MAssive Timing Hodoscope
for Ultra-Stable NeutraL PArticles

Collab meeting
Simons Center,
August 27-31, Stony Brook

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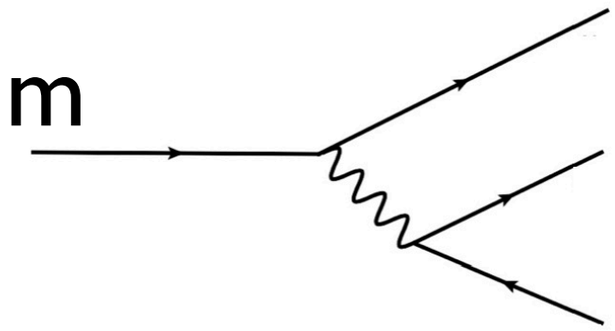
Weak lifetimes in the SM



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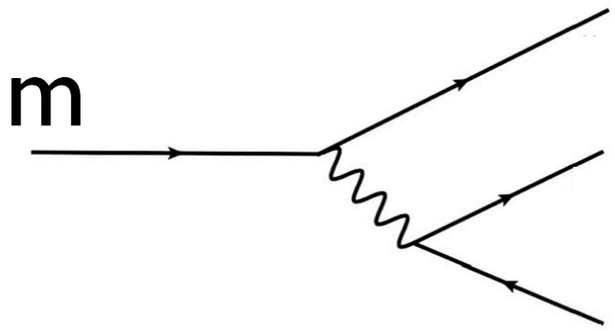

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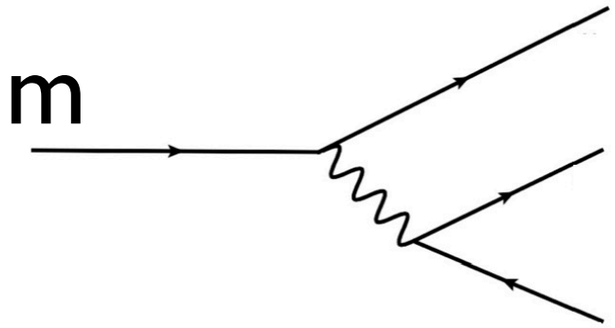

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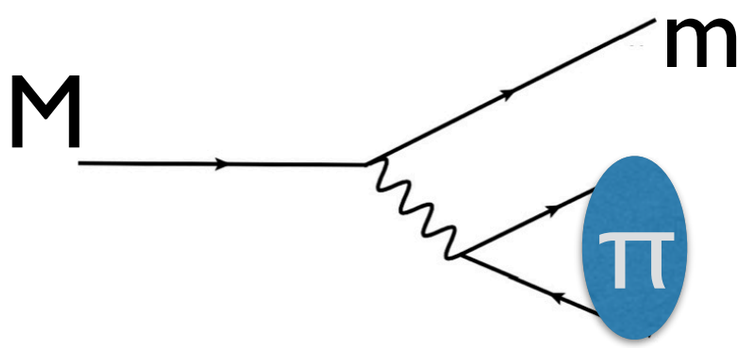

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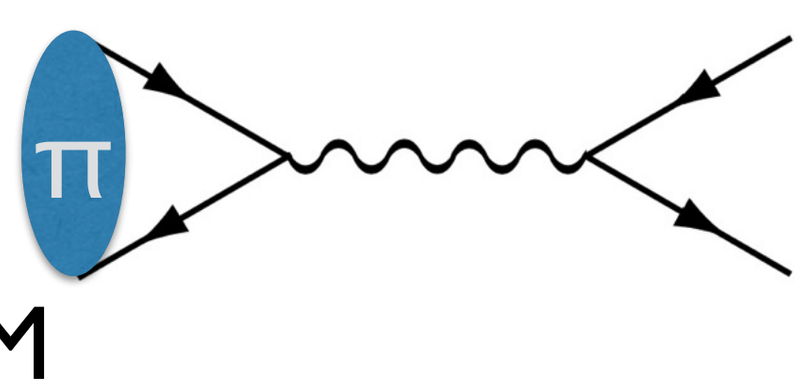

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… all occasionally corrected by CKM factors, isospin violation, etc.etc.

Lifetimes and detector technology: a tale of *anthropic** coincidences in establishing the SM

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- for E~ few GeV, $\tau(K^+)$~few 10's m
  - make kaon beams!
  - study S=2,3 hadrons
  - establish $SU(3)_F$ and quark model!

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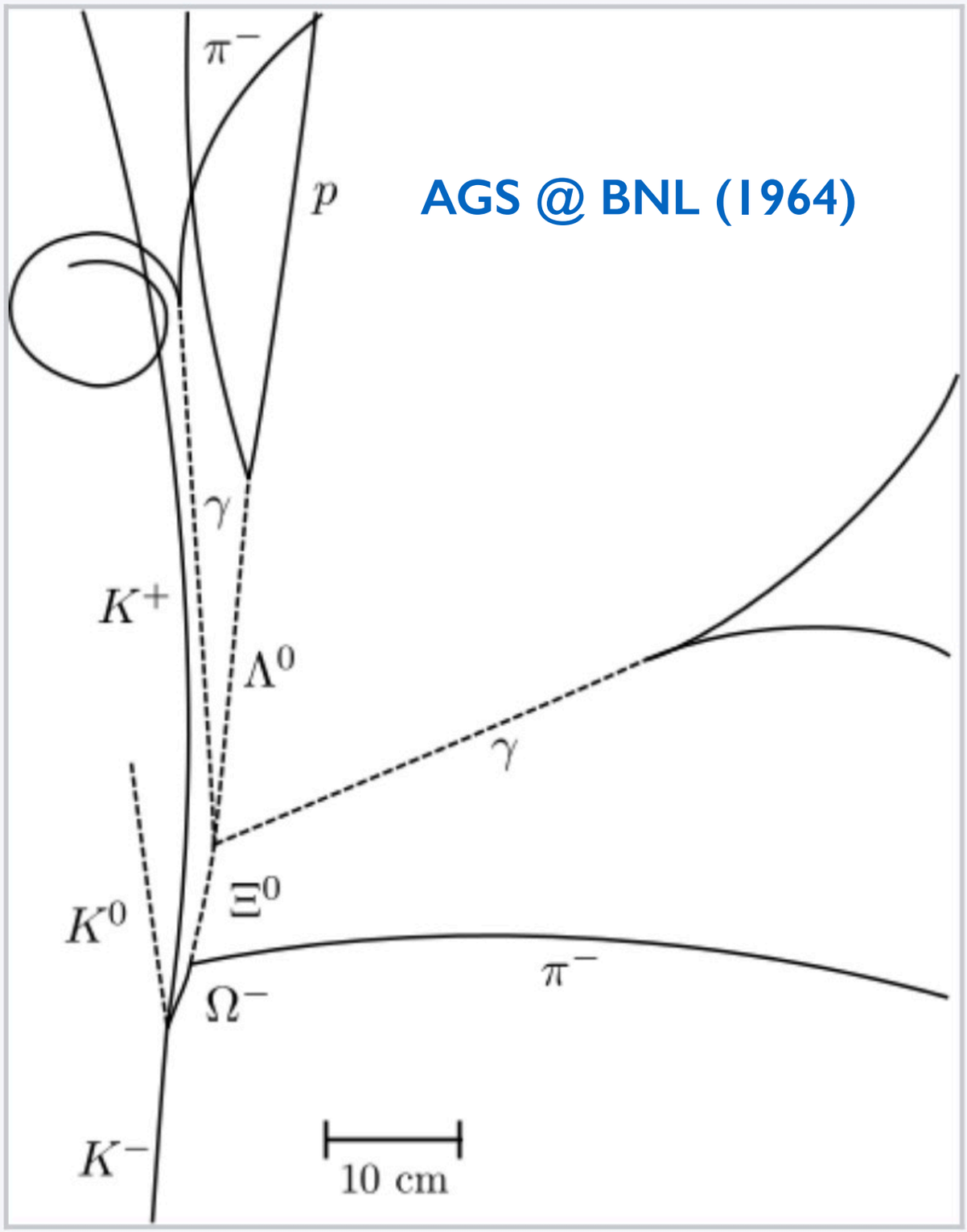

Hyperon	Quark Content	Decay Modes	Lifetime
Λ	uds	$p\pi^-$, $n\pi^0$	$0.26ns$
Σ^+	uus	$p\pi^0$, $n\pi^+$	$0.80ns$
Σ^0	uds	$\Lambda\gamma$	$7 \times 10^{-20}s$
Σ^-	dds	$n\pi^-$	$0.15ns$
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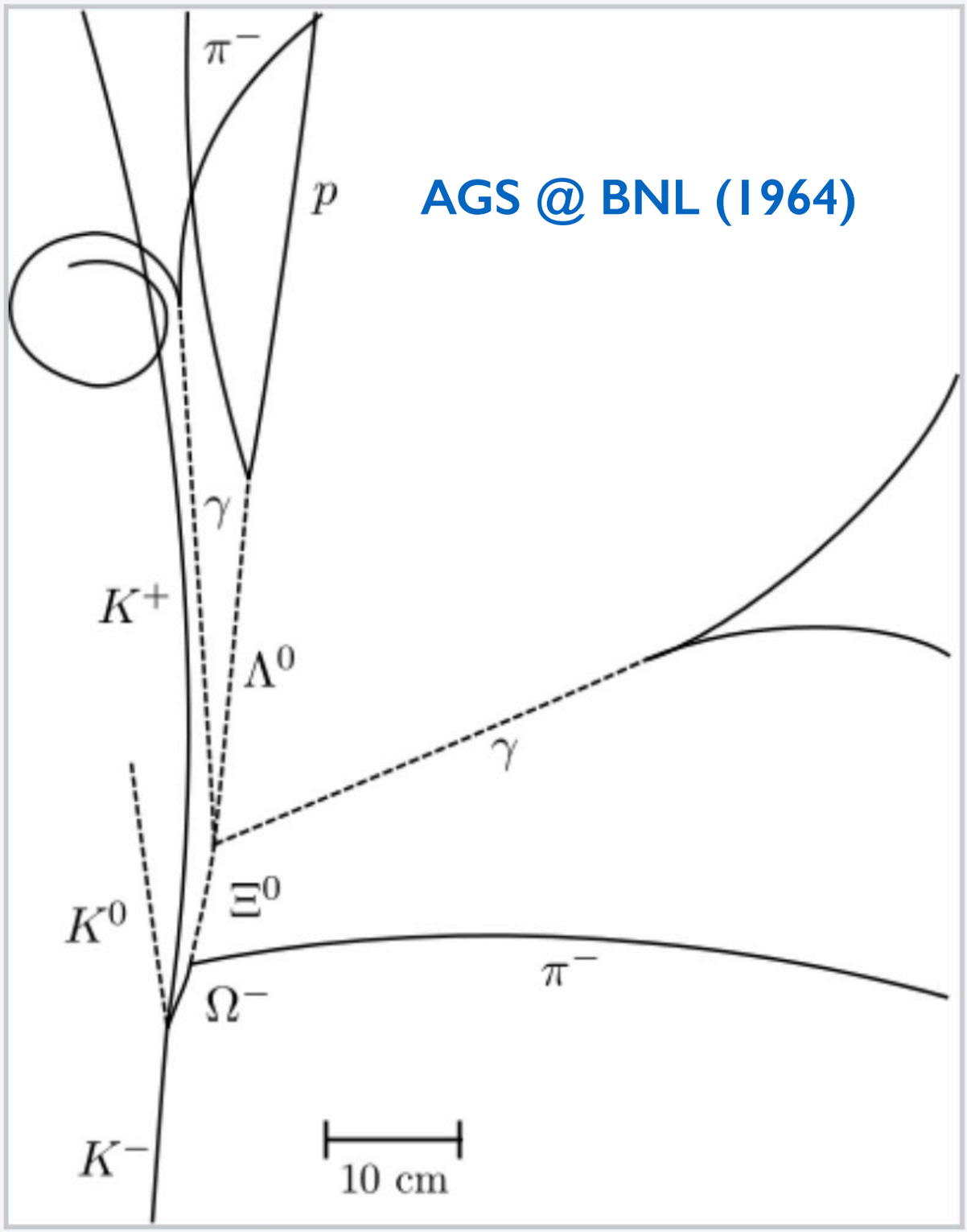
0.1 ns = 3cm => ideal for bubble chamber or emulsion pictures!!



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NB: The lifetime of neutral K's has also be critical to allow the discovery and measurements of CP violation (beams, regeneration, ….)

Accidental stability of lifetimes across flavours

~0.7 ~0.3 ~0.2 ~20

$$\frac{\Gamma(\pi \to \mu\nu)}{\Gamma(K \to \mu\nu)} \sim \frac{f_\pi^2}{f_K^2} \frac{m_\pi}{m_K} \frac{[1-(m_\mu/m_\pi)^2]^2}{[1-(m_\mu/m_K)^2]^2} \frac{\cos^2\theta_C}{\sin^2\theta_C} \sim 1$$

=> $\langle \tau_K \rangle \sim 0.5 \langle \tau_\pi \rangle$

(includes K→had's)

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$$\frac{\Gamma(b)}{\Gamma(c)} \sim \left(\frac{4.75\,\mathrm{GeV}}{1.5\,\mathrm{GeV}}\right)^5 \times \left(\frac{V_{cb}}{V_{cs}}\right)^2 \sim 0.5$$

=> $\langle\tau_B\rangle \sim 2\,\langle\tau_D\rangle$

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Through the yrs, nature provided us lifetimes adapted to the detector technologies we had available and could afford!

MATHUSLA

MAssive Timing Hodoscope
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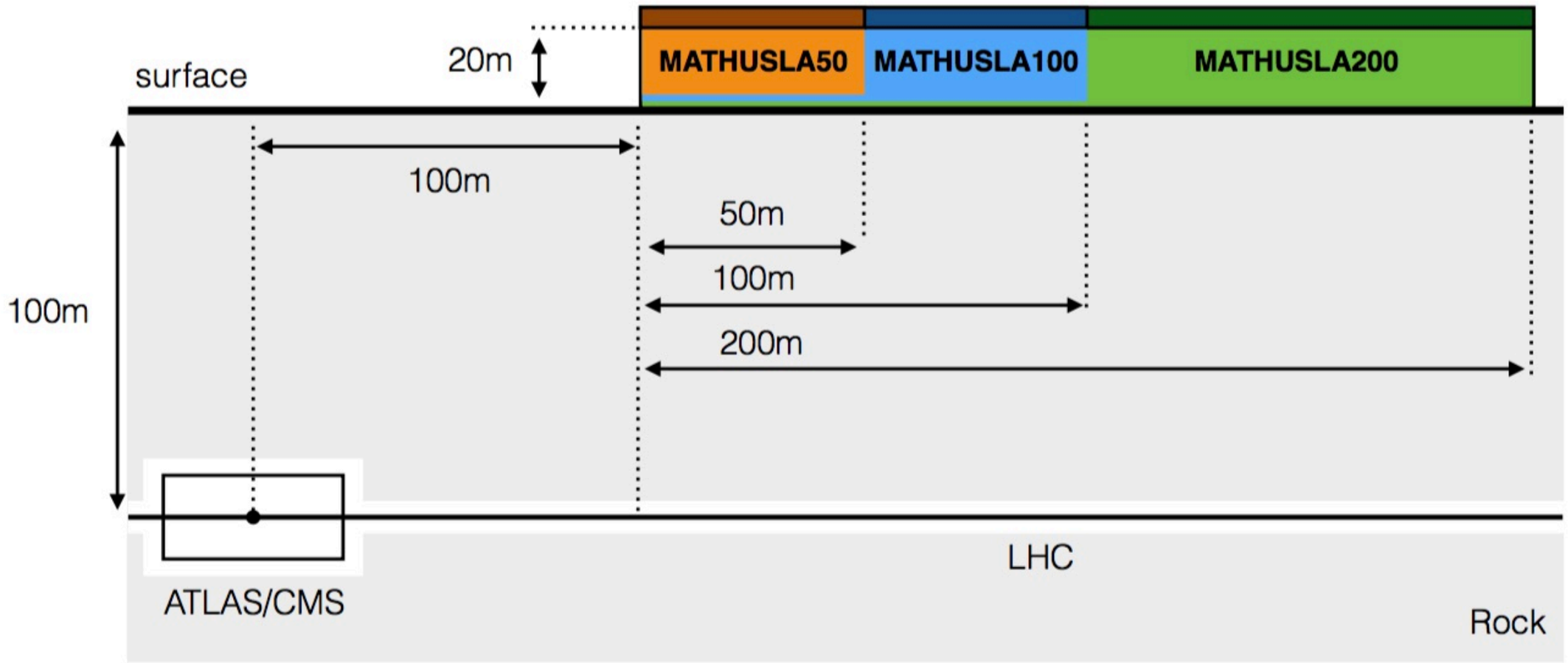
tracking system

air-filled LLP decay volume

Decay Volume:

MATHUSLA50: 50m x 50m x 20m
MATHUSLA100: 100m x 100m x 20m
MATHUSLA200: 200m x 200m x 20m



Will nature be kind to us, once more, in establishing the BSM ??

from my standard FCC motivational talk:

The physics potential (the "case") of a future facility for HEP should be weighed against criteria such as:

(1) the **guaranteed deliverables:**
- knowledge that will be acquired independently of possible discoveries (*the value of "measurements"*)

(2) the **exploration potential:**
- target broad and well justified BSM scenarios .... *but guarantee sensitivity to more exotic options*
- exploit both direct (large Q^2) and indirect (precision) probes

(3) the potential to provide conclusive **yes/no answers** to relevant, broad questions.

Mathusla does not pretend to be a facility, and doesn't need to optimally fulfill these criteria. But proving it does, helps build a case in view of the competition for Beyond-colliders projects at CERN (SHIP, …)

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not sure we can expect this

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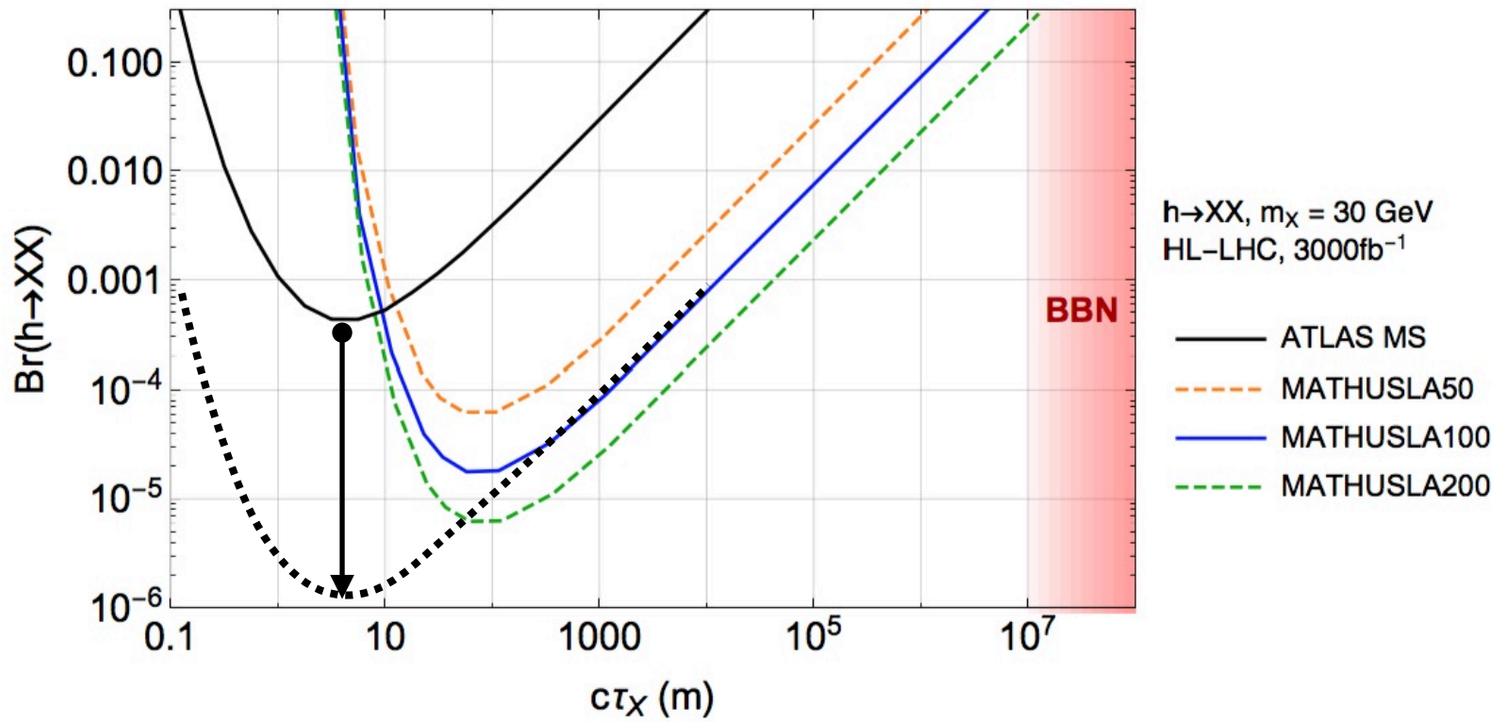
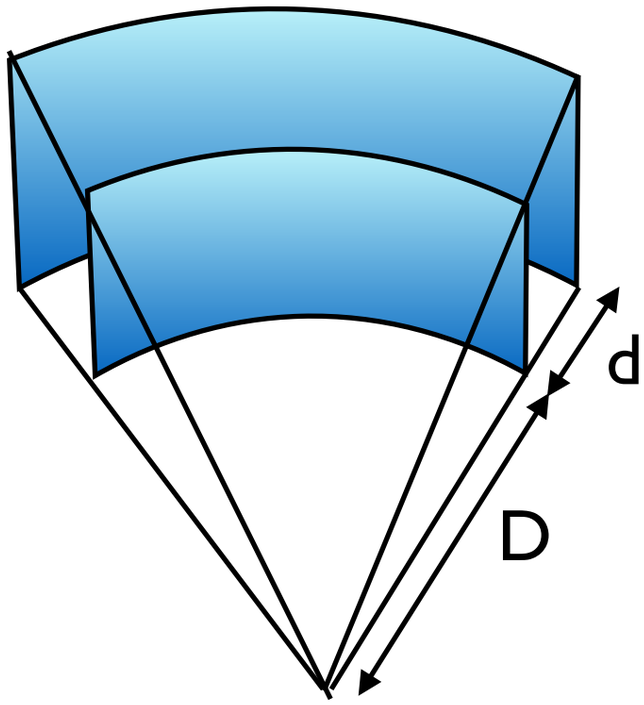
- It would be usful to provide explicit examples of complementarity with ATLAS/CMS discovery of MET signals: under which conditions, for which class of models, covering which part of parameter space, will Mathusla contribute to the exploration of these MET sources?

Comparison with ATLAS, a remark





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$N_{ATLAS} \sim \Omega_{ATLAS}\, d_{ATLAS}\, \varepsilon_{ATLAS}$ → solid angle

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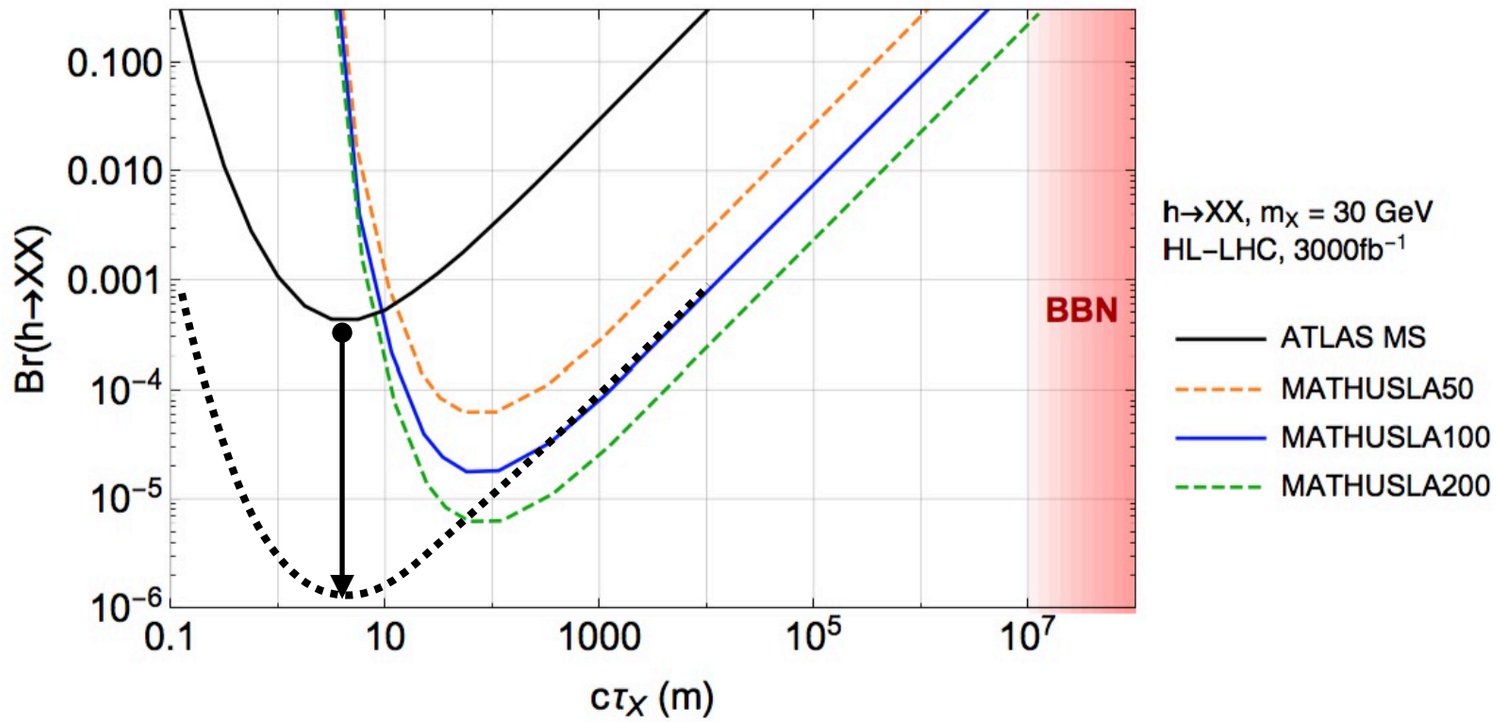

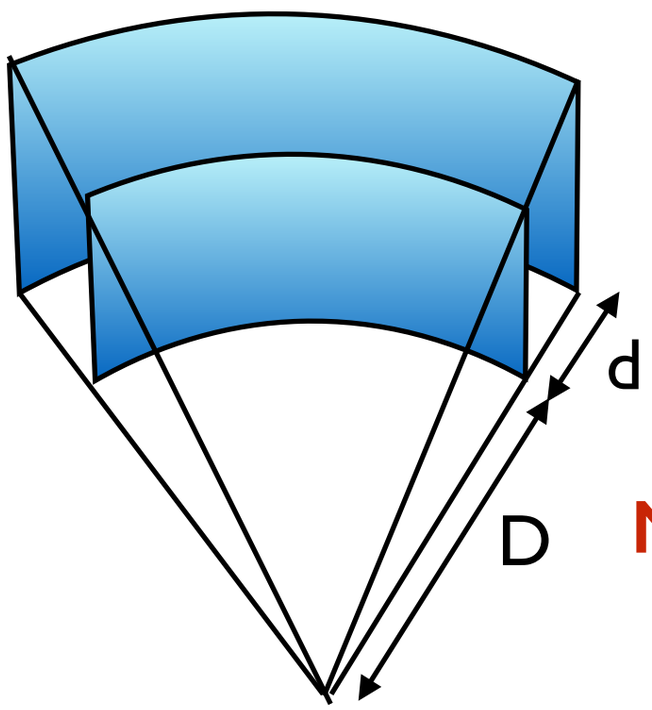

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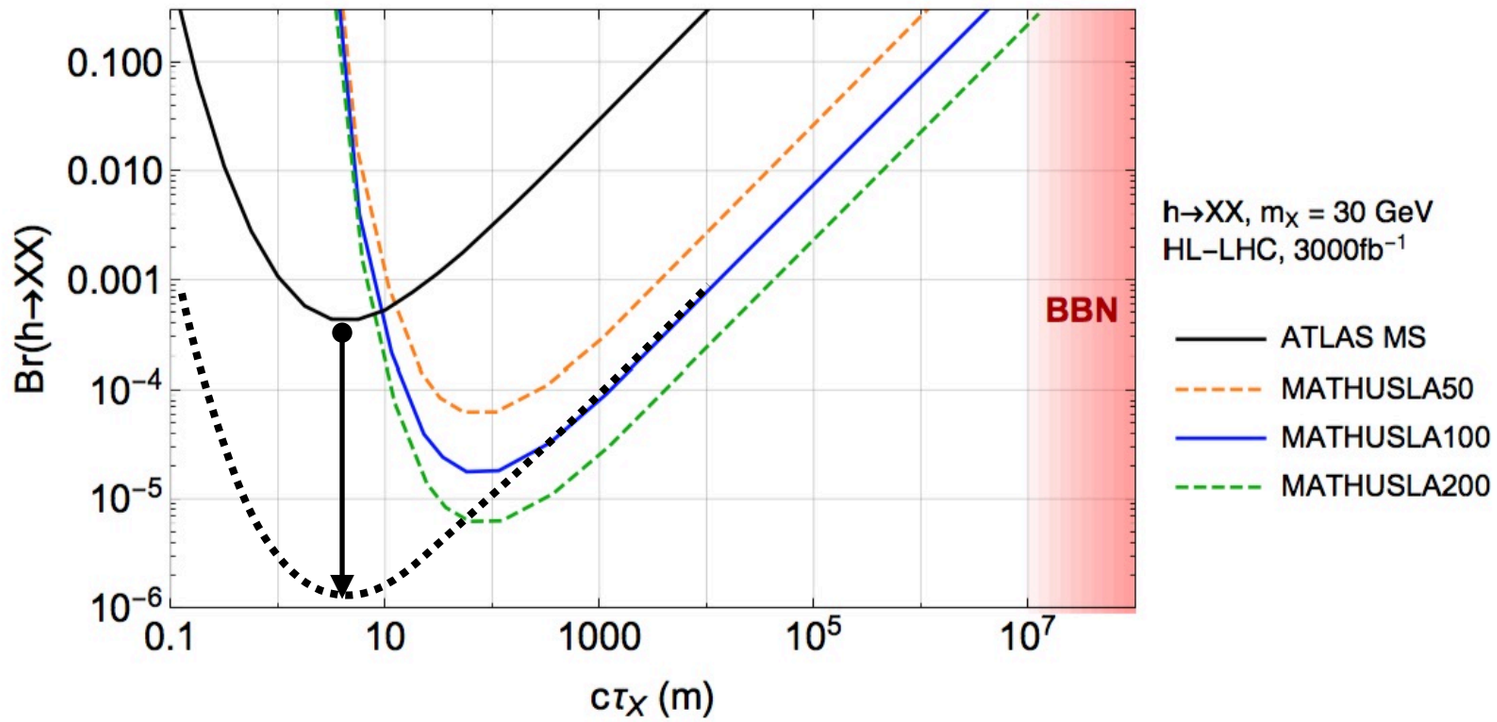

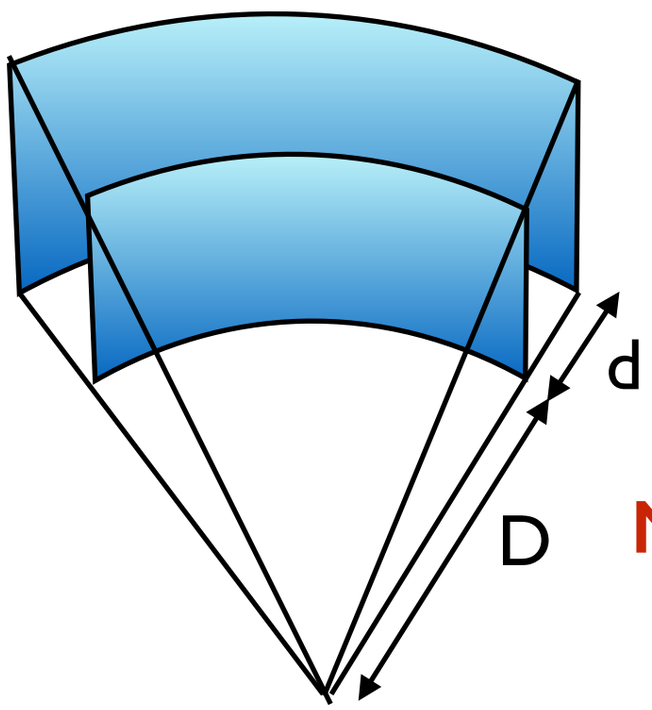

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=> it is signal efficiency, not geometry, that handicaps ATLAS

Yes/no answers

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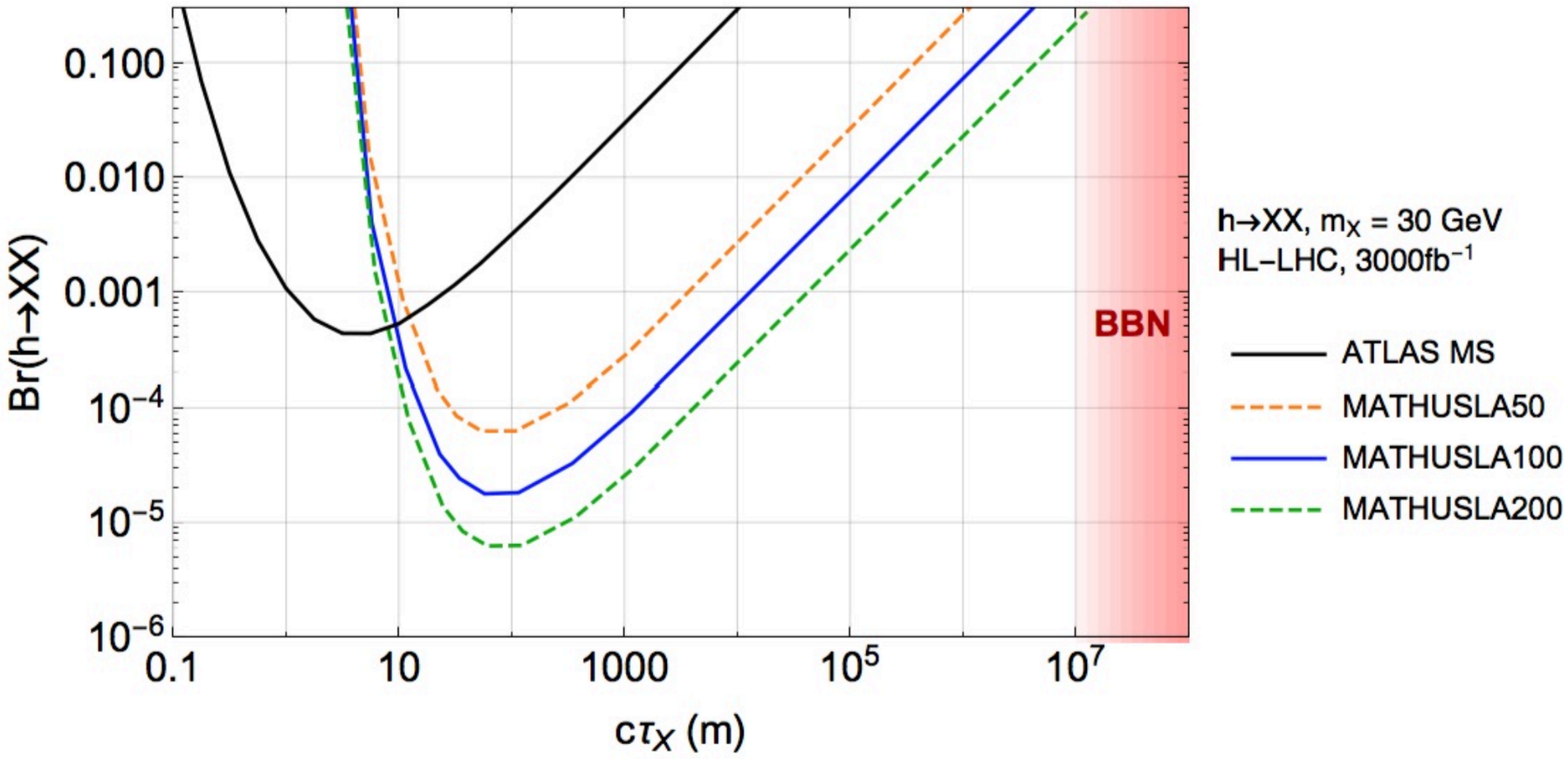

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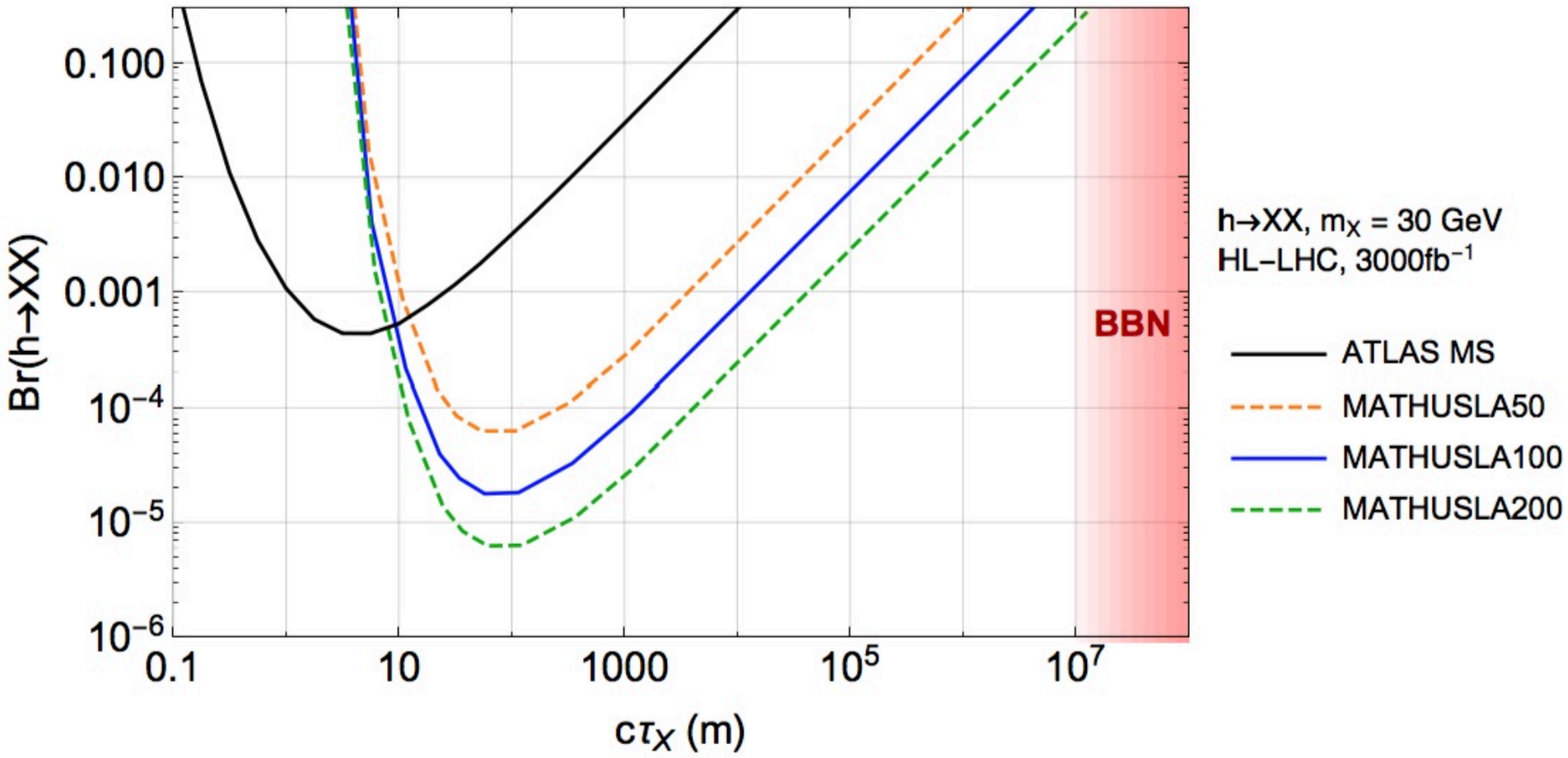
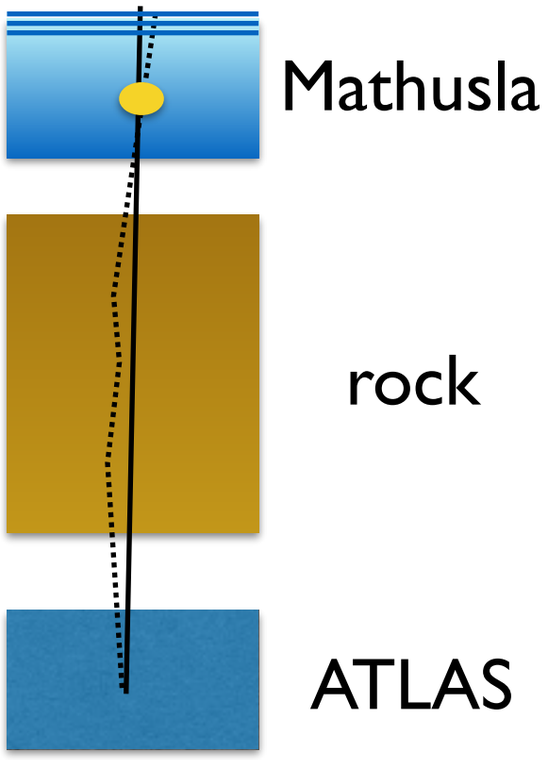


reaching the BBN limit is a good example of a relevant target for definitive confirmation/exclusion. Anything else?

Some general questions/remarks emerged in the first discussion among LHCC referees

backgrounds

Multiple scattering in the rock for low-mass dimuon pairs ?



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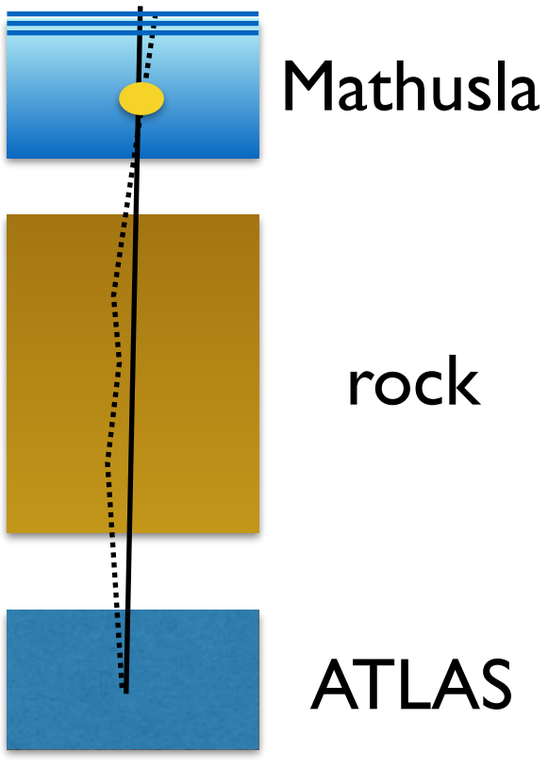
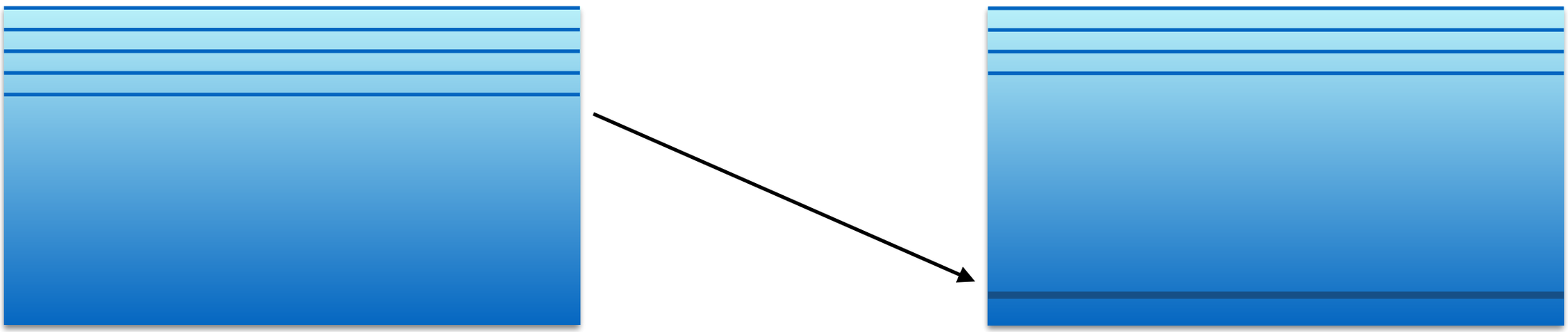


	p_T>100	p_T>200	p_T>300
b→J/ψ→μμ	2.5 10^6	8 10^4	4 10^3
direct J/ψ→μμ	?	?	?
DY(μμ), 5<m(GeV)<30	2.5 10^6	3 10^5	6 10^4
b→μ	3.5 10^7	10^6	5 10^4
W→μ	1.5 10^8	1.1 10^7	1.8 10^6

p_T min for μ or μμ

N_{events} in 3ab^{-1} at the IP (|η|<2.5)



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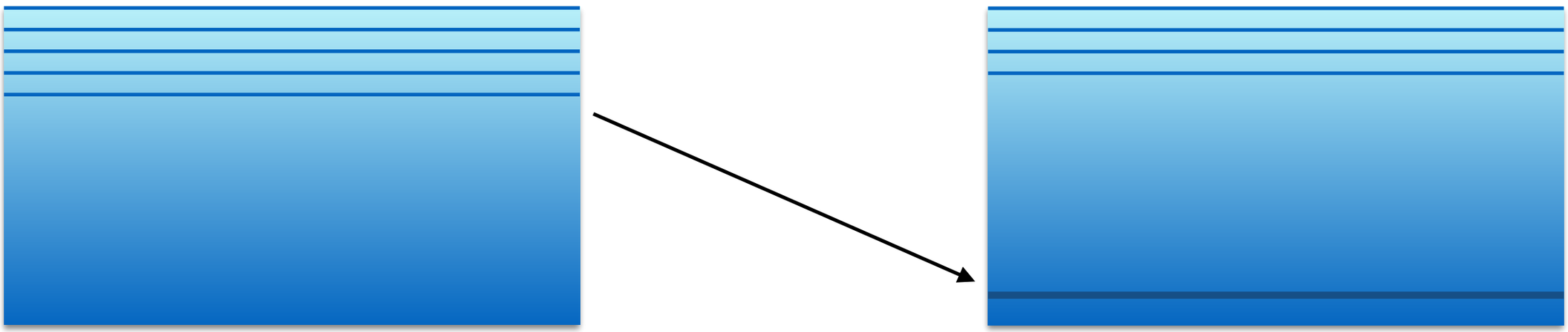

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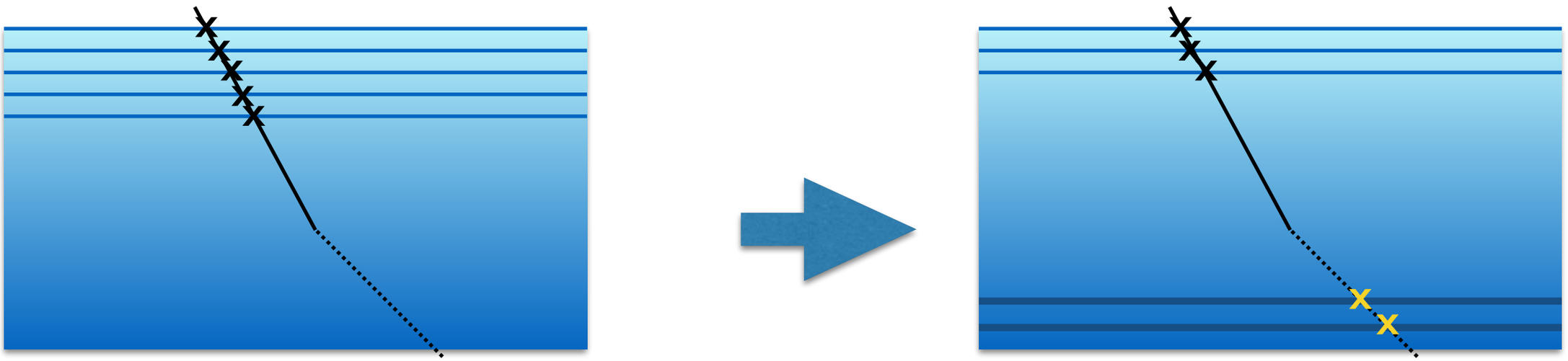
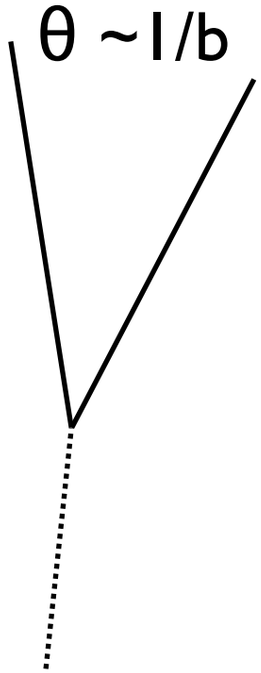
It could also give higher acceptance to slow, heavy-LLP decays



μ+δ rays



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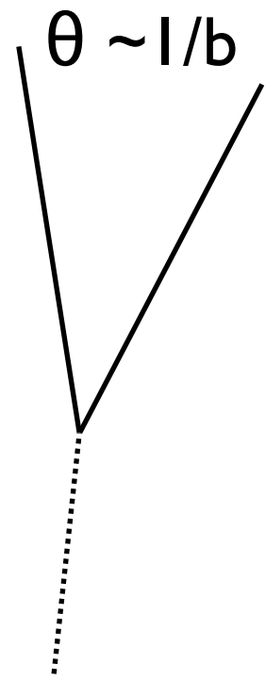

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How are the estimates of reach in mass and boost affected by the $\theta > 2^{\circ}$ cut required to eliminate mu+δ-ray bgs??

Does this limit some component of the physics reach?

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- Allow ambition in the plan: how much more could be gained if more resources were available?

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- Funding strategy:
  - How do you plan building the collaboration? Currently most members are penniless theorists! Resources for LHC experiments are pretty much capped already by funding agencies => engage new groups and communities (eg CRs) not currently committed to LHC programme?

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- In the LHCC we are looking forward to the interaction with you
- A lot of work still remains to be done, and we'll be happy to follow and encourage your progress