IX FOOT Collaboration Meeting
9-11 December 2020

PRIN 2020

Ministero dell'Università e della Ricerca

PRIN & FOOT

Vincenzo Patera

Main features…

- Time span: 3 years program. Application deadline: 26 Jan 2021. Actual starting (money arrives to Dept/section): early 2022-> end early 2025.
- Max budget: 1.2 Meuro. Number of units up to 5. Both contracts and material funding allowed.
- INFN personnel must go in ONE unit. Also associate personnel from university can join INFN unit, but can not coordinate INFN unit
- The FOOT community already presented in 2018 a proposal focused on the neutron detection in a FOOT-like. The evaluation was 92/100. The funded proposals had 94/100 minimum.

Valutation (I)

CRITERI DI VALUTAZIONE	PUNTEGGIO
1. **Qualità del progetto di ricerca** – *merito scientifico e natura innovativa del progetto dal punto di vista internazionale* – con particolare riguardo a:	Totale: 40
a) Chiarezza e pertinenza degli obiettivi del progetto;	a) 10
b) Rilevanza ed originalità del progetto proposto nella specifica area scientifica;	b) 10
c) Metodologia adottata, organicità del progetto, anche rispetto allo specifico contributo delle unità locali (se previste);	c) 10
d) Posizionamento del progetto rispetto allo stato dell'arte nella specifica area scientifica;	d) 10

TOTAL POINTS: 100

Valutation (II)

2. **Composizione del gruppo di ricerca, fattibilità e congruità del progetto** – *merito scientifico della compagine di ricerca, fattibilità del piano di lavoro e ragionevolezza della richiesta di finanziamento* – con particolare riguardo a:	Totale: 40
a) Eccellenza del *Principal Investigator,* dei responsabili delle unità locali (se previste) e dell'intera compagine di ricerca;	a) 10
b) Capacità di realizzare il progetto proposto (qualificazione, composizione e complementarietà dell'intera compagine proposta);	b) 10
c) Organizzazione del progetto riguardo agli obiettivi proposti, ai tempi ritenuti necessari per il completamento del progetto e alle risorse richieste (strumentazione, dimensioni della compagine di ricerca, management);	c) 10
d) Coerenza degli impegni temporali dei componenti della compagine di ricerca, congruenza e pertinenza del piano di spesa con gli obiettivi e l'articolazione delle attività;	d) 10

TOTAL POINTS: 100

Valutation (III)

3. **Impatto sociale del progetto**, con particolare riferimento a:	Totale: 20
a) Sfide che la ricerca affronta sotto il profilo dell'incidenza sull'innovazione tecnologica, sulle applicazioni industriali, sulla crescita economica ovvero sulla soluzione di problemi sociali, sulla protezione dell'eredità culturale o dell'ambiente anche con approcci interdisciplinari;	a) 10
b) Efficacia delle azioni di divulgazione del progetto di ricerca e dei relativi risultati; impatto del progetto sulla comunità scientifica e sulla società alla luce degli obiettivi definiti dal programma quadro di ricerca ed innovazione dell'UE;	b) 10
TOTALE PUNTEGGIO	**0-100**

??

TOTAL POINTS: 100

Idea di base per l'apparato(2018)

REGIONE UPSTREAM: START COUNTER + BEAM MONITOR DI FOOT

TARGET

Distaza da determinare/variare cercando l'ottimizzazione in risoluzione di TOF, dimensioni trasversali del calorimentro/copertura angolare,....

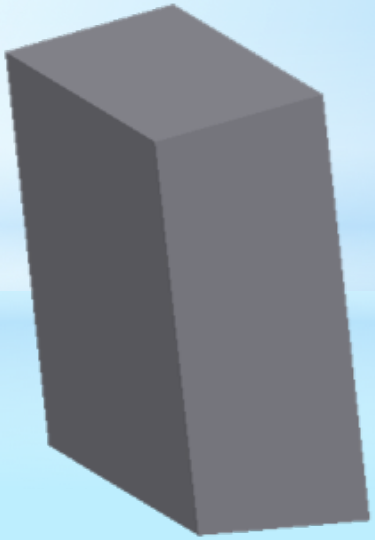
CALORIMETRO CON ALTA RISOLUZIONE TEMPORALE ALTA EFFCICIENZA

VERTEX TRACKER/MSD

(PIU' ESTESO RISPETTO A QUELLO DI FOOT?)

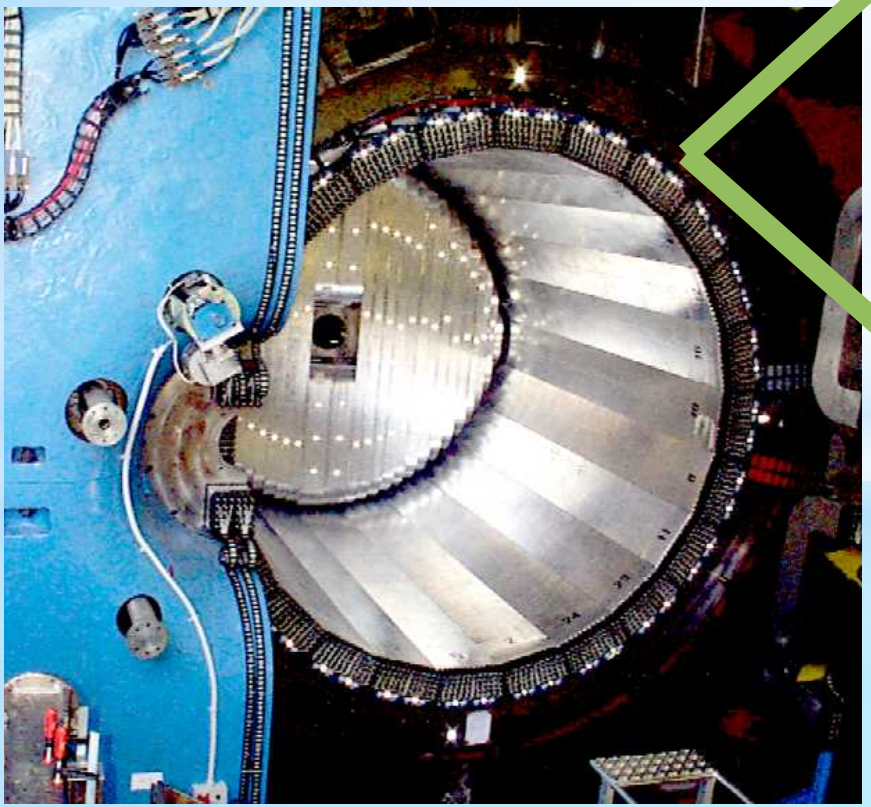
In FLUKA ..


Y
LeFt
50
40
30
20
10
0
-10
-20
-30
-40
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 Z

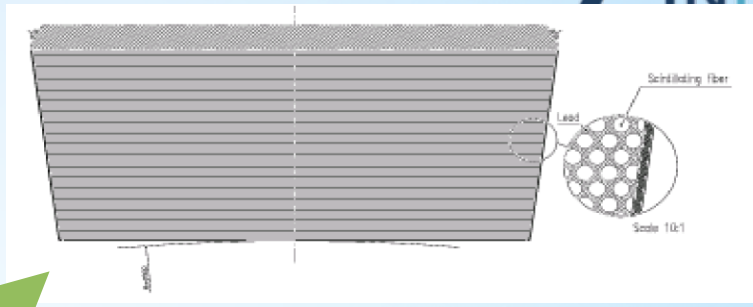


The detector would be a sector of one barrel module pf KLOE calorimeter
Namely a 60 cm long part:
Dimension: 52x60x23 cm^3
Weight : 250 kg

The KLOE calorimeter



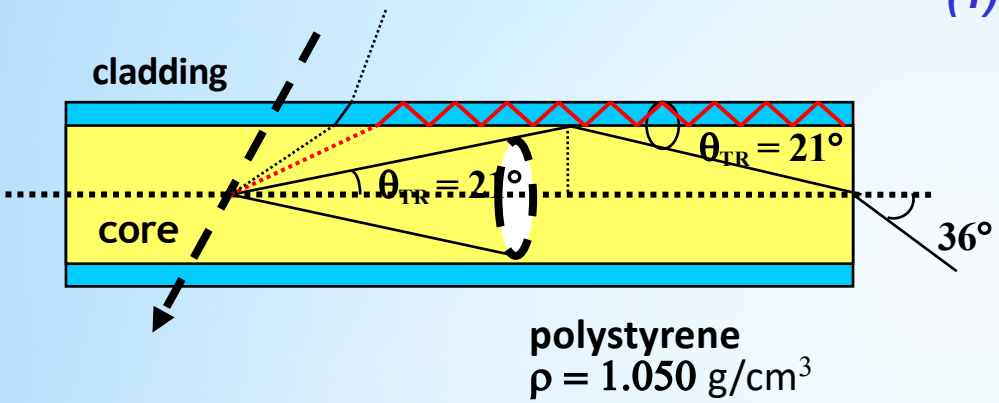
Calorimeter module



24 barrel modules
Trapezoidal section
(52 – 59)x23 cm^2
length: 430 cm

Pb/Sci fibres structure
200 layers, lead foils + glue + fibres

Working principle



(1) Scintillating fiber (1mm diameter) [emitting in the blue-green region (λ_{peak}~460 nm)]

(2) Lead: 0.5mm grooved layers (95% Pb and 5% Bi)

(3) Glue: Bicron BC-600ML (72% Epoxy resin, 28% Hardener)

n(core=**polystyrene**) = **1.6** n(cladding=**PMMA**) = **1.49**

Only **~3%** of photons produced are trapped in the fiber

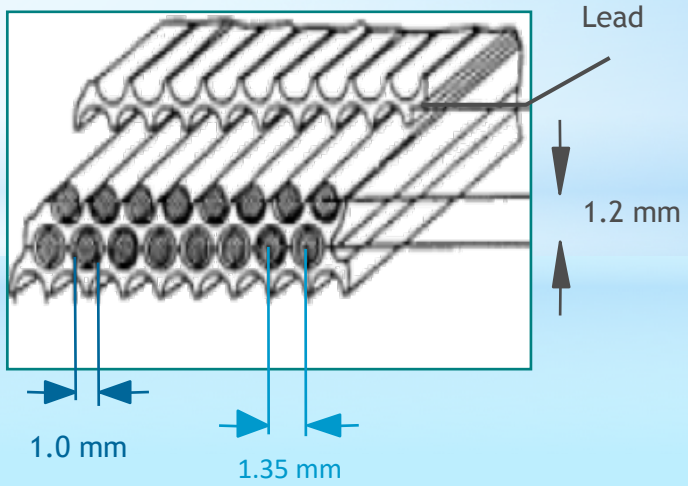
But :

(a) ~ uni-modal propagation at **21°** ➔ small transit time spread

(b) Small attenuation (λ ~ **4-5 m**)

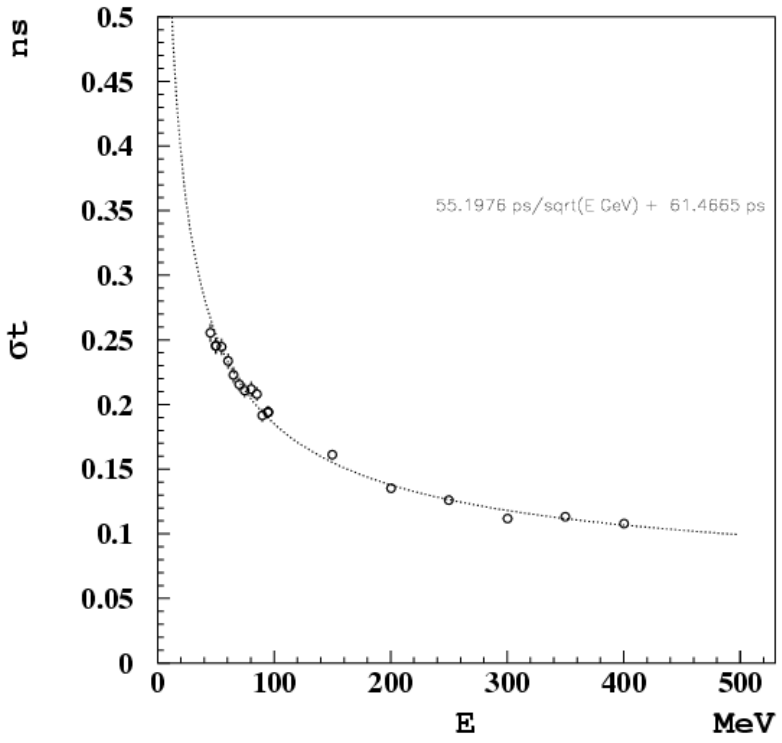
(c) Cladding light removed by optical contact with glue
n(glue) ~ n(core)

Fibers used: *Kuraray SCSF-81 Pol.Hi.Tech 00046*
15.000 km of fibers
(fully tested: *A.Antonelli et al., NIM A370 (1996) 367*)



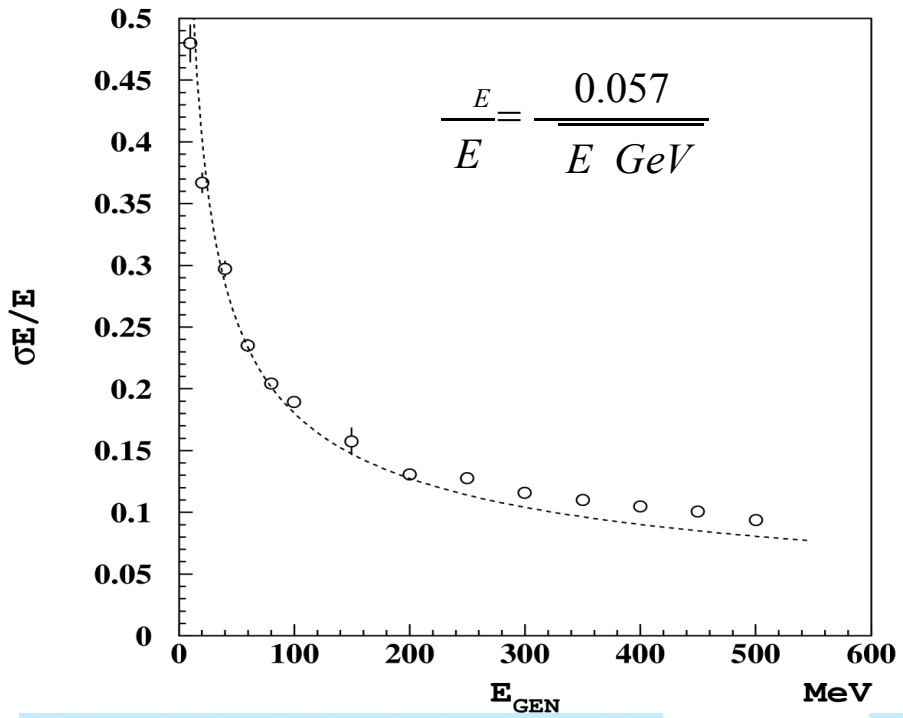
DAT –MC (FLUKA) PHOTON RESPONSE comparison

Excellent time resolution on e.m. particles: 50 ps/sqrt(E[gev])
Similar on cosmic



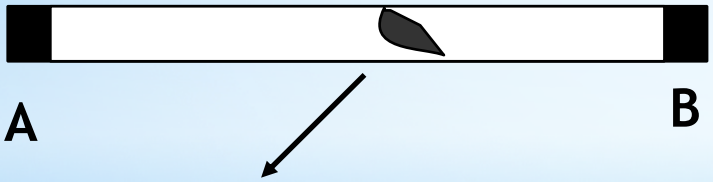
Energy response

The curve is the known detector resolution, dots FLUKA simulation



CLUSTER POSITION – longitudinal resolution

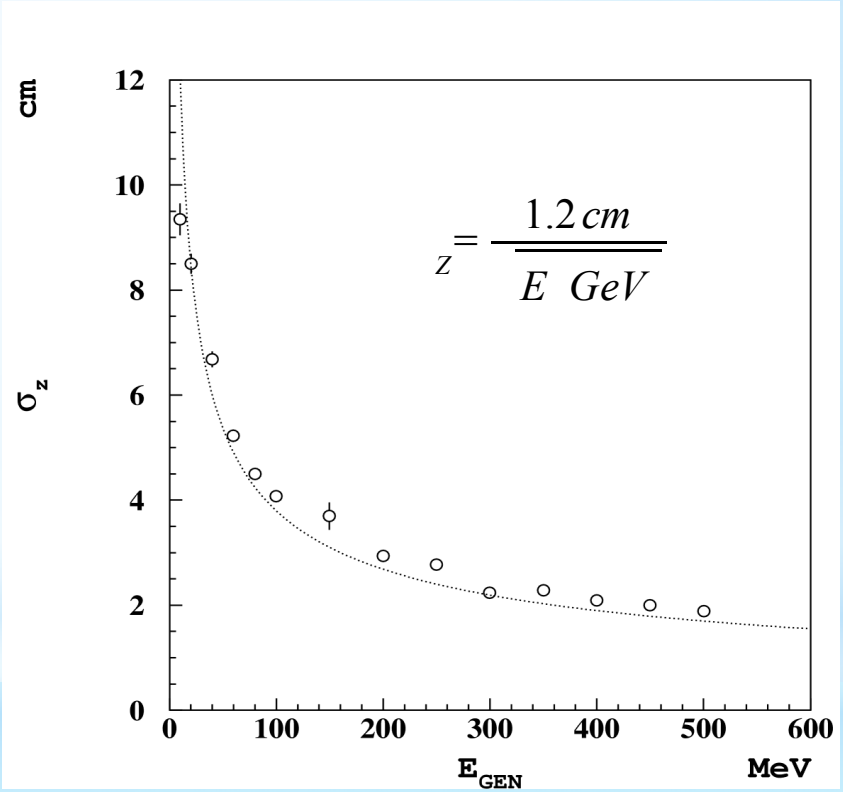
Resolution of the cluster centroid position along the module.



Energy deposit

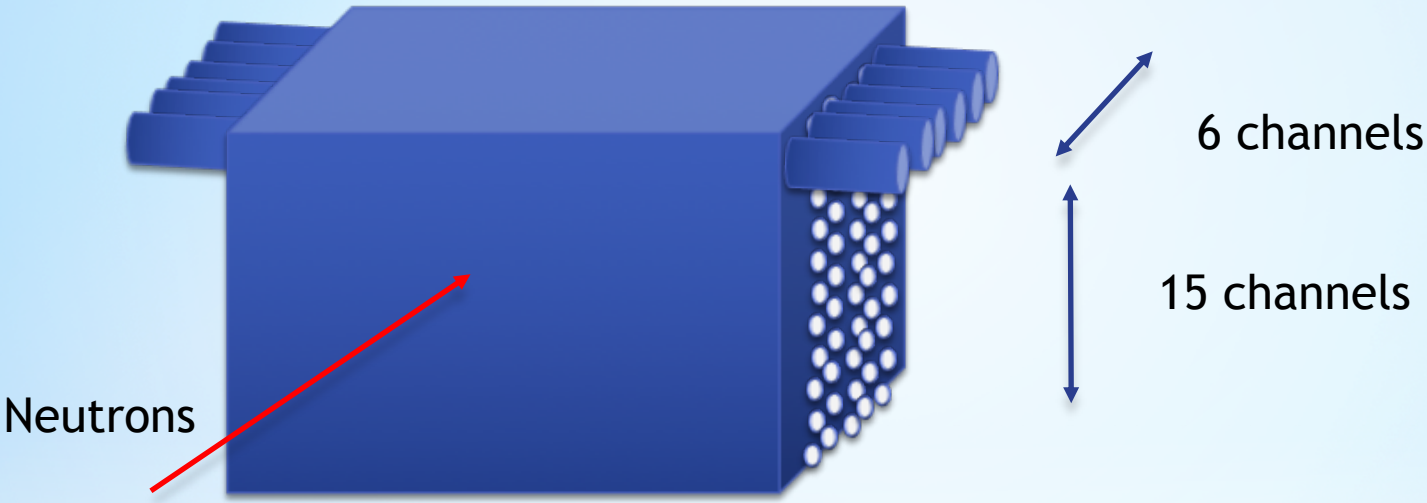
$$Z = \frac{t_A - t_B \; v_{light}}{2}$$

The curve is the known detector response, dots FLUKA simulation



Read out scheme

6x15 read out channels x side
3.5x3.5 cm2 active surface
6 detection planes

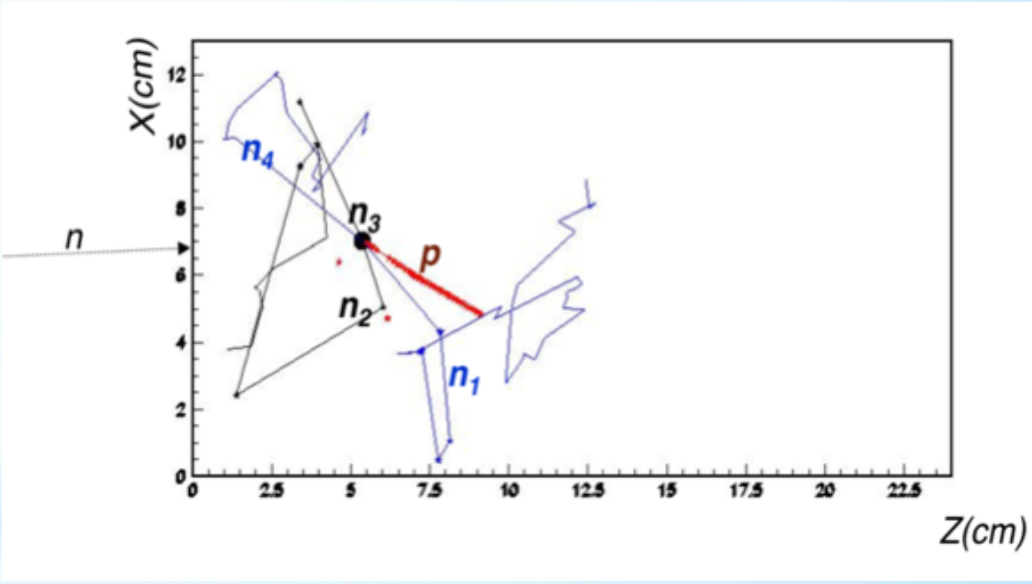


- ✓ Position along the fiber obtained via left - right time difference
- ✓ 90+90 electronic channels
- ✓ Coupling to photodetector via light guides
- ✓ 2 possible readout solution : pmt / sipm
- ✓ Neutron energy obtained via TOF
- ✓ First plane act as charged veto

Possible performances: eff

The enhancement of the efficiency appears to be due to the large inelastic production of neutrons in Pb. These secondary neutrons:

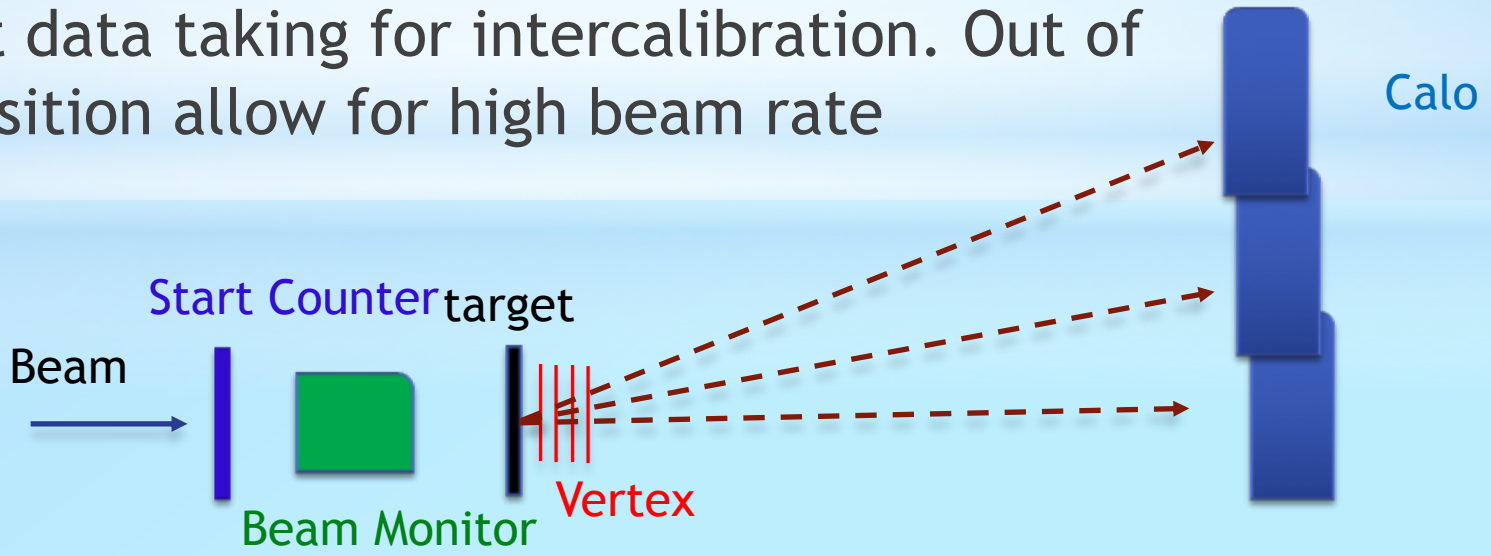
- are produced isotropically;
- are associated with a non negligible fraction of e.m. energy and of protons, which can be detected in the nearby fibers;
- have low energy and then have a large probability to do new interactions in the calorimeter with neutron/proton/γ production.



Eff ~ factor 4 higher wrt plastic scintillators

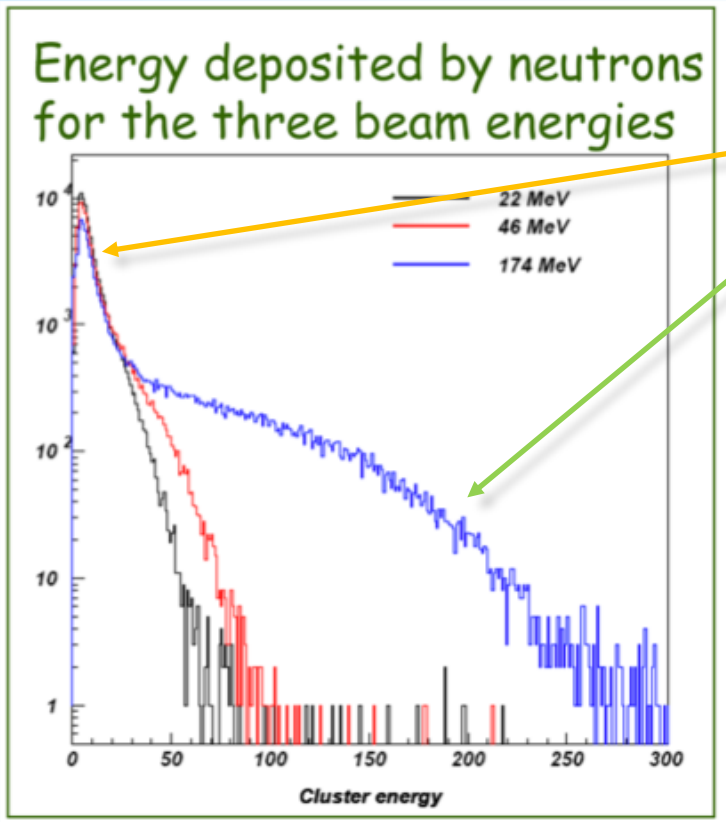
Possible performance: TOF

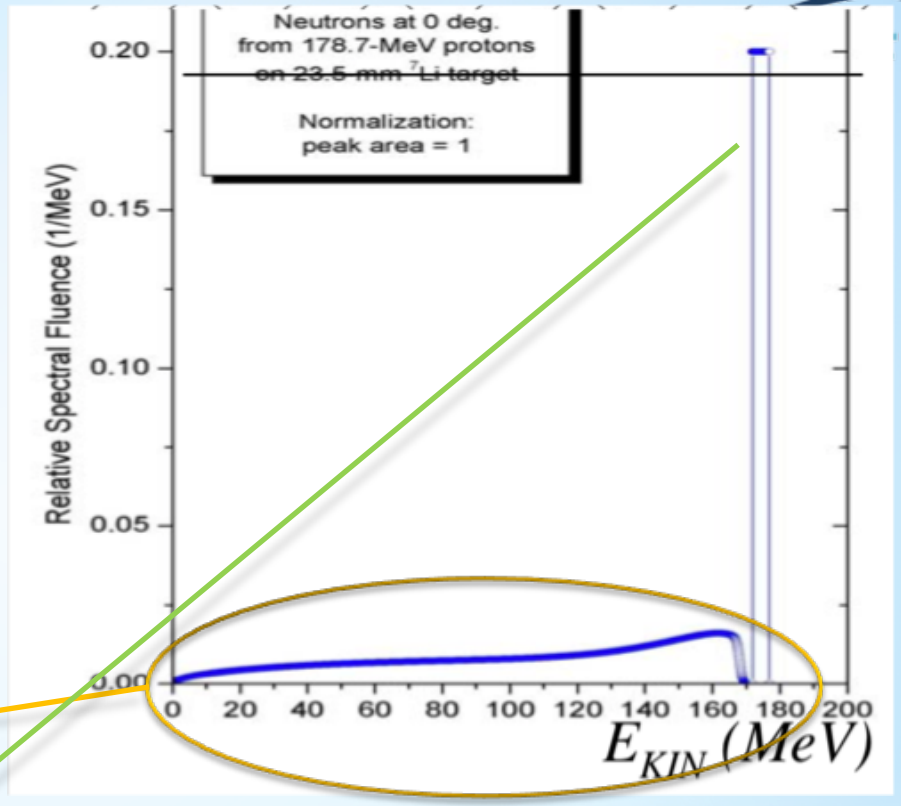
* Critical issue $\sigma_E/E = 2\ \sigma_t/t$. Only small fraction of the neutron energy release in calo is visible
* Trade off: long lever arm-> good energy res, little acceptance
* High efficiency allows to have moving setup with multiple data taking
* Es: 3 different positions with overlap region in different data taking for intercalibration. Out of beam position allow for high beam rate



TOF res?

The TOF resolution is driven by the release energy: some hint form a KLONE test beam at Uppsala neutron beam:





With 20 MeV energy release ~300 ps resolution can be obtained.

For 10 MeV energy release 400 ps would give-> σ_{Tof}/Tof ~5-10%

σ_E/E ~10-20% improving with E neutron

Read out choices…

Using SiPM:

* Light guides, Sipm matrixes (8x8 mm^2?), WaveDream electronics

Using PMT:

Light guides, pmt (2 cm diameter, PADME like), VME CAEN 32 ch WFD x 7 boards

"Mixed" read-out

* Light guides, PMT, WaveDreams electronics
* …..

Una possibile divisione compiti

* Roma La Sapienza:
  * KLONE, FEE calo (?), start counter
* INFN (LNF, PG, To):
  * Tracciatore carichi
  * Beam monitor
  * Simulazioni
* Univ. Bologna:
  * DAQ
  * FEE Calo?
* Univ Napoli:
  * Arm ad emulsioni
* Univ. Trento:
  * Beam monitor
  * Meccanica, guide di luce

NB, in case of different read-out approach different sharing can be envisaged

Verso la costruzione del Budget

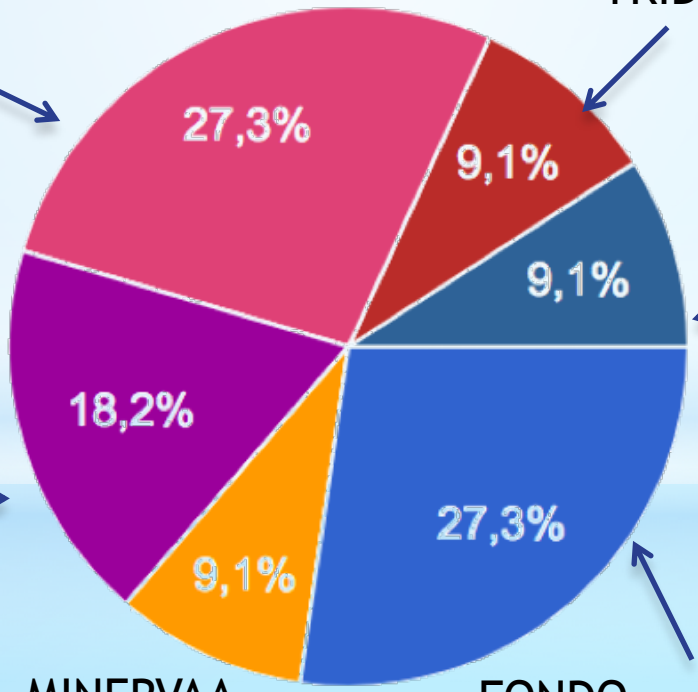
* Envelope: ≤1.2 Meuro
* Overhead: Warning: INFN nel 2018 tratteneva il 30% della quota non rendicontabile assegnata alla su unita'.
* Costi per Apparato:
  * fotomoltiplicatori: ……
  * vertex tracker: ……
  * Elettronica di lettura: ……
  * Emulsioni: ……
* Costi di operazione e run: …..
* Personale: max 100 kEuro/unita' operativa (max 600 kEuro totali)

Proposta per il Nome

Il contest nel 2018 aveva dato FOOTnote come vincitore… vogliamo cambiare?

NEUTRA
(NEUtron TRacking Apparatus)

TRIDENT
FOOTNOTE (Fragmentation Of Target for NeutrOn producTionmEasurements)



FOOTNOTE
(Forward NeutrOn producTion Experiment)

MINERVAA

FONDO
(FOrward Neutron DetectOr)

I due FOOTNOTE assommano a 27.3%

Slowly moving… a bit like lethargy

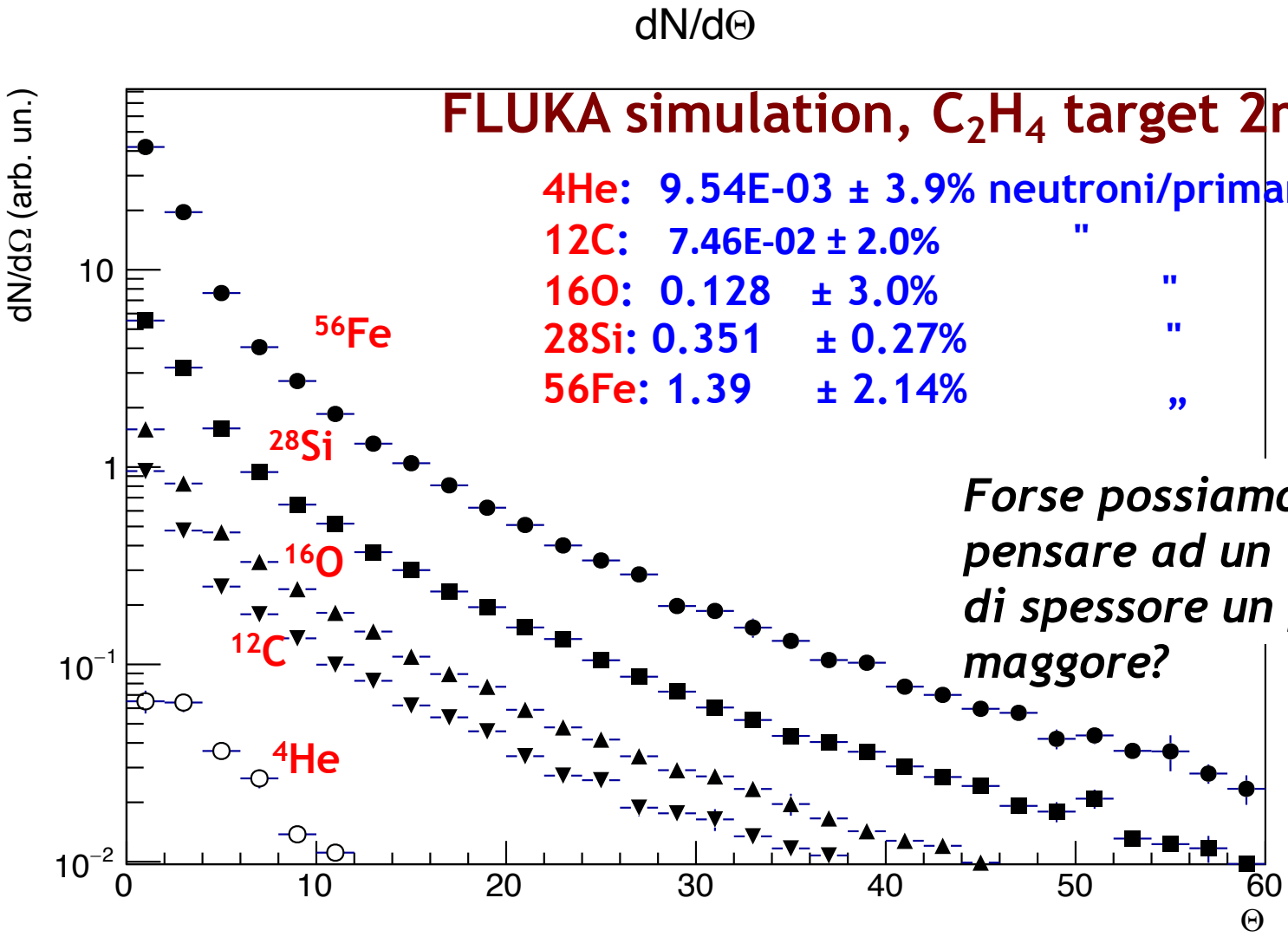
- Neutrons are just beyond the horizon: our time landscape can go well beyond the 2022 if neutron data taking can be undertaken (educated guess: INFN would like to exploit the FOOT detector as much as possible)
- PRIN : is an opportunity to explore a possible continuation (see neutron item)
- Congrats to Luca Galli (new Trigger coordinator) and Alessio Sarti (already software coordinator) that substitute A. Sciubba for Roma 1 in the Institution Board
- “Congrats” also to Maria Cristina Montesi, Graziano Bruni, and Francesco Tommasino to be appointed in the Magnet Bid (thanks!)
- Last comment: the meeting has very busy schedule !!!

Clock is counting

- The Team should be frozen asap. We should use january to refine the physics proposal and budget request.
- A team has been set up (Chiara La Tessa, Silvia Muraro and Sara Valentinetti) to review the proposal, but others should join them
- The neutron activity will be accepted very well by CSN3, also because is a natural prosecution of the FOOT program

Let's discuss….

Neutron Yield @ 800 MeV/u



FLUKA simulation, C_2H_4 target 2mm

4He: 9.54E-03 ± 3.9% neutroni/primario
12C: 7.46E-02 ± 2.0% "
16O: 0.128 ± 3.0% "
28Si: 0.351 ± 0.27% "
56Fe: 1.39 ± 2.14% „

Forse possiamo pensare ad un target di spessore un poco maggore?

Neutron Yield @ 800 MeV/u