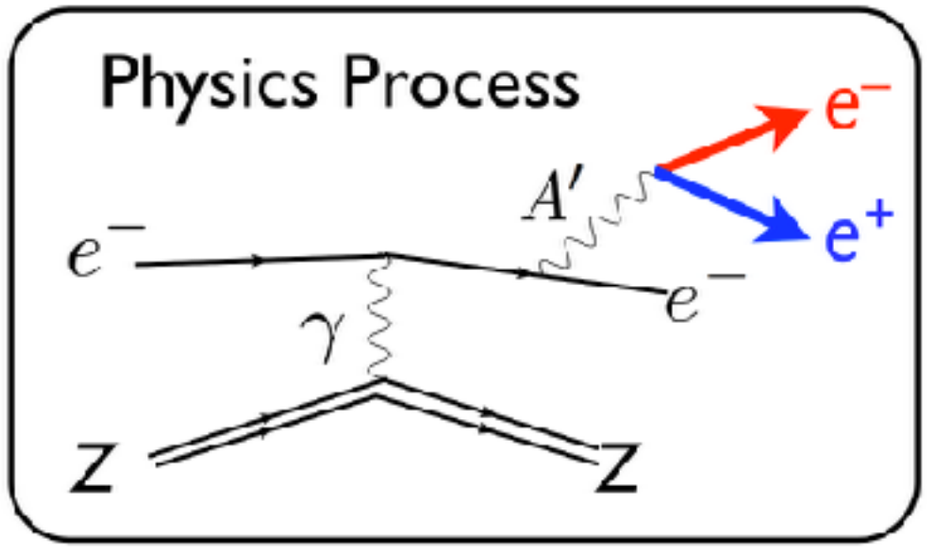
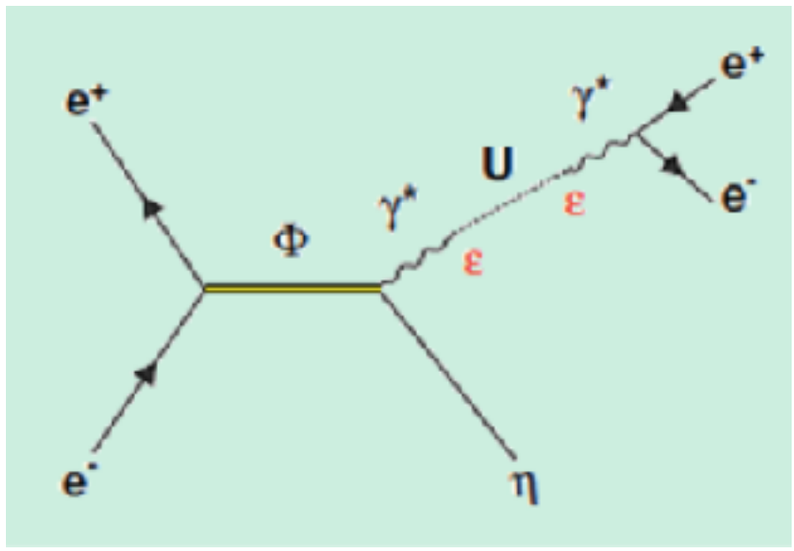
Summary of "Visible"Session





I Visible A

09:00 **Visible Dark Photon Decay: Overview** *35'*
Speaker: Dr. Maxim Pospelov (Perimeter Institute/University of Victoria)
Material: **Slides**

09:35 **Jlab A' searches** *20'*
Speaker: Timothy Nelson (SLAC)
Material: **Slides**

09:55 **The MAGIX Experiment** *20'*
Speaker: Sabato Stefano Caiazza (DESY)
Material: **Slides**

10:15 **Triggerless DAQ for next generation dark matter searches** *20'*
Speaker: Dr. Tommaso Chiarusi (BO)
Material: **Slides**

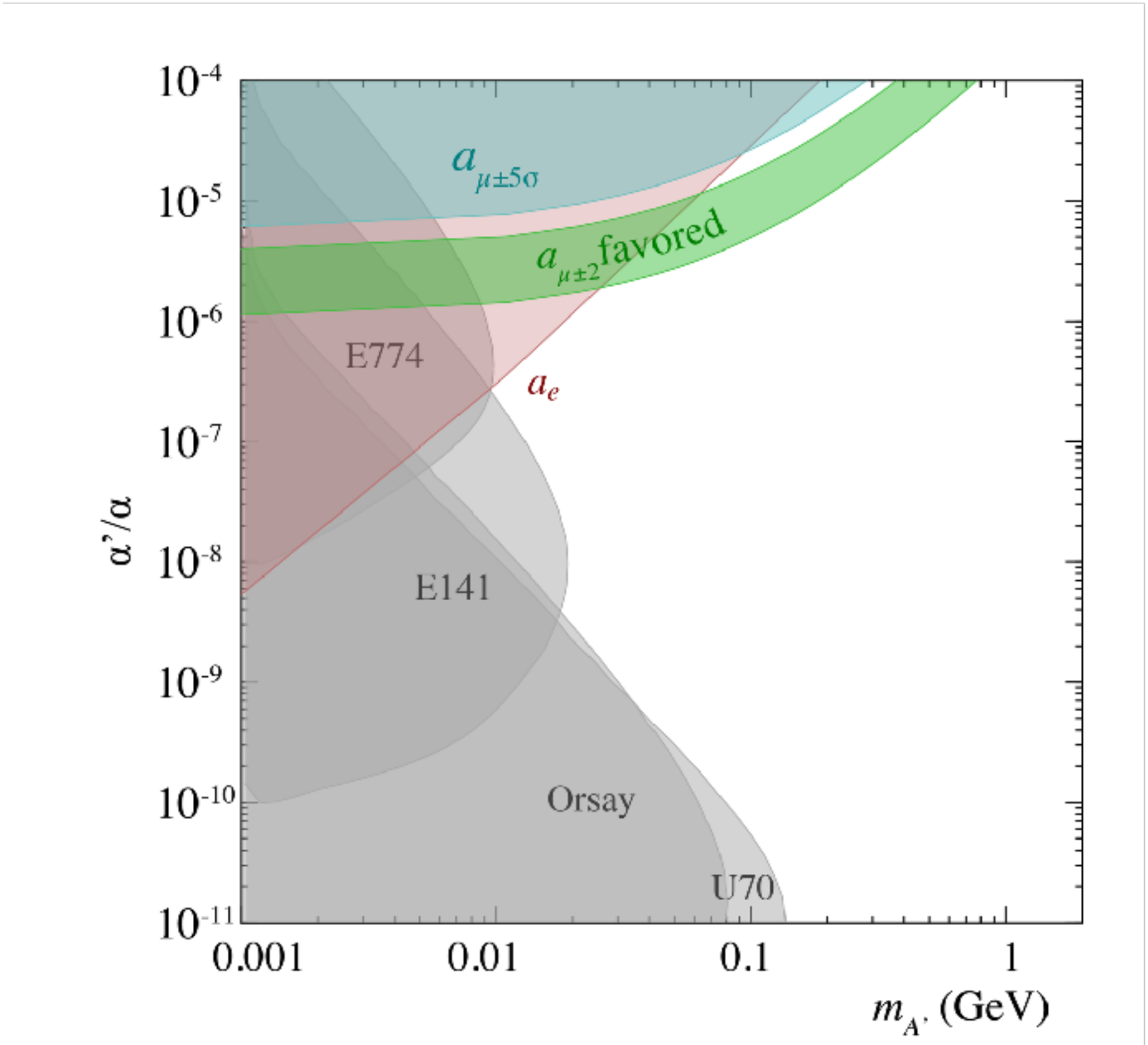
III Visible B

16:00 **Search of Dark Photons in KLOE** *20'*
Speaker: Simona Giovannella (LNF)
Material: **Slides**

16:20 **Dark Sector Physics at LHCb** *20'*
Speaker: Mike Williams (MIT)
Material: **Slides**

16:40 **Search for the dark photon at NA48 & NA62** *20'*
Speaker: Mauro Raggi (ROMA1)
Material: **Slides**

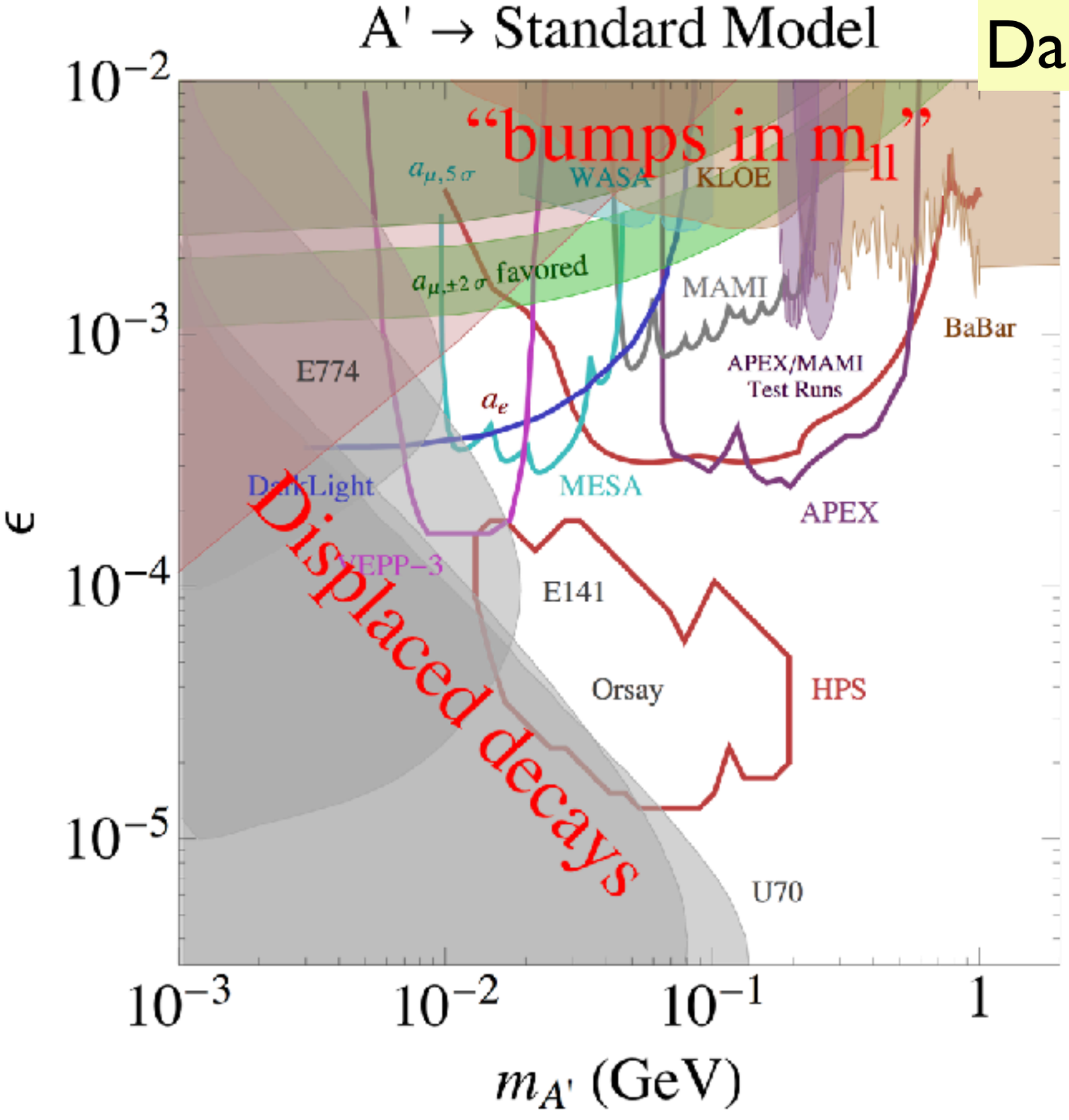
A'→S.M. ~2010



Rouven Essig

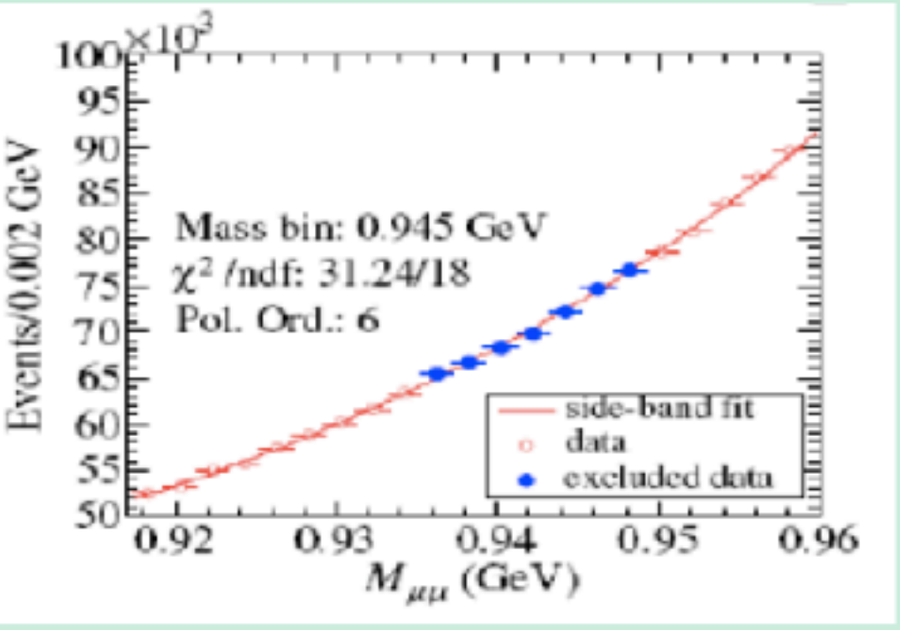
A’→S.M. 2013

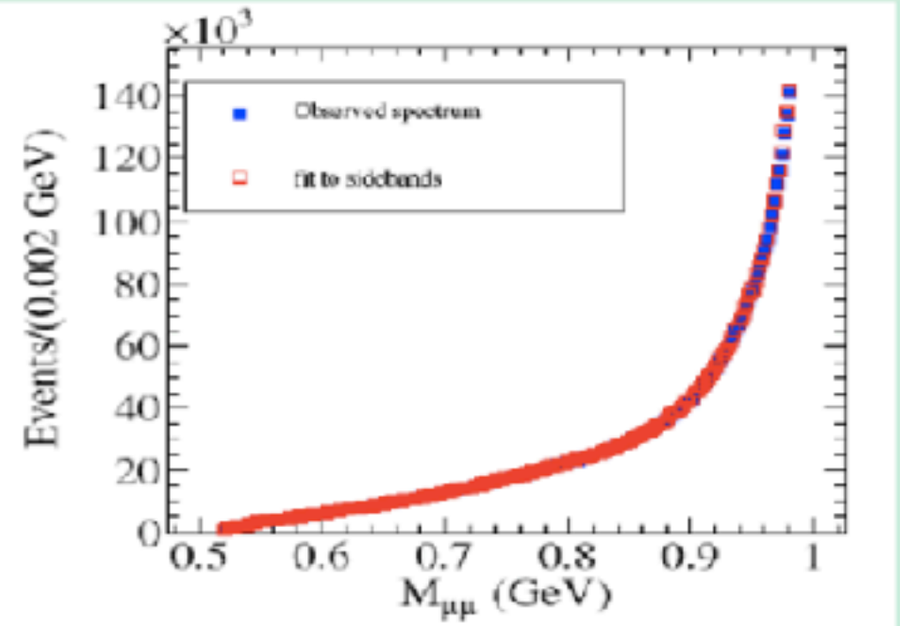
Maxim Pospelov
“Visible Decays
Dark Photons++”

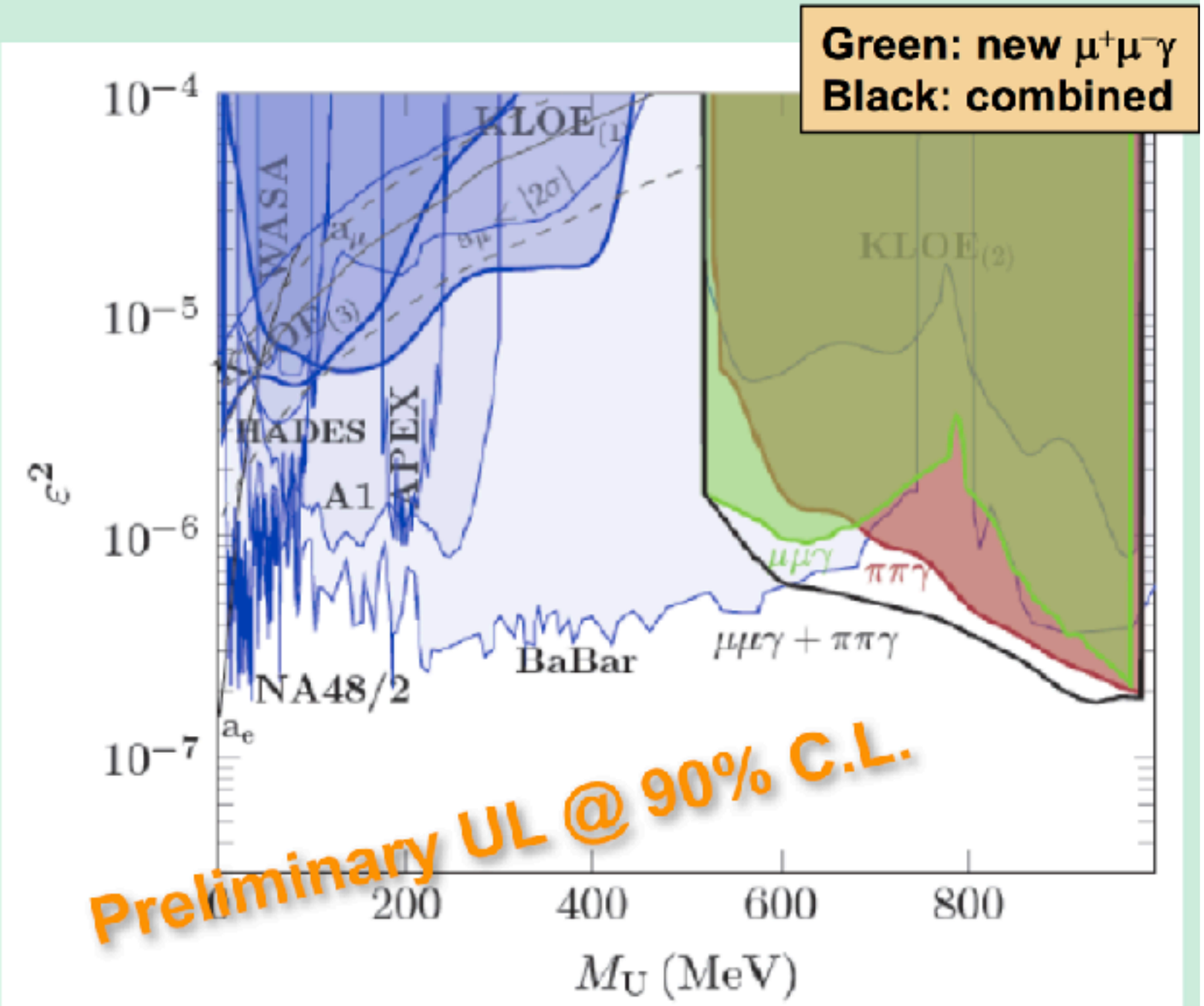


Combined search: $e^+e^- \to \mu^+\mu^-\gamma/\pi^+\pi^-\gamma$

- ✗ $U \to \mu^+\mu^-$ search extended to the whole KLOE data set (1.93 fb^{-1})
- ✗ Analysis similar to $e^+e^- \to \pi^+\pi^-\gamma$ (bckg fitting sidebands of the observed spectrum)



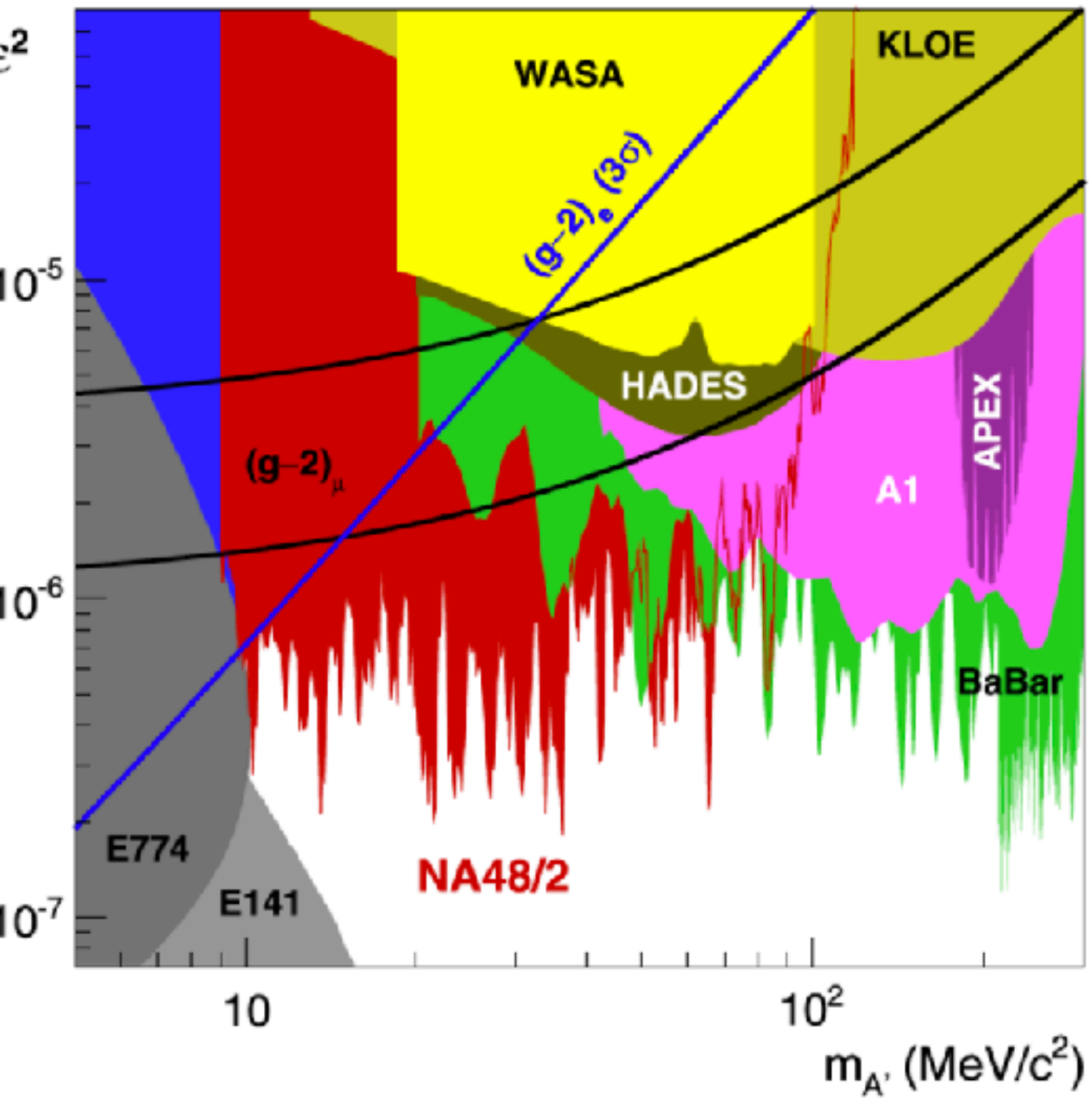




NA48/2 DP exclusion limit

DP exclusion summary

Final result: **PLB746 (2015) 178**



Improvement of the existing limits in the range 9-70 MeV/c^2.

If **DP couples** to SM through **kinetic mixing** and **decays only to SM fermions**, it **is ruled out** as the explanation for anomalous **(g-2)μ.**

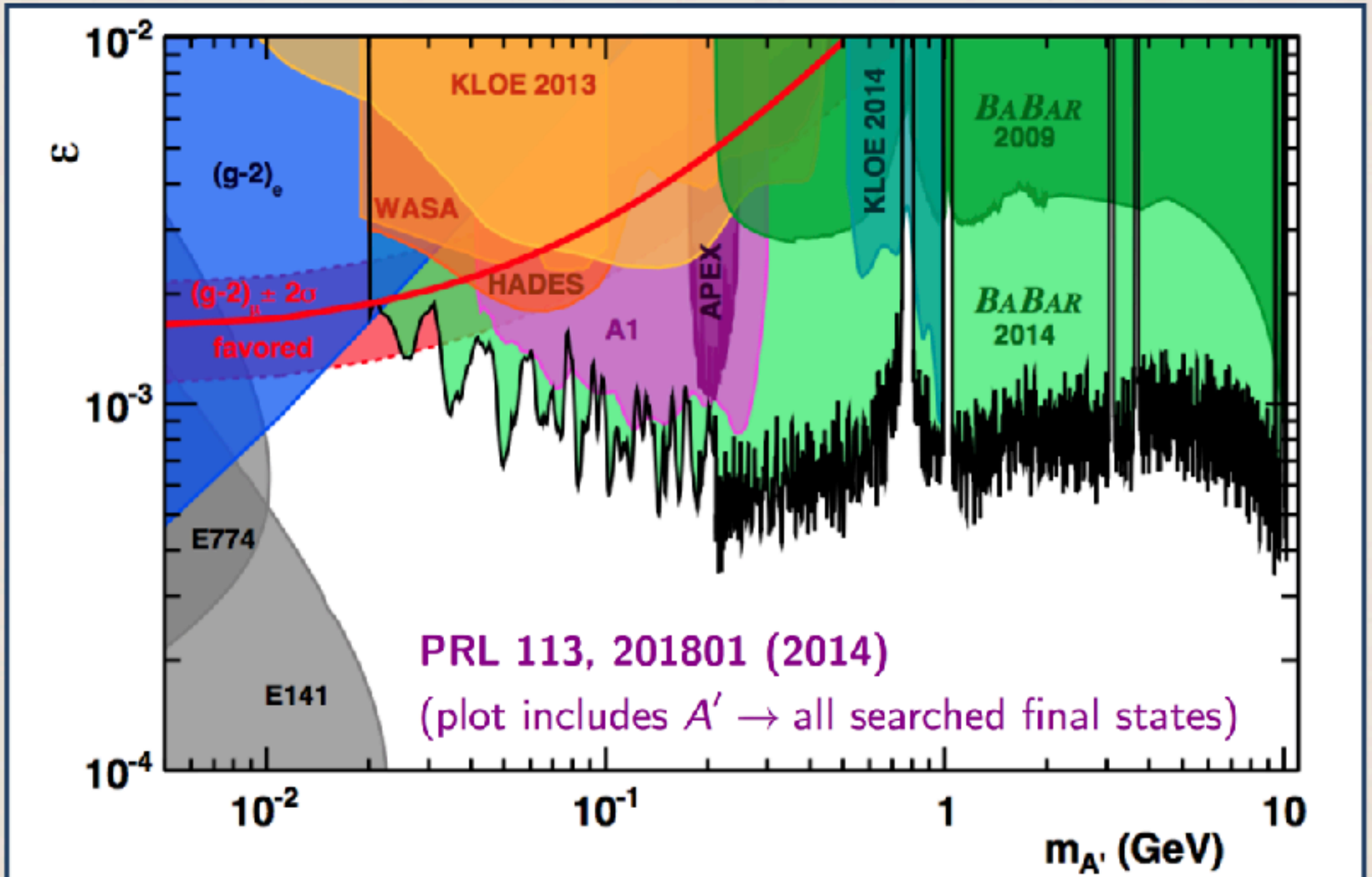
Sensitivity limited by irreducible π^0_D background: upper limit on ε^2 scales as $\sim(1/N_K)^{1/2}$, modest improvement with larger data samples.

Mauro Raggi
"Search for Dark Photon at NA48 & NA62"

Alberto Lusiani (different session)

Existing upper limits on A' mass and coupling

- PRL 113, 201801 (2014), former *BABAR* search $e^+e^- \to A'\gamma$, $A' \to e^+e^-, \mu^+\mu^-$ using 514 fb^{-1} data sample, 90% CL limits on model parameters ϵ, $m_{A'}$



Zooming in: A1, Babar, NA48

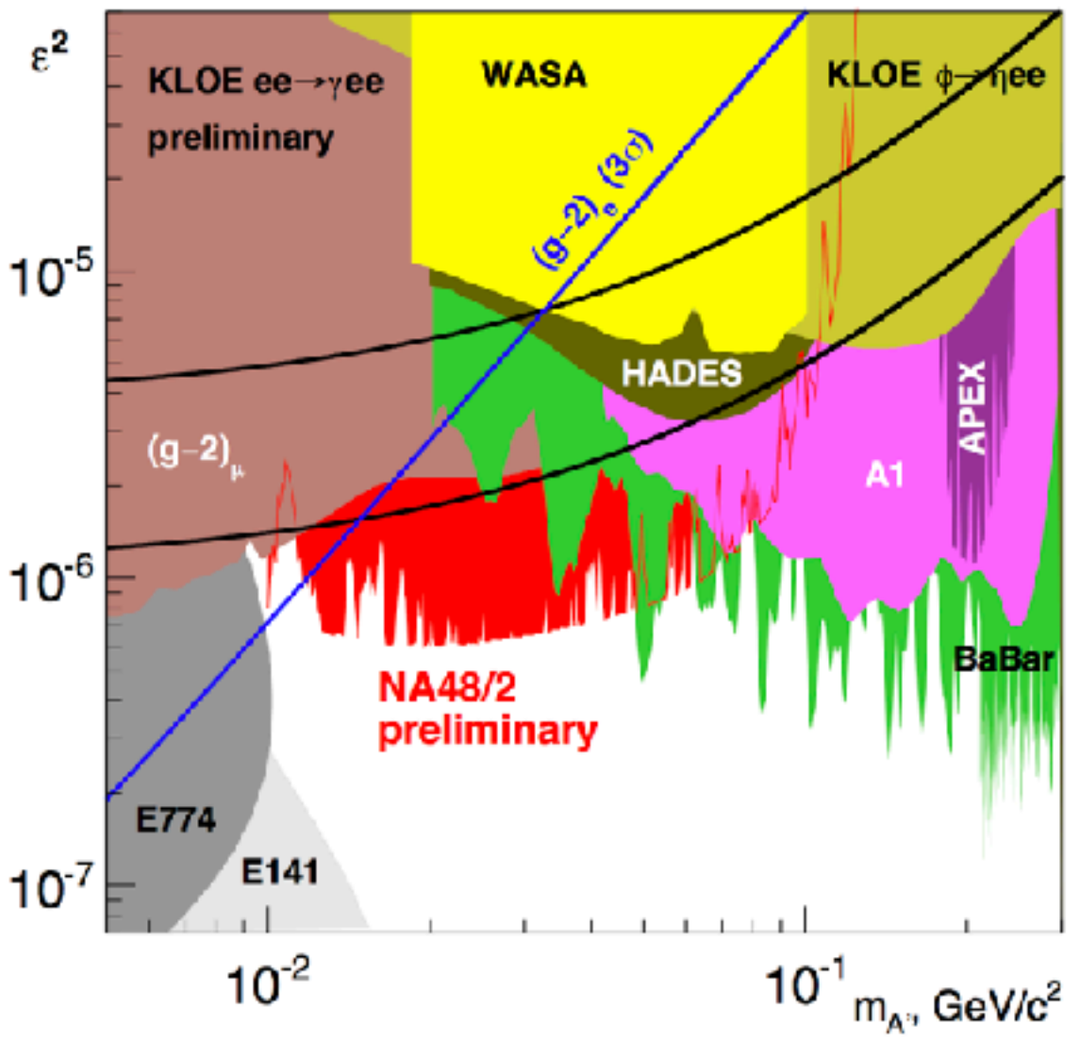
Maxim Pospelov "Visible Decays Dark Photons++"

Signature: "bump" at invariant mass of e^+e^- pairs = $m_{A'}$

Babar: $e^+e^- \rightarrow \gamma V \rightarrow \gamma l^+l^-$

A1(+ APEX): $Z\, e^- \rightarrow Z\, e^- V \rightarrow Z\, e^- e^+e^-$

NA48: $\pi^0 \rightarrow \gamma V \rightarrow \gamma e^+e^-$

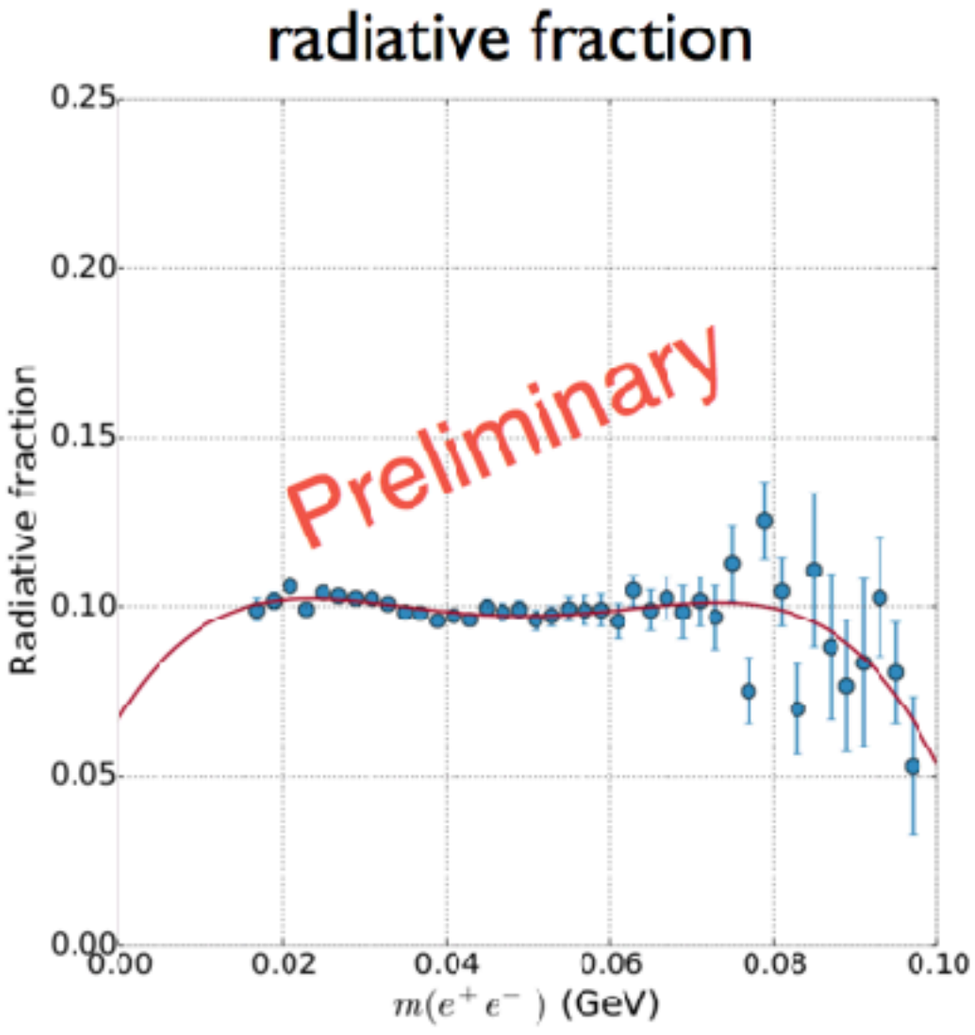


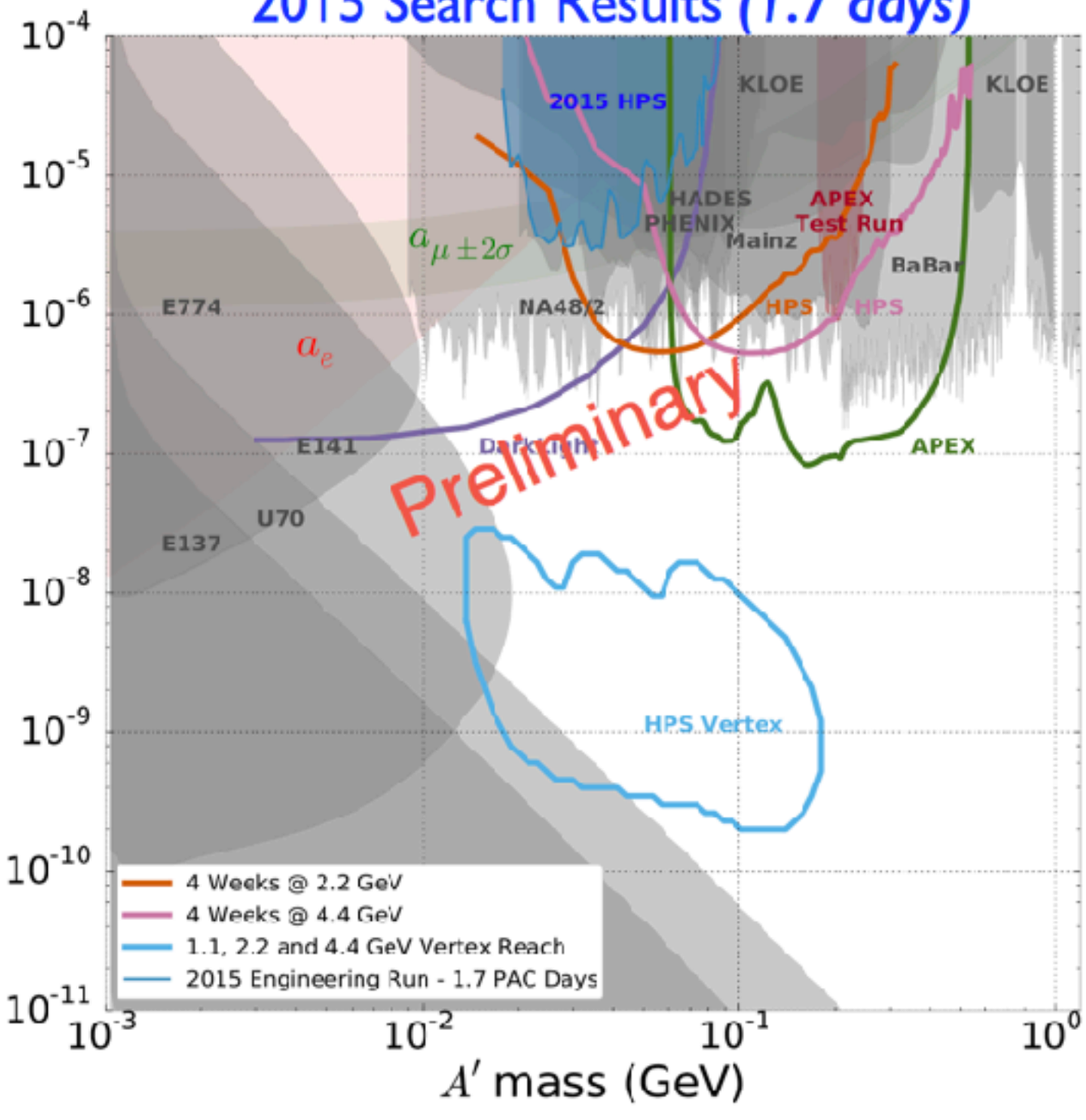
Latest results by NA48 exclude the remainder of parameter space relevant for g-2 discrepancy.

Only more contrived options for muon g-2 explanation remain, e.g. $L_\mu - L_\tau$, or ~~dark photons~~ ~~*decaying to light dark matter.*~~

Tim Nelson - JLab A' searches

2015 @ 1.06 GeV: Resonance Search Results

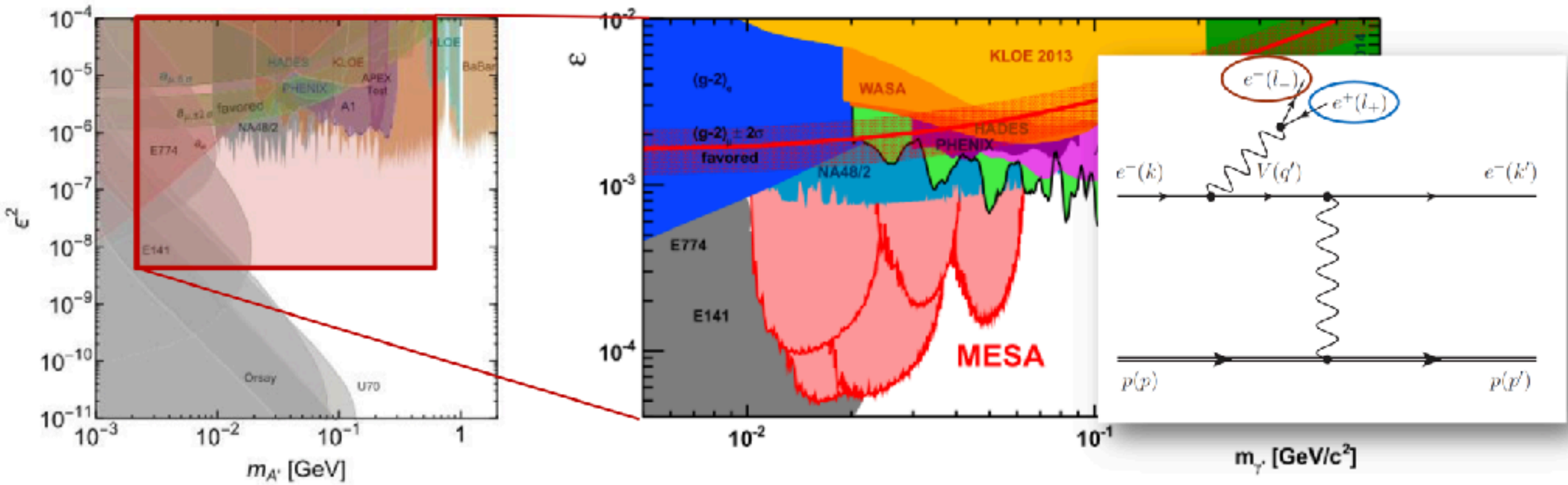




Expected results from JLab

Stefano Caiazza - The Magix Mystery Tour
Expected results from Magix + Mesa

DARK PHOTON VISIBLE DECAYS



Measure the momenta of e^+ e^- in coincidence

Bump hunting in the invariant mass distribution

Mass sensitivity: 10 – 60 MeV

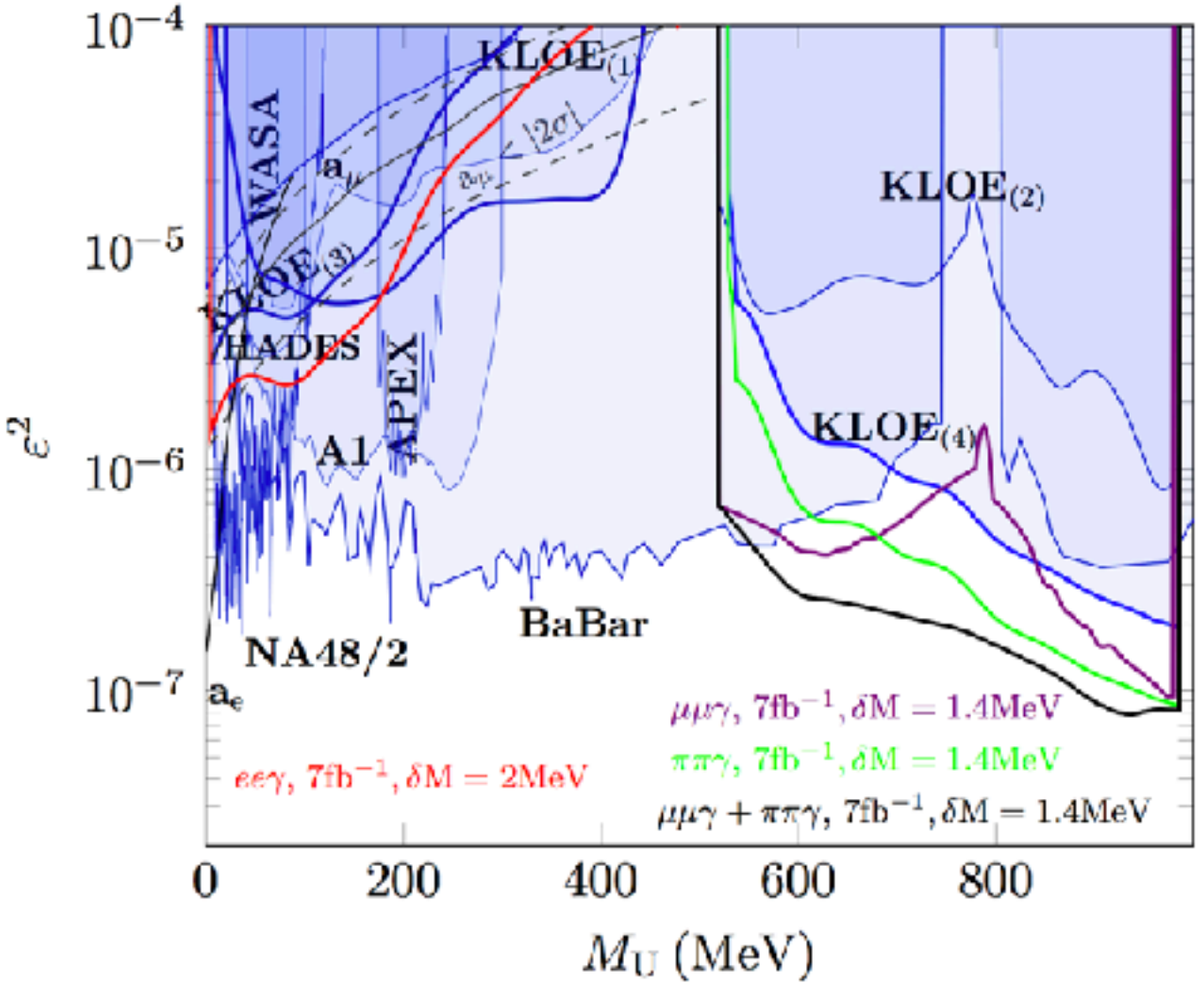
Coupling down to about $\epsilon > 5 \cdot 10^{-5}$

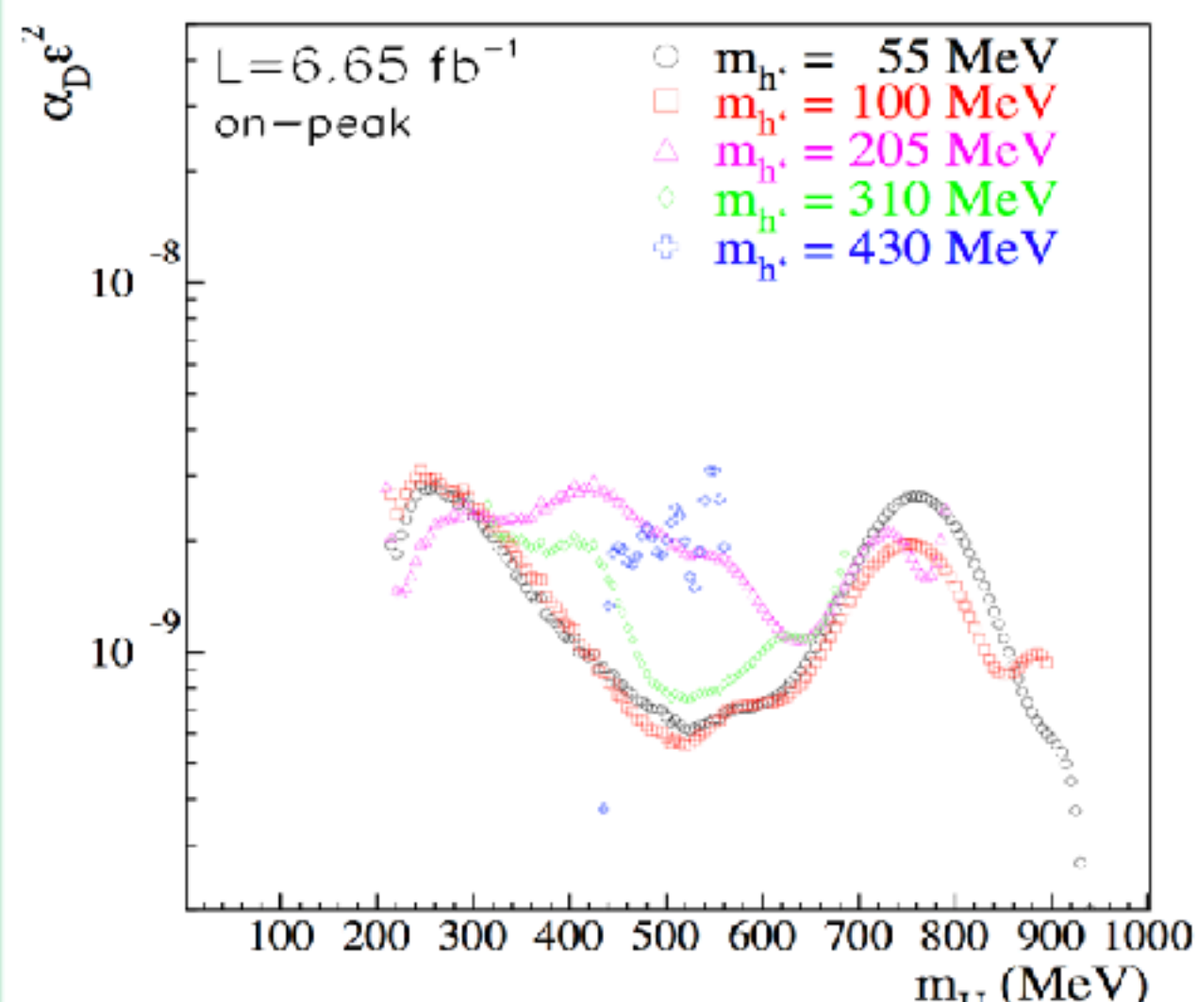
Dark photon @ KLOE-2

Expected results from KLOE-2

Projections for KLOE-2 assumes:

- ✓ $L = 5\ fb^{-1}$ fully available for analyses
- ✓ 30% improvement in mass resolution (S/B ratio)
- ✓ 2-3 improvement in vertex position ($K^{\pm}$ rejection)





Tommaso Chiarusi - Triggerless DAQ for the next generation of dark matter searches

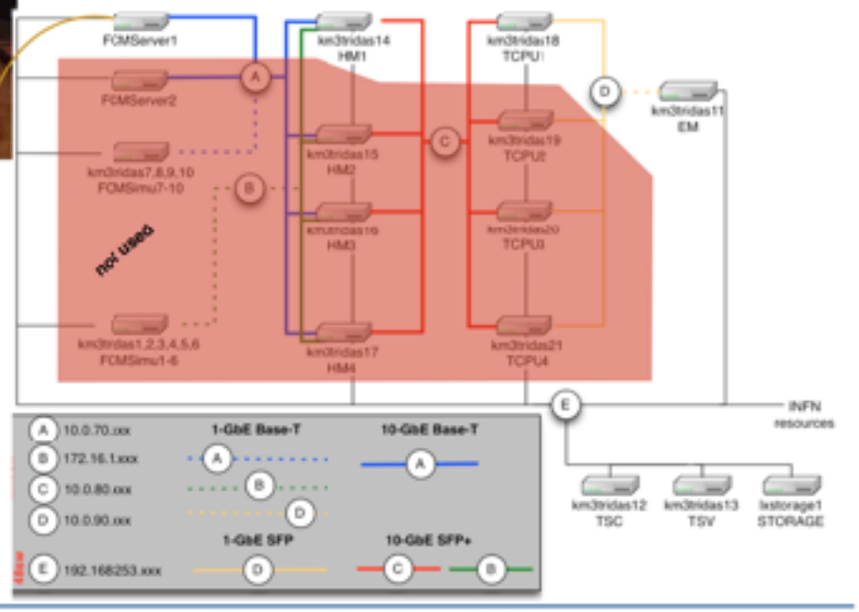
System used for Antares/KM3net can be used for particle physics experiments as well.

Porting ν-tel DAQ to DM experiments. A first compatibility test

KM3NeT-Tower DAQ test-bench

Used gear:
- 1 FCM
- 6 FEM (1 per channel)
- a selection of the available computing resources

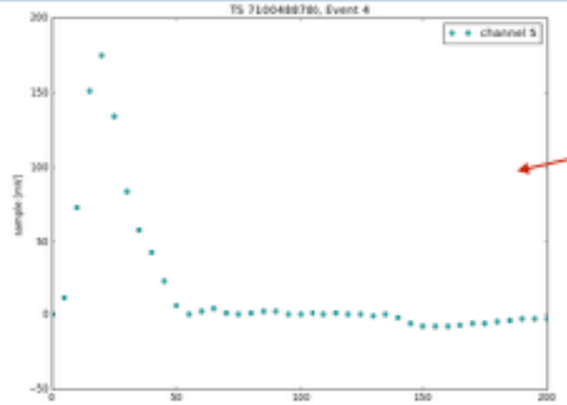
(*note: multi-servers use is here overkilling but remind this is a step 0 test!*)

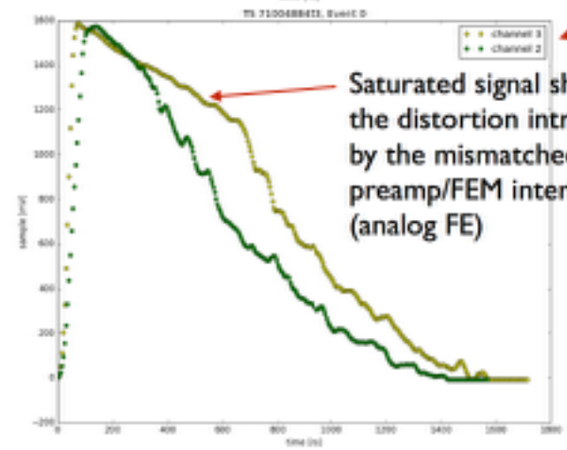


BDX gear

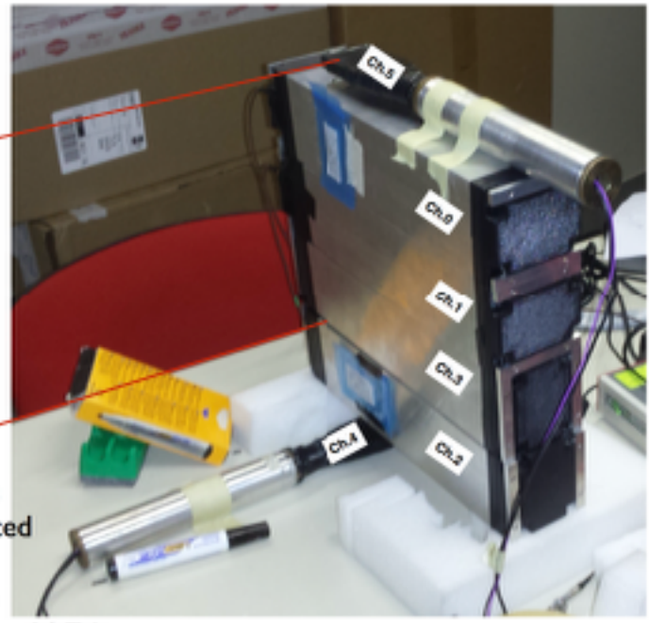
- 4 CsI(Tl) crystals
- 2 scintillators
- 6 SiPMs for readout

A look at the acquired atmospheric muon data





Saturated signal shows the distortion introduced by the mismatched preamp/FEM interface (analog FE)



L1 Trigger

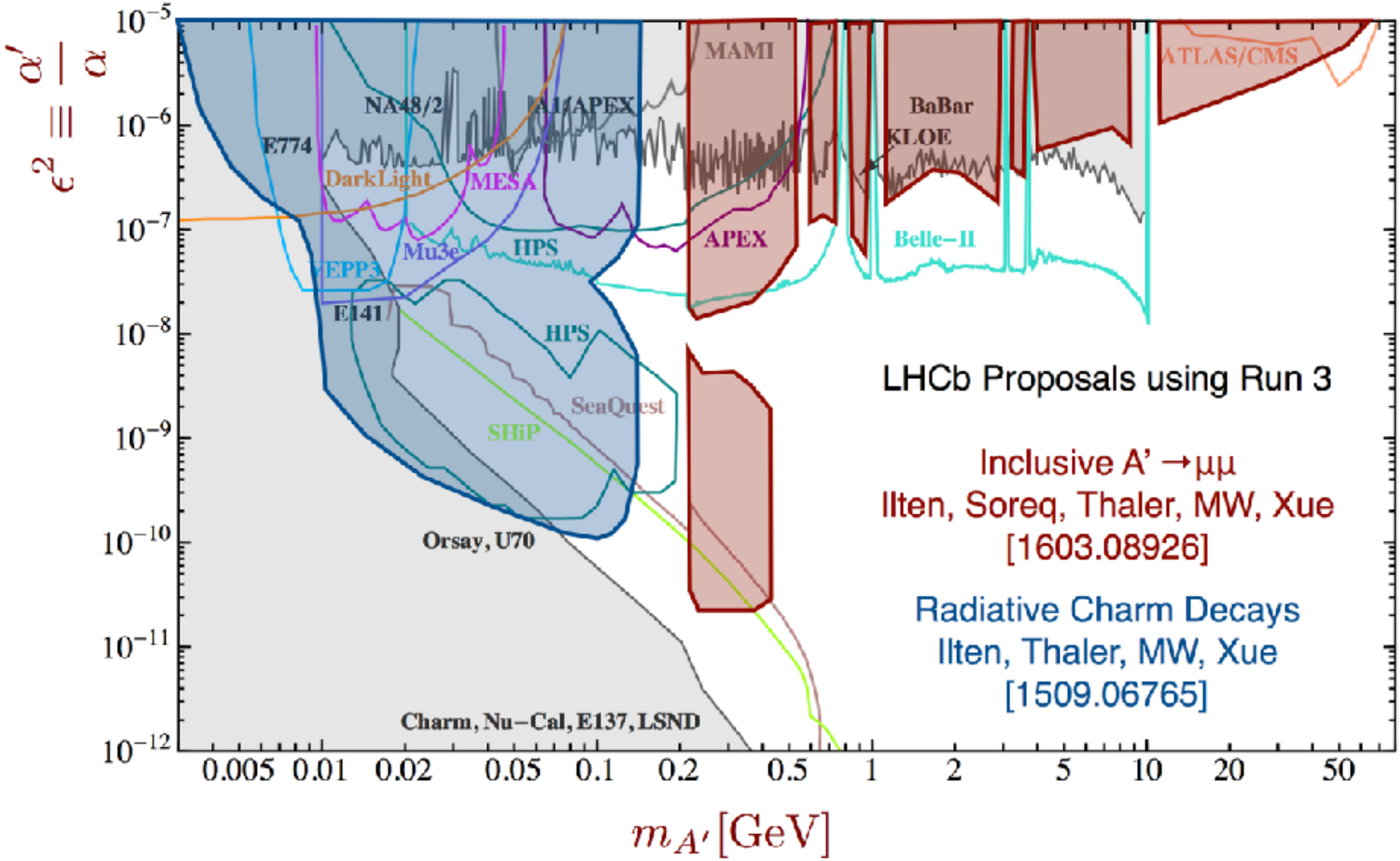
★ Simple Coincidence (SC) in 20ns ★ Q>Q_0 (300-400 pC)

L2 Trigger

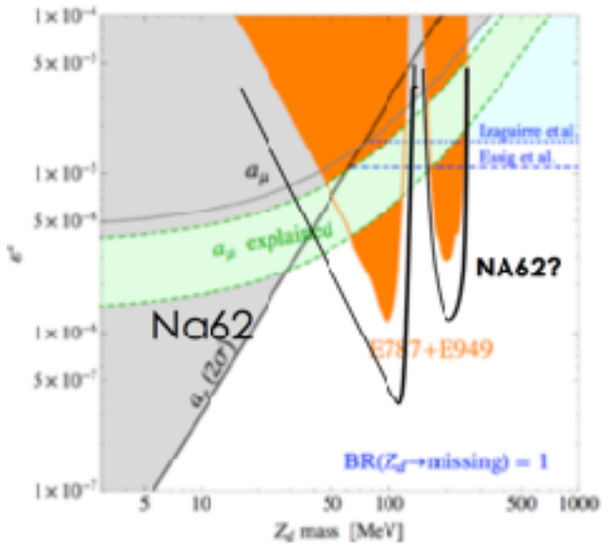
★ &[all crystals Q]
★ Q(2)&SC(5,4)
★ Random Trigger (RT)
★ SC(4,5)

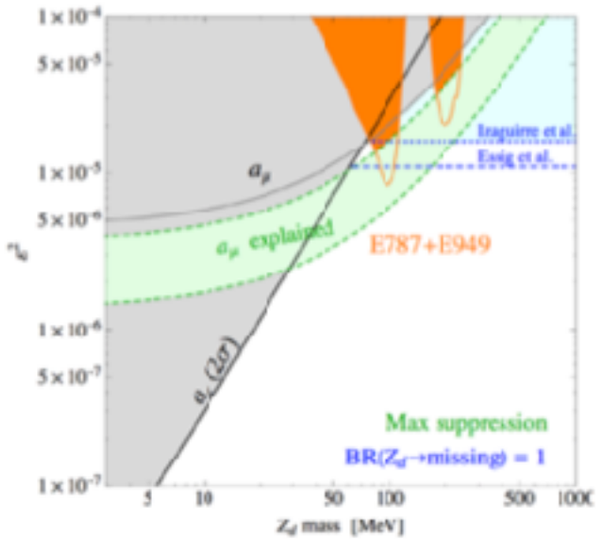
Visible A' Decays

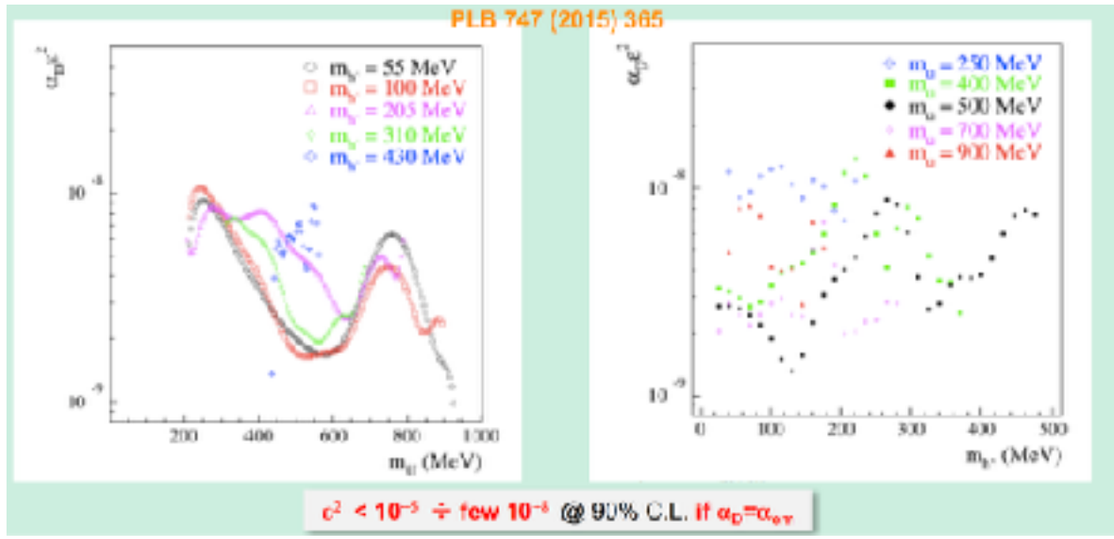
Move to a triggerless detector readout in Run 3 will have a huge impact on low-mass BSM searches, including dark photons.



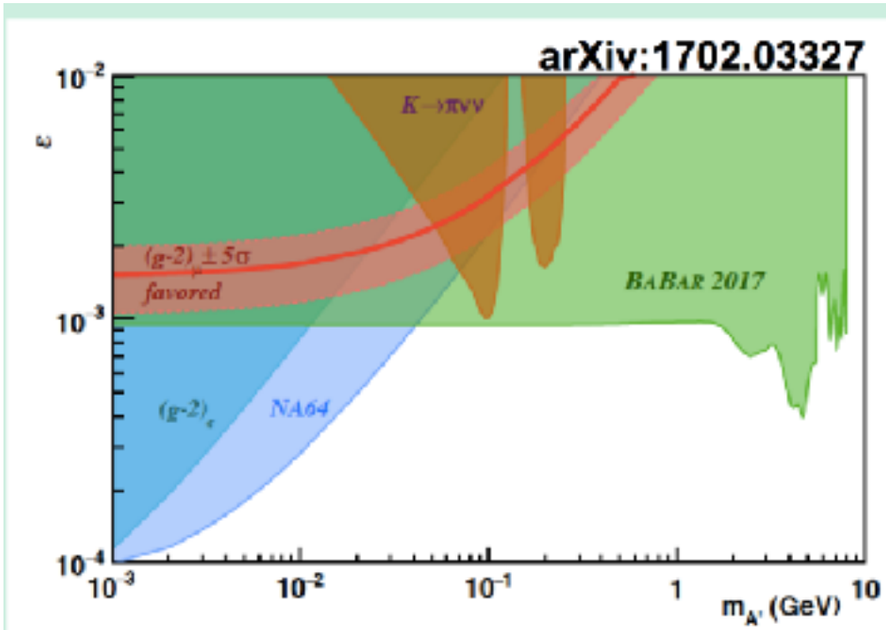
Invisible decays: NA48,NA62 KLOE, KLOE-2

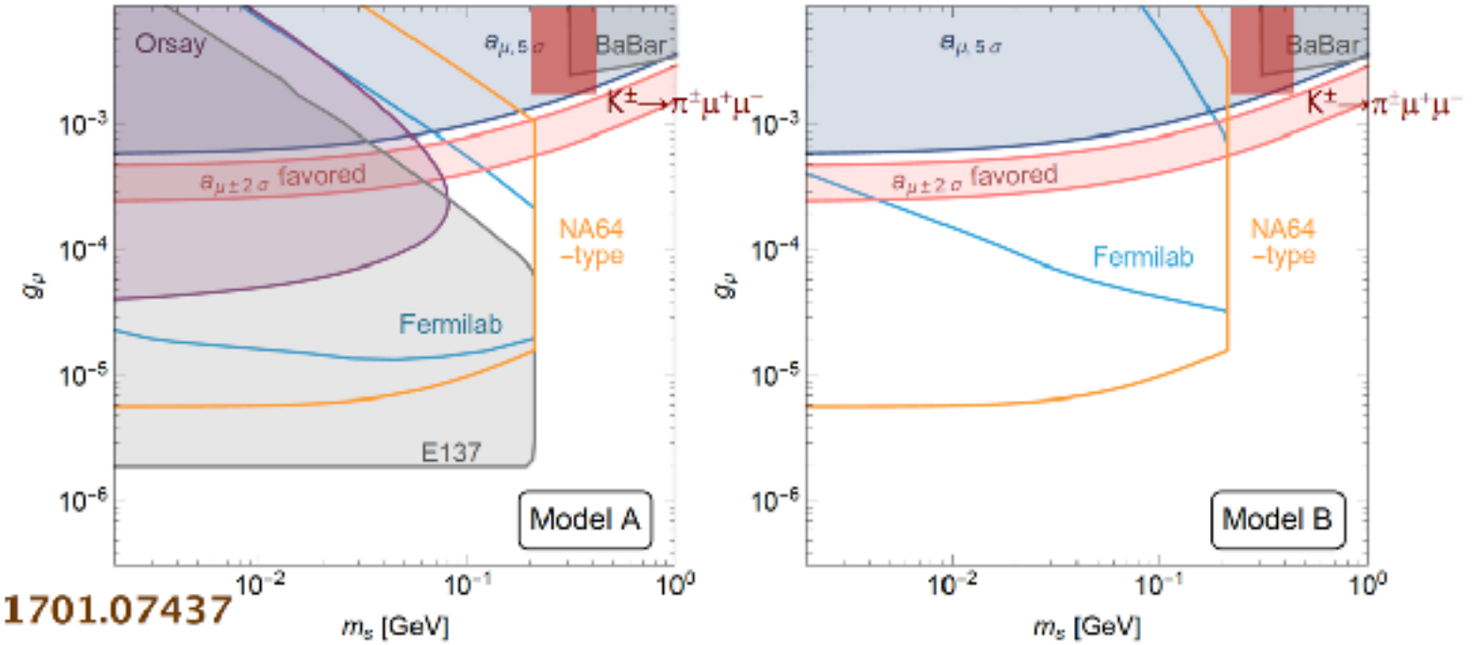






$K^{\pm} \to \pi^{\pm} \nu\nu$ can be used to constrain $K^{\pm} \to \pi^{\pm} A'$ $A' \to \chi\chi$





arXiv:1701.07437

Simona Giovannella
Search of Dark Photons in KLOE

Muon dominated coupling?

Mauro Raggi
"Search for Dark Photon at NA48 & NA62"

Dark Photons ++

Maxim Pospelov

Neutral "portals" to the SM

Let us *classify* possible connections between Dark sector and SM

$H^+H\ (\lambda\, S^2 + A\, S)$ Higgs-singlet scalar interactions (scalar portal)

$B_{\mu\nu} V_{\mu\nu}$ "Kinetic mixing" with additional U(1)' group

(becomes a specific example of $J_\mu^{\ i} A_\mu$ extension)

$LH\,N$ neutrino Yukawa coupling, N – RH neutrino

$J_\mu^{\ i} A_\mu$ requires gauge invariance and anomaly cancellation

It is very likely that the observed neutrino masses indicate that Nature may have used the *LHN* portal…

Dim>4

$J_\mu^{\ A}\ \partial_\mu a\ /f$ axionic portal

.....

$$\mathcal{L}_{\rm mediation} = \sum_{k,l,n}^{k+l=n+4} \frac{\mathcal{O}^{(k)}_{\rm med}\mathcal{O}^{(l)}_{\rm SM}}{\Lambda^n},$$

Dark photons ++ Maxim Pospelov

Let's classify them into 3 cartegories

1. *Dark photon: technically natural, UV complete, couple to a conserved current.* $\varepsilon =$ 
2. *B-L, L_μ-L_τ, and other anomaly free combinations: all of the above, but coupling constant g_X is small – somewhat unusual. Strong constraints from neutrino physics.*
3. *Models coupled to the tree-level conserved current broken by anomalies. E.g. gauged baryon number, or lepton number. Presumes cancellation of anomalies at high-energy. Nice low energy behaviour, weak constraints on gauged baryon number?*
4. *Models coupled to a non-conserved current. (e.g. vector particle coupled to an axial-vector current)*

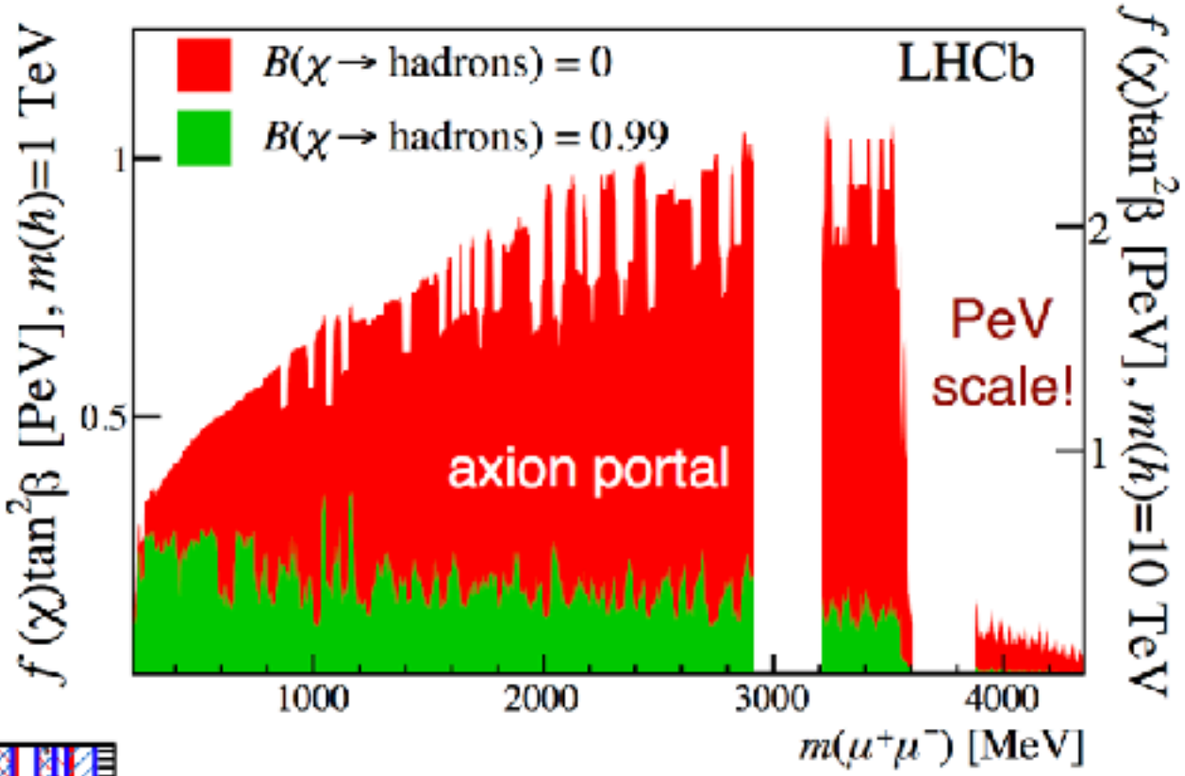
- Phenomenology-driven demand often force speculators to consider 3 and 4. (proton charge radius, ^{8}Be decay anomaly)

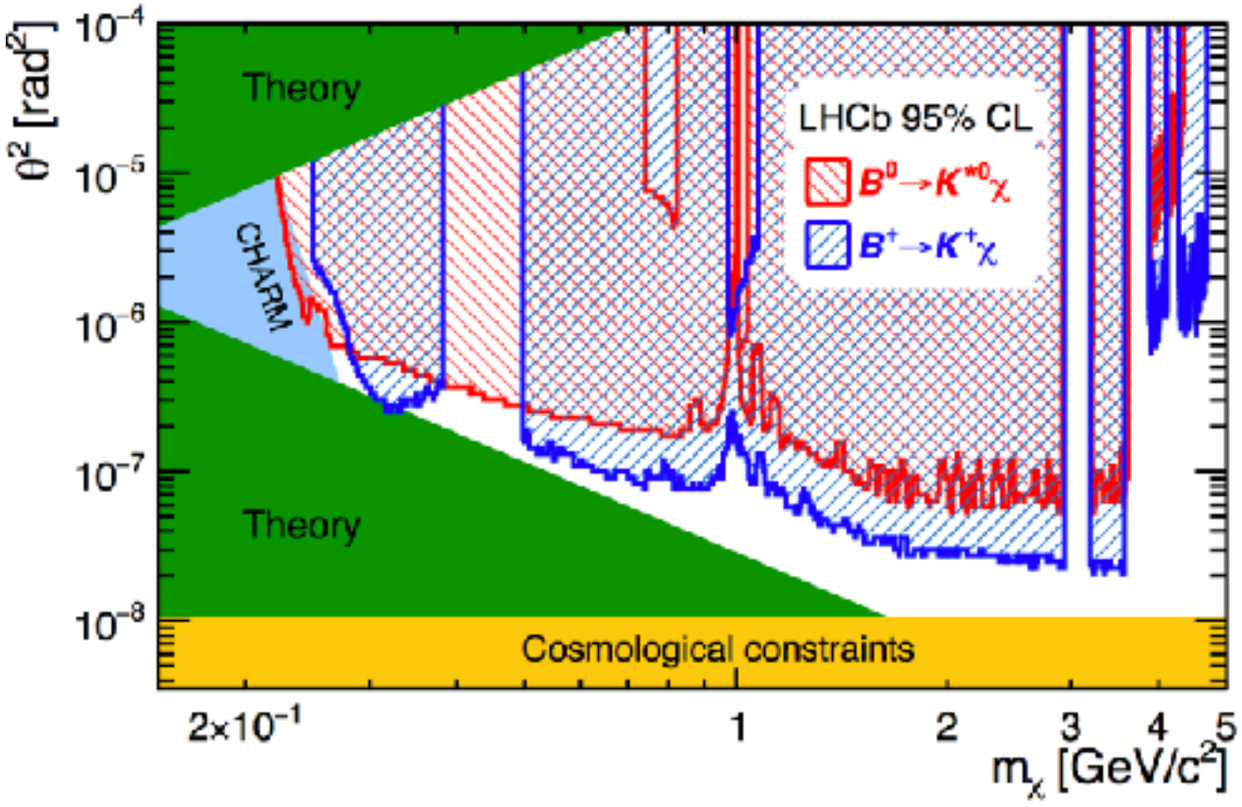
PRD 95 (2017) 071101
LHCb-PAPER-2016-052

Benchmark Models

PRL 115 (2015) 161802
LHCb-PAPER-2015-036

Constraints in the axion portal reach the PeV scale on the axion decay constant in 2HDMs.
[Freytsis,Ligeti,Thaler, 0911.5355]





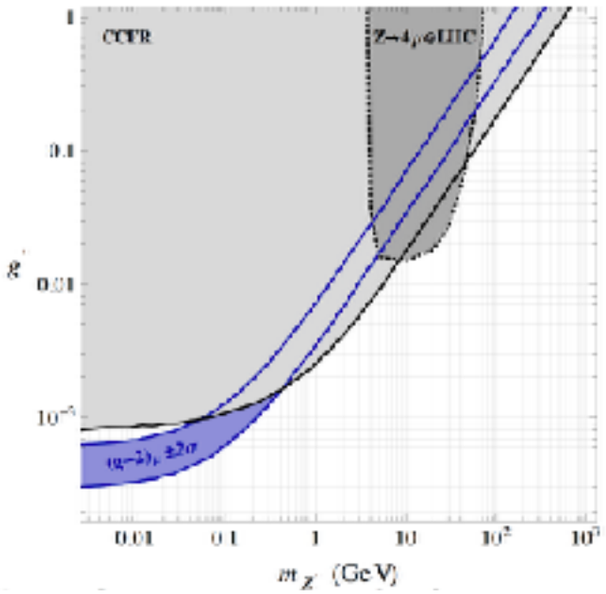
Strongest constraints on a scalar with $2m(\mu)<m<2m(\tau)$ mixing with the Higgs.

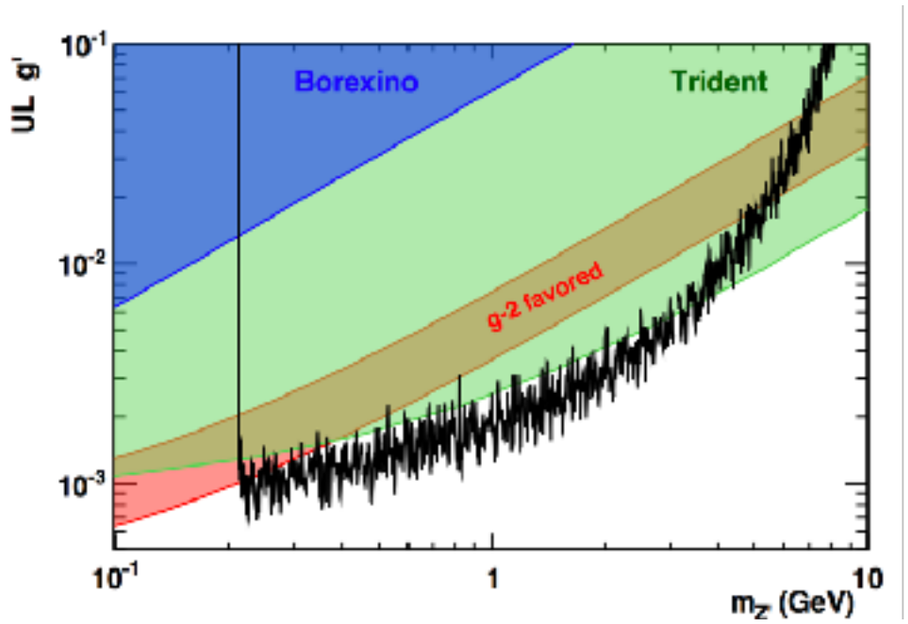
Nearly rules out the Inflaton parameter space below $2m(\tau)$ in these models.

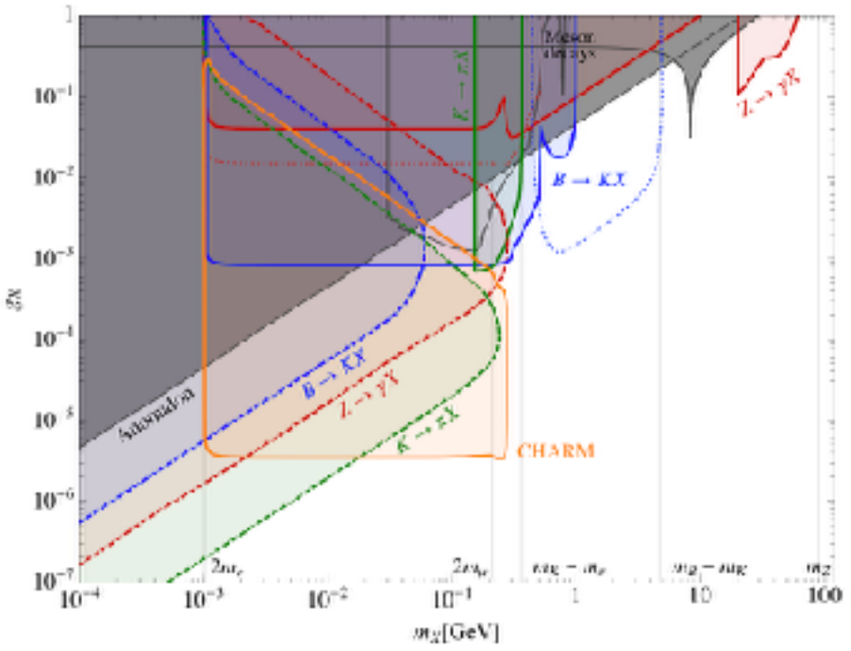
Batell, Pospelov, Ritz [0911.4939];
Bezrukov, Gorbunov [0912.0390,1303.4395]

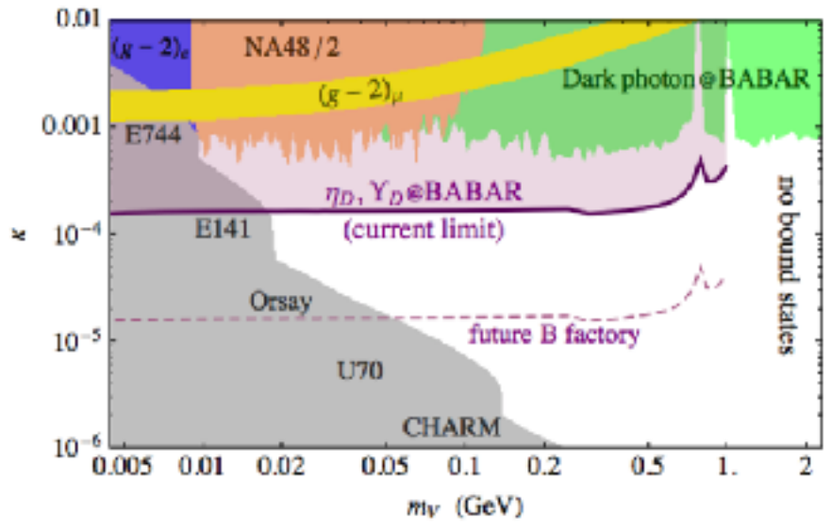
More than can be summarized!

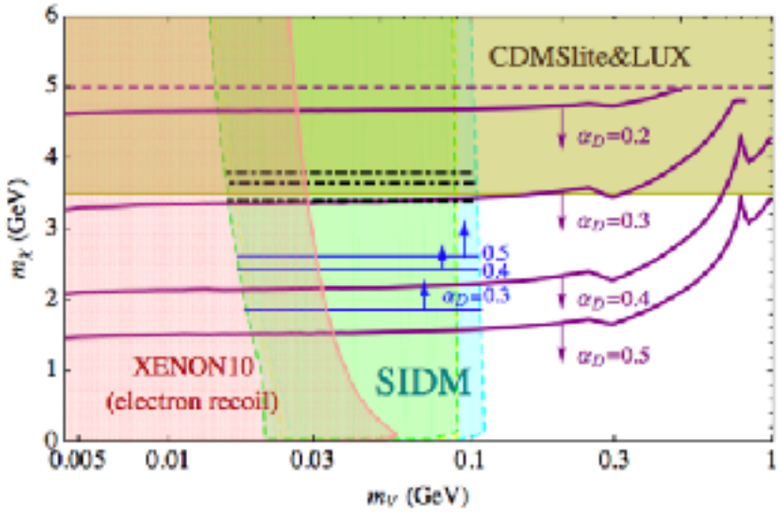
Maxim Pospelov

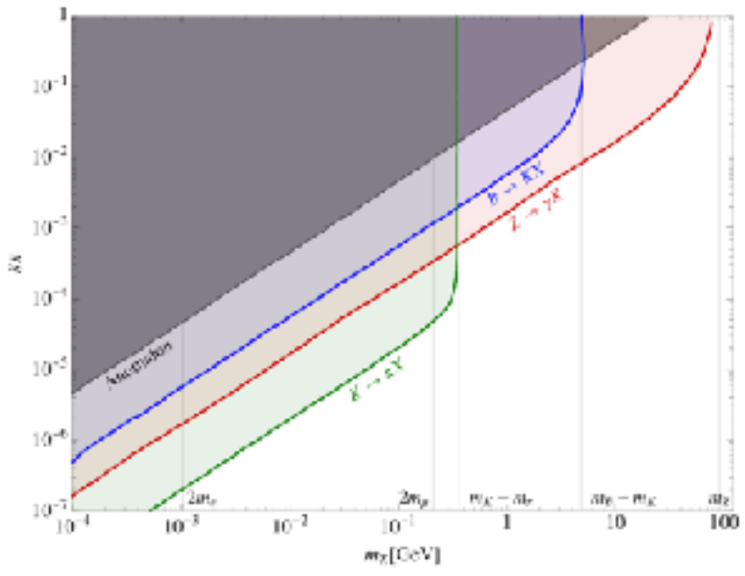


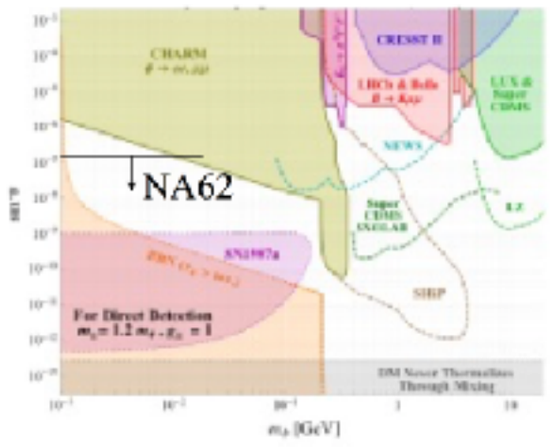


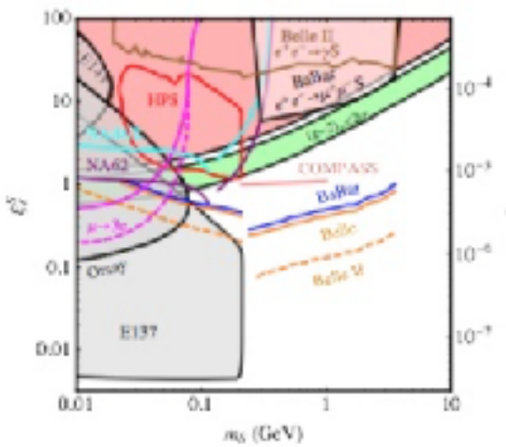


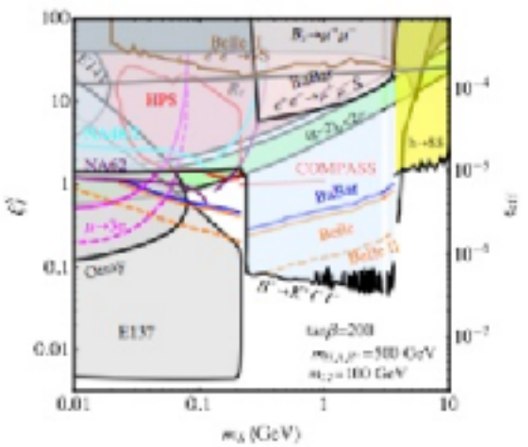












Thank you for an excellent conference
and excellent sessions