HPS ECal & Trigger

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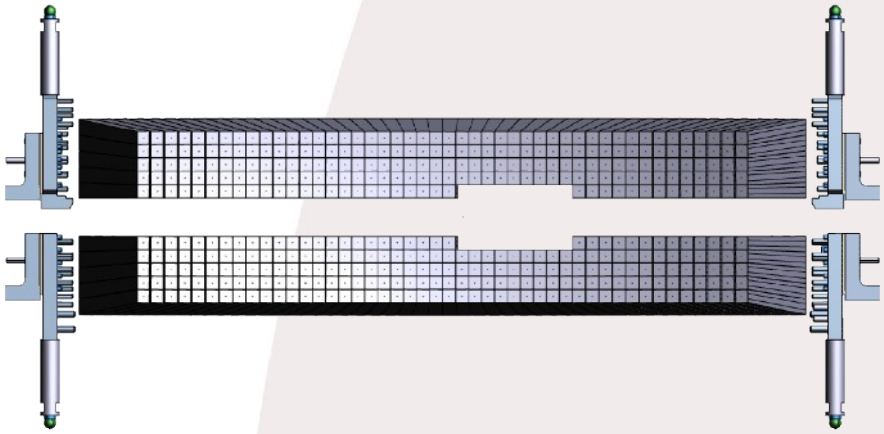
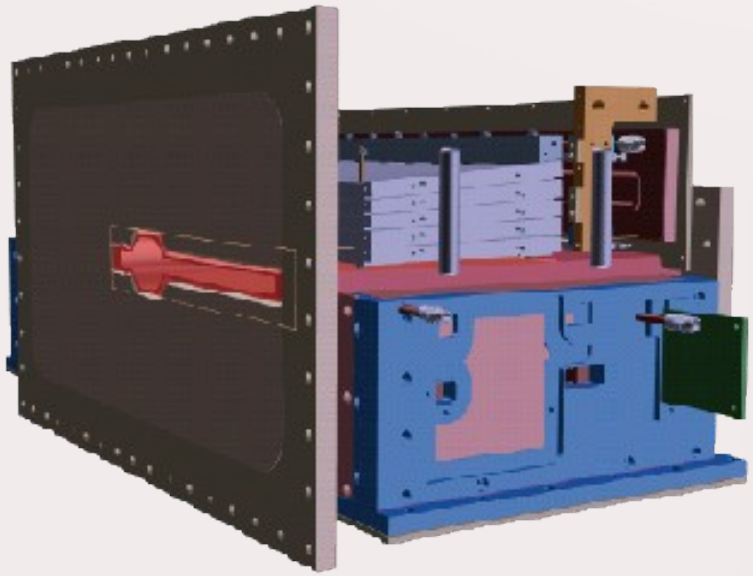
The ECal

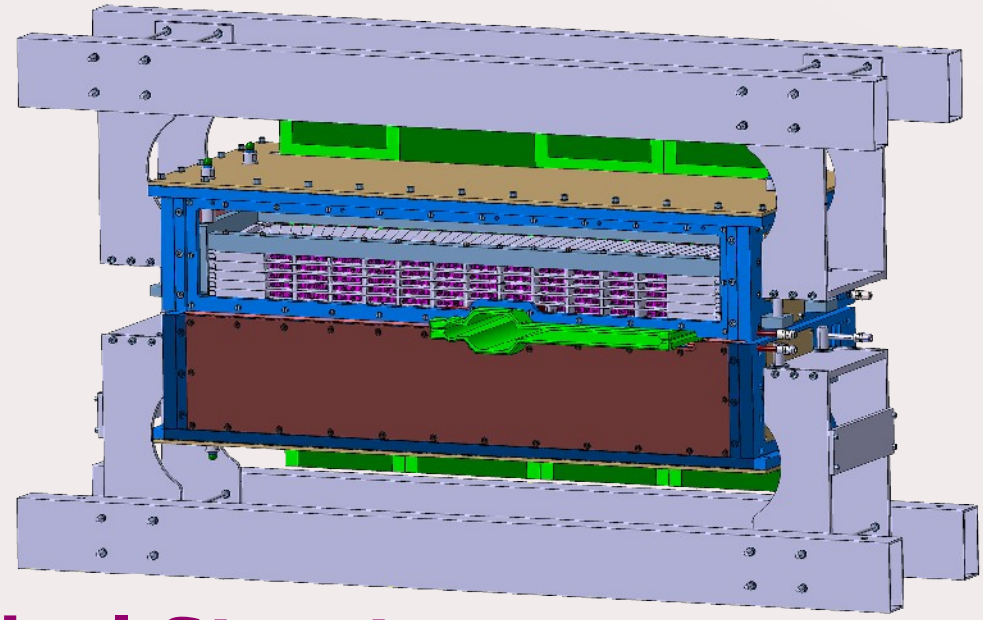




The calorimeter and its vacuum box

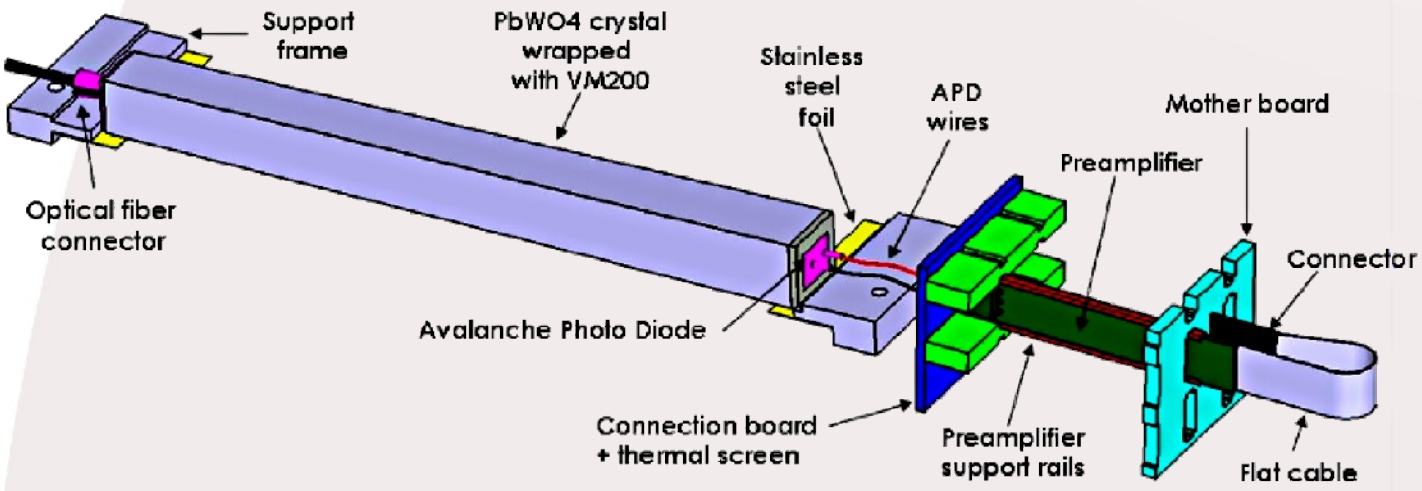
- 442 Crystals of PbWO4
- Used for electron/positron identification
- Provide signal for the trigger

Mechanics



- **Mechanical Structure**
  - Mostly as developed for the test run
  - Including cooling system and thermic isolation
  - Adaptation for
    - new mother boards
    - light monitoring system
  - Addition of more precise mounting system

The Detection Chain



- **Detection Chain**
  - Light produced in the crystal
  - Processed by Avalanche Photo-Diode (APD)
  - Amplified with preamplifier
  - Signal sent to FADC
    - Trigger path
    - Readout path

The Trigger

- **Trigger system**
  - Timing directly provided by FADCs
  - One Crate Trigger Processor (CTP) per side
    - Form clusters every 4 ns
    - Time coincidence in a given cluster (8 ns)
    - Send cluster information to SSP
  - Sub-System Processor (SSP)
    - Time coincidence between clusters (4 ns)
    - Topological selection

Trigger Algorithm

- **Cluster finding**
  - Look at energy deposit for all 3x3 configurations of crystal
  - Look for maximum configuration if several neighboring clusters pass the threshold
- **Topological Selection**
  - High energy sum
  - Time coincidence
  - Reduced energy difference
  - Coplanarity
  - Energy slope

Trigger Rates

- **Maximum rate for electronics 43 kHz**
- **Monte-Carlo Simulation**
  - Reproduce bunches of electrons
  - We simulated 50 millions bunches per energy
  - Simulation also helped determine trigger cuts

Sample	Rate (kHz)
1.1 GeV beam background	15.7 ± 0.4
1.1 GeV beam background+tridents	18.3 ± 0.4
2.2 GeV beam background	11.2 ± 0.3
2.2 GeV beam background+tridents	15.8 ± 0.4
6.6 GeV beam background	10.2 ± 0.3
6.6 GeV beam background+tridents	12.6 ± 0.4
6.6 GeV beam background+tridents+pions (FLUKA)	13.4 ± 0.4
6.6 GeV beam background+tridents+pions (G4)	13.5 ± 0.4

TABLE XVIII: Trigger rates using various background samples, with statistical uncertainties.

Test Run Issues

- **Mostly linked to electronics**
  - Two mother boards not working properly
  - HV shortage & HV group issues
  - One FADC not working properly
  - LV control only in the hall
- **Leads to several dead channels**
  - 39 disabled or disconnected
- **Trigger worked as intended**
  - Some problem of gain variations
- **Some difficulties for precise positioning of the ECal**
- **All these can be easily solved**

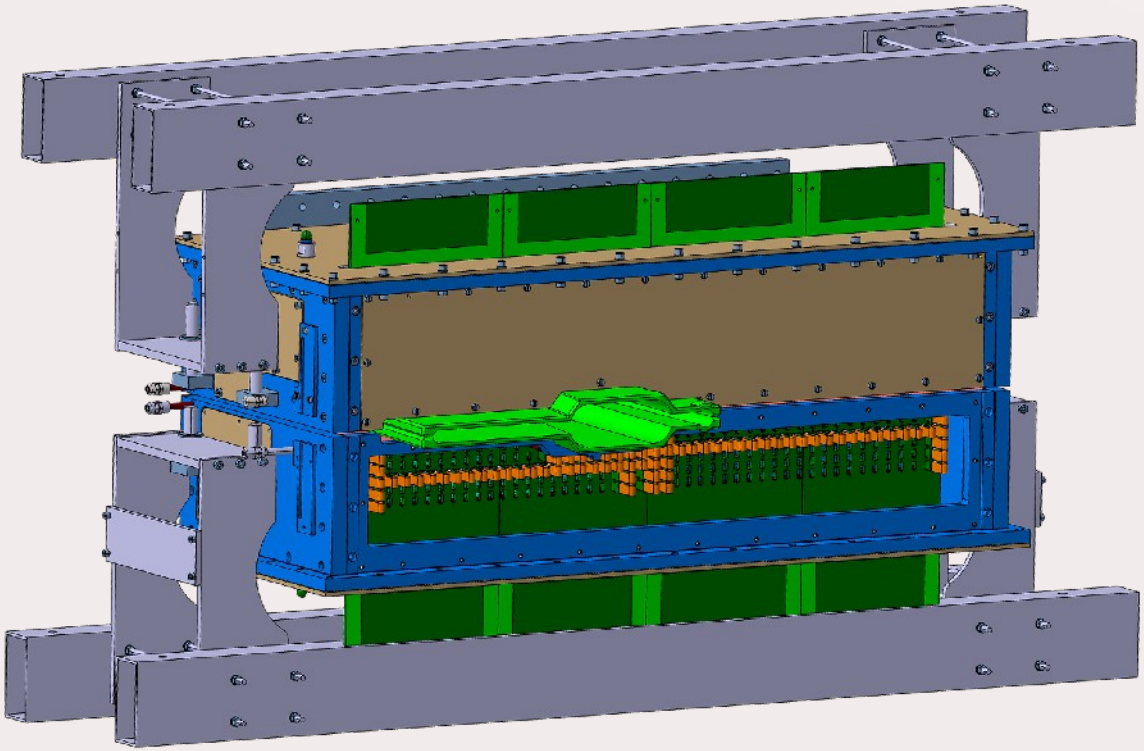
The Test Run ECal

- **Mostly the same detector**
  - Same crystal pattern
  - Same cooling system
  - Same mechanical structure
- **Few differences with final ECal**
  - Update HV map
  - Splitting of signal from preamplifiers
  - New preamplifiers settings
  - New mother board design
  - Minor adaptations on the mechanic to get the new electronic boards out
  - More precise Mechanical mounting system
- **One big addition**
  - Light monitoring system

Electronics Upgrades

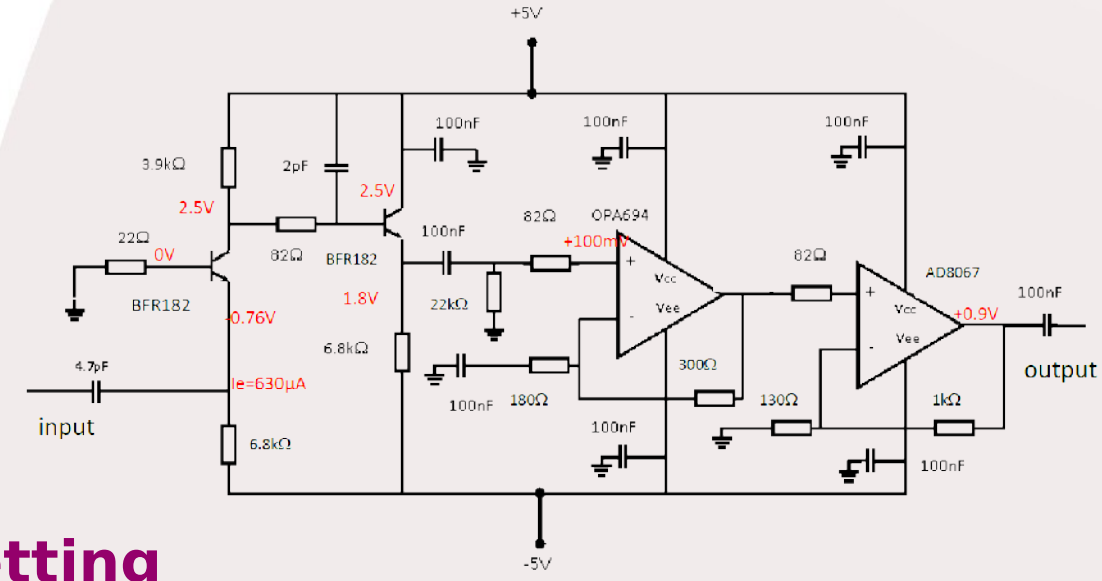
- **We identified needed repairs and several possible improvement**
  - Fix of shorted HV groups
  - Fix Mother Boards
    - We also will improve design and therefore replace all of them
  - Adapt preamplifiers
    - The different conditions in term of electronic might help to reduce the integration time

Mother Board



- **Exit through the top/bottom instead of sides**
  - Possible because of the reduction of the ECal size compared to first plans
  - Reduce the constraints to get the signal out of the box
    - From 16 to 11 levels in the board

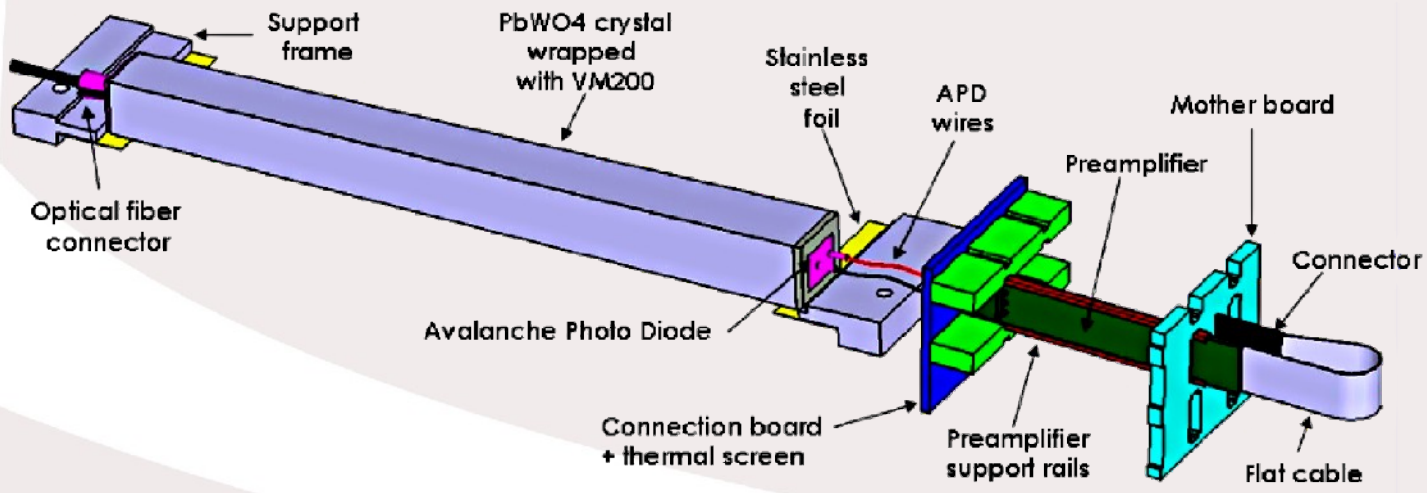
Pre-amplificators



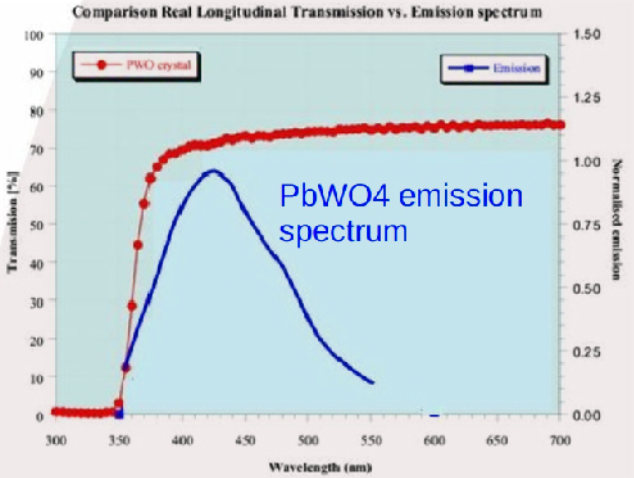
- **New setting**
  - Find the good balance of three parameters
    - gain – speed – noise
  - Adapt to new environment without splitters
- **Need to renew the stock of spares**
- **Tests during the Summer in IPNO**
  - What is the best balance while keeping linearity on the full band width?
- **Production in IPNO end of 2013, early 2014**

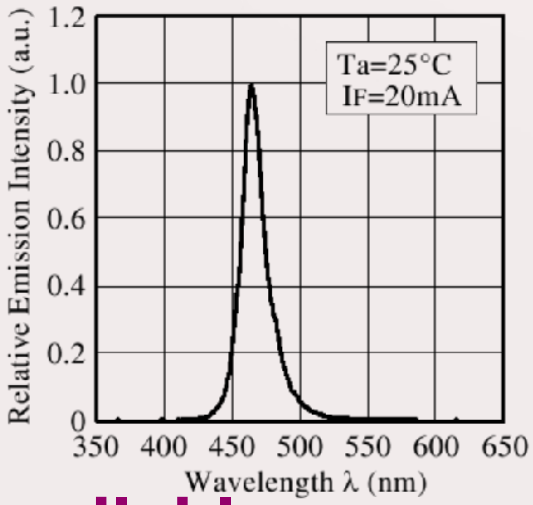
Light Monitoring System

- **Used to follow radiation damages and electronics status**
- **Design based on tests in INFN**
  - Place one LED in front of each crystal
  - Including electronics to control the system
- **Use of individual LEDs placed directly in front of each crystals**
  - Cheap system compared to optic fibers used for the previous IC calorimeter since each LED costs only ~ 1$



Light Monitoring System





- **Some results are already available**
  - LED was selected to match the PbWO4 emission spectrum
  - LED need to be individually tested
    - factor 2 rejection
  - Very high stability
    - ~2% for a given channel over 100h
    - ~0.1% from one channel to another
- **Other tests are ongoing**
  - How to fix the LEDs to the crystals?
  - Should we use bi-color LEDs?

Monitoring and Calibration

- **Online monitoring to insure data quality**
  - Characterization of crystals/APD before making the HV groups
  - LED light monitoring system
  - Dedicated cosmic runs (self triggered)

- **Offline calibration**
  - Track based calibration (used in test run)
  - Pi0 mass reconstruction

Schedule

	Tasks					2013							2014							
	Title	Duration	Start	End	Location	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Aug.
Mother Boards (MB)	Mechanics for MBs	1 m	01/06/13	01/07/13	IPNO															
	MB Design	2 m	01/07/13	01/09/13	INFN															
	MB Construction	2 m	01/09/13	01/11/13	INFN															
	MB Test	1 m	01/11/13	01/12/13	INFN															
	Ship to IPN Orsay	2 w	01/12/13	15/12/13	INFN															
	Mechanics Assembly	1 m	01/01/14	01/02/14	IPNO															
	Ship to JLab	2 w	01/02/14	15/02/14	IPNO															
Preamplifiers (PA)	PA tests	2 m	01/07/13	01/09/13	IPNO															
	Procurement PA parts	2 m	01/09/13	01/11/13	IPNO															
	PA specs dead line		01/10/13	01/10/13	IPNO															
	PA Production	4 m	01/11/13	01/03/14	IPNO															
	PA Tests	3 m	01/01/14	01/04/14	IPNO															
	Ship to JLab	2 w	01/04/14	15/04/14	IPNO															
MS	Mounting System Design	1 m	01/12/13	01/01/14	IPNO															
	MS construction	1 m	01/01/14	01/02/14	JLab															
LMS	LED LMS Design	5 m	01/07/13	01/12/13	INFN															
	LED holder production	3 m	01/09/13	01/12/13	INFN															
	LMS tooling	3 m	01/10/13	01/01/14	INFN															
	LMS mechanic	1 m	01/12/13	01/01/14	IPNO															
	Procurements LMS	2 m	01/12/13	01/02/14	IPNO															
ECal	Disassemble ECal	3 m	01/09/13	01/12/14	JLab															
	Crystal characterization	3 m	01/12/13	01/02/14	JLab															
	Assemble ECal	4 m	01/02/14	01/06/14	JLab															
	Test and calibrate ECal	2 m	01/06/14	01/08/14	JLab															
	ECal installation	1 m	01/08/14	01/09/14	JLab															

Budget

Tasks					Costs (€)			
	Title	Start	End	Lab	Labor	Travel	Material	Total
Mother Boards (MB)	Mechanics for MBs	01/06/13	01/07/13	IPNO	4 000			4 000
	MB Design	01/07/13	01/09/13	INFN	6 000			6 000
	MB Construction	01/09/13	01/11/13	INFN	4 000	1 000	10 000	15 000
	MB Test	01/11/13	01/12/13	INFN	6 000	8 000	3 000	17 000
	Ship to IPN Orsay	01/12/13	15/12/13	INFN			2 000	2 000
	Mechanics Assembly	01/01/14	01/02/14	IPNO	12 000		2 000	14 000
	Ship to JLab	01/02/14	15/02/14	IPNO	1 000			1 000
								59 000
Preamplifiers (PA)	PA tests	01/07/13	01/09/13	IPNO	6 000		1 000	7 000
	Procurement PA parts	01/09/13	01/11/13	IPNO	1 000		12 000	13 000
	PA Production	01/11/13	01/03/14	IPNO	8 000			8 000
	PA Tests	01/01/14	01/04/14	IPNO	4 000			4 000
	Ship to JLab	01/04/14	15/04/14	IPNO	1 000			1 000
								33 000
MS	Mounting System Design	01/12/13	01/01/14	IPNO	4 000			4 000
	MS construction	01/01/14	01/02/14	JLab				0
								4 000
LMS	LED LMS Design	01/07/13	01/12/13	INFN	6 000	3 000		9 000
	LED holder production	01/09/13	01/12/13	INFN	4 000		5 000	9 000
	LMS prototyping	01/10/13	01/01/14	INFN	1 000	3 000	5 000	9 000
	LMS mechanic	01/12/13	01/01/14	IPNO	4 000		2 000	6 000
	Procurements LMS	01/12/13	01/02/14	IPNO			15 000	15 000
								48 000
ECal	Crystal characterization	01/12/13	01/02/14	INFN	10 000	10 000	8 000	28 000
	Assemble ECal	01/02/14	01/06/14	IPNO	12 000	16 000		28 000
	Test and calibrate ECal	01/06/14	01/08/14	IPNO	6 000	8 000		14 000
	ECal installation	01/08/14	01/09/14	IPNO		4 000		4 000
								74 000
	TOTAL	01/06/13	01/09/14	INFN	37 000	25 000	33 000	**95 000**
	TOTAL	01/06/13	01/09/14	IPNO	63 000	28 000	32 000	**123 000**
	TOTAL	**01/06/13**	**01/09/14**	**IPNO + INFN**	**100 000**	**53 000**	**65 000**	**218 000**

Does not include physicist/postdoc salaries

Emphasis here on European contribution

- INFN committed to
  - MB Design and construction
  - LMS Design
  - Crystal characterization tooling & manpower
- IPNO committed to
  - All mechanic design and most construction
  - Preamplifiers design and production
  - LMS construction
  - Manpower for ECal assembly

Total 218 k€ (280 k$)

Conclusions

- **ECal is already in good shape**
  - Core elements are ready
    - Crystals, mechanics and DAQ electronics
- **Many improvements are planned**
  - Various replacements/improvements in electronics
  - Small adjustments in mechanics
  - Addition of a light monitoring system
  - Most work will be carried on by the European partners
- **Test run showed that trigger works as expected**
  - No major change here but will take advantage of ECal upgrades

APD plans

- **Orsay have ~70k€ for it on ANR grant dedicated to HPS (already secured) and has an application pending for 350k€ more**
- **INFN will also apply for local funding (~250k€)**
- **If one of the grant application is successful it will lead to**
  - Reduction of preamplifiers gains (reducing noise and/or timing)
  - Allow better calibration with cosmic muons
  - But will make the schedule tight for replacement
    - Travel money is included in INFN grant to have technicians come to JLab to help for the replacement