

Laser-Plasma Acceleration: Plasma Guiding Sub-Group

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- Laser-Plasma Working Group: 12 Laser-Plasma Guiding Presentations
- Milestone achievements for accelerator applications reported at AAC04 Workshop:
 - Guiding of laser pulses of *relativistic* intensity in preformed plasma channels:
 - Geddes (LBNL) reported guiding in preformed plasma channel of $>10^{18}$ W/cm² laser pulses
 - Zigler (Icarus) reported guiding $\sim 10^{18}$ W/cm² in discharge-ablative capillaries
 - Laser-plasma *acceleration* obtained in channels:
 - Kitagawa (Osaka) reported generation of up to 100 MeV electrons using laser-illuminated glass capillary
 - Geddes (LBNL) reported laser wakefield acceleration of beams up to 3×10^9 electrons at 78 MeV (<4 MeV energy spread).

Guiding Technique	Density (cm ⁻³)	Length (mm)	Radius (microns)	Comments
Hollow Capillary	0-10 ¹⁷ ? (ablation from wall, gas-filled)	100	>20	- Limited capillary lifetime AAC04: Kitagawa (Osaka) reported generation of 100MeV electrons. AAC04: Sung (UCLA) reported guiding of 10 micron laser pulses
Hydro-dynamic expansion (axicon, ignitor-heater)	3x10 ¹⁸ - 10 ¹⁹	15	>10	- Complexity (auxiliary laser(s) required) - Low density difficult + diagnostic accessibility AAC04: Geddes (LBNL) reported guiding of relativistic intensities (>10¹⁸ W/cm²).
Hydro-dynamic compression (z-pinch)	10 ¹⁷	100	>20	-Plasma fully ionized? -Complex circuit -Timing jitter

Guiding Technique	Density (cm ⁻³)	Length (mm)	Radius (microns)	Comments
Laser-triggered open discharge	>10 ¹⁸	25	>20	<ul style="list-style-type: none"> - guiding still to be demonstrated - high density required for laser triggering + open discharge allows for probing <p>AAC04: Lopes (IST) reported production of He channels.</p>
Discharge ablative capillary	~10 ¹⁸	20	20	<ul style="list-style-type: none"> - Partially ionized plasma - Limited capillary lifetime - difficult to diagnose <p>AAC04: Zigler (Icarus) reported evidence for guiding at relativistic intensities (~10¹⁸ W/cm²).</p> <p>AAC04: Pogorelsky (BNL) CO₂ laser channeled in plasma guide.</p>

Guiding Technique	Density (cm⁻³)	Length (mm)	Radius (microns)	Comments
Clustered Gases	10 ¹⁸	<20	10	+ simplicity + efficient channel production AAC04: Kumarappan (Maryland) reported self-focusing and guiding in clustered gases at 3x10¹⁷ W/cm².
Gas-filled discharge capillary	10 ¹⁸ -10 ¹⁹ (5x10 ¹⁷ straight forward to achieve)	50	>20	+ tapering straightforward + simplicity in staging + side-diagnostics achieved AAC04: Hooker (Oxford) reported guiding and plasma channel production in gas-filled discharge capillaries.

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Laser-Plasma Guiding progress:

1. $\sim 10^{18} \text{ cm}^{-3}$ plasma density channels
2. cm-scale plasma channel lengths
3. Relativistic intensities guided ($a_0 \sim 1$)

Future goals and challenges:

1. (accelerator scalings suggests lower density yields higher energy gain)

Stable guiding of relativistic intensities at plasma densities $\sim 10^{17} \text{ cm}^{-3}$

2. Staging plasma channels