

The cluster-jet target for the $\bar{\text{P}}\text{ANDA}$ experiment

Esperanza Köhler

Institut für Kernphysik



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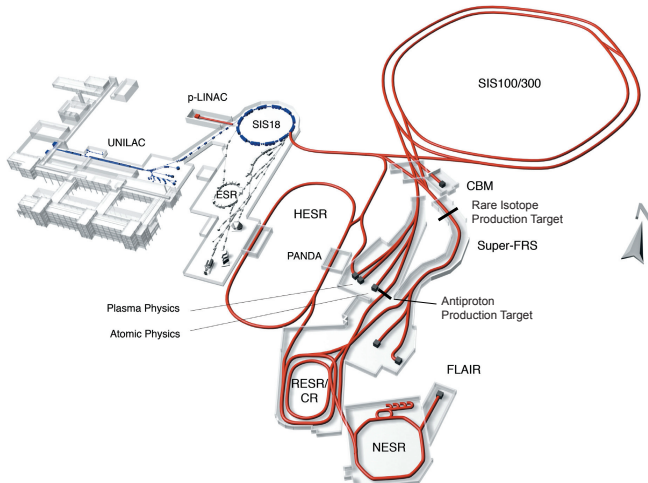


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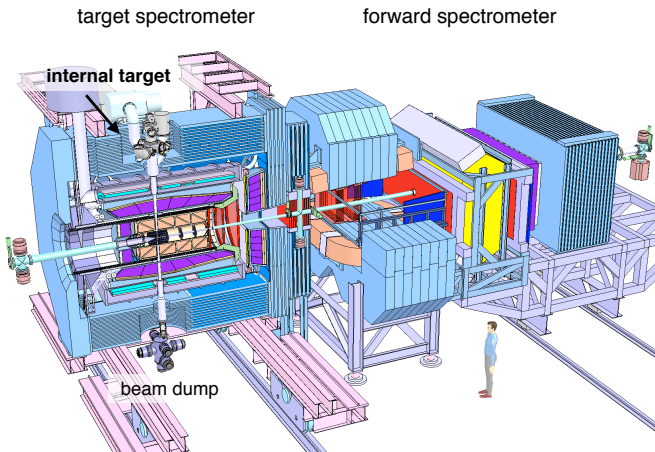
The $\overline{\text{P}}\text{ANDA}$ experiment at FAIR

- $\overline{\text{P}}\text{ANDA}$: AntiProton ANnihilation at DArmstadt
- FAIR: Facility for Antiproton and Ion Research



The $\bar{P}$ ANDA experiment at FAIR

- $\bar{p} + p \longrightarrow$ mesons, exotic hadrons $\Rightarrow$ insights into strong interaction



Requirements for an internal target for the $\bar{\text{P}}\text{ANDA}$ experiment

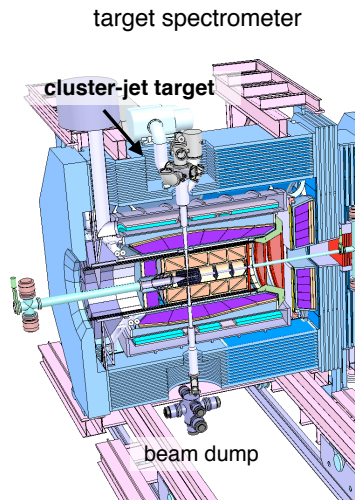
- Target density constant in time and adjustable
- Target beam size and shape variable (depending on used orifice)
- Effective target beam size as small as possible
- Low influence on vacuum conditions in the accelerator
- High purity of used target material (H_2 , D_2)

All requirements are fulfilled by using a cluster-jet target

Requirements for an internal target for the $\bar{\text{P}}\text{ANDA}$ experiment

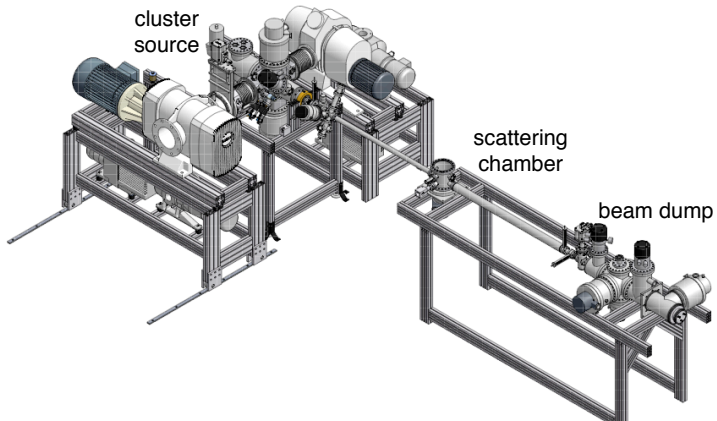
- Distance between target source and interaction point : 2.1 m
- Required target density: above $10^{15} \frac{\text{atoms}}{\text{cm}^2}$
- Previous cluster-jet targets (**COSY-11, ANKE**):
 - Working distance: up to 0.65 m
 - Target density: above $10^{14} \frac{\text{atoms}}{\text{cm}^2}$

Target density decreases with $\frac{1}{r^2}$

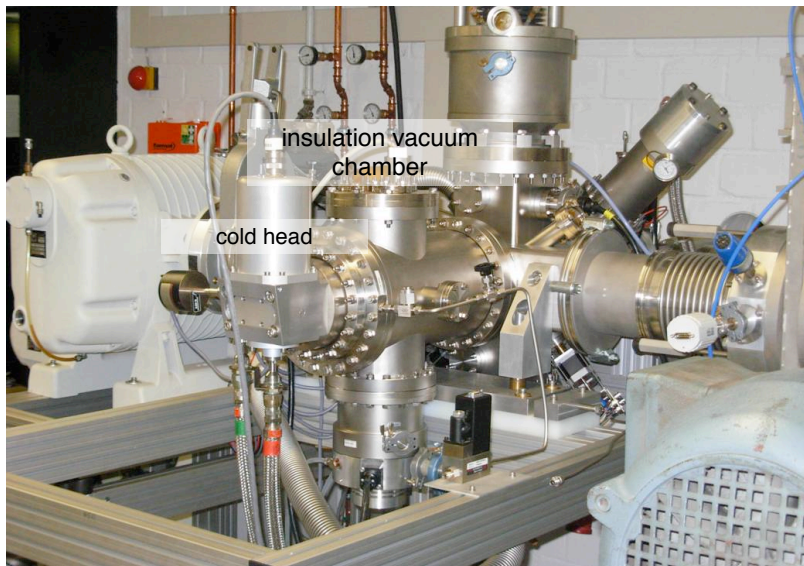


Prototype of a high density cluster-jet target for $\bar{\text{P}}\text{ANDA}$

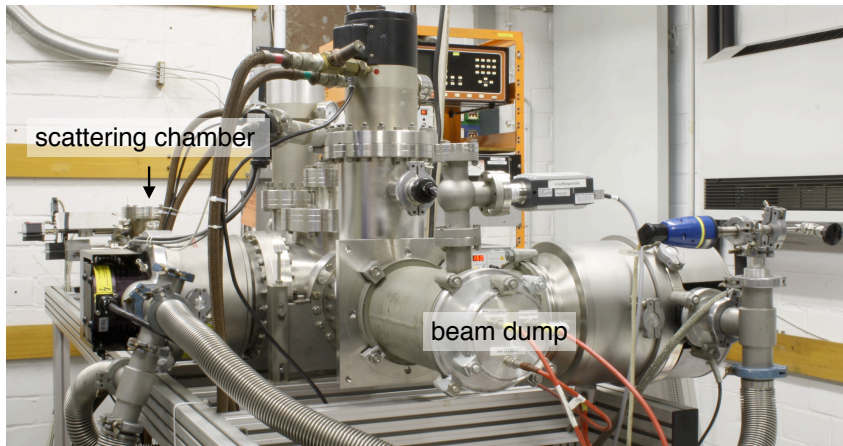
- Prototype of a cluster target generator, already built up and set successfully into operation
- Complete system installed in $\bar{\text{P}}\text{ANDA}$ geometry
- Scattering chamber $\hat{=}$ $\bar{\text{P}}\text{ANDA}$ interaction point



Cluster-jet target

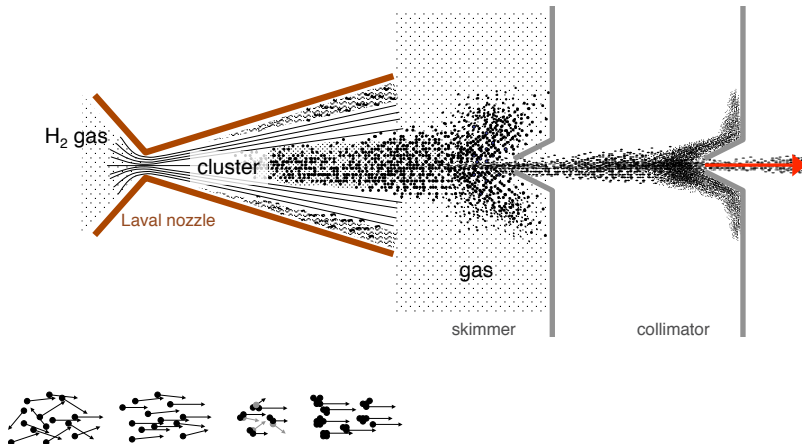


Cluster-jet target

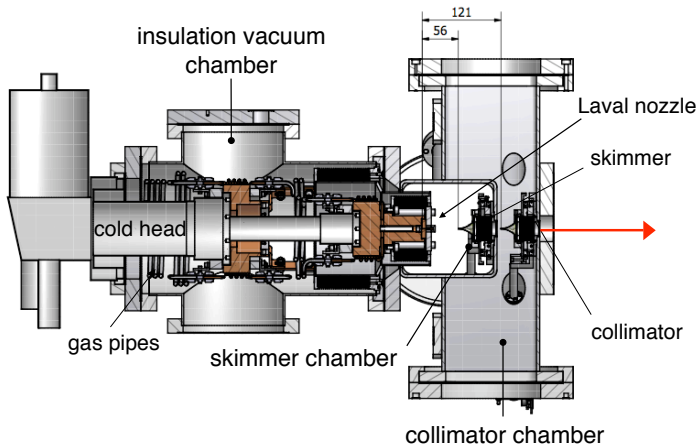


Cluster production with a Laval nozzle

- **Cluster:** Particle with n atoms/molecules, in this case: van der Waals force responsible for bonding



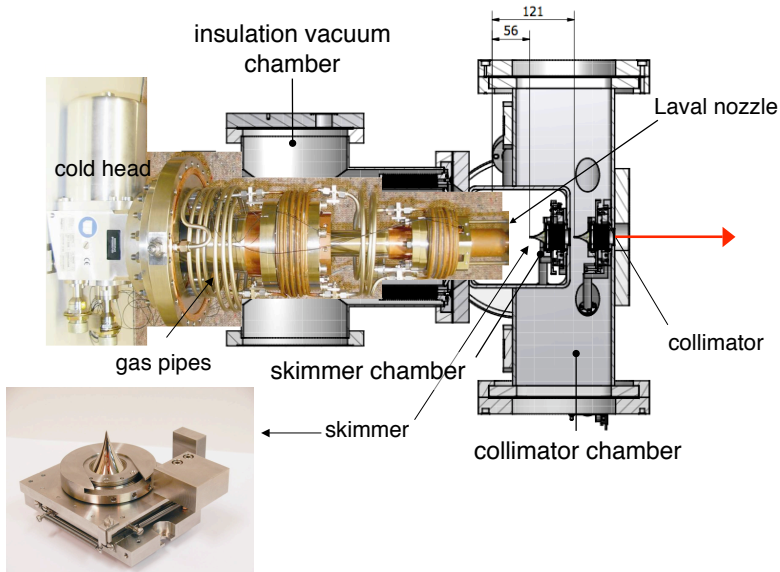
The cluster source



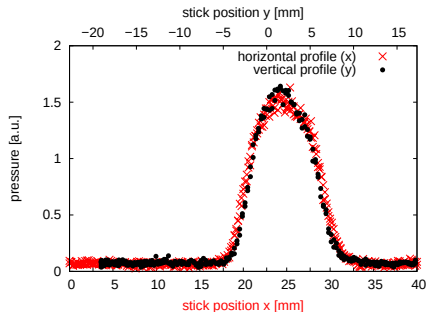
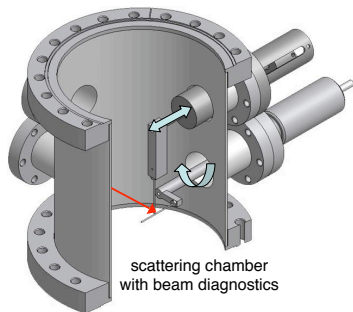
- Cold head: $T = 20 - 50 \text{ K}$
- Pressure: $p = 7 - 20 \text{ bar}$
- Laval nozzle: $\varnothing = 28 \mu\text{m}$

- Skimmer: $\varnothing = 0.5 \text{ mm}$ (movable)
- Collimator: $\varnothing = 0.7 \text{ mm}$ (movable)

The cluster source



Determination of the target density



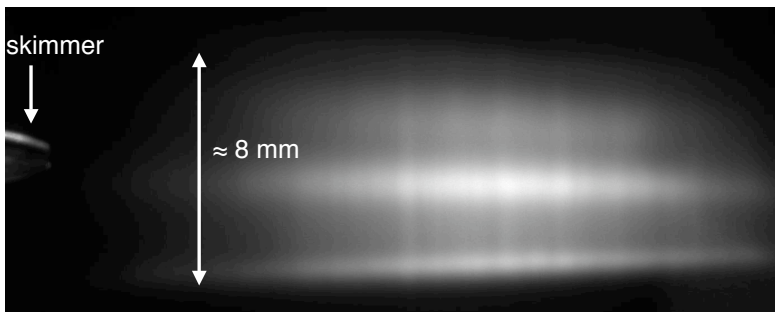
$$\rho_T \sim \frac{p_{sc}}{v_c}$$

- ρ_T : Target density
- v_c : Cluster velocity (200 – 1000 m/s)
- p_{sc} : Pressure increase in scattering chamber

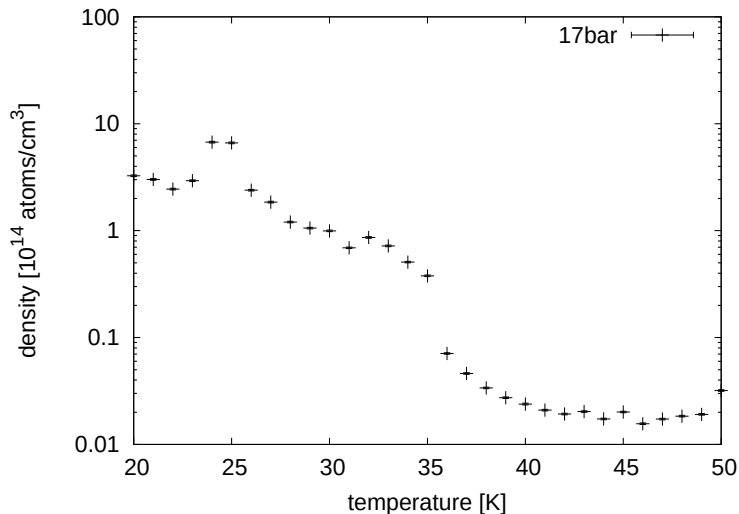
Determination of the target density

Premiere

$$\rho_T = 6.7 \cdot 10^{14} \frac{\text{atoms}}{\text{cm}^3}$$
$$\Rightarrow 10^{15} \frac{\text{atoms}}{\text{cm}^2} \text{ using } \varnothing = 15 \text{ mm beam at } 2.1 \text{ m}$$

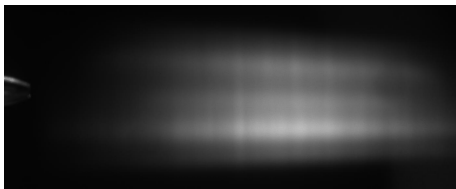


Adjustable target density

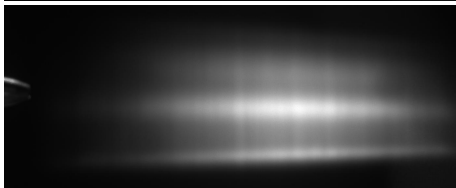


Improvement of target density

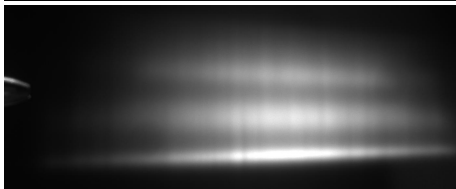
- 30 K



- 25 K



- 20 K



Summary and Outlook

Summary

- Cluster-jet target prototype built up in $\overline{\text{PANDA}}$ geometry
- Prototype set successfully into operation
- Target density is $10^{15} \frac{\text{atoms}}{\text{cm}^2}$ by using $\varnothing = 15 \text{ mm}$ beam at 2.1 m

Outlook

- Improvement of target density
- Research and improvement of vacuum pressure in scattering chamber
- Research on cluster size and mass
- Design and construction of a final target for the $\overline{\text{PANDA}}$ experiment

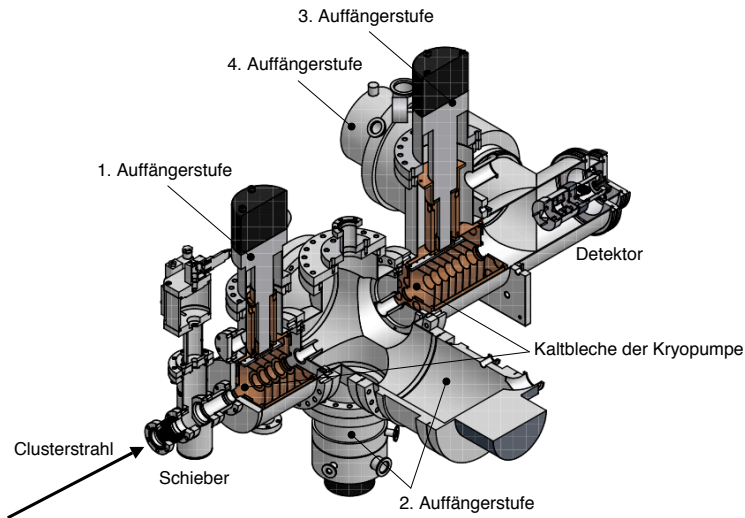
Thank you for your attention!



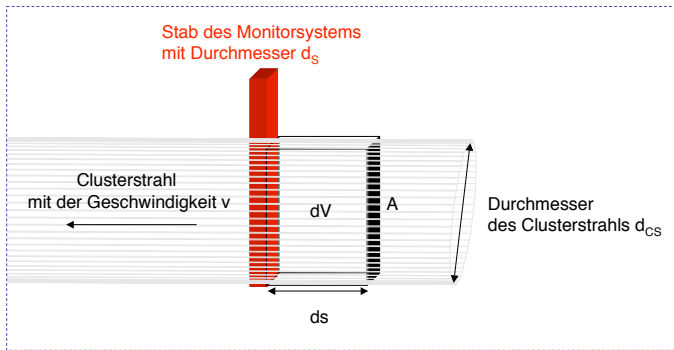
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Auffänger



$$\rho = 2 \cdot \frac{p \cdot S \cdot \frac{N_A}{RT}}{d_S \cdot d_{CS} \cdot v}$$



Streukammer mit Saugvermögen S und Druckanstieg p

Vakuumsystem

n	$VP_n \left[\frac{m^3}{h} \right]$	$RP_n \left[\frac{m^3}{h} \right]$
1	175	1000
2	200	600
3	65	2000
4	25	500
5	25	3000
6	200	500

n	TP _n [l/s]
1	360
2	1000
3	1000
4	150
5	360
6	1000
7	360
8	1000

