Future analyses for neutron physics

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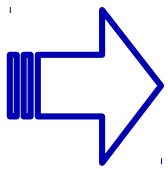
Goals

Neutron detection:

1. count them
2. define their energy → **TOF**

Setup

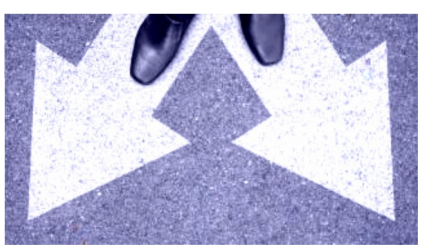


Number of neutrons

Efficiency

Energy resolution

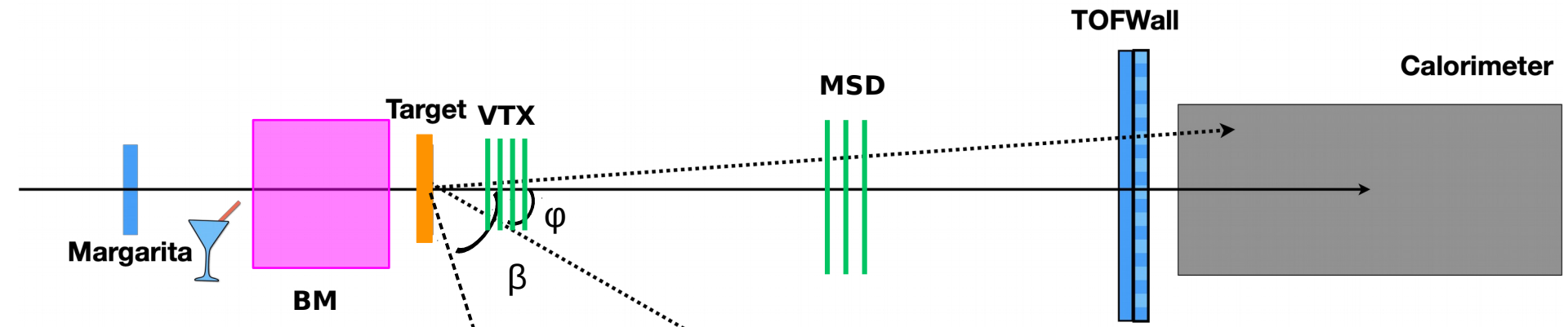
Two possibilities under study



Benefiting from the current FOOT configuration

Possible FOOT upgrade on neutron detection

Test beam @CNAO - Possible setup



VETO

VETO

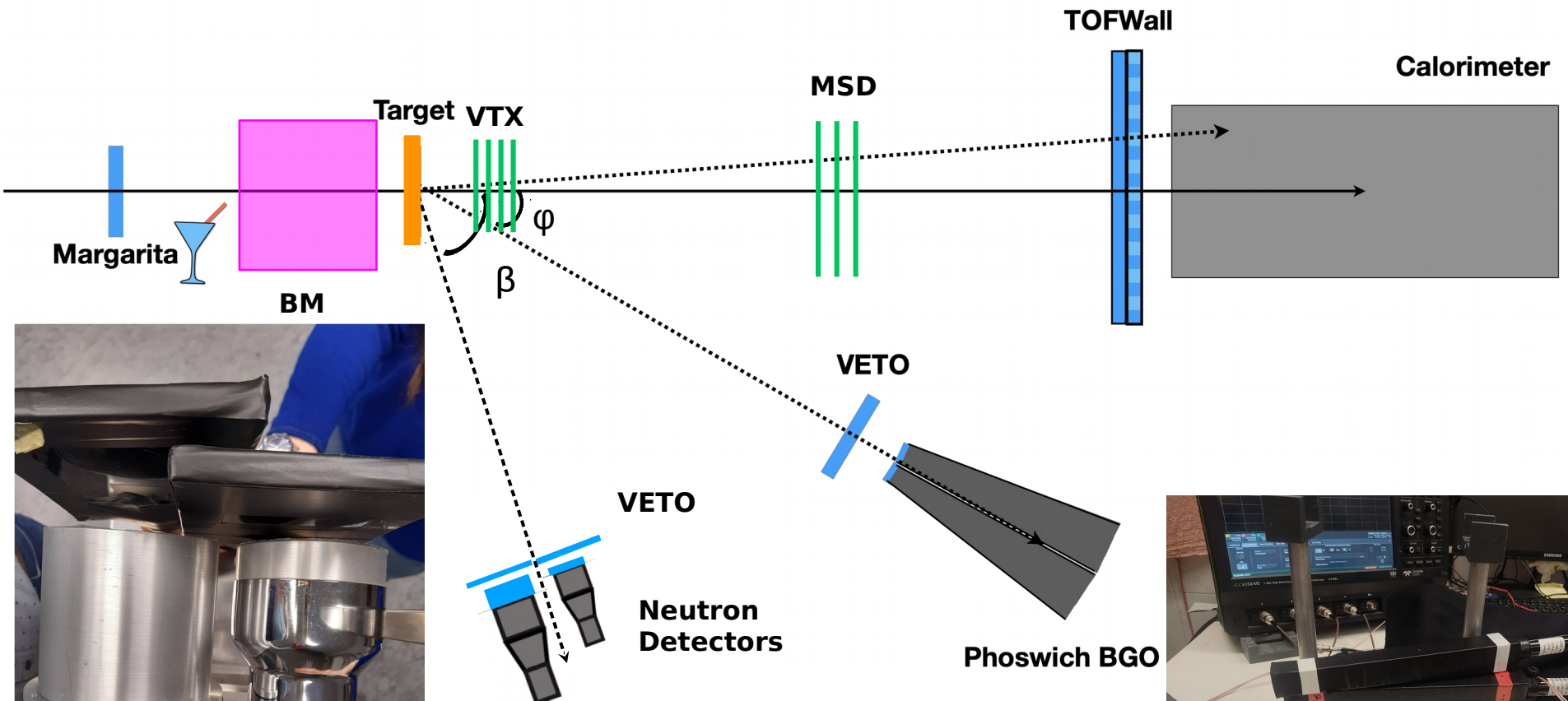
Neutron Detectors

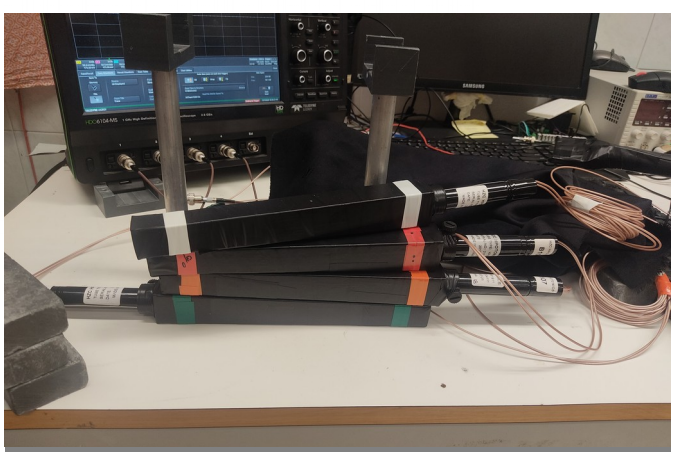
Phoswich BGO

- [x] 1 BC-720 - Bacco
- [x] 1 NE213 - Nike
- [x] 2 plastic scintillator veto

- [x] 4 BGO_pw crystals
- [ ] 1 plastic scintillator veto

Test beam @CNAO - Possible setup





$^{12}C + ^{12}C$ differential cross section

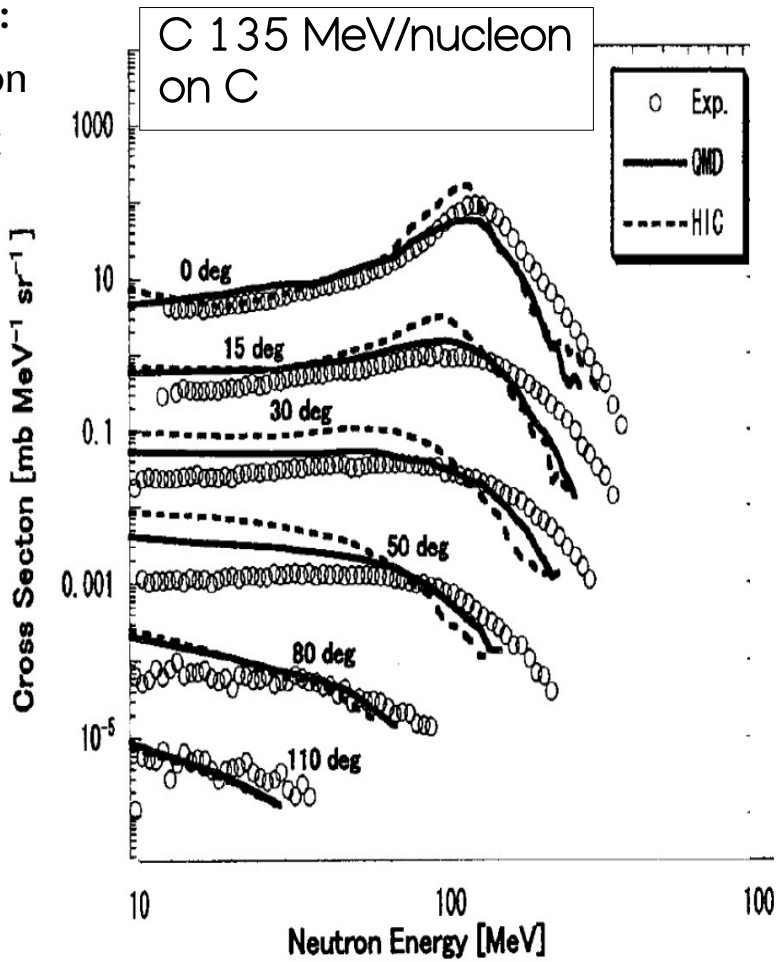
Repeating experiments in the literature: double differential inclusive cross section for the production of neutron in $^{12}C+^{12}C$ reactions

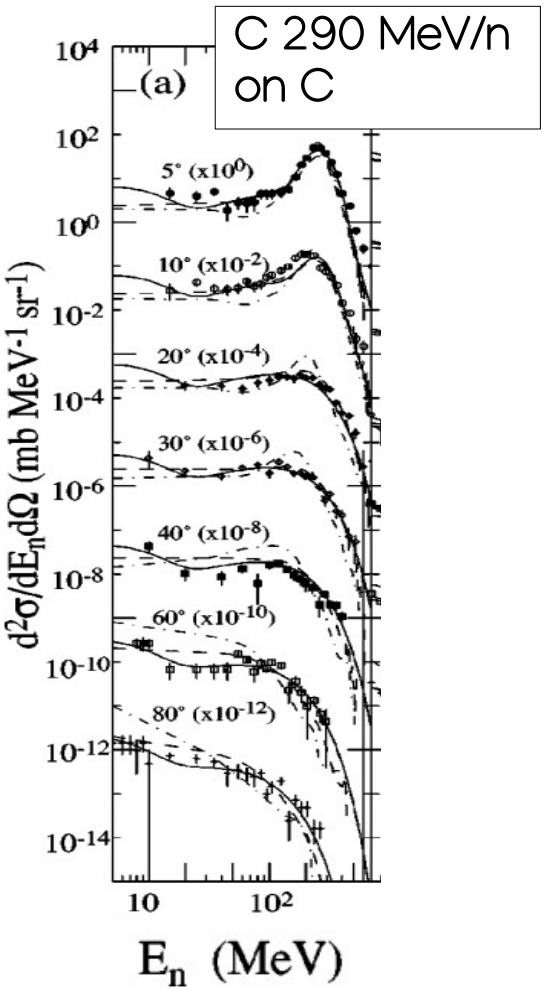
^{12}C @ 135 MeV/u

→ 0°, 15°, **30°**, 50°, **80°**, 110°

^{12}C @ 290 MeV/u

→ **5°**, 10°, 20°, **30°**, 40°, 60°, **80°**





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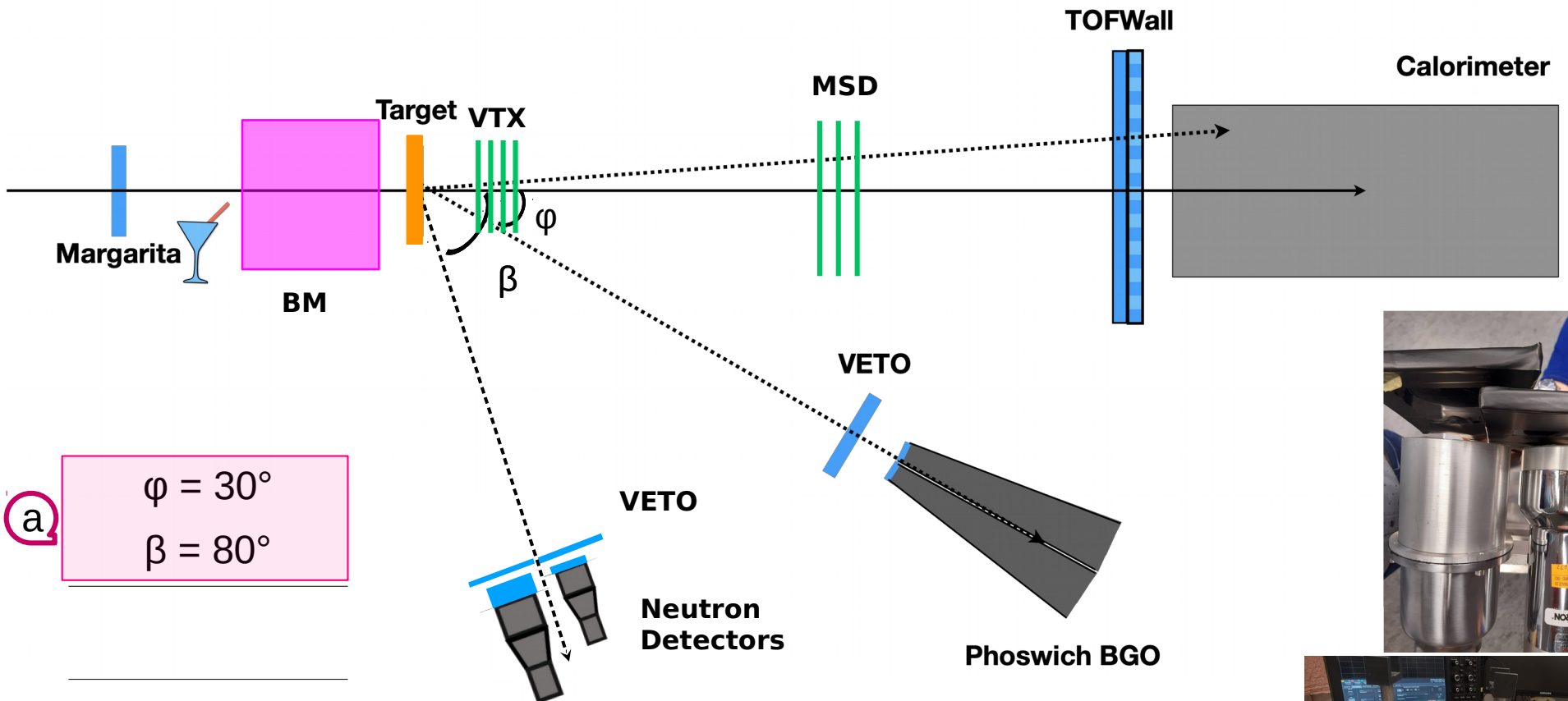
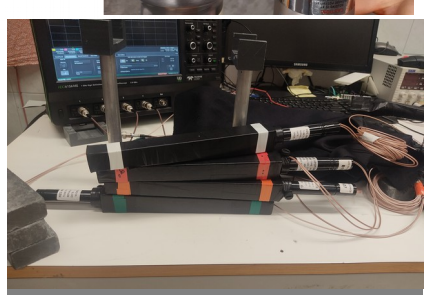
Test beam @CNAO - Possible setup



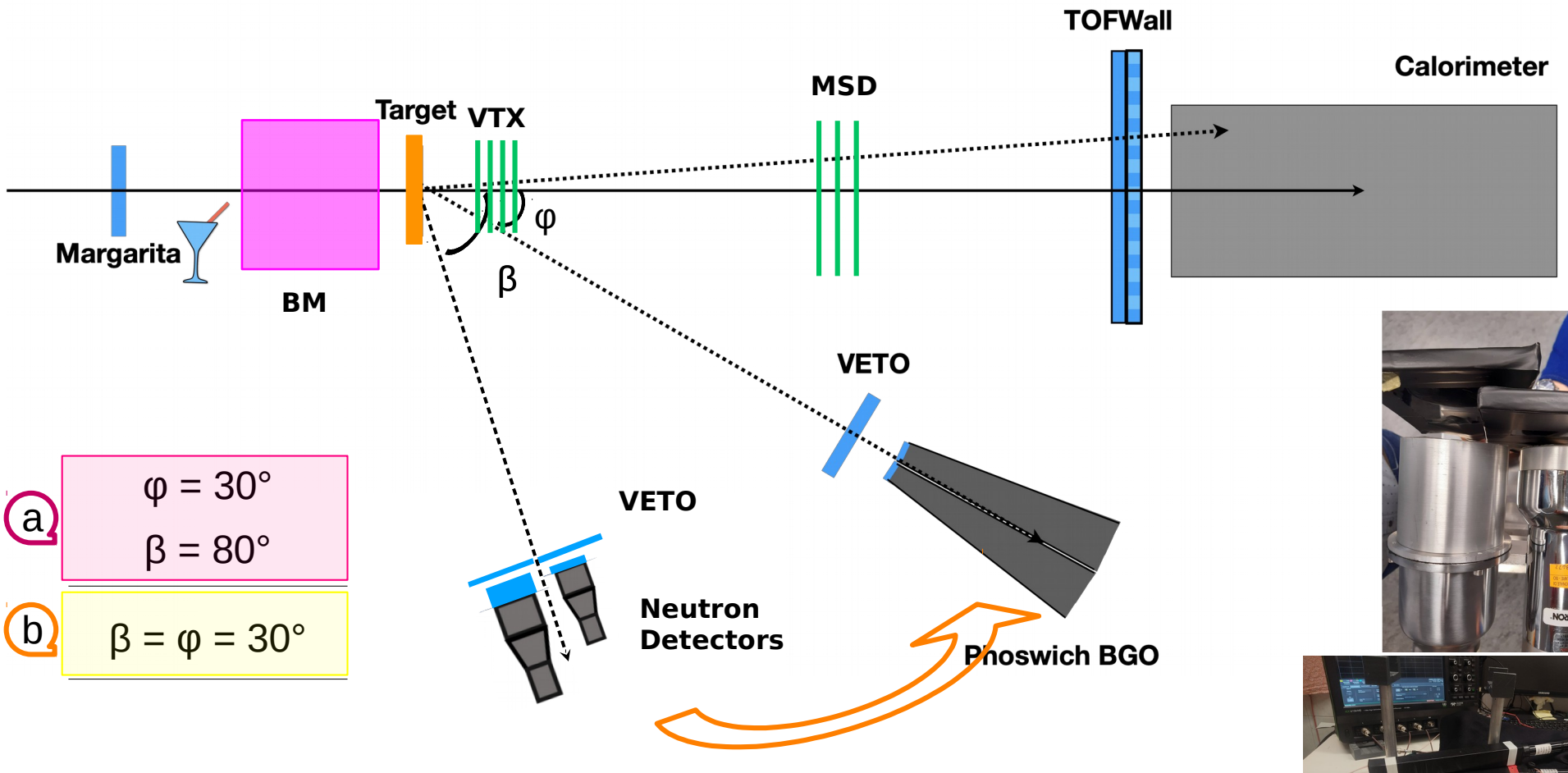
a

φ = 30°

β = 80°

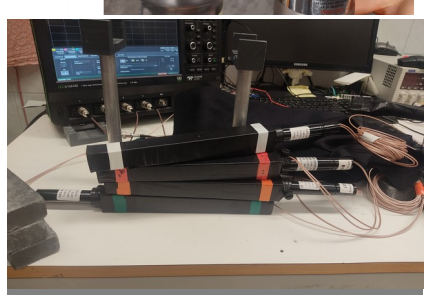


Test beam @CNAO - Possible setup

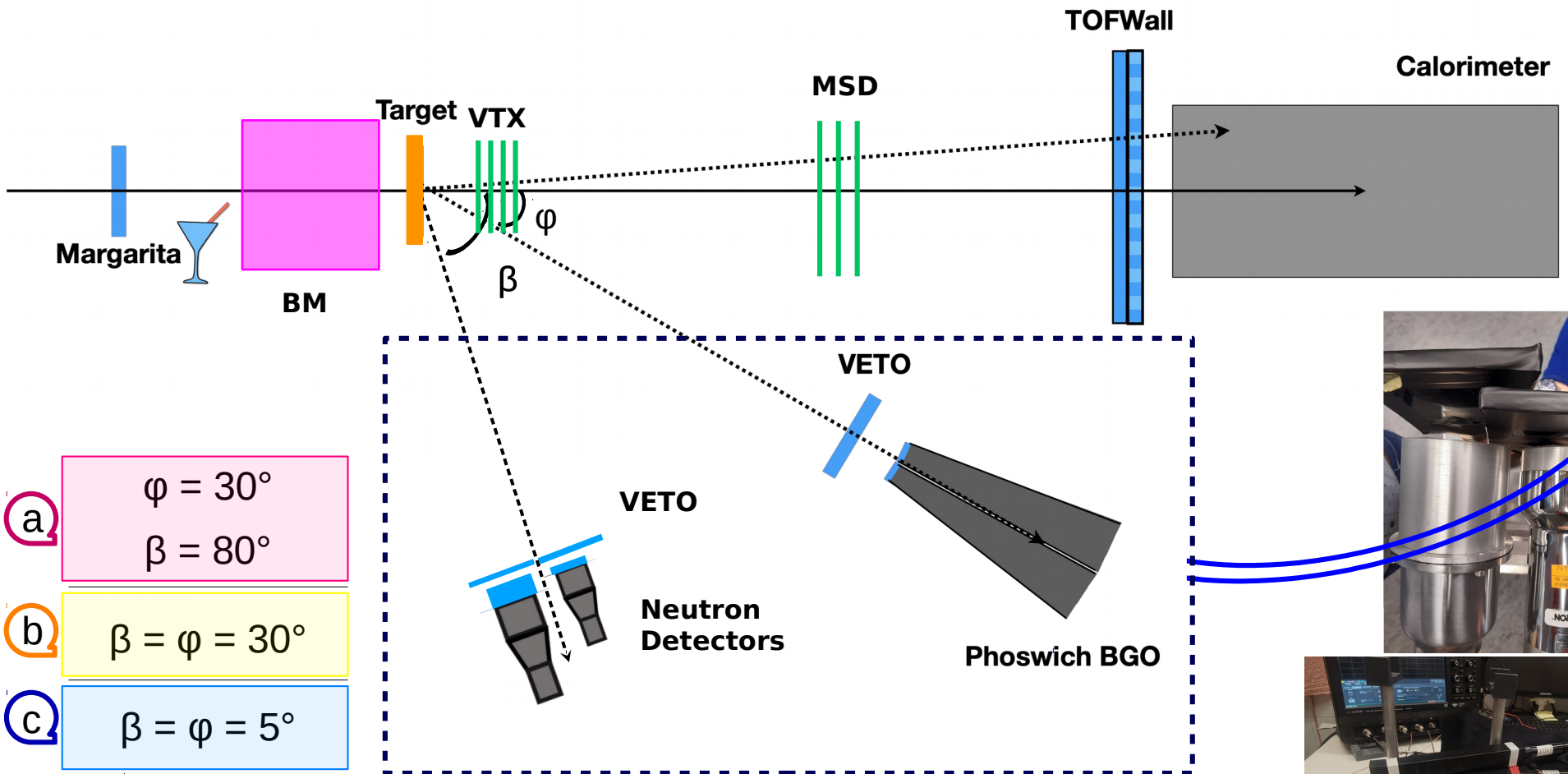


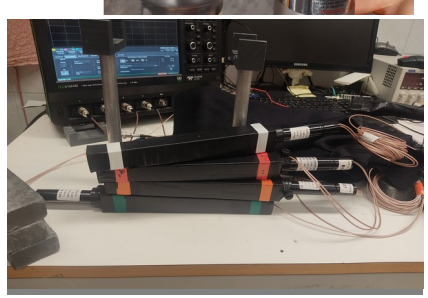
a) φ = 30°, β = 80°

b) β = φ = 30°



Test beam @CNAO - Possible setup





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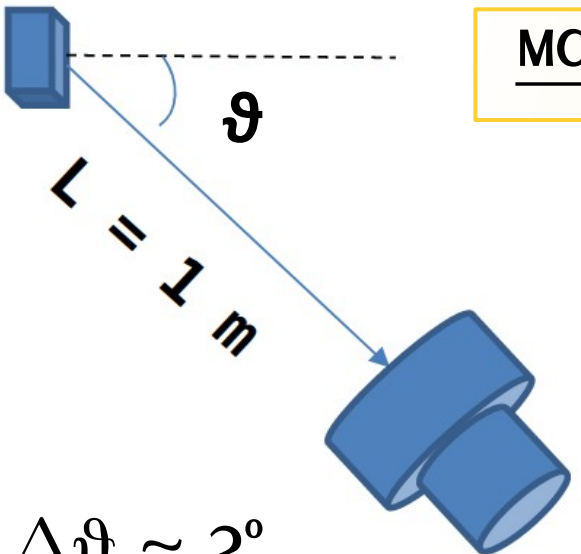


$\Delta\vartheta \sim 2^{\circ}$

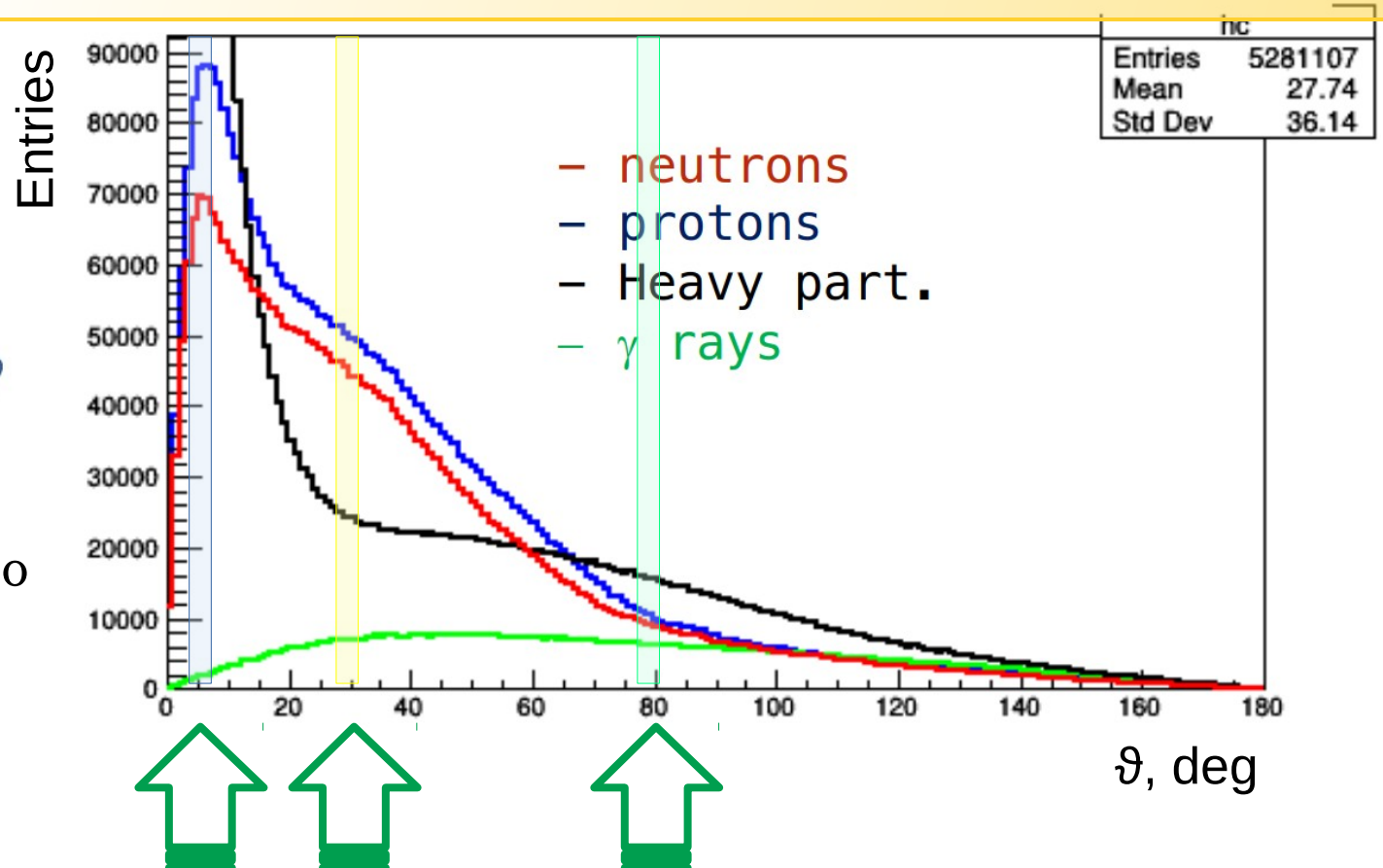
Signal-to-background ratio (n/γ)

@ 5° ~ 35

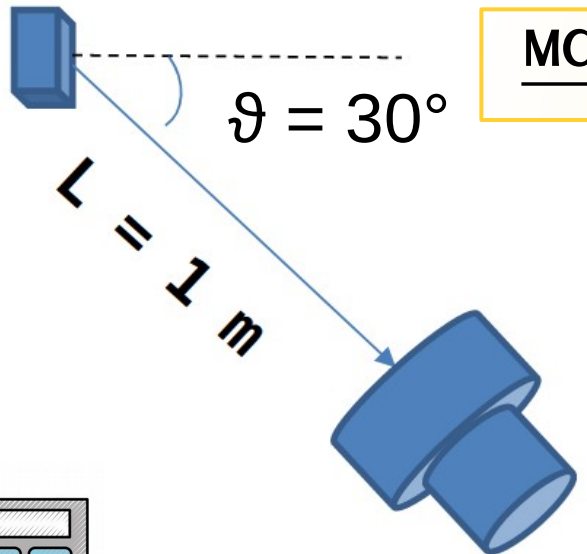
@ 30° ~ 7

@ 80° ~ 2

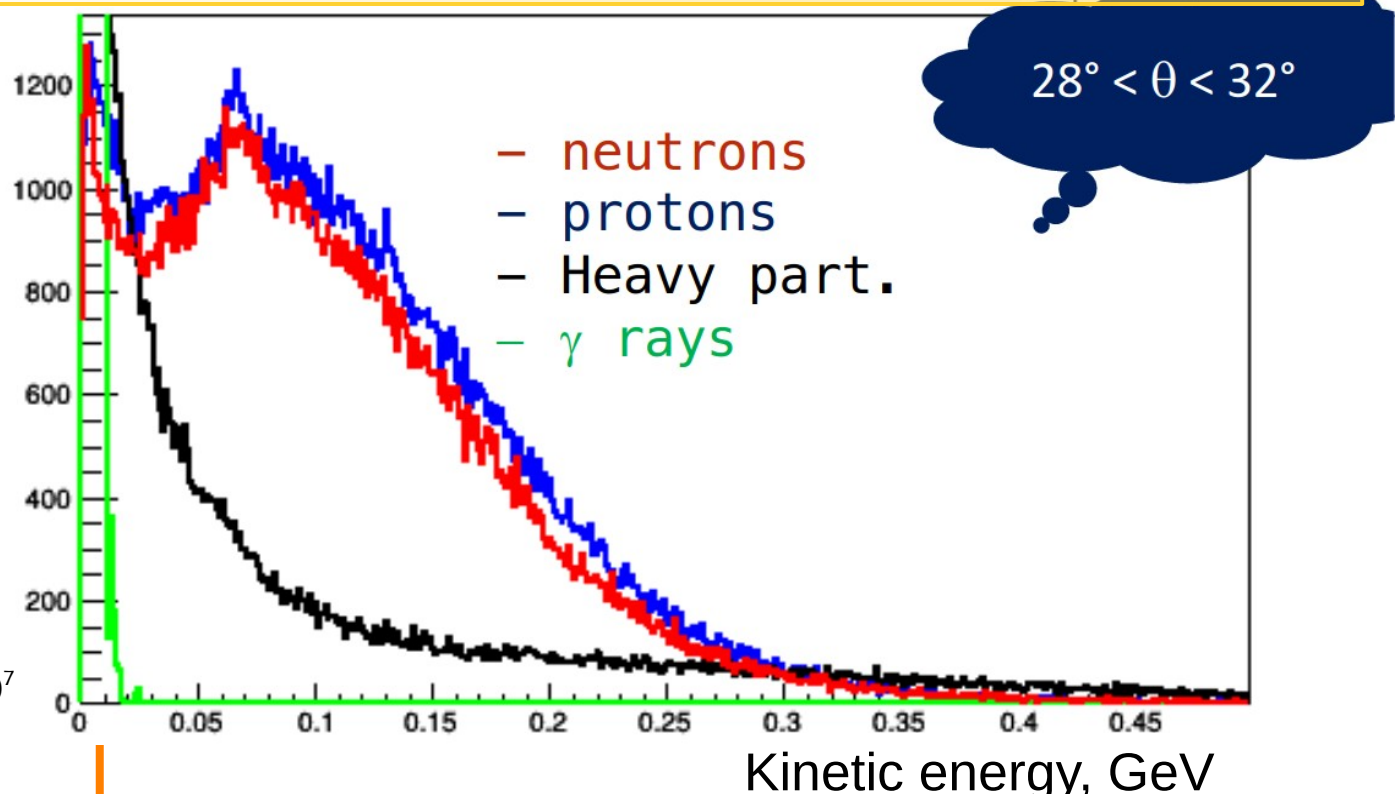
MC simulations: $^{16}O+C_2H_4$ @200MeV/u - statistics: $5 \cdot 10^7$ primaries



Test beam @CNAO - Possible setup



MC simulations: $^{16}O+C_2H_4$ @200MeV/u – statistics: $5 \cdot 10^7$ primaries



~181000 neutrons

Geometric efficiency ~1%

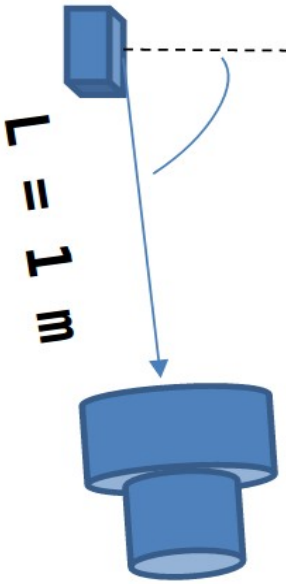
Detection efficiency ~10%

→ **181 events** in the detector for $5 \cdot 10^7$ primaries

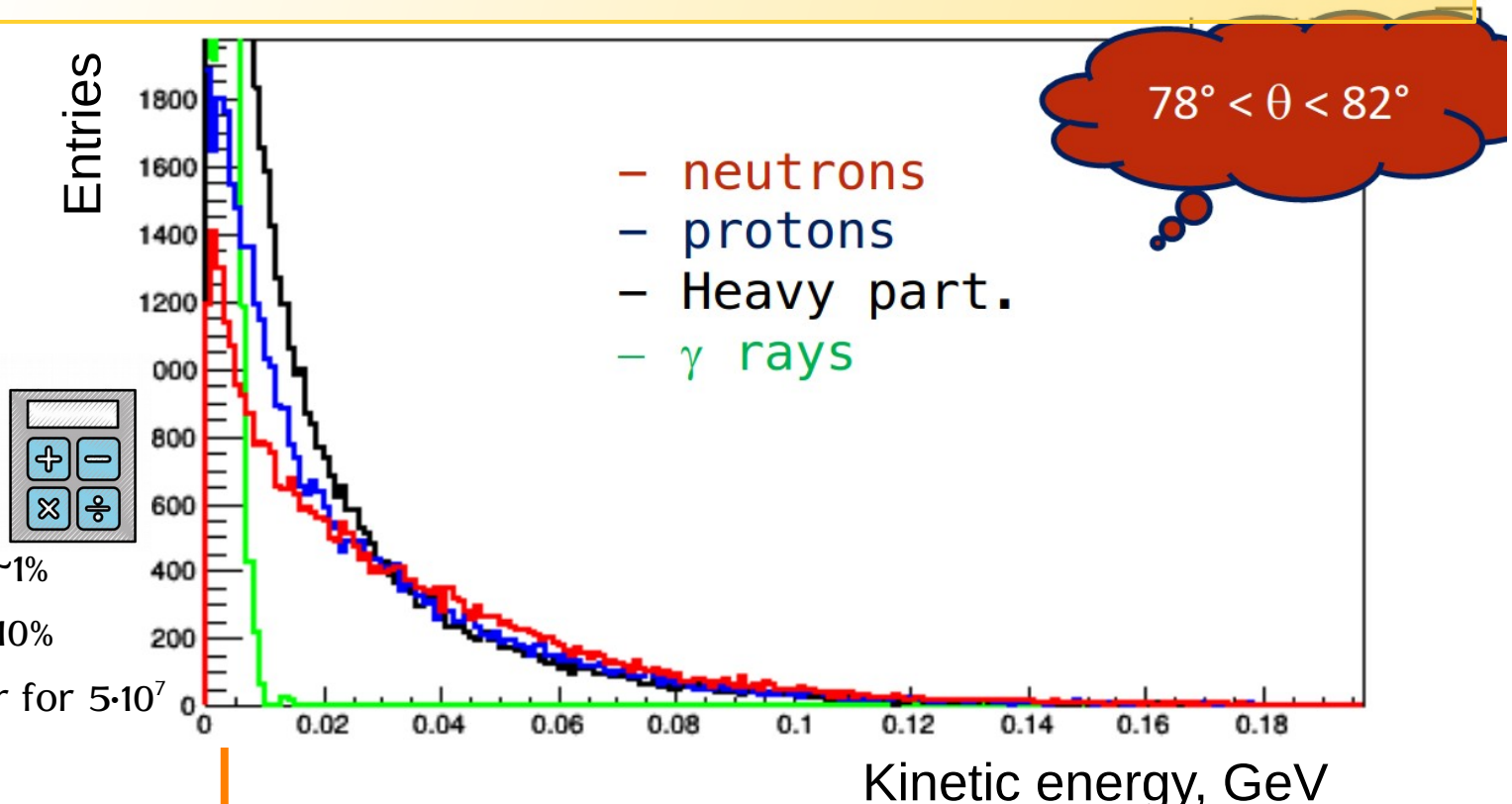
30 h for ~180 neutrons (beam 1 kHz)

1 h for ~6000 neutrons (beam 1 MHz)

Test beam @CNAO - Possible setup



MC simulations: $^{16}O+C_2H_4$ @200MeV/u - statistics: $5 \cdot 10^7$ primaries



~36000 neutrons

- Geometric efficiency ~1%
- Detection efficiency ~10%

→ **36 events** in the detector for $5 \cdot 10^7$ primaries

30 h for ~30 neutrons (beam 1 kHz)

1 h for ~1200 neutrons (beam 1 MHz)

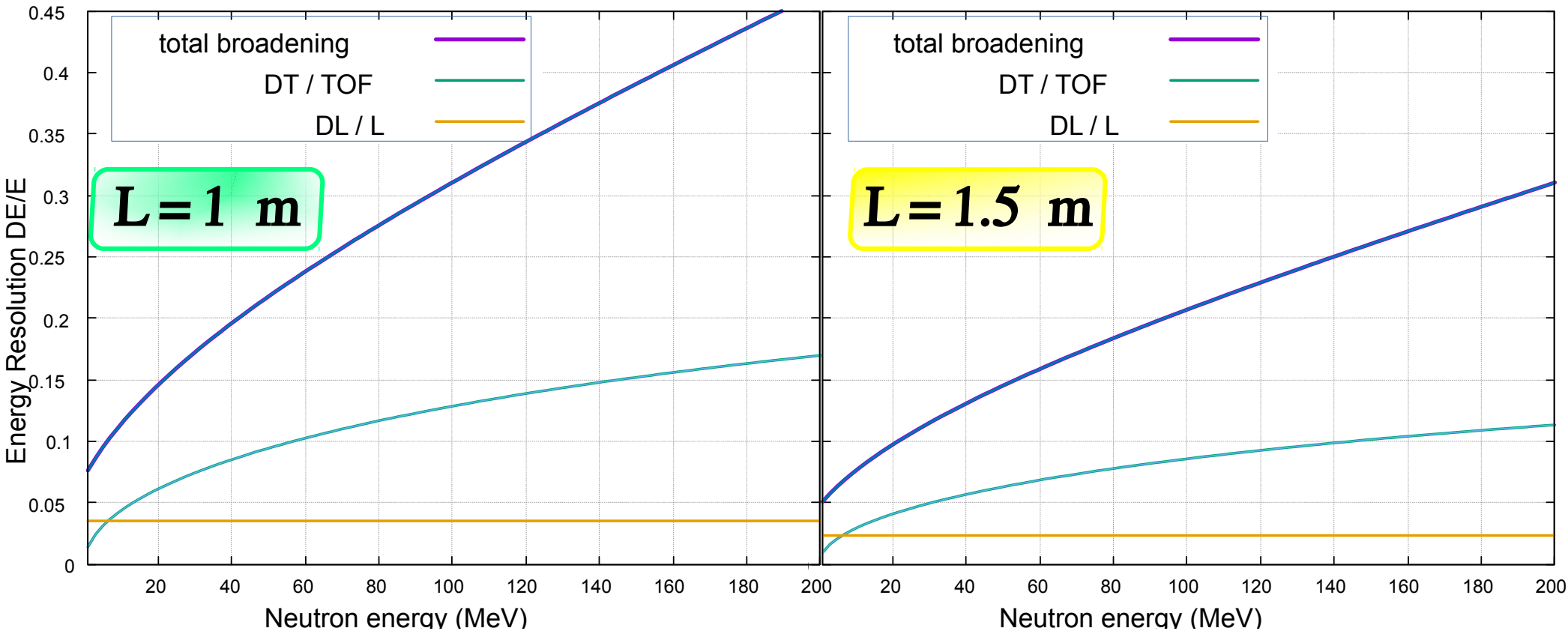
Energy resolution

$$\frac{\Delta E}{E} = \gamma(\gamma+1)\sqrt{\left(\frac{\Delta L}{L}\right)^2 + \left(\frac{\Delta T}{TOF}\right)^2} \Rightarrow \frac{\Delta E}{E} = \frac{\gamma(\gamma+1)}{L}\sqrt{(\Delta L)^2 + (\Delta T\,\beta c)^2}$$

$TOF = L/\beta c$

with: ΔL = 0.0354 m

ΔT = 1 ns



MC simulations Request

we will communicate to Giuseppe and Silvia the geometric specifications of the detectors

$5 \cdot 10^7$ primaries

a. **Phoswich BGO @30° and L = 1.5 m + Bacco & Nike @80° and L = 1 m**

b. **Phoswich BGO @30° and L = 1.5 m + Bacco & Nike @30° and L = 1.5 m**

c. **(Phoswich BGO @5° after Calo + Bacco & Nike @5° after Calo)**

Conclusion

- **Dedicated simulations** are required to better prepare the test and estimate the required beam time

- During the next test beam at CNAO It could be possible to repeat some measurements present in the literature about neutron production in **$^{12}C+^{12}C$ reactions:**
  •12C + 12C @ 30, 80 and 5 deg. with energy of 135 and 290 MeV/u. These tests will provide the information about the feasibility of detecting neutrons with the present setup and with other detectors.

- **Dedicated beam time** to perform the test
  => 1 hours at 1 MHz ?