

Tourniquet Section 01 Date 3-5 Feb 2020

## **Team 5 – MANOIR**

# Synergy based on cryogenic detectors: Direct dark matter with EDELWEISS

- CENNS and neutrino physics with Ricochet
- Double beta decay search with CUPID-Mo

2015-2020



## **Current team**

- 6+1 permanent positions: 4EC + 2C + 1 IR
  - Corinne Augier (UCBL), Antoine Cazes (UCBL), Jules Gascon (UCBL), Véronique Sanglard (UCBL, long-term sick leave)
  - Julien Billard (CNRS), Maryvonne De Jésus (CNRS)
  - Alexandre Juillard (IR CNRS, Instrumentation, ex-technical coordinator of EDELWEISS, current technical coordinator of Ricochet)
- 2 PhD students (+ 1 thesis stopped after 6 months sick leave Eva Elkhoury)
  - Dimitri Misiak
    - Director J. Billard (+ C. Augier HDR guarantor)
    - Defense expected in 10/2020 (Development of low-threshold cryogenic detectors for low-mass dark matter study and search for new physics with neutrino-nucleus scattering)
  - Jean-Baptiste Fillipini
    - Direction A. Juillard (+ C. Augier HDR guarantor)
    - Defense expected in 10/2022 (Development of low-threshold cryogenic detectors with high discrimination power for low-mass dark matter study and low-energy neutrino-nucleus scattering)
- 3 postdocs
  - Thomas Salagnac (2-year postdoc ERC since 2019, 1st April)
    - Simulations for the Ricochet project
  - Quentin Arnaud (2-year Marie Curie fellowship since 2019, 1st April)
    - Selendis project and analyses for the EDELWEISS-SubGeV project
  - Hugues Lattaud (2-year postdoc In2p3 since 2019, 1<sup>st</sup> December)
    - Analyses for the EDELWEISS-SubGeV projects and the Ricochet R&D developments
- 1 long-stay visitor: Valérian Sibille (Postdoc MIT, Simulations for Ricochet, MISTI funds)
  Groupe MANOIR
   Tourniquet Section 01 de l'IP2I 3-5 Feb 2020
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## **Team evolutions**

- 3 PhD theses defended:
  - Quentin Arnaud (11/02/2015, direction Jules Gascon) EDELWEISS-III data analysis with FID detectors, projections and study of charge trapping (→ Postdoc @Queens on NEWS-G 02/2016-01/2019, then Marie Curie fellowship @IP2I)
  - Cécile Kéfélian (05/02/2016, co-direction Corinne Augier + Klaus Eitel KIT Karlsruhe (Germany)) – EDELWEISS-III muon veto detector calibration, data analysis of neutrons induced by muons (→ Postdoc @Berkeley on SNO+ 10/2016-09/2017, then industry job in Karlsruhe)
  - **Emeline Queguiner** (23/10/2018, direction Jules Gascon) EDELWEISS-LT data analysis + heat-only event study, 1st likelihood limit for WIMPs below 6 GeV/c<sup>2</sup> ( $\rightarrow$  CDI data scientist, Clermont-Ferrand since April 2019)
- 0 HDR :
  - 1 HDR is planed (J. Billard) before Sep 2020 (UCBL research committee agreement already obtained)
- 1 postdoc :
  - Romain Maisonobe (LIO postdoc position 09/2016-08/2018 for R&D detector and improvement of cryostat vibration levels @IP2I (realization of the suspended tower) (→ postdoc Subatech stopped end of 07/2019, CDI engineer, R&D for scientific applications, Clermont-Ferrand, since September 2019)

**Florence Charlieux** (IE instrumentation) resigned as responsible of LSM cryogenics for EDELWEISS (until 31/12/2018)

**27 traineeships 2015-2019: 2015** : 1 L3, 1 M1, 1 M2; **2016** : 1 L3 ENS, 1 M1, 2 M2; **2017**: 1 L3 ENS, 3 M1, 1 M2 ENS, 1 MIT student (MISTI program); **2018** : 1 L3 ENS, 2 M1, 1 stage long M1 ENS, 1 M2, 2 MIT (MISTI program), 1 PhD LPMS, University Frères Mentouri of Constantine, Algeria; **2019** : 1 stage long CPE, 1 L2, 1 M1, 1 M2, 1 MIT (MISTI program), 1 Terminale (La Réunion, IN2P3 program)

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## Scientific Production Highlights 2015-2020 – EDELWEISS-III & EDELWEISS-LT

Collection of an exposure of 8 kg.y with the most massive cryogenic detector array for DM

searches (20 kg) and completion of physics analyses. (C. Kéfélian, Q. Arnaud and E. Queguiner PhD theses)

#### See slide 18 for more details

- Improvement by more than two orders of magnitude of the EDELWEISS sensitivity for 7 GeV/c<sup>2</sup> WIMPs relative to EDELWEISS-II, confirming the relevance of the excellent rejection performance of the FID technology for DM searches.
- Best sensitivity for DM searches involving electron Recoil signals, such as axion-like particles (ALPs) below 1 keV/c<sup>2</sup> and direct dark photon searches below 10 keV/c<sup>2</sup>.



• First precise production rate measurement of tritium due to cosmogenic activation in Ge by cosmic rays (one of the main constraints of the SuperCDMS experiment design).

#### See slide 19 for more details

- Study of physics potential achievable with an improvement of thresholds x10 using Luke-Neganov boost from 8 V to 100 V. Sensitivity of 10<sup>-41</sup> cm<sup>2</sup> to low-mass WIMP @LSM (EDELWEISS-LT) and 10<sup>-43</sup> cm<sup>2</sup> (50000 kg.d).
- First step toward EDELWEISS-LT: HV boost of EDELWEISS-III detectors @LSM





## Scientific Production Highlights 2015-2020 – EDELWEISS-Surf results

Major breakthrough paving the way for new projects Ricochet and EDELWEISS-SubGeV



- 17.7 eV phonon energy resolution obtained on a 33.4-g cryogenic detector operated in the LIO facility.
- First sub-GeV spin-independent DM limit with Ge target.
- Most stringent above-ground limit above 0.6 GeV/c<sup>2</sup>.
- Most stringent limits on spin-dependent interactions for neutron [0.5-1.3] GeV/c<sup>2</sup> and for proton [0.6-0.8] GeV/c<sup>2</sup>.
- Best world limit for SIMPs (DM particles with strong interactions) in the mass range [45-150] MeV/c<sup>2</sup>
- First Ge limit using Midgal effect.
- Demonstration of impact on physics of best world performance achieved by LIO cryogenic facility (slide 20).
- Demonstration of low thresholds for EDELWEISS-SubGeV: forerunner of RED30 @LSM (slide 21).
- Demonstration of aboveground operation of cryogenic Ge detector: 1<sup>st</sup> step towards CryoCube for Ricochet (slide 22).

#### See publications 8, 23, 24 on slides 25 and 27

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## Scientific Production Highlights 2015-2020 – Ricochet

ERC-CENNS starting grant + CNRS "Médaille de Bronze 2019"

**Slides 22-23-24** 



#### See publication 20 on slide 27

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Neutron calibration with AmBe source and measurement of neutron background @IP2I to compute expected neutron background at the ILL reactor

(Dimitri Misiak PhD Thesis)



Particle ID with discrimination down to 1 keV demonstrated  $\rightarrow$  extension to 50 eV with HEMT ongoing

Characterization of the ILL reactor site (neutrons + vibrations)  $\rightarrow$  formal proposal for Ricochet@ILL to be submitted Feb. 2020 See publications 18 and 19 on slide 27

- 10 institutions joined Ricochet Collaboration
- Ricochet cryostat delivered @IP2I end of 2020

## **Scientific Production** Highlights 2015-2020 – CUPID-Mo @LSM

#### **CUPID (CUORE Upgrade with Particle ID)**



Corresponding publications signed by all members of the MANOIR team in 2019 (except TS, ERC postdoc), who also signed the CUPID pre-CDR

### See publications 9 to 14 on slide 26

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BI = 1E-3 cnts/(yr kg keV)

BI = 1E-2 cnts/(yr kg keV)

Ge sensors (synergy with Ricochet/EDELWEISS) + optimization of NTD-based light detector performance + calibration sources for CUPID-Mo

## **Team organization**

### Internal organization

#### Team

- 1 team head: CA for link with IP2I direction and administration
- Weekly meetings Monday morning:
  - with the whole team:  $\sim$  3/month
  - with permanent people only:  $\sim 1/month$

**R&D meeting** (visioconfs): weekly (Friday morning, resp. AJ, common with Ricochet & CUPID)

#### **EDELWEISS:** visioconfs

- General meeting: weekly or 2/month (Tuesday morning, spokesperson JG)
- Cryogenic meeting: weekly (Thursday afternoon)
- Analysis meeting: weekly (Thursday morning, resp. JB)
   Ricochet: visioconfs
- General meeting: weekly (Thursday afternoon, co-spokesperson JB)
- Monthly meetings on simulations + radiopurity
   CUPID-France: visioconfs
- Monthly meetings

### Inside IP2I: relations with services and other teams

- Regular general assemblies organized by the IP2I direction
- Participation to APPN events
- RGCS monthly meetings with all team/staff heads and IP2I direction: team/staff heads are in charge to transmit all information to the team/staff members.
- Annual meetings between team responsible and financial direction.
- Direct discussions between the team (including technical coordinator) and people from technical staffs involved in the team projects (also discussed in CSP = comité de suivi de projet)
- No specific discussions within the « Infinitely Large » axis, except during prospective studies

## **Scientific Responsibilities**

#### EDELWEISS: Spokesperson JG, Technical coordinator AJ (until 2015),

Members of: Institutional Board: JG, CA; Publication Board: JG, MDJ, Coordination Board: JG, JB (Analysis), AJ (R&D), AC (Simulations), VS (DB & Monitoring), MDJ (Backgrounds), FC (Cryogenics < 12/18)

**Ricochet:** Co-spokesperson and PI of ERC-CENNS JB, technical coordinator AJ (since 2019), Simulation meeting coordinator MDJ

LIO cryogenic facility @IP2I: scientific coord. JB, technical coord. AJ

**Low radioactivity & screening measurements** with HPGe Gentiane detector and responsible of **calibration sources** for EDELWEISS, RICOCHET and LUMINEU/CUPID-Mo: MDJ

**CUTE:** simulation coordinator AC (until 2018)

CUPID-Mo: IB member JG

**GDR DULP (Deep Underground Laboratory Physics)**, in preparation (submitted @CoNRS section 01 in June 2020): CA responsible and MDJ convener of WP3 "Low-Radioactivity technics"

## **Responsibilities**

#### **Teaching:** 4 teachers in the team + some PhD and researchers have teaching activities

#### Teaching responsibilities @physics department and @IUT, GEii department

- CA: UE physics, L1 SVT, 2nd semester (~400 students/semester), M2 Physics, Suba: UE Particle physics, then UE Particles and Astroparticles
- AC: L1 PCSI: thermodynamics experimental platform (550 students/year), educational referent for ~80 L1-L2 students/year, co-organizer of a teacher training day
- JG: L3 RD2: TP nuclear physics, M1 Physics: UE Nuclear Physics and Nuclear Matter
- DM (PhD): M2 Physics, Suba: resp. of lab training @LIO cryogenic facility (3 student groups, 1 day/group) Participation of AJ
- VS: traineeship supervision for 5 2<sup>nd</sup> year students/year, implementation of a level evaluation QCM in mathematics for new IUT students, publication of a pedagogical article on "Jigsaw project: learn electronics differently"

#### Others

- JB, MDJ: 3h each lectures@48<sup>th</sup> Ecole de GIF on "Underground Physics", on "Dark Matter direct detection" and "Background identification in rare event search experiments in underground labs »
- JB: DRTBT2018 school, 1h30 lecture on "Rare event detection: dark matter, coherent neutrino scattering", M2 Suba 2h specific lecture on "Detectors for direct DM search"

#### **Outreach:** AC: "responsible of communication" @IP2I

Involved in the organization and participation of all IP2I events (Fête de la Science, Festival particules.com, Oufs d'Astro, Traineeships for 3ème schoolboys and schoolgirls), **participation of all team members, including post-docs and PhD students**.

Specific outreach conferences and communications: @Cycle de conférences du CPPM (2016), @Journées des nouveaux entrants IN2P3 (2018), Portrait Femmes de Sciences Taille XX-Elles et interventions associées (2019-2020) (CA), @lycée Ste Marie (2014, 2015, 2016, 2017), @Société Astronomique de Lyon (2014), @Université du Savoir, Sud-Ardèche (2018), @Lycée Ampère (2019) (AC), @LSM, IN2P3 event: Facebook live for the Dark Matter Day (2018) (JG)

## **Responsibilities**

#### **Implications @University level**

- CA: IP2I representative member at doctoral school (ED PHAST) council
- AC: Member of physics department council (since 2013), Member of Faculté des Sciences council (since 2018)
- AJ: Scientific coordinator of CCIF Dark Matter platform for LIO2 LabEx (since 2019)
- JG: Section 29 local coordinator (2012-2017)
- VS: Member of Geii department council of IUT, Resp. of Communication of Geii department (until Dec. 2018)

### **Implications @National level**

- CA: vice-president of CNU section 29 and president of group 6 "Physics" (2011-15), president of CNU 29 (2015-19), Scientific Council of IPHC Strasbourg (since 2014), President of Scientific Council of CENBG Bordeaux (since 2019), SOC of international conference EDU2017 Vietnam, Organization committees of: In2p3 prospects group 6 "Neutrinos and Dark Matter" (2019) and "Journées Matière Sombre" since 2016 (@IP2I in 2018), Member of HCERES committee of LPSC Grenoble (01/2020)
- JB: Member of Scientific committee of Ecole de Gif 2016 (Underground Physics), Dark Matter GPS coordinator of IRN "Terascale"
- JG: Member of CoNRS section 01 (2012-16), Scientific Director of LSM research platform (since 2019), Member of Scientific Advisor Board of the Institute of High Energy Physics of the Austrian Academy of Sciences (since 2014), Member of Scientific Council of LabEx LIO (since 2012), Member of AERES committee APC and LUPM
- AJ: Organization committees of In2p3 prospects group 8 "Detectors" (2019), Member of DRTBT18 school organization committee

## **Responsibilities**

#### **Implications @IP2I level**

- CA: MANOIR team responsible (since 01/2017), resp. of IP2I PhD students (lab addressee for Doctoral School ED PHAST, mentoring, CST) (since 2011), responsible of the organization @IP2I of Ricochet coll. Meeting (2018) and Ricochet kick-off meeting (2019) with LabEx LIO funds
- AC: Lab Council member (2016-18), Resp. of Lab communication (since 2013)
- MDJ: Coord. of new clean room for LIO cryogenic facility installation
- JG: MANOIR team resp. (until Dec 2016), Lab Scientific Council (since 2008)
- AJ: Lab Council member (until 2015)
- VS: Lab Council member (2016-18)

### **Specific fundings other than IN2P3**

- ERC-CENNS: 1,5 M€ (02/2019-01/2024)
- PICS Berkeley: 6 k€/yr (2015-2017+ 2018-2020)
- PICS MIT: 6 k€/yr 2018-2020
- JINR Dubna cooperation agreements for Russian trips: 6 k€
- FRAMA 2016 for JB installation @IP2I: 15 k€
- LIO: 2 postdoc (JB 1yr, RM 2yrs) + help for Ricochet meeting 2018 @IP2I (1 k€), Ricochet kik-off meeting 2019 @IP2I (2 k€), 3<sup>rd</sup> "Journées Matière Sombre" @IP2I 2018 (3 k€)
- IP2I: 10 k€ for Ricochet (2018), 5 k€ for EDELWEISS (2019)
- JINR: 25 k€ (2016) for LIO cryostat shielding (lead + lifting table)
- Strong manpower support from IP2I technical staffs

## **Scientific project and anticipation**



I	Project	2018	2919	2020	2021	2022	2023		2024
	ICOCHET	•R&D CryoCube Ge/Zn + 10 eV + 20 eVee HEMT + discrimination		•2021: <b>Ricochet TDR</b> , including mechanical infrastructure, cryostat and •2022: <b>Ricochet</b> tubing, cabling and the warm electronics		•2024: C		ta-taking	
KI		•02/2019: start of ERG •End 2019: <b>Decision</b> site (proposal submitte	C-CENNS <b>for ILL</b> as nuclear ed Feb. 2020)	•End 2020: <b>Ricochet cryostat</b> @IP2I •End 2021: <b>CryoCube detector ready</b>				results	
	ELWEISS SubGeV	•R&D 1kg Ge (part of Ricochet R&D) + HV boos (SELENDIS) + low-background characterization		boost R&D ation	•HV developments towards single electron with few detectors		New cryostat @LSM	yostat @LSM	
ED S		•Optimizing physics reach of R&D detectors @LSM for 33g + 200 g NbSi (phonon + discrimination)			•2022: <b>EDELWEISS-SubGeV TDR</b> , Detector ins including cryostat, etc		Detector installatior commissioning @LS	n & SM	DM search
		•End 2020: CDR to search for cryostat and detector fundings (CPER: LSM cryogenic platform?)			•End 2022: 1 kg detector « à la Ricochet » ready				
CUPID-Mo		•Run preparation + <b>Data taking with 20 detectors</b> in EDELWEISS cryostat @LSM							
	3 postdocs until 2021 – Need a permanent position for Ricochet @IP2I Request an IR Request a CR position (DIALOG 2019) Instrumentation po						sition		

## **SWOT** analysis

#### Strengths

- Attracts new members.
- Attracts Master + PhD students (including international students) resulting in a x2 in manpower in peak periods.
- Strong synergy between EDELWEISS and Ricochet (detector & readout developments) + R&D synergy with CUPID
- Leadership in two projects: Pis (Ricochet and EDELWEISS), scientific strategy, technical developments, data analysis.
- LIO cryogenic facility resulting in major R&D breakthrough and published scientific results. LIO2 accepted.
- CENNS ERC Starting Grant (2019 2024)
- Important contributions from IP2I technical services, resulting in a central role in the development of original R&D programs.

#### **Opportunities**

- Strong involvement in attractive scientific projects using a common cryogenic detector technology recognized worldwide as complementary with other programs in the domain of Dark Matter and the study of CENNS.
- Prospects for new collaborations with partners in France and abroad.
- Ricochet is an ideal opportunity for the group to expand its expertise in a new domain of physics.
- Mature detector developments program ready to evolve towards new breakthroughs, with possible industrial applications and patents.

#### Weaknesses

- High proportion of academic staff, with large commitments to local, national and international responsibilities (help attracts students, but constrains the available manpower for research).
- Growth of Ricochet and EDELWEISS-SubGeV requires to develop collaborations with groups in other labs.
- Need to invest forces in different projects (however, the timing of their R&D and science return phases are complementary)
- Strong pressure to reach the HEMT+NTD technology goals for both Ricochet and EDELWEISS-SubGeV.
- Lack of support from IN2P3 for Ricochet and CUPID.

#### **Threats**

- Scientific risks: Dark matter might not be light or detectable in direct detection experiments, or new physics might not be observable with coherent neutrino-nucleus elastic scattering. In that case the importance to be the first experiment to set those constraints results in a strong international competition requiring a great reactivity.
- Financial risks: complexity of managing funding from multiple sources with very different rules and constraints. Entire funding of the projects not ensured yet (risks for delays).
- IN2P3 policy on ERC/ANR demotivates future submissions.

Note: positive developments have occurred on most of the budget risks mentioned in the initial swot written in 2019.

## **Points to discuss with committee**

#### Strengths

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## Annexes

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## **Visibility and reach**

### 2015-2020: 36 talks - see slides 28-31

- 2015 (23 talks, 6 MANOIR = 5 permanents + 1 PhD student)
- 2016 (18 talks, 9 MANOIR = 7 permanents + 2 PhD students)
- 2017 (12 talks, 6 MANOIR = 3 permanents + 1 PhD student + 2 postdocs)
- 2018 (7 talks, 5 MANOIR = 4 permanents + 1 PhD student)
- 2019 (12 talks, 9 MANOIR = 6 permanents + 1 PhD student + 1 postdoc + 1 M1-CPE/ENS)
- 2020 (1 talk, 1 MANOIR)

Since 2016, more than half of talks by MANOIR people: problem of funding despite IP2I help with COMEXT program

### Recent Highlights – see slide 21

#### Underground search for electron-DM interactions with a 33-g Ge detector (RED30 results)

Results presented @TMEX conference, J. Gascon (EDELWEISS Collaboration), Vietnam, Quy Nhon, January 2020

http://vietnam.in2p3.fr/2020/tmex/transparencies/2\_tuesday/2\_afternoon/5\_gascon.pdf

### Meeting organizations:

- 1 EDELWEISS collaboration meeting /yr @IP2I 2015-2019
- 1 Ricochet meeting @IP2I in 2018 and in 2019
- 1 « journée matière sombre » @IP2I in 2018

## Scientific Production - Details Highlights 2015-2020 - EDELWEISS-III

Collection of an exposure of 8 kg.y with the most massive cryogenic detector array for DM searches (20 kg). (C. Kéfélian & Q. Arnaud PhD theses) See publications 2 and 5 on slide 25

Improvement by more than two orders of magnitude of the EDELWEISS sensitivity for 7 GeV/c<sup>2</sup> WIMPs relative to EDELWEISS-II, confirming the relevance of the excellent rejection performance of the FID technology for DM searches. See publications 1 and 3 on slide 25



First precise production rate measurement of tritium due to cosmogenic activation in Ge by cosmic rays (one of the main constraints of the SuperCDMS experiment design). See publication 4 on slide 25



Best sensitivity for DM searches involving electron Recoil signals, such as axion-like particles (ALPs) below 1 keV/c<sup>2</sup> and direct dark photon searches below 10 keV/c<sup>2</sup>. See publication 7 on slide 25



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### **Scientific Production - Details** Highlights 2015-2020 – EDELWEISS-LT



### Scientific Production - Details Highlights 2015-2020 – R&D @ the LIO cryogenic facility

LIO cryogenic facility @IP2I

With its spring-suspended tower, the facility is now a worldwide reference for the lowest vibration levels ( $< \mu g/\sqrt{Hz}$ ) achieved in a dry cryostat at the heart of EDELWEISS and Ricochet collaboration programs. It led to the cryogenic decoupling of the bolometers required by our new high sensitivity detectors.

(R. Maisonobe post-doctorat) See publications 23-24 on slide 27

#### **Toward discrimination at low thresholds** Development of low-noise HEMTs with C2N and CEA. R&D to achieve a 20 eVee ionization resolution. (D. Misiak and J.B. Fillipini PhD theses) **See publication 25 on slide 27**



Evolution of the resolution with the of detector + cabling capacitance for 5 HEMT geometries and the IF1320 Si-JFET from InterFET. Noise of the bias resistor is included. (J.B. Fillipini M2 internship)





Electrostatic simulation of a Full Inter-Digitized electrodes scheme on a 38 g germanium crystal ( $\Phi$  = 30 mm, h = 10 mm). The crystal is surrounded at 2 mm distance by a chassis connected to the ground (not shown). The capacitance of the 4 electrodes with respect to the ground is about 20 pF. (D. Misiak PhD Thesis)

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## Scientific Production - Details Highlights 2015-2020 - New results for EDELWEISS-SubGeV

#### Underground search for electron-DM interactions with a 33-g Ge detector

For the 1<sup>st</sup> time, operation @LSM of a massive cryogenic Ge detector (RED30) with large Luke-Neganov amplification has provided constraints on DM-electron interactions competitive to lighter Si detectors. The sensitivity extends into the domain of sub-MeV DM particles. With a resolution of  $\sigma = 1.6$  eVee (0.53 electron-hole pairs) there is some sensitivity to single-electron events

(Q. Arnaud postdoc analysis)



Results presented @TMEX conference, J. Gascon (EDELWEISS Collaboration), Vietnam, Quy Nhon, January 2020 http://vietnam.in2p3.fr/2020/tmex/transparencies/2\_tuesday/2\_afternoon/5\_gascon.pdf

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### **Scientific Production - Details** Highlights 2015-2020 – ERC-CENNS & Ricochet



#### ERC-CENNS starting grant + CNRS "Médaille de Bronze 2019" awarded to CNRS researcher Julien Billard, leader of the design and construction of the CryoCube detector @IP2I and co-PI of the

*Ricochet experiment to study low-energy coherent elastic neutrinonucleus scattering at the ILL research reactor site.* 

See publications 18-19-20 on slide 27

Projected sensitivities for the Ricochet experiment to new physics search in the low-energy CENNS sector.

Ricochet is assumed to be located at 8 m from the ILL reactor core, with a 50 eV energy threshold and an electromagnetic background rejection power of 10<sup>3</sup>.



Constraints on Z' searches assuming unified coupling to the quarks. The results are shown as 90% C.L. upper limits on the Z' coupling. Also presented are current leading constraints from the APEX fixed target experiment, LHC di-electron searches, and COHERENT.



Constraints on Non-Standard neutrino-quark Interactions in the neutrino-electron sector. Results are shown as 90% C.L. allowed regions. Also shown are current experimental constraints from LHC mono-jet searches, CHARM, and COHERENT. The cross represents the Standard Model.

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## Scientific Production - Details Highlights 2015-2020 - New results for Ricochet

Neutron calibration and measurement of neutron background @IP2I to compute expected neutron bkg @ILL reactor

10.37 keV

(Dimitri Misiak PhD Thesis)

Calibration setup @IP2I with 2 configurations:

- Calibration: 78 hours with AmBe neutron source, using K-shell and L-shell lines obtained by Ge activation @1.3 keV, and @10.37keV
- Background: 34 hours without source

 $10^{7}$ 

Particle identification with discrimination down to 1 keV demonstrated  $\rightarrow$  extension to 50 eV with HEMT ongoing



Quenching factor (ionization yield =  $E_l/E_R$ ) as a function of the recoil energy  $E_R$  (keV)



## Scientific Production - Details Highlights 2015-2020 - New results for Ricochet



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## **Scientific Production** Publications 2015-2019 – MANOIR team

#### **EDELWEISS (8)**

**1)** Constraints on low-mass WIMPs from the EDELWEISS-III dark matter search By EDELWEISS Collaboration - JCAP 05 (2016) 019.

**2)** Signals induced by charge-trapping in EDELWEISS FID detectors: analytical modeling and applications By EDELWEISS Collaboration \* - JINST 11 (2016) 10008.

**3)** Improved EDELWEISS-III sensitivity for low-mass WIMPs using a profile likelihood approach By EDELWEISS Collaboration - Eur. Phys. J. C76 (2016) 548.

**4)** Measurement of the cosmogenic activation of germanium detectors in EDELWEISS-III By EDELWEISS Collaboration - Astroparticle Physics 91 (2017) 51–64

**5)** Performance of the EDELWEISS-III array for the direct search of dark matter By EDELWEISS Collaboration \* - JINST 12 (2017) no.08, P08010

**6)** Optimizing EDELWEISS detectors for low-mass WIMP searches

By EDELWEISS Collaboration \* - Phys.Rev. D97 (2018) no.2, 022003

**7)** Searches for electron interactions induced by new physics in the EDELWEISS-III Germanium bolometers By EDELWEISS Collaboration - Phys.Rev. D98 (2018) no.8, 082004

**8)** Searching for low-mass dark matter particles with a massive Ge bolometer operated above-ground By EDELWEISS Collaboration \* - Phys.Rev. D99 (2019) no.8, 082003

\* for corresponding author MANOIR = 4

L. Vagneron and F. Charlieux from Instrumentation group are also EDELWEISS authors

## **Scientific Production** Publications 2015-2019 – MANOIR team

#### LUMINEU/CUPID-Mo (6)

**9)** Development and underground test of radiopure ZnMoO4 scintillating bolometers for the LUMINEU  $0v2\beta$  project JINST 10 (2015) no.05, P05007.

**10)** Development of 100Mo-containing scintillating bolometers for a high-sensitivity neutrinoless double-beta decay search Eur.Phys.J. C77 (2017) no.11, 785

**11)** Complete event-by-event  $\alpha/\gamma(\beta)$  separation in a full-size TeO2 CUORE bolometer by Neganov-Luke-magnified light detection Phys.Rev. C97 (2018) no.3, 032501

12) CUPID pre-CDR, CUPID Collaboration, arXiv:1907.09376

**13)** The CUPID-Mo experiment for neutrinoless double-beta decay: performance and prospects Eur. Phys. J. C80 (2020) 44

**14)** Precise measurement of  $2\nu\beta\beta$  decay of 100 Mo with the CUPID-Mo detection technology, arXiv:1912.07272

## **Scientific Production** Publications 2015-2019 – MANOIR team

#### Phenomenology studies and CENNS/Ricochet (JB publications)

15) Comparing readout strategies to directly detect dark matter, Phys.Rev. D91 (2015) no.2, 023513 \*

**16)** Readout strategies for directional dark matter detection beyond the neutrino background, Phys.Rev. D92 (2015) no.6, 063518 \*

17) A review of the discovery reach of directional Dark Matter detection, Phys.Rept. 627 (2016) 1-49

**18)** Coherent Neutrino Scattering with Low Temperature Bolometers at Chooz Reactor Complex, J.Phys. G44 (2017) no.10, 105101 (+JG+MdJ) \*

**19)** Unfolding Neutron Spectrum with Markov Chain Monte Carlo at MIT Research Reactor with He-3 Neutral Current Detectors, JINST 13 (2018) no.02, P02004

**20)** Prospects for exploring New Physics in Coherent Elastic Neutrino-Nucleus Scattering, JCAP 1811 (2018) no.11, 016 \*

#### **CUTE (AC publications)**

**21)** CUTE: A Low Background Facility for Testing Cryogenic Dark Matter Detectors, J.Low.Temp.Phys. 193 (2018) no.5-6, 813

#### R&D (JB, AJ, MDJ + EQ, DM, JBF (PhD) + RM (postdoc)

22) Characterization and Optimization of EDELWEISS-III FID800 Heat Signals, J.Low.Temp.Phys. 184 (2016) no.1-2, 308 \*

23) Vibrations on pulse tube based Dry Dilution Refrigerators for low noise measurements, NIM A858 (2017) 73 \*

**24)** Vibration decoupling system for massive bolometers in dry cryostats, JINST 13 (2018) no.08, T08009 (+ L. Vagneron) \*

**25)** Low-noise HEMTs for Coherent Elastic Neutrino Scattering and low-mass Dark Matter cryogenic semiconductor detectors, J.Low.Temp.Phys. (2019), arXiv:1909.02879 (+ L. Vagneron, D. Chaize (*Instru*)) \*

#### AJ @Berkeley

**26)** A HEMT-Based Cryogenic Charge Amplifier with sub-100 eVee Ionization Resolution for Massive Semiconductor Dark Matter Detectors, arXiv:1611.09712

#### \* for corresponding author MANOIR = 8

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#### 2015 (23 talks in total including those from collaborators, 6 MANOIR)

*Low mass searches in EDELWEISS-III,* Jules Gascon for the EDELWEISS Collaboration, Prospects in low mass dark matter 30 Nov - 1 Dec 2015, MPP Munich, Germany

*Recent results from the EDELWEISS-III WIMP search experiment,* Maryvonne De Jesus for the EDELWEISS Collaboration, 11<sup>th</sup> Axion-WIMP conference (Patras workshop), 22-26 June 2015, Universidad de Zaragoza, Spain

*The neutrino background to direct detection of Dark Matter,* Julien Billard for the EDELWEISS Collaboration, Rencontres de Moriond - EW Interactions and Unified Theories, 21 Mar 2015, La Thuile, Italia

*Direct dark matter searches review,* Jules Gascon for the EDELWEISS Collaboration, 3<sup>rd</sup> International Conference on New Frontiers in Physics, 8 June 2014, Kolymbari, Crete, Greece

*Recent results from the EDELWEISS-III WIMP search experiment,* Antoine Cazes for the EDELWEISS Collaboration, The European Physical Society Conference on High Energy Physics, 29 Jun 2015, Vienne (Austria)

Status of the EDELWEISS-III Dark Matter search, Cécile Kéfélian for the EDELWEISS Collaboration, 2<sup>nd</sup> Workshop on Germanium Detectors and Technologies, 17 Sep 2014, South Dakota, USA

#### 2016 (18 talks, 9 MANOIR)

*Optimizing Cryogenic Detectors for Low-Mass WIMP Searches,* Quentin Arnaud for the EDELWEISS Collaboration, 16<sup>th</sup> International Workshop on Low Temperature Detectors (LTD 16), Jul 2016, Grenoble, France

*Characterization and Optimization of EDELWEISS-III FID800 Heat Signals*, Emeline Queguiner, Julien Billard, Maryvonne De Jesus, Alexandre Juillard, 16<sup>th</sup> International Workshop on Low Temperature Detectors (LTD 16), Jul 2016, Grenoble, France

Status and Prospects of the EDELWEISS-III Direct WIMP Search Experiment, Alexandre Juillard for the EDELWEISS Collaboration, 16<sup>th</sup> International Workshop on Low Temperature Detectors (LTD 16), Jul 2016, Grenoble, France

Search for low-mass WIMPs with the EDELWEISS-III experiment, Julien Billard for the EDELWEISS Collaboration, UCLA Dark Matter 2016, 17-19 Feb 2016, Los Angeles, UCLA, USA

Search for Low-Mass WIMPs with EDELWEISS, Emeline Queguiner for the EDELWEISS Collaboration, GDR Terascale, 23-25 May 2016, Subatech Nantes, France

*Recent results on low mass wimp search with the EDELWEISS-III experiment*, Véronique SANGLARD for the EDELWEISS Collaboration, IDM2016, 18-22 Jul 2016, Sheffield, UK

*Prospects for light WIMP searches with Edelweiss*, Jules Gascon for the EDELWEISS Collaboration, GDR Terascale @Paris, 23-25 Nov 2016, LPNHE, Paris, France

*Direct detection of Dark Matter with the EDELWEISS experiment*, Julien Billard on behalf of the EDELWEISS Collaboration, Journée Matière Sombre France, 1 Dec 2016, APC, Paris, France

*Eureca: Perspectives, Challenges and Plans*, Jules Gascon for the EDELWEISS Collaboration, 3rd Berkeley Workshop on the Direct Detection of Dark Matter, 5-6 Dec 2016, LBNL Berkeley, USA

#### 2017 (12 talks, 6 MANOIR)

*Low-mass WIMP search with the EDELWEISS experiment: Latest results and developments,* Emeline Queguiner for the EDELWEISS Collaboration, 29<sup>th</sup> Rencontres de Blois, 28 May - 2 Jun 2017, Château de Blois, France

*Low-mass WIMP searches with EDELWEISS,* Jules Gascon for the EDELWEISS Collaboration, TAUP 24-28 Jul 2017, Sudbury, Canada

*Experimental study and modeling cryogenic detectors decoupling within dry cryostat,* Romain Maisonobe, J. Billard, M. De Jesus, L. Dumoulin, A. Juillard, S. Marnieros, D. Misiak, S. Sayah & L. Vagneron, 7th international workshop on Low Temperature Detectors, 17-21 Jul 2017, Kurume City Plaza, Kurume, Fukuoka, Japan

Status and Prospects of the EDELWEISS-III Direct WIMP Search Experiment, Romain Maisonobe for the EDELWEISS Collaboration, 7<sup>th</sup> international workshop on Low Temperature Detectors, 17-21 Jul 2017, Kurume City Plaza, Kurume, Fukuoka, Japan

*Low-mass WIMP search with EDELWEISS experiment,* Corinne Augier for the EDELWEISS Collaboration, Exploring Dark Universe - 13th Rencontres du Vietnam, 23-29 Jul 2017, ICISE - Quy Nhon, Vietnam

*HPGe detectors at mK temperature for DM Search,* Julien Billard, 2017 International Germanium Radiation Detector Technology, 4-5 Dec 2017, LBNL, Berkeley, USA

#### 2018 (7 talks, 5 MANOIR)

Searching for low-mass dark matter with cryogenic detectors, Julien Billard, The 14th International Workshop Dark Side Of the Universe, 25-29 Jun 2018, Annecy, France

Status of EDELWEISS, Jules Gascon for the EDELWEISS Collaboration, IDM 2018, 23-27 Jul 2018, Brown University, Providence, RI, USA

*EDELWEISS-III and EDELWEISS low-mass program,* Jules Gascon for the EDELWEISS Collaboration, IN2P3 Scientific Council, 25 Oct 2018, Paris, France

*ERC CENNS and RICOCHET,* Alexandre Juillard for the Ricochet Collaboration, IN2P3 Scientific Council, 25 Oct 2018, Paris, France

*The CryoCube detector array for Ricochet,* Dimitri Misiak for the Ricochet Collaboration, The Magnificent CEvNS, workshop, 2-3 Nov 2018, Chicago IL, USA

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Tourniquet Section 01 de l'IP2I – 3-5 Feb 2020

#### 2019 (12 talks, 8 MANOIR)

Above-ground direct searches for WIMPs, Jules Gascon, ALPS 2019 An Alpine LHC Physics Summit, 22 – 27 Apr 2019, Obergurg, Austria

SubGeV dark matter searches with EDELWEISS, Maryvonne De Jesus for the EDELWEISS Collaboration, CoSSurf2019, 15-17 May 2019, Rapid City, South Dakota, USA

*Recent results from EDELWEISS Dark Matter searches,* Dimitri Misiak for the EDELWEISS Collaboration, 31st Rencontres de Blois, 2-7 Jun 2019, Blois, France

*Cryogenic charge and phonon detectors: EDELWEISS-SubGeV*, Julien Billard for the EDELWEISS Collaboration, Light Dark Matter Workshop, 3-7 June 3-7 2019, Chicago, USA

*Recent results from EDELWEISS*, Jules Gascon for the EDELWEISS Collaboration, SuperCDMS Science Seminar, 21 Jun 2019, Web seminar

Development of Kinetic Inductance Detectors with contactless feedline as heat sensors for rare events experiments, Jules Colas (+J. Billard, A. Juillard), 18th International Workshop on Low Temperature Detectors (LTD 18), 22-26 July 2019, Milano, Italia

EDELWEISS searches for low-mass Dark Matter particles, Jules Gascon for the EDELWEISS Collaboration, TAUP Conference, 9-13 Sep 2019, Toyama, Japan

Sub-GeV dark matter searches with the EDELWEISS experiment, Quentin Arnaud for the EDELWEISS Collaboration, IRN Terascale, 16-18 Oct 2019, Bruxelles, Belgium

#### 2020 (1 talk, 1 MANOIR)

Sub-GeV dark matter searches with EDELWEISS, Jules Gascon for the EDELWEISS Collaboration, TMEX Conference, 5-11 Jan 2020, Quy Nhon, Vietnam