SiPM + Scintilliating fibers for the AMADEUS experiment trigger

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati

Oton Vázquez Doce
LNF - INFN

I3HP-FP7 Silicon Multiplier Workshop
GSI - 6, October, 2011

SiPM + Scintilliating fiber: what for?

AMADEUS EXPERIMENT

Experimental timeline at DAΦNE

past

DEAR kaonic hydrogen

KLOE CP violation

FINUDA hypernuclei

present

SIDDHARTA kaonic atoms

KLOE2

proposal for the future

(KLOE2+) **SIDDHARTA2***

AMADEUS* kaonic nuclei

AMADEUS: the main program

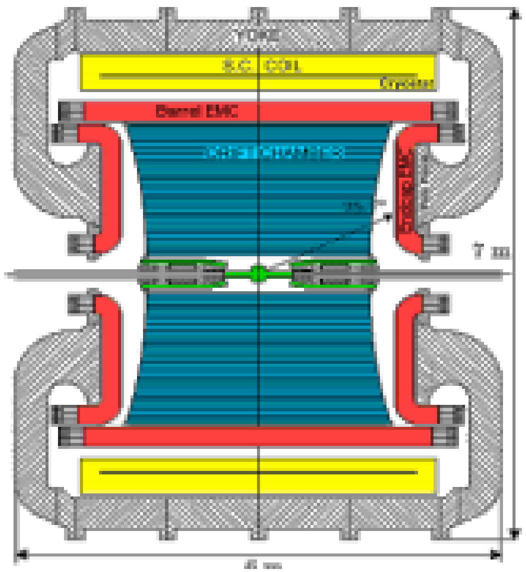
- Search for fundamental kaonic nuclear systems in **formation** and **decay** processes:

kaonic dibaryon states:
ppK^- and pnK^-
produced by interacting K^- at rest
in a **^3He** gaseous target

kaonic 3-baryon states:
$ppnK^-$ and $pnnK^-$
produced by intreacting K^- at rest
in a **^4He** gaseous target

The KLOE detector

- for CPT symmetry and QM tests, hadronic physics and more.



Almost full acceptancy 4π:

*** DRIFT CHAMBER**

- 90% He
- momentum resolution ~ 0.4%

*** ELECTROMANETIC CALORIMETER**

- $\sigma_E/E = 5.7\%/\sqrt{E}$ (GeV)

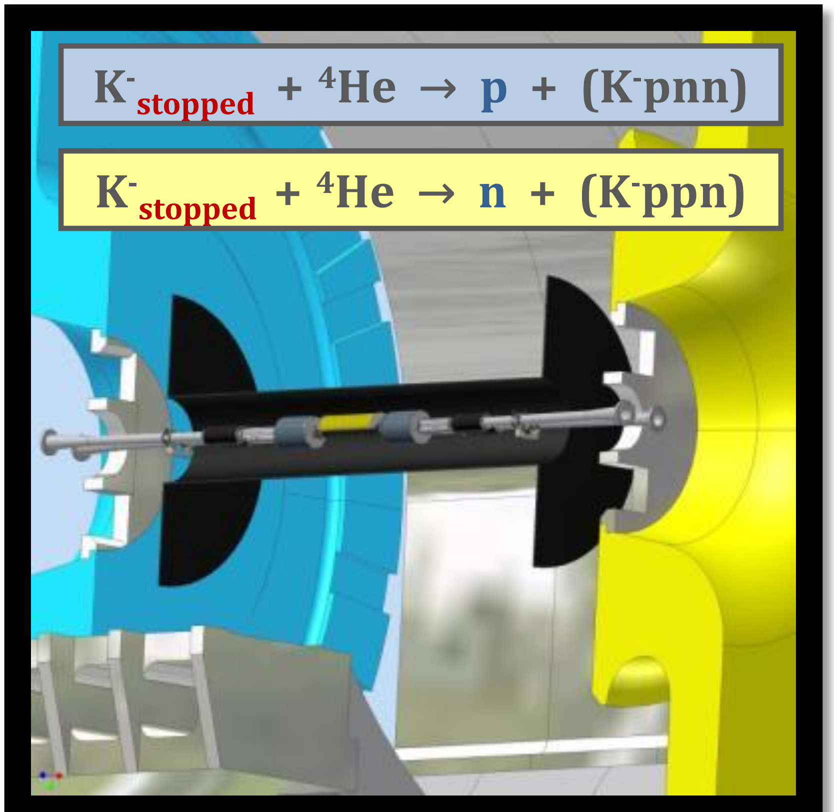
KLOE experiment @DAΦNE

- Kaon physics: $|V_{us}|$ and CKM unitarity, CP and CPT violation, rare decays, χPT tests, quantum mechanics tests
- φ radiative decays: pseudoscalar and scalar mesons
- Hadron production in γγ collision
- Had cross-section via ISR $[e^+e^- \rightarrow \gamma\,(\pi^+\pi^-)]$ hadronic corrections to $(g\text{-}2)_\mu$

Status of KLOE2. arXiv:1001.3591, G. Venanzoni for the KLOE2 collaboration

From KLOE to AMADEUS

- Full acceptance and high precision measurements will be made by **implementing the KLOE detector with an inner AMADEUS setup**



(50 cm. gap in KLOE DC around the beam pipe)

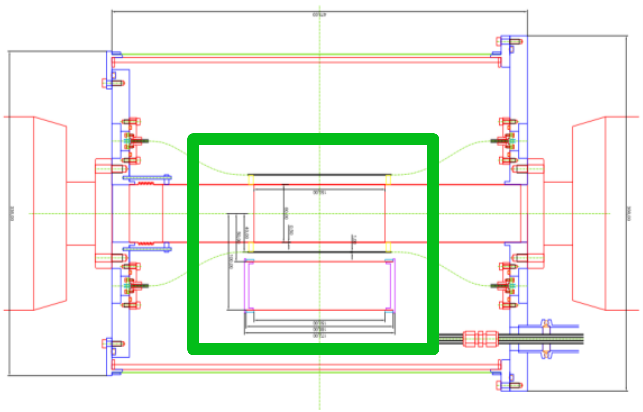
Setup for AMADEUSwithin KLOE:

- Modification of the **beam pipe** of KLOE-2 in order to allow access
- **Target** (A gaseous He target for a first phase of study)
- **Trigger** (1 or 2 layers of ScFi surrounding the interaction point)
- **Inner tracker** (eventually, a first tracking stage before the DC)

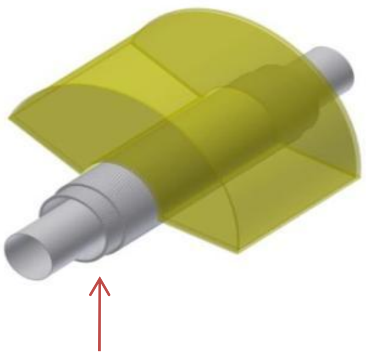
The implementation of the AMADEUS dedicated setup around the beam pipe will modify the topology of the events, stopping the K- in a target inner to the DC.

Target cell + interaction region

- Central region made of **CARBON FIBER**:
  - -Vacuum chamber
  - -External part of cryostate and target walls
  - -**Aluminium** for the peripheral part

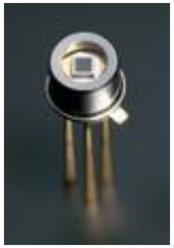


- Low-mass cryogenic gas target cell:
  - T = 10 K, P = 1.0 bar
  - Rin = 5 cm, Rout = 15 cm
  - Length = 20 cm,



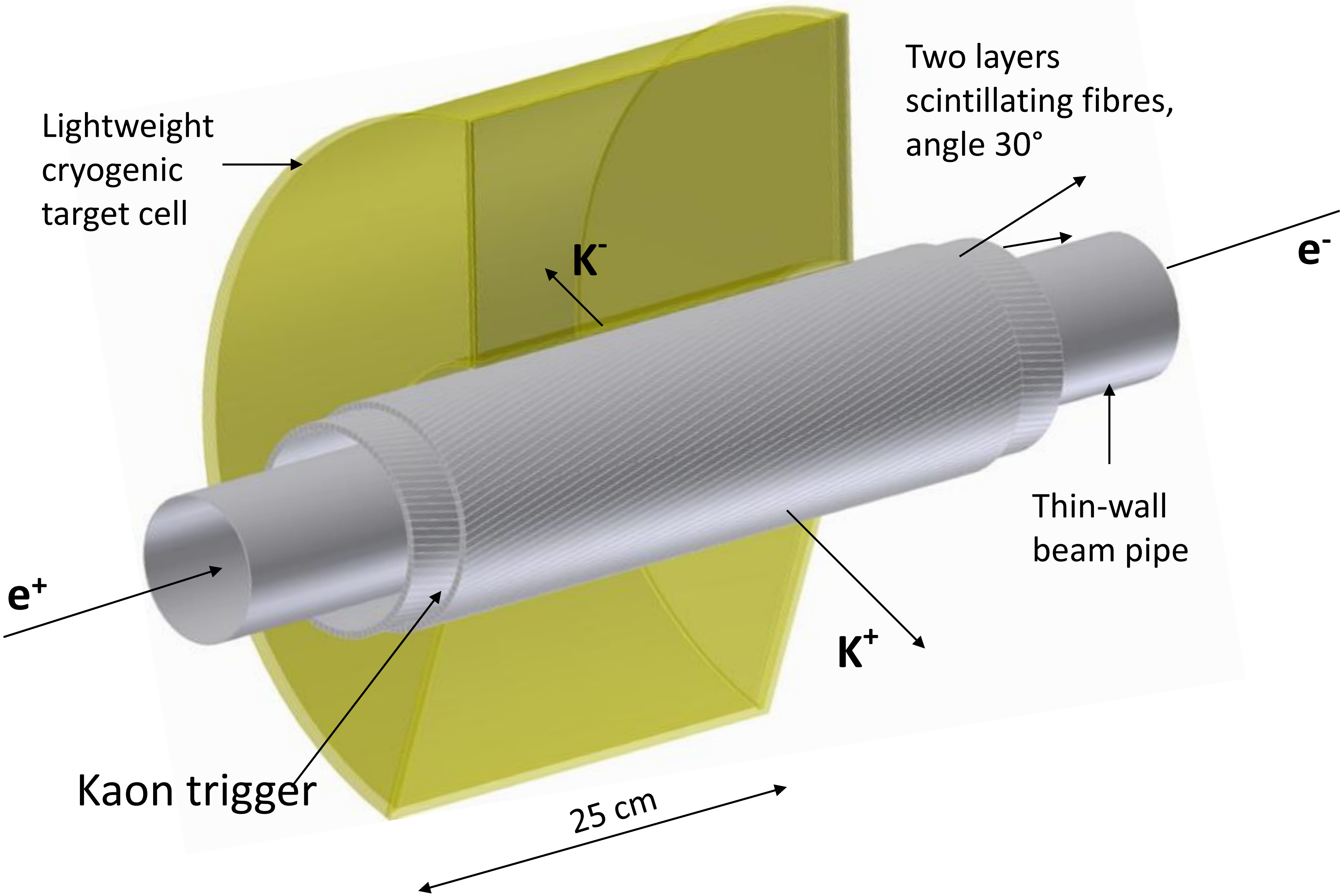
Trigger system

-Single or double layer of ScFi surrounding the interaction point
- Readout made by silicon photomultipliers:
  - Ideal for ScFi couplin and high granularity detector
  - Time resolution below 1 ns
  - -**Insensitive to strong magnetic fields**
  - **no cooling needed**
  - High gain ($>10^6$) and quantum efficiency



Hamamatsu S10362-11-050U,
efective area $1mm^2$,,400 pixel
wlorking biases ~ 70 V .

AMADEUS: stopped K-



Trigger system: why?

- KLOE data taking currently based on “tagging” in order to collect neutral and charged kaons, and e+ e- events as well
- The characteristics of the events will be changed by introducing the target, with the Kaons not likely entering in the DC

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Trigger system requirements

-sipm+trigger efficiency for hadrons (ADC)
-Time resolution for mips/kaon separation

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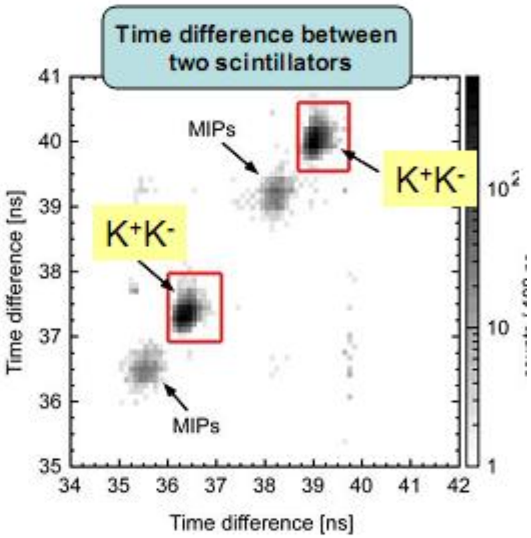
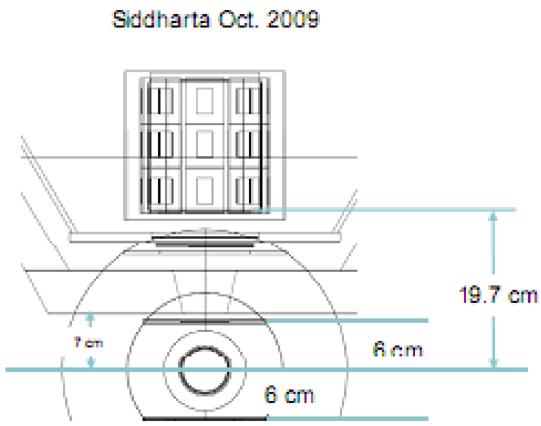
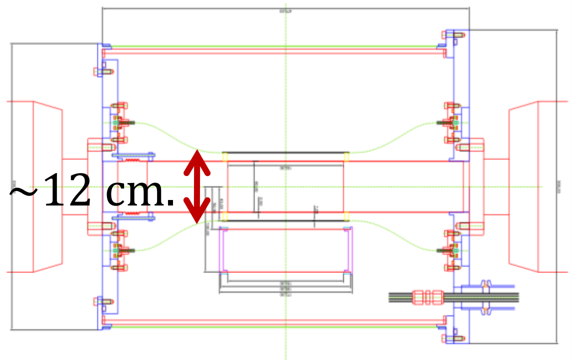


SIDDHARTA vs AMADEUS





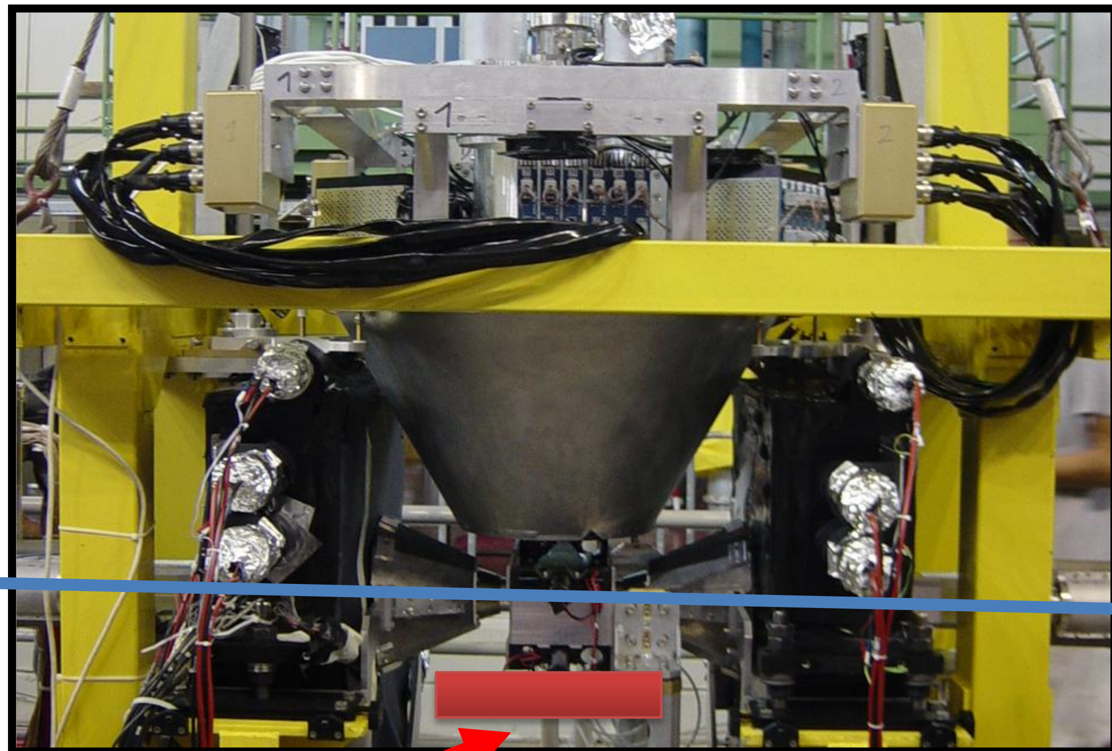
- Resolution needed for SIDDHARTA with a distance to the IP: **better than 1 ns**

The Past: Test @ DAΦNE

Siddharta experiment

Test @ DAΦNE
Siddharta experiment

SIDDHARTA setup

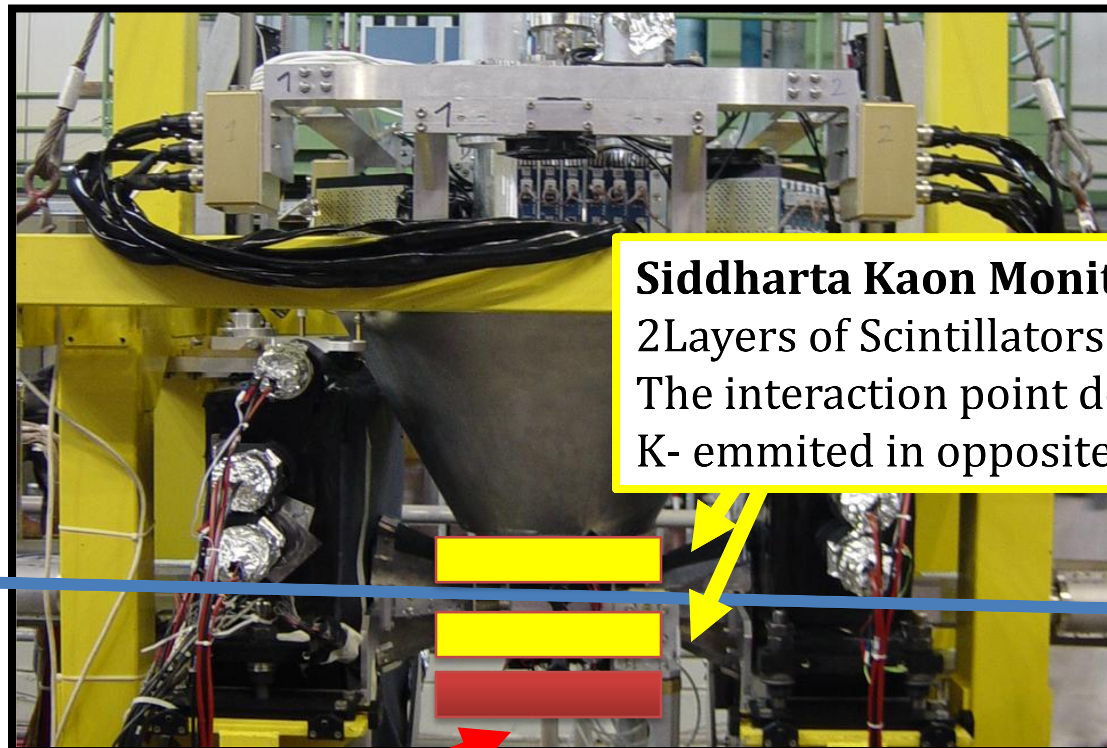


DAΦNE beam pipe

Our test setup

Test @ DAΦNE
Siddharta experiment

SIDDHARTA setup

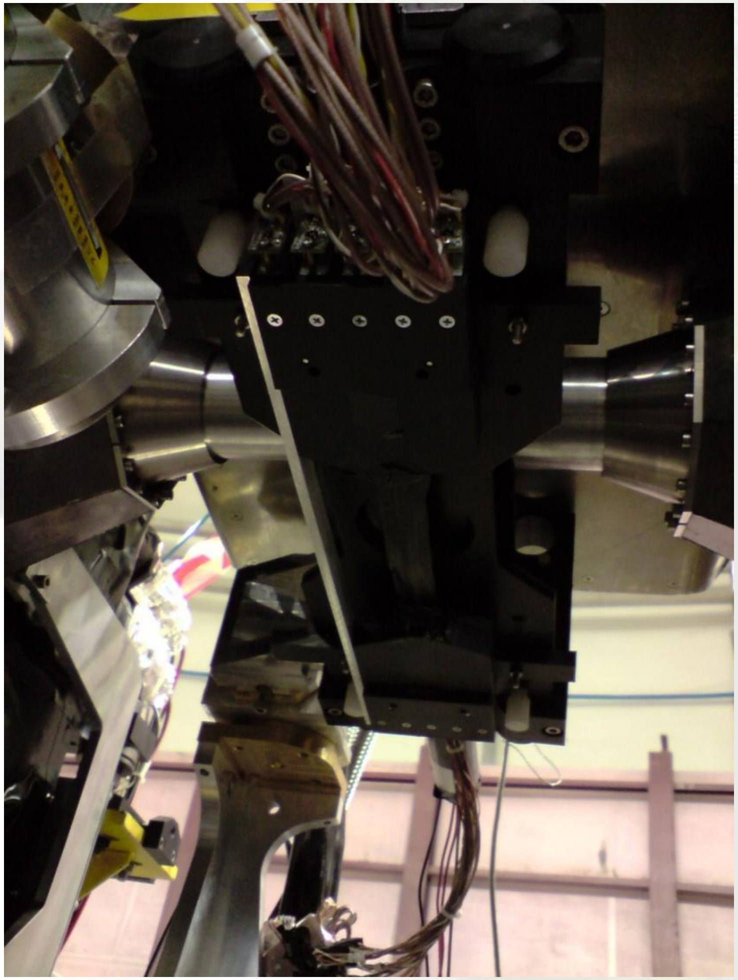


Siddharta Kaon Monitor
2Layers of Scintillators up&down
The interaction point detecting K+
K- emmited in opposite directions

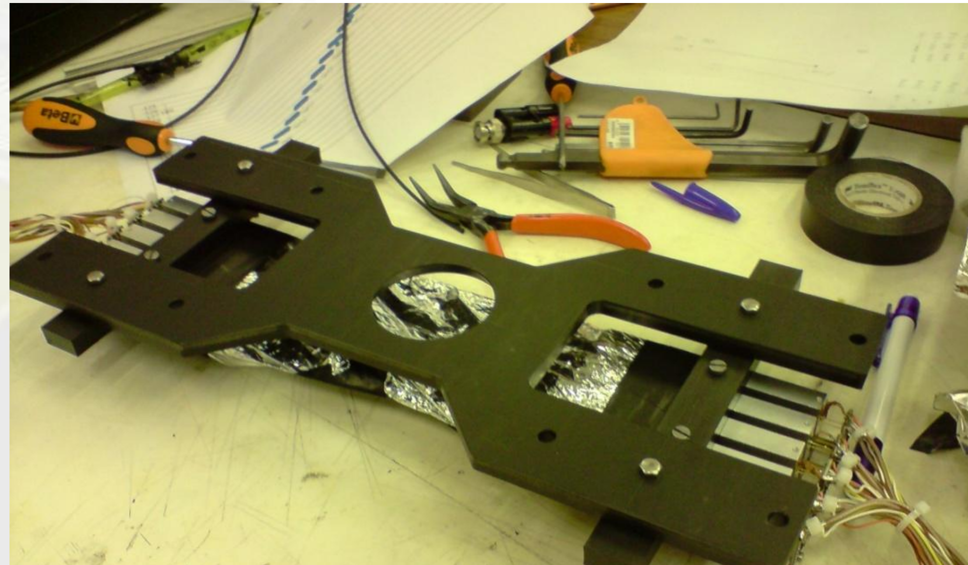
DAΦNE
beam pipe

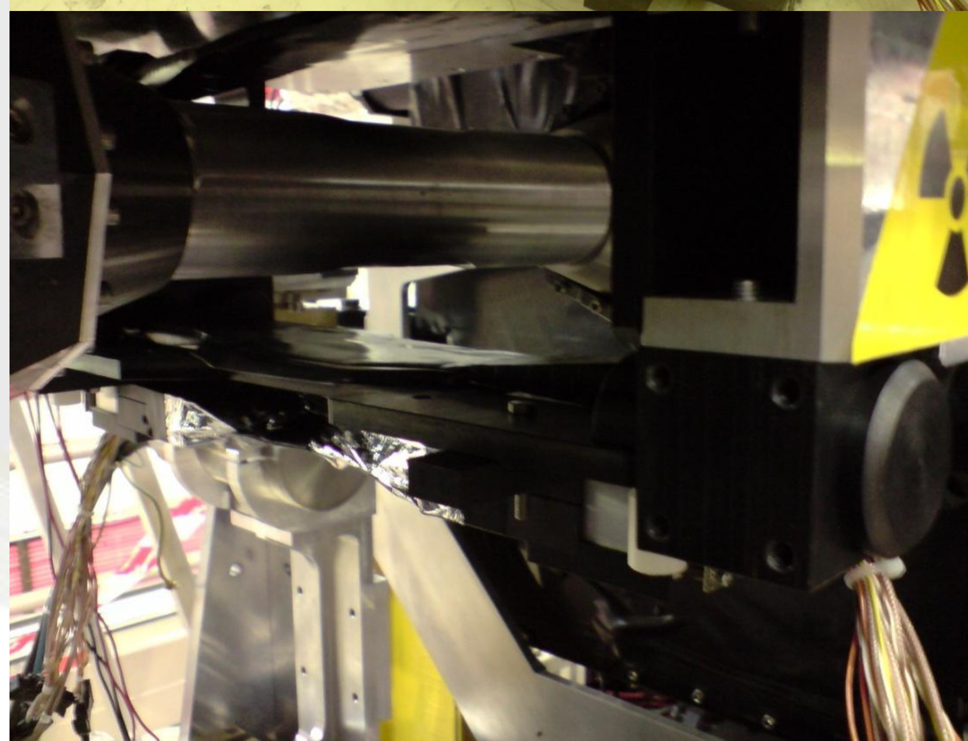
Our test setup

Results of tests on DAΦNE

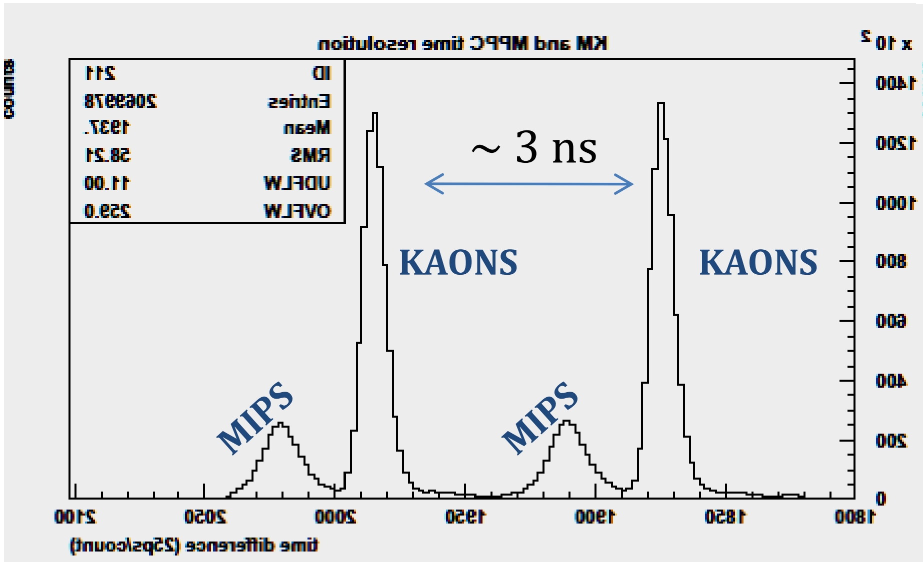


During last SIDDHARTA run



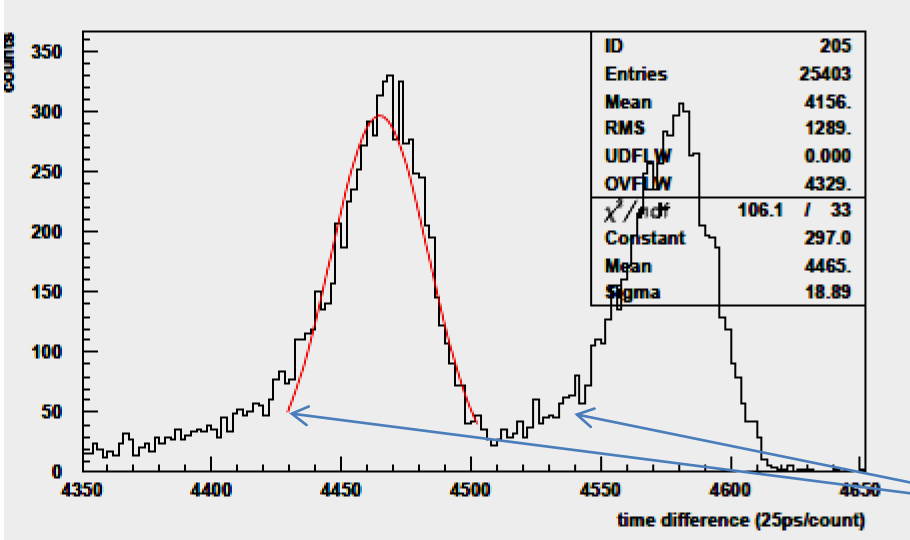


Results with Kaon Monitor



Kaon Monitor TDC (upper/lower coincidence)

- TDC working in Common Start (RF/2)
- Single peak resolution~ 100 ps
- MIP/K separation ~ 1 ns



MPPC tdc spectra

- TDC working in Common Stop (RF/4)

Achieved best single peak resolution around 500 ps

Missing MIPS

The present: New setup + electronics

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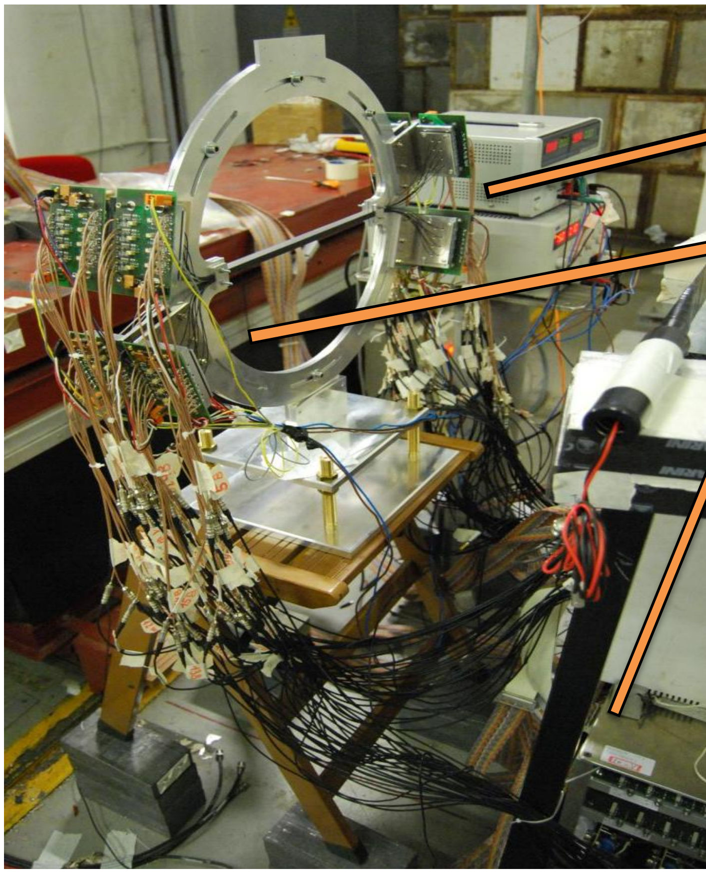
- test setup for SIPM+fiber coupling and reading electronics.

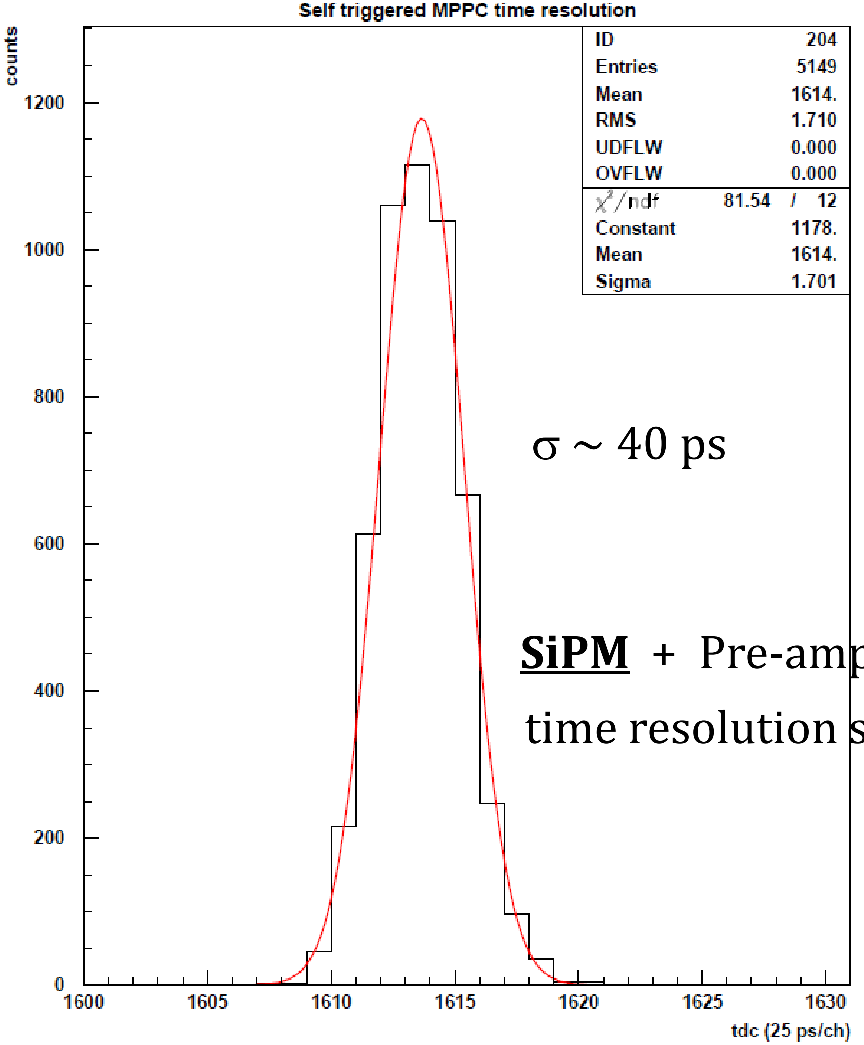


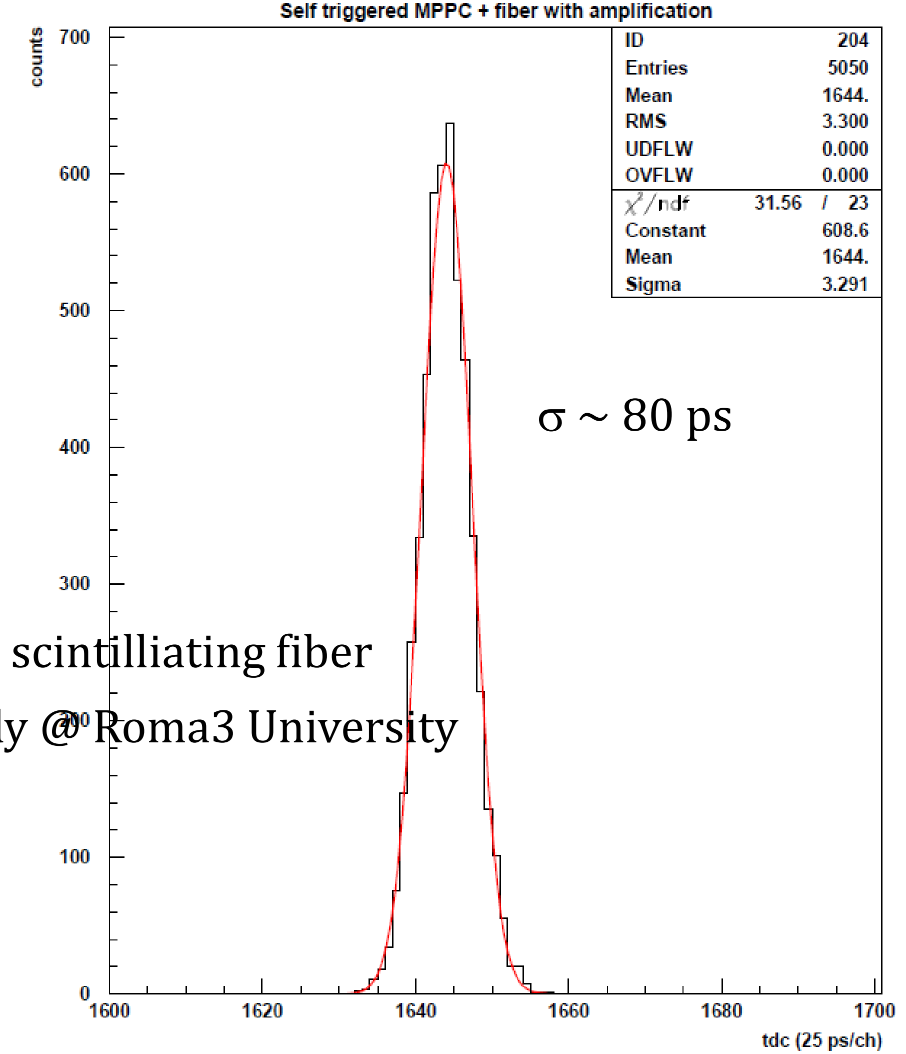
2-rings of double layer 16 fibres

64 fast pre-amplifiers (64x)

2 boards of 32 constant fraction discriminator with zero jitter

New electronics capabilites: time resolution





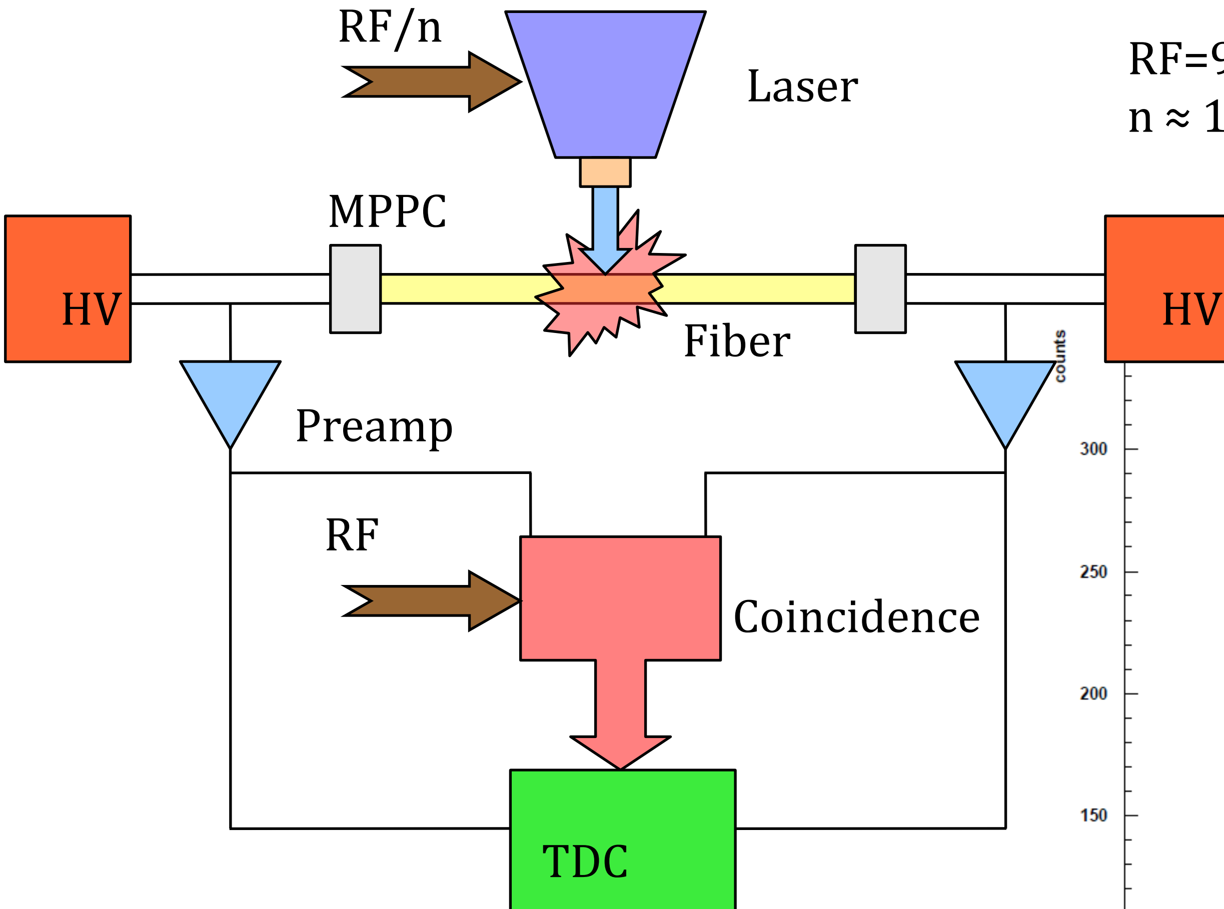
SiPM + Pre-amp + scintilliating fiber

time resolution study @ Roma3 University

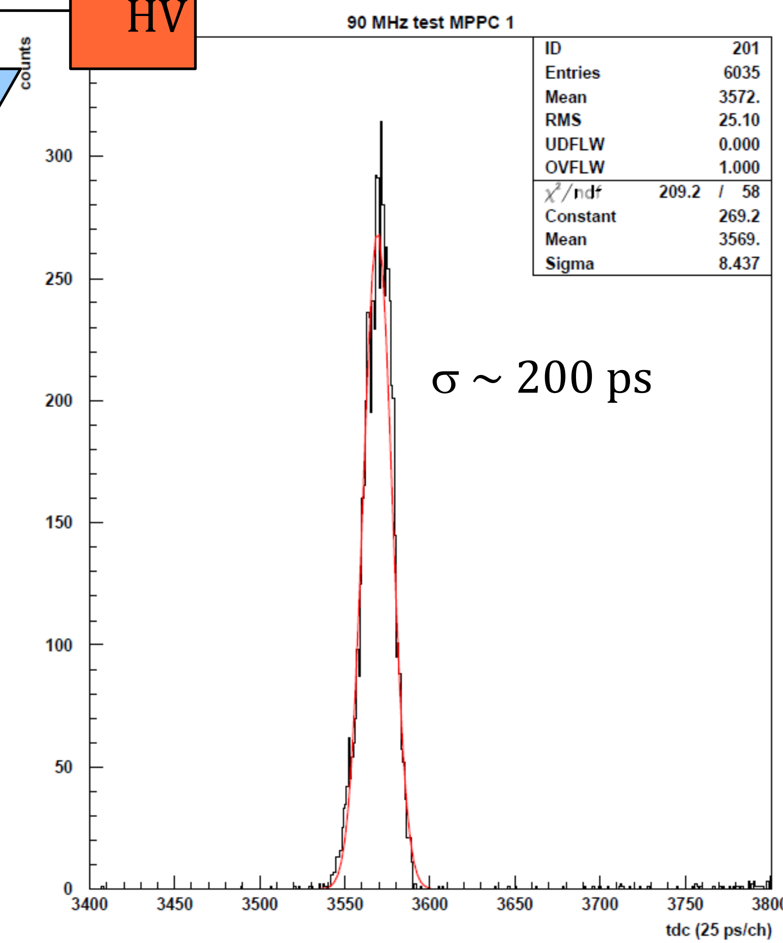
Direct laser on MPPC

MPPC + Sci-Fi

New electronics capabilites: time resolution

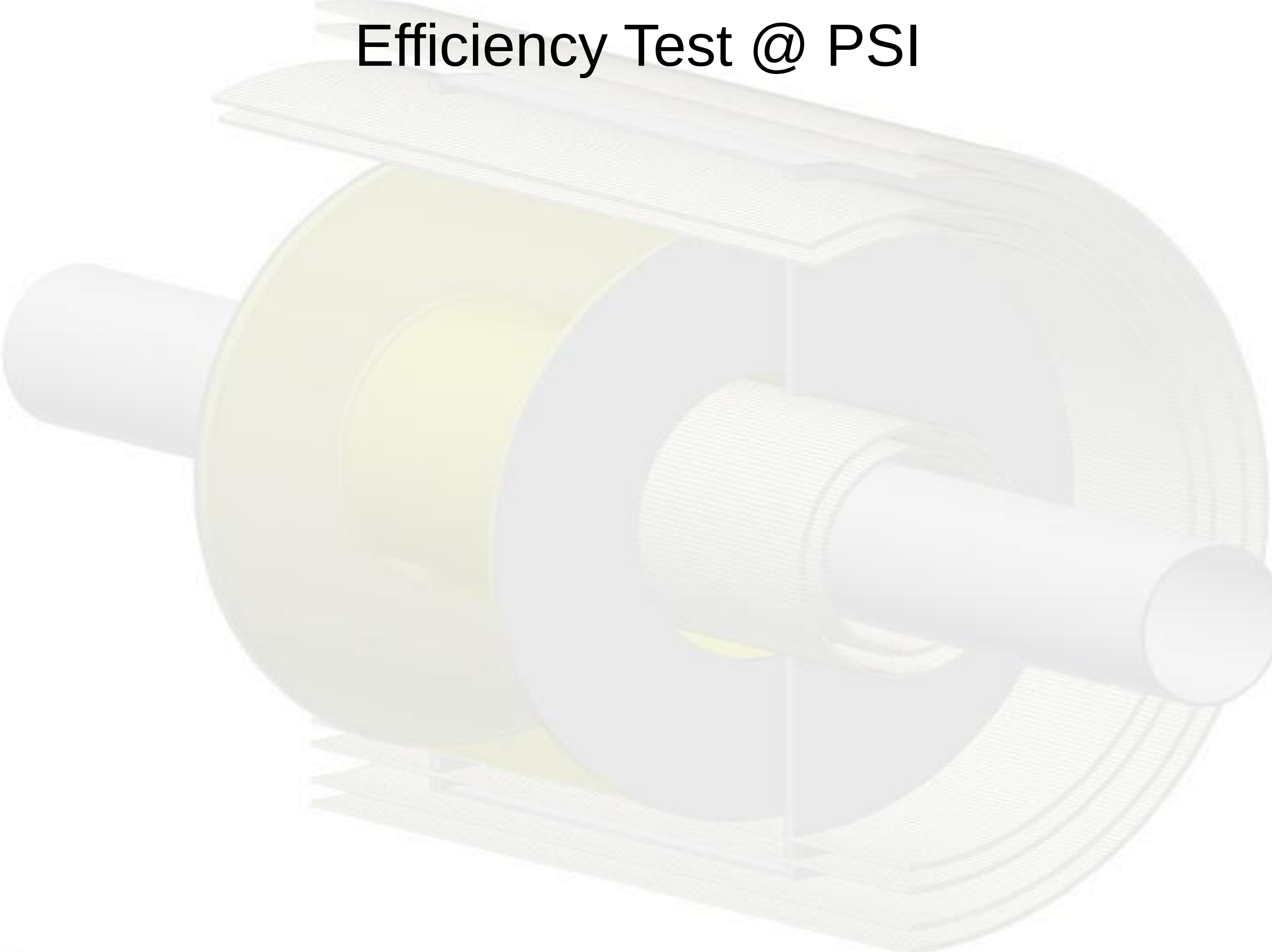


RF=90 MHz (≈ RF/4)
n ≈ 10000



No jitter from photon generation
(to be considered)

Efficiency Test @ PSI



Efficiency Test @ PSI

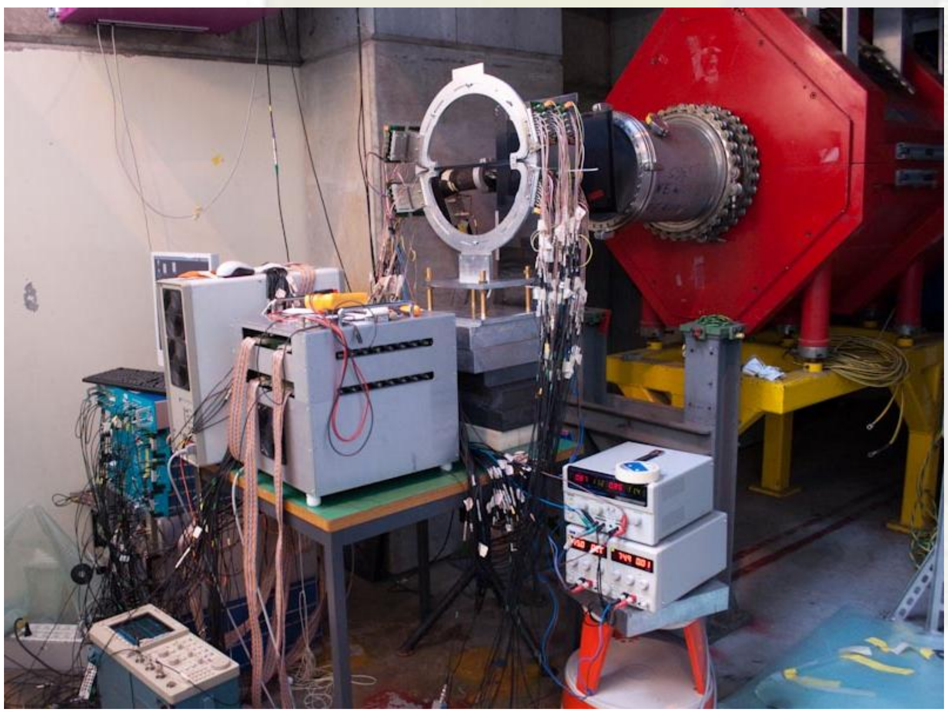
Test beam @ PSI πM1 beam

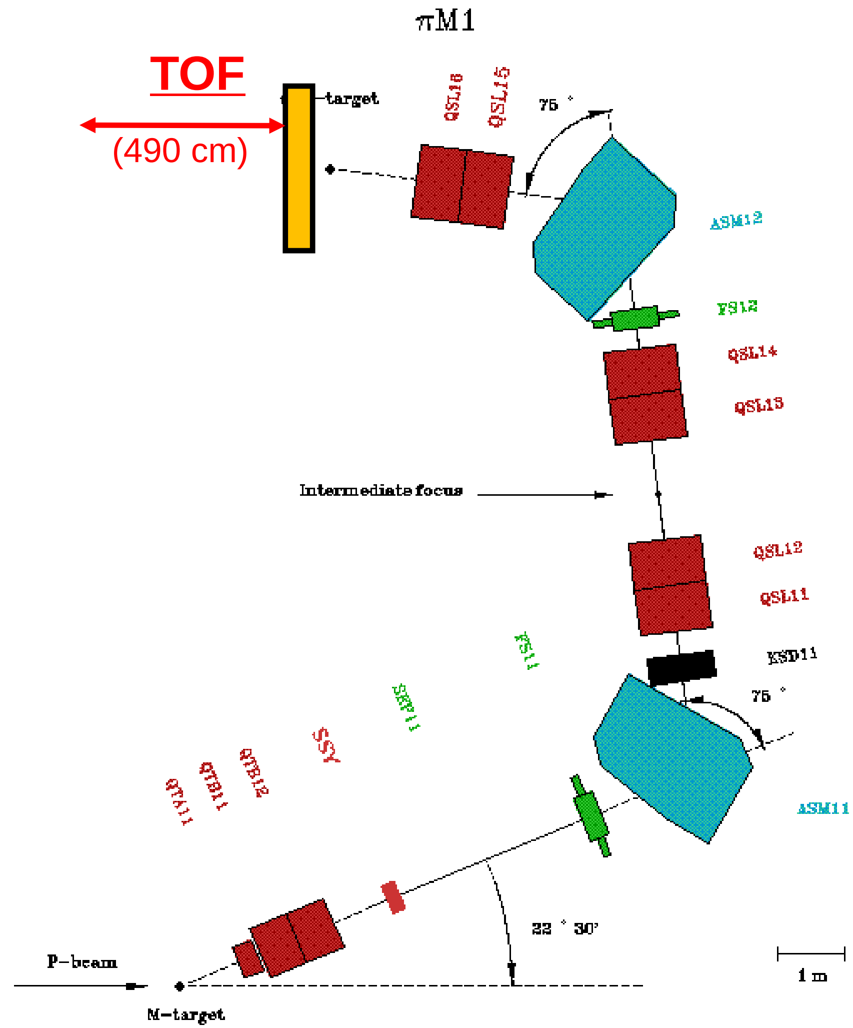
-continuous high-intensity secondary beam

10^7 π^-/s or 10^8 π^+/s a 170 MeV/c or 10^7 proton of 500 Mev for mA

Pions or proton sarrive in 1 ns-wide bunches every 20 ns.

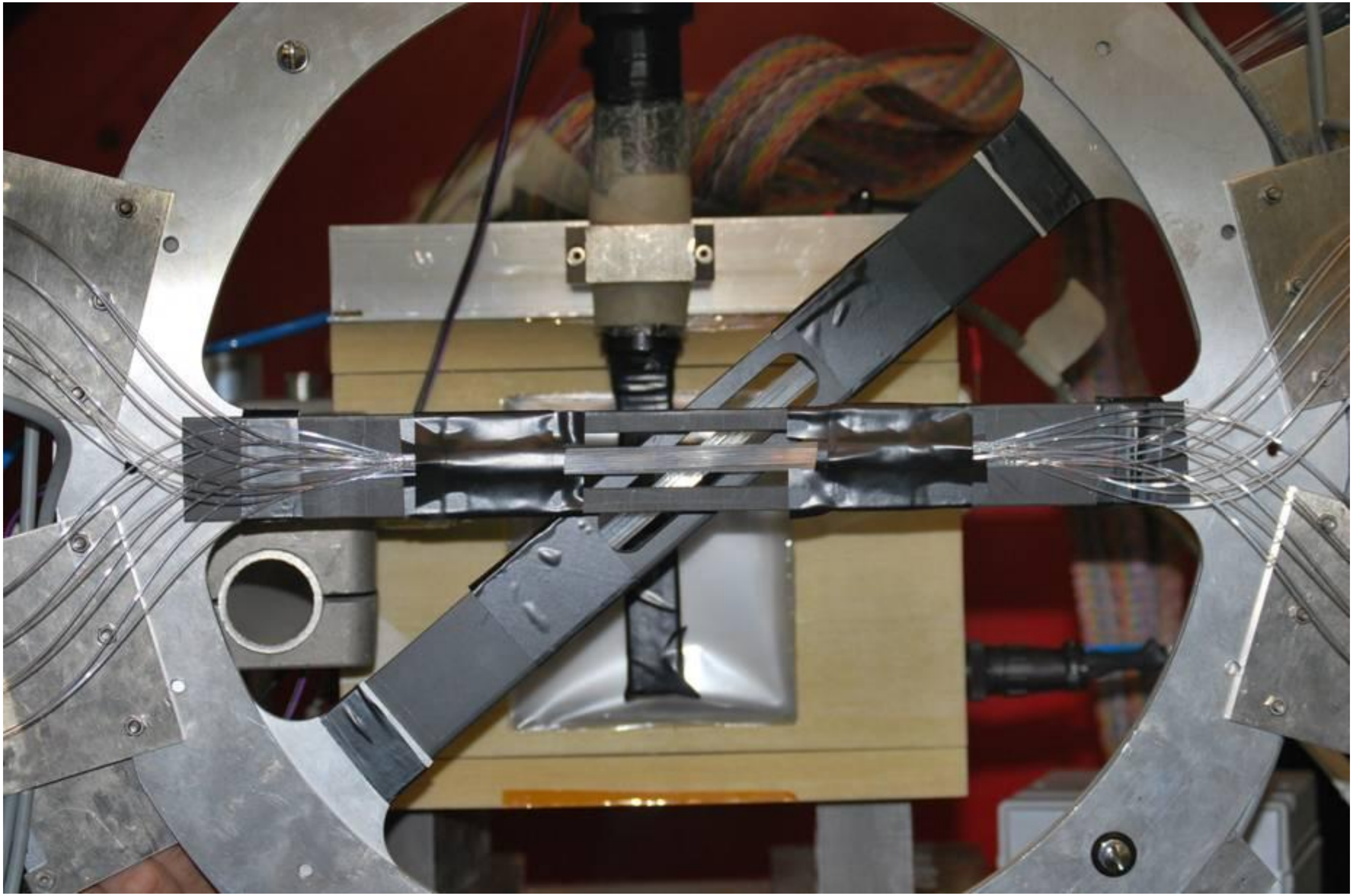
Spot size on target (FWHM): 15 x 10





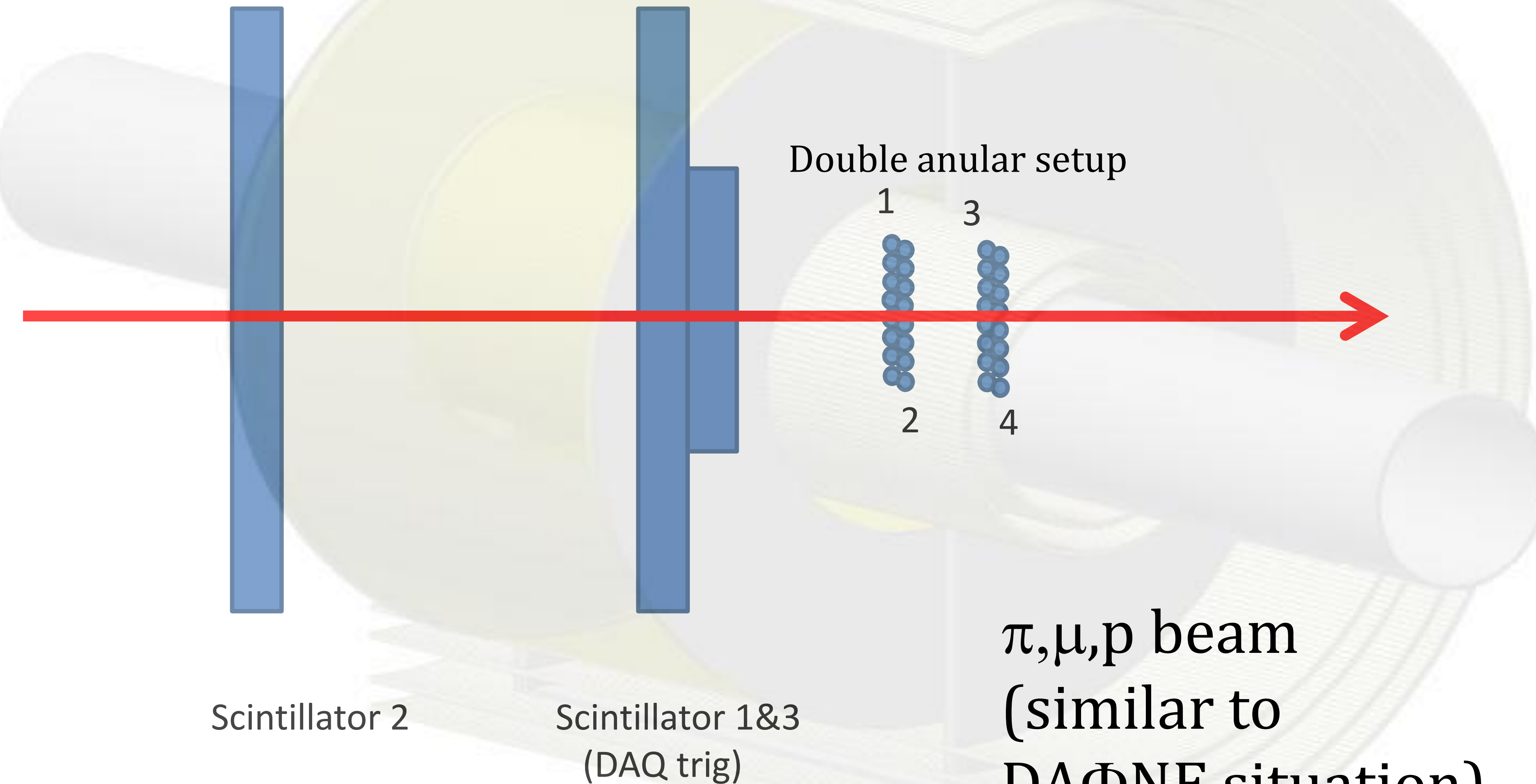
Beam RF -> 50 MHz
Proton beam at 170 MeV/c

Setup - detail



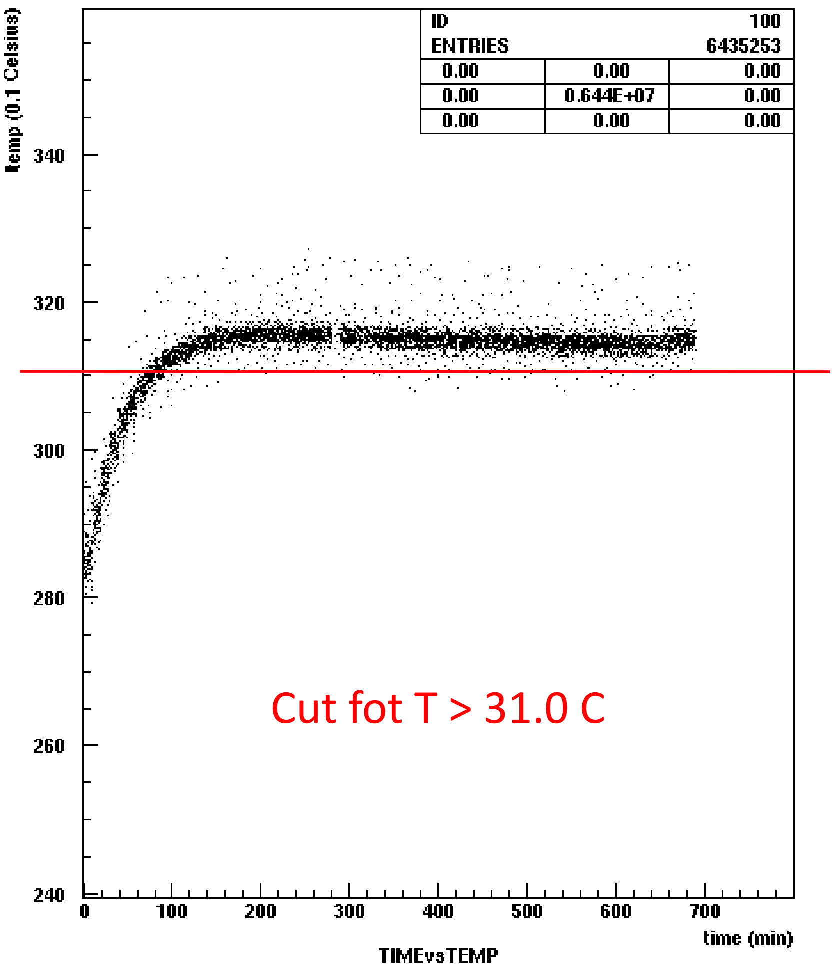
Tests on hadronic beam

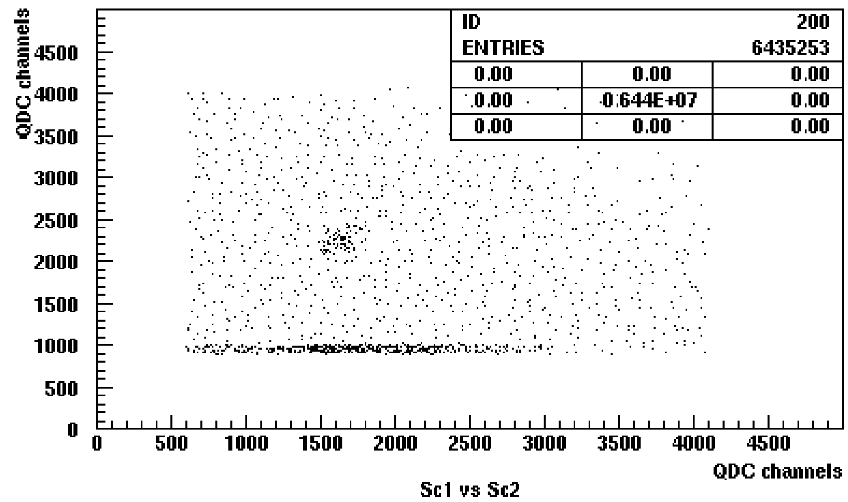
πM-1 beam at Paul Scherrer Institute (PSI, Zurich)

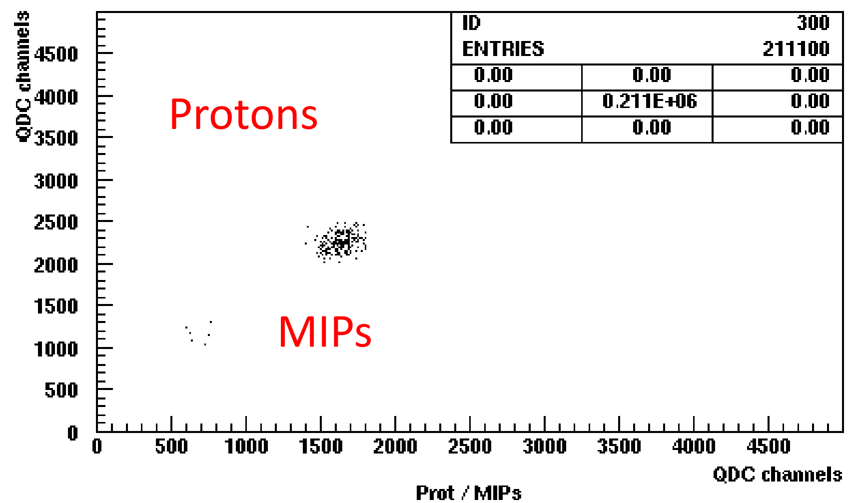


π,μ,p beam (similar to DAΦNE situation)

Tests on hadronic beam

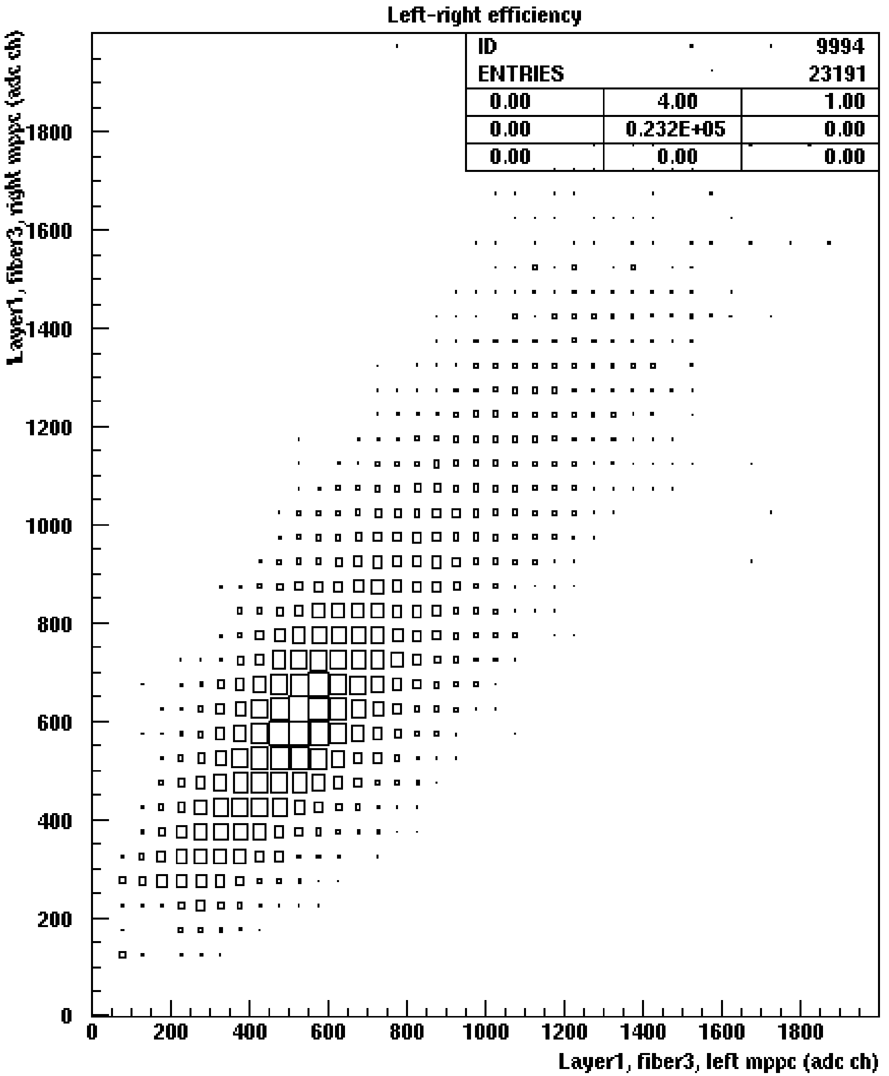




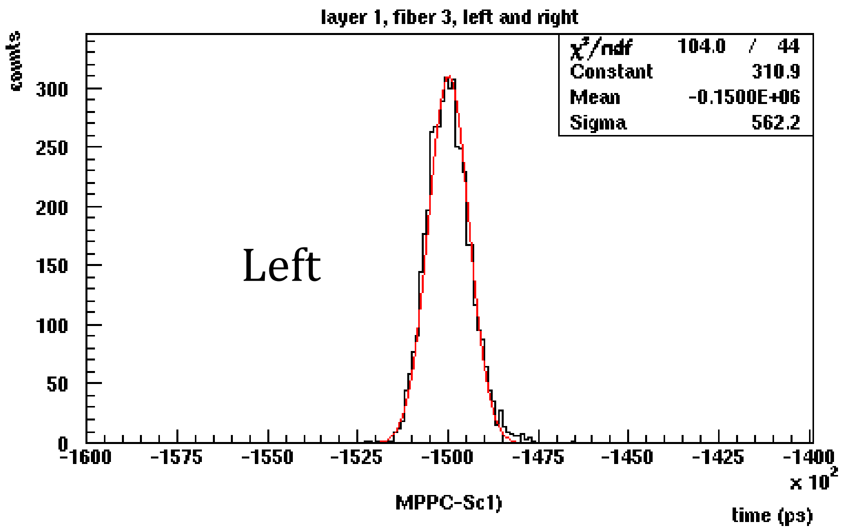


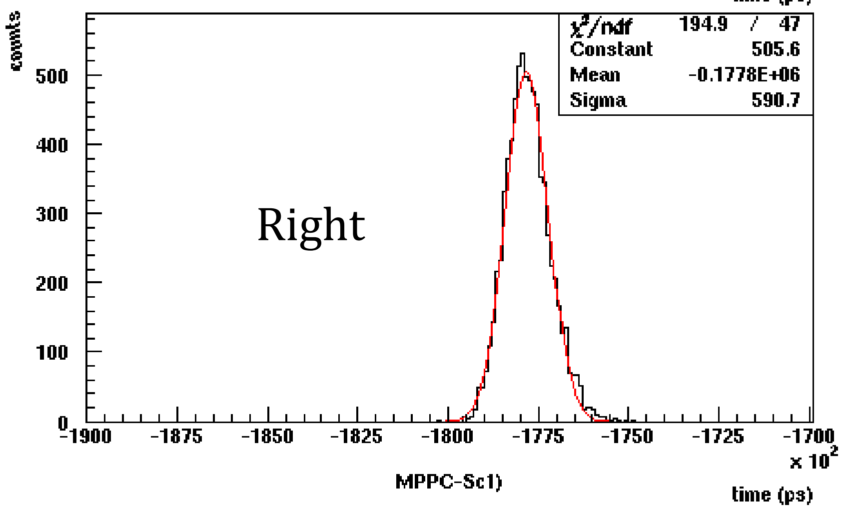
Common cuts for the analysis

Tests on hadronic beam



Perfect correlation and coupling

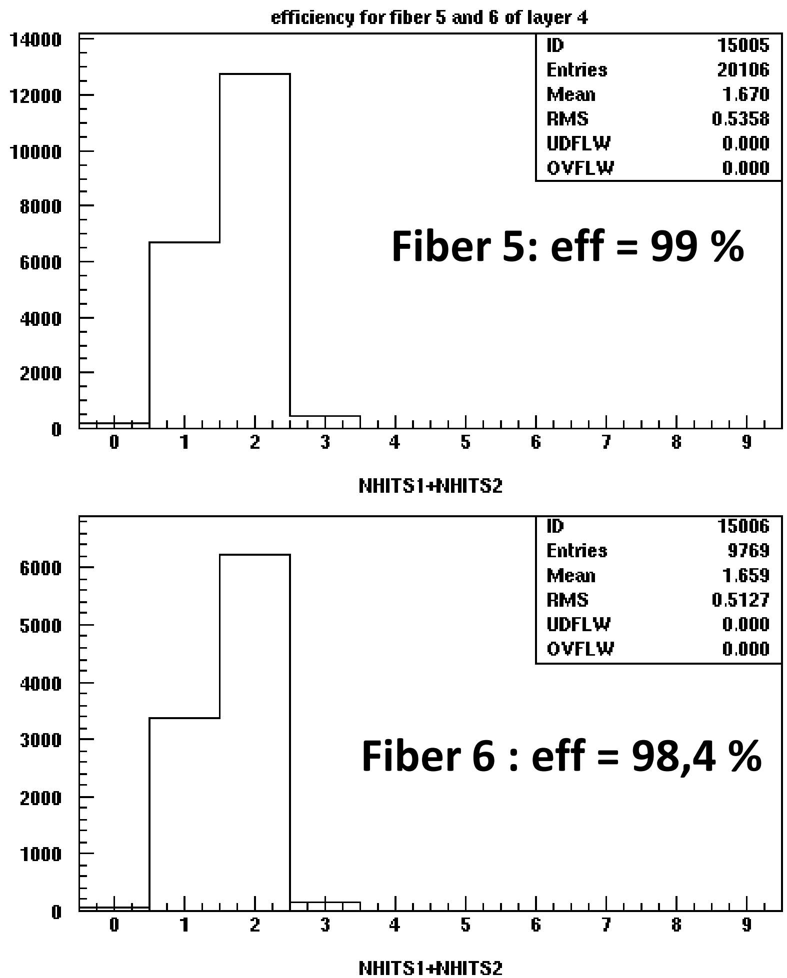




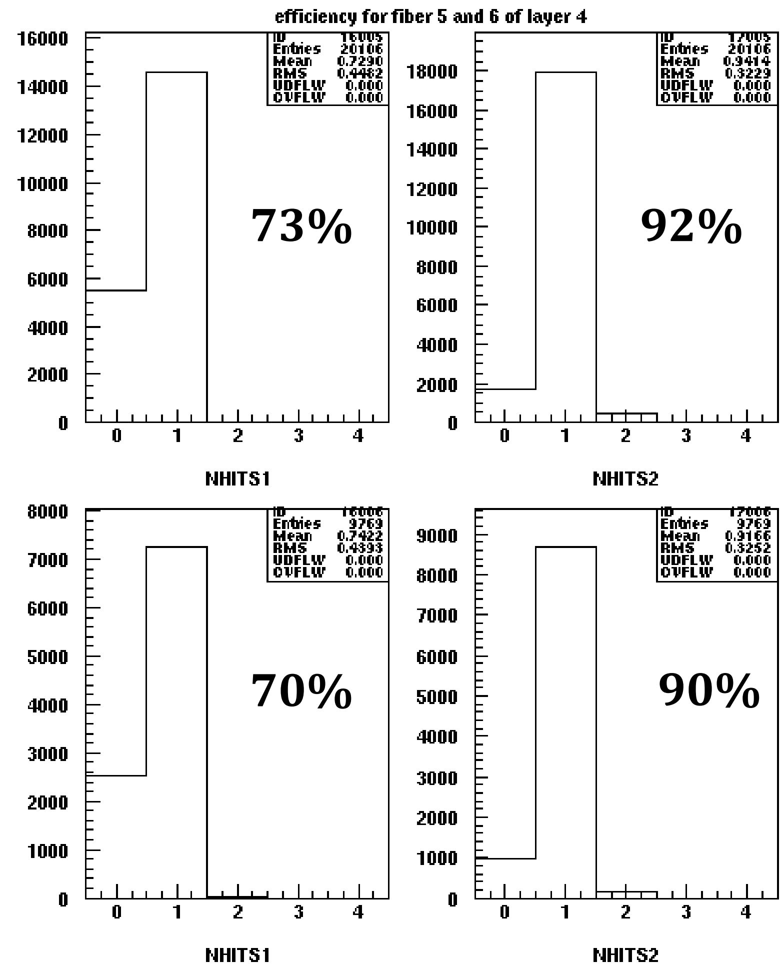
Sc1 is used as reference

Tests on hadronic beam: “relative” efficiency

Double layer efficiency

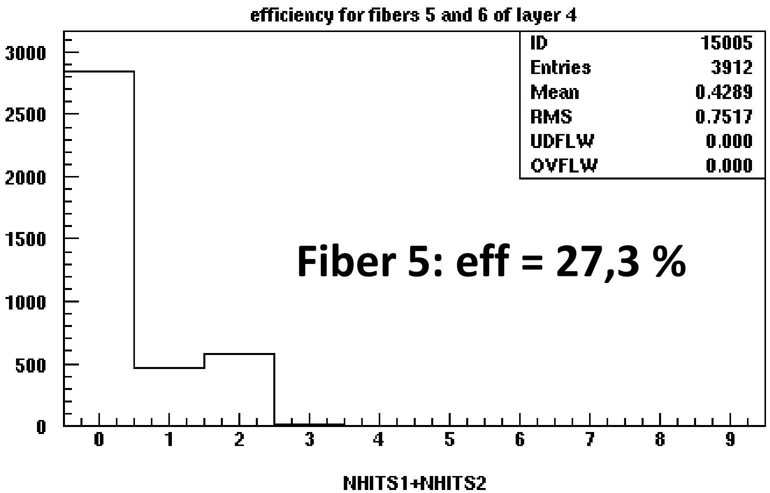


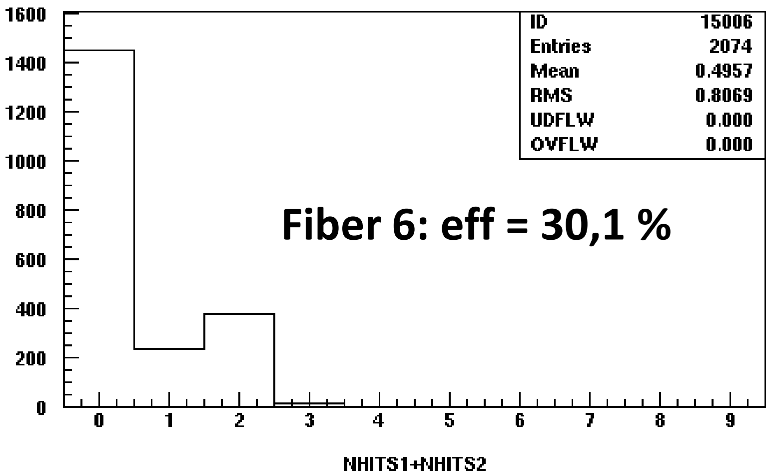
Single layer efficiency



Tests on hadronic beam: “relative” efficiency

Double layer efficiency

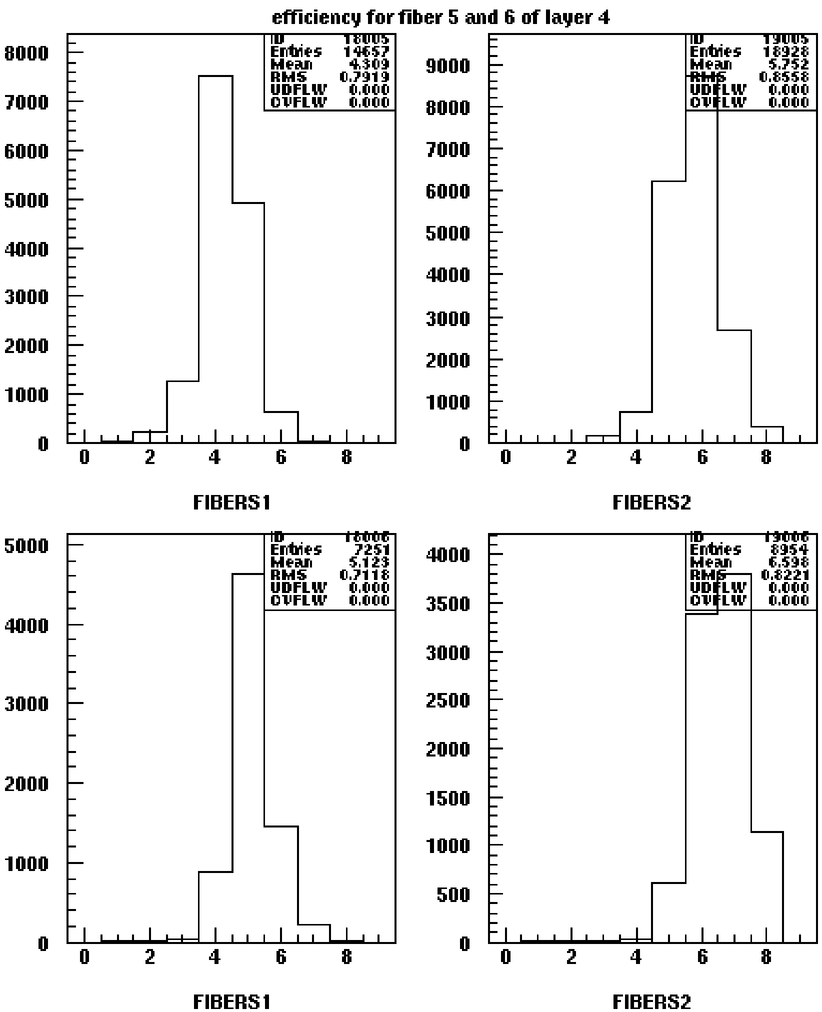




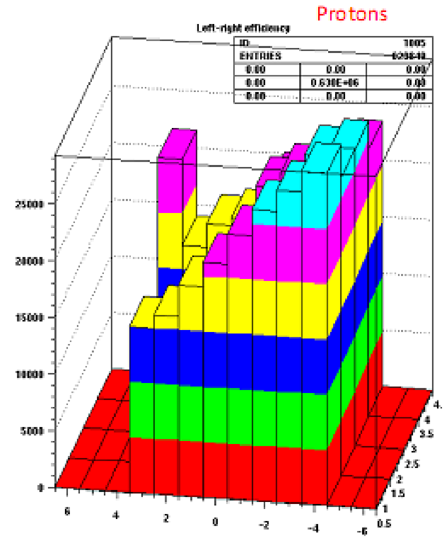
In the case of non parallel double layers the geometrical efficiency is drastically reduced

Tests on hadronic beam

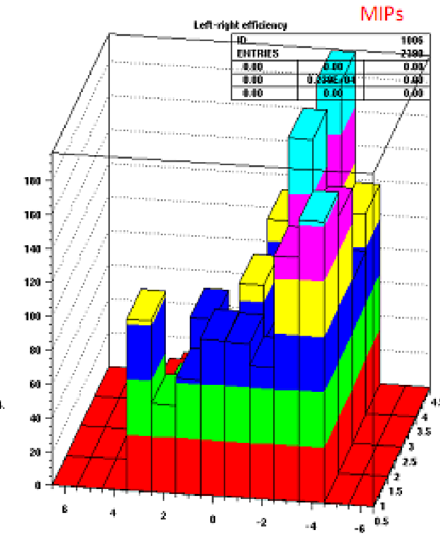
Geometrical correlation



Beam profile



PROTONS

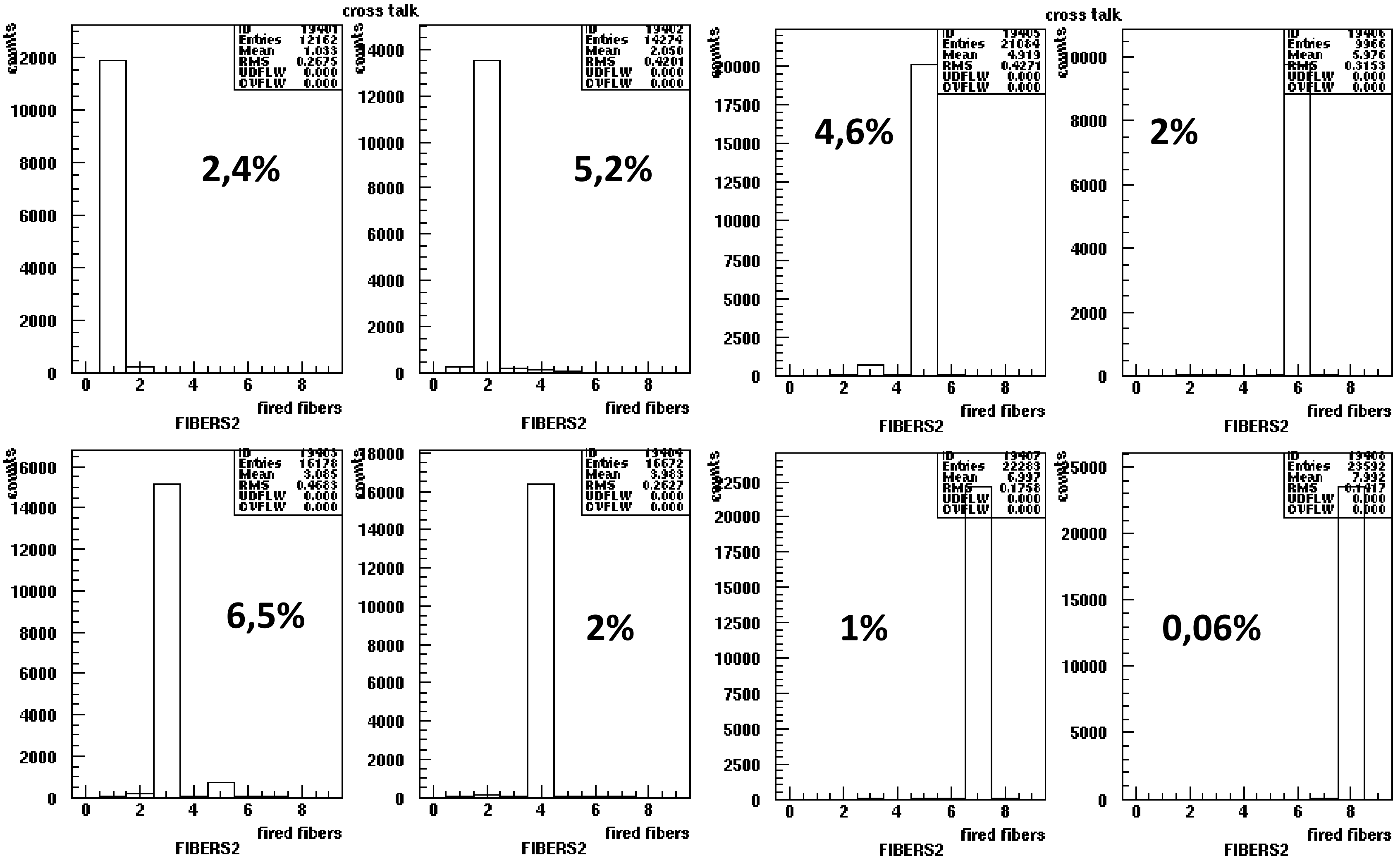


MIPS

Tests on hadronic beam: cross talk

Crosstalk for adjacent fibers

Fired fibers of layer 4 if fiber i of layer 4 is fired

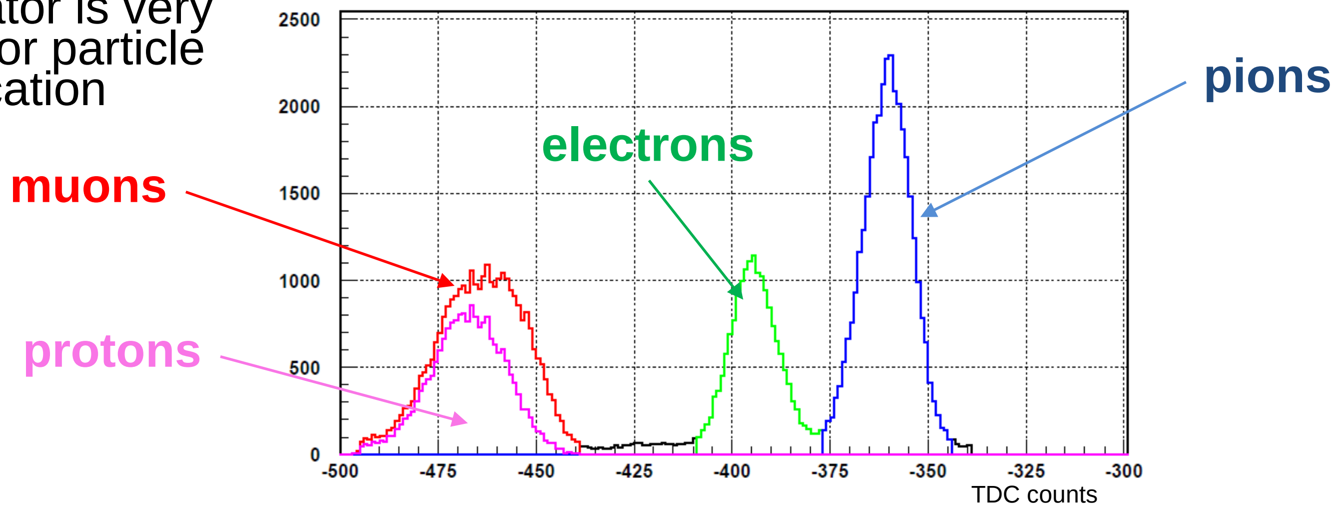


Test @ PSI: time

Test @ PSI: time

Scintillator is very useful for particle identification

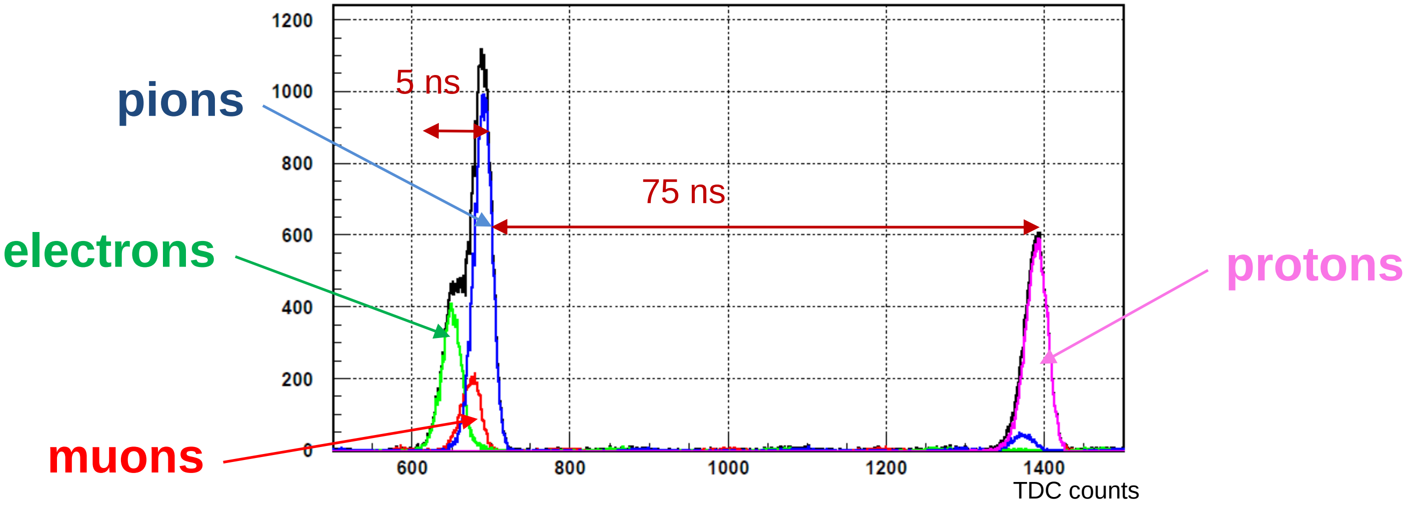
PSI scintillator in coincidence with the RF



TOF for 492 cm of particles at 170 MeV/c:

- **electrons 16.40 ns**
- **muons 19.28 ns**
- **pions 21.18 ns**
- **kaons 50.31 ns**
- **protons 91.96 ns**

TOF between our setup and PSI scintillator (~492 cm)



Conclusions…

1) Small dimensions
2) Working in magnetic field
3) Working at room temperature
4) Very good time resolution (σ ~ 300 ps)
5) High efficiency

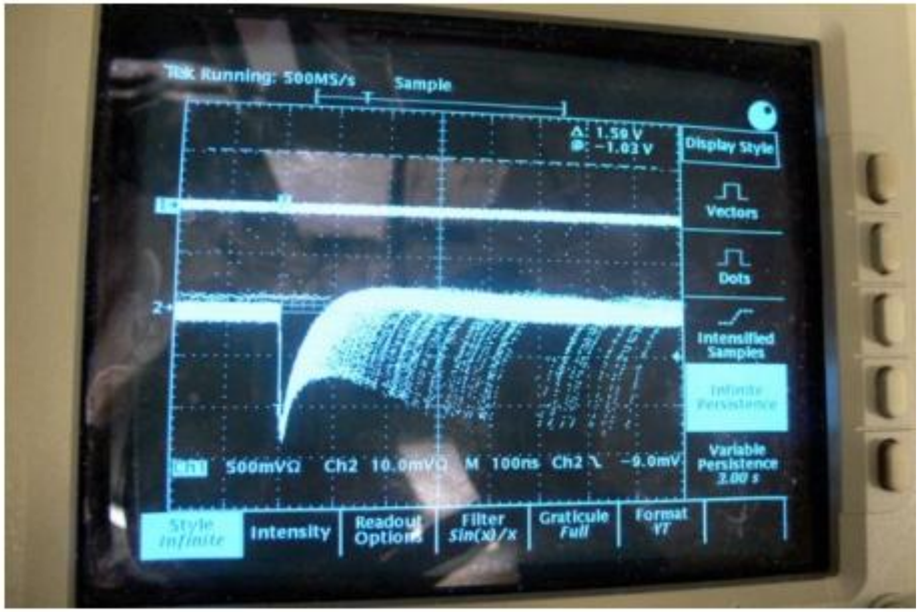
…

…and future plans

- Temperature feedback circuit implementation
- New time resolution measurements
- R&D of electronics
- Delayed 2nd pulse signal reduction

Delayed 2nd pulse signal reduction

tests @ Vienna and Frascati by LNF & SMI groups



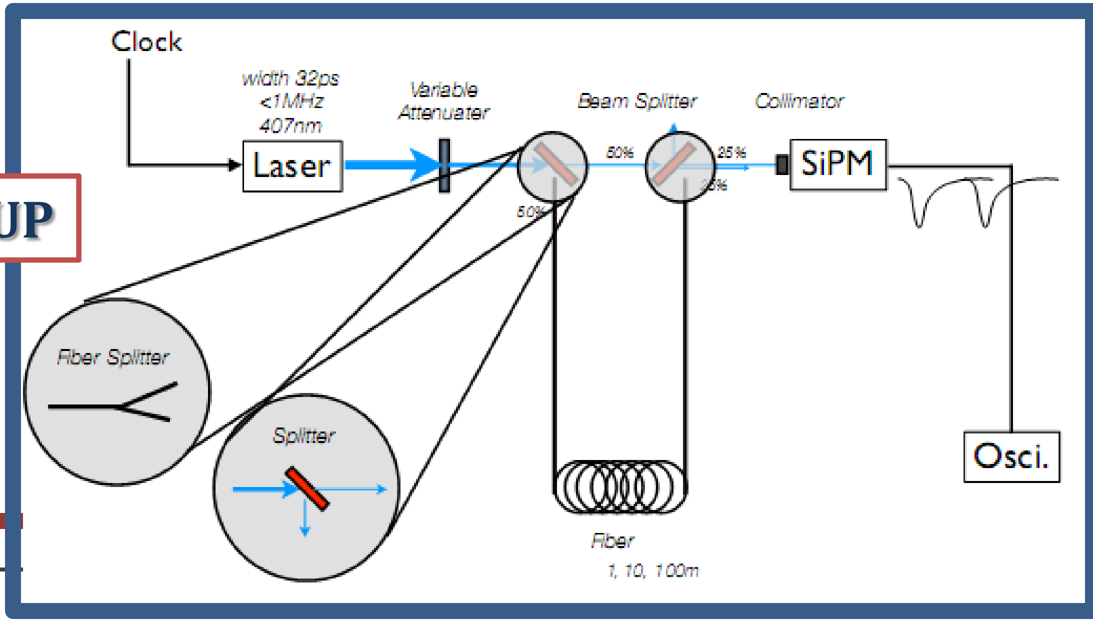
In a first step, we aim to reproduce the curve "pulse height vs delay of 2nd pulse" and understand it. This study has been already started with the light from the laser beam for small delay times (arriving to 6 ns) thanks to the black box and the mirrors.
I has been proposed that the decrease of signal in the record of the second pulse can be deduced in terms of the gain and the number of pixels fired in the first time.

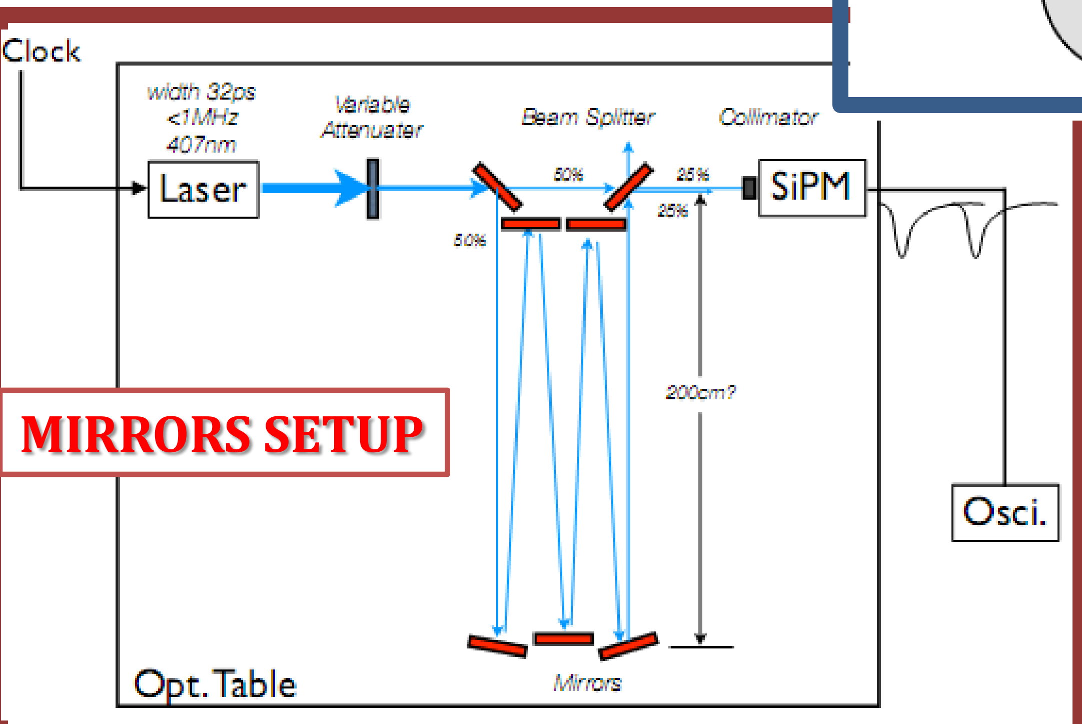
Recovery times of
Sensor
Ampl.
Light source
are convoluted here

Delayed 2nd pulse signal reduction

tests @ Vienna and Frascati by LNF & SMI groups

OPTICAL FIBERS SETUP





MIRRORS SETUP

...stay tuned

Talk tomorrow by Massimiliano Bazzi on electronics description and R&D:

- **-Pre-amplifiers**
- **-Constant fraction discriminators**
- **-etc**