Sensors for **Wi**de band **M**agnetic field **M**easurement **SWiMM**

ICI4

LPP (**L**aboratoire de **P**hysique des **P**lasmas)
& **L2E** (**L**aboratoire d'**E**lectronique et d'**E**lectromagnétisme)
& **DT INSU**

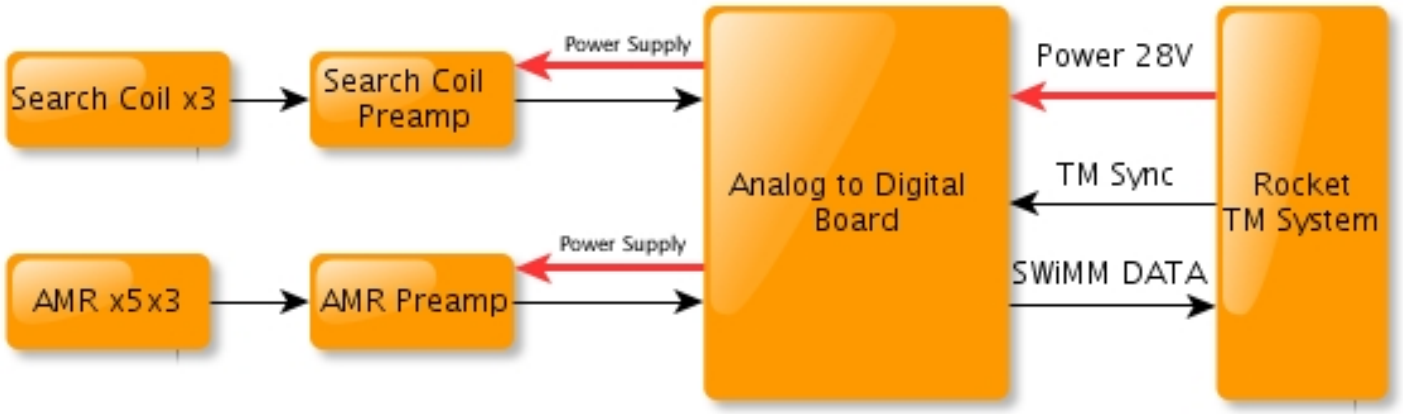
The team

	Institute	Function
Patrick Robert		Scientists
Mathieu Berthommier		
Alexis Jeandet		Technical Manager & digital board design
Dominique Alison		Analog electronic board design
Christophe Coillot		Search-coil sensor design & ASIC design
Paul Leroy		ASIC design
Kaveh Moahamadabadi		AMR magnetometer design
Nicolas Gesykens		Mechanical & Thermal design
Gérard Sou/Amine Rhouni		ASIC design

Summary

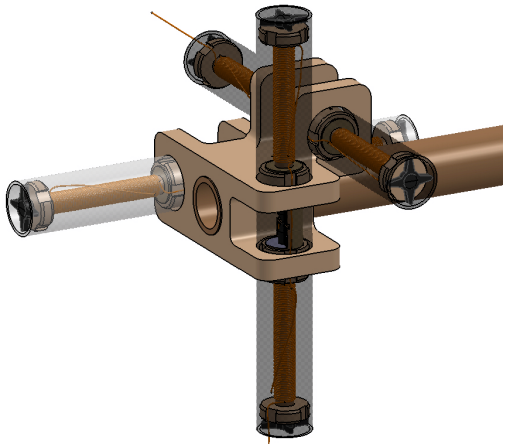
- SWiMM overview
- Triaxial search coil magnetometer
- Search Coil Pre-amplifier
- AMR magnetometers
- Digital board
- Electronic box
- Telemetry status
- Funding status

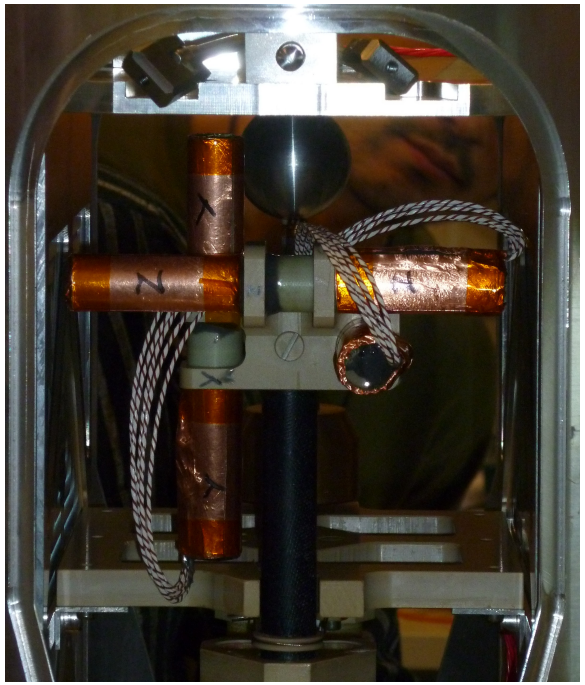
SWiMM OVERVIEW



- **Tri-axis search coil magnetometer few Hz up to 30kHz, based on Ohmic design.**
- **5x tri-axis AMR magnetometer from DC to 80Hz, based on PHD student work (Kaveh).**
- **Analog to digital electronic board close to ICI3 design.**

Search Coil Antenna



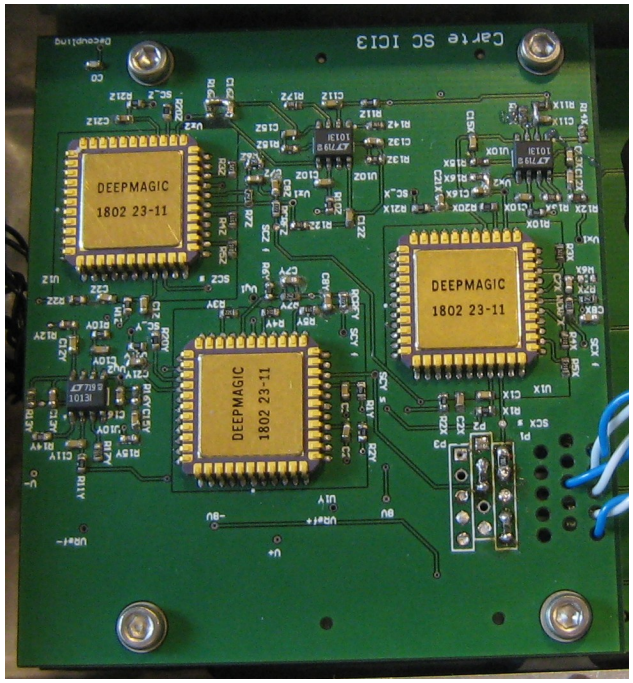


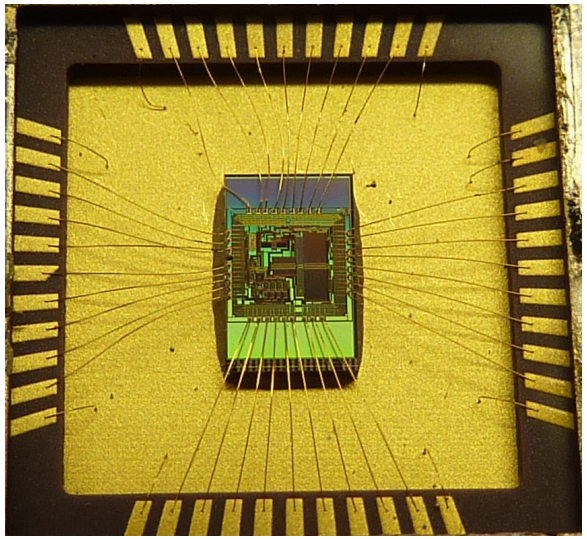
- Heritage: CLUSTER, THEMIS(flying), Bepicolombo & MMS (on going)

  ICI4 search coil will be design to fit OHMIC performances

  - **ICI3**
    - 3 sensors: 140mm length, 15mm diameter and 450g.
    - 80fT/sqrt(Hz) @ 1kHz, 8kHz bandwidth
    - Boom length ~70cm.
    - No issues.
  - **ICI4**
    - 3 sensors: 180mm length, 14mm diameter and 350g (45° rotation?)
    - SWiMM Sensors should be mounted on a boom (>50cm)
    - 20fT/sqrt(Hz) @ 1kHz, 4fT/sqrt(Hz) @ 10kHz, 30kHz bandwidth
  - Backup possible with MMS or Bepi sensors.

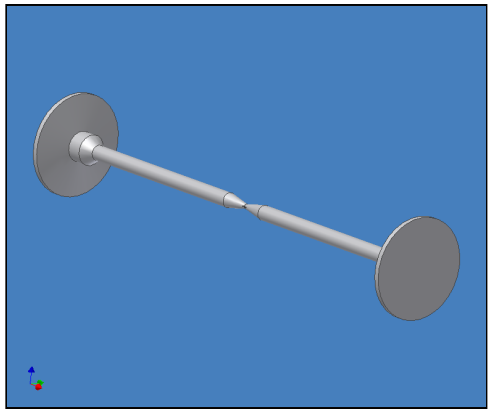
Search Coil pre-amplifier

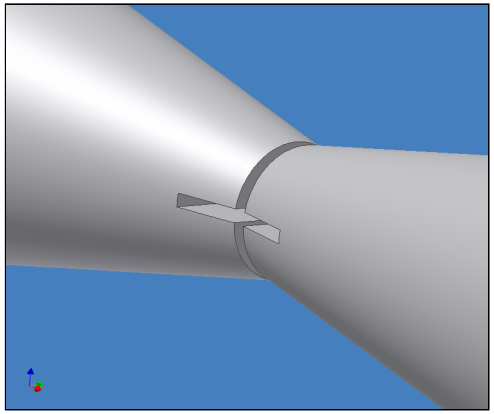


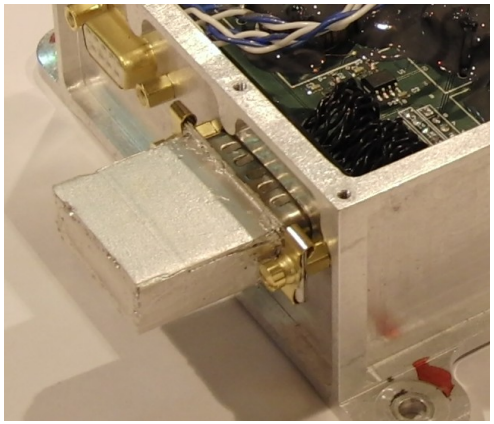


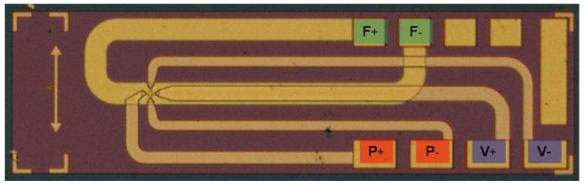
- **ICI3**
  - 2 stages amplifier & feedback manager
  - 4nV/sqrt(Hz) & 10fA/sqrt(Hz) @ 10Hz
  - ASIC design in CMOS 0.35µm technology.
  - No issues.
- **ICI4**
  - 2 stages amplifier, feedback manager, high pass filter & temperature compensated voltage regulator.
  - Lower LF noise.
  - Input Protections added.
  - Low power consumption <2mA per channel.
  - 30KHz bandwidth.
  - ASIC design in CMOS 0.35µm technology.
- Backup possible with ICI3 ASIC already processed.

AMR Sensor / ICI3



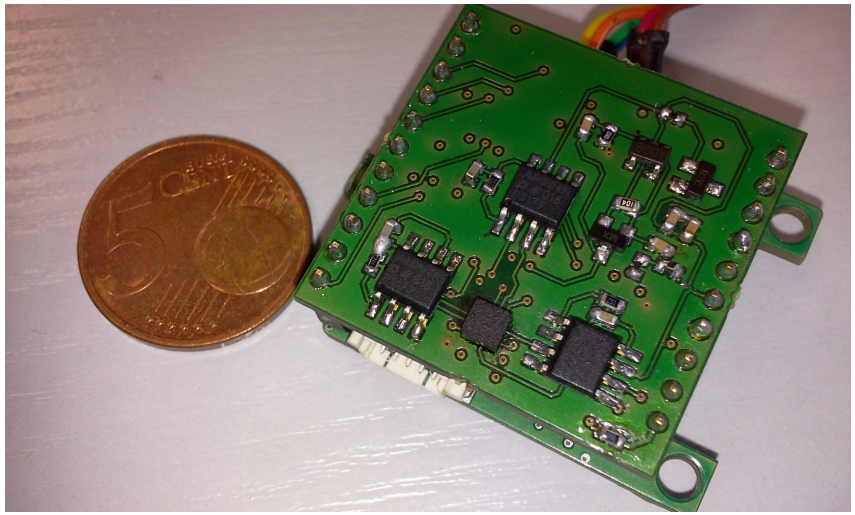


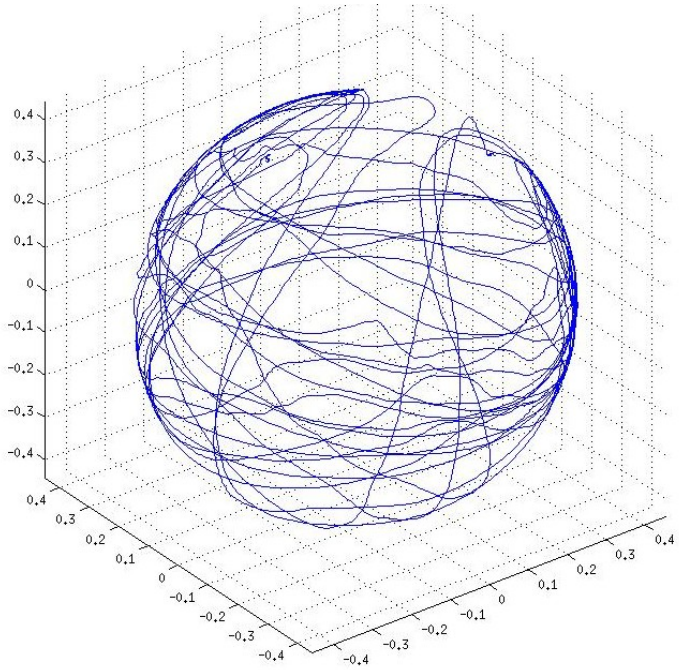




- **Good results:**
  - Core magnetic gain ~350
  - 200pT/sqrt(Hz) @ 0.1Hz
  - Ultra low noise electronic 300pV/sqrt(Hz) @ 0.1Hz
  - 300mW
  - Sensor design partially validated
- **Problems:**
  - Due to some critical operations on the lasts building steps, the sensor did break few days before the last integration.
  - Backup solution outside of the Search Coil.
    - 20nT/sqrt(Hz) @ 1Hz

AMR Sensor / ICI4



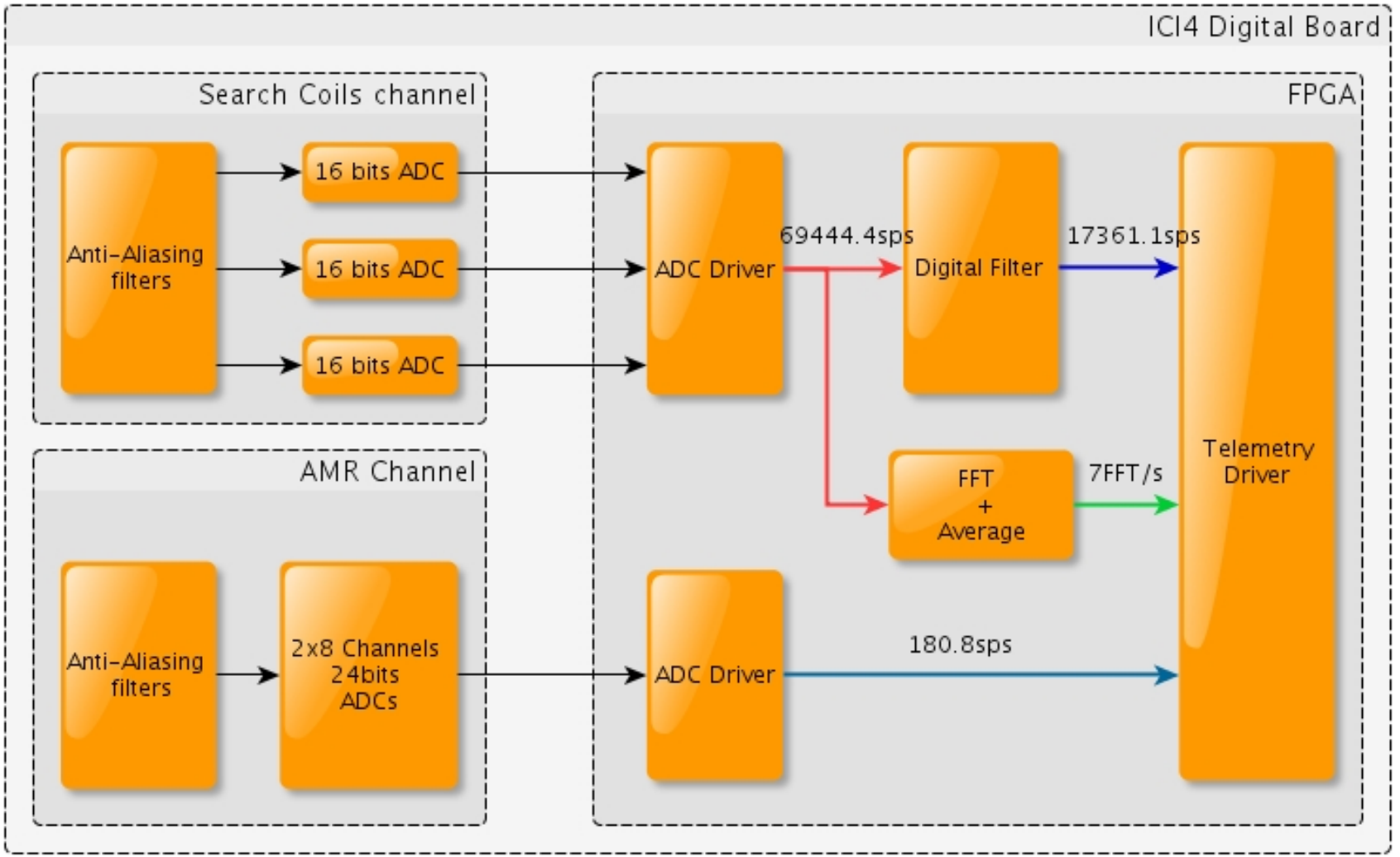


- Configuration of 5x3 axis sensors spaced by ~ 5cm, placed in the electronic box.
- Based on a commercial 3 axis sensor HMC1043 (Honeywell).
- Performances:
  - 20nT/sqrt(Hz) @ 1Hz

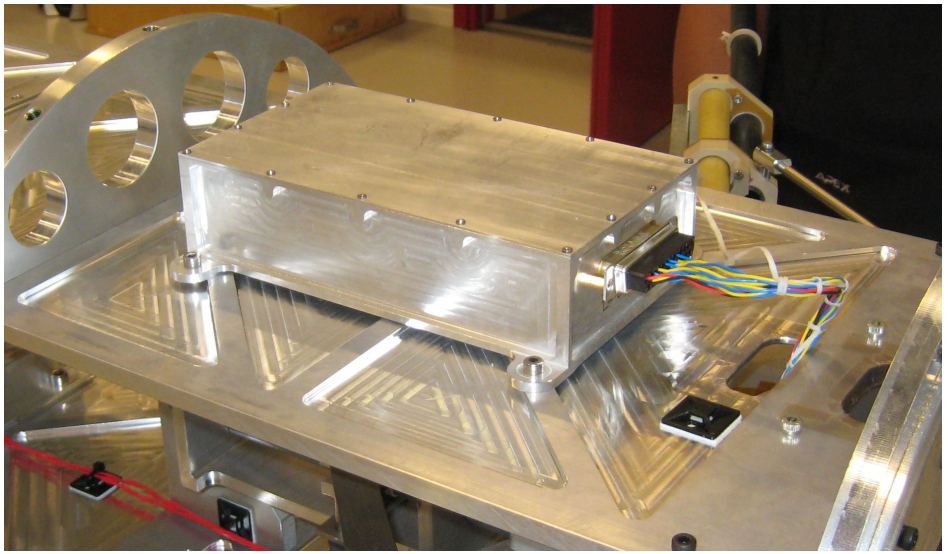
    30nT/sqrt(Hz) @ 0.1Hz
  - 0.08% non linearity @ full scale
  - 0.5% cross axis effect
  - 80Hz bandwidth
  - >250mW per 3 axis sensor

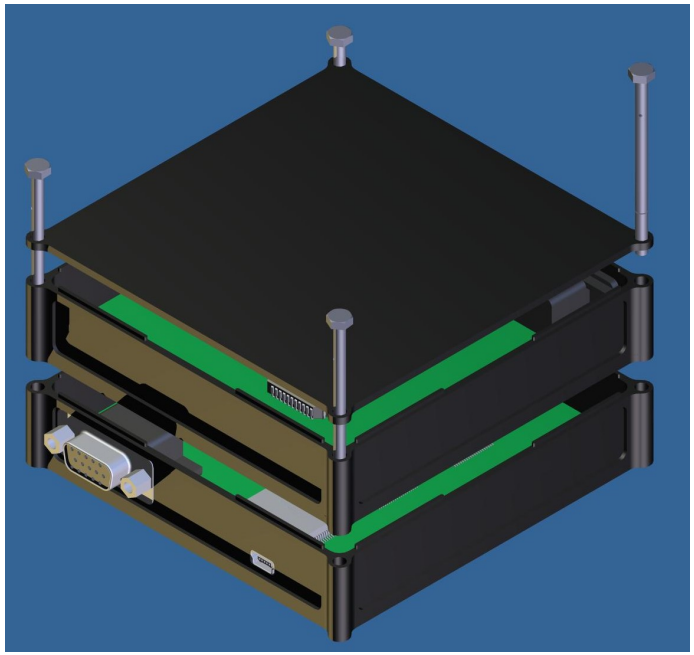
Digital Board

Design and code based on ICI3 with some modules from Solar Orbiter's LFR instrument.



Electronic box





- **ICI3**
  - 170x107x44mm
  - ~500g
- **ICI4**
  - 100x100x40mm
  - ~500g
  - Same location as ICI3

Telemetry Status

- **Search Coil waveform:**

  3*16*17361.1sps = 833332.8 bps (same as ICI3)

- **Search Coil Spectrum:**

  3*16*256*7 = 86016 bps (slots ADM_SubCom_2)

- **AMR sensors waveform:**

  16*24*180.84sps = 69444 bps (slots ADM_SubCom_1)

- **Total telemetry budget identical to ICI3.**

FrameSync_MSB	FrameSync_LSB	SP1	SP2	SFID_LSB [0-5]bit	HK opt word + 2 Status Bits	ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
ADM_SubCom_1_MSB	ADM_SubCom_1_NSB	SP5	SP6	ADM_SubCom_1_LSB	ADM_SubCom_1_dummy	ADM_LF3_MSB	ADM_LF3_LSB
ADM_SubCom_2_MSB	ADM_SubCom_2_NSB	SP1	SP2	ADM_SubCom_2_LSB	ADM_SubCom_2_dummy	ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
ARR_HK_SubCom_MSB	ARR_HK_SubCom_LSB	SP5	SP6	SM_Ch1_MSB	SM_CH1_LSB	ADM_LF3_MSB	ADM_LF3_LSB
		SP1	SP2			ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
DC1-2_MSB	DC1-2_LSB	SP5	SP6			ADM_LF3_MSB	ADM_LF3_LSB
DC3_MSB	DC3_LSB	SP1	SP2			ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
		SP5	SP6			ADM_LF3_MSB	ADM_LF3_LSB
		SP1	SP2			ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
		SP5	SP6			ADM_LF3_MSB	ADM_LF3_LSB
		SP1	SP2			ADM_LF1_MSB	ADM_LF1_LSB
AC1_MSB	AC1_LSB	SP3	SP4	AC3_MSB	AC3_LSB	ADM_LF2_MSB	ADM_LF2_LSB
		SP5	SP6	Format counter MSB	Format counter LSB	ADM_LF3_MSB	ADM_LF3_LSB

Funding status

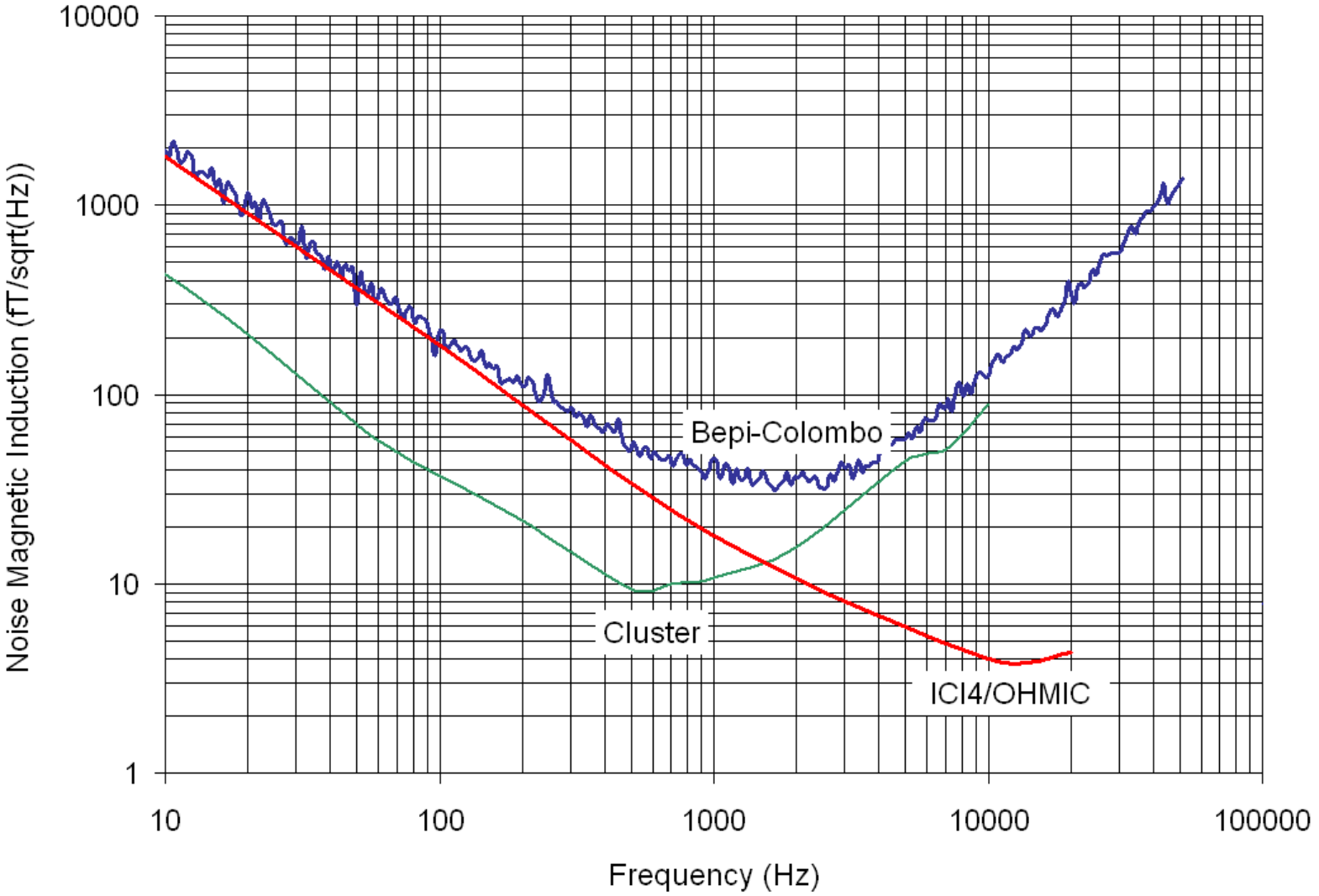
- **Available**:

25k€ for instrument design and manufacturing (including boom)

- **Pending**:

- **42k€ for meetings and travels up to the launch (shared with 3D plasma analyzer team)**

SWiMM magnetic noise objective



Noise Equivalent magnetic Induction objective:

1.8pT/sqrt(Hz) @ 10Hz **18fT/sqrt(Hz)** @ 1kHz **4fT/sqrt(Hz)** @ 10kHz