CSN1 perspectives/2

Mainly from LTS1 workshop @Elba :

- **«classical» Flavour**
- **(charged) Lepton flavour violation**
- **Fixed target ideas**
- **International HEP scenario**

WHY FLAVOUR?

- No tree-level flavour changing neutral currents in the SM
- GIM suppression of FCNC @ the loop level
- Tiny CP violation in K and D mesons due to small CKM angles
- Unobservable LFV & EDM's

$\Rightarrow$ Flavour & CP violation ideal places to get indirect evidence of NP

ROLE OF FLAVOUR

- In the framework of future experimental developments, Flavour physics should:
- Guarantee that the flavour structure of any directly discovered NP can be efficiently probed, and/or
- Push the NP scale that can be indirectly probed up by (at least) one order of magnitude (ε_K now at 5 10^5 TeV)

multi-purpose flavor expts @ hadron colliders

An "Extreme Flavor" experiment @ LHC?

Future progress on Lattice QCD (& SM-TH in general)

Ultimate Lattice precision on HF form factors?

K/π beams

Can we hope to measure $K_L \to \pi\nu\nu$?

EDMs (& g-2)

An electron-EDM storage ring [@ LNF]?

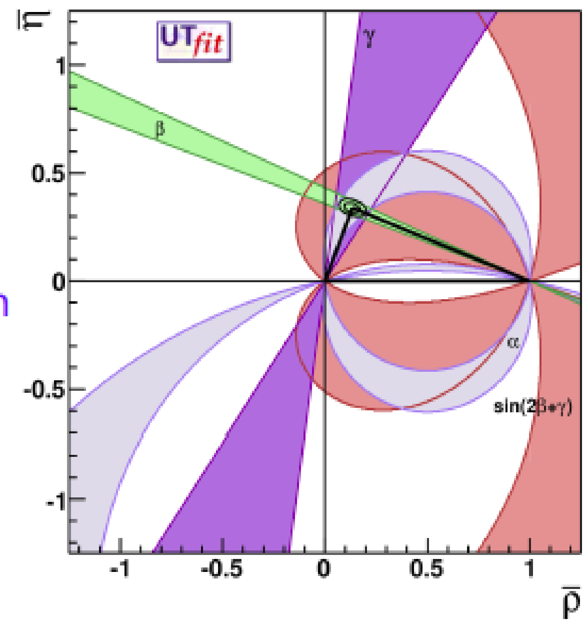
LFV [μ→e]

What's the ultimate sensitivity on $\mu \to e\gamma$?

From Gino's talk @ What Next

Measurements of UT angles

- Interpretation in terms of CKM matrix elements does not depend on strong theory inputs
  - $\sigma_{th}(\gamma)$ negligible from tree-level decays
    - Brod and Zupan, JHEP 01 (2014) 051
  - $\sigma_{th}(\beta)$ small and controllable with data-driven methods
    - Ciuchini *et al.*, PRL 95 (2005) 221804
    - Faller *et al.*, PRD 79 (2009) 014030
  - $\sigma_{th}(\beta_s)$ small and controllable with data-driven methods
    - Faller et al., PRD 79 (2009) 014005
  - $\sigma_{th}(\alpha) \approx 1^o$
    - Gronau *et al.*, PRD 60 (1999) 034021
    - Botella *et al.*, PRD 73 (2006) 071501
    - Zupan, Nucl. Phys. Proc. Suppl. 170 (2007) 33

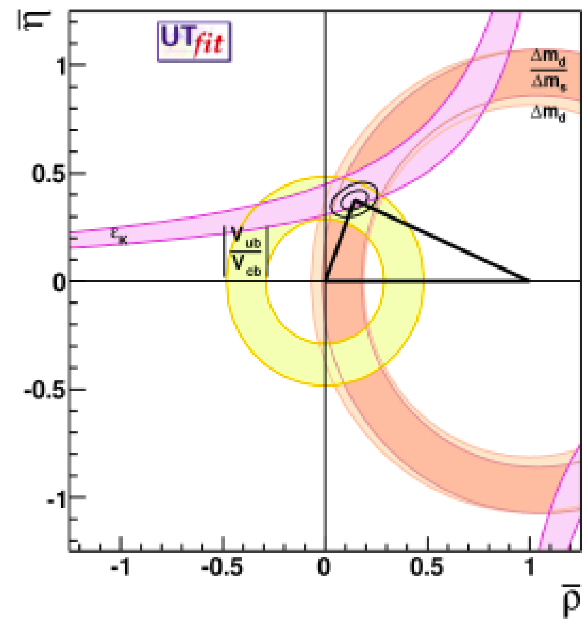


- Measurements can be affected by NP at different levels
  - γ from tree-level is basically unaffected
  - β (β_s) can be affected in B_d (B_s) mixing
  - α can be affected both in mixing and decay (loops in penguin diagrams)

Measurements of UT sides and ε_K

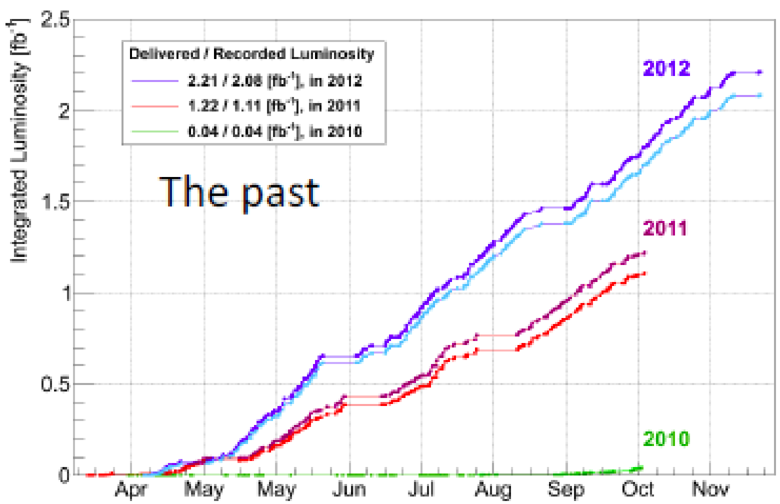
- Here theory matters a lot
  - Improvements in lattice QCD are particularly important
  - Can we go below 1% for the relevant hadronic quantities in the next decade?

Hadronic parameter	L.Lellouch ICHEP 2002 [hep-ph/0211359]	FLAG 2013 [1310.8555]	2025 [What Next]
$f_+^{K\pi}(0)$	- First Lattice result in 2004 [0.9%]	[0.4%]	[0.1%]
$\hat{B}_K$	[17%]	[1.3%]	[0.1-0.5%]
f_{Bs}	[13%]	[2%]	[0.5%]
f_{Bs}/f_B	[6%]	[1.8%]	[0.5%]
$\hat{B}_{Bs}$	[9%]	[5%]	[0.5-1%]
B_{Bs}/B_B	[3%]	[10%]	[0.5-1%]
$F_{D^*}(1)$	[3%]	[1.8%]	[0.5%]
$B\to\pi$	[20%]	[10%]	[>1%]



See C. Tarantino in parallel session

LHCb luminosity profile



The future

	LHC era		HL-LHC era	
Run 1 (2010–12)	Run 2 (2015–17)	Run 3 (2019–21)	Run 4 (2024–26)	Run 5+ (2028–30+)
3 fb^{-1}	8 fb^{-1}	23 fb^{-1}	46 fb^{-1}	100 fb^{-1}

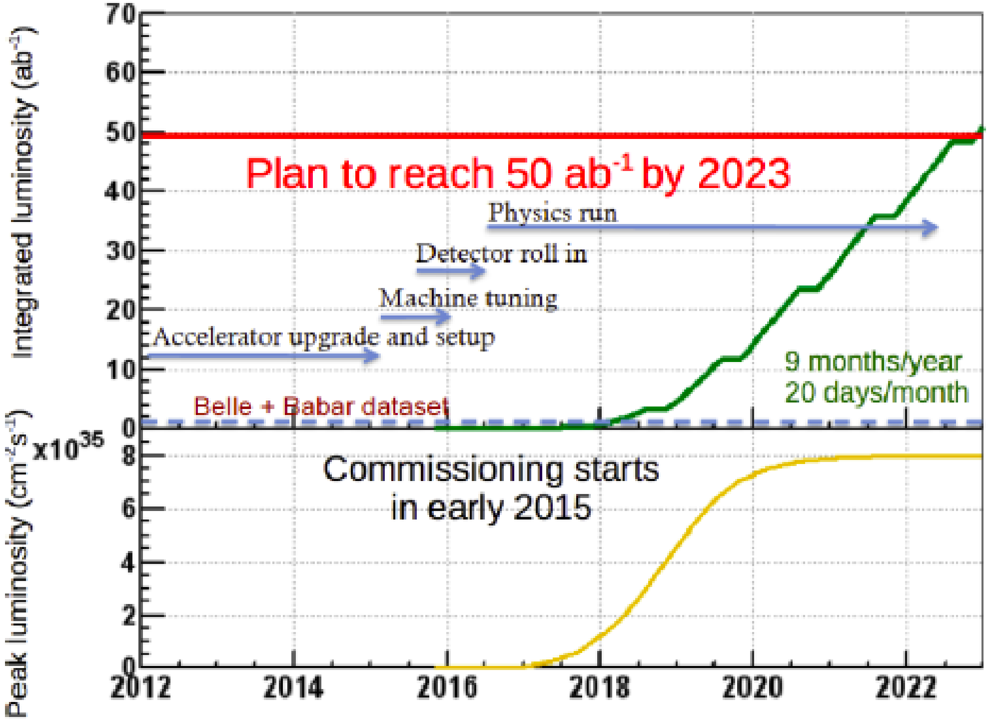
Upgraded detector

2 x $\sigma_{b\bar{b}}$

- The LHCb upgrade aims at integrating a luminosity of 50 fb^{-1} by 2026
  - x2 at every LHC run
  - can continue to be operational till the end of the HL programme up to O(100) fb^{-1}

Belle II luminosity profile

- Physics run expected for 2016-2017
- Competitive results starting to be available very early
  - In 2018 will match the size of data sets of BaBar and Belle
- Will start deploying the full potential by 2020
  - Integrating 50 ab^{-1} in about 6 years



Summary tables

LHCb-PUB-2013-015

Type	Observable	LHC Run 1	LHCb 2018	LHCb upgrade	Theory
B_s^0 mixing	$\phi_s(B_s^0 \to J/\psi\,\phi)$ (rad)	0.05	0.025	**0.009**	~ 0.003
	$\phi_s(B_s^0 \to J/\psi\, f_0(980))$ (rad)	0.09	0.05	**0.016**	~ 0.01
	$A_{\rm sl}(B_s^0)$ (10^{-3})	2.8	1.4	**0.5**	0.03
Gluonic penguin	$\phi_s^{\rm eff}(B_s^0 \to \phi\phi)$ (rad)	0.18	0.12	**0.026**	0.02
	$\phi_s^{\rm eff}(B_s^0 \to K^{*0}\bar{K}^{*0})$ (rad)	0.19	0.13	**0.029**	< 0.02
	$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$ (rad)	0.30	0.20	**0.04**	0.02
Right-handed currents	$\phi_s^{\rm eff}(B_s^0 \to \phi\gamma)$	0.20	0.13	**0.030**	< 0.01
	$\tau^{\rm eff}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	5%	3.2%	**0.8%**	0.2 %
Electroweak penguin	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.04	0.020	**0.007**	0.02
	$q_0^2\, A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$	10%	5%	**1.9%**	$\sim 7\%$
	$A_{\rm I}(K\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.14	0.07	**0.024**	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	14%	7%	**2.4%**	$\sim 10\%$
Higgs penguin	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ (10^{-9})	1.0	0.5	**0.19**	0.3
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	220%	110%	**40%**	$\sim 5\,\%$
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	7°	4°	**1.1°**	negligible
	$\gamma(B_s^0 \to D_s^\mp K^\pm)$	17°	11°	**2.4°**	negligible
	$\beta(B^0 \to J/\psi\, K_S^0)$	1.7°	0.8°	**0.31°**	negligible
Charm *CP* violation	$A_\Gamma(D^0 \to K^+K^-)$ (10^{-4})	3.4	2.2	**0.5**	–
	ΔA_{CP} (10^{-3})	0.8	0.5	**0.12**	–

- Before the upgrade (8 fb^{-1})
- After the upgrade (50 fb^{-1})
- Theory uncertainty (as far as we know today)

Summary tables

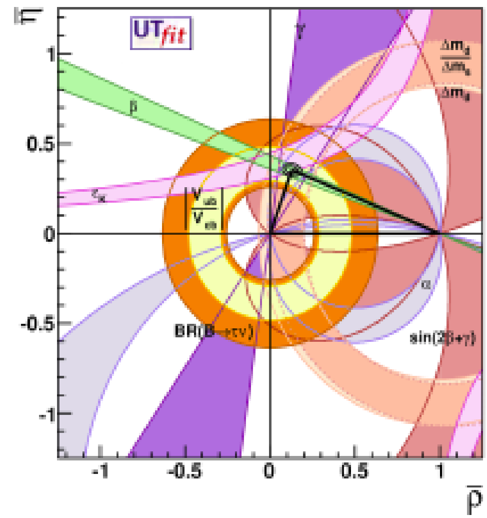
Observables	Belle (2014)	Belle II 5 ab^{-1}	Belle II 50 ab^{-1}
$\sin 2\beta$	$0.667 \pm 0.023 \pm 0.012$	± 0.012	± 0.008
α		$\pm 2^\circ$	$\pm 1^\circ$
γ	$\pm 14^\circ$	$\pm 6^\circ$	$\pm 1.5^\circ$
$S(B \to \phi K^0)$	$0.90^{+0.09}_{-0.19}$	± 0.053	± 0.018
$S(B \to \eta' K^0)$	$0.68 \pm 0.07 \pm 0.03$	± 0.028	± 0.011
$S(B \to K_S^0 K_S^0 K_S^0)$	$0.30 \pm 0.32 \pm 0.08$	± 0.100	± 0.033
$\lvert V_{cb} \rvert$ incl.	$\pm 2.4\%$	$\pm 1.0\%$	
$\lvert V_{cb} \rvert$ excl.	$\pm 3.6\%$	$\pm 1.8\%$	$\pm 1.4\%$
$\lvert V_{ub} \rvert$ incl.	$\pm 6.5\%$	$\pm 3.4\%$	$\pm 3.0\%$
$\lvert V_{ub} \rvert$ excl. (had. tag.)	$\pm 10.8\%$	$\pm 4.7\%$	$\pm 2.4\%$
$\lvert V_{ub} \rvert$ excl. (untag.)	$\pm 9.4\%$	$\pm 4.2\%$	$\pm 2.2\%$
$\mathcal{B}(B \to \tau\nu)$ $[10^{-6}]$	96 ± 26	$\pm 10\%$	$\pm 3\%$
$\mathcal{B}(B \to \mu\nu)$ $[10^{-6}]$	< 1.7	5σ	$>> 5\sigma$
$R(D\tau\nu)$	$\pm 16.5\%$	$\pm 5.2\%$	$\pm 2.5\%$
$R(D^*\tau\nu)$	$\pm 9.0\%$	$\pm 2.9\%$	$\pm 1.6\%$
$\mathcal{B}(B \to K^{*+}\nu\bar{\nu})$ $[10^{-6}]$	< 40		$\pm 30\%$
$\mathcal{B}(B \to K^{+}\nu\bar{\nu})$ $[10^{-6}]$	< 55		$\pm 30\%$
$\mathcal{B}(B \to X_s\gamma)$ $[10^{-6}]$	$\pm 13\%$	$\pm 7\%$	$\pm 6\%$
$A_{CP}(B \to X_s\gamma)$		± 0.01	± 0.005
$S(B \to K_S^0 \pi^0 \gamma)$	$-0.10 \pm 0.31 \pm 0.07$	± 0.11	± 0.035
$\mathcal{B}(B \to X_d\gamma)$ $[10^{-6}]$			
$S(B \to \rho\gamma)$	$-0.83 \pm 0.65 \pm 0.18$	± 0.23	± 0.07
$\mathcal{B}(B_s \to \gamma\gamma)$ $[10^{-6}]$	< 8.7	± 0.3	
$\mathcal{B}(B_s \to \tau^+\tau^-)$ $[10^{-3}]$		< 2	
$\mathcal{B}(D_s \to \mu\nu)$	$5.31 \times 10^{-3}(1 \pm 0.053 \pm 0.038)$	$\pm 2.9\%$	$\pm(0.9\%\text{-}1.3\%)$
$\mathcal{B}(D_s \to \tau\nu)$	$5.70 \times 10^{-3}(1 \pm 0.037 \pm 0.054)$	$\pm(3.5\%\text{-}4.3\%)$	$\pm(2.3\%\text{-}3.6\%)$
y_{CP} $[10^{-2}]$	$1.11 \pm 0.22 \pm 0.11$	$\pm(0.11\text{-}0.13)$	$\pm(0.05\text{-}0.08)$
A_Γ $[10^{-2}]$	$-0.03 \pm 0.20 \pm 0.08$	± 0.10	$\pm(0.03\text{-}0.05)$
$A_{CP}^{K^+K^-}$ $[10^{-2}]$	$-0.32 \pm 0.21 \pm 0.09$	± 0.11	± 0.06
$A_{CP}^{\pi^+\pi^-}$ $[10^{-2}]$	$0.55 \pm 0.36 \pm 0.09$	± 0.17	± 0.06
$A_{CP}^{\phi\gamma}$ $[10^{-2}]$	± 5.6	± 2.5	± 0.8
$\tau \to \mu\gamma$ $[10^{-8}]$	< 4.5		< 0.1
$\tau \to e\gamma$ $[10^{-8}]$	< 12.0		
$\tau \to \mu\mu\mu$ $[10^{-9}]$	< 21.0	< 4.5	< 0.9

- Soon after startup (5 ab^{-1})
- By the end of the present programme (50 ab^{-1})

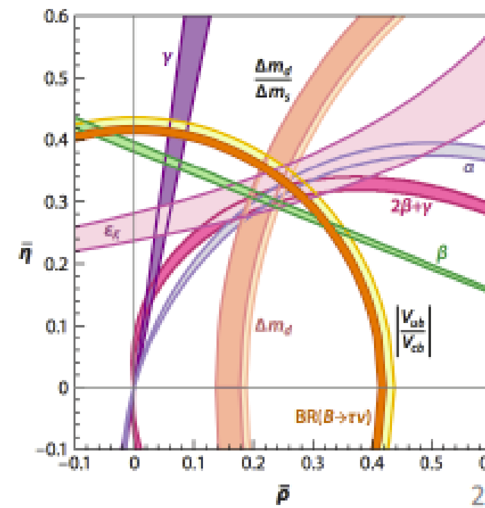
See e.g. G. De Nardo at IFAE 2014

- Flavour physics has large room for improvements in many key measurements
- LHCb is developing a programme extending over the next 15 years
  - the standard detector will take data till 2017 and the upgraded detector will start taking data in 2019
- Belle II is expected to roll in late 2016 with the first physics run
- Rich complementary between LHCb and Belle II physics programmes
- ATLAS and CMS can also give key contributions in some specific areas

Today



Tomorrow?



M. Moulson

NA62 in the near future

Goal: Measure BR($K^+ \rightarrow \pi^+ \nu\bar{\nu}$) to 10%
Collect ~100 signal events with S/B > 10 in 2-years' equivalent data taking

Other elements of physics program:
- Measurement of R_K to ~0.2%
- Searches for LFV K^+ and π^0 decays
- ChPT tests & precision BR mmts.

Start of NA62 running: October 2014

Possible to request more running during Run 2 to improve sensitivity!

Planned and potential upgrades:
- New trigger hodoscope
- Small changes to level-0 architecture to allow more restrictive triggering
- Continuous WFD readout for critical detectors (e.g. LAVs)?

Ambitious upgrades to justify running in Run 3?

None proposed yet, but NA62 just starting up: First need to get experience

M. Moulson

NA62: From K^+ to K_L

Possibility of a neutral beam forseen in the NA62 Technical Proposal:

- Slight changes to production angle and upstream beam optics
- Running for $\pi^0\nu\bar{\nu}$ and $\pi^0\ell^+\ell^-$ will require a substantial increase in primary intensity, but **well within** what the SPS can provide

	NA62 K^+ beam	Future NA62 K_L beam
Primary intensity (ppp)	3×10^{12}	2.4×10^{13}
Production angle for secondary (mrad)	0	2.4
Angular acceptance (μsr)	12.7 μsr	0.125 μsr
Momentum	75 GeV ±1%	97 GeV (mean) 40-140 GeV (50% peak)
Rates into FV	750 total 525 π 170 p 45 K^+	3000 total 2000 γ 800 n 90 K_L
K decays in FV	4.5 MHz **4.5×10^{12}/year**	0.9 MHz **9×10^{11}/year**

M. Moulson

PRIN studies: $K_L \to \pi^0 \nu\bar{\nu}$ at the SPS

Beam sweeper: Reduce 2 GHz of beam photons by at least 10×
May require innovative approach: Iridium monocrystal?

Large angle photon vetoes: Hermetic coverage out to 100 mrad for E_γ down to 20 MeV
26 new LAV stations with scintillator/tile design

Small angle photon vetoes: Be relatively insensitive to 800 MHz of beam neutrons
Amdist this background, reject γ from $\pi^0\pi^0$ to 10^{-3} level
Prototypes under development:
- Converter + NA62 Gigatracker (Si pixel)-based veto
- Dense inorganic Cerenkov crystal veto

Expected results with 2 yrs of data:
- $\pi^0\nu\bar{\nu}$ cand. with 2γ on LKr, nothing else
- Vertex in FV with $p_\perp(\pi^0) > 0.1$ GeV

~10 signal evts
~10 $\pi^0\pi^0$ background evts

Nominally 2× better than KOTO (JPARC)

A $K_L \to \pi^0 \nu\bar{\nu}$ experiment will require long lead time
- Significant construction work, R&D, prototyping necessary
- Aim for turn-on in Run 3 or for a more ambitious measurement in Run 4?

Possible future kaon experiments at the SPS – M. Moulson (Frascati) – LTS1 – Isola d'Elba, 22 May 2014 13

LFV decays $\mu \rightarrow e\,\gamma$ and $\mu \rightarrow e\,e\,e$ at PSI

G. Signorelli

Key elements to MEG II

μ

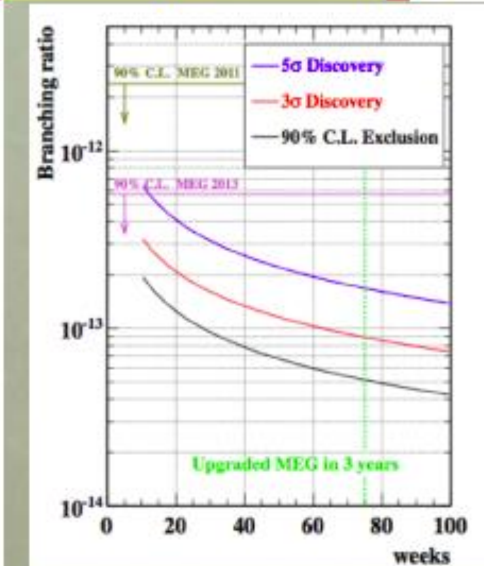
1. Increasing μ^+–stop on target
2. Reducing target thickness to minimize e+ MS & brehmsstrahlung

e

3. Replacing the e+ tracker reducing its radiation length and improving its granularity and resolutions
4. Improving the timing counter granularity for better timing and reconstruction
5. Improving the positron tracking-timing integration by measuring the e+ trajectory up to the TC interface

γ

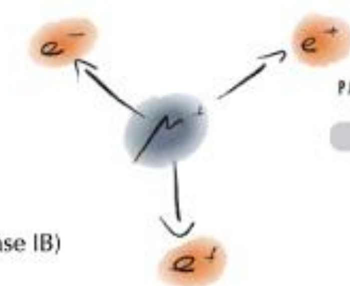
6. Extending the γ–ray detector acceptance
7. Improving the γ-ray energy and position resolution for shallow events
8. Integrating splitter, trigger and DAQ maintaining a high bandwidth



Expected Sensitivity up to few x 10^{-14}

Mu3e at PSI

- Search for $\mu \rightarrow e\,e\,e$
  - 10^{-15} sensitivity in phase IA / IB
  - 10^{-16} sensitivity in phase II
- Project approved in January 2013
  - Double cone target
  - HV-MAPS ultra thin silicon detectors
  - Scintillating fibers timing counter (from phase IB)



PAUL SCHERRER INSTITUT

What is g-2? Why is needed ?

a_μ = (g-2)/2 is derived from the precession of the muon spin in a well-measured magnetic field

- New experiment at FNAL (E989) at magic momentum, Consolidated method.
- **20 x** μ w.r.t. E821 @ BNL.
- **Relocate the BNL storage ring to FNAL.**

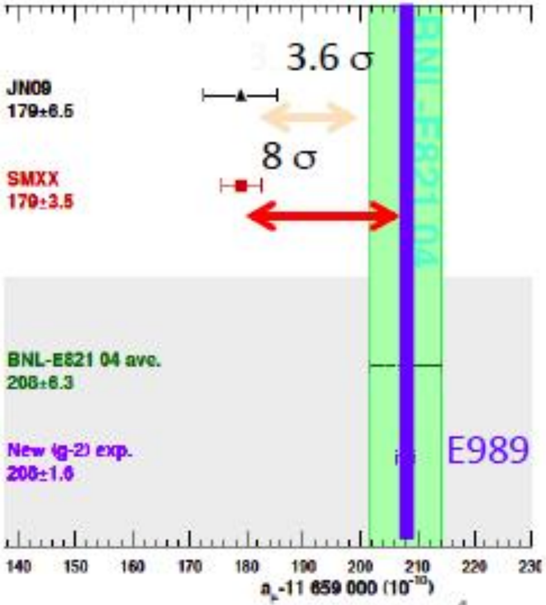
$\Rightarrow$ **a x4 improvement on a_μ (from 540 ppb to 140 ppb)**

If the central value remains the same $\Rightarrow$ 5-8 σ from SM* (enough to claim discovery of New Physics!)

*Depending on the progress on Theory

From G.Venanzoni

Thomas Blum; Achim Denig; Ivan Logashenko; Eduardo de Rafael, . oberts, B.; Thomas Teubner; Graziano Venanzoni (2013). "The Muon (g-2) heory Value: Present and Future". arXiv:1311.2198 [hep-ph].

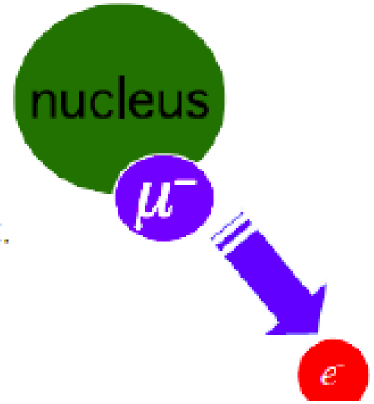


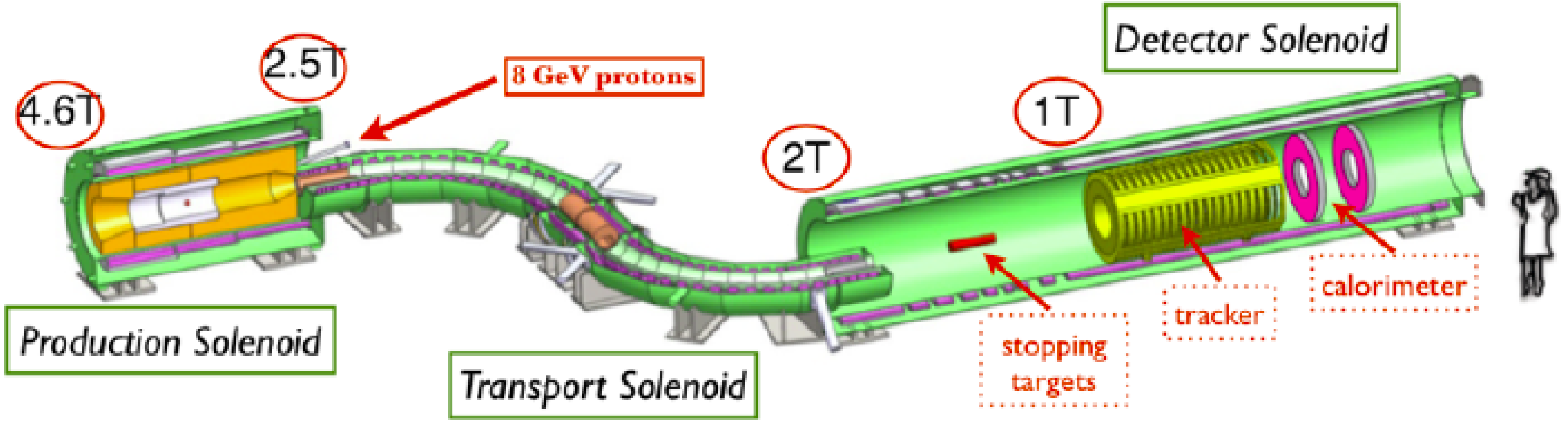
What is Mu2e? Why is needed ?

- Initial state: muonic atom
- Final state:
  - a single mono-energetic electron.
    - the energy depends on Z of target.
  - recoiling nucleus is not observed
    - the process is coherent: the nucleus stays intact.
  - neutrino-less
- Standard Model rate is 10^{-54}

60% Muon Capture
40% DIO

$$\mu N \rightarrow eN$$

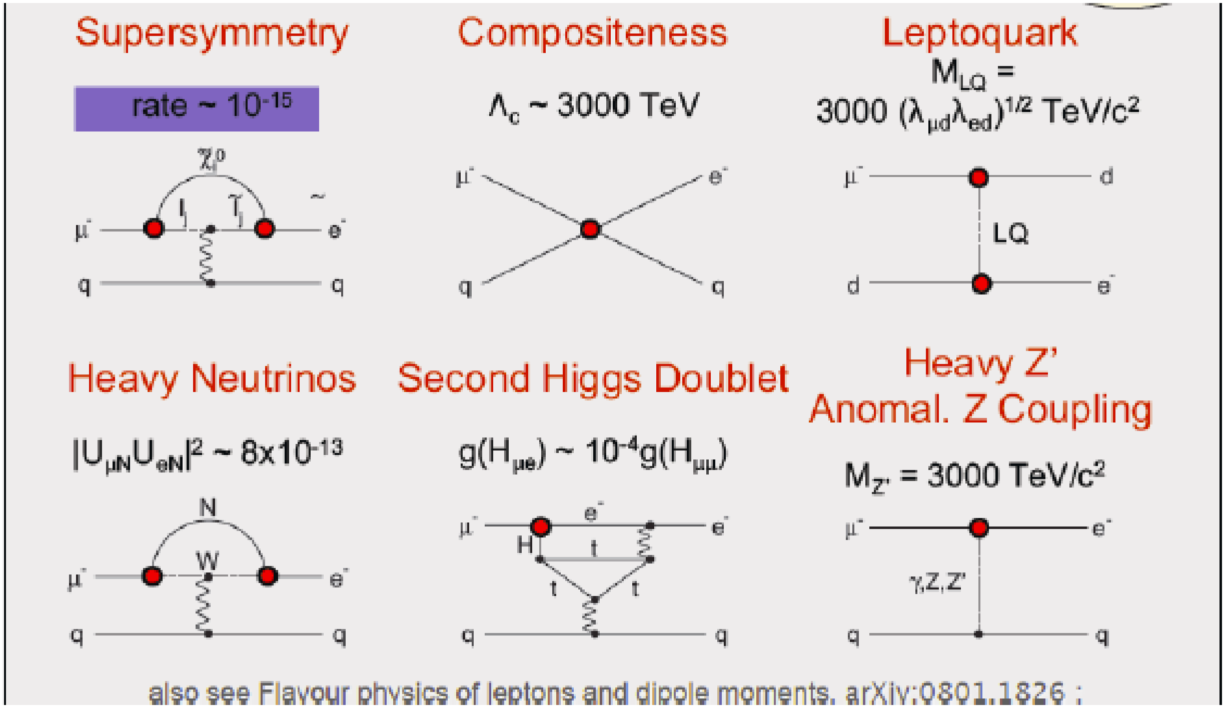




Mu2e….

Sensitivity reach:
10^4 improvement with respect to previous conversion experiment (Sindrum-II)

→ Extinction
→ Delayed gate
→ Precise Resolution

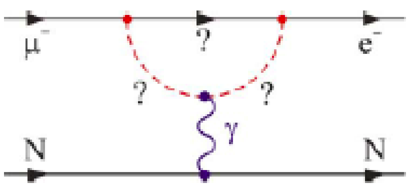


$$R_{\mu e} = \frac{\Gamma(\mu^- + N(A,Z)) \rightarrow e^- + N(A,Z)}{\Gamma(\mu^- + N(A,Z) \rightarrow \text{ all muon capture})} \leq 6\times10^{-17} \text{ (@90\%CL)}$$

Mu2e….

$$L_{CLFV} = \frac{m_\mu}{(\kappa+1)\Lambda^2}\bar{\mu}_R\sigma_{\mu\nu}e_L F^{\mu\nu} + \frac{\kappa}{(1+\kappa)\Lambda^2}\bar{\mu}_L\gamma_\mu e_L(\bar{u}_L\gamma^\mu u_L + \bar{d}_L\gamma^\mu d_L)$$

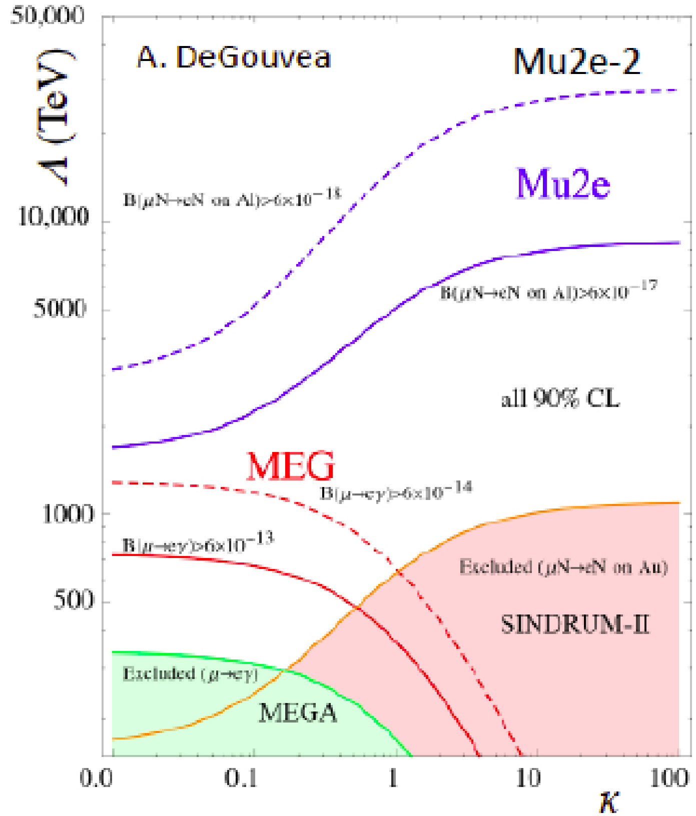
Loops dominate for $\kappa \ll 1$



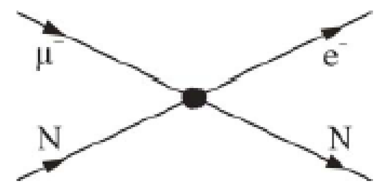
$\mu \to e\gamma$

$\mu N \to eN$

$\mu \to eee$



Contact terms dominate for $\kappa \gg 1$



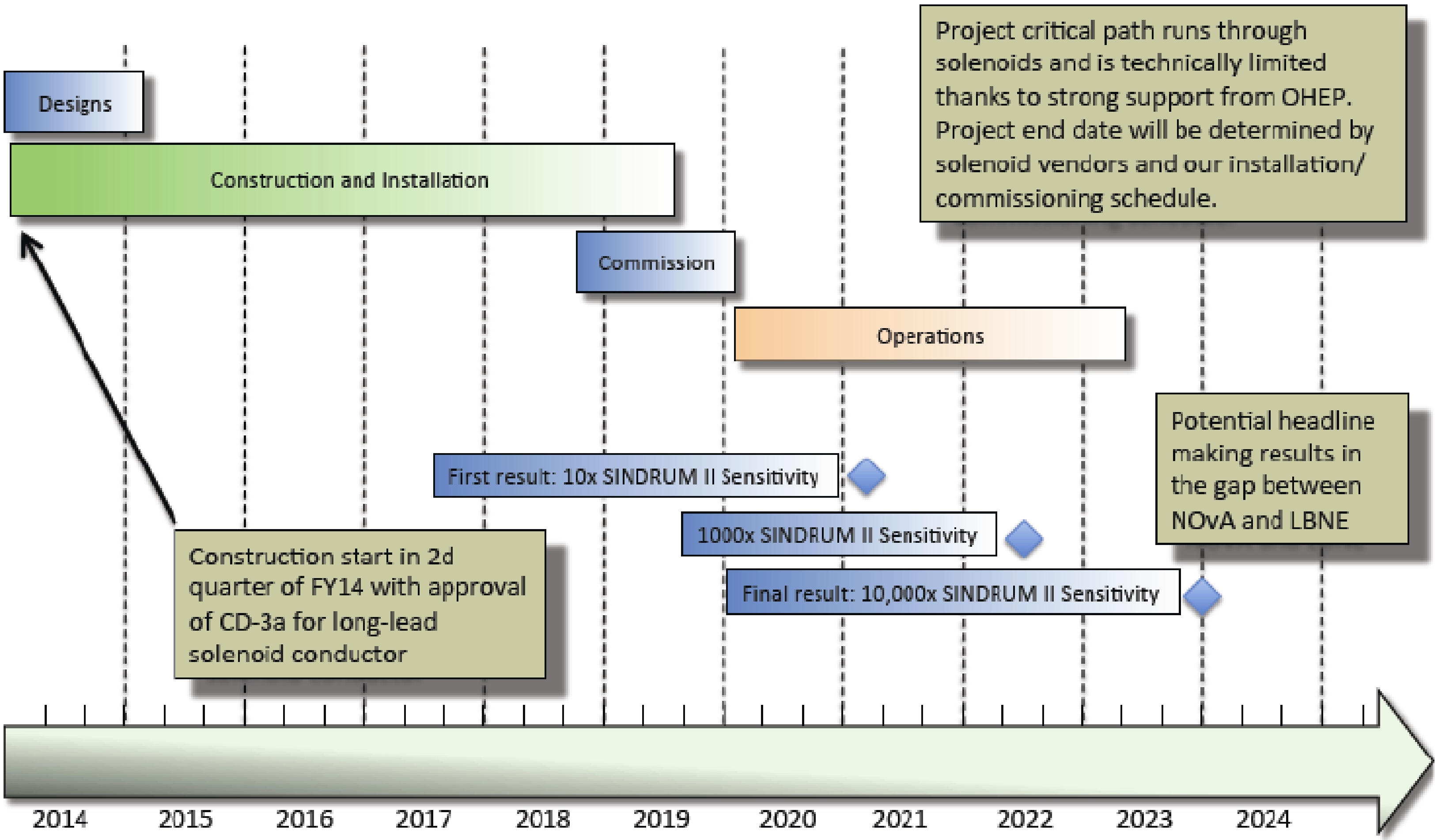
~~$\mu \to e\gamma$~~

$\mu N \to eN$

$\mu \to eee$

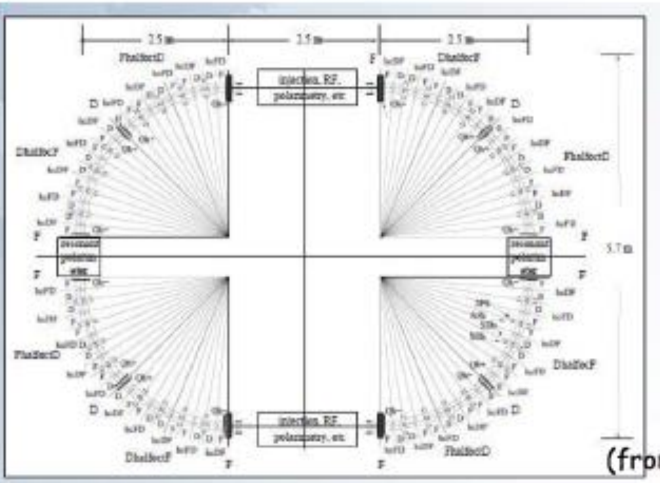
Sensitive to mass scales up to $\mathcal{O}(10^4\ \text{TeV})$

Schedule Mu2e



Electrostatic electron ring at LNF?

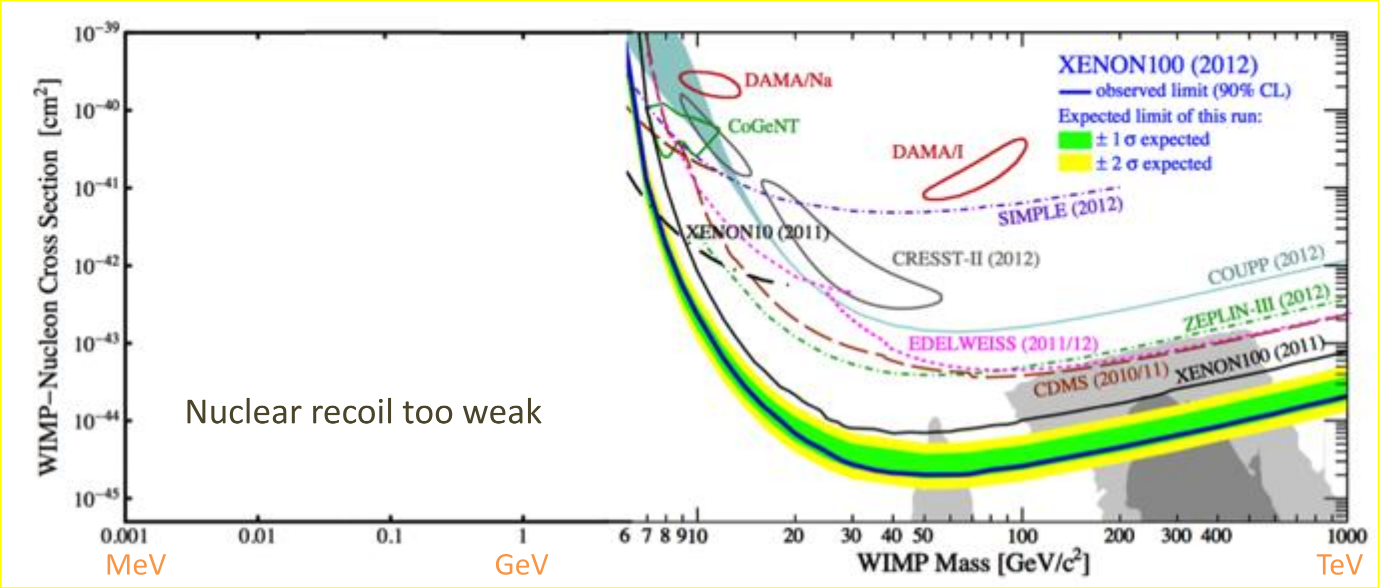
- First ever DIRECT measurement of electron EDM.
- Compact
  - Magic energy for electron: 14.5 MeV (γ=29.4)
  - E = 2-6 MeV/m $\rightarrow$ $2\pi R$ = 50 - 20 m
- Technical challenge, modest investment.
- Mandatory step for larger machines (proton and deuteron $\rightarrow$ $2\pi R$ > 250 m).
- Open issue: polarimetry.



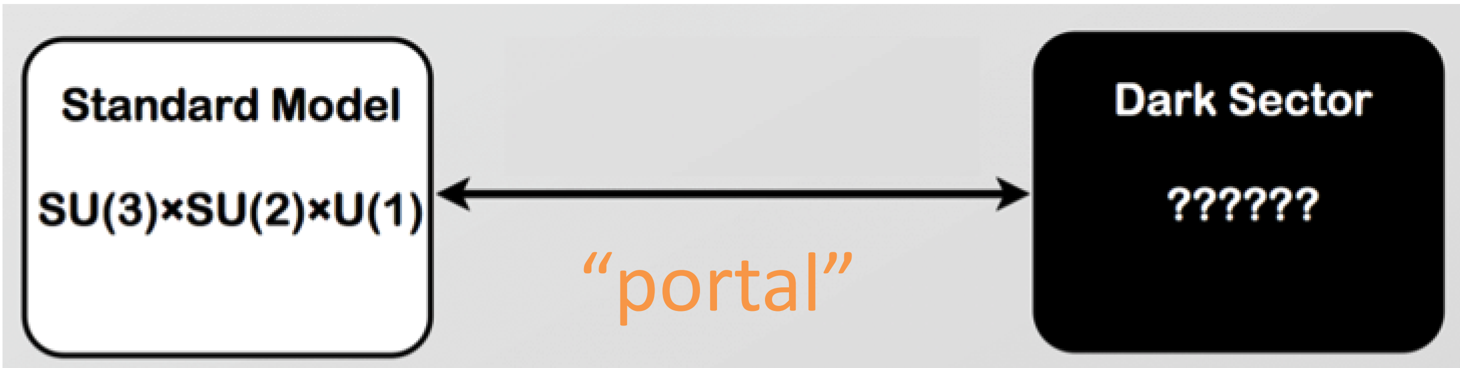
(from R. Talman)

BSM: secluded DM

- **Problem**: connect dark matter (e.g. WIMPs) to *SM* particles while being compatible with direct measurements:
  - Low elastic cross section on nuclei
  - Low production rates at colliders
- **Solution**: DM not directly connected to the *SM*, but only through “mediator” particles
- Hidden or secluded or dark sectors often present in string teories and supersymmetry
- Simple model: add additional U(1)’ gauge group, but a vector boson is not the only possible mediator
  - Singlet scalar, right-handed neutrino, non-Abelian interactions in the secluded sector, arXiv:0711.4866 [hep-ph]
- The mediator could be not the lightest dark particle and thus it is not itself a DM candidate



Portals to secluded sector



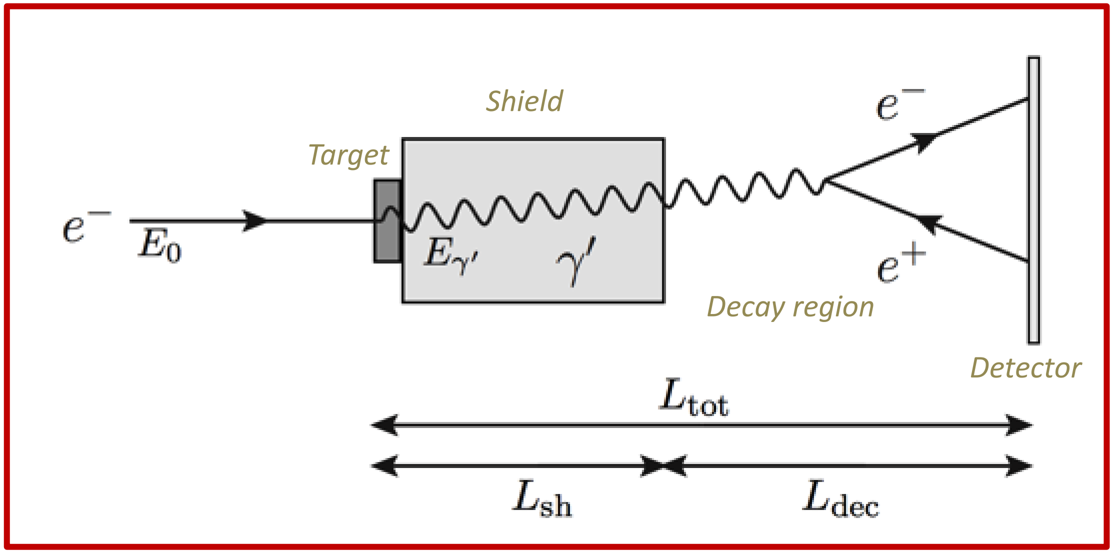
vector	$\frac{1}{2}\epsilon F^{Y}_{\mu\nu} F'^{\mu\nu}$	dark photon
Higgs	$\epsilon_h \lvert h\rvert^2 \lvert\phi\rvert^2$	dark scalar
neutrino	$\epsilon_\nu (hL)\psi$	sterile neutrino
axion	$\frac{1}{f_a} a F_{\mu\nu} \tilde{F}^{\mu\nu}$	ALPs

Dark photon experiments

- Thick target (beam-dump)
- Thin target + decay of dark photon:
  - Decay to visible particles ($e^+ e^-$, $\mu^+ \mu^-$, …)
    - "Bump hunting", looking for a peak in the invariant mass
    - Displaced vertices, looking for long-lived particles
  - Decay to invisible particles
    - Look for missing mass
    - DM particles recoil

[Meson decays]

Electron beam-dump experiments



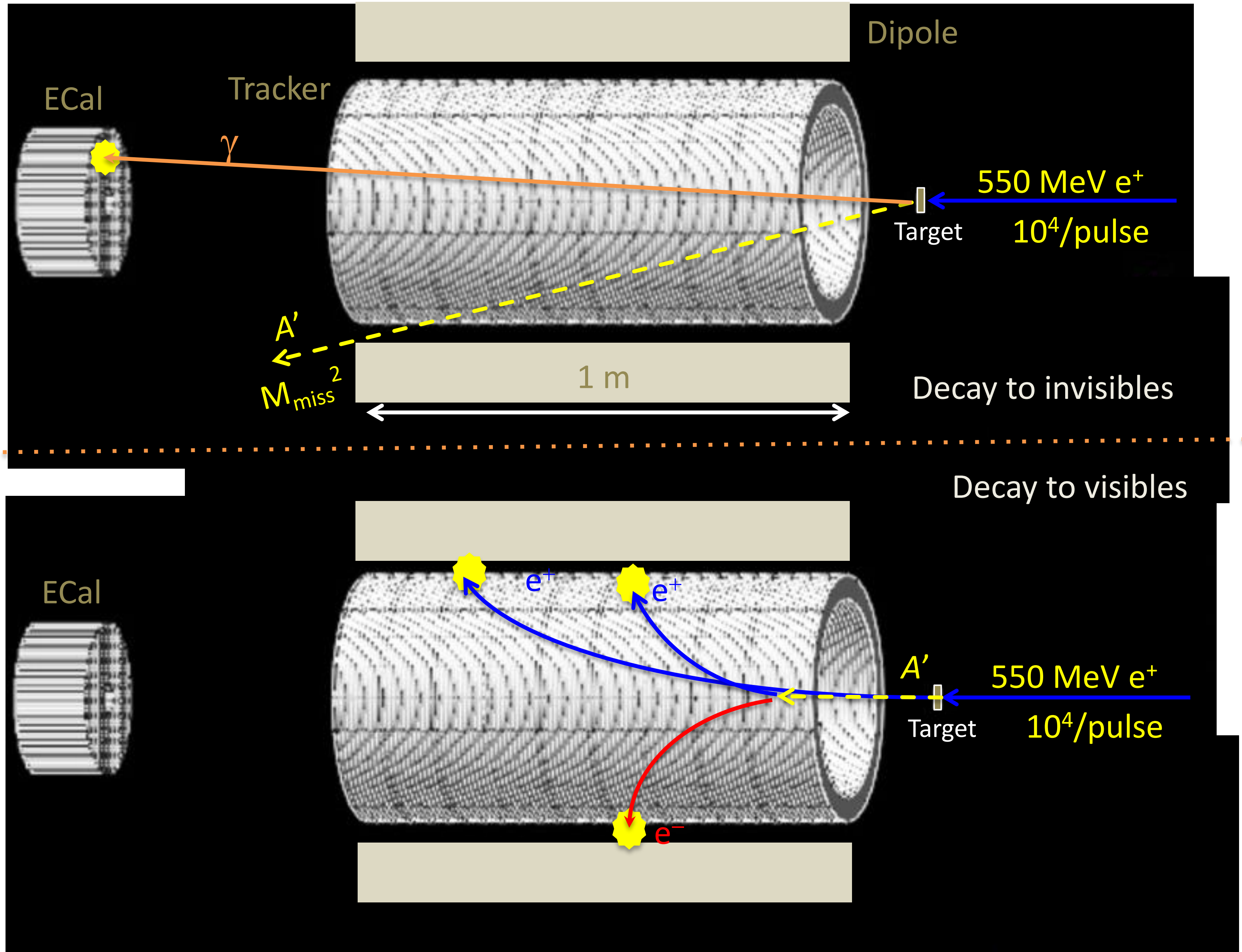
Luminosity: $$\mathcal{L}^{\rm ft} \simeq N_e \frac{N_0 \rho_{\rm sh} l_{\rm sh}}{A}$$

At colliders: $$\mathcal{L}^{\rm coll} \simeq \frac{N_e^2}{\mathcal{A}_{\rm b}}$$

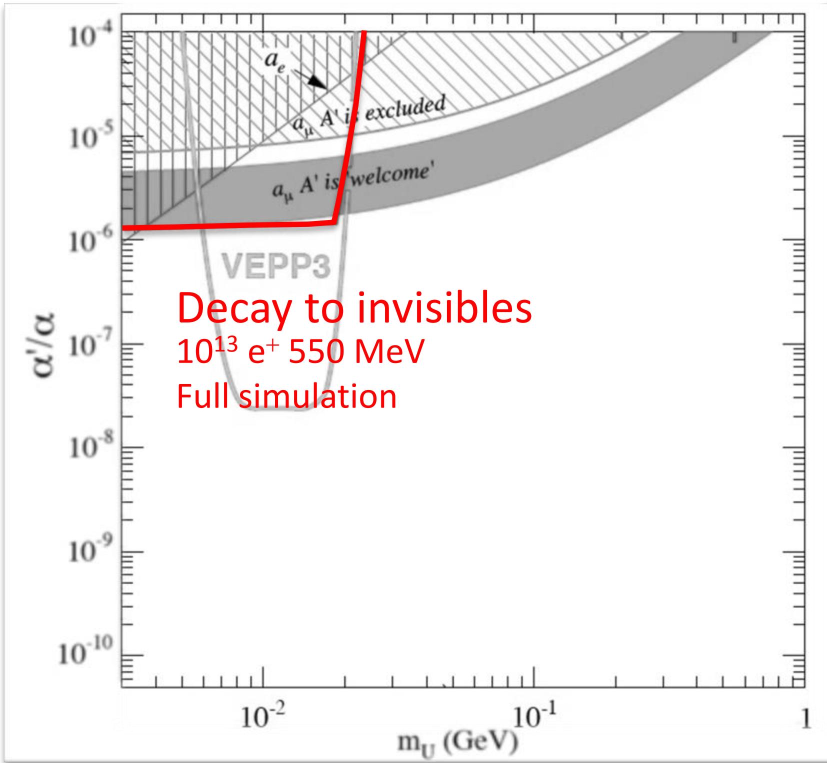
Beam section

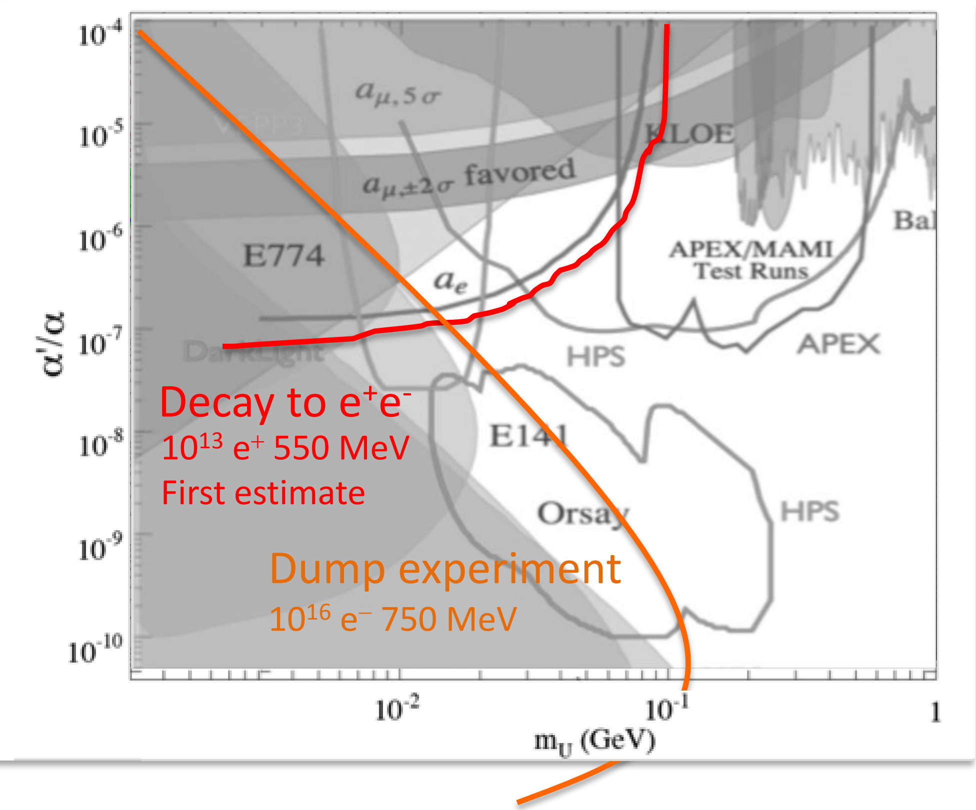
In addition to cross section advantage

PADME at Frascati



PADME at Frascati



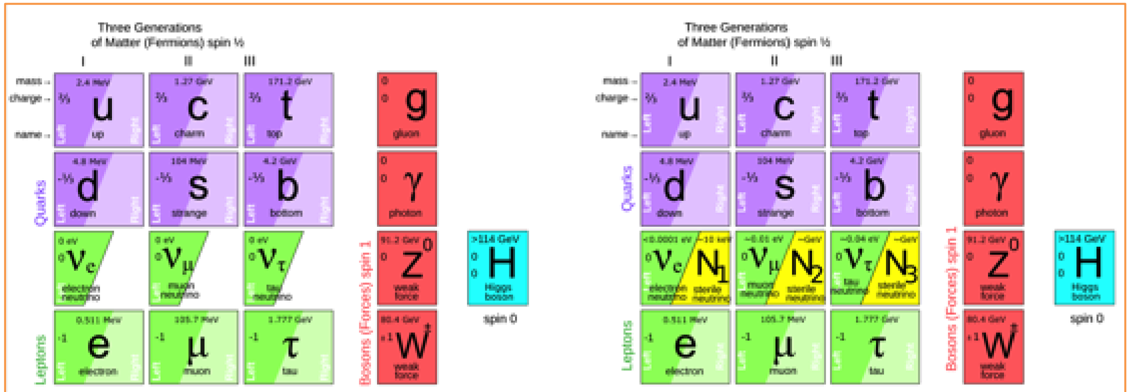


- **Positron annihilation experiments (decay to invisibles and e+e-): 10^4 electrons/bunch × 50 Hz × $2\cdot10^7$ seconds**
- **Beam dump on thick target: 10^{16} electrons at 750 MeV dumped**

Heavy neutral lepton

- **Alternative to see-saw mechanism for neutrino masses: instead of a very heavy neutral lepton, new leptonic flavours with masses similar to those of known quarks and leptons. This gives the possibility of direct experimental search.**
- **This can explain the missing of WIMP particles at LHC (DM particles are just too light)**
- **Baryogenesis due to those new leptonic flavours**

Shaponikov neutrino (νMSM) is a realization of this model



Role of N_1 with mass in keV region: dark matter

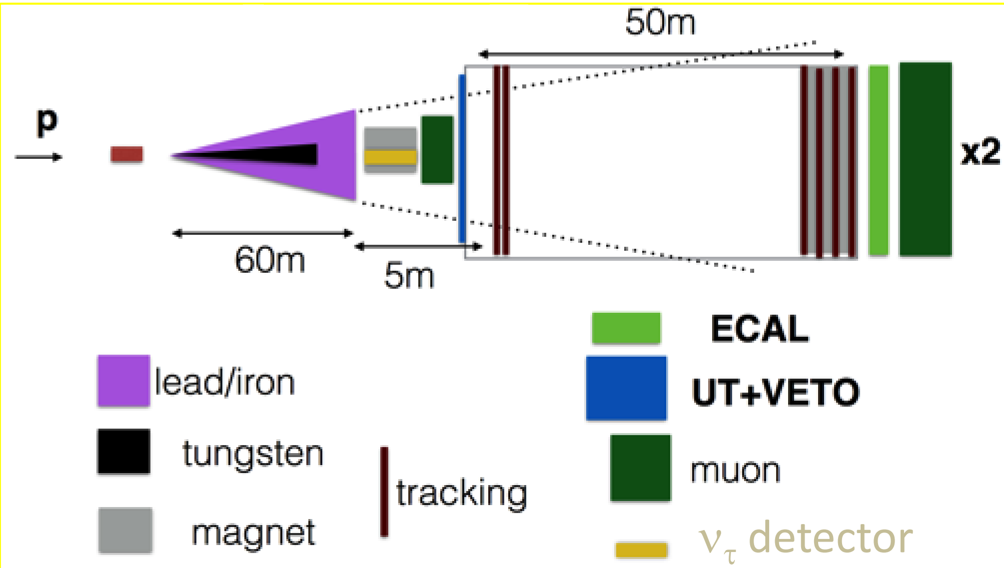
Role of N_2, N_3 with mass in 100 MeV – GeV region: "give" masses to neutrinos and produce baryon asymmetry of the Universe

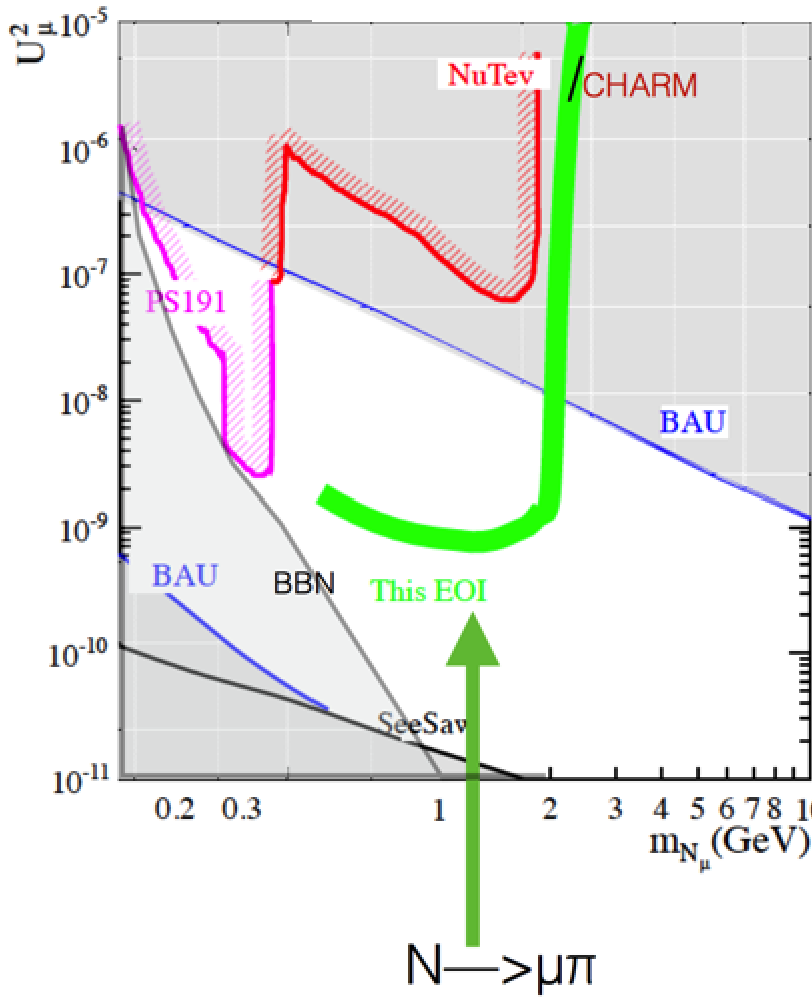
Role of the Higgs: give masses to quarks, leptons, Z and W and inflate the Universe.

Role of scale invariance and unimodular gravity: dilaton gives mass to the Higgs and $N_{1,2,3}$ and provides dynamical dark energy

Heidelberg, 13 and 14 July 2011 – p. 12

SHiP at CERN SPS

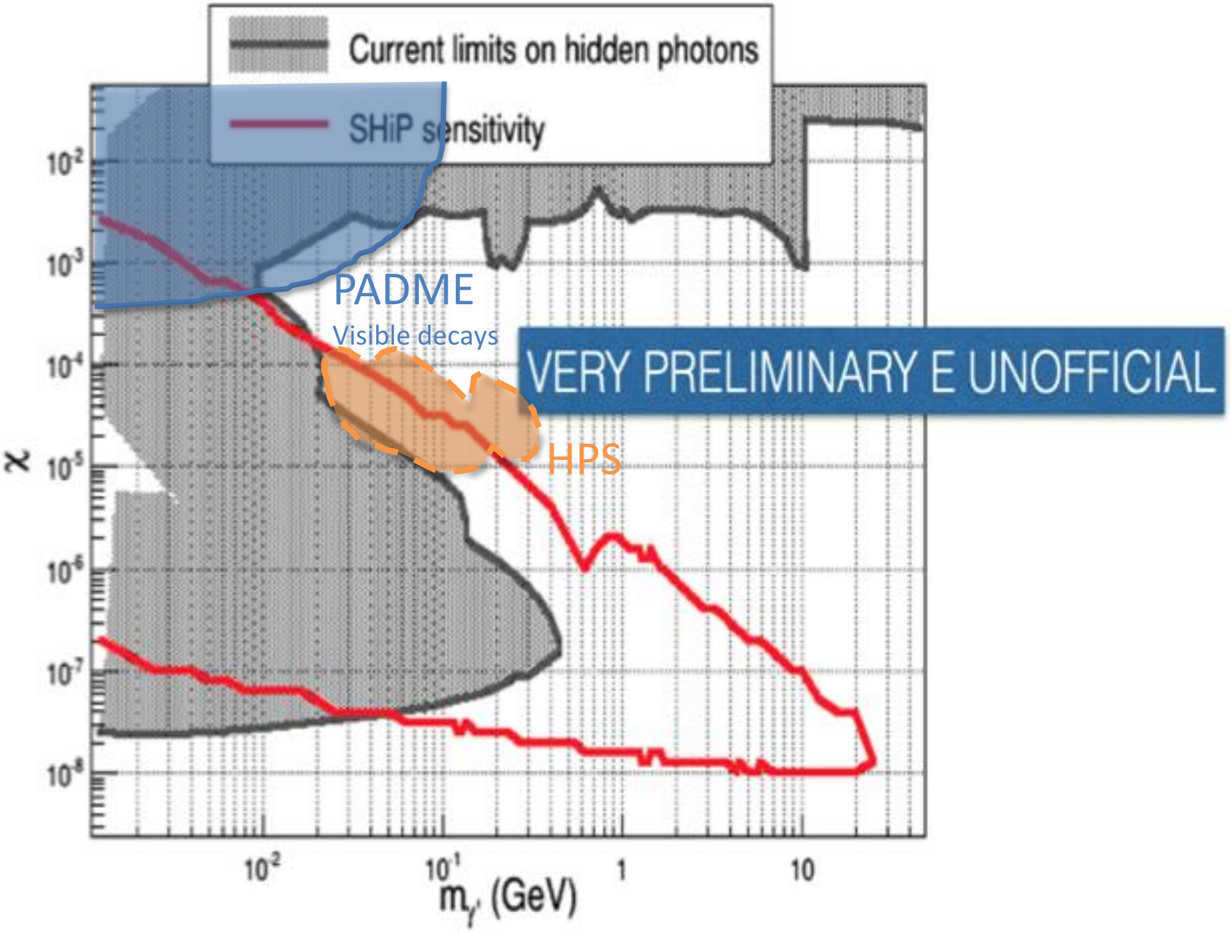




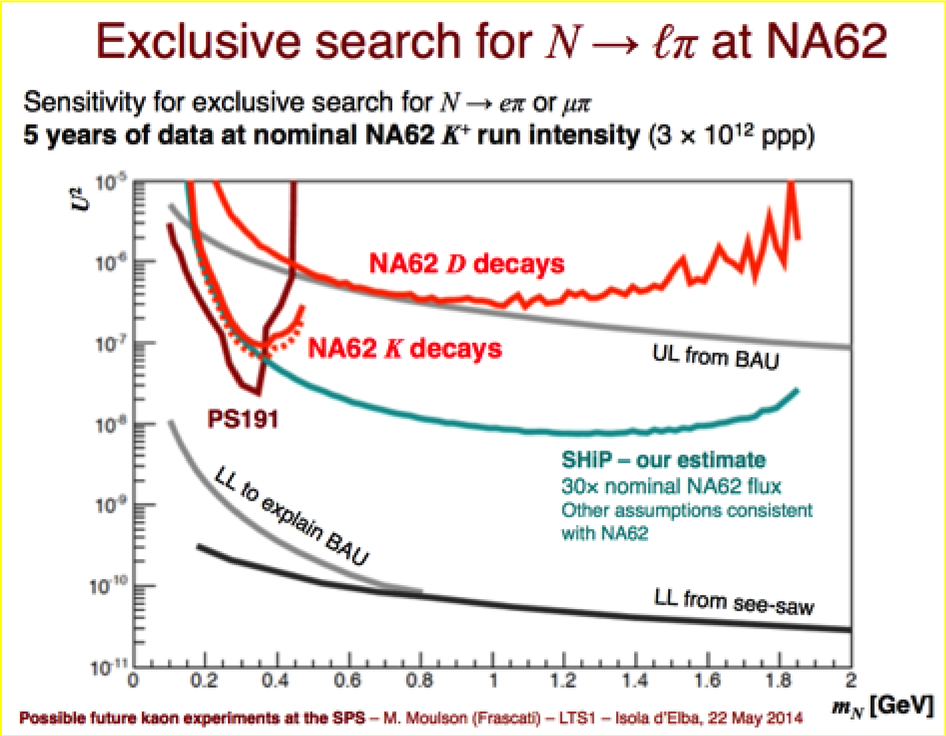
$2{\times}10^{20}$ pot

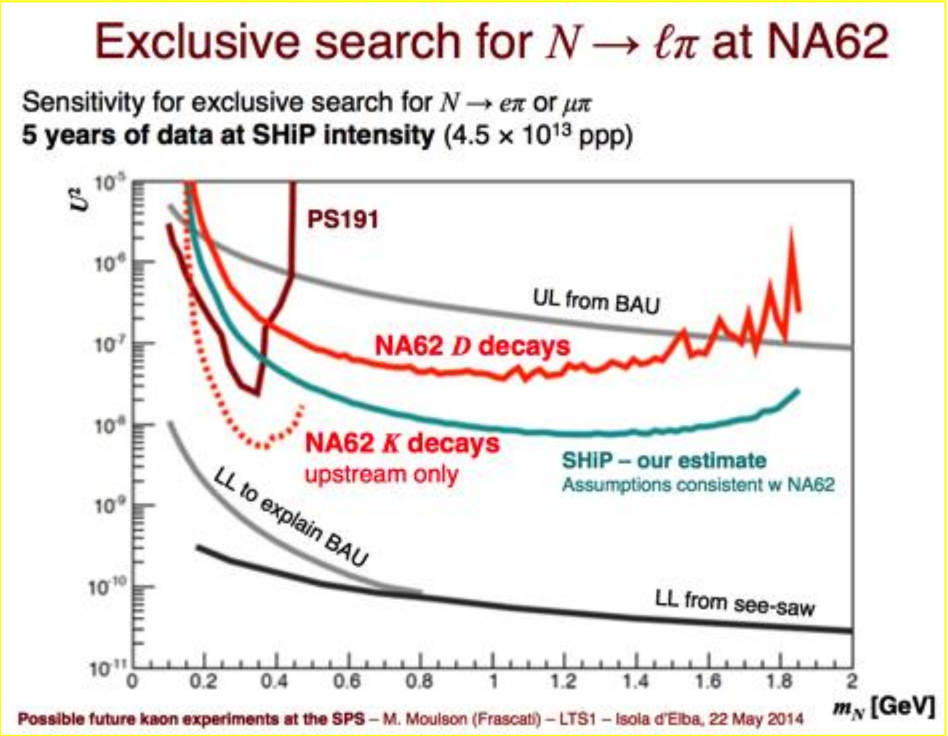
Zero background

SHiP (dark photon search)



HNL at NA62





Still **a factor 10 below** SHiP for D decays

International scenario:

- **EU strategy update May 2013**
  - ***Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade*.**
  - ***CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines.***
    - ***high-field magnets and high-gradient accelerating structures***
  - ***Europe looks forward to a proposal from Japan to discuss a possible participation.***
  - ***Experiments in Europe with unique reach should be supported, as well as participation in experiments in other regions of the world.***

- P5 report released May 22, 2014
  - **Use the Higgs boson as a new tool for discovery**
  - Complete the LHC phase-1 upgrades and continue the strong collaboration in the LHC with the phase-2 (HL-LHC) upgrades of the accelerator and both general purpose experiments (ATLAS and CMS). The LHC upgrades constitute our highest-priority near-term large project.
  - Motivated by the strong scientific importance of the ILC and the recent initiative in Japan to host it, the U.S. should engage in modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise.
  - Complete the Mu2e and muon g-2 projects
    - the Mu2e profile could be adjusted by a small amount if needed

- SuperKEKB
  - Full support to Belle2
- J-PARC
  - COMET phase1 funded/started – phase2 future funding
  - KOTO in progress
- LHC
  - Participation to phase2 upgrade (magnets and Atlas)
- ILC
  - Negotiating international cooperation → decision by 2018
  - Potential construction schedule 2021 -2028 (250 GeV option)
    - 360 and 500 GeV will follow

- BEPC2: Explore full potential
  - 8-10 yr more then need new project
  - Super tau-charm factory does not have large enough scope!
- Limited interest in LHC and ILC

FALC FUNDING AGENCIES FOR LARGE COLLIDERS

- Circular Higgs factory fits our strategic needs:
  - Science (great & definite physics)
  - Timing (after BEPCII)
  - Technological feasibility
  - Manpower reality (our hands are free after ~2020)
  - Economical scale (although slightly too high)

A 50-70 km tunnel is very affordable in China NOW

- The risk of no-new-physics is complemented by a pp collider in the same tunnel
  - A definite path to the future
- ee schedule: build 2021-27, physics 2028-35
- pp schedule: build 2035-2042, physics 2042 - ....

CSN1 vs LHC future

- Large INFN involvement ~ 500 FTE/ 60% of CSN1 budget:
  - ATLAS/CMS: Phase 1 fully funded and in progress
  - ATLAS/CMS: Phase 2 R&D funded & starting
  - ATLAS/CMS: Phase 2 upgrades under discussion
    - Logical continuation for INFN-LHC community
    - Strong physics case
    - Strong international support in Europe, US and Japan
    - Construction: 2018 – 2025, data: 2026-2035
      - A long way to get to 3000 fb-1 ..... Is it sustainable?
      - Does TOTEM makes still sense after completion run2 ... (3)?
  - LHCb:
    - Upgrade approved by INFN
    - Construction: now – 2019, data: 2020 - > 2028 ???
      - How long can it really last? How far can we push flavor physics at LHC?
      - Where does the community go?

CSN1 vs Asia

- Belle2:
  - Completing constructions, data 2016 for ~10 yrs
  - Minor upgrade in between running periods
  - What then? Not obvious physics is compelling after that, nor upgrade path
  - Community has interest in ILC if it happens
    - Timing roughly matches/ Could get support from part of LHC communities → this could have implications on LHC experiments
- BES-III:
  - Data taking in progress for 8-10 more years
  - INFN group growing. Participating in tracking chamber upgrade
    - What happens 10 years from now? TLEP or ILC?
- These communities play important role in case of major developments in Asia

CSN1 vs muons

Strong case for CLFV physics

MEG@PSI:

- **Upgrade in progress. Data 2015-2018.**
- **Room for additional update? Potential for joining Mu2e upgrade**

Mu2e@FNAL:

- **R&D/planning fase – critical decisions 2014-15 – data 2020 – 25**
- **INFN collaboration getting ready for constrution**
  - **What are chances for future expansion? Upgrade for PIP-I/II?**

G-2@FNAL

- **R&D/Construction fase – data 2016-19**
- **Part of collaboration could merge into Mu2e or upgrade for EDM**?

CSN1 vs LNF future

- PADME@BTF:
  - Search for dark photons in visible and invisible channels
    - Simple layout and interesting physics
    - Is physics reach competitive enough?
- Electron EDM@LNF:
  - Need to construct small ring $2\pi R \sim 20\text{-}50$ m
  - Are costs and physics reach competitive?
  - Are there technical issues still to be solved (eg. Polarimetry)?
    - In general very challenging technically

CSN1 vs SHIP ?

- SHiP:
  - Search for HNL with beam dump experiment
  - Physics interesting, but
    - Is it covering enough parameter space? Can it be increased by improving the design?
    - Is the large cost of the beam dump justified by the physics? Waiting to SPSC recommendations.
  - R&D/Studies starting now
  - What are the limits of potential reach of LHCb, NA62 in this measurement?

CSN1 vs large electron colliders

- Lepton collliders:
  - ILC:
    - Is the physics still compelling given the small Higgs mass (can build TLEP for similar or smaller price and have tunnel for pp)?
      - Room for new physics after LHC results is reduced.
    - Decision will be political in the end (or major discoveries at LHC?)
    - If ILC goes on should participate: it will be the first leptonic Higgs factory
      - «Higgs can potentially couple wildly» → detailed study is mandatory!
  - TLEP (CERN or China):
    - An attractive possibility, but needs a large tunnel
    - Feasiblity/cost in CERN area still to be verified (?)
    - Is China serious or is it just politics?
- Better keep all options open to these possibilities

CSN1 vs future hadron colliders

- **Hadron colliders O(33-100 TeV):**
  - **Largest discovery power!**
  - **Need tunnel and new generation of magnets**
    - **Magnets ready for construction ~2025, industry could start delivery 2030 with completion few years later**
    - **In LHC tunnel could upgrade energy to 33 TeV if nothing else happens in the world**
      - **Is factor 3 sufficient? Cost is ~ 7 BCHF! Depends on discoveries!**
    - **If aim to 100 TeV large tunnel (~100 km):**
      - **Can it really be done in CERN area? Can EU sustain the cost?**
      - **If China goes ahead, what is the future of CERN? CLIC?**
- **LHeC (... and american variants EIC etc ...)**
  - **Besides specific physics large reduction of pdf systematics**
  - **May leave something in EU if energy frontier goes to Asia**

Morale

Molte più domande che risposte

Gli scenari cambiano radicalmente in caso di possibili scoperte nel Run II di LHC

HL-LHC è ormai sicuro

Fra le opzioni «in pista» al momento ILC resta la più forte, sia scientificamente (naturale completamente di LHC), sia politicamente e finanziariamente.

Esperimenti piccoli e medi possono ancora dirci cose importanti su modelli di NP alternativa.