eRD22: GEM based Transition radiation detector/tracker for EIC

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on behalf of GEM-TRD/T working group
Presented (and slightly modified) by Lubomir Pentchev

eRD22 GEM-TRD/T

TEAM

- Jefferson Lab:
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  - ✓ Chris Stanislav
  - ✓ Fernando Barbosa
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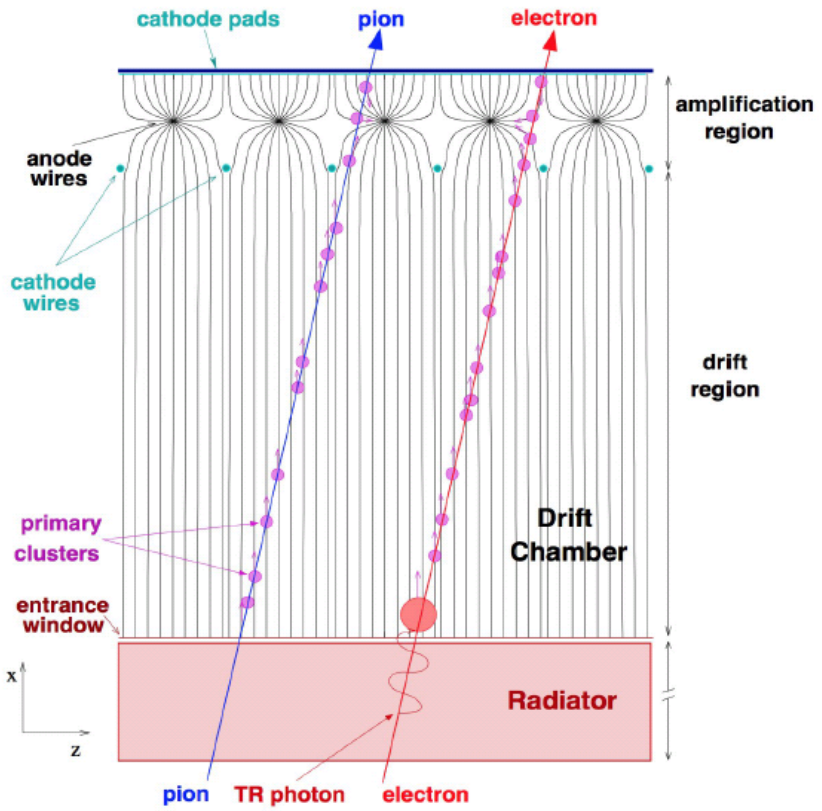
  - ✓ Nilanga K. Liyanage
- Temple University
  - ✓ Matt Posik
  - ✓ Bernd Surrow

Goal: To develop a next generation of transition radiation detectors to improve electron identification (e/hadron separation) at EIC

Example: Alice TRD



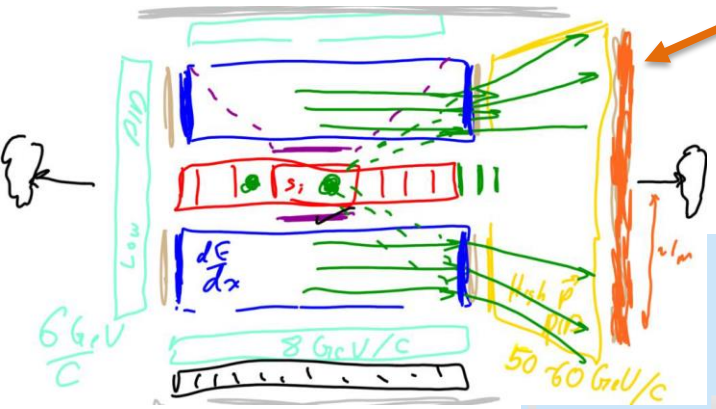
Critical issues/solutions of TRD operation:

- Space charges suppress late signals; need cluster separation in time
  use GEM technology combined with fADC
- Electron recombination in wide drift region
  use pure gases
- Xe is expensive – recirculation
- Low keV TR photons stop in entrance foil
  Optimize foil material/thickness, radiator

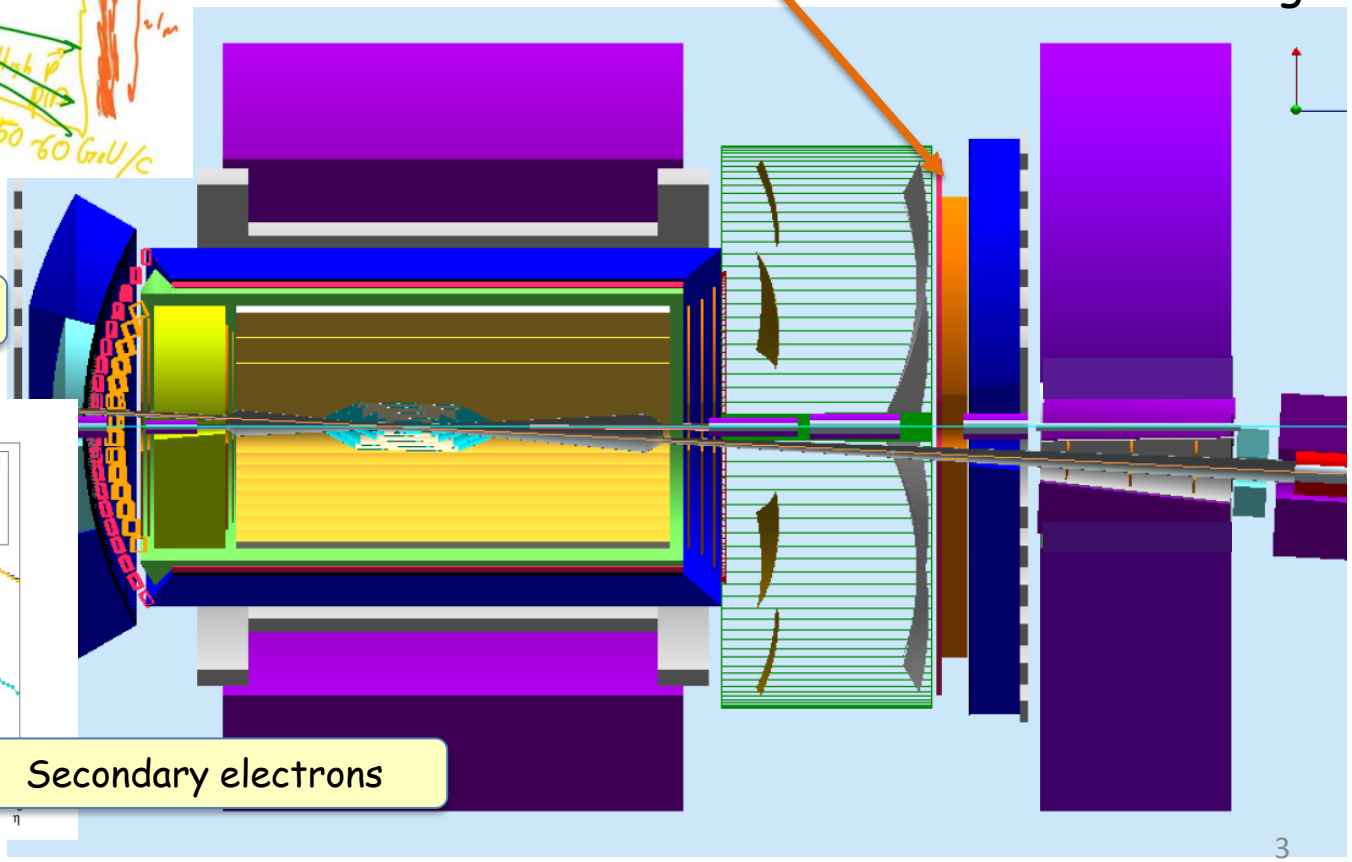
Hadron endcap

For EIC, the ideal place to install is at hadron endcap, where we expect a high hadron flux.

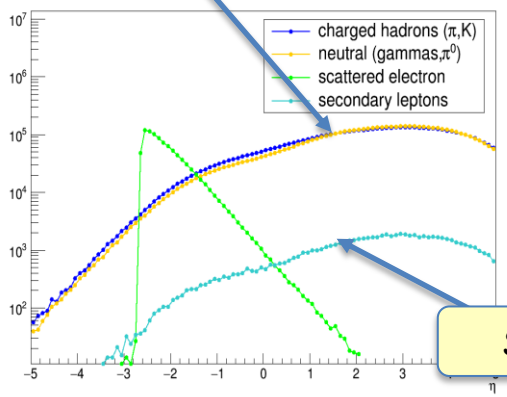
GEM-TRD/T



JLEIC design

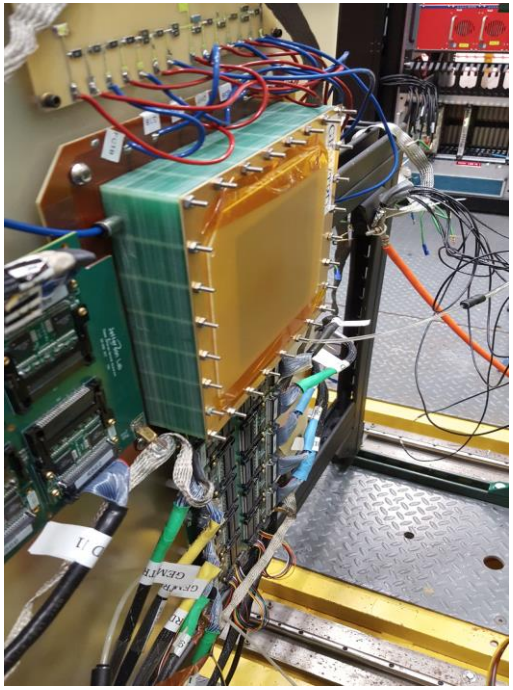


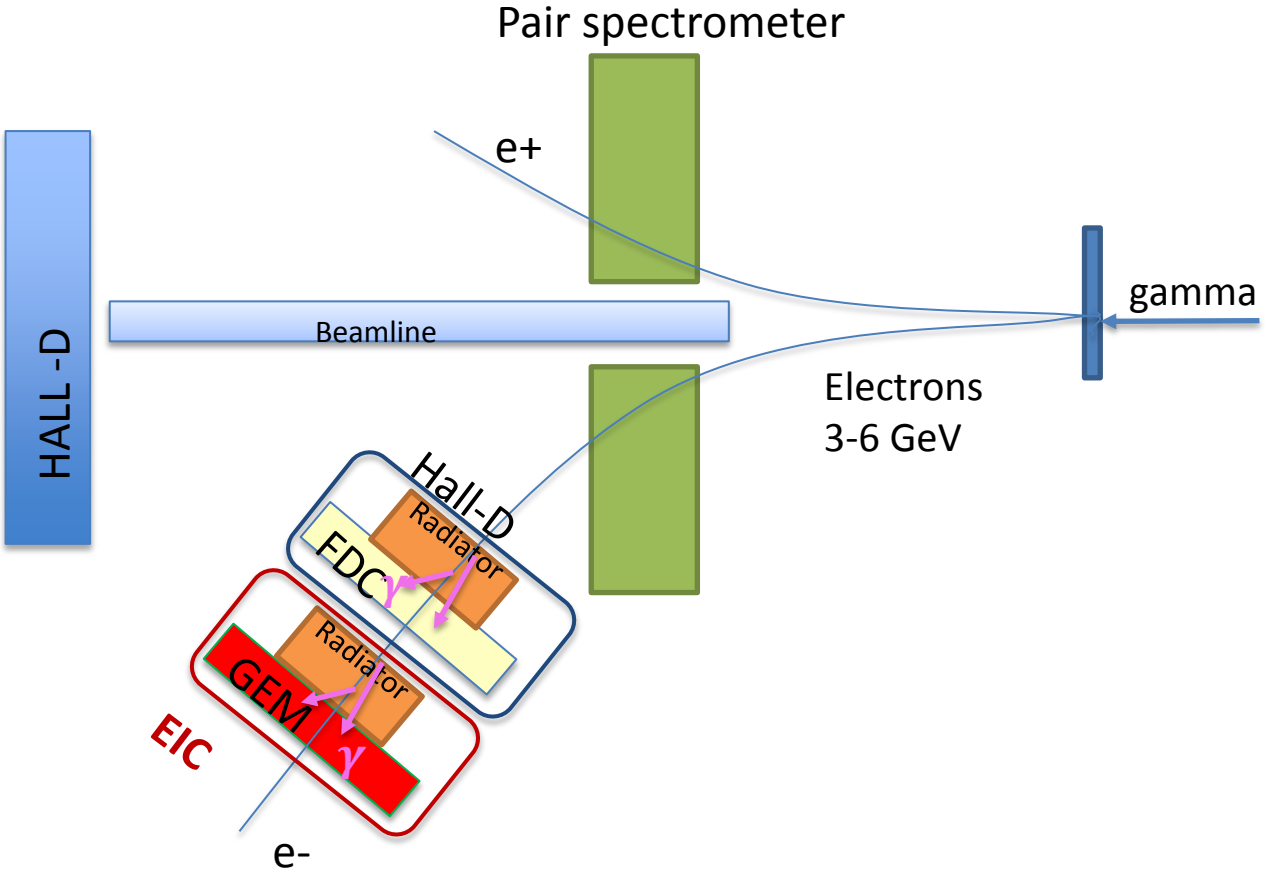
High hadron background



Secondary electrons

Test Setup at JLAB HALL-D



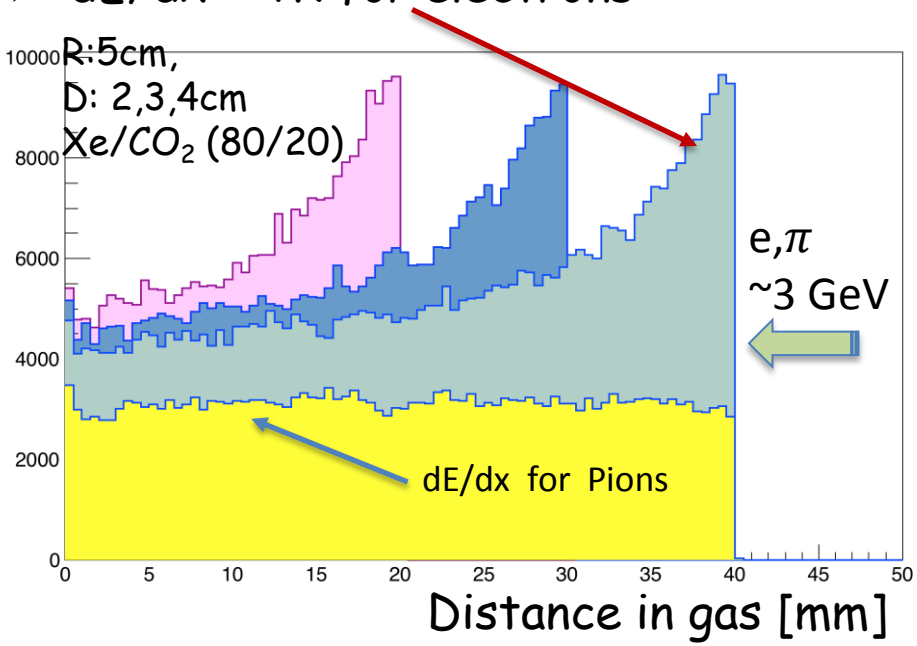


- 3-6 GeV electrons in Hall-D from pair spectrometer
- Tests in collaboration with Hall-D TRD prototype (wire-based) sharing same gas system, electronics (GASII pre-amps, flashADC125), DAQ, analysis software
- Comparing radiator/no radiator effects

Energy deposition (dE/dx + TR) vs distance

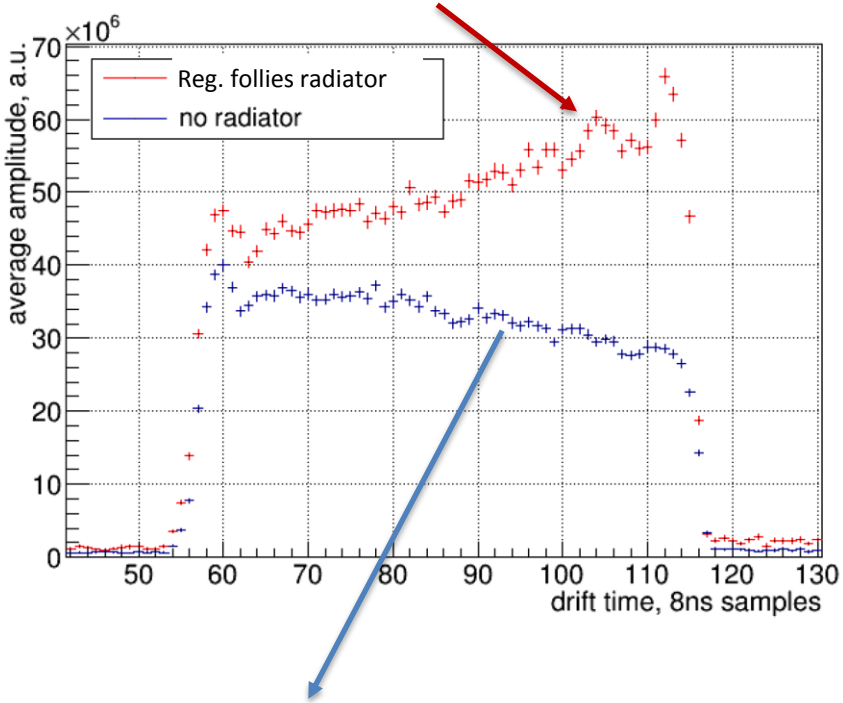
GEANT4 simulation

- dE/dx + TR for electrons



Measured data

- Clearly see TR-photons (2cm drift)



Very preliminary rejection, single module (likelihood method)

	90% eff	**70% eff**
2cm Xe	2.5	12
4cm Xe	4.5	17

- Slope in dE/dx indicates presence of gas contamination

eRD22 GEM-TRD/T

Achievements:

- We performed a GEANT4 simulation of TRD setup with GEM detector (gas and radiator volumes) for a single layer operation and estimated e/π rejection factor.
- We built and tested a new GEM based TRD prototype and optimized its performance (new HV divider, different drift filed voltages, gas gain, etc)
- Front-end electronic / DAQ :
  - Test DAQ with Flash ADCs
- Using the existing facility at JLAB Hall-D perform a test with different TR-radiators
- New gas-mixing system is ready to use.

Proposal for FY19

In addition (budget request fro FY19)
We have identified a several issues and studies which should be pursued in addition to those in our original plans as important steps towards the realization of a new generation of transition radiation detectors as a part of the EIC project.

- **Gas system**: gas analyzer to measure and monitor contaminations (split a cost with Hall-D) ca. $7k (40%)
- **Tracking:** evaluate the performance of our prototype as a tracker (no cost)
- In collaboration with readout consortium:
  - **On-line particle identification:** to move a part of an off-line reconstruction software into on-line (FPGA evaluation board ~$7k)
  - **Readout hardware:** find a cheaper solution/replacement of FlashADC125 (<<$50/channel)
- **Radiator optimization:** identify and test new radiator materials.
- **Detector prototyping:**
  - Continue test beam measurements with a Cr-GEM prototype (improved entrance window for TR photons) and test of different Xe-gas mixtures: new gas-mixing system is ready to use.
  - following the EIC R&D (tracking consortium eRD6) effort on new technology such as μRWELL detectors, we are planning to work in parallel with the consortium toward an optimization of the detector for TRD/Tracking application. ($15k)

The table 1 below summarizes the Temple University budget request for FY19.

Table 1: **Temple University-Gas System** FY19 request.

	Request	**-20%**	**-40%**
Gas supplies	\$700	\$400	\$0
Travel	\$3,000	\$2,000	\$2,000
Overhead (58.5%)	\$2,165	\$1,404	\$1,170
Total	**\$5,865**	**\$3,804**	**\$3,170**

The table 2 below summarizes the Jefferson Lab budget request for FY19.

Table 2: **JLAB: FPGA and Gas Analyzer** FY19 request.

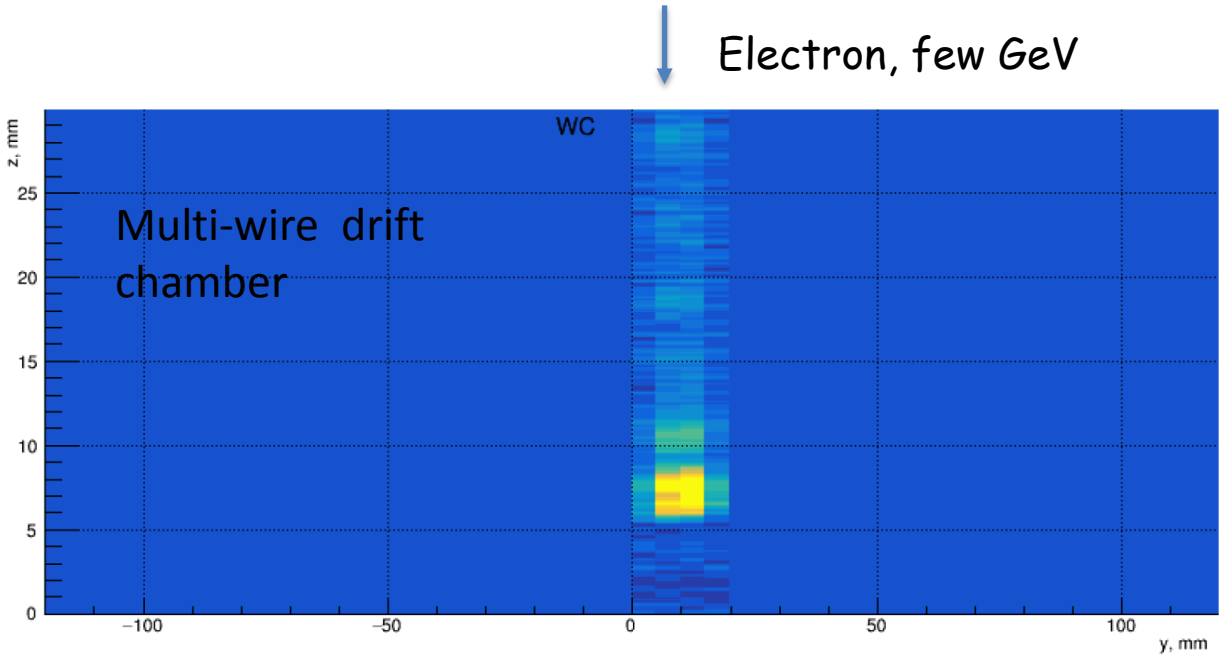
	Request	**-20%**	**-40%**
FPGA evaluation board	\$7,000	\$0	\$0
Gas analyzer (% with Hall-D)	\$8,000 ($\tilde{50}$%)	\$ 5,000 ($\tilde{30}$%)	\$ 0
Travel	\$5,000	\$4,000	\$3,000
Overhead (36.5%)	\$7,300	\$3,300	\$1,100
Total	**\$27,300**	**\$12,300**	**\$4,100**

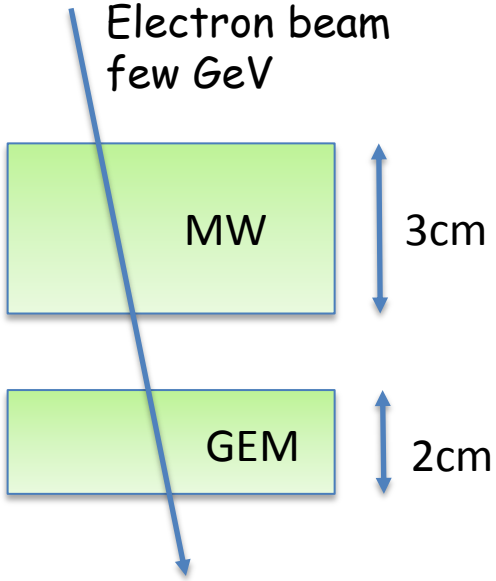
The table 4 below summarizes the University of Virginia budget request for FY19.

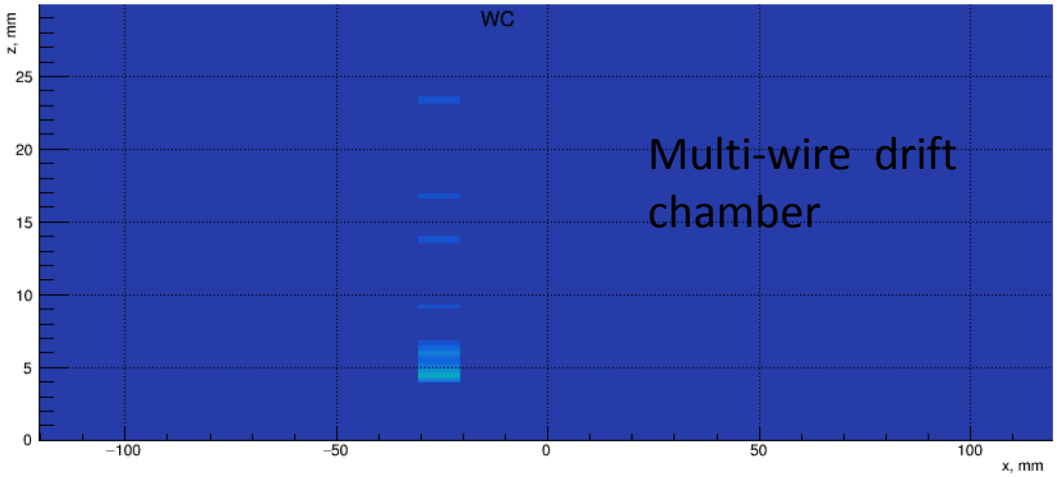
Table 3: **UVA prototyping** FY19 request.

	Request	**-20%**	**-40%**
μRWELL prototype	\$5,000	\$0	\$0
Gas/Field cage	\$5,000	\$ 0	\$ 0
HV power supply	\$5,000	\$ 5,000	\$ 0
Travel	\$5,000	\$4,000	\$3,000
Overhead (61.5%)	\$3075	\$2460	\$1845
Total	**\$23,075**	**\$ 11,460**	**\$4,845**

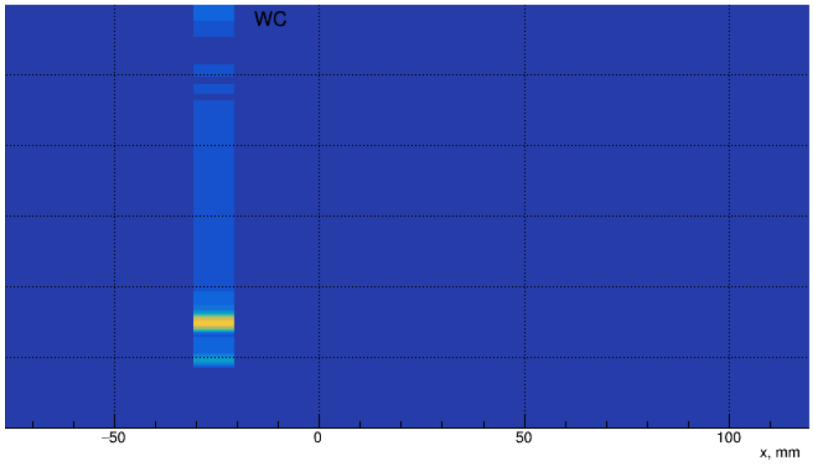
BACKUP

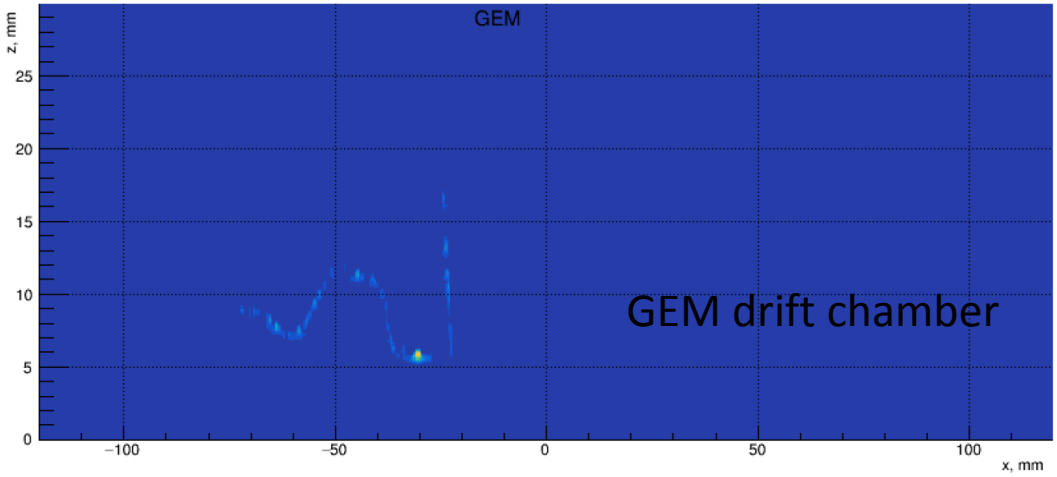

Electron, few GeV
WC
Multi-wire drift chamber
z, mm
y, mm
GEM
GEM drift chamber
z, mm
y, mm


Electron beam few GeV
MW
3cm
GEM
2cm

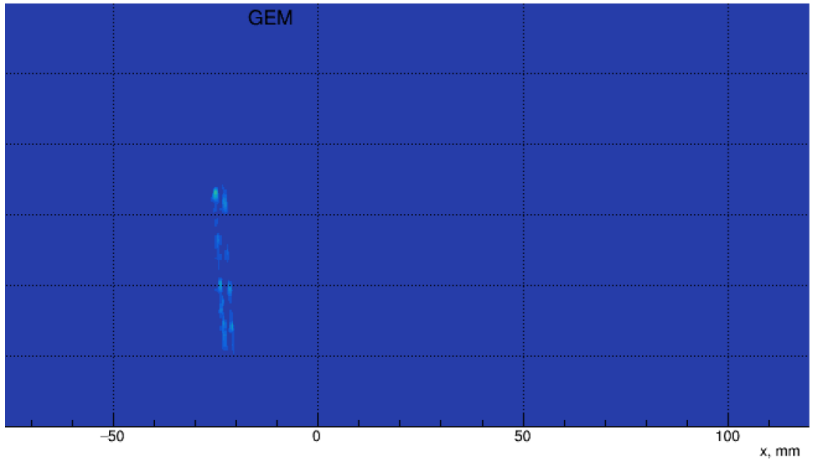


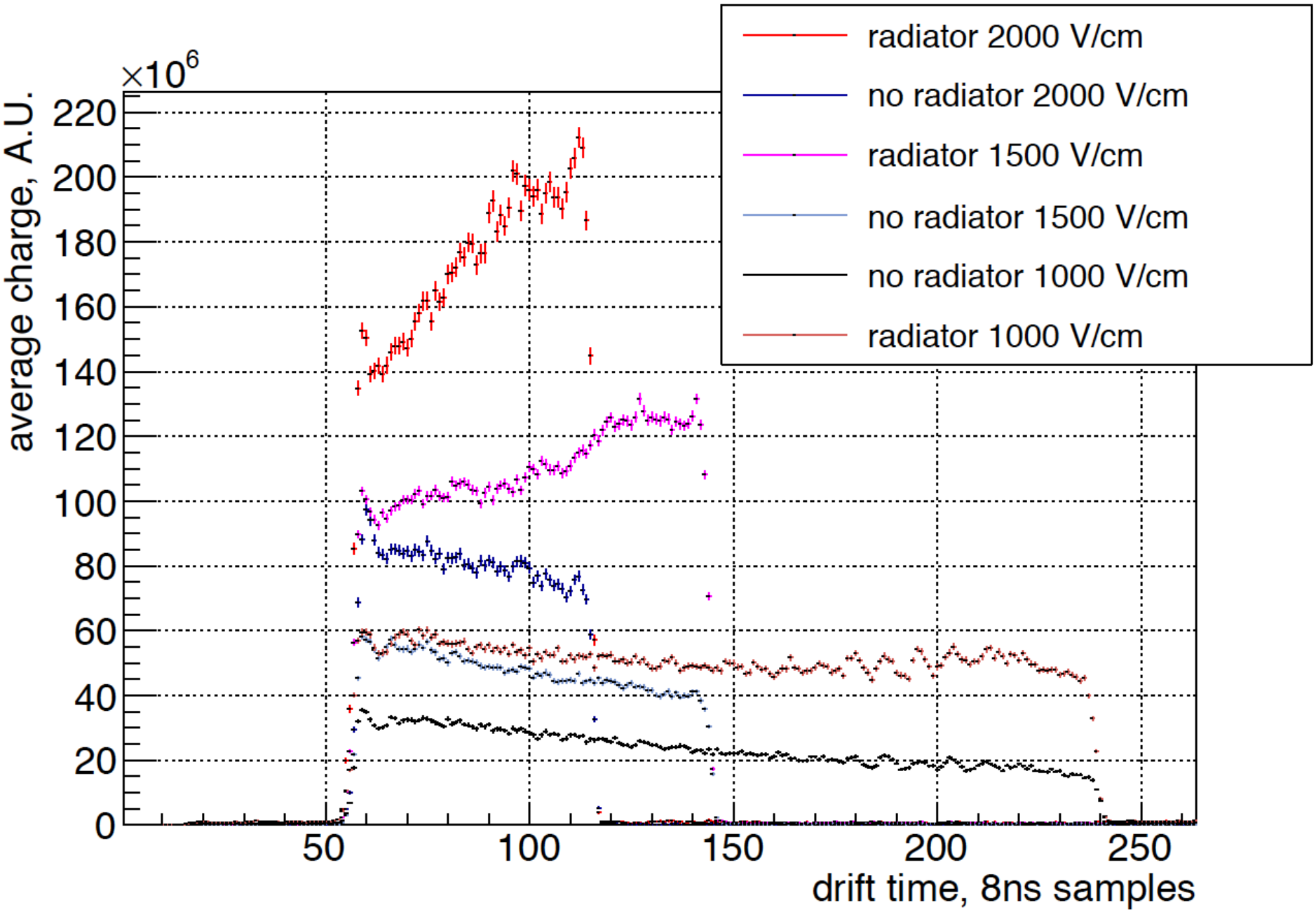
Multi-wire drift chamber



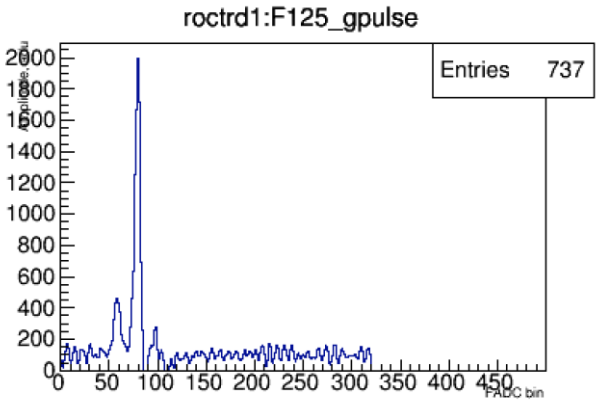


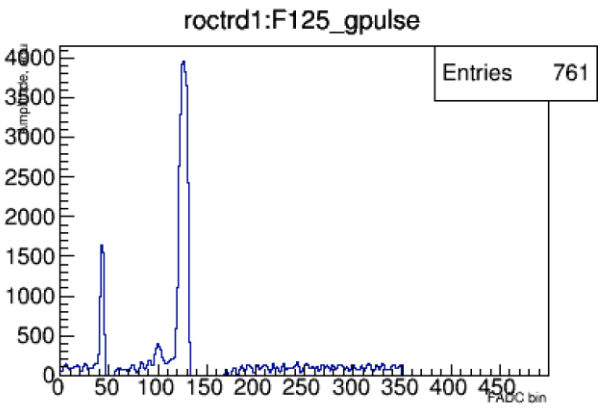
GEM drift chamber

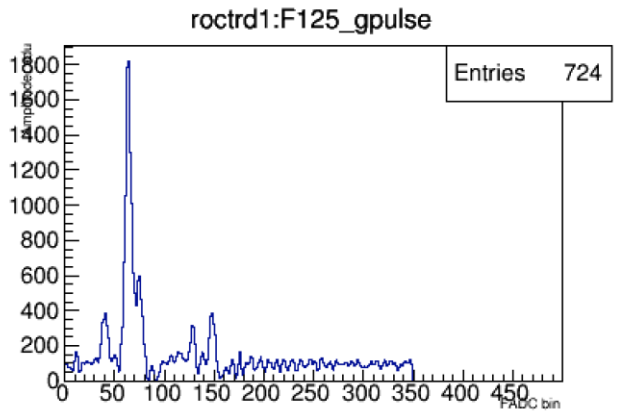


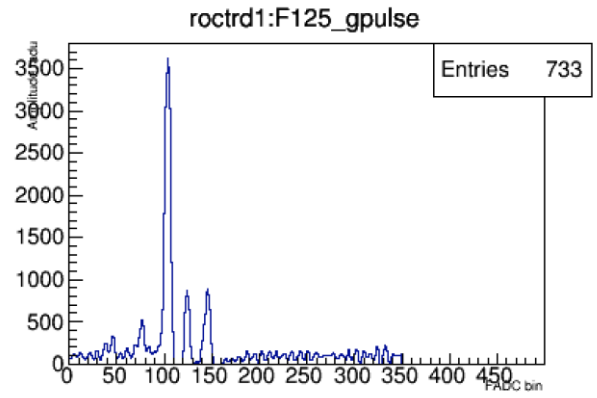

radiator 2000 V/cm
no radiator 2000 V/cm
radiator 1500 V/cm
no radiator 1500 V/cm
no radiator 1000 V/cm
radiator 1000 V/cm
×10^6
average charge, A.U.
0
20
40
60
80
100
120
140
160
180
200
220
50
100
150
200
250
drift time, 8ns samples

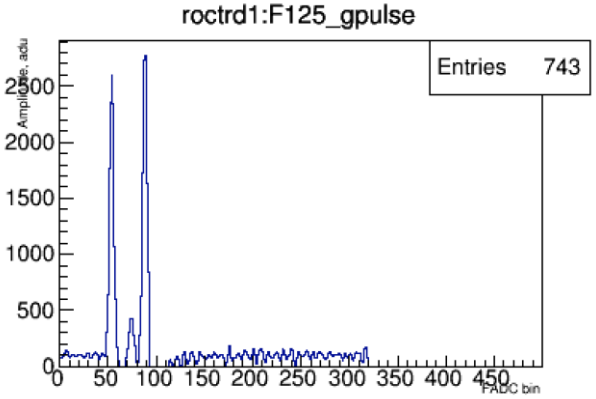
GEMTRD signals

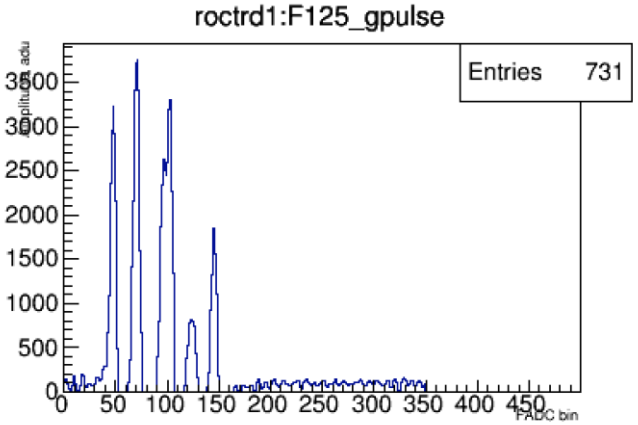


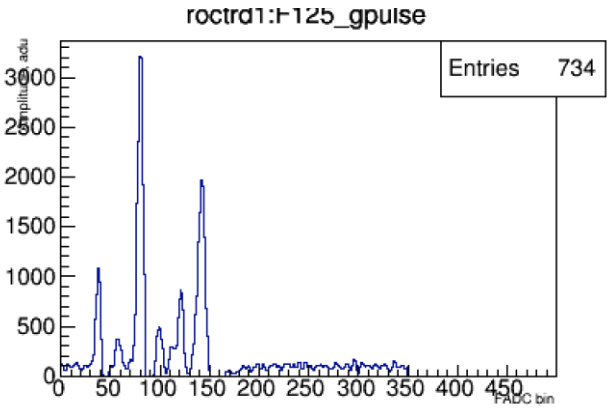


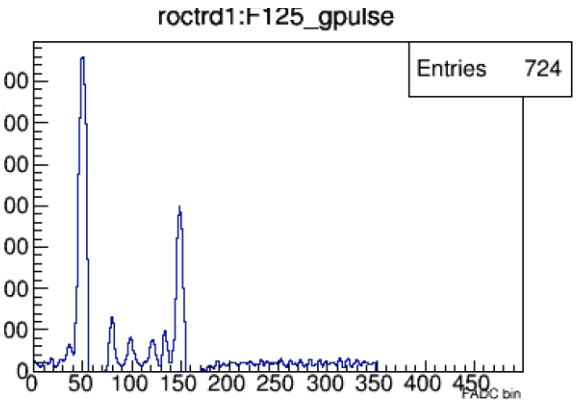


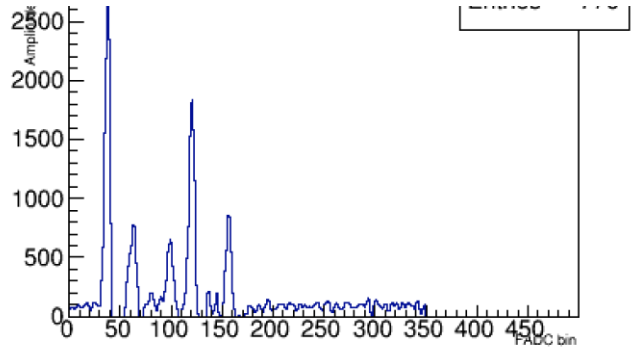












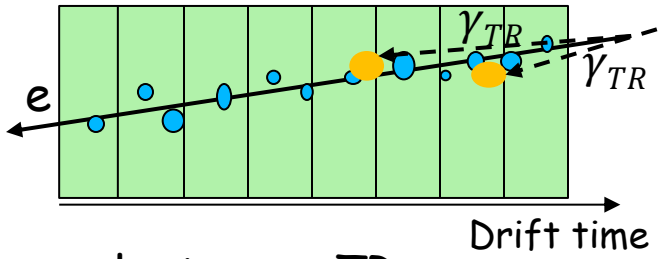
TR identification: Artificial Neural Network

Input variables:

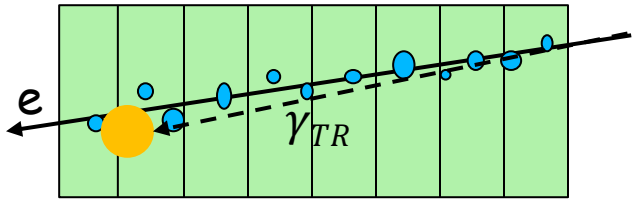
Total or per slice or per cluster (we use ca 30var)

- ‹dE/dx›
- Number of clusters
- Timing
- Etc.

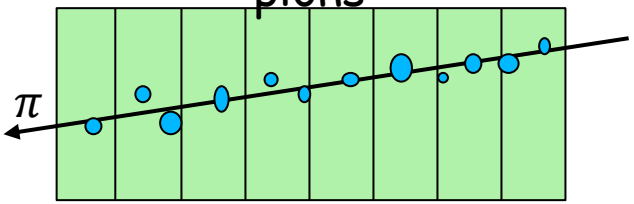
electrons +TR



electrons +TR

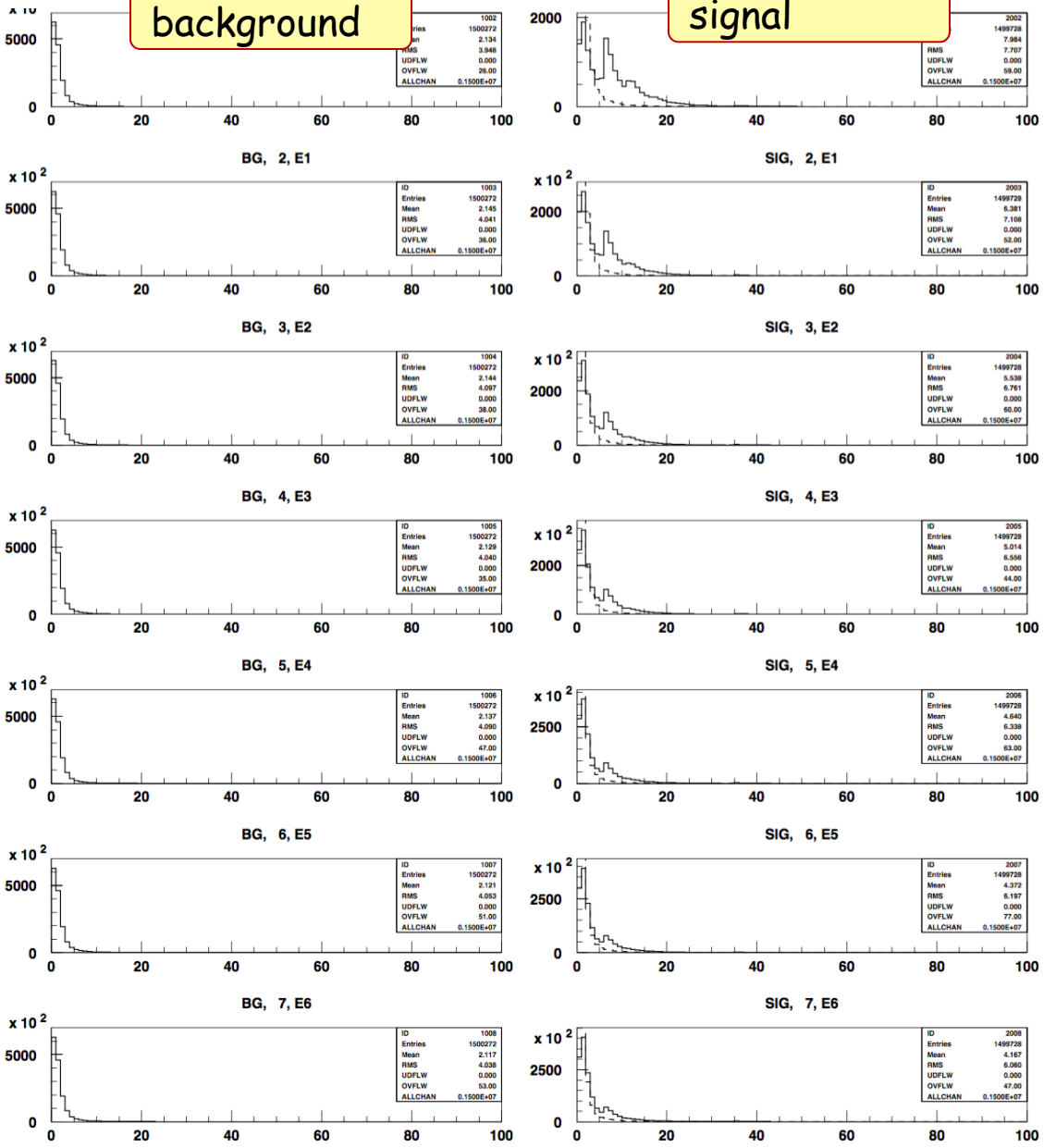


pions



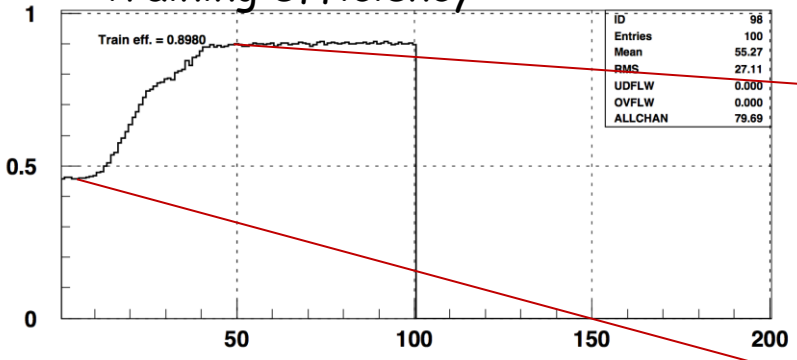
background

signal

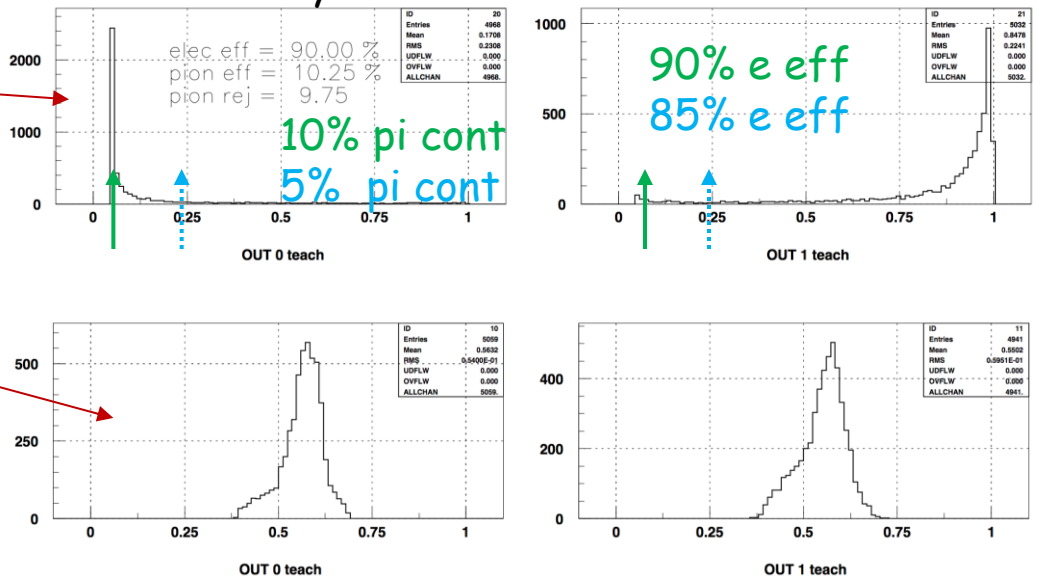


TR identification: Neural Network

Training efficiency



efficiency for 1 module



for 1 module : 90% e/π =10

But for 3 modules:

e/pi =10x10x10 = 1000

but e efficiency: 0.9x0.9x0.9=73% (not good!)

efficiency for 3 (N) modules

Efficiency for 3 modules:

e efficiency 90%

but e/π ~ 400.