

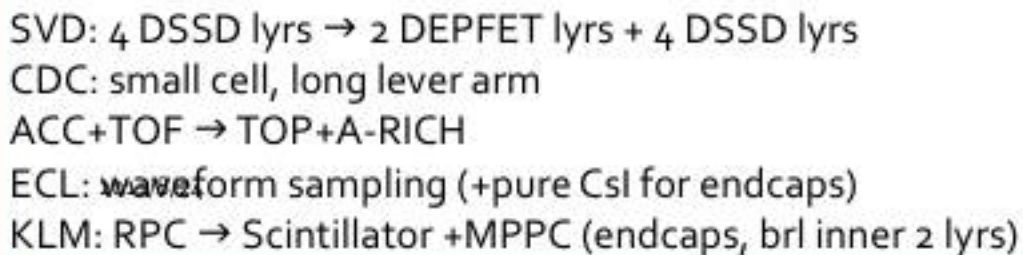
Belle-II PID

Roberto Mussa (INFN-Torino)

Riunione con i Belle-II referees

5/9/13

PID in Belle-II vs Belle



parameters are preliminary

16 barre di quarzo , $32 \times 16 = 512$ MCPPMT Hamamatsu, $512 \times 16 = 8192$ canali

quartz

Beam spot

915mm

875mm

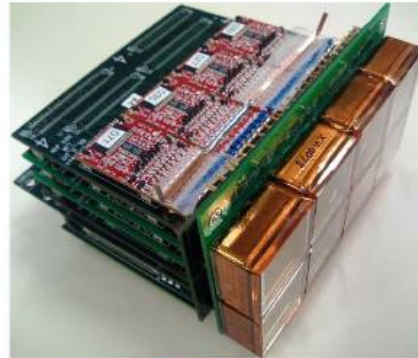
1st

2nd

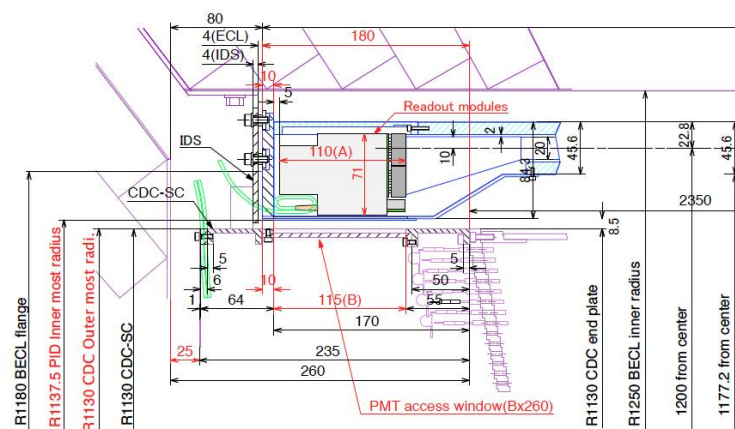
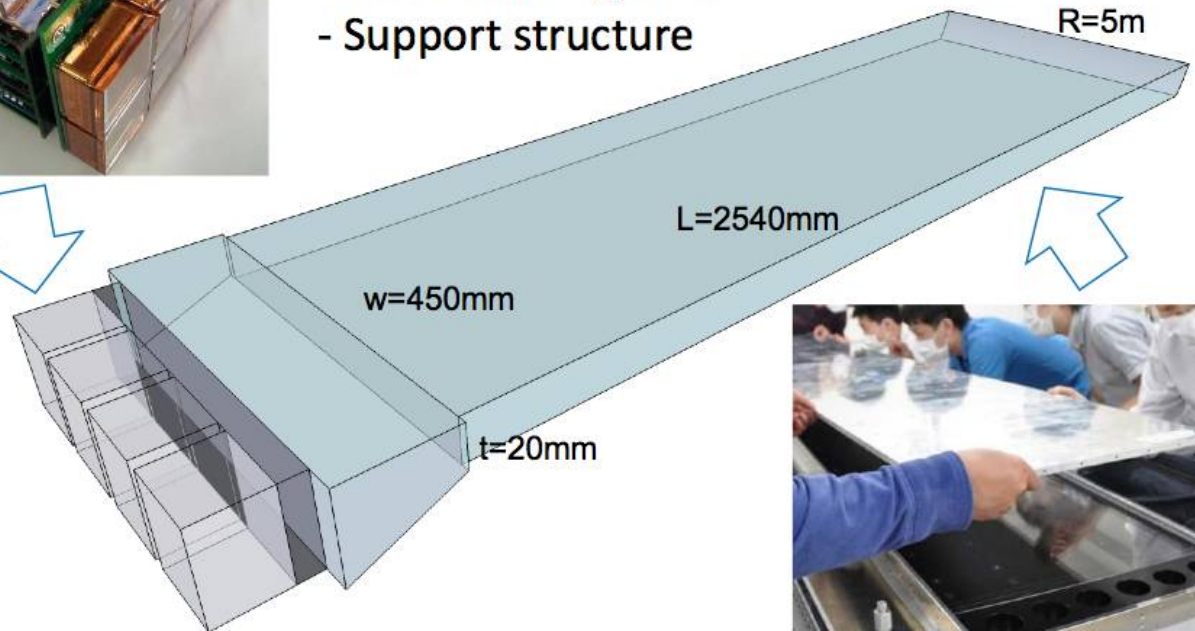
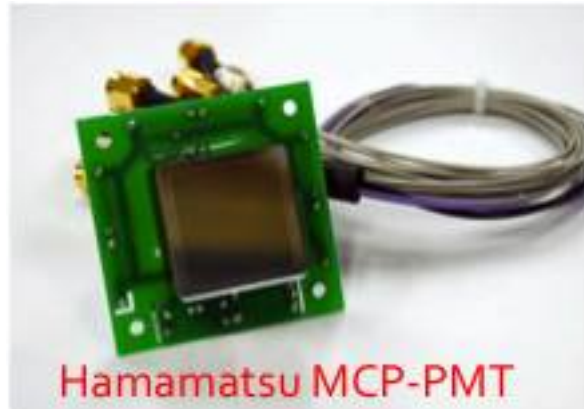
3rd

Barrel PID: [Nagoya,KEK,Hawaii,Cincinnati,Lubiana,PNNL]

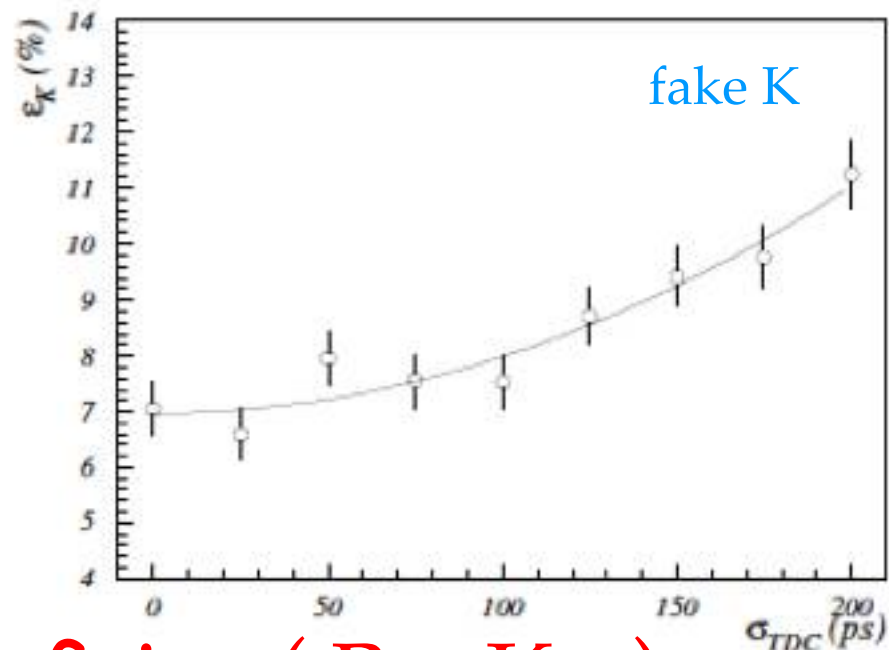
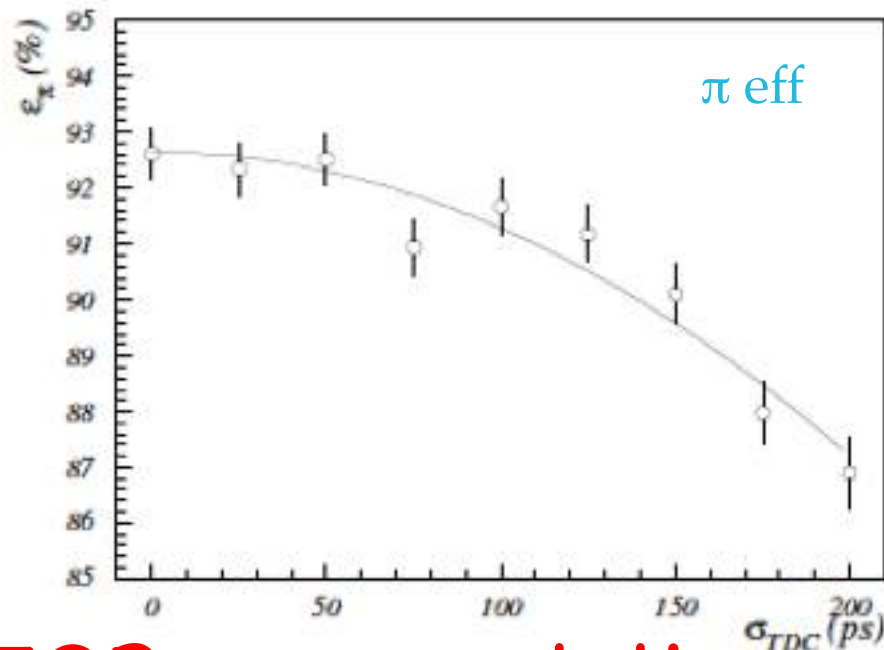
TOP



- Quartz radiator, mirror and wedge
- MCP-PMT
- Waveform digitizer
- Support structure



TOP: time resolution vs fisica ($B \rightarrow K\pi$)



TOP: segmentation vs fisica ($B \rightarrow K\pi$)

	π eff	fake K
4 x 4 segmentation	91.1%	8.9%
1 x 4 segmentation	90.1%	9.9%
1 x 2 segmentation	89.0%	11.0

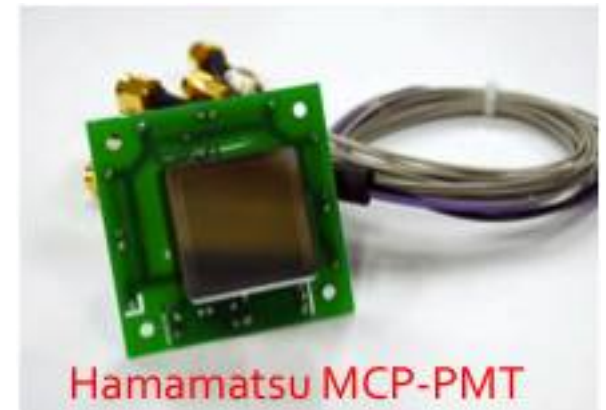
Belle vs Belle-II

	$B \rightarrow \pi\pi$		$B \rightarrow \rho\gamma$	
	Effic.	Fake	Effic.	Fake
Belle-II	98.1%	2.9%	99.0%	1.9%
Belle-I	88.5%	11.6%	87.5%	10.0%

Specifiche dei MCPPMT

Il TOP utilizza in totale 512 MCP-PMTs
Entro l'Aprile 2014 , la Hamamatsu si e'
impegnata a fornire 550 dispositivi con le
seguenti caratteristiche:

Transit Time Spread (TTS) < 50 ps
QE : 28% average, 24% minimum
Capacita' di operare in B=1.5 T
QE lifetime > 2 C / cm² @ G=5x10⁵



MCP-PMT: catena di test

HAMAMATSU photonics K.K.

~20 PMTs/month

Rejected PMTs

2 PMTs / 2 months
(Q.E. < 24%)

Nagoya University

HV test

No discharge

Gain/TTS measurement

$\sim 2 \times 10^6$ gain at HV_{nominal}
TTS < 50 psec

QE measurement

QE(~ 380 nm) > 24%

4 PMTs/day

Nagoya University

Lifetime measurement

Sampling test

KEK

Gain/TTS measurement in 1.5 T

Gain > 5×10^5
TTS < 50 psec

9 PMTs/day

Storage

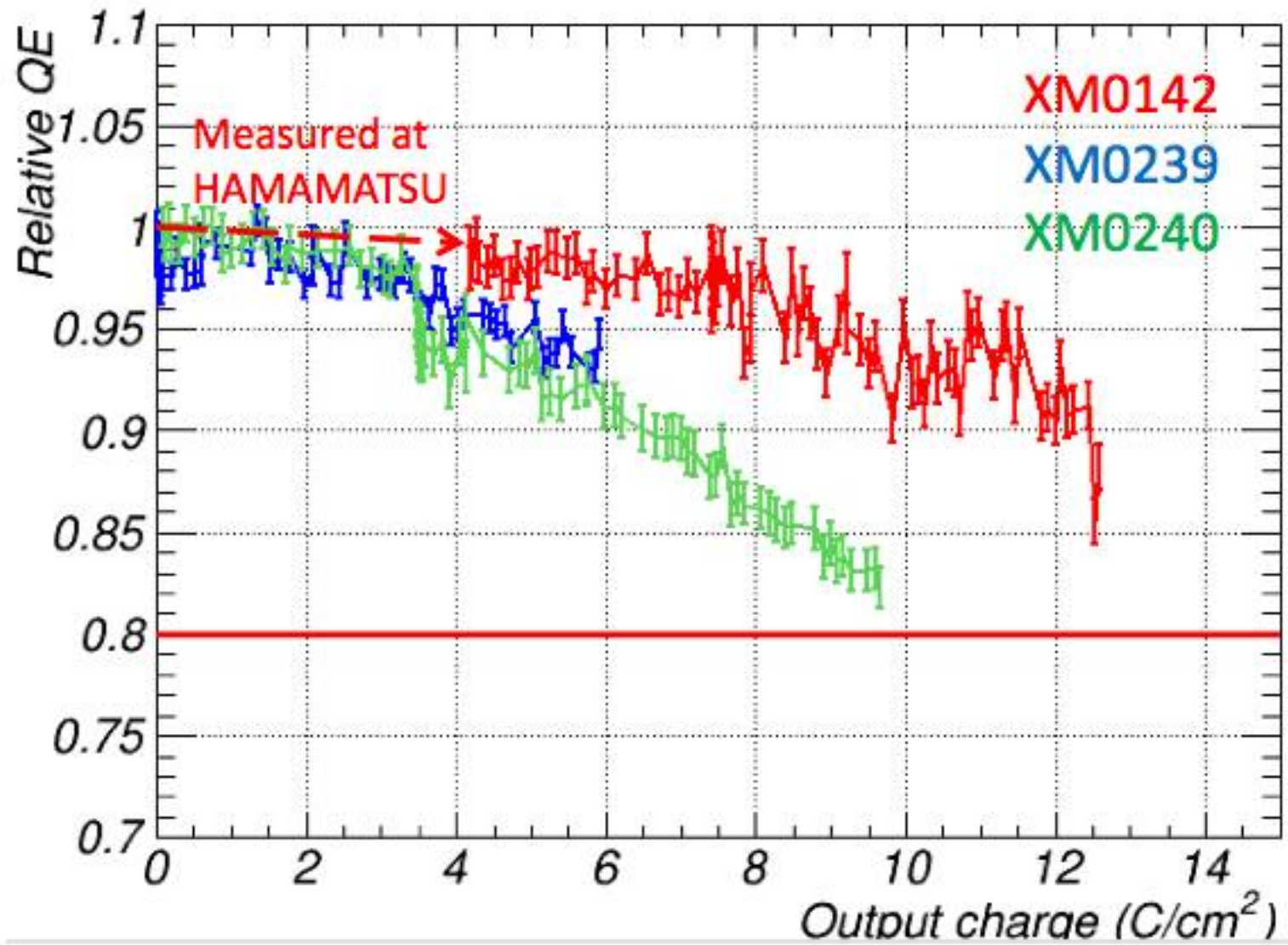
TOP counter assembly

MCP-PMT convenzionali

- We improved the MCP-PMT with the QE lifetime to $\sim 1 \text{ C/cm}^2$, while the background estimation was $\sim 1 \text{ C/cm}^2 / 1 \times 10^6 \text{ gain}$.
 - Started the MCP-PMT mass production in 2011.
- Latest background estimation: $\sim 4.1 \text{ C/cm}^2 / 1 \times 10^6 \text{ gain}$
 - Need further improvement
- Approaches to improvement
 - Reduce the background by optimizing the beam optics and shields.
 - Reduce the MCP-PMT output charge by lowering the gain
 - Background estimation becomes $\sim 2 \text{ C/cm}^2$ at $5 \times 10^5 \text{ gain}$
 - TTS and efficiency does not change down to 5×10^5 .
 - Since May 2013, produced MCP-PMTs with ALD (Atomic Layer Deposition) coating MCPs.

ALD-MCPPMT

The lifetime is defined as the output charge where the Q.E. declines down to 80% of the beginning.



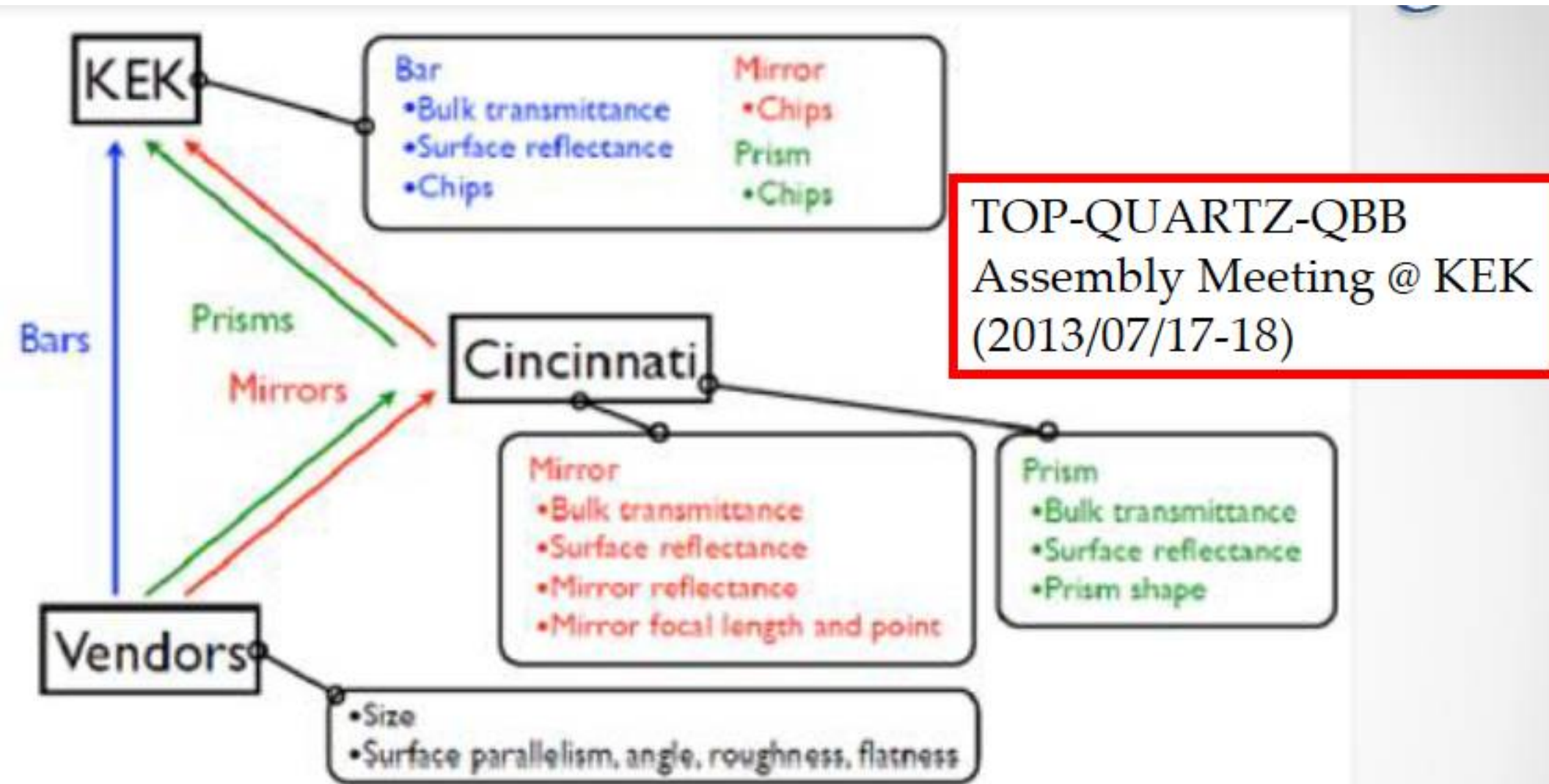
MCPPMT contabilita'

Delivered	289 (normal) + 30 (ALD)		
Inspection	done	rejected	
• QE	287	15	
• HV test	247	6	
• Gain/TTS	111	0	Catching up
• Gain/TTS in 1.5 T	63		Just started
• Total	–	21	

- The number of the **normal MCP-PMTs** will be $289 - 21 = 268$.
- The number of the **ALD-MCP-PMTs** will be $550 - 268 = 282$.
 - If the number of the rejected PMTs increases, we will get more ALD-MCP-PMTs.

Finiremo con ½ MCPPMT a low gain e ½ di tipo ALD

Quarzi: forniture



Quarzi: fornitura

$\frac{1}{4}$ dei quarzi necessari per il detector completo sono stati comprati come prototipi e già pagati dal DOE.

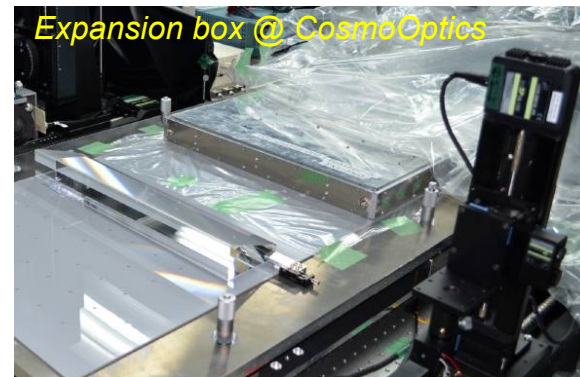
Barre di quarzo: Okamoto(JPN) e Zygo(USA)

Chiaramente la Okamoto e' peggiore (9 mesi in ritardo sulla fornitura), ma le specifiche sono OK, e non si vuole perdere altro tempo, quindi lavoreranno in parallelo.

Specchi a fondo barra: ITT

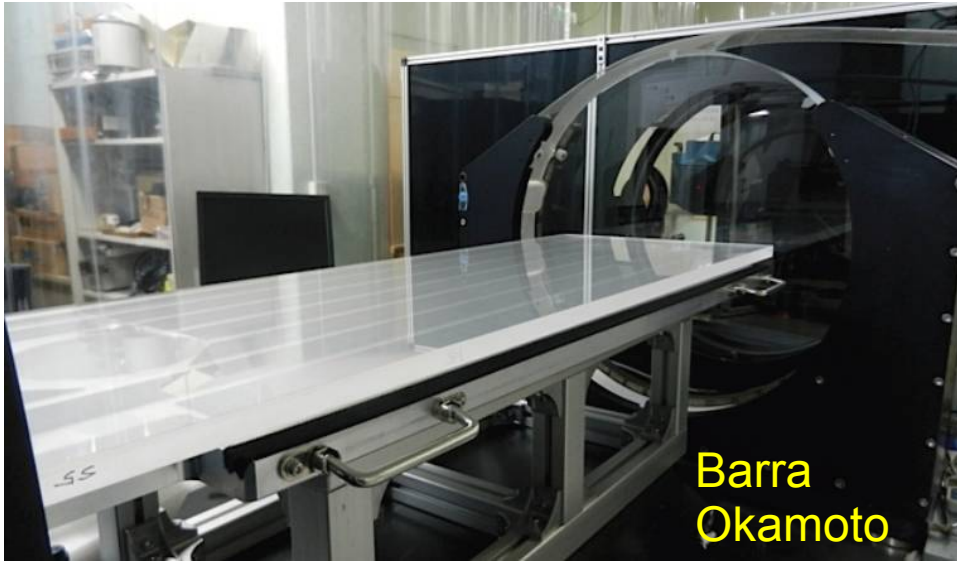
Prismi (Expansion Boxes): Zygo

La CosmoOptics ha partecipato alla gara e ci venderebbe il loro prisma, leggermente fuori specifiche, ma inessenziale per noi.

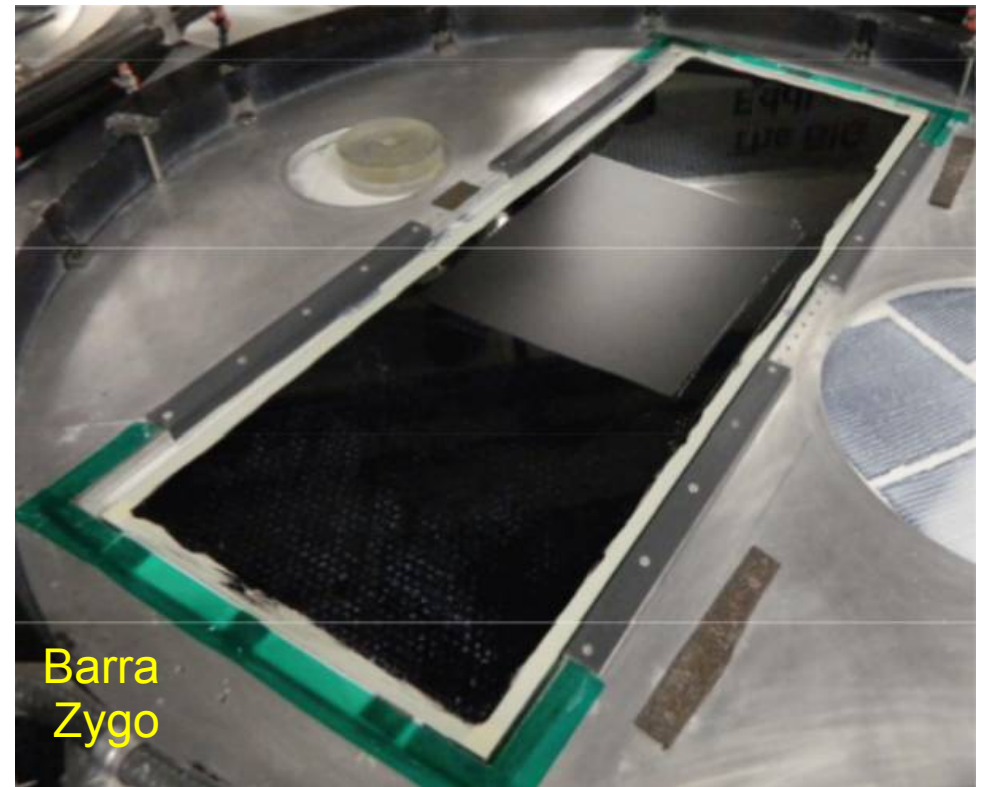


Il resto dei soldi verra' sbloccato dal DOE dopo la CD 2/3 review, ma si sta cercando di anticipare il denaro per la produzione con denaro da USA+Japan.

Quarzi: prototipi



Barra
Okamoto



Barra
Zygo



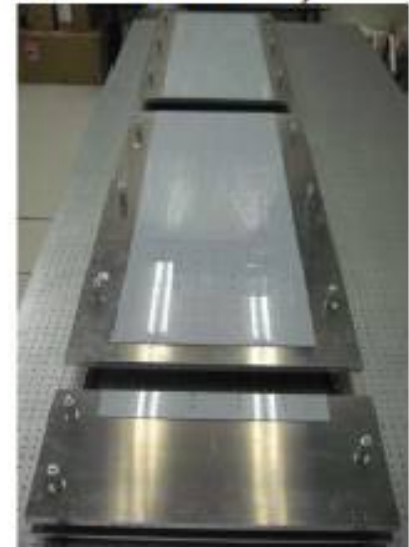
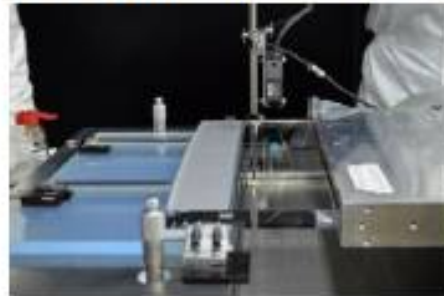
Misura dello
Specchio
ITT



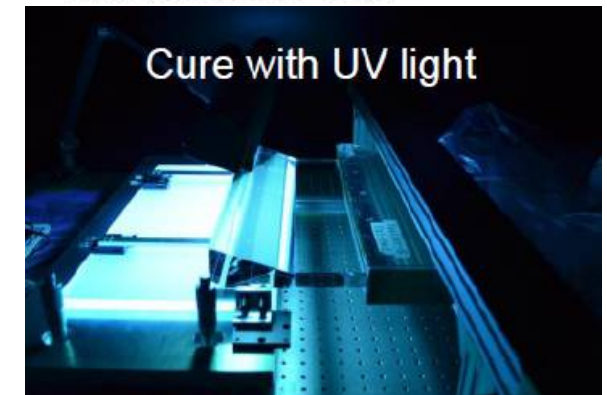
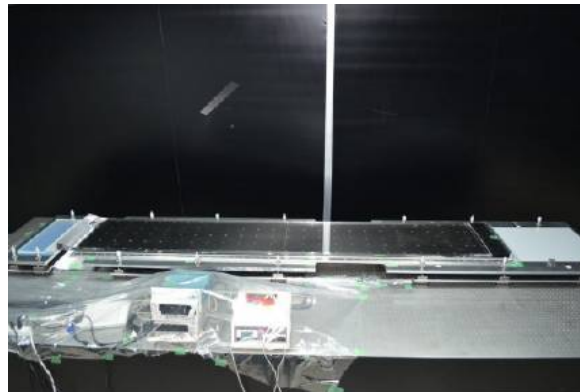
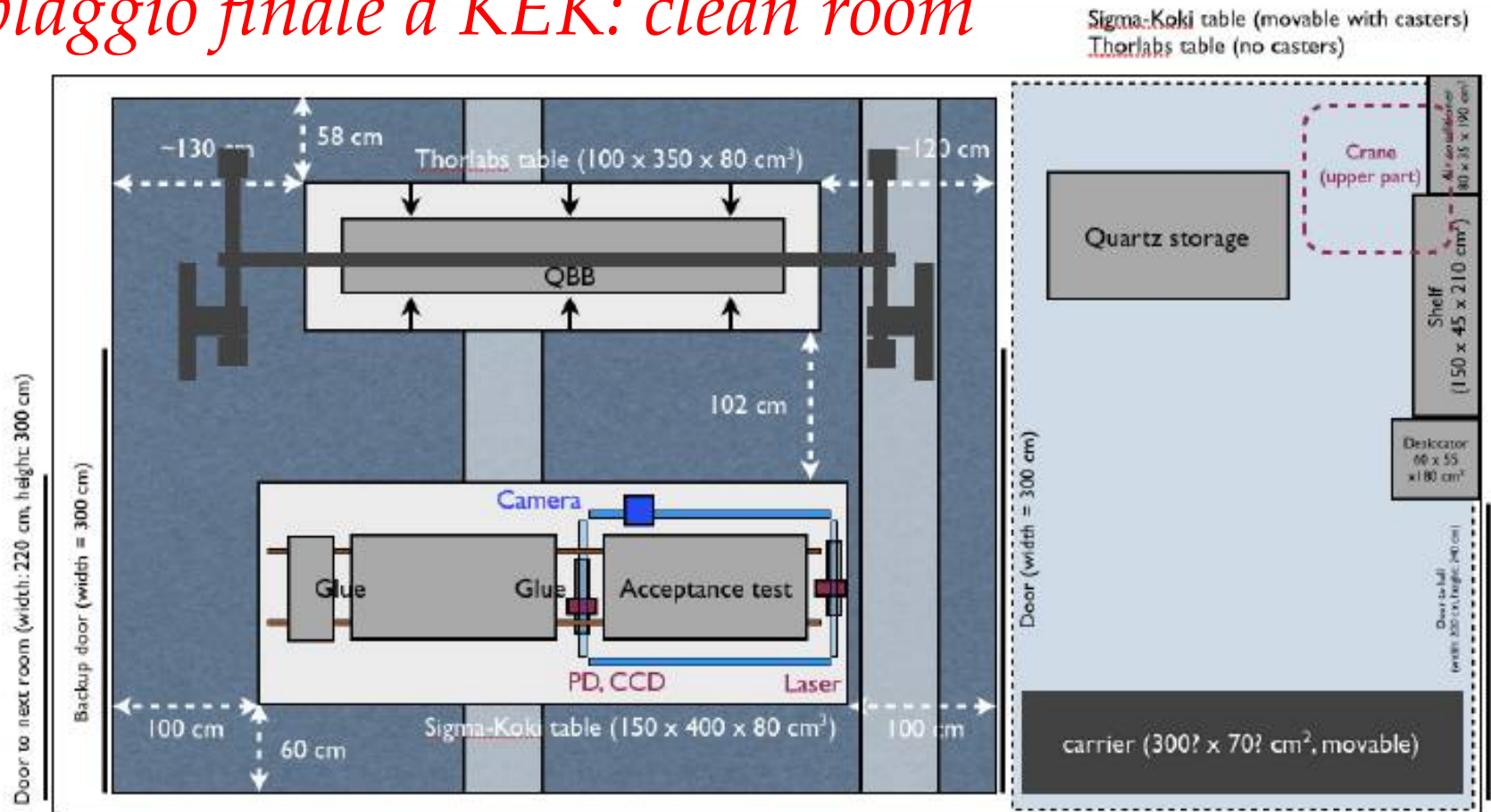
Specchio dopo il coating

Assemblaggio finale a KEK: procedure+training

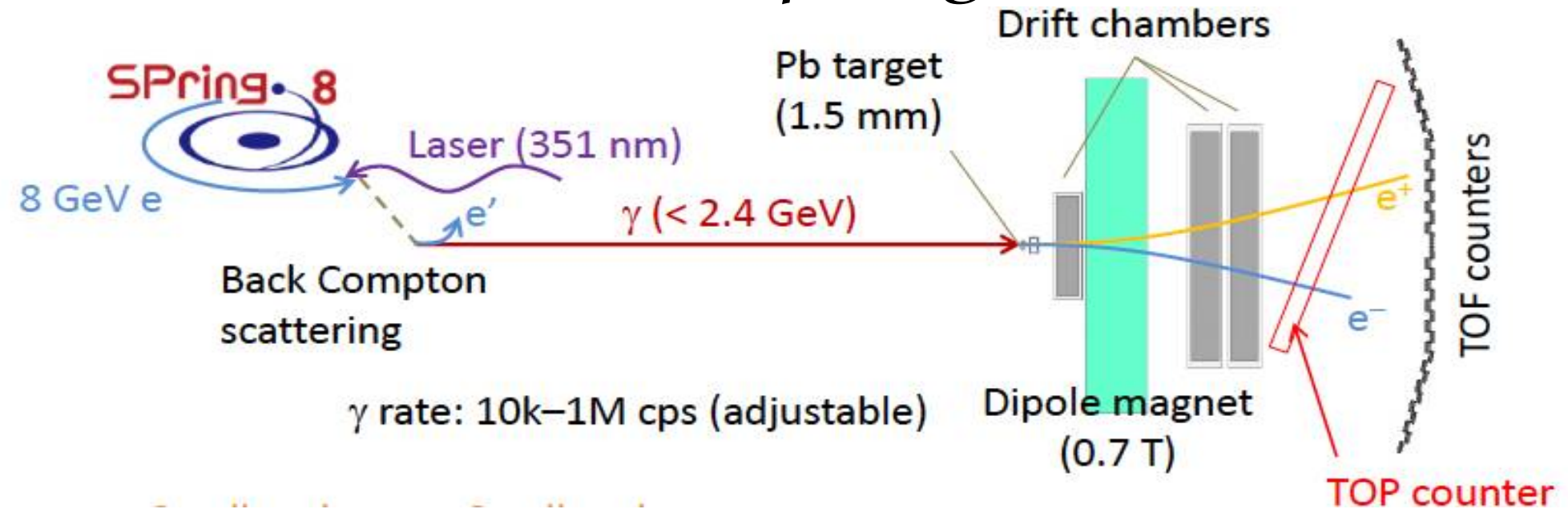
- Preparation
 - Nagoya Gluing Stage modification in Sep
 - New prism fixture in Sep
 - Dummy (glass) 10cm mirrors + prism to be delivered in Oct
- Alignment practice (Sato-san, Boqun, new UC PD, and TH)
 - (1) Dummy (Al) mirrors in Aug/Sep
 - (2) Dummy (glass) mirrors in Oct/Nov
 - (3) Dummy (glass) prism + mirror in Oct/Nov
- Gluing practice (Sato-san, Boqun, new UC PD, and TH)
(to tune gluing parameters such as gap, temp., and working time..)
 - (1) Dummy (glass) mirrors in Oct/Nov
 - (2) Dummy (glass) prism + mirror in Oct/Nov
- Special quartz practice @ next B2GM (for other shifters)



Assemblaggio finale a KEK: clean room



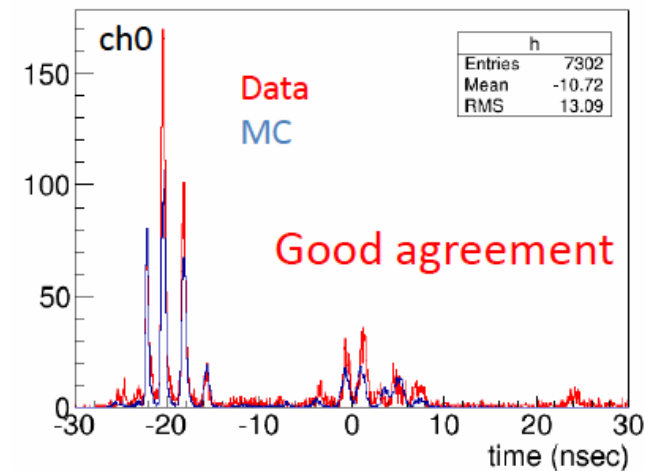
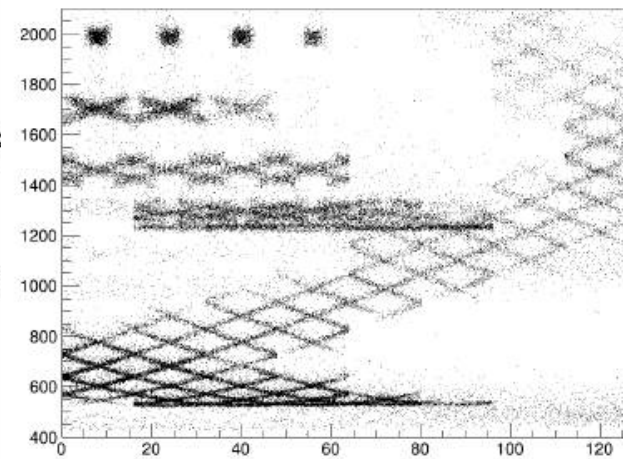
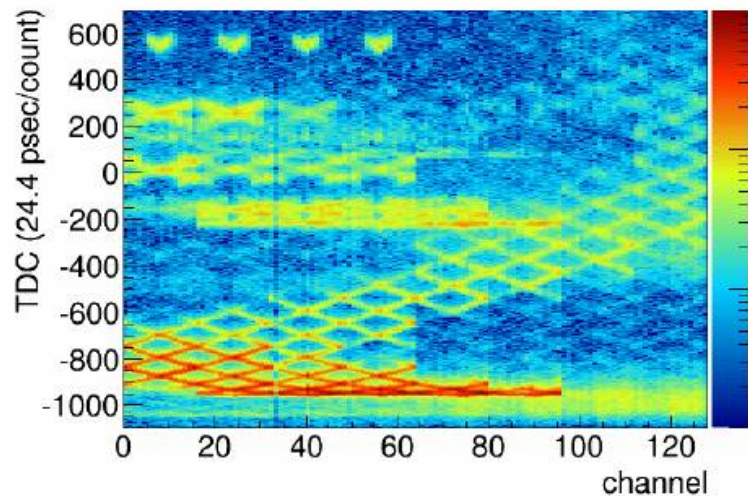
LEPS beam test @ Spring-8



$\cos\theta = 0.009$, $x = 0.0$ cm

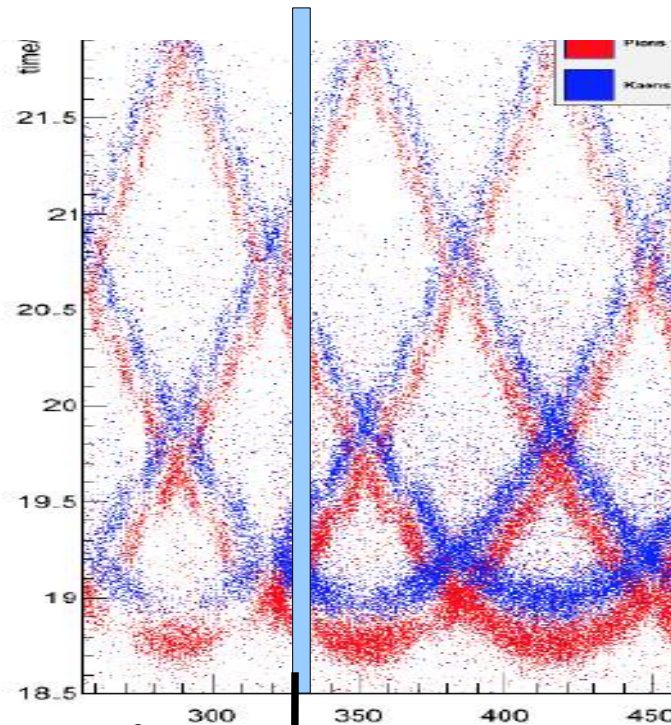
Data

MC



Buon accordo con MC, ma necessarie alcune modifiche all'ASIC, SLAC test rimandato.
Analisi intensiva dei dati, per superare la CD-2/3 Review, e sbloccare i fondi DOE.

LEPS results



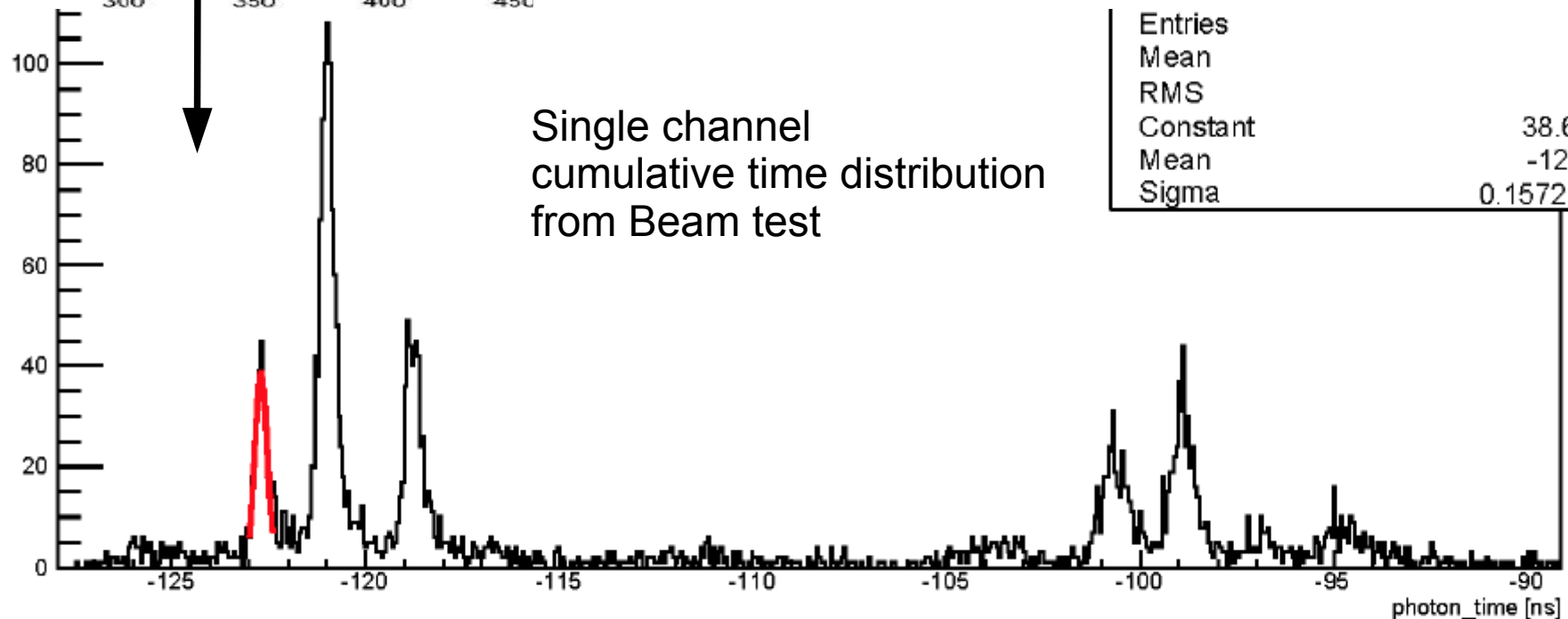
Space-time correlations (MC)

Single photon timing
Resolution from Beam test:

$$\sqrt{[120 \text{ ps}]^2 + [100 \text{ ps}]^2} = 156 \text{ ps}$$

“physics”
contribution:
confirmed by
GEANT4
simulation

Electronics contribution:
PMT + IRS3B + Amplifiers + ...
Measured using laser pulse



Single channel
cumulative time distribution
from Beam test

Plans: IRS3C and beyond

How to get the target electronic resolution of 50 ps?

1) Increase signal amplitude

2) Reduce signal risetime

New amplifiers (LHM6629 single stage)

→ 4x gain, > 2x risetime
→ 2x dynamic range

3) Improve timebase stability

New filtering of the timebase adjusting voltage
New carrier thermal isolation

→ fluctuation reduced from ~100 ps to ~75 ps

Single photon timing
Resolution from Beam test:

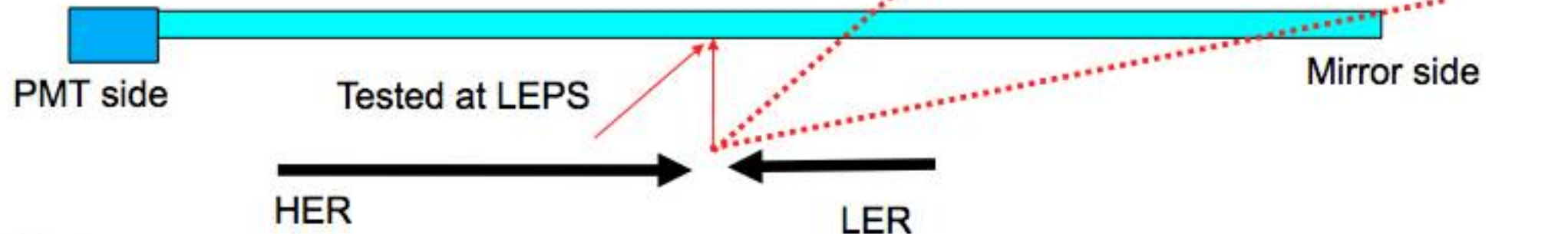
$$\sqrt{[120 \text{ ps}]^2 + [100 \text{ ps}]^2} = 156 \text{ ps}$$

Electronics contribution:
PMT + IRS3B + Amplifiers + ...
Measured using laser pulse

Cosmic Ray Test @ KEK

Test the region near to the mirror at high $\cos\theta$

- Common situation expected at Belle II
- Not covered by previous CRTs
- Not covered by LEPS test

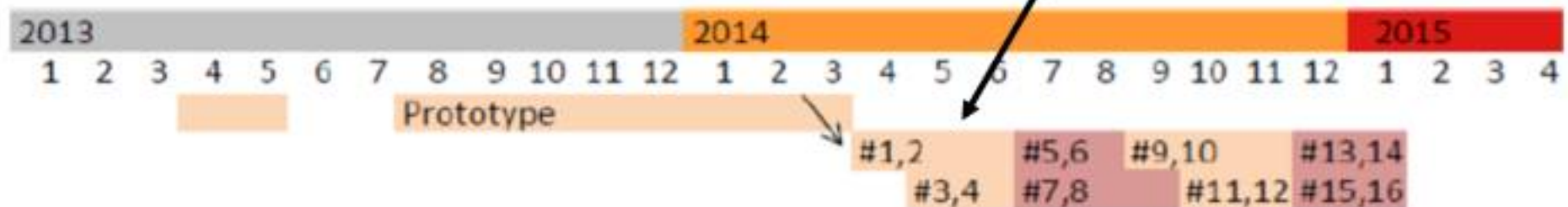


Setup:

Atlas drift tube tracker from Kobe University

- 8 layers ($\sim 1.8 \text{ m} \times 1.0 \text{ m}$)
- Large acceptance, but to be modified for our purpose
- **Assembly test done in August**
- **Leak test with N₂ done in August**
- Testing and validation ongoing
- Trigger design ongoing

This will be likely the setup that will be used for the final test of each bar



August, 31st 2013: news from U.Tamponi@KEK

IRS3B / LEPS beam test analysis

- Laser test show an intrinsic resolution of the electronic of ~ 100 ps
- Resolution due to physics is ~ 120 ps
- Resolution from beam Test is ~ 150 ps
- IRS3C has been developed and is going to production
 - improved amplification, reduced time base jitter

Mirror and Quarz assembly

- Clean room is ready and stable
- Gluing studies are ongoing on both prism and mirror
- Alignment studies ongoing
 - Goal: find the optimal coupling strategy

CRT

- Kobe Univ. tracker has been tested for assembly and gas leakage
- Gas leakages have been fixed
- Optimal assembly pattern is under study

Calibration system

- MC code almost ready (needs some inputs on final design parameters)
- (at least) Two lasers must be included (timing calibration and single photoelectron amplitude calibration)

2013: disegno del sistema di timing calibration

Obiettivo : definire le specifiche della sorgente laser , delle fibre, degli splitter, della tecnica di iniezione della luce per consentire di monitorare a livello < 40 ps la risoluzione temporale del detector.
(nb: 40 ps~8 mm)

Padova: sistema ottico per l'illuminazione dei MCP-PMT

- disegno del sistema di iniezione degli impulsi luminosi
- tests incollaggio dei diffusori / prismi / lenti sull'expansion box
- ray tracing simulations

Torino :

- ray tracing simulations
- tests: sistema di distribuzione della luce dal laser alle fibre:
- tests: confronto del time jitter su diversi tipi di fibra
- processing dei segnali in uscita dall'ASIC per l'analisi delle calibrazioni laser
- programmazione VHDL del FPGA di backend per la sparsificazione dei segnali

TOP: richieste finanziarie 2013

Missioni ancora da fare:

- Cosmic Ray Test a KEK : 4 kEu
- BPAC di settembre a KEK : 2 kEu
- contatti PID italia,
OEM+analysis Workshops : 3 kEu



Inventario+Apparati: Ass. 14 kE a PD (+6 ex SuperB)

- 4 MCPPMT @6kEu/PMT --> 24 kEu (2 a PD , 2 a TO)

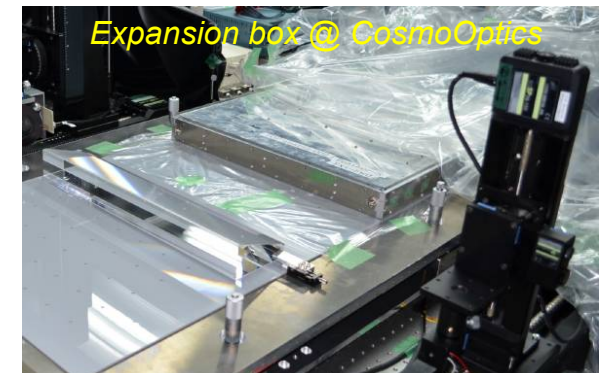
Incontro con esperti Hamamatsu prossimo venerdi a To

- 1 expansion box: 15 kEu (PD) , da comprare da CosmoOptics
- laser head upgrade per scendere sotto 25 ps: 8 kEu (PD)

Consumi: Ass.4 kE a TO (+4 ex Super B)

- Fibre + attrezzature ottica: 3 kEu (TO)
- Minuteria ottica e meccanica: 5 kEu (PD)
- Readout MCPPMT: 4 kEu (TO)
- elettronica, cavi , connettori, boards: 3 kEu (TO)

--> Stiamo mettendo insieme quanto serve per cominciare i tests



Belle-II PID in Italia

Torino

Roberto Mussa	1. Ricercatore	60%
Umberto Tamponi	Dottorando	100%
Giuseppe Giraudo	Tecnologo	10%

Buon supporto dal direttore: sono stati allocati 4 m.u. officina meccanica, che ha già realizzato dei fiber bundles per calibrazione TOF di esperimenti di gr.3. Un tecnico disponibile a viaggi in Giappone.

Padova

Posocco Mario	Senior	80%
Sartori Paolo	Ric.Univ.	40%
Torassa Ezio	1. Ricercatore	30%

Interesse da parte di altri docenti e ricercatori di CMS, possibilità di un loro contributo ma per il momento senza percentuali ufficiali.

Possibilità di un aiuto limitato da parte di un ingegnere meccanico e di un fisico elettronico senza per il momento percentuali ufficiali.

TOP: richieste finanziarie 2014-5

Spese 2014:

- FPGA per sottrazione dei piedestalli online: 2 kE
- Altri MCPMT per tests: 2 modello nuovo (ALD) ~ 12 kE
- Fotonica: fibre, connettori, splitters, diffusori/ prismi: 25 kE
- CAEN HV 1 mainframe + 2 schede: 21 kE

Spese 2015, a disegno finalizzato:

- sistema di monitoraggio stabilita' : radiometro/ fibre: 10k
- Fotonica: fibre, connettori, splitters, diffusori/ prismi: 125 kE
- Unità laser? Disegno base: 4*12 kE/ laser ~ 50 kE
- CAEN HV: 1 mainframe + 4 schede (35 kE)

Pending: su richiesta di Nagoya sarebbe necessario manpower tecnico: 8 mesi-uomo (2 tecnici) in 2 anni, per l'assemblaggio delle barre e del sistema di calibrazione a KEK

Torino: richieste finanziarie 2014

Capitolo	Descrizione	Parziali		Totale	
		Richiesta	SJ	Richieste	SJ
MISSIONI	1. Metab: 1 m.u/FTE + 1.5kE/FTE *2.1FTE	16.00			
	2. PID:2 TOP workshops x 2 pers x 2 kE	8.00			
	3. PID:Tests TOP in Italia	2.00			
	4. PID:Coordinamento TOP	5.00			
	5. PID :Beam test a SLAC	4.00			
	6. COMP:2 Workshop Computing x 2K x 1 persona	4.00			
	7. COMP:Coordinamento Computing	5.00		44.00	0.00
CONSUMO	1. Metab: 1.5kE/FTE *2.1FTE	3.00			
	2. PID:meccanica per tests calibration system	10.00		13.00	0.00
INVENTARIO	1. PID:2 ALD MCPMT	12.00			
	2. PID:HV: 1 Caen SY4527+1 card mod.1550	14.00			
	3. PID :1 Belle readout unit (board stack)	28.00		54.00	0.00
APPARATI	1. PID:fiber bundles e connettori: 1st batch	25.00		25.00	0.00

Ricercatori					
	Nome	Età	Contratto	Qualifica	Aff. %
1	Bianchi Fabrizio		Associato	Prof. Associato	CSN I 50
2	Mussa Roberto		Dipendente	Primo Ricercatore	CSN II 60
3	Tamponi Umberto		Associato	Dottorando	CSN I 100
Numero Totale Ricercatori				3	FTE: 2.1

Tecnologi					
	Nome	Età	Contratto	Qualifica	Aff. %
1	Girauda Giuseppe		Dipendente	Primo Tecnologo	CSN III 10
Numero Totale Tecnologi				1	FTE: 0.1

Tecnici					
	Nome	Età	Contratto	Qualifica	Aff. %
Numero Totale Tecnici				0	FTE: 0.0

Servizi	
Servizio	M.U.
1 Officina Meccanica dughera@to.infn.it	4.00
Totale Mesi/Uomo Servizi Per BELLE2 Torino	
	4.00

Padova: richieste finanziarie 2014

Capitolo	Descrizione	Parziali		Totale	
		Richiesta	SJ	Richieste	SJ
MISSIONI	1. Metab: 1 m.u/FTE + 1.5kE/FTE *1.3FTE	10.00		22.00	0.00
	2. PID:2 TOP workshops x 2 pers x 2	8.00			
	3. PID:Beam test a SLAC	4.00			
CONSUMO	1. Metab: 1.5kE/FTE *1.3FTE	2.00		2.00	0.00

Ricercatori					
	Nome	Età	Contratto	Qualifica	Aff. %
1	Posocco Mario		Associato	Senior researcher	CSN I 80
2	Sartori Paolo		Associato	Ricercatore	CSN V 40
3	Torassa Ezio		Dipendente	Primo Ricercatore	CSN I 30
Numero Totale Ricercatori				3	FTE: 1.5