

Roma
16 Aprile 2012

JLAB I2 - Genova
Rapporto di attivita
Anno 2011-2012

M. Battaglieri
INFN - GE
Italy

Invited Talks

- ★ M. Battaglieri: Trento, Erice
- ★ R. De Vita: Trento, PINANI I

Responsabilita'

- ★ M. Battaglieri: Chair CSC, chair JLab-TFC
- ★ R. De Vita: Segr. CSC, Steering Committee, Chair CLAS12 Cal-Com

Studenti

- ★ A. Celentano (phD dal Ott-2010)
- ★ A. Casale: laureata Novembre 2011 FT
- ★ B. Caiffi: laureata Ottobre 2011 proposta per CLAS12

Attivita'

- ★ Sim: RICH, FT
- ★ Hardware: FT
- ★ Organizzazione ATHOS12

- ★ Analisi dati
- CLAS: EG6
- CLAS12: PWA, N-Λ FF

Genova-FT Milestones

2011

31-12-2011	presentazione al PAC del JLab di un proposal completo per la spettroscopia adronica con CLAS12
31-12-2011	completamento del conceptual design del calorimetro (forward tagger)
31-12-2011	realizzazione di un prototipo del forward tagger

100% Presentato al PAC37 Gennaio 2011, Approvato con rate A-, tutto il tempo fascio richiesto

100% Simulazioni completate, CDR completato

100% Prototipo realizzato e testato al JLab
Sara testato nuovamente a Maggio alla BTF

2012

31/12/12	Avvio procedure acquisto e test dei cristalli per forward tagger
31/12/12/	Sviluppo software per analisi dati con le GPU
31/12/12	Completamento disegno meccanico e termico del FT-Cal

80% Bandita la gara per l'acquisto di 370 cristalli (150k euro)

60% Implementato a Genova il codice per PWA su GPU

60% Disegno preliminare presentato agli ingegneri di JLab a Marzo, progetto completo entro l'autunno

FTE 2012-13 JLab I2-Genova

2012

M. Battaglieri	80%
A. Celentano	100%
R. De Vita	80%
M. Osipenko	80%
M. Ripani	80%
G. Ricco	0%
M. Taiuti	100%
A. Bersani	40%
P. Musico	20%
	5.8 FTE

*Term members

- Gabriel Charles (Saclay) 3 weeks in March
- Mark Andreson (Glasgow) 6 months from May
- DOE/INFN Summer student 2 months from June
- Assegno di ricerca: 1+1 year from September (?)

*Active collaborations

- Sebastien Procurer (Saclay)
- Emmanuel Rouly (Orsay)
- Derek Glazier (Edinburgh)
- Adam Szczepaniak (IU)
- Sal Lombardo (IU)
- Hrayr Matevosyan (Adelaide)

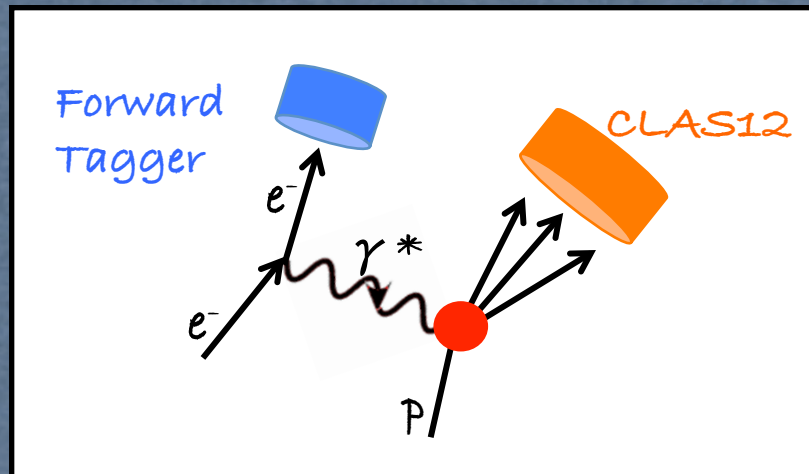
*Local collaborators

- Progettazione Meccanica
R. Cereseto, F. Parodi
R. Puppo
- Progettazione Elettronica
G. Mini', F. Pratolongo

The FT project: status report

Apr 2012

The Forward Tagger for CLAS12



New system to detect electrons at small angle and perform **quasi-real photo-production** experiments

Calorimeter (FT-Cal)

electron energy/momentum

Photon energy ($\nu = E - E'$)

Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$

PbWO₄ crystals with APD/SiPM

readout

INFN-GE

Scintillation Hodo (FT-Hodo)

veto for photons

Scintillator tiles with WLS readout

Edinburgh

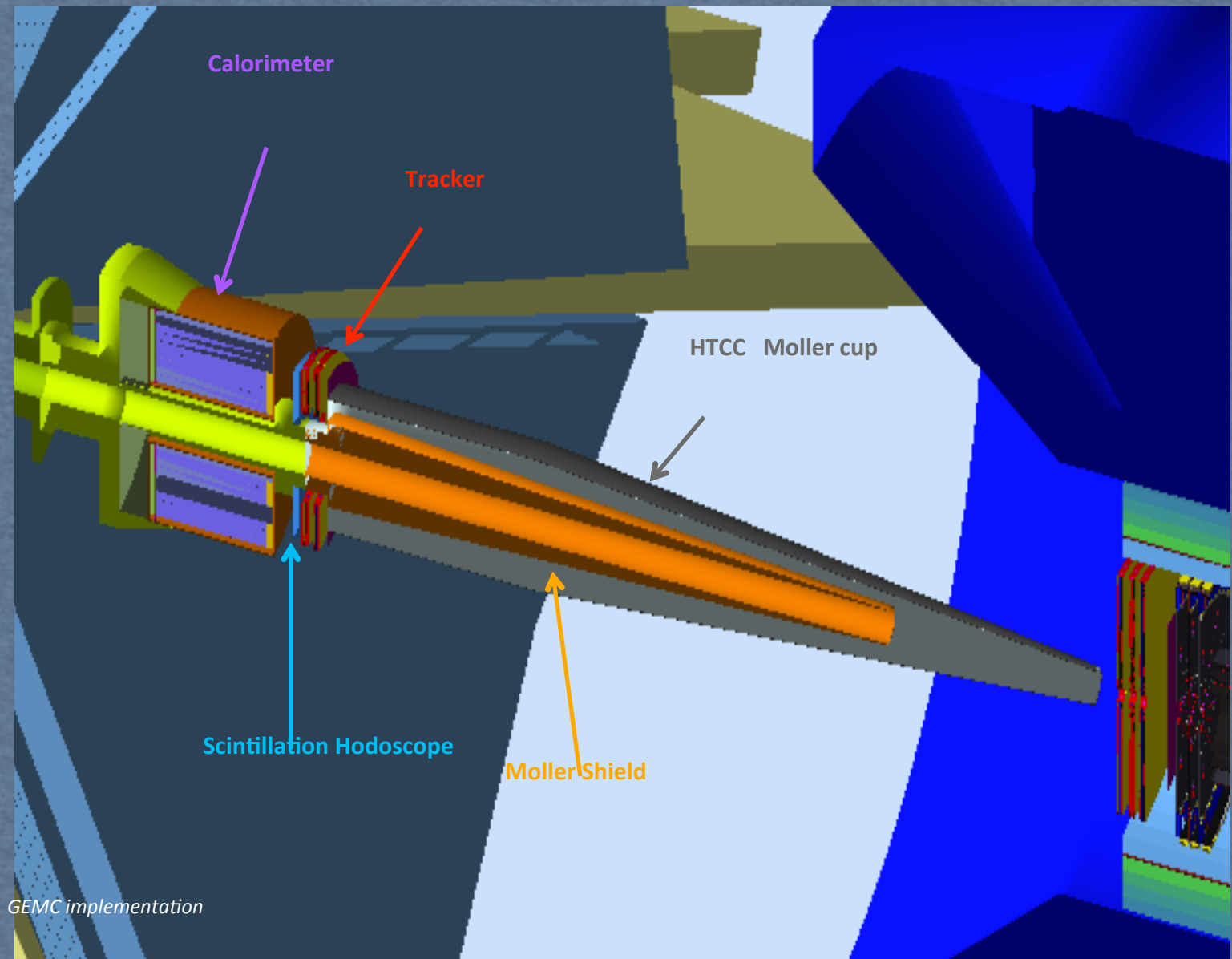
Tracker (FT-Trck)

electron angles

Polarization scattering plane

MicroMegas detectors

Saclay + Ohio



GEMC implementation

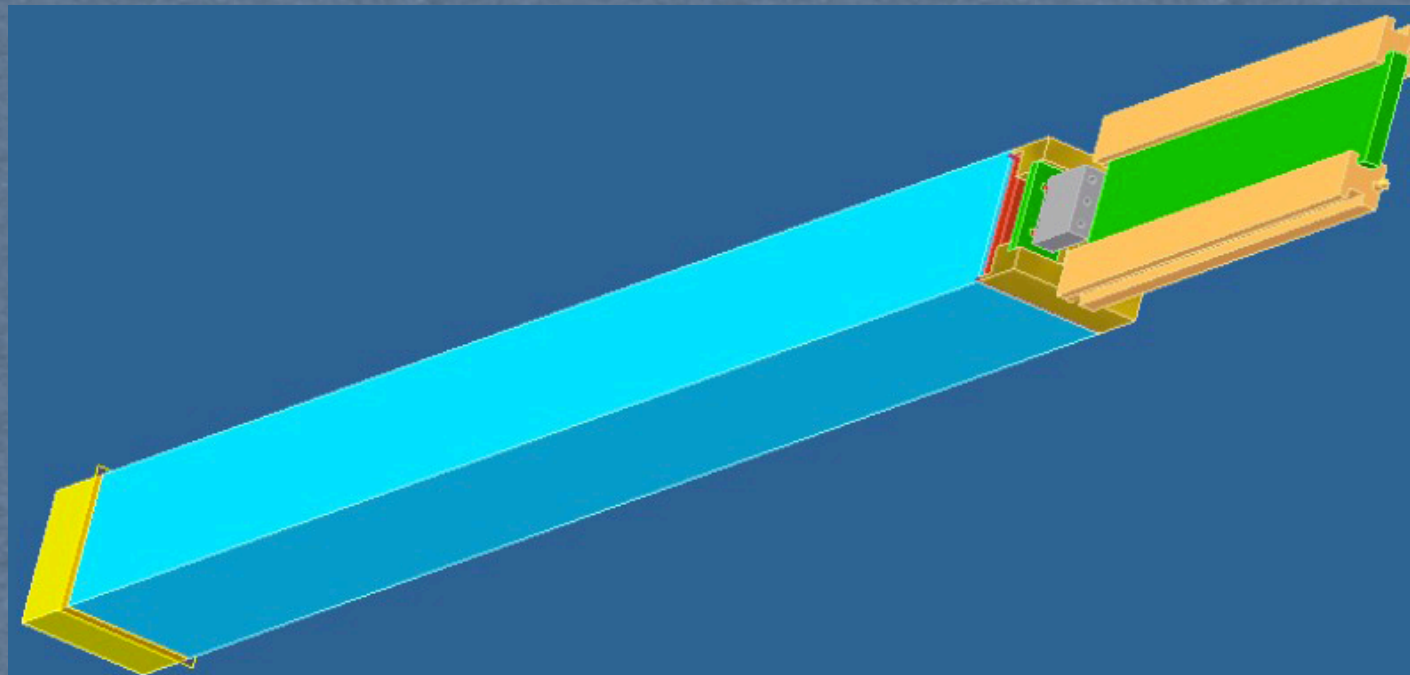
FT-Cal (INFN-GE)

Crystals

**Front-end
electronics**

**Read-out
electronics**

**Test
activity**



**LED
monitoring
system**

**Tools and
facilities**

**Integration
in CLAS12**

**Mechanical
assembly**

Crystals

* **PbWO₄ Type-II**

* **330 + 40, 15x15x200 mm³**

* **INFN started a 150k €**

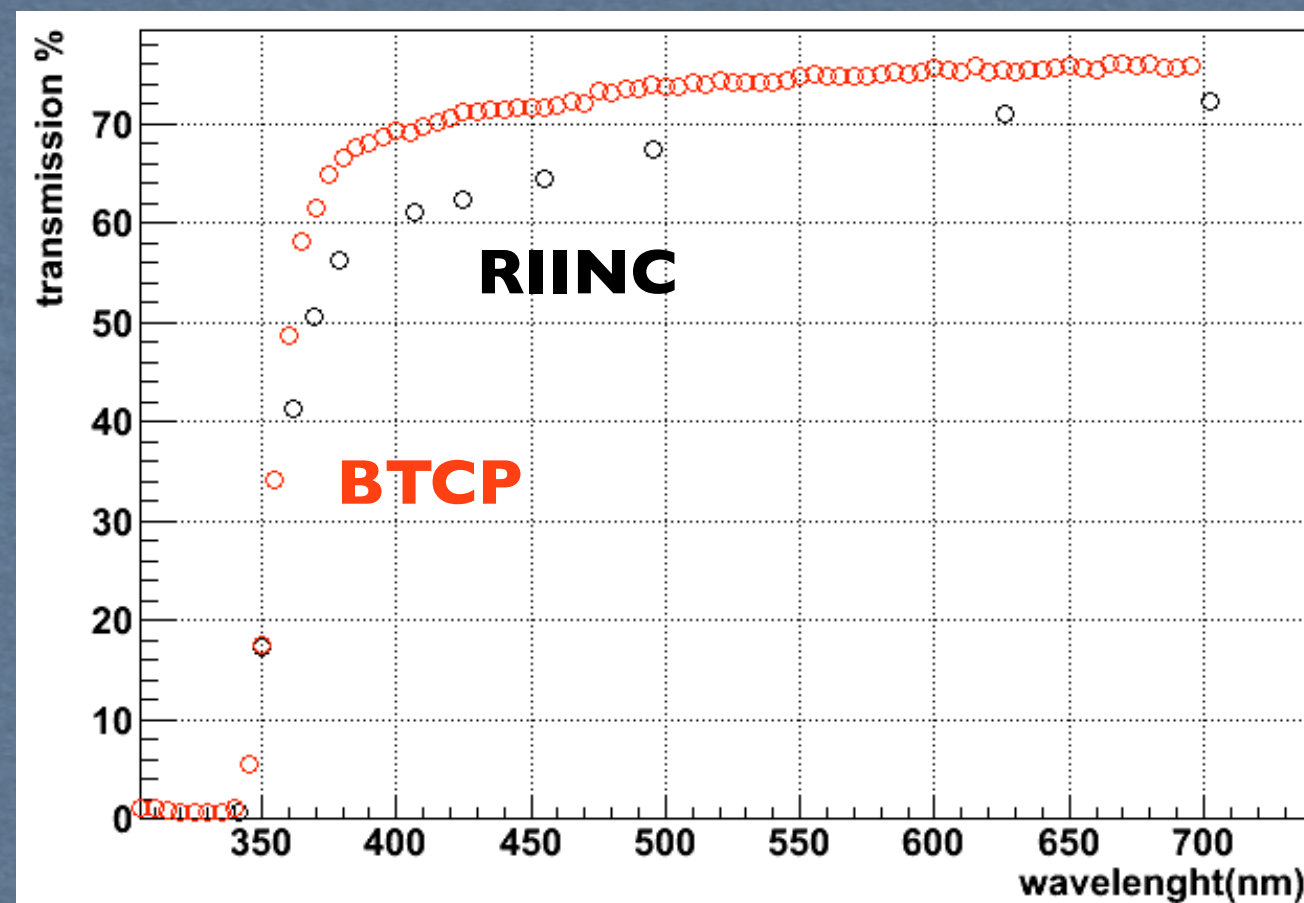
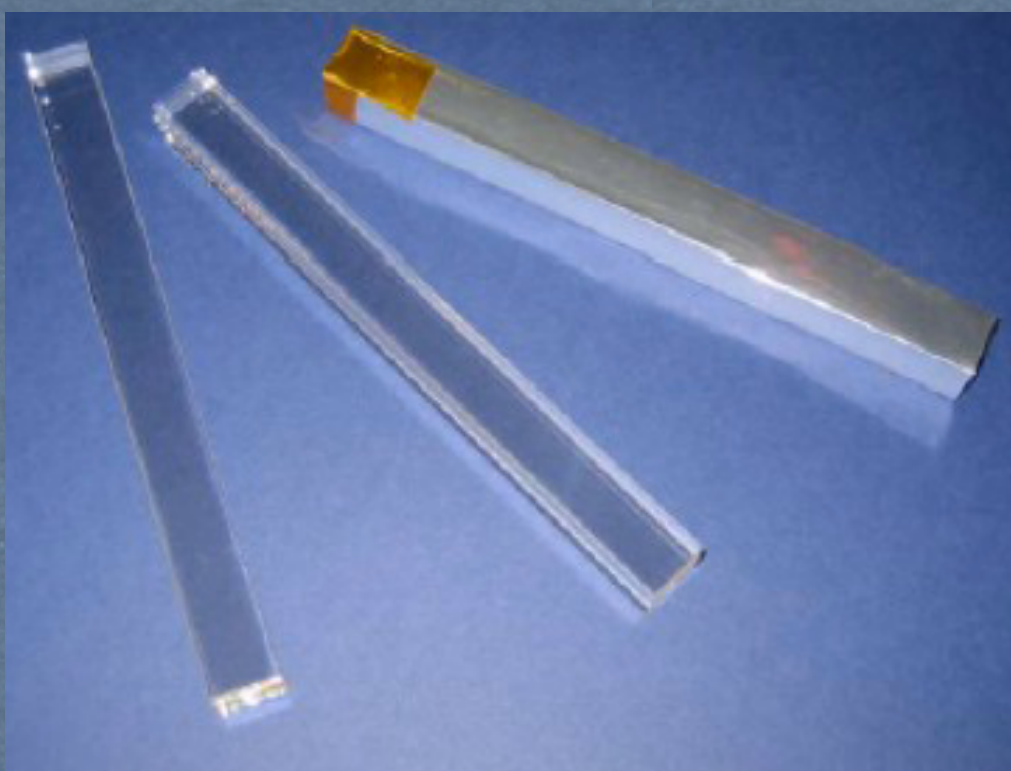
public tender

* **Crystal expected in 2012 Q3**

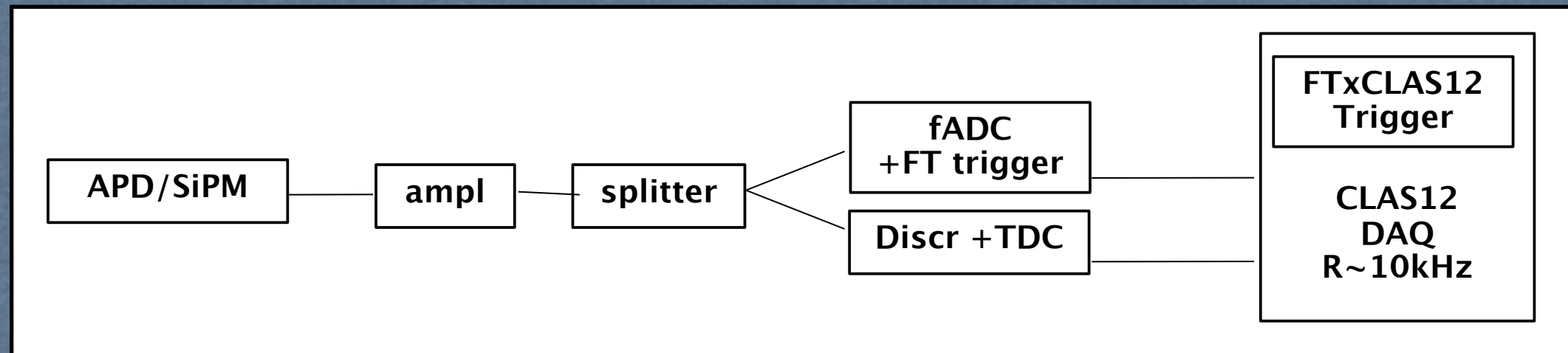
* **CERN delivery for testing**

* **Options:**

BTCP, RIINC, SICCAS



Front-end electronics



Energy (spectroscopy)

- * Low noise and excellent linearity
- * Wide dynamic range (10MeV-250 phe - 5fC → 5GeV 125k phe - 2.5pC)@+15°C
- * 12 bit 250 MHz digitizer

Timing ($\Delta T < 200\text{ps}$)

- * Narrow coincidence window between FT/CLAS12
- * High rate (<MHz) → pile-up
- * Rise time < 10 ns & Fall time < 80 ns

FT Trigger

- * FE $R_{\text{max}} < 500$ kHz/ch ($E_{\text{ch}} > 10\text{MeV}$) dominated by em bg (low energy γ/e)
- * EM clusters (whole FT-Cal): $R < 200$ kHz ($E_{\text{cluster}} 0.5 - 4.5$ GeV)
- * FT-Trig x CLAS12-Trig x 50 ns window → 3.6(good) + 2(RND) KHz to CLAS12 DAQ

Front-end electronics

E.Rauly, A.Celentano

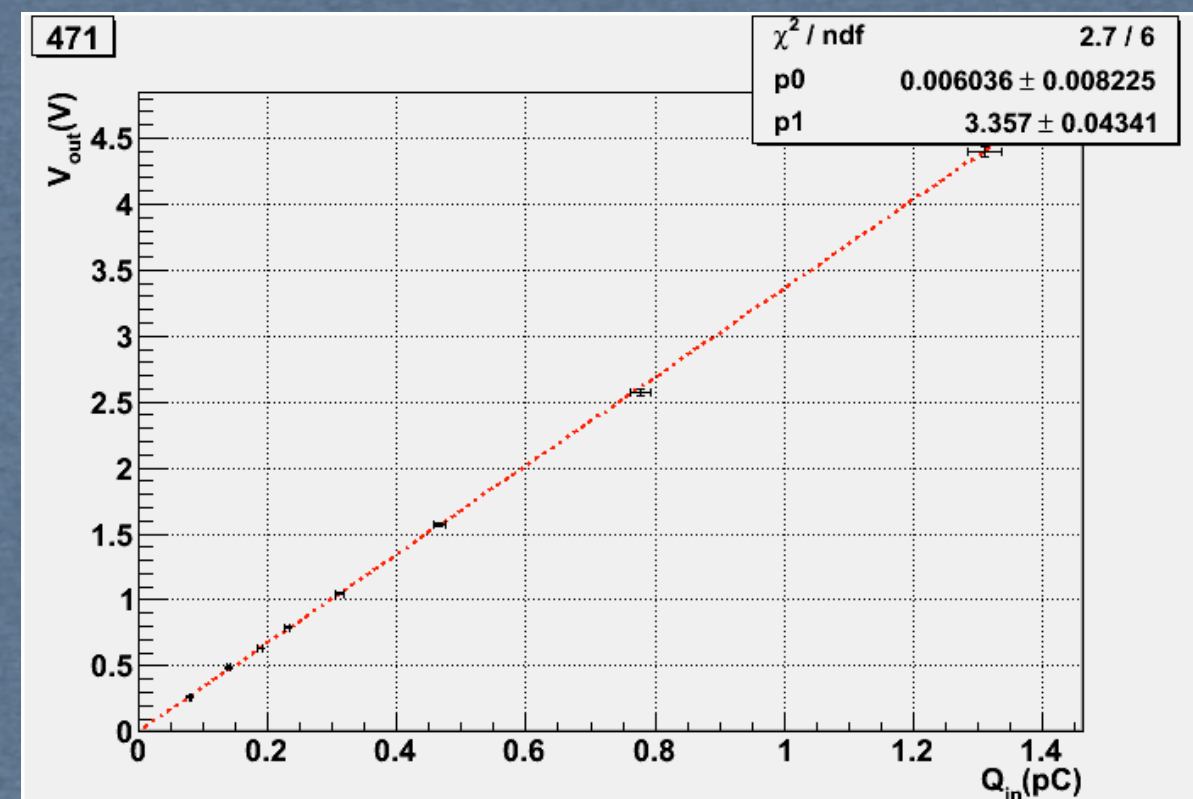
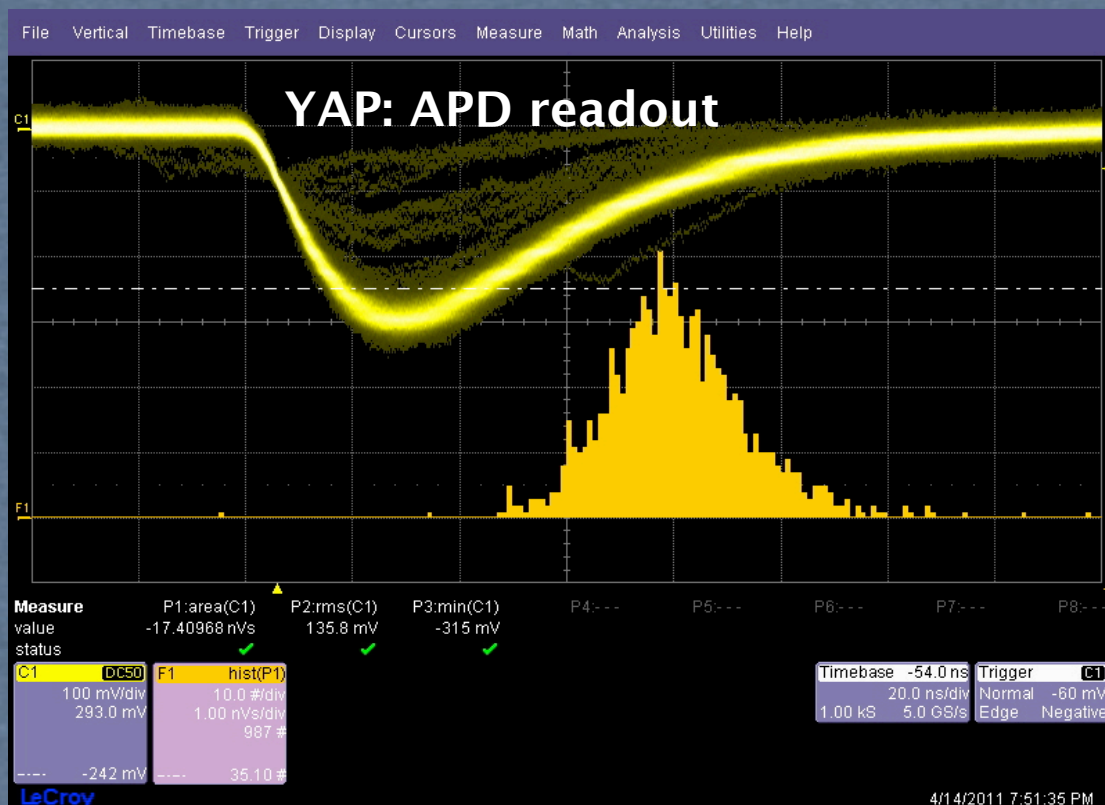
Agreement with Orsay Electronics group to modify IC-Orsay → FT-Orsay and produce the 330+40 channels for FT-Cal

IC-Orsay specs

- * 2V output dynamics
- * Gain= 6.6V/pC
- * coupled to C=80pF 5x5 mm² APD
- * Noise = 2.5mV RMS

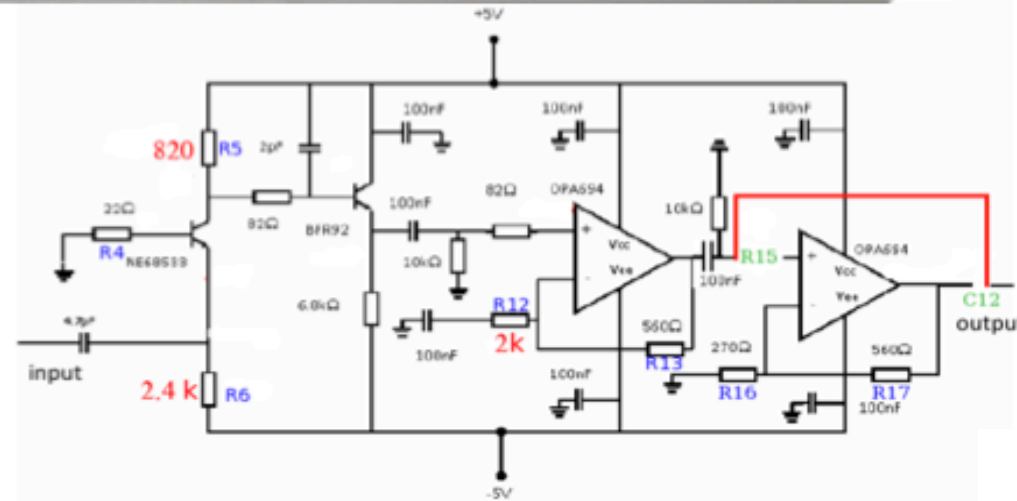
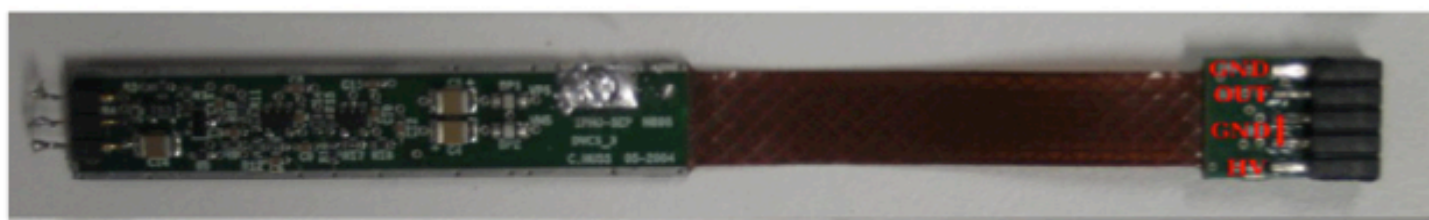
FT-Orsay specs

- * 5V output dynamics: 60% → TDC, 40% → fADC
- * Reduced gain: 2.0V/pC (10 MeV ↔ 4.9fC-50ns ft-10mV)
- * Coupling to LAAPD capacitance (C=280pF)
- * Reduced noise by a factor of 2 (RMS=5mV)
- * Timing of (crystal+APD+amplifier): width ~ 150 ns leading edge ~ 20 ns.



Front-end electronics

FTh-Orsay preamp for FT-Hodo SiPM readout



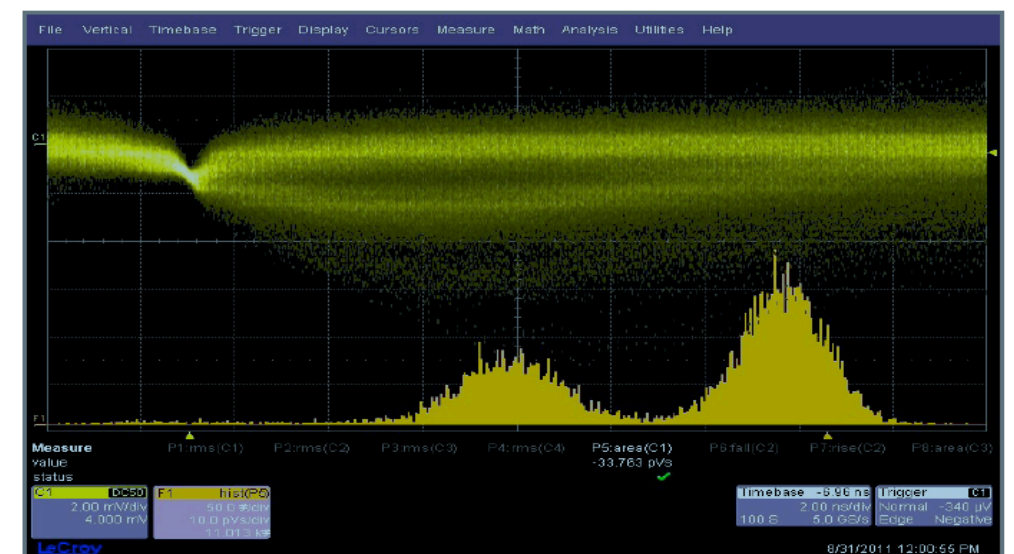
FTh-Orsay

- * Mips: ~100 gammas at SiPM
- * T resolution: ~500ps
- * Bypassed last stage
- * Reduced 1st stage
- * Reduced 2nd stage to 1.3
- * Gain = $820 \times 1.3 / 50 = 21.3$

- Active are: 3x3 mm²
- Number of pixels: 14400
- Intrinsic Capacitance 320 pF
- Nominal gain: 275000

INFN-GE Electronic Workshop (under Orsay supervision)
will produce 16 boards x 16ch each for the FT-Hodo readout

INFN-GE Electronic Workshop (under Orsay supervision)
will work on FT-Cal motherboard design



Read-out electronics



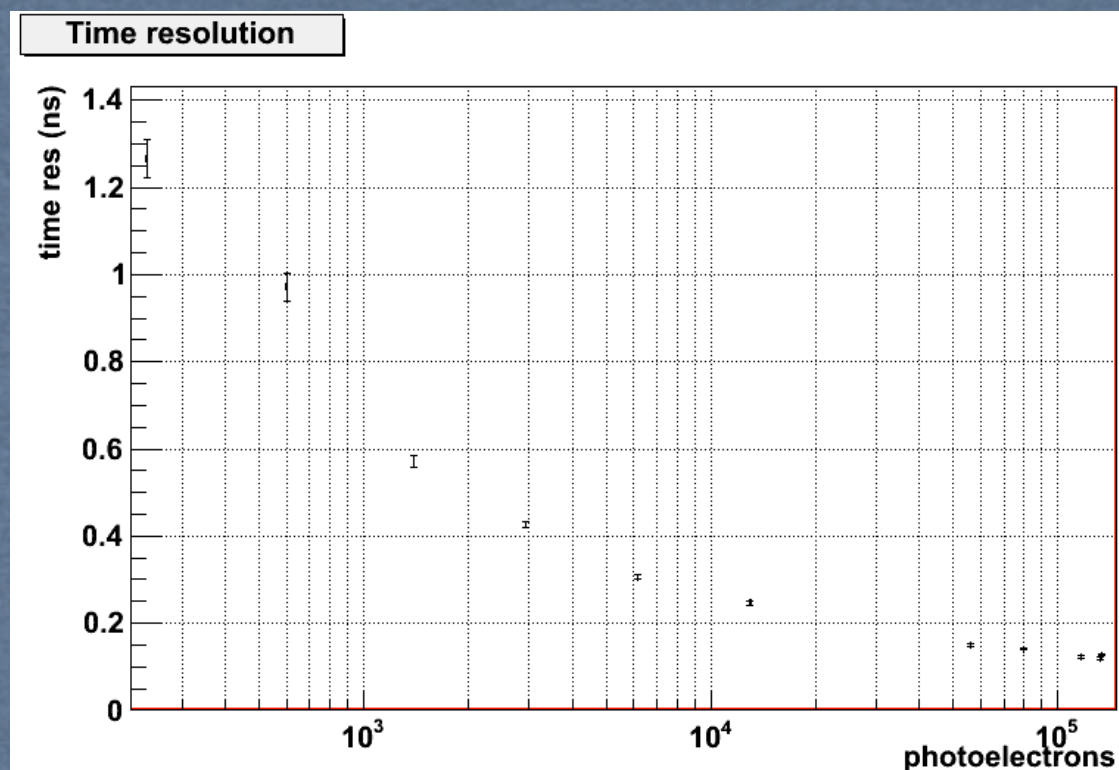
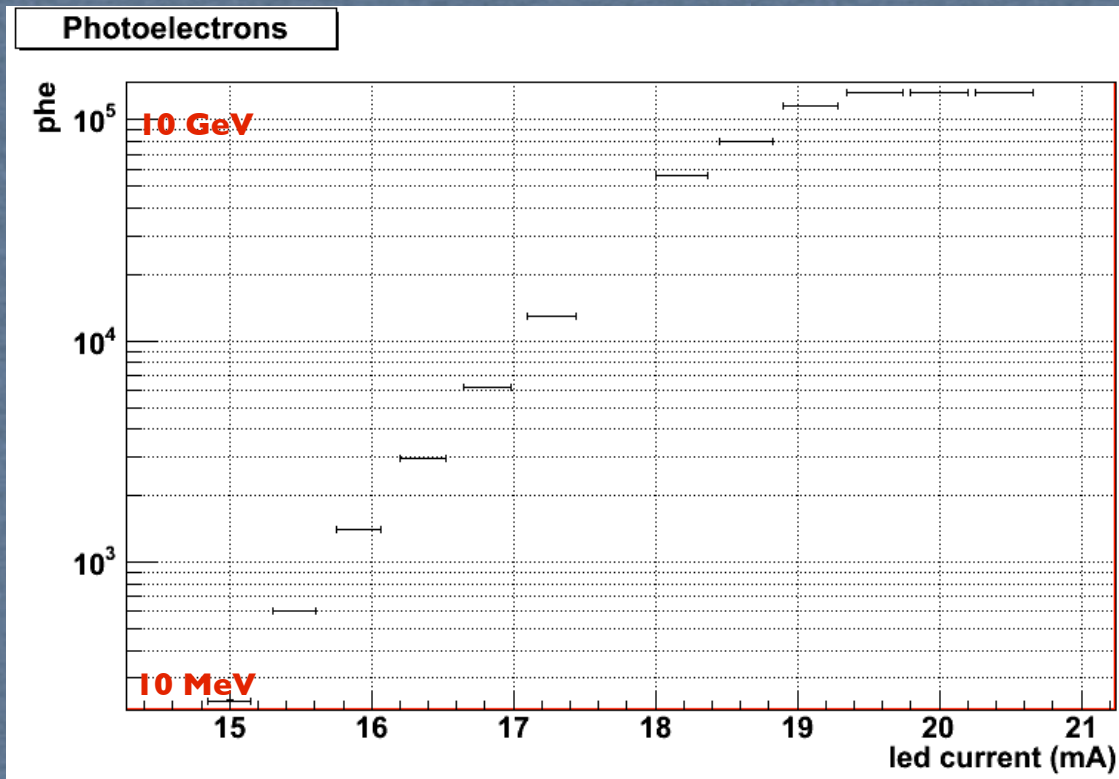
JLab fADC

- * 250 Msamples/s
- * 12 bit resolution
- * 2 Volts maximum input signal
- * 16 channels
- * VXS extension
- * Trigger capabilities

**FT-Cal DAQ implemented in
CODA12**

Reuse of LAC cables/splitters

LED monitoring system



Why?

- * Channel matching
- * Check crystal/sensor optical coupling
- * Crystal transparency
- * Gain and stability
- * Front-end electronic linearity

Requirements

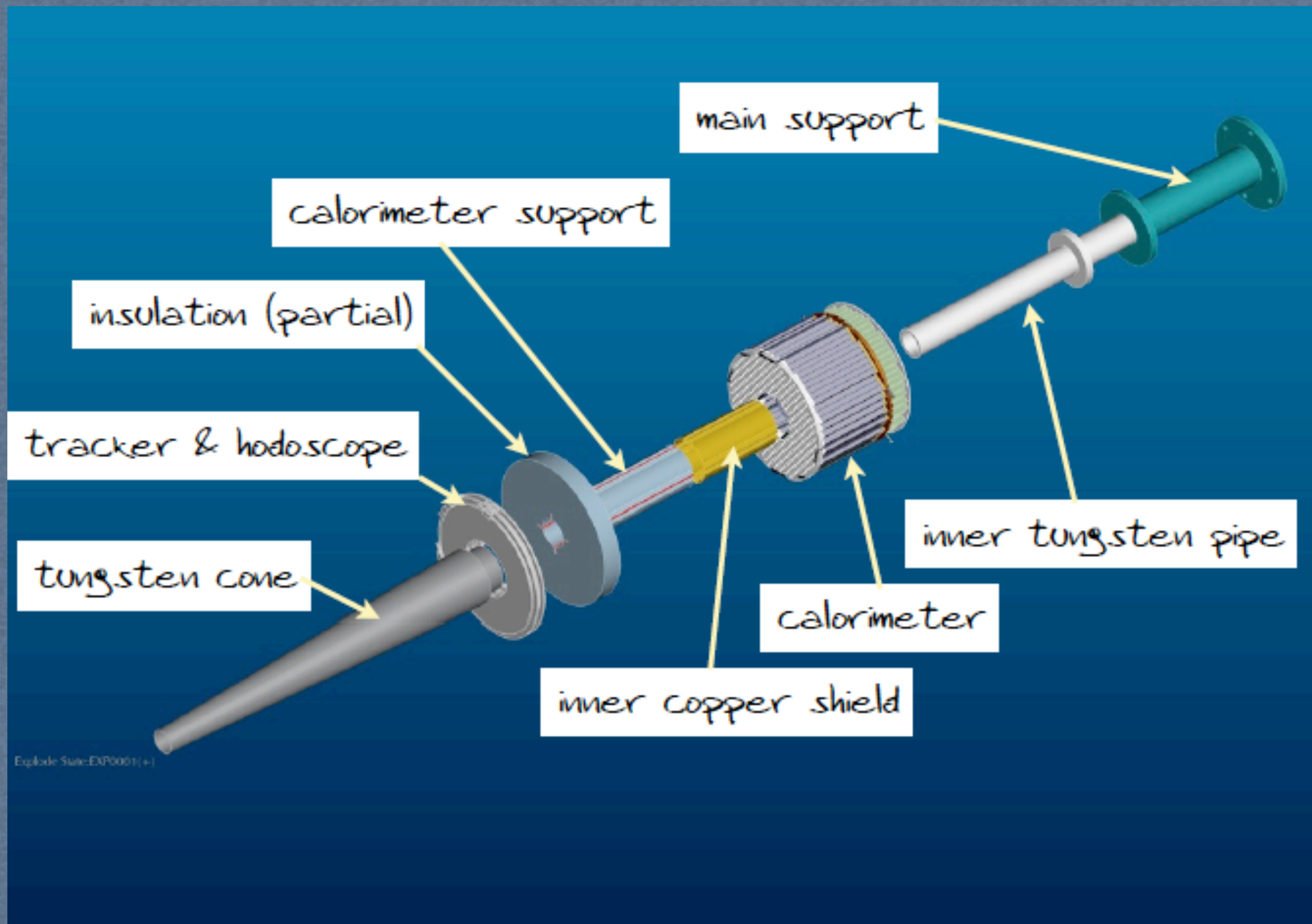
- * Large dynamic range (10 MeV to 5 GeV)
- * Low time jitter (~ 100 ps)
- * Stability in time

Proposed solution

- * Custom circuit from INFN-GE EW
- * Individual blue LED (470nm)
- * All specs fulfilled

Mechanical Assembly

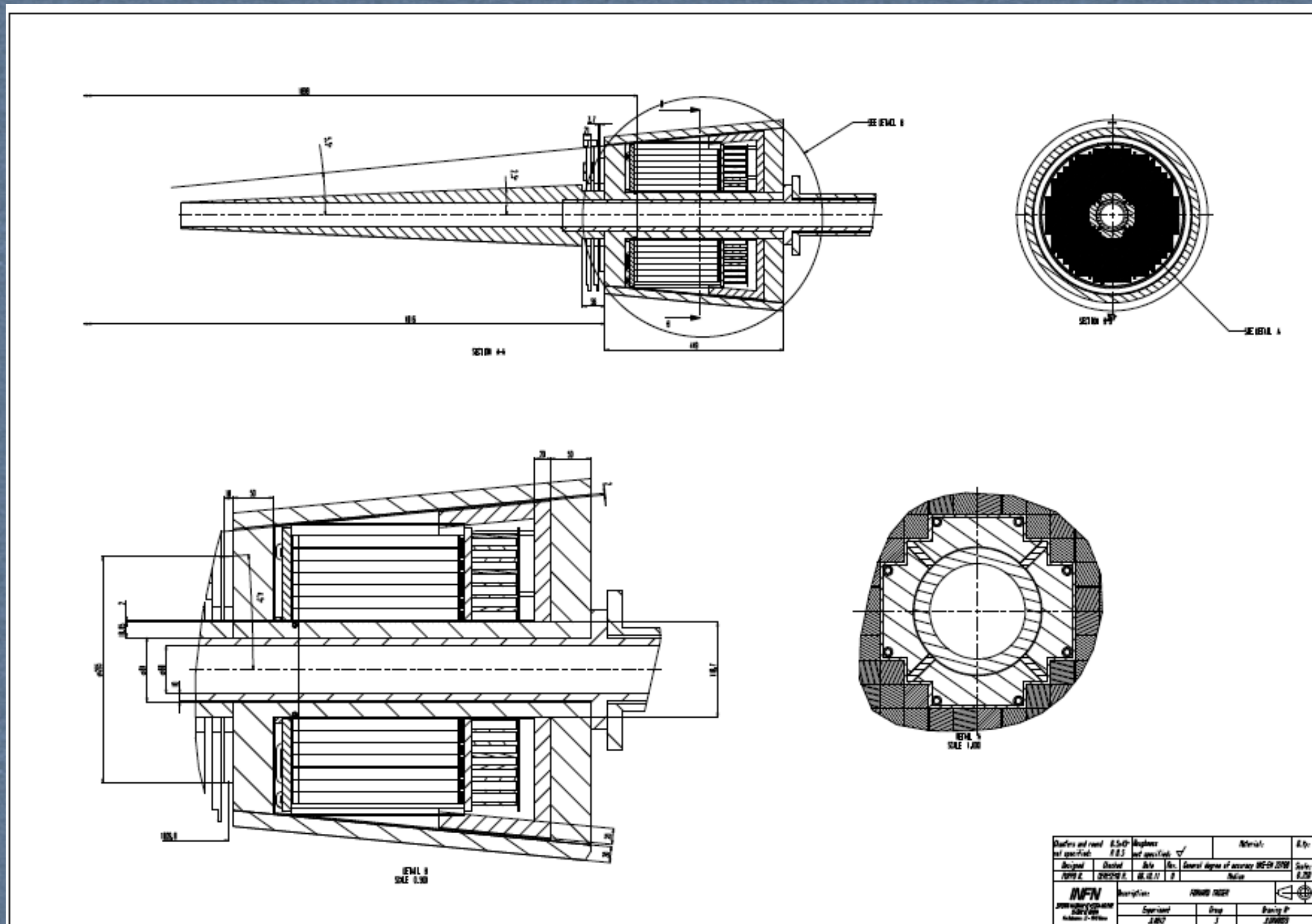
A.Bersani, R. Cereseto



Mechanical Assembly

R.Puppo, R. Cereseto

Towards final design



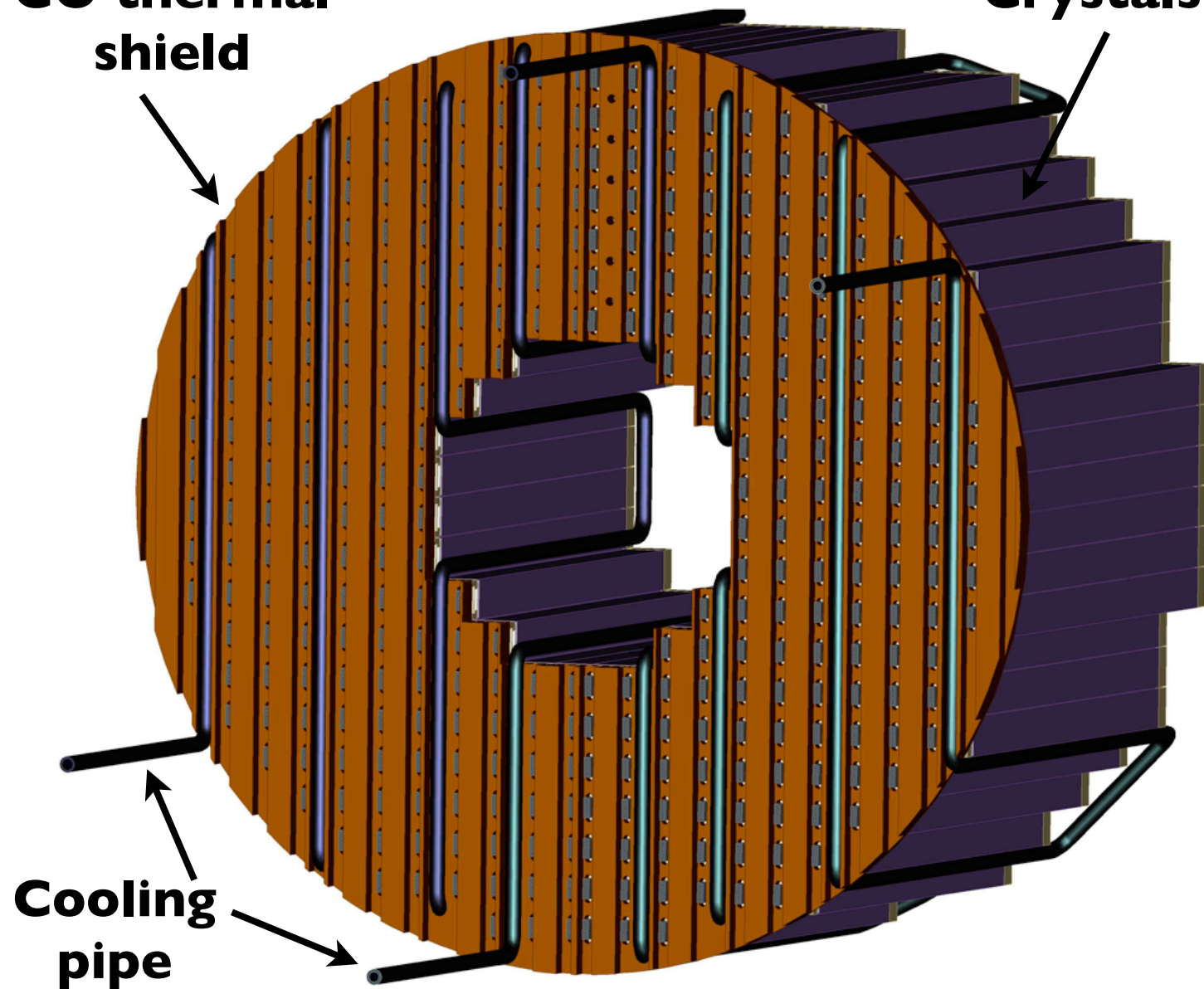
Mechanical Assembly

Cooling

A.Bersani, R. Puppo

CU thermal shield

Crystals



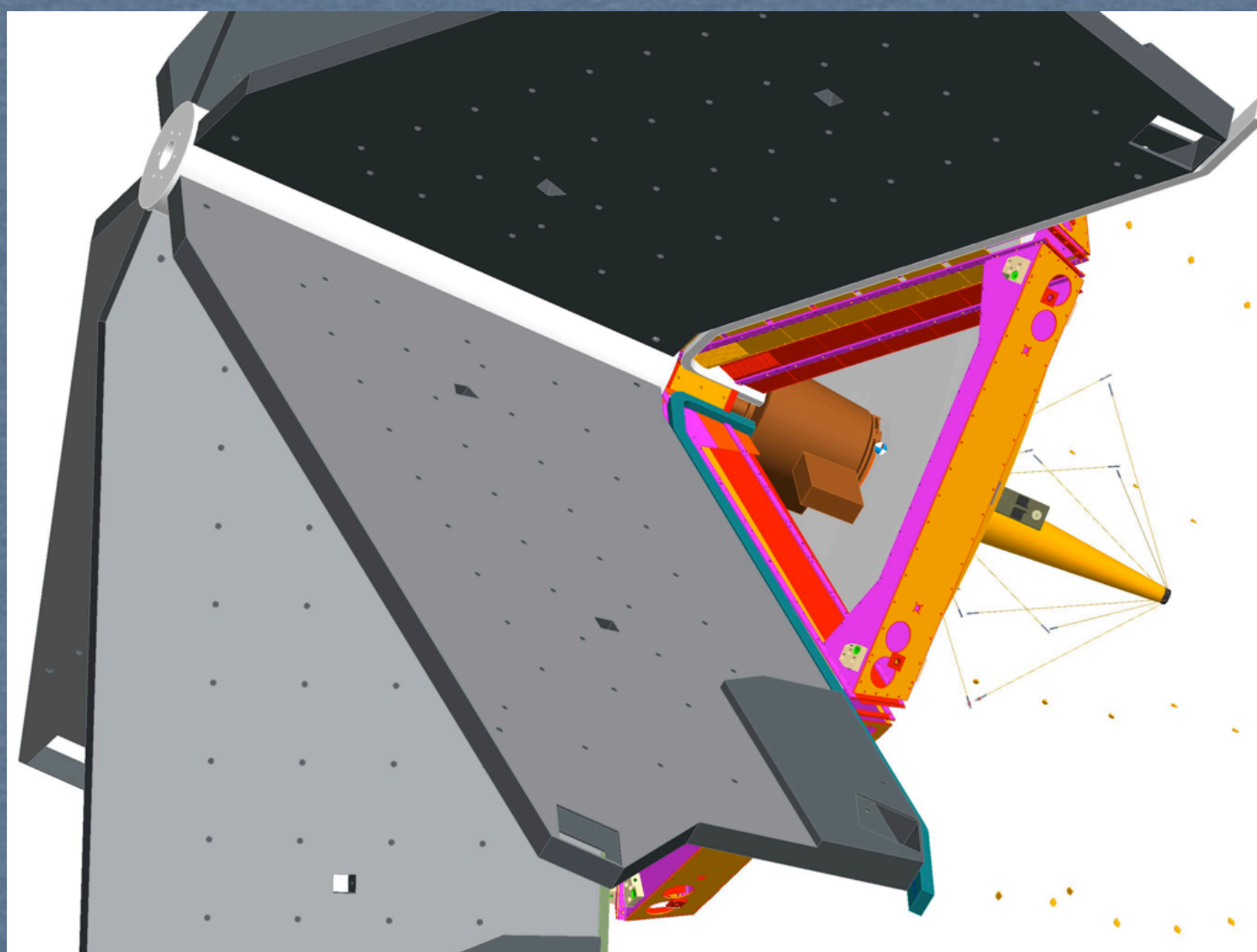
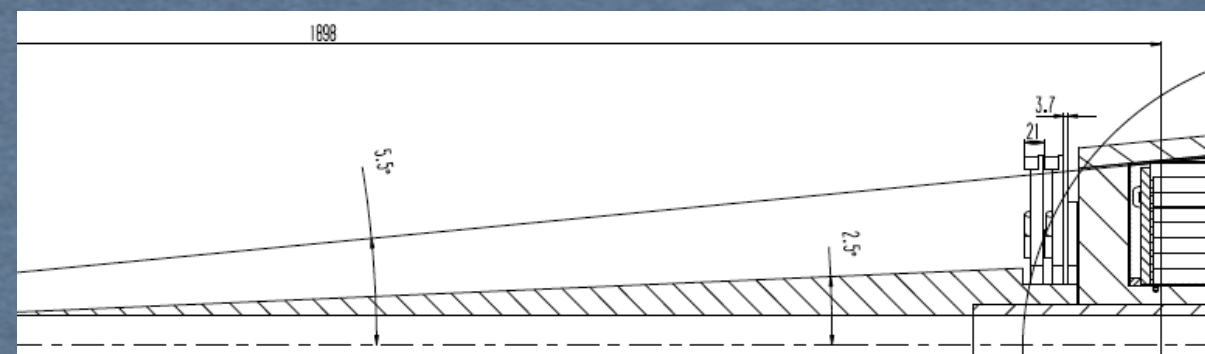
Cooling pipe

- * Design for $T=-25\text{C}$ operation
- * Thermal stability: 0.1C
- * Thermal disuniformity: $<-0.5\text{C}$
- * Heat load: 150W (mainly FE-el)
- * Crystals are attached to two flanges (DSF and USF)
- * Cooling: in, around and DSF
- * No cooling on USF
- * Heaters are necessary to keep the pipe above the dew point
- * Detailed simulations are needed to finalize the mechanical design

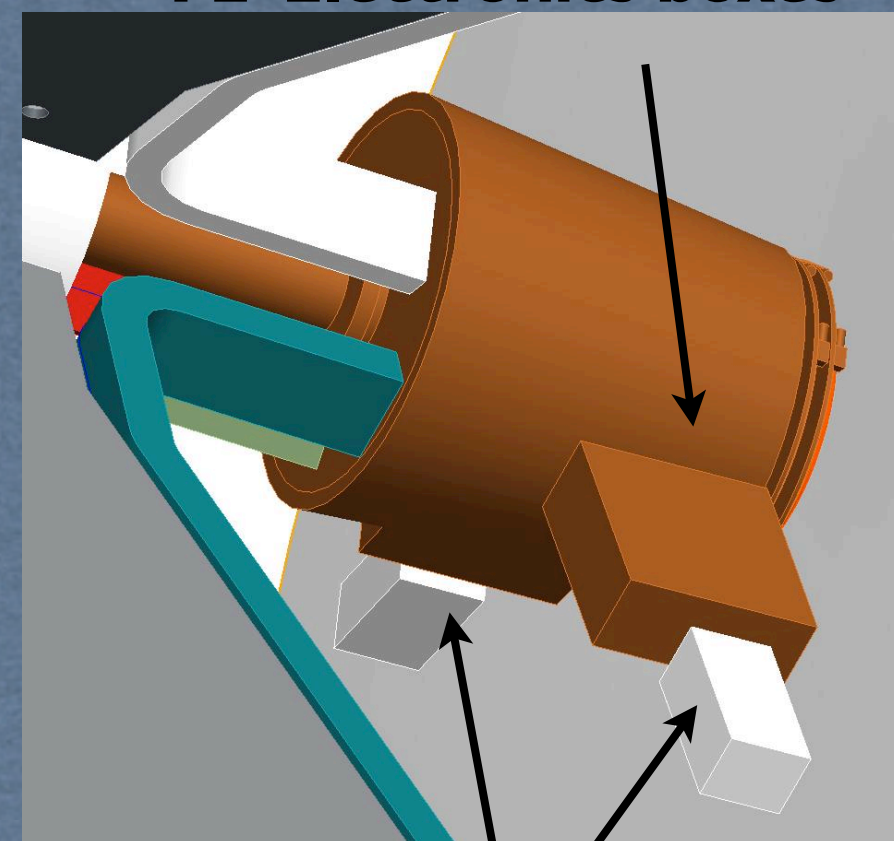
FT integration in CLAS12

Services and clearance

- * Limited clearance (DC & HTCC)
- * FT max angle = 5.5 deg



FT-Trck
FE-Electronics boxes



FT-Hodo
FE-Electronics boxes

Tests

* Test on single components

- Crystal properties (geometry, optics, LY, kinetics, radiation hardness) @ ACCOS
- Facility to measure the APD gain @ Genova
- Thermal tests on some critical components @ Genova

* FT-Cal Prototype 9ch @ JLab

- Tagger area
- $E=1.3$ GeV and $E=1.9$ GeV
- $T=3C, 18C$

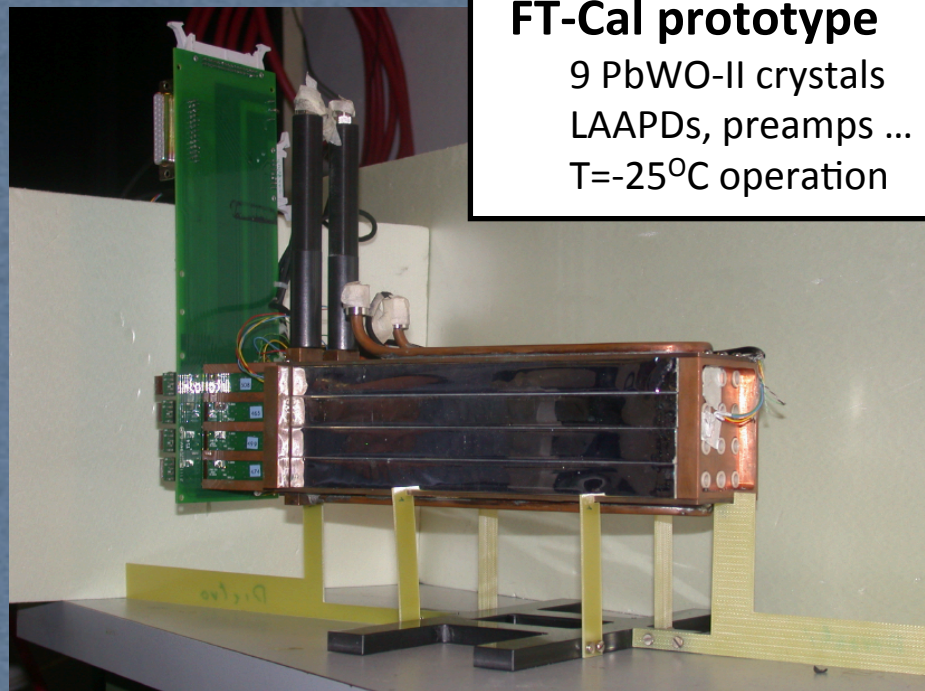
* FT-Cal Prototype 16ch @ BTF (LNF)

- Dedicated run
- $E=0.5$ GeV, $E=1.0$ GeV, $E=1.5$ GeV, $E=2.0$ GeV,
- $T= -25C, -5C, +5C, +18C$

FT-Cal Proto-9

FT-Cal prototype

9 PbWO-II crystals
LAAPDs, preamps ...
T=-25°C operation



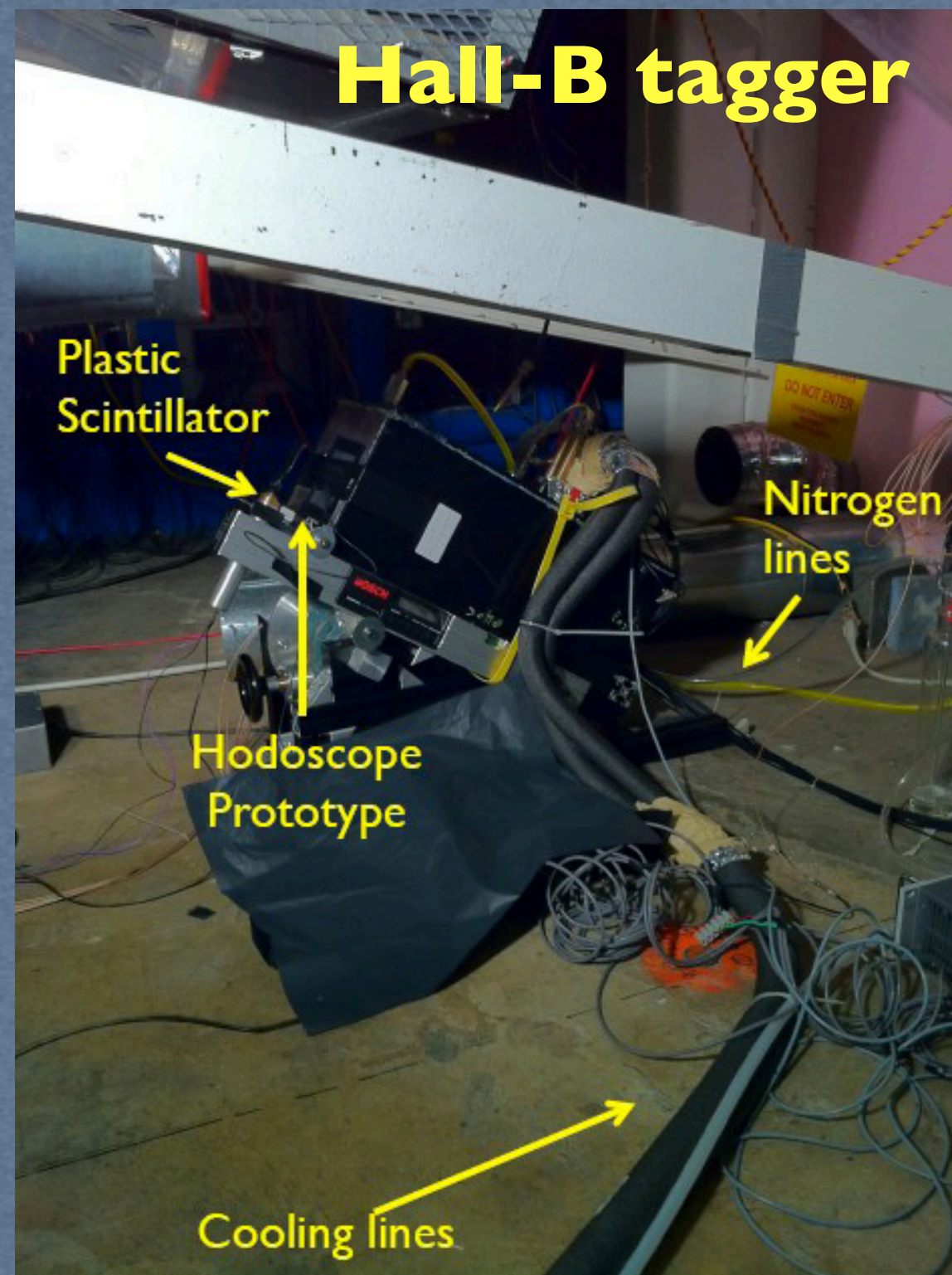
Hall-B tagger

Plastic
Scintillator

Nitrogen
lines

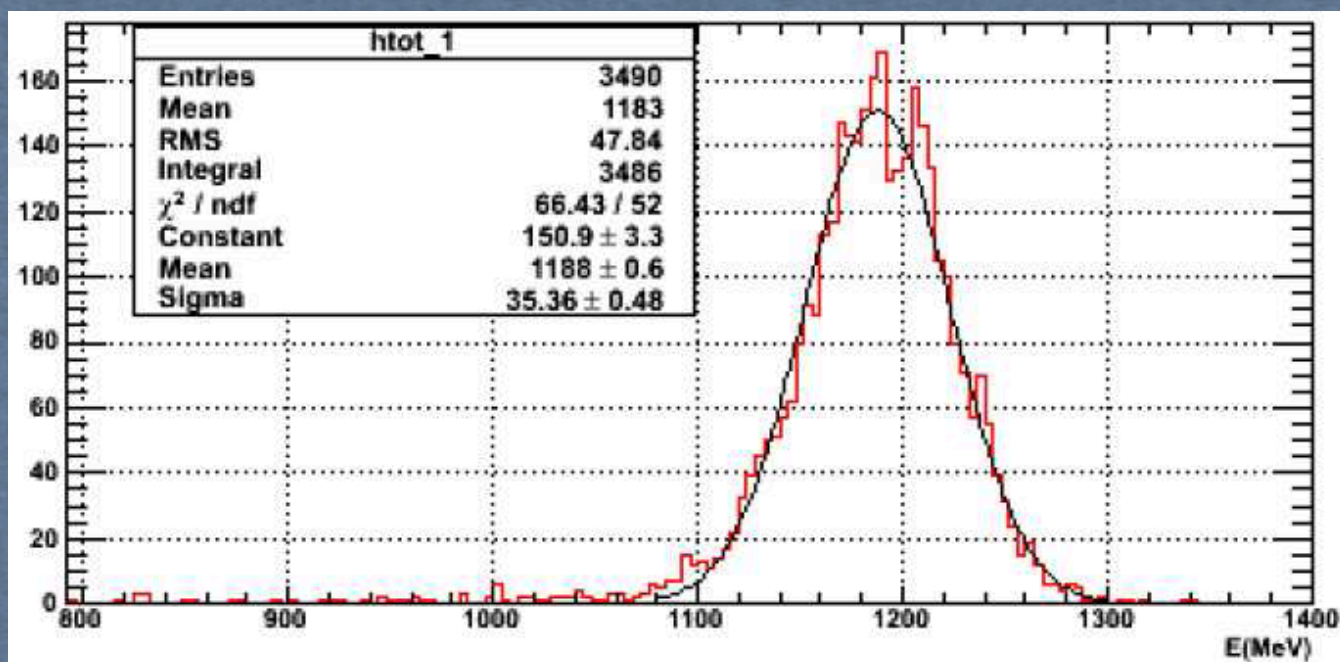
Hodoscope
Prototype

Cooling lines

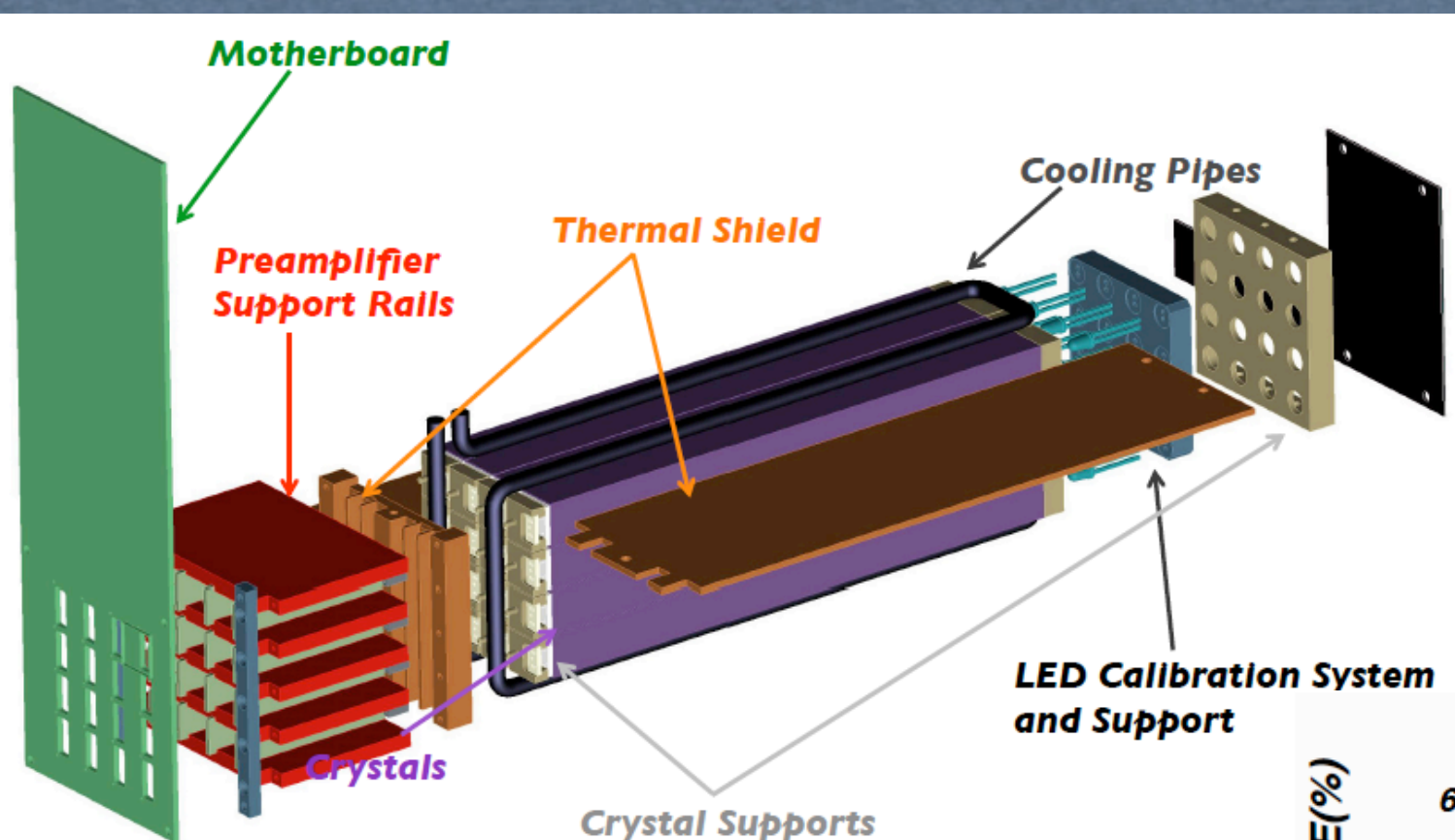


* Proto-9@ JLab

Measured $\Delta E/E$ (@1.3 GeV) = 3% (expected 2.7%)

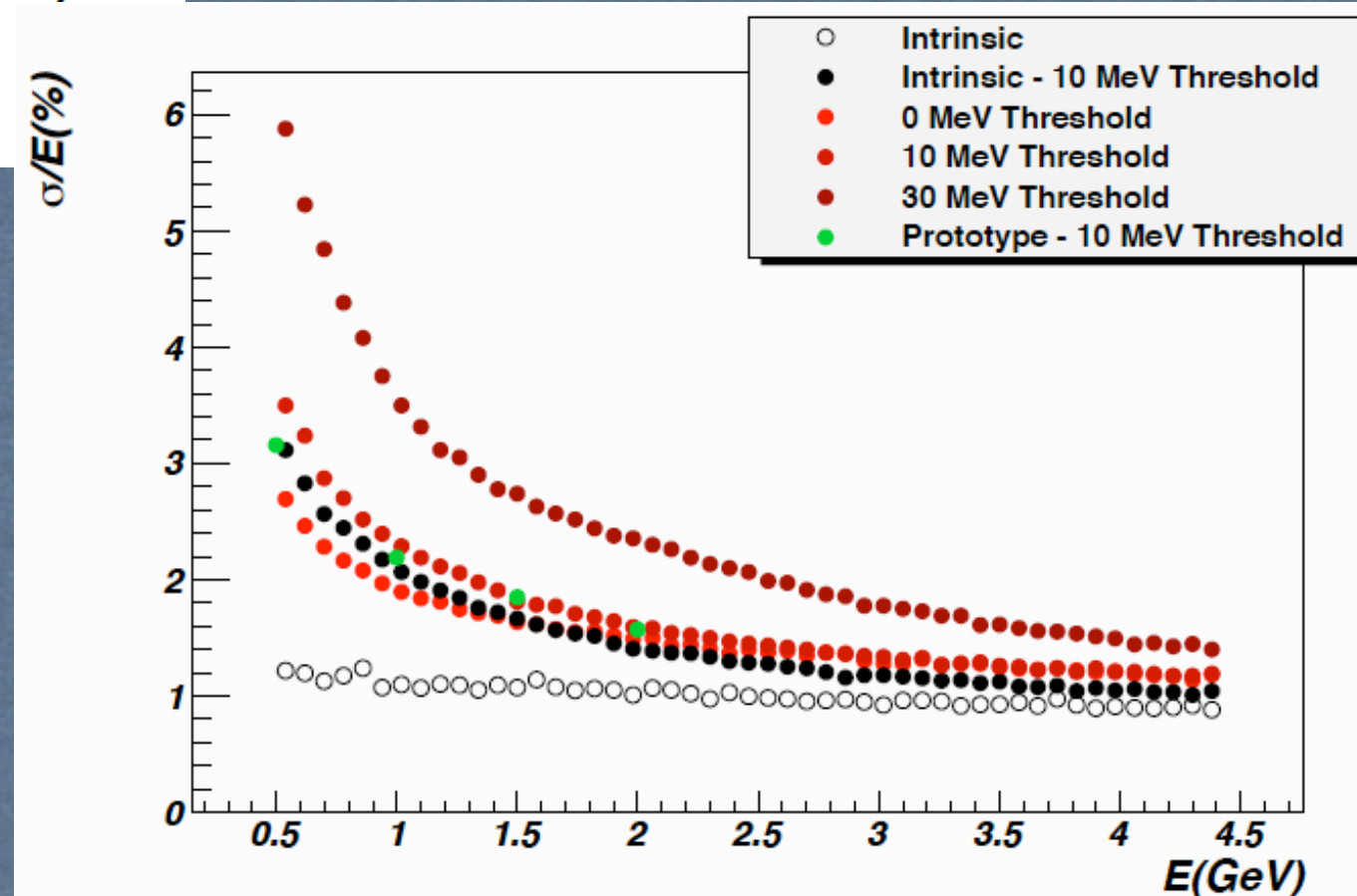


FT-Cal Proto-16



* Proto-9@ BTF (LNF)

- Final mechanical solutions
- Negative T tests in May with 0.5, 1, 2 GeV electron beam
- Expected energy resolution similar to the FT-Cal



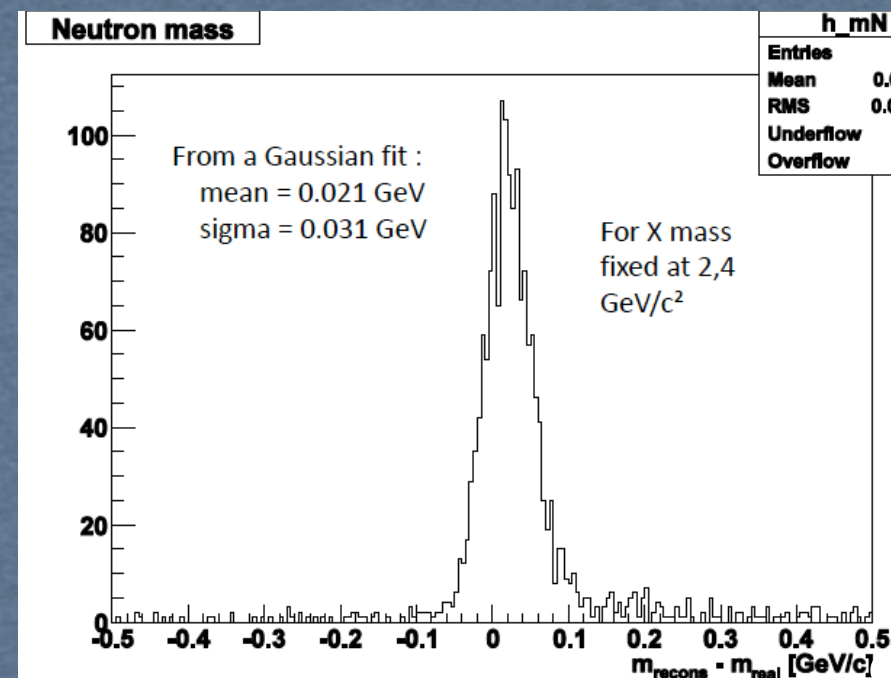
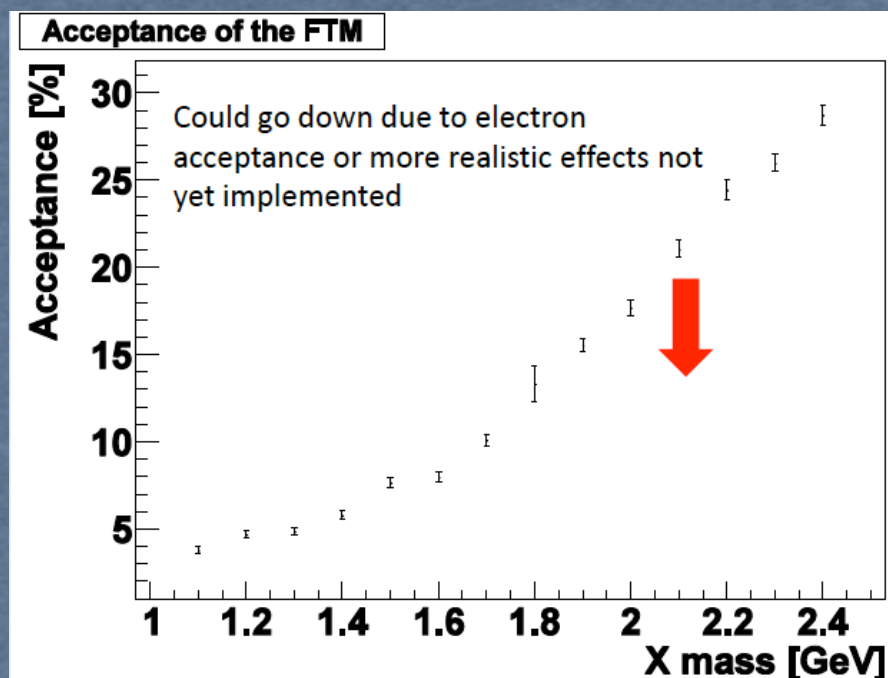
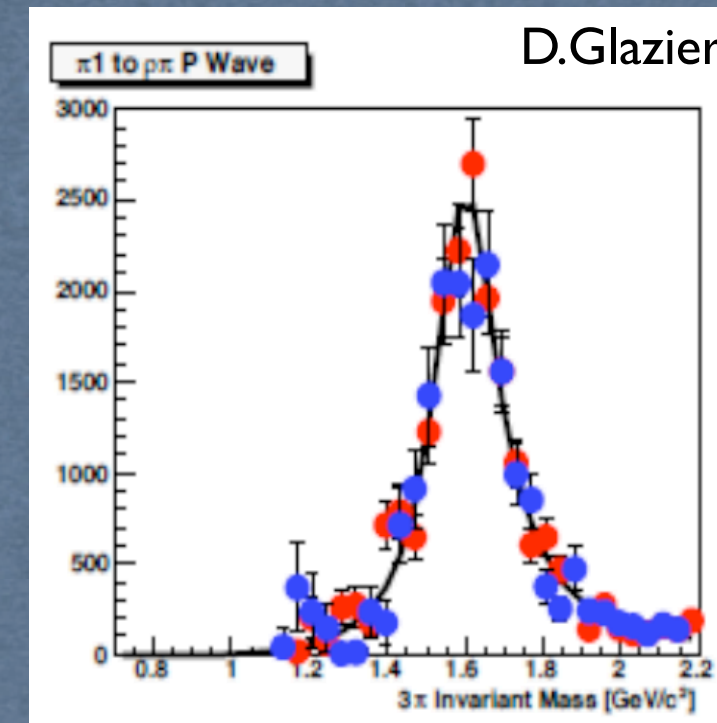
Partial Wave Analysis and reconstruction

Benchmark reaction:
 $\gamma p \rightarrow (n) \pi^+ \pi^+ \pi^-$

An exotic wave ($J^{PC} = 1^{-+}$) was generated at level of 2.5 % with 7 other waves. Events were smeared and accepted (FASTMC), passed to PWA fitter
 Statistics correspond to few days of running

$X \text{ (exotic)} \rightarrow \rho \pi^+ \rightarrow \pi^+ \pi^+ \pi^-$

- * We are working at PWA implementation on GPU D.Glazier, S.Lombardo, H.Matevosyan
- * Dedicated workshops (PWA-Day, ATHOS12, ...)
- * First FULL reconstruction with GEMC (FT-Cal+FT-Trck+CLAS12)



Charles, R. De Vita

Conclusion

* A lot of work has been done but a lot of work has to be done

* Short range plan:

- Conclude the crystal tender within Q3 2012
- APD procurement Q3 2013
- Set up tools and benchmark facilities for crystal tests and APD gluing Q4 2012
- Produce the 330+40 FT-Orsay preamp board within Q4 2012
- Test a 16ch FTh-Orasy board prototype within the end of 2012
- Design and produce the FT-Cal motherboard within Q2 2013
- Test the 16ch LED monitoring system prototype Q3 2012
- Design the full LED sytem Q2 2013
- Run tests with FT-Cal/FT-Hodo proto-16 Q3 2012
- Define the FT-Trck design and related mechanic/service Q4 2012 (MRI pending)
- Define the FT-Hodo design and related mechanic/service Q4 2012 (MRI pending)
- Work out the FT-Cal thermal design Q3 2012
- Define service/cable routing Q3 2012
- Work out the FT-Cal and FT mechanic structure Q2 2013

FT-Calorimeter - Funding plan

<i>Item</i>	<i>Description</i>	<i>#</i>	<i>kEuro/ch</i>	<i>Total (kE)</i>
Crystals	PbWO4 Type-II	370	0.4	148
Light sensors	LAAPD S8664-1010	370	0.475	175
FE electronics	Orsay preamps	370	0.06	22
RO electronics	fADC/Discr/TDC	370	0.5	175
Monitoring	LED system			30
LV/HV/cabling	Crate+24ch boards			10+20
Cooling	Chiller/pipes/ Temp control			20
Mechanical	Support/wrapping			15
Trigger	JLab boards			15
				TOTAL 630 (410)
				+VAT+contingency=1.2*1.1 830 (540)

- * FT-Hodo and FT-Trck are funded by Edinburgh University and Saclay
- * MRI for a total of ~360k \$ placed in January to fund FT-Hodo (partial) and FT-Trck (full)
- * Participant institutions: Ohio, NSU, and JMU + Edinburgh and Saclay
- * Decision expected in June

Scheduling

Original funding plan (2008)

Year	201x	201x+1	201x+2	Total
Project A (ke)	80	250		270
				600

New funding plan (2012)

Year	2011	2012	2013	2014	Total
Project FT (ke)	30	220	220	150	620

