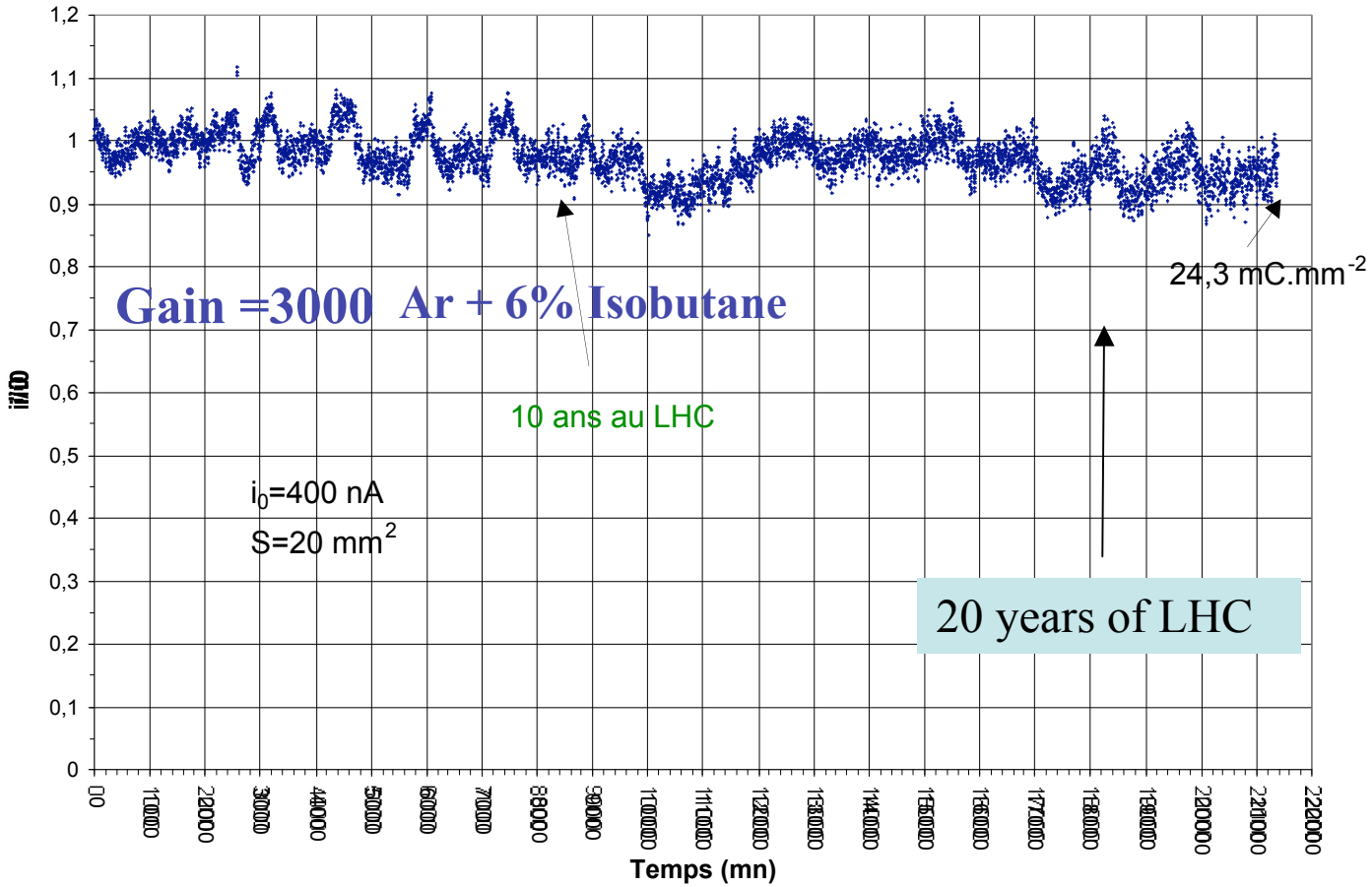
High rate applications of Micromegas and prospects

Giomataris Ioannis, DAPNIA-Saclay

- Radiation resistance and high rate hadron beams
- Issues in single or pre-amplification mode
- High rate experiments
- NA48, KABES and differential HBD
- High rate neutron detectors
- Piccolo-Micromegas in the reactor core
- Conclusions

High radiation resistance

G. Puill, et al., IEEE Trans. Nucl. Sci. NS-46 (6) (1999)1894.



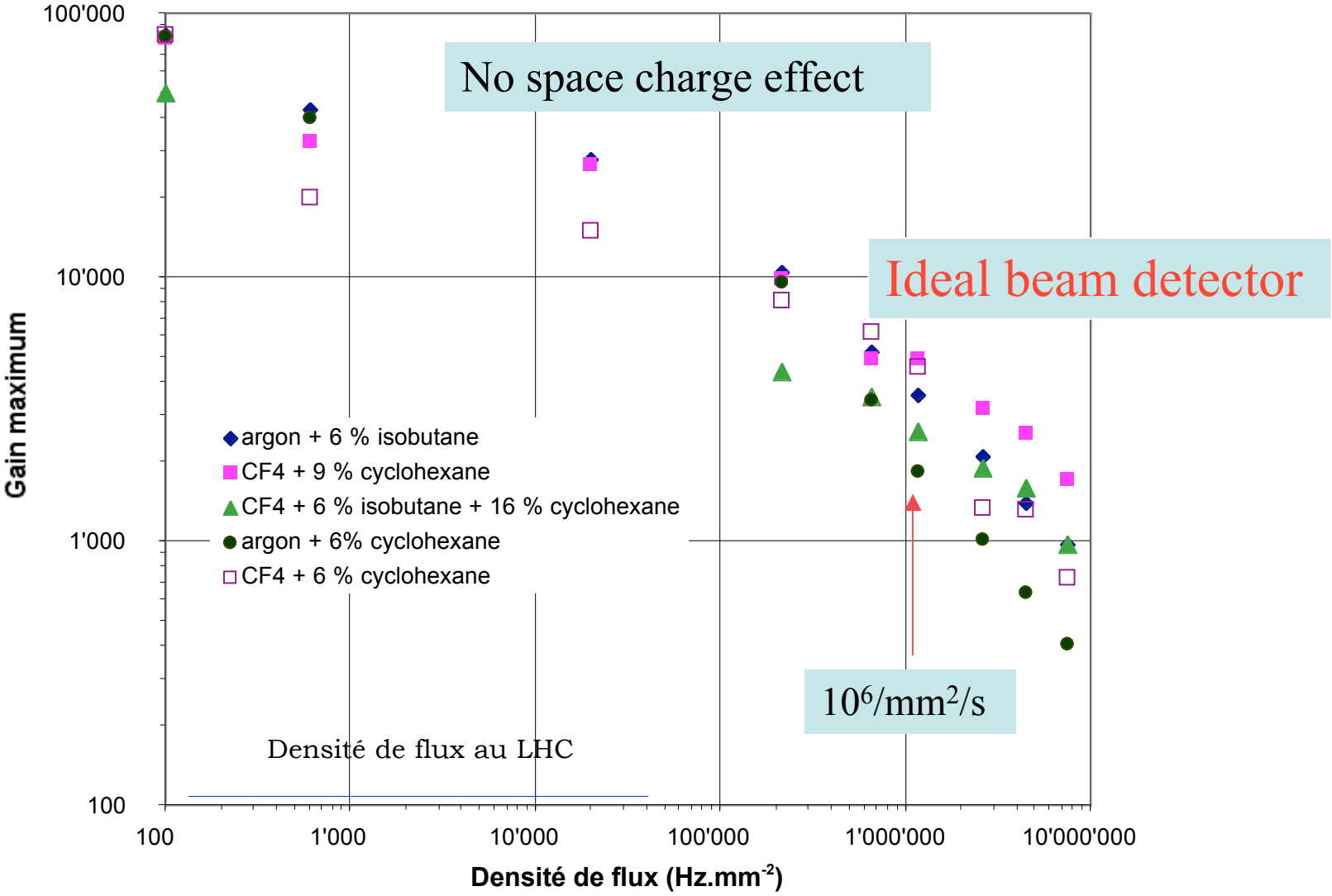
Accumulated dose: NA48 4 mC/mm^2 , COMPASS 2 mC/mm^2 (Ne + 11% CF4 + C2H6)

New tests are under way in Nikhef, H.V Graaf, J. Timmermans, P. Colas et al.

Total current 2.5 μA/mm^2 using Xe UV lamp

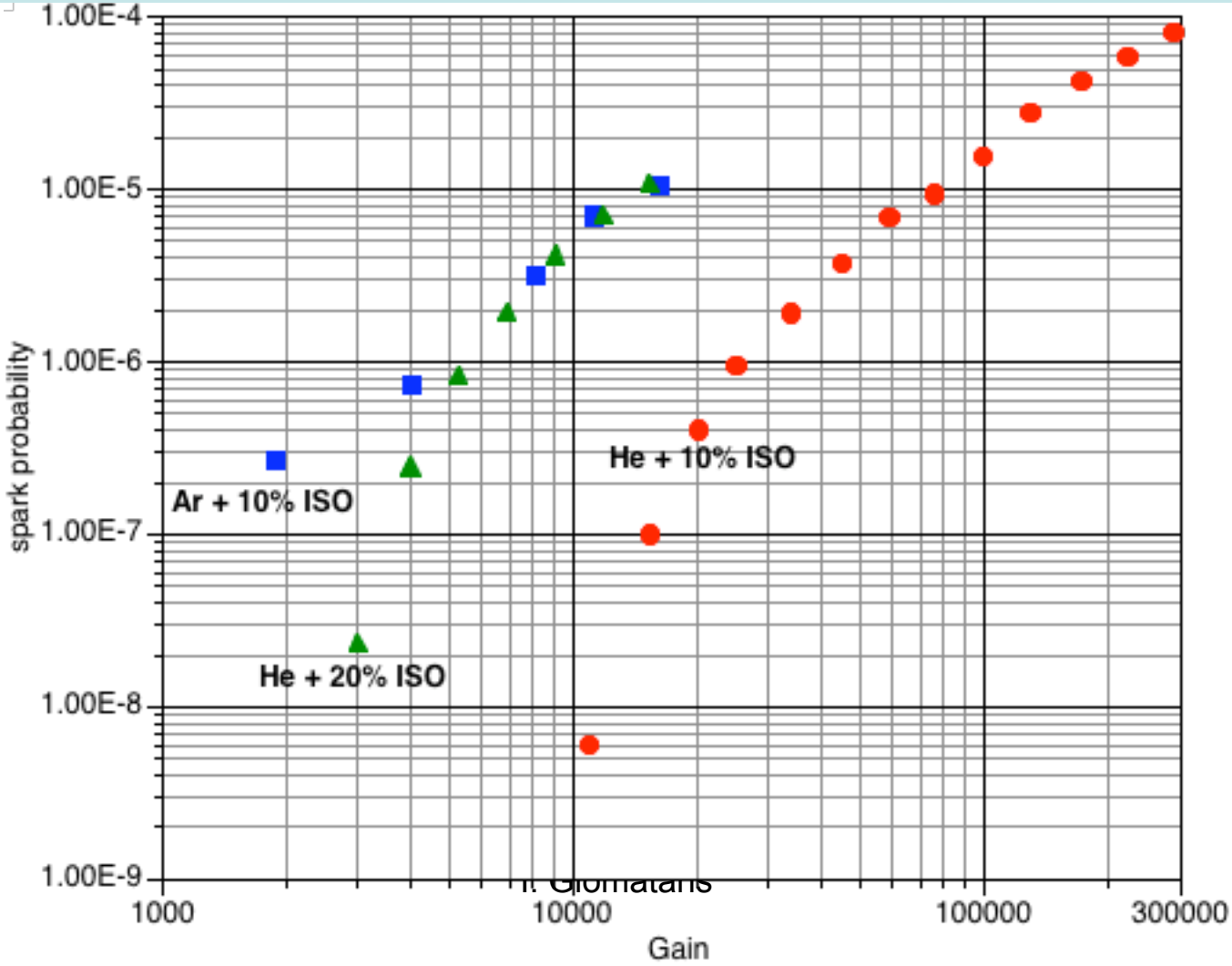
New in core reactor operation: under analysis

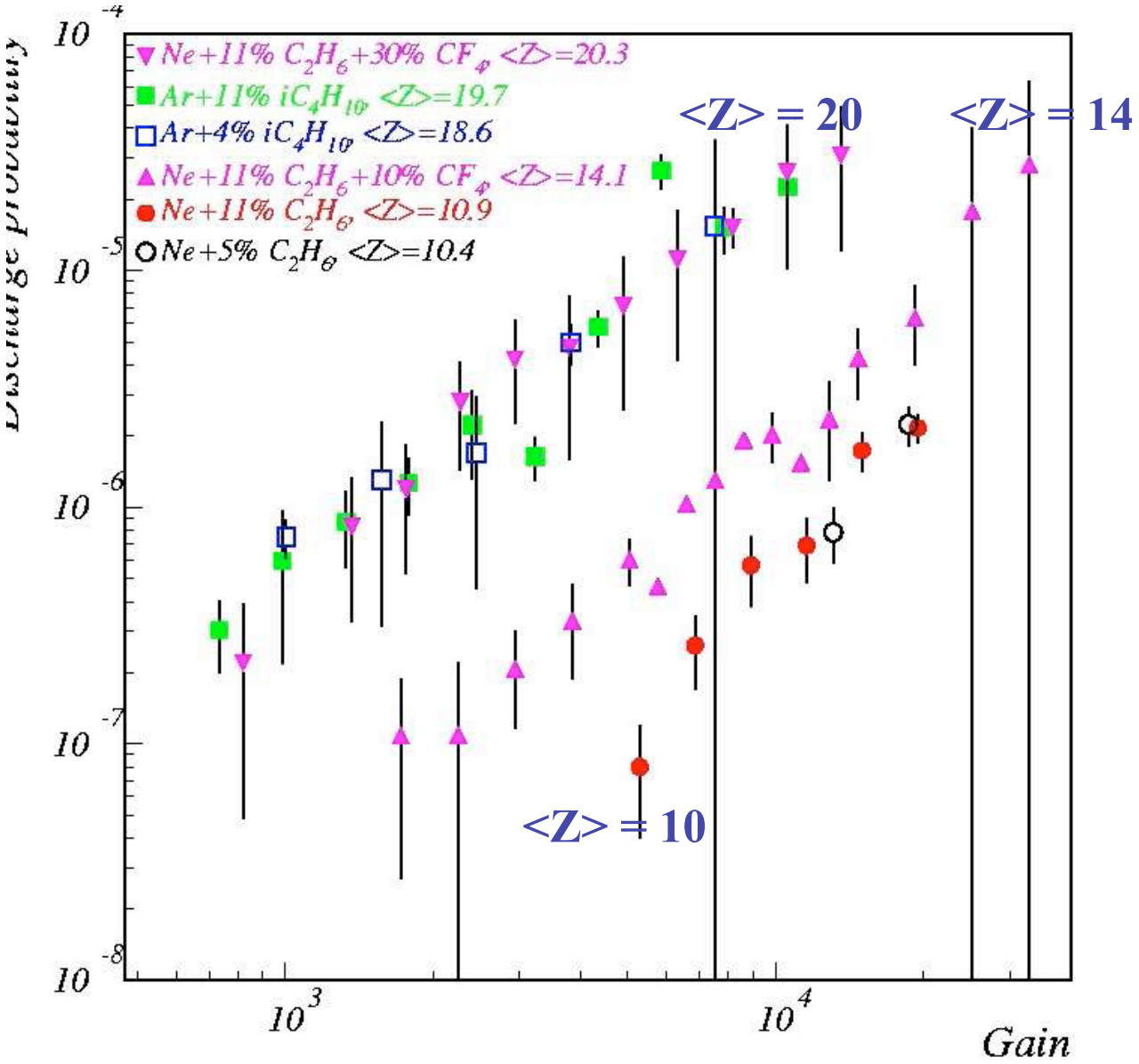
Rate capability with 8 keV x-rays



In high energy hadron beam discharges could occur

- **Induced by heavy ion recoils**
- **Deterioration in heavier gases**
- **Dependence with distance from mesh**





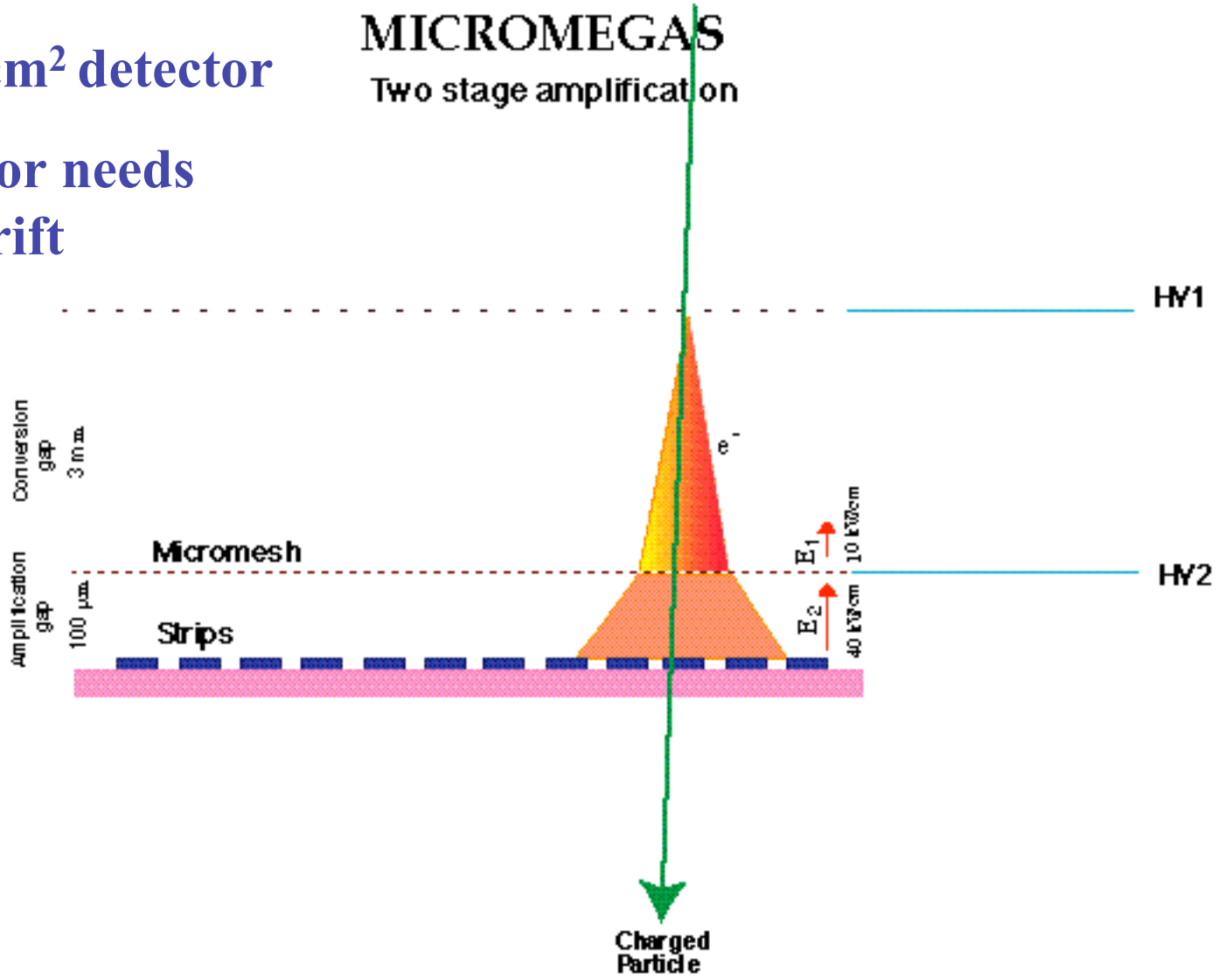
D. Thers et al., NIMA 469(2001)133

1st issue: two stage amplification

A. Delbart et al.,DAPNIA-01-04, Apr 2001. 10pp.

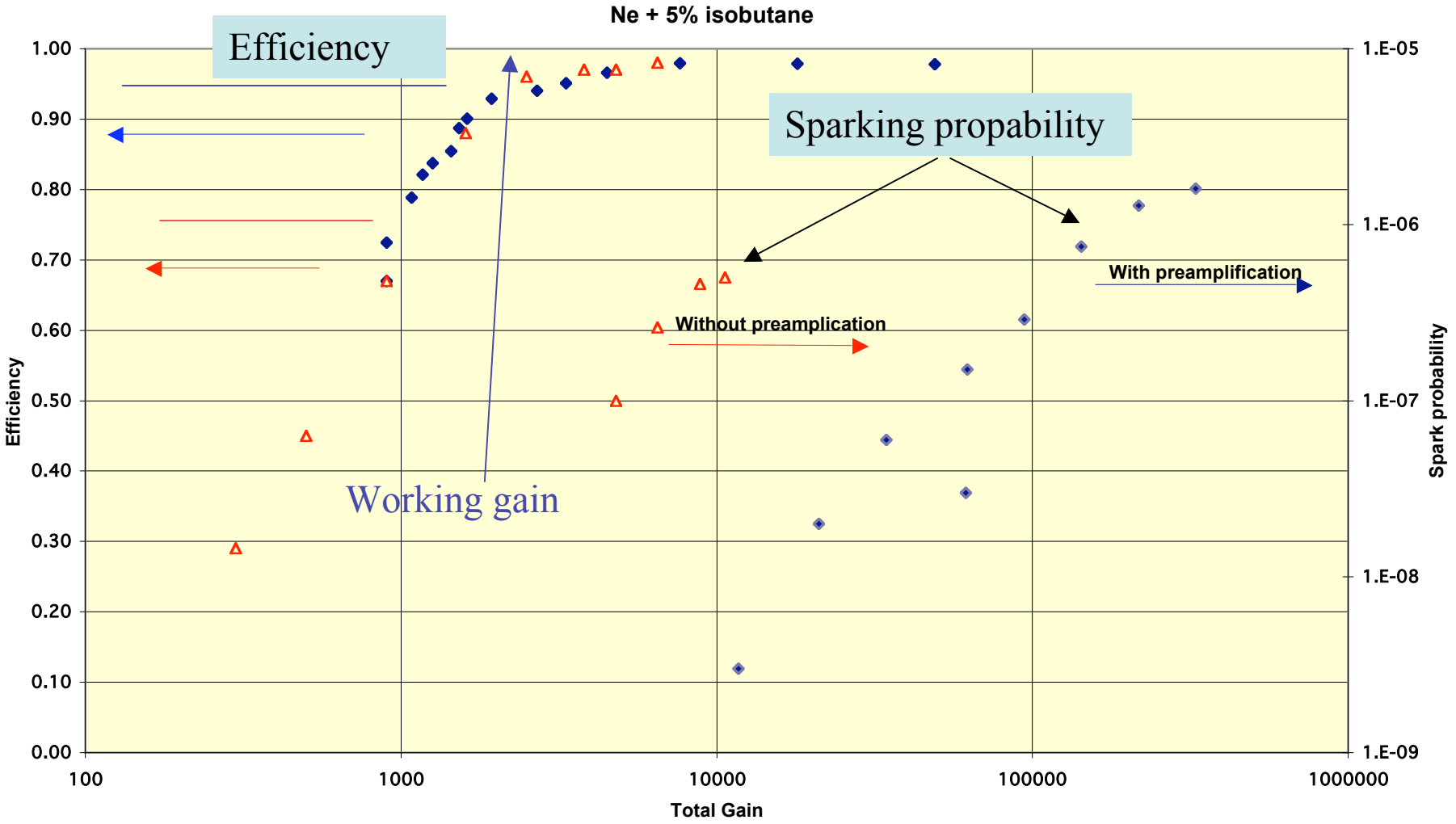
Tested in 10x10 cm^2 detector

For larger detector needs spacers for the drift



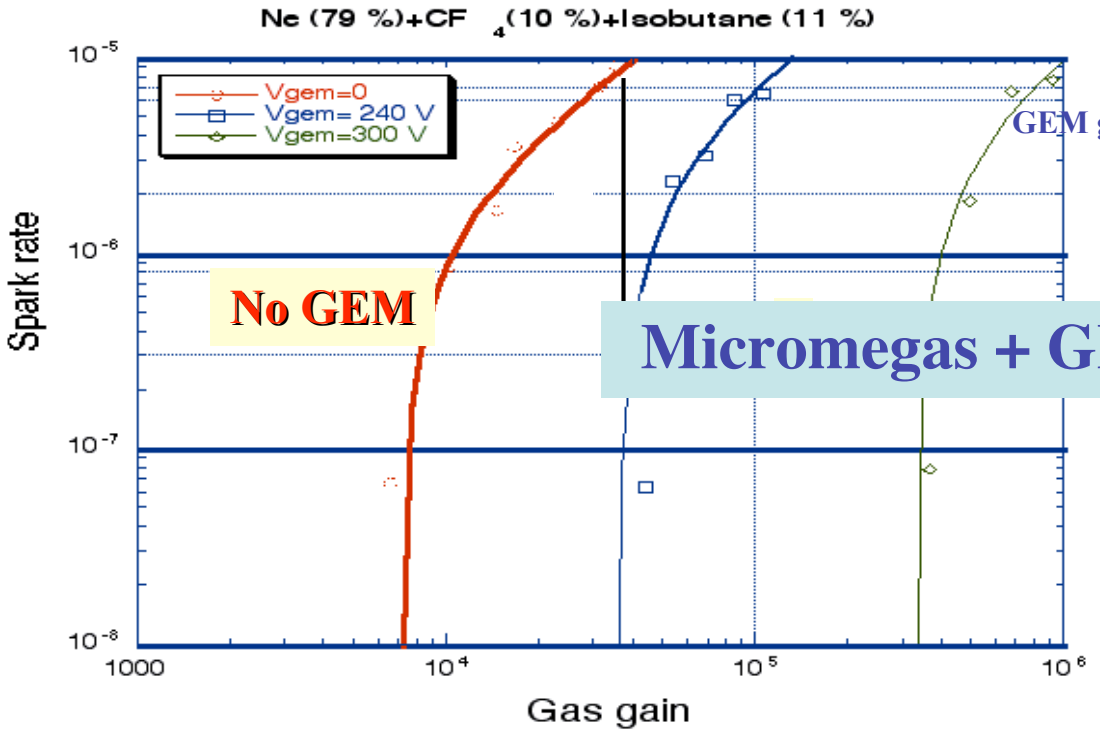
Micromegas + preamplification results
In pion beam

A. Delbart et al., Nucl.Instrum.Meth.A478:205-209,2002



2nd issue: Micromegas + GEM

GEM gain = 10

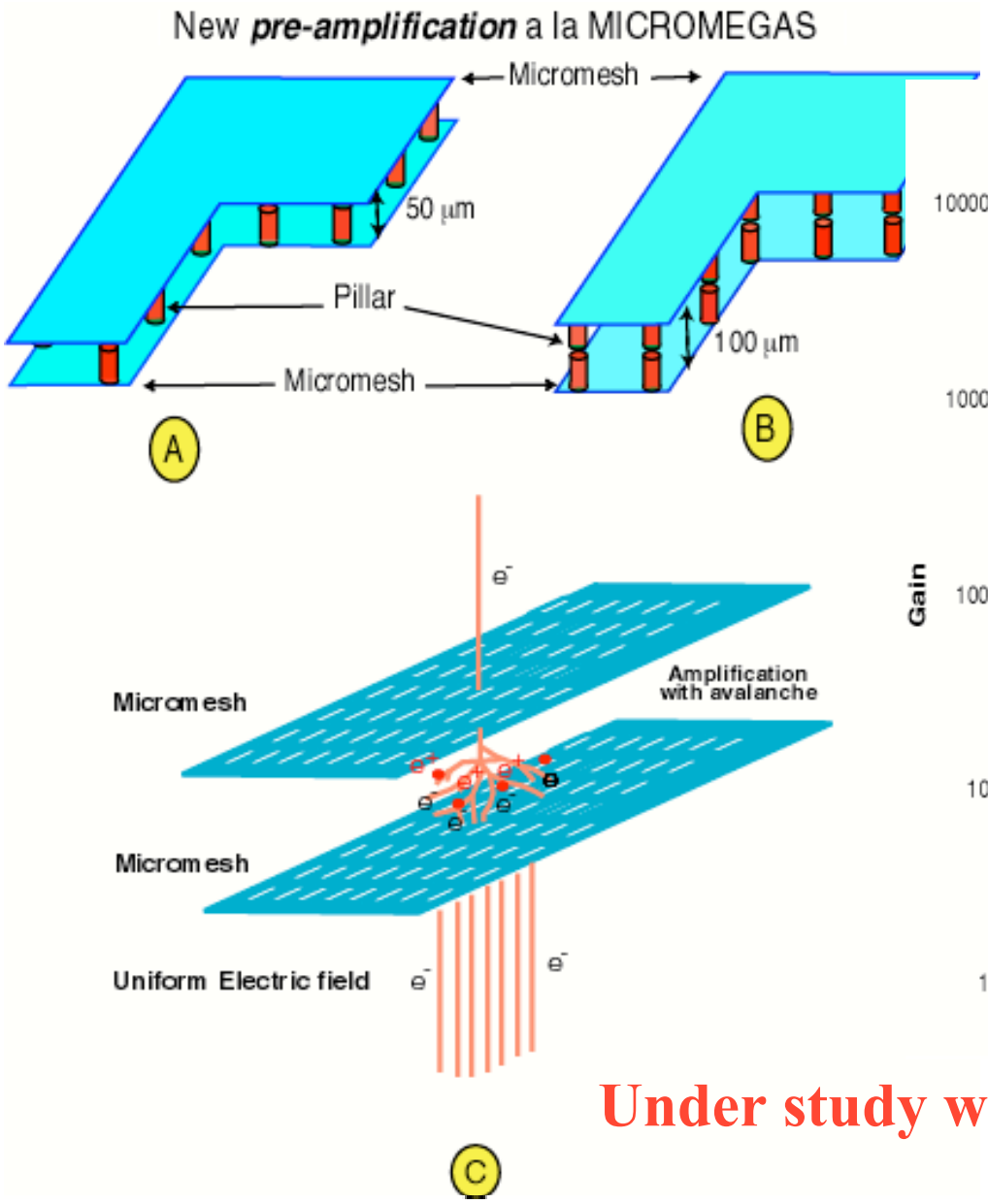


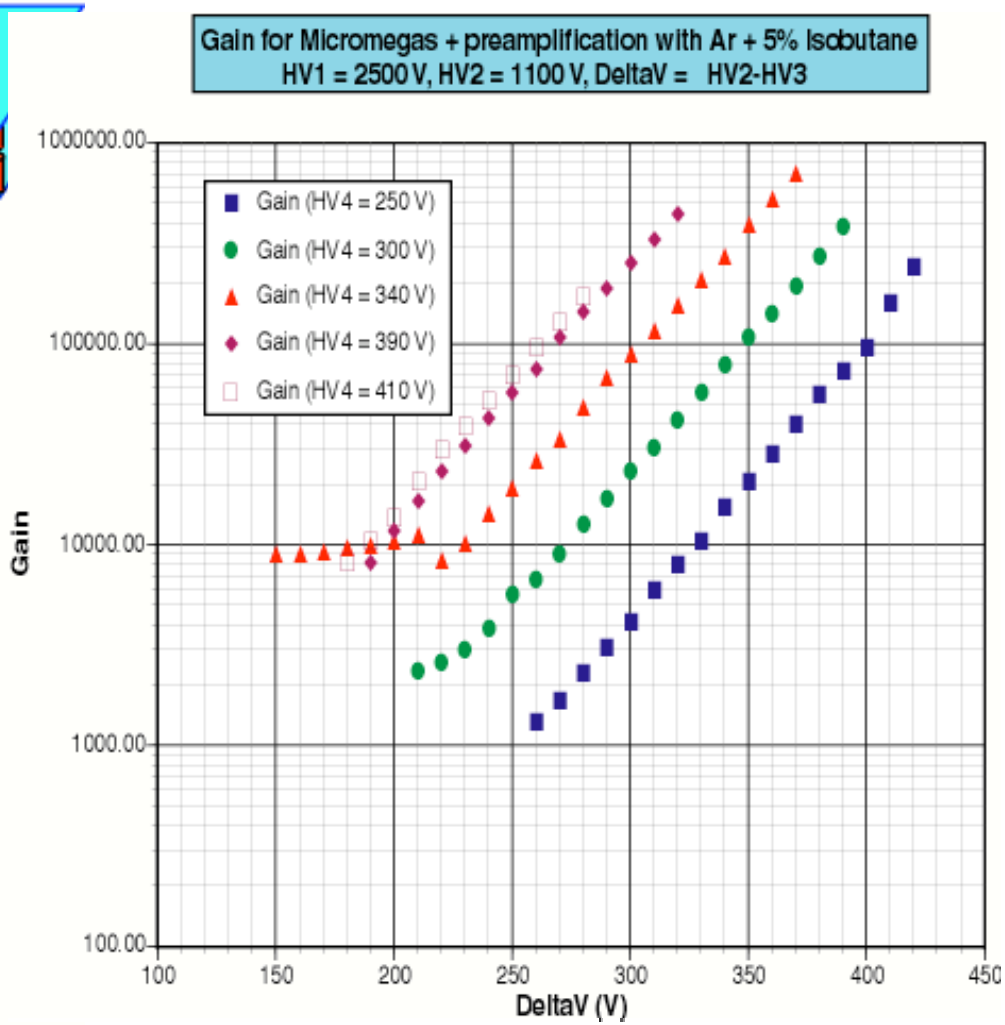
GEM gain = 100

No GEM

Micromegas + GEM in hadron beam

Ref: S. Kane et.al., A study of Micromegas with preamplification by a single GEM, COMO conf., submitted to World Scientific

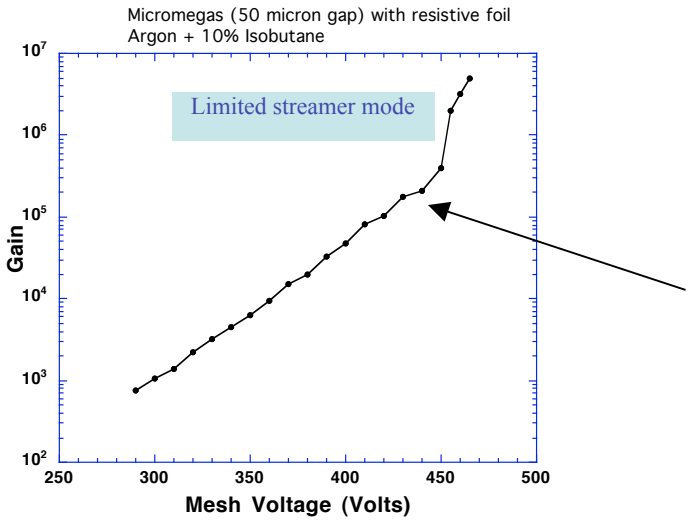




Under study with the Bulk technology

Samuel Andriamonje , Stephan Aune , Esther Ferrer Ribas , Arnaud Giganon , Yannis Giomataris and Pierre Salin, DAPNIA-04-349, Nov 2004

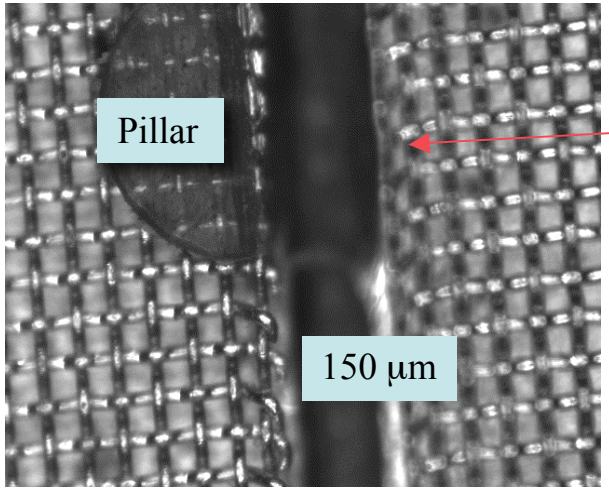
Issues in single mode operation



Improvements of the hadron rate capability of Micromegas detector in the **single mode**

- **Resistive foil on anode strips**
  M.Dixit et al.

Quenches the sparking mode
Produces limited streamers
Increases the maximal proportional gain
Spreads-out the avalanche signal



- **Grid Segmentation**

Reduces the charge released in sparks
Keeps the active area functioning
Reduces the dead time

Other ideas :

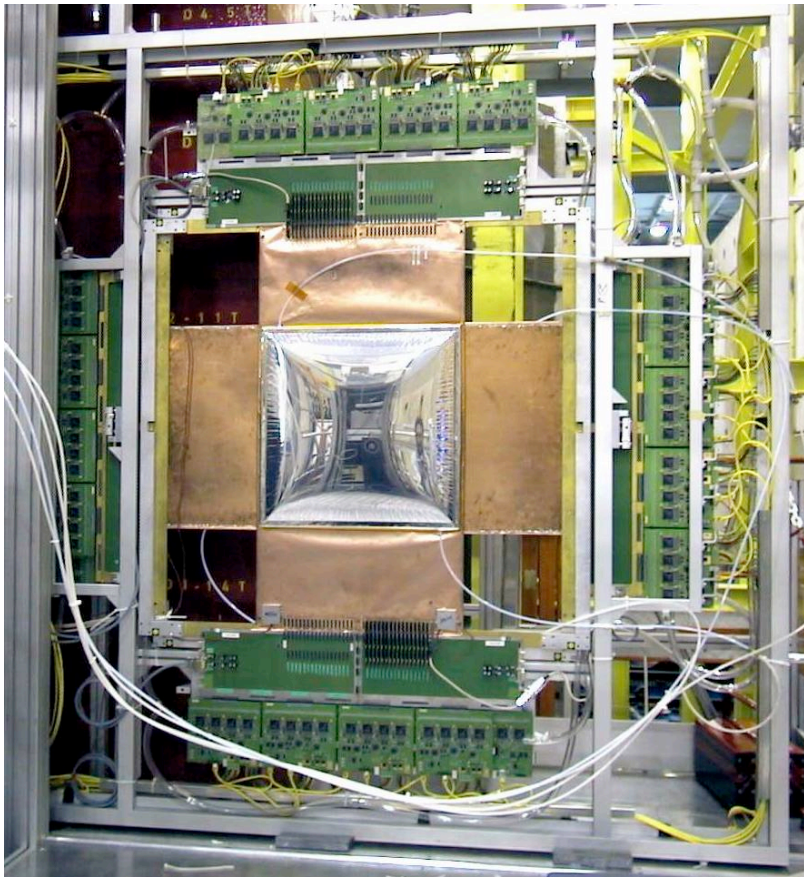
- Use a resistive grid
- Resistive layer deposit on pixels

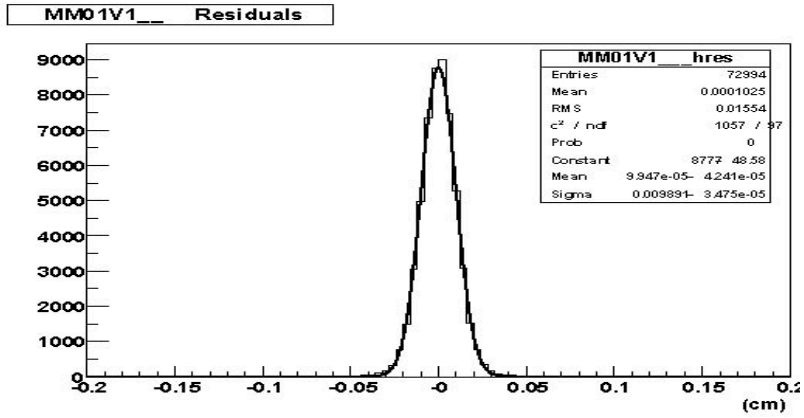
Micromegas up-stream tracker in COMPASS

The largest MPGD (40x40 cm^2)

- MIP detection for measuring the nucleon spin structure
- High particle flow : 10^5 Hz/cm^2
- Sparks give less than 1 per mille dead time
- Space resolution < 70 μm with 350μm strips
- In operation at CERN since 2002

  efficiency>97%

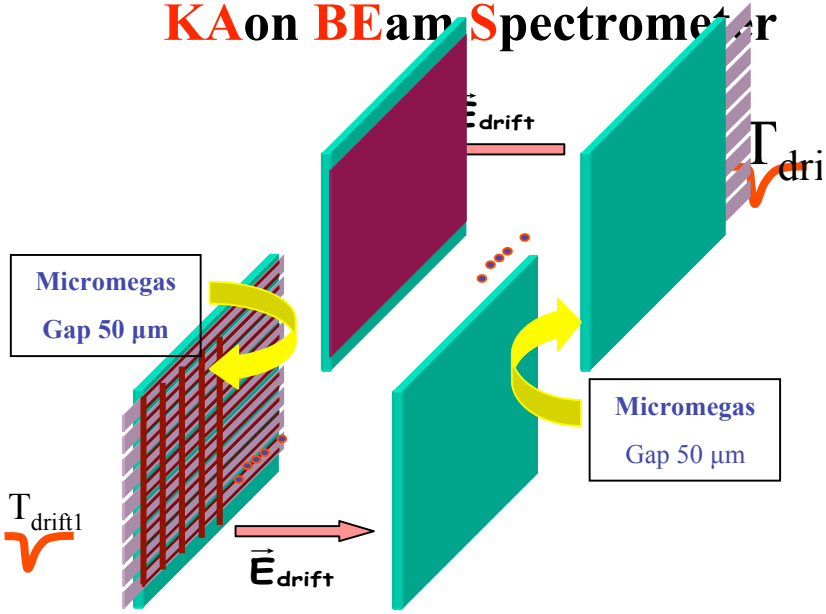




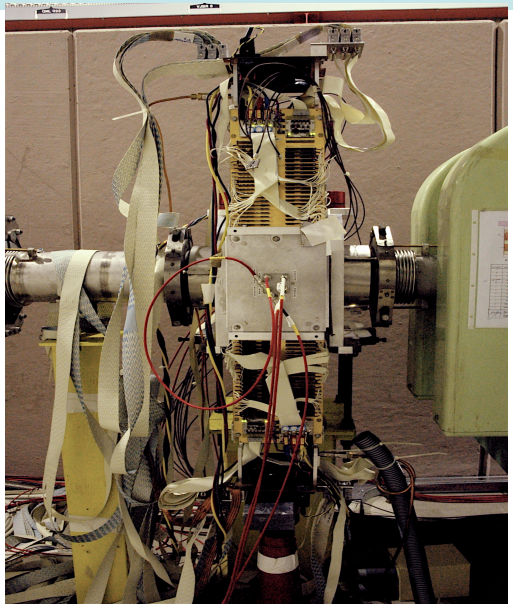
I. Giomataris

NA48/KABES

- CP violation experiment in operation at CERN from summer 2003 to end of 2005. Flux $3 \times 10^6/cm^2/s$ ($10^7/cm^2/s$ at hottest region)
- Principle : TPC + micromegas
- Fast, light and high rate BEAM detector

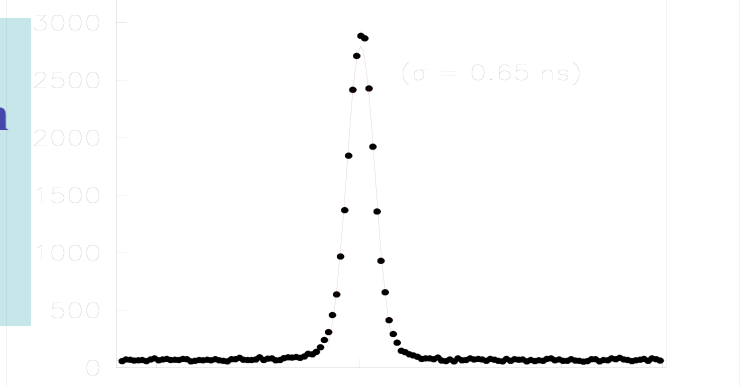


KABES in K12 (K^++K^-) beam line



Space resolution from drift time measurement: 70 µm

Time resolution: 0.6 ns



$(T_0)_{KABES} - (T_0)_{DCH\ Spectrometer}$ (ns)

I. Giomataris

Tagging with reconstructed $K^{\pm}$ ® $p^{\pm}$ p^+ p^-

Future of KABES

P326 - NA48/3 $K^+ \Rightarrow \pi^+ \nu \bar{\nu}$ Rare Decay Experiment

Extreme flux : 800 Mhz of pion beam (6% kaons)

The Kabes has been exposed to 400 Mhz beam without any saturation!!!

Prospect detector (discussed with J. Derre, A. Ceccuci, E. Mazzucato, B. Peyaud)

- **25 μm gap Micromegas tested (time occupancy of < 7 ns)**
- **12 μm gap Micromegas under study (occupancy < 3 ns)**
- **Helium mixture to be tested (occupancy < 1 ns!!!)**
- **Filling with a gas having lower diffusion coefficient and reduce the strip pitch accordingly**

Attractive solution (4 T magnet, B||E could reduce transverse diffusion by more than 10 in A_r+ CF4+ Ethane)

New idea

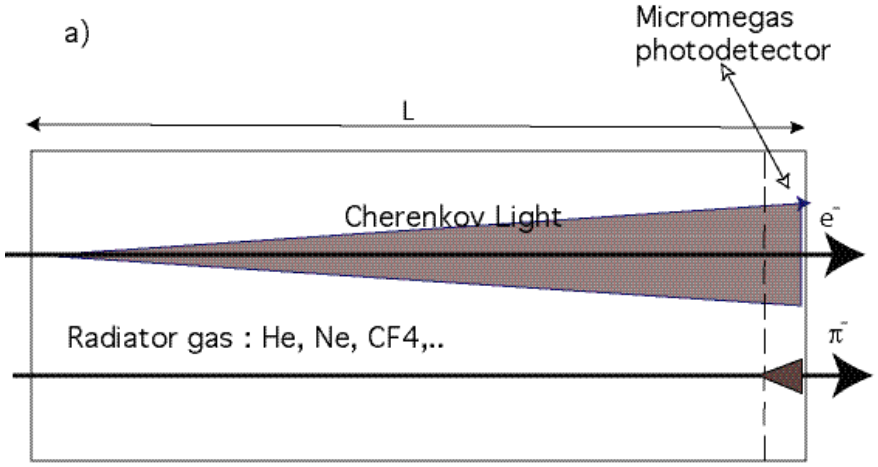
A differential Hadron Blind (HBD-Pion blind) Detector

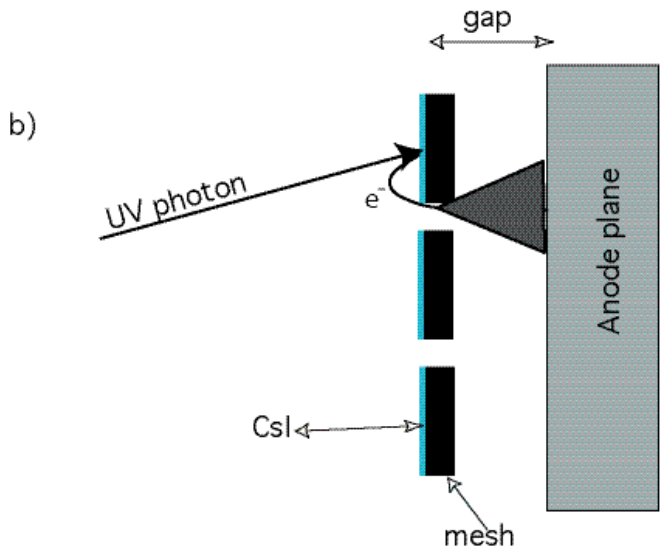
On line Kaon tagging at 800Mhz

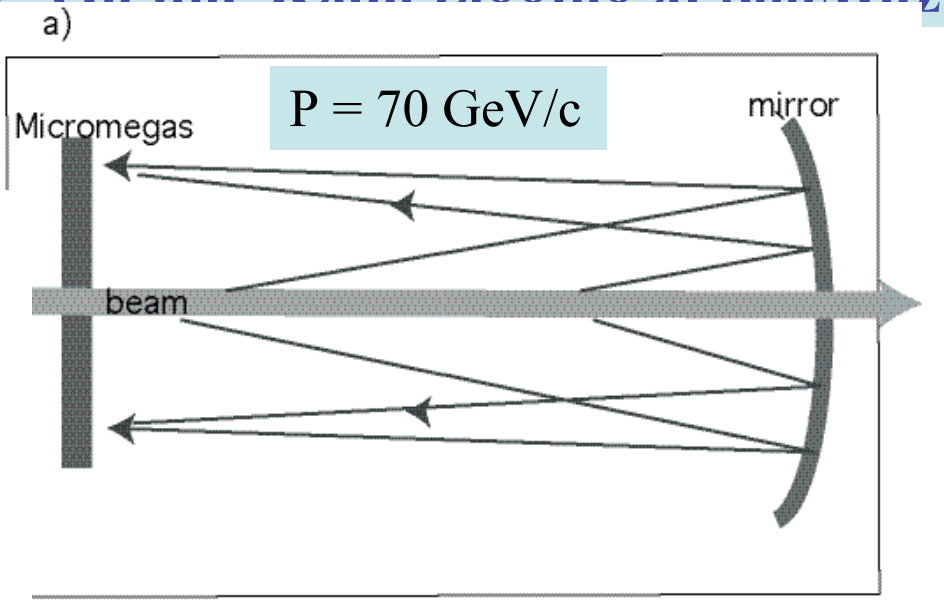
Principle of HBD

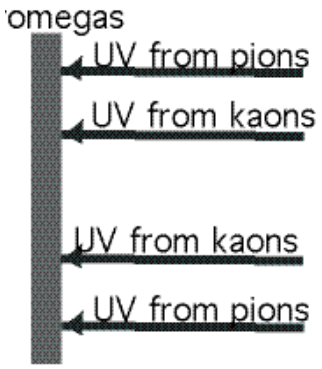
I. Giomataris,G. Charpak, NIM A310(1991)589

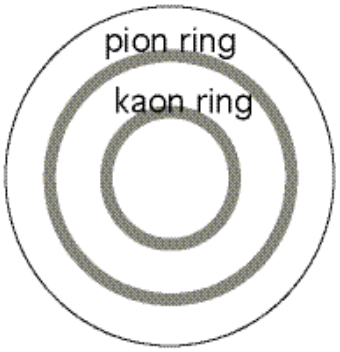
Micromegas ideal photodetector











Radiator length 100 cm, n-1 = 1.39×10^{-4}

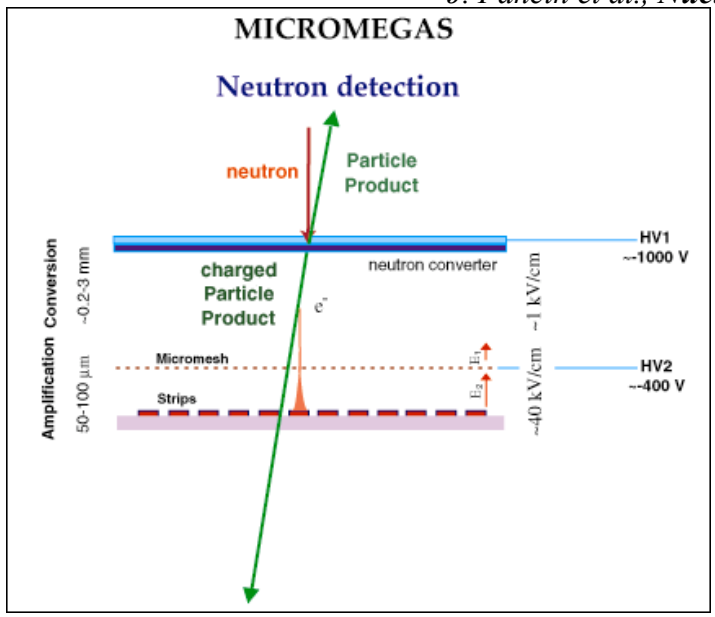
Rring = 24 mm, P(CF4)=280 mbars

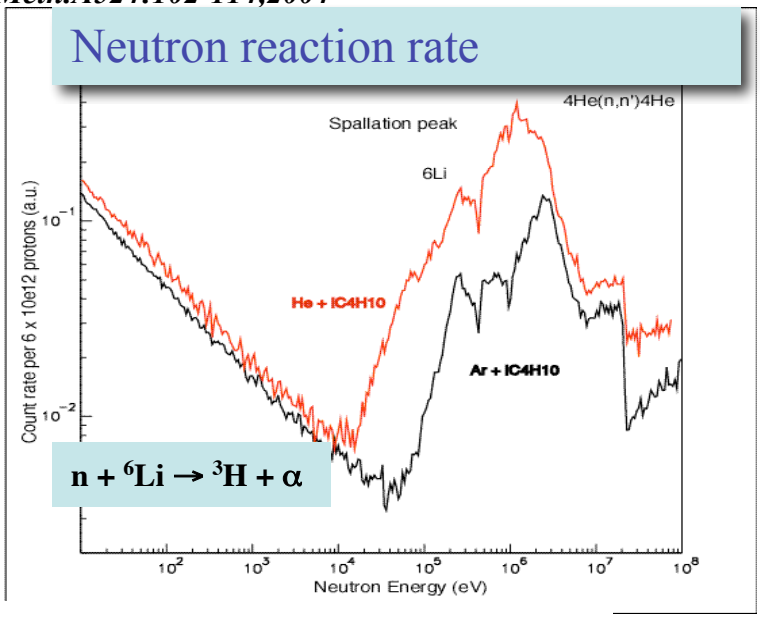
Neutron beam profiler for n-TOF

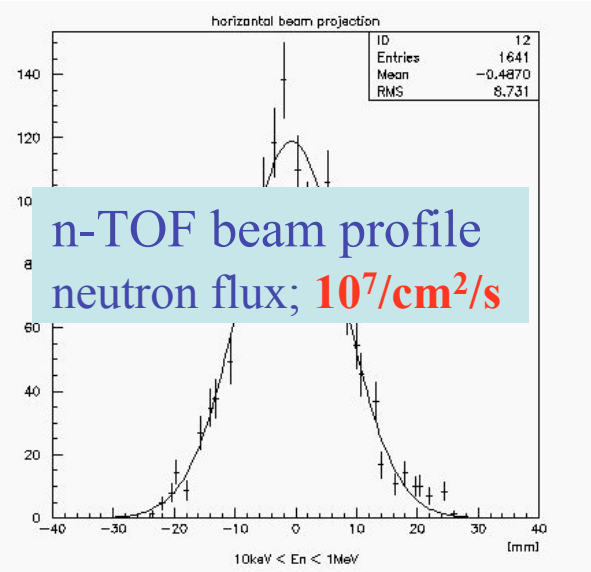
Trigered several high-rate neutron projects

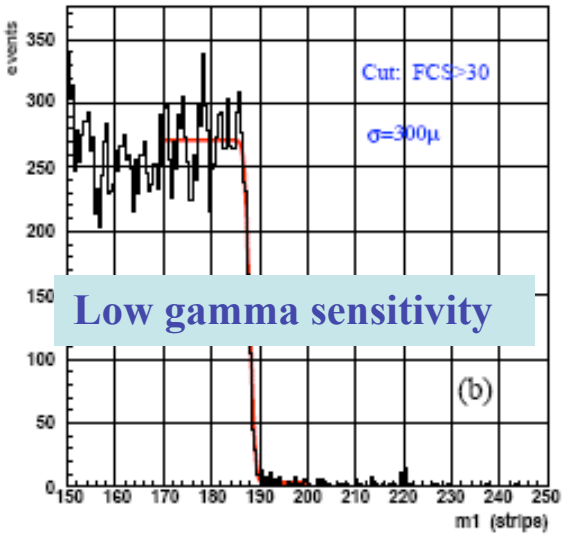
S. Andriamonje et al., ***Nucl.Instrum.Meth.A481:120-129,2002***

J. Pancin et al., ***Nucl.Instrum.Meth.A524:102-114,2004***





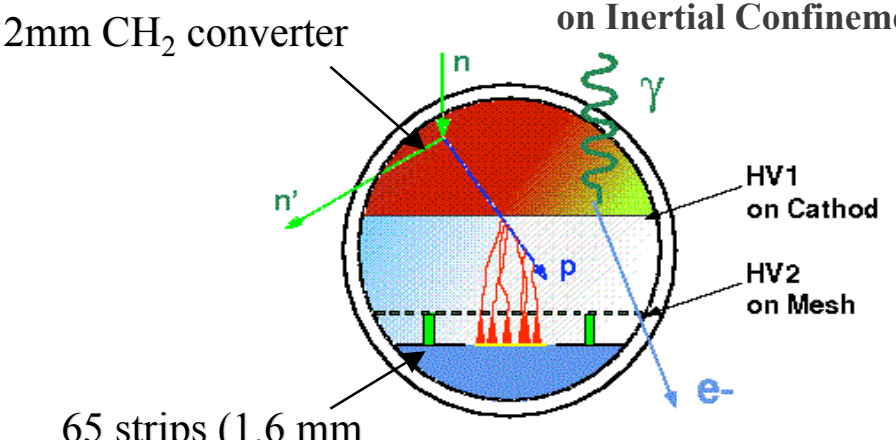




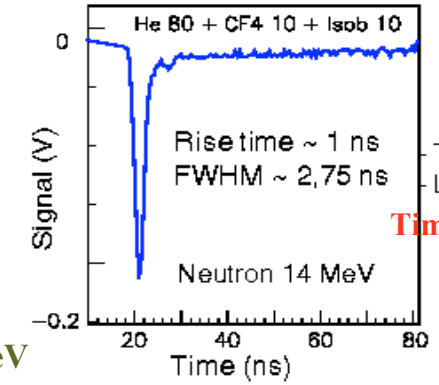
Micromégas Concept for Laser MégaJoule and ICF Facilities

M. Houry et al., Nucl. Instrum. Methods A 557 (2006) 648.

The γ insensitivity of Micromégas applied to neutron spectroscopy on Inertial Confinement Fusion experiments



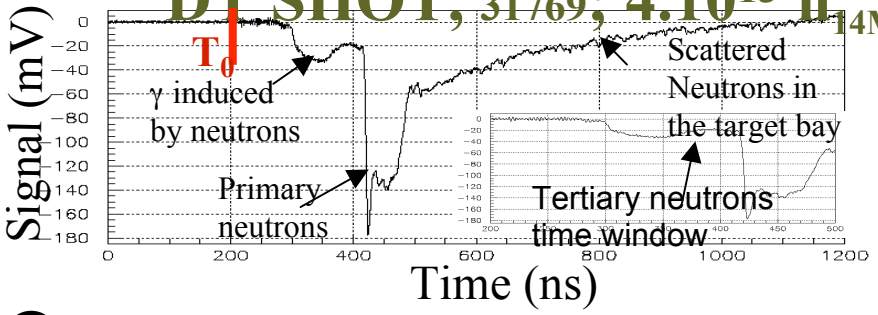
Neutron measurement by TOF in time windows of ~ 100 ns
-> Fast pulses



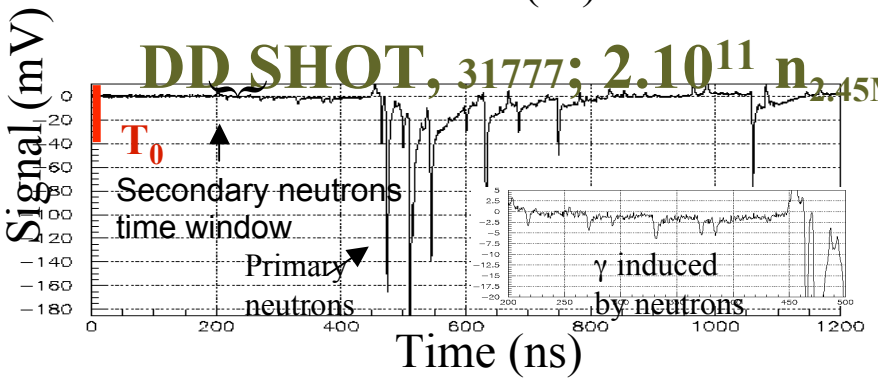
Time of flight : δE/E~1%
Low pile-up

Time response < 500 ps

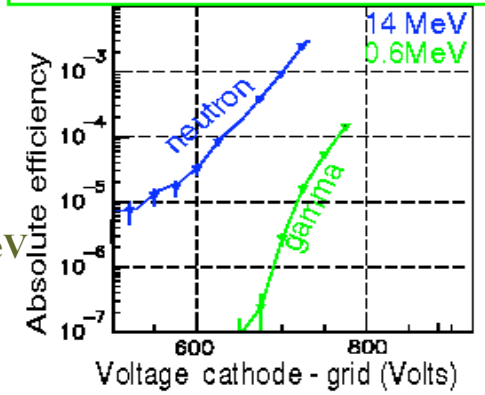
DT SHOT, 31769; 4.10^{13} n_{14MeV}



DD SHOT, 31777; 2.10^{11} $n_{2,45MeV}$



Neutron measurement in a High γ Background
-> n/γ discrimination

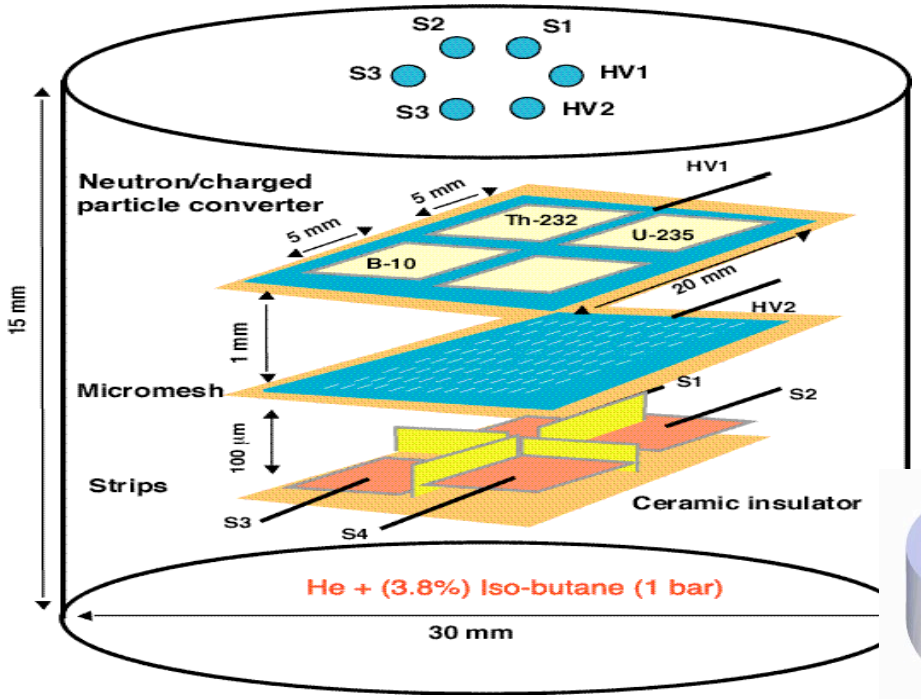


Efficiency Ratio

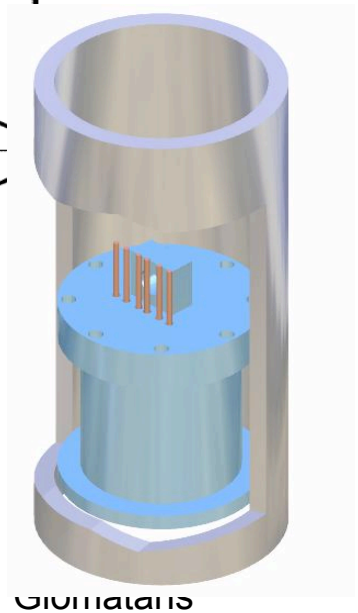
-> 10^3

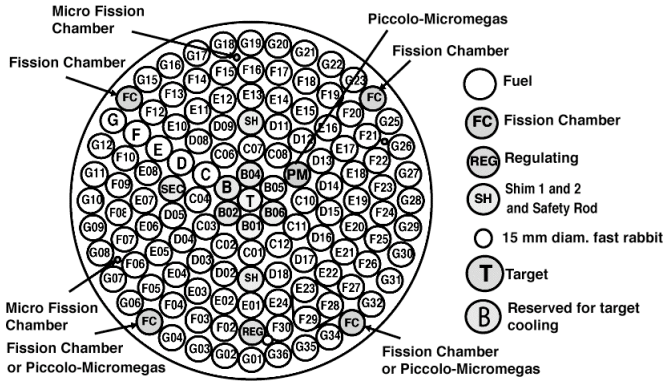
Piccolo Micromegas

Nuclear reactor in-core neutron measurement



Successfully tested at the CELINA 14 MeV neutron source facility at CEA-Cadarache



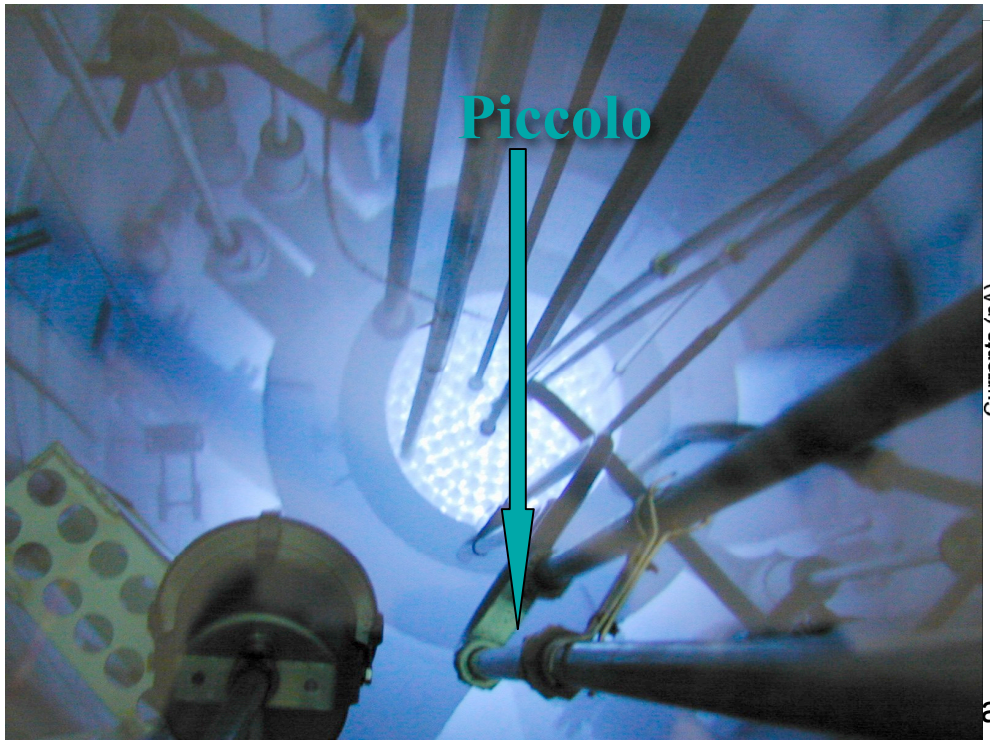


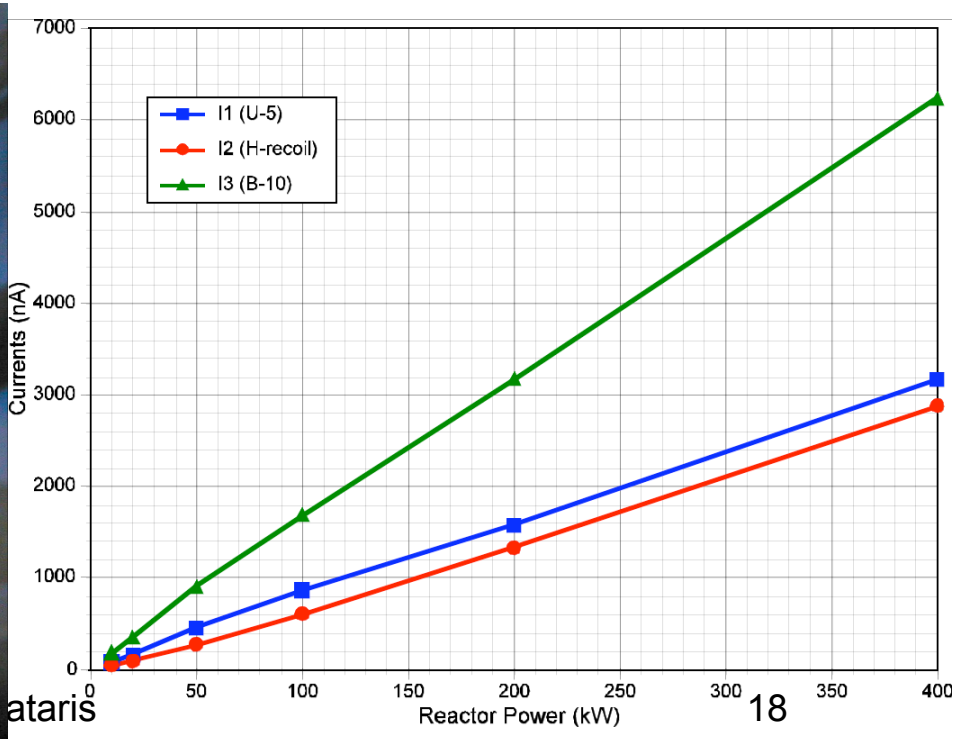
Challenges

- Very small Micromegas
- Seal detector
- High radiation resistance
- High temperature
- Large dynamic range

Two week operation in the core of nuclear reactor (Casacia - Italy- ADS project)

- No obvious aging effect (2 weeks operation)
- Detector response linear with power
- Space charge effect observed in drift space





Conclusions

- High radiation resistance of the detector
- Several issues for operation in high-rate hadron beams
- Micromegas successfully used in several experiments
- Ideal beam detector
- Stable operation in the core of nuclear reactor
- A novel differential HBD is proposed