Integral	4.388e+04
χ² / ndf	82.01 / 13
Prob	4.608e-12
Constant	4822 ± 32.9
Mean	18.63 ± 0.00
Sigma	0.3193 ± 0.0019

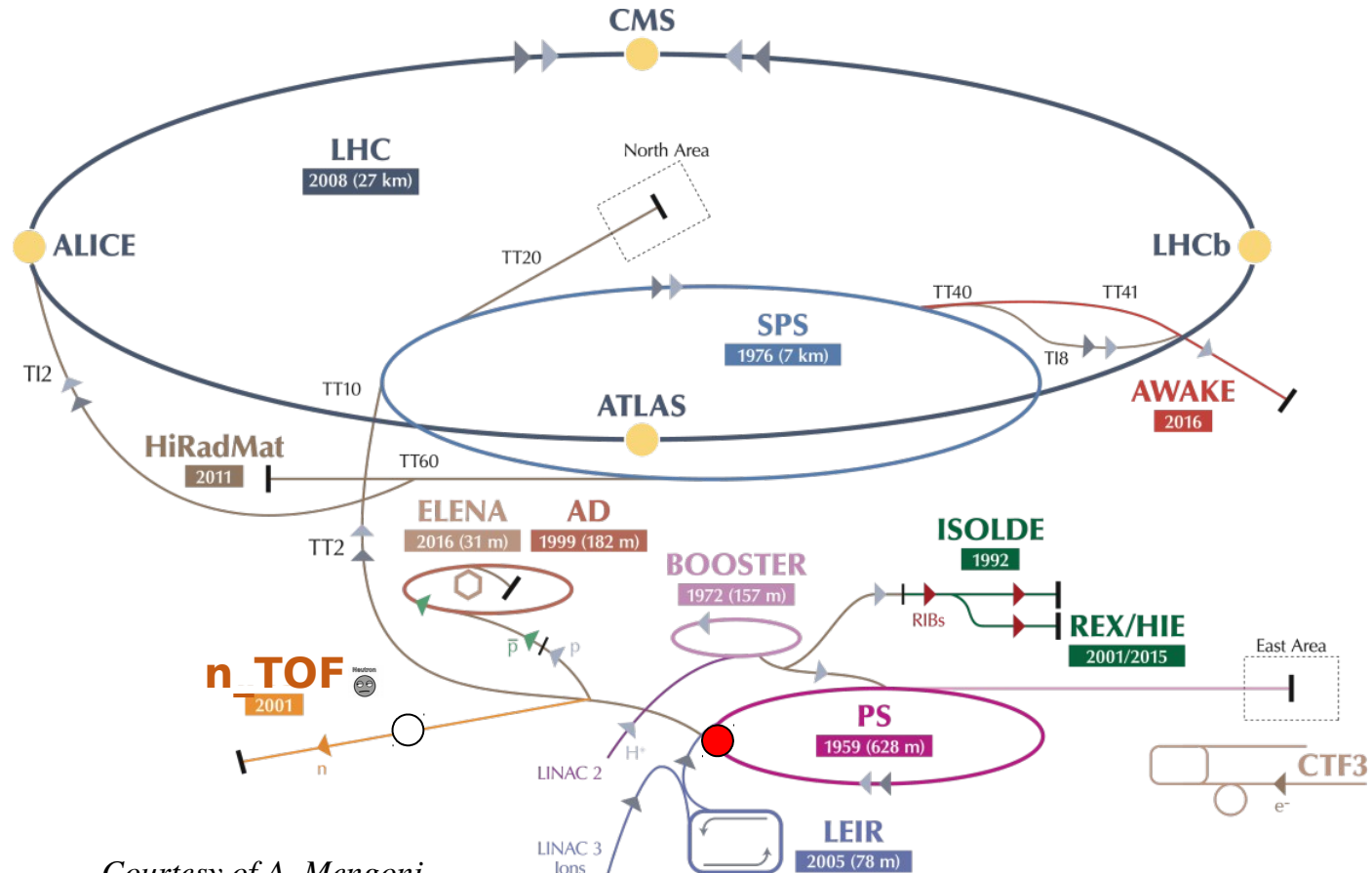| htBGO	
Entries	37616
Mean	21.58
Std Dev	1.424
Underflow	840
Overflow	1354
Integral	3.542e+04
χ² / ndf	374.3 / 97
Prob	3.301e-34
Constant	1897 ± 14.1
Mean	21.11 ± 0.00
Sigma	0.6024 ± 0.0035

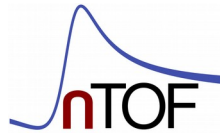# n_TOF @ CERN

Proton beam

20 GeV/c p from PS

7 ns bunch length

Min. 1.2s btw bunches

Courtesy of A. Mengoni

Neutron flux @ n_TOF

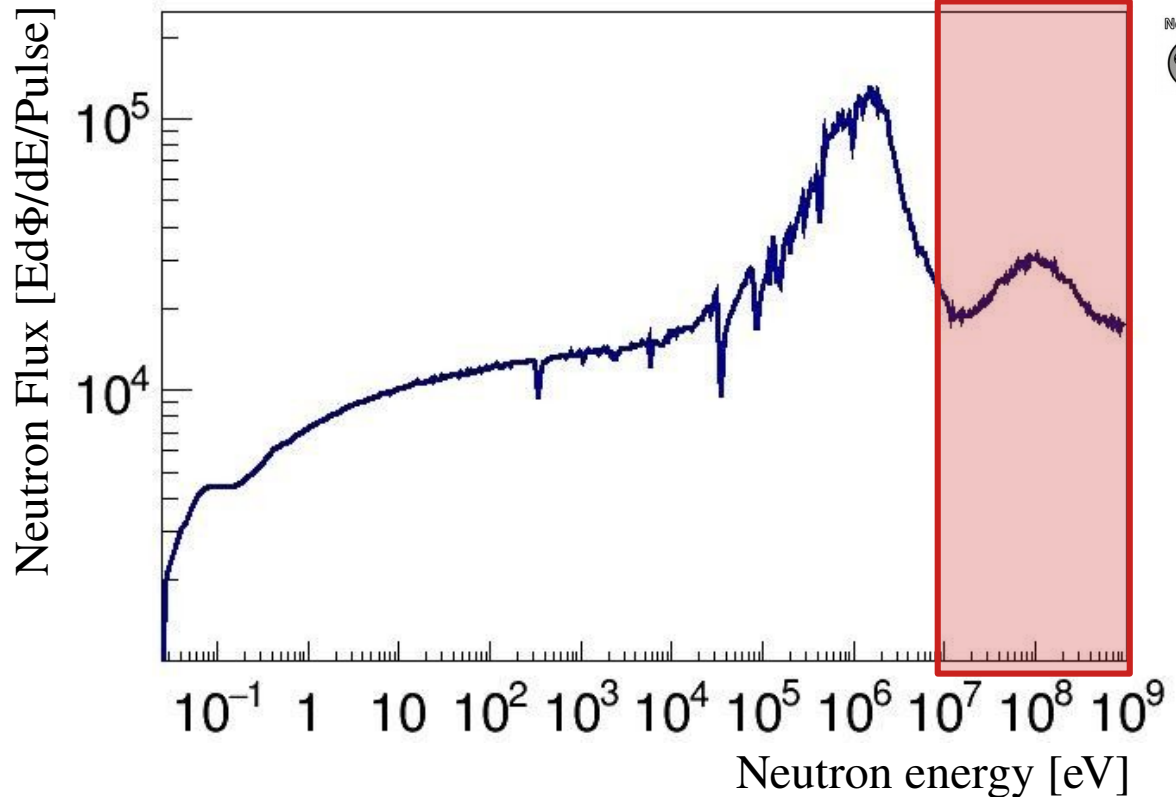**High neutron flux**

7×10^{12} p $\rightarrow 10^{15}$ n
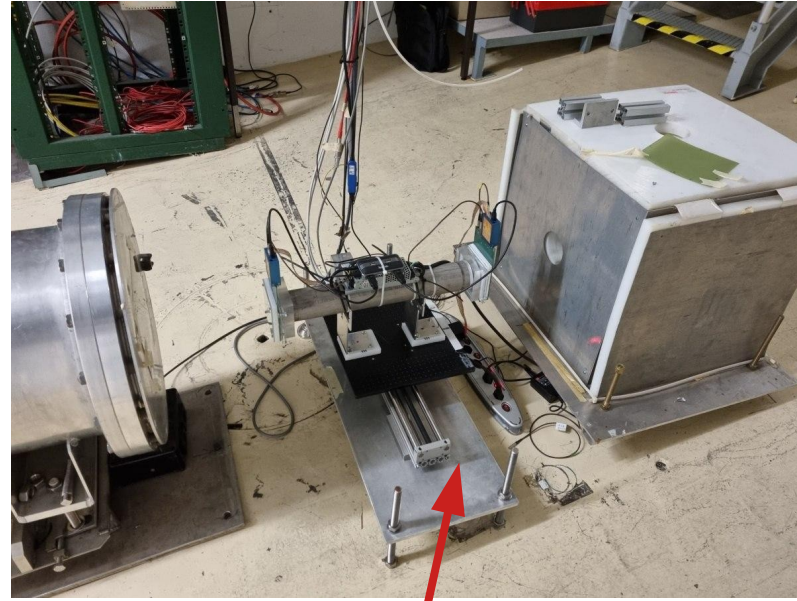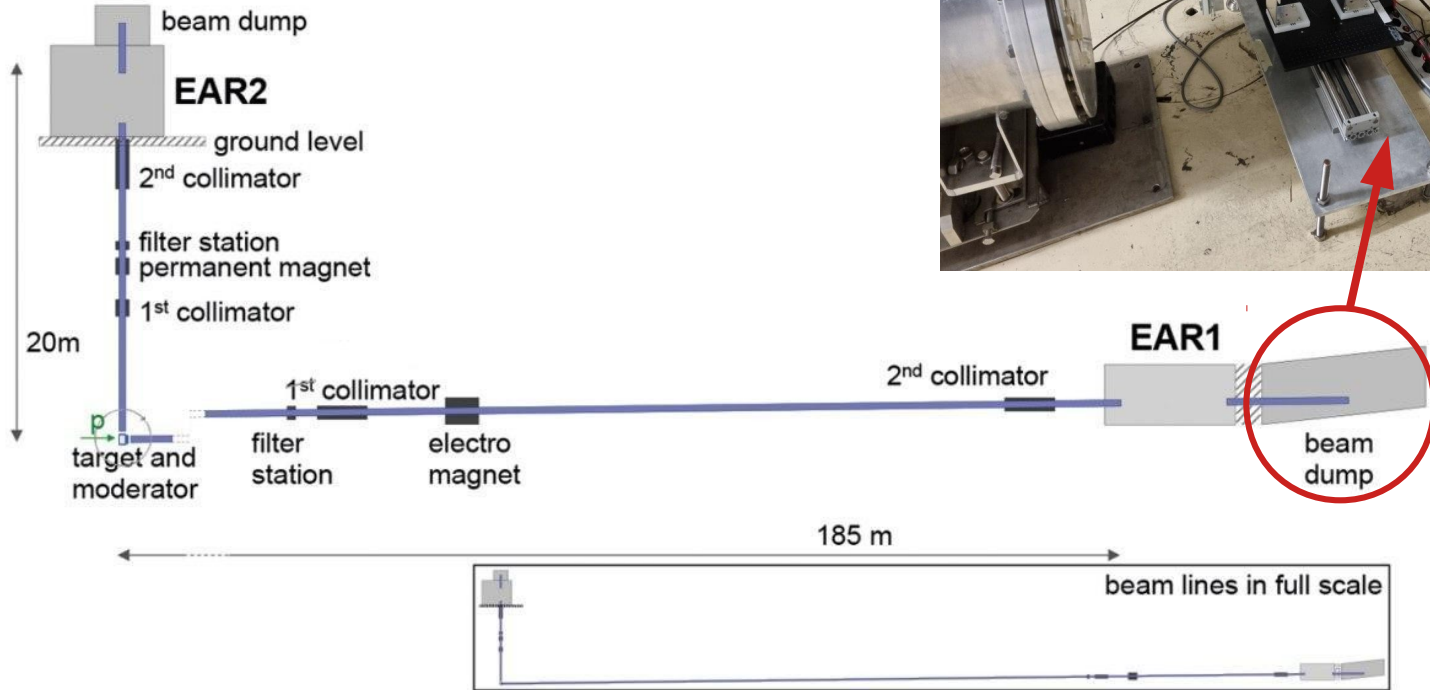
Wide energy range

Thermal – up to 1 GeV

High energy resolution → TOF

EAR1 →185 m flight path

ΔE/E 10^{-5} - 10^{-3}

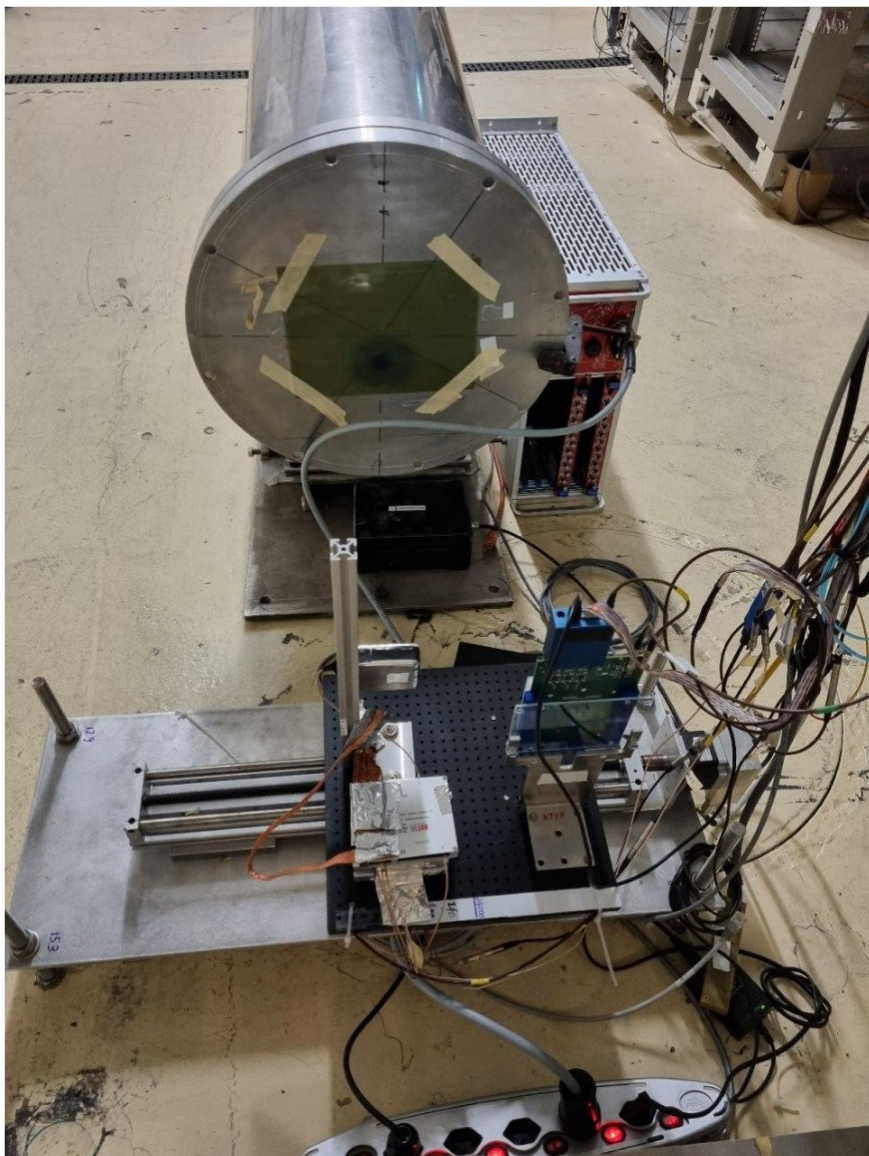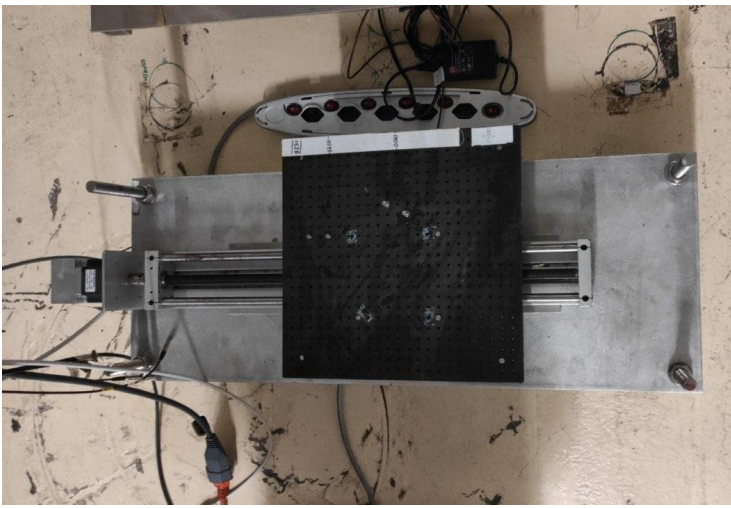# n_TOF @ CERN

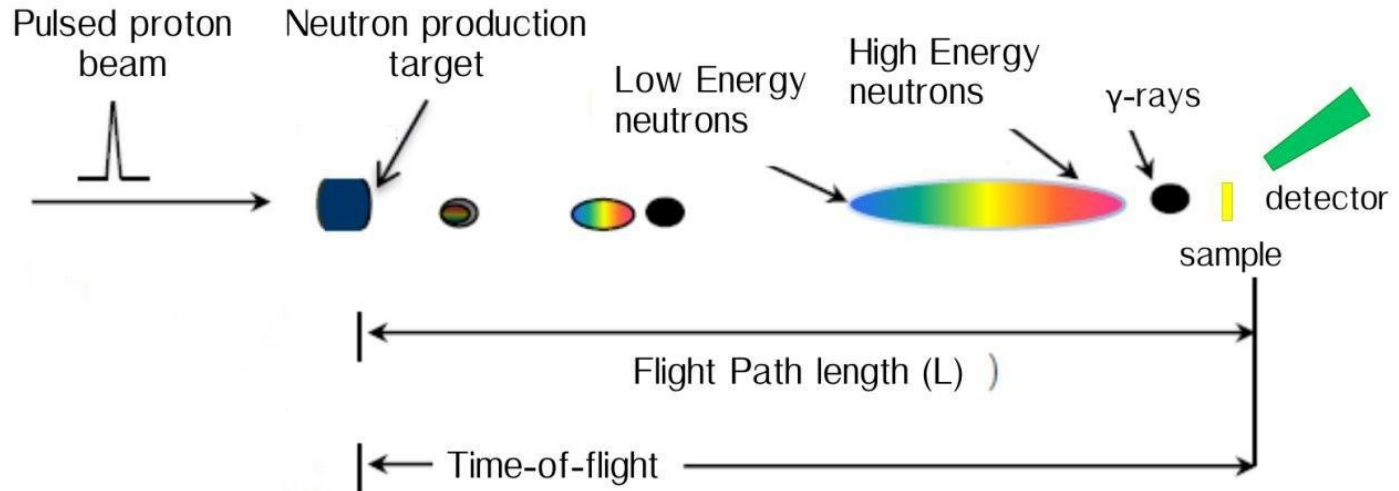**Possible to carry out measurements in the beam dump ~ 200 m flight path**

Beam dump

TOF-Energy conversion

Energy (MeV)	TOF(µs)
1	13.8
10	3.94
50	1.46
100	0.89
150	0.65
200	0.51
250	0.42
300	0.36
400	0.27
500	0.21
1000	0.10

Pulsed proton beam — Neutron production target — Low Energy neutrons — High Energy neutrons — γ-rays — detector — sample
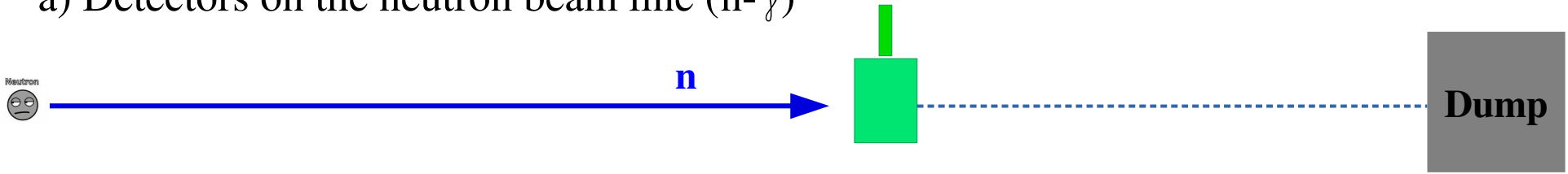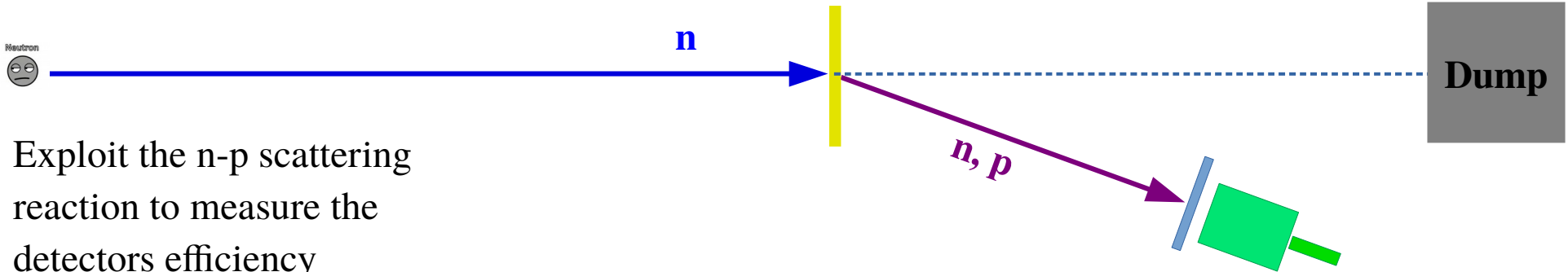
Flight Path length (L)

Time-of-flight

Detector characterization

1) Am-Be source for preliminary particle identification (n-γ) studies

2) Neutron efficiency studied with neutron beam

10 MeV – 1 GeV: 100000 neutron/bunch
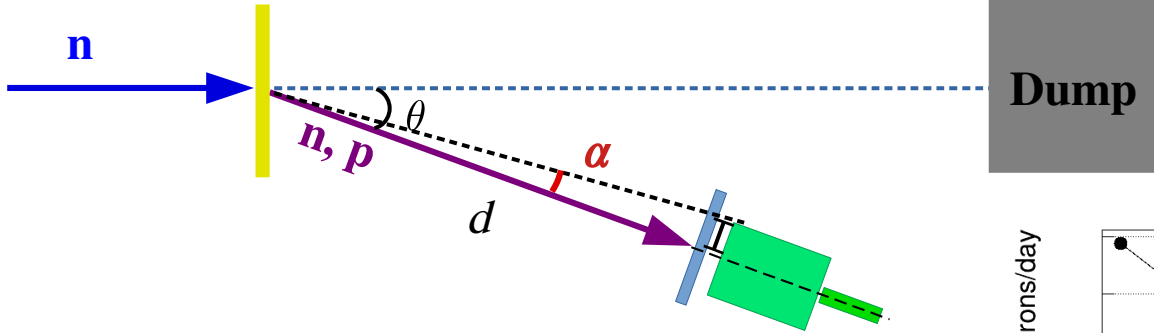
  a) Detectors on the neutron beam line (n-γ)

Neutron   **n**   **Dump**

  b) PE-C targets on the beam line and detectors (+ vetos) at a fixed angle (20-25°)

Neutron   **n**   **Dump**

n, p

Exploit the n-p scattering reaction to measure the detectors efficiency

Detector characterization

$$E'_n = E_n cos^2(\theta)$$

nTOF

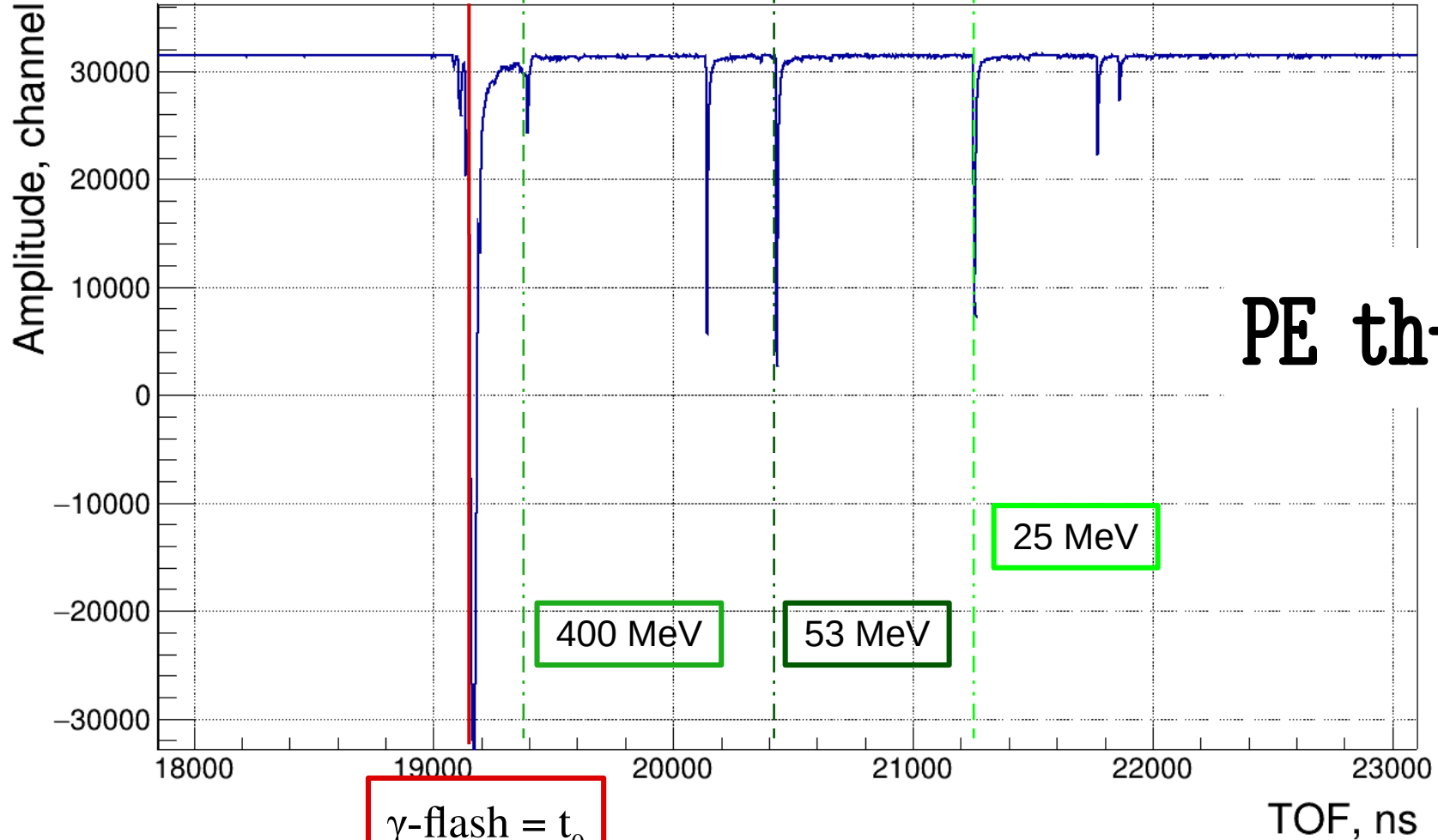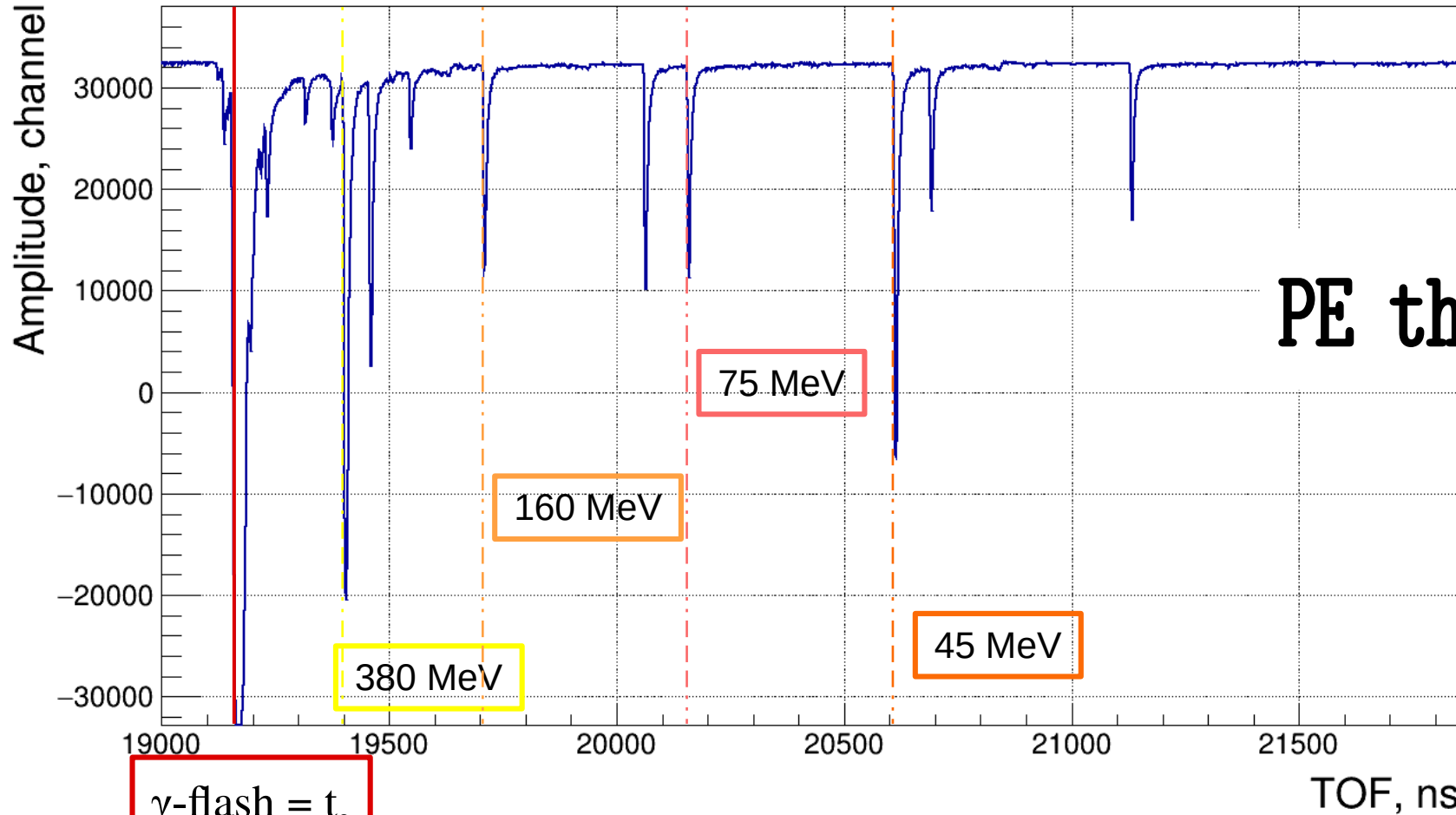| d [cm]	α [°]	$cos^2(\theta \pm \alpha)$ [%]	
20	10.8	14.6-19.5	→ ±17
25	8.6	12-16	→ ±14
30	**7.2**	**10-12**	**→ ±11**
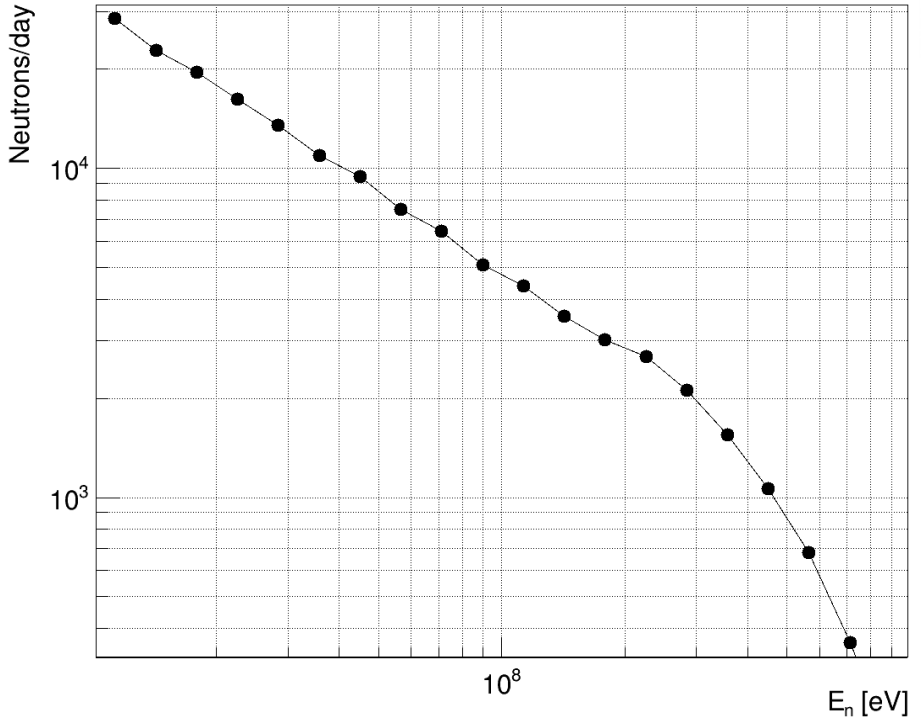
1 bunch every 6 s

dΩ = 0.05 sr

n (PE, th 5 mm) ≈ 0.04 at/barn

10 bins/decade

8-10% energy bin resolution

Expected signals distribution
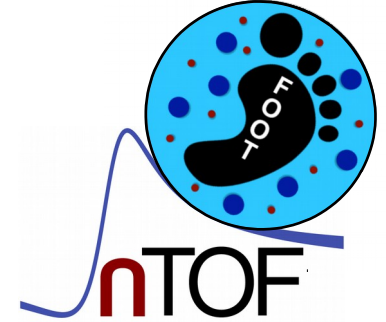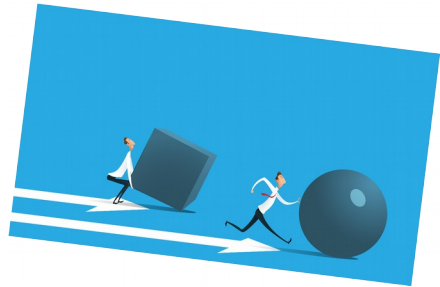
Expected signals distribution

Conclusion

from March to July/August
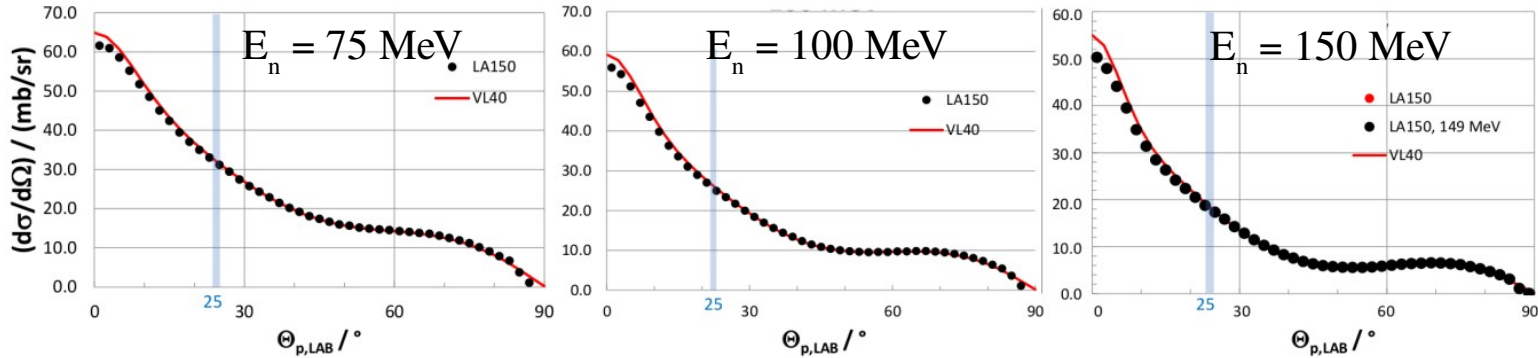
n/γ discrimination: AmBe source

neutron beam

Neutron efficiency of the detectors: neutron beam

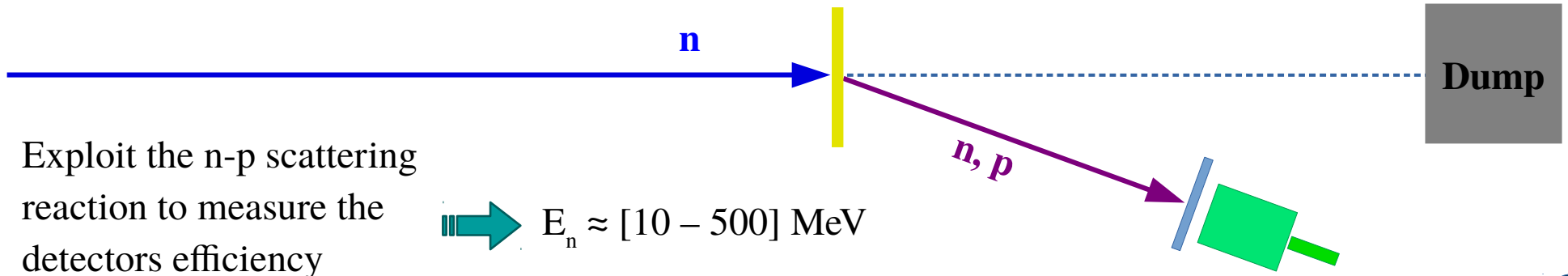(from 10 to 300 MeV) n-p elastic scattering

Backup slides

Detector characterization

$E_n = 75$ MeV

$E_n = 100$ MeV

$E_n = 150$ MeV

100000 neutron/bunch · dσ/dΩ · dΩ · n ≈ 16 neutron/bunch

dΩ = 0.2 sr

n (PE, th 5 mm) ≈ 0.04 at/barn

b) PE-C targets on the beam line and detectors (+ vetos) at a fixed angle (20-25°)

n

Dump

n, p

Exploit the n-p scattering reaction to measure the detectors efficiency

$E_n \approx [10 - 500]$ MeV

Hardware at n_TOF

Stuff available @ n_TOF:

- DAQ:

  fADC 12bit

  Full Scale Input Range 0.1-5 Vpp

  1 GSPS

  100 ms acquisition time

- HV channels:

  - up to 3.5kV, uA - 3mA (1 a 4kV)

  + up to 3kV, 200-20 uA