Futuri acceleratori: attività nella sezione INFN-Bari

N. De Filippis
Politecnico/INFN Bari,
e LPC-FNAL Batavia

per il gruppo RD_FA

Bari
3 Luglio 2018

Organizzazione

- **Diverse aree di interesse ed attività:**
  - Misure di precisione per acceleratori e^+e^- (FCC-ee, CepC)
  - Misure di precisione per acceleratori pp (FCC-hh) e SppC
  - Misure per electron ion collider (EIC) - NEW
  - Prospettive di scoperta di nuova fisica
  - Generatori MC, simulazione del rivelatore
  - Infrastruttura di calcolo per simulazione ed analisi
- **Sono coinvolti fisici teorici e sperimentali**
- **Contributi per CDR per CepC (2018) e a FCC per EU Strategy (2018)**
  (attività strettamente legata agli studi di CMS per Run2 e HL-LHC)
- **Anagrafica Bari 2017/2018:**
  - Nicola De Filippis (ric. poliba: 10%
  - Marcello Abbrescia (prof. ass., uniba): 10%
  - Antonio Valentini (prof. ass., uniba): 50%, Grazia Cicala (ric. CNR): 30%
  - Pier Verwilligen (ric. INFN): 10%
- **Fondi RD_FA per missioni confluiti su INFN Pisa**

Gruppi di lavoro

WP 1 - Fisica e simulazione

WP 2 – MDI (Machine Detector Interface) Fondi macchina

WP 3 – Rivelatori Pixel/Strip

WP 4 – RICH/TPC

WP 5 - Drift Chamber

WP 7 - Muon systems

WP 8 - Muon Collider

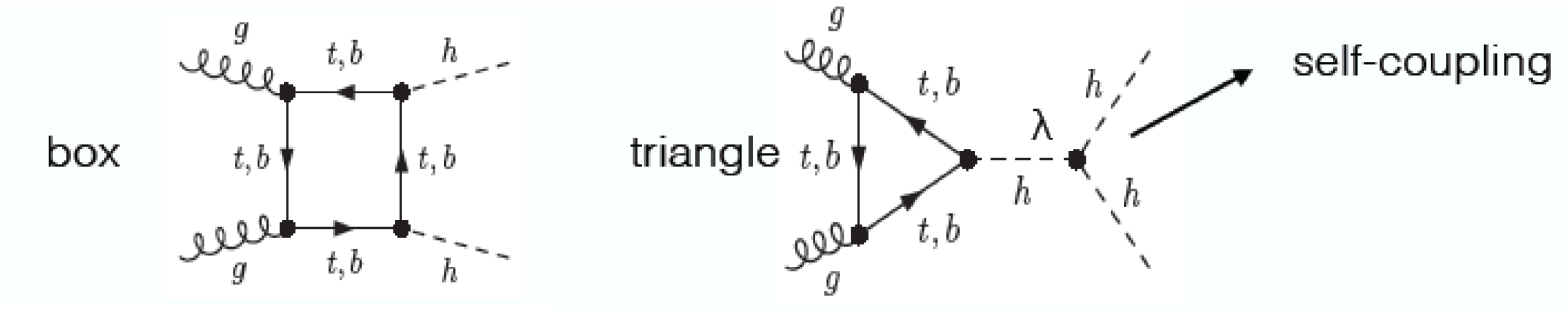
WP 9 - Calorimetry

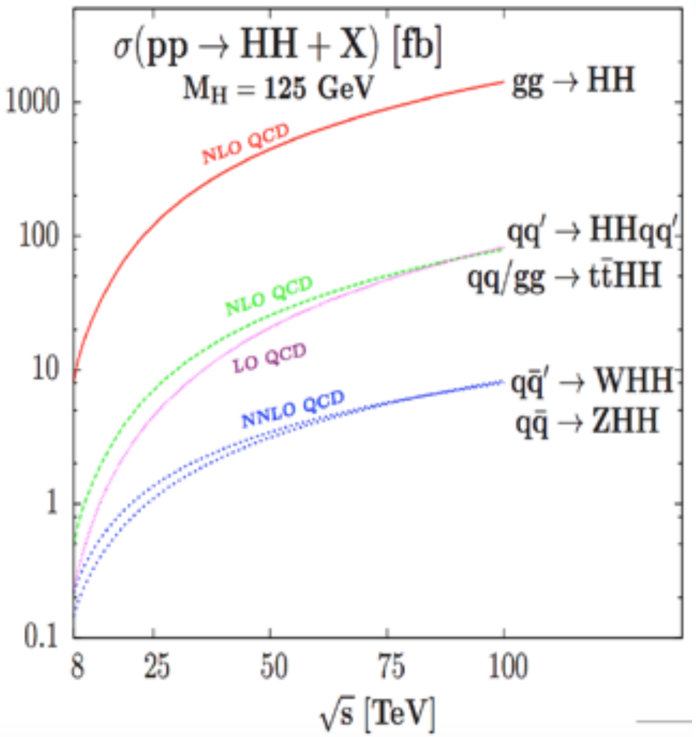
WP11 – electron-positron collider

WP1

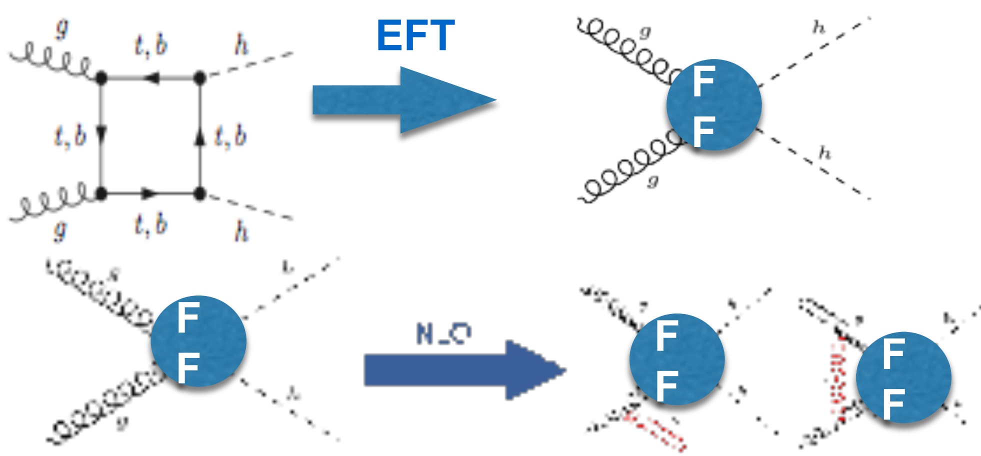
Studi per FCC-hh/SppC: fisica

Produzione di-Higgs per studiare l'accoppiamento triplo di H e non solo:

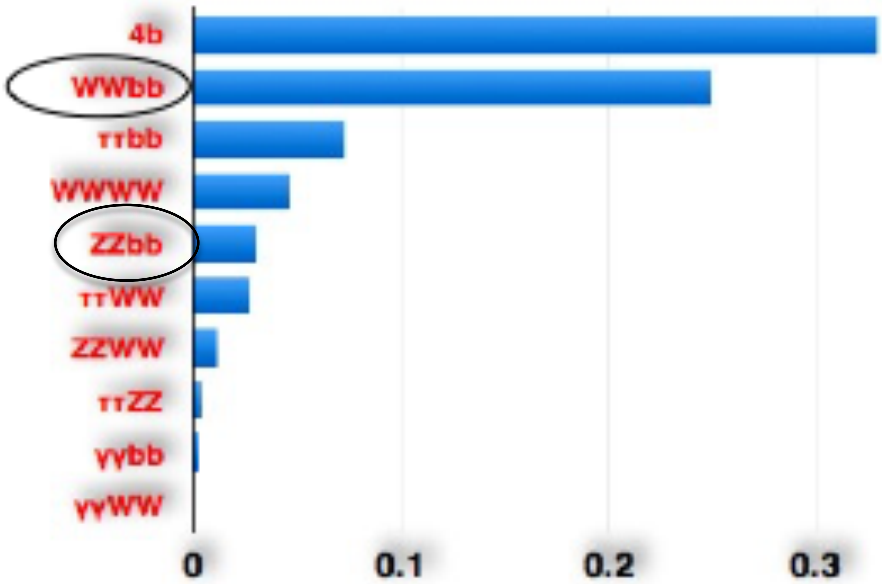




- Modo di produzione dominante: fusione di gluoni
- Signale simulato con Madgraph5_aMC@NLO
- "NLO reweighting"del p_T del sistema HH con correzione legata alla massa finita del top implementata attraverso dei "Form Factor" , *R. Frederix et al., Phys. Lett. B732 (2014) 142*



Studi per FCC-hh/SppC: canali di decadimento



- Noi ci siamo concentrati su:
  - **WWbb**
  - **ZZbb**
- Simulazione delle performance del rivelatore parametrizzata in Delphes
- Simulazione del pileup: 50, 200, 900 eventi sovrapposti al segnale

Il bosone di Higgs può decade in stati finali differenti:

- 4b, WWbb sono quelli dominanti
- γγbb, ZZbb sono i più puliti

Nell'FCC physics report 2016 sono quotati I risultati per:

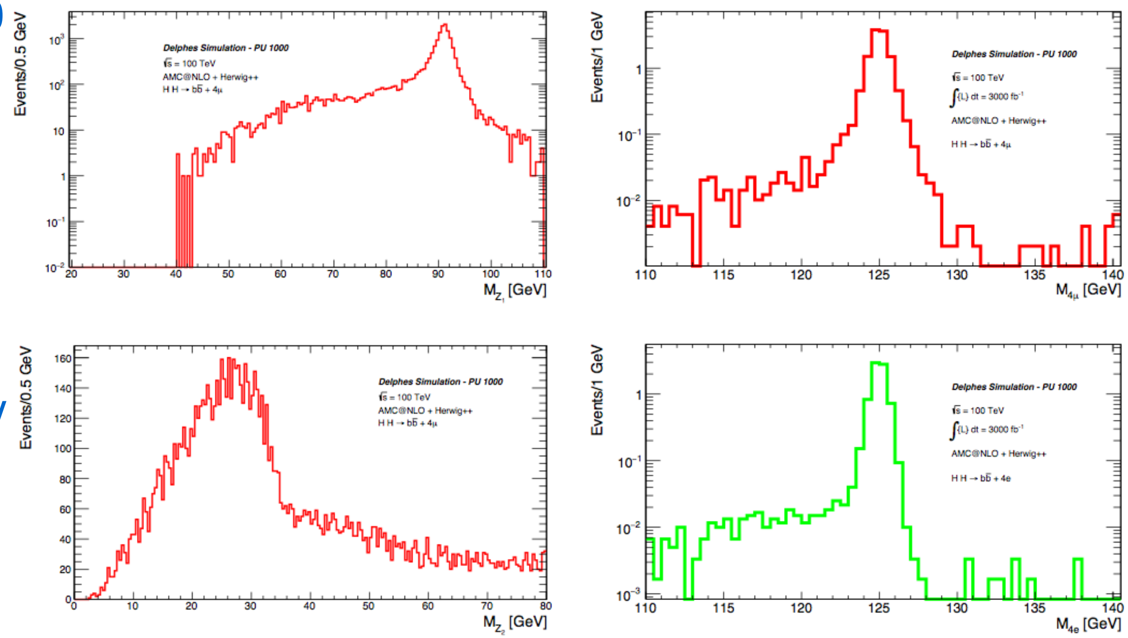
$L=30\ ab^{-1}$	$\Delta\sigma/\sigma$	$\Delta\lambda/\lambda$
γγbb	1.3%	2.5%
4b	25% (S/B ~2%)	200%
ZZbb, 4l	~30%	~40%

Per WWbb c'è un paper fenomenologico nello stato finale con 1 leptone: PRD87 (2013) 0011301:

- osservazione a 4σ con 600 fb^{-1} @14 TeV,
- risultati di CMS preliminari con l 3.2 fb^{-1} di dati a 13 nello stato finale con 2-leptoni trova dei risultati peggiori [CMS-PAS-HIG-16-024]

Studi per FCC-hh/SppC: HH→ZZbb→4lbb

- $\geq$ 4 muoni con p_T > 5 GeV, $|\eta|$ < 4.0
- $\geq$ 4 elettroni con p_T > 7 GeV, $|\eta|$ < 4.0
- selezione Z_1 : coppia $\ell^+\ell^-$ con massa più vicina alla massa della Z nominale: 40 GeV < m_{Z1} < 120 GeV
- selezione Z_2 : seconda coppia $\ell^+\ell^-$ 12 GeV < m_{Z2} < 120 GeV
- tra I 4 leptoni selezionati: almeno uno con p_T>20 GeV ed uno con p_T>10 GeV
- soppressione risonanze QCD: $m(\ell^+\ell^-)$ > 4 GeV
- 120 < $m_{4\ell}$ < 130 GeV
- almeno 2 b-jets con p_T > 30 GeV



- ❑ 4l permette di ricostruire la massa dell'Higgs con precisione
- ❑ Il b-tagging è un importante ingrediente dell'analisi

L=3 ab^{-1}	$\sigma \cdot L \cdot$ Br(hh→ZZbb→4lbb)	**no b-jet req.**	**with b-jet**	**ε (no b-jet)**	**ε (b-jet)**
4μ	161	61	12,1	38%	7,4%
4e	161	40	7,7	25%	4,8%
Tot	322	101	20	31%	6,2%

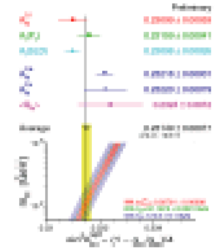
Analisi presentata a LHCP 2018 e finalizzata per il CDR per FCC

Studi per FCC-ee: proposta per 2019

FCC-ee strategy for neutral couplings and $\sin^2\theta_{eff}$

$$\mathcal{A}_e = \frac{2 g_{Ve} g_{Ae}}{(g_{Ve})^2 + (g_{Ae})^2} = \frac{2 g_{Ve}/g_{Ae}}{1 + (g_{Ve}/g_{Ae})^2}$$

- Muon forward backward asymmetry at pole, $A_{FB}^{\mu\mu}$ (m_Z) gives $\sin^2\theta_{eff}$ with 5 10^{-6} precision
  - **uncertainty driven by knowledge on CM energy**
  - **assumes muon-electron universality**
- **Tau polarization can reach similar precision without universality assumption**
  - tau pol measures A_e and A_τ, can input to **$A_{FB}^{\mu\mu} = 3/4\ A_e\ A_\mu$** to measure separately electron, muon and tau couplings, (together with Γ_e, Γ_μ, Γ_τ)
- Asymmetries A_{FB}^{bb}, A_{FB}^{cc} provide input to quark couplings together with Γ_b, Γ_c



NOTE that LEP approach was different: all asymmetries were limited by statistics and primarily used to measure $\sin^2\theta_{eff}$

Studi per FCC-ee: proposta per 2019

tau polarization plays a central role at FCC-ee

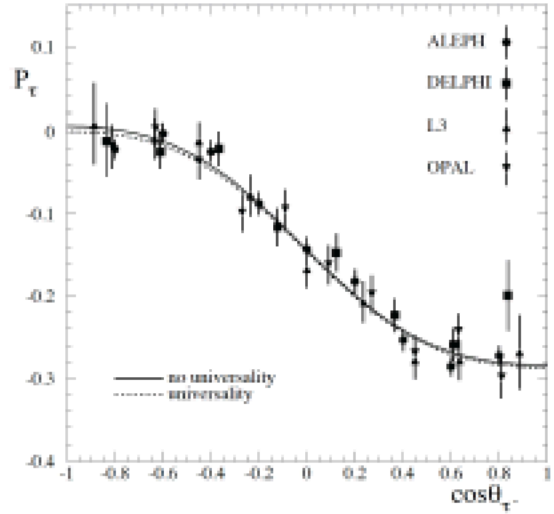
- Separate measurements of A_e and A_τ from

$$P_\tau(\cos\theta) = \frac{A_{pol}(1+\cos^2\theta) + \frac{8}{3}A_{pol}^{FB}\cos\theta}{(1+\cos^2\theta) + \frac{8}{3}A_{FB}\cos\theta}$$

$$A_{pol} = \frac{\sigma_{F,R} + \sigma_{B,R} - \sigma_{F,L} - \sigma_{B,L}}{\sigma_{tot}} = -A_f$$

$$A_{pol}^{FB} = \frac{\sigma_{F,R} - \sigma_{B,R} - \sigma_{F,L} + \sigma_{B,L}}{\sigma_{tot}} = -\frac{3}{4}A_e$$

Measured P_τ vs $\cos\theta_{\tau^-}$



At FCC-ee

- very high statistics: improved knowledge of tau parameters (e.g. branching fraction, tau decay modeling) with FCC-ee data
- use best decay channels (e.g. $\tau \rightarrow \rho\nu_\tau$ decay very clean), note that detector performance for photons / π^0 very relevant

→**measure $\sin^2\theta_{eff}$ with 6.6 10^{-6} precision**

WP7

Studi per rivelatore a muoni per FCC-hh:

I sistemi di muoni per FCC-hh saranno molto grandi (10000 m^2)

- è quindi una scelta obbligata l'uso di tecnologie basate su rivelatori a gas

Diverse soluzioni tecnologie:

- Resistive Plate Chambers: per triggering e tracking
  R&D su: high-rate, high time e spatial resolution

- Micro Pattern Gaseous Detectors: per tracking @ high η
  R&D su: production on large surfaces, readout electronics

- Wire chambers: per tracking @ low η
  R&D su: high rate, high spatial resolution at low occupancy

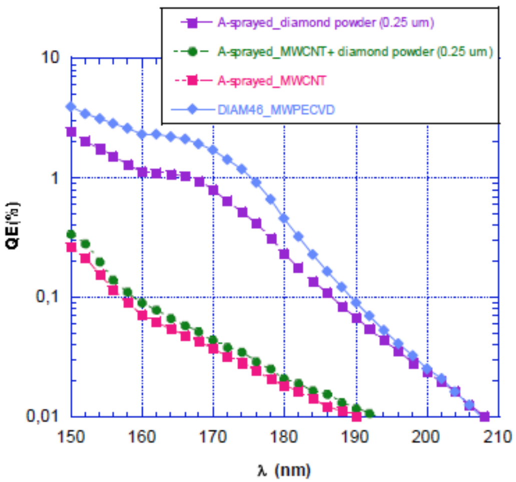
Proposta INFN di rivelatore **IDEA** →

Attività di test beam per 2018 e 2019

Fotocatodi a nanodiamante

New photocathode based on NanoDiamond (ND) particles: the planned activity consists in initial studies to understand the compatibility of this innovative photocathode material with the operation in gaseous detectors. So far, the only photoconverter compatible with large-size, operative gaseous detector is CsI.

The use of CsI in gaseous detector suffers of some intrinsic limitations: ageing, causing a severe decrease of the quantum efficiency after a collected charge of the order of some mC/cm2 and long recovery time (about 1 day) after an occasional discharge in the detector. CsI is chemically fragile: if exposed, even for short time, to atmospheres with water vapour the molecule is broken and therefore the QE is lost



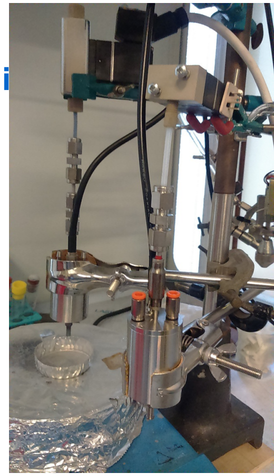
The ND powder is hydrogenized before the cathode coating, the spray procedure by an ultrasonic atomizer used to form the photocathode does not require temperatures exceeding 120 degrees C. **This is compatible with gaseous detector components**

Preliminary tests of mechanical attachment of the photocathode and ageing due to exposure to air indicate that this photocathode material is robust.

Achievements of 2018:

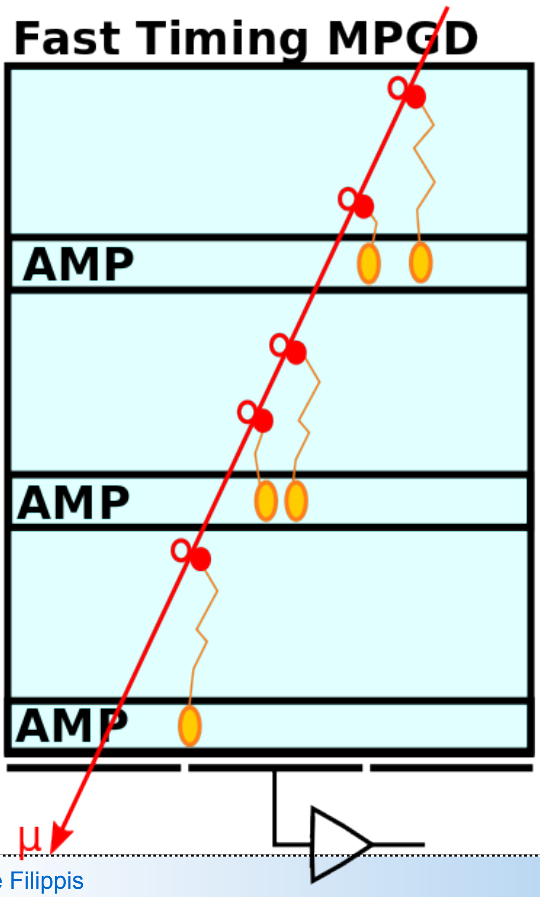
- comparison the quantum efficiency of photocathode samples in vacuum and in different gaseous atmospheres;
- realization of a photon detector prototype with a photocathode using as substrate a THGEM and to characterize it;
- made a preliminary ageing study measuring the QE before and after collecting defined amount of charge at the photocathode itself.

CRESCITA degli STRATI di DIAMANTE



Development of Fast Timing MPGD

- In the view of the possible 200MHz (5ns bx) running of FCC-hh, time tagging of muon hits need to be performed with < ns precision.
- Micro Pattern Gaseous Detectors (MPGDs) will be used for Phase-II upgrades of the ATLAS and CMS experiments. They combine high spatial resolution (<50um) with high rate capability (> 1 Mhz/cm^2). ==> Development of Fast Timing MPGD = FTM



Goal: reach 500ps (and ultimately also less), reducing the fluctuations of closest e- by having several (~10) independent amplification stages.

Principle: The charges created in the resistive amplification stages are picked up capacitively by the outside cu strips.

Proposal: We will make a couple of prototypes with thick wells (e.g. produced by Eltos) and coated with diamond evaporation (Valentini, INFN Bari)

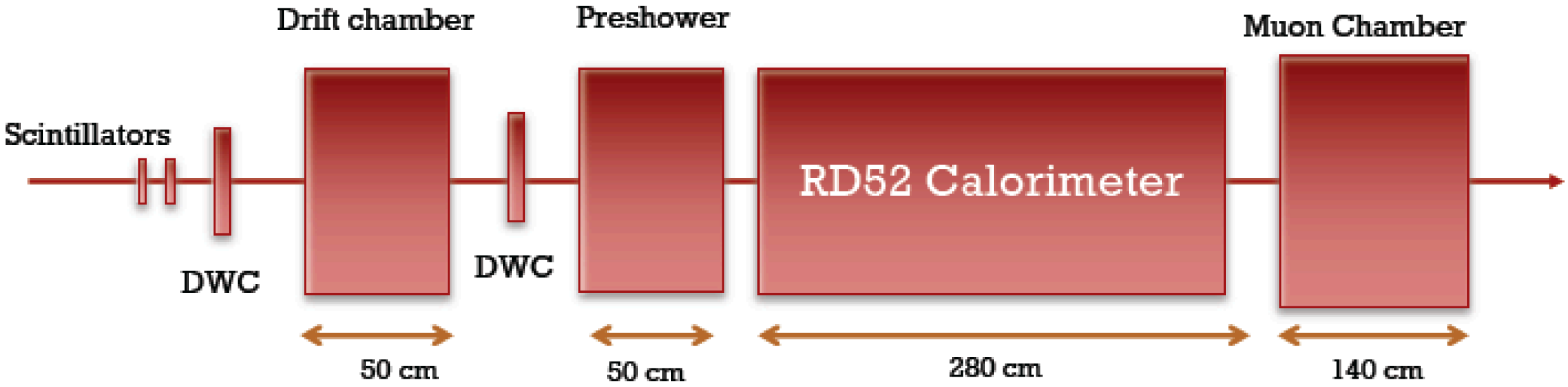
Research: evaluate the thickness of the structure, hole shape, width and pitch and resistivity of the diamond coating to come with a fast timing detector with high spatial resolution and rate capability.

Responsible: Piet Verwilligen (INFN Bari)

Development of Fast Timing MPGD

- MPGD-FaTimA (Fast Timing Applications) was funded 2016-2017 in CSN-V and has ~2.0 FTE
- In 2018 Piet put 0.1 FTE in RD-FA to have additional funds for the detector: idea was to ask 3kEUR for additional detector planes → unfortunately no support
- FTM electronics tested fall 2017; FTM detector constructed Spring 2018.
- Detector & Electronics tested: detector seems to work fine (however we cannot quantify the gain with the current setup → Grant 20kEUR) however electronics suffer from problems of internal power supply in chip → 2 x lower gain; 20ns time jitter;
- Delays in detector construction & problems with electronics did not justify request for detector extension (yet).
- Activities will continue in new CSN-V experiment dedicated to R&D of the FTM. Collaboration Bari-Lecce-Pavia

Test beam 2018 al CERN: area H8



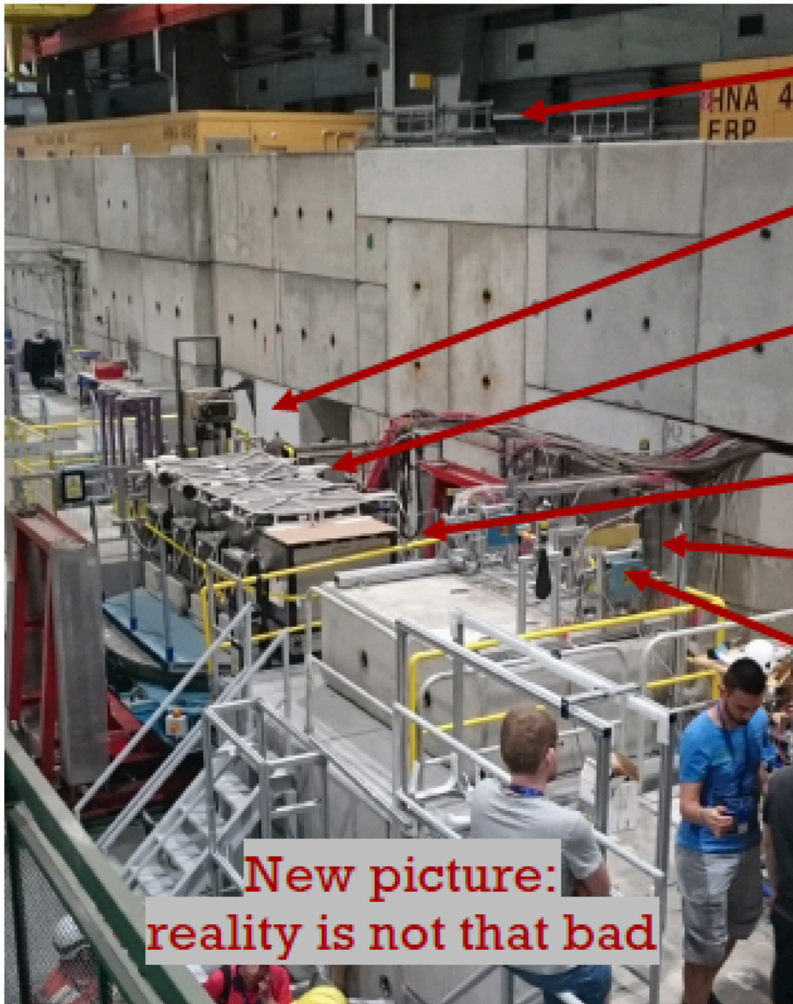
- Trigger with 2 scintillators in coincidence + 1 veto (if needed)
- 2 DWC (Delayed Wire Chamber)
- CEDAR (Differential Cherenkov detector)
- Drift Chamber Prototype
- Preshower with GEM
- Few different Dual Readout prototypes
  - RD52 calorimeter with PMT readout
  - RD52 calorimeter with longitudinally displaced fibers
  - Small calorimeter module with SiPM readout
- Muon chamber 1 layer GEM + 2 layers μRWell

Test beam 2018 al CERN: area H8

- **Measurements:**
  - Particle Identification with:
    - Drift Chamber Prototype (p, π, k) using dE/dx VS cluster counting
    - Preshower + Dual Readout Calorimeters (e, π, μ)
    - μRWell (e, μ)
  - Preshower optimization studies
  - Tracking qualification
  - Small calorimeter module with SiPM readout qualification
  - RD52 calorimeter with longitudinally displaced fibers qualification
- **Beam Requirements:**
  - 6, 10, 20, 40, 60 GeV hadrons (both positive and negative)
  - 10, 20, 40, 60 GeV electron
  - 20, 100 GeV muons
  - Beam pipe close to the experimental area (no parasitic upstream of our setup)

Test beam 2018 al CERN: area H8

Control room: HNA – 468 (0887-1- Q70)



Gas delivery

Space for the muon chamber

RD52 calorimeter (already installed in the area)

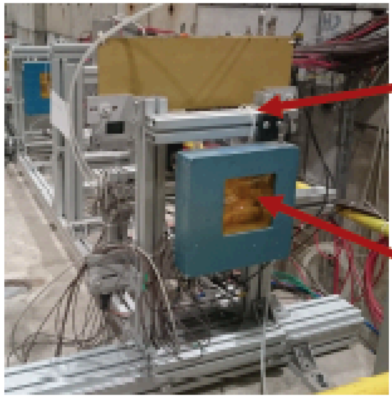
Some space for the preshower

Space for the drift chamber

Trigger + Delay Wire Chamber (DWC) already installed

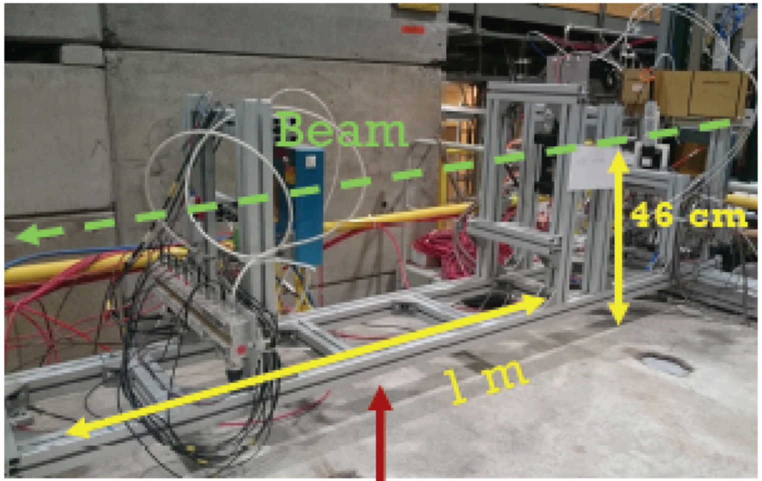
Test beam 2018 al CERN: area H8

Control room: HNA – 468 (0887-1- Q70)



Trigger

DWC

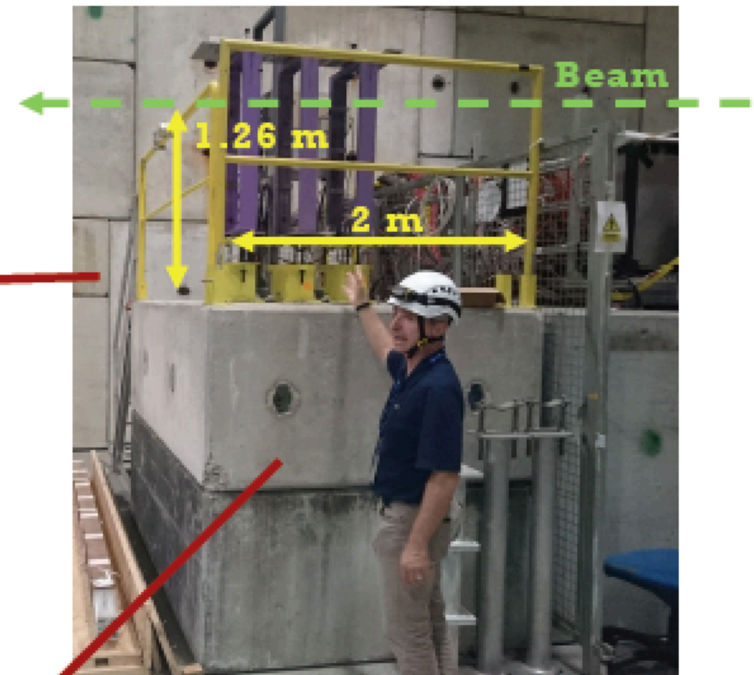


The space for the drift chamber

Test beam 2018 al CERN: area H8

Control room: HNA – 468 (0887-1- Q70)

Space for the muon chamber downstream the calorimeter



1 RAC to install the electronics for the preshower and mu-chamber + HV power supply

Test beam 2018 al CERN: area H8

Control room: HNA – 468 (0887-1- Q70)

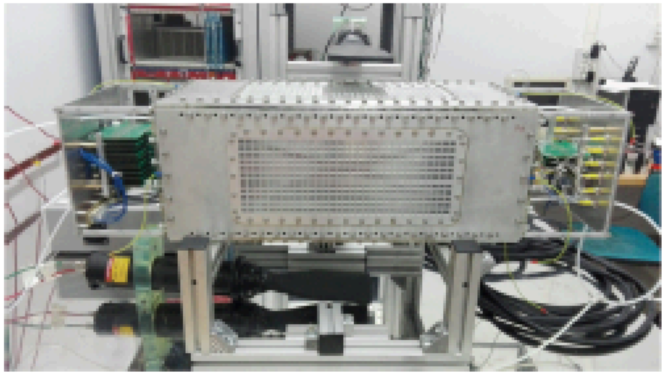
Place where to install the gas bottles (?? m from the detector)

$ArCO_2CF_4$: requested by preshower and muon chamber

He/Isobutene (90/10): requested by drift chamber

I nostri interessi: Camera a deriva

- Detector
  - 12 layers X 12 cells = 144 channels
  - 1x1 cm^2 drift cells instrumented with MEG2 front-end
    - DRS4 8 channels
    - LeCroy 12-bit ADC 16 channels (under discussion)
    - 96 channels readout with Discriminator + TDC
    - 24 channel: not equipped



Rivelatore costruito e testato a INFN Lecce → contiamo di partecipare alla analisi dei dati del testbeam ed allo sviluppo di software per il tracking

I nostri interessi: Misure

- The program is still under discussion and it will be strongly affected by the chamber event rate
- This is the request:
  - Goal: Pion / kaon separation at different energies
  - External detector for particle ID (CEDAR)
  - Beam Energies: 6, 10, 20, 40, 50, 60, 100
  - 10k events per particle type and energy
- Measurement with 2 gas mix for 2 energies
- High Voltage scan for one energy

Bari conta di partecipare a queste misure

I nostri interessi: Camere a μ

- Geometry
  - Preshower: (detector + support) 35 x 50 x 50 cm^3 (xyz)
  - Muon chamber: (detector + support) 35 x 50 x 100 cm^3 (xyz)
- Detector
  - Preshower
    - 2 layers of Gem (2 points xy)
    - Different absorber layers (0 – 2 X0) (4 points?)
    - Detector planes 10 x 10 cm^2
  - Muon chamber
    - 2 layers of Gem (2 points xy)
    - 2 layers of muR-Well (2 points xy)

Contiamo di partecipare alla analisi dei dati del testbeam (misure di risoluzione spaziale, etc..)

Schedula

- Access to the Area since Aug 29: Free access with beam dumped upstream (beam dump before PPE168)
- Safety inspection: 5 – Sept 12:00
- Alignment service: 5 – Sept 14:00
- Beam on: 5-Sept at 18:00
- No machine development between us and the next users

Partecipazione di Bari al testbeam:

- **A. Taliercio dal 2 and 13 settembre**
- **N. De Filippis dal 7 al 11 settembre**

Anagrafica 2019

De Filippis	- 10%
Abbrescia	- 10%
Taliercio	- 10%
Valentini	→ EIC
Cicala	→ EIC
Verwilligen	→ GR5

Richieste finanziarie per 2019

- MI: meeting/workshop (in particolare quello in Cina a Novembre) e testbeam 2019
  - De Filippis: 2k euro per attività WP1 e WP7
  - Abbrescia: 2k euro per attività WP7
  - Taliercio: 2k euro per attività WP1 e WP7

Futuro di medio termine: attivazione attività di sviluppo e test rivelatore a Bari → strumentazione e utilizzo camera pulita

Conclusioni

- Attività avviate su molti aspetti legati agli acceleratori futuri , in particolare hh
- Comunità barese da rimpolpare
- La comunità italiana sta crescendo con ottime sinergie al CERN ed in Cina → a Novembre un MoU in preparazione per movimentare studenti e ricercatori
- Numerosi eventi in programma

Backup

Studi per FCC-ee/hh: calcolo

- Simulazione di eventi di segnale e fondo in Italia (ove non esistono già dei sample) → creazione di una libreria di eventi simulati al CNAF
  - la simulazione di eventi si segnale e fondo con 50,200 e 900 eventi di PileUp è CPU intensive e richiede spazio disco (tra 10 e 100 TB per analisi)
- Siamo in attesa dei 100 TB di spazio disco per il CNAF richiesti al CSN1 precedente

- E' stata creata una "virtual organization" per attività RD_FA in GRID:
  - prima coda del CNAF da associare alla VO a breve
  - poi verranno associate risorse CPU da Napoli, Bari (**per gentile concessione degli altri esperimenti)** e Roma 3 (**grazie a fondi di Ateneo per Roma Tre**)
- Possibile interesse di RD_FA ad usare il centro ReCaS Bari in quanto:
  - ci sono le risorse per ospitare le simulazioni per RD_FA
  - c'è il know-how su strumenti di calcolo
  - Il ranking come Tier2 di CMS ed Alice è buono

I nostri interessi: Preshower e camere a μ

- Services
  - 1 fill $ArCO_2$ (70/30)
  - Pipes to be verified by expert
  - 1 Crate high voltage (Sy1527?) from Ferrara (exp. area)
  - High voltage module from Ferrara (exp. area)
- DaQ
  - System in the experimental area
  - Remote control from counting room
- Trigger
  - Latency (ok)
  - Busy propagation (it should be ok… under test)
  - Trigger counting (ok)
  - Rate 1 kHz
- Measurements
  - No request for a dedicated program to characterize the detector
  - Space point will be provided for the others detectors