MEG status

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Lecce – 27/06/2013

Obiettivo dell'esperimento

- L'esperimento MEG ha lo scopo di misurare il rapporto di decadimento

  $$B=(\mu^+ \rightarrow e^+ \gamma)/(\mu^+ \rightarrow tot)$$

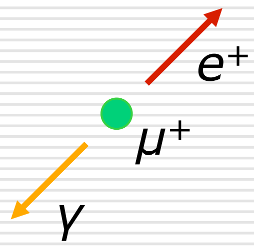
  al livello di circa 10^{-13} .
- Il modello standard prevede la conservazione del numero leptonico a tutti gli ordini. Anche includendo nel modello una massa dei neutrini diversa da zero, il nuovo modello prevede un rapporto *B* non accessibile sperimentalmente ($B < 10^{-40}$).
- Tuttavia alcune teorie di grande unificazione supersimmetrica prevedono un valore di *B* molto più grande ($10^{-14} \div 10^{-11}$). In questo senso MEG potrebbe fornire un utile contributo all'esplorazione della fisica oltre il modello standard.

Rivelazione

- La segnatura del decadimento

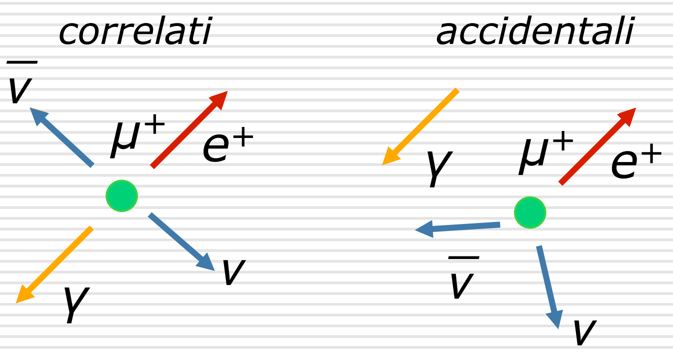
  $\mu^+ \rightarrow e^+ \gamma$

  è l'emissione della coppia $e^+ \gamma$, in direzioni opposte e con energia di circa 52.8 MeV, siccome il decadimento del μ^+ avviene a riposo.

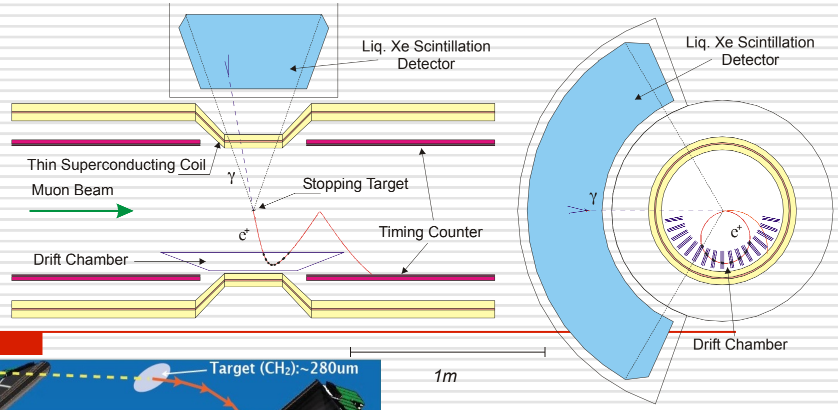


- Pertanto l'identificazione di questo processo necessita di una buona capacità di riconoscere le due particelle e una misura con elevata risoluzione delle loro energie, dell'angolo relativo e della contemporaneità della loro emissione.

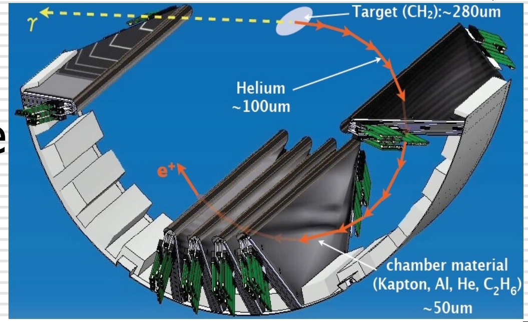
- I fondi principali sono dovuti ai decadimenti radiativi del μ^+ e decadimenti di Michel col γ proveniente da altri processi



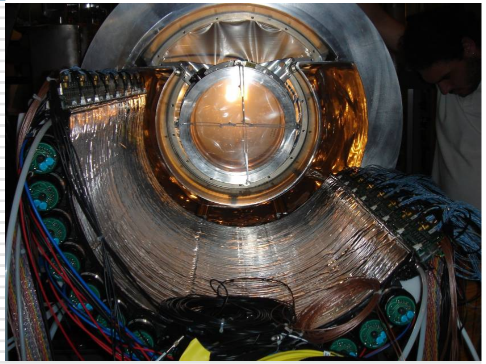
Lo Spettrometro



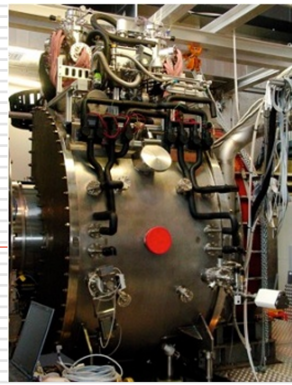
- Il fascio di muoni (circa 3×10^{7}/sec) viene arrestato su un bersaglio di polietilene spesso 150μm

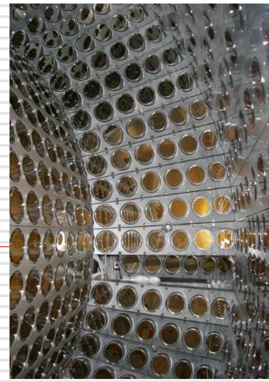


- La quantità di moto e la direzione di volo dei positroni sono determinati mediante un magnete superconduttore ed un tracciatore realizzato con un sistema di 16 camere a drift



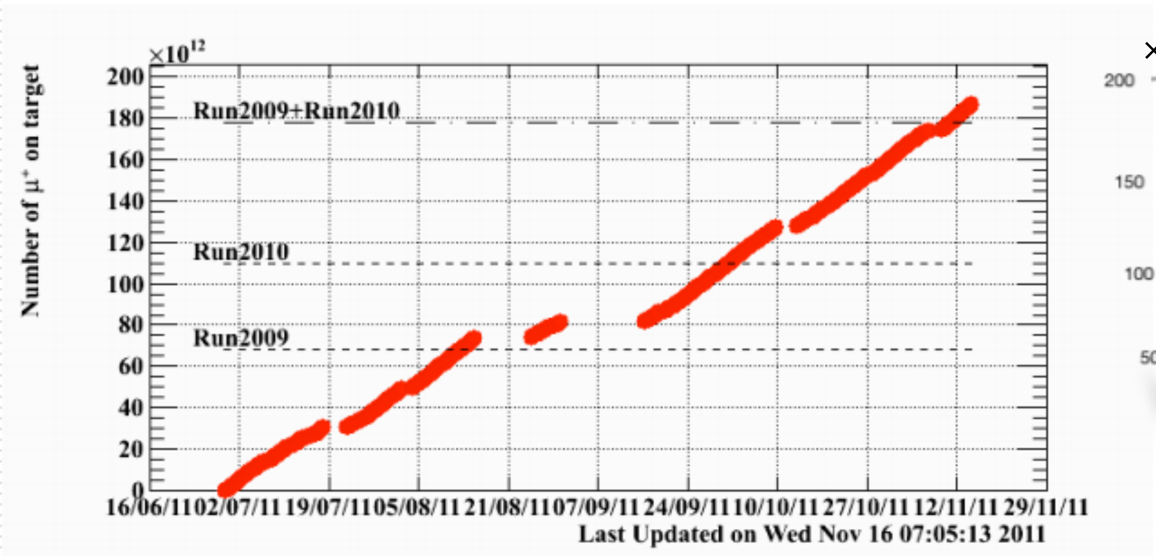
- Il tempo di volo dei positroni è misurato da un sistema di scintillatori.
- Energia, posizione e tempo di volo dei fotoni sono determinati attraverso le scintillazioni prodotte in un calorimetro a Xe liquido.

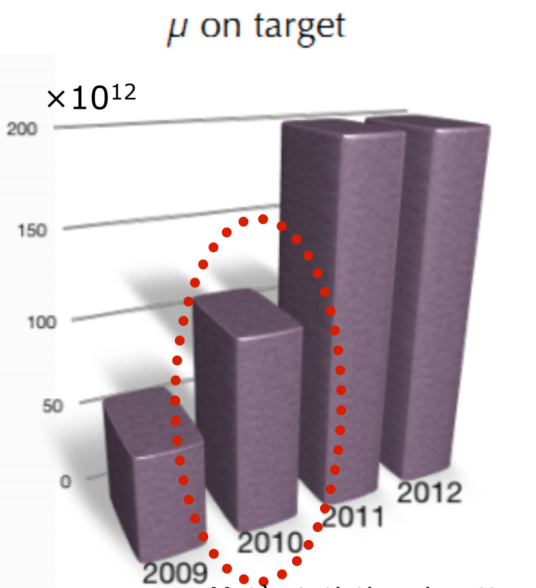




Runs

- 3 anni di run (2009-2011) hanno permesso di migliorare di un fattore 5 il limite superiore sul decadimento cercato [($\mu^+ \rightarrow e^+ \gamma$)/($\mu^+ \rightarrow e^+ \nu \nu$)] al 99% C.L.
  - 2009 → 9.6×10^{-12}
  - 2010 → 1.7×10^{-12}

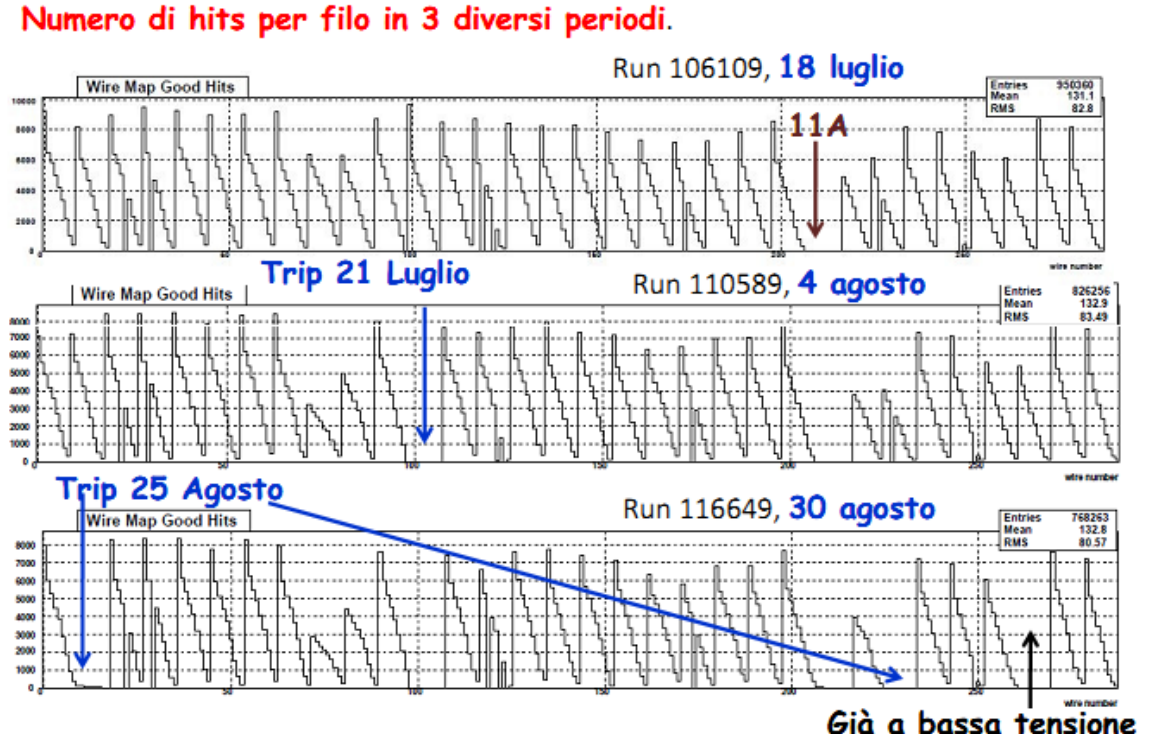




Metà statistica rispetto Al 2011 a della rottura del solenoide di trasporto del fascio (BTS)

Tracciatore di positroni

- L'instabilità intrinseca del sistema di tracciamento ha inficiato in maniera consistente efficienze e risoluzioni spaziali
- A questo si è aggiunto il problema di disturbi rilevati dall'elettronica di FE ricondotti a possibili ground loop nei circuiti e mai completamente risolti
- Questo ha indotto la collaborazione a considerare la completa sostituzione del tracciatore con uno basato su un disegno differente



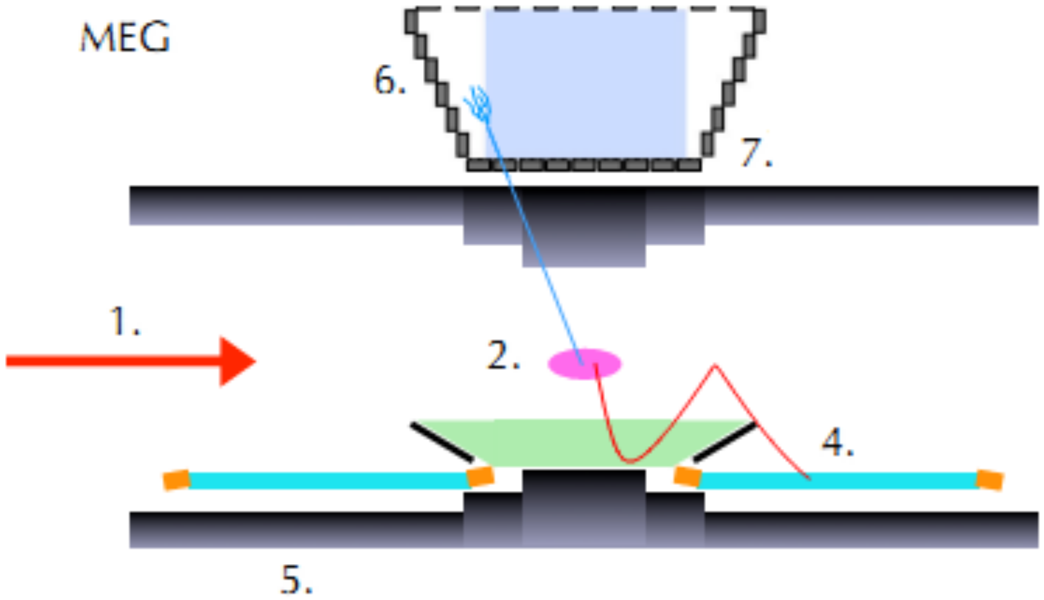
Variabile	Previsto	Ottenuto
Photon Energy (%)	1.2	1.9
Photon timing (psec)	43	67
Photon position (mm)	4(u,v),6(w)	5(u,v),6(w)
Photon efficiency (%)	> 40	60
Positron momentum (KeV)	200	380
Positron angle (mrad)	$5(\phi_e)/5(\theta_e)$	$7(\phi_e)/9(\theta_e)$
Positron timing (psec)	50	107
Positron efficiency (%)	90	40
Relative angle (mrad)	7.2	10.3
Relative timing (psec)	65	120

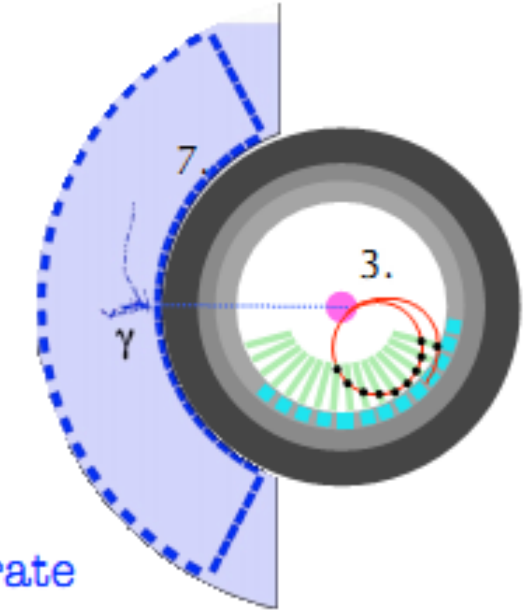
Upgrade

- La proposta di upgrade prevede
  - Sostituzione del tracciatore con una DC a volume continuo
  - Sostituzione dei PMT della faccia più interna del calorimetro LXe con SiPM (array di PMT da 1" quadrato), per migliorare la risoluzione nella posizione di arrivo del γ
  - Realizzazione di un bersaglio attivo con fibre scintillanti singolarmente accoppiate a una matrice di SiPM, per migliorare la risoluzione nella posizione di arresto/decadimento del μ
  - Uso di SiPM per la lettura degli scintillatori del TC (aumenta la risoluzione temporale, aumenta l'efficienza, riduce il pileup)
- L'ultimo punto è ancora oggetto di discussione relativamente alla miglioria introdotta in relazione al costo

upgrade design based on our long time experience

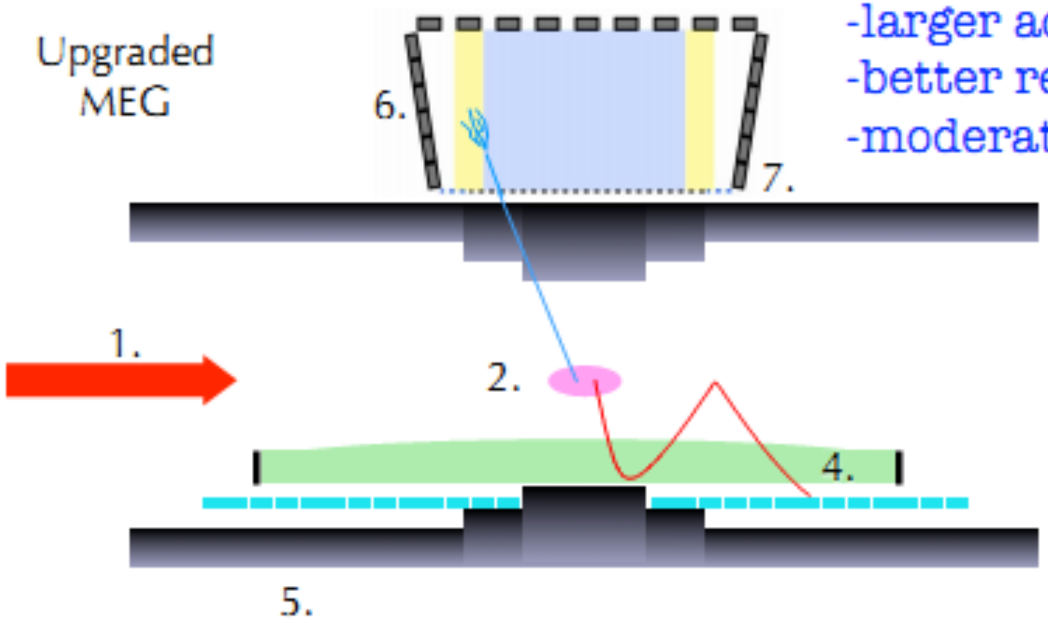
MEG

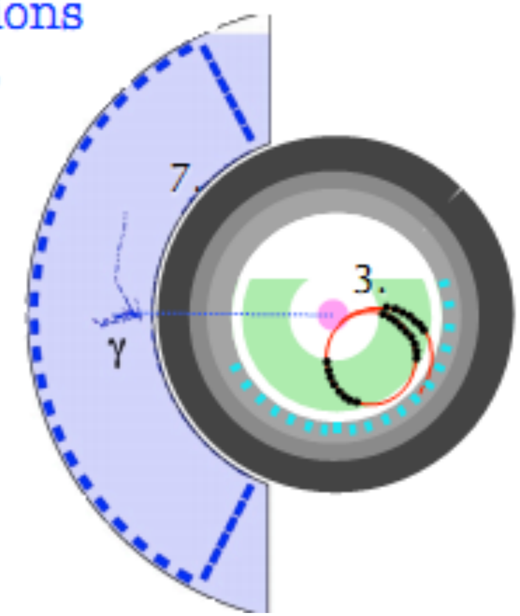




- higher beam rate
- larger acceptance
- better resolutions
- moderate cost

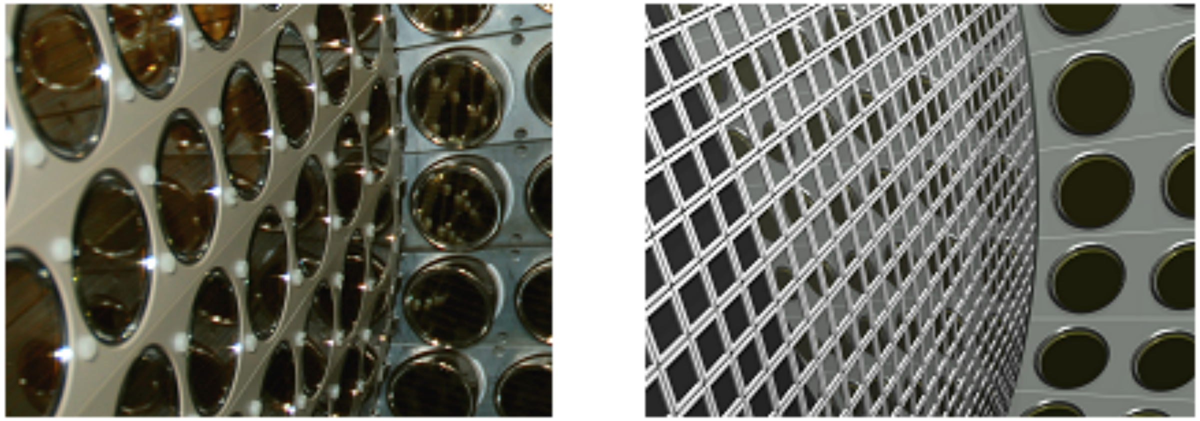
Upgraded MEG





LXe Detector

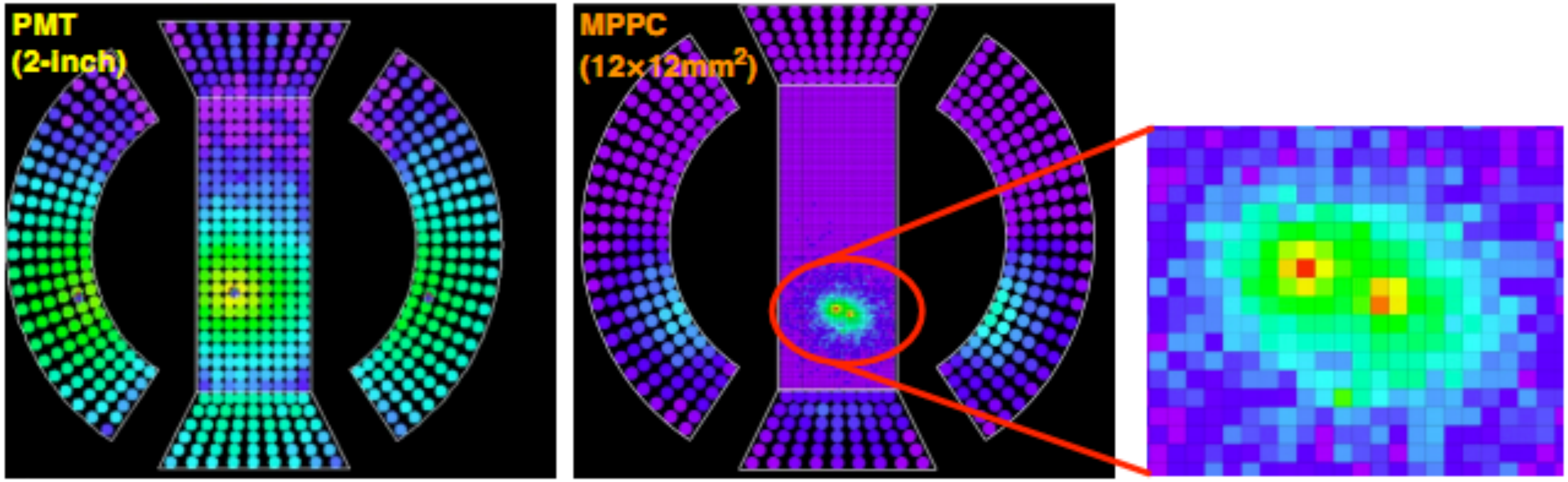
- finer photon sensors at entrance face
- better uniformity - better resolution
- better handles for pile ups



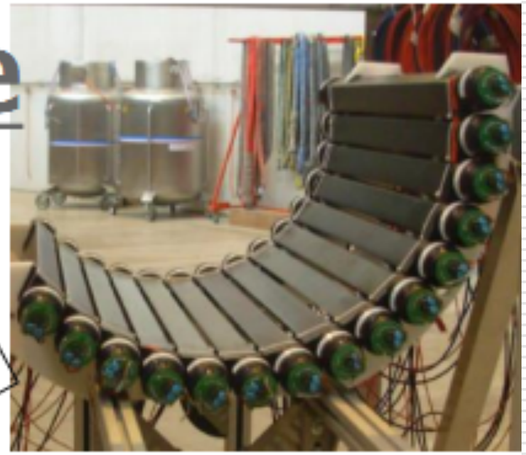
(a) Present detector

(b) Upgraded detector (CG)

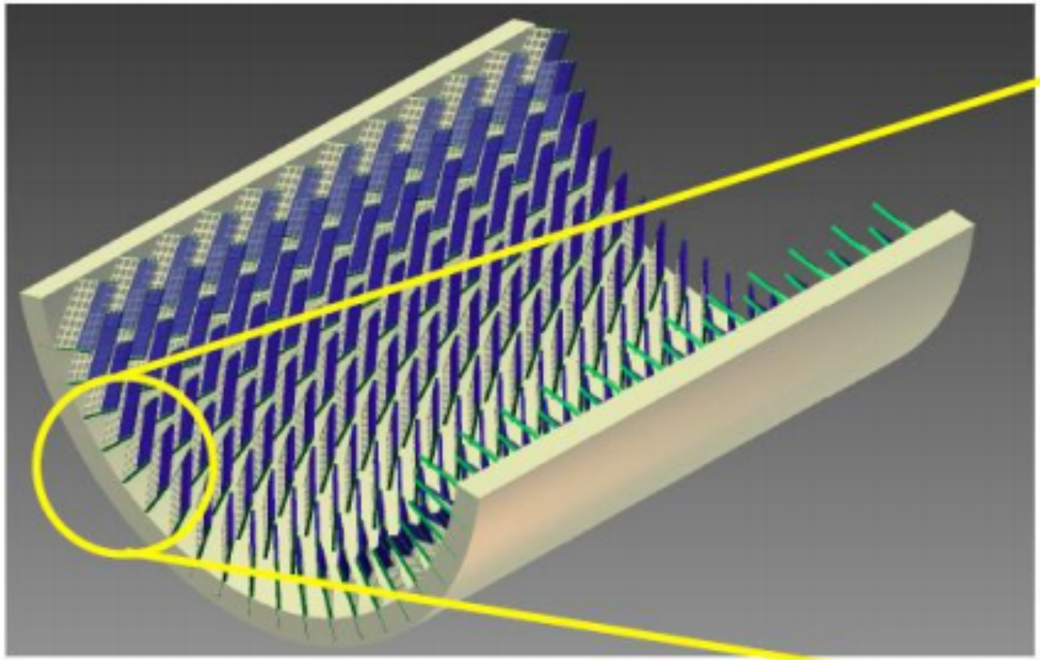
LXe detector proved to work at 10^8 muons/s w/o pileup issues

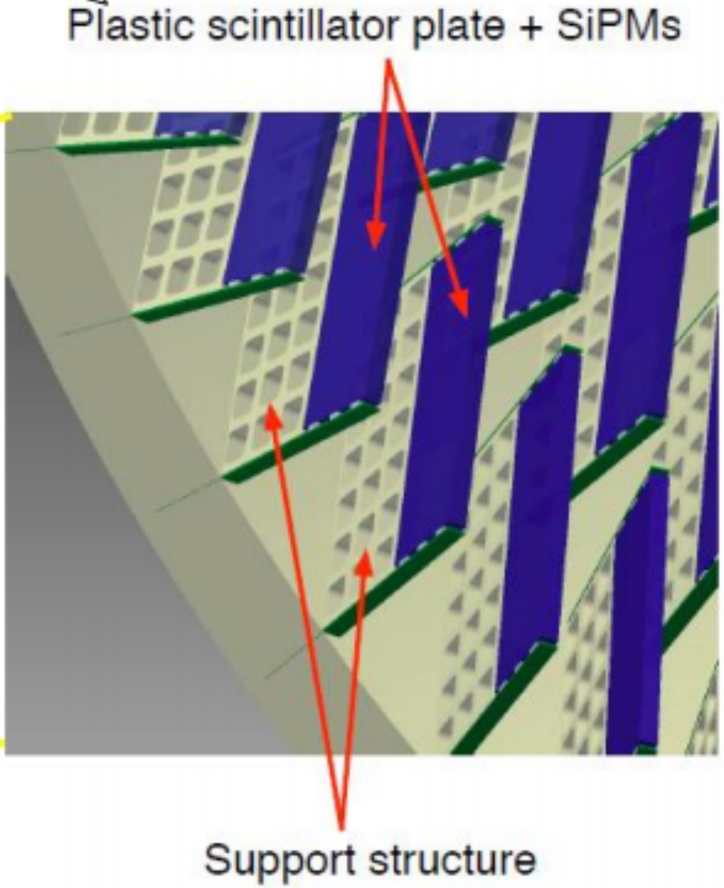


Concept of TC upgrade

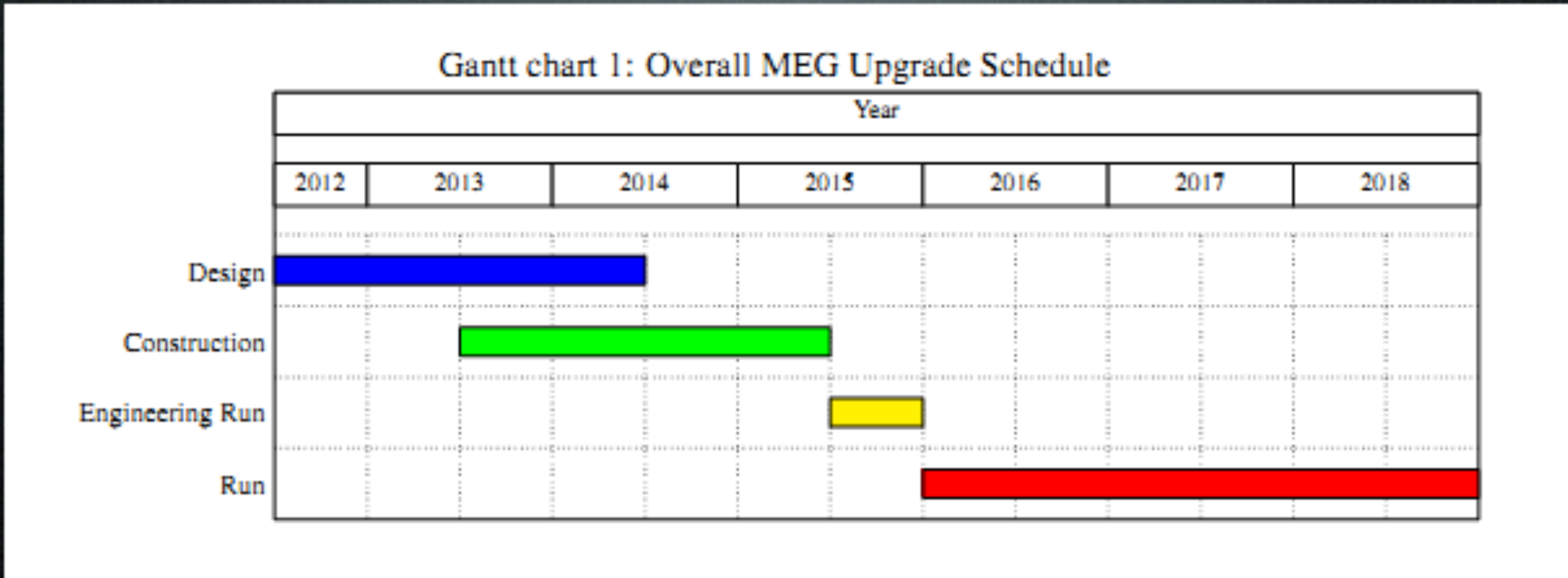


- **Pixelated scintillator detector**
  - Small scintillator plates
  - Several hundreds of counters
  - Readout by SiPMs



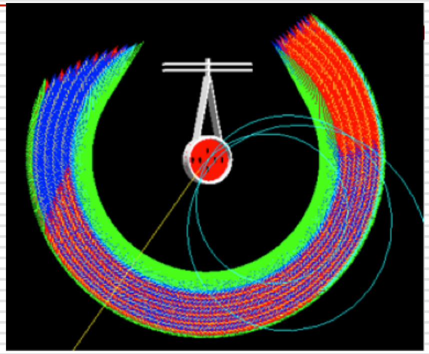


Time Line of Upgrade

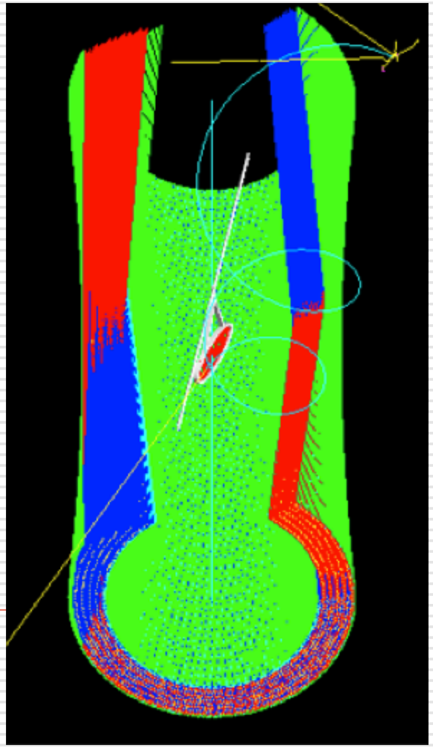


New e^+ spectrometer: Drift Chamber

- We selected the following detector:
  - single volume gaseous detector
  - cylindrical shape with longitudinal wires
  - U–V stereo for hit positioning along the chamber axis
  - low mass gas (He : iC_4H_{10} – 90:10)
  - thin wires and small cell size



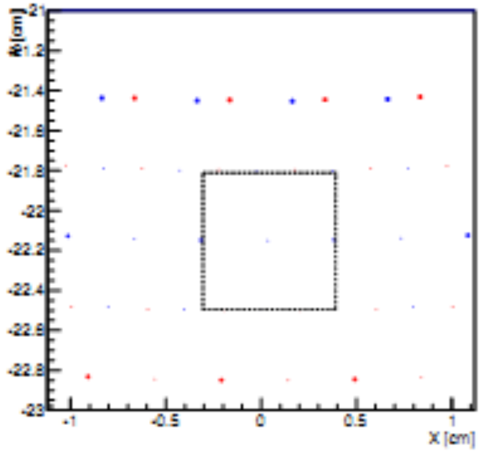
- Performances:
  - Single hit resolution ≤130 mm in r (proven exp.)
  - Momentum resolution ~130KeV (MC simulation)
  - Angular resolution ~5 mrad (MC simulation)
  - DC-TC matching eff. ~ 90 % (MC simulation)

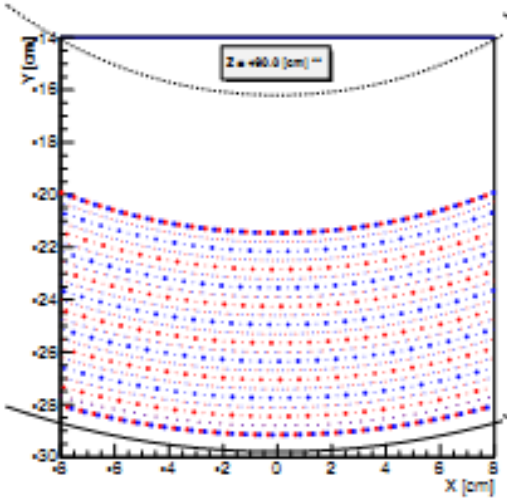


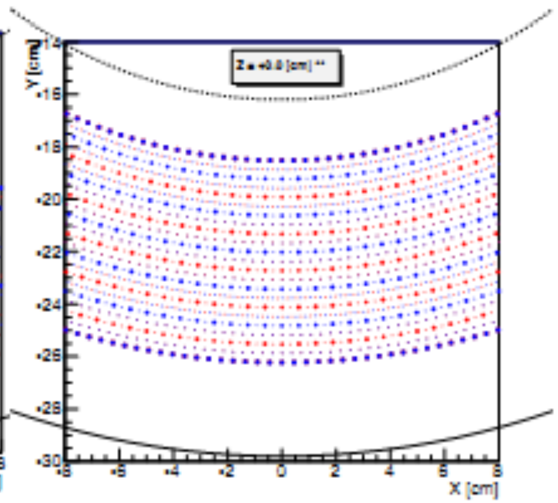
Geometry

Starting configuration

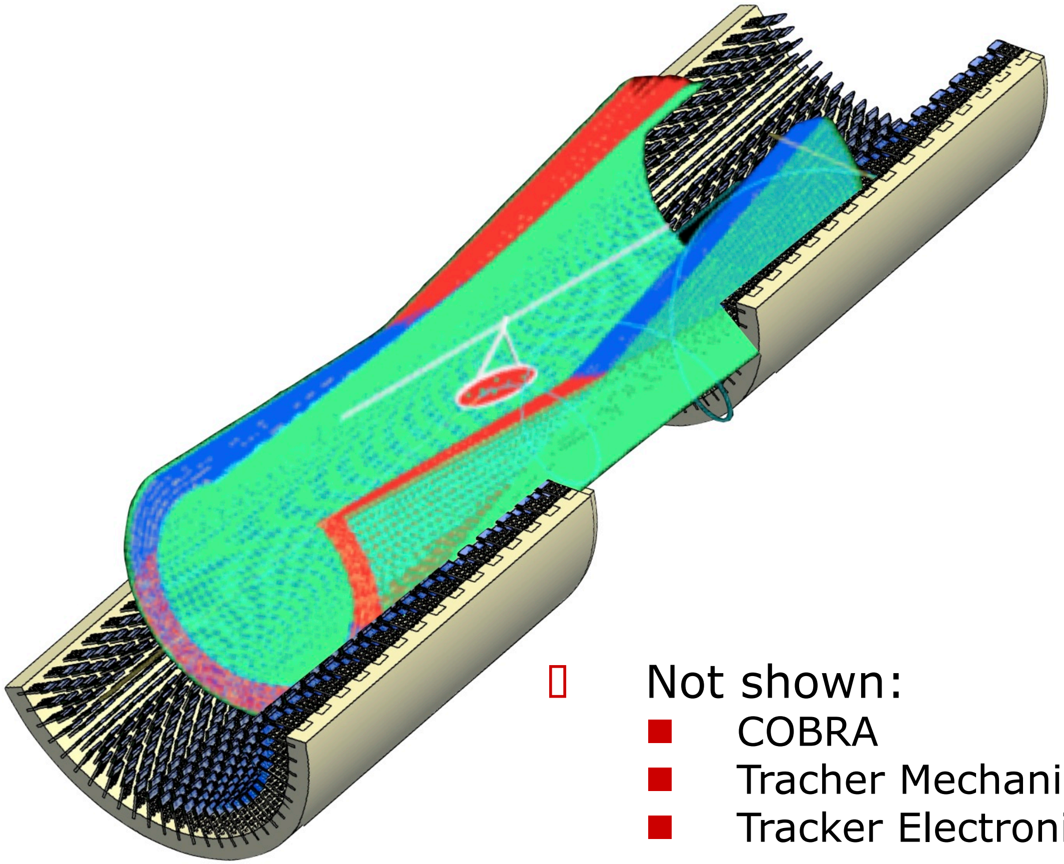
- 10 layers
- Square projective cells of 0.7 cm
- Stereo angle of ~ 8 deg with respect to Z
  - Z resolution ~ 7 time the transverse resolution
- 25 and 40 μm anode and field wires
- He / iC_4H_{10} mixture at 90/10 ratio
- Total length 180 cm
- Outer radius 29.2 cm
- ~1380 anode wires
- ~7500 field wires







Pictorial view of positron spectrometer

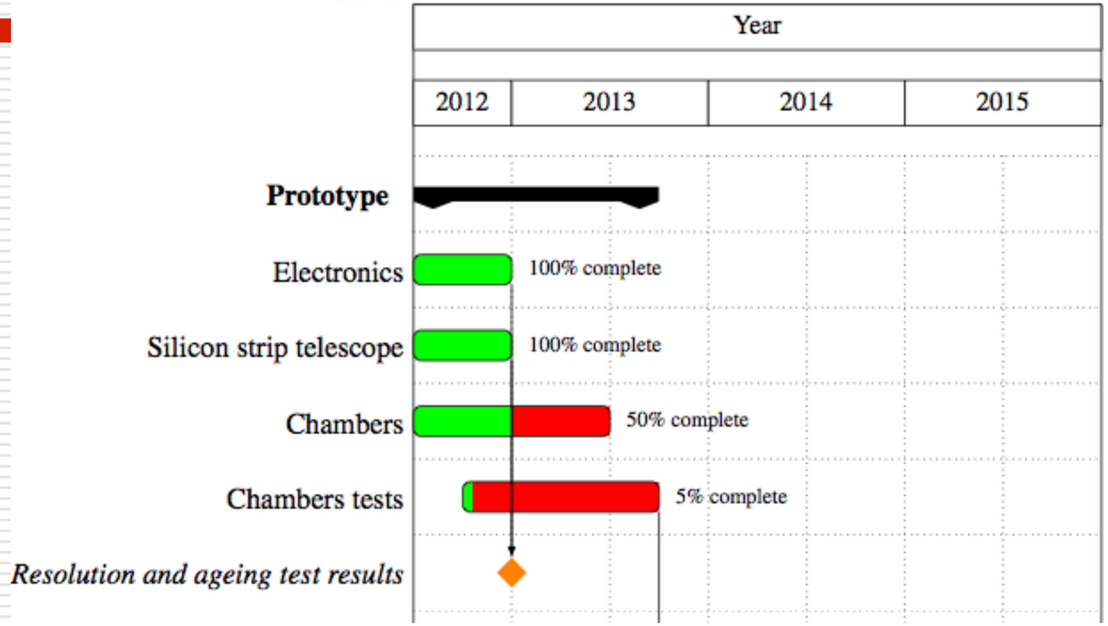


- Not shown:
  - COBRA
  - Tracher Mechanics
  - Tracker Electronics

Key elements

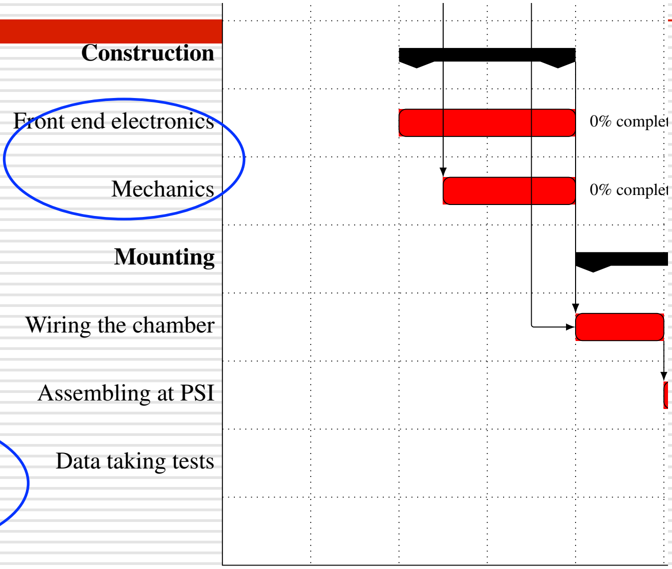
- Benefit from past experience and know how
  - similar chambers were already successfully operated for many years
  - new assembly technique has been defined and proved
- Use or reuse of existing infrastructures
- Work in parallel
  - PSI
  - INFN – Lecce
  - INFN – Rome
  - INFN - Pisa

Schedule and milestones



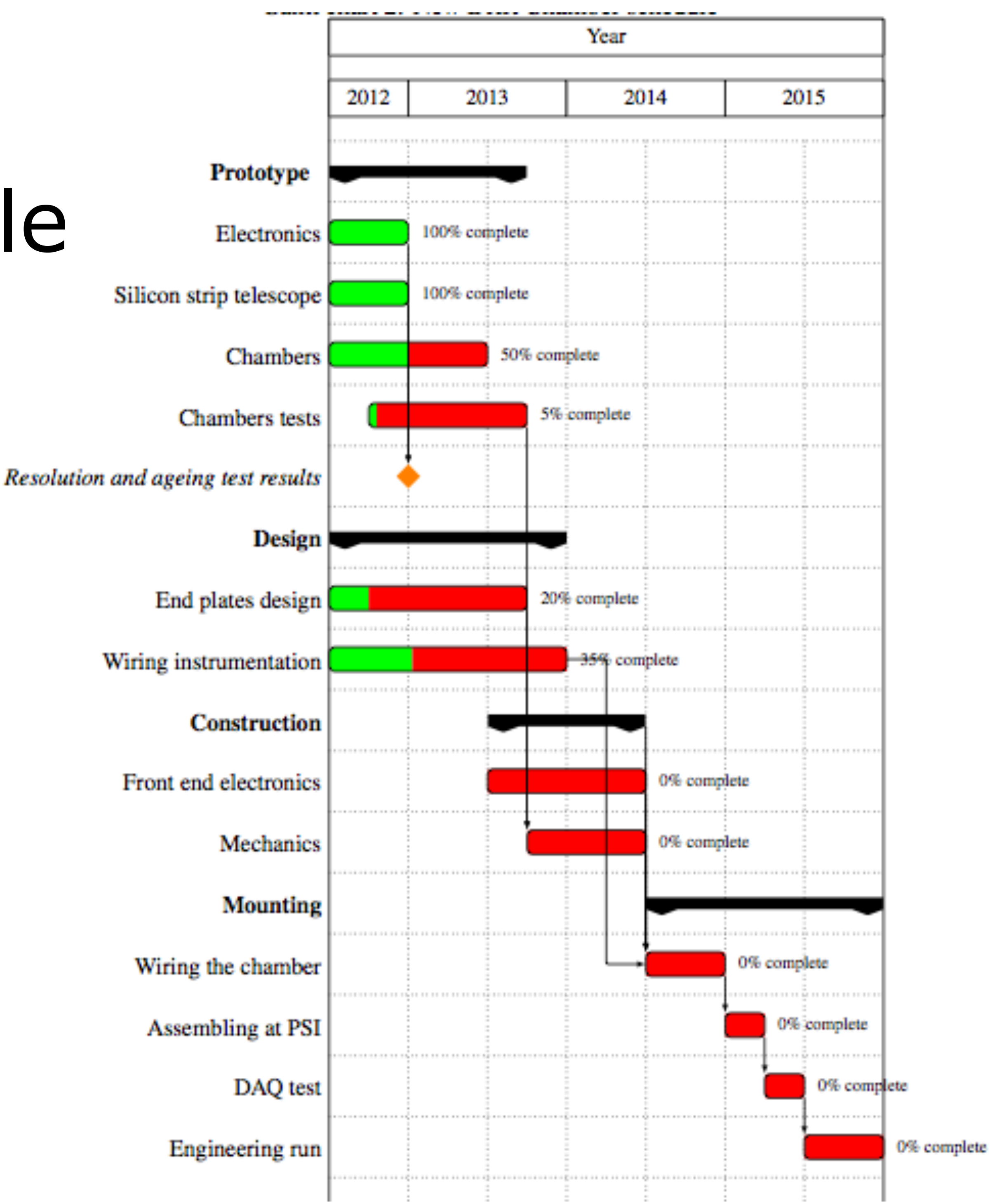
- Prototypes
  - Short prototypes for hit resolution (Rm, Le, Pi)
  - Si telescope for high precision traking (Pi)
  - Simple prototype for ageing (Pi)
  - Long prototype to validate wire selection and mounting (Pi-Le)
  - “complex” prototype for valdation of construction procedure (Le)
  - Mechanical prototype to compare End-Plates structure (le-Pi)

New year commitments



Full schedule

- Internal milestones
  - 10/2013 end of prototyping phase and end-plate design completion
  - 06/2014 ready for assembly
  - 04/2015 shipment to PSI
- Contingency
  - 06-09/2015 start of test run



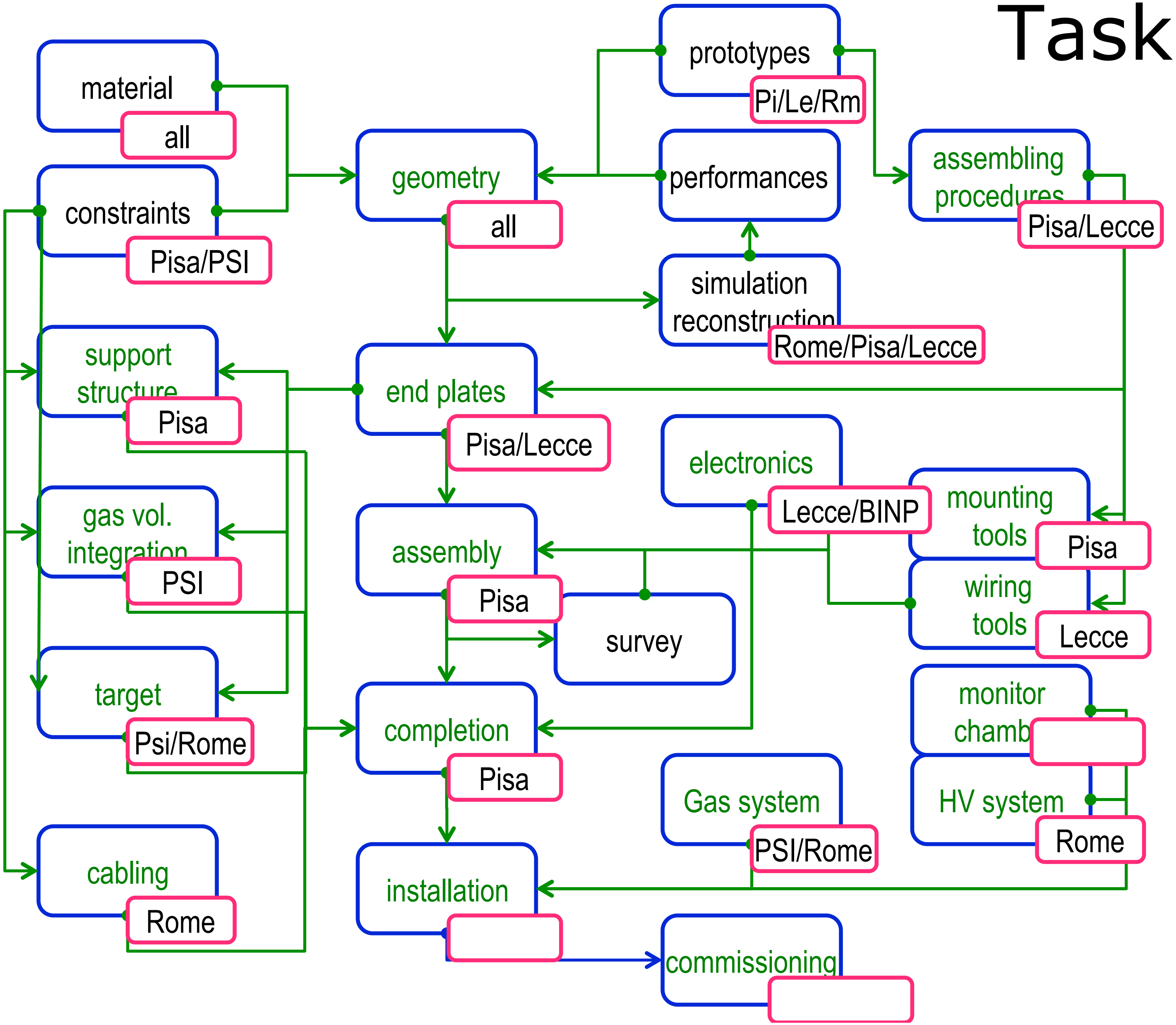
Tasks: prototypes

Several prototypes dedicated to answer specific questions

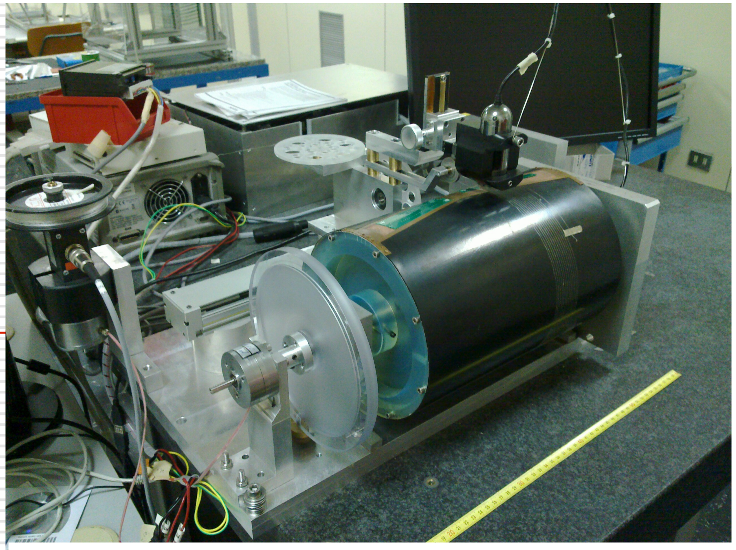
- Existing prototypes
  - Single hit resolution
    - Rome 8x8 chamber
    - Lecce tri-tube
    - Lecce large chamber (Mu2e)
  - Ageing
    - Pisa prototype
  - Mounting procedure
    - Lecce large chamber (Mu2e)
  - FE electronics
    - Single, 6 channels, 10 channels differential

- Other prototypes
  - Charge/Time division
  - Wire type and cell stability
    - Full lenght simple prototype
  - End-plate structure
    - MEchanical prototype
  - FE electronic
  - HV system
    - Custom vs. commercial vs. PSI solution
  - Final mounting procedure
    - Single ended with cabling

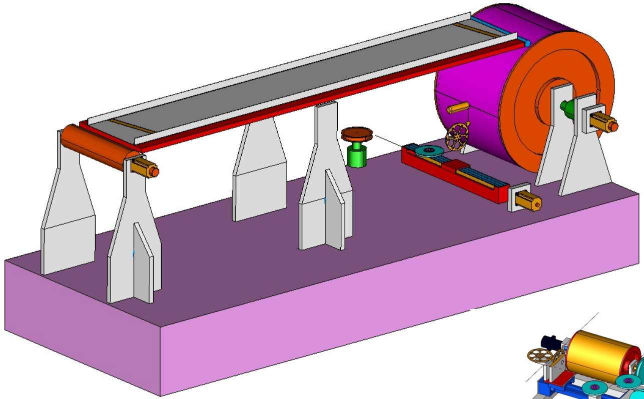
Tasks


material
all
constraints
Pisa/PSI
geometry
all
prototypes
Pi/Le/Rm
performances
simulation
reconstruction
Rome/Pisa/Lecce
assembling
procedures
Pisa/Lecce
support
structure
Pisa
end plates
Pisa/Lecce
electronics
Lecce/BINP
mounting
tools
Pisa
wiring
tools
Lecce
gas vol.
integration
PSI
assembly
Pisa
survey
target
Psi/Rome
completion
Pisa
monitor
chamb
HV system
Rome
Gas system
PSI/Rome
cabling
Rome
installation
commissioning

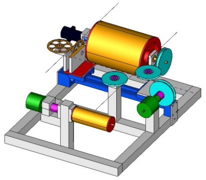
Wiring robot parts procurements



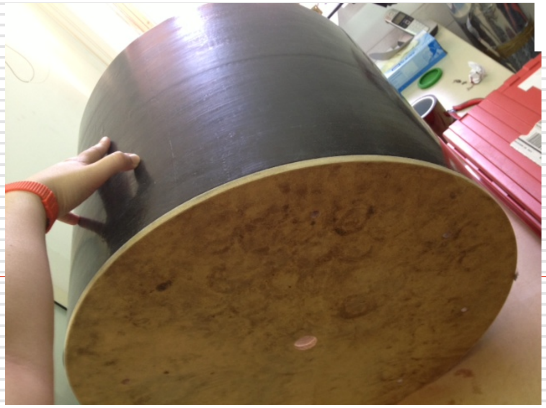
- Recycling parts from Mu2e prototype wiring robot: rotating axis, translation axis, torquemeter, e.m. friction, e.m. brake, digital microscope, monitoring system → **done**



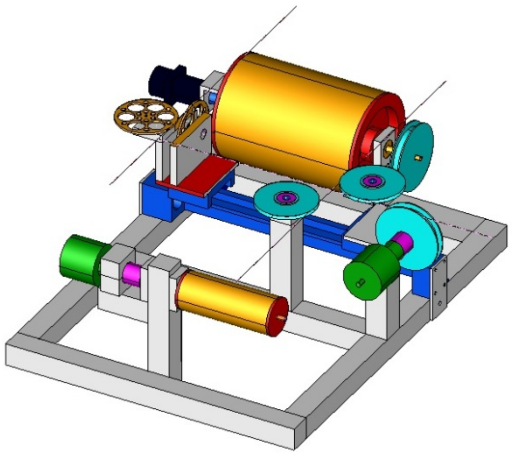
- New parts: winding drum → **to be refurbished**



- Wire trays transport system → **design in progress**

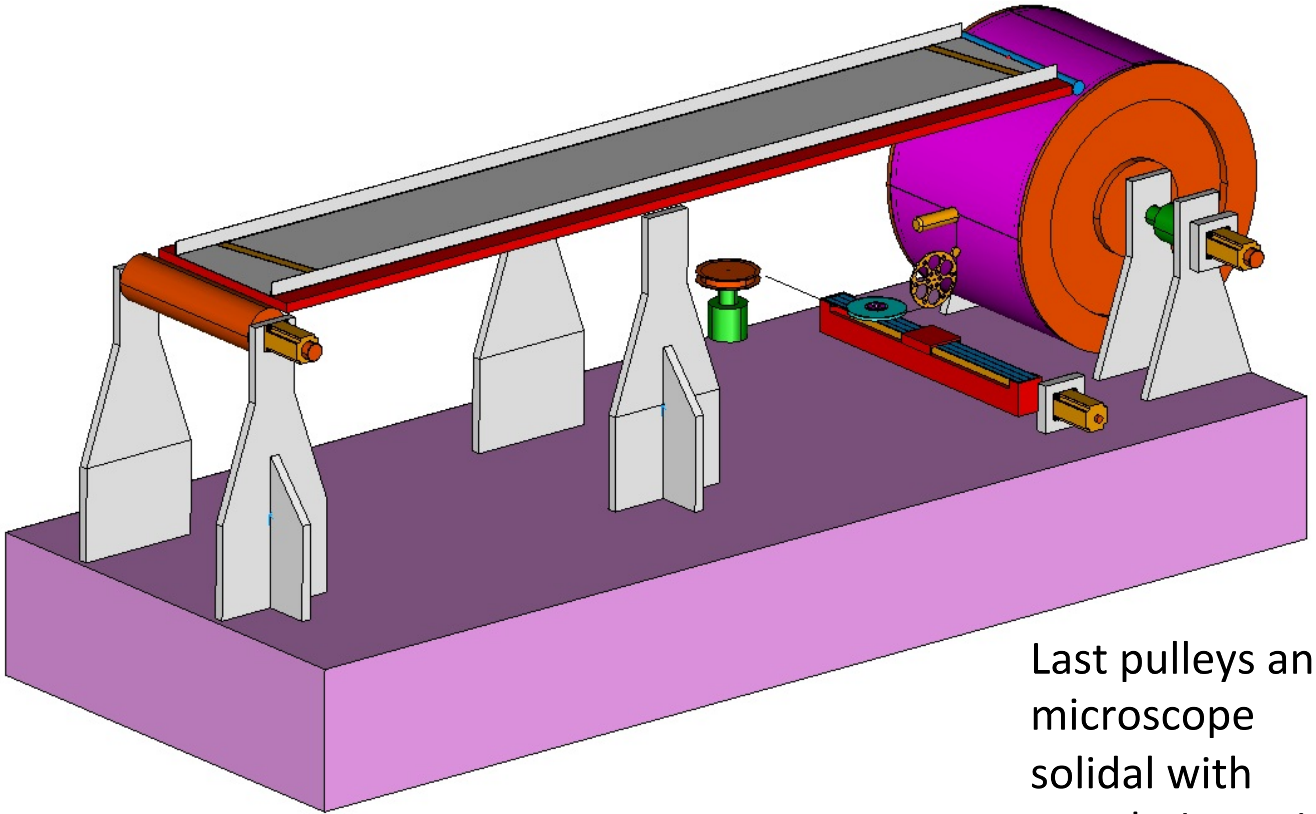


- New mechanical supports → **to be designed and machined**

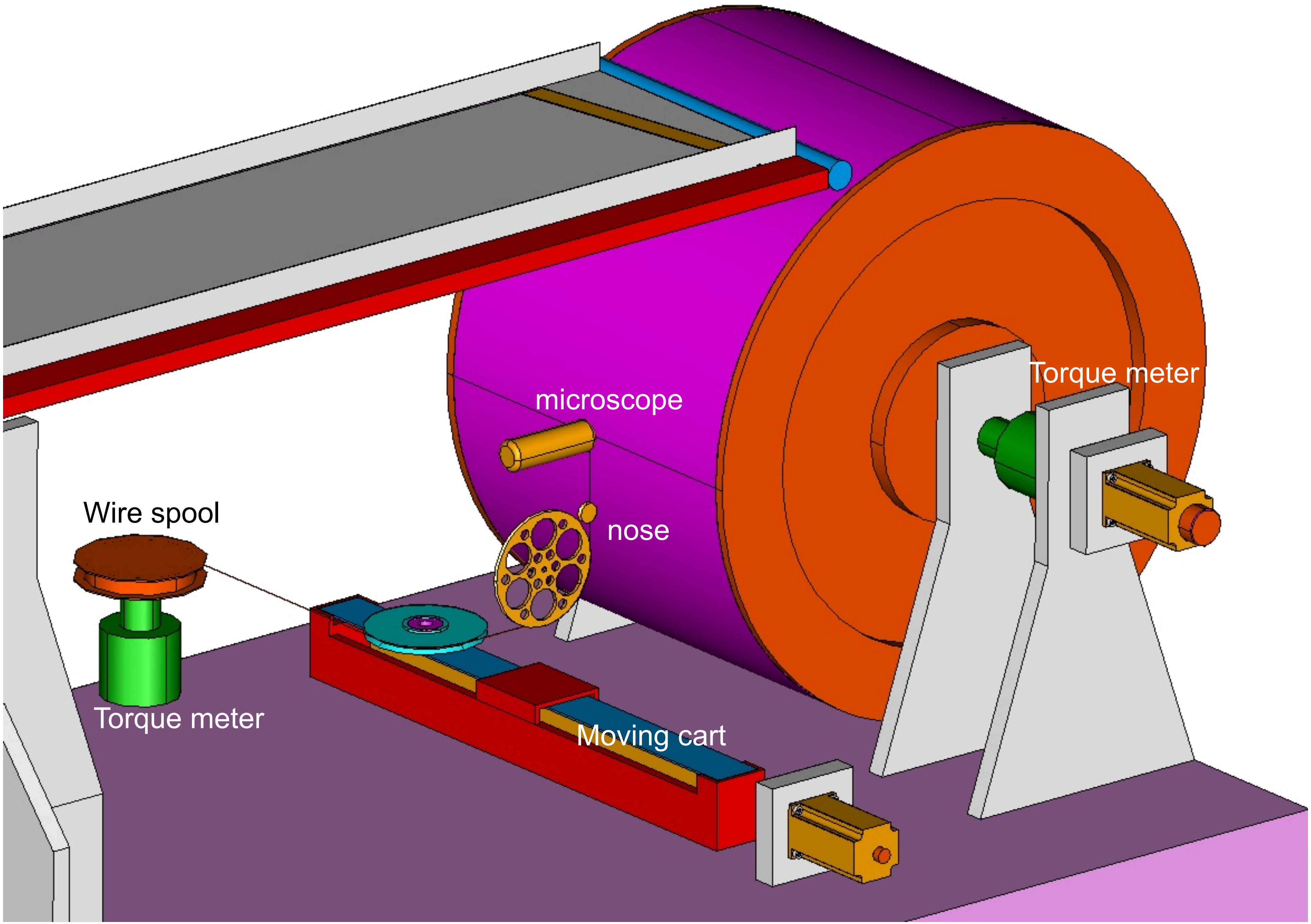


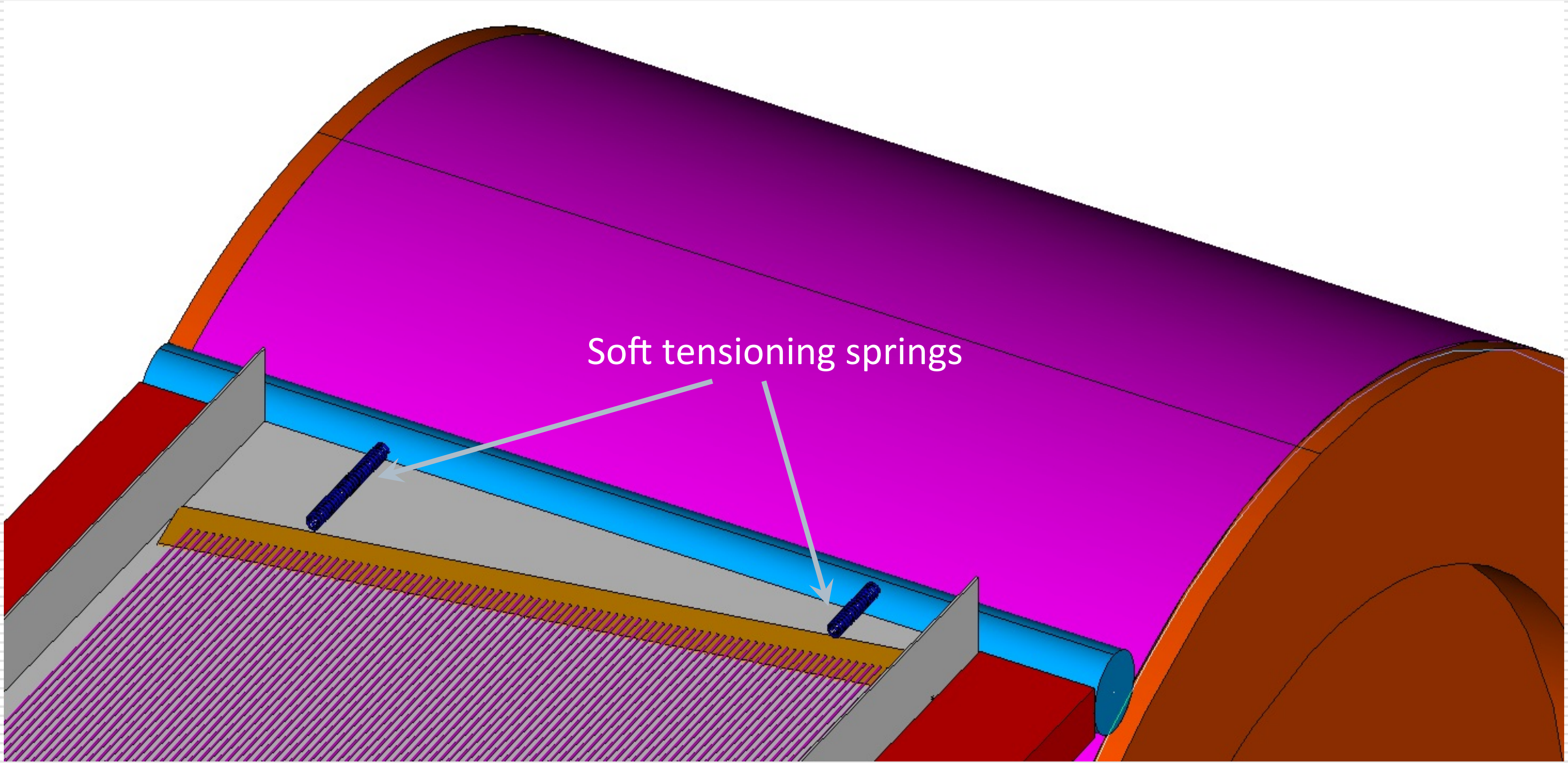
Old System

New system

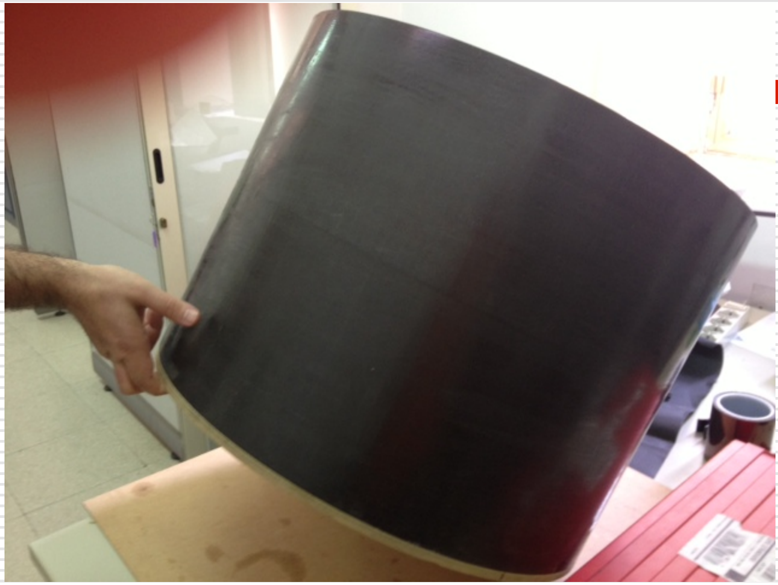


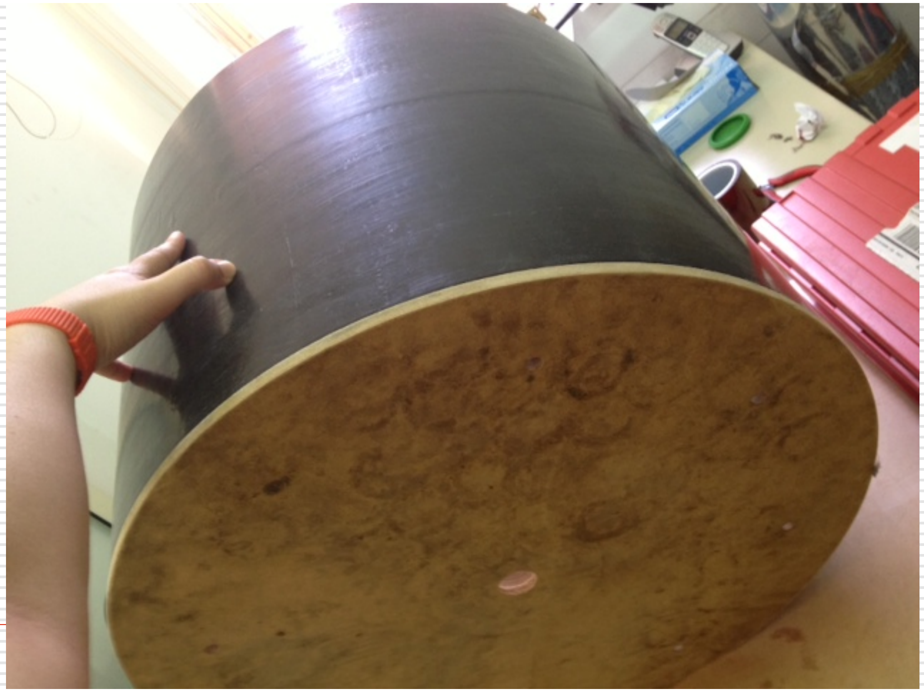
Last pulleys and microscope solidal with translation axis


Torque meter
microscope
nose
Wire spool
Torque meter
Moving cart


Soft tensioning springs

Carbon fiber cylinder





Wires

- **Order placed**:
  - 6000m Al-Ag plated ø 40μm (0.0016”)
  - 1500m Al-Ag plated ø 50μm (0.0020”)
  - 1500m W-Au plated ø 20μm (0.008”)
- Delivery: End of September (unfortunately partial delivery not allowed)

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73100 LECCE (LE)
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Fax : +39 0832.325128

e-mail : prot@le.infn.it

Purchasing order n. 635 del 24-MAG-13
(Please refer to this number in all future communications)
Your reference
Vendor Code INFN: 710717
Our reference **CIG ZAC09FD438**

CALIFORNIA FINE WIRE COMPANY
338 SOUTH FOURTH STREET P.O.BOX 446
- GROVER CITY CA 93433 STATI UNITI D'AMERICA

We are hereby placing our formal order for the following items:

Short Description: **FILI PER PROTOTIPO DI CAMERA A DRIFT DI MEG**

QUANTITY	DESCRIPTION	DISCOUNT	%	UNIT PRICE	AMOUNT
6000	0.0016 ALUMINIUM 5056 SILVER PLATED 12 MICRO INCHES			2,66	15.960,00
1500	0.002 ALUMINIUM 5056 SILVER PLATED 12 MICRO INCHES			3,50	5.250,00
1500	0.0008 TUNGSTEN GOLD PLATED 3-5%			0,88	1.320,00
				TOTAL USD :	22.530,00

PLACE OF DELIVERY	Via Arnesano 73100 LE IT
DELIVERY TERMS	30 Giorni
METHOD OF SHIPMENT	At your charge
PAYMENT CONDITIONS	60 DAYS I. D. Please, specificy the bank details code in the invoice.
SUBCONTRACTS	Subcontracting all or part of this contract is not permitted without formal authorization of INFN
JURISDICTION	Any dispute relating to this contract is competent in the esclusive the Forum in Rome
APPICABLE LAW	The supply must be in accordance with existing legislation on safety at work

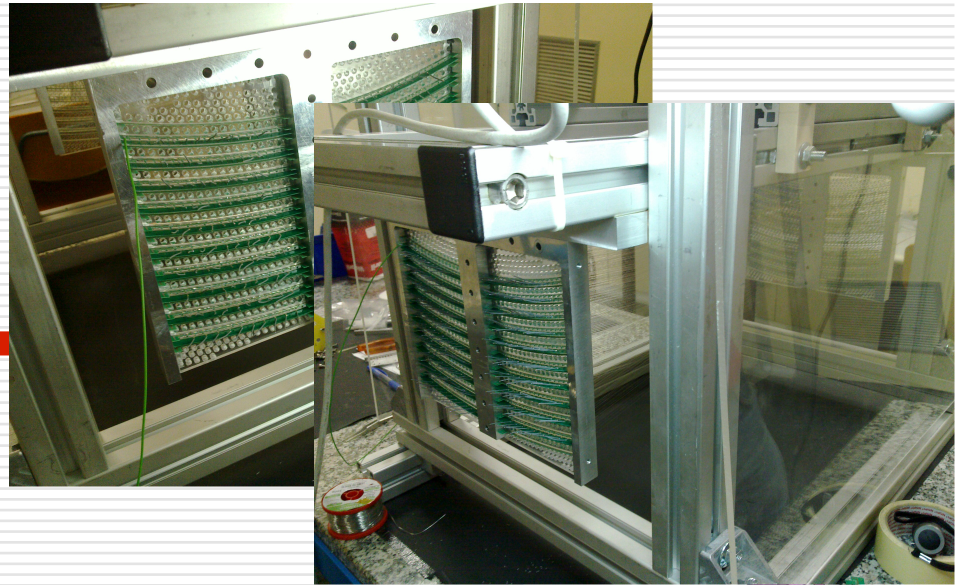
PROCEDURE MANAGER FIORE GIUSEPPE **E-Mail Address fiore@le.infn.it**

IL RESPONSABILE AMMINISTRATIVO
RAG. CARLA GENTILE

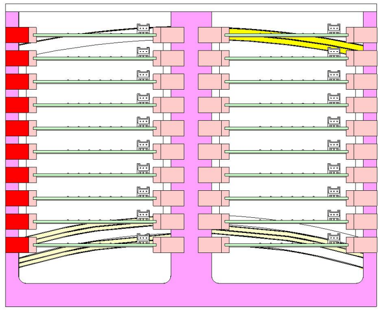
IL DIRETTORE
PROF. GIOVANNI MANCARELLA

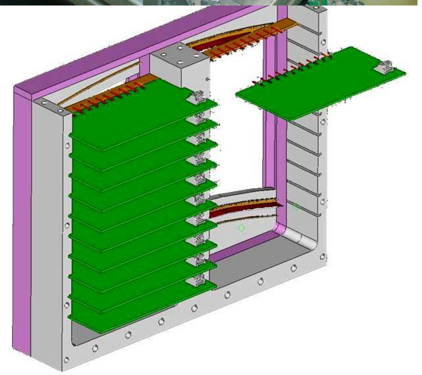
GESTIONE	ESERCIZIO	GRUPPO	ESPERIMENTO	CAPITOLO	IMPORTO
CP	2013	LE	MEG	U212_520910	17.413,44

Mu2e prototype

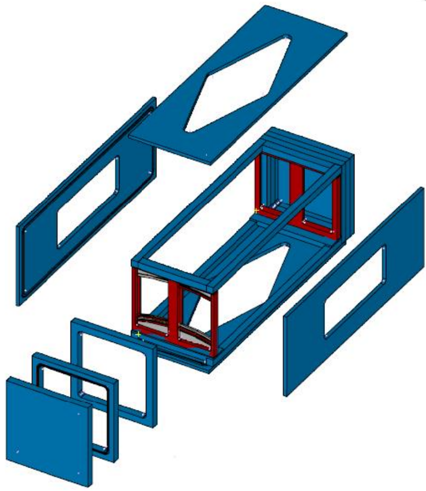


- Wiring: → **completed**



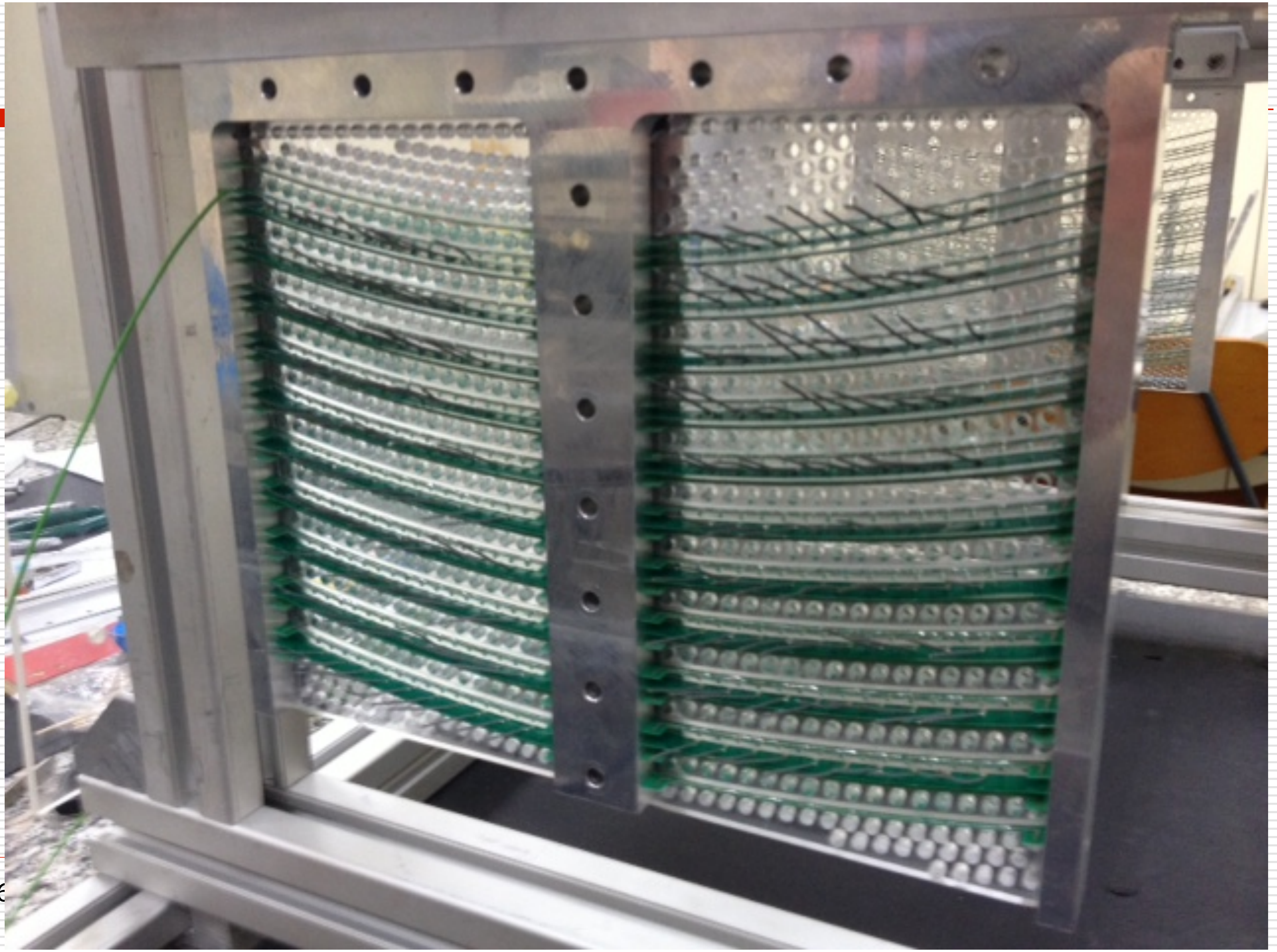


- Front-end and HV cards supports: → **completed**

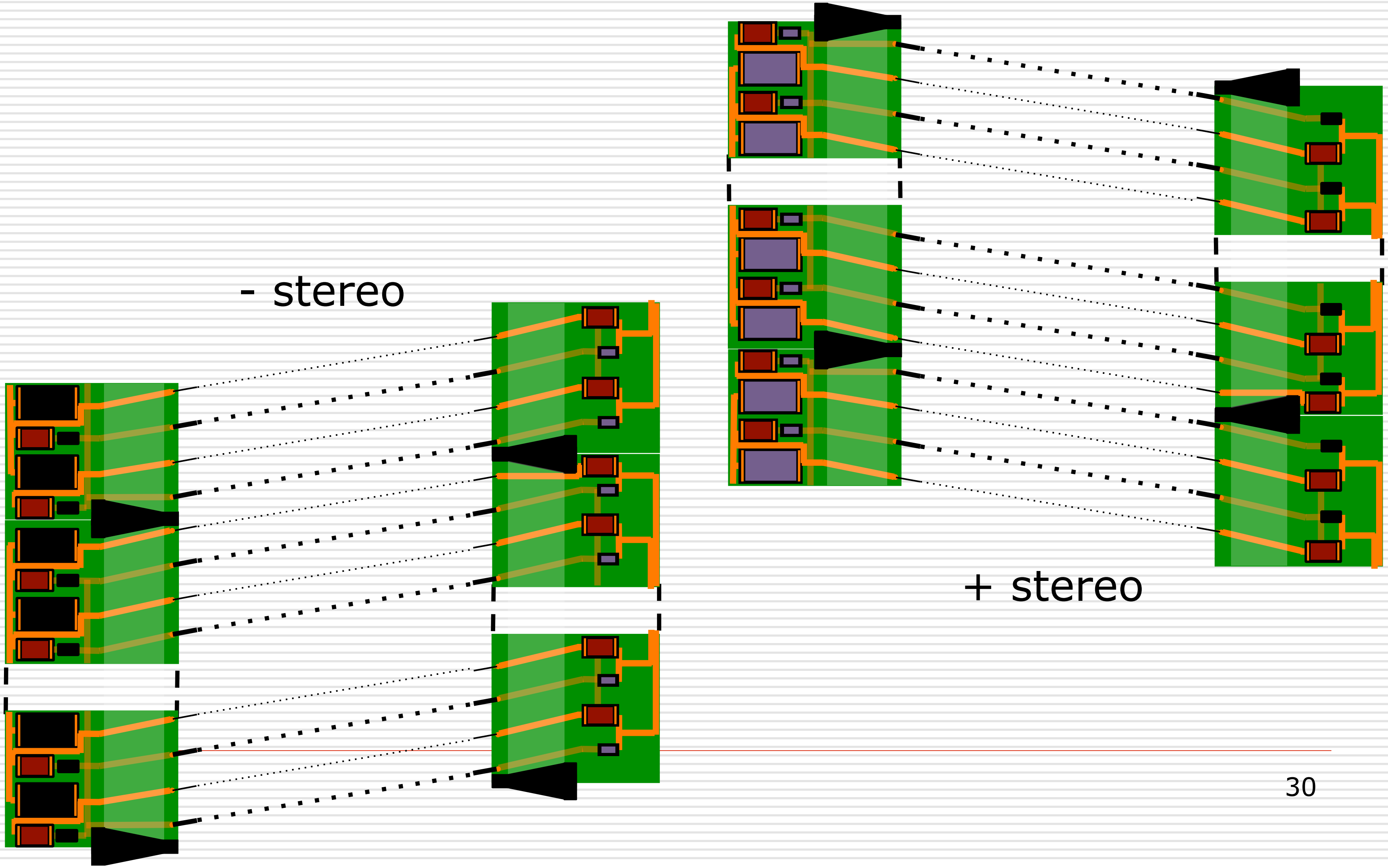


- Gas envelope box: → **in progress**

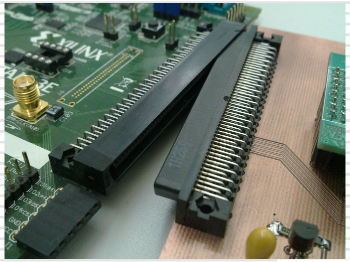
Wiring and connection complete
Waiting for interfacing PC-boards to front-end



Sense/Field wires boards

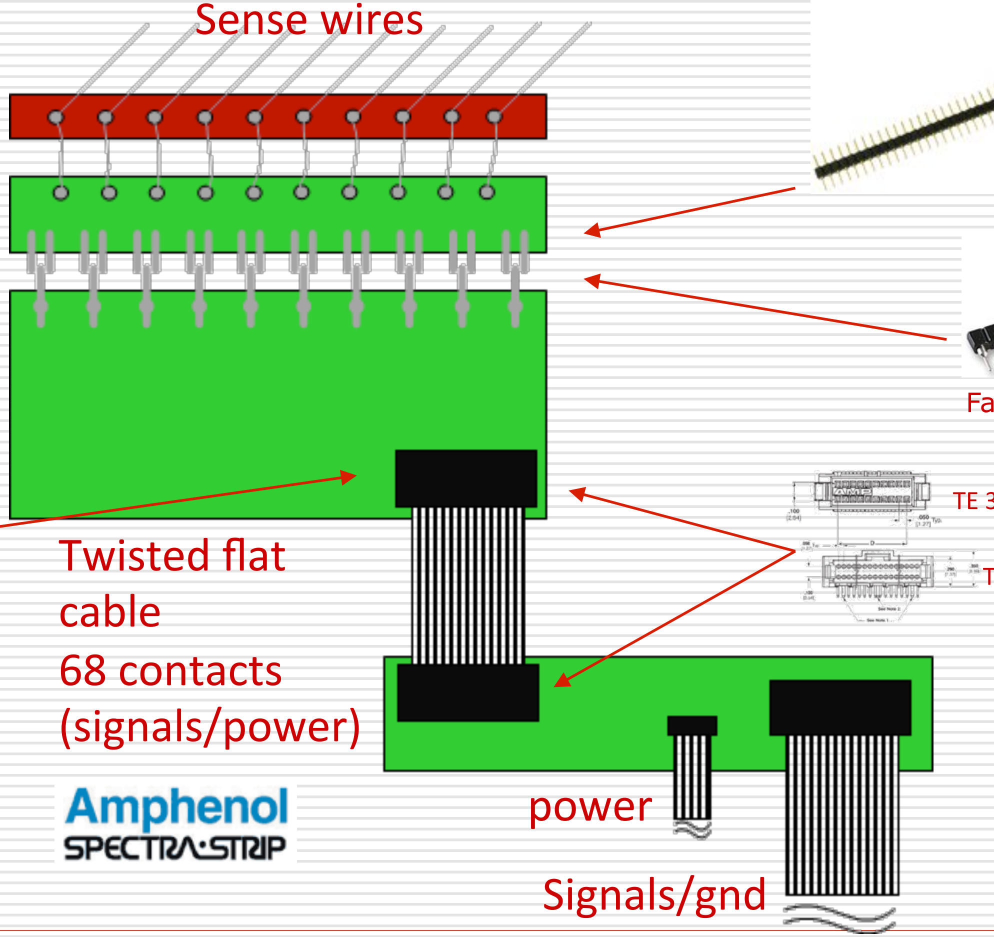


Mu2e prototype FrontEnd Cabling



alternatively :
HRS FX2 Series

Sense wires



Twisted flat
cable
68 contacts
(signals/power)

Amphenol
SPECTRA-STRIP

power

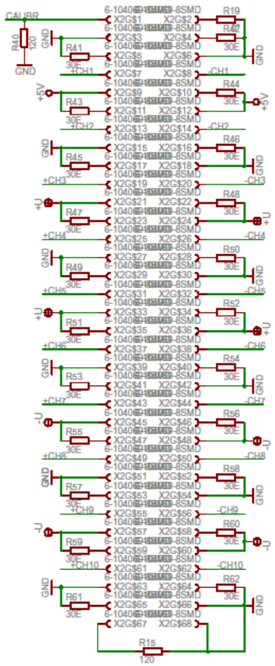
Signals/gnd

Farnell 1925201

Farnell 1218870

TE 3-111196-4

TE 6-104069-8



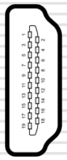
Wire signals/
power
distribution

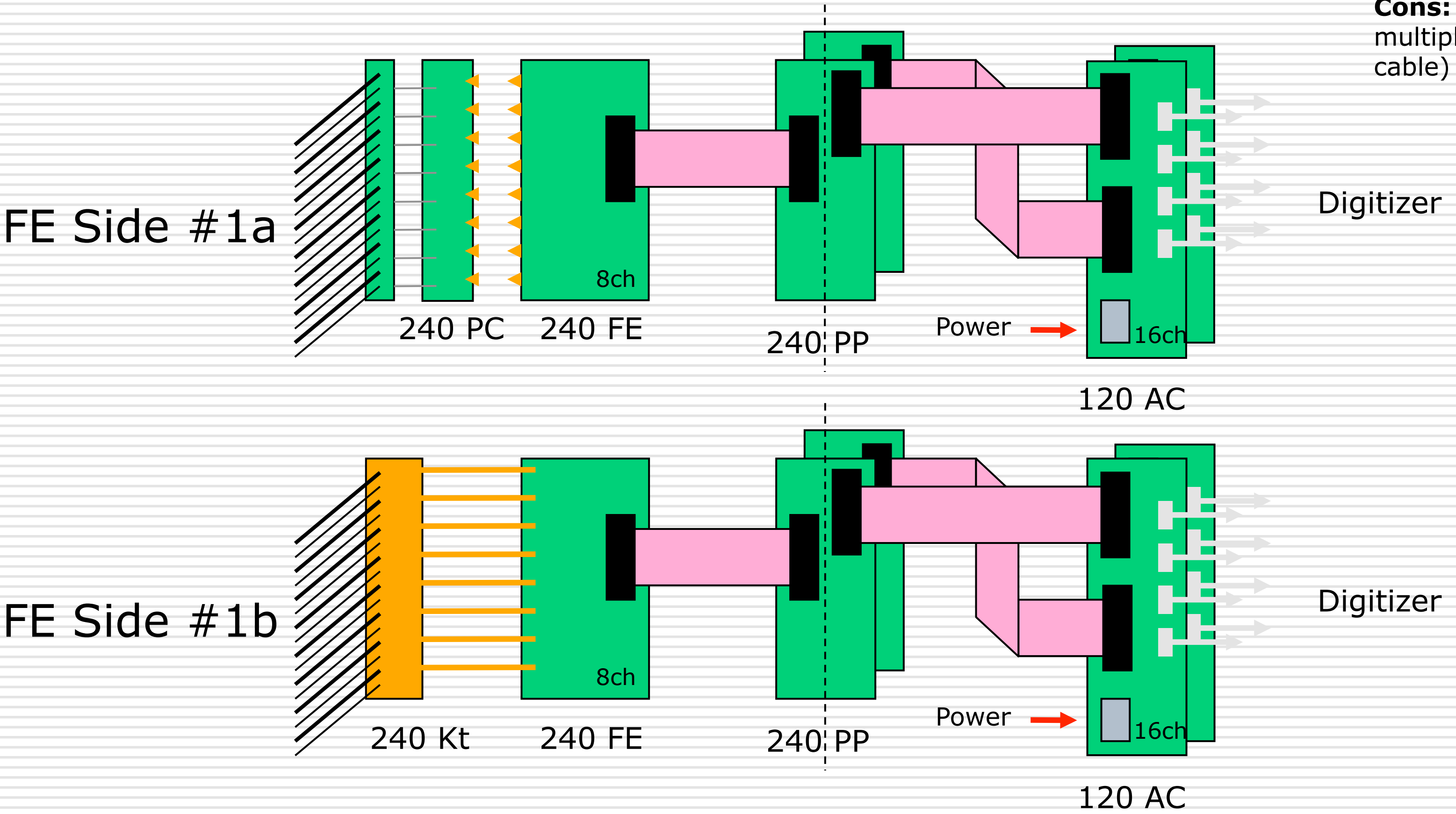
FE Side #1

HDMI standard

Pros: high speed (3.4GS/s), cheap

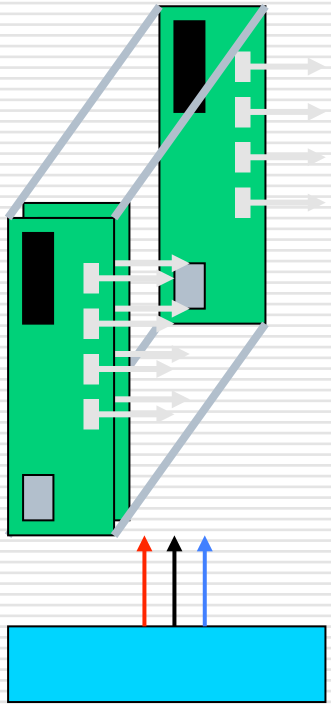
Cons: Low multiplicity (4ch/ cable)





Power supply

$\boxed{Ch := 1920}$		canali
$P := 200\,mW$		Potenza per alimentazione del canale
$V_{ch} := 3V$		tensione di alimentazione
$I := \frac{P}{V_{ch}}$	$I = 66.667\,mA$	corrente assorbita per canale
$Slot := 20$		slot AC (una usata per servizio)
$Ch\_dig := 16$		canali per AC
$Slot \cdot Ch\_dig = 320$		canali per crate
$\frac{Ch}{(Slot \cdot Ch\_dig)} = 6$		numero crate
$Slot \cdot Ch\_dig \cdot P = 64W$		potenza per alimentazione del crate
$fc := 1.2$		fattore di sicurezza
$I \cdot (Slot \cdot Ch\_dig) \cdot fc = 25.6A$		corrente per alimentazione del crate
$25 \cdot 3 \cdot 2 = 150$		
$N_c := 2$		alimentatori per crate
$I \cdot (Slot \cdot Ch\_dig) \cdot fc \cdot V_{ch} \cdot N_c = 153.6W$		potenza per crate



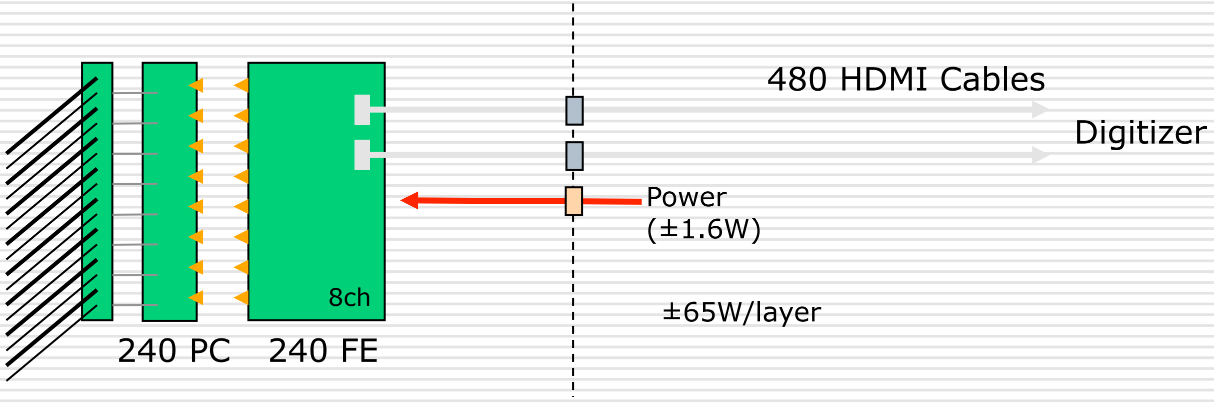
20+1 slots crate
320 Ch's

±3V / 25A
Power Supply

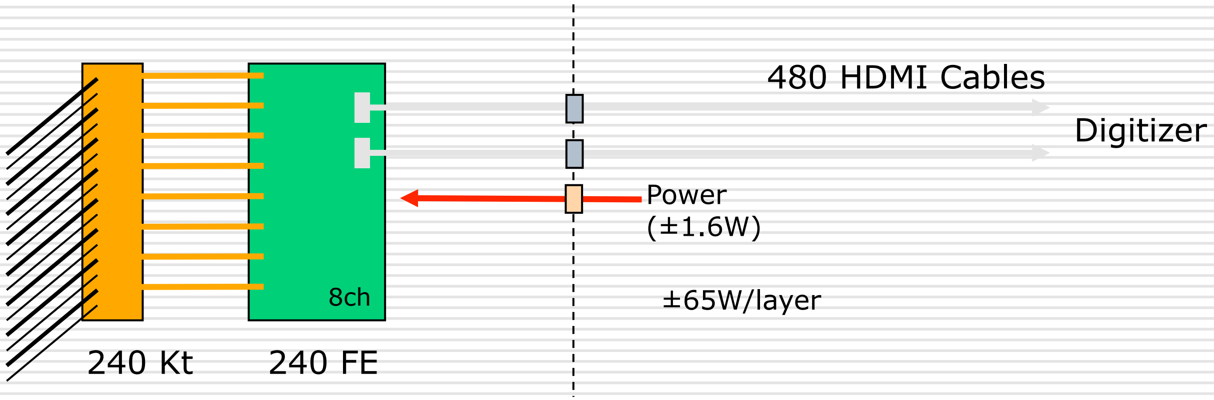
6 crate
150W/crate

FE Side #2

FE Side #2a

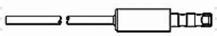


FE Side #2b

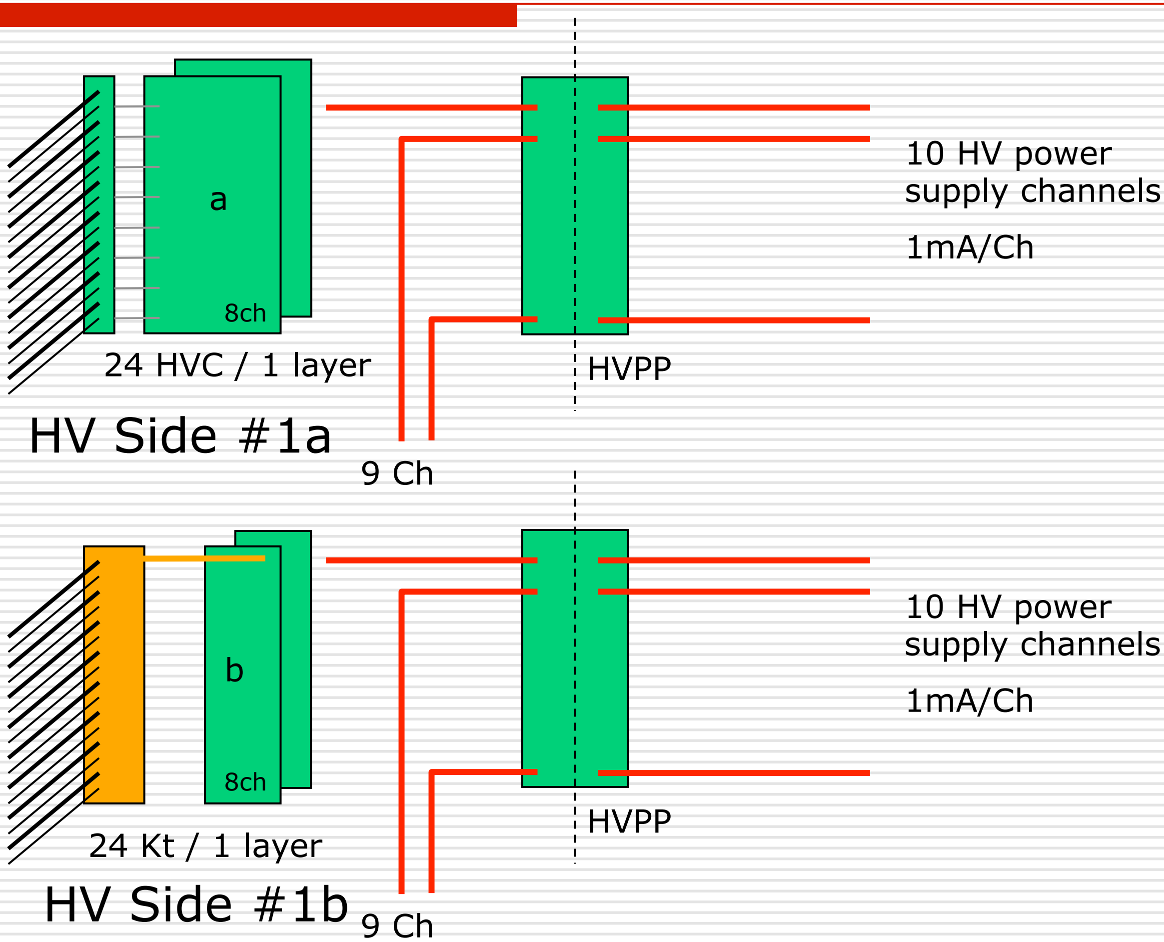


HV Side

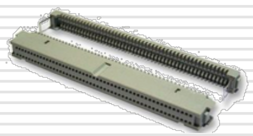
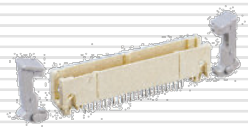
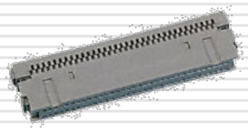
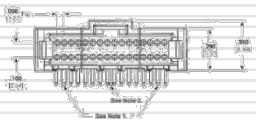
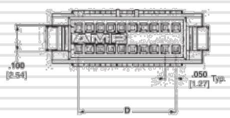
TE 1218055-1
LGH Micro-Miniature Connectors and
Cable Assemblies

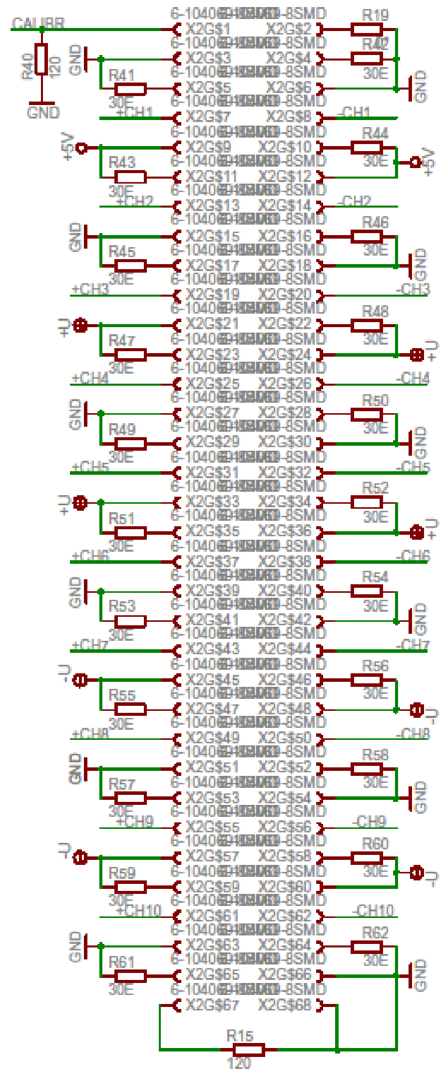


TE 1218147-1
LGH Micro-Miniature Connectors and
Cable Assemblies

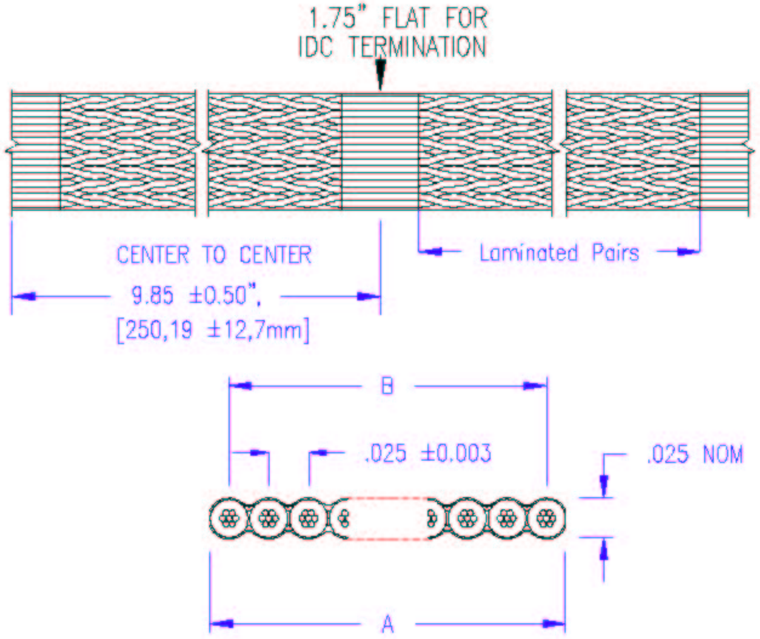


Card connector

Male on PCB	Female on PCB
	
3M 81068-520203	3M 82068-6000RB
	
3M 81068-600203-RB	3M 82068-6000RB
	
TE connectivity 6-104069-8	TE connectivity 3-111196-4



Flat cable



CROSS SECTION THRU FLAT

Part Number	Count	Pairs	A Span	B Span
125-3097-998	68	34	1.701 NOM	1.675 ±0.010

PHYSICAL

Conductors:	30 AWG 7/38 Tinned Copper
Insulation:	.006" TPO
Color Code:	1st Pair Red/White followed by Orange/White and Repeat
Laminate:	Polyester
Temperature Rating:	80°C

ELECTRICAL

Impedance:	90 ±6 ohms [1]	122 ±5 ohms [2]
Capacitance:	17 pF/ft @ 1 MHz [1]	11 pF/ft @ 1 MHz [2]
Propagation Delay:	1.45 ns/ft	
Voltage Rating:	150 V	
Current Rating:	0.75 A	
DC Resistance:	106 ohm per 1,000 ft @ 20°C	

[1] Above values measured Single-Ended.

[2] Above values measured Differentially.

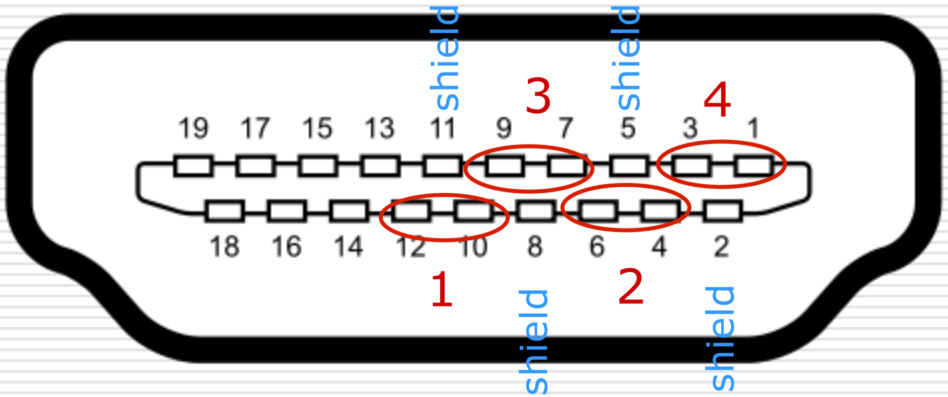
Approvals: UL AWM Style 20744
CSA AWM

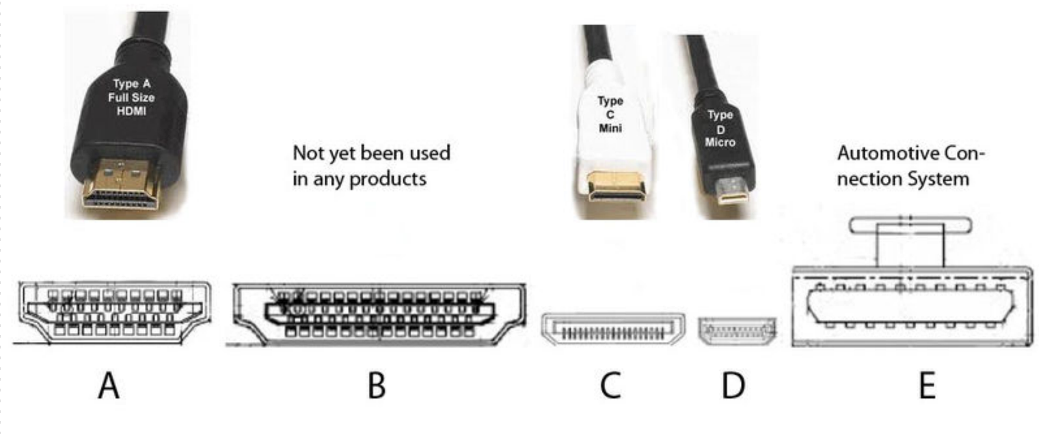
Print Legend: **Amphenol SPECTRA-STRIP**
UL® AWM 80C LL31941 CSA AWM I A80C 150V FT-1
30 AWG Stranded ULTRA 320 SCSI™ Compliant

All Dimensions in Inches, Unless Otherwise Noted

DRAWN	PROD ENG	QA	MKT	P/ECN#		DRAWING NO. 125-3097-998	AMPHENOL SPECTRA-STRIP	Rev F
FITTS 8/15/01						TITLE: .025" Twist 'N' Flat® Full Lamination, 30 AWG 7/38	720 SHERMAN AVE HAMDEN CT 06514 TEL (203) 281-3200 FAX (203) 281-5872	SHEET 1 of 1

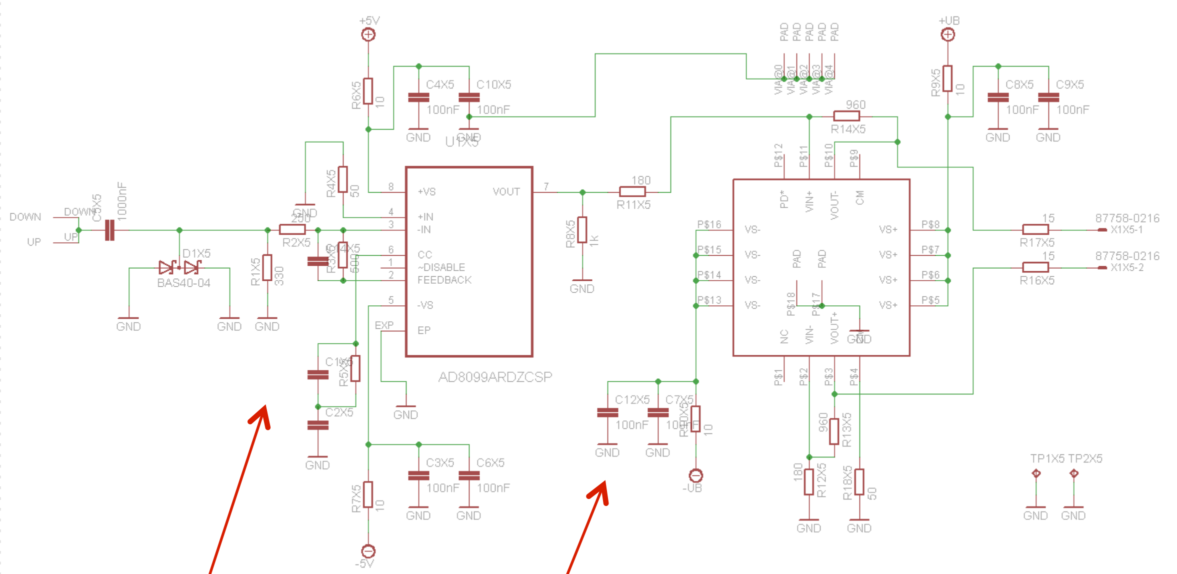
HDMI Connector (Type A)

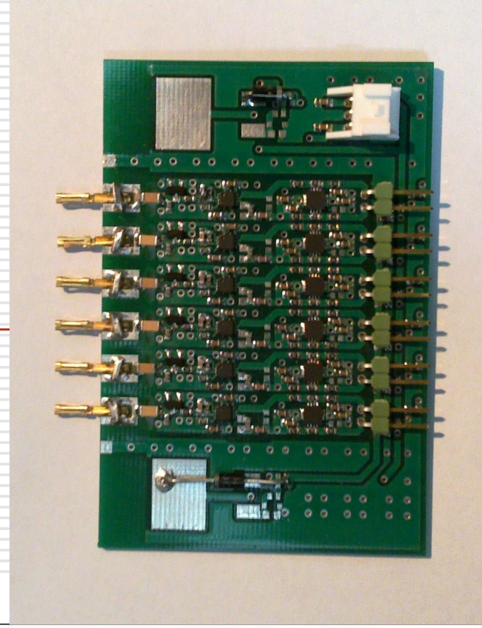


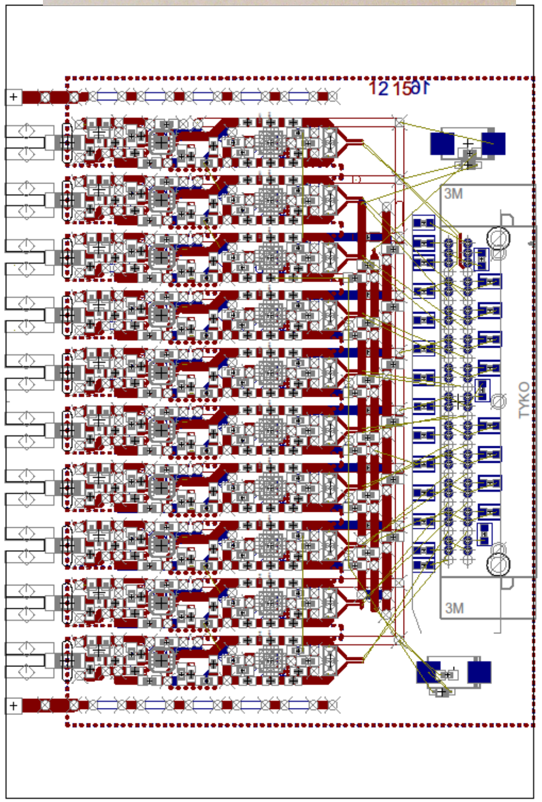


- Pros:
  - High speed (3.4GS/s)
  - Very Cheap : 1.8m w connectors 8.23€(Farnell)
- Con:
  - Low multiplicity (4ch/cable)

Lecce FE





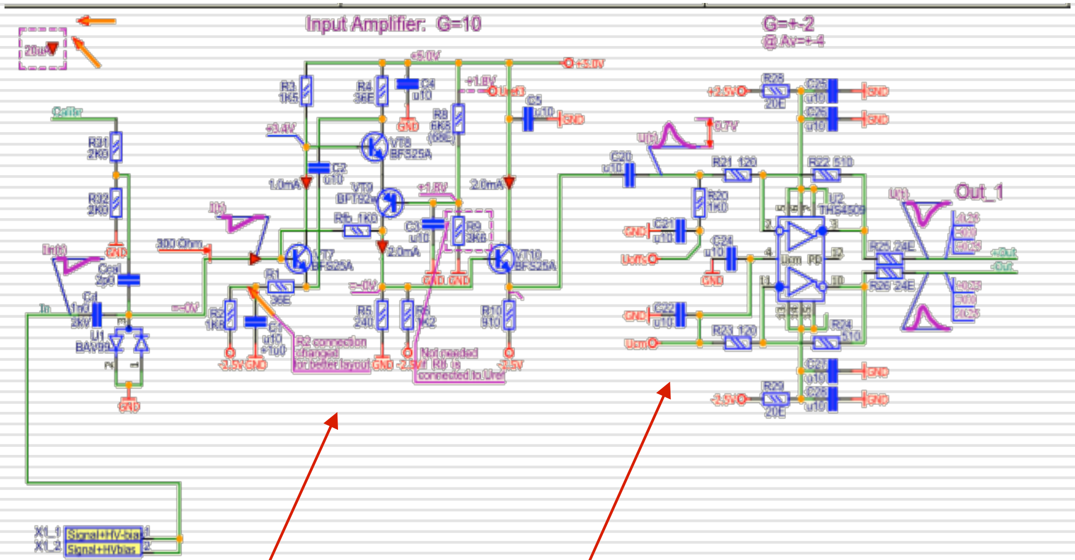


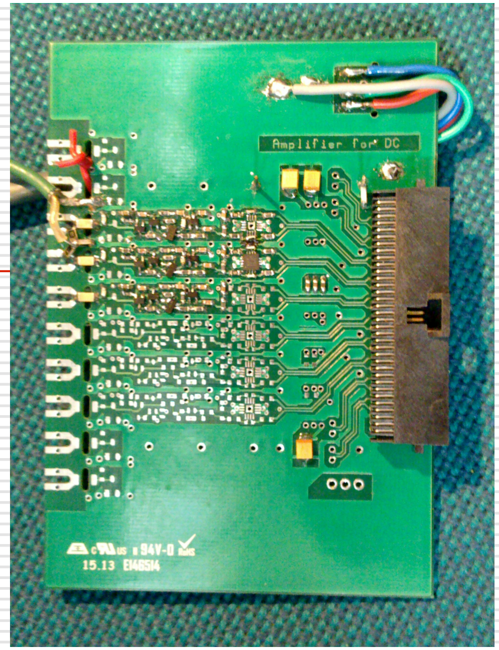
AD8099 Low Noise and Low Distortion High Speed Op-Amp → pre amplifier

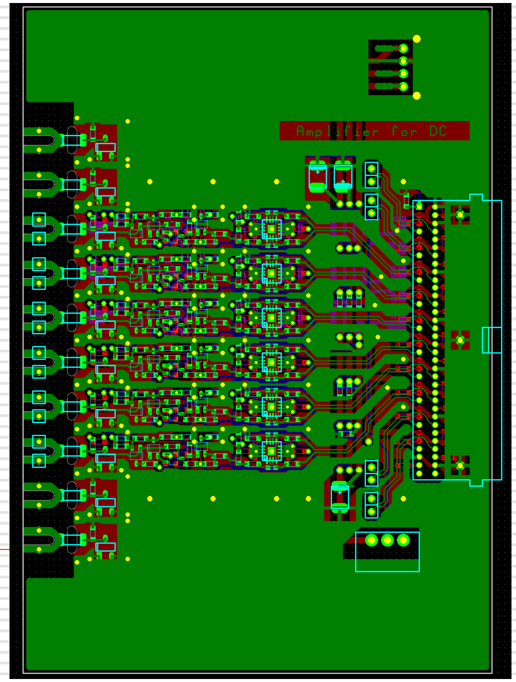
THS4509 Wideband Full-Differential Op-Amp → second stage gain output driver

- Input voltage dynamical range 0÷150mV
- Differential output
- Integral non-linearity < 1.5%
- Output voltage noise (120Ω load) < 2mV
- -3dB bandwidth ~ 800MHz
- Power consumption 150mW/ch (50mA @ ±3V)

BIMP FE





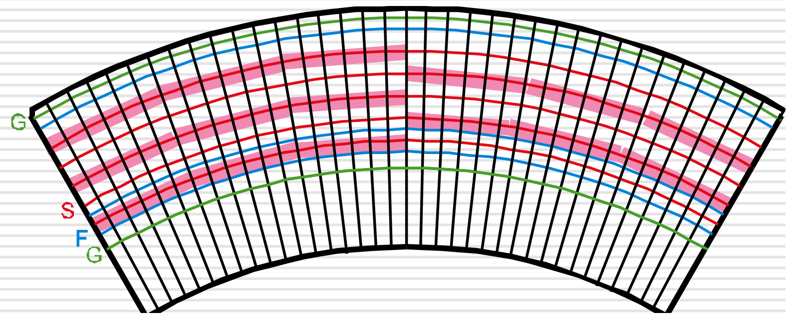


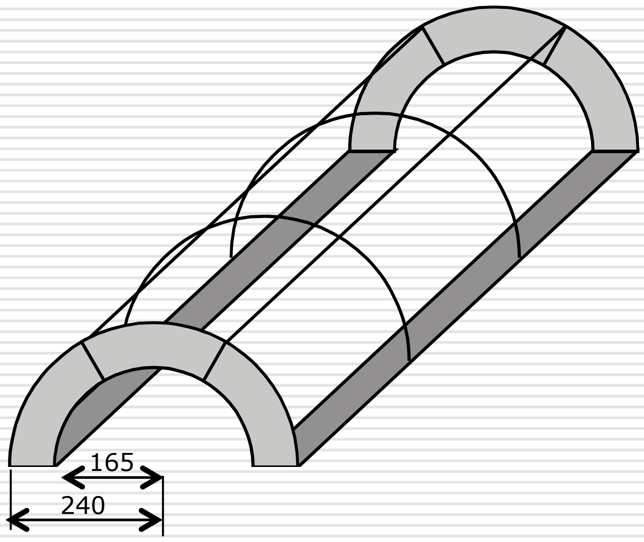
Discrete components (4BJTs)
→ pre amplifier

THS4509 Wideband Full-Differential Op-Amp → second stage gain output driver

Full length prototype

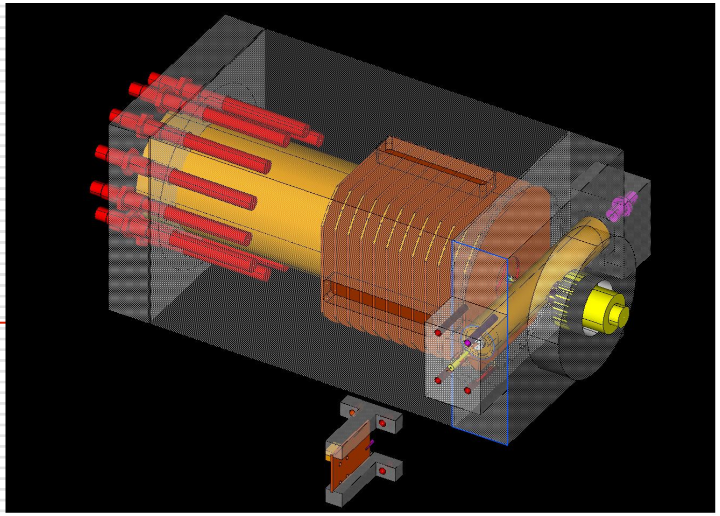
- System design: → **in progress**
- Wire board anchoring system: → **conceptual design done**
- Wire boards: → **to be designed**
- Spacers: → **to be designed**

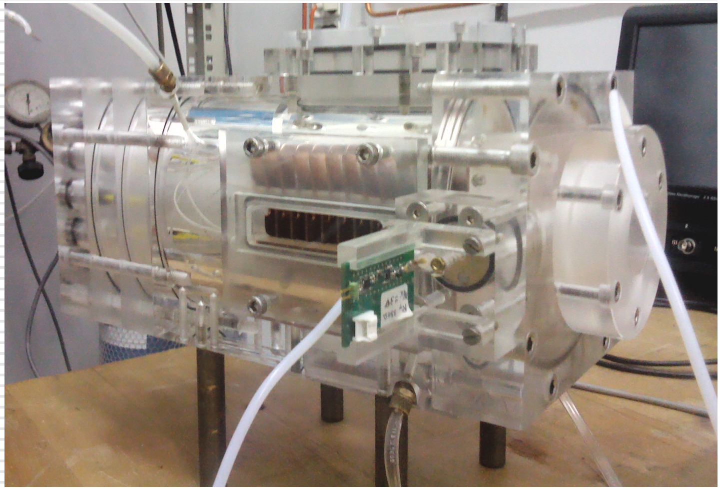


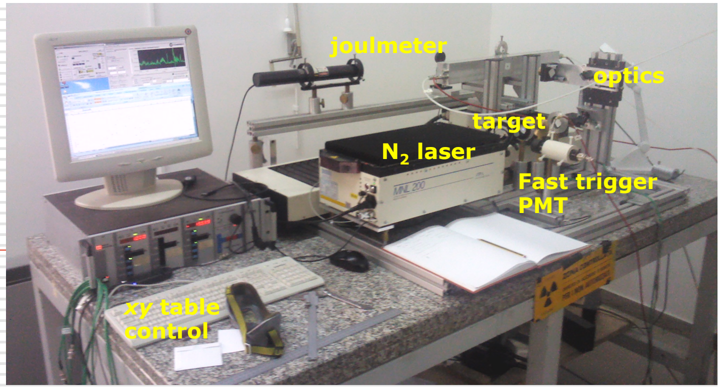


Drift velocity, diffusion and ionization yield measurements

- Uniform E field (>1.2kV/cm) between plates
- N_2 laser generate a single electron between plates
- Arrival times give precise determination of v_{drift}
- Variance gives longitudinal diffusion
- After that: Lateral diffusion, primary ionization
- Gas leakage tests and HV test are in progress
- **Full working**







Lecce people

Michele Cascella	AssRic	70
Cavallo Emanuela	AssRic	100
Grancagnolo Francesco	Ric	70
Maffezzoli Alfonso	PO	20
Panareo Marco	PA	100
Pepino Aurora	Dott	100
Tassielli Gianfranco	Ric	50
Zavarise Giorgio	PO	20
TOT		**530**
Primiceri Patrizio	CTech	100
TOT		**100**

Descrizione	Costo	FE Opt. #1a	FE Opt. #1b	FE Opt. #2a	FE Opt. #2b				
HDMI Passante	€ 10,00	0	0	480	480	€ 0,00	€ 0,00	€ 4.800,00	€ 4.800,00
Cavo HDMI Int	€ 2,00	0	0	480	480	€ 0,00	€ 0,00	€ 960,00	€ 960,00
Cavo HDMI Ext	€ 3,00	480	480	480	480	€ 1.440,00	€ 1.440,00	€ 1.440,00	€ 1.440,00
FE pcb	€ 5,40	240	240	240	240	€ 1.296,00	€ 1.296,00	€ 1.296,00	€ 1.296,00
FE mont/test	€ 340,00	240	240	240	240	€ 81.600,00	€ 81.600,00	€ 81.600,00	€ 81.600,00
PC pcb	€ 3,30	240	0	240	0	€ 792,00	€ 0,00	€ 792,00	€ 0,00
PC mont	€ 120,00	240	0	240	0	€ 28.800,00	€ 0,00	€ 28.800,00	€ 0,00
Wires pcb	€ 2,80	240	0	240	0	€ 672,00	€ 0,00	€ 672,00	€ 0,00
Kt pcb	€ 5,50	0	240	0	240	€ 0,00	€ 1.320,00	€ 0,00	€ 1.320,00
Kt mont	€ 120,00	0	240	0	240	€ 0,00	€ 28.800,00	€ 0,00	€ 28.800,00
PP pcb	€ 4,50	240	240	0	0	€ 1.080,00	€ 1.080,00	€ 0,00	€ 0,00
PP mont/test	€ 80,00	240	240	0	0	€ 19.200,00	€ 19.200,00	€ 0,00	€ 0,00
AC pcb	€ 12,00	120	120	0	0	€ 1.440,00	€ 1.440,00	€ 0,00	€ 0,00
AC (active) mont/test	€ 235,00	120	120	0	0	€ 28.200,00	€ 28.200,00	€ 0,00	€ 0,00
Crate AC	€ 208,00	6	6	0	0	€ 1.248,00	€ 1.248,00	€ 0,00	€ 0,00
Flatcable int	€ 50,00	240	240	0	0	€ 12.000,00	€ 12.000,00	€ 0,00	€ 0,00
Flatcable ext	€ 100,00	240	240	0	0	€ 24.000,00	€ 24.000,00	€ 0,00	€ 0,00
totali		**€ 201.768,00**	**€ 201.624,00**	**€ 120.360,00**	**€ 120.216,00**				
				missing booster amplifier					
Wires HV pcb	€ 2,80	240	0			€ 672,00	€ 0,00		
Wires HV Kt pcb	€ 5,50	0	240			€ 0,00	€ 1.320,00		
Kt mont	€ 120,00	0	240			€ 0,00	€ 28.800,00		
HVC a pcb	€ 3,40	240	0			€ 816,00	€ 0,00		
HVC a mont	€ 135,00	240	0			€ 32.400,00	€ 0,00		
HVC b pcb	€ 3,30	0	240			€ 0,00	€ 792,00		
HVC b mont	€ 100,00	0	240			€ 0,00	€ 24.000,00		
HV_panel_connector	€ 48,40	10	10			€ 484,00	€ 484,00		
HV cable int	€ 80,00	10	10			€ 800,00	€ 800,00		
totali		**€ 35.172,00**	**€ 56.196,00**						
LV Power supply	€ 3.388,00	8				€ 27.104,00			
Cable 10mm^2	€ 45,30	4				€ 181,20			
Sense cable 2.5mm^2	€ 164,00	1				€ 164,00			
Connettori	€ 25,00	1				€ 25,00			
totali		**€ 27.474,20**							

Richieste

- Chamber wiring and construction
  - Positioning and alignment monitoring: **5k€**
  - Material (wires, supports): **90k€**

- Front-end Electronic
  - Preamplifier, drivers, cables, connectors: **257k€**
  - LV power supply: **27k€**

- Totale: **359k€**

The End