

Russian Academy of Sciences

P.N. Lebedev



Physical
Institute

L P I

Geant4 ASSOCIATES
INTERNATIONAL
Experts in Radiation Simulation

SOFT



New extended example dmparticle

V. Grichine and V. Ivanchenko

P. N. Lebedev Physics Institute, Moscow, Russia

CERN, Geneva, Switzerland

22th Geant4 Collaboration workshop

UOW Campus, Wollongong, Australia¹

25-29 September 2017

Dark matter particles

Three Generations of Matter (Fermions) spin $\frac{1}{2}$

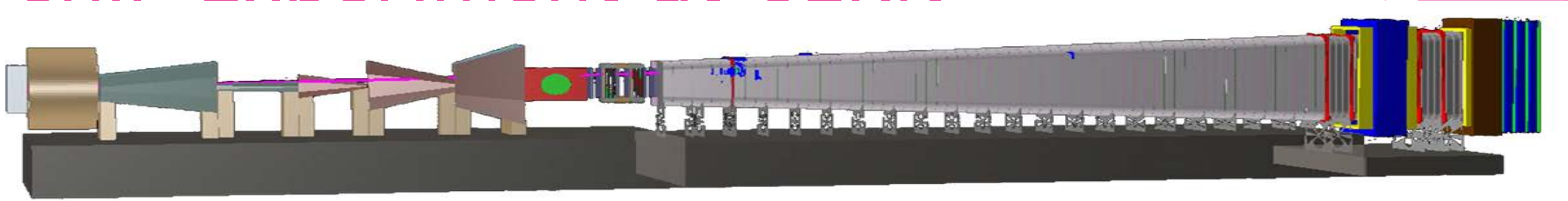
	I	II	III	
mass →	2.4 MeV	1.27 GeV	173.2 GeV	
charge →	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	
name →	u up	c charm	t top	
Quarks	Left Right	Left Right	Left Right	
	mass →	4.8 MeV	104 MeV	4.2 GeV
	charge →	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$
name →	d down	s strange	b bottom	
Left Right	Left Right	Left Right	Left Right	
Leptons	mass →	~ 10 keV	\sim GeV	\sim GeV
	charge →	0	0	0
	name →	ν_e N₁ electron neutrino	ν_μ N₂ muon neutrino	ν_τ N₃ tau neutrino
Left Right	Left Right	Left Right	Left Right	
Leptons	mass →	0.511 MeV	105.7 MeV	1.777 GeV
	charge →	-1	-1	-1
	name →	e electron	μ muon	τ tau
Left Right	Left Right	Left Right	Left Right	

Bosons (Forces) spin 1	mass →	0	0	91.2 GeV
	charge →	0	0	0
	name →	g gluon	γ photon	Z⁰ weak force
Bosons (Forces) spin 0	mass →	126 GeV		
	charge →	0		
	name →	H Higgs boson		

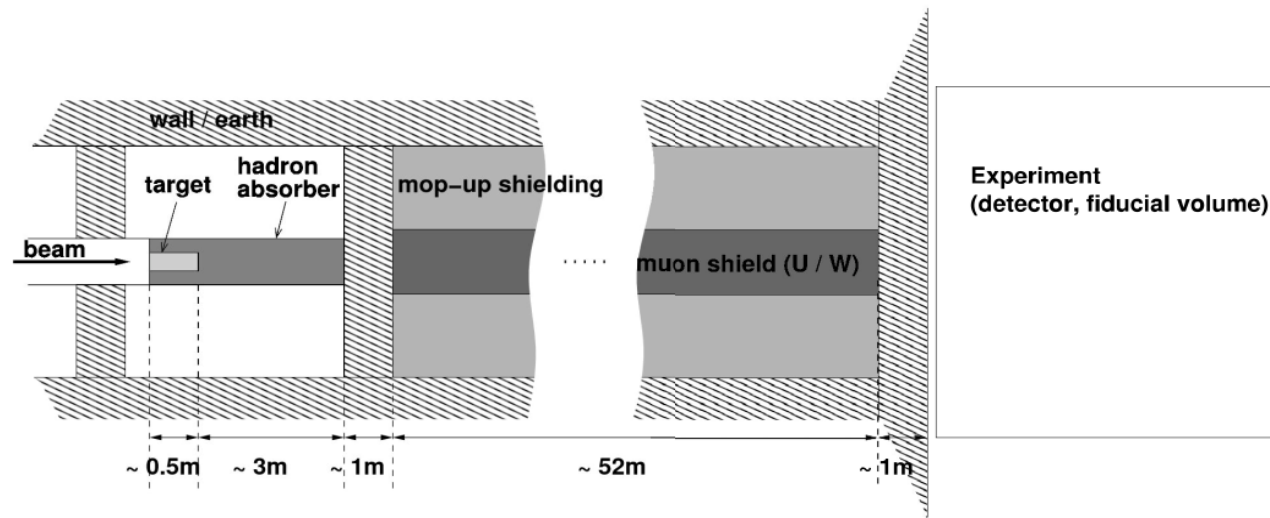
The minimal set of left hand fermions includes N_1, N_2, N_3 light objects having very weak coupling with standard fermions and bosons

Interactions of left hands fermions are very similar to electromagnetic and weak interactions of standard fermions and bosons but with different coupling constant

SHiP Experiment at CERN



- The SHiP Experiment is a new general-purpose beam dump facility at the SPS
- Search for dark matter, neutrino oscillations, and the origin of the full baryon asymmetry in the Universe
- It is aimed at searching for very weakly interacting long lived particles including Heavy Neutral Leptons (HNL) or Light Dark matter particles (LDM)
- Background is neutrino flux and residual muon flux



New Geant4 extended example

- ▶ `$G4INSTALL/example/extended/exoticphysics/dmparticle`
 - ▶ New example created for run in MT mode
- ▶ It is a preliminary and simplified LDM particle creation and interaction
- ▶ New particles can be `G4LDMPhoton`, `G4LDMHi` and `G4LDMHiBar`
 - ▶ Particle masses should be defined in command line
 - ▶ before `G4MTRunManager` is created property of LDM particles should be defined
- ▶ Physics List include components:
 - ▶ EM physics from standard builders
 - ▶ Decay physics
 - ▶ LDM physics
 - ▶ For today only bremsstrahlung process creating `G4LDMPhoton` is implemented
 - ▶ Base class `G4MuBremsstrahlung`
- ▶ Geometry - a simple target with size and material defined via UI commands

Plans beyond 10.4

- ▶ **Implementation of new LDM models**
 - ▶ Enable various mechanisms of LDM production
 - ▶ EM interactions of LDM particles
 - ▶ Variable coupling between LDM and standard particles
- ▶ **Add neutrino interactions**
- ▶ **Study of biasing with natural space distribution of rare events**
 - ▶ Embedding realistic space distribution of LDM and neutrino forced interactions
 - ▶ Introduce more complex geometry