Thesis: Study of the Time Resolution through Geant4 for the configuration of plastic scintillators coupled to SiPM as a function of its dimensions.

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OBJECTIVES

1. Geometry Implementation of the coupled scintillator arrangements to SiPMs through **GEANT4 software**.

2. Obtain the optical **photons time of flight,** generated by muons that interact with the scintillator, coupled to 1 or 2 SiPM, varying**: the scintillator material, its dimensions and the beam interaction zone with the scintillator.**

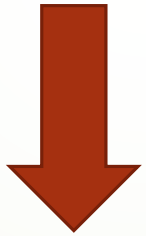
3. Through an **statistical treatment made in ROOT** quantify the intrinsic time resolution of detectors arrangements.

INTRODUCTION

High Resolution detectors

→ Exp. or Sim. Were Time of Flight of p. are short.

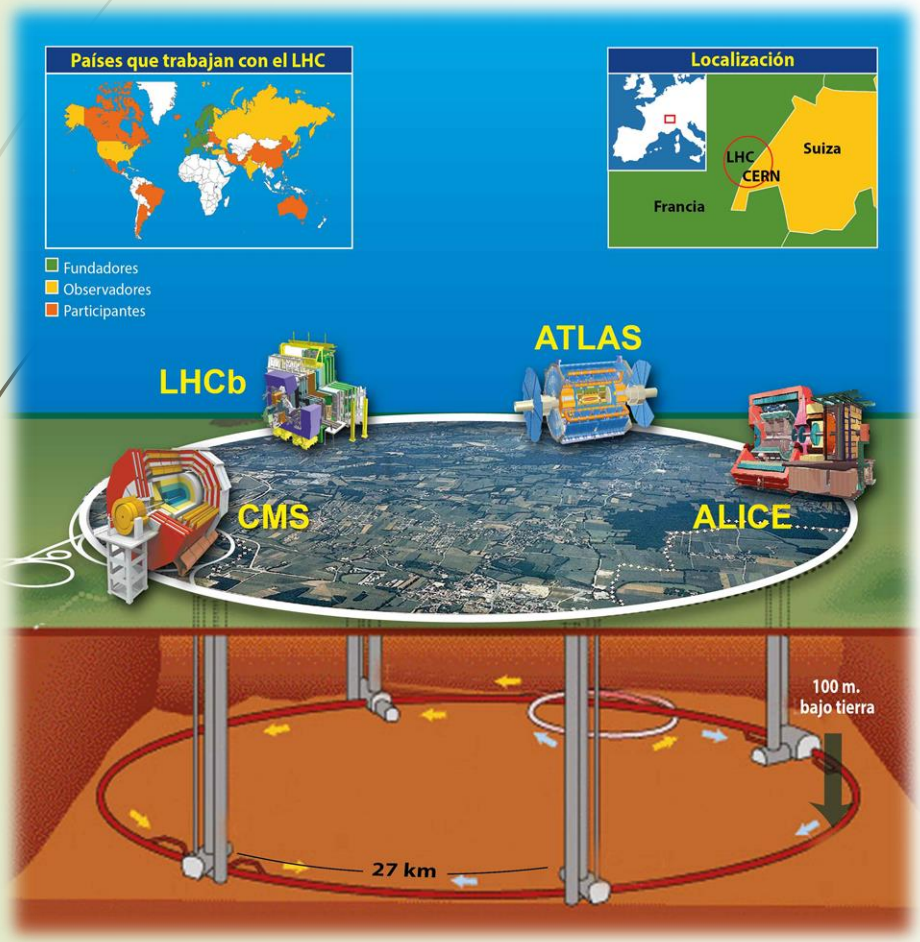
* Detection time between *ns. y ps.*

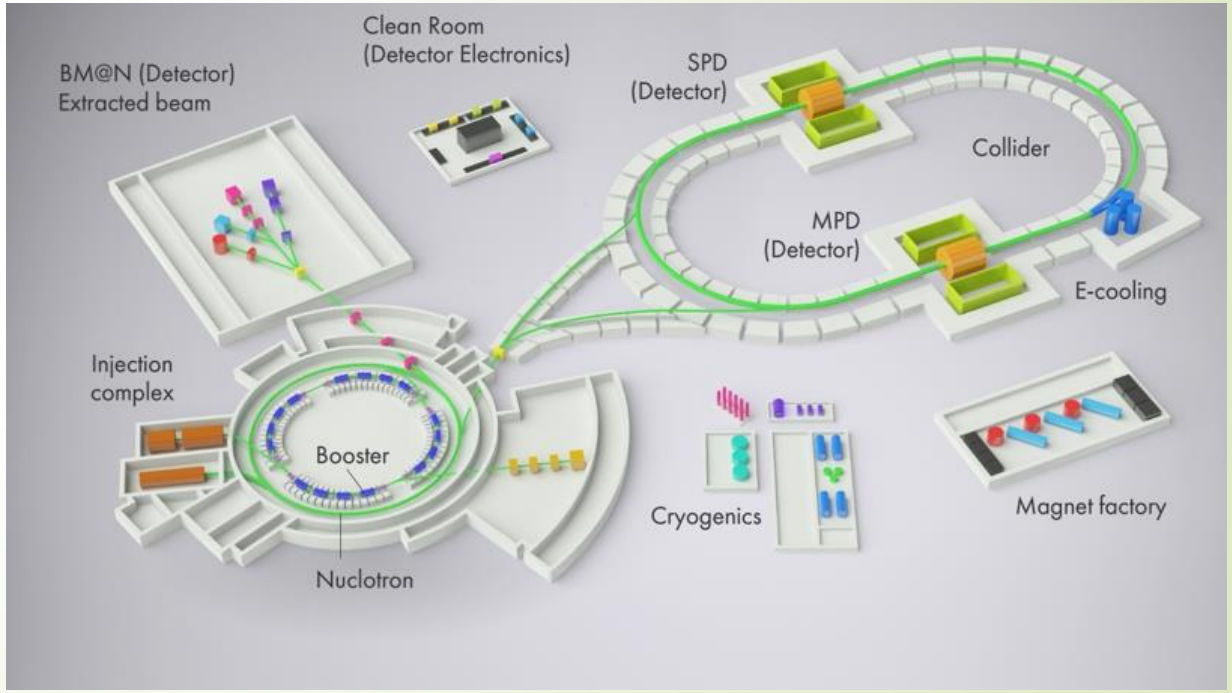


Integrated detectors with other detectors **(coincidental events or Triggers) which serves to optimize particles identification**

INTRODUCTION: APLICATIONS

Particle Physics and High Energy Physics: Projects such as* *(LHC, ALICE, ATLAS, CMS) & JINR (NICA).***





INTRODUCTION

*Trough Monte Carlo techniques → obtain → Time Resolution

Geant4 → software → simulation → Particles through matter.

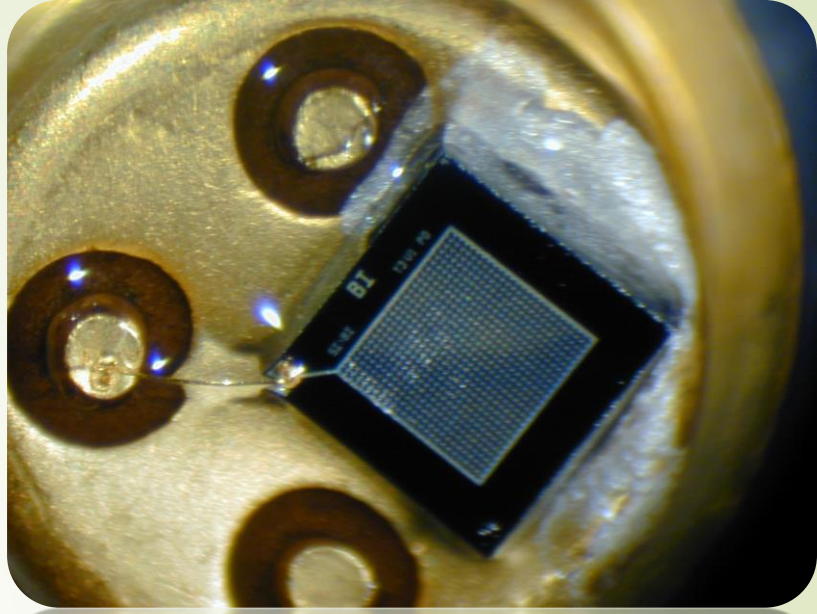
Application areas: high energy physics, nuclear physics and particle accelerators, spatial and medical sciences.

INTRODUCTION

- Detector is a device→ allow to track or identify ionized particles.
- Produced by → nuclear desintegration, cosmic radiation or reactions by a particle acelerator, reactor, etc.
- There are Different kinds of detectors(gas chambers, liquids, calorimeters, tracking). This study confers to depeen just of …

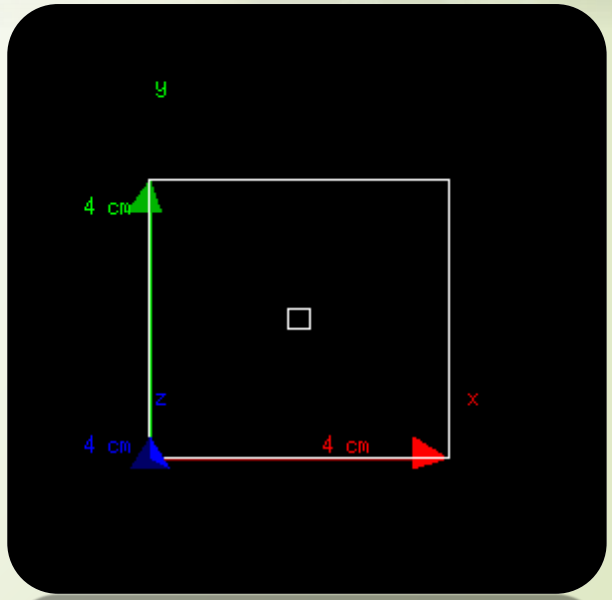
Solid State Physics	Semiconductor counter	Scintillator counter
Coupling	Silicon Counter (SiPM)	Plastic Scintillator

INTRODUCTION



SiPMs

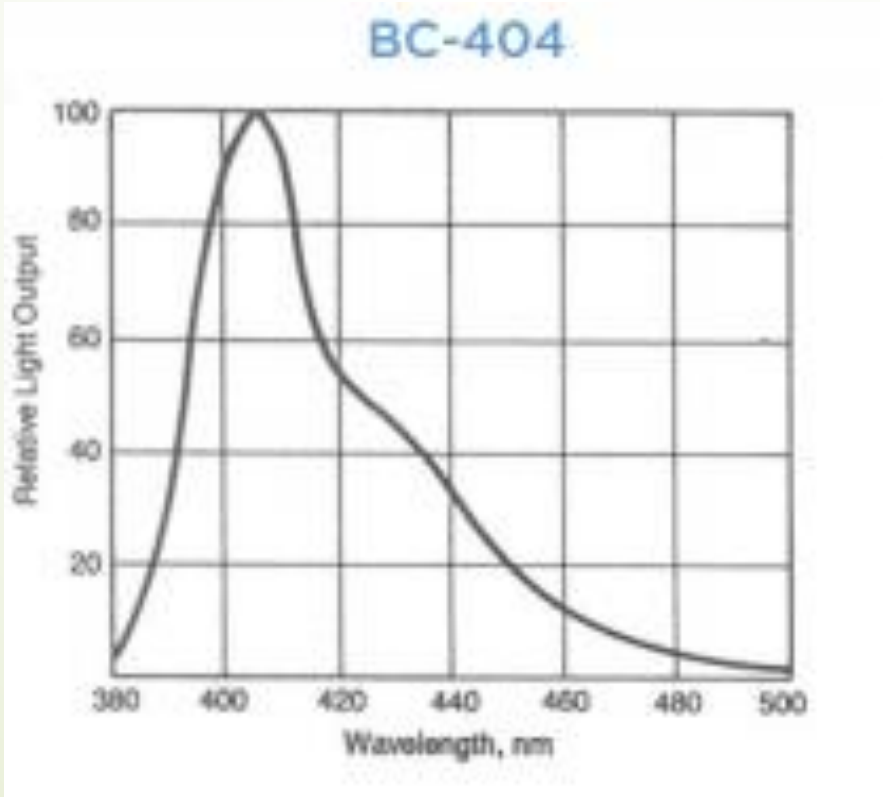
- The SiPMs are made of silicone (abundant in Earth) → allows low manufacturing costs in comparison with vacuum tubes.
- High damage thresholds.
- Low operating voltages.
- Also sensibility over infrared spectrum.
- **Its size and geometry allows to be easier to transport and to simulate → it's a portable high electronic device**.

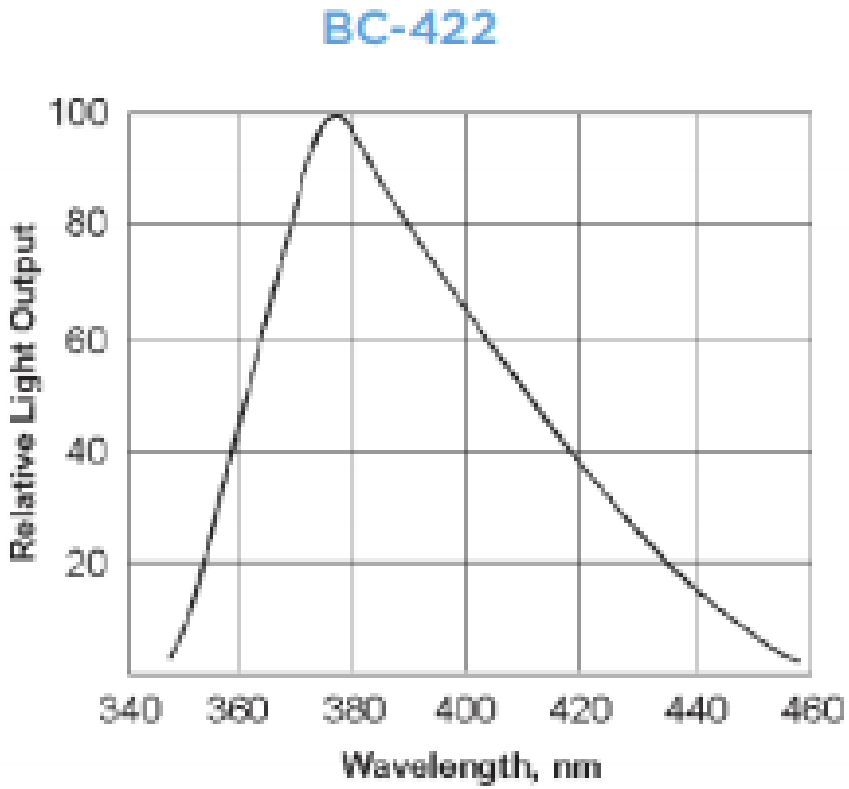


METODOLOGY

BC404 & BC422

- In GEANT4 it was configured:
- Emission peak referred to emission spectrum.
- Refraction Index (1,58) near value of the glass.
- Optical Photons Energy

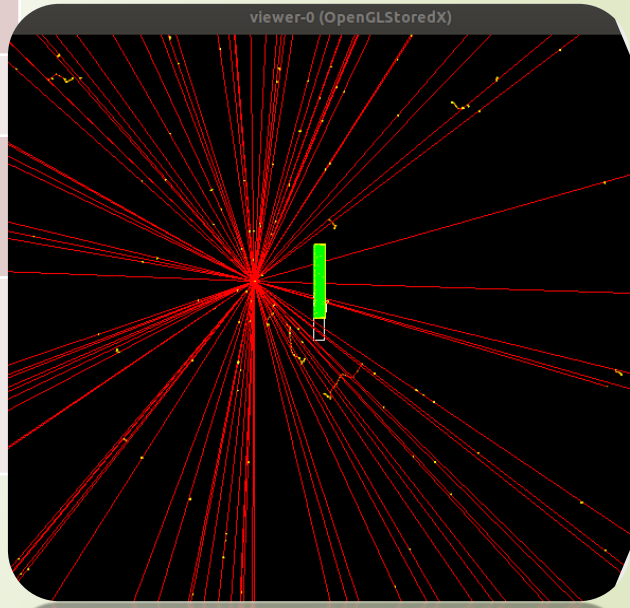




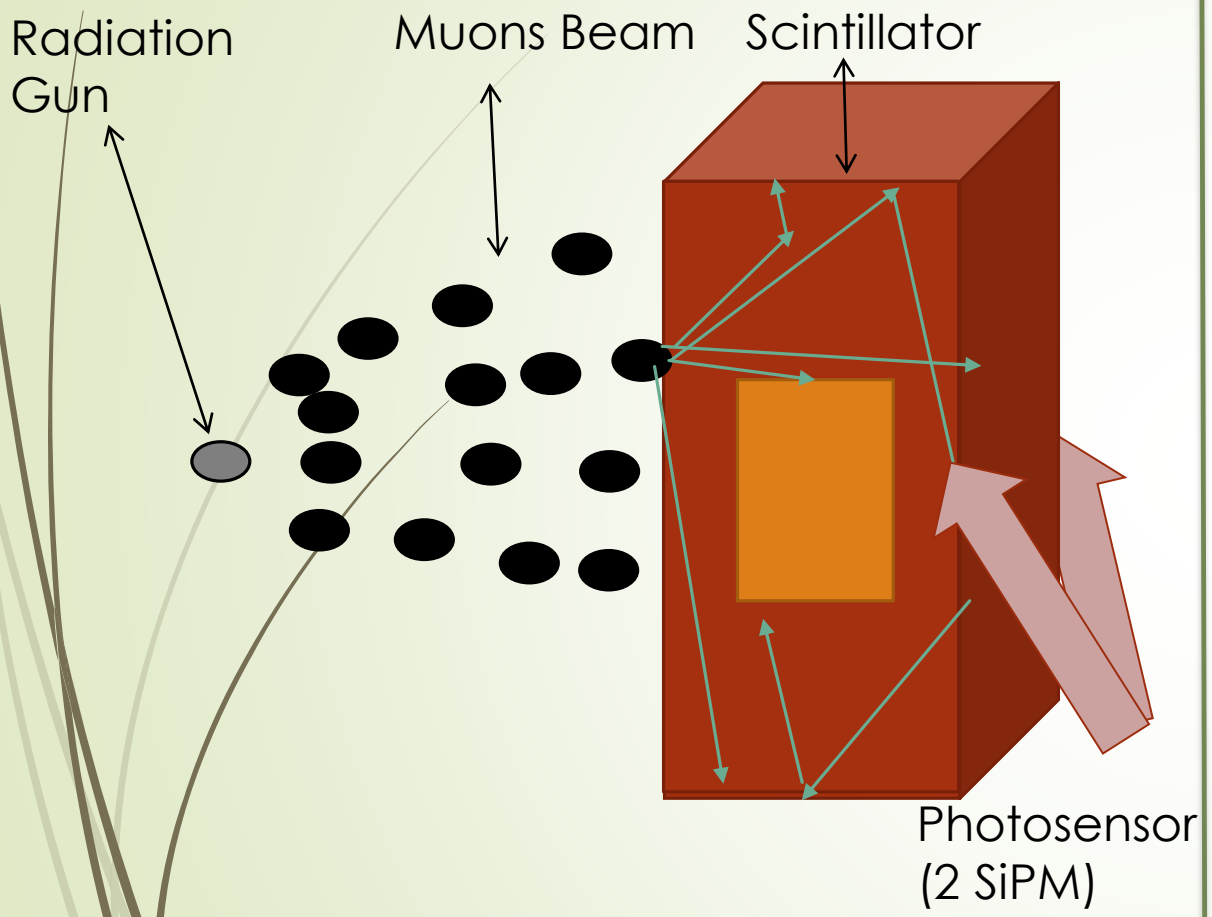
METODOLOGY

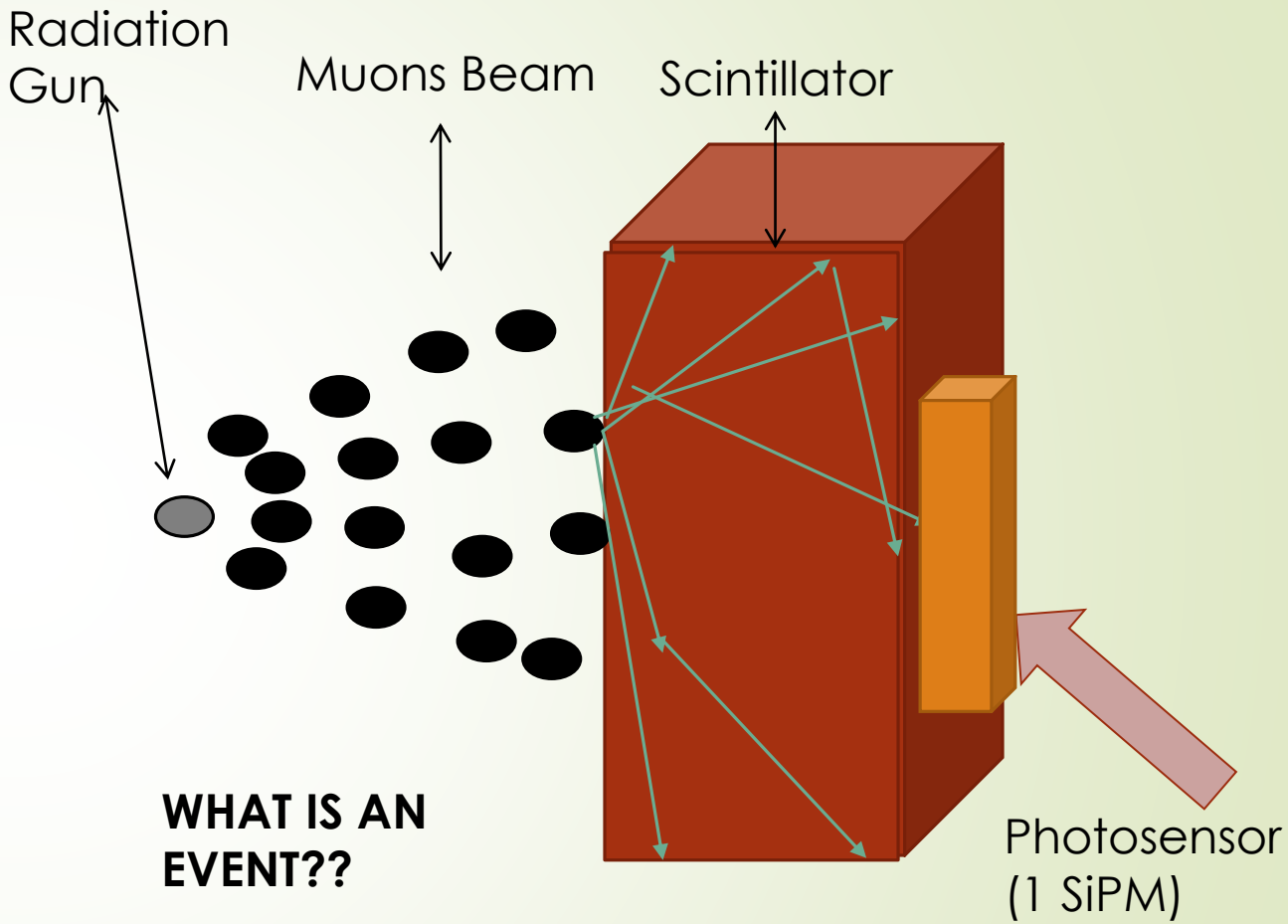
Air	N	O
Porcentage	70%	30%

PARAMETERS	BC404	BC422
Emission peak	408 nm (UV)	370 nm (UV)
Refraction	1.58	1.58
Manufacturing base material	Polyvinyl Toluene	Polyvinyl Toluene
Principal uses and applications	Fast Counting	Ultra Fast-Timing Ultra Fast-Counting



METODOLOGY



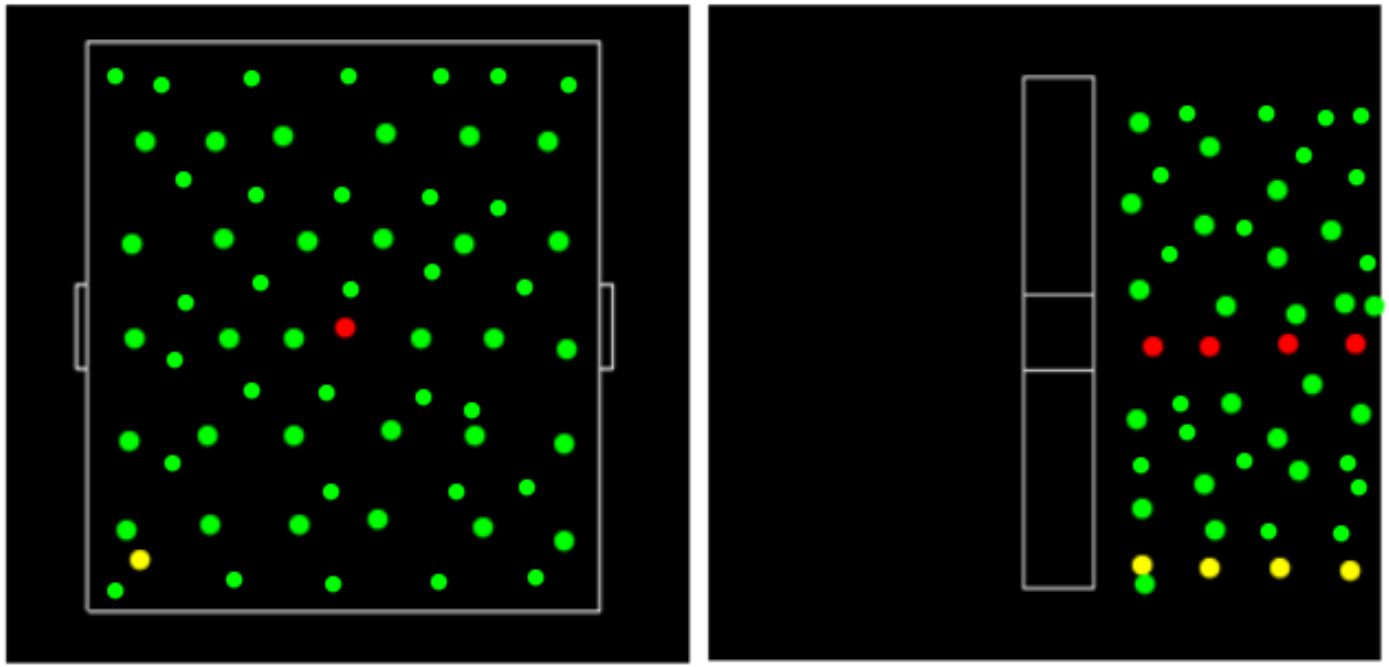


WHAT IS AN EVENT??

30 Simulations with 2 SiPM & 1SiPM
15 Sim. with BC404 & 15 sim. BC422
5 Sim. per 3 beam configuration.
Random, center and corner beam.

Electronics is not simulated easily in Geant4→ a sensitive area called **"Score"** will be simulated instead of SiPM:
Score= SiO_2 (just for counting the photons) 3x3x0.5

METODOLOGY



Conditions:
scintillator- 100% reflective
SiPM/Score- 100% absorbent
The particle gun is a distance of 1mm from scintillator

CUANTITATIVE STUDY IN GEANT4:

Time resolution measurement for various detectors configurations →

***Muons beam was simulated at 1 GeV**
→ will arrive to the detector (2 SiPM at scintillator central sides and 1 SiPM on the scintillator rear face)

PARAMETERS:

***Two scintillator material**
(BC404 & BC422) based in PVT (Polyvinyl Toluene)

***Scintillator volumetric dimensions.**
(100x100x20, 50x50x10, 40x40x5, 20x20x5, 20x20x3 mm^3)

***Location of the radiation source ←→ determine zone interaction radiation**

- **After the simulation it was made an statistical treatment which needs the use of the framework called ROOT**

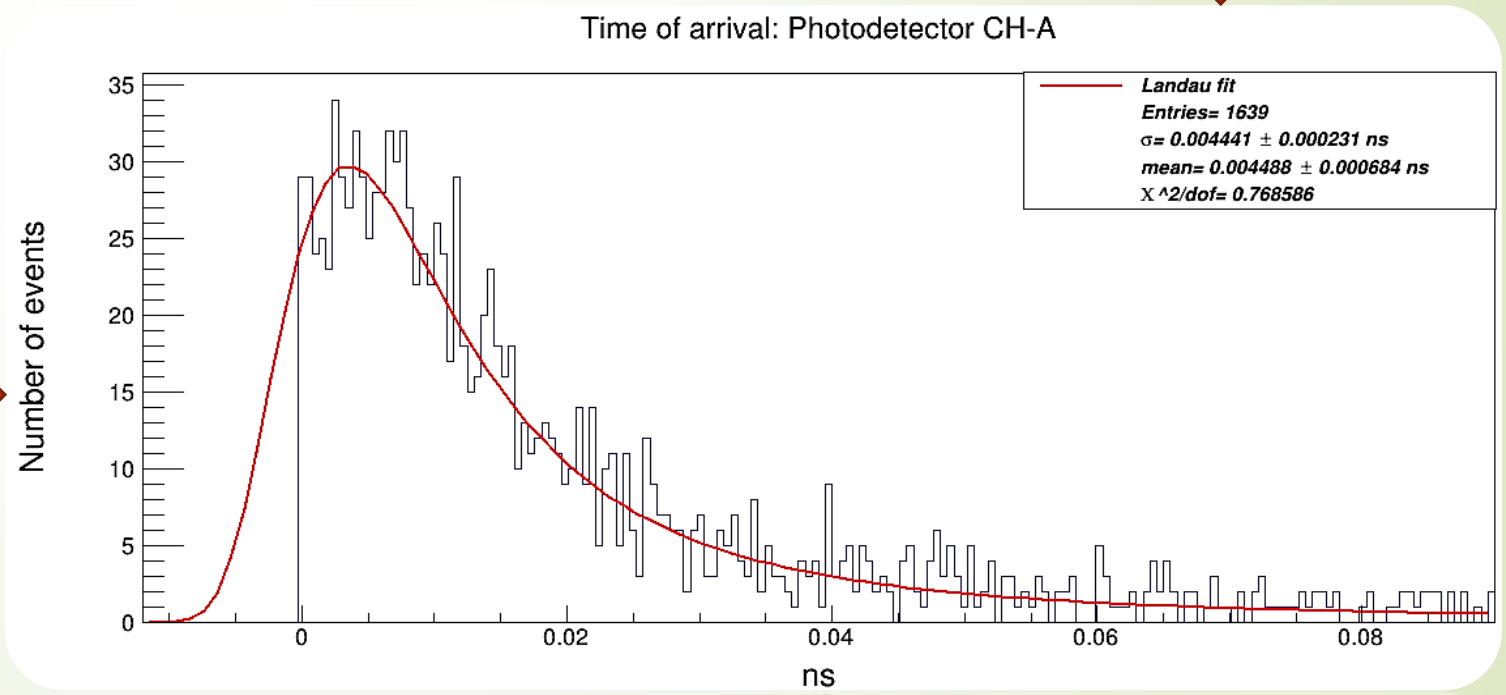
RESULTS AND ANALISYS

- The Time of flight of the optical photons→was taken for analyze them statistically.
- In ROOT the arrival time from the optical photons were procesed by event (strike in the scintillator by the muon) for fit them to Landau distributions.

OPTICAL PHOTONS BY EVENT

The Mean (μ) of each *Landau fit* *(Each event)*

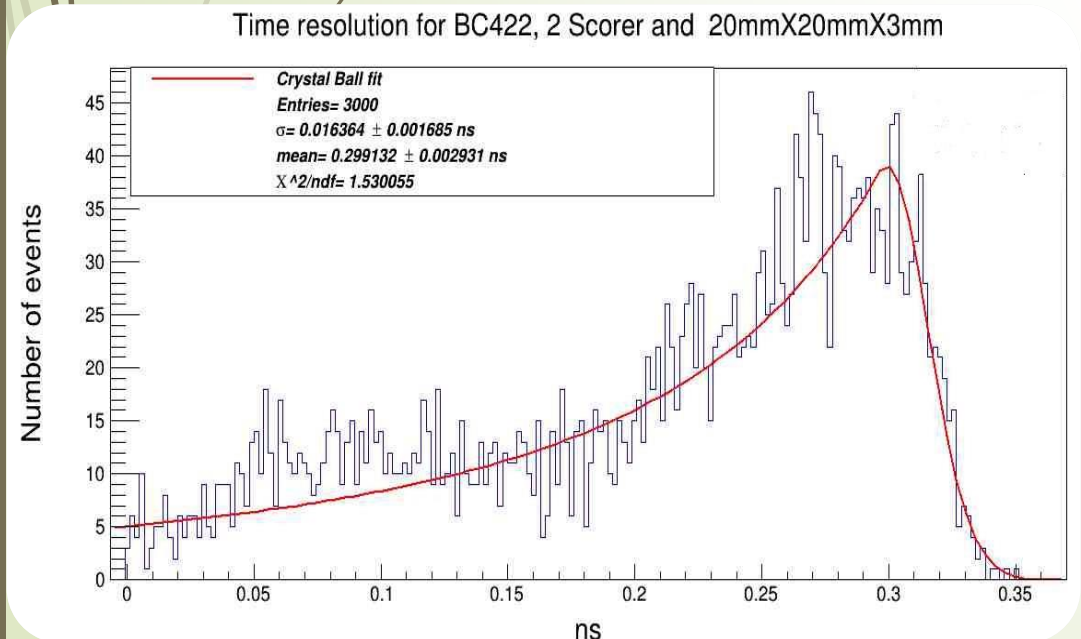
Allow to construct → New Distribution

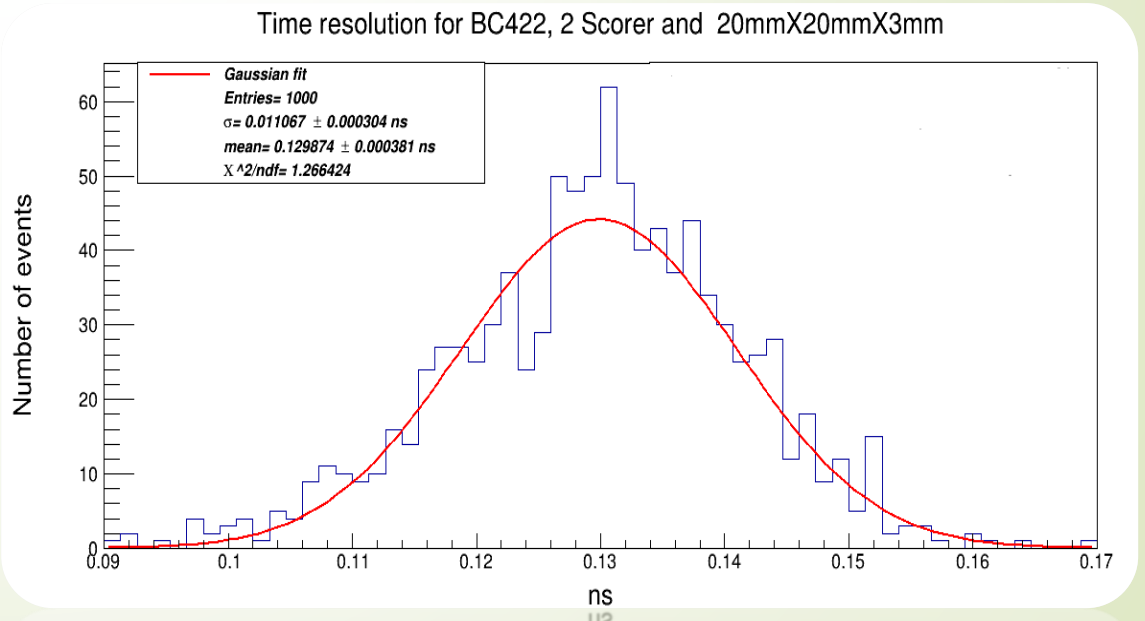


RESULTS AND ANALYSIS

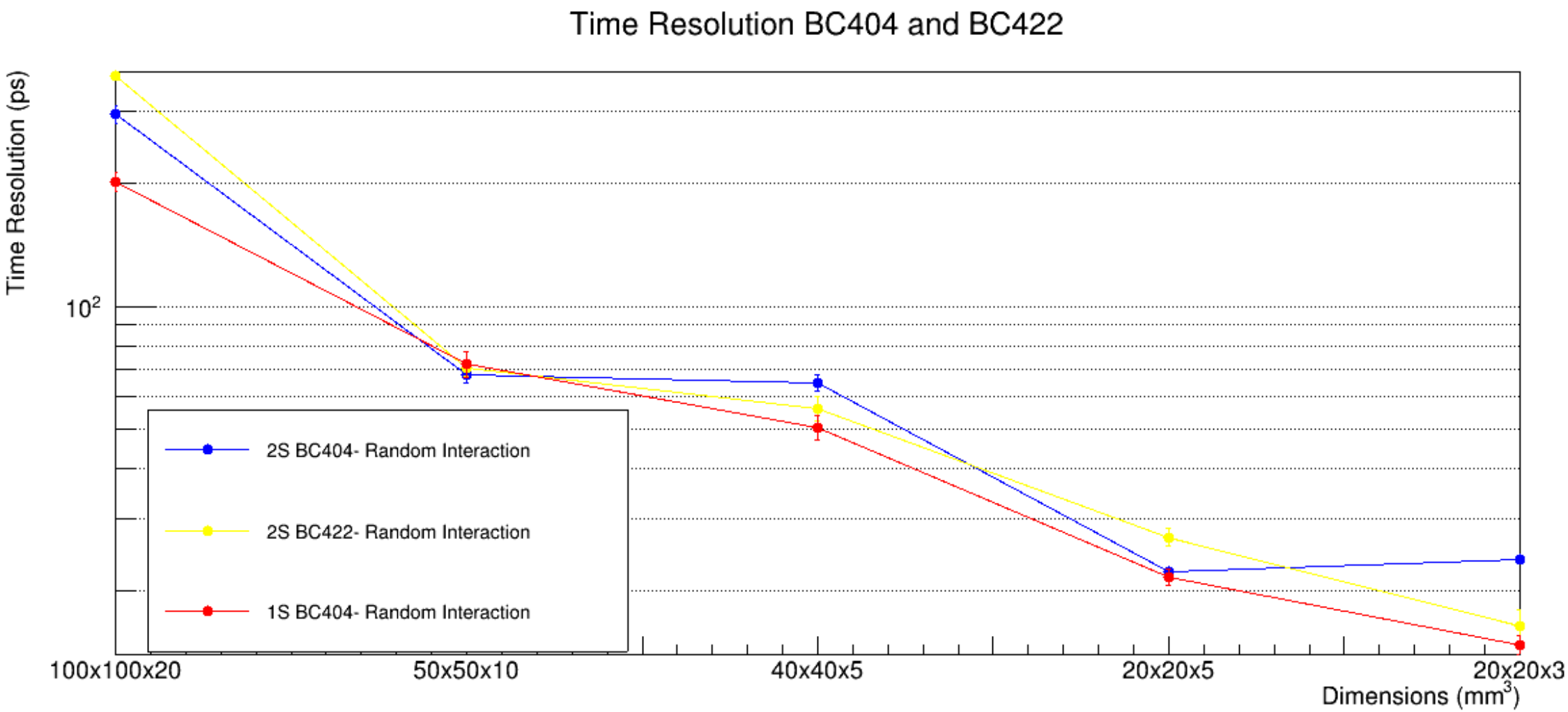
The means (μ) referred to each Landau Fit (of all events) allows to construct a new statistical distribution.

The standard deviation (σ) of this last distribution, is the **Time Resolution**



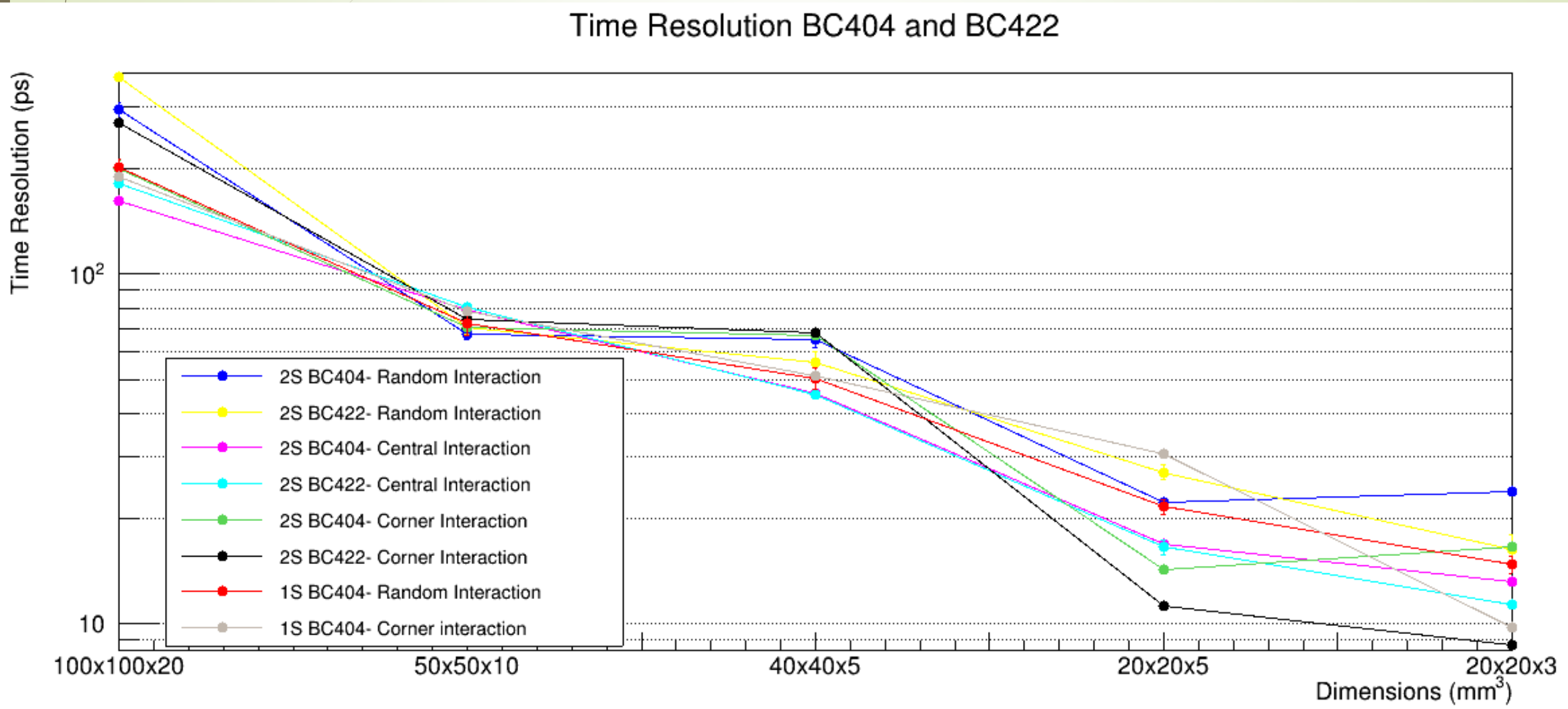


RESULTS:GRAPH THAT SHOWS RANDOM BEAM INTERACTION BC404 VS BC422

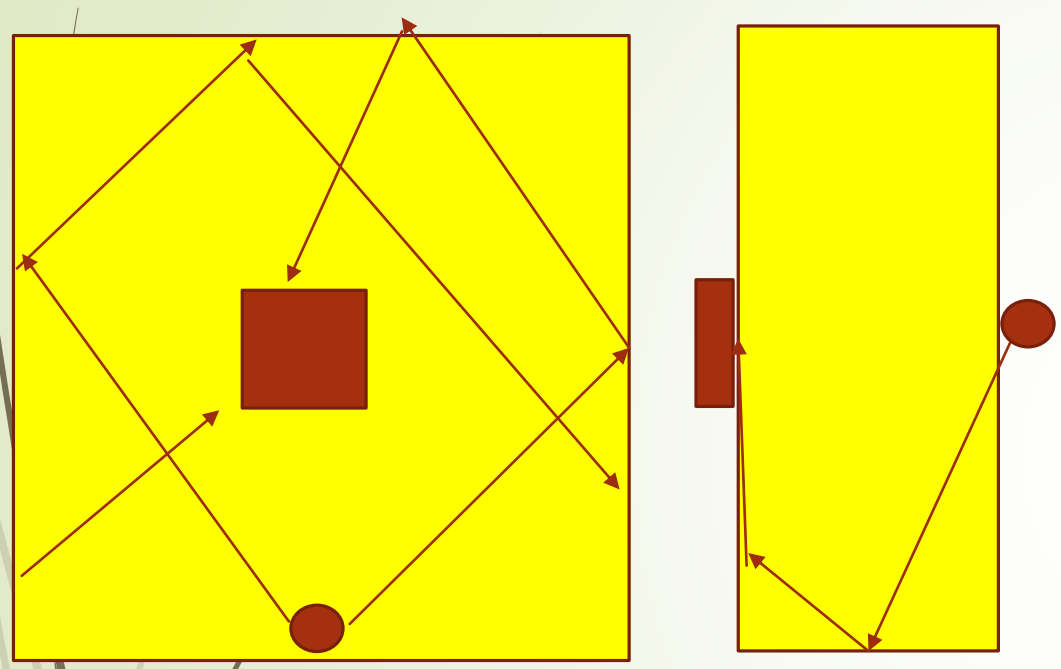


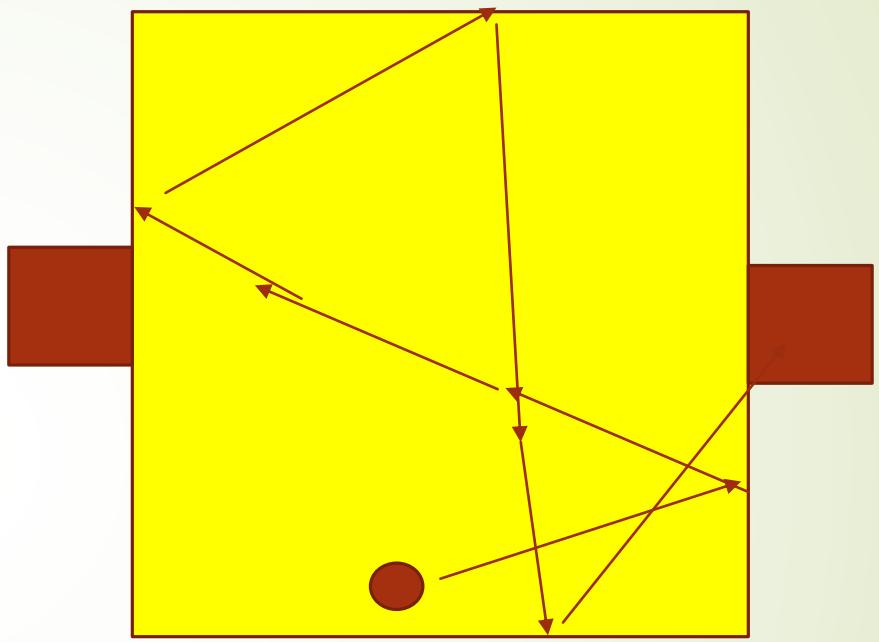
RESULTS:

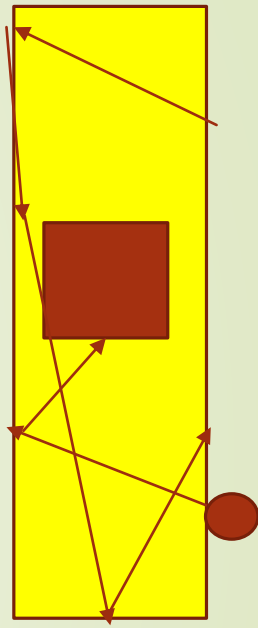
Beam contributions at the corner and center of the scintillator



RESULTS: RANDOM MUONS BEAM

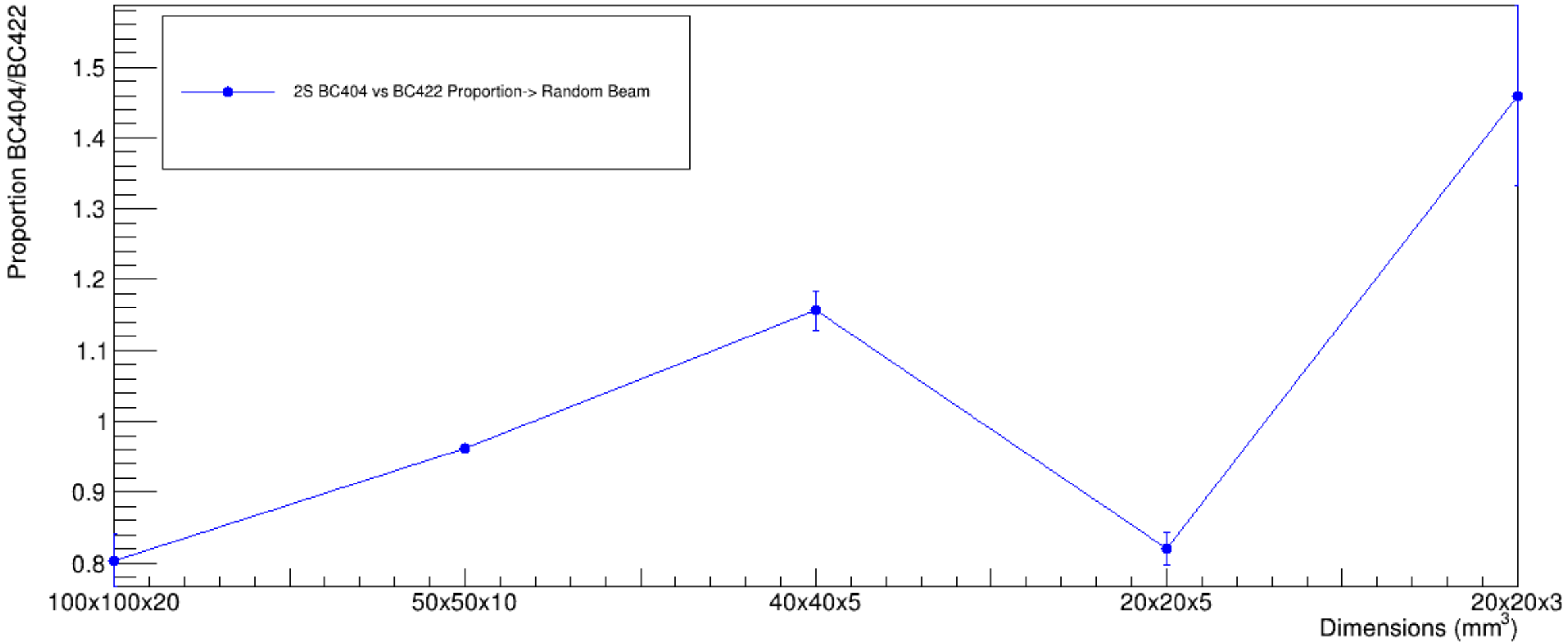






***Optical path trajectory:**
Disposition → 1 y 2 Scores/SiPM
Front View & side View

RESULTS: RANDOM MUONS BEAM



CONCLUTIONS

BC404 has a better performance than BC422 at bigger scale > 50x50x10 mm^3
BC422 has a better performance than BC404 at smaller scale < 40x40x5 mm^3

The best values of time resolution that has been obtained are:
8.7- 11.3 PS (2 Scores BC422) – beam guided at the left corner.

CONCLUTIONS

*The best values of temporal resolution **depend inversely** of the dimensions of the scintillator.

*The time resolution depends on the **optical path and the interaction zone**.

*In a real experiment→ the particles arrive randomly at the detector.

*With this simulation it is confirmed **the smallest time resolution contribution** corresponds to the beam interaction at the corner.

Thanks for your attention

Happy Holidays

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