DREAM Collaboration: Recent results on dual readout calorimetry

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For the DREAM collaboration

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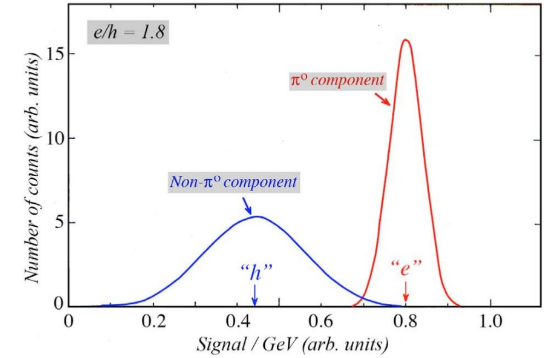
Introduction

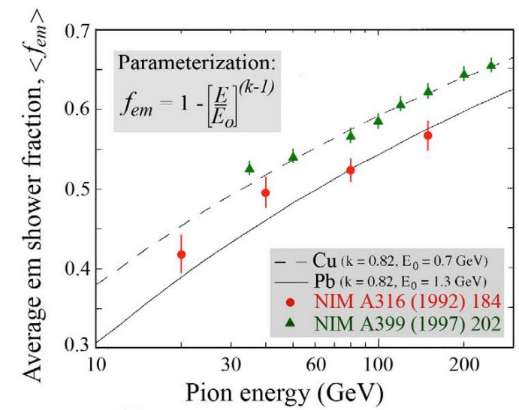
- Introduction to dual readout calorimetry
- Dual readout with crystals
  - BGO/BSO
  - PbWO4
- Dual readout with a sampling fiber module
  - The newDREAM module

Dual readout calorimetry

Investigating and eliminating factors that limits the performance of hadron calorimetry

- Em / hadronic component of the shower
  - different response
  - large fluctuations
- Measure em and had components event-by-event
  - Scintillation vs Cherenkov
  - C/S is a function of f_{em}
- Neutron component (triple readout)



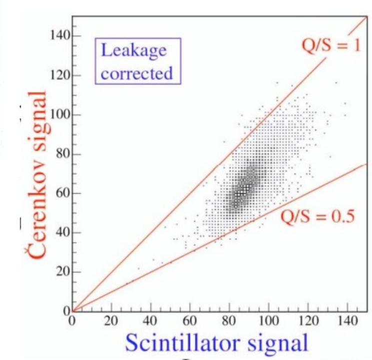


$$S = E\left[f_{em} + \frac{1}{(e/h)_S}(1 - f_{em})\right]$$

$$Q = E\left[f_{em} + \frac{1}{(e/h)_Q}(1 - f_{em})\right]$$

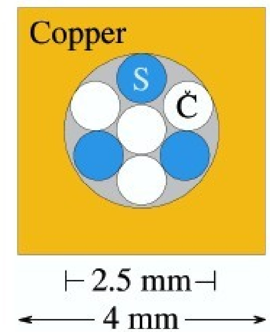
$e.g.$ If $e/h = 1.3\ (S),\ 4.7\ (Q)$

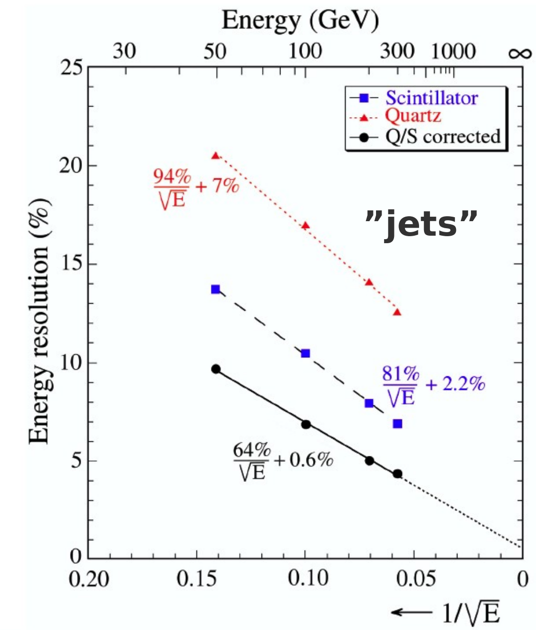
$$\frac{Q}{S} = \frac{f_{em} + 0.21\,(1 - f_{em})}{f_{em} + 0.77\,(1 - f_{em})}$$

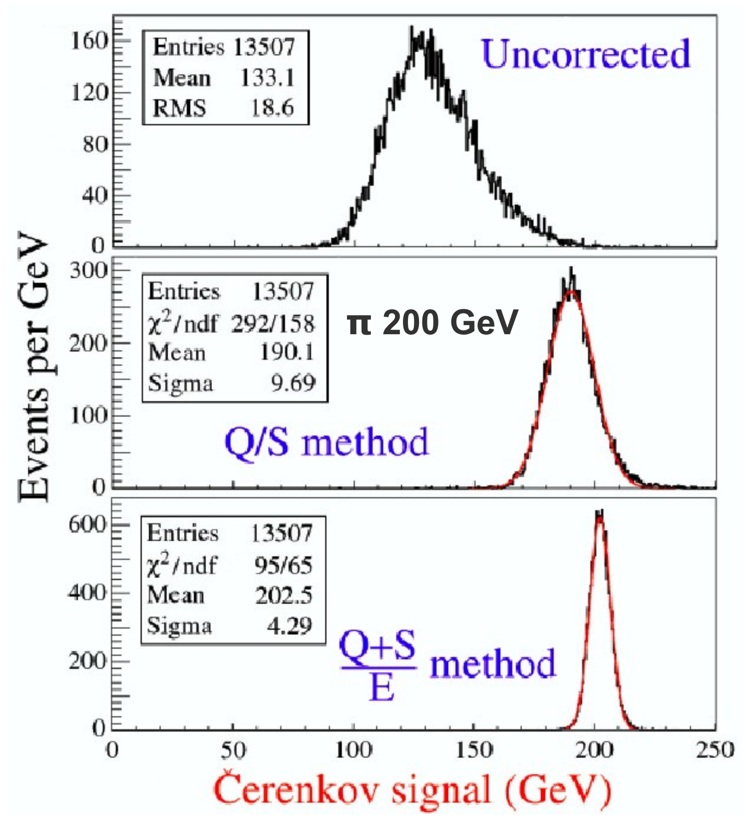


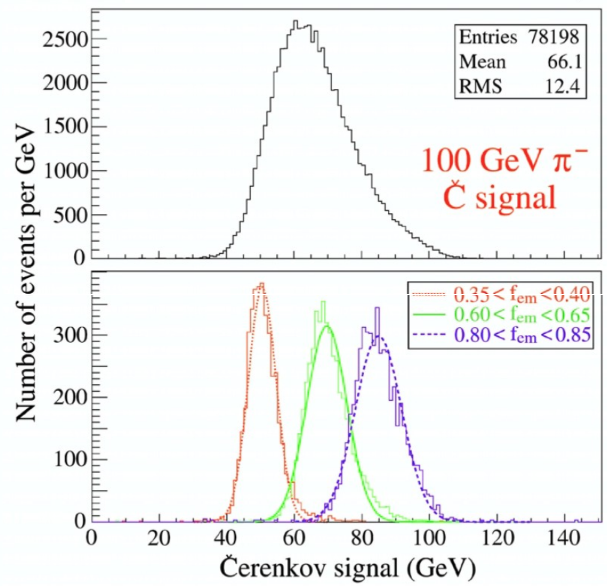
The DREAM calorimeter

- Copper/fiber calorimeter built in 2003
- Resolution limited by leakage and f_{samp}





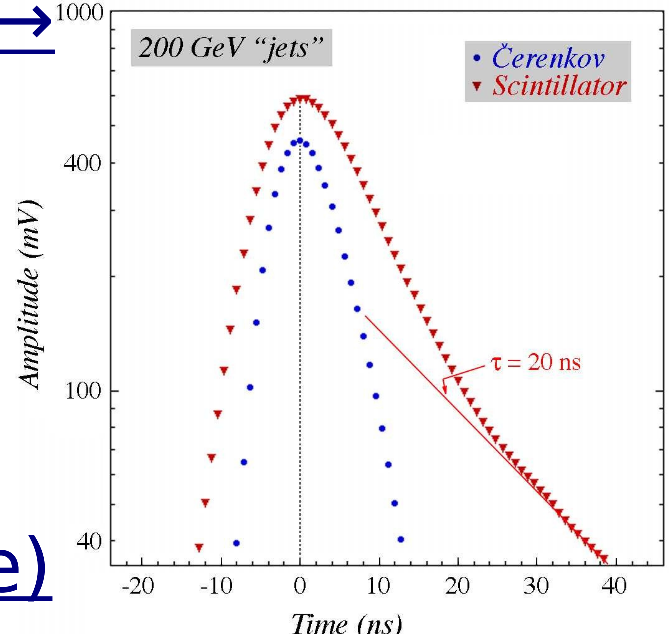




Nucl.Instrum.Meth. A617 (2010) 129-133

Domino Ring Sampler

- Accurate readout 1Gsample/sec → 1μs sampled in bins of 1ns
- C/S separation
- Spatial resolution of ~30cm in a non segmented calorimeter
- Measure event-by-event the (late) neutron component of the shower



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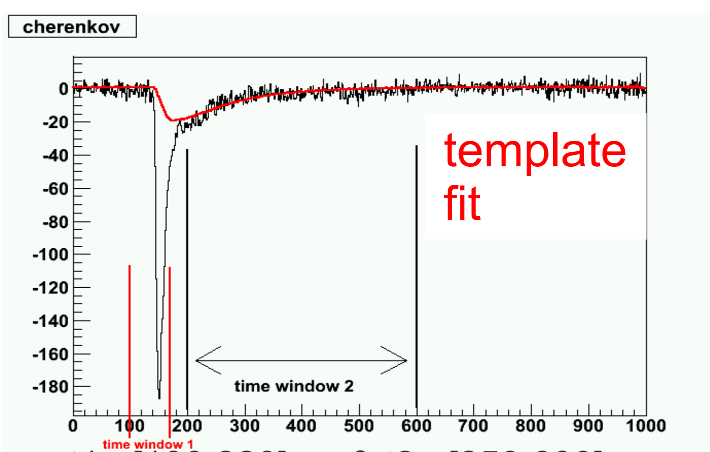
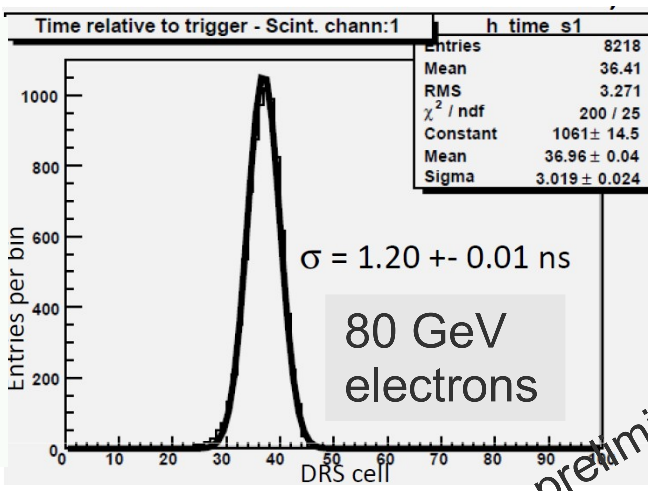
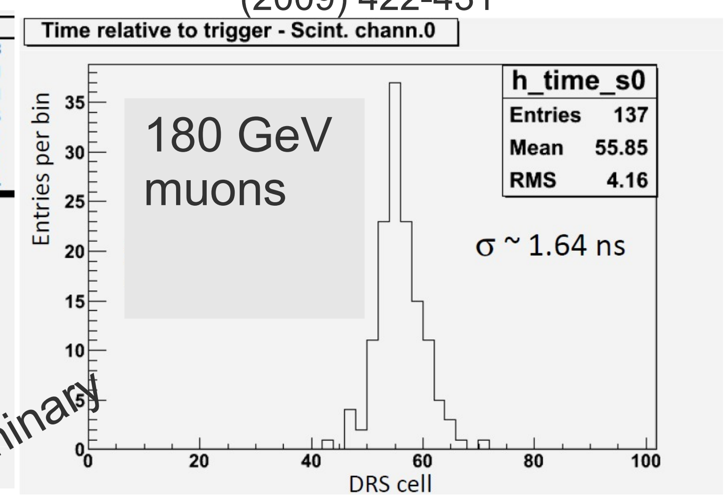


t1= [100,220] ns & t2= [250,600] ns

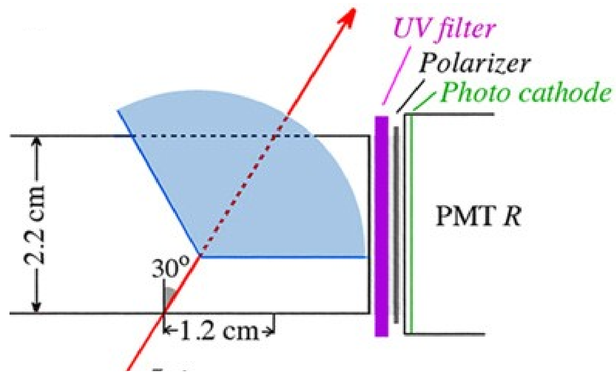


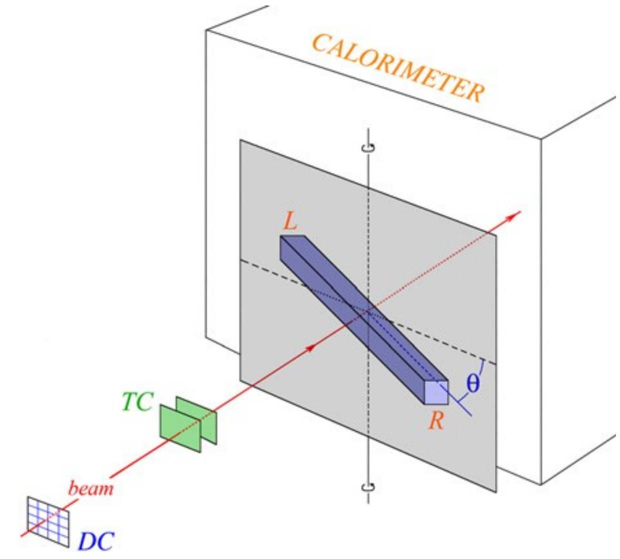


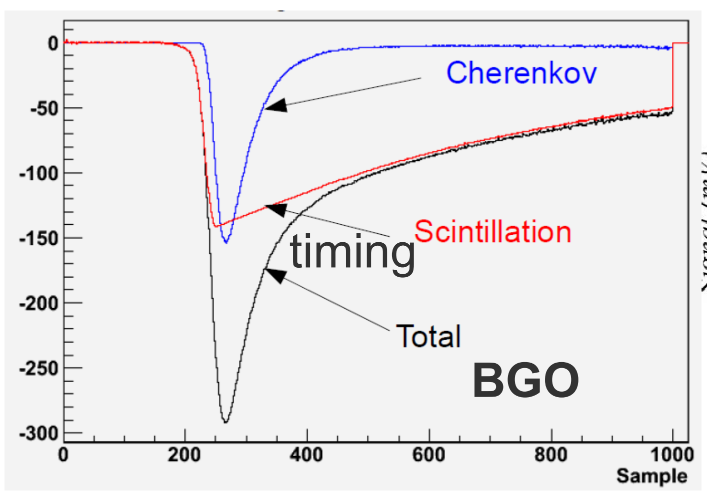
Crystal studies

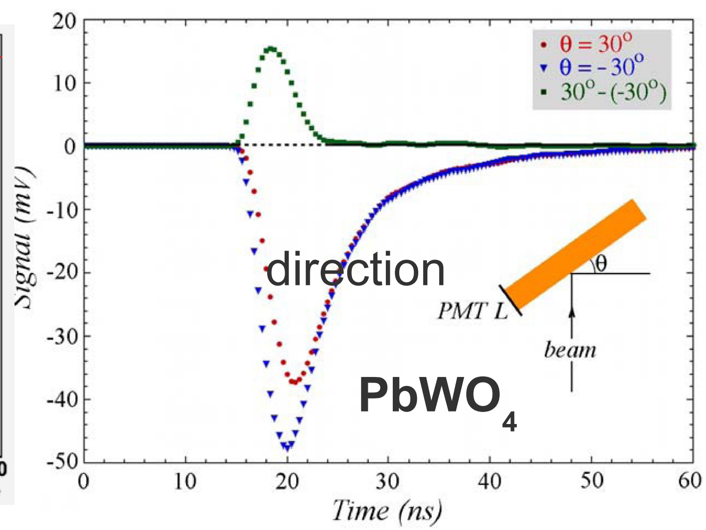
How to separate Cherenkov light

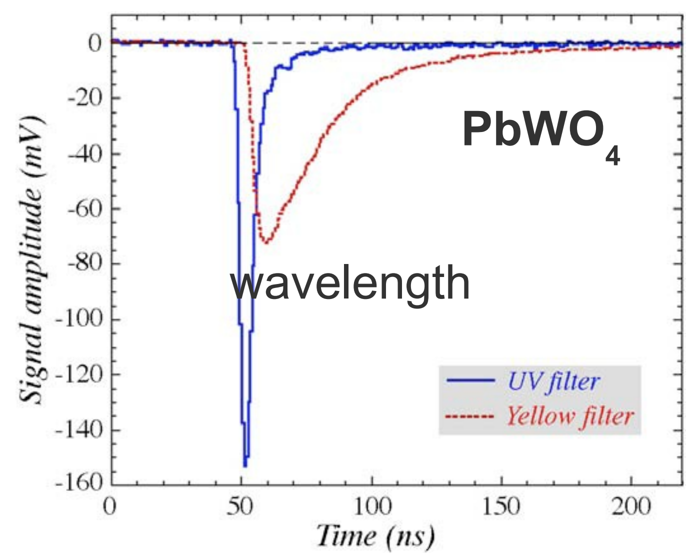
- Time structure (DRS)
- Directionality
- Wavelength
- Polarization





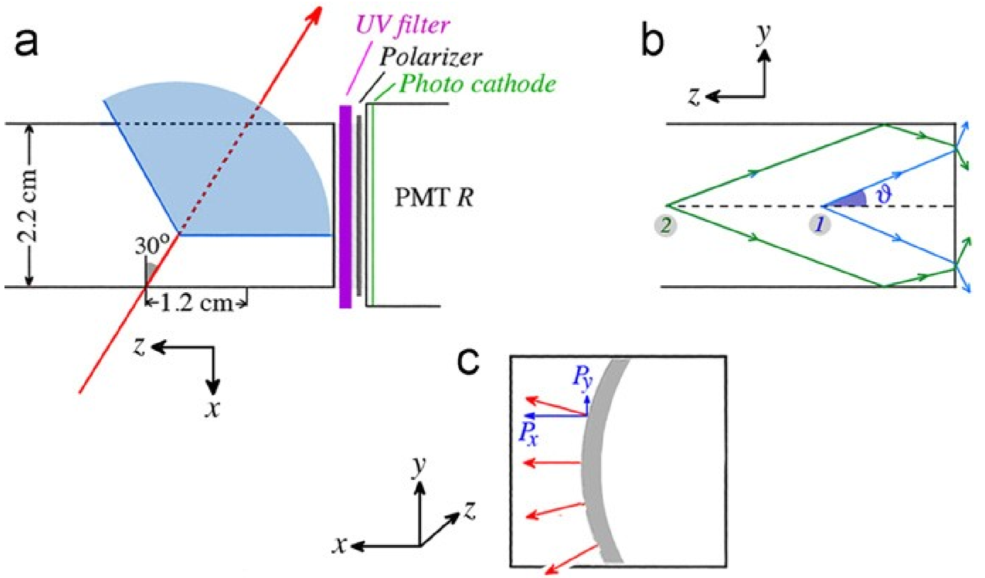


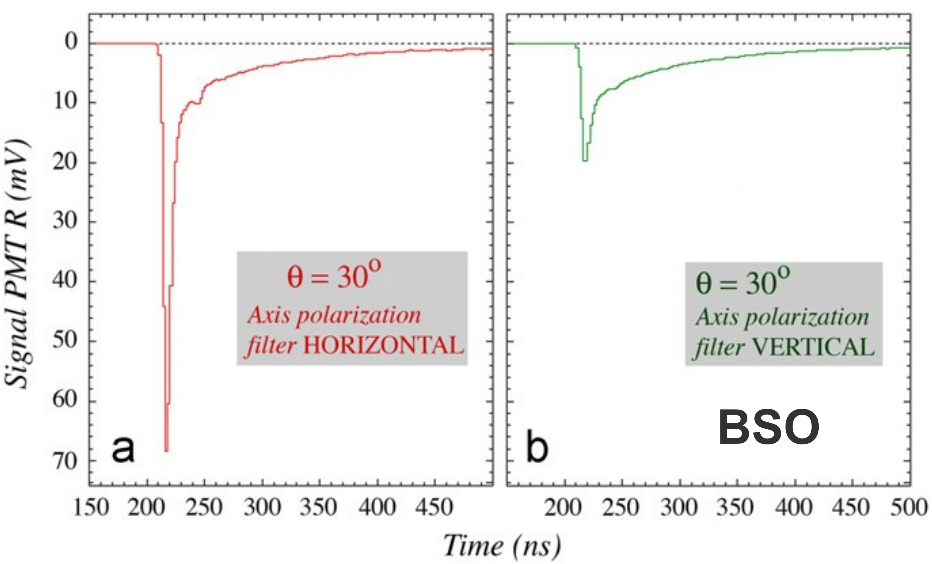


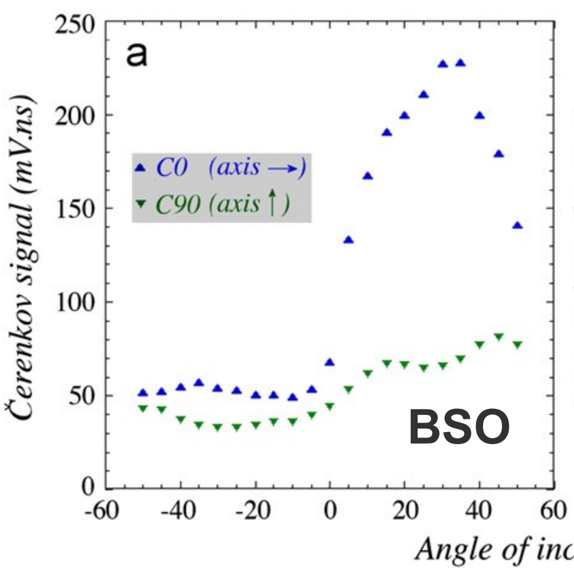


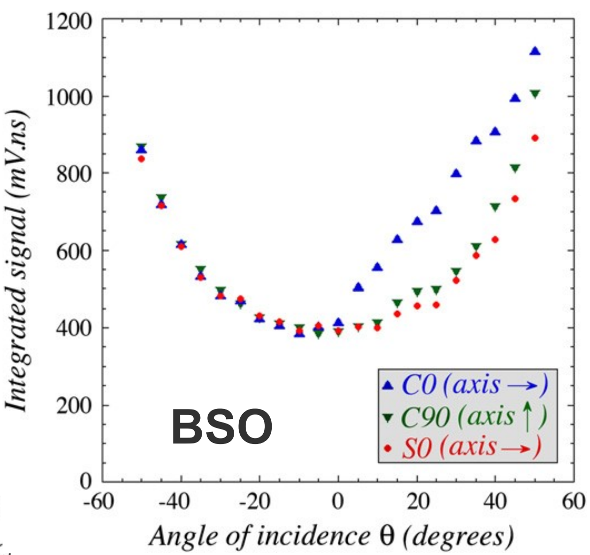
Polarization studies

- Separate the Cherenkov component using polarization
- Use directionality and time structure as a cross check





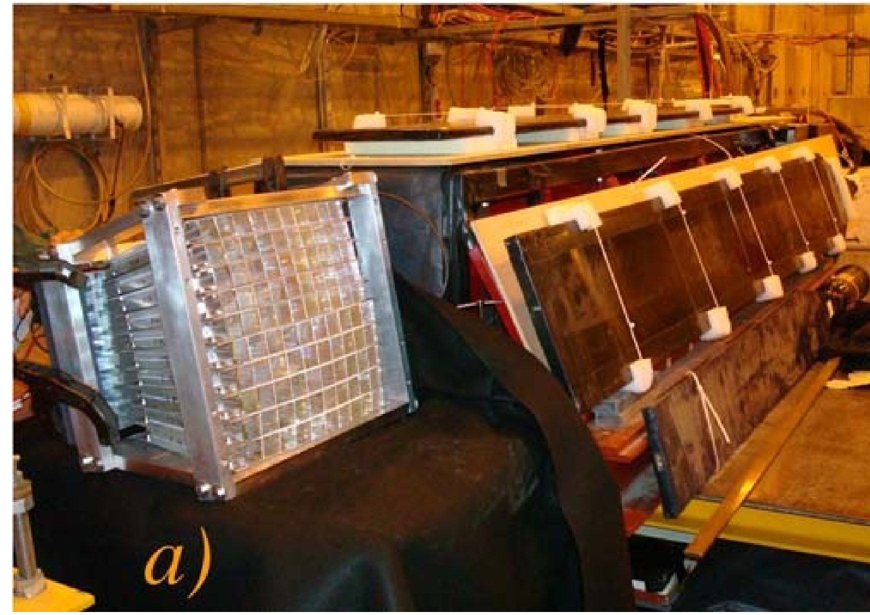


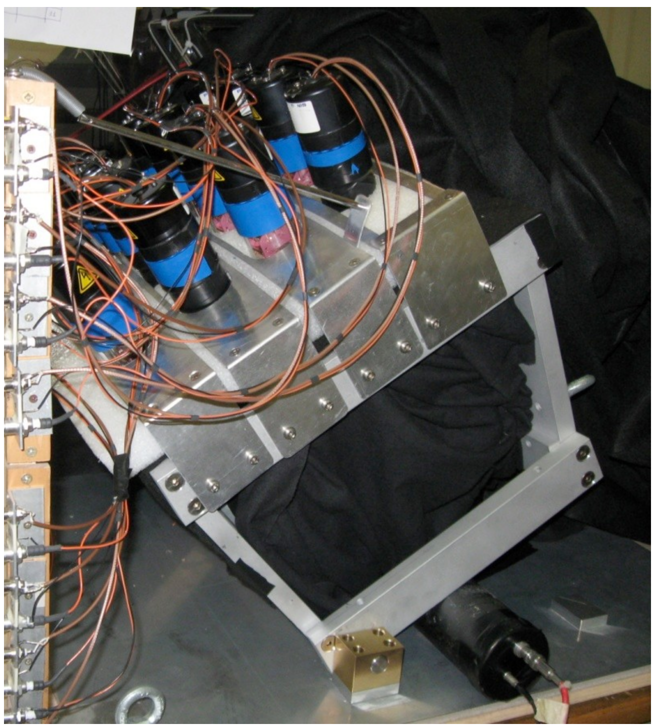


NIM A 638 (2011) 47–54

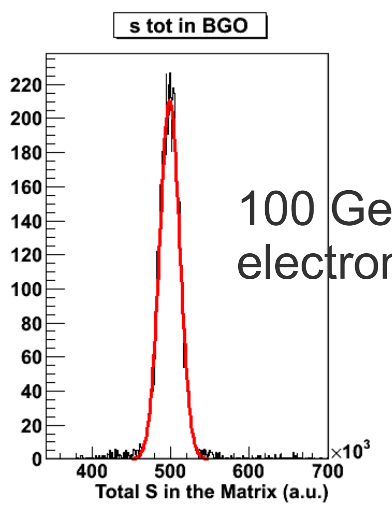
BGO matrix

- Improved optical coupling w.r.t. 2009
- 10 p.e. → 60p.e.



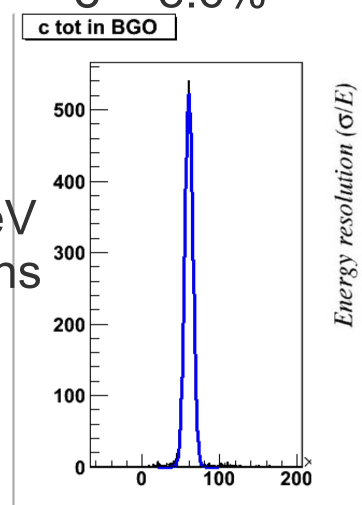


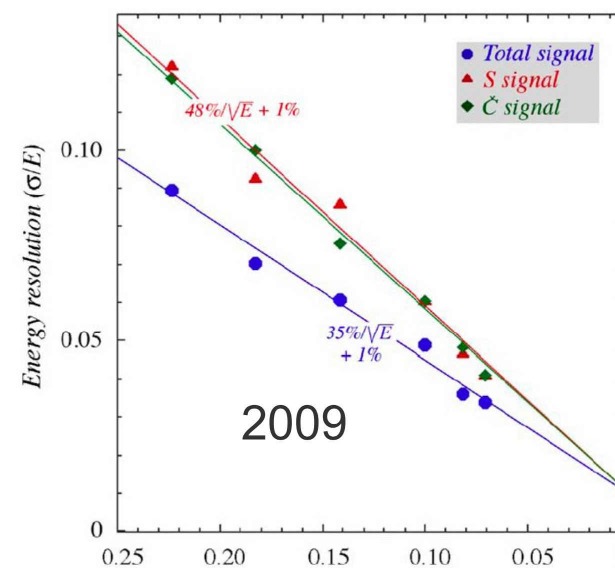
σ = 2.5%



100 GeV electrons

σ = 8.6%





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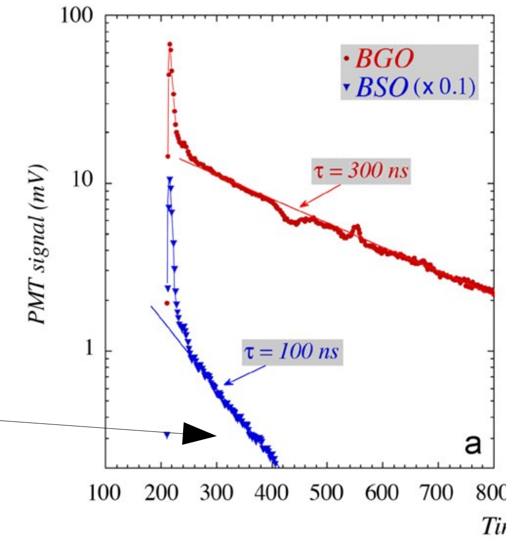
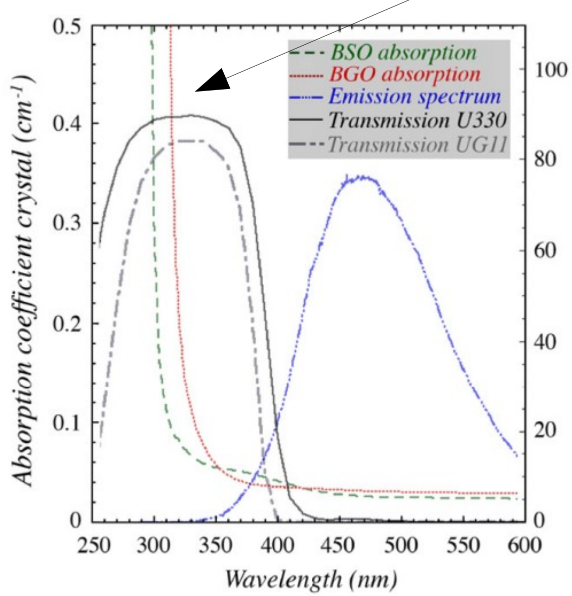
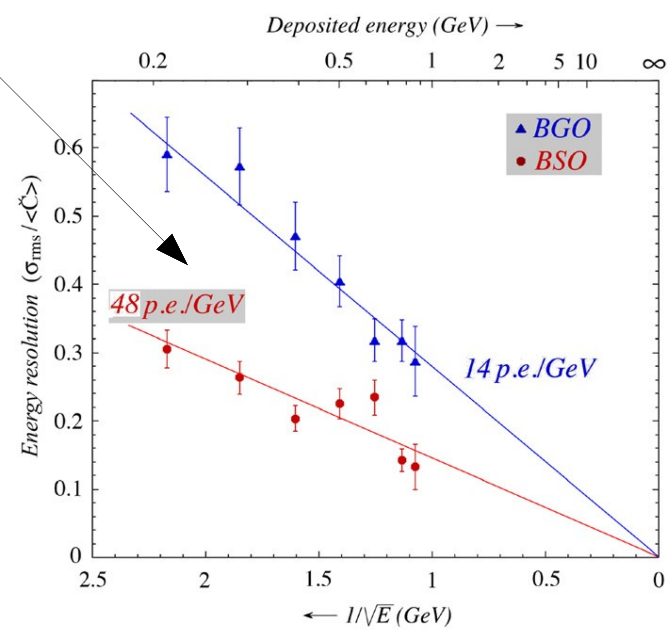
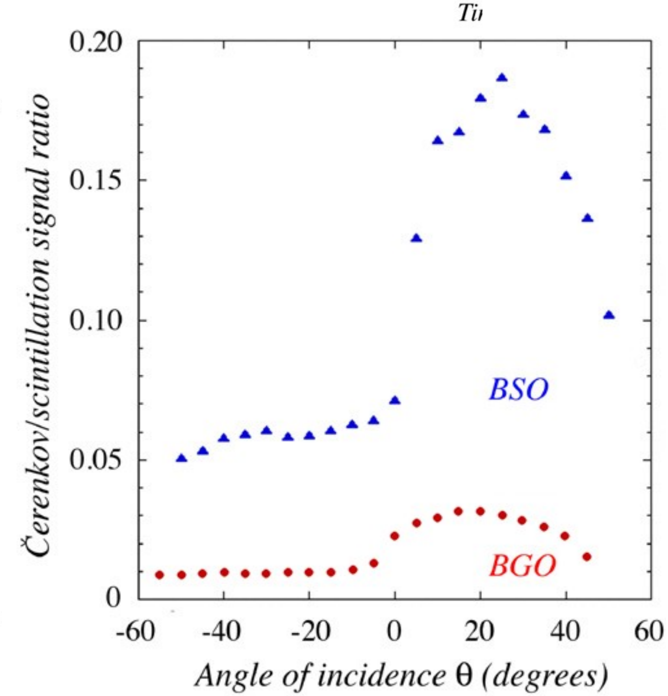
BGO/BSO comparison

- Comparison of Cherenkov absorption and light yeld
- Advantages of BSO
  - Faster scintillation
  - More Cherenkov light









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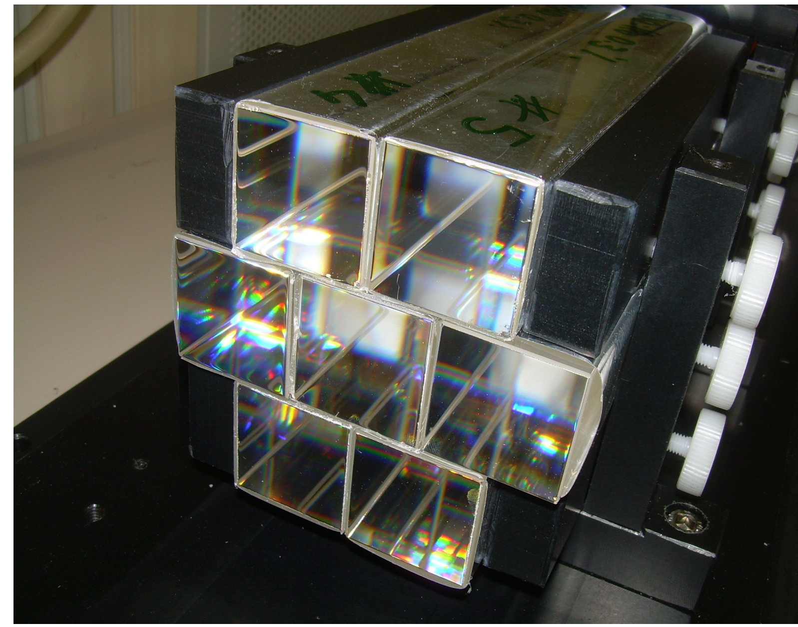
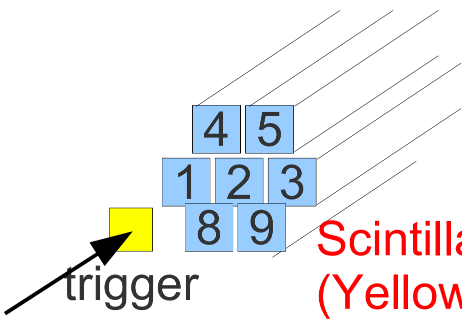
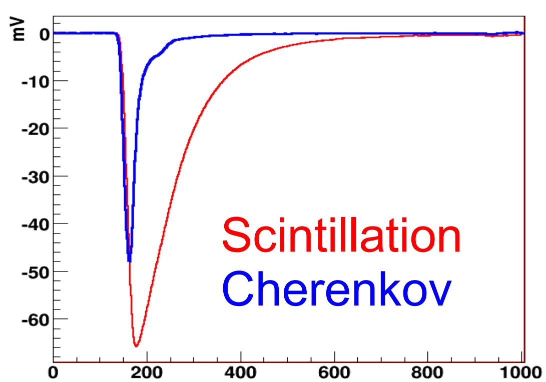
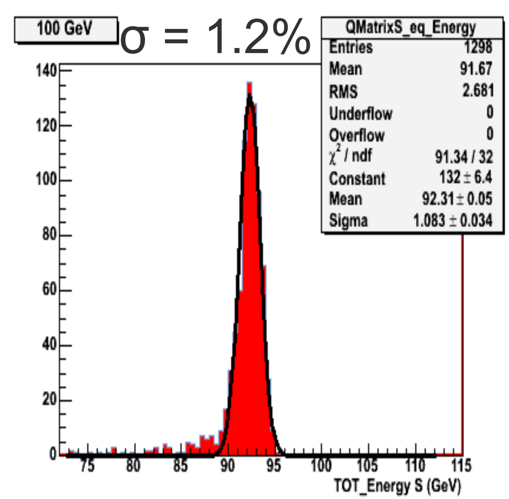
PWO matrix

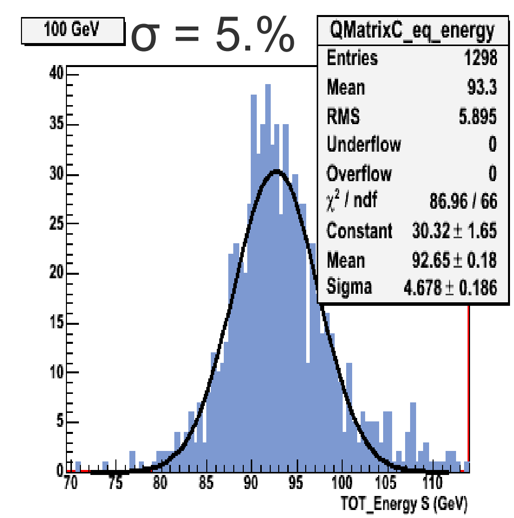
- Seven $PbWO_4$:0.3%Mo ($3x3x20\ cm^3$) previously characterized crystals
- Use both: wavelength and timing analysis









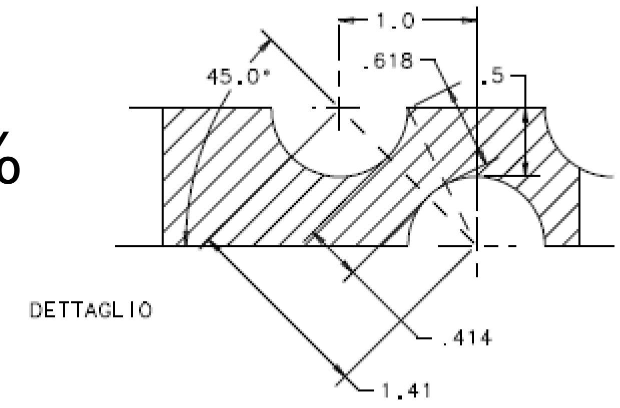


100 GeV electrons

The new Dual REAdout Module

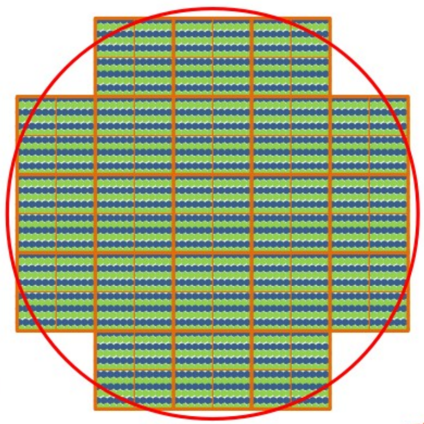
Improvements over DREAM

- Filling fraction f_{abs}=55% f_{fib}=40% → f_{samp}=5% (was: 2.6%)
- Better Cherenkov LY (larger fiber aperture, aluminization)



Two option:

- Lead (1^{st} prototype built)
- Copper (under construction)



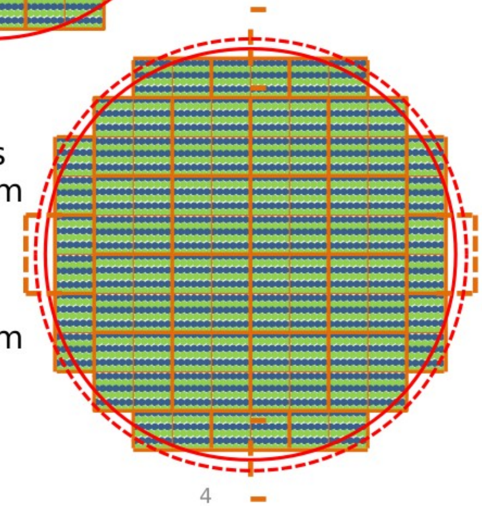
21 modules
R_eq = 23.8 cm

Final goals

- 99% had containment
- 24 modules, 216 channels

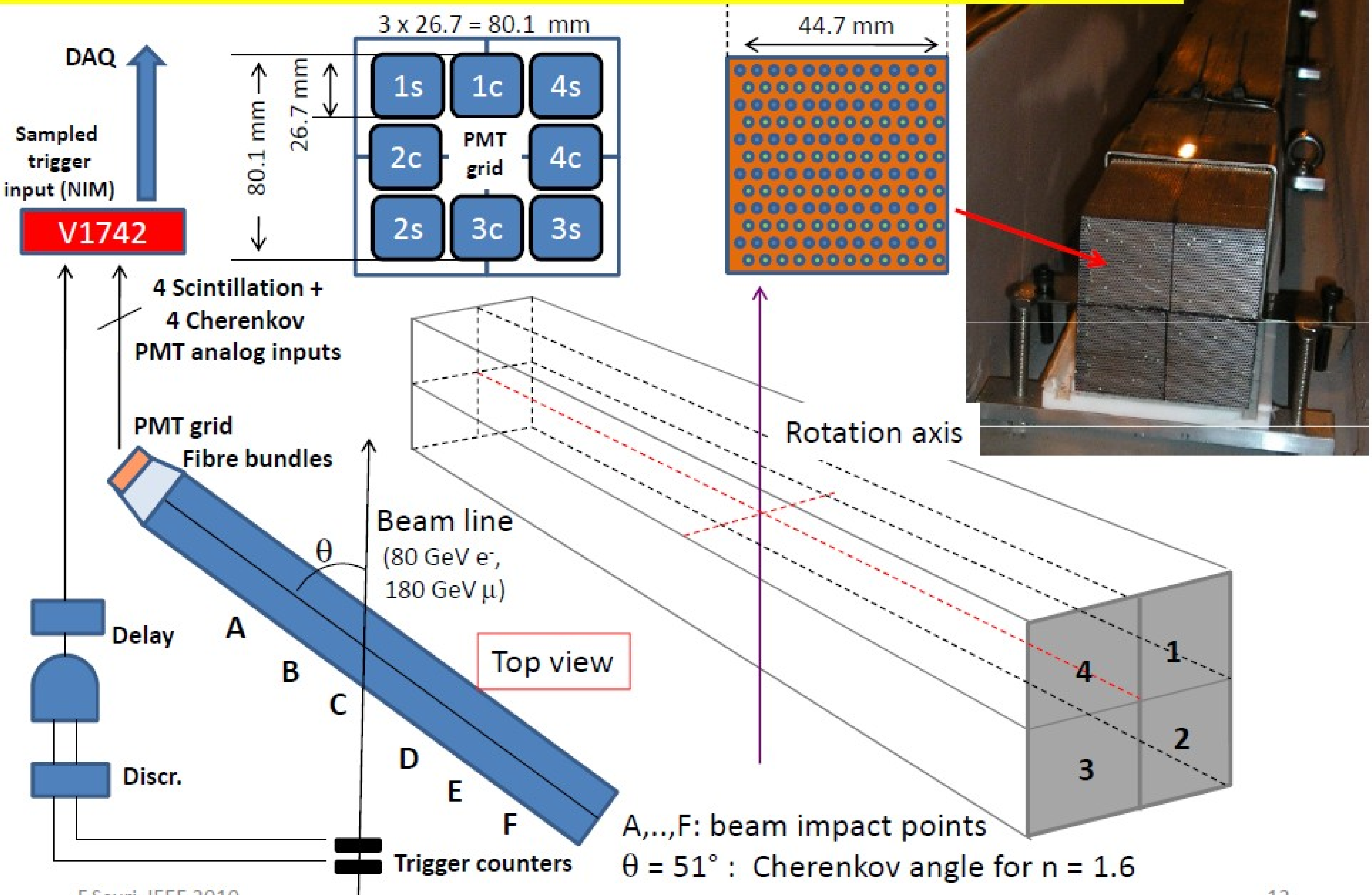
16 modules +
12 half-modules
R_eq = 24.35 cm

20 modules +
8 half-modules
R_eq = 25.43 cm
(dashed)

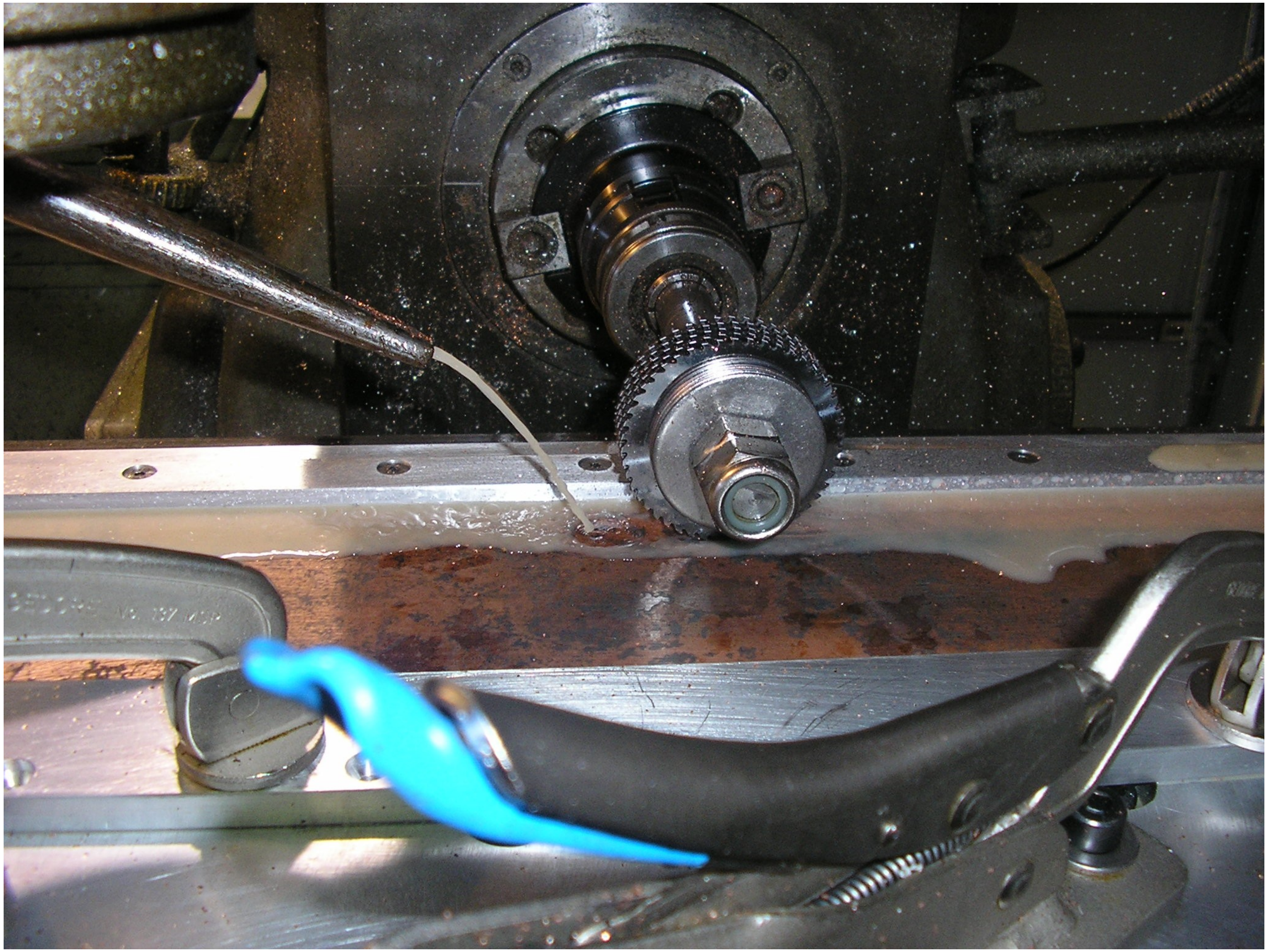


The newDREAM prototype module

Experimental set-up during CAEN DRS-IV V1742 tests with the module prototype of the New Dream fibre calorimeter at CERN test beam line H8 (October, 2010)



Copper profiling

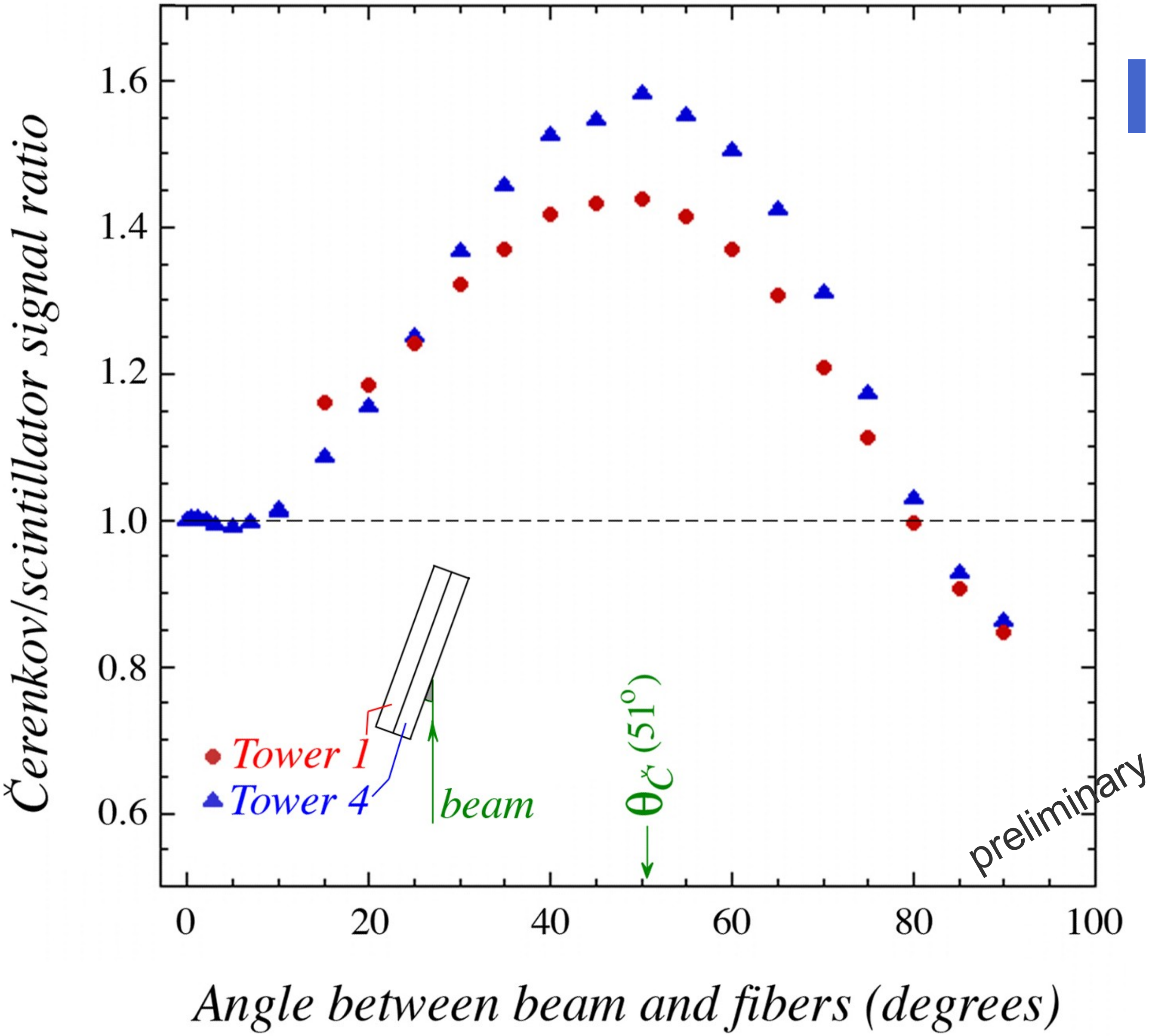


Conclusions

- Event-by-event measurement of the em and had components of the shower
- Toward a complete dual readout solution
  - Polarization technique
  - BSO characterization
  - BGO and PWO matrices
- 2011 is the year of the newDREAM fiber module

The End

First measurements with the lead/fiber module



- Decoherence of shower particle direction along the shower axis

Cherenkov light polarization