Status of GEMTPCs

A. Prochazka

NUSTAR Week 2014, IFIC Valencia, Spain

Collaboration

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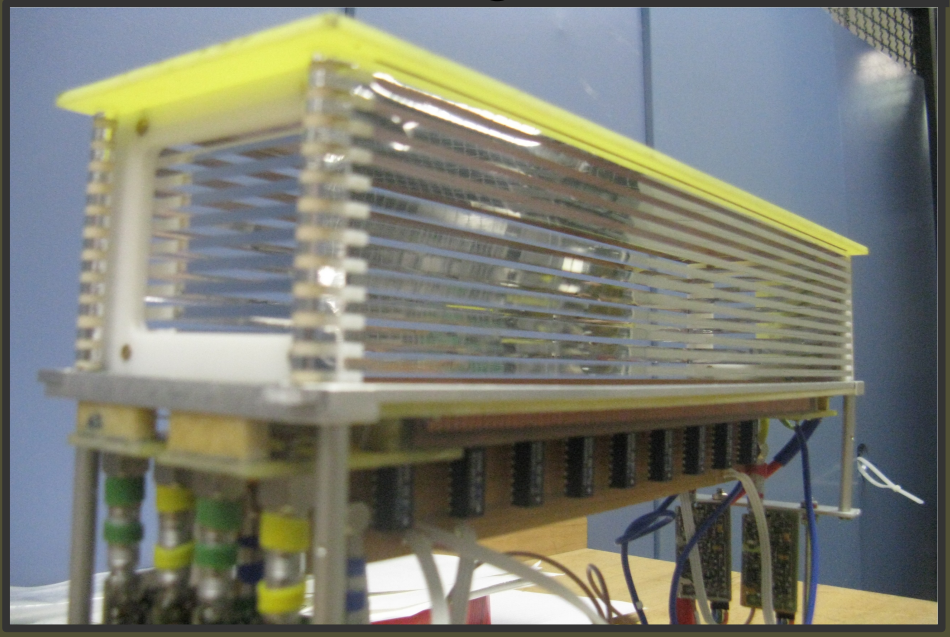
TPC@FRS

TPC



Design

20cm x 6(8,10,12)cm
Integrated delay-lines
VME TDCs (8ch/TPC)
P10 gas at 1 atm.
E field ~ 400V/cm

Resolution

$\sigma_x \approx 100\mu m$

$\sigma_y \approx 40\mu m$

Efficiency

>99% @ 50kHz (U)
>90% @ 250kHz (U)
>90% (p)

R. Janik et al, NIM A640(2011)

TPC@Super-FRS

Size

38 x 8 cm^2
38 x 15 cm^2
20 x 8 cm^2

SFRS Requirements

position resolution < 1mm
high dynamic range
Tracking at MHz
beam-profile at 10MHz

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38 x 8 cm^2
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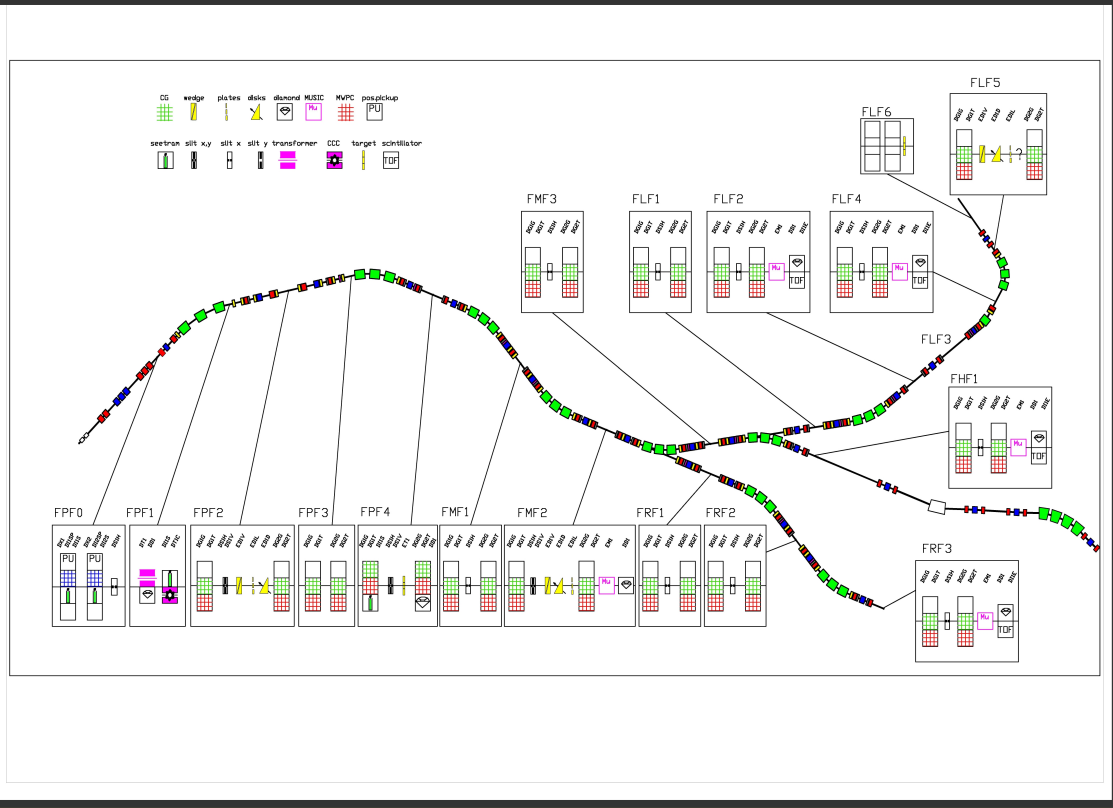
SFRS Requirements

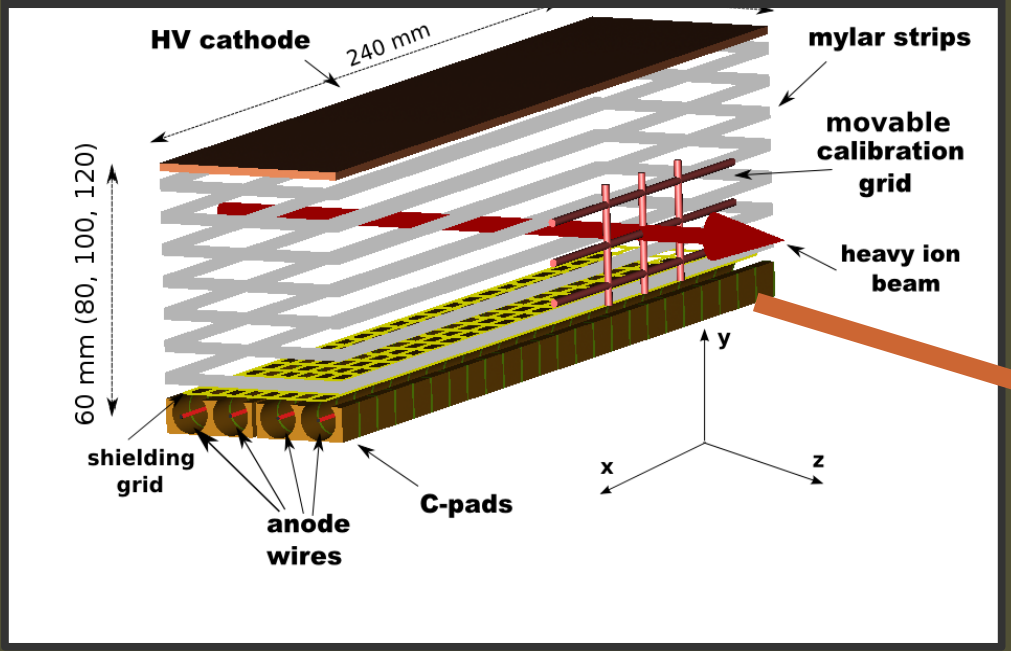
position resolution < 1mm
high dynamic range
Tracking at MHz
beam-profile at 10MHz
32 detectors required

Super-FRS layout



FRS -> SFRS

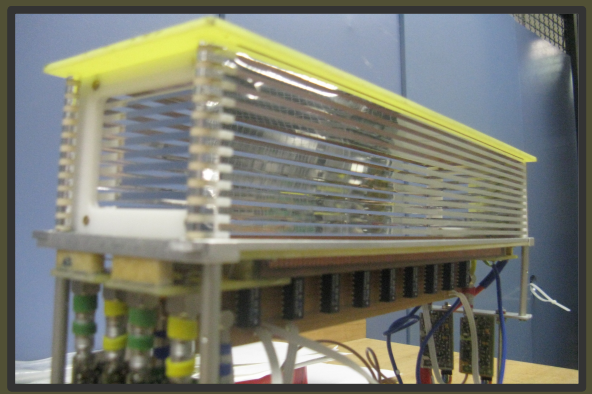
TPC Scheme



Gas Amplification

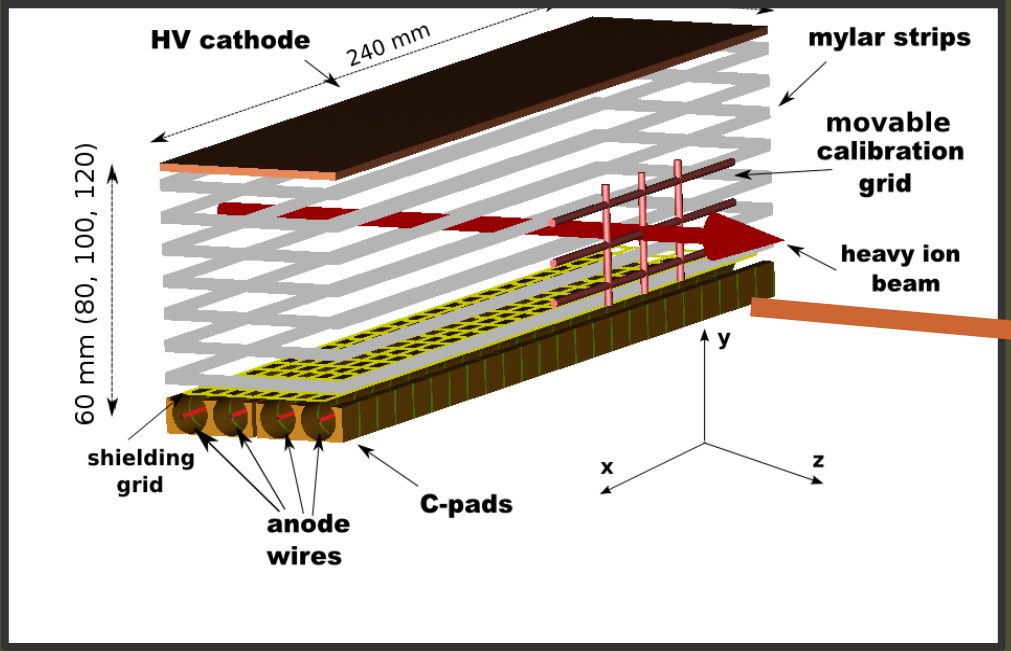
anodes -> GEM foil stack

GEM stack



FRS -> SFRS

TPC Scheme

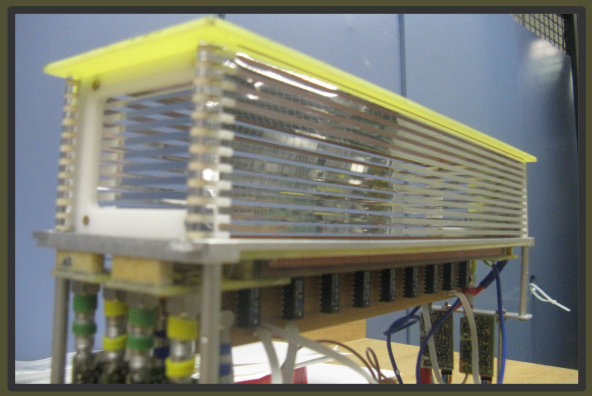


Gas Amplification

anodes -> GEM foil stack

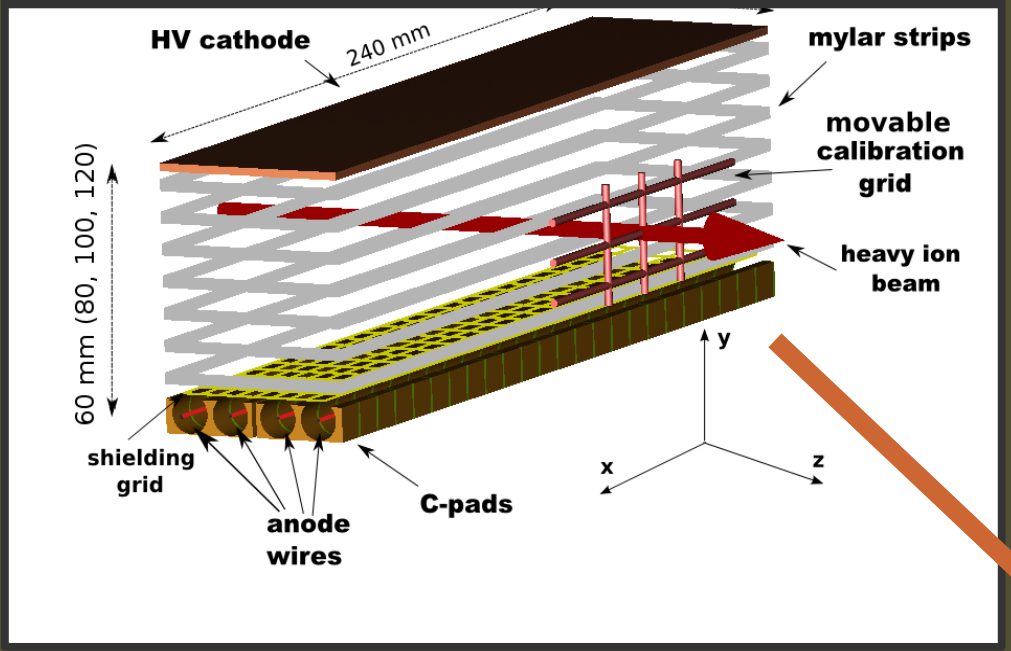
Readout

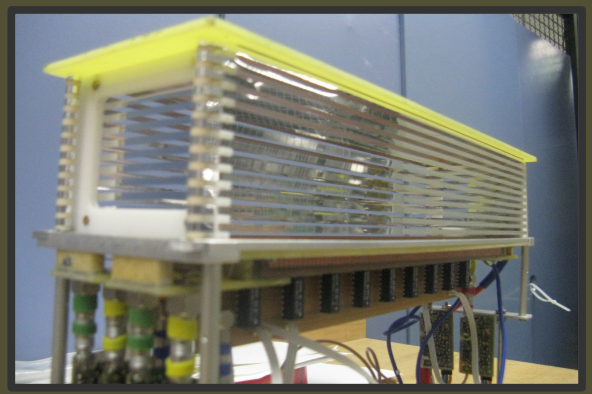
single-strip readout
multihit electronics
time+amplitude
1ns resolution
GEMEX



FRS -> SFRS

TPC Scheme





Gas Amplification

anodes -> GEM foil stack

Readout

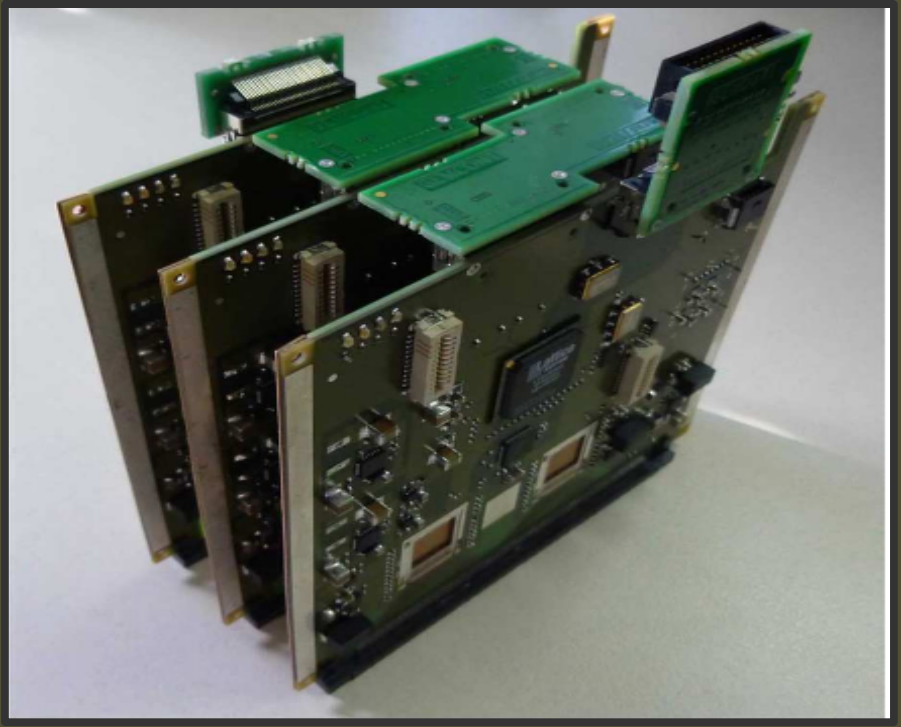
single-strip readout
multihit electronics
time+amplitude
1ns resolution
GEMEX

Design

Twin design – 2 drift volumes
New Field Cage

GEMEX

3 Gemex cards



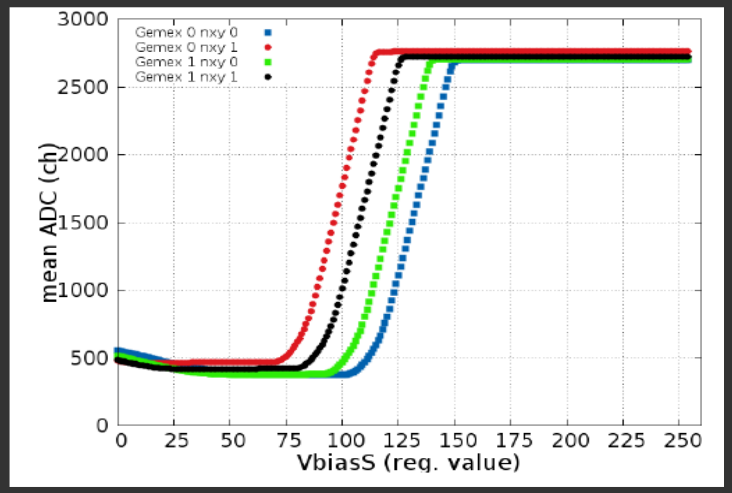
Specification

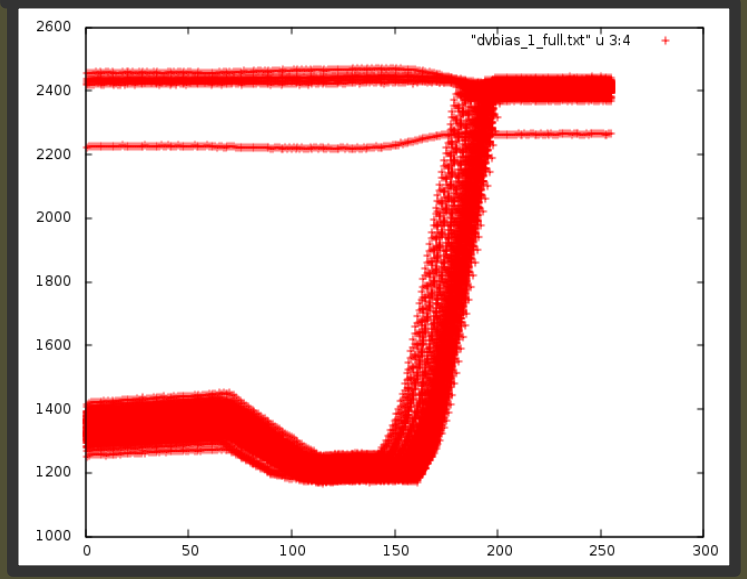
Development at GSI
nxyter based electronics
256 ch/card
multihit
time + amplitude
time resolution = 1-2ns
ADC = 11bit
optical link readout
I2C slow control
100+ registers
test modes
internal calibration

B.Voss et al, GSI Sci. Rep. 2011

GEMEX

VbiasS scan





problems

still prototype phase
dynamic range

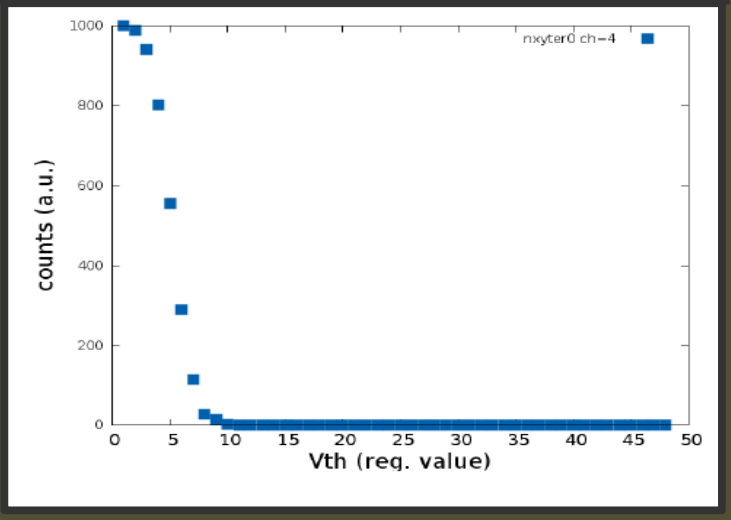
work in progress

software developement
automated testing and calibration
debugging

B.Voss et al, GSI Sci. Rep. 2011

GEMEX

Vth scan



problems

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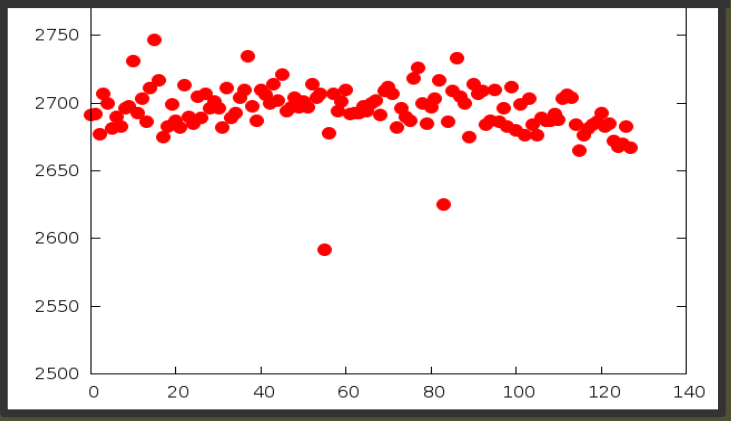
dynamic range

Baselines



work in progress

software developement
automated testing and calibration
debugging

B.Voss et al, GSI Sci. Rep. 2011

GEMTPC milestones

Steps towards GEMTPC

1. TPC + GEM stack + DL readout
2. TPC + GEM stack + GEMEX
3. TwinTPC design + DL readout

4. TwinTPC + new FC + GEMEX

GEMTPC milestones

Steps towards GEMTPC

1. TPC + GEM stack + DL readout 2011
2. TPC + GEM stack + GEMEX
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GEMTPC milestones

Steps towards GEMTPC

1. TPC + GEM stack + DL readout — 2011
2. TPC + GEM stack + GEMEX — 2012
3. TwinTPC design + DL readout — 2012 2014
4. TwinTPC + new FC + GEMEX

GEMTPC milestones

Steps towards GEMTPC

1. TPC + GEM stack + DL readout — 2011
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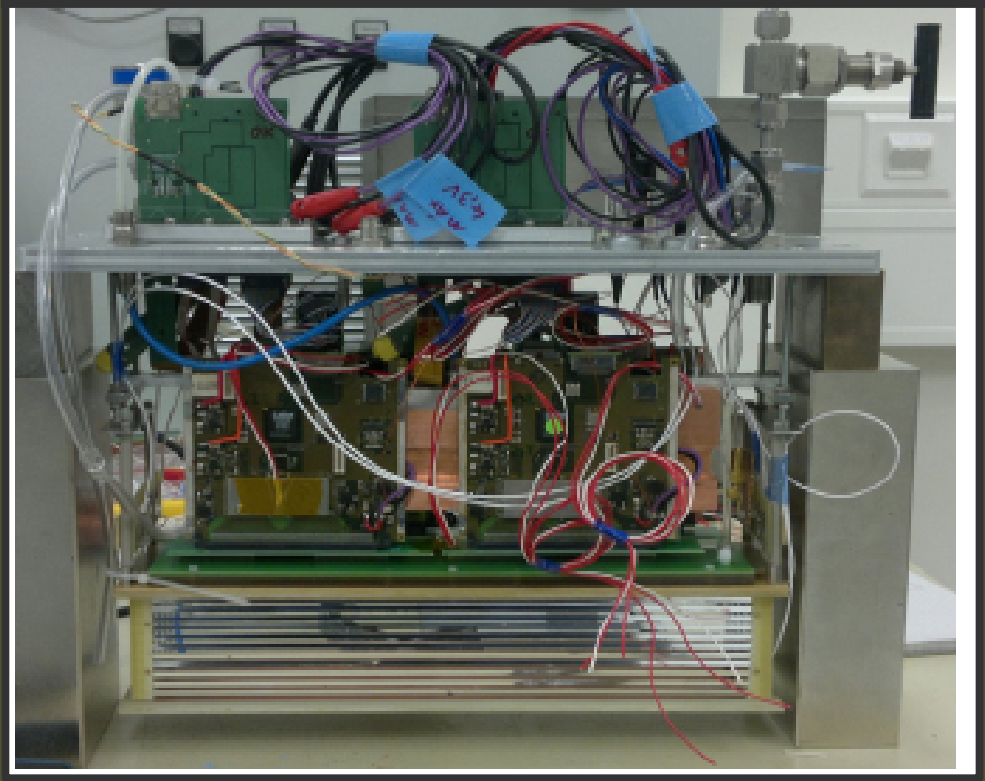
GEMTPC Prototypes

GEMTPC Prototype

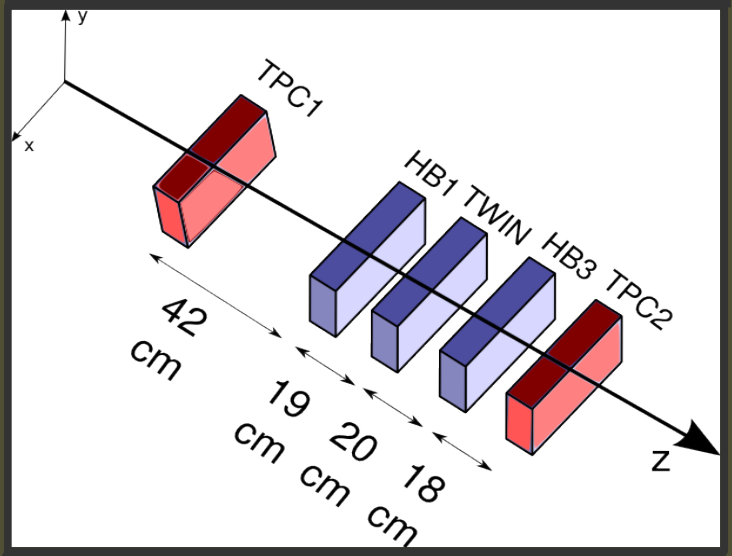


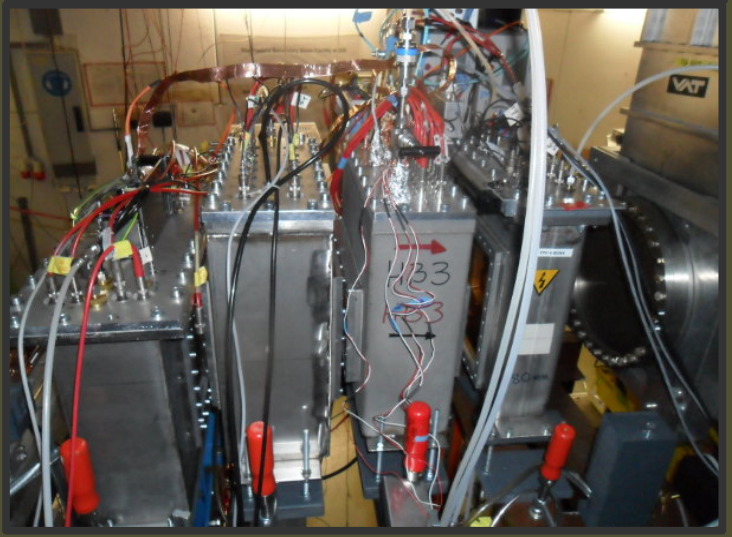
20 cm x 6 cm
TPC drift volume
GEM stack
GEMEX readout
2 prototypes built
with different pad planes

F.Garcia et al, GSI Sci. Rep. 2012

GEMTPC Prototypes

Beam test setup





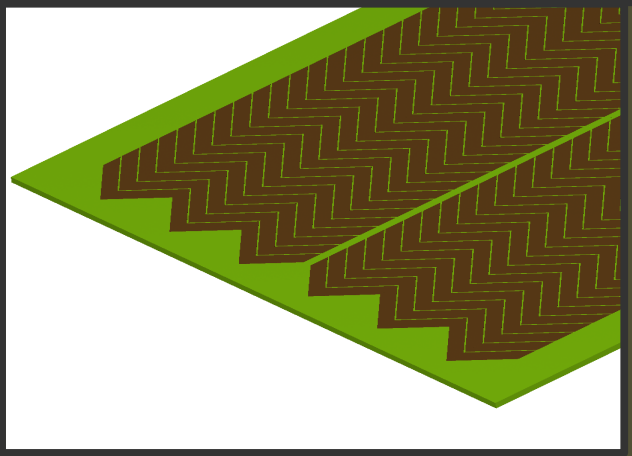
20 cm x 6 cm
TPC drift volume
GEM stack
GEMEX readout
2 prototypes built
with different pad planes

tested in may 2012
at FRS
Au beam @ 700MeV/u
P10 gas at 1 atm

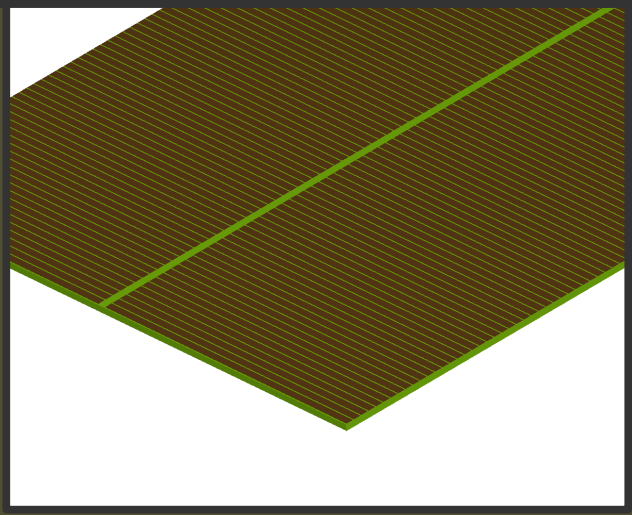
F.Garcia et al, GSI Sci. Rep. 2012

GEMTPC Prototypes

Pad Plane 1



Pad Plane 2



Prototype 1

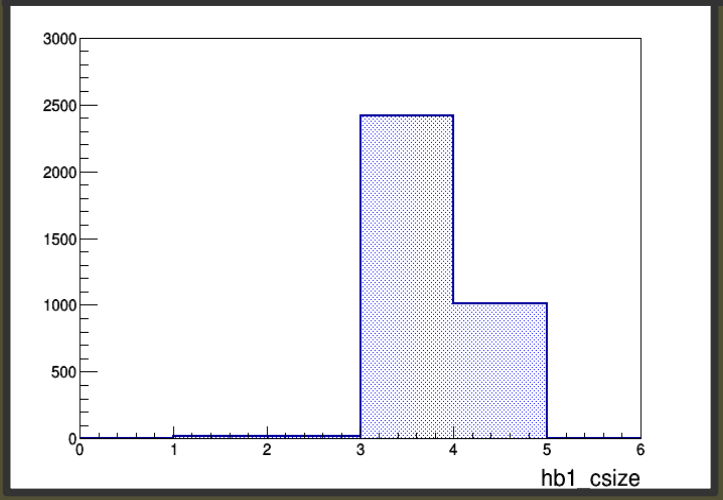
chevron pad plane
2.5mm pitch
100ch/plane
2 planes / detector

Prototype 2

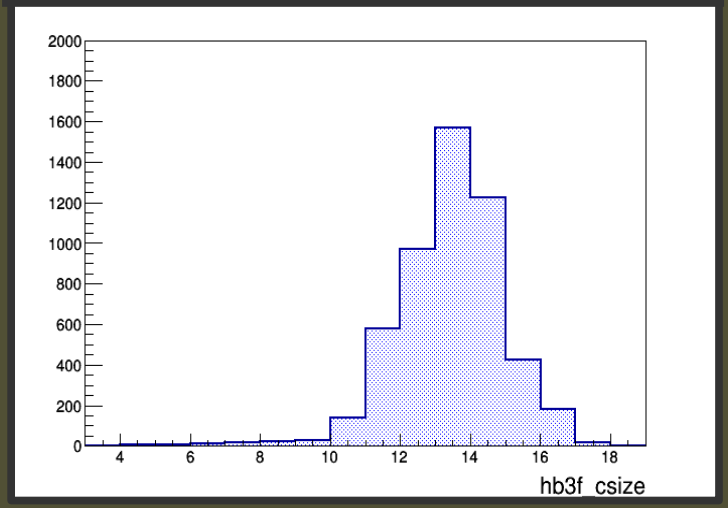
strip pad plane
0.5mm pitch
512ch/plane
2 planes / detector

GEMTPC Prototypes

Cluster Size 1



Cluster Size 2



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chevron pad plane
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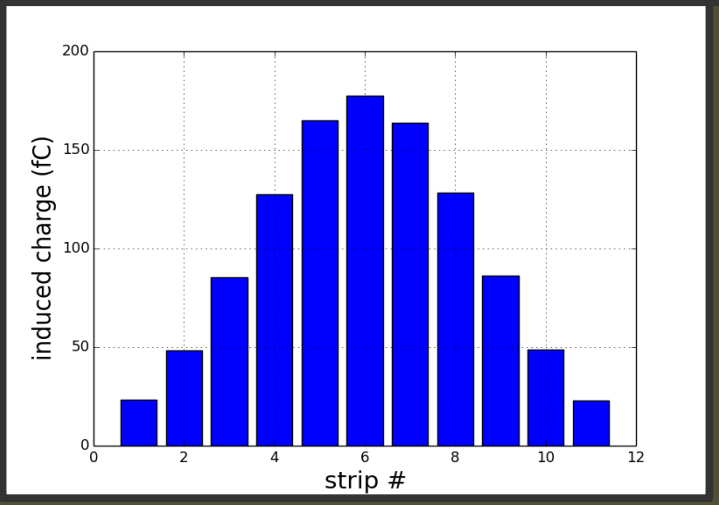
GEMTPC Prototypes

Ind. Charge Sim.



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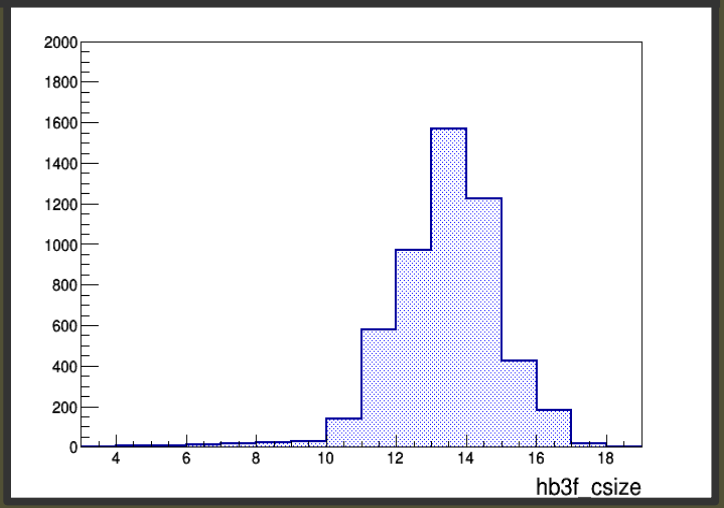


Simulation

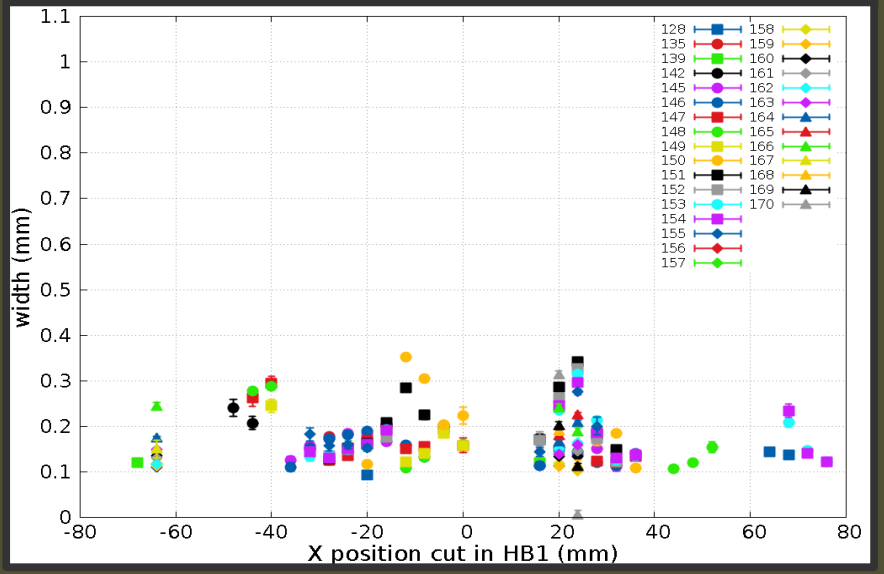
Garfield + FEM method
Drift
GEM stack
Induction

Prototype 2

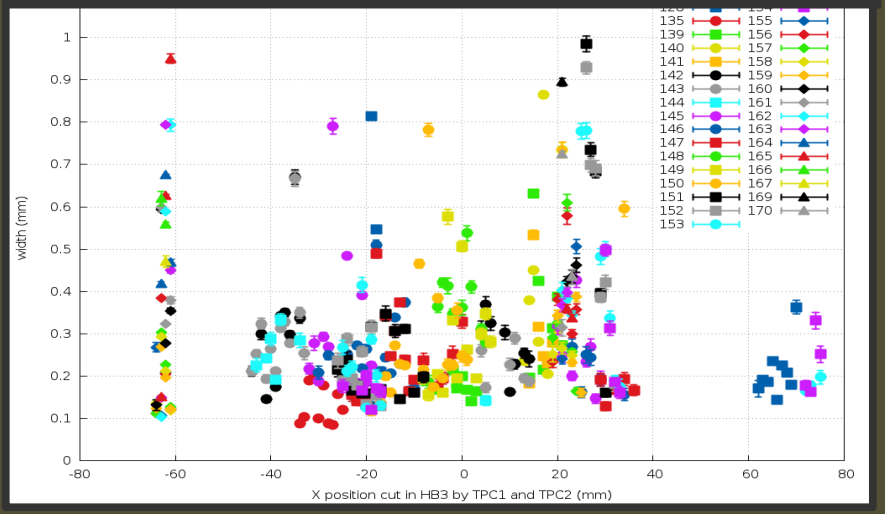
strip pad plane
0.5mm pitch
512ch/plane
2 planes / detector

GEMTPC resolution

X-Pos. Resolution 1



X-Pos. Resolution 2



results

Au beam @ 700MeV/u

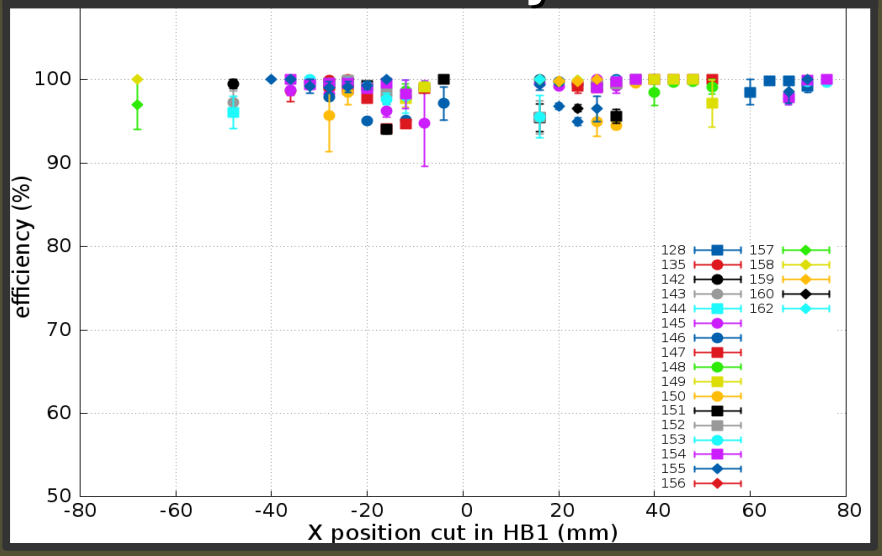
$\sigma_x \approx 150\mu m$

proof of GEM + GEMEX

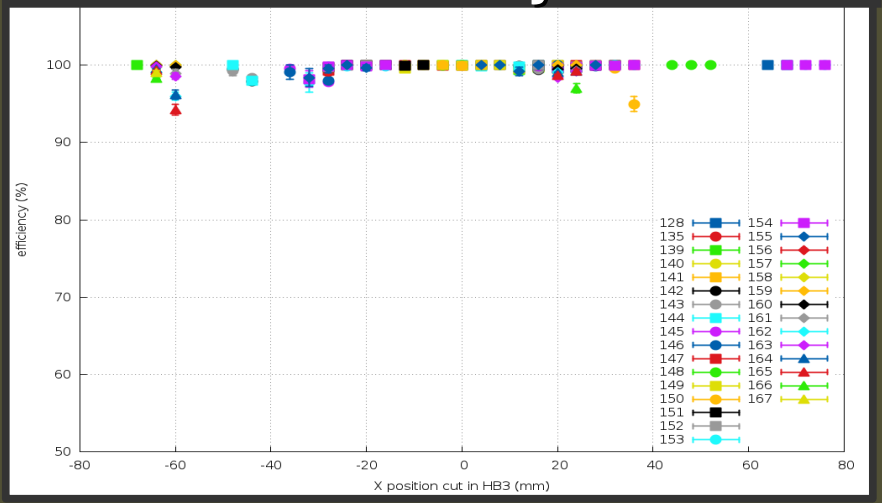
>99% efficiency @ 60kHZ

GEMTPC efficiency

Efficiency 1



Efficiency 2



results

Au beam @ 700MeV/u

$\sigma_x \approx 150\mu m$

proof of GEM + GEMEX

>99% efficiency @ 60kHZ

problems

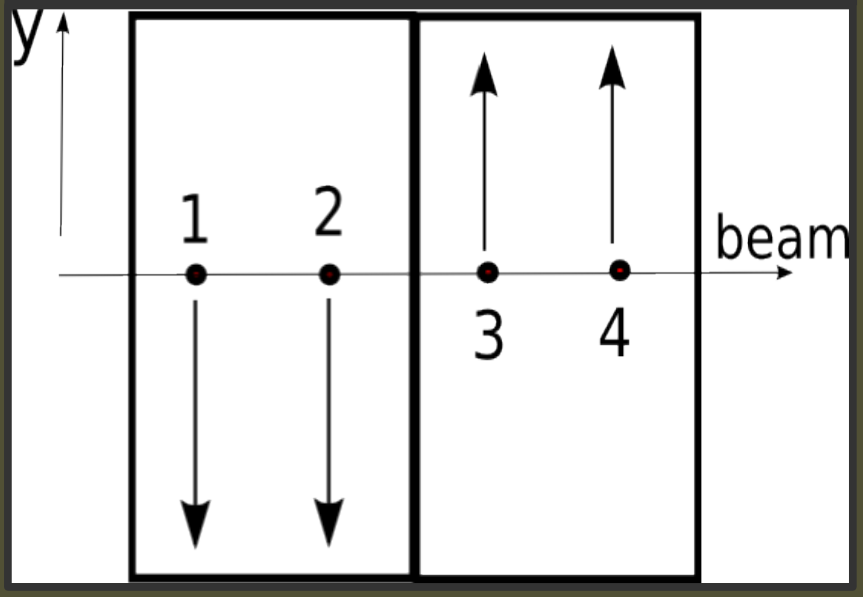
small dynamic range

many broken channels

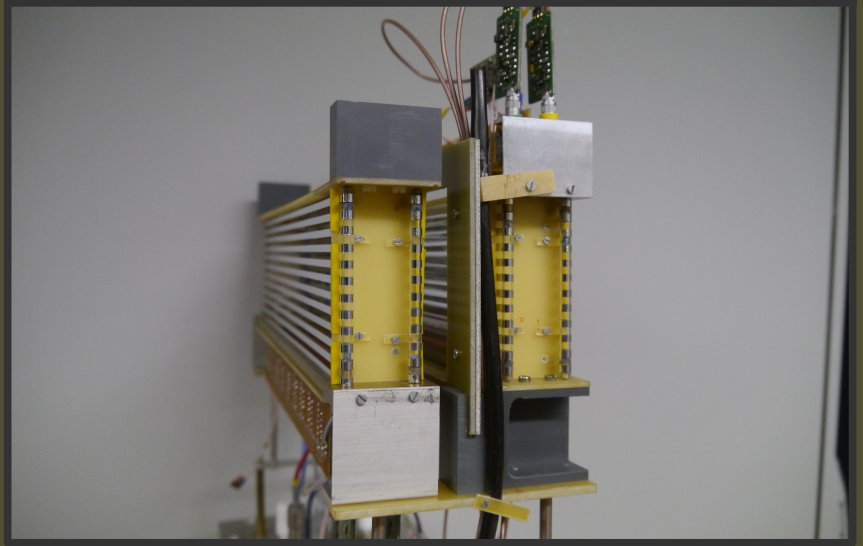
electronics is the bottleneck

TwinTPC

TwinTPC Scheme



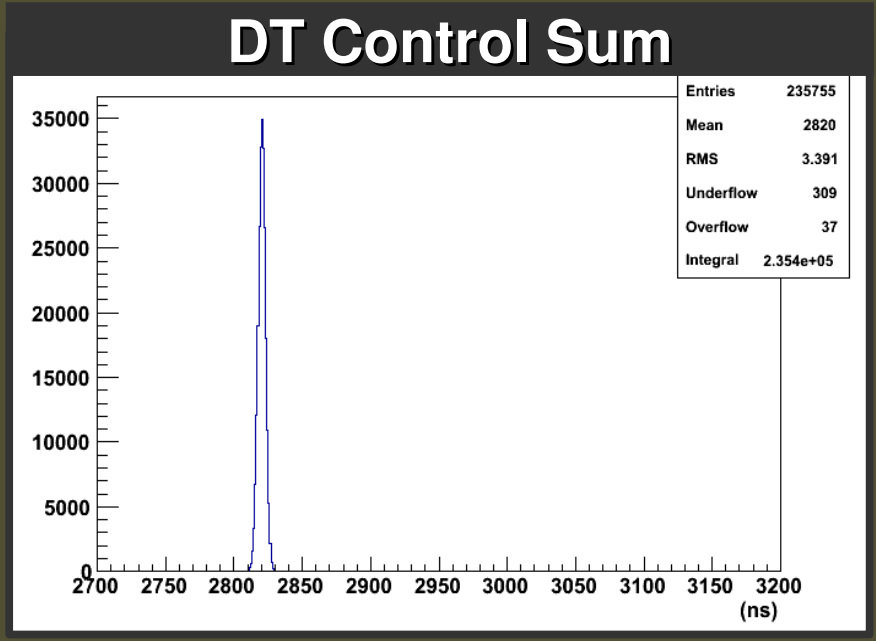
TwinTPC Photo



design

20x7.5 cm^2
2 identical drift volumes
E fields opposite directions
DL readout
multi-hit TDC
25ps resolution
10 us window
P10 gas used at 1 atm.

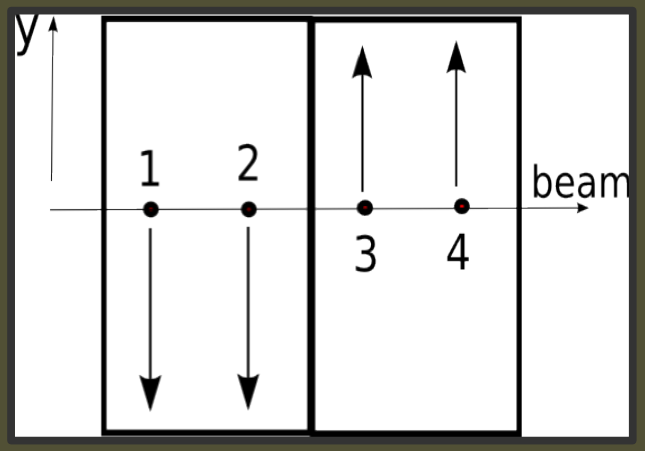
TwinTPC



working principle

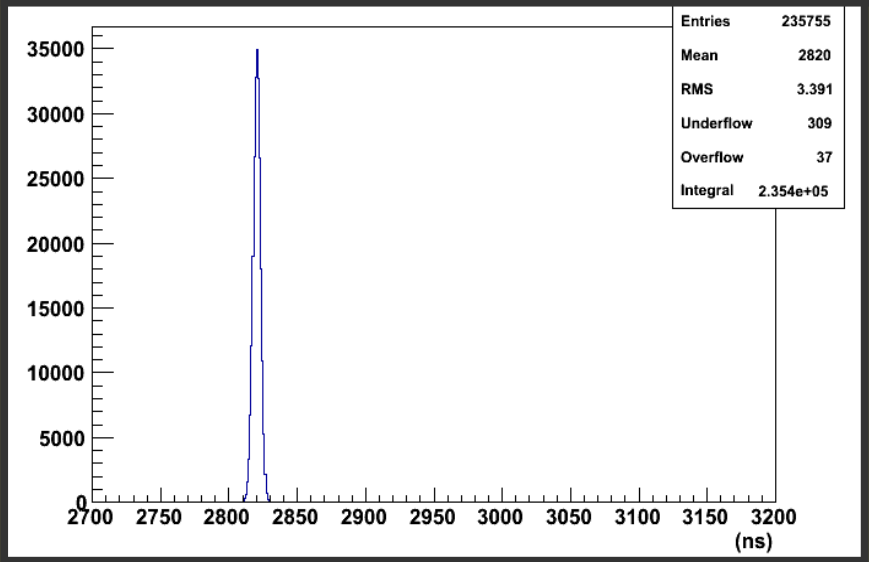
drift time ~ y-position
multiple hits at high rates
DT1 + DT2 = const. = CS

tested in may 2012
august 2014



TwinTPC

DT Control Sum



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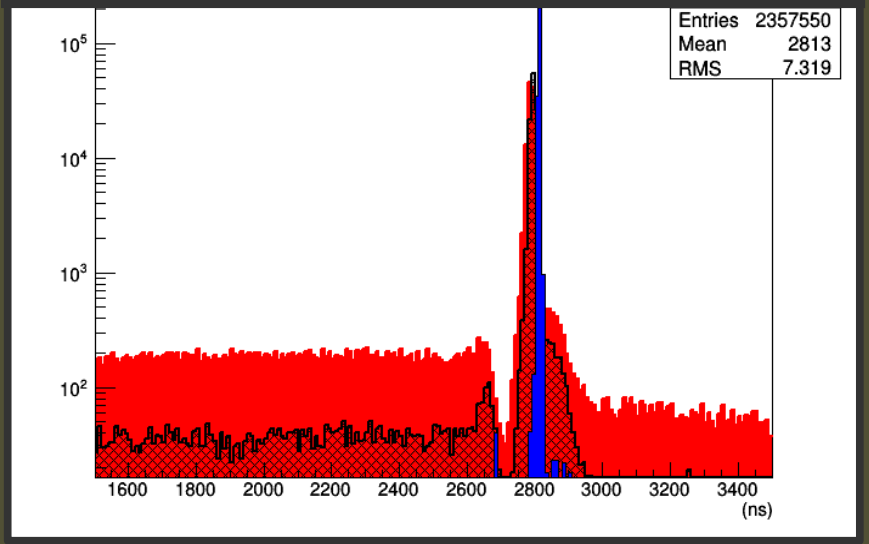


working principle

drift time ~ y-position
multiple hits at high rates
DT1 + DT2 = const. = CS

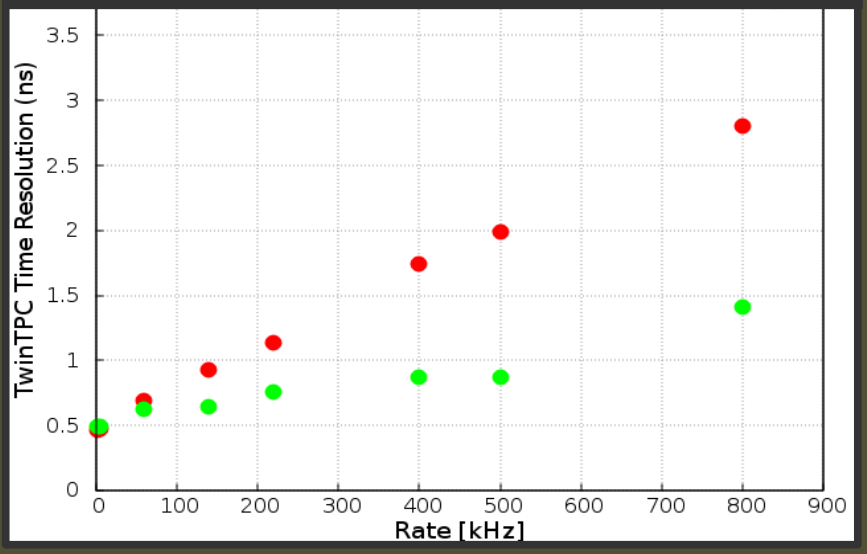
tested in may 2012
august 2014

limitations

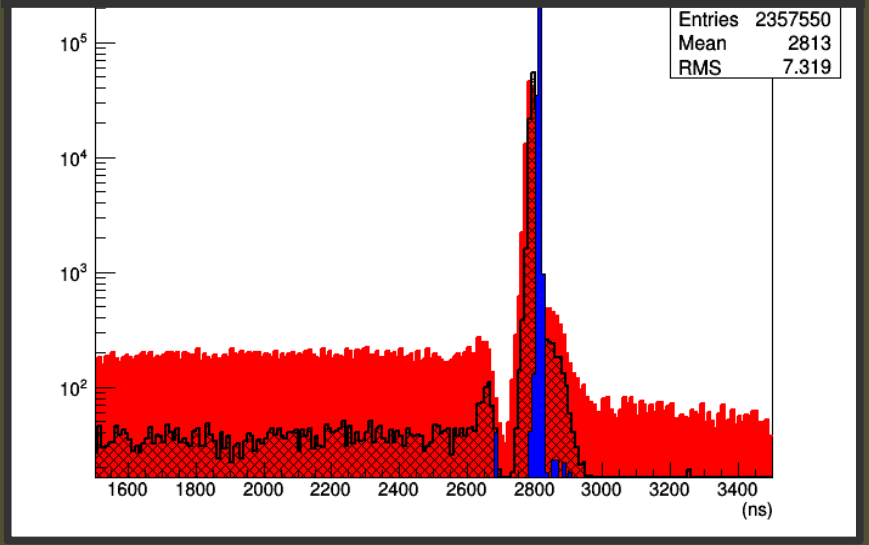
time resolution
Space-charge effect
high rates – many combinations
deadtime

TwinTPC time res.

TwinTPC Time Resolution



DT Control Sum

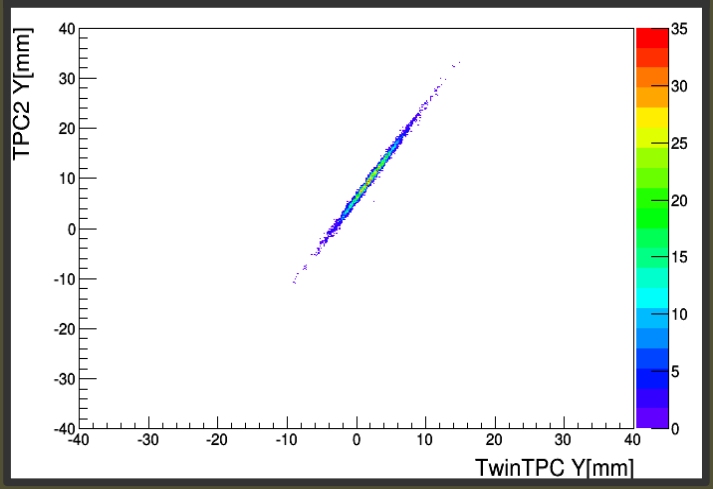


results

Au beam @ 700MeV/u
time resolution ≈ 0.5ns
pos. res. ≈ 20 µm (P10)
y-position well correlated with standard TPC

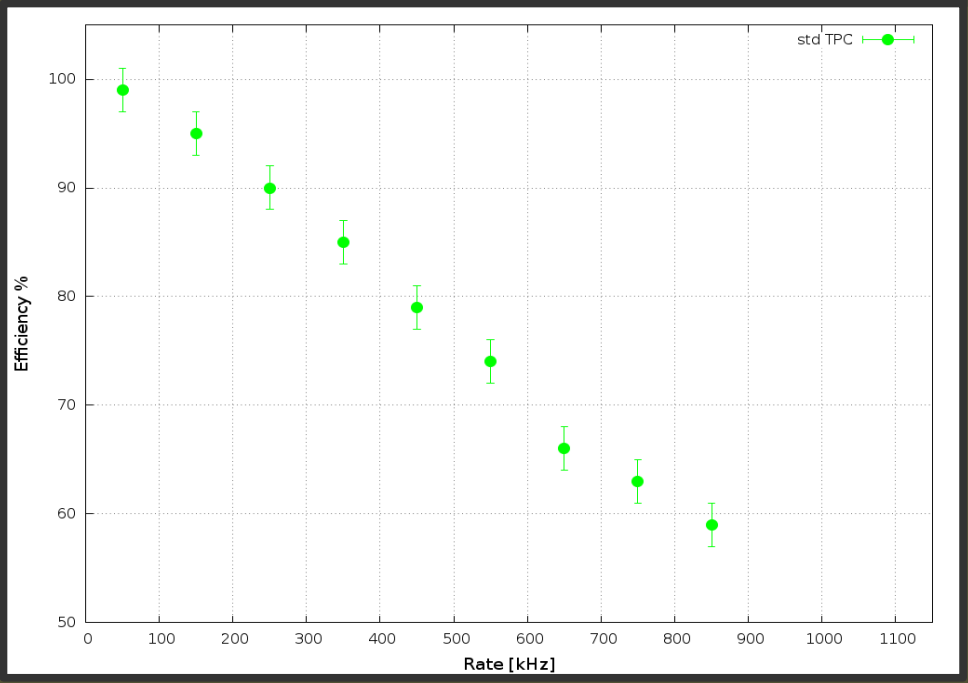
high rate – worse time res.
GEM stack should help

TwinTPC vs TPC



TwinTPC efficiency

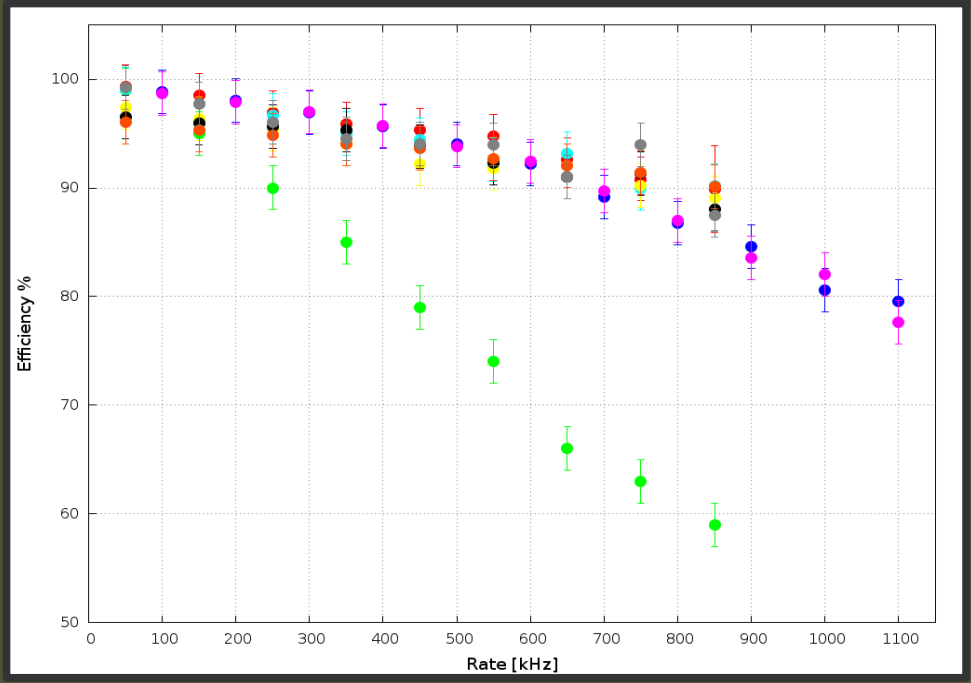
TwinTPC Efficiency vs Rate



Rate from Sci. Multiplicity
Window 10us

TwinTPC efficiency

TwinTPC Efficiency vs Rate



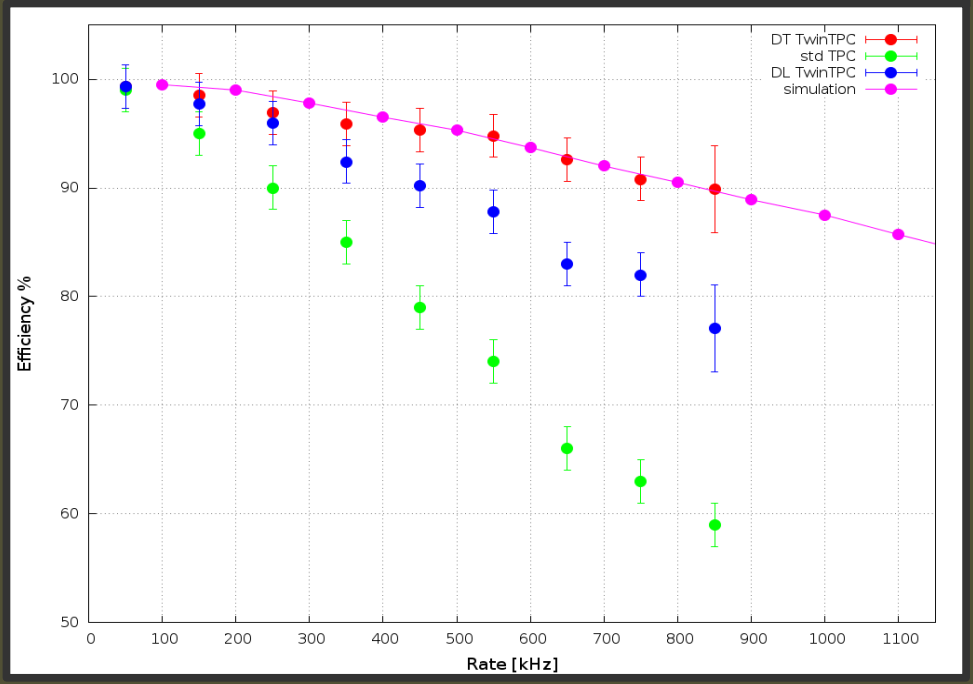
results

DT reconstruction efficiency
>90% efficiency @ 800kHz
Measured for several beam and detector configurations

Better results expected

TwinTPC efficiency

TwinTPC Efficiency vs Rate

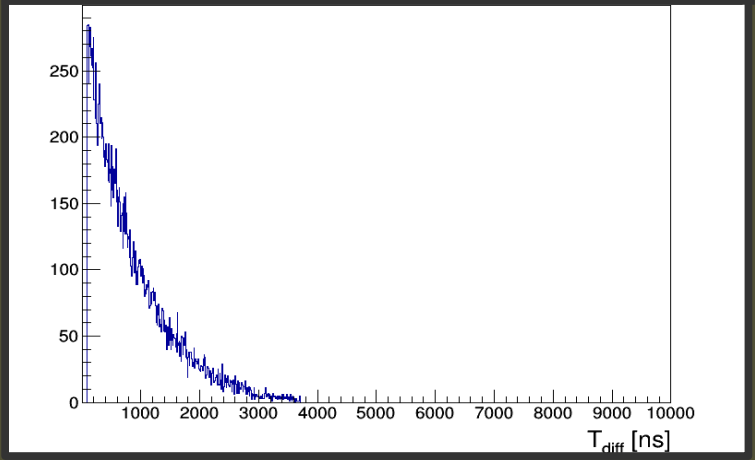


results

Bad spill structure
Many particles close in time
Deadtime is important

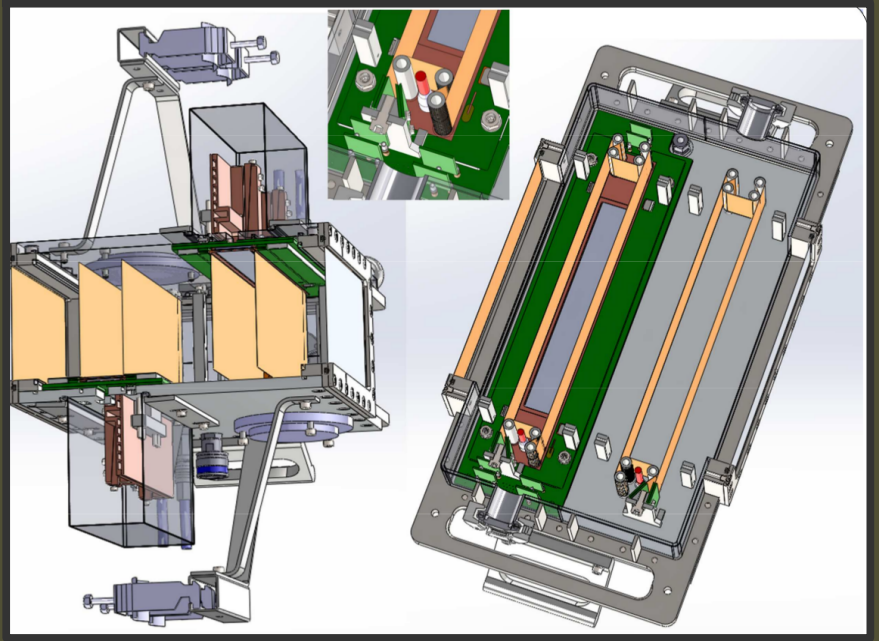
Deadtime – 85ns estimated and used for simulation

Part. Time Dif Distr.



Next Prototype

new TwinTPC



Prototype

No parts from old TPC
Twin design with new FC
GEMEX readout

assembled in Aug. 2014
next beam test Oct. 2014

TODO

test with different gas
low pressure test
debug electronics
debug new FC

Summary

Several prototypes were tested
GEM+GEMEX worked
Twin design worked
pos. resolution in x ≈ 150 µm
>99% efficiency for moderate rates
>90% efficiency with Twin design @ 800kHz
TwinTPC+GEM+GEMEX still to be tested