Status dell'esperimento Auger

R. Assiro, C. Bleve, G. Cataldi, M.R. Coluccia, A. Corvaglia, P. Creti, S. D'Amico, I. De Mitri, A. Donno, G. Fiore, G. Marsella, D.Martello, L.Perrone, C. Pinto, V. Scherini, F. Strafella

Dipartimento di Fisica

INFN Istituto Nazionale di Fisica Nucleare Sezione di Lecce

Summary

- **Introduzione**
- Produttività Scientifica
- Il programma di upgrade
- Attività a Lecce

Il progetto Pierre Auger: range di operatività

Studio della radiazione cosmica di altissima energia

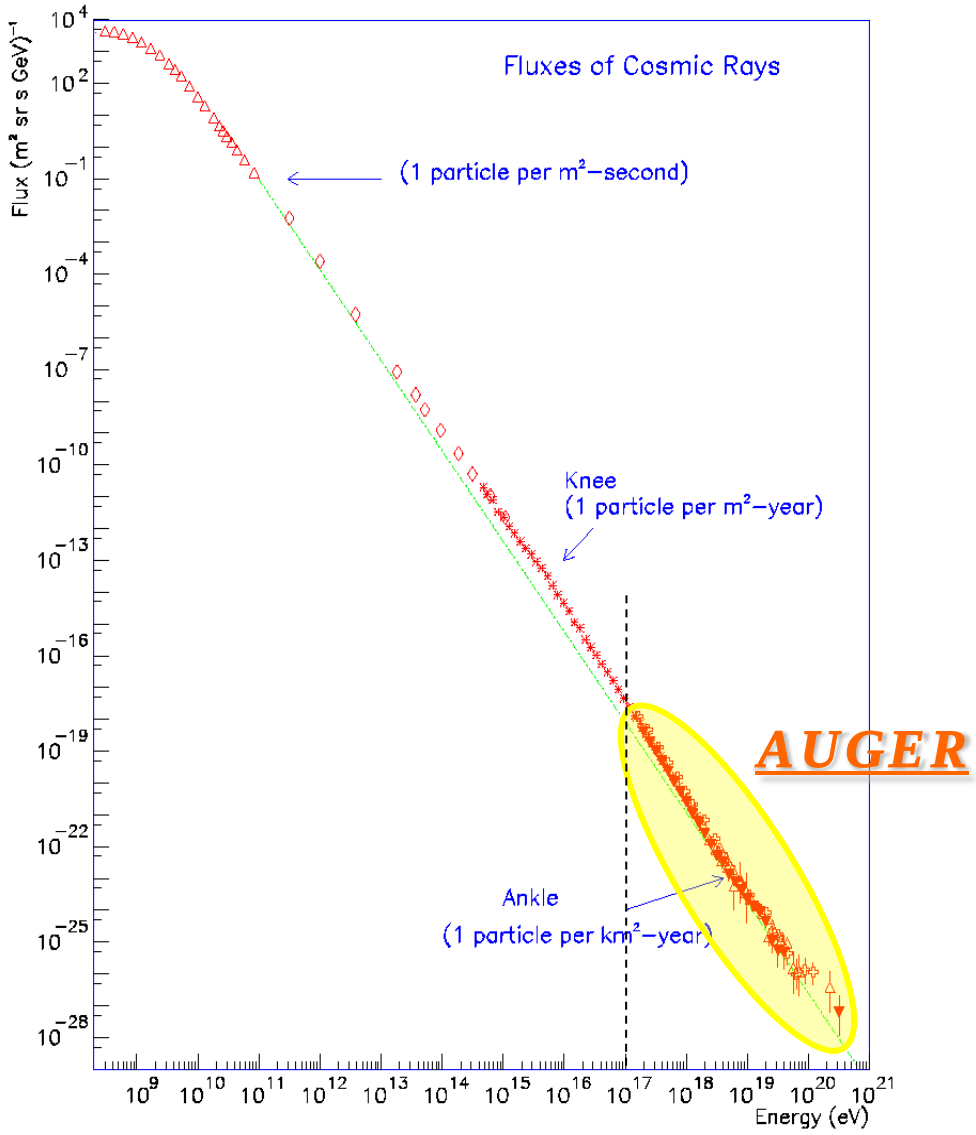
$(10^{17}\text{-}10^{21})$ eV

Flusso ad $E > 10^{19.5}$ eV molto basso

1 particella / (km^2 sr secolo)

Apparato di grandi dimensioni: 3000 km^2 (Auger)

30 eventi/anno



Summary

- Introduzione
- **Produttività Scientifica**
- Il programma di upgrade
- Attività a Lecce

Produttività Scientifica della Collaborazione

Auger Top 10 (by citations, INSPIRE)

paper	# citations	rank in Journal
NIM 2004 (Engineering Array)	555	2 (after D0)
Science 2007 (VCV)	521	2 (after CDMS II)
PRL 2008 (spectrum)	455	23
PRL 2010 (X_{max})	406	14
APP 2008 (VCV)	353	1
PLB 2010 (spectrum)	294	8 (only Higgs got more)
APP 2010 (VCV update)	244	1
NIM 2010 (Flouresc. Det.)	167	3 (after ALICE, T2K)
APP 2008 (photons)	157	3 (after Auger, Fermi-LAT)
PRL 2008 (tau neutrinos)	143	179

Total number of citations of Auger papers ~6300

average of 83 citations per Journal paper

Summary

- Introduzione
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- **Il programma di upgrade**
- Attività a Lecce

The upgrade Science Case

1) The primary objective of the upgrade of the Auger Observatory is to elucidate the origin of the flux suppression and the mass composition at the highest energies…

2) The search for a flux contribution of protons up to the highest energies will be the second key science objective. We aim to reach a sensitivity to a contribution as small as 10%. …

3) …Estimating the number of muons in air showers from Auger data, a discrepancy between the observed and expected muon numbers is found. Therefore the third key science objective will be the study of extensive air showers and hadronic multiparticle production….

AUGER PRIME: Organization

Pierre Auger Observatory Upgrade - Cost Estimate - Preliminary Design Report — 09 April 2015 — 5.4

WBS	Activity	Total Cost[2] with Contingency and Infrastructure cost (IFL)		Contingency Part	Infrastructure cost Part (IFL)	Total Cost[3] with Contingency only (No Infrastructure cost, IFL)		Infrastructure cost[4] only (IFL)	
	Currency[1] >	US $	€	%	%	US $	€	US $	€
0	***Pierre Auger Observatory Upgrade***	***15,175,050***	***14,416,298***	***13.9%***	***16.3%***	***12,694,152***	***12,059,445***	*2,480,898*	*2,356,853*
1	Scintillator Surface Detector	14,811,450	14,070,878	13.9%	16.7%	12,330,552	11,714,025	2,480,898	2,356,853
1.1	Scintillator Surface Detector	10,300,788	9,785,749	14.2%	18.9%	8,356,898	7,939,053	1,943,890	1,846,696
1.1.1	Detector development	*6,720,478.50*	*6,384,454.58*	*14.8%*	*1.2%*				
1.1.2	Photodetector development	*1,328,234.50*	*1,261,822.78*	*10.6%*	*3.2%*				
1.1.3	Assembly, deployment and tests	*2,252,075.00*	*2,139,471.25*	*14.6%*	*80.9%*				
1.2	Surface Detector Electronics	4,510,662	4,285,129	13.1%	11.9%	3,973,654	3,774,971	537,008	510,158
1.2.1	Upgraded Unified Board Production	*3,066,260.28*	*2,912,947.27*	*12.2%*	*12.6%*				
1.2.2	Small PMT	*1,144,671.50*	*1,087,437.93*	*13.2%*	*3.6%*				
1.2.3	Test Benches Production	*22,710.00*	*21,574.50*	*20.0%*	*30.1%*				
1.2.4	Assembly and deployment	*277,020.25*	*263,169.24*	*22.0%*	*36.6%*				
2	Preparation to Upgrade	363,600	345,420	16.7%	0.0%	363,600	345,420	0	0
2.1	Surface Detector Preparation	363,600	345,420	16.7%	0.0%	363,600	345,420	0	0
2.1.1	Photodetectors	*363,600.00*	*345,420.00*	*16.7%*	*0.0%*				

Notes:
1 - Exchange rate Euro/US Dollar = 0.95
2 - Total cost with contingency, spares, wastages, labor and infrastructure charges
3 - Total cost with contingency, spares, wastages.
4 - Infrastructures charges including labor

The total cost of the project is dominated by the cost of PMTs, Scintillator and fibers (55% of the total cost) .

AUGER PRIME: Organization

MoU are under the way but the Collaboration Board (with the approval of the Finance Board) has defined the sharing between the different countries.

Country Shares according to OCL

	OCL	Share (%)	Share (M$)	Share (M€)
Argentina	35	13,31 %	0,21	0,18
AMD			1,55	1,37
Australia	3	1,14 %	0,16	0,14
Brazil	23	8,75 %	1,26	1,11
Colombia	2	0,76 %	0,11	0,10
Czech Rep.	13	4,94 %	0,71	0,63
France	17	6,46 %	0,93	0,82
Germany	40	15,21 %	2,19	1,93
Italy	33	12,55 %	1,81	1,59
Mexico	11	4,18 %	0,60	0,53
Netherlands	8	3,04 %	0,44	0,39
Poland	6	2,28 %	0,33	0,29
Portugal	11	4,18 %	0,60	0,53
Romania	8	3,04 %	0,44	0,39
Slovenia	5	1,90 %	0,27	0,24
Spain	14	5,32 %	0,77	0,68
USA	34	12,93 %	1,86	1,64
total SDU	263	100,00 %	**12,69**	**11,19**

AUGER PRIME: Finance Board

The FB has appointed a Scientific Advisor Committee in May 2013 to follow and evaluate the Auger Upgrade Proposal

Francis Halzen (chair)
Christian Spiering
Tom Gaisser
Roberto Battiston
Christophe De La Taille
Henry Sobel
Felix Mirabel

AUGER PRIME: SAC

May 2015

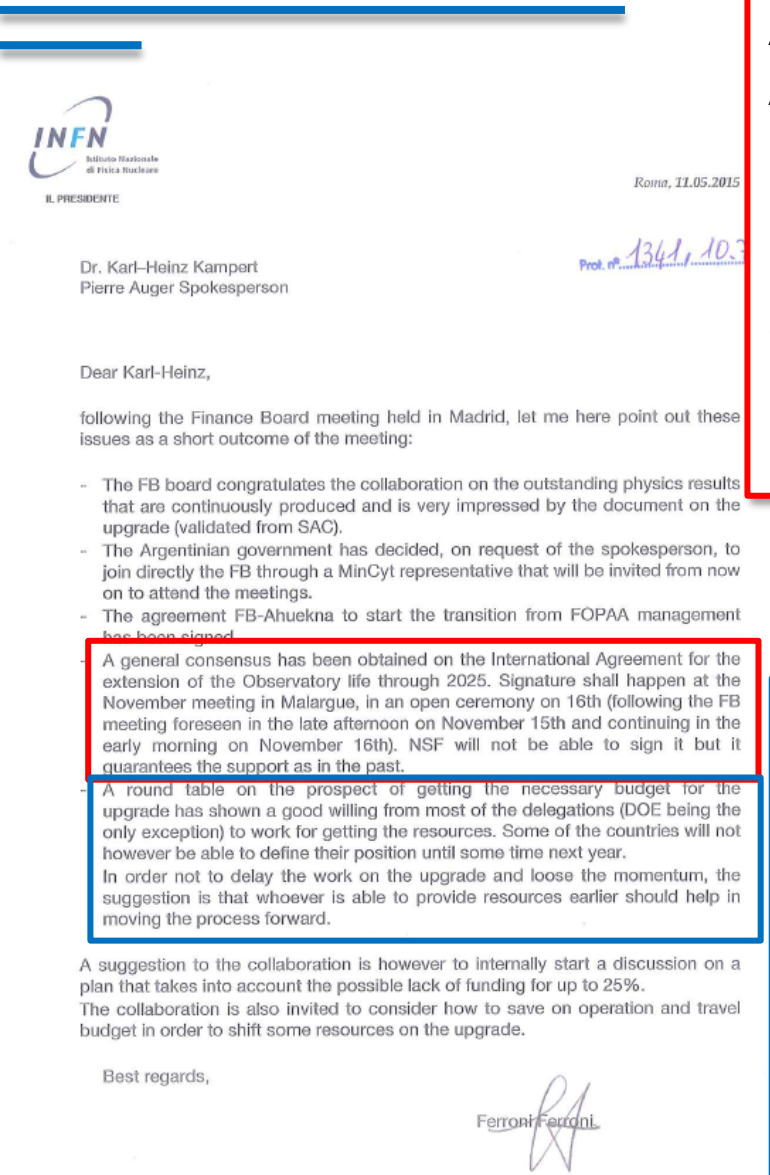
Francis Halzen Letter

The committee reviewed the Upgrade-PDR that clearly lays out the enormous amount of work done by the collaboration to get to this stage. It is a very comprehensive document that seems to address all of the issues that can possibly be addressed at this point. Essentially all of the projected sensitivity is obtained on the basis of existing components whose performance is understood. As a result there is a high degree of certainty in the eventual performance of the upgrade.

We are impressed with the thoroughness of the work of the internal upgrade committee and their decision making process. The ASCII solution certainly represents the most cost-effective of the four technological options initially considered. The use of two independent approaches, shower universality and matrix inversion, makes the ASCII performance estimates more robust than might have been anticipated at the beginning of the process and delivers convincing results. We also support the cross calibration with the AMIGA counters which in addition covers the energy range of the LHC and allows a better comparison to accelerator data.

We believe that the upgraded Auger has an excellent chance of answering long-standing questions about the origin of cosmic rays and strongly endorse the plan.

AUGER PRIME: Finance Board



INFN Istituto Nazionale di Fisica Nucleare

IL PRESIDENTE

Roma, 11.05.2015

Prot. n° 1341/10.3

Dr. Karl-Heinz Kampert
Pierre Auger Spokesperson

Dear Karl-Heinz,

following the Finance Board meeting held in Madrid, let me here point out these issues as a short outcome of the meeting:

- The FB board congratulates the collaboration on the outstanding physics results that are continuously produced and is very impressed by the document on the upgrade (validated from SAC).
- The Argentinian government has decided, on request of the spokesperson, to join directly the FB through a MinCyt representative that will be invited from now on to attend the meetings.
- The agreement FB-Ahuekna to start the transition from FOPAA management has been signed.
- A general consensus has been obtained on the International Agreement for the extension of the Observatory life through 2025. Signature shall happen at the November meeting in Malargue, in an open ceremony on 16th (following the FB meeting foreseen in the late afternoon on November 15th and continuing in the early morning on November 16th). NSF will not be able to sign it but it guarantees the support as in the past.
- A round table on the prospect of getting the necessary budget for the upgrade has shown a good willing from most of the delegations (DOE being the only exception) to work for getting the resources. Some of the countries will not however be able to define their position until some time next year.
  In order not to delay the work on the upgrade and loose the momentum, the suggestion is that whoever is able to provide resources earlier should help in moving the process forward.

A suggestion to the collaboration is however to internally start a discussion on a plan that takes into account the possible lack of funding for up to 25%.
The collaboration is also invited to consider how to save on operation and travel budget in order to shift some resources on the upgrade.

Best regards,

Ferroni Ferroni

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The Upgrade

Science

Determine the electromagnetic and muonic components of the EAS and extend the dynamic range

New Surface Detector Electronics

Statistics: extended duty cycle of the Fluorescence detector

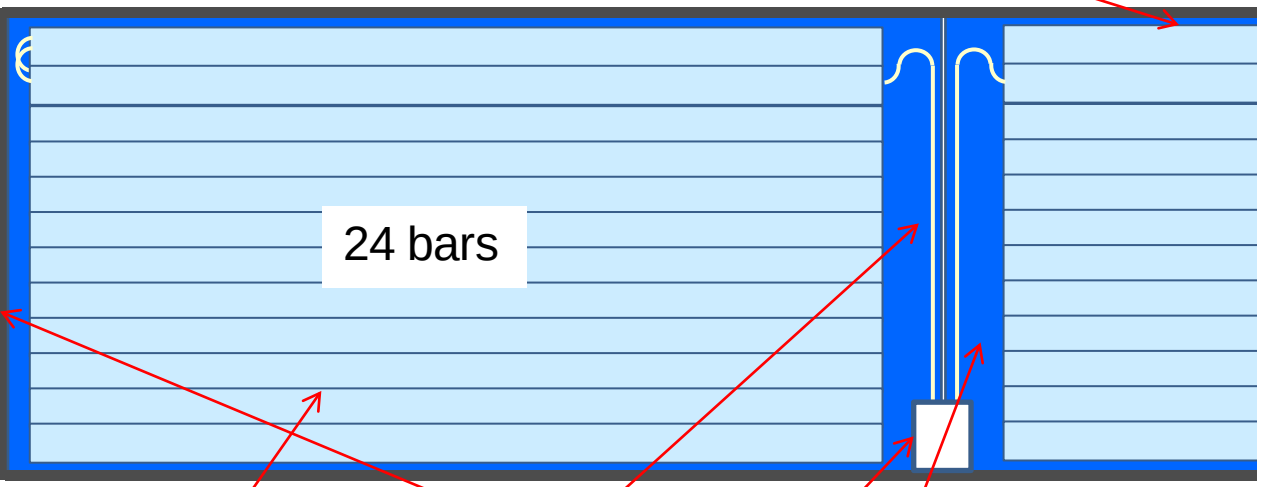
SSD: Surface Scintillator Detector

Determine the electromagnetic and muonic components

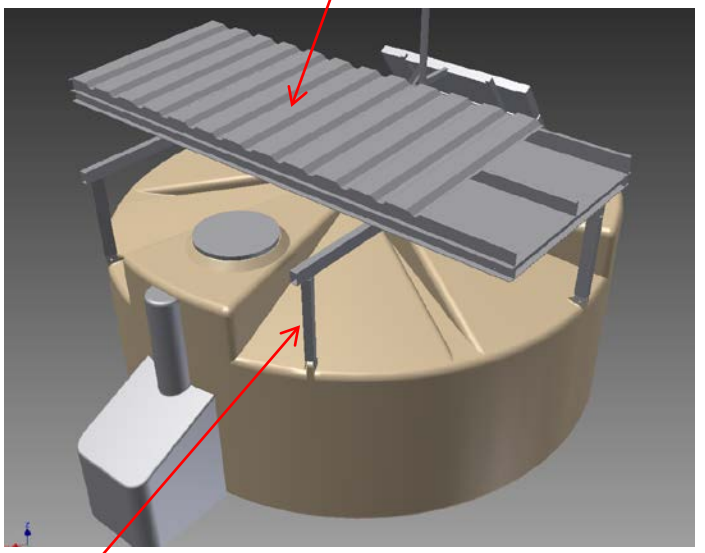
The Surface Scintillator Detector

Aluminum Box

Extruded Polystyrene Vessel



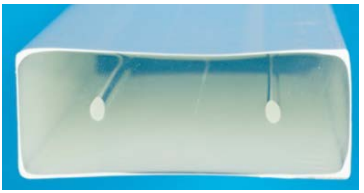
Second roof for thermal insulation



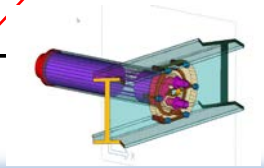
Scintillator bars

fibers

Routers to route the fibers



PMT

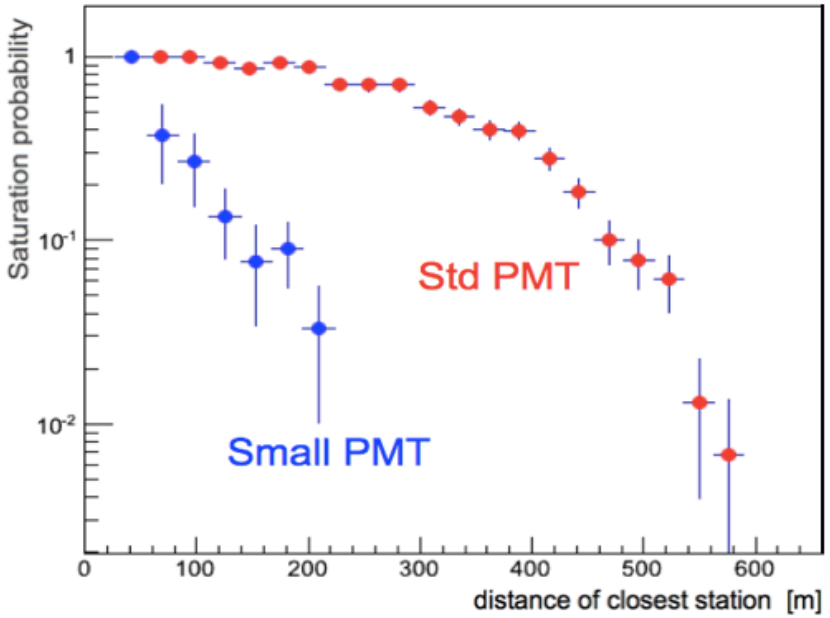


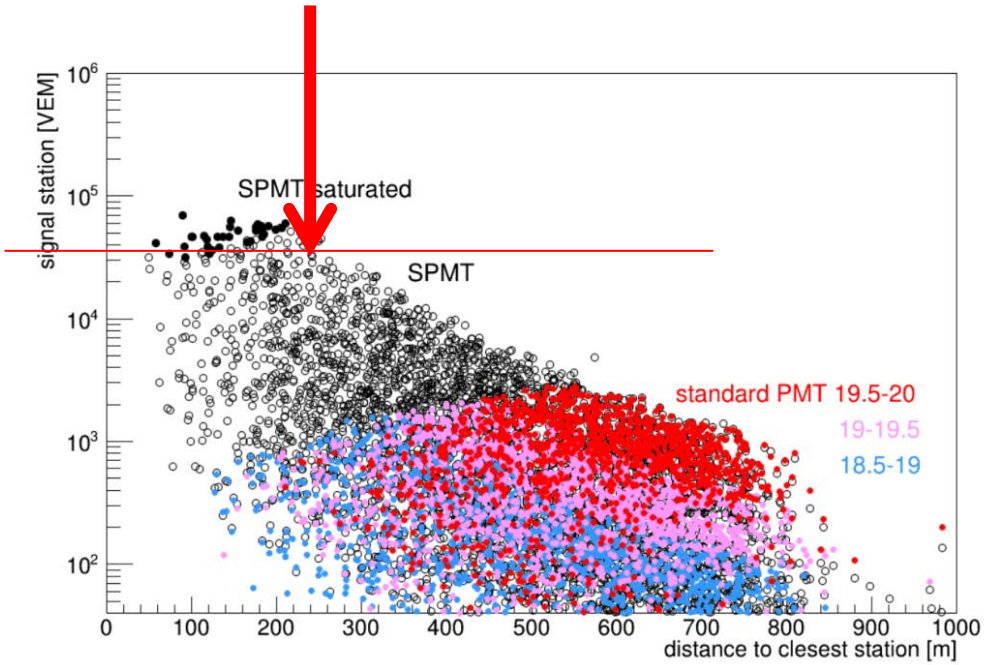
Support

DRE: Dynamic Range Extension

Add a 4th PMT of 1/9 diameter wrt the PMTs of the WCD

1. dynamic range from fractions of VEM to >40000 VEM
2. less than 2% saturated events at the higher energies
3. unambiguous determination of the particle density down to < 300 m from the core

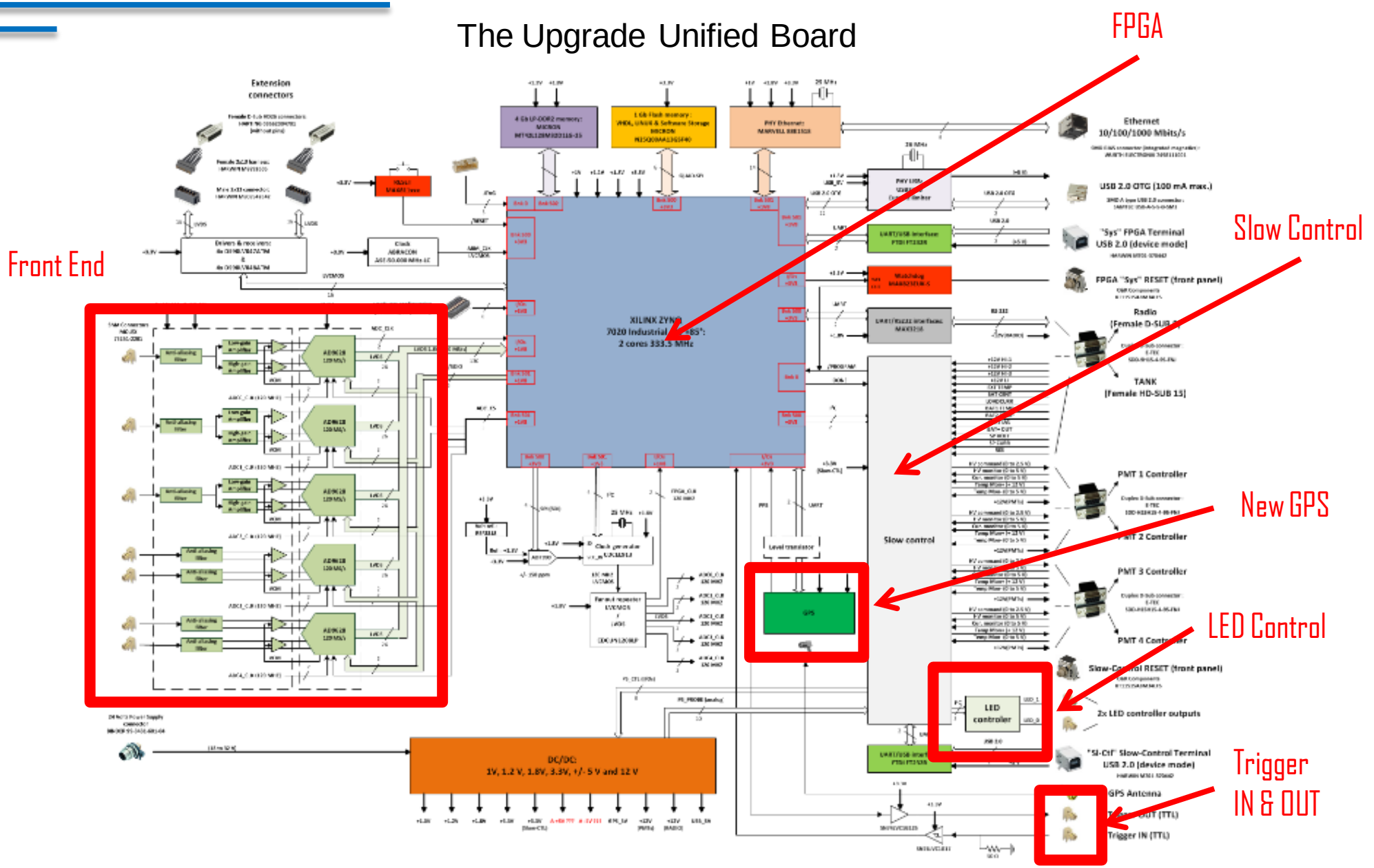




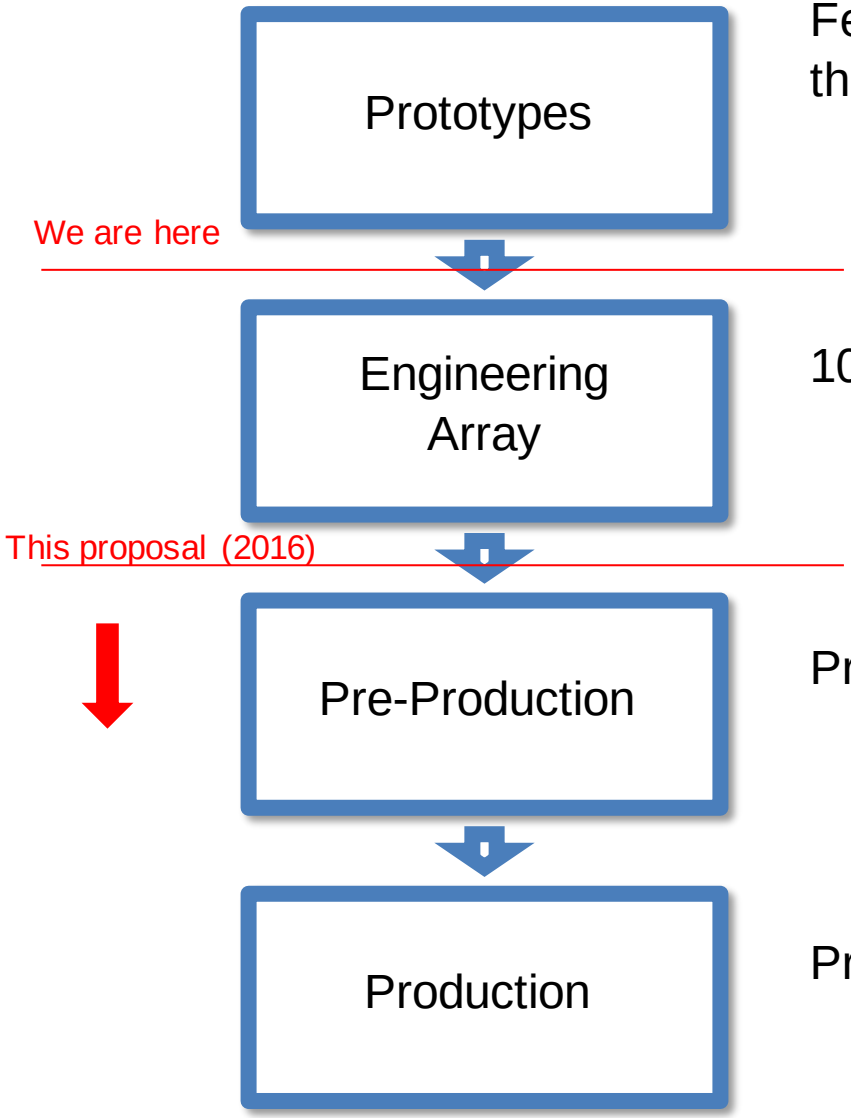
L. Perrone V. Scherini

SDE: Surface Detector Electronics

The Upgrade Unified Board



AUGER PRIME: Organization



Few elements tested in the lab. or in the field

- Identify critical points
- Define the procedures
- Compare technical solutions

10 Units in the field

- Test all the components together in the field and with true showers

Pre Production of 100 units.

- Test and tune the production factories

Production of all the other elements.

Not necessary in the final production factories

AUGER PRIME in Italy: Organization

The Italian contribution is organized in four Work Packages

PMT Procurement, preparation and validation

HV Procurement and validation

SDE Procurement and validation

LECCE

SSD assembling and validation

LECCE

1. Half (800) SPMTs and 400 SSD-PMTs (1200 PMTs)
2. All the HV (CAEN) for the SPMTs and for the SSD-PMTs (3600 Units)
3. Contribution to the SDE production (all the FADCs)
4. Assembling of 400 SSD Units (no scintillator and fibers)

SSD: Organization

Colorado

400 Units

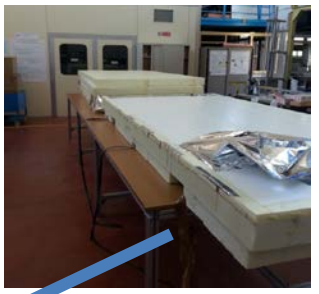
Nikhef

400 Units

KIT

460 Units

INFN- Lecce



400 Units

INFN-NA
Chicago
Wuppertal

PMTs and Mechanics

Assembling of PMT and SSD

Argentina-local stuff

Validation facility at Malargue

Portugal-Brasil

Deployment

Argentina L.S. & US

SSD: Organization

Prototype to define the details

Fibers Orsay

One SSD prototype in preparation at INFN-LE.
INFN economical contribution: Enclosure, Vessel, Routers, mechanics of PMT, Scintillator
Activity: procurement, preparation, validation, installation, analysis.

Already funded

Engineering Array of 10 stations.

The EA will be prepared in KIT and will be deployed in the field in the first half of 2016.
No economical contribution required to INFN.

none

Activity: installation, analysis.

Scintillator and Fibers no INFN

Pre - production of 100 units.

The pre production will be prepared and validated in 4 assembling facilities 3 EU 1 US. One of this facility will be INFN-LE.

Required in this proposal

INFN economical contribution: enclosure, vessel, routers for 25 units.
Activity: procurement, preparation, validation, installation, analysis.

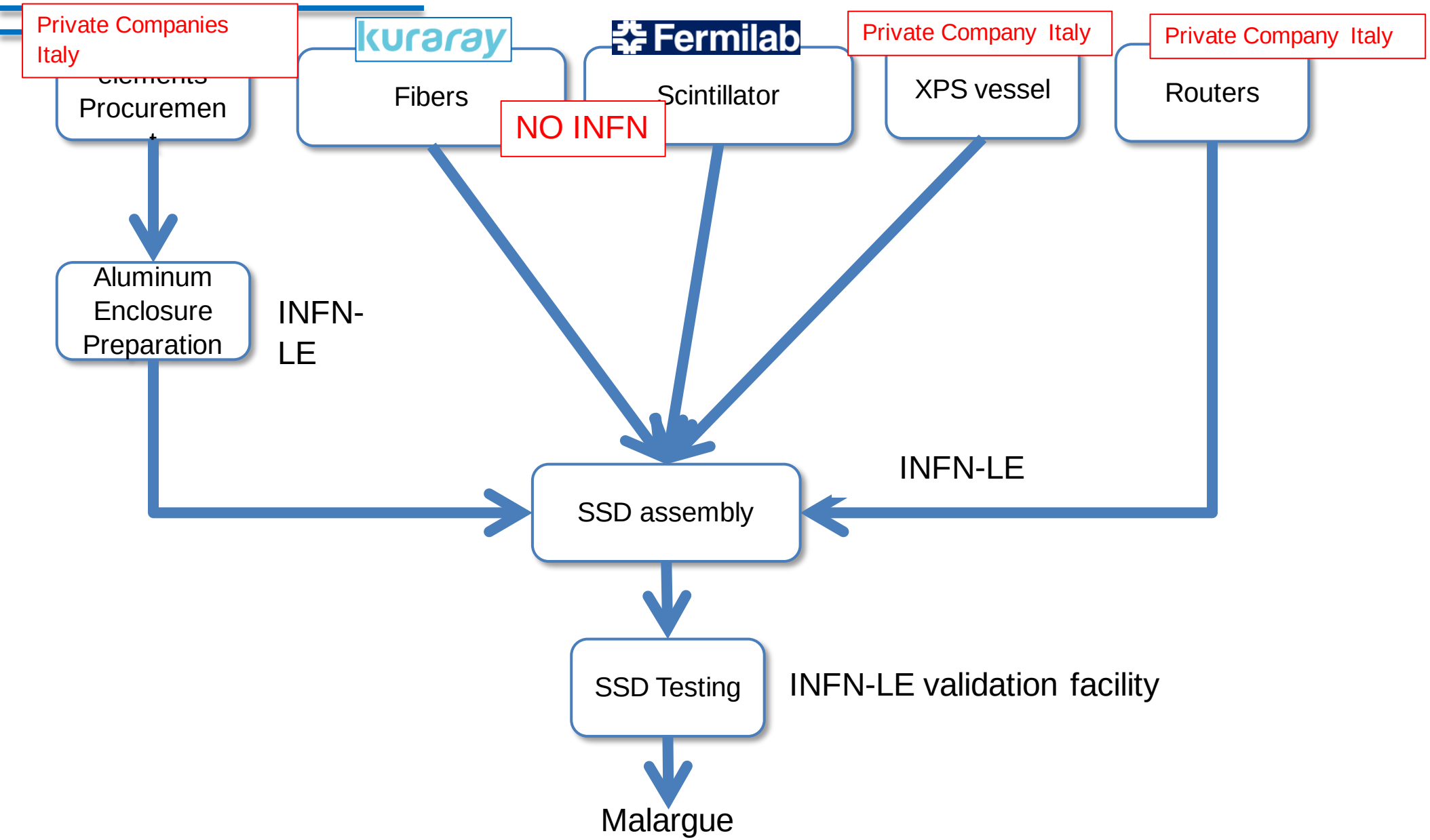
Production of 1600 units.

Scintillator and Fibers no INFN

Production in the facilities prepared in the pre-production phase.
INFN economical contribution: enclosure, vessel, routers for 375 units.

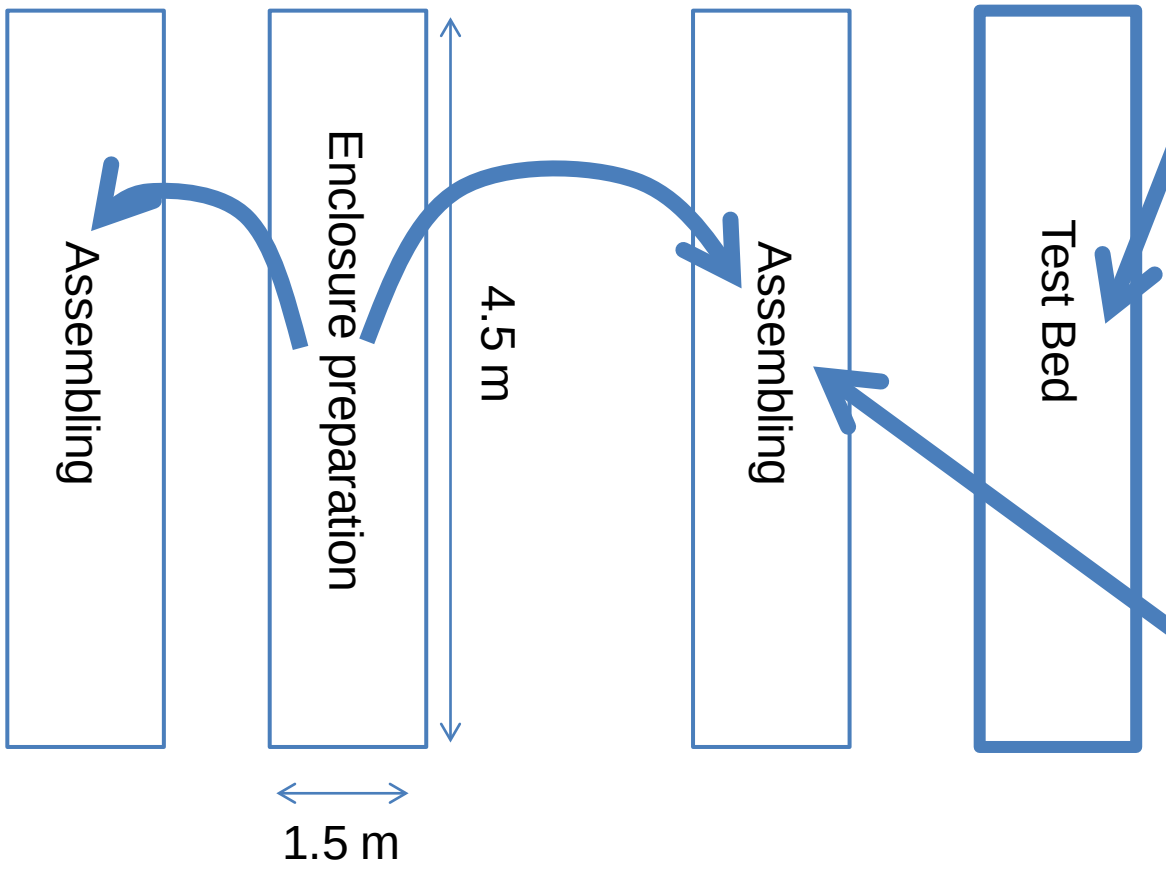
Required in this proposal

SSD: Organization

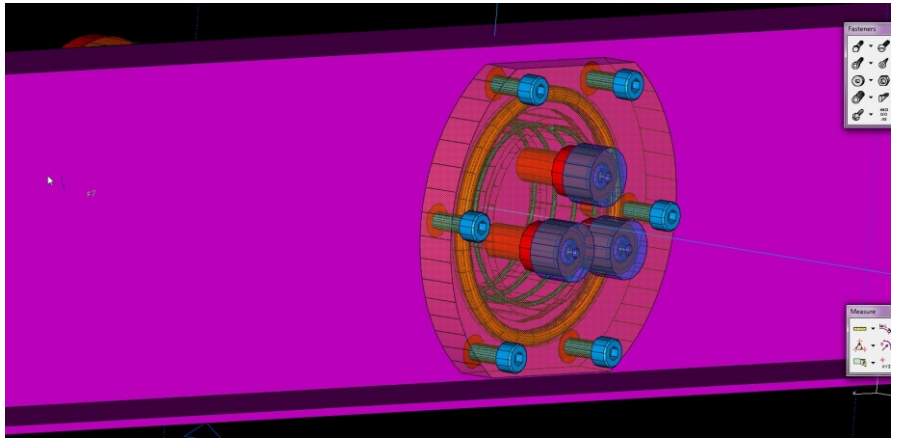


SSD: Organization

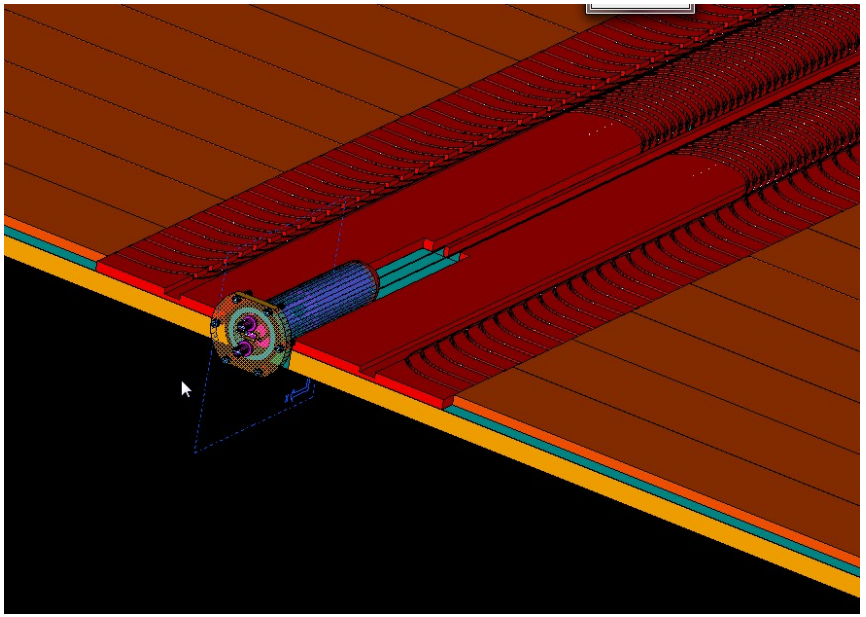
The Assembling facility in Lecce



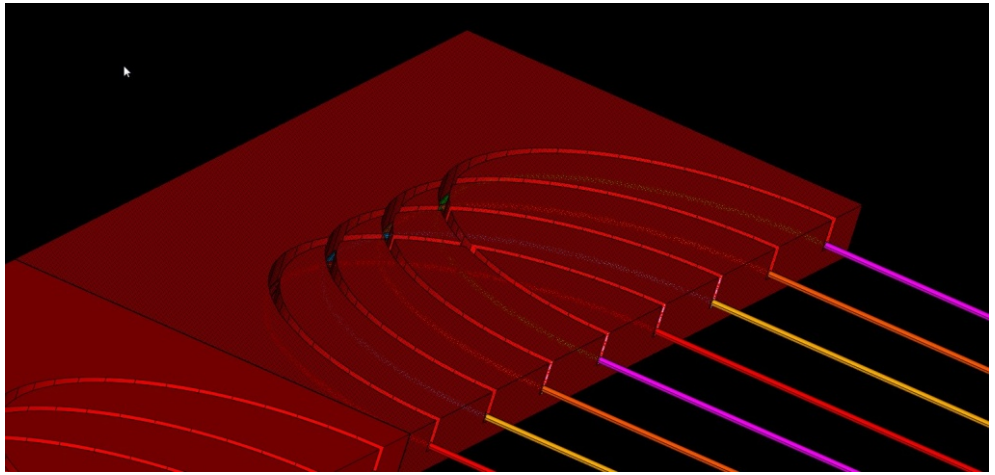
SSD: Surface Scintillator Detector



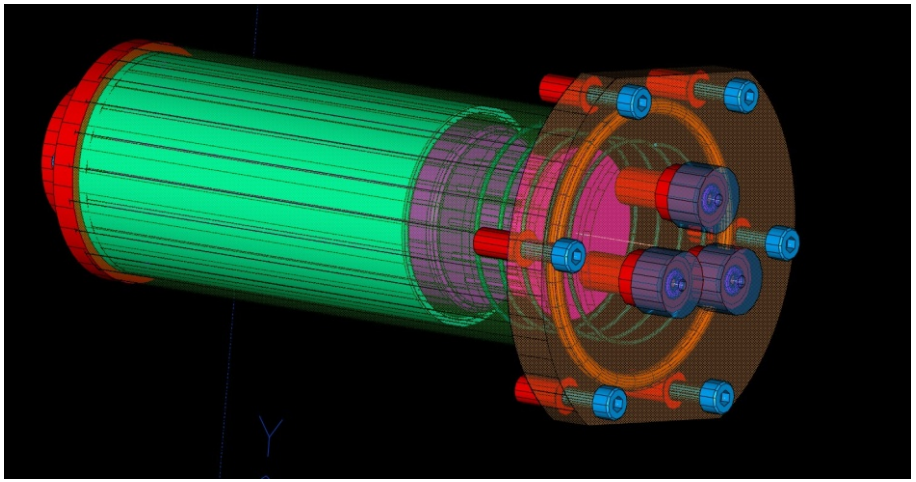
Rear panel of the PMT



View of the inside of the unit



Lateral Routers

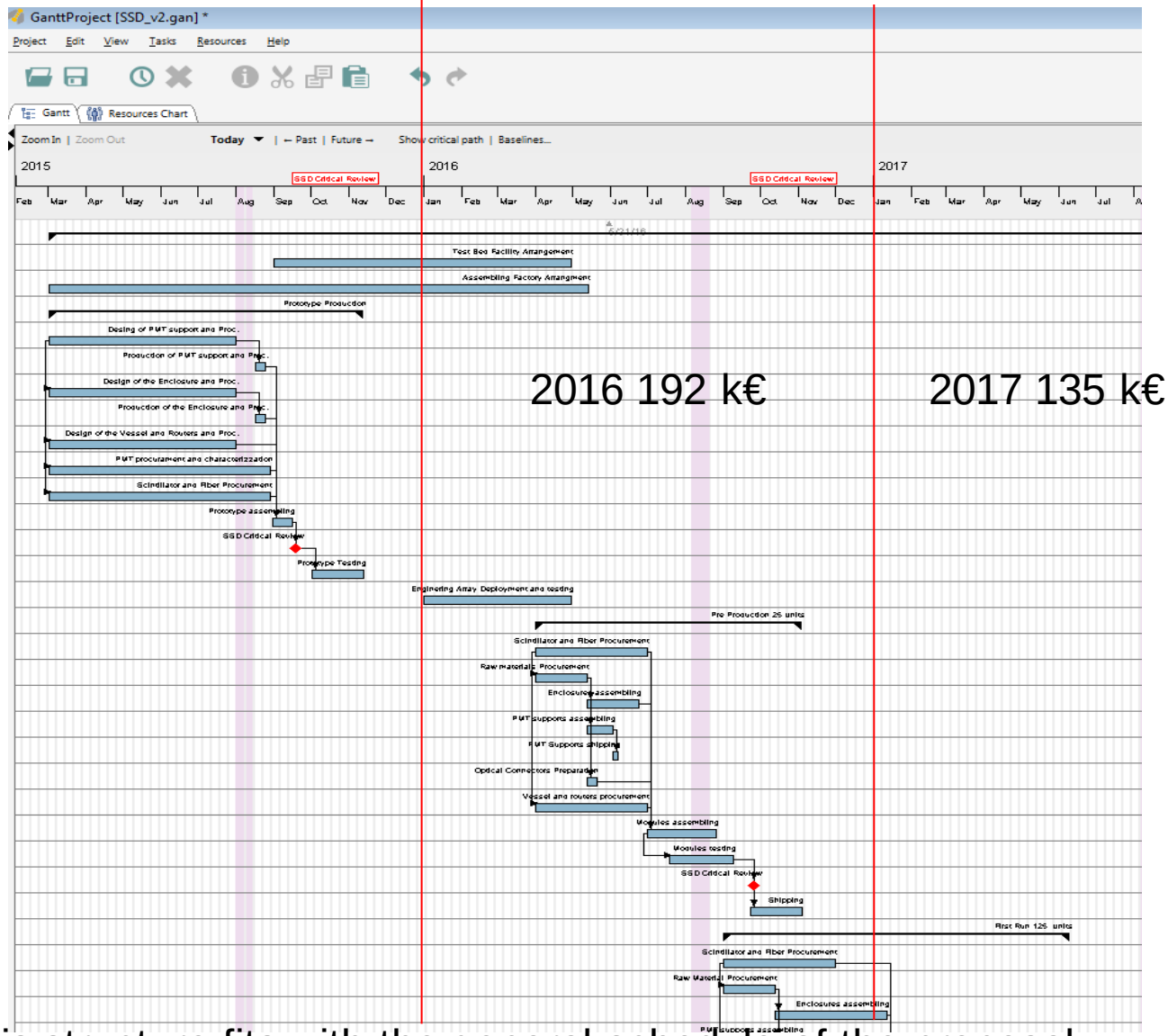


PMT support

P. Fiore, A. Miccoli

SSD: Organization

Schedule in this proposal



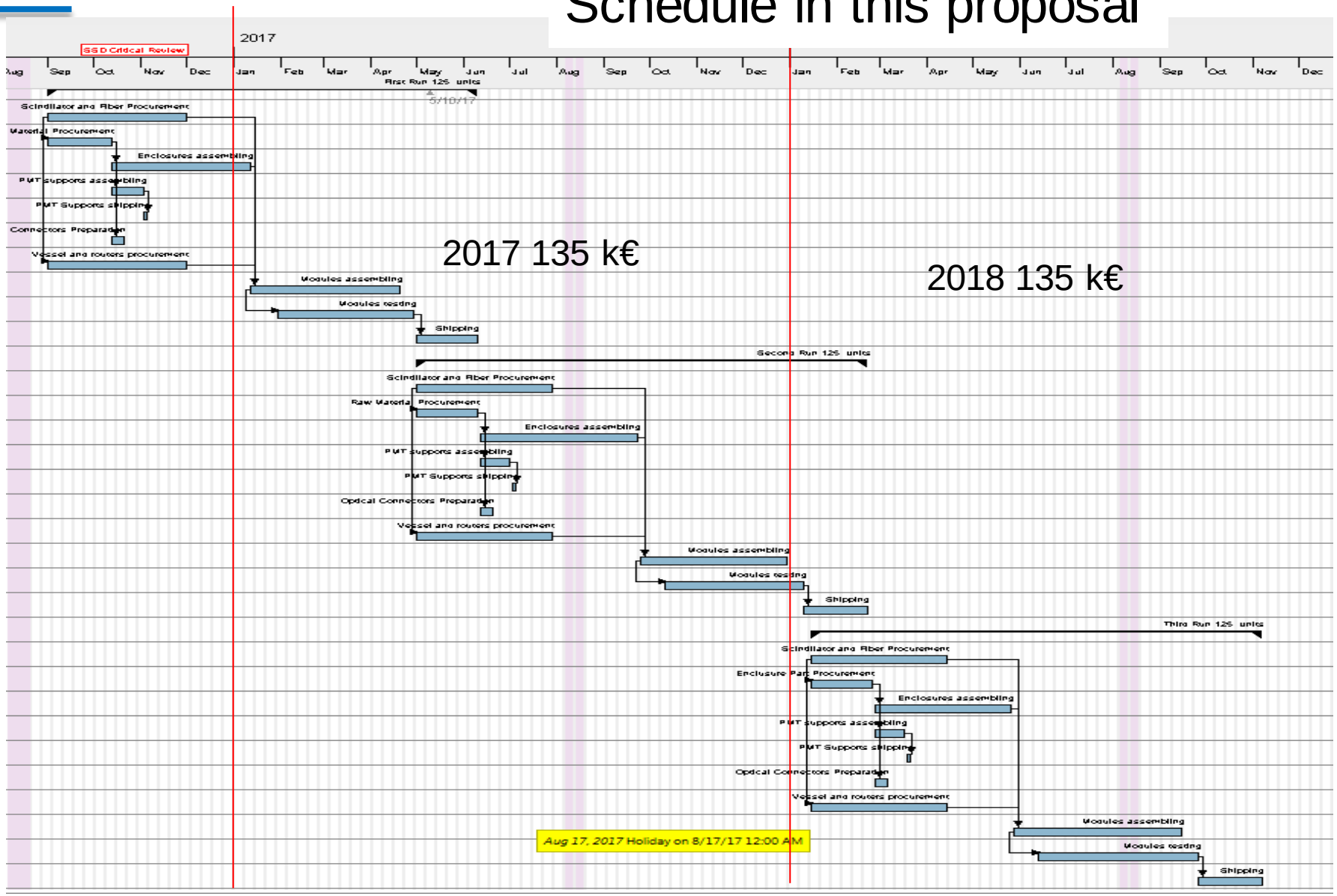
2016 192 k€

2017 135 k€

This structure fits with the general schedule of the proposal.

SSD: Organization

Schedule in this proposal



This structure fits with the general schedule of the proposal.

SDE: Organization

6 prototypes for verification in the lab.s

The prototypes have been assembled in KIT and are under test.
INFN economical contribution: the FADC Already funded
Activity: check and validation of the Front-End and of the LED system

Engineering Array of 10 stations.

The EA will be assembled in KIT and deployed in the field in the first half of 2016.
INFN economical contribution: the FADC Already funded
Activity: check and validation of the Front-End and of the LED system

Pre - production of 100 units.

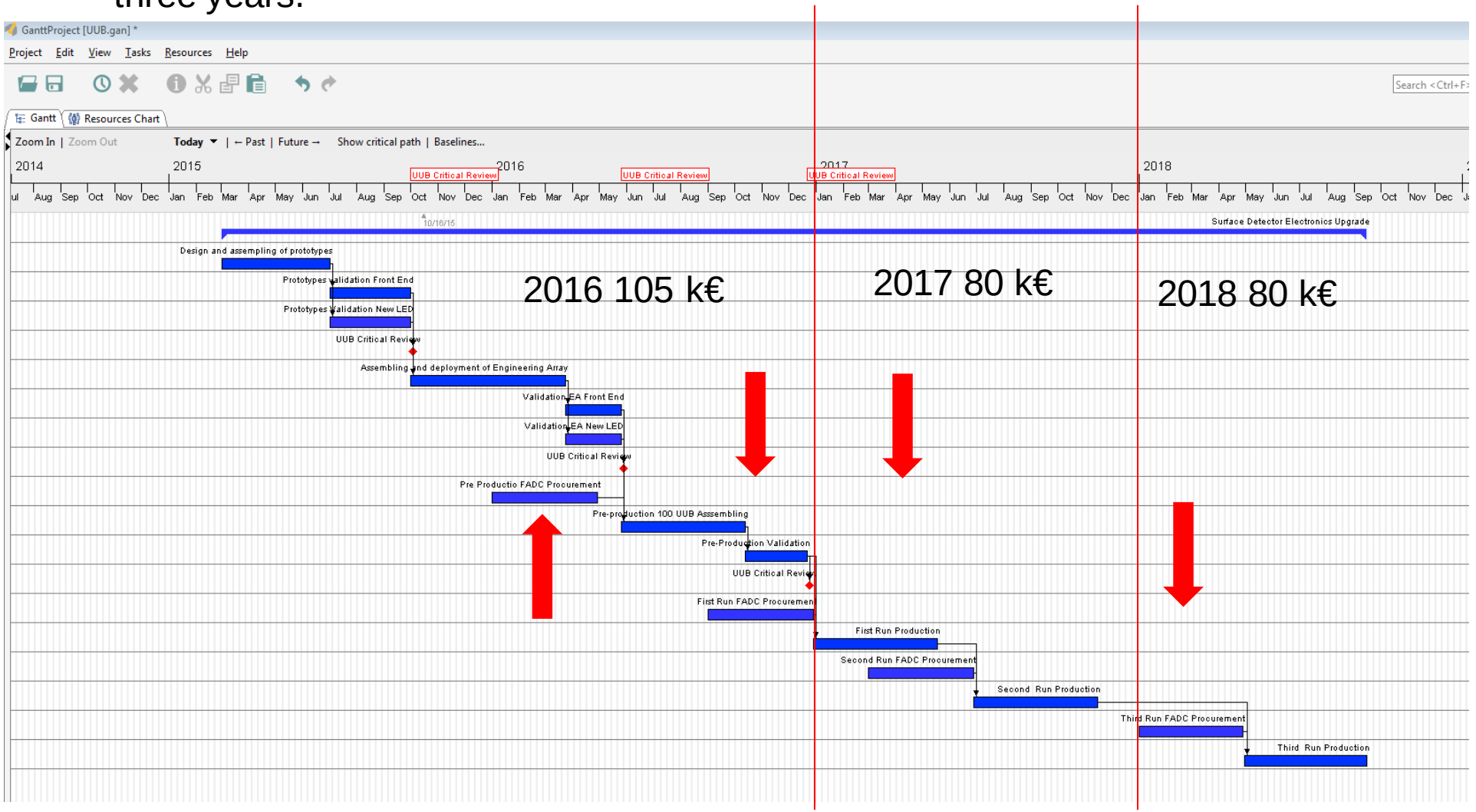
The pre production boards will be assembled in the final assembling facilities (2 EU, 1 US, 1 South America).
INFN economical contribution: the FADC Required in this proposal
Activity: check of the Front-End and of the LED system

Production of 1600 units.

Production of the boards in the final assembling facilities (2 EU, 1 US, 1 South America).
INFN economical contribution: the FADC Required in this proposal

SDE: Organization

Gantt structure for INFN. The procurement of the FADC has been distributed in three years.



This structure fits with the general schedule of the proposal (with one year shift).

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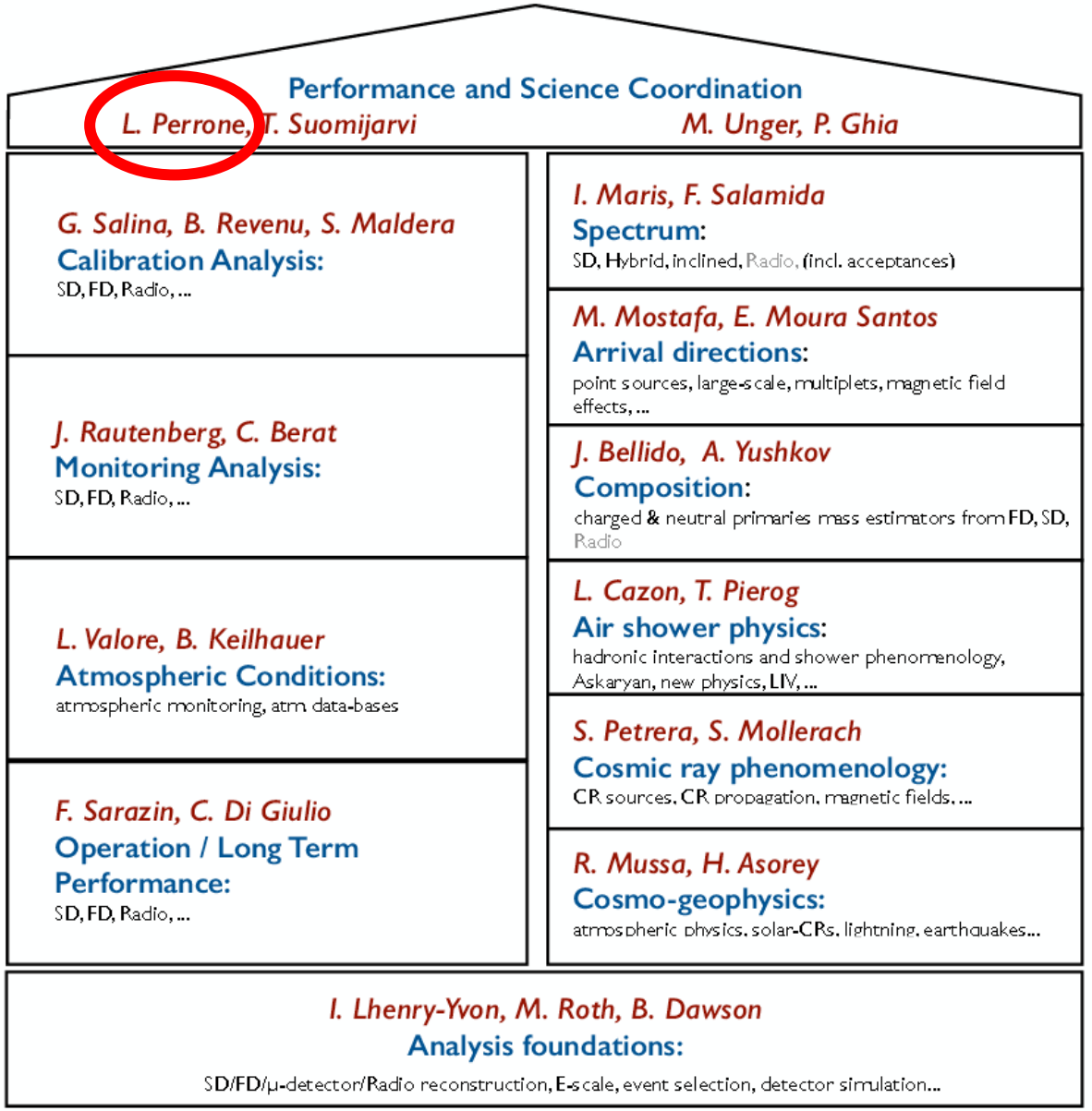
Upgrade Roadmap:The Task Force



Upgrade Roadmap:The Task Force

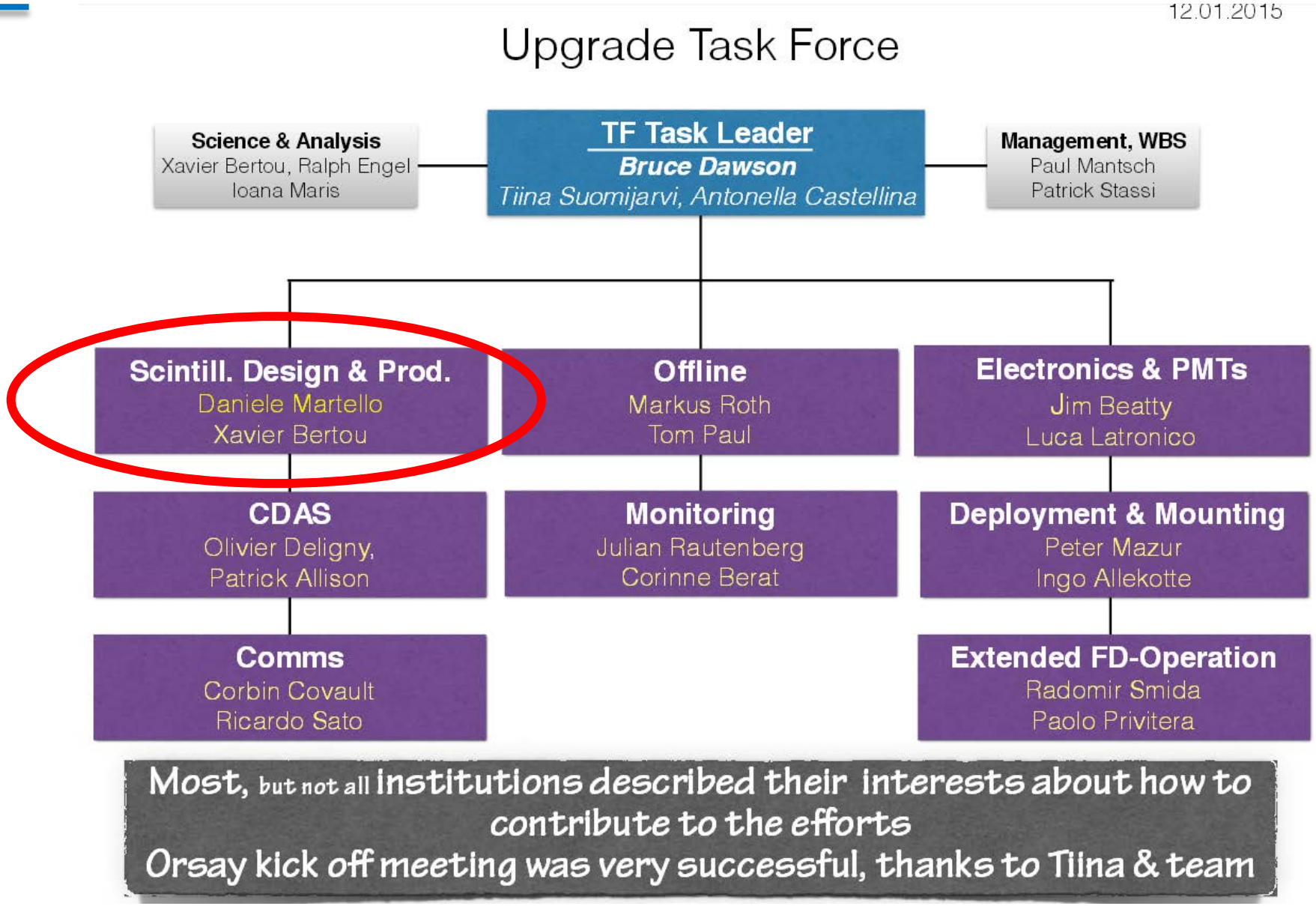
The Pierre Auger Collaboration

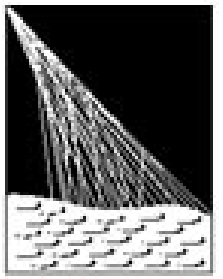
The Pierre Auger Collaboration includes over 500 scientists from Argentina, Australia, Brazil, Croatia, the Czech Republic, France, Germany, Italy, Mexico, Netherlands, Poland, Portugal, Roumania, Slovenia, Spain, the United Kingdom, and the United States of America.

These are the elected officers in the Collaboration:

- Spokesperson: Karl-Heinz Kampert (Wuppertal)
- Co-Spokesperson: Antonio Bueno (Granada)
- Spokespersonae Emeriti: James W. Cronin (Chicago), and Alan A. Watson (Leeds)
- Collaboration Board Chair: Lukas Nellen (UNAM)
- Collaboration Board Co-Chair: Lorenzo Perrone (Lecce)
- Project Manager: Jonny Kleinfeller (Pierre Auger Observatory)

Upgrade Roadmap:The Task Force



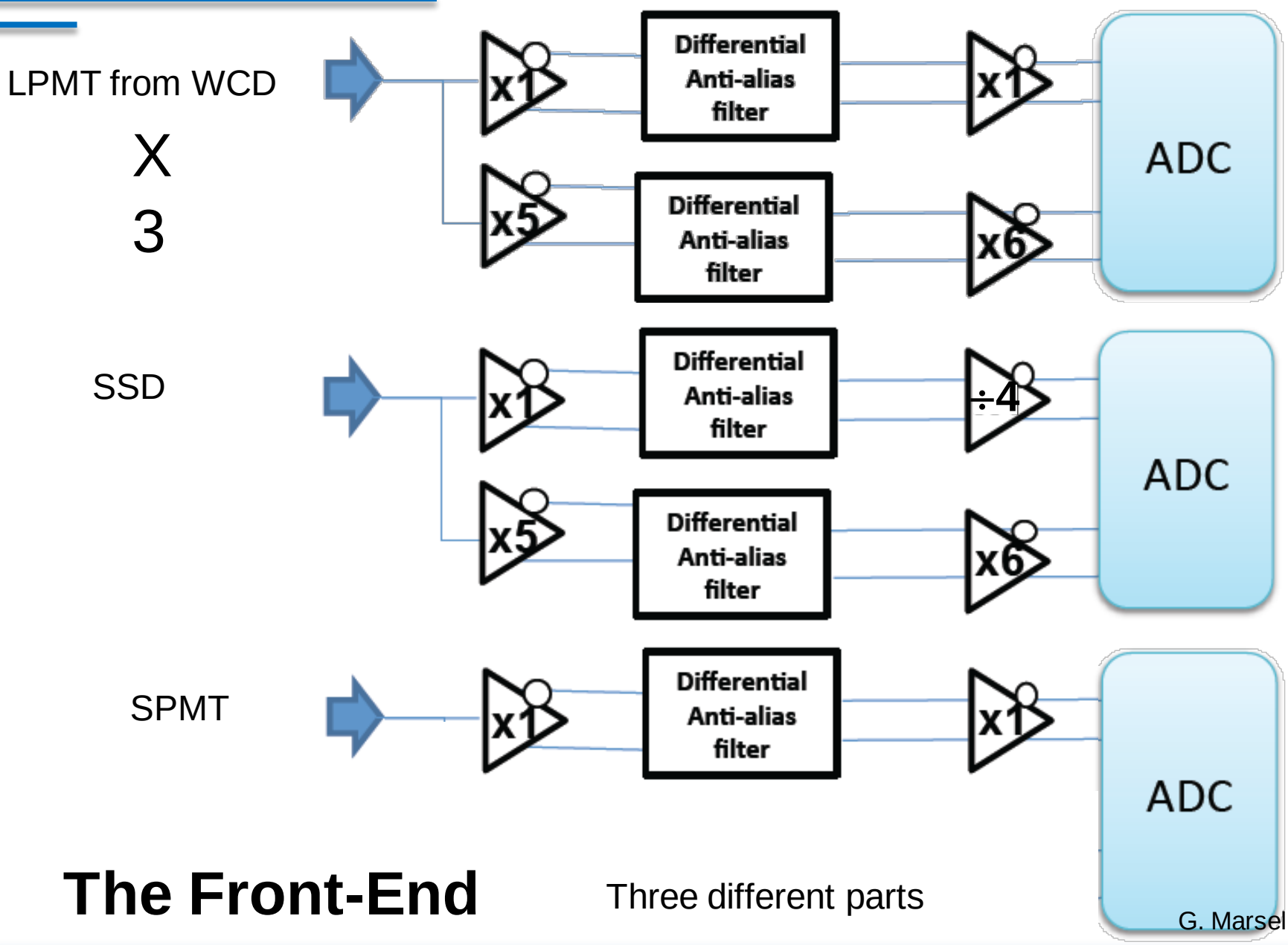


WP1 for Auger SDE upgrade

http://elettronica.le.infn.it/?page_id=216

R. Assiro, P. Creti, S. D'Amico, A. Donno, G. Marsella – Lecce group

SDE: Surface Detector Electronics



Design INFN-LE

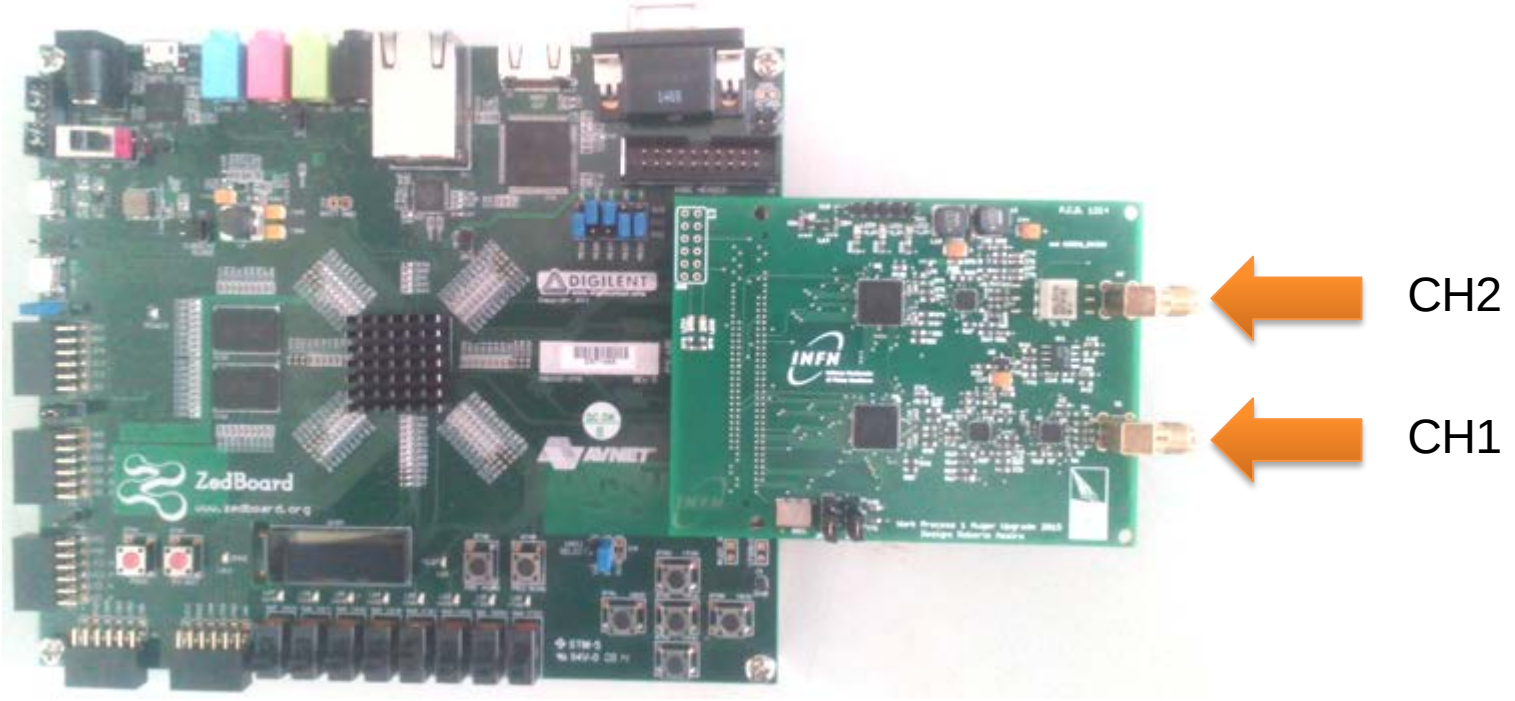
The Front-End

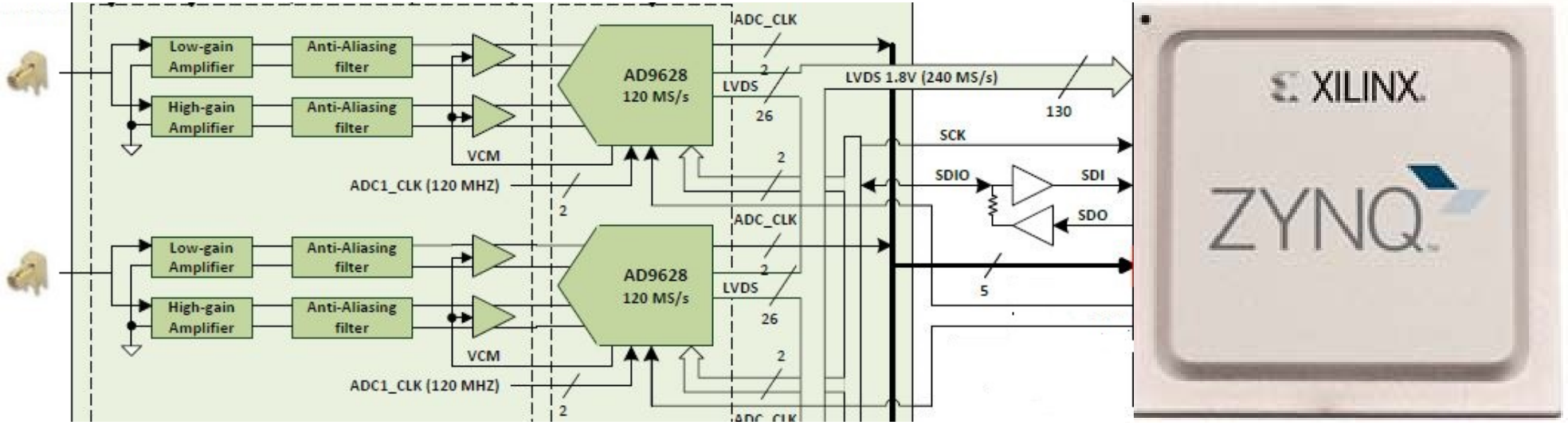
Three different parts

G. Marsella, R. Assiro P. Creti

The prototype board

A couple of ADC connected to the zedboard by double LVDS bus

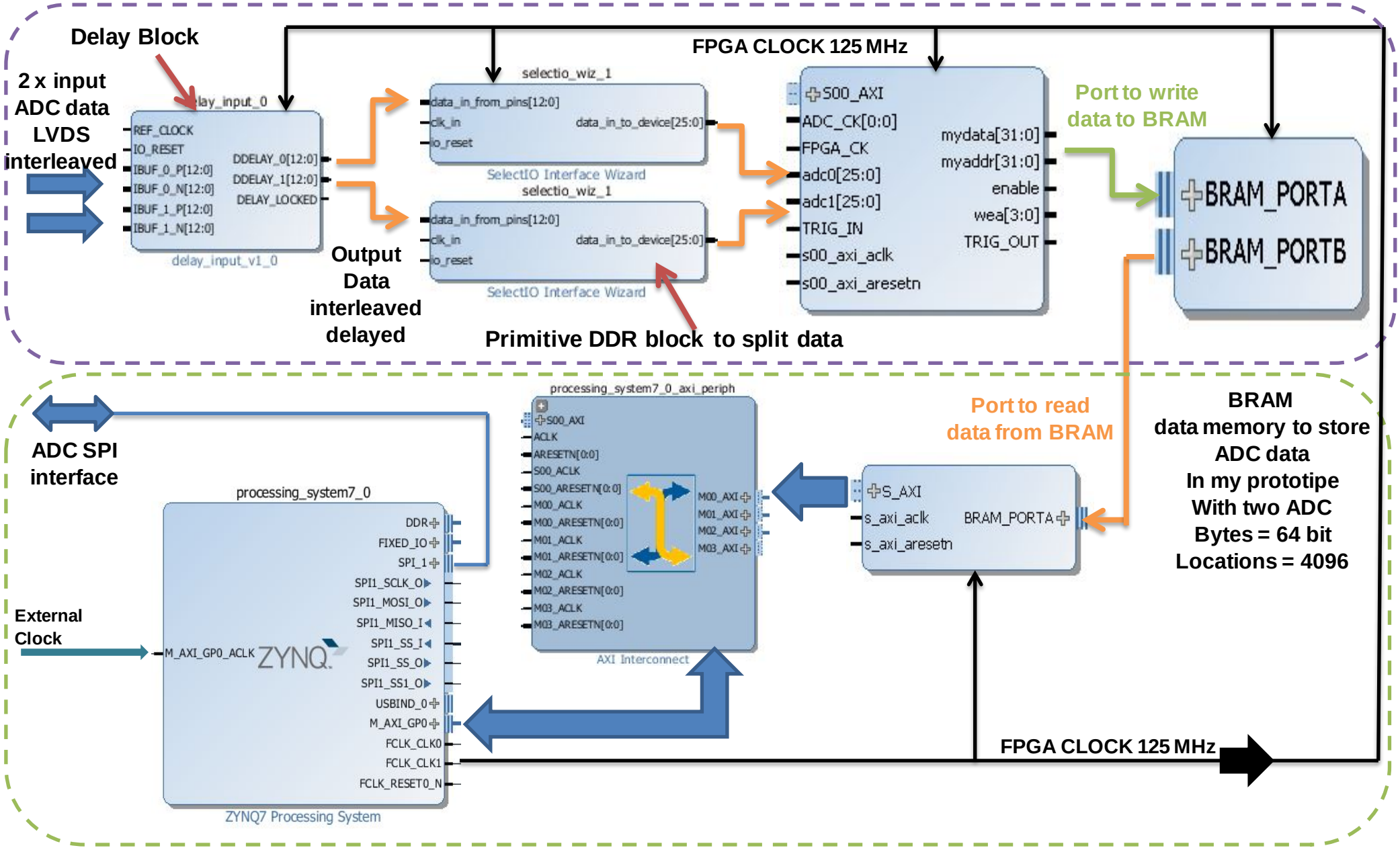




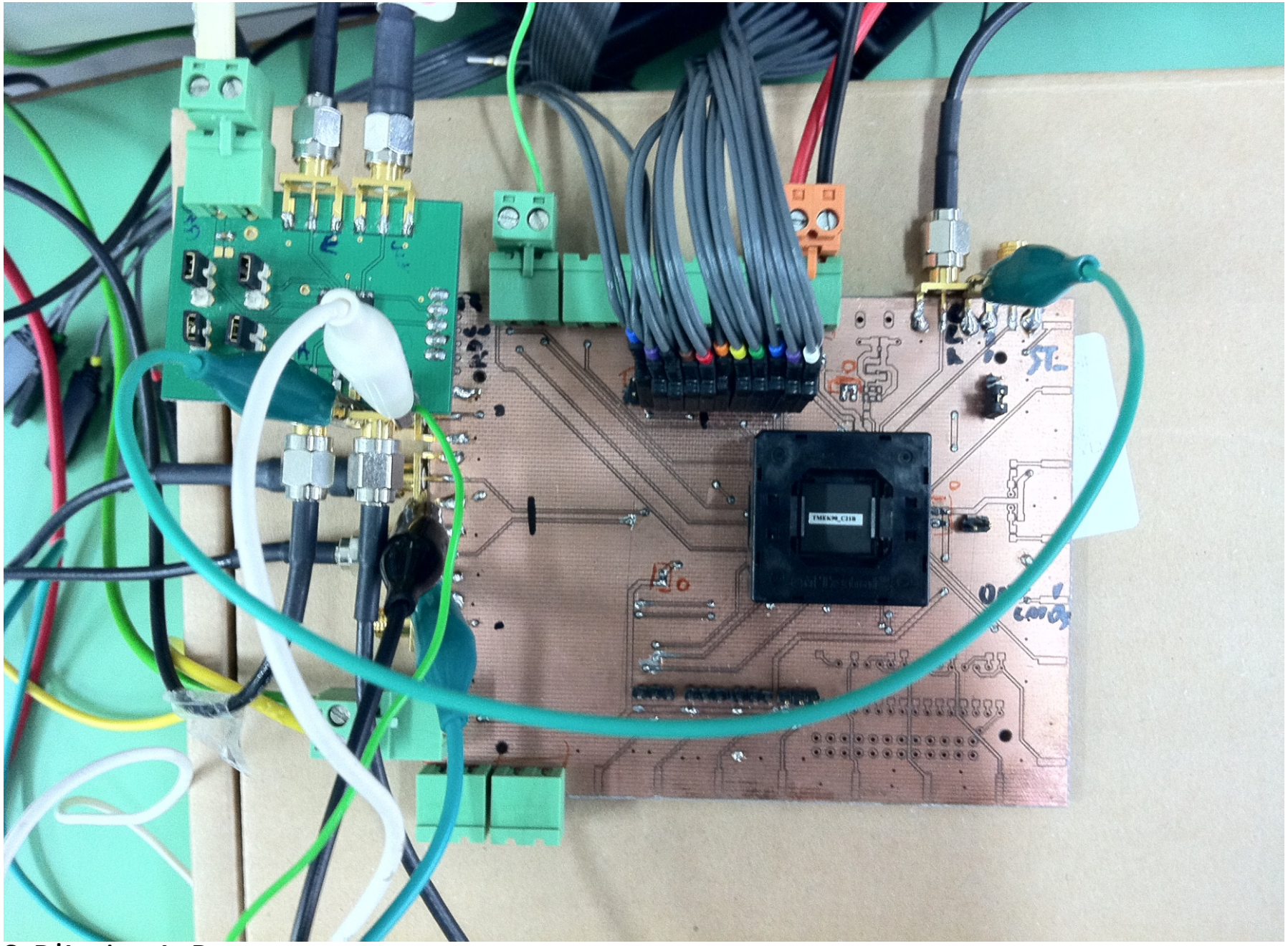
SDE: Surface Detector Electronics

The Upgrade Unified Board. One of the prototypes

Block diagram of Vivado project to acquire data from two ADC



Chip Setup measurement



S. D'Amico A. Donno

The Small PMT and of the SSD-PMT

G. Cataldi & M.R. Coluccia
L. Perrone, V. Scherini

Motivation

To extend the linear dynamic range of the SD
→ E> $10^{19.5}$ eV ~ 50% events have a saturated station

Goal:

- have a measurement closer to shower core
- reduce the impact of saturation stations and enhance reconstruction performance

The installation of a small PMT in the stations is part of the SDE upgrade proposal

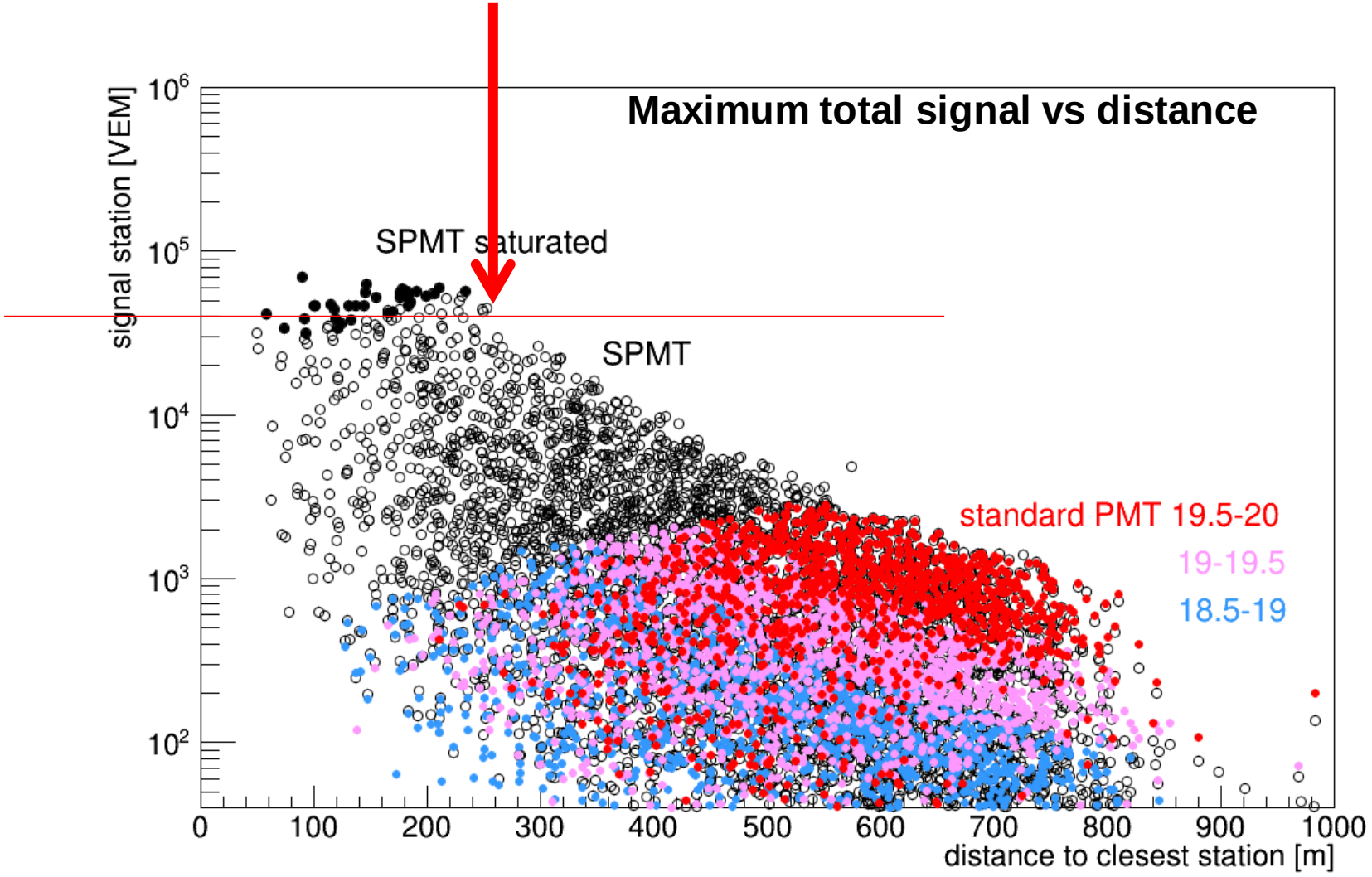
Candidate PMT:

- Hamamatsu R6095-100 28 mm diameter (S_{std}/S_{small}~ 75)

Motivation

To extend the linear dynamic range of the SD

→ E> $10^{19.5}$ eV ~ 50% events have a saturated station



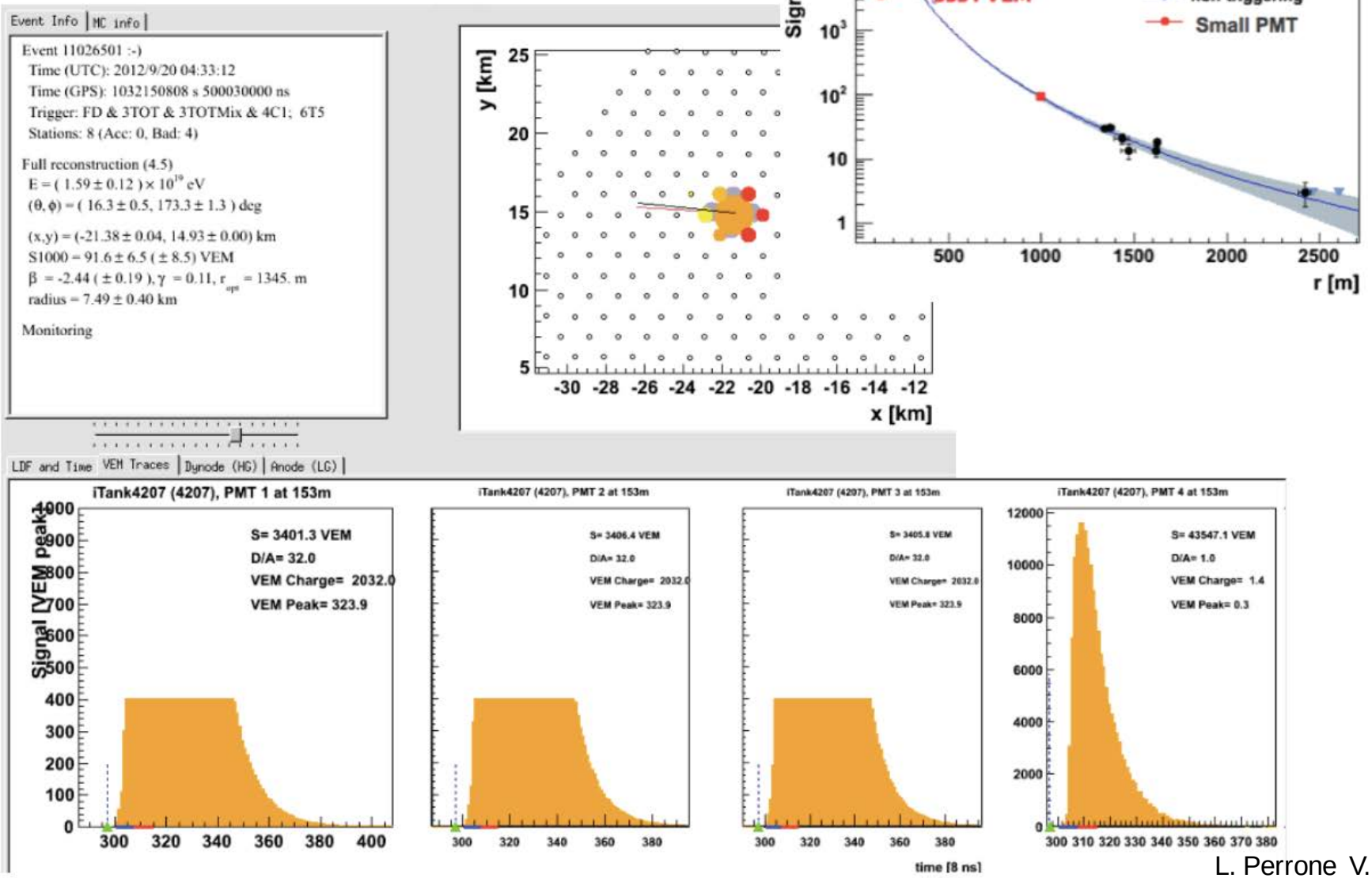
Simulated Corsika showers: proton 18.5 < log10(E/eV) < 20

DRE: Dynamic Range Extension

Small PMT

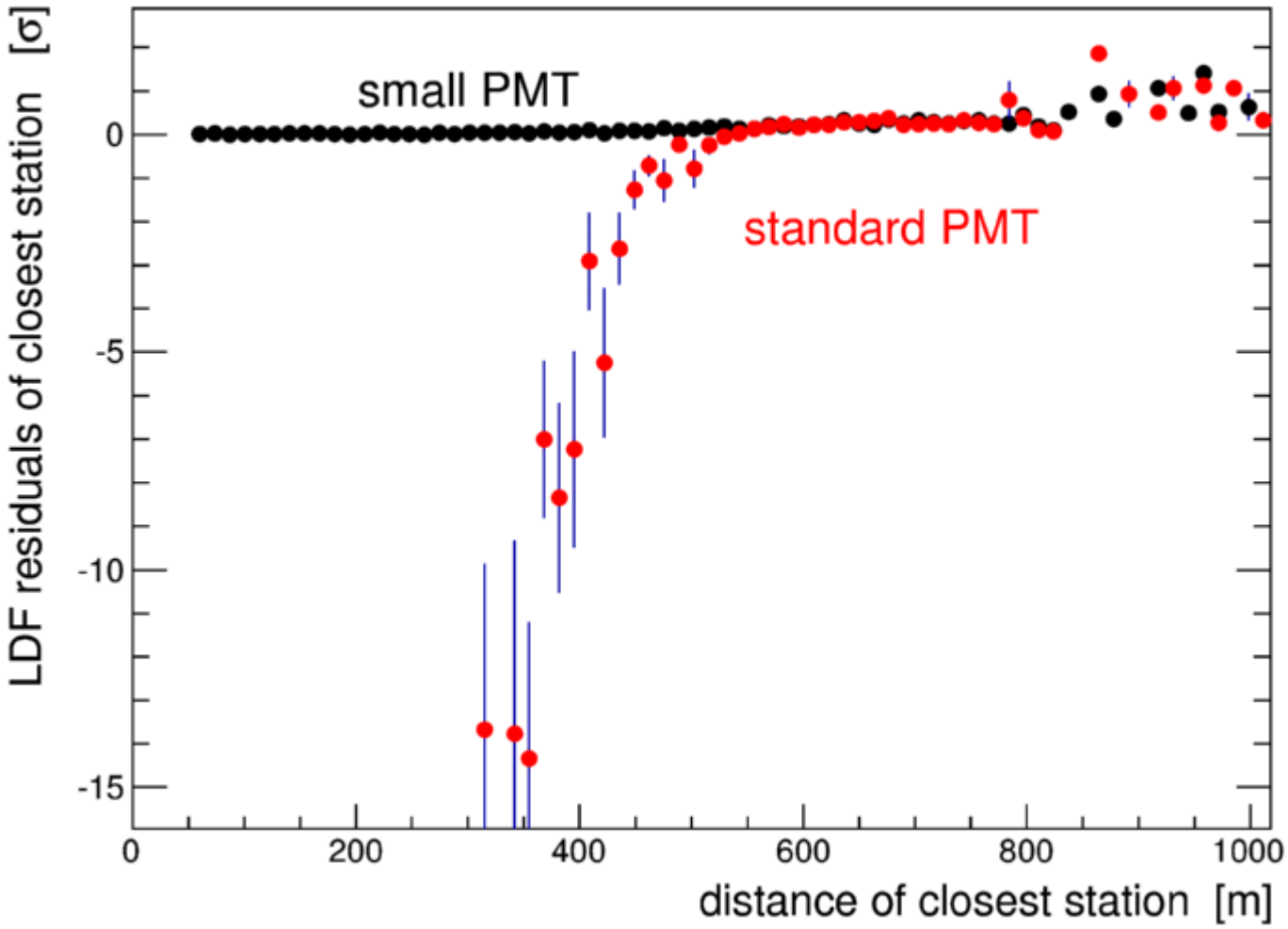
Saturated WCD

One example



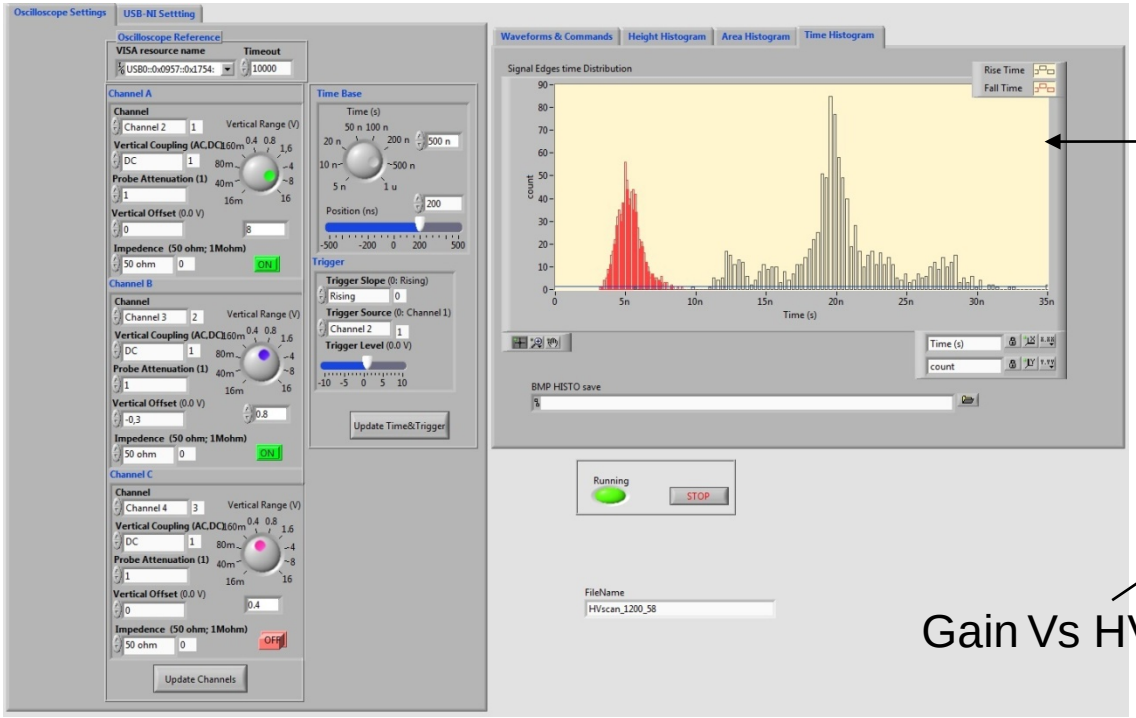
L. Perrone V. Scherini

LDF residuals of closest station



→ LDF description improves close to core

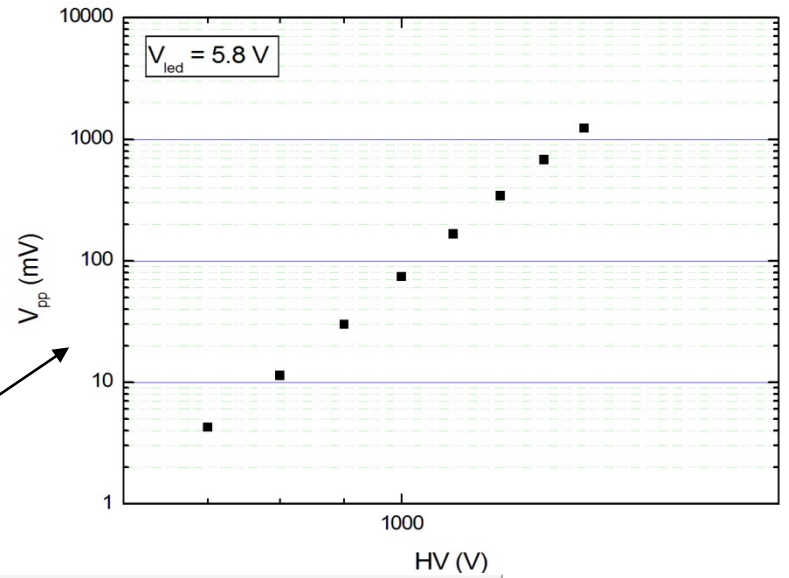
Test of the SPMT in Lecce (R6095)



LabView DAQ with online Monitoring:

e.g. Fall Rise Time of the PMT signal

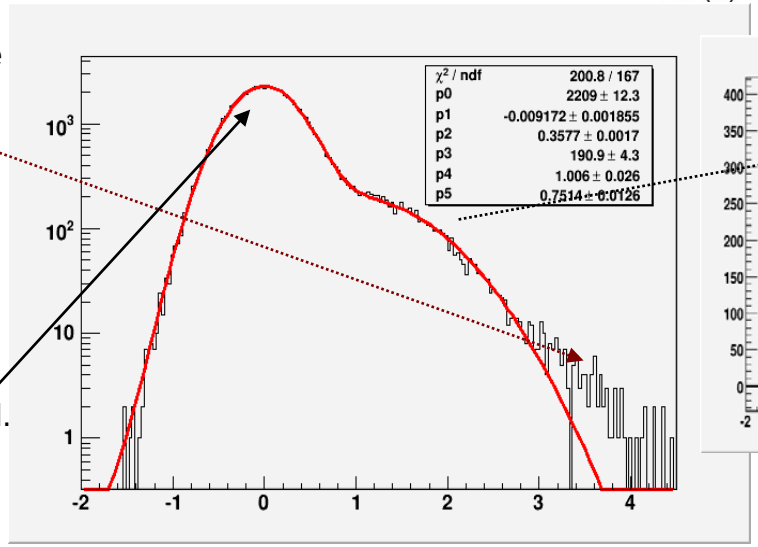
Gain Vs HV

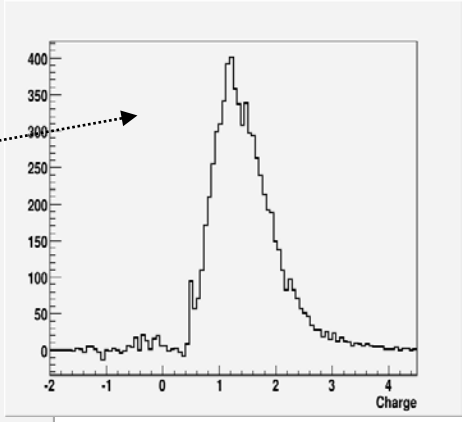


The SPE of the system is distinguished from higher order peaks (i.e. The response of the system to multiple photons), and from the pedestal.

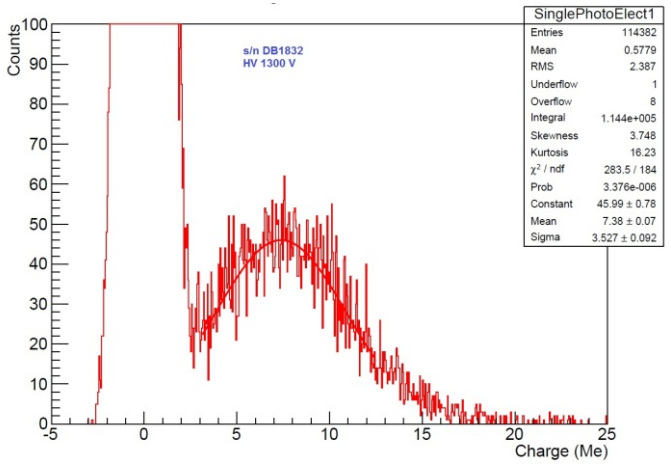
To distinguish the SPE from higher order peak, the pulsed light source has been tuned to have
90% pedestal, and 10% signal for Poisson distribution of average 0.1 photo electrons. The tuning is performed by mean of a transmittance filter.

To distinguish rom the pedestal- an offline analysis is implemented.



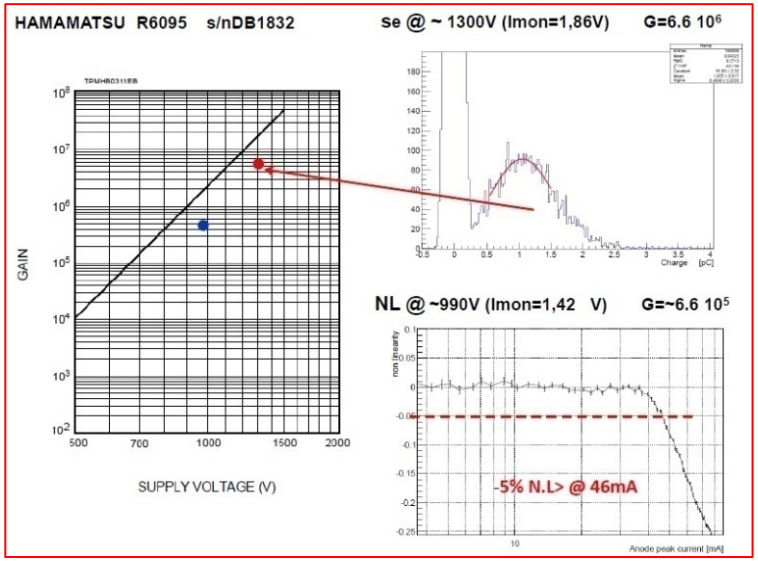


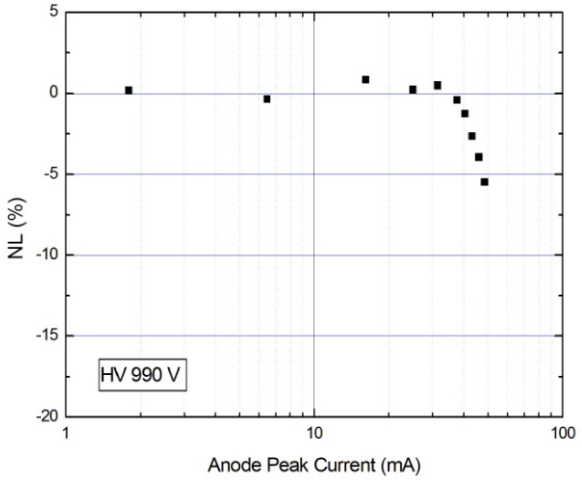
R6095 (sn1832)

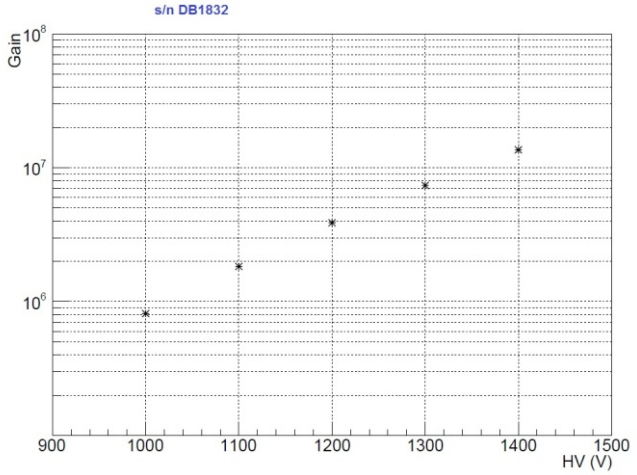


spe @ -1300 V ---> Gain 7.38 10^6
NL @- 990 V ----> NL -4 % @ 46 mA, NL > -5% @ 48 mA

Torino Results







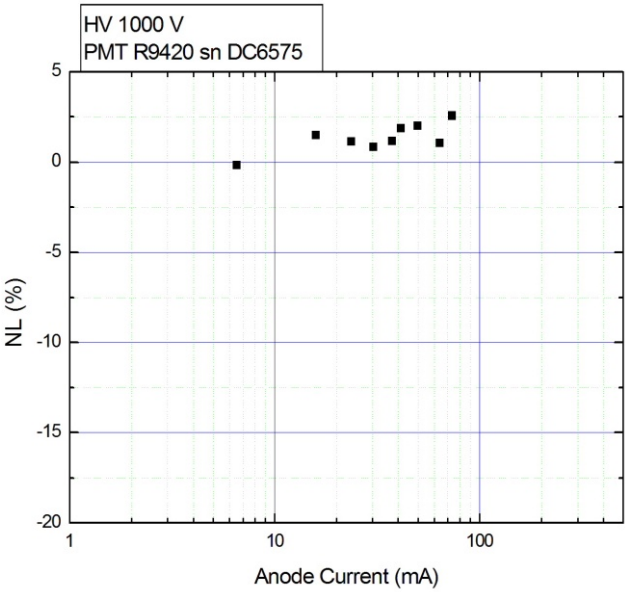
Cross check with Torino for the definition of calibration methods and PMT acceptance rules.
6 PMT tested.
Good agreement results .

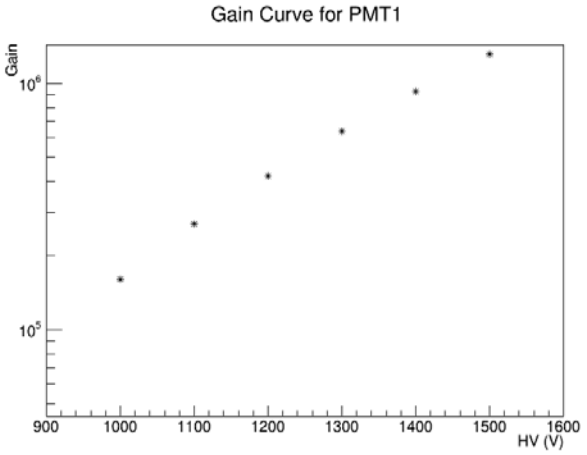
Test Performed on Hamamatsu PMTs

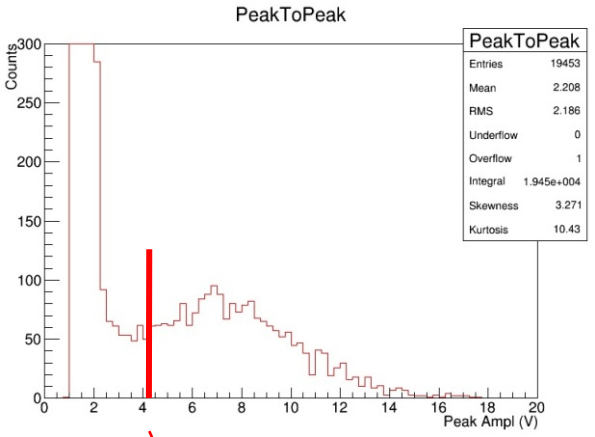
- R6095
  - 4 PMT tested
- R9420
  - 2 PMT: one with active driver, one with passive driver
- R6094
  - 1 PMT
- R8619
  - 1 PMT

R9420 with passive driver

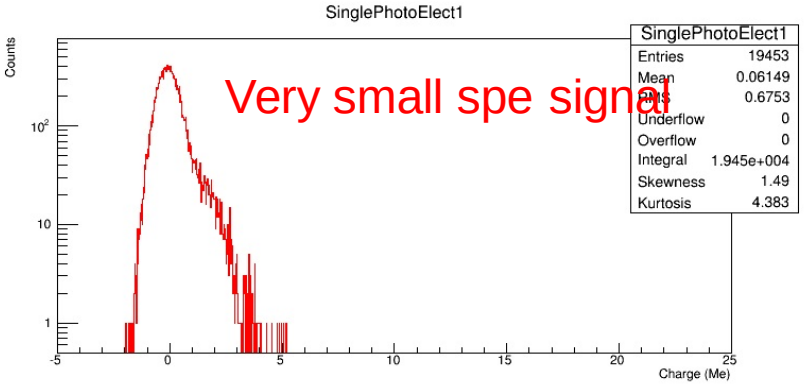
Linearity results compatible with Torino.
Larger light output needed (next).

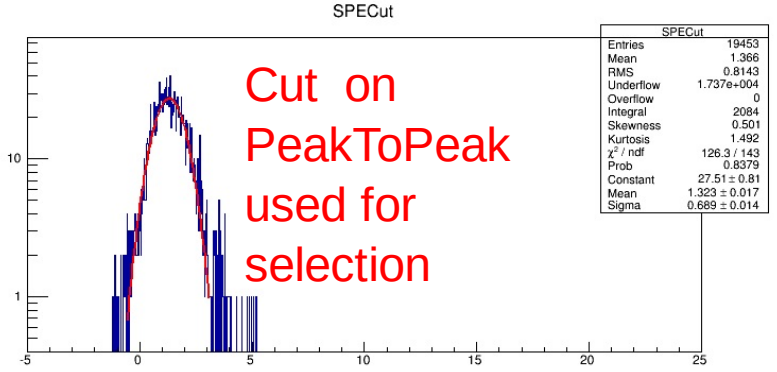




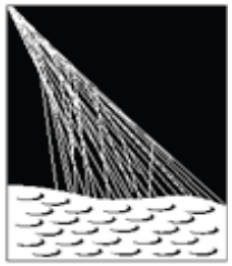


R9420 will be used for the EI and mounted on prototypes.





CDS Lecce Luglio 2015



PIERRE AUGER OBSERVATORY

INFN Istituto Nazionale di Fisica Nucleare

Alcune attività di analisi del gruppo AUGER di Lecce

Hybrid Exposure

L.Perrone, F.Salamida, V.Scherini

Shower generator → Conex longitudinal profiles
Hadronic Models: Sybill, QGSJETII, Epos-LHC
Energy: 10^{17} 10^{21} eV
Angle: 0°-70°

Method → Simulation of the array and telescopes accordingly to the *T2Life* and the *On-Time*
Closest tank forced to trigger, then apply LTP functions

Time dependent Offline detector simulation performed at CNAF (INFN)

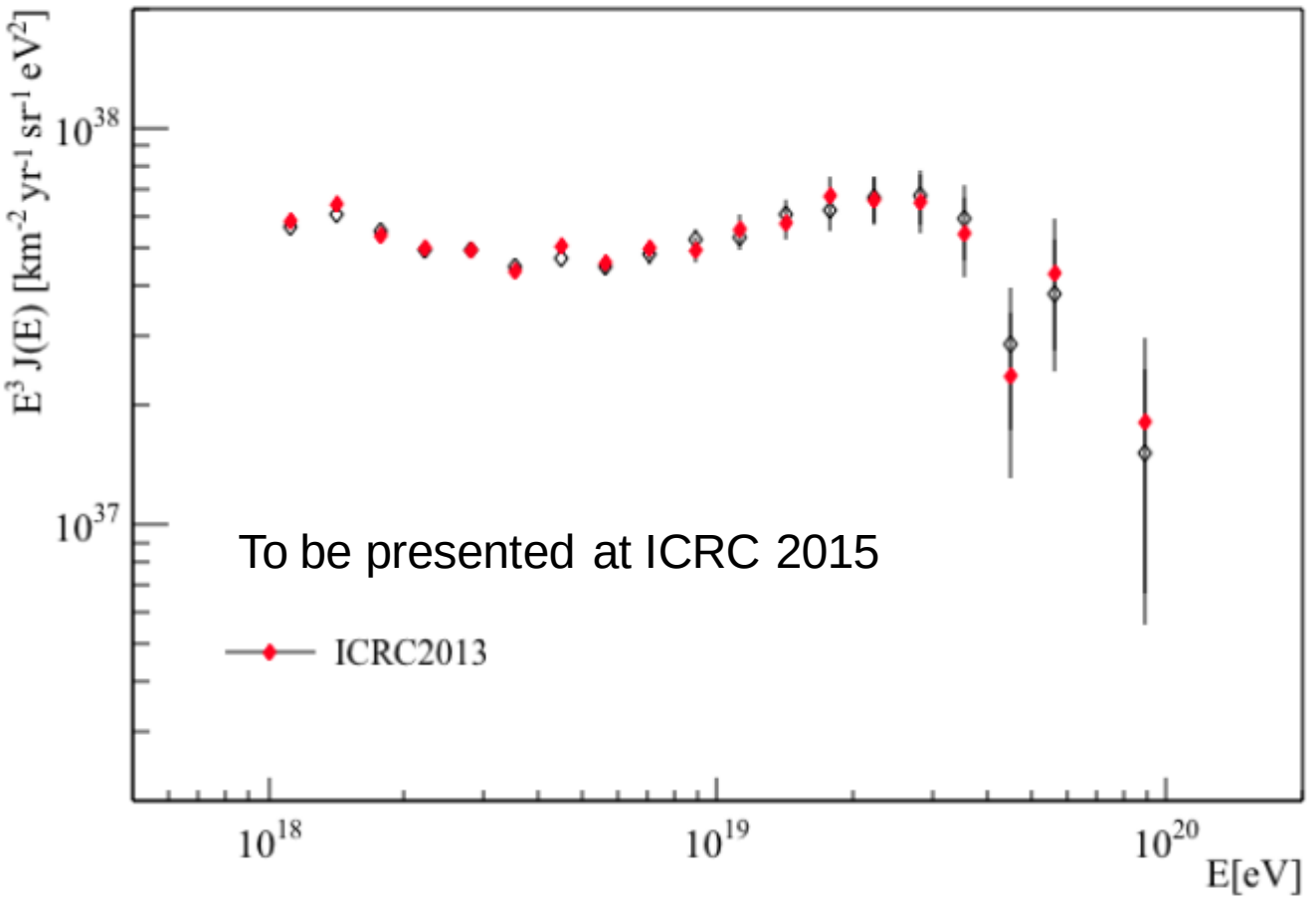
A dedicated cluster of about 300 virtual machines with individual mysql server for managing databases.
Demanding from the point of view of computing and time
2 months of full operation to generate a sufficient data sample

Event sample →

QGSJETII	: 12	10^6 events
Sibyll	: 21	10^6 "
Epos-LHC	: 10	10^6 "

~45 10^6 events

Hybrid Spectrum

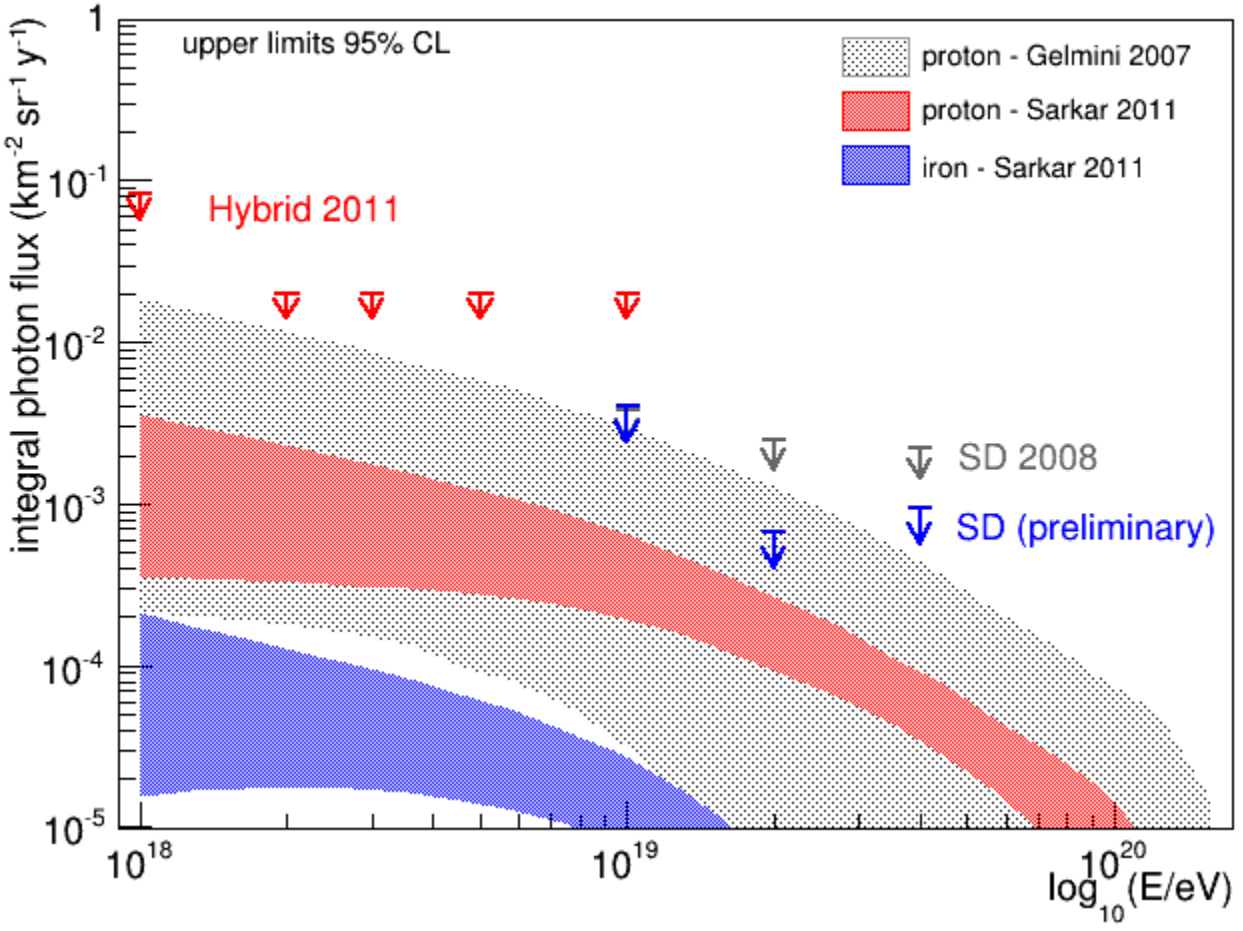


To be combined to SD-Infill Spectrum and presented at ICRC 2015

Good agreement with past analysis

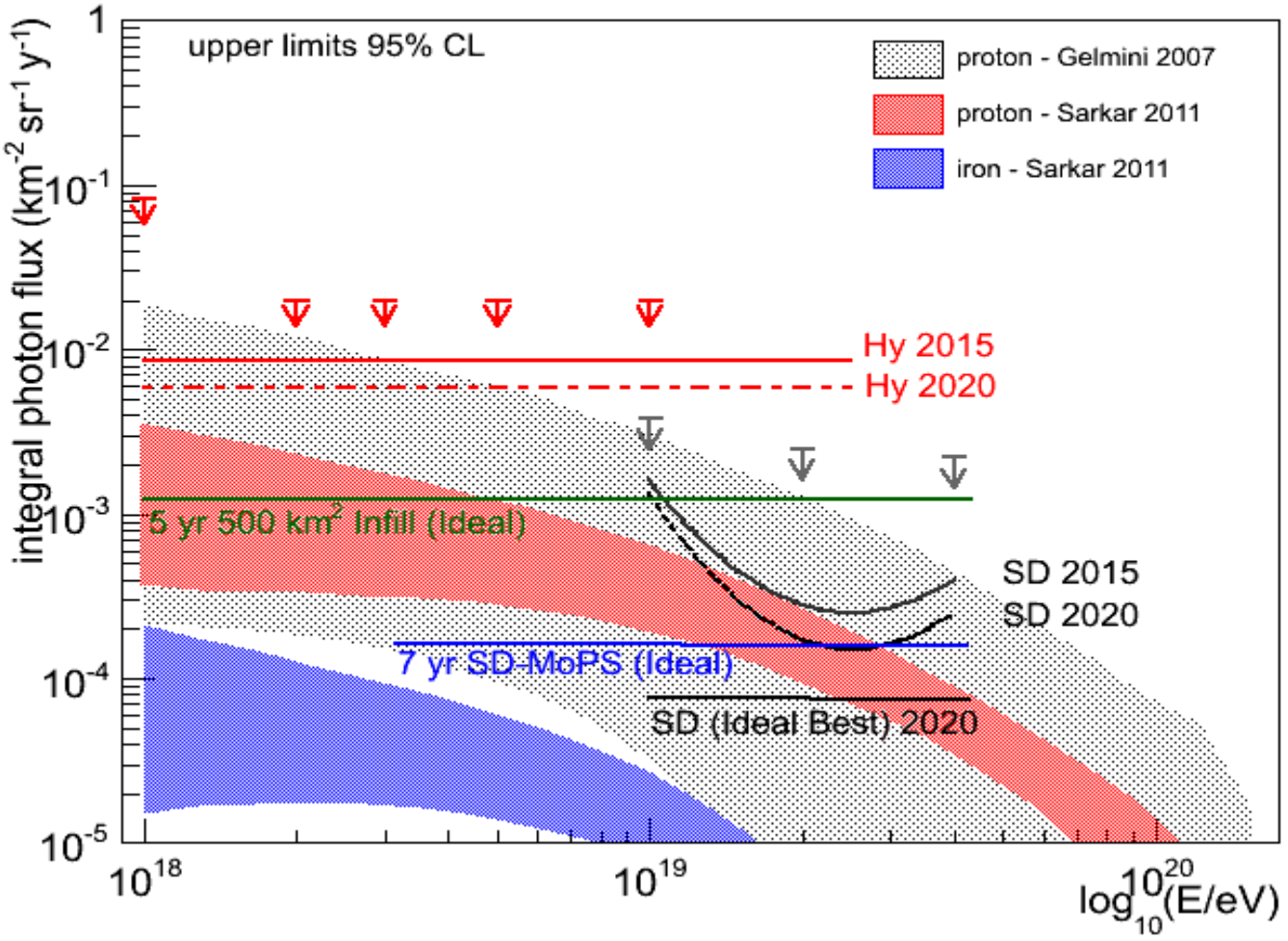
Search for photons

Searches for UHE photons - status



→ World lowest upper limits on the diffuse photon flux
→ SD analysis starts to exclude part of the parameter space in GZK fluxes predictions

Future of diffuse photon searches



→ Ideal case: no background contamination, 50% photon efficiency

→ Goals: approach the ideal case improving the analysis, extend the SD search to lower energies where the cosmogenic photon flux is higher.

C. Bleve

Directional search for photons

A. Aab et al.[the Pierre Auger Coll.] 2014 ApJ 789 160

$E>10^{17.3}$ eV

→ No source Identified

→ Targeted searches ongoing

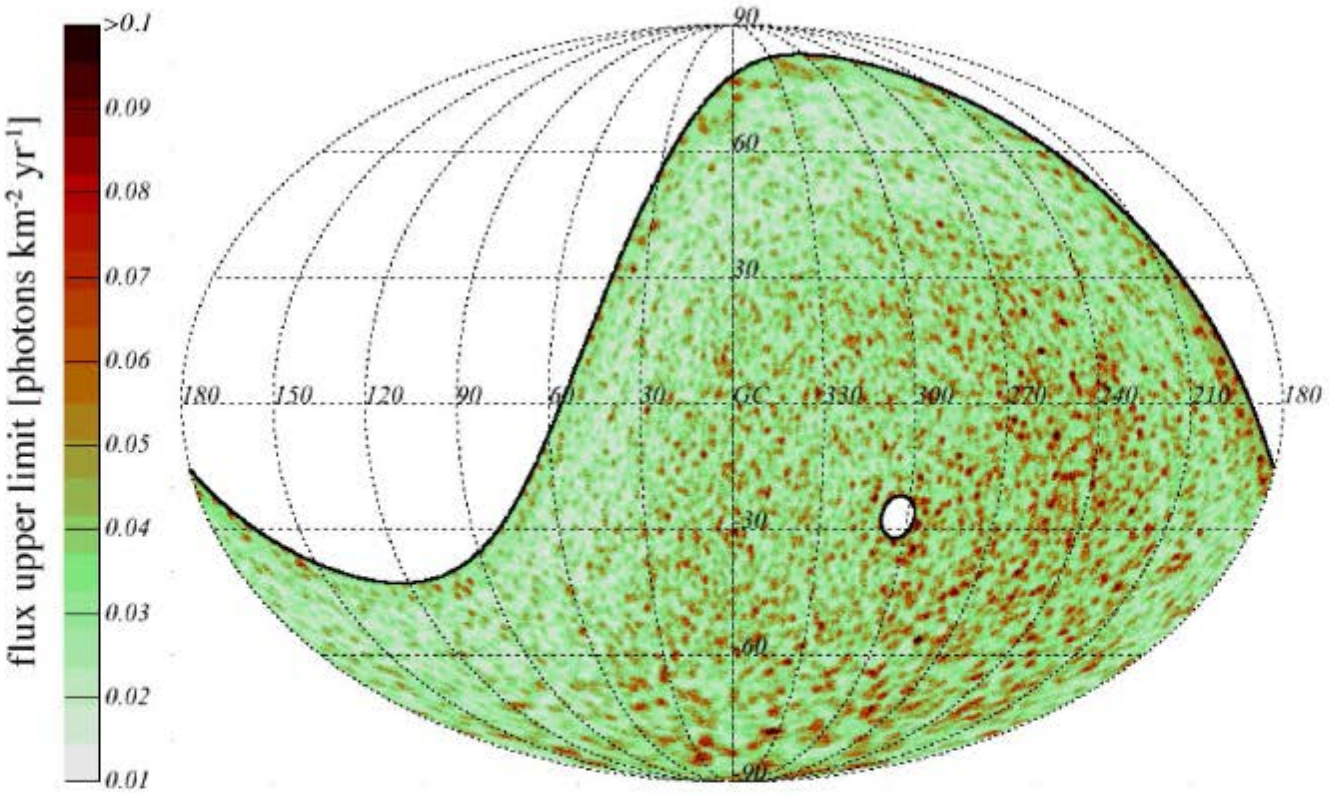
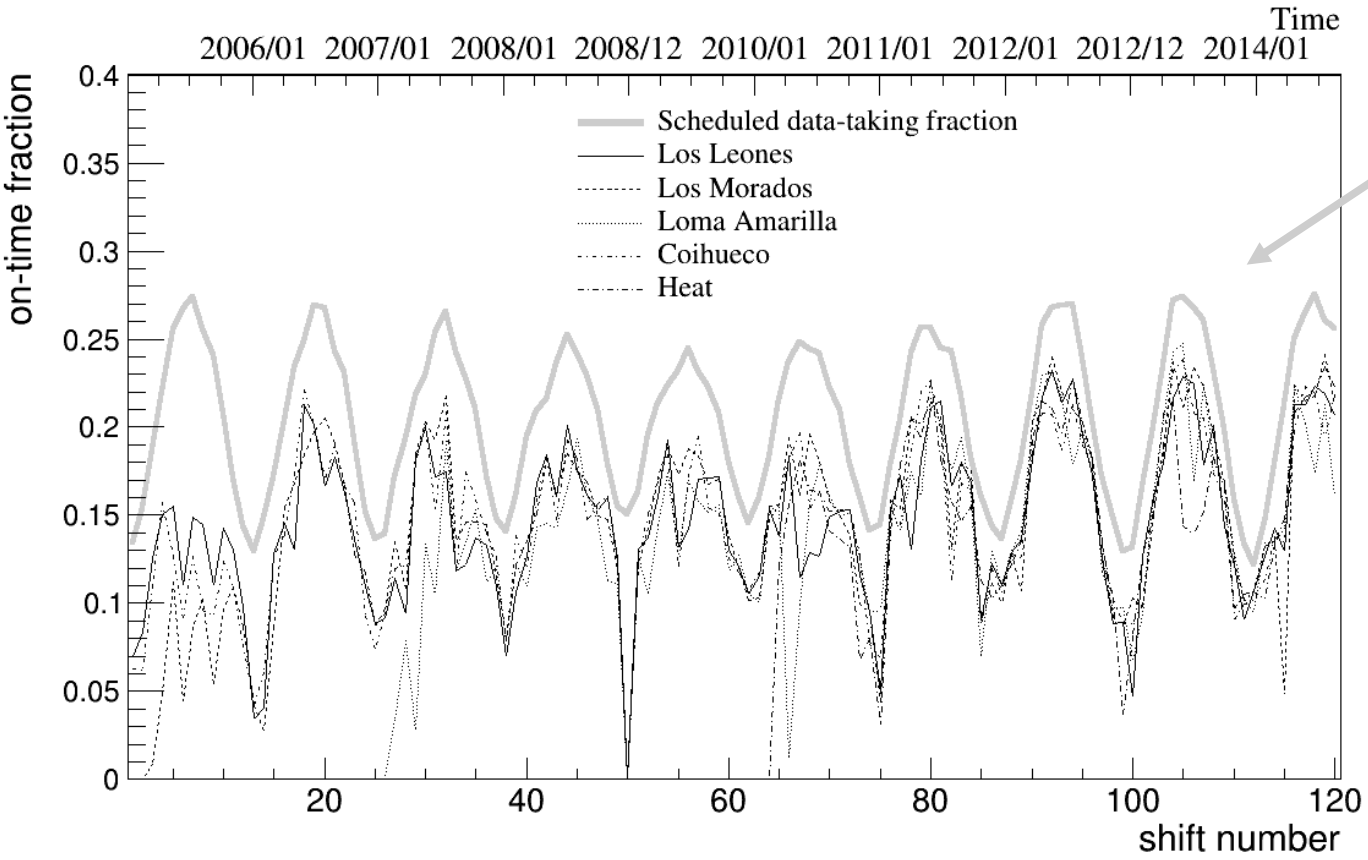


Fig. 10.— Celestial map of photon flux upper limits in photons km^{-2} yr^{-1} illustrated in Galactic coordinates.

Hybrid Detector Performance

Hybrid ontime



NOMINAL:
- moon fraction below 70%
- moon below the horizon for more than 3 hours

- Shutter status
- Lidar Veto
- FD Veto
- CDAS status

Paper accepted for publication on NIMA
"The Pierre Auger Observatory"
aimed at being a reference paper for the community

Significant contribution of our group in the section related to the hybrid detector performance

Backup

Fondi esterni: Status
EPLANET

CERN Document Server

EPLANET: the Europe-Latin America alliance for physics research and education

Twenty-nine partner institutions participate in EPLANET – the EU-funded project aimed at strengthening the links between the physics communities in Europe and Latin America. The project will help the Latin-American scientific community to reach and consolidate the critical scientific mass, and profit from the educational, technological and industrial impact of high-energy physics.

Auger inserito nel progetto. (WP9)
Referente Nazionale G. Matthiae
Referente Locale D. Martello

Risorse in corso di trasferimento
Durata del finanziamento 4 anni (2011-2014)

Progetti di ricerca scientifica e tecnologica bilaterale di "Grande Rilevanza" co-finanziati per l'anno 2011

Allegato IV

Progetti di Grande Rilevanza selezionati nel quadro del Programma Esecutivo di Cooperazione Scientifica e Tecnologica fra la Repubblica Italiana e la Repubblica Argentina per gli anni 2014-2016

Scienze di base (matematica, fisica, chimica, biologia e geologia)	Definizione di una soluzione tecnologica per lo studio della composizione dei Raggi Cosmici di Altissima Energia con l'Osservatorio Pierre Auger	Daniele Martello – Istituto Nazionale di Fisica Nucleare (INFN)	Alberto Etchegoyen Instituto de Tecnología de Detección y Astropartículas (CNEA, CONICET, UNSAM)

AUGER@CNAF

Il cluster Nazionale Auger attivo presso il CNAF costituisce il CE e SE di riferimento per i gruppi INFN.
Sul CE sono installati e aggiornati i programmi standard di simulazione e analisi della collaborazione. Il CE e parte dello SE fanno parte della griglia di produzione per le campagne di simulazione della collaborazione AUGER

Ci sono varie categorie di jobs:
-Produzione Corsika. Sviluppo di sciami raggi cosmici in atmosfera
-Offline a rivelatore ideale.
-Offline a rivelatore reale (accesso DB)-solo al CNAF o su farm dedicate.
Al 2014 - PLEDGE -> 2372 HS06 / Spazio Disco - 396 TB
PER il 2015 Richiesti in base al mod. calcolo:120 TB di Disco e 400 HS06 in termini di CPU

PRO – A parte il lavoro legato alla griglia di produzione assolutamente necessario, l'aver concentrato il nostro calcolo al CNAF ci ha permesso di avere un utilizzo CE/SE non confrontabile con le precedenti esperienze su farm locali. Inoltre alcuni tipi di produzioni/analisi (con DB) erano fortemente limitanti per i gruppi italiani.
CONTRO – L'utilizzo come “Centro di Calcolo” non e' sempre facile.
Abbiamo due code batch: auger e augerdb. La prima ha come carico maggiore di lavoro la produzione degli sciami in atmosfera che ha bisogno di pochissimo.
Sono jobs che girano su quasi tutte le CPU ad installazione quasi nulla.
Ci sono poi dei jobs di simulazione del rivelatore "ideale" e cioe' senza accesso
ai DB che sono anche questi abbastanza tranquilli. Un discorso a parte va fatto per la coda augerdb. Questa si e' basata finora e si basa sulla
infrastruttura WNODES (specifica del CNAF).
Da parte nostra questo tipo di coda e' necessaria in corrispondenza di una produzione di spettro ibrido, che di fatto non viene fatta continuamente. Da parte del CNAF, mentre nei primi periodi della nostra implementazione anche i ``giganti'' (LHC-exp) erano su wnodes, ora di fatto non e' piu' cosi' e quindi un problema su wnodes e' un problema quasi esclusivamente auger.
Diciamo che dopo l'ultima produzione siamo un po' perplessi sull' utilizzo di questa ``soluzione''.