# First look at ALP—>γγ

**very much work in progress…**

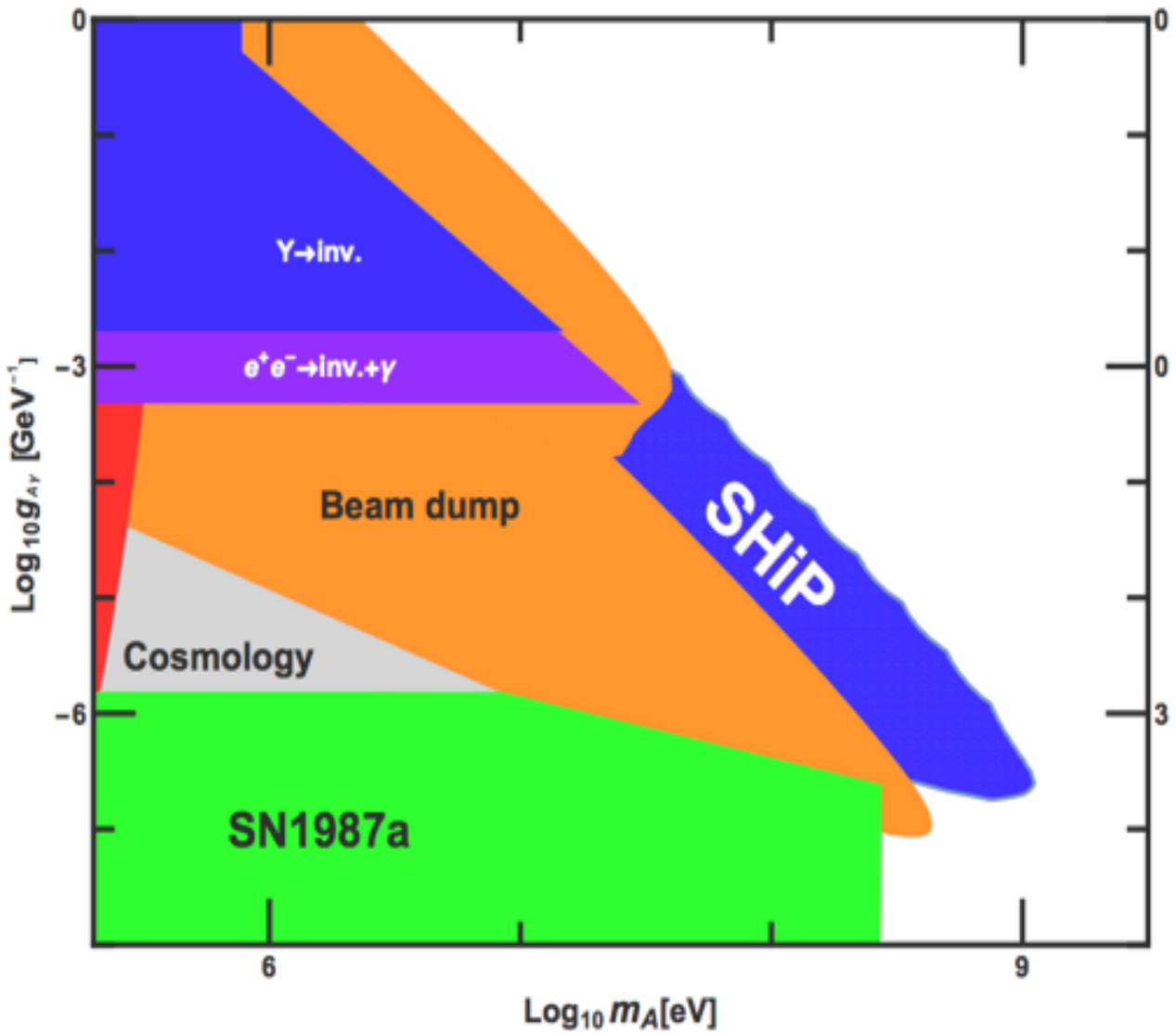
# History of the ALP—>γγ saga

**In the PP the theorists added a plot 90% CL UL**

**It was done only taking into account lifetime acceptance and some wrong assumptions on our acceptance and 0 background**

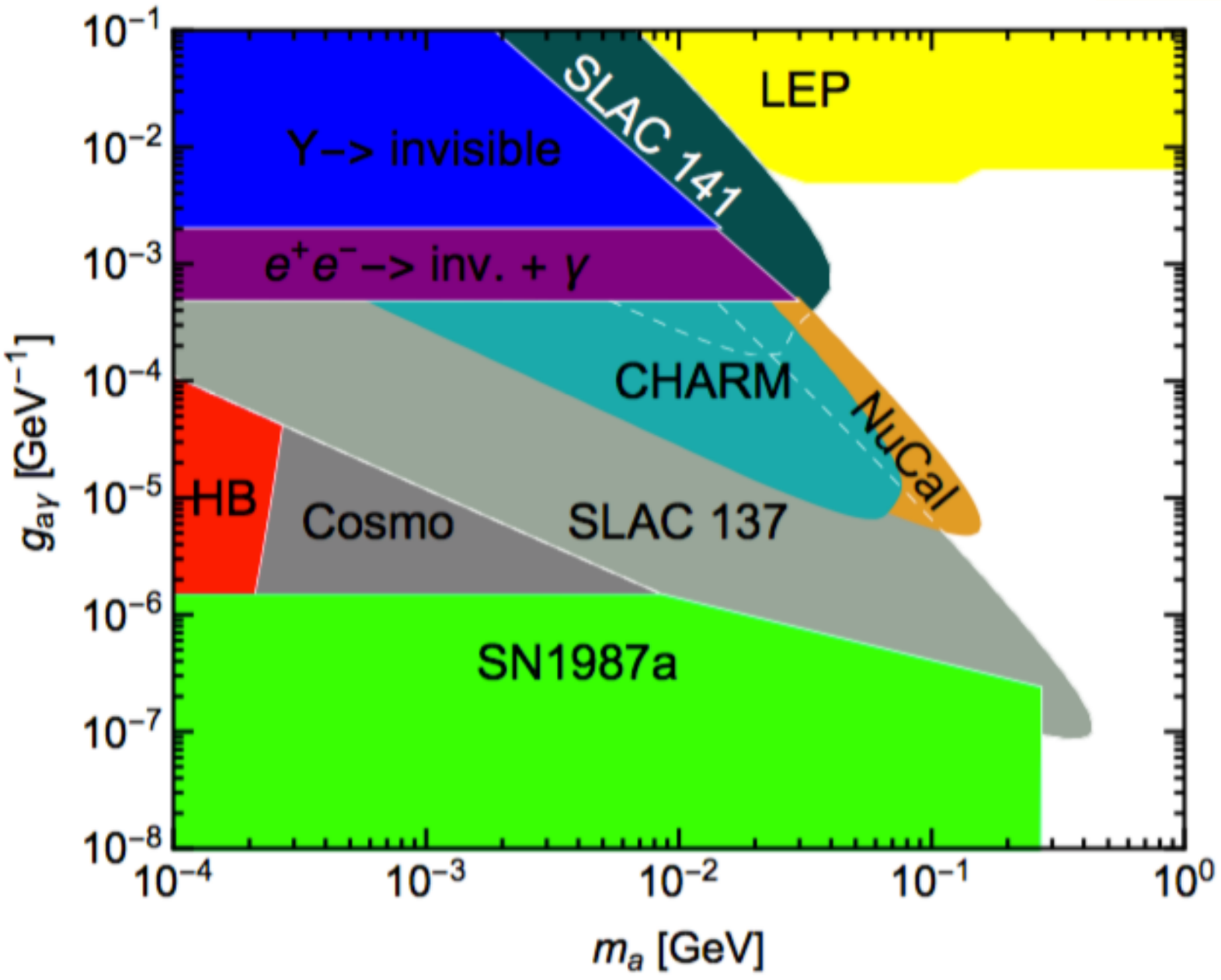
**The referees asked about it and of its realism**

**Of course this is important since it is the only way to detect this important class of ALPs with coupling only to photons**

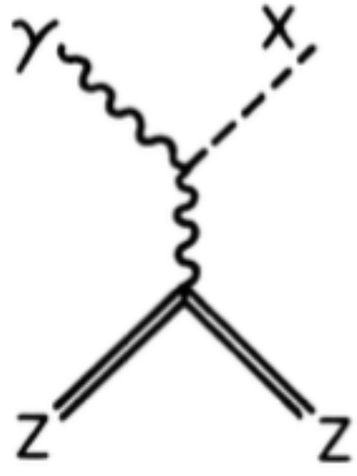


# New study

**arXiv:1512.030069v2**



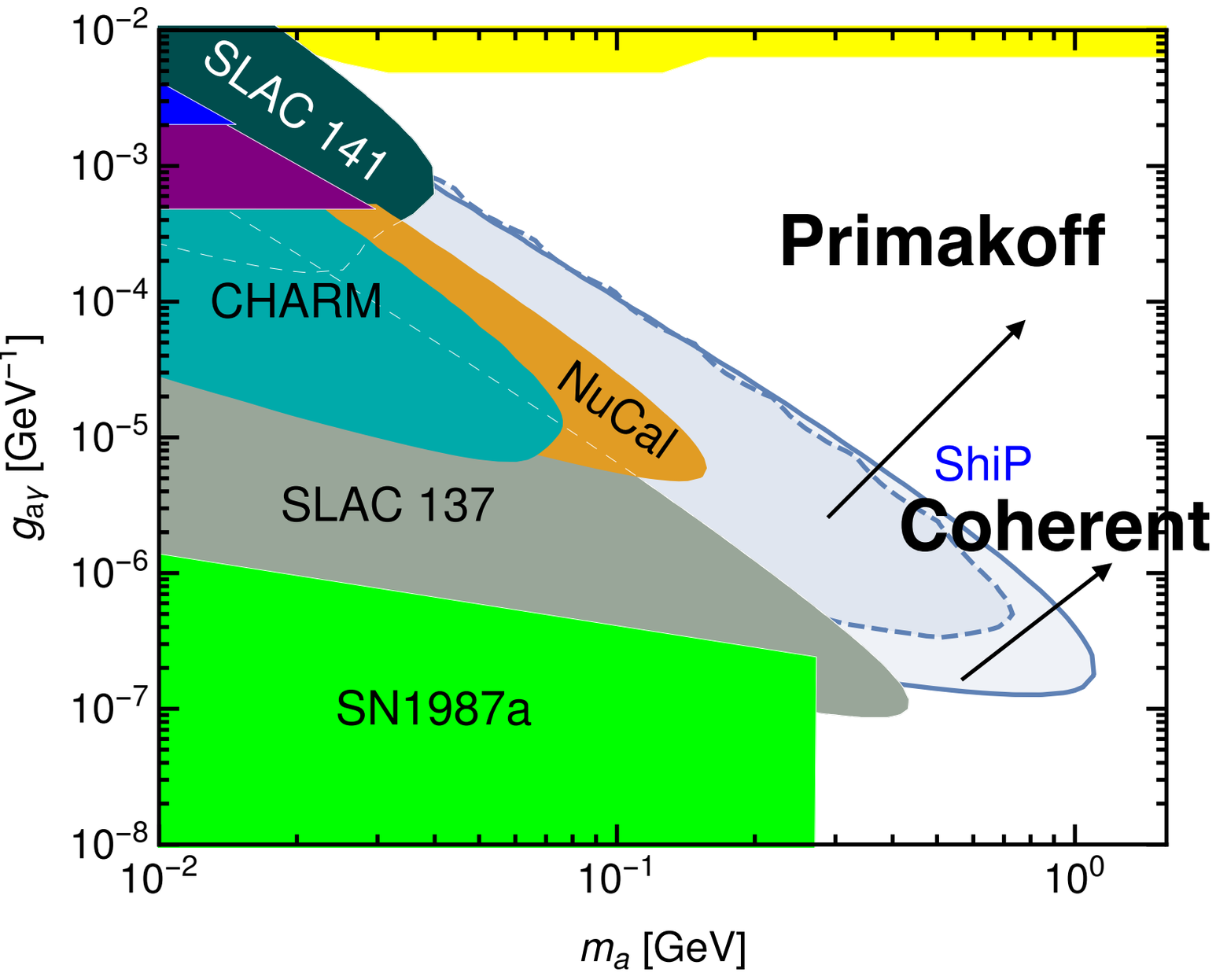
# Production processes




**Primakoff:**

**In arXiv:1512.030069v2 also coherent production was considered**

# Comparison Primakoff-coherent




**all "our" cuts applied except showe pointing**

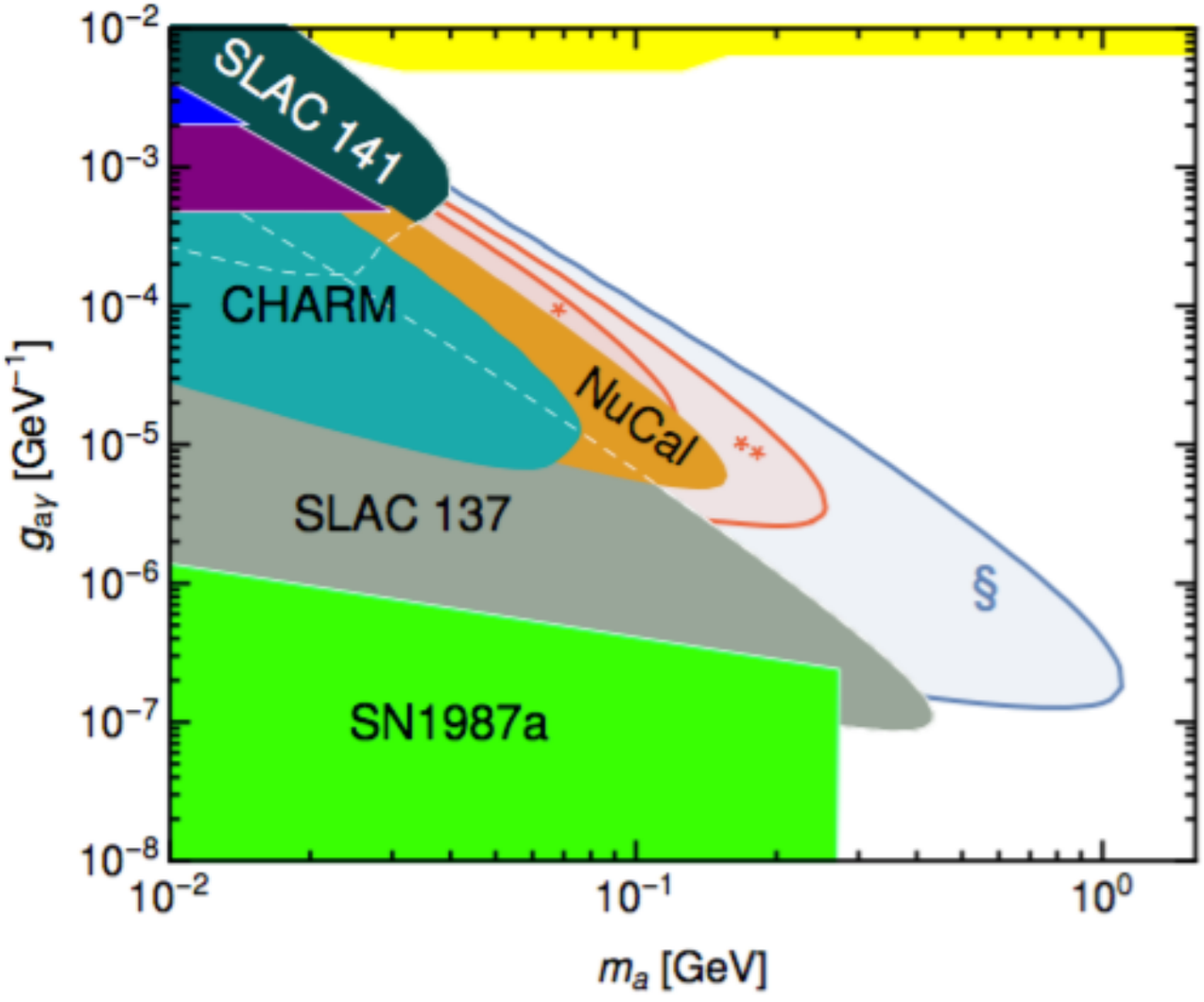
**1) the 2 photons in the ECAL acceptance (2.5m radius for simplicity)**

**2) the distance between the two photons hit points on the ECAL surface >10cm**

**3) minimum photon energy to have decent pointing : guess 3GeV**

**These cuts came from our studies… with a toy we cross-checked these results**

# Including also NA62



# Toy MC of acceptance

**Input from Felix:**

**the differential production cross sections  for few mass values(discuss lifetime acceptance correlation and exclusion of regions) and theory formulas from PP**

**Toy MC:**

**for each $g_{A\gamma}$ value, the lifetime is calculated for each mometum and acceptance is calculated.**

**ALP is decayed and the 2 photons are tracked to the detector**

# Toy MC of acceptance

**STEP 1—>white dots : calculation with no experimental efficiencies**

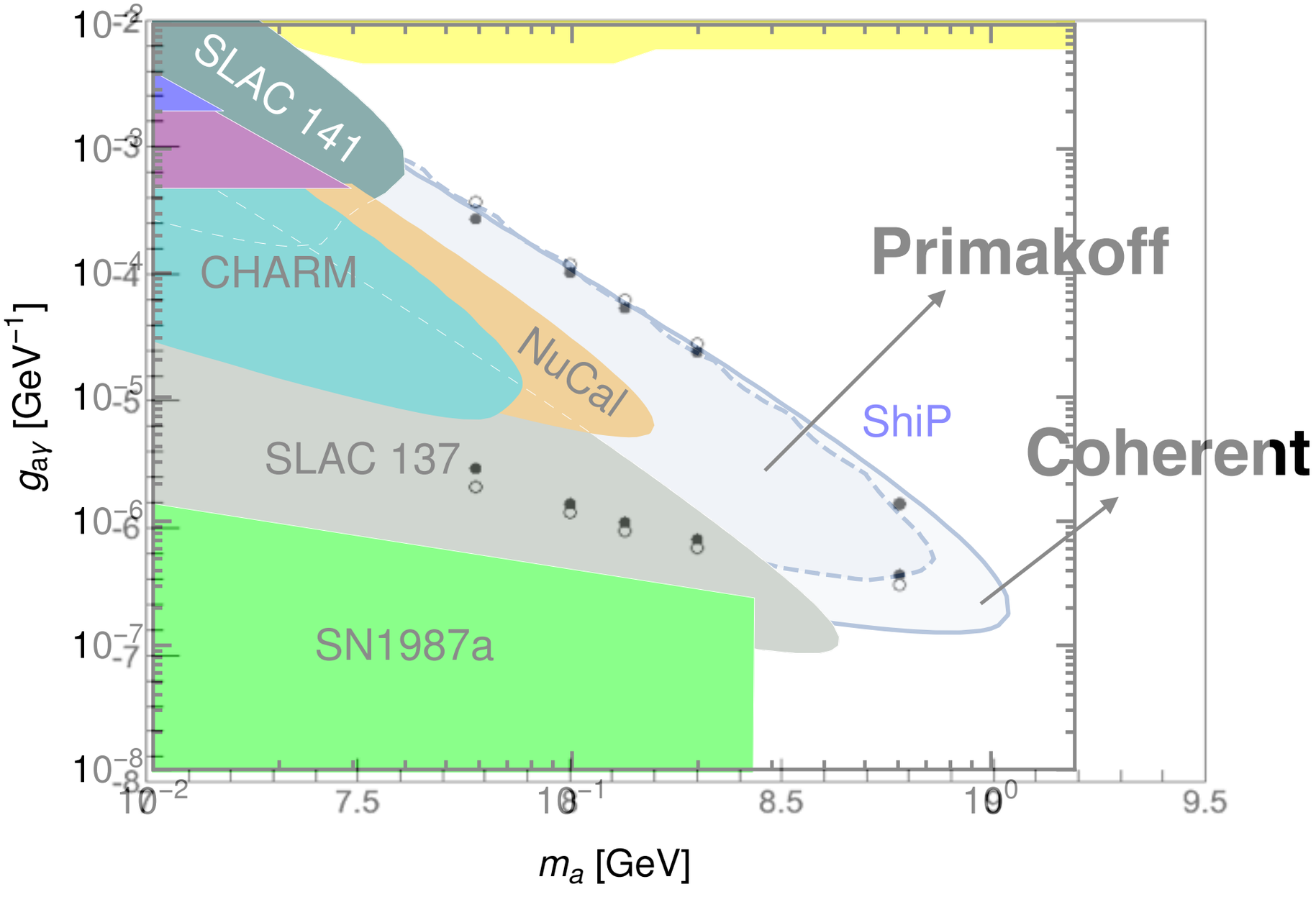
**STEP 2—>black dots: the ALP get decayed and some more cuts added**

1) **the 2 photons in the ECAL acceptance (2.5m radius for simplicity)**

2) **the distance between the two photons hit points on the ECAL surface >10cm**

3) **minimum photon energy to have a decent  pointing : guess 3GeV**

# Comparison with our toys



# Now let’s see what FairSHiP gives in terms of backgrounds

# FairSHiP selection

**2 Ecal clusters E>1(3)GeV**

**no Ecal cluster below 1(3)GeV (I guess some 250MeV threshold)**

**all veto's on**

**total HCAL energy (no HCALclusters yet) < 0.05GeV; to be optimized based on photon Energy**

# Calibration of the energy/cuts

**Efficiency test on HNL—>γγ(*) and single γ OK**

**HCAL threshold found  with single γ and single p**

**(*) this is of course a fake l introduced**

# Neutrino background

**run the whole of neutrino background for the addendum: /eos/ship/data/nuDataAdditionalProduction/rec/  10M event**

**6 events left with E>1GeV:**

**- ν interactions close to the border/supports of the tracking chambers**

**- 4/6 CC with tracks making only 2 or 3 tracking stations or with protons or e- zigzagging (we could redo the tracking for those)**

**- 1 with large shower with 2 maxima (from charged pion)**

**- 1 NC very tough; only one TS hit… but E1,E2 1,0GeV**

# anti-Neutrino background

**run the whole of anti-neutrino background for the addendum: /eos/ship/data/antinuAdditionalProduction/rec/ 20M events**

**dominant background: coherent NC $\pi^0$ production upstream the decay tunnel :**
**completely absent in neutrino sample. why???; large $\sigma$!**

**large!: 60 in 20M for E>1GeV**

**for E>3 GeV 30 in 20M—> about 4.5 events in 2e20pot**

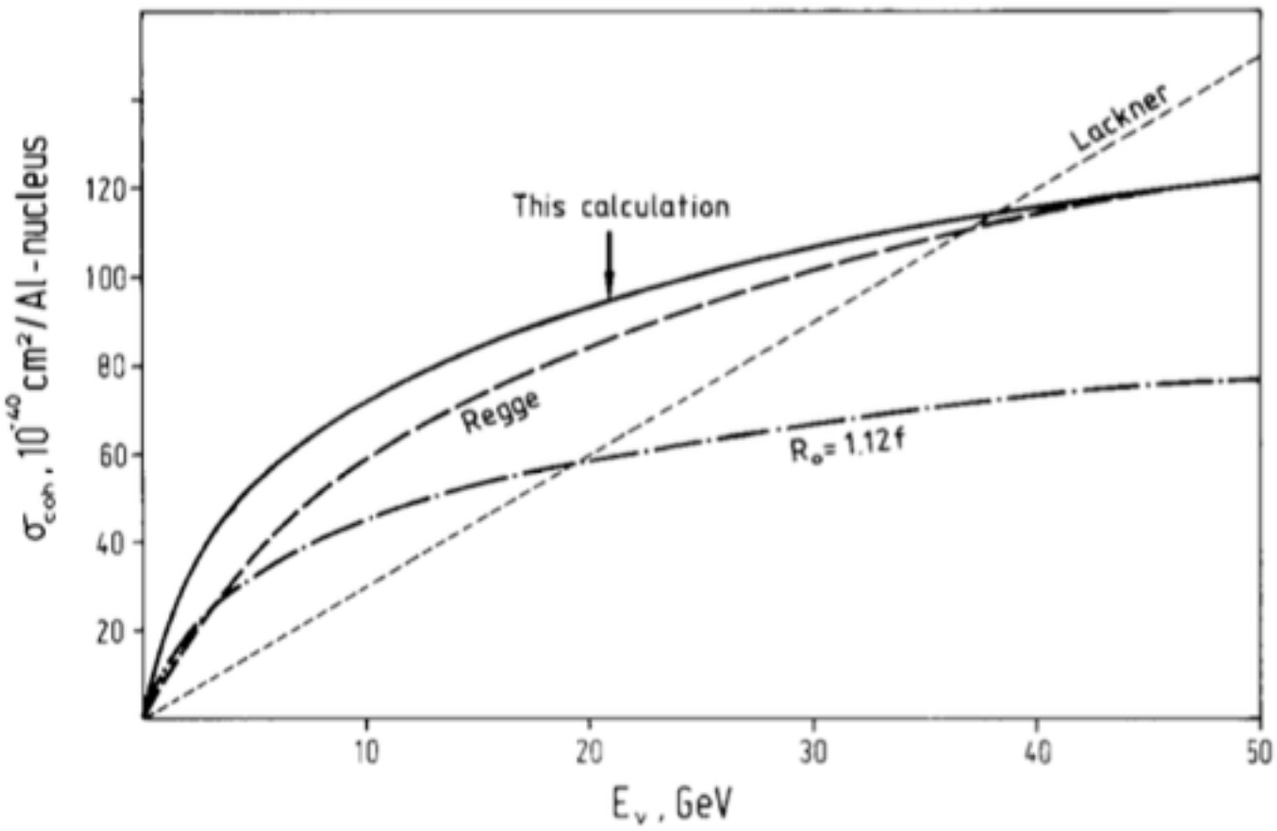
| Bkg source | Stat. weight |
|---|---|
| $\bar{\nu}$ (2.0 < p < 4.0 GeV/c) | 2.39 |
| $\bar{\nu}$ (4.0 < p < 10.0 GeV/c) | 2.76 |
| $\bar{\nu}$ (p > 10.0 GeV/c) | 6.79 |

**mostly interacting between -23.7m(T1Lid) and -25.4m,-26.0m(volHPT) -26.2m(volIron) (beginning of decay volume)**

**pi0 energies between 5 and 35GeV**

**+ as many events with signals in some straw tubes (need ad-hoc tracking)**

# anti-Neutrino background




**COHERENT ~o PRODUCTION IN NEUTRINO REACTIONS**

**Dieter REIN and Lalit M. SEHGAL**

**Nuclear PhysicsB223(1983)29-44**

**same cross section for neutrino and anti-neutrino**

**(not clear if there is a factor 2 in the plot)**

**$A^{(1/3)}$ dependence of the cross section**

# anti-Neutrino background

**Let say we have 4.5+4.5 for neutrinos —> 9 events in 2e20pot**
***3.5 (cascade) —> >30 events in 2e20pot**

**back-of-the-envelope calculation #events=N(incident)x n(target nucleons/unit area)x $\sigma$(cm^2)**

**from TP assume N($\nu\mu$)=5e16 as for $\nu$ target at 8GeV**

**assume interaction in the two last $X_0$ of Fe**

**70 events with full efficiency x a factor due to cascade not included here…**

**with He in the decay volume it will be another 1/100 events i.e O(1) but scattered all along the volume**

# muon DIS background

**161772 events—>2e20pot**

**0 candidates over 500k**

**—> forget about this**

# muon e.m. background

more tricky…
can 2 muons give a candidate?

assume 10e-4 /track inefficiency of UV
—>10e-8
we have 2e20pot —> need to simulate 2e12pot
then they need to be within some few ns ecc.

—>only one muon which radiate twice: need to simulate 2e16 pot

# muon e.m. background

**so far generate 103k muons**

**Thomas said this is 2e15 pot**

**required <=1 track reconstructed (assuming we could miss one)**

**UV<=2hits**

**0 candidates**

**so 2e15*1e4(VETO)=2e19 pot**

**we need some 10x more to study to be safe!**

# Preliminary conclusion

**We are not “swamped by background”**

**but we are not 0 background as such—> at least about 25 coherent ν events in 2e20pot**

**From hardware point of view, in addition to what we have, we need:**

**- highly efficient UV (also on the borders)**

**- ad-hoc tracking to veto interactions for left over candidates**

**- HCAL as veto with cut on energy**

# Next steps

**Look at the new neutrino background production**

**Study the dynamics of coherent ν scattering events**

**Test idea of rejecting 2 photon candidates compatible with π0 decaying at the beginning of the decay volume**

**—> first look shows that for m>500MeV the inefficiency is small**

**Determine relation between shower direction resolution, background rejection and invariant mass resolution of candidates; tough…**

**Higher statistics of em background**

# Help…