Sheet Beam Profile Monitor

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AGENDA

1. Introduction about Gas Profile Monitor
2. Other Gas Profile Monitor (CERN SPS)
3. Gas Sheet Generation and Current Status
4. For Low Intensity Beam (NIRS-HIMAC Synchrotron)
5. Design for High Intensity Beam (JKJ-50 GeV PS)
6. Summary

1.Introduction

#Popular Method (Demerit Only)

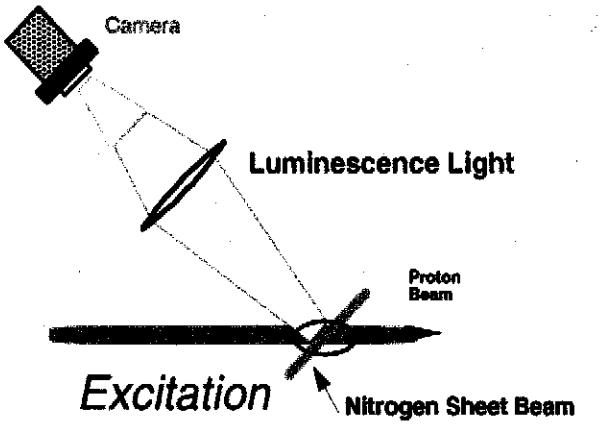
- Ionization Profile Monitor

  → Widening Profile by ***Beam Induced Field*** (>1e12 part./pulse@KEK-PS)

- Wire Scanner

  → ***Wire is Broken*** by Energy Deposition (>1e12 part./pulse@KEK-PS)

#Gas Sheet

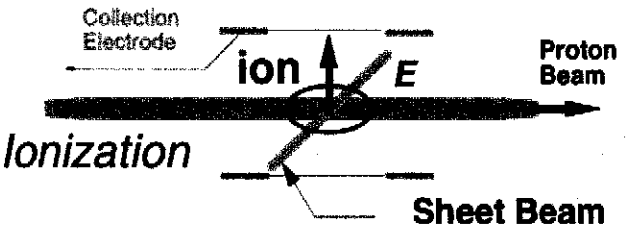


Gas Sheet Design

Density : >1e-5 Torr
Sheet Thickness : ～1 mm

For High Intensity Beam (ex. JKJ 50 GeV PS)

- **Gas Luminescence** → Free from Large Beam Induced Field
- (Almost) Non Destructive
- **Fast Measurement: ～several 10 bunches**
- Whole profile (H,V)
- Cleared Scintillation Point

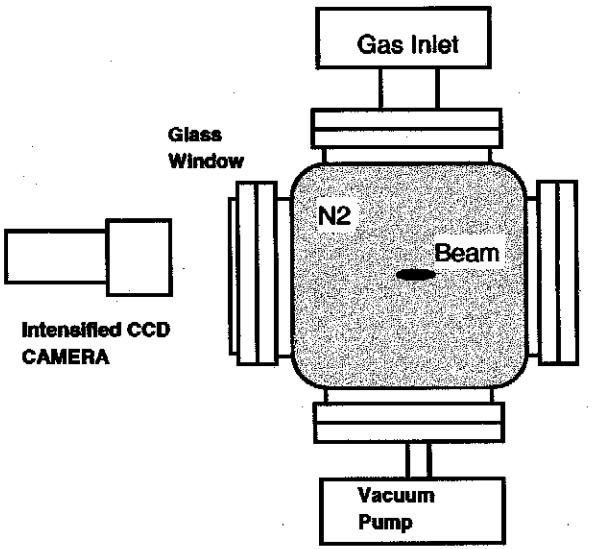


For Low Intensity Beam (ex. NIRS HIMAC)

- **Gas Ionization**
- **Fast Measurement : ～One Bunch**

2. Other Gas Luminescence Profile Monitor

The CERN SPS Gas Luminescence Profile Monitor [1,2,3]



Method :

- Local Vacuum Bump: >1e-8 Torr
- Gas Luminescence from Nitrogen

Limit (Sensitivity):

*Minimum Time for One Profile Measurement

- 2×10^{13} p @ 450 GeV, 1×10^{-8} Torr N_2
- 870 turn (20msec) Needed.

Estimation For the JKJ 50 GeV PS Beam (roughly)

Beam : 50 GeV, 2×10^{13} p

Gas Sheet Density : 1×10^{-5} Torr (Design Value)

One Bunch Measurement is possible.

*But the only case of the Beam Size and Detectors are much same.

Ref. [1] First Test in the SPS of a Gas Scintillation Beam Profile Monitor, J. Camas, et al., CERN, SL-Note-98-037

Ref. [2] The Luminescence Profile Monitor of the CERN SPS, G. Burtin, et al., EPAC 2000

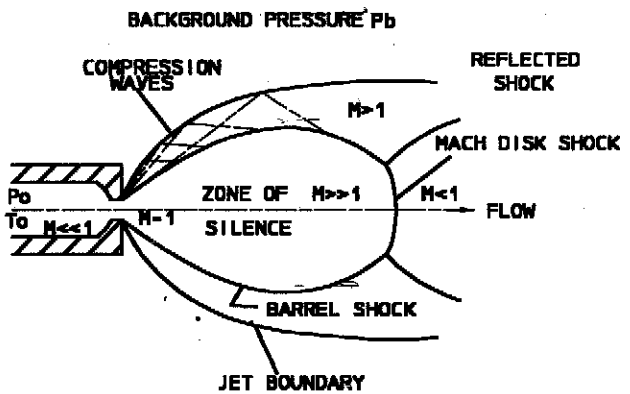
Ref. [3] Luminescence monitors, A. Variola, J. Koopman, LHC emittance workshop 2000, CERN, July 2000

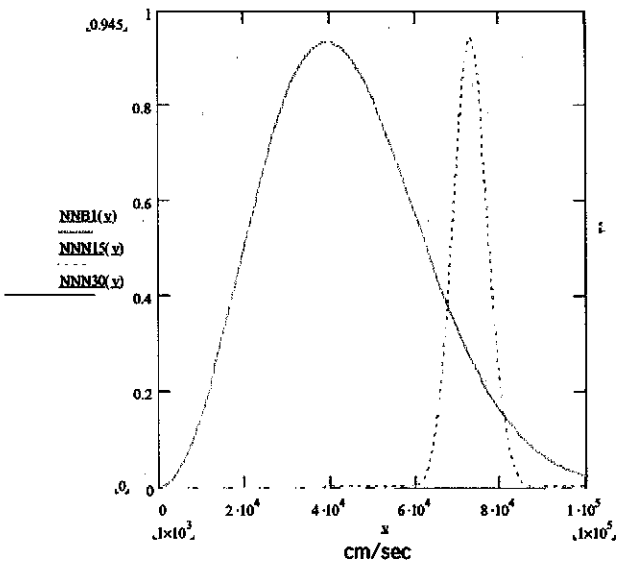
3. Gas Sheet Beam

Nozzle Beam Method

- ***High Pressure Source*** (≈5000 Torr) with ***Small Orifice*** (0.2-1.5 mm)
- ***High Intensity Molecular Beam*** (more than 1000 times larger than oven beam)
- Uniformed Momentum and ***good directivity***: Termination Velocity (780 m/s @N_2, 735 m/s@O_2)
- Adiabatic Free Expansion, Frequently Collision near the Nozzle → ***Cooling*** : < 10 K @M=15
- Skimmer should be positioned into the Shock Surroundings (20-30 mm from the Nozzle)

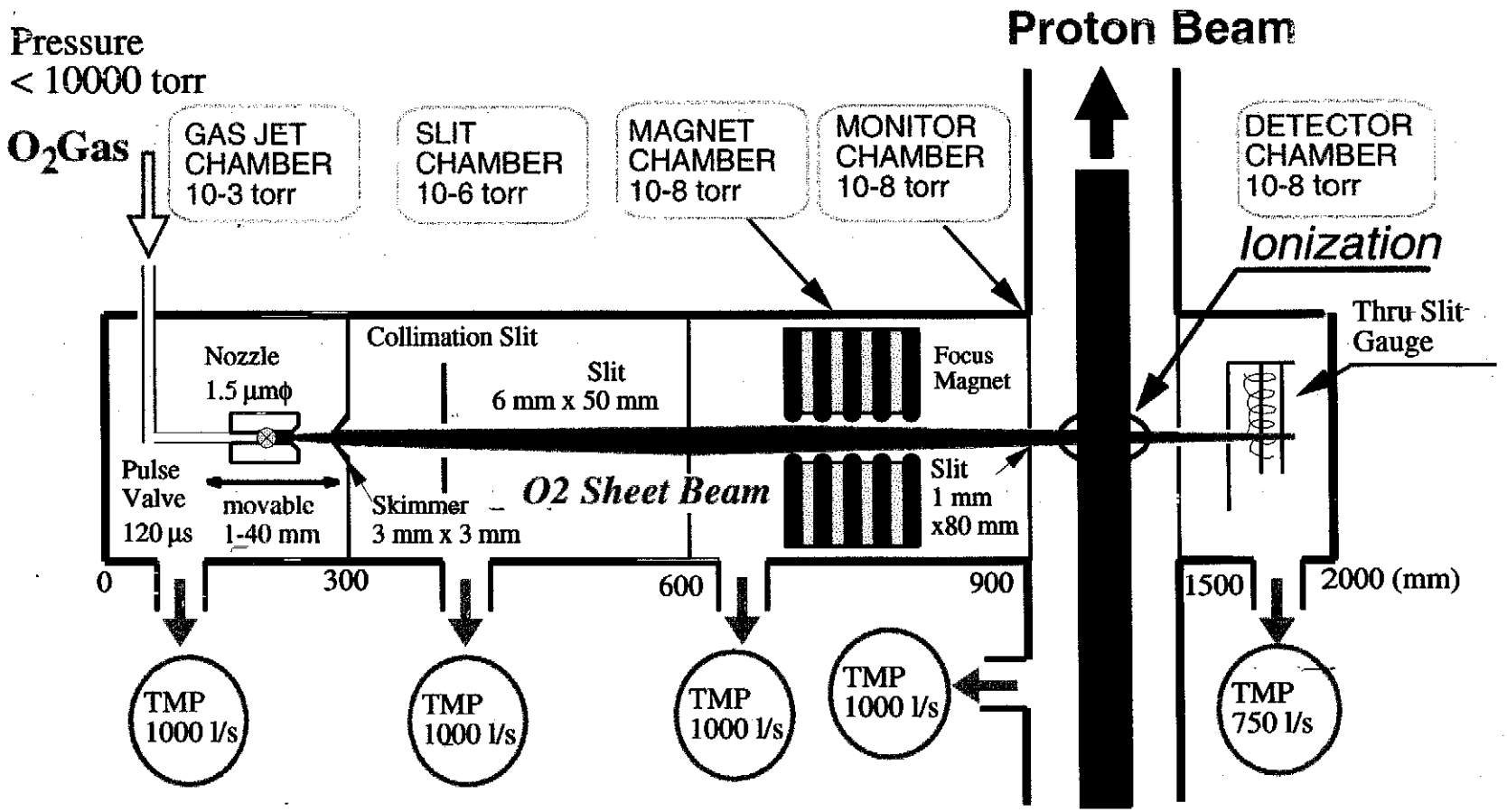
  *Because the Shocks destroy stable jet beams.





3. Gas Sheet Beam-2 (Gas Sheet Generator)

• ***Gas Sheet is shaped with four rectangular slits.***



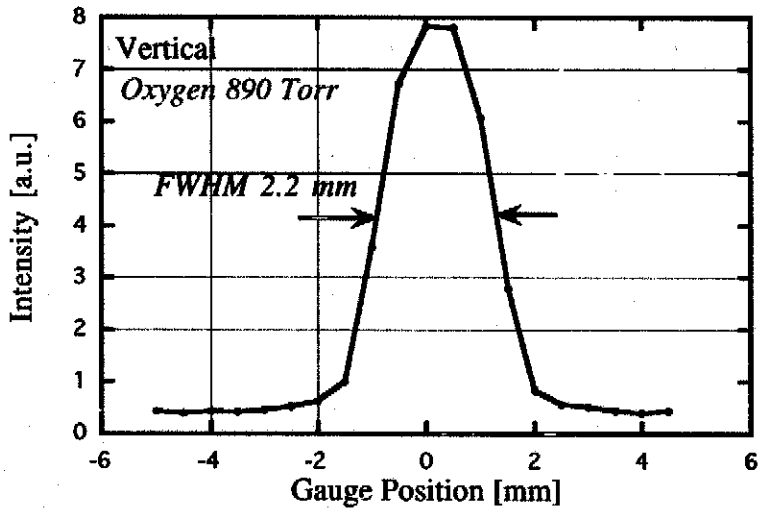
3. Current Gas Sheet Status

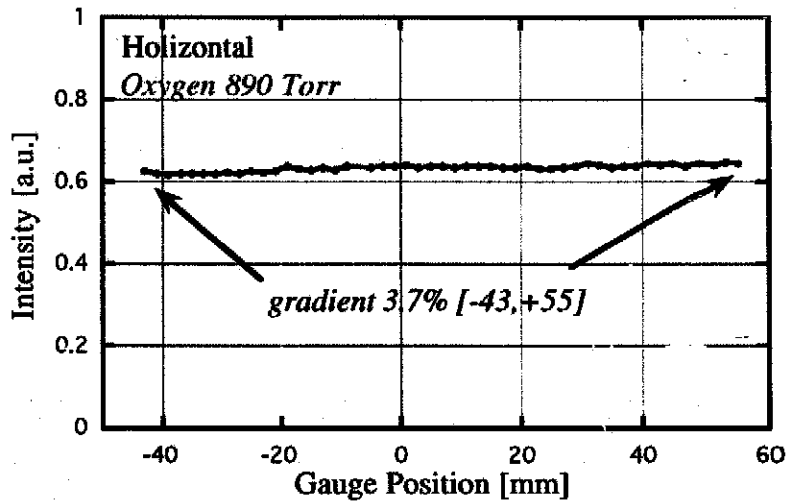
Measurement

- 150 μsec (Variable)Pulse Sheet Beam
- Detector : B-A Gauge (ULVAC) attached 0.5 mm slit (Thru Type)
- Measurement Device:Fast Current Amplifier (Keithley 420 : rising time 5 μsec)

Sheet Status

- Density : ***7e-7 Torr*** at the target point (1250 mm downstream from the Nozzle)
  → 3e-6 Torr at the point of 60 cm from the nozzle (for shortened model : after described).
- Thickness : 2.2 mm (FWHM)@2.3m point→ ***1.2 mm(FWHM)@target center***
  * the thickness is variable and depend on the slit sizes
- Horizontal Uniformity : ***Within about 4%*** over 100 mm





4. Setup for the HIMAC (Low Intensity Synchrotron Beam)

- ***NIRS-HIMAC Synchrotron***

  Beam Species : $^{12}C^{6+}$ (other Heavy Ions)

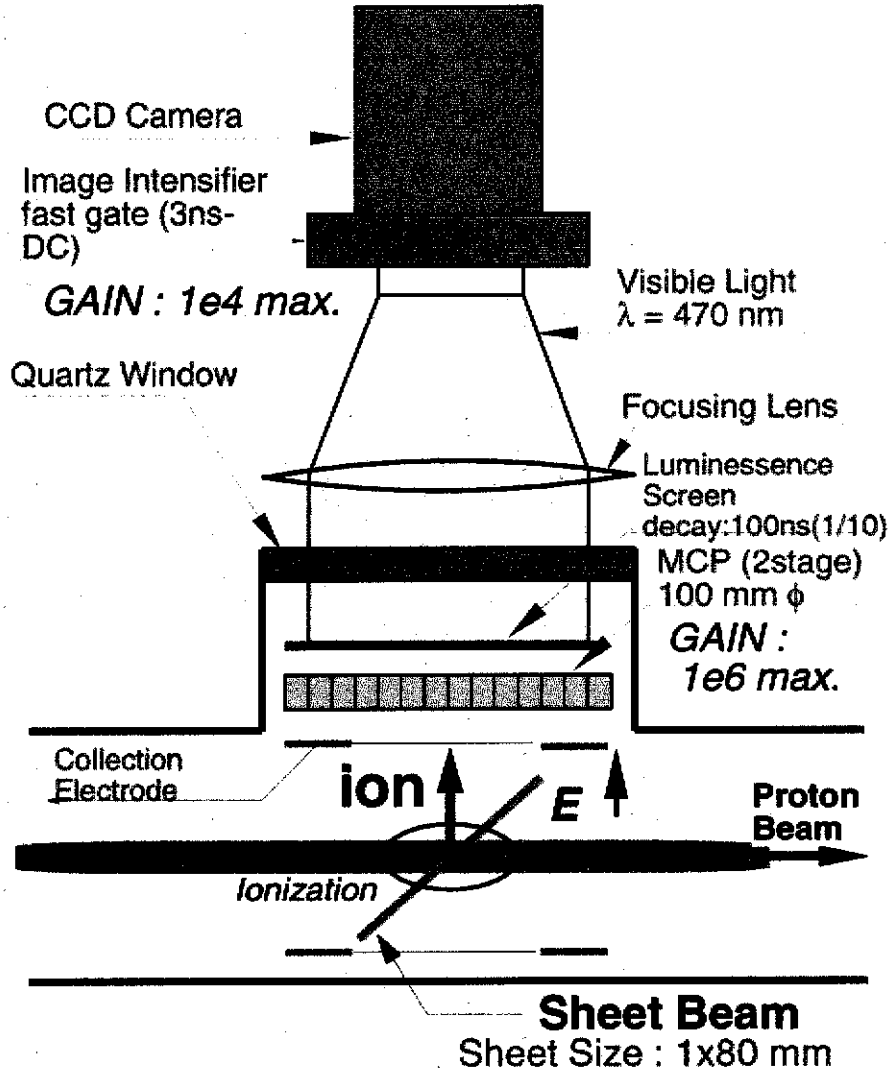
  Energy : 6 MeV/u → 800 MeV/u

  Intensity : 2.5 x 10^{8} part./bunch (h=4, 1 x 10^{9} part./pulse)

- ***Detector Principle***

  Ionization

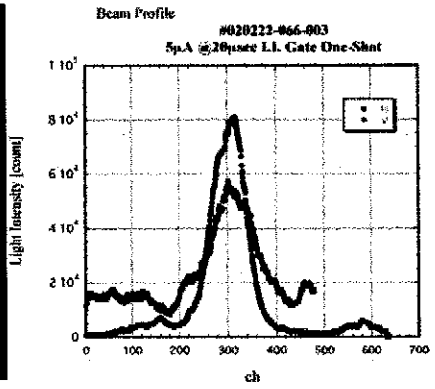
  MCP+ Phosphor Screen → Visible Beam Profile



4. Pre-test for the HIMAC (Low Intensity Heavy Ion Synchrotron Beam)

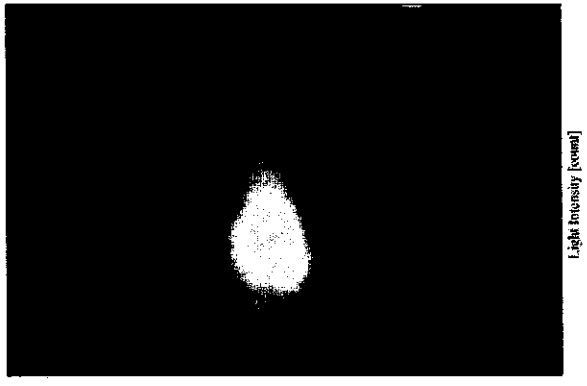
- This March the monitor was installed into the NIRS-HIMAC Synchrotron, beam studies will be started soon.
- Beam tests were done by extracted NIRS-Cyclotron beams.

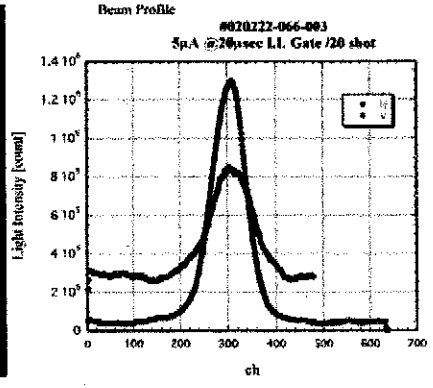
Cyclotron P-8 MeV 5 μA : I.I Camera Gate = 20 μ sec



Limit : Proton 8MeV
5uA-20usec(gate) --> 6.25 e8 protons

Cyclotron P-8 MeV 5 μA : I.I Camera Gate = 20 μsec x 20 shot





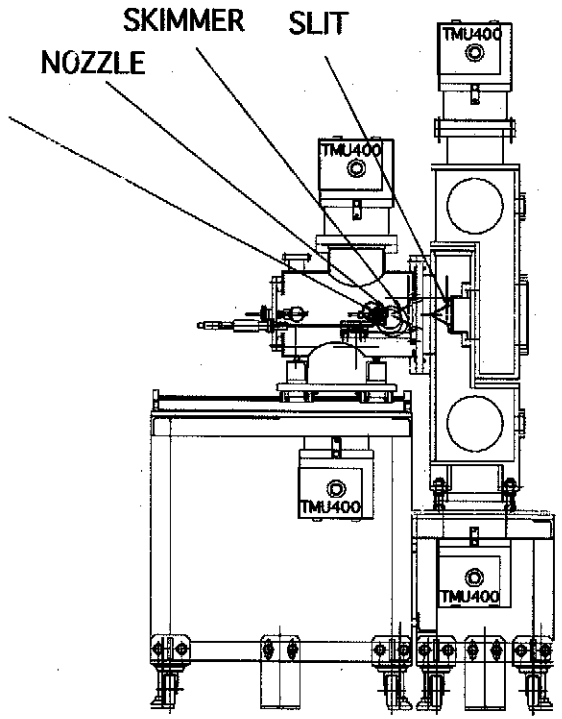
Scaling for the HIMAC beam with Bethe-Bloch Formula:
One Bunch Detection is expected possible.
@ Energy<270 MeV/u,
@ Bunch Intensity> 2.5 e8 Carbon(12,6+)

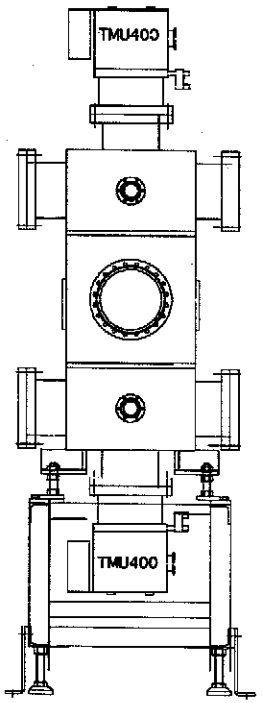
5. Gas Sheet Generator Design for the JKJ 50 GeV synchrotron

- Shortened Sheet Beam Generation Region 30 cm
- Nozzle Study : Wider (> 100 mm) Sheet Width, More Intense Sheet Beam

Differntial Pumping :
3 stage
Dist. Nozzle-Target Center :
50-60 cm
Expected Target Density :
> 3.2 x 10-6 Torr

Nozzle improvement is needed for reach to the sheet density of 1 x 10-5 Torr.





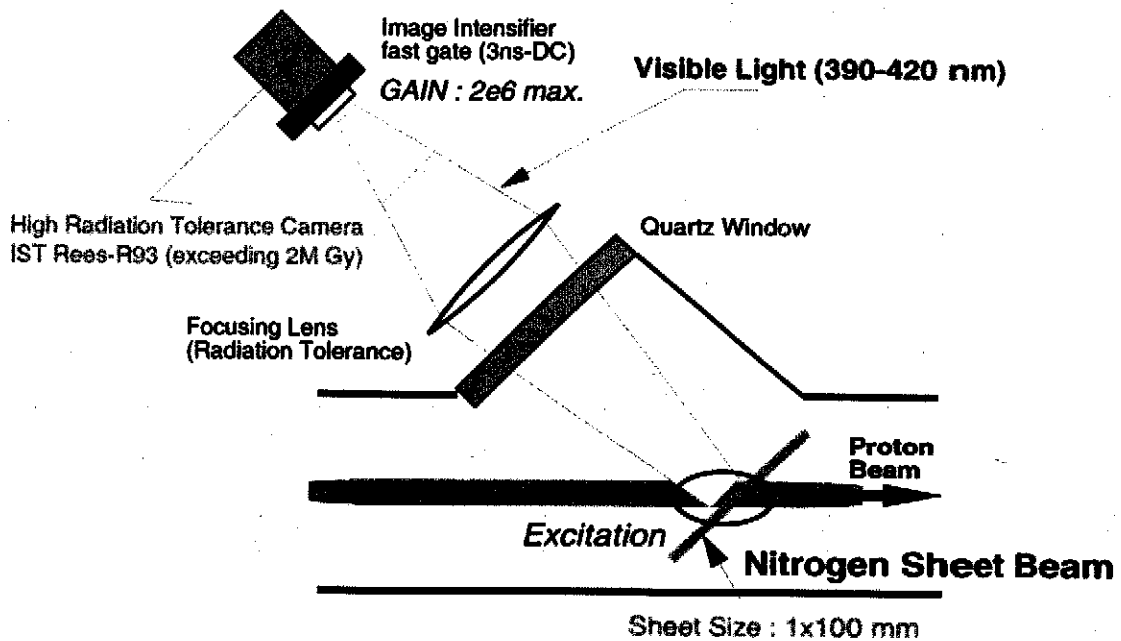
6. Design set up and components for High Intensity Beams

High radiation activity
1 M Gy / year

1 Detector
Image Intensifier
(with 2 stage MCP : Max. Gain 1e6)
High Radiation Tolerance Camera
(IST-Rees R93 : exceeding 2 M Gy)

1 Other Components
Turbo Molecular Pump
(Pfeiffer TMU 400)
Dry pumps (Oil free)

1 Radiation Shielding



7. Summary

- ***Gas Sheet***
  - Density is achieved **7 x 10-7 Torr** at the point of 1.25 m downstream from the nozzle.
  - Shortened gas sheet generator is under manufacturing.
  - The density is estimated **larger than 3 x 10 –6 Torr for the shortened generator.**
  - More nozzle improvement is required for design intensity of 1x 10-5 Torr.
  - In the shortened generator, study for sheet widening (> 100 mm) is needed.
- ***For Low Intensity Synchrotron Beams (NIRS-HIMAC)***
  - **Within the time of several bunches passing, one profile detection is expected possible.**

    @(< 270 MeV, 2.5 x 10^8 part./bunch, $^{12}C^{6+}$).
  - Study will be started soon!
- ***For High Intensity Synchrotron Beams (IKI-50 GeV PS)***
  - Material for the monitor equipment must be examined under high radiation activity.
  - **Within the time of several ten bunches passing, one profile detection is expected possible.**

    @(3-50 GeV, 2 x 10^{13} part/bunch, proton)
  - Study will be started this fiscal year with KEK PS-Booster proton beam.

    @(500 MeV, 2 x 10^{12} part/bunch, proton)