News and progress in SHiPId

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on behalf of many people working on this subject

Introduction

Since the last SHiP meeting we've been concentrating on answering the most urgent question:

can (TP)SHiP work with He instead of 10^{-5} atm vacuum?

Indeed Jaroslava's studies showed that without PID we are not a 0 background experiment anymore (already with the neutrino background alone)

This study has been performed with the TP PID detector configuration. Some alternative detector configurations ares starting to be implemented but we do not have results yet.

Moreover for this last issue we needed to start from a reference performance to compare!

FairSHiP

with TP
PID detector

- PID software in FairSHiP

- performance of PID with HNL and Dark-Photon like signals

- performance on neutrino background with He instead of vacuum —>you will see that PID gives the safety factor that was missing from the geometric selection only

- studies of coherent neutrino background

- some open issues

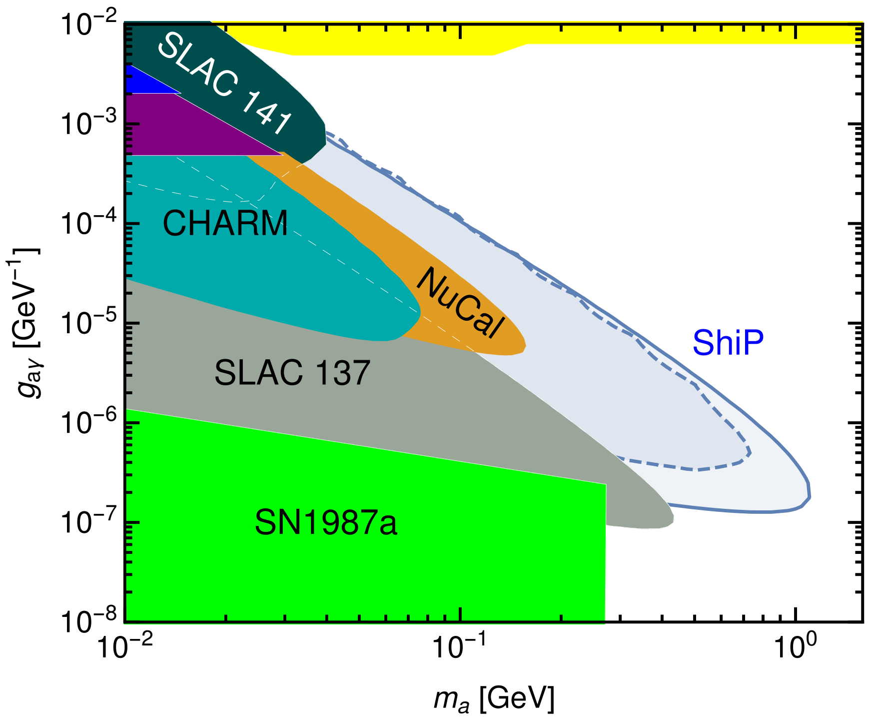
see Behzad talk

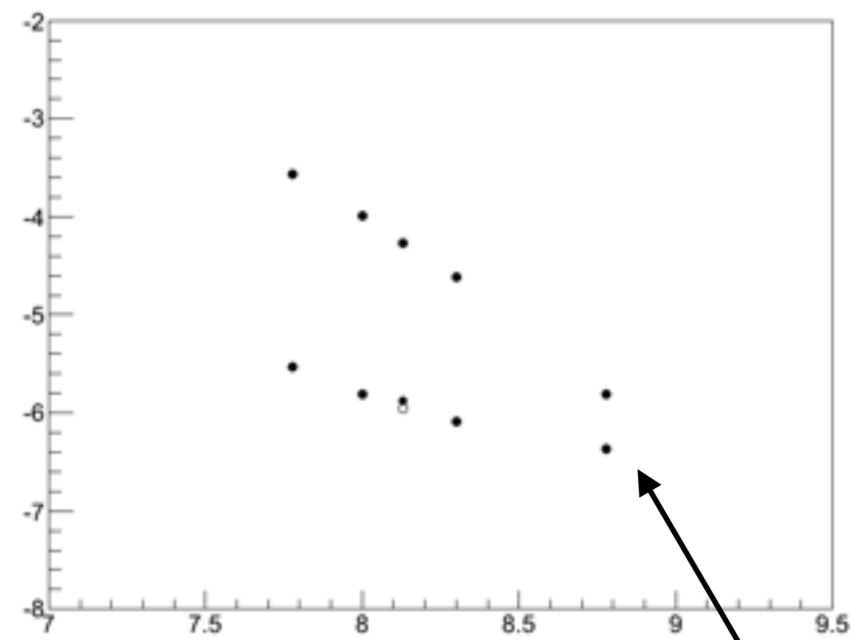
(in particular study not complete due to long awaited reco software)

About why the e.m. shower angle reconstruction

For ALP—>γγ basics see my previous talks

arXiv:1512.03069v





log$_{10}$m(eV)

Sensitivity after cuts (only Primakoff—> coherent would extend up to few GeVs) from ToyMC, no pointing cut yet; coherent ν background cuts applied

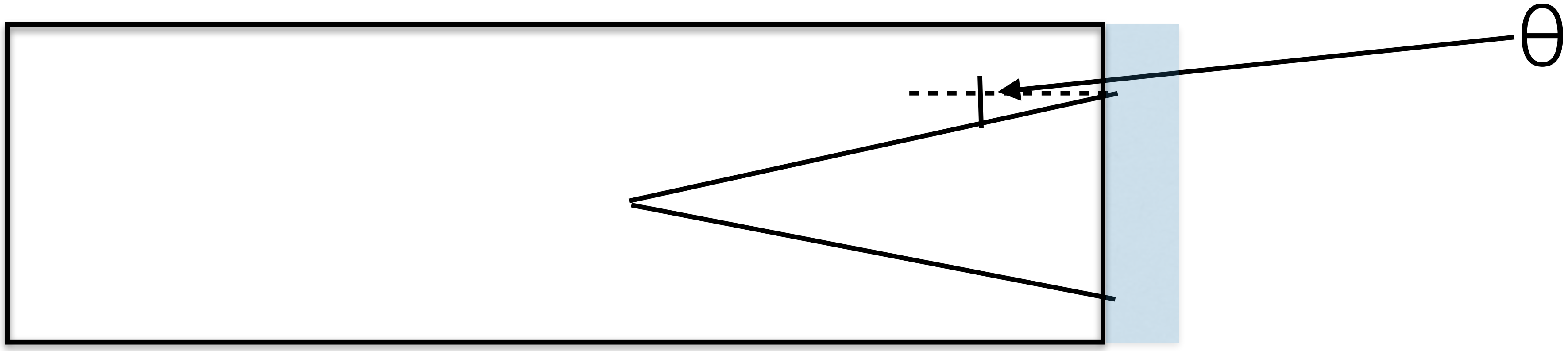
Can one determine the mass of observed candidates?

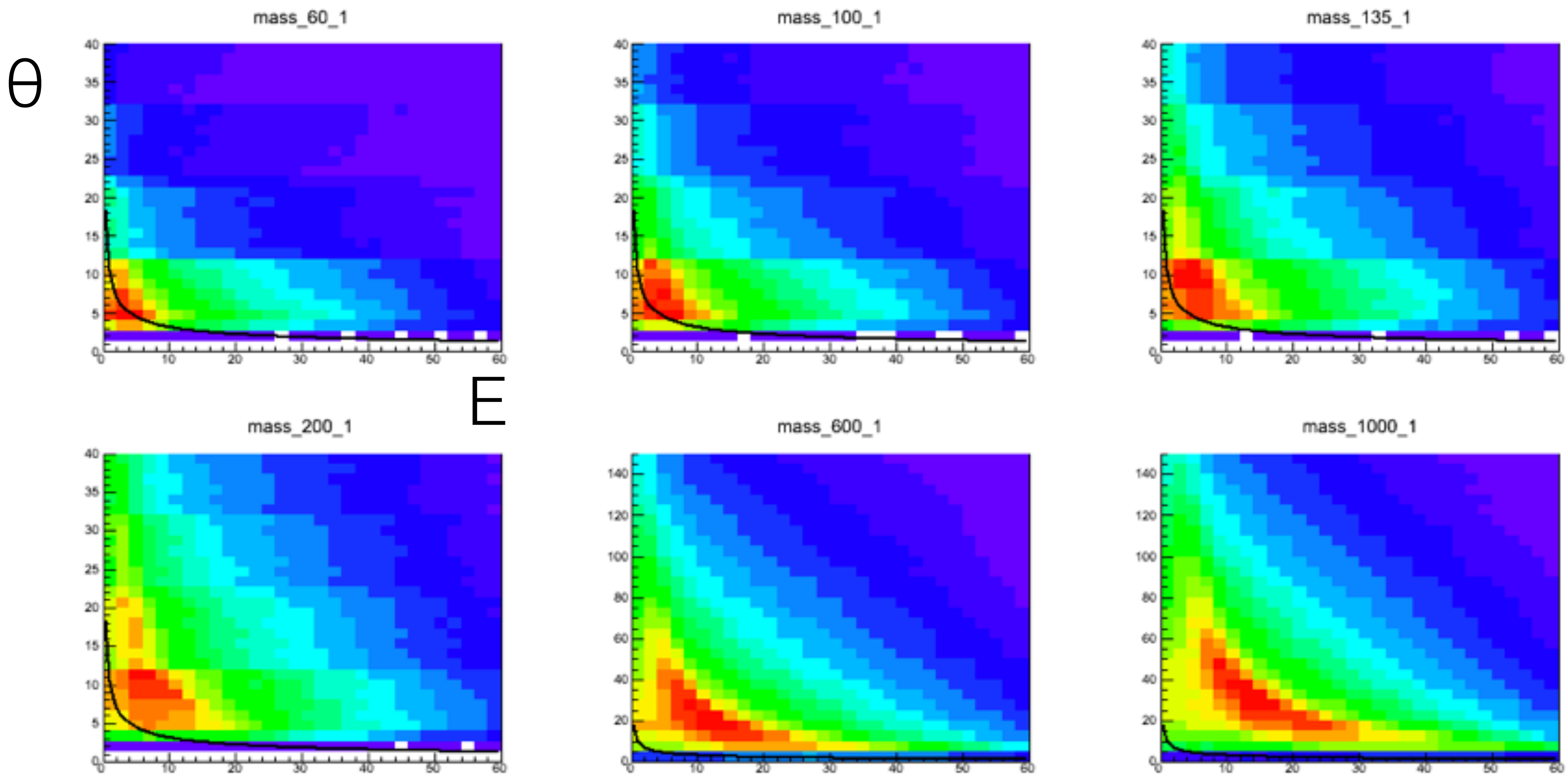
News on the Toy studies

- 3d reconstruction of decay vertex (before it was 2d)

- rejection of background

ANGLES


θ


θ
E
mass_60_1
mass_100_1
mass_135_1
mass_200_1
mass_600_1
mass_1000_1

Parameters for the ToyMC

ECAL:

$\sigma(E)/E=10\%/\sqrt{E}\oplus 1\%$ (also tried 5.7% no change on conclusions)

$\sigma_{x,y}=1.35cm/\sqrt{E}\oplus 0.28cm$ (6cm cells)

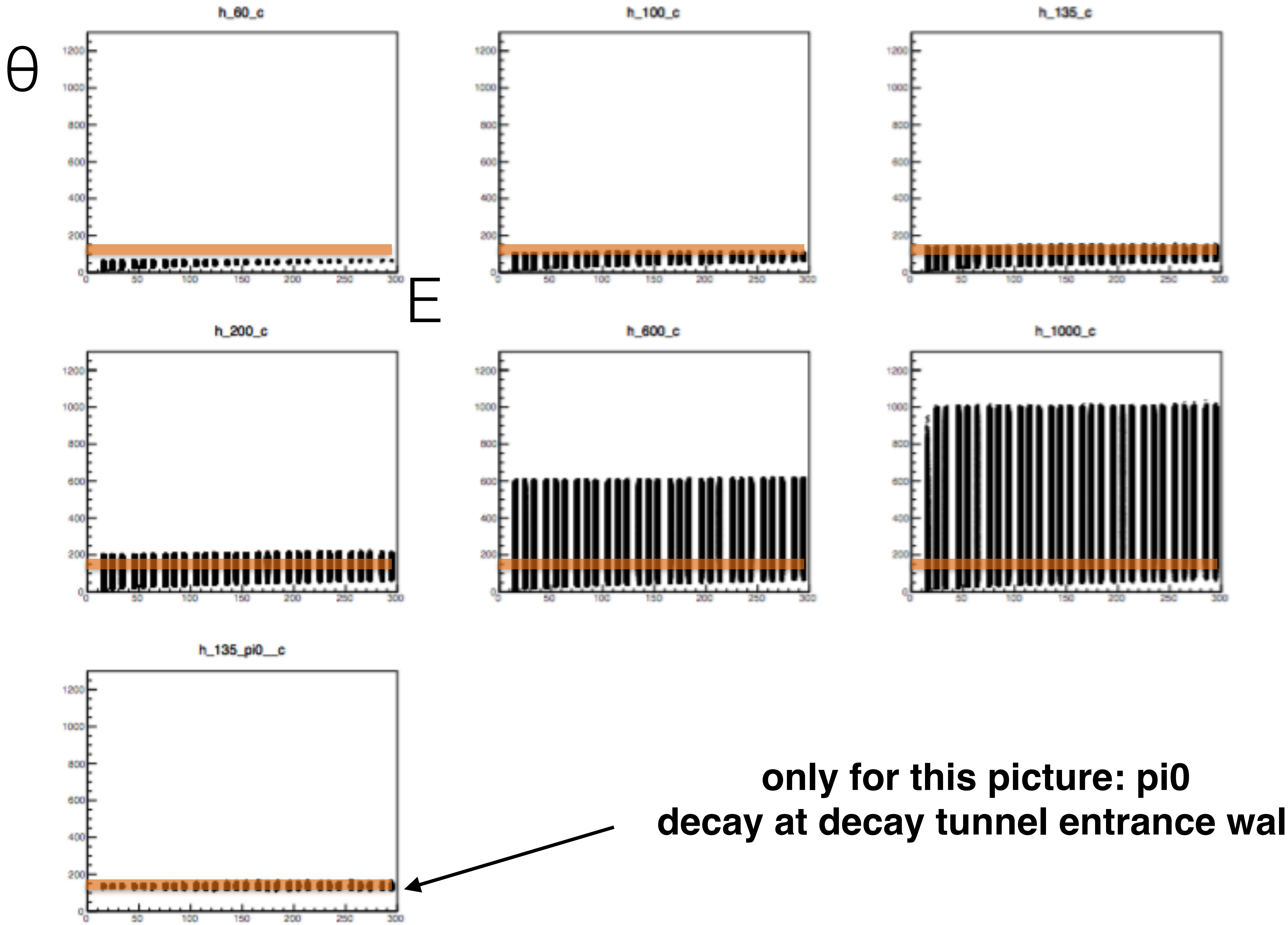
$\sigma(\theta)=10mrad/\sqrt{E}$ ->black curve of previous page

Coherent pi0 background suppression

Idea of Tomas works: no need to reconstruct the mass to suppress it

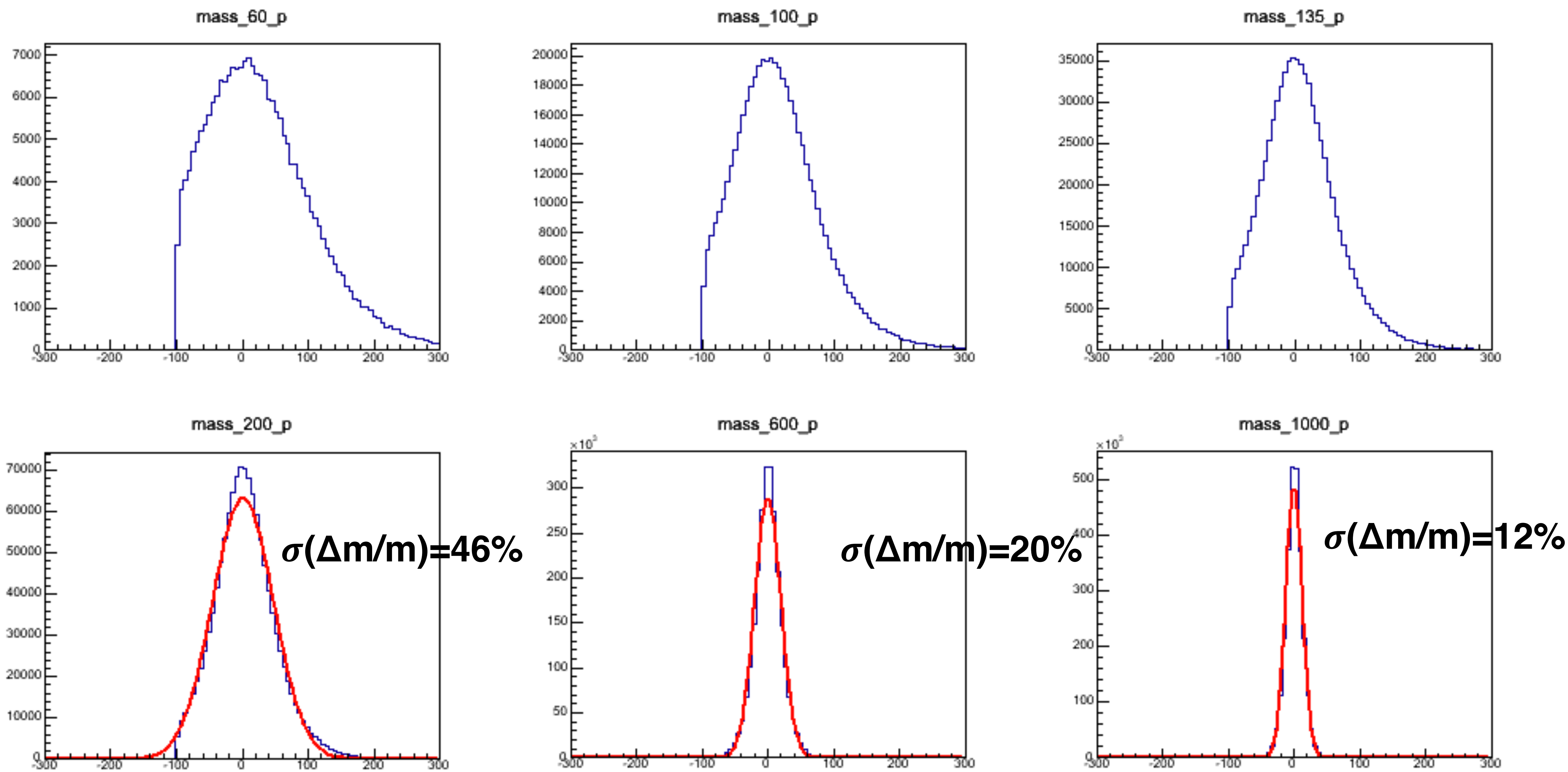
- just reconstruct the photon pair in the hypothesis of pi0 decay at the entrance wall of the decay tunnel

—> relatively small inefficiency



ALP signals reconstructed in the coherent background hypothesis: in red what we cut away

mass resolution



still work in progress…

Some ideas on alternative ECAL

revisit ECAL requirements after many physics studies

Energy resolution requirements moderate:

only neutral clusters need an energy measurement

- dominant only for determining the mass of HNL—>ρ+l candidates and DP—>π+π-π0

- for photon only decays all dominated by vertex resolution

probably 20%/sqrt(E) enough

revisit ECAL requirements after many physics studies (ii)

Shower angle determination for ALP —>γγ

- fine transverse segmentation (need to reach few mRad resolution)

electron/pion separation -> from PID studies it emerged that 2% of the pions are misidentified to e- due to the pion charge exchange reaction —>can be reduced by longitudinal segmentation

- pre shower

or

- longitudinally segmented ECAL

ECAL

Some ideas on possible replacement of Shashlik

- **cost considerations**
- **cost vs readout cell size**

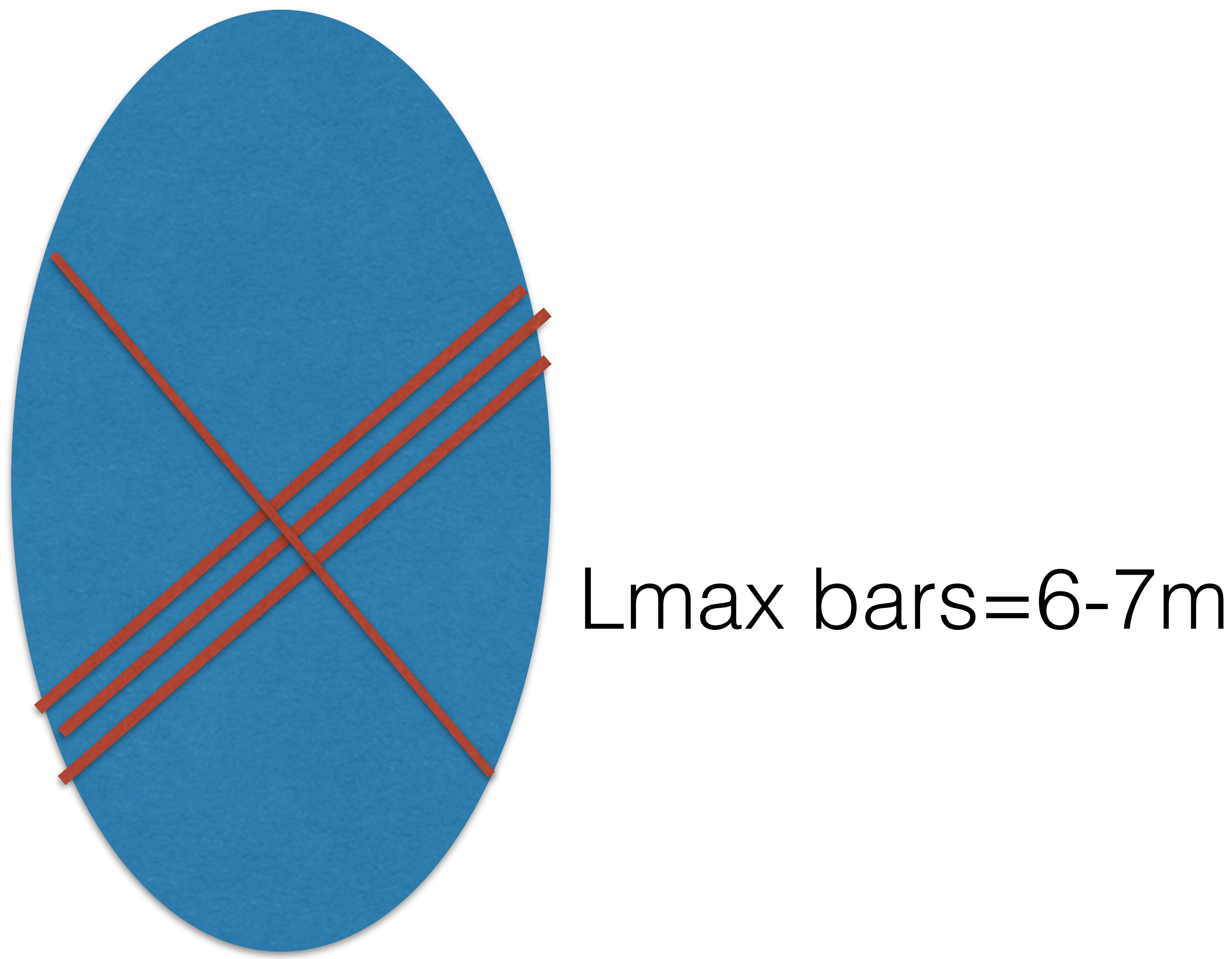
- extruded scintillator bars with WLS fibres

- gas calorimeter with Iarocci tubes or RPCs

- keeping Shashlik with large cells but add pre shower

We did not have time so far to do detailed simulations —> need a couple of months (and/or help)

Extruded scintillator



extruded scintillator with WLS fibres read by sides —> if it works, large cost reduction in machining, # of sensors

allows longitudinal segmentation —> shower angle

needs analog readout with TDC readout from both sides

of readout channels

Comparison of the ECAL two versions:

Transverse bars:

- no longitudinal segments

for 4cm granularity (not what I propose here!)

from the sides, 1 bar of max 6-7m crossed: ~500 ch that become 1000ch reading the 2 sides;

- three longitudinal segments —>3kch

2cm bars —> 6k ch

Shashlik; no longitudinal segmentation 24k channels

To be investigated

- is the light collected at the end sufficient for enough energy resolution?

  - good ratio WLS fibre diameter and ES bar size (2mm vs 2cm?)

  - test different concentration of dopants

- x vs y matching and barycentering of showers completely not trivial!

- what is the timing performance that can be met at reasonable cost?

- sampling ratio and frequency

- use of iron vs lead vs mixed absorber

- optimisation of bar dimensions and longitudinal segments for angle reconstruction

Plan

It seems that some experience of this layout is already there (Spinetti, LNF)

ECAL simulation to be started (Behzad?others?)

(had some useful discussions with A. Montanari on simulation parameters)

Another possibility: DIGITAL GAS CALORIMETRY

Calorimeter HARGD

- High Angural Resolution Gamma Detector
- Accuracy on shower direction much more interesting than accuracy on energy

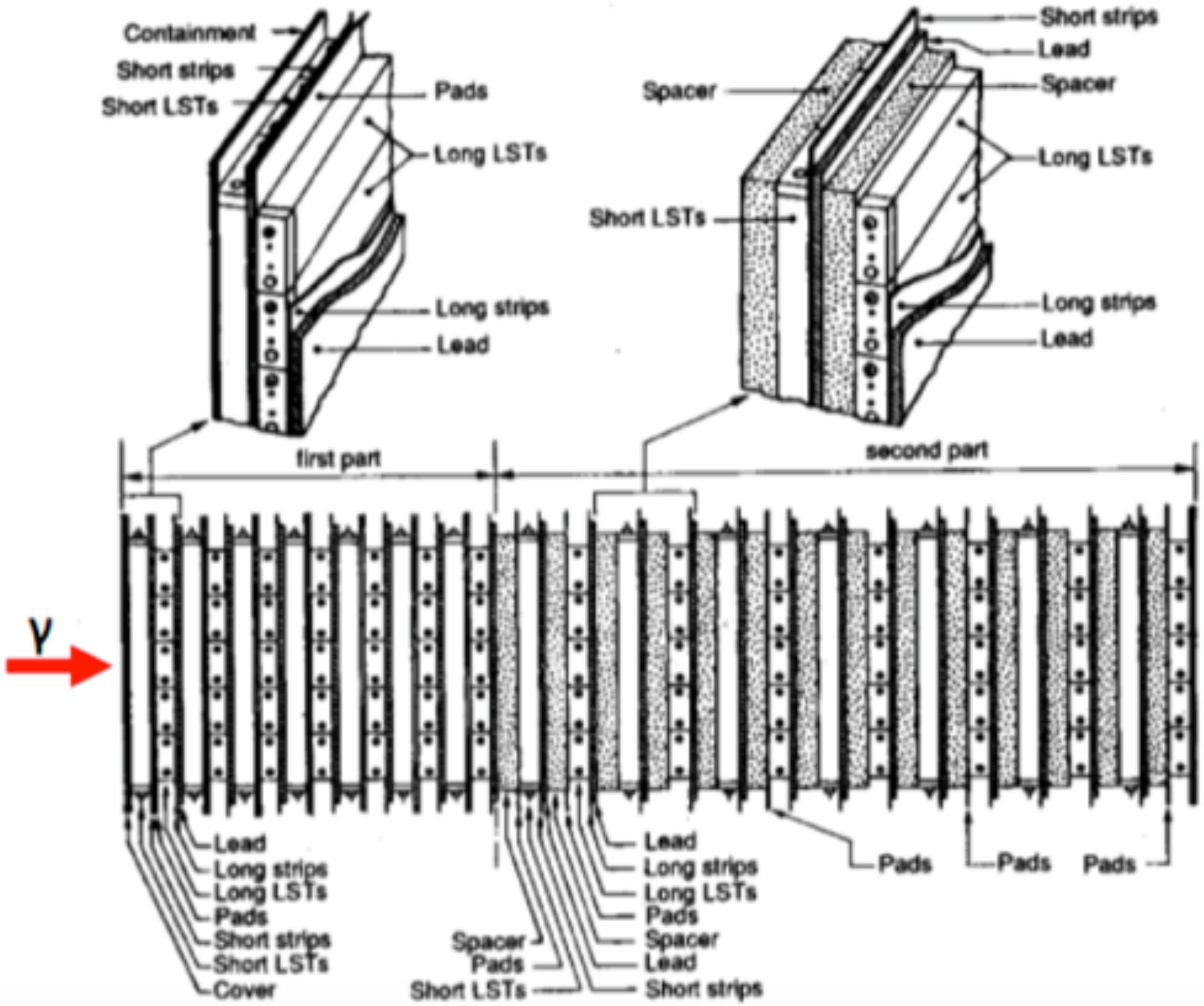


Fig. 2. Electromagnetic calorimeter stratigraphy.

- Sampling calorimeter.
- Converter: lead
- Active: Limited streamer tubes (1cm pitch)
- Dual reading: on strips and or pads
- Digital: hit/not hit
- 10 Xo
- Spatial accuracy below 3 mm (-> 2 mrad)

ıetry

see Mauro's talk

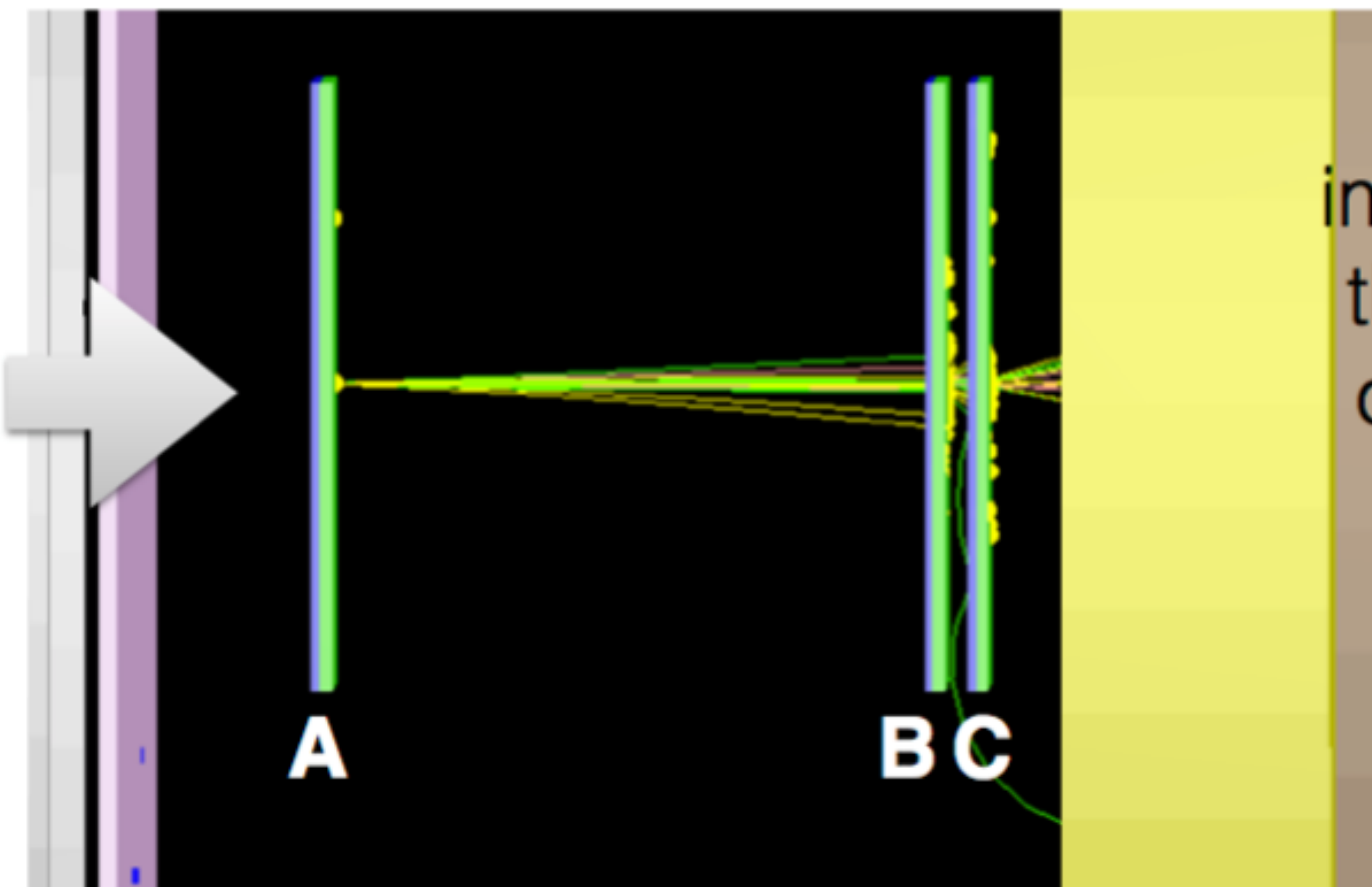
Simulation of the pre-shower (still some “old” results)

Some trials

With FairSHiP:

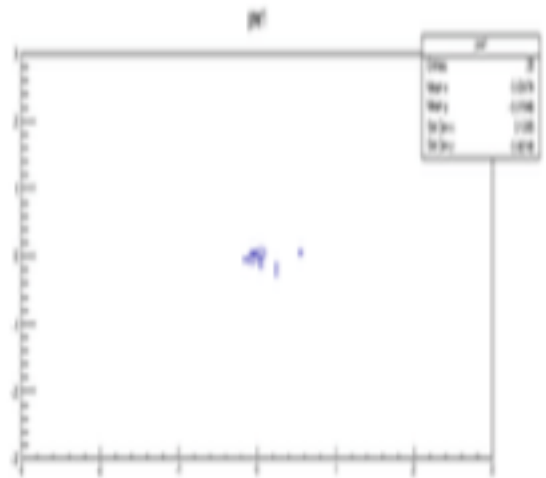
3 layers of scintillator : one sampling the shower at the beginning (2.5X0) and two after another 1.5X0 (as if they were sampling INSIDE the ECAL); 1m lever arm

20GeV γ
θ=0

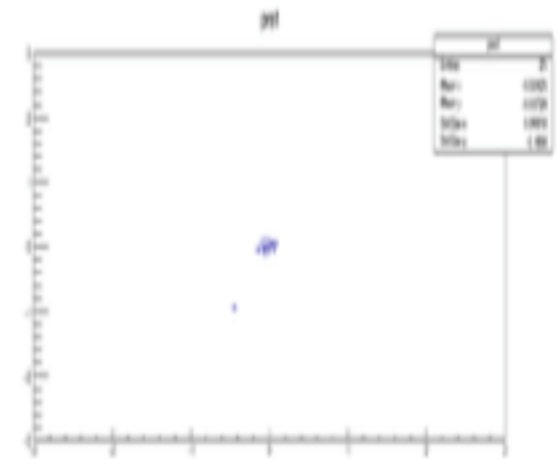


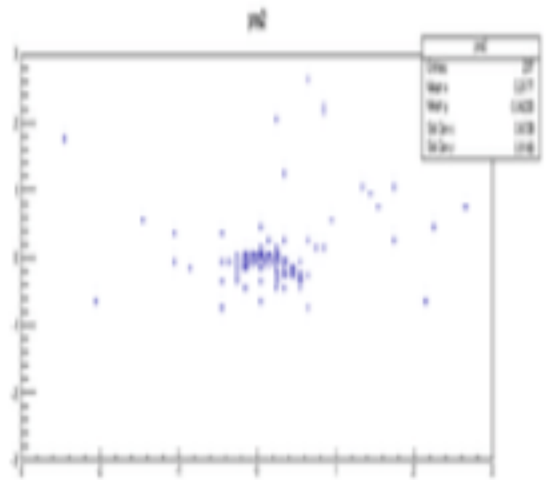
important to have thin exit window of VV like NA62 (He..)

Some events

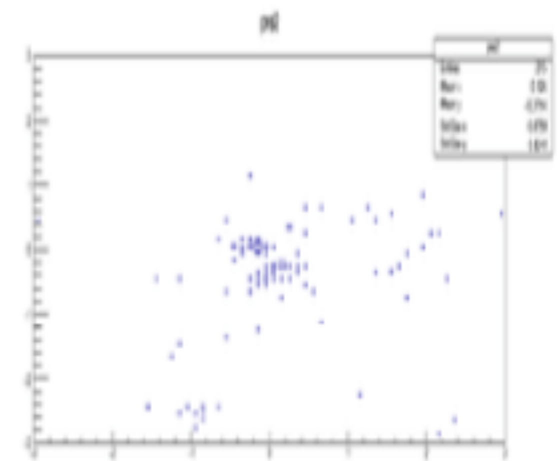


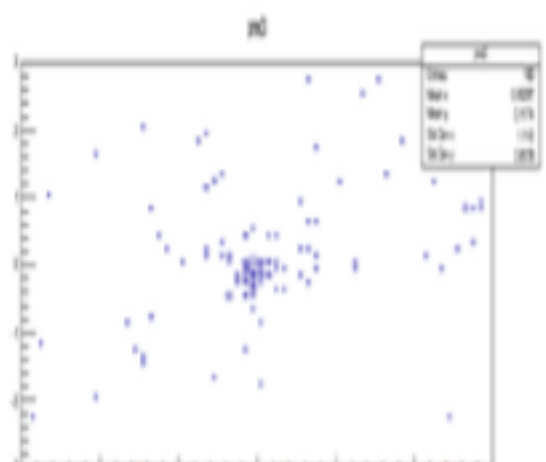
A



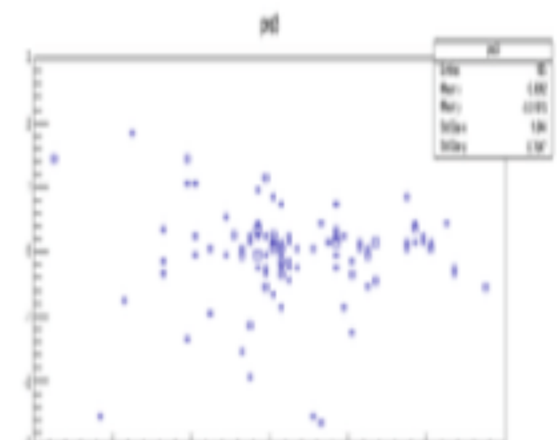


B



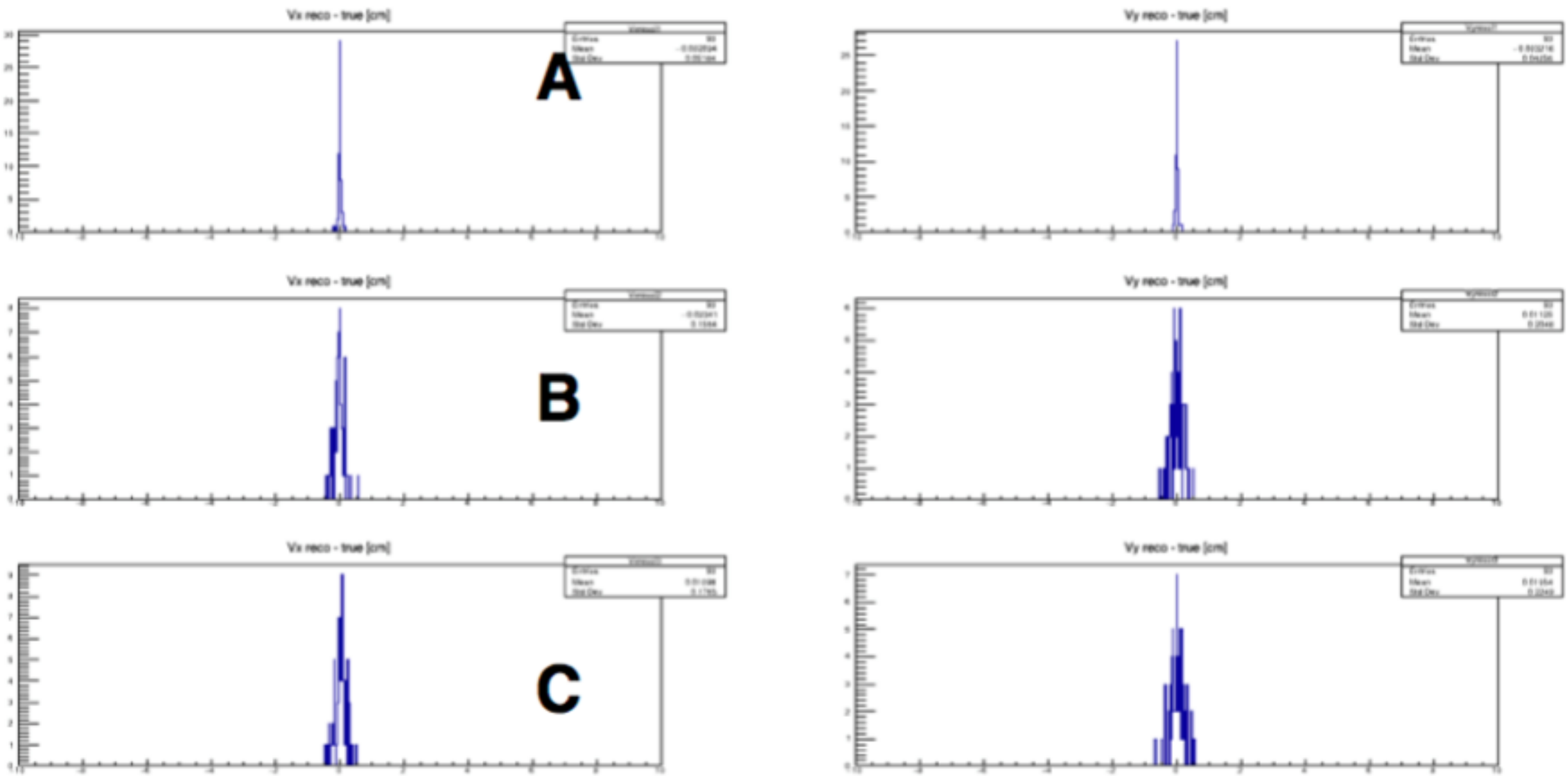


C



single photons at 0angle; 20GeV; 1mm pixels
—> some clustering is possible

Distributions



barycentre of positions of energy depositions
for <2cm from 0; 100 ev
for 20GeV —> rms in 2nd and 3rd layer 2mm

Muon/hadron optimisation —> work in progress

Pion/kaon separation using TOF

(J.Chaveau and)

Physics motivation

New studies on SUSY (I)

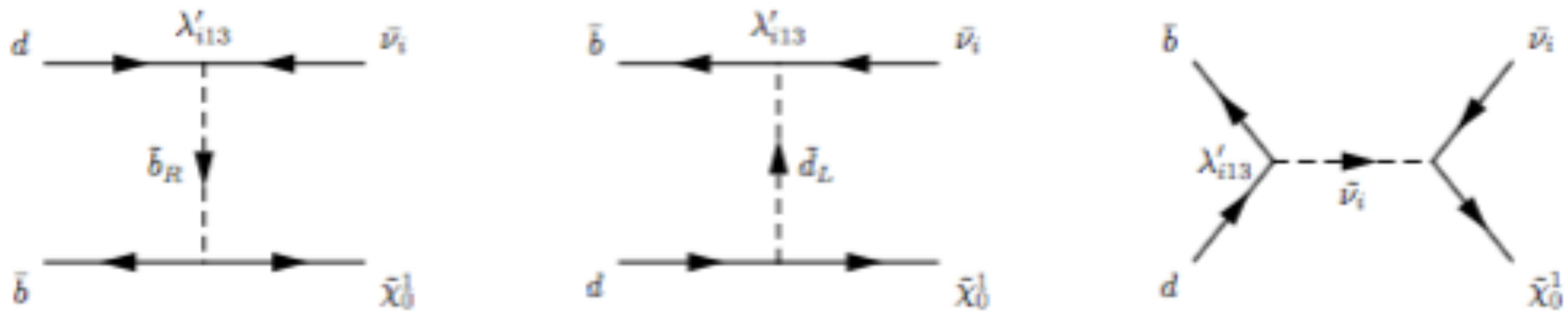
Phys. Rev. D 92, no. 7, 075015 (2015)

Search for SUSY renegades, below the EW scale

Neutralino's in RPV SUSY models

In the constrained MSSM with 5 parameters the lightest neutralino must be heavier than 46GeV but in general even massless neutralino is allowed

production: from decays of D and B mesons



decay: eeν, $\mu\mu$ν, πe, πμ, Ke, Kμ like the HNL

New studies on SUSY (I)

$$W_{\not R_p} = \lambda_{ijk}\epsilon_{ab}L_i^a L_j^b E_k^C + \lambda'_{ijk}\epsilon_{ab}L_i^a Q_j^b D_k^C$$

$$+\lambda''_{ijk}\epsilon_{\alpha\beta\gamma}U_i^{C\alpha}D_j^{C\beta}D_k^{C\gamma} + \mu_i\epsilon_{ab}L_i^a H_U^a,$$

$$\Gamma(\tilde{\chi}_1^0 \to \bar{\nu}_i \ell_j^+ \ell_k^-) = \left(\frac{\lambda_{ijk}}{M_{\tilde{f}}^2}\right)^2 \frac{3g^2 M_{\tilde{\chi}_1^0}^5}{4096\pi^3}$$

$$\Gamma(\tilde{\chi}_1^0 \to K^- \ell_i^+) = \frac{9}{256\pi}\left(\frac{\lambda'_{i12}}{M_{\tilde{f}}^2}\right)^2 \frac{g^2 f_K^2 m_{K^+}^4 (M_{\tilde{\chi}_1^0}^2 - m_{K^+}^2 - m_{\ell}^{i\,2}) p_{cm}}{M_{\tilde{\chi}_1^0}^2 (m_s + m_u)^2} \quad (9)$$

and the expression analogous to (9) for $\tilde{\chi}_1^0 \to \pi^- \ell_i^+$, which is proportional to $|\lambda'_{i11}|^2$. One can see from Eqs. (8) and (9)

the couplings here are generation dependent and are different in general from HNL!

New studies on SUSY (II)

arXiv:1511.05403

If SUSY is spontaneously broken at not very high energy scale (see models with gauge mediation of SUSY breaking as an example), the particles from SUSY breaking sector may show up at quite low energies.

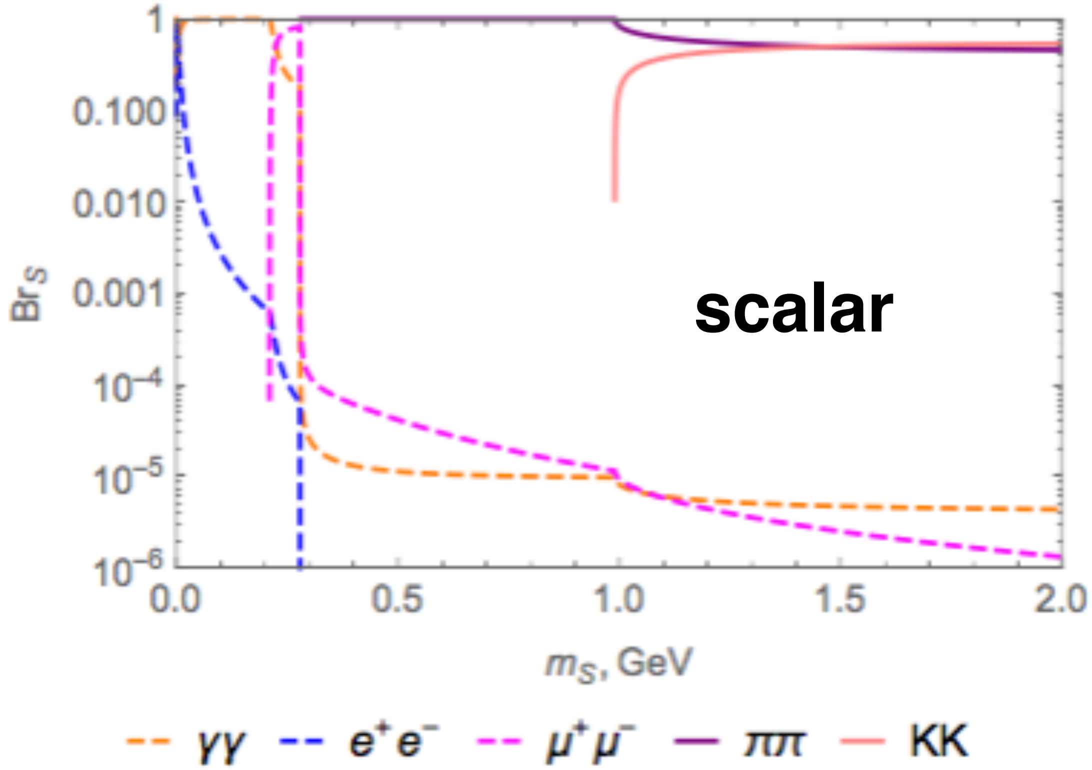
The Goldstino supermultiplet contains the Goldstino (the Nambu–Goldstone field, fermion) and its superpartners, scalar and pseudoscalar s-goldstinos.

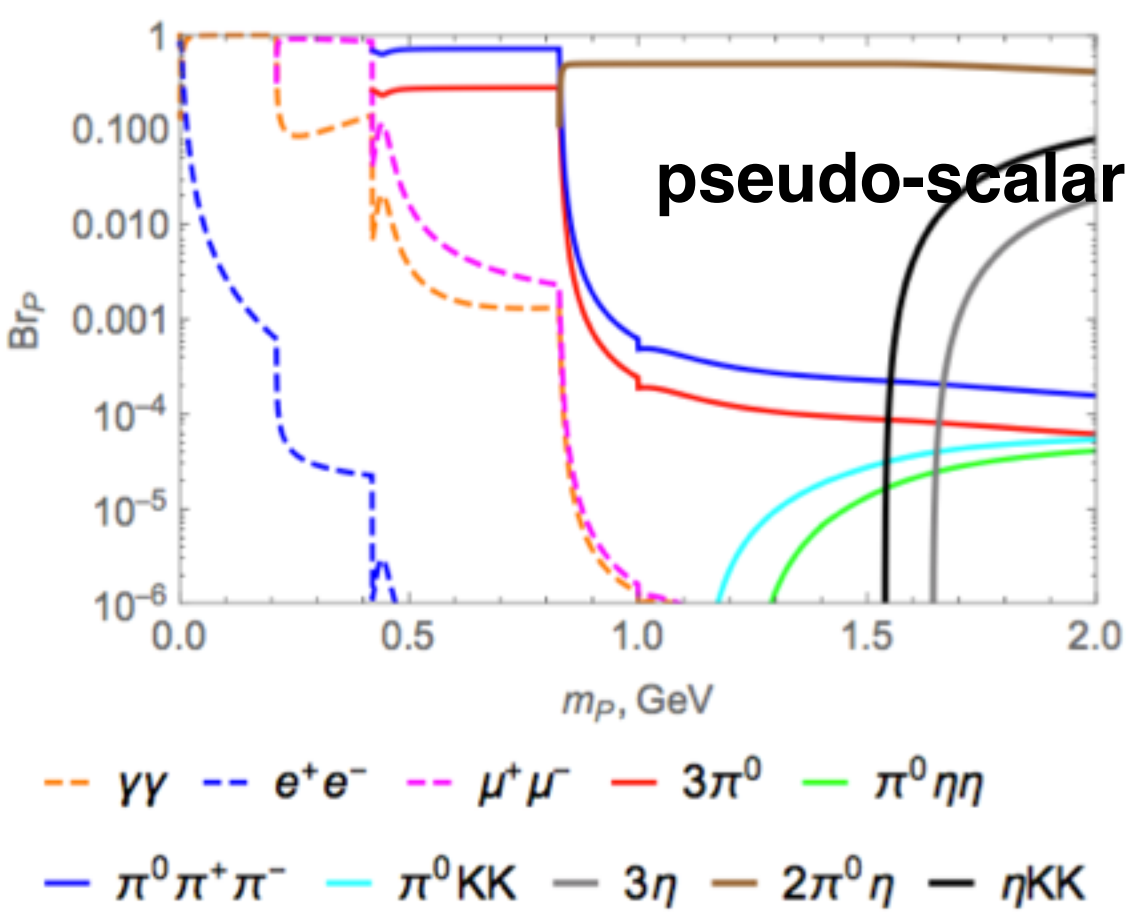
S-goldstino couplings to the SM fields are inversely proportional to the parameter of the order of squared scale of SUSY breaking F in the whole model

—> their couplings are anticipated to be rather weak.

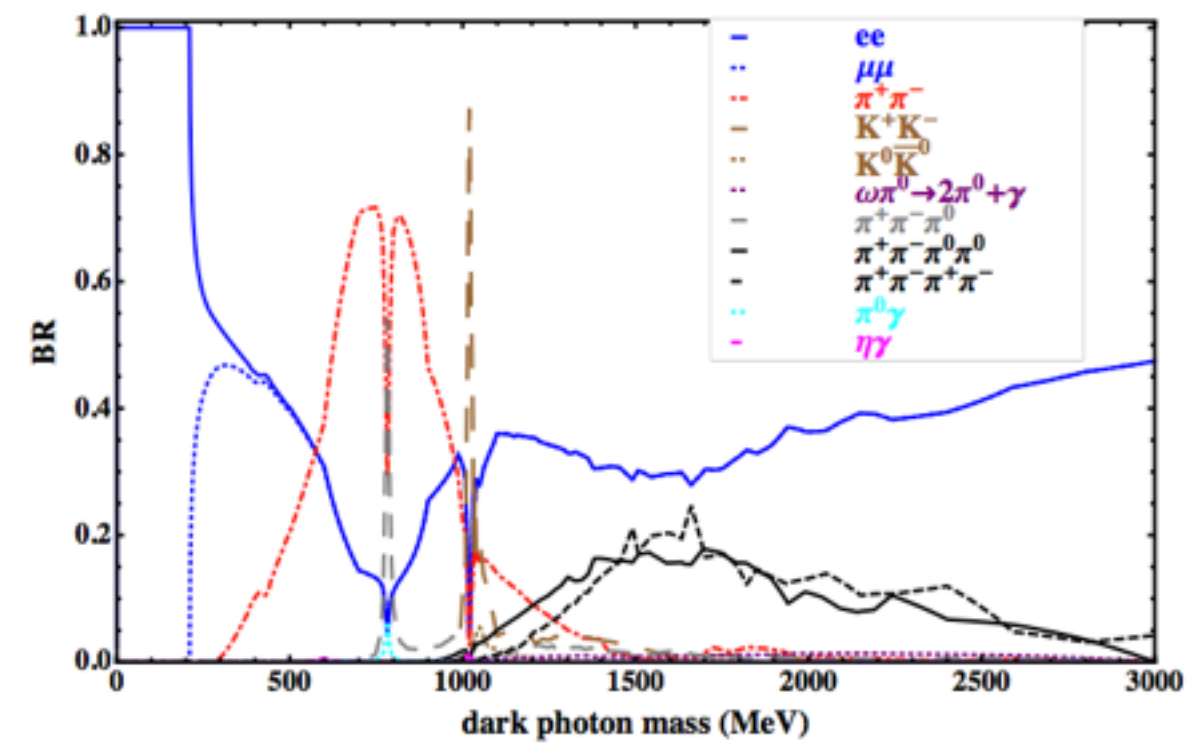
—>test the SUSY breaking scale by hunting for the light s-goldstinos

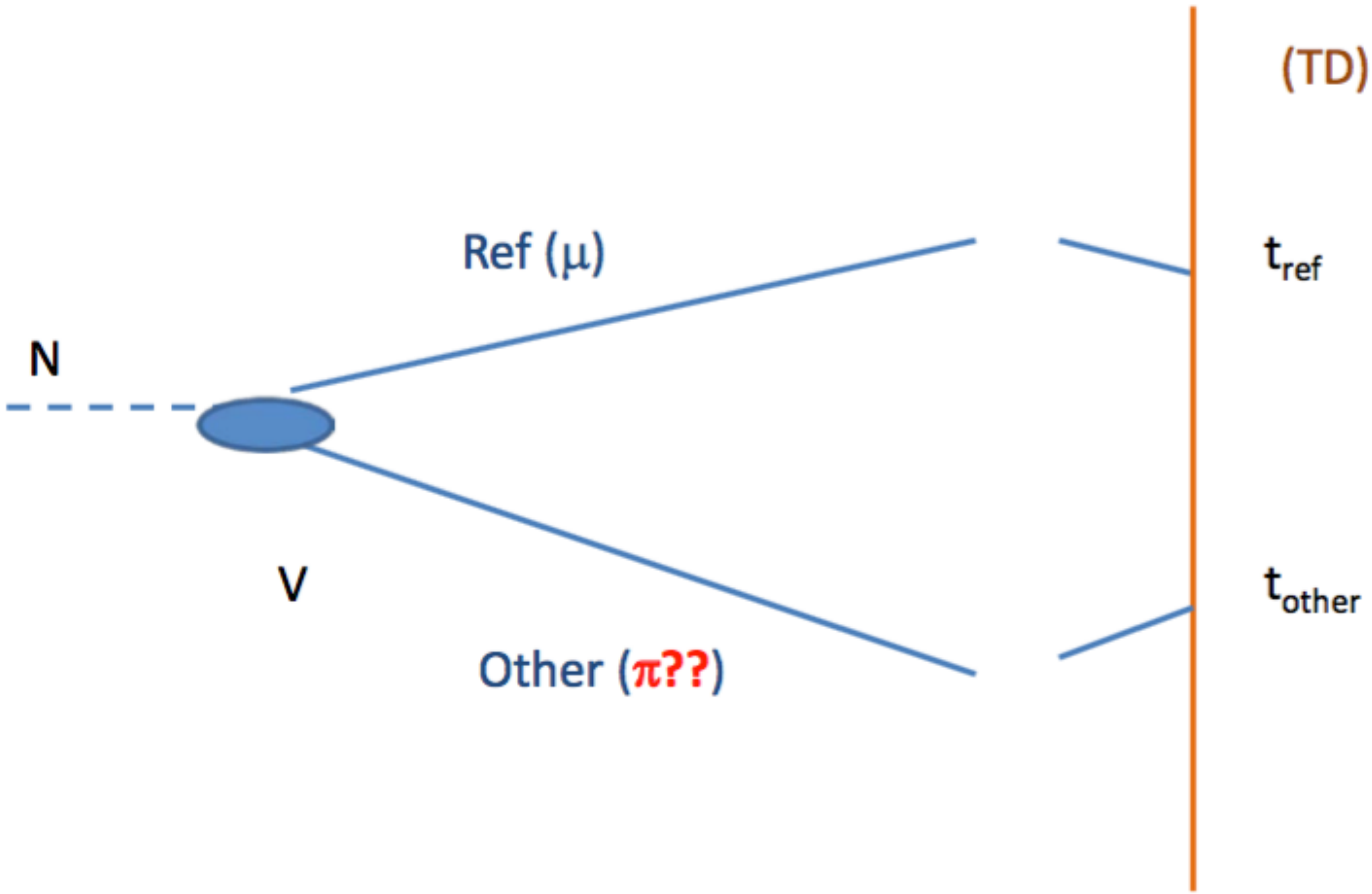
New studies on SUSY (II)





Dark Photon

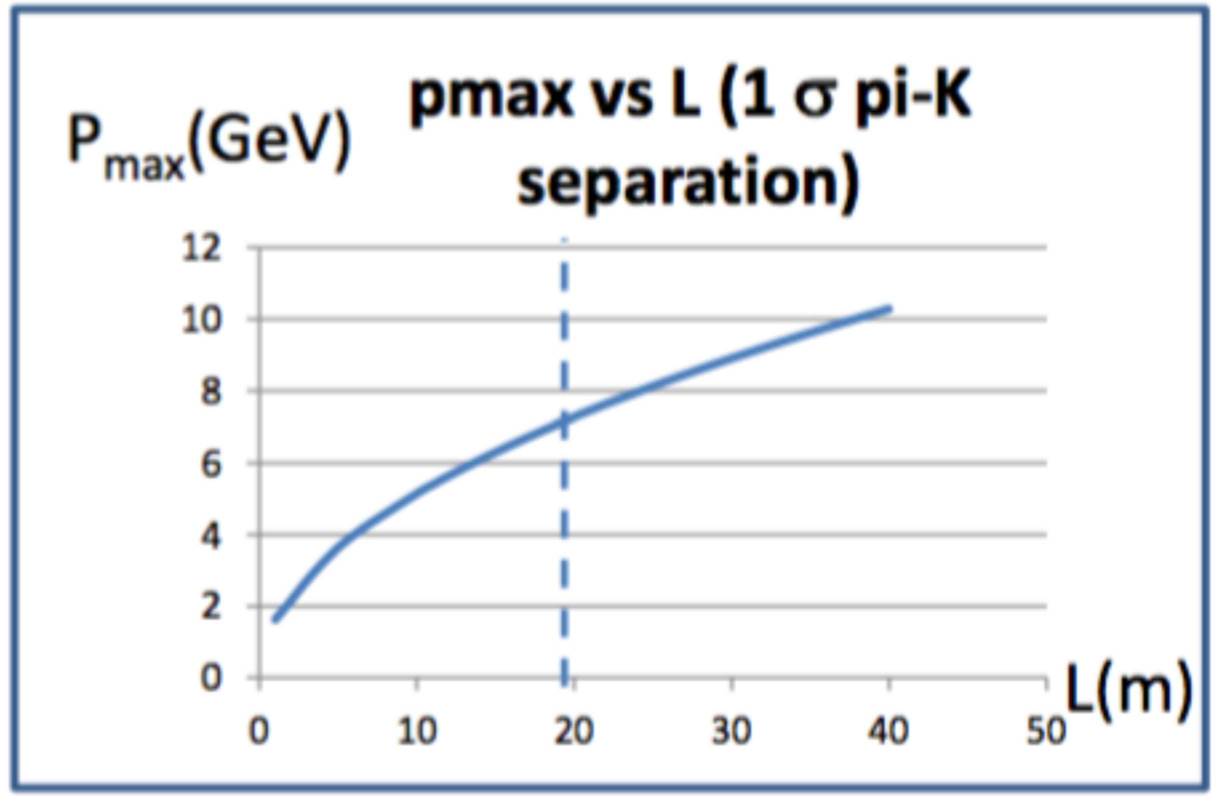


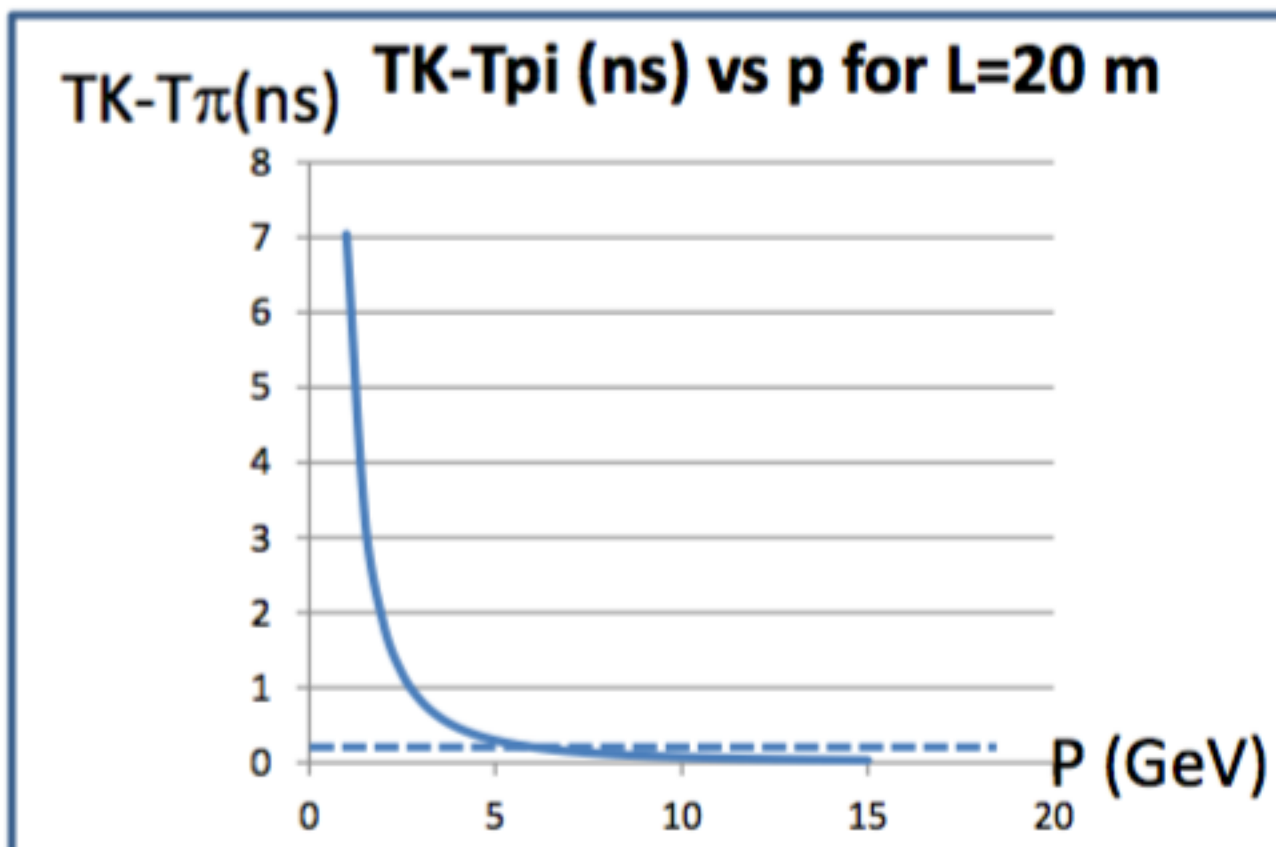

(TD)
Ref (μ)
t_{ref}
N
V
t_{other}
Other (π??)

Theory

assuming 100ps

works but at low p!





In **ShipAna** reconstructing HNL → μπ, we look for HNL → « ref » + « other ».

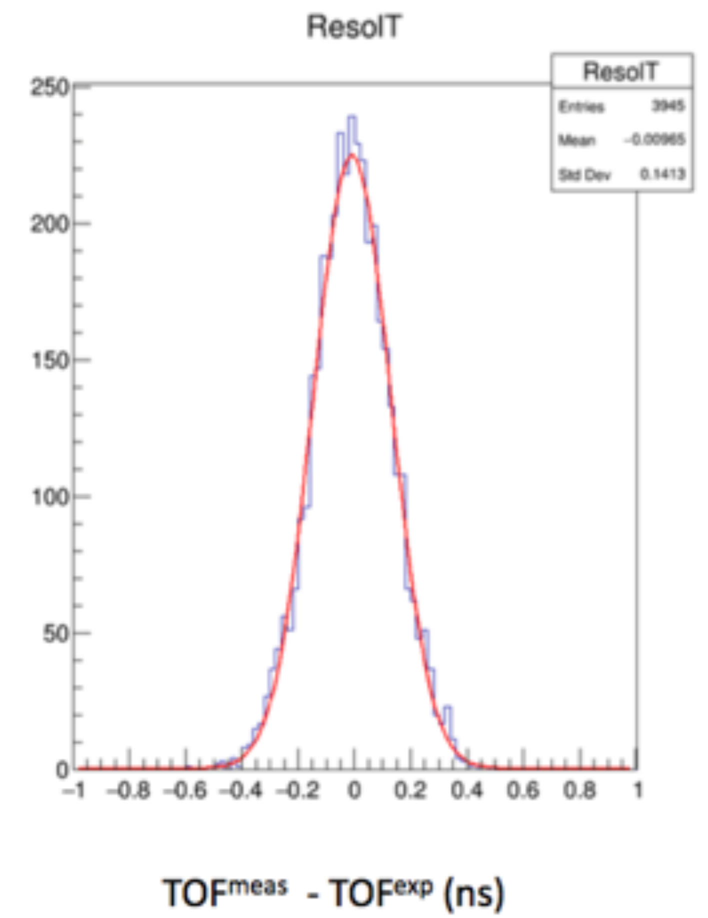
We test PID hypotheses for « ref » and « other », starting with « μ » and « π ».
We associate (no ambiguity management yet) FitTracks and TD hits.
The HNL candidate is a Particle, i.e. a 2-body vertex with position **V**, momentum $\mathbf{P_N}$, and FitTracks with track lengths and associated times: (L_{ref}, t_{ref}) and (L_{other}, t_{other}).
The associated times smeared by 100 ps are the **simulated measured times.**

TOF computation

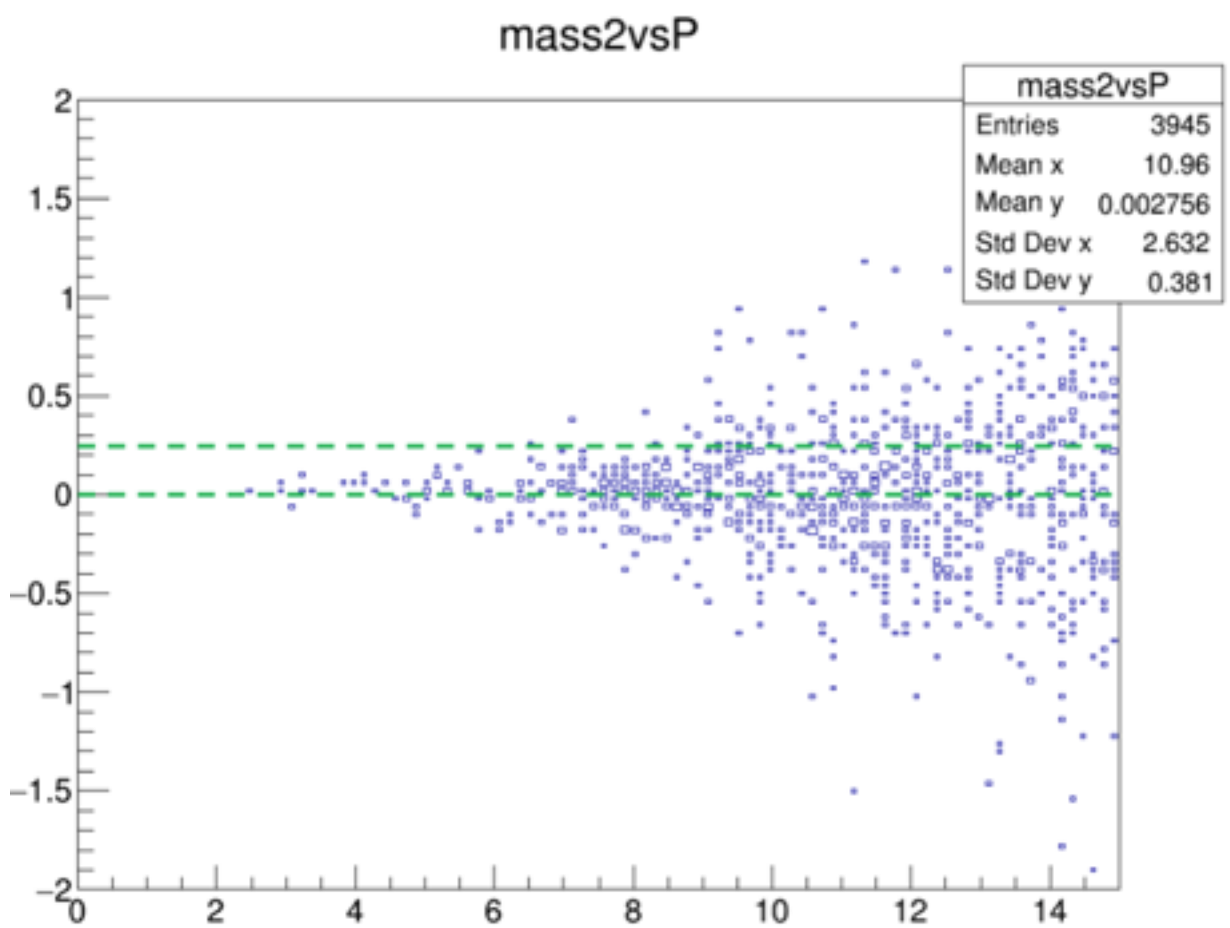
We determine the TOF of the « other » particle

- Assume PID of the « ref », e.g. μ
- Compute $t_0 = t_{ref} - L_{ref}/(\beta_{ref}\, c)$,
- **Measured** $TOF^{meas} = t_{other} - t_0$
- **Expected** $TOF^{exp} = L_{other}/(\beta_{other}\, c)$

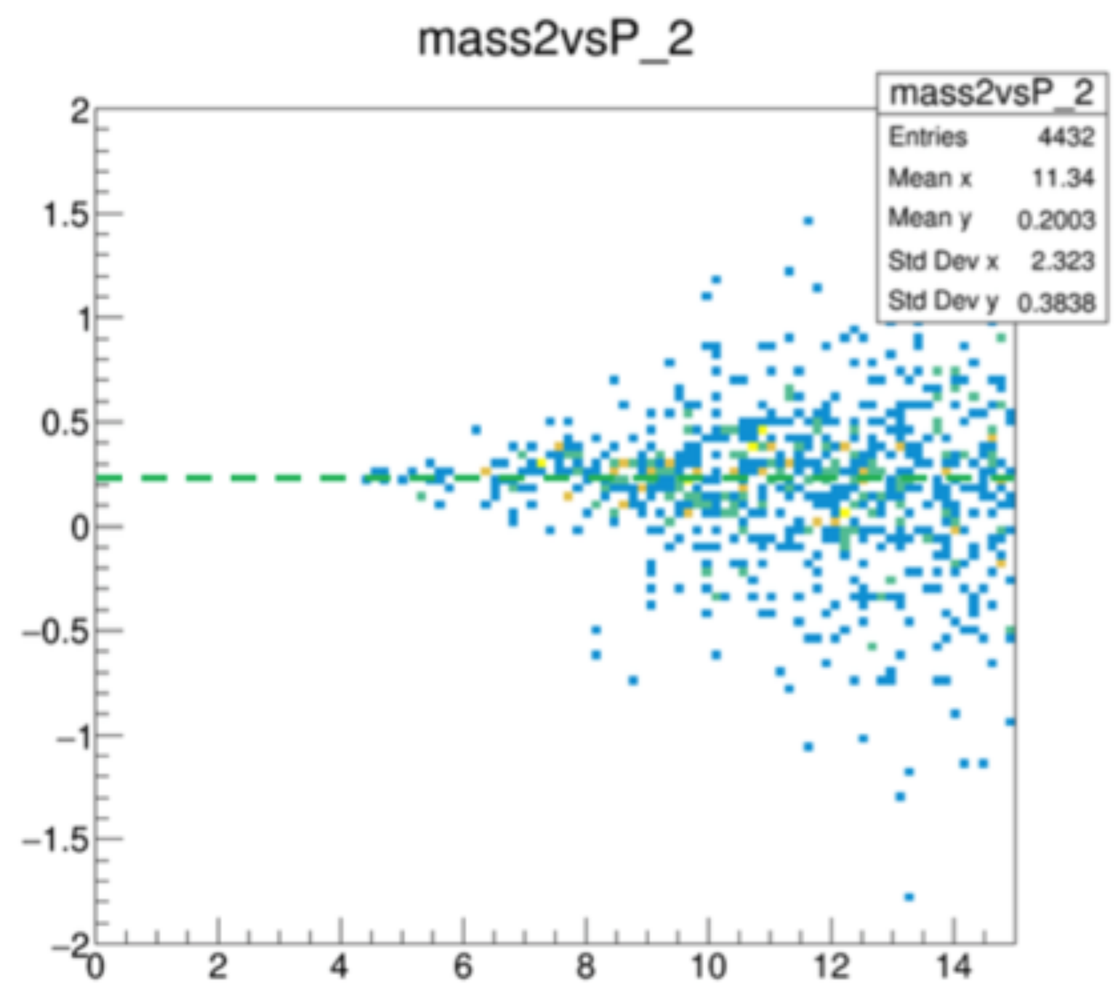
- Compare TOF^{meas} and TOF^{exp}
- Compute PID observable $(m)^2 = (p)^2 \left[\left(\frac{c\,TOF}{L} \right)^2 - 1 \right]$



Performance



HNL—>$\mu\pi$



HNL—>μK

To be continued…

RICH?

Conclusions

Progress in many areas:

- PID in FairSHiP

- evaluation of efficiency/background on real signal and background events

- background rejection in ALP—>γγ

Start of K/pion discrimination studies

Detector optimisation/improvements a bit lagging behind —>next goal of simulations

Backup