

---

# NA48 Future Plans

---

**RHIC & AGS Annual Users Meeting - Brookhaven**

**Giuseppe Ruggiero**

**University of Firenze**

On behalf of NA48 – Future Working Group

---

# Outline

- From the address of Aymar (CERN CEO) 13/1/2004:

“  
...

- iv. Another goal [for 2004-2010] would be: **to define possible new fixed-target experiments** (praised in another Cogne\* meeting in September 2004).
- v. **To decide in 2006** (...) any proposed R&D or **experiment** depending on the **funds available or expected** at that time.

...”

\*Cogne=Villars

# Proposal (NA48/3)

CERN-SPSC-2004-010 / SPSC-EOI-002

- **NA48 detector upgrading to study  $K^+ @ p^+ n\bar{n}$**
- **High Physical potential**
  - Aim to a 10 % measurement of  $|V_{td}|$
- **Availability of experimental infrastructures (NA48/2):**
  - Location for the experiment (ECN3 – high radiation area)
  - Beam line (*high intensity*, slowly extracted protons from SPS)
  - Subdetectors (e.g. LKr calorimeter)
  - 2004 run (beam test)
- **Goal:**
  - ✓ *About 50 Events with a S/B of 10:1 in 2 years of data taking*

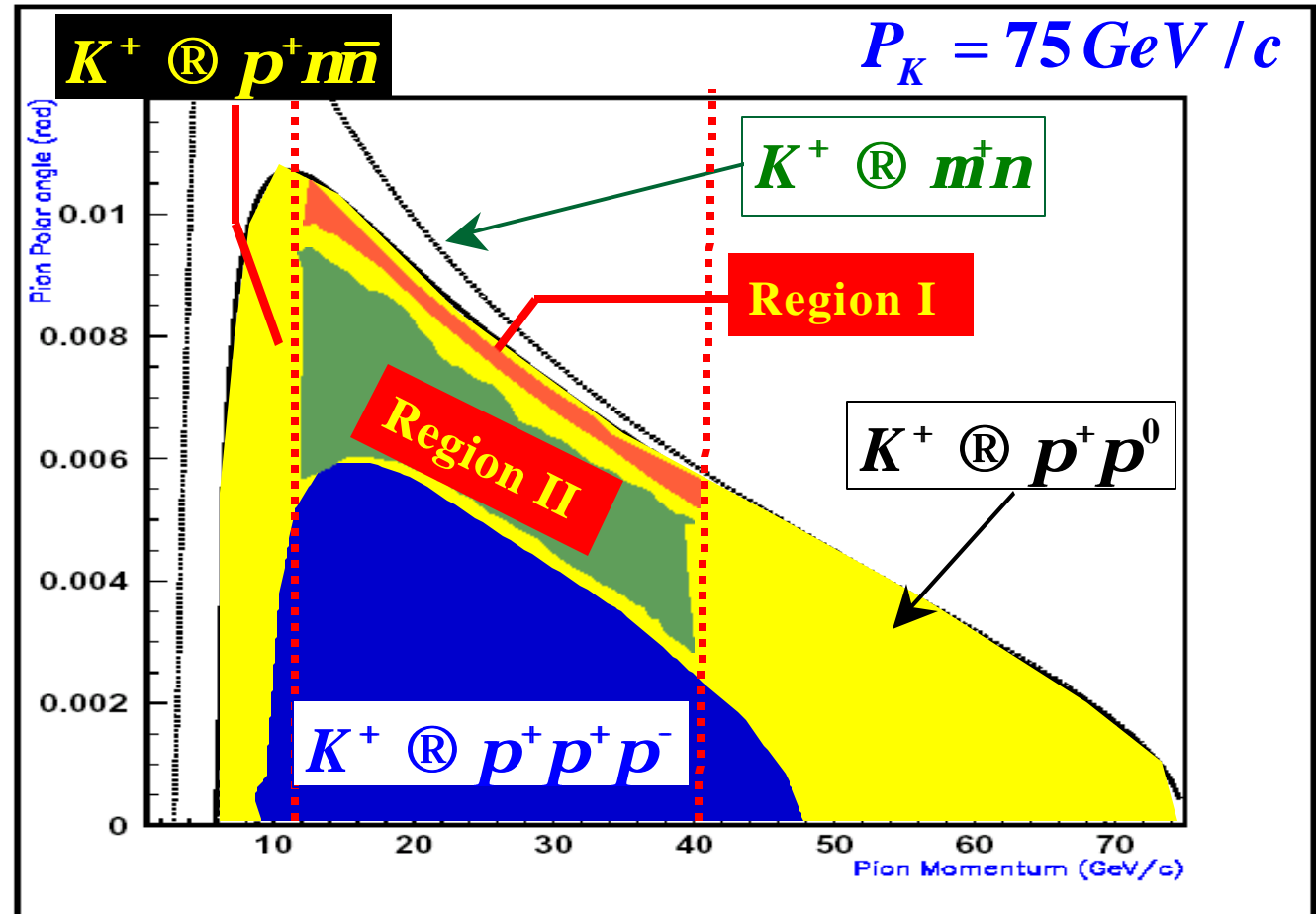
# Experimental features

$K^+$  decay in flight  
High energy  $K^+$

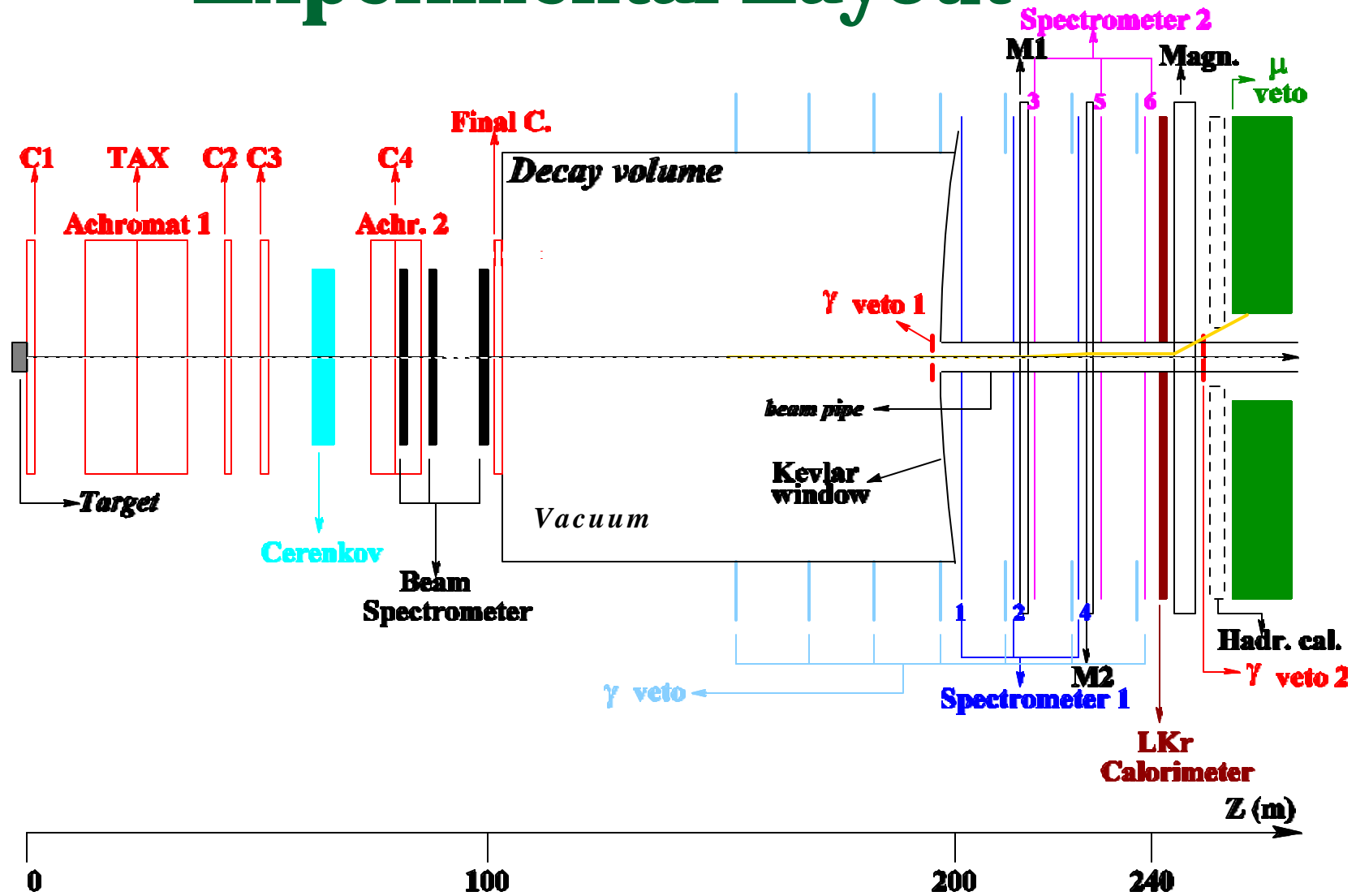
Super-rare decay:  
BR  $\sim 10^{-10}$



- ✓ Kinematical cuts
- ✓ Veto systems
- ✓ Particle ID



# Experimental Layout



# Beam Layout

- **Beam line:**

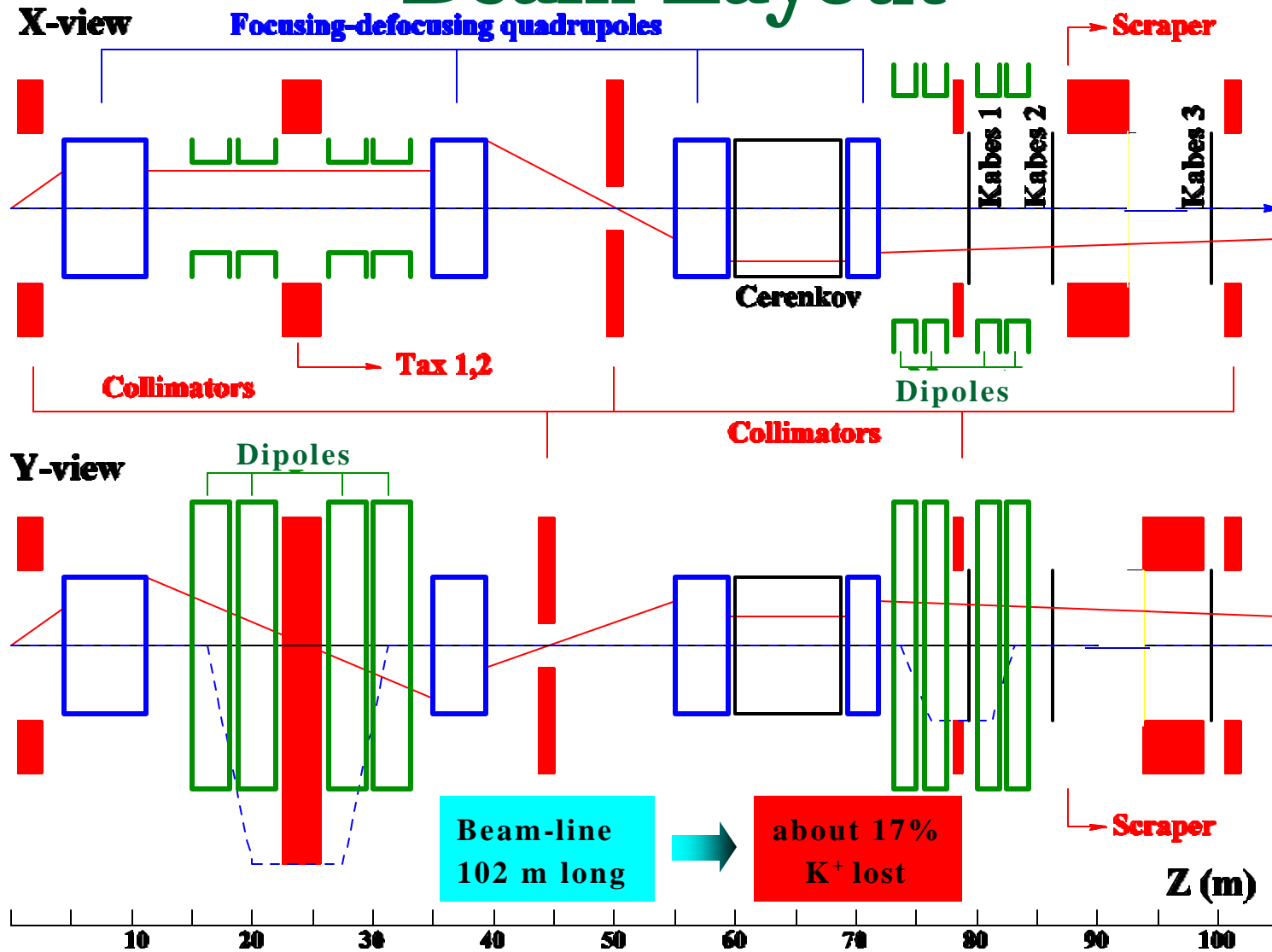
- **Unseparated** positive  $p^+ / K^+ / p_{\text{beam}}$
- $P = 75 \text{ GeV}/c$ ,  $DP/P \sim 1\%$  ( $P_p = 400 \text{ GeV}/c$ )

- **Beam detectors:**

- **Differential Cerenkov detector (CEDAR)**
  - **Tag Kaons (made blind to  $p^+$  and  $p$ )**
- **Beam spectrometer (KABES):**
  - **Redundant measurement of beam momentum**
  - **Measurement of the kaon direction**

**Micromega-type chambers (already employed in NA48/2)**  
**Silicon – pixel detector**

# Beam Layout



# New high-intensity beam (1)

BEAM	NA48/2	NA48/3	Factor
SPS protons per pulse	$1 \times 10^{12}$	$3 \times 10^{12}$	3
Duty cycle (s/s)	4.8/16.8		1
Beam acceptance (mrad)	$\pm 0.36$	$\pm 2.4, \pm 2.0$	
Solid angle (m sterad)	0.40	16	40
$\langle P_K \rangle$ GeV / c	60	75	1.35
$DP_K$ GeV / c	6	1.5	0.375
RMS (DP/P %)	4	0.95	0.25
Beam size (cm)	$\pm 1.5$	$\pm 2.5$	2.8
Area at KABES (cm <sup>2</sup> )	7.0	20	
Divergence (mrad)	0.05	0.1	2

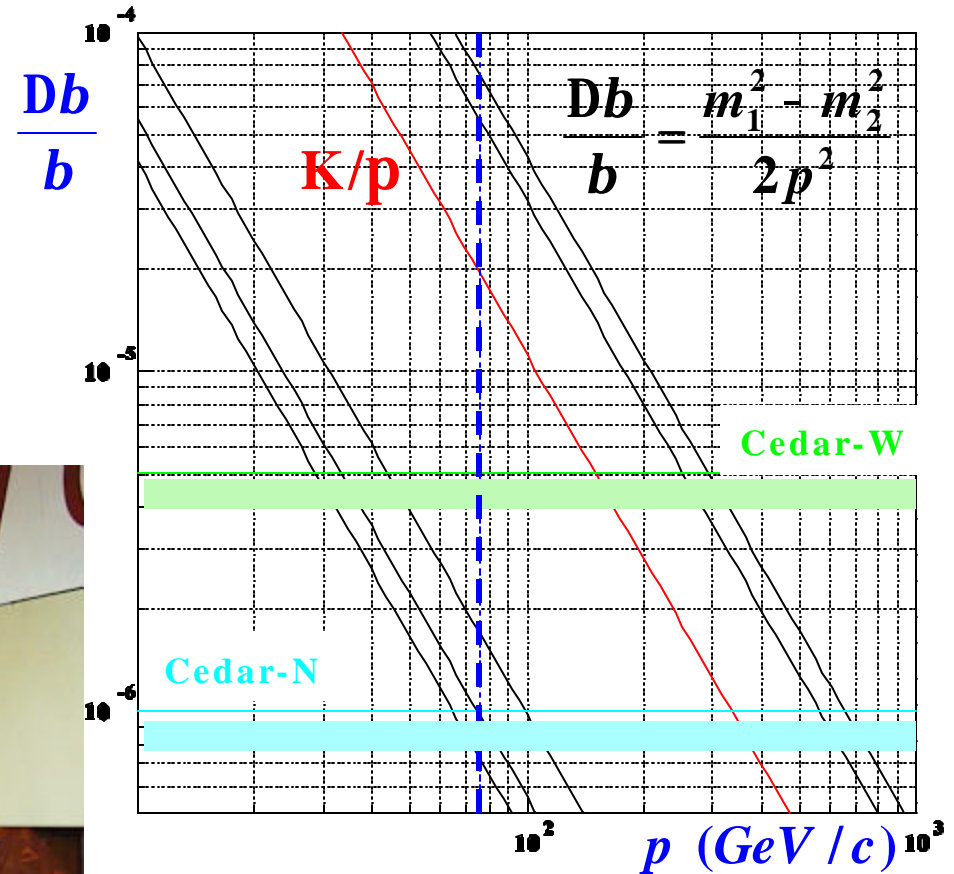


# New high-intensity beam (2)

BEAM	NA48/2	NA48/3	Factor
Decay fiducial length ( $t_k$ )	50 m (0.11)	50 m (0.09)	(0.8)
Beam flux / pulse			
p ( $\times 10^7$ )	0.86	49	
K <sup>+</sup>	0.31	15	50
p <sup>+</sup>	3.32	150	45
e <sup>+</sup>	0.95	35	
Total per pulse ( $\times 10^7$ )	5.5	250	45
per spill length (MHz)	18	800	45
@ KABES / cm <sup>2</sup> (MHz)	2.5	40	16
Eff. Run time / days	0.5 x 120	2/3 x 90	1
K <sup>+</sup> decays per year (inside fiducial length)	1 x 10 <sup>11</sup>	4 x 10 <sup>12</sup>	40

# Cerenkov (CEDAR)

- ✓ Cerenkov differential counter
- ✓ Highly parallel beam



**Test foreseen during 2004 run**

# Kaon Spectrometer (KABES)

Currently used in NA48/2  
@ 2 MHz/strip

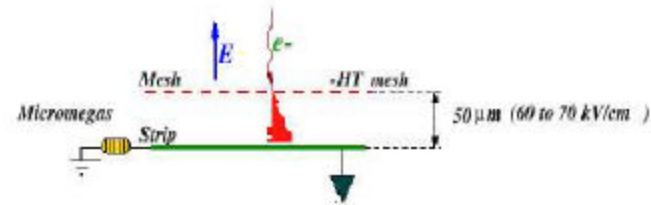
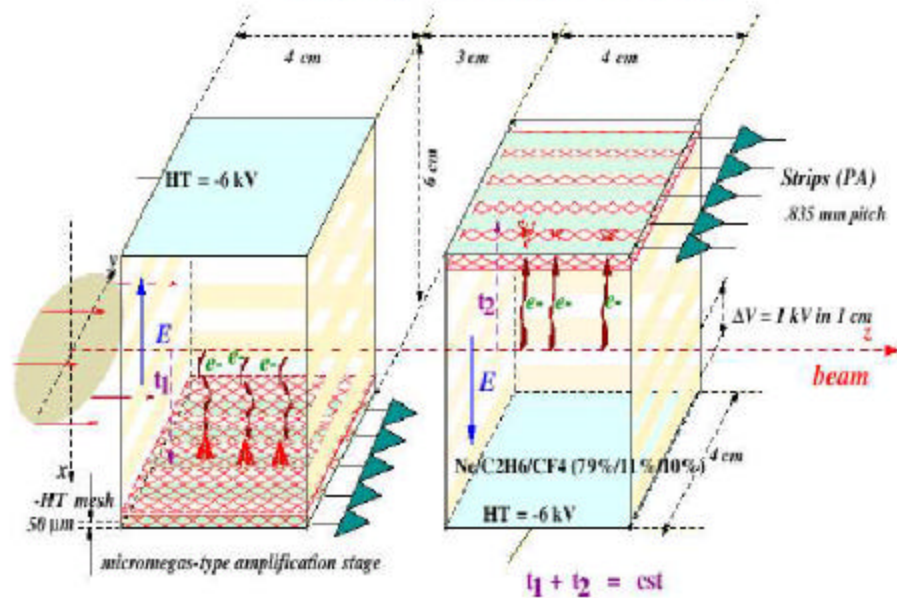
- Resolution strips 80 mm
- Resolution drift 50 mm
- Time resolution 0.7 ns
- Dead time/strip 40 ns
- DP/P 0.5 %



Improvement for NA48/3  
(expected 20 MHz/strip)

- New micro-mesh 25 mm
- New gas
- FADC → Old NA48 Tagger readout (1 GHz FADC)
- Smaller strip size
- Si micro-pixels (sub-ns time resol.)

Micromegas Time Projection Chambers



Test foreseen during 2004 run

---

# Detector Layout

- **Subdetectors downstream the beginning of the fiducial region:**
  - **Double spectrometer**
    - **6 drift chambers (4 chambers already employed in NA48)**
    - **2 magnet (1 magnet already employed in NA48)**
    - **Momentum redundant measurements**
  - **Photon veto:**
    - **LKr calorimeter (already in NA48) + charged particle sweeping magnet**
    - **2 small angle vetoes (CMS prototypes)**
    - **8 rings as large angle vetoes (upgrade of AKL detectors in NA48)**
  - **Hadron calorimeter**
  - **Muon veto**

# Detector Layout

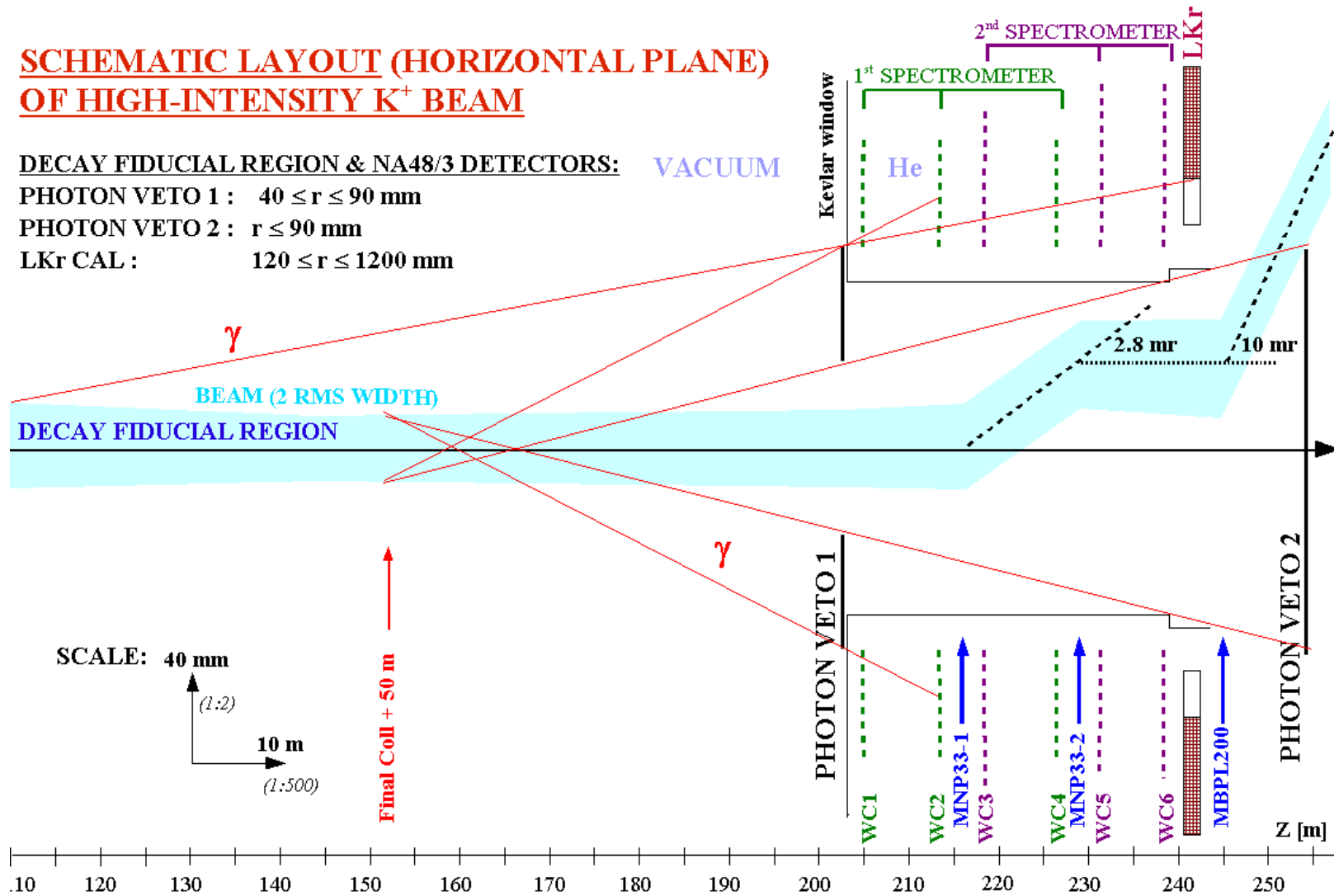
## SCHEMATIC LAYOUT (HORIZONTAL PLANE) OF HIGH-INTENSITY $K^+$ BEAM

DECAY FIDUCIAL REGION & NA48/3 DETECTORS: VACUUM

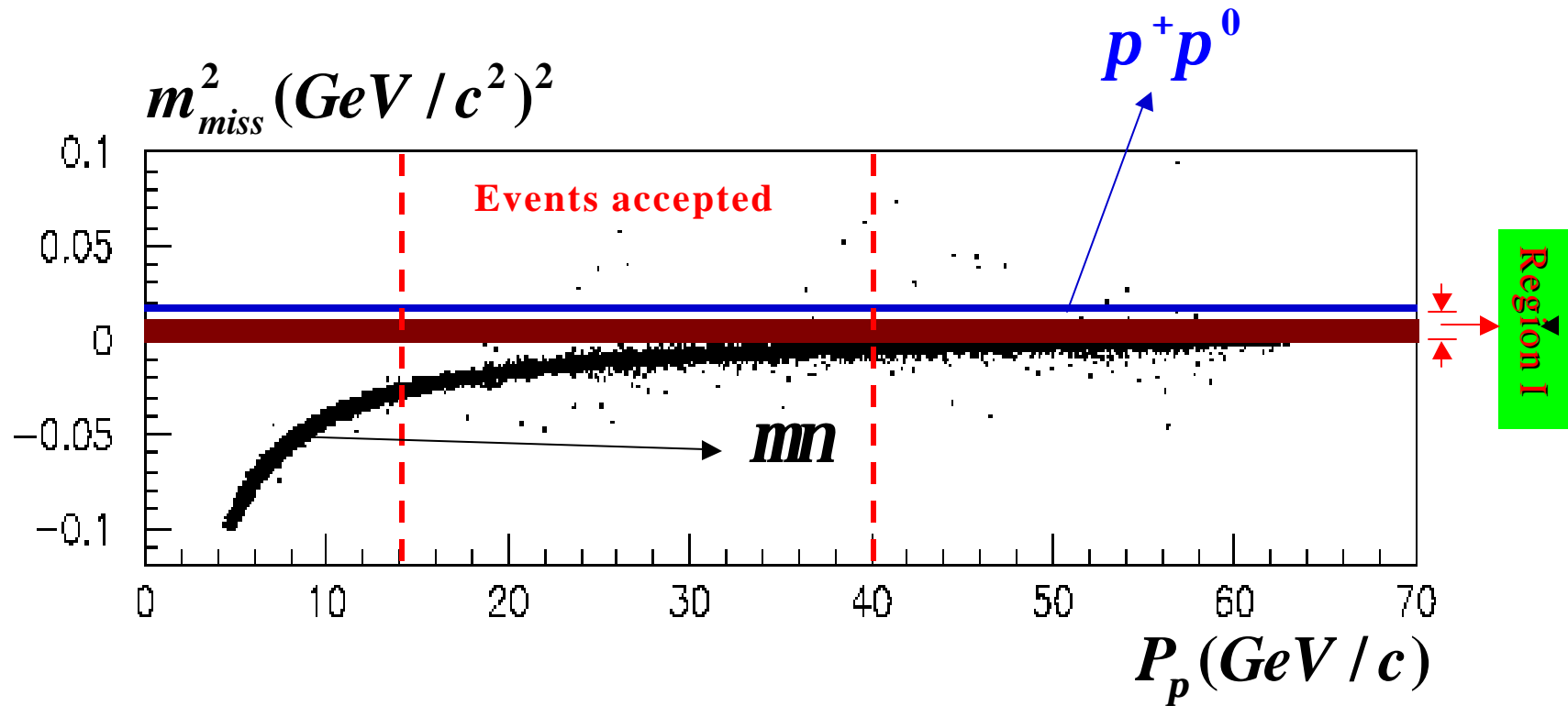
PHOTON VETO 1 :  $40 \leq r \leq 90$  mm

PHOTON VETO 2 :  $r \leq 90$  mm

LKr CAL :  $120 \leq r \leq 1200$  mm



# Kinematical rejection

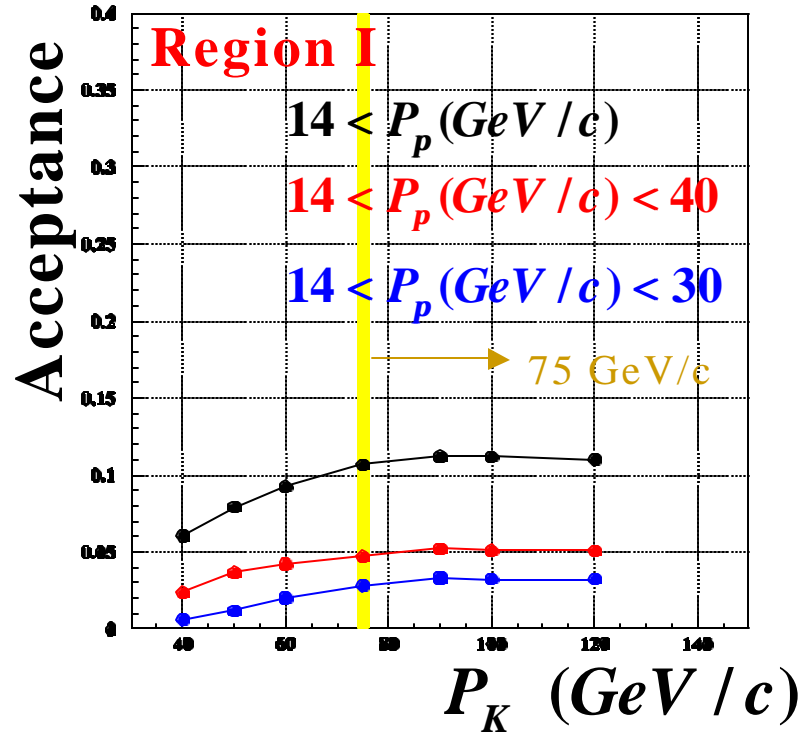


$$m_{miss}^2 = m_K^2 + m_p^2 - 2(E_K E_p - \boxed{p_K p_p} \cos \boxed{q_{Kp}})$$

Measured quantities

# Acceptance

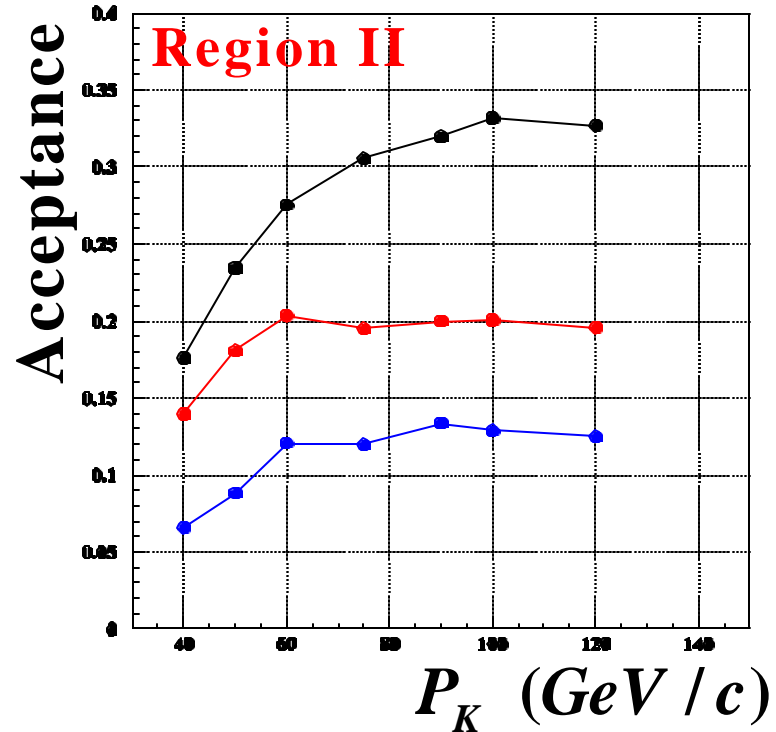
$$0 < m_{miss}^2 < 0.01 \text{ (GeV / c}^2\text{)}^2$$



$P_K = 75 \text{ GeV / c}$   $P_p < 40 \text{ GeV / c}$   
 Acceptance (Region I) =  $\approx 5\%$

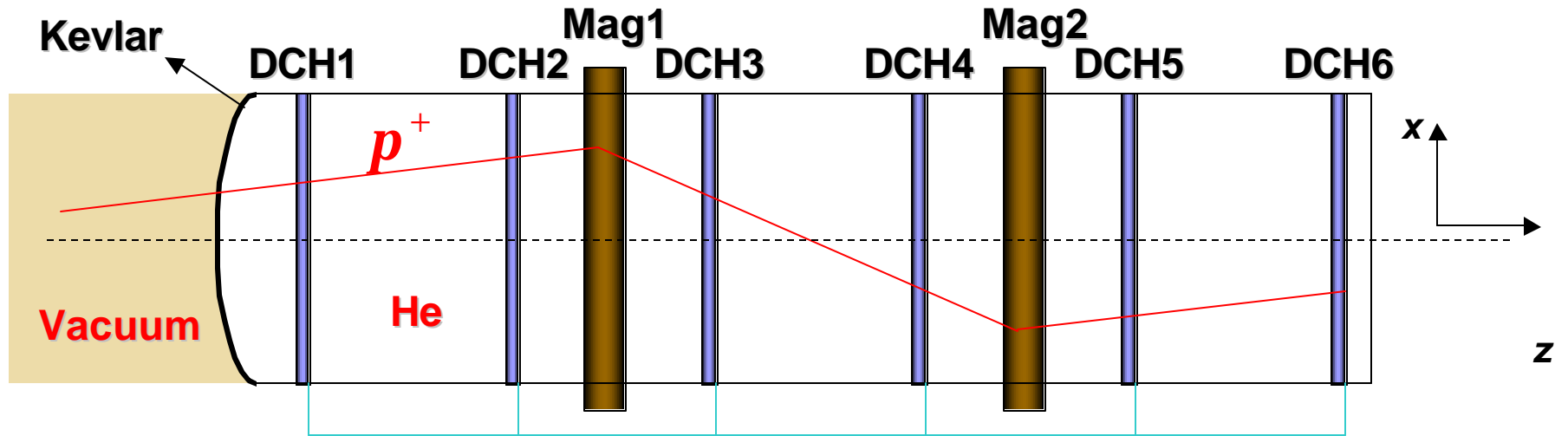


$$0.026 < m_{miss}^2 < 0.068 \text{ (GeV / c}^2\text{)}^2$$



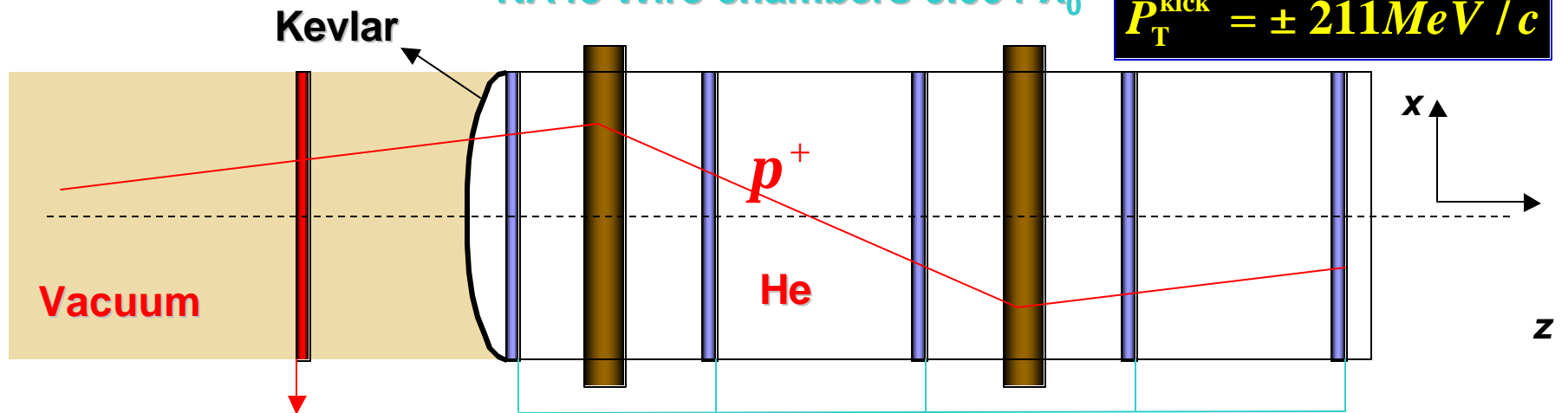
**20 events per year**  
 @  $\text{BR} = 10^{-10}$  (Region I)

# Double spectrometer layout



NA48 Wire chambers  $0.004 X_0$

$$P_T^{\text{kick}} = \pm 211 \text{ MeV} / c$$

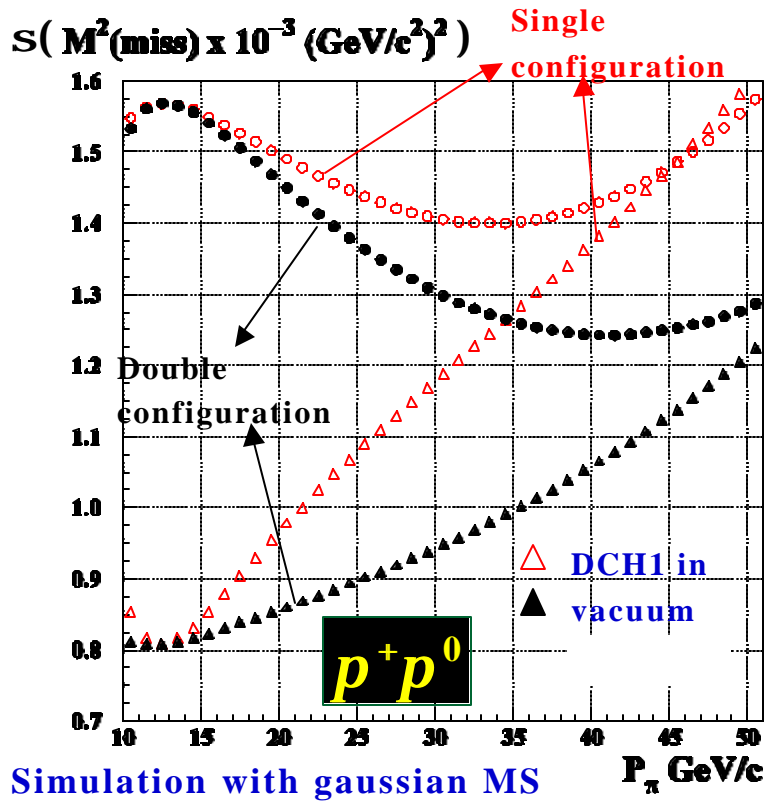


Straw tube  $0.0025 X_0$

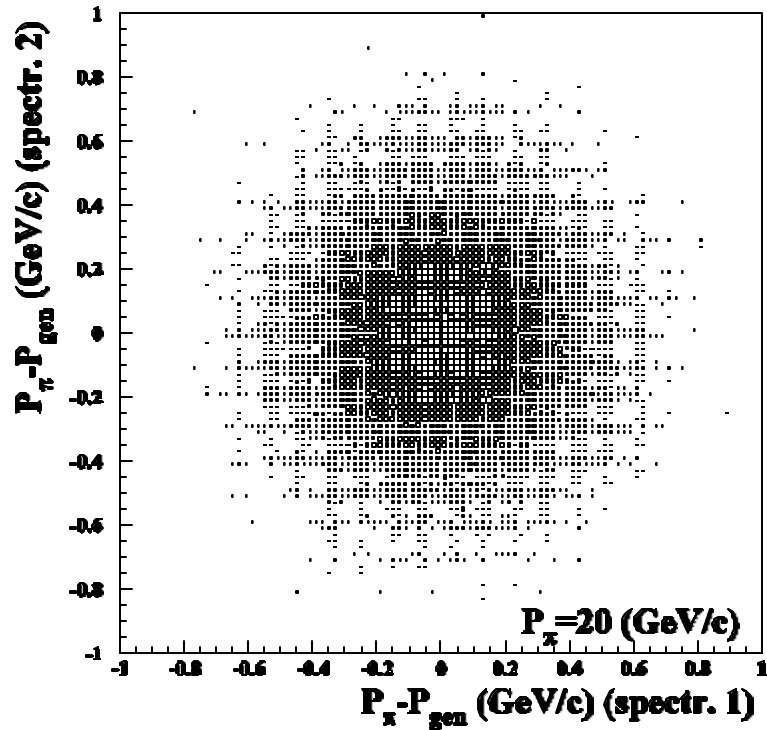
NA48 Wire chambers  $0.004 X_0$



# Double spectrometer performance



Two independent measurement of  $P_p$



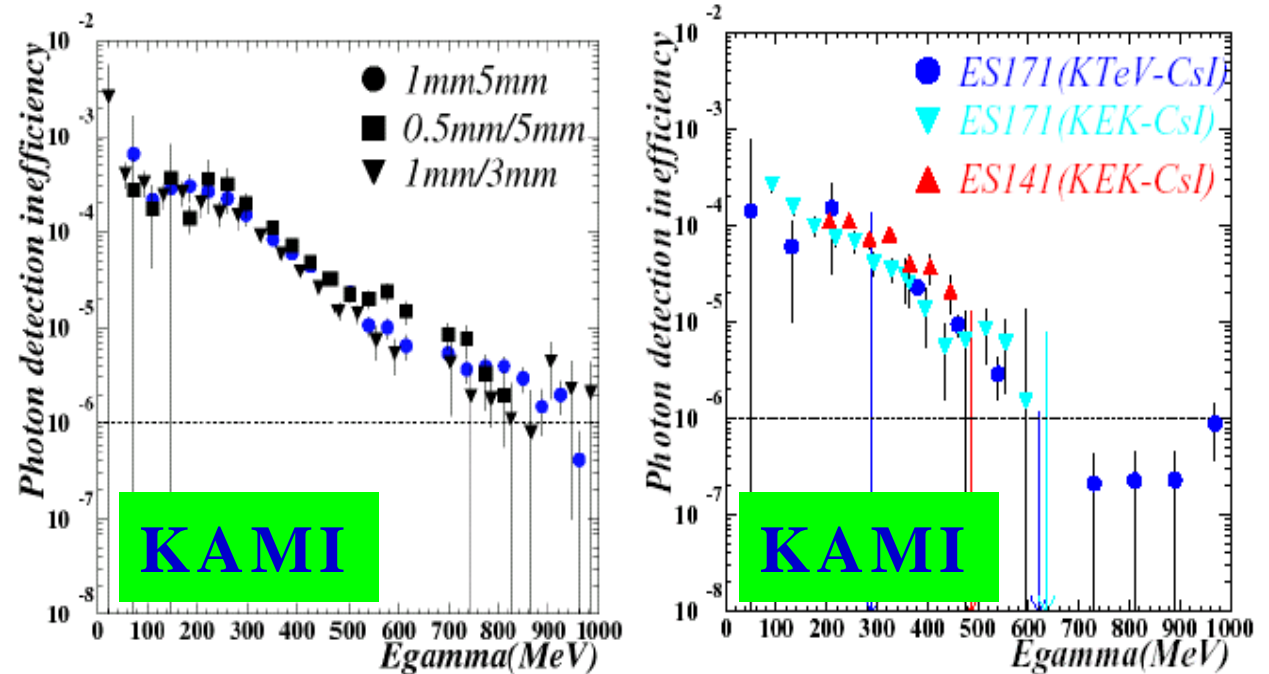
● Much higher intensity on DCH in NA48/3



Intensity and performance vs HV tests foreseen in 2004 run

# Photon rejection

- Aim to reach  $10^{-6}$  inefficiency
- For  $P_p < 40$  GeV/c there are at least 35 GeV/c in the e.m. calorimeters



- Plans to study our inefficiency (LKr calorimeter + small angle veto) by collecting a large sample of  $p^+p^0$  events in 2004 run

# Small angle photon veto

## **PbWO<sub>4</sub> crystals (CMS)**

- ✓ Dimension of crystals  
2x2x23 cm<sup>3</sup>
- ✓ 7 x 7 cm matrix
- ✓ ~ 25 X<sub>0</sub>
- ✓ Readout with light guides and PMT
- ✓ Hard to radiation damage

**Low intensity hermetic photon veto test foreseen in 2004 run**



---

# Muon rejection

- ▶ **Better than  $10^{-5}$  rejection inefficiency mandatory**
  - ✓  $10^{-5}$  obtained by NOMAD
- ▶ **Present detector not enough efficient**  
**( $5 \times 10^{-3}$  inefficient)**
  - ✓ **3 scintillator arrays separated by iron planes 80 cm thick.**
- ◆ **We are planning to build a new detector**  
**(Hadron calorimeter + muon detector)**

---

# Tests in 2004 run

- **Muon sweeping**
  
- **CEDAR** (with COMPASS collaboration)
  
- **KABES (micromega):**
  - ✓ FADC readout
  - ✓ 25 mm mesh
  
- **Si pixel chip**
  
- **High Intensity DCH test**
  
- **Low intensity hermetic g-veto test**

---

# Conclusions

- We are working on the upgrade of the NA48 detector to study the  $K^+ \rightarrow p^+ n \bar{n}$  decay.
- We have established a Working Group.
- Fundamental tests foreseen in 2004 run.
- We plan to contribute to the Villars SPSC meeting (22-28 september).