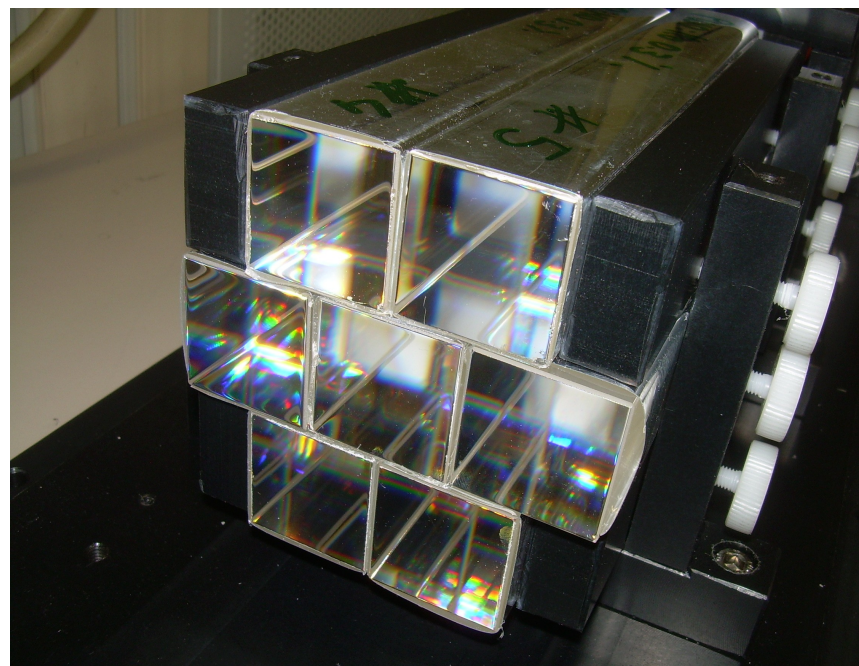
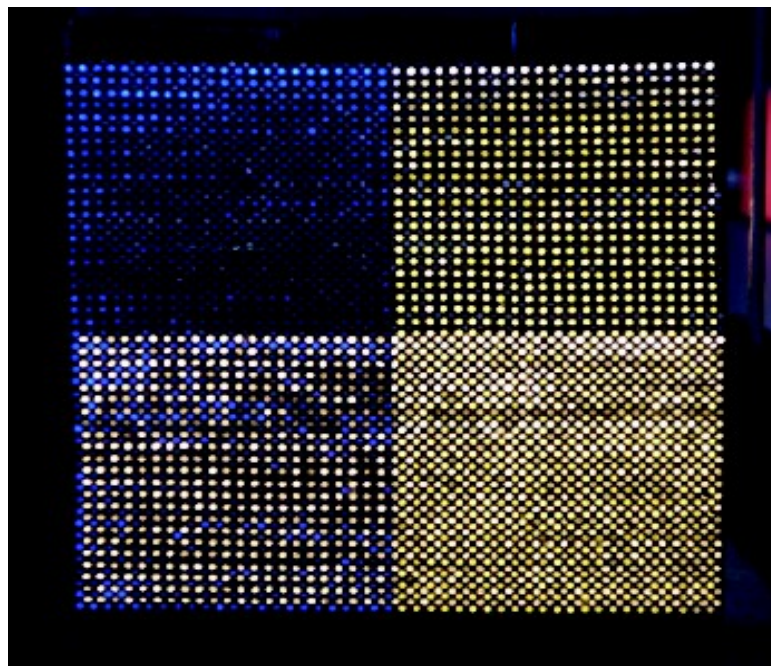


RD52- NewDream status report



Pavia, INFN CdS
20 giugno 2012

Silvia Franchino

Italia: Cagliari – Cosenza – Roma1 – Pavia – Pisa

USA: Iowa State – Texas Tech

- Spokeperson: R. Wigmans
- Deputy: M. Livan (responsabile nazionale)
- Testbeam coordinator: G. Gaudio
- **Da Ottobre 2011 riconosciuto come sigla ufficiale CERN (RD52)**

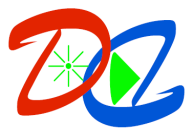
- **Gruppo di Pavia:**

R. Ferrari, M. Fraternali, S. Franchino, G. Gaudio, P. Genova, M. Livan, A. Negri;

Sostanziale supporto officina elettronica e meccanica

- Laureandi:

L. Collica (Settembre 2011), S. Fracchia (ongoing)



RD52 DREAM

Calorimetria a doppio readout

2/11

Silvia Franchino (NewDREAM - RD52) - Pavia INFN CdS 2012

● Fattori limitanti calorimetria adronica:

- ★ Fluttuazione della frazione elettromagnetica
- ★ Misura e fluttuazioni dell'energia invisibile (neutroni)

● Soluzioni:

- ★ Compensazione tradizionale
- ★ Particle flow algorithm
- ★ **Dual readout**

● Dual readout: uso di due mezzi attivi, uno scintillatore e un radiatore Cherenkov

- ★ lo scintillatore misura tutta l'energia visibile
- ★ il Cherenkov solo l'energia depositata da sciame em

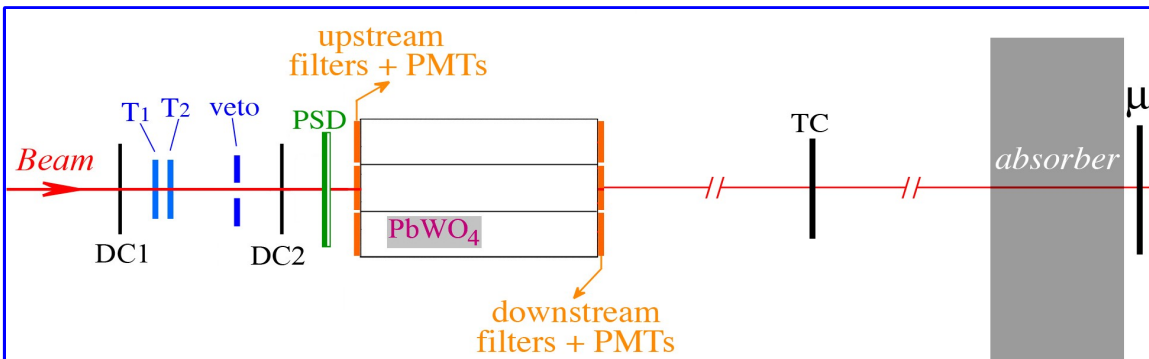
● Con scint. (ricco di H), possibilità di misura della componente neutronica

● **Due implementazioni:**

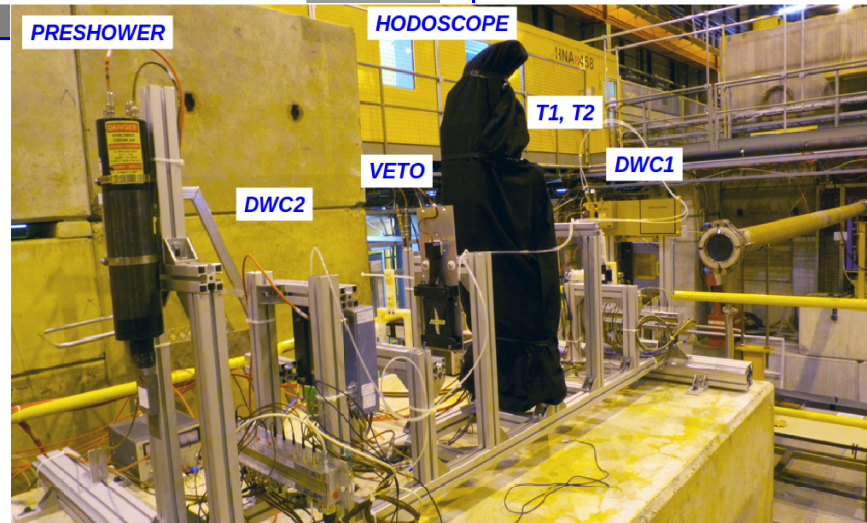
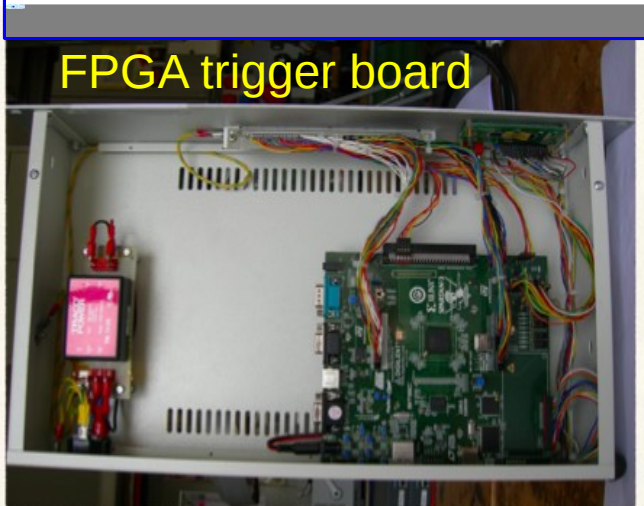
- ★ Calorimetri a **fibre scintillanti e Cherenkov**
- ★ **Cristalli** scintillanti (emettono anche Cherenkov). Necessaria separazione delle due componenti luminose mediante:
 - ★ differenza in lunghezza d'onda (uso di filtri),
 - ★ differenti proprietà temporali del segnale e polarizzazione (lettura con digitizzatore segnale).

- Matrice di cristalli 0.3% Mo: PbWO_4 : costruzione, test e analisi dei risultati
- Costruzione moduli Pb-fibre
- Preparazione e svolgimento testbeam
- Trigger ed acquisizione dati
- Miglioramento dell'elettronica di lettura
- Simulazione con GEANT 4 di diverse configurazioni di rivelatore

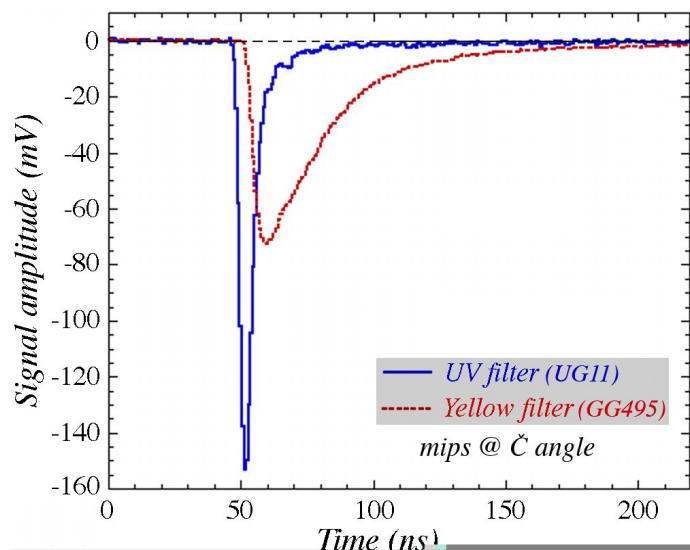
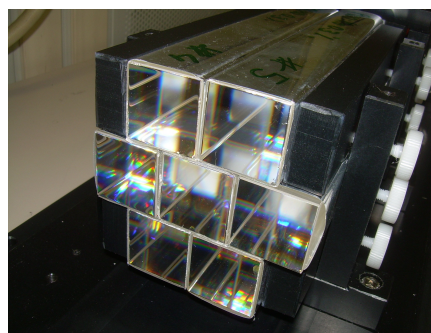
- 3 periodi di testbeam nel 2011
- Ampio programma svolto (test matrici di cristalli BGO e PbWO_4 , studi di polarizzazione luce Cherenkov, test 2 moduli a fibre (1 costruito a Pavia))
- Migliorato notevolmente il setup aggiungendo detector ausiliari per beam cleaning; struttura rigida mobile per quando non siamo in presa dati (officina PV)
- Implementazione dell'elettronica di trigger in un chip FPGA (elettronica PV)



“Ancillary detectors”
e struttura di supporto



- 7 cristalli 30x30x200 mm³ (20.5 X0) 0.3% Mo-doped
- Testata nel 2010 e 2011 (migliori condizioni di “beam cleaning”)
- NIM paper sottomesso e accettato per pubblicazione (Marzo 2012)
- Risultati presentati da pavesi alle conferenze: IEEE2011 (Franchino), Calor 2012 (Gaudio) e ELBA 2012 (poster)
- tesi laurea Laura Collica, settembre 2011

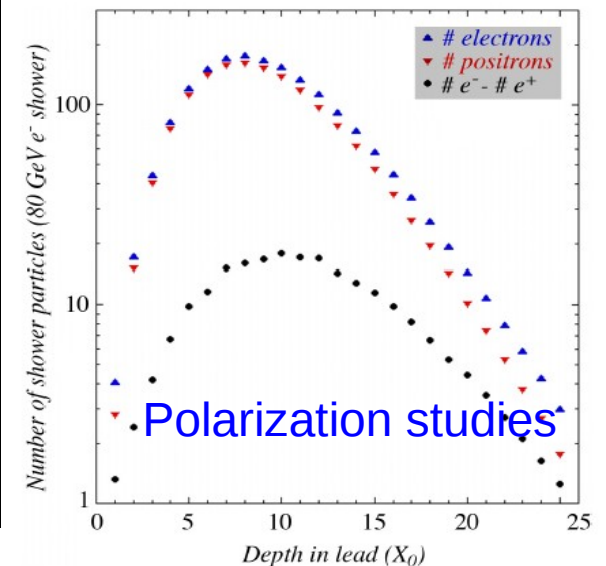
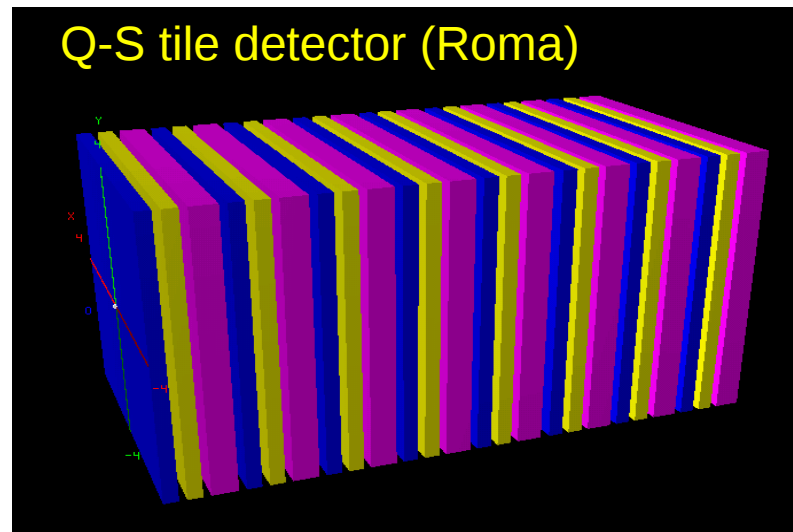
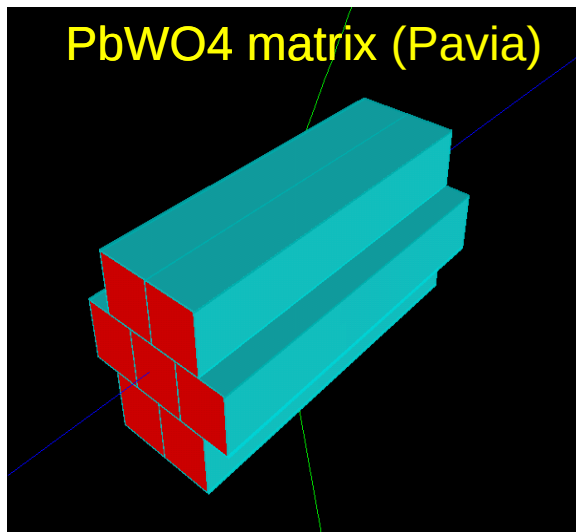


Detection of electron showers in Dual-Readout crystal calorimeters

N. Akchurin^a, F. Bedeschi^b, A. Cardini^c, M. Cascella^d, G. Ciapetti^e, A. d’Orazio^e, L. Collica^{f,1}, D. De Pedis^g, R. Ferrari^h, S. Franchino^f, M. Fraternali^f, G. Gaudio^h, P. Genova^f, J. Hauptmanⁱ, F. Lacava^e, L. La Rotonda^j, S. Lee^a, M. Livan^f, E. Meoni^k, A. Negri^f, D. Pinci^g, A. Policicchio^j, F. Scuri^b, A. Sill^a, T. Venturelli^j, C. Voena^g and R. Wigmans^{a, 2}

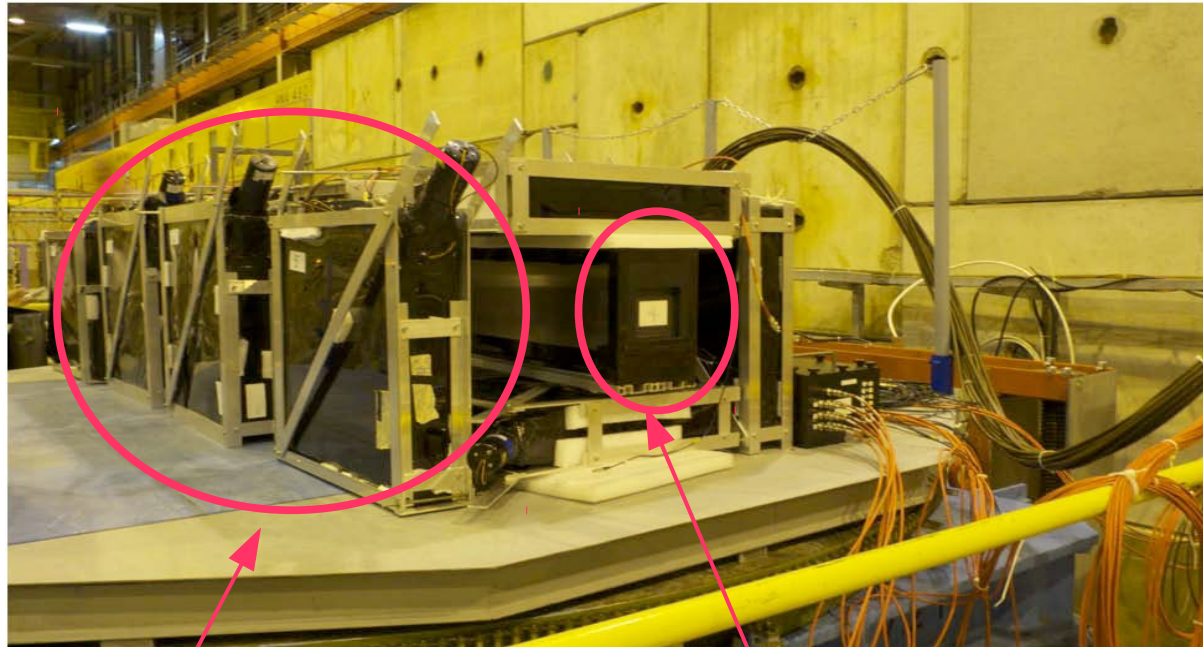
Simulazioni fornite all'intera collaborazione di RD52 per diverse configurazioni:

- energia depositata nella matrice di cristalli PbWO_4 (fattori di conversione)
- energia depositata nel rivelatore Q-S tile di Roma (fattori di conversione)
- Confronto tra numero di γ , e^+ , e^- a diverse profondità della cascata em (studi di contributi per la polarizzazione luce Cherenkov, ulteriori verifiche prossimo testbeam)



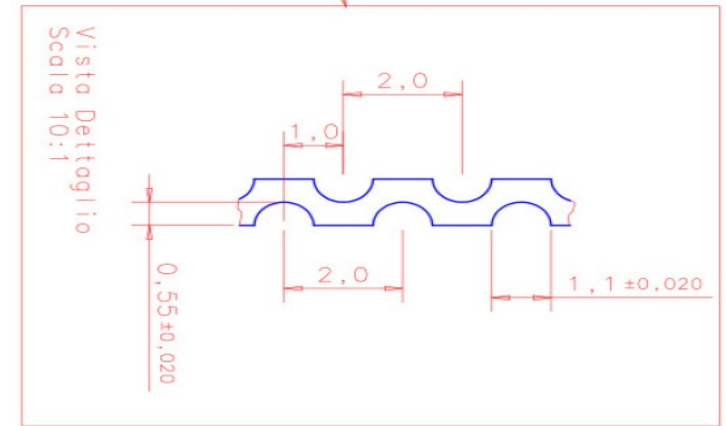
Interessamento pavese per trovare una ditta in grado di fornirci Pb estruso a freddo con specifiche richieste (ottimizzazione sampling frequency and fraction);

Primo modulo costruito a Pavia (Giugno 2011) e testato nei TB 2011

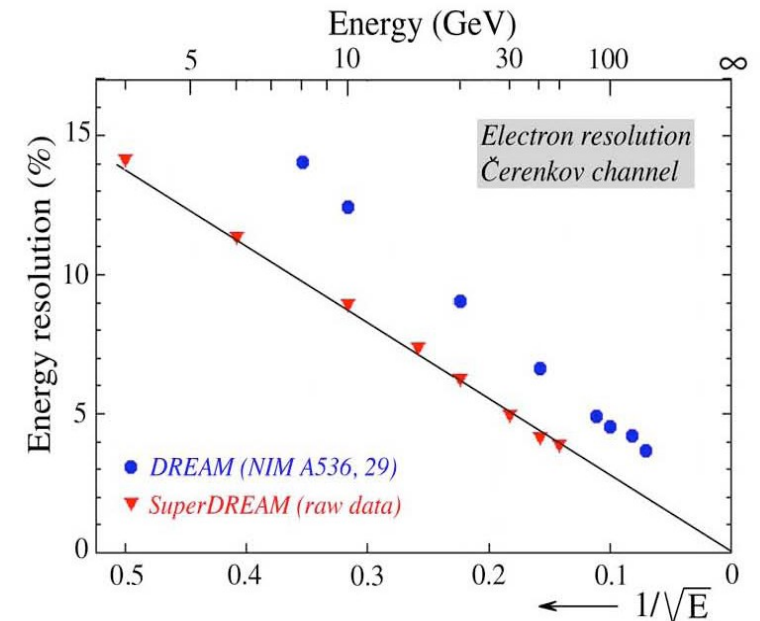


Scintillatori di leakage

Modulo a Pb-fibre

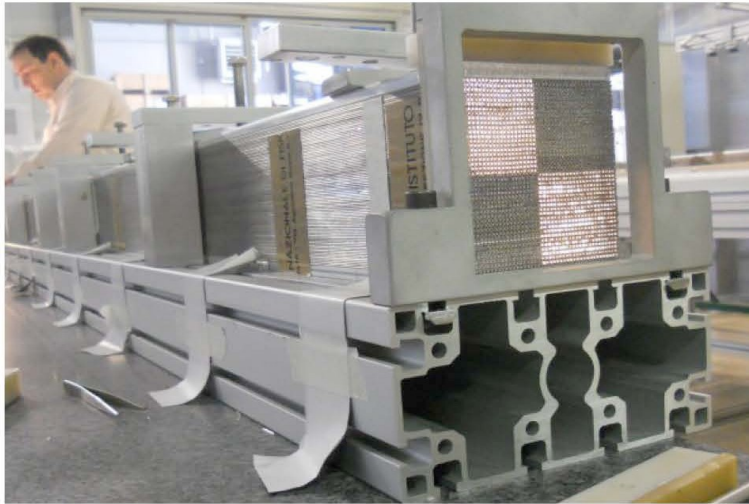


RESOLUTION MUCH BETTER THAN IN DREAM!



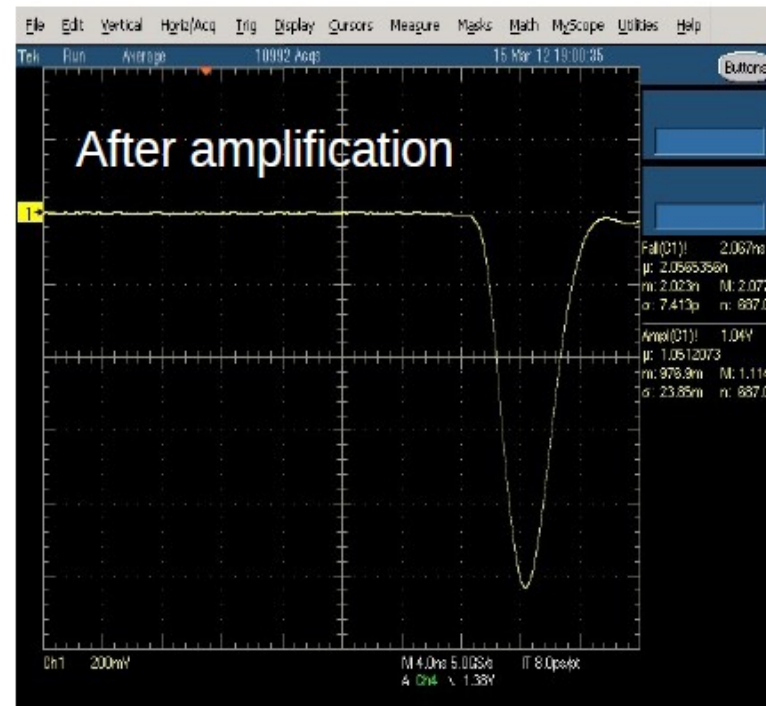
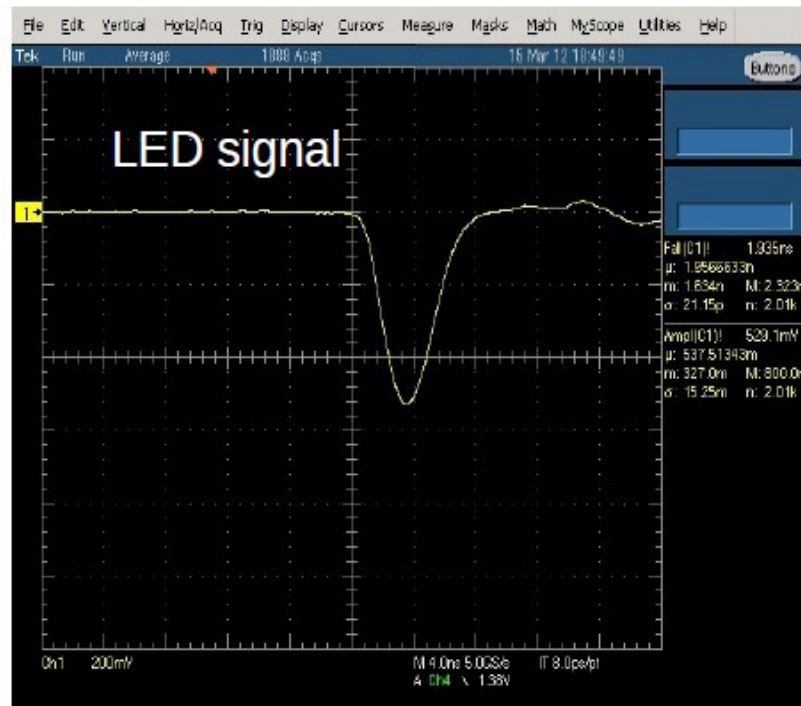
Dai risultati del TB 2011 si e' deciso di continuare con la costruzione di 6 (9) moduli a Pavia Che faranno parte del full containment calorimeter (6*6 moduli) in programma per il 2014

- Preparazione di 2 periodi di TB (2 settimane luglio, 10 giorni Novembre)
- Costruzione nuovi moduli (test a novembre)
- Ottimizzazione elettronica lettura (test a luglio)



- Costruzione iniziata a marzo 2012
- Turni mezza giornata a rotazione (1 fisico + 1 tecnico)
- ~ 2 weeks/modulo (solo impilaggio)
- 4 moduli costruiti fino ad oggi.
- In programma 6 (9 se riusciamo).

- Ottimizzazione grounding e filtraggio di HV
- Amplificazione segnali per le torri centrali (maggior linearita` nel range dinamico)
- Ottimizzazione partitore tensione dinodi PMTs (riduzione G, aumento range dinamico)
- Alimentazione indipendente ultimo dinodo per ridurre carica spaziale
- Testeremo il tutto al TB di luglio 2012



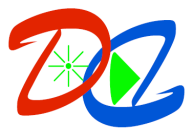
First tests by Agostino with amplifiers $G=2$ using PMT excited by a LED:
 not distortion of the signal observed

Pubblicato dell'inizio (5 anni DRC, 2 Newdream)

- 14 lavori (13 su NIM ed uno su JAP),
- 1 lavoro in fase di pubblicazione
- 23 contributi a conferenze internazionali, di cui 16 presentate da colleghi INFN.

The end

BACKUP



RD52 DREAM

The Dual Readout Method

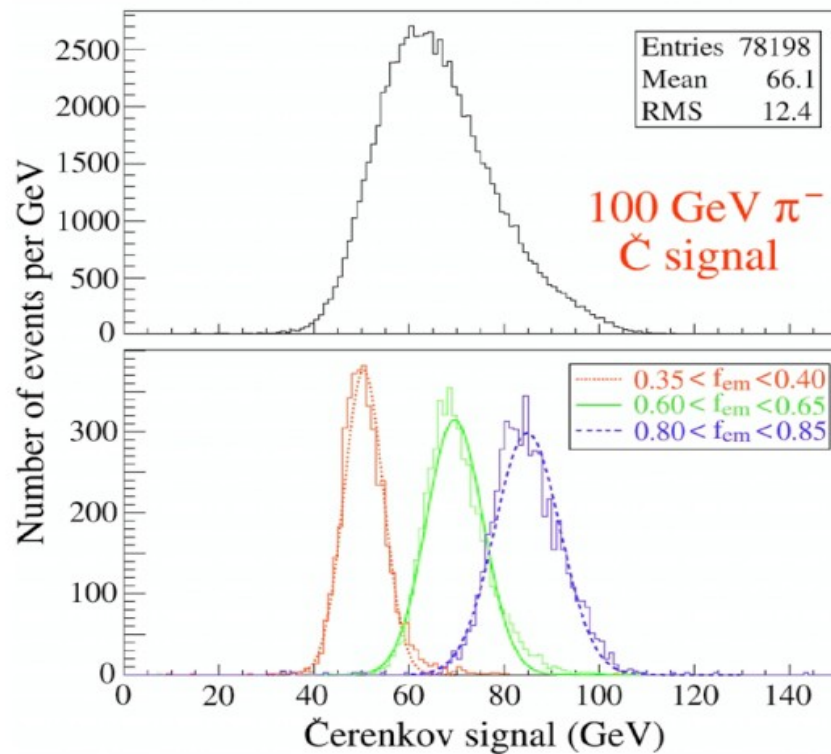
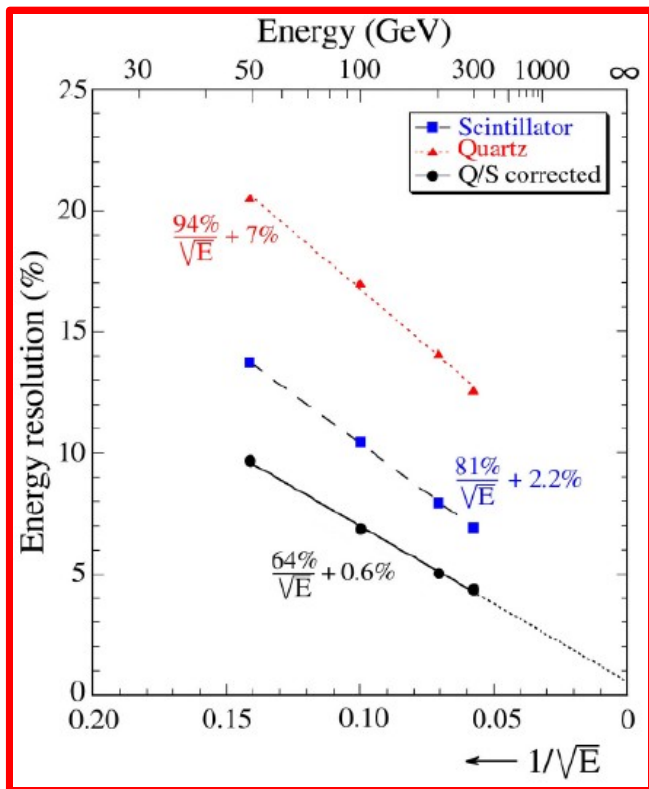
Response of each active media for hadronic showers:

$$R(f_{em}) = f_{em} + \frac{1}{e/h} (1 - f_{em})$$

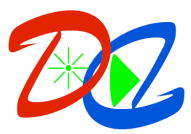
from the ratio of the signals in quartz (Q) and scintillating fibers (S)

$$\frac{Q}{S} = \frac{f_{em} + 0.21 (1 - f_{em})}{f_{em} + 0.77 (1 - f_{em})}$$

(0.21 and 0.77 are h/e for S and Q fibers)



f_{em} is measured event-by-event
and energy is corrected



RD52 DREAM

DREAM with homogeneous materials?

4 ways to separate Scintillation from Cherenkov light :

1) Time structure of the signal

Signals read by fast electronic (DRS) and separated offline event by event.

C fast pulses, S long tail

2) Spectral difference

Crystal equipped with 2 different optical filters, high-pass frequencies for C, low pass for S

	Cherenkov	Scintillation
Time response	Prompt	Exponential decay
Light Spectrum	$\propto 1/\lambda^2$	Peak
Directionality	Cone: $\cos \theta_c = 1/\beta n$	Isotropic
Polarization	Polarized	Not polarized

3) Directionality of Cherenkov light

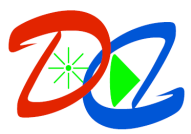
(not reliable for 4π calorimeter, used just to prove the existence of C light in crystals).

Crystal rotated wrt the beam and signals acquired in both ends

4) Polarization of Cherenkov light

Crystals equipped with polarized filters

Time structure and spectral difference were used for the PbWO_4 matrix analysis



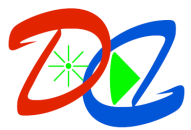
RD52 DREAM

The Dual Readout Method

- Addresses the limiting factors of the resolution of hadron calorimetry with the aim of reaching the theoretical resolution limit ($15\%/ \sqrt{E}$)
- Performances of hadronic calorimeters limited by:
 - Different response to electromagnetic (em) and non electromagnetic (non-em) hadron shower components
 - Fluctuations on the em component
- The Dual-Readout technique is based on the simultaneous measurement, event by event, of
 - **Čerenkov light (C)** only produced by relativistic particles, dominated by em
 - **Scintillation (S)** a measure of dE/dx
 - **C/S** correlated to electromagnetic fraction of hadron shower (f_{em})



Measurement of the electromagnetic fraction (f_{em}) of the hadron shower on event-by-event basis



RD52 DREAM

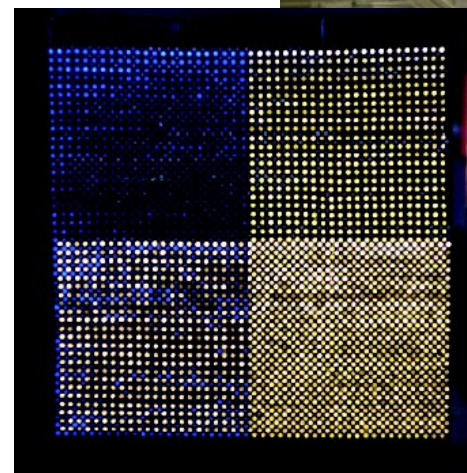
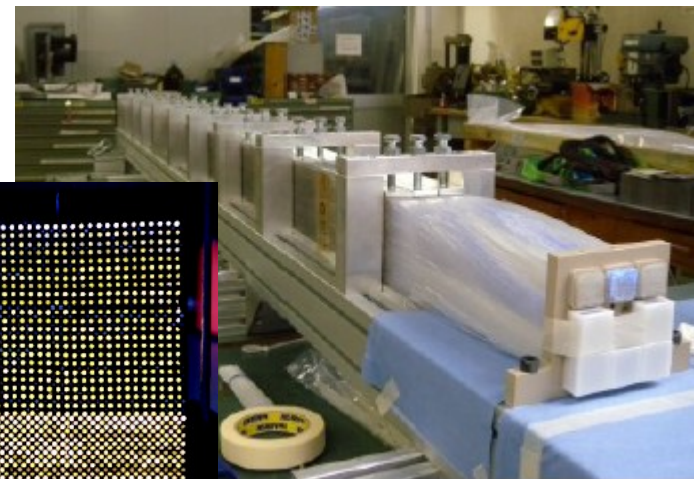
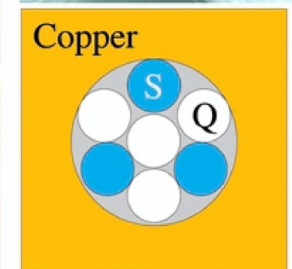
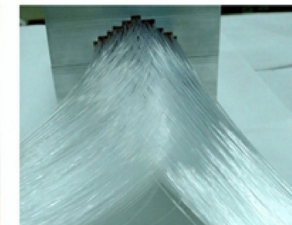
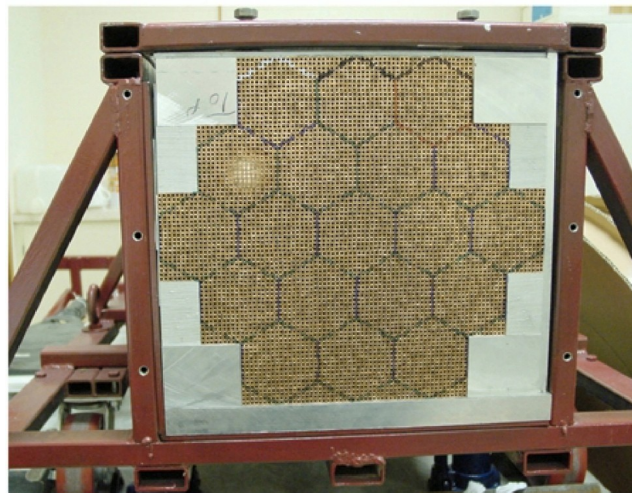
The DREAM project - Fibers

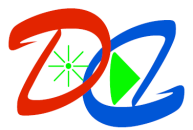
First DREAM: from 2003:

- 2.6% samp. frac – > limited em res.
- limited Cherenkov light yield (8 p.e./GeV)

Future plans: NewDream from 2010

- **full containment detector** with
 - ◆ improved sampling fraction (5%)
 - ◆ improved sampling frequency
(one fiber per each hole of passive material)
- two modules already built and tested in 2010 and 2011: Pb, 2.5m long, 92*92 mm².
- New modules are being built by PI (Cu) and PV (Pb)





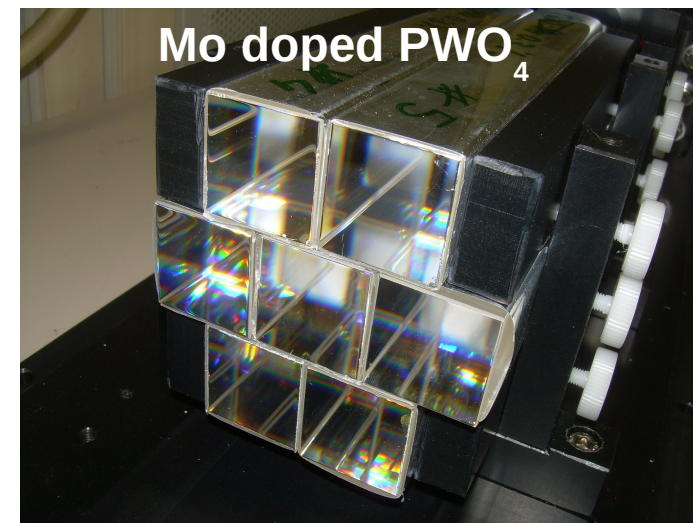
RD52 DREAM

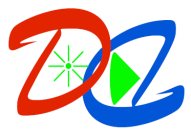
The DREAM project - Crystals

- C and S separated with different techniques
- Optimal em resolution
- Increased Cherenkov light yield
- Eliminated sampling fluctuations
- Hybrid system operated with a dual-readout technique allows to overcome e/h difference between the two types of detector and therefore maintain a good hadronic resolution

Crystals tested so far (since 2007):

- PbWO_4 Single Crystal + Matrix
- **BGO** Single Crystal + Matrix
- **BSO** Single Crystal
- **Doped PbWO_4** with different % of Pr and Mo
- **Mo-doped PbWO_4 matrix**





RD52 DREAM

Dual readout with crystals

Since 2007 extensive studies were performed at the H4 and H8 of SPS to extend the Dual Readout technique to crystals

PbWO₄

NIM A582 (2007)

NIM A584 (2008)

NIM A593 (2008)

BGO

NIM A598 (2009)

NIM A598 (2009)

NIM A 610 (2009)

Pr, Mo doped PbWO₄

NIM A604 (2009)

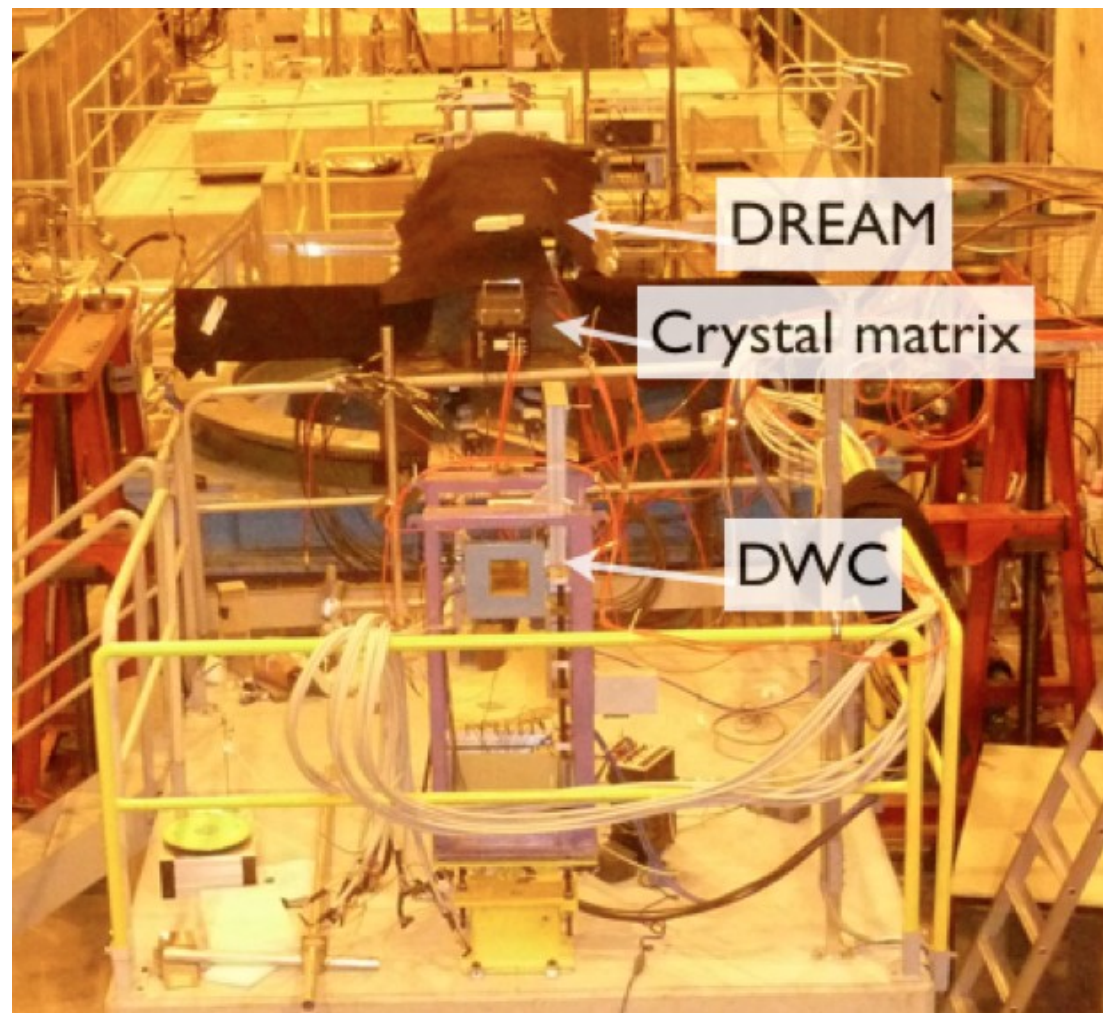
NIM A621 (2010)

BGO-BSO comparison

NIM A640 (2011)

Polarization

NIM A 638 (2011)



PWO matrix results

