The European Future of Dark Matter Searches with Cryogenic Detectors

LSM

30 June 2008

European Underground Rare Event Calorimeter Array

- Started March 2005; based initially on EDELWEISS and CRESST, with additional groups joining.
- Target materials: Ge, $CaWO_4$, etc (A dependence)
- Mass: above 100 kg towards 1 ton
- CRESST-II and EDELWEISS-II are EURECA R&D
- Aligned with Roadmap Recommendations: Multiple targets and multiple techniques

The Collaboration

CRESST, EDELWEISS, ROSEBUD + CERN, others

United Kingdom

Oxford (H Kraus, coordinator)

Germany

MPI für Physik, Munich

Technische Universität München

Universität Tübingen

Universität Karlsruhe

Forschungszentrum Karlsruhe

International

JINR Dubna

CERN

France

CEA/IRFU Saclay

CEA/IRAMIS Saclay

CNRS/Neel Grenoble

CNRS/CSNSM Orsay

CNRS/IPNL Lyon

CNRS/IAS Orsay

Spain

Zaragoza

Ukraine

Kiev

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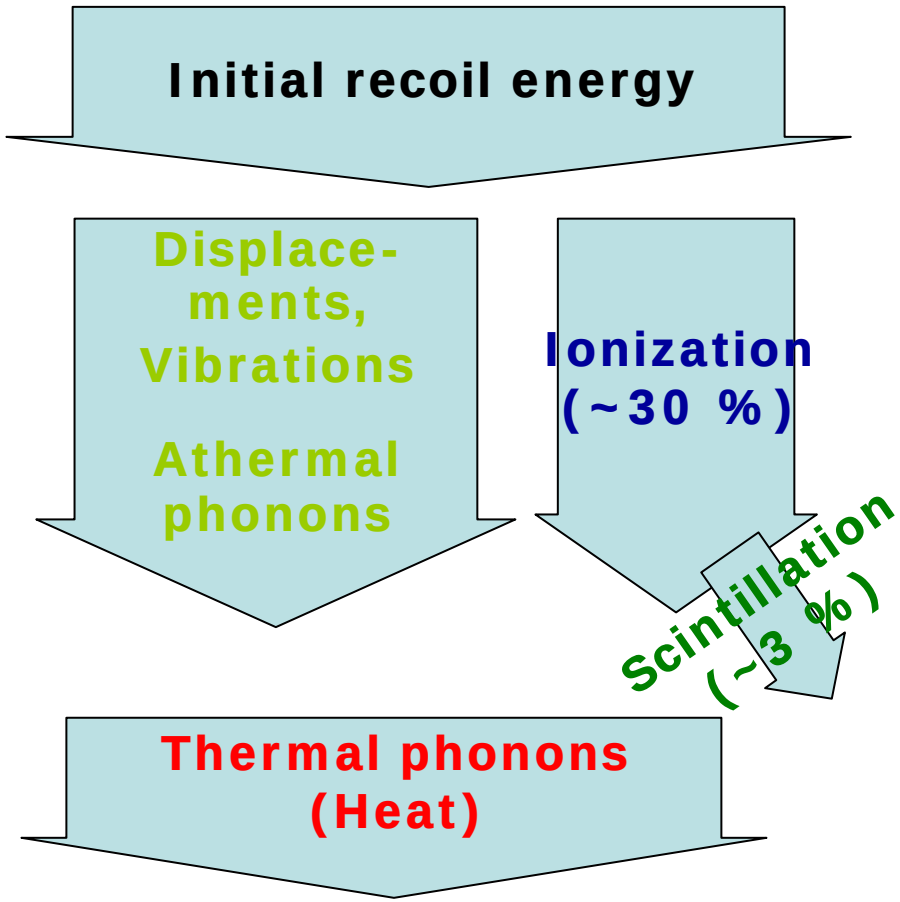
111 people (63 FTE) = $\sum$ (Cresst, Edelweiss, Rosebud, a.o.)

Cryogenic Techniques

Combination of phonon measurement with measurement of ionization or scintillation



Phonon: most precise total energy measurement

Ionization / Scintillation: yield depends on recoiling particle

Nuclear / electron recoil discrimination.

Physics Aims / Requirements

Probe currently most favoured cross section in the region 10^{-8} pb to 10^{-10} pb.

This requires a target mass of ~ 1000 kg to get few evts / y.

Use cryogenic detectors, which are scalable, mature technology.

Cryogenic detectors offer excellent discrimination nuclear / electron recoil, energy resolution and large potential for further background rejection.

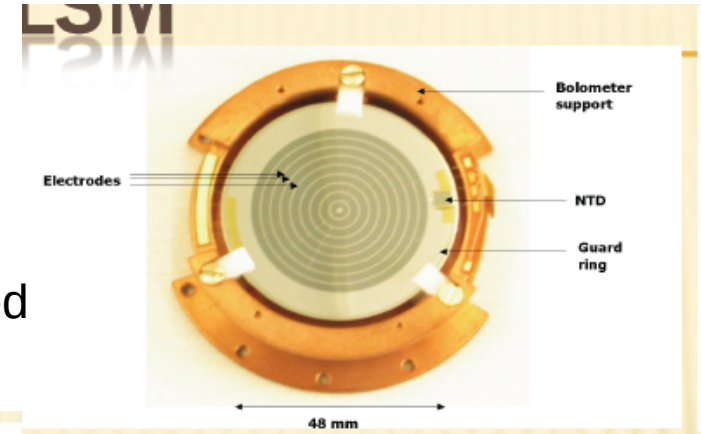
Use range of target materials for positive identification of signal.

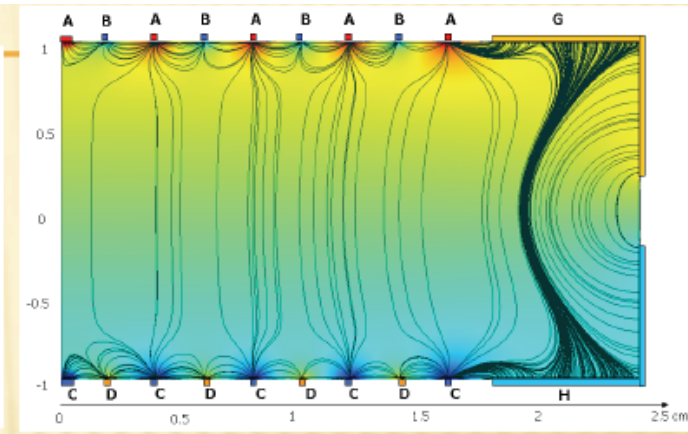
Use complementary cryogenic detectors in common volume to reduce systematics.

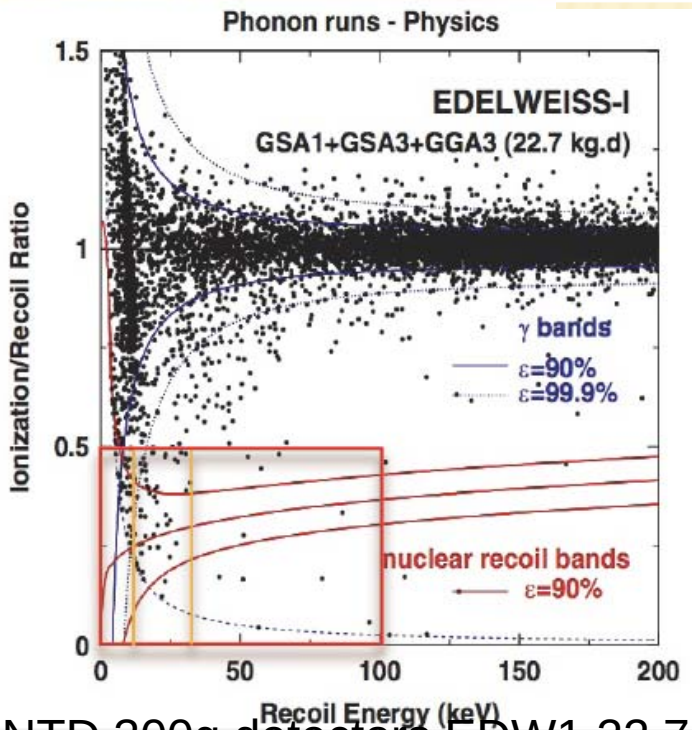
EDELWEISS Detectors 2008

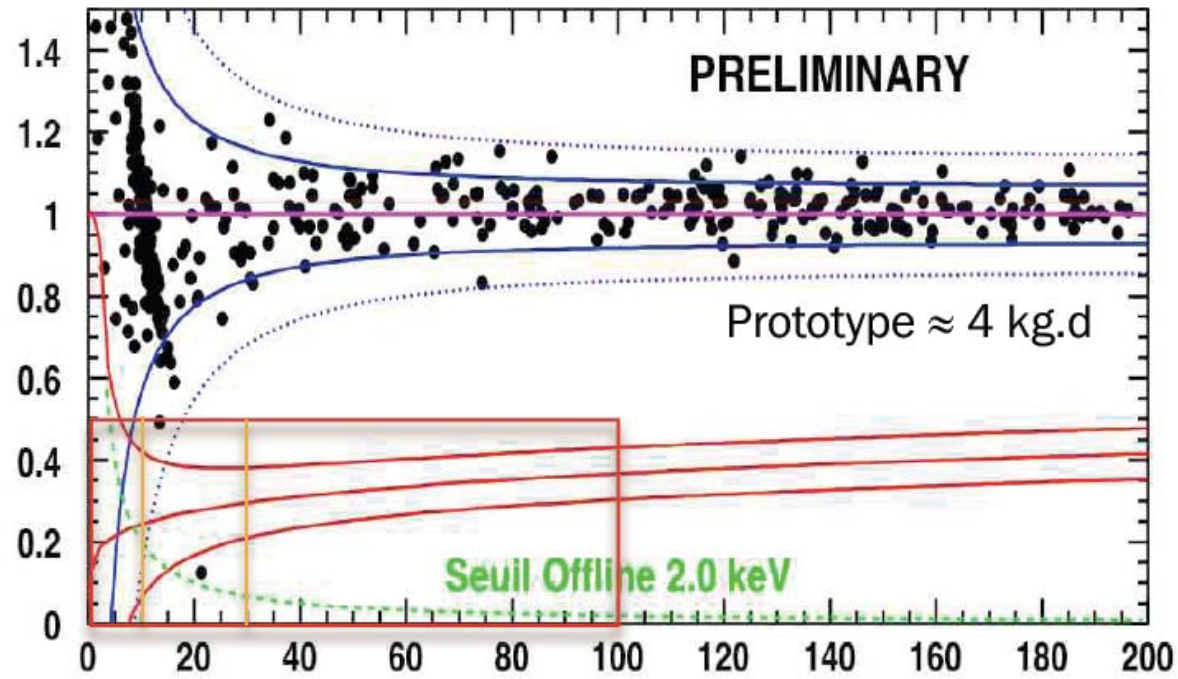
New surface event rejection detector

12 * 400g detectors in fabrication and operated by end 2008





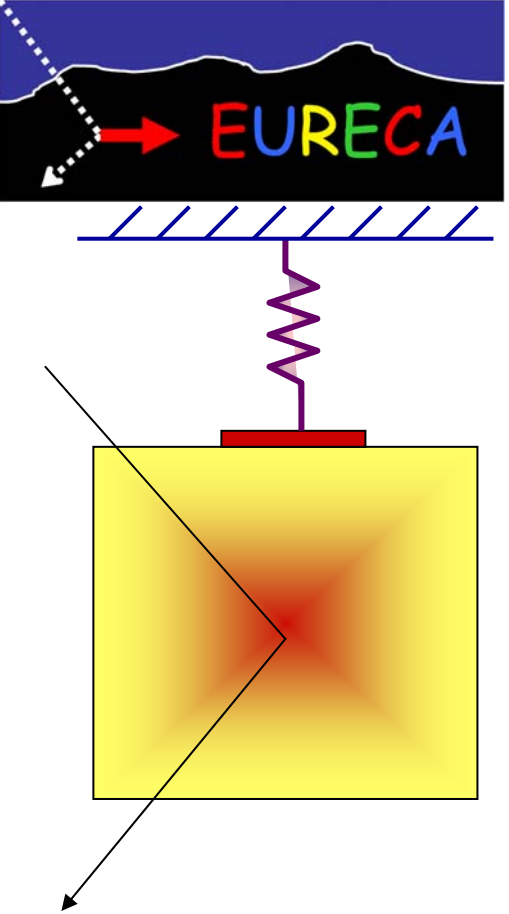


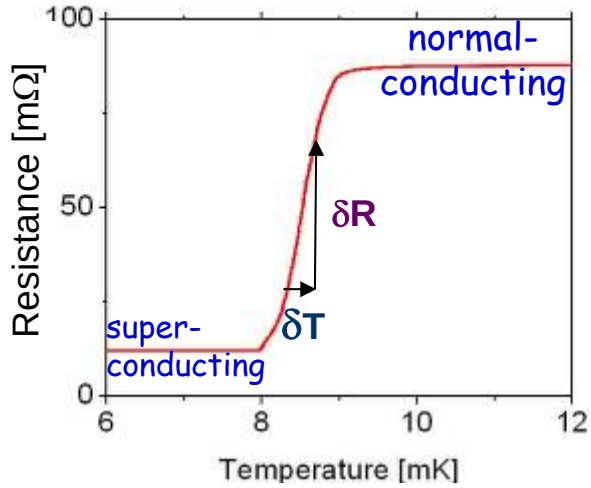


NTD 300g detectors EDW1 22.7 kg.d

Interdigit 200g 4 kg.d, Ei threshold 2keV
After surface event rejection, no quality cut

CRESST – Detectors

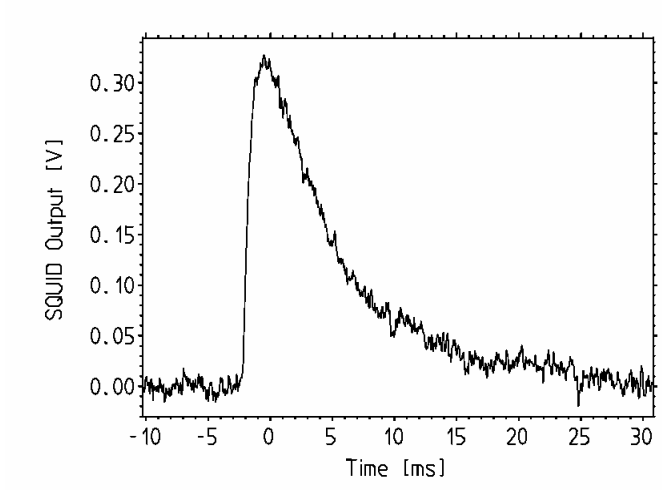




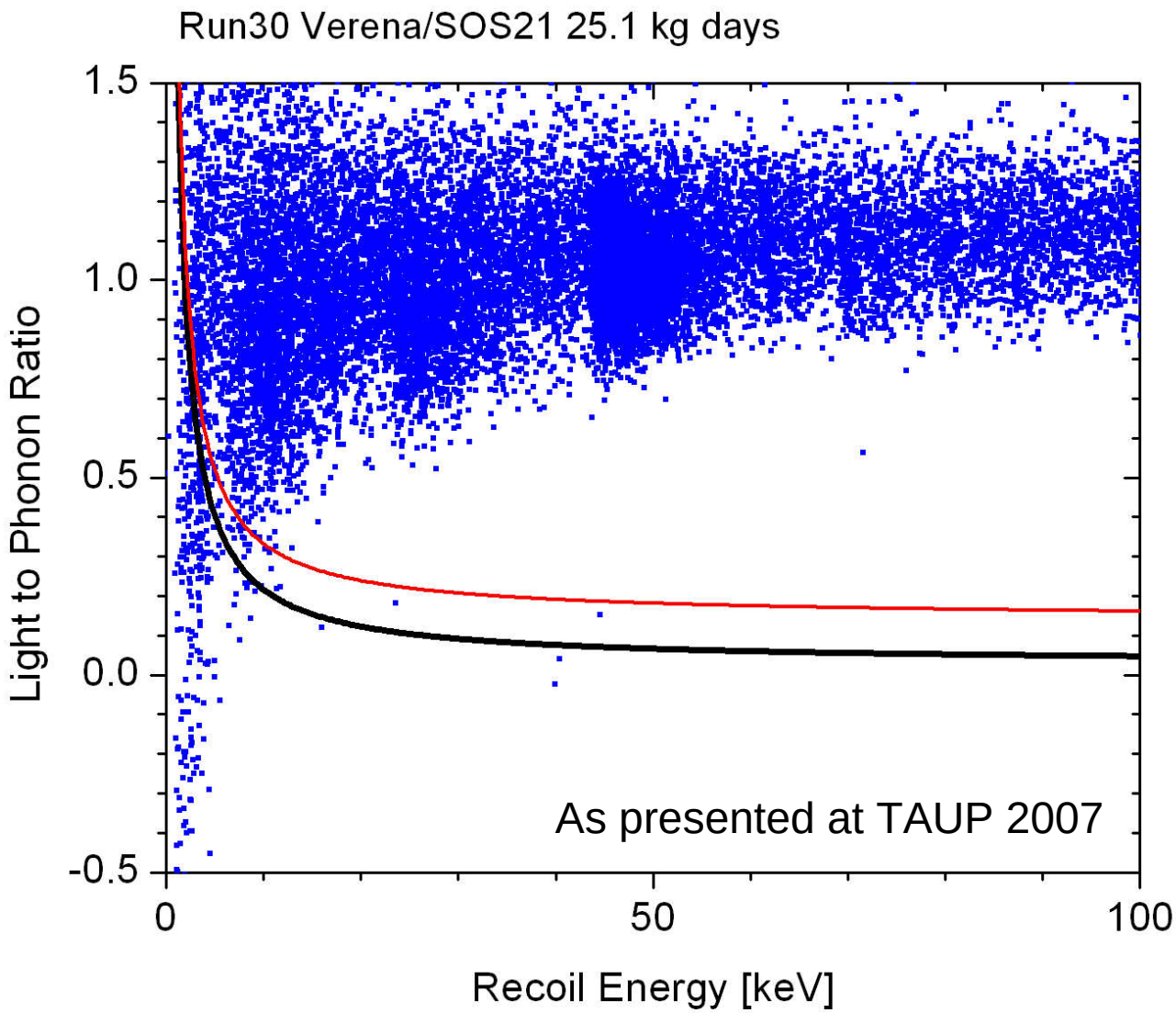
Width of transition: ~1mK
Signals: few μ K
Stablity: ~ μ K

Particle interaction in absorber creates a temperature rise in thermometer which is proportional to energy deposition in absorber

Temperature pulse (~6keV)



Preliminary CRESST Data



CRESST Status

Improvements during winter/spring 2007/08:

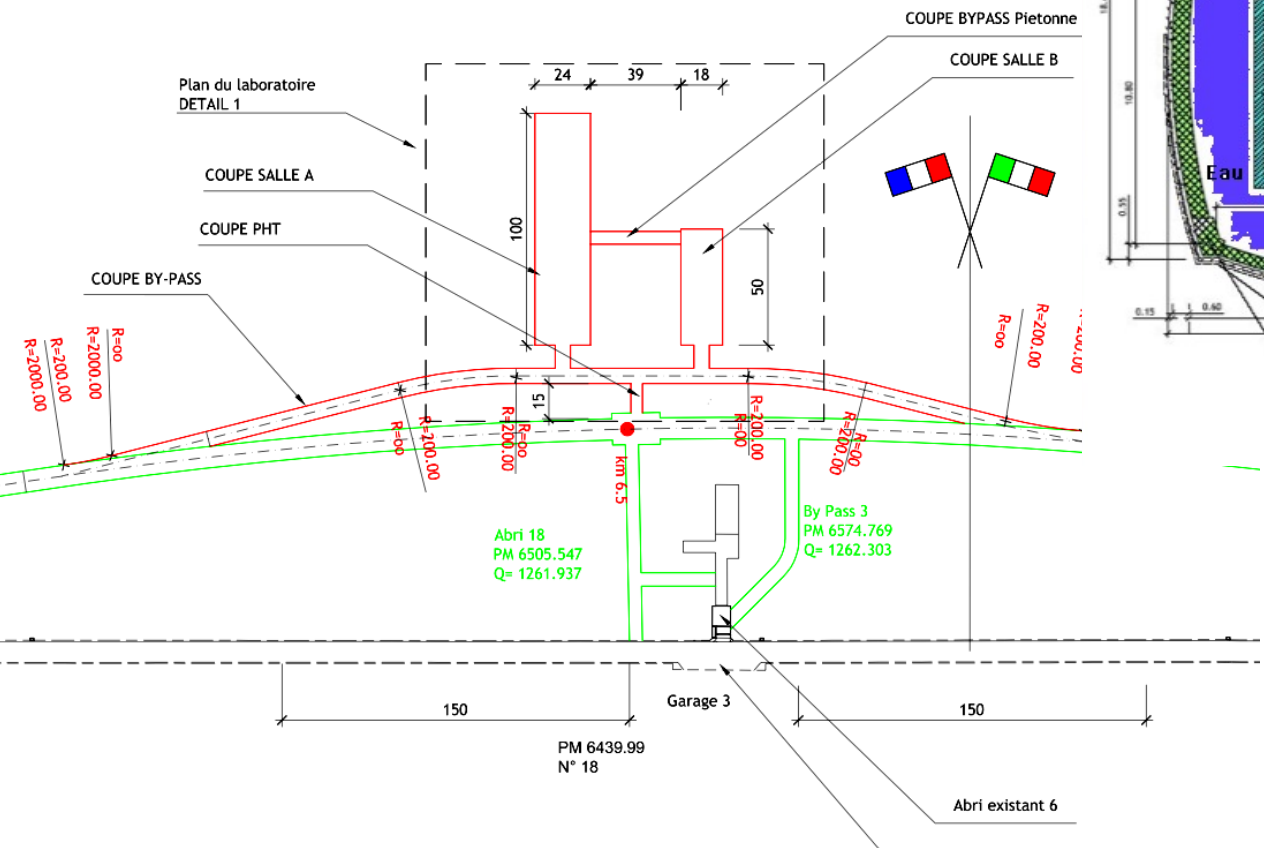
- Holes in neutron shield fixed
- Detector holders improved
- Digital electronics for SQUID readout replaced

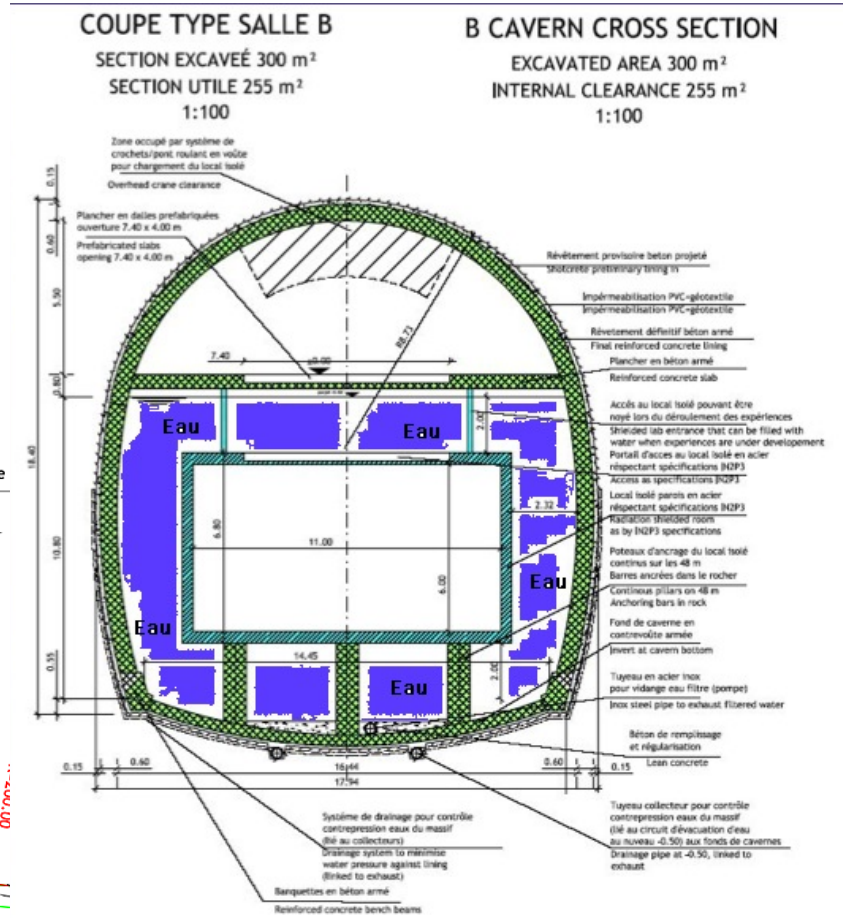
17 modules (300 g each) installed (includes R&D versions)

Cooldown and detector setup / tuning since May 2008

EURECA in LSM

Clean Infrastructure



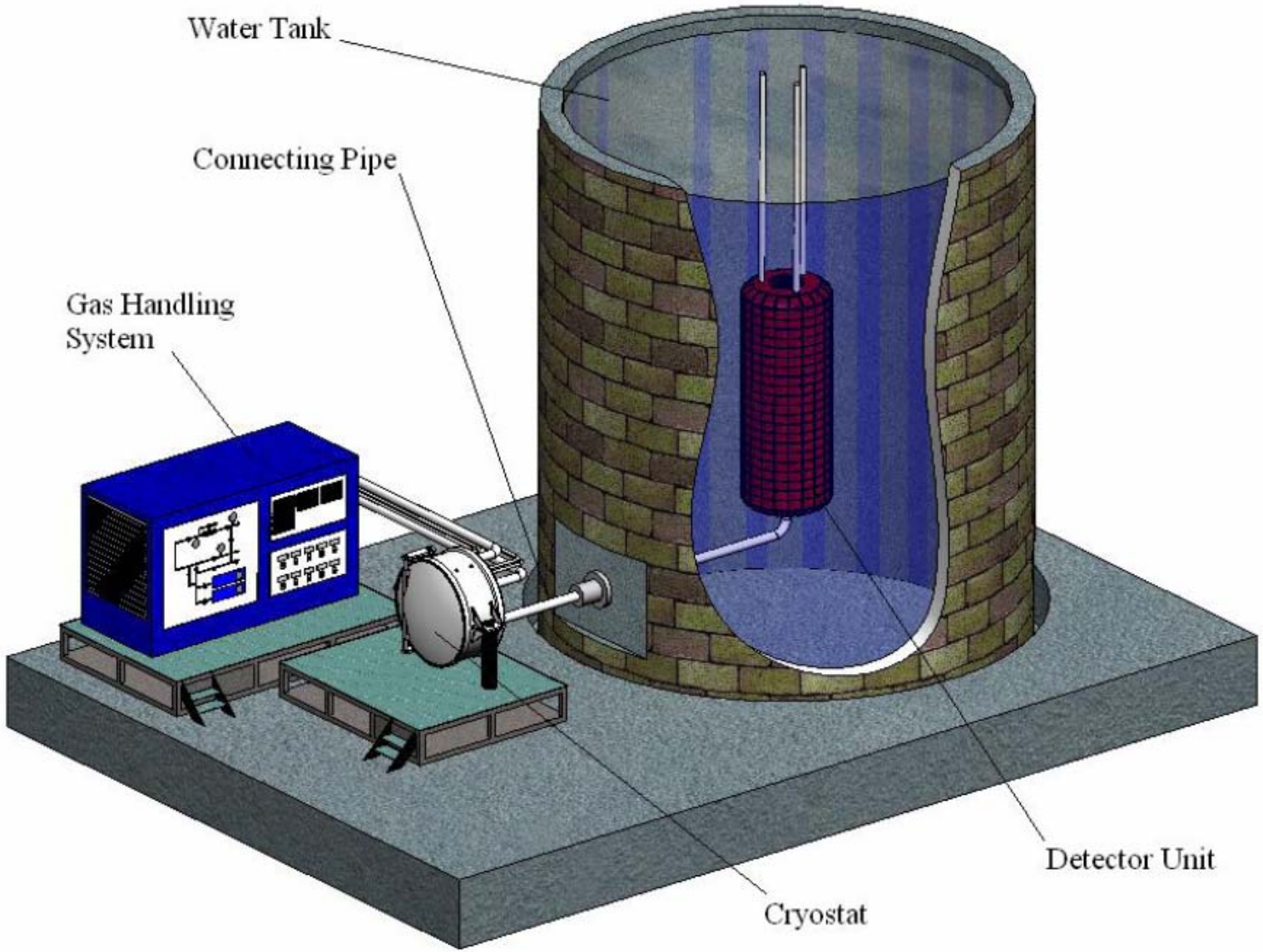


Timeline

2008	Grant applications / first financial support arrives. Low-cost studies ongoing.
2009/10	Design Study Phase
2011	Begin construction in home institutes and pre-tests in temporary underground space
2014	Bring experiment into LSM

Decision on how to fit EURECA into ULISSE needed as soon as possible.

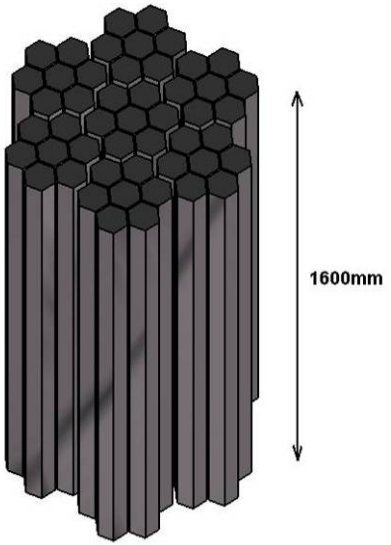
Early Artist's View of EURECA

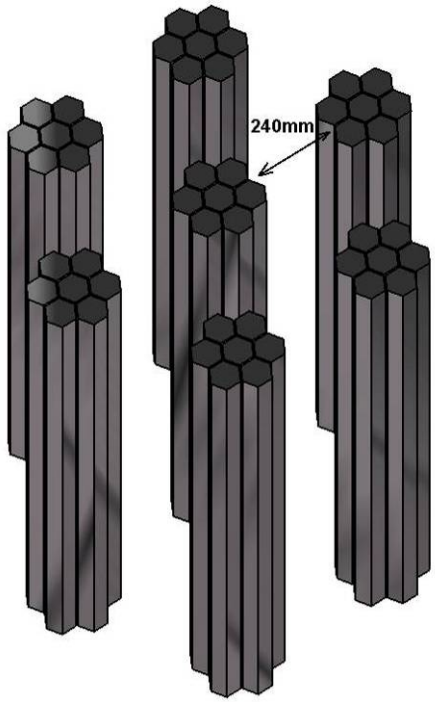


Cryostat Layout and Design

- Separation of dilution refrigerator and detector unit
- Easy access to cryostat as well as detector unit
- Number and size of pipes / feedthrough
- Closest package of detectors
- Load lock system or individual cryostats
- Detector exchange without long interruption
- Different detectors types / expansion

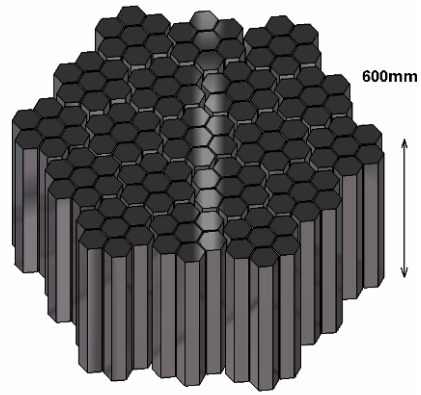
1 Cryostat
with 7 Towers



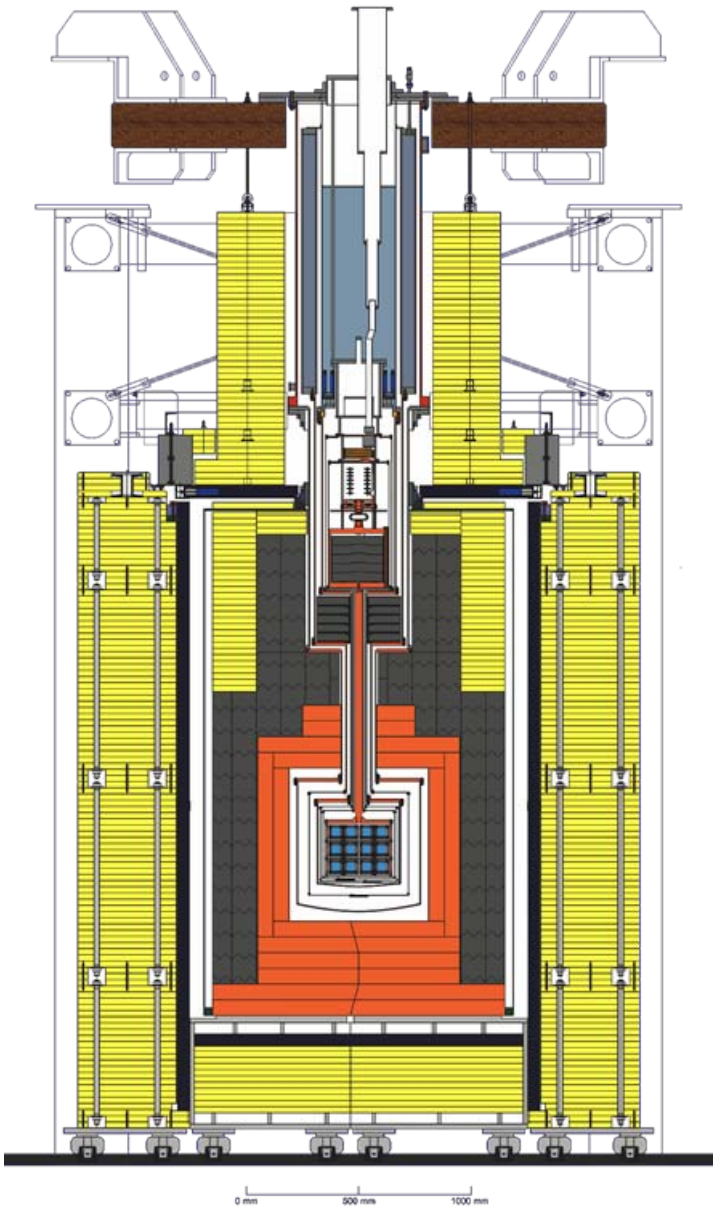


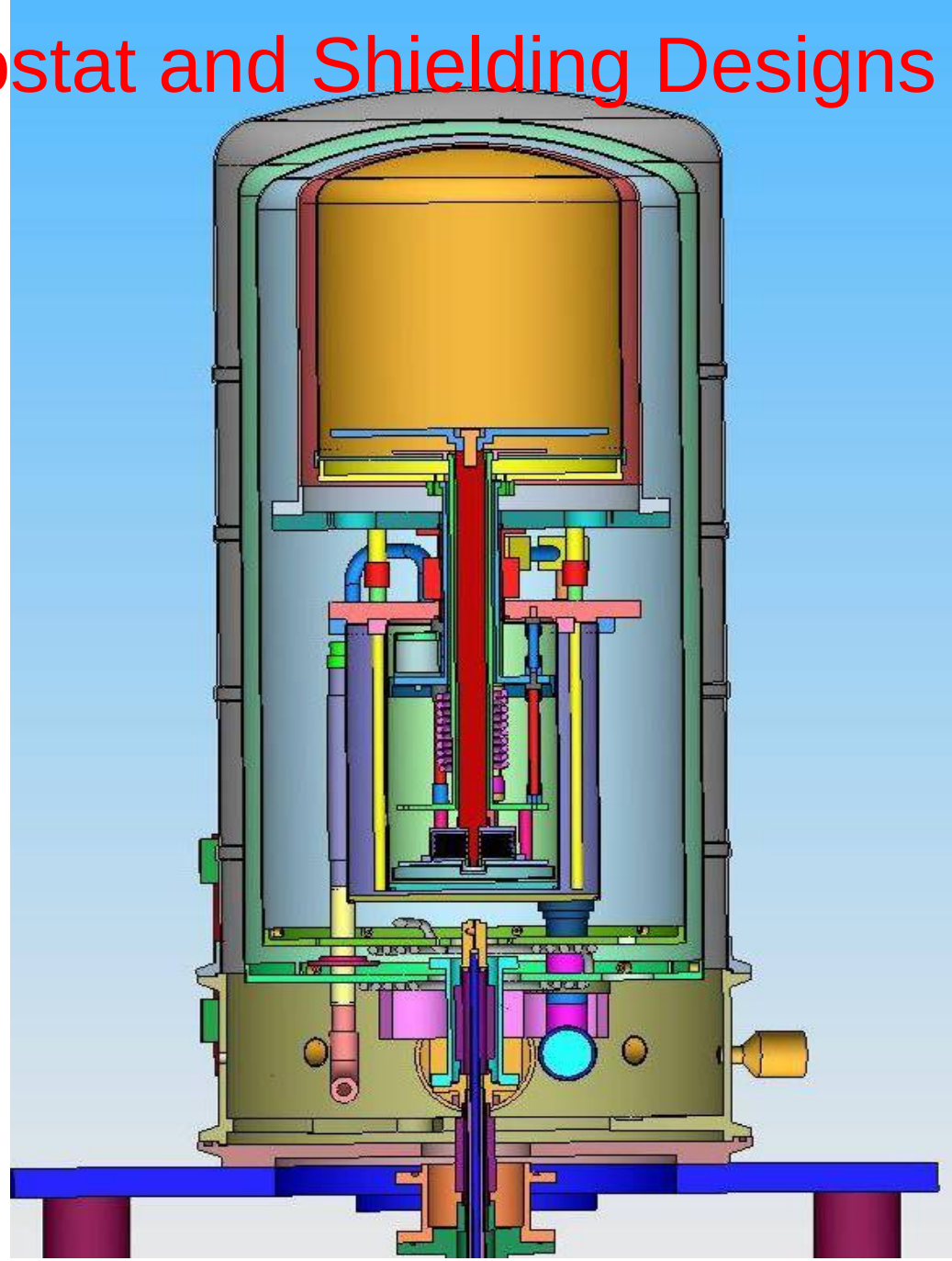
7 independent Cryostats
with 7 Towers

1 Cryostat
with 19 Towers



Cryostat and Shielding Designs





Readout Systems and DAQ

- ~1000 channels per unit (~6000 -- ~10000 total)
- low + high impedance amplifiers for scintillation and germanium detectors
- Same back end for SQUID and FET front end

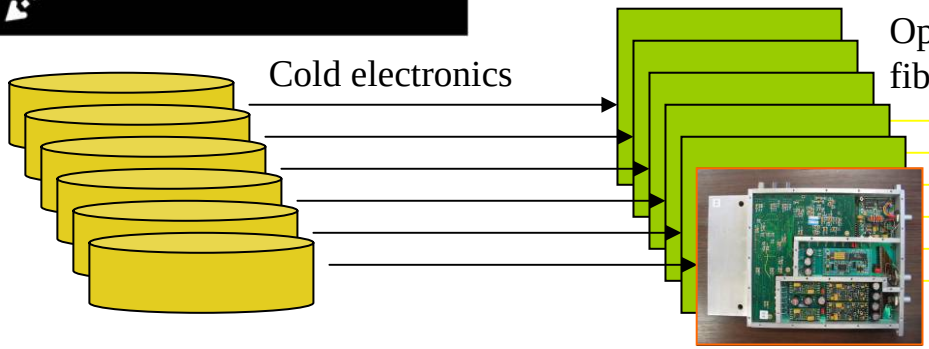
We need to …

- Reduce the size and complexity of electronics
- Reduce the number of wires – multiplexing?
- Digitize at an early stage.

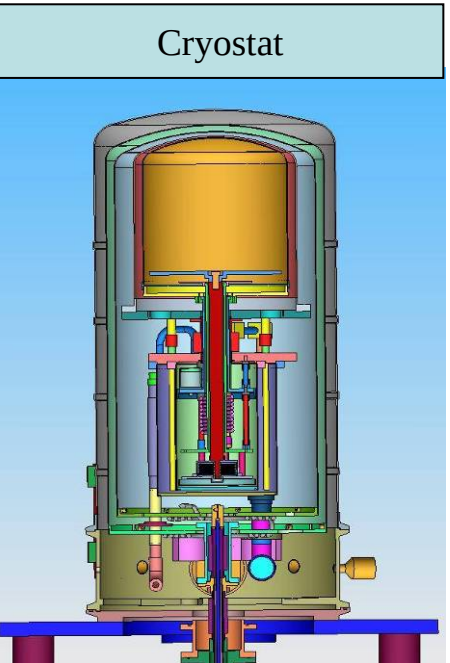
Research and Demonstration needed for …

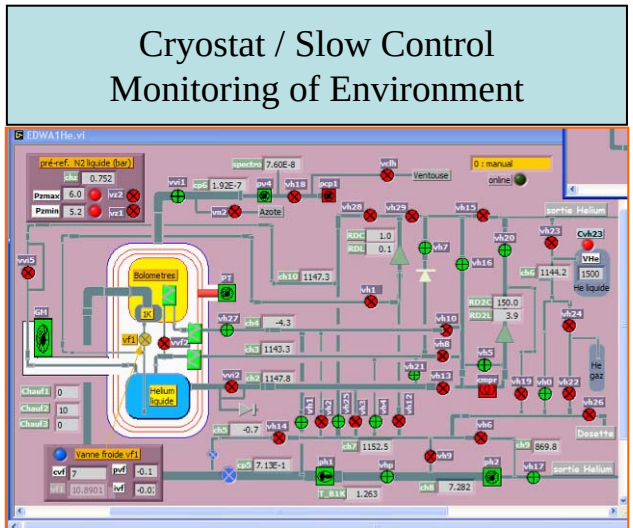
- Avoiding crosstalk
- Minimizing electromagnetic interference

Readout Systems and DAQ



EDELWEISS Approach

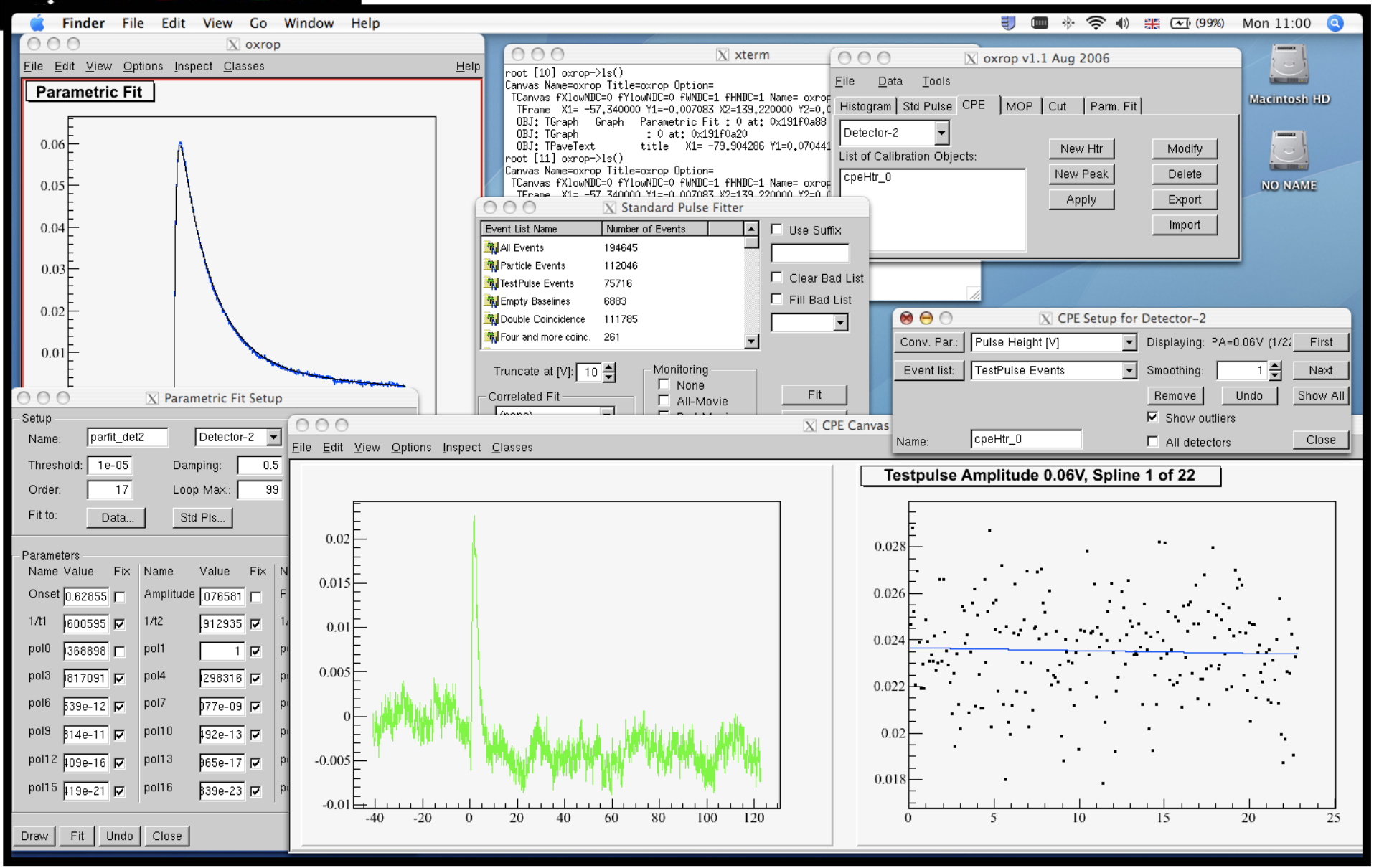




CPU Control event builder

Archive

Common Data Analysis



Summary

Time is flying…

Time is most precious resource

Avoid duplication / multiplication of effort

Re-use / build for multi-purpose