This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 657751

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Laboratori di Frascati

L'esperienza di una vincitrice

NITEC: a Negative Ion Time Expansion Chamber for directional Dark Matter searches
MSCA IF 2014

Workshop sulle Azioni Individuali Marie Sklodowska Curie

Universita' di Bologna, 19-20 Maggio 2016

CAVEAT

1) La mia esperienza MSCA e' stata <u>fortemente</u> influenzata dalla mia carriera scientifica precedente

i.e. vi auguro di non dovervi mai trovare nella mia precedente situazione

2) La mia esperienza MSCA proviene da un mio desiderio di cambiare campo di studi

HEP is dead, long live Dark Matter and Neutrinos

3) La mia esperienza MSCA proviene da una idea che ho avuto e che ho cercato di far finanziare applicando a tutti i grant possibili, italiani e non

Tipicamente la MSCA viene usata per integrare fondi di progetti gia' esistenti, con un gruppo alle spalle

<u>La mia esperienza MSCA e' peculiare</u>

Dall'origine dell'idea...

(2) The case for directional Dark Matter detectors and the status of current experimental efforts (arXiv:0911.0323)

Approcci classici

Approcci innovativi

Collaboration	Technology	Target	Interactions	Head-tail	Readout	V (m^3)
DRIFT	NITPC	CS_2, CS_2-CF_4	SI/SD	yes	MWPC 2D + timing	1
DMTPC	TPC	CF_4	SI/SD	yes	Optical (CCD) 2D	0.01
NEWAGE	TPC	CF_4	SI/SD	no	μPIC 2D + timing	0.03
MIMAC	TPC	$^3He/CF_4$	SI/SD	yes	Micromegas 2D + timing	0.00013
Emulsions	emulsions	AgBr	SI/SD	no	Microscope 3D	N/A

E perche' non combinare due approcci innovativi???

..allo sviluppo dell'idea...

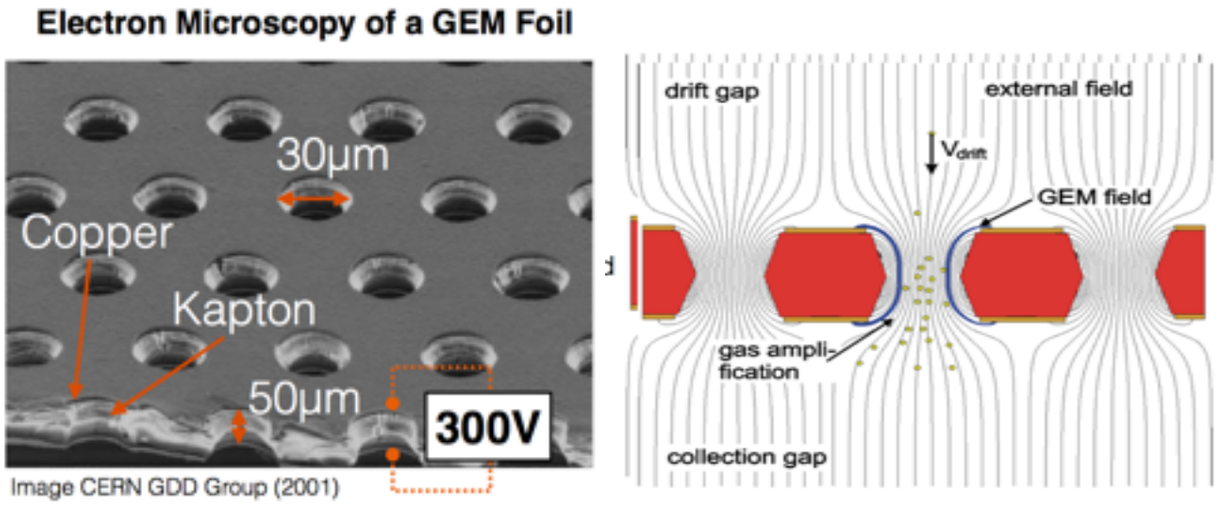
7 anni di ricerca all'estero dopo il PhD mi permettono di usare la mobilita' per *tornare* in Italia

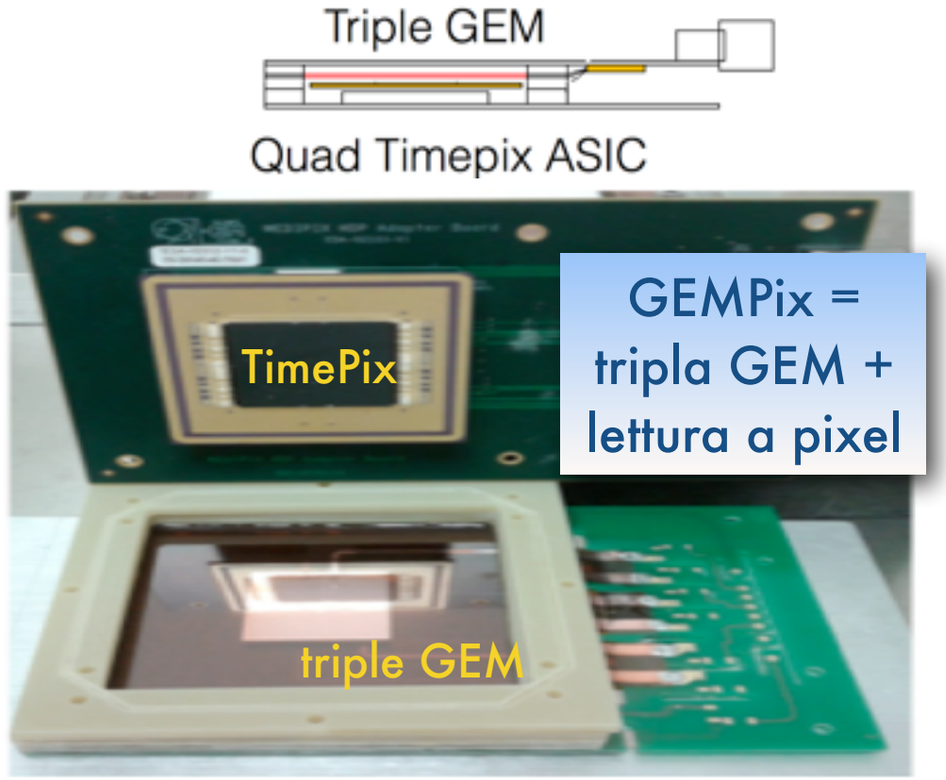
(1) Che tipo di readout innovativo per una Time Projection Chamber e' stato recentemente sviluppato in Italia?

i.e. sono andata a *cercare* Supervisor e collaboratore in funzione di quello che volevo fare (non li conoscevo prima)

G.Bencivenni (LNF, il mio Supervisor),
tra i massimi esperti di sviluppo di grandi detector a gas con amplificazione a GEM

F.Murtas (LNF, collaboratore),
sviluppatore del GEMPix





…alla stesura del progetto..

1. **SUMMARY**
2. **EXCELLENCE**
3. **IMPACT**
4. **IMPLEMENTATION**
5. **CV OF THE EXPERIENCED RESEARCHER**
6. **CAPACITIES OF THE PARTICIPATING ORGANIZATIONS**

NOTA BENE: e' la stesura del progetto che vi obbliga davvero a svilupparlo :) quindi iniziate il prima possibile!

Summary

Il summary e' l'abstract del progetto e lo scheletro di tutto il proposal.
E' molto importante perche' deve essere in grado di sintetizzate in *poche ed efficaci* parole:

1. Summary

The goal of this project is the construction of a Negative Ion Time Projection Chamber (NITPC) with triple Gas Electron Multiplier amplification and pixel readout (GEMPix) for directional Dark Matter (DM) searches. DM is 5 times as prevalent as normal matter in the Universe, but its identity remains unknown. Its mere existence implies that our inventory of the basic building blocks of nature is incomplete: deciphering its nature is one of the most compelling tasks for fundamental physics and astronomy. Weakly Interacting Massive Particles (WIMP) are well motivated DM candidates, independently predicted by Standard Model extensions and Big Bang cosmology. Direct detection experiments aim at observing very low energy (10-100 keV) nuclear recoil of WIMP scattering in the matter. While today leading experiments have managed to reach excellent rejection for electromagnetic components, other background sources (such as neutrinos and environmental radioactivity) will forbid to even think larger mass next-generation detectors without a drastic change in technology (See Fig.1). We believe that the combination of the large volumes and improved position and energy resolutions provided by the negative ion technique, together with the excellent performances of the GEMPix, can offer a significant contribution to this research field. In a NITPC, negative ions drift rather than free electrons, drastically reducing diffusion thanks to their higher mass. This is why we want to combine for the first time this idea with one of the most advanced readout, the GEMPix: a triple GEM detector coupled to a Medipix ASIC board, able to provide excellent spatial, energy and time resolutions. Its sensitivity to single ionization cluster will allow this NITPC, together with the slow motion of the anions, to function effectively as a Time Expansion Chamber, hence NITEC. It is important to notice how the NITEC concept could work also as neutrino-less double beta decay detector, X-ray polarimeter and micro-dosimeter for hadrotherapy.
NITEC will give the Experienced Researcher (ER) the chance to grown personally and professionally to the level of a completely independent and mature researcher, while expanding her expertise in gas detector R&D and rare events search. At the same time, it will provide the beneficiary important opportunities to broaden its proficiency and research activities.

- Lo scopo del progetto: il summary inizia con "The goal of this project.."
- L'importanza dell'oggetto di studio "deciphering (DM) nature is one of the most compelling tasks for fundamental physics and astronomy"
- Lo stato dell'arte e l'innovativita' del progetto rispetto ad essa
- Come realizzerete il vostro progetto: fattibilita'
- Come e perche' i beneficiari della MSCA (sia l'ER che l'istituto) traerranno vantaggio da essa: "chance to grow professionally to independent researcher"/ "broaden research activity (for LNF)"

Ripetere queste stesse parole/concetti attraverso tutto il proposal

Summary

Il summary e' l'abstract del progetto e lo scheletro di tutto il proposal.
E' molto importante perche' deve essere in grado di sintetizzate in *poche ed efficaci* parole:

1. SUMMARY

1) Lo scopo del progetto: il summary inizia con "The goal of this project.."

2) L'importanza dell'oggetto di studio "deciphering (DM) nature is one of the most compelling tasks for fundamental physics and astronomy"

2. EXCELLENCE

2) Lo stato dell'arte e l'innovativita' del progetto rispetto ad essa

4. IMPLEMENTATION

4) Come realizzerete il vostro progetto: fattibilita'

3, 5, 6) Come e perche' i beneficiari della MSCA (sia l'ER che l'istituto) traerranno vantaggio da essa: "chance to grow professionally to independent researcher"/ "broaden research activity (for LNF)"

3. IMPACT

5. CV OF THE EXPERIENCED RESEARCHER

6. CAPACITIES OF THE PARTICIPATING ORGANIZATIONS

Excellence

2.1 ***Quality, innovative aspects and credibility of the research*** *(including inter/multidisciplinary aspects)*

2.1.1 Introduction

2.1.2 State of the art

2.1.3 Objectives, Originality, Innovative Aspects and Research Approach

2.1.4 Potential Interdisciplinary Applications

FISICA

NOTA BENE:
1) conta come la fisica nel giudizio
2) piu' difficile da scrivere (almeno per me)

2.1.5 Scientific Impact and Opportunities for the Beneficiary

2.2 Clarity and quality of transfer of knowledge/training for the development of the researcher in light of the research objectives

2.3 Quality of the supervision and the hosting arrangements

2.4 Capacity of the researcher to reach and re-enforce a position of professional maturity in research

TRAINING & KNOWLEDGE TRANSFER

Excellence: Fisica

2.1 *Quality, innovative aspects and credibility of the research* *(including inter/multidisciplinary aspects)*

2.1.1 Introduction e' il background scientifico:

- Cosa e' la DM
- Come si misura
- Perche' la direzionalita' e' diventata cruciale in questo momento (timeliness)

2.1.2 State of the art in relazione alla vostra proposta (io non ho discusso liquid Xe o Ge)

Collaboration	Technology	Target	Amplification + Readout	Volume (m^3)	Country
DRIFT	NITPC	CS_2, CS_2:CF_4	MWPC	1	UK-US
DMTPC	TPC	CF_4	mesh chambers + Optical CCD	0.02	UK-US
NEWAGE	TPC	CF_4	Micro Pixel Chamber μPIC	0.02	Japan
MIMAC	TPC	$^3He/CF_4$	pixelized Micromegas	0.006	France
D^3 (prototype)	TPC	CF_4	double GEM + pixel	1×10^{-6}	US
NITEC	NITPC	CS_2/CH_3NO_2:CF_4	triple GEM + pixel	0.005	Italy

Table 1: Summary of main characteristics of all the existing directional dark matter detectors, together with the proposed prototype

- A che punto sono arrivati i correnti esperimenti
- Quali sono i challenge futuri
- Usare elenchi puntati e tabelle per sintetizzare e chiarire confronti

Excellence: Fisica

2.1.3 Objectives, Originality, Innovative Aspects and Research Approach

e' il **CORE** della vostra proposta originale ed innovativa

- Chiarire subito quale e' lo scopo del progetto "The final objective of NITEC is to build a Negative Ion Time Projection chamber with triple GEM amplification and pixelated readout"
- Attraverso quali studi e quali step otterrai il tuo scopo
- Quali sono i contributi di originalita' ed innovazione che il tuo progetto porta allo stato dell'arte attuale e/o come intende risolvere i challenge sperimentali elencati in 2.1.2 (State of the art)

2.1.4 Potential Interdisciplinary Applications

- Discutere sinteticamente possibili applicazioni, ricopiando lo schema del summary, ovvero:
  - Importanza delle applicazioni alternative
  - Problematiche sperimentali di tali applicazioni
  - Come il tuo progetto innovativo puo' risolvere anche quelle/essere originale anche in quel campo

Excellence: Training & Transfer

2.1.5 Scientific Impact and Opportunities for the Beneficiary

il BENEFICIARIO e' l'istituto che vi assumera'

- Come l'istituto beneficiera' della ricerca originale che svilupperete
  - In generale "NITEC will be the first R&D project in Italy on directional DM gaseous detector possibly opening new research lines"
  - Nel particolare "GEMPix developed by LNF will be employed in a new environment. This will be an innovation for LNF"

2.2 Clarity and quality of transfer of knowledge/training for the development of the researcher in light of the research objectives

- Come il progetto aiutera' a sviluppare vostre qualita' gia' acquisite fino a rendervi indipendenti, grazie ai nuovi collaboratori/nuove opportunita' che si apriranno: "The Supervisor long-lasting experience will be transferred through the close collaboration" [...] "The MSCA will give the ER the chance to manage and fulfill a project for the first time completely on her own, a new fundamental experience to further develop her carrier"
- Come, attraverso lo sviluppo del progetto, trasferirete vostre capacita' precedentemente acquisite ai vostri nuovi collaboratori/nuovo istituto: "The LNF will benefit from the skills the ER gained in the previous state-of-the-art experiments she worked in: data analysis, tracking algorithm, simulation and study for planning of a new experiment"

Excellence: Training & Transfer

2.3 Quality of the supervision and the hosting arrangements

e' il CV del vostro Supervisor e dei vostri collaboratori

- Mettete in particolare in luce gli aspetti che si riferiscono al progetto che proponete
- Mettete in luce attivita' di Tutoring e supervisione di tesi e dottorato
- Discutete brevemente come vi relazionerete con loro:
  - "The ER will be the focus of all activities and will coordinate the department"
  - "The ER and the Supervisor will draw together a career development plan and held forthnightly meetings to monitor the advancement and define the strategy"

2.4 Capacity of the researcher to reach and re-enforce a position of professional maturity in research

Come il progetto vi rendera' dei ricercatori completamente indipendenti

Ovvero come, dopo aver avuto delle posizioni di responsabilita' all'interno di progetti di altri e grazie all'esperienza cosi' acquisita, siete pronti davvero a guidare una proposta

Impact

3.1 ***Enhancing research- and innovation-related human resources, skills, and working conditions to realize the potential of individuals and to provide new career perspectives***

Come si inserisce questo progetto in questo momento della vostra carriera e come puo' aiutarvi a realizzare pienamente il vostro potenziale

Tutte le esperienze acquisite fino a ora e che utilizzerete nel nuovo progetto, grazie alla sua originalita' ed innovazione, rafforzeranno la vostra expertise e vi renderanno indipendenti

3.2 ***Effectiveness of the proposed measures for communication and results dissemination***

3.2.1 Communication and public engagement strategy of the action

Divulgazione scientifica attraverso i mezzi dell'INFN (riviste scientifiche, notti della ricerca, tutoraggio di scuole ecc.)

3.2.2 Dissemination of research results

Diffusione dei risultati a conferenze specialistiche e non e produzione di articoli

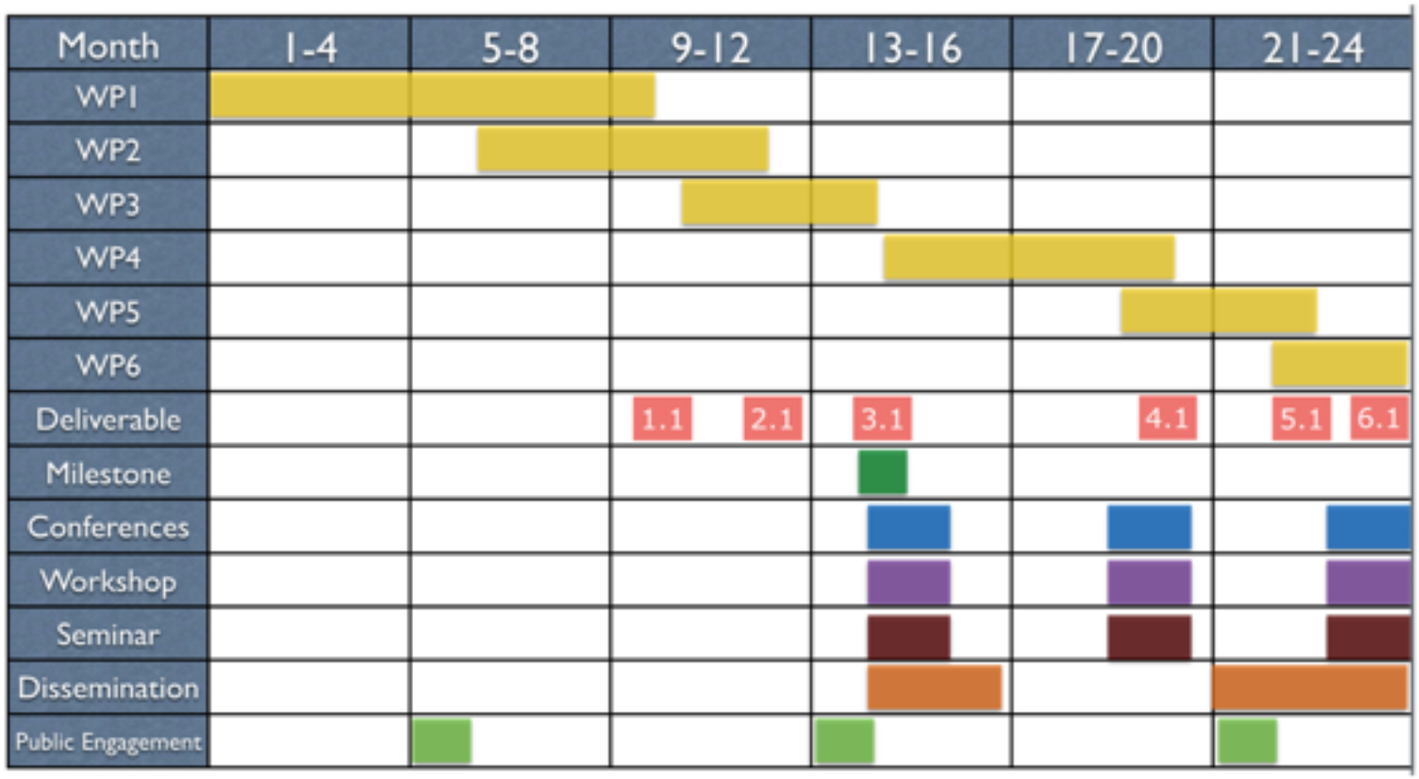
3.2.3 Exploitation of the results and intellectual property

Due parole sulla proprieta' intellettuale e possibilita' di applicazioni commerciali

Implementation

4.1 ***Overall coherence and effectiveness of the work plan,*** *including appropriateness of the allocation of tasks and resources*

- Descrivere l'implementazione attraverso Working Packages, con stima dei tempi necessari
- Usare liste, elenchi puntati, sintetizzare
- Chiarire come i WPs interagiscano e si influenzano
- Essere realistici sui tempi
- USARE GANTT CHART



- Definire Milestones e Deliverables
  - Milestone: sono i risultati fondamentali che dovete ottenere per poter proseguire con gli altri WPs
    "Our fundamental milestone is the measurement and assessment of NITEC working point: if it will not be working as expected, we will need to redesign and rebuilt it"
  - Deliverables: quello che produrrete: "NITEC prototype, laser calibration system, measurement of NITEC working point and performances, data analysis ecc"

Implementation

4.2 *Appropriateness of the management structure and procedures, including quality management and risk management*

- Discutere brevemente management structure ("we will have a flat organizational structure, where the ER in liaison with the Supervisor will coordinate activities")
- Discutere brevemente risk assessment, incluso frequenza dei meeting e della ridiscussione della strategia

4.3 *Appropriateness of the institutional environment (infrastructure)*

- Come l'istituto/sezione dove svolgerete il progetto (i.e. per me LNF, non INFN) possiede tutti i requisiti per svilupparlo appieno in termini di infrastrutture (camera pulita, BTF, XLAB, officine meccaniche e elettroniche ecc)

4.4 *Competences, experience and complementarity of the participating organizations* and *institutional commitment*

- Come l'istituto/sezione dove svolgerete il progetto (i.e. per me LNF, non INFN) possiede tutti i requisiti per svilupparlo appieno in termini di esperienze e competenze tecniche (esperienza grandi detector a gas, GEM)
- Come il progetto proposto aggiungera' conoscenze e competenze all'istituto in termini di complementarita'

Curriculum Vitae

- Sintetico, in tabella e non in forma discorsiva
- Citare i propri articoli in riferimento a momenti del CV
  - Tesi di laurea e Phd, responsabilita' di analisi, presa dati ecc
- Mettere in evidenza la mobilita'
- Mettere in evidenza la capacita' di adattarsi a nuovi problemi e nuove sfide
  - Aver cambiato esperimento, campo di ricerca, laboratorio ecc
- Mettere in evidenza le posizioni o incarichi di responsabilità
  - Conveener di working groups o conferenze, responsabilita' di analisi o R&D, run coordination dcc
- Mettere in evidenza tutto cio' che della vostra esperienza e' propedeutico al progetto che presentate
  - Sviluppo, monitoring, analisi dati e simulazione di detector a gas (prima HEP, ora DM)
  - Sviluppo del caso di fisica e potenzialita' di un esperimento (runnare alla Y(5S) a SuperB prima, esperimento direzionale di DM a gas ora)

5. CV of the Experienced Researcher

Name: Elisabetta
Surname: Baracchini
Date of birth: 26/04/1982
Place of birth: Rome, Italy
Telephone: +41 787 836 227, +39 328 358 4926
E-mail: baracch@icepp.s.u-tokyo.ac.jp, baracch@gmail.com

Curriculum Vitæ

Current Position

April 2012 - Present
Project Researcher at the International Center for Elementary Particle Physics (ICEPP) of the University of Tokyo, Japan, for the MEG experiment, fully based at Paul Scherrer Institut (PSI), Villigen, Switzerland.

Previous Positions

January 2012 - March 2012
Researcher in the framework of the European project "Research Chairs of Excellence Based University - Universities of Paris" (RBUCE-UP) at the Laboratoire de l' Accélérateur Linéaire (LAL), Orsay Cedex, France, for the SuperB project.

March 2011 - December 2011
Cooperative Researcher for the Lepton Flavour Violation group of the Institute for Particle and Nuclear Studies (IPNS) at the High Energy Accelerator Research Organization (KEK), Tsukuba, Japan, for the MEG experiment, fully based at the Paul Scherrer Institut (PSI), Villigen, Switzerland.

November 2008 - March 2011
PostDoctoral Scholar Employee for the Department of Physics and Astronomy, University of California Irvine, USA, for the MEG experiment, fully based at Paul Scherrer Institut (PSI), Villigen, Switzerland.

Qualifications

January 2014
Italian national scientific qualification as Associate Professor in the sector "02/A1 - Experimental Physics of Fundamental Interactions"

September 2009
Italian national scientific qualification for fixed-term employment as III level Researcher for the INFN.

Education

2nd February 2009
PhD thesis defense with grade "optimum". Thesis title "Search for B-> lν at BaBar with l = (e, μ) and Phenomenological Implications" [33], PhD tutors: Dr. R. Faccini, Dr. G. Isidori and Dr. G. Pireddu. PhD student in Physics at Università "La Sapienza" of Rome (**October 2005 - October 2008**)

23rd June 2005
Graduation thesis defense with grade 110/110 *cum laude*. Thesis title: "Correzioni radiative ai decadimenti in due corpi del mesone B" [34], tutors: Prof. F. Ferroni, Dr. G. Cavoto and Dr. G. Isidori. Student in Physics at Università "La Sapienza" of Rome. (**September 2000 - June 2005**)

33 B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. D 79 (2009) 091101
34 E.Baracchini and G.Isidori, Phys. Lett. B 633 (2006) 309,
B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. D 75 (2007) 012008.

Aiuto da parte del personale fondi esterni

FONDAMENTALE E IMPAGABILE

GRAZIE GRAZIE GRAZIE per avermi insegnato a scrivere grant, senza di voi non avrei mai vinto

Fatevi aiutare e seguite i loro consigli

Due parole sui fondi MSCA

- Lo stipendio e' OTTIMO, io sono Primo Ricercatore di II fascia
- I fondi dati per fare ricerca sono FISSI e indipendenti dalla ricerca proposta
  - Se fate solo simulazione e vi serve un computer nuovo e fondi per le missioni, va bene
  - Se dovete costruire, sviluppare, ottimizzare e far funzionare un detector sono molto molto limitati
- Il costo di Management & Overhead tipicamente viene utilizzato dall'INFN/sezione del progetto per potervi offrire adeguate condizioni di lavoro come un laboratorio e un ufficio ben attrezzati
  - Per me e' stato possibile chiedere l'overhead indietro per poter portare a termine la mia MSCA, che senza questo contributo non sarebbe neanche partita
- Io posso effettivamente portare avanti il mio progetto perche' ho trovato dei nuovi collaboratori al di fuori della mia struttura che stanno contribuendo in termini di FTE e fondi, perche' ho avuto indietro l'overhead e perche' sono riuscita ad ottenere in prestito molto materiale

Institutional Unit Cost	
Research, training and networking costs	Management and Overheads
19 200	15 600
19 200	15 600

BE VERY CAREFUL
e fatevi due conti prima

Due parole su altri grant

Programma "SIR"
Decreto del 23 gennaio 2014 prot. n. 197
Protocollo: RBSI14N9OV

Giudicato <u>INFERIORE ALLA SUFFICIENZA</u> al primo step

Programma Per Giovani Ricercatori

"Rita Levi Montalcini"

PROPOSTA DI CONTRATTO

Codice: PGR1335VLA

Posizionata tra i primi 5-10 esclusi, come gli ultimi 3 anni

Istituto Nazionale di Fisica Nucleare

Bando n. 16555

Concorso per il finanziamento di n. 6 progetti per giovani ricercatrici/ricercatori nell'ambito delle linee di ricerca e sviluppo tecnologico proprie dell'Ente (acceleratori, elettronica/informatica, rivelatori, interdisciplinare)

Giudicata molto favorevolmente al primo step, giudicato tra i miglior orali, bocciata perche' <u>non fattibile</u>

Non fatevi abbattere dagli insuccessi

MARIE SKŁODOWSKA-CURIE ACTIONS

Individual Fellowships (IF)
Call: H2020-MSCA-IF-2014

Vinta con <u>92/100</u>
"Very high quality, original innovative idea of the ER, implementation simple and highly coherent

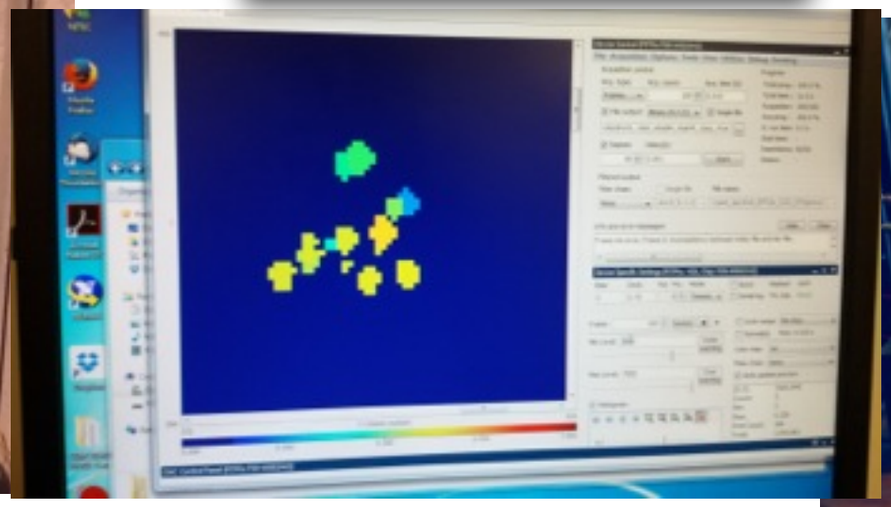
European Research Council
Established by the European Commission
Supporting top researchers from anywhere in the world

Progetto ancora piu' ambizioso, ottenuta la votazione massima di <u>A/A</u>
"Fully meet ERC excellence criterion and is recommended for funding if available"

E oggi a un anno dall'inizio?

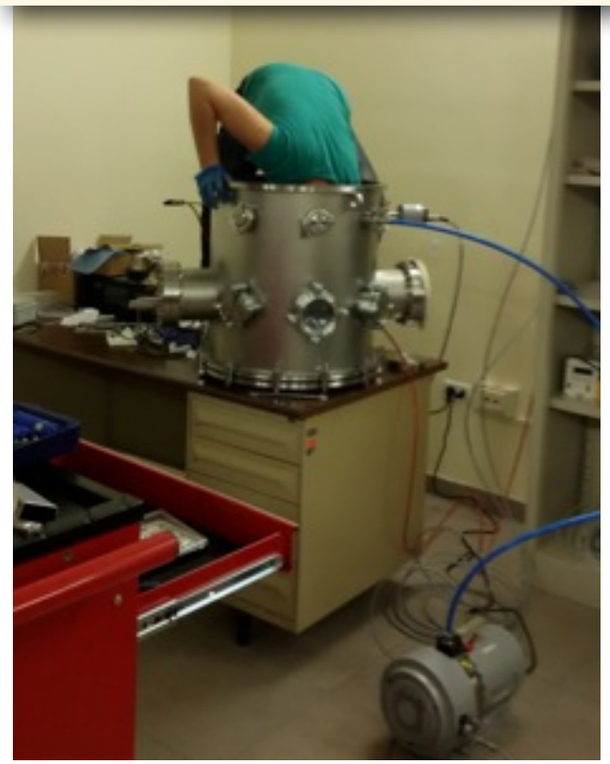
Un detector funzionante

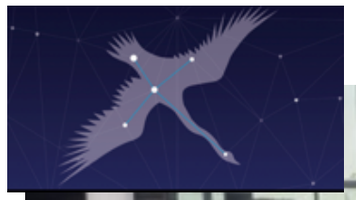
Una Negative Ion TPC con SF_6 : **tra i primi al mondo!!!**



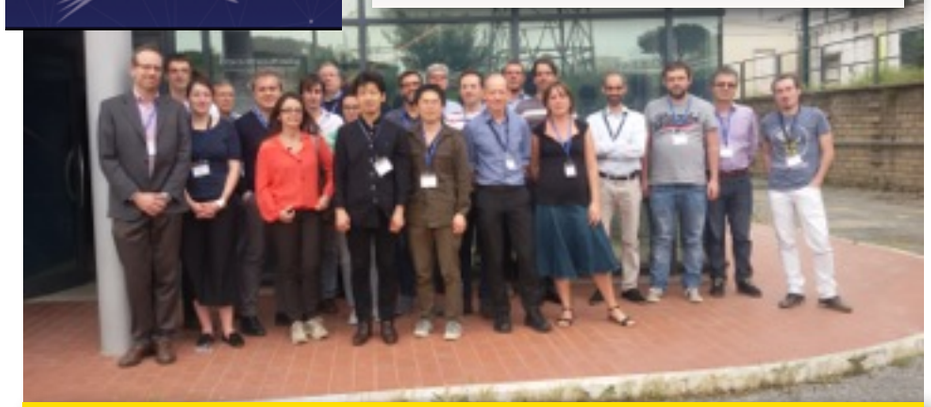
Dati da raggi cosmici, sorgenti radioattive, fasci elettroni alla BTF: **materiale per 3-4 articoli**

Un laboratorio ben attrezzato anche per un (si spera....) futuro





CYGNUS Galactic Nuclear Recoil Observatory



Tra i **fondatori** di una **nuova collaborazione** internazionale per il primo directional DM detector alla ton-scale

Si e' effettivamente verificato **tutto** quello che avevo scritto nel proposal, compresa la mia emancipazione e crescita a ricercatore completamente indipendente, capo del proprio progetto.

E oggi a un anno dall'inizio?

...ma il mio contratto scade comunque il 4 Maggio 2017, non ho alcuna prospettiva per il futuro e continuo ad applicare a tutti i grant possibili ed immaginabili (compresa la MSCA a cui applicherete voi.....)

(1) **(2)** **(3)**

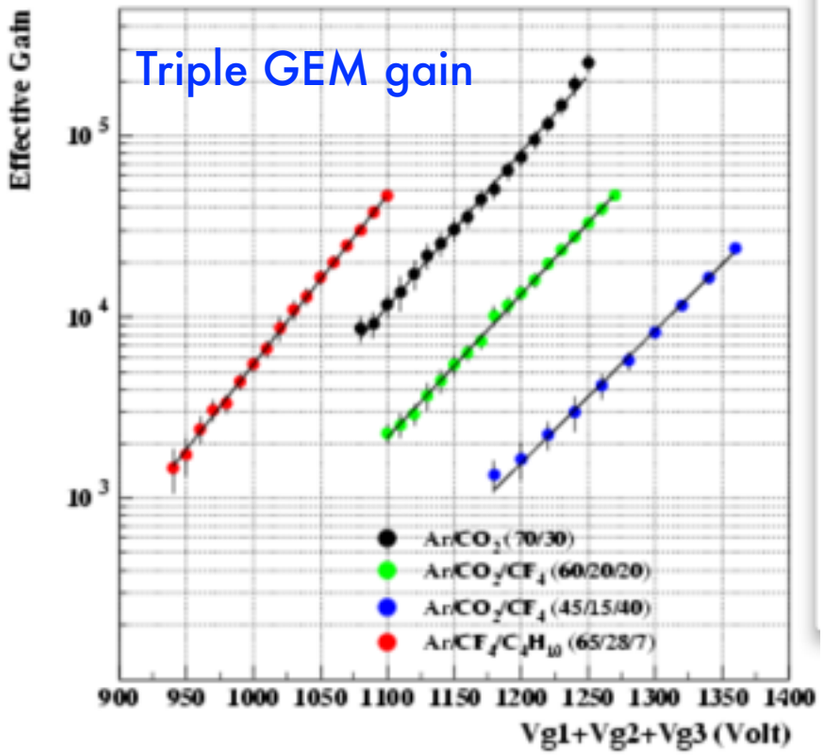
NOTA MOLTO BENE: io ora posso applicare all'European Fellowship Reintegration Panel....forse???

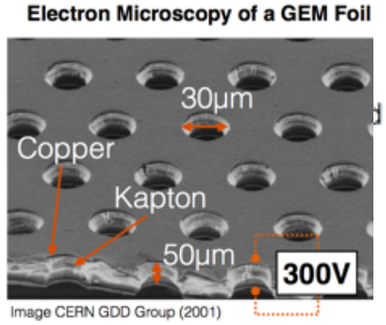
..non si smette mai di combattere e i mulini a vento diventano sempre piu' grossi....

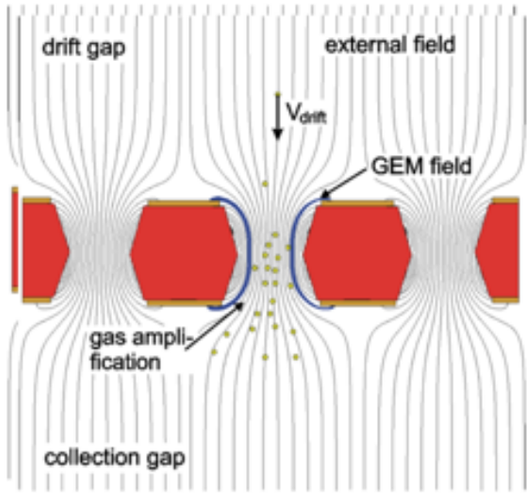
In bocca al lupo a tutti!!!!!

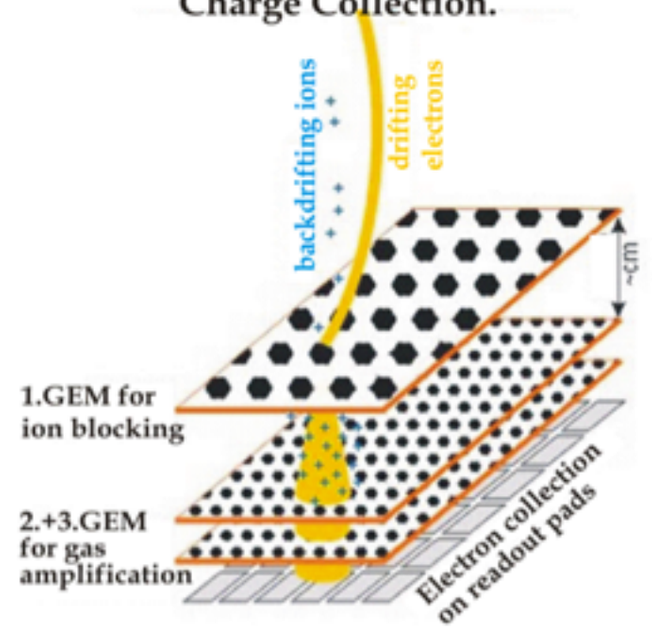
Backup

GEM



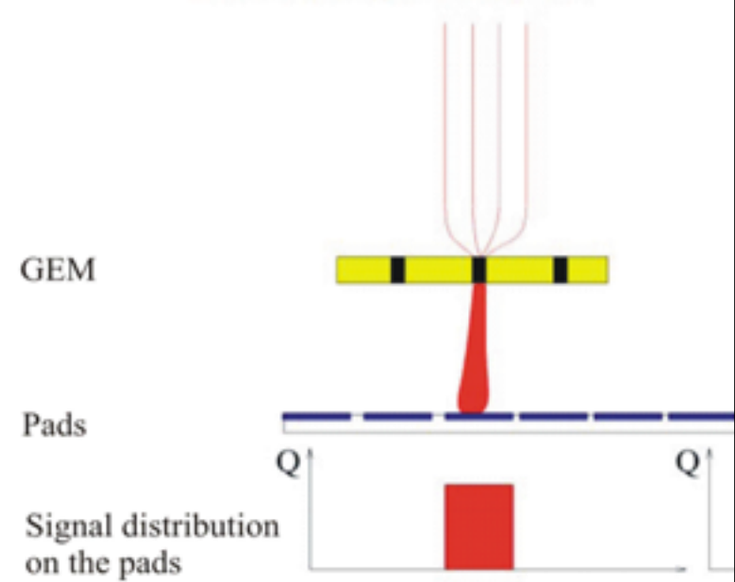






- Particle conversion, charge amplification and signal induct zones are physically separated
- Large dynamic range: from 1 t 10^8 particle/cm^2 /s
- Gain up to > 10^4
- High stability/granularity

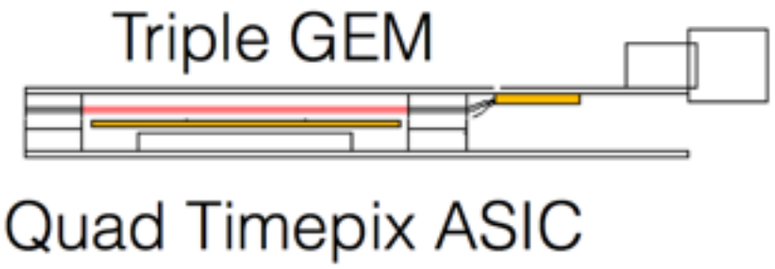
- Micro pattern gas detector
- Thin holes are etched in a metallised kapton foil and a potential is placed across it
- Very large electric field around the holes (40 kV/cm) which creates a localised electron avalanche



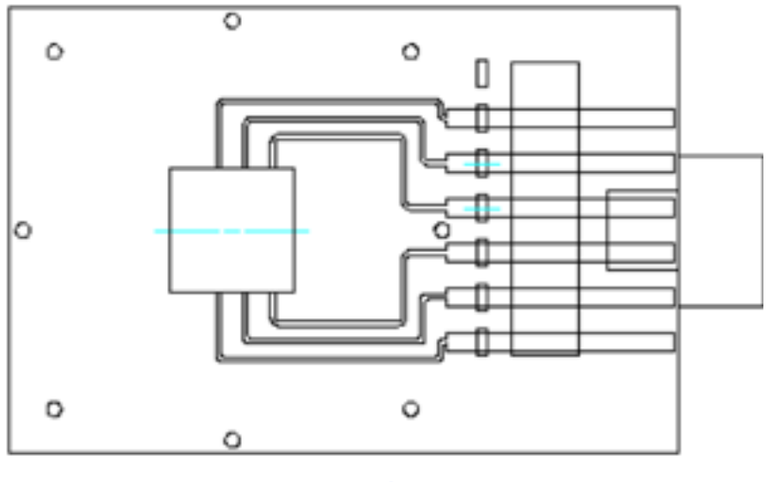
GEMPix

Developed by LNF in collaboration with CERN

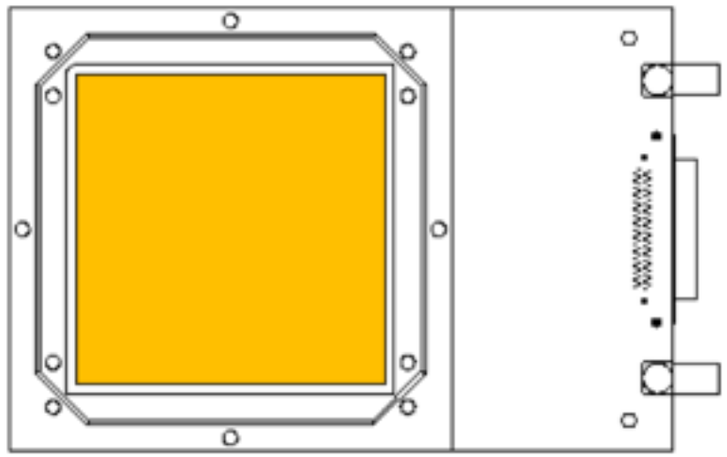
Triple GEM detector with HV filters and connector



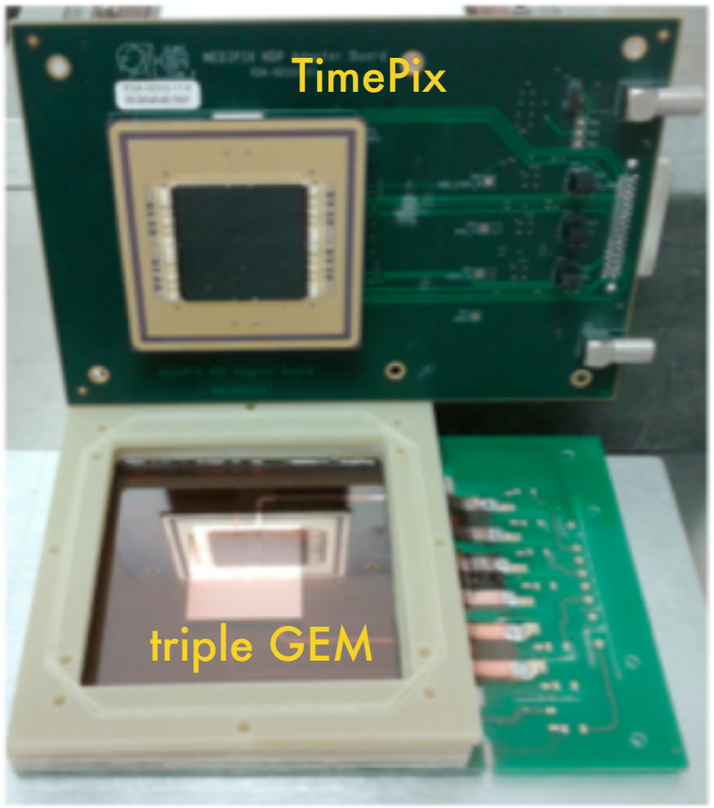
Quad Timepix ASIC board with naked devices (i.e. no silicon)



top view



side view

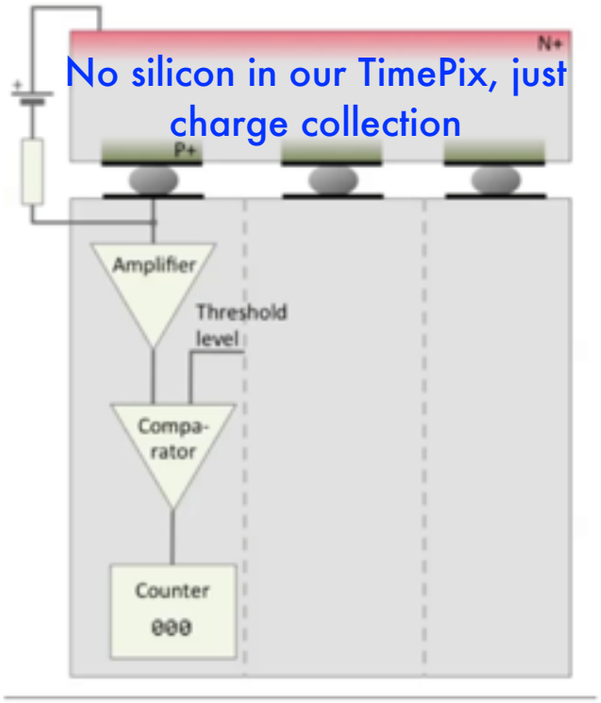


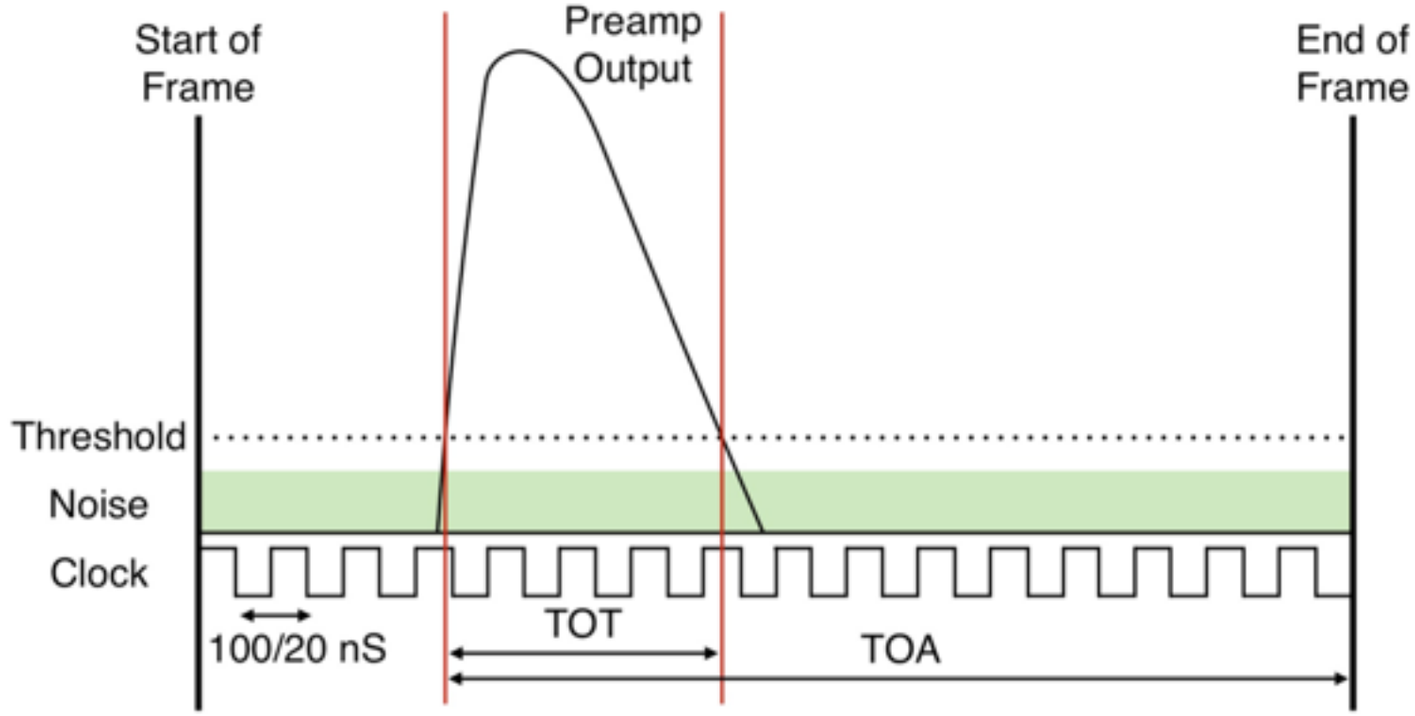
pixel size 55 x 55 um

Quad Timepix (512 x 512 pixels) = 4 Timepix chips (256 x 256 pixels each)

TimePix

- TimePix is a pixelated silicon detector developed by MediPix2 collaboration
- We use a 2x2 array for a total of 512x512 pixel of 55 um side WITHOUT silicon sensors
- Processing electronics, including preamplifiers, discriminator threshold and pseudo-random counter fit inside the footprint of the overlying semiconductor pixel.
- Can be operated in counting TOA, TOA and TOT mode but also *TOA/TOT MIXED mode*



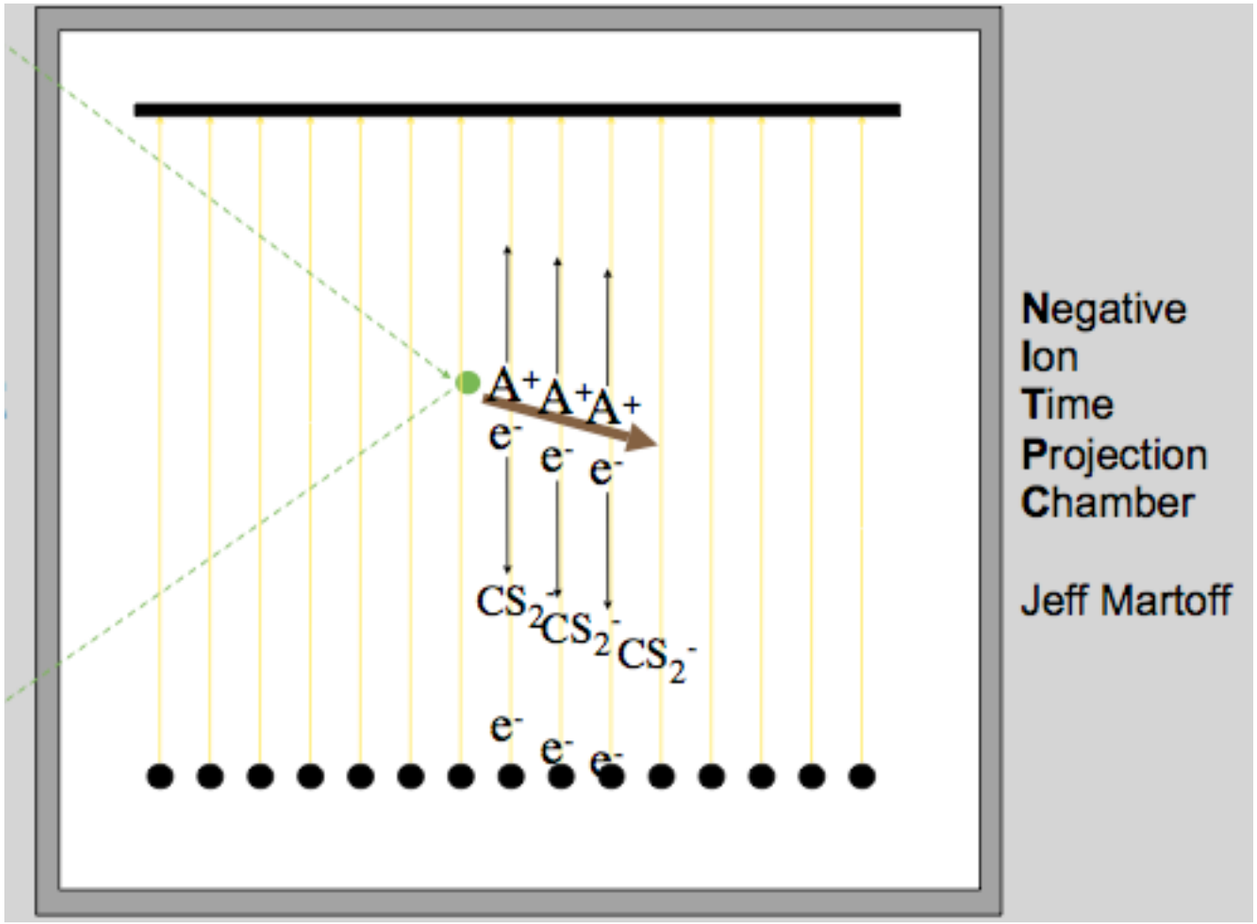


- Timepix clock can run at 1, 10 or 50 Mhz (100 as well, but unstable)
- Timepix counter depth is 11810 —> limits total acquisition time —> is ok for negative ion slow drift as well

TimePix vs Timepix3

	Timepix (2006)	Timepix3 (2013)
Pixel arrangement	256 x 256	
Pixel size	55 x 55 µm²	
Technology	250nm CMOS - 6Metals	130nm CMOS - 8Metals
Acquisition modes	1) Charge (iTOT) 2) Time (TOA) 3) Event counting (PC)	1) Time (TOA) AND Charge (TOT) 2) Time (TOA) 3) Event counting (PC) AND integral charge (iTOT)
Readout Type	1) Full-Frame	1) Data driven (DD) 2) Frame (FB)
Zero suppressed readout	NO	YES
Dead time per pixel	> 300µs readout time of one frame	> 475ns **~600x** Pulse measurement time + packet transfer time
Minimum timing resolution	10ns	1.562ns **6.4x**
On-chip Power pulsing (PP)	NO	YES
Minimum detectable charge	~750e-	>500e- **1.5x**
Output bandwidth	1 LVDS ≤200Mbps 32 CMOS ≤3.2Gbps	1 to 8 SLVS @640Mbps DDR ≤5.2Gbps **1.6x**

Negative Ion drift



< 0.5 mm diffusion achieved over 0.5 m drift length w.r.t. 10 mm obtained with electrons (no magnetic field)

J. Martoff et al., NIM A 440 355

T. Ohnuki et al., NIM A 463

- Mixture of target gas + electronegative gas (typically CS_2)
- Primary ionization electrons are captured by the electronegative molecules at O(100) um
- Anions drift to the anode acting as the effective image carrier instead of the electrons
- Thanks to the much higher anions mass w.r.t. electrons, longitudinal and transversal diffusion is reduced to thermal limit w/out any magnetic field
- At the anode, the electron is stripped from the anion and normal electron avalanche occurs

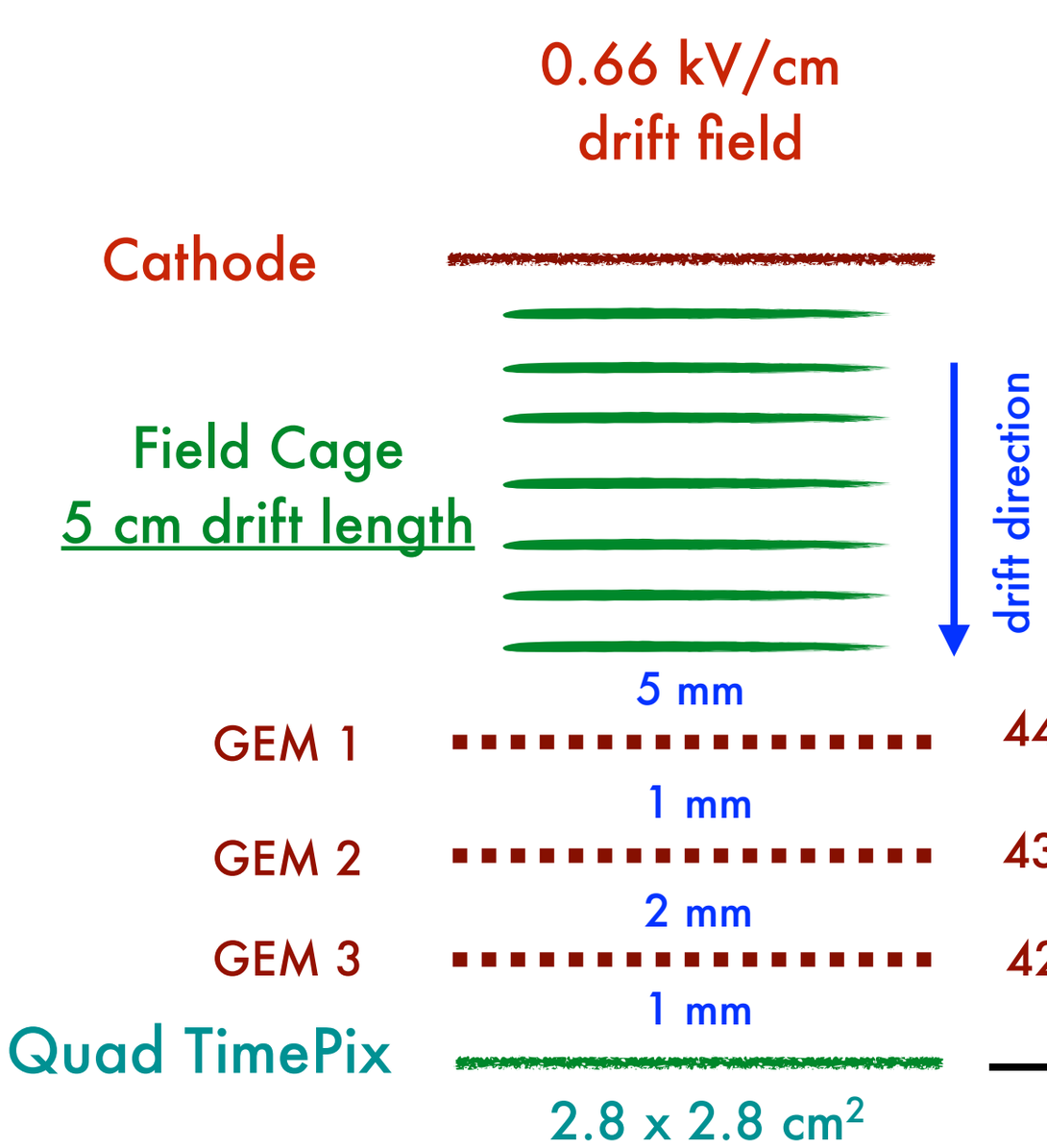
Address TPC typical volume limitations

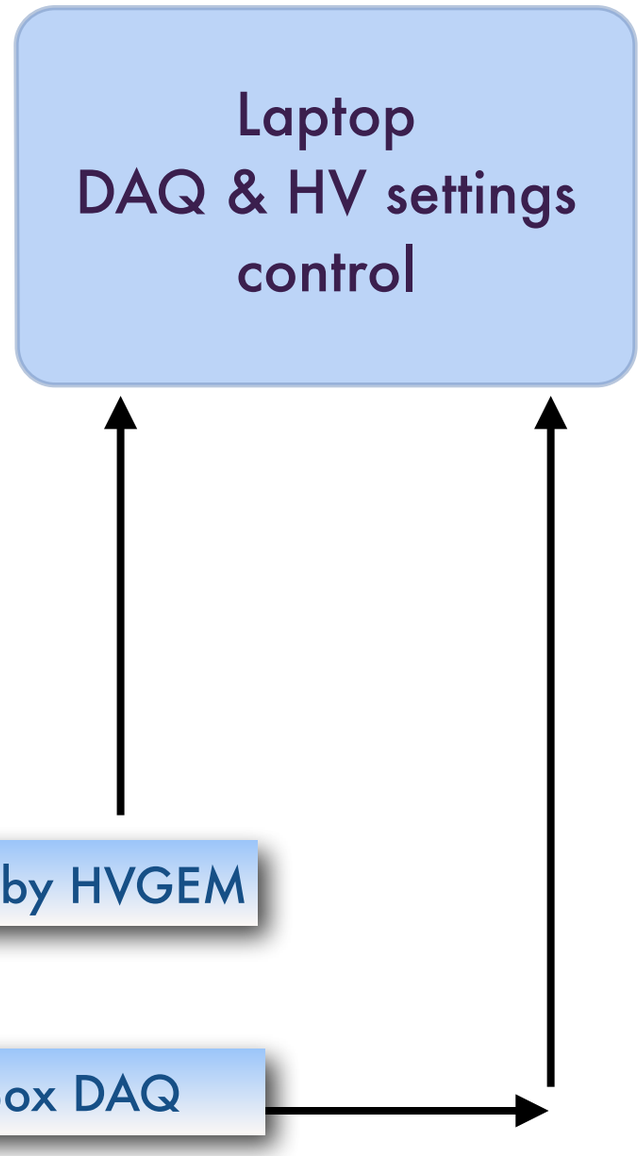
GEMPix + NITPC: A Time Expansion Chamber

- At moderately high reduced fields, anions drift at about 100 m/s, compared to about 10^4 m/s for electron in typical atmospheric pressure drift chamber conditions
- Excellent GEMPix time, energy and spatial resolutions
- Slow anions speed + typical separation of primary ionization clusters in gas + GEMPix performances = Time Expansion Chamber
  - Single ionization clusters drift slowly and can be individually observed with high precision: a relative time expansion between ionization process and signal readout has effectively been achieved
- Single ionization cluster observation can provide excellent dE/dx information, improved position resolution and possibility of superior energy resolution for low energy radiation (< 1 keV)

"The Time Expansion Chamber and single ionization measurement" (A.H.Walenta, IEEE TNS 26 73)
"Suppressing drift chamber diffusion without magnetic field" (C.J.Martoff et al, NIM A 440)

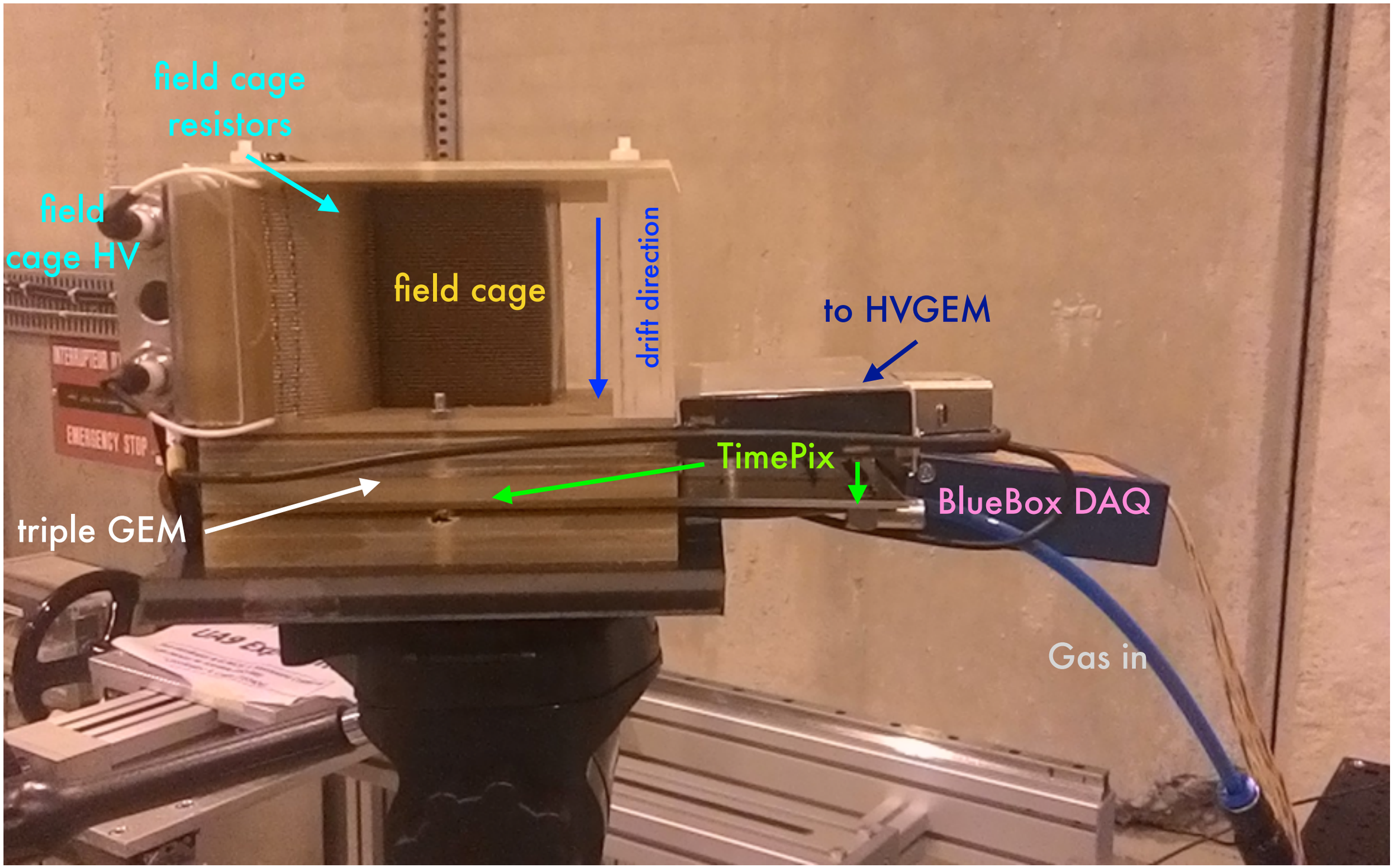
A first prototype: schematically



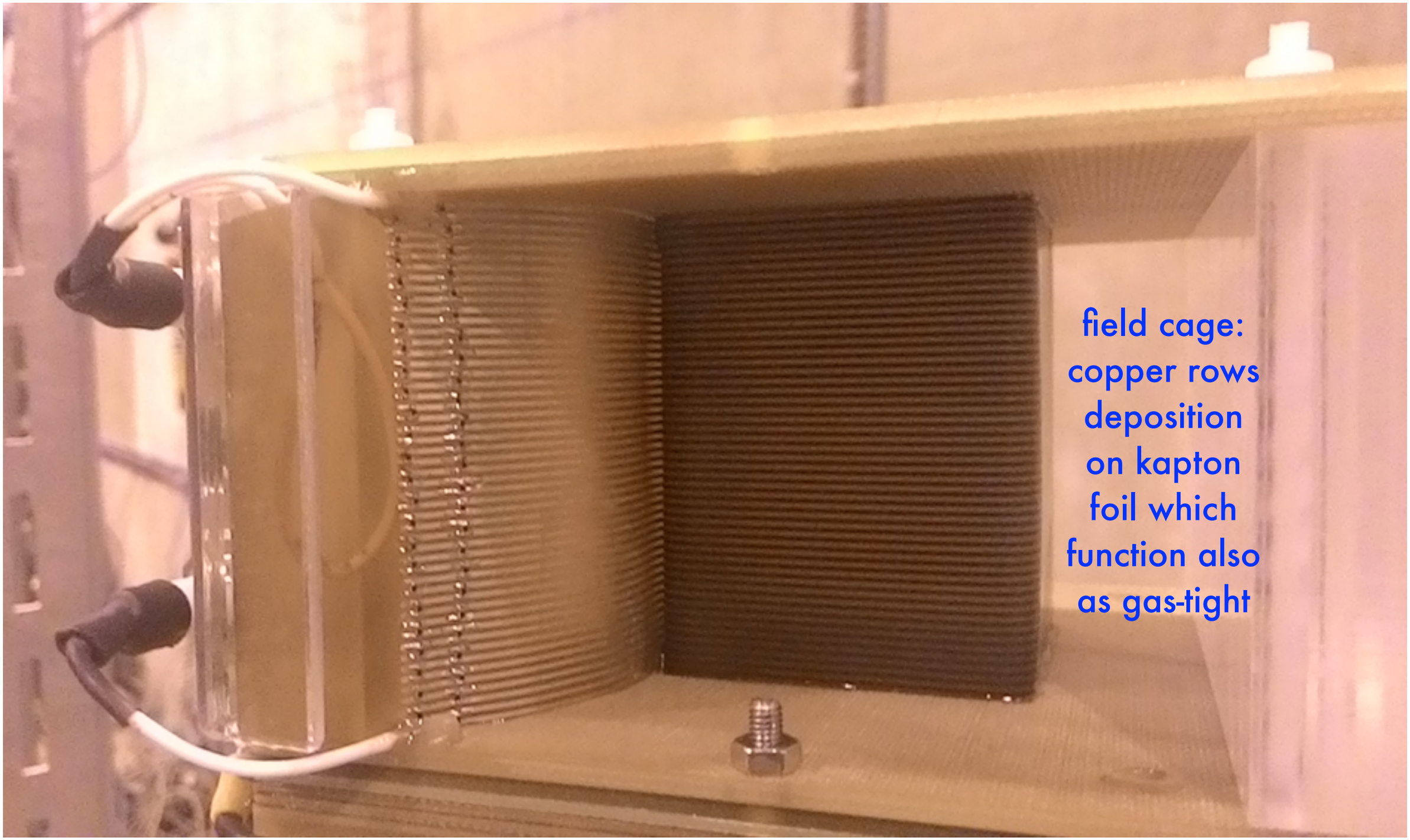


This is the first ever realized 5 cm drift TPC equipped with GEMPix

A first prototype: for real



Details: field cage

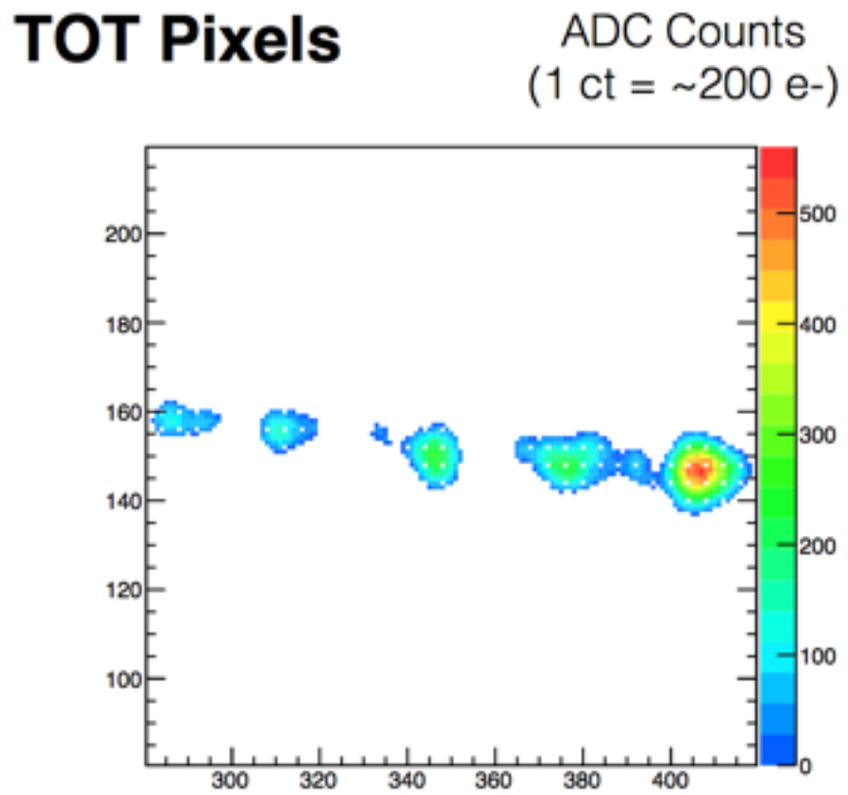


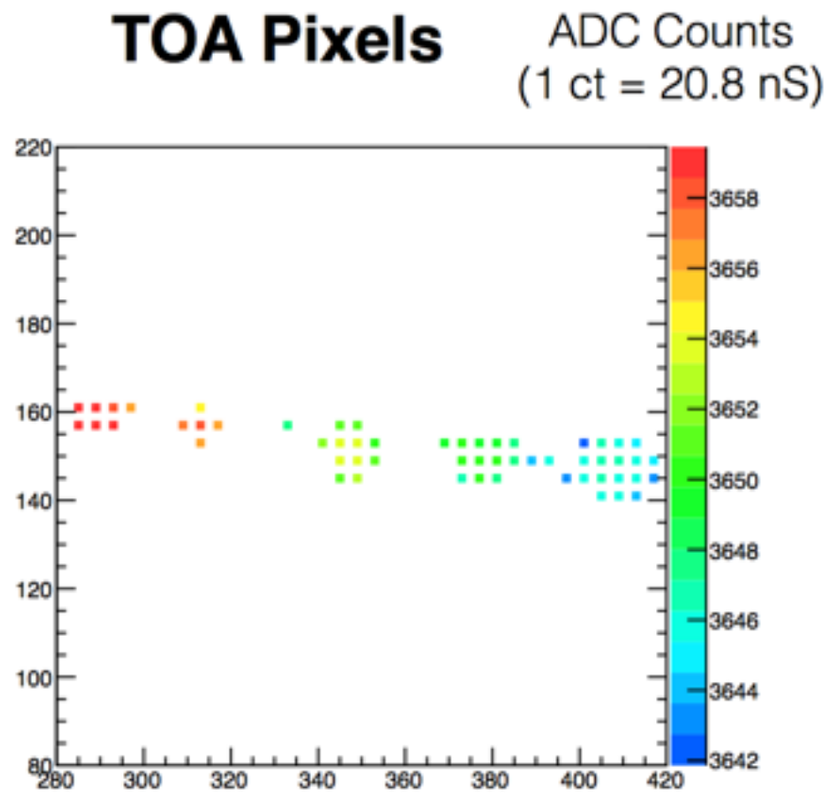
field cage:
copper rows
deposition
on kapton
foil which
function also
as gas-tight

GEMPix potentialities: mixed mode operation

from another prototype

- Simultaneous TOA/TOT measurement
- Beyond the advantages of simultaneous 3D tracking, TOA measurement and TOT measurement also allows improved clustering
- Obviously redundant with timepix3





Note, TOA pixels are doubled in lateral size for visual effect

TOA	TOT	TOT	TOT	TOA
TOT	TOT	TOT	TOT	TOT
TOT	TOT	TOT	TOT	TOT
TOT	TOT	TOT	TOT	TOT
TOA	TOT	TOT	TOT	TOA

will take data in mixed mode as soon as beam becomes available again (~next week)

NITEC potentialities

Directional Dark Matter Gaseous Detector with $CF_4 + CS_2$ / $CF_4 + CH_3NO_2$

- Large allowed drift length –> thanks to negative ions operation
- 3D track reconstruction –> thanks to highly performing GEMPix with charge & time measurement
- Head-tail discrimination capabilities –> charge & time measurement along path
- Improved position and energy resolution –> thanks to slow ions motion and possibility of observing single ionization cluster with GEMPix
- Possibility of z fiducialization –> with minority carriers “a la DRIFT” and with measurement of diffusion along drift direction