MOnitor for Neutron Dose in hadrOntherapy

3 Dicembre 2014

1) **Abbiamo vinto**

-nuova sigla G5: MONDO => 2 anni

-75 keuro l'anno.. il secondo anno forse meno

- il mio contratto.. :)

Tempistica da definire

2) **Cosa ho detto che avremmo fatto**

- 2.0 simulazione FLUKA

- 2.1 tracciatore con fibre scintillanti 250μm

- 2.2 GEM

-photocatodo

-triple GEM

-faccia trasparente di uscita

- 2.3 CMOS

-back-illuminato

-passivato

-antiriflesso

1) **Persone coinvolte**

- PMF 50%

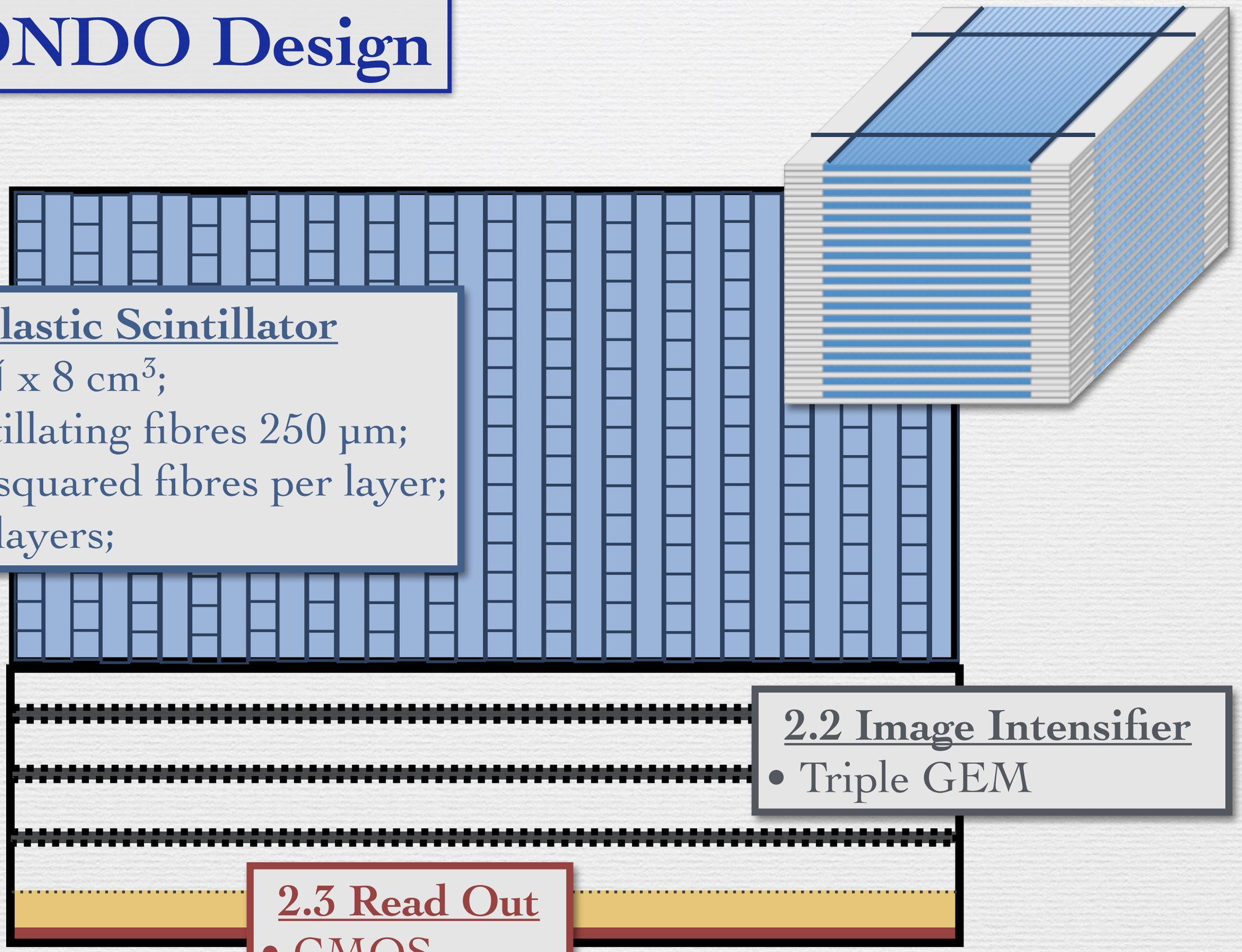
- DP 20%

- ES 10%

- Vincenzo, Alessio, adb, MarcoToppi?

- Silvia

MONDO Design



2.1 Plastic Scintillator

- 4 x 4 x 8 cm^3;
- scintillating fibres 250 μm;
- 160 squared fibres per layer;
- 320 layers;

2.2 Image Intensifier

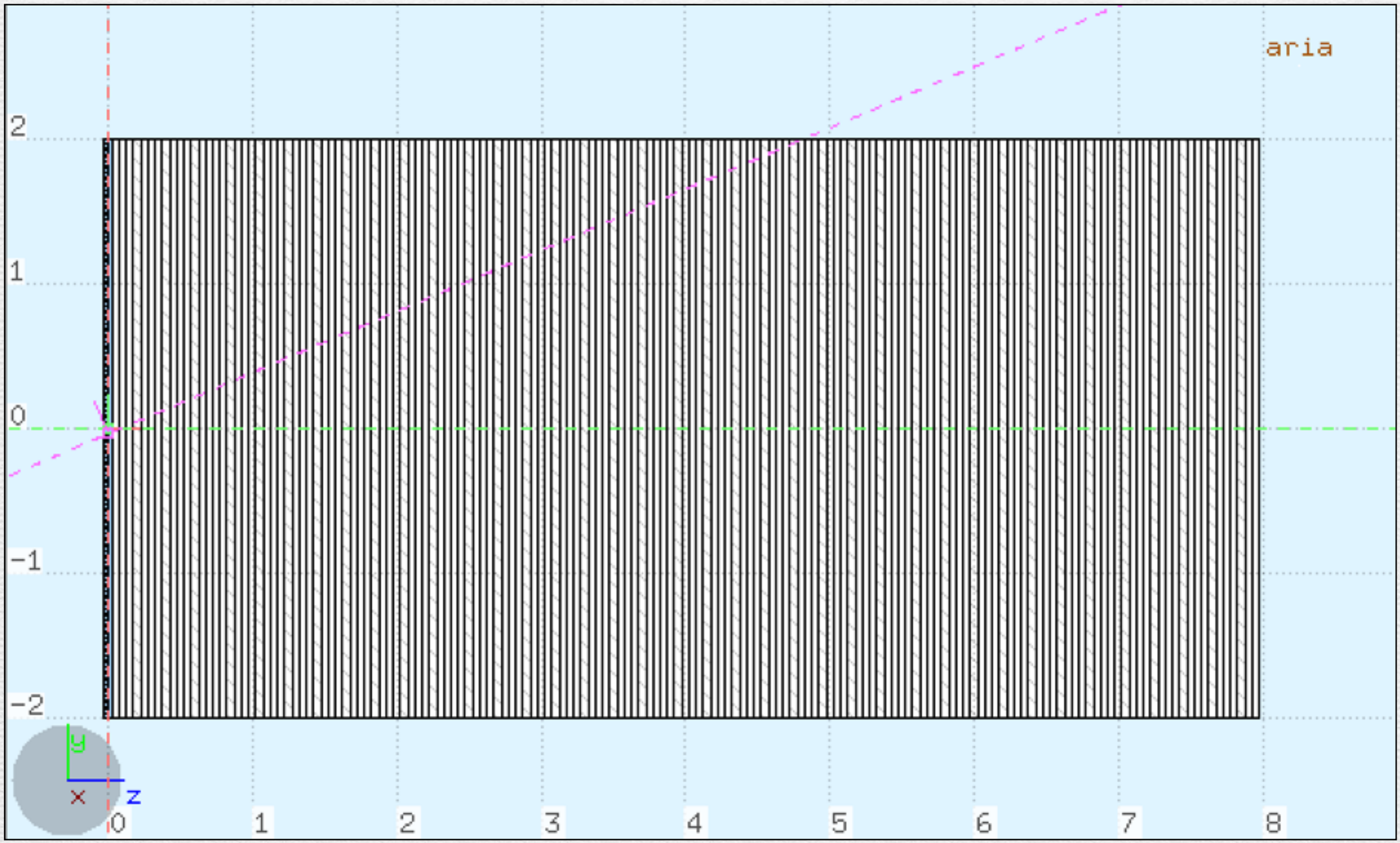
- Triple GEM

2.3 Read Out

- CMOS

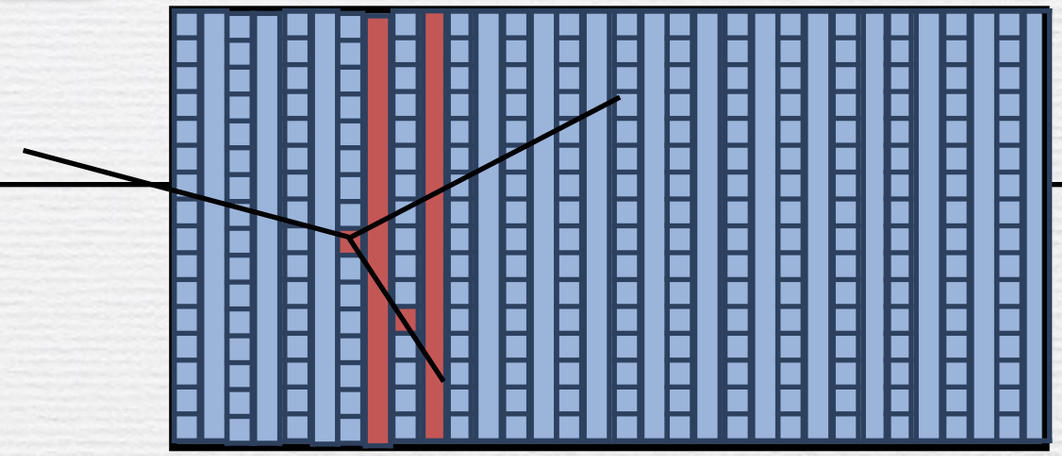
2.0) SIMULAZIONE

SILVIA e co..

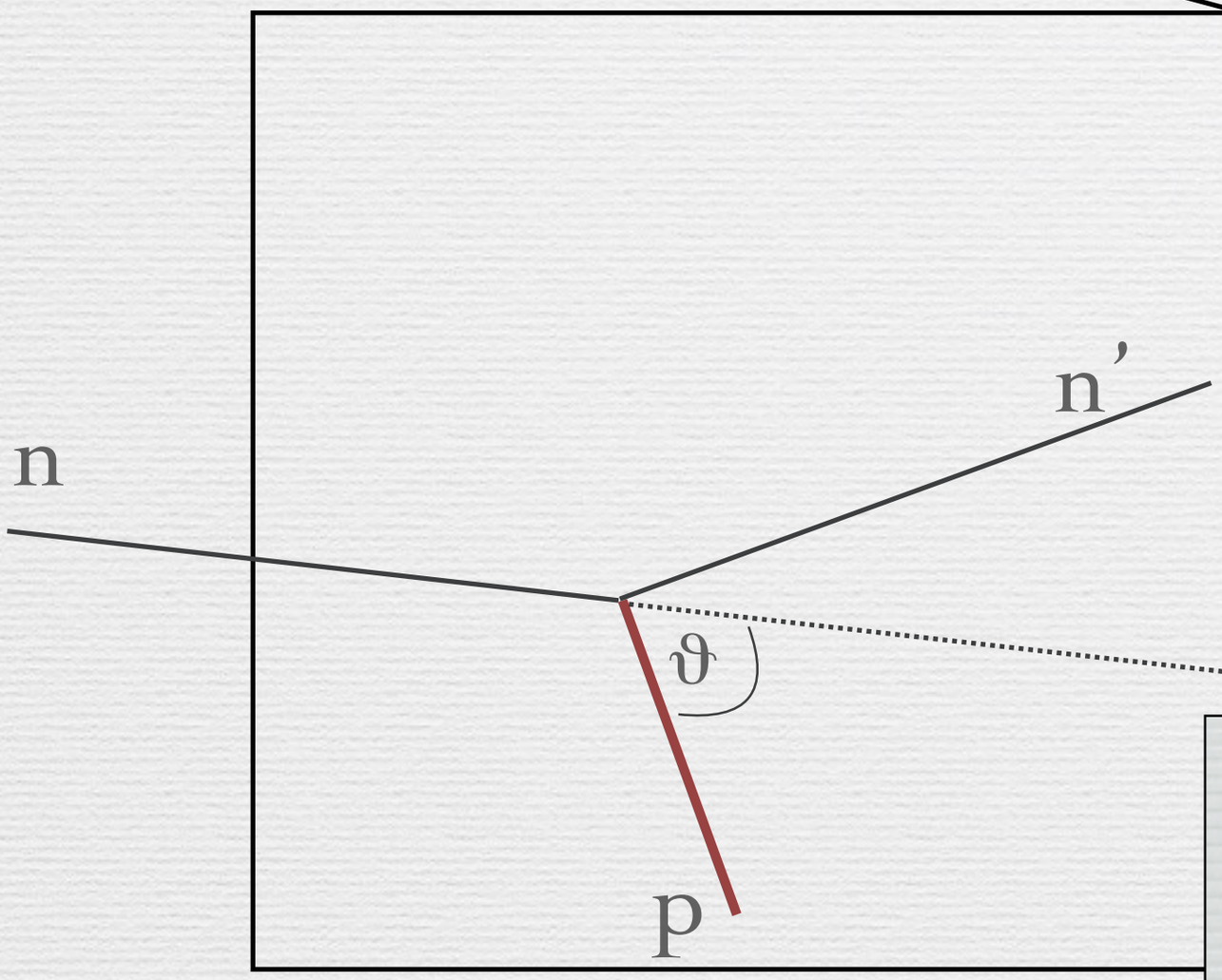


FLUKA

2.0) SIMULAZIONE



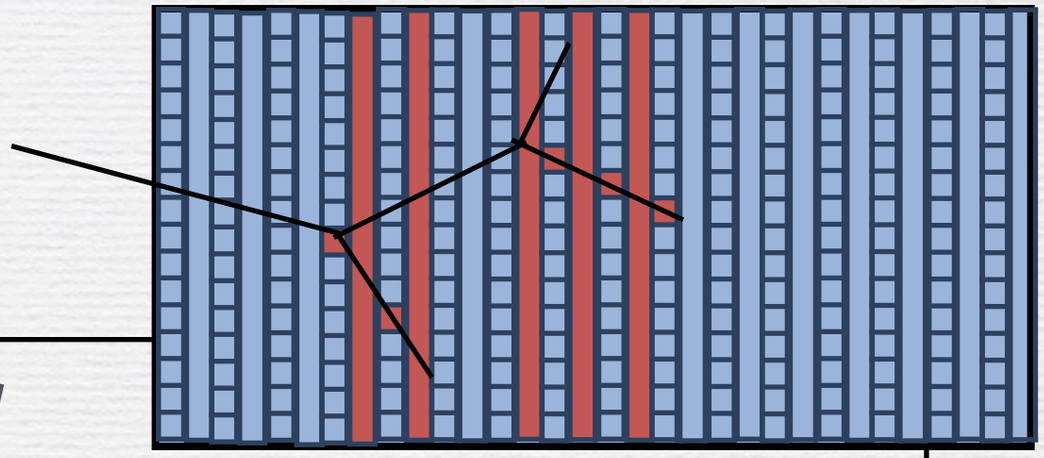
Single Scattering



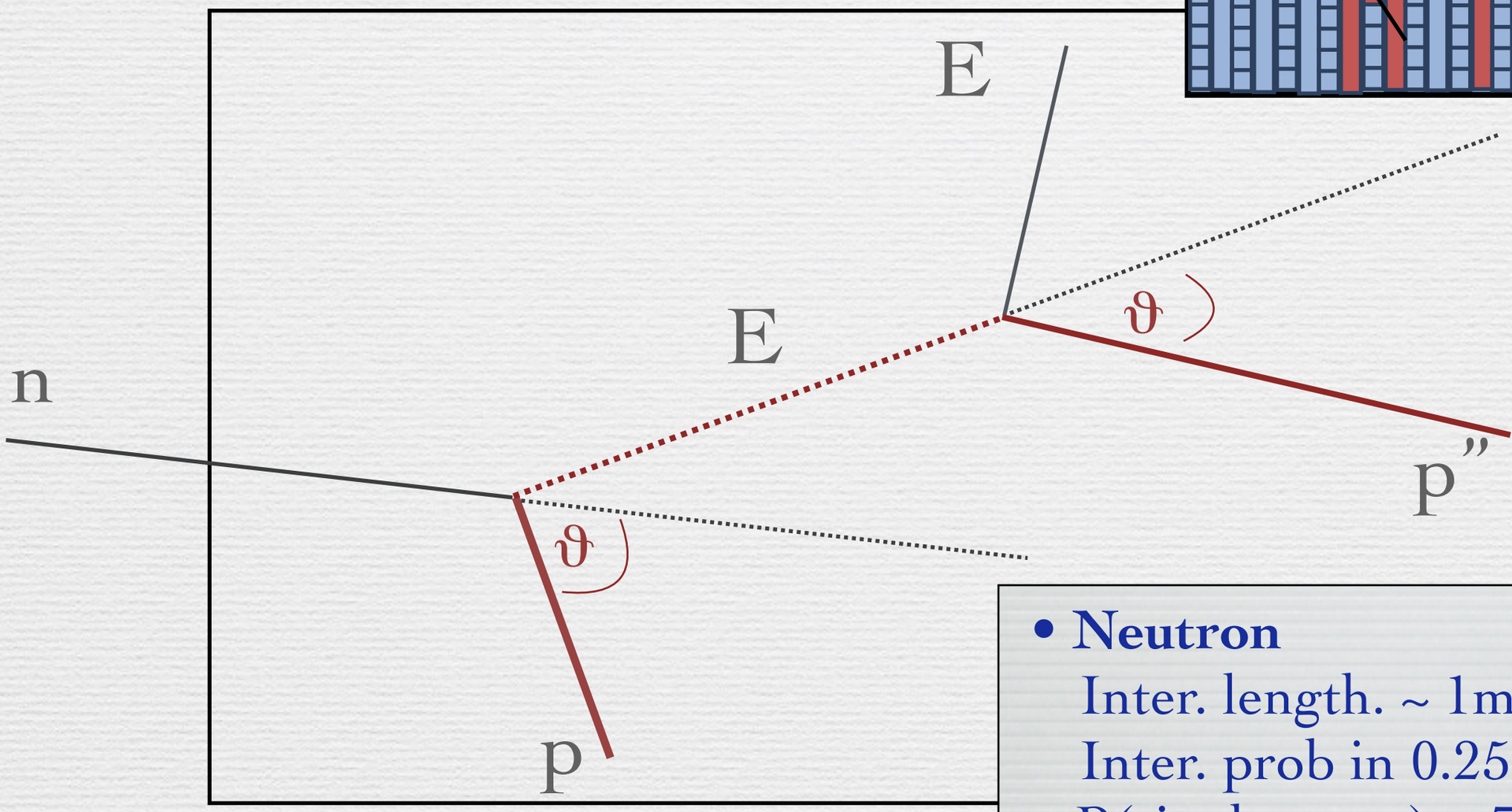
$$E_n = \frac{E_p}{cos^2\theta}$$

- **Neutron**
  Inter. length. ~ 1m
  Inter. prob in 0.25 mm ~10^{-4}
  P(single scatt.) ~ 7%
- **Proton mean path**
  T = 100 MeV=> 8 cm
  T = 50 MeV=> 2 cm
  T = 30 MeV=> 1 cm
  T = 10 MeV=> 0.1 cm

2.0) SIMULAZIONE



Double Scattering



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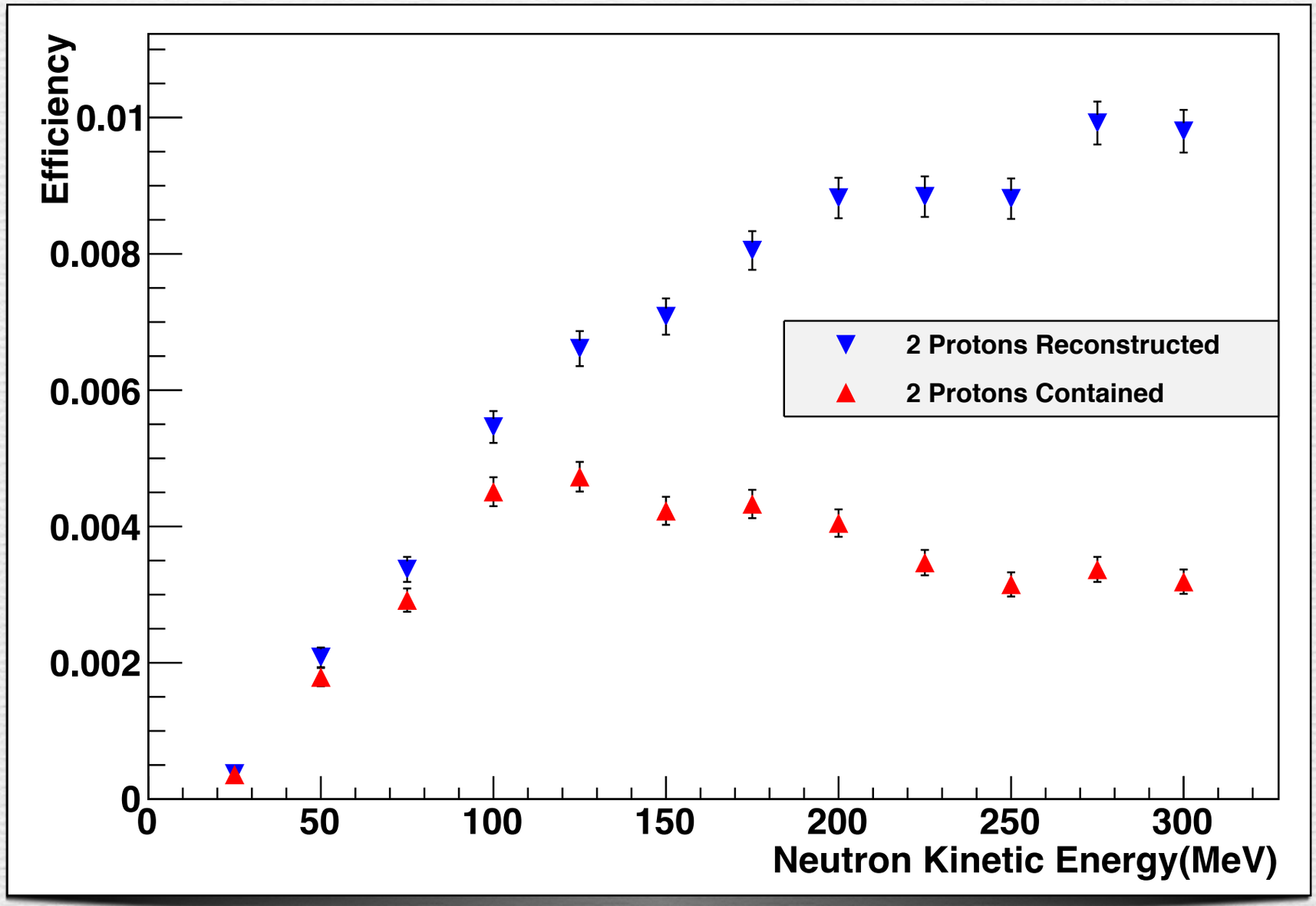
2.0) SIMULAZIONE

Efficiency

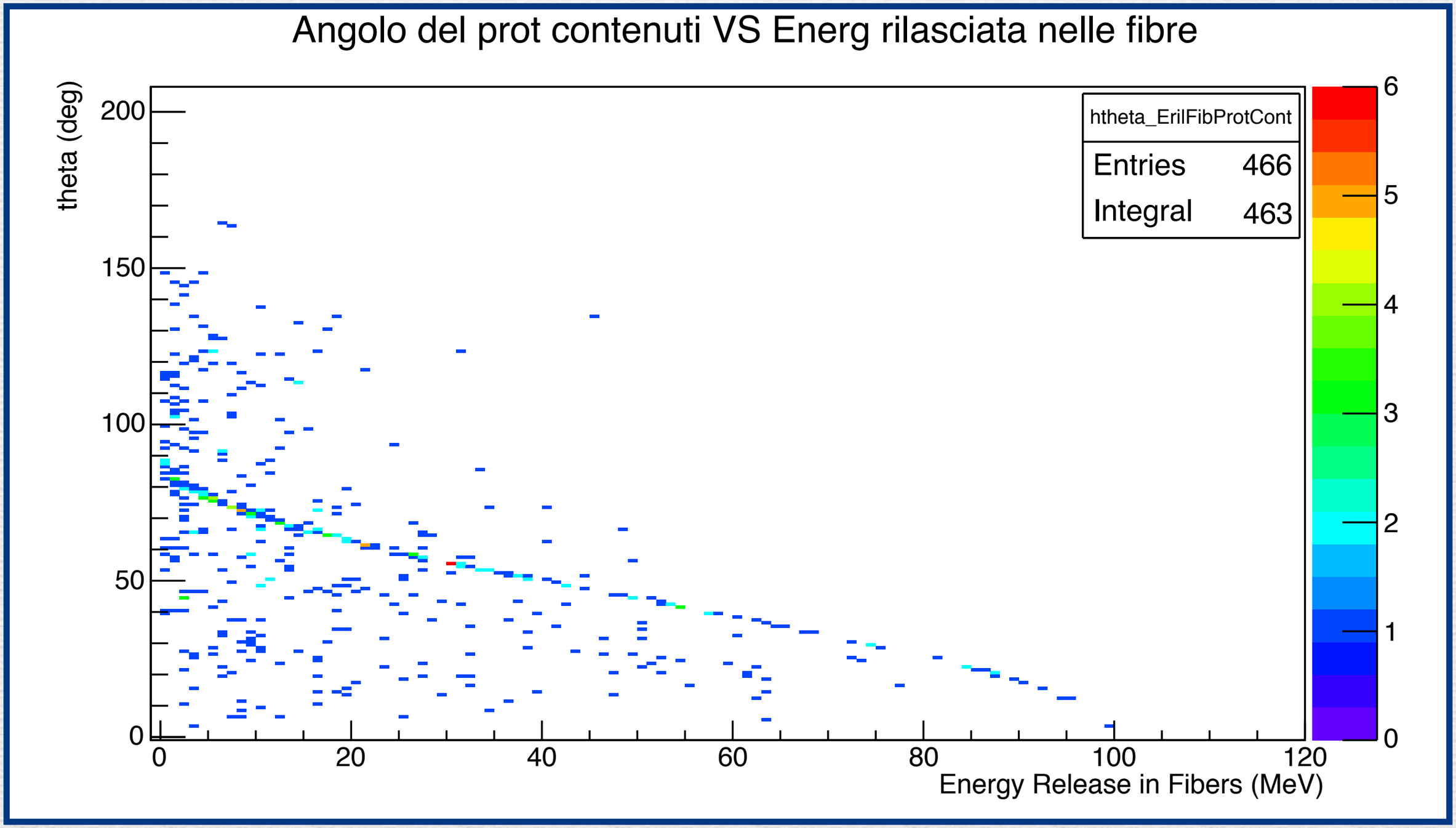
- Events are reconstructed only if 2 protons have a signal over threshold in more than 6 fibers;
- To release a signal over threshold in a given fiber, the proton must deposit more than 100 KeV

The neutron energy can be computed by measuring the proton range ONLY if both protons are contained.



2.0) SIMULAZIONE

SILVIA

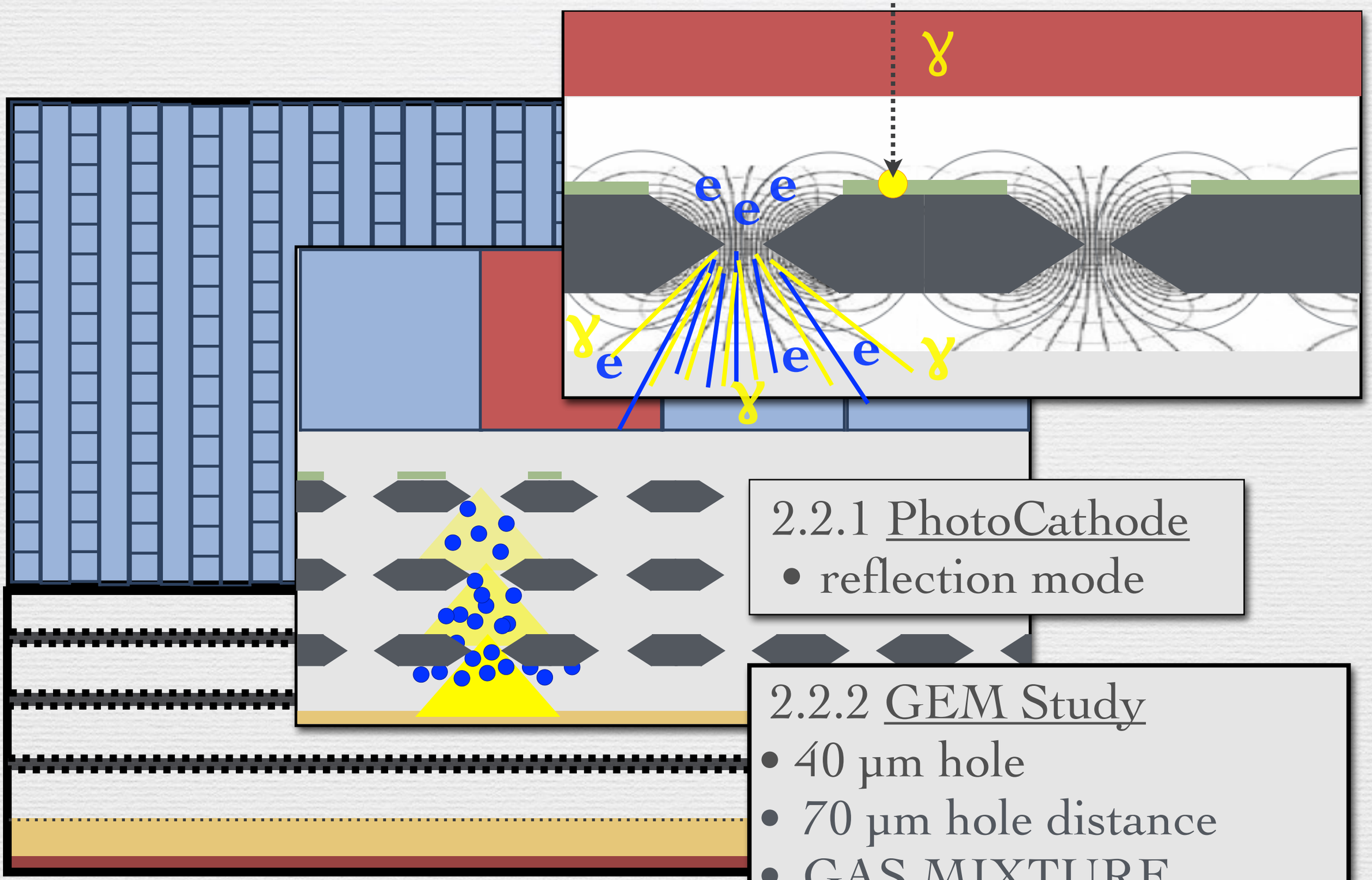


2.1) FIBRE

… manca tutto il discorso della meccanica..

adb

2.2) GEM



2.2.1 PhotoCathode
- reflection mode

2.2.2 GEM Study
- 40 μm hole
- 70 μm hole distance
- GAS MIXTURE

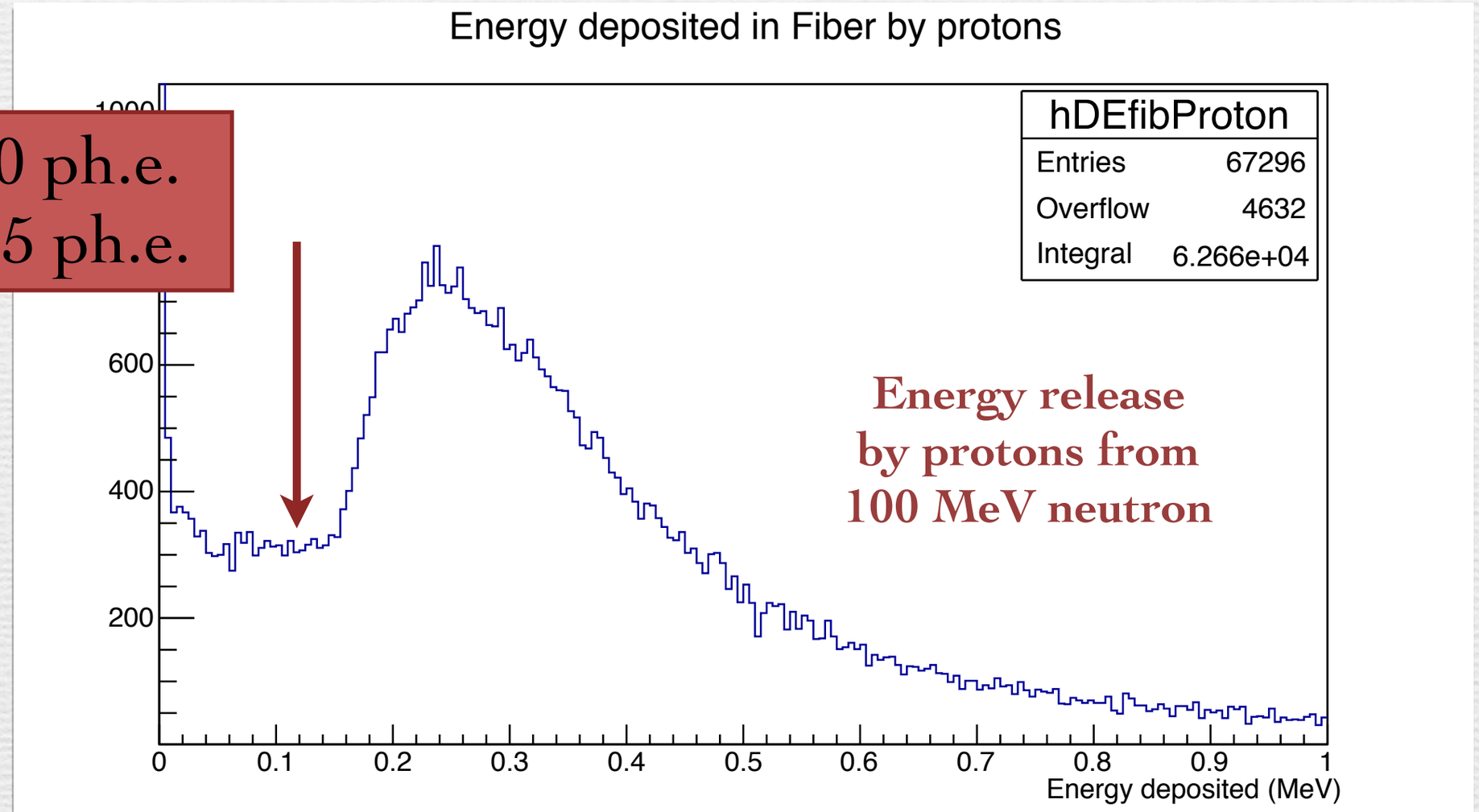
2.2) CONTI

Ph.Electrons

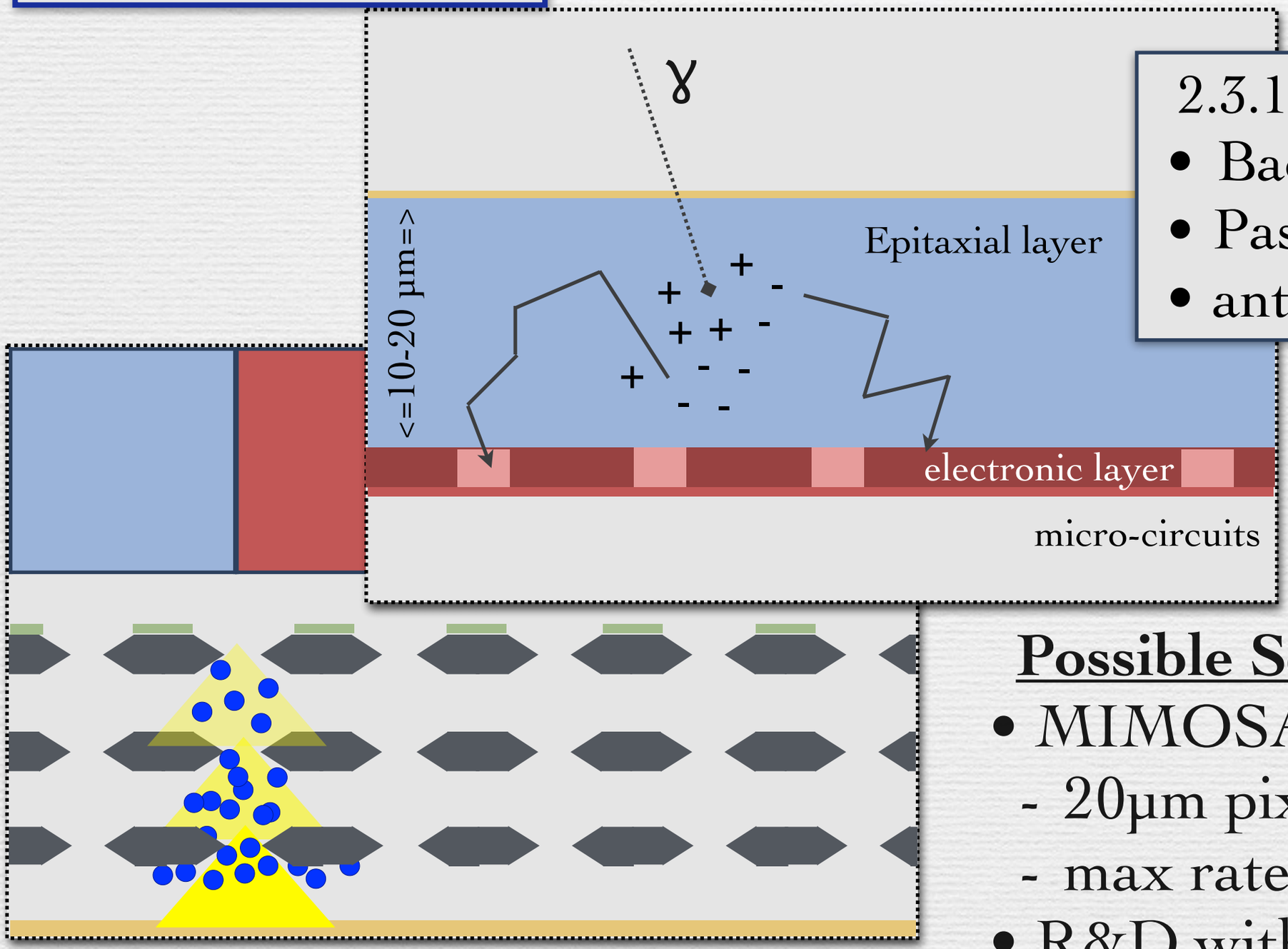
The ph.e. produced by the GEM cathode, due to a proton signal in a can be estimated using realistic parameters:

- Minimum Energy: >150 KeV (50 KeV m.i.p.)
- Fiber light yield: $9x10^3$photons/MeV
- Fiber collection eff: 4%
- Photo Cathode eff: 20%

p produces ~ 10 ph.e.
m.i.p produces 5 ph.e.



2.3) CMOS



2.3.1 CMOS Study

- Back-illuminated
- Passivated face ~1µm
- antireflective coating

Possible Sensors:

- MIMOSA28
  - 20µm pixel
  - max rate 10kHz
- R&D with Strasbourg
  - 50µm pixel
  - rate 100kHz
- FBK ?

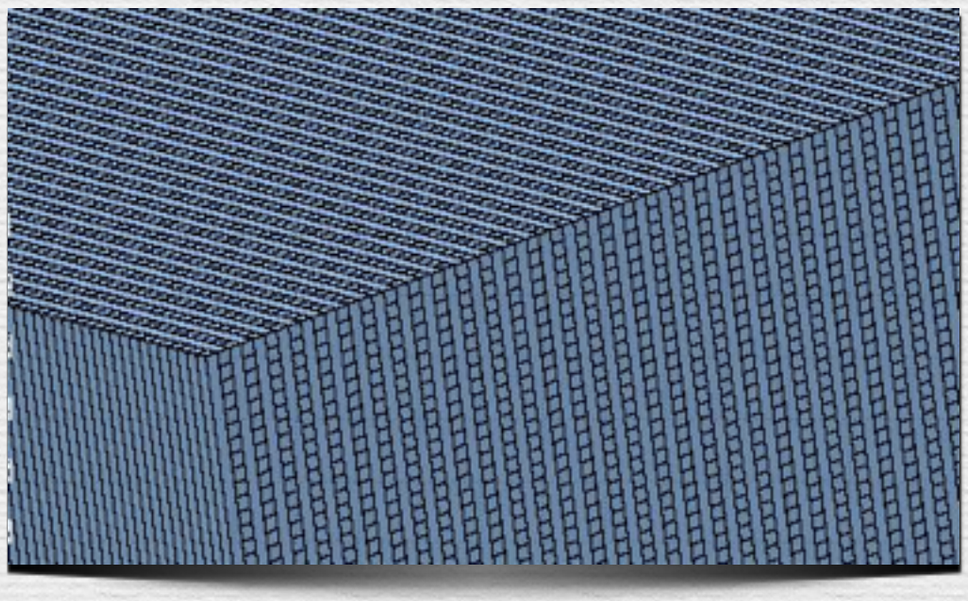
2.3) CONTI

Ph.Electrons

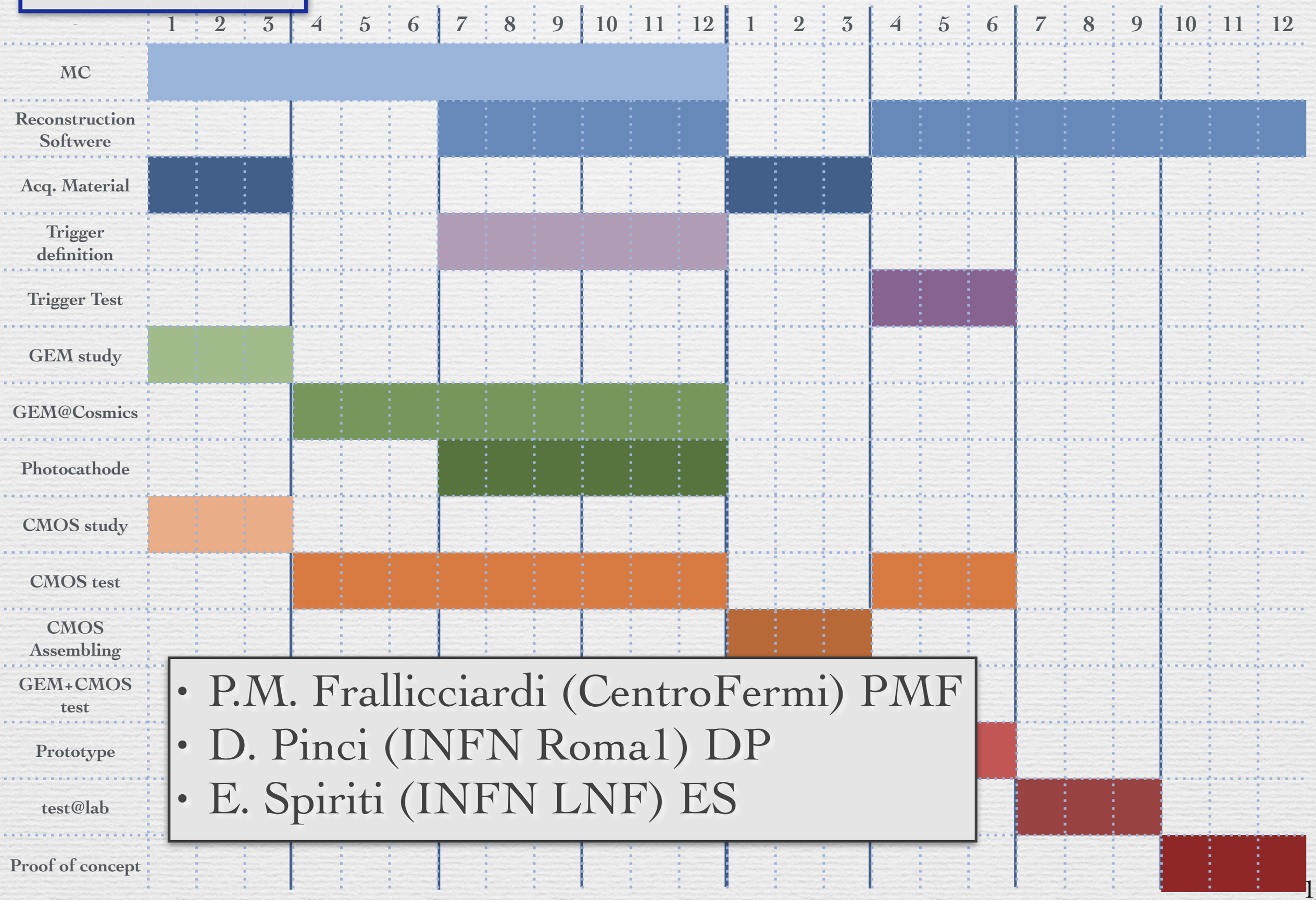
The photons reaching a single CMOS pixel
realistic parameters:

- 50 ph.e per fiber
- 50 ph.e x 20% photocathode effQ => 10 ph.e
- 10 ph.e x 30% photocathode effGeo => 3 ph.e
- 3×10^4 photons after the last stage
- x 50% GEM effGeo [half of the electrons (and photons) goes in the wrong direction]
- 15000 from 250 µm => 600 ph per pixel (50µm)
  => 100 ph per pixel (20µm)

in CMOS sensor: 15 pair of bkg
=> 100 ph -> 100 pairs
=> 50 ph -> 50 pairs



Timetable



- P.M. Fralliccіardi (CentroFermi) PMF
- D. Pinci (INFN Roma1) DP
- E. Spiriti (INFN LNF) ES

Timetable

1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

MC

Reconstruction Softwere

PMF,MM

SOFTWARE

Acq. Material

Trigger definition

DP,PMF,MM

Trigger Test

GEM study

GEM@Cosmics

DP,MM

GEM

Photocathode

CMOS study

CMOS test

ES,PMF

CMOS

CMOS Assembling

GEM+CMOS test

Prototype

test@lab

MM,PMF,DP,ES

Proof of concept

TEST

Timetable=> persone Vere..

1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

MC — SOFTWARE — ??, MM!? SILVIA, VINCENZO?

Reconstruction Softwere

Acq. Material

Trigger definition — adb, MM, DP

Trigger Test

GEM study

GEM@Cosmics — GEM — photocathode study MM; GEM study DP; GEM test DP MM

Photocathode

CMOS study

CMOS test — CMOS — ES + ?

CMOS Assembling

GEM+CMOS test — tutti.. quello poi si vedrà..

Prototype

test@lab — TEST

Proof of concept

Cost Table

						Total
Instrumentation	CMOS	CMOS Readout	BaF_2 + PMT	Multianods PMT	Commercial Electronics (CAEN)	
	60 k€	10 k€	10 k€	10 k€	20 k€	**110 k€**
Consumables	GEM + Phtocathode	Fibres				
	15 k€	5 k€				**20 k€**
Services	HV, LV, cables, gas	Mechanics structure tooling for fibers and GEM				
	10 k€	5 k€				**15 k€**
Travel	Mission and Test Beam					
	5 k€					**5 k€**
MONDO BUDGET						**150 k€**

TEST planning

Several test will be performed in different laboratories with different beams

- **charged particles**
  - **cosmic (at SBAI lab)**
  - **protons (at CNAO)**

To test the tracking capabilities of the detector

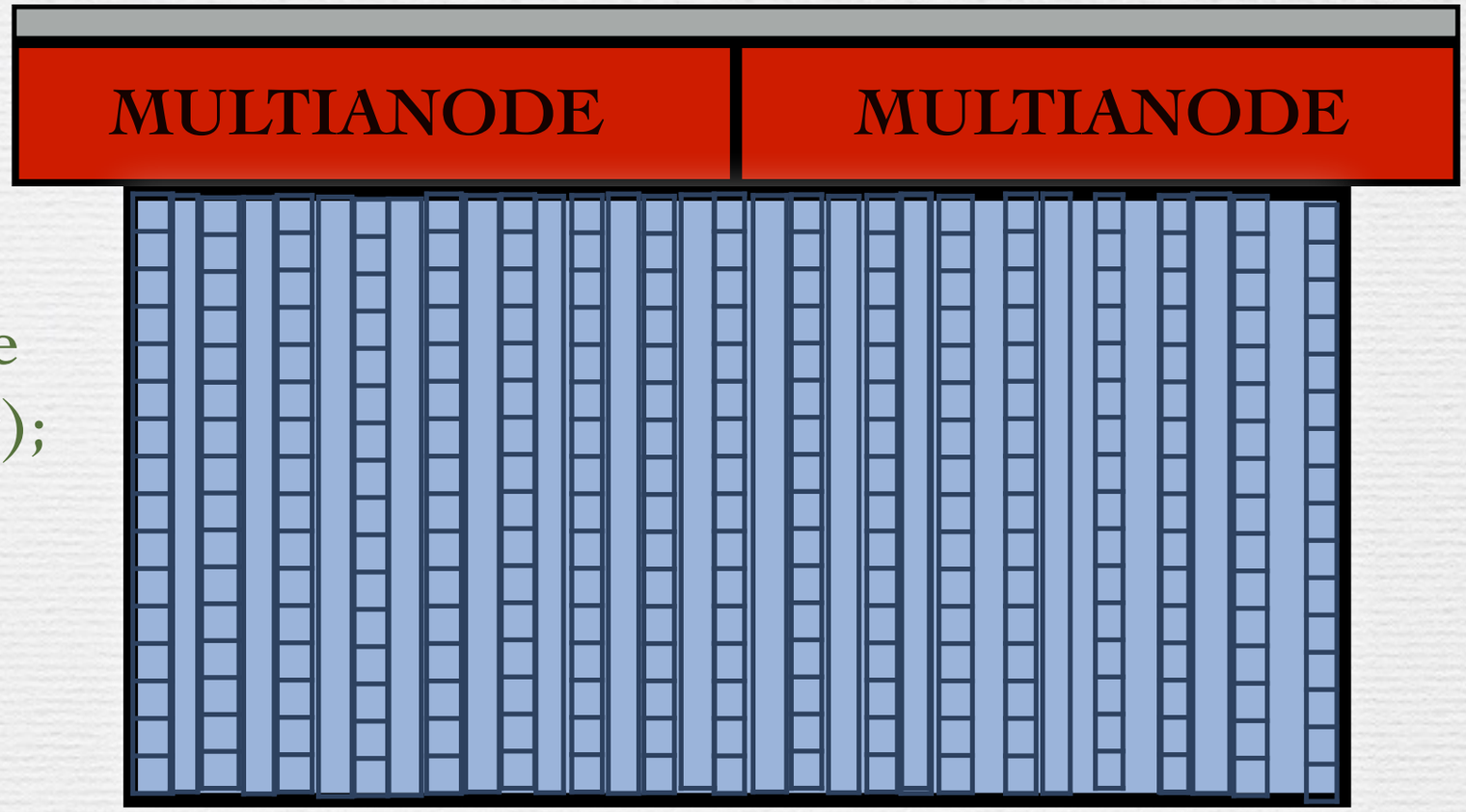
- **neutrons**
  - **neutron facility**
  - **neutrons emitted from a therapeutical beam on phantom (at CNAO)**

To measure the detector performances

TRIGGER

- The trigger will be performed with Multi-anode PMTs (64 ch. 5.8 x 5.8 mm^2);

- PMTs readout chip [AGE Scientific s.r.l.]



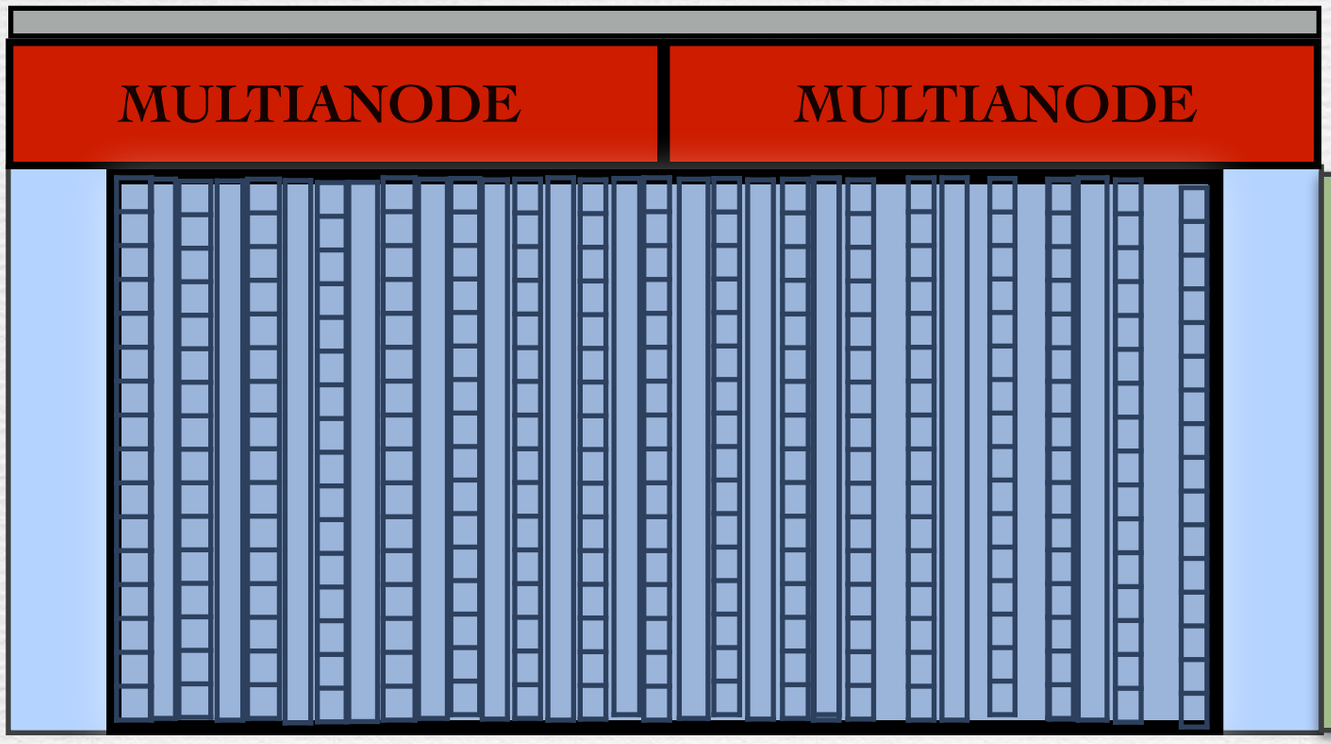
- TRIGGER STRATEGY:

=> Fast (using the first two dynodes of each PMTs)

=> Slow (logic programmable with the total information of the devices)

=> For the first measurements (total flux, device background study, implementation of the patter recognition, etc.) an easier one-level trigger is more coherent with the effectively man power of the project.

TEST SYSTEM



- BaF_2 crystal for pulse shape discrimination