Status of the NSW project

Paolo Iengo (INFN Naples)

On behalf of NSW Italian groups:

Bologna, Cosenza, Frascati, Lecce, Napoli,
Pavia, Roma1, Roma2, Roma3

Timeline

2012

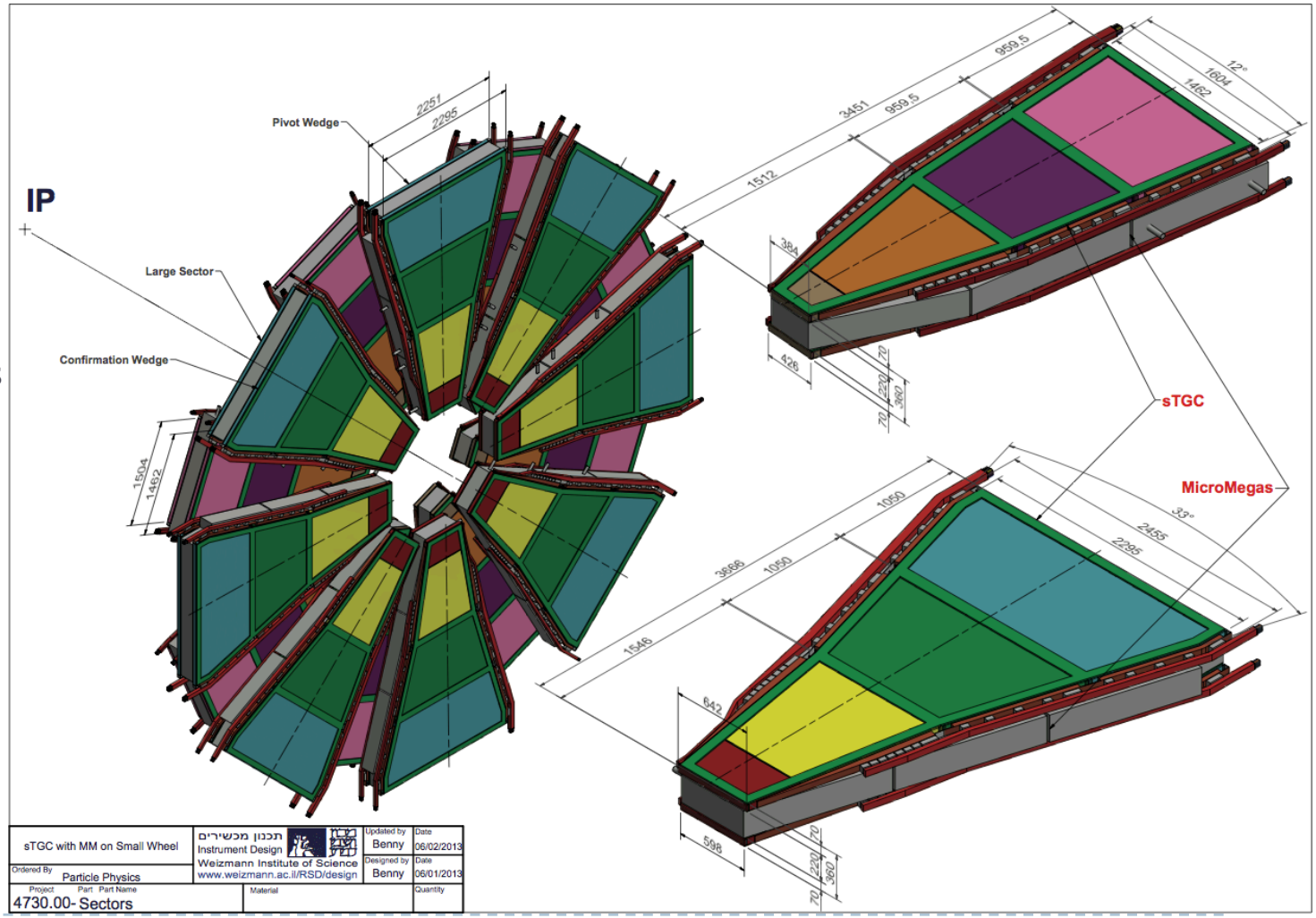
- Jan — NSW workshop (Les Brassus)
- March — Project baseline definition
- NSW Milestones & Reporting items
- Aug. — Initial Design Review
- Aug. — Kick-off meeting
- Oct. — ATLAS approval

2013

- Jan — NSW workshop (Aix-les-Bains)
- March — Milestone definition for 2013, Election of new NSW PL
- May — TDR, new NSW management takes over
- June — LHCC, CB Approval
- Aug. — MOU
- Oct. — RRB

NSW baseline layout

- 16 Sectors per wheel
  - 8 large
  - 8 small
- 2 multilayers per sector
- Each multilayer:
  - 4 sTGC planes
  - 4 MicroMegas planes



2012

Milestones

- Micromegas:
  - Resolution for inclined tracks
  - Demonstration of full-size detector (2x1 m^2) construction principle
  - Ageing with high radiation tests
- sTGC
  - Trigger demonstrator
- Common items:
  - Operation in magnetic field
  - Mechanical precision

Reporting Items

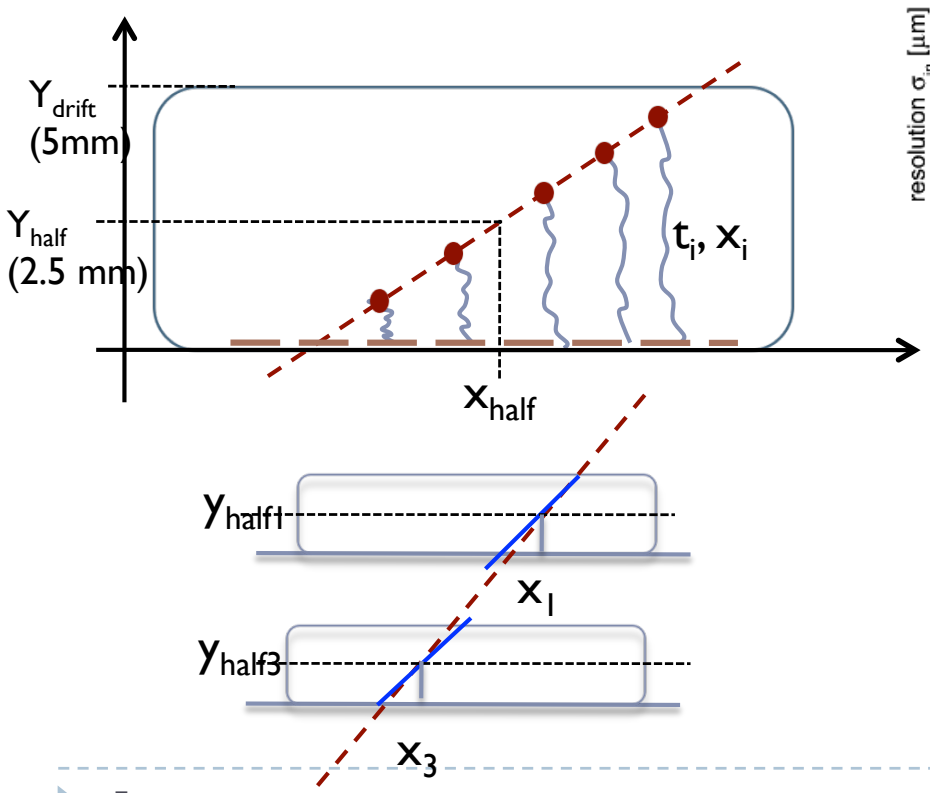
- Micromegas
  - Industrialization
  - Trigger scheme
- sTGC
  - Production sites
- Common items
  - Alignment system
  - Mechanical design and layout
  - MM+sTGC trigger
  - Long term ageing

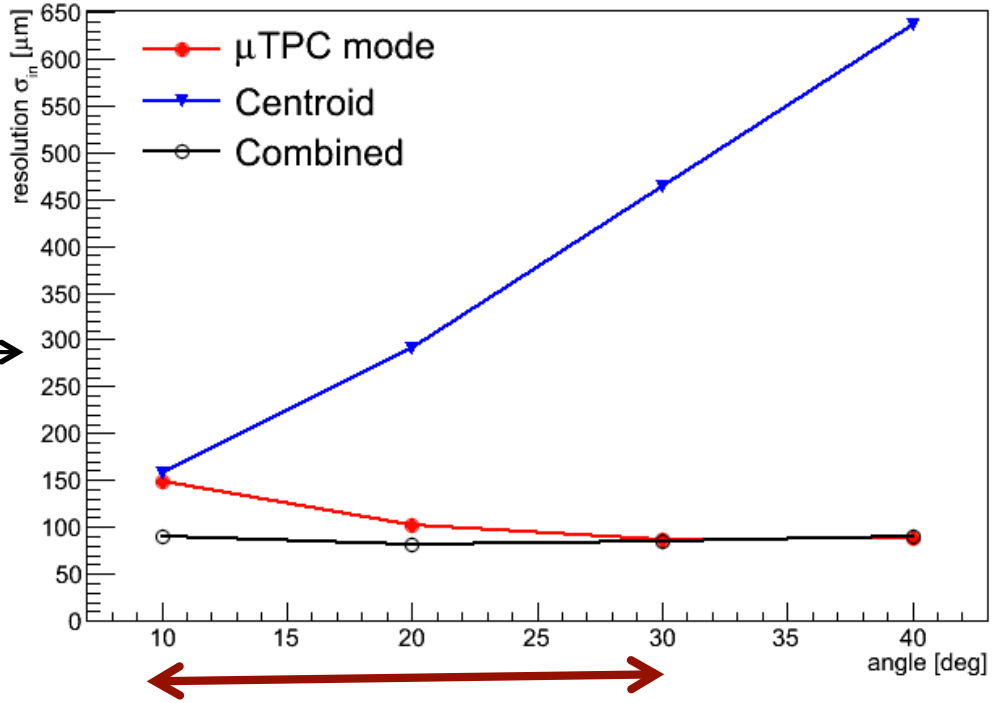
Red: current INFN involvment
Blue: possible future INFN involvement

MM single plane spatial resolution

- Long test beam campaign during 2012 (June-November)
- Important Italian contribution to test beams
- Leading role in data analysis (w/ and w/o magnetic field)
- Two complementary algorithms: μ TPC and charge centroid

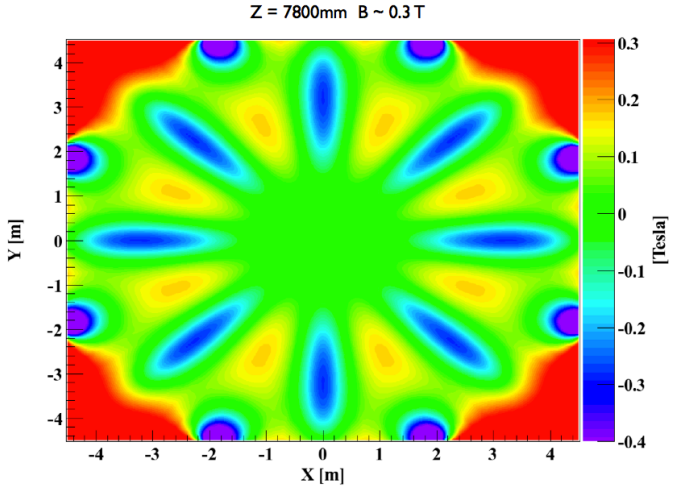
Requirement: 100 um



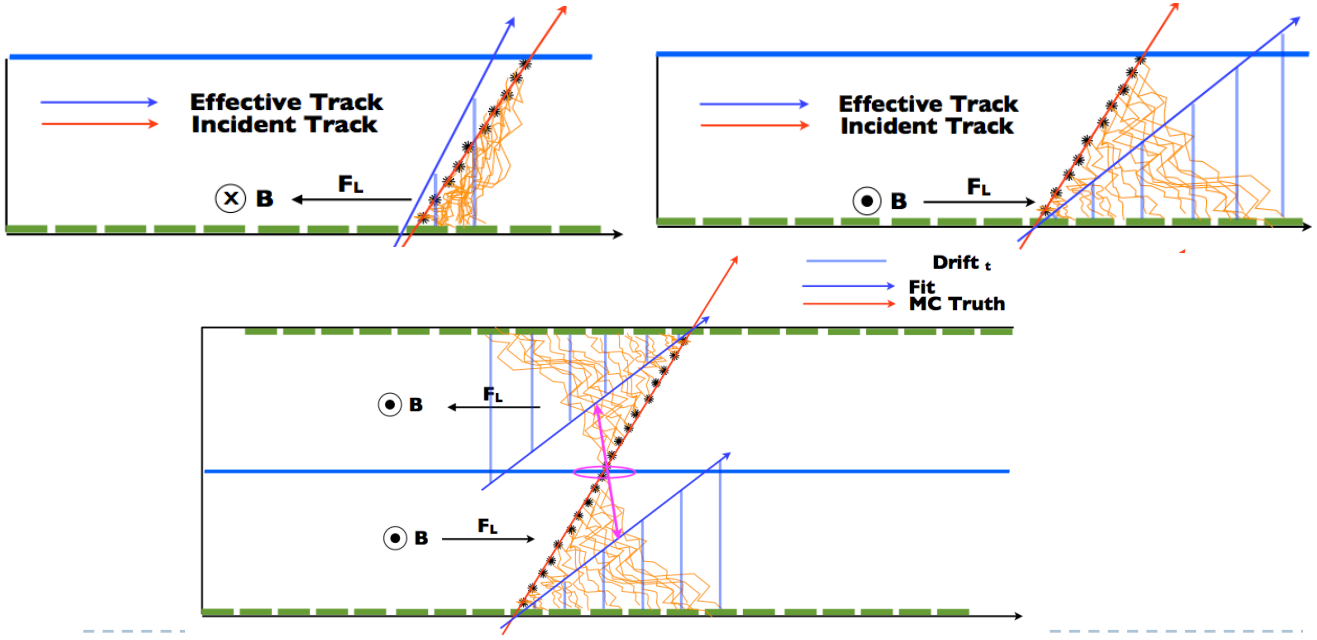


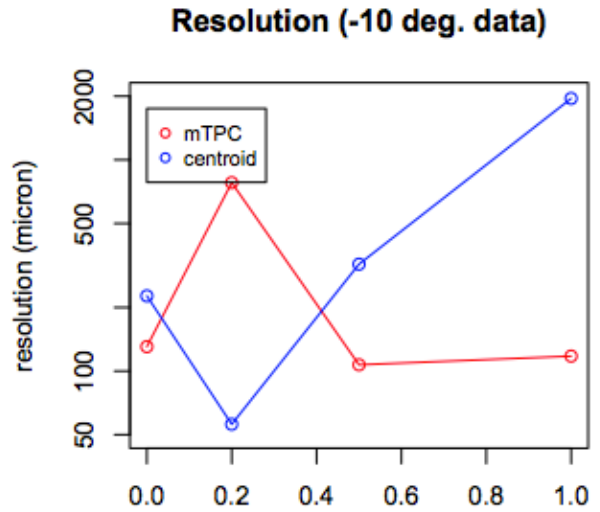
Muon anglular range in NSW

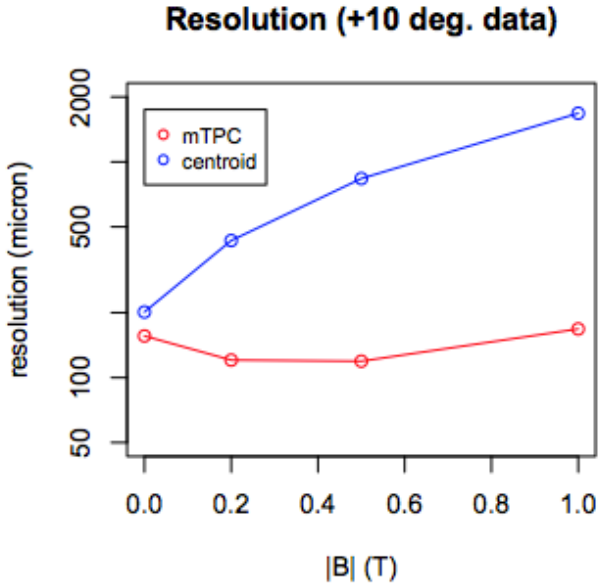
MM in Magnetic field



- Large variation of magnetic field inside the wheel (B up to 0.3T)
- Simulation validated with beam test in magnetic field up to 1T
- Resolution (combining uTPC and centroid) not substantially degraded
- Systematics can be corrected with the back-to-back configuration







MM ageing with high radiation tests

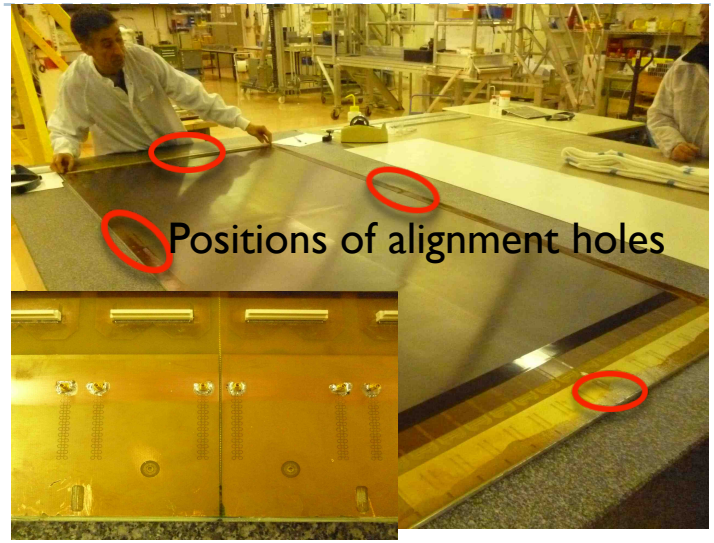
- Extensive tests performed at Saclay on a small prototype (10x10 cm^2)

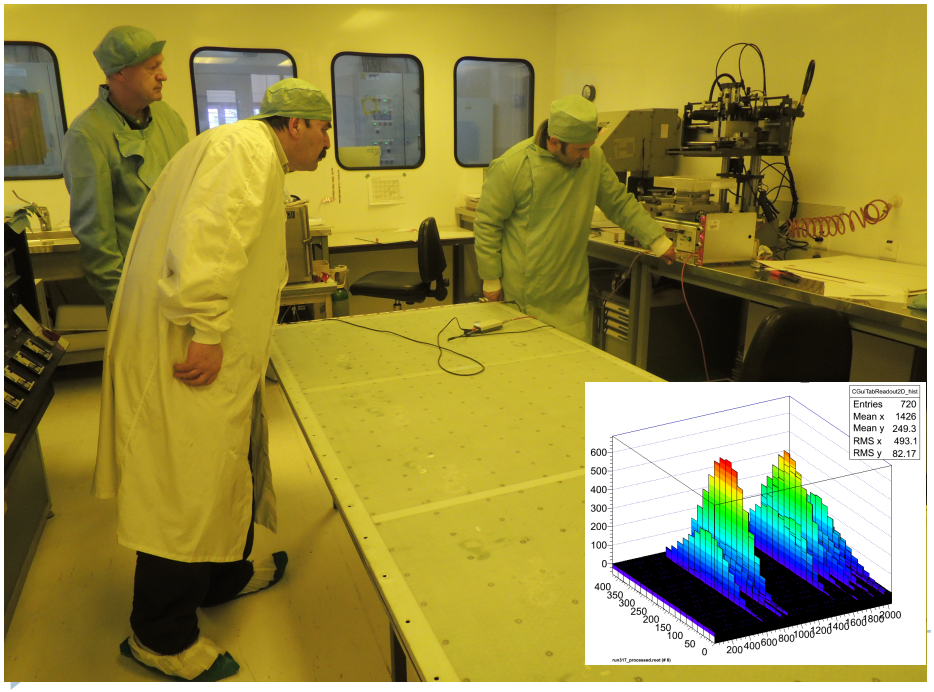
Radiation	Integrated charge	Result
X-ray	5 HL-LHC years equivalent	No evidence of ageing
Neutron	10 years HL-LHC years equivalent	No evidence of ageing
Gamma (from Cb)	10 years HL-LHC years equivalent	No evidence of ageing
Alpha	5 10^8 sparks equivalent	No evidence of ageing

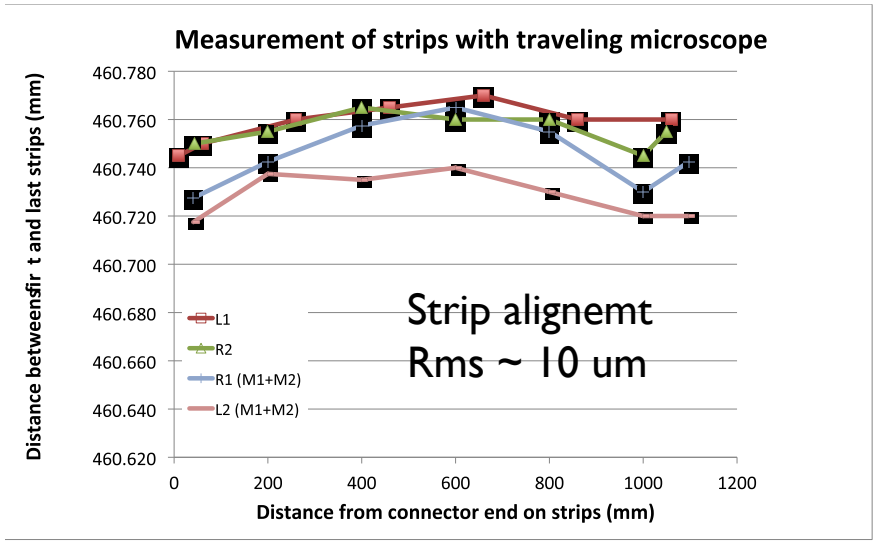
- No significant difference in response of the irradiated detector compared to the reference detector
- Future:
  - Large prototype with global irradiation
  - Material irradiation in cold neutron beam
  - Long term ageing on large prototype (at GIF++ or somewhere else)
    → interest from INFN groups

MM full size prototype

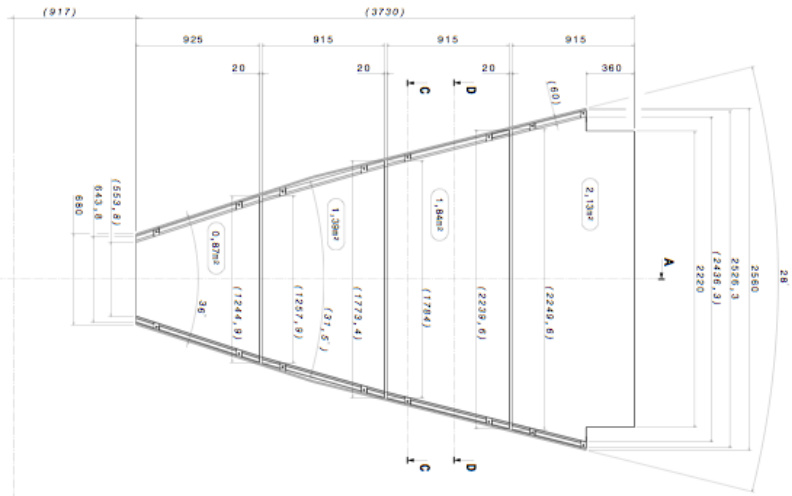
- Dimensions: 1x2.4 m^2 (active area 0.92x2.12 m^2)
- 4 PCBs 0.5x1.2 m^2, 0.5 mm thick
- 2x2048 1m-long read-out strips (0.45 mm pitch)
- PCB production and chamber assembly at CERN, resistyve strips printed in industry
- Good result for single layer alignemt; alignement of multilayer to be done
- Construction of two full sector size mechanical prototypes to be completed by the summer



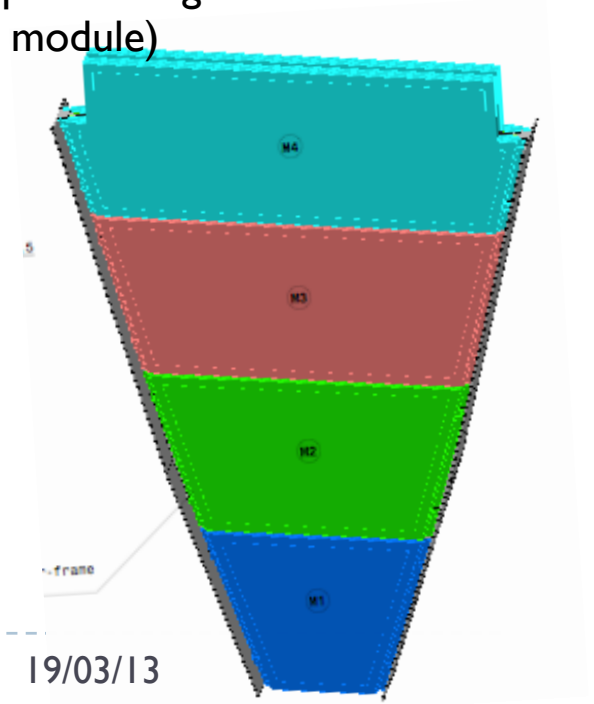




MM construction

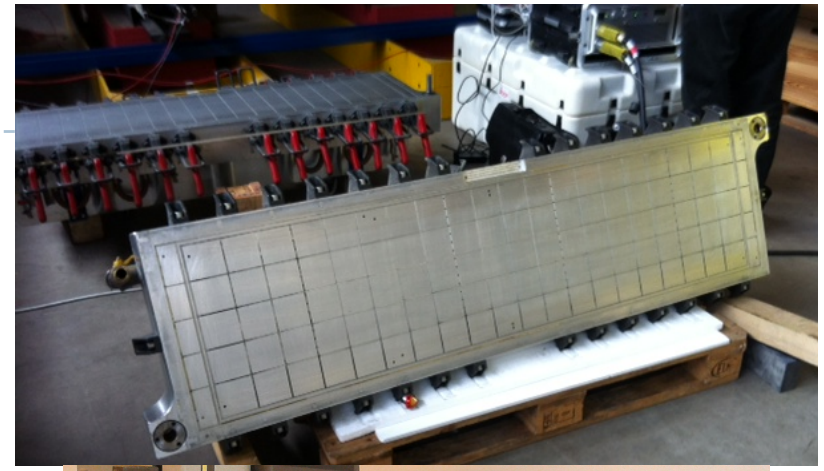


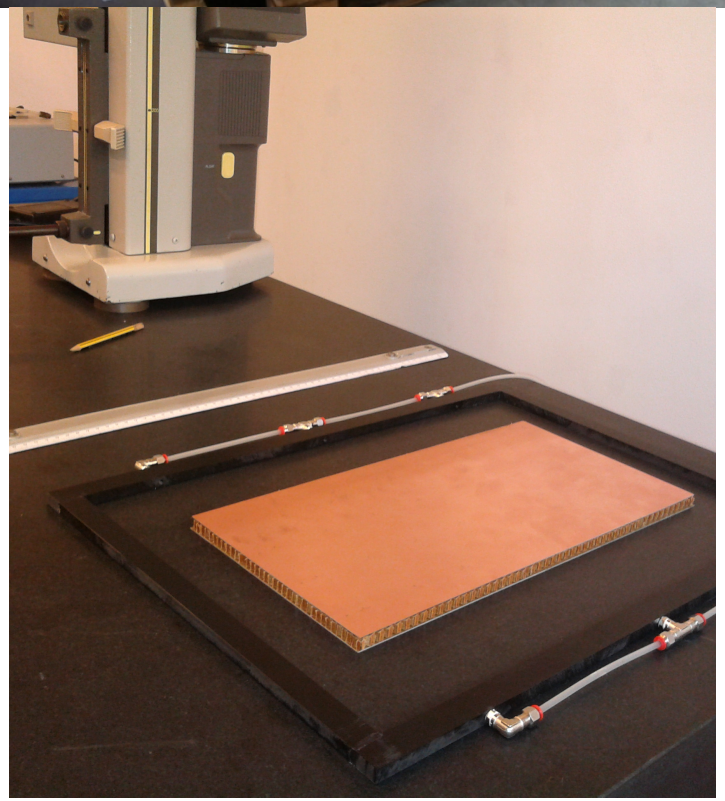
- Micromegas industrialization:
  - funcional small prototypes built in industries
  - industrial production procedure still to be defined
  - Chamber production elements will be defined in ~1 month
- Mechanics design and layout: not finalized yet (sTGC layout OK, MM layout definition ongoing)
- INFN groups contribute to the development of MM contruction procedure and to the construction of a mechanical prototype a module.
- Together with Saclay, LMU and USA cluster we will build a mech. Prototype of a large sector divided in four modules (CERN will build a small sector made by a single module)
- Three sites of INFN activities: Frascati, Pavia, Roma1
  - Supporting groups: Cosenza, Lecce, Roma3, Napoli
- Different construction methods will be tested in each site
  - Parallel advancement of the work
  - Develop experiences on site, involving more people
  - Work in collaborative way: exchange results and experience
  - Common material procurement
  - Eventually evaluate the most relaiable solution or a merged solution

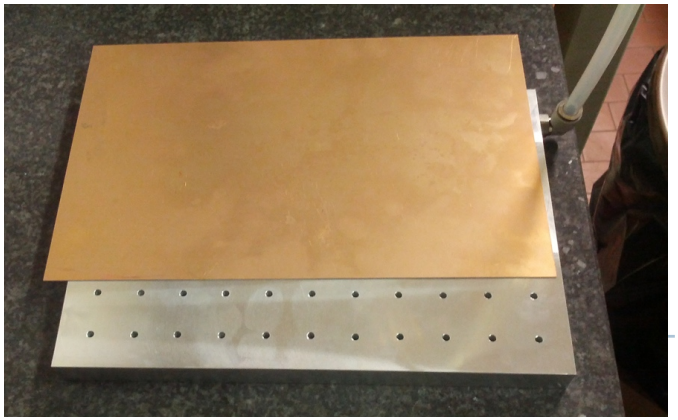


MM construction procedures

- LNF: use of molds as stiffback
  - Reuse existing tooling (from LHCb) of limited dimension (40x50 and 40x160 cm2)
- Pavia: use of granite table + vacuum pump + stiffback (tbd)
  - Reuse tooling available from MDT assembling
- Rome-1: granite table + vacuum bag
  - Reuse tooling available from MDT assembling
- Glueing test on small samples with different materials ongoing in all sites. Common material procurement ongoing

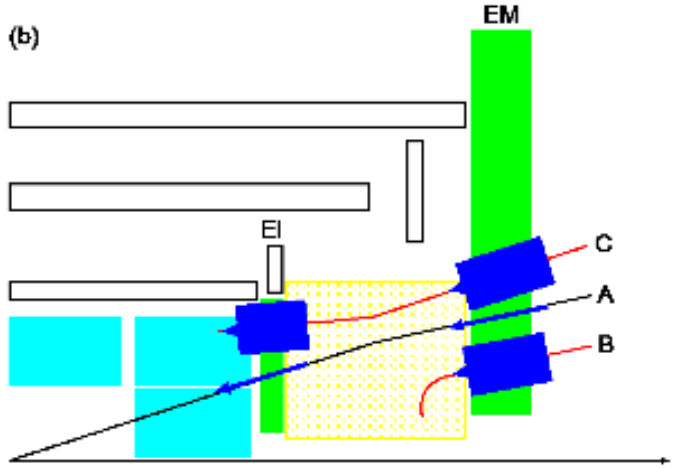


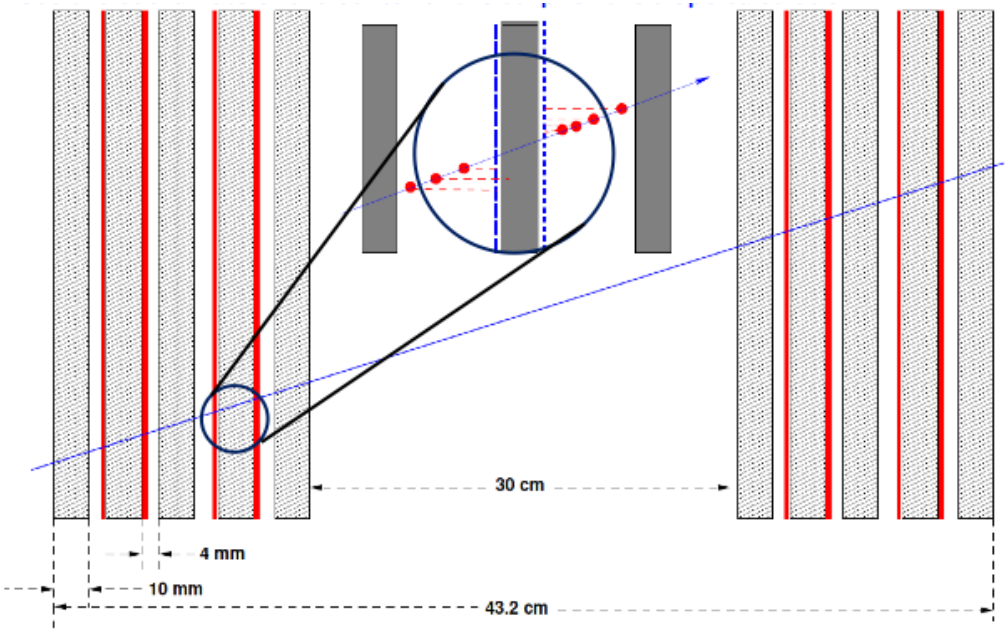




NSW read-out and trigger

- NSW read-out based on a common asic (VMM) under development at BNL. First prototype tested on detector at beam test in 2012; new version expected in fall 2013. INFN groups not involved.
- NSW trigger concept:
  - Find track segments pointing to the IP
  - Extrapolate the NSW candidates to the Big Wheel and match to coincidences found there
- Not yet clear how to combine sTGC and MM

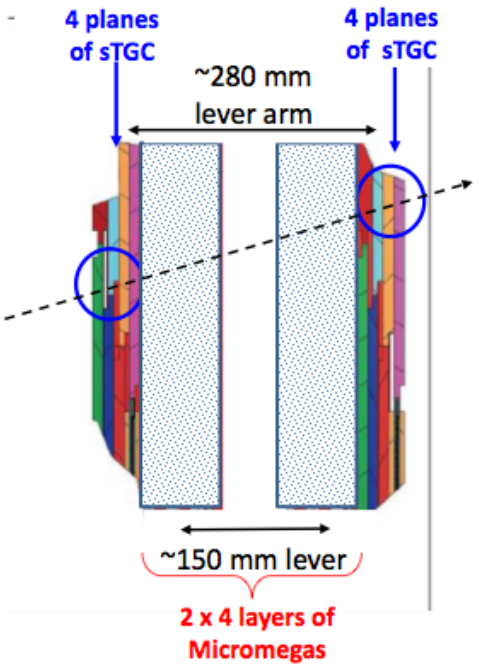


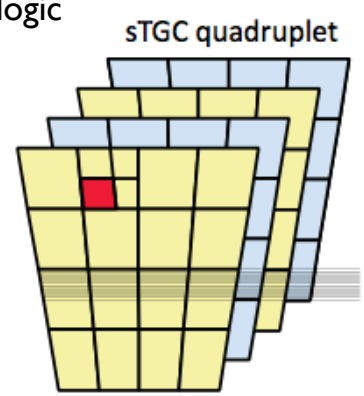


- Concept for MM trigger:
  - Get the address of the strip with the earliest hit (in a group of 64 channels =3.2 cm)
  - Use the coordinate of the center of the strip for the track reconstruction at L1
- INFN not involved in MM trigger so far, we are considering to join this activity

NSW trigger

- Concept of sTGC trigger
  - Find the centroid of 3 to 5 3.2 mm strips in each layer
  - From the 8 centroids extrapolate to the Big Wheel
  - Use PAD tower coincidence to choose the relevant strips before reading them out to the track finder
    - Reduce bandwidth
    - Reduce amount of centroid track finding logic

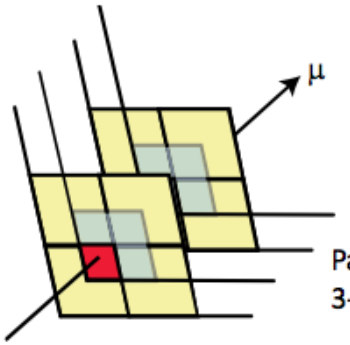




Physical pads, each layer staggered by ½ pad in both directions

Logical pad-tower defined by projection from 4 layers of staggered pad boundaries

Pad trigger selects a band of strips under row of logical pads



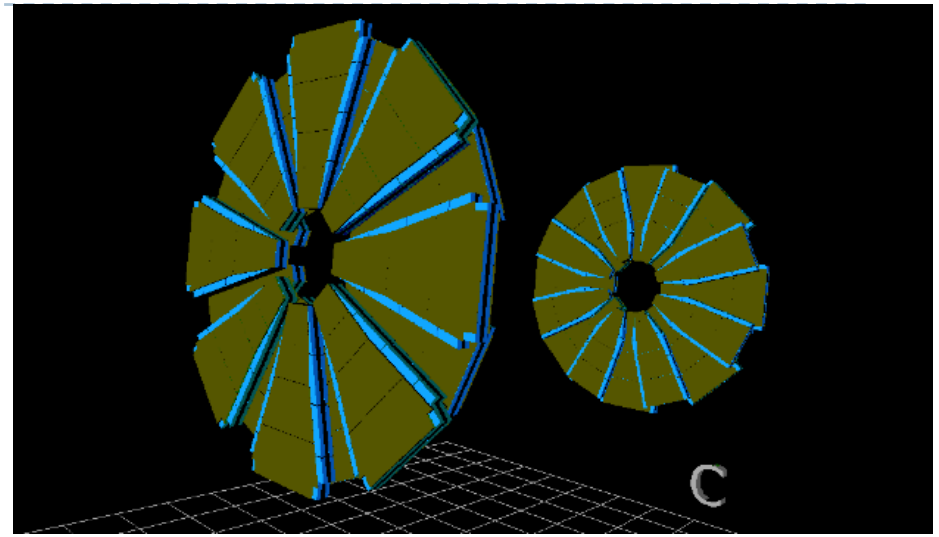
Pad-tower coincidence = 3-out-of-4 overlapping pads

Channels	strips	pads	wire groups
End cap	130,368	22,592	8192

Total: ~322,000
~ existing TGC

Simulation and physics cases

- Simulation:
  - A complete ATHENA/Geant NSW exists
  - With not final support structues
  - No detector internal structures yet
  - Need to converge to a layout here too
  - Digitization ongoing
  - Need to start performance studies for TDR



- Physics case studies:
  - Need to study some physics case for TDR
  - With NSW parametrization compared with present SW: reproduce the result for WH (H→bb) using present H→bb analysis
  - Analyze other decay channels WH (H→ τ τ and H→WW) to produce a trigger table similar to what has been done for H→bb for LOI

	Efficiency (%)	Rate (kHz)
E_t^{μ} > 20 GeV old SW	82	40
E_t^{μ} > 20 GeV NSW	78	15
E_t^{μ} > 40 GeV old SW	50	18

TDR Editorial Board and page allocation

NSW TDR Chapters

Chapter	Editor	number of pages allocated
Overview	Tatsuo Kawamoto	5
ATLAS Run 2 Requirements	Sotiris Vlachos	4
New Small Wheel Layout	Joerg Dubbert	8
sTGC Detector technology and performance	George Mikenberg	8
MicroMegas Detector technology and performance	Paolo Iengo	8
New Small Wheel Performance	Carlo Dellapiccola	6
sTGC construction	George Mikenberg	12
MicroMegas construction	Paolo Iengo	12
Integration and Commissioning	Joerg Dubbert	5
Installation Schedule and procedures	Joerg Dubbert	5
Alignment system	Christoph Amelung	8
Trigger and data acquisition and detector control	Lorne Levinson	12
Services and Infrastructure	Joerg Dubbert	5
Compatibility with ATLAS phase II upgrade	Robert Richter	3
Project management, resources and responsibilities	Tatsuo Kawamoto	5
Naming conventions	Daniel Lelouch	5
Glossary of terms and abbreviations		
List of NSW collaboration institutes		

INFN contribution to TDR:
Simulation: Pv
Physics case: Rome3
MM: LNF, Na, Pv, Rome1, Rome3
Services: Pv

Ruolo gruppi italiani: attivita' di 'produzione'

- Una delle ditte interessate alla produzione di MM e' la ELTOS di San Zeno (Arezzo). Al momento ELTOS e' la piu' avanzata nel processo di trasferimento tecnologico seguito dal CERN.
- ELTOS gia' partner INFN (TGEM). Rapporti diretti gia' attivati in ambito ATLAS MM
- Ottime possibilita' di ottenere in Italia uno dei (due o tre) centri di produzione delle Micromegas
- Con una parte di produzione, almeno un sito di assemblaggio sara' italiano
- Sistema di HV compatibile con quello attuale (CAEN)
- Elettronica di trigger L1 on-detector (sTGC) e ROD di competenza italiana

Ruolo gruppi italiani: ruolo scientifico

- Comunita' italiana gia' ben inserita nelle attivita' Micromegas e TDAQ per la NSW
  - Partecipazione attiva a tutte le attivita' Micromegas (ruolo determinante nei test beam e analisi dati, impegno intenso nella meccanica e nella costruzione MM)
  - Test beam effettuati alla BTF (Frascati) in luglio e settembre 2012 solo di ambito INFN. BTF ospitera' TB di collaborazione (MM) duranti il LS-1
  - Primo workshop di 1.5 giorni sulla meccanica micromegas (MMM) ospitato a Frascati in novembre 2012. Workshop a cadenza ~bimestrale (al CERN in Febbraio, a Saclay in Aprile, di nuovo in Italia in estate
  - Coordinamento beam test Micromegas
  - Co-editor documento IDR Micromegas ed editor TDR MM
  - Coordinamento software NSW e coordinamento task-force sw per TDR
  - Persona di contatto con ELTOS per attivita' MM
  - Trigger/DAQ (sTGC on-detector L1 Pad Coincidence Logic, sTGC test beam)

Attivita' di interesse INFN

	Attivita' di interesse			
	MM (R&D, production and commissioning)	NSW Services	Software/ Simulation	Trigger/DAQ*
Bologna (Bo)			X	X
Cosenza (Cs)	X		X	
Frascati (LNF)	X	X		
Lecce (Le)	X	X		
Napoli (Na)	X	X		X
Pavia (Pv)	X	X	X	
Roma1 (Rm1)	X		X	X
Roma2 (Rm2)				X
Roma3 (Rm3)	X		X	X

Richieste

- Costo totale NSW ancora non definitivo, nuova stima aggiornata allo studio per il TDR
  → possibile ri-definizione delle richieste
- Nessun cambiamento rispetto a richieste presentate nel 2012
- Possibile interesse a partecipare anche al trigger MM
  (impegno scientifico ed economico da quantificare)

- Costi (core) in kCHF stimati in base ai possibili deliverables

	% su tot NSW	2013	2014	2015	2016	2017	2018	Tot
Micromegas	30		152	352	252			756
Trigger/DAQ	10		148	196	148			492
NSW Services	15				238	238		476
Tot	13.8		302	552	640	238		1724

- Costi non core (tooling) non inclusi nella tabella; stimati intorno ai 180 kCHF

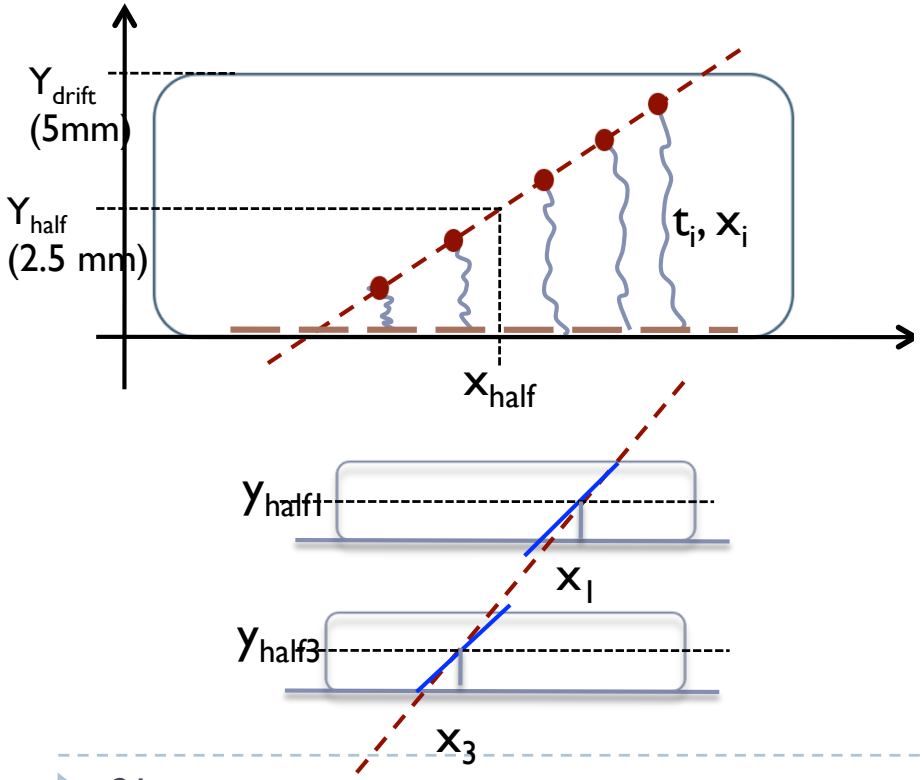
Conclusions

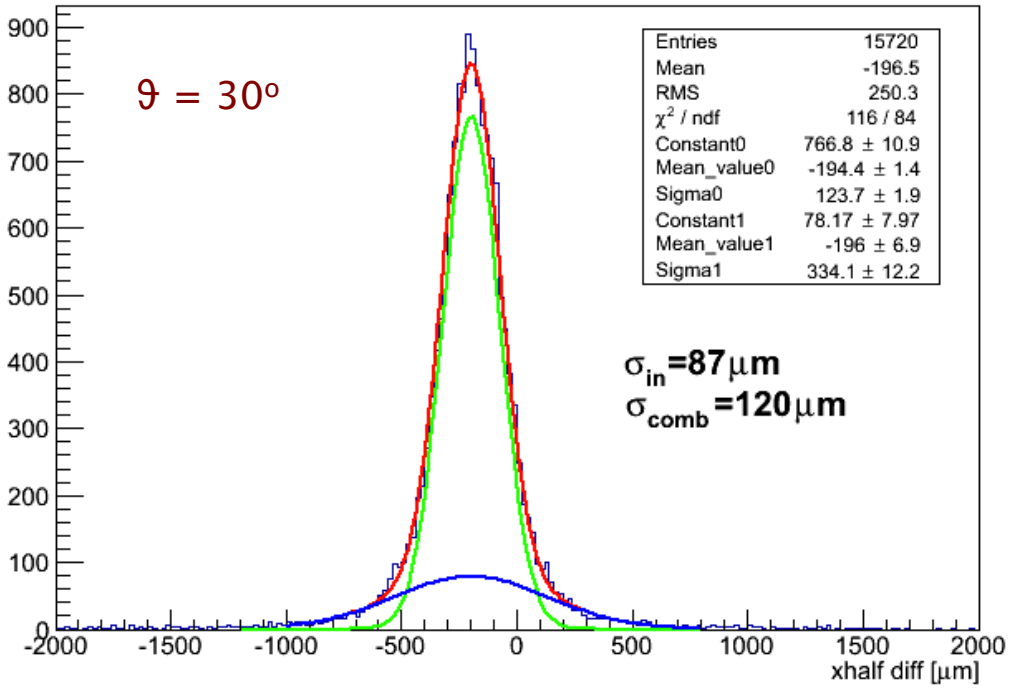
- Milestone 2012 verificate con successo, anche grazie al contributo significativo della comunita' italiana
- Preparazione del TDR in corso
  - Tempi molto stretti
  - Alcuni aspetti ancora da definire nei dettali
- Impegno per il 2013 concentrato su
  - Costruzione e test prototipi MM (modulo-1, modulo-0) definizione procedure di costruzione e trasferimento tecnologico
  - Simulazione
  - Trigger/DAQ
- Nuove attivita' breve/medio termine
  - Test di invecchiamento a lungo termine MM (GIF++)
  - Trigger/DAQ MM in fase di studio/discussione
- NSW compatibile con upgrade di fase-II: non si prevedono attivita' sul lato rivelatori (per le end-cap)

Additional Material

MM single plane spatial resolution

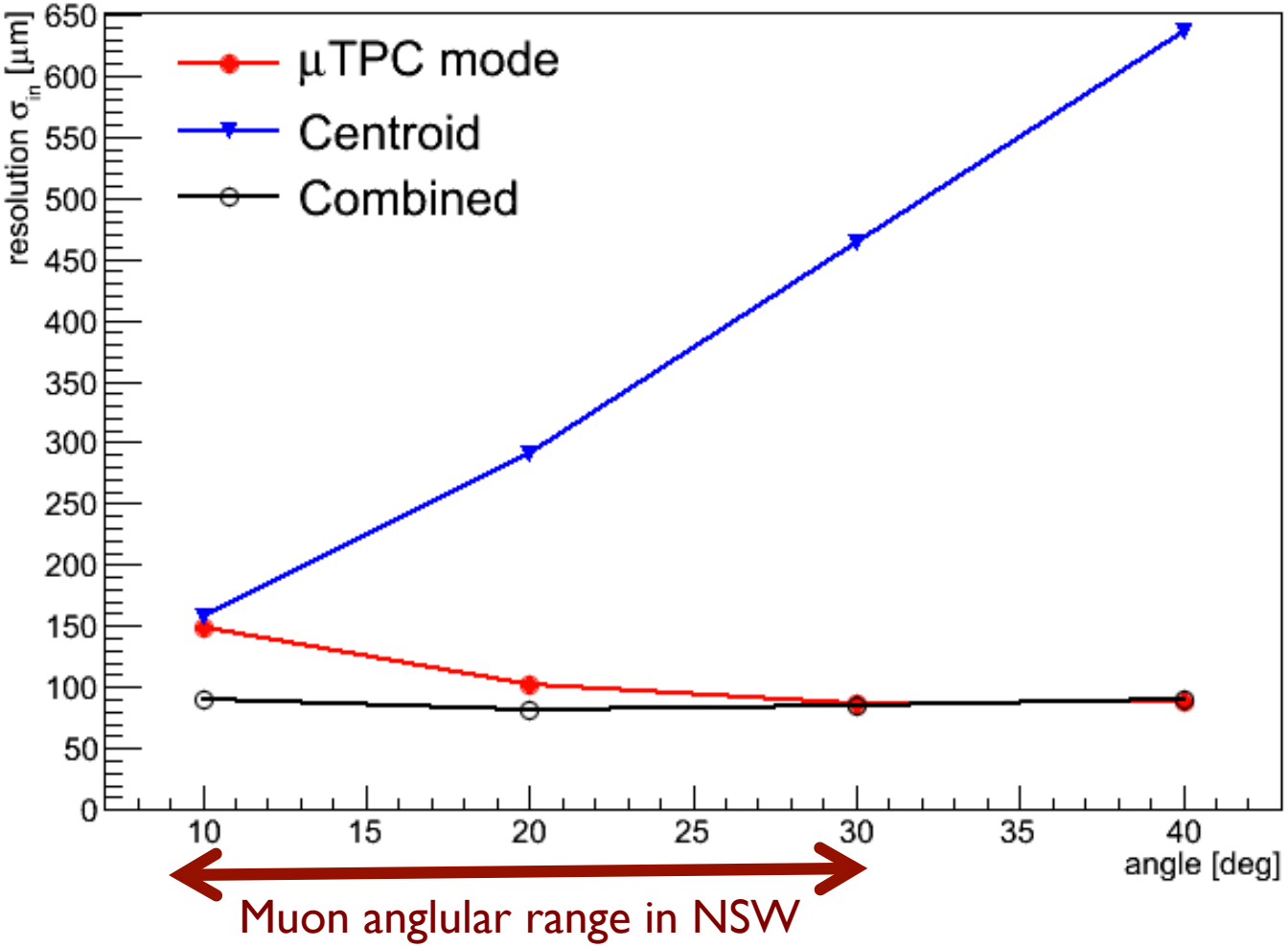
- Long test beam campaign during 2012 (June-November)
- Important Italian contribution to test beams
- Leading role in data analysis (w/ and w/o magnetic field)
- Two complementary algorithms:
  - μ TPC and charge centroid

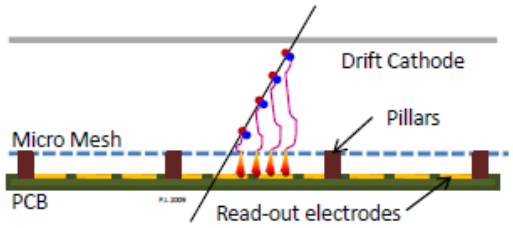




MM single plane spatial resolution

- Combined μ TPC and centroid – inner gaussian

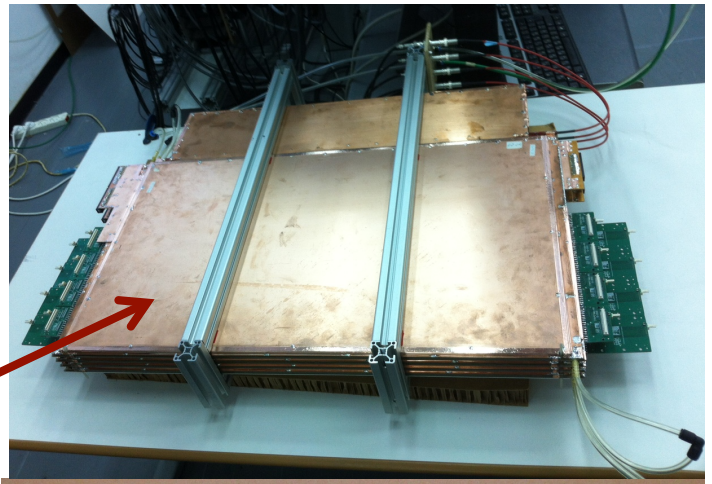




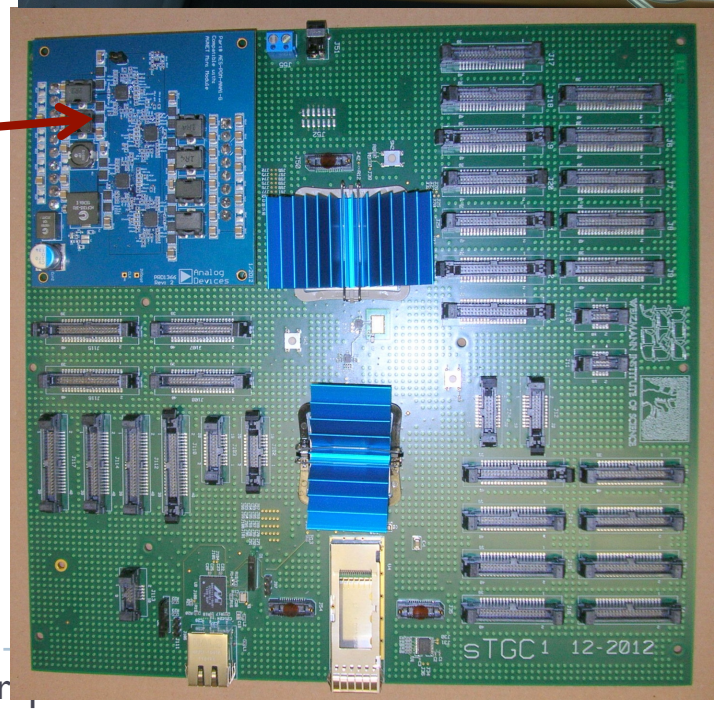
More details on NSW trigger in A. Negri's talk

VMM ASIC & sTGC trigger demonstrator

- VMM ASIC is designed by BNL to be used as FE chip common to MM and sTCG
- VMM1 is the first version tested in 2012
- Test results on sTGC satisfactory on most parameters
- Charge-to-ToT convertes saturated → use Charge-to-peak value conversion (available in VMM1)
- Digitization will be added in VMM2, expected in fall 2013



- Study done with:
  - sTGC quadruplet trigger demonstrator
  - Demo-1 FPGA board
- FPGA correctly receive LVDS signals from VMM ASD: ok
- ToT measurement within 1ns sampling: ok
- Centroid finding, averaging using FPGA DSP blocks: ok
- Diagnostic readout: ok
- Dual 3 out-of 4 PAD logic for 148 PADs: ok
- Test with cosmics to be done in next weeks (second quadruplet is needed)



Costi NSW

- Costo totale NSW rivisto dopo la scelta della soluzione omogenea
- Numeri ancora non definitivi, nuova stima aggiornata allo studio per il TDR → possibile ri-definizione delle richieste INFN

		Costi kCHF
Micromegas	Detector, supports, assembly	2522
sTCG	Detector and assembly	1859
FE+Trigger	FE, Trigger Elx, RO	3944+1000
NSW Common	HV/LV, Controls, Alignment, Installation	3174
Tot		11499+1000

Personale

	Personale			
	Staff	**Post-doc/dott.**	**Servizi (El/Mec)**	**FTE 2013**
Bologna (Bo)	Bellagamba, Boscherini, Corradi, Polini			**1.5**
Cosenza (Cs)	Schioppa, La Rotonda, Tassi	Policicchio (Pd), Lavorini (dott), Scarfone (dott)		**2**
Frascati (LNF)	Antonelli, Gatti, Laurelli, Maccarrone		Mec/El	**3**
Lecce (Le)	Gorini, Primavera		Fiore, Miccoli (Mec)	**0.4**
Napoli (Na)	Alviggi, Canale, de Asmundis, Della Pietra, Di Donato, Iengo, Izzo, Sekhniaidze (CERN fino al 30/6)		Mec	**3**
Pavia (Pv)	Ferrari, Fraternali, Gaudio, Lanza, Livan, Rimoldi		Mec/El	**1.5**
Roma1 (Rm1)	Bagnaia, Bini, Ciapetti, De Pedis, Giagu, Lacava, Pasqualucci, Petrolo, Safai Tehrani, Vari, Veneziano		Mec/El	**2.5**
Roma2 (Rm2)	Liberti, Salamon			**0.4**
Roma3 (Rm3)	Baroncelli, Biglietti, Branchini, Iodice, Petrucci	Trovatelli (dott)	Tagnani (El)	**1.7**
TOT	**46**	**4**		**16.0**

Richieste 2013

	ME			TOT ME	MI		TOT MI	Consumo		Inv. (+Cons.)	
	Test fuori CERN	Test al CERN	Riunioni e contatti tecnici		TB LNF	Riunioni e contatti produzione					
Bologna	4 MU			4 MU		4 kE	4 kE	3 kE	Prototipi Elx trigger L1		
Cosenza	0.5 MU	1 MU		1.5 MU	2 kE		2 kE	10 kE	Prototipi MM + RO	1 kE	Elx
LNF	2 MU	1 MU	4 MU	7 MU		8 kE	8 kE	15 kE	TB LNF + test cosmici	20+15 kE	HV+Elx + Mecc
Lecce	0.5 MU		1 MU	1.5 MU	2 kE	4 kE	6 kE	5 kE	Meccanica/TB		
Napoli	4 MU	4 MU	3 MU	11 MU	4 kE	6 kE	10 kE	10 kE	Prototipi MM + Elx+ test cosmici	11 kE	HV+SRS +prototipi trigger
Roma1	4 MU	1 MU	2 MU	7 MU	2 kE	4 kE	6 kE	20 kE	Prototipi MM + test cosmici + prototipi elx trigger L1		
Roma3	4 MU	2 MU	2 MU	8 MU	2 kE	5 kE	7 kE	13 kE	Prototipi MM + test cosmici + meccanica	5 kE	Elx
Pavia			1 MU	1 MU		2 kE	2 kE	7 kE	Ing. Servizi + meccanica		
TOT	19 MU	9 MU	13 MU	41 MU	12 kE	33 kE	45 kE	83 kE		52 kE	

- Test fuori CERN comprendono: test su fascio per MM, test ad alto rate MM, test elettronica di trigger su fascio e test irraggiamento elettronica di trigger
- Test al CERN comprendono: test su prototipi MM, test irraggiamento MM, MM istallate in ATLAS (run LHC prolungato fino a marzo 2013)