JRA Detectors
Gaseous Scintillation Proportional Counters

CNR, FZJ, ILL, LIPC, STFC, TUM

JRA presentation

General Assembly

Villigen, CH

2009, March 31

Objectives

- Development of new detector technologies based on Gaseous Scintillation Proportional Counters (GSPC)
- Explore their potential to overcome the limitations in light output and rate capability of existing scintillation detectors
- Build and study small scalable prototypes
- Investigate their potential as high resolution detectors e.g.used for reflectometry or time resolved SANS.

Structure and participants

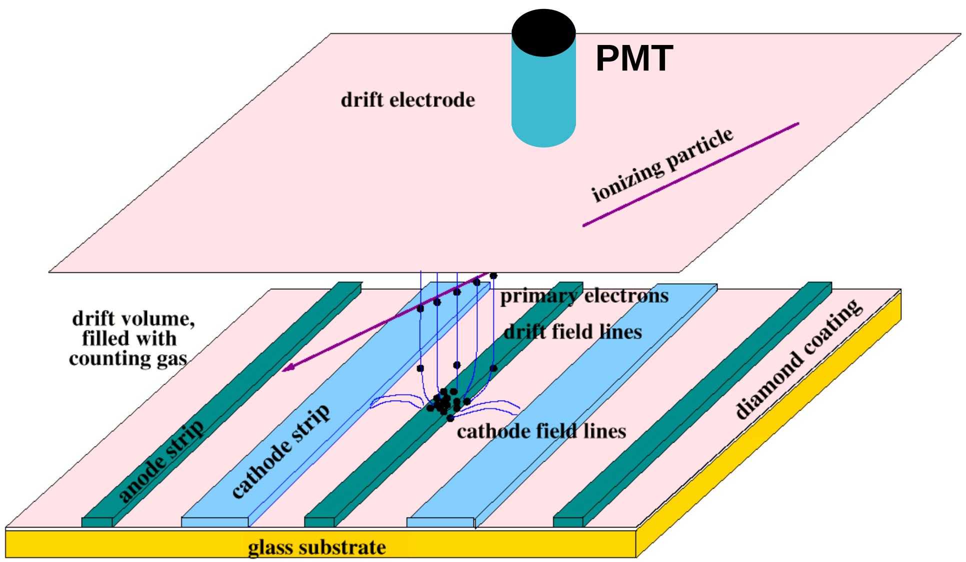
Task	*Title*	*Task leader*
T22.1	JRA management	K. Zeitelhack, TUM
T22.2	Gaseous Scintillation Proportional Counter (GSPC)	B. Guerard, ILL
T22.3	Light detecting devices, Front end, processing & readout electronics	N. J. Rhodes, STFC

Partner	*Acronym*	*Institute*	*Task*
P1	ILL	Institute Laue-Langevin	T22.2
P2	LIPC	LIP Coimbra	T22.2
P3	STFC	Science and Technology Facilities Council	T22.2 T22.3
P4	FZJ	Forschungszentrum Jülich	T22.3
P5	CNR	Consiglio Nazionale delle Ricerche	T22.3
P6	TUM	Technische Universität München (FRM II)	T22.1,T22.3
O1	ToU	University of Tokyo	T22.2, T22.3

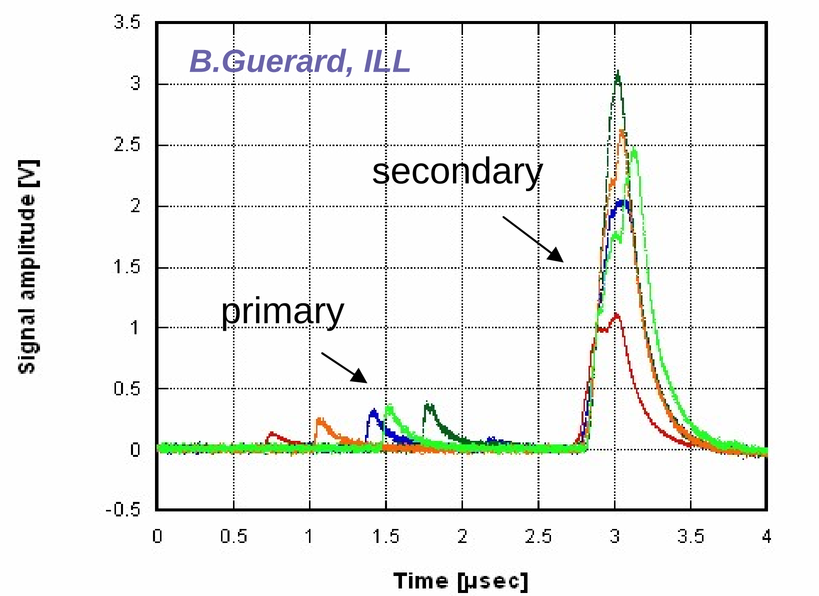
Gaseous Scintillation Proportional Counters (GSPC)

Production of light during ionization ("primary") and charge amplification ("secondary") in a Gaseous Proportional Counter

Intensity and spectral response depend on gas, pressure, charge amplifying structure

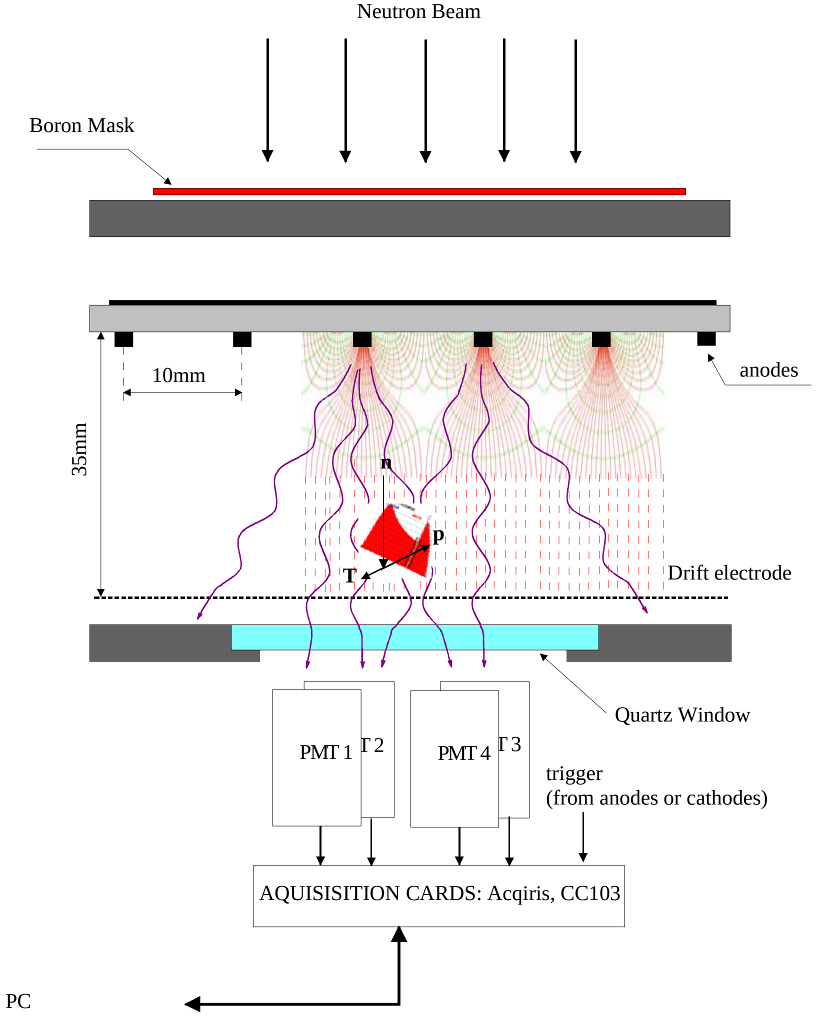


Micro pattern charge amplifying structure (e.g. MSGC)



PMT signals of primary and secondary light produced in a MSGC at ILL

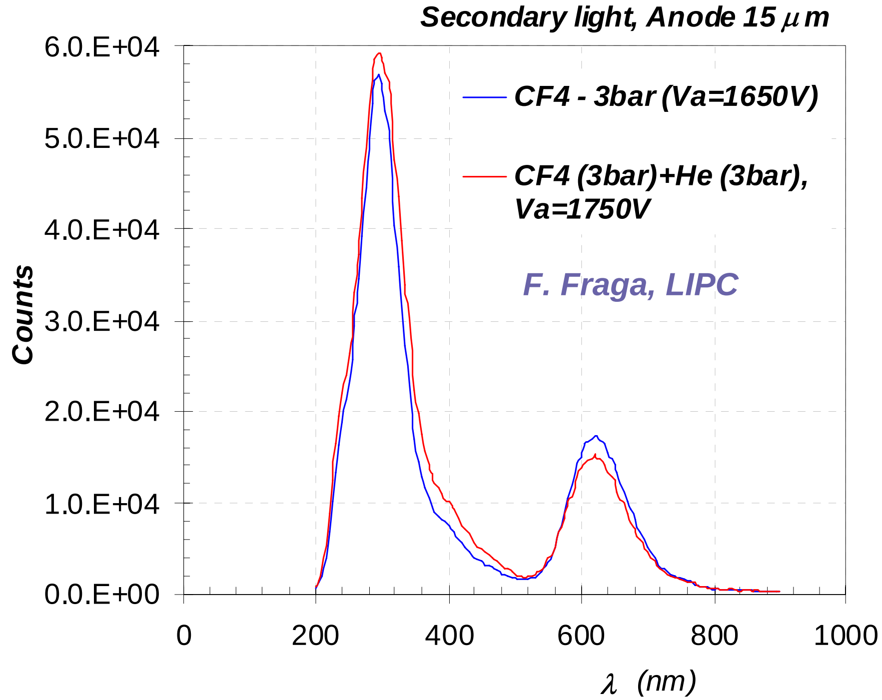
Neutron Detection with a GSPC



$n + {}^3He \rightarrow t + p + 765$ keV

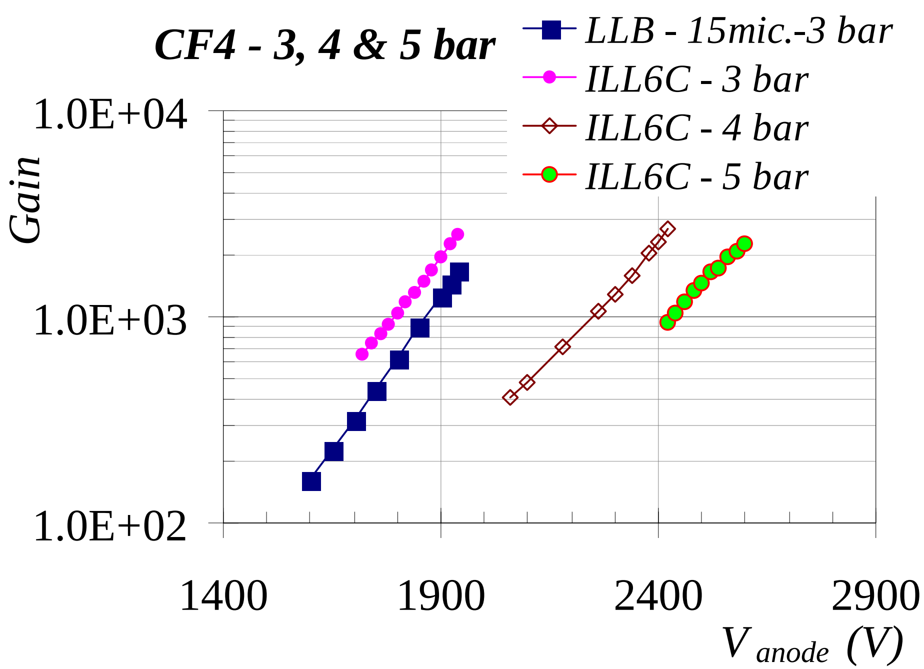
High-p gas filling: ${}^3He+CF_4$

Spectral response

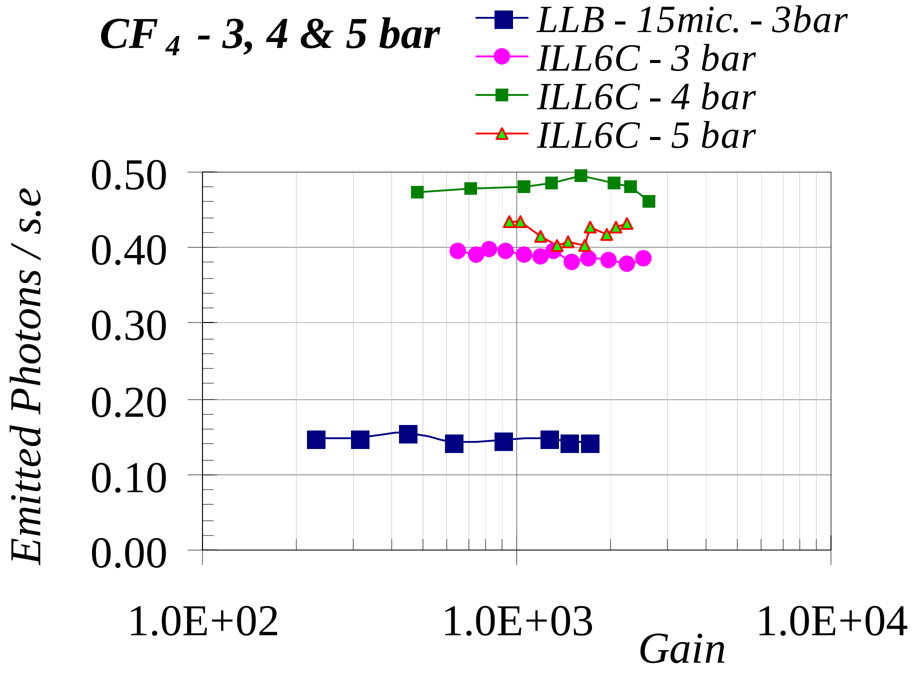


Pilot study of MSGC based GSPCs within “MILAND”

Charge gain *versus* anode voltage of two MSGCs operated at high pressure



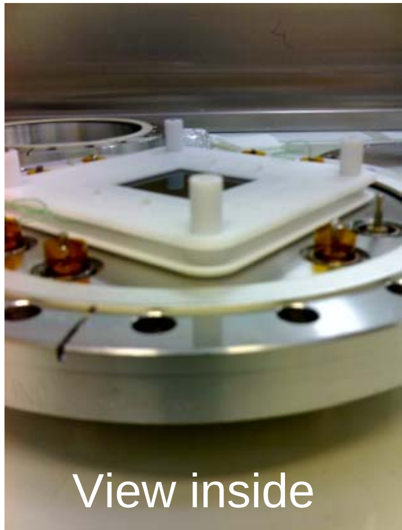
Number of emitted photons / electron



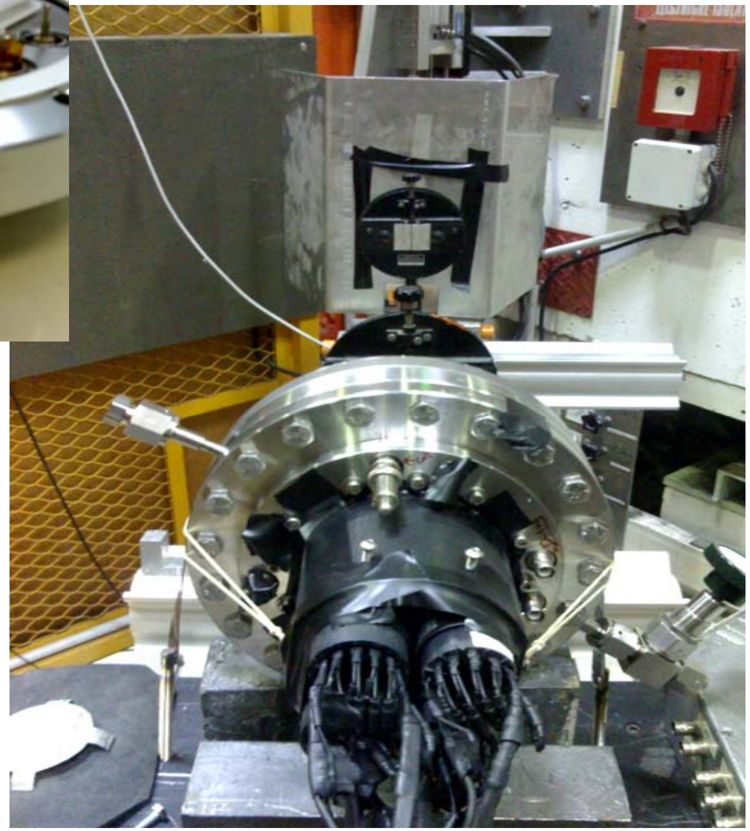
A light output of 10^6 –10^7 photons / neutron seems possible.
This should allow sub-mm position resolution

MSGC (ILL6C) based GSPC built at LIPC / ILL


Rear view without PMTs


View inside

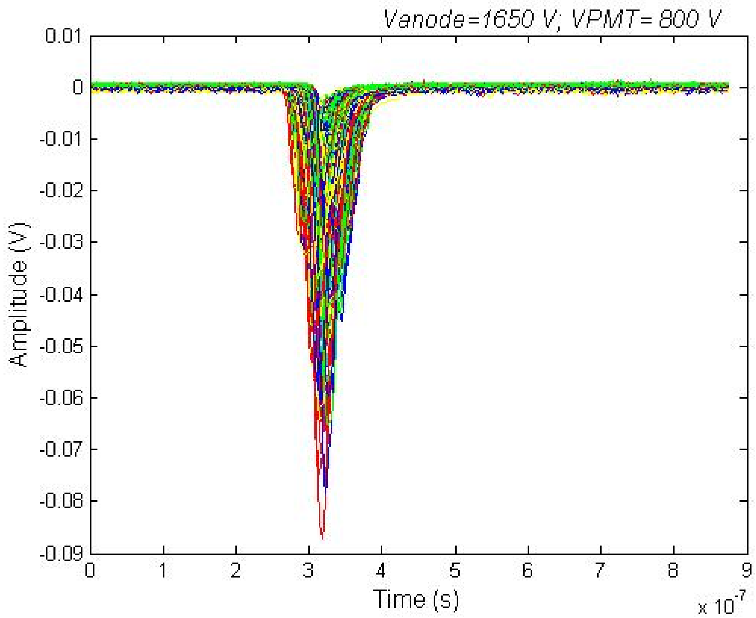
GSPC with Anger Camera readout mounted for a test at ILL beam station CT1



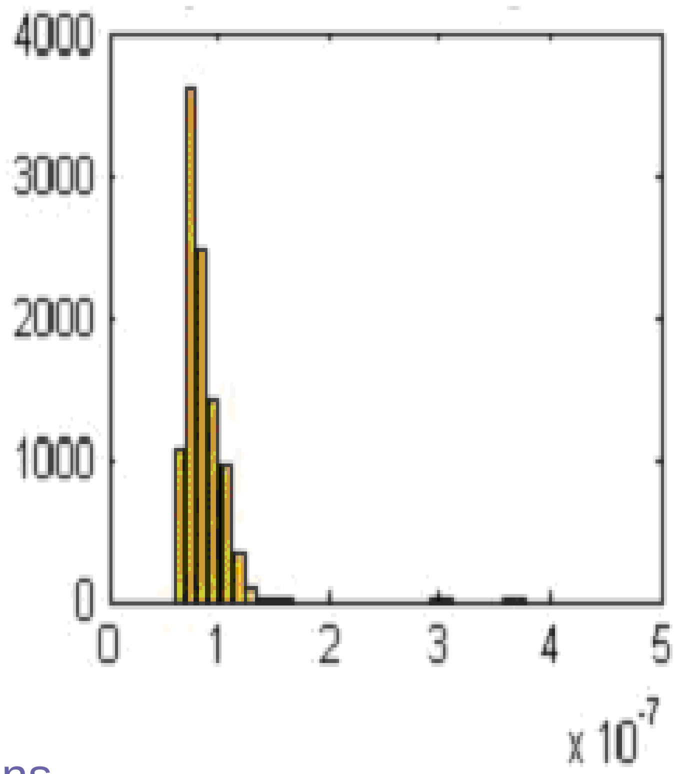
He+CF4 (bar)	2+3
Absorption gap (mm)	5
MSGC-PMT gap (mm)	27.5
Anode width (µm)	8
Anode pitch (mm)	1
2 x 2 PMT array; PMT Ø (mm)	38

Light signals of GSPC prototype

Typical PMT signals



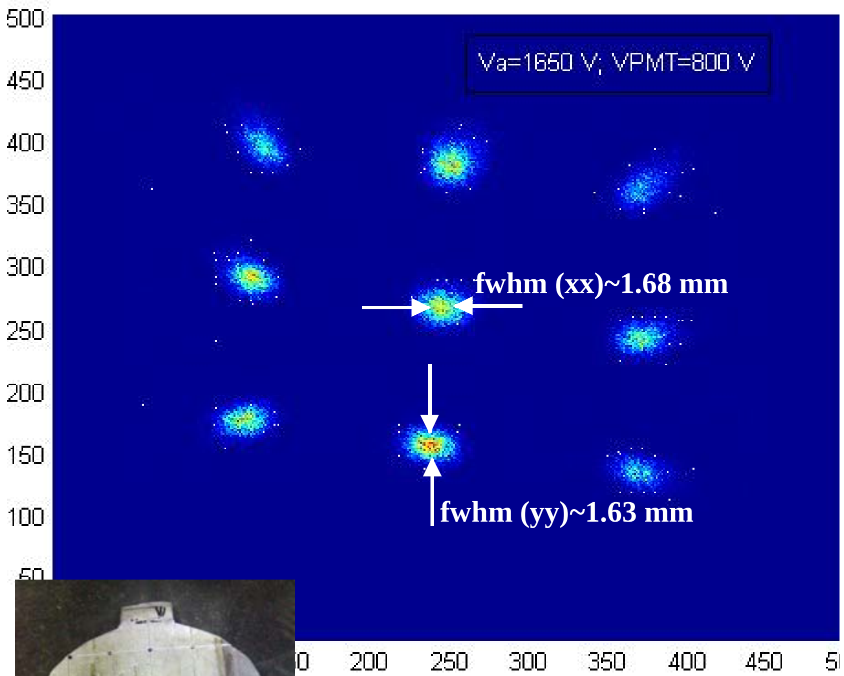
Light signal length [sec]



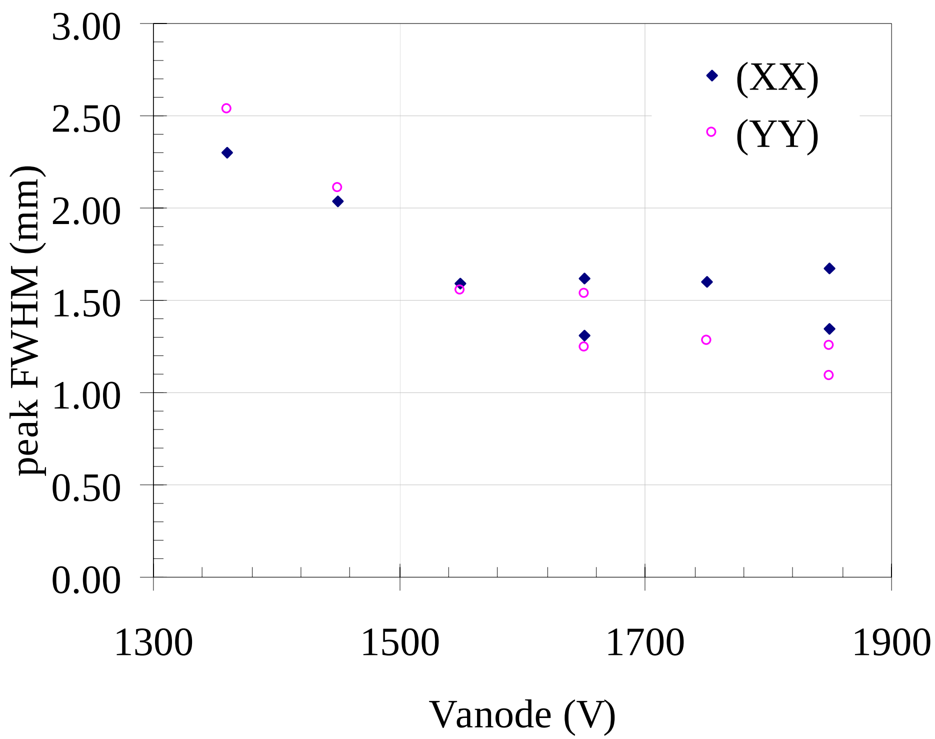
High amplitude ➔ good discrimination
Fast signals: rise time ~20ns, duration ~60ns
➔ Should allow high count rate capability

F. Fraga, LIPC,
E. Schooneveld, STFC

Position resolution of GSPC prototype



Cd mask with 1mm holes at 10mm pitch



<1.5 mm intrinsic resolution after deconvolution of beam width

F. Fraga, LIPC, E. Schooneveld, STFC

Task 22.2

- Investigate micro pattern charge amplifying structures for GSPCs study achievable gain in high-p operation, light output, time constants,…
- Study the GSPC performance, photon yield and spectral response as a function of gas composition, purity, pressure,…
- Investigate the application of optical elements like dispersers, lenses or collectors to enhance the photon yield of the light readout devices
- A He+CF_4 based GSPC requires high pressure operation (detection efficiency, light yield). Need for a modular pressure vessel design with minimum dead space
- Simulate GSPC performance taking into account photon yield, optical and geometrical parameters, light detecting readout to optimize the GSPC design.
- Design and produce a small scalable demonstrator

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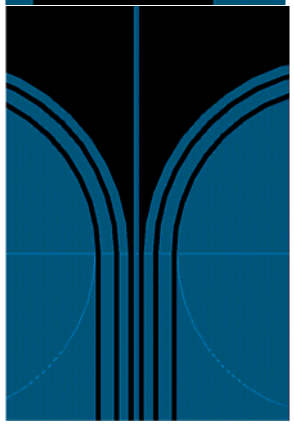
  Standard MSGC only allow back illumination mode. Optical window and conversion gap limit MSGC – PMT distance.

  Perspective: transparent multigrid MSGC produced by Tokyo University



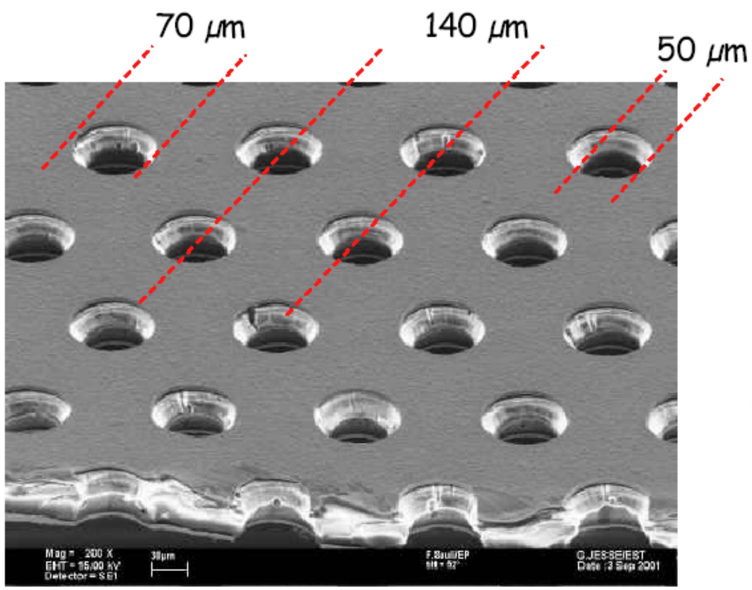
  ITO- MSGC can act as window
  90% electrode transparency
  PMT close to light production
  Multigrid design provides high local count rate capability
  Large active area feasible

Task 22.2

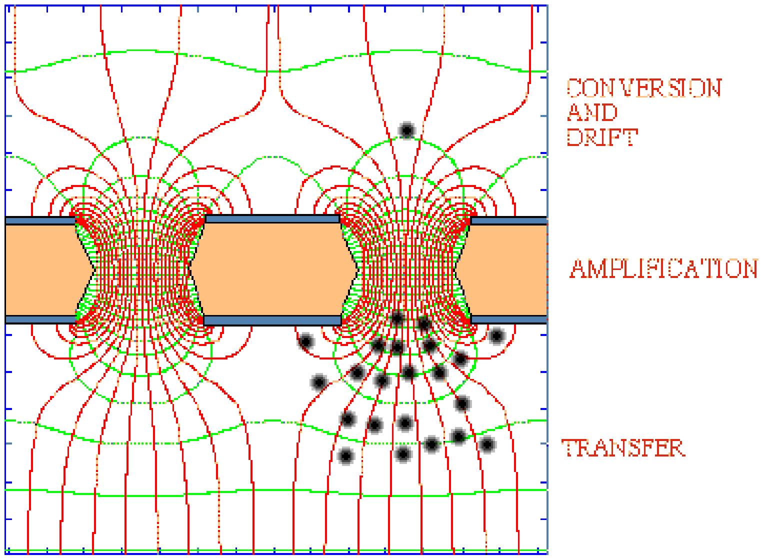
- Alternative micro pattern devices

GEM (Gaseous electron multiplier) manufactured at CERN

Drawback: seems to allow less gain at high CF4 pressure



50 μm Kapton cladded with
5 μm Copper on both sides



F.Sauli. NIMA386(1997)351

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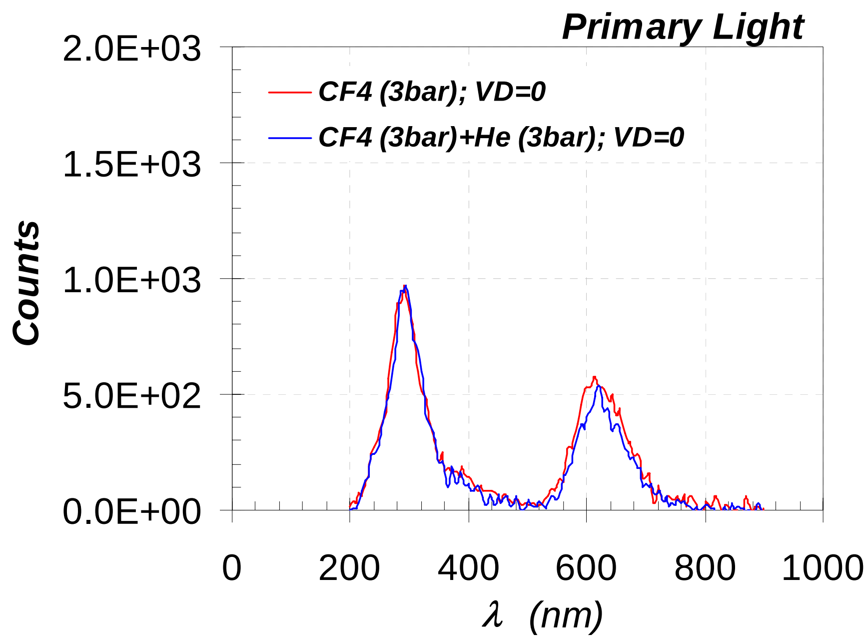
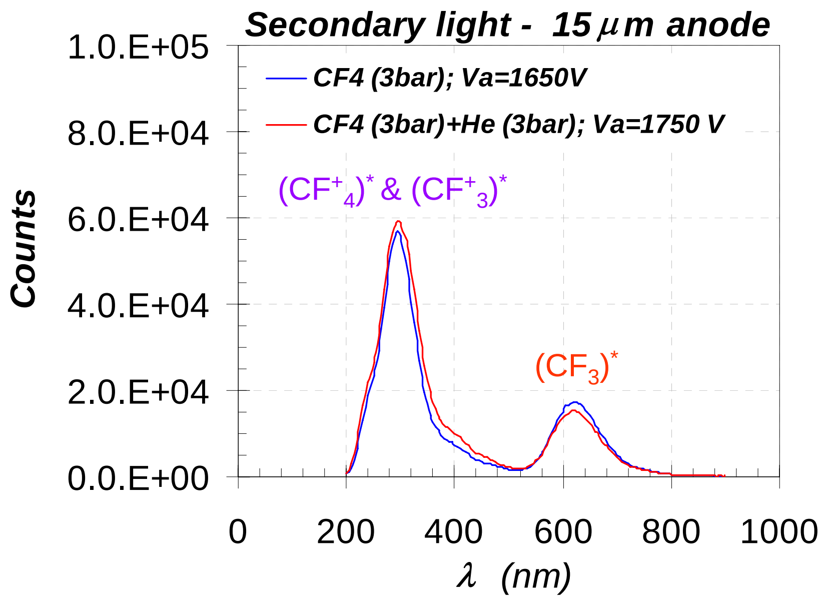
Scintillation spectra



Primary Light



MSGC Scintillation spectra

L. Margato, LIPC

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- Explore various photomultiplier (PMT) devices for use in a GSPC
- Investigate innovative light detecting devices (APDs, Si-PMTs)
- Analyze electronics response of small prototypes recorded with digitizing systems
- Based on this analysis develop a compact modular high performance front end electronics
- Develop dedicated signal processing hardware to carry out neutron identification and position determination in real time

Task 22.3

- Single cathode PMTs

Anger Camera Readout

Array of single cathode PMTs

High gain up to 10^6-10^7

Peak efficiency ~ 25-30%

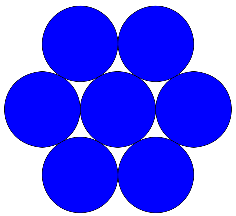
Fast signals 1~5 ns

Background <10 c/s

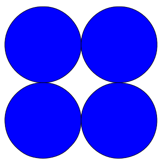
few readout channels required

- Quartz, blue or red PMTs ?
- PMT size, pitch, arrangement

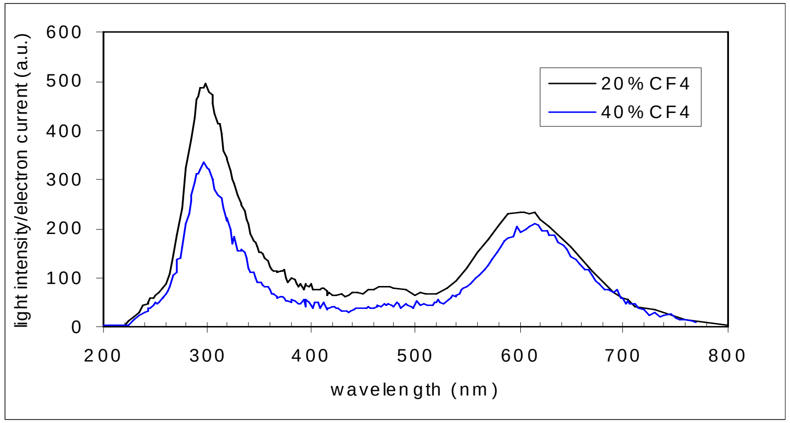
hexagonal

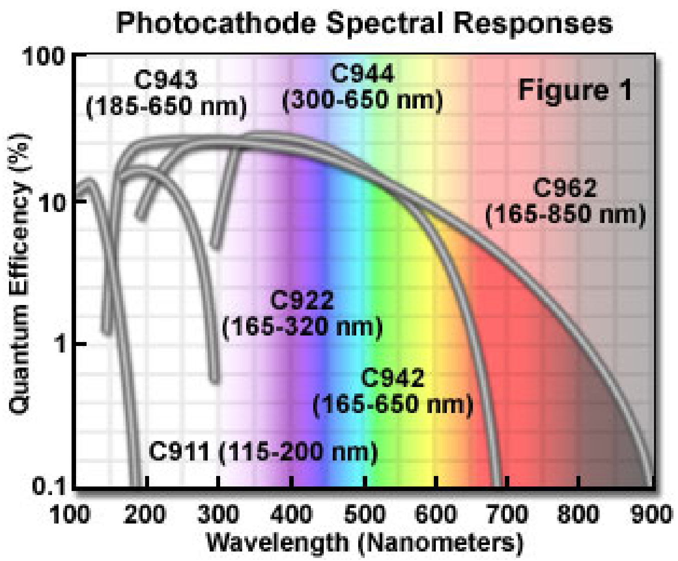


quadratic



Spectral response



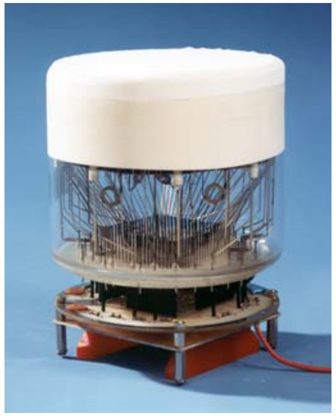


Task 22.3

Position Sensitive PMTs (PS-PMT)

- Single Photocathode
- Multi anode wires crossing one another in X and Y direction
- Anodes connected to resistor chain
- Only four readout channels required
- Needs calibration for gain uniformity
- Position resolution proportional to light yield
- Square shape

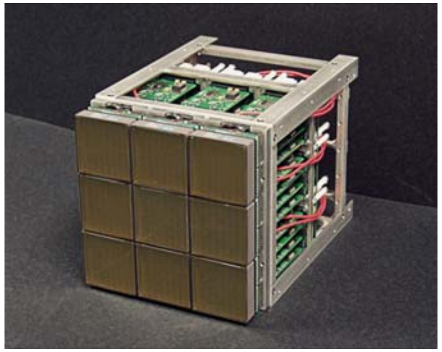
Hamamatsu R3292-02
5” PS-PMT
28 wires in X, Y



Multi Anode PMTs (MA-PMT)

True pixel layout
16, 64 or 256 pixel / PMT
Pixel size 2.8 – 5.8 mm
Gain can vary by a factor of 3, needs calibration
High number of readout channels
Small pixel size could offer higher position resolution

Hamamatsu 8500
64 pixel PMT
6mm x 6mm pixel



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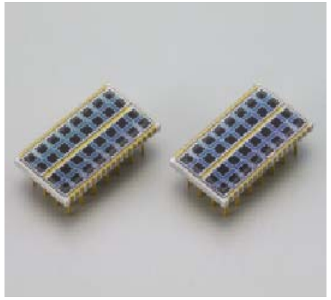
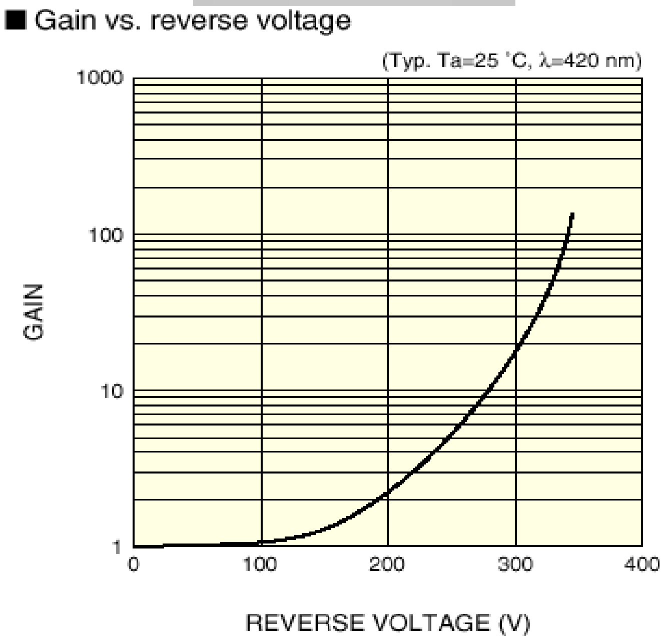
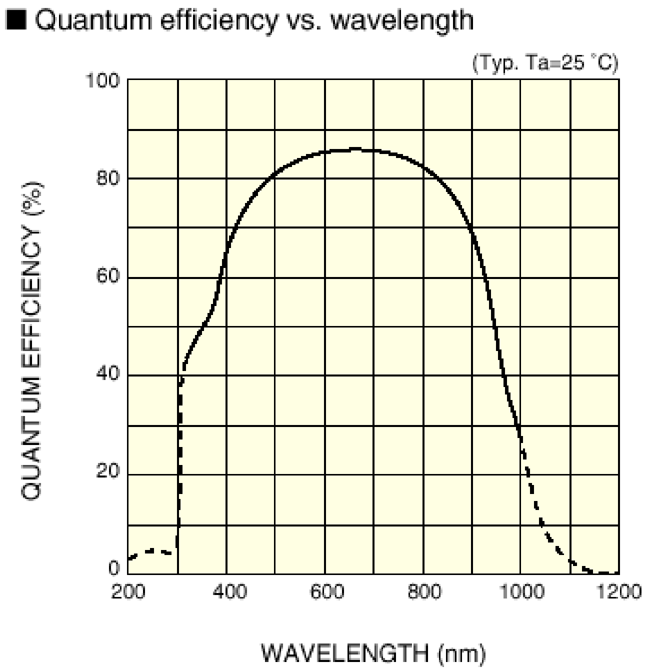
Photon counting APD-array







- Hamamatsu S8550
- Still expensive
- Impressive recent results obtained in PET detectors

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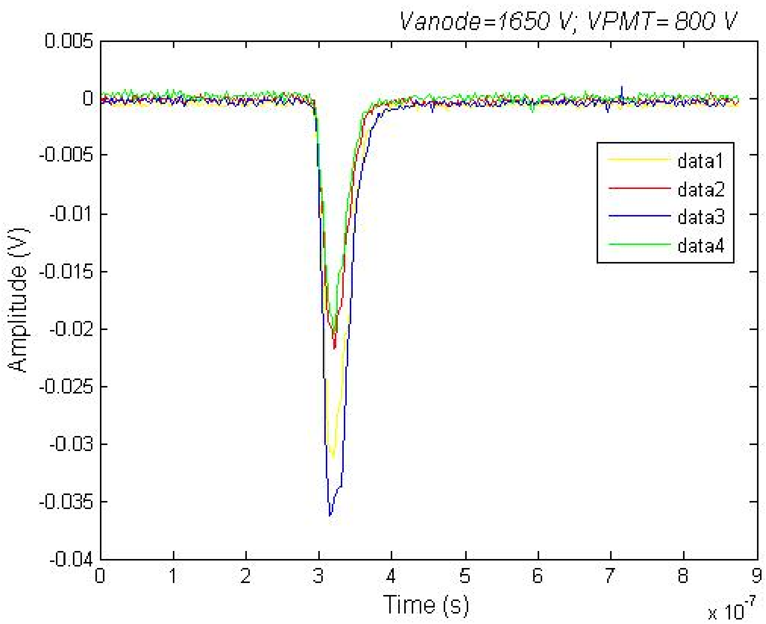

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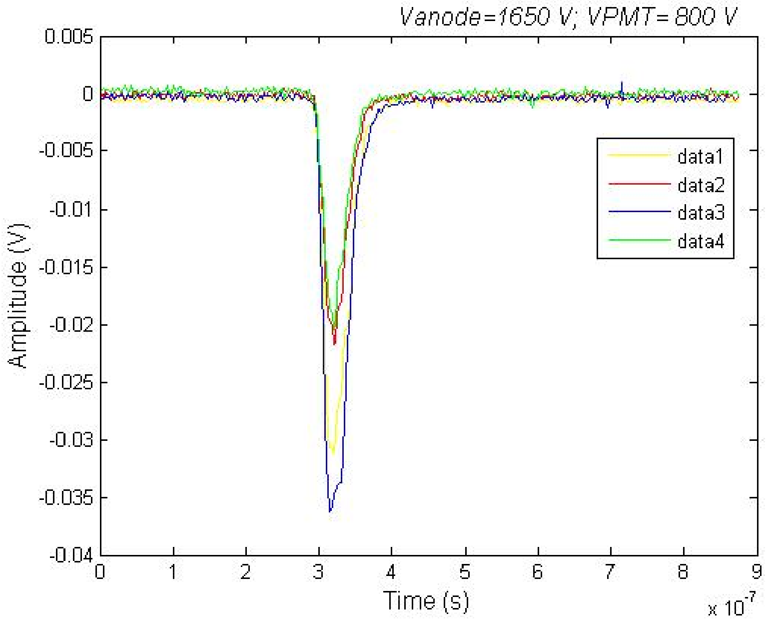

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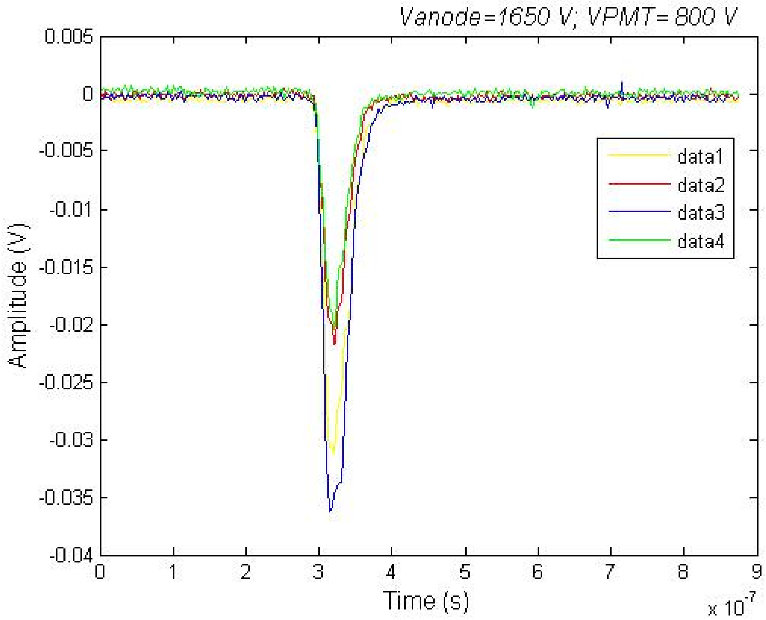

Outlook to the future

- JRA is a really joint effort of the contributing labs to evaluate a new technology for neutron detectors
- Building small demonstrators the goal is to step ahead towards a neutron detector technology with the perspective of

high position resolution Δx ~0.5 - 1mm

high count rate capability 1-10 MHz

low gamma sensitivity